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JUNE 17-21, 2024 | HUNGUEST HOTEL SUN RESORT, HERCEG NOVI, MONTENEGRO

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Laser-driven ion beams and applications: status of the ELI-Beamlines (Czech Republic) and I-LUCE (Italy) facilities

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The laser-driven ion acceleration community aims to enhance particle beam characteristics, such as maximum energy, particle charge, and beam divergence, while developing reliable methods for diverse applications. In this work, we detail the status of the ELIMED/ELIMAIA beamline and the I-LUCE facility, highlighting their advancements and contributions to the field of laser-driven ion acceleration.

ELIMAIA, a specialized ion acceleration facility at ELI-Beamlines in the Czech Republic, harnesses advanced laser capabilities to deliver stable, characterized beams of particles accelerated by high-power lasers. Named ELIMED, this facility focuses on ion beam control, characterization, and irradiation for interdisciplinary research. ELIMED enables precise delivery of high-dose-rate proton and ion beams (up to Gy/min) with energies spanning 5 to 250 MeV. Within ELIMED, the ion collection and focusing subsystem employs permanent magnet quadrupoles (PMQs) to collimate the ion beam and reduce its initial high divergence. These PMQs are essential for achieving focused ion beams on both transversal planes and for optimizing compatibility with subsequent selection systems. ELIMED incorporates an advanced dosimetry system crucial for accurate evaluation of ion dose. It includes a Secondary Electron Monitoring (SEM) system, a Multi-Gaps Ionization Chamber (MGIC), and a Faraday Cup (FC) for absolute dosimetry. These devices ensure reliable and independent dosimetric assessment with an error rate below 5%. Moreover, passive detectors like CR39 and radiochromic films (RCF) complement the active ion diagnostic and dosimetry tools, providing benchmarking and validation for comprehensive beam characterization.

Concurrently, in 2024, the INFN-LNS in Italy will establish the "I-LUCE" facility, funded by Italy's PNRR program. This facility will feature a high-power Ti: sapphire laser with two outputs: a 50 TW beam line (25 fs, 25-30 mJ, 10 Hz) and a 350 TW main beam line (25 fs, 10 J, 2 Hz). I-LUCE will include two distinct experimental areas, E1 and E2. E1 will provide a unique setup combining laser-generated plasmas with accelerated heavy ion beams from a Superconducting Cyclotron and a Tandem, facilitating pioneering experiments in plasma, nuclear, and atomic physics, including nuclear fusion and stopping power studies in plasma. The E2 experimental room will specialize in proton and electron acceleration, with a specialized beamline to select, transport, and focus proton beams ranging from 5-60 MeV for radiobiological experiments. The acceleration method achievable using the I-LUCE laser system is known as target normal sheath acceleration (TNSA). It is widely recognized as one of the extensively studied and well-established techniques for laser-driven ion acceleration in current research. The TNSA regime will be accomplished by directing the I-LUCE laser onto a micro-metric thick target placed within the interaction chamber, using a specialized target positioning system known as the Target Tower (TT).

Novel applications of progeny of Radium-226 as tracers and chronometer to evaluate global climate change: A review

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Disequilibria between long-lived parents and short-lived particle-reactive daughters in the ^{238}U-series radionuclides have been extensively used over the past six decades as tracers and chronometers in Earth's subsystems. In particular, ^{226}Ra along with its progeny (^{210}Po, half-life, $T_{1/2}$ = 138.4 days and ^{210}Pb, $T_{1/2}$ = 22.3 years, ^{222}Rn, $T_{1/2}$ = 3.82 days) have been widely utilized to determine the residence time of atmospheric aerosols, dating of sediment, mollusks, otoliths, speleothem, bridge stone, ice core, and melt-pond, as well as biogeochemical changes in Earth's subsystems. These radionuclides also serve as a tracer for stable Pb and as analogs for key micro- and macro-nutrient and lithogenic elements such as N, P, Cu, Zn, Fe, Al, Th, etc. In this presentation, the historical evolution of the utility of ^{210}Pb as the second-most widely used geochronometer (after ^{14}C) will be presented. The use of the ^{210}Pb/^{226}Ra ratio to determine the residence time of lead released from the combustion of leaded gasoline and its impact on the geochemical cycling of lead and radium in the deep ocean will be demonstrated. The disequilibrium between ^{210}Po and ^{210}Pb in particulate, dissolved and total (= particulate + dissolved) phases for the global oceans will be evaluated. Dating of melt ponds, ice core, ice-rafted sediment, and aerosols in the Arctic using ^{210}Po/^{210}Pb activity ratios has been successfully employed and a summary of the results will be discussed. The global atmospheric ^{210}Pb fallout curve based on published fallout data will be contrasted with the ^{210}Pb activity in the global surface oceans. Some of the anomalous finding on the radon storm and its implications on the regional atmospheric ^{210}Pb fallout and surface water concentrations of ^{210}Pb will be presented.

Isolation of resistance genes to yellow disease barley complex

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The Potyviridae are the largest family of plant-pathogenic viruses. Members of this family are the soil-borne bymoviruses Barley yellow mosaic virus (BaYMV) and Barley mild mosaic virus (BaMMV) which, upon infection of young winter barley seedlings in autumn, can cause yield losses as high as 50%. Resistance breeding plays a major role in coping with these pathogens. The Eukaryotic Translation Initiation Factor 4E (EIF4E) is a well-known susceptibility gene for potyvirus infections in many plant species. Its resistance-conferring alleles are widely used in winter barley breeding, but new virus strains have overcome these resistances. Thus, there is a need for novel sources of resistance. In ancient landraces and wild relatives of cultivated barley, alleles of the susceptibility factor Protein Disulfide-Isomerase-Like 5-1 (PDIL5-1) were identified to confer resistance to all known strains of BaYMV and BaMMV in Europe.

During isolation of further two resistance genes rym13 and rym15 KASP assays were developed based on functional SNPs from candidate genes that are under targeted mutagenesis at project partner from IPK were used for genotyping of the diagnostic set. The diagnostic set consisting of 130 genotypes with known reaction to both viruses BaMMV and BaYMV was designed to test the power of differentiation of molecular markets from isolated and characterized resistance genes to these viruses. Alleles of resistant genotypes from the East Asia from the set showed presence of the same allelles. At the same time, presence of same alleles at local landrace MBR530 and MBR532 from Montenegro indicated a simultaneous bi-phyletic origin of both resistance gene. These KASP markers could be used in direct transfer of rym13 and rym15 resistance genes in elite barley cultivars.

Fatty acid enzyme activities and risk of diabetes mellitus

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The prevalence of diabetes mellitus, especially of Type 2 diabetes (T2D) is high worldwide and there is a constant challenge to find potential biomarkers that might predict the onset diabetes and provide insight into possible mechanisms for its development. Previous data showed that free fatty acids (FFA) concentrations in plasma and FFA composition demonstrate an association with incident of diabetes. Recent studies suggest that both depend on many factors such as age, gender, ethnicity, endogenous synthesis of FFAs, dietary habits, but also genetic predisposition and gene-gene interaction as well as gene-diet interaction. The purpose of this research was to evaluate the association between the activity of different fatty acid enzymes and incident of diabetes.

In 205 individuals (aged 30-70 years, both gender) of which 54 T2D patients, 44 PREDM patients, 24 NT-T2D patients and 81 healthy controls, delta 6 desaturase (D6D), delta 5 desaturase (D5D), stearoyl CoA-desaturase-1/2 (SCD-1/2) and elongase (ELOVL) activity were estimated at baseline by plasma FFA ratios (D6D=C18:3n-6/C18:2n-6; D5D=C20:4n-6/C20:3n-6; SCD-1=C16:1n-7/C16:0 and SCD-2=C18:1n-9/C18:0; and ELOVL=C18:1n-7/C16:1n-7, respectively). The clinical parameters were measured including fasting plasma glucose (FPG), glycated hemoglobin (HbA1c), and lipid profile by IFCC methods while the concentrations of individual FFAs were determined by gas chromatography-mass spectrometry.

Genetic predisposition to higher plasma concentrations of nine FFAs were statistically significantly associated with lower or higher risk of T2D, fasting glucose levels and HOMA-IR (C12:0 0.347, p=0.031; C16:0 0.221, p=0.008; C18:0 0.232, p=0.005; C18:2 0.171, p=0.042; C18:3 -0.540, p=0.000; C20:0 -0.544, p=0.001; C20:4 0.550, p=0.001; C22:0 -0.401, p=0.014; C22:5 -0.642, p=0.033; HOMA-IR 0.553, p=0.008, respectively). The six of FFAs were also associated with D6D, D5D, SCD-1/2, and elongase activity (C14:0, $p<0.001$; C14:1, $p<0.01$; C16:1, $p<0.001$; C18:0, $p<0.001$; C18:2, $p<0.05$; and C20:4, $p<0.05$, respectively). The association were driven by variants in D6D and D5D encoded by the FADS1 and FADS2, SCD genes as well as various fatty acid elongases encoded by different ELOVL genes.

These findings suggest that estimate of D6D, D5D, SCD-1/2, and ELOVL activity, particular estimation of D6D, SCD-1 and ELOVL have strong association with incident diabetes. Also, including known risk factors for T2D, obtained results support possible roles for these fatty acid enzymes and different types of FFAs, particularly C16:0, C16:1, C18:0, and C18:1 as main fatty acid in de novo lipogenesis, in the development of diabetes mellitus in humans, and represent potential biomarkers for diagnosis and individual therapeutically treatment in Type 2 diabetes patients.

Effect of dexketoprofen on hematological parameters of *Rattus norvegicus* (Berkenhout, 1769)

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Dexketoprofen is a non-steroidal anti-inflammatory drug, and it works by blocking the action of cyclooxygenase (COX) enzymes. Since in large quantities dexketoprofen can cause various toxic damages, it has become the subject of many studies, both at the hematological and biochemical levels. The main goal of this research was to examine the influence of the non-steroidal anti-inflammatory drug dexketoprofen on the hematological parameters of *Rattus norvegicus*. These hematological parameters are: number of erythrocytes and leukocytes, hematocrit values, hemoglobin concentration and hematological index values. The application of dexketoprofen in a concentration of 0.032 mg/180 g to ten individuals of the *Rattus norvegicus* species for five days led to changes in hematological parameters. The obtained results of erythrograms in individuals of the species *Rattus norvegicus* (Berkenhout, 1769) exposed to dexketoprofen in a dose of 0.032mg/180g of body weight, show that this dose of dexketoprofen in the experimental group leads to a reduced number of erythrocytes, causes an increase in the value of hemoglobin, and also leads to a change in the value of hematological of the MCH index. However, the same dose of dexketoprofen in all five individuals of the species *Rattus norvegicus* (Berkenhout, 1769) of the experimental group leads to a decrease in the hematocrit value, and consequently leads to disturbed values of the hematological indices MCV and MCHC.

Ferredoxin: NADP+ oxidoreductases as the sources of free radicals of redox active xenobiotics and drugs

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Ferredoxin:NADP$^+$ reductases (FNRs) contain flavin adenine dinucleotide (FAD) in their active center, and transfer redox equivalents between NADP(H) and the low redox potential FeS proteins ferredoxins or low m.w. low potential flavoproteins flavodoxins. FNRs are found in variety of microorganisms and perform various functions, ranging from photosynthesis to cell wall biosynthesis. In addition, FNRs reduce various redox active xenobiotics and drugs (quinones, aromatic nitrocompounds and *N*-oxides) in a dominant single-electron way into their radicals. These reactions may be responsible for the antibacterial, antiparasitic and pesticidal effects of the above compounds. Our previous [1-4] and ongoing research on various FNRs in this direction can be summarized as follows:

- FNRs reduce nitroaromatic compounds in a single-electron way. Quinones can be reduced in a single-electron way (*Anabaena* PCC7118, *Plasmodium falciparum* FNR) or a mixed way with 54-18% single-electron flux (*Rhodopseudomonas palustris* and *Bacillus subtilis* FNR).

-The reactivity of Q, $ArNO_2$, and ArN-O is not structure-specific, since the log of their bimolecular reduction rate constants increases with increasing one-electron reduction potential of the compounds (E^1_7). However, the reactivity of Q and ArN-O is systematically one order of magnitude higher than that of $ArNO_2$. According to the 'outer-sphere' electron transfer theory (references are given in [1-3]), this is associated with a two orders of magnitude lower rate constant for internal electron exchange in $ArNO_2$.

- The limiting reaction step is the reoxidation of FAD semiquinone (FADH·), and the reoxidation of 2e-reduced FAD can occur up to 40 times faster [2].

- The reactivity of neutral oxidants is insensitive to ionic strength, but in the case of charged oxidants, a bell-shaped dependence of reactivity on ionic strength is often observed. This indicates that there are both electrostatic and hydrophobic interactions between them and FNRs.

- Based on the 'outer-sphere' electron transfer model [1-4], electron transfer distances were calculated using the following E_7(FAD/FADH·) values of FNRs: -0.280 V (*Anabaena* PCC7118), -0.308 - -0.337 V (*P. falciparum*), -0.285 V (*Rps. palustris*), and -0.228 V (*B. subtilis*). For quinones and nitroaromatics, they were equal to 4.4-5.0 Å (*Anabaena* FNR), 4.9-5.6 Å (*P. falciparum* FNR), 5.2-5.4 Å (*Rps. palustris* FNR), and 3.8-4.2 Å (*B. subtilis* FNR). This indicates that despite the contact of the FAD dimethylbenzene ring with the solvent, the electron transfer distance sometimes exceeds the optimal value, ~3.5 Å. This can be linked to a deviation from the one-electron transfer model, with concomitant proton dissociation during the oxidation of FADH·.

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Metabolic rate changes of the long-tailed ground squirrel *Urocitellus undulatus* in preparation for hiberation

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Previously, it was shown that long-tailed ground squirrel *Urocitellus undulatus* undergoes several physiological and biochemical changes in blood, brain and bone marrow, heart and skeletal muscles already in autumn (pre-hibernation) [1]. No such data have been obtained on changes in metabolic rate, although this is an important marker of the transition of heteroterm organisms to another level of vital activity. The purpose of this study was to compare metabolic indices during summer and autumn in long-tailed ground squirrels.

Methods: Ground squirrels *Urocitellus undulatus* of both sexes of the same group of animals (n = 7) in the states of: "summer" and "autumn" activity were used. Animal care was performed according to the guidelines established by the European Council Directive 2010/63/EU and in accordance with the “Regulations for Studies with Experimental Animals” (Decree of the Russian Ministry of Health of 12 August 1997, No. 755). The measurement of metabolism was performed with a MM-100 metabolic monitor system (CWE Inc., USA). The parameters that were determined include oxygen consumption (O_2, ml/kg/h), carbon dioxide emission (CO_2, ml/kg/h), respiratory exchange ratio (RER) and heat release (Heat, kcal/kg/h). In addition, blood levels of the thyroid hormone thyroxine (T4) in free form, which plays an important role in regulating energy metabolism in the body, were monitored. Serum free thyroxine concentrations were measured (n = 5 per group) using commercially available ELISA kit (ImmunoFA-fT3 IF-01-08; Immunotech, Russia) according to the manufacturer’s instructions. The absorbance was read at a wavelength of 450 nm with a Multiskan FC microplate reader (Thermo Fisher Scientific Inc., USA).

Results: All metabolic indices were found to increase (O_2, CO_2, RER и Heat) by 30-75% in ground squirrels in autumn. In addition, during the autumn preparation for hibernation, more than 2.5-fold increase in blood levels of the hormone T4 was recorded.

Conclusion: Thus, the decrease of metabolism from summer activity to the state of torpor (hypometabolism) in obligate hibernators *Urocitellus undulatus* does not occur linearly, but through the phase of intensification of metabolic processes in the preparatory autumn period. This phenomenon can be explained, in particular, by the increased synthesis of new blood cells (leukocytes and platelets) for subsequent marginalization in organs (intestine, liver, lymph nodes, etc.) during the torpor period, as well as by other synthetic processes occurring in autumn [1,2]. The hormone thyroxine regulates the rate of basal metabolism, tissue growth, and macronutrient metabolism and reflects the function of the thyroid gland, which also appears to increase in activity in heterothermic ground squirrels in autumn. Research in this direction is needed throughout the annual cycle of animals.

Keywords: ground squirrel, hibernation, metabolism

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Effects of IGF-1 on the IGFB proteins level in the serum of obese male rats

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Insulin-like growth factor binding (IGFB) proteins are a group of six highly conserved proteins that bind to insulin-like growth factors (IGFs) and transport them through the bloodstream to the target cells. The IGFB proteins play an important role in regulating IGF signaling pathways by lengthening their half-life. Obesity and associated disorders are linked to abnormal levels of IGFB proteins. Thus, this study aimed to evaluate how IGF-1 affects the levels of IGFB proteins in the serum of obese rats.

Methods: For 12 weeks, male Wistar rats were fed either a standard laboratory diet or a high fat (HF) diet (42% fat), and then half of the animals were given one dose of IGF-1 (50 g/kg.i.p.). The serum was collected after 24 hours of treatment. The levels of IGFB-1, IGFB-2, and IGFB-3 proteins in rat serum were determined using the western blot method.

Results: Obese rats had lower IGFB-1 ($p<0.05$) and IGFB-2 protein ($p<0.05$). IGF-1 increased the protein level of IGFB-1 ($p<0.001$) and slightly elevated the protein level of IGFB-2 ($p=0.06$) in obese rats. There were no significant changes in IGFB-3 protein levels in obese or obese rats treated with IGF-1.

Conclusion: The findings suggest that IGF-1 positively affects the levels of IGFB-1 and IGFB-2 proteins in the serum of obese rats.

Polyamine metabolizing enzyme activities in testicular tissue of rats exposed to microwave radiation

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Mobile phones have become omnipresent in everyday life. In adolescents, the occurrence of testicular tumors is found to be associated with exposure to microwave radiation arriving from mobile phones. Cells that enter the division process (proliferation) require polyamines, i.e., spermine, spermidine, and putrescine, which are controlled by polyamine oxidase (PAO) and diamine oxidase (DAO). This study aims to evaluate testicular tissue polyamine levels in rats after exposure to microwave radiation for 20, 40, and 60 days. Male Wistar rats were exposed to microwave radiation from mobile phone model Nokia 3110 (Nokia Mobile Phones Ltd.) connected to a communication Test Set PCDK with PC and appropriate software module for 4 hours/day for 60 days. After each time period, 6 animals from the experimental and 6 animals from the control group were sacrificed, and testicular tissue was removed and used for the polyamine content determination. Exposure of rats to microwave radiation led to a statistically significant increase in testicular PAO activity compared to the activity of this enzyme in the tissue of animals belonging to the control group. Also, in the experimental group of rats, testicular tissue DAO activity was found to be statistically significantly increased when compared to the DAO activity in the control group. These data indicate that microwave radiation significantly potentiates polyamine metabolism in the rat testicular tissue.

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Effects of *Tricoderma* spp. on secondary metabolism of tomato plants under drought conditions

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Trichoderma species are cosmopolitan soil and rhizosphere inhabiting fungi providing various advantages in agriculture. During *Trichoderma* - plants interaction, *Trichoderma* can positively impact the plant by enhancing nutrient absorption, promoting biomass growth, improving tolerance to abiotic and biotic stresses, and elevating germination rates.

Tomato plants (cv. Gružanski zlatni) were sown in substrate and grown in pots under controlled conditions of the plant phenotyping platform. The plants were subjected to two water availability levels: well-watered (70%) and drought (15%). The second factor was treatment with *T. harzianum* and *T. brevicompactum*. To investigate the effect of *Trichoderma* spp. on secondary metabolites in tomato leaf, quantification of ABA and 12 phenolic compounds was performed using the LC-MS-MS technique. The chlorophyll index and anthocyanin index were determined through hyperspectral analysis of the phenotyping platform.

The treatment with *T. harzianum* increased the content of sinapic, p-OH-benzoic, caffeic acids, luteolin-7-O-glucoside, and ABA in optimally watered plants. However, in the same treatment there is a decrease in the content of kaempferol-3-O-glucoside, quinic acid and 5-O-caffeoyl-quinic acid. Effects of T. *brevicompactum* are unlike *T. harzianum* were significant on the impact of plants that were exposed to drought. In the treatment with *T. brevicompactum* in plants subjected to water deficit as well as in the treatment of drought, there was an increase in the content of syringic, p-OH-benzoic, ferulic, sinapic and caffeic acids. Additionally, under the same watering regime, *T. brevicompactum* increased the content of luteolin-7-O-glucoside, esculetin, and ABA. On the other hand, individually observed drought and *T. brevicompactum* in the aforementioned watering regime had an inhibitory effect on the content of kaempferol-3-O-glucoside as well as on the content of quinic and 5-O-caffeoyl-quinic acids. In the treatment with *T. harzianum* and *T. brevicompactum*, the tomato plant exhibited significant changes in the content of chlorophyll and anthocyanin in the leaves, indicating the activation of the plants secondary metabolism. The results of this research show that the tolerance of tomato plants to drought as well as interactions with *Trichoderma* are significantly correlated with the phenylpropanoid pathway. These findings highlight the interdependence and complexity of secondary metabolites involved in plant response to drought stress and interaction with *Trichoderma*.

Biocontrol efficiency and peptaibol profiles of selected *Trichoderma* species

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Fungi of the genus *Trichoderma* are cosmopolitan species present in different ecosystems, with important ecological and biological roles. Beneficial effects of these fungi are responsible for their use in various fields of biotechnology and agriculture.

Objectives: Main aim of this study was to analyze the antagonistic potential of selected *Trichoderma* strains and the peptaibol profiles of these strains in order to investigate the role of peptaibols in the antagonistic effect of *Trichoderma* species.

Methods: *Trichoderma*–plant pathogen combinations were used for direct dual interaction assays. Five strains belonging to *Trichoderma* species (*T. harzianum* SZMC 22660, *T. virens* SZMC 22659, *T. brevicompactum* SZMC 22661, *T. longibrachiatum* SZMC 22664 and *T. citrinoviride* SZMC 22668) previously isolated from Serbian soils and four strains of plant pathogenic fungi (*Fusarium solani, Rhizoctonia solani, Alternaria alternata* and *Phoma cucurbitacearum*) were selected from the Szeged Microbiology Collection (SzMC; www.szmc.hu). *Trichoderma* strains with good *in vitro* antagonistic activities against the tested plant pathogenic fungi were selected for the extraction of peptaibols and elucidation of their amino acid sequences by HPLC/MS.

Results: The Biocontrol Index (BCI) values calculated based on the images taken from the confronted cultures was similar for all tested strains with BCI values from 56.22% to 100%. The results of this study indicate that the peptaibols produced by different *Trichoderma* strains are potential growth inhibitors of mycelia of plant pathogenic fungi, therefore, their contribution to the antagonistic properties against phytopathogens causing negative effects on plants can be suggested.

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Sexual dimorphism in shape and size of viscerocranium

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The development of effective methods for sex estimation depends on the level of sexual dimorphism expressed in a definite structure. The aim of the present study was to investigate sexual dimorphism in shape and size of viscerocranium using geometric morphometric approaches. The sample included 340 computed tomography (CT) images of adult individuals (156 males and 184 females), which were generated using a Toshiba Aquilion 64 CT system. Polygonal surface models of the skulls were segmented from the CT images. The three-dimensional coordinates of 31 landmarks describing the viscerocranium were recorded on the polygonal skull models. Generalized Procrustes superimposition was applied to the raw landmark configurations. The sex differences in size and shape of the viscerocranium were tested for statistical significance. Principal component analysis was carried out to analyze shape variability in the sample. Discriminant analysis was performed to evaluate the sex classification accuracy based on the separate data for size and shape of the viscerocranium. Significant differences were established in size and shape of the viscerocranium. The combined size and shape data provided higher classification accuracy compared to the separate data characterizing either size or shape of this part of the skull. **Acknowledgement:** The study was funded by the Bulgarian National Science Fund, Grant number КП-06-Н51/4–11.11.2021.

A geometric morphometric study on the pelvic inlet using CT scans

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The pelvic inlet (superior pelvic aperture) defines the boundary between the pelvic and the abdominal cavity. The shape of its contour is among the numerous pelvic traits showing differences between males and females. The present study aimed to evaluate the sex differences in shape and size of the pelvic inlet using the geometric morphometric approach. Abdominal CT scans of 280 adult Bulgarians (137 males and 143 females) generated by a Toshiba Aquilion64 CT system were used in the study. The three-dimensional coordinates of 13 landmarks located on the pelvic inlet contour were acquired. The raw landmark configurations were transformed using Generalized Procrustes superimposition. The sex differences in size and shape of the pelvic inlet were tested for statistical significance. Principal component analysis was used to analyze the variability in the pelvic inlet shape. Discriminant analysis was performed to evaluate the classification ability of the size and shape of the pelvic inlet to distinguish the male and female pelves. The size of the pelvic inlet was significantly bigger in females than in males. Significant sex differences were also observed in the inlet shape which was hearth-shaped in males and more rounded in females due to the position of the largest transversal diameter and the protrusion of the promontorium. The shape of the pelvic inlet achieved a sex discrimination accuracy of 89%, which was much higher than the accuracy based on the size data (around 65%). **Acknowledgement:** The study was supported by the Bulgarian National Science Fund, Grant number КП-06-Н51/4–11.11.2021.

Orthopoxvirus infection does not induce maturation of mouse FLT3L-derived dendritic cells

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Ectromelia virus (ECTV) and vaccinia virus (VACV) are DNA viruses, that belong to the genus *Orthopoxvirus* from the *Poxviridae* family. The genus *Orthopoxvirus* also includes the variola virus (VARV), which causes smallpox in humans. ECTV is the causative agent of mousepox, while VACV was used to vaccinate Edward Jenner against smallpox in the 18th century. Both viruses provide a suitable model for studying the immunobiology of orthopoxviruses. Dendritic cells (DCs) are professional antigen-presenting cells (APCs) whose function is to control the pericellular environment, capture antigens, and present them to T lymphocytes in secondary lymphoid organs. DCs as APCs determine the induction of the immune response as well as being involved in the induction of immune tolerance. DCs are divided into two main populations - conventional DCs (cDCs), which are mainly involved in antigen presentation, and plasmacytoid DCs (pDCs), which have a relatively minor role as APCs and are mainly involved in the production of type I interferons (IFN-I). DCs, upon recognition of the infectious agent, undergo a maturation process that is necessary for the stimulation of the immune response. During maturation, expression of major histocompatibility complex class II (MHC II), costimulatory molecules (CD) such as CD80, CD 86, and chemokine receptors increase on the surface of DCs, which enhances DC migration to lymphoid organs. Since DC maturation underlies the immunoregulatory functions of DCs, we evaluated how ECTV and VACV infection affect the maturation of FLT3L-derived dendritic cells.

For this purpose, primary cultures of mouse tyrosine-protein kinase ligand (FLT3L)-derived dendritic cells (DCs) were used in the experiments properly. FLT3L controls DC development and is particularly important for pDCs and cDCs (cDC1 and cDC2). Cells were infected with ECTV strain Moscow and VACV strain Western Reserve at MOI=1 and stimulated with LPS as a control for cell maturity. At 18 hours of infection, cytometric analysis was performed to determine cell maturity. DCs were stained with the following mAb: anti-MHC II-PerCP-Cy5.5, anti-CD80-APC, anti-CD86-BV711, anti-CD11c-BV421, anti-CD11b-BV605, anti-XCR1-BV786 and anti-Sirp1α-PE.

Our results show that DCs ($CD11c^+$, $XCR1^+$, $Sirp1\alpha^+$, $CD11b^+$) were unable to fully mature after infection with ECTV and VACV. For this purpose, the levels of MHC II molecules and CD80 and CD86 were analyzed in control DCs and cells treated with ECTV, VACV, LPS, or ECTV+LPS and VACV+LPS after an 18-hour exposure. In ECTV-infected or VACV-infected cells, the MFI for MHC II decreased significantly and the MFI for CD86 and CD80 did not change significantly compared to uninfected control cells. Treatment of uninfected cells with LPS for 18 hours induced cell maturation, as the MFI for all analyzed markers increased significantly on the surface of DCs compared to control cells. ECTV-infected and VACV-infected cells and stimulated with LPS were not able to increase the expression of MHC II molecules to the levels observed in cells treated with only LPS, while CD80 expression did not change significantly and CD86 expression increased compared to cells treated with only LPS.

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Investigation of the radio-sensitizing effect of cyclin dependent kinase 4/6 (CDK4/6) inhibitors in glioblastoma cell line

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In the clinic, CDK4/6 inhibitors are successfully used to treat certain subtypes of breast cancer and various other tumours (lung, head and neck, bladder cancer, certain sarcomas). Preclinical results are also promising in the therapy of glioblastoma. The aim of our experiments is to investigate the modulating role of CDK4/6 inhibitors combined with X-ray irradiation in glioblastoma cells.

Methods: U251 glioblastoma cells were irradiated with 250 keV X-rays at a dose of 0/2/4/6/8 Gy, to obtain a dose-effect curve for colony forming and cell viability (MTT) assays. The cells were treated with either 0.5/1/5 μM ribociclib or 0.1/0.5/1 μM abemaciclib at 24 h before, or 6 h after irradiation for varying durations. DNA damage was analysed by immunofluorescence labelling of γH2AX. The number of labelled cells, and the ratio of apoptotic/necrotic cells were analysed by fluorescence microscopy. Migration capability of the cells was analysed with the scratch assay and results were evaluated using ImageJ software.

Results: 0.1 μM abemaciclib caused an 80.08% decrease in colonogenic survival, while ribociclib was able to exert comparable effect only at 0.5 μM concentration, causing only 63.74% decrease. Treatment with inhibitors 6 h post-irradiation showed greater effect, compared to 24 h pre-irradiation. Ribociclib was less efficient in the reduction of cell viability than abemaciclib, even when ribociclib was used at 1 μM concentration. This is consistent with the higher number of necrotic cells present in the abemaciclib-treated cell cultures, while the number of apoptotic cells was similar with both inhibitors. In the scratch assay, ribociclib inhibited migration more effectively than abemaciclib when radiation treatment was not applied; however, abemaciclib was more effective than ribociclib when used in combination with 2 Gy radiation treatment. γH2AX labelling, marking DNA repair foci, was not detectable in any of the non-irradiated treatment groups. At the same time, the number of foci was higher in non-treated cell cultures receiving 2 Gy irradiation, compared to cultures receiving both radiation and inhibitor treatment.

Conclusion: CDK4/6 inhibitors are greatly effective in reducing the proliferation of glioblastoma cancer cells; however, we could find no evidence for the benefit of their application in combination with radiation therapy. Our results highlight that CDK4/6 inhibitors do arrest cells in the G0/G1 phase, therefore has a mild radioprotective effect when cell are treated with high doses of radiation.

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Monolacunary Wells-Dawson polyoxotungstate as a potential anti-tumor agent

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Polyoxometalates (POMs) are polyanions containing early transition metals (such as V, W, Pd, and Mo) in their high oxidation states surrounded by oxygen. These metal-based inorganic nanoclusters have been studied as promising biomedical agents due to their approved biological actions such as anti-microbial, -cancer, and -diabetic activities and promising contrast properties for clinical imaging. Numerous *in vitro* and *in vivo* studies recently reported remarkable POM-induced cytotoxic effects against various tumor cells. Thus, POMs could be considered as a promising platform for developing next-generation chemotherapeutics. The purpose of this study was to evaluate anti-tumor properties of monolacunary Wells-Dawson polyoxotungstate, α_2-$K_{10}P_2W_{17}O_{61}{\cdot}20H_2O$ (mono-WD POM**)** using human melanoma cell line, A375 as a model system. Mono-WD POM-induced cytotoxicity was compared with the anti-melanoma effect of cisplatin which has been used as a gold-standard chemotherapeutic in clinical practice. Mono-WD POM was synthesized by following a procedure described in the literature. A stock aqueous solution (5 mmol/L) was prepared by mixing and heating at 30-40 °C. Appropriate concentrations of working solutions were prepared by diluting (with water) the stock solution. Human melanoma A375 cell line was purchased from the American Tissue Culture Collection (ATCC, Manassas, VA, USA) and cultured in high-glucose DMEM medium (Sigma-Aldrich, Steinheim, Germany) supplemented with 10% fetal bovine serum (Sigma-Aldrich), and penicillin/streptomycin (Sigma-Aldrich) in a humidified atmosphere of 5% CO_2, at 37 °C (Heraeus, Hanau, Germany). A375 cells were seeded into flat-bottom 96-well plates, at a density of 2×10^3 cells/well. Then, exponentially growing cells were exposed to increasing mono-WD POM concentrations for 24, 48, and 72 hours. Mono-WD POM-induced cytotoxicity was determined using sulforhodamine B (SRB) assay measuring cellular protein level. A375 cells were *in vitro* exposed to mono-WD POM within the concentration range from 0.001 to 1 mmol/L. The results were expressed as cell viability (% of control), as an indicator of cytotoxicity and anti-tumor potential of the investigated polyoxotungstate nanocluster, and showed as a function of mono-WD POM concentration. The obtained results demonstrated a cytotoxic effect of mono-WD POM on tumor A375 cells by reducing the cell viability in a time- and dose-dependent manner. Indeed, after 24 hours exposure, the highest studied concentration (1 mmol/L) induced a decrease of cell viability by 16%, whereas lower mono-WD POM concentrations did not affect A375 cells. During 48 hours treatment, the lowest studied concentration resulting in the decrease of A375 viability (9%) was 0.01 mmol/L, and a 55% decrease was obtained for 1 mmol/L mono-WD POM. The most significant effect (from 20 to 74% decrease compared to control) was observed for 72 hours exposure within the concentration range of 0.005-1 mmol/L. For cisplatin (positive control), significantly lower IC_{50} values (in mM) were obtained: 0.09, 0.07, and 0.043, for 24, 48, and 72 hours, respectively. Accordingly, although mono-WD POM demonstrated significant cytotoxic effects against the human melanoma A375 cell line at micromolar concentrations, its anti-tumor potency was not superior compared with cisplatin, the gold standard in cancer chemotherapy.

Micronuclei frequency in lymphocytes of patients with acute coronary syndrome before and after coronary angiography

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Acute coronary syndrome (ACS) represents different clinical conditions that result from abrupt circulatory disorders in coronary arteries induced by a rupture of atherosclerotic plaque. It includes conditions from unstable angina pectoris to acute myocardial infarction. The most frequently used method for diagnosing patients with coronary artery disease is coronary angiography (CAG), where radiographic contrast agent is used, so that patients are exposed to the effect of ionizing radiation - X-rays. The study aimed to evaluate chromosomal damages in peripheral blood lymphocytes (PBLs) of patients with ACS and to explore the effect of CAG in these patients. The study included 30 patients of a mean age of 57.77 ± 4.70 years who were exposed to different doses of radiation depending on the severity of the disease, from 68 to 1805 mGy, in different time period, from 01:05 to 23:23 minutes. Two peripheral blood samples were obtained from each patient, the first immediately before, and the second sample seven days after the CAG. Chromosomal damages were measured as micronuclei (MNs) frequency using the cytokinesis-block micronucleus (CBMN) assay. The average MN frequency was significantly higher after CAG (25.23 ± 3.65 vs. 21.93 ± 3.54, $p < 0.0005$), while NDI (nuclear division index) was significantly lower (1.35 ± 0.09 vs. 1.41 ± 0.10, $p < 0.0005$). By analyzing the distribution of MN in lymphocytes before CAG it was observed that of the total 30.000 analyzed binucleated (BN) cells, 565 (1.88%) cells had MN, of which 487 (1.62%) had 1MN, 67 (0.22%) 2MN, 9 (0.03%) 3MN and 2 (0.01%) had 4 MN. Seven days after CAG, in the same patients, the number of BN cells with MN increased to 654/30.000 (2.18%), of which the most abundant were BN cells with 1 MN (1.87%), followed by 2MN (0.25%), 3 MN (0.04%), and only 1 BN cell was recorded with 4 MN (0.01%). There was no significant difference between the average MN frequencies in PBLs of patients at doses up to 500 mGy and over 500 mGy (24.83 ± 3.87 vs. 25.83 ± 3.35, $p > 0.05$), as well as between their average NDI values (1.37 ± 0.10 vs. 1.35 ± 0.10, $p > 0.05$). We can conclude that radiation doses to which patients are exposed during CAG increase the frequency of chromosomal damages in PBLs of patients, but since the number of survivors with coronary diseases increases after CAG, its use must not be neglected.

Effects of ionizing radiation on the structure of deoxyribonucleic acid investigated by infrared spectroscopy

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In this study, we applied infrared spectroscopy with Fourier transformation (FTIR) on DNA thin films to study changes in the vibrational characteristics of deoxyribonucleic acid caused by ionizing radiation. Commercial salmon DNA was dissolved in a 10 mM NaCl solution to make the samples. The DNA solution was separated into a number of containers, and multiple sets of DNA containers were exposed to 1.25 MeV photon energy with varying dosage absorption rates using the Leksell Gamma Knife, a device used in brain radiosurgery. Dimensions and the material of the container were carefully considered so that we were able to produce a uniform dose delivery through the targeted volume. An additional set of DNA solutions was irradiated on a Gulmay D3150 X-ray for skin radiotherapy using 100 keV photon energy. Any beam attenuation was ignored since the irradiated layer of DNA was only 0.65 mm thick. In the latter case, DNA samples were irradiated, so we had a wide range of absorbed doses for the targeted volume of 0.1 -100 Gy.

Irradiated DNA was pipetted on a silicon plate as an optical window and then dried in the vacuum pump until a thin DNA film was formed. The FTIR spectrum was obtained in transmission mode with 64 scan accumulations in the range of 650 - 4000 cm^{-1} with the resolution of 4 cm^{-1} and automatic solution corrections. Normalization and baseline correction were performed using Kinetics as part of the MatLab software, while additional spectra processing was performed using eFTIR software. Recorded FTIR spectra of irradiated DNA do not show any significant changes in the intensity nor the shift of the characteristic bands in the base region of the DNA. However, the intensity of the DNA has been slightly changed in the region of the backbone vibrations which is more prominent for higher absorbed doses. Additionally, in order to quantify and categorize changes in DNA thin films caused by ionizing radiation, we used principal component analysis (PCA).

Mini-gamma-quantum irradiation and device for differentiation biological tissues

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The quality of the diagnosis of oncological diseases mostly depends on the accuracy of the results of studies that determine the type of neoplasm. The tactics of further examination and treatment of the patient are based on the results of these studies, with the selection of necessary programs of possible complex combined treatment (radiation therapy, chemotherapy, surgery).

An inexpensive instrumental method of differential diagnosis of biological tissues developed by us and currently being implemented in medical practice, which will not only speed up the time of obtaining research results, but also significantly increase their objectivity and reliability on the basis of evidence and fixation of results in physical quantities in a computer program.

The developed device for mini-gamma-quantum irradiation is a portable medical apparatus for non-invasive and non-contact differential express diagnostics of normal and pathologically changed tissues of the human body based on the study of biopsies directly during surgical intervention in patients with suspected cancer.

The proposed device allows differentiation of biological tissues according to 3 groups:

1. Normal biological tissue without pathological formations;
2. Biological tissue with non-malignant neoplasms;
3. Biological tissue with malignant neoplasms.

Our biological tissue analyzer enables the doctor to establish the nature of the tumor, assess the local or regional spread of the process, determine the boundaries of neoplasms of different localization, assess the extent of surgical intervention and surgical tactics, ensure a negative result at the edges of the resection and reduce the risk of tumor recurrence after its removal.

Features of HPV infection and association with clinical and morphologic factors of cervical cancer

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Cervical cancer (CC) is the leading cause of death from malignant diseases in women of reproductive age. The study of human papillomavirus (HPV) features of high carcinogenic risk (HR) and its association with clinical and morphological parameters of CC may provide an opportunity to predict the course and efficacy of radiation treatment, thereby implementing effective personalized therapeutic programs.

Purpose of the study: To study the peculiarities of HPV infection, to compare HPV status, molecular genetic parameters of HPV with clinical and morphologic characteristics of CC.

Materials and Methods: 240 patients with morphologically verified stage I-III CC were included in this study. Patients were analyzed for the presence of HPV DNA of 14 genotypes before treatment, and if detected - viral load (VL), presence and degree of HPV DNA integration. The analysis was performed by real time polymerase chain reaction (PCR) on a Rotor Gene Q amplifier using AmpliSense HPV HR genotype-titer FL reagents.

Results: HPV-negative CC was 3.5 times more frequent among patients older than 55 years ($p = 0.004$) and at stage III (18.2%) compared to stages II (3.4%, $p = 0.001$) and I (7.4%, $p = 0.05$). In squamous cell cancer, there was a prevalence of genotypes of group A9 (80.0%, $p = 0.0002$) with a predominance of HPV 16 (74.3%, $p = 0.0002$); in adenocarcinoma, of group A7 (66.7%, $p = 0.0003$) with a predominance of HPV 18 (60.0%, $p < 0.0001$). Among HPV 16/18-associated squamous cell CCs, HPV type 16 was more common (86%) and in adenocarcinoma, HPV 18 (64.3%) ($p = 0.0001$). There was a statistically significant increase in the proportion of cases with low VL with increasing age ($r = 0.86$, $p = 0.04$), prevalence of the tumor process (at stage III of the disease the average level of VL - 6.2±1.6 vs. 5.4±1, 9 and 5.4±2.1, respectively, at stages I ($p = 0.006$) and II ($p = 0.02$)), histological type of tumor (in squamous cell cancer there were more cases of high VL (73.9%, $p = 0.08$), and in adenocarcinoma - low VL (13.3%, $p = 0.07$)).

Associative relationships between molecular genetic parameters of HPV: genotype and VL level - the mean VL level in HPV 16 was statistically significantly higher than that in HPV 18 (respectively 6.0±1.7 and 5.0±1.1, $p < 0.001$), genotype and HPV DNA integration into the host genome - integrated forms of the virus were prevalent in HPV 18 infection compared to HPV 16 (respectively 82, 1% and 55.7%, $p = 0.01$) with a predominance of highly integrated (DNA integration ≥ 50%) forms (64.3% and 40.7%, respectively, $p = 0.019$), a high percentage of which were full (100%) HPV DNA integration (50.0% and 20.7%, respectively, $p = 0.003$), and a negative linear correlation between VL and degree of integration ($r = -0.41$, $p < 0.0001$). Multivariate exploratory analysis using the clustering method, allowed to identify the most interrelated parameters - morphological tumor shape and HPV status, in HPV-positive CC - morphological tumor shape and the following features of HPV infection: the number of HPV HR genotypes present, genotypes 16 and 18, the physical status of viral DNA - presence/absence of integration into the host cell genome.

Conclusions: The obtained data on the relationship between molecular-genetic parameters of HPV infection and traditional prognostic factors may become the basis for further studies on the development of prognostic models to personalize multimodal radiotherapy programs.

Keywords: human papillomavirus (HPV), high risk (HR), cervical cancer (CC), HPV genotype, multiple infection, viral load, HPV - status, integration of virus DNA into cellular genome.

Selection of radionuclide(s) for Targeted Radionuclide Therapy based on their nuclear decay properties

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Targeted Radionuclide Therapy (TRT) is a form of cancer treatment that delivers a therapeutic dose of radiation to disease sites by the selective delivery of radionuclides. Cytotoxic radiation is emitted at tumours by either exploiting the natural bio-distribution of the radionuclide (e.g Xofigo®) or by fixing the radionuclide to a targeting moiety that is selective for specific proteins overexpressed at the tumour sites (e.g ^{177}Lu-PSMA-617).

Targeted Alpha Therapy (TAT) and Targeted Beta Therapy (TBT) are the primary focus of TRT. For TAT, the alpha emissions from the radiopharmaceutical have a high Linear Energy Transfer (LET) depositing a high amount of ionising energy over a short distance, and so are highly damaging to the cancer cells to which they bind. Radionuclides that decay by beta radiation deposit lower energy over a relatively long pathlength, depending on the beta particle spectrum, hence delivering a range of observed pathlengths and LET. It may be possible to coordinate a beta-emitting radionuclide to the anticipated size of the tumour target, as long-range beta-emitting radionuclides could be more effective in treating large tumours, whilst short-range beta-emitting radionuclides (and alpha-emitting radionuclides) could be more effective in treating smaller tumours.

TRT is limited by the availability of suitable radionuclides. Clinical and preclinical researchers can only work with the radionuclides to which they have access. Therefore, researchers may not be working with the radionuclide with the most appropriate decay properties, due to availability.

This project's aim was to identify radionuclides that could be utilised for TAT and TBT so that future supply routes could be considered. For a radionuclide to be appropriate for TAT it must meet the criteria of being an alpha emitter with a suitable half-life, whilst for TBT it must be a beta emitter with a suitable half-life. The methodology involved setting a series of criteria, based on nuclear decay properties and applying it to the 3359 nuclides available in the IAEA's 'Live Chart of Nuclides'.[1]

The study identified 22 radionuclides potentially appropriate for TAT, and 80 radionuclides potentially appropriate for TBT. Many of the beta-emitting radionuclides have not been previously considered, and some could be produced using the UK's current infrastructure or be present within legacy materials.

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Synthesis, structural and UV-absorption studies of 4-aryl substituted fused triazinobenzimidazole azaheterocycles

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Sun ultraviolet A (UVA) (320–400 nm) and ultraviolet B (UVB) rays (280–320 nm) are responsible for the proper functioning of a number of systems in the human body and in nature as a whole, but they also have some harmful effects. They cause a number of adverse clinical effects on human skin, such as sunburn (erythema), pigmentation (tan), photoaging, photosensitivity, and skin cancer. This necessitate using of sun protection when exposed to the sun for a long period of time [1]. Also, UV radiation causes damage and destruction of some materials, such as most polymers for example.

The triazine group is known to be found in some commercially used UV filters such as ethylhexyl triazone (EHT), diethylhexyl butamido triazone (DBT), anisotriazine (BEMT) and the more recent triazine derivative tris-biphenyl triazine (TBPT) [2]. The benzimidazole core is widely used in various fields, including UV filters in cosmetics, and can be found in active ingredients 2-phenyl1H-benzimidazole-5-sulfonic acid (PBSA) and disodium salt of phenyl-dibenzimidazole-tetrasulfonate (Neo Heliopan) - benzimidazole-based compounds already used in cosmetics for sun protection. [3].

Within the frame of our current research, we have synthesized several hybrid molecules containing fused triazinobenzimidazole azaheterocycles and hydroxy and methoxy substituted benzaldehyde moiety. The interaction of 2-guanidino-benzimidazole with the corresponding commercial substituted benzaldehydes was carried out in a medium of absolute ethanol at a molar ratio of the reactants of 1:1 by using piperidine as a catalyst [4]. The structure of the thus obtained compounds was confirmed with IR and NMR spectroscopy. By means of UV-VIS spectroscopy, we tested the UV absorption capacity of the obtained triazines and calculated the UVA and UVB sun protection factor (SPF) from the data. We also evaluated the optimal geometry of the molecules and several molecular characteristics by DFT calculations at the B3LYP/6-311++G** level of theory to help better understand the structure-activity relationship.

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Assessment of the µ-SPE-PT method for the analysis of inorganic anions: iodide determination

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µ-solid-phase extraction pipette tips (µ-SPE-PT) is a miniaturized variant of solid-phase extraction. A large number of works using this technique are devoted to the determination of organic substances with a chromatographic ending. This is justified because in µ-SPE-PT several tens of microlitres of eluent can be used, which is quite sufficient for chromatographic finishing of the determination. As for the classical UV-Vis detection, this volume is not sufficient for accurate measurements. However, the combination of UV-Vis and using of micro- or semimicrocuvettes could solve this limitation.

The possibility of determination of inorganic anions using iodide as a model analyte using the µ-SPE-PT technique has been evaluated. The method is based on the oxidation of Leucocrystal Violet to crystal violet (CV) by molecular iodine and subsequent extraction of the formed CV on 5 mg of sorbent - polysterendivenylbenzene with a particle size of 6-10 µm. The extracted CV was then eluted with 200 µl of organic solvent and the absorbance was measured at 592 nm in a semi-microcuvette using a spectrophotometer. The sorbent was placed in a disposable pipette tip with a volume of about 200 µl. To prevent loss of sorbent, the end of the tip was closed with a special porous PE frit with a diameter of 2.5 mm and a length of about 2 mm. The sorbent retained its effectiveness for 5 complete cycles of analysis. It was found that the maximum efficiency of analyte extraction is achieved at 6 sorption cycles of 150 µl each. The whole extraction protocol was: 1) sorbent reconditioning - 1×200 µL MeOH and 1×200 µL H2O; 2) sample loading - 6×150 µL; 3) sample washing - 1×200 µL H2O; 4) elution – 1×200 µL MeOH; 5) sorbent washing – 2×200 µL MeOH and 1×200 µL H2O. Methanol, ethanol, 2-propanol, acetone, and acetonitrile were studied as potential eluents. The best elution efficiency is obtained when 200 µl methanol is used. Ethanol led to a decrease in sorbent washing efficiency, which further showed itself in the increase of blank absorbance, i.e. a carry-over effect was observed. Acetone and acetonitrile lead to sorbent damage and the impossibility of its reuse.

The investigation has shown that for iodide determination using the developed technique about 1 ml of sample is enough, which is much less than in the standard technique - from 5 to 25 ml depending on iodide concentration in the sample. The concentration ratio was about 3 and the extraction efficiency reached 72%. The LOD of the developed method was 0.03 mg/l as iodide. Thus, the possibility of µ-SPE-PT application for the analysis of inorganic anions with spectrophotometric detection is shown in the example of iodide determination.

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Inductively coupled plasma-optical emission spectroscopy approach for the determination of some trace elements in stinging nettle

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The popularity of herbal medicine is rapidly increasing and at the same time a rapid development the studies focused on the determination of trace elements, which reflect their role in human health and nutrition. Medicinal plants are either direct or indirect sources of minerals in the human diet. Metal ions in the chemical components of plants determine the medicinal, nutritious, and toxic properties of the plant. Toxicity of some trace elements in plant materials has a great impact on the quality of herbal raw materials, and herbal extracts. The stinging nettle (*Urtica dioica L.*) represents a perennial plant. Stinging nettle have a complex chemical composition and the chemical substances in which they are contained can have a biological activity in humans. This plant is a weed and its leaves and roots are used as both medicine and food. This paper presents determination of content eight elements (Mo, Ti, Cr, Al, As, Co, Sb, and Tl) in leaves samples *Urtica dioica L.* collected from five localities in Republic of Serbia. For the sample preparation was used standard method described in Ph. Eur. 10.0. The blank sample was prepared in the same way with no stinging nettle.

All elements were analysed using an inductively coupled plasma-optical emission spectrometry (ICP-OES). We have repeated this analysis three times with each sample collected from each site/region to get much more precision and fewer errors in our results.

The contents of Mo, Ti, Cr, and Al in the leaves were found to be in the ranges of 5.25±0.48 to 0.07±0.02 < 2.78±0.42-0.30±0.10 < 0.978±0.10-0.54±0.00 and 144.15±11.67-64.94±7.03 mg/kg dry weight, respectively. The value of elements As, Co, Sb, and Tl has been below the detection limit.

Also, the estimated daily intake values was calculated. The estimated daily intake (*EDI*) (mg/kg body weight/day) of analyzed elements a fundamental parameter for element transfer from plant to human.

Keywords. Stinging nettle, inductively coupled plasma-optical emission spectrometry (ICP-OES)

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Optimization of molecular imprinted polymer synthesis for extraction of quercetin

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Quercetin is a polyphenol compound and categorized as a flavonol. It is present in various foods including vegetables and fruits like tea, cocoa powder, cranberries, kale, celery, broccoli, lettuce, tomatoes and carrots. Quercetin is often suggested as a main flavonol for anti-oxidant therapy. Quercetin exhibits therapeutic and preventable potential against various diseases such as cancer, osteoporosis, asthma, Alzheimer, diabetes and dermatological disorders. Therefore, development of a selective, simple and accurate method for the determination of quercetin is very significant.

Thanks to its properties, QCT is widely used in the medical and pharmaceutical fields. The traditional procedures used for the separation and extraction of QCT from the plant extracts were always time-consuming and solvent-dependent. Therefore, the elaboration of a selective, fast, simple and accurate method for the extraction and detection of QCT is highly desired. Molecularly imprinted polymers (MIPs) possessing unique advantages in terms of its specificity and selectivity might present a desirable approach.

Molecularly imprinted polymers (MIPs) are attractive artificial receptors which can specifically adsorb the target molecule. For preparation of MIPs, covalent or non-covalent interactions are formed between template and monomers before polymerization. By adding a cross-linking agent, three-dimensional network of polymer is produced. After polymerization, template is removed by chemical reaction or extraction. The resulting MIP includes microcavities with a specific structure which are in agreement with the template molecule in both shape and size. Combination of MIPs with SPME technique enhances the efficiency of the extraction process. SPME is a simple method which reduces the consumption of organic solvents, amount of extracting phase and sample, also has a high selectivity in combination with the MIPs. Therefore, the MIP-SPME was used to measure of quercetin.

In this study, molecularly imprinted polymers (MIPs) with different formulations were synthesized with a sol-gel polymerization mechanism at room temperature using quercetin as the template, 3-aminopropyltriethoxysilane (APTES) as the functional monomer, and tetraethoxysilane (TEOS) as the cross-linker. The preparation of MIPs for extraction via sol-gel polymerization mechanism using APTES as the functional monomer and TEOS as the cross-linker was optimized. Non-imprinted polymers (NIPs) were synthesized without a template for each MIP formulation and used for comparison in the extraction of plant samples. UV-VIS Spectroscopy was used to measure the removal of Quercetin percentage.

Is COVID-19 vaccination associated with increased all-cause mortality in infants, children, and young adults?

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Preliminary evidence links the onset of COVID-19 vaccination to increased all-cause mortality in infants, children, and young adults. All vaccines show both specific and nonspecific effects. The specific effects relate to antibody production, while nonspecific effects can be inferred from unexpected decreases or increases in all-cause mortality. Two earlier studies regarding the nonspecific effects of COVID-19 vaccination against adults in England indicate that the specific effects of vaccination peak between ages 60 and 80. In contrast, the detrimental nonspecific effects increase progressively for ages below 60.

Results: This study demonstrates that a shift to higher all-cause mortality occurs when COVID-19 vaccination commences in children. The magnitude of this shift appears to depend on age and looks to be highest in those aged 10–14 years, i.e., around the age of puberty. The residual effects upon all-cause mortality in May 2024 roughly follow the same trend with notably increased mortality in the 1-4, 5-9, and 10-14 age groups. The nonspecific effects of the vaccines were previously investigated using non-COVID-19 all-cause mortality (NCACM). A range of protective and harmful effects can be discerned which depend on age, vaccine dose, and time since vaccination. For example, the worst outcome (increased mortality /harm) under the age of 20 occurs during the second dose of the vaccine at greater than 21 days since vaccination. The effect is worse at greater than six months than for 21 days to 6 months. Best performance across all categories usually occurs at ages 80-84.

Conclusions: While our study does not prove causation, we suggest that more detailed international studies be conducted investigating all-cause mortality (perhaps excluding accidental death) in the vaccinated versus the unvaccinated looking at the role of age, sex, risk factors, prevailing COVID-19 variant, time since vaccination, and specific vaccine types/manufacturers. Government press releases for childhood COVID-19 vaccination emphasized 'lifesaving' benefits – which for the Omicron variant is only strictly true for the elderly, and perhaps marginally true for a few children with very particular immune impairments and is specific to COVID-19 but not all-cause mortality.

Fear of COVID-19 among healthcare workers and recovered patients during the COVID-19 pandemic

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The COVID-19 pandemic made an significant impact on global psychological wellbeing. To investigate the impact of COVID-19 on different groups behavior, the current study assessed fear of COVID-19, anxiety, depression and sleep quality among medical professionals and patients. The study was proceed during the period February-June 2021 following the highest number of pandemic-related deaths in Bulgaria. The fear predicted elevated levels of anxiety, depression, and sleep quality were assessed.

Purpose: The aim of the study is to assess fear of COVID-19 among frontline female healthcare workers in comparison with patients, recovered after the disease.

Materials and Methods: The study was a questionnaire-based analytical incorporating four questionnaire-based tools. First questionnaire was used to assess fear of COVID-19. The second was for sleep disturbances assessment, the third questionnaire was used to assess general depression and the forth - anxiety.

Results: In terms of sleep status, their average PSQI score was 7.6 (SD = 3.5) points, with a range from 0 to 16 points. According to the cut point of PSQI, 58(40.6%) of medical professionals were suffering from sleep disturbances. On the contrary - average PSQI score was 3.4 (SD = 2.6) points, with a range from 0 to 16 points. According to the cut point of PSQI, 24(18.7%) of recovered patients were suffering from sleep disturbances. Anxiety, depression and fear of COVID-19 were more common in healthcare workers than in patients.

Conclusions: 81.9% of female nurses shared sleep disturbances comparing with 13.1% of male medical professionals and 18.1% of patients. During the epidemic period, particular attention must be paid to the mental well-being and sleep quality of female medical staff and the follow up is needed now.

Capturing energy from thin air: Radio wave energy harvesting

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Many electronic devices, particularly those used in wireless sensor networks and Internet of Things (IoT) applications, rely on batteries for power. By harvesting energy from sources such as Wi-Fi, cellular networks, and broadcasting stations, these devices can operate without the need for disposable batteries, thus reducing the environmental impact associated with battery production, usage, and disposal.

Collecting energy from ambient sources is more challenging than collecting energy from a single source due to factors such as low energy density, conversion efficiency, and other unknowns like source polarization, frequency, and stability. Another challenge is the need for high-frequency operation Schottky diodes for voltage rectification. So far, the maximum rectification efficiency we have achieved using SMS7360 diodes is 36% at 2.45 GHz and 0 dBm input power. The harvested energy depends on the distance between the energy harvester and the source, following the inverse-square law relationship. In real conditions rectification efficiency drops even lower, around 5-10%. To mitigate these problems, we focus on collecting energy from a single 2.4 GHz WiFi source.

Our RF energy harvesting system consists of two slot-loaded patch antennas (8 dBi gain), an impedance matching network, a full-wave voltage rectifier, a power managing module, and a 2200 µF supercapacitor. The antenna collects RF energy from the source and converts it to an alternating current, a rectifier converts it into direct current. Because diodes used in voltage rectification are nonlinear and exhibit reactance, an impedance-matching network is required to match 50 Ω antenna output to 4-i30 Ω rectifier input impedance. The power management module stores collected energy in the capacitor and periodically powers the load.

The antennas are connected in series to achieve the optimal voltage level. Voltage rectifiers with impedance matching networks are located on the backside of the antenna's ground plane to reduce system dimensions and minimize power losses that appear from connectors. When a 200 mW CW power source is positioned 1 m away the RF harvester can charge the 2200 µF supercapacitor from 3.3 V to 4.2 V in 6 s. When the supercapacitor voltage reaches 4.2 V, the internal transistor reroutes the power to the load. In our experiment, the load consists of a red LED and a 400 Ω resistor connected in series. LED lights up for 0.06 s and then turns off, when the supercapacitor discharges to 3.3 V, after which the charging cycle begins again.

A higher gain antenna should be used to increase range and improve efficiency. We are currently developing a dielectric-loaded helix antenna, known for its high gain and directivity, making it ideal for energy harvesting from a single source. Moreover, we can make helix antenna fairly compact when employing ceramics with high dielectric permittivity.

Radio wave energy harvesting promotes energy efficiency and reduces the overall energy consumption associated with powering electronic devices. This technology could be used for power wireless sensors, wearable electronics, medical implants, IoT devices, energy-efficient electronics, and environmental monitoring stations, which typically exhibit average energy consumption ranging from several microwatts to milliwatts.

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Origin of lipid tracers in the surface soils using diagnostic indices and Hierarchical Cluster Analysis

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Petroleum hydrocarbon-related soil contamination is a serious environmental issue. The different causes of this pollution, which include industrial emissions and the unintentional spilling of petroleum and its derivatives, can have detrimental effects on entire ecosystems. To ascertain the anthropogenic input of hydrocarbons in the examined soil samples, a variety of assessment indices were produced. In this investigation, soil samples were taken from surface layers near the heating plant in New Belgrade, Serbia. The initial exploratory approach involved the use of Hierarchical Cluster Analysis (HCA) on the log-transformed data set of 20 sampling sites. Spatial HCA identified similar monitoring sites, and in this case, produced a dendrogram grouping all the samples into individual groups. Based on the level of grouping, three separate clusters of soil samples have been found from the output of the Q-mode hierarchical cluster analysis. Differences in photosynthetic pathways of plants as well as anthropogenic input had an impact on soil organic matter composition. Since the biogenic contribution tends to be reduced at all sites, the group of HC1 clusters can be predominantly attributed to native organic matter. C4 plants that were present in soil organic matter transmitted a stronger signal. In certain sampling sites, in the HC1 cluster the contributions from aquatic organic matter were higher. These findings might be linked to an occasional rise in the water table. The fluctuation of isoprenoids in this alluvial area indicated the variation in redox potential during sedimentation. The n-alkanes which represented hydrocarbons dominated by higher plants and traffic activity are defined by the second cluster, HC 2. This group has a higher concentration of C3 plant compounds than the rest of the groups. Sedimentary alkane assemblages like in some soil samples (position sites which are located in the outskirts of the urban areas (residential block and near a motorway with a medium traffic density) may result from the intake of hydrocarbons from petrogenic (without petroleum seepage) sources. Samples of group HC 3 contained the maximum amounts of total petroleum hydrocarbon, higher than the other groups. Contaminations are probably historically and/or chronically petrogenic with continuous input of the biogenic origin. The relative content of C3 and C4 plants fluctuated during this area.

Keywords: Soil alkane assemblages, C3 and C4 plants, anthropogenic emissions, diagnostic indices, hierarchical cluster analysis (HCA)

Design and implementation of photovoltaic parks with low power to increase the weight of green energy and reduce pollution due to fossil fuels

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The design of photovoltaic parks has become in Romania, now, one of the most profitable and safe investments in the field of renewable energy sources, not only at present, but even more so in the future. Solar photovoltaic parks are favored by maximum exposure to solar radiation, a minimal impact on the environment, allowing the production of energy with a cost per kWp lower than that of other installations. The profitability of such photovoltaic parks depends on several factors and is definitely given by the ratio between income and construction costs. Mainly the revenues can come from the sale of energy and the trading of green certificates. The green certificate is a document that certifies a quantity of 1MWh of electricity produced from renewable sources. The purchased green certificates cover the mandatory minimum share of renewable energy in the total energy supplied to final consumers, this share being established every year by ANRE (National Energy Regulatory Agency). Green certificates are valid for 16 months. Suppliers and producers who do not meet the mandatory annual quota are fined by the Environmental Fund Authority with 110 euros for each unpurchased certificate. Solar energy producers (power plants and photovoltaic parks) receive six green certificates for 1MWh of electricity, produced and delivered. The market value of a green certificate at this moment is a maximum of 50 euros. The realization costs involved in building and designing a photovoltaic park are between 1.1-1.9 Euro/Watt. The quality of the equipment used in construction, the shape of the land, the costs of connection to the national energy system, are factors that can constitute the cost of realization. Another important factor in terms of income is the level of operational expenses, which is between 2% and 8% of the annual income and includes: security, equipment and land maintenance, system monitoring. The execution period of a photovoltaic park varies between 3-6 months depending on location and weather conditions. Romania has a high degree of solar radiation, suitable for investment in photovoltaic parks. There are three categories of documents required for the establishment of a photovoltaic park: those related to the land on which the park is built, the solution study for obtaining the technical approval for connection (ATR) to the electrical network and obtaining the establishment authorization. The first category includes the deed of sale, purchase of the land, the second category includes the technical documentation for the construction authorization and the third category of documents involves obtaining the ATR, then obtaining the establishment authorization (given by ANRE), obtaining the commercial exploitation license, registration on the regulated electricity market (OPCOM) with (accreditation for green energy). The paper will present a technical and economic calculation for a photovoltaic park with a power of 100 kW.

