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Design of the Affordable FLASH Proton Therapy Facility with Permanent Magnets

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We present a complete design of the proton cancer FLASH therapy facility using permanent Halbach type magnets. The FLASH therapy is still in the evaluation stage with a treatment of very small number of patients. Most of the studies were done with animals. The FLASH cancer radiation represents relatively recent developments where ultra-high-dose-rate of more than 40 Gy/sec is delivered. It has been demonstrated, mostly through multiple animal experiments and just few human exposures [1, 2] that the FLASH can decrease the normal tissue injury while maintaining destruction of the tumor cells as in conventional radiotherapy. This proposal removes limitations of the existing proton therapy facilities as it delivers during the treatment protons with required energies in a very short time as there is no need to change the magnetic field in either accelerator or transfer beam line or in the gantries – delivery systems. The proposal includes 1.3 kHz fast cycling permanent magnet synchrotron with kinetic energy range between 10-250 MeV with 10 MeV 78 MHz injection cyclotron. The facility continues with the permanent magnet beam lines and the delivery system with the permanent magnet gantry.

Permanent magnets proposal for the Fast Cycling Synchrotron, beam transfer lines and delivery system - gantry is based on already achieved technology recently demonstrated in the **C**ornell-**B**NL **E**lectron **T**est **A**ccelerator "**CBETA**" commissioning [3].

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Cytotoxicity of nitroaromatic drugs: a role of sulfone group

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Nitroaromatic compounds ($ArNO_2$) are widely used as radiosensitizers and antiparasitic and antitumour agents. Their nonspecific mammalian cell cytotoxicity has a prooxidant character, and is caused by the redox cycling of free radicals, formed after the single-electron enzymatic reduction of $ArNO_2$. The cytotoxicity of $ArNO_2$ increases with their single-electron reduction potential (E^1_7) and octanol/water distribution coefficient at pH 7.0 (log D) ([1], and References therein), and can be described by regression log (cytotoxic concentration) = a - b E^1_7 – c log D. Apart from using pulse-radiolysis technique, the unavailable E^1_7 values of $ArNO_2$ can be calculated from the geometric average of their bimolecular reduction rate constants by single-electron transferring flavoenzymes such as NADPH:cytochrome P450 reductase, ferredoxin: $NADP^+$ oxidoreductase and adrenodoxin reductase/adrenodoxin [2]. Using this approach, we obtained the previously unavailable E^1_7 values of antiparasitic drugs fexinidazole and tinidazole (CAS 59729-37-2 and 1989387-91-8, respectively) (-0.458 V), antidepressant AR-A14418 (CAS 487021-52-3, E^1_7 = -0.360 V), and experimental anticancer drugs Tri-1 (CAS 246020-68-8, E^1_7 = -0.368 V), Stattic (CAS 149983-44-9, E^1_7 = -0.302 V), and NSC697923 (CAS 343351-67-7, E^1_7 = -0.285 V). The studies of mouse hepatoma MH22a and human colon carcinoma HCT-116 cells revealed that the cytotoxicity of fexinidazole, tinidazole, AR-A14418 followed the regressions previously obtained for the model nitroaromatic compounds with available E^1_7 values [2], whereas the cytotoxicity of Tri-1, Stattic and NSC697923 was by 6.5-53 times higher than expected. It is possible that an enhanced cytotoxicity of the latter compounds is attributed to the presence of sulfone groups, which covalently modify and inactivate the antioxidant flavosulfoselenoenzyme thioredoxin reductase (TrxR) [3]. We found that in accordance with the previous observations [3], the latter compounds inactivated reduced TrxR at micromolar concentrations less than in 1 h. This is also supported by the fact than in both cell lines, the cytotoxicity of a classical irreversible inhibitor of TrxR, 1-chloro-2,4-nitrobenzene (E^1_7 = -0.299 V, this work) was also by 10 times higher than expected.

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Association of free fatty acids with glucose in newly diagnosed Type 2 diabetes

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Although there is ample evidence to suggest a strong association of glucose as well as glycated hemoglobin and fatty acid values with type 2 diabetes mellitus (T2D), a limited number of studies have examined the association of individual fatty acids with disease progression. Acute elevated plasma fatty acids stimulate insulin secretion, while chronically elevated plasma fatty acids alter and disrupt insulin secretion. Also, free fatty acids (FFA) are known to interfere with normal glucose homeostasis and affect pancreatic β-cell dysfunction. The study included 24 patients from Sarajevo University Clinical Centre, newly diagnosed with Type 2 diabetes, and 27 healthy individuals as control. Analysis of glucose and glycated hemoglobin levels were done by IFCC methods while FFAs concentrations were determined by gas chromatography. The results showed statistical significant differences in glucose, HbA1c, lipid profile, palmitic, linolenic, arachidic, arachidonic, behenic acids, as well as DHA levels in all participants. In healthy subjects, significant correlation was not found between glucose and individual FFAs while a negative association was observed between DHA and glycated hemoglobin ($p<0.05$). Newly diagnosed diabetics show negative significant association between glucose and lauric acid concentrations and also, glycated hemoglobin being correlated with myristic acid levels ($p<0.01$and $p<0.05$, respectively). These data point out associations of different types of FFAs with glucose levels and its control in serum of healthy and newly diagnosed type 2 diabetic subjects, and therefore, suggest the importance of monitoring glucose levels as well as glycated hemoglobin with individual free fatty acid concentrations, in the progression of diabetes.

Dried fruits of *Sorbus torminalis* L. Crantz. as functional food

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Fruits of *Sorbus torminalis* L. Crantz. (Wild service tree) have been traditionally used, fresh or dried, for the production of preserves such as jam, jelly, syrup, compote or tea. Furtheremore, these fruits are well known worldwide as a traditional remedy for treating respiratory tract infections, as traditional astringent, diarrheic and antidiabetic agents. As a part of broad research, the aim of this study was to define phenolic profile as well as antioxidant activity of water and methanolic extracts of dried fruits. The presence and content of 44 plant phenolics and quinic acid was determined using LC-MS/MS technique. In order to examine antioxidant potency, few in vitro assays were carried out: DPPH• (diphenylpicrylhydrazyl), HO• (hydroxyl radical), and reducing power (FRAP) assay. In addition, total phenolic and flavonoid contents were determined spectrophotometrically. Among examined compounds, quinic acid (precursor of phenolics) was the most dominant among both samples. Moreover, protocatechuic an ferulic acids were the most abundant amongst phenolics acids. Furthermore, analysis of selected flavonoids showed notable content of amentoflavone as well as quercetin glycosides (quercetin-3-O-glucoside and hyperoside). In applied antioxidant tests, methanolic extract showed the highest antiradical activity. Compared to propyl galate, a well known synthetic antioxidant, both extracts exhibited a potent antioxidant activity. Total phenolic content was significant, expecially in methanolic extract, while total phenolic content was low in both extracts. Obtained results indicates a significant antioxidant potential of S. torminalis fruits and higly support traditional use of this species in diet, but also points to its use as a functional food.

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Determination of the inhibitor effect of thiourea on urease activity

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Urease catalyses the hydrolysis of urea to carbonic acid and ammonia via the formation of carbamic acid (H_2NCOOH) In aqueous solutions, the carbonic acid and NH_3 are in equilibrium with bicarbonate and ammonium ions, respectively. Urease is produced by bacteria, fungi, plants, and invertebrates, and its primary structure and active site are surprisingly conserved among different species. The active site of urease contains two Ni^{2+} ions, which are bridged by a hydroxyl group and a carbamylated lysine. Inhibition of urease is often part of the medical treatment of infections by ureolytic bacteria. This inhibition is normally carried out by small molecular inhibitors that are safe and metabolically stable *in vivo*. In this work, the inhibitory effect of thiourea on urease activity was tested using the potentiometric method. The results obtained indicate an acompetitive type of inhibition. Using the Lineweaver-Burk equation, the values of kinetic parameters of maximum velocity and Michaelis-Menten constant were calculated.

How to wake up space-related bacteria from a copper-induced dormant state

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Alternative strategies to sanitize water sources and surfaces prone to microbial contaminations are emerging. Metal-based antimicrobials (e.g. metal ions or metallic coatings) are currently tested for their efficacy in disinfection practices. Space agencies are specifically interested, as prevention of contamination needs to be secured for space missions. In this regard, the effect of copper on bacteria is studied for free-living planktonic cells and biofilms.

It has been shown that certain bacteria enter the so-called viable but non-culturable (VBNC) cell state under copper stress. The VBNC cell state, proposed to be a deeper dormant state than the persister phenomenon, remains largely enigmatic. Due to their dormant nature, VBCN cells stay undetected by microbial monitoring methods currently applied in space. Here we investigate the cellular mechanisms controlling the Cu-induced VBNC state in *Cupriavidus metallidurans,* a contaminant of space vehicle drinking water.

Besides chromosomal metal (loid) resistance genes, type strain CH34 also contains two plasmids carrying extra operons involved in metal resistance. CH34 and its plasmid-cured derivative strain AE104 were exposed to low levels of Cu^{2+} in mineral water. Viable counts showed that while there is an initial decrease in cell counts for both strains, only CH34 is able to regain growth (resuscitate) in the later stage of incubation. Following this comparison, we hypothesized that the plasmid-borne gene clusters of CH34 may be responsible for this observation. Consequently, those gene clusters associated with metal resistance were cloned into AE104 separately, revealing that only presence of the *cop* cluster enabled resuscitation after Cu-treatment. In addition, analysis of the proteome from cells that had undergone resuscitation showed that proteins of the *cop* cluster were significantly upregulated compared to samples from early-stage Cu-treatment.

To further investigate the *cop* cluster on its involvement in resuscitation, the cluster was split into two parts which then were studied individually. Our results indicate that the part containing the *copABCD* operon (encoding periplasmic Cu resistance proteins) plays an essential role in resuscitation, while the part containing *copF* (encoding a P-Type ATPase involved in cytoplasmic Cu(I) efflux) is not required for this phenomenon. Currently, we are creating a *cop*-gene mutant library in order to answer the question whether the resuscitation phenotype can be pinned down to one specific gene of the *cop* cluster. With the aim of elucidating the mechanisms behind the Cu-induced VBNC state, we seek to help to optimize and score efficacy of Cu-based antimicrobials for space applications.

Mechanism of antibacterial action of bioactive peptides from the *Helix aspersa* mucus

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Recently, the World Health Organization has declared that antimicrobial resistance is one of the global public health threats facing humanity, and announced the start of the “post-antibiotics era”. This fact shows the new challenges for scientists related to the discovery of new effective antimicrobial agents, with a mechanism of action other than conventional antibiotics.

The mucus of garden snail *Helix aspersa* is a complex, multicomponent biological fluid containing mixture of different biochemical active substances with potentially application in pharmacology and medicine.

The *H. aspersa* mucus was collected from garden snails living in Bulgarian eco-farms, using patented technology from us, that keeps the snails alive. The purified mucus extract was separated into several fractions by ultrafiltration on Millipore membranes with different pore size. After *in vitro* assays it was found that peptide fraction with MW < 10 kDa showed antibacterial activity against various Gram– and Gram+ bacteria, including *Escherichia coli*. To explain this effect, after purification, the peptides were analyzed by MALDI-TOF-TOF using Autoflex™ III. Most peptides were identified by de novo MS/MS sequencing using tandem mass spectrometry. Some of them contain a high level of glycine, leucine, proline, tryptophan and valine residues, which are typical for antimicrobial peptides. Using the ExPASy ProtParam tool, the physicochemical characteristics of the identified peptides were determined. Their 3D-structures were generated by PepFold3 software. *In silico* study on several peptides led to hypothesis for a multistage nature of their antibacterial activity and the formation of mixed peptide clusters as a transport and concentration agent to deliver the active ingredients to the target bacterial membrane. The antimicrobial activity of a number of two- and three-component peptide mixtures was confirmed by *in vitro* assay. In order to identify changes in the expression of proteins secreted *by E. coli* before and after treatment with active fraction, a proteomic analysis was performed, including two-dimensional gel electrophoresis (2D-PAGE), mass spectrometry and bioinformatics. A significant change was found in the expression of a number of proteins, such as Outer membrane protein A and Outer membrane porin F, which have an important role in the stability of the outer membrane and in the survival of bacterial cells under toxic stress, as well as other important proteins, such as Exodeoxyribonuclease III, Stringent starvation protein A, Succinate-CoA ligase, Enolase and DNA-directed RNA polymerase.

The observed antibacterial effect is due to disturbances in the vital functions and cellular metabolism of *E. coli*, caused by the cytotoxic action of low molecular weight metabolites and peptides in the active fraction, which exhibit a synergistic effect.

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Design and synthesis of multidentate organic ligands for protein-based supra molecular constructs

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Among the diversity of materials used in nanomedicine and biotechnology, proteins offer full biocompatibility, structural and functional versatility [1]. Protein modification is usually achieved through covalent strategies; however, recent new advances in supramolecular chemistry may constitute an alternative and complementary approach for achieving bioconjugation in a controllable manneri [2]. Thus, we report herein design and synthesis of multidentate organic ligands which in conjunction with metal-ions or small molecule chemical probes such as activity-based probes can be used to prepare enzyme-ligands supramolecular constructs [3].

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Characterization, mechanical and biomedical properties of titanium oxynitride coating

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In this study titanium oxide-nitride coating through reactive magnetron sputtering deposition was applied on 12Cr18Ni10Ti stainless biomedical steel. The different flow rates of oxygen and argon were used to test microstructure and chemical bond evolution during film sputtering, namely N_2/O_2 ratios of 1, 1.5, and 2. Obtained samples were analyzed by IR spectroscopy, SEM, XPS, and XRD. Additionally, the nanoindentation procedure measured the hardness and elastic modulus for each coating on steel. Oxynitride coatings exhibit the nanocrystalline structure, where nitride and oxide phases are present in the unbound state. A nitrogen-rich sample experienced the crystalline structure of (110)-oriented rutile with 124 nm large clusters. In contrast, with an increase in oxygen gas flow mixed rutile-anatase (111)-oriented phase became more pronounced with fragmented grains 25 – 27 nm in diameter. Mechanical tests reveal that hardness and deformation resistance rely on microstructure and titanium oxide orientation. Cell culture experiments show that coating deposited at regime $N_2/O_2 = 1$ is capable of efficient cell proliferation concerning pristine steel and other oxynitride samples. The findings of this work are beneficial to understanding the mechanisms of oxynitride barriers in coronary stent modification.

Characterization and degradation of natural polysaccharide multilayer films

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Key words: Polyelectrolyte multilayers, Optical profilometry, Atomic force microscopy

Polyelectrolyte multilayer films are three dimensional complexes, constructed by the interactions between oppositely charged polyions. In this study layer by layer technique was used for fabrication of natural pectin/chitosan (Pe/Chi) multilayers, consist of 5 and 10 bilayers, on a solid substrate, as a model of different medical devises. Specific surface morphology of these multilayer films and differences in roughness, depending on the number of the bilayers were established by means of atomic force microscopy. Adhesion of human red blood cells (RBCs) on the surface of the coatings was tested in order to verify the potential of the Pe/Chi films to cover medical devices that directly contact with human blood and applying optical profilometry we found that there is no adhesion of RBCs on the Pe/Chi multilayer surfaces. This would allow their use for biofunctionalization of medical materials, coming into contact with blood.

The stability of the 5 and 10 bilayer films was tested applying spectrophotometry. For this purpose, the chitosan was replaced with fluorescence-labeled chitosan (Chi^{FITC}). The obtained Pe/Chi^{FITC} films were stored at different temperatures (4, 24, and 37 ^{o}C) and the kinetic of degradation was monitored. The temperature at which the films remain intact for the longest time was found to be 4 ^{o}C and the rate of deconstruction was accelerated at the higher temperatures. Thus, the appropriate storage temperature (at 4 ^{o}C) and degradation period of the coatings at physiological temperature were established.

Our data demonstrate a potential of Pe/Chi multilayers for biofunctionalization of medical device surfaces.

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Use of neural networks in bioengineering

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This paper presents an overview of the application of neural networks in the field of biomedical engineering. Artificial neural networks in general are explained; some limitations and some proven advantages of neural networks are discussed. The use of artificial neural network techniques in various biomedical engineering applications is summarized. A case study was used to demonstrate the effectiveness of artificial neural networks in this area. The paper ends with a discussion of the future use of artificial neural networks in the field of biomedical engineering.

Quantum chemical study of the charge transfer in an ionized complex of three stacked guanines

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Deoxyribonucleic acid (DNA), the carrier of human genetic information, is daily exposed to many influences, including both natural and artificial ionizing radiation generated by the environment in which we live. Biologically, these can lead to mutagenesis, carcinogenesis, and aging. Photochemically, the interaction with ionizing radiation can initiate processes such as charge transfer (CT) along a DNA strand [1]. This process has been intensively investigated over the last thirty years due to its role in oxidative damage and DNA repair mechanisms and its possible applications in nanoelectronics [2,3].

The first part of our work, dedicated to the determination of the vertical ionization potential of single-stranded DNA sequences of different lengths and types in the gas phase, provided a general overview of the ionization of stacked DNA base complexes and confirmed that guanine-rich sequences are the most easily ionized sequences, as previously suggested [4]. Thus, charge migration from one guanine to another appears to be the key event in the process although its exact mechanism is not yet known [3,5,6].

Here, we have investigated the charge transfer process within an ionized complex of three stacked guanines (GGG^+) using multiconfigurational quantum chemistry methods (CASSCF/CASPT2). This approach has already been successfully employed to characterize ground and excited electronic states of two contiguous guanines within the same strand [5,7]. Methodological tests were performed to adjust the previously developed computational methodology to consider the influence of a third guanine. The calculation level was then used to explore the potential energy surfaces, as a function of three intermolecular structural parameters of DNA base stackings, namely the shift, slide and twist. The charge distributions on each guanine of the complex have been also determined.

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On application of some machine learning algorithms for sex identification based on linear mandibular measurements derived from CT scans

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The present study aims to compare the classification accuracy of models for sex identification learnt by some sub-symbolic ML algorithms based on linear mandibular measurements. The sample of the study includes head CT scans of 116 males and 123 females generated by a Toshiba Aquilion 64 CT system. Forty-five landmarks of the mandible were digitized and their three-dimensional coordinates were used for calculation of all possible interlandmark distances between the landmarks. Thus constructed dataset consists of 990 mandibular measurements (attributes). The classification models were created by means of three sub-symbolic ML algorithms including Support Vector Machines (SVM), Naïve Bayes (NB) and Random Forest (RF). The classification accuracy of the models was evaluated using 10x5-cross-validation procedure. Based on the full dataset of 990 interlandmark distances, the highest accuracy of sex identification was achieved by SVM model (88.3%), closely followed by RF and NB models. An attempt to raise the classification accuracy of the models was done by means of a specially designed attribute selection algorithm aiming at selecting the best attribute subset specific for each of the tested ML algorithms. As a result, the accuracy of all models used in the experiments has been increased and the best classification accuracy of 95.3% was achieved by the SVM model trained on a dataset consisting of 19 interlandmark distances.

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In silico validation of grapefruit seed extract (GSE) as antibiotic enhancer against MRSA strains

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Antimicrobial resistance is one of the leading global health problems, whereby Gram-positive Methicillin-Resistant *Staphylococcus aureus* (MRSA), a widespread drug-resistant bacterium is a great threat for humankind. The *mecA* gene of MRSA encodes the penicillin-binding protein 2a (PBP2a) that is responsible for the resistance to β-lactam antibiotics. Using virtual screening methods such as molecular docking, researchers are trying to find potential inhibitors against not only MRSA strains, but also against other multidrug-resistant pathogens. From the previous *in vitro* studies, grapefruit seed extract (GSE) was found to have promising antimicrobial activity, particularly against MRSA. To determine the potential inhibitory effect of GSE against MRSA, we analyzed the binding affinity of selected compounds from this extract against SauPBP2a protein (PDB:1MWT). Selected compounds were naringin, naringenin, narirutin, limonin, citric acid, ascorbic acid and tocopherol. As positive controls of binding affinity, we used ceftopibrole and oxadiazole because of their high binding affinity to the SauPBP2a active site in other molecular docking studies. Results showed highest binding affinity (rmsd l.b. 0.000; rmsd u.b. 0.000) for narirutin (-9.3), just as well for naringin (-9.3), limonin (-8.8), naringenin (-8.4), ceftobiprole (-8.0), methicillin (-6.7), tocopherol (-6.6), ascorbic acid (-5.5), citric acid (-5.5) and oxadiazole (-3.9), all expressed in kcal/mol. Narirutin and naringin, except that they had the highest binding affinity, showed significant hydrogen bonding with SauPBP2a active site, indicating the potential inhibition against MRSA. Our findings of *in silico* analysis, supported also by previous *in vitro* outcomes, indicated potential antimicrobial effect of GSE compounds against MRSA. In conclusion, GSE could be used as an adjuvant to the conventional antibiotic treatment against infections caused by MRSA strains. Before actual usage, further studies such as *in vivo* activity and clinical safety application should be evaluated and conducted.

Degree of monomer conversion in dual cure resin-based dental cements material

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Introduction: The degree of monomer-to-polymer conversion is an important characteristic of dental materials based on composite resins used in tooth restoration as well as for the permanent bonding of crowns, bridges and fiber posts. Available data indicate that 100% polymerization of composite resin-based materials is not attainable in practice, which leads to inferior mechanical properties of the material, as well as a weaker bond strength between the restorative material and the tooth structure. In addition, unreacted monomer leaching has potential biological implications, especially in the case of triethylene glycol dimethacrylate (TEGDMA), which has been shown to cause DNA changes in mammalian cells. Unreacted monomer can also stimulate bacterial growth in the immediate vicinity of the restoration and cause allergic reactions in some patients.

Materials and methods: Infrared spectroscopy with Fourier transform (FT-IC) was used to determine the degree of monomer-to-polymer conversion in dual cure cements based on composite resins. Two materials from the group of resin-based dual cure cements were analyzed (Variolink II and RelyX ARC, 10 samples of each material). After preparation, the samples were stored in a water bath at 37 ° C for 24 hours, after which FT-IC spectrophotometer was used to record the spectra at wavelengths ranging from 400 to 4000 cm^{-1}as a means of establishing the degree of cementitious material polymerization.

Results: The degree of monomer-to-polymer conversion in the tested materials ranged from 69.18% to 98.74% for Variolink II and from 30.6% to 97.92% for RelyX ARC, with an average of 73.58%.

Conclusion: The tested materials showed a satisfactory degree of polymerization, which was influenced by the chemical structure of the cementitious material in terms of the presence of a dominant organic resinous matrix. Cement material based on TEGDMA organic resin matrix exhibits a significantly higher degree of monomer-to-polymer conversion.

Keywords: dental resin-based cement; degree of conversion; infrared spectrophotmetry; dual-cure resin-based cement; bond strength

Titanium with a surface structured by ultrashort laser pulses - a new direction in the technology of dental implants

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Titanium (Ti) and titanium alloys are widely used in medicine and dentistry due to their resistance to body fluids, high corrosion resistance, high tensile strength, flexibility and biocompatibility. Their good interfacial and chemical compatibility with tissues is well-known from both basic research and clinical trials. The disadvantage of metal biomaterials is that they are artificial materials and do not have biofunctions. To increase the biocompatibility of metals, surface modification or treatment is required, as biocompatibility is not achieved by conventional manufacturing processes such as melting, casting, forging, and heat treatment. Dental implants require compatibility with hard tissues for bone formation and bone union, compatibility with soft tissues for gingival epithelial adhesion, and antibacterial properties to inhibit bacterial invasion. Surface treatment is a process that changes the morphology, structure and composition of the surface, leaving the mechanical properties of the volume.

Linearly polarized femtosecond laser pulses make it possible to form self-organized nanostructures. Ultrashort lasers make it possible to form various types of nano/microstructures by adjusting their parameters. By changing the angle of incidence of the laser light or the wavelength of the laser, the period of the structures can be determined. In addition, by changing the laser flux, the height and morphology can be changed, while the direction of the structure can be tuned by the configuration of the optics. During femtosecond laser processing and formation of self-organized structures, an oxidizing layer is formed on the surface.

In this work, two types of self-organized microstructures that were created using high-power femtosecond laser pulses are investigated. The first type of surface microstructures consists of so-called herringbone structures, while the second type consists of typical spike structures. A special feature is the photocatalytic properties of the obtained structures. Their effectiveness was investigated in the degradation reaction of methylene blue (a model organic pollutant). The novelty of the presented research lies in the absence of additional oxidation treatment (absence of chemical oxidation and annealing). The use of ready-made materials for photocatalysis was carried out to demonstrate the ability of the surface to produce reactive species. This expands the functionality of the implant surface.

Microfluidic properties of laser exposed metallic surface

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Keywords: imprinting polymeric materials, lasers surface modifications, superhydrophobic surfaces

Nanoscience and nanotechnology research is strongly encouraged and developed nowadays due to its positive impact on the development of new areas such as nano-biology, nano-electronics, nano-photonics and micro- and nano-fluidics. The requirements of these new scientific domains have prompted the emergence of innovative techniques conceived to obtain structures with dimensions under micrometer range. Recently, superhydrophobic surfaces, for which the water contact angle is higher than 150° and sliding angle less than 10°, have received attention due to the many potential applications ranging from biological to industrial processes and usable even in daily life.

In this paper, an innovative, flexible and low-cost system for producing superhydrophobic metal surfaces modeled by nanosecond laser ablation will be presented. The main goal of this patterned superhydrophobic metallic surfaces.is to obtain a fingerprint device to be used on polymeric materials such as: polydimethylsiloxane-PDMS; polyethylene terephthalate-PET, synthetic latex polymers, polyvinyl chloride-PVC material. It should be mentioned that the polymeric structures have the same properties as those of the metal pattern and are used in a large number of remarkable applications, in biology, food industry, marine industry and textile industry.

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Optical limiting properties of a new class of DNA-based materials functionalized with natural chromophores

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The high-power lasers have important implications for present and future light-based technologies, therefore the protection measures against their high intensity radiation are extremely important. Due to the fast evolution of lasers with ultrashort pulses and, correspondingly, with very high light intensities, much interest is currently being directed toward the development of the new nonlinear optical materials for passive optical limiters which are used to protect the human eye and the sensitive optical and opto-electronic devices from laser induced damage. The natural dyes are emerging as an important class of optical materials for this application and are intensely studied lately due to their interesting photosensitive properties. Also, the synthetic polymers that have been used so far in optical limiters can be successfully replaced by these bio-polymers that have some advantages over synthetic materials.

The optical limiting capability of a new class of DNA bio-polymer functionalized with natural dyes have been investigated by the Intensity-scan (I-scan) method, in the IR spectral domain at the 1550 nm wavelength. Several optical properties of these natural dyes are presented and discussed. The values of the optical transmittance, in the linear regime, and the saturation intensity of the nonlinear transmittance curves have been determined. The influence of the DNA biopolymer and of the natural dye concentration on optical limiting properties of the investigated bio-materials is reported and discussed. Our results evidenced the influence of the DNA that embeds the natural extracts on optical limiting functionality.

These studies reveal the potential of these bio-materials for photonic applications, such as optical limiting and may serve as an eco-friendly alternative for hardly degradable and highly polluting synthetic polymers and dyes.

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IPSCs more effectively differentiate into neurons on PLA scaffolds with high adhesive properties for primary neuronal cells

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Adhesive properties of scaffolds, which predominantly depend on the chemical and structural features of their surface, play the most important role in tissue engineering. The basic requirements for such scaffolds are biocompatibility, biodegradation, high cell adhesion which promotes cell proliferation and differentiation. In many cases, synthetic polymers scaffolds have proven advantageous because they are easy to shape, they are tough, and they have high tensile properties.

The regeneration of nerve tissue still remains a big challenge for medicine and neural stem cells provide promising therapeutic potential for cell replacement therapy. However, experiments with stem cells have their limitations such as low level of cell viability and poor control of cell differentiation. Whereas the study of already differentiated neuronal cell culture obtained from newborn mouse brain is limited only to cell adhesion.

The growth and implantation of neuronal culture requires proper scaffolds. Moreover, the polymer scaffolds implants with neuronal cells could demand specific morphology. To date, it has been proposed to use numerous synthetic polymers for these purposes, including polystyrene, polylactic acid (PLA), polyglycolic acid, and polylactide-glycolic acid.

Tissue regeneration experiments demonstrated good biocompatibility of PLA scaffolds, despite the hydrophobic nature of the compound. Problem with poor wettability of the PLA scaffold surface could be overcome in several ways: the surface can be pre-treated by poly-D-lysine or polyethyleneimine peptides; roughness and hydrophilicity of PLA surface could be increased by plasma treatment or PLA could be combined with natural fibers, such as collagen or chitosan.

This work presents a study of adhesion of both induced pluripotent stem cells (iPSCs) and mouse primary neuronal cell culture on the polylactide scaffolds of various types: oriented and non-oriented fibrous nonwoven materials and sponges – with and without effect of plasma treatment and composites with collagen and chitosan. To evaluate the effect of different types of PLA scaffolds on the neuronal differentiation of iPSCs, we assess the expression of NeuN in differentiated cells through immunostaining. iPSCs more effectively differentiate into neurons on PLA scaffolds with high adhesive properties for primary neuronal cells.

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Microfluidic properties of laser exposed metallic surface

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Keywords: imprinting polymeric materials, lasers surface modifications, superhydrophobic surfaces

Nanoscience and nanotechnology research is strongly encouraged and developed nowadays due to its positive impact on the development of new areas such as nano-biology, nano-electronics, nano-photonics and micro- and nano-fluidics. The requirements of these new scientific domains have prompted the emergence of innovative techniques conceived to obtain structures with dimensions under micrometer range. Recently, superhydrophobic surfaces, for which the water contact angle is higher than 150° and sliding angle less than 10°, have received attention due to the many potential applications ranging from biological to industrial processes and usable even in daily life.

In this paper, an innovative, flexible and low-cost system for producing superhydrophobic metal surfaces modeled by nanosecond laser ablation will be presented. The main goal of this patterned superhydrophobic metallic surfaces.is to obtain a fingerprint device to be used on polymeric materials such as: polydimethylsiloxane-PDMS; polyethylene terephthalate-PET, synthetic latex polymers, polyvinyl chloride-PVC material. It should be mentioned that the polymeric structures have the same properties as those of the metal pattern and are used in a large number of remarkable applications, in biology, food industry, marine industry and textile industry.

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Optical limiting properties of a new class of DNA-based materials functionalized with natural chromophores

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The high-power lasers have important implications for present and future light-based technologies, therefore the protection measures against their high intensity radiation are extremely important. Due to the fast evolution of lasers with ultrashort pulses and, correspondingly, with very high light intensities, much interest is currently being directed toward the development of the new nonlinear optical materials for passive optical limiters which are used to protect the human eye and the sensitive optical and opto-electronic devices from laser induced damage [1-6]. The natural dyes are emerging as an important class of optical materials for this application and are intensely studied lately due to their interesting photosensitive properties. Also, the synthetic polymers that have been used so far in optical limiters can be successfully replaced by these bio-polymers that have some advantages over synthetic materials [7-11].

The optical limiting capability of a new class of DNA bio-polymer functionalized with natural dyes have been investigated by the Intensity-scan (I-scan) method, in the IR spectral domain at the 1550 nm wavelength. Several optical properties of these natural dyes are presented and discussed. The values of the optical transmittance, in the linear regime, and the saturation intensity of the nonlinear transmittance curves have been determined. The influence of the DNA biopolymer and of the natural dye concentration on optical limiting properties of the investigated bio-materials is reported and discussed. Our results evidenced the influence of the DNA that embed the natural extracts on optical limiting functionality.

These studies reveal the potential of these bio-materials for photonic applications, such as optical limiting and may serve as an eco-friendly alternative for hardly degradable and highly polluting synthetic polymers and dyes.

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Clinical decision support system in the Russian registry of chronic hypoparathyroidism

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Introduction: Chronic hypoparathyroidism refers to a relatively rare disease characterized by low blood calcium levels and the absence or deficiency of parathyroid hormone, and leads to disturbances of phosphorus-calcium metabolism. The most common cause of the disease is unpremeditated removal of the parathyroid glands during surgical interventions in the neck with the development of postoperative hypoparathyroidism. In childhood, a chronic hypoparathyroidism is most common in the framework of autoimmune polyglandular syndrome type 1 — a severe disease with polyglandular insufficiency requiring lifelong multicomponent replacement therapy.

Aim: In order to assess the actual prevalence, incidence of hypoparathyroidism, analysis of clinical features and key epidemiological characteristics of the disease in the Russian Federation in 2020, the All-Russian Registry of Patients with chronic Postoperative Nonsurgical hypoparathyroidism was developed.

Results: The Clinical decision support system (CDSS) is an analytical option of the system designed to help doctors and other medical professionals in working with tasks related to clinical decision-making. CDSSs link the results of clinical trials to the data available for a particular patient, influencing the choice of a medical decision for more effective medical care.

The CDSS implemented in the hypoparathyroidism registry is based on the positions approved by the Russian clinical guideline of hypoparathyroidism. It is designed to provide support by deriving an algorithm about the need for additional examination and/or correction of therapy, based on the completed laboratory data of a patient and the indicated therapy analyzed by the system.

The main objectives of the CDSS are to attract the attention of a clinician to a specific clinical situation in patient's condition, indicating the violation of laboratory parameters or the presence of inefficiencies in the therapy, as well as visualization of the algorithm of his possible actions in accordance with the standard - while the clinical decision in each case, of course, is taken directly by an attending endocrinologist.

The developed CDSS algorithm analyzes the presence and deviation of the necessary laboratory examinations of phosphorus-calcium metabolism (total and albumin-corrected serum calcium, ionized serum calcium, serum phosphorus, 25(OH) vitamin D and serum magnesium levels; 24-h urine calcium excretion), according to the clinical guideline. The entered results of the laboratory examination are compared with the References range (RR). The RR of the laboratory that conducted the study can be entered by an endocrinologist. If RR are not specified, then the preset range boundaries established by the clinical guideline are taken into account. There are "hints" in the algorithm to establish the status of the disease — compensation/subcompensation/decompensation. Also, the CDSS, based on the completeness of entering data into the registry and analyzing fields related to patient's therapy, issues recommendations on the need for further examination in the absence of key indicators and correction of therapy.

Conclusion: The Russian Registry of Chronic hypoparathyroidism is a highly functional information and analytical platform. Evaluation of the laboratory and therapeutic parameters is crucial for quality of medical care in chronic postsurgical and non-surgical hypoparathyroidism. The created CDSS opens the additional opportunities for effective management of this disease.

A role of vitamin D in temporomandibular disorders

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Introduction: Temporomandibular disorders (TMD) are a heterogeneous group of diseases involving the temporomandibular joint and related structures, mainly characterized by symptoms as pain, alterations in joint movement and articular sounds. Vitamin D is an important component in calcium homeostasis, which has a key role in maintenance of healthy bones, articular structures and muscles.

Methods: An association between low vitamin D status and musculoskeletal disorders has been proposed. In some studies, researchers found that 8-84% patients with TMD have vitamin D deficiency. Vitamin D deficiency plays an important role in development of erosive temporomandibular joint (TMJ) osteoarthritis by induction of DNA alteration and production of inflammatory cytokines. Decreased vitamin D levels have also been associated with radiographic changes in TMJ. Another important biochemical parameter in patients with TMDs which is related to vitamin D is parathyroid hormone level. Parathyroid hormone is higher in patients with TMDs, but the trigger of this increased level is still unknown.

Results: The differences in the TMJ discomfort can not only be related to vitamin D levels, but also to the qualitative differences in endogenous pain inhibitory systems, the influence of gonadal hormones as well as to some psychological factors like sex role beliefs, pain coping strategies, pain related expectations etc.

Conclusion: In patients with TMD, level of serum vitamin D should be assessed and, if necessary, corrected.

Protection of dentists and dental stuff from inhalation of aerosols

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Introduction: Routine dental interventions, from the simplest to complicated therapeutic procedures, involve the dispersion of aerosols into the immediate environment, which exposes the doctor and support staff to the potential risk of transmission of infection through droplets.

Backround: There is an extremely wide range of diseases that can be transmitted from patient to staff and vice versa, and only against infection with the hepatitis B virus vaccination can completely protects against that specific infection. In response to the emerging epidemiological situation considering the newly discovered virus from SARS group (Sars-CoV-2 or COVID-19), the level of protection in the dental environment has been sharply increased in the last two years, but there is an extremely small amount of scientific evidence that answers the question of which type of available protective measures is the safest and most effective. Also, very little research on the quality of aerosols and the quantity of pathogenic microorganisms in bioaerosols, as well as the size of dispersed particles, as an extremely important parameter in the process of droplet transmission, indicate the need to investigate this issue.

Results: Several studies have been conducted on the filtration efficiency of various general purpose surgical face masks. At the end of the last century, Micik et al., examining 15 types of surgical masks by sampling the aerosol generated during dental interventions, discovered that only those infiltrated with glass or synthetic fibers showed satisfactory filtering efficiency. Fifteen years later, Pippin et al proved that even when surgical masks, which are routinely used in dentistry, are worn properly, airflow during inhalation can bypass the mask material, resulting in reduced filtration efficiency and increased health risk for dental personnel. Furthermore, they concluded that general-purpose surgical face masks are designed mainly to stop microorganisms from being exhaled, rather than to protect dentists from airborne pathogen infections. The first study that dealt with the evaluation of the filtering efficiency of a certified respirator specially designed for the protection of dental personnel was carried out by Checchi et al. in 2005. The results of their research showed that the respirator is indeed more effective in filtering particles of sizes that commonly appear in routine dental practice than surgical masks. In 2009, Jothi et al compared the filtering ability of N95 multilayer masks and surgical masks for particles of 0.1 to 0.4 μm and proved that the efficiency of N95 masks was about 90%, in contrast to surgical masks which showed less than 50% efficiency. The most recent research on the topic of comparative analysis of the efficiency of surgical masks, N95 protective masks of the 1st class and respirator masks of the 3rd class was carried out by Ionescu et al. (2021) in laboratory conditions and proved that there is no significant difference in the filtering of the tested particles of the generated aerosol when simulating clinical conditions in dentistry, but also that the combination of masks with a protective visor on the therapist's simulated head showed a drastically better protection against particles that were carriers of the human corona virus.

Conclusion: The relevance of such studies is indisputable, but the results of those few studies are confusing, difficult to compare and applicable in clinical practice. There is a need for further studies and investigations.

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Temporomandibular disorders in fibromyalgia patients

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Backround: Fibromyalgia is a disorder characterized by widespread musculoskeletal pain accompanied by fatigue, pain treshold, temporomandibular disorders (TMD), sleep disturbance, chronic headache, irritable bowel syndrome, anxiety, depression, and fatigue. According to American Academy of Orofacial Pain defines TMD as "a collective term that embraces a number of clinical problems that involve the masticatory muscles, the temporomandibular joints (TMJ), and the associated structures".

Methods: The original diagnostic criteria of fibromyalgia does not include the evaluation of the craniofacial area, however fibromyalgia patients often present orofacial pain including TMD disorders. Women are more likely to develop fibromyalgia than are men.

Results: TMJ arthralgia could represent sensitivity of TMJ structures. Some studies have shown that TMD symptoms are more severe and determine more limitations in patients with fibromialgia. Other studies also reported that difficult TMD patients report more complaints about generalized body pain and that patients with generalized body pain are susceptible to develop facial pain.

Conclusion: Despite the evidence that TMD and fibromyalgia could have similar pathophysiological mechanisms there are just a few studies analyzing the relationship between the onset of TMD symptoms and the onset of widespread pain.

Keywords: fibromyalgia, temporomandibular joint, temporomandibular disorders, pain

Bilateral and sex distribution of pterygospinous bridge in Bulgarians

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Pterygospinous bridge represents osseous bar stretched between the angular spine and the spine of Civinini situated on the lateral pterygoid plate of the sphenoid bone. It encloses the so-called pterygospinous or Civinini's foramen, the axis of which is vertical and lies either below or on the medial side of foramen ovale. Through pterygospinous foramen could pass branches of the mandibular nerve to the medial pterygoid muscle and to the tensors tympani and veli palatini. Pterygospinous bridge may cause entrapment of nerves, occlusion of vessels, and obstruction of foramen ovale. In this study we aimed to investigate the bilateral and sex differences in the distribution of pterygospinous bridge in Bulgarians. The study was performed on head CT scans of 315 Bulgarians (148 males and 167 females) generated using CT system Toshiba Aquilion 64. Pterygospinous bridge was accounted either as a complete (enclosing pterygospinous foramen) or an incomplete one (projecting bone spicules). There were no significant bilateral differences in the pterygospinous bridge distribution. However, there were considerable sex differences concerning the left-side occurrence, which was significantly higher in the male series.

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Decision trees for sex estimation based on mandibular measurements: A CT study

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Decision tree algorithms are commonly used tools for data mining and machine learning. They learn effective and understandable classification models, which makes them very appropriate for forensic purposes. The aim of the present study is to develop decision tree models for sex estimation based on a set of mandibular measurements. A total of 239 computed tomography (CT) images of adult Bulgarians (116 males and 123 females) were used in the study. The scanning was performed using a CT scanner Toshiba Aquilion 64. The mandibular measurements were calculated based on the three-dimensional coordinates of 45 landmarks acquired in MeshLab. A dataset of 51 attributes (including linear, projective and angular measurements) was assembled. The data mining algorithm J48 was applied to learn the decision tree models. The Weka implementation of C4.5 was used in the study. An attribute selection procedure was also applied to select the most relevant attributes for sex estimation. The evaluation of classification accuracy was performed by 5-cross-validation repeated 10 times at different randomly selected initial conditions. The model learnt on the full dataset of 51 attributes provided accuracy of nearly 81%. The attribute selection provided models with higher accuracy. The best accuracy of 83.4% was achieved by the model trained on a dataset of 10 mandibular measurements. This tree included 9 attributes in its decision nodes and had 12 leaves. The sex bias of this model was 1.4%.

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Impact of epidermal growth factor receptor gene RS1468727 polymorphism on the survival of patients with oral squamous cell carcinoma

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Introduction/Objective: Genetic aberrations together with environmental factors are known to play an important role in oral squamous cell carcinoma (OSCC). It is conceivable that single nucleotide polymorphisms (SNPs) that affect *EGFR* gene expression, protein levels, or signaling could be a factor in the erratic clinical outcomes and survival of cancer patients. Here we aim to clarify the potential influence of *EGFR* gene polymorphism rs1468727 on overall survival in patients with OSCC.

Methods: Sixty-one OSCC patients were included in the study. By using a conventional extraction procedure (QIAamp DNA FFPE Tissue Kit, *Qiagen*), genomic DNA was extracted from formalin-fixed, paraffin-embedded tissue blocks of OSCC patients. The *EGFR* single nucleotide polymorphism rs1468727 was genotyped using TaqMan SNP Assays MTO Human SM 10 (Applied Biosystems, Foster City, USA) for *EGFR* rs1468727 SNP. The assay was performed in a 96-well plate and the fluorescence was measured in the Applied Biosystems 7500 Fast Real-Time PCR System instrument where the thermal cycling and detection were carried out. Negative control was added in each run. The follow-up period for each patient was 3 years from the date of surgery.

Results: Genotype EGFR rs1468727 CC was found in 31 patients (50.8%), 25 patients were heterozygotes CT (41.0%) and genotype TT was present in 5 (8.2%) out of 61 patients. After 3 years follow up from surgery more than a half of survived patients had genotype *EGFR* rs1468727 CC and 22 patients did not survive (36.1%). Genotype *EGFR*rs1468727 CC has shown a statistically significant influence on overall survival. A person with genotype CC is more likely to survive. Among patients who did not survive, the distribution of CC and CT genotypes was equal (chi-square=0.397, df=2 p=0.820).

Conclusion: Rs1468727 *EGFR* homozygote (genotype CC) showed statistically significant influence on overall survival in the period of 3 years from the surgery date. To further confirm the predictive value of this polymorphism to overall survival, a study with a larger sample size would contribute, as well as collecting additional information on other polymorphisms of the EGFR gene and a broader panel of oncogenes.

Keywords: oral squamous cell carcinoma; epidermal growth factor receptor; polymorphisms.

Prenatal exposure to an antiepileptic combination (levetiracetam and valproic acid) throughout gestation and postnatal sensorimotor development in mice

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Introduction: Treatment of epilepsy always has an individual and unique path. Despite effective classical and novel antiepileptic drugs (AEDs), monotherapy is limited and insufficient in some cases, such as refractory epilepsy. Pregnant women with epilepsy are a population that requires a special approach. Protocol guidelines and experience dictate the rational use of AEDs during pregnancy, which means that monotherapy and the lowest therapeutic (curable) dose should be used. Epilepsy as a multifactorial condition involving different categories of epileptic disorders sometimes requires treatment with highly potent therapeutic drugs, such as valproic acid (VPA), which is known to be teratogenic. In some cases, not only can it not be substituted, but it must also be combined with another drug. The combination of VPA and levetiracetam (LEV), at a dosage of 1:1, achieves additive efficacy with no evidence of toxicity.

Aim: Thus, the aim of the present study was to investigate the sensorimotor development of mice whose mothers were treated with a combination of VPA and LEV (1:1 ratio) during breeding and gestation.

Method: Adult, 8-week-old female NMRI mice were used in this study. Two groups of animals were formed: one group (8 females) treated with a combination of LEV at a dose of 211 mg/kg/day (LEV-211) and VPA at a dose of 200 mg/kg/day (VPA-200), and a control group (8 females) receiving an equivalent amount of saline. The doses administered correspond to human doses of 1000 mg/day for both antiepileptic drugs. All animals were treated subcutaneously into the loose skin on the back of the neck twice daily. Treatment was initiated at the mating of males and females and continued throughout the entire period of breeding and gestation. After the females gave birth, each of them was housed separately with her litter. Offspring were separated by sex on postnatal day (PND) 21. Sensorimotor system performance and conditional learning were assessed on PND25 and PND32 in the hot plate test (HPT).

Results: Female and male offspring treated prenatally with a combination of AEDs (LEV-211 + VPA-200) showed a significantly faster response than the control group on PND32, whereas female offspring also showed a faster response than the control group on the first day of testing, PND25.

Conclusion: Considering the results of the HPT and the different sensorimotor responses in offspring prenatally treated with antiepileptic drug combinations in animal models, it would be necessary for the human practice to continuously monitor (until the end of adolescence) the children prenatally exposed to this antiepileptic drug therapy.

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Fatty acids profiles of *Juglans nigra* l. leaf

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Juglans nigra L. (black walnut) might be a source of healthy nutrition compounds. Consumption of black walnut nuts has been associated with many health benefits due to their phytochemical composition. However, chemical structure of black walnut leaf has not been analysis so far. The aim of this research is to determine proportion of fatty acids in the composition of *J. nigra* leaf. *J. nigra* leaf was collected during summer at Aleksinac locality in southeast region of Serbia (located at 43^{o} 32′ 11″N/, 21^{o} 42′ 11′′E). The voucher specimen was deposited at the Herbarium of the Department of Botany, University of Belgrade-Faculty of Pharmacy (HFF), under the number 3906HFF. The powdered leaf of *J. nigra* was extracted with petroleum ether (solvent-to-solid ratio 1:1) by indirect ultrasonication. Ultrasonic-assisted extraction was performed during 80 minutes at 40 °C. The fatty acids composition of leaf was determined using petroleum ether extracts by Gas Chromatography (GC) analysis. *J. nigra* leaf contained two saturated fatty acids (SFA): palmitic acid (16:0) and stearic acid (18:0), then, monounsaturated fatty acids (MUFA): palmitoleic (16:1n-7) and oleic (18:1n-9), as well as polyunsaturated fatty acids (PUFA): linoleic (18:2n-6), γ-linolenic (18:3n-6), and α-linolenic (18:3n3). The most polyunsaturated fatty acids were extracted from *J.nigra* leaf, i.e. 48.69 mol%, of which 37.26 mol% is α-linolenic acid. The α-linolenic acid (ALA) is one of three types of Omega 3 fatty acids, plant originated. Although essential it cannot be produced in the body and must be taken by food. In light of the currently available data, ALA reduce risk of cardiovascular disease by affecting the arteriosclerosis process, impacting the circulating lipid profile, platelet aggregation, modulate inflammation and immunity. ALA has a positive effect on some of the gastrointestinal, rheumatological and dermatological disorders. In addition, ALA has a neuroprotective role. The results proved that *J. nigra* leaf can actually be a possible relevant source of essential fatty acid.

Synergistic effect of snail mucus compounds and plant extracts for wound healing

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Nature is a rich source of biologically active substances for health. Therefore, the medicinal properties of mucus extract from garden snail *Helix aspersa* and plantain leaf and *Calendula officinalis* plant extracts for wound healing have been investigated. Chronic diabetic wounds are a serious health problem worldwide.

The active components in the mucus extract were determined by MALDI-MS, in addition, the primary structure of the peptides was determined by *de novo* sequencing by tandem mass spectrometry. The wound-healing effect of mucus extract of *H. aspersa* is related to its antioxidant capacity as well as its regenerative properties, as it has been shown to stimulate fibroblast proliferation and collagen synthesis.

Phytocomponents such as vitamins, glycosides, flavonoids, terpenes, carotenoids, etc. have been proven in the herbal extracts of *P. major* leaves and marigold flowers with antioxidant, antimicrobial and anti-inflammatory properties.

The regenerative effect of the extracts was followed after treatment of selected patients with difficult-to-heal and chronic wounds of different ages and genesis of different genders and ages. In the wound healing process, activated charcoal gel is applied, which absorbs toxins and thus cleans the wound. Activated carbon is obtained by pyrolysis of apricot kernels.

The results obtained show that a synergistic effect is observed between the active components and the extract of mucus and two plant extracts, which leads to a significant reduction in the healing time of wounds, an effective reduction of the local inflammatory process and chronic pain.

Healing of chronic wounds is achieved after limiting bacterial infection, stimulating tissue growth, and providing an appropriate local alkaline-acidic, moist, and nutritious environment. Early and regular application of the new treatment approach will prevent amputation of limbs and is a promising mainstay therapy for the treatment of chronic wounds.

Keywords: snail *Helix aspersa*, mucus extract, *Calendula* flower extract, *Plantago major* leaf extract, wound healing.

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Mandelic and hyaluronic acids nanoemulsions in PVP, PEG and agar hydrogels

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Hydrogels are eclectic materials and increasingly find important applications in biomedical, agricultural, wastewater treatment, and electronic devices. In the biomedical and cosmetics areas, hydrogels are widely used and can be combined with nanoemulsions in order to enhance its effectiveness. In this research, hydrogels were prepared with mandelic and hyaluronic acids. The research aims to contribute to the cosmetic field by obtaining anti-aging cosmetic without the need of cosmetic preservatives. The hydrogels were composed of PVP 7%w, PEG 3%w and agar 1%w containing pseudoboehmite (PB) in the concentrations of 1%w, 3%w and 5%w with mandelic acid (MA), hyaluronic acid (HA) and palmarosa (PR) nanoemulsions. They were submitted to irradiation doses of 25 kGy. All nanoemulsions were characterized by acidity, density, optical microscopy, visual analysis and particle distribution and size. All hidrogels were characterized by isothermal dehydration with air entrainment and dehydration as a function of time. The results showed that the nanoemulsions formulations D, E and F, containing HA, presented levels similar to skin´s pH, after 7 days. Samples B and E, containing 3%w PB, presented uniformity and good dispersion of the particles and sample F 5%w PB, containing 7%w PR, 2.1%w HA had the best results in particle size determination analysis. Isothermal dehydration levels didn´t vary substantially according to the composition. In dehydration as a function of time analysis, samples hydrogels HII (3%w PB, 7.0%w PR, 2.1%w MA) and HVI (5%w PB, 7.0%w PR, 2.1%w HA) had the best performance.

Antiviral treasure hunt: Novel compounds from plants and invertebrates

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Fighting viral infections has always been an uphill battle for mankind. As antiviral resistance induced by current antiviral agents in practice is a growing problem, the need for new antiviral agents is more urgent than ever. Among the large number of highly active medicinal preparations that have been created, there are those that have many side, unwanted effects on the body. That is why phytoproducts and biologically active substances are of increasing interest. Since ancient times, nature has been a rich source of therapeutic agents applicable in the fight against various diseases. With the progress in the development of analytical methods, the active substances contained in the composition of biological products are detected and investigated for their potential abilities as antiviral preparations.

In this study, a wide range of plant extracts (7 plant species) and invertebrate proteins (19 different fractions) were investigated. Several active compounds were discovered. A strong effect on viral replication was found for Astragalus glycyphyllos extract against Human coronavirus 229E. Several fractions from the hemolymph of *Eriphia verrucosa* and *Rapana venosa* inactivate the extracellular form of Herpes simplex virus type 1 and type 2.

Only at 2 µg/ml R. venosa 30-100 kDa hemolymph fraction inactivated virions over 97% after the first 30 min of contact and over 99% after 4 h. Further investigation of the extract showed that the virucidal effect was due at least in part to activity on the viral adsorption process.

Active screening for potential antiviral agents is rarely laborious, but continued efforts in this direction are necessary to limit the spread of the virus in the human population, especially with established antiviral resistance to available therapeutics. Our results indicate that nature may be a promising source of novel antiviral compounds.

Polymeric stabilized micelles affect pea seed germination and plant growth in concentration-dependent manner

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Seed priming is emerging technique for enhancement of specific seed properties related to plant growth, development and stress resistance. There are still scarce investigations of the application of polymeric micelles as nanoscopic seeds coating and priming agents, with some indications for beneficial agricultural applications.

In the present work, we explore the effect of garden pea priming with stabilized micelles of the biocompatible triblock copolymer Pluronic P85 that is widely used for biomedical applications but is rarely applied to plants. We study the effects of wide range of P85 concentrations (0.04 – 30 g/L) on seed germination and early plant development, and apply non-invasive chlorophyll fluorescence imaging to evaluate the photosynthetic operation of 14-day old intact plants grown in hydroponic conditions.

Our data demonstrate that seeds priming with 0.2 g/L has stimulating effect with respect to plant development (in particular the number of developed plants, roots length, vigor index), without affecting plants photochemistry. On the contrary, priming with 10 g/L P85 does not affect the germination process but hinders plants development, as evidenced by the lower nitrogen balance index, vigor index and dry biomass; it is also associated with higher number of photosystem II reaction centers, which possibly is an adaptive mechanism for overcoming the mentioned inhibiting factors.

The presented data shine light on the mechanism of interaction of polymeric micelles and pea seeds, and might be used for future development of protocols for seeds priming with P85 micelles that can enhance plant growth in laboratory and field conditions.

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Human serum albumin nanoparticles for targeting colon cancer cells

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Albumin-based nanoparticles used as drug delivery systems are an important research topic in nanomedicine due to the special properties of albumin, such as biocompatibility, biodegradability, and well-tolerance without any side effects. Herein, human serum albumin (HSA) nanoparticles (NPs) were synthesized via the nanoprecipitation method, analyzed through spectroscopy and microscopy, and evaluated *in vitro*. UV-Vis absorption spectroscopy was used in order to investigate their stability over time, scanning electron microscopy (SEM), fluorescence microscopy (FM) and atomic force microscopy (AFM) were used for morphological characterization and the MTS protocol was assessed for the biocompatibility evaluation. The AFM and SEM results for HSA-NPs on a solid surface indicated a uniform distribution and sizes around 50 - 70 nm. Also, FM images obtained for HSA-NPs labeled with the fluorescent indicator Thioflavin T showed that HSA-NPs have the propensity to form large aggregates that tend to structure into amyloid fibrils. The *in vitro* studies on the fibroblast L929 and colon HT-29 cell lines demonstrated that HSA-NPs did not reduce cell viability, and the microscopy images revealed the tendency of HSA-NPs to concentrate on the cell surface. These results could be exploited in the development of new folic acid-containing drug delivery systems that target cancer cells that have membrane receptors for folic acid.

Keywords: Human serum albumin, drug delivery, viability

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Measurement of thermophysical parameters of human hair

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The method for measuring of thermophysical parameters of the hair such as thermal conductivity, volumetric heat capacity, thermal diffusivity, and heating and cooling time constants was studied.

In the experiment, one end of a horizontally located hair is maintained at the temperature T_0, starting from time t = 0, the other at ambient temperature T_c. Using a thermal imager, the temperature distribution along the hair is measured from the initial time t = 0 to when the stationary temperature is established at each moment.

The heating progress is described by the heat conduction equation which solution can be obtained analytically.

The time changing of the average temperature along the length of the hair is characterized by a thermal time constant which can be found by the least squares method. The thermal diffusivity was found from the analysis of the propagation of the thermal front in time by finding the parameters of the heat equation using this method.

The method for calibrating a colour image on the screen of a thermal imager by temperature has been developed.

Pathogenicity of *Fusarium* isolated from weed growing in potato fields

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Pathogenic fungi can survive on alternative hosts during unfavorable conditions, very often without causing disease symptoms. Fungi isolated from weeds often show better vigour and infection ability, what is attributed to wild gene pool of weeds as ancient plant species. In our research *Fusarium* sp. has been isolated from common weed growing in potato field in Germany, Kleve. Isolate ability to cause potato infection and symptoms of potato dry rot has been investigated. The results have confirmed the ability of isolated fungus to cause potato disease. Potato dry rot is a major problem in global potato production. It is a disease caused by *Fusarium* species that can survive in the soil, on plant debris or weeds.

Halogen substituted 4-Thio-2'-Deoxyuridines as photosensitizers: in vitro studies

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Cancer is a leading cause of death worldwide. According to the World Health Organization, the most common neoplasm concerns breast, lung, colon, and prostate. The latter is the second most common cancer in men[1]. Surgery (prostatectomy), radiation therapy, hormone therapy and chemotherapy are the four main prostate cancer treatments, but although effective, have many side effects. An alternative modality is photodynamic therapy (PDT) which aims at treating cancer cells with light. PDT uses chemical compounds, photosensitizers, and visible or ultraviolet (UV) light with a wavelength corresponding to the sensitizer's absorption, which triggers photochemical processes resulting in the formation of genotoxic reactive species in cells[2].

One of the groups of photosensitizers are modified nucleosides (MNs). Due to their structural similarity to the native nucleosides MNs may be incorporated into DNA during its biosynthesis or repair. Modified nucleosides show selectivity towards cancer as a result of the uncontrolled division and rapid growth of cancer cells. Moreover, good photosensitizers should be marginally cytotoxic and DNA damage should only occur after irradiation[3]. The nucleoside derivatives with these features are 5-bromo-4-thio-2'-deoxyuridine (BrSdU) and 5-iodo-4-thio-2'-deoxyuridine (ISdU). Introducing the sulfur atom into position 4 of uracil shifts the MNs' absorption to the near UV – nontoxic radiation to a native DNA (normal cells)[4]. Literature reports suggest that genotoxic cross-linking and DNA breaks are formed in DNA labeled with BrSdU/ISdU[5,6]. The formation of such damage does not require oxygen which in the light of hypoxia characteristic for solid tumors seems to be extremely important[7].

The current project aims at exploring the photosensitization of human prostate cancer cells by two modified nucleosides – BrSdU and ISdU. To this end, the cytotoxicity MTT test and clonogenic assay were performed against PC3 cell line. We observed no cytotoxic effects up to 0,1 mM concentration of the tested nucleosides. Moreover, treatment of prostate cells with 50 mM BrSdU or ISdU resulted in a significant decrease (about 20% and 30%, respectively) of their survival after UV irradiation, even with doses as low as 5 kJ/m^2.

In summary, using stationary photolysis we demonstrated that BrSdU and ISdU are non-toxic, active photosensitizers that efficiently help to kill PC3 cells with UVA light. In the future studies, we plan to find out the cellular mechanisms responsible for BrSdU/ISdU photosensitizing properties. Hence, we aim at determining the efficiency of DNA double-strand breaks (DBS) formation and oxidative stress generation in the cells treated with both MN and radiation.

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Senescence and death induced by radiation and alkylating drugs in cancer therapy

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First-line therapy of the most severe form of brain cancer, glioblastoma, is radiation concurrent with the alkylating drug temozolomide (TMZ). The mechanism of TMZ has been studied intensively by us (see References) and others. TMZ methylates the DNA and induces, among other adducts, O6-methylguanine - a highly cytotoxic and mutagenic/genotoxic lesion. In glioblastoma cells treated with TMZ, not only apoptosis but also cellular senescence (CSEN) are induced, with CSEN being the major response. Apoptosis and CSEN rest on conversion of O6-methylguanine through mismatch repair into DNA double-strand breaks (DSB) that trigger downstream death and senescence pathways. Consequently, DNA repair has a great impact on glioma resistance, and evidence was provided for the repair pathways mediated by MGMT, mismatch repair, DSB repair through BRCA2, Rad51, XRCC3 and others. Downstream are ATR/ATM triggered signaling cascades that activate apoptosis and senescence pathways. Data will be shown demonstrating that the ATR/ATM-SIAH1-HIPK2-p53ser46 pathway plays a key role in regulating temozolomide-induced apoptosis and presumably also senescence. The question of whether there are thresholds for activating survival and death pathways will be addressed and results of a search for senolytic drugs that specifically kill senescent GBM cells will be presented. It will also be discussed how radiation and TMZ cooperate in evoking antitumor responses.

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Anticancer properties of novel Thiazolidinone derivatives tested in MDA-MB-231 breast cancer cell lines.

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In the modern world high cancer incidence is observed, which is one of the essential reasons for death worldwide. Hence many new, innovative, and selective drugs that act on cancer cells are being sought. Such efforts aim to reduce the side effects and cost of chemotherapy. Thiazolidinones are a well-known group of drugs mostly applied to treat II type of diabetes. The newest studies confirmed their promising anticancer properties. They are synthetic ligands for PPARγ receptors, which are found not only in adipose tissue cells (they sensitize peripheral tissues to insulin), but also in the prostate, breast, colon epithelial cells, and in epithelial cells and smooth muscles of blood vessels, which may be used against tumors of these organs. Many mechanisms responsible for the anticancer activity related to the activation of PPARγ receptors have been discovered. However, recent studies point to a new pathway of the mechanism of action, which is the inhibition of tubulin. That's why we decided to synthesize 10 new 5-[3-(5-nitrofuran-2-yl)propenylidene]-2-thioxo-4-thiazolidinone-3-alkylcarboxylic acids, and we've started carrying on the MTT assay. The MDA-MB-231 cell line was chosen for the first research. The most active compound no. 19968 has a value of IC_{50} 4,65μM. The second one with the best results was compound no. 19967 with IC_{50} value 6,39μM. Moreover, the correlation between obtained results and chemical structure was observed. The best value of IC_{50} was shown by the compound which has a semi-long chain of methylene groups. The IC_{50} value was decreased in other compounds along with the shortening of the methylene group chain. Compounds no. 19970 with the isopropyl moiety and 19637 also demonstrate good results with a value of 7,59μM, and 9,511μM of IC_{50}, respectively. Thus, we determined that additional tests to investigate anticancer properties against other cancer cell lines have to be conducted.

Setup and protocol for high dose-rate irradiation of glioblastoma cells using secondary radiation from a high-power laser

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The mechanisms of high dose-rate radiation damage in cells are an active topic of research, due to implications for the clinic. [1] High-intensity laser beam impacts on gas or solid targets generate secondary radiation in pulses with durations of fs to ns [2]. The short time in which radiation is delivered to cells can lead to free-radical recombination, saturation of biochemical pathways and other mechanisms underlying the FLASH effect [3, 4], which *in-vivo* results in lower radiation-induced toxicity to healthy tissue for high dose-rate radiation compared to standard radiation [1].

We developed a protocol and irradiation setup using secondary radiation stemming from the interaction chamber of a 100 TW laser operating in pulses of 1.5-2J and 28 fs duration delivered onto a gas target consisting of a 98 % - 2% mixture of He and N2/ Argon gases. Glioblastoma U271 cells were irradiated in suspension using the secondary radiation delivered outside the laser interaction chamber and variations in metabolite concentrations between control and irradiated samples were measured using Nuclear Magnetic Resonance spectroscopy. In order to have a dose estimation for each cell radiation experiment, BeOSL dosimeters were placed in the back of each sample.

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Investigation of EGFR in odontogenic tumor

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Introduction

The epidermal growth factor receptor (EGFR) regulates physiological processes in cells that are usually reprogrammed in an oncogenic environment, including proliferation, differentiation, and survival. EGFR protein is usually overexpressed in glioblastoma, brain, lung, breast, bladder, prostate, colorectal, and ovarian cancers, but not so much in odontogenic tumor. Here we analysed EGFR expression in odontogenic keratocyst. The recent classification of odontogenic keratocysts (OKSs) recognized them as benign neoplasms, although previous findings have revealed their aggressive nature. Based on this it is very important to analyses role of molecular analyses for definition of tumor characteristics.

Case presentation

Here we show a large keratocyst that progressed rapidly in oral region and was surgically removed. The cyst was surgically enucleated under local anesthesia. The mucoperiosteal flap was raised, and if necessary, a bur was used to remove the bone under irrigation with sterile saline solution, avoiding injury to the cyst wall. The tissue was analyzed on pathological preparations and observed under a microscope. For immuno-histochemical analysis, the EGFR antibody (Santa Cruz, Biotehnology) was routinely prepared and analyzed for the level of expression. Immuno-histochemical analysis from paraffin tissue showed high positivity of the epithelium for EGFR (3+).

Discussion

Some studies have shown that certain cysts have a high expression of EGFR, but not all, and that it depends on the type of cyst and localization: Based on immuno-histochemical analysis, there is no definitive opinion on neoplastic transformation. Other individual mutations that have been carried out in odontogenic cysts indicate that these cysts have malignant potential. We believe that in the future, molecular analyzes for EGFR mutation should also be performed in this type of tumor in order to clearly show the malignant potential and undertake adequate treatment.

Radiation hormesis effect on cancer patients in Hibakusha

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The term hormesis is defined as a process in which exposure to a low dose of a chemical agent or environmental factor that is damaging at higher doses induces an adaptive beneficial effect on the cell or organism (Calabrese-2007; Mattson, 2008). To survive and reproduce in harsh competitive environments, organisms and their cellular components have, through evolution , developed molecular mechanisms to adaptively to various hazards or stressors that they encounter. The response of the cell or organism to the stressor exhibits a biphasic dose response, with beneficial/adaptive responses at low doses and adverse/destructive effects at high doses. Hormesis is a fundamental principle of biology, Hormesis is at the epicenter of the molecular and cellular responses to their environment. Early in the 16th century, Paracelsus recognized that all drugs are poisonous at high doses and that careful evaluation of dose-response relationships are necessary for optimizing treatments. The low-dose data have been largely ignored, and the prevailing view is that it is important to reduce levels of toxins as much as possible. Hormesis can be considered a major mechanism underlying Darwin's theory of evolution by natural selection. The ability of organisms to respond adaptively to low levels of exposure to environmental hazards in a manner that increases their resistance to more severe similar or different hazards is fundamental to the evolutionary process. Many of the genes selected by the genes for their survival value encode proteins that protect cells against stress or that mediate behavioral responses to environmental stressors.

Radiation Hormesis in Humans. All-cause mortality and all-cause cancers (leukemia and prostate cancer) were significantly lower for nuclear workers than for nonradiation workers (Atkinson 2004). Low-dose radiation from A-bombs elongated lifespan and reduced cancer mortality relative to un-irradiated individuals (Shizuyo Sutou 2018). Japan is the only country that sustained a nuclear attack. The weapons dropped in 1945 killed approximately 200,000 people instantaneously. However, cancer mortality of A-bomb survivors has been lower than the Japanese average. Low-dose radiation from A-bombs elongated lifespan and reduced cancer mortality relative to un-irradiated individuals. Low-dose radiation sometimes stimulated our defense mechanisms and beneficial (radiation hormesis). Humanity must learn that low-dose radiations is not only harmless but beneficial.

Prognostic role of fibrinogen level on Covid-19 mortality

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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative agent of coronavirus disease 2019 (Covid-19) created global pandemic health crisis. Highly contagious infectious disease affected mostly respiratory system of host with diverse range of clinical symptoms and signs. Hypercoagulability of blood and microthrombosis are recognized as prominent cause of complications in critically ill Covid patients. Among ordinary biomarkers it is essential to find ones which are applicable for clinicians to detect timely high risk of blood coagulation disorders associated with Covid-19. Aim of our study is to compare fibrinogen level among survivors and non-survivors with confirmed SARS-CoV-2 infection. We carried out retrospective observational study on 100 patients admitted to Clinic for Urgent Pulmonology in Institute for Pulmonary Diseases of Vojvodina in Sremska Kamenica Serbia. All data from medical records of critically ill patients with confirmed Covid-19 infection were analyzed (labaratory findings, age, sex, comorbidities, course of disease, outcome of hospitalization). Patients were selected according to outcome on 28th day in 2 groups: survivors and non-survivors. Study were conducted on 70 men and 30 women. Average age in male group was described as median and interquartile range IQR (Median 67, IQR 56.75-75.90); average age in female group (median 68, IQR 60.75-74). Fibrinogen values between 2 and 5 g/L were considered as physiological, but values lower than 2g/L and higher than 5 g/L were marked as pathological. Patients with fatal outcome had higher vales of fibrinogen in comparison with survived (χ^2 =5.022, df=1, p=0.025). ROC analysis showed that value of fibrinogen 5,34 g/L could predict lethal outcome with sensitivity of 67,7% and specificity of 51,4% (ROC=0.642, SE=0.056, p=0.02, CI 95% = 0.533– 0.751). Fibrinogen is positive acute phase reactant, during coagulation converted into insoluble fibrin network-basic structure of thrombi. Elevated values correlate with strong inflammation and severe forms of Covid-19 disease and could indicate higher risk for poor outcome.

Roles of age, gender, vaccination history and SARS-Cov-2 variants in all-causes of mortality: unexpected outcomes in a complex system

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Abstract: All vaccines exhibit both specific and non-specific effects. The specific effects are measured by the efficacy of the vaccine against the targeted pathogen, while the non-specific effects can be measured by evaluating the change in all-cause mortality (**ACM**). The widely reported higher ACM deaths in males was confirmed for most ages above 43 years in both 2020 and 2021. During 2020 (+ COVID but no vaccination) both male and female population-adjusted ACM deaths were significantly increased above age 35. A significant reduction in all-cause mortality among both males and females aged 75+ could be demonstrated in 2021 during widespread COVID–19 vaccination, however, below age 75 ACM deaths progressively increased. This curious finding was demonstrated to arise from single-year-of-age (**SYOA**) death profiles for the different SARS-CoV-2 variants. In particular, the Delta (Indian) variant specifically targeted persons below 65 years old and had the highest mortality in infants compared to other variants. The Omicron variants showing significantly lower overall mortality but are highly skewed to both age tails. The all-cause mortality data at monthly intervals between January 2021 and May 2022 were cross-checked against vaccination data compiled by the Office for National Statistics. As is to be expected, COVID–19 vaccination gave good protection on many monthly occasions. However, highly concerning levels of harm can be discerned for certain combinations of vaccination (first, second, third dose, at less than or more than 21 days after vaccination) and month of vaccination/death – especially among persons only receiving the first dose of the vaccine. Each gender and age group shows its own unique time profile. The results can be partly explained by References to the non-specific effects of vaccination including mechanisms behind 'pathogen interference' in which the COVID-19 vaccination may influence circulation dynamics of some human pathogens, and by References to the SYOA specific profile of the original strain-based vaccine compared with that of various waves of variants.

