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FOURTEENTH INTERNATIONAL CONFERENCE ON RADIATION, NATURAL SCIENCE, MEDICINE, ENGINEERING, TECHNOLOGY AND ECOLOGY

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Serum proteomic signatures in nonhuman primates following treatment with a radiation countermeasure and exposure to a partial- or total-body supralethal radiation dose

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As countries face emerging conflicts and evaluate military strategies, the potential for nuclear-related accidents continues to rise, putting large populations of civilians at risk. As a result, the development of pharmaceuticals that can be administered prior to radiation exposure that protect from radiation-induced injury are of utmost importance. However, there are currently no prophylactic drugs that can be used to protect against radiation injury. One drug under advanced development, gamma-tocotrienol (GT3), has proved to be promising in terms of its antioxidant activity as well as its accelerated hematopoietic recovery and reduction of DNA damage in treated animals exposed to various doses of ionizing radiation. In this study, nonhuman primates (NHPs) were leveraged to investigate the protective effects of GT3 on proteomic profiles in conjunction with a supralethal dose (12 Gy) of either total-body irradiation (TBI) or partial-body irradiation (PBI), performed with 5% bone marrow sparing. Animals were treated with either GT3 or vehicle 24 h prior to irradiation and blood samples were collected at various time points pre- and post-exposure to assess changes in serum proteomic profiles. Both PBI and TBI induced significant dysregulation to pathways related to extracellular matrix and organization, hemostasis, and immune response. Notably, administration of GT3 offered significant protection against radiation-induced damage by either partial- or total-body irradiation in these pathways. Overall, this study offers insight into the biochemical mechanisms of the drug, pathways and proteins adversely affected by radiation, and potential biomarkers that can be further investigated to accurately assess absorbed radiation doses in exposed populations.

Disclaimer: The opinions and assertions expressed herein are those of the author(s) and do not necessarily reflect the official policy or position of the Uniformed Services University or the Department of War.

Conflicts of Interest: Authors declare no conflict of interest.

From radiation damage to materials design: modeling radiation effects across scales

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Defects are central to the behavior of semiconductors and oxides, and understanding how they form and recover under energetic particle exposure is essential for electronic and sensing applications. In this presentation, I will use molecular dynamics simulations, interpreted alongside experimental observations, to examine how energetic ions modify defect populations and can, under some conditions, promote defect recovery. The focus will be on the atomistic processes that govern defect creation, early-time structural reorganization, and the competing pathways that lead either to persistent damage or to healing. I will discuss how irradiation conditions and materials characteristics influence defect survival, including point-defect production, defect interactions, and local rearrangements that drive partial ordering or disordering. Comparisons with experiment will be used to connect atomic-scale mechanisms with measurable radiation response. Together, these results provide a mechanistic picture of irradiation-driven defect dynamics in semiconductors and oxides and support broader efforts to model microstructural evolution and predict functional outcomes under ion beam processing and radiation environments.

Work was supported by the Center for Nanophase Materials Sciences, a US Department of Energy, Office of Science User Facility at Oak Ridge National Laboratory.

Precise measurement of $^{234}U/^{238}U$ and $^{235}U/^{238}U$ isotope ratios in soils and water using multi collector inductively coupled plasma mass spectrometry (MC-ICP-MS) and thermal ionization mass spectrometry (TIMS)

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In recent years, environmental sampling for nuclear safeguards or after any nuclear accidents has significantly expanded because of advances in detection technology. Measurement of uranium (U) and plutonium (Pu) abundances and in particular isotopic composition is a challenge in environmental samples due to low abundances. Accurate and precise measurement of minor isotopes ^{234}U and ^{236}U are increasingly difficult for many samples analyses.

Uranium (U) is known to cause both chemical and radiological contamination. Therefore, it is necessary to understand their spread in the environment after the Fukushima Daiichi Nuclear Power Plant accident. U has three naturally occurring isotopes e.g. ^{234}U ($t_{1/2}$ = 2.455 × 10^5 y), ^{235}U ($t_{1/2}$ = 7.04 × 10^8 y), and ^{238}U ($t_{1/2}$ = 4.468 × 10^9 y) with relative abundances of 0.0054%, 0.720%, and 99.275%, respectively. 236U has an extremely low natural abundance ($^{236}U/^{238}U$~10^{-14} atom ratio) in the environment.

Rapid chemical separation method was developed for uranium using two UTEVA resin columns as well as single DGA resin column from soil and water samples. The $^{234}U/^{238}U$ and $^{235}U/^{238}U$ isotope ratios were measured using MC-ICP-MS with combination of Faraday cups and Daly detectors from soil and water samples of Fukushima and in natural high background radiation area [1-3]. The $^{234}U/^{238}U$ and $^{235}U/^{238}U$ isotope ratios were measured using MC-ICP-MS with combination of 10^{12} Ω special resistor Faraday cups and double Daly detectors. A simple and rapid method of separation of uranium has been developed and U isotope ratios were measured at femtogram level in the Fukushima water samples. The ^{137}Cs activity concentration of soils ranged from 30 to 4500 kBq kg^{-1}. The ^{238}U activity concentrations are ranged from 5.0 to 20.0 Bq kg^{-1}. The activity ratios of $^{234}U/^{238}U$ ranged from 0.97 to 1.02. The $^{235}U/^{238}U$ isotope ratios of these exclusion zone soils varied from 0.007246 to 0.007260, and close to the natural terrestrial ratio. The $^{235}U/^{137}Cs$ activity ratio was theoretically estimated for highly ^{137}Cs contaminated soils and ranged from 5.01 × 10^{-8} to 6.16 × 10^{-7} with a mean value of 2.51 × 10^{-7}. The Japanese population's exposure to radiation from ^{235}U with Fukushima origin is very negligible compared to ^{137}Cs.

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Why is it important to measure "difficult-to-measure" radionuclides? Their activity in environmental monitoring and in tracking compartmental

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Difficult to measure radionuclides typically do not have high energy gamma emissions offering a chance for relatively easy determination, but instead requires complex chemical procedures, and the application of specialised equipment, such as alpha or beta spectrometry, thermal ionization mass spectrometry (TIMS), inductively coupled plasma mass spectrometry (ICP-MS), neutron activation analysis, or liquid scintillation counting (LSC).

The measurement of difficult to measure radionuclides (H-3, C-14, Sr-90, alpha emitting isotopes such as U and transuranic elements Pu, Am, etc.) is very important for assuring the environmental safety of nuclear facilities, but their usefulness does not stop there. The concentration and ratio of these radionuclides, and the change of these over time offers valuable insight into various atmospheric, hydrological, hydrogeological processes, in multiple fields of study. Activity concentration ratios of fission and activation products give clues on the nature of nuclear accidents and explosions, they can be used to track back the emitting source, be it an accident, natural processes or industrial activity. Natural and artificial releases can be used to track air and water currents, determine the last contact of water with the atmosphere, track biological and biochemical processes and more. For example, partitioning of volatile isotopes through combustion can serve as a tracer for industrial activities, forest fires, winter heating and traffic in conjunction with the trace element profiles. The safety or lack of a release event can also be proven, which can be crucial for reassuring the public and preventing deleterious psychological effects that can be much higher than the actual physiological risk.

Radon measurement in Croatia

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Research on environmental radon measurement in Croatia has become a critical area of inquiry due to radon's significant contribution to natural background radiation and its established health risks, particularly lung cancer [1, 2]. Since the 1990s, studies have progressively mapped indoor radon concentrations and geogenic radon potential across Croatian regions, highlighting elevated levels in karst areas such as Lika-Senj and the southern part of Karlovac counties [3, 4]. Scientific research and systematic measurements of radon in Croatia indicate significant regional differences, with some areas being among the most exposed to radon in Europe. The Dinaric karst, characterised by extensive carbonate formations and complex hydrogeology, presents unique challenges and opportunities for radon research, especially within cave systems and karst aquifers. The practical importance of this research is underscored by the high radon concentrations measured in Croatian caves and indoor environments, which often exceed national averages and international reference levels, posing occupational and public health concerns [3, 5].

This review synthesizes research on environmental radon measurement in Croatia, focusing on indoor and outdoor environments, water, and cave systems within the Karst region, to address gaps in understanding radon distribution, variability, and exposure risks. The review aimed to evaluate radon concentration levels across diverse settings, benchmark measurement methodologies, characterize temporal variability, compare dose assessments for public and occupational exposure, and elucidate geological influences on radon behavior. A systematic analysis of studies employing solid state nuclear track detectors, active monitoring devices, and spectrometric methods was conducted, emphasizing karst terrains and cave microclimates. Findings indicate that radon concentrations vary widely, with cave air levels ranging from tens to over 10 000 Bq/m^3 and indoor radon typically between 30 and 500 Bq/m^3, exhibiting pronounced seasonal fluctuations linked to ventilation and microclimate. The average radon concentration in Croatian homes is around 68 Bq/m^3[3], which is below the European reference limit of 300 Bq/m^3. However, in some areas, concentrations are many times higher [6, 7]. In speleological sites dose assessments reveal visitor exposures generally below safety limits, while occupational doses for cave guides may approach or exceed regulatory thresholds. Geological and hydrogeological factors, including karst lithology, fissure networks, and cave morphology, critically govern radon emanation and transport. These findings inform radon risk management and support targeted mitigation strategies in Croatia's unique karst environments.