Bilateral proficiency test on radon measurements in soil

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A bilateral comparison between two expert laboratories in the region for testing of radon in the soil was carried out to check the equipment, as well as to compare the results, develop the methodology, and estimate the measurement uncertainty. For the intercomparison measurements, a location in Osijek (the garden behind the family house) was chosen, where previous measurements had determined a high concentration of radon in the soil (about 100 kBq/m^3). To avoid the influence of soil permeability, as well as high humidity on the measurement of radon concentration, the same stainless-steel probe from the Radon JOK kit was used, inserted to a depth of 80 cm, and alternate measurements were taken at 4 measuring points at 2.5 m. During the measurement, the flow of air from the ground and the operation of the automatic pump on the device were controlled.

A qualitative scheme of testing the same parameter using different techniques under the same conditions and for the same period was applied following the international standard method ISO 11665-11:2016. Two active devices for direct measurement of radon concentration in the soil were used, a radon monitor RAD7, manufactured by DURRIDGE Co, and a radon detector RM-2 manufactured by Radon v.o.s. Czech Republic.

Since the values of the En-score parameter are less than 1 at all measurement points, all reported results have met the set criteria of the proficiency test. The large deviation in the measured values at points was discussed and explained by unfavorable weather conditions and the large influence of soil moisture on the concentration of radon in the soil.

Overlooked electromagnetic pollution

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Electromagnetic radiation from communication and electronic devices, networks, systems and base stations has drawn concern due to excessive global usage with increasing operating frequency level. These multimillions of wireless devices generate a rather significant amount of unused residual electromagnetic radiation spread all around us. Here, we tag these unwanted and unnecessary electromagnetic radiations as 'Electromagnetic Pollution' [1].

According to Planck's equation: $E = hf$, the energy (E) of a photon particle is directly proportional to the frequency level (f). At lower operating frequency, for instance, in the MHz range, the energy at the 10^{-6} eV produces only an induced current, hence there is nonionizing radiation, yet exposure to machines operating in this range (e.g. magnetic resonance imaging (MRI) at 1–300 MHz) too long and often, is not recommended. Nonionizing radiation is generated at frequencies below the ultraviolet regime, where $f < 10^{15}$ Hz and $E < 10$ eV. This nonionizing radiation corresponding to the energy level creates different elements and effects, i.e. 1) low currents ($f <$ Microwave), 2) high currents (f: Microwave-Infrared) and 3) electron excitations ($f >$ infrared). There are multiple applications operating within these frequency ranges, where nonionizing radiation is inevitably polluting. The thermal effects of RF radiation focusing on the absorption range and temperature elevation, from various mobile phone frequencies and different usage patterns, in the human head [2] and different human organs [3-4] were studied. It normally takes an extended time to track any long-term effects of these nonionizing radiation on humans. Several short term or even immediate side effects have been reported, including psychiatric effects (depression, anxiety, neurodegenerative issues), cardiac arrhythmia, tachycardia, fertility, affected eyesight or changed cell development, to name a few.

In this research, several case studies of electromagnetic radiation and residue from new 5G-FR2 devices, operating in the 24.25-52.6 GHz range, including n257, n258, n259, n260 and n261 from various number of users in different closed areas, e.g. coffee shop, conference room, commercial airplane, etc., will be presented.

Keywords: Electromagnetic; microwave; radiation; pollution; absorption; human organs; 5G.

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Exploring radiation effects on meristem regenerative restoration in relation to chromosome structural deficiencies: A practical scheme for assessing plant vitality at Pb emission sites in the Meža valley, Slovenia

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Understanding the complex interplay between radiation effects on meristem regenerative restoration and chromosome structural deficiencies is essential for evaluating genetic threats to plant vitality in environments contaminated with radiomimetic pollutants. This study introduces a practical scheme for assessing health hazard of plants at lead (Pb) emission sites in the Meža Valley, Slovenia, where soil contamination with heavy metals is geogenically conditioned and a consequence of centuries of environmental pollution due to Pb metallurgy. Despite emission controls, installation of air filter devices, and mine closure, environmental issues persist, highlighting the critical need for effective biomonitoring strategies.

Ionizing radiations induce permanent chromosomal aberrations, yet the precise relationship between chromosome structural changes, cell death, and reduced vegetation growth remains poorly understood. To address this knowledge gap, we introduced a novel scheme for evaluating chromosome damage at sublethal and lethal doses, derived from extensive irradiation experiments conducted on *Allium* plants as standard bioindicators in plant cytogenetics for exploring harmful effects under controlled growth conditions, using Feulgen squash root tip preparations for precise cytological analyses of chromosome aberrations. We categorized aberrant cells into three groups based on the extent of structural changes as well as their consequences: altered cells with minor chromosome changes, damaged cells exhibiting gross structural-chromosome aberrations, and decaying cells undergoing complete disintegration of their chromosomal set. Such a categorization provides valuable insights into the genetic threats posed by radiomimetic pollutants. Fragment (Fr) frequencies emerge as specific indicators of chromosomal material loss due to irradiation, stabilizing at sublethal doses (5%) and influencing cell vitality and survival. The stability of Fr levels in irradiated plants correlates with reduced vitality, as evidenced by poorer root and leaf growth and lower storage tissue production at the end of their vegetative period.

This scheme was applied to evaluate the environmental threat to naturally growing plant populations near the former Pb smelter Žerjav in the Meža Valley. Assessment of several emission sites revealed elevated Fr frequencies, indicating ongoing genetic endangerment. Reprocessing data from the 1980s underscores the persistence of genetic threats, with plants closest to Pb emission sources exhibiting higher Fr frequencies. Comparison with the former uranium mine at Žirovski Vrh showed similar aberration frequencies, with minor chromosome changes increasing with distance from the emission source in the Meža Valley. Additional pollen grain deformation (PGD) assays could provide further evidence of chromosome mutations in affected plants. These PGDs are helpful for evaluating species reproductive success in monitoring the effects of pollution on plants from different environments.

The study emphasizes the importance of biomonitoring and assessing genetic endangerment of plants, particularly in habitats threatened by radiomimetic pollutants. Improved data presentation methods are crucial for evaluating fitness of natural populations threatened by pollutants. Our findings underscore the urgent need for proactive conservation efforts to preserve biodiversity in polluted environments.

Neutron activation analysis in the assessment of marine pollution

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A wide range of pollution, from heavy metals to microplastic, affects marine ecosystems. Neutron activation analysis (NAA) along with other analytical techniques is widely applied in the assessment of marine environment pollution. For long time NAA is used to determine the elemental composition of mussels considered as one of the most important biomonitors, which reflect the state of marine environment. Examples of the technique application in the determination of elemental composition of mussels collected in different zones of South Africa will be provided. Special attention will be given to approaches applied to assess the safety of mussels' consumption. Sponges, is another type of environmental indicators of water pollution. NAA was applied to assess the prospects of using Baikal endemic sponges as bioindicators of lake pollution by toxic elements.

Enhancing health impact estimation for construction workers: simultaneous noise measurements using noise dosimeter and phonometer

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The construction industry is generally hazardous and primarily land-based, where site workers may be exposed to various risks, some of which may go unnoticed. Working at height, moving machinery, power tools, and electrical equipment, dangerous substances, and the impacts of excessive noise, dust, and vibration are all potential hazards on the job site. Hearing loss and other health problems are prevalent among construction workers, particularly those who operate heavy machinery and equipment. Recent research has shown that the noise levels that construction equipment operators are exposed to can potentially cause hearing impairment. On the other hand, when construction workers are exposed to impulsive noise, the rate of ear damage is greater than when they are exposed to continuous noise. This research emphasises the significance of utilising a dosimeter and a photometer when assessing noise levels at specific workstations to accurately predict their impact on health. This approach is particularly important due to the inherent mobility of machinery and the concurrent operation of diverse tasks, which often renders measurements with a photometer challenging during the standard 8-hour workday. This research is a case study, keeping in mind that the excavator operator was monitored during one working day. Sound pressure level was measured within the range of frequencies between 25 Hz and 10 kHz using the TES 1358A Sound Level Meter (SLM), while noise dose was measured using the personal noise dosimeter Bruel&Kjer tip 444-8B, which is moving with the worker, measuring the exposure at their exact location and for their particular behaviour. The measurements obtained during the channel digging operation, considered a typical task for this machinery, reveal the following values: Leq = 71.8 dBA, Lamax = 86.5 dBA, and Lamin = 60.4 dBA. In this case, performing a 1/1 octave analysis is unnecessary, considering that the measured values do not exceed the allowed values given by the rule book. However, the measurements of the personal dosimeter reveal the following values: Leq = 82.9 dbA, sound exposure = 0.62 Pa^2h, dose = 19.3%, Lcpeak = 143.1 dB,, and Lceq = 102 dB. According to these results, it is possible to calculate the time-weighted average noise level (TWA in dB) for machinery operators. This variable can be used to propose a hearing protection device (HPD) and predict the incidence of occupational hearing loss. It can be seen that the noise equivalent level measured by the personal dosimeter is near the allowable limit of 85 dBA for an eight-hour workday. On the other hand, the Lc peak is very high, implying the presence of another high-value periodic or impulsive noise. According to new regulations, hearing protection must be worn at and above Lpeak = 137 dB (C), while nobody will be exposed to levels at or above Lpeak = 140 dB (C). Nevertheless, the dose value implies that the worker was exposed to excessive noise for about 20% of the workday. One of those time intervals lasted 30 minutes when the average Leq value was 85.3 dBA and Lpeak was 132 dBC while excavating the soil and loading it into the truck. In any case, on the basis of measurements, it can be concluded that in the construction industry, more precise and useful data can be obtained with simultaneous measurements as far as protection measures are concerned. Furthermore, the observed noise values suggest that workers should be protected during certain operations, and if the protective measure is not implemented, the long-term and cumulative effects on human health will undoubtedly be harmful.

Gross beta-radioactivity of leaves of Thuja pyramidalis in conditions of hydroponics and soil in Ararat Valley and Dilijan forest experimental station

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Armenia is affected by the ecological disaster connected with the forest area reduction. Forests are approximately 11.2% of its area (334.1 thousand ha). Armenia is a mountainous country with a dry subtropical climate and it has a nuclear power plant (NPP), located in the Ararat Valley. All these are not only the basis of the ecological disaster but also make it deeper. For its prevention, it is necessary to restore and expand green zones, and forests. The use of decorative trees and shrubs with the ability to filter the air from radionuclides (RN) is extremely important in green construction. In recent years, the decorative coniferous tree Thuja occidentalis “Pyramidalis” is one of the most demanded landscaping trees in Armenia.

Objective: The characteristics of gross β-radioactivity of Thuja pyramidalis leaves were studied under outdoor hydroponic and soil cultivation conditions in the territory of the Institute of Hydroponics Problems (IHP) in the Ararat Valley (a zone with a radius of 30 km from the Armenian NPP (ANPP)) and the Dilijan Forest Experiment Station (DFES) (a zone with a radius of 90 km from the ANPP). This has a practical significance because the use of radio-ecologically favorable tree species and shrubs in green construction will have an important ecological significance.

Methods: The gross β-radioactivity of the leaf samples was determined by radio-chemical methods using a small background UMF-1500 /RF/ radiometer.

Results: According to results, regardless of the growth zone, hydroponic trees exceeded soil ones in the amount of β-radiating technogenic and natural RN by 1.2-1.3 times. Leaves of the Thuja pyramidalis grown in the IHP territory exceeded those grown in DFES in gross β-radioactivity: in hydroponics - 1.6 times, in soil - 1.7 times.

Conclusion: Thuja pyramidalis as a radio-ecologically beneficial tree species is proposed to be used for the creation of green zones. This will have important ecological significance as it will reduce the movement of RN in the biosphere.

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Keywords: Decorative tree - Thuja pyramidalis – technogenic and natural radionuclides - practical offer

A four-year study of the pigment content on wild-growing plants at Moussala Peak

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Moussala (2925 m a.s.l.) is the highest peak in the Rila Mountains, as well as in Bulgaria and the entire Balkan Peninsula, which is characterized by specific microclimate conditions. Wild-growing plants at this high altitude are exposed to more than one environmental factor: prolonged UV irradiation, low temperature, high wind velocity, etc. With the increase of the altitude, alpine conditions are rapidly changing.

This study aims to reveal changes in the pigment content of 10 wild-growing plant species at Moussala Peak from 2020 to 2023. The following species were used as plant material: *Saxifraga cymosa* Waldst & Kit (Saxifragaceae), *Anthemis carpatica* Waldst. & Kit. ex Willd. (Asteraceae), *Geum repens* L. (Rosaceae), *Doronicum columnae* Ten. (Asteraceae), *Achillea clusiana* L. (Asteraceae), *Armeria alpina* Willd. (Plumbaginaceae), *Festuca valida* (R.Uechtr.) Pénzes (Poaceae), *Sesleria coerulans* Friv. (Poaceae), *Pedicularis ornantha* Griseb. (Scrophulariaceae) and *Campanula alpina* Jacq. (Campanulaceae). Plants were collected from Moussala Peak in (the July/August) growing seasons of 2020-2023. As an endpoint, photosynthetic pigment content was applied.

Our data showed different plant responses depending on the environmental conditions of the studied years. Higher levels of total chlorophylls, chl. *a*, chl. *b* and total carotenoids were obtained in 2022-2023 years for most of the plant species than those obtained in 2020-2021. The biological data are in good correlation with the UV data. The four-year study (from 2020 to 2023) found an insignificant increase in the intensity of UV radiation with time. The highest UV intensity was measured for July 2023. On the other hand, statistical data showed that the effect of the studied species is significantly higher than the effect of the studied year. No change in the chlorophyll *a/b* ratio was obtained for all studied alpine plants. However, higher values of chlorophyll *a/b* ratio for all studied species were detected for 2023 year than those from 2020 to 2022. Alterations in pigment content were found depending on the studied plant species and alpine conditions for the respective studied years. It could be suggested that examined alpine species have different adaptive mechanisms to cope with the environmental stress at this altitude. Having in mind that at this altitude environmental conditions are extremely varying and high UV intensity is combined with the action of other environmental factors further long-term studies on pigment content are needed for a better understanding of the mechanisms of interaction of factors and plant response.

Composite adsorbents based on natural zeolite for selective removal of toxic metals and radionuclides

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The development of effective adsorbent materials for the selective removal of heavy metals and radionuclides from contaminated water and soil is a global problem, as these toxic metals can accumulate in the human body through the food chain.

Natural zeolites have long been used to bind toxic metals in soil and decontaminate radioactive water due to their efficiency and low cost. However, their wider application for selective removal of toxic metals is limited due to the decreasing selectivity with increasing solution salinity and the reversible nature of adsorption.

The synthesis of composite adsorbents based on natural zeolites with a sorption-active inorganic phase deposited on their surface seems to be a promising approach for obtaining inexpensive adsorption materials with high selectivity for specific metals/radionuclides.

Within the framework of the MSCA4Ukraine project, the synthesis of composite adsorbents based on natural zeolite was developed and implemented. The results of the synthesis of composite adsorbents for the selective removal of cesium radionuclides and heavy metals (Pb, Cd, As, etc.) based on clinoptilolite tuff from the Sokyrnytsia deposit (Ukraine) are considered. The adsorbent for cesium was synthesized by deposition of potassium-copper ferrocyanide phase on the surface of zeolite tuff, while various adsorbents for heavy metals were synthesized by deposition of FeOOH and /or MnOOH phases. Samples of natural and composite clinoptilolite tuffs were tested for the selective removal of ^{137}Cs and heavy metals from single and multi-component model solutions, as well as from soil solutions. The presence of the inorganic phase was shown to increase the selectivity of the composite adsorbent compared to natural clinoptilolite and to improve the fixation of adsorbed ions.

Evaluation of ionising radiation with life cycle impact assessment methods

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Life cycle assessment provides a complete and comprehensive analysis of potential environmental impacts associated with products and services through the life cycle phases. The evaluation in life cycle assessment is performed through life cycle impact assessment methods that provide results within various impact categories. Ionizing radiation as an impact category is present in the majority of life cycle impact assessment methods, and therefore, the focus of this research is on different evaluation approaches for ionizing radiation. This research compares life cycle assessment results from several life cycle impact assessment methods for impact categories that evaluate ionizing radiation and its potential emissions to the environment. A distinctive production activities from the life cycle inventory database with potential ionizing radiation, production of construction materials, has been evaluated with several life cycle impact assessment methods. Results confirm previously known facts that the bricks with fly ash content have more radiation levels per kg of product than common bricks from clay or concrete. The majority of life cycle impact assessment methods provide results for the ionizing radiation impact category only, however, there are life cycle impact assessment methods that provide ionizing radiation results as the emission of radioactive substances in air, water, and soil or radioactive waste. Furthermore, selected life cycle inventory results can show the presence of radioactive actinides, aerosol, radon, and radium in air emissions, as well as actinides, nuclides, radium, and tritium in water emissions.

Vulnerability of forest ecosystems from the Republic of Moldova to climate change in the context of ecological security

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Climate change is becoming one of the most visible and obvious phenomena, globally, regionally, but also locally, recognized by spatial and temporal changes in climate components. Forest ecosystems are part of a unique natural heritage and are highlighted by the major importance of maintaining the ecological balance, protecting land and water resources, mitigating climate change and carbon emissions, protecting biodiversity, etc. At the same time, forests cover a series of social needs (food security, energy, etc.), the ecosystem services generated by forests being important for the national economy sectors (tourism, agriculture, water supply, etc.). According to historical data, the territory of the Republic of Moldova, only two centuries ago, was covered by forests in a proportion of over 30%, the area occupied by forest lands reducing to about 6% (1945 year), recovering, partially, in the post-war period, with an increase up to 370 thousand ha in 2022, i.e. approximately 11.2% of the country's territory. That indicator is well below the European average (about 37%), being closer to the medium-term task of 15%, established by a series of national policy and strategy documents. Among the factors with a negative impact on forests, more and more often, climate change is also listed. Studies in the field indicate that the development of forest species in the temperate zone will be limited by the availability of water and the decrease in the annual precipitation amount or inter- and intra-annual changes in its distribution, with an even more severe impact than the current one. For the forests located at the border of the natural distribution area (xeric limit) from the silvosteppe zone (the Republic of Moldova' case), the availability of water will determine changes in the ecosystem structure and functioning, in the soil moisture balance, the species' distribution and ratio, reduction of ecosystem services, etc.

In the scientific work of the Institute of Ecology and Geography (Moldova State University), entitled - *"Atlas: Abiotic environmental factors and ecological security"*, recently launched (2024), there is a sub-compartment in which, for the first time, it was evaluated and mapped the impact of climate change on forest ecosystems, for the entire territory of the country, through 4 eco-climatic indices (De Martonne Aridity Index - IM, Forest Aridity Index - FAI, Forest Stress Aridity Index - FASI and the beech climate tolerance index - Q_{BTI}). *The following were identified, analyzed, described and mapped:* 4 areas of forest vulnerability to droughts/aridity (according to IM); 3 areas with climatic conditions that favored the development of various types of natural communities – forest ecosystems, forest-steppe vegetation and steppe communities (according to FAI); territories with 2 types of arid climate conditions, with potential stress on forest ecosystems (according to FASI); and the territories (very limited), favorable for the growth and development of beech on the country territory (according to Q_{BTI}).

Studies on the impact of climate change and the risks generated by it on the representative forest ecosystems in the country, located at the border of the natural distribution areas - regions considered to be the most vulnerable to climate change, are necessary for the entities in the field of forestry sector administration, and current, in the context of the ambitious national plan for the expansion and rehabilitation of forests (2023-2030).

Lessons from the 2011 Tohoku Megaquake and Tsunami-in order to survive

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Japan is one of the most earthquake-prone countries in the world, because it sits on the top of four converging tectonic plates that constantly grind together. On 11, March , 2011, a devastating tsunami accompanied by a M9.0 earthquake struck the northern Pacific coast of Japan,. The tsunami run-up height reached 40m. The 11 March event was the largest known tsunami in Japan. Since the 1896 Meiji Sanriku earthquake and tsunami that killed 22,000 people and since the 1960 Chilean earthquake and tsunami, Japan has developed a coastal protection infrastructure of seawalls and breakwaters. The Kamaishi tsunami breakwater which is in the Guiness World Book of Records as the deepest tsunami breakwater at nearly 63m in deep, was designed to protect the area in Kamaishi city. Its construction required an investment of almost 30 years and 120 billion yen. However even this barrier could not protect citizens from the 2011 tsunami. Even the great seawalls can fail. We should not rely too much on coastal infrastructure. An extreme instance is the 1958 lituya Bay earthquake : Height of the Megatsunami wave was 524m.

It was widely believed that Japan was one of the most prepared countries in the world for tsunami. The 2004 Sumatra-Andaman earthquake (M 9.0-9.3) and tsunami killed 220,000 people, while the 2011 event (M9.0) caused approximately 20,000 fatalities . Both events are geologically similar with regard to the size of the earthquake and tsunami. The striking difference in the number of fatalities is the level of preparedness. Coastal cities and towns had prepared tsunami hazard maps with estimated inundation zones. In many coastal communities , people have conducted regular evacuation drills and have held workshops to learn which areas are at risk, by referring a hazard maps. In some coastal regions , the 2011 tsunami was far more extensive than had been expected by the computer simulation. The lesson is that computer simulations cannot predict the whole picture of any disaster.

Hazard maps have two functional aspects. One-to tell people that they are at risk. On the other hand, to assure residents living outside of the expected inundation zone that their area is not at risk. In the 2011 event, hazard maps failed to offer accurate predictions. The maps indicated the uncertainty of estimations based on computer simulation. Tsunami warning information can inform people that they are in danger, but it cannot guarantee people's safety. The lesson is that one should not wait for official information to act . Strong ground shaking is the first alert to take action in order to survive. Tragedy in Okawa Elementary School. The school lost 74 pupils and 10 teachers in the 2011 tsunami. The teachers and pupils gathered on school ground to discuss where to go -50 minutes before the tsunami attacked the school. One option was a hill behind the school. The other was a small overlook at the river bridge. Teachers decided to head for the bridge. Shortly thereafter, the tsunami penetrated along the river and overtopped the river bank , sweeping away pupils and teachers. The lesson is that we must know the geographical features of our district. How can we educate children to be prepared? How should teachers be trained to provide appropriate guidance to save children's lives and their own? Many lessons are remained to be solved.

In conclusion

- Prevention of Megaquake and Tsunami is impossible.
- Some mitigation might be possible by preparedness and resilience.

- Megaquake and Tsunami might be an alarm for omnipotence and hubris of human beings from Earth.

Layered nano MoS_2 photocatalyst for organic water pollutants degradation

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In recent decades, much attention has been devoted to the development of new wastewater treatment methods. Among them, heterogeneous photocatalysis seems to be very promising, but the most effective catalysts are based on expensive and rare precious metals such as platinum and gold. Recent research indicates that transition metal dichalcogenides may be a cheap and handy alternative to precious metal catalysts. Molybdenum disulfide is a layered material with a sandwich-like structure that belongs to the family of transition metal dichalcogenides (TMDs). MoS_2 exists in three phases, two stable semiconductor phases with a trigonal prismatic structure (2H and 3R) and a metallic octahedral metastable phase (1T). Bulk MoS_2 has an indirect band gap of ~ 1.2 eV, which changes to a direct band gap of ~ 1.9 eV after the reduction of layers. MoS_2 nanomaterials provide good catalytic activity due to the high absorption response in the visible wavelength range. The disadvantage of this material is the rapid recombination of photogenerated electron–hole pairs. Charge separation can be improved by increasing the ratio of the metal edge sites to the face.

MoS_2 powders of different morphologies have been obtained using a wide variety of methods such as thermal decomposition of ammonium tetrathiomolybdate or amorphous MoS_3, high-temperature reaction of the stoichiometric mixture of molybdenum and sulfur powders under vacuum, gas-phase reactions of H_2S and molybdenum oxides under reducing atmosphere. Developed by the authors synthesis procedure, based on a Li_2MoO_4 solution as the starting material, is simple and convenient, leading to the preparation of layered MoS_2.

The morphology of MoS_2 demonstrates the layered structure of the material. The surface topography observed by atomic force microscopy was rough, which suggests that the sample comprises multiple sheet-like structures, creating layered objects. XRD results showed that the obtained MoS_2 had a pure 2H phase. Five diffraction peaks were observed at the 2Θ values 13.95; 33.3; 39.8; 48.2; and 59.2, respectively. The peak broadening at 13.95 2Θ indicates a sheet-like crystallite morphology with an average size of 50 nm. The material exhibited a good optical response to ultraviolet and visible light.

The photocatalytic activity tests of the layered MoS_2 were evaluated by carrying out the degradation of bromophenol blue (BPB) in a weakly acidic aqueous solution (pH 5.2). The photocatalytic degradation was performed using a Heraeus LRS2 glass photoreactor in a continuous argon flow (reductive conditions). The photocatalytic reaction was performed up to 120 minutes illumination time. The progress of the photodegradation reaction was monitored by recording changes in the concentration of the BPB solution at regular intervals and bromide ions concentration. Observed for BPB debromination directly indicates the reducing pathway of BPB degradation.

The MoS_2 layer structure is favourable for the separation of charge carriers. The electron mobility plays a major role in the photocatalytic degradation of BPB. Results of BPB degradation show that MoS_2 is a highly efficient photocatalyst for the reduction processes.

Investigation of the anthropogenic effects on St. Anna Lake sediment dynamics

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The Pb-210 dating method is widely utilized for investigating the dynamics of lake sediments. Through this method, we gain insight into the sediment deposition processes over the past 150 years. A significant challenge in analyzing the alternating intensification stages lies in the high sediment formation rates, particularly affecting lake ecosystems. Often, pinpointing the exact cause for these elevated rates proves challenging. They can stem from a combination of natural processes and events induced by human activities. To accurately determine their origins, various other proxies, such as elemental analyses, particle size distribution assessments, and pollen analyses, among others, must be employed.

In the present study, we employ a methodology capable of elucidating natural processes. Lake Saint Anna is the sole crater lake in Romania, boasting significant national and international tourist appeal. Adjacent to the lake lies the Mohos peat bog, forming a twin crater ecosystem. By examining the development of these two ecosystems using the Pb-210 dating method, we aim to reveal the anthropogenic effects on the lake.

Differentiation of pea and grass pea samples based on GC-MS analysis of sugar compounds coupled to multivariate statistics

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Legumes became very popular in bakery industry lately since they do not contain gluten. Also, they are rich in proteins, carbohydrates, vitamins and minerals. Legume species analyzed in this work were pea and grass pea. The aim was to develop a legume authentication method based on sugar components. The first step was to remove lipids from pea and grass pea samples using solvent n-hexane for triple extraction of liposoluble compounds. In the second step, methanol was used as a solvent for extraction of sugars from the samples. Derivatization of the sugar compounds was performed using reagent trimethylsilyl-imidazole (TMSI). A GC-MS (gas chromatography with mass spectrometry) analysis was performed and the obtained chromatograms were processed in term to identify the eluting compounds. Peak surface areas of identified sugar compounds were collected into a data matrix. Multivariate statistics was performed on the data matrix. Performing hierarchical cluster analysis (HCA) similarity dendrogram was obtained. Grass pea samples are grouped together in the same cluster, while pea samples are clustered separately. The level of similarity of about 0.5 is obtained in the case of both pea and grass pea clusters. Principal component analysis (PCA) was also performed on the data matrix. PCA score plot presents a clear separation of pea and grass pea samples in two clusters. These clusters are separated by principal component 1 (PC1). Thus, pea cluster is located on the negative side of PC1, while grass pea cluster is mostly located on the positive side of PC1. The proposed method based on GC-MS analysis of sugar composition, coupled to multivariate statistics, shows a potential in legume authenticity.

The effect of fermentation by *Bacillus subtilis* on the disappearance kinetics of pesticide in legume seeds

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Pesticides are used in legume plantations to reduce crop losses and maintain good quality; however, even after harvesting, legumes may contain unpredictable quantities of these chemicals**.** The process of pesticide degradation in foodstuffs is initiated by microorganisms, which decompose those compounds in chemical and biological reactions.

Purpose: In this study, four plant matrices, including soybeans (*Glycine* Willd.), peas (*Pisumsativum* L.), lens (*Lens culinaris* Medik.) and chickpeas (*Coronilla* L.), underwent fermentation by *Bacillus subtilis* var. natto. Then, the process influence on the content of two pesticides: clomazone (herbicide), azoxystrobin (fungcidide) was evaluated, depending on the fermentation length.

Methods: Fermentation was conducted for 312 hours in controlled conditions of temperature and relative humidity (37°C, 75%) [1]. The pesticide residue content in fermented seeds was assessed with the QuEChERS multiresidue method, combined with gas chromatography coupled with tandem mass spectrometry (GC-MS/MS) [2]. The dispersion kinetics of active substances were determined by plotting the concentration vs. time elapsed from the moment of adding their mixture to the fermentation samples. It was found that an exponential relationship corresponding to the first order kinetics equation applies to the dispersion of the target pesticides in the tested samples.

Results: The studies demonstrated that *Bacillus subtilis* can biodegrade pesticides in legume seeds. The highest pesticide degradation occurred during first hours of fermentation. At the end of fermentation, the azoxystrobin and clomazone levels ranged from 0.0203 mg/kg (soybean) to 0.0475 mg/kg (lens) and from 0.001 mg/kg (chickpeas) to 0.0753 mg/kg (lens), respectively. For clomazone, the observed half-lifes ($t_{1/2}$) were 2.60, 1.74, 2.83 and 0.63 days for soybeans, peas, lens, and chickpea, respectively. MRL established for this active substance is 0.01 mg/kg, apart from 0.02 mg/kg for soybean. The azoxystrobin half-life was estimated as 2.02 days (lens), 3,65 (soybean), 2,16 (peas) and 1.75 (chickpeas). In all studied plant matrices, the azoxystrobin level after the end of fermentation was below the established MRLs (0.5 mg/kg for the soybean, 3.0 mg/kg for the peas and the chickpeas, and 0.15 mg/kg for the lens).

Keywords: *Bacillus subtilis* (natto), bacterial fermentation, legume seeds, pesticide residues, dissipation kinetics

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Determination of the effects of radiation sterilization process on alder buckthorn *(Rhamnus cathartica L.)* and marshmallow *(Althaea officinalis L.)* and the radio sterilization detection by electron paramagnetic resonance (EPR) technique

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As stated by WHO reports, that is known contaminated food causes over 200 illnesses, and these illnesses contribute to global mortality and disease burden. Furthermore, this issue has a significant socioeconomic impact, affecting trade, tourism, and the healthcare system. While this is the case, the importance of researching the preservation and processing techniques to prevent contamination at any stage of the food production, distribution, and consumption chain is quite clear. In recent years, storing foodstuffs by sterilizing them through irradiation has become one of the most popular preservation methods. Although the radio-sterilization process has many advantages, it is necessary to determine the optimum sterilization dose for each food item and to reveal the changes caused by radiation in the structure of the food.

With this motivation, in the present study, the radiosterilization process of Alder Buckthorn (Rhamnus Cathartica L.) and marshmallow (Althaea Officinalis L.), well-known medicinal herbs in the Mediterranean area used for many diseases, were investigated by using the electron paramagnetic resonance (EPR) technique. Alder Buckthorn (Rhamnus Cathartica L.) is a plant from the Rhamnaceae family. Although its most common use is to reduce constipation symptoms, it is also known to be used in diabetes and cholesterol control. It is known that the marshmallow (Althaea Officinalis L.) plant has been used for many years to treat diseases such as fever, eczema, constipation, and cough.

In the present study, to reveal the radiation effects on the herbs and the detection of the radio sterilization process EPR analyses were performed.

Keywords: electron paramagnetic resonance (EPR), radiosterilization, marshmallow, alder buckthorn

Genotoxic screening of the effect of *Rosa gallica* L. essential oil evaluated by induction of chromosome aberrations and micronuclei in plant and human lymphocyte test-systems

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Rosa gallica L., also known as the French rose, is one of the species belonging to the Rosaceae family spread in various countries in Europe, being also grown in the Rose Valley, Bulgaria. Its fine essential oil finds application in folk medicine, perfumery, cosmetics and culinary. Irrespective of its wide use by humans, a lack of information exists about the toxic and genotoxic effects of this rose product. Thus, it is important to assess its safety and non-toxic concentrations.

The aim of the present study was to test the cytotoxic and genotoxic/clastogenic activity of the *R. gallica* L. oil using tests for induction of chromosome aberrations and for micronuclei in higher plant *H. vulgare* (barley) and human lymphocytes *in vitro*. The cytotoxicity was evaluated by the mitotic index and nuclear division index.

The cells of *H. vulgare* were affected by *R. gallica* oil in concentrations of 100, 200, 500 μg/ml, and lymphocytes by 50, 100, 500 μg/ml (4 hs), respectively.

The essential oil was not cytotoxic for barley cells, while the mitotic index measurements indicated minimal cytotoxicity in lymphocytes. The rose product had low but statistically significant genotoxic activity as it increased both the endpoints for genotoxicity - chromosome disturbances and micronuclei in the test-systems used. No concentration dependence was obtained for the frequency of aberrations and micronuclei in barley, whereas in the lymphocyte cells, such effect was registered for the chromosome aberrations only. The cytotoxic/genotoxic effect of this rose oil applied at all concentration in our study was much weaker than that of the positive control N-methyl-N'nitro-N-nitrosoguanidine.

The obtained data reveal the safety concentrations and conditions for this rose product application and would be useful for its further application in human life.

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The impact of melatonin treatment during the vinification of Moldova wine on its cytotoxic effects

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Melatonin, an indoleamine hormone that regulates the circadian sleep cycle, is primarily secreted in the pineal gland. It is also produced by plants and yeasts. Different grape varieties and wines contain varying amounts of melatonin. Recent studies have explored melatonin's role in various fields, including vinification, due to its potential health benefits and protective effects against oxidative stress. As a powerful antioxidant, melatonin can protect against oxidative damage by scavenging free radicals, potentially enhancing the antioxidant profile of melatonin-treated wine and reducing oxidative stress, a factor in cancer development and progression. Melatonin also exhibits anti-inflammatory properties, creating a less favourable environment for cancer cells. Additionally, it influences cellular signalling pathways that regulate cell proliferation, apoptosis, and metastasis, thereby inducing apoptosis in cancer cells and inhibiting their growth and spread. The Moldova grape variety, an international hybrid, is one of the most popular black grape varieties in Serbia, Macedonia, and other Balkan countries. Moldova is resistant to phylloxera and fungal diseases, particularly downy mildew and gray mold, making it suitable for organic production without chemical protection.

The objective of this study was to examine how the addition of melatonin during the vinification process affects the cytotoxic potential of Moldova red wine against HCT116 and PANC-1 cancer cell lines.

Materials and Methods: For this experiment, healthy fibroblast cells (MRC-5), as well as two cancer cell lines, HCT116 (colorectal carcinoma) and PANC-1 (pancreatic carcinoma), were used. The cytotoxic activity of the analyzed wines on MRC-5, HCT116, and PANC-1 cell lines was determined using the MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) tetrazolium reduction assay. After 48 hours of treatment with two different wine concentrations (2.5% and 5%), absorbance was measured at a wavelength of 550 nm using an ELISA plate reader (Victor2 1420 Multilabel Counter, Wallac, Turku, Finland). The results were expressed as a percentage of the control (100% survival).

Results: Cytotoxic effect of V1 (Moldova wine without added melatonin in vinification process) and V2 (Moldova wine with added melatonin in vinification process) wines was the lowest on MRC-5 cells, ranging between 98.5 and 73.7% compared to untreated cells. Conversely, the cytotoxic impact on the two cancer cell lines demonstrated higher percentages, reaching 75.9% to 46.2% on HCT116, and 82.1% to 63.9% on PANC-1 cells. Notably, the HCT116 cells displayed greater sensitivity when compared to PANC-1 cells. Additionally, the wine with added melatonin during the fermentation process demonstrated a greater effect on both cancer cell lines compared to wine without added melatonin during fermentation. The same effect was noted on the healthy cell line, although considerably smaller in comparison to the examined cancer cell lines. As the concentration of tested wines increased, a corresponding rise in its cytotoxic effect on cancer cells was observed, suggesting a dose-dependent relationship between the wine concentration and cytotoxicity.

Conclusion: Melatonin treatment in the vinification of Moldova wine enhanced its cytotoxic effects on cancer cell lines. Further *in vitro* and *in vivo* studies are necessary to confirm these effects and understand the underlying mechanisms. If proven effective, melatonin-enriched wine could become a beverage with added health benefits.

Keywords: red wine, melatonin, vinification, cytotoxic activity, cancer cell lines

The testing of current characteristics of adaptive potential of the body in patients with catarhal gingivitis against the background of radiation and chemotherapy

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Oncopathology treatment using radiation and chemotherapy often leads to the development of periodontal diseases of an inflammatory nature, which aggravate the general condition and worsen the life quality of patients. The result of any pathological process is determined by the state of the body's adaptive potential, which is characterized by the current level of reactivity (LR) and the type of nonspecific adaptation reaction (NARO).

Aim: To determine the type of nonspecific adaptive reactions and the level of reactivity of the body in patients with inflammatory periodontal pathology that developed after a course of radiation and chemotherapy of common oncological diseases.

Methods: Clinical observations were carried out in the dynamics of treatment of 37 patients aged 35 to 50 years with catarrhal gingivitis, with a history of antitumor radiation (3 months before the first visit to the dentist) and chemotherapy (5 months before the first visit to the dentist) for malignant neoplasms. The control group consisted of 17 somatically healthy patients with catarrhal gingivitis. The determination of the current type of NARO and UR was carried out according to the signal indicators of the leukocyte formula (Garkavi L.H., Ukolova M.A., Kvakina E.B., 1998, 2015) taking into account the practical recommendations of Stupin F.P. and Tatkov O.V. (2017). The hygienic status was evaluated by the PI and API indices; inflammation activity in the periodontium – by the SBI index.

Results: A chemotherapy for breast cancer using medicines with high stomatotoxicity (doxorubicin, paclitaxel, taxotere) was established in 19 patients according to the anamnesis. Nine patients in their anamnesis underwent three courses of chemotherapy for gastric cancer using cisplatin and capecitabine, lasting 14, 21 and 28 days. Nine patients underwent radiation therapy (radiiodine therapy) for a year with intervals of 1 time every 2.5-3 months for papillary thyroid carcinoma. During examination all observed patients had increased gum bleeding (SBI - 2.5±0.01), a large amount of soft dental plaque (PI - 46.2±0.02), the presence of dark-colored hard dental deposits, mainly in the interdental spaces and in the area of the necks of the teeth (API – 68.03±0.02).

Signal indicators of the leukocyte formula of peripheral blood, characterizing the type of NARO and the level of reactivity in 18 patients after chemotherapy corresponded to a negative reaction of reactivation in combination with a low level of reactivity, and in 10 patients - to negative reactions of stress and reactivation in combination with an average level of reactivity. In 9 patients which were observed after radiation therapy, parameters characteristic of the stress reaction and the average level of reactivity were identified.

Out of 17 patients in the control group with catarrhal gingivitis, 10 patients were diagnosed with negative stress reactions and reactivation in combination with a low level of reactivity. Positive reactions of training and calm activation in combination with an average level of reactivity were identified in 7 observed patients. The index evaluation of hygienic status and periodontal disease with unfavorable characteristics of adaptive potential (PI – 32.3±0.03, API – 46.8±0.03) differed significantly from the corresponding indicators for persons with positive combinations of NARO and UR types (24.6±0.02, API –26.4±0.02, SBI – 1.83±0.01).

Conclusion: The inflammatory process in periodontal tissues in all patients with cancer pathology after radiation and chemotherapy develops against the background of unfavorable characteristics of the adaptive potential in the form of negative reactions of reactivation and stress in combination with a low and medium level of reactivity, which reduces the effectiveness of standard treatment regimens and requires the development of an individual approach to planning and carrying out treatment and rehabilitation measures for this category of patients.

Calculations of electric and magnetic fields at the location of the intersection of two overhead power lines

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The paper is related to an important topic of the exposure of the general public to electric and magnetic fields in the vicinity of transmission overhead power lines. The analysis is carried out for the real situation where there is an intersection of 110 kV and 400 kV overhead power lines. The analysis is based on results of electric field strength and magnetic flux density calculations. The calculations are based on two models. In the first case the lines are modeled with infinite straight-line conductors. In the second case the lines are modeled with series of catenaries. The results obtained by using these two models are compared. The results are also compared with the calculation results obtained in the case when there is only one power line. The influence of different phasing on one of these power lines is also analyzed. All the results obtained by calculations are compared with the reference levels prescribed by the Serbian and international legislation regarding protection of the general public from electromagnetic fields.

Calculations of magnetic flux density in the vicinity of the 10/0.4 kV substations with 0.4 kV busbars

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The paper addresses a very important topic of the general public exposure assessment to magnetic field in the increased sensitivity areas near 10/0.4 kV substations. According to Serbian regulations, increased sensitivity areas include residential buildings, houses, schools, hospitals etc. The levels of power frequency magnetic flux density which occur in the increased sensitivity areas located near 10/0.4 kV substations are analyzed in the paper. The analysis is based on the results of magnetic flux density calculations which are based on 3D modelling. With the purpose of estimating the exposure of the general public to magnetic field, the obtained results were compared to the reference levels prescribed by both Serbian and international regulations. Regarding international regulations, the obtained results are compared to the levels prescribed by the Recommendation 1999/519/EC and by the ICNIRP guidelines from 1998 and 2010. Regarding Serbian regulations, the Law on protection from non-ionizing radiation and accompanying rulebooks are taken into account. Taking into consideration the national regulations of the Republic of Serbia is very important for the topic of this paper as well since the reference level for magnetic flux density prescribed by the Serbian regulations is lower compared to the levels prescribed by Recommendation 1999/519/EC and ICNIRP guidelines. Previous testing results have shown that 10/0.4 kV substations located inside buildings can represent a significant source of magnetic field in increased sensitivity areas located next to them. The levels of magnetic flux density in these cases primarily depend on transformer type and its rated power as well as on the equipment disposition in the substation in relation to the nearby increased sensitivity areas. In the Republic of Serbia oil transformers are frequently used in 10/0.4 kV substations. In these cases the dominant source of magnetic flux density are the 0.4 kV busbars which connect the transformer and 0.4 kV switchboard. For that reason, this paper focuses on this type of 10/0.4 kV substations. The magnetic flux density calculations are based on 3D model of 0.4 kV busbars. The calculations are repeated for different distances from the busbars and for different values of the transformer rated load. The objective of the performed analysis is reaching general conclusions on the levels of magnetic flux density which may occur in the vicinity of the abovementioned substations, as well as the assessment of compliance with the national and international regulations on protection of the general public from electromagnetic fields.

Applying principles of circular economy to wearable devices for greener production and use

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Considering that by 2030 it is expected that 65% of the world's population will use some kind of wearable device, that the market for wearable devices will grow exponentially, and that the amount of electronic waste will greatly exceed 50 million tons annually, this amounts to an incredible figure of a predicted 852 million metric tons of annual carbon dioxide emissions generated by electronic waste in 2030, a large percentage of which will be generated due to the use of wearable devices. A reduction of waste can be achieved by applying principles of circular economy to the production and use of wearable devices. Since the lifecycle of a hardware product includes development, application of novel technologies, the possibility of improvement, replacement or modification of a component, disassembly, repair and reuse of different components, there is room for minimizing waste at each stage of the lifecycle. Using the example of a wearable device produced by our spinoff company, which is in the prototype phase, we present a plan to create guidelines for the application of circular economy principles when developing prototypes to final products, especially applied to wearable devices. Guidelines related to this early stage of product development can have a major impact on reducing e-waste on the wearables market, as each such product goes through a development path that includes a prototype in the first phase, then moving towards a final product for production. The expected result of the implementation of the plan is an extension of the lifetime of the product by up to 70% (with the use of bioplastic and thermoplastic materials), which will result in a reduction of carbon dioxide emissions by up to 50%. The plan is based on the 7R principle: Redesign, Refuse, Reduce, Reuse, Repair, Recycle and Recover.

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Diagnostic and dosimetry for laser-driven proton beams

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Laser-based radiation stands at the forefront of acceleration techniques. When high-power (>TW level), short-duration (< 30 fs) laser pulses are focused on a small spot size, the resulting radiation pressure initiates a cascade of physical processes capable of accelerating ions to intensities ranging from E9 to E11 particles/steradians.

Laser-driven acceleration presents a highly promising avenue for future medical physics applications. Laser technology offers the potential to produce various types of radiation—photons, electrons, protons, neutrons, and ions—using a single accelerator machine. With the right target and transport system in place, it could enable the selection of diverse radiation types with characteristics compatible with conventional accelerator machines.

Furthermore, laser-driven proton beams exhibit remarkable intensity, with peak dose rates reaching up to 10^7 Gy/sec, making them particularly appealing for clinical applications. However, integrating laser-driven acceleration machines into medical contexts poses significant technical challenges for the scientific community. Currently, there is no established dosimetric protocol for laser-driven proton beams. Transport, selection, diagnostics, and detection systems must be tailored to operate effectively within these unique regimes.

This presentation will offer an overview of the latest advancements in laser-driven ion diagnostic and dosimetry. It will showcase cutting-edge developments in detector technology, alongside a critical examination of current limitations and potential avenues for future progress.

Optimizing Capillary Design for Very High Energy Electron (VHEE) Applications

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In recent decades, high-energy electron radiotherapy (VHEE) has garnered attention for its potential to revolutionize dose distribution, surpassing traditional photon-based radiotherapy. This refers to a type of radiotherapy that utilizes high-energy electrons for the treatment of cancer. These electrons are accelerated to high speeds and energies before being directed at the tumor site to deliver therapeutic radiation. One of the primary advantages of VHEE is its ability to enhance dose distribution compared to traditional photon-based radiotherapy. Electrons, being charged particles, exhibit different physical properties compared to photons. They deposit energy more selectively and with greater precision, allowing for more precise targeting of tumors while minimizing damage to surrounding healthy tissues. This enhanced dose distribution can potentially lead to better treatment outcomes and reduced side effects for patients. Traditional photon-based radiotherapy has limitations in terms of dose distribution and the ability to spare nearby healthy tissues from radiation exposure. VHEE offers the potential to overcome some of these limitations by providing more focused and precise radiation delivery. This approach not only promises improved dose distribution but also offers potential for high dose-rate irradiation, presenting a compelling avenue for enhanced cancer treatment outcomes using both a better conformationally and the beneficial effects of the FLASH radiotherapy. On the other hand, practical implementation has been hindered by the limited availability of hospital-scale accelerators. To address this challenge, the utilization of high-gradient laser-plasma accelerators (LPAs) has emerged as a promising solution.

In this work we wish to address this challenge studying and designing a comprehensive set-up permitting the LPA electron acceleration using a laser interacting with a plasma generated in a capillary discharge. These electrons will be then susceptible to be used in a combined FLASH/VHEE modality. Plasma sources play pivotal roles in various industrial, scientific, and technological applications. These sources, including gas cells, gas jets, and plasma-discharge capillaries, are potential candidates for LPAs. Gas jet systems for LPA electron acceleration, offer flexibility but often have lower plasma densities, broader energy spreads, and reduced energies. Capillary systems, on the opposite, produce high-quality electron beams with precise control over final energy, though they require accurate laser focusing and a slightly more complicate set-up. Capillaries, indeed, excel in guiding and confining laser pulses and resulting plasmas over extended distances, this allowing for higher acceleration gradient and a more controlled emittance. In our upcoming work, we will outline the design of our future capillary system, slated for installation within the forthcoming laser facility, I-LUCE (INFN-Laser indUCEd radiation production), located in Catania, Italy. In addition to discussing the generated capillary and plasma characteristics, we will delve into an analysis of the expected electron beam characteristics. This comprehensive examination aims to provide a thorough understanding of the performance and capabilities of the system under consideration. As we further explore electron FLASH therapy and Very High Energy Electron (VHEE) sources, our endeavors are focused on bridging the divide between theoretical potential and practical implementation. This pursuit aims to pave the way for advanced cancer treatment modalities, ultimately leading to improved efficacy and better patient outcomes. The utilization of capillaries for e- LPAs holds promise, particularly in very high energy electron (VHEE) applications via the Laser Wakefield Acceleration (LWFA) scheme where energies and flux up to a few GeV can be reached.

Influence of energy factors of magnetron spray systems in the formation of transition metal diborides films

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Transition metal nitrides, carbides and diborides are members of a family of materials known as ultra-high-temperature ceramics. The most studied are film coatings of transition metal nitrides and carbides, which, due to their physical, mechanical and tribological characteristics, find wide practical application as a protective wear-resistant coatings on cutting tools.[1]

Film coatings of transition metal diborides (CrB_2, HfB_2, TiB_2, TaB_2, etc.) having high hardness with a rather low elastic modulus can be promising as heat-resistant and wear-resistant protective coatings in various industries. Due to the high melting point, the most widely used method for applying such coatings is magnetron sputtering, primarily using DC and RF magnetron sputtering. By changing the parameters of magnetron sputtering (working pressure, discharge power, substrate temperature, distance between the target and the substrate, bias potential), a wide range of particle energies can be achieved for the deposition and formation of films on the surface of the substrate. This makes it possible to obtain coatings of different structures and compositions with different physical and mechanical properties [2-4].

Based on experimental studies, we can identify the most significant factors that determine mass transfer processes during the formation of coatings during magnetron sputtering. In [5], three main parameters were identified with the help of which it was possible to regulate the growth process of titanium diboride films (substrate bias potential Us, ion current density on the substrate i_s, and temperature T_s). As a result, thermally stable super-hard coatings of transition metal diborides with high physical and mechanical characteristics were obtained.

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Alpha particle production from Laser-driven proton-boron nuclear reaction in hole-boring scheme

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Most of previous studies [1,2,3,4] on laser-driven proton-boron nuclear reaction are based on the measurement of α-particles with Solid-state nuclear tracks detector (Cr39). However, interpretation of Cr39 results is difficult due to the presence of several other accelerated particles which can bias the analysis [5]. Furthermore, in some laser irradiation geometries, cross-checking measurements are almost impossible. In this case, numerical simulations may play an important role in guiding the analysis of experimental results.

In this study, we analyze the data from two closely related experimental campaigns, exploiting different laser irradiation schemes (pitcher-catcher and direct-irradiation) but with the same laser parameters. Numerical simulations, validated in the pitcher-catcher geometry, have allowed obtaining conclusive results on laser-driven proton-boron reactions also in the direct-irradiation geometry.

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Optimizing capillary design for very high energy electron (VHEE) applications

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In recent decades, high-energy electron radiotherapy (VHEE) has garnered attention for its potential to revolutionize dose distribution, surpassing traditional photon-based radiotherapy. This refers to a type of radiotherapy that utilizes high-energy electrons for the treatment of cancer. These electrons are accelerated to high speeds and energies before being directed at the tumor site to deliver therapeutic radiation. One of the primary advantages of VHEE is its ability to enhance dose distribution compared to traditional photon-based radiotherapy. Electrons, being charged particles, exhibit different physical properties compared to photons. They deposit energy more selectively and with greater precision, allowing for more precise targeting of tumors while minimizing damage to surrounding healthy tissues. This enhanced dose distribution can potentially lead to better treatment outcomes and reduced side effects for patients. Traditional photon-based radiotherapy has limitations in terms of dose distribution and the ability to spare nearby healthy tissues from radiation exposure. VHEE offers the potential to overcome some of these limitations by providing more focused and precise radiation delivery. This approach not only promises improved dose distribution but also offers potential for high dose-rate irradiation, presenting a compelling avenue for enhanced cancer treatment outcomes using both a better conformationality and the beneficial effects of the FLASH radiotherapy. On the other hand, practical implementation has been hindered by the limited availability of hospital-scale accelerators. To address this challenge, the utilization of high-gradient laser-plasma accelerators (LPAs) has emerged as a promising solution.

In this work we wish to address this challenge studying and designing a comprehensive set-up permitting the LPA electron acceleration using a laser interacting with a plasma generated in a capillary discharge. These electrons will be then susceptible to be used in a combined FLASH/VHEE modality. Plasma sources play pivotal roles in various industrial, scientific, and technological applications. These sources, including gas cells, gas jets, and plasma-discharge capillaries, are potential candidates for LPAs. Gas jet systems for LPA electron acceleration, offer flexibility but often have lower plasma densities, broader energy spreads, and reduced energies. Capillary systems, on the opposite, produce high-quality electron beams with precise control over final energy, though they require accurate laser focusing and a slightly more complicate set-up. Capillaries, indeed, excel in guiding and confining laser pulses and resulting plasmas over extended distances, this allowing for higher acceleration gradient and a more controlled emittance. In our upcoming work, we will outline the design of our future capillary system, slated for installation within the forthcoming laser facility, I-LUCE (INFN-Laser indUCEd radiation production), located in Catania, Italy. In addition to discussing the generated capillary and plasma characteristics, we will delve into an analysis of the expected electron beam characteristics. This comprehensive examination aims to provide a thorough understanding of the performance and capabilities of the system under consideration. As we further explore electron FLASH therapy and Very High Energy Electron (VHEE) sources, our endeavors are focused on bridging the divide between theoretical potential and practical implementation. This pursuit aims to pave the way for advanced cancer treatment modalities, ultimately leading to improved efficacy and better patient outcomes. The utilization of capillaries for e- LPAs holds promise, particularly in very high energy electron (VHEE) applications via the Laser Wakefield Acceleration (LWFA) scheme where energies and flux up to a few GeV can be reached.

Radiation protection at the ELI Beamlines facility

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The ELI ERIC (Extreme Light Infrastructure European Research Infrastructure Consortium) aims at developing and operating the next generation of high-power laser systems in Europe. The Czech pillar of the consortium is the ELI Beamlines facility. It hosts world-class lasers with peak powers reaching 10 PW and repetition rates of up to 1 kHz. There, laser-driven beamlines deliver ultra-bright and ultra-short sources of X-rays, ions, and electrons for fundamental and applied research. Beam time is offered to users worldwide. The pulsed mixed radiation fields generated at the facility are challenging from a radiation protection standpoint. The facility beamlines feature peak energies reaching up to hundreds of MeV for ions and GeV for electrons. The beams are characterized by a broad spectrum with radiation delivered over an extremely short time structure, generally less than 1 ps. Furthermore, copious amounts of stray ionizing radiation are produced in reason of the intrinsic laser-matter interactions and beam scattering. An overview of radiation protection considerations at the facility is presented on the topics of radiation shielding and monitoring, Monte Carlo simulation studies, and personal safety interlock. Additionally, lessons learned from the latest beamline commissioning campaigns and user experiments, which provided considerable insight, are presented.

Empowering physics through large language models: A new paradigm for data analysis and simulation

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The development of large language models (LLMs) such as ChatGPT marks a significant step in artificial intelligence, impacting the field of physics and scientific education in general. This article examines the current progress in LLMs, focusing on their potential to improve learning by gathering and analysing vast amounts of information and its capability to generate detailed meta-analysis. It is highlighted how these AI tools are transforming access and processing of information, making advanced research and education more inclusive.

The paper discusses the benefits of LLMs for students and researchers in physics, showing how they can easily access “Big Data” and aid them in their work. Specifically, it looks at how LLMs help in writing code, enabling those with basic programming knowledge to create complex programs for analysing data, running simulations, and more. This support is vital in contemporary physics research and educational activities, making complicated computational methods much more approachable.

We explore how LLMs are instrumental in performing meta-analysis, integrating results from various sources to uncover new patterns and insights. Such comprehensive analyses are vital for progressing in both theoretical and practical physics, offering a richer, more detailed perspective that can generate innovation.

In summary, the integration of large language models into the physics domain promises to simplify and enhance research and education. By streamlining data analysis and simulation tasks, LLMs like ChatGPT are poised to significantly influence the future of physics, enabling wider participation and faster progress in scientific discoveries.

Optical and dielectric properties of BaF_2:(Er,Yb) double-doped crystals

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Luminescent materials incorporating rare-earth (RE) ions remain a focal point within the scientific community, owing to their captivating properties that bear immense relevance across a broad spectrum of burgeoning applications. Among these, rare-earth-doped fluorite materials stand out as active mediums for solid-state lasers, spanning the ultraviolet to middle infrared spectral region [1]. The up-conversion phenomenon observed in fluorites doped or co-doped with rare-earth ions has spurred investigations into their potential uses as optical temperature sensors [2], converters of solar radiation [3], and materials for scintillation purposes [4].

The vertical Bridgman technique was employed to grow a BaF_2:(Er,Yb) double-doped crystal. The optical absorption spectrum at room temperature revealed distinct bands characteristic for Er^{3+} and Yb^{3+} ions. In addition, abosrption bands in the UV spectral range characteristic of Yb^{2+} ions were observed. Using the Judd–Ofelt (J–O) formalism facilitated the estimation of forced ($4f$–$4f$) transition probabilities for Er^{3+} ions in (Er,Yb):BaF_2 crystals. The calculation of the J–O intensity parameters, Ω_t (t=2,4,6) from the optical absorption spectrum allowed assessment of spontaneous transition probability, line strength, branching ratio, and radiative lifetime. Comparative analysis with existing literature was conducted.

Upon 290 nm excitation, an UV emission band centered at 320 nm was observed, while excitation at 378 nm yielded the well-known green and blue emissions. For low dopant concentration the charge compensation take place through interstitial F^- ions in the next-nearest neighbor (NNN) lattice positions, resulting in trigonal site symmetries (C_{3v}). These dipoles can reorient in the presence of an external electric field. Throughout the investigated temperature range, a singular type of dielectric relaxation was observed, with an activation energy of 0.58 eV assigned to trigonal NNN centers. The number of NNN dipoles corresponding to the observed relaxation was determined. A detailed study of the dielectric properties of BaF_2:(Er,Yb) crystals has not been reported before.

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Computation of electron density in alloy semiconductors for device applications

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Alloying of semiconductors is often used to tune material properties desired for device applications. For instance, by changing the mole fractions of material chemical components one can vary the band gaps responsible for light absorption and light emission. The price for this tunability is the extra disorder caused by alloying.

Theoretical approaches developed recently [1-3] to compute the distribution of electron density caused by disorder potential are in the focus of the presentation. Mixed lead–tin triiodide perovskites $FAPb_{1-x}Sn_xI_3$ [4], atomically thin transition-metal dichalcogenides $Mo_xW_{1-x}Se_2$ [5], and organic semiconductor blends [6] are considered as examples. 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 [7].

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Effect of polyol molecular weight and structure cyclodextrins on biodegradable polyurethanes for pharmaceutical purposes

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Polyurethanes (PURs) are an important group of materials which are used for biomedical applications such as tissue engineering, orthopedic implants, transdermal patches, and drug delivery carriers. The applications of PUR have increased in recent years, because of their properties which can be adjusted according to their chemical structure. Polyurethanes are made as a result of the reaction of polyols, which form the "soft" or flexible segments, and diisocyanates and chain extenders, which form the "hard" or rigid segments, from which the microdomain structure is formed. Soft and hard segments with high molecular weights are immiscible and therefore create a mircophase-separated microstructure. The primary driving force for this microdomain formation is the immiscibility between the soft and hard segments, depending on the nature of both soft and hard segments and their chemical compositions. The microdomain structured polyurethanes, consisting of two different phases where one phase is a reservoir and another is a transport channel, allow regulation of the release profile of a drug.

In this paper the preparation and detailed characterization of designed polyurethanes (PURs) are reported for potential pharmaceutical applications. Two series of polyurethane networks were synthesized by using *β*-cyclodextrin (*β*CD) or hydroxypropyl-*β*-cyclodextrin (HP*β*CD) as cross-linker from alicyclic isophorone diisocyanate (IPDI) and polyethylene glycols (PEG2000 or PEG6000) or poly(ethylene glycol)-block-poly(propylene glycol)-block-poly(ethylene glycol) (BLOCK 1100).

The PURs were characterized by Fourier transform infrared (FTIR), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA) and X-ray diffraction (XRD). To visualize the morphology of the PUR samples, scanning electron microscopy (SEM) was used.

FTIR assignments confirmed the formation of urethane linkages. XRD patterns revealed that the crystallinity decreased mainly due to the crosslinking process. While the degree of crystallinity of both polyurethane systems based on *β*CD and HP*β*CD is approximately the same, it slightly increases with the length of the polyol chains of soft segments.

The thermal stabilities of two series of polyurethanes have been correlated with their soft-segment molecular weights and structure of cross-linker. The series of polyurethanes based on HP*βCD* displayed similar degradation profiles, suggesting that changes in soft segment molecular weight did not significantly alter the mechanism of thermal decomposiotion. It seems that the presence of the methyl group side of HP*βCD* is detrimental to the phase separation and hence reduces the extent of interurethane hydrogen bonding. The TGA curves also revealed that higher soft-segment molecular weights increase the thermal stability of polyurethanes based on *βCD* as cross-linker.

The DSC shows peaks of melting of soft segment in cross-linked polyurehanes based on HP*β*CD from 251.8 to 260.8 °C. As the molecular weight of used polyol increases, the peak of melting of hard segments increases from 296.1 to 311.4 °C. The series of polyurethanes based on *βCD* displayed similar trend in thermal transitions of soft and hard segments. The increase of melting point is attributed to an increase in the size of the crystallites or an increase of complete crystalline phase due to the greater phase separation the hard and soft segments. The results from the SEM micrographs showed that *βCD* contribute to the microphase separation.

The results showed that by varying the cyclodextrins as a cross-linker and the chain length of the soft segment, the stated properties of polyurethanes as potential drug delivery carriers can be influenced.

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Montmorillonite K10 and NaK10 as bifunctional materials: scavengers of formaldehyde from urea-formaldehyde resins and methylene blue in aqueous media

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In this study, montmorillonite K10 powder was compared with its chemically modified form with sodium chloride (NaCl), which we named NaK10. The comparison was mainly based on their possible ability to reduce the emission of formaldehyde (FA) from urea-formaldehyde (UF) resins, as well as to remove methylene blue (MB) dye from the aqueous medium. The ion exchange capacity (CEC) and specific surface area (SSA) of unmodified and modified montmorillonite were determined. The value of CEC for unmodified montmorillonite was 0.2 mol/kg and for modified 0.14 mol/kg. The specific surface area (SSA) of the K10 sample is 93.5 m^2/g and that of the NaK10 sample is 74.3 m^2/g. The disulfite method was used to determine free and liberated FA from UF resins modified with K10 (UF/K10) and NaK10 (UF/NaK10). By comparing the percentage of free FA in UF/K10 and UF/NaK10 resins, we determined that they have the same ability to reduce FA, regardless of the montmorillonite modification. The percentage of free FA in both modified resins is 0.12%. On the other hand, after acid hydrolysis, the percentage of liberated FA is higher in UF/K10 resin (2.76%) compared to UF/NaK10 resin (1.08%). Adsorption studies show approximate results for both montmorillonites. Montmorillonite K10 (0.5 g K10/50 cm^3 aqueous dye solution, c=20 $mgdm^{-3}$) was able to remove 97.64% of the methylene blue dye, while NaK10 removed 98.75% of the dye under the same conditions. Based on the obtained results, it is suggested that the NaK10 sample is more successful as an adsorbent both for the released FA from the resin and for the MB dye from the aqueous solution.