Conclusions: The all-cause mortality outcomes of COVID–19 vaccination are far more nuanced than have been widely appreciated. Vaccination with the mRNA vaccines may have unanticipated side effects and for some SYOA groups correlates with increased all-cause mortality. Given the level of unpredictable adverse effects and all-cause mortality outcomes we question the wisdom of widespread vaccination of healthy persons including children and adults below the age of 60 years, and especially below age 40.

Study of olfactory and taste receptors variation possibly associated with dysosmia/disgeusia symptoms in Covid 19

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Significant evidence suggests that odor and taste dysfunction (dysosmia and dysgeusia) is common in SARS-CoV-2 infection. For that, we decided to investigate the association of genetic factors of dysosmia and dysgeusia in SARS CoV-2 infection, by next generation sequencing of selected olfactory and taste receptors, as well as some inflamatory factors and COVID-19 specific receptors.

The study included physically healthy volunteers over 18 years of age, fully recovered from previously confirmed SARS CoV-2 infection. Total DNA was isolated from buccal swabs, quantified and diluted to 10 ng/μl for NGS sequencing. NGS sequencing of custom olfactory receptors panel (67 genes) was done on an Illumina MiniSeq sequencer. After the preparation of the library, a pool of samples and sequential sequencing is performed. The genotyping was done using the Variant caller application available through the Illumina website, and significant variants were identified.

Preliminary results on 20 samples are as follows: we found variations on all our selected genes. In all samples there was from 233 to 292 single nucleotide polymorphisms (SNPs), 7-14 insertions and 9-14 deletions. Mean aplicon coverage was around 500, with uniformity of coverage over 90%. Mean call rate was 97%. We identified several frameshift variants, like c.787_808del on CD36 gene, c.587dup on OPB2A gene, c.893dup on OR2W3 gene, c.307del on OR5H15 gene and c.24dup on OR6C1 gene. Missense, synonymous and intron variants were numerous, but we find only 2 stop gained variants in our preliminary sample: c.576T>A on UGT2A1 gene and c.1036G>T on OR4C15 gene.

Variation in olfactory and taste receptors possibly related to quality of dysosmia/disgeusia symptoms in COVID 19 is derived mainly from the coding region variation in following genes: UGT2A1 and OR4C15, as well as OPB2A. Functional analysis should be done in order to better understand its influence to certain phenotype.

Data from the Vojvodian study regarding the effect of heat inactivation on the detection of the severe acute respiratory syndrome Coronavirus 2 (SARS-Cov-2) using quantitative real-time reverse transcription-polymerase chain reaction (QRT-PCR)

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Background: Because of possible transmission to healthcare professionals, the coronavirus disease of 2019 (COVID-19) has been of significant public health relevance, and its specimen has to be handled carefully. Prior to nucleic acid isolation, heat inactivation of the material can enable secure testing procedures. Therefore, it's crucial to evaluate how heat inactivation affects SARS-CoV-2 QRT-PCR detection in settings with limited resources.

Methods: A prospective study was conducted at the University Clinical Center of Vojvodina (UCCV) from March 29 to April 4, 2022. A total of 160 randomly selected specimens were collected sequentially from adult participants with suspected COVID-19. One nasopharyngeal swab and one oropharyngeal swab (NOS) were taken from each patient and placed into the same tube with 3 ml of viral transport medium (VTM). One batch of the sample was inactivated at 56 °C for 30 minutes, and the other batch was stored at 4 °C for a similar period of time. Viral RNA was extracted using the Viral DNA and RNA Extraction Kit (Xi'an Tianlong Science and Technology Co., Ltd., Xi'an City, China) using the Rotary Nucleic Acid Extraction System (GeneRotex 96L) (Xi'an Tianlong Science and Technology Co., Ltd., Xi'an City, China). The LabGun™ COVID-19 ExoFast RT-PCR Kit (LabGenomics Co., Ltd., Korea) was used to detect SARS-CoV-2. The Gentier Real-time Quantitative PCR (Gentier 96E) (Xi'an Tianlong Science and Technology Co., Ltd., Xi'an City, China) was used for amplification and detection. Statistical analysis was performed using IBM® SPSS (version 20.0, IBM SPSS Inc., Armonk, NY, USA). Statistical significance was defined as a p-value less than 0.05.

Results: In the non-inactivated group, out of 160 samples, 107 (66.9%) were positive and 53 (33.1%) were negative. In contrast, in the batch of heat-inactivated samples, 101 (63.1%) of the samples were positive and 59 (36.9%) were negative. There was no statistically significant difference in the rate of positives between the groups ($p > 0.05$). Between the two groups of the RNA-dependent RNA polymerase (RdRp) gene and the nucleocapsid (N) gene, the mean Cycle threshold (Ct) value difference was 0.067 (95% CI: 0.354–0.411; $t = 0.32$; $p = 0.825$) and 0.41 (95% CI: 0.089–0.536; $t = 2.421$; $p = 0.012$), respectively.

Conclusion: The QRT-PCR detection of SARS-CoV-2 was unaffected by heat inactivation at 56 °C for 30 minutes. However, the results demonstrated that after heat inactivation, there was a statistically significant Ct value increment when compared to untreated samples. Thus, it was discovered that the difficulty with this protocol was producing false-negative results for samples with high Ct values (Ct > 34). Therefore, alternative inactivation techniques ought to be looked into, and more research ought to be taken into account.

Keywords: Ct value, Heat inactivation, Molecular Diagnostics, QRT-PCR, RNA isolation, SARS-CoV-2

Rheological red blood cell changes in mild SARS –Cov2 infections

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The latest COVID-19 pandemic has generated an urge into understanding the effect of dysregulated inflammatory coagulation bio-markers and various cytokines that are binding with endothelial receptors and by this generating endotheliopathies and disturbances in microcirculation.

The damage present in erythrocytes has been briefly attributed to the preformed amyloid clots present in the plasma of COVID patients, but there are also debated studies that use spike protein from anti-COVID vaccines into generating alterations in blood rheology.

Thus, our study aimed to evaluate the rheological changes in erythrocytes of COVID-19 patients with acute mild disease, assuming the evaluation of deformability and agreeability of red blood cells measured in fresh blood collected samples. Analysis was performed compared with age matched healthy controls and the correlations included also coagulation bio-markers like D-dimers, fibrinogen and C-reactive protein (CRP). Alterations in platelet counts and the use of anti-platelet / anticoagulant medications have been considered into separate groups. Special attention has been given to previously vaccinated patients and patients with second or third infection with COVID-19.

23 patients with mild COVID-19 disease process were tested after the acute phase of SARS-CoV-2 infection; the data were compared to 21 healthy controls. Analysis of venous blood samples, taken at rest, revealed an increased percentage of modified shape RBC, a reduction in RBC deformability, but apparently, RBC aggregation index remained unaffected. Higher shear rates were necessary. Also, patients' D-Dimers correlated with RBC loss of deformability, implying a possible contribution of the red blood cells in the thrombotic events associated with the SARS-CoV-2 disease.

Results obtained in our study sustain the effect of SARS-CoV-2 infection on red blood cells and these red blood cell markers may represent an important tool into evaluation of disease severity and a prognosis instrument for monitoring long Covid complications.

Batteries versus supercapacitors: recent trends in applications

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Batteries are electrochemical devices known after their high-power density. Supercapacitors, in other hand are known after their high-power density and long life. It is possible to use electronic power converters in order to improve properties of both components however technological issues are even more important. Recent technology improvements enable supercapacitors to replace batteries in several applications and there is a question which is about to arise: is this trend is going to continue, slow down or even to reverse making the batteries even more important than today. This question is important because of technology, economic and ecology impacts on the global society especially because of its impact to automotive and photovoltaic industries as the leading industries in the modern world.

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Electrochemical performance of supercapacitors based on carbon material electrodes in different electrolytes

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Supercapacitors are one of the most promising energy-storage devices that can meet the demands of high-power supply and long cycle life. The type of electrode material is one of the main factors which determine the supercapacitors performance.

A variety of porous carbon materials are widely used as electrode materials in energy storage applications, and among these, activated carbons are considered promising alternatives due to its low cost, high specific surface area and the possibility of use environmentally friendly raw material. Besides the large surface area, highly porous structure, good adsorption properties, and high electrical conductivity, the carbon surface chemistry is very important factor to develop a device with high performances.

On the other hand, the correct choice of electrolyte and potential window is essential for the optimal performance of supercapacitors.

Commercial activated carbon obtained by pyrolysis of coconuts shells (YP-50F, “Kuraray Europe” GmbH) with high specific surface area and narrow pore size distribution was used as electrode material. Electrodes without current collector were prepared by a casting technique based on spreading an ink. Poly (vinylidene fluoride-co-hexafluoropropylene) in grain form was dissolved in N,N-dimethylacetamide before the use. All components are mixed for 20 minutes. The layer was formed on a glass-plate and dried at 40°C for 5 h and 12 h at 70°C, then soaked and separated by water. After, the layer was dried at 120 °C for 1 h and then treated at 160 °C for 20 min.

The symmetric supercapacitor cell contains two identical coin type electrodes and Na+-, Li+- and K+-form Aquivion® E87-05S electrolyte membrane. The supercapacitors were tested by different electrochemical methods - cyclic voltammetry, galvanostatic charge/discharge measurements, long-term tests and impedance spectroscopy in neutral and alkaline environments. The supercapacitors displayed rectangular voltammograms at different scan rates, high specific capacitance and also excellent cycle stability. The influence of the electrolyte type on the supercapacitor cell performance is shown.

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Activated carbon xerogel as an electrode material in supercapacitor systems

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Supercapacitors show a number of advantages over conventional electrochemical energy sources such as batteries and fuel cells. Although they do not exhibit high energy density, supercapacitors can provide much higher powers, higher efficiency and long life cycles. These characteristics and their simplified manufacturing make them promising energy storage systems.

Activated carbon is the most widely used active material due to its high specific surface area, high conductivity and thermal stability, and its controlled pore size distribution.

The present study aims to investigate the capacitive characteristics of activated carbons in symmetric supercapacitors using different types of electrolytes and polymer films.

Carbon xerogels were synthesized by polycondensation of resorcinol and formaldehyde, followed by carbonization and activation. Their porous structure were modulated by changing the pH of the precursor solutions and characterized by N2 adsorption-desorption isotherms, a helium pycnometer, and a shell density analyzer. The obtained samples were also characterized with other modern physicochemical methods.

Two-electrode symmetric supercapacitor cells with organic electrolytes and polymer films were assembled with the obtained carbon xerogel and investigated by galvanostatic charge/discharge and cyclic voltammetry measurements to evaluate their lifetime stability and electrochemical characteristics. Specific capacitance, energy and power density, Coulomb and energy efficiency were also calculated.

The results show that the synthesized carbon xerogels have porous structure and a high specific surface area, which is a necessary condition for the demonstrated good electrochemical performance as electrode materials in supercapacitor systems.

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Electrochemical examination of chemical decontamination technologies in the aspects of radioactive wastes management

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Nuclear power generation is present worldwide, but many reactors will be decommissioned in the coming years because of technical, political or economic reasons. The application of the decontamination technologies is the major nuclear decommissioning activity, therefore the safe, effective and low-waste technologies are requirements in order to achieve successful radioactive waste management. According to the World Nuclear Waste Report only in Europe 1.4 million m3 of radioactive wastes will be created by the decommissioning of nuclear capacities. Chemical process is preferred among many decontamination technologies due to the possibility of decontamination of difficult geometries and tube bends. However, the corrosion resistance, the chemical - and mechanical properties of the structural materials in the nuclear reactors affects the decontamination efficiency of the chemicals.

In this study two well-known chemical decontamination technologies were studied. Chemical Oxidation Reduction Decontamination (CORD) and AP-CITROX technologies were analysed by electrochemically. The rates of electron transfers between the different chemicals in same concentrations of two technologies and stainless steel metal samples were investigated in the electrochemical cell. In the results significant differences were observed between the effects of the different chemicals on the metal sample.

Mesoporous hydroxyapatite powders containing molybdate anions obtained by the hydrothermal method as a promising heterogeneous catalyst

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The new efficient heterogeneous catalyst formation for the reprocessing of bioresources takes a key position for green chemistry technologies. Soluble complexes Mo(VI) are known as effective liquid-phase catalysts for oxidation reactions. The transition from a liquid-phase homogeneous to a heterogeneous catalyst can reduce the catalyst recovery cost, as well as make the process cleaner and more environmentally friendly. Hydroxyapatite (HA, $Ca_{10}(PO_4)_6(OH)_2$) is one of the least water-soluble calcium phosphates, widely studied and used as a material for replacing bone defects, coating implants, and a precursor for obtaining biocompatible composite materials. At the same time, HA, due to its low solubility, thermomechanical stability, the possibility of obtaining mesoporous powders during its synthesis, and ability to ion exchange and adsorption behavior, began to be considered as a promising heterogeneous catalyst for various processes, including oxidation reactions. This is due to the presence of both alkaline and acid sites in the HA structure. Hydrothermal synthesis is promising for the synthesis of substituted HAs. Because the processes of obtaining materials proceed in closed systems, the method is characterized by high reproducibility of the properties of the obtained materials. It is possible to control both the phase composition and the dispersion and morphology of powders.

HA powders containing up to 10 mol.% molybdate anions were obtained by precipitation from aqueous solutions followed by hydrothermal treatment. Single-phase HA powders and composite materials containing calcium molybdate were synthesized. The study of textural characteristics by the Brunauer-Emmett-Teller method showed the formation of a mesoporous structure with a decrease in the specific surface area with an increase in the content of the molybdate anion.

The influence of hydrothermal treatment conditions - temperature, exposure time, and the concentration of molybdate anions- on the phase composition and dispersion of powders was established.

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Environmentally friendly composite materials with bamboo and trimethoxysilylated polystyrene

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Bamboo is one of important forest resources in the world, compared to wood, growing faster, being mature earlier, gaining higher yield, a forestation features continuous usage, which is an inexhaustible, inexhaustible green materials[1]. The utilization of bamboo went back to ancient times, it is thought as one of the highest efficiency materials in the nature. Compared to steel and concrete, bamboo has fairly good mechanical properties, thermal insulation performance, good effect of energy conservation and emissions reduction[2,3].

For the past several years, public attention has gone to natural fibers as a resource due to their fast growth. Bamboo is an abundant natural resource in Asia and South America, because it takes only several months to grow up. It has been traditionally used to construct various living facilities and tools[4]. The high strength with respect to its weight is derived from fibers longitudinally aligned in its body.

Therefore, bamboo fibers are often called 'natural glass fiber'. To practically apply the benefit of bamboo fibers, it is necessary to develop a process to fabricate bamboo composites as well as to extract qualitatively controlled fibers from bamboo trees. However, it is difficult to extract bamboo fibers having its superior mechanical properties. The bamboo fiber is often brittle compared with other natural fibers, because the fibers are covered with lignin. Therefore, a devised process should be adopted to extract the bamboo fibers for reinforcement of composite materials[5].

The objective of the work is the synthesis of the ecologically pure binder: silylated polystyrene with Friedel-Crafts alkylation reaction of vinyltrimethoxysilane with polystyrene, which was performed in the presence of anhydrous $AlCl_3$. Poly[alkoxy(4-vinylphenethyl)] silane has been obtained. The synthesized products were identified by ^{1}H, ^{13}C, ^{1}H COSY NMR, and FTIR spectroscopy. Then manufactured new composites with improved properties containing dispersed bamboo particles (with a length of fewer than 50 μm) plus the binder: Poly[trimethoxy(vinylphenethyl)]silane. The composites were studied by Fourier transformation infrared spectroscopy (FTIR), optical and scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). Some mechanical properties were determined along with thermal stability by the thermogravimetry method. Water absorption was also determined. FTIR results show the formation of primary chemical bonds between bamboo surface active groups and the binders. Mechanical property improvement goes symbatically with thermal stability.

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Measurement of complex formation process of lead (II) with fulvic acids isolated from natural waters at pH=9

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Keywords: lead fulvate; Stability Constant; active associates

Fulvic Acids (FA) are are the major organic matter of natural waters [1,2]. FA form stable complexes with heavy metals and radionuclides and stipulate migration forms thereof in natural waters and soils. Therefore, FA may affect the transport, accumulation, bioavailability and toxicity of metals in the environment.In spite of researches, experimental data on stability constants (β) of complex compounds of FA with lead (as in the case of other metals) are heterogeneous [1,3,4] and they differ in several lines from each other. This condition is mainly stipulated by the ignoring the average molecular weight (Mw) of the associates of FA, which value in its turn depends on value of pH and finally causes the wrong results. Objective of the work was to investigate complex formation process between the pure samples of FA, isolated from natural water. Complex formation process was studied at pH=9.0 by the solubility method. During complex formation process every 0.24 part of an associate of fulvic acids, inculcates into lead's inner coordination sphere as an integral ligand, so it may assume, that the average molecular weight of the associate of fulvic acids which takes part in complex formation process equals to 1826,4. This part of the associate of fulvic acids was conventionally called an "active associate". The average molecular weight of the "active associate" was used for determination the concentration of free ligand and average stability constant .It was established, that in the system at pH=9.0, dominates the lead dihydroxy fulvate complex with the structure 1:1,which average stability constant $\beta=1{,}26\times10^{7}$, lg $\beta=7{,}10$.

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Multivariate analysis of airborne radioactivity in the polar region (Hornsund, Svalbard) since the beginning of the 21st century

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The research concerns the dynamic of changes of selected radionuclides suspended in the Arctic atmosphere based on a long-term dataset of aerosol samples collected at The Stanisław Siedlecki Polish Polar Station in Hornsund, Svalbard (77°00′ N, 15°33′ E) from the years 2002-2018. Isotopes under study represent essential (due to the origin) groups of radioactive substances found in the environment, i.e. lithogenic (^{40}K, ^{210}Pb), cosmogenic (^{7}Be), and anthropogenic (^{137}Cs, $^{238, 239, 240}$Pu, ^{241}Am) isotopes. The polar atmosphere research is currently even more important as the northern regions are undergoing a strong transformation due to rapidly changing climatic conditions. Global warming may be a significant factor triggering or intensifying the spatial and temporal differences in the distribution of pollutants accumulated in the Arctic. The following objectives are pursued as part of the project:

- Analysis of seasonality and long-term trends in the time series of activity concentrations of considered radioisotopes,
- Recognition of mutual correlations, in particular, seasonal correlations between the anthropogenic, cosmogenic and lithogenic isotopes,
- Study of the relationship between the activity concentration of radionuclides and concentration of dust suspended in the air,
- Study of the dependence of radionuclide activity concentrations on selected meteorological indicators,
- Identification of Pu origin in the polar atmosphere based on the ^{238}Pu/$^{239+240}$Pu and ^{240}Pu/^{239}Pu isotopic compositions,
- Estimation of doses from external and internal exposure to ionizing radiation emitted by studied isotopes suspended in the polar atmosphere. Complementary analysis of the radionuclide content and variability over time in the ground-level layer of air for such a long measurement period can be a valuable contribution to the knowledge in the field of atmospheric radioactivity in the polar region.

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Geothermal energy used in cascade for power plant, residential heating, greenhouses and fishing farms

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The purpose of this work is focuses on following applications: district heating systems based on geothermal water, greenhouses and fish farming heating, geothermal aqua-parks and renewable power generation by conversion of geothermal energy. Such a project is based on two drilling wells (Doublet) and a primary circuit of geothermal water. The geothermal water is actually a transporter of earth energy. The thermal water is pumped from the production well in a heat exchanger and afterwards, the water is pumped back in the geothermal aquifer, through a reinjection well placed at a specific distance. The energy of the primary circuit is transferred through the heat exchanger to a secondary circuit, being then used for heating purposes, or other cascade applications, as greenhouse heating or aquaculture facilities, electrical power generation, etc. We evaluate the thermal potential of one geothermal project in the western Romania to over 150MWt. This value is calculated by considering one Doublet, having a depth of around 4,200m, a flow of 80-85l/s (around 83kg/s), and the thermal water temperature of at least 225°C.

By having this potential, we can realize:

Version 1: A project for an extensive greenhouse facility heated with geothermal energy. **Version 1A**: in this case, the geothermal project would remain only a thermal energy provider for a third partner-client. **Version 1B**: in this case the geothermal project includes also the 106ha greenhouses facilities. The object of activity is the production of vegetables / flowers in greenhouses with an additional activity for geothermal dehydration of vegetables (tomato, carrots, parsley, celery, etc.) and fruits (apricots, apples, plums, etc.) and/or fish farming.

Version 2: Geothermal district heating system for the centralized heating and the warm water supply of apartments and houses, the commercial units (industrial parks, shopping malls, office buildings, commercial stores, private companies, etc).

Version 3: A geothermal project with cascade applications. In this version, the project will produce both electrical energy and thermal energy. The generated renewable electrical power can be sold in to national electricity network, while the thermal energy can be directed to the city heating system and/or to a greenhouse facility. In the version including also the greenhouses, the electrical power can be used completely for the night illumination of the greenhouses.

For each version, a calculation is made of the value of the necessary investment and an economic calculation of its recovery.

Yellow-green high-efficiency TADF OLED with phenoxazine and quinoxaline as emitter

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The compound 2,3-bis(4-(10H-phenoxazin-10-yl)phenyl)benzo [5,6][1,4]dioxino[2,3-g]quinoxaline was synthesized and characterized as an emitter material for undoped OLEDs. This compound exhibits delayed thermally activated fluorescence (TADF) in the long wavelength region. The highest emission intensity of the synthesized compound film was observed at 556 nm. The electroluminescence of undoped organic light-emitting diodes demonstrated a similar emission maximum value when the compound was used as an emitter. It was found that the value of the photoluminescence decay time of 2,3-bis(4-(10H-phenoxazin-10-yl)phenyl)benzo [5,6][1,4]dioxino[2,3-g] quinoxaline in the Zeonex film (1 wt.%)) in vacuum are in the range of 30 μs at room temperature. Accordingly, there are 8.43 ns in air, which is associated with oxygen quenching of triplet states. The newly synthesized material demonstrates a bipolar charge transfer mechanism with drift mobility in the vicinity of 10^{-3} $cm^2/V\times s$. The undoped OLED based on this TADF emitter showed a maximum external luminescent quantum efficiency of up to 10.0% and a maximum brightness of up to 28,000 cd/m^2.

Isotopic signatures of plutonium in the global cryosphere

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Glaciers are temporary repositories for radionuclides and other airborne contaminants (eg. heavy metals and organics). Retreat of glaciers results in the release of these contaminants to downstream ecosystems where they can be accumulated by biota, with further consequences along the trophic chain. Fallout radionuclides and especially Pu released from nuclear weapons testing and nuclear accidents, concentrates on glacier surfaces in cryoconite granules. These aggregates of mineral and organic components are associated with biological consortia composed of archaea, algae, cyanobacteria, fungi and heterotrophic bacteria. Contaminants are effectively trapped in cryoconite granules for long periods due to the "sticky" nature of the material. Cryoconite can thus be useful in monitoring of radionuclide deposition in mountain and polar areas, where glaciers are present.

Previous studies showed that activity and mass ratios of radionuclides present in cryoconite can return information about the source of radioactivity. However, such studies only dealt with specific glaciers or regions, while a global overview about the source of radioactivity in cryoconite is still missing. This work provides new insights about Pu radioactivity measured in cryoconite samples collected across the global cryosphere. The activity of 238Pu and 239+240Pu was analysed by alpha spectrometry, while the 240Pu/239Pu mass ratio was determined through triple quadrupole mass spectrometry.

This collective research reveals widespread incidence of Pu isotopes in cryoconite across multiple sites on both hemispheres, including 25 polar and mountain glaciers (Svalbard, Sweden, Norway, Iceland, Greenland, British Columbia, the European Alps, Qilian, Himalayas, South America and Antarctica). The levels of plutonium isotopes (238,239,240Pu) found in cryoconite at these sites are orders of magnitude higher than those typically found in environmental matrices from non-glaciated environments, raising questions about the role of glaciers and cryoconite in concentrating radionuclides.

The activity ratio of 238Pu/239+240Pu show that plutonium-related radioactivity of cryoconite from the Northern hemisphere is mostly compatible with the signature of global radioactive fallout (0.025). Some samples from Svalbard, presenting a higher ratio, point to the role of an additional source of pure 238Pu, likely the SNAP-9A satellite atmospheric burn up occurred in 1964. Activity ratios from South America and Antarctica are also consistent with the hemispheric fallout signature of the southern hemisphere (0.14, including the SNAP-9a re-entry), with the exception of cryoconite from the Exploradores Glacier (Chilean Patagonia) which shows a mean ratio of 0.35. There are no known nuclear test sites near this glacier which could explain this anomalous value. However, there is also no information about the atmospheric re-entry of the automatic Interplanetary Station "Mars'96" which was launched on 16 November 1996. It fell off the coast of Chile near the border with Bolivia and was not found so far. There were considerable quantities of 238Pu on board the station, with a total activity of 174 TBq (IAEA, 2001). We hypothesize that this event could explain the anomaly observed at Exploradores Glacier, confirming the unmatched ability of cryoconite to study environmental radioactivity in glacial contexts and reconstructing their contamination history.

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Arsenic, cobalt, chromium, and nickel content in topsoil of industrial areas

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Soil pollution by heavy metals originating from anthropogenic sources has been widespread over the past few decades. The study of heavy metal content in soil is of great importance due to their biological non-degradability, the long residence of metals in soil, and long biological half-life for elimination from the body. This study aimed to determine arsenic, cobalt, chromium, and nickel content in the industrial soils of Novi Sad, Serbia. Twenty topsoil samples (0 - 10 cm depth) were collected according to the methodology of the References sample (circle method). The mean values of the particle size fractions of the soil samples were 65.67 % sand, 20.64 % silt, and 13.69 % clay. The pH values determined with KCl were in the range of 7.07 - 8.46, and the contents of free $CaCO_3$ vary from 0.59 to 28.85 % with a mean value of 10.21 %. The organic matter content of the analyzed soils ranges from 0.22 % to 4.70 %, with an average value of 2.33 %. The results showed that elevated nickel concentration was detected at one location. The measured value was 36.9 mg/kg, which exceeds the limit value of 35 mg/kg. The concentration of Co at one site was very close to the limit value (9 mg/kg). The results revealed that no elevated concentrations were detected for As and Cr, all values were consistent with background concentrations.

Characterization of air quality in the surrounding environment due to the emissions of TEKO Kostolac Power Plants, Serbia

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For the past 50 years, air pollution was a widely recognized problem that comes with long and short term impact on human health and the environment. With high rate of urbanization, industrialization and increase in motorized transport from the rapid population growth has resulted in increased concentration of various air pollutants: nitrogen oxides, sulfur oxides, carbon monoxide, carbon dioxides, ozone, VOCs, unburned hydrocarbons, particulate matters, heavy metals. Combustion of fossil fuels is the main contributor to the air pollution. The main sources of air pollution in the region of Kostolac in Serbia are thermal power plants Kostolac A and Kostolac B, erosion from mining zones, dust scattering during coal unloading and spontaneous combustion of outdoor coal storage yard.

The aim of this paper is to determine the impact of Power Plants and Mines Kostolac, (TE-KO) on the quality of ambiental air in the surrounding environment. The pollutants (SO_2, NO_2, VOCs, soot, Pb, Cd, Zn) were monitored from five monitoring stations from different distance surrounding the plant, from Novembar 9, 2017 until December 28, 2017. A multivariate technique (Principal Component Analysis) has been applied to a set of data in order to determine the contribution of different sources. Compared with the Regulation on conditions for monitoring and air quality requirements ("Official Gazette of RS") introduced by the Government of the Republic of Serbia the variables soot, metals such as Pb, Cd, and Zn were slightly higher than the maximum the permissible levels. The air pollutants concentrations were found higher in the Stations 1 and 2 nearest power plant. The results showed that air quality parameters at other locations in around industrial area were in a good category based on the Serbian regulations. It was found that the main principal components, extracted from the air pollution data, were related to traffic acctivities and coal combustion. These results provide information to be used for developing better pollution control strategies for the air near Kostolac Basin, Serbia.

Keywords: TEKO Kostolac power plant, air pollution, Regulation on conditions for monitoring and air quality requirements of Serbia, soot, cadmium, lead, zink, multivariate technique

Fabrication of hybrid nanostructures by laser technique for water decontamination

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Today's global society are facing with environmental issues and water crisis due to the rapid development of industrialization and continuous urbanistic expansion. Water is an essential resource, but unfortunately, about 20% of the world's population has no access to clean drinking water, problem which is further complicated by the increasing world population. The excessive use of pollutants, such as toxic dyes, pharmaceuticals, especially antibiotics, and the presence of microorganisms in drinking water, affect the quality of water leading to severe health-related problems. In order to address these issues, highly efficient water purification techniques have to be developed. Photocatalytic degradation processes are attracting significant attention during the last decade, as a method allowing the elimination of toxic pollutants from water resources. Over the last few years, different transition metal oxide semiconductor photocatalysts have been explored to degrade emerging contaminants in the view of environmental protection. Semiconductor materials, TiO_2, ZnO, Fe_2O_3 and MgO, are widely investigated, because they are non-toxic, eco-friendly, and cost effective. However, their use in practical applications is limited due to their relatively wide band gap and high recombination rate of photo-induced electron-hole pairs. In order to overcome these inconveniencies, mixtures of semiconductor nanoparticles and carbon-based nanomaterials, graphene-like reduced graphene oxide, were prepared. The role of carbon-based nanomaterials is the separation of electron-hole pairs, reducing the recombination rate. On the other hand, carbon-based nanomaterials can also contribute to the generation of electron-hole pairs. The hybrid nanocomposite layers were obtained by reactive matrix assisted pulsed laser evaporation (MAPLE), in a single step, without post-processing treatments.

Laser-based methods and in particular reactive MAPLE technique could become an alternative for conventional solvent-based nanocomposite thin layers synthesis techniques, being a solvent free, environmental friendly technique. In this work we focus on the investigation of the photocatalytic degradation efficiency of complex nanocomposite layers against organic products. Our main purpose was to obtain hybrid nanostructures in form of surface layers with high photocatalytic efficiency under UV and visible, as well as simulated solar light irradiation. The optical properties of the layers were analysed with the aid of a UV-visible spectrophotometer. The chemical composition and chemical bonds between the elements were investigated by X-ray photoelectron spectroscopy, and attenuated total reflection Fourier transforms infrared spectroscopy. The photocatalytic properties of the layers were correlated with the diminishment of main absorption line of the organic pollutant containing solutions. The enhanced photocatalytic efficiency of the hybrid materials as compared to the References single component graphene oxide or transition metal oxide layers was attributed to the synergistic effects between the constituent materials.

Bio-monitoring on ICP sample plots Level II using lichen as the biological indicator for air pollution in Serbia

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Lichens, a symbiotic association of fungi and algae, are suitable to serve as a bio-indicator of air pollution due to their ability to absorb toxic materials into their thallus. The photobiont performs photosynthesis; it belongs to blue-green algae, i.e. cyanobacteria and/or green algae; a mycobiont is a fungus from the Ascomycetes, Basidiomycetes or Deuteriomycetes group. There are three types of thallus distinguished according to appearance: crusted, leafy and bushy.

This study aimed to assess the air pollution status in Serbia based on Lichen Biodiversity Index (LBI) which was used to determine the effect of phytotoxic gases released from pollutants on the diversity of lichens, especially on Level II Sample Plots with conifers. One of the goals of the study was to determine which species of lichen are the most tolerant and the most sensitive to air pollution. This is one of several different methods that have been developed to monitor the environmental quality. Two main biomonitoring techniques using lichen were identified, with varying research scope and types of parameters researched in the last two years. Previous annual studies on ICP Sample Plots Level II in Serbia from the last decade could help compare and analyse not only the methods for gaining insight into the current practices, but also the progress and challenges that may be expected.

The analysis of the obtained results was conducted to systematically characterize and classify the existing biomonitoring using lichens from several groups, based on the area and scope of the research. Biodiversity of lichens decreases significantly with physical proximity to factories - “Zlatibor” Dairy and Construction company “Tomić gradnja” for the Sample Plot Mokra Gora, and the Steelworks “Kopaonik”, Beograd, Kraljevo branch for the Sample Plot Kopaonik. The results are represented graphically through maps. Different aspects of the current biomonitoring should be compared to the results obtained in practice to date, in order to increase the number of the related studies in the years to come. Lastly, the current studies, progress, and challenges of biomonitoring using lichen as the biological indicator were discussed, and relevant recommendations were formulated.

The most common lichen species on sample plots include *Usnea barbata*, *Ramalina farinacea*, *Xanthoria parietina*, *Physcia adscendens* (all Migule, 1931), etc. The extent, zoning and biodiversity of lichen vegetation in Serbia are far more complex and related to the local conditions of each individual area, which is of great importance considering the relief and the overall influence of different climatic conditions, as well as the impact of the presence and proximity of pollutants.

Implementation of an early warning system for marine pollution in Albania through Interreg ADRION Project SEAVIEWS

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This paper describes the implementation aspects in Albania of the Interreg ADRION project SEAVIEWS (SEctor Adaptive VIrtual Early Warning System for marine pollution), for developing an early warning system for preventing and mitigating the marine pollution. 6 countries participated in the project: Greece as the lead partner, Albania, Croatia, Italy, Montenegro and Slovenia. SEAVIEWS aimed to promoting and enhancing the international cooperation related to environmental vulnerability and the safeguarding of ecosystem services in the ADRION area. This was achieved through two project main outputs: the transnational repository network (smart sensors installed in critical coastal areas, web platform, servers, mobile application, marine pollution hubs), and the amendment of the macro regional action plan.

The first output of the project was the development of a transnational repository network which receives, stores and analyses the sea water quality data. This is enabled by using a network of smart sensor probes installed in critical points of Adriatic-Ionian Sea. The transnational repository network receives also information from public observations through mobile application developed for this purpose, SEAVIEWERS. The ultimate goal of this output is to promote through the network the people's understanding and sensitivity and therefore, engage them in the prevention of marine pollution.

Two multi-parametric probes were installed in Vlora Bay and Durrësi Bay in Albania. This paper will describe the implementation aspects of the project SEAVIEWS in Albania, basic principles of the virtual early warning system, description of the selected installation areas, equipment characteristics and technical issues related to the installation, operation and maintenance.

The composition and the strategic plan for the operation of Albanian National Pollution Hub will be described here. It will establish links with public authorities and policy makers in order to promote SEAVIEWS overall vision. Through the creation of an open community supported by the marine hubs, the project expects to raise awareness on marine pollution, ensure exploitation activities, identify new relevant stakeholders and in the long-term achieve contributions to the amendment of current policies applied in the ADRION area.

Optimization of sample preparation for GC-MS analysis of pahs in solid waste samples

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Polycyclic aromatic hydrocarbons (PAHs) are natural or anthropogenic organic compounds with two or more fused benzene rings, which are formed as a result of incomplete combustion of different organic materials, such as coal, oil or natural gas. Because of their strong cancerogenic, mutagenic and immunologic activity, they are considered to be very dangerous pollutants, and are restricted with Commission Regulation (EU) No 835/2011.

This study aims to develop a GC-MS method for the analysis of PAHs and optimization of solid phase extraction (SPE) procedure for their isolation and concentration.

The GC-MS method was developed using PAH-Mix 18 References Material. The instrument experimental conditions (temperature gradient, retention times, molecular ions, etc.) were specified in a scan method which were subsequently used for quantitative analysis in selected ion monitoring mode (SIM) method.

To optimize the sample preparation step, solid waste samples were spiked with the analyzed compounds. The extraction of PAHs was performed with hexane, followed by their isolation and concentration by SPE. A comparison of the analytical characteristics of different stationary phases and eluents for SPE was determined. Two different stationary phases (silica gel and Al_2O_3) and varying eluents (hexane, dichloromethane, methanol, and acetonitrile) were examined to test the polarity dependence of the targeted compounds and to obtain the optimal conditions for SPE procedure. The recovery values for 17 PAHs were evaluated and compared.

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Water vapor condensation on vertical tube bundle from biofuel flue gas

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Energy and water shortages are predicted to get worse in the future, according to many governments. In order to resolve the issue at hand, it needs to be addressed to either boost the efficiency of energy production or modernize outdated energy systems utilizing renewable and alternative fuel sources. As a result of this, there is a growing interest in utilizing condensing heat exchangers in thermal power and boiler facilities to recover waste heat and water from exhaust flue gas. Despite this, due to the complexity of the condensation processes, their performance has not yet been properly investigated.

There exists a knowledge gap about how to optimally design and manage condensing vertical tube-equipped heat exchangers in the flue gas environment since studies regarding condensation heat transfer have primarily focused on single vertical tubes in parallel flue gas flow conditions or horizontal tube bundles in a crossflow.

Experimental studies on water vapor condensation with non-condensable gas had been performed at the Lithuanian Energy Institute using a coiled-tube counter-current type condensing heat exchanger with vertical tube bundles set up in line. For the purpose of determining the influence of various variables on the process of condensation, experiments were carried out by altering the flue gas (inlet temperature – 414-424 K; velocity – 0.5-2 m/s) and cooling water (inlet flow rate – 1 and 3 l/min) parameters, in addition to the flue gas composition (inlet water vapor mass fraction – 0.09-0.15). Both open and closed loops of cooling water were used during the experiments.

The results of this study showed that the flue gas and cooling water temperatures, as well as the overall Nusselt number (Nu) fluctuation along the test section, were comparable in the two analyzed cases. Nusselt number increases and starts decrease in the last stages of the test section. This variation can be explained, as the water vapor mass fraction decreasing starts affect the condensation process.

The effect of cooling water on condensation was analyzed by comparing flue gas and cooling water temperature differences. The result showed that in identical circumstances (Reynolds number, flow rate), temperature deference can increase from 8 to 40 percent compared to different cooling water loop types. It was noticed that the temperature difference increases when the Reynolds number is about 920 and decreases with a lower Reynolds number - 320.

Condensate was collected in the separate sections of heat exchanger. In order to determine the effects of the flue gas inlet velocity on the condensation capture rate, the experiments are conducted at different flue gas velocities. It is observed that at low flue gas velocity condensate capture rate increases with the increase of water vapor mass fraction. Also, condensation capture rate decreases 2 times in closed comparing it with open loop.

According to the study, changes in the Reynolds number had a relatively little effect on the total Nu number, especially when the water vapor mass percentage was lower in both circumstances. For identical circumstances, an increase in water vapor mass percentage caused Nu to increase roughly 2.8 times in a closed loop and 2 times in an open loop for higher flue gas Reynolds numbers.

Comparative study of active and passive biological monitoring in the city of Chisinau

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Currently, about 200 species of lichens are known in the Republic of Moldova, of which 74 are folliculose and 17 are fruticulous, which constitutes a sufficient basis for monitoring the quality of the environment. Considering that the abundance of more than 10% is true, a scale with 6 steps was created: 5 - characterized by species with different toxitolerance to the content of SO2 in the air, and the last one - in which lichens are completely absent, therefore the most polluted. In active monitoring, the first visual changes appear after 4-6 months, and after 9 months the content of chlorophyll "*a*" and "*b*", decreases by 2.5-40 times compared to the control, being the largest decrease in the species *Parmelia sulcata*, the difference being statistically significant. În *Parmelia caperata* follows - 1.5-25 times, *Evernia prunastri* - 15-6.5 times and *Hypogymnia physodes* - 1.1-10 times compared to the control.

Thus, the degree of destruction of the pigments confirms that there is a good correlation between the degree of morphological and biochemical damage of the lichen thallus. The content of chlorophyll "*a*" and "*b*" decreased considerably in the samples of the most polluted variant - str. Paris, recording extremely low values for all species studied, and the cleanest air is in the Râşcani sector, followed by the Ciocana sector.

Comparing the maps of pollution areas, established by lichen indication with those of the atmospheric purity index (A.P.I.), in passive monitoring, we notice that an A.P.I. with high values (>40) corresponds to areas with insignificant pollution, an A.P.I. small (<10) for polluted areas, and moderate A.P.I. for areas with light pollution and obvious pollution.

The comparative analysis of the results of active and passive monitoring shows a significant difference, because only in 2 cases, out of the 13 analyzed, the results were identical, and in 4 cases active monitoring demonstrated a more pronounced power and in 7 cases – weaker. Passive monitoring depends on the share of green spaces, the spectrum and mosaic of the spread of host species for lichens, the presence of indicator species with different degrees of sensitivity to the pollutant, etc. Active monitoring can test the quality of the environment in any location, through transplants, so it can provide us with data from the most polluted and devoid of vegetation sectors. We consider it necessary to apply both active and passive monitoring methods, which complement each other, especially in urban, rural, industrial centers, etc.

Monitoring of biomass and biofuels contribution to atmospheric pollution by using nuclear techniques

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Renewable energy resources are of great interest for prevention and mitigation of the climate change effects. Here is presented a study on the utilization of green energy fuels derived from available resources as prevent for diminishing potential environmental pollution levels influencing this change. The atmospheric particulate matter composition, also recognized as hazardous and most responsible for human health and premature deaths would be adequate parameter to be followed in these terms. A biomass burning contribution to the aerosol fraction with particles less than 2.5 μmin diameter (PM2.5) was assessed in the Belgrade residential area. Daily $PM_{2.5}$ aerosol samples collected on membrane Teflon filters over four seasons were analyzed by PIXE (proton induced X-ray emission) nuclear analytical technique and multi-wavelength (405-1050 nm) light attenuation measurements. Results have indicated presence of several biomass and biofuel related tracer elements like Ni, V, Cu, Zn, Ti, Mn, and Cr and significant contents of Pb and Cd, proving that it may be used for detection of their presence in the mix of energy related emissions. Black carbon concentration was also a good indicator candidate as its values have shown strong seasonality, although for more sophisticated recognition of specific species, additional analysis would be necessary. Receptor modeling using positive matrix factorization (EPA PMF 5.0) revealed about 40% of PM2.5 mass belonging to the biomass-related emission sources coming from the energy production sector. Besides the black carbon measured at wavelengths up to 600nm, K was recognized as a main tracer for biomass sources like wood and biofuels. A V/Ni ratio, characteristic for heavy oil burning, was noticed in all seasons indicating contribution of industrial emission sources during the summer in addition to its appearance in the heating season. Nevertheless, recently encouraged use of the individual biofuels such as biochar, bio-oil, methanol, and crude glycerol, could not be distinguished by applied methodology from the mixed ones. Use of HP Ge spectrometry for ^{210}Pb/Pb ratio and K concentrations determination should be considered in specific cases only, due to differences in sampling periods and sample preparation procedures for radionuclides and $PM_{2.5}$ elemental analysis. Obtained results support the use of nuclear analytical techniques for analysis as well as development of new tools and techniques for simple and efficient control of biofuel combustion products in emission exhausts, having in mind the intention of their more frequent application in everyday life in urban areas.

The risks assessment in consumption of mussels (M*ytilus galloprovincialis*) from the different regions: microelement contribution study

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The wild mussels in coastal areas in many countries around the world are usually used as food by local population. At the same time, they often grow under anthropogenic pressure, accumulating the sediments of different origin from the water masses and coastal runoff, which could contain high levels of microelements and toxic elements. The lack of control of content of toxic elements in consumed mussels by guidelines and national authorities leads to increasing of the risks for human health. The sets of samples for analysis were collected from the zones with different anthropogenic and natural features of the Black Sea region and the Western coast of South Africa. By using neutron activation analysis, the mass fraction of 24 elements in soft tissue of mussels were determined.

For analysis of risks associated with consumption of mussels three approaches were: direct comparison of the mass fraction with the maximum permissible levels established by countries; estimation of maximum consumption dose at the highest levels of appropriate element; assessment of levels of the target hazard quotients and hazard indices based on the established guideline oral References dose. The calculated risks were higher for wild mussels in comparison with the farmed in the same coastal water zone.

The obtained results showed the relative safety of wild mussels from the recreational and pristine areas at the levels of consumption less than 300 g per week per person that is higher than the average consumption rate. The obtained results could be used in the coastal ecological management and future biomonitoring studies.

Production of liqueur from green walnuts using ionizing radiation

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Liqueur from green walnuts is one of the many traditional medicines in folk medicine. It owes its healing properties to the main ingredient - unripe green walnuts. Green walnuts are a natural reservoir of vitamin C, vitamin B complex, vitamin E, calcium, potassium, magnesium, phosphorus, iron, zinc and iodine. Liqueur made from green walnuts is mostly used for problems with the thyroid gland, anemia, and various stomach infections.

The liqueur is made by adding green walnuts to a container with sugar or honey and brandy, and leaving them to be exposed to the sun's rays for a period of 40 days. Photons accelerate the release of medicinal substances from green walnuts.

This period of exposure is quite long, the quality of the liqueur is affected by the amount of solar energy delivered during that period, and contamination may occur during manual handling. All these problems can be solved by using photons from a radioactive gamma source instead of photons from the sun.

The paper describes the process of obtaining liqueur from green walnuts using gamma radiation, as well as the comparison of the composition of liqueur obtained in the traditional way, with the effect of sunlight, and the application of an innovative method using gamma rays.

Legume authentication method based on GC-MS analysis of lipid components coupled to multivariate statistics

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Legumes are widely consumed around the world due to their high nutritional values. They are rich in proteins, carbohydrates, vitamins and minerals. Unlike cereals, legumes do not contain gluten, so they became very popular in bakery industry in last few years. The aim of this work was to develop a legume authentication method based on lipid composition. Solvent n-hexane was used to extract lipid components from samples of bean, green bean, faba bean, peas and grass pea. Fatty acids were derivatized into corresponding fatty acid methyl esters using reagent trimethylsulfonium-hydroxide (TMSH) and GC-MS analysis was performed. Peak surface areas of identified lipids collected by processing of obtained chromatograms were used to create a data matrix. Two multivariate statistic tools were employed for further data processing: hierarchical cluster analysis (HCA) and linear discriminant analysis (LDA). Both HCA and LDA separate the legume samples into corresponding clusters according to their botanical origin. In both cases four clusters were obtained. Faba bean, peas and grass pea samples form clearly separated clusters, while bean and green bean samples are grouped together in the fourth cluster. In the case of HCA, one sample of grass pea was an outlier grouped together with the faba bean samples. On the other hand, there is no outliers in the case of LDA indicating this tool as a better choice to use for data processing in proposed legume authentication method based on GC-MS analysis of lipid components.

Cytoprotective and genoprotective potential of *rosa damascena* mill. Hydrosol

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Extracts and hydrosols from different medical and aromatic plants are widely used in various sphere of human life from the ancient time. This is because of the many biologically active substances in them, to which their biological activity is due. Bulgarian Rosa damascena Mill. from Rosaceae family is an emblematic plant for Bulgaria and is well known for its high quality oil and hydrosol, respectively. The chemical composition of the rose hydrosol suggests that it would exhibit a number of valuable biological activities as the oil. Although the hydrosol has been used in the perfumery, cosmetics and food industries, a limited number researches exist on its anticytotoxic/antigenotoxic effect.

The aim of the present study was to assess the defense potential of Rosa damascena Mill. hydrosol against the alkylating genotoxin N-methyl- N'-nitro -N-nitrosoguanidine in plant and human lymphocyte test-systems by endpoints for cytotoxicity (mitotic index and nuclear division index) and genotoxicity (chromosome aberration and micronuclei) using appropriate experimental schemes.

Five different concentrations of rose hydrosol (3%, 6%, 11%, 14 и 20 %) applied as a single treatment for 4 hs were assessed for cytotoxicity and genotoxicity. The rose hydrosol protective potential against the direct mutagen MNNG was tested using two types of experimental design: i) conditioning treatment with non-toxic or low toxic concentrations of hydrosol, followed by damaging with the alkylating agent (50 µg/ml) with 4 hs inter-treatment time, and, ii) treatment with hydrosol and mutagen with no time between the treatments.

The results show a good cytoprotective / genoprotective effect of rose hydrosol against the DNA damaging agent MNNG in both used test-systems (higher plant Hordeum vulgare and human lymphocytes in vitro). The defense potential of R. damascena hydrosol was expressed by more than twice reduction both of the frequency of chromosome aberrations and micronuclei and by enhancing the mitotic activity compared with these induced by the alkylating mutagen. The protective effect was manifested applying both types of experimental schemes with combined treatment. On the other side, treatment only with the rose hydrosol did not induce real cytotoxic and clastogenic effect.

The obtained data are promising for further application of the rose hydrosol in the pharmacy and medical practice.

Does hydrosol from *Rosa centifolia* l. Have genotoxic effect on different types of test-systems *in vivo* and *in vitro*?

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Rosa centifolia L., or commonly known as Provence Rose or Cabbage Rose, is a result of hybridization from Dutch breeders in the 17th and 18th centuries. The fame of the “hundred petaled roses” or “cabbage roses” is also due to Dutch still-life painters. R. centifolia L. hydrosol is a product of essential oil distillation and is wildly used, because of its relaxing, soothing, anti-aging, anti-inflammatory effects; soothing emotions as anxiety and depression; as well as potent aphrodisiac and sexual wellness applications. Even though of it’s widely application data available in literature related with genotoxic effect of this hydrosol are insufficient.

This study aims to access whether different concentrations of hydrosol from R. centifolia L. have genotoxic effect in different on hierarchic level test-systems.

Three different types of experimental test-systems were used: higher plant in vivo (Hordeum vulgare L.), ICR mice in vivo, and human lymphocytes in vitro. As genotoxic endpoints induction of chromosome aberrations and micronuclei were applied. Single treatment for 4 hs with the following concentrations of 6%, 11%, 14% and 20 % were tested. As a positive control alkylating agent MNNG (50 µg/ml) was used.

Genotoxic effect of rose hydrosol showed a dependence on the applied concentrations in the experimental scheme in and the sensitivity of the test-system used both in vivo and in vitro. Treatments with all tested concentrations of R. centifolia hydrosol did not lead to high induction of chromosomal aberrations and micronuclei. The highest concentration was with more expressed levels both of induced chromosome aberrations and micronuclei. The highest sensitivity to rose hydrosol was observed in human lymphocytes in vitro, followed by higher plant in vivo and ICR mice in vivo. Our results showed that genotoxic effect of rose hydrosol were significantly lower than the effect of DNA damaging agent MNNG in all studied types test systems.

Based on our observations it could be suggested that R. centifolia hydrosol did not have significant genotoxic effect and could be used in various areas of human life such as cosmetics and pharmacy.

Key words: Rosa centifolia L. hydrosol, genotoxicity, chromosome aberrations, micronuclei, higher plant in vivo, ICR mice in vivo, human lymphocytes in vitro

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Towards a greener tomorrow: the promise of hydrogen fuel cells and sustainable hydrogen production

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Today, the production of hydrogen via electrolysis using renewable energy sources is becoming increasingly common, and this is known as "green hydrogen" production. The efficiency and cost of green hydrogen production have improved in recent years, making it a viable alternative to conventional hydrogen production methods.

Hydrogen fuel cell technologies are also advancing rapidly, with improvements in cell design, materials, and manufacturing processes. Fuel cell vehicles, for example, have been developed by major automotive manufacturers and are now available in several markets. These vehicles emit only water vapor and do not produce harmful emissions like traditional gasoline and diesel vehicles. Moreover, fuel cells are being used in stationary applications, such as backup power for buildings and remote locations, and for power generation in off-grid areas.

Despite the progress made in green hydrogen production and fuel cell technologies, there are still challenges that need to be addressed. For instance, the cost of hydrogen production and fuel cell technologies needs to be reduced further to compete with conventional technologies, and this can be achieved, for example, by exploring cheaper and earth-abundant novel materials as cathode for the hydrogen evolution reaction and more efficient electrodes in fuel cells. Additionally, the infrastructure for hydrogen storage and distribution needs to be expanded to support widespread adoption.

Overall, we are currently at a pivotal moment in the development of green hydrogen production and fuel cell technologies. With continued investment and research, these technologies have the potential to become key components of a sustainable energy system. In this talk, we will see where we are standing today with regards to green production of hydrogen, and we see some recent results on material discovery for hydrogen evolution.

Lignocellulosic biosorbents modified with deep eutectic solvents for purification of gaseous fuel streams

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Biogas is an alternative fuel that can be used for heat and electricity production or as a transport fuel. However, they must be properly treated before use. Appropriate treatment technology should not only be selective and effective but should also meet all the standards of green chemistry, green engineering, and sustainable development. Among known technologies, adsorption is one of the most popular because of the high efficiency of the process without the need to use toxic chemicals. However, to ensure the high efficiency of the process, appropriate types of adsorbents should be used.

This paper presents a new approach to biogas stream treatment using lignocellulosic biosorbents impregnated with new green solvents called deep eutectic solvents (DES). This research focused on the removal of volatile organosulfur compounds (VSCs) and carbon dioxide from model biogas. The biosorbents used included *Prunus mahaleb, Secale L., Fagus L. and Populus L.*, which differed in lignin and hemicellulose content. To select DES liquids with the highest potential for removing VSCs, DES screening was performed using headspace gas chromatography. As a result of the preselection of DES composed of quaternary ammonium salts and glycols, tetrabutylammonium bromide: 1,8-Octanediol (1:3) was selected. The basic physicochemical properties of the new DES, that is, viscosity, density, and melting point, were evaluated. The shredded, purified, and sieved adsorbents were then impregnated with the new DES. Thermogravimetric analysis (TGA), scanning electron microscopy (SEM), and X-ray diffraction analysis (XRD) were performed on the new biosorbents before and after modification. Subsequently, the adsorption process of the VSCs from the biogas was performed. This study showed the high competitiveness of the new sorbents compared to that of commercially available sorbents. The coexistence of the two processes, absorption and adsorption, was attributed to the high removal efficiency of volatile organosulfur compounds.

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New generation of green sorbents for desulfurization of biogas streams

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In recent years, there has been growing interest in "green technologies" for removing volatile organic compounds (VOCs) from gas streams (i.e., wastewater or landfill biogas). Physical absorption can be classified as an environmentally friendly technique if non-toxic, biodegradable absorption materials are used. Deep eutectic solvents (DESs) are alternatives to absorbents based on mineral oils, organic solvents, and ionic liquids (ILs). The physicochemical properties of DESs are similar to those of ILs. However, the synthesis of DESs is much simpler, cheaper, less toxic, and easier to biodegrade than ILs. According to this definition, DESs are formed as a result of specific interactions between two solid compounds, mostly hydrogen bonding. In the literature, studies on the use of DESs in the absorption processes of impurities from gaseous phases are limited to the removal of inorganic compounds, such as H2O, CO2, SO2, H2S, and NH3.

In this work, various types of new sorbent materials based on amino acids (i.e., proline, L-carnitine, and betaine) combined with different glycols (i.e., ethylene glycol, dimethacrylate, caprylic glycol, pentylene glycol, propylene glycol, decylene glycol, and 1,2-hexanediol) in the appropriate molar ratios were evaluated and compared. The obtained DESs were used for the sorption of methyl- and ethylmercaptan and carbon dioxide (CO2) from the model biogas stream. The obtained results of the division coefficient vapor–liquid coefficient (K) indicate that the highest efficient methyl- and ethyl-mercaptan sorption was achieved by the proposed hydrophobic DES based on L-carnitine and 1,2-hexanediol in a 1:2 molar ratio. For the best DES dynamic sorption studies, the simultaneous removal of methyl- and ethyl-mercaptan and CO2 was performed. In these studies, the sorption capacity of DES was almost unchanged through five absorption-desorption cycles. The obtained results indicate that efficient methyl- and ethyl-mercaptan and CO2 sorption can be achieved using the proposed non-ionic DES while ensuring easy recycling and sorbent recovery.

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Starc*h* wars - looking for ecofriendly packaging materials

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Natural carbohydrate polymers are of great interest regarding to their possible use as materials in various industries. One of the most abundant natural polysaccharide in nature is starch. Is the biopolymer that has been popular as a raw material for the production of biodegradable packaging for many decades. The main disadvantage of this polysaccharide as a potential packaging material is its high sensitivity to moisture, poor strength properties and very poor miscibility with hydrophobic components. A great opportunity to improve the processing of this biopolymer was seen in thermoplastic starches (TPS). This method of starch plasticization does not eliminate brittleness, sensitivity to external factors and poor mechanical properties in comparison with other polymer materials. I t was improved with the formation of blends (blends) of thermoplastic starch with synthetic or natural polymers, usually aliphatic, such as e.g. polylactide (PLA) or poly-ε-caprolactone (PCL). Nevertheless, there was still a compatibility problem.

As part of the research, the use of a new type of potential plasticizers and compatibilizers in processing of starch was proposed. Hydrophobic derivatives of glycerol and its carbonates were obtained in reactions preceded by oil hydrolysis or synthesis with fatty acids. In the synthesis of glycerol or monoacyloglycerols carbonates, urea and its derivatives were used. In the next step, the obtained products served as components to production of starch based films/fittings extruded on a single-screw extruder. The structural analyses of the obtained compounds and materials (ATR FTIR, NMR), as well as the analysis of physicochemical (thermal stability), processing (mechanical strength) and environmental (phytotoxicity, biodegradability) properties were carried out.

Cytokines of mixed oral fluid in the dynamics of the treatment of patients with catarrhal gingivitis against different levels of reactivity

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Background: The activity and prognosis of the inflammatory process in periodontal disease are determined by the parameters of the immune response. The functioning of the immune system depends on the adaptive potential of the organism, which can be characterized by the current level of reactivity (LR) and the type of nonspecific adaptive reaction of the organism (NARO).

Methods: For first year, 100 patients aged 19 to 35 years with catarrhal gingivitis were monitored. In the Main group (54 people), patients received complex therapy using bioregulatory drugs Traumel C and Coenzyme compositum. The treatment of patients in the Control group (46 observed) was carried out according to the traditional scheme. The hygienic status was assessed according to the OHI-S and API indices. The activity of the inflammatory process in periodontium was determined using the SBI and PMA indices, and was also evaluated by the cytokine profile coefficient of the oral fluid (CCPRF), reflecting the ratio of anti- (IL-1Ra, TGF1b) and pro-inflammatory (IL-1b, IL-8 and IL-17a) cytokines in the mixed oral fluid. The determination of LR and the type of NARO was carried out according to the results of a general blood test, taking into account the recommendations of Garkavi L. X.

Results: Prior to the start of treatment, 61 patients out of all observed had unfavorable variants of the adaptive potential of the body - a low level of reactivity, as well as an average level in combination with adverse reactions of stress and reactivation. The reactivity of the organism of the 39 observed was at an average or high level, while positive types of the reaction of training, calm and increased activation were determined. CCPR was significantly reduced, while the level of anti-inflammatory cytokines against the background of favorable types of adaptive potential was 1.4 times higher than their content in patients with maladaptation phenomena. A year after therapy, unfavorable types of adaptive potential of the body remained in all patients of the Control group. They had an exacerbation of catarrhal gingivitis, the ratio of pro- and anti-inflammatory cytokines remained at the level of baseline values. In patients with persistent mean LR, the content of proinflammatory cytokines prevailed in the oral fluid after a year. The use of bioregulatory drugs Traumel C and Coenzyme compositum in the Main group 3 months after the therapy allowed to achieve a positive transformation of the initial low LR in 96.1% of patients into the average LR, which persisted after 6 months. In 70.8% of patients with baseline mean LR, a transition to high LR was recorded. CCPR was characterized by stable positive dynamics throughout the entire follow-up period and almost complete normalization after a year. For patients with an average LR, it is characteristic to achieve control values of CCPR after 6 months, which indicates a fairly rapid normalization of the immune response against the background of a positive transformation of the adaptive potential of the body. There were no relapses during the entire follow-up period.

Conclution: Catarrhal gingivitis develops in most cases against the background of depleted adaptive resources of the body, while the ratio of anti- and pro-inflammatory cytokines in the mixed oral fluid depends on the current LR and the type of NARO. Traditional therapy, even after a year, does not lead to a stable positive transformation of the adaptive potential of the body and normalization of the cytokine profile of the mixed oral fluid, which creates a background for the recurrence of the inflammatory process in the periodontal. The inclusion of bioregulatory agents contributes to an increase in the effectiveness of therapy for catarrhal gingivitis due to the fairly rapid elimination of maladaptation phenomena, an increase in the level of anti-inflammatory and a decrease in pro-inflammatory cytokines.

Accumulation and effect of silver nanoparticles functionalized with *Spirulina platensis* on rats

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The effect of unmodified and functionalized Spirulina platensis biomass silver nanoparticles on rats during prolonged oral administration was assessed. Silver nanoparticles were characterized by using transmission electron microscopy, while their uptake by the biomass was confirmed using scanning electron microscopy and energy dispersive analysis. The content of silver in the different organs of rats after a period of administration (28 days) or after an additional clearance period (28 days) was ascertained by using neutron activation analysis. In animals administrated with the unmodified nanoparticles, the highest content of silver was determined in the brain and kidneys, while in animals administrated with AgNP-Spirulina, silver was mainly accumulated in the brain and testicles. After the clearance period, silver was excreted rapidly from the spleen and kidneys; however, the excretion from the brain was very low, regardless of the type of nanoparticles. Hematological and biochemical tests were performed in order to reveal the effect of nanoparticles on rats. The difference in the content of eosinophils in the experimental and control groups was statistically significant. The hematological indices of the rats did not change significantly under the action of the silver nanoparticles except for the content of reticulocytes and eosinophils, which increased significantly. Changes in the biochemical parameters did not exceed the limits of normal values. Silver nanoparticles with the sizes of 8–20 nm can penetrate the blood–brain barrier, and their persistence after a period of clearance indicated the irreversibility of this process.

Functional materials based on renewable raw materials: hydrochar and chitosan as formaldehyde scavengers in urea-formaldehide composites

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In this work, urea-formaldehyde (UF) resins modified with chitosan and hydrochar, biomaterials known as adsorbents, were analyzed.

The most polluted places on our planet are apartments. The danger of pollution in the home has increased tremendously, as housing technology has turned to better thermal insulation and cheaper materials. One of the possible dangers is UF adhesive, which is most often used for the production of wooden panels, such as plywood, chipboard or, Medium-density fibreboard (MDF). The main disadvantage of these adhesives is the emission of formaldehyde (FA) from wood products. It is desirable to reduce the percentage of free FA in the resin itself because it is known that FA vapors even in low concentrations can cause chronic respiratory diseases, while higher concentrations can cause death in just a few minutes. Apart from free FA in the resin itself, which is spontaneously emitted due to its low resistance to moisture, hydrolysis of the UF resin can also occur, which implies the breaking of the bonds in the resin (methyl ether) and additional emission of FA into the environment. There are various ways to reduce FA emissions from products bonded with UF resin. One way is the addition of various substances known as "scavengers" of free FA in the resin.

In this work, the biomaterials chitosan and hydrochar were used as "scavengers" FA in UF composites. As a new functional material, hydrochar is usually prepared from biomass and solid waste such as agricultural and forest waste, sewage sludge, livestock, and poultry manure. The wide application of hydrochar is due to its ability to remove pollutants, rehabilitate contaminated soil and reduce the greenhouse effect. Hydrochar, which was synthesized for this experiment, was obtained from the spent mushroom subrateby the hydrothermal carbonization at 180°C, autogenous pressure (2-10 MPa), and water medium in a hydrothermal reactor. The liquid phase in the hydrothermal carbonization system plays an important role because it affects the increase in the number of surface functional groups and forms a rich pore structure on the surface of the hydrosoot. In general, hydrochar is a carbonaceous material with similar properties to activated carbon, so it behaves well as an adsorbent.

Chitosan, like hydrochar, is also a functional material. Chitosan is a natural linear polysaccharide containing reactive amino and hydroxyl groups. The starting material for the production of chitosan is chitin, which is found in the shell of crabs, shells and the wings of beetles. It is characterized by hydrophilicity, biocompatibility, and biodegradability, and is non-toxic. Since chitosan is the only cationic polysaccharide of natural origin, it is considered suitable for various biomedical and pharmaceutical research as a carrier of the active substance in medicine, but also as an excellent adsorbent for anionic dyes.

Determination of free FA in modified UF resins was performed using the disulfite method. The results showed that the percentage of free formaldehyde in chitosan-modified UF resin is 0.1%, while the percentage of free FA in biochar-modified resin is 0.5%. These results are in accordance with the structure of chitosan, which also contains amino groups, so during the in vivo synthesis of UF composites, there is an additional binding of FA with chitosan. The hydrolytic stability of the modified UF resin was determined by measuring the concentration of liberated FA in the modified UF resins, after acid hydrolysis. The percentage of liberated FA in both modified UF composites after acid hydrolysis was similar (2.8% for the UF/chitosan composite and 2.5% for the UF/hydrocarbon composite, respectively).

Near-infrared luminescence properties of germanate based glasses as a function of glass modifier TiO_2

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Over the past years, the progress in the capacity of modern optoelectronic and photonic technologies has contributed to the increasing interest in luminescence materials, particularly glasses containing trivalent lanthanides (Ln3+) ions [1-3]. Inorganic systems doped with Ln3+ ions have been paid attention to due to their spectroscopic properties and possible applications as laser and broadband fiber amplifiers [4, 5]. Among glasses containing lanthanide ions, the especially interesting are trivalent praseodymium (Pr3+) and thulium (Tm3+) ions because of the spectroscopic properties related to near-infrared luminescence [6, 7]. The most crucial advantage of doping these ions in optical systems is the possibility of emitting radiation in the NIR region at about 1.5 µm and 1.8 µm due to characteristic transitions of Pr3+ and Tm3+ ions. Numerous reports prove that the luminescence properties of oxide and oxyfluoride glasses doped with Ln3+ ions like praseodymium and thulium strongly depend on the system composition [8, 9]. Especially our previously published results indicated that some glass modifiers added to host matrices could be promising sensitizers for enhanced and broadband near-infrared emission in germanate glasses containing Ln3+ ions [10, 11].

In this work, germanate based glasses singly doped with Pr3+ and Tm3+ ions with various concentrations of glass modifier (TiO2) have been examined using luminescence spectroscopy. The near-infrared emission spectra and luminescence decay curves for glass systems doped with Pr3+ and Tm3+ ions were registered and analyzed. The broad emission bands corresponding to 1D2 → 1G4 (1.5 µm) and 3F4 → 3H6 (1.8 µm) transitions of praseodymium and thulium ions were observed, respectively. It was noticed that the intensity of near-infrared emission bands significantly changes with increasing glass modifier content. Additionally, the dependence of spectroscopic parameters such as full width at half maximum (FWHM) and measured luminescence lifetime (τm), and the quantum efficiency (η) on the increase of TiO2 concentration in glass composition was established and discussed. Our results suggest that germanate based glasses singly doped with Pr3+ and Tm3+ ions can be suitable for near-infrared luminescence and be useful for laser and broadband amplifiers applications.

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Thulium-doped barium gallo-germanate glasses modified by titanium dioxide: optical investigations for near infrared applications

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Rare-earth-doped glasses have attracted much attention to develop near-infrared lasers operating in the eye-safe region due to their wide applications, such as laser surgery, environmental monitoring, and optical telecommunication. All these applications require the optimization of glass properties that is achievable by tuning their chemical composition. The use of barium gallo-germanate glass belonging to the low-phonon glass family in technological applications, such as optical fibers and infrared transmit ting windows, has stimulated extensive investigations of their optical properties. Compared with the traditional silicate glasses, barium gallo-germanate glass system possess a series of attractive properties, i.e. relatively large glass-forming region, good thermal stability parameters, quite strong chemical and mechanical stability. Recent studies indicate that the choice of glass-host matrix is important to achieve efficient near infrared radiation. For this reason, titanium dioxide is considered to be a valuable glass constituent in some special glasses for its optical properties and is used occasionally as a nucleating agent in the preparation of bioactive glass ceramics. Depending on its concentration, the titanium oxide may act either as a network modifier or as a network former. As experimentally verified, among various transition metal-oxide-doped glasses, titanium dioxide depending on its concentration, has a positive effect on the luminescence properties of rare-earth ions. These facts motivated us to fabricate multicomponent germanate host matrices containing titanium dioxide singly doped with trivalent thulium ions. Moreover, it is assumed that the luminescence bands of thulium ions in the infrared range will be significantly enhanced and broadened as a result of the presence of titanium dioxide.

Thulium-doped glasses, due to near-infrared emission transitions, are important from the scientific and technological point of view. The glasses with general formula GeO2-TiO2-BaO-Ga2O3-Tm2O3 were prepared by the conventional melting-quenching technique using high-purity reagents. In particular, luminescence spectra have been examined for glass samples where germanium dioxide was substituted by titanium dioxide and also contained various content of optically active ions. Measured properties confirmed a dominant effect of chemical composition in modifying the optical properties of the glassy matrix. The broad luminescence bands corresponding to 3H4 → 3F4 (1.4 μm) and 3F4 → 3H6 (1.8 μm) transitions of thulium ions were registered for all the samples, respectively. It was observed that the intensity of near-infrared emission bands significantly changes with increasing transition metal oxide. On the other hand, independent of the concentration of titanium dioxide in the glass composition, the emission centered at 1.8 μm is significantly more intense than due to the band centered at 1.4 μm, which was affected by non-radiative transitions between thulium ions. The dependence of spectroscopic parameters referred to as full width at half maximum (FWHM), which is crucial due to possible applications for optoelectronic devices, was established. The low phonon energy of the glass host can be very important to reducing the non-radiative relaxation probability of thulium ions. Therefore, we analyzed the luminescence decay curved from the upper 3F4 excited level of thulium ions and evaluated luminescence lifetimes. Based on the research, the most favorable glass system was selected for further study. Our spectroscopic studies clearly indicate that developed thulium-doped barium gallo-germanate glasses modified by titanium oxide are very promising optical materials for the generation of 1.8 μm fiber laser applications.

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Luminescence characterization of olivine-type ceramic phosphors $Li_2MgGeO_4:RE^{3+}$ (RE: Pr^{3+}, Er^{3+}, Ho^{3+}, Tm^{3+})

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Germanate olivines have been arousing interest for a long time due to their spectroscopic properties [1], high stability [2], and high conductivity as oxide hosts [3]. Ceramic phosphors based on germanate olivines can be excellent luminescent materials. Among others, compounds $Li_2MgGeO_4:Mn^{4+}$ [4] or long-persistent phosphors $Li_2ZnGeO_4:Mn^{2+}$ show even 8h emission [5]. Studies confirm the excellent luminescence properties of Li_2AGeO_4 (A= Mg, Zn) doped with transition-metal ions, but research on $Li_2MgGeO_4:RE^{3+}$ ions still needs to be done. The following study aimed examination the luminescence properties of the germanate olivine matrix with the formula Li_2MgGeO_4 doped with selected trivalent rare earth ions.