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An Overview of neutron activation analysis in environmental radioactivity measurements

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Neutron activation analysis (NAA) is primarily known as a technique for elemental analysis. Ove the past several years we have shown that NAA can judiciously be used for environmental radioactivity measurements. In particular NAA can drastically reduce the amount of material and gamma-ray counting time to determine uranium, thorium and K-40 in various samples. We will provide examples of NAA's unique nuclear properties including uncertainty and detection limits, and application to dosimetry measurements.

I-LUCE facility and the future of particle accelerators: Laser–plasma interactions for radiation production, acceleration and applications

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Objective: The I-LUCE facility at INFN-LNS investigates laser–plasma interactions, particle acceleration, and radiation generation under controlled conditions, with a strong focus on both fusion-energy research and medical applications. INFN-LNS contributes to the HiPER+RF project, aimed at the conceptual design of a European Direct-Drive Inertial Confinement Fusion facility capable of achieving ignition, high energy gain (Q ≥ 100), and high repetition rates. In parallel, I-LUCE supports the development of compact laser-driven accelerators for next-generation radiotherapy, including ion-beam therapy and Very High Energy Electron (VHEE) treatments.

Methods: I-LUCE operates a high-power Ti:Sapphire laser system with two beamlines: a 50 TW beam (upgradeable to 500 TW) delivering 23 fs pulses at 10 Hz, and a 320 TW beam delivering 23 fs pulses at 2.5 Hz. Dedicated experimental areas enable independent studies of proton and electron acceleration for both fusion and medical applications. Laser-accelerated proton and relativistic electron beams are investigated as candidates for compact radiotherapy systems, particularly for future VHEE accelerators.

INFN-LNS combines experiments, theoretical studies, and numerical simulations to investigate stopping power in plasma for protons and alpha particles. Advanced models are implemented in the GEANT4 framework, including temperature- and density-dependent effects. Complementary experiments at the Prague Asterix Laser System used nanosecond laser pulses (~600 J, 300 ps, 1.315 μm) in a pitcher–catcher configuration to study proton acceleration and proton–boron fusion. Diagnostics included CR-39 detectors, Time-of-Flight systems, and Thomson Parabola spectrometers.

Results and Discussion: The combination of ultrashort pulses, high peak power, and high repetition rate at I-LUCE enables systematic studies of laser-driven particle acceleration and nuclear processes. These capabilities are highly relevant for compact, high-gradient accelerators that could reduce the size and cost of future radiotherapy facilities. Laser-driven proton beams are being explored for hadrontherapy, while laser-accelerated electron beams in the VHEE range are promising for the treatment of deep-seated tumors due to their favorable dose distribution.

Simulation developments improve the accuracy of particle transport modeling in warm and dense plasma, supporting both fusion studies and medical dosimetry applications. Experiments at PALS demonstrated proton energies up to 6 MeV, increasing to ≈7 MeV using optimized ammonia-borane targets. Alpha-particle production from the $^{11}B(p,\alpha)2\alpha$ reaction was confirmed through CR-39 detectors and activation analysis, highlighting the role of target optimization and laser–plasma coupling in enhancing fusion yield and particle acceleration efficiency.

Conclusions: I-LUCE provides a versatile platform for laser-driven acceleration and plasma-interaction studies, spanning inertial fusion and advanced medical applications. INFN-LNS contributions to HiPER+RF improve the understanding of energy transport in fusion plasmas, while the development of laser-driven proton and electron sources supports compact next-generation accelerators for radiotherapy, including ion-beam therapy and VHEE treatments.

Keywords: High power lasers, Inertial Confinement Fusion, Proton-Boron Fusion, Laser-driven particle acceleration, VHEE radiotherapy, Hadrontherapy, Geant4, Alpha stopping power, Compact accelerators.

An overview of AI applications in data processing related to environmental radioactivity and the nuclear industry

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Day by day, by growing populations, rapid developments in sciences & technologies, expanding human demands, such as energy, food, and etc., huge amount data are produced minutes by minute and second by second. While, nuclear sector the nuclear sector is not exempt from this data generation, in fact, it might even be among the most sensitive domains because it's not only related to human, it can directly and indirectly effect nature and its ecology. surveillance networks and nuclear facilities routinely produce large, heterogeneous datasets, such as time series of variables, as well as laboratory data and plant instrumentation and control signals. Processing these data, no matter for which propose, is a time consuming with possibility of human errors, however, already in most sensitive nuclear sectors the machine and programs takes these responsibilities, while in research or lab or even in environmental monitoring scale, still direct human processing has the key role, which motivate the growing adoption and application of AI-driven methods and machine learning, to enhance accuracy, automation, and decision support across monitoring and operational workflows. Most common and well-studied reports were used to map how AI and deep learning would be used to augment workflows across the two key sectors of (i) environmental radioactivity monitoring and (ii) nuclear-industry data processing and emerging "digital twin" architectures that integrate sensor data with simulation and analytics. It could be concluded that the adoption of AI in environmental radioactivity and nuclear applications requires traceable uncertainty quantification, explainability for safety cases and human-in-the-loop decisions, robustness for domain shift from simulation to field data, verification/validation, and cybersecurity-aware deployment. We propose a roadmap from prototype to operational qualification based on benchmark datasets, standardized evaluation protocols, and hybrid physics-AI approaches that balance interpretability with timeliness and resilience.

Keywords: environmental monitoring; gamma spectrometry; radionuclide identification; anomaly detection; uncertainty quantification; digital twins; nuclear power plant analytics; emergency response;

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Fatty acid receptors: New targets in the treatment of diabetes and related complications

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Globally, the incidence of diabetes mellitus is increasing and is expected to exceed 800 million by 2050. The resulting serious and severe microvascular, macrovascular and other complications encourage research into the underlying mechanisms that can aid in the nutritional and pharmacological management of these patients. Fatty acids, especially free fatty acids (FFA), are important as energy biomolecules that play a key role in numerous metabolic processes as signaling molecules and regulators of various biological functions. The role of FFA in the regulation of glucose metabolism and the pathogenesis of diabetes, especially type 2 diabetes, is well established. Recent studies have shown that specific FFA (short-, medium- and long-chain saturated and unsaturated fatty acids) activate several important free fatty acid receptors or the G protein-coupled receptor (GPR) family, whose natural ligands are fatty acids, mediating the effects of fatty acids (FA) and suggesting the possibility of new therapeutic approaches for this serious metabolic disease. In this paper, it is indicated which free fatty acids and their receptors can be used for signal modulation pathways that can help treat patients and reduce the burden of diabetes and its complications.

Keywords: free fatty acids, free fatty acid receptors, therapy treatment, Type 2 diabetes

Effects of statins on dehydrogenase

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Lactate dehydrogenase (LDH) is an enzyme found in almost all tissues in our body. It can be found in the brain, heart, liver, muscles and other organs. This enzyme plays an important role in energy metabolism. LDH is responsible for the conversion of lactate (lactic acid) to pyruvate and vice versa. During intense physical activity or when the body does not get enough oxygen, there is an accumulation of elbow in the muscles. LDH has the ability to break down alkane and convert it back to pyruvate, which can then be used as an energy source. Atorvastatin belongs to a group of drugs that lower the concentration of lipids and prevent the progression and spread of cardiovascular diseases.

In this work, the inhibitory effect of atorvastatin on LDH activity was tested using the spectrophotometric method. The results obtained indicate an acompetitive type of inhibition. Using the Lineweaver-Burk equation, the values of kinetic parameters of maximum velocity and Michaelis-Menten constant were calculated.

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Association of glycemic parameters with pro-oxidative–antioxidative balance in the obese pediatric population

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Introduction: Pediatric obesity is increasingly recognized as a multifactorial immunometabolic disorder, associated with systemic inflammation, oxidative stress, and insulin resistance, predisposing to early metabolic complications. Data on the relationship between pro-oxidative – antioxidative balance (PAB) and glycemic regulation in obese children remain scarce, particularly with respect to C-peptide dynamics as an early indicator of metabolic risk. This study aimed to examine associations between glycemic parameters and PAB in obese children, evaluating its potential as an early marker of metabolic dysfunction.