Keywords: urea-formaldehyde resin, montmorillonite, methylene blue, free and liberated FA

Laser-induced graphenization of poly (dimethylsiloxane)/poly(ethylene glycol) composite

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Laser-induced graphenization (LIG) of polymeric surfaces has emerged as a highly promising technology for fabricating wearable LIG-based sensors [1]. However, the single-step fabrication of LIG/polymer composites that are both biocompatible and conductive, as well as stretchable, remains a significant challenge.

This paper addresses LIG on novel biocompatible poly(dimethylsiloxane)/poly(ethylene glycol) (PDMS/PEG) materials using optimal processing conditions. The physicochemical properties of the prepared composite films were thoroughly characterized by Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy, scanning electron microscopy with energy-dispersive X-ray analysis (SEM/EDS), and electrical investigations. The study explored the effect of varying the PEG content (1-50 wt.%) within the PDMS substrate, revealing that adding PEG to PDMS is favorable for induction of graphene.The results confirm the formation of graphene on the surface of PDMS/PEG. FTIR and SEM/EDS analyses also indicated the presence of SiO 2 nanoparticles, attributed to the thermal degradation of the PDMS matrix under CO 2 laser treatment. The study of Raman spectroscopy peaks related to defects in graphene reveals an optimum concentration of PEG in the PDMS matrix for this type of process, similar to what was observed earlier with PEEK/PDMS composites [2]. Laser- induced graphene, prepared in a single step on a flexible PDMS/PEG composite film, presents a suitable candidate for bioelectronic applications, including medical wearable devices.

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Application of microwaves at treatment mineral raw materials

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Microwaves are currently widely used in many industrial applications due to their ability to produced intense heat. The condition for rapid heating is the absorption of high-frequency electromagnetic radiation. During the processing of primary mineral raw materials, the useful components of the ores /tetrahedrite, siderite, chalcopyrite, galena, pyrite/ are intensively heated due to different dielectric properties compared to useless components /quartz, barite/. The paper describes the effect of microwaves on the heating process of selected mineral raw materials. The heating rate depends on the method of irradiation, size, shape and the possibility of mixing samples. The powder samples containing Fe, Cu, Sb, Pb, Ag, Au and other metals are heated less intensively in the microwave field compared with bulk samples. By heating Fe-containing ores, such as $FeCO_3$, $CuFeS_2$, $(Cu, Fe, Ag, Zn)_{12}Sb_4S_{13}$ in the microwave field the magnetic properties of ores are modified. The result is an intensification of the processes of magnetic separation of microwave irradiated ores before the subsequent extraction of metals.

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Utilization of microwave radiation at brown coal treatment

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In its essence, coal is an accumulator of radiant and thermal solar energy, which our planet Earth received in its long-term geological history. Coal was mainly formed from plant remains, accumulated in the middle belt areas in water courses, lakes, sea bays and lagoons. Coal contains in its organic structure a large number of organic compounds, aliphatic or aromatic, which may be suitable for isolation with valuable chemical products. The organic structure of coal is various heterogeneous aromatic structures, including sulfur, oxygen and nitrogen in functional periods. Oxygen-containing groups in the structure of coal are mainly phenols, carboxyl and carbonyl groups.

Coal can be used to obtain various carbon materials such as carbon fibers, activated carbon, graphite materials, fullerenes or nanotubes. The sample of Slovak brown coal before and after microwave extraction in organic solutions were analysed by Fourier Transform Infrared (FT-IR) spectroscopy. This is an analytical method for characterizing and refining the chemical structure of coal. It is possible to obtain a spectrum of high quality and a semi-quantitative distribution of aliphatic and aromatic groups. FTIR confirmed the presence of aliphatic CH_x stretching vibration at 3000 - 2800 cm^{-1} and deformation vibration occur at 1470 - 1450, 1380 - 1375, 720 - 700 cm^{-1}. More intense aromatic C=C ring stretching vibration is at 1600 cm^{-1}. The peaks 900 - 750 cm^{-1} are due to two to four adjacent H atoms in the aromatic nuclei. The broad band at 3500 – 3400 cm^{-1} represents -OH stretching vibration of water.

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Effects of the injection of CrN nanolayers and Y in arc-deposited TiAlN nanocoatings: A precise X-ray diffraction study

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New-generation coatings for cutting tools, with improved adhesion and superior properties such as high hardness, high-temperature oxidation resistance, and low coefficient of friction, hold the potential to address numerous challenges encountered in high-speed cutting of difficult-to-cut materials. Traditional nitride coatings often do not meet these requirements effectively. Consequently, nanocomposite coatings such as TiAlN, TiAlSiN, and TiAlYN have emerged as promising alternatives because of their remarkably superior mechanical properties. Among these coatings, the TiAlYN nanocomposite stands out because of its low heat conductivity and other exceptional features. Yttrium promotes a significantly finer-grained and more equiaxed structure. Segregating to the nitride grain boundaries, it has been found to impede the outward diffusion of cations and the inward diffusion of oxygen. The next step to further enhance the properties of TiAlYN coatings is the introduction of a nanoscale multilayer modulation. Multilayer architecture shows the benefits of improving the meaningful properties of hard functional coatings. Whereas CrN is an established coating in machining and working applications for wear and oxidation protection, the conjunction effect of both structures in TiAlYN/CrN nanocoatings can bring its structural strength and, therefore, beneficial properties forward.

In this research, we performed the precise investigation of structural changes of TiAlYN/CrN nanocoatings employing an X-ray diffraction study to ascertain the effects of yttrium addition into the TiAlN matrix nanolayer and multilayer CrN modulation on the structural phase state. Filtered cathodic vacuum arc deposition provided a radical reduction, up to 80%, in the proportion of microparticles on the surface of the coating and within its volume. The conventional XRD and adjusted GI-XRD analyses enabled us to trace the shifts of peak positions, characterise the substructural variables, and interpret the diffraction data many-sided.

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Investigating the effects of weathering on barium crystal glass

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The model glass compositions were based on barium crystal glass [(10.49 Na_2O·2.36 K_2O·9.06 CaO·0.78 ZnO·2.44 BaO·0.85 Al_2O_3·74.02 SiO_2) mol%] and were changed by increasing and decreasing of each oxide content [1]. The composition of the prepared glasses was determined using X-ray fluorescence elemental analysis (XRF) [2], and an optical emission spectrometer with inductively coupled plasma (ICP-OES). Glass samples were subjected to controlled weathering conditions in a climatic chamber (Angelantoni Discovery DY110). Confocal microscopy (Sensofar S neox) was used to measure the roughness, and the results were compared to the roughness of the original pristine glasses. It was shown that obtained surface roughness can be used to quantify the degree of weathering. The results indicate a 2 to 3-times increase in roughness compared to non-corroded samples. The native and weathered surface of the samples was examined by optical microscopy (NIKON LV 100 UDM) [3], and no significant surface differences were observed with this method.

Keywords: glass, weathering, confocal microscopy, surface, roughness

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Physicochemical properties of modified silica glass compositions for medical applications

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The model silica glass compositions based on medical glass have been modified by increasing or decreasing the oxide content. The chemical composition was determined by X-ray fluorescence elemental analysis (XRF). Basic physicochemical properties such as density, low and high-temperature viscosity, glass transition temperature, and thermal expansion were investigated. The densities were measured at T = 25°C using the Archimedes Principle with distilled water and ranged from 2.383 to 2.515 g/cm^3. The thermal expansion coefficient and the glass transition temperature of the model glass were obtained by thermal dilatometer during cooling from a sufficiently high temperature with a cooling rate of 5 °C/min. The temperature dependence of viscosity was measured using a combination of rotational viscometer and thermomechanical analysis in the range from 10^2 dPas to 10^{12} dPas. The results were described by the empirical Vogel-Fulcher-Tammann equation. The Littleton Point, Annealing Point, and Strain Point were calculated.

Keywords: Silica glass, medical glass, viscosity, glass transition temperature

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Basic characterization of glasses for production of glass fibrous insulations used in nuclear power industry

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In the nuclear power industry, glass fibers are used as thermal insulation materials for pipelines and technological blocks. The chemical composition of glass fibers was determined by X-ray fluorescence analysis (BRUKER, Tiger S8) SiO_2-Al_2O_3-Fe_2O_3-CaO-MgO-Na_2O-K_2O. Thermal expansion and low-temperature viscosity were measured on prismatic samples by NETZSCH 402 thermomechanical analyzer. The coefficients of thermal expansion of the glass (167.10^{-7} K^{-1}), the metastable melt (413.10^{-7} K^{-1}), and the glass transition temperature (717 K) were determined from the cooling dilatometric curve, recorded at a cooling rate of 5 °C/min. The Arrhenius equation was used to evaluate the experimental viscosity points, and the obtained parameters were A = -22.72 and B = 37 479 K. Measurements were made on a DSC instrument TA Q2000 on powder and bulk samples in an inert atmosphere. The values of DC_p and the height of the relaxation peak were about 21% higher in the case of the powder sample. The liquidus temperature was determined using the first crystal method, and the density was measured using the Archimedes method. Finally, the molar volume was calculated.

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Physicochemical characterization of Au/PNiPAAm hydrogel nanocomposites: influence of nanoparticle shape

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Hydrogels are a class of polymeric materials with easily adjustable characteristics, and a wide range of applications, especially in medicine and biotechnology. Because of their great fluid absorption and retention capacity as well as their stable cross-linked three-dimensional structure, hydrogels provide an excellent platform for the stabilization of nanoparticles (NPs). Recently, hydrogels that exhibit environmentally responsive behavior and reversibly switch from hydrophilic to hydrophobic state in response to temperature changes represent a special class of intelligent materials. Poly(N-isopropylacrylamide) (PNiPAAm) is the most investigated thermosensitive polymer with a well-defined volume phase transition temperature (VPTT) around 32°C. On the other hand, noble metal NPs are very attractive due to their unique physicochemical, optical, catalytic, structural, and electronic properties. A hydrogel nanocomposite with the appropriate and preferred characteristics can be created by combining the benefits of metal nanoparticles and selected polymer material. Therefore, we present a simple, straightforward two-step synthesis of nano Au/PNiPAAm hydrogel nanocomposites that includes the chemical formation of NPs, followed by gamma irradiation induced PNiPAAm crosslinking in the presence of NPs. The gamma irradiation technique merges sterilization and synthesis in a single technological step, optimizing the process and opening up a wide range of innovative biomedical applications. The presence of AuNPs in the polymer matrix was confirmed by UV-Vis spectroscopy. The morphology investigation (TEM) of the colloid AuNPs indicated that the synthesized nanoparticles exhibited the intended shapes (nanospheres and nanorods), while SEM micrographs revealed the expected fibrous and porous structure of the PNiPAAm matrix. Physicochemical characterization was conducted in order to examine the swelling and deswelling processes, as well as a VPTT. The aim of this work is to investigate the influence of different AuNPs morphologies on the physicochemical properties of hydrogel nanocomposites, considering the potential applications and the ongoing need for the widespread use of biocompatible materials.

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Structural and optical properties of $CdWO_4$ films synthesized by chemical bath deposition

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Last decades thin $CdWO_4$ films have gained exceptional applications because of their high x-ray absorption coefficient and low radiation damage. Thin Cd-wolframite films can be used as sensors in a variety of applications such as radiation detectors but also in the processes of photocatalytic degradation of organic compounds.

In this work, we present a simple and effective chemical bath deposition method of $CdWO_4$ on glass substrates from one solution. The main challenge in the process of synthesis of tungstate thin films is the deposition rate and the chemical nature of transition metals tungstates which are insoluble in water. In the absence of the complexing agent, the nucleation and the quality of the films are challenging due to the high density of the $CdWO_4$ particles. Hence, complexation agents need to be included in the formulation of the deposition solution.

In our study, the Cd-tungstate films were deposited in an acidic environment at 100 ℃. They were annealed in the air from the room to 600 ℃ for 1 h. The process of thermal treatment was applied to induce the decomposition of the coordinative compounds and the improvement of the crystallinity of the deposited film. Preliminary FTIR results showed $CdWO_4$, with successful detection of υ_1 and υ_3 modes. Raman spectra confirmed the results from the FTIR analysis. XRD patterns showed a typical monoclinic structure. UV-Vis transmission spectra and the Tauc-plot confirmed the direct transition with a band gap E_g= 3.25 eV, which is in good agreement with the literature data.

Overview of the complex dehydration processes of hydrogels described by novel kinetics models

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The most abundant substance on the planet Earth and the main component of all living tissues is water. Mainly, the majority of materials in its natural conditions contain water either as chemically bound or retained in pores due to intermolecular interactions. However, water is also often deficient and the most sought-after substance on our planet. That is why the diverse methods for its recuperation and collecting have been extensively developed over time.

Dehydration is a complex reversible and endothermic physicochemical process of removing water from the material, which takes place under conditions of simulated energy exchange (especially heat) and mass transfer between the material and the external environment. The most important feature of the dehydration process is the dominant influence of the dehydration product on the mechanism and kinetics of water removal from the material.

Hydrogels are mainly defined as three-dimensional, cross-linked hydrophilic polymeric networks which have the ability to absorb a significant amount of water or other aqueous fluids (swelling) without dissolving or losing structural integrity. Hydrogels are extremely prominent against other polymeric materials because of their characteristic properties such as smart response to external stimuli, swelling ability, high water content, biocompatibility, adjustable porosity, and mechanical properties.

Due to their unique properties, hydrogels found versatile applications. Knowledge and governing of the hydrogel dehydration process is of astonishing practical and theoretical importance. Due to high water content, hydrogels should be assumed as model systems suitable for modeling the description of the kinetics of dehydration of foods and living tissues. It is especially convenient that in the case of pH-sensitive hydrogels, the dehydration process can be initiated not only by the temperature increase but also by the pH-change of the medium. For example, anionic hydrogels will desorb in medium with low pH value.

Water in hydrogels can be classified generally into three types: (a) bound water, which involves strongly bound and weakly bound; (b) associated water, involving strongly associated and weakly associated water; and (c) free water. According to their phase transition behavior, three types of water in hydrogels have been identified: nonfreezing, freezing bound, and free non-bound water. Many physical properties of hydrogels depend on the organization of water within and at the surface of hydrogels, including the way the water will be desorbed and to what extent under the applied conditions. Initially, the kinetic of the dehydration of hydrogels has been almost solely described by the diffusion kinetic model. However, new kinetic models have been developed that can describe hydrogel dehydration more precisely and with a higher degree of reliability. The complex kinetics of dehydration of hydrogels was described by a series of novel kinetic models: distribution apparent energy activation model, Webull's distribution of reaction times, the dependence of the degree of conversion (α) on the temperature, which is defined by the logistic function, coupled single step-approximation with iso-conversional curve. These models were applied to evaluate the dehydration kinetics of different synthetic and natural hydrogels based on: poly(acrylic acid), poly (methacrylic acid), poly(acrylic-co-methacrylic acid), poly(acrylic acid)-g-gelatin, alginate, gelatin.

It was determined that these new kinetic models can very appropriately describe the kinetics of dehydration of the investigated hydrogels covering the whole range of the dehydration process. The correlations among the values of the rate constants (k), activation energy (Ea), preexponential factor (lnA), with the primary structural properties of the investigated xerogels (hydrogels in dry state) were determined.

Stability of zircon in fluorine-containing hydrothermal fluids

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Zircon is a key mineral for geochronology and geochemistry. An important property of this mineral is stability in a wide range of natural conditions, therefore zircon is regarded as a potential material for the storage of radioactive waste. However, there is increasing evidence of zirconium mobility and zircon formation during relatively low-temperature hydrothermal processes, at temperatures around 250°C (Hay and Dempster, 2009; Rasmussen, 2005). Most cases of hydrothermal zirconium transport are associated with fluorine-containing fluids.

Fluoride ion is an important ligand for HFSE elements, including zirconium. The $Zr(OH)_3F_{(aq)}$ and $Zr(OH)_2F_{2(aq)}$ complexes in hydrothermal solutions were previously studied (Ryzhenko et al., 2008; Migdisov et al., 2011), but they cannot provide high solubility of zircon. The work (Tarnopolskaia and Bychkov, 2020) shows that zirconium is capable of forming the ZrF_6^{2-} complex, which predominates in hydrothermal solutions at near-neutral pH values.

Calculations have shown that the stability of the complex can provide high solubility of zircon in fluorine-containing solutions. At a constant fluoride concentration in solutions, the solubility of zircon will depend on pH. Dissolution reactions show that at pHHF solubility increases, reaches a maximum at $pH=pK_{HF}$, and decreases at $pH>pK_{HF}$. In turn, pK_{HF} depends on temperature and varies from 3.17 at 25°C to 7.12 at 350°C and saturated vapor pressure of water. The solubility of zircon was calculated based on data from (Tarnopolskaia and Bychkov, 2020) at a fluorine concentration of 0.1 mol/kg, which is characteristic of post-magmatic fluids. The calculation results showed that at $pH=pK_{HF}$ the concentration of zirconium in the solution reaches 300-700 ppm. An experimental study of the solubility of zircon in a HF-NaF buffer solution was carried out at a total fluorine concentration of 0.1 mol/kg. For the experiments, zircon single crystals were used, pre-treated with hydrofluoric acid. The experiments were carried out in autoclaves made of nickel alloy at 200, 250, 300, 350°C and saturated water vapor pressure. The time to reach equilibrium was determined by a series of kinetic experiments and amounted to 7 days at 300°C. The concentration of zirconium in experimental solutions was determined by XRF.

The results of the study coincided with thermodynamic calculations. The maximum concentration of zirconium was 300-700 ppm, at the point with $pH=pK_{HF}$. Such a high solubility of zircon is possible only in a narrow pH range, which is determined by the HF dissociation constant. Since the dissociation constant of HF increases with increasing temperature, at low temperatures the solubility of zirconium in fluoride solutions is maximum in the acidic range, and when the temperature rises to 350°C, in the neutral range.

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Microstructural, electrical, and tribomechanical properties of Mo-W-C nanocomposite films

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Features of the phase composition and microstructure and their influence on the properties of Mo-W-C nanocomposite films deposited by dual-source magnetron sputtering were discovered. Synthesised films consisted of metal carbide nanograins embedded in the amorphous C matrix. It was found that at a low carbon source power nanograins composed of a hexagonal b-(Mo_2+W_2)C phase. An increase in the power led to the change in the structure of the carbide nanoparticles from a single-phase to a mixture of the b-(Mo_2+W_2)C and NaCl-type α-(Mo+W)$C_{(0.65\leq k\leq 1)}$ solid-solution phases. The analysis of electrical properties revealed that the nanograin structure of the films favoured the occurrence of hopping conductivity. The double-phase structure led to a twofold increase in the relaxation time compared to the single-phase one. Films with both types of nanograin structures demonstrated tunnelling conductance without the need for thermal activation. The average distance between the potential wells produced by the carbide nanograins in nanocomposite films was approximately 3.4 ± 0.2 nm. A study of tribomechanical properties showed that Mo-W-C films composed of a mixture of the b-(Mo_2+W_2)C and α-(Mo+W)$C_{(0.65\leq k\leq 1)}$ phases had the highest hardness (19-22 GPa), the lowest friction coefficient (0.15-0.24) and wear volume (0.00302-0.00381 mm^2). Such a combination of electrical and tribomechanical properties demonstrates the suitability of Mo-W-C nanocomposite films for various micromechanical devices and power electronics.

Research of radiation resistance of diferent materials at the IBR-2 reactor in 2025-2032

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In the spring of 2025, the IBR-2 pulsed fast research reactor will continue its work on a physical experiment at the Frank Laboratory of Neutron Physics of the Joint Institute for Nuclear Research after a planned shutdown.

The unique characteristics of a pulsed reactor make it possible to study not only the radiation resistance of electronic components or semiconductors (nanoheterostructures etc) for tokamaks, colliders, and other megascience-class facilities, but also to conduct various studies of a wide range of materials and equipment for power and research nuclear reactors, as well as to conduct research in the field of radiochemistry, radiobiology, archaeology, mineralogy, etc.

Currently, the Joint Institute for Nuclear Research continues to collect applications for conducting such experiments in broad collaboration with the participating countries of the Institute, scientific and any other organizations interested in using neutrons to study the structure and properties of materials.

The role of ion-exchange natural bentonites in changing dielectric properties and AC conductivity

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In this study Na-bentonite (NaB) was prepared by modification the natural bentonite material (NB). NaB was cationically exchanged with Cu and Zn and samples with different concentration of Cu and Zn were obtained. The aim of this paper was investigation dielectric properties of Zn and Cu modiffied bentonite samples in the frequency range 30 Hz to 120 kHz at 25°C. The frequency dependence of the dielectric constant and dielectric loss tangent were explored. According to the results, for all samples, dielectric constant decreases rapidly at low frequency, whereas at high frequency shows almost independent behavior which suggested Maxwell-Wagner interfacial polarization. By modifying NaB with Zn and Cu particles, the dielectric constant decreases. The effect of Cu and Zn on AC conductivity was also explored. AC conductivity has showed a plateau at low frequency range and again NaB bentonite showed the highest value of conductivity. The AC conductivity of NaB and modified bentonites samples increased with increasing of frequency. Based of this, we assumed that the mechanism of charge conduction is a charge tunnelling. According to the presented results, we could assume that modiffied bentonite samples have high dielectric constant and could be good candidates for use in energy storage applications.

Influence of Cu on the microstructure and properties of CrMnFeNiCu high-entropy alloy and coating

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The abstract outlines a comprehensive investigation into the preparation and characterization of polycrystalline High Entropy Alloys (HEAs) containing varying concentrations of copper, as well as the deposition of films derived from these alloys onto silicon and stainless steel substrates. Deposition involved the use of an electron beam in the melting mode to generate gas-plasma clouds for subsequent film formation, resulting in thicknesses of up to 2 μm. Substrate preheating to 450°C was employed to enhance film-substrate adhesion. Microstructural, physical, and mechanical analyses were conducted on selected samples using X-ray Photoelectron Spectroscopy (XPS), Scanning Electron Microscopy (SEM) with Energy Dispersive Spectroscopy (EDS), and X-ray Diffraction (XRD) techniques. Additionally, High-Resolution Transmission Electron Microscopy (HRTEM) and Scanning Transmission Electron Microscopy (STEM) analyses are planned for more detailed characterization. Corrosion resistance assessments in various environments, including seawater and microbiological settings, will be performed to evaluate the suitability of these coatings and derived products for demanding operational conditions.

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Changes of podosomes morphology in the macrophages (RAW 264.7) as an indicator of inflammation (M1) or repair (M2) phenotype

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Podosomes (PDs) are cell adhesions structures that play a pivotal role in cell migration, mechanosensing, cell-matrix attachment, extracellular matrix degradation. Their morphology changes depending on the alterations in the surrounding microenvironment (e.g. substrate on which cells migrate or cell contact with foreign antibodies). Based on these changes, it is possible to assess the strength of adhesion, the speed and type of migration, and the reaction to foreign factors. The ability to identify specific changes in PDs morphology may become a valuable method for assessing the interactions of cells, primarily from the immune system, with various materials, crucial, for example, in regenerative medicine. Macrophages initiate and regulate the inflammatory process, destroy microorganisms, and participate in effective tissue regeneration process. Their role in implant acceptance or rejection is critical, because macrophage polarization M1 or M2 may be induced. Macrophage polarization is a reaction to specific microenvironmental stimuli and triggers immflamation or regenerative processes. PDs are dynamic, micron-sized structures with an F-actin core, cap structure on top of the core, and a ring of plaque proteins, such as vinculin, paxilin, talin that mediates the attachment to the extracellular matrix through binding to integrins. PDs form complex and picturesque structures named rings, clusters, rosettes or belts. Because PDs architecture may determine many immune function of macrophages, the aim of the present study was to identify PDs morphology in M0, M1 and M2 RAW 264.7 macrophages. M1 and M2 macrophages were generated by classical (IFN-γ and LPS) or alternative activation (IL-4 and IL-13), respectively, whereas M0 macrophages were cultured in a complete medium without addition of any factors. M1 and M2 macrophages were distinguished by the expression of NOS2 and arginase-1, respectively, using intracellular staining and flow cytometry analysis. PDs architecture in M0, M1 and M2 cells was assessed based on the distribution of actin and vinculin using immunofluorescence staining and fluorescence microscopy analysis. All phenotypes of RAW 264.7 macrophages presented the presence of PDs organized in clusters, rosettes and rings, but without podosomes belts. In M1 also single podosomes were identified and located in different parts on the ventral cell surface. Moreover, stimulation with LPS and INFγ resulted in further cell spreading and appearance of structures resembled podosomes fusion with a strongly marked ring of actin and peripheral accumulation of vinculin. Evans et al. (2003) reported the cluster of podosomes, which form transient actin-containing rings that vary in size after LPS and INFγ stimulation of mouse macrophages. Similar structures were also identified by Ronzier et al. (2022) but already 20 min after LPS and INFγ stimulation, especially in the perinuclear area, where F-actin is enriched during the contractile phase. Linder and Barcelona (2023) called these structures as „phagocytic podosomes". Our hypothesis assumes that macrophages treated with LPS for 24 h and INFγ for 48 h responded to inflammatory stimulation and organized the ring-shaped podosomes-like structures in RAW 264.7 cells. Taken together, our results indicate that the differences between M1 and M2 also apply to formation and organization of PDs in RAW 264.7 macrophages.

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Mobile X-ray systems with tomosynthesis mode

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In Ukraine, until now, about 900 extremely outdated film fluorography systems are used. Applying of this type of equipment is prohibited in almost all countries of the world. A formal ban of its usage is not implemented in our country. Thus, 8-10 million examinations are performed on film fluorography systems, which have high exposure and low quality of diagnostic images. Film fluorography systems need immediate replacement or adaptation to digital technologies. The organization of effective chest screening is especially relevant due to the presence of a tuberculosis epidemic in Ukraine, which was significantly worsened by the war.

The practice of fight with COVID-19 makes us take a fresh look at the place and role of X-ray diagnostics. A mass X-ray examination of chest organs revealed insufficient diagnostic sensitivity of digital radiography near 0,4.

The standard way to increase sensitivity in the diagnosis of lung pathologies is the implementation of computed tomography, the diagnostic sensitivity of which reaches 98%. This equipment is expensive, heavy, and has high radiation dose.

In a number of research are justified the application of devices with the regime of digital multi-slice linear tomography - tomosynthesis.

Taking into account world experience, since 2018, domestic enterprises in Ukraine have launched the production and installation of stationary X-ray machines with the tomosynthesis mode. In practice, they demonstrated both a significant advantage in diagnostic sensitivity compared to radiography, and a ten times lower radiation load compared to computed tomography.

Unfortunately, such stationary large X-ray systems can be installed only in the conditions of large medical institutions of 2-3 levels. The mobility allows to increase significantly the scope and place of use. Thus, there is a need for rapid development of a mobile X-ray complex with tomosynthesis.

This work presents two concepts of a mobile system with tomosynthesis for the medical diagnosis and for veterinary of small animals . They are based on already completed developments used in medicine and veterinary medicine and will combine their advantages.

It is expected that, in terms of diagnostic sensitivity, the devices will exceed existing x-ray mobile devices by a factor of two and will closely approach to computed tomography.

It is planned to create a mobile x-ray diagnostic device with tomosynthesis and radiography modes with the following parameters: the field of view of the receiver is not less than 430x430 mm, resolution of tomosynthesis and radiography mods not less 1,8/3,7 lp/mm, the mass, not more 120 kg and autonomous power supply.

Tribological and biomedical applications of boron nitride coatings

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Boron Nitride (BN) is a compound of Boron and Nitrogen. It has seven crystal structures (polymorphs or allotropes). Most stable allotropes are hexagonal boron nitride (h-BN) and cubic boron nitride (c-BN). h-BN is a soft and lubricous material whereas c-BN is very hard and an abrasive allotrope. The other five allotropes are turbostratic (t-BN), rhombodoidal (r-BN), explosive (e-BN), amorph (a-BN), wurtzig (w-BN) with intermediate properties. BN allotropes are very stable with a melting point of 2950 ° C . h-BN is used to lower friction and wear in mechanical systems. c-BN is used to increase hardness and wear life cutting tools. The authors have developed a PVD coating technique to coat BN allotropes on metallic surfaces to increase hardness or to lower friction. It is also found that, BN allotropes provide an osteoblastic and antibacterial property if coated on implants used in surgery.

Improved bio-performance of stainless steel 316L

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This study introduces a novel surface modification technique aimed at enhancing the biocompatibility of stainless steel grade 316L (SS316L) for biomedical applications. The process involves electrochemical anodization to create nanopores of varying diameters (100-300 nm) on the SS316L surface, followed by non-thermal oxygen plasma treatment. The modified surfaces were extensively characterized using scanning electron microscopy (SEM), atomic force microscopy (AFM), X-ray photoemission spectroscopy (XPS), and water contact angle measurements (WCA) to assess changes in surface morphology and chemistry.

Methodology: The experimental approach began with electrochemical anodization to produce nanoporous structures on SS316L substrates, controlling pore sizes between 100-300 nm. This was followed by non-thermal oxygen plasma treatment to enhance surface properties. Characterization techniques included SEM for surface morphology, AFM for topographical analysis, XPS for chemical composition, and contact angle measurements (WCA) for wettability assessment. Hemocompatibility was evaluated by analyzing platelet adhesion, while cytocompatibility was assessed through endothelial and smooth muscle cell adhesion studies.

Results: The combined treatment significantly improved the hemocompatibility and cytocompatibility of SS316L. Anodized samples with pore diameters ranging from 150-300 nm, followed by oxygen plasma treatment, showed optimal performance. These surfaces exhibited reduced platelet adhesion, enhanced endothelialization, and decreased smooth muscle cell adhesion compared to untreated SS316L and samples with smaller pores (100-150 nm). The absence of platelet adhesion on the treated surfaces suggests a promising application in vascular stents, potentially reducing the risks of restenosis and thrombosis. The study highlights the potential of this surface modification strategy to improve the interaction of SS316L with blood platelets and human coronary cells, making it highly suitable for biomedical implants. This innovative approach offers a significant advancement in the field of biomedical materials, promising to enhance the safety and effectiveness of SS316L-based medical devices.

Differential diagnosis characteristics for children's pilocytic astrocytoma

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The goal of our study was to identify MRI patterns and distinctive features of various forms of pilocytic astrocytoma (PA) in children.

We carried out a prospective examination of brain MRIs in 42 children aged between 1 and 15 years, diagnosed with PA, which was complicated by local recurrence and metastasis in the brain and spinal cord. The diagnosis was confirmed in specialized laboratories through immunohistochemistry and molecular diagnostics. Patients were observed for a period ranging from 1 to 5 years. Each underwent standard MRI, Diffusion Weighted Imaging (DWI), Arterial Spin Labeling (ASL) perfusion, and comprehensive spine MRI – T2 and T1 sagittal weighted imaging (WI) both with and without Gadolinium.

In 31 cases (77%), the PA presented as a solid mass with cysts of varying sizes, irregular contours, and expansive growth, with minimal surrounding edema. The solid portion of the tumor did not exhibit diffusion restriction. Post-contrast images revealed significant enhancement of the MR signal.

These tumors were found in the chiasmal region (13 cases), posterior cranial fossa—including the fourth ventricle, cerebellar hemispheres, brainstem (11 cases)—and in the temporal and parietal lobes (7 cases).

In one instance, bleeding within the solid portion of the tumor was observed.

In 11 cases (23%), the PA presented as a diffuse, infiltrative tumor without diffusion restriction or contrast enhancement. These tumors were located in the chiasm and extended along the optic pathways.

In six instances (14%), PA was complicated by leptomeningeal metastatic spread, evident through small foci of contrast enhancement along the ventricular walls, brain and spinal cord meninges.

Metastasis occurred in both nodular and diffuse lesions of the optic pathways. When PA was situated in the posterior cranial fossa, differential diagnosis included medulloblastoma, ependymoma, and hemangioblastoma. The key morphological distinction was the presence of a clearly defined tumor with a contrasting solid component without diffusion restriction. When PA was located in the brainstem, the main difference from diffuse brainstem glioma was its expansive growth. PA typically affected less than 50% of the stem area, with parastem expansion and compression of adjacent structures. Notably, it contained cystic inclusions of various sizes and contrasting solid parts, uncommon in diffuse gliomas.

In the middle cranial fossa and chiasmal-sellar region, PA was differentiated from craniopharyngioma, germinoma, and pituitary macroadenoma by its suprasellar positioning and distinct from pituitary tissue. Unlike other tumors, PA cysts did not contain protein.

PA constitutes up to 20% of all primary brain tumors in children and is classified as low-grade malignancy (WHO Grade 1). Despite its generally benign nature, a variety of chromosomal aberrations and gene mutations are found in the tumor, leading to variability in imaging patterns. Typically, the characteristic imaging of a PA suggests a probable diagnosis at the preoperative stage. However, the presence of numerous mutations can result in atypical appearances, a more aggressive tumor behavior, and misdiagnosis. Therefore, two primary tumor types are identified: a cystic-solid nodular tumor with defined contours and expansive growth, typically located in the posterior cranial fossa, chiasmal-sellar region, and cerebral hemispheres; and a diffuse tumor with infiltrative growth spreading through the optic tracts. Criteria for differential diagnosis from other tumors with similar MRI characteristics and locations include expansive growth, contrast enhancement by a solid nodule, absence of protein in the cysts, and diffusion restriction. Despite the benign nature of PA, all patients require a comprehensive spine MRI to rule out metastatic spread, as early detection can alter treatment approaches and prognoses.

Nuclear medicine imaging in paediatric nephro-urology

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Tc-99m-dimercaptosuccinic acid renal scintigraphy (DMSA) is the gold standard in the investigation of regional renal parenchymal function and estimates the contribution of each kidney to the total renal function. Diuretic dynamic renal scintigraphy, assesses drainage, showing if there is urinary stasis and where it is (in the renal pelvis or ureter, or at both sites).

Regarding the choice for imaging, after initial renal/bladder ultrasonography (RBUS), no uniform opinions have been relayed on the order of micturating cystourethrography (MCUG) or DMSA renal scintigraphy. Two approaches are recommended for the diagnosis of VUR: the bottom-up method (MCUG and, if positive, a DMSA scan) or the top-down method (DMSA scan and, if positive, MCUG). Because of the risks and cost of the MCUG test and radiation burden (from 0.5 – 3.2 mSv depending on technique), as well as its low yield for clinically significant (ie, high-grade) VUR, many have advocated obtaining MCUGs selectively. Our results showed that positive MCUG results increase the probability of renal damage by about 15%, while negative reduces the probability of renal damage by only 9%. Damage to the kidney tissue, which was previously attributed to UTIs or reflux nephropathy, can to be congenital also. DMSA scan is the current gold standard for assessment of renal parenchymal damage in a child with a history of febrile UTI. It is more sensitive to renal scarring than RBUS, which misses a substantial proportion of such cases. DMSA cannot differentiate acquired scarring from ante-natal dysplasia. Direct and indirect radionuclide cystourethrography is proposed for VUR diagnosing, but their accuracy is lower in comparison with MCUG accuracy.

Antenatal management includes antenatal ultrasound monitoring, usually repeated every 4-6 weeks. It is recommended that the assessment of the severity of postnatal hydronephrosis is based on the antero/posterior diameter (APD) of the renal pelvis. Extensive postnatal investigation was proposed to be limited to those with moderate or severe dilatation. MCUG and scintigraphy are usually preserved for children with postnatal APD >15 mm and/or abnormal kidney parenchyma, severe calyx dilatation ureteral dilatation, and bladder pathology.

Diuretic renal scintigraphy is important in the postnatal evaluation of infants with antenatally diagnosed hydronephrosis, particularly in distinguishing kidneys with poor drainage from nonobstructive hydronephrosis with good drainage. According to our diuretic renal scintigraphy results, we conclude that in the presence of partial or no drainage, the separate renal function may not be significantly impaired. The finding of poor renal emptying is significantly more common among children with increasing renal pelvis APD.

Artificial Intelligence in radiography: reviewing current applications and providing e-learnings for (future) radiographers

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Artificial Intelligence (AI) has changed radiology substantially in the last years, where the focus of attention has mainly been on the radiologist. However, the radiographer's role has been largely ignored even though AI is also affecting for example patient positioning, treatment planning and image reconstruction: tasks that are typically carried out by radiographers (and RTTs). Radiographers are currently 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, 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 study, retrospective study, 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 appears 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 and the results from previous steps into e-learnings for (future) radiographers to provide basic and more advanced knowledge on AI. A pilot was conducted among radiographers who followed the e-learnings and their feedback was incorporated into a finalized version that will become freely available online for radiographers and students of radiography.

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 and e-learnings for (future) radiographers, will be presented. The e-learnings will become freely available online for (future) radiographers.

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

Optimization of the accuracy of the electrical impedance tomography images of the lung

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Electrical impedance tomography (EIT) is a non-invasive method[1] for monitoring[2] of lung ventilation at the bedside. To improve the personalization and increase the information value of the method, optimization of the accuracy of the lung EIT images must be achieved.

Objective: To develop a methodology for individualized reconstruction of the EIT images

Materials and Methods: The investigation includes computer tomography (CT) and electrical impedance tomography (EIT) data of two mechanically ventilated trauma patients with pulmonary contusion, admitted to the Department of Anesthesiology and Intensive care, University hospital “St. George” (Plovdiv, Bulgaria). Following a CT scan analysis, a fem mesh is used for determination of the contour of the patient’s thorax. Subsequently the raw EIT data is reconstructed in the resulting individualized contour.

Results and Discussion: A protocolized approach to the individual patient is created. As a result of a comparative analysis between the lung areas on the CT image and the reconstructed EIT image taken at the corresponding thoracic level, the spatial morphological sensitivity of the EIT is determined (conformity index > 0.82). Thus, overcoming the limitations for placing the EIT electrodes at different than initially recommended positions[3,4], enables the clinical application of EIT in conditions characterized by heterogeneously disseminated or solitary lesions occur[5].

Conclusion: The personalized approach reveals the EIT potential to provide sufficient spatial resolution and image accuracy to support the optimization of mechanical ventilation, especially in case of heterogeneously disseminated or solitary lesions. It enables EIT practical application as a hybrid method for image diagnostics and monitoring of the pathophysiological changes in ventilation and perfusion in pulmonary contusion.

Key words: EIT, electrical impedance tomography, personalized monitoring, lung ventilation monitoring

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Simulation-based study of scattered radiation influence on contrast and spatial resolution in projection radiography

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The influence of noise that appears on a flat panel detector in projection radiography due to scattered x-rays was analyzed using Monte Carlo simulations. The model included a virtual contrast-detail phantom, containing metal discs of various thicknesses and diameters imbedded within a flat water-equivalent casing. Impact of scattered radiation was considered from the perspective of image quality, as expressed by the visibility of phantom structures, signal-to-noise ratio and contrast-to-noise ratio, for two different materials of the discs within the phantom (aluminium and copper) and for two x-ray energy spectra. Contribution of scattered photons to image noise was determined and analysed in conjunction with quantum noise. The obtained results demonstrate that the imaging conditions can be adapted to the physical contrast, scattering properties and dimensions of structures in the region being imaged, so that a better quality image is produced.

Improving the efficiency of X-ray diagnostics using lightweight digital X-ray diagnostic complexes

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All x-ray equipment in Ukraine is concentrated in less than 2,500 medical institutions of the second and third level. Half of the X-ray equipment is not used due to insufficient number of X-ray technicians. The average annual load on an X-ray machine in Ukraine does not exceed 2.5 thousand studies. The number of radiological studies is decreasing every year. If in 2009, for 10.0 thousand of the population, 9.3 thousand radiological studies were performed, then in 2022 - only 6.0 thousand.

As a result of this state of X-ray diagnostics, millions of Ukrainians do not have access to it, and general practitioners do not send patients for X-ray examinations due to the inability to quickly obtain their results. As a result, a significant number of violations of clinical protocols and a decrease in the quality of primary care. The paper considers the possibility of improving the availability and efficiency of X-ray diagnostics through the use of lightweight digital X-ray diagnostic complexes in primary care facilities.

Materials and methods: The lightweight digital X-ray diagnostic complex includes a monoblock-type X-ray emitter with an output power of 5.0 kW on a mobile stand, a mobile vertical stand for digital detector , a mobile trolley with an X-ray transparent deck, a digital X-ray detector and an operator's workstation. Such a set of equipment allows for X-ray examinations in the patient's standing, sitting and lying position.

In the work, a comparative analysis of the use of 3 lightweight digital X-ray diagnostic complexes in primary medical institutions in 2022, as well as the use of such a complex as part of mobile medical teams, is carried out.

Results: In 2022, the average annual load on one X-ray machine in Ukraine was 2,400 studies, and for the complexes under consideration, this figure was 3,788 studies, which is in 1.57 time above the national average. At 250 working days, this means that on average 15 studies were performed per day, and the national average was 10 studies. Mobile teams examined an average of 30 people per day. In 2022, 45 new cases of tuberculosis and 27 cases of lung cancer were detected at the 3 complexes, which is approximately 0.25% of the total number of these diseases detected in Ukraine. There are more than 8,500 x-ray machines in the country. If all X-ray machines were used with such efficiency as the complexes under consideration, the incidence rates of tuberculosis and lung cancer in the country would increase many times. The more active use of X-ray diagnostics by family doctors, when X-ray equipment is nearby, is evidenced by a significant number of detected pneumonias (12% of the total number of chest organ examinations), as well as a significant amount of detected pathology of the musculoskeletal system, which was detected in every fifth X-ray examination.

Conclusion: The use of lightweight digital X-ray diagnostic complexes in primary medicine institutions is more effective than the average in the country, both in the number of studies conducted and in the number of pathologies identified. GPs use X-ray diagnostics more in their work when X-ray equipment is nearby. Lightweight digital X-ray diagnostic complexes allow to bring X-ray diagnostics closer to the patient and to cover even those who cannot come to the medical institution with X-ray examinations

Mathematical modeling of stress-strain state of the thoracic spine in children

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Modeling of the stress-strain state of the thoracic vertebrae in children to justify the mechanism of radiological symptoms occurrence of compression fractures.

Materials and methods: To analyze the stress-strain state of the vertebral block, it was used the Finite Element Analysis (FEA). When constructing the model, the anatomical features and the average size of the vertebrae T5 - T7 and the corresponding intervertebral discs for children 14 (1 model) and 5-6 years (2 model) were taken into account. The calculations were carried out using the BioCad calculation program and the Looker visualization software for engineering calculations. The load was studied in vertical position (80% on the vertebral body and 20% on the articular processes), intermediate and full (100% load only on the vertebral body in the absence of contact in the articular masses of the vertebral segment T5-T7) torso inclination.

Results: In the 1st model, stress concentration zones with the vertical position of the body are located at the junction of the roots of the vertebral arches and articular masses. The level of stress-strain state in the vertebral bodies is 3.5 times lower (1-1.6 MPa) than in the junction zone of the roots of vertebral arches and articular masses (5.5 MPa). In case of partial tilt forward, the main zone of stress-strain state localization is in the middle of the front surface of the vertebral body. At full tilt, vertebral bodies become the main elements of the system, perceiving the load, additional stress concentration zones appear closer to the front and surfaces of the vertebral bodies in contact with the intervertebral discs. Compared with the vertical position, the tress-strain state level in T6 body increased to 3 MPa. For the calculations, emerging stresses do not exceed the strength limits of the vertebrae, however, with an increase in 6-10 times in load, it is possible to achieve a critical state in which a compression fracture can occur.

For the 2nd model, distribution pattern of the tress-strain state has changed: stress values remained at the same level, but the most stressed were the subchondral surfaces of the zygapophyseal joints, as well as areas of bone tissue near the vertebral end plates.

Conclusions: Changes in the value of stress-strain state in T5-T7 segment, in case of torso inclination, indicate critical areas and coincide with the localization of the most frequent radiological signs of vertebral bodies compression fractures in children.

Prevalence of emphysema in patients undergoing lung cancer screening using low-dose CT lung

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Chronic obstructive pulmonary disease (COPD) and lung cancer are leading causes of death globally, that share common risk factors such as age and smoking exposure.

Aim: To determine the prevalence of emphysema in high-risk population that underwent LDCT screening for lung cancer.

Methods: A secondary analysis of Lung Cancer Screening Database of Secretariat for Health Care of Autonomous Province of Vojvodina, Serbia between 20 th September 2020 -31 st December 2022. Persons aged 50-74 years, with a smoking history of ≥30 pack-years/or ≥20 pack-years with additional risks (COPD, prior pneumonia, other malignancy, family history of lung cancer or exposure to environmental carcinogens) were offered LDCT.

Results: Of total 1 288 participants, mean age 62.1±6.7 years, 535 male (41.5%), 386 (30.0%) had emphysema. Majority of patients with emphysema (301/386, 78.0%) had no prior history of chronic lung diseases. Compared to patients without emphysema, patients with emphysema reported more dyspnea (140/386, 36.3% vs. 276/902, 30.6%, p=0.046), chronic cough (117/386,30.3% vs.209/902, 23.17% p=0.007), purulent sputum expectoration (70/386, 18.1% vs. 95/902, 10.53%, p<0.001) and weight loss (45/386, 11.7% vs. 63/902, 7.0%, p=0.005). Patients with emphysema had longer exposure to smoking (pack/years, 43.8±18.8 vs. 39.3±18.1, p<0.001) and higher prevalence of solid or semisolid lung nodules (141/386, 36.5% vs. 278/902 30.8%, p=0.04). Radiation doses were maximally below the mean values of radiation doses when applying the standard and amounts : CTDIvol 0.77mGy, DLP 30,98mGy/cm, .avarge 0.42mSv

Conclusions: Almost one third of the patients who underwent LDCT screening had emphysema that was commonly undiagnosed despite being associated with significant symptom burden. Spirometry screening should be considered in high-risk population.

X-ray spectrum optimization for low dose CT

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The aim of the research is to increase the dose efficiency by using optimal X-ray photon distribution. The photon energy that, at the same dose, results in the highest contrast-to-noise ratio among the tissues relevant for brain imaging was searched. High atomic number filter materials were investigated to taking advantage of the jump of the linear attenuation coefficient at the K edge. Tube voltage- filter combinations were determined, which can be used to achieve an optimal near X-ray spectrum.

Materials and methods: The diagnostic usefulness of the image was characterized by the ratio of contrast between two tissues and the image noise (contrast-to-noise ratio, CNR). To measure the dose efficiency, we used the contrast-to-noise ratio normalized by the square root of the dose (CNRD), which is independent of the chosen noise level. The CNRD was analytically determined using the python program package called SpekPy [1, 2]. The harmonic mean of clinically relevant soft tissue contrast-to-noise ratios (HM-CNRD) were optimized as a function of tube voltage and filter material and thickness. The available dose rate was investigated assuming that the tube has the same thermal properties independently of the applied tube voltage and filter. 120 kV tube voltage with 5 mm aluminium filtration was considered as reference beam quality.

Results: The proper choice of the tube voltage and aluminium filter makes 2.1 % improvement of the HM-CNRD possible while maintaining the dose rate. A further 1.5 % improvement is possible by using filter material with high atomic number (e.g. thallium). The reduction of the dose rate to 10 % of the reference dose rate allows 18 % improvement of the HM-CNRD with aluminium filter and 21.4 % improvement with hafnium filter. 80 kV tube voltage with 0.23 mm hafnium filter resulted 16 %, 57 % and 44 % improvement of the CNRD in case of the three lowest contrasts, respectively.

Conclusions: Significant optimization is possible in the lowest contrasts of the brain imaging (e.g. grey matter - white matter contrast), but at the cost of a decrease in the dose rate, so low- dose imaging may be the main area that benefits from spectrum optimization.

Keywords: dose efficiency, X-ray energy spectrum, contrast-to-noise ratio, image quality optimization

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Molecular magnetic resonance imaging of prostate cancer using core/shell nanoparticles

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After lung cancer, prostate cancer (PC) is the most common and the second leading cause of cancer death (1). Currently, the gold standard for PC diagnosis is prostate-specific antigen (PSA) testing and digital rectal examination (2), Computed Tomography, Positron Emission Tomography (3), etc. are used for PC diagnosis and staging, yet they are of limited value. Molecular MRM using targeted contrast agents may rectify limitations of these methods.

To improve the tumor contrast we have developed new core/shell $NaDyF_4/NaGdF_4$ nanoparticles changing both T_1 and T_2 relaxation times of surrounding water molecules and conjugated them with tumor specific antibodies and proteins. We also investigated toxicity, biodistribution and clearance of the new contrast agent. The relaxation times (T_1 and T_2) of the nanoparticles with various core/shell sizes and concentrations were measured at 9.4T. We performed in vivo imaging using mouse model of cancer and used 9.4T MRI system. We imaged nude mouse with the tumor before and after the injection of targeted and non-targeted contrast agents.

Our results show that the new contrast agents may allow earlier detection of cancerous tissues than standard T1- or T2-only contrast.

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A multicentric study on a dosimetric comparison of extended SSD technique, VMAT-based and helical tomotherapy (HT) for total body irradiation (TBI)

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Various methods such as extended SSD (source skin distance), HT (helical tomotherapy), and VMAT-based, have been described to be applied in total body radiotherapy planning with developing technological infrastructure and new linacs. In study, it was aimed to evaluate the dose volume histograms (DVH) of extended SSD technique, VMAT-based, and helical tomotherapy plans dosimetrically in a multi-institutional context to achieve higher plan quality and to harmonize total body irradiation plans.

Methods: Four different clinical centers participated in the study. The CT images of ten patients (5 male, 5 female) with AML or ALL underwent allogenic stem-cell transplantation following TBI were used in this study. During the first phase, ten patients enrolled for TBI were planned by multiple centers according to a common protocol. The prescription dose was 12 Gy in 6 fractions. During the second phase, all centers shared their plans' DVHs. Treatment plans were evaluated according to the critical organ dose limits. Statistical analysis was performed in the SPSS (version 22.0) program ($p<0.05$).

Results: Forty TBI plans from 4 centers were evaluated. In study, the results indicated that there was a statistically significant and considerable difference in the dose coverage of PTV between the four techniques ($p<0.001$). The results showed that the mean lung doses of the four centers were below 10 Gy. No significant difference in maximum liver doses between plans was obtained. The results for the lenses indicated that there was a statistically significant and considerable difference between plans. The statistical analysis shows the significance of dose differences for kidneys resulting from four techniques in radiotherapy. And, the results indicated that there was a statistically significant and considerable difference in the beam delivery time and MU between the four techniques ($p<0.001$).

Conclusion: In conclusion, although four treatment techniques were suitable for TBI treatment, more homogeneous dose distribution, and lower critical organ doses were obtained with the tomotherapy technique. However, treatment time, MU, and dose rate for lung were disadvantages of the tomotherapy technique. When it comes to deciding on the TBI treatment method, it need to be reviewed some important points. An acceptable treatment and planning time, repeatability of treatment, dose rate, and being comfortable for both patient and team, room size and shielding are the other important points. It is needed to sufficient data on long-term results to be able to standardize TBI techniques between centers.

Keywords: Total body irradiation, Helical tomotherapy, VMAT, X-SSD, dosimetry

Assessment of intrafraction prostate movement based on ultrasound monitoring

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The basic assumption in radiotherapy is the precise delivery of the prescribed dose to the volume of the tumour. Therefore, it is important to control the position of the target during exposure (intrafractional movement) and determine the occurring shifts. This is particularly important in the case of irradiation of the prostate, which is surrounded by the organs at risk (rectum, urinary bladder). One method of checking the position of the prostate is ultrasound monitoring. In our study, we determined the location of the prostate in patients undergoing conventional and hypofractionated therapy, using 4D ultrasound monitoring. The aim of the analysis was to detect the intrafractional prostate movement and determine the frequency, duration and size of the dislocation during irradiation.

Material and methods: The Clarity® Autoscan (Elekta) Transperineal Ultrasound (TPUS) system was used to monitor 4D prostate movement in real time during treatment. TPUS monitoring data were assessed for 131 fractions for 10 patients (32 trajectories for 5 patients who underwent hypofractionated radiotherapy with dose per fraction 6 and 6.1Gy and 99 for 5 patients treated conventionally with 2.7 and 2.75Gy per fraction). The ultrasound system was used for intrafraction monitoring along the 3 directions: superior-inferior (SI), left-right (LR) and anterior-posterior (AP). Intrafraction prostate displacements exceeding thresholds of 3mm and 5mm were assessed for frequency and duration of motion.

Results: Prostate motion exceeded the 3 mm threshold during 9 of 32 fractions in patients receiving hypofractionated radiotherapy. For 3 of the 9 cases, the displacement was greater than 5 mm. Movements exceeding 5 mm lasted 50%, 27% and 2% of the irradiation time and occurred only during one fraction, suggesting unusual mobility during this one fraction of irradiation. The displacement greater than 3 mm occurred in 35 of 99 fractions in patients receiving conventional radiotherapy. Exceeding the 5 mm threshold, which lasted an average of 31% of the treatment time (ranging from 4% to 91%), was found in 20 of 35 fractions. Only for one fraction a shift exceeding 5 mm was recorded twice. The mean prostate displacements of (0.6 ± 0.78)mm, (-0.3 ± 0.64)mm and (-1.0 ± 1.1)mm in the SI, LR and AP directions were determined, respectively for hypofractionated radiotherapy and (0.5 ± 1.1)mm SI, (0.0 ± 1.6)mm LR and (-0.4 ± 1.3)mm AP for conventional radiotherapy. The recorded movement of the prostate during irradiation was limited to the area defined by the applied margin for each patient and for each fraction.

Conclusion: Intrafraction ultrasound monitoring can increase the accuracy of determining prostate displacement during both conventional and hypofractionated radiotherapy. Our study confirmed the correctness of the margins used in both therapies. However, it was found that despite small values of average displacements, displacements exceeding 5 mm associated with intrafraction motion are significant. The results suggest the need to expand research to a large group of patients. The study identified cases in which prostate displacement during fractional irradiation exceeded the accepted margins. This may be due to many factors, most likely a change in pelvic muscle tone that occurred after the initiation of irradiation. This type of displacement cannot be corrected during patient positioning and is only visible when monitoring intrafraction motion. Ultrasound monitoring therefore allows for individual verification of the correct positioning of patients who experience unusual changes in the position of the prostate during irradiation. This may result in a decision to change the size of the margins and implement a new treatment plan. It should be mentioned that ultrasonic monitoring also allows for the use of motion correction during exposure. This is most beneficial for patients with extremely frequent changes in the position of the prostate who require individual treatment.

Risk management in a calibration laboratory accredited for compliance with the ISO/IEC 17025 standard - practical examples

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The Secondary Standards Dosimetry Laboratory (SSDL) in Warsaw in Poland has been accredited by the Polish Centre of Accreditation for the conformity with the ISO/IEC 17025 standard *General requirements for the competence of testing and calibration laboratories* [1]. The accreditation No. AP 155 granted in May 2014 covers the calibration of ionization chambers together with electrometers in a ^{60}Co gamma ray beam in terms of dose absorbed to water and calibration of well chambers with a ^{192}Ir source in terms of air kerma. The status of accreditation and validity of the scope of accreditation can be confirmed at PCA website www.pca.gov.pl. The Polish SSDL performs its laboratory activities in the aforementioned accreditation scope for radiotherapy centers in Poland.

In this work, the ways of implementing requirements of the ISO/IEC 17025:2017 standard [1] regarding actions to address risk and opportunities associated with the laboratory activities are presented. These requirements (see section 8.5 of the ISO/IEC 17025:2017 standard) are as follows:

a. consideration of risks and opportunities associated with laboratory activities;
b. planning and taking actions in relation to risks and opportunities and assessing the effectiveness of these actions.

Due to the fact that the ISO/IEC 17025:2017 standard does not recommend the use of specific risk management methods, each laboratory can define its own methodology. At the Polish SSDL, it was assumed that risk management lowsis the overall process, as shown in the ISO 31000:2018 standard *Risk management – Guidelines* [2] which standard can be applied to any organization and its context or activity. Risk can be defined as effect of uncertainty on objectives [2]. This effect is a deviation from the expected and it can be positive, negative or both, and can address, create or result in opportunities and threats [2]. According to the ISO 31000:2018 standard, the risk management process involves such activities as:

a. communication and consultation;
b. establishing the scope, the context and criteria;
c. risk assessment, i.e.: risk identification, risk analysis and risk evaluation;
d. risk treatment;
e. monitoring and review risk;
f. recording and reporting risk.

In this work, each step of the risk assessment will be discussed in detail using the example of several selected threats important from the point of view of the Polish SSDL.

Practical examples of risk management presented in this work may be helpful for calibration and testing laboratories that plan to join the process of obtaining accreditation for compliance with the requirements of the ISO/IEC 17025:2017 or for such laboratories that would like to improve their risk management.

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2. International Organization For Standardization, Risk management – Guidelines, ISO 31000:2018, ISO, Geneva (2018)

Replicate calibrations using the same method as one of the ways to ensure the validity of the results of the laboratory calibrating ionization chambers for radiotherapy centers in Poland

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According to section 7.7.1 of the ISO/IEC 17025:2017 standard [1], accredited calibrating laboratory shall have a procedure for monitoring the validity of results. This monitoring shall be planned and reviewed and shall include, but not be limited to replicate calibrations using the same method. And according to section 7.7.3 of the standard [1] data from monitoring activities shall be analysed and used to both control and improve the laboratory's activities.

These requirements are crucial in any calibration field, but especially in the field of calibration of ionization chambers used in dosimetry for radiation therapy centers.

In this work, we will present the ways of implementing the aforementioned requirements of the ISO/IEC 17025:2017 standard [1] at the Secondary Standards Dosimetry Laboratory in Warsaw in Poland accredited by the Polish Centre of Accreditation (accreditation No. AP 155). In particular, we will discuss the content of the procedure we have developed. In addition, we will highlight the most important aspects of replicate calibrations, such as the establishment of acceptance criteria for results from repeated calibrations. Finally, we will give some results from the routine activities of our laboratory and analyze these results according to the dispositions in our procedure.

We believe that the practical examples presented in this work can be useful to other calibration laboratories and, with minor modifications, can undoubtedly be applied to many areas of calibration.

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Pilot study of HDR brachytherapy dosimetry audit in Poland

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Dosimetry audits are recommended by the International Atomic Energy Agency as an independent verification of the radiation therapy devices. Such verification should be performed prior to implementation of each device for clinical use, after major repairs or after significant updates to treatment planning systems. In addition, regular participation in dosimetry audits should be included in quality control procedures. The main purpose of such audits is to ensure the safety of the patients being treated.

Each year in Poland, approximately 99000 patients undergo radiotherapy, of which 86% are treated with teletherapy and 14% with brachytherapy. Brachytherapy is a technique that has generally received less attention when conducting audits worldwide.

The Secondary Standards Dosimetry Laboratory (SSDL) in Warsaw, Poland, prepared a dosimetry audit methodology for HDR devices with Ir-192 source used in brachytherapy. In order to validate the prepared procedure, a pilot audit is being conducted for several centres.

The audit methodology involves the use of thermoluminescent detectors (TLD) to measure dose and gafchromic film to measure dose distribution. TLD detectors are routinely used for dosimetric auditing (to measure dose in water) of photon beams from conventional linear accelerators. Their preparation in application to Ir-192 sources required the determination of an energy correction and corrections associated with the phantom used. Gafchromic films also required the preparation of calibrations in terms of the doses used. Due to the high gradient of dose distributions from radioactive sources, it was necessary to define a precise measurement geometry. For this purpose, a phantom was designed in which two capsules of TL powder are placed exactly between two applicator positions and a gafchromich film on the side to verify the dose distribution. A 3D printer, which is available in the Department of Medical Physics, was used to make the phantom. The audit methodology is to deliver a homogeneous dose to a volume of TLD powder capsules located between two applicators placed in a geometric phantom that provides precise measurement geometry.

The newly developed brachytherapy audit methodology allows for the expansion of the Secondary Standards Dosimetry Laboratory. The implementation of this methodology at a national level will verify the accuracy and quality of brachytherapy treatment, resulting in increased safety of HDR therapy treatment using the Ir-192 source.

The estimation and optimization of possible occurring errors from the commissioning of a LINAC to clinical use

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Given the desire to deliver radiotherapy treatments in a manner that is as close as possible to the ideal case, as calculated by the treatment planning system, all processes involved in the day-to-day treatment of patients must be considered and optimized. A decisive factor in the correct delivery of treatments is the correct acquisition of the data needed to be entered into the calculation algorithms of the treatment planning system. This is a very important detail because not paying attention or making measurements of any kind without expert training beforehand can result in the apparent correct delivery of treatments according to the treatment planning system but the actual data being wrong. For this reason, most systems have either pre-existing data sets or data sets available from the manufacturer, thus offering the possibility of verifying the data against reference data for a particular model of linear accelerator.

In addition to the measurements taken throughout the commissioning process, which are used to create specific dose calculation algorithms, an equally important aspect is the environment in which this calculation is performed, namely the patient volume defined by the CT images. These images are necessary to estimate the dose distribution within the patient and for this reason the quality of these images is a very important factor in determining the most accurate dose. In addition, to increase the accuracy of the dose calculation, for densities not directly measured, the calibration curve of relative electron densities should be analyzed for a wider range of densities so that calculations for unknown densities are not performed based on interpolation of the data.

Given the ongoing desire to optimize the delivery of radiotherapeutic treatments, it is desired to observe and estimate the factors that may influence the measurements made, at any step of the commissioning phase. These influences can be either specific to the measurement process based on specialized detectors such as ionization chambers, or to data generation based on data extrapolation or deconvolution from measured data to obtain the parameters needed in the treatment planning system. For this reason, the aim of this work is to observe the magnitude of different factors on treatment delivery, as well as to determine possible new methodologies by which these factors can be systematically optimized or considered, either based on experimental measurements or simulations.

Small radiation field dosimetry and its implication in the accuracy of stereotactic treatments

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Technological advances in medical linear accelerators have led to the implementation and refinement of new irradiation techniques for the treatment of cancer patients. Irradiation techniques such as IMRT/VMAT or stereotaxy involve the use of small radiation fields, which have different characteristics from conventional fields and for which new implications for their dosimetry arise.

A radiation field is considered small from dimensions smaller than 3 cm x 3 cm, but according to the new dosimetry protocol specifically designed for small radiation fields, a field must meet at least one of the following conditions in order to be considered small: loss of lateral charged particle equilibrium, partial occlusion of the primary source with collimating systems or the detector has dimensions comparable to or larger than the field size.

With the development of new dosimetric protocols, new corrections are introduced, such as volume averaging and a different definition of the output factors, since the uncertainties arising in these field sizes are significant compared to those present in large, conventional, radiation fields.

Ionization chambers, which have so far been the basis of dosimetry measurements for standard fields, are not always suitable for small field dosimetry, due to the occurrence of volume averaging and lack of charged particle equilibrium.