The samples were prepared by the conventional solid-phase reaction method. In order to study luminescence properties, the excitation and emission spectra in the visible range were recorded. The luminescence properties as a function of the excitation wavelength were investigated. The presence of bands due to characteristic transitions of the rare earth ions was confirmed on the registered emission spectra. The results indicated that both Li_2MgGeO_4 systems containing trivalent holmium and erbium ions exhibit red and green luminescence. For LMG:Ho^{3+} the $^5F_4$, $^5S_2$ - $^5I_8$ (Ho^{3+}) transitions are responsible for the characteristic green emission (~ 546 nm), while on the contrary, for the LMG:Er^{3+}, the green bands observed at 527 nm and 550 nm are as a consequence of $^2H_{11/2}$, $^4S_3$ - $I_{15/2}$ transitions. On the other hand, blue emission with a maximum at 459 nm assigned to the $^1D_2$-$^3F_4$ transition was also recorded for ceramic phosphors doped with thulium ions. Moreover, the luminescence spectra have been recorded for LMG:Pr^{3+}, and the most significant emission in the blue light range, was observed. Additionally, while examining the influence of the matrix on the luminescent properties, a broad emission in the visible light range, with a tail of 700 nm was observed. The emission is probably associated with defects and oxygen vacancies in MgO assigned to F-type centers [6].

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Energy scales of compositional disorder in alloy semiconductors for device applications

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Alloying of semiconductors is often used to tune material properties desired for device applications, particularly in radiation emission, absorption and sensing. Changing the mole fractions of material chemical components allows, for instance, varying in broad ranges the band gaps responsible for light absorption and light emission. The price for this tunability is the extra disorder caused by alloying.

In the presentation, we address the features of the unavoidable disorder caused by statistical fluctuations of the alloy composition along the device. Combinations of material parameters responsible for the alloy disorder are revealed, based solely on the physical dimensions of the input parameters. Theoretical estimates for the energy scales of the disorder landscape are given separately for several kinds of alloys desired for applications in modern optoelectronics. Among those are mixed lead–tin triiodide perovskites FAPb1-xSnxI3 [1], atomically thin transition-metal dichalcogenides MoxW1-xSe2 [2] and organic semiconductor blends [3]. While theoretical estimates for perovskites and inorganic monolayers are compatible with experimental data, such a comparison is rather controversial for organic blends, indicating that more research is needed in the latter case [4].

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Gamma irradiation-induced synthesis and characterization of bi-layered Au-(PNiPAAm/PVA) hydrogel nanocomposites

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The development of polymer-based smart materials has significantly expanded in the recent years. These materials can change physical or chemical properties in response to external stimuli, making them suitable for a variety of applications. One kind of these materials - photoactuators, that can produce a reversible mechanical deformation under light exposure, have received considerable attention due to their broad range of possible applications, such as soft robotics, artificial muscles, and smart devices. Multi-layered hydrogel systems have proven to be promising materials for this purpose.

The current study investigates a new bi-layered material made of thermosensitive poly(N-isopropyl acrylamide) (PNiPAAm) as the active layer and poly(vinyl alcohol) (PVA) as the passive layer. To make photoactuators, different-shaped gold nanoparticles (spheres - AuNPs, and rods - AuNRs) were incorporated into the active layer. These functional NPs have unique photo-thermal capabilities to convert the absorbed light into thermal energy, causing local shrinkage of the active layer, and thus enabling the wireless control of the device (bending and curling motions). The presence of NPs within the active layer was confirmed by characteristic SPR bands at around 540 nm for AuNPs and at around 530 nm and 700 nm for transversal and longitudinal oscillation, respectively, for AuNRs. For any practical implementation of hydrogel-based materials, their highly porous structure is required. The SEM analysis revealed that the polymer chains formed a honeycomb-like structure with a high number of micro- and macropores. The impact of various NPs shapes on the physicochemical properties, such as swelling and deswelling, and volume phase transition temperature (VPTT), was investigated. Understanding the swelling capacity of hydrogels as well as the kinetics of the process is essential to their application in systems for the release of active chemicals. The incorporation of AuNRs into the active layer of the photoactuators leads to an increase in both, the swelling capacity and VPTT. Knowing the values of the kinetic parameters and diffusion coefficient can help predict the rate and efficiency of the release process and optimize the design of the hydrogel for a specific use. The mechanical properties of hydrogels (strength, rigidity, and deformation) are crucial to understanding how they will behave in different applications, such as tissue engineering, drug delivery, or soft robotics. The results obtained from compression measurements show that the mechanical response of investigated systems depends on the shape and concentration of incorporated gold NPs.

In summary, bi-layered Au-(PNiPAAm/PVA) hydrogel nanocomposites were successfully synthesized using a combination of freeze-thaw and radiolytic methods. The incorporation of different shapes of gold NPs has an influence on the investigated properties of the photoactuators. The Au-PNiPAAm/PVA hydrogel nanocomposites showed an improvement in swelling capacity, a faster rate of swelling and deswelling, and a higher VPTT in comparison with the neat PNiPAAm/PVA hydrogel matrix. Moreover, the study of the diffusion transport mechanism revealed that the effects of diffusion and polymer chains relaxation are comparable.

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Optimization of acid treatment of brown seaweed biomass (*Laminaria digitate*) during alginate isolation

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Commercial production of alginate from brown seaweed (Laminaria digitate) is still based on a conventional acid/base procedure performed in several steps. Therefore, this extraction process requires innovation to improve its efficiency. The acid treatment of brown seaweed biomass is processed by maceration for 2 h and up to 12 h so it is considered an inefficient step in the alginate isolation. The aim of this study was to accelerate the acid treatment of algae biomass using ultrasounds and to make the conventional procedure more efficient. The effects of sonication time, the liquid-to-solid ratio, and the temperature on the alginate yield were analyzed using the Box-Behnken design. The obtained alginate yields were fitted using a second-order polynomial equation. Of the linear terms in the polynomial equation, the liquid-to-solid ratio had the greatest influence on the alginate yield. Unlike sonication time, which had a positive effect on the alginate yield, the liquid-to-solid ratio and temperature had negative effects. After the application of the numerical optimization method, the following optimal conditions were obtained: a sonication time of 30 min, a liquid-to-solid ratio of 30 mL/g, and a temperature of 47 °C. Under the given conditions, the predicted and experimental values of alginate yield were 31.3% and 30.9%, respectively. A good agreement between the experimental and predicted values for alginate yield is the confirmation of the model's adequacy.

Keywords: seaweed biomass, alginate, acid treatment, Box-Behnken design, optimization.

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Microstructure and mechanical properties of biomedical alloys spark plasma sintered from elemental powders

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Several titanium-based alloys with the composition Ti-(29-35)Nb-7Zr-0.7O were prepared by spark plasma sintering (SPS) from elemental powders and titanium dioxide. This particular alloying system is studied as a perspective material for load-bearing orthopaedic implants with low elastic modulus and high strength exceeding 900 MPa. Sintering was performed at comparatively high temperatures of 1300-1500°C, which are required for achieving chemical homogeneity. On the other hand, significantly lower temperatures would be sufficient for successful material compaction. Diffusion of alloying elements at different sintering temperatures was qualitatively studied by SEM equipped with EDS. Niobium, which is the major alloying element, exhibited the slowest diffusion, resulting in its non-homogeneous distribution for lower sintering temperatures. Local chemical composition variations significantly influence local phase composition. Nb enriched areas consist of pure beta phase, while Ti rich areas show alpha + beta phase structure. Due to the comparatively slow cooling in the SPS device, beta phase is stable only when local niobium content exceeds 18-20 wt % of Nb. The composition of individual phases was studied by XRD. Alloys containing higher nominal content of Nb showed the highest content of beta phase for given sintering conditions. Microhardness measurements proved high hardness - and potentially strength - of the alloys which is caused by the intentionally high content of the interstitial oxygen.

Synthesis and crystal structure of new mixed niobates $La_{1-x}Y_xNbO_4$ and $La_{1-x}Gd_xNbO_4$

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Nominally pure and variously doped rare earth (RE) niobates have considerable potential for numerous applications. $RENbO_4$-based materials show high dielectric constant, low phonon frequencies, good photoelastic and nonlinear optical properties as well as an excellent chemical, mechanical, and thermal stability. Owing to that, RE niobates are used as microwave dielectric ceramics, scintilators and laser materials. Bi-doped $YNbO_4$ and $GdNbO_4$ were proposed for use in field emission displays, while $LaNbO_4$, $YNbO_4$ and $GdNbO_4$ co-doped with Bi^{3+} and different rare-earth ions (e.g., Tm^{3+}, Dy^{3+}, Yb^{3+}, Eu^{3+}, Nd^{3+}) were found to be suitable for white light emitting diodes or solar cells. Rare earth niobates are also considered as new class of materials for non-contact luminescent thermometry.

At ambient conditions, $RENbO_4$ compounds adopt a monoclinic fergusonite-type structure. At the elevated temperatures, they undergo a reversible ferroelastic phase transition from a monoclinic to the high-temperature tetragonal scheelite-type structure. Among the key parameters, which determine the transition temperature in these materials, are the ionic radii of RE cations.

In order to reveal impact of RE cation substitution in $RENbO_4$ compounds on crystal structure parameters and the temperature of ferroelastic phase transitions, two series of mixed lanthanum-yttrium and lanthanum-gadolinium niobates were obtained. Single phase microcrystalline powders of $La_{1-x}Y_xNbO_4$ (x=0.2, 0.8) were obtained from La_2O_3, Y_2O_3 and Nb_2O_5 by solid state reaction in air by subsequent calcination of the mixtures of initial oxides at 1273 K for 6 h and at 1673 K for 3 h and 5 h, with intermediate regrinding of the powders. In the case of lanthanum-gadolinium niobate system such procedure led to formation of multiphase products. Phase pure $La_{1-x}Gd_xNbO_4$ materials with x=0.2 and 0.8 were obtained by a reaction of corresponding oxides in Li_2SO_4 flux at 1473 K. Phase and structural characterization of the synthesized materials was performed by using Aeris X-ray powder diffractometer (Malvern Panalytical) equipped with $PIXcel^{1D}$ strip detector. Crystal structure parameters were derived from experimental XRD patterns by full profile Rietveld refinement. In the refinement procedure, unit cell dimensions, positional and displacement parameters of atoms were refined together with profile parameters and corrections for absorption and instrumental sample shift. Rietveld technique was also used for the evaluation of average crystallite sizes and microstrain values from an analysis of angular dependence of Bragg's peaks profile. Thermal behaviour of the materials synthesized in the temperature range of 288–1773 K was monitored by DTA/TG/DTG method.

Obtained structural parameters of the mixed lanthanum-yttrium and lanthanum-gadolinium niobates agree very well with the References data for the end members of the systems – nominally pure $LaNbO_4$, $YNbO_4$ and $GdNbO_4$ compounds, thus proving formation of continuous solid solutions with monoclinic fergusonite structure in both systems. It was found that the lattice parameters and unit cell volumes of $La_{1-x}Y_xNbO_4$ and $La_{1-x}Gd_xNbO_4$ structures decrease almost linearly with increasing La content in corresponding series. Experimental XRD data and structural parameters of new mixed niobates are accepted by International Centre for Diffraction Data (ICDD) to be included as standard References data in PDF-4 database.

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Multilayer laminate manufactured from near-alpha titanium alloy

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Metallic layered materials have received tremendous attention due to their striking characteristics. In particular, from a mechanical point of view, multilayer laminates are able to reach outstanding result of strength and toughness simultaneously [1, 2]. It is known that internal interfaces play an important role in the mechanical behavior of these materials [1-4]. The authors of [3] analyzed the effect of interfacial pores on the impact fracture characteristics of a multilayer laminate based on α+β titanium alloy. The present paper is devoted to the study of the mechanical behavior of layered material based on near-alpha titanium alloy under impact loading.

The initial material was the Ti-6Al-2Zr-1.2Mo-1.3V commercial sheet with the thicknesses of ~0.8 mm. This material was characterized by pronounced structural heterogeneity. The sheets were manufactured by the VSMPO-AVISMA corporation, Verkhnyaya Salda, Russia.

For comparative studies, two types of laminates were manufactured. They consisted of thirteen sheets, which were stacked relative to each other so that: in one case, the rolling direction (RD) coincided in them (laminate of type 1) and in the other, it did not match (laminate of type 2), the angle between the RD in the neighboring sheets was 0 and 90 degrees, respectively. The laminates were manufactured by diffusion bonding in a vacuum furnace under argon pressure using a flexible membrane [5].

The samples with dimensions of 10×10×55 mm3 and with a 2 mm deep U-notch were used in the impact tests. These samples were tested in the crack divider (the crack propagates simultaneously through all the layers) and crack arrested (the crack propagates sequentially from one layer to another) orientations [2]. The samples were cut from the laminates in the rolling direction and transverse direction.

The impact tests were carried out according to ASTM E23 standard on an Instron CEAST 9350 testing machine with recording dynamic loading diagrams at room temperature.

Microstructural and fractography analyses were carried out using a TESCAN MIRA3 LMU scanning electron microscope equipped with backscattered electron imaging setup.

The results of metallographic studies showed that the microstructure of the material after diffusion bonding is predominantly homogeneous with equiaxed α-grains [5]. The interfacial pores in the solid-state joints is not observed on the BSE images. Moreover, the interfaces between the layers are not distinguishable.

The results of impact tests showed that the laminate of type 2 (the angle between the RD in the neighboring sheets equal to 90 degrees) is characterized by isotropic properties as compared with laminate of type 1 (the angle between the RD in the neighboring sheets equal to 0 degrees). These results also indicate a significant effect of layer orientation relative to the direction of load action on the mechanical behavior of the laminates. In this paper, the features of the mechanical behavior of the manufactured laminates are considered in detail, taking into account the results of a quantitative assessment of the impact fracture characteristics (the total energy of fracture, the energy of crack initiation, the energy of crack propagation), as well as fractographic studies.

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Debris fretting testing in PWR conditions

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The ongoing attempts to limit or eliminate fuel failures are economically rightful and mainly tend toward the safe and reliable operation of the power units. The fuel pin failures due to debris fretting are still prevalent, despite vast actions that have been taken to solve this problem – e.g. anti-debris filters' implementation. The debris fretting resistance of the cladding materials is a composed phenomenon to be studied, mainly due to its random character. The Research Centre Rez (CVR) has developed its own methodology to simulate the debris fretting to be able to compare various potential cladding materials in the Accident Tolerant Fuel (ATF) R&D actions. Although the method is based on the simplification of the debris fretting phenomenon, the so-far-obtained results reveal consistency and repeatability of the tests. This allows for building up the basic ground for a database where the samples can be compared according to the tests' parameters. This work shows the process of the debris fretting method verification and qualification due to the results' repeatability (on dummy aluminum samples) and consistency to the set-up and environment (dry, wet & increased temperature, and LWR conditions) changes respectively. The most important result from the qualification tests is the consistency in the obtained groves' depths – the discrepancy is less than 10 μm when the total depth of more than 100 μm is considered. Furthermore, the work summarizes the first tests on real cladding samples in each possible condition: dry & RT, wet & elevated temperature, and LWR autoclave environment. Samples used for those tests were selected as Zr-1%Nb as the References, Zr-1%Nb coated with TiN, CrN, and CrN-Cr composite. Next step within the R&D actions at the CVR is to work on samples that are closest to technological deployment as ATF fuel cladding material such as SiC/SiC, FeCrAl alloy, CrNi alloy as well as cladding with Cr coating. The scope includes tests on non-active samples from RT up to as-real conditions as well as on irradiated samples. In this way, the effort will be to create equipment for working on irradiated samples at hot cell facility, where the samples will come from irradiation program LVR-15 research reactor.

Radiation sensitivity of chalcogenide glasses thin films prepared by spin coating

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Chalcogenide glasses (CHGs) and their thin films are semiconducting optical materials that possess unique properties such as wide IR transparency window, high refractive index and high optical nonlinearity [1]. In addition to these properties, they also possess sensitivity to exposure to various types of radiation. Sensitivity to either UV light or electron beam allows their micro and nanostructuring either directly by exposure or consequently by wet/dry etching.

In this contribution, we present the results of the radiation (VIS, UV, e-beam) sensitivity studies of thin films of CHGs prepared by the spin coating method. As one of the solution-based deposition techniques, this method offers an alternative way for the preparation of thin films with different properties and allows to overcome several specific problems of vacuum deposition techniques such as cost efficiency, maintaining targeted composition and tunable photo- or e-beam sensitivity [2]. It is shown that chemical processes occurring during the chalcogenide glass dissolution and thin films deposition by spin coating determine their structure and consequently their optical and chemical properties. UV light and/or electron beam exposure results in structural changes and consequent changes in their chemical stability. Both positive and negative types of selective etching can be achieved even in thin films of the same composition depending on the conditions of their pretreatment.

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Sensitized polyvinyl alcohol structures under the mechanical and vacuum UV treatment

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The optical properties of thin film iodine-polyvinyl alcohol sensitized with graphene oxide polarizers such as transmittance and polarizing efficiency have been demonstrated in the present works. The surface AFM (atomic force microscopy) investigation results of pristine polyvinyl alcohol (PVA) film and PVA sensitized with shungite after UV-radiation with wave length 126 and 173 nm have been shown as well.

The PVA is a widely known material for optics, medicine, food technology etc. Also there is an investigation of PVA as a potential shielding material against gamma ray [1]. The spectral, strength and hydrophobic properties of PVA sensitized with carbon nanoparticles mixture and carbon nanotubes were investigated in our previous work [2, 3].

The present work demonstrates the graphene oxide influence on iodine-polyvinyl alcohol polarizers leads to increase of parallel light component transmittance at 5-10 % (70-75%) and the polarization efficiency has been varied from 95% to 99% in 450-800 nm spectral range.

The surfaces of the thin films of PVA sensitized with shungite (a natural material consists from carbon and Si oxide) have been investigated before and after UV-radiation. The AFM calculated average roughness has been decreased to 6 times for PVA+shungite sample after radiation at 126 and 173 nm.

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Shungite influence on the ITO-coatings basic features: mechanical, spectral, wetting parameters change

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It is well known that conductive indium-tin oxide (ITO) coatings are the key element of the different optoelectronic devices and schemes. Thus, to extend the methods and instruments in order to modify the ITO characteristics using complex optoelectronic and radiation tasks, are very important and actual.

In the present work the properties of the ITO coating structured with the shungite nanoparticles were demonstrated. One of the possible ways to improve the properties of the transparent conductive coatings is their structuring with nano-particles (NPs), such as fullerenes, carbon nanotubes and shungite. Recently it was shown that the nanotechnology approach connected with the laser technique have some advantages in searching for the natural materials that can replace the artificial ones by including some nanoparticles [1]. Among them the shungite nanoparticles are unique due to their non-toxic parameters, the ability to be easily accepted from the earth's surface and good refractive characteristics [2,3].

The purpose of the current work is to study the optical and mechanical properties of ITO coatings, structured with shungite: to measure transmission spectra in visible and IR ranges, microhardness and wetting parameters of the surface. To modify the ITO surface with the shungite NPs the laser scheme was used connected with the vacuum chamber and an additional network with the field of 100 V/cm2 and 600 V/cm2. The transmission spectrum of ITO with shungite has a shift relative to the spectrum of pure ITO by 40 nm towards the IR range, in the IR range there is also a change of the spectrum. The values of microhardness parameters are higher for a sample with shungite (more than 80 MPa) than for pure ITO sample (up to 55 MPa). According to studies of wetting parameters samples with shungite demonstrate more hydrophilic behavior than samples with pure ITO. The data obtained were compared with that established for the ITO structured with the carbon nanotubes (CNTs).

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Plasmonic nanoaggregate arrays for fluorescence intensity improvement

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Sensors with high sensitivity with the ability to identify low concentrations of analytes in a variety of matrices (such as air, water, blood, food, etc.) are crucial in fields like medicine, drug detection, food analysis, and environmental protection. Optical sensors are one of the most suitable option due to their ability to identify an analyte in the surrounding environment using a variety of techniques, including surface-enhanced Raman scattering, fluorescence (FL), refractive index shift, or interferometry [1,2]. For instance, for rapid diagnosis and personalized medicine, but also environment monitoring, FL-based biosensors are the main focus due to properties like reliability, speed, and affordability [3].

An essential method to increase the sensibility and selectivity of optical sensors is to develop sensitive areas based on metasurface structures. Metasurfaces are a subtype of metamaterials consisting of metallic or dielectric meta-atoms (nano-antennas) in planar or multilayer configurations with sub-wavelength thicknesses and, in the FL-biosensors, can be used for increasing the fluorescence emission intensity. In the case of plasmonic metasurfaces, the metallic meta-atoms exhibit resonances that, by exciting localized surface plasmons, can concentrate the electromagnetic fields in small volumes, well below the diffraction limit [4]. These metamaterials exhibit advantages such as low weight, simplicity of manufacture and the ability to control wave propagation both at the interface and in free space.

In this paper, we suggest a low-cost metasurface platform based on metallic aggregates with random distributions for fluorescence enhancement that can match the outcomes of artificially designed structures. We examined the fluorescence emission of three fluorophores with low quantum efficiencies (Nile red, Rose Bengal and Crystal violet) dispersed in polymethylmethacrylate (PMMA) and coated on top of the metallic nanoparticles arrays. In this study, silicon and glass were used as substrates, and gold (Au), aluminum (Al), and silver (Ag) were the analyzed metals. The nanoaggregates were manufactured by e-beam evaporation of either discontinued layers (very thin- 2–4 nm-thick mass equivalent) or thin continuous layers annealed at specific conditions to percolate [3].

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BOOK OF ABSTRACTS rad-conference.com

Radiation-resistant high-entropy boride (TiZrNbHfTa)B_2 coatings: Experiment and theory

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Transition metal diborides are technologically important materials due to their high hardness, chemical inertness, high radiation-, wear- and corrosion-resistance. High entropy diborides (HED) are composed of five or more principal elements with nearly equiatomic concentrations. They possess many excellent properties that exceed those of the constituent diborides owing to high entropy, sluggish diffusion and severe lattice distortion. Up to data, there are a number of studies of bulk HED materials, whereas, the investigations of the high entropy diboride coatings are in an infant stage.

In this study, the (TiZrNbHfTa)B_2 coatings (in further, HED coatings) were prepared under effect of substrate bias (U_{bias}= 0, -50, -100, -150, -200 V) by dc magnetron sputtering of the target manufactured of TiB_2, ZrB_2, HfB_2, NbB_2, and TaB_2 powders. The structure, chemical bonding, Knoop hardness, and friction coefficient are studied by XRD, XPS, indentation and tribological tests. A comparative first-principles investigation was performed to interpret the properties of the deposited films.

The nanocrystalline phase of solid solution of constituting diborides was revealed in the films structure. Grain size calculated by Scherrer formula increased from 9.5 nm to 40 nm when increasing bias voltage from 0 to –200 V. The composition of the deposited films corresponds to formula $MeB_{1.96}O_{0.04}$, i. e. the films are boron depleted. The films contain an admixture of oxygen. We suppose that oxygen atoms are distributed in grains boundaries and may occupy some of boron vacancies in the (TiZrNbHfTa)B_2 matrix. The Knoop hardness (HK) of the HED coatings depends on U_{bias} extremely: it reached a maximum value of 38 GPa for the coatings deposited at -150 V. The observed dependence of HK on substrate bias can be the result of competitive action of the mechanisms that govern hardness behavior, namely: nanocrystalline structure of films (Hall-Petch effect), creating compressive stress under ion bombardment of growing film, and increase in crystalline size after definite value which promotes initiation and growth of dislocations in large grains. Obviously, there is an optimum bias voltage value at which the film hardness is maximal at about 38 GPa. The film deposited with U_{bias}= -200 V exhibited the least value of friction coefficient (0.49). This fact agrees with radical decrease in films hardness deposited under this condition.

A first-principles study of the stability and mechanical properties of the random high entropy diborides (TiZrHfNbTa)B_2, and the constituting binary diborides showed that the estimated value of the formation energy of boron vacancies in TaB_2 is the lowest among all the binary diborides. As a result, the boron vacancies are supposed to surround preferably Ta atoms in the deposited films thus causing the low-energy shift of the XPS Ta 4f spectrum of the coatings as compared to the corresponding spectrum of TaB_2. The calculated mechanical characteristics of (TiZrHfNbTa)B_2 are medium between largest and lowest those of the constituent diborides, approximately obey the rule of mixture. This allows one to suppose that an increase of the Knoop hardness of the HED coatings relatively a mean value of HKs of constituent diborides occurs mainly due to a structural factor.

All-optical spatial phase modulation in dye-doped DNA films

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The DNA-based materials have an important role in organic photonics and organic opto-electronics. The DNA is biodegradable and can be extracted by modern technologies from renewable resources, in particular from the waste of food processing industry. While the pure DNA is soluble in water only, by adding the cetyltrimethylammonium chloride (CTMA) surfactant, the resulting complex DNA-CTMA becomes insoluble in water but soluble in organic solvents, such alcohols. DNA-CTMA represents a good matrix for photosensitive chromophores. The CTMA surfactant does not alter the large DNA transparency in visible and NIR spectral domains.

We report our recent results obtained in an experimental study of all-optical spatial light modulation in films of DNA-CTMA functionalized with Disperse Orange 3 (DO3) chromophore. In the all-optical spatial light modulation, the optical phase of a probe laser beam that passes through a nonlinear optical material is modified by a pump laser beam, which temporarily changes the refractive index of the nonlinear optical material according to its intensity spatial distribution. The spatial light modulation is investigated using a pump-probe interferometric method introduced by us. The change of the optical phase of the probe beam induced by the pump beam and its dependence on the pump beam intensity are determined by processing interferometric fringe patterns using a method for the Direct Spatial Reconstruction of the Optical Phase (DSROP), implemented by us.

These results are important for applications of light-induced phase modulation in nonlinear photonics.

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Cathodic arc deposition and characterization of tungsten-based nitride coatings with effective protection

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Common structural materials in the aerospace industry (titanium, aluminum alloys, stainless steels and Inconel) are prone to galling, which can lead to adverse surface effects in contact areas. The related phenomenon of fretting wear can cause underperformance or even failure of critical components. This aim, the priority task is to develop functional coatings for effective protection against fretting, galling and other aircraft-specific mechanical surface damages.

When looking at the raw materials as the constituents of the coatings, 39 raw materials are identified as most necessary for the main industries. Of these 39 raw materials, 22 are critical for the EU economy based on the latest 2020 assessment. Based on the critical rating and their use in the aerospace application (aeronautics, naval, land, space, missile), Tungsten and Titanium are the most used.

As one important member of metal nitrides, tungsten nitrides (W_xN) have many promising properties, including good chemical stability, high strength, high hardness and high melting point with good electrical conductivity. These unique properties make (W_xN) and tungsten-containing nitrides have wide applications in the following aspects: effective barriers in microelectronic circuits, wear-resistant coatings, contamination-resistant coatings, material for fusion applications, etc.

Tungsten nitrides, however, are intrinsically difficult to prepare, primarily because the incorporation of nitrogen into the tungsten lattice is thermodynamically unfavorable at atmospheric pressure. As a result, most materials in the W–N system are produced as thin films with poor crystallinity, and for the majority of known nitrides the crystal structures are either not determined or remain a controversy.

According to the literature review, there are rare investigations of tungsten nitride multilayer systems combined with different transition metal nitrides. Tsai et al. [1] reported on the magnetron sputtered CrN/WN thin films with ceramic/ceramic structure that result in improved hardness from 28.6 and 30.5 GPa. Wang et al. [2] reported on ZrN/WN coatings with a higher hardness of about 34 GPa due to the formation of a low energy interface between fcc-ZrN and bcc-W_2N layers. However, even a small number of articles proving that WN-based materials are promising candidates for tribological applications. WN transfers to WO_3 in the air at 600 °C, which has been reported as a good solid lubricant. Therefore, the WN-based coatings should be able to demonstrate higher specific strength (strength/density), durability and damage tolerance.

The purpose of our investigation is to expand the available data on the structure and properties of WN-based coatings and approve them as new reserve materials for the aerospace industry. For this purpose, the new and most suitable we think are WN, TiN/WN, and (TiSi)N/WN systems. Among the advantages that influence our choice were: the exceptional characteristics of the WN, TiN, and (TiSi)N structures in terms of the criteria proposed by Pugh and Pettifor; the significant differences between the elastic characteristics of WN, TiN, and (TiSi)N; the possibility of varying the lattice parameter of WN through the concentration of vacancies. Within this abstract, we report on the formation of WN and WN/TiN and WN/(TiSi)N coatings by the cathodic arc deposition (CAD); investigation of the effect of the structural-phase state on critically important mechanical and tribological parameters (hardness, Young modulus, resistance to elastic deformation, friction coefficient, wear rate).

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Structural features and practical application of films of transition metal carbidonitrides

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Coatings and films made of nitrides and carbides based on the transition and refractory metals are widely in demand in various industries through their high-performance characteristics, such as hardness, wear, corrosion resistance, etc. [1, 2].

Therefore, both the preparation of such coatings and the study of microstructure, elemental composition, and properties are urgent tasks.

An analysis of works on this topic showed that as a result of a change in the deposition conditions, a texture is formed and a columnar structure of films is observed. At the same time, films of transition metal nitrides (TiN, HfN, etc.) with compositions close to stoichiometric had a plane growth texture of (111), while the hardness increased to 40.86 GPa compared to single-component TiN and ZrN. The corresponding trend is preserved for high-entropy multicomponent coatings (TiHfZrVNb)N, in which the (111) texture is formed and their physical and mechanical characteristics are improved depending on deposition conditions [1-3].

One of the methods to improve the durability of the cutting tool is to apply the coatings onto its working surface. Currently, the most popular are multi-layer protective coatings based on nitride, carbide and titanium carbonitride, such as TiN, TiC, TiCN and TiAlN, as well as Al2O3, which has the unique power of lowering the thermal conductivity with temperature advances.

In addition to the fact that coatings improve the physical and mechanical properties of the surface of the cutting tool, they also affect the temperature distribution in the tool during cutting.

Currently, a new class of two-dimensional materials consisting of carbides, nitrides or carbonitrides of transition metals with unique properties has appeared. These are MXenes. Their active research led to the rapid formation of new systems of carbides/nitrides/carbonitrides based on transition metals with different chemical compositions, structures and specific physical-chemical and biological properties such as hydrophilicity, high thermal and electrical conductivity, chemical stability, high level of light absorption in the near infrared spectrum, low cytotoxicity, high biocompatibility, and even some selectivity for cancer cells. Therefore, MXenes have attracted increasing interest in various fields, like energy storage and conversion, environmental remediation, catalysis, and biomedicine [5].

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Organic-inorganic nanocomposites for biomedical applications

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Polyurethane (PU) and PU nanocomposites with good biocompatibility and mechanical properties can be used as the biomedical matrix and tissue engineering biomaterials. Magnetic nanoparticles, especially ferrite nanoparticles have attracted much interest due to their specific physicochemical properties in various areas including magnetic recording, biosensing, catalyst, drug delivery systems, magnetic resonance imaging (MRI) and cancer therapy. Despite all these advantages, the nanoparticle agglomeration reduces the efficiency of the nanoparticles, so the nanoparticle incorporation into an appropriate polymeric matrix to prepare organic-inorganic nanocomposites is a right direction in the current scenario of biomedical nanotechnology. In this study, organic-inorganic PU nanocomposites based on zinc and copper ferrites and with the same composition of PU were prepared. The properties of PU nanocomposites were evaluated by nanoindentation, water contact angle and water absorption measurements. The presence of the nanoferrite nanoparticles affects properties of PU nanocomposites such as bulk morphology, mechanical, and biological properties. The biocompatibility of PU nanocomposites was investigated by MTT assay and cell attachment using endothelial cells. According to the results, the prepared PU nanocomposites with noncytotoxic chemistry could be a potential choice for vascular implants development.

Preparation of MXene reinforced polymer nanocomposites

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Poly(dimethylsiloxane)-based polyurethanes (PU) have excellent mechanical properties and good biocompatibility, making them an attractive option for use as electronic device components or implant materials. The idea of preparing nanocomposites with a polymer matrix is to modify their properties in order to produce a new material suitable for specific applications. MXenes are promising fillers for various nanocomposites due to their specific properties, such as metallic conductivity, high specific surface area, and mechanical strength. In this study, the in-situ polymerization method was used to prepare PU/MXene nanocomposites with a soft segment content of 50 wt.% and a nanoparticle content of 1 wt.% in the PU matrix for all prepared nanocomposites. The synthesis parameters, such as the MXene nanoparticle preparation procedure and the moment of MXene addition to the reaction mixture, were varied. The atomic force microscopy (AFM), X-ray diffraction (XRD), and differential scanning calorimetry (DSC) techniques were used to investigate the structural, surface, and thermal properties of the polymer nanocomposites. The AFM images showed that the roughness coefficient increased with the addition of MXenes to the PU matrix compared to pure PU. From the XRD spectra, it can be concluded that only the first series contained MXenes, as indicated by the characteristic MXene peak present only in that sample, suggesting marked inhomogeneity in the other series. The glass transition temperature of the hard segment increased with the addition of nanoparticles. Varying the preparation of the MXene dispersion and the moment of addition to the reaction can affect the surface morphology and homogeneity of the material, which can be crucial for various electronic applications.

The investigations of mechanical stability of highly transparent UVC-blocking ZnO-SnO$_2$/PMMA nanocomposite coatings

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The thinning of the ozone layer has led to an increase in the amount of UV radiation reaching the Earth's surface in the last decades. The harmful effects of UV radiation on humans and the environment are numerous, while UVC irradiation in the range of 100-290 nm has the most harmful effect on health. Therefore, developing UV shielding materials is an important step in protecting ourselves and the environment from the harmful effects of UV radiation. Here we present a detailed study of ZnO-SnO2/PMMA nanocomposite coatings, which completely block UVC radiation. Additionally, we study the effect of the addition of ZnO-SnO2 nanoparticles on mechanical properties in the means of Vickers microhardness and find out that they positively affect the microhardness of the PMMA coatings up to a certain concentration. Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) reveal the quite homogeneous distribution of nanoparticles for lower concentrations and the presence of nanoparticle aggregates for higher concentrations such as 1 wt.% and 5 wt.% of ZnO-SnO2 nanoparticles.

IR and micro-Raman study of the inorganic and organic painting materials used in the murals of Orlitsa convent, Rila monastery

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Orlitsa convent is one of the oldest convents of Rila monastery - it was first mentioned in a document issued by tsar Ivan Shishman in 1378. During the Bulgarian National Revival (XVIII-XIX century) it was one of the numerous convents constituting the large convents' network of Rila monastery and provided a shelter for the pilgrims traveling to the Rila Monastery.

The small single-nave church St Apostles Peter and Pavel of the convent was built in 1469. In the succeeding period until 1491 the church was decorated by wall paintings, and later on – redecorated by Nikola Obrazopisov from the Samokov school of icon-painting in 1863. The original XV century wall paintings are preserved in the altar and above the door in the naos. The prominent composition depicting "The return of the relics of St. John of Rila the Wonder-Worker", painted by Nikola Obrazopisov, embellishes the narthex (entrance part) of the church.

Within our ongoing study concerning the mural painting materials and technology used in different churches of Rila monastery, we have investigated the organic and inorganic painting materials used for the wall painting decoration from both periods – XV and XIX century by infrared and micro-Raman spectroscopy. It was found that the XV century wall paintings are executed by egg tempera technique on wet plaster evidenced by the simultaneous presence of egg binder and large amount of calcium carbonate in the painting layer. The pigments identified in the XV century wall paintings encompass red lead, cinnabar, red and yellow ochre, green earths and ultramarine. The XV century wall paintings showed the presence of oil binder, earth pigments of red, yellow and brown color, ultramarine and calcium carbonate. The attenuated total reflectance (ATR) infrared spectra allowed the identification of beeswax mixed with calcium carbonate and gypsum applied as filler material in the XV century wall painting decoration. The ATR-IR spectra revealed also the presence of metal oxalates in several microsamples from the painting layers, indicative of binder degradation processes.

The information provided by the study allows reconstruction of the color palette of the painters from the different periods and contributes to the assessment of the wall paintings preservation state and the necessary treatment.

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Keywords: Rila monatery, mural paintings, pigments, binders, degradation

Saint George the Zograf Monastery, Mount Athos: pigments, binders and other organic materials identification

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Herein we report a detailed study on the wall painting materials and technologies used in the Saint George the Zograf Monastery (Zograf Monastery) - one of the Eastern Orthodox monasteries in Mount Athos (the "Holy Mountain") in Greece, founded in the IX-X century, inhibited by Bulgarian Orthodox monks. The study was focused on the identification of the inorganic pigments and organic binders, adhesives, varnishes and other painting materials used for the wall painting decoration.

The "Holy Transfiguration" chapel is located in the eastern part of the "St. Vmchk. George - Zograf". As an architectural building, the chapel is one of the oldest. The frescoes are from the 18th and 19th centuries. The preserved dating above the entrance - 1869 - is from a painting period with clear corrections and overpaintings. It is written on an older layer with a monochrome color and thus forms the so-called "optimal date" of the object.

The painting materials were characterized by analyzing a set of microsamples from the painting layers of different color by spectroscopic techniques – infrared and micro-Raman methods, complemented with microextraction, spectral analysis and thin layer chromatography of the organic substances. The infrared spectroscopy enabled the identification of egg and oil binders, protein adhesive materialsas well as metal carboxylates detected in several microsamples as oil binder transformation products. The combined data from the infrared and micro-Raman analysis showed that the polychromy was created by natural earth pigments of varying colors, lime white, lead white, carbon black pigment, blue ultramarine pigment, red cinnabar, and red lead. The painting materials and techniques revealed by the study are valuable contribution to the characterization of the painting traditions in Mount Athos during in XVIII-XIX century and enable more detailed comparison to the wall paintings created in the Bulgarian orthodox churches in the same and succeeding periods

Acknowledgements: This work has been financially supported by the National Science Fund of Bulgaria, Contract КП-06ОПР 05/5. Equipment of INFRAMAT (Research Infrastructure from National roadmap of Bulgaria), supported by Bulgarian Ministry of Education and Science is used in the investigations.

Keywords: Saint George the Zograf Monastery, wall paintings, pigments, binders, painting technique

New batteries, environmentally friendly, based on nanotubes - an inspiration for the energy industry

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An important part of energy planning and management is a rational policy based on saving. The main problems of the modern world include the growing demand for energy and, at the same time, ever deeper environmental restrictions. Although there are many sustainable sources of energy available, more efficient ways of its production, processing, storage and use are still being sought. The most commonly used energy storage systems include batteries and capacitors. The subject of the research was the development of a technology for the production of environmentally friendly batteries based on modified carbon nanotubes, which, due to increased electrical conductivity and increased surface area, can replace the commercially used graphite in anodes, thereby improving the battery capacity (Pat. 240569). Innovative batteries are safer (no risk of explosion under mechanical loads and as a result of operation at high temperatures), and their charging time is several times shorter than that of lithium-polymer and lithium-ion batteries. The designed product - a cost-effective battery - can be implemented e.g., for markets of mobile devices, wearables, specialty electronics, premium laptops.

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Possibilities of modern CZT SPECT-CT gamma cameras in NET diagnostics

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Current commercialy used gamma cameras with CZT detectors, compared with standard (with NaI:Tl detectors) have almost two times better energy resolution, 1.2-1.8 times better sensitivity, allow reproducible semi-quantification of nuclear medicine studies, they are far more compact and not hydroscopic. Considering imaging of neuroendocrine tumors (NET), improved spatial resolution brings more accurate (T)NM staging of the disease and earlier detection of tumor rest/recurence, and improved sensitivity leads to shorter acquisition time and more accurate semi-quantification of the biological activity of treated NET lesions during the follow-up. Implementation of newly upgraded CZT state-of-the-art technology will bring more, in both aspects.

Artificial Intelligence for radiographers: reviewing current applications, providing future vision and setting up e-learnings

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Purpose: Artificial Intelligence (AI) has changed radiology substantially in the last years, where the focus of attention has mainly been on the radiologist profession. However, the radiographer's role has been largely ignored even though AI is also affecting for example workflow management, treatment planning and image reconstruction. Radiographers are not prepared for the changes in their profession that will come with the introduction of AI into everyday work.

Materials and Method: Firstly, a survey was conducted among Dutch radiographers to investigate what role AI currently plays in their everyday work and what needs with respect to education and training currently exist. Secondly, a project was developed and funded consisting of three main steps, leading to online AI education (e-learnings) tailored to the needs of radiographers. The steps in this project consist of a systematic review of AI applications in radiography, focus groups with AI experts, writing a vision document on the future role of AI in radiography, and setting up e-learnings to train current and future radiographers in AI.

Results: From the survey we learned that 90% of the radiographers is familiar with the concept of AI, and 70% already encounters some form of AI in their day-to-day work. In most cases this concerns image reconstruction (40%), image recognition (35%) and image fusion (33%), but also quite often postprocessing and automatic delineation (both 29%) and dose optimization (28%).

For the systematic review a total of 70 articles were found, ranging from review, prospective, retrospective to survey articles in search engines like PubMed, Scopus and Google Scholar. Results show a wide variety of applications of AI that (will) influence the work of radiographers, ranging from changes in everyday workflow, like patient checks, planning of examinations, acquisition of images and post-processing activities, to changes in work flexibility, like cross-modality employability or performing radiologist tasks, and training, implementing and quality control of AI systems. Knowledge of AI, the basics as well as pitfalls, challenges, ethical and legal complications is prerequisite for radiographers.

The review was used in focus group sessions with AI experts to provide views on the future role of AI in radiography. Together, the members of the research consortium translated these views into a vision document on AI for radiographers. This vision document and the results from previous steps in this study will be used to construct e-learnings for (future) radiographers to provide basic and more advanced knowledge on AI.

Conclusions: A survey among Dutch radiographers shows that they often encounter AI applications in their everyday work. They indicate a need for (preferably online) education to increase their knowledge about AI. A project has been funded to fulfil this wish. The results of this project, namely a systematic review of AI applications in radiography, a vision on the future role of AI in radiography, and preliminary e-learnings for (future) radiographers, will be presented.

Keywords: Artificial intelligence, radiography, education, e-learning

A step closer to a benchtop x-ray diffraction computed tomography (XRDCT) system

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X-ray diffraction (XRD) is a well-established non-destructive technique that utilises x-ray scattering phenomenon to extract atomic or molecular structural information of materials. In a technique similar to transmission x-ray computed tomography (CT), data collected from multiple angular positions can be used to reconstruct a cross-sectional slice or 3D volume that can be used to identify regions with varying atomic of molecular structure within the sample. This data is then used for material characterisation by comparing reconstructed XRD signals with known XRD signatures.

The technique requires knowledge of the energy and angle of the diffracted x-ray relative to the incoming beam. Current techniques fall in to two categories; energy dispersive (EDXRD), where the angle is fixed and energy is measured, and angular dispersive (ADXRD), where the energy is fixed by means of a monochromatic beam and data is collected over a range of angles.

Both techniques use a pencil beam geometry, meaning only a small part of the sample is irradiated at any given time. As a result, scan times can be extremely long. To overcome this, high brilliance, highly monochromatic synchrotron radiation can be used to produce exceptionally detailed XRDCT scans in a relatively short time. However, limited access to synchrotron facilities renders this technique relatively inaccessible and costly.

Attempts at developing lab based techniques using conventional x-ray sources have shown promise but result in very long scan times – over 10 hours for a single 2D slice of diameter 20 mm. We have developed a technique that achieves similar results with a very weak x-ray source, running at 80 W. This is approximately 20 times weaker than x-ray generators used in other lab based XRDCT systems.

Using the current setup, we are able to scan a 2D slice of a sample of diameter 30 mm in 17 hours. This will soon be scaled up to make use of a more powerful lab based x-ray source with the aim of reducing the scan time to less than an hour, an order of magnitude shorter than previous lab based XRDCT techniques.

Our system uses a pixelated, energy dispersive x-ray detector (HEXITEC), allowing for a hybrid angular- and energy-dispersive approach. We have also developed a novel coherent/incoherent deconvolution technique that utilises the additional information collected by this detector, improving material characterisation by increasing the signal-to-noise ratio of partially crystalline materials.

Functional neuroimaging in states of impaired consciousness

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Introduction: Disorders of consciousness are a continuum of pathologies, including coma, the minimally conscious state, and the vegetative state, in which the level of consciousness is severely impaired. The vegetative state (VS) is particularly important due to its bioethical implications, since in cases where the alleged incapacity for conscious activity can be legally considered equivalent to the state of cessation of functional activities that characterize human life, the problem of the continuation or the suspension of therapies arises. A deep understanding of the real conditions of patients in these states is therefore of paramount importance.

Brain activity and consciousness: As to our present knowledge, the presence of cerebral activity is a necessary condition for being able to assess consciousness; on the other hand brain activity does not necessarily imply the existence of consciousness “There may be a functionally active brain without consciousness, but there is no consciousness without a functionally active brain." [1] Evaluation at the bedside can only give a qualitative assessment. Differently, neuroimaging techniques can help determining whether, in the absence of conscious responses from the patient at the bedside, there is or is not brain activity that can be considered voluntary.

Functional imaging as a method to determine conscious brain activity: The most widely used imaging techniques for the investigation of brain function are Functional Magnetic Resonance [2] (fMRI) and Positron Emission Tomography [3] (PET). By means of fMRI it has been measured [4] that in PVS patients global brain metabolism is severely reduced. Furthermore, even if in such patients an auditory stimulation at a disturbing level showed partial cerebral activation in the primary somatosensory cortex, the higher-order associative cortices that were expected to activate contemporaneously were functionally disconnected and showed no activation in any patient. A similar result has been obtained by means of H215O-PET tomography. [5] These findings suggests in the VS the residual cortical activation is unable to lead to the integrative processes that is thought can lead to a normal level of awareness. A PET study on a 16yo patient in VS measured the activation in the emotion processing brain areas differ whether an auditory stimulation consisted of a speech from his mother or sound without words. [6] One patient was studied with fMRI, and although diagnosed with VS at the bedside, showed conscious brain activity when asked to imagine a physical activity or to stimulate memory. The obtained results were completely superimposable to those expected from patients in a conscious state. Using the same method, 54 patients were examined, some in VS and some in MCS. In 10% of the cases, the patients' ability to perform the required task was demonstrated and in two patients the diagnosis was revised. [7]

Conclusions: Although this application of neuroimaging techniques is only in its infancy, it has been shown that they can provide information of enormous impact in many cases of disorders of consciousness, and in some cases they make it possible to correct incorrect diagnoses made at the bedside. Furthermore, in a few sporadic cases it has been possible to establish a limited communication with such patients.

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The breast cancer architecture and extracellular vesicles investigated by FIB/SEM

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Background: Breast cancer (BC) is now the most commonly diagnosed cancer and is the leading cause of cancer death in women worldwide (1). Malignant breast tumors are high invasive with high metastasis and recurrence rate. Imaging, where the gold-standard method is mammography, cannot be used alone to diagnose BC; currently, histopathologic analysis of the patient's tissue is necessarily for a definitive diagnosis. The most abundant of different cell types surrounding the breast tumor are those that form the breast adipose tissue. Tumor cells are capable of modifying the adipocyte phenotype to a malignant phenotype that mediates crosstalk between adipocytes and BC cells, which in turn promotes aggressive tumor behavior and local invasion by remodeling the extracellular matrix (ECM). The aberrant adipose tissue has been confirmed as a BC hallmark (2 - 4). One of the novel diagnostic tools for cancer are also extracellular vesicles (EV) which are used for intercellular signaling and information exchange, regulating tumor progression by promoting tumor invasion, extracellular matrix remodeling, angiogenesis, and immunosuppression (5). Aim of our work was to test the potential of scanning electron microscopy coupled with Focused Ion Beam (SEM/FIB) to study breast cancer tissue architecture and visualize possible presence of EV. Methods: The patients tumor tissue was surgically removed and the tumor and surrounding tissue together were obtained by a core biopsy. The tissue was immediately chemically fixed in modified Karnovsky fixative (4% paraformaldehyde, 2.5% glutaraldehyde in 0.1M sodium cacodylate buffer), post-fixed in 1% osmium tetroxide and prepared for inspection (SEM, JEOL JSM-6500F, Tokyo, Japan and ZEISS CrossBeam 550 dual beam FIB/SEM, Oberkochen, Germany). Permission for this study was received from the Commission for Medical Ethics of University Medical Center of Maribor. Results: We demonstrated that the peritumoral adipose tissue is characterized by large adipocytes up to 150 μm in diameter in a loose fiber network, whereas the invasive front of the tumor is characterized by less abundant and smaller adipocytes that have an adipocyte-like, rounded morphology and a denser fiber network. The tumor stroma is characterized by overexpression of extracellular fibers. Significant differences were observed in the size distribution and density of matrix vesicles in the tumor stroma, invasive front, and adipose tissue surrounding the tumor. FIB milling reviled the homogenous nature of large vesicles confirming their lipid content. Conclusion: We confirm the findings of molecular studies on the remodeling of adipocytes and ECM of breast tumors by the morphological evidence. SEM/FIB allows inspection of vesicles of different sizes including nanovesicles in solid tumor. As these events contribute to breast cancer progression, we suggest that the morphological markers could be used as an approach to monitor the tumor upon treatment and for early detection.

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Molecular magnetic resonance imaging of prostate cancer using Core/Shell nanoparticles and mice animal model

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After lung cancer, prostate cancer (PC) is the most common and the second leading cause of cancer death (1). Now, the standard for PC diagnosis is prostate-specific antigen testing and digital rectal examination (2). Computed Tomography, Positron Emission Tomography (3) are used for PC diagnosis and staging. They are of limited value because of the low sensitivity and specificity.

To improve the tumor contrast we have developed new core/shell $NaDyF_4/NaGdF_4$ nanoparticles changing both T_1 and T_2 and conjugated them with tumor specific antibodies, PSMA.(5) We also investigated toxicity, biodistribution and clearance of the new contrast agent. The relaxation times of the nanoparticles with various core/shell sizes and concentrations were first measured at 9.4T and 3T. In vivo imaging at 9.4T using a mouse model of cancer was perfomed.

We imaged nude mouse with the tumor before the injection of targeted and non-targeted contrast agent and at different times after injection (10 min after,1h, 2h and 24h).

We measured T_1 and T_2 relaxation times of the whole tumor and small area of muscles. We noticed that after intravenously injection of non –targeted NaDyF4–NaGdF4 NPs the mean pixel intensity at the tumor site with time, gradual darkening at the tumor site is achieved up to 2 h in the T_2-w images while brightening in the T_1-w.(4) The darker contrast (T_2) at the tumor site was seen to be maximum after 24 h of injection. Histology confirmed the results.

NaDyF4–NaGdF4 NPs showed shortening of T_1 and T_2 relaxation times at clinical 3 T and 9.4T. We conlcuded that molecular MRI using targeted CAs can localize small (a few mm size) prostate cancers. T_1-w and T_2-w images using core/shell NPs of a prostate cancer provided enhanced contrast and edges.

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Multiparametric ultrasound diagnosis of nonalcoholic fatty liver disease as a pathological continuum

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Introduction: Nonalcoholic fatty liver disease (NAFLD) affects a third of the population and has become a pandemic. NAFLD has a slowly progressive character over time (pathological continuum) from a simple fatty disease due to nonalcoholic steatohepatitis (NASH) to cirrhosis and its complications (portal hypertension (PH), hepatocellular carcinoma (HCC), liver failure). At all stages of the development of the pathological process, ultrasound diagnostics (US) with modern technologies (elastography, steatometry, viscometry, contrasts and Doppler) plays a leading role in patient management. The presence of NAFLD aggravated the course, complications and mortality of the COVID-19 pandemic - "a pandemic within a pandemic".

Aim: To propose an ultrasound continuum with a clinically justified increase in parameters (multiparametric US, mp-US), which would correspond to the progression of the pathological liver continuum of NAFLD from simple steatosis to cirrhosis.

Materials and methods: 1st group of 7318 people was examined in the period before COVID-19 (2016-2018) of both sexes aged 18-82 years. The 2nd group of 226 people was examined in the period after the COVID-19 pandemic (2022) of both sexes aged 19-75 years. Mp-US of the abdominal organs and, in particular, the liver, was carried out in B-mode, steatosis was staged by of the attenuation coefficient measurement (ACM) in dB/cm, fibrosis was staged by two-dimensional shear wave elastography (2D SWE) in kPa, Doppler of splanchnic blood flow. MP-ultrasound was performed by Soneus P7 device (Ultrasign, Kharkiv, Ukraine).

Results: In the 1st group, B-mode detected steatosis in 1,317 people (18.0%): mild - 302 (4.1%), moderate - 893 (12.2%), severe - 122 (1.7%). According to ACM steatosis was detected in 1819 people (24.8%): mild S1 in 962 (13.1%), medium S2 - 637 (8.7%), severe S3 - 220 (3.0%). In the 2nd group, B-mode detected steatosis in 104 people (46%): mild in 35 (15.5%), moderate in 56 (24.8%), severe in 13 (5.7%). According to the ACM data, steatosis was detected in 114 people (50.4%): mild S1 in 44 (19.5%), medium S2 - 55 (24.3%), severe S3 -15 (6.6%).

In the 1st group, 2D SWE revealed fibrosis in 132 people (1.8% of the total population and 7.2% of people with steatosis by ACM): mild F0 - 104 (respectively, 1.8% and 7.2%), medium F2 – 25 (respectively 0.34% and 1.37%), severe F3 – 2 (respectively 0.03% and 0.1%), cirrhosis F4 - 1 (respectively 0.03% and 0.05 %). Signs of subclinical PH were found only in 15 patients with S2-S3 and 3 patients with F3-F4: extension of the portal vein ≥ 14 mm and/or a decrease in the maximal linear velocity of blood flow < 16 cm/s without porto-systemic shunts (0.25% of the general population and 0.99% of people with steatosis).

In the 2nd group, according to 2D SWE, fibrosis was detected in 10 people (4.4% of the general population and 8.8% of people with steatosis): mild F0 - 5 (1.4% and 7.9%), medium F2 – 3 (respectively 2.2% and 4.3%), severe F3 –1 (respectively 0.44% with and 0.87%), cirrhosis F4 - 1 (respectively 0.44% with and 0.87%). Signs of PH were found in 2 people with steatosis (0.88% of the general population and 1.75% of people with steatosis).

Conclusions:

1. All stages of the progression of the pathological process of NAFLD over time (pathological liver continuum) from simple fatty liver through NASH to cirrhosis and its complications must correspond to the logic of increasing the number of US parameters from B-mode with mandatory steatometry of the population through to estimation of fibrosis when was found steatosis S2-S3 (US diagnostic continuum).
2. The severe fibrosis F3 and cirrhosis F4 (advanced chronic liver disease) prompts the use of doppler to detect PH.
3. The COVID-19 pandemic aggravated and accelerated the progression of NAFLD in the Ukrainian population.

Digital radiography and tomosynthesis in the diagnosis of lung changes with covid-19

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Introduction: During the COVID-19 epidemic, digital chest radiography (DXR) was most often the first imaging method used in patients in Ukraine suspected of having this disease. Digital X-ray helped clinicians to identify lung changes at the first stage of examination and select patients for inpatient treatment. To reduce the load on computed tomography rooms, we used digital tomosynthesis (DT), which plays an important role in the diagnostic process, respectively, in providing care to patients with COVID-19.

The purpose of the work. Determination of the possibilities of digital tomosynthesis in lung pathology in the family of COVID-19.

Materials and methods: 1420 patients with a proven diagnosis of COVID-19 (average age - 38.8±12.6 years) who were examined on an outpatient basis during the period 02.1.2020-02.28.2021 were analyzed. DT was performed in 256 (18%) on a home digital X-ray diagnostic complex with digital tomosynthesis mode after performing DXR.

The results: The distribution of patients by age was: 19-29 years - 5%, 30-79 years - 93%; over 80 years old - 2%. Patients applied on the 3-12th day from the onset of the disease. In 540 (38%) patients, a mild degree of the disease was established; of moderate severity – in 752 (53%); severe – in 128 (9%). At the first examination, a diagnosis of bilateral interstitial pneumonia was established in 1032 (72.7%) widespread, focal or focal-draining pneumonia in 286 (20.1%) patients, no changes were detected - 102 (7.2%) patients with a mild degree of the disease. In all cases referred on the 3rd-5th day, changes in the lungs were detected in 78.6% of cases. The use of DT made it possible to clarify the x-ray picture of the pathology in 68.4% of cases, in 46 (17.6%) patients the x-ray conclusion was changed, during dynamic observation process complications were identified in 20.3. %. The advantage of DT can be considered that it can be performed in the same room as the X-ray picture without moving the patient.

Conclusions: Digital radiography is a highly informative method in the early diagnosis of lung changes in COVID-19. Tomosynthesis can be considered as an alternative to CT at the stage of primary diagnosis, as well as during control of the treatment.

Economic and logistical justification of the use of tomosynthesis in clinical practice

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The purpose of the work: In 2017-2019, 15 domestic digital X-ray systems with tomosynthesis (TS) mode were purchased for medical institutions in Ukraine, the price of which is 1.5 times higher than digital radiography systems. The purpose of the work is to assess the feasibility of additional costs for equipment with tomosynthesis mode from a logistical and economic point of view.

Materials and methods: Based on data on the use of 11 digital X-ray systems with TS mode in the city of Kyiv in 2020-2021, a logistic and economic analysis of the provision of diagnostic assistance to patients is being conducted.

The results: The average purchase price of digital x-ray systems in Kyiv in 2017-2019 was $110,000, digital x-ray systems with tomosynthesis mode were $171,000, i.e. additional costs for the purchase of 11 units of new equipment amounted to $671,000. In 2020-2021, 3 medical institutions (27%) did not use TC for various reasons. 5 medical institutions (46%) used TS often and 3 (27%) - rarely. If necessary, tomosynthesis was performed immediately after radiography, that is, the time spent by the patient on diagnosis did not actually increase. In institutions that actively used TS, the number of referrals for CT and MRI decreased by 20-50%, where it was rarely used - by 5-10%. No more than 10% of patients after TS were referred for CT and MRI. When referred for a CT scan or MRI, the patient additionally spent at least a day on obtaining a diagnosis and starting treatment, and his additional financial costs amounted to at least 100 dollars, excluding transportation costs.

In total, in 2020-2021, more than 80,000 radiography and about 2,500 TS were performed on 11 systems with TS mode. That is, 2,250 patients received a diagnosis on the spot, which allowed them to collectively save at least $225,000 and 2,250 working days, provided that the CT or MRI was performed the next day, which is the ideal option. For other cities and towns of the country, these indicators would be higher due to additional transport costs and less accessibility to CT and MRI.

Conclusion: The obtained results indicate that in no more than 6 years, the additional costs of the TC equipment will be compensated by the saved costs and patient time, even if only half of the installed equipment with TS is used effectively. However, this period of time is really much shorter, due to the fact that the work did not take into account transport costs, as well as the economic effect of accidental diagnosis and treatment of diseases.

The use of tomosynthesis for differential diagnosis of lung diseases

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Introduction: Digital tomosynthesis is a new method of radiodiagnosis, which is currently being implemented in the clinical practice of various health care institutions in Ukraine.

The goal of the work: To show the advantages of digital tomosynthesis for the differential diagnosis of lung diseases.

The purpose of the work is to analyze (or evaluate) the possibility of using tomosynthesis for the differential diagnosis of lung diseases based on the examination of clinical cases.

Material and methods: The work was carried out on the basis of the Vinnytsia Clinical Regional Phthisiopulmonological Center, Vinnytsia. 864 chest X-rays (CXR) were done for patients aged from 18 to 78 years old, 421 of which were chest tomosynthesis. The average age of the patients was 48 years old. 421 patients also underwent tomosynthesis in order to clarify the diagnosis, and 103 patients were sent for computed tomography scan (CT scan). The research was being conducted during the process of treatment. KRDC-02-ALPHA was used for X-ray examinations of the patients. On average, digital tomosynthesis was performed in about 50% of the total number of CXR examinations.

Data from X-ray research and tomosynthesis were retrospectively analyzed, taking into account the verification of their results.

Results: According to the results of the analysis, the diagnosis was confirmed for 340 patients when using digital radiography, while for 421 patients it was changed. 103 patients were sent for CT scan after tomosynthesis. By the time tomosynthesis was available in the medical institution, up to 20% of the patients were sent for CT scan. As of today, this number does not exceed 12%.

The comparison of the effectiveness of radiodiagnosis methods in patients with tuberculosis showed that the tomosynthesis method surpasses traditional radiography in terms of sensibility: the sensibility of tomosynthesis in detecting specific pathological changes in the lungs was 74.9%, which is 17.7% higher rather than in radiography. Digital tomosynthesis cannot fully show all lymph nodes, miliary foci, and interstitial changes with the minimal lesions of the lungs, and CT scan provides the possibility of conducting an examination with intravenous enhancement, which has to be used in case of suspicion of oncological diseases, determining stages of lung cancer.

Conclusions: In general, tomosynthesis does not replace the use of computer tomography, however, in some situations their data are almost completely comparable. In a number of cases, a radiological conclusion was established without further examination, for example CT scan. At the same time, tomosynthesis allows to significantly expand diagnostic possibilities of radiography without substantially increasing the radiation exposure on patients.

Tomosynthesis can be used for differential diagnosis of lung diseases. Its use reduces the number of patients to be sent for CT scans by 8-10% and, therefore, accelerates the start of treatment of the patients, increasing their chances of recovery.

25 years of the x-ray technologies center of association of radiologists of ukraine: from digital screening radiography to tomosynthesis

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The end of the 20th century was marked by fundamental changes in the technique of receiving X-ray images. The 100-year use of X-ray film in radiography and the 30-year use of photodiodes lines in spiral tomographs were replaced by semiconductor matrix systems and computer networks. Such changes made it reasonable for the Association of Radiologists of Ukraine (ARU) to organize the X-ray Technologies Center (XTC). The main task of such Center was to spread knowledge and skills of working with new reception equipment and computer systems. During the first years (2000-2006) more than 2,000 radiographers and radiologists were retrained on new technology.

An equally important task of XTC was the objective expert assessment of the quality of the equipment and the fight against unfair advertising that supports corruption ties. Ukraine has formed its own school of manufacturers of digital X-ray equipment and doctors who use it for diagnosis. During the years of operation of the Center, more than 4,000 digital X-ray receivers were produced, of which about 1,500 were installed in Ukraine and 2,500 in 22 countries of Europe, Asia and America.

The first significant results were obtained in the transfer to digital technology of 800 film fluorographs from a fleet of 1,700 units. More than 7.7 million citizens of Ukraine are examined annually on digital screening X-ray machines. At the same time, to obtain high-quality chest images, the dose load is 10 times less than that of film fluorographs.

Then there was the transfer to digital technology of hundreds of X-ray machines and dozens of mammography machines. Remote diagnosis became possible. The technology has been developed, according to which an experienced radiologist can be available at any place where X-ray examinations are carried out.

The advent of digital X-ray receivers allowed to look at tomography in a new way. Digital linear tomography named tomosynthesis became available. The diagnostic sensitivity of this technology is higher than that of radiography, closely approaching tomography. The tomosynthesis mode of gives a significantly lower dose load on the patient compared to spiral tomography. It can be implemented on a remote-controlled table, on a X-ray complex with two work places, as well as on an inexpensive basic x-ray system. More than 25 domestic X-ray machines with the tomosynthesis mode and more than 5 foreign X-ray machines are operating in Ukraine. Together, they make it possible to accumulate diagnostic experience using a new modality.

Digital X-ray receivers have another important feature - high detective quantum efficiency (DQE), which is a few times higher than that of X-ray film. This makes it possible to reduce the negative consequences of X-ray irradiation of living organisms many times over. Radiography, Tomosynthesis and Cone Beam Computer Tomography (CBCT), which use matrix receivers, are becoming green technologies. They are safe, do not create waste and emissions, and have a minimal carbon footprint.

The current task of the X-ray Technologies Center of ARU is the implementation of these green technologies in medical institutions of the 1st level to provide high-quality X-ray diagnostics and effective treatment in the places of primary patient care.

The role of tomosynthesis in the diagnosis of breast pathology

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Purpose: Breast cancer (BC) remains one of the main problems of modern oncology. Numerous studies have shown that early diagnosis leads to an increase in the duration and improvement in the quality-of-life women who have a BC. The main method for diagnosing breast diseases is mammography. The purpose of this study is to evaluate the diagnostic capabilities of Digital Breast Tomosynthesis (DBT) in comparison with Full-Field Digital Mammography (FFDM).

Methods and materials: 265 women were studied using (FFDM) and (DBT). The age of the patients ranged from 35 to 74 years (mean age 46 years). Patients were sent to the FFDM and DBT after a clinical examination.

Results: Benign lesions were detected in 51 patients (19.2%). BC was detected in 48 patients (18.1%). Additional information during DBT was obtained in 14 patients with benign lesions (27.5%) and in 11 patients with malignant tumors (22.9%). This led to a change of category BIRADS in these patients.

Conclusions: The use of DBT contributes to the improvement of differential diagnosis and the quality of diagnosis and contributes to the detection of BC cancer at earlier stages, primarily due to better visualization of the contours of the masses and the detection of matrix deformations that are not detected by FFDM. DBT helps reduce the number of biopsies.

Digital radiogrphy and tomosynthesis in the diagnosis of pulmonary tuberculosis

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Introduction: Digital tomosynthesis (DT) is a modern method of radiation diagnostics, which is actively implemented in the practical work of various health care institutions in Ukraine.

The purpose of the work is to illustrate the advantages of digital tomosynthesis (DT) in the diagnosis of pulmonary tuberculosis.

Material and methods: We retrospectively evaluated the clinical feasibility of DT in 124 patients with suspicion of initially detected tuberculosis, examined in an anti-tuberculosis dispensary in an average-sized region of Ukraine, the study was conducted during 2022. The average age of the patients is 42.4 ± 13.5 years. Medical and surgical treatment of patients for various forms of tuberculosis was carried out in the institution, so the results of diagnostics in all patients were verified. All DT studies were performed to evaluate questionable or incomplete standard radiographic data. Examinations were performed on a domestic digital X-ray diagnostic complex with digital tomosynthesis mode KRDTS-02-ALFA after performing DT. DT in 64% of patients was performed lying down, in 36% - standing.

Research results: Among the examined patients, tuberculosis of various forms was confirmed in 108 (87.1%) patients, 6 (4.8%) had lung tumors, and 10 (8.1%) were diagnosed with acute community-acquired pneumonia. According to the forms of tuberculosis, 16 (14.8%) had focal tuberculosis, 60 (55.6%) had infiltrative tuberculosis, 13 (12.0%) had tuberculosis, and 11 (10.2%) had relapsed fibrous-cavernous tuberculosis, in 8 (7.4%) - disseminated pulmonary tuberculosis. In 48 (44.4%) patients with tuberculosis, it was established against the background of a chronic non-specific lung disease. In 38 patients (30.6%), the diagnoses were changed, compared to the previous diagnoses. We managed to reduce by 42% the number of services that refer to CT for follow-up examinations, change additional radiographic projections and improve the selection of users for CT.

Conclusions: DT provides anatomical detail and allows clear detection of tuberculous changes in the lungs, so it can be recommended for clarifying doubtful radiological indicators, as well as for dynamic control of treatment of pulmonary tuberculosis.

The use of tomosynthesis in the diagnosis of bone pathology

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Introduction: Digital tomosynthesis (DT) is a radiological research method, which is a sequence of tomograms produced at a given depth with a fixed distance between slices. This technique refers to reconstructive imaging methods. The method occupies an intermediate position in terms of diagnostic capabilities between radiography and computer tomography. Patients can be placed in different positions (standing, lying down, sitting), which allows examination of a selected part of the body in each position.

Purpose of work: Identify the advantages and disadvantages of digital tomosynthesis (DT). assess bone damage and disease as a secondary imaging

Materials and methods: We retrospectively evaluated the results of 128 patients with clinically suspected traumatic injury (68.8%) or disease (31.2%) of bone who underwent DT at our institutions between 2019 and 2021. All DT studies were performed to evaluate equivocal or incomplete standard radiographic findings. The examination was carried out on a domestic digital X-ray diagnostic complex with a digital tomosynthesis mode KRDTS-02-ALPHA after performing the digital X-ray. When using DT, the patient's dose during the examination of the extremities did not exceed 0.01 mSv, in the examination of the spine - 1.0 mSv. At each DT, 250 images were obtained with a step of 1 mm. The aim of the study was to reduce the number of sites referred for further examination, to change the additional radiographic projections and to improve the selection of patients suitable for CT.

The results: The detection of fractures and bone destruction using DT turned out to be higher than X-ray data and comparable to CT: X-ray - 70.0%, DT -93%, CT 100%. A dynamic study of the fusion of fractures allowed in 47.7% of cases earlier than on digital radiographs to establish the formation of a bone callus or to detect a delay in their healing. Small sequestrations, which are not visible on radiographs, were detected by DT and CT in 30.0% of cases. DT made it possible to more clearly assess the presence of a paravertebral abscess and its extent (85.7%) in comparison with a digital spondylogram and reveal the surface destruction of the cortical layer of the vertebrae on the lateral surface under the spinal ligament in case of polysegmental lesions (66.7%).

Conclusions: DT provides clear anatomical detail and allows detection of hidden fractures, clarification of questionable radiological findings, it should be used to control the treatment of fractures. In addition, it should be considered as an effective adjunct to standard X-ray examination and should be chosen as a secondary imaging modality in case of inconclusive X-ray examination due to its quick performance and low dose radiation.

Mobile diagnostic teams to help the primary chain of medicine

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The aim of the work: A current trend in modern radiology, which uses digital imaging technologies and teleradiology, is bringing diagnostics closer to the patient and conducting the necessary radiological (XR) and ultrasound examinations (US) at the place of the patient's medical treatment and even at home. In particular, in ultrasound, this is an internationally established principle of "Point of care ultrasound" (POCUS). The use of teleradiology makes it possible to realize for primary medical care (PMC) the principle "The radiological information about the patient moves in space, not the patient himself!"

According to the Ministry of Health in Ukraine, as a result of the war, more than 616 medical institutions were damaged, among them more than 100 were completely destroyed. It will take time and more than 1.0 billion dollars to restore them. People require medical services on the territories affected by hostilities already today. This medical support should be provided in circumstances of transport logistics disruption in the country, especially on territories affected by hostilities, which significantly reduces the population mobility.

Currently, the Red Cross of Ukraine provides medical support to the population in remote areas and, in particular, in areas affected by the war, with the help of mobile medical teams. Unfortunately, these brigades are currently equipped only with tonometers and glucometers, as a result of which the efficiency of mobile brigades' visits is low.