Methods: The study included 119 children (mean age 13.83 ± 2.92 years) with excess body weight who presented for the first time to the Endocrinology Outpatient Clinic of the Pediatric Clinic, Clinical Center of the University of Sarajevo. The participants had no comorbidities and were not receiving pharmacological therapy. All procedures were conducted in accordance with the Declaration of Helsinki, with informed parental consent obtained. Biochemical parameters were determined using standardized and validated methods in line with International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) recommendations. PAB was measured by a spectrophotometric method at a wavelength of 450 nm. Glucose, insulin, C-peptide, and glycated hemoglobin (HbA1c) were analyzed on automated analyzers, while Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) was calculated using the standard formula. Spearman's correlation coefficient was used to assess associations.

Results: No significant correlations were observed between PAB and anthropometric variables ($p > 0.05$). However, within the obese group, statistically significant negative correlations were identified between PAB and certain glycemic indicators. The most pronounced negative correlation was observed with fasting C-peptide concentration ($r = -0.370$; $p < 0.001$), as well as with postprandial C-peptide ($r = -0.310$; $p = 0.002$) and glucose concentration ($r = -0.296$; $p = 0.003$). Other glycemic indices, including insulin, HbA1c, and HOMA-IR, did not show significant associations. Consistent with previous studies, the stronger association between PAB and C-peptide compared to insulin and HOMA-IR suggests that oxidative stress may influence β-cell secretory activity at an early stage of metabolic dysregulation, preceding overt insulin resistance detectable by conventional indices

Summary: The results suggest that a disturbed pro-oxidative – antioxidative balance is significantly associated with glycemic disturbances in obese children, independent of anthropometric characteristics. These findings support the hypothesis that oxidative stress plays an important role in the early stages of metabolic dysfunction in the pediatric population. Identification of PAB as a potential early biomarker of metabolic risk may contribute to improved early diagnosis and the development of personalized preventive strategies in obese children, with the aim of reducing long-term metabolic and cardiovascular consequences.

The relationship between the intensity of lipid peroxidation and the activity of polyamine oxidase enzyme in thymus tissue during chronic exposure to microwave radiation

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The modern way of life and the IT revolution have led to an increase in the number of microwave radiation emitters in work, urban and immediate home environments. The most common emitters of microwave radiation in our environment are mobile phones and mobile phone repeaters, cordless phones, means for satellite mobile communication, radio transmitters, microwave heating devices and radar installations. The dangers posed by exposure to the electromagnetic field of mobile phones are not visible in the short term because the effects on human health and the environment are small and cumulative. The results of numerous studies indicate that the increase in the intensity of oxidative stress is one of the pathogenetic mechanisms involved in cellular damage after exposure to microwave radiation. Cells entering the division process need polyamines, the amount of which is controlled by the activity of the enzyme polyamine oxidase (PAO). The aim of this study is to evaluate the relationship between the intensity of lipid peroxidation (measured through the level of malondialdehyde-MDA) and the activity of the enzyme PAO in thymus tissue during chronic exposure to microwave radiation. Male Wistar rats were exposed to microwave radiation from a Nokia 3110 mobile phone (Nokia Mobile Phones Ltd.) connected to a PCDK communication test set with a computer and corresponding software module for 4 hours per day for 60 days. After 60 days of irradiation, 6 animals from the experimental and 6 animals from the control group were sacrificed, the thymus tissue was taken, which was repeatedly washed in cold isotonic NaCl solution, immediately frozen at -20° C and thus stored until homogenization. A 10% thymus homogenate was then prepared in distilled water at 0° C (on ice) using a homogenizer. MDA concentrations and PAO enzyme activity were determined in the thymus tissue homogenate. The intensity of lipid peroxidation in the thymus was measured using a spectrophotometric method by determining the level of MDA, as the final product of lipid peroxidation. PAO activity was also determined spectrophotometrically through the amount of amino aldehyde formed under the action of this enzyme on the appropriate substrate. Chronic exposure of rats to microwave radiation led to a statistically significant increase in MDA intensity and PAO activity in the thymus compared to the control group. A linear correlation coefficient of C=0.61 was obtained, and it shows that there is a strong and statistically significant positive correlation ($p<0.05$) between MDA values and PAO activity during exposure to microwave radiation.

This may indicate that the increase in PAO activity significantly contributes to the increase in the level of MDA - a secondary product of lipid peroxidation - in the thymus tissue during chronic exposure to microwave radiation.

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Beyond platinum: Tricarbonyl Rhenium(I) complexes with iminoquinolines as a novel strategy in colorectal cancer therapy

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Colorectal cancer (CRC) remains one of the leading causes of cancer-related deaths worldwide, particularly among patients with microsatellite-stable (MSS) tumors, in whom resistance to conventional chemotherapy significantly limits therapeutic efficacy. Conversely, biologic therapies require precise molecular characterization of the tumor and are often effective only in patients with specific genetic profiles, meaning that a large proportion of patients, especially those with advanced diseases or molecularly nonspecific CRC subtypes, are either not eligible for biological treatment or derive limited therapeutic benefit. The development of organometallic compounds with mechanisms of action distinct from platinum-based cytostatic agents represents a promising strategy to overcome therapeutic resistance.

The aim of this study was to evaluate the anticancer potential of newly synthesized rhenium(I) complexes of the general formula [Re(CO)3(QC=NPhX)Cl], shortly marked as ReQX (X denotes different substituents in the para-position of the phenyl ring (e.g., F, Cl, Br, I, OH, Me), and QC=NPhX is the bidentate N,N-donor ligand belonged to iminoquinolines) in genetically diverse colorectal cancer cell lines (HT-29, SW-48, and Colo-205).

In the first phase, cytotoxicity assays were performed at three time points (24, 48, and 72 hours), enabling the construction of dose–response curves and determination of IC_{50} values. The studies showed that the free ligands exhibited no significant cytotoxic activity under any of the tested conditions (IC_{50} > 50 μM in all cases). In contrast, the rhenium(I) complexes demonstrated markedly enhanced, substituent-dependent cytotoxic activity. The most potent effects were observed for complexes ReQBr (IC_{50}: 2–24 μM), ReQI (3–10 μM), and ReQMe (3–27 μM). The observed effects of all active complexes were both dose- and time-dependent. Subsequently, preliminary analyses of the mechanisms of action of the most active complexes were performed. In this context, the effects of the compounds on cell cycle progression and apoptosis induction were evaluated.

Cell cycle analysis revealed significant changes after 72 hours of incubation. The most pronounced effect was observed following treatment with ReQBr
(10 μM) in HT-29 cells, where a decrease in the G1 phase fraction was accompanied by accumulation of cells in the S and G2/M phases. A similar trend was observed in SW-48 cells, whereas in Colo-205 cells, a significant reduction in the G1 population was accompanied by a substantial increase in the sub-G1 fraction, indicating induction of cell death. Apoptosis assays confirmed a structure- and time-dependent induction of programmed cell death. The complex ReQBr (10 μM) exhibited the strongest effect, with the percentage of apoptotic cells increasing from 33–46 % at 24 h to 49–76 % at 48 h, reaching 83–95 % after 72 h of incubation, depending on the cell line; SW-48 cells were the most sensitive to the treatment. The remaining complexes, ReQI and ReQMe, also induced significant, time- and dose-dependent apoptosis, while ReQOH and ReQCl showed only weak activity. It should be noted that due to the limited solubility of the ReQI complex, ReQBr and ReQMe were selected for further studies.

The obtained results clearly indicate that coordination of iminoquinoline-type ligands to the rhenium(I) tricarbonyl core significantly increases their anticancer activity, transforming biologically inactive ligands into potent cytotoxic agents with low micromolar activity. The pronounced structure-dependent induction of apoptosis across multiple CRC models underscores the critical role of metal coordination in modulating biological efficacy. Collectively, these findings provide strong experimental evidence that rhenium(I) tricarbonyl complexes represent a promising and rationally designable platform for the development of novel organometallic anticancer agents in colorectal cancer therapy.

Comparative analysis of beetle (*Coleoptera*) community diversity, structure, and composition in forest habitats of Putna-Vrancea Natural Park

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Assessing entomofauna biodiversity in protected areas is necessary for validating conservation strategies. Putna-Vrancea Natural Park represents a comprehensive forest ecosystem where differentiated management may significantly influence insect community dynamics. This study evaluates the impact of park zoning on beetle communities, comparing species structure and diversity between Sustainable Management Zones (SMZ) and Integral Protection Zones (IPZ). Data collection was conducted from June 15 to September 15, 2024, across four representative sites (two in SMZ and two in IPZ). For an exhaustive inventory, an experimental design featuring four complementary trap types was used: pitfall (Barber), Moericke (yellow) pan, flight intercept, and trunk traps. Statistical analysis included abundance and diversity tests, the non-parametric Kruskal-Wallis test for mean comparisons, and Non-Metric Multidimensional Scaling (NMDS) to visualize variations in community composition. Preliminary results led to the identification of 243 species belonging to 49 beetle families. Analyses indicate structural differences between areas with distinct protection regimes. Diversity and abundance tests reflect the influence of habitat type and anthropogenic intervention levels on species richness. NMDS modeling suggests a separation of communities based on zoning-specific microhabitats, highlighting indicator species for integral protection zones. The use of four capture methods allowed for detailed documentation of taxonomic diversity. The differences observed between SMZ and IPZ underline the importance of both types of zoning for the conservation of sensitive species. These findings contribute to the substantiation of sustainable management measures within the park.