Ionization chambers used for standard field dosimetry induce too large perturbations in the fluence of particles in the medium to be used in small fields. This implies that the transition from ionization to absorbed dose, according to small cavity theory (Bragg-Gray) and the associated correction coefficients recommended to be applied in the case of standard fields, bring a large degree of uncertainty. Also, as the field size decreases, the beam spectrum changes. By collimating the source, only a part of its true size remains visible from the detector's point of view, which can lead to penumbra overlap, hence the decrease in delivered dose for small fields. To reduce the perturbations induced by the detectors used, other classes of detectors can be used, such as diodes, with or without shielding.

In order to see the influence of detector selection on the dosimetric measurements, i.e. dose profiles, dose distribution along the central axis and output factors, this paper aims to perform these measurements with two categories of detectors.

Based on this measurements a new model will be developed using profiles, PDDs and output factors up to 10 cm x 10 cm field size, measured with ionization chambers and diode detectors, suited for the specific range of field sizes.

Keywords: small field, stereotactic treatment, shielded diode, axial, source occlusion

Comparison of FOTELP software and treatment planning system efficiency in brachytherapy for cervical cancer: A case study

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In gynecological radiotherapy, Monte Carlo programs are invaluable tools for optimizing treatment plans focusing on precision and efficiency. By leveraging sophisticated simulations, these programs enable detailed modeling of radiation interactions within the female pelvic anatomy. This level of accuracy is particularly crucial in gynecological cancers, where the proximity of critical structures like the bladder and rectum to the target area demands meticulous treatment planning.

This research presents a comparative analysis of the outcomes achieved by applying Monte Carlo software FOTELP (PHoton ELectron Positron) and brachytherapy (BT) techniques in the context of cervical cancer treatment. Cervical cancer remains a significant global health concern, and advancements in radiation therapy techniques play a crucial role in improving treatment efficiency.

A comprehensive treatment plan was devised for a patient currently undergoing therapy at the Centre of Radiation Oncology, University Clinical Center Kragujevac. The treatment plan for this patient was done on the treatment planning system Oncentra 4.0 of Nucletron. Dosimetric parameters such as calculating the values of the received dose in catheter points, as well as organ-at-risk sparing, are thoroughly examined. Additionally, clinical outcomes, including treatment response and potential side effects, are analyzed to provide a comprehensive understanding of the overall treatment effectiveness. Deliveries of doses to the rectum and bladder were controlled within the tolerance ranges.

The research utilizes a sample of cervical cancer case, employing both FOTELP and brachytherapy (BT) techniques, with a detailed comparison of treatment plans and outcomes. The findings aim to contribute valuable insights to the medical community, aiding in the selection of optimal radiation therapy techniques for cervical cancer patients. Ultimately, this comparative analysis seeks to enhance the knowledge base surrounding radiation therapy options and improve the overall quality of care for individuals facing cervical cancer.

Real time (in vivo) dose measurements in brachytherapy using scintillation detectors

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Conventional detectors based on ionization chambers, semiconductors or thermoluminescent (TL) materials in principle cannot be used for in vivo verification of the dose delivered in brachytherapy procedures. The first way to solve this problem is to use dosimetric materials that can be placed in the patient's body to record the delivered radiation dose using the OSL detectors. Namely, authors [1] proposed the use of the well-known dosimetric OSL Al_2O_3:C crystal to measure the radiation dose during brachytherapy treatments. Meanwhile, the complication of this OSL detector is the use of two optical pathways in the fiber to stimulate and record OSL light. We found that not only the OSL modes of the conventional materials (Al_2O_3:C and BeO), but also their scintillation properties, such as intensity and emission spectra of radioluminescence (RL), can also be used for in situ dose determination [2-4]. This measurement method can be performed in real time, absolutely non-invasively, using very sensitive compact spectrometers equipped with a long optical fiber terminated with scintillation crystals located intracavitary next to the tumour. The crystals, due to their density similar to tissues, can be placed in close proximity to radiation sources, without dose-distribution distortions.

In this work, the scintillation detectors based on the YAG:Ce (ρ=4.5 g/cm^3; Z_{eff}=35**)**, LuAG:Ce (ρ=6.75 g/cm^3; Z_{eff}=63) and GAGG:Ce (ρ=6.63 g/cm^3; Z_{eff}=54.4) garnet crystals with different density ρ and effective atomic number Z_{eff} as well as tissue-equivalent Al_2O_3:C and Al_2O_3:C,Mg crystals (ρ=3.95 g/cm^3; Z_{eff}=10.2) with 2*2*1mm size were tested. The measurements were performed in the clinical conditions of the Oncology Center in Bydgoszcz for in-situ measurement of applied dose in the 0.05-8 Gy range at brachytherapy treatment procedure with of ^{192}Ir source (392 keV).

The obtained results are promising. We observed a very good linear correlation between the dose and signal registered by detector based on the GAGG:Ce crystal. Close to linear dependence between the dose and intensity of scintillation response was obtained also for tissue equivalent Al_2O_3:C crystals. However, due to low density and Z_{eff} for this material the scintillation signal is significantly lower than that for GAGG:Ce crystals .

The proposed method is fully non-invasive and safe. The crystal with close-to tissue density can be used in any location, including the respiratory ways, because they do not interfere with dose distribution. However, there are many cases of radiation therapy where the detector can be located behind the target. In this case, the use of heavy, high-density and high-Z_{eff} scintillators is strongly preferred.

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The effect of low energy X-rays on the measurement of absorbed dose using TLD-100 dosimeters in radiological studies

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In order to calculate the radiation risk of patients in diagnostic and therapeutic imaging, it is very important to measure the absorbed dose at the exposed region. For this purpose, ion chambers, solid state detectors, luminescence dosimeters, etc. are used to measure the radiation dose. Thermoluminescence (TL) dosimeters are usually preferred because they are small and can be placed in the exposed regions without causing shadow effects or artifacts on the radiographic image. Today, the most preferred TL dosimeter for this purpose is the commercial TLD-100 (LiF:Mg,Ti). The effective atomic number of TLD-100 dosimeter (Z_{eff} = 8.2) is very close to soft tissue, its energy dependence is low (at the energies above 100 keV), it can be produced in millimetric geometries, and its linear dose-response range is wide (from μGy to Gy orders). In diagnostic and interventional radiology, where low-energy X-rays (<100 keV) are used, the dosimeter used to determine the absorbed dose with the TL method should be calibrated with a known radiation dose. This requires consideration of the energy dependence of the dosimeter irradiated at low energies. In this study, TL intensity obtained as a result of irradiation of TLD-100 dosimeters (Thermo Scientific Co., USA) to be calibrated with 5 mGy radiation dose at different energies in the diagnostic energy range (40-120 kVp) was investigated. The same dosimeters were irradiated with a high-energy Cs^{137} photon source (Eγ = 661.7 keV) to compare the TL intensities obtained as a result of low and high energy irradiation and also to obtain whether the change in sensitivity depending on the energy. Irradiations were performed in a conventional X-ray system (General Electric Silhouette VR) and the radiation dose was measured with a 6 cc ion chamber (Radcal Corporation, calibrated at SSDL). The energy spectra of irradiations at different tube voltages were simulated using XCOM5R software (Nowotny and Höfer 1985) their average energies were calculated. Accordingly, it has been observed that TLD-100 dosimeters irradiated with a high energy photon source have an increase of approximately 25-35% in TL sensitivity when irradiated with the same dose with low-energy X-rays at 40-120 kVp. This result shows that if TLD-100 dosimeters are used for radiation dose measurement in radiological studies performed with low-energy X-rays, dose-response calibration should be performed with the same tube voltage/energy spectrum planned in the study. Only then the absorption of radiation in the relevant tissue can be measured or compared with the TLD-100 dosimeter. Once the energy dependence is known, TL dosimeters can be used to measure the absorbed dose after calibration performed at the same energy as the energy used during therapy.

Radiological properties of MAGAT gel formulas

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Dosimetric gels are used for measuring three-dimensional dose distributions with good spatial resolution and accuracy. Polymer gels are an emerging class of dosimeters that meet these challenges. They have been used to validate a number of conventional and novel radiotherapy modalities, including brachytherapy, intensity-modulated radiotherapy and stereotactic radiosurgery, and all studies have confirmed the value and versatility of this dosimeter technique.

It is important to check that the interacting properties of a polymer dosimeter are close to those of the biological medium. The most important water-equivalent or tissue-like radiological properties. The radiological properties of different MAGAT gel formulations and water equivalence were investigated by determining mass attenuation and effective atomic number.

Materials and methods: Total mass attenuation coefficient (μ/ρ) of water and different MAGAT gel formulations were calculated using NIST XCOM database over the energy range 0.01-20 MeV. The effective atomic number Zeff of the MAGAT gel was calculated using the Auto-Zeff software .

Results: The Zeff values in are almost identical, at low energy the values vary between 0.1 and 0.5% for MAGAT1 and MAGAT2 and between 0.2 and 0.7% for MAGAT3. In the intermediate energy range the values vary between 0.6 and 1.3% for MAGAT1 and between 0.6 and 1.2% for MAGAT2 and for MAGAT3 the variation is between 0.7 and 1.4%. In the high energy range, for the MAGAT1, MAGAT2 and MAGAT3 gels, the difference between the values varies between 0.7 and 1.3%, between 0.6 and 1.2% and between 0.8 and 1.4% respectively.

the curves of the total mass attenuation coefficient (μ/ρ) as a function of the energy of water and MAGAT gel. It can be seen that the relative difference does not exceed 4% for MAGAT1 and MAGAT2 and 5% for MAGAT3 for low energies below 30 kev. The difference is less than 1% for all MAGAT gel formulas for the rest of the energy range.

Conclusion: The study of the variation in the radiological properties Zeff and mass attenuation coefficient of the three formulations of MAGAT gels shows that the variation is due to the different concentrations of gelatin in each formulation, knowing that gelatin is the matrix on which the polymers precipitate. The three formulations of MAGAT gel presented show that the two radiological properties studied are almost similar to those of water. However, we can say that MAGAT2 gel is more water equivalent than the other two formulas. Click here to insert your Conclusions text. Type it in or copy and paste from your Word document or other source.

The effect of artifacts from metal structures in the body on the distribution of absorbed dose

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Artifacts on computed tomography (CT) can pose a significant problem when planning radiation therapy, as they can distort the patient's anatomy and electron density data, affecting the accuracy of dosimetric calculations. Artifacts on computed tomography (CT) can be caused by various factors: equipment (detector malfunction, calibration inaccuracy, table movement, high-energy artifacts), patient (metal structures, patient movement, obesity), reconstruction (band artifact, noise artifact, clipping artifacts).

During radiation therapy, the presence of metal structures in the patient's body can lead to a significant distortion of the absorbed dose distribution. The metal introduces artifacts, causing scattering and amplification of radiation, which leads to overestimation of the dose in some areas and underestimation in others.

This study shows the effect of artifacts from metal structures on the distribution of absorbed dose during radiation therapy. The data analysis was carried out on the ArcCHECK dosimetric complex. The CT simulation was performed on a Philips Big Bore CT with a piece of lead attached to the ArcCHECK to obtain artifacts. Three techniques were used to calculate the dose: calculating the dose on raw CT, calculating the dose on CT with OMAR reconstruction, and calculating the dose using additional artifact structures with an assigned value of Hounsfield units.

The results showed that artifacts from metal structures can significantly distort the dose gradient, creating high and low dose areas. Various strategies can be used to minimize the impact of artifacts, such as using image reconstruction techniques and assigning electron density.

Understanding the effect of artifacts from metal structures on the distribution of absorbed dose is crucial to ensure accurate and effective delivery of radiation therapy to patients with metal structures in the body.

SPECT and hybrid TC-99m-tektrotyd imaging in the follow-up of neuroendocrine neoplasms of appendix

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Neuroendocrine tumors of appendix (ANETs), are rare tumors with the incidence of 0.08-0.2 cases/100000 during one year. They originate from enterochromaffin cells of gastrointestinal tract, and are considered as the third most frequent (16.7%) gastrointestinal neuroendocrine tumors. Usually, the first manifestation of ANETs occur by incidence, during emergency surgical resections caused by suspicion of appendicitis. In spite of lot of data of somatostatin receptor scintigraphy (SRS) in gastrointestinal tumors, there is no much data about ANETs particularly.

Aim/Introduction: To establish the role of somatostatin receptor scintigraphy (SRS) with SPECT and SPECT/CT in the follow up of the patients with ANETs.

Materials and Methods: The total of 58 patients was investigated, 36 females and 22 males, average age (48.3 ± 17.8 years). All patients had histological diagnosis of ANET (55 carcinoids of appendix and 3 tubular carcinoid). Majority of tumors have been found incidentally during surgery of: acute appendicitis (n = 20), perforated appendicitis (n = 4), ileus (n = 4), hysterectomy (n = 5), ruptured ovarian cyst (n =3), caecal volvulus (n =2), while 20 patients had diagnosis of appendiceal tumor before the surgery. Twenty two patients had tumor grade (G) G1, 19G2 and 17G3. The right hemicolectomy was performed in 32, while the rest of the patients had appendectomy only. SRS was performed for restaging in all the patients after surgery early (2 h) and late (24 h) after i.v. application of 740 MBq technetium-99m ethylenediamine-N, N'-diacetic acid Hydrazinonicotinyl-Tyr3-Octreotide. In 45 patients only planar viewes and SPECT were performed, while SPECT/CT was performed in 13. SPECT was performed during 15 min with two detectors, rotating around the patient 180 degrees each, in step and shoot mode, at the angle of 5 degrees per position. In 13 patients SPECT acquisition was followed by CT of the region of interest, with MPR reconstruction and attenuation correction. SPECT matrix was 128x128.

Results: There were 23 true positive (TP), 29 true negative, 4 false positive and 2 false negative SRS result. Sensitivity of the method (including both SPECT and SPECT/CT) was 92%, specificity was 87.9%, positive predictive value was 85.2%, negative predictive value was 93.6% and accuracy 89.7%. Receiver operating characteristics analysis showed that SRS scintigraphy is a good test for detection TP cases [area under the curve of 0.850, 95% confidence interval (CI): 0.710-0.990, P < 001]. Single photon emission computed tomography contributed diagnosis in 12 TP findings in comparison to planar images. SPECT/CT contributed in 7/15 patients, in 5 confirming the positive finding (Krenning score 2) and in 2 excluding it in comparison to SPECT. In 12 patients Krenning score was 4, in 6 patients it was 3 and in 5 it was 2. In 21 patients SRS significantly changed the management of the patients (in 8 surgery was repeated, in 10 somatostatin analogues included and in 3 peptide receptor radionuclide therapy performed). Median progression-free survival in SRS positive patients was 53 months (95%CI: 39.8-118.1 months) while in SRS negative patients it was 61 month (95%CI: 42.9-77.9 mo), without statistically significant difference between the two groups (P = 0.434).

Conclusion: In conclusion, our results confirmed the value of SRS in the follow-up of the patients with ANET after surgery, if recurrences or metastases are suspected, with added value with SPECT and particularly with SPECT/CT.

Arginase activity in different tissues of rats exposed to mobile phone microwave radiation

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In a rapidly developing world, we face an imminent threat to humans' health from constant exposure to mobile phones. Long-term exposure to microwave radiation from mobile phones is known to cause various unspecific symptoms in humans. Arginase is an intracellular enzyme enrolled in various cell functions such as metabolism, detoxification, cell proliferation, etc. This study aims to evaluate the effects of long-term exposure to microwave radiation on rat tissue arginase activity. Male Wistar rats were exposed to microwave radiation produced by a mobile test phone (model Nokia 3110; Nokia Mobile Phones Ltd.) connected to a communication Test Set PCDK with PC and appropriate software module for 4 hours/day for 60 days. The electromagnetic field parameters in the cage were measured using the SPECTRAN HF 6080 instrument manufactured by AARONIA AG (Germany). Arginase activity was determined in the brain, testicular, thymus, and liver tissue of experimental and control group rats using a standard method based on quantifying the formed ornithine after adding arginine and Mn^{2+} ions. The range of the measured power, electric, and magnetic field values was E=9.884 to 18.356 V/m (electric field) and B=4.68 to 8.69 μT, respectively. Based on these parameters, the Specific Absorption Rate (SAR) for the whole rat body was calculated from 0.043 to 0.135 W/kg. The activity of arginase in the brain and thymus tissue of rats exposed to microwave radiation was statistically significantly lower than in the same tissue obtained from the control rats. On the other hand, the activity of arginase in liver and testicular tissue was unaffected by the exposure to radiation compared to the control group rats. A decrease in arginase activity in the brain and thymus tissue of rats exposed to microwave radiation could indicate a significant shift in cell function in the affected tissues.

Organization models of kilovoltage X-ray therapy care and system used

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The study demonstrates the results of country-level research of X-ray therapy care. Patient flows, kilovoltage energies and X-ray therapy systems were investigated to find out patterns in radiotherapy care.

Purpose of the study is to reveal current trends in usage of X-ray therapy and develop recommendations for improving X-ray therapeutic care in current healthcare trends.

Materials and methods. Systematic approach, methods of mathematical and simulation modeling, observation and questionaries methods were used.

Results. Three main models for the organization of X-ray therapy care have been identified - multidisciplinary hospitals use X-ray therapy range 150-200kV to treat benign diseases - 97% of all radiotherapy patient flow; 1st and 2nd level oncological dispensaries use X-ray therapy of 200-300kV to treat a variety of oncological pathologies; 3d level oncology clinic with the focused oncodermatology centers treat non-melanoma skin cancers using up to 100kV X-ray therapy systems. Regions with high incidence of skin cancers requires not less than 1 kilovoltage system per 800 000 population. The high incidence of skin cancer, requires easy accessibility for oncodermatological care and early start of treatment. X-ray therapy care demonstrated higher operational efficiency than other modalities (RT session duration = 12.1 min.) and equipment utilization efficiency (throughput of 36 patients per shift). Analysis of the patients flows allow to adopt model of care depending on number of factors – morbidity, reimbursement coverage, patient flow. Changes in clinical guidelines affects the throughput of radiotherapy rooms (the average bed-day increased from 12 to 24 days), which requires to account this factor planning the workload. The use of simulation computer methods reduces the risks of irrational patients routing and improve the quality of management decisions. The time from the beginning of the patient's first visit to discharge by 9 days in the case of surgical treatment was reduced, and by 6 days for radiotherapy.

Conclusion. The organizational and methodological approaches to improve X-ray therapeutic care were developed in accordance with modern goals and trends in healthcare. The developed organizational and methodological approaches make it possible to increase the accessibility and quality of oncological care.

Physiotherapy program in adulthood patients with idiopathic cervical scoliosis

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Idiopathic scoliosis occurs clinically in childhood with different localization of deformity in the spine departments - cervical, thoracic, lumbar. Not effectively treated spinal curvatures in childhood, persist as a pathology in adult patients. They are one of the reasons for the more severe degenerative changes in the intervertebral discs and the cause of pain and disability of such patients in adulthood.

Objective: The aim of the study is to demonstrate the effect of the physiotherapy program on adult patients with idiopathic cervical scoliosis. We followed the effect of the treatment on posture, neck pain and mobility in the cervical spine of adult patients with idiopathic cervical scoliosis.

Material and method: Participants in the study were 3 adults diagnosed in adolescence idiopathic scoliosis. All three patients had three spinal curvatures. Clinical complaints of cervical scoliosis are leading the way. All patients were treated with the following physiotherapy program: paraffin, iontophoresis with nivalin, TENS and Schroth exercises. Clinical, kinesiological methods and a visual-analog scale were used to assess treatment outcome. Patients were followed for a 1 month.

Results: The physiotherapy program was for 14 days with continuously Shroth exercises at home. All patients have a reduction in cervical pain, an increase cervical mobility of spine and improvement in posture after 1 month.

Conclusion: There are short-term benefits in improving the subjective and objective complaints of adulthood patients with idiosyncratic cervical scoliosis. Shroth exercises added to the physiotherapy program of these patients gives additional benefits to improve the posture of these patients.

Keywords: Adulthood, idiopathic scoliosis, Schroth exercise, physiotherapy, neck pain

Success of performing the technique of forced oscillations (FOT) in the diagnosis of small airways disease in children

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The diagnosis of respiratory diseases in children has always been a great challenge. The gold standard in the diagnosis of airway obstruction is spirometry, but it requires effort and is difficult to perform, especially in children. That is why in recent years FOT (forced oscillation technique) is gaining popularity, due to the easy and quick implementation as well as the high sensitivity of the method.

Aim: The purpose of this study is to show the success rate of the method in different children's age groups.

Materials and methods: We examined 43 children aged between 3 - 17 years with the RESMON PRO device. Each patient was required to complete 3 successful trials.

Results: The Forced oscillation technique is a lung function modality based on the application of an external oscillatory signal in order to determine the response of the respiratory system. It is used in the diagnosis of obstructive diseases such as bronchial asthma, cystic fibrosis and COPD. A huge advantage of the method is that it requires minimal cooperation from the patient: quiet, spontaneous tidal breathing and a total of three to five technically acceptable measurements. The children were divided into three age groups as follows: Group 1: under 6 years (13 patients), Group 2: 7-12 years (21 patients), Group 3: 12-17 years (9 patients). In groups two and three we observed a study success rate equal to 100%, and in group 1 the success rate was close to 85%. The difficulty in performing the examination is observed mostly in children under 4 years of age, as they must feel comfortable and not intimidated, which is not always possible even in the presence of a parent. Two children (at the age of 3) failed the study, one due to crying out of fear and one due to laughing. The child's laughter was mainly caused by the oscillations which created a tickling sensation in the child's oral cavity and chest.

Conclusion: The technique of forced oscillations is an extremely effective and informative method in the diagnosis of obstructive diseases, even at the young age of less than 6 years.

Kynurenic pathway activation reduces bone turnover in the bone of young rats with experimental chronic kidney disease

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Chronic kidney disease (CKD) is associated with the development of mineral bone disorder (CKD-MBD), leading to osteoporosis and increased risk of fracture. The low bone turnover is considered to be one of the most common types of renal osteodystrophy. Bone turnover defines the rate of skeletal remodeling, reflected as the ratio between bone formation and bone resorption. Bone resorption is achieved by osteoclasts (OCs), after which the osteoblasts (OBs) form new bone matrix, leading to the restoration of the removed bone. In physiological conditions, these two processes, which are referred to as coupling bone remodeling, are tightly balanced.

Recently, tryptophan (TRP) metabolism through the kynurenine (KYN) pathway has been postulated as an important factor in promoting bone-aging phenotypes. However, knowledge on the impact of the KYN pathway activation on bone turnover in CKD is very limited.

Aim: We wanted to establish the potential interactions between bone kynurenine (KYN) pathway activation in relation to bone turnover in young rats after one month (CKD-1) and three months (CKD-3) of experimental CKD.

Materials and Methods: Forty-four male, 4 weeks old Wistar rats were randomly divided into two groups, in which rats were subtotal nephrectomized (CKD) and sham operated (CON). Blood samples and femoral bones were collected one month (CKD-1, CON-1) and 3 months after 5/6 nephrectomy and in appropriate controls (CKD-3, CON-3). The concentrations of TRP and KYN in trabecular and cortical bone tissue homogenates were determined by HPLC method. The bone turnover markers (BTMs): alkaline phosphatase (ALP) activity and tartrate-resistant acid phosphatase 5b (TRAP-5b) activity were measured in bone homogenates using colorimetric method from Biomaxima and rat-specific RatTRAP™ assay from

Immunodiagnostic Systems Ltd.; respectively. KYN/TRP ratios and TRAP-5b/ALP ratios were also calculated.

Results: During 3 months of CKD development, the concentrations of TRP, KYN and KYN/TRP ratio were higher in trabecular bone uremic rats compared with appropriate controls. In cortical bone, KYN levels and the KYN/TRP ratios were significantly lower in CKD-3 than in CON-3. During three months of CKD progression, ALP activity was significantly lower, TRAP-5b activity was similar, and TRAP-5b/ALP ratio remained higher in the CKD-3 group compared with controls in trabecular bone. In cortical bone, TRAP-5b activity was significantly elevated in CKD-3 compared with CON-3, what resulted in an increased TRAP-5b/ALP ratio. Independently from the analyzed bone region, KYN was inversely correlated with BTMs, especially with TRAP-5b activity.

Conclusions: Three-month development of CKD resulted in the activation of KYN system in trabecular bone, but its supression in cortical bone of young rats with CKD. The activation of KYN system was associated with inhibition of bone turnover, which was particularly seen in relation to the marker of osteoclast activity – TRAP-5b.

Indoxyl sulfate alters AHR signaling, sirtuins gene expression, oxidative DNA damage, and bone mineral status in rats

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Indoxyl sulfate (IS), is one of the most potent uremic toxins, an agonist of aryl hydrocarbon receptors (AhR), can accumulate in patients with chronic kidney disease. Recently, some studies suggested that IS and other uremic toxins may contribute to the loss of bone quantity and quality in chronić kidney disease (CKD) but majority of these works were conducted in bone cell culture models with high micromolar IS concentration, or in animal CKD models, so their physiological relevance remain uncertain. The present study investigated the effect of chronic exposure to low (100 mg/kg b.w.; 100 IS) and high (200 mg/kg b.w.; 200 IS) dose of IS on bone AhR pathway, sirtuins (SIRTs) expression, oxidative DNA damage and bone mineral status in Wistar rats.

Concentrations of IS in the bone tissue homogenates were evaluated using high-performance liquid chromatography (HPLC) with fluorescence detection (FLD). Oxidative status assay in bone homogenates - were measured the levels of 8-hydroxy-2'-deoxyguanosine (8-OHdG) with ELISA kit from Enzo Life Sciences (ELS) AG, Lausen, Switzerland. The expression of sirtuins and AhR pathway genes were determined - quantitative real-time polymerase chain reaction (qRT-PCR) assay. Densitometry analysis of left femurs was performed using dual-energy x-ray absorptiometry (DXA) scans (Horizon QDR Series X-ray Bone Densitometer, Hologic), and analyzed with the specific small animal software. For each scanned femur the results of the bone mineral area (BMA, cm2), bone mineral content (BMC, mg), and areal bone mineral density (BMD, mg/cm2) were obtained. The variation coefficient of BMC and BMD measurements were less than 4%.

Shapiro–Wilk's test of normality was used for data distribution analysis. The normally distributed data were presented as mean +/- SD. The non-Gaussian data were expressed as median (interquartile range; IQR). Comparison between parametric data was made by one-way analysis of variance (ANOVA), and significant differences between the groups were assessed using Tukey's post-hoc test at $p < 0.05$. The Kruskal–Wallis with Dunn's test was used for nonparametric data at $p < 0.05$. The correlations were calculated by Spearman's rank correlation analysis. p-value < 0.05 was considered statistically significant. Graphic design presentation of results was prepared using GraphPad Prism 6 (GraphPad Software) or Statistica ver.10 computer software (StatSoft).

The accumulation of IS was observed only in trabecular bone tissue in both doses. The differences were observed in the bone parameters, depending on the applied IS dose. The exposure to 100 IS increased AhR repressor (AhRR)-CYP1A2 gene expression, which was associated with SIRT-1, SIRT-3 and SIRT-7 expression. At the low dose group, the oxidative DNA damage marker was unchanged in the bone samples, and it was inversely related to the abovementioned SIRTs expression. In contrast, the exposure to 200 IS reduced the expression of AhRR, CYP1A, SIRT-3 and SIRT-7 genes compared to 100 IS. The level of oxidative DNA damage was higher in trabecular bone in 200 IS group. Femoral bone mineral density was decreased, and inverse relations were noticed between the level of trabecular oxidative DNA damage and parameters of bone mineral status.

In conclusion, our data clearly demonstrate that chronic exposure of control group to IS can modulate AhR-depending biological signaling at bone level, affecting SIRTs expression, oxidative DNA damage level and bone mineral status. The results presented describe for the first time a specific, dose-dependent intracellular target of IS in bone, on the basis of which we propose the mechanism, showing both protective, as well as detrimental nature of IS in CKD-related osteoporosis. Because the patients with CKD are continuously exposed to high IS levels it would be expected that their bone AhR should be fully and sustained activated, that might predispose these patients to bone loss and risk of fracture.

Nanoformulation with antimicrobial and antioxidant properties

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The key mechanisms of UV-induced damage are oxidative and nitrosative stresses that lead to suppression of immune function and skin damage. In previous studies we used substances with antioxidant effect to explain the mechanisms of UV-induced damage of skin. These compounds block UV-induced oxidation and excessive nitric oxide formation in model of ultraviolet erythema. The most effective was thiotriazoline ointment 2% manufactured by opened Joint-Stock Company (Kharkiv, Ukraine) with the addition of silver nanoparticles that have immunomodulatory and antibacterial effects. Therefore, to combine antioxidant potential of some drugs with antimicrobial effect of silver nanoparticles is highly desirable to reduce or avoid the immunosuppressive effect induced by ultraviolet radiation.

The aim of our study was to investigate the antibacterial effect of a nanocomposite containing thiotriazoline and silver nanoparticles.

Materials and methods: The antibacterial properties of nanocomposite with different concentrations of silver nanoparticles (1.9, 0.95, 0.45, 0.025, 0.12, 0.06, 0.024, 0.012; 0.006 mg/ml), obtained at the Int. Centre for Electron Beam Technologies of the Paton Electric Welding Institute of the Nat. Acad. Sci. of Ukraine, were studied *in vitro* condition by the agar well diffusion method on clinical and reference strains of *Staphylococcus aureus, Pseudomonas aureginosa, Haemophilus influenzae, Streptococcus pyogenes, Escherchia coli* at different times of the day (8am, 12pm, 6pm). The antibacterial activity was evaluated by measuring the diameter of inhibitory zones. A zone of less than 15 mm was considered to have no antibacterial activity.

Results: The antibacterial effect of the nanocomposite on clinical strains of *S. aureus, P. aureginosa, H. influenzae, S. pyogenes, and E. coli* was revealed. We did not notice any antibacterial effect of thiotriazoline itself. The study was carried out at different times of the day, since it is known that the biorhythmic approach to the study of the biological properties of microorganisms allows to detect variations in the trait during the day, reflects the adaptation of the pathogen to changing conditions, including antibiotic sensitivity. The clinical strains show high sensitivity to the studied nanocomposite at 6pm. The samples were resistant at 8am and 12pm, while antimicrobial therapy and antiseptic measures are carried out in the hospital, which is expressed by the modification (adaptive) variability of the tested clinical strains compared to the reference strains that show high sensitivity to the nanocomposite at all concentrations regardless of the time of day. The nanocomposite containing thiotriazoline and silver nanoparticles shows high activity against *S. aureus* and *P. aureginosa* regardless of concentration. The most effective concentration of the nanocomposite, which is characterized by a wide spectrum of antimicrobial action, was found to be 0.95 mg/ml.

Conclusions: The studied clinical bacterial strains show high sensitivity to the nanocomposite at 6pm and remain resistant at 8am and 12pm. We confirmed the antibacterial effect of silver nanoparticles in the presence of drug thiotriazoline. Such combination, when introduced into ointment, can be used to improve the effectiveness of treatment of wounds, skin lesions of various origin - ultraviolet and radio-induced, chemical, thermal, infectious, etc.

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Low-dose computed tomography and AI in lung cancer screening

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Nearly one-quarter of all cancer deaths worldwide are due to lung cancer, making this disease the leading cause of cancer death among both men and women. The most important determinant of survival in lung cancer is the disease stage at diagnosis, thus developing an effective screening method for early diagnosis has been a long-term goal in lung cancer care. Most lung cancers are discovered in the middle and late stages of the disease, when treatment choices are limited, and patients' survival rate is low.

The aim of lung cancer screening is the identification of lung malignancies in the early stage of the disease, when more options for effective treatments are available, to improve the patients' outcomes. In the last decade, and based on the results of large clinical trials, lung cancer screening programs using low-dose computer tomography (LDCT) in high-risk individuals have been implemented in some clinical settings. In our country we introduced lung cancer screening program since 4 years ago.Artificial intelligence (AI) plays a key role in each process of the lung cancer screening workflow. First, in the acquisition of low-dose computed tomography for screening programs, AI-based reconstruction allows a further dose reduction, while still maintaining an optimal image quality. A computer-aided detection (CAD) system provides automatic detection of potential lung nodules with high sensitivity, working as a concurrent or second reader and reducing the time needed for image interpretation. Once a nodule has been detected, it should be characterized as benign or malignant. In our setting AI-based approach makes automatic segmentation with a consequent assessment of the lesion size, volume, and densitometric features. We use combination of some other aproches called ECALP model which uses nodule volume not just a diameter like fleichner model for risk stratification.

The doses from screening “low dose” CT are comparable with dose of lung radiograpy.

Ultrasound densitometry for bone fractures in children

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Traumatic bone injuries in children take the first place among the pathology of the bone system without a tendency to decrease. The frequency of fractures in childhood is higher than same data in adults, reaching the previous frequency in men only after 75 years, in women - after 50. However, not all children, even with intense trauma, could have fractures, so that is why questions about bone hardness and the fractures reason still open.

According to the literature, measuring bone mineral density, which by 70-80% reflects its strength, is the main method for predicting the risk of fractures in older people, ultrasonic densitometry (UDM) can be used.

Material and methods: 85 children with fractures (29 girls and 56 boys) aged from 5 to 16 years old - main group (I) and 295 children (179 girls and 116 boys) from one of Kharkov's schools aged from 8 to 17 years old were examined and compared with main group (I). Investigations were performed on an Achilles + ultrasonic densitometer, determining the following parameters: ultrasound propagation rate (UP, m / s); Broadband ultrasound attenuation (BUA, dB / MHz); bone hardness index (IS,%), calculated using a computer based on the UP and BUA indicators.

Results: The surveyed children of group II showed a uniform growth of all indicators from 9 to 16 years (from 1 to 4% annually), which indicates a gradual formation of bone tissue and increase its hadness. The UDM indices in boys were not significantly difference from girls, except at 13 and 16 years, when a sharp increase in IS and UP was determined.

In girls of group I all indicators of IS, except of 14 years old, were lower than group II at 9 years ($p < 0,05$), which indicates a delay of bone formation and, as a consequence, a decrease bone hardness in girls with fractures.

IS in boys from primary group probably was lower than in the control group, starting at 9 years, and its level in the main group and at 14 years corresponds to the 10-year age of children of group II ($p < 0,05$). Boys 5 to 9 years with fractures had no increase in IS and other indicators of ultrasound, because the bone development is delay.

Low-energy fractures in girls were estimated at 86.2%, boys - 66.1%, high-energy fractures - 13.8% and 33.9%, respectively. IS with low energy fractures were probably lower in all age groups, with high energy fractures they did not differ from group II.

Osteopenia in group I was defined in 28,2%, in II - in 17,1% ($p < 0,05$), osteoporosis - in 23% and 4,3% ($p < 0,01$), respectively.

Conclusions: 51.2% of children with fractures were found bone hardness insufficiency. Ultrasonic densitometry could be used for bone hardness determination in children, including in preventive examinations.

Activity of superoxide dismutase and its cofactors in maternal venous blood and umbilical cord blood of newborns

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Superoxide dismutase (SOD) is a key enzyme of the body's antioxidant barrier of the body. SOD catalyses the dismutation reactions of anion radicals superoxide ($O_2^{\bullet-}$) to hydrogen peroxide and molecular oxygen, thereby protecting cells from the action of $O_2^{\bullet-}$, but also indirectly prevents the formation of the hydroxyl radical ($^{\bullet}OH$) in a reaction catalysed by transition metal ions, i.e. zinc, copper, manganese.

The aim of this study was to determine the effect of delivery on the activities of superoxide dismutase and its cofactors (Zn, Cu and Mn) in maternal venous blood and umbilical cord blood of newborns from low-risk pregnancies.

Material and method: The study was conducted on a group of 199 mother-child pairs. The studied women were on average 30 years old, for most of them it was the second pregnancy ending in caesarean section at term. The newborns in this group were born in a good general condition and with quantitative characteristics corresponding to eutrophic newborns. Superoxide dismutase activity was determined spectrophotometrically using a Randox kit (Randox Laboratories, Crumlin, UK). SOD cofactors analysis zinc, copper and manganese concentrations were conducted using atomic absorption spectrometry (ASA). To indicate the existence of statistically significant differences between groups non-parametric (Mann-Whitney U) test (after checking test assumptions) was used. For evaluating correlations between analysed variables, Pearson's correlation was used. The results for which the probability level was $p < 0.05$ were considered statistically significant.

Results: The study showed that superoxide dismutase activity was higher in the venous blood of mothers than in the neonatal group. This difference proved to be statistically significant ($p = 0.014$). With regard to the superoxide dismutase cofactors assessed in maternal venous blood, copper and manganese concentrations were higher and zinc concentrations were lower compared to neonatal cord blood. For copper ($p = 0.000$) and zinc ($p = 0.020$), this difference proved to be statistically significant, indicating the presence of competition between the elements. Although this situation occurs during low-risk births, waiting too long to deliver after the due date will favour an increase in zinc concentration and a decrease in copper concentration in the neonate's body by lowering the activity of superoxide dismutase.

Keywords: Superoxide dismutase, zinc, copper, manganese, childbirth, venous blood, umbilical cord blood

Content of selected bioelements and antioxidant potential of *Urtica dioica* in the body of a pregnant woman

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Common nettle (*U. dioica*) is a source of minerals, phenolic and protective compounds. Nettle is also a good antioxidant because of the high content of quercetin, rutin and ascorbic component. Its antibacterial activity affects Gram-positive and Gram-negative bacteria, yeasts from the groups of *Candida albicans*, *Staphylococcus aureus* and *Escherichia coli*. Due to its vitamin content, common nettle tea is recommended for pregnant women.

The aim of the study was to determine and compare the concentration of selected bioelements and antioxidant potential in herbal medicinal raw materials from nettle.

Material and method: The research material consisted of samples from randomly selected medicinal preparations from different manufacturers, which contained *U.dioica* and were available to consumers in Poland. The total content of phenols in herbal medicinal raw materials was determined using the Folin-Ciocalteu colorimetric method, while the concentrations of selected chemical elements: Zn, Cu, Mg, Fe and Mn were determined using flame atomic absorption spectrometry.

Results: In most cases, the content of the tested elements differs statistically significantly between different preparations and manufacturers. In the case of common nettle, statistically significant differences were observed in the content of Mg (P1 4721 ± 175 mg/kg vs. P2 5701 ± 253 mg/kg vs. P3 5278 ± 101 mg/kg, p≤0,01), Fe (P1 176 ± 39 mg/kg vs. P2 260 ± 7 mg/kg vs. P3 128 ± 8, p≤0.01 i p≤0.05) and Mn (P1 80,9 ± 13,0 mg/kg vs. P2 70,0 ± 8,0 mg/kg vs. P3 50,9 ± 4,9 mg/kg, p≤0,05) between samples from different producers of medicinal raw materials: P1 samples from Poland (producer Kawon), P2 – from Ukraine (producer Agrest) and P3 – Poland (producer Natura Wita). However, no statistically significant difference was observed in the tested preparations from various plant producers and the total content of phenols in *U. dioica* tea.

Conclusions: Stinging nettle products showed the highest significant concentration of Mg in the analyzed medicinal products, therefore they can be recommended to pregnant women as a natural ingredient that reduces the contractility of uterine smooth muscles in the prevention of premature birth. Due to the different content of this element in medicinal products available on the market, it is advisable to choose a given preparation based on the manufacturer, country of origin, and in the case of confirmed pregnancy, consult its supplementation with a gynecologist.

Keywords: Common nettle, micro and macro elements, antioxidant system, pregnancy

Synthesis and biological activity of some novel complexes of (methylcarbamoyl)phenyl)carbamate

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Anthranilic acid analogues and their derivatives have significant therapeutic potential for crafting designed compounds aimed at regulating cancer-causing pathways and addressing metabolic challenges linked to diabetes, antiviral agents, and biologically tolerant anti-inflammatory compounds.

The research described here was focused on the synthesis of new metal complexes with (methylcarbamoyl)phenylcarbamat. The compounds were characterized by their melting points, IR, ^{1}H-, ^{13}C-NMR, Raman spectroscopy. All metal complexes were obtained after mixing water solutions of the corresponding metal salts and the ligand dissolved in DMSO and water solutions of NaOH, in metal-to-ligand ratio to base 1:2:2.

In the current work we described the synthesis and reaction conditions to obtain of new Cu(II), Ni(II) and Co(II) complexes with (methylcarbamoyl)phenylcarbamat, as well as the characterization of the obtained complexes and the investigation of the antimicrobial activity against Gram-positive, Gram-negative bacteria and yeasts. The cytotoxic effect was investigated also. In order to evaluate the in vitro biocompatibility of the experimental compounds, a series of cell viability assays were performed against human malignant leukemic cell lines (LAMA-84, K-562), as well as normal murine fibroblast cells (CCL-1).

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Direct acting oral anticoagulants (DOACs) in the treatment of renal preservation in NVAF patients

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A 65-year-old female patient presents to the cardiology clinic with palpitations. Former smoker, with hypertension and has combined hyperlipoproteinemia (total cholesterol 6.7 mmol/l, LDL 4.1 mmol/l, HDL 0.8 mmol/l and TG 2.8 mmol/l). Laboratory results—including electrolytes, degradation products in the blood, and fasting blood glucose—are within normal limits. Her creatinine clearance (CrCl) is moderately decreased, calculated glomerular filtration rate (eGFR) 50 mL/min/1.73m The echocardiogram showed concentric left ventricular hypertrophy and mild enlargement of the left atrium; otherwise the results are within normal limits.

Patient regular therapy: Tbl. Metoprolol 47.5mg. Tbl. Perindopril 4mg. Tbl. Indapamide 1.5mg. Tbl. Atrovastatin 20mg.

HA2DS2-VASc is used to calculate stroke risk. The patient has a score of 3, which is considered "moderate-high" risk. HAS-BLED is used to calculate bleeding risk. The patient has a score of 2, indicating that anticoagulation therapy may be considered. However, it has a moderate risk of bleeding.

At this point we decided that anticoagulation therapy was needed. We started on a direct acting oral anticoagulant (DOAC) – tbl. Rivaroxaban 20mg./day

Follow – up: During routine examinations in the last 2 years after the diagnosis of non-valvular atrial fibrillation (NVAF) in the patient, renal function was monitored, it was all about choosing OACs to help protect the kidneys by slowing the rate of decline of their function.

Laboratory results - degradation products in the blood are within normal limits.

Over the two-year period, we had a calculated mean decline in renal function of 1.65 ml/min/1.73 m2/year in the patient placed on rivaroxaban therapy. So, we appropriately anticoagulated the patient, protected her from the risk of stroke, while adequately preserving her renal function.

Some facts: Kidney function is an important factor in stroke prevention in patients with atrial fibrillation. Patients with NVAF and renal impairment are at higher risk of bleeding and stroke, and vice versa.

AF is associated with an 80% increased risk of renal function decline, even in patients who do not yet have abnormal renal function at diagnosis.

Conclusion: It has been shown that patients with NVAF, preserved renal function at baseline and treated with rivaroxaban have a significantly reduced risk and rate of decline in renal function, then we have lower risks of acute kidney insufficiency or progression to CKD stage 5 or the need for dialysis in patients with chronic kidney disease, compared to those treated with vitamin K antagonists. A number of clinical studies are underway treating patients with NVAF and preserved renal function at baseline or patients with renal disease with DOACs versus VKA.

Polarized microscopy in genetic hair disorders: case series

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Here we present microscopy of selected hairs in ten patients with rare genetic disorders in early childhood. Among them, there were six patients with Netherton syndrome, two patients with hypotrichosis congenita hereditaria Marie Unna, and two patients with ectodermal dysplasia (smurf syndrome). We used an optical microscopy device with a polarized mode. Polarized microscopy is the examination of histological sections of the skin and hair by passing a beam of polarized light. By interposition of the polarizer and the analyzer in the track of a white polychromatic light, that vibrates in all planes, the light starts to vibrate in one plane, and if the object of observation is a crystal structure, the orientation of the light beam is changed. This phenomenon of refraction in the case of a thick hair shaft is symmetrical about the diameter of the shaft. The color of the light beam depends on the type and thickness of the crystal through which it passes. In the case of the disturbed orientation of cortical hair fibers, changes in coloration also appear. In this way, polarized light helps in determining hair thickness, microfibrillar composition, and structural anomalies. It is used to distinguish either acquired or congenital hair shaft irregularities, such as local extensions, twists, invaginations, fractures, changes of medulla or cuticula, and many other specific or less specific changes. This noninvasive diagnostic method in trichology provides valuable clues for quickly detecting a very wide spectrum of hair shaft pathology. Thus, polarized light microscopy has a huge importance in our ten cases of alopecia, which is the first and the most persistent sign due to these rare genetic syndromes.

Atopic dermatitis

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Atopic dermatitis is chronic relapsing exematous skin inflammatory reaction manifested by hyperkeratosis, spongiosis and pronounced pruritis.

Case presentation: A female child, 8 years old Is referred to a dermatological ambulance because of worsened clinical condition of untreated atopic dermatitis in the last two years.

On physical examination: dry, thin,erythematosis exclusions (scratches), lichenification and crustolic skin changes in the facial area, ears, neck, flexor and extension side od the arms, folds and joints. Standard biochemical examinations showed high concentration of total IgE, presence od eosinophils and pinned values on leukocytes and platelets. Positive Prick test of inhaled and nutritive allergens. Familly history negative for atopical diseases. Because of the allergic rhinitis, the patient is using topical corticosteroids. In the treatment we used systemic and tpopical corticosteroids, antibiotical and antihistaminic therapy, probiotic and we gived advice for respectively maintaining hygiene and skin moisture with using emolients. Two weeks later, on the control examination, the patient was with visible improvement of skin changes.

Conclusion: Because of the chronic course of the disease, in the therapy, treatment and the maintenance of atopic dermatitis, besides the family, included are and the healthcare workers who treat newborns, infants and children for the purpose of their education for daily care of the skin care and proper management for improving quality of life and outcomes patient and family.

Keywords: Atopic dermatitis,treatmant of atopic dermatitis

Electromagnetic bio-effects on human organs, tissues and cells in high microwave radiated environment

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All human tissues, organs and fluids, except bones, contain more than 70% water. What they have in common is the high percentage of Hydrogen (H), Oxygen (O), and C (Carbon), with Nitrogen (N), Sodium (Na), and Magnesium (Mg) found in most organs. The water content of 93.33% in liquid tissues (blood) is the highest, followed by lungs (83.74%), kidneys (79.47%), and muscles (79.52%). The brain has the highest content of H, while C, N, and O, are found highest in breast, bone, and lungs, respectively. Thermal conductivity, heat transfer rate, and heat generation rate are the highest in the heart [1].

In this research, Effective Medium Approximation and Effective Medium Theory will be first applied to model the macroscopic properties of human organs, tissues and cells, based on the properties and relative fractions of the materials' components. Computational electromagnetics will be then implemented to model the interaction between the human organs, tissues, cells, and the electromagnetic stimulations in the high power/high frequency environment, considering all specific parameters, including sources and boundaries.

This research focuses on detailed examination of electromagnetic bioeffects on organs, tissues, and cells, perturbed by electromagnetic radiation, i.e., electric and/or magnetic energy from high-power and high frequency in the Microwave range. Basic principles and reasons for occurrence of damage, destruction and malformation of human organs, tissues and cells by high power/high frequency stimulation will be investigated. The variables of fatigue and radiation toxicology, as they relate to performance decrement in the specific highly radiated electromagnetic environment, will be also discussed.

Keywords: electromagnetic, bio-effects, microwave, human organs, tissues; cells

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Exploring the effects of pulsed radar exposure on rat behavior and neural response

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Pulsed radar, a radar system emitting short bursts of radiofrequency electromagnetic radiation, serves mainly military purposes but has recently expanded into new sectors, notably autonomous vehicles. This study investigated the behavioral changes and potential neural distress resulting from prolonged exposure to radiofrequency electromagnetic radiation emitted by a pulsed radar simulator in rats.

Thirty young male Wistar rats were evenly distributed into a radar-exposed and a sham-exposed group. The radar-exposed group underwent 30-minute daily exposures, five days per week, within a semi-anechoic chamber, while the sham group was handled similarly, without radar activation. Surface body temperature measurements were taken before and after each exposure session. Behavioral assessments which included evaluations of short-term memory, anxiety, and locomotor activity were conducted prior to the commencement of exposure and subsequently every other month. Monitoring of S100 calcium binding protein B (S100B) plasma levels was conducted every three months to assess neural distress.

While the experimental protocol aims for a year-long exposure period, preliminary data were gathered over the initial 32 weeks. Analysis of body surface temperatures revealed noteworthy fluctuations post-exposure, both within the same group and between radar-exposed and sham-exposed groups, indicating a significant rise in temperature post-chamber exposure, particularly among radar-exposed animals. Performance in behavioral tests, including short-term memory, anxiety behavior, and locomotor activity, showed no marked differences between the two groups during the initial 32-week exposure period. Radar-exposed rats displayed an upward trend in locomotor activity, prompting the need for continued investigation as the study progresses. S100B protein couldn't be detected in the plasma of animals at any time point, indicating the absence of neural distress.

To date, no significant changes in rat behavior have been observed. Ongoing research will further investigate the lasting effects of radar exposure, shedding light on its implications for central nervous system health and behavioral patterns.

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Dielectric sealers as a source of RF overexposure in working environment

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Dielectric heaters/sealers are widely used in the industry for different purposes as: welding, sealing, or curing dielectric materials. They are amongst EMF sources in the industry that may cause excessive exposure to radiofrequency (RF) fields. This is due to their high power and possible use of unshielded electrodes. The frequencies used for sealers operation are in the range 10-100 MHz (mainly 13.56, 27.12, 37.00 and 40.68 MHz).

The paper presents study of the electric and magnetic fields in plastic industry in Bulgaria covering 71 dielectric sealers of different types: frequencies 27.12 MHz, 40.68 MHz, 37 MHz. Most of them emit at frequency 27.12 MHz with powers from 0.4 kW to 7 kW. The article discusses specificity of the dielectric sealers as sources of EMFs in working environment and related approaches for measurements and exposure assessment.

The average values of the electric field strength measured at the working places were from 8.8 V/m to 28.1 V/m; the maximal values were in the range 130 - 600 V/m, as the highest ones were registered around the highest power sealers (7 kW). Higher values were registered in the working premises with several sealers as well.

Maximal electric field strengths reached up to 10 times action levels according to 2013/35/EU). The measured magnetic field strengths were in the range 0.15 A/m to 0.20 A/m (0.19 – 0.25 μT), exceeding the action levels according to 2013/35/EU.

The EMF exposure assessment corresponds to the results of the medical study of workers in plastic industry conducted in our country that has shown adverse health effects observed in 31 % of persons working with dielectric sealers.

Radiation for prostate cancer nanotheranostics - radiopharmaceutical meets nanomedicine

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Radiation is emerging as an efficient and relatively simple tool with great potential for synthesis of polymeric nanoparticles. In radiation method, coiled macromolecules of water-soluble polymers, such as poly(acrylic acid), can be internally chemically crosslinked via the reactive species generated during water radiolysis, yielding materials with beneficial physicochemical and biological properties. Thanks to that, in this synthetic procedure there is no need for any harmful additives such as catalysts, crosslinkers, or initiators, which might contaminate the final product if not removed carefully. The fundamental science behind the radiation synthesis of nanogels is already well understood, therefore the next step is to exploit the nanomaterials obtained with the radiation method and use them as carriers with desired properties for application in targeted delivery.

Prostate cancer is the most prevalent cancer in males, increasingly diagnosed in developed countries. This is why further advancements in the field of early diagnosis and treatment of prostate cancer are of essence and diverse modalities of radiation can be a part of the solution. One of the most promising ideas is nanoradiotherapy, which exploits both already established principles of nuclear medicine as well as developments in the targeted delivery of biologically active compounds using diverse nanosystems.

The presented research aimed to exploit ionizing radiation as an efficient tool in prostate cancer nanotheranostics. Radiation from both linear electron accelerator as well as from theranostic radioisotopes was employed to develop a novel platform of biologically active polymer nanostructures, which can actively target prostate cancer cells. Using fast electrons from a linear accelerator, nanogels based on poly(acrylic acid) were synthesized and exploited as substrates for further functionalization towards targeted nanocarriers of biologically active compounds, primarily theranostic radioisotopes. Obtained nanogels were functionalized with a targeting ligand – bombesin derivative equipped with a radioisotope chelator – (1,4,7,10-tetraazacyclododecane-1,4,7,10-tetraacetic acid). Through diligent process optimization, successful nanogels functionalization with bombesin derivative was achieved with a conjugation yield of nearly 100% and high colloidal stability. Remarkable radiochemical purity upon labeling with ^{90}Y and ^{177}Lu was shown for up to 14 days. Following biological *in-vitro* characterization has proven that the obtained functional radionanocarriers were able to selectively accumulate in prostate cancer cells. Even though *in-vivo* characterization has led to the conclusion that formulation requires further optimization for more satisfactory performance in this particular application, it is important that for the first time actively targeted radiolabeled nanosystem based on PAA has been tested *in-vivo,* both in healthy animals and in murine subcutaneous prostate tumor models. This important milestone paves the way for further, more comprehensive and detailed preclinical studies on radioisotope nanocarrier system for prostate cancer theranostics based on radiation-synthesized polymer nanogels.

The integration of Astatine-211 as potential radiotheranostics in personalized cancer treatment

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Astatine-211 (At-211) belongs to the group of alpha radioisotopes used for targeted radiotherapy (TAT). The advantages of astatine-211 over other alpha emitters are its higher linear energy transfer - LET (~100 keV/µm) and short-range tissue penetration range (max 100 µm). Moreover, its primary advantage lies in the emission of only a single alpha particle per decay until the formation of stable Pb-207, without formation of radioactive daughters. The last few years it is alpha medicinal radioisotopes with major interest for personalized therapy in cancer patients.

Appropriate molecules that can be labeled with astatine-211 include monoclonal antibodies, proteins, Fab'-fragments, peptides and astatine-211 without a vector molecule. These diverse groups of labeled molecules with astatine-211 could be used for treating prostate cancer, lung cancer, leukemias, multiple myeloma, thyroid gland cancer, ovarian cancer and another micro metastasis (1).

Astatine-211 is the heaviest element in the halogen group that also exhibits metallic properties, adding complexity to the study of its the characteristics. It possesses somehow similar characteristics to iodine. This similarity is particularly useful for researching chemical behavior, as astatine-211 is one of the rearrest elements on the earth with limited access. Astatine can exist in several oxidation states depending on the pH conditions (- I, 0, + I, + III, + V, and + VII). The most clearly established is oxidation state -1. Astatine-211 is produced in a cyclotron by irradiating bismuth-209 and is mostly purified from the target by dry distillation. There are several appropriate labeling procedures such as: aromatic nucleophilic substitution with halogen exchange, dediazonation, direct electrophilic aromatic substitution, demetallation and usage of boron clusters (2). Firstly, the two step labeling procedure of monoclonal antibodies using N-succinimidyl 3-[211At]astatobenzoate (SAB) as prosthetic group, was well established. For a much faster labeling procedure, which is very important due to the 7.2 h half-life of the isotope, and higher labeling yield, there is a single step labeling procedure with boron moiety as prosthetic group (3).

Recently, the research focus is to improve the therapeutic effect of astatine-211 and to involve the benefits from this radioisotope to prepare formulation with other isotopes such as gallium-68, so they will have radiotheranostic effect (4, 5). In that case, both radioisotopes use the same precursor, peptides. This approach with multiradionuclides could contribute to the radiotheranostic formation of astatine-211.

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Copper radiopharmaceuticals as cancer theranostics: Advantages, limitations, and clinical applications

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The main objective of this article is to overview the status of ^{64}Cu radiopharmaceuticals in molecular imaging and cancer therapy.

Copper-based radiopharmaceuticals are emerging as powerful and innovative tools in nuclear medicine, offering a dual advantage in both diagnostics and therapy. These compounds, using the unique properties of copper isotopes such as Cu-64, Cu-67 and Cu-61, have opened new avenues in medical imaging and targeted treatments, particularly in oncology. The diagnostic power of these isotopes, demonstrated particularly in PET imaging, provides high-resolution information on disease processes, facilitating precise diagnosis and monitoring. In terms of therapeutic use, copper-based radiopharmaceuticals enable targeted treatment strategies, delivering radiation directly to tumor cells, thus minimizing damage to healthy tissue and reducing side effects.

After the advent of suitable production procedures based on a new generation of advanced cyclotrons, several Cooper radioisotopes with a broader range of biological functions have recently become available. Several biologically active small-molecule labeled with the radioisotopes ^{60}Cu, ^{61}Cu, ^{62}Cu, ^{64}Cu, ^{67}Cu are currently under preclinical and clinical investigation as potential diagnostic and therapeutic agents in oncology and, remarkably, a ^{64}Cu radiopharmaceutical targeting neuroendocrine tumors has already been approved for clinical use in patients. It is expected that, in a few years, other ^{64}Cu radiopharmaceuticals will find their route to market authorization for the treatment of prostate cancer and brain tumors.

Copper ions ($Cu^{2+/+}$) are essential components for a multitude of biological processes. They are necessary as catalytic cofactors of many enzymes and are key structural components for functional proteins with fundamental roles in cell biology. More precisely, monitoring the in vivo biological behavior of copper ions using radioactive [^{64}Cu]Cu^{2+}] could provide a valuable biomarker to reveal crucial molecular information in cancerous tissues. In particular, the associated b-decay combined with the emission of Auger electron could also be exploited to trigger a therapeutic effect on cancerous cells, thus forming the basis for the use of ^{64}Cu as a genuine theranostic agent. This suggests that copper radionuclides have enormous potential to advance the search for new approaches for the detection and characterization of cancer at the deepest molecular level.

Copper-based radiopharmaceuticals, with their unique properties and applications, have emerged as a significant advancement in the field of nuclear medicine. These compounds offer several key advantages, but also face some limitations that affect their clinical use.

These limitations may include challenges related to manufacturing and availability, as well as issues related to stability, pharmacokinetics, and dosimetry. Furthermore, the complexity of synthesis and radiolabeling procedures for some copper compounds may pose practical obstacles to large-scale clinical implementation.

Addressing these challenges requires continued research and technological advances to optimize the synthesis, radiolabeling, and pharmacokinetic properties of copper-based radiopharmaceuticals. Collaborative efforts between researchers, clinicians and industrial partners are essential to overcome these obstacles and fully realize the potential of copper-based radiopharmaceuticals in clinical practice.

New applications of radiation processing and development of nanoradiopharmaceuticals

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Radiation processing offer new routes to develop novel nanoparticles which can be used for diagnosis or therapy. Our group studied the application of radiation processing to the synthesis of gold nanoparticles, hydrogel nanoparticles, albumin, and papain nanoparticles as well as the development of advanced dressings. Albumin and papain nanoparticles were conjugated with ^{99m}Tc and tumor uptake was shown. Hydrogel, albumin, papain, and gold nanomedicines are being investigated for the treatment of infection diseases.

Evaluation of “honesty” based on initial effect using biological information

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According to a recent survey [1] conducted by the Organization for Economic Cooperation and Development (OECD), the average sleep duration in Japan is the lowest in the world. In terms of sleep, it has been reported that the afternoon nap (15 minutes of sleep in the afternoon) conducted by Fukuoka Prefectural Meizen High School is effective in improving the efficiency of afternoon classes [2]. On the other hand, in society, "honesty" is required for the smooth functioning of all organizations, but it tends to be difficult to quantitatively evaluate how honest a person is. Therefore, it is thought that incorporating psychological effects and performance changes derived from "honesty" could be one of the evaluation methods for "honesty".

Objective: The purpose of this study is to quantitatively evaluate "honesty" by examining the change in performance due to the initial effect of providing false information about "performance improvement after a caffeinated nap," which is known to be effective.

Method: Six subjects will be divided into three groups of two to derive the initial effect by giving false information, and changes in performance before and after a caffeine-induced nap will be compared by analyzing biological information (electroencephalogram (EEG) and electrocardiogram). Performance will be measured by (1) domino alignment (physical) and (2) Kraepelin test (mental), and sleep duration, beverage, and psychological test questionnaires will be administered after the experiment.

Results and Discussion: EEG measurements showed that (β/α), which represents the stress level [3] in terms of the intensity ratio of alpha and beta waves in the EEG, increased in almost all subjects before and after napping. Electrocardiogram measurements showed individual differences. In terms of changes in performance, all subjects showed improvement, although there were differences in the effects of the initial effect. Looking at the percentage of performance improvement, the change was smaller in the order of longer waiting time, suggesting that waiting time may have affected performance. Also, when the low percentage of performance for each group for each waiting time was compared with the questionnaire honesty ratings, the two were in agreement, confirming the analogy of the degree of "honesty". The low values of (β/α) in the EEG of the subjects who waited for long periods of time suggest that not only relaxation and stress, but also boredom, discomfort, anxiety, and other feelings were induced.

Conclusion: “Honesty” was assessed quantitatively by examining the change in performance due to the initial effect of providing false information about the known effect of "performance improvement after a caffeinated nap". Although the effect of waiting time is considered to be a factor, we confirmed that the degree of "honesty" is analogous to the degree of "honesty" in subjects tested at the same time, as there was a match between the "honesty" of the questionnaire evaluation and the low percentage of performance improvement in subjects tested.

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Machine learning in cognitive neuroscience: A promising approach for early detection of alzheimer's disease

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Alzheimer's disease (AD) is the most common cause of dementia, affecting a significant number of individuals globally. AD is classified as a subtype of dementia, a comprehensive term that encompasses a decline in cognitive abilities and behavioural changes to the extent that it significantly disrupts everyday activities (Orru et al., 2009; Coin et al., 2009). In this context, early detection of AD is crucial for timely intervention and treatment, enabling more effective symptoms management and potentially slowing the disease's progression (Dubois et al., 2016). In recent year, machine learning (ML) techniques have become evident as a promising avenue to evaluate brain imaging data and detect characteristics linked to different neurological or psychiatric conditions (i.e., Dwyer, Falkai, & Koutsouleris, 2018; Ferrucci et al., 2022) and it has been successfully applied in various fields, including forensic sciences (i.e., Pace et al., 2019; Mazza et al., 2020), psychological research (i.e., Orrù et al., 2021; 2023) and liver transplantation (i.e., Ferrarese et al., 2021), amongst others.

Aim: the objective of this study was to provide a brief overview of the current state of research on the application of ML in cognitive neuroscience for the early detection of AD.

Methods/Data Sources: we conducted a literature search of studies published in peer-reviewed journals. We included some of the studies that applied ML techniques to neuroimaging data, cognitive assessments, or multimodal data for the purpose of early detection of AD.

Results: Moradi et al., (2014) introduced an innovative magnetic resonance imaging (MRI)-derived technique for forecasting the progression MCI to AD up to three years prior diagnosis. The authors have created a "*novel MRI biomarker*". This biomarker when combined with age and cognitive assessments, resulted in a comprehensive biomarker, referred to as the *aggregate biomarker,* which demonstrated a 10-fold cross-validated AUC of 0.9020 in accurately distinguishing between progressive and stable MCI patients. In another study, Khedher et al., (2014) have developed and introduced a computer-aided diagnosis system for early AD detection. The system was able to achieve promising results in distinguishing AD and MCI patients from healthy controls (sensitivity = 85.11%, specificity = 91.27% and accuracy 88.49%).