Therefore, increasing the efficiency of such mobile medical teams is an urgent task.

Materials and methods: To expand the capabilities of mobile diagnostic teams, it is proposed to additionally equip them with portable digital X-ray machines, ultrasound scanners, electrocardiographs and devices for anthropometric measurements.

Discussion: With the help of lightweighted digital x-ray diagnostic complexes, mobile teams would have the opportunity to conduct preventive examinations of the chest as a minimum with the aim of early detection of tuberculosis and its residual changes, malignant neoplasms, non-specific lung diseases, cardiovascular pathology, as well as to assess lung damage in persons recovered from COVID-19.

With the help of a modern ultrasound scanner, mobile teams would have the opportunity to perform standardized protocols of ultrasound diagnostics, in particular, to perform thyroid gland examination; atherosclerosis of the carotid arteries detection and the intima-media complex thickness evaluation, as well as steatometry of the liver for non-alcoholic fatty liver disease, a third of the population is affected with.

The mobile team consists of two specialists in ultrasound diagnostics (US) and one radiographer with the capability, after additional training, of electrocardiography (ECG) investigation and anthropometry measurement for the patients. Such mobile team can examine 40-60 patients daily.

Nurses and general practice physicians can be trained within a few weeks for the X-ray and ultrasound equipment operations, and will be able to use already existing equipment. Analysis of X-ray and ultrasound images can be done remotely by the radiologists.

Conclusions: The use of mobile diagnostic teams is one of the few methods of improving medical care in regions affected by hostilities, as well as in settlements remote from regional and district centers. The results of examinations performed by the mobile diagnostic teams will help family doctors and general practice physicians in terms of the patient management and timely detection of dangerous diseases.

The experience of using the tomosynthesis in pediatric radiology

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Introduction: Tomosynthesis is a digital linear tomography and it is a good compromise between radiography and computed tomography (CT). Tomosynthesis does not replace studies using CT, but significantly expands the diagnostic capabilities of radiography without a significant increase in patient dose, which is especially important in pediatrics. Tomosynthesis is performed to obtain additional data for the examination on the same device as digital radiography (DR). In this case, the detector captures the series of low-dose exposures, which are mathematically processed and reconstructed into a thin layers image series.

Aim: Effectiveness evaluation of DT use in pediatrics

Materials and Methods: The research was conducted on digital equipment «Indiagraf-01». 925 children underwent the examination. Pathology has been revealed for 611 (66%) patients. DT of the thoracic organs was performed in 325 and the osteoarticular system in 600 children

Results: The following groups of pathology were identified in the study of lungs:

1. Pneumonia
2. Tuberculosis
3. Developmental anomaly

Five groups of pathology in the examination of the osteoarticular system:

1. Developmental disorder
2. Acute trauma
3. Tumors
4. Joint diseases

Conclusions:

1. Digital tomosynthesis is one of the latest advances in X-ray technology.
2. It helps to determine in details the structure of bones: in complex malformation, erosion, minor, destruction, necrosis, fractures.
3. Study the bone structure without artifacts in case of metal implants presence.
4. Research of bone fractures in plaster and corset,
5. allows accurate assessment of the healing process fracture, including callus formation.
6. Possibility of research the cervical spine (C1- C2) during tomosynthesis without opening the patient's mouth.
7. Changes in the lungs are comparable with DT and CT data (foci less than 1 cm, bronchiectasis).

Advantages of using x-ray diagnostics in primary healthcare facilities

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Objective: Patient-oriented medicine involves providing assistance to patients at the place where they seek medical attention. Most often, patients turn to primary medical and sanitary care facilities (PMSC). The lack of X-ray diagnostics, which is used to determine the majority of diagnoses, significantly limits the ability to provide quality medical care at the first level in PMSCs.

Equipping PMSCs with X-ray equipment in Ukraine is not provided for in regulatory documents. However, during the war, several simplified digital X-ray diagnostic systems were installed in PMSCs through charitable assistance last year. In particular, one of such systems was installed in the center of PMSC "Central" in Rivne, which serves almost 100,000 people in the city.

The objective of this work is to analyze the advantages of using X-ray diagnostics in PMSCs.

Materials and methods: In the second half of 2022, with the help of the American charitable fund "Nova Ukraine," 15 simplified digital X-ray diagnostic complexes were installed in medical facilities in Ukraine, 2 of which were installed in PMSCs. A comparative analysis of the use of these complexes was conducted, taking into account the statistical data of the Ministry of Health of Ukraine.

Results: Over the six months, diagnostic assistance was provided to 4,288 patients, and 5,508 images were taken. This is more than all the other 14 complexes combined, 1.5 times more than the average annual workload per X-ray machine in Ukraine.

Among the conducted studies, X-ray of the chest organs accounts for 2,165 (50.5%), limbs - 667 (15.5%), DPS - 418 (9.7%), spine - 149 (3.47%), and others - 20%. The number of conducted X-ray studies is determined not by the needs of the facility but by the capability of the personnel working on the equipment. The actual needs of the facility in X-ray studies are much higher, considering that in 2022, the doctors of the PMSC "Central" center identified about 200,000 diseases, including about 40,000 diseases of the circulatory system, over 50,000 diseases of the respiratory organs, and about 20,000 diseases of the musculoskeletal system and connective tissue. Even with the coverage of preventive X-ray studies of chest organs by only 5% of the served population, in 2022, during their implementation, 6 cases of tuberculosis, 2 cases of lung neoplasms, 1 case of sarcoidosis, and 159 cases of cardiovascular pathology were detected.

The main advantage of having X-ray diagnostics in the facility is that patients receive the results of the X-ray study on the same day that they are referred to it, and the doctor who issued the referral can jointly review the obtained digital X-ray images with the radiologist and, if necessary, promptly involve relevant specialists in consultations. That is, the patient receives a diagnosis during one visit to the medical facility.

Conclusion: The presence of X-ray diagnostics in PMSCs allows for a significant increase in the effectiveness of primary medical care.

New possibilities of ultrasound diagnostics (US) at the level of primary medical care (PMS)

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Introduction: In the current realities of Ukrainian medicine, two powerful trends have combined. The first is the fact that 80% of medical services are provided by family doctors (FDs) at the PMC level and they are heavily overloaded with various responsibilities. The second trend is the miniaturization of US devices (handheld US - HHUSD), which allowed clinicians of various specialties, including FD, to perform urgent US at the point of care - POCUS. The COVID-19 epidemic accelerated the implementation of POCUS lung US, and the war, which is essentially a traumatic epidemic, forced the FDs to master the eFAST protocol. However, the "silent" epidemic of nonalcoholic fatty liver disease (NAFLD) also requires early US diagnosis at the level of PMC. Ukrainian-made lightweight US devices with the option of the attenuation coefficient measurement (ACM) are sensitive to the first mild stage S1 of liver steatosis, in contrast to the conventional B-mode (Soneus P7 and HandyUsound).

Aim: To determine the new possibilities of US for screening of NAFLD at the PMC level by ACM.

Materials and methods: In the period after the subsidence of the manifestations of the COVID-19 pandemic (2022) in Ukraine, a group of 226 people of both sexes, aged 19-75, was examined. Patients were referred for examination by FDs and gastroenterologists for a general abdominal ultrasound. Liver US was performed in B-mode by Hamaguchi’s criteria and by ACM in dB/cm. Opportunistic US screening of liver steatosis was performed by Soneus P7 device (Ultrasign, Kharkiv, Ukraine) with a C1-5 convex sensor in the frequency range of 1-5 MHz. Exclusion criteria: viral hepatitis B and C (blood test), alcohol (questionnaire and gamma-glutamyl transpeptidase).

Results: The procedure of US screening of liver steatosis by measuring the attenuation coefficient (ACM) of 5 region of interest (ROI) with the formation of a protocol by the calculation of the median, mean and interquartile range took 2-3 minutes. Intuitive and simple navigation of ACM ROI allows the operator to precisely avoid artifacts and quickly obtain reliable results.

Using the B-mode, liver steatosis was detected in 104 people (46%): mild in 35 (15.5%), moderate in 56 (24.8%), severe in 13 (5.7%). According to the ACM, 114 people had steatosis of the liver (50.4%): mild S1 in 44 (19.5%), moderate S2 - 55 (24.3%), severe S3 -15 (6.6%).

Conclusions:

1. B-mode, as expected, was less sensitive to the mild stage of steatosis S1. This determines the priority of ACM in modern US using HHUSD for screening of NAFLD at the PMC level.
2. Early detection of a mild degree of steatosis S1 will allow patients with the help of FDs to overcome NAFLD without medication in accordance with the recommendations of the EASL only by strong lifestyle modification.

Long term stability of $N_{D,w}$ calibration coefficient for Farmer type ionization chambers

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Modern highly-specialized radiotherapy techniques require accuracy and assurance that dose delivered to the target volume is in accordance with dose planned for this volume. Adequate certainty of correct realization of planned treatment can be achieved by highly trained and experienced professionals who obey prepared procedures and use properly calibrated equipment.

Even the best, state of the art dosimetric equipment (electrometer and ionization chamber) can become defective, compromising trustworthiness of measurements. Hence need for regular calibration of dosimetric equipment by independent laboratory. Such service is provided by Secondary Standards Dosimetry Laboratory (SSDL) run by Medical Physics Department of Maria Sklodowska-Curie National Research Institute of Oncology, member of Secondary Standards Dosimetry Laboratories Network established by the International Atomic Energy Agency and the World Health Organization. Polish SSDL fulfills all the requirements of the ISO/IEC 17025 standard, and since May 28th, 2014 is accredited for conformity with the previously mentioned standard by the Polish Centre for Accreditation. Accreditation certificate number is AP 155.

Calibration of medical linear accelerators bonds dose absorbed to water or delivered to patient during treatment session, expressed in Gy unit, with Monitor Units (MU) - unit used as a reference scale for linear accelerators. Proper calibration is crucial to maintain accordance between planned and delivered dose of radiation. The manner of conducting measurement as well as definition of reference conditions has been determined by international Code of Practice published by the International Atomic Energy Agency (IAEA).

Calibration of dosimetric equipment is carried out as a comparison of dose measured by reference set and set provided by user - calibrated set. Dose measurement is carried out in gamma ray produced by decay of ^{60}Co. Both measurements are carried out in the same geometrical manner and in similar atmospheric conditions. Any influence of changing atmospheric pressure and temperature is taken into account when calculating dose measured by each set. $N_{D,w}$ coefficient is determined as a quotient of dose measured by reference set and calibrated set.

Basing on experience of Polish SSDL stability of $N_{D,w}$ coefficient was analyzed. In this study only Farmer ionization chambers were taken into account. Decision was based on widespread use of this type of chambers in dosimetric measurements in radiotherapy.

Results of interlaboratory comparisons in the field of testing of thermoluminescent detectors in terms of absorbed dose to water

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Every calibration and testing laboratory accredited for the conformity with the norm ISO/IEC 17025 has to fulfill the requirements of the norm. One of these requirements is monitoring the validity of the tests undertaken. The Polish Secondary Standards Dosimetry Laboratory (SSDL) has been accredited for the conformity with the norm ISO/IEC 17025 by the Polish Centre for Accreditation since April 9th, 2014 and has the accreditation certificate No AB 1499. In the scope of this accreditation there is testing of thermoluminescent detectors in terms of absorbed dose to water, by thermoluminescent dosimetry method. At the Polish SSDL, it was decided that monitoring of the validity of the testing results will include participation in the interlaboratory comparison between the Polish SSDL and Dosimetry Laboratory of the International Atomic Energy Agency (IAEA).

The aim of this study is to present the results of the interlaboratory comparisons and a simple method of analysis of results that can be useful in routine activity of the testing laboratories in the above-mentioned area in order to check if results are stable in specified limits.

The material of the study were the results of the interlaboratory comparisons conducted from 2004 to 2022. These comparisons were carried out once a year and they consisted of a comparison of the TLD dose reported by the Polish SSDL (i.e. D_{SSDL}) with the value of the IAEA-stated dose (i.e. D_{IAEA}).

The acceptance criterion of the result was established at the Polish SSDL and was based on the relative percentage value of the combined uncertainty of the measurement of the D_{SSDL} value and D_{IAEA} value, i.e. 3.4% value of D_{SSDL} and D_{IAEA}. The result of the interlaboratory comparison was acceptable when the value of $|E_n|$ defined as the quotient of the absolute value of the difference D_{SSDL} and D_{IAEA} values to the square root of the sum of the squared combined uncertainty of D_{SSDL} value and D_{IAEA} value, did not exceed 1.0. The trend of changes in the results was correct when the value of the absorbed dose in water determined by TL detectors (D_{SSDL}) and the value of the undisclosed dose absorbed in water (Blind Check: D_{IAEA}) were consistent within the measurement uncertainty, i.e. D_{SSDL}/D_{IAEA} ranges from 0.966 to 1.034.

All the results were acceptable in the analyzed period. The maximum value of $|E_n|$ was 0.25 in 2018. The minimum value of $|E_n|$ was 0.02 in 2009. The obtained results indicated that there was no trend of changes of the interlaboratory comparisons results from 2004 to 2022. Therefore, there was no need to take appropriate action to prevent incorrect results from being included in the test results reported by Polish SSDL to the clients. Moreover, there was no need to perform any corrective actions specified in the current edition of the Polish SSDL management system document. In addition, there was no need to analyze the situation in the context of the risk of testing being not-conforming to the established procedure and to take appropriate actions set out in other document establishing the procedure for such non-conforming work.

All the results of the interlaboratory comparisons for the Polish Secondary Standard Dosimetry Laboratory in the field of testing of thermoluminescent detectors in terms of absorbed dose to water were acceptable in the analyzed period. The presented analysis of the results of the interlaboratory comparisons is useful in routine activity of the testing laboratories carrying out tests of the thermoluminescent detectors in terms of absorbed dose to water.

TLD postal dose audit in Poland – 2022 results

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First thermoluminescent dosimetric (TLD) postal dose audit in Poland was organised by the Secondary Standards Dosimetry Laboratory (SSDL) of the Institute of Oncology in Warsaw in 1991. The aim of these audits conducted to radiotherapy centres is to assure proper calibration of radiotherapy beams, to avoid mistreatment of cancer patients, and prevent radiation accidents. Polish SSDL offers dose measurement in water, for which it is accredited by the Polish Centre for Accreditation for compliance with the ISO/IEC 17025 standard (accreditation No AB 1499). SSDL in Warsaw is the only laboratory in Poland performing postal TLD dose audit. Currently, i.e. at the end of 2022, Polish legislation does not impose any obligation on radiotherapy centres to undergo dosimetry audit. However, in accordance with good dosimetry practice, audits will continue to be organized by the SSDL in Warsaw for radiotherapy centres in Poland.

One of the requirements of the ISO / IEC 17025 standard is to monitor the validity of the results. In Polish SSDL it includes e.g. participation in interlaboratory comparisons with the IAEA. A set of TL detectors is delivered to the IAEA and is irradiated with a radiation dose unknown to SSDL. An unknown dose value is determined in the same manner as for the radiotherapy dosimetry audits. The obtained result (D_{SSDL}) is forwarded to the IAEA. Finally, the IAEA reports to the Polish SSDL the dose value that the dosimeters have been irradiated (D_{IAEA}). After obtaining positive result of this comparison the audit for radiotherapy centres in Poland continues and certificates of performance are issued by the Polish SSDL and sent to customers.

In 2022 42 radiotherapy centres located in Poland participated in this audit. In this centres there were 159 linear accelerators installed. These treatment units generated 490 high energy photon beams and 492 electron beams. Most of radiotherapy centres requested an audit for more than one beam quality. Total number of audited radiation beams was 144, including 134 photon beams (15 beams in non-reference conditions) and 10 electron beams. Thermoluminescent dosimeters (TLD) of Li-F MT-F type (Institute of Nuclear Physics, Cracow, Poland) were mailed to each participant. The participants were instructed to irradiate three TL detectors for each beam with a dose of 2.0 Gy in reference conditions. After irradiation the detectors were sent back to the SSDL. At the same time, set of reference detectors was irradiated with known doses at the SSDL. All detectors were read out at the SSDL with a Fimel PCL 3 TLD reader. The delta parameter was defined as the quotient of the difference between dose value reported by the participant and dose value estimated by the SSDL to the dose value estimated by the SSDL. The delta parameter was calculated as a percentage value.

The biggest difference found between the dose estimated by the SSDL and the dose declared by the participant was 3.1%. The average delta value for all beams was 0.18%. The uncertainty of audit methods was 3.4%.

At the time of COVID-19 pandemic, TLD postal dose audits are an important element of ensuring safe and effective radiotherapy in Poland.

Stereotactic Body Radiation Therapy - dosimetric and mechanical preparation of linear accelerator

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Stereotactic Body Radiation Therapy (SBRT) is a specialised treatment technique that is characterised by high fractional and total dose of radiation, delivered in a few fractions to a small-volume tumour. The features mentioned above concerning this technique require particular attention to the technical performance of linear accelerator delivering this therapy. Main factors that should be considered when SBRT treatment is scheduled to be performed are:

1. Consistency of dose output and its accordance with output defined in treatment planning system (TPS);
2. Radius and location of radiological isocenter and its coincidence to isocenter pointed by laser system;
3. Performance of multi leaf collimator, precision of leaf positioning in different gantry positions and during gantry rotation.

As a part of routine weekly quality assurance (QA) program, until September 2022, Polish legislation obligated medical physicists to perform the following checks:

1. Consistency of dose output;
2. Radius of mechanical isocenter;
3. Coincidence of mechanical isocenter with isocenter pointed by laser pointers and proper distance measured by telemeter;
4. Functionality of any routinely used accessories;
5. Functionality of anti-collision system.

As a part of preparation to introduce SBRT technique in clinical application, some additional tests were performed on a weekly basis.

Point of this study was to determine the optimal agenda of performing additional tests, not compromising on the patient's safety and not interfering with routine clinical operation of the linear accelerator more than necessary. This point seems to be of a great importance since according to current legal regulations, only References procedures in SBRT demand a check of radiation isocenter. This test is of extreme importance, but does not seem to be sufficient as the only one preparing the linear accelerator for the treatment in SBRT technique. What is more, frequency of this test is not defined in the References procedure. Hence each user, having in mind safety of the patient treated with SBRT technique, needs to come up with a specific QA schedule to be implemented in radiotherapy centre.

Simulation study of C-arm CT/SPECT imaging-based patient dose verification with TOPAS for online adaptive brachytherapy

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Purpose: Locally advanced cervical cancer is required to be treated with image-guided adaptive brachytherapy (IGABT) for excellent local control and reduced toxicity [1]. For online IGABT, a mobile CT scanner-based in-room 3D imaging system was suggested, but these required enough shielding design and space to install it. Therefore, we proposed a C-arm CT/SPECT system that can acquire not only the patient CT image but also the SPECT image of a moving radioactive source inside the patient based on the conventional C-arm fluoroscopic device by adding 2D collimation system and machine-running algorithm in image reconstruction method. In this study, the feasibility of C-arm CT/SPECT imaging-based online patient dose verification was assessed with the Monte Carlo method using TOol for Particle Simulation (TOPAS).

Materials and Methods: A C-arm CT imaging is a cone-beam CT imaging with limited angular rotation (e.g., 110°), delivering a lower imaging dose to a patient than the full rotation CT imaging, but having lower image quality. Machine running method was implemented with Wave U-Net which is a U-shaped encoder-decoder network architecture to increase the quality of C-arm CT image by training it with 66 non-contrast pelvic CT image sets. For three brachytherapy patient cases, patient dose distribution was evaluated based on C-arm SPECT images obtained with 2D collimation system for the 192Ir seed source moving inside the patient using the TOPAS simulation.

Results: The Wave U-net successfully transformed the low-quality C-arm CT image sets into high-quality ones, considerably reducing the streaking artifacts and preserving anatomical structures, for nine brachytherapy patient cases. For three patient cases, the dose distributions calculated with the high-quality C-arm CT image sets for the TG-186 192Ir source using the DICOM-RT interface of the TOPAS toolkit were successfully verified by the limited-angle C-arm SPECT images, showing similar image intensity to the gamma emission intensity for each source location. For the low gamma emission intensity in the treatment plan, dose estimation accuracy was decreased due to high statistical uncertainty, however, the dose estimation accuracy can be improved if we apply deep learning techniques in the future.

Conclusions: In this study, we evaluate the feasibility of the C-arm CT/SPECT imaging-based IGABT and online 3D patient dose verification. With synthetic high-quality C-arm CT images, the online adaptive plan modification to improve the conformality of target dose distribution is available through patient dose calculation after deformable image registration based on the prior simulation CT. With C-arm SPECT images, online adaptive treatment validation is possible by monitoring the source movement inside the patient. We believe that this simple and compact multi-imaging modality can be widely applicable regardless of the specific brachytherapy operating conditions of each institution.

Keywords: TOPAS, patient dose verification, C-arm CT/SPECT, Monte Carlo simulation, online adaptive brachytherapy

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Prague: Proton RAnGe measure Using silicon carbidE

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In hadrontherapy, the monitoring of the PDD distribution is a fundamental step in beam quality control programs, due to its correlation with the beam range, which is closely involved in the definition of the treatment plan. The uncertainties in the estimation of the proton range in the biological tissue lead to the extension of the treatment volume, with a consequent increase in the total dose absorbed by the patient. The dosimetry protocols currently in force (IAEA TRS 398) recommend the use of the ionimetric method for the measurement of the PDD distribution of proton beams, a method which, although well established, exhibits a limited spatial resolution (of the order of mm) and which is not suitable for high intensity and high dose-rate beams, such as those used in Flash Radiotherapy. The PRAGUE (Proton RAnGe measure Using silicon carbidE) project, exploiting the use of silicon carbide (SiC) devices, aims to optimize the PDD distribution measurement of proton beams. In particular, the objective of the PRAGUE project is to design, realize and characterize a system capable of measuring, in real time and with high longitudinal spatial resolution (of the order of 150 μm water equivalent), the PDD distribution of a 30-150 MeV proton beam with both high (1010 pps) and low (105 pps) intensity. To satisfy these purposes, the potential of SiC is exploited. Indeed, the high radiation hardness and the independent response from Linear Energy Transfer and from the dose rate of the beam make SiC detectors suitable for the characterization of hadron beams even at high intensity. The longitudinal spatial resolution will be obtained through the combination of an etching procedure used to remove the passive layer of the SiC detectors and a stack configuration in which the detectors will be arranged. A first protype of the final detector, designed to be composed by 60 SiC devices placed in stack configuration, was already designed and tested. The stability, reproducibility and linearity of the SiC devices response were also analysed. The results validate the aims of the project, encouraging to continue the feasibility study with higher intensity beams.

Towards the development of a Compton Camera based on HEXITEC detectors for in vivo range verification in proton beam therapy

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Proton beam therapy has become a recurrent form of cancer treatment over conventional radiotherapy due to the physical properties of protons, which allow for a higher dose delivery in the target while decreasing radiation to nearby organs at risk. However, there is a concern about the uncertainty in the proton range inside the body, which may limit the ability of proton therapy to spare organs at risk to their maximum potential. In vivo range verification is a promising method to tackle this uncertainty, and can be achieved by detecting secondary prompt gammas produced during treatment. Given that the prompt gamma production cross section is higher near the end-of-range of the beam, a reconstruction of the prompt gamma creation origin within the patient yields an accurate estimation of the proton range. The present work shows the progress made towards the creation of a Compton camera imaging system based on a hybrid pixellated CZT detector (HEXITEC). Furthermore, the experimental detector response to the complex secondary radiation field during proton therapy is presented, along with advanced Monte Carlo simulation results to optimise the Compton camera imaging system in terms of sensor thickness, layer positioning, image reconstruction and event filtering.

Improvement of the treatment procedure based on dose verification and deformable image registration

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Aim: Nowadays, image-guided radiation therapy (IGRT) is the standard in modern radiotherapy. However, determining the location of the soft tissues is still problematic. The poorly visible borders of such organs as the duodenum and stomach make it difficult to decide on the correct irradiation conditions. There is an increased probability that the dose delivered to the organ at risk (OARs) will be higher than expected and unintended complications will occur. In this study, the positions of the organs were verified using the well-known CT-on rails tomograph. The obtained CT images were used to calculate the real dose distribution for each fraction of irradiation. Deformable image registration and dose verification made it possible to assess the correctness of the irradiation conditions and introduce improvements in the treatment procedure. The aim of the study was to estimate the dose deposited in the stomach and duodenum during radiotherapy and to compare it with the dose calculated in the treatment planning system.

Material and methods: The patient with pancreatic cancer underwent radiotherapy. The prescribed dose was 45Gy in 25 fractions with a simultaneous integrated boost of 70Gy. Before each irradiation fraction, a control CT examination was performed to assess the location of internal organs. 25 therapeutic fractions were analysed in terms of the dose delivered to the duodenum and stomach.

Calculations of the dose distribution were made based on CT-on rails images, maintaining the parameters of the treatment plan - the real dose distribution was calculated taking into account the current patient anatomy for each radiation fraction. The doses deposited in the OARs were determined and compared to the planned doses for 3 plans in the Eclipse treatment planning system.

25 calculated dose distributions were imported into the Velocity system and subjected to deformable registration. Then, the sum dose distribution was created for the complete treatment course. The total doses delivered to OARs were compared to the planned one.

Results: Based on the CT-on rails images, a decision was made to implement the Active Breath Coordinator (ABC) during therapy. Due to changes in the patient's anatomy, two new plans were prepared.

The doses delivered to the duodenum in the first stage of therapy were lower than planned, contrary to the doses deposited in the stomach. This effect was smaller in the second stage. The doses deposited in the OAR were equal to those planned in the third stage of treatment. The dose constraints for duodenum and stomach were met for the realised radiotherapy course.

Conclusion: The organ localization verification based on CT-on rails images allows to significantly improve the control of irradiation conditions. The implementation of ABC results in remarkably high precision of delivering the prescribed dose and thus protection of the OARs. The determination of dose delivered to the OARs during treatment is essential in high-dose radiotherapy.

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BOOK OF ABSTRACTS rad-conference.com

Determination of volume averaging correction factors for ionization chambers of different effective volumes in narrow Co-60 beams

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Volume-averaging of a measured detector response is a known problem in small photon beam dosimetry. This affects the reading of detectors and erroneously makes wider the penumbra region of a measured dose profile which results in an underestimation of the absorbed dose on the beam central axis. To account for this, the measured response must be corrected by the volume averaging correction factor, calculated using Kawachi formalism. However, due to the difference in radiation field geometry, this formalism must be modified to be applicable to Gamma Knife (Elekta, Stockholm, Sweden). The purpose of this work was to determine the volume averaging correction factors for different ionization chambers and field sizes in narrow Co-60 beams used by Gamma Knife Icon.

Small-volume ionization chambers that were studied are: Semiflex TM31010 V=125 mm^3, PinPoint TM31014 V=15 mm^3, PinPoint 3D TM31016 V=16 mm^3 (PTW, Freiburg, Germany), RAZOR chamber V=10 mm^3, and RAZORnano chamber V=3 mm^3 (IBA Dosimetry, Schwarzenbruck, Germany). To determine a volume averaging correction for different detectors a 3D elliptical dose model was implemented using normalized dose profiles provided by Elekta (Sweden). With fitted dose profiles and an elliptical 3D dose model, an analytical expression and visualization of different field sizes were obtained using MATLAB (TheMathWorks Inc., USA). Using numerical integration (Simpson's rule), we were able to determine the volume averaging correction factors as a function of different field sizes.

Semiflex chamber has the largest volume averaging correction factor: 1.006, 1.042, and 1.627 for 16, 8, and 4 mm field sizes respectively. Furthermore, the corrections for the PinPoint ionization chamber are 1.005, 1.011, and 1.181; for PinPoint 3D, the corrections are 1.003, 1.005, and 1.057 for 16, 8, and 4 mm field sizes respectively. The corrections for the RAZOR chamber are 1.004, 1.006, and 1.074 while the RAZORnano chamber has corrections of 1.003, 1.003, and 1.025 for 16, 8, and 4 mm field sizes respectively.

This work has illustrated the possibility to determine volume-averaging correction factors for narrow photon beams of Gamma Knife devices using an elliptical dose model. It is shown that volume averaging increases with the increase in the detector's sensitive volume. Therefore, the Semiflex ionization chamber had the largest correction factor for all field sizes and the RAZORnano chamber had the smallest. For all studied detectors volume averaging decreased with an increase in field size.

Artificial Intelligence algorithms in Mammographic Imaging: a preselection tool, a stand-alone reader or a possible Ethics' violator?

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Introduction: Several global challenges have boosted the continuous development and gradual adoption of Artificial Intelligence (AI) algorithms in Healthcare. Such challenges include the growing total – and aging developed- world population, the increasing Healthcare providers' shortfall and the chronic and preventable diseases epidemic. Specifically for the case of mammographic imaging, population-wide screening has proved to result in earlier tumor detection and subsequent reduction of breast cancer mortality by 20-40%. However, it also carries the disadvantages of increased radiologists' workload, combined with the broad variation in the performance of human readers assessing the mammograms. These disadvantages have driven the increasing development of AI algorithms in mammographic imaging. The current study focuses on the different roles of AI algorithms in mammographic imaging, as well as the prerequisites for their clinical adoption, without violation of keystone ethical principles.

Materials and Methods: Contemporary scientific publications on AI algorithms in mammographic imaging and underlying ethical principles were selected. Special emphasis was put on commercially available AI algorithms, results of their application in clinical context and published AI and Ethics guidelines and principles.

Results: Our study revealed the increasing international efforts on the design and implementation of AI algorithms in mammographic imaging. Until less than a decade ago, most AI algorithms were used as a concurrent assistant to the radiologist, a tool to preselect regions considered to be suspicious for abnormality, providing a score of malignancy likelihood per region. Nowadays, Deep Learning (DL) approaches have blossomed, resulting in targeting AI algorithms to be rather used as stand-alone mammographic readers. In certain cases (especially in Digital Mammography-DM) AI systems outperformed radiologists in cancer detection, further yielding a lower recall rate than the original reading (up to 2% for DM). In addition, these algorithms have proved to be robust, with respect to ethnic and imaging equipment distributions. The keystone AI ethical principles presented in the corpus of literature include transparency, justice and fairness, non-maleficence, responsibility, privacy and autonomy.

Conclusion: There is no doubt that Healthcare's near future will be the development of a novel AI ecosystem. Clinical adoption of such AI algorithms in mammographic imaging appears to be highly promising, as long as the ethical principles are fully respected. Their implementation and adoption should be based not only on scientific efficacy, technical robustness and financial effectiveness criteria, but also on prior full investigation of ethical consequences and the establishment of human agency and oversight procedures.

Multicomponent crystals of nimesulide: design, structures and properties

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Multicomponent crystals, especially pharmaceutical ones, are the object of interest in the modern pharmaceutical industry. Designing alternative solid forms of drugs (mainly salts and cocrystals) can improve their physicochemical properties compared to pure active pharmaceutical ingredients (APIs). New forms of multicomponent pharmaceutical solids can overcome problems such as poor solubility, poor tablebility, instability or hygroscopicity [1-3].

Nimesulide (4–nitro–2–phenoxymethanesulfonanilide) is a non-steroidal anti-inflammatory drug (NSAID) used as a painkiller, mostly in severe primary dysmenorrhea treatment [4]. Like many other drugs, the substance has poor water solubility [5]. In addition, there are only a few crystal structures containing nimesulide in the crystallographic database (The Cambridge Structural Database). That means that the structures of nimesulide are barely known.

Given the above, the presentation will contain the results of the latest research on multicomponent nimesulide salts. It will present the method of obtaining crystals and their physicochemical features. Additionally, the presentation will study molecular structure by single-crystal X-Ray diffraction measurements and analyze intermolecular interactions in multicomponent crystals of nimesulide.

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Influence of the structures of THIQ derivatives on their inhibitory properties toward acetyl- and butyrylcholinesterase

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Alzheimer's disease (AD), the most common form of dementia, is a progressive neurological disorder characterized by losing memory and other intellectual abilities that are serious enough to interfere with daily life. The disease is associated with loss of cholinergic neurons in the brain and the decreased level of ACh. In order to raise the ACh level in the brain the acetylcholinesterase (AChE) inhibitors have been applied as relevant drugs in the AD therapy. On the other hand, these inhibitors treat and improve only symptoms indicating necessity for new better therapies. One of them could be based on the inhibition of butyrylcholinesterase (BuChE) because of its increased activity during late stage of AD. Therefore, the BuChE inhibitors should be of great importance in therapy. 1,2,3,4-tetrahydroisoquinolines (THIQ) are a large group of natural and synthetic compounds which exert diverse biological activities against various infectious pathogens and neurodegenerative disorders. Due to these reasons, the THIQ have attracted a lot of attention in the scientific community which has resulted in the development of novel THIQ analogues with more potent biological activity. In this study the inhibitory potency of derivates of N-phenyl-1,2,3,4-tetrahydroisoquinoline, 178, 196 and 202, were investigated toward two cholinergic enzymes, AChE and BuChE. The performed screening tests pointed out the different inhibition potency of the selected compounds toward both enzymes which was related with their structures. The most potent compound has been 178 with IC50 values 1.30 μM and 2.50 μM toward AChE and BuChE, respectively. However, no selectivity was observed. Introducing F-atom in the para position of N-phenyl group of the compound 178, the compound 202 was obtained. In this way, the selectivity was increased towards acetylcholinesterase without significant influence on the IC50 value. However, introducing a methoxy groups in the position C3 and C4 of the tetrahydroisoquinoline's ring of 202, the compound 196 with decreased inhibitory activity was obtained. IC50 value of 196 was one order of magnitude higher compared with compound 202. Based on the obtained results it is possible to conclude that introducing F atom in the para position of the phenyl ring lead to increased selectivity of the investigated compounds while introducing methoxy group in the position of C3 and C4 of tetrahydroisoquinoline ring leads to decrease of their inhibitory potency.

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In vitro genotoxicity assessment of a monolacunary Wells-Dawson nanocluster as a promising contrast agent candidate

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Tungsten-based nanoparticles possess high density and capability to attenuate X-rays and thus have been studied as interesting candidates for the development of new-generation contrast-enhancing staining agents (CESAs) for computed tomography (CT). Polyoxotungstates, as polyoxoanions containing tungsten in its high oxidation state (W6+) were reported as promising CESA candidates to visualize long bones and kidney tissues. However, some polyoxotungstates induced side effects in toxicity studies in vivo, which could limit their clinical application. Thus, the aim of this study was to evaluate genotoxic effects in vitro of monolacunary Wells-Dawson polyoxotungstate, α2-K10P2W17O61.20H2O (lacunary WD) that was found as a potential contrast agent for CT in our previous studies in situ and in vitro. Lacunary WD was synthesized by following the reported procedure. The genotoxicity evaluation was performed by using the standard procedure for the alkaline comet assay. Briefly, human whole blood samples were taken from healthy male and female donors and exposed to different lacunary WD concentrations within the range of 10-6-10-4 mol/L, for 4 and 24 h at 37 °C. Then, 5 µL of whole blood was embedded into an agarose matrix and subsequently lysed (2.5 M NaCl, 100 mM EDTANa2, 10 mM Tris, 1% sodium sarcosinate, 1% Triton X-100, 10% DMSO, pH 10) overnight at 4 °C. After the lysis, the slides were placed into an alkaline solution (300 mM NaOH, 1 mM EDTANa2, pH 13) for 20 min at 4 °C to allow DNA unwinding and subsequently electrophoresed for 20 min at 1 V/cm. Finally, the slides were neutralized in 0.4 M Tris buffer (pH 7.5) for 5 min 3 times, stained with ethidium bromide (10 µg/mL), and analyzed at 250× magnification using an epifluorescence microscope (Zeiss, Göttingen, Germany) connected through a camera to an image analysis system (Comet Assay II; Perceptive Instruments Ltd., Haverhill, Suffolk, UK). One hundred randomly captured comets from each slide were examined. Multiple comparisons between groups were done by means of ANOVA on log-transformed data. Post hoc analyses of the differences were done by the Scheffé test. The percentage of tail DNA was determined to evaluate the level of DNA damage and genotoxicity potential. The obtained results showed that lacunary WD did not induce a statistically significant relative increase of tail DNA compared to the corresponding control at all investigated concentrations, after both 4 and 24 h exposure. Accordingly, the investigated promising contrast agent candidate could be regarded in further studies as toxicologically safe for healthy human blood cells from a genotoxicity point of view.

Platinum(IV) complexes of the 1,3,5-triamino-1,3,5-trideoxy-cis-inositol- synthesis: structure and antiproliferative properties

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Platinum-based chemotherapy is widely used for the treatment of various types of cancer. However, the clinical efficacy of these agents is often limited by drug resistance and toxicity. To address these challenges, Pt(IV)-complexes have been developed as a prodrug strategy aimed at overcoming these limitations. In this study, we discuss the design and synthesis of two octahedral cationic Pt(IV)-complexes with the tridentate ligand 1,3,5-triamino-1,3,5-trideoxy-cis-inositol (taci), namely $[Pt(taci)I_3]^+$, taciplatin and $[Pt(taci)_2]^{4+}$, ditaciplatin. The complexes were characterized by various techniques, such as Single Crystal X-Ray Diffraction, NMR spectroscopy and Mass spectrometry. Their cytotoxicity was evaluated in vitro against a panel of human cancer cell lines using the MTT assay.

The ligand taci is coordinated through the NH_2-groups, each molecule occupying three coordination places in the inner coordination sphere of Pt(IV). To the best of our knowledge, the new compounds are the first example of a Pt(IV)-compound designed as an antitumor drug in whose inner coordination sphere a tridentate ligand is coordinated as a non-leaving group ligand that occupies two equatorial and one axial positions simultaneously and exhibits promising pharmacological properties in in vitro experiments.

The stability of taciplatin and ditaciplatin, according to their hydrolytic behavior, was investigated with NMR spectroscopy and Mass spectrometry. Monitoring of the hydrolysis processes at different acidity showed that ditaciplatin remained stable over the study period, while the I^- -ions, in taciplatin, were successively substituted, with the main product under physiologically mimetic conditions being fac,cis-$[Pt(taci)I(OH)_2]^+$. The antiproliferative tests involved eight cancer cell models, among which chemosensitive (derived from leukemias and solid tumors) and chemoresistant human Acute myeloid leukemia lines (HL-60/Dox, HL-60/CDDP), as well as the non-malignant kidney' cells HEK-293T showed that the complexes are characterized by a fundamentally different profile of chemosensitivity and spectrum of cytotoxic activity compared to cisplatin. Remarkable activity was recorded for taciplatin, which showed an effect (IC_{50} = 8.9 ± 2.4) at more than 16-fold lower concentration than cisplatin (IC_{50} = 144.4 ± 9.8) against the resistant cell line HL-60/CDDP. These results show unequivocally that the studied complexes are capable of overcoming the mechanisms of cisplatin resistance.

Anthranilic acid amide and its complex with Cu(II) ions

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The favoured profile of anthranilic acid and its analogues as pharmacophores allows as they have potential uses as P-glycoprotein inhibitors for controlling the purposeful and logical development of medications intended to manage the pathophysiology and pathogenesis of various diseases. The substitution on an anthranilic acid scaffold generates compound libraries that allow a thorough examination of the structure activity relationship study. The amides of anthranilic acid analogues play a crucial role in the treatment of numerous metabolic disorders in addition to their extensive use as anti-inflammatory fenamates. The anthranilic acid derivatives also have intriguing antibacterial, antiviral, and insecticidal capabilities, as well drug resistance in cancer cells.

The transition metal complexes of anthranilic acid derivatives, on the other hand, offer therapeutic implications in obesity and diabetes mellitus by regulating the activity of -glucosidase.

Due to the variety of biological activities, we have synthesized anthranilic acid amide and its Cu(II) complex. The in silico analysis predicted spasmolytic activity for the starting amide. Ethyl (2-(methylcarbamoyl)phenyl) carbamate was applied in a reaction with Cu(II), varying the solvents. When the ligand dissolved in DMSO combines with a water solution of CuCl2 in an alkaline environment in a molar ratio of M: L: OH- = 1: 2: 2, the reaction results in the creation of a coordination compound.

The structures of the new compounds are discussed based on their melting points, IR, 1H, 13C-NMR and Raman spectral data.

Not a myocardial infarction

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Introduction Takotsubo cardiomyopathy (TCM) is an unusual form of acute cardiomyopathy showing left ventricular apical ballooning. It is often triggered by intense physical or emotional stress. We report here an interesting case of TCM and a review of the literature on the topic. Backgroung First described in Japan in 1990 by Sato et al., TCM is an acute cardiac condition that involves left ventricular apical ballooning and mimics acute myocardial infarction. It is also known as 'broken heart syndrome.' TCM patients present with symptoms of chest pain, electrocardiograph ST-segment elevation, and cardiac markers consistent with an acute coronary syndrome. However, angiography finds no significant coronary stenosis, and the LV apex is found to balloon, which usually resolves in weeks. The syndrome appears to be triggered by emotional or physical stress. TCM is being diagnosed more frequently, possibly because of increasingly stressful times and public attention to ACS. Although well known in cardiology, awareness of this entity is still developing in EM. It is important to consider this diagnosis, as patients may present to the ED with what appears to be uncomplicated ACS. C.P A 38-year-old healthy woman with negative past medical history presented to our Emergency Department with chest pain developing a few hours after sudden emotional event, winning a lottery. Our patient had typical substernal chest pain and was relieved by sublingual nitroglycerin in the ED. The pain started after 2h following the intensive emotional reaction. On review of her history, our patient was noted to be taking spironolactone 125mg once daily for hirsutism for the past year. Our patient denied any family history of cardiac disease or heart failure. She admitted to being a former smoker and she denied any drug use. She works as a social worker, and reported that she does not experience much stress in her life and denied any "big life-changing event" or any major stressful news. While in the ED, our patient was hemodynamically stable and an electrocardiography was performed and showed sinus rhythm with no ST elevation/depression but noted T-wave inversion in leads I and aVL, and T wave flattening in leads V1 and V2. Her troponin levels were 0.294 and 0.231 consecutively. An echocardiogram was done and showed hypokinetic apical and mid-distal walls and hyperdynamic basal walls of the left ventricle with an EF of 35-40%, consistent with apical ballooning syndrome. Cardiac catheterization was subsequently done and showed depressed left ventricle systolic function, EF of 30–35% with anteroapical dyskinesia and no evidence of coronary artery disease. Our patient was diagnosed with Takotsubo cardiomyopathy, and was subsequently treated with a beta blocker and angiotensin-converting enzyme inhibitor. Conclusions our patient had an emotional disturbance, leading to excessive sympathetic stimulation leading to catecholamine-induced microvascular spasm or through to direct myocardial toxicity, which is postulated to be behind the pathophysiology of Takotsubo cardiomyopathy. Another interesting finding in our patient was her use of spironolactone, as treatment for hirsutism, which is an aldosterone antagonist. Aldosterone actually potentiates the effects of catecholamine and thus activates the sympathetic system. Spironolactone can thus be considered as cardioprotective against the effects of catecholamine on the heart and that is why it is considered to be beneficial and subsequently improves mortality in chronic heart failure as described in several studies. The adrenaline's effects on the heart during broken heart syndrome are temporary and completely reversible-the heart typically recovers fully within weeks or months. We have followed our patient, an echocardiogram was done four to six weeks after the first symptoms to make sure that the heart is recoverd. The patient had significant improvement under the therapy, including cardiac rehabilitation.

Hair loss after covid 19 - case series

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Covid 19 is an infectious illness that has been associated, in addition to other skin lesions, with an increased incidence of hair loss. There are literature reports of dystrophic anagen effluvium (ae), telogen effluvium (te), alopecia areata (aa), and newly developed androgenetic alopecia (aga). We assessed 25 cases of hair loss occurring after covid 19 infection (cov19) using a pull test, trichoscopy, and trichogram, to investigate patterns related to the disease. Five patients with te complained of acute hair loss after a median of 2 months (range 1-3 months) following covid 19, with the duration of hair loss a median of 4 months (range 1-8 months). Fifteen patients had signs of chronic te after a median of 6 months (range 1-12 months) following covid 19, with the duration of hair loss a median of 9 months (range 1-18 months). They all also had trichodynia as a symptom. We also present five more patients with patchy aa beginning 2-3 weeks after being positive for the covid 19, with the duration of hair loss a median 10 months (range 1-20 months). In sum, the age of patients ranged from 18 to 75 years. Among all, 7 were male and 18 were female. In all the cases, covid 19 was confirmed by pcr test. Although we know that patients with covid 19 can have post covid hair loss, there are many possible types of alopecia that could be noticed. Te is most common and could be acute or chronic, and the chronic type can be intermittent, too. Aa is not so rare after covid 19, as it seemed to be in the earlier investigations.

Cases of vibration disease in workers exposed to prolonged vibration

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Intoduction: Vibrations are mechanical oscillations periodically repeated and characterized by different frequencies, as the energy is pressed by the vibrating neighboring material particles. Industrial vibrations are the cause of vibration disease, characterized by polymorphic clinical picture with involvement of the whole organism.

The aim of the study is to improve the diagnostics, treatment and prevention of occupational injuries from industrial vibrations.

Material and methods: The object of the study are 65 cases of vibration disease in workers of various enterprises in Northern Bulgaria. The persons were hospitalized in the Department of Occupational Diseases, University Hospital - Pleven in the period 2019 - 2022. The group was related with the action of vibrations and the length of service was more than 5 years. Clinical, laboratory, functional, imaging and statistical methods were applied in the study. Treatment with medication and physical factors was carried out.

Results and discussion: Damage to persons exposed to chronic vibration is manifested by clinical symptoms summarized in neurological, vascular, musculoskeletal and auditory syndromes. In 91% of the examined persons with more than 10 years of work experience, socially significant diseases were found - diabetes mellitus, arterial hypertension, ischemic heart disease, stomach and duodenal ulcer disease.

Conclusions: Injuries from industrial vibrations are a current healthy problem for workers in various branches of modern production.

Huntington's disease case report: intermediate number of repeats expansion in paternal transmission

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Huntington's disease (HD) is an autosomal dominant neurodegenerative disorder caused by an inherited CAG trinucleotide expansion in huntingtin (HTT) gene. The diagnosis of HD is usually established in a proband with a symptoms of disease by the identification of an abnormal CAG trinucleotide repeat expansion in HTT gene by molecular genetic testing.

Routine genetic testing of Huntington's disease consists of DNA isolation from the blood, PCR amplification, agarose or capillary gel electrophoresis and fragment size detection of number of repeats. Samples with 26 or fewer CAG repeats are classified as normal, unaffected individuals. Range from 27 to 35 CAG repeats is classified as intermediate and potentially unstable allele whose number of repeats can be elevated in next generations. Pathogenic HD-causing alleles are with 36 or more CAG repeats.

A 49 years old male was referred for Huntington's disease genetic testing and was confirmed as a carrier of intermediate (27 CAG repeats) and pathogenic (48 CAG repeats) allele. Two years later, his son was referred for genetic testing as a suspected carrier. He appeared to carry normal (14 CAG repeats) and intermediate – de novo (30 CAG repeats) allele.

It can be assumed that the son inherited intermediate allele from his father, but there has been increase in size of 4 CAG repeats. Similar cases have been reported before and it is known that children can inherit the expanded number of repeats from parent with intermediate allele.

Personal radiofrequency exposure measurements at a summer music festival

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The radiofrequency (RF) exposure is continuously increasing in the public area. However, most users of 2G-5G mobile communication systems are young adults, little is known about personal RF exposure of their life-like situations. A summer outdoor music festival allowed us to collect realistic electric field strength data faithfully reflecting their entertainment habits.

Two young volunteers received personal exposimeters (ExpoM RF) during two days (weekday/ weekend) of a music festival. They wore them close to their body (in their belt pack) moving freely at the festival staying close to each other. Their mobile phone use was not restricted. They made various scenarios – e.g. visiting concerts with crowded people, resting areas, passing by base stations. Their activities were marked in the exposure diaries and subsequently compared with collected data of the exposimeters (field strength (V/m) and GPS data). Band-selective RF exposure sorted along 2G-4G uplinks and downlinks and 5G (3.5 GHz) band were calculated. Field strength data subsets were classified on the basis of crowd (high/ med/ low/ very low) as well as activities (concert/ beach/ other/ control) and locomotion (go/ stay).

While the majority of RF exposure was recorded from 2G-4G systems, the contribution of 5G was negligible. From this result we concluded that the use of the 5G system was not yet typical. In the case of other frequency bands it was found that electric field strength data separated along selection criteria differed. This reflects the importance of consider young adults' behaviour when characterizing RF exposure in a real life situation.

About the influence of different external fields on the swelling kinetics of PMAA hydrogels

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Hydrogels are 3D cross-linked structures that, due to their unique physical and chemical properties and possible applications, are the subject of intensive research in recent decades. In this work, the effects of external physical fields (ultrasonic (US) and microwave (MW)) on the isothermal swelling kinetics of poly(methacrylic acid) hydrogel were examined. A sample of poly(methacrylic acid) (PMAA) xerogel (PMMA-X) was synthesized by the process of cross-linking free radical polymerization, which is described in detail in the paper [1]. The basic primary structural properties of PMMA-X including the equilibrium swelling degree in distilled water (SDeq), the density of xerogel (ρxg), the average molar mass between the crosslinks of a network (Mc), the degree of crosslinking (ρc) and the distance between the macromolecular chains (ξ), were determined and calculated. The isothermal kinetic swelling curves were determined by the tee-bag method at a temperature range of T= 293-323K in the presence of thermal, ultrasonic, and microwave fields. The isothermal kinetic curves of swelling were fitted with the Peppas' kinetic model [2]. The values of the isothermal kinetic parameters of the Peppas model (k, n) were calculated. Based on the temperature dependence of the parameter using the Arrhenius equation, all values of the activation energy (Ea) and the pre-exponential factor (lnA) of the swelling process in the presence of different physical fields were calculated. The obtained results indicate that the presence of US and MW fields leads to an increase in the values of k, n, Ea, and compared to the corresponding values during conventional heating. The US field relatively slightly increases the value of SDeq, while the MW field significantly reduces the value of SDeq. The values of Ea and lnA at different physical fields are interrelated by a correlation relationship (compensation effect) which is given by the relation: lnAf=0.326+0.406Ea, f The existence of a compensation effect [3] is an indication of the unique mechanism of activation of the polymer network at different physical fields for swelling and of the quantum nature of Ea. The influence of US and MW fields on the diffusion of water molecules through the polymer network, activation of the polymer network for swelling, and relaxation of the polymer network was analyzed.

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Exposure assessment of electromagnetic field from telecommunications sources in populated areas in correlation with public concern

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The conclusions of the EC survey carried out on the territory of the EU in 2009-2010 (Eurobarometer 73.3. Electromagnetic fields, Report) show that in most cases the reasons for the fears among the population are the lack of adequate information, the contradictions in the scientific literature, as well as the doubt that the government does not take adequate measures to protect the population concerning new technologies. In 2012, WHO conducted a policy analysis regarding the risk of electromagnetic fields (EMF) exposure to workers and the general public. The results show that most countries apply similar approaches for limiting exposure and risk from EMF and there are no proven adverse health effects arising from EMF exposure on the population, incl. from base stations (BS) for mobile communication. This is also confirmed by SCENIHR reports, 2009, 2012 and 2014.

These results were also confirmed in Bulgaria in 2014-2015 in the project conducted by the Medical University-Pleven, together with the National Center for Public Health and Analyses by the team of Prof. M. Israel. The aim of the project was to analyse and evaluate the electromagnetic exposure in relation to the fears of the general population connected to the introduction of new telecommunication technologies.

The purpose of the present study is to check the working hypothesis of the project, namely that the electromagnetic exposure caused by base station for mobile communication is minimal (within the permissible limit values) and that the fears of population are mainly due to insufficient information or to other interests and less to adverse health effects.

For this purpose, the electromagnetic exposure data collected within the cited project are analysed by applying statistical methods. The received complaints are also analysed, and the analysis is redone based on the Eurobarometer 73.3 survey using new data collected after 2015.

In our country the EMF legislation concerning control of base stations for mobile communication is in force since 1991 (SG, No. 35/1991; Amendment and addition, SG No. 8/2002). The control of this type of transmitters is carried out according to the requirements of the Law on Territorial Planning and the Health Law, and mounting of broadcasting facilities that not meet the regulatory requirements and have an adverse impact on the population is very unlikely

The measurements carried out by the team of the NCPHA show that the EMF values almost everywhere in the country are within the permissible exposure limits and comply with national legislation. Compared to the current EU Council Recommendation 1999/519/EC, the national limit value is much lower, and for the different frequencies it is 40 to 100 times stricter. These data are also confirmed by the annual EMF monitoring performed by the regional health inspections in the country. Our studies of general public complaints related to the EMFs exposure often show ulterior interests and very few are based on real health effects. Until 2012, there were many observed complaints, after which their number decreased and at the moment they are negligible. In 2019-2020, with the implementation of the new 5G technology, a certain increased number of complaints was observed. What we have been able to identify is that this is organized by a group of the population. Despite of being small in number, it is very "noisy" and uses the means of manipulation and disinformation. With the COVID, this group has refocused on a different kind of disinformation and fake news.

All this confirms the need for applying a state policy when serious social problems arise, as well as creating a risk communication and management program on time in order to prevent fears among the population and possibility to make adequate decisions.

Problems with the implementation of the European legislation for the protection from laser radiation in the working environment

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Lasers have many and essential applications in different areas. These include medicine (medical treatment and diagnostics, surgery, dentistry, etc.) material processing (cutting, welding, laser marking, etc.), data reading and storage, distance measurement, and many others.

The differences between lasers and other conventional sources of optical radiation are connected to the specific characteristics of the laser radiation: single wavelength, coherence, low divergence, and negligible change in the power or energy over long distances, possibility to focus the laser beam to a small area. The laser radiation has great potential to cause harmful health effects on eyes and skin. High power/energy lasers could represent risk of fire as well.

In Europe, a Directive 2006/25/EU of the European Parliament and of the Council of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation) is in force. It states that "the employer, shall assess, and, if necessary, measure and/or calculate the levels of exposure to optical radiation to which workers are likely to be exposed". For laser radiation the exposure assessment is to be made by calculation on the basis of relevant IEC standard (EN60825-1) using technical characteristics provided by manufacturer.

Unlike other physical factors of the working environment, such as noise, vibrations, electromagnetic fields, etc., which disseminate in a large part of the working premise, laser radiation has a strictly defined route (path) of propagation. The laser radiation from a certain source does not change its characteristics as wavelength, beam diameter, pulse duration, repetition rate, etc. These characteristics can only be changed by operator intervention. This allows the exposure assessment of the laser radiation to be performed by laser safety classification according to the degree of risk on the basis of the technical characteristics of the laser beam. The classification schemes for lasers indicate the potential risk of adverse health effects. Lasers can be grouped into 8 classes: 1, 1C, 1M, 2, 2M, 3R, 3B, 4. The potential to cause harmful health effects rises with the class of the laser. On the basis of classification, appropriate control measures to minimize the risks could be selected.

Depending on conditions of use, exposure time or environment, these risks may or may not actually lead to adverse health effects. Laser sources with equal output characteristics create the same occupational risk if they emit under absolutely equal conditions in the working environment. Otherwise, the specific conditions of the situation also create a different occupational risk.

Considering these specifics of lasers/laser radiation for the ensuring of safety in working environment following principles:

- Knowledge of technical characteristics of laser system and risk classification by degree of risk;
- Assessment of the specific conditions of working environment;
- Training/qualification of the personnel in laser safety.

Here, several real cases of assessment of lasers in working environment are presented. The main problems established during the assessment are connected with a lack of complete information by the manufacturer, about the environment which creates additional risks, also lack of training in the field of laser safety. In general, the reasons for established problems are connected to neglecting health risks connected to laser radiation, lack of competence of occupational health services and control bodies.

Early life irradiation-induced hypoplasia and impairment of neurogenesis in the dentate gyrus are mediated by Microrna- 34a-5p/T-cell intracytoplasmic Antigen-1 pathway

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Early life radiation exposure causes abnormal brain development, leading to adult de-pression. However, few studies have been conducted to explore pre- or post-natal irradia-tion-induced depression-related neuropathological changes. Relevant molecular mechanisms are also poorly understood. We induced adult depression by irradiation of mice at postnatal day 3 (P3) to reveal hippocampal neuropathological changes and investigate their molecular mecha-nism, focusing on MicroRNA (miR) and its target mRNA and protein. P3 mice were irradiated by γ-rays with 5Gy, and euthanized at 1, 7 and 120 days after irradiation. A behavioral test was conducted before the animals were euthanized at 120 days after irradiation. The animal brains were used for different studies including immunohistochemistry, CAP-miRSeq, Re-al-Time Quantitative Reverse Transcription PCR (qRT-PCR) and western blotting. The interac-tion of miR-34a-5p and its target T-cell intracytoplasmic antigen-1 (Tia1) was confirmed by lucif-erase reporter assay. Overexpression of Tia1 in a neural stem cell (NSC) model was used to further validate findings from the mouse model. Irradiation with 5 Gy at P3 induced depression in adult mice. Animal hippocampal pathological changes included hypoplasia of the infrapyramidal bladeof the stratum granulosum, aberrant and impaired cell division, and neurogenesis in the dentate gyrus. At the molecular level, upregulation of miR-34a-5p and downregulation of Tia1 mRNA were observed in both animal and neural stem cell models. The luciferase reporter assay and gene transfection studies further confirmed a direct interaction between miR-43a-5p and Tia1. Our results indicate that the early life γ-radiation-activated miR-43a-5p/Tia1 pathway is involved in the pathogenesis of adult depression. This novel finding may provide a new therapeutic target by inhibiting the miR-43a-5p/Tia1 pathway to prevent radiation-induced pathogenesis of depression.

Beneficial effects of *Helix aspersa* extract in Parkinson's disease

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Parkinson's disease (PD) is the second most common neurodegenerative disorder after Alzheimer's disease. PD is caused by lack of neuromediator dopamine (DA), which transmits the nerve impulses leading to movements coordination and balance of the human body. The causes of PD are related to a degenerative process in a midbrain structure (striatum) containing dopaminergic neurons: substantia nigra or "black substance", so called because of the characteristic color of its constituent cells. As a result of the neurodegenerative process, over time, the disease literally collapses the entire nervous system of a person. To this day, the reasons leading to the destruction of nerve cells and "unlocking" PD have not yet been fully established. Through immunohistochemical methods and quantification of histological staining, we verified *in vivo* animal model of PD by intraperitoneal administration of the neurotoxin 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP) in BALB/c mice, and also investigated the effect of standardized extract from *Helix aspersa* (SE) on vitality of dopaminergic neurons. since SE is well known to possess antioxidant, anti-inflammatory and antiapoptotic properties. Changes in substancia nigra pars compacta (SNpc) and striatal tyrosine hydroxylase (TH)-immunoreactivity are marker of reduced density of dopamine-containing neurons after MPTP intoxication, indicating the loss of dopamine neurons. We determined DA-containing neurons by assessing changes in the density of TH immunoreactivity in the SNpc, striatum, and changes in the number of tyrosine hydroxylase-positive cells in the SNpc. Our data demonstrated that TH-immunoreactivity was reduced by 14 % ($P < 0.05$, n=6) and by 19 % ($P < 0.05$, n=6) in SNpc and striatum, respectively, in Parkinsonian animals. Repeated administration of SE preserved the number of dopamine neurons. Multiple SE administration increased dopamine brain level (by 176 %) and decreased those of noradrenaline (by 42 %,) as compared to MPTP group. After 12 days with SE treatment (7 days before and 5 days simultaneously with MPTP) an improvement in motor and memory performance in Parkinsonian animals was observed. In conclusion, our results showed the capacity of snail extract from *Helix aspersa* to preserve dopaminergic neurons, improve neuromuscular coordination and memory performance in experimental model of Parkinson's disease *in vivo*.

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How to fight Alzheimer's type dementia: the role of snail extract

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Alzheimer's disease (AD) is the most widespread neurodegenerative brain disorder, which manifests itself with dementia, has its own characteristic clinical and morphological characteristics and a progressive course. The etiology of the disease has not been clarified. In AD, there are disturbances in the production of acetylcholine, which is one of the main neurotransmitters in the central nervous system. It is believed that the main reason for the manifestations of AD is the postponement of the so-called amyloid plaques in the brain tissue. At a later stage in Alzheimer's dementia, degeneration of brain tissue is observed, as a result of massive neuronal death, which correlates with an irreversible and profound disorder of brain activity. It has been established that the extract of mucus from representatives of the type Mollusca - land snails, includes a wide variety of active substances with proven properties, such as antibacterial and antioxidant activity, which stimulate tissue regeneration and suppress inflammatory processes. Investigations performed by Trapella *et al* (Sci Rep 8, 17665, 2018) proved the regenerative activity of *Helix aspersa* snail mucus extract on fibroblast cultures and demonstrated its anti-apoptotic effect as well as the possibility of significantly inducing cell proliferation and migration through direct and indirect mechanisms in combination with absolute lack of cytotoxicity. The task of our research was to create a product which beneficially influences Alzheimer's type dementia (ATD), based on the qualities and properties of bioactive components from the mucus of the garden snail *Helix aspersa*. The effects of standardized snail extract (SE) from *Helix aspersa* on learning and memory deficits in ATD induced by scopolamine (Sco) in male Wistar rats were examined and mechanisms of action underlying these effects were evaluated. SE (0.5 mL/100 g) was applied orally through a special food tube for 16 consecutive days: 5 days before and 11 days simultaneously with Sco (2 mg/kg, intraperitoneally). At the end of Sco treatment we evaluated memory performance. In cortex and hippocampus (two brain structures mostly related to memory) the acetylcholinesterase (AChE) activity, acetylcholine and monoamines (dopamine, noradrenaline and serotonin) content, levels of main oxidative stress markers, and expression of brain-derived neurotrophic factor (BDNF) and cAMP response element-binding protein (CREB) were determined. We demonstrated that SE significantly improved the cognitive deficits in ATD. Furthermore, SE possessed AChE inhibitory activity, moderate antioxidant properties and the ability to modulate monoamines content in brain structures related to memory. Multiple SE applications not only restored the depressed by Sco expression of CREB and BDNF, but significantly upregulated it. Summarizing all results we conclude that SE could be considered as potential remedy to alleviate Alzheimer's type dementia.

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Latest results on NArCoS: a new correlator for neutrons and charged particles with high angular and energy resolution

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The advent of new facilities for radioactive ion beams mainly rich in neutrons, SPES @ LNL, FRAISE @ LNS and FAIR @ GSI only to give some examples, imposes the joint detection and discrimination of neutrons and charged particles in Heavy radioactive Ion collisions, with high angular and energy resolutions. The construction of novel detection systems suitable for this experimental task is both a scientific and a technological challenge.

The contribution will illustrate the results of recent tests performed on a new plastic scintillator material, the EJ276, both in the "green-shifted" and in the base version, coupled with PMT and SiPM. This experimental activity pave the way for the construction of a workhouse of a detector for neutrons and charged particles with high energy and angular resolution, based on a 3D cluster of scintillation units, with the technical goal of high energy and angular resolution.

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Some results for the study of the efficiency and cross-talk probability by using GEANT4 simulations for the neutron correlator NArCoS

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The detection of neutrons and charged particles with high angular and energy resolutions has become a crucial feature for future experiments with radioactive ion beams that will be provided by new facilities such FRAISE at LNS, SPES at LNL and FAIR at GSI.

The aim of ANCHISE project (2020H8YFRE) is to investigate the possibility of using innovative scintillators material coupled with compact photosensors as read-out devices to be the basic elements of a segmented and modular versatile multi-detector prototype, detecting at the same time neutrons along with light charged particles, both with high angular and energy resolution.

The present contribution shows some results of recent GEANT4 simulations performed for different segmented geometries of a EJ276 plastic scintillator detector in order to evaluate the detector efficiencies as a function of the neutron energy and to estimate the probability of cross-talk in different configurations.

Research station for tomographic and radiographic studies of large objects and the possibilities of its application

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Neutron technologies represent a promising set of methods for researching additive technology products. The use of neutron tomography in the industry of additive technologies makes it possible to investigate and evaluate the quality and integrity of finished products of various shapes, thicknesses and sizes without destruction. The ability to study the internal volume of additive manufacturing products without destruction is the main advantage of neutron technologies and makes this method an indispensable research tool. The absence of a loss in the quality of the result with an increase in the neutron beam energy for studying thick-walled structures, as happens in X-ray tomography, makes this method an indispensable tool. The ability to investigate not only metallic materials increases the relevance of this meter. In this paper, the possibilities of using neutron tomography to study products obtained by additive manufacturing methods will be considered.

The medical proton complex of NRC “Kurchatov Institute” – PNPI

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Construction of a medical proton complex was carried out since 1967 till 1972. In January 1973, a 1000 MeV synchrocyclotron of the Leningrad Institute of Nuclear Physics was put into operation. The method of treatment with a high-energy (1000 MeV) beam of protons "through-out" differs from the others, in which protons with an energy of 70-250 MeV are mainly used, releasing the maximum of their energy in the target - the Bragg peak. The proton beam extraction used system is stationary; there is no technical possibility of beam rotation around the patient. To ensure stereotaxic irradiation, a set of equipment was developed that makes it possible to center the radiation beam exactly in the target area. The irradiation area and the administered dose were chosen taking into account the structure of the neoplasm, its volume, and the opinion of the neurophysiologist. The irradiation was carried out in a single dose, and the maximum absorbed dose varied from 40 to 120. The dose fields for this irradiation technique are characterized by a pronounced maximum of the absorbed dose in the center. Isodoses from 90% to 30% have a shape close to an ellipse, at lower values - the shape of butterfly wings. The method was applied to patients with pituitary adenoma (477 cases), arterial-venous aneurysms (502 cases), to relieve pain (268 cases), and other nosology (147 cases). Proof of the validity of the application and effectiveness of the method was that treatment was carried out without damage to the integrity of the skull and the destruction of brain tissue, and there were no complications. In 2017, the modernization of the complex began in order to improve operational characteristics of the complex and bringing the hardware to modern radiation therapy standards. The modernization program included 3 main sections: a general revision of mechanical and electrical facilities, a visualization system, and software. Mechanical parts were fixed. The main parts of Visualization system namely the X-ray centralizer which were replaced include the X-ray emitter and the image intensifier tube, New plane-parallel digital detector provides a higher quality of the X-ray centralizer operation, surpassing that previously used on the basis of an image intensifier tube in most characteristics. The advantage is a low noise level, a large dynamic range, high resistance to direct X-ray irradiation, low overall / weight characteristics, no spatial distortion and nonuniformity, and no sensitivity to magnetic fields. The digital format of the obtained images can be subjected to additional computer processing.

Software for managing the proton stereotactic therapy unit allows to control the facility in automatic and manual mode. It displays all necessary information about the therapy unit: the current position of the head fixing device and treatment couch, the facility position as a whole in 3D, and the speed of movement. The software is responsible for monitoring the parameters of the beam. The program is synchronized with detection devices, such as proportional chambers and ionization chambers. In order for treatment to be effective, treatment planning is carried out. This plan is created by a separate program ProtoPlan. After that, the file with the data is received to the control program. In terms of treatment, all treatment unite parameters are prescribed: initial positions, speed of movement, total dose, etc. The program ProtoPlan is designed to simulate the irradiation conditions and calculation of dose distributions within the area of interest, to create an optimal irradiation plan, which is ensured by selecting optimal parameters (beam size, the head fixing device and the therapeutic table deck rotation angles, the number of passages of the head fixing device and the deck of the treatment table, the irradiation time, the parameters of field docking), for proton radiation therapy with a 1000 MeV beam. Both software products have been tested and patented.

Dose planning system for the proton beam therapy complex

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Proton therapy unit at PNPI B.P. Konstantinov Research Center Kurchatov Institute" in the Gatchina city, designed to irradiate intracranial targets with a proton beam with an energy of 1 GeV. The method differs from proton therapy, which uses the Bragg peak. The method of irradiation “through-out” is based on the rotation of a patient within a volume angle. The main element of the installation - the table on which a patient is placed, rotates in the horizontal plane in the range of ±40°. The front part of the table is a head fixing device, the deck of which swings like a pendulum around the horizontal longitudinal axis in an arc of ±36°, either simultaneously with the turns of the table deck, or independently. Both rocking axes, vertical and horizontal, as well as the axis of the radiation beam perpendicular to them, intersect at one point, which is the isocenter of rotations - thus, protons with an energy of 1000 MeV, passing through the object of irradiation (phantom, biological tissues, etc.) through, produce uniform ionization along their path and practically do not experience scattering in biological tissues, while maintaining the isocenter in a certain area of the irradiated object, they provide the required therapeutic effect in a certain area with minimal negative consequences for surrounding tissues.

Treatment of patients in Gatchina began in 1975 and was interrupted in 2013. A total of 1394 patients received proton therapy during this period. Therefore, in order to preserve this unique technique, meet modern requirements for high-tech medical care and resume treatment, the proton therapy unit was upgraded. The final stage of modernization was the creation of a radiotherapy planning system.

Radiation therapy, including proton therapy, implies pre-radiation preparation, which includes dosimetric planning - performed using special software.

As a rule, such software is designed for the Bragg peak irradiation technique in gantry facilities. Therefore, such software solutions cannot be applied to the treatment method “throughout”, since the mechanisms of irradiation are significantly different.

The presented planning system is a specialized software product that performs modeling and calculation of dose distributions within the area of interest, selection of the optimal irradiation plan (angle of rotation, number of passes of the head fixator and treatment table deck, as well as irradiation time) for PMT with beam energy 1 GeV.

The planning system makes it possible to evaluate the quality of an irradiation program by calculating dose-volume histograms. The minimum set of parameters for assessing the quality of planning includes dose unevenness in the planned target. It also provides the ability to work with all used data formats of diagnostic devices and tools used to diagnose brain tumor diseases.

Importance of nuclear medicine in diagnosis of transthyretin cardiac amyloidosis (ATTR-CM)- single centre experience

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Background: Transthyretin amyloid cardiomyopathy (ATTR-CM) results in a restrictive cardiomyopathy caused by extracellular deposition of transthyretin, normally involved in the transportation of the hormone thyroxine and retinol-binding protein, in the myocardium. Diagnosis of ATTR-CM remains challenging because it is frequently under recognized, or misinterpret with other similar conditions. The challenge persists to increase recognition and achieve effective, timely diagnosis.

Aim: To introduce nuclear medicine method in the diagnosis of ATTR –CM and evaluate accuracy of the method in our Centre.

Patients and Methods: From August 2017 to February 2023**,** seventy-eight patients (mean age 62±14 years, 39 females) with heart failure with preserved ejection fraction (HFpEF) and echocardiography findings suspected for ATTR –CM were included in the study. In all subjects whole body scintigraphy and SPECT or SPECT/CT were performed 3 hours after i.v. application of 555MBq of ^{99m}Tc-DPD. Perugini grading scale was used for semi-quantitative assessment of the accumulation of radiopharmaceutical in the extracellular space of the heart muscle on whole-body scintigrams. Myocardial biopsy and or laboratory findings and clinical follow up were used as gold standard for evaluation of the accuracy of the method.