Keywords: Coleoptera, NMDS, Kruskal-Wallis, forest management, Putna-Vrancea, biodiversity

Preliminary data on ecological succession of ant communities (Hymenoptera: Formicidae) in mining areas. Case study: Roşia Montană mining area, Alba County, Romania

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Ecological succession is a series of progressive changes in the diversity, abundance, and dynamics of populations and communities over time. Two types of succession are usually identified, differing mainly in their starting point: primary succession, where newly exposed or newly formed rock is colonized by organisms for the first time, and secondary succession, when an area previously occupied by organisms is disturbed and then recolonized.

Anthropogenic disturbances such as open-pit mining are probably some of the most extensive and dramatic reshaping of the Earth's surface. The process of soil removal, followed by the rock to be mined (often called denudation), and the disposal of the material that cannot be used, lead to a local extinction of most of the organisms originally in that area.

However, once these activities cease, organisms from neighboring unaffected areas, as well as those specialized to the new conditions, begin to colonize the denuded surface, a process that represents the establishment of secondary ecological succession. Among the first organisms to begin to colonize these habitats are ant communities, which, through their general activity on the substrate, contribute to the establishment of subsequent stages. Moreover, ant is relaible study models due to their active role in terestrial ecosystems (e.g. generalist predators, seed-dispersers, soil-enrichment).

This study investigates the diversity, abundance and compositionof ant communities in four exploitation areas of the Roşia Montană Mining Complex, whose activity was terminated at different times, as well as a control area, unaffected by mining activity.

The analysis was carried out in three habitat types that dominate the exploitation areas and that represent the theoretical stages of ecological succession, namely: tailings dump (H), open habitat/meadow (O) and forested area (W). A seasonal replication in March, June and October was carried out to capture the phenology of the target group species.

Different habitat parameters (exposure, slope, altitude, etc.) were evaluated. They were tested to highlight the valid successional chronosequence. Seasonal differences in abundance and diversity are disscused further on.

Keywords: ants, community ecology, ecological succession, mining areas

New metal-containing complexes of salinomycinic acid with promising antitumor activity

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In recent years, the antitumor activity of the ionophore antibiotic salinomycin has attracted the attention of scientists, especially for its ability to target cancer stem cells and its unique mechanism of action. In our previous investigations, the promising cytotoxic activity of composites of two-line ferrihydrite with salinomycin acid was revealed in human tumor cell lines, including model systems established from human cervical cancer (HeLa), non-small-cell lung cancer (A549), colon cancer (SW480), and ovarian teratocarcinoma (CH1/PA1) cells.

The aim of the presented study was to evaluate the effect of new complexes of Zn(II), Cu(II), Co(II), Mn(II), and Gd(III) with salinomycin acid in human cervical carcinoma (HeLa) and melanoma (A375, SH-4) cells, as well as non-tumor cells (HaCat, Lep-3). Experiments were performed using various cytotoxicity tests (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide test, neutral red uptake assay, and crystal violet staining), double staining with acridine orange and propidium iodide, the scratch test, and the 3D colony-forming method.

The results showed that the evaluated compounds significantly reduced survival, migration, and 2D/3D growth of the treated cells at concentrations of 0.05-133 μM for 24-72 hours. All the compounds investigated showed high cytotoxicity and even exceeded the activity of the antitumor agents used in clinical practice, including cisplatin, oxaliplatin, and epirubicin.

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Schiff base metal complexes with potent antitumor activity in human and animal cancer cells

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Metal-based compounds provide an attractive opportunity for the development of new anticancer agents, as transition metals can interact with biomolecules and influence key cellular processes. Essential elements, in particular, have emerged as a promising alternative to platinum drugs due to their lower toxicity and their role as biological response modifiers.

In this work two series of new coordination compounds were biologically investigated: *i*) three mononuclear Cu(II) complexes with mixed ligands, [Cu(VTr)(Dp)], [Cu(VS)(Dp)]·CH_3OH, and [Cu(VTyr)(Dp)], where the Schiff base ligands were obtained through condensation reactions between *o*-vanillin and the corresponding amino acids DL-tryptophan (VTr), L-serine (VS), and L-tyrosine (VTyr), and the auxiliary ligand was Dp =2,2'-dipyridylamine; *ii*) three metal complexes of Cu(II), Co(II), and Ru(III) with a Schiff base obtained by condensation of salicylaldehyde and 2-aminobenzothiazole (SALTIAZ): [Cu(SALTIAZ)(NO_3)(H_2O)], [Co(SALTIAZ)$_2$(H_2O)$_2$] and [Ru(SALTIAZ)$_2$ H_2O)Cl]. Their cytotoxic and potential antitumor properties were evaluated in human (A375 –melanoma, HeLa -cervical carcinoma) and animal (LSR-SF-SR –rat sarcoma), as well as in non-tumor Lep-3 and HaCaT cells. Short-term experiments (lasting up to 72h) were performed with monolayer cell cultures using the MTT test, neutral red uptake assay, crystal violet staining, double staining with acridine orange and propidium iodide, and the scratch test. The long-term effects (more than 2 weeks) of the compounds were studied using a 3D colony-forming assay in a semi-liquid medium. The results obtained demonstrated the ability of the tested transition metal complexes to suppress, in a time- and concentration-dependent manner, survival, proliferation, and 2D/3D growth of the treated cells.

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Inter-Ionic competition determines cellular accumulation and toxicity of implant-derived metals

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The release of metal ions from orthopaedic implants represents a persistent source of biologically active degradation products whose toxicity is governed primarily by intracellular metal burden rather than extracellular exposure levels. In multicomponent alloys, divalent metal ions share membrane transport systems and homeostatic pathways, creating a competitive environment in which inter-ionic interactions critically influence cellular accumulation and subsequent biological responses.

To elucidate how such competition shapes intracellular metal distribution, we analysed the uptake of ions derived from clinically relevant orthopaedic alloys using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). This approach enabled spatially resolved and quantitative mapping of cobalt, chromium, molybdenum, and nickel following both single-metal and combined exposures, allowing direct assessment of inter-metal interactions at the cellular level.

Our data demonstrate that ions originating from the same alloy exhibit distinct intracellular accumulation profiles, consistent with selective transport via shared divalent cation transporters. Nickel displayed particularly pronounced cellular accumulation accompanied by significant cytotoxicity. Importantly, modulation of the extracellular ionic milieu revealed that magnesium markedly reduced intracellular nickel levels and attenuated metal-induced toxicity, supporting a mechanism of competitive interference at the level of cellular entry and transport.

Collectively, these findings demonstrate that toxicity of implant-derived metals is not an intrinsic property of individual elements but is instead dynamically regulated by inter-ionic competition. Competitive uptake therefore emerges as a fundamental determinant of intracellular metal accumulation and cellular response to implant degradation products.

Cytotoxicity assessment of a Graphene Monolayer in direct contact with RAW 264.7 cells

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Graphene in the form of a monolayer, when employed as a scaffold in wound dressings, may have promising applications in wound-healing therapies. However, its lack of toxicity must first be demonstrated, as biocompatibility is a fundamental requirement for all materials intended for contact with the body, including the skin. Macrophages are key cells of the innate immune system and are among the first to respond to the presence of foreign materials, such as pathogens, damaged tissues, or functional biomaterials, thereby initiating the immune response. To investigate this, RAW264.7 macrophages were seeded onto a graphene monolayer. The graphene on copper foil, purchased from Graphenea (San Sebastián, Spain), was transferred onto rounded glass coverslips via an electrochemical delamination process (Ciuk et al., 2013). The cells' viability, morphology, and membrane integrity—directly in contact with the nanotopography of the graphene monolayer—were assessed. Flow cytometry and fluorescent microscopy were employed to evaluate cellular responses. Zombie Green dye was used to assess viability, while WGA (wheat germ agglutinin) staining enabled visualisation of membrane integrity and cell morphology. Additionally, flow cytometric parameters including FSC-A (cell size) and SSC-A (cellular complexity or granularity) were analysed. RAW264.7 macrophages cultured on the graphene monolayer (GM0) did not show significant differences in cell size or granularity compared with the control group (CM0), suggesting that the monolayer does not markedly affect macrophage morphology under the applied conditions. The level of macrophage death was comparable between CM0 (16.5 ± 2.5%) and GM0 (18.3 ± 5.7%), although a higher standard deviation was observed in the GM0 group. WGA staining revealed well-defined plasma membranes, with RAW264.7 cells exhibiting a round to slightly irregular or polygonal morphology and visible surface extensions. The plasma membrane appeared continuous and intact, indicating no detectable membrane damage.