Interestingly, the study conducted by Uddin et al., (2023) applied a ML model which included different algorithms to accurately predict the occurrence of AD. The model was trained using the open access *OASIS dataset*. The results revealed that the *Voting Classifier* achieved the highest level of validation accuracy (96%). Salvatore et al., (2015) demonstrated that ML algorithms applied to structural brain MRI data have yielded encouraging results in discriminating among AD patients, MCI patients who will convert to AD (MCIc), MCI patients who will not convert to AD (MCInc), and healthy controls (AD vs healthy controls, 76%; MCIc vs healthy controls, 72%; MCIc vs MCInc, 66%). The study conducted by Nanni et al., (2020) attempted to assess the effectiveness of ensemble transfer-learning methods in predicting early diagnosis and prognosis of AD. The results demonstrated that the ensemble transfer-learning approach effectively discriminated between AD and healthy controls, MCIc and healthy controls, and MCIc and MCInc. The study by Venugopalan et al., (2021) used deep learning (DL) models combined with multiple data. The study revealed that deep models had superior performance compared to shallow models.

Conclusions: based on the literature presented, ML algorithms and deep learning models have shown promising results in analysing complex patterns in neuroimaging data, cognitive assessments, and other biomarkers to identify individuals at risk of developing AD.

Principle of general optimization of administered activity in bone scintigraphy, introducing new gamma cameras, based on FOM

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Dose optimization is important part of nuclear medical practice. The goal was to find simple quantitative solution to be used by medical employees in step with technical development, in order to reduce administrated activities. In order to to that without subjective assessment, Figure of Merit (FOM) was selected for the image evaluation criteria and we estimate administrated activity reducing possabilities on new gamma camera, to the level which obtain images with similar (slightly better) FOM, compared to old gamma camera.

Bone scintigraphy was selected, as one of most frequent nuclear medicine procedures, where patients' radiation doses are relatively high. Old camera was E-Cam, new Symbia S, both produced by Siemens. The exported raw data DICOM images were analyzed in the Image J software.

In first research phase, we calculated FOM for 20 images from old camera and 20 images from new camera, with the same activity (15mCi) of Tc-99m, and FOM was 54% better on the new camera.

Next step was measurements with (Jaszczak) phantom: after imaging spheres with difference in specific activity by 20 % and 40 %, respectively, what we came to the conclusion that it`s still reliably better FOM with new camera (0,041) versus old (0,035), with 12 mCi compared with 15 mCi, so this optimization was ready to be applied in clinical conditions.

Third and final step was patient studies analysis with this (20% reduced) administrated activity. Optimization was passed subjective check of two nuclear medicine specialists, on the 10 patients sample, and became part of new examination standard.

More advanced detector type (fourth generation compared to third) and completely integrated electronic and software development, which allows detectors to get closer to the patient during SPECT examination, were primary technology reasons which allowed this optimization.

Consequently, we recommend this administrated activity evaluation for every new gamma camera, both because of the lower dose and to exam more patients - based on radiopharmaceutical savings.

Exploring intermediate-energy proton reactions for non-standard positron emitters radiopharmaceutical applications

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Radioactivity plays a vital role in medical applications, particularly in diagnosis and radiotherapy, with the efficacy of these procedures contingent upon the judicious selection of suitable radionuclides [1]. The decay characteristics of a radionuclide are pivotal in determining its suitability for a specific medical application. Equally critical are the production parameters, which dictate the attainability of the radionuclide in both high purity and sufficient quantities.

While both nuclear reactors and cyclotrons are employed in radionuclide production, there has been a notable shift towards the use of cyclotrons/accelerators in recent decades. Over the past 30 years, extensive experimental studies have focused on accelerator-based production of radionuclides, encompassing energies of up to approximately 30 MeV [2]. The cross-section database pertaining to nuclear reactions induced by charged particles up to 30 MeV is robust, with theoretical frameworks demonstrating notable success in describing low-energy reactions.

Protons with energies up to around 70 MeV are commonly utilized in the production of several widely used radionuclides. There is a burgeoning interest in leveraging intermediate-energy protons for the production of numerous other radionuclides. However, the existing reaction cross-section database in this energy regime remains relatively sparse, with nuclear model calculations offering only partial success in characterizing the available data [3].

In this study, we investigate the production of select non-standard positron emitters utilizing proton beams with energies up to 60 MeV. Specifically, we delve into the nuclear reactions of $^{nat}Ge(p,x)^{68}Ge \rightarrow ^{68}Ga$ (with a half-life of 1.1 hours), $^{nat}Ge(p,x)^{69}Ge$ (with a half-life of 39.05 hours), and $^{nat}Pr(p,x)^{140}Nd$ (with a half-life of 3.37 days), providing detailed experimental procedure, analyses of their characteristics and potential applications.

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Selection of a reference region in PET with radiolabeled amino acids for assessment of the pons in children

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The aim of the study was to evaluate the relative distribution of uptake of radiolabeled amino acids MET and FET in the posterior fossa structures in children with a normal brain, in order to select an optimal reference area for assessing brainstem lesions.

For retrospective analysis, 38 children (aged 3 to 16 years) who underwent PET-MET and PET-FET were selected. Inclusion criteria were children who had not undergone treatment with an intact brainstem and cerebellum (20 - PET-MET and 18 - PET-FET). The pontine-cerebellar ratio (PCR) and the pontine-frontal cortex ratio (PFR) were analyzed. For each ratio, six methods of calculation were used, depending on the size of the region of interest (ROI) and SUV (standard uptake value - maximal, medium, peak SUV in 10 mm ROI or medium SUV in banana-shaped ROI). MET and FET uptake in the pons and cerebellum was significantly higher than in the frontal cortex in both groups, regardless of the measurement method used ($p<0.05$). All PCRs showed no significant differences between PET-MET and PET-FET scans ($p>0.05$).

The obtained results allow us to recommend the cerebellum as a reference structure in the analysis of PET-MET and PET-FET in children with brainstem lesions.

Orphan radiopharmaceutical drugs registered in EU

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According to World Health Organization orphan diseases are group of diseases that have a low prevalence of less than 6.5 to10 cases in10,000 people. Nuclear medicine is an effective and advanced approach to detecting and treating many different types of diseases. Radiopharmaceuticals are often used for life threatening rare conditions, not allowing accumulation of patients over longer periods of time.

Methods and aims: Empirical study of orphan radiopharmaceutical drugs within the EU, registered respectively in "Public Health - Union Register of medicinal products".

Results: According to the results of the analysis diagnostic orphan radiopharmaceutical drugs are based of well-known radioisotopes as ^{18}F and ^{68}Ga and ^{125}I. The β-particle emitters ^{177}Lu, ^{90}Y and ^{131}I have been introduced and commonly used over the past years. The most familiar and frequently used of these is ^{131}I, which is used to treat thyroid cancer. Since the first market authorization in 2018 of [^{177}Lu] Lu-DOTATATE (Lutathera) targeting somatostatin receptor type 2 in the treatment of gastroenteropancreatic neuroendocrine tumors, some progress has been made in getting a few alpha radionuclide therapy concepts to the clinic, where can be seen a number of successes. Several clinical trials have been done with ^{213}Bi, ^{221}At and ^{212}Pb, and pre-clinical studies are being carried out with ^{149}Tb. In the near future it is expected significant growth in target therapy field.

Conclusion: Orphan drugs benefit patients with rare diseases as well, increasing the likelihood that treatments will be developed for their condition. With the incorporation of theranostic approaches into clinical practice, progressive radiopharmaceuticals have already been developed and initial results show promise. Still there are many obstacles in front of development of new radiopharmaceuticals due to the limited patient population, little financial incentive, complicate radiation protection requirements and complexity of regulatory requirements.

Keywords: Radiopharmaceuticals, nuclear medicine, rare diseases

Lutetium-177 immunoconjugates – Immunotheranostics for successful translational in molecular imaging and therapy

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Theranostics has gained significant attention and advancement in recent years, particularly in the field of nuclear medicine and oncology. Targeting radionuclides to cancer using monoclonal antibodies (mAbs) as therapeutics has been an area of great interest in the past decades and has demonstrated significant improvements in cancer treatment, leading to increased patient responses. In the last decade, several mAbs and peptides have been labeled with Lutetium-177 and evaluated as potential radiopharmaceuticals for cancer therapy. This is due to the appropriate physical characteristics of Lu-177, such as a relatively longer half-life (6 days) and beta particles with an average energy of 497 keV, making it suitable for targeted therapy.

The purpose of this paper is to present our contribution in obtaining freeze-dried formulations of immunoconjugates (conjugated rituximab and trastuzumab with three types of bifunctional chelating agents, p-SCN-Bn-DOTA, p-SCN-Bn-DTPA, and 1B4M-DTPA) suitable for labeling with Lu-177.

Various protein characterization methods were used to determine the possible changes in physicochemical properties of immunoconjugates, including size- exclusion HPLC, SDS-PAGE, FT-IR and Raman spectra and MALDI-TOF-MS.

Our additional interest lies in contributing to the successful clinical translation of these potential radiopharmaceutical formulations in nuclear medicine, demonstrating their immense value and potential for innovation.

It's undeniable that experimental animal models have significantly contributed to a deeper understanding of disease mechanisms. They are equally crucial in addressing the challenges associated with analyzing the complex mechanisms underlying pathophysiological processes in vivo.

Based on our experience, animal models have a role in the development of new radiopharmaceuticals. They are likely to remain the only source of information on their in vivo behavior and an indispensable link between in vitro and clinical studies.

However, directing the development of new drugs, including radiopharmaceuticals, towards veterinary cancer research can lead to significant advancements in the proof of concept and align with the One Health initiative.

By expanding the focus of radiopharmaceutical research to include veterinary cancer patients, the development and implementation of novel therapeutic agents can be accelerated, bringing us closer to achieving the goals of the One Health initiative. This approach fosters collaboration between medical and veterinary disciplines, emphasizing the importance of a comprehensive and collaborative approach to health and disease.

Hematological toxicity of radionuclide therapy with ^{153}Sm-oxabiphore of bone metastases in oncological patients

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Radionuclide therapy (RNT) is an effective systemic treatment for patients suffering from metastatic bone lesions, which reduces mortality and improves patients' quality of life; has a high efficiency in reducing metastatic bone pain, contributing to the improvement of motor function. Meanwhile, hematological complications of RNT may prevent the continuation of specific antitumor treatment, thereby reducing the life expectancy of such patients.

Purpose. To study the degree and frequency of hematological complications of radionuclide therapy with ^{153}Sm-oxabiphore in cancer patients with bone metastases.

Materials and methods. The analysis of complications of 45 treatment courses of RNT was carried out in 24 cancer patients with bone metastases, of which 18 were women (average age 53.2 years); 6 men (average age - 63.2 years). Before treatment, patients had stable hematological and biochemical indicators: hemoglobin more than 90 g/l, leukocyte count more than $4 \cdot 10^9$/l, and platelet count more than $100 \cdot 10^9$/l. Recommended renal blood parameters: urea less than 12 mmol/L, creatinine less than 200 μmol/L. Patients received from 1 to 4 courses of RNT. ^{153}Sm-oxabiphore was administered to patients intravenously through an angiocatheter in individually determined activities at the rate of 11.0–90.8 MBq/1 kg body weight with sequential administration of 400.0 ml of physiological solution. The hemogram was evaluated before the start of RNT, 1, 10 and 30 days after the injection of 153Sm-oxabiphore. The patients were monitored for hematological indicators for 2–3 months after therapy. The analysis of hematological toxicity (HT) of radionuclide therapy with an assessment of the degree of intensity of reactions and complications was carried out according to the WHO and International Anticancer Union Recommendations for toxicity assessment. Statistical processing of the obtained data was carried out using standard methods of variational statistics (mean value, standard squared error of the mean value), Student's t-test was used to assess the probability of changes in indicators.

Results. Among the hematological side effects of RNT with 153Sm-oxabiphore, there was generally a slight significant decrease (by 4.9%) in the level of hemoglobin ($P \geq 0.95$) after RNT. There was an average 10.7% decrease in granulocytes and a 10.6% decrease in platelets, but these changes were not reliable. For the entire group as a whole, the average level of leukocytes was almost the same both before and after RNT. Evaluating the degree of HT, it was found that the zero degree of HT occurred most often during the first week after the administration of 153Sm-oxabiphore for granulocytes in 100%, for platelets - in 97%, for leukocytes - in 91%, for hemoglobin - in 89% of cases. 3-4 weeks after RNT, the zero degree of HT was minimal for all the studied blood parameters: for hemoglobin - in 7%, for granulocytes - in 3%, for platelets - in 6% of cases. The zero degree of HT for leukocytes was not diagnosed. Hematological toxicity of the first degree in this time interval was noted for the leukocyte count in 4% and for platelets in 3% of treatment courses.

Conclusions. Hematological toxicity from RNT is temporary. The toxic effect of ^{153}Sm–oxabiphore after administration can be assessed by indicators of the morphofunctional state of red bone marrow and peripheral blood. A tendency to decrease the level of hemoglobin, the number of leukocytes, granulocytes and platelets with an increase in the injected specific activity of ^{153}Sm-oxabiphore was proven. The most significant prognostic factor is the dynamics of the count of granulocytes.

Quality assurance and quality control of dose calibrators used in nuclear medicine department

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Implementing a quality assurance (QA) program for radioactivity measurements in nuclear medicine is not just essential but a responsibility. It ensures the accuracy and consistency of these measurements, maintaining the safety and efficacy of both diagnostic and therapeutic nuclear medicine procedures while keeping the patient's exposure as low as possible. The IAEA-Technical Reports Series No. 454, a cornerstone in nuclear medicine, describes the QA for radioactivity measurements in nuclear medicine. A quality assurance program for radiopharmaceuticals must include testing the instruments used in their preparation and dispensing. The document details the types of tests and acceptance criteria for radionuclides and dose calibrators to be performed upon the initial acceptance in the unit or after repair, daily check, monthly and annually. The quality control (QC) of the dose calibrator is significant as it ensures that the administered radioactivity to the patient is within a predefined acceptable range. This work aims to establish a comprehensive set of test procedures, including acceptance testing and regular quality control procedures for dose calibrators as reference instruments for comparison of activity measurements.

Materials and Methods: The Capintec CRC®55t dose calibrator was tested using different radionuclides to ensure accuracy and reliability. The tests were carried out using standard reference sources of two radionuclides with varying energies of photon: Cs-137 to check the response of the dose calibrator to high-energy gamma emitters and Co-57 to check the response to gamma energies in the range of Tc-99m. After testing for background response, clock accuracy, zero adjustment, and bias voltage level, each source was initially measured. The system readout was then compared to the actual activity of the source. However, the linearity and the geometry tests were performed employing Tc-99m sources.

Results: The linearity and geometry test volume correction factors were calculated within the recommended limits of 0.95< VCF <1.05. The accuracy test's percentage error was less than the recommended limit of ±5 %. The accuracy, the standard deviation between the measured and actual (calculated) value, was found to be 0.87 % for the Cs-137 source and -1.87 % for the Co-57 source. In this study, the error of the reading of the isotopes Cs-137 was found to be in the range of (1.32 % - 2.37 %) thus, the constancy being lower than the tolerance of ±5% is acceptable, and it gives confidence that any repetitive measurement will give out the same result at a volume increase of 0.5 ml and a maximum reading error of 2.75 %, less than the tolerance of ±5 %. For the linearity test, we found that the error between the measured and calculated values is 1.12 % and within tolerance.

Conclusion: This study highlights the importance of the QA program in the nuclear medicine department, which increases diagnosis and therapy accuracy and reduces patient dose. Regular QC should cover the instrument's precision, accuracy, linearity, and geometry according to the manufacturer's manual and comply with international quality control guidelines

Therapeutic options in advanced renal cell carcinoma (RCC): Clinical case

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Kidney cancer represents a heterogenous group of cancers derived from renal tubular renal epithelial cells which is neither common enough to cause a large percentage of cancer related deaths nor uncommon enough to be considered an orphan malignancy. It accounts between 3%-5% of all adult malignancies worldwide and is considered to be the 7th most common cancer in men and the 10th most common type of cancer in women. More than 50% of RCC are detected incidentally, the classical triad of flank pain, gross haematuria and palpable abdominal mass being less frequent than in the past. The most common histological subtype of kidney cancer is represented by clear cell renal carcinoma (ccRCC), accounting around 80% of all kidney cancer.

In early stages, the preffered therapeutic option was represented by partial or total nephrectomy, depending of the tumor dimensions, followed by active surveillance, every 6 months. At the moment, it is also available adjuvant immunotherapy with Pembrolizumab. In case of progression, according to the results of JAVELIN Renal 101 clinical trial, the association between tirosin kinase inhibitors and immunotherapy have remarkable benefits regarding the overall survival (OS) and progression free survival (PFS).

In the following it will be discussed the case of a 47 years old male patient, with plenty commorbities that are being considered risk factors for developing renal cell carcinoma, who discovered a mass on an routine abdominal utrasonography in may 2017, without any malignant characteristics. It was monitorized every six months, until June 2021 when the reassessment pointed out a growth of the tumor mass, with signs of malignancies. It was performed radical nephrectomy, the histological subtype being clear cell renal carcinoma. The recommended therapeutic decisions according to the guidelines was active surveillance every 6 months. In may 2022, it was discovered a mass on the left psoas muscle and multiple lymph nodes in the mediastinum. The lesion in the muscle was surgically removed, the hisopathology exam revealing a metastasis of clear cell renal carcinoma. According with the JAVELIN Renal 101 clinical study, giving the disease progression, it was decided to start treatment with immunotherapy (IO) with Avelumab in association with tirosin kinase inhibitors (TKI) with Axitinib. The patient undergoes treatment for almost 2 years, without any sign of radiological progression, on the contrary, it was observed a regression of the lymph nodes on the last image reassessment.

New therapeutic approaches in advanced clear cell renal carcinoma - How to choose

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According to GLOBOCAN, in 2022 the number of new cases of kidney cancer in the world exceeded 430,000. Clear cell renal cell carcinoma (ccRCC) is the most prevalent histological subtype of renal cancer and it is characterized by resistance to radiotherapy and chemotherapy. Cytokines, targeted medications as tyrosine kinase inhibitors, mTOR inhibitors and immune checkpoint inhibitors (ICI) have successively become the standard clinical options for metastatic kidney cancer. Although the survival advantages of these medications are widely known, single-class drug therapy is vulnerable to drug resistance. In this presentation we review the established clinical therapies and novel potential therapeutic approaches for advanced CRR, IO-IO or IO-TKI combination therapies being preferred in the first line of treatment for advanced renal carcinoma. We will also try to discuss the optimal sequential treatment algorithm in case of disease progression after a first line of treatment. However, no head-to-head phase-3 randomized controlled trials have compared the efficacy of different ICI-based combination therapies. If the combined IO-IO regimens mean an additional benefit on OS versus the IO-TKI combinations is not yet known, but it is know that some patients will pay a quality of life penalty for some combined treatments.

The elucidation of the specific alterations in key molecular and metabolic pathways responsible for renal cancer but also placing the patient in a specific risk group and also

personalized treatment, adapted to each individual patient, is essential in the choice of the therapeutical regimen.

Parametric investigation on a serpentine condensing heat exchanger

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The utilization of waste heat in industrial settings plays a crucial role in maximizing production efficiency and adheres to the principles of the circular economy. Repurposing waste heat enhances resource efficiency and mitigates environmental impact. The European Union actively advocates for the transition to efficient technologies to minimize waste heat generation, thereby reducing energy costs and maintaining competitiveness in the market. Improved energy efficiency not only decreases pollution but also aligns with environmental imperatives. Lithuania's energy strategy places significant emphasis on objectives pertaining to electricity, heating, and energy efficiency, with a specific focus on promoting energy generation from waste sources. These endeavors contribute to both economic prosperity and environmental sustainability. EU Horizon 2020 projects such as The Innovative WAter recoverY Solutions through recycling of heat, materials, and water across multiple sectors (iWAYS) further enhance waste heat recovery processes in industrial applications.

The LEI Nuclear Engineering Laboratory (NEL) has conducted experimental investigations involving a specialized setup within its facilities. This setup includes a serpentine heat exchanger through which both cold and hot fluids are circulated. The hot fluid comprises dry air with varying amounts of steam injected according to experimental specifications, resulting in the circulation of humid air around the serpentine. In contrast, municipal water serves as the cold fluid flowing through the serpentine during the experiments.

The experiments conducted at NEL are designed to probe the effects of different inlet temperatures of humid air (ranging from 80°C to 200°C) and variations in mass fraction (ranging from 10% to 20%) at 5000 Reynolds number and ratio of flow rates is 3:1 (cold fluid to hot fluid). By systematically adjusting these parameters, researchers aim to elucidate how fluid behavior and condensation efficiency are influenced under diverse operating conditions. The carefully designed experimental setup provides a controlled environment conducive to capturing crucial data on heat exchange dynamics and condensation phenomena.

The experimental findings reveal that the variation of humid air inlet temperature and mass fraction can play a critical role in condensing heat exchanger design. At operating certain conditions, these parameters can influence heat transfer and condensation process according to the application intended.

Keywords: Waste heat recovery, heat exchanger, condensation, condensation efficiency

Theoretical analysis of delamination in a viscoelastic multilayered bar built-up at both ends

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This paper reports the results of a theoretical consideration of the delamination problem in a multilayered load-bearing bar of rectangular cross-section loaded in time-dependent torsion. The bar is built-up at both ends. Besides, the bar is supported by a spring and a dashpot. The bar has two portions with different thickness. There is a delamination near the border between the two portions of the bar. The viscoelastic behaviour of the bar is treated by a model that is subjected to shear stresses which vary with time. The torsion moments in the bar portions are determined by analyzing the time-dependent equilibrium with taking into account the effects of the spring and dashpot supports. Then these torsion moments are used to find-out the time-dependent strain energy in the bar. The strain energy release rate for the delamination is obtained by differentiating the time-dependent strain energy with respect to the delamination area. The time-dependent compliance of the bar is analyzed to verify the strain energy release rate. Effects of the external loading, locations of the spring and dashpot supports, bar geometry, material properties and other parameters on the delamination are evaluated and discussed. The results of the analysis are presented in forms of various graphs illustrating the change of the strain energy release rate.

Twist velocity influence on lengthwise fracture of inhomogeneous bars under torsional loading

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This paper is concerned with studying the influence of the twist velocity on lengthwise fracture of inhomogeneous load-carrying bar subjected to torsional loading. The bar under consideration has non-linear elastic behaviour. The cross-section of the bar is a circle. The bar has three portions with different radius of the cross-section. The bar is under angles of twist that are time-dependent. The material of the bar is continuously inhomogeneous in radial direction. The influence of the twist velocity is taken into account by applying a non-linear stress-strain constitutive law that includes a term with the first derivative of the shear strain with respect to time. This constitutive law is used to develop a theoretical analysis of lengthwise fracture in terms of the strain energy release rate with considering the twist velocity. The parameters of the stressed and strained state of the twisted bar that are needed for deriving the strain energy release rate are obtained by analyzing the equilibrium of the bar portions. The energy balance in the bar is investigated to verify the strain energy release rate. Numerical results are obtained and reported in form of graphs for clarifying the effect of various factors and parameters on the strain energy release rate in continuously inhomogeneous bars under time-dependent twist.

Functionally graded frames under support displacements: a longitudinal fracture analysis with taking into account the non-linear relaxation

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The current study deals with the problem of longitudinal fracture in functionally graded load-caring frame structures under support displacements in the conditions of non-linear relaxation behaviour. The latter is taken in account by applying a non-linear stress-strain-time constitutive law that holds for viscoelastic engineering materials subjected to constant strains. The frame under consideration is functionally graded along its thickness (thus, the material properties vary continuously along the thickness of the frame members). The frame is statically undetermined. Therefore, the support displacements induce stresses in the frame. These stresses lead to longitudinal fracture in the frame that is analyzed theoretically. The time-dependent strain energy release rate for a longitudinal crack in the frame is derived by considering the energy balance under non-linear relaxation. The time-dependent complementary strain energy in the frame is analyzed for verifying the solution of the strain energy release rate due to support displacements. Various graphs are drown to illustrate the effects of different factors (material inhomogeneity, magnitude of support displacements, frame geometry, etc.) on the longitudinal fracture behaviour

EPR radio-sterilization detection study for some medicines

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Considering the interests of patients and the international pharmaceutical industry, the radio-sterilization technique has many advantages compared to other sterilization techniques. For example, many pharmaceutical raw materials are unsuitable for heat treatments, and chemical sterilization processes will likely leave behind unwanted residues. Moreover, the fact that the radio-sterilization process is the only technique that can be applied to the final packaged form of medicines is the most important feature that makes this process unique. Due to these advantages, radio-sterilization has been accepted as a reliable technique in sterilizing medicines for many years. Since the requirements of the radio-sterilization process are different in each country, and the process can cause undesirable changes in medicines, the detection of radio-sterilization of pharmaceuticals is known to be a concern for regulatory agencies of many governments.

In this study, the focus is on the detection of radio-sterilization of two gamma-irradiated drugs by using EPR spectroscopy. For this purpose, EPR spectra of unirradiated and 25kGy gamma-irradiated samples were recorded with a JEOL JesFa-300 X-band EPR spectrometer, and kinetic studies were performed. The medicines with the trade names Karazepin (Terra Pharmaceuticals, Türkiye), and Meresa Fort (Adeka Pharmaceuticals, Türkiye) examined in this study, are used for the treatment of epilepsy.

Maintenance of PCNFS physical protection system

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Nuclear security and nuclear safety have the same aim - protecting persons, property, society and the environment. The PCNFS physical protection system (hereinafter PPS) is designed to provide the necessary level of protection, taking into account the principles of defense in depth and a balanced approach, in accordance with obligations based on national legislation, obligations assumed on the basis of international conventions and recommendations of the IAEA. Equipment used in PPS must be maintained in systematic approach to ensure the reliability of the PPS. PC NFS has implemented preventive maintenance which includes: routine tasks, based on checklists, and periodic inspections and maintenance tasks scheduled at predefined times. However, Reliability-Centred Maintenance (hereinafter RCM) is approach where systems and components are analyzed according to their function and priority. RCM integrates preventive maintenance, predictive testing and inspection, and repair to ensure required functionality. In fact, studies from organizations that have implemented RCM indicate that reacting to maintenance problems costs approximately 20% more than planning for them using a reliability centered approach. PCNFS has moved forward, and started transition to RCM. This paper presents how preventive maintenance was implemented in PPS and preparatory activities for transition to reliability centered maintenance as one of operation preformed to achieve the main goal of protecting persons, property, society and the environment.

Designing, engineering and implementation of transport container for disused Category I source

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First Decommissioning project of disused radioactive source was done by the Public Company Nuclear Facilities of Serbia (hereinafter PC NFS) as the only nuclear operator in Serbia in cooperation with Pacific Northwest National Laboratory (PNNL) of the Ministry of Energy of the United States of America who funded the project. The disused radioactive source was ^{60}Co, a Category I source, used in the teletherapy unit in the Medical Center in Kladovo.

One of the project requests was transporting the source with the shielding (hereafter cobalt head). Therefore, it was necessary to design, engineer, manufacture, and implement new transport container specially for this situation. Planning and implementation of transport container was a complex and multi-disciplinary process that involved both technical and non-technical aspects and required timely and effective management.

This paper presents all the phases which include the following phases: the preparatory phase, design and simulation of the transport container loads, manufacturing of the transport container, disassembly of the head of the teletherapy device, and placement in the protective container.

Theranostic potential of Lutetium-177: Characteristics and applications

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The purpose of this paper is to comprehensively describe the characteristics of Lutetium-177 and highlight its significant potential in nuclear medicine in the era of personalized medicine.

Its real-time imaging capabilities empower clinicians to introduce treatments based on individual patient characteristics. This personalized approach not only improves treatment efficacy but also minimizes adverse effects.

With a half-life of 6.65 days and the emission of beta β(-) particles (max = 497 keV), Lutetium-177 stands out as an ideal candidate for targeted radionuclide therapy. The therapeutic range of its beta particles enables precise irradiation of pathological tissues (tissue path length (mean path length = 0.16 mm, maximum path length = 2 mm), presenting a promising avenue for effective cancer treatment while minimizing collateral damage to adjacent healthy cells.

Simultaneously, with the emission of gamma photons (208 keV (11%) and 113 keV 6.4%)), Lutetium-177 can perform accurate imaging, localize lesions, and monitor treatment responses. This dual functionality of this radioisotope encapsulates the essence of theranostics, integrating diagnostic and therapeutic capabilities within a single radionuclide.

The clinical application making it compatible with a diverse range of targeting agents, spanning from peptides to large biomolecules such as monoclonal antibodies. Its chemical attributes, including a small ionic radius (0.86–1.03 Å), facilitate chelation with clinically endorsed bifunctional chelators like DOTA and DTPA.

The biodistribution and pharmacokinetics of Lutetium-177 further enhance its theranostic potential. Demonstrating a high affinity for specific tumor receptors, Lutetium-177 exhibits selective accumulation in cancerous tissues, optimizing therapeutic outcomes and reducing systemic side effects. The chelation adaptability of this radioisotope facilitates the development of various radiolabeled compounds, extending its applications beyond oncology to diverse medical fields, such as neurology and cardiology.

Lutetium-177 based radiopharmaceuticals have significantly transformed the landscape of personalized medicine in nuclear medicine and oncology. However, their successful clinical implementation necessitates a multidisciplinary team approach with comprehensive training on various aspects of radiopharmaceuticals and patient management. Unlike conventional chemotherapy, the clinical use of radiotheranostics can pose additional complexities due to logistical challenges and regulatory hurdles.

As ongoing research continues to unveil new applications for Lutetium-177-based theranostics, its potential continues to evolve. The comprehensive exploration of its theranostic capabilities is underway, holding considerable promise for advancing medical science and improving patient outcomes.

The fundamental role of information in exploring of the universe

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Information is a category that is currently being studied in many aspects in relation to various scientific disciplines, especially biology and physics. However, individual aspects of its specific action in relation to matter and energy are often cognitively separated from each other depending on the cognitive perspective within which scientific research is conducted. In this respect, e.g. in physics, they often focus on the processing of research data including thermodynamic parameters, with the state of information measured using entropy. On the other hand, in biology, the issue of precise determination of information's action relates, among others, to the morphogenetic multi-aspect nature of organism development, such as processes associated with the differentiation of totipotent cells into various tissues and organs during embryogenesis."Cognitive separation", which ignores the overall image of information reality as a whole at the very starting point, reducing it only to understanding its selected "slices", limits our ability to fully understand the comprehensive nature of reality. In a broader perspective, this approach adversely affects our ability to understand and explain the universe as a functional whole, taking into account the incomplete role of information in the context of material-energetic foundations. Therefore, the category of information should be considered as a universal natural parameter, encompassing both physical and biological reality. In the longer term, it requires a clear formulation in the form of a general law covering the entire material and energy reality. In this sense, it would involve specifying a hypothesis of such dependency that would enable capturing the controlling role of information alongside material and energy potentials in the execution and synchronization of universal events within the framework of its informational logic, harmonious balance, and purposefulness of ongoing events, both physical and biological. The success of this challenging endeavor could ultimately lead to a clear and final determination of the genesis and direction of development of reality in the context of the comprehensive role of information as a basic and universal category controlling material-energetic potentials in the overall development of events in the unknown universe. This, in turn, could lead to new discoveries and opportunities in various fields of science, technology and philosophy etc.

Keywords: information, matter, energy, thermodynamics, physics, biology, philosophy.

Convolutional integrals, spline polynomials and fractional order derivatives in more accurate pharmacokinetic, bioequivalence and individual anticancer dosage evaluations

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The study of drug input plays a fundamental role in pharmacokinetics, bioequivalence and personalized dosage therapy. This work presents a very effective numerical methods for the solutions of the pharmacokinetic models for oral drug administration.

Firstly, calculation of the absorption rate based on mathematical deconvolution with cubic spline (3rd degree) polynomials show that the accuracy of the spline method was of the same order of magnitude as the noise level of the simulated data and superior to classical absorption convolutional models based on Lagrange polynomials. This may be attributed to the great flexibility of cubic polynomials in approximating various local behaviours often seen in actual absorption data. The major advantage of the spline function over the Lagrange polynomials is the complete smoothness of the fitted curve and so the constitution of a better approximation to the system.

The second model consists of a set of fractional order differential equations which connect compartments. The main characteristic of our fractional model with derivatives of positive real order is the memory effect. Since the state of biological systems at a given time depends on their configuration at previous times, the fractional derivatives, which take into account this history in its definition as a convolution with a function whose amplitude decays at earlier times as a power-low, is natural to use when modeling the uptake and kinetics of drugs. The created numerical solution show that the accuracy of the fractional model was of the same order of magnitude as the noise level of the simulated data and superior to classical pharmacokinetic model based on linear first-order differential equations.

Presented spline and fractional derivative methods in convolutional modeling of a calcium-chanel blocker and a class IV antiarrhythmic verapamil, a NSAIL diclofenac, a diuretic bumetanide and a folic acid antagonist and most commonly used antimetabolite in cancer therapy metotrexate absorption, bioequivalence and individual dosage calculations in humans showed supperior results in comparison to classical pharmacokinetic compartmental models. Predicted concentrations of these drugs almost exactly fitted measured levels, promising excellent new more accurate methods in pharmacokunetical predictions.

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Keywords: spline polynomials; fractional order derivatives; verapamil; diclofenac; bumetanide; metotrexate

Influence of UVB irradiation on N-alkylamides from *Acmella oleracea* extract

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Acmella oleracea is a native plant in the tropics regions of Asia and South America. Due to the presence of many bioactive compounds, it is commonly used in traditional medicine for the treatment of several diseases. The main aim of this study was to investigate the influence of UV-B irradiation on identified N-alkylamides stability and to identify obtained degradation products. For identification and determination of the UV-B irradiation effect on N-alkylamides, the UHPLC-DAD-ESI-MS/MS method was used. The identification of N-alkylamides was done based on UV-Vis and PDA spectra, mass spectra, and characteristic fragmentation ions formed by CID. UV-B irradiation effect was investigated in methanol, ethanol, saline solution, and water, for 120 min.

The study revealed that commercial *A. oleracea* extract contains nine N-alkyl amides, with spilanthol and homospilanthol as the most abundant ones. Investigations of the UV-B irradiation effect on the stability of N-alkylamides demonstrated that the degree of degradation of N-alkylamides depends on the irradiation time and the solvent nature. Among the N-alkylamides found in *A. oleracea* extract, spilanthol and homospilanthol demonstrated the highest stability. The photostability of all identified N-alkylamides decreased in the following order: methanol > ethanol > saline solution > water. The main degradation products of spilanthol after UV-B irradiation were identified as 6,9-dihydroxy-deca-2,7-dienoic acid isobutyl-amide and 8,9-dihydroxy-deca-2,6-dienoic acid isobutyl-amide, that most likely represent oxidized spilanthol derivatives.

Keywords: Spilanthol; UV-B irradiation; UHPLC-DAD-ESI-MS/MS; Degradation products

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Identification of hyperforin degradation products; UVA irradiation impact studies

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Hyperforin is a phytochemical generated by the plants of the *Hypericum* family. It is a major antidepressant component in the *Hypericum perforatum* extract but also an anti-inflammatory, anti-carcinogenic, and antibacterial agent. The stability of pure hyperforin, when it is not in the extract with other components, has not been fully tested. Its activity is certainly conditioned by its stability under different stress conditions. Photodegradation of hyperforin standard solution in methanol at a concentration of 15 ppm was monitored after UVA irradiation induced stress. The samples were irradiated in a period of 0 - 120 min., in a cylindrical photochemical reactor "Rayonnet" with 7 symmetrically placed lamps, having an emission maximum at 350 nm and a total energy flux of 11 W/m^2. Ultrahigh liquid chromatography coupled with a diode array and electrospray ionization mass spectrometry was used to monitor the loss of hyperforin after irradiation as well as to detect possible new products. The intensity of the main identified hyperforin peak decreases with increasing irradiation time. Two degradation product are identified after 60 minutes of UVA irradiation at retention times of 14.34 and 15.24 minutes, with molecular ion $[M+H]^+$ at *m/z* 569. New products are identified as furohyperforin hydroperoxide and its corresponding isomer, respective. A significant reduction in hyperforin concentration in the chromatograms is observed after 30 minutes of irradiation; after 120 min., no pics are identified. Furthermore, the implication of rapid loss of hyperforin upon irradiation, may result in alteration of potential pharmacological benefits.

Keywords: Hyperforin, irradiation, degradation.

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Improved nitrite quantitation method for testing N-nirosamines reduction in pharmaceuticals

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N-nitrosamines, potent carcinogens, have been found in our everyday food, environment and water. Since 2018, the issue of N-nitrosamine contamination in pharmaceuticals has been a major concern for human health [1]. Therefore, the analysis of nitrite anion, which causes the formation of N-nitrosamines when it reacts with secondary amines, has become important to predict the risk of N-nitrosamines contamination. The selective reaction of 2,3-diaminonaphthalene (DAN) with nitrite provided a stable fluorescent 2,3-naphthotriazole (NAT) which could be well separated and selectively detected in the HPLC-FLD system [2]. The separation and detectability were improved by modifying the sample pretreatment and increasing the stability of the NAT. The analysis of nitrite in 22 drugs (DP) showed that four DP were detected at levels ranging from 10 to 200 ng/g. For nitrite reduction, activated carbon filters could reduce nitrite contamination by 68% in the synthetic organic solvent. In aqueous solution, povidone effectively reduced the amount of nitrite over time. Depending on the type and amount of excipients, activated carbon could be used to reduce nitrite, which is a source of N-nitrosamine formation in pharmaceuticals.

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Perception of physical stressors in a potentially controlled work environment

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The intangible resources of an organization, particularly its employees and their competencies, carry significant importance alongside the material resources. The success of an organization depends on its ability to prioritize its employees' well-being by providing them with a quality, pleasant, and safe work environment. Given that employees dedicate a significant portion of their day and life to work, it is imperative to cultivate an environment that shapes their cognitive and emotional states, concentration, behaviour, actions, and abilities. This notion holds true across various industries and organizational activities. Important factors of the workplace environment include room design, workplace layout, cleanliness, equipment quality, temperature, ventilation, lighting, noise, vibration, radiation and air quality. A comfortable physical workplace environment encourages employee mobility, higher concentration, sensory and physical connection to work roles, encourages employee engagement, and improves their physical and mental well-being. The aim of this paper is to determine the perception of employees in restaurants where the conditions of ambient factors should be controlled. The research was conducted on 66 employees of different socio-demographic characteristics in three restaurant facilities in the City of Novi Sad. The structure of the sample was observed according to the following independent variables: working shifts, gender, age, education, the total length of service, length of service at the current job, and size of the working place, i.e. cookroom of a restaurant in which work tasks were performed. The second part of the questionnaire evaluates seven factors: working conditions, ambient factors - noise, lighting, temperature, air, employee productivity- and an assessment of the impact of ambient factors on the health of the respondents. In addition, a subjective assessment of the adequacy and intensity of the employees' ambient factors was also carried out. According to the results obtained, it can be concluded that the respondents are highly satisfied with the quality of the lighting (mean=4.15; SD=0.82). However, air quality (mean=2.51; SD=1.36) is identified as the most problematic ambient factor in those establishments, while temperature (mean=3.15; SD=1.14) and noise (mean=3.18; SD=1.01) were rated equally. In the linear regression model, the variable „employee productivity“ is set as a criterion variable in relation to perceived environmental factors. According to the results, the coefficient of determination indicates that the group of predictors explains 76.4% of the variance of the productivity variable. Based on the partial contributions, lighting and noise measured through the statements on the questionnaire proved to be statistically significant positive predictors. Additionally, the t-test results indicate the uniformity of the scores implies no differences in the perception of ambient factors in relation to whether the assessment was performed in the morning or evening working shifts. According to the results of the Pearson correlation, it can be concluded that with the increase in age, total length of service and length of service in the current position, the negative attitude towards a noisy working environment increases, as well as the awareness of the impact of environmental factors on productivity and health. The findings of the investigation indicate a formidable challenge in achieving conditions conducive to controlled working environments. Moreover, it is evident that these conditions exert a pervasive influence on various facets of employee dynamics. In order to gain better insight into results, further investigation will include experimental measurements of these physical parameters.

Cold gas dynamic spraying method for creating barrier coatings with boron

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Boron is an important chemical element for science and industry related to neutron radiation. The high neutron absorption capacity of the boron isotope makes this element interesting and in demand for use in structural barrier materials. The well-known problem of the impossibility of exceeding a certain concentration of boron in alloys, the tendency of boron to crystallize, as well as a sharp increase in the strength of the alloys in which it is included, has not currently been solved when using classical production methods. The cold gas dynamic spray (CGDS) method allows you to avoid these problems when working with boron. This work will not disclose the methodology of the CGDN method. Instead, the results of tomographic studies carried out on samples whose boron-containing coating was obtained by this method will be presented. Based on the results of tomographic studies, it becomes possible to evaluate the uniformity of boron distribution in the coating and its effectiveness in absorbing neutron radiation.

Measurements of ^{115}In(γ,n) reaction cross-sections using bremsstrahlung photon irradiation

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Photonuclear reactions of indium isotopes attract nowadays considerable attention due to their importance for nucleosynthesis processes of proton-rich p-nuclei, such as ^{114}Sn and ^{113}In [1]. Natural indium contains 4.3% of the stable ^{113}In isotope and 95.7% of β-radioactive ^{115}In having $T_{1/2}$=441 Ty [2]. The (γ,n) reactions on ^{113}In and ^{115}In produces ^{112}In and ^{114}In nuclei, correspondingly. These radioactive indium isotopes decay similarly via β^+ and β^- branches to neighbour Cd and Sn isotopes. Also, a relatively long-lived isomer state is populated in both ^{112}In and ^{114}In as well. However, there are marked differences.

The ^{115}In(γ,n) reaction results in production of the ^{114g}In $I^\pi=1^+$ ground state decaying with $T_{1/2}$=71.9 s via two branches: to ^{114}Sn - 99.5% and to ^{114}Cd - 0.5%; and the ^{114m}In $I^\pi=5^+$ isomer state at 190.3 keV with $T_{1/2}$=49.51 days [2]. However, in difference from the ^{112m}In $I^\pi=4^+$ isomer state at 156.6 keV 100% of which decays to the ^{112}In ground state [2], only a part of ^{114m}In decays via isomer transition to the ^{114}In ground state. There is a ca. 3.25% β^+ decay branch to ^{114}Cd which was first established in [3]. The aim of present study is to validate the amount of that decay channel and to assess its contribution to the cross-section of ^{115}In(γ,n) reaction.

Two metallic targets made of natural indium and indium enriched to 87.3% of ^{113}In were activated by photons using the microtron MT-25 of the Nuclear Physics Institute of the Czech Academy of Sciences (Prague). The irradiations were performed at different photon bremsstrahlung end-point energies ranging from 7.11 up to 22.82 MeV with a step of ~2 MeV. The decay γ-spectra have been measured with HPGe detector after different cooling times. The registered γ-ray energy range was from 100 keV to 2.4 MeV. Comparison of γ-intensities in spectra obtained from enriched and natural indium targets facilitated isotopic assignment of corresponding reaction product decay lines. The measured intensities of ^{114m}In isomer transition as well as those of γ-transitions assigned to ^{114}Cd and ^{114}Sn were used to obtain experimental cross-sections of ^{115}In(γ,n)^{114g,114m}In reactions in dependence on photon energy. The results are compared with the data available in literature and with theoretical statistical model predictions calculated using TALYS computer code [4]. The differences between ^{112}In and ^{114}In decay processes are analyzed.

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Control of light propagation in photonic lattice

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Photonic lattices (PL) are artificial structures composed of periodic arrays of coupled dielectric waveguides that which are suitable for manipulation and control of light propagation in photonic devices. PL are represent optical materials with a periodically modulated refractive index. These lattices control the propagation of light waves through various mechanisms such as diffraction, interference and band gaps. A one-dimensional (1D) PL is a periodic structure that confines and controls the propagation of light along a single spatial dimension. 1D PLs exhibit periodicity only along one direction, making them simpler in structure but still capable of inducing interesting optical phenomena. Due of their periodic nature, PL form allowed and forbidden zones (gaps) for light propagation. Control of light propagation in (1D) PL is possible by changes system parameters, such as refractive index, lattice period and the width of defect [1-3].

We investigated PL made of photorefractive crystals characterized by the saturable nonlinearity such as lithium niobate (LiNbO3). Defects are located in the lattice and can be linear or nonlinear. Various types of strongly localized defect modes were found at the defect position as well as in the cavities between the defects [4]. In addition to localized modes, we found reflection and transmission of light. The light propagation is modelled by the time-independent Helmholtz equation [5]. The split-step Fourier method is used for the numerical simulations. PL find applications in a wide range of fields including optical communications, sensors, photonic integrated circuits, and quantum optics. They provide a versatile platform for designing custom optical components and devices with tailored optical properties.

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High-resolution X-ray photoelectron spectra of isoxazole and oxazole

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X-ray photoelectron spectroscopy (XPS) has been extensively used to study the core-ionization energies of molecules because these energies are directly related to fundamental chemical properties, including the distribution of charge in the molecule, the determination of the nature of chemical bonds, and the ability of the molecule to accept or provide charge at a given site. The 1s ionization energies of carbon, nitrogen, and oxygen are the most relevant in those studies because these atoms are incorporated into large numbers of compounds essential in physics, chemistry, biology, and technology.

Therefore, the present work explores the ionization of inner-shell excited isoxazole and oxazole molecules at the photon energies encompassing the C, N, and O *K*-edges. The experiments were performed at the FinEstBeAMS multipurpose beamline at the 1.5 GeV storage ring at MAX IV Laboratory (Lund, Sweden) utilizing a Scienta R4000 electron spectrometer crossed with a TOF mass spectrometer. Both oxazoles were chosen as targets because they are essential in designing new drugs. The numerous functional groups, easily interacting with specific target proteins, are readily attached to their scaffolds because isoxazole and oxazole molecules have prototypical ring structures comprising two heteroatoms, N and O, with specific electronic properties and chemical reactivity. Isoxazole has three carbon atoms and O and N atoms at adjacent 1 and 2 positions, whereas oxazole has an O atom at position one and N at position 3, separated by a C in-between. Although these two molecules are their own analogs, the chemical environments of their atoms differ, which is reflected in the high-resolution core-shell X-ray photoelectron spectra of both molecules measured at the C, N, and O *K*-edges. We determined the binding energies, widths, and line shapes from these core-shell XPS spectra. On that basis, we will discuss the chemical environments of the atoms ionized, the core–hole relaxation dynamics, and the changes in geometry after the ionization of both molecules.

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Collisions of furan and trihydrogen cations studied by collision-induced emission spectroscopy

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Ion-molecule reactions are found in many distinct environments. For example, these collisions are widely detected in various physicochemical processes in interstellar matter. These interactions also occur in ion beam processing and fabrication techniques. In addition, cations interact with cellular molecules during irradiation of cancer cells in hadron therapies. Medical applications, in particular, drive more and more research to understand the changes induced by ionic collisions with the building blocks of living cells, particularly DNA/RNA molecules. Thus, this gives rise to experimental and theoretical investigations on the fragmentation processes of deoxyribose sugar, nitrogen bases, and their analogs.

This communication shows investigations on trihydrogen cations (H_3^+) collisions with furan molecules (C_4H_4O). The measurements have been carried out at the University of Gdańsk, exploiting a collision-induced emission spectroscopy [1],[2] in the the incident energy range of 50–1000 eV corresponding to 56-254 km/s velocities of the H_3^+ cations. In the above context, furan is an archetypal heterocyclic molecule regarded as one of the simplest gas-phase analogs to deoxyribose sugar and a precursor moiety to many chemicals. H_3^+ is the simplest polyatomic molecular ion existing in space. The emission spectra reveal strong luminescence of atomic hydrogen Balmer lines. The spectra also displayed emission bands of CH radicals excited to the first $A^2\Delta$ and second $B^2\Sigma^-$ electronic states. The emission yields of these excited products were measured by recording their intensities at different projectile energies. Different collision processes can lead to the observed products via diverse fragmentation pathways. Thus, the present results are compared with furan collisions with protons to disentangle these reactions.

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

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Sediment chronologies with ^{210}Po and ^{137}Cs as fundamental tools for environmental forensic studies: Examples from Italy

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Accreting aquatic sediments are extremely important sources of information when dealing with the reconstruction of past events. Indeed, their potential as natural archives acts through the retention of significant signals about the surrounding environment at the time of their deposition and accumulation. Specifically, their role as recorders of past chemical signatures makes them ideal matrices for the reconstruction of relatively recent anthropogenic impacts. However, this is possible only when geochronological studies supply reliable analytical results in order to allow the comparison between historical information and observed changes along the core profile. It might happen that this kind of information is necessary for environmental forensic studies that aim at recognizing, for example, when environmental pollution started in a specific place, how it changed, and, eventually, who has to be held responsible for it. Indeed, impacts on aquatic environments from industrial activities and urban settlements that have largely developed in the western world during the 20th century have generally followed the same pattern everywhere: great quantities of uncontrolled contaminated wastes discharged at the onset and during the phase of greatest expansion, then a clear and constant decrease when major environmental laws or control procedures came into force. The chronological dating provided by the ^{210}Po technique through alpha counting and its external confirmation by gamma measurements of the artificial radiotracer ^{137}Cs are necessary background information in order either to correctly assess and recognize the above described trend in sedimentary records or to help identify those situations that diverge from it and understand why.

In this contribution, we present two examples from as many Italian sites heavily impacted by nearby industrial areas (i.d. the Augusta Harbor in Southern Italy and the Venice Lagoon close to Porto Marghera in the Northeastern sector of the country). In both cases, the role of sediment chronologies derived from ^{210}Po and ^{137}Cs profiles was fundamental, without which no coupling of scientific evidence from sediment cores with historical information could have been attained, and no clear view of polluting sources, timings, and mechanisms could therefore have been provided. The approaches developed and the experience acquired could be used in developing countries that present similar risks of uncontrolled industrialization.

Radon and its progeny migration in a natural gas extraction and treatment facility: In-situ characterization of Pb-210 - Case study

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In the Oil&gas facilities, radon and its progeny can be found in the gas and in films on the inside of the gas treatment/handling equipment. The radon appears to concentrate preferentially in the natural gas output of the plant . Pb-210 and Po-210 that accumulate in films are especially problematic because they are more difficult to be measured on the inside of piping and equipment due to the lack of a strong gamma decay. Generally in order to measure for Pb-210 and Po-210, it is necessary to open the piping or valves. This paper presents a real-world case study focusing on in-situ characterization measurements and analysis conducted at a natural gas extraction and treatment facility and on the results that measurement methodology can achieve. In situ gamma spectrometry analyses detected significant levels of Pb-214 and Bi-214, attributed to the passage of compressed gas containing Rn-222. Bypassing the filter resulted in a rapid decrease in Rn-222 progeny concentrations, reaching near-zero levels after approximately 2 hours, preventing any contamination meter from detecting potential issues during a plant shutdown. Since the filter accumulates solid Pb-214 and Bi-214, it is reasonable to assume the accumulation of Pb-210 and Po-210 as well. Measurements conducted on the exhaust filter confirmed this hypothesis. By removing the filters from their cylindrical containers and performing multiple measurements along the filter's length using a portable HPGe detector, the distribution of Pb-210 contamination along the filter was delineated. The results indicated levels exceeding general clearance levels outlined in RP122 Part 2 and included in the Council Directive 2013/59 EURATOM. This case study highlights the importance of comprehensive in-situ characterization and the challenges associated with detecting and managing radioactive contamination in gas processing facilities, particularly when dealing with Pb-210 and Po-210. Moreover, the study has enabled the development of a characterization strategy for plant components aimed at managing the potential removal of residues or maintenance activities that may involve them. Given the nature of the matrices and contamination distribution in this type of residue, sampling and quantitative analyses performed in laboratory are often not feasible. Therefore, Non-Destructive Assay (NDA) measurements are proposed as a viable alternative when it is necessary to determine the radiological status of a component within the scope of radiation protection. Furthermore, these measures would allow for a reduction in the quantity of residues destined for disposal by identifying hotspots in components contaminated with Pb-210 and Po-210. If these were entirely disposed of in a landfill, it would result in a significant increase in costs.

Distribution and mobility of Polonium-210 in Castillos lagoon: Concentrations and trophic transfer

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The Castillos lagoon, located on the eastern coast of Uruguay, is one of the largest freshwater lagoons in the region and is part of Uruguay's National System of Protected Natural Areas, as well as being designated as a Ramsar Site "Bañados del Este", renowned for its biodiversity. This lagoon is situated near the Atlantic coast and connects to the ocean via the Valizas Stream, which periodically opens, enabling the mixing of freshwater and brackish waters.

Polonium-210 (210Po), belonging to the uranium-238 series, is a natural radionuclide that emits alpha particles and is characterized by its high radiotoxicity and its ability to bioaccumulate in the soft tissues of organisms. 210Po is primarily found in the Earth's crust, where it can be released into the atmosphere through the emanation of radon-222 and subsequently deposited on the ground due to atmospheric precipitation of aerosols (wet and dry deposition). Additionally, this element enters the environment as a by-product of human activities such as phosphate fertilizer production, uranium mining, and oil industries.

Due to its widespread distribution in different environmental compartments, 210Po can enter the food chain through various pathways, primarily through food ingestion. In marine species, the distribution of 210Po is not uniform and tends to accumulate in internal organs such as the liver, hepatopancreas, and digestive system. This radionuclide is also a significant source of internal exposure for humans through food ingestion, contributing to approximately 80% of the internal radiation dose received.

Despite the abundance of studies on 210Po in marine environments, research in freshwater and brackish water systems is limited. To cover partially this gap, a study was conducted in Castillos lagoon to determine the concentrations of 210Po in water, sediment, and biota at 5 selected points within the lagoon during seasonal sampling. The analysis of 210Po was performed using alpha spectrometry, involving radiochemical separation and self-deposition on a silver disc.

The activity concentrations of ^{210}Po obtained in the water samples were in the range between 0.5 ± 0.1 –30.5 ± 0.7 mBq /L, while in the sediment samples vary between 24 ± 1 and 129 ± 5 Bq/kg. In the case of biota, the ranges obtained were 15 ± 1 to 33 ± 2 Bq/kg in phytoplankton, 33 ± 2 to 200 ± 6 Bq/kg in mixed zooplankton, 125 ± 4 to 183 ± 6 Bq/kg in razor clam (*Tagelus aff. plebeius*) , 94 ± 2 Bq/kg in crab (*Callinectes sapidus*), 10 ± 1 to 422 ± 10 Bq/kg in shrimp (*Penaeus paulensis*) , and, in the case of the fish, 1.8 ±0.2 to 497 ± 10 Bq/kg in muscle tissue, and 47 ±2 to 1750 ±32 Bq/kg in stomach and intestine tissue. The transfer coefficients (CR) values vary between 10^1 to 10^5 depending on the aquatic organism and the tissue considered.

The results showed variable concentrations of 210Po in different compartments, with high accumulation in phytoplankton and zooplankton. It was observed that 210Po is primarily absorbed by phytoplankton and zooplankton, and then transferred to higher trophic levels along food chains. This study highlights the importance of understanding the dynamics of 210Po in coastal lagoons, contributing to knowledge of its distribution and transfer in freshwater and brackish water ecosystems.

Natural radioactivity assessment of ^{210}Pb, ^{226}Ra, ^{228}Ra and ^{40}K in food samples of the south Tunisian phosphate area

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Over the past two decades, awareness of environmental issues has increased, prompted by evidence of the harm caused in the environment by industrially derived pollutants (UNSCEAR, 2000). Phosphate mining activities are recognized to be one of various industrial processes generating enhanced Naturally Occurring Radioactive Materials (NORM) by introducing natural radionuclides into the surrounding environment. When a significant amount of radioactive materials is discharged into the environment, it eventually infiltrates the soil, plants, and water. These radionuclides are the main source of exposure of the human body to ionizing radiation, potentially leading to adverse health effects. Hence, the aim of the present study is to determine radionuclide (^{210}Pb ,^{226}Ra, ^{228}Ra, and ^{40}K) concentration in food materials and to estimate radiation doses to the general population due to external exposure and internal exposure resulting from ingestion of radioactivity through food in locations situated 2 km away from the phosphate industries in Southern Tunisia.

Samples of vegetables and animal origin products were collected from the study area and were then, subjected to gamma spectrometric analysis using the gamma spectrometry employing a 38% relative efficiency p-type low background HPGe detector (energy resolution of 2.1 keV at 1.33 MeV) having a composite carbon entrance window, which allowed for easy detection of the 46.58 keV gamma line of ^{210}Pb. Four (4) dose quantities were introduced to quantify the effect of radiation emitted from food samples on human health. The gamma absorbed dose rate in the air at a height of 1m above the ground surface (GDR) external annual effective dose AED, internal AED resulting from the ingestion of radionuclides through food and the risk assessment (RA). The results of radionuclide activity concentrations in food samples showed that average activity values of ^{40}K, ^{210}Pb, ^{226}Ra, and ^{228}Ra (^{232}Th) of vegetable samples were 100.2, 1.5, 0.2 and 0.1 Bq kg^{-1} fresh weight, respectively. Average activity concentrations in animal products were lower than those in vegetables. The ^{40}K, ^{210}Pb, ^{226}Ra and ^{228}Ra (^{232}Th) activity values varied in the range of 11.1-90.3 Bq kg^{-1}; 0.2-1 Bq kg^{-1}; <0.02-1.7 Bq kg^{-1} and 0.01-0.2 Bq kg^{-1}, respectively. In general, the activity concentrations of ^{228}Ra in all the food samples were found to be the lowest. Additionally, lower activity concentrations of radionuclides from the ^{232}Th and ^{238}U decay series were observed in food compared to those of ^{40}K. This could be due to the low transfer factors from soil to plants for these nuclides. A comparison with the reported values by UNSCEAR (2000) shows that the activity concentration of ^{226}Ra and ^{210}Pb in the food products in this study are higher. The computed GDR values in vegetable samples varied between 0.8 and 22.7 nGy h^{-1}, with leafy vegetables exhibiting the highest average value of 6.5 nGy h^{-1}. Among animal products, GDR ranged from 0.8 to 22.7 nGy h^{-1}, with average values of 1.7, 2.7, and 2.1 nGy h^{-1} in milk, meat, and eggs, respectively. Similarly, the calculated external AED ranged from 1.5 to 41.7 µSv y^{-1}, in vegetables while it varied between 1.1 and 6.9 µSv y^{-1} in animal products. The average external AED in all the food samples was found to be 6.7 µSv y^{-1}. However, these values were found to be below their permissible limits of 59 nGy h^{-1} for GDR and 70 µSv y^{-1} for external AED. The results of AED due to the ingestion of the radionuclides in food samples showed average values of 139.4; 53.9; 33.8 and 37.3 µSv y^{-1} in leafy vegetables, root and fruits, milk and meat, respectively. The total ingestion AED from all these foods was found to be 264.4 µSv y^{-1} which is close to the average acceptable ingestion dose of 290 µSv y^{-1} set by UNSCEAR (2000). The average value of RA was of 2.5 $\times 10^{-4}$ which is lower than the limit of 2.9 $\times$ 10^{-4} considering the annual limit dose of 1 mSv for the general public.

Lead-210 application in the reconstruction of peat bog carbon dynamics

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The lead-210 dating method is a widely recognized technique in the reconstruction of high-resolution age-depth models for lacustrine environments. Although it is extensively applied in lake sediments, peat bogs share similar stratigraphical features, thus rendering possible the incorporation and burial of the atmospheric lead in the ecosystem. The growing scientific focus on peat bogs arises from their pivotal role in the global carbon cycle. These long-term carbon stocks formed as a result of the C uptake via plant photosynthesis, which has surpassed the carbon emissions associated with degradation and evapotranspiration in the ecosystem. The anthropically accelerated recent climate changes threaten the equilibrium of these carbon-exchange mechanisms, with considerable potential implications for the stability of peat reservoirs, converting them into carbon sources. The atmospheric release of the stocked carbon as CO_2 is mediated by the establishment of oxidative conditions in peat bogs, themselves induced by the water table level in the ecosystem. The outcome of such alterations would result in positive feedback to climate change, potentiating the radiative forcing and CO_2 levels in the atmosphere. At present, the degradation of peatlands through anthropic intervention is responsible for 5-10% of global annual anthropogenic carbon dioxide emissions (Loisel and Gallego-Sala, 2022). This effect, superimposed on a low potential resilience to climate change, can have disastrous outcomes.

The present work aims to investigate the carbon dynamics of temperate peat bogs from Central and Southeast Europe to establish the balance between carbon uptake and release and to highlight the variations and trends followed in the last 150 years. This time interval is of particular interest, as it encompasses the most intense anthropic development and rapidly shifting climate of the recent period.

Therefore, several peat bogs from Romania, Poland, Bulgaria, Serbia, Bosnia-Hercegovina and Lithuania have been sampled. The lead-210 specific activities were determined by nuclear spectrometric techniques (alpha, beta, gamma) and the age-depth models were constructed using the Constant Rate of Supply model. The organic, inorganic and carbon fractions have been determined by combustion via the loss on ignition method, serving as a basis for the calculation of the recent rates of apparent carbon accumulation (RERCA). Furthermore, a novel methodology has been developed for the estimation of carbon emissions, using humification-derived degradation data obtained via the colorimetric method. Ultimately, the carbon balance was established for each peat bog, using the above results.

The results indicated an upward trend of the RERCA values, suggesting increased carbon uptake, strongly associated with the expansion of the vegetation growth season with up to 30 days in the last century. The values varied between sites, from an average of 6 ± 2 C g/m^2/year (Bulgaria), to 230 ± 260 C g/m^2/year (Serbia). The stocked carbon values for the last 150 years varied between 20.43 to C 7.99 kg/m^2, while the carbon loss was estimated in the 0.33 – 2.85 C kg/m^2 (1.3 - 11.4 kg/m^2 CO_2).

Novel method for ^{210}Po determination in environmental samples

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The ^{210}Pb ($t_{1/2}$=22.2y, beta emitter) dating method is of paramount importance in environmental and geological sciences. It allows for precise dating of environmental samples such as soils and sediments, covering the past two centuries. Although both gamma and beta spectrometric techniques are widely used for measuring ^{210}Pb specific activity in the literature, they have several drawbacks, such as process complexity, higher error margins, and challenges in measuring beta radiation. Gamma spectrometry, while non-destructive and requiring minimal sample preparation, has a high detection limit due to the small gamma yield of lead (4.25%). On the other hand, the alpha spectrometry can be use after the ^{210}Pb reach the secular equilibrium with his daughter radionuclides ^{210}Po. Despite of this method also requires comprehensive radiochemical preparations ^{210}Po measurements provides significantly lower detection limits and is suitable for low activity samples.

The aim of this work is to develop a new methodology for ^{210}Po determination using liquid scintillation counting (LSC, beta spectrometry) to counterbalance the shortcomings of the mentioned techniques.

The proposed method, which is similar in procedure to ^{210}Po ($t_{1/2}$=138d, alpha emitter) disk deposition, involves ion exchange between Cu wires and ^{210}Po in solution, providing a more suitable geometry for the LSC spectrometer (Packard Tri-Carb 2300TR liquid scintillation counter) and capable of ensuring high chemical yield and low detection limit for low activity, while requiring minimal sample preparation.