Results of whole-body scintigraphy were as follows: grade 0 had 61 patients (78%) , grade 1, 2 patients (2%), grade 2: 6 patients (7%) and grade 3: 9 patients (13%). 15 out of 78 patients (19%) had high grades (2 or 3), and in 14 ATTR was confirmed (93%). In two patients with grade 0, AL amyloidosis was confirmed. Overall sensitivity was 93%, specificity 96% and accuracy 96%.

Conclusion: Our results indicate that whole-body scintigraphy with ^{99m}Tc-DPD is accurate method for the evaluation of ATTR-CM.

Nuclear medicine procedures in the follow-up of patients with medullary thyroid carcinoma

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Medullary thyroid cancer (MTC) is the third most common thyroid cancer. It occurs sporadically or familially in the context of multiple endocrine neoplasias, it arises from parafollicular cells, which are also called C cells and secrete the hormone calcitonin and CEA. Various biochemical parameters, genetic tests and standard diagnostic procedures such as US, MSCT, MR are used for diagnosis and monitoring. In nuclear medicine diagnostics, imaging can be done using a gamma camera (SPECT, SPECT/CT) or positron emission tomography with computerized tomography (PET/CT). Nuclear medicine methods use different radiopharmaceuticals labeled with gamma and positron emitters such as 99mTc, 123I, 18F-FDG.

In our study, 18F-FDG PET/CT examination was performed in 57 patients with operated medullary carcinoma of the thyroid gland and suspicion of recurrence or metastases. Gamma emitter scintigraphy was performed in 23 patients using 99mTc-dimercaptosuccinic acid (DMSA), 123I-metaiodobenzylguanidine (MIBG) was used in 8, while somatostatin receptor scintigraphy was performed in 23 patients using 99mTc-HYNIC TOC (TCT). Visualization of increased focal uptake of radiopharmaceuticals at the site of suspected tumor is considered a positive finding.

18F-FDG PET/CT is a useful method with high diagnostic accuracy postoperatively, especially with high calcitonin values, it can be used alone or in combination with other nuclear medicine methods (99mTc-(V)-DMSA, 99mTc-TCT, 123J-MJBG). Nuclear medicine procedures are of particular importance in evaluating the possibility of applying radionuclide therapy using 131I-MIBG or labeled somatostatin analogs.

Incomplete fusion reactions for enhanced production of radioisotopes: scope in nuclear medicine

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It has been a constant research endeavor to find new ways of producing radionuclides for diagnostic and therapeutic purposes in nuclear medicine. The research area has ever grown due to technological developments and facilities like heavy-ion accelerators. The iodine isotopes are very common in nuclear medicine, *e.g.,* ^{131}I has been widely used as a radiotracer for thyroid-related diseases. This neutron-rich isotope (^{131}I) is produced using a reactor. Although often difficult to procure locally, it can be transported easily because of its long lifetime ($\tau_{1/2}$= 8.04 d). Another isotope ^{123}I produced using cyclotron, is also utilized in recent times. The suitable γ-ray energy (E_γ) range is 100-600 keV which is high enough for the gamma to be sufficiently penetrating through the medium of human body, and can be fully absorbed in the detector. These two isotopes of iodine – ^{131}I emitting the photon of energy 364 keV and ^{123}I of energy 159 keV – qualify the requirement.

We investigated the production of four isotopes of iodine ^{123,124,126,128}I via incomplete fusion reactions (ICF) by bombarding the beams of ^{10,11}B (60-78 MeV) on ^{122,124}Sn foils using the 14-UD Pelletron accelerator at the Tata Institute of Fundamental Research, Mumbai, India. The experimental results of our initial experiment ^{11}B+^{122}Sn were presented [1] at the conference NN2012. Later we performed more experiments and adopted the same experimental procedure. Our purpose was two-fold. Firstly, we measured the cross sections of all long-lived (minutes to days) radioisotopes using the off-line γ-ray spectrometry. Our objective was to understand the reaction mechanism for ICF. Secondly, we paid special attention to iodine isotopes (ICF products) because of their relevance in nuclear medicine. Interestingly, the results were very promising. These isotopes are – ^{123}I ($\tau_{1/2}$=13.2 h, E_γ=159 keV), ^{124}I ($\tau_{1/2}$=4.2 d, E_γ=603 keV), ^{126}I ($\tau_{1/2}$=12.9 d, E_γ=389 keV), and ^{128}I ($\tau_{1/2}$=25 m, E_γ=443 keV) – suitable radiotracers because of long lifetimes. Moreover, they were produced through ICF (α-channels) with enhanced cross sections, an order of magnitude higher than the expected results. The main products (Cesium nuclei) of complete fusion reactions (CF) were high in cross sections as expected, and in the good agreement with the statistical model code PACE4 [2] predictions.

Earlier works on ICF reactions in literature were carried out at high beam energies, and the sum rule model (original-SRM) [3] was quite successful in explaining the observed results. However, we found original-SRM underestimating the ICF cross sections at our experimental low beam energies. We, therefore, made modification in the model mainly to incorporate the energy dependence in the definition of critical angular momentum. Using our modified-SRM, we found a significant improvement in the theoretical estimates for ICF in predicting the enhanced cross sections. The present work indeed has a potential in nuclear medicine, as it can improve the accessibility of many iodine isotopes for their utilization and circulation.

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Comparison of dose calibrator accuracy using standardized sources as a part of multicentre clinical assessment in Bulgaria

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Introduction: The accuracy test aims to ensure that the activity values determined by the dose calibrator are traceable to national or international standards of radioactivity within the indicated uncertainties. This study has two purposes: to provide national data on the accuracy of dose calibrators in use across the country and also provide an opportunity for the calibration of an individual calibrator to be corrected and brought within specification if initial verification shows that the readings are in error.

Materials and Methods: An intercomparison study has been performed on twenty-one dose calibrators in nineteen nuclear medicine facilities. Three certified radioactivity standard sources with relatively long half-life: Co-57 (1946-39-14, Eckert & Ziegler), Ba-133 (KF 951, AEA Technology QSA GmbH), Cs-137 (Nds180/78-LB 165, PTW Freiburg) were used in the survey to verify the accuracy of the dose calibrators over the full range of energies used in clinical practice. Calculations of decay for each source were performed, so that their activities were fitted to the actual value at the time of measurement. After correction for decay between the time of calibration and the time of measurement, the difference between the calibrated activity and measured activity was expressed as a percentage of the calibrated activity.

Results: Prior to calibration, deviations in the measured activity from the References values were found in the range from to -26.3% ÷ 18.2%, -8.5% ÷ 20.3% and -23.2% ÷ 16.6% for Co-57, Ba-133 and Cs-137, respectively. For Co-57, the results after calibration are in the References range of ± 5% except for two dose calibrators for which the values were -6% and -8.2%, respectively. For Ba-133, all dose calibrators systematically overestimate the activity by -7.7% to 21.3%, except for one dose calibrator up to 0.4%. For Cs-137 the results after calibration are in the range from -2.6% to 0.1%, which covers the References limit of ± 5%.

Conclusions: The reported deviations in measured activity for all radionuclides and dose calibrators are in all likelihood due to systematic miscalibration during clinical operation of the dose calibrators. It is important to note that not all dose calibrators tested were clinically used to measure all radionuclides included in this study. This emphasises the fact that dose calibrators must only be used for radionuclides for which the calibration has been checked.

Renal cancer in adjuvant setting – present and future direction

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Renal cell carcinoma (RCC) represents 2% of global cancer diagnoses and deaths and the 14th place world type of cancer. The incidence has doubled in the developed world over the past half-century. If currently therapeutic strategies in the metastatic setting are multiple, tyrosine kinase inhibitors, checkpoint inhibitors, mTOR inhibitors and combination therapies such as IO-IO or IO -TKI having a clearly demonstrated benefit, in the adjuvant setting most of these therapies have failed to show any benefit on the primary or secondary objectives of studies. At the moment, the classification of patients in the risk groups for recurrence is based on clinical and histopathological factors such as T category, the status of the locoregional lymph nodes, the tumor grade, attention being also directed to certain metabolic factors or pre-existing conditions that could influence the subsequent evolution of diseases such as diabetes or hypertension. According to the guidelines, there are currently only two options as adjuvant treatment, namely Sunitinib, the tyrosine kinase inhibitor and Pembrolizumab, the PD-1 inhibitor, the approval coming following the positive results from the S-TRACK study and Keynote 564 study, respectively. Unfortunatelly, the other adjuvant studies for PD-1 inhibitors (Check Mate 914), PD-L1 inhibitors (Immotion 010) or for combined IO-IO therapies failed to show any benefit. Similarly, the PROTECT, ATLAS and SORCE studies did not show any impact on disease free survival for tyrosine kinase inhibitors Pazopanib, Axitinib and Sorafenib. The EVEREST study also had negative results for mTOR inhibitor Everolimus. Why did these studies fail to show any benefit in the adjuvant setting? The lack of molecular details and the heterogeneity of the population included in the studies could explain the failure The molecular classification of the tumor, the identification of pro-immunogenic or pro-angiogenic status, careful selection of patients eligible for a certain type of therapy from a heterogeneous population could be the key. Another aspect is that the effectiveness of tyrosine kinase inhibitors is questioned in micro metastatic disease when the process of tumor angiogenesis is still not clearly outlined. Also, the excision of the primary tumor leads to the decrease of tumoral antigens, which may explain the failure of checkpoint inhibitors in the adjuvant setting. Therefore, we need further directions to identify molecular subsets as predictive factors, genomic and transcriptions classification, metabolic classification, specifying the pro-immunogenic vs pro-angiogenic tumor profile. Treatment selection based on clinical and histopathological factors is not enough.

Prostate cancer - mHSPC, a new perspective

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Prostate cancer is the second most frequent cancer diagnosis made in men and the fifth leading cause of death worldwide. Prostate cancer may be asymptomatic at the early stage and often has an indolent course that may require only active surveillance. Based on GLOBOCAN 2018 estimates, 1,276,106 new cases of prostate cancer were reported worldwide in 2018, with higher prevalence in the developed countries. Unfortunately, many patients present with metastatic disease from the diagnostic or have progression to metastatic disease after the treatment of localized disease. Recently, attention has been directed towards the intensification of treatment in the first line, especially in patients diagnosed with the novo metastatic disease and high volume disease. These patients have a worse prognosis and early progression to castration-resistant disease. They can be usually younger patients or patients with a high Gleason score and high volume disease, according to Charteed criteria. The idea of intensifying upfront treatment by combining ADT with a new-generation antiandrogen therapy, or with a testosterone biosynthesis inhibitor or by adding docetaxel comes from the coherent and logical need to manipulate the androgen receptor for a long period of time.The basic idea is to prevent the progression of the disease to mCRPC status, for as long as possible. Titan and Enzamet studies have shown benefits for these combinations between ADT and apalutamide or enzalutamide, with a positive impact on PFS, OS but also on quality of life. In addition, the large Peace 1 and Aranses studies showed a major benefit on rPFS with an impressive difference of 2 years for triplet therapy, Abirateron/docetaxel/ADT and Darolutamide/DTX/ADT.

Therefore, the current consensus of the Urology and Oncology guidelines is to intensify the treatment, especially in patients diagnosed with a novo metastatic disease. Coherent and long-term manipulation of the androgen receptor delays the progression to the mCRPC status, a still unknown landscape that raises great therapeutic challenges and in which sooner or later the battle is lost. It seems that manipulation of the androgen receptor with NHT delays the modification of the receptor to the truncated version AR V7 which means the establishment of resistance to castration.

What is the benefit of MDT in oligometastatic prostate cancer, what would be the impact of PET/PSMA as a standard imaging investigation, what is the optimal time of identifying BRCA1/2, HRD and MMR mutations, how PARP inhibitors or immunotherapy could benefit the mCRPC, whether PARP inhibitors (discussing the fact that these agents act through the mechanism of synthetic lethality) should be administered concurrently with NHT or chemotherapy are still open to question. The intensification of the treatment and the selection of patients with high volume/ high risk disease who are docetaxel fit are essential points, and at this moment the new backbone of the treatment in mHSPC is ADT plus NHT to which Docetaxel is added depending on the endpoints we want to achieve, safety profile and patients characteristics.

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The relationship between the pH value of Midazolam syrup made in the Clinical Pharmacy of the UKCS and the degree of sedation of pediatric patients

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Introduction: Midazolam is a benzodiazepine, available as Midazolam hydrochloride syrup for oral use. Midazolam, a white to light yellow crystalline powder, is not soluble in water. It can be dissolved in aqueous solutions by forming hydrochloride salts. Under acid conditions, Midazolam is present as a mixture of ring-closed and ring-open structures. To dissolve Midazolam in the aqueous solution, it is required to catalyze a benzodiazepine ring-opening reaction in an acidic environment. Above pH 5, at least 99% of the mixture is presented as a closed ring. Under the conditions under which the product is absorbed (pH from 5 to 8) into the systemic circulation, any present open-ring form reverts to the physiologically active, lipophilic, closed-ring form (midazolam) and is absorbed as such.

The pH dependence of mucosal absorption is suggested by the dependence of ring opening or closing in the molecular structure of midazolam. A significant amount of orally administered Midazolam can be absorbed in the mucous membranes of the oral cavity, esophagus, and stomach. This contributes to the rapid onset of action and good clinical tolerance.

Objective: The objective of this paper is to show the relationship between the pH value of midazolam syrup and the degree of sedation in pediatric patients to determine the possibility of optimally prepared midazolam syrup.

Method: The degree of sedation is subjectively assessed using a motor activity assessment scale. Three age groups of pediatric patients (from 0 to 3 years, from 3 to 8 years, and over 8 years) were examined at three clinics for three months. The children's demographic information is as follows: Out of 72 kids, 56 are male and 16 are female. The concentration of midazolam in the syrup is 1 mg in 1 ml. The dose of Midazolam is adjusted individually based on the child's age and weight, degree of anxiety, and desired level of sedation. In a clinical pharmacy, the pH values of midazolam syrup were determined. Midazolam syrup is made from Midazolam ampoules, which have a concentration of 15 mg per 3 mL, so the solubility of Midazolam has already been achieved in the ampoules. How the patient will accept the preparation that has been made depends a lot on its taste. Better-tasting pharmaceutical preparations are easier to administer to infants and young children, reducing wastage due to spillage during oral use. The general taste perception includes the initial taste, the taste after swallowing, and the appearance and texture of the preparation itself. The bitter taste of midazolam syrup can be improved with cherry, peppermint, and anise.

Results: Out of 24 prepared midazolam syrups, seven midazolam syrups have a pH value of 5.10 to 5.20. The lowest pH value of Midazolam syrup is 4.70 to 4.80, and this pH value was measured in two syrups. The highest pH value of midazolam syrup is above 5.50 and is measured in two midazolam syrups. Clinical effectiveness of premedication with Midazolam syrup - the degree of sedation during the observation period is as follows: the child is excited and crying (4 children), the child is awake and active (14 children), the child is active and calm (27 children), and the child is sleepy (3 children). The period from taking Midazolam syrup to the appearance of the first symptoms of action for all three age groups of pediatric patients is usually 10 to 15 minutes (14 patients).

Conclusion: The available data on the pH value of Midazolam syrup suggest that Midazolam syrup is effective for the sedation of pediatric patients. Midazolam syrup has a bitter taste, so it is necessary to add an agent to mask the taste.

New multicomponent crystals derived from acridine and selected hydroxybenzaldehydes: structural diversity and physicochemical examination

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The preparation, identification and characterization of different crystalline forms (cocrystals, salts, solvates, hydrates and their polymorphs) is one of the most active areas of modern solid chemistry [1]. The study of crystalline forms has implications for both basic science and applied purposes, as their different forms can exhibit a wide range of various physicochemical properties such as solubility, dissolution rate, thermal stability or bioavailability [1-2]. The family of multicomponent crystals containing drug combinations has great pharmacological potential and some technological advantages [3-4]. Acridine and two commonly found in nature hydroxybenzaldehyde isomers (3-hydroxybenzaldehyde and 4-hydroxybenzaldehyde), were selected for the study. Acridine and its derivatives are able to intercalate into the DNA double strand, causing deactivation of the genetic material [5]. 3-hydroxybenzaldehyde is described as a novel therapeutic agent with vasculoprotective potential [6] and therapeutic effect in atherosclerosis [7]. 4-hydroxybenzaldehyde sensitizes bacteria to antibiotics, has antioxidant and antipathogen properties, accelerates acute wound healing, shows beneficial effects on insulin resistance in an animal model of type II diabetes [8-9] and it also significantly increases specific protein production in infected host cells causing an enhanced defense response to invasion by the selected pathogen [10].

This studies describe the synthesis and formation of two new multicomponent crystals obtained from acridine and two isomers of hydroxybenzaldehyde: 3-hydroxybenzaldehyde (1) and 4-hydroxybenzaldehyde (2). Single-Crystal X-Ray Diffraction measurements show that compound 1 crystallizes in the triclinic P-1 space group, whereas compound 2 crystallizes in the monoclinic P21/n space group. In the crystals of title compounds, the molecules interact via O–H···N and C–H···O hydrogen bonds, and C–H···π and π–π interactions. An analysis of melting points shows that the compound 1 melts at a temperature lower than separate cocrystal coformers, whereas the compound 2 melts at a temperature higher than separate components of cocrystal. The FTIR measurements shows that the band attributed to the stretching vibrations of the hydroxyl group of hydroxybenzaldehydes disappeared, but several bands appeared in the range of 3000–2000 cm-1. The fact of obtaining new crystalline forms, characterized by unique crystal structures is confirmed by the analysis of the state of knowledge described in the Cambridge Structural Database (CSD).

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Keywords: Acridine; 3-hydroxybenzaldehyde; 4-hydroxybenzaldehyde; Multicomponent crystals; Salt; Cocrystal; SCXRD; FT-IR; Molecular interaction analysis; Melting point analysis.

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Synergistic effect of snail natural products and plant extracts with practical application

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Pure nature is a rich source of active substances, which have been proven to be important for human health. Therefore, as a result of many years of scientific research on Cornu aspersa garden snail extract and accumulated results, various extracts suitable for innovative cosmetic products and nutritional supplements have been developed.

Natural components from various plant species and in combination with a high-quality purified extract of the snail C. aspersum have proven the effect of accelerating tissue regeneration and strengthening the body's immune system.

The unique properties of the developed extracts are due to extremely important components such as collagen, elastin, allantoin, glucosamine glycans, proteoglycans, peptides and glycopeptides, glycolic acid, vitamins A, C and E.

The active ingredients are very similar in composition and structure to those in the human body, which supports the processes of skin recovery and regeneration.

The effectiveness and safety of the extracts, as well as antibacterial, antifungal, antitumor and antiviral effects, have been proven by mass spectrometric, proteomic analyses, as well as animal experiments.

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Photothermal performance of bimetallic Ag-Fe nanoparticles obtained by green synthesis

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Photothermal therapy is a type of cancer treatment that uses laser-irradiated nanoparticles to destroy cancer cells by heat. Among the many methods of nanoparticle synthesis, green synthesis combines simplicity, cost-effectiveness and versatility. The process involves the use of plant extracts as reducing agents. Furthermore, bioactive molecules in these extracts can offer additional therapeutic benefits. Metal and metal oxide-based nanoparticles are widely used in cancer therapy as drug delivery carriers, diagnostic agents and mediators of innovative therapies. Various metal ions, such as silver and iron, have demonstrated anticancer properties through different mechanisms. Bimetallic nanoparticles are of increasing interest because of the potential synergistic effect of the metals used.

The aim of our research was to develop bimetallic Ag-Fe nanoparticles as mediator for photothermal therapy using green synthesis. The shape and the size of the nanoparticles were analyzed using TEM and DLS, while energy-dispersive spectroscopy and FTIR were employed to determine their elemental composition and surface functional groups, respectively. The temperature changes of the nanoparticles suspensions under 808 nm laser irradiation were monitored using a thermal camera. Our results demonstrated that the nanoparticles were nearly spherical and had an average core size of 16-33 nm. Upon laser illumination, the suspensions exhibited a significant increase in temperature, sufficient for achieving hyperthermia. The Ag-Fe nanoparticles produced in this study demonstrated a great potential as a mediator of photothermal therapy.

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Development, characterization and stabilization of magnetic iron oxide nanoparticles for targeted drug delivery and magnetic hyperthermia

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The aim of the study is o develop iron oxide magnetic nanoparticles with optimal characteristics for targeted drug delivery and magnetic hyperthermia. Three models of uncoated iron oxide magnetic nanoparticles were obtained by co-precipitation method. For the traditional precipitation reaction, iron salts (FeCl3.6H2O, FeCl2.4H2O) were used in a 2:1 molar ratio and an alkalizing agent - 25% ammonia solution. The temperature conditions and the mixing sequence of the phases were varied. In order to limit the oxidation processes, an inert environment is provided by means of nitrogen. Based on literature data, two different techniques were applied to incorporate the biopolymer casein into the system. Particle shape, size and agglomeration were determined by dynamic light scattering, scanning and transmission electron microscopy. FTIR analysis was performed and superparamagnetic properties were investigated by Mössbauer spectroscopy.

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8-benzylamino-2'-deoxyadenosine as a potential radiosensitizer of DNA damage

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More than 80% of cancer cases are solid tumors, which are characterized by high levels of hypoxia resulting in their reduced sensitivity (radioresistance) to ionizing radiation used in radiotherapy. Radioresistance can be partially defeated by using compounds that sensitize cancer cells to ionizing radiation - radiosensitizers (RS).

A promising group of RS are modified nucleosides (Mnuc), characterized by high structural similarity to native nucleosides, so that they can be efficiently incorporated into genomic DNA. Structural modification of these compounds involves introducing of a substituent that increases the susceptibility of Mnuc to electron-induced degradation. The mechanism of action of modified nucleosides is related to the process of dissociative electron attachment (DEA). As a consequence of solvated electron (one of the main products of water radiolysis), an unstable anion radical of the nucleic base dissociates into a substituent anion and a highly reactive nucleoside radical. If DEA occurs for Mnuc incorporated into tumor cell's DNA, the reactive nucleic base radical may induce single-strand DNA break and even cell death [1]. Only a few examples of the DEA-based radiosensitizers from the purine group, such as halogenated derivatives of 2'-deoxyadenosine, can be found in the literature, although in double-stranded DNA the number of purine bases is the same as that of pyrimidine bases. Therefore, in the current work, we propose a new, potentially radiosensitizing derivative of adenine.

In this project, we perform quantum-chemical (QM) calculations using DFT method with the hybrid B3LYP functional, 6-31++G(d,p) basis set and PCM (polarizable continuum model) model of water in order to estimate if the titled derivative undergoes electron-induced degradation. The results of QM modelling show that after electron attachment 8-benzylamino-2'-deoxyadenosine (BenzylNH_2Ade) decomposes, with low activation barrier, to the benzyl radical and amino-2'-deoxyadenosine anion, which suggests that the studied Mnuc may have a radiosensitizing potential. Within the current study, we propose a synthetic protocol that efficiently leads to BenzylNH_2Ade. Namely, the first step was the bromination reaction of commercially available 2'-deoxyadenosine with using bromine in a mixture of acetate buffer and 1,4-dioxane to obtain the brominated derivative. Then, the resulting intermediate was reacted with benzylamine in methanol affording the desired product. The identity of the obtained derivative was confirmed with the ^{1}H NMR, ^{13}C NMR, and LC-MS methods, while its purity was determined with RP-HPLC.

In the next step, the susceptibility of BenzylNH_2Ade to electron-induced degradation in an aqueous solution will be tested, employing stationary radiolysis. If the radiolysis of the studied derivative efficiently produces degradation products, BenzylNH_2Ade will be subjected to *in vitro* experiments with chosen cancer cell lines in order to assess its radiosensitizing activity at the cellular level.

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The overabundance of excited hydrogen atoms produced in the H_2^++ furan reaction

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Ion-molecule interactions proceed in nature and are of technological importance. For instance, they account for most reactions occurring in space. On the other hand, they are highly applicable to microscopy, etching, and deposition triggered by focused ion beams. Probing the ion-molecule collisions also shed light upon the ion-induced damages in hadron therapies and the biological material of astronauts in a space radiation environment.

This communication presents the survey on the H_2^+ + C_4H_4O collisions. Furan, C_4H_4O, is an archetypal heterocyclic molecule viewed as a simple gas-phase equivalent to deoxyribose sugar and a forerunner to many speciality chemicals [1]. H_2^+ is the simplest molecular ion existing in the cosmos. The measurements have been carried out at the University of Gdańsk, exploiting a collision-induced emission spectrometer [1]-[3] operating in the cations' energy range of 20–1000 eV.

The ion-molecule interaction is governed by three collisional processes (i.e., charge transfer, dissociative ionization, and dissociative excitation) that lead to the decomposition of the target molecule. In typical conditions, the ion-induced fragmentation channels are statistically distributed across all degrees of freedom of the target. However, in the furan fragmentation spectra induced by H_2^+ ion impact, we have detected very strong luminescence of the hydrogen Balmer lines whose intensities decrease more quickly than derived by the quantum-theoretical principle ($I \sim n^{-3}$). The spectra also reveal the bands of vibrationally and rotationally excited CH radicals. The respective branching fractions of H and CH emissions are 47.2 and 52.8%. Such unprecedented unstatistical behavior cannot be explained only by the fragmentation itself. Some fraction of excited hydrogen atoms may come from the direct dissociative excitation of H_2^+ projectiles or an electron transfer from furan molecules to cations following the neutralization and further H_2 fragmentation. These and other likely collisional mechanisms leading to enhanced production of the hydrogen atoms will be discussed in detail, considering measured spectra, relative emission cross-sections of the excited species, and depopulation factors of hydrogen excited states.

Acknowledgments: The experiments were carried out at the University of Gdansk using a spectrometer for collision-induced emission spectroscopy. Therefore author thanks professors: A. Kowalski (Univ. of Gdansk) and B. Pranszke (Gdynia Maritime Univ.) for enabling the present measurements.

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Research and characterisation of novel flexible materials for radiochromic film design

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According to Slobodan[1], in radiotherapy, an accurate dose determination and a precise dose delivery to the tumour are directly associated with better treatment outcomes in terms of higher tumour control and lower post radiotherapy complications. For a long time, radiochromic films have become an indispensable tool for radiotherapy treatment verification and quality assurance.

In this project, physicists, electronic engineers, organic and analytical chemists are collaborating to develop a flexible radiochromic film, as only semirigid radiochromic films are currently commercially available, which is a disadvantage for clinical use.

Therefore, we have made different tests with several materials (plastics, papers, fabrics, etc). Finally choosing the fabric as a support for the radiochromic film because it is a flexible material capable of adapting to different parts of the human body. Examples of fabrics that have been used are polyester, polyacrylic, cotton twill, cotton flannel and corduroy, selecting those that showed the best results when irradiated with ionising radiation. Currently the best performers have been polyester, polyacrylic and cotton flannel.

In order to measure ionising radiation, we use a chemistry based on 10,12-pentacosadiynoic acid (PCDA), a photoactive compound, when is irradiated with ultraviolet, X – ray, or γ – radiation, it suffers a polymerisation causing a visible colour change from colourless to blue[2]. The radiochromic film is prepared as follows: a solution of PCDA is prepared, the fabric is immersed in the solution and them is allowed to dry completely. Once dried, it must be protected from light until irradiation in the linear electron accelerator (LINAC) to avoid polymerisation of PCDA.

Several calibrations from 0.3 to 50 Gy have been carried out to test the sensitivity and reproducibility of different types of fabrics. After each radiation, the fabrics were photographed in controlled lighting conditions and the saturation (S) coordinate from the HSV colour space was used as analytical parameter. A linear relationship have been obtained when cotton flannel ($y=0.023x+0.172$, $r^2=0.998$) and polyester ($y=0.010x+0.253$, $r^2=0.981$) were radiated from 0.3 to 2.7 Gy. In addition, the relative standard deviation obtained for each material was 2.8 % (n=5) for cotton flannel and 2.1 % (n=5) for polyester. Finally, stability tests have also been carried out over time to check how the fabrics are affected by environmental conditions (ultraviolet light, heat, etc.) and it has been found that the chemistry used is very sensitive to light, so the fabrics must be stored in dark conditions.

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Cyclotron production of thulium-167 for medical applications

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In nuclear medicine, targeted radionuclide therapy (TRT) has been highlighted for its capability to target small tumor masses while sparing healthy tissues. This technique is particularly appealing when using Auger-electron emitters, which potentially exhibit high efficacy in treating small metastases, including single tumor cells [1]. However, their radiobiological effects have yet to be fully understood ([2], [3]). To assist in determining these effects, various Auger-electrons emitters should be produced in high quality and activities for systematic preclinical studies. Thulium-167 is listed among the candidate radionuclides for its suitable nuclear decay properties (half-life 9.25 days, > 10 Auger e^-/decay). In particular, it could be exploited in both therapy and diagnosis due to the emission of a large number of low-energy Auger electrons [4] and of an intense ($I_\gamma = 42$ *%*) 208-keV gamma ray, respectively.

The aim of this work is to study the feasibility of large-scale production of the Auger emitter thulium-167. The production cross sections of thulium-165, thulium-166, thulium-167, and thulium-168 were investigated using a medical cyclotron. Enriched erbium oxide materials ($^{167enr}Er_2O_3$, $^{168enr}Er_2O_3$) were proton-irradiated up to 18 MeV at the Bern University Hospital Cyclotron Laboratory. The results were compared with theoretical calculations obtained from the TENDL 2019 library. Production tests were also performed to assess the measured experimental cross sections. Furthermore, thulium-167 production yields were determined using five different target materials ($^{167enr}Er_2O_3$, $^{168enr}Er_2O_3$, $^{nat}Yb_2O_3$, $^{171enr}Yb_2O_3$, $^{nat}Tm_2O_3$) at Paul Scherrer Institute. Several experiments were performed with each material using various proton energies up to 63 MeV to determine maximum thulium-167 production conditions.

The experimental cross sections are generally in good agreement with the TENDL 2019 theoretical calculations. The experimental production yields results were also well predicted by theoretical calculations. In addition, our experiments showed that proton irradiation of enriched $^{171enr}Yb_2O_3$ ($E_p = 53$ *MeV*, irradiation time of 8 hours) produces about 400 MBq of thulium-167 with a radionuclidic purity of 99.94 %. On the other hand, predictions based on 2-hour irradiations (with $E_p = 19$ *MeV*) show that 1 GBq activity of thulium-167 could be produced by irradiating $^{168enr}Er_2O_3$ with a radionuclidic purity of about 98.5 % after a 5-day cooling time. The next step will involve developing a fast and well-resolved chemical separation method to maximize the chemical purity of the final product in view of a radiolabeling procedure.

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Antimicrobial activity of PPIX-SUV liposomes against *Escherichia coli* and *Pseudomonas aeruginosa*

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Protoporphyrin IX (PPIX) is a well-known photosensitiser (PS) that has potential for use in antimicrobial photodynamic therapy (aPDT). Liposomes can allow the incorporation of lipophilic and hydrophilic drugs and PS in their matrix, enhancing their clinical effects, solubility, delivery to the target cells and usage in PDT therapy. The objective of this study is to determine if PPIX encapsulated inside the SUV liposomes has the ability to kill two types of bacteria, *E. coli* and *P. aeruginosa*.

PPIX-loaded liposomes ($C_{PPIX} = 1 \cdot 10^{-5}$ M) were prepared using dry PPIX-lipid film method and extrusion through filters with 100 nm pores to obtain SUV (small unilamellar vesicles) liposomes. PPIX-SUV liposomes were added in sterile erlenmeyer with bacterial cultures, and placed on magnetic stirrer with continuous stearing. Antimicrobial activity of PPIX-SUV liposomes was initiated by photosensitization reaction with visible light in cylindrical hand-made photochemical reactor. Light intensity of used lamps was approximately 40000 lux.

Obtained results showing that PPIX-SUV liposomes has inhibitory effect in both cases, against *E. coli* and *P. aeruginosa*. The number of *E. coli* and *P. aeruginosa* in control samples were 7.28±0.02 and 7.38±0.09 log CFU/ml, respectively. After 10, 20 and 30 min of irradiation the number of bacterial colony units were 6.77±0.08, 6.83±0.04, 6.26±0.05 log CFU/ml for *E. coli* and 6.31±0.01, 6.29±0.01, 6.05±0.08 log CFU/ml for *P. aeruginosa*, respectively. Presented results implicating that PPIX-SUV liposomes have good potential for aPDT therapy, but antimicrobial properties are time and light intensity dependent.

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In situ monitoring of the influence of water on DNA radiation damage by near-ambient pressure X-ray photoelectron spectroscopy

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Ionizing radiation damage to DNA plays a fundamental role in cancer therapy [1]. X-ray photoelectron-spectroscopy (XPS) allows simultaneous irradiation and damage monitoring. Although water radiolysis is essential for radiation damage, all previous XPS studies were performed in vacuum. Here we present near-ambient-pressure XPS experiments to directly measure DNA damage under water atmosphere. They permit in-situ monitoring of the effects of radicals on fully hydrated double-stranded DNA. The results allow us to distinguish direct damage, by photons and secondary low-energy electrons (LEE), from damage by hydroxyl radicals or hydration induced modifications of damage pathways. The exposure of dry DNA to x-rays leads to strand-breaks at the sugar-phosphate backbone, while deoxyribose and nucleobases are less affected. In contrast, a strong increase of DNA damage is observed in water, where OH-radicals are produced. In consequence, base damage and base release become predominant, even though the number of strand-breaks increases further [2].

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Processes limiting performance of heavily-doped lead tungstate scintillators

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Substantially faster scintillator response is put forward as the key property needed for the scintillation materials to be exploited in the radiation detectors for the coming high-energy physics (HEP) experiments and the next generation of medical imaging devices. In spite of its relatively low light yield, lead tungstate ($PbWO_4$, PWO) is the scintillator of choice for big HEP facilities, already running (e.g., CMS and ALICE at CERN) or under construction (e.g., PANDA at DESY). The prospective to make this scintillator even faster by heavy doping by yttrium and lanthanum is under focus of the current study.

Time-resolved photoluminescence spectroscopy in the temperature range from 80 to 400 K and large dynamic range of excitation intensities has been performed on PWO samples with different doping level, dynamics of nonequilibrium carriers has been studied using the measurements of transient optical absorption, and the light-induced transient grating (LITG) technique has been exploited to study excitation diffusion.

A single emission band observed in the luminescence spectra of all samples evidenced the dominance of a single emission mechanism – the recombination of self-trapped excitons localized at oxyanionic complexes in the regular lattice of PWO. The small upper limit of the diffusion length of this excitation (100 nm) revealed in LITG experiments supports this interpretation. The luminescence decay is strongly nonexponential. Doping by Y and La enhances the fast decay component dominating within the first few nanoseconds of the decay. The nonexponential decay is interpreted by the contribution of radiative centers distorted at a different extend due to the influence of the impurities located at different distances from the centers. Temperature dependences of luminescence intensity and its decay time enabled us to reveal the influence of different decay components and to estimate the activation energies for nonradiative recombination.

Nonlinear phenomena have been observed at increasing density of nonequilibrium carriers. The luminescence intensity increases linearly, as expected for recombination of self-trapped excitons, at low excitation intensities but tends to saturate at intensities resulting in the generation of nonequilibrium carriers at densities above 10^{20} cm^{-3}. Moreover, our transient absorption experiments revealed a fast component in the decay of nonequilibrium carriers which increases at increasing carrier density. The emission intensity saturation and the decay kinetics were interpreted by the contribution of nonradiative Auger-type recombination due to dipole-dipole interaction. The rate of tis Forster dipole-dipole interaction has been calculated as a function of dipole density and enabled a satisfactory description of the decay of the density of self-trapped excitons observed in transient absorption experiments.

We showed that the luminescence decay in PWO can be substantially accelerated by heavy Y and La doping, however, at the expense of emission efficiency. Thus, a trade-off between these properties have to be selected. Further enhancement of the luminescence decay is caused by nonradiative Auger recombination but occurs only at high excitation densities.

Crystal evaluation and gamma-ray detection performance of press mold thallium bromide semiconductors

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High atomic number compound semiconductor, thallium bromide (TlBr), has excellent gamma-ray attenuation coefficient and were suited for photon counting detectors with high detection efficiency. In this study, TlBr crystals were formed by the hot press technique using originally purified TlBr materials by the multi-pass zone refining method. The purified TlBr crystals (17.5 mm diameters x 5 mm) were located on between punch prates inside press molds. Press temperatures varied between 455 and 465 °C and the period keeping pressure (~30 kN) was 2 hours. Resultant TlBr crystals were 2 mm x 2 mm x 2.5 mm. Stress induced TlBr crystals was observed using polarized light. Crystal orientation on TlBr crystal surface and depth direction ware evaluated by X-ray diffraction and electron back scatter diffraction (EBSD). The mold TlBr crystals were cut into 5 mm x 5mm samples and the both crystal surfaces were mechanically polished using # 2000 SiC sheets. Gamma-ray energy spectra and current-voltage characteristics have been measured as detector evaluation.

Parts for gamma radiation detectors made of electrically conductive thermoplastic filaments by additive 3D printing

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In recent years, additive manufacturing, or extrusion 3D printing, has developed rapidly.

3D printing from a variety of thermoplastic materials makes it possible to produce complex-shaped parts faster and easier than traditional manufacturing processes such as turning, milling or casting. This opens up new possibilities for design. This method allows integrating the properties of different materials into one part without a special process of joining them. For example, an electrically conductive material can be combined with a dielectric material to create conductive circuits within a manufactured part.

Various samples of filaments with the highest electrical conductivity were fabricated. The effect of printing modes on the properties of the samples, the dependence of an electrical resistance of the samples on ambient temperature and behavior of the samples, when they are connected to a voltage source and used as heaters were studied.

As a practical use of conductive filaments, some parts of housings for gamma and X-ray detectors were fabricated. One of the main requirements for such parts is a good EMI shielding. Therefore, detector housings are usually made of metal. However, due to the complex design, the process of making a metal case often can be time consuming and expensive. Therefore, the ability to manufacture housings from conductive thermoplastic using 3D printing will simplify the production process, especially at the initial stage of product development, when it can be necessary to manufacture several product variants. Cases of miniature gamma-ray detectors, previously made of brass, were manufactured and tested. Tests have shown the possibility of replacing brass cases with 3D printed ones.

In addition, microspectrometer housings, previously made of aluminum, were manufactured and tested. The test results showed that the additive 3D printing method could be used for the production of such cases.

Another important requirement for housings of radiation detectors designed to detect low-energy gamma and X-ray radiations is the presence of a low-absorbing entrance window through which the radiation reaches the detector. In addition to low radiation absorption, such a window should provide reliable EMI shielding and mechanical protection, as well as protection from visible light. To ensure low absorption of radiation in the entrance window, materials with a low atomic number and low density are used.

The electrically conductive thermoplastic material, primarily based on graphene, having a relatively high electrical conductivity and relatively low atomic number and density, could in principle be used as low-absorbing detector entrance windows instead of traditional used aluminum or beryllium windows. Entrance windows of various conductive filaments were fabricated and tested. The degree of radiation absorption in the windows of different thicknesses for different energies of gamma radiation was studied, and the possibility of using them to provide EMI shielding was evaluated.

Non-destructive testing of alternative materials for storing radioactive waste using computed 3D gamma tomography

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In May 2021, the SPE-CT equipment for computed gamma tomography of the Research Center Rez underwent its third major modernization in a row. The modification enabled an unprecedented refinement of the method and, among other things, the expansion of the static 3D display with a time-lapse recording, which can provide information, for example, about the kinematics of groundwater migration processes in the geological subsoil of locations selected for the construction of a future permanent repository for radioactive waste.

One of the set goals was to assess the possibilities of using the SPE-CT equipment for the TA CR project TREND ALMARA Program, which is discussed in this presentation. As part of this project, small cores made of irradiated metals were embedded with the studied fixation matrices. After solidification of the matrix, the possibility of determining the exact position of these coupons in the matrix using our device was tested by a non-destructive method. The formation of corrosion products on contact with both materials and the subsequent migration of radioisotopes in the matrix were also studied.

Small detectors with inorganic scintillator crystals of CsI(Tl) for gamma radiation and heavy ions detection

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It were manufactured three small detectors with inorganic scintillators crystals of CsI(Tl) to search which size is the best for a good detection of gamma and alpha radiation. The crystals are produced in China. The differences between these crystals are the dimensions: 18x18x25mm^3, 18x18x30mm^3 and 18x18x40mm^3. Each crystal is connected to a large area PIN silicon photodiode (type S3208-04 from Hamamatsu, Japan). The impurity of thallium is 1500ppm and from this reason the crystals have spectrometric properties. The signal from each detector is send to a miniaturized charge sensitive preamplifier (30x35x5mm^3), dedicated for this type of photodiode. To test these detectors we use some punctual gamma radioactive sources of Co-60, Cs-137, Am-241 and the triple alpha source (Pu239-Am241-Cm244). The best energy resolution (2.8keV at the 1332keV) was obtained for gamma radiation and 3.8keV for alpha radiation in the case of 18x18x40mm^3 crystal dimensions of CsI(Tl). For the other two crystals, the values of the energy resolutions are not good. The spectra were registered with a multichannel analyzer type N957 and a Spectroscopy Amplifier N968, from CAEN Italy. The software of acquisition is called Interwinner 6.0.The advantage of this small detector is the lower price and the possibility to introduce it in any tight space from a nuclear setup, near other bigger detectors, because the photodiodes are not affected by magnetic fields.

Temperature effect on the sensitivity of PIN diodes used as gamma dosimeters

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Introduction: The temperature effects on PIN photodiode-based dosimeter has to be considered to obtain a correct readout of the dose due to the high temperature dependence of these devices [1]. According to some previous works, the BPW34S PIN photodiode was characterized as a promising dosimeter for gamma photon beams [1,2]. In this work, the thermal dependence of the sensor sensitivity has been studied varying the device's temperature during irradiation.

Method and materials: Radiation source: Irradiation tests were conducted at the CNA (National Accelerators Centre), in Sevilla (Spain). In particular, tests were carried out with a GammaBeam X200 based on Co-60 source. Eight irradiation sessions, at different temperatures, were programmed with an average dose rate of 0.5 Gy/min to provide an accumulate total dose of 8 Gy (Si) per sample. The devices were irradiated during 2 minutes to provide 1 Gy per session.

Reader unit: The reader unit developed in our research group was used to monitor the photo current induced by the proton beam [2]. Sensors were reverse biased at 10 V, and the device´s induced current was converted to voltage with a transimpedance amplifier based on the operational amplifier TL072 (Texas Instruments, Dallas, TX USA) with a feedback resistor of 4.7 MΩ, achieving a theoretical current resolution of 80 pA. However, the circuital electronic noise limited this resolution to 200 pA, which is enough for our application. To measure the temperature and thus be able to compensate the strong dependence on the dark current, the devices were forward biased using a current source to obtain the diode forward voltage which is related to the photodiode temperature [1].

Experimental setup: a PRESTO A80 by Julabo was used for the temperature swept, capable of adjusting the temperature from -80 to 250 °C. Three samples were situated on a heatsink connected to the temperature system. We used thermal paste to provide a hight heat conductivity ensuring thermal equilibrium. The temperature during the irradiation sessions was set[C1] from about -25°C up to 75°C. First, the devices were irradiated at room temperature and the initial sensitivity was registered. After, the temperature was set at 75°C and the cooling process started down to -25 °C.

Results: An increase of the sensitivity of (26 ± 3) % was found from the lowest to the highest temperature, observing a monotonous but non-lineal behaviour. In addition, the current during non-irradiation periods (dark current) has been compensated to avoid errors in the dose determination.

Conclusions: A nonlinear increment of sensitivity with temperature has been found. This effect could be explained due to the band gap energy reduction with temperature. This fact favours the creation of electron-hole pairs by decreasing the energy required for pair creation [3]. Furthermore, the dark current compensation [1] was successfully applied removing the increasing photocurrent induced by the higher temperatures.

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Graphene based nanostructures for ionizing radiation sensing

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Hybrid nanocomposites combine the useful properties of individual components and therefore have a high potential for application in devices of different purposes. Nanosystems based on silicon and graphene nanostructures are the focus of particular attention [1-3]. The exceptional properties of graphene are due to the cone-shaped energy structure of the 2D carbon material. The high mobility of charge carriers, the high electrical conductivity, and the low noise of graphene are significant advantages for creating a new elemental base of nanoelectronics. The development of graphene field-effect transistors (FETs) and highly sensitive gas and radiation sensors is based on the ability to control graphene conductivity by an electric field [2, 3].

The sensitivity of the electrical properties of graphene to local changes in the electric field enables graphene FET to detect light photons and other types of ionizing radiation due to radiation-induced charge carriers in the silicon substrate. In this study, the field-effect transistors based on the oxidized porous silicon (PS) – reduced graphene oxide (rGO) sandwich-like composite has been created. The electrical characteristics of the obtained FET were studied in both DC and AC modes. *I-V* curves and switching characteristics of the PS–rGO-based FET were analyzed. An increase in resistance and a decrease in capacitance of the experimental structures have been found in the 25 Hz – 1 MHz frequency range due to the joint action of α-, β-, and γ-radiation. The parameters of the equivalent circuit model of the PS–rGO-based FET before and after irradiation with ^{226}Ra isotope have been determined using impedance spectroscopy. The formation of radiation-induced defects and the charge accumulation in the PS layer is considered a possible mechanism of the ionizing radiation influence on the graphene FET conductivity. The FET based on the PS–rGO structures has a high potential for application in ionizing radiation sensors due to the linear dependencies of resistance and capacitance on the irradiation duration. The obtained results can be used to create a new type of dosimetry device based on graphene FET integrated into modern silicon technology.

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Performance evaluation of gamma emission tomography to interrogate partial defects of spent nuclear fuel assembly

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Introduction: Spent nuclear fuel (SNF) is the high-level waste from nuclear power generation, and it includes fissile materials such as U^{235} and Pu^{239}. The SNF can be diverted to a nuclear weapon for military purposes, and an accurate inspection method has been required to prevent missing, theft, or defect of SNF. The IAEA has developed the gamma emission tomography (GET) device, which is named passive gamma emission tomography (PGET), to detect partial defects within the SNF. The GET device has been reported high-reliable inspection technique because it can interrogate partial defects by pin-by-pin level using a cross-sectional image of SNF. The PGET device, however, has low inspection accuracy owing to which is composed of a CdZnTe detector with a small radiation detection area. To improve the inspection accuracy of the GET device, we proposed the GET device named Yonsei single-photon emission computed tomography version 3 (YSECT.v.3) which was composed of the GAGG scintillator with a larger detection area than the CdZnTe detector. This current study aims to evaluate the performance of the YSECT.v.3 prototype device and to develop a denoising technique based on a machine learning.

Materials & Methods: The detection module of YSECT.v.3 was composed of the parallel collimator, 46-channel trapezoidal GAGG scintillator, and SiPM, and it was fabricated based on the optimal geometrical structure. To evaluate the performance of the YSECT.v.3 device, the projection images and the sinograms were obtained using the 1 μCi Cs-137 sources. To obtain a high-quality tomographic image using the machine learning-based denoising algorithm, a large amount of training data set is required. For this reason, the data extension technique based on the Monte Carlo method was developed. The particles were generated at all fuel rod locations using the GEANT4 toolkit, and the rotation angle, detection module number, channel number, deposited energy, and particle generation position were stored if the particle was detected on the channel of detection module. The sinograms for any pattern of partial defects can be generated by choosing the source generation position with one simulation. Based on the developed technique, 6,000 sinograms for training the machine learning algorithm were generated. The tomographic images were converted using the iterative reconstruction with geometry awareness prior. To evaluate the performance of the developed algorithm, pattern classification accuracy was analyzed through a true/false map.

Results & Discussion: To validate the performance of the fabricated detection module, the full width at half-maximum (FWHM) of the projection and the tomographic image was calculated. The sinograms were reconstructed using the filtered back-projection with the Ram-Lak filter. The FWHMs of projection and tomographic images were analyzed as 7.2 mm, respectively. The pitch of the fuel rod within the SNF assembly is above 12.32 mm, thus the YSECT.v.3 could discern the fuel rod location. The convolutional autoencoder (CAE), which is an artificial neural network optimized to image data, was employed to obtain a high-quality tomographic image. The CAE algorithm was a symmetric structure, and it was composed of the input layer, the encoder (2x convolution layer, 2x maxpooling layer), the decoder (2x upsampling layer, 2x maxpooling layer), and the output layer. Among the 6,000 tomographic images, 5,950 images were used for the training data set, and 50 images were used for the test data set. The pattern classification accuracy of denoising images was analyzed as almost 100%.

Conclusion: In this study, we evaluated the performance of the YSECT.v.3 prototype device and developed a machine learning-based denoising algorithm. Our results show that the YSECT.v.3 device and machine learning-based denoising algorithm could be employed for SNF inspection. The experimental study will be followed fort the on-site application of this technique in Korea.

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Study of the angular dependence of a photodiode-based dosimeter using Monte Carlo simulation

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Ionization chambers are the devices most commonly used as dosimeters in radiotherapy. They show, however, some limitations compared to other systems based in semiconductors: large sizes, high voltage requirement for biasing, etc. Some current-mode semiconductor devices have been studied for the same purpose, such as photodiodes and phototransistors. For these devices, the absorbed dose is proportional to the current integrated over the exposure time.

Nevertheless, one of the most important features of this type of dosimeters is its angular dependence. This characteristic refers to the possible change in the sensitivity of the dosimeter according to the direction of the incident radiation. The angular dependence of dosimeters can be important, especially in situations where the radiation source is not isotropic or when they are not positioned in the direction of the radiation. In such cases, dosimeters may not accurately measure the radiation dose received by the patient.

Aiming at reducing this angular dependence, a special dosimeter has been developed. It consists of a cube with a photodiode in each face, connected forming a parallel circuit that allows us to accumulate the induced charge in the whole device. Theoretically, this configuration should reduce the angular dependence due to its symmetry. The sensor used in this cubic configuration has been the BPW34S photodiode, because it presents good properties for radiation measurements [1].

Using the Monte Carlo codes PENH [2,3] and FLUKA [4], we have analyzed the response of this device. In the simulations, a 10x10 cm^2 square field photon beam impinges in a water phantom, where the dosimeter is situated. An air layer is considered between the phantom and the radiation source. The incidence angle of the radiation is changed to study the angular dependence. The angles considered in our analysis were 0°, 15°, 30°, 45°, 60°, 75° and 90°. The implemented geometry reproduces the experimental setup that is going to be used to characterize the angular dependence of the device.

Each photodiode was modeled as a plastic housing with an internal silicon die according to the dimensions provided by the manufacturer. The energy deposited in the six silicon dies was calculated as a function of the incidence angle and compared to the response for the normal, 0°, incidence that is considered as the References value. Our results show a significant angular dependence for the device. This is due to the fact that electron equilibrium is not reached in all the photodiodes in the configuration considered [5]. In order to reach electron equilibrium, a plastic encapsulation is added to it. The encapsulation size depends on the energy of the source used during the irradiation [6]. The encapsulation produces a reduction in the angular dependence, improving the response of the dosimeter.

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Sensory properties of new films based on poly(vinyl-alcohol) and pyridone azo dyes

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Polymeric materials are widely used in the chemical and optical industries, the packaging materials industry, and biomedicine. New technologies and the search for innovative and sustainable solutions have contributed to the development of polymer sensors and smart materials. Poly(vinyl-alcohol) (PVA) is a thermoplastic polymer soluble in water. It belongs to the group of non-toxic and completely biodegradable polymers, with excellent thermal and mechanical properties. Polymer-colored films have great potential as sensor systems, primarily due to their visual color change, which makes them easy to use. Azo dyes, which are used for coloring polymer films, represent the most important class of synthetic dyes, and their exceptional properties are reflected in high extinction coefficients, as well as excellent fastness to light and wet processing. Traditionally, azo dyes are used in the food and cosmetic industries, and are also used as pH indicators.

In this work, in addition to the synthesis of azo pyridone dyes, polymeric films were also synthesized. The first series of films were synthesized based on PVA and newly synthesized azo dyes, and the sensory properties of the new films were tested. The second series of films were synthesized in order to test the films as dosimeters for γ-radiation, and for this reason, TTC was added to their synthesis. The dye used in the experiments were characterized by ATR-FTIR, NMR and UV-Vis spectra. The chemical structure of the synthesized films was analyzed by ATR-FTIR spectroscopy. The sensory properties of the film were tested in solutions of different pH values, while the possibility for application in dosimetry was tested at different doses of γ-radiation at the ^{60}Co source. Changes in the color of the films were monitored spectrophotometrically by recording reflection spectra.

Ionization chamber for gamma measurement in harsh environments: calibration and first steps

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Energy generation through nuclear fusion processes is one of the main objectives of the European Fusion Plan, composed of three main projects: ITER, DEMO and IFMIF-DONES [1].

To achieve the fusion of the plasma particles, the idea is to build a tokamak, where the monitoring of the environmental parameters is essential in the development of the operation, with the difficulty that the conditions in which the detectors are located are extreme, compromising not only their response capacity but also their durability, as unprecedent large radiation fields and high temperature are expected.

In this framework, IFMIF-DONES will be one of the most demanding facilities, since its main purpose is to test and validate materials to be used in future fusion power plants, so it must generate extreme conditions that allow to characterize the evolution of materials in an accelerated manner [2]. Considering this, both a strong gamma radiation field and a high neutron flux (~ 5×10^{18} n cm^{-2} s^{-1} of 14 MeV neutrons) are foreseen.

One of the sensors selected to carry out the gamma radiation measurements is the ionization chamber, which is not only useful to perform this detection, but also to discriminate this component from that due to neutrons when combined with other sensors such as fission chambers or self-powered neutron detectors (SPNDs). Specifically, the model chosen is the CRGR10/C5B/UG2 from the manufacturer Photonis, which have a coaxial geometry with very small diameter, 3 mm, and a length of the sensitive part of only 14 mm.

Before its implementation in the final system, it is necessary to undertake a complete characterization of its response under conditions as similar as possible to those expected in the final project. To do that, ionization chambers will be tested in different settings to understand the influence of parameters such as temperature, polarization voltage, or the influence of a certain density of sensors in the surroundings, among others.

The first radiation test is planned at the Radiodiagnosis Unit of the San Cecilio Hospital (Granada), with a LINAC capable of generating a photon beam for clinical applications. The main objective is to ensure that the device measure correctly, generating signals easily distinguishable from the background one. After these first tests, it is planned to move to harsher radiation environments in the medium/long term, looking for conditions increasingly similar to those expected at IFMIF-DONES. In this work, the very preliminary results are presented.

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NFC-based dosimeter with stacked pMOSFET configuration for enhanced sensitivity

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Introduction: Aiming to enhance the quality of medical ionizing radiation, in vivo dosimetry is a technique used to measure radiation doses received by patients during radiotherapy sessions [1]. Dosimetry systems have been developed for this purpose, but they require a reader unit apart from the sensor modules, which can make the system complex and costly. Here, a portable and wireless alternative to desktop reader units for radiation dose measurement is proposed. The developed system uses Near Field Communication (NFC) technology [2, 3] and a customized smartphone application for measurement, data storage, and cloud publication. The system harvests energy through the NFC link and uses the Message Queue Telemetry Transport (MQTT) protocol for data uploading, allowing for individual patient control and follow-up. The system presented in this study is an improved version of a previously developed NFC dosimeter [3] that features a lateral commercial pMOSFET CD4007 biased at Zero Temperature Coefficient drain current to minimize thermal dependence, and in a two-stacked configuration to improve sensitivity [4]. The new design[APG1] retains the microcontroller unit (MCU) and high-resolution channel (HRC) of the previous design, but it now includes full control over the measurements. This allows for multiple measurements to be taken in a single reading with improved sensitivity.

Materials and methods: The use of a two-stacked configuration in the dosimeter system requires additional energy to operate, as compared to the previous design. In order to address this, two successful strategies have been tested, including the utilization of an auxiliary antenna to harvest energy, and the full-wave rectification facilitated by the diode bridge included in the design. To irradiate the dosimeter tags, a LINAC Siemens Artiste will be used with 6 MeV photon beams in a 20x20 cm² irradiation field, administered in 3 Gy sessions. To reach electronic equilibrium, a 1.5 cm solid water layer will be employed as a build-up layer. The threshold voltage will be subsequently measured after the irradiation of 2 minutes, and the voltage shift will be calculated.

Results and conclusions: In previous studies, the sensitivity value obtained was (5.70 ± 0.04) mV/Gy for single CD4007-based dosimeter, respectively, with corresponding resolutions about 1 cGy. The employment of a stacked CD4007 configuration is expected to result in a twofold increase in sensitivity, as well as enhanced resolution. In summary, the current study proposes a wireless NFC-based alternative for radiation dose measurement designed to enhance patient comfort and create a user-friendly interface for healthcare staff while reducing the overall expenses and complexity of the system.

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Characterization of a MSND detector inside a rem counter

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In hadrontherapy centers one of the main concerns for radiation protection are the secondary neutrons generated by the impinging of the beam with structural elements and the patient. In fact, several neutron attenuation studies were conducted over the years. Neutron energy distribution can vary from meV to GeV so over the years many devices were developed from gaseous to scintillators detectors.

In recent years, the interest in Microstructured Semiconductor Neutron Detectors (MSNDs) is growing for their low voltage requests (5V), high photon-neutron discrimination ratio, low costs and in general their ease of use.

In this study the characterization of a MSND detector inside an extended-range rem counter is carried out for neutron dosimetry evaluations. The detector adopted is the DOMINO V5.4 manufactured by Kansas State University. The detector is made of a 4 cm^2 silicon substrate with trenches backfilled with LiF with a thermal neutron efficiency of 30%. The rem counter adopted is a 12.5 radius polyethylene sphere with cadmium inserts and a lead shell inside.

The detection system was simulated in the Monte Carlo code FLUKA. The first set of simulation was performed in order to evaluate the detector response curve as function of the neutron energy. In particular, the detector response needs to be consistent with the “fluence to ambient dose equivalent conversion factors” over an extended range.

Another set of simulations were conducted to calculate the calibration coefficient, from counts to ambient dose equivalent, evaluated in nSv/count, of the detection system with a Am-Be isotropic source simulated in FLUKA.

Finally, the calibration coefficient was validated with different neutron fields from the Neutron Metrology Laboratory of the Polytechnic University of Milan and the CERN-EU high-energy References Field (CERF) facility.

Scintillation characteristics of pure cesium iodide crystals and doped with Tl^+, Br^- and Li^+ ions for use as radiation detectors

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In recent years, more attention has been devoted in the discovery of new scintillators or to improve the characteristics of known scintillators. Today inorganic scintillators are exploited in many new fields such as positron emission tomography (PET) computerized X-ray tomography, space physics and astronomy. Inorganic crystals are the scintillators most commonly used for the detection of gamma rays, X-rays and thermal neutrons. CsI:Tl, CsI:Br, CsI:Li and pure CsI crystals were grown in our laboratory using the vertical Bridgman technique. The concentrations of dopants ranged from 10^{-1}M to 10^{-4}M. The intentional introduction of a certain ion into a crystal depends on physical and chemical properties, that is, the dopant and the matrix. In physical terms, there is a limitation on the volume of ions that can in principle be introduced into the crystal lattice. Furthermore, any substitutional arrangement must preserve the electrical neutrality of the crystal. In chemical terms, one must consider which dopant will accumulate in the phase in which its introduction results in a smaller increase in the free energy of the system. This parameter is represented by the impurity segregation coefficient. It was observed that the wavelength of maximum luminescence emission is characteristic for each crystal. Pure cesium iodide crystal showed maximum intensity of luminescence at the wavelength of 320 nm. The CsI:Tl crystal showed luminescence at a wavelength of 540 nm. CsI:Br and CsI:Li crystals showed maximum luminescence around 420 nm. Analyses were carried out to evaluate the scintillators concerning neutron radiation from AmBe source, with energy range of 1 MeV to 12 MeV. The activity of the AmBe source was 1Ci Am. The fluency was 2.6 x 10^6 neutrons / second. The crystals response gamma radiation was evaluated in the energy range of 355keV to 1333 keV. In this work, the main optical properties of pure and doped CsI with different ions were studied in order to understand the scintillation mechanism and its application in devices that use the principle of scintillation to detect radiation.

Keywords: scintillators, crystals, radiation detectors.

Spectrometric gamma radiation detection units based on high-resolution crystals SrI 2(Eu) and LaBr3(Ce)

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According to the requirements of international standards, the energy resolution of spectrometric equipment for radiation monitoring systems should be less than 4.5%. A spectrometric detection unit with a resolution of not above 4.5% for 137Cs radionuclide to be used at the radiation monitoring station ASCRO. Also, the ANSI N42.34-2015 standard introduces a requirement for the energy resolution of the spectrometric channel of radionuclide composition identifiers to be no more than 4%.

ATOMTEX SPE has developed a spectrometric detection unit based on the $SrI_2(Eu)$ scintillation detector with dimensions Ø38×38 mm. According to the results of the spectrometric studies of the detection unit, the typical resolution was 3.3% for the 662 keV line of the ^{137}Cs radionuclide.

Special mathematical operators are implemented in spectrometric detection units based on Monte Carlo simulation, which allow calculating the dose rate in real time with a high degree of accuracy. The correctness of the dose rate calculation was evaluated on a neutron calibration fasility AT140 in the fields of high-energy capture gamma radiation with energies up to 10 MeV.

To minimize the influence of external factors on the characteristics of the spectrometric path, classical LED stabilization is used. To correct superimposed pulses from the ADC, pulse superposition rejection is used.

The developed spectrometric detection units, due to their high resolution and correspondingly high rate of formation of distinct peaks of total absorption, are widely used in intelligent identifiers of radionuclides of the RIID type.

Practical aspects of the application of lithium-containing scintillators in neutron detection tasks

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Modern trends in the development of radiation monitoring equipment require the creation of highly efficient detection devices with minimal size and a wide range of functions. This will allow the security services to solve the task of monitoring the radiation situation as efficiently as possible.

Currently, many neutron detection devices use ^{3}He counters. However, technology is not standing still and the alternative is to use lithium-containing scintillators, which allow the functions of gamma spectrometry and neutron detection to be combined. The most widely used members of this class of detectors are CLYC [Cs_2LiYCl_6(Ce)], NaIL® [NaI (Li+Tl)] and CLLB [$Cs_2LiLaBr_6$(Ce)] crystals.

ATOMTEX is developing probes for the separate detection of neutron and gamma radiation based on CLYC and NaI(Li+Tl) detectors. According to the results of the studies, the NaI(Li+Tl) scintillator is promising for use in the absence of stringent requirements for energy resolution, due to the simpler discrimination of radiation types and the lower cost of the detector. Although less sensitive to thermal neutrons (at 1% lithium concentration), the required performance can be achieved by increasing the size of the scintillator.

The CLYC scintillator has high sensitivity to thermal neutrons and excellent performance in gamma spectrometry (typical resolution of 4% of 662 keV of ^{137}Cs), but requires optimization of the light collection as its light output is half that of NaI(Li+Tl) and its spectrum is shifted into the UV region. Also, the process of discriminating the types of particles registered is more complicated and requires digital signal processing methods compared to NaI(Li+Tl). However, it should be noted that this scintillator can be promising for neutron radiation spectrometry due to the reactions on the detector contained in ^{35}Cl.

An analysis of the results of nuclear simulations of the thermal neutron sensitivity of lithium-containing scintillators of different sizes in different measurement geometries is presented in this report. The practical aspects of the application of lithium-containing materials in portable radiation monitoring devices such as RIID, PRD, SPRD are considered, as well as the analysis of pulses from CLYC, NaI(Li+Tl) detectors obtained from photomultiplier tubes and the developed methods of pulse processing for the discrimination of radiation types.

Pre-charged floating gate MOSFET as an ultraviolet dosimeter

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Introduction: UV radiation is known to have harmful effects on human health, including the risk of sunburn and skin cancer. In order to provide personalized UV protection, there is a need for a reliable and convenient method to monitor UV exposure. This study proposes the use of an EPAD, a commercially available semiconductor device based on a floating-gate NMOS transistor, as a potential solution. The floating gate of the EPAD structure can be pre-charged with electrons from the channel before being used as an ultraviolet dosimeter. It can then store information about UV irradiation and be subsequently read using a handheld readout system, enabling real-time monitoring of UV dose.

Experimental setup: The experiment involved decapsulating the ALD1108E IC to expose the EPADs to UV light. To protect the decapsulated integrated circuit during handling and measurements, a specially designed housing made of polylactic acid (PLA) material with a quartz window was fabricated using a 3D printer. The housing was mounted on a zero insertion force (ZIF) socket, and the quartz window enabled UV light to pass through. The transmittance of the housing was measured to ensure an adequate amount of UV light reached the EPADs.

Results: The sensitivity of the EPADs to UV radiation was evaluated by measuring the drift of two floating-gate MOS transistors during irradiation. The drift was monitored at the zero temperature coefficient (ZTC) point, which allowed for the calculation of the threshold voltage of the MOS transistor without temperature interference. The results showed that EPADs with a higher threshold voltage, indicating a greater charge on the floating gate, exhibited higher sensitivity to UV light. Linear dependence was observed between the threshold voltage shifts and the UV radiation dose, similar to the behaviour observed for gamma radiation in our previous publication. These findings suggest that the presented floating gate structure is capable of accurately recording UV irradiation.

Conclusions: The conducted experiments demonstrated the ability to detect and measure UV radiation with the floating gate MOS transistor. EPADs with a higher threshold voltage value exhibited greater sensitivity, making them suitable for dosimetry applications. The proposed EPAD technology holds promising potential for personal UV protection, such as wearable patches integrated with electronic devices that monitor UV radiation and provide timely alerts to avoid potential health risks associated with excessive UV exposure. The findings of this study suggest that further research and development efforts are justified to maximize the potential of the floating gate MOS transistor for UV dosimetry and personal protection applications.

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Investigation of natural radioactivity in soil and vegetation samples from farming lands in Qatar and estimation of their health effects

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The present work aims to give insight about natural radioactivity levels and also give recommendations to the policy and decision makers about the acceptable radioactivity levels in vegetables. The study gives an insight about the natural radioactivity levels in farming soil and vegetation. The investigative study was conducted on one of the farms which showed elevated natural radioactivity level (Ra-226) in 2020 during routine groundwater screening in farms. Hence, analysis of more soil samples to recognize possible source of this anomaly, through investigating uranium series disequilibrium is needed. The determination of gamma-emitting radionuclides in food was performed using high purity germanium (HPGe) gamma spectroscopy (Canberra, USA). The mean activity concentrations for all natural radionuclides in soil samples were within global average (UNSCEAR) except for Ra-226. Excluding Ra-226, all mean values for Th-232 and K-40 were comparable to local values. The investigation of geochemical behavior of U-series in soil showed a clear disequilibrium between U-238 and its daughter Ra-226 (high Ra-226:U-238 ratio) which designates likelihood of external sources for Ra-226. Fertilizer samples had normal activities for Ra-226 and U-238, but extensive usage would accumulate radioactivity concentration over time. The leafy vegetables seem to have higher tendency to uptake Ra-226. Cheera was found to exhibit the highest Ra-226 concentration and highest effective dose (82.0 μSv/y). This can be utilized by using Cheera as a bio indicator for soil contamination and bioremediation agent in case of any contamination. The estimated hazard indices (due to natural radioactivity) from soil samples were found to exceed UNSCEAR 2000's global average values. The Ra-226 activities in 3 of the 5 investigated soil samples from the farm were found to be greater than 1 kBq/kg; however, the annual effective doses were below 1 mSv/y (GSR3). 95% of the annual effective doses equivalent in all of the studied soil samples were generated by Ra-226. The committed effective dose (due to ingestion) for all the investigated radionuclides were found to be far below the References dose level (1 mSv/y) mentioned in the IAEA GSR Part-3 and the FAO/WHO Codex Alimentarius Commission.

Successive irradiation and thermal annealing of commercial p-channel LDMOSFETs

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Introduction: In recent years, trend of usage of low-cost devices for commercial multi-measuring systems is noted. Beside other, there is increase in interest for dosimetry and its implementation in wearable electronics. Reports suggest that double diffused MOSFET transistors can be viable solution for the task. Change of the MOSFET threshold voltage can be related to the absorbed dose. Still, disadvantages of MOSFET structure like dependance on the temperature and some other parameters can present an issue. In the present work, change in sensitivity due to two phases of irradiation and thermal annealing of the lateral double diffused MOSFET transistors is reported.

Methods and materials: Samples for the experiments were p-channel LDMOS devices that are part of the CD4007 digital integrated circuits manufactured by Texas Instruments. This device was chosen based on the lateral structure that can provide good sensitivity to ionizing radiation. Irradiation sessions were performed in the facilities of the hospital of San Cecilio in Granada (Spain). Irradiation was performed using a linear accelerator (LINAC) Siemens Artiste, used for radiotherapy treatments. Dose of 40 Gy was delivered to the samples, with the rate of 2.6 cGy/s, where all the pins of all the samples were short-circuited. Thermal annealing was performed using the programmable VCL4006 climate chamber. Value of the threshold voltage was obtained from the transfer characteristics of devices. Transfer characteristics was measured using semiconductor analyzer B1500.

Experiment and results: First irradiation session was followed by first phase of thermal annealing. Sample were annealed for 168 hours. During this period, measurement of the transfer characteristics was done in predefined time intervals, with the goal to observe the value of the threshold voltage. After thermal annealing, second phase of irradiation under same conditions was performed, and subsequently, second phase of thermal annealing in the same duration. Irradiation caused threshold voltage shift. Threshold voltage was changed for 30.0 %, showing sensitivity of 10.5 mV/Gy. With annealing, recovery of the threshold voltage was observed, leading to change of only 7.5 % from the initial value. Second irradiation session caused similar threshold voltage shift, but during the latter phase of annealing different recovery was noted. After irradiation session, threshold voltage was changed for 27.2 %, showing sensitivity of 9.4 mV/Gy, but after thermal annealing, observed change was 13.1 %. Sensitivity after different phases of experiment is reported and analyzed in more detail.

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PMMA optical fibre irradiated with Co-60 for optical fibre sensors

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Plastic optical fibres (POFs) made of polymethyl methacrylate (PMMA) have several advantages over traditional optical fibres, including lower cost, larger diameters, and better mechanical resistance. These properties make them an attractive option for sensor technology, including radiation dosimetry. This paper presents the use of PMMA optical fibres for measuring ionising radiation, focusing on their potential applications in scintillation radiation transport. We discuss the direct and indirect methods of using optical fibres for radiation dosimetry. In the direct method, the optical fibre is irradiated, and changes in its state are used to determine irradiation parameters. In the indirect method, the optical fibre is used as a transport medium to transport the signal, such as light from the scintillation material, to the measuring and evaluation device. We also examine the effects of ionising radiation on the attenuation of PMMA optical fibres and their potential use in dosimetry applications. Overall, we conclude that PMMA optical fibres offer a promising solution for radiation dosimetry and have the potential for use in a wide range of applications, including medical imaging, environmental monitoring, and nuclear power plant safety.