Taken together, these results demonstrate that RAW264.7 macrophages can adhere to and grow on a graphene monolayer without significant alterations in viability or morphology, supporting the biocompatibility of graphene monolayers for potential wound-healing applications.

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Information and the problem of biological organization: Between thermodynamics and biology

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The second law of thermodynamics is often colloquially interpreted as a law of the inevitable increase of disorder, although in a strict sense it refers to the statistical behaviour of entropy in isolated systems. From this perspective, the emergence and long-term maintenance of complex organisation in open systems require a special explanation. A classical point of reference here is the paradox of Maxwell's demon, which shows that a local decrease in entropy may be achieved not through the supply of additional energy, but through the selective regulation of the course of physical processes. This paradox reveals a fundamental distinction between energy balance and the organisation and control of a system's dynamics. Contemporary analyses of Maxwell's demon, however, demonstrate that regulation is not a cost-free process. In order to select microstates, the demon must collect, process, and erase information, which entails unavoidable thermodynamic consequences. Claude Shannon's information theory and Landauer's principle reveal a close connection between information and entropy: information is not an energetic quantity, yet its processing requires physical realisation and is subject to the laws of thermodynamics. In this sense, information constitutes an intermediate concept – irreducible both to purely abstract formal structures and to energetic quantities alone – describing physically realised constraints and possibilities for the regulation of processes. This perspective acquires particular significance in biology. Living organisms function as systems far from thermodynamic equilibrium, capable of maintaining stable organisation through the precise regulation of internal processes. Biological information plays a central role here: it is physically encoded and employed in the regulation of cellular processes. The genetic code, described by Erwin Schrödinger as an "aperiodic crystal", constitutes a physical realisation of processes of information encoding and decoding, whose purely energetic description, though necessary, proves insufficient to capture their regulatory and organisational functions. A similar intuition was articulated by Hans Driesch, who argued that energy conservation alone is insufficient to explain biological organisation and postulated a non-energetic regulatory factor (entelechy). Although no longer a scientific hypothesis, this concept serves as a historically significant heuristic pointing to the problem of regulation irreducible to energy balance. From this perspective, both the paradox of Maxwell's demon and Hans Driesch's concept of entelechy do not constitute alternative theories of nature, but rather serve as heuristic indicators of the limits of explanations based solely on energy balances. In both cases, it becomes apparent that the key problem is not the source of energy itself, but the manner in which processes are organised and regulated over time. Contemporary physics of information shows that such regulation is not "free": it requires the physical realisation of information and entails unavoidable entropic costs, even though it cannot be reduced to a simple transfer of energy. In this sense, the question posed by Erwin Schrödinger – "What is life?" – does not call for an answer in the form of a new substance or a special kind of energy, but points instead to the problem of organising physical processes capable of sustaining ordered structure far from equilibrium over time. Information appears here not as an ontological entity, but as a descriptive category that makes it possible to grasp physically realised constraints and possibilities for regulating the dynamics of biological systems. As a bridging concept between physics and biology, it allows life to be interpreted as a process of regulated organisation, consistent with the second law of thermodynamics and yet irreducible to energy balance alone.

Keywords: thermodynamics, information, biology, organisation, entropy, energy conservation

Viromimetic systems on gold nanostructures: Design, synthesis and therapeutic potential

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Viromimetic particles are engineered structures that mimic viral architecture while lacking any pathogenic effect. These particles have garnered significant interest across various scientific fields due to their structure, tunable size and composition, and capacity for functionalization, enabling advanced applications in drug delivery, nanomedicine, and immunotherapy.

This study aims to develop different sizes of viromimetic particles through the synthesis of gold nanoparticles, followed by their functionalization, detailed characterization, and subsequent assembly with specific protein molecules

In this paper, we report the results of studies focused on the fabrication of virus-like particles (VLPs) and the determination of the kinetic and thermodynamic parameters governing their self-assembly.

Gold nanoparticles of varying sizes (8-20 nm) were synthesized via the tannic acid reduction of $HAuCl_4 \cdot 3H_2O$. These were subsequently functionalized with polyethylene glycol (PEG) and assembled with Brome Mosaic Virus proteins to form the final viromimetic structures. Characterization was performed on both non-functionalized and modified nanoparticles, utilizing UV-Vis absorption spectroscopy to assess optical properties and quantitative determinations, as well as scanning electron microscopy (SEM) for morphological evaluations. The assembly process of the virus-like shells was monitored via spectrometric titrations using fluorescence measurements.

To determine the physical parameters driving viral shell self-assembly, real-time molecular interactions were monitored using fluorimetry and surface plasmon resonance (SPR).

The results demonstrate that different sizes (8-20 nm) of gold nanoparticles directly influence their physical properties.

Assessment of the radiomodulatory properties of cannabidiol (CBD) in an in vitro model of nerve sheath tumors

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Radiotherapy of schwannomas typically involves doses in the range of 12 – 13 Gy, depending on the irradiation technique. Due to the close proximity of critical structures, including the vestibulocochlear and facial nerves as well as the brainstem, current clinical strategies aim at dose de-escalation to preserve neurological function while maintaining therapeutic efficacy [1]. Therefore, the identification of agents capable of modulating cellular responses to ionizing radiation is of considerable clinical interest.

Cannabidiol (CBD) is currently being investigated as a potential adjuvant to radiotherapy because of its unique neuroprotective properties, including anti-inflammatory effects and ion channel modulation, as well as its selective cytotoxicity associated with oxidative stress mechanisms.

In this study, we evaluated the potential of CBD as a radiomodulatory agent in an in vitro model of peripheral nerve sheath cells using hTERT and SNF02.2 cell lines. Cells were treated with CBD (0–9 μM) in combination with ionizing radiation (10 Gy). DNA damage levels and cell viability were assessed to determine the combined effects.

The results suggest that CBD may exert a bidirectional effect, enhancing radiosensitivity in tumor cells while potentially protecting normal cells. These findings indicate that CBD could represent a promising candidate for radiotherapy modulation in nerve sheath tumors [2].

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Improvement of the cancer contrast in MRI using superparamagnetic nanoparticles

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Magnetic Resonance Imaging (MRI) has been used for early cancer detection, treatment monitoring and image guided surgery. Standard contrast enhanced MRI based on tumors vasculature, including Gd-based T_1 contrast agents, do not provide sufficiently high specificity for tumor diagnosis. Their accumulation in tissue is solely based on differences in vasculature between tumor and normal tissues. 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. To obtain optimal tumor contrast we bioconjugated our nanoparticles with specific antibody. 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 9.4 T. We perform in vivo imaging using mouse model of cancer and used 9.4T MRI system for animal study. We imaged nude mouse with the tumor before the injection of targeted and non-targeted contrast agent and in different time after injection (10 min after,1h, 2h and 24h) and then we collected T_1 and T_2-weighted MR images. Our results showed that molecular MRI using targeted contrast agents can improvement cancer contrast and allowed localize small (a few mm size) cancers.

Cu-In alloys deposition by means of electroless plating using Co(II)-ethylenediamine complexes as reducing agents

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Advancements in electroless deposition methodologies have enabled obtaining of high-quality metallic coatings including Cu, Ag, Au, Fe-group metals, Pt-group metals etc. A recently developed approach employing cobalt(II) complexes with amine-ligands including, ethylenediamine, diethylenetriamine and ammonia has demonstrated considerable potential as a chemical reducing system for metal film deposition. This strategy facilitates controlled metals and metal alloys deposition on various substrates without the application of an external electric current. The present investigation addresses the electroless deposition of Cu–In alloy coatings with particular emphasis on the effect of selected process parameters. Specifically, the influence of reactant concentrations and solution pH on both the deposition rate and the compositional characteristics of the resulting films was systematically evaluated. Under optimized experimental conditions the deposition rate attained values up to 1.3 $mg \cdot cm^{-2} \cdot h^{-1}$. The indium incorporation within the coatings was adjustable over a compositional range from 0 to approximately 2 wt%. In addition, the initial stages of film growth were examined using electrochemical quartz crystal microgravimetry (EQCM) which indicated a deposited mass of 120 $\mu g \cdot cm^{-2}$ after 3 minutes of deposition.