The experiment was performed using six wires of different diameters: 1 mm, 1.25 mm, 1.5 mm, 2 mm, 2.5 mm, 3 mm of Cu wires. Each subjected to ^{210}Po deposition of 112 mBq in samples with two different standards. Preliminary results indicate good repeatability of the method and high chemical yield of ^{210}Po. A series of experiments were conducted to evaluate the applicability of the procedure to environmental samples on chemically characterized peat moss samples (from Crveni Potok in Tara National Park, Serbia) directly from the sample material without prior processing.

Our hypothesis suggests that precise, low-dispersion measurements can be achieved without using tracer elements through deposition on Cu wires.

Radon -222 diffusion in sediment-water interface and it's effect under Pb-210 dating method

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The radiochronology method used to study changes in lake ecosystems over the last 150 years is based on the Pb-210 isotope. When applying the method, the measurable change in the concentration of Pb-210 falled down from the atmosphere in the sediment gives the age of the sediment layers (excessPb-210). The sediment also contains Ra-226, which, during its desintegration, generates insituPb-210, over time. This is only valid if the system is considered closed, and we assume that the intermediate gas phase element of the decomposition, Rn-222, does not leave the sediment layers. This is almost true for systems characterized by rapid sediment formation, since the diffusion length from the pore space is short, so only the uppermost centimeter is where the effect can be detected, and this does not significantly influence the dating results. If sediment formation is slow and the sediment is rich in organic matter, the system cannot be considered closed from the point of view of gas outflow.

The present work examines the problem in the sediment of Lake Balaton (Hungary), in which the atmospheric Pb-210 concentration follows an exponential decrease, but the Ra-226 concentration is higher than the presumably generated insituPb-210 concentration. The hypothesis that the radon-222 gas leaves the system, and this is the cause of the incorrect dating horizon is investigated during the measurement of the rdaon gas from the pore space/pore water. The measurements of the pilot study are still ongoing.

Determination of lead-210 by the liquid scintillation counting method. Development of radiochemical methods for solid and liquid samples preparation in connection with gross alpha-beta and gamma spectrometry, and XRF methods

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Lead-210 determinations at NIPNE Romania are done by liquid scintillation counting (LSC), but also by surface and underground gamma spectrometry (microBq laboratory, Mina Unirea, Slănic-Prahova). Depending on the nature of the samples and the problems raised to be solved, gamma spectrometry won more and more, the method being simple and non-invasive. When the samples raise special problems in obtaining a result with higher accuracy, but also in the interpretation of the obtained values, radiochemical separation and measurement by LSC method will prevail. To respond to the challenges raised by such samples, the laboratory has been refined the methods in use. But it also made contributions regarding the correctness of the final results, the LSC technique being a relative measurement method. The elements of originality on the workflow of radiochemical procedures will be reviewed. Different sources of lead nitrate used as a tracer were investigated for obtaining the best measurement quenched background to which the values obtained for the analytes are related. It is also shown how LSC method can be mutually supported with gross alpha-beta spectrometry, and surface gamma spectrometry. Sometimes XRF method becomes useful in selecting optimal way to find out a reliable result. Some study cases are highlighted.

Effect of gamma ray irradiation on structural and optical properties of zinc-phthalocyanine

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In the research, two different systems of dye based on the zinc phthalocyanine were prepared by an efficient and environmentally friendly approach microwave-induced synthesis and conventional methods in order to compare their structural, morphological and optical properties. High yields and purity of β-ZnPc were obtained, with excellent gamma radiation stability for usage in sterilization of prospective medicament. According to EPR findings, microwave-produced crystals have a great potential for synglet-oxygen production, making them excellent candidates for photodynamic therapy.

The obtained compounds possess a rhombus-like shape, and tightly packed impressive layered structure, gamma-irradiated samples showed similar flattened, planar shapes with smooth surfaces as unirradiated crystals. The UV-Vis spectra of the synthesized compounds show strong absorption Q band in the visible region (600-800 nm) and a strong absorption B band in the near ultraviolet region (300–400 nm), while a small shoulder of the Q band is appeared at 642 nm, which can be assigned to the vibronic band due to the dimers and multimers.

In addition, gamma rays-exposed ZnPc-based samples were studied for a novel polymer-dye dosimeter system. These compounds were evaluated as new effective chemical-based dosimeters for low-dose measurement of gamma irradiation within the dose range from 1-25 kGy. The sensitivity of the prepared dosimeters was examined by studying the comparative results between them through the changes in structural and optical properties upon exposure to different gamma radiation doses. The color bleaching of the solutions was followed spectrophotometrically. [1]

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Singlet oxygen production induced by UV-A irradiation of PPIX-SUV liposomes

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Singlet oxygen ($^1O_2$) is usually the focus of studies in many fields including phototoxicity and photodynamic therapy (PDT). Protoporphyrin IX (PPIX) is a well-known photosensitiser with great potential for singlet oxygen production and accordingly, use in PDT as a source of $^1O_2$. The main mechanism of PPIX photodynamic effects includes light/irradiation induced generation of singlet oxygen and free radicals that can potentially kill cancer and microbial cells. So, the objective of this study is to detect and determine singlet oxygen production by UV-A irradiated PPIX molecules encapsulated inside the SUV liposomes.

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. Singlet oxygen generated by UV-A irradiation of PPIX-SUV liposomes is monitored by using imidazole/p-nitrosodimethylaniline method (Imd/RNO). Irradiation UV-A treatments of the samples were performed in cylindrical photochemical reactor with emission maximum at 350 nm and the corresponding flux at 12.9 Wm^{-2}. The photosensitizing production of singlet oxygen was determined UV-VIS spectrophotometrically, following RNO bleaching at λ=440 nm, during time of irradiation treatment of the PPIX-SUV liposomes.

According to the results of used Imd/RNO method, continual UV-A irradiation of PPIX-SUV liposomes induces $^1O_2$ production which is proportional to the time periods of the treatment. Kinetics of the photosensitizing singlet oxygen production obeying first order rate with a value 0.0307 min^{-1}. Simultaneously with singlet oxygen production, PPIX degradation was also observed. Obtained results confirmed PPIX-SUV liposomes as good basis for their use in photodynamic therapy.

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Possibilities for research in radiation chemistry and photochemistry at the ELI Beamlines facility of the Extreme Light Infrastructure ERIC

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The ELI Beamlines facility is one of the three pillars of the Extreme Light Infrastructure (ELI ERIC), an international laser user facility that is dedicated to the fundamental study and applications of laser-matter interaction using high-intensity femtosecond laser systems.

One of the capabilities that were developed over the years at ELI Beamlines are endstations / instruments that are utilizing femtosecond pulses of secondary extreme ultraviolet (XUV) photons (E = 10 – 250 eV) from high-harmonic generation processes (HHG) and X-ray photons (E = 3 - 30 keV) from laser-driven plasma X-ray sources (PXS). The generated pulses have durations on the order of 10s femtoseconds for HHG and 100s fs for PXS. These pulsed sources seem to be promising for performing photon-based pulse radiolysis, i.e., a pump-and-probe technique with sub-picosecond temporal resolution where the pump is represented by a pulse of ionizing photon radiation and the probe by ultrashort (~10 fs) optical probing pulses.

In addition to the sources of ionizing photon radiation, a state-of-the art advanced optical spectroscopy setup for transient absorption and femtosecond stimulated Raman spectroscopy has been already in active user beamtime operation at ELI Beamlines for several years. This setup can provide optical pump pulses of sufficient power to achieve multiphoton ionization in liquid samples to study radiation-chemical processes with time resolution below 10 fs using advanced optical spectroscopy techniques.

Several different liquid sample delivery systems are available for different scenarios to enable shot-to-shot refreshment rate, including a liquid sheet microjet with liquid thickness of several micrometers that potentially allows to perform experiments limited by time resolution by the duration of the pulses.

In situ testing of a prototype of a laser dosimetry probe with wireless data transmission, based on the radiochromic phenomenon in an organic detection element

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The development of a laser dosimetric probe with wireless data transmission, based on the radiochromic phenomenon in polycarbonate detection element located on the tip of probe, started in May 2020. The laser the beam passes through a light guide formed internally polished stainless steel tube with an outer with a diameter of 10 mm and an inner diameter of 7 mm, on at the end of which the beam is reflected at an angle of 90° to the transparent polycarbonate detection element 10 mm thick. After passing through the element is a ray again reflected at a 90° angle to the other parallel light pipe of the same design, by which it is returned, after which it falls on the sensitive optical sensor Sonel LXP 10-A which measures and records in real time to its memory the intensity of the incident light. The probe was developed based on the previous one of long-term radiochromic research phenomenon in the polycarbonate that took place since 2015 at the Research Centre Řež. Thanks to the construction solution of the probe, which also allows a telescopic design, it is possible to place the dosimetric element at the end of a very long and thin light pipe, and perform as well as measurement of dose and dose rate even in narrow and difficult-to-access spaces with dangerously high levels of ionizing radiation, such as the active zone of a nuclear reactor.

In 2023, the Radiochemistry II Department of the Research Centre Řež tested a prototype of the laser telescopic probe. This poster includes a detailed description of the entire device, documentation of the course of the experiment, and measurement results.

Growth of CZTSe Bulk Crystals by Vertical Gradient Freeze technique

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Cadmium Zinc Telluride Selenide (CZTSe) has emerged as a promising alternative to conventional material Cadmium Zinc Telluride (CdZnTe) for room-temperature gamma-ray detectors. This transition is attributed to CZTSe's superior properties, such as reduced Tellurium (Te) inclusions and improved compositional homogeneity. Notably, the incorporation of Selenium (Se) into the CZTSe matrix has shown remarkable enhancements, addressing inherent material limitations such as high cost and defects.

In this study, CZTSe ($Cd_{1-x}Zn_xTe_{1-y}Se_y$) was grown using the multi-zone Vertical Gradient Freezing (VGF) furnace at the Crystal Growth Laboratory of Middle East Technical University (METU-CGL). Specifically, two compositions were explored: MTSe-1 with 2% Se and MTSe-2 with 3% Se concentration, respectively. Current-voltage (I-V) and Mobility-Lifetime ($\mu\tau$) measurements were applied for electrical characterization. The compositional investigation was conducted with IR microscopy, Time-of-Flight Secondary Ion Mass Spectrometry (Tof-SIMS), and Photoluminescence (PL) techniques for both ingots.

Overall, the results indicate that both compositions had good detector-grade performance. Further investigations are underway to delve deeper into the ingots' detailed characteristics, focusing on aspects such as defect reduction and charge transport properties.

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Design and evaluation of a State-of-the-Art Single-Plane compton gamma camera for nuclear imaging

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In the realm of radiation imaging, spanning from Astro-particle physics, medical imaging to homeland security, the discourse revolves around the transformative role of Compton cameras. As technology and computational prowess advance, the construction and successful implementation of numerous radiation detectors become paramount. Among these, the Compton camera emerges as a beacon of promise, offering distinct advantages such as a broad field of view, the capability for 3D image reconstruction sans tomography, and a portable lightweight design devoid of cumbersome collimation.

Our dedicated research group is at the forefront of developing a groundbreaking, compact, and cost-effective gamma ray imager. Tracing its origins back to the 1950s when the Compton gamma camera (CGC) employed mechanical collimators like the Anger camera, our endeavor represents a significant evolution. Initially utilizing two planes of semiconductor detectors with photomultiplier tubes, we transitioned to scintillator detectors due to their superior angular and energy resolution, cost-effectiveness, low maintenance, and robustness.

The innovation in our Compton gamma camera design lies in the utilization of segmented scintillators read out on a single side by silicon photomultipliers. Each detector element comprises two scintillator crystals coupled by a light guide, fostering a novel approach. Employing GAGG:Ce scintillators and plexiglass light guides, our 8 x 8 matrix configuration maintains a compact form factor. Noteworthy is the front scintillator layer acting as the scatterer and the back layer as the absorber, both read out by the same silicon photomultipliers array. This minimizes the number of read-out channels, a crucial factor for compactness and portability.

Our constructed Compton gamma camera, aligned with the proposed design, underwent rigorous laboratory tests using Cs-137 and Na-22 sources, demonstrating an average energy resolution of 8.9 ± 1.9% and 10.8 ± 1.6% for the front and back GAGG:Ce layers, respectively. The basic imaging test showcased a spatial resolution of $\sigma = 5.1 \pm 0.2$ mm. This innovative detector promises applications in environmental gamma-ray detection and localization, positioning itself as a highly compact and portable Compton gamma camera. We will showcase the detailed characteristics, efficiency, and Angular Resolution Measurement (ARM) of our single-plane Compton gamma camera in RAD 2024. Additionally, we are exploring the implementation of the MLEM method for image reconstruction, with plans to compare its performance against the traditional Simple Back Projection (SBP) approach.

Keywords: Radiation imaging, Compton camera, gamma-ray detection, scintillator detectors, silicon photomultipliers.

Improvement of timing properties of multicomponent Ce-doped garnet-type scintillators by composition engineering and cooping

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Fast scintillators are currently in especial demand for ionizing radiation detectors to be exploited in the future high energy physics experiments and advanced medical imaging devices. Cerium-doped multicomponent garnets are prospective as fast scintillators due to their purposeful composition engineering enabled by the flexibility of the garnet lattice to accommodate various ions without substantial deterioration of the lattice. In particular, gadolinium is introduced in such scintillators to increase the scintillation light yield. However, the Gd sublattice in the crystal might serve as a channel for the delayed transfer of a part of excitation to the activator ions Ce^{3+} resulting in the deterioration of the timing properties of Ce-doped Gd-containing garnet-type scintillators. We studied the importance of this delayed transfer by measuring the luminescence decay at short-pulse excitation by of 10 keV electrons and by photons resonantly to the emitting level 5d1 of activator Ce^{3+} with no excitation transfer expected. In Gd-containing $Lu_{0.75}Gd_{2.25}Ga_{2.5}Al_{2.5}O_{12}$:Ce (LuGAGG:Ce), we observe that the cathodoluminescence decay is substantially slower than that of photoluminescence, whereas in $Lu_3Al_5O_{12}$:Ce (LuAG:Ce) containing no Gd, cathodoluminescence and photoluminescence decay at the same rate.

The experimentally observed excitation transfer via the Gd subsystem was quantitatively described using a model taking into account the excitation transfer between Gd^{3+} ions and from a Gd^{3+} ions to a Ce^{3+} ions via dipole-dipole and Dexter transfer mechanisms, respectively, and performing Monte Carlo simulation of the excitation transfer through the crystal. Fitting the simulated and experimental results revealed that multiplets ^6P and ^6I of Gd^{3+} ion have substantial role in the excitation transfer. The simulations demonstrate that the delayed excitation transfer to Ce^{3+} via the Gd subsystem substantially slows down the emission decay within the first tens of nanoseconds of the decay.

Codoping of Ce-doped garnet-type scintillators by magnesium has been shown to be efficient in the improvement of scintillation properties. This is usually attributed to transformation of Ce^{3+} to Ce^{4+}, elimination of electron traps, and formation of Ce^{3+}+Mg^{2+} pairs at high codoping levels. We studied a set of LuGAGG:Ce samples codoped by Mg at different levels to reveal the influence of codoping on the timing properties of this scintillator and found out that Mg codoping blocks the channel of the slow excitation transfer through Gd sublattice to Ce^{3+}, since the optical transitions in Gd^{3+} ions spectrally overlap with the codoping-induced absorption band. These excitations decay nonradiatively. Thus, blocking of the excitation transfer through the Gd sublattice by aliovalent codoping substantially accelerates the luminescence decay, although, at the expense of the light yield of the codoped scintillator.

A method for verifying dose-anatomical plans for stereotactic proton therapy based on the SC-1000 accelerator using radiochromic films

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The purpose of this study was to test the possibility of using radiochromic films to verify dose-anatomical treatment plans using a proton beam with an energy of 1000 MeV.

Ionizing radiation therapy is always accompanied by means to ensure safety and quality. These tools include a verification system that allows you to verify the treatment plan without risk to the patient. Radiochromic films are actively used in clinical practice of photon radiation therapy, but until now the reaction of films to irradiation with protons with an energy of 1000 MeV has not been studied.

Radiochromic film Gafchromic EBT2 from Ashland was chosen as an experimental sample [1]. A total of 3 experiments were carried out at different beam parameters and irradiation doses. The first experiment examined the overall response of films to irradiation with a proton beam with an energy of 1000 MeV. Also, the possibility of calibrating radiochromic films using this beam was investigated. The beam size was 10 mm x 10 mm. The dose range studied was from 1 to 40 Gy according to the recommendations specified in the documentation for radiochromic films. In the second experiment, the possibility of irradiation with smaller beam sizes and obtaining the first dose distribution under the standard operating mode of the installation for moving the patient was considered. At the same time, the dose range was limited at the upper limit to 35 Gy due to the limitations obtained as a result of the first experiment. In the third experiment, different irradiation modes were already considered, close to those used in the treatment of patients.

Experimental results showed that irradiation with proton radiation with an energy of 1000 MeV does not cause anomalous damage or other effects. Also, other features were derived, in the form of a saturation point at a limit radiation dose below 40 Gy. Processing of data from the second experiment showed that radiochromic films can also be used when irradiated with a standard beam size of 6 mm x 6 mm. It has also been proven that the tolerable dose range is limited to less than 40 Gy. In this case, the first dose distribution was obtained, which can be compared with the distribution observed during modeling in the planning system.

In the process of processing data from the second experiment, an algorithm for processing film images was developed, which in the future can be used as an alternative to commercial processing programs. This algorithm was also used in the third experiment, where different dose distributions close to real treatment regimens were obtained.

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Femtosecond laser TCT station to study radiation hard detectors at ELI Beamlines facility

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Continued increase of luminosity in the modern accelerators imposes rigorous requirements on performance of tracking detectors. State-of-the-art particle sensors have to be robust to extreme radiation conditions and high fluences (up to 2.5×10^{15} n_{eq}/cm^2) offering excellent timing (~ 10 ps) and spatial (~ 10 µm) performance at the same time. Hence, the precise characterization of the operational parameters of such detectors in different conditions is critical for relevant R&D.

One of the most convenient tools to get insight into the spatial, temporal and breakdown characteristics of the particle detectors is transient current technique (TCT). This method exploits the transient signal coming from the charge carriers (electron-hole pairs) generated by different sources (e.g. electric bias pulses, ionizing particles or light pulses) in the investigated device. Application of the laser pulses is especially beneficial due to the ease of tuning important parameters such as amount and location of deposited energy.

We present here very versatile TCT station developed at ELI Beamlines facility in Czech Republic. In our setup, the femtosecond (~ 50 fs) laser pulses of different wavelength are used to achieve instantaneous charge generation within the selected areas of the probed sensors. The laser beam, focused to a diameter of ~ 1-3 µm, can be very precisely (0.2 µm accuracy) directed to the selected regions of the detector. Wavelength tuning (250 – 2500 nm by optical parametric amplification) offers excitation of the sensors made of different materials by single (SPA) or two (TPA) photon absorption mechanisms. TPA mode enables deposition of the charge only at the close vicinity of the beam focal point what enables 3D scanning (including depth) of the sensor volume. In addition, the measurements can be carried out at different temperatures with lower limit of -30 °C. All the capabilities of our setup will be presented in details and supported with example results obtained on the Low Gain Avalanche Detectors (LGADs) [1-4].

ELI Beamlines is thought of as a user facility open to all scientists. Details of how to submit a proposal to carry on experiments using our TCT station will be also provided.

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Annealing effect on TlBr crystal for gamma-ray detectors

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Gamma-ray semiconductor detectors based on thallium bromide (TlBr) compound semiconductor crystals have been proposed for use in medical and scientific applications. This study was focused on improving crystallinity of TlBr crystals produced from a grown TlBr ingot by an annealing technique and demonstrating the crystal properties of TlBr crystals and TlBr detector performance. In this study, the annealing temperature varied from 80 °C to 350 °C and TlBr crystals were kept in nitrogen atmosphere for 1 hour. After the annealing, the TlBr crystals were evaluated in terms of crystallinity using X-ray diffraction (XRD) measurement, crystal surface observation by a field emission scanning electron microscope and remained strain in the TlBr crystals. In addition, gamma-ray detector performance evaluated using the TlBr crystals treated by the annealing. White spots corresponding to strain in the TlBr crystals observed by passing polarized light through the TlBr crystals minimized at between 200 °C to 250 °C annealing. This result agrees with XRD results and improvement in FWHM calculated from rocking curve at (200) diffraction peak was realized at between 200 °C and 250 °C annealing.

3D structure for dosimetry with Silicon PIN photodiode BPW34S

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Ionization chambers, MOS transistors, and photodiodes are commonly used as sensors for dosimetry [1]. The first can be considered as a gold standard in this field but all of them have some disadvantages. In this work, the angular dependence of the PIN photodiode BPW34S [2] was studied and a solution using a three-dimension sensing structure was tested to reduce this dependence.

Method and materials: Radiation source and experimental setup: Irradiation tests were conducted with a linear accelerator (LINAC) Elekta Versa HD (Elekta Solutions AB, Stockholm, Sweden), placed at "Hospital Universitario Clínico San Cecilio" (Granada, Spain). The photon beam was produced with an electric potential of 6 MV. DUTs were located in the radiation isocenter (at 100 cm) and were irradiated with a field of 10x10 cm^2. Fifteen irradiation sessions, at different incident angle, were programmed with an average dose rate of 6 Gy/min to provide an accumulate dose of 3 Gy (Si) per angle. The devices were irradiated from -180° to 180° in steps of 15° obtaining a total accumulate dose of 45 Gy. To study and compare the results of an individual sensor and the 3-D sensor, first, one photodiode was irradiated and then the mentioned 3-D sensor was studied under the same conditions.

Reader unit: The reader unit developed in our research group was used to monitor the photo current induced by the photon 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.

Results: To reduce the angular dependence of the PIN photodiode, we propose a cube made of ABS (Acrylonitrile Butadiene Styrene) which include one sensor per face. ABS was selected to build the body of the cube as it has a similar density to the water. Moreover, all the photodiodes were connected in parallel mode to obtain the sum of the photocurrent induced by the radiation. After the irradiation tests, a maximum sensitivity dependence of 35.3% was found for the induvial photodiode. In contrast, for the proposed sensor, this dependence was reduced to 10.6%.

Conclusions: In conclusion, the suggested 3D sensing structure is capable to reduce the angular dependence more than 3 times. Therefore, this together with the low degradation founded in this photodiode model [2] are promising results for future application in *in vivo* dosimetry.

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Radiation damage investigation on SiC detectors

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Silicon Carbide (SiC) represents a new challenge for detector manufacturing. The frontier activities of nuclear and subnuclear physics require devices with excellent performance in terms of stability and ability to operate at high fluxes of incident particles. SiC should be potentially very robust devices from a radiation hardness point of view; it is a wide band gap semiconductor and is presently the most intensively studied, as an alternative to silicon for the production of radiation hard devices [1-2]. The irradiation is known to cause an appreciable deterioration of the detector performance [3]. Generally, the main evidence of damage is a fluence proportional increase of the leakage current. Loss of energy resolution and of charge collection efficiency are also signs of increasing damage.

The construction of innovative detection systems, for the next generation of nuclear physics experiments at high beam luminosity, requires the development of large area devices able to survive at the exposure of highest radiation levels.

In this work we present the radiation damage study of a new, large area, p-n junction silicon carbide detectors from the point of view of both the spectroscopic behavior as a nuclear particle detector. Several devices were irradiated in different experimental conditions to study their general performance as a function of fluence. Some detectors were collimated and irradiated with an oxygen beam, other devices instead were irradiated without collimation and with an aluminum beam. Spectroscopies characteristics were investigated after the irradiation: the new detectors manifest excellent performance in terms of stability of the main parameters, i. e. charge collection efficiency and energy resolution.

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Integration of a radiation sensor into a modular CBRN system

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European Commission is aware of the relevance of security elements. In particular, Chemical-Biological-Radiation-Nuclear (CBRN) awareness systems are becoming more important. The development of a European system is mandatory to guarantee unrestricted access to these technologies. The NEST project aims to fabricate a low-cost and modular integrated detection system against CBRN threats (biological, chemical and radiation).

In particular, we mainly focus on the design and implementation of the radiation sensor sub-system. The radiation sensor requires a system able to detect low levels of radiation, for this we selected a Scintillator, as a low-cost gamma sensor. The sensor working principle bases on a material that exhibits scintillation (luminescence) when an ionizing radiation pass through the material. The scintillation detector is obtained when it is coupled to an electronic light sensor such as a photomultiplier tube or a photodiode. There are different scintillator types as a function of the core element, among others, organic crystals or plastic. Scintillators with high-Z, high atomic number, materials are ideal for gamma radiation detection as they present larger sensitivity. In fact, the selected scintillator is based on cesium iodide (CsI(Tl)), which is a cost-effective general purpose radiation detector, rugged and non-hygroscopic. We use the Scionix 51B51/SIP-CS-E3-X model, CsI(Tl) SiPM scintillation detector with built in temperature compensated bias generator and preamplifier.

In general, the CBRN system of the project is designed with a main unit that manages the information from the different sensors (sensor-HUB) by using a master-slave communication. Each sensor integrates as slave, and it communicates with the I2C protocol, due to its simplicity and robustness. In case of the radiation sensor, it provides a voltage pulse signal with an amplitude proportional to the incident radiation energy. A sampling microcontroller should acquire this information. Due to the fast signals (560ns), we use a microcontroller with a fast acquisition data. We selected an Arduino Nano RP2040 (ANRP), which is in charge of continuously acquiring the voltage level from an ADC (Analog to digital converter), due to its fast sampling time (2µs). All this information is collected and in case of the pulse rate exceeds a defined level, the system will consider a radiation threat and it alarms the sensor-HUB. As the ANRP has not an EEPROM, we use an additional Arduino Nano (AN) to store the data and later communicate it to the master of the NEST system. While the data acquisition between the scintillator and ANRP is continuous, the ANRP sends the number of counts every second to the AN, which integrates the counts over a time specified by the sensor-HUB (integration time). The communication between the AN and the master/sensor-HUB is on demand. To minimize the size of the system we stacked both microcontrollers.

To characterize the system we have used 137Cs (3.7kBq) and 241Am (100MBq) as radiation sources. We determined the system response in counts/second, when the scintillator is subjected to an external irradiation. We define the alarm threshold level when the signal presents a value larger than a 3-sigma level (3σ) over the natural radiation background. Our system detects the presence of the radiation element, validating the configuration. We have also characterized the performance of the system when the radiation source is located at difference distances from the scintillator, in centimeters. Our sensor system detects both radiation sources (137Cs and 241Am) in a distance range between 10cm to 1m, in function of the source. By adjusting the integration time, less fluctuation is regarded and thus the system sensitivity is enhanced.

Summarizing, we have designed a low-cost gamma radiation system able to detect low levels of radiation able to implement in a modular CBRN system.

Method for determination the energy distribution of neutron radiation flux density using AT1117M radiation monitor with BDKN-06 detection unit and a set of moderator spheres

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For the most correct assessment of dose loads on personnel from neutron radiation it is necessary to have information on the energy distribution of neutron flux density at a particular workplace. Based on the reconstructed energy distribution it is possible to correct the readings of the individual dosimeter assigned to the personnel at a given workplace.

The neutron radiation detection unit BDKN-06 is a ^{3}He counter placed in a polyethylene sphere-shaped moderator. The design of BDKN-06 allows sequential measurement of pulse count rate with sphere-moderators with diameters from 3 to 12 inches. Methodological support with application of special mathematical algorithm allows to obtain energy distribution of neutron radiation flux density on the basis of measured pulse count rates with each sphere.

The dosimeter-radiometer AT1117M with the detection unit BDKN-06 and a set of moderator spheres is designed to measure the characteristics of neutron radiation in order to recover the energy distribution of neutron radiation flux density.

The neutron radiation detection unit BDKN-06 and information processing unit PU4 are placed on a tripod. The design of BDKN-06 makes it possible to measure sequentially the count rate of neutron radiation pulses by a proportional counter based on ^{3}He in moderator spheres of different diameters. The diameter of the spheres is from 3 to 12 inches.

Measurements are carried out according to the specially developed measurement technique MT AAAA.7031.004-2020 "Reconstruction of energy distribution of neutron radiation flux density. Determination of average neutron radiation flux density".

The result of neutron radiation flux density energy distribution reconstruction obtained in accordance with the technique is used to calculate such quantities as: integral neutron flux density, average neutron radiation energy by spectrum, average neutron radiation energy by dose, dose equivalent per unit flux density, dose equivalent, effective dose.

The mathematical algorithm is implemented in application software with user-friendly interface as an appendix to the measurement methodology.

Response of VT06 RADFET to low energy proton beams

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RADFETs of Varadis (Cork, Ireland) with oxide thickness of 100 nm aimed to high-dose measurements have been tested with low-energy proton beams, studying the response at three energies, showing very good linearity and low fading.

Method and materials: The irradiation tests were carried out in the irradiation vacuum chamber of the 3 MV Tandem Pelletron, installed at the Centro Nacional de Aceleradores (Seville, Spain)[1]. Six runs of up to 200 Gy in Si were performed at energies of 1, 2, and 3 MeV. A printed circuit board (PCB) with three chips, two RADFETs per chip, were irradiated per energy under study. Therefore, six devices were irradiated simultaneously at the same energy. The RADFETS were assembled without lids to allow the proton beam to reach the sensitive material (silicon dioxide).

The PCBs were placed into the irradiation chamber and connected with an external switcher that permits to connect sequentially the transistors one by one to the reader unit. Thus, up to six transistors can be read per irradiation session. The source voltage is measured by our reader unit developed by the University of Granada [2] biasing the transistor at I_{ZTC} current (17 μA). The measurement process consists of three phases:

1. Zeroing: The initial source voltage is recorded.
2. Irradiation: The devices were irradiated during.
3. Measurement: The source voltage shift is measured and stored.

Five irradiation sessions were provided to reach a total irradiation dose higher than 210 Gy (218 Gy at 1 MeV; 217 Gy at 2 MeV; and 212 Gy at 3 MeV). After 15 hours, the source voltage was measured again to assess the fading effect.

Results and conclusions: The sensitivity showed an energy dependence around (0.122 ± 0.009) mV/(Gy·MeV), in fact the sensitivities found for the sets of the transistor were: (0.679 ± 0.007) mV/Gy at 1 MeV; (0.785 ± 0.006) mV/Gy at 2 MeV; (0.922 ± 0.008) mV/Gy at 3 MeV. The fading recorded after 15 hours was measured for proton energies of 1 MeV (3% fading) and 3 MeV (6% fading) showing good stability. In conclusion, the RADFET VT06 from Varadis shows a very suitable performance for high-dose measurements for different applications with low-energy proton beams.

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Response of 3N163 MOSFETs to a high energy proton beam

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Proton therapy has emerged as a cutting-edge modality in cancer treatment. This innovative approach relies on the use of high-energy protons to deliver radiation doses with remarkable accuracy, offering distinct advantages over conventional photon therapy. To ensure the efficiency and safety of these treatments, it is necessary to measure the applied dose accurately. To achieve this, semiconductor detectors are widely used. This work endeavours to characterize a general propose commercial MOSFET as dose sensor for high energy proton beam.

Irradiation sessions were performed in the Proton Irradiation Facility (PIF) at PSI (Switzerland), with a proton beam of high energy. Tests were performed with energy set at 69.78 MeV, 151.23 MeV and 230 MeV, planned in runs of 2 minutes to provide a dose of about 10 Gy. 5-minute non irradiation intervals were interposed between each run. Each device was administered a dose of approximately 60 Gy. Devices under test (DUTs), 3N163 pMOSFET, were grouped in sets of three and placed on a printed circuit board. The shape of the provided beam consisted of a 5 cm diameter circular area. DUTs were centred in this region, at 8 cm from the beam output. DUTs were left with the TO-72 encapsulation since the protons were expected to have enough energy to penetrate through it and reach the active volume.

The reader unit used to acquire the signals was developed by our research group [1]. It was placed in the control room and connected to a laptop via USB. DUTs were inside a bunker separate to the control room. The connection was established through un-shielded cables with a total length around 40 meters. The reader unit was set to bias the transistors with a constant current of 230 μ A.

To conduct the tests, two methodologies were employed: real-time monitoring and deferred mode. In real-time mode, the evolution of the source voltage was continuously registered every two seconds. In deferred mode, measurements were taken only twice, before and after irradiation.

With real-time mode, the sensitivities obtained at 60 Gy of accumulated dose were 8.7± 0.8 mV/Gy, 7.2± 0.6 mV/Gy and 22± 3 mV/Gy with the aforementioned energies respectively. Analogously, with deferred mode sensitivities were 13.7± 0.3 mV/Gy, 17.3± 0.2 mV/Gy and 21.2± 0.5 mV/Gy.

Therefore, further tests could be considered to improve setup conditions and assess the influence of different variables, such as bias voltages and long-term fading.

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Versatile NFC-reader for MOSFET sensors with enhanced voltage operation

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To enhance the quality of radiotherapy treatments, in vivo dosimetry is widely used to regulate the radiation dose received by patients [1]. Various desktop dosimetry systems have been devised for this purpose, yet their reliance on complex power management systems significantly escalates both the cost and the system complexity. Presenting an alternative to these systems, we introduce a portable, battery-less, and wireless solution. The system leverages Near Field Communication (NFC) technology [2] along with an NFC-enabled smartphone equipped with a custom application for measurement, data storage, and cloud-based publication, enabling seamless monitoring of the patient's treatment progress. Harnessing the NFC link, the tag harvests energy and communicates with the smartphone. The presented system is an improved version of the previously developed NFC dosimeter [3]. It features a variable current source to bias different interchangeable pMOSFET modules at Zero Temperature Coefficient (ZTC) drain currents, thereby minimizing thermal dependence. In addition, it incorporates a DC-DC boost converter to accommodate stacked configurations [4] or RADFETs that require high bias voltages.

System description: The inclusion of the DC-DC boost converter extends the maximum voltage operation of the dosimeter compared to previous designs. To preserve the battery-less design, a supercapacitor is added, which must be charged before the boost converter starts operation. The charging, measurement, and communication processes are controlled by the tag's microcontroller. Thanks to the higher voltage operation, the system can handle transistors with higher source voltages, such as the 3N163 [5] (Vishay Siliconix), in single and stacked configuration. Additionally, the system features a programmable source current, controlled by the 8-bit DAC of the embedded microcontroller, enabling operation with different pMOS transistors models with different I_{ZTC} values. The irradiation tests will be conducted using a LINAC Elekta Versa HD (Elekta Solutions AB, Stockholm, Sweden), placed at the "Hospital Universitario Clínico San Cecilio" (Granada, Spain) using a 6 MeV beam.

Conclusions and future tasks: Different models of transistors, whether in single or stacked configurations, can be managed thanks to the programmable source and the higher voltage operation achieved with a low-power consumption DC-DC boost converter in a battery-less NFC tag. The inclusion of the supercapacitor resolves the power requirements of the DC-DC boost converter, necessitating a charging period before the measurement process. In summary, this work proposes an enhanced wireless and battery-less NFC-based system that offers capabilities comparable to desktop reader units butat a lower cost. Additionally, it features a user-friendly application for healthcare personnel, facilitating the classification, control, and follow-up of each patient in the cloud using just a smartphone.

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Application of detectors based on LiF:ZnS(Ag) mixture with natural and elevated concentration of ^{6}Li isotope for detection of neutron radiation

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Nowadays neutron radiation detection is an important task in the sphere of radioactive materials transport control, especially nuclear materials. This requires the creation of small and highly effective detectors, which can be used as an independent device or as a module of RIID, PRD and SPRD devices.

Helium counters are traditional, but are losing market share due to their large size. An alternative that combines both gamma spectrometry and neutron detection capabilities are lithium containing crystal scintillators such as CLYC, NaIL, CLLB, but they cannot be used in all types of systems because they are expensive and require complex processing methods to separate neutron and gamma pulses.

An alternative is to use separate modules based on the composite material LiF:ZnS(Ag), which is a mixture of powders of these salts with the addition of an optical binder. Neutron detection is based on the reaction of ^{6}Li with a neutron, producing an alpha particle and a triton, which are detected by zinc sulfide. Due to the high energy output of this reaction, high light yield ZnS pulses are easily separated from gamma quants and neutrons by a conventional amplitude discriminator, and the small size of the ZnS particles provides low sensitivity to gamma radiation, which together allow false alarm of the neutron detector to be almost completely eliminated. To increase the sensitivity to neutron radiation in these detectors, Li is usually enriched in the ^{6}Li isotope up to ~95%.

ATOMTEX develops small size neutron radiation detectors based on lithium screens and silicon photomultipliers (SiPM) used in RIID, PRD, SPRD detectors. In addition, the development of LiF detectors with natural content of the ^{6}Li isotope is underway, which will greatly simplify the fabrication technology for devices in which larger detectors can be used.

The results of Monte Carlo modeling of detectors based on LiF:ZnS(Ag) in different geometric configurations to achieve maximum sensitivity at natural and enhanced content of ^{6}Li isotope, as well as the results of experimental studies on samples of lithium screens are presented in the report. Practical aspects of application of each studied type of detectors in RIID, PRD, SPRD devices are considered.

Border safety for RN Treats with small devices: High-K RADFETs with preliminary electrical characterization

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Today, border security emphasizes the detection of smuggling activities, particularly the increasing threat of radioactive material smuggling. Consequently, prioritizing the prevention of nuclear and radiation-related threats has become paramount. Addressing these challenges at borders necessitates the implementation of radiation detection systems. In this context, RADFETs (Radiation-Sensitive Field-Effect Transistors) have garnered significant attention for their compact size, low power requirements, and ease of integration with integrated circuits. Our objective was to manufacture RADFETs using High-k dielectric materials, such as Erbium Oxide (Er_2O_3), Ytterbium Oxide (Yb_2O_3), and Hafnium Oxide (HfO_2), as alternatives to the conventionally used Silicon Dioxide (SiO_2) dielectrics. Following the fabrication process, we conducted initial electrical characterizations of the High-k RADFETs. These assessments revealed promising features, including a reduced threshold voltage compared to traditional RADFETs. Consequently, High-k RADFETs could potentially be employed at borders to mitigate radiological and nuclear threats in the future.

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The gain associated discharge of the inter-pixel region in TI-LGAD: Insights into two-stage charge multiplication at Si/SiO_2 interface between SiO_2 trenches

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Low Gain Avalanche Diode (LGAD) is now baseline technology for timing detectors for the ATLAS and the CMS experiments at the CERN. The gain in Low Gain Avalanche Diodes is obtained by implanting an appropriate density of acceptors (of the order of ~ 10^{16}/cm^3) close to the *p-n* junction, that, when depleted, locally generates an electric field high enough to activate the avalanche multiplication; this layer of acceptors is called gain layer. The two challenges in the development of segmented LGAD for high energy physics detectors are the radiation hardness and the fine segmentation of large area sensors. Irradiation fluences of the order of 10^{15} n_{eq}/cm^2 have a dramatic effect on the LGADs: neutrons and charged hadrons reduce the active acceptor density forming the gain layer; this mechanism, called initial acceptor removal, causes the complete disappearance of the internal gain above fluence of 10^{15} $n_{eq/}$ cm^2. From other side, for the segmentation of LGADs, the crucial point is the electrical insulation of pads and the extension of the inactive area between pads. Different linter-pixel layouts are designed to solve the problem of low fill factor. However, downscaling of inter-pixel distance in synergy with increased leakage current from the inserted isolation structures may set a limit on the operable conditions of the device. In this paper, we present the latest results on observed discharges from the inter-pixel region. The specificity of the behavior of the observed phenomenon is related to the specificity of the discharge signal formation conditioned by an interesting synergy of different effects which will be analyzed in this contribution.

Coupled floating gate MOS transistors as a radiation detector

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Floating gate metal-oxide-semiconductor (MOS) transistors feature an additional gate, known as the floating gate (FG), embedded within the oxide layer, unlike standard MOS transistors. This floating gate can be charged with electrons from the channel by applying a positive bias to the control gate. Initially, before exposure, the floating gate is fully charged with electrons, leading to an increased threshold voltage. Upon exposure to radiation, the floating gate discharges, resulting in a decreased threshold voltage, which can be monitored. The innovative concept of coupled floating gate MOS transistors involves using two FGMOS transistors, both fully charged on the same chip. During irradiation, the first transistor acts as a radiation detector, while the second remains fully charged by a designed electronic system. Once the first transistor discharges to a predetermined level, the roles switch, and the cycle repeats. This design ensures continuous operation without blind time, facilitated by latch relays for switching between the electrical configurations of the FGMOS transistors.

Experimental setup: The experiment utilized commercially available electrically programmable floating-gate NMOS transistors (EPADs) from Advanced Linear Devices (ALD), USA. Conducted at the Department of Radiation and Environmental Protection, "Vinča" Institute of Nuclear Sciences, Belgrade, Serbia, the system was placed in front of a Cobalt-60 ionizing gamma radiation source.

Results: The coupled floating gate MOS transistors exhibited a highly linear response to ionizing radiation. Zero-biased configurations demonstrated higher sensitivity and reliability compared to those with static bias, as indicated by the floating gate charge stability per cycle during irradiation.

Conclusions: The degradation of the floating gate MOS structure was observed with an increasing number of floating gate charges per cycle under static bias compared to zero bias when irradiated with gamma rays. Future research will focus on further analyzing the influence of bias on the floating gate structure's degradation and identifying conditions that maximize the reliability of the coupled floating gate MOS transistor system, aiming to increase the total ionizing dose.

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Effect of cobalt ionizing radiation on RADFETs with SiO_2 oxide and high-k dielectric

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RADFETs (Radiation-Sensitive Field-Effect Transistors), when irradiated, lose their original properties. In the non-irradiated state, they have one threshold voltage value, however, when they are irradiated, their threshold voltage shifts, and the change depends on the accumulated radiation dose. Therefore, with different doses of ionizing radiation, different threshold voltage values are obtained. Monitoring these changes is very important so that RADFETs can be used as ionizing radiation sensors. Determining changes in the threshold voltage occurs by recording the current-voltage characteristic of the transistor before and after each irradiation, and then comparing those results. Considering the nature of the event itself, the process of automated measurement of such characteristics is highly desirable.

A special PCB (Printed Circuit Board) was designed and implemented for the purposes of carrying out RADFETs irradiation experiments. The main problem in the design was the inclusion of two configurations during transistor irradiation: successive application of gate voltage on transistors and measuring their electrical characteristics at certain moments of time. By using relays as switches, the desired requirements of the electronic circuit were obtained. In order to achieve complete modularity of the PCB board, the transistors were placed on sockets. The board was primarily designed for a DIP-8 package RADFETs and first choice for component placement on board was Zero Insertion Force sockets, with the aim of maximally eliminating the possibility of component damage. Also, separate sockets were placed on the board for future research with different kinds of power transistors.

The very significant functionality of the PCB has been extended by adding an option to automatically measure the gate voltage at the end of each irradiation cycle. The board has maximum capacity for eight transistors to be irradiated and measured at the time.

The correctness of the PCB and its functioning was checked by performing an experiment at the Institute for Nuclear Sciences “Vinča”, Belgrade, Serbia. The experiment was done on RADFETs with different types of dielectrics, SiO_2, as well as Hf_2O_2/SiO_2, Er_2O_3 and Yb_2O_3 which are known as high-k dielectrics.

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SPICE modeling and simulation of RADFETs

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RADFET (Radiation-Sensitive Field-Effect Transistor) is p-channel metal oxide FET-based transistor, which is used as semiconductor sensor for detecting and measuring ionizing radiation. As a result of radiation, transistor parameters such as threshold voltage and transconductance change, and the changes are proportional to the total accumulated dose. This paper presents the procedure for extracting RADFET parameters from the transfer characteristics in the saturation region and ID-VDS characteristics, their dependence as a function of the dose, and the implementation of the model in the LTSpice program. The model is obtained for RADFET fabricated on 6-inch low resistivity silicon wafers using diffused p+ source and drain contacts. The gate oxide material is preferred as SiO2 with thickness of 300 nm, and the gate channel width and length of RADFETs are 300 μm and 50 μm, respectively. Irradiation experiment was conducted in NUKEN, TENMAR, Ankara, Turkey. In addition to the parameters that define the transistor geometry (L – channel length, W – channel width, tox – gate oxide thickness), key transistor parameters that can be extracted from the transistor's transfer characteristics in the saturation region are: zero-bias threshold voltage VTO, surface mobility UO, bulk p-n saturation current IS. Channel length modulation factor LAMBDA is extracted from output transistor characteristics. Parameters such as mobility modulation THETA, saturation field factor KAPPA, and some RADFET capacitances take the default values. To determine the value of these parameters, additional experimental data is needed. The zero-bias threshold voltage is determined by drawing a tangent to the linear part of the curve √ID = f(VGS). Obtained value for the sensor sensitivity is 9.86 mV/Gy. Surface mobility parameter is calculated from transconductance in function of gate-source voltage. Bulk p-n saturation current IS can be determined from the transfer characteristic of the RADFET in the saturation region, by representing the drain current in log scale. Channel length modulation factor – LAMBDA refers to an increase of the depletion layer between drain and gate as the drain voltage is increased. The parameter LAMBDA is calculated by selecting two points on drain current axis and their corresponding VD voltage values from the output characteristics curve keeping the gate voltage constant. The channel length modulation factor was found to be 0.00793 for fresh samples, and 0.00909 for irradiated ones.

RADFET is described by a model card for a PMOS transistor in LTspice. A good agreement between the experimental and simulation values is observed in the above threshold RADFET operating range, while a deviation is observed in the subthreshold range. Only one parameter (IS) is defined for the subthreshold operating range, which causes the obtained results. In future research, the model will be extended for RADFETs with high-k dielectrics. In this way, the SPICE model of RADFET will be able to be applied in the design of electrical circuits that use this component as a sensor element.

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Assessment of NBT Stressing Impact on the Continuous Operation of Power VDMOS Transistor

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This study provides a comprehensive examination of the behavior of vertical double-diffused metal-oxide-semiconductor (VDMOS) power transistors subjected to irradiation and negative bias temperature (NBT) stress. The research methodology involved a series of carefully designed experiments aimed at understanding the post-stress performance of these transistors under standard operating conditions. The objective was to elucidate the impact of the NBT-induced degradation on the device reliability and functionality.

In the experimental setup, the transistors were exposed to controlled NBT stress conditions, simulating the negative gate bias voltage at elevated temperatures typically encountered in practical applications. The resultant self-heating effects within the devices were meticulously monitored using a high-resolution thermographic camera. This approach allowed for the precise capture of thermal profiles and localized temperature variations across the transistor structures, thereby providing valuable insights into the heat dissipation characteristics and the onset of potential thermal hotspots. After the irradiation and NBT stress exposure, the transistors were evaluated under normal operating conditions to assess any variations in their electrical characteristics and overall performance. For this purpose, the displacement of the voltage threshold was measured and analyzed, which served as an indicator of the degree of degradation and facilitated a comparative analysis between the device under stress and without stress. The gathered experimental data were systematically analyzed to derive correlations between the degree of NBT stress and the observed performance degradation. This analysis included statistical evaluations and modeling to predict the long-term reliability impacts on the VDMOS transistors. Additionally, the study explored the underlying mechanisms contributing to the degradation, including the charge trapping and interface state generation, which are critical to understanding the longevity and stability of these devices in power electronics applications.

The findings of this investigation underscore the significance of irradiation and NBT stress as a crucial factor in the reliability assessment of VDMOS power transistors. By delineating the stress-induced changes in device behavior, this study provides a foundation for developing the improved design and fabrication strategies aimed at enhancing the durability and performance of these transistors in demanding operational environments.

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Gamma-irradiation effect on physical aging in vitreous As-Ge selenides and sulfides

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Prolong gamma irradiation is known to induce changes in physical, optical and structural properties of chalcogenide glasses. In this research, the radiation-induced physical ageing effects in binary Se- and S-based As- and Ge-containing glasses are compared. The samples were irradiated with gamma-quanta under ambient conditions with a few Gy/s power and a few MGy total dose. The effects of physical ageing were quantified by measuring the surface area of endothermic peaks observed with differential scanning calorimetry (DSC) in a heating mode within the glass transition region. This peak is known to contain information on regaining of the enthalpy lost during structural relaxation at below glass transition temperatures. It is shown that gamma radiation leads to additional ageing in selenide glasses possessing under-constrained networks over the effect caused by isochronal natural storage of the samples at normal conditions. Despite structural similarity of main constituent building blocks, the gamma-irradiated S-based glasses demonstrate more prominent changes in the glass transition temperature and area of endothermic peak as determined from DSC curves on heating. It is concluded that structural network of gamma-irradiated chalcogenide glasses relaxes in a new thermodynamic state closer to the equilibrium of supercooled liquid than if the physical aging occurred under normal conditions for the same period of time. The nature of the observed phenomena is explained within modified configuration-coordinate diagram and mean-field constraints theory.

On the functionality of chalcogenide semiconductor glasses modified by gamma-irradiation

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Effects of gamma-irradiation from Co^{60} source (1.25 MeV) on physical properties of chalcogenide semiconductor glasses (ChGS) of multicomponent Ge-As/Sb/Bi-S/Se systems are critically examined in respect to the intrinsic free volume determining compactness of their glass-forming networks. Destruction of covalent chemical bonds in the ChGS under continuous irradiation is accompanied by radiation-assisted physical ageing tending these glasses towards newly attained metastability. Within such relaxation occurring via direct interaction of bond-forming atoms and nearest neighbors, the pairs of over-coordinated and under-coordinated topological defects possessing an excess of positive or negative electrical charge appear. Optical response in the metastability of the ChGS is completely defined by combination of irradiation-induced excitation and relaxation effects. The role of atomic compactness in the relaxation pathways activated under continuous gamma-irradiation is analyzed for ChGS possessing different free volumes. The unified configuration-enthalpy model based on conjugated configuration-coordinate and thermodynamic enthalpy diagrams is developed to describe metastability-related effects in multicomponent ChGS under combination of different external influences, such as natural physical ageing, gamma-irradiation, thermal annealing and rejuvenation.

The influence of various types of radiation on microfungal strains of polar latitudes

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Fungi belong to the group of eukaryotes with high radioresistance. Microfungi isolated from polar latitudes are further adapted to increased levels of cosmic radiation, ultraviolet light and low temperatures. Many radiotolerant fungi have a common distinctive feature - the production of pigments: melanin or carotene. Melanin, a high-molecular-weight dark pigment constitutively synthesized by fungi, accumulates in the fungal cell wall and is assembled into many concentric layers consisting of densely packed small particles. This arrangement increases the scattering of incident photons, resulting in superior shielding and protection from UV light. The mechanism of interaction of melanin with ionizing radiation remains relatively unexplored. It is assumed that the radioprotective effect of melanin may consist in the removal of free radicals, primarily those formed during the radiolysis of water. The physical interaction between melanin and recoil electrons generated by Compton scattering of incident photons in the melanin itself or transferred to melanin by other molecules and radicals may be another important factor in radioprotection. Carotenoids are a class of pigmented terpenoids. The general function of carotenoids in heterotrophic organisms is to protect as antioxidants from reactive oxygen species produced as a result of photosensitizing reactions.

We compared the ability of vegetative and spore-forming cells of five species of microfungi: *Rhodotorula colostri* (contains carotene), *Cladosporium herbarum* (contains melanin), *Pseudogymnoascus pannorum* (contains carotene), *Exophiala xenobiotica* (contains melanin) and *Aureobasidium pullulans* (contains melanin) to resist the effects of vacuum ultraviolet radiation (VUV) [1], bremsstrahlung and relativistic protons [2] in exponential and stationary phases of development. The work *used* cultures of micromycetes from the collection of the Botanical Institute. V.L. Komarova RAS (St. Petersburg, Russia).

The source of VUV radiation (166 – 182 nm) was excimer lamps with a radiation power of 1.8 mJ s-1 cm-2 (Vavilov State Optical Institute, St. Petersburg). The source of bremsstrahlung photons is a linear electron accelerator Elekta Compact (St. Petersburg), inducing flows of fast electrons with an energy of 6 MeV (dose rate 3.50 Gy/min). The source of protons was the SC-1000 accelerator (National Research Center "Kurchatov Institute" - PNPI, Gatchina) with a beam energy of 1 GeV (dose rate 5 Gy/min). The maximum dose of radiation from photons was 200 Gy, and from protons – 500 Gy.

At low doses for all micromycetes and with all types of radiation, activation of the process of germination of spores and conidia was observed. At medium and high doses, radiation suppressed the growth of spores and conidia (caused temporary inhibition of the formation of growth tubes and reduced the length of germ tubes), caused damage to cell membranes and DNA degradation. Partial cell destruction was observed already from medium doses, and at high doses visually discernible changes in the surface of the propagules could be determined. The studied microfungi had high radiation resistance, which varied depending on the species, stage of development and metabolism. *E. xenobiotica*, a strain containing melanin, showed the greatest resistance to ionizing radiation.

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Study of the process of radiation defect formation in 4H-SiC

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Traditional semiconductor materials - Si, Ge, GaAs - due to their physical and chemical properties cannot satisfy the increased requirements of modern industry. This is especially true for devices that are planned to be used in extreme conditions - space technology, nuclear power plant equipment. This necessitates the use of new materials, on the basis of which it would be possible to obtain devices more resistant to extreme operating conditions. In this paper the effect of high-temperature electron and proton irradiation on SiC-based devices characteristics is investigated. Industrial integrated 4H-SiC Schottky diodes, for each of which the base was of n-type, and the blocking voltage is either 600 V, or 1200 V, or 1700 V, manufactured by CREE is studied. 0.9 MeV electron and 15 MeV proton irradiation was applied. The maximum radiation doses were 7×10^{16} cm^{-2} for the electrons and 1×10^{14} cm^{-2} for the protons. To assess the radiation resistance of the samples under study, the parameter "*carrier removal rate*" (Vd) was used. This parameter was calculated on the basis of capacitance-voltage characteristics as the ratio of the difference in Nd-Na concentration in the sample before and after irradiation to the irradiation dose.

It has been found that silicon carbide Schottky diodes irradiation resistance at a high temperature significantly exceeds their irradiation resistance at room temperature. The Vd value in the case of irradiation at a temperature of ~ 400 C decreased by 5-10 times compared to irradiation at room temperature. It is shown that this effect occurs due to annealing of compensating defects induced by high-temperature irradiation. The parameters of radiation-induced defects are determined by the method of *deep level transient spectroscopy (DLTS)*. Under high-temperature ("hot") irradiation, the spectrum of radiation-induced defects introduced into SiC looks to differ significantly from the spectrum of defects introduced at room temperature.

Using silicon carbide as an example, the features of radiation compensation of wide-gap semiconductors are considered. The dependence of the base resistance of high-voltage (blocking voltage 600 V) SiC Schottky diodes on the irradiation dose by electrons (energy 0.9 eV) and protons (energy in MeV) in the range of 8 orders of magnitude was experimentally traced. It is shown that the observed experimental dependences can be qualitatively interpreted on the basis of a simple three-level model, which takes into account the formation of acceptor levels in the upper half of the band gap during irradiation of SiC. It has been demonstrated that measuring the current-voltage (I-V) characteristics makes it possible to unambiguously and reliably determine the dependence of the carrier concentration (base resistance) on the radiation dose in a very wide range.

It was found that the dependence of Vd on temperature is of an activation nature. The activation energies (Eact) are ~ 49 meV for electron irradiation and 76 meV for proton irradiation. These Eact values are close to the energies of acoustic phonons in SiC. A more detailed consideration of the dependence of Vd on temperature will be presented in the full volume paper.

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Radiation effects on electronic devices

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High radiation environments are present in many fields, such as high-luminosity accelerators, ignition facilities and space. The devices to be used in these conditions can be affected by the particularly stressful radiation levels. Most of the employed equipment is made of *Commercial Off-The-Shelf* (COTS) components, cheaper than the *radiation tolerant* and *rad-hard* ones. Preliminary qualification tests against radiation effects on the components are thus required to guarantee the devices radiation performances.

Devices such as Electrical, Electronic and Electro-mechanical (EEE) components, that are the basic elements of any electronic system, must withstand hostile radiation conditions. Radiation effects on electronics are divided into: Total Ionizing Dose (TID) effects, Displacement Damage (DD) and Single Event Effects (SEE) (1). Both TID and DD are cumulative effects, dependent on the energy deposited in the electronics: in the former, electron-hole pairs are produced and it is mainly a semiconductor oxide effect (surface damage). The latter consists in the displacement of an atom in the semiconductor lattice by hadrons with enough energy (bulk damage). Contrarily, SEE are related to a single individual interaction and can cause an error in the device at any moment during the operation.

The active region of electronic devices is generally made of silicon. When incoming particles interact with silicon, different kinds of damages, such as surface or lattice defects, are produced by specific processes and ionization as well as non-ionization energy-loss (NIEL) processes can occur (2)

A study of the radiation-induced damage and of its effect on the device parameters was carried out in specific laboratories, by employing different types of radiation sources and different characterization methods. In particular, laser-accelerated protons with broad energy spectrum and ^{60}Co gamma radiation were used in this project to perform irradiation tests on Bipolar Junction Transistors (BJTs). Gamma irradiation was performed at the Calliope gamma irradiation facility at ENEA Casaccia R.C. (Rome, Italy) (3). The facility is equipped with a ^{60}Co gamma source (mean energy 1.25 MeV). Proton irradiation was performed at the Advanced Laser Light Source (ALLS) facility (https://alls.inrs.ca/beamlines-endstations) of the Institut National de la Recherche Scientifique (INRS) located in Varennes (Québec, Canada).

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Attenuation of silica-core optical fibres under gamma irradiation

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The optical fibres with pure silica core can be used as a transport medium between the scintillation material and the detector to keep sensitive electronic detector devices away from radiation. The optical fibres with pure silica cores are characterised by high resistance to ionizing radiation. They also have unique properties such as good chemical stability, low Rayleigh scattering and low bending loss. Optical fibres with a pure silica core need different construction in comparison to standard telecommunication fibres where the core is dopped to increase the refractive index. The optical fibres have dopped silica cladding by fluorine or are made from different materials without silica such as special plastic optical cladding (Hard Polymer). Optical cladding doped with fluorine lowers the refractive index, so it is a type of fibre with suppressed optical cladding.

This work evaluates the effect of ionizing radiation on the attenuation of pure silica core optical fibres, using a technique that involved measuring changes in laser power transmitted through the optical fibre at a constant dose of gamma radiation. To perform our experiment, we used a wavelength-stabilized DBR diode laser source that emitted radiation at a wavelength of 633 nm. We compared 3 optical fibres with a core diameter of 1 mm with an irradiance length of 5 m and numerical apertures of 0.22 and 0.5. The optical fibres differed in the content of hydroxyl groups inside the optical core, NA, and fluorine doping of the optical cladding. The total irradiation dose of each fibre was 9 kGy with a dose rate of about 42 Gy/hr. After irradiation, relaxation was measured for each fibre after 100 hours.

Analysis of the effects of various thin film fabrication methods on the performance of Yb_2O_3 metal-oxide semiconductor capacitors

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This study aimed to provide comprehensive results on the structural properties of Yb_2O_3 dielectric deposited on n-type Si substrates using various thin film deposition techniques and its impact on electrical characteristics. In this context, Yb_2O_3thin films with a thickness of ~120 nm were deposited on n-type Si substrates (100) using RF magnetron sputtering and electron beam physical vapor deposition (EBPVD) methods. XPS depth profiles of the films annealed at 400 °C in nitrogen ambient were obtained from nine different layers to assess the structural properties. The crystal properties of the films were determined using XRD. Subsequently, the front Al contacts of the MOS capacitors were grown using DC magnetron sputtering with a 1.5 mm radius mask. The back contact of the wafer was entirely covered with Al using the same method. The electrical characteristics of Yb_2O_3 MOS capacitors were obtained covering low and high frequency regions, and oxide and interface trap densities were determined. The results showed that data obtained from capacitors fabricated using RF magnetron sputtering exhibited a more stable behaviour.

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Sensitivity of selected photomultipliers in field gamma and neutron radiation

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The photomultipliers are commonly used in the development of ionizing radiation detectors. We have has found that some of the photomultipliers we use are more sensitive to ionizing radiation than other types. We decided to test the selected photomultipliers in the field of gamma and neutron radiation. The following types of photomultipliers equipped with an active negative voltage divider have been used for testing. The signals from the photomultipliers have been connected to the input of the MCA-1000 multi-channel analyzer. For each photomultiplier, the response spectrum has been measured and the sensitivity for Cs-137 and Cf-252 was determined. The results of measurements and comparison of radiometric parameters of individual photomultipliers are presented.

First test of cosmic-ray muon telescope with off-axis movable objective

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The use of various cosmic ray muon telescope systems for investigation of thickness of material layers covering certain location is very useful technique. Thus, in such way can be studied the presence of different caves within rocks, lava level within volcanoes, existence possible rooms within ancient objects (such as pyramids), or even the status of core of nuclear reactor. Most of these muon telescopes are designed as coaxial detector system, providing inclination of the muon telescope axis for certain angle, regarding vertical direction, by rotation of muon telescope as whole. In this study, we constructed and tested cosmic-ray muon telescope system, with off-axis movable objective. That means that selecting certain solid angle around direction inclined for some angle regarding vertical direction, can be achieved by simple sliding of upper detector (muon telescope objective) laterally from vertical axis. Such off-axis objective movements doesn't require mechanical rotation all muon telescope detectors in order to point muon telescope toward certain direction. The muon telescope consisted of two plastic scintillation detectors: lower square-shape plastic with 0.5m x 0.5m dimensions and thickness of 0.05 m, and upper circular shape plastic (objective) with diameter of 0.2 m (0.05 m thickness), operating in coincidence mode within coincidence interval of 5 microseconds. The coincidence spectra of muon telescope located inside laboratory room were acquired by MPA-3 multiparameter system (including 2-dimensional plastic-plastic spectra, as well as time dependent spectra of both detectors), for 3 positions of muon telescope objective , which corresponded to the 3 different telescope orientations regarding vertical axis: coaxial orientation toward zenith, orientation to building walls, and one orientation to building window. The intensity, as well as energy distribution of acquired coincidence spectra of muon deposited energies were analyzed, together with influence of concrete layers thickness at these spectra. The Monte-Carlo simulations, based on generating of cosmic-ray muons by Geant4 simulation software, were performed in order to make energy calibration of coincidence spectra acquired in experimental setup. The spectral intensity ratio was found by measurements for two different telescope orientations regarding vertical axis. The same ratio was also found by simulations and compared with experimental result.

Neutron and gamma radiation in vertical irradiation channels of the LVR-15 research reactor

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The LVR-15 research reactor situated at the site of the Research Centre Rez near Prague, is a light water moderated and cooled tank nuclear reactor with forced cooling. The maximum reactor power is 10 MW. It is a multi-purpose research reactor utilised for basic and applied material research, isotope transmutation and production of medical and technical isotopes. Received neutron fluence is the main parameter of the irradiation experiments. Horizontal and vertical channels of the reactor are used for the irradiation. The presentation focus on neutron fluence evaluation in vertical irradiation channels of the LVR-15 reactor using calculation and measurement.