To evaluate the impact of ionising radiation on our system, we employed a technique that involved measuring changes in laser power transmitted through an optical fibre at a constant gamma radiation dose rate. To conduct our experiment, we utilised a DBR diode laser source with wavelength stabilisation that emitted radiation at 633 nm. For the optical fibre, we selected a 1.0 x 1.5 mm ESKA Hi-Temp PMMA fibre from Mitsubishi, which has an optical core diameter of 1 mm, a numerical aperture of 0.58, and an insertion loss of 0.25 dB/m at 650 nm.

Effects of self-heating and NBTI-induced stress on p-channel power VDMOSFETs

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The reliability of power electronic devices is crucial, and it is known that self-heating is one of the factors that affect their reliability. Self-heating is being investigated during reliability tests since it can significantly affect the threshold voltage and Safe Operating Area of MOS (*Metal Oxide Semiconductor*) power devices, especially in high-temperature environments. This research focuses on examining the self-heating effects on p-channel power VDMOSFETs (*Vertical Double-Diffused MOS Field Effect Transistor*) when the heatsink is left out.

It is known that VDMOS devices are mostly used as switches in switching power supplies, automotive, and space industries, with operating switching frequencies in the MHz range. In recent years, the demand for high-power and high-temperature devices has been increasing due to the growth of electric and hybrid vehicles, and renewable energy sources. However, power electronic devices suffer from reliability issues such as thermal aging, which is exacerbated by high-temperature environments. Therefore, the impact of self-heating on power electronic devices must be thoroughly investigated to ensure their reliability and longevity.

This paper examines the impact of self-heating on fresh and previously stressed p-channel power VDMOSFETs when different types of controlling signals are delivered for different drain currents. The paper describes three types of controlling signals used for VDMOS devices in switching power supplies. These signals have different rise and fall times. As t_{rise} and t_{fall} values increase, pulse narrowing is induced through NBTI (*Negative Bias Temperature Instabilities*), creating different operating conditions. The high current flow through VDMOS devices in active state and thermal stress caused by load switching represent real-life operating conditions for these devices.

The devices under test are VDMOS transistors IRF9520 with hexagonal gate structure, divided into two groups: previously stressed and fresh samples. The conditions of previous stress were: applied gate voltage of -50 V and increased temperature of 175 °C for one week. A setup for new experiment was designed to measure the temperature of the device under operating conditions, consisting of a load driving circuit, arbitrary waveforms from Agilent Waveform generator, and an active load Rigol 3021 in the constant current regime. The temperature was recorded using an infrared thermographic camera Varioscan high-resolution model 3021, and 25 thermographic images were taken in the 15 s interval while the current flowed to the transistor for 375 s. Transfer characteristics in the saturation region were measured before and after the experiment using the Keysight B2901A as a source measure unit.

In the experiment, the temperature of devices from two groups was measured using an infrared thermographic camera for three different drain currents and three controlling signals. The results show that self-heating was found to induce a shift in the transfer characteristic. The impact of each condition on the device's lifetime is significant, and their combined effect is even more pronounced. It is demonstrated that the device temperature of fresh and previously stressed devices varies for the same current but different controlling signals, with the highest temperature observed for the longest rise time and fall time controlling signal. Cooling of devices occurs exponentially after turning off the load. Also, it is shown that the self-heating effect is the most pronounced for the highest of the three currents for both groups of devices. The change in threshold voltage affects channel generation, causing slower creation of the channel, which leads to higher power dissipation and more self-heating. It was found that the devices previously stressed are more prone to self-heating due to their degradation of parameters, seen through threshold voltage shift.

Automatic calibration of radiation portal monitor using deep learning

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Radiation portal monitors (RPMs) are deployed at the nations border to monitor smugglings of radioactive materials. RPMs are generally based on large volume plastic scintillation detectors, which is inappropriate spectroscopic measurements because of absence of photo peaks and poor energy resolutions. Therefore, RPMs are used as counting measurements to identify existence of radioactive materials in the sample. To overcome these drawbacks, various applications on radioisotope identification for RPMs have been proposed. Most of those applications need energy spectra. To acquire an energy spectrum, relationship between raw multichannel readout and physical energy should be identified. However, this relationship is varied according to environmental conditions, e.g. temperature, humidity, etc. In this paper, we address a deep learning technique to conduct energy calibration of RPM automatically. A convolutional neural network model was designed to output energy calibration parameters from the channel spectrum of ^{137}Cs. Dataset to train the CNN model was generated using random number generation following the spectrum of the RPM. The performances of the CNN model was evaluated using the measured spectra of the RPM, and it was confirmed that calibrated energy spectra measured in different conditions were overlapped by one another.

Development of dose distribution analysis algorithm for airborne radiation monitoring

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After the Fukushima nuclear power plant accident, Japan Atomic Energy Agency(JAEA) has developed airborne radiation monitoring technology using manned helicopters, unmanned helicopters, and drones, and they used it for dose rate distribution analysis. Airborne radiation monitoring technology is very useful for remote radiation monitoring because it enables radiation measurement in areas that are not easily accessible to people, such as forests and rivers.In addition, it is effective in responding to accidents by enabling rapid analysis of widely contaminated areas through fewer personnel.The dose rate distribution map obtained with airborne radiation monitoring is effective in visualizing the distribution of atmospheric dose rates and radioactive contamination on the ground. JAEA developed basic methods such as the Flat Source Model (FSM) and Topographic Source Model (TSM) to respond to the Fukushima accident, and improved the accuracy of dose conversion by applying the Inverse Radiation Problem Method used in proton emission tomography (PET). Recently, researchers trying to improve mapping technology by applying artificial neural networks. However, an error occurs in the process of converting the dose measured in the air to the dose on the ground. This is because dose in the air are measured from a wide range of contamination distributions, but are converted to values at one point on the ground during the conversion process. Therefore, in this study, an algorithm was developed to separate multiple surface contaminations from airborne dose. In the algorithm development process, a generalized dose distribution model according to altitude and horizontal distance were obtained using Monte Carlo N-Particle(MCNP) code. Based on the model, we developed a algorithm using Python code that can analyze the distribution of sources from aerial measruement data. As a result of verifying by placing an arbitrary source, the algorithm successfully predicted the distribution of the sources.

Radiation survey at the Fukushima restricted area

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We conducted joint environmental radiation survey near the Fukushima nuclear power plant with JAEA (Japan Atomic Energy Agency). Radiation energy spectrum was measured by NaI(Tl) and LaBr3 scintillation detectors at two contaminated sites. One site (Site A) was a parking lot and it has a hotspot deposited with Cs-137. Another site (Site B) is mainly contaminated with Cs-137 with dense forest.

First, in situ ground measurements at 1m height were conducted to inspect contamination of radionuclide at ground position. Radioactivity of Cs-137 on the ground was estimated from the peak spectrum data by using ERS (Environmental Radiation Survey) program developed in KAERI. Dose rate was estimated by using DRS (Dose Rate spectroscopy) program developed in KAERI. The highest dose rate was measured as 20.17 μSv/h at the hotspot of site A.

Manned backpack surveys were conducted to measure ambient dose rate site A and site B. GPS information was linked to the measurement data was applied to estimate dose rate from the energy spectrum data. Backpack survey data was converted to In situ ground measurement at 1m height by applying correction factor.

Comparative analysis with JAEA (shows that two scintillation detector operated accurately in highly contaminated area.

Analysis of low-energy part of big-volume HPGe detector background spectrum

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In many previously published studies, the background spectra of different types and sizes HPGe (High Purity Germanium) detectors, placed inside various passive shields, were investigated within energy range 50 keV – 3 MeV. However, the detailed studies of background low-energy spectral part - from few keV to 100 keV, have not been often performed. This spectral part is important for astroparticle physics experiments, because theoretically predicted dark matter WIMP particles should leave their signatures within low-energy region in extremely rare interactions with detector nuclei, leading to nuclei-recoils, in the similar way as neutrons from detector vicinity which interact via elastic scattering.

In this work, we analyzed the background spectrum in the energy range 1.7 keV – 70 keV of big-volume HPGe detector (105% relative efficiency, active volume of 411 cm^3), positioned inside passive led shield with 15cm wall thickness, and inner lining of Sn and Cu, operating in surface based laboratory (~ 80 m a.s.l.). Detector endcap was made of carbon fibers with thickness of 1.6 mm, while carbon fiber window was 0.9mm thick. The low-energy background spectrum of this ultra-low background system with HJ cryostat configuration was explored experimentally, as well as by Monte-Carlo simulations. In experimental low-energy part of background spectrum, the continuous spectral distribution is dominant (count rate: 1.83 c/s in the range 1.7 keV – 70 keV), with steep increase below ≈ 3keV and corresponding count rate of 1.26 c/s for 1.7 keV – 3.0 keV region. Only two weak peaks are detected in the low-energy region: at 10 keV and 66.3 keV. The low-energy HPGe detector spectrum, obtained using cosmic-ray muons and neutrons in Monte-Carlo simulations by Geant4 software was compared with experimental results.

Analysis of the possibility of recognizing radioisotopes by measuring the absorbed dose using passive detectors with different atomic numbers

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The work is devoted to the problem of identifying an unknown source of gamma-radiation as a task of emergency dosimetry in the case of the use of radiation-dispersive means for terrorist purposes. The possibility of identifying an unknown gamma-source is considered based on the energy dependence of the absorption of photon ionizing radiation, which in passive (TSL or OSL) dosimetry manifests itself as dosimetric sensitivity.

The idea of ionizing irradiation source recognition utilizing measurements of absorbed dose using at least two different detectors with strongly different effective atomic numbers (Z_{eff}) has been around for a long time. However, to date, this approach has not been implemented in practice mainly due to the lack of appropriate detectors made of high atomic number materials.

The tissue equivalent BeO ceramics with Z_{eff} = 7.1 has been considered as a “light” detector material, while the single crystalline yttrium-aluminum perovskite ($YAlO_3$) with Z_{eff} = 31.4 or lutetium-aluminum perovskite ($LuAlO_3$) Z_{eff} = 61.6 have been chosen as a “heavy” one.

According to available published data, the number of radioisotopes that can be used by terrorists in radiation-dispersive means is very limited, and only three isotopes, namely ^{137}Cs, ^{192}Ir, and ^{60}Co are dangerous from the point of view of external gamma-irradiation. Therefore the possibility of recognition of these three isotopes has been analyzed in detail.

The influence of the accuracy of the absorbed dose measurement on the reliability of radioisotope identification is discussed and approaches for its practical implementation are proposed.

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Calibration of HPGe detector with non-calibrated sources

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There are only a few single gamma emitting sources with sufficiently long half-lives that are suitable for calibrating gamma spectrometers. If cascading sources are used, in order to avoid systematic errors, the effects of true coincident summation must be taken into account. However, the coincident peaks that suggest the existence of a ture coincident summation and are a nuisance to the usual analysis, can be used as an advantage for the analysis and processing of the spectrum so that, based on the spectral data, the activities and efficiencies of the full-energy peaks can be obtained. In this approach, full energy peak efficiencies are automatically corrected for the true coincidence summing. In order to demonstrate this calibration technique, Monte Carlo simulations were carried out for the isotopes ^{60}Co, ^{133}Ba, ^{152}Eu and ^{56}Co.

Modeling of germanium crystal in determination of ^{40}K efficiency by Monte Carlo method

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Humans have been irradiated by natural radiation emitting from cosmic-rays coming from space to the earth's atmosphere and natural radioactive materials found in the earth's crust (soil, air, water, etc.) for millions of years. Due to the gamma-rays emitted by radioisotopes on the earth, our body is exposed to external radiation. The gamma emitting ^{238}U and ^{232}Th series and ^{40}K are three important components of external radiation. The activity concentration of ^{40}K, which constitutes 2.4% by weight of the earth's crust, is generally greater than ^{238}U and ^{232}Th. ^{40}K; since it is found naturally in foods, building materials, environmental samples and industrial products, the 1460.8 keV energy peak of this radionuclide is very important in radioactivity analysis and dose calculations. In this study, the parameters to be considered in determining the efficiency of this peak with 1460.8 keV energy by simulation method were examined. While the geometric dimensions given by the manufacturer guide the user in HPGe detector modeling, there are other parameters to be considered. These are modeling the front edge of the crystal as rounded, incorporating the copper contact pin, and determining the time-varying dead layer thickness.

In this study, two different HPGe detectors, one n- and the other p-type, and IAEA-RGK-1 material containing 14000±400 Bq·kg^{-1} ^{40}K and produced from 99.8% potassium sulfate were modeled in volumetric geometry. The existing dead layer thicknesses of the detectors used were determined in advance from the efficiency values obtained by experimental and simulation methods with many point sources in the energy range of 59.5 keV-1408 keV. It has been observed that the rounded and sharp modeling of the front edge of the crystal in the detectors modeled according to the existing dead layer thicknesses also causes a <1% change in 1460.8 keV energy, so this parameter is not critical in the high energy region. According to the results obtained, the presence of the copper contact pin is at 1460.8 keV; it caused a decrease in efficiency of 5.2% in the n-type detector and 5.1% in the p-type detector. Therefore, it has been observed that the copper contact pin located in the middle of the detector has a serious effect on the efficiency in the so-called high energy region such as 1460.8 keV, regardless of the crystal type.

Assessment of dose distribution for uniform irradiation in large-scale gamma irradiation facility based on Monte Carlo simulation

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Purpose: Gamma irradiation was used as a sludge reduction and resource recovery method, and correlations between sludge characteristics and biogas conversion rates according to dose were studied using the large-scale irradiation facility. Large-scale gamma irradiation facilities have been used to efficiently irradiate large amount of samples. However, the dose of sample could differ by up to a factor of two depending on the position of the sample within the carrier, and it can reduce the reliability and accuracy of the analysis of results. Dose distribution, which can evaluate dose uniformity of the area, is mainly measured with dosimeters, but it is difficult to know the dose in all areas by point-by-point measurement. In the present study, we evaluated the dose distribution for sample in the large-scale gamma irradiation facility and decided the area for uniform irradiation using a general-purpose Monte Carlo (MC) radiation transport code, MCNP6. To validate calculations, simulated results were compared with the dose measured by alanine dosimeter.

Materials and Methods: Co-60 gamma irradiation facility manufactured by Nordion, Canada, was modeled for MCNP6, which consists of a source of about 297×0.81×190.4 cm^3 and a carrier of 120×65×400 cm^3 including sample, by simplifying only the irradiated part. The volume source was defined for Co-60 emitting gamma of 1.17 and 1.33 MeV in a 1:1 ratio. The thickness of the sample, filled with water, was determined to be 6 cm among values that did not affect the dose uniformity (<1% differences). The height was 150 cm, which could enter the middle compartment of a three-compartment carrier. Simulations were performed for carriers at 26 locations moving around the source to investigate the dose contribution by location. The measurements were carried out with alanine dosimeters positioned at 13 points in the sample. The temperature during the irradiation is 3 °C. The alanine signals were analyzed by the ESR system and converted into the doses. Measured doses were compared with simulated dose at the same position as that of alanine.

Results: The differences between the simulation and measurement of relative dose distribution of 13 points in the sample were below 5%, indicating that the implementation of the irradiation part of the gamma irradiation was successfully conducted. The dose distribution within a height of 150 cm showed the non-uniform dose with significant difference of about 20% between the center and the top (bottom) of the sample, and the dose distribution with a width of 6 cm showed the uniform dose with the difference of less than 1%. Based on the simulation, the height to obtain 90% uniformity in the sample was determined as 90 cm. In addition, the dose contribution according to the 26 locations of the carrier was calculated and showed that the dose received at 4 locations close to the source accounted for 68% of the total dose.

Conclusion: In this study, we implemented irradiation part of the large-scale gamma irradiation facility for MCNP6 to evaluate the dose distribution. The size of the sample to obtain the uniform dose (>90%) was determined. The result of our study expected to be useful for evaluating the dose distribution and increasing dose uniformity of various sample irradiated in large-scale gamma ray irradiation facilities.

Key word: Monte Carlo, Cobalt-60 gamma irradiation facility, Dose uniformity, Alanine dosimetry

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Fast digitizer card with integrated peak analysis

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In this paper, we describe the development of a fast digital multichannel analyzer (MCA) with peak analysis for gamma ray characterization. We have been developing fast digitizer cards since 2010. During this time, we developed digitizer cards for neutron/gamma analyzers for measuring radiation fields around linear and medical particle accelerators, as well as digitizer cards for neutron/gamma stationary probes for the radiation situation monitoring, e.g. in spent nuclear fuel stores or in experimental reactors.

Fast digitizing cards are built on programmable gate arrays (FPGA) and fast 12-bit analog-digital convertor (ADC) with a sampling frequency of (100 - 1000) MS/s. The fast digital MCA follows on from the previous development of the DIM-09 and NGA-01 digitizer cards. These cards use modern technologies and are capable of processing data with transfer speed higher than 40 Gbit/s. They contain integrated high voltage module, preamplifier, digital interface for communication with a PC and advanced algorithms for peak analysis of the measured spectra.

A newly developed digital MCA card has been implemented into a volume activity gamma detector. The probe with digital MCA has been tested in the laboratory of VF, a.s. and the results are presented.

Environmental microdosimetry in very low dose rate radiation fields

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It is well known that intermediate and high doses of ionizing radiation have deleterious effects on human health, however whether low level radiation exposures are detrimental or beneficial and their underlying mechanisms is still debated [1]. Among other effects, low dose radiation (LDR) has been shown to modulate a variety of immune response processes, which can induce stimulatory and adaptative response on living systems [2]. The basic cellular and molecular mechanisms underlying the radiation-induced immune response are still largely unknown and deserve further studies. In vitro and vivo studies on LDR effects are influenced by several uncertainties that include the radiation quality, which is usually not monitored, and confounding physical variables that are not under control. In this framework, the availability of laboratories outside and inside the Gran Sasso Laboratories of the Italian National Institute of Nuclear Physics (INFN-LNGS) represents a great opportunity to investigate the influence of both low and extremely low doses in triggering immune response. In LNGS underground structures the dose contribution from cosmic rays is negligible and thanks to the thorium and uranium-poor dolomitic rocks, the neutron flux is also extremely low and reduced by a factor of 10^3 with respect to the Earth's surface. The gamma dose rate amounts to about 20-25 nGy/h both underground and outdoor, and in the underground laboratories it is the main contribution to the total dose. In one week, the total gamma dose amounts to approximately 4 μGy. At this low dose level, the process of radiation interaction is dominated by its stochastic effects, even for low LET radiation. Considering a LET=0.2 keV/μm, the probability that a microscopic target (diameter = 1 μm) experiences an energy deposition event is very low (order of 10^{-4}), and decreases with LET. The probability of a multiple hit is negligible (about 10^{-8}) and the fluctuations in the energy imparted from event to event are large. In these conditions, the energy is deposited in a highly inhomogeneous fashion, and the absorbed dose alone is not sufficient to characterize the radiation field. To reduce the dispersion of radioimmunological data and to improve the correlation of the biological observable with physical quantities, we plan to measure not only the absorbed dose but also the stochastic aspects of the interaction at the microscopic level, for the whole duration of the biological observation. Microdosimetric techniques will be applied for a continuous monitoring of the absorbed dose and the LET distribution of the environmental radiation field. A large spherical tissue equivalent proportional counter (TEPC) will be used, 5 cm in diameter, filled with propane gas to simulate 1-2 μm of biological tissue. The TEPC, designed and constructed at the Legnaro National Laboratories (LNL) of INFN, has a segmented cathode that produces a uniform electric field. At the documented gamma dose levels of about 20nGy/h, the expected number of events is 1250/h, for a total of 3 10^4 events detected in one day. Therefore, this TEPC allows both the dose and the microdosimetric spectrum to be monitored on a daily basis, with significant statistics. The detector will be used as ambient microdosimetric monitor to characterize the background radiation field in indoor and outdoor environments.The first results of microdosimetric spectra measured in different scenarios will be presented and discussed.

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Measurement of RF exposure around indoor private 5G network antennas in university environment

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The aim of this study was to assess the exposure around indoor private 5G network antennas in a university environment. For this purpose measurements were taken in September 2022 at Óbuda University in Budapest. This university has a private 5G network at 3,5 GHz frequency band with 40 MHz bandwidth operating with pico and micro antennas respectively. The pico antenna is located in a laboratory where students have laboratory practice. The micro antenna is placed in the corridor in front of the laboratory. Both antennas are mounted on the wall around 2.5 m height.

The measurements were taken by three ExpoM-RF recording devices which can acquire data in 16 separate predefined frequency bands between 87.5 MHz – 5875 MHz: FM Radio (87.5 - 108 MHz); DVB-T (470 - 790 MHz); LTE800 DL (791 - 821 MHz); LTE800 UL (832 - 862 MHz); GSM900 UL (880 - 915 MHz); GSM900 DL (925 - 960 MHz); GSM1800 UL (1710 - 1785 MHz); GSM1800 DL (1805 - 1880 MHz); DECT (1880 - 1900 MHz); UMTS UL (1920 - 1980 MHz); UMTS DL (2110 - 2170 MHz); ISM 2.4 GHz (2400 - 2485 MHz); LTE2600 UL (2500 - 2570 MHz); LTE2600 DL (2620 - 2690 MHz); WiMax 3.5 GHz (3400 - 3600 MHz); ISM 5.8 GHz (5150 - 5875 MHz). The devices were fixed during the measurement. The sampling rate of the EXPOM-RF device was 15 s. We performed two measurement campaigns around the pico and the micro antenna.

We used the following scenario for both campaigns:

- measurements without switched on the 5G network, for one hour
- measurements with 5G network switched on working in idle mode (no generated data traffic), for one hour
- measurements with 5G network with generated data traffic, for one hour

During the data analysis we evaluated electric field strength values (V/m) of the measured bands. We compared the Mobile 3.5 GHz band (3400-3600 MHZ) to other mobile downlink (DL) bands and Wi-Fi 2.4 GHz band.

The results show that the measured average electric field strength values in the 3.5 GHz band around the pico antenna were under 0.02 V/m while the 5G network was turned on in idle mode. During data traffic this value reached a maximum 0.12 V/m. At this place the indoor RF exposure level of Wi-Fi routers was around 0.1 V/m while the total mobile downlink RF exposure was around 1 V/m. This means that the exposure coming from outdoor RF sources into the building is much higher than the exposure generated by the indoor pico antenna under 5G data services. In the vicinity of the micro antenna in the corridor which was located further inside the building the total mobile downlink was around 0.2 V/m. The 5G exposure without 5G data traffic was under 0.1 V/m while during data traffic it reached 1.4 V/m.

In conclusion the exposure around the measured indoor private 5G network antennas is the same range or less than exposure coming from the downlink services of outdoor base stations into the building.

Quantification of radioactive metabolite Sr-90 in environmental samples

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The radionuclide Sr-90, which is present in our environment, is an artificial radionuclide, produced essentially by the U-235 and Pu-239 fission reaction, which occurred mainly during the previous atmospheric nuclear tests and nuclear reactor accidents. It is biologically hazardous radioactive metabolite. Due to its chemical and biochemical similarities with calcium, more than 99 % of Sr-90 is efficiently incorporated into the bone tissue and teeth. Characterized by a long physical and biological half-life (28.2 and approximately 7 years, respectively), Sr-90 may cause damage to bone marrow and induce bone sarcoma and leukemia, because of its high-energy β-particles (546 keV). This radionuclide decays to Y-90, which emits a strong β radiation with maximum energy at 2.28 MeV although it has a short half-life of 64.1 h. The product of Y-90 decay is Zr-90, which is a stable isotope. The knowledge about Sr-90 content in environmental samples is of extreme importance to prevent and control contamination of the food chain. Due to all above-mentioned, it can be concluded that the analysis of Sr-90 in the environment is an important task in the routine environmental radiological monitoring.

A lot of techniques such as co-precipitation, ion exchange, solvent extraction, and extraction chromatography have been described for the determination of radiostrontium in environmental samples. In Laboratory for Radiation Measurement at the Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, for determination of Sr-90 activity in environmental samples, the validated radiochemical analytical technique is used. This technique is based on radiochemical analytical oxalate precipitation method, whereby interfering radionuclides are removed by precipitation scavenging. The quality control and assurance of the method was performed using standard samples prepared by International Atomic Energy Agency, IAEA - certified References materials. Beta counting is performed with gas Multi-low-lever proportional counter Thermo Eberline FHT 770 T (ESM Eberline Instruments GmbH, Germany) with the measurement time of 5400 s per each sample. The calibration of the detector for measurement of beta radiation was performed using the Sr-90 certified radioactive standard point source (9031-OL-335/11, Czech Metrology Institute) which is traceable to BIPM.

Environmental radioactivity monitoring consists of measurement of radionuclide activity concentration relevant for public exposure in the environmental samples. The main pathways of exposure of the public are external exposure due to radionuclides present in the atmosphere and on the ground, ingestion of contaminated food and inhalation of airborne radionuclides. In this paper, Sr-90 results of activity measurement in the environmental samples for the period of 2014 to 2020 are presented. The Sr-90 activity were as follows: from < 0.09 to 1.5 Bq/m^2 for precipitation, from 1.1 to 5.7 μBq/m^3 for aerosol samples, from 0.009 to 0.019 Bq/L in surface water, from < 0.19 to 3.74 Bq/kg for soil samples, from 0.18 to 0.82 Bq/kg for sediment samples, from < 0.10 to 1.72 Bq/kg in plant material samples, from < 0.032 to 0.043 in vegetables, from < 0.044 to 0.055 Bq/kg in fruit samples, and from < 0.012 to 0.080 Bq/kg for milk samples. The obtained values are in accordance with the data from the available literature. An assessment of radionuclide Sr-90 dose by ingestion for the public was done using radioactivity measurements in the food samples. The assessed values met the criteria given by Official Gazette of the Republic of Serbia, No. 36/18: Regulation on limits of radionuclide content in drinking water, foodstuffs, feeding stuffs, drugs, items of general use, building materials and other goods to be placed on the market.

Investigation of radiation doses emitted by patients injected with 18FDG in PET/CT

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Aim: Positron emission tomography/computed tomography (PET/CT) is frequently used for cancer diagnosis and staging in medical imaging. 18F-fluorodeoxyglucose (18FDG) is one of the most commonly used radiopharmaceutical agents. Since radiation workers will come into contact with many patients during the day, it is thought that the amount of radiation they are exposed to has a cumulative effect. This study aimed to determine the radiation dose rate emitted from patients to the environment in PET/CT.

Methods: A total of 31 patients (14 female, 17 male, mean age 51.70 ± 11.40 years) who underwent an 18F-FDG examination in PET/CT were included in this study. 18F-FDG was injected intravenously into the patients. Post-injection patients were kept in incredibly isolated patient rooms for 40-60 minutes until PET/CT scan. Dose rate measurements were taken in 3 different periods and from 20 locations in the patient's head, chest, abdomen and pelvis regions. Dose rates were measured by GM counter at 25, 50, 100, 150, and 200 cm distances from the front of the patient for each site.

Results: Strong correlations were calculated between normalized dose rates obtained by all regions and time. Considering the nuclear medicine staff handling time with a PET/CT patient, the average dose received by staff was calculated between a range of 0.002-0.004mSv/pt. The radiation dose exposed to the porter and nurse was calculated as 0.049mSv/pt for the 2nd hour and 0.001-0.007mSv/pt for the 4th hour, respectively. The companion was exposed to a dose between 0.073-0.147mSv and 0.024-0.048mSv for public and private car transportation after 4-6 hours of injection (for 30-60 min of travel duration), respectively.

Conclusion: The radiation dose of nuclear medicine staff, porters, nurses, and companions are found to be below the recommended dose limit by the ICRP. According to our results, there is no need for any restrictions for patients, companions, or healthcare personnel in PET/CT.

Keywords: PET/CT, Radiation dose rate, 18F-FDG, exposure.

An influence of the final volume of samples during the electrolysis of water, on counts for tritium activity determination

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Tritium levels in natural waters today have a similar value to the concentration before thermonuclear bomb testing conducted between 1954 and 1963. Because of the low concentration of this radioisotope, the analysis requires enrichment techniques to produce low detection limit, accurate results and to reduce uncertainties. This analysis includes preliminary distillation, electrolytic enrichment of the samples, the second distillation, and measurement on ultra low-level liquid scintillation spectrometer.

The enrichment system consists of 16 electrolytic cells, each with a capacity of 250 ml, placed in the freezer and connected to a direct current source. One cell contains *spike water* with known tritium concentration and is used for enrichment factor determination. The initial volume for all samples is 250 ml. Na_2O_2 is used as an electrolyte to make the solution alkaline. Each cell has a gas outlet to ensure the escape of gases H_2 and O_2. In order to obtain a high enrichment factor, the system works on 5 A, to reduce the initial volume of the samples by 10-15 times. After electrolysis, second distillation must be performed to eliminate electrolyte. 8 ml of water sample after the second distillation is mixed with a scintillation cocktail in polyethylene vials and measured on a liquid scintillation spectrometer Quantulus 1220.

At the end of the electrolytic enrichment process, the final volumes of the samples can be different, which causes different enrichment between the cells. To eliminate this influence, the final volume of all enrichment samples can be normalized at one value. In order to determine the corrected count rates obtained for each sample, the separation factor must be first calculated, taking into account initial volume, normalized final volume, count rate for *spike water* (after enrichment), count rate for *spike water* (before enrichment), and background count rate. In the example of one electrolysis, with 15 samples of drinking water, precipitation, and surface water, and one sample of *spike water*, with 670 Ah and an enrichment factor of 8.10, the final volume is normalized on a value of 18 ml. The calculated separation factor was 4.88. The corrected count rates for samples vary from 0 to 9.6 %, which causes a change in the final activity concentration of tritium from 0 to 22.2 %.

Keywords: Electrolytic enrichment, tritium, the separation factor

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Inter-laboratory comparison of surface emission rate measurements of wide area sources

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The National Institute of Ionizing Radiation Metrology of ENEA (ENEA-INMRI) organized 7 national Inter-Laboratory Comparisons (ILC) on the measurement of the environmental radioactivity and of radionuclides of medical interest. In this paper, the ILC N°6, on surface contamination measurements, will be described. The objective of this ILC was to test, at the national level, the participant capability in measuring the surface emission rate *s-1* of two Wide Area Sources (WAS) of ^{241}Am (alpha emitter) and of ^{90}Sr (beta emitter). The References values of the two surface emission rates were determined using the ENEA-INMRI Primary Standard, a window-less gas-flow proportional counter. The participants were asked to collect 10 surface emission rate readings for each of the two WAS. Each participant could use the most appropriate instrument and method, whose type, characteristics and efficiency had to be communicated to ENEA-INMRI along with the values of the readings carried out under the same measurement conditions. From these data it was possible to check the consistency of the values of the surface emission rate determined by each participant, and their deviation from the References values.

Optimization of neutron activation analysis of rare-earth elements

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During neutron activation analysis (NAA), if the material being analyzed is partially composed of a lanthanide content optimization of rare-earth analyses is crucial. To enhance these procedures a database was created to help assess the likelihood that a certain lanthanide isotope and gamma ray is indeed the best one to be determined by NAA. First, the most common isotopes through the (n,γ) reaction of each element was determined, along with the strongest and most abundant gamma rays to be used, and a chart was formulated with their relevant properties. A weighting factor was constructed based on seven characteristics of the properties of the lanthanides: thermal cross section, resonance integral, natural abundance of the element itself, half-life of the activation product, the branching ratio, the Igamma(relative) value, and relative detector efficiency of the photon spanning from 80 – 1596 keV. The seven individual characteristics were then added together and divided by the total possible value to get their total weighting factor. In addition, the application of gamma- gamma coincidence and Compton suppression was also evaluated to determine which radionuclides may be better evaluated.

A fast coincidence-summing correction procedure for gamma spectrometric measurements in close geometries

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The spectrometric analysis of a sample measured in "close geometry" can be affected by errors due to coincidence-summing effects that can occur when two or more coincident photons are emitted within the resolution time of the spectrometric system. The probability that these effects occur depends primarily on the nuclide decay scheme, the sample-detector distance and intrinsic efficiency of the detector. Instead, they results independent from the sample radionuclide activity. Coincidence-summing corrections of photopeak areas are requested, in particular, when the g-ray spectrometric analysis is aimed to efficiency or activity determination.

In this work is described a fast and simple procedure to evaluate true coincidence-summing correction values for point and simple shape volume sources. The values of correction factors were quickly get by using well known expressions for the evaluation of the g - g and g-X_K coincidences and the recent data tables available for most of radionuclides on web (http://www.lnhb.fr/nuclear-data/nuclear-data-table/). The needed Full-Energy-Peak Efficiency (FEPE) and Total Efficiency (TE) values or suitable calibration curves are evaluated by a Virtual Point Detector approach, as demonstrated in [1], or for only TE calibration through an interpolation of experimental Total-to-Peak ratios. Alternatively, a Monte Carlo simulation program (PENELOPE 2018) is used to compute FEPE and TE trends, assumed some experimental values as validation points.

Finally, a suitable application of the known "efficiency transfer method" is used to calculate correction values for simple volume geometries by integration of "elementary efficiencies" over the whole source volume.

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Radionuclide analysis of the simulated contaminated surface sample for the purpose of IAEA-TERC-2022-01/02 Proficiency Test

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In accordance with general requirements for the competence of testing and calibration laboratories (SRPS ISO/IEC 17025:2017 standard), a regular participation of an accredited laboratory in the international and/or interlaboratory intercomparisons is required. The laboratory within Department of radiation safety and environmental protection, Public company „Nuclear Facilities of Serbia“, participated in the proficiency test on determination of anthropogenic and natural radionuclides in water, soil (gamma-ray spectrum analysis exercise) and simulated contaminated surface, organized by the International Atomic Energy Agency (IAEA-TERC-2022-01/02 ALMERA). This international intercomparison envolved over 300 laboratories from more than 70 countries.

The purpose of this paper is to present the outcome of the radionuclide analysis for the simulated contaminated surface sample. A portable surface contamination monitor for surface emmission rate was used in order to determine the presence of alpha and beta emitters on a 10 cm x 15 cm rectangle that was printed (blue ink) on a matte polyester canvas carrier material. A blank sample of the same size has also been provided. The alpha and beta emitters are distributed evenly across the printed area and the stability and homogeneity of the samples have been checked.

This paper shows the obtained values, as well as the results evaluation in terms of accuracy and precision. Since all the results were satisfactory, the laboratory showed its reliability and competence. This experience will be used for further quality improvement of analytical capabilities.

^{210}Pb dating method: applicability and limitations

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^{210}Pb dating represents the most extensively used method to determine recent (~150-175 years) chronologies and accumulation rates in aquatic systems, and has been predominantly approached to effectively reconstruct environmental processes linked with global change. Extensively outlined by Appleby and Oldfield in 1992, the technique is based on "excess" ^{210}Pb resulting from the decay of atmospheric ^{222}Rn, and encompassed in sediments following scavenging from the atmosphere via dry or wet precipitation. The suitability of lead dating extends to determinations of atmospheric deposition and contamination, sedimentary processes, carbon dioxide sequestration, pollution of aquatic systems, etc. The large applicability and accessibility of the lead dating method determined numerous authors to adopt this technique for the study of environmental archives, however oftentimes the resulting chronologies are not critically assessed. The most common ^{210}Pb dating models are the Constant Initial Concentration (CIC) and Constant Rate of Supply (CRS), based on specific initial assumptions. The interpretation of ^{210}Pb profiles proves to be a complex process that must consider external influences, such as sedimentary processes and isotope migration, that may affect excess ^{210}Pb results, and alter the fundamentals of the model approached. Throughout the literature, the majority of the studies do not consider or properly discuss the limitations and external influences on the produced age-depth models, thus leading to an overestimation of activities and disputable chronologies. Besides uncertainties induced by sedimentary processes, limitations that may arise while applying the ^{210}Pb dating method include, but are not limited to ^{210}Po vertical migration, variations in ^{226}Ra activities, model-validation by alternative temporal markers, irregular Pb_{ex} profiles and interpolation for missing data and incomplete inventories. The present work performs a critical review of the ^{210}Pb dating method, with emphasis on applicability, limitations, and implications of different spectrometric measurement techniques, thus highlighting important considerations in constructing the ^{210}Pb age-depth model.

The complexity approach to food irradiation: how to increase the efficiency of processing

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Departments of Chemistry and Physics of Lomonosov Moscow State University with a collaboration of scientists from SINP MSU, FGBNU VILAR and SFSC RAS, conduct research in three main areas.

The impact of ionizing radiation on physical and chemical processes in biological objects: Currently, food irradiation is increasingly used to ensure the microbiological safety of products and increase their shelf life. Physics Department in collaboration with Chemistry Department of Moscow State University and FGBNU VILAR is studying the impact of various types of ionizing radiation with different characteristics on physical, chemical and biological processes in food during storage. The focus of the research is to establish technological modes of irradiation processing for certain categories of food using proven methods of microbiological and biochemical analysis, as well as high accuracy physical methods, such as GC-MS analysis, the method of electron paramagnetic resonance, fluorometric and spectrophotometric methods. It was found that the doses ranging from 250 Gy to 1000 Gy effectively reduce the microbiological component 10 to 100 times without altering organoleptic or chemical properties of meat and fish. A mathematical model was proposed to estimate the shelf life of products taking into account the quantitative and qualitative bacterial content in the source product which is selected for irradiation treatment.

Irradiation treatment of agricultural products to inhibit the growth of phytopathogens: Irradiation technologies are widely used in agriculture not only to inhibit the sprouting of root crops during storage, but also for preplanting seed treatment to suppress various types of fungal, bacterial and viral diseases in crops. Physics Department in collaboration with the Siberian Federal Scientific Center for Agrobiotechnologies of the Russian Academy of Sciences is studying the impact of ionizing radiation on sprouting, biometric properties and yield of zone seeds which are contaminated with region-specific fungal diseases. The research is aimed at the following:

- monitoring the formation of crops, productivity and its fractional composition, microflora, biochemical parameters after irradiation;
- searching for irradiation modes which reduce the growth of pathogens without affecting the yield of root crops and grain crops;
- stimulation of crop growth in order to reduce the negative impact of phytopathogens which can be found in the soil.

It was found that the doses ranging from 30 Gy to 50 Gy effectively reduce the black scurf without altering potato yield. It was shown that the doses ranging from 10 Gy to 30 Gy stimulate crop growth of oilseed crops.

Improving the efficiency of radiation treatment of organic and inorganic objects: Due to the nature of how the absorbed radiation dose is distributed over the depth of the object during processing with accelerated electrons, the inhomogeneity of the irradiation of objects is unavoidable. Under- or over-irradiation of biological objects can have an unfavorable impact on the object's integrity and quality, and may not have the desired microbiological effect. The development of techniques to improve the uniformity of the absorbed dose distribution over the depth of biological objects with a variety of forms and thicknesses is currently a hot topic. Research is being done to improve the homogeneity of the radiation exposure by modifying the beam of accelerated electrons in order to maximize the effectiveness of radiation processing. A universal algorithm has been developed in order to calculate the dose absorbed by a product of any geometry and chemical composition during radiation processing with various types of ionizing radiation, and to assess the uniformity of the distribution of the radiation dose over the product's entire volume for any irradiation scheme.

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BOOK OF ABSTRACTS rad-conference.com

Space radiation variations during solar energetic particle events and geomagnetic storms

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Energetic electron and proton flux variations have been observed by the Energetic Particle Telescope (EPT) from the launch of PROBA-V satellite on 7 May 2013 up to now. This detector that flies on a polar Low Earth Orbit (LEO) at an altitude of 820 km was designed to measure space radiations and provide uncontaminated spectra of electrons, protons and alpha particles.

Strong Solar Energetic Particle (SEP) events, like in January 2014, June 2015 and September 2017, inject energetic protons at high latitudes, but not in the inner belt where protons are trapped at long term at low L. Nevertheless, big geomagnetic storms, including those following SEP a few days after, can cause losses of protons at the outer border of the proton belt, due to magnetic field perturbations. At solar minimum, the proton fluxes are higher at low L corresponding to the northern border of the South Atlantic Anomaly. This solar cycle modulation of the inner belt is mainly due to losses by increased atmospheric interactions during solar maximum.

Electrons of the outer belt are very dynamic during geomagnetic storms. Electron flux dropout events are observed during the main phase of each storm and even during substorms: a rapid reduction of the electron flux is noted throughout the outer electron radiation belt at all energies above about 0.5 MeV on timescales of a few hours. The electron spectrograms measured by the EPT between 2013 and 2019 show that after each geomagnetic storm, dropout events are followed by a flux enhancement starting first at low L values, and reaching the slot or even the inner belt for the strongest storms. We have determined the link between Disturbed Storm Time (Dst) and the minimum value of the L-shell where the dropouts deplete the outer belt, as well as the non-linear relation between Dst and the minimum L-shell where the flux penetrates in the slot region or even the inner belt during the storms. Dropouts appear at all energies measured by EPT and penetrate down to L~3.5 for the strongest events. Dropouts are observed at LEO each time Dst has an inverted peak < -40 nT. Flux enhancements appear at lower L only for big storm events with Dst < -50 nT. They penetrate down to an impenetrable barrier with a minimum L-shell related to Dst and to the energy. For E > 1 MeV, this limit is also linked to the plasmapause position.

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Estimating geothermal and background radiation hotspots from primordial radionuclide concentrations in geology of South Africa

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Naturally occurring radionuclides are the main generator of geothermal energy in the Earth's crust and mantle. The generated energy is consequently directly proportional to the concentrations of the three main naturally occurring radionuclides (uranium, thorium and potassium), which are primordial in origin. Concentrations of these naturally occurring radionuclides were extracted for all the different geological rock units in South Africa. The radionuclide concentrations were then mapped and integrated by using QGIS. The results were used to estimate and map the geothermal energy production rates for the rock units. The radionuclide concentrations in the rock units were also used to identify regions with high radiation background. These radiation hotspots were plotted and investigated. The estimated geothermal energy and background radiation hotspots were compared to measurements and projections of other studies and good corelations were found.

Current status of the Turkish accelerator and radiation laboratory

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A new accelerator laboratory is taking shape in Ankara, Turkiye. At Turkish Accelerator Radiation Laboratory (TARLA) a superconducting electron linac is being built with research in nuclear, radiation, and optical physics as well connected applications as its goal. The primary electron beam energy will range from 4 to 45 MeV with a current of up to 1.6 mA. The primary beam will be used to generate photons from bremsstrahlung (gamma radiation) as well as being used to make a free electron laser (FEL). The scientific goals of TARLA are mainly focused on material science, nuclear physics, photo-chemical processes, photoactivation, biotechnology, non-linear optics, semiconductors, and medicine. At this time the construction of the injector section is being finalized and it is expected to achieve the 20 MeV beam by the end of the year. In addition, a multi-detector gamma-spectroscopy setup based on 2 Clover HPGe, 2 single crystal HPGe with their BGO's characterization. We aim to present the current status of the injector and the gamma-spectroscopy setup as well as to introduce the laboratory as a whole to the scientific community.

Imaging of low atomic number materials via muon induced secondary particles

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Versatile application of muography and the world-wide trend in further development of this field in applied scientific research is evident based on numerous scientific papers in highly distinguished journals. Cosmic-ray muography has been used for the inspection of geological and industrial structures. However, the muon imaging of small structures with low atomic number and density was not yet solved appropriately. Our research group has demonstrated completely new imaging method by cosmic-ray muons, based on the detection of secondary produced radiation in object material. Taking advantage of the production rate of secondaries in the target materials, detected in coincidence with muons by plastic scintillator detectors, together with muon tracker, the first cosmic-ray muon images of bone and soft tissue were created. These pictures represent the first radiographies of structures of organic origin ever recorded by cosmic rays. The research using Monte-Carlo (MC) simulations, done by Geant4 software, includes simulations of the interactions of cosmic-ray muons with different detectors and different target materials. In this work, we have presented the latest updates of experimental setups in Novi Sad and Budapest, used for muography of different test materials and the obtained images via those setups. The aim of this research is to provide imaging and composition study of various objects, emphasizing low atomic number and density materials, using only naturally omnipresent cosmic radiation. MC simulations have been useful for distinguishing the origin of secondary produced radiation in object material and contribution of each component, along with the energy spectrum of the particles created in the material investigated. Thus, comparison of experimental results and results obtained from MC simulations provides a good basis for upgrade of experimental setup as well as better understanding of the processes leading to image creation.

Photoactivation study of ^{163}Tb ß-decay

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The beta-decay of ^{163}Tb nuclei ($T_{1/2}$=19.5 min) was studied in the photoactivation reaction ^{164}Dy(γ,p)^{163}Tb. Targets made of enriched (97.8% of ^{164}Dy) and natural dysprosium were activated using the bremsstrahlung with energy up to 20.36 MeV at the microtron MT-25 of the Nuclear Physics Institute of the Czech Academy of Sciences (Prague). Gamma-spectra following beta-decay were measured with high resolution spectrometer based on HPGe detector (energy resolution 0.3 keV) in the energy range up to 2.4 MeV. The cooling times were 3 min 15 sec for enriched dysprosium target, and 2 min 51 sec for natural dysprosium target. Comparison of γ-intensities in spectra obtained from enriched and natural dysprosium targets facilitated isotopic assignment of corresponding lines and subtraction of contamination intensities from decay of other photonuclear reaction channel products. For confirmation of isotopic assignment of γ-lines, activation measurements with same targets were performed also with bremsstrahlung energy up to 22.82 MeV. Corresponding spectra were registered after 9 min 7 sec, and 1 hour 5 min 31 sec cooling times. Most of γ-transitions observed in the spectrum of enriched dysprosium target were assigned to the β^-decay (Q_β=1785(4) MeV [1]) of ^{163}Tb levels (ground state $3/2^+$[411]) to the levels of ^{163}Dy (ground state $5/2^-$[523]). Several ^{163}Dy γ-lines were observed in the β-decay experiment for the first time. Corrected energy values and branching ratios were established for a number of ^{163}Dy γ-transitions published earlier [1]. The proposed level scheme of ^{163}Dy was compared with the results of quasiparticle-plus-rotation-vibration interaction model calculations.

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A perovskite-thermoplastic composite for 3D printing novel radiation detectors

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The fabrication of perovskite-polymer composites has proved useful in overcoming stability limitations in perovskite radiation detectors and offers mechanical qualities such as flexibility. Facile production of all-inorganic perovskite nanocrystals (NC), such as $CsPbBr_3$, offers convenient and cost-effective production of perovskite material. By loading NCs into commercially available thermoplastics, this composite may be extruded into filaments suitable for fused filament fabrication (FFF) and subsequently 3D printed into a radiation detecting object. 3D printing would enable the manufacturing of complex and bespoke detector designs with future developments leading to detector layers being printed directly onto existing electronic architectures. The low-cost materials and accessibility of 3D printing would allow for detectors to be manufactured on-site and as needed.

In this work, first attempts at producing and characterizing perovskite-polymer composite objects from $CsPbBr_3$ NCs and the thermoplastic polycaprolactone (PCL) are presented. $CsPbBr_3$ NCs dispersed in toluene were mixed with PCL pellets dissolved in toluene. The resulting solution was cast and the solvent was dried off, leaving a solid plastic composite material. This composite was heated above the melting point of PCL, cast into a custom silicone mold and cooled. The resulting disc-shaped pellets have been polished to smooth the faces for improved electrode deposition and to control the thickness. Additional centrifugation techniques have been employed to remove inhomogeneities and obtain more uniform distribution of NCs in the composite solution.

Test devices for direct radiation detection have been fabricated by depositing gold electrodes via thermal evaporation onto the sample surface and then mounting these onto printed circuit boards. These devices integrate into an RF-shielded enclosure positioned in-front of a tungsten target X-ray source. A Keithley 6487 picoammeter/voltage source is used to apply a bias across the device and to record current measurements with and without X-ray illumination. Compositional analysis of early samples has been carried out using microCT, x-ray fluorescence imaging (XRF) and scanning electron microscopy (SEM). The microCT reconstructions offer a look into the internal structure of each sample to reveal defects such as air pockets or cracks. XRF and SEM imaging has been used to study the uniformity of NC dispersion in the composite which is crucial in determining whether sufficient conductivity pathways are in place for the charge collection.

The first $CsPbBr_3$/PCL device presented here is composed of 8.1% $CsPbBr_3$ by weight. Bias sweeps from -10 V to 10 V were performed and the dark current of 0.045 nA has been measured. The X-ray source was switched on at 70 kV for a series of mA values and a clear photocurrent response of the device at 10 V bias was observed. From these measurements, the photocurrent response as a function of dose-rate was found, demonstrating a linear response at dose-rates greater than 2000 µGy/s. Future improvements to this method will use measured electrode dimensions to accurately determine values for the sensitivity and conductivity of each device. MicroCT and SEM images have been used to demonstrate improvements between first- and second-generation samples, validating recent improvements to composite production. Improvements to the gold deposition process for device preparation has improved repeatability of current measurements between samples.

This work lays the foundation for novel 3D printable perovskite-polymer composites for use in direct radiation detection by exploring the compositional makeup of these materials and characterizing their detective properties. Recent device sensitivity to radiation will be presented and progress made in producing high-quality composite devices for characterization will be explored.

Electron-induced dissociative ionization of the pyridine molecules

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Interactions of ionizing radiation with cells produce a cascade of ionization and dissociation events that leave low-energy electrons, radicals, and ions. These particles can interact resonantly or directly with biomolecules through multiple reactions, causing lesions to DNA and RNA via single or double-strand breaks. Thus, measuring cross-sections for electron-impact ionization of biologically active molecules is required to elucidate the complete sequence of mechanisms leading to the final chemical state of the molecules and understand the role played by electron-impact dissociative ionization in the processes of DNA damage.

In that regard, we will show the results of investigations on the electron-induced dissociative ionization of pyridine, the simplest six-membered nitrogen-containing heterocyclic molecule being the structural unit of the B vitamins, NAD and NADP coenzymes, and alkaloids produced by living organisms. The well-resolved mass peaks of pyridine have been detected in the mass range of 10–80 amu and assigned to specific ionic molecular fragments. The absolute total and partial ionization cross-sections of pyridine have been obtained as functions of electron energy in the 5–140 eV range. Appearance energies of selected ionic fragments have been measured and analyzed using the ThreSpect software [1], [2]. We will compare these results to the electron- and photon-induced dissociative ionization of pyridine studied previously.

Acknowledgments

The experiments were performed using a quadrupole mass spectrometer at the Laboratory of Complex Systems Spectroscopy of the Gdansk University of Technology (core laboratory of Fahrenheit Universities).

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A new approach to directional radiation detection

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The ability to identify the presence of a source of radiation is important in a number of situations, including for nuclear security, oil and gas well logging, medical treatment monitoring, and post radiological incident remediation. Detecting a source is relatively trivial using well-established detector technologies, however it would also be advantageous to provide activity mapping and radionuclide identification. A number of techniques have been developed, including using pin-hole cameras, coded apertures and Compton cameras. These have all been demonstrated to varying degrees of success, but a limiting factor is that they are complex, difficult to handle and do not make best use of the available detector area. We have previously developed a novel approach to directional radiation detection called RadiCAL. The concept utilises a CsI(Na) scintillator and a photomultiplier tube. The scintillator is cuboid in shape, having typical dimension of 100 × 100 × 5 mm. The scintillator is rotated with respect the environment. If a source of radiation is present, then the recoded signal fluctuates as the wide face and narrow face are presented to the source. By encoding the scintillator rotation position, it is possible to infer the direction of one or more radioactive sources. RadiCAL has been shown to work exceptionally well for point sources with lower energy emissions (e.g. 60 keV (^{241}Am), 662 keV (^{137}Cs)) where the total number of detected counts is all that is required to determine the source locations.

In this study we have extended the capability of the RadiCAL technique to higher energies by introducing an additional $CeBr_3$ detector which is run in coincidence with the rotating scintillator. This higher energy range is important in proton cancer therapy, for example, where there is interest in looking for prompt gamma emissions at ~4.4 MeV (which come from relaxation following nuclear excitation due to proton interactions in the patient) for range verification. However, at these energies, the incoming gammas have a tendency to Compton scatter or undergo pair-production in the CsI(Na) scintillator, resulting in partial energy deposition only. Coupled with that, there is a significant low energy background resulting from scatter and activation decay in the proton therapy scenario which does not serve to elucidate the proton range.

By including the coincidence detector, it is possible reject incomplete and low energy events compared to RadiCAL alone. Monte Carlo models have been developed (in Geant4) and the geometry has been set to mimic an experimental setup in the laboratory. From the model we have shown ~85% reduction in the low energy signal, while almost completely preserving the number of full energy events. We anticipate this being advantageous for isolating gamma sources in noisy environment, like a proton therapy treatment room, which would otherwise distort the shape of the idealised detector response and make source localisation more difficult.

Preliminary results of laser-driven gamma imaging studies with 100TW laser at ELI-NP

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Bright photon beam sources in the range of tens-MeV are essential tools in many research fields of which we mention: medical and biophysical applications, material science, high-energy density plasma-physics, nuclear and atomic science, and so forth. The high-energy gamma-rays are useful also for non-destructive test applications, especially for investigation of small-size defects in big-size objects, which are hard to penetrate. Nowadays, these objects are scanned by gamma-ray beams from few-MeV electron linear accelerators (LINAC), however, the spatial resolution of such gamma sources is limited due to the beam spot size around 0.5-1 mm. The development of laser-plasma type accelerators made possible the acceleration of electron bunches with much smaller spot size and by further impinging those electrons on different solid targets, high energy Bremsstrahlung radiation micro-spot gamma-ray can be obtained[1,2,3].

The aim of this contribution is to present the most recent results of laser-driven gamma imaging experiment performed at ELI-NP on the 100 TW laser arm. Ultra-short pulses of 28 fs were focused down to 24 µm spot size on 3 mm supersonic gas jets of low-density Argon (3-6 x 10^{18} cm^{-3}) at laser pulse energy on target of $1.5 \text{ J} \leq E_L^{onT} \leq 2 \text{ J}$. Further on, the laser-accelerated electrons were incident on a 2 mm thick Al target for Bremsstrahlung gamma-ray generation. Experimental set-up, laser and plasma parameters leading to the generation of good quality images of the irradiated samples (a Brass rabbit amulet with 3 cm X 2.5cm size and 6-10 mm thickness and a 6 mm thick Lead brick with 35 mm x 35 mm size, with 4, 3.5, 3, 2.5, 2, 1.5, 1, 0.8, 0.7 and 0.5 mm diameter holes) will be presented and commented.

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Radiation exposures of staff in diagnostic radiology in Serbian general hospitals

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Long-term exposure to ionizing radiation may increase the risk of carcinogenesis as well as other effects (ICRP, 2007). The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has determined that globally several million personnel are occupationally exposed to ionizing radiation as a result of various applications. Of these, about 10% are medical workers, and the monitored doses are usually below the defined annual effective dose limit of 20 mSv (Euratom, 2014; UNSCEAR, 2008). Dose limits are set to prevent tissue reaction effects and to decrease the chance of radiogenic cancer incidence (Alkhorayef et al., 2020).

Staff doses depend on the workload and radiation protection measures. To minimize exposure in diagnostic radiology, appropriate personnel protection methods are necessary, including the use of lead shields, well-designed departmental infrastructure, and the practice of safe work procedures. As a key component of this, staff dose monitoring is recommended, which ensures a safe working environment and all in accordance with the ALARA principle (Alkhorayef et al., 2020).

In this paper, the level of exposure of personnel in the centers for radiological diagnostics of the General Hospital in Šabac (Center A) and the General Hospital Pančevo (Center B) in Serbia is presented. Monitoring of staff exposure to radiation in both centers was carried out using thermoluminescent personal dosimeters (TLD) in the period 2017 - 2021. The analyzed period also includes the Covid-19 virus pandemic when the staff had an increased workload and were more exposed to radiation than usual. Dosimetry information included operational personal dose equivalent amounts at a References depth of 10 mm $H_p(10)$. The personnel whose exposure was monitored were radiologists and technicians at both centers. In both centers during the analyzed period, standard X-ray procedures, mammography procedures and computed tomography (CT) procedures are performed in both centers. Based on the obtained TLD dose values, the dose values according to the performed procedure were estimated. The obtained values of H_P (10) parameters indicate that all personnel were exposed to a dose of less than 20 mSv per year, and to a dose of less than 100 mSv for the analyzed period of 5 years (Euratom, 2014; UNSCEAR, 2008), and it can be said that the radiation protection measures implemented in an adequate manner.

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Nuclear calculation and simulation studies for the nuclear safety in GANIL

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Nuclear calculation and simulation are of great interest for nuclear facilities in GANIL. The dimensioning and the conception of new facilities last fifteen years in GANIL, namely SPIRAL2, as the modification of existing facilities (Cyclotrons) as well are based on the modelling studies using nuclear codes especially Monte Carlo ones. Thank to these studies, the major nuclear characteristics of these facilities are defined.

One of the current projects in GANIL is the re-evaluation of the nuclear safety of nuclear facilities, namely the Cyclotrons. Several departments are involved in this work. This re-evaluation is planned every ten years following the nuclear regulation. In the frame of this re-evaluation, we recalculate the activation of different structures and of the air in cyclotron areas considering the improvement of nuclear physics models included in the most recent versions of simulation codes. Then, the consequences of these calculation on the radioactivity releases and on the nuclear safety aspects are re-estimated.

The simulation work is based on both Monte-Carlo method and the nuclear data. The use of nuclear data is of great interest in this work. Since some nuclear data are missing from data libraries we performed several experiments to measure these data and to compare them to the existing ones and/or to the nuclear physics models. This experimental program allowed us to benchmark the physics models used in this work.

In this talk we will mainly present the methodology used to perform these calculation studies. We will also present the comparison between old and new physics models versions and their impacts on the nuclear activation. Some benchmark results of the simulation thank to the TTNY experimental work will be discussed.

Keywords: Nuclear calculation, Monte Carlo simulation, particles transport, activation, calculation codes, nuclear data, benchmark

Dose assessment according to location and energy using machine learning based on Monte Carlo simulation data

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Personal dose monitoring of radiation workers in Korea is usually performed by measuring the cumulative dose for 3 months using personal dosimeter such as TLD and OSLD. This is an effective method for protection purposes to prevent overexposure when managing a large number of workers, but there are limits to accurate dose assessment for specific situations. For workers engaged in work where high exposure is expected, more accurate dose assessment specific monitoring is required. In order to achieve it, database of dose conversion factor for various conditions such as the posture of worker and the source distribution is being built through Monte Carlo simulation. In this study, an attempt was made to predict the dose of conditions not included in the database using machine learning to meet the purpose of building a database to obtain more accurate dose evaluation results. The exposure situation considered in this study is only a situation in which the MRCP phantom in a standing position is exposed by a point source. The input variables were selected as a source location and energy. Output variables were equivalent doses of lens, lung and foot as organs representing the upper, middle, and lower parts of the human body. As for the x, y, z coordinates of source location, each 10 values were selected from 0.1 to 1 at intervals of 0.1. Source energies were selected from 0.2 to 1 MeV in 0.1 MeV steps. Simulations for dose evaluation for a total of 9000 exposure conditions were performed using GEANT4 code. The simulation results were shffled and divided into training and test data at a ratio of 8:2. The training data was trained on a deep neural network model with hyperparameter tuning. Hyperparameter tuning was performed with a random search method for the number of neurons, activation function, batch size, and learning rate, and was optimized by k-fold cross-validation. For the loss function, the mean absolute error was used. It was confirmed that the predicted value using the learning model in the test data showed a difference within 5% from the true value. Through the results of this study, it was confirmed that the dose value at the time of exposure to the point source of the standing phantom could be predicted using machine learning, and by using this, it is expected that the dose value for various source distributions can be calculated by weighting the probability of the source distribution to the dose value.

CT number accuracy and uniformity comparison for four CT scanners in different hospitals in Albania

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As the contrast gained from CT images is vastly superior to that gained from projection radiography the use of CT scanning is increased especially during the last years in Albania. Therefore, to ensure that the quality of CT medical images production provide the right anatomical information, the quality control tests for these medical devices is needed. The quality control of radiological medical devices in Albania has started since 2015 and is applicated every three years from the Institute of Applied Nuclear Physics according to Albanian regulation. Quality control testing of CT scanners in our region includes a measurement of CT numbers and uniformity which is expressed in Hounsfield unit (HU). CT number values are clinically relevant in determining the composition of various tissues in the body and their accuracy is important in the characterization of tumors, assessment of coronary calcium, and identification of urinary stone composition. In our quality control of diagnostic medical devices laboratory, the image quality test is performed using an American College of Radiology (ACR) Gammex 464 phantom containing five inserts of different tissue materials (polyethylene, solid water, air, acrylic, bone) equivalent to human tissue. This paper presents the results of CT number measurements and uniformity using the best images during the performance of quality control tests for acceptability criteria on 4 scanners (1 new installed Toshiba in 2021and 3 Philips installed in 2012). All measurements are performed using an average adult abdomen protocol for the phantom scanning. Analyzes of the results are performed using the ImageJ software, based on the HU measurements of specific materials within the ACR phantom and compared with the acceptable ranges for these materials specified by the ACR Accreditation Program. Among the five materials polyethylene, solid water, air, acrylic, and bone equivalent, the measured CT numbers for all scanners are within the tolerances. Especially for the new one scanner the HU value of five different tissues was closed to the References value. For the three Philips scanners the CT number measurements had minor differences between each other. CT number uniformity for water values was also within the tolerances for three of scanners but significantly lower on one of Philips scanners. Consequently, the measured value near to the lower limit range, indicates the need for further investigation and possible recalibration of the scanner, as the radiologists should be aware of this, as long as HU are used for quantification and tissue characterizing for diagnostic purposes.

Development of caesium antidote enterosorbents for the protection in the case of radioactive fallout

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Explosion of atomic bomb or the accident at a nuclear power plant may cause production of long living radionuclides such as caesium isotope Cs-137 (physical $t_{1/2}$ = 30.2 years), which can be propelled into the upper atmosphere at a height of more than 10 km and be transferred by the wind more than 100 km away from the epicentre of the explosion, where they can fall in a concentrated form causing nuclear and radiological contamination of these territories, as was the case in Chernobyl, where contamination was detected thousands of kilometres away. Due to radioactive contamination, the government was forced to evacuate people and animals. Radiogardase®-Cs (RG) (HEYL Chem.-pharm. Fabrik GmbH, Germany) is a commercial radioactive Cs and thallium antidote based on iron hexacyanoferrate (Prussian Blue (PB) solid form) available in many European countries recommended to be used weekly for each poisoned person, determining large amounts of drugs and treatment costs (1).

Aim: This study aims development of a combined antidote formulation that can be quickly prepared in a pharmacy for the protection in the case of a radioactive accident at a nuclear power plant or a nuclear explosion in a nearby region in the case of fallout causing contamination of the environment. When people and animals must be evacuated, this is time consuming process causing proper protection, therefore, it is necessary to be prepared for preventive protection with antidotes.

Method: We used the mechanochemical synthesis process for production of controlled particle sizes that can be divided into three fractions. The mechanochemical synthesis method is a classic “green synthesis”. After obtaining the PB, the nano fraction was separated. Nanoparticles are known to be able to enter the cell, so it is important to separate this potentially dangerous size from the total mass. The combined preparation we developed contains a formulation of PB, pectin and activated carbon. It is known that activated carbon is a non-specific sorbent, while pectin, which is also a non-specific sorbent, are harmless to macroorganisms and can be used to absorb heavy metals.

The efficiency of PB was checked depending on the capsule shells used for packaging the active pharmaceutical substance (API). The preparation was tested in deionized water (pH=5.5), artificial gastric juice (pH=1.2) and artificial intestinal juice (pH=7.4).

Results: Testing our preparation in gastric artificial juice, intestinal artificial juice, deionized water by comparing the sorption efficiency with RG indicated that that Cs ion adsorption with the combined antidote substance synthesized was by 34% better compared to that of RG in the case of pH=1.2, and a bit better than RG in the case of intestine juice conditions (pH =7.40), whereas they were comparable in the case of deionised water conditions (e.g., pH =7.4).

The developed antidote for the oral intake can be used for personal protection in the case of radioactive fallout. The preparation contains a low amount of active substance, e.g., iron ferrocyanide with the selected size of 100-200 nm has been obtained by the "green synthesis" method and particle separation. Gastric ulcer patients can use PB packaged in capsules resistant to gastric juice.

Conclusion: A "green synthesis" methodology for obtaining PB has been developed to prepare capsules in the pharmacy with different choose the type of capsule shells adjustable depending on the gastrointestinal diseases, or for those who do not use gelatine capsules.

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Space radiation damage: calculation of astronauts' doses and comparison with dose limits

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A renewed interest in space research is growing in recent times, also considering that human missions to the Moon, and possibly Mars, are being planned. Astronauts' exposure to space radiation is one the highest-priority problems, being classified by NASA as a "red risk". In this work, exploiting a pre-existing interface between the BIANCA biophysical model and the FLUKA Monte Carlo transport code, a study was performed to calculate absorbed and equivalent doses following astronauts' exposure to Galactic Cosmic Rays (GCR) and Solar Particle Events (SPE) under different shielding conditions. More specifically, the interface with BIANCA allowed calculating both the relative biological effectiveness (RBE) for cell survival, which is more related to non-cancer effects, and that for chromosome aberrations, more related to the induction of stochastic effects. Calculations were performed in a spherical water phantom and also in the References male and female computational phantoms reported in ICRP Publication 110. The results were then compared with astronauts' dose limits for cancer and non-cancer effects.

Concerning GCR exposure, the equivalent doses calculated by multiplying the absorbed dose by the chromosome-aberration RBE were similar to those calculated using the Q-values recommended by ICRP. For a 650-day mission (representative of a possible Mars mission scenario) at solar minimum, the obtained values were always lower than the career limit recommended by ICRP (1 Sv), but higher than the 600-mSv limit recently adopted by NASA. More generally, both at solar minimum and at solar maximum, a shielding of 10 g/cm^2 Al resulted to be a better choice than 20 g/cm^2 for astronauts' protection against GCR. For SPE exposure, considering the spectra from the events of January 2005 and October 2003, the values obtained by multiplying the absorbed dose by the RBE for cell survival resulted to be above the NASA non-cancer limits for blood forming organs (BFO) for all considered Al shielding (up to 30 g/cm^2). For skin, the results were below the limits with a shielding of 20 g/cm^2.

Following this work, BIANCA, interfaced with a radiation transport code like FLUKA, allows predicting GCR and SPE equivalent-dose values based on the RBE for cell death and chromosome aberrations.

Estimated actual and potential radiation safety and nuclear security situation in Ukraine in the context of the ongoing military operations

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All ionizing radiation applications except nuclear weapons (which the country gave up the world's third nuclear arsenal in 1994 after the collapse of the Soviet Union) are present in Ukraine. This includes 15 power reactors at four NPPs, producing more than 50% of the electricity the country needs, decommissioned Chornobyl NPP complex, including the Unit 4 confinement, uranium mines, and various other applications of radiation and nuclear technologies in medicine, industry, research, and education. According to the national registry, the country has about 26,000 various radiation sources. This includes the use of 8,728 radioactive sealed sources. The impact of war significantly affected the safety and security of radioactive sources, waste repositories and potentially also nuclear power plants and other nuclear installations. Virtually any of these facilities and laboratories are at risk of damage or destruction due to Russia's military operations after the Ukraine invasion. Many objects were attacked and severely damaged. Since some places are currently out of the control of the national regulatory authorities, these circumstances have to be reliably identified and assessed to determine the latest conditions regarding radiation levels and potential radioactive contamination, especially in war-affected areas where access is limited. It has to be considered at least five different aspects of the problem, namely:

The status of the four nuclear power plants that are in operation (Rivne NPP, Khmelnytskyi NPP, South Ukraine NPP, and Zaporihzhaya NPP);

The situation at decommissioned nuclear units in Chornobyl;

Spent nuclear fuel stores;

Medical, industrial and other workplaces where high-activity sealed and unsealed radioactive sources are (were) used, including those that became orphan sources;

Repositories, where spent radioactive sources and nuclear materials have been kept.

The paper analyses and presents the latest overview of the status of radiation safety and nuclear security in Ukraine based on information from open sources and especially findings of inspectors from the International Atomic Energy Agency as well as materials from Ukrainian regulators and other relevant institutions.

Development of drones for radiation protection applications

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A drone prototype, which is suitable for the exploration of radioactive sources, is under development in the Nuclear Security Department (EK SBL) of the Centre for Energy Research. Furthermore, other directions of this development (e.g. measurement of pulsed fields using a drone, drone suitable for decontamination) are presented.

In recent years, the use of drone technology has become available, but at the same time, the search for radioactive materials requires a drone that meets certain special conditions (e.g. it can detect orphan radiation sources from a sufficiently high height and distance, without the drone blowing up the supposedly open source). Currently, many developments are taking place in the world, but their structure is not appropriate in all cases since the more special needs of radiation protection are not taken into account (e.g. drone-source distance, decontamination ability, appropriate testing of drone-mounted measuring devices, training of drone pilots for radiation source detection.). That is why the EK Double-RingWings (DRW) co. with his cooperation, we started the development of a drone that meets special needs.

Air activation studies in the new proton therapy center planned for the Marques de Valdecilla University Hospital (HUMV), Santander (Spain)

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Purpose: Air activation is an important concern in proton therapy centers as it can lead to the production of radioactive nuclides that can pose a health risk to staff and patients. Understanding and mitigating the effects of air activation can help ensure a safer environment for everyone involved in proton therapy. This air activation is produced not only by neutrons, but also by the protons in the beam, who can equally generate radioactive nuclides when they directly interact with atoms in the air. The aim of this work is to study the activation of air in proton therapy centers to assess the exposure and to propose mitigating actions, such as ventilation rate. This understanding can help ensure the safety of staff and patients in the new proton therapy center planned for the Marques de Valdecilla University Hospital (HUMV), Santander (Spain).

Material and methods: MCNP6 and PHITS codes have been used for that purpose. Following the study based on calculations, several scenarios were considered in the HUMV.

Results: On the one hand, $_{41}$Ar is the main source of inhalation radiation in proton therapy centers, for several reasons. Firstly, due to its high cross-section of neutron capture and secondly, due to its high dose coefficient, e50, which is between one and three orders of magnitude higher than the rest of the isotopes produced. Therefore, removing the argon from the air in the installation would practically eliminate the inhalation dose. On the other hand, ventilation reduces the inhalation load very effectively, and relatively cheaply.