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Nanodiamonds as enzymes carrier

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An enzyme is a specialized molecule (usually a protein) that acts as a highly specific biological catalyst. Reducing activation energy enables and accelerates metabolic reactions in the cells of living organisms. They have many advantages over chemical catalysts; enzymes are more specific and active. Moreover, proteins can function under mild conditions, making them potentially more environmentally friendly. The main problems related to their use are low stability and the inability to separate them from the reaction system, which makes them disposable. To terminate the reaction, the enzyme must be denatured. Immobilization on the solid matrix is the solution to this problem. It can increase stability, and the most important thing is that the enzyme immobilized on a solid support can be easily removed from the reaction system without denaturation.

Nanodiamonds are a very promising material for this application. Their surface is highly functionalized, with numerous functional groups, including carboxyl, carbonyl, and hydroxyl groups. The presence of these chemical groups promotes the formation of intermolecular interactions, particularly dipole-dipole interactions and hydrogen bonds.

In this research, nanodiamonds are used to immobilize two different enzymes: NHase and PETase. These proteins differ in molecular weight, structure, and function. NHase belongs to the hydratase group and catalyzes the hydration of nicotinonitrile to nicotinamide. PETase is a hydrolase enzyme capable of catalyzing the degradation of polyethylene terephthalate (PET) by hydrolyzing the ester bonds in its structure. Both compounds are therefore industrially important.

By measuring adsorption isotherms, it was demonstrated that enzymes adsorbed to nanodiamonds in large quantities. Furthermore, immobilization improved protein stability in all cases. The results of the conducted research also show that immobilization can induce conformational changes in the enzyme's structure, altering activity and even specificity. This represents a major breakthrough, as it turns out that specificity can be changed without terminating mutations. All that is needed is the appropriate selection of the carrier and control of the reaction conditions.

In conclusion, enzymes are ecological catalysts with high activity and specificity, but immobilization significantly increases their stability and facilitates their use, thereby increasing their applicability. Therefore, research on enzyme-solid interactions is extremely important.

^{36}Cl determination from filter and evaporator concentrate samples

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A method for the simultaneous determination of ^{36}Cl ^{129}I was implemented and tested on real samples originating from the Nuclear Powerplant. Sample types included ultrafiltration membranes and evaporator concentrates stored in the plant. After initial tests the implemented measurement method proved to be able to separate the nuclides in question from other contaminants, thus it can be used for routine measurements in the future. The sludge samples were degraded by a multi-step nitric acid-hydrochloric acid digestion, and the filters were prepared in a similar way by means of hot acid soaking. Based on preliminary studies, the samples are brought into solution without residue in three steps, therefore this procedure was used. The separation of radiohalogenides is performed simultaneously using a combined procedure. For the separation, we use a specific resin developed for this purpose. The resin (Triskem Cl resin) is primarily used for the separation of platinum group elements, as well as silver and gold ions. From the column purified of impurities, the chlorine and iodine fractions can be selectively eluted using the appropriate solvent, whose activity can then be determined using an LSC.The data gathered during the experiments showed that the activity concentrations of the evaporator concentrates lie in the range of 5.0E1 – 1.7E2 Bq/kg, while ultrafilter membranes showed an activity concentration in the range of 4.7 Bq/kg. The difference is to be expected due to the occurrence and chemistry of the nuclides in the technology.Gamma-spectrometric analysis of the samples proved the prepared samples to be free of any gamma-emitting contaminants – measurement of the raw samples show Cs-137 and Co-60, and silver isotopes in the case of membranes as the main constituents.In conclusion a method was adapted for the simultaneous measurement of radiohalogenides – namely ^{36}Cl and ^{129}I from samples originated from an operating nuclear power plant. After verifying the working of the method two types of samples were analyzed:

- Ultrafilter membranes
- Evaporator concentrates

Both samples contained a multitude of radiometric contaminants with sometimes multiple orders of magnitude higher activity concentrations than the nuclides in question. When evaluating the results it could be shown that the acquired samples are free of contaminants and the results lie in the range that is expected. It can be concluded that the method is suitable for routine measurements ^{36}Cl and ^{129}I from samples of NPP origin

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Radiation response and degradation thresholds of semiconductor quantum well nanoheterostructures under neutron irradiation

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This work presents an experimental study of the effects of neutron irradiation on the electronic, optical, and structural properties of AlGaAs/InGaAs/AlGaAs quantum well semiconductor nanostructures with a two-dimensional electron gas. The study is motivated by the demand for radiation-tolerant materials for applications in space electronics, nuclear energy systems, and high-sensitivity electronic and optoelectronic devices.

Samples grown by molecular beam epitaxy were irradiated with neutrons in the fluence range of 2×10^{14} –1.2×10^{16} n/cm^2. Electrical properties were characterized using Hall-effect measurements at 300 K and 77 K, complemented by low-temperature photoluminescence and high-resolution X-ray diffraction analysis. Monte Carlo simulations (Geant4) were performed to support the experimental observations.

No degradation of the crystal structure was observed within the studied fluence range, indicating predominantly point-defect formation. A degradation threshold at approximately 3.2×10^{15} n/cm^2 was identified, above which a significant reduction in carrier concentration and mobility occurs. An in-situ measurement technique was developed and validated, enabling real-time monitoring of radiation-induced changes and eliminating artifacts associated with post-irradiation analysis. The results provide insight into radiation-induced processes in quantum well structures and are relevant for the development of radiation-hardened semiconductor devices.

Automation system for the complex of cryogenic moderators of the IBR-2M reactor

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In scientific research conducted at the IBR-2M reactor, the analysis of large-scale structures requires cold neutrons, which are produced by moderating the neutron flux in cryogenic environment. The cryogenic moderator complex is a sophisticated technological facility operating at the intersection of cryogenic engineering, vacuum technology, and reactor physics. This work addresses the critical task of enhancing the reliability of the cryogenic moderator complex through the development and implementation of an industrial-grade automation system. The implemented system enables the autonomous execution of routine operations and ensures the safety of the facility during emergency situations.

Portable temperature-controlled chamber for measurements under variable ambient conditions

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Temperature stabilization is a critical requirement for the proper operation of temperature-sensitive devices whose performance parameters strongly depend on, and in some cases are determined by, ambient temperature. Maintaining an optimal and stable temperature improves operational characteristics, enhances efficiency, and increases system reliability. This is particularly important for semiconductor radiation detectors, whose performance is significantly affected by environmental temperature variations.

As an example, spectrometric detectors based on cadmium zinc telluride (CdZnTe, CZT) are considered. These detectors provide high gamma-ray detection efficiency over a wide energy range, offer good energy resolution, and operate without cryogenic cooling. However, their energy resolution is highly temperature-dependent. Optimal performance is typically achieved within the +10 to +20 °C range. Deviations from this range, either higher or lower, result in degradation of spectrometric characteristics and may lead to a loss of spectroscopic functionality.

CZT detectors are used in laboratory and industrial environments, including nuclear fuel monitoring, radioactive waste management, radiation surveillance systems, nuclear medicine, and scientific research. In many applications, ambient temperature may vary significantly (from sub-zero to elevated temperatures), leading to instability in measurement results.

Therefore, temperature stabilization of the detector is required to ensure optimal and reproducible spectrometric performance. Existing commercial solutions do not fully meet the requirements of mobility and autonomy. Laboratory climate chambers are bulky, expensive, and require stationary power supplies. Portable cooling devices (e.g., those designed for medical storage) lack sufficient temperature control range and precision. Specialized temperature calibration systems are primarily intended for laboratory use.

To address these limitations, a prototype of a portable temperature-controlled chamber based on a thermoelectric (Peltier) element has been developed. The chamber is designed to stabilize the temperature of radiation detectors and other temperature-sensitive devices under variable ambient conditions.

The chamber incorporates advanced low thermal conductivity insulation materials, including aerogel, enabling stabilization of the internal temperature within the 0 to +50 °C range under ambient conditions from −20 to +50 °C. Materials used in the housing, particularly in the entrance window region, are selected to minimize attenuation of low-energy gamma radiation.

The system is controlled via a push-button interface with real-time parameters displayed on a digital screen. Power is supplied through two USB-C Power Delivery ports (15 V, 2 A each), allowing operation from both mains adapters and portable power banks.

The prototype dimensions are 23 × 20 × 23 cm with a total weight of 3 kg. The internal temperature-controlled volume measures 5.9 × 5.9 × 14 cm.

The paper presents the operating principle, key technical characteristics, and results of experimental testing.

This work was supported by the European Recovery and Resilience Facility Project NR. 5.1.1.2.i.0/2/24/A/CFLA/006.

Study of the influence of taVNS on the trend of nonlinear dynamics in the electroencephalographic signal

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An original system for generating electrical stimuli was assembled to apply the transauricular stimulation of vagus nerve (taVNS). The generator was set to apply biphasic bursts of 5 Hz pulses with a 1-second pause. EEG signals were acquired by means of a remote single-channel encephalograph, and their analysis was performed with specialized software. Computational investigation of various electroencephalographic signals has focused on the correlation dimension and the largest Lyapunov exponent, searching for evidence of the influence of electrical stimulation on brain wave dynamics, as well as for the possible connection with the effects of ganoderma extract administration or physical training.