Vertical channels are used for irradiation experiments with required neutron fluence from 1E+15 cm^{-2} to 1E+21 cm^{-2}. Before an experiment, neutron fluence estimation is usually made using theoretical calculation with MCNP code. During the experiment, activation detectors are irradiated near the samples, and after the experiment, final value of neutron fluence is evaluated using theoretical neutron spectrum and measured activities of activation detectors. The form of activation detectors is usually foil or wire and usual materials contain elements of Fe, Cu, Ti, Ni, Nb and Co. The induced activities are measured with HPGe spectrometry assembly.

On the LVR-15 reactor, 5 to 8 vertical irradiation channels are available at the same time, depending on reactor core configuration. Values of neutron fluence rates in the irradiation positions are between 1E+12 $cm^{-2}s^{-1}$ and 2E+14 $cm^{-2}\cdot s^{-1}$. In the presentation, typical values of neutron fluence rates are given for individual irradiation channels including vertical profile. Dose rates are also given for gamma radiation, which always accompanies neutron radiation.

A novel method for detection of new Ac-228 isomer with a $CeBr_3$ crystal scintillator doping with Ra-228 radioactive source

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Radioactive sources have been used in many applications. However, some of the radioactive decay modes are still under research because it is difficult to identify them. We developed a novel method using fast and high light yield crystal scintillators doped with radioactive sources to identify isomers with low energy gamma's. The Bridgman method is used to grow CeBr3 and CeBr3 crystal scintillators doped with Ra-228. The CeBr3 scintillator is an excellent choice for this application due to its high light yield, good energy resolution, and fast decay time. The scintillation properties of CeBr3 crystals such as light yield, energy resolution, decay time and non-proportionality with and without Ra-228 doping, are compared to check the performance of the doped crystals for radiation detection. The Ra-228 has a half-life of 5.75 years with a Q value of 45.8 keV and its emission of low-energy beta particles and multiple gamma rays. Thus, the current method is suitable for studying the decay characteristics of Ac-228 isomers, which are of interest in nuclear physics and rare event searches. Using the fast decay and good energy resolution CeBr3 scintillator, Ac-228 isomers can be identified using a delayed coincidence method. This technique involves correlating the detection of beta and gamma rays emitted from the decay of Ra-228 with a time delay, allowing for the discrimination of background radiation and the specific decay signatures of Ac-228 isomers. The development and characterization of CeBr3:Ra-228 scintillators for identifying Ac-228 isomers are presented, including measurements of their energy and decay time using the delayed coincidence method.

Use of spectral unmixing for rapid foodstuffs analysis in radiological post-accidental situations

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Radionuclides release by a nuclear incident can contaminated large zones of the environment. Then they can be found in plants, animals and thus in foodstuffs. During the post-accident phase, the main risk for the population is the exposure through ingestion of food contaminated by radioactive deposits. This risk assessment is based on Maximum Permitted Level (MPL) defined by the European standard (Euratom 2016/52). In order to quickly identify contaminated foodstuffs, IRSN is developing a new instrument base on gamma spectrometry: Tri-Latac. The detector chosen for the Tri-Latac is a NaI(Tl) 3"x 3" due to its high detection efficiency. Thus, Minimum Detectable Activity (MDA) below MPL are rapidly obtained. However, its full width at half maximum (FWMH) of 7 % at 662 keV is higher than other detectors such as $LaBr_3$, HPGe, etc. Therefore, a classic deconvolution is not adapted to identify two radionuclides with close energies. To resolve this issue, Tri-Latac is using an automatic analysis tool based on spectral unmixing[1]. The hypothesis used by spectral unmixing is that an acquired spectrum is a linear combination of spectra from each radionuclide present. In opposition to the usual gamma spectrometry, spectral unmixing uses the complete acquired spectrum to determine radionuclides activity.

The presentation will describe the process to determine the range of application of the Tri-Latac: matrix, counting time, performance... First, the study of various sample matrices has enabled to define the MDA for the three radionuclides of interest that are $^{134,137}Cs$ and ^{131}I. Spectra have been simulated, using the modeling software MCNP and data from Chernobyl, to test the Tri-Latac with radionuclides from an accidental situation. Finally, the performances will be compared with those of a commercial instrument in terms of acquisition time and radionuclides determination.

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Strengthening radiation safety infrastructure in public company "Nuclear Facilities of Serbia"

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Whole body counting (WBC) measurement is a direct method for measurements of internal contamination by gamma emitters in the human body, that could have been inhaled or ingested. This method is used to assess the level of internal exposure of occupationally exposed workers in the framework of decommissioning and radioactive waste management activities In the Public Company Nuclear Facilities of Serbia" (PC NFS). This article shows the improvement of capacity for WBC measurement within TC IAEA national Serbian Project "Strengthening Radiation Safety Infrastructure in Public Company Nuclear Facilities of Serbia".

With IAEA assistance, PC NFS will improve the methodology for internal occupational exposure assessment trough the upgrade of the existing infrastructure for WBC measurements. New system will include two sodium iodide scintillation detectors activated with thallium (NaI:Tl), supporting digital electronics, software and phantom for calibration purposes. The detectors and electronics will be installed in existing WBC cabin made of 20 cm thick pre-nuclear steel wall and dimensions 200 cm x 198 cm x 145 cm.

By installing new equipment, PC NFS will improve the radiation safety system, ensuring greater protection of workers from potentially harmful effects of ionizing radiation and also PC NFS will be able to offer its radiation protection services in the area of whole body counting and internal exposure assessment to all interested stakeholders in the country, as well as in the region.

HPGe detector: From acceptance to commissioning

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Between the acquisition of a new HPGe gamma detector and its commissioning for routine measurements, a lot of work has to be done. The aim of this poster is to present the protocol of the Nuclear Measurement Laboratory of the Nuclear Safety and Radioprotection French Institute in France to use an HPGe detector for routine measurements with integrated coincidence corrections.

After the reception of the detector, the first step is to characterize its intrinsic efficiency using point sources of known activity, measured at 10 cm (negligible coincidence) and 5 cm from the detector. Using Gespecor 5.0 software [1], the experimental results are compared with simulations based on detector dimension given by the supplier. From these results, the detector dimension is adjusted in Gespecor to reach a difference below 5 % between simulation and measurement. Then a validation is carried out on a 500 mL geometry used for routine measurement in contact with the detector. Difference between simulation and measurement results must be below 5 %.

The second stage consists of determining the efficiency curves for each geometry used in the laboratory. They are based on the measurement of a muti-gamma calibration source covering the entire working range, i.e. from 29 keV (^{129}I) to 1836 keV (^{88}Y). Once measurements are done, the coincidences must be corrected using Gespecor simulation. The corrected curves are then implemented in Genie2k, the spectrum processing software.

Once the curves corrected, surfaces of the full energy peaks must be corrected for coincidence. The solution is to apply the coincidence correction factor to the emission intensity in the radionuclide's library used for analysis. Therefore, the laboratory uses an Excel macro developed at the Environment Radioactivity Metrology Laboratory (LMRE) called CorAna.

The other advantage of this Excel macro is the application of self-attenuation corrections. It integrates the work carried out by V. Spielmann presented in an internal report : self-attenuation correction in gamma spectrometry measurement for environmental samples. For the correction, different types of samples are sorted into classes considering their natures and densities.

Finally, the validation stage consists in measuring international proficiency test entities on the detector, to check the conformity of the results. The automatic treatment is a tool to facilitate the work of technicians and researchers to be able to undergo thousands of measurements each year. However, the competences and knowledge as to be maintained to guarantee the quality of the results.

Alpha/beta discrimination by liquid scintillation for post-accidental analysis: Comparison of liquid scintillation counters

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In case of nuclear crisis, it is necessary to determine rapidly the activities of samples from the area of the incident. Rapid results are needed on samples with different matrices such as water or foodstuffs. To fasten the process, it is advantageous to have a method without radiochemical separation. For alpha and beta emitters, this parameter makes the measurements challenging.

However, one of the methods that can be used is the alpha and beta discrimination by liquid scintillation[1]. Once the samples are in solution, they just have to be mix to the scintillation cocktail and can be count directly. Then, alpha and beta activities can be estimated to determine rapidly if they are above the Maximum Permitted Level (MPL)[2].

To differentiate alpha and beta disintegration, an analysis of the signal is realized. Indeed, the pulses from alpha disintegration are longer than the beta disintegration. By comparison of the signal decay, it is possible to discriminate the two types of emissions. Practically, it is done by determining a discriminator time above which a signal is sorted as alpha and below as beta.

In liquid scintillation, there are two main suppliers of counters: Perkin Elmer (that has recently change to Reevity) and HIDEX. On the different models of TriCarb and Quantulus counters from Perkin Elmer, the discrimination is realized by setting a Pulse Decay Discriminator (PDD)[3,4]. To set it, it is possible to use an automatic option based on the measurement of standards solution and by determining the optimal PDD with the less spillovers. On the 300 SL Super Low Level from HIDEX, one of the parameters to set is the Pulse Length Index (PLI)[5]. In option, HIDEX propose a visual feature to help optimized the discrimination.

In this presentation, the method developed at IRSN in France will be described. The parameters influencing the discrimination and the limits of the method for its application in post accidental situation will be discussed. Then, a focus will be done on the difference between the counters from Perkin Elmer and Hidex in term of performances.

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Noisy radioactivity data analysis using parametric Poisson models

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In metrology, the use of the concepts of decision limit and detection limit often poses many problems for metrologists in radioactivity analysis laboratories. It is usual to censor data when it becomes difficult to discern the presence or absence of activity, due to noise in the measurement data. This means that if the measurement results are insignificant (below the decision threshold), the analysis simply indicates that the actual value (signal) of radioactivity is below a certain limit called the detection limit. These problems are often due to a misunderstanding of the decision threshold formulas. In addition, it is not clear how to generate an appropriate and justified decision threshold in ISO(2020). In this research paper, we develop a statistical method for determining the most powerful decision threshold. Next, methods of statistical approaches are adopted to estimate the density, expectation and variance of radioactivity. The effectiveness and feasibility of these approaches are corroborated by applications on IRSN data sets.

Measurement of RF exposure around indoor private 5G network antennas at different levels 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 with three different emitted 5G power levels.

For this purpose measurements were taken in October 2023 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. The pico antenna is located in a laboratory where students have laboratory practice, and 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 total emitted power of the system can be set arbitrarily between 10-35 dBm. We choose three different power levels for pico antenna: 14, 17 (as operational use) and 20 dBm; and three levels for micro antenna: 27 (as operational use), 30 and 33 dBm, respectively.

To measure the electric field strength we used the following two devices:

1. ExpoM-RF personal radio frequency exposure meter which can acquire data in 16 separate predefined frequency bands between 87.5 MHz – 5875 MHz;
2. Narda SRM-3006 spectrum analyser with 3502/01 three-axis antenna (420 MHz-6 GHz).

The devices were fixed during the measurement. The sampling rate was 3 s for the ExpoM-RF device and 6 s for the SRM-3006. We performed two measurement campaigns around the pico and the micro antennas. We used the following scenario for both campaigns:

a) measurements without switched on the 5G network
b) measurements with 5G network switched on working in idle mode (no generated data traffic)
c) measurements with 5G network with generated data traffic

During every measurement we collected the samples for 2 minutes. After measurements 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 0.04 V/m while the 5G network was turned on in idle mode. During data traffic this value reached a maximum 0.25 V/m. Around the micro antenna these values were 0.17 V/m and 1.43 V/m, respectively.

In conclusion the electric field strength values around indoor 5G antennas are quite below the public exposure limit values (61 V/m).

Pb-210 activity concentrations in cigarettes tobaccos and estimation of annual committed effective dose

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This study is important to assess the radiological effects associated with tobacco smoking for smokers. Monitoring of radiation doses through internal pathways is an important parameter of public health studies. Internal pathways of natural radiation exposure include inhalation and ingestion of radionuclides during consumption of food, water, smoking of tobacco cigarettes etc. Smoking of tobacco may cause health hazards due to internal radiation exposure. The activity concentration of ^{210}Pb in cigarettes, which is a ^{210}Po precursor in the ^{238}U decay series, was determinate. Samples of thirteen different commonly sold brands of cigarette tobacco were analyzed by employing a P-type high purity germanium detector (HPGe) with low background. The LabSOCS (Laboratory Sourceless Object Calibration Software) was used to simulate the absolute efficiency curve for an organic matrix in the energy range from 20 keV to 2.0 MeV with appropriate corresponding percentage uncertainty values ranging from 10% at low energies to 4% at high energies. Activity concentrations of ^{210}Pb were measured from its gamma peak at 46.5 keV. The mean activity concentration of ^{210}Pb was measured to be 18 ± 4 Bq kg^{-1} from all samples analyzed. The annual committed effective dose for a smoker was estimated to be 64 ± 15 μSv.

Keywords: Pb-210, Gamma Spectrometry, HPGe detector, smoking

Assessment of X-ray quality control parameters at thirty-one private facilities across states in Nigeria

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Quality control (QC) techniques are usually used in monitoring and for maintenance of the components of an X-ray system. Regular performance of quality control in an x-ray diagnostic equipment is vital to provide images of excellent quality that would inform correct diagnosis at minimal hazard. The main objective of this study was to assess the performance of some X-ray machines in terms of quality, at some privately healthcare facilities in Nigeria.

Method: Quality control tests were conducted on 31 X-ray machines spread across different parts of Nigeria including Lagos. A Diavolt meter with valid calibration, was used to evaluate Peak kilo-voltage accuracy, Exposure time accuracy, Exposure reproducibility, mAs Linearity and half-value layer (HVL).

Results: 12.5% of the x-ray units failed kVp accuracy test while 25% demonstrated that exposure time accuracy were out of the acceptable limits. In 16.1% and 13.8% of X-ray machines investigated, the variance was greater than the acceptable range for exposure reproducibility and linearity respectively. Only one X-ray machine has HVL lower than the recommended value.

Conclusion: Most of X-ray machines assessed in this study indicated an acceptable performance and few machines required re-calibration for some parameters such as kVp accuracy and exposure timer accuracy. Regular QC tests, together with routine equipment maintenance services, are essential for promoting the performance of these X-ray machines.

Monte Carlo simulations of the cosmic-ray doses for aircraft members

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The exposure of the human population to ionizing radiation from natural sources is a continuing and unavoidable feature of life on Earth. Two main components contributing to the natural radiation exposures are cosmic ray particles and radionuclides originating in the Earth's crust. The worldwide average exposure to cosmic rays contributes to about 16% of the annual effective dose from natural radiation sources, with an average of 0.4 mSv annually [1]. Exposure to cosmic rays is strongly dependent on the altitude, as well as on the solar activity, and weakly on the latitude [1, 2]. The assessment of the dose originating from cosmic radiation received by the population is necessary to understand the overall exposure of humans to natural radiation. Especially important is to estimate the dose received by the aircraft members. The aim of this paper is the assessment of cosmic radiation doses at sea level, as well as at different altitudes. The Geant4 simulation package is used to perform a Monte Carlo simulation of the cosmic radiation at the ground level and two other heights (2 100 and 11 300 m) [3], and on several latitudes. The chosen particles of the cosmic rays were muons, neutrons, electrons, positrons, photons, protons, and pions [4, 5, 6, 7]. In addition, for several flights, the annual dose received by a traveler and for aircraft members was assessed. It was found that the equivalent doses originated from cosmic radiation received by an individual estimated on the sea level and different altitudes, as well as annual effective doses, significantly contribute to the overall exposures of the human population to the ionizing radiation.

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Baseline assessment of diagnostic reference level for two digital mammography in North Macedonia

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Early detection of breast cancer decreases mortality rates. Digital mammography facilitates early detection of breast cancer owing to its superior contrast resolution and dose efficiency. Regular inspections and quality assurance assessments are essential to guarantee the optimal performance of these devices, thereby ensuring high-quality images while minimizing radiation exposure. Diagnostic Reference Levels (DRLs) are predefined dose levels established for standard imaging procedures tailored to typical patient demographics or standard phantoms. The adoption of DRLs for optimizing patient doses aligns with recent recommendations put forth by the International Commission on Radiological Protection (ICRP) in 2007, particularly for Europe, encompassing General Radiography and Mammographic examinations. If the patient dose falls below the minimum, the images will be underexposed and diagnosis becomes difficult when the dose delivered is higher than normal then the normal tissues are exposed to radiation and there are chances of occurrence of stochastic effects which are difficult to diagnose. Herein we compare the Mean Glandular Dose (MGD) delivered to an average patient with compressed breast thickness of 10 mm – 110 mm among two mammography units in North Macedonia. From a total of 5672 examinations in the Mammography unit A –FUJI Amulet S, the calculated median MGD is 0.86 mGy and from a total of 6372 examinations in the Mammography unit B – FUJI Innovality, the calculated median MGD is 0.94 mGy. In both type of mammography machines Mammography unit A –FUJI Amulet S and Mammography unit B – FUJI Innovality, MGD in mGy were found lower than the European and Belgian Diagnostic Reference Levels.

A new dimension of the physical protection (countermeasures against UAV attacks)

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The technology and the capabilities of the UAV (Unmanned Aircraft Vehicles) increased rapidly in recent years. Nowadays UAVs are affordable, and easy to learn how to use them. Therefore, the dangers of new technology, such as a drone-mounted dirty bomb attack, must also be taken into account. The existing physical protection plans do not contain this kind of threat, this is why physical protection has to extend with a new dimension: countermeasures against UAVs. The legal and technological background of protection must be developed. The UAV developers, vendors, National Atomic Energy Authority, and security system developers have to be involved.

The guards must be equipped with different kinds of countermeasure technological solutions and also have to do training in a special training site. The main principles in the creation of new dimensions can be used.

Potential aminothiol-based radioprotective agents derivatized by quinolines

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The escalating threat of nuclear accidents, particularly stemming from terrorist activities and the potential deployment of nuclear weapons by rogue nations, is a pressing concern in contemporary times. Historic catastrophes such as those witnessed in Chornobyl (1986) and Fukushima (2011) underscore the profound risks associated with nuclear mishaps. Both in terms of the initial event and the subsequent management of its aftermath, which often entails significant dangers of acute radiation exposure. Compounding these concerns is the ongoing conflict in Ukraine, a nation housing numerous nuclear facilities, including the largest nuclear power plant in Europe located in Energodar, proximal to active conflict zones, thus emphasizing the immediacy of these issues.

Despite decades of research into radiation countermeasures for mitigating injuries resulting from radiation exposure. Particularly acute radiation syndrome, the absence of safe and efficacious anti-radiation approved by regulatory bodies like the United States Food and Drug Administration (FDA) remains a stark reality. The quest for effective radioprotective agents is imperative yet remains largely unmet.

Efforts to identify novel compounds with high potency and low toxicity, drawing from both natural and synthetic sources, have focused extensively on nitrogen-containing heterocycles, notably quinolines, and their derivatives, which exhibit significant biological activity. The structural versatility of quinolines presents opportunities for the conjugation of additional pharmacophores, thereby expanding their therapeutic potential. In recent years, a burgeoning body of literature has elucidated the antioxidant properties inherent in various quinoline derivatives, suggesting their promise as foundational elements in developing radioprotective medications with antioxidative mechanisms of action.

Significantly, investigations into S-quinoline modified cysteamine as a potential radioprotective agent have yielded promising outcomes. It includes a twofold increase in survival rates, a 1.2-fold extension in average lifespan, a 1.4-fold reduction in the incidence of acute radiation sickness bone marrow syndrome, normalization of serum blood enzyme levels, and preservation of the morphostructure of internal organs in irradiated subjects.

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Assessment of the engineering barriers shielding effectiveness from radioactive waste disposed of in an industrial waste disposal facility at Ignalina NPP

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Industrial waste generated during operation of Ignalina Nuclear Power Plant (Ignalina NPP) was disposed of in an industrial waste disposal facility (dumps). The facility is located inside the controlled area of the Ignalina NPP. The industrial waste disposal was stopped in 2014 when approximately 20 000 t of the waste was already placed. At the time of disposal, according to the Soviet Union regulations, the waste was considered as non-radioactive waste. Due to changes in the regulatory requirements a part of the waste was reclassified to a very low-level radioactive waste. Thus, it is not possible to remove the industrial waste from regulatory control by applying general clearance levels. Justification of specific clearance levels would allow to remove the industrial waste from regulatory control and convert the facility into a conventional waste disposal facility.

In this work, in the frame of the specific clearance levels derivation activity, the effectiveness of engineered barriers to protect members of the population against the radioactive waste disposed of in the facility was analysed using the VISIPLAN software. Comparative analysis revealed that the measured doses are also affected by the radioactive waste stored in the adjacent buildings.

Keywords: Radioactive waste, specific clearance, industrial waste disposal facility, radiation

The concept of self-protected X-ray units and tomographs for veterinary clinics

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Thanks to the transition from the use of X-ray film to digital technology, the simplicity and availability of radiography (DR) has increased many times. This led to an increase in the number of x-rays for small veterinary clinics from 20...30 to 200...300 per month. A large part of the examinations is performed without significant sedation of the animals by means of fixing the animals by hands. As a result, the radiation load on clinic staff also increased tenfold. In addition, cone beam X-ray tomographs (CBCT) are starting to be used in small veterinary clinics, which also creates additional beam load. This necessitates the development of new concepts for the protection of veterinary clinic personnel.

Based on the existing concept of protection, means are divided into individual: aprons, gloves, collars, hats and glasses, as well as structural ones: lead sheets, barite plasters and protective curtains. This causes disadvantages. Individual protective equipment weighs 6...10 kg, which is inconvenient for clinic staff to use. Structural ones do not protect personnel in the X-ray room. They cover a large area of walls and ceilings and, as a result, are expensive.

When justifying the new concept of protection, all radiation was divided into direct, including sources of radiation not in the direction of the receiver, and Compton radiation scattered by the animal. In both DR and CBCT systems, the field of direct radiation of the X-ray tube coincides with the X-ray sensitive field of the receiver. Experimentally, in 3D, these radiation components were measured separately. The direct beam was measured directly by dosimeters. This made it possible to calculate the protective power Kd of the screens behind the receiver and Km(x,y,z) - on the reverse side of the emitter. Scattered radiation was measured in 3D. The animal was simulated using an equivalent cylindrical water phantom. The Compton nature of scattered radiation necessitated measurements of both the power G(x,y,z) and the effective anode voltage Uae(x,y,z). The measurement results made it possible to calculate in 3D the coefficients of multiplicity of radiation attenuation Kc(x,y,z). The necessary thicknesses of lead protection Pb(x,y,z), which guarantee the fulfillment of the relevant safety standards, are calculated from the coefficients of multiplicity of radiation attenuation Km(x,y,z) and Kc(x,y,z).

The essence of the new concept of protection lies in the development of local protective covers surrounding the 3D X-ray diagnostic zone in both DR and CBCT systems. Consider the designs of DR and CBCT devices corresponding to the new protection concept, as well as the results of measurements of their protection systems.

Local covers of protection according to the new concept have a much smaller area than has the existing concept and reasonably priced. There is no need to use heavy personal protective equipment and large protective structural parts. At the same time, efforts are needed to improve the methodology and practice of using protective covers in small veterinary clinics.

Radioprotective properties of *Helianthus tuberosus L. polysaccharide* in proton radiation

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Protecting the body from the harmful effects of ionizing radiation is an important medical task. This problem is especially relevant for patients undergoing radiotherapy, as well as for astronauts exposed to increased radiation levels. Currently available radioprotectors do not provide complete protection. It has been previously shown that some polysaccharides possess radioprotective properties [1, 2]. Therefore, the aim of this study was to investigate the effect of Helianthus tuberosus L. polysaccharide on mouse survival after irradiation, as well as to assess the degree of DNA damage in animal cells.

Materials and methods: The study used 5-month-old male SHK mice weighing 30-35 g. The HTLP polysaccharide was isolated from Helianthus tuberosus as described in previous studies [1-3]. HTLP was administered intravenously into the tail vein at a dose of 100 μg per animal 15 minutes before irradiation. The irradiation was performed on the Prometheus proton therapy facility [4] PTC PHIAN, Protvino, Moscow region) at doses of 1.5 Gy and 6.5 Gy. The control group received the same dose of X-ray radiation on the RUT device [IBCh RAS]. 50 mice were used, divided into 5 groups: 1) proton irradiation control; 2) HTLP + protons; 3) X-ray control; 4) HTLP + X-rays; 5) HTLP without irradiation. Survival was assessed in a 30-day Kaplan-Meier test. Statistical processing was performed in R using the survival and survminer packages.

Results: To assess the radioprotective properties of HTLP, the frequency of cytogenetic damage in bone marrow cells was analyzed using the micronucleus test. Micronuclei are a relevant biomarker of radiation-induced genetic damage to cells [5]. In animals treated with HTLP before irradiation, the number of micronuclei in bone marrow cells was 5 times lower compared to the irradiated control group. In the group of animals which received HTLP without subsequent irradiation, the micronuclei frequency did not differ from the control group, indicating that the drug is not genotoxic.

With 6.5 Gy irradiation, the pre-administration of HTLP polysaccharide 15 minutes before irradiation increased the median life expectancy of mice by 48% compared to the control groups that received irradiation without prior protection. The effect was observed for both X-ray and proton irradiation. The control group of animals receiving HTLP without subsequent irradiation showed 100% survival. The obtained data demonstrate that HTLP polysaccharide possesses radioprotective properties comparable to applied chemical drugs. Further research on the mechanisms of this effect seems promising.

This study was conducted in the framework of the State assignment of PSCBR RAS № 075-00609-24-01 (No 1022080100047-5-1.6.4 "New generation neuroprotective drugs")

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Modelling radionuclide transport using different representations of sorption

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Radionuclide migration assessment is an important part of near surface repository safety assessment. A multitude of physical and chemical properties of both the engineered barriers and the local environment, as well as their changes over time, are assessed for a potential impact on radionuclide and other hazardous contaminants transport. Sorption is one of the key factors that strongly affects radionuclide and hazardous contaminants retention. It encompasses a number of reactions of dissolved contaminants with solid surfaces, including surface complexation and ion exchange reactions, among others. There are multiple ways how the sorption can be described in a waste disposal site performance assessment. One of the most common approaches considered in safety assessment to describe the interactions of contaminants with the solid is using the sorption coefficients or Kd values. The Kd values represent the ratio of the concentration of the sorbed contaminant to its concentration in the solution. A less common approach is reactive transport modelling with surface complexation and ion exchange reactions between the solute and minerals taken into account. This approach allows a more detailed representation of processes in the barriers and their effect on radionuclide transport. However, it requires significantly more computational resources and specific input data that are not in all cases available. As a simplified case, the Kd values in the reactive transport model can be used.

The aim of this study is to investigate the difference in contaminant distribution in soil obtained with different contaminant sorption implementation. For this purpose, an evaluation of contaminant migration in clayey soils using two different approaches was performed. In the first case, a simple solute transport model was developed where sorption was described using the Kd value. While this approach is simplistic, it allows for a quick evaluation of the radionuclide retention in a given material. In the second case, the Kd values were introduced in the reactive transport model. For this purpose, the approach described by Parkhurst et al. (2010) was used. The sorption is modelled in this approach as a contaminant reaction with the surface defining number of surface sites and equilibrium constant in such a way that they appropriately represent the Kd value. In both models a 1 m high column of clayey soil is considered as a porous medium through which contaminants are transported and are expected to be sorbed. The modelling is performed for two contaminants with weak and strong sorption. Contaminant concentrations in the entire column are evaluated. The modelling is performed using HYDRUS 1D software (Jacques and Šimůnek (2005)) for both cases.

The results indicate, in general, good agreement between both of the modelling approaches. A larger difference was observed between the results of the modelling approaches only when contaminant flow conditions changed (contaminant infiltration into the modelled region stops) with a difference of up to 2.2%. This difference could be caused by numerical issues induced by a sudden change in flow conditions.

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Designing radiation protection (shielding) with an environmental approach for hadron therapy centers using Monte Carlo simulations

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This study introduces an innovative radiation shielding model tailored for the upcoming SEEIIST particle therapy center, emphasizing sustainability and environmental friendliness. Utilizing sandwich walls made of concrete-soil-concrete (CSC), inspired by MedAustron particle therapy center near Vienna, a comparative assessment with conventional full concrete walls (CCC) is conducted in a realistic treatment room setting. Monte Carlo simulations with a substantial number of particles (10^8) explore secondary neutron fluence, illustrated through the FLUKA interface Flair in a horizontal beam treatment room geometry. The research advances radiation shielding methodologies, prioritizing sustainability, and performance optimization for cutting-edge particle therapy centers. Exploring the impact of primary particles on parameters like neutron fluence, dose equivalent, and neutron spectra, the study aims to develop a “green” shielding solution for SEEIIST. Utilizing concrete sandwich walls filled with on-site excavated soil aims to achieve significant concrete usage savings and reduce soil removal during foundation laying. Monte Carlo simulations with FLUKA model the treatment of a human phantom - AHUBO with protons and C-ions, assessing the Concrete-Soil-Concrete (CSC) sandwich wall configuration against the Full Concrete Configuration (CCC). The analysis involved graphical design, MC simulations, and a comparison of neutron fluencies for primary particle scenarios: 250 MeV for protons and 430 MeV/u for C-ions. This research represents a comprehensive effort to design a “green” shielding solution for radiation protection for any future advanced hadron therapy centre to come.

Simulations of particle therapy with protons and heavier ions (C, He, Ne and Ar) with the code Fluka

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This study explores the application of particle therapy, a cutting-edge cancer treatment, through Monte Carlo simulations focusing on protons and heavier ions (carbon, helium, neon, and argon). Targeting a human head phantom (AHUBO) to simulate real-world scenarios encountered in medical settings, the research showcases results from simulated medical treatments involving protons and C-ions, treatments have gained approvals from reputable medical societies and regulatory bodies for their effectiveness in tumour therapy. Expanding the scope, the study also considers other ion species, such as argon, carbon, helium, and neon, which are still in the experimental phase and under consideration for future clinical studies. The simulation methodology employed FLUKA code, a robust tool for modelling particle interactions with matter, enabling a thorough examination of the stopping power and 2D fluence distribution of each ion species. This analysis is conducted as a function of phantom depth. By presenting a comprehensive evaluation of various ion species, this research contributes significantly to the evolving landscape of particle therapy.

The significance of quantities and units in conveying CBRN risk to the public: A big difference in assessing the risk of C and B agents in comparison to R and N components

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It is crucial to communicate clearly and understandably the information on safeguarding against potential threats posed by CBRN (chemical, biological, radiological, and nuclear) agents to the general population. This approach is vital because practical cooperation between rescue teams and the public is essential. This principle extends to various emergencies, such as accidents or terrorist attacks, where a prompt response is necessary to mitigate panic or disorder that could undermine the effectiveness of protective measures. A deliberate assault utilizing even a minimal amount of CBRN material has the potential to induce significant, unwarranted fear among the public. Responding to a CBRN attack poses an immense challenge for emergency services, quickly drawing significant public and media attention. Meeting the need for information while prioritizing public safety and efficiently managing the incident places substantial demands on rescue personnel. Typically, during the initial stages of a CBRN emergency, the police take the lead in reaction efforts. They are responsible for ensuring the public receives timely and accurate information, safeguarding them from potential harm. Rapid and effective delivery of information is crucial to saving the lives of those impacted or at risk. The assessment of hazards arising from chemical and biological agents differs significantly from that of radiological and nuclear agents. While numerous quantities have been introduced to evaluate the risk of stochastic and deterministic effects for nuclear and radiological constituents, there is no such a comprehensive system for categorizing and quantifying the level of danger for chemical and biological materials. Typically, noteworthy incidents involving the latter are confined to specific areas, but there is also potential for contamination to spread over a wide area. Traditional communication planning heavily relies on mass media, mainly broadcast media. Despite its importance, individuals vulnerable to such incidents may not have access to television and radio broadcasts. Consequently, communication advisers must explore alternative channels, including social media and direct communication methods. The paper aims to streamline approaches to disseminating information to the public to avert chaos, panic, and misconceptions during CBRN emergencies. The presentation incorporates insights from safeguarding against ionizing radiation from radiological and nuclear materials.

Keywords: CBRN; quantities and units; risk assessment; CBRN components

Application of dispersion models of ESTE for modelling of the radiological impact of released Cs-137 in a specific urban environment

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The paper presents some results of modelling dispersed radionuclide Cs-137 in a specific urban area in front of one of Prague's shopping centres and the nearby university complex. The software ESTE was used to assess the activity of spreading contaminated air in terms of parameters from which radiation exposure of people affected could be calculated. The computer simulation proved a reliable tool for obtaining relevant radiation protection quantities and their dependence on such parameters as the initial source activity, its position, wind direction, and wind velocity. An inevitable condition for appropriate dispersion modelling in urban conditions is the evaluation of wind fields for specific environments and atmospheric conditions. The urban wind field is calculated in ESTE by solving Navier-Stoke equations to approximate the K-epsilon turbulence model. Dispersion modelling in urban conditions is performed by the software ESTE, applying an assimilated Lagrangian particle urban model. The location, structure, and relief of building configurations are reflected in the simulation of the behaviour and movement of radioactive air. The modelling considers external exposures expressed in ambient dose equivalent and internal exposure leading to committed effective dose. Dispersion models of ESTE proved extremely useful in obtaining essential parameters to predict the impact of the dispersed radioactivity on persons present in the investigated compounds. These data could help introduce efficient protection measures for people present in such compounds where exposure also depends on the configuration of the building structure, which can be taken into account in adopting appropriate measures to minimise the exposure of persons located on the spot or moving around.

Keywords: ESTE software, dispersion model, Cs-137 release, radiological impact, radiation protection

Case report: Hand-held intraoral X-ray unit

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The rapid development of technology used in medical imaging requires regulatory bodies of constant update of legislation in order to properly implement new technologies into radiation practice. However, this is only valid if the improvement of the technology is according to basic principles of radiation protection (justification, optimization, and dose limits). In this study, a hand-held dental X-ray unit was tested. The test consisted of (1) a QC parameters test and (2) measurements of ambient dose equivalent at the operator position. Results from this study show that this type of X-ray unit satisfies dose requirements for both patients and operator and presents a basis for regulatory bodies to consider implementing hand-held dental X-ray units in justified practice.

Radiation protection program for deccommisioning of a Cyclotron U-120 type particle accelerator

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The Cyclotron U 120 particle accelerator from IFIN-HH, Romania was commissioned in 1957. The main purpose was to produce intense beams of protons, deuterons and alpha particles with 15 MeV/nucleon maximum energies as well as fast neutron fluxes with maximum fluxes of 10^{11}n/cm^{2}s for research purposes. The owner decided to shut down and decommissioning the radiological installation due to the safety reasons. According to the Romanian Radiological Safety Norms in force, the decommissioning of a radiological installation is done on the basis of a "Decommissioning Plan" whose main component is the Radiological Protection Program. The program considers all the processes that could lead to a potential radiation exposure and /or to radioactive contamination of personnel, property and the environment. The paper describes the program which ensures the workers radiological protection during the decommissioning activities (dismantling/decontamination of contaminated/activated components) as well as during handling and transport of the radioactive waste to the Radioactive Waste Treatment Plant for conditioning, treatment and intermediate storage purpose.

A three dimensional CFD-based approach for the dispersion of radioactive cloud in urban environment

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The presence of buildings and obstacles in urban environment can modify the velocity and spatial concentration fields of a radioactive cloud emitted by a source, therefore affecting the dispersion of the plume. A simplified model for estimating the enhanced dispersion due to the presence of obstacles and buildings has been presented by Huber, by introducing modified parameters in the framework of the Gaussian Plume Model (GPM).

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. In the model developed by Huber dispersion parameters and Brigg's coefficients have been properly modified by including looping movement of the plume as a result of its interaction with vortices induced in the flow filed surrounding the obstacles. The limit of the model is represented by the lack of detailed geometrical information of the obstacles, resulting in a simplified description of the spatial distribution of the concentration and velocity of the radioactive cloud in the surrounding of the radioactive source.

A more accurate estimation of the dispersion of a radioactive plume in an urban environment can be obtained by recurring to computational fluid-dynamics (CFD) models. In the work, similarity Theory (MOST) for the entire vertical Atmospheric Boundary Layer (ABL) profile under non-neutral stability conditions has been included in the framework of the Reynolds-Averaged Navier-Stokes (RANS) approach, which is a well-established method in CFD, known for its effectiveness across different applications, showing satisfactory results in similar applications of pollutant transport in urban areas. Subsequently, the radionuclide dispersion can also be implemented in the Monte Carlo code FLUKA to make more accurate dose evaluations. CFD models can be particularly useful for evaluations at short distances in urban areas where the hypothesis or the GPM plume cannot be applied. This is particular important for nuclear medicine and hadrontherapy centers situated in populated areas in which GPM models can excessively overestimate submersion doses. In the work, comparisons between Gaussian plume and fluid dynamic models are performed in order to make comparison at short and long distances. The case study geometry used in the numerical simulation was inspired by the actual urban agglomeration similar to the one surrounding the CNAO (National Oncological hadrontherapy Center, in Pavia-Italy), structure of international excellence in the field of oncological treatments with hadrontherapy techniques using a synchrotron for the particle acceleration. A sample chimney was modeled on the CNAO building, emitting exhaust. The domain for the CFD-simulation has been discretized by an hybrid type mesh, with refinement regions set to accurately solve the flow field and the plume transport near the obstacle surfaces, close to the ground, and in the surrounding of the chimney.

Numerical results have been obtained by considering different stability atmospheric conditions and comparisons and differences with Huber approximation are presented and discussed.

Experience in monitoring professional doses of radiation for medical personnel in Ukraine

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In accordance with the Radiation Safety Standards of Ukraine (1997) and the Directives 2013/59/Euratom, it is necessary to carry out regular dosimetry monitoring of professional irradiation. There are two main types of dosimetry control of radiation exposure for staff - workplace monitoring and individual dose control (IDC).

In Ukraine IDC of personnel exposure is mandatory if annual doses may be more than 10 mSv, but in Basic Radiation Safety Rules of Ukraine (2005) there are additional mandatory conditions of individual dose control for personnel: age up to 45 years for women and those working with open and closed radionuclides in medicine.

At the same time, only at initial stage, when assessing the working conditions of personnel and the effectiveness of radiation protection at new workplaces, it is necessary to conduct IDC for all groups of staff. Given the established level of radiation protection, in many cases, especially when working on digital X-ray installations, the requirement to organize individual dose monitoring for all medical workers is impractical and leads to unjustified expenditure of time and money on organizing IDC.

The paper presents the results of a centralized IDC of various groups of medical personnel in Ukraine for 1982-2023. Currently, there are about 6.5 thousand people on the centralized IDK; monitoring is carried out quarterly using the TL-dosimetry method. There are 8 main types of work with radiation sources in medicine with 3-5 professional groups for each type (doctors, technicians, nurses, engineers, etc). It has been established that for most professional groups of medical workers, average annual doses do not exceed 1-2 mSv. But the medical staff performing manual procedures of intracavitary radiation therapy using Co-60 and Ra-226 sources were classified as high-risk groups according to the level of average annual doses.

In the groups of radioactive substance keepers and radiomanipulation nurses, the average annual doses were 5-8 mSv/year, and for 10-15% of the personnel the individual annual doses could exceeded 10 mSv and reach the annual dose limit of 20 mSv.

However, since 2010, intracavitary radiation therapy procedures began to be mostly carried out using brachytherapy devices. In this regard, the number of nurses in Ukraine who were involved in manual procedures with radiation sources decreased by almost 8 times.

At the same time, the other types of work with sources of ionizing radiation in medicine have appeared and are actively developing: these are interventional procedures and operations under the control of X-ray radiation. These types of work involves various groups of medical personnel (cardiologists, surgeons, traumatologists, neurosurgeons and others), who can receive fairly high doses of radiation. According to the centralized IDK in Ukraine, for the period 2000-2023, the number of persons employed in interventional radiology in Ukraine increased more than 10 times. Average annual radiation doses are comparable to the doses of medical personnel who were involved in manual contact gamma therapy and amount to 1.4-2.5 mSv. Similarly high average annual doses are observed for nurses in nuclear medicine departments (radionuclide diagnostics and therapy) – 1.4-3.0 mSv. Individual radiation doses can reach 6-10 mSv.

Thus, based on the results of a long-term centralized IDC, it has been established that mandatory IDC is necessary only for those groups of medical personnel where there is a risk of emergency exposure - work with radionuclide sources (external gamma therapy and brachytherapy procedures with Co-60 sources, nuclear medicine procedures), and also for personnel involved in performing interventional radiology procedures, fluoroscopic examinations directly under X-rays control.

For the personnel of X-ray diagnostic departments, who in most cases work on digital devices, IDC is not mandatory; radiation doses are close to the values of natural background radiation.

Medical exposure to ionizing radiation - The national results of monitoring in 2022

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Medical exposure is the most important anthropogenic source of population exposure to ionizing radiation, this aspect being emphasized countless times, internationally, by experts in protection against ionizing radiation. Taking into account this aspect, the national legal framework harmonized with the Community provisions stipulate the obligation and responsibility of the public health network to ensure the radiological protection of the patient during the medical exposures to ionizing radiation.

The national application of the methodology for monitoring the level of population exposure from the medical procedures with ionizing radiation has identified for 2022 a number of 6.791.606 radiological procedures: 3.749.552 radiographies and fluoroscopies, 203.394 mammography exams, 1.273.854 CT exams, 37.408 cardiovascular interventional procedures and 20.042 non-cardiovascular interventional procedures, 152.173 DEXA exams and 1.355.183 dental X-rays. At the same time, 23.992 diagnostic nuclear medicine procedures were reported.

At the national level, chest radiography remains the most frequent examination (38,6%) of all conventional radiological examinations, followed by radiography of the limbs and joints, spine – all sections, mammography, pelvis, skull and abdomen radiography and thoracic fluoroscopy. The CT exams with the highest frequency are native scan of head region (29.5%), followed by both native scan and contrast scan of the chest (24.2%). Other common CT procedures are contrast scan of abdomen, pelvis, abdomen-pelvis region, trunk and head. For cardiovascular interventional radiology, the most frequent examination is cardiac angiography and for non-cardiovascular interventional radiology - the orthopedic procedures are very common. In the top of nuclear medicine procedures are bone scintigraphy, followed by the PET-CT and SPECT-CT hybrid procedures.

The most significant contribution to the estimated collective effective dose for diagnostic and interventional procedures is recorded by CT examinations, which are very common, but also with high radiation doses. In the top of the contribution to the estimated collective effective dose, the CT exams are followed by the cardiac angiography combined with PTCA, on the 21st position, as interventional radiology procedures and thoracic radiography on the 22nd position, as conventional radiology examinations. In the overall picture of the contributions to the collective effective dose, the diagnostic nuclear medicine has a much lower contribution - the 34th position - bone scintigraphy, mainly due to the low number of the performed procedures.

In general, the same trends as in previous years are maintained, both from the point of view of examination frequencies, distribution by age groups and gender, as well as typical dose values per type of examination/procedure.

Greater attention must be paid to the process of justifying the exposure for each individual patient, especially in the case of highly irradiating procedures such as computed tomography. Medical personnel involved in the medical exposures, both referring physicians and medical practitioners who approve the performance of examinations and diagnostic procedures, must be aware of the risk to patients in the case of repeating highly irradiating diagnostic procedures at short time intervals and to thoroughly analyze such necessity, for each individual patient, taking into account the risk-benefit ratio.

Optimizing the examination protocols, especially those of computed tomography, must be a permanent concern for the medical staff, so that the exposure parameters are adapted to the physical dimensions of each patient. This is especially important in the case of pediatric patients who are much more radiosensitive than adults and for whom the life expectancy is much higher.

Survival of A549 cells after ultrahigh dose rate proton irradiation

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Keywords: proton therapy, flash effect, ultrahigh dose rate irradiation

Flash radiotherapy is an innovative method of irradiation, which ensures the delivery of the therapeutic dose to the pathological focus in a time of about several tens of milliseconds. In this mode of irradiation, the degree of damage to normal tissues surrounding the tumor and falling under the influence of radiation decreases, at the same time, the effect on cancer cells remains almost at the same level, which improves the prospect of local control of the tumor with a lower frequency of side effects. To date, the exact radiobiological mechanisms underlying the flash effect are not fully clear.

A high-intensity proton beam with energy of 660 MeV was formed at the Phasotron accelerator of the Joint Institute for Nuclear Research, Dubna, designed to conduct radiobiological studies under flash therapy irradiation of cell cultures and small laboratory animals (mice, rats). The survival of A549 cells under proton beam irradiation in two modes, flash and standard was also compared. A difference in the survival of A549 cells irradiated in flash and standard modes was found. The magnitude of the flash effect is represented by the dose change factor (FID).

Aim: Comparison of cell survival under proton beam irradiation in flash and standard modes.

Materials and methods: *Cell culture:* Human lung carcinoma cells A 549. *Proton irradiation:* The irradiation of cells was carried out with the 660 MeV proton beam of the JINR Phasotron by the "shoot-through" technique in two modes: standard at a dose rate of 0.1 Gy/s and in flash mode at a dose rate of 70 Gy/s. Other beam parameters were the same. *Clonogenic survival.* Cells were seeded at the rate of 50 cells /ml after irradiation with protons at doses of 0, 1, 2, 4 and 6 Gy. 12-14 days after sowing, the number of grown colonies was calculated. The changes in the survival of cells under irradiation in two modes, standard and flash, were represented by survival curves.

Results: A slight difference was found in the survival rate of A549 cells irradiated in flash and standard modes. It should be noted that a statistically significant level of differences (*p <0.05) is manifested only at high doses of 4 and 6 Gy. In the dose range up to 2 Gy the error bands intersect, no statistically significant differences between the curves were found. Nevertheless, if we consider the general trend of all data points, it is clearly seen that proton irradiation at ultrahigh dose rates increases the survival rate of human lung carcinoma cells of the A 549 line compared to standard irradiation mode. The magnitude of the flash effect is represented by the dose rate coefficient (FID). The feed dose was defined as the ratio (instant dose)/(standard dose) for 10 % survival, for these studies the FID was 1.1. This value does not contradict the data of other research groups, where the FID was usually 1.1-1.5 [1]. Our results, namely, a higher survival rate under ultrahigh dose rate irradiation, are consistent with [2], but it should be noted that there are other results indicating no differences [3]. The presence of contradictory results requires further more detailed study in this field.

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The human element: Recognizing the vital role of the scorer in the dicentric chromosome assay

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The dicentric chromosome assay (DCA) remains the "gold standard" in biodosimetry for estimating radiation exposure. However, its widespread implementation is hindered by its time-intensive process and the necessity for skilled scorers. While technological advancements have facilitated the automation of some aspects of cytogenetic analysis, the role of the scorer remains indispensable. The expertise, experience, and attention to detail of the scorer significantly influence the accuracy and reliability of chromosome aberration scoring, thereby shaping outcomes in biodosimetry and radiation biology studies. Our objective was to evaluate the pivotal role of scorers in accurately interpreting DCA results.

Here, we exposed human peripheral blood samples to X-ray radiation doses ranging from 0 to 4 Gy. To induce chromosome aberrations, irradiation was performed at a dose rate of 0.7 Gy/min using an X-RAD 225 XL device operated at 160 kV and 18.7 mA. Following irradiation, chromosome spreads were prepared, and metaphases with good morphology were captured. Micrographs were categorized into three dose groups, namely 0-0.5 Gy, 1-1.5 Gy and 2-4 Gy. Aberrations were scored in blind by three scorers. A dicentric chromosome was numbered if accompanied by an acentric fragment. Ring chromosomes were also marked. The scorer's ability to identify aneuploidies, dicentric chromosomes, and maintain consistency throughout the analysis process were paramount in ensuring the validity of the study results.

While scorers correctly identified aneuploidy instances and marked ring chromosomes, some disparities emerged in dicentric chromosome and acentric fragment identification. Our findings emphasize the human element in DCA, as the scorer's proficiency directly influences data quality, highlighting the necessity for robust training initiatives. While automation can expedite processing and reduce some errors, its integration should coincide with comprehensive training programs to enhance the reliability and efficiency of radiobiology studies and addressing biodosimetry requirements for radiation protection.

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The radioprotective effects of plants *Ononidis radix, Alnus glutinosa and Atriplex littoralis* on micronucleus distribution on human lymphocytes

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People can protect themselves against IR by using compounds that prevent the structural and/or functional tissue and cell damages. Such compounds are called radioprotectors [D. Murray, W.H. McBride, Radioprotective agents, in: Kirk-Othamer Encyclopedia of Chemical Technology, 4th ed., John Wiley&Sons, New York,Vol. 20 (1996) 963-1006.]. Besides synthetic radioprotectors, there are also numerous plants and herbs, as well as the compounds isolated from plants, that represent very effective radioprotectors [R. Arora, D. Gupta, R. Chawla, R. Sagar, A. Sharma, R. Kumar, J. Prasad et al.,Radioprotection by Plant Products:Present Status and Future Prospects, Phytother. Res. 19 (2005) 1-22.]. Unlike the synthetic, herbal products are non-toxic, without harmful effects to human health, cheaper and are generally dosed orally.

The radioprotective effect of plants on the human body are 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 [Cytogenetic dosimetry:Applications in preparedness for and response to radiation emergencies.Intenational Atomic Energy Agency Vienna, 2011.].
Our tests have shown that extracts of many plants from our climate that contain polyphenolic compounds (*Ononidis radix, Alnus glutinosa, Atriplex littoralis*) show strong antioxidant activity and protect genetic material from damage caused by IR.Studies have shown that plant polyphenols (*Ononidis radix, Alnus glutinosa, Atriplex littoralis*) in concentrations 1-5 μM entered the cell cultures in vitro show a radioprotective effect and decrease in the frequency of micronuclei from the 30% to 50%, compared to control cell cultures [M. Novaković, M.Stanković, I.Vučković, N.Todorović, S.Trifunović, V.Tešević,V.Vajs,S.Milosavljević:Diarylheptanoids from Alnus glutinosa Bark and Their Chemoprotective Effect on Human Lymphocytes DNA. Planta Med. 79: 499–505 (2013); D.Godjevac, J.Stanković, M.Novaković, B.Anđelković, Z. Dajić-Stevanović, M.Petrović, M. Stanković:Phenolic Compounds from Atriplex littoralis and Their Radiation-Mitigating Activity. Journal of Natural Product,Vol.78, No.9, pp. 2198-2204,(2015)].The antioxidant compounds of medicinal plants (*Ononidis radix,Alnus glutinosa,Atriplex littoralis*) have beneficial effect on irradiated cells,since they reduce the level of reactive free radicals and repair DNA damaged by radiation. It is thought that the antioxidant properties of medicinal plants inhibit the development of many diseases due to its ability to keep the balance of mitochondrial redox potential. It enables the preservation of the physiological ability of damaged cells elimination without inflammation and necrosis.

There is insufficient information about the radioprotective and mitigation effects of herbal extracts against ionizing radiation-induced chromosomal abnormalities in human lymphocytes. In fact, "radioprotectors" should be comprehended in terms of protection (prophylaxis or mitigation) and treatment when describing the use of drugs to potentially modify radiation injury. In addition to the ROS-scavenging properties of flavonoids, their protecting role against oxygen species-induced DNA damage was also reported [Zlatanovic, I.; Stankovic, M.; Ickovski, J.; Dimitrijevic, I.; Stojanovic, G. Comprehensive Analysis of the Herbal Mixture Made of Juniperus oxycedrus L. Berries, Inner Bark of Betula Pendula Roth.,and Grains of Avena sativa L. Nat. Prod. Commun. 2022, 17, 1–8.]. Because the investigated compounds were added after irradiation in our experiment, it may be assumed that the protective activity could be ascribed similarly to their DNA repair potential, as it was deduced for amifostine WR-2721. However, the mechanisms of these flavonoids' mitigating activities are not fully comprehended and should be further studied.

Advancing precision in cellular radiobiology: Initial findings from the newly developed irradiation method utilizing diagnostic X-ray beam qualities

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This study represents a significant stride in enhancing precision within the area of cellular radiobiology, focusing on the utilization methods of standard X-ray beam qualities. Employing Monte Carlo simulations within the Geant4 framework, we meticulously validated and simulated the RQR spectra alongside the cell irradiation geometry and materials. Through these simulations, we were able to derive specific air kerma to cell dose conversion factors, forming the foundational layer of our research.

The experimental phase was conducted in Laboratory for Metrological X-Ray Irradiations at the Institute for Medical Research and Occupational Health. Laboratory is equipped with PTW's 225 kV X-ray calibration system commissioned for radiation protection and diagnostic beams.

In the *in vitro* experiment cells were irradiated with RQR10 beam quality with doses of 100 mGy (boundary between low and high doses) and 1 Gy, to serve as a baseline and control, respectively. This approach allowed us to monitor and quantify the ensuing DNA damage, providing tangible markers of the irradiation effects.

The initial results of this study have substantiated our hypotheses, revealing the anticipated DNA damage within the irradiated cells, consistent with the theoretical predictions based on our robust simulation frameworks. The implications of these findings extend towards more accurate, reproducible, and scientifically robust radiobiological experiments, ultimately contributing to a deeper understanding of cellular responses to radiation.

This research lays a groundwork for future investigations into more complex biological systems and the refinement of radiobiological techniques.

Toxicity and radiation-modifying effects of nanoparticles on zebrafish (*Danio rerio*) embryo model

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Nanoparticles (NPs) have proven to be effective in a variety of applications (e.g. delivery of therapeutic molecules, imaging, and radiosensitization). Recent advances in nanotechnology have also led to their emergence as new therapeutic agents in the field of radiation oncology. Various metallic nanoparticles have been investigated to increase the radiosensitivity of cancer cells while simultaneously minimizing radiation toxicity in normal tissues.The enhanced radiosensitivity of tumor cells treated with nanoparticles is well established, but little is known about their effects on healthy tissues which warrants further exploration. The main aim of our research was to investigate the toxic effects and biodistribution of nanoparticles of different sizes (AuNP, PtNP, HfO_2NP) in a zebrafish embryo model. Our secondary objective was to examine the radiation-modifying capabilities of AuNP, PtNP, and HfO_2NP in normal tissues.

Materials and methods: 24 hours post fertilization zebrafish embryos were exposed to nanoparticles of different concentrations and sizes. For toxicity measurements, the embryos were incubated for 24 h with AuNP (12 and 47 nm) at concentrations of 5, 25, 50 mg/L, PtNP (5 and 20 nm) at concentrations of 25, 50, 75 mg/L, and HfO_2NP (solution contained 55 - 75 nm particles) at 10 and 30 ug/mL. Following incubation, embryos were washed with embryo medium, placed in 96-well plates and irradiated with 20 Gy photon dose (250 keV). Microscopic observations were carried out for 7 days after the treatments to study the hatching rate, viability and various morphological changes (e.g. pericardial edema, spine curvature) of the embryos.

Results: We found that AuNP at the concentrations used did not have significant effect on embryo development and mortality. 47 nm AuNP increased the effect of radiation independently from the concentration. After 24 h of AuNP treatment and irradiation, we observed that different developmental abnormalities started to appear first on day 3 and then increased on the following days. The PtNP treatment was found to be toxic irrespective of size and enhanced the effects of radiation i.e. increased the number of dead individuals and the extent of morphological lesions. Furthermore, we found that PtNP affected the hatching rate of embryos compared to AuNP and HfO_2NP nanoparticles. In contrast, HfO_2NP showed no significant effect on survival and morphological abnormalities.

Conclusion: Our comprehensive studies have demonstrated that zebrafish embryos are suitable for studying the effects of NPs on normal tissues. The observed radiosensitizing effect of AuNP and PtNP suggests that the particles have penetrated through the embryo chorion possibly by passive diffusion. AuNP and PtNP's toxicity raises concerns regarding its use in combination with radiation therapy while HfO_2NP show promise with relatively low radiation toxicity. Further research is needed to understand better the mechanisms underlying these effects and to optimize the use of nanoparticles in radiation oncology protocols.

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Radiobiology investigation on low intensity neutron beam with zebrafish embryo model

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Recently laser-driven neutron sources such as fast neutrons generated by deuterium-deuterium (D-D) fusion reactions attract lots of attention due to their potential applications in various fields particularly in biology and medicine sciences. However, preliminary investigations have revealed that neutron yield generated by these experiments remains constrained by multivarious factors. The effect of such low-intensity neutron beams on biological samples is not well understood. Therefore a comprehensive endpoint assessment has to be validated in preparatory experiments with conventional radiation sources. We aimed to investigate the Relative Biological Effectiveness (RBE) of a low-intensity neutron beam compared to reference LINAC photon radiation, utilizing a zebrafish embryo model. To that purpose, the study seeks to establish reliable quantitative endpoints.

Method: Zebrafish embryos at 24 hours post-fertilization (hpf) were exposed to a single fraction of whole-body irradiation using a cyclotron-based (d+D) quasi-monoenergetic fast neutron source with doses of 137, 298, and 688 mGy, alongside conventional 6 MeV photon beam doses of 300, 900, 1200, and 1800 mGy. Neutron irradiation was conducted at the d+D neutron source operated at the MGC-20E cyclotron of ATOMKI. Neutrons were produced with energy in the E_n = (2.55 - 4.1) MeV range with < E_n > = 3.7 MeV average energy. During their exposition to the neutrons, the embryos were in 2 ml Eppendorf tubes and were positioned along a circle of the same isodose rate level of the irradiation field. The doses delivered to the samples were controlled by varying the irradiation time. Photon irradiation occurred at the LINAC of the Radiotherapy Department of the University of Szeged. The experiments were 3 times replicated.

Post-irradiation, diverse endpoints were evaluated to analyze and compare the biological effects of different radiation modalities. *In vivo* acridine orange (AO) fluorescent staining was employed 24 hours post-irradiation to detect apoptosis, with quantification focusing on the tail region of the embryos. Additionally, gamma-H2AX whole-body immunostaining was performed 30 minutes post-irradiation to detect DNA double-strand breaks. Hatching rate, developmental malformations and viability were detected daily up to 7 days postirradiation. Neurofunctional changes were assessed on the 6^{th} and 7^{th} days post-irradiation via analysis of photomotor response and visually mediated reflexes using a Zebrafish behavior analysis device.

Results: Hatching rate, survival, body length, spinal curvature, cardiac edema, and eye diameter did not reveal significant changes in the applied dose range in the treated groups. However, the method of apoptotic cell quantification proved highly reliable, resulting in significant dose-dependent differences and allowing the derivation of an RBE value of 5 for cyclotron-based fast neutron beams, along with reduced locomotion activity.

Conclusion: This study provides insights into the comparative radiobiological effects of low-intensity neutron beams and conventional photon radiation using a zebrafish embryo model. Establishing reliable quantitative endpoints in the low dose range enables the examination of biological responses to laser-driven neutron beams at the initial developmental phase of this emerging technique. Additionally, it holds significance for both fundamental radiobiology research and potential clinical applications.

Evaluation of the assessment dose with biodosimetry methods, applicable in Bulgaria. Use of Dicentric Chromosomal Assay (DCA) and Cytokinesis-Block Micronucleus Assay (CBMN)

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In recent years, biodosimetry has gained progress in the calculation of the absorbed dose of the ionizing radiation. The biodosimetry methods include cytogentic methods such as dicentric chromosomal assay (DCA), cytokinesis-block micronucleus assay (CBMN), FISH anasay, Premature chromosome condensation (PCC), etc. All of them score the marking damages such dicentric chromosomes or circle chromosomes to calculate the absorbed dose of ionizing radiation. As a part of the European union, Bulgarian radiobiology laboratories had to switch the direction of the mainly research activity to possibility for routine practice of analysis and diagnostic of the assessment dose after ionizing exposure. That possibility determines to be used the most accurate methods for diagnostic of the cellular injuries. For a short period of time Bulgarian laboratories had to choose method of analysis, to develop working protocols and their own calibration curves for them. The Research laboratory of Radiobiology and Radiation protection, Military Medical Academy-Sofia is in a beginning stage of development and application of two main methods for biodosimetry (DCA as a main method and CBMN as a method for conformation of the result). Next stage is to organize the whole process of integration as a routine diagnostic practice as additional source of information for the patients used by the clinical hematologists and oncologists.

Aim of the study: The aim of the current study is to analyze and describe current biodosimetry methods, planned to be used in the Military Medical Academy-Sofia.

Materials and methods: Dicentric chromosomal assay (DCA) and cytokinesis-block micronucleus assay (CBMN).

Results: The detailed analysis and review of the described methods, give the priority to the golden standard method (DCA). It is chosen as the most applicable, shorten and highly effective for the needs of the Scientific laboratory of Radiobiology and Radiation protection, Military Medical Academy-Sofia. Cytokinesis-block micronucleus assay (CBMN) is good method to confirm the results obtained by the DCA, but is not proper to be used as a single use method as is not specified of radiation injuries.

Conclusion: The biodosimetry assessment of the absorbed dose is a high skilled activity. It has involved team of professionals, correct selection of applicable methods and preliminary optimization of the process. Take into consideration of the described details for our routine work the optimal option is use of DCA analysis.

Keywords: DCA, CBMN, radiobiology, biodosimetry methods

Cytogenetic dose response on 6 MV linear accelerator: the reduced RBE of megavoltage X-ray photons is not obvious

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Modern methodology of cytogenetic biodosimetry necessitates the construction of a dose response curve (DRC) *in vitro* for each type of radiation that can potentially cause a radiation emergency. Also, due to a unified methodology of quantification of cytogenetic biomarkers, such experiments are beneficial in terms of fairly accurate assessment of the relative biological effectiveness (RBE) of different types of radiation. The aim of the present study was to generate a DRC for classical dicentric assay in human lymphocytes with exposure to 6 MV X-ray photons, and to compare the cytogenetic damage outcome per unit dose with that previously reported in the literature for radiation beams of similar radiation quality and orthovoltage X-rays.

Technical conditions of the irradiation setup and dicentric assay were in strict compliance with international requirements [IAEA 2011; ISO 19238:2014]. Peripheral blood samples from 4 healthy volunteers were irradiated with acute 6MV photons on a clinical linear accelerator over a dose range of 0.46 – 5.46 Gy, at 3 Gy/min, in a water-filled phantom at 37 °C, with zero dose control. Blood lymphocytes were cultured in presence of 5-Bromo-2'-deoxy-Uridine for 48-50 h; metaphase preparations were stained with Fluorescence-plus-Giemsa technique. Photo-images of metaphases were collected on Metafer_v.4 (MetaSystems) and analyzed for the presence of unstable chromosomal aberrations in the 1st division metaphases. Also, data on dicentric dose response yields induced *in vitro* by megavoltage X-ray photons or electrons or orthovoltage X-rays ≥ 80 keV were extracted from the literature. Linear-quadratic (LQ) DRCs were fitted from the obtained experimental data or published datasets using Dose Estimate_v.5.1 software package.

The dose response for dicentrics induced by 6 MV X-ray photons fit well to the LQ model with linear coefficient $\alpha = 0.0318 \times cell^{-1} \times Gy^{-1}$, and quadratic coefficient $\beta = 0.0741 \times cell^{-1} \times Gy^{-2}$. At each dose point in our experiment, the dicentric yield was at the upper limit of the range of values, compiled on the basis of 14 publications on the cytogenetic effects of megavoltage beams. For these published datasets, re-fitted DRC coefficients varied as $\alpha = (0.0006–0.0588) \times cell^{-1} \times Gy^{-1}$, and $\beta = (0.0396–0.0662) \times cell^{-1} \times Gy^{-2}$. There were also fairly wide ranges of DRC coefficients itted across 31 datasets in 25 publications on orthovoltage X-rays: $\alpha = (0.0047–0.1075) \times cell^{-1} \times Gy^{-1}$, $\beta = (0.0256 – 0.0910) \times cell^{-1} \times Gy^{-2}$. In 15 of these datasets coefficients ranged as $\alpha = (0.025 – 0.045) \times cell^{-1} \times Gy^{-1}$ and $\beta = (0.055 – 0.085) \times cell^{-1} \times Gy^{-2}$, i.e. were comparable with those obtained in our experiment. While, in 11 recalculated datasets higher values of α, or both α and β took place, reflecting higher RBE of orthovoltage X-rays.