Comparative Analysis of Internal Dose Conversion Coefficients due to Inhalation of Particulates for Workers according to the ICRP OIR Update: Zircon Industries

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In Korea, zircon is used as a raw material for a variety of products, including refractories, welding rods, and glazes. Typical radioactivity concentrations of the U-238 series at zircon are 2-4 Bq/g, and the zircon industry is classified by the IAEA Safety Report Series No.49 as one of the industries handling naturally occurring radioactive materials (NORMs) requiring regulatory consideration. In Korea, the zircon industry is managed under the Domestic Act on Action Guidelines against Radiation in the Natural Environment because it generally exceeds the registration criterion for radioactivity concentration (1 Bq/g), and the number of registered facilities is dominated by potassium compounds. Workers handling this zircon can be exposed to internal exposure due to inhalation of particulates. The ICRP has also updated its occupational radionuclide intake (OIR) data to 2022, with changes to the internal dose conversion coefficients for the major natural radionuclides. In this study, the recent OIR were compared with previous values for the internal dose conversion coefficients due to inhalation of particulates by workers handling zircon. The recent OIR was compared with ICRP 119 publication for internal dose conversion coefficients for 46 natural radionuclides, including the U-238, U-235, and Th-232 series. ICRP default values were used for particulates properties (AMAD = 5 μm, GSD = 2.49, ρ = 3 g/cm^3, χ = 1.5). For the absorption type, default absorption type S was used to account for the extreme resistance to leaching of uranium and thorium and their decay progeny due to the chemical properties of zircon, and default absorption type M or F has been used for nuclides for which type S coefficients are not available. The dose contributions for the U-238 and Th-232 series were summed using typical zircon radioactivity concentration ratios, while the U-235 series used natural abundance of ratio. Secular equilibrium was assumed for each natural radionuclide series. The internal dose conversion coefficients according to the recent ICRP OIR were assessed to be 5.6.E-05 Sv/Bq for the U-238 series, 1.3.E-04 Sv/Bq for the U-235 series, and 1.0.E-04 Sv/Bq for the Th-232 series, an increase of approximately 2 times for the U-238 series, 1.5 times for the U-235 series, and 2.5 times for the Th-232 series compared to previous values. Applying the typical radioactivity concentration ratios of the U-238 and Th-232 series in the zircon, the dose contribution of each series is added together, and the internal exposure dose conversion coefficient for the worker is approximately doubled. This is due to the large overall increase in dose conversion coefficients for highly dose-contributing nuclides such as U and Th for the default absorption type S. In addition, the ICRP 119 publication lacked a dose conversion coefficient for absorption type S, such as Radium, which was added in the recent OIR, resulting in dose differences. The results of this study will be used to validate worker dose assessment and risk assessment in the NORM industry.

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Three-dimensional computational fluid dynamics investigation of the dispersion of radioactive cloud

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The evaluation of spatial distributions of plume dispersion into the atmosphere is an important task for estimating the release of radioactive gas. The Gaussian Plume Model (GPM) represents the most adopted implementation for submersion dose evaluations from an emission stack. The radioactive cloud dispersion is obtained by calculating the Brigg's coefficients that varies with the meteorological conditions, mainly the wind speed and the atmosphere stability. The ideal scenarios for GPMs are nuclear plants that are located usually few hundred meters far from population centers. Once the spatial distributions of contaminants are known, doses can be calculated multiplying the radionuclide concentration in a certain point by Dose Conversion Factors.

On the other hand, nuclear medicine and hadrontherapy centers are situated in populated areas and GPM models can excessively overestimate submersion doses. For this reason, the correct estimation of a radioactive plume dispersion can be estimated with computational fluid-dynamics (CFD) models. Subsequently, the radionuclide dispersion can be implemented in the Monte Carlo code FLUKA to make more accurate dose evaluations.

In this work, comparisons between the results obtained with the U.S. Department of Energy (DOE)-certified software Hotspot and CFD Ansys Fluent are performed in order to compare a GPM model with a CFD model at short and long distances.

CFD numerical results have been obtained by solving the steady-state Reynolds Averaged Navier-Stokes (RANS) equations using the k-ε turbulence closure model. The RANS modelling is modified to account for atmospheric stability, thermal stratification, and ground roughness effects. The Monin-Obukhov Similarity Theory (MOST) is employed to define consistent inflow conditions to simulate different levels of atmospheric stability.

An unstructured hybrid mesh with local refinement regions is generated to accurately resolve the plume transport region and the flow field close to the ground and the chimney.

Numerical results have been obtained by considering different stability atmospheric conditions and comparisons and differences between GPM and CFD models are presented and discussed.

New design for Hp(10) standard

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To ensure maximum safety for people professionally working with ionizing radiation, special procedures for radiation protection have been created. One of the obligations arising from such protection is the measurement of the dose received by individual workers In order to facilitate the determination of radiation doses received by an occupationally exposed man and the determination of acceptable limits, working values of the ICRU (International Commission on Radiation Units and Measurements) are used. These are quantities that can be measured or determined experimentally. To control human exposure to penetrating radiation, the individual dose equivalent Hp(10) determined in sieverts is used.

The new standard for Hp(10) measurement developed in the Central Office of Measures in Poland introduces a new approach to simulation and takes into account the influence of the real human body structure in relation to the radiation received. In accordance with the currently obligatory guidelines, the standards used so far simulated the chest in the form of a block of soft tissues. The new Hp(10) standard, designed and launched, takes into account (in the context of reflected radiation) the real structure of the human chest through the additional simulation of the ribs which are modelled by an innovative construction of the aluminum collecting electrode.

Tests of the correctness of the standard's operation in X-rays (Narrow series) were carried out. During the measurements, in accordance with the accepted standard, the new Hp(10) standard was placed 100 cm from the radiation source to the center of the active volume of the standard. The data collected during the measurements confirm the correctness of operation of the newly created measurement standard. In addition, the results indicate an improvement in the metrological accuracy of the pattern, which is due to the new construction method used.

The collected results show that the presented chamber may soon be used as a secondary standard of the Hp(10) working value, and the innovative method of construction will improve the measurement accuracy of this quantity, ensuring greater safety for people who are occupationally exposed to radiation.

Implications of the relative strictness of building material indices

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Limiting indoor radiation exposure from building materials is an important regulatory task, helped by various indices, however not all legislation has the same criteria, potentially presenting barriers for trade. Some natural resources, as well as the valorization of industrial by-products may lead to higher than average radionuclide concentrations, presenting a relatively high risk. Building material indices are intended to be used for screening building material, preventing an unacceptable radiation dose burden from materials used in the construction industry. Such indices include radium equivalent concentration, external hazard index, internal hazard index, alpha index, representative level index, gamma-index, and more. These indices have varying underlying dose models and permitted level of exposure, so they are usually not directly convertible to each other, even though all of them are based on the activity concentrations of gamma emitters in the U-238, Th-232 decay chains, and K-40. Furthermore, understanding the underlying dose model is very important for the application of these indices, otherwise erroneous conclusions might arise from implausible material and exposure scenarios. The relative merits of the commonly used indices will be presented and compared based on their exposure scenario and strictness.

Attenuation properties of minerals found in Sri Lanka for high-energy photons

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The use of high-energy photons in the fields of medicine, agriculture, and industry is on the increase. According to the radiation protection basics, in addition to time and distance, shielding plays a significant role in the safer use of these high-energy radiation. In this study, attenuation properties of ten minerals found in Sri Lanka were explored using 662 keV photons. The minerals used in the study were apatite ($Ca_5(PO_4)$), cordierite ($Mg_2Al_4Si_5O_{18}$), quartz (SiO_2), ilmenite ($FeTiO_3$), feldspar ($AlNaO_8Si_3$), garnet ($[Mg, Fe, Mn]_3Al_2(SiO_4)_3$ and $Ca_3[Cr, Al, Fe]_2(SiO_4)_3$), dolomite ($C_2CaMgO_6$), calcite ($CCaO_3$), graphite (C) and zircon sand ($ZrSiO_4$). Samples of 4 mm thick were synthesized using epoxy as a matrix, with a 60 (wt.)% of the powdered minerals. A Cs - 137 isotope was used in the study, along with a GS-1525-NaI scintillation detector, where the detector was placed 40 cm away from the gamma source. The gamma spectra were recorded using PRA Gamma spectroscopy software, and the Half-Value Layer (HVL) of each material was calculated. A lead sheet of 4 mm thick was used as a References material to validate the experimental setup and the calculation. The calculated HVL value of the lead sheet is 0.6 cm, which is in line with the standard values already published.

The tested minerals were clustered into three groups, according to the HVL profile. The group determined to have a high potential to be used as shielding material were zircon, graphite, ilmenite, and garnet, all of which had HVL values in the order of 4-6 cm. The group identified as having the medium potential to be used as shielding material were apatite, feldspar, and quartz, having HVL values varying between 9-15 cm. The minerals with high HVL values, in the range of 21-51 cm, were cordierite, calcite, and dolomite.

Taking the calculated values into consideration, it can be concluded that zircon, graphite, ilmenite, and garnet - epoxy composites can be utilized as radiation shielding materials to attenuate high energy photons.

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Do the physicians and technicians in a radiation oncology clinic differ in received effective doses? A retrospective dosimetry analysis for a 5-year period

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Introduction: In radiation oncology units, radiotherapy should be administrated in conditions optimized for both patients and personnel working with radiation. In this study, we compared the personal dosimetry reads of physicians and technicians working in a radiation oncology clinic and using linear accelerator and computed tomography devices, for a period of 5 years, retrospectively.

Methodology: Total n=9 personnel including 6 physicians and 3 technicians were included to the study. The personal dose equivalents Hp 10 as whole-body effective dose, and Hp 0.07 as dose to the skin were obtained from previous records. The characteristics of age, gender, occupation, and time period for measurement were recorded along with dosimetry reads. Data were transformed into longitudinal (panel) data, and linear and binary logistic regression models with random effects were applied. Stata 15.1 and Microsoft Excel were used for data analysis and visualization.

Results: The median age of personnel was 46.0, and the majority were female (77.8%). The age and gender of the personnel showed no significant effect on yearly Hp 10 (p= 0.416 and p= 0.902, respectively), and Hp 0.07 readings (p=0.316 and p=0.888, respectively). Yearly Hp 10 doses of physicians ranged between 1.0 and 1.59 mSv, and showed no difference from the yearly doses of technicians ranging from 1.03 to 1.51 mSv (d=0.041, 95% CI= -0.050 and 0.132, p=0.377). For yearly Hp 0.07 reads, the doses of physicians were between 1.06 and 1.63, and doses of technicians were between 1.06 and 1.55, and no significant difference was found (d=0.058, 95% CI= -0.044 and 0.160, p=0.263). However, the technicians had 0.04 to 0.08 mSV higher median yearly Hp 0.07 readings compared to physicians for each year. Thus, we dichotomized the Hp 0.07 readings according to the median yearly Hp 0.07 reading (1.29 mSv), and found that being a technician increased the risk to receive yearly skin doses higher than median value (OR = 4.17, 95% CI=1.062 and 16.041, p=0.041). For yearly Hp 10 readings, we dichotomized the doses according to the median reading of 1.26 mSv, however we did not find a significant effect of occupation group on median equivalent doses (OR= 3.599, 95% CI= 0.930 and 13.925, p=0.064).

Discussion: According to our analysis, the Hp 0.07 dose equivalent readings were higher for technicians, compared to the physicians working in our clinic. The technicians are working closely with patients in both CT and linear accelerator devices and in closer proximity to devices producing ionizing radiation, which may explain the relatively higher skin doses received by the technicians. Previously, similar results were found for physicians and technicians applying radiosynovectomy (cumulative dose of 1.1 µSv/MBq vs 4.5 µSv/MBq), however physicians receive more dose per one brachytherapy implant (420 µSv vs 65 µSv. Despite the readings far below the yearly safety limit of 50 mSV/year, all personnel should receive education on radiation safety regularly, regardless of occupation group, age, and gender. For our clinic, any safety measure and education of radiation safety should specifically target the personnel working close to radiation sources.

Dose assessment and shield estimation for the dismantling of the combustible radioactive waste incinerator combustion chambers model simulation concept using microshield code

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Dose assessment is a critical step in the process of preparation for decommissioning of the radiological installation. The objective is to follow ALARA principle (as low as reasonably achievable), to protect professionals, public and environment from radioactive waste radiation exposure without unreasonable restriction of beneficial use of radiation.

The combustible radioactive waste incinerator was purchased by Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering - IFIN-HH in the 1970s from Fairey Engineering Limited Company, United Kingdom. At present, this installation is in preservation status. Taking into consideration the reduced demand for the treatment of combustible radioactive waste, the risk of environmental pollution and the increased costs involved by the high efficiency filters mounting, it was decided the incinerator decommissioning.

The interior of the incinerator combustion chamber are divided into 2 rooms, the primary one or the furnace room and the secondary one or the afterburner room. The interior is lined with refractory bricks. The partition wall is also made of refractory bricks with an opening at the top through which the combustion gases pass into the post-burning chamber. Two tilting grates form a floor in the furnace room; they can be tilted with the help of a handle mounted outside, for the purpose of cleaning the accumulated ash.

In this study the combustion chambers of the incinerator are analyzed using Microshield software to assess the radiation risk involved in the characterization and dismantling. It is used ash samples from the evacuation ash drums- secondary waste of the incinerator. The radionuclides resulted from gamma spectrometric analyses show the possible radionuclides as follow Co 60 ($3.05 \times 10^4 – 1.06 \times 10^5$Bq), Cs 137 ($1.31 \times 10^5$-$8.40 \times 10^5$Bq), Th 232 ($1.98 \times 10^6 – 1.23 \times 10^7$Bq), U-235 ($4.83 \times 10^3 – 2.23 \times 10^5$Bq), U238 (Pa-234m)($1.05 \times 10^5 – 4.85 \times 10^6$Bq) and Am 241 ($2.33 \times 10^5 – 9.41 \times 10^5$Bq).

Final objectives are:

- To minimize occupational dose for individuals' external and internal exposure.
- To meet goal of occupational collective dose as low as reasonably achievable (ALARA).
- To minimize radiation contamination.
- To minimize production of radioactive waste
- To prevent radioactive material from leaking to off-site.

Keywords: dose assessment, radioactive waste, incinerator, data simulation

Problems of the unified system of quantities in radiation protection for the risk assessment due to external and internal exposure

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The paper presents some critical remarks on the present system of radiation protection quantities proposed by the ICRP and ICRU, and widely used in national legislation to control radiation risk by the relevant regulatory bodies. It is generally recognized that principal radiation protection objectives consist in reducing the probability of the risk of stochastic effects and preventing the occurrence of harmful deterministic effects. The approach was proposed to be applied for both external and internal exposures of persons expressed in the same quantities, which can then be summed to assess the total impact from each of these exposure components. Although there have been attempts to include two main quantities for this purpose, namely effective dose and RBE-weighted dose, with the units of Sv and Gy-Eq, the current situation is still confusing and difficult to apply in practice. Since these radiation protection quantities are virtually unmeasurable directly, they have to be assessed through the monitoring of other quantities and then convert results using a rather complicated process into the relevant main quantities. The interpretation of monitoring results is sometimes so problematic that even those who are responsible for radiation protection at workplaces do not sometimes fully realize the role of all factors which have to be taken into account. The existing problems relevant to the use of radiation protection quantities are discussed in order to point out some inconsistencies in the current intricate state of presenting the results of external and internal exposures in a unified and comprehensive way.

Mapping of static magnetic fields near the surface of mobile phones

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Whether the use of mobile phones (MP) represents a health hazard is still under debate. As part of the attempts to resolve this uncertainty, there has been an extensive characterization of the electromagnetic fields they emit and receive. While the radiofrequencies (RF) have been studied exhaustively, the static magnetic fields (SMF) have received much less attention, regardless of the fact there is a wealth of evidence demonstrating their biological effects. We performed 2D maps of the SMF at several distances from the screen of 5 MP using a tri-axis magnetometer. We built a mathematical model to fit our measurements, extrapolated them down to the phones' screen, and calculated the SMF on the skin of a 3D head model, showing that exposure is in the μT to mT range. Our literature survey prompts the need of further research not only on the biological effects of SMF and their gradients, but also on their combination with extremely low frequency (ELF) and RF fields. The study of combined fields (SMF, ELF, and RF) as similar as possible to the ones that occur in reality should provide a more sensible assessment of potential risks.

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BOOK OF ABSTRACTS rad-conference.com

Gamma and X radiation attenuation characteristics for ultrahigh properties of concrete, concrete with barite and concrete with magnetite and steel

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During the implementation of construction barrier design procedures for protection against gamma and X radiation, the inevitable question arises of choosing building materials with suitable mechanical and radiation characteristics for protective barriers. Based on engineering practice, it is necessary to compare different types of concrete used for the construction of buildings in which there are sources of gamma and X radiation, as in cases where radiation sources appear in medical institutions with linear accelerators, cyclotron installations for the acceleration of nuclear particles, in the environment of nuclear reactors, in radioactive waste warehouses or in radiation sterilization units. In the analysis of costs and benefits, several criteria are used to evaluate the characteristics of concrete, so that, in addition to the mechanical ones, the radiation characteristics of the building material are also taken into account. One of the most important characteristics of radiation shielding concrete is its overall mass attenuation coefficient. In this paper, the XCOM computer code was used to calculate the total mass attenuation coefficients in the energy range from 0.01 MeV to 100 MeV for three types of concrete: ultrahight properties concrete (UHPC), concrete with barite and concrete with magnetite and steel. Based on the comparison of the calculation results, it was concluded that concrete with magnetite and steel has a greater protective power than the other two types of concrete for gamma and X radiation energy lower than 30 keV. Another important conclusion is that concrete with barite has a higher protective power than the other two types of concrete in the photon energy range from 30 keV to 300 keV, and for photon energy greater than 6 MeV. A detailed analysis of the calculation results revealed that in the energy range from 400 keV to 6 MeV the values for the total mass attenuation coefficients are approximately the same for three different types of concrete.

Keywords: barite, magnetite, UHPC, gamma and X radiation, total mass attenuation coefficient

The repair inhibitors effect on DNA damage in melanoma B16 Cells

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In recent years of special interest are the studies aimed at changing cell radiosensitivity, especially malignant cells. Due principally to the fact that the accumulation of DNA double-strand breaks (DSBs), which are considered the most severe damage, can lead to cell death. In this regard, the study of the DNA DSBs induction and repair patterns in tumor cells under the action of ionizing radiation and in the presence of modifying agents is an important and prior topic of modern radiobiological research.

In this work, we studied the modifying effect of repair inhibitors – 1-β-D-arabinofuranosylcytosine (AraC) and SCR7 pyrazine (SCR7), on the kinetics of DNA damage formation under the action of X-rays. The mechanism of AraC action is based on the transformation of long-term unrepaired DNA single-strand breaks into enzymatic DSBs. SCR7 blocks nonhomologous end joining (NHEJ) repair pathways in a DNA Ligase IV dependent manner. This, in turn, leads to DNA DSBs accumulation, thereby increasing the probability of malignant cell death. DNA comet assay method was used for studying the repair inhibitors influence in melanoma B16 cells under the action of X-rays.

It was found that under the combined action of AraC/SCR7, the greatest amount of DNA DSBs is formed, exceeding the control level of damage by 1.6 times, and 1.15 times under the influence of AraC. The repair kinetics of DNA DSB was studied during 24 hours of post-radiation incubation. It was shown that the DNA DSB yield in the presence of repair inhibitors increases up to 6 hours after irradiation, and then decreases. However, it was noted that under the combined action of DNA repair inhibitors, by 24 h of postradiation incubation, the number of unrepaired DNA DSBs exceeded the control level by 10.3 times, and under the action of AraC, by 1.76 times.

The obtained results showed that using the modifying agents that affect the biochemical mechanisms of induction and repair of such severe damage as DNA DSBs is promising. For the reason that it makes it possible to increase the biological effectiveness of ionizing radiation in clinical use.

Blood cell count after *in vitro* exposure at frequencies of 5G in pig

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Today, public concern about the negative effects of the radio frequency electromagnetic radiation (RF-EMR), is rising, especially because of the widespread usage of the devices that work at a frequency of 5G. Additional, results of many studies showed that RF-EMR can cause various non-thermal biological effects, for example, oxidative stress, altered gene expression, increased haemolysis, inducing permeability in the red blood cells membrane, decreasing sperm quality and changes in protein conformation. To authors knowledge, there is no available information about biological effects of RF-EMR from 5G frequencies in domestic animals, in particular on hematopoietic system (standard analyses of blood cells). The aim of this study was to determine its effect after a short-term (2h) *in vitro* exposure of pig's blood samples. The research was conducted on blood samples from 16 sows of the German Landrace breed, aged 1 to 2 years, body weight around 170 kg. Blood was taken once from the vena *cava cranialis* into vacuum tubes (N=64, in total) with the addition of the EDTA anticoagulant. Blood of each animal was separated in four tubes, two of which served as a control, and the other two were experimental. The experimental blood samples were exposed to continuous RF-EMR at 700 MHz (1 tube per sow, N=16) and 3.5 GHz (1 tube per sow, N=16) using gigahertz transverse electromagnetic (GTEM) chamber for 2 hours and field level of 10 V m^{-1}. GTEM was constructed at the Department of Communication and Space Technologies, Faculty of Electrical Engineering and Computing, University of Zagreb. In addition to the GTEM exposure chamber, an HP 8657A signal generator and an RFGA0101-05 linear amplifier was used to obtain electromagnetic field level. The control samples (2 tube per sow, N=32) were kept the same conditions as experimental except exposure to RF-EMR. In the control and experimental blood groups number of red blood cells, hemoglobin, mean corpuscular volume of erythrocytes per litre of blood, average amount of hemoglobin in erythrocytes, average concentration of hemoglobin in erythrocytes total number of white blood cells and the total number platelets, and as well the number of lymphocytes were determined immediately, and 72 hours after 2 hours exposure to RF-EMR, using fully automated counter made for *in vitro* use, the Abacus Junior Vet hematology analyzer (Diatron, Hungary). All analyzes were performed with official reagents (Daitro Lyse_DIFF, Diatro Cleanerand Diatro-Rinse) in four stages and a maximum error of < 4%. The results were statistically analysed by two-tailed student t-test (to determine the differences between experimental and control group) and by the variance analysis test ANOVA (to determine the differences between the groups) followed by a post hoc Tukey HSD test using Statistica 12 (StatSoft, Inc.; USA) software package. The results showed that RF-EMR at a frequency of 700 MHz and 3.5 GHz and field level of 10 Vm^{-1} after a two-hour *in vitro* blood exposure did not cause a statistically significant change in the number of erythrocytes, leukocytes, lymphocytes, platelets and also did not affect statistically significant changes of erythrocyte indices in exposed samples, immediately, or 72 hours after exposure when compared to the control. According to the results of this research it can be concluded that RF-EMR at a frequency of 700 MHz and 3.5 GHz and field level of 10 Vm^{-1} do not cause a change in the investigated blood parameters in *in vitro* exposed pig blood. Further research is needed to confirm this novel finding. Furthermore, the results of this study could serve as a base for further investigations of the RF-EMR effects at a frequency of 5G, for example after longer exposure time, lower field levels, or a different design experiment (*in vivo*).

Medicinal plants as potential radioprotectors

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Ionizing radiation (IR), have enough energy to dislocate electrons from the atoms of the matter they fall on, hence ionizing them. In a living cell, IR alters the chemical structure of cell constituents at a level dependent on the dose and the duration of exposure, as well as on the tissue sensitivity. Biological effects of IR in cell can be direct and indirect [S. J. Hosseinimehr, A. Mahmoudzadeh, A. Ahmadi, S. Mohamadifar, S. Akhlaghpoor: Radioprotective effects of hesperidin against genotoxicity induced by gamma-irradiation in human lymphocytes. Mutagenesis 2009, 24, 233]. Directly, IR damages the macromolecules proteins, lipids, but DNA is known to be the prime target of IR-induced damage in the cell. It provokes an array of changes ranging from mutations, base lesions, crosslinking, and single and double stranded breaks. Indirectly, IR collides with H_2O molecules within the cell, causing spontaneous generation of free-radical species. Damage macromolecules afterwards, which could even lead to the death of the cell itself.

The radioprotective effect of plants on the humans are generally tested on the peripheral blood lymphocytes as models, where the main criterion of efficiency is the reduction of IR damage of the cells which are in contact with the preparation to be examined.

Numerous of plants, as well as the compounds isolated from plants, are very effective radioprotectors. Unlike the synthetic compounds, herbal products are nontoxic, without harmful effects to human health, inexpensive, and are generally administered orally [G. C. Jagetia, J. Clin: Radioprotective Potential of Plants and Herbs against the Effects of Ionizing Radiation. Biochem. Nutr. 2007, 40, 74].

Various plant species have been examined as potential radioprotectors, since the entire plant kingdom, including, Colchicum autumnale, Vinca rosea, Thuja occidentalis, Datura stromonium, Chelidonium maus, Podophyllum peltatum and Peucedanum officinale.

Polyphenolic compounds from thuja occidentalis (besides alkaloids, flavonoids, glycosides, b-carotene, vitamin C, macro- and micronutrients) strongly inhibit lipid peroxidation, protect the structural proteins of the blood vessels, and preserve their selective permeability [D. Gođevac, V. Tešević, V. Vajs, S. Milosavljević, G. Zdunić, B. Ordević, M. Stanković: Chemical composition of currant seed extracts and their protective effect on human lymphocytes DNA. J. Food Sci. 2012, 77, C779].

The results from the study of the protective effects of Datura stromonium confirmed that the compounds isolated from this plant showed strong antioxidant and antimutagenic effects, thus reducing the level of reactive free radicals in the cell, leading to a positive physiological effect [M. Stanković, V. Tešević, V. Vajs, N. Todorović, S. Milosavljević, D. Gođevac: Antioxidant properties of grape seed extract on human lymphocyte oxidative defence. Planta Med. 2008, 74, 1].

The substance Peucedanin, from the group of lactones, which exhibits antioxidant and radioprotective properties, was isolated from Podophyllum peltatum. Peucedanin makes it possible to reduce the dose of cytostatic compounds without reducing the effectiveness of the therapy.

A number of medicinal plants evaluated for their radioprotective afficiencies has displayed protective effects against the damaging effects of IR. All plants with antioxidant properties, i.e., whose active ingredients are free-radical “capturers”, are potential radioprotectors, but their protective effect can be confirmed only after experiments on human lymphocyte.

Determining the genetic vulnerability of plants due to ionizing radiation: a comprehensive analysis of the cytogenetic balance and responses of the *Allium* root meristem to various radiation doses

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This study aims to improve the prediction of genetic vulnerability in plants exposed to harmful environmental factors through the use of rapid bioassays in biomonitoring. We introduced a novel method for processing and presenting chromosome aberration results in the *Allium* test model in a series of ionizing radiation experiments, focusing on sublethal and lethal doses of Co60 gamma rays. The primary goal was to analyze the cytogenetic balance (CG) to assess the physiological impairment of the meristem and predict the genetic vulnerability of plants in nature. The *Allium* root tip model was employed to describe, explain, and interpret chromosomal and meristem damages, correlating them to reduced growth, vitality, and plant survival. Our findings demonstrate the balance between chromosomal damage and instability, as well as cytological disturbances and meristem cell decay in root tips, which influence root system growth, plant vitality, and response to environmental factors. We evaluated the effects of radiation on the dynamic equilibrium of the meristem and its restorative regeneration capacity. Empirical data confirmed a CG balance is established in the active meristem when there are more decaying cells than chromosomally damaged cells in the course of nuclear division. We derived a new data processing procedure based on the following fundamental principles in plant cytogenetics: chromosomally injured cells divide until more extensive aberrations encompass all chromosomes in the cell, leading to the disintegration of the chromosomal complement and cell decay. The final stage in the life of dividing cells is manifested by aberrations such as fragmentation and dissolution of chromosomes and clumping of chromosomes and amorphous chromatin mass. Together, they make up the proportion of decaying and eliminated cells from the meristem. This loss of cells represents the selection of aberrant mitosis, which acts as a regulatory system in the restorative regeneration of the meristem, i.e., maintaining a dynamic equilibrium between still dividing more or less damaged meristematic cells. We determined critical levels of damage based on the accumulation of chromosomal fragments in cells and identified when meristem dysfunction is only a transient and reversible physiological change or an irreversible change leading to plant decay. Sublethal doses resulted in inhibited root and leaf growth, reduced plant vitality, and smaller bulb weight, while lethal doses led to irreversible physiological impairment in meristem pathophysiology and premature decay of the root meristem. The level of established CG balance in the root meristem depends on the dose of radiation. To extrapolate data on chromosomal damage and predict the degree of plant vulnerability due to radiation using rapid bioassays, we have developed a new practice of presenting results on the *Allium* model, which accounts for chromosomally abnormal cells, acentric chromosome fragments, and cells eliminated from mitosis due to decay. We assessed the degree of balance and consequences of chromosomal damage for the life of meristematic cells and thus the irradiated plant. In conclusion, this study advances our knowledge of the functional mechanisms and restorative regeneration capabilities of root meristems in rapid response and subsequent reactions to lethal and sublethal doses of gamma rays in laboratory and field conditions. Our research also provides calculations for acute aberration indicators related to radiation-induced chromosomal abnormalities and plant endangerment in natural populations. These findings contribute to the development of efficient biomonitoring strategies and enhance the predictability of genetic vulnerability in plants exposed to harmful environmental factors, ultimately supporting more effective conservation efforts.

Space Radiobiology with the Alpha Magnetic Spectrometer detector data: Dose-Effects Models for Carcinogenesis risk prediction

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Space radiobiology is an interdisciplinary science that examines the biological effects of ionizing radiation on humans involved in aerospace missions. The knowledge of the risk assessment of the health hazard related to human space exploration is crucial to reducing damages induced to astronauts from Galactic Cosmic Rays (GCRs) and sun-generated radiation. GCRs have been identified as one of the primary sources of radiation exposure in space. In this context, an accurate characterization of the possible risk of carcinogenesis induced by exposure to GCRs particles is mandatory for safe human space exploration and one of the most crucial open problems is the contribution to carcinogenesis due to the effects on the cells not directly irradiated (Bystander or Non- Target Effects (NTE)). It is accepted that the detrimental effects of ionizing radiation are not restricted only to the irradiated cells but also to non-irradiated bystanders or distant cells are manifesting various biological effects. This talk will present the status of the research on this topic at the INFN Roma Sapienza Alpha Magnetic Spectrometer (AMS) research group, which is in progress an extensive study about the risk evaluation of the NTEs that the GCRs radiation will imply when added to the Target Effects(TE). Tumour Prevalence (TP) is often used to investigate the effects of Non-Target Effects (NTEs) in predictions of chronic GCR exposure risk and a theoretical framework will be presented for TP-induced NTEs modeling, ready to be used with the data collected from the AMS02 detector.

Structural regularities in double sulphates of trivalent actinides

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Studies of actinide contraction and the level of participation of valence orbitals in covalent bonds in the series of actinide compounds are still the subject of discussion. The 5f orbitals of the lighter actinides can be very active up to Am; after that, they are highly compressed and are considered as the main orbitals, similar to their 4f analogues, the lanthanides.

In this work we performed experimental (SC-XRD, Raman-IR Spectroscopy, XANES, thermal stability) investigations and ab initio XANES calculations for different clusters of atoms and local density of states for isostructural double sulfates of trivalent actinides $CsAn(SO_4)_2$, An = U, Np, Pu, Am. The synthesis of $CsU(SO_4)_2{\cdot}4H_2O$ was performed using electrochemical reduction and $CsNp(SO_4)_2{\cdot}4H_2O$ was prepared with Jones reducer. Pu was reduced by chemical reduction and Am is stable in trivalent state.

Uranium double sulphate is described below as an example. The results of Raman spectroscopy indicate the presence of sulfate anions (990 cm^{-1}): mono- and bidentate - with the uranium cation. Peaks combination near 410 cm^{-1} (T_{2g}) and 490 cm^{-1} (LO), is typical for defective uranium dioxide, but here are shifted to the left by more than 30 cm^{-1}.

The XANES spectrum at the U L3-edge has a shift of the white line to lower energies by 5 eV compared to the spectrum of tetravalent uranium, and the shapes of its post-edge structures differ from those of uranium dioxide and uranyl salt: the second feature is closer to the edge total absorption by 1-2 eV compared with the spectrum of dioxide. The shoulder to the right of the white line, characteristic of uranyl salts, is also missing in the spectrum of $CsU(SO_4)_2{\cdot}4H_2O$.

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Problems in metal hydrolysis studies: the U(IV) case

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Metal hydrolysis is a very interesting and substantial topic. To date, the question of metal hydrolysis speciation has not yet been fully elucidated. The main difficulties in metal hydrolysis studies are: complicated experimental set-up (especialy for metal ions which are easily oxidised in air), lack of reliable literature data (e.g., unreliable speciation models, missing and/or questionable thermodynamic parameters, literature discrepancies, etc.), narrow ranges of available experimental conditions (e.g., analyte concentration, acidity, ionic media and ionic strengths, temperature, etc.) and often slow hydrolysis kinetics.

This work is focused on U(IV) hydrolysis, as uranium plays an important role in industry and its behavior could help us to understand the hydrolysis of other 4-valence elements. The literature data on U(IV) hydrolysis and on UO_2 solubility has been examined. Although much data are available on hydrolysis and precipitation of U(IV), several points remain unclear. Most probably, current difficulties in U(IV) chemical equilibrium studies are due to the slow kinetics of solid phase formation (UO_2) and the limited stability of U(IV) in air. Most of the work on U(IV) hydrolysis has been carried out by the spectrophotometric method. The limitations of spectrophotometry and potentiometry for U(IV) hydrolysis studies are discussed as well as the suggested formation of U(IV) polynuclear species. It is postulated that these polynuclear hydrolysis species improve the fitting of experimental data obtained by potentiometric and/or spectrophotometric methods, but confirmation of their existence by other physicochemical methods is lacking.

Radiochemical research program at SHE Factory: first results

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The new accelerator complex SuperHeavy Element Factory (SHE Factory) started operating in 2019 at FLNR, JINR (Dubna, Russia). Radiochemical studies are a key research area of SHE Factory research program. The increased beam intensities open up unique possibilities for radiochemistry of new superheavy elements from the end of 7th period of Periodic Table (from Cn to Og) which synthesized in fusion reactions with extremely low cross sections at picobarn level. Main facility of the Factory is the new cyclotron DC280 accelerating heavy ions up to world breaking beam intensities 10 *pmk*A also sets new chemical studies of high-power radioactive targets making and synthesis of metal compound using enriched isotopes for beam developments. We have created new setup for radiochemical on-line research with short-lived isotopes produced at DC280, combining physical and chemical separation from target material, beam and nuclear reactions by-products. It includes gas-filled recoil separator GRAND coupled to recoil stopping gas cell, gas jet system and cryogenic gas chromatography detector. The first chemistry experiment at the SHE Factory will focus on speciation of elements copernicium (Cn) and flerovium (Fl), employing online gas adsorption thermochromatography on gold surface. In this summary talk we also discuss results of recent studies of stopping ranges, transport time and adsorption on gold for the heaviest atoms of Cn and Fl light homologues in the gas phase in on-line studies and current status of preparation upcoming experiments.

The development of a theoretical approach to the chromatographic separation of transplutonium elements with an application for the identification of nuclear transfer reaction products

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The only way to obtain elements heavier than Fm for studying their chemical properties and spectroscopy are accelerator methods, in particular multi-nucleon transfer reactions [1]. The method that meets all the necessary separation criteria is proven to be cation exchange chromatography in ammonium α-hydroxyisobutyrate (α-HIB). Known empirical dependencies do not allow accurate prediction of the position of heavy actinides on the chromatogram in this system and collect the required volume of eluent for following spectrometry. Analytical solutions of mass transfer equations are cumbersome and have a fairly large number of parameters, which complicates the calculation process. In this work, we developed model for prediction of position, using dependence K_d from equilibria concentration of complex agent. The theoretical part of model is based on solving a system of one-dimensional differential equations of mass transfer. Also, we considered influence of longitudinal diffusion with use of the equation of stationarity and subsequent application of the method of greatest similarity to clarify the parameters of the cation exchange chromatographic process. We used basic machine learning methods, currently widely used to identify various parameters and artifacts of chromatographic separation [2]. The developed approach was applied for identification of isotopes synthesized in reaction $^{238}U(^{48}Ca, xnyp)$. Results from the measurements are presented with respect to their detection limits for the investigated nuclides.

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Research on properties of superheavy elements copernicium and flerovium in a gas phase chemistry setup

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Studying chemical properties of Superheavy Elements (SHEs) of the periodic table is a fundamental task which requires development of unique setups and experimental approaches for an extremely short-lived isotopes separation and registration immediately after their production in a cyclotron. The whole identification cycle includes SHE production by accelerated heavy ions irradiation of radioactive targets, followed by a fast transportation, chemical separation, and detection of a radioactive decay [1]. So, in order to study chemical properties of single atoms of SHEs we created a special setup called Cryodetector in our laboratory FLNR at JINR. Using this setup, we did the first chemical characterisation of nihonium (Nh, Z = 113) [2,3] in FLNR by means of the gas adsorption chromatography. However, we had to substantially optimise and modernise Cryodetector for conducting chemical experiments of Cn (Z = 112) and Fl (Z = 114) in the world's first SHE Factory, FLNR. Cryodetector was installed behind the online recoil separator GRAND put into operation in 2021. We also designed a closed gas loop for a rapid transportation of volatile species and a carrier gas purification system. We tested our newly modernised Cryodetector system in on-line experiments with SHEs and their group analogues. First, ^{174}Yb, ^{170}Er и ^{144}Sm targets were irradiated by accelerated ions of ^{40}Ar and ^{48}Ca with the energy of 190 MeV at the heavy ion accelerator DC-280 of SHE Factory. The reaction products Hg (lighter Cn analogue) and Rn as recoils were parted from the beam and other nuclear reaction products with the help of the GRAND separator, directed to and stopped inside the recoil transfer chamber filled with He and Ar, chamber being separated by a thin polyethylene terephthalate film from the separator low pressure volume, and after that transferred by a carrier gas flow along a capillary into the alpha and spontaneous fission (SF) detection system resembling a narrow rectangular chromatographic channel, and presented by an array of strip detectors on top and bottom covered by different metallic surfaces to study volatile species adsorption. After a radioactive element is adsorbed on a particular strip at a certain temperature it decays by alpha or SF decay at some point, released particles hit the detector surface which is immediately recorded with a related detection position and time frame.

The full-scale experiment for chemical study of Cn and Fl was completed and the results of model experiments with Hg, as well as adsorption temperatures of SHEs together with the analysis based on Monte-Carlo simulation will be presented at the conference.

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Utilization of Cherenkov radiation for ^{226}Ra determination in water samples

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Cherenkov radiation is a type of electromagnetic radiation emitted when a charged particle is moving through a light-transparent polar medium at speeds greater than the speed of light. The principle of radioactivity measurements based on Cherenkov radiation detection is established on the fact that the number of photons emitted per Cherenkov event is proportional to the energy of the particle causing it. Using a liquid scintillation counter, Cherenkov radiation can be detected by the light-detection system, and activity concentration of radionuclides can be determined based on counts in the spectrum and known detection efficiency.

In this paper, the activity concentration of ^{226}Ra in natural water samples was measured with a liquid scintillation counter based on the detection of Cherenkov radiation, created due to the passage of beta particles emitted from ^{226}Ra progenies (^{214}Pb and ^{214}Bi) through a water medium. This method is in principle simple and does not require special chemical preparation or scintillation cocktail. Samples were collected from the radon spa Niska Banja (south part of Serbia), where the activity concentrations of ^{226}Ra progeny, radon ^{222}Rn, were known to be high. Samples were prepared and left for 40 days in order to achieve secular radioactive equilibrium with ^{222}Rn and its progenies.

Results of activity concentration of ^{226}Ra in water samples based on the detection of Cherenkov counting are compared with the standard liquid scintillation method for the determination of ^{226}Ra. Differences between the standard method and the pros and cons of the utilized Cherenkov counting method were analyzed and discussed. Furthermore, the activity concentration of radon was measured and the relation between ^{226}Ra and ^{222}Rn was analyzed.

Interaction of uranium with diatoms

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Diatoms are important bio-indicators for the study of heavy metals release or other hazardous materials pollution in water bodies (E.A. Lobo et al. 2016). Besides, these ubiquitous microorganisms show different sensitivity or tolerance to radiation (F. Millan et al. 2019) and thus have been studied in the context of uranium mining site monitoring (O. Herlory et al. 2013). Nevertheless, there is a lack of information at the interaction level between diatoms and uranium, especially on the uranium localization and speciation. Therefore, in this work which takes part in ZATU (la Zone Atelier Territoires Uranifères, https://zatu.org/en/) program, the objective is to better understand the interaction of uranium with an aquatic diatom species of *Achnanthes* genus by coupling macroscopic and molecular approaches. From an experimental point of view, the study was performed in both simple conditions (pH 7, 2 mM NaCl) and in full culture medium at different diatom growth states. The uranium adsorption kinetics on diatoms as well as the adsorption isotherm in concentration were studied from batch-type experiments. Investigation on uranium retention behavior at different diatom growth states revealed a potential uranium incorporation in the diatom cells at stationary growth phase, i.e., 35 days after the uranium exposure. TRLFS analysis confirmed the formation of one predominant uranium species on diatom cell surface. FTIR measurement indicated the interactions of uranium with carboxylic and phosphorus functional groups, which both can be found on the surface of the diatom cell. SEM/EDX measurement also confirmed the binding of uranium on the diatom surface and a correlation with phosphorus was found.

Levels of ^{137}Cs in game animals in Poland

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Introduction: More than three decades have elapsed since the accident at the Chernobyl Nuclear Power plant, despite this concentrations of radioactive cesium can still be high in natural foods such as game, forest mushrooms and berries. Official monitoring tests on game meat systematically carried out in Poland indicate that this type of food is the most contaminated.

Objective: The aim of the study was to assess the radioactive cesium contamination of game muscle and to estimate the ^{137}Cs radiation dose to game consumers in Poland.

Material and methods: In the years 2017-2021, 114 muscle samples of game animals, wild boars, roe deer and red deer were tested. The muscles were homogenized, then samples weighing about 450 g were placed in Marinelli containers. Measurements were performed made using scintillation (NaI/Tl) and germanium (HPGe) detectors. The factor 1.3×10-8 Sv Bq-1 (ICRP, 2012) was used to convert the dose per kg of body weight. The effective dose factor involved for ^{137}Cs was defined by the equation:

$$H_E = A_k m D_{kf(k)}$$

where H_E is the effective dose expended (Sv), A_k is the concentration of radionuclide k (Bq kg-1), m is the amount of food consumed (kg) and $D_{kf(k)}$ is the dose conversion factor for radionuclide k.

Results and discussion: Cesium-137 activities varied (from values below the MDA to over 4000 Bq/kg). Importantly, there were more results above the MDA (67 samples) than below (47 samples). Mainly, wild boar muscle samples showed significant cesium-137 activity, the highest being 4136.8 ± 238 Bq/kg f.w. The mean concentration of the measured activities in wild boar muscle samples was 113.7 ± 27.5 Bq/kg fw. The average activity of all tested samples was used to determine the effective dose. After calculation, the effective equivalent dose for wild boar muscles was 0.83 µSv/kg.

Conclusions: Free-living game animals are a unique group in terms of exposure to the intake of radioactive cesium-137 from the environment. This is partly due to the wild animals' diet. Forest mushrooms and berries, which constitute a significant part of the diet of game animals, are characterized by a particularly high concentration of cesium-137 activity.

The highest concentrations were obtained in wild boar, therefore in the case of these animals the occurrence of samples with high activity is confirmed, sometimes exceeding the permissible limits of 1250 Bq/kg (Regulation of the Council of Ministers of April 27, 2004) and, in accordance with European law, 600 Bq/kg in (Commission Implementing Regulation (EU) 2020/1158). The calculated effective dose indicates low consumer exposure from the consumption of wild game meat. However, there is a risk for consumers to eat wild boar muscles that could be contaminated, so it is recommended to consume this type of meat in moderation to be safe.

Keywords: ^{137}Cs, contamination, game animal

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Assessment of radioactive contamination with the ^{90}Sr isotope of dairy products

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Introducion: Strontium-90, as a beta radiation emitter, plays an important role in toxicity in radioactive contamination. Due to its long half-life (T1/2=28.50 years) and chemical properties similar to calcium, it is one of the more dangerous radionuclides. Competing with calcium in metabolic processes, ^{90}Sr effectively accumulates in bone tissue posing a risk of leukemia or bone cancer. As a result of various radiation events, Strontium-90 can enter and contaminate the environment by which, along with radioactive fallout, it accumulates in areas intended for livestock grazing in fields and pastures, among other places. Therefore, an important task is to inspect milk and the resulting dairy products, intended for a wide range of consumers, for radiotoxicity.

Aim. The aim of this study was to determine and evaluate the presence of ^{90}Sr in dairy products from the food sector.

Materials and methods. The material for the study consisted of commercial samples of cheese, whey powder and raw milk obtained in 2018-2022. Among the cheese samples tested were various types of cheese: long-maturing cheeses, reduced-fat cheeses, smoked cheeses, Swiss-type ripened cheeses. A 250g weighted sample was used to carry out the measurement. After grinding and appropriate homogenization, the samples were ashed and then analyzed by scintillation spectrometry using a Quantulus 1220™ detector.

Results and discussion. Very low concentrations of ^{90}Sr (<0.06 Bq/kg) were found in the dairy product samples tested, the vast majority not exceeding the MDA (Minimum Measurable Activity) value. A few cheese samples showed activities slightly above the MDA value. Using about 10 liters of raw milk to obtain 1 kg of cheese can contribute to the concentration of ^{90}Sr and the detection of its activity.

Conclusions. An assessment of the contamination of dairy products with the radioactive isotope ^{90}Sr showed that these products were fully safe for consumers. Measured activities in dairy products were at a very low level and these products did not pose a radioactive threat. The results made it possible to make a proper and necessary assessment of the contamination of dairy products intended for consumption.

Keywords: ^{90}Sr, dairy, contamination, food products

Content of natural and man-made radionuclides in Antarctic mosses

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Mosses are collectors of anthropogenic pollution and are suitable as bioindicators for the content of heavy metals and radionuclides in the air. Due to their lack of a real root system, the main way nutrients are supplied to them is through air moisture. Airborne substances are absorbed and retained in the moss, even when these plants are thousands of kilometers from the source of pollution. In regard to radionuclides, mosses are very indicative. The subject of the research are mosses from Livingstone Island, South Shetland Islands, Antarctica. The presence of natural and man-made radionuclides is investigated. The presence of natural and man-made radionuclides was investigated by Gamma-spectrometric measurements. The content of Cs-137 and Pb-210 was determined., а за Pb-210 между 93±8 и 128±10 Bq/kg. The activity of cesium-137 is between 6.5±0.7 and 12±0.7 Bq/kg, for Pb-210 - between 93±8 and 128±10 Bq/kg. Results from samples taken in 2012 and 2022 are compared. This allows to assess the current state of the Antarctic ecosystem and to ascertain changes over a 10-year period. The research confirms that even the most distant points on the globe are contaminated with radionuclides.

Produced radionuclides in foods of animal origin 2016-2022

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The very rapid development of nuclear sciences, and especially nuclear technology, has made livestock production, as an extremely important source of food for human consumption, significantly and very harmfully endanger the health and life of people, and even their offspring. The constant increase in total radioactivity in the biosphere is mostly caused by the increase in artificial radioactivity. This especially applies to the biological cycle: air-land-water-forage-animals-food of animal and animal origin and the final consumer - Man. That is why knowledge of the distribution of natural and artificial radionuclides forms the basis on which the radiation safety criteria of the entire biosphere are built. Since 1986, the laboratory LABRAH - laboratory for radiation hygiene, at the Scientific Institute of Veterinary Medicine of Serbia, has been continuously performing gamma spectrometric measurements of foodstuffs of animal origin. By identifying biologically significant radionuclides and determining activity levels - the possibility of radiation hygiene assessment of their utility value is created. In the period from 2016-2022. over 4000 samples of products of animal origin were measured, the values of which are within the prescribed limits. Milk and milk products, fish and several samples of meat and meat products had a slightly higher activity, but still below the prescribed limits prescribed by our rulebook. The occurrence of nuclear accidents in Chernobyl and Fukushima, which caused a major environmental disaster, stand as a warning but also an imperative that we should regularly implement RH control so that the food safety of our population is at a high level.

Surveying the NORM contamination of soils, sediments and water, due to mining activities from the lower basin of river Pra in the Central and Western Regions of Ghana

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Naturally occurring radioactive materials (NORM) existing in the soil, sediment and water poses potential health risk especially if assisted by natural processes such as mining and mineral processing, weathering deposition and erosive activities. River Pra is an important source of water supply serving four regions flowing from the Kwahu plateau in the Easter Region to the southward entering the sea at Sharma in the Westering Region covering over 150 miles. Unfortunately, the Pra river is polluted with polluted as a result of illegal mining activities. Hence gamma spectrometry analysis was carried out within lower basin of river Pra where majority of the mining activities takes place to assess the radiological quality of the river for drinking. The average activity concentrations of 226Ra, 232Th and 40K in the soil and sediment were determined to be 25.51 Bq/kg, 28.04 Bq/kg and 238.98 Bq/kg, and 16.02 Bq/kg, 20.31 Bq/kg, and 27.39 Bq/kg respectively. The activity concentrations of 226Ra, 228Ra and 40K in the water were calculated to be 2.51 Bq/L, 1.71 Bq/L and 41.43 Bq/L respectively and the corresponding annual effective dose ranged from 0.35 µSv/y to 3.91 µSv/y with an average of 1.82 µSv/y. Although the average activity concentrations in the soil were higher than that of sediment followed by its content in the water, the values were within the levels recommended by the World Health Organisation.

Earthworm as environmental radioactive bioindicator: the behavior and sensitivity of earthworm organs to changes in the concentration of the radioactive substance

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Earthworms are important in soil formation. As a result, they are exposed to a variety of chemicals including the contaminants. Earthworms are one of the most important biotic components in the soil whose elemental composition gives useful information on background levels and possible accumulation of toxic metals as well as related radionuclides. Earthworms prove particularly sensitive to an increased NORM background. They are among the best bioindicators of polluted soils. In this study a controlled laboratory environment was prepared for farming and studying the behavior and sensitivity of earthworm organs to changes in the concentration of the lead isotopes in the soil of their living environment. To find out how the earthworm would respond to the lead isotopes changes and how the lead isotopes would deposit and distribute through the earthworm body artificial Pb-203 isotopes were used as a tracer.

Several farms with different activities prepared (in addition to two control sample and one normal known activity natural soil). The activity of each farm was known and after the finishing the experiment, earthworm of each farm was collected and studied by autoradiography in terms different of exposure timing. In this way, in addition to investigating the distribution and accumulation of radioactive substances in earthworms, the behavioral sensitivity of earthworms as a bio-indicator to changes in the environmental concentration of radioactive substances was investigated. The concentration of Pb in the earthworms reflected the average value of the Pb that was uniformly distributed in their controlled living environment. Studying the change of deposition in terms of time and Pb concentration changes, the earthworms could be a good bioindicator for monitoring radioactive material contamination in environment.

Preliminary results of the radioecological survey in the Bakony region, Hungary

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Bakony is a mountainous region in Transdanubia, Hungary, north from lake Balaton. The mountains consist of flat-topped or undulating fragments of a step-faulted range rising toward the north. Limestone and dolomite constitute most of the Bakony, which range from 210 to 700 metres. In western and southern Bakony are sheets of basalt. Deposits of lignite, bauxite, and manganese in the Bakony have stimulated industrial development.

Various surveys have been carried out in the area in the past: the main gamma-emitting isotopes of the source waters have been studied, the air quality of the area has been monitored using moss samples, and monitoring surveys are regularly carried out in the vicinity of NORM reservoirs (e.g. red mud reservoir, Ajka).

The aim of the current study is a complex radioecological survey of the Bakony region over a longer period, which will assess the radioecological status of the region via several environmental elements (soil, water and moss).

During the survey, locations were selected that cover the Bakony region, are representative of the isotope content in the environment and where possible, soil, water and moss samples can be collected at the point. In the selection of the measurement points, it was considered that the industrial activity in the region is significant, so samples were also collected in the vicinity of the main anthropogenic sources. Furthermore, samples were collected in spring and autumn to study seasonal effects.

In all water, soil and moss samples, the major natural radionuclides were determined by gamma-spectrometry. Due to the karst type of the field, the Ra-226 content of the water and the Rn-222 exhalation rate of the soil were determined. To monitor local anthropogenic effects, the Po-210 activity concentration of mosses was determined.

Soil radon exhalation measurements in Transdanubia, Hungary

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Nowadays, increasing attention is being paid to reducing health hazards in homes and workplaces. One of these factors is the radiation risk in these areas. This is mainly caused by naturally occurring radioisotopes (mainly radon and its daughter compounds) in the soil. Recently, the development of spatial information technology and complex data management methods has brought the radiological assessment of certain areas back to the fore. The development of the Hungarian radon map has included the radiological analysis of soil samples. In this study, 65 soil samples were analysed by gamma spectrometry and the radon emanation factor was determined. The concentrations of 232Th, 226Ra, 40K in the soil samples were determined by low-background HPGegamma spectrometry. The air-dry samples were measured in an aluminium Marinelli vessel after 30 days of airtight sealing for 80 000 seconds. The radon mass exhalation was determined by an accumulation method using an AlphaGuardmonitor.The following values were measured for the soil samples with exhalation values ranging from 6.52 ± 3.56 mBq/kg*h to 64.29 ± 5.23 mBq/kg*h. The median of the data was 30.95 ± 3.88 mBq/kg*h. The results of these measurements are comparable to those obtained in other studies abroad.

The measured 40K activity concentrations range from 211.3-992.1 Bq/kg, 232Th 7.7-96.3 Bq/kg, 226Ra from 9.1-94.9 Bq/kg. By adding the data obtained to a complex database containing several important data such as soil mechanics, geology, hydrogeology, field radon and soil gas measurements, a radiological map of the area can be constructed. The database can play an important role in the assessment of areas of radiological risk and in the issuing of building permits, thus supporting the work of decision-makers.

Simulation of the radiation exposure of microorganisms living in submarine hydrothermal systems using GATE and Geant4-DNA Monte Carlo simulation tools

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Introduction: The European project Radioactivity Monitoring in Ocean Ecosystems (RAMONES) (EU-H2020-FETPROACT) aims to offer new and efficient solutions for *in situ*, continuous, long-term monitoring of radioactivity in harsh subsea environments. Within this project, a first campaign of measurements of natural radioactivity present near shallow-water hydrothermal systems, often found around volcanic islands, has been set up in Milos Island (Greece). The understanding of the impact of radioactivity present in hydrothermal vent fields on prokaryotic and eukaryotic microorganisms is yet poorly documented. In this study, we used the Monte Carlo simulation toolkits GATE (opengatecollaboration.org) and Geant4-DNA (geant4-dna.org) to assess dose rates and DNA damage to microorganisms submitted to alpha emitters from the ^{238}U and ^{232}Th decay chains.

Materials and Methods: Samples of sediments, water (sea and thermal) and gas were collected in three different onshore and offshore sites in Milos Island. To identify a gradient of radioactivity, the water and sediment samples were collected directly at the exit of the thermal water and at 50 cm to 1 m from the area. Radon in gas was measured using a Radon Eye detector in an airtight container. Thermal and sea waters were dehydrated before being analyzed with a gamma spectrometer (HPGe) as for sediments.

First, GATE, an open-source MC platform based on Geant4 libraries, has been used for the simulation of the absorbed dose rates to microorganisms. Bacterial communities (e.g. Archaebacteria, *Nitrosopumilus maritimus sp.*) and micro-algae (e.g. Coccolithophore, *Emiliania huxleyi sp.*) were identified as predominant species in this environment. The microorganisms were simulated as water cylinders or spheres with sizes ranging from 1 to 150 µm. We considered the radionuclides ^{210,214,218}Po, ^{226}Ra and ^{222}Rn from the ^{238}U decay chain and ^{228,232}Th, ^{224}Ra, ^{220}Rn, ^{216,212}Po, ^{212}Bi from the ^{232}Th, both in water and sediments. The EM_standard_option_4 was used to track the particles. Statistical uncertainties were kept under 5%. The Geant4-DNA toolkit was used to assess DNA single and double strand breaks.

Results: ^{222}Rn *in situ* measurements in water indicate concentrations lower than 0.5 Bq/L, nearly on the detection limit. Concentrations in gas bubbles are in the range of 10 to 40 kBq/m^3 and can reach a maximum of 140 kBq/m^3 in certain areas. This results are being supplemented with gamma spectrometry for water and sediment samples.

First, absorbed doses per primary particle generated for 2 species, *N. maritimus sp.* and *E. huxleyi sp.*, are 2.01 mGy and 1.16 mGy, respectively from sediment's simulations. This work has been extended to different microorganisms' geometry and sizes and it has been gathered in an open source database accessible through a Python script interface.

Conclusions: The GATE platform associated to the Geant4-DNA toolkit have been used to provide an open-source database of absorbed dose rates for different microorganism sizes submitted to natural radioactivity (alpha emitters from ^{238}U and ^{232}Th decay chain). This work contributes to the understanding and evaluation of the doses received by microorganisms living in submarine hydrothermal ecosystems.

Environmental remediation of complex site: challenges and lessons learned

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The purpose of this paper is to summarize implemented initial stages of remediation activities and further challenges as the last phase of decommissioning process at location of the old radioactive waste storages in Public company „Nuclear Facilities of Serbia“.

There are a number of legacy sites at the location of Public company „Nuclear Facilites of Serbia“ with certain amount of radionuclides present in the environment, mostly due to unregulated past activities regarding radioactive waste management. Thus, the remediation measures are set with the aim to reduce the adverse effects of ionizing radiation on to the people and the environment, either by radiation source removal or changing/breaking the pathways of radiation exposure. Since the site of interest is already under decommissioning, integrated approach with subsequent remediation has been foreseen. From the given strategic planning, several activities are considered in this paper, such as site investigation, historical data and inventory, preliminary radiological characterization, selection of the References levels, initial delelopment of conceptual site model, and radioactive waste management. Recognized challenges that include identification, evaluation and selection of remediation methodology and further development of the remediation plan are presented.

Radionuclides in volcanic ash on Livingston island, Antarctica

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Volcanic ash is a feature of the landscape of Livingston Island and neighboring islands of the Antarctic archipelago South Shetland Islands, West Antarctica. It has a major impact on the number of processes in terrestrial and indirectly - in the marine ecosystem. The ash is the result of the eruption of the active volcano, located at the northern end of the nearby island – Deception, which is located 30 km. south of Livingstone. The last eruption was 12 and 13 August 1970.

90% of the territory of Livingston Island is eternally covered with ice, the remaining 10% are without snow and ice only during the Antarctic summer. Therefore, the main source of natural radionuclides is volcanic ash. The content of radioisotopes (in Bq/kg dw) in volcanic ash is respectively: Cs-137 10±1, Pb-210 120±20, Th-232 6±1, U-238 8±2, Ra-226 4±1, K-40 180±10.

The data for natural terrestrial radionuclides in volcanic ash were expected to exceed the concentration in soil samples, lichens and mosses, but the values are close to/or below the results on soil and biological samples from the area of the archipelago.

The concentrations of artificial radionuclides in the examined samples from volcanic ash are comparable with the results of soil (8.1±1 Bq/kg) as excess doses of Cs-137. The reason can be morphometric parameters of volcanic ash particles and their structure to retain cesium.

The radiation hazard index was calculated by activity concentrations. The results were insignificant.

^{210}Pb dating as a fundamental tool in retrospective analyses of peatland recent carbon dynamics in the context of global climate change

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Increased concentrations of anthropogenically-induced emissions of greenhouse gases (GHGs) linked with the diminishing carbon stocks of natural sinks have considerable implications on the growing concerns of climate change and global warming. Peatlands represent crucial ecosystems in the global carbon cycle, as their CO_2-sequestration potential is of an order of magnitude higher than global forests. Their intrinsic carbon storage capacity and atmospheric CO_2 exchange properties are highlighting the importance of the retrospective analysis of carbon dynamics within peatlands, in order to acquire a comprehensive understanding of their feedback in the context of global warming. If environmental conditions are becoming unsuitable for the accumulation of peat, degradation occurs, providing positive feedback by converting the carbon sinks into carbon sources, thus releasing the stored CO_2 into the atmosphere. ^{210}Pb dating method coupled with the ^{137}Cs time-marker provides fundamental data that allows for constructing high-resolution chronologies covering the last two centuries of peatland dynamics. Following peat chronologies, multi-proxy analyses (*δ^{13}C, δ^{15}N, C/N ratio, humification, X-ray fluorescence (XRF), inductively coupled plasma mass spectrometry (ICP-MS) GC-MS gas chromatography*) can be approached to represent on a time scale the variations in peat development and carbon-related properties (*REcent Rates of Carbon Accumulation (RERCA), carbon stocks, CO_2-equivalent, C loss*) relative to climatic conditions. Preliminary data on six-sphagnum-dominated peat bogs from Romania and Bosnia-Herzegovina, southeastern Europe regarding the retrospective analysis of their recent carbon dynamics using ^{210}Pb dating are presented. The isotopic measurements (^{210}Pb, ^{226}Ra, ^{137}Cs) were performed using gamma and alpha spectrometric techniques. The ^{137}Cs alternative marker was in good agreement with the results obtained by ^{210}Pb dating, further validating the age-depth models. The results of RERCA varied between 9.5 and 437.5 g C m^{-2} yr^{-1}, with a mean value of 144 ± 90.1 g C m^{-2} yr^{-1}, while the average C storage per unit area was 17.6 ± 7.6 kg C m^{-2}. Recently formed peat layers generally show higher carbon accumulation rates, yielding an average increase of 18.25% of the rate from 1950 to the present period, thus suggesting an enhanced contemporaneous C uptake and storage in the peatlands. The results validate and reaffirm the potential of ^{210}Pb and ^{137}Cs chronologies in constructing high-resolution age-depth models in peat ecosystems, allowing representation of the environmental processes on a time scale.

Comparison of stroke visualization with standard and „stroke" window CT settings – how helpful is it?

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Windowing is a process by which the grayscale of the window is changed using specific CT parameters. It is otherwise known as grey-level mapping, contrast stretching, histogram modification or contrast enhancement, and the modification is called a CT window. The parameters that are being modified are the window width, which is the measure of the range of CT numbers that a window contains, and the window level, is the midpoint of the range of the CT numbers displayed. These two numbers are used to define the upper and lower grey level which sets the range above which the element will appear as white or bellow which it will appear as black.

Most programs use standard or brain windows to spot strokes, but due to the often lower contrast between the brain tissue and the ischemic part it can be easy to miss, especially in hospitals with a high number of CT patients. Due to this a push has been made to make "stroke" windows a more standard part of examinations of the brain. The aim of this paper was to see if it is a good practice and make an argument for including it in standard examinations of the brain.

This study included 7 patients that were sent to have a CT of the head done; due to suspicions they were having strokes, and which were noticed on the examination. Their scans were then put in the standard window, "stroke" window with the window width of 8 and a window level of 32, and a "stroke" window with the window width and window level of 40. This set the upper level for the standard window at 80, for the first "stroke" window at 36 and for the second "stroke" window at 60. As for the lower grey level the number are 0 for the brain window, for the first "stroke" window 28, and the second "stroke" window at 20. After the images were processed the affected areas of the brain were actually more visible then the standard. Their scans were then put through all three windows and multiple radiologists with different degrees of experience were asked to identify strokes and say which window helped them the most. Although the first stroke window allowed a larger contrast between the affected area and the healthy, its setback was the fact the part of the brain being affected could not be easily identified on its own. The second window, although offering a lower contrast level then the first still had a better visualization then the standard and first "stroke" window. It also was easier to identify anatomical features, and was much more preferred for our radiologists.

In conclusion, using "stroke" windows helps visualize the lesion cause by the ischemia, and may reduce the risk of a stroke being missed even in earlier scans, before the lession is more prominent, though further research should be conducted.

Keywords: radiology; medical imaging; neurology; stroke; CT scan

The prediction of radioprotective dose of a *Juglansnigra* L. leaf extracts in diagnostic irradiation using response surface methodology

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*Juglansnigra*leaf is a source of health-promoting biologically active compounds and used in traditional medicine. Can we predict theradioprotective dose level of plant extracts based on modeling change biodistribution of radiopharmaceuticals by response surface methodology (RSM)? The present study aimed to the effects of *J. nigra* leaf extract oral intake on the biodistribution of 99mTc-radiopharmaceutical in healthy rats and to formulate a mathematical model that will associate the changes in radioactivity in organ with dose levels of extract and body mass of rats. The extract was administered daily by oral gavage to rats at dose levels of 6.9, 10.3, or 13.7 mg kg-1 body weight (bw) day^{-1} for 10 days. On the eleventh day, 0.1 ml (approximately 148 kBq) of the ^{99m}Tc-dimercaptosuccinic acid (DMSA) was injected into the tail vein. The organs of interest were isolated and radioactivity in each organ was counted by a gamma counter with a NaI (Tl) detector. After treatment of rats with the extract, there was a statistically significant decrease ($p<0.05$) in the uptake of ^{99m}Tc-DMSA (%ID/organ) in the kidneys compared to controls.The RSM model based on the second-order polynomial equation was apply to correlate changes in radioactivity in kidney with dose levels of extract and body mass of rats.The statistical significance of RSM as well as independent variables and their interactions were estimated by ANOVA (Analysis of variance). The *F*-value (265) and *p*-value (< 0,001) demonstrated that the developed model has statistical significance at the confidence level of 95%. The R^2 values (0.987) proved a good fit by the second-order polynomial equation, while relatively low values of the *CV (0.69)* indicated the remarkable precision and reliability of the model. The low value of mean relative percent deviation (0.4) between the experimental data and the predicted radioactivity of kidney obtained by RSM showed that RSM was suitable for modeling the change biodistributionof radiopharmaceutical. Modeling data provided evidence that the radioactivityof kidney statistically depended dose levels of extract and statistically not depended of body mass of rats. RSM gave the minimum predicted value of radioactivity of kidney 59%, which corresponded to minimum dose levelof 11.18 mg kg^{-1}and minimum body massof 130 g. RSM showed that extracts of *J. nigra*leaf kidney system protectionat doses higher than 11.18 mg kg^{-1}. These results suggest the potential use minimal dose level of *J. nigra*leaf extract as a radioprotector in cases of planned radiation exposures.

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BOOK OF ABSTRACTS rad-conference.com

Evaluation of the clinical acceptability of the Artificial Intelligence Automatic Contouring: an example of the use of artificial intelligence in prostate radiotherapy

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Purpose/Objective(s): This study aimed to evaluate the usability of the deep learning software (DirectORGANS) that automatically identifies organs, segments and auto-contours them as the first step in creating prostate radiotherapy plans.

Materials/Methods: The CT images of 10 patients with prostate cancer were selected separately, and the prostate were manually contoured on CT images by five experienced physicians. Also, MRI-guided prostate contours were used as References structure. And then, the same datasets were automatically contoured based on artificial intelligence (Al) and transfered to treatment planning system, respectively. The volumes of prostate were measured, and the Overlap index (OI), Dice similarity index (DSC) and Volume difference (Dv) were calculated based on contours. The Kruskal-Wallis H test was performed with SPSS ($P<0.05$).

Among them, V_a represents the volume (cm^3) autimatically contoured by the artifial intelligence, and V_m represents the volume (cm^3) manually contoured by the clinicians. The closer the OI index and the DSC index are to 1, and closer the Dv value is to 0, the better the delineating result.

Results: We have analyzed OI, DSC, and Dv for patients with prostate cancer. There was no significant difference in OI, DSC and Dv between the results of users and artificial intelligence. But, MRI- based contouring results are better than users and artificial intelligence. The comparison results of the users, artificial intelligence and MRI-based contouring are shown Table 1.

The most significant difference among users, artificial intelligence and MRI-based contouring was contouring time ($p <$ **0.001).** The OI, DSC and D_V results of MRI- based contouring were closer to 1 and 0 but it was time consuming.

Conclusion: Artificial Intelligence's automatic contouring of prostate can be used clinically after modification. Clinicians should review and confirm prostate volume using MRI before it was used in the treatment plan. Artificial intelligence demonstrated its value for automated contouring of prostate volumes to save time. Artificial intelligence based contouring showed important benefits in time-sparing combined with an improved inter- and intraobserver contouring variability.

High-dose-rate brachytherapy in patients with localized prostate cancer: an analysis of therapeutic parameters

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Brachytherapy (BT) is one of the most effective radiotherapy modality which enables application of a high dose of radiation to the tumour/target with maximum sparing of healthy tissue and organs in the immediate vicinity of the target. High-Dose-Rate Brachytherapy (HDR-BT) is an effective radiation modality in patients with localized prostate cancer (CaP) of all risks concerning relapse and disease progression, as well as, overall survival. In contrast to the external beam radiotherapy and the Low-Dose-Rate BT, it can be noted that the total dose of radiation and the fractionation scheme have not been clearly defined, yet. In the literature, one can find different therapeutic doses of radiation (19-54 Gy) fractionated in 1 to 9 fractions (hypo- and accelerated-fractionated) with different fractionation schemes, which provided similar results, i.e. local five-year disease control (mean for all risks about 91%; range 66-100%) with an acceptable level of late post-radiation complications (mean about 15%; range 3-35%).

Here we analyse the data on the dose, fractionation method and effectiveness of HDR-BT in patients with localized CaP of different risk (6099 patients), which were published in the available literature by different authors. Based on previous experience in modelling of therapeutic parameters in a group of 35 patients with localized CaP (17.1% low-risk, 60% intermediate-risk, 22.9% high-risk patients) using MANN (Multilayer Artificial Neural Network) an optimization criteria were set. Preliminary analysis showed that modelling is possible using following data: total dose, number of fractions, the effectiveness of the therapy (degree of local/biochemical control), the length of follow-up and the frequency of late complications (especially on the urethra).

The obtained data could be clinically significant for further optimization of the therapeutic dose and fractionation.

Gold radioactive nanoparticles for brachytherapy

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The development of new materials emerges as an alternative to the treatment of cancer, Nanobrachytherapy is born from the union of nanotechnology and brachytherapy being a modality of radiotherapy in which the nanosources are placed close to or in contact with the region to be treated. In nanoparticle synthesis, a key role is played by coatings, certain sizes of uncoated nanoparticles tend to accumulate in tumors due to vessel irregularities. When coated with gum arabic, the size of the nanoparticles is controlled, allowing the particles to properly penetrate the vasculature.