The correlation dimension analysis, important for estimating the fractal dimensions of the system, was performed based on the graph of its variation as function on the embedding dimension with the algorithms provided by the commercially available CDA (Chaos Data Analyzer) software. The study of the largest Lyapunov exponent aimed the highlighting of the system sensitivity to the initial conditions as a hallmark of the complexity of the system dynamics. The comparative study was based on the EEG recordings: (a) in the absence of taVNS and any other stimuli; (b) after the application of taVNS; (c) after the administration of the anxiolytic ganoderma extract; (d) after the administration of ganoderma extract and the application of taVNS; (e) after performing a physical training; (f) after performing physical activity and taVNS.

The positive variation of the correlation dimension with the increase of the embedding dimension, as well as the decrease of the Lyapunov exponent in all the mentioned cases, in comparison to the initial state was highlighted. The discussion of the results focused on the values of the correlation dimension and the Lyapunov exponent for that value of the embedding dimension that satisfies the theoretical condition of Procaccia for both the primary and numerically smoothed data. It was shown that the taVNS treatment shifts both the Lyapunov exponent and the correlation dimension graph towards higher values, suggesting that the sensitivity to the initial conditions and, therefore, the complexity of the system dynamics increased. The average intensities of the brain wave rhythms, as provided by the NeuroSkyMindWave software associated with the data acquisition, contributed to the development of the picture related to the influence of the treatment with anxiolytic ganoderma extract on the activity of the central nervous system - brain, as well as the combination of this treatment with the application of taVNS.

Circuit-level modeling and simulation of single event transients in CMOS circuits using LTSpice

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Single Event Transients (SETs) represent one of the most significant radiation-induced reliability challenges in modern CMOS integrated circuits, particularly in nanoscale technologies operating at reduced supply voltages. This paper presents a circuit-level approach for modeling and simulation of SET effects in CMOS circuits using the LTSpice simulation environment. A compact SET current model based on a double-exponential current pulse is implemented and integrated into transistor-level CMOS schematics. The proposed approach enables realistic analysis of transient effects caused by energetic particle strikes, including the influence of Linear Energy Transfer (LET) on the generated voltage pulses. Simulations are performed on CMOS inverter structures implemented in 130 nm CMOS technology, considering different LET values and supply voltages. The obtained results demonstrate the dependence of SET pulse width and amplitude on radiation conditions and operating parameters, providing insight into transient fault propagation mechanisms in CMOS circuits. In addition to research-oriented analysis, the presented methodology is suitable for educational purposes and laboratory exercises focused on radiation effects and reliability of integrated circuits.

Voltammetric and liquid-chromatographic determination of 1,1-dimethyl-3-phenyltriazene and its halogeno derivatives

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1,1-dimethyl-3-phenyltriazene and its *o*-, *m*- and *p*- halogeno-derivatives rank among genotoxic substances that also exhibit cancerostatic activity. Therefore, there is an increasing demand for sensitive and selective analytical methods for their determination. In the present contribution, an attempt was made to improve the sensitivity of voltammetric determination of 1,1-dimethyl-3-phenyltriazene and its Cl, Br and I-derivatives by adsorptive stripping voltammetry at an environmentally friendly silver amalgamated electrode. The selectivity of the determination of the investigated substances was improved by using an HPLC method.

For the electrochemical measurements, the Britton-Robinson buffers with different pH (2.8 – 9.50) were employed, the working electrode was amalgamated Ag microelectrode in the connection with Pt auxiliary and Ag/AgCl/3M $KCl_{(aq)}$ reference electrodes. The optimal pH values of the basic electrolyte for voltammetric determination of the tested substances (with limited selectivity) are in the range of 5.1 to 6.5, depending on the tested substance. At optimal conditions of pH value of the basic electrolyte (5.8), accumulation potential (-0.500 V) and accumulation time (180 s), quantification limits of 1×10^{-9} mol/dm^{-3} were achieved.

Improved selectivity for the determination of 1,1-dimethyl-3-phenyltriazene and its halogeno-derivatives, but also lower sensitivity, was achieved using high-performance liquid chromatography. The optimal chromatographic conditions are as follows: separation was performed on a column (stationary phase) Luna Omega 3 mm PS C18, 100 x 4.6 mm (Waters), mobile phase was methanol/water (40/60 v/v), flow rate 1.20 mL/min, detection wavelength 278 nm. In this way, a good separation of 4 substances (para-substituted derivatives of 1,1-dimethyl-3-phenyltriazene) was achieved within 12 min. Limits of quantification of the investigated substances 1,1-dimethyl-3-phenyltriazene, 1-(4'-chlorophenyl)-3,3-dimethyltriazene, 1-(4'-bromophenyl)-3,3-dimethyltriazene and 1-(4'-iodophenyl)-3,3-dimethyltriazene was in the range from 1.0×10^{-6} mol/dm^{-3} to 1.8×10^{-6} mol/dm^{-3}.

In addition, the mechanisms of the electrode reduction (4-electron, two-steps) and chromatographic separation of the investigated substances were established.

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From CO_2 waste to programmable carbon feedstock: A closed-loop enzymatic–mineral–plasma platform

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Rising atmospheric CO_2 levels remain one of the most pressing environmental challenges, driving climate change and ecosystem destabilization. Transforming CO_2 from an abundant waste gas into a usable carbon resource is therefore a critical scientific and technological priority.

This work presents a concept of a closed-loop CO_2 conversion platform in which carbon dioxide is no longer treated as waste, but as a controllable carbon feedstock for the synthesis of value-added products. The approach integrates three coupled stages: enzymatic hydration of CO_2 to bicarbonate using engineered and immobilized carbonic anhydrase, controlled precipitation with selected metal cations to generate carbonate intermediates, and their subsequent conversion into products such as CO, CH_4, and, under exploratory conditions, oxygenated C1+ compounds via non-thermal plasma.

The central innovation lies in redefining carbonate intermediates as active, pre-organized catalytic states that determine downstream reactivity. By selecting specific metal cations, the system enables programmable control over product selectivity, transforming the mineralization step from passive separation into a design tool for reaction engineering. In parallel, the enzymatic stage shifts the CO_2 hydration equilibrium, enabling continuous uptake even at low concentrations, opening a pathway toward direct air capture-compatible processes.

The platform is developed through a synergistic collaboration combining enzyme engineering, interfacial immobilization strategies (nanodiamonds, magnetic particles, polymer matrices), and plasma-driven conversion. The outcome is a modular, tunable system that bridges biotechnology, materials design, and plasma chemistry, offering a new paradigm for integrated CO_2 valorization with controllable selectivity.

Field dosimetry measurements in the city of Bački Petrovac

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In this paper, authors present results of field dosimetry measurements in the city of Bački Petrovac. Authors used Safecast bGeigie Nano Kit dosimeter, which is a mobile, GPS enabled, logging, radiation sensor. It is designed for mounting on the outside of a car window but can be used on bicycles, trains, planes, and other modes of transportation. It can also be used for taking static readings and contamination findings. In logging mode, the Nano takes a measurement every 5 seconds and logs the time and location coordinates (https://safecast.org/devices/bgeigie-nano/#).

Dosimeter was mounted on bicycle, at about 75 cm from the ground surface, with the radiation sensor facing down. Measurements were executed on the public roads in the city of Bački Petrovac in a few afternoons of the summer of 2024(23rd-29th July 2024). Average speed of bicycle was about 19 km/h and total distance covered in one segment was 15 to 20 km, within 45 to 60 minutes' drive. Authors covered more than 95% of public roads in the city with at least one drive through and about 75% of roads with 2 or more drive through.

Results vary from 0.04 to 0.24 μSv/h with mean value of 0.13 μSv/h which is in the range of normal background for this area. Measurements were performed also on the city cemetery with granite monuments, to check, if there are some higher values of dose rates in that type of environment. Mean value was slightly higher in that area (0.16 μSv/h), but still in the range of natural background. Also, there is one "heat zone" in northwestern part of the city, on the border with agricultural soil, where results are around 0.20 μSv/h. That can indicate overuse of artificial fertilizer in that part of agricultural area and it should be investigating more detailed in the future.

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Evaluation of radium activity levels in beach sand samples collected from the Şile Coast, Istanbul

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Naturally occurring radionuclides such as radium are widely present in coastal sediments and beach sands due to geological formations and sediment transport processes. Determining the activity concentrations of these radionuclides is important for assessing environmental radiation levels and evaluating potential radiological risks to the public.

In this study, radium activity concentrations in beach sand samples collected from the Şile coastal region of Istanbul, Türkiye, were determined using a high-purity germanium (HPGe) gamma-ray spectrometry system. A total of five sand samples were collected along a 5 km section of the coastline to investigate the distribution of natural radioactivity in the study area. The collected samples were dried, homogenized, and sealed in appropriate containers before measurement to ensure radioactive equilibrium.

The measured radium activity concentrations in the samples were found to be **5.21 ± 0.82 Bq/kg, 5.68 ± 1.06 Bq/kg, 3.27 ± 0.39 Bq/kg, 4.39 ± 0.75 Bq/kg, and 4.23 ± 0.37 Bq/kg,** respectively. The obtained results provide useful information about the distribution of natural radioactivity in beach sands along the Şile coast. These findings contribute to environmental radiation monitoring studies and may serve as baseline data for future radiological assessments in coastal regions.

Keywords: Radium, Beach Sand, Natural Radioactivity, HPGe Detector, Gamma-Ray Spectrometry, Şile Coast

Ionizing radiation technology for wastewater treatment in China: Current status and prospects

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The presentation will introduce the basic principles, characteristics, and technological advantages of ionizing radiation (including electron beam and gamma ray) technology for wastewater treatment, as well as the research and development process of the author's research group in this field since 2003. The current application status of electron beam radiation technology for industrial wastewater treatment will be introduced in detail, including practical projects for treating dyeing wastewater, chemical wastewater, coking wastewater, pharmaceutical wastewater, hospital wastewater etc., and the application prospects of this technology in the environmental remediation are discussed.

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Assessing anthropogenic pressures on water quality degradation in Serbian saline lakes

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Climate variability and human activities have the potential to alter water balance and solute concentrations in shallow saline systems. This study evaluates the anthropogenic influence on the chemical and microbiological status of lakes Velika Rusanda and Mala Rusanda in northern Serbia. Water samples were collected seasonally and analyzed for electrical conductivity, pH, nutrients (NO_3^-, PO_4^{3-}, NH_4^+), and microbiological indicators to investigate anthropogenic influence. Major cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) and anions (Cl^-, SO_4^{2-}, HCO_3^-) were analyzed by ion chromatography, volumetry and spectrophotometry, while selected metals (Mn, B, Al, Ba, Sr) and trace metals (As, Pb, Cr, Cd, Cu, Ni, Zn, Co, Li) were determined using ICP-OES. Results revealed significant anthropogenic influence, particularly in Lake Mala Rusanda. Elevated levels of total and fecal coliform bacteria indicated contamination from nearby septic systems and confirmed fecal pollution. Ammonium concentrations were up to three times higher in agriculturally influenced areas and up to eight times higher in zones dominated by septic discharge, indicating nutrient enrichment and eutrophication risk. Although the chemical characterization of lakes Velika Rusanda and Mala Rusanda reflects their natural saline-soda character, certain trace metals suggest a modest anthropogenic contribution. Elevated concentrations of As (0.678 mg/L), Pb (0.116 mg/L), Cr (0.361 mg/L), and Ni (0.287 mg/L) exceed typical background levels for soda pans and may indicate inputs from agricultural or urban sources. These findings highlight that, while geogenic processes dominate, localized anthropogenic activities affect the lakes' trace metal profile. Effective management strategies should include improved wastewater infrastructure and regulation of agricultural runoff to protect the water quality and biodiversity of these nationally protected soda lake systems.

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Keywords: soda lake, trace metals, water degradation, chemical characterization

Enhancing low-cost air quality monitoring using LSTM networks for in-field sensor calibration

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Air pollution remains a major global challenge with significant impacts on environmental quality, public health, and sustainable development. The deployment of low-cost sensing technologies enables the creation of dense air-quality monitoring networks and more realistic assessments of personal exposure. However, despite their high spatial and temporal resolution, low-cost sensors are strongly influenced by variable field conditions, which limits measurement accuracy outside controlled laboratory environments. This study addresses these limitations through the development of an advanced in-field calibration framework for the PAQMON 1.0 mobile air-quality monitoring platform developed at the Mining and Metallurgy Institute in Bor, Republic of Serbia. PAQMON 1.0 enables continuous monitoring of particulate matter and key meteorological parameters. The current configuration integrates the NOVA SDS011 optical sensor for $PM_{2.5}$ and PM_{10} detection based on Mie light scattering, together with the AM2302/DHT22 module for temperature and relative humidity. The system operates with a 1 s acquisition interval and flexible averaging, enabling high-resolution monitoring under dynamic outdoor conditions. The calibration pipeline combines structured preprocessing with deep learning. Raw low-cost and reference data were synchronized by timestamp, followed by interpolation of missing values and outlier removal using z-score filtering ($z<3$) to eliminate physically implausible readings and noise spikes. The dataset was chronologically split into training and testing subsets (80/20) to preserve temporal causality. Features were normalized to [0,1] using MinMax scaling and transformed into supervised sequences via a sliding window (lookback = 24). Inputs included low-cost sensor measurements of temperature, relative humidity, absolute humidity, PM_{10}, and $PM_{2.5}$, while the targets were reference PM_{10}, and $PM_{2.5}$ concentrations obtained from the Serbian Environmental Protection Agency monitoring station. The stacked LSTM architecture consisted of: Layer 1-LSTM (50 units; parameters = 4 × (units × (units + input_dim + 1)) ≈ 11,200); Layer 2- Dropout (0.2); Layer 3 -LSTM (50 units; parameters = 4 × (50 × (50 + 50 + 1)) ≈ 20,200); Layer 4-Dropout (0.2); Layer 5- Dense (32 neurons, ReLU activation; parameters = 50 × 32 + 32 = 1,632); and Layer 6-Dense output layer (2 neurons, linear activation; parameters = 32 × 2 + 2 = 66). The total number of trainable parameters was approximately 33,098. Training used the Adam optimizer (learning rate 0.001), Mean Squared Error loss, batch size 32, and 100 epochs. Performance was evaluated using R^2, RMSE and MBE. Results demonstrate clear performance gains. For platform n24, the model achieved R^2 = 0.41 and 0.74 for PM_{10} and $PM_{2.5}$, respectively, with RMSE values of 2.56 μg/m³ (PM_{10}) and 1.70 μg/m³ ($PM_{2.5}$). For platform n25, performance metrics reached R^2 = 0.57 (PM_{10}) and 0.75 ($PM_{2.5}$), with RMSE of 2.20 μg/m³ and 1.67 μg/m³, respectively. Mean bias remained low for both platforms, indicating stable calibration behavior. These findings confirm the suitability of temporal deep learning for improving low-cost optical PM sensing in real conditions. Ongoing work will explore hybrid and quantum machine learning approaches to further enhance performance and support scalable, reliable air-quality monitoring systems.

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Evaluation of urban green areas as sinks for polycyclic aromatic hydrocarbons based on soil environmental analysis

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This study investigates the presence of polycyclic aromatic hydrocarbons (PAHs) in soils of urban green areas as indicators of anthropogenic environmental pollution. Soil samples were collected from urban parks located in zones with varying degrees of traffic intensity, including areas adjacent to major transport routes and inner park zones. Thirteen PAHs were determined using the QuEChERS multiresidue method followed by gas chromatography–tandem mass spectrometry (GC-MS/MS).

The results demonstrated a clear spatial variability in PAH concentrations, with higher levels consistently observed in soils collected near park boundaries compared to central park areas. This distribution highlights the significant influence of traffic-related emissions on soil contamination in urban environments. Pyrene was identified as the dominant compound, while fluorene occurred at the lowest concentrations. Several high-molecular-weight PAHs exceeded established maximum residue limits, indicating potential environmental risk.

The findings confirm that urban green areas are subject to ongoing anthropogenic pressure and may serve as sinks for persistent organic pollutants. These results emphasize the importance of systematic monitoring of soil quality in urban ecosystems to support environmental protection and sustainable urban management.

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Ecotoxicological effects of rare earth element–containing nanoparticles across freshwater trophic levels

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Rare earth element (REE)–containing nanoparticles have attracted considerable attention in biomedical research owing to their distinctive electronic configurations and associated optical and magnetic properties, which enable applications in imaging, biosensing, and therapeutic technologies. However, increasing production and potential environmental release raise concerns regarding their environmental fate and ecotoxicological impacts. Despite their technological relevance, the effects of REE–containing nanoparticles across multiple freshwater trophic levels remain insufficiently characterized. This study aimed to systematically evaluate the environmental behavior and biological effects of REE–containing nanoparticles in representatives of primary producers, primary consumers, and vertebrates. Exposure experiments were conducted with the freshwater green alga *Desmodesmus communis*, the filter-feeding cladoceran *Daphnia magna*, and zebrafish (*Danio rerio*) embryos and larvae. Organisms were subjected to 48- and 96-hour exposure scenarios to capture acute and early sublethal