Among potential experimental factors, the studied radiation dose range, the depths of sample placement in a water phantom for irradiation, the use of control of post-radiation mitoses in culture, and inter-laboratory variations in aberration scoring criteria seem to be more influencing than the effect of beam energy or donors' individual chromosomal radiosensitivity. Further cytogenetic assessment of the RBE of megavoltage beams in the interests of radiological protection or radiation oncology requires more stringent standardization of experimental conditions.

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Method for determination of Po-210 in water by alpha spectrometry via spontaneous deposition

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This study aims to describe the development and application of a new laboratory method for determining the Po-210 content in drinking, mineral, surface and other waters. This relies on spontaneous deposition on silver or cupronickel discs. The method is fast and efficient with high yield under suitable conditions (such as temperature, pH, measurement time, etc.). The developed new method is based on EN ISO 13161:2020, but several improvements have been introduced, some of which are based on literature publications.

It is known that the yield and the detection limit depend on several factors such as sample volume, measurement time, pH, etc. When applying this method, the detection limit is approximately 5 mBq/l and the yield is over 90% when a 500 ml water sample is analyzed with a measurement time of 24 hours.
A significant challenge in method development was the dissolution of MnCl2 in hydrochloric acid. According to literature data, this reagent is 100% soluble, but it was found necessary to add a few drops of H2O2 and conc. HCl to obtain a clear and transparent solution. A special decantation technique is applied in the method to decant the extremely light and mobile precipitate obtained upon addition of MnCl2.

An experiment was performed to determine the optimal conditions for the self-deposition process. It was found that heating the sample to 83°C and stirring at 175 rpm for 17 hours yields optimal results.
Procedure: It is recommended that the sample be analyzed as soon as possible after sampling. If necessary, the sample is pre-filtered. The main steps include: acidification with HCl, addition of tracer (Po-209), 0.2M KMnO4, NH3 (to pH 9), 0.3M MnCl2 and ascorbic acid. Po-210 is spontaneously deposited on a silver disk upon stirring and heating. The silver disk is measured for minimum of 24 hours by alpha spectrometer, Alpha Analyst.

Since the method was introduced, mainly mineral and drinking waters have been analyzed, with results varying around and below the MDA. A single mining water sample has been measured as part of interlaboratory comparison. The obtained result is 0.0164±0.0023 Bq/l with a measurement duration of 243900 seconds. The result is comparable to those obtained by the other laboratories participating in the comparison. This also shows that the method is applicable to water samples of various origins, including mining waters.

The obtained results represent an important first step for radiation status assessment of waters in Bulgaria.

Control of radiochemical purity of ^{99m}Tc-DMSA radiopharmaceutical

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Radiochemical purity is the fraction of total radioactivity in the desired chemical form present in the radiopharmaceutical. In the radiopharmacy, it is the presence of the undesired radiochemical impurities that is checked. These impurities include the presence of free and hydrolyzed technetium. Radiochemical purity can be determined by liquid chromatography, either planar or column chromatography. In this study it is used planar chromatography (as routinely used in radiopharmacy) to determine radiochemical purity of 99mTc-DMSA (Di Mercapto Succinic Acid) commonly used for static imaging renal scintigraphy. In planar chromatography, the stationary phase can be a paper strip or a thin layer of adsorbent on a plate. The separated fractions appear as spots behind the solvent front on the stationary phase. The content of kit vials (1.25mg 2,3-dimercaptosuccinic acid, 0.5mg tin chloride, 0.4mg ascorbic acid, 25mg calcium gluconate) are labelled with technetium eluate from ^{99}Mo-^{99m}Tc generator and are analyzed for radiochemical control on these different systems: ITLC-SG/Acetone, NaCl 0.9%, Whatman No.31 ET Chr, Whatman S&S 2698c and Whatman S&S 2598a/Acetone, NaCl 0.9%, Acetonitrile 50%, MEK, Absolute Alcohol, Ethyl Acetate : MEK 3:2, Sodium Acetate 13.6%. A drop (1-10 μl) of the vials is spotted on a miniaturized instant thin layer chromatography (ITLC) strip and developed in a solvent by ascending method under atmospheric conditions. The developed strips are dried and scanned. According to our results the different systems assayed were not equivalent, some being more suitable than others to get clear picks and good separation of the patterns.

Keywords: radiopharmaceutical, planar chromatography, technetium, labelling.

Redistribution of tritium in the water-to-soil-to-air system

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Taking into account a relatively short half-life of tritium (^{3}H), its high migration ability and the presence of several physicochemical forms, the modern knowledge of regularities in ^{3}H environmental behavior is quite ambiguous. The migration of ^{3}H in environmental components is complex multi-year and multi-stage processes. The extent of tritium contamination in natural ecosystems in the impact zone of radiation-hazardous objects and nuclear facilities may be greatly underestimated. In order to assess the content of ^{3}H in the environment correctly, it is important to understand its redistribution mechanisms there. The most important role in studying ^{3}H migration is played by at least three key components - water, soil and air, which are the main abiotic chain in vital activities of all living beings on earth.

The goal of this work is to study the content and redistribution of ^{3}H in the water-to-soil-to-air system.

The selected research areas were at the Semipalatinsk Test Site (STS): the 'Degelen' site, the riverside zone of the Shagan riv. and a section of a conventionally 'background' area in the southeastern STS.

Research findings showed the presence of ^{3}H in various forms in environmental compartments of interest. The presence of ^{3}H was recorded not only underground nuclear test locations but also in the 'background' area - the southeastern STS. Research undertaken suggests that water plays a key role in processes of ^{3}H migration in the natural system of interest. While performing the work, ^{3}H activity concentration in water was found to vary from <6 to 61,000 Bq/kg in STS research areas. The second most and equally important constituent is soil. In the soil of study areas, the bulk of ^{3}H is in the form of free water - up to 5,170 Bq/kg. This form of ^{3}H dominates where ^{3}H migrates with surface waters (creeks of the 'Degelen' site, the Shagan riv.). Bound forms of ^{3}H were also identified in the soil of the 'Degelen' site and in the 'background' area - up to 1,700 Bq/kg. The third component for the redistribution of ^{3}H in the natural system is air. The air is closely associated with open tritium sources - soil and water, in which ^{3}H is non-uniformly emanated without fail throughout the year. The dynamics of HTO and HT concentration in the air of areas in question throughout the research period ranged from <0.5 to 56 Bq/m^3. Vegetation growing in study areas - the process of transpiration that is also able to affect the mechanism of ^{3}H production in the air, may be an additional ^{3}H open source.

^{3}H in the STS territory was found to be readily redistributed in abiotic environmental compartments depending on several factors. The major contributors to ^{3}H redistribution may be both the radiation effect after nuclear tests and the following ones: weather conditions (temperature/humidity), seasonal variations, the type and state of the land cover, hydrogeological changes leading to changes in ^{3}H behavior in surface waters, the transpiration by plants, microorganisms' vital activities in the soil and others.

Distribution of natural radionuclides and ^{137}Cs in waste jarosite/Pb-Ag precipitate

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Chemical industry Zorka Šabac in the eighties of the last century was one of the largest zinc producers in Europe with its own zinc ore reserves in Serbia. The factory ceased operations in 2007, after which a large amount of various wastes from the production process remained. The production of zinc involves the roasting of zinc sulfide concentrate, followed by the neutral leaching of roasted zinc sulfide concentrate with sulfuric acid. In order to use as much zinc as possible, the unleached precipitateis further subjected to hot-acid leaching, which is carried out in several stages. Jarosite/Pb-Ag precipitate is a mixture of two wastes: Jarosite and Pb-Ag precipitate that are produced from different segments of the leaching process of zinc sulfide concentrate. These two wastes were deposited together at the same landfill, where they mixed with each other. The landfill of Jarosite/Pb-Ag deposits covers an area of 5.8 hectares, and the height of the deposit reaches up to 2.5 m. It is estimated that for about 30 years of operation of the zinc factory (1976-2007), a total of about 300 thousand tons of this waste was stored in the open air without adequate environmental protection measures, which in its composition contains considerable amounts of heavy metals: Zn, Fe, Pb, Cu, Cd, and others.

The aim of this work was to determine the activity concentrations of natural radionuclides: ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K, as well as the artificial radionuclide ^{137}Cs. On the basis of the obtained values, the radiation risk for workers who were exposed to gamma radiation from this waste in the operation of the leaching plant in the zinc industry, Zorka non-ferous metallurgy, Šabac, was estimated. 15 samples of jarosite/Pb-Ag precipitate were analyzed by the gamma spectrometry method. Sampling was carried out in the surface layer of the landfill. The measured activity concentration values range from (< 0.9 – 4.8) Bq kg^{-1}; (20.1 – 91.5) Bq kg^{-1}; (1.49 – 5.4) Bq kg^{-1}; (13.5 – 88.0) Bq kg^{-1} for ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K, respectively. Average values are 2.7; 41; 3.6 and 52 Bq kg^{-1} for ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K, respectively. All measured values of ^{137}Cs are < 0.7 Bq kg^{-1}, which is lower compared to previous results for soil (Forkapić, et al., 2017; Szabó et al., 2012). The measured values for ^{238}U, ^{232}Th and ^{40}K are far below the average values for soil, while ^{226}Ra in some samples has three times higher value compared to the average 32 Bq kg^{-1}. Gamma index values for all samples are below 1. The estimated values of annual effective doses are far below the recommended 1 mSv (average 0.029 mSv), so it can be said that there was no excessive external exposure of the workers in the leach plant. The measured values of the concentration of ^{226}Ra activity indicate that there is a possibility to increase the concentration of this radionuclide in the soil. It was also observed that ^{226}Ra accumulated in this waste to a considerable extent compared to zinc sulfide concentrate as the starting raw material, where the average value is 9.4 Bq kg^{-1} (Kuzmanović et al., 2023), which indicates that the leaching process affects the largest part of ^{226}Ra from the initial concentrate accumulates in the jarosite and Pb-Ag precipitate.

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Radiocaesium in Polish roe deer and red deer: 2015 – 2022 results

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Monitoring radioactive contamination in food samples of animal origin is the main task of veterinary services in order to ensure radiological protection of consumers, especially after the accident at the Chernobyl nuclear power plant.

Objective: The aim of the present study was to assess radiocaesium contamination of roe deer*(Capreolus capreolus)* and red deer *(Cervus elaphus)*.

Material and methods: In total, 205 deer muscle samples and 145 roe deer muscle samples from 10 provinces were examined. Muscles were chopped and minced, then samples weighing approximately 450 g were placed in Marinelli type containers and measured using gamma-ray spectrometry with a solid-state detector (high-purity germanium HPGe detector) and a scintillation detector (NaI(TI) crystal).

Results and discussion: Activity concentrations of ^{137}Cs varied widely (from MDA values to over 100 Bq/kg), even in the same region. Most often they ranged from a few to tens of Bq/kg. The highest concentration of ^{137}Cs was 86.7 ± 3.47 Bq/kg and 111.5 ± 12.5 Bq/kg in red deer and roe deer muscle samples, respectively. Additionally, equivalent effective doses from the consumption of 1 kg of red deer or roe deer meat were calculated, taking into account the average concentration of ^{137}Cs in individual years. The highest value for red deer was 0.91 µSv in 2015 and for roe deer 0.18 µSv in 2016. The fact of occurrence of higher concentrations of ^{137}Cs in game animals (in comparison to the values observed in livestock) is connected with their consumption of plants and fungi that have the ability to accumulate radionuclides present in forest ecosystems.

Conclusions: The consumption of game meat in Poland is low, so it can be concluded that from the point of view of radiological protection it does not pose a threat to the general public. However, certain precautions can be recommended to groups for which it may be a significant source of food (hunters and their families).

Keywords: ^{137}Cs, contamination, red deer, roe deer

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Contamination of farm animal bones with the radioactive isotope ^{90}Sr

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Strontium-90, as an emitter of beta radiation, plays an important role in toxicity in radioactive contamination. Due to its long half-life (T1/2 = 28.50 years) and its chemical properties similar to calcium, it is one of the most dangerous radionuclides. By 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 may penetrate and contaminate the natural environment, and together with radioactive fallout, it accumulates in areas intended for grazing farm animals, including fields and pastures. Examination of animal bone samples is an important parameter in estimating environmental contamination.

Objective: The aim of the study was to estimate the concentration of ^{90}Sr in the bones of farm animals.

Material and methods: In order to assess contamination of farm animal bones, research material was collected from four groups of animals (sheep, cows, pigs, horses). A total of 40 bone samples were collected and analyzed. After initial grinding and cleaning, the samples were incinerated and then analyzed by liquid scintillation counting (LSC) in Quantulus 1220™ (Perkin Elmer) detector. It was important to use an additional sample purification step using a special Dowex 1x8 ion exchanger, which allowed for the removal of interferences.

Results and discussion: Concentrations of ^{90}Sr were detected in all tested animal bone samples. The highest values were recorded in horse bones, where the average was 8.52 Bq/kg. For the remaining matrices, the averages were 4.74 Bq/kg for sheep bones, 1.80 Bq/kg for beef bones, and 0.67 Bq/kg for pork bones. The highest concentration of ^{90}Sr, which was 14.1 ± 1.88 Bq/kg, was found in horse bone. However, the lowest concentration was recorded in pork bone and was below MDA (0.15 Bq/kg). ^{90}Sr, as an emitter of beta radiation with chemical properties similar to calcium, easily penetrates and accumulates in the bone tissue of living organisms, which is confirmed by the results obtained.

Conclusions: As a result of radiation events, various elements of the environment (water, soil, vegetation) may be contaminated. Strontium-90 accumulated in the environment, mainly as a result of the Chernobyl nuclear accident, is taken up from the soil by vegetation. It is mainly the diet of animals that influences the absorption of ^{90}Sr with food. Therefore, the presence of radioactive ^{90}Sr is most often observed in farm animals that graze on pastures. The analysis of contamination of farm animal bones with the radioactive isotope ^{90}Sr allows for estimating the degree of environmental contamination and setting it at a low level.

Keywords: ^{90}Sr, bones, contamination, farm animals

Estimation of some natural radioisotopes in forest ecosystems at eastern Lithuania

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Nowadays the anthropogenic pressure on landscapes is high, except reserves. The forest ecosystem is a natural, long-term environment in comparison to agroecosystem, however, is usable to the needs of forestry management. Pine forest grows about a hundred years before is harvested. The pine forest forms the unique, semi-natural biome with its own microclimatic and recirculation characteristics during this period. The specific activity of natural radionuclides was investigated in eight points at central part of Lithuanian east boarder. The pine forest growing at three sampling points is younger than at other five, and refers to the first cycle of the forest management. It has been hypothesized that longer-existing ecosystems of forests differ in the distribution of radionuclides from shorter-existing. Short living compartments of flora were investigated for concentrations of natural radioisotopes for the purpose of comparing the distribution according to two variants of pine forest ecosystems maturity. The data showed no statistically significant differences between investigated two groups in cases of C-14 specific activity (Bq/kg d. w.) in mugwort (*Artemisia vulgaris*) as well as in case of H-3 specific activity in rowan (*Sorbus aucuparia*) leaves (Bq/kg raw weight). Gama-spectrometric measurements of rowan leaves also showed no statistically significant differences between specific activities (Bq/kg d.w.) of Be-7, Pb-210 (and Pb-210exc), Pb-214, K-40 radionuclides. Dispersion of data matches in varied about 30% standard deviation from averages. In lower layer of forest in lower shrubs blueberries (*Vaccinium myrtillus*) in cases of coming from the bottom-up distribution of natural radionuclides Pb-214 and K-40 for mature forest is more compact (standard deviation is less than 15%) inside the group, that shown similarity of these parameter to these group. In bottom layer of forest (mosses) similar tendency shown specific activity of Pb-210(and Pb-210(exc), natural radionuclide coming from above to the forest ecosystem.

Phytoremediation of soil from German nuclear facilities

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Germany shut down its nuclear power plants on April 14, 2023, and hence the need for research on the decommissioning of nuclear facilities has never been greater in Germany. This work is part of the RENA (biological radionuclide removal by using natural association processes) project. The goal is to reduce the volume of medium and low-level radioactive waste - precisely soil - for a final repository. Excavated soil from the decommissioning of German nuclear facilities is the basis for this work. In contrast to previous remediation projects, only natural association processes are used. Therefore, we grow plants, fungi and their symbiosis, harvest them and analyze their extraction capabilities. Based on the results, a process for the ex situ treatment of radionuclide-contaminated soils in a dismantling area in Germany will be developed.

The soil investigated originates from sites of the first and the second nuclear reactors built in former East Germany. The research reactor in Dresden, Saxony, operated from 1957 until 1991 and the nuclear power plant in Rheinsberg, Brandenburg, followed 1966 until 1990. Hence, the soil was contaminated over decades and all radioactive and chemical equilibria have settled to date. This is impossible to mimic by spiking of inactive soil. Hence, original contaminated soils were sampled and brought to the IRS hot lab for further investigations. Without pre-treatment of the delivered soil, pieces of concrete as expected to be in a deconstruction process were found. Consequently, all soil, with the exception of a control group, was sieved to a corn size of 2 mm and homogenized. Starting with a precise analysis of the soil, one of the leading radionuclide contaminant was ^{137}Cs. The complete nuclide vector consists of more than 25 activation products (i.e. ^{60}Co, ^{134}Cs, ^{152,154,155}Eu), fission products (i.e. ^{90}Sr, ^{137}Cs) and transuranic radionuclides (i.e. ^{241}Pu, ^{241}Am). A grain size analysis showed a high mass share of 90 % sand. Share of silt and clay sum up to 10 %. However, the proportion of ^{137}Cs activity of this fraction exceeds its mass share by far.

The setup for the plant cultivation consists of plant pots (Ø x H: 18 cm x 17 cm) in a climate chamber with optimized growth parameters such as daylight, temperature and humidity. We chose small-growing sunflower (*helianthus annuus*) and Lucerne (*medicago sativa*) because they displayed promising results in inactive pretests. To ensure sufficient growth, Hoagland solution was used to water the plants. Various parameters were tested to determine the optimum conditions. These parameters include charcoal, the growth period and fungi. A commercially available mix of fungi (*Tyroler Glückspilze Mykorrhiza*) was used based on the theory that different sprouts support different uptake. A control group of plants grew in untreated soil to observe the influence of the concrete. For the general monitoring of radionuclides, the plants were harvested and divided into leafs, stem and blossom. Afterwards they were dried, ashed and digested. The γ-emitters were monitored by HPGE-detectors.

In summary, this work gives new transfer factors for radionuclides and the extraction potential by plants. Furthermore, it shows problems of phytoremediation of soil from the dismantling of nuclear power plants.

Radionuclide activity in milk and dairy products

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The use of nuclear energy for peacetime purposes, in addition to multiple benefits, brings with it a number of negative effects, among them the potential contamination of the environment with radioactive substances. Due to the radioactive contamination of milk, from a health-hygienic point of view, a whole series of problems can arise due to the further processing and processing of milk, because all routes of transfer of radionuclides end in humans, as the ultimate consumer of food - milk and milk products. These radionuclides, together with natural radionuclides, reach milk and milk products through the food chain, and through them contribute to the radiation load of the population. The paper presents the results of the Department of Radiation Hygiene at the Scientific Institute of Veterinary Medicine of Serbia in Belgrade. The implemented radiation hygiene control was carried out by gamma spectrometric analysis of a total of 867 samples of milk and milk products in the course of 2023, in internal and border traffic. Based on the obtained results of radioactivity measurements on the territory of the Republic of Serbia, we can conclude that the activities of natural radionuclides in milk and dairy products were within the limits of the basic activity background, except for a few samples of powdered milk, the value of which was slightly higher, but still below the permissible limits prescribed by our rule book. The activity level of ^{137}Cs in the environment is also in a constant downward trend, so we can state that it is almost identical to the level before 1986.

Assessment of boundary parameters of radioactive contamination of STS 'background' areas

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Currently, the basis for assessing the degree of radiation risk is a nonthreshold ionizing radiation model generally accepted and regulated by documents of the Republic of Kazakhstan (Health standards for radiation safety assurance (HS)), in which the quantity of the effective dose is the measure of radiation risk. The committed annual effective dose from man-made exposure must not exceed 1 mSv per year for population. The Resolution of the Government of the Republic of Kazakhstan dated July 31, 2007 No. 653 'On approval of criteria for assessing the environmental situation in areas' states criteria for assessing the radioecological conditions of areas, while the assessment of the effective dose parameter is decisive and is a priority. In case man lives and/or carries out any economic activity in the STS territory, the main criterion for assessing the degree of human radiation safety is the annual effective public dose from man-made radionuclides produced by nuclear weapon tests.

The establishment of the highest levels of maximum permissible exposure of people to the greatest risk from man-made radiation sources has been and remains a basis for the science-based approach to the radiation protection problem. Therefore, conservative approaches have been developed to calculate the doses to the public while living and carrying out activities in the former STS territory. This approach is conservative based upon several assumptions about the lifestyle of people in which radiation impact may be higher. It is assumed that a person lives in a contaminated area, is engaged in crop production and animal breeding, cultivates and produces products in this area, consumes them.

If, according to estimates, a predicted dose and risk to a farmer who is engaged in subsistence farming are very likely to be below maximum permissible limits, then one might assume that the rest of locals will also be safe. Using this approach allows a conservative estimate of the committed annual exposure dose to the public living and carrying out activities in the STS territory.

Most of the STS territory is represented by conventionally 'background' areas. In these areas, the concentration level of man-made radionuclides is comparable to the background level of global fallout. The major man-made radionuclides are ^{137}Cs, ^{90}Sr, $^{239+240}$Pu, ^{241}Am. Studies of many years, which were conducted in the STS territory, showed that potential pathways of human exposure to ionizing radiation from man-made radionuclides in radioactively contaminated areas are: external exposure from man-made radionuclides contained in the topsoil (5 cm); internal exposure from inhaled radionuclides; internal exposure from man-made radionuclides ingested with food/water from STS.

Taking into account the ratios of man-made radionuclides in conventionally 'clean' STS areas, boundary values of activity concentrations of man-made radionuclides (^{137}Cs, ^{90}Sr, $^{239+240}$Pu, ^{241}Am) were determined for the topsoil for each radionuclide through potential exposure pathways that ensure that the effective dose of 1 mSv is not exceeded. In addition, boundary values of activity concentrations of radionuclides for the annual effective dose of 1 mSv were determined with only one radionuclide present in the soil from the total exposure to all pathways.

Natural radioactivity of bicarbonate mineral waters from central Serbia

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Geological structure of the territory of central Serbia is characterized by numerous types of rocks whose ages range from the Precambrian to the Quaternary. Due to a specific structure of geotectonic environments, the occurrence of mineral waters in this area is related to 4 types of geological environments: hydrogeological massif, volcanogenic massifs, metamorphite area and karst areas.[1] Results of the study on the natural radioactivity of selected mineral waters from central Serbia, mainly of Na-HCO3 and Ca/Mg-HCO3 type, sampled at the source will be presented here. After preparation of samples, those were analyzed for total alpha and total beta activity. Following the establishment of the radioactive equilibrium, samples underwent to high-resolution gamma-radiation spectrometry analysis, for the content of the elements of natural radioactive series: Ra-226, Th-232, U-238 and U-235 and for the content of primordial K-40. Results have shown enhanced total alpha and total beta activities for about 30% of the analyzed samples if compared with prescribed reference values for drinking water.[2] The results of the gamma-spectrometric analysis revealed Ra-226 activity concentration values in the range: 0.02-0.91 Bq/L, with the maximum value in the Bukovička banja-park sample and with the content of this radionuclide below the minimum detectable concentration (MDC) for 30% of samples. Th-232 concentration was in the range: 0.05-0.79 Bq/L, uranium isotopes U-238 and U-235 were not detected in any of the analyzed samples, while the K-40 concentration was in the range of 0, 10-1.98 Bq/L. Obtained results were discussed in relation to our previous studies on the radioactivity levels and non-equilibrium observed in mineral waters from other regions in Serbia [3, 4] as well as to the other authors studies. Geochemical characteristics of the sampling regions and physico-chemical processes occuring underground and in the near-surface soil have a crucial role in correct interpretation of the results. Due to a fact that presented radioactivity levels in mineral waters in many cases may be characterized as significantly low, more sensitive analytical techniques should be considered for further mineral water analysis.

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Anesthesia for interventional neuroradiologic procedures in children: Our experience

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Gamma knife radiosurgery is a treatment method when radiation therapy is performed in a very precise area of the brain. The child's head should be absolutely motionless during the procedure. In this regard, the issues of sedation and premedication are challenging for younger children who are not inclined to cooperate with doctors. Dexmedetomidine is a selective alpha-2 agonist with sedative, analgesic, and anxiolytic properties has been used in our center for many years to provide sedation for chilgren.

Case History: A 3-year-old child diagnosed with medulloblastoma was hospitalized to the National Medical Research Center for Neurosurgery named after Academician N.N. Burdenko for radiosurgery. We administered dexmedetomidine intranasally (4 mcg/kg) 30 minutes before the installation of an intravenous catheter, then used propofol infusion (5-8 mg/kg/hour) during the procedure. Heart rate, pulse oximetry saturation and noninvasive blood pressure before and after procedure were made. The patient maintained spontaneous breathing, and there was no desaturation or any complications.

Conclusion: This case report shows the adequate rate of sedation in a child after intranasal dexmedetomidine administration with continuous propofol, as it allows spontaneous breathing and fast turnover. Intranasal dexmedetomidine is safe and the most effective drug when a nonintravenous route is employed. Described scheme is been successfully used in radiosurgery in children with no noted adverse effects.

Dependence of dose enhancement on gold nanoparticle shape in photon radiotherapy

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Gold nanoparticles (AuNPs) have emerged as a promising radiosensitizer in photon radiotherapy due to their high atomic number, ease of production in various shapes and sizes, and biocompatibility. Targeted delivery of AuNPs can further improve the precision of dose deposition. This study investigates how AuNP shape affects energy deposition efficiency, independently of other tested influencing factors. Optimized Monte Carlo simulations of radiation transport are employed to model energy deposition patterns in nanoparticle-laden regions with nanoscale accuracy. Three shapes of AuNPs are tested for the ability to deliver a higher dose to the tumor. The obtained results offer guidelines into designing nanoparticles, as well as into optimizing future dosimetric Monte Carlo studies in metal nanoparticle enhanced photon radiotherapy.

Initial insights into radiosensitization of rhabdomyosarcoma for enhanced hadrontherapy outcomes: Progress from the SaRHa project

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Rhabdomyosarcoma (RMS), the foremost pediatric soft tissue sarcoma, presents profound treatment challenges owing to its intrinsic radio-resistance and propensity for metastasis, which contribute to poor prognoses. Addressing these challenges, the SaRHa project takes an innovative approach to enhance the efficacy of hadron therapy—a precision radiotherapy modality utilizing protons and carbon ions. This presentation focuses on our progress through the initial phases of the project, which lay the groundwork for future therapeutic breakthroughs. Our multidisciplinary research effort, utilizing irradiation platforms such as CYCLHAD hadron therapy center and GANIL platform, in combination with proteomic platform at UniCaen, has embarked on the ambitious goal of identifying molecular pathways contributing to RMS radio-resistance. The first work package established a radio-resistant RMS cellular model, setting a foundation for comprehensive biological pathway analyses. Concurrently, our bioinformatics studies have started to unravel the complex genetic landscape of RMS radio-resistance, identifying potential targets for intervention. Preliminary results offer a glimpse into the biomarkers and genetic determinants that could redefine RMS treatment protocols, steering towards personalized hadron therapy. Although the project's full scope includes experimental validation of identified targets and evaluation of their impact on treatment outcomes, our current findings already contribute valuable insights into RMS radio-resistance mechanisms. This early-stage work not only paves the way for optimizing RMS treatment but also exemplifies the potential of integrating bioinformatics and experimental research in tackling pediatric sarcomas. Through this presentation, we share our journey, methodologies, and the challenges encountered, aiming to foster dialogue and potential collaborations that will further the field of oncological research.

Fractionated stereotactic radiation therapy for large intracranial brain tumours: Plan quality

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Stereotactic radiosurgery (SRS) has been used in the management of primary small brain tumors including meningiomas, vestibular schwannomas, pituitary tumors and brain metastases. There may be selected cases, where radiosurgery is inappropriate because of tumor location and tumor size within the brain. Treatment in multiple fractions of stereotactic radiosurgery potentially provides both adequate tumor control and low toxicity rates (radiation necrosis). SRS and fractionated Stereotactic Radiotherapy (fSRT) utilize the stereotactic frames and multiple planar or non- coplanar arc beams, by delivering a concentrated dose in tumor while sparing organs at risk.

This study aims to report the clinical experience of fractionated stereotactic radiation therapy (FSRT) for intracranial tumours, by evaluating the plan quality indices as dose coverage, and conformity index. Treatment planning was performed using XKnife-5 system with relocatable Gill-Thomas-Cosman frame, tertiary cones and Linac. Based on results, FSRT potentially provides an efficacy alternative modality to radiosurgery to treat relatively large volume brain tumours.

Exploring radiation therapy during pregnancy in Hodgkin's lymphoma treatment

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Cancer during pregnancy is rare yet anxiety-inducing, with Hodgkin's lymphoma being a notable example.

Materials and methods: The presented material constitutes a segment of the doctoral dissertation authored by the principal investigator, delving into the cases of patients diagnosed with Hodgkin's lymphoma undergoing treatment during pregnancy. It represents a summary of over three decades of the medical team's efforts and the amassed data over the years. Between 1990 and 2020, 162 pregnant patients diagnosed with Hodgkin's lymphoma were treated at the Oncology Institute in Warsaw. Radiation therapy was administered to only 138 patients either during or after pregnancy. In the analyzed group, none of the patients received radiation both during and after pregnancy; 115 (83.3%) underwent postpartum radiotherapy. Radiation during pregnancy was conducted in only 23 patients (16.7%). Radiation procedures were not employed in any patient during the third trimester. Only 2 patients (8.7%) were irradiated in the first trimester, while the remaining 21 patients (91.3%) were irradiated in the second trimester of pregnancy. The extent of radiation (involved field vs. mantle field) was determined by the location of the initially affected areas, taking into consideration the gestational age. Treatment utilized gamma radiation from Cobalt-60 units and linear accelerators LINAC, Siemens, Varian, with radiation energy ranging from 1.25 to 4-6 and 15 MV. Radiation treatment planning was conducted using 2D and 3D systems with computed tomography. During pregnancy, radiation therapy was performed with individual shielding for the uterus and fetus, utilizing lead coverings. The positioning of dosimeters was monitored and adjusted based on weekly ultrasound examinations of fetal position and uterine fundus. Dose correction was based on the location of the fetus and uterine fundus relative to the lower boundary of the radiation field. Radiation was administered to the supra-diaphragmatic areas under the supervision of medical physicists with dose monitoring on the fetus. Doses reported by dosimetrists ranged from 0 to 15.7 Gy - 19.9cGy.

Results: In the analyzed group, fetal doses during maternal irradiation were most frequently reported ranging from 0 to 10 cGy. No fetal complications were observed at higher doses received by the fetus. From 2018 to 2020, comprehensive radiotherapeutic surveillance was conducted involving a team of medical physicists using their developed dosimetric method. Attention was drawn to the duration of patient positioning in the therapeutic apparatus in the supine position, as three patients experienced transient fainting episodes. Fetal doses were verified multiple times. The toxicity of both prenatal and postnatal radiation therapy was clinically acceptable, comparable, and fell within the range of toxicity grades on the EORTC RTOG scale 1-2: skin reactions, oral mucosal reactions, esophageal mucosal inflammation, nausea, vomiting, hematologic symptoms (such as leukopenia, neutropenia, thrombocytopenia), and cardiac disturbances. In the group of pregnant patients undergoing radiation therapy, four cases of Lhermitte's syndrome were reported (when gamma radiation from cobalt-60 machines was used). All complications did not require interruptions in the ongoing treatment or additional hospitalization.

Conclusions: Despite the developed principles of modern radiation therapy planning, techniques, equipment, and dosimetry, the possibilities of radiotherapy during pregnancy are limited. Indications for radiotherapy may include massive nodal changes located above the diaphragm. Radiation therapy can only be applied when there is the possibility of proper planning, treatment delivery, and monitoring of fetal and uterine exposure doses, with the involvement of an experienced team of medical physicists.

Keywords: radiotherapy, cancer, pregnancy

Is Thoron a problem in radon measurements with SSNTD? Experimental study

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Radon (Rn-222) is the largest source of natural radiation exposure for most of the population. It accounts for 48% of the overall radiation exposures received by an average member of the public in the UK from both natural and man-made sources. In some countries, however, thoron (Rn-220) can also be an exposure problem.

Passive solid state nuclear track detectors are the most popular and convenient method of measuring radon. Although there are available detectors on the market which can distinguish and concurrently measure both radon and thoron exposure independently, for typical detectors they would be indistinguishable. Having a relatively short half-life of 56 s compared to the diffusion time into the detector's chamber of 20 minutes, the chances of low concentration thoron entering it are reduced. However, it can still have some minor effects on the value of recorded exposures.

A set of standard UKHSA radon passive detectors was exposed at Sofia University to a high thoron concentration to receive a total exposure of 8 MBq h m^{-3}. The thoron was supplied by a flow-through thoron source produced by Pylon Electronics Inc. The thoron concentration in the exposure vessel (50 L Emanation & Calibration container, Saphymo GmbH, Germany) was homogenized with the help of a fan situated just below the inlet of the exposure vessel. The exposure vessel, which was a closed container, was kept under thermostatic control to provide a constant temperature and dryer units were used to keep air coming from the source at low humidity. The concentration of thoron in the exposure vessel was controlled by measurements with an AlphaGUARD 2000 RnTh PRO monitor with 10 minute intervals. The AlphaGUARD monitor used in the exposure was traceable to a reference thoron measurement system developed at LNE-LNHB, France.

In a separate experiment, an unused thorium incandescent gas mantle was used as the thoron source and standard radon detectors were placed at different distances from it. The detectors were kept in place for 24 h and the highest received exposure was 500 kBq m^{-3}.

The results showed that thoron can be detected by a standard radon detector at high exposure, but the yield of the recorded concentration would be small. It was also demonstrated that the ability to detect thoron by passive radon detectors is highly dependent on the distance from the source.

In conclusion, it has been demonstrated that thoron at high concentrations can have some, small impact on standard radon detectors, but this effect can be easily controlled by the distance from the source.

Relationship between Ra-226 activity concentration in building materials and indoor radon concentration: An example of Russian high-rise residential buildings

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The expansion of high-rise building construction in the first quarter of the 21st century and the prospects for maintaining this trend in the future make it relevant to study building materials as a source of radon. In some multi-story buildings, the radon exhalation from building materials has been proven to cause indoor radon concentrations above reference levels. The aim of this study was to analyze the relationship between the content of Ra-226 in building materials and the indoor radon concentration using the example of multi-story buildings in Russian cities.

To study the relationship between indoor radon and Ra-226 concentration in building materials in high-rise buildings, the results of two sources of information were analyzed:

1) survey of indoor radon in nine large Russian cities, conducted using solid-state nuclear track detectors in 2018-2022;
2) survey of natural radionuclides content in building materials in nine large Russian cities conducted by non-destructive method in 2020-2023.

The analysis of the architectural characteristics of the buildings included to indoor radon and natural radionuclides surveys revealed that high-rise buildings in Russian cities can be divided into two groups by year of construction and energy efficiency class: buildings built before 2000, low energy classes C, D and E (old buildings group); buildings built after 2000, high energy classes A and B (new buildings group).

The radon concentration was measured by means of solid-state nuclear track detectors, RSKS type (Radosys, Hungary). The samples of apartments were selected by a quasi-randomized approach. More than 100 apartments were surveyed in each city. Weighted annual arithmetic mean radon concentration in multi-story buildings in Russia is about 25 Bq/m^3; geometric mean – 21 Bq/m^3; geometric standard deviation – 1.81. With regard to the period of building construction, the weighted arithmetic mean radon concentrations in old and new buildings are 24 and 29 Bq/m^3, respectively.

The activity concentration of natural radionuclides (Ra-226, Th-232, K-40) in existing buildings was measured using a non-destructive method which allows to estimate an integral quantity characterizing a variety of the building materials. Measurements of the activity concentration of Ra-226 in building materials by the non-destructive method were carried out in 100 residential buildings in nine cities. The obtained values of Ra-226 activity concentration in building materials ranged from 3.8 to 51 Bq/kg. Coefficients of variation of Ra-226 activity concentration in building materials do not exceed 0.4 in most cities.

The average ratio Rn/Ra varies by cities in the range from 0.64 to 1.1 (Bq/m^3)/(Bq/kg) and from 1.4 to 3.1 (Bq/m^3)/(Bq/kg) in old and new buildings, respectively. The ratio Rn/Ra varies depending on climatic conditions and characteristics of a building (in particular, energy efficiency class). The relationship between the average Rn/Ra ratio in new buildings and the annual average temperature in a city is characterized by correlation coefficient -0.87. The average increase in radon concentration normalized to Ra-226 in new buildings compared to old buildings was 2.1 times. Diffusion entry rate adjusted to Ra-226 concentration 1 Bq/kg (D/Ra ratio) in Russian cities depends on the type of building materials and architectural characteristics of the building. Estimated average D/Ra ratio is approximately 0.4 Bq/h/m^3. The parameter characterizing the rate of radon entry from building materials by diffusion can be used to predict the radon concentration in buildings.

Development of a new Thoron primary standard

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Thoron (^{220}Rn) is the second isotope of radon, the risk related to its exposure must be evaluated and its contribution on the actual annual ^{222}Rn dose received by workers and by the population, estimated to amount to about 8% on average, can no longer be neglected. This circumstance, besides being documented in several scientific papers, has also been verified by radon progeny measurements carried out by ENEA-INMRI in cooperation with INAIL and ARPA Lazio. From the spectra acquired in these measurements, the alpha emission peak of ^{212}Po is appreciated, which has an area comparable to that of ^{214}Po.

Project Purpose: The purpose of this work was to improve the thoron standard developed in 2015 by ENEA-INMRI in cooperation with CEA under the Metro NORM (Metrology for Naturally Occurring Radioactive Materials) project.

Due to the short half-life of thoron (half-life t_(1/2)55.8 s) it is practically impossible to realize a reference atmosphere of the radionuclide to calibrate ^{220}Rn measuring instruments, for this reason, it is necessary to determine the measuring instruments efficiency through appropriate mathematical models. This is the reason why it was decided in this work to use a measuring instrument based on the Lucas scintillation cell, both because of the simplicity of its operating principle and the possibility of making a suitable mathematical model based on the Monte Carlo method.

Materials and the methods: Several experimental setups for measuring radon and thoron concentrations in controlled atmospheres have been developed at ENEA-INMRI's RAN sector laboratories.The ENEA-INMRI thoron chamber, with a volume of about 220L was used for the development of the primary thoron standard and one or two ^{220}Rn sources consisting of ^{232}Th in secular equilibrium with all its progeny up to ^{224}Ra were placed inside, with also a fan to distribute thoron evenly and an internal monitor based on an electrostatic collection cell. Outside the thoron chamber the MR1 scintillation cell-based monitor was placed. Atmosphere sampling has been done with a pump with adjustable flow rate between 0.5 and 4 L/min. To isolate the counts due to ^{220}Rn and ^{216}Po from the contribution of ^{212}Bi and ^{212}Po in the measurement process, a protocol is followed.

The concentration of ^{222}Rn evaluation in the Lucas cell versus the concentration in the thoron chamber has been the most critical aspect in the development of the novel thoron standard, to overcome this limitation, measurements were made with two Lucas cells in series, and this setup allowed the problem to be overcome as it will be explained in the full paper. Lucas cell efficiencies for the different alpha emissions of thoron, radon and their progeny were calculated with the Monte Carlo Fluka code.

Results and conclusions: The results obtained in the experiment confirmed that the two models applied in INMRI for calculating the average thoron concentration in the Lucas cell are in agreement, the previous model was validated by the new experimental setup. Measurements with Lucas cells in series showed that at a sampling flow of 0.86 L/min, in the cell the activity concentration is about 85 percent of that in the thoron chamber, this value is in good agreement with the old model estimates. The values of the alpha particle detection efficiencies of ^{222}Rn and its progeny calculated in Fluka are in good agreement with the experimentally measured values, This circumstance allows us to consider the efficiencies calculated for ^{220}Rn and ^{216}Po to be valid as well.

Artificial intelligence radon flux measuring system at ENEA-INMRI

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Rn-222, also known as radon, is a radioactive noble gas which is exhaled from soil and rock to the atmosphere- Building materials and radon infiltrations from soil have been identified as main factors influencing indoor Rn-222 levels in most buildings.

Understanding the distribution of Rn-222 exhalation from the ground's surface can help identify areas with a higher risk of radon exposure for the public.

The Radon flux can be measured using either a direct or indirect method. The indirect method involves using parameters such as the Ra-226 activity concentration in soil, terrestrial gamma dose rate, and radon in soil gas that are then correlated with the radon flux. A direct measurement of radon flux can be achieved using the accumulation method, where Rn-222 gas is allowed to accumulate and then measured in a chamber placed over the soil. The system developed by ENEA-INMRI, in the framework of the EMPIR 19ENV01 traceRadon project, consists of a steel drum acting as accumulation chamber and a continuous radon monitor (AlphaGUARD PQ2000 PRO) operating in diffusion mode to measure radon concentration, temperature, pressure, and humidity changes over time inside the drum.

The measuring system was placed on the soil and left to measure for at least one week. The data used in this work were collected over the course of one year.

The variation of radon concentration with time inside the chamber follows an exponential behavior. The exhalation rate or radon flux can be determined from the parameters obtained through by exponential fitting.

The radon concentration inside the drum shows both increasing and decreasing trends and it is not periodic due to the fluctuations in external environmental factors. This irregular behavior makes it challenging to determine the appropriate time interval for fitting the data.

Several machine learning algorithms were trained, and results were compared to estimate their prediction performance and select the most effective. Chosen algorithm was used to select the right time intervals on which perform the exponential fits and obtain radon flux values. This procedure was very time consuming, but machine learning provides a fast and automated solution to this problem.

The primary objectives were to develop an automatic measurement system using a machine learning algorithm to obtain direct radon flux values. Addionally, the influence of several measured variables affecting the radon release from soils was analyzed.

This project 19ENV01 traceRadon has been funded by the EMPIR program co-financed by the Participating States and the European Union's Horizon 2020 research and innovation program.

Seasonal changes in the Radon content of mineral and thermal waters in the Erzincan/Türkiye region

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The effect of seasonal change was examined by measuring radon activity concentration in the mineral and thermal water resources of Erzincan province, located along the North Anatolian Fault Zone and Ovacık Fault Zone in the Eastern Anatolia Region of Turkey. Measurements were made between July 2023 and February 2024. Radon activities of water samples were measured with the AlphaGUARD PQ 2000PRO radon detector. Summer and winter radon activities of water samples were determined between 0.17-5.06 and 0.3-6.70 $Bq.l^{-1}$, respectively. Additionally, annual radiation dose estimates due to radon were calculated for the local people consuming these waters. The results obtained were interpreted from a public health perspective.

The Effect of the 7.7 and 7.6 magnitude earthquakes centered in Pazarcık and Elbistan on February 6, 2023, on possible radon anomalies in groundwaters in the Hatay/Türkiye region

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In this study, the effects of the 7.7 and 7.6 magnitude earthquakes centered at Pazarcık and Elbistan on February 6, 2023 and the subsequent aftershocks on possible radon anomalies in groundwaters in the Hatay region were investigated. Radon concentration measurements were performed with the AlphaGUARD PQ 2000PRO radon detector. According to the results, it was observed that there were significant radon anomalies in 2 locations. The earthquakes on February 6 may have an impact on these anomalies, as well as the many aftershocks that occurred afterwards. There may be a relationship between the radon anomalies observed in these two sources and the earthquakes with magnitudes of 4.9 and 4.2 ML that occurred around these sources. Therefore, despite the limited data, these two anomalies can be interpreted as a preliminary indicator of the aftershocks with a magnitude of 4.2 ML that occurred at Hatay-Samandağ on April 28 and a magnitude of 4.9 ML that occurred at Topboğazı-Kırıkhan on May 7. In addition, long-term radon measurements in these two sources may be important in terms of observing a precursor sign before possible earthquakes.

Study of Radon in workplaces with continuous monitors Radoneye+2

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The measurements of radon indoor in workplaces in Albania is very low, this is due to the long measurement time with CR-39 also the lack of government policies. In workplaces such as offices, where hazards are normally low, radon can be the largest occupational health risk. In in the framework of the project ALB 9011 supported from IAEA were provided 10 continues radon monitors Radoneye+2 as a new opportunity for studying the temporal variations of indoor radon and for more precise exposure estimates based on the actual hours spent in workplaces. The measurement of radon concentration with Radoneye+2 monitors were performed in the same workplaces with different typology and ventilation including response time as with passive detector CR-39 before in the institute of Applied Nuclear Physics.

The Radoneye+2 monitors stayed during for tow-weeks continuous monitoring. It is observed that the average of indoor radon concentration was approximately as average value measurement with passive method. The deviation of the values is found to vary from 15-20%. The RadonEye+2 have high sensitivity and for this case shown that have linearity of values up to 2000 Bq/m^3. This study is in the early stages and requires more measurements to give more accurate results.

The continuous monitoring of radon concentration is important as a tool to keep under control the radon concentrations as indicator to increase the awareness against radiation hazards among the workplaces and critical population groups.

Radon levels in Biserujka cave and assesessment of effective dose received by visitors and tourist guides

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Because of their uniqueness, speleological objects have always attracted the attention of many researchers, but also other visitors (tourists), which is why some of the facilities are still touristic today. This also makes them potentially suitable spaces for the accumulation of the radioactive gas radon. Radon is a gas that is created as an intermediate product of the radioactive decay of uranium and occurs naturally in minerals on Earth. When radon reaches the surface, concentrations are quickly diluted, while increased concentrations can occur in enclosed, underground spaces. By inhaling air with a high concentration of radon can cause damage to the body and increase the risk of respiratory diseases. Therefore, measuring the concentration of radon in the environment is important both for science and for identifying areas with elevated radon concentrations, which is an important step in preventing the harmful effects of radon on humans.

In this work, the radon concentration was measured in the Biserujka cave on the island of Krk, Croatia. The measurements were carried out with the AlphaE device (Saphymo GmbH, Germany), which enables radon measurements in real time. The aim of this work was to measure the radon concentration in the mentioned caves and to estimate the effective dose received by tourist guides and cave visitors. The radon concentration in the Biserujka Cave was measured over a period of three months, i.e. in June, July and August 2023. The average radon concentration values in the measured period were (6.4 ± 1.5) kBq/m^3. It was calculated that visitors to Biserujka Cave receive an effective dose of about 10.1 μSv during a half-hour tour, while the maximum annual dose to employees is about 8.03 mSv, which is well below the recommended maximum levels. It has been calculated that the doses received by visitors during a visit are many times lower than legally allowed, and that the doses received by turist guides during the working season are acceptable as they are below the maximum allowed effective dose.

Keywords: Radon, radiation, effective dose, Biserujka cave

Development of microwave metamaterial-inspired sensors with multiple-band sensitivity for breast tumor detection

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Breast and lung cancers were the most common cancers worldwide, contributing 12.5% and 12.2% of the total number of new cases diagnosed in 2020 [1]. There are five stages of breast cancer, from 0 to 4. In stage IA, a tumor measures up to 20 mm, and there is no cancer in the lymph nodes. Stage IB can be described as either a small tumor in the breast that is less than 20 mm plus small clusters of cancer cells in the lymph nodes, or no tumor in the breast plus small clusters of cancer cells in the lymph nodes [2]. Early detection is one of the most impactful tools for beating cancer. If cancer is caught at an early stage before a tumor spreads to other parts of the body, the survival rate is much higher than when cancer is found after it has spread.

Most existing microwave imaging techniques for breast cancer detection operate in the frequency range of 10-15 GHz. However, in order to detect a 5mm or smaller malignant, a higher operating frequency is required, where the image resolution can be improved by at least 3 times at a 30 GHz range or higher [3]. Recently, a single-frequency band breast tumor detection mmWave antenna sensor and resonator antenna operated at 33 GHz, were proposed [3-5].

In this research, compact, mobile, contactless metamaterial-inspired microwave sensors, composed of a multi-band printed bowtie antenna and metamaterials, are developed to detect and identify breast tumor. The sensor operates in the Ka-band regime, 30-38 GHz, using reflection coefficients. A multi-negative refractive index band metamaterial structure is specifically designed as a sensing enhancer, where the multi-negative bands can effectively trigger the electromagnetic properties, as well as enhance the differentiation between breasts with and without tumor. The geometry of the metamaterial enhancer and its arrangement with the sample location and the radiating bowtie antenna are optimized to reach the highest sensitivity of the whole system. The proposed sensors are tested on breast phantoms, with and without tumors of various sizes and locations. Our study has shown that the electromagnetic responses of the breast tumor in the microwave frequency range are predictable. Multiple distinguishable resonance frequency responses generated while testing the samples are found within the frequency range of interest, specifying the sensor's ability to trace breast tumors.

Keywords: electromagnetic; metamaterials; microwave; sensors; breast tumors.

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The Langmuir-Blodgett nano thin film deposition method. Chemical sensor applications

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Our 35 years of investigating Langmuir-Blodgett (LB) films and developing instrumentation for their research are presented. The method and its several modifications will be discussed based on examples of our research. Different substances were investigated over the years: lipids, phospholipids, metal nanoparticles, quantum dots [1], adsorption of enzymes from the water subphase, and Metal-Organic Framework (MOF). Different layer manipulation techniques will be presented. One example is obtaining a well-developed 3D structure thus allowing for high-speed and sensitive chemical sensors.

One of the most essential applications of LB films is the preparation of the sensing layer in chemical sensors. Detections in both gas and liquid environments are discussed. Results on gravimetric detection of volatile organic compounds (VOCs) by an ultra-sensitive 434 MHz Surface Acoustic Wave (SAW) two-port resonators are presented [2]. The interdigitated electrodes of the SAW resonator are used to enhance the sensitivity in Electrical Impedance Spectroscopy (EIS) detection of PFAS contaminants in water. A combination of gravimetry and electrochemistry transduction on a single device provides additional selectivity. If one of the methods gives similar results the other can still differentiate between analytes.

Application of the electrohydraulic shock method for cleaning resins and resin-like contaminants from metal surfaces

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In industries where various heat exchangers are used, periodic maintenance is required, including cleaning of internal and external surfaces. Heat exchangers usually consist of a number of pipes through which the heat transfer fluid circulates. External cleaning of the pipes does not present any major difficulties. In contrast, deposits on the inner walls of the pipes are more difficult to clean. Deposits are mainly of two types: solid (calcium, magnesium oxides, etc.) and sticky - resins, bitumen, etc., depending on the working conditions - temperature regimes or type of working agent. Over time, as contaminants accumulate, the internal diameter of the pipe becomes too small and the required flow rate of the working fluid cannot pass through it.

Cleaning the inner surface of pipes can be done with brushes, high-pressure water injection, special chemical solutions, ultrasonic water waves etc. One of the most effective methods, well suited for cleaning both solid and adhesive fractions, is shock wave cleaning. Shockwave cleaning cleans surfaces in two ways: the shockwave carries the contaminants away and the cavitation created by the shockwave lets them to detach from the walls. One of the simplest ways to produce a shockwave is the so-called electrohydraulic shock.

Cleaning the surface of pipes using the electrohydraulic shock method is an environmentally friendly cleaning method that does not use any chemicals. Our proven cleaning method can be used to clean the internal surfaces of heat exchanger pipes. The cleaning process takes place in water, so the cleaning products will also immersed in water. This eliminates any possibility of fire or explosion. The water after filtration can then be used for cleaning other components, i.e. the cleaning cycle does not produce contaminated water that should also be disposed of.

Experimental studies have been carried out to determine the effectiveness of the electrohydraulic shock method in removing bituminous plaque. An experimental setup was constructed consisting of a tank of water containing the samples to be cleaned and high-voltage electrodes. These were fed with pulses from a capacitor which was charged from a high voltage source up to 30 kV. In the water, a pulsed transient discharge of tens of μs is produced through an atmospheric arcing short circuit, providing energy of tens to hundreds of J. This energy can be released in a short time (hundreds of microseconds) to produce very high discharge powers (up to MW) of the electric pulse. This causes both cavitation and a shock wave. The samples were metal with varying amounts of bitumen layer. The cleaning was carried out by electrohydraulic shocks at different energy stored in the capacitor and at different distances between the electrodes. The maximum cleaning effect, with more than 90% of the pollutant removed, was obtained by varying the amount of stored energy and the number of discharges, which was in the order of 1000 units.

Keywords: Electrohydraulic shock, high voltage, cavitation, surface cleaning.

The investigation of reference formulations with real radioactive waste, the study of radionuclide binding and leaching

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The binding and release of radionuclides are two of the most important features in terms of the waste acceptance criteria of low-level waste/intermediate-level waste repositories. Organic matter has the potential to influence the behaviour of radionuclides in the repository environment via the formation of complexes that may act toalter the solubility and/or sorption parameters, both of which are important for the safe retention of radionuclides in the conditioning material. Therefore, this study addressed the influence of organic substances, which are present in real waste, on the binding and release of radionuclides.

The investigation was conducted of reference formulations with real radioactive waste, a scintillation cocktail and an ionic solution. Compressive strength, sorption and leaching tests were performed for the ^{63}Ni and ^{14}C radionuclides on blast furnace slag and geopolymer (metakaolin and activator) matrices.

The study was carried out as part of the Horizon 2020 PREDIS „PRE-DISposal management of radioactive waste“ project.

Approach for specific clearance of tritium sources inadvertently disposed of in the landfill facility at Ignalina NPP

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The tritium self-luminous informative signs (for the display of emergency escape routes etc.) at Ignalina NPP have been used in the past. At the time of use, the signs with initial activity of up to 7.4E+10 Bq of tritium were not considered as radioactive sources, and therefore, have not been managed as radioactive sources. As a result, some quantity of the spent tritium sources potentially could be disposed of as non-radioactive solid waste items in the landfill facility at Ignalina NPP.

In-situ performed investigations of the landfill facility disposed of waste revealed the presence of moisture spots with an increased tritium concentration. The tritium concentration in the groundwater at the Ignalina NPP site exceeds the background values. The potential source of the tritium release might be degraded or crashed self-luminous signs.

The final decommissioning plan of Ignalina NPP foresees the specific clearance of the landfill facility disposed of waste, removal from regulatory control, and conversion of the landfill facility to conventional waste disposal.

The presentation discusses the applicability of the landfill facility dedicated specific clearance level for the clearance of tritium-contaminated waste together with the consideration of additional impacts, not addressed during derivation of the specific clearance level. The additional impacts may arise due to the release of gaseous tritium and due to the damage of self-luminous signs during intrusion into the disposed waste.

Modelling of flow and convective heat transfer in serpentine heat exchanger

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Condensing heat exchangers play a key role in the waste heat recovery process, which can be of various designs depending on the primary heat source, its pollution level, the place where the heat exchanger needs to be installed, etc. In order to be able to evaluate various influencing parameters, it is most appropriate to use numerical simulation, which can be used to quickly evaluate the efficiency of a heat exchanger of a specific design in the case of different flow regimes. It is the most difficult to model the condensation process, because in this case two phases appear, the interaction of which requires a lot of theoretical and practical knowledge. In order to be able to analyze the interaction of two-phase flows, it is necessary to approach this task step by step, starting from the analysis of single-phase flow to understand the physical processes taking place in the heat exchanger, which usually contains variously arranged tube bundles of different shapes. Therefore, in this paper, numerical studies of hydrodynamics and convective heat transfer were performed to better understand the fluid behavior in a serpentine type condensing heat exchanger. This research study is related to the EU Horizon 2020 iWAYS project (Innovative WAter recoverY Solutions through recycling of heat, materials, and water across multiple sectors) activities. The presented analysis was conducted in parallel on two different well established CFD softwares. One with Ansys Fluent and the other with Siemens Star-CCM+ CFD softwares. Both simulations considered monophase currents of hot air flowing into the serpentine heat exchanger thermodynamically coupled with the cooling water flowing into the pipes. The flows were organized in counterdirections. The metallic pipes were included and characterized by means of thermal conductivity and specific heat of the considered steel material. The cooling water, due to the relatively small increase in temperature, was characterized by a constant density approach. The calculation of the inflowing air Reynolds number led to the intermittent regime to that a turbulent model is required to the calculation. The flowing air than was characterized by realistic thermodynamic properties by means of tabular values. Both the simulations were considered as steady-state. The realized meshes followed two diverse methods. Ansys Fluent case implemented a fully tetrahedral mesh, thus exploiting the ability of this kind of cells to fully adapt to peculiar geometries. Star-CCM+ then implemented both automated and directed meshes methods. The automated method resembles the classic meshing method where the entire volume is meshed by means of macro parameters and user defined refinements or modifications. The directed mesh was fully employed in the regular extrusion of the surface mesh for the cooling water region starting from an automated surface mesh and a patched regular mesh used for the metallic pipes. The hot air region was generated by means of polyhedral cells with the automated method to exploit the same tetrahedral adaptiveness to irregular geometries but reducing the total amount of the employed cells. The Ansys Fluent simulation then resulted in 10 milion cells and Star-CCM+ in a reduced 7 milion cells. The temperature field was recorded by means of numerical probes realized in correspondence of experimental thermocouples, recording a three point average value for the inflowing air, metallic pipes and cooling water. The comparison between the experimental and the simulated results confirmed the good agreement between both the numerical and the experiment. Little divergences were recorded but resulted in being perfectly acceptable based on current differences unavoidable between experimental and numerical setups.

Interaction of synthetic geopolymer and cementitious materials with ^{85}Sr and ^{137}Cs

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High-level radioactive waste is allowed to be stored only in deep geological repository. The radioactive waste stored in this repository will be produced by the decommissioning of nuclear facilities. In Czechia, a search for the optimal location for constructing the deep geological repository is currently in progress. Simultaneously, experiments that are necessary for the safety of the deep geological repository are taking place. The aim of the ALMARA project is to find infill materials that will make deep geological repository safe for a long period of time and to test those materials.

The subject of this work is strontium and caesium sorption on cementious materials and synthetic geopolymer. Batch-type experiments were performed. Synthetic granitic water (SGW) with the addition of $^{85}SrCl_2$ or $^{137}CsCl$ was used as the liquid phase. The following materials were used as solid phases: hardened cement paste (C), cement mixed with 20 wt.% of bentonite (AFM), cement mixed with 1 wt.% of nanoiron particles (NNM), and synthetic geopolymer (GP). Those materials were used after curing or after interaction with SGW. Two different grain sizes of those materials were used (mesh fraction smaller than 0.5 mm and mesh fraction between 1 and 2 mm), and two different solid-liquid ratios were used (1/5 and 1/10 g/ml). To find the equilibrium time needed for sorption, sorption efficiencies were calculated for each sampling. Distribution coefficients (R_d) were calculated to compare those materials.

For strontium sorption, the best result was obtained for GP, with equilibrium time being one week and the R_d value being in the thousands of ml/g. As for cementious materials, equilibrium time is between two and eight weeks, and R_d values are in the tens of ml/g and decreasing as follows: AFM>NNM≈C. The R_d values are smaller for materials after interaction with SGW.

For caesium sorption, the best result was obtained for GP, with equilibrium time being one day and the R_d value being in the hundreds of ml/g. For cementitious materials, the equilibrium time is between one and seven days. For AFM, R_d values are around one hundred ml/g. For NNM and C, R_d values are in the range of ml/g. The R_d values are higher for materials after interaction with SGW.

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A new prototype system for producing pure CO_2 of interest for radiocarbon measurements

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Radiocarbon (^{14}C) is produced naturally in the atmosphere through the $^{14}N(n,p)^{14}C$ reaction, which occurs at a constant rate due to the interaction of thermal neutrons produced by cosmic rays with atmospheric nitrogen. ^{14}C constantly decays with half-life of 5700 years, resulting in a relative abundance of 1.2 parts per trillion (ppt) for $^{14}C/C$. In a nuclear power plant, radiocarbon is produced through the same above reaction involving thermal neutron in the reactor core, as well as from other reactions with ^{17}O and ^{13}C, found in reactor coolant, moderator, and fuel. Concentrations of $^{14}C/C$ in nuclear reactors can vary from 1 parts per billion (ppb) to one thousand ppb. In its gaseous form, the produced ^{14}C is mostly bound to carbon dioxide (CO_2) and organic molecules such as methane. For all these reasons, continuous monitoring of radioactive $^{14}CO_2$ is essential for the operation of a nuclear power plant (NPP), the operation of dismantling and decommissioning of NPP, and the safe storage of nuclear waste materials. The very low levels of concentration of ^{14}C in CO_2 make the direct detection of radiocarbon very difficult.

A new transportable system - called SKID - has been constructed as part of the funded European project named “Cyber physicaL Equipment for unmAnned Nuclear DEcommissioning Measurements” (CLEANDEM). It is designed to capture atmospheric CO_2 using a cryogenic trap based on liquid nitrogen. The system has been developed through a collaboration between two Technical Units, the Italian National Institute of Ionizing Radiation Metrology (INMRI) and the Nuclear Fission Technology, Facilities and Materials (FISS), belonging to ENEA and located at the Casaccia Research Centre, and the Italian company AIR LIQUIDE. The system has met its design goals and is capable of producing approximately 23 grams (about half mole) of pure solid CO_2 in a 4-hour cycle, which is then delivered in gaseous form to the user in order to detect traces of ^{14}C in the resulting gaseous pure CO_2 produced.

The new prototype was delivered to ENEA at the end of January 2024. In February 2024, the properties of the SKID were tested. The prototype was found to effectively trap atmospheric CO_2 at cryogenic temperature using 180 L of liquid nitrogen for an entire production cycle, demonstrating its potential as a tool for carbon capture. The preliminary results achieved with the new prototype in detecting traces of ^{14}C were also investigated using both a portable gas proportional counter (mod. Contamination-Monitor LB 122 Berthold) and a Tricarb 3100 TR liquid scintillation counter (LSC). While the first technique did not show distinct signals above natural background levels, the second technique using a liquid scintillator counting system revealed potential signals in the range of energies of ^{14}C beta-emissions. These results are preliminary and further investigations are necessary and planned for the future. Innovative technologies beyond traditional proportional counters and liquid scintillator counting systems may be considered.

The ability of producing an amount of pure CO_2 in a laboratory using the new SKID prototype system enabled initial testing to detect radiocarbon traces in the specifically generated carbon dioxide. These initial tests, conducted at ENEA C.R. Casaccia, have demonstrated that the SKID developed through the CLEANDEM project has opened up new opportunities in addressing and resolving challenges related to radiocarbon in various applications, ranging from environmental to nuclear field.

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