The choice of radionuclide depends on the radiobiology of the cancer and the dose deposited in the tissue, which takes into account the type of decay (beta particles penetrate less into the tissue than X-rays and gamma rays), energy and half-life time (which influence the deposited dose per duration of radioisotope). In this work, 198Au will be used, which presents Beta as the main type of emission with an energy of 314.55 KeV, gamma 411.8 KeV, and a half-life of 2.7 days.

The synthesis of radioactive nanoparticles is carried out in a closed chemical reactor, developed during the tests. The chemical reactor gold nanoparticles and precursor chloroauric acid are obtained. The morphology of nanoparticles and their size is guaranteed cold by TEM and radioactive by DLS. With an average diameter (TEM) of 5 nm, gum arabic nanoparticles have a curious property, when solution they form stable agglomerates of 45 nm (DLS), optimal size for in vitro and in vivo tests. They were tested with cancer cells of prostate and mice.

In one of the evaluated LNCaP strains, 11% cytotoxicity was observed at the lowest concentration (0.9 µCi/well). At the concentration of 1.8 µCi/well, there was cell proliferation and at the highest concentration (2.7 µCi/well) it showed 32% cytotoxicity.

After statistical analysis, the results revealed that although none of the animals showed regression of tumor mass. Tumor growth was slower at treated animals when compared to the tumor growth of the control animals (zero dose). Signaling us then that there is a positive effect on therapeutic efficacy, but these data suggest that the activity used was relatively low to achieve the regression of this mass. In the next experiments we will increase the injected radioactive activity to confirm these results and evaluate its real therapeutic potential.

Measurement of pretreatment verification MV doses in radiotherapy

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Background/Aim: Image-guided radiotherapy (IGRT), i.e. pre-treatment image verification of the patient positioning in radiotherapy (RT), has always been imperative for a precisely delivered RT treatment to the patient. Electronic Portal Imaging Devices (EPID) have largely replaced film-based verification, which has improved the quality of the obtained image, i.e. information about the position of the tumor volume. Depending on the applied verification modality (two orthogonal MV scans, two orthogonal kV scans or Cone beam CT) and the radiation photon energy, a different imaging dose will be applied to the patient. The aim of this study was to measure patient's pre-treatment verification doses using MV photon radiation.

Methods: In our RT center, we use the medical linear accelerator True Beam (*Varian Medical Systems, Palo Alto CA, USA*), which has a-Si 1200 EPID. All the measurements were done at the lowest photon energies, 2.5 MV flattening filter free (FFF) and 6 MV with flattening filter (FF).

For the purposes of the study, a heterogeneous phantom CIRS Thorax 002LFC (*Computerized Imaging References Systems Inc., Norfolk VA, USA*) was used, which anatomically and dimensionally represents an average human thorax (30 cm long, 30 cm wide and 20 cm high). It is made of plastic water, lungs and bone, with 10 cylindrical inserts in which the ionization chamber can be placed and the absolute dose can be measured. To measure the absolute dose in ten defined measurement points of the Thorax 002LFC phantom, a farmer-type ionization chamber Exradin A-19 (0.62 cm^3) with a SuperMax electrometer (*Standard Imaging Inc., Middleton WI, USA*) was used.

All dose measurements were made using the isocentric method for each of the measurement points from two projections AP and LAT, with one monitoring unit (MU) each. The size of the field is 16x16 cm^2. Absolute doses were calculated according to the protocol Technical Reports Series No. 398 (TRS 398)- absorbed dose determination in external beam radiotherapy.

Results: The depth dose percentages at 10 cm and 20 cm (10x10 cm^2, SSD 100 cm), for photon beams 2.5 MV FF and 6 MV FF are: 52.7 % and 22.7 % vs 66.3 % and 38.1 %. Quality index (D_{20}/D_{10}) was 0.485 vs 0.669 (2.5 MV FFF vs 6 MV FF). The measured absorbed doses (2.5 MV FFF) in the soft tissue (positions 1-5), for two orthogonal projections (1 MU each), were 14.1-16.7 mGy. Under the same measurement conditions in the lungs (positions 6-9), absorbed doses of 16.8-18 mGy were measured. In position 10 (bone) 11.4 mGy was measured. For 6 MV FF, under the same conditions, all measured doses were to higher by 29 % compared to 2.5 MV FFF. For an average number of about 20 RT treatments (fractions), the patient receives an additional imaging dose of 15 mGy 20 fractions = 300 mGy (2.5 MV), i.e. about 400 mGy (6 MV).

Conclusion: IGRT is the gold standard in external photon beams RT. Treatment without image verification is unacceptable in terms of the precision of dose delivery to a tumor volume. If using MV photon beams for pre-treatment image verification one should use lover MV energy, if possible. Imaging modalities based on kV photon beams (kV-kV and kV CBCT) additionally reduce the patient¢s dose and provide an image with more information and a simultaneous reduction of the CTV-PTV margin (irradiating volume), which is in accordance with the ALARA principle. Most RT centers routinely use kV imaging exclusively in clinical practice (except for treatment fields).

Key words: radiotherapy, MV imaging, dose, MV photon beam.

Experiment study on using Prompt Gamma–Positron Emitter Tomography (PG-PET) system for verifying dose distribution in carbon ion therapy

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Carbon ion therapy is a promising treatment for cancer patients that delivers high doses of radiation directly to the tumor site with minimal damage to the surrounding healthy tissue, but it is difficult to predict the beam range precisely because of the very sharp dose gradient of carbon beam Bragg peak. Various techniques, such as prompt gamma (PG) imaging, and positron emission tomography (PET), have been studied for in-vivo particle beam range verification. The PG imaging techniques measure the gamma of 3–5 MeV emitted by excited target nuclei, and they have a strong relationship with the actual dose. PET imaging can provide higher spatial resolution than PG imaging because PET imaging relies on the coincidence detection of annihilation photons, used in PET imaging can help reduce background noise and improve image quality. Our research team developed an integrated PG-PET-based imaging system to increase the accuracy of dose distribution prediction for carbon ion therapy. The purpose of this study was to evaluate the performance of the PG-PET system experimentally.

The PG-PET system is comprised of dual-head detector modules, each with parallel-hole collimators and scintillator arrays. The parallel-hole collimators and scintillator arrays in each detector module facilitated photon detection. Customized SiPMs were paired with each detector module to read out the optical signals of the 256 channels. The multi-channel signals were processed using an ASIC-based data acquisition system. An ASIC-based data acquisition system was employed to process the multi-channel signals generated by the SiPMs that can be high precision and reliable, enabling accurate detection and measurement of the gamma counts. To evaluate the performance of each detector module, ^{137}Cs, and ^{22}Na test sources were positioned between each detector face to measure the gamma counts. The system performance was assessed in terms of its energy resolution and sensitivity for each channel.

The detector module consists of arrays of GAGG crystals and SiPM pixels measuring 3 × 3 mm^2. The collimator was composed of tungsten and had a thickness of 300 mm, a slab thickness of 1.5 mm, and a hole width of 6.5 mm. The mean energy resolutions were measured at peak energies of 511, 662, and 1,275 keV for each test source to evaluate the performance of the PG-PET module. The results showed that the energy resolutions were 12.7±3.3%, 11.4%±1.1%, and 5.2%±2.2%, respectively. Coincidence events were also evaluated in the 511 keV peak region, and the time resolution for these events was less than 4 ns. The energy resolution was found to be better evaluated at higher energies. In terms of sensitivity variations for every scintillator pixel, the study found that the standard deviations of peak counts were 12%, respectively. These results suggest that the detector module with GAGG crystals and SiPM pixels is capable of providing good energy resolution and sensitivity for photon detection.

Our research team developed an integrated PG-PET-based imaging system to improve the accuracy of dose distribution prediction in carbon ion therapy. We experimentally evaluated the performance of the system and demonstrated its feasibility for photon detection. The results suggest that the PG-PET system has the potential to improve the accuracy of dose distribution prediction in carbon ion therapy. In the near future, we plan to evaluate the system's performance in a carbon ion therapy center to prove its effectiveness.

Dosimetry audit for Italian radiotherapy centres

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Purpose: The Italian National Institute of Ionizing Radiation Metrology (ENEA-INMRI) and the Italian Association of Medical Physics (AIFM) offer a certified audit service to radiotherapy (RT) centres for dosimetry in References condition in photon beams. Connected to the audit service, a technical protocol for verification of dose delivery in VMAT treatments is being developed.

Materials and Methods: Audits are provided for photon beams in the range 6-18 MV including flattening filter free beams, CyberKnife and TomoTherapy.

Thermoluminescent dosimeters consisting of a set of TLD chips (Thermo Scientific TLD-100) embedded in a PMMA waterproof holder are used. Dosimeters are calibrated at ENEA-INMRI in terms of absorbed dose to water in a References ^{60}Co gamma beam. Correction factors accounting for energy dependence, signal reproducibility and response stability are applied to evaluate absorbed dose.

In the audit, measurements are performed in References conditions according to the international dosimetry protocols [1-3]. For each beam, irradiation of two dosimeters with 2 Gy is required. Audit results are evaluated in terms of the normalized error En [4]: it is satisfactory if $|En| \leq 1.0$.

Meanwhile, a new technical protocol for verification of dose delivery in VMAT treatments is being developed. The VMAT plans simulated a Simultaneous Integrated Boost head-neck treatment for two target volumes with two different dose prescriptions and several Organs at Risk with proper dose constraints. A uniform dose (within 2%) was required on a region with dimensions comparable to sensitive volume of the detector (TLD, ionization chamber) used to measure the delivered dose in a cylindrical water phantom.

Results: Distribution of En scores for all irradiated dosimeters shows that 99.4% of values are in the range [-1.0, 1.0]. As for the single unsatisfactory result, data from the form filled in by the RT centre allowed to identify an error in the dosimeter positioning.

In non-References conditions study, TLD measurement accuracy is evaluated by comparison to a References ionization chamber and TPS dose evaluation. From preliminary results, the agreement between TLD and ionization chamber measurements is around 1.0% that is well within the TLD measurement uncertainty. In VMAT plans, the percentage difference between TLD measured dose and TPS dose on the TLD ROI is up to about 2.7%.

Conclusion: The References dosimetry audit was successfully performed for the 40 RT centres and 90 photon beams. Feedback from the participant centres was essential to improve the reporting of detailed uncertainties in the audit certificate. For non-References conditions, our TLD dosimetry system has proven to be suitable for dose measurements also for VMAT. Other measurements will be planned to evaluate different VMAT plan configuration. A pilot study involving some Italian RT centers will be started to evaluate the complexity of VMAT treatment planned by different Linac-TPS systems.

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2 IAEA TRS 483 - Dosimetry of Small Static Fields Used in External.

3 AAPM TG-51 protocol for clinical References dosimetry of high-energy photon and electron beams.

4 ISO/IEC 17043:2010 Conformity assessment – General requirements for proficiency testing

An Italian intercomparison for radiotherapy dosimetry in different field sizes

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Purpose: The Italian National Institute of Ionizing Radiation Metrology (ENEA-INMRI) has organized an intercomparison program for absorbed dose measurement in 6 MV radiotherapy (RT) photon beams in different field sizes from 12 cm to 2 cm. The intercomparison program is free and is funded by Ministry of Economic Development (MiSE). In the following we report on the intercomparison methodology and results.

Materials and Method: For the intercomparison, a technical protocol has been established for the methodology and the operating procedure. In particular, the protocol specifies irradiation set-up, detector positioning, field sizes, absorbed dose to be delivered and measurements mode.

A dosimetry system composed by microDiamond (PTW60019) detector and electrometer (PTW ROMEO) is calibrated in terms of absorbed dose to water in a References ^{60}Co γ-beam at ENEA-INMRI and tested in 6 MV photon beams in References conditions.

The ENEA-INMRI provides the dosimetry system with instructions for use to RT Centre (participant).

In the intercomparison measurements, the detector will be irradiated at Source to Surface Distance SSD=90 cm and depth d=10 cm in water phantom with side of at least 30 cm. The field sizes considered are 5 cm x 5 cm, 3 cm x 3 cm, 2 cm x 2 cm and 12 cm x 2 cm.

For each field size, it is required to irradiate the detector with a number of monitor units (MU) estimated by the RT Centre to delivery an absorbed dose to water of 2 Gy at the detector position. The participants fill out a data sheet with measured charge and uncertainty of dose delivered. ENEA-INMRI manages the data collected by participants. Measurements (charge collected by microdiamond detector) are converted in absorbed dose to water using the calibration factor and correction for energy.

Comparison results are evaluated in terms of E_n score [1]. The intercomparison performance is satisfactory if $| E_n | \leq 1$ and unsatisfactory if $| E_n | > 1$.

Results: Italian radiotherapy centres showed great interest for the intercomparison, as demonstrated by the 50 registrations received. To date, 23 RT centres have performed the intercomparison. On basis of E_n analysis, all intercomparison are satisfactory. In general, the E_n score increases as the field sizes decreases.

Conclusions: The intercomparison is ongoing and will be completed in the following months. At the end of intercomparison program, all results will be shown anonymously in a report, issued by ENEA-INMRI, while a secret code will be assigned to each participant, to verify own performance. Some participants perform the intercomparison to compare different TPS available. From feedback of the participants, there is an interest to extend the intercomparison for other beam qualities, as 10 MV.

References:

1 ISO/IEC 17043:2010 Conformity assessment – General requirements for proficiency testing

Development of TL and OSL materials for the analyzation of dose and energy distributions of photon beams for radiotherapeutic applications

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Thermostimulated luminescence (TSL) and optically stimulated luminescence (OSL) dosimetry are a versatile tools for the assessment of ionizing radiation dose at radiotherapeutic procedures. Meanwhile, the intensity of the TSL glow curves is strongly influenced not only by the dose but also by the energy of X ray radiation generated by radiotherapeutic equipment. For this reason, the radiation effect has a very strong dependence on the density and effective atomic number of the absorbed TSL materials, especially at the registration of the high energy X- or γ-rays [1]. In the first stage of our research, for control of photon beam dose and energy distributions generated by clinical 6MV and 15MeV linac accelerators, we used the non-conventional TSL detectors based on the crystals of Ce^{3+} doped $Y_3Al_5O_{12}$:Ce garnet (YAG:Ce) with a density ρ=4.5 g/cm^3 and effective atomic number Z_{eff}=35. The set TSL detectors with 10*10*0.5mm size was prepared from Czochralski grown YAG:Ce crystal. Samples of YAG:Ce crystals were irradiated with 6MV and 15MV X Rays using linear accelerator Clinac 2300 C/D from Varian Medical Systems located in Oncology Center in Bydgoszcz and 1.17/1.3 MeV γ-rays from ^{60}Co source in the National Institute of Oncology in Warsaw. The obtained results shows that the YAG:Ce crystals is very suitable TSL material for application in radiotherapy with 6 MV photon beam due to its excellent radiation stability, high intensity TL response at typical therapeutic dose of 2 Gy and good position of main TSL peak around 280K [2]. However, due to relatively low ρ and Z_{eff} values, the YAG:Ce detector is less suitable for photon beam control at high energy (> 6 MeV) of X rays in open field mode [1]. The next step of our research is connected with the investigation the TSL detectors with higher density and effective atomic number. We investigated in this work the sets of TSL detectors based on the crystals of $Lu_3Al_5O_{12}$:Ce garnet (LuAG:Ce) with ρ=6.7 g/cm^3 and Z_{eff}=61 and $Gd_3Al_3Ga_3O_{12}$ (GAGG:Ce) garnet with ρ=6.7 g/cm^3 and Z_{eff}=61. The two sets of TSL detectors based on the LuAG:Ce and GAGG:Ce garnets with 10*10*0.5mm size were prepared from two different Czochralski grown crystals. The contained results were analyzed in comparison with YAG:Ce TSL detectors [1]. Another approached in the detectors creation is connected with efficient OSL properties of GAGG:Ce and YAG:Ce crystals [2, 3]. Similarly to developed by us composite scintillators [4], the registration of the signal coming from different parts of composite detectors occurs in this case using the differences in OSL decay kinetic. For this reason, the development of YAG:Ce/GAGG:Ce composite OSL detectors can be even more prospective in comparison with their TSL counterparts. Furthermore, based on the data obtaining with YAG:Ce and LuAG:Ce TSL detectors, the creation of multilayered composite TL and OSL detectors based on the YAG:Ce single crystalline film and LuAG:Ce and GAGG:Ce crystals detectors were considered using liquid phase epitaxy growth method [4].

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The concept of a detector for in vivo dose measurements in brachytherapy based on advanced OSL materials

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The use of ionizing radiation for therapeutic purposes (external beams radiotherapy and brachytherapy) absolutely requires verification of the dose deposited in the patient's body. This can be achieved by repeating the exposure time calculations in the independent treatment planning system (TPS). However only the direct dose measurements give a clear answer on the value of deposited dose. For therapies using external beams, a several measurement methods have been developed: from TLD detectors, semiconductor detectors to the so-called transit dosimetry.

In vivo dose measurement in brachytherapy is a big challenge. This is because *active detectors* that could be safely placed deep into the patient's body have not yet been invented. The active detectors (ion chambers, diodes) usually require high voltage for operation, which always brings a risk of electric and thermal shock. An alternative is to use passive detectors based on the stable and non-toxic OSL materials. On the other hand, placing a detector with high Z_{eff} value very close to the irradiated area will significantly perturb the delivered to tumor dose.

We propose to used novel solution for in vivo measurements in brachytherapy connected with the application of the composite detectors based on the anion-deficit crystals of Al_2O_3 sapphire [1] with extended OSL properties. As Al_2O_3 crystal have a rather close effective atomic number value Z_{eff} =10.2 with respect to the different parts of human tissue (Z_{eff}=6-12), insertion them into selected patient body cavities should not significantly disturb the effective distribution of dose. The Al_2O_3 crystal, integrated with the optical fiber, can be placed in close neighbourhood of the target [2-4]. Triggering and reading will take place using optical fibers, so in a completely safe way [2-4].

Furthermore, the application of composite film-crystal OSL materials based on the LPE grown epitaxial structures of sapphire, is considered. These structures can consist of singly Mg doped and Mg,A (A= Mn, Ti, Cr, Mn) single crystalline films of Al_2O_3 sapphire, grown by LPE methods onto anion-deficit Al_2O_3 crystals. As it has been shown in our previous work [5], such type composite detectors can possess a selective radiosensitivity to various components of the ionizing radiations. Although our latest venture is at a very early stage, the initial results seem very promising.

Acknowledgements: The work was performed in the frame of Polish NCN 2018/31/B/ST8/03390 project.

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Left sided breast cancer with deep inspiration breath hold: comparison of dose distribution of hybrid (IMRT+VMAT) and 3D conformal treatment planning

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Background/Aim: For women with left sided breast cancer, a major concern is the dose of radiation delivered to the heart. In order to reduce the dose to the heart during tangential breast irradiation, in our institution we implemented a deep inspiration breath hold (DIBH) technique. Aim of this retrospective study was to compare dosimetric effects of the DIBH on the heart, left anterior descending artery (LAD) and ipsilateral lung (IL) planned with hybrid plan (IMRT+VMAT) and conformal-forward IMRT plans.

Methods: Twenty patients who underwent RT with DIBH at our institution were retrospectively analysed. Conformal plans consisted of two opposed tangential segmented 6MV beams and one direct beam with small dose contribution. Hybrid plan consisted of two tangential IMRT 6MV beams with 90% of the dose contribution and two 180° arcs (6MV) with 10% of the dose contribution. Doses to the planning target volume (PTV), clinical target volume (CTV), heart, LAD, IL and contralateral breast were assessed.

Results: Dosimetric comparison between hybrid and conformal DIBH radiotherapy for mean dose to the heart was 2.42Gy vs. 2.88Gy (p=0.137), and the mean percentage of the volume receiving 25Gy was 0.54% vs. 0.85% (p=0.04), respectively. Mean PTV coverage was 98.98% vs. 96.33% (p<0.001), mean CTV coverage was 99.49% vs. 97.85% for hybrid and conformal treatment plans, respectively. Mean dose for LAD was 7.73Gy vs. 11.88Gy (p<0.001). Mean percentage of the volume receiving 20Gy for the IL was 12.06% vs. 13.26% (p<0.001) for hybrid and conformal plans, respectively. Mean percentage of the volume receiving 5Gy for the contralateral breast was 1.71% vs. 0.81% (p=0.002) for hybrid and conformal treatment planning, respectively. Mean percentage of the volume receiving 10Gy for the contralateral breast was 0.40% vs. 0.49% (p=0.414) for FB and DIBH, respectively.

Conclusion: Comparison of two planning techniques showed better target coverage for hybrid radiotherapy plans. Hybrid planning and delivery reduces the dose delivered to the heart, LAD and ipsilateral lung. Conformal planning technique showed better results for contralateral breast.

Key words: Breast cancer radiotherapy, Deep inspiration breath hold, Hybrid planning

Small field dosimetry overview

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Recent advancements in the field of radiotherapy have resulted in the utilization of small static photon beams in various treatment techniques, including Intensity-Modulated Radiation Therapy (IMRT), Volumetric Modulated Arc Therapy (VMAT), Stereotactic Radiosurgery (SRS), and Stereotactic Body Radiation Therapy (SBRT). These methods may be executed with both specialized machines and conventional accelerators equipped with MLC. However, accurately measuring radiation doses in small fields presents a significant challenge, primarily due to factors such as collimation of the radiation source, loss of lateral electronic equilibrium, dose averaging in a small volume, and dose perturbation by the detector.

Furthermore, selecting the appropriate patient-specific quality assurance (QA) device is imperative to ensure precise delivery of the radiation dose to patients. Extensive scientific research has been conducted on the theoretical basis and dosimetry techniques for small photon fields.

In light of the available commercial equipment, our poster was created with the intention of synthesizing fundamental aspects related to the physics of small photon fields, dosimetry formalisms, detectors for small field dosimetry, and quality assurance methods for patients treated within small fields.

Comparison of results of radon level measurements obtained with charcoal canisters and airthings detectors during summer at TCAS

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Radon is the main source of natural radiation and has been classified as a carcinogen by the relevant international organizations. It is released from soil, water, building materials in the atmosphere and the most significant part of dose due to radon is received by the inhalation of ^{222}Rn and its progeny in closed spaces. At Technical College of Applied Sciences in Zrenjanin (TCAS) two-day long radon concentration measurements were performed in eight rooms during summer holidays by using open charcoal canisters (EPA520 method) and by simultaneously engaged active type Airthings radon detectors. During the measurements open charcoal canisters and Airthing detector were placed one near the other at the table of about 1 m height, windows and doors in the rooms were kept closed and rooms were also not ventilated for some time before the start of the measurements. These studies were performed in order to check radon concentration levels at TCAS as part of the project Radon Level Measurement activities financed by the Provincial Secretariat for Higher Education and Scientific Research. The results were compared and discussed.

Dose assessment from exhalation and gamma spectrometry measurements of soils and stones as building materials

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Natural building materials such as soil and rock can contribute to increased gamma dose rates as well as indoor exposure to radon and thoron. About 20 samples of soil and stones were collected in the industrial and mining area near Zvečan, Kosovo and Metohija. Based on previous measurements this region is identified as radon prone area. The radioactivity content of samples was determined with gamma spectrometry. The method for the determination of radon and thoron exhalation rates from soil samples by an active RAD7 device connected to an exhalation chamber with a closed circulation system was proposed and applied. Particle size analysis was performed using a Malvern Mastersizer 2000 analyzer. The grain size distribution for all samples is shifted towards the higher values, d(0.5) ~ 200-250 μm which indicates a large proportion of sandy fraction. In all samples high concentrations of natural radionuclides are detected in the ranges of: 23.3 – 142.0 Bq/kg for ^{226}Ra, 38.0 – 142.0 Bq/kg for ^{232}Th, and 33.0 – 235.0 Bq/kg for ^{238}U. The influence of the particle size distribution and elevated levels of radium and thorium on exhalation rate was analyzed and discussed. The gamma index for building materials and annual effective doses due to external gamma exposure and inhalation of radon and thoron gas and their progenies were estimated.

Radon background in rare event searches at DARWIN experiment

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One of the most intriguing questions of new physics is the possible existence of, so called, “dark” or “missing” matter. One of the possible candidate for the cold dark matter, is the weakly interacting massive particle (WIMP) which is investigated using several types of experiments. Among many, the direct detection liquid noble gasses experiments are the leading ones in terms of sensitivity to >GeV WIMP mass parameter space. The foreseen future European astroparticle observatory, DARWIN, is designed as an ultimate direct detection liquid xenon based experiment in dark matter searches. DARWIN’s rich experimental program of also includes other rare event searches, such as an investigation of the Majorana nature of neutrinos though neutrinoless double beta decay, the search for the axion, a hypothetical particle proposed as a solution of the strong CP problem or many others.

Rare event searches, besides large scale detectors with low detection threshold, require high control and almost background free environment. Two types of background processes can mimic the WIMP recoil signal, nuclear and electronic recoil events. The dominant electronic recoil background is coming from the radon progenies (Rn^{222}). Since it is created by radioactive decay inside all detector materials, the effective detector shielding is hindered. Here we present the requirements of radon level in xenon target necessary to reach the foreseen sensitivity in rare event searches. We also give the state-of-the-art of radon mitigation strategies which include material selection and screening, on-line radon removal techniques, as well as the off-line methods of tagging electronic recoil events from radon progenies.

Radon concentrations in the Sudwala cave, South Africa

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There has been a growing interest in the effect of radon gas on humans visiting caves. A radon survey was consequently done in the Sudwala tourist cave close to Nelspruit in the eastern part of South Africa to determine the radon exposure of tourists and guides. The Sudwala cave, which evolved in karst geology, is a popular tourist destination. Twenty-eight electret ion chambers were placed in various locations throughout the cave for a period of 24 hours. Radon concentrations varied between a minimum of 255 Bq/m^3 and a maximum of 1822 Bq/m^3 with a geometric mean of 750 Bq/m^3. The radon levels were found to be relatively stable up to 600 m from the entrance, after which they sharply increased. This suggests that different processes disperse radon in the initial and deeper parts of the cave. It was concluded that this is the result of natural cave ventilation which is caused by changes in ambient barometric pressure. Despite the measured level being higher than the World Health Organization (WHO)'s mitigation level of 200 Bq/m^3, the occupational exposure is quite low due to the frequency and duration of a typical cave tour and therefore poses no risk to the tourists and tour guides.

Temporal uncertainty as a key parameter for the international standardization of indoor radon measurements

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Introduction: Significant temporal variations of radon (and other air pollutants) are always observed in any room, even one with permanently closed windows and doors. Obviously, the longer lasts the measurement, the lower the temporal uncertainty in the estimate of the annual average indoor radon (AAIR) concentration. However, short-term tests are much more common than long-term ones. Therefore, the following question remains relevant: how can one assess the conformity of a room with a normative and make a reliable decision if the test lasts days or months (it means shorter than 1 year)?

The measurement protocol fundamentally differs between Europe with long-term tests lasting several months and the US applying short-term tests (several days), while none of the protocols consider the temporal uncertainty $U_V(t)$. The absence of a rational and harmonized approach seems to be a result of the deep-rooted conservatism in the regulation of indoor radon is because the international standardization principles based on the ISO/IEC concepts of "measurement uncertainty" and "conformity assessment" had spread over relatively recently, while the need to study and estimate temporal variations of indoor radon arose much earlier. In fact, temporal variations of indoor radon have been the subject of many studies for the last three decades. However, none of these publications discussed the challenges and needs of international standardization of indoor radon measurements. Therefore, instead of well-defined concepts associated with uncertainty within ISO/IEC, Seasonal Correction Factor (SCF) and Coefficient of Variation (COV) as the characteristics of indoor radon temporal variations were introduced. Unfortunately, the SCF and COV have since become firmly rooted and continue to be used in the current regulation of indoor radon.

Therefore, the problem of determination of temporal uncertainty is the key to creating a rational and harmonized international standard based on the ISO/IEC concepts which are vital for reliable decision-making.

Methods: The $U_V(t)$ is defined as the 95th percentile in the distribution of all deviations of the measured concentrations $C_{ij}(t)$ in the representative sample of N buildings (rooms) within an international or national case study from the AAIR: $D_{ij}(t)= C_j^{AAIR} / C_{ij}(t) - 1$ ($i=1...M; j=1...N$). In each of N buildings (rooms), year-long continuous measurements of radon concentration with an integration period of 1 hour (at $M=8760$) are carried out. This provides good statistics of the arrays $D_{ij}(t)$ for any measurement period t.

Results: The values of $U_V(t)$ as a function of the measurement duration for the buildings in Finland, Israel, Russia, and the US have been obtained by a statistical analysis of the experimental data, as well as through a conversion of the published *COV* values. Temporal uncertainty of indoor radon is a factor that usually significantly exceeds instrumental uncertainty U_D. In addition, it is found that the temporal uncertainty is about 2-3 times higher than the coefficient of variation. It is also shown that the obtained $U_V(t)$ values are reliable in the range of measurement durations from 6 to 12 months.

The current values of the temporal uncertainty which are the most reliable for practical use are suggested. However, these values need to be verified and clarified, so the actual solution would be to conduct 200–300 annual continuous monitorings of indoor radon (and other air pollutants) in different countries, for example, in Europe and America.

Conclusions: Within ISO/IEC rules, a rational criterion of conformity assessment of a room with a normative which considers two main uncertainties ($U_V(t)$ and U_D) with a probability of 95%, and covers both short- and long-term measurements, is proposed.

Measuring technique of the average equivalent equilibrium concentration of thoron in modern buildings

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The radioactive gases both radon and thoron are known as a factor of population exposure in residential premises and the main reasons of lung cancer. The major source of thoron is the building materials. Unlike radon, thoron (Rn-220) has a shorter half-life (55 s) and does not move far from the formation source. However, when irradiating the population, the main damage to the lungs is caused by thoron daughter decay products. In Russia, the average annual equivalent equilibrium concentration (EEC) of radon isotopes is normalized in residential air by sanitary standards. However, there is no instrumental and metrological support for determining the average annual thoron EEC in Russian Federation. Unlike the Rn-222, it's impossible to use equilibrium factor to calculate the average thoron EEC. It's due to this factor can vary from 0.02 to the magnitude of 0.2 and will strongly depend on the air exchange rate in the room.

To close the absence both methodological and instrumental resources for the annual average thoron EEC determination in modern buildings and workplaces the novel method was developed. The method is using the combination of short-term (3-5 days) and long-term (3 month and higher) measurements of Pb-212 and Rn-222 concentrations in air. To measure the ^{222}Rn in studied room, the AlphaGUARD PQ2000 Pro or Radon Scout Professional monitors were used. The Pb-212 concentration measurements were performed using the simple air pump and aerosol filter the type of AFA-RSP 20. The long-term Rn-222 measurements were conducted using the RadoSys RSKS nuclear track detectors, based on the plastic CR-39 material. The Th-232 specific activity was estimated in examined rooms. The specific activity was measured by non-destructive method of the unscattered gamma-quanta flux rate. The relationship of thoron average annual thoron EEC and Th-232 specific activity was obtained after spectra processing. The obtained values of Th-232 specific activities can be used for radiation doses prediction in modern buildings.

The novel method of the average annual thoron daughter decay products EEC measuring was performed in Ekaterinburg city, in Russia. The average annual EEC of thoron was estimated for 7 modern residential premises and 2 office rooms. It was obtained the average value of thoron EEC 0.61 Bq/m^3 for Ekaterinburg city. The range is from 0.02 to 1.3 Bq/m^3. It has been established that the average annual values of thoron EEC are significantly affected by the mode of premises maintenance by residents, the nature of the walls decoration, which affects the rate of diffusive thoron entry from the building materials. The correlation of thoron EEC and Th-232 specific activity in building materials (from 9.5 to 41.8 Bq/kg) is discussed.

The relative benefits of different spatial evaluation methods for visualizing geogenic radon

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The most important geological sources of radiation exposure for the public come from radon and its daughter elements. One of the main sources of radon, along with building materials, is the soil. The Geogenic Radon Potential (GRP) is an index that measures the potential indoor radon risk danger from the surface soil, independent of the effect of any building-related or lifestyle-related factors, since it is based on soil permeability and soil gas radon concentration. Using the GRP-based radon risk maps, it can be possible to pinpoint places that are more likely to experience indoor radon dangers.

600 locations were used to test soil permeability and radon concentration levels in the soil in the Northern Trans-Danubian region of Hungary. The research area is primarily distinguished by low and medium GRP values, with a few high values. Quantified, 269 locations can be classified as low, 315 as medium and 16 as high risk category. The data was converted into a raster map in accordance with the current European Union radon survey concept, using 10x10 km grid cells. Each cell was assigned five measuring locations, that were preferably close to populated areas. After the conversion, the results were as follows: only 1 cell was classified as high, 78 as medium, and 41 as low risk category GIS software was used to create Geogenic Radon Potential maps on a 10 km by 10 km grid, and many spatial interpolation methods were tried to see which one is best for using maps to interpret observed data.

The spatial resolution can be reduced by hiding or enlarging local outliers when just processed aggregate data is displayed in raster or interpolation format.

Relation between radon concentration, number of smokers, and lung cancer morbidity in the conditions of the Republic of Moldova

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Residential radon exposure and tobacco smoking are the two most important risk factors for lung cancer. Of these, exposure to radon indoors has garnered greater interest as a risk factor for lung cancer. Radon is a colorless and odorless gas ubiquitous in rocks and soils and, thus, can accumulate in buildings. The cumulative effects thereof were evaluated in the Republic of Moldova, based on the number of tobacco smokers (age group 18-69 years old) from the results of National Population Study STEPS 2021, average data on bronchopulmonary cancer incidence and prevalence for 2012-2020 (per 100 thousand of the population) and results of the national survey on radon concentration radon measurements using RADTRAK2 detectors in 36 territorial units of the country during 2018-2021. Proportional extrapolation of data on the number of smokers to standardized indicators allowed us to evaluate the studied variables in the aggregate. Statistical tools included summary statistics of variables and cluster analysis.

In the center of the country, the largest number of smokers was recorded (947.6 per 100 thousand) due to multiple excesses of the urban population compared to other regions of the country (together with the municipality of Chisinau, ¼ of the population lives here). But the morbidity index of lung cancer was higher in the North of the country, while the radon concentration in the region is below the level set by the WHO (300 Bq/m^3). The average concentration of radon above the norm was observed in the South of the country (316.6 Bq/m^3), as well as the highest values of the maximum measured value; however, here the number of smokers and the incidence/prevalence of bronchopulmonary cancer was lower than in other regions. Statistical summary description of variables using standardized kurtosis, skewness, and Shapiro-Wilks and Kolmogorov-Smirnov tests made it possible to choose cluster analysis as the most adequate method for evaluating these heterogeneous data. Clustered multifactorial analysis was performed with the determination of the Euclidean distance and the linkage distance of the interaction of the studied parameters. The formation of the higher cluster (Euclidean Distance = 1.8) combining all variables proceeded by the formation of two clusters with the smallest distance between variables (which indicated on their similarity) - 1. Incidence and prevalence of lung cancer, the number of total tobacco smokers, number of male smokers, number of female smokers, and number of urban smokers (Euclidean Distance = 1.1) - 2. Radon concentration and the number of rural smokers (Euclidean Distance=1.6). Such a relationship between risk factors and the incidence of lung cancer demonstrates the leading role of tobacco smoking on morbidity among the adult population, regardless of gender in an urban environment with a rather low concentration of radon, and at the same time indicates the cumulative effect of smoking and increased radon concentration in rural areas due to the construction features of houses and lifestyle (building material, the presence of basements, living in one-story houses, etc.), which is in good agreement with European regional and world studies.

First national intercomparison on radon active monitor at INMRI-ENEA Casaccia research center

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The National Institute of Ionizing Radiation Metrology (INMRI) belonging to the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) has organized a national program to promote the reliability of ionizing radiation measurements in the country based on Inter-Laboratory Comparisons (ILC). The Program was funded by the Italian Ministry of Economic Development (MiSE) as part of the initiatives and studies on the subject of controls on measuring instruments, in a context of particular relevance for consumers with implications for health and safety. In particular, ILC N.3 is aimed to measurements of concentration of radon (Rn-222) activity in the air by means of active monitors.The ability to measure the concentration of radon activity in the air, in particular the temporal evolution of the entire concentration of activity, is a topic particularly felt not only in Italy, but in the entire world, due to the diffusion of radon measurements in numerous applications in the field of environmental surveillance, dwellings and workplaces, as well as in the study of radon diffusion processes in buildings and the evaluation of the effectiveness of appropriate application actions. To date, very few ILCs, aimed at measuring the concentration of radon over time,have been carried out. Therefore, such ILC is necessary to verify the calibration of radon detectors used by the laboratories and investigate their measurements capabilities. The instruments participating in the ILC were subjected, for a certain time interval, to defined conditions of exposure to the radon gas. The sample exposure conditions were carried out in the INMRI-ENEA "walk-in radon chamber" plant. The instruments received by the users were placed on suitable laboratory tables; furthermore, some radon detectors, previously calibrated by INMRI-ENEA for the concentration of radon activity, were placed, as a References, in the same exposure chamber. The analysis of the results was based on the comparison of the measurand values provided by the various participants with the References values of the measurands provided by INMRI-ENEA.

Geochemical and structural properties with regard to radon and thoron behavior in adobe building materials: study case from three different areas in Angola

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Keywords: Radon and thoron emanation, adobe geochemical composition, Angolan adobe

Adobe building material is one of the most used building materials in Angola, both in villages and suburban areas, and it is the most widespread building material for families with low income. Previous studies from the author have shown the levels of indoor radon and thoron activity concentrations as well as activity concentrations of Ra-226, Th-232, and K-40 in the studied adobes from three distinct areas: Cabinda (in the North part of the country), Huambo (the central part) and Menongue (the south part). This time, the aim of the study is to determine the emanation fractions and investigate the structural and geochemical properties that could influence the emanation of the studied adobe. For this purpose, 30 adobe samples were collected in the three study areas making 10 samples per area. Radon and thoron emanation of adobe samples was determined using a RAD7 detector. Radon emanation fraction calculation was done using the growth curve method. The grain size distribution measurements were analyzed by laser diffraction with a Horiba Partica 950-V2 LA Analyzer after being sieved under 63 μm. The mineralogical composition was determined by the XRD and confirmed with the SEM. Results about radon and thoron emanation properties show that samples from Huambo have the lowest radon and thoron emanation fractions, Menongue the highest, and Cabinda in the middle.

Thermal and adsorption study of the spent mushroom substrate and its hydrochar

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Mushroom cultivation and consumption have been steadily increasing in recent decades, however, after mushroom cultivation, a large amount of by-products, known as spent mushroom substrate (SMS), are left behind in open dumps where about 5 kg of SMS are generated for every kilogram of mushroom (*Agaricus bisporus*). Around 51 million tons of SMS are produced in the world every year. Hydrothermal carbonization (HTC) is a promising technology for the conversion of SMS into a rich carbon product, hydrochar. The hydrochar was synthesized in a hydrothermal reactor at a temperature of 180 °C for a reaction time of 1 h. The characterization of the SMS and its chars was done by FTIR, SEM, and TGA analysis. The FTIR analysis showed that aromatic and oxygen-rich functional groups are dominant on the hydrochar surface. It was noticed that the hydrochar had more visible pores compared to the SMS. The porous structure and oxygen functional groups of hydrochar probably influenced the improvement of adsorption performance, since the adsorption capacity of SMS for Cd^{2+} ions was 28 mg L^{-1}, while for hydrochar it was 92 mg L^{-1}. On the other hand, the thermal kinetic analysis has shown that hydrothermally treatment upgrades the combustion behavior of hydrochar. The kinetic parameters were determined by Kissinger and Ozawa methods. The hydrochar had notably lower activation energy compared to the SMS, which means that this hydrochar requires a smaller amount of energy to start combustion. The preliminary results show that HTC effectively transforms SMS into alternative solid biofuel and eco-friendly sorbent.

Modelling of radionuclide transfer through the concrete barrier of the near-surface repository under different environmental conditions

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Radioactive waste generated by human activity is a long-term issue demanding very specific waste handling, storage and disposal requirements. One of the options for low and intermediate level short-lived radioactive waste disposal is sealing in near-surface repositories. In such radioactive waste disposal facilities concrete barriers are arranged with the aim to prevent and/or retard radionuclide migration to the environment. The concrete barriers in these facilities react with various chemical elements in the environment, and in the long term physically and chemically degrade. This can reduce radionuclide retention and increase their leaching to the environment. The long-term ability of engineered barriers to retain radionuclides can be evaluated by modelling concrete leaching taking into account various environmental phenomena, such as acid rain or groundwater infiltration into the repository, which causes more rapid concrete degradation.

This study presents modelling of the potential degradation of the concrete slab constructed at the bottom of the near surface repository assuming different environmental conditions and associated impact on radionuclide flux to the environment. At first, concrete leaching is modelled to obtain changes in pH in the bottom slab. Then, depending on the pH value, radionuclide distribution coefficients are selected and radionuclide transfer through the concrete slab is modelled. Three cases of concrete leaching are analysed: (1) leaching with rain water, (2) leaching with rain water taking into account biological processes in the top soil layer, and (3) leaching with groundwater. Modelling is performed using computer tools PHAST (for water flow through porous media and chemical evolution) and AMBER (for radionuclide migration). Five weakly and strongly sorbing radionuclides with different half-lives, namely C-14, Cl-36, Cs-137, I-129 and Pu-239, are considered in this study. The initial activity of each radionuclide is assumed to be 1 TBq and considered time frame is 1E+5 years. Based on the changes of pH value, four stages of concrete degradation can be distinguished. Depending on pH value in the concrete pore water, the distribution coefficient for each radionuclide is selected based on literature survey and linked to the degradation stages of the concrete barrier. A fractional flux, i.e., estimated radionuclide flux out of the concrete barrier divided by the initial activity of the radionuclide in the repository, is compared for the 3 above mentioned leaching cases.

The modelling results indicate that the highest fractional flux from the repository is for mobile long-lived radionuclides Cl-36 and I-129. For these radionuclides concrete degradation has minimal impact on increase in fractional flux out of the bottom concrete slab. Radionuclide release from the repository in case of leaching with rainwater and rainwater with increased carbon dioxide partial pressure are very similar – the difference in maximal fluxes is less than 16%. Concrete leaching with groundwater causes more rapid degradation, leading to increased radionuclide migration in comparison with the rain water cases. The only exception is radionuclide Cs-137 as due to its short half-life Cs-137 decays to insignificant amounts before the effect of concrete degradation takes place. The highest difference (more than one order of magnitude) between the cases can be observed for long-lived radionuclides with high sorption values: C-14 and Pu-239.

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BOOK OF ABSTRACTS rad-conference.com

Development of the concept for derivation of conditional clearance levels for an industrial waste disposal facility at Ignalina NPP

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Industrial waste generated from the operation of Ignalina Nuclear Power Plant (Ignalina NPP) was disposed in industrial waste dumps, the so-called "landfill facility". The facility is located inside the controlled area of the plant. The industrial waste disposal was stopped in 2014 with approximately 31 000 m^3 of the waste accumulated in two disposal locations.

At the time of disposal, the waste was considered as exempt waste. Due to changes in the regulatory requirements, including the radioactive waste classification system, a part of the waste was reclassified to a very low-level radioactive waste. Application of unconditional clearance levels revealed the necessity for regulatory control of the facility beyond the planned date of decommissioning of the Ignalina NPP – 2038.

As a possible option for the industrial waste management, the Ignalina NPP final decommissioning plan foresees the analysis and development of conditional clearance levels for the industrial waste landfill. Application of conditional clearance levels should allow conversion of the existing landfill to a conventional non-radioactive waste disposal facility and removal of nuclear regulatory control till the end of decommissioning of Ignalina NPP.

The presentation discuses conceptual aspects of the development of conditional clearance levels for the industrial waste disposal at Ignalina NPP:

- Radiation safety context and applied radiation protection requirements;
- Scenarios addressed, including scenarios for intentional intrusion into the facility.

Multiphysics simulation to support analysis of engineered materials in geological repository

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During the operation of every nuclear power plant or research reactor the radioactive waste is generated. Responsible use of nuclear energy requires to manage all resulting radioactive waste in safe manner to protect human and environment from ionizing radiation impact. For highly radioactive material such as spent nuclear fuel, vitrified waste deep disposal in geological formation is internationally accepted as safe and sustainable solution. At the end of 2021, Finish company Posiva Oy submitted the license application for the operation of the encapsulation and final disposal facility. In 2022, the Government of Sweden allowed SKB, the Swedish Nuclear Fuel and Waste Management Co., to construct a DGR for used nuclear fuel in Forsmark and an encapsulation plant in Oskarshamn. In France, the license application for the DGR construction was submitted for regulatory review in the beginning of 2023.

Geological repository is a multibarrier system which consists of a number of engineered and natural barriers. While developing repository design, selecting engineered barrier materials it is necessary to evaluate their performance in the long-term perspective. Barrier must be compatible with surrounding natural environment in order to fulfill safety function assigned to it. The evaluation of such performance under repository condition means the assessment of a large number of coupled processes physical-chemical origin. As these processes are interrelated and nonlinear, they cannot be evaluated separately. Each process could be described by partial differential equations, but the analytical solution of system of those partial differential equations under variable boundary conditions do not exist. However, with increasing computational power this could be solved with numerical models via different numerical schemes. COMSOL Multiphysics is a general-purpose platform for modeling a number of various processes and their applications. It contains conventional physics-based user interfaces, as well as interfaces for the definition of partial differential equations by the user. The defined system of partial differential equations is solved with the finite element method.

In this work using COMSOL Multiphysics we analyze the impact of engineered barriers (steel liner, cementitious filling material) impact on thermo-hydro-mechanical (THM) response of anisotropic clayrock under elevated temperature conditions. The processes being considered are thermal expansion, heat transfer, porewater flow, poroelastic behavior of porous media. Temperature dependencies of key parameters (viscosity, thermal expansion coefficient) are considered as well. Multiphysics simulations is a powerful tool to support analysis of engineered barriers and their performance in geological repository determined by complex coupled processes.

Keywords: radioactive waste, geological repository, thermos-hydro-mechanical behaviour, clayrock, modelling

Low and intermediate level aqueous radioactive waste treatment in a modular installation

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The Radioactive Waste Management Department (DMDR) from Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Romania has a wide experience in the management of the non-fuel cycle radioactive wastes from all over the country generated from nuclear and radiological techniques and technologies application, assuring the radiological safety and security of operators, population and environment. Treatment of radioactive liquid wastes is receiving considerable attention due to the recognition of its importance for the protection of human health and the environment from the adverse effect of radiation associated with these wastes. In addition to the radioactive components, LILW may contain non-radioactive components (such as, heavy metals and organics) that can result in harmful effects on human health and the environment. In some cases, radionuclides can exhibit chemical toxicity as well. In light of the above, DMDR applies technologies for treatment of these types of waste based on a combination of conventional methods as filtration and sorption with modern methods as ultrafiltration and reverse osmosis, which should provide not only maximal enlargement of the spectrum of radionuclides to be separated, but also to solve the problems associated with the effect of chemical composition of the wastes.

The paper describes the results obtain in the development of a treatment of aqueous radioactive waste technology that takes into account all safety aspects, IAEA principles, regulatory bodies requirements. Aqueous radioactive waste containing Co-60 (0.16 kBq/L), Cs-137 (0.35 kBq/L), U-235 (0.02 kBq/L), U-238 (0.3 kBq/L), Am-241 (0.03 kBq/L) and H-3 (1.6 MBq/L) and a conductivity around 1300 µS/cm was used to test treatment technology.

The modular design allows treatment units to be added or removed from technological flux quickly and efficiently to match actual requirements. This ability to scale a system up and down provides flexibility and cost efficiencies. Volume minimization of 500:1 for liquids and a decontamination factor up to 1000 were obtained.

Physico-chemical and radiochemical parameters of treated effluent meet the legal requirements for environmental release.

Keywords: aqueous radioactive waste, modular installation, minimization, decontamination

Microwave-assisted extraction of antioxidants from black locust flowers *(Robinia pseudoacacia flos)*

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In folk medicine, black locust *flowers* (*Robinia pseudoacacia flos*) are used to alleviate the symptoms of colds, fevers, migraines, and skin diseases. For the extraction of bioactive compounds from flowers, conventional extraction techniques are commonly used. They are increasingly being replaced by energy-efficient and economically sustainable extraction techniques. Among them, an ultrasound-assisted extraction is mostly used, while a microwave-assisted extraction is poorly described in the available literature. The aim of this study was to apply microwave-assisted extraction of antioxidants from black locust flowers. The effects of microwaves and solvent polarity on the total antioxidant content, mineral composition, and antioxidant activity of the extract were analyzed. The liquid-to-solid ratio of 10 mL/g was the same in all extractions. A microwave oven (Vivax MWO-2070 BL) with a constant radiation power of 462 W was used for the extraction. The extraction of antioxidants was modeled using kinetic models, such as Ponomaryov and non-stationary diffusion models. The parameters of the kinetic equations were determined by the least squares method. Based on the analysis of kinetic models, the extraction time of 90 s was chosen as the optimal value for the extraction of antioxidants. The total antioxidant content in black locust flower extracts was in the range of 0.75 – 1.84 g/100 g of dry weight. The analysis of the mineral composition showed that the black locust flower extracts are rich in potassium. The extracts are considered safe for use because the presence of heavy metals was not confirmed. The DPPH assay showed that the extracts have antioxidant activity, which depends on the solvent polarity.

Keywords: antioxidants, microwave-assisted extraction, antioxidant activity, modeling, kinetics.

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Zinc(II) complex with 4-ethynyl-2,2'-bipyridine: synthesis, characterization and DNA/BSA interactions

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Zinc, as one of the most abundant elements in an organism, plays an important role in biological systems, such as the synthesis of proteins and DNA. It has also been shown to be essential to stabilize the structure and thus the function of many enzymes [1]. Besides its essential role in the living systems, the zinc(II) ion is a constituent of compounds which have been used as antimicrobial agents, while zinc(II) complexes with aromatic nitrogen-containing heterocycles have shown good antifungal activity [2]. In the present study, we used 4-ethynyl-2,2'-bipyridine (ebpy) as a ligand for synthesis of a new zinc(II) complex, [Zn(ebpy)Cl_2]. The complex was characterized by NMR (^1H and ^{13}C), IR and UV-Vis spectroscopy, and its crystal structure was determined by single-crystal X-ray diffraction analysis. The interaction of [Zn(ebpy)Cl_2] with calf thymus DNA (ct-DNA) and bovine serum albumin (BSA) was investigated by fluorescence emission spectroscopy with aim to gain an insight on its behaviour towards these biologically important molecules.

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Radiation protection for children in preschool age – how to prepare kindergarten teachers to safeguard children's health

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The present theoretical formation consults about the problem of radio protection in the context of its significance for the educational scientific community and the well-being of preschool children. It appears a lack of pedagogical research on the relation between the nuclear safeguards requirements and the pedagogical training of kindergarten teachers. The contribution aims to underline the necessity for inclusion of knowledge on radio protection issues in order to add to the professional figure of future kindergarten teachers: conception about radiation, vulnerable parts of the human body and how radiation affects them, general competences of protective measures, awareness of nuclear power plants (NPP) perils near kindergartens, news about environmental monitoring, safety systems represent, etc. Through the scientific methods of theoretical analysis and theoretical synthesis, the article appeals to radiation protection experts to provide guidance on pedagogical approaches to specific knowledge, which should be included in the training of students in pedagogical specialties and to enrich the cognitive horizons of kindergarten teachers. Because they are responsible for the lives of children aged 3-6 during the majority of their daily time spent in the kindergarten. It is emphasized that there is an urgent need for the development of a modernized, aproved and updated pedagogic protocol or action plan in kindergartens to be implemented in the event of a nuclear accident. Based on their proficiency, the author also invite radiation protection specialists, to make an expert assessment of the minimum permitted distances between kindergartens and unsafe area and to present a common standard for the minimum suitable zones for the localization of children's facilities in an environment with a source of radioactive materials (reactors and waste repositories).

Supraorbital notch and supraorbital foramen of the skull: osteometric analysis and clinical significance

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Introduction: The supraorbital notch can be elongated with a bony extension and transformed into a supraorbital foramen. The supraorbital nerve provides sensory innervation of a relatively wide field of the forehead and head, so this nerve is the target site for conducting peripheral block anesthesia before maxillofacial interventions, as well as for therapeutic purposes in patients suffering from various types of headaches. Complications that can occur during surgical procedures of the periorbital and frontal region are excessive dissection and retraction of neurovascular structures, scars, neuropathy, and other pain syndromes.

The aim: To determine the incidence of a supraorbital foramen in the examined sample; to calculate the morphometric dimensions of the supraorbital foramen/notch and more precisely define their localization in relation to the surrounding bony structures.

Material and methods: The study analyzed 100 bony orbits that are photographed from the frontal aspect (*Olympussp-560uz*). The morphological analysis included inspection of the supraorbital edge and notation of the morphological forms: supraorbital notch or foramen, multiple and accessory openings, or their absence. Measurements of morphometric parameters of dimensions (vertical and horizontal diameter) and position of the foramen (in relation to the midline of the face, *fronto-malare temporale* anthropological point, and infraorbital foramen) were performed in the *ImageJ* program (version 150i).

Results: The incidence of supraorbital foramen was 11%. It was found bilaterally on 10 skulls. The average vertical diameter was 2.24 mm, and the horizontal 5.50 mm. The supraorbital foramen is 21.06 mm away from the midline of the face, and 23.26 mm from the *fronto-malare temporale* point. No statistically significant difference was found between the left and right orbits. The infraorbital foramen is most often localized in the level between the medial and lateral edges of the supraorbital opening (44%).

Conclusion: The supraorbital nerve is exposed to traumatic injuries, considering that it is placed superficially in the frontal region. Precise knowledge of the dimensions and position of the supraorbital foramen/notch and their anatomical variations is of clinical importance since it can contribute to the more precise and safer performance of surgical procedures in the frontal region.

Keywords: supraorbital foramen; morphometric analysis; the clinical significance

Flexible technologies for anti-counterfeit holographic metallic microparticles

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Products spread across a range of markets including clothing, coins/banknotes, fuels, automotive components, pharmaceuticals, and microelectronics are commonly replicated and thus, must be authenticated at any shipping and storage point from manufacturer to user [1]. Currently, most widely used anti-counterfeiting methods are based on reproducible large holographic tags produced by a deterministic process, for which low complexity and high predictability make it easy to copy.

To increase the security of a label, metal microparticles with anti-copying properties can be embedded into the structure of the holographic background.

To facilitate the authentication, the manufacturer has to mark the product with an anti-counterfeit label and a unique identification code obtained with the random distribution of specifically configured particles.

The authenticity is then systematically verified during the distribution process. When the tag is read for the first time, the corresponding non-reproducible security elements are digitized and stored in a secure external database under an identification code. The random distribution of metal microparticles, obtained by the non-deterministic process, ensures the uniqueness of the previously generated (digitized) code, which is impossible to reproduce even by the manufacturer. An ideal non-reproducible code should meet several requirements, such as structural integration with the physical tag, infinite encoding capacity, and low manufacturing cost [2].

This paper presents flexible and low-cost technologies required to fabricate anti-counterfeit holographic microparticles which are then embedded in a SMART holographic label along with a RFID element and temperature sensor to attest to authenticity, but also the transit/storage conditions for temperature sensitive pharmaceuticals/chemical product. The proposed security microparticles are complex structures having various shapes (e.g., hexagon, disc, square, etc.), and security codes engraved or etched on the surface/volume (e.g., holographic background - diffractive optical elements (DOE) arrays which create visual effects by diffracting the incident light, or micro-code.

Metal (nickel - Ni) microparticle manufacturing and separation technology includes low-cost adapted processes adapted low-cost processes such as: i) deposition of a photoresist layer; ii) exposure with a specific holographic equipment and development to obtain the holographic background; iii) deposition of a 50 nm Ag layer; iv) photolithography to configure the shape and micro-code (deposition of a second photoresist followed by exposure and development of to open the windows for selective Ni electroplating); v) Ni electroplating; vi) photoresist templates removal; and vii) final separation after Ag etching.

These simplified processes permit local electroplating through a photoresist pattern without mask corrections or chemical etching, making the fabrication of security holographic microparticles easy, fast, straightforward, and inexpensive.

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Lutetium endometallofullerenes: preparation and properties

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Due to its unique properties, fullerene is a promising object for introduction into the chemical and pharmaceutical industries. Endometallofullerenes (fullerenes with metal atoms inside the carbon frame) can be used in the development of new effective contrast materials for tomographic diagnostic methods, as well as in the production of radioactive labels and radiopharmaceuticals (radioactive isotopes), by activating the nuclei of heavy atoms inside the fullerene frame irradiated with neutrons or protons [1].

^{177}Lu is of the greatest interest among other EMFs with radioactive isotopes, due to its nuclear physical characteristics. In [2], on the example of cyclic polyaminophosphonates labeled ^{177}Lu, positive dynamics was found in the treatment of prostate cancer, since good radiotherapy effect is achieved in combination with a relatively low myelotoxicity. The radionuclide protected by a fullerene framework retains its nuclear-physical properties and does not have a toxic effect on the body [3].

The aim of this work was to search for improving the efficiency of the electric arc method parameters for obtaining EMF Lu and its further analysis.

In this study, the following materials were used to fill hollow graphite electrodes: lutetium oxide (Lu_2O_3) with powdered graphite and lutetium phthalocyanine pyrolyzate (LuC_{32}), Lu was taken from the natural isotope composition. The average Lu content in the prepared electrode is 1 at.%. Electric arc evaporation was carried out at currents from 130 to 180 A. As a result, fullerene-containing carbon black extracted with N, N-dimethylformamide was obtained with the addition of 0.2% (vol.) hydrazine hydrate [4]. The resulting extract was analyzed by IR spectroscopy methods, according to which absorption bands were recorded: 582, 630, 1090, 1459, 1652 and 1710 cm^{-1}, characteristic of fullerenes. Mass spectrometry was used to detect masses indicating the presence of Lu@C_{60}, Lu@C_{74}, Lu_2@C_{82} etc., and hollow C_{2n} fullerenes (where n = 30-61). It is established that the maximum performance can be achieved when using an electrode filled with Lu_2O_3 and powdered graphite at currents from 130 to 140 A. The results obtained are discussed.

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Importance of fire protection in the event of an emergency – PC NFS experience

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Public Company Nuclear Facilities of Serbia (hereinafter PC NFS) is the only nuclear operator in Serbia. It was founded in 2009 under the Law on Ionizing Radiation together with the Serbian Regulatory Body. Importance of drafting plans and procedures in the field of response to emergency situations and testing and simulations of various scenarios, is recognized by law/regulation, both domestic and foreign. Emergency caused by fire is one of the most expected scenarios and must be treated in systematic way.

This paper presents fire protection at PC NFS (establishment, routine maintenance, etc.) and how that systems are incorporated in emergency plans. Coherent treatment of nuclear safety and security has high importance in emergency management. In 2022 PC NFS has simulated emergency response caused by fire in the waste processing facility. All the best practices and lessons learned during preparation and simulations of that kind of emergency will be shown in this paper.

Work-related health disorders among computer users

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The use of computers and digital electronic devices, video display terminals, including e-mail, internet access and entertainment is almost universal in modern society. Computers have become key tools in virtually every aspect of work and learning, from managerial activities to document preparation and electronic communication. Unsafe use of computers can contribute to the health damage of exposed operators. The aim of this article is to examine the prevalence of health disorders and to estimate the work ability index among the computer users.A total of 152 computer users, aged 25-50 years, was devided in to two groups according to the length of computer work during the day. The group1 consisted of 82 computer users who work longer than four hours per day. The group 2 consisted of 70 computer users who work less than four hours per day. There was no statistically significant differences between these two examined groups in relation to the age (38,4±9,1 in group 1 vs.39,7±8,9 years in group 2) and the duration of occupation (15,9±4,8 vs.16,2±3,9 years) ($p>0,05$). Computer work duration in the group 1 (8,15 ± 1,12 hours/day; 42,11 ± 3,08 hours per week; 5,21 ± 0,08 working days per week) is significantly higher than in the group 2 (1,61 ± 0,42 hours/day; 8,91 ± 0,92 hours per week; 4,95 ± 0,09 working days per week)($p<0,0001$).Vision and musculoskeletal disorders, work-related symptoms and addiction to computers are statistically significant more common in the group 1 than in the group 2 of computer users ($p<0,0001$).The following types of visual disorders more often are presented in group 1 compared to group 2 : short-sighted (30,2% vs. 1,2%); long-sighted (12,6% vs. 0,6%); red eyes (10,9 % vs. 0,6 %); dry eyes (31,3 % vs. 10,5 %); changes in visualizing colours (11,5 % vs. 0,6 %) and pain around the eyes (29,1 % vs. 1,2 %) ($p<0,0001$).According to anatomical areas of the body, significantly more prevalence of musculoskeletal disorders are presented in group 1 compared to group 2: shoulder (46,1 % vs. 19,9 %); elbow (21,4 % vs. 1,16 %); wrist/hand (25,27 % vs. 1,75 %); upper back (11,53 % vs. 0,58 %); low back (57,1% vs. 19,8 %); neck (22,5 % vs. 1,75 %) and leg (14,3 % vs. 0,58 %)($p<0,0001$). Significantly more incidence of work-related general symptoms are presented in group 1 compared to group 2: headache (23,07 % vs.1,75 %); general body fatigue (35,1 % vs. 11,1 %); lack of concentration (13,73 % vs. 0,6 %) and sensitivity to light (14,8 % vs. 0,6 %) ($p<0,0001$). Addiction to computers are presented at 31(17,03%) computer users in group 1 which is significantly more than in group 2 (2,34 %) ($p<0,0001$). Unsafe ergonomic solutions, longer exposure time, addiction to computers, work related vision and musculosceletal disorders significantly reduce work ability of computer users. The factors associated with the degree of working ability reduction are the duration of occupation service, daily computer usage, unsafe ergonomics solutions and health disorder. The significant finding of this study is that those who had the work related symptoms, health disorders and reduced working ability are those who used computers for more than four hours per day.

Physical encryption-compression and decryption-decompression of data using the Fourier transform

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Data encoding and compression using Hadamard matrices has been known for some time. It is an elegant and simple way to send secret messages and even make the transmitted data compact, short. The input data is encoded by multiplying the data matrix with the Hadamard matrix, and if the input data contains many identical elements, the resulting matrix has many zero elements, therefore the information is compacted (or compressed). A useful aspect of the method is the possibility to use a Hadamard matrix with rows and columns permuted according to a secret key. In this way, not only is the message encrypted, but the cipher is also secret to the recipient and must be received separately. There is a major drawback with this method that the data to be encrypted must be available in an easily manipulated form, such as an array of ASCII characters or gray-level points. Hadamard encoding is a matrix multiplication and one must either calculate the multiplication by hand or enter the data into a computer to perform the multiplication. One way to avoid this problem is to use optical pattern recognition methods. Another, simpler way is to use ordinary Fourier optical instruments, such as lenses, as in Fig. 1. Except now, data encoding and compression is not done using the Hadamard transform, but a Fourier transform, which has less compression power. There is however the great advantage of physically encrypting the data instead of doing the manual or digital calculation. The input data can be a note, an image, a diagram, anything. It can come at a moment's notice and does not require any special training on the part of the operator. Real time coding can be done. It may, however, require that the message data be made available in a specific physical format independent of the message content. For example, it may need to be written on a transparency, to have certain dimensions and above all have a high contrast.

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o-Sulfonamidophenols and analogs as extractants for integrated actinide and cesium removal from alkaline high-level waste

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The nuclear arms race between the United States and former Soviet Union resulted in the generation of large volumes of alkaline High-Level Waste (HLW). The majority of this legacy waste is still stored in the US in underground tanks at the Savannah River Site (SRS) and the Hanford Site (HS). The environmental cleanup and decontamination of these sites concentrates on the generation of a stream of low activity waste (LAW) for saltstone disposal and high activity waste (HAW) for vitrification. The stored tank waste is comprised of three layers: (i) the high activity sludge, (ii) the saltcake, and (iii) the supernatant. The sludge and salt cake can directly be processed for vitrification and for saltstone disposal. However, for the liquid supernatant a two-step process is currently applied. The Actinide Removal Process (ARP), where Strontium and minor actinides are adsorped on monosodium titanate (MST), and the Next-Generation Caustic-Side Solvent Extraction Process (NG-CSSX), selectively separating Cesium, isolating the main contributors of the overall radiotoxicity. Development of NG-CSSX compatible f-element extractants could achieve a simultaneous separation of Cs and An in a single solvent extraction process, reducing the need for the expensive titanate sorbent in the slower ARP and contributing to a more efficient, faster and cost-effective reprocessing. In this regard, we identified *o*-aminophenol-derived sulfonamidophenols as promising chelators for f-elements and investigated their Sm(III) extraction performance from alkaline aqueous solutions. Initial studies showed remarkably high Sm(III) recovery values of > 90% at pH = 14 in dichloromethane. Encouraged by these results and to enable solubility in the NG-CSSX process solvent, we developed and now presenting highly lipophilic dodecyl substituted *o*-(monosulfonamido)-phenol based derivatives. Starting from commercially available, low cost materials we synthesized N-(5-(tert-butyl)-2-hydroxyphenyl)dodecane-1-sulfonamide (**msa1**) and N-(5-(tert-butyl)-2-hydroxyphenyl)-4-(dodecan-3-yl)benzenesulfonamide (**msa2**) in multigram scale. UV-Vis titrations of the deprotonated extractants showed strong binding towards Sm(III) (**msa1**: $\log b_{2:1}$ = 11.19 (+/- 0.46), **msa2**: K_{11}= 1.60 (±0.70) x 10^6 M^{-1}). Cold extraction experiments revealed consistent Sm(III) recoveries of around 30% for **msa1** and **msa2**, after only a single extraction/stripping cycle, using a formulated NG-CSSX simulant from up to 2.5 M NaOH. Extraction experiments in the presence of the most prevalent HLW salts [Na^+ (5.1 M), K^+ (45 mM), NO_2^- (0.5 M), NO_3^- (2.0 M), CO_3^{2-} (0.15 M), SO_4^{2-} (0.14 M)] showed for **msa1** robust Sm(III) recovery of 31.3 (+/- 0.5)% at 2 M NaOH concentrations. Finally we tested the combined Cs(I)/Sm(III) extraction and recovery with the actual NG-CSSX solvent obtaining comparable results to the prior applied simulant (**msa1**: Sm(III) = 30.4 (+/-3.7)%, Cs(I)= 17.1 (+/-2.7)% **msa2**: Sm(III)= 27.1 (+/- 4.5)%, Cs(I)= 15.8 (+/- 3.3). Consequently, both extractants are currently tested at SRNL for their radiolytic stability and extraction capability using an HLW simulant (Sr-90, Cs-137, Eu-154, Pu-239, Am-241). Our progress and recent results will be presented.

Dentition in the identification of human remains

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This presentation will explore the value of dentition in terms of detection and identification of human remains.

Dental remains may comprise of a skull, full mandible or individual teeth. The composition of teeth means that they are usually preserved when in the ground, however the extent of this depends upon a variety of factors which will be explored in the presentation.

Teeth are generally comprised of a mixture of hard and soft material which includes enamel, dentin, and cementum. As a result research suggests that teeth can be well preserved in the ground for many years.

This presentation will initially focus upon the use of canines in the detection of human dental remains. The first part of the presentation will explore the detection of human dental remains in a rural setting and will include details of the process used to find the remains.

The second part of the presentation will explore the identification of dental remains using Radiographic imaging and its value.

Managing the nuclear safety/security interface at the public company "Nuclear Facilities of Serbia"

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The overall performance of the nuclear facility may be affected if interfaces between nuclear safety and security are not properly managed. Public Company Nuclear Facilities of Serbia (hereinafter PC NFS), as a nuclear operator, has recognized the importance of identifying interfaces between nuclear safety and security and importance of the properly addressing and managing those interfaces in a timely way. If the management of the nuclear safety and security interfaces is not considered in a systematic manner, the overall goal of maximizing performance while optimizing protection during routine operation and reducing the risk of harm to people, property, and the environment from accidents and security events will not be achieved.

This paper will present how the nuclear safety/security interfaces have been identified at all levels (requirements, physical, procedural) at PC NFS and also how those interfaces have been addressed at all layers of the organization (strategic, operational, and personal). It will be shown how to harmonize different perspectives of nuclear safety and security and prioritize the same aim, to protect human lives and health and the environment during routine operations and during safety and security events. All the best practices (training, joint exercises, discussions, etc.) and lessons learned at PCNFS will be presented.

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Science and art in the development of human progress

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Introduction: Since its appearance on the earth, the human species has been characterized by a continuous yearning for discovering nature and its phenomena, but also by an ability to represent itself, and the world in which it was living, in many ways that allowed to hand down the memory of its existence [1]. Humanity has expressed its progress in very different ways, which despite the variety of its manifestations, nonetheless suggest a common plot. In particular, a parallel between artistic creation and scientific discovery can be drawn, between the artist's representation of reality and the description of nature given by the scientist [2].

Perspective and Galilean relativity: Between 14th and 15th century, in the turn from medieval to modern painting, while maintaining the subject of the image of sacred inspiration, a new approach emerged to describe the contour. Firstly perspective was introduced by Brunelleschi, and the method was later described in Leon Battista Alberti's treatise De Pictura (1434-1436): precise rules are given for the representation of the subject surroundings: the artist must guide the observer to see the background as it really appears, so that everyone receives the same description. Nearly two centuries later Galileo laid the foundations of the scientific method, one its fundamental elements being the invariance of the physics laws for inertial observers. A parallel can be cast: in both cases perception is independent of the observer: all observers of the painting must have the same vision of the subject surroundings and all (inertial) observers of a physical phenomenon must verify the same laws.

Impressionism and quantum mechanics: A couple of centuries later, another change of point of view took place both in art and in physics. The quantum revolution lead to Einstein's explanation of the photoelectric effect, i.e. the electromagnetic radiation may be revealed both as a wave and as a particle, depending on how the observer interacts with it:, the observation now depends on the observer. But twenty years before the classical physics crisis, a strong change in art happened, with the birth of Impressionism: the artist tries to reproduce his personal optical sensation with the greatest possible fidelity, avoiding any References to the ideal construction of reality; this in turn has the effect that the perception of the work by the observer strongly depends on the sensations that the painting produces in him, which evidently differ for each observer. Once again we find a parallelism between art and science: now the observation is a result of an interaction between the observer and the observed.

Pollock's fractals: A quite notable and quantitative example of this parallel development of art and science is represented by the paintings by Jackson Pollock, who intended to "deal with the rhythms of nature". It has been demonstrated that Pollock's paintings are fractals, and fractal geometry, which was discovered only 20 years after Pollock's death, is the best possible description of nature.

Conclusion: It is possible to find a parallel vision between the artist's representation of reality and the description of nature given by the scientist; furthermore the intuition of the artist, who has a much greater speed of expression than that inherent in scientific research, is able to show in advance the direction in which the evolution of thought is heading.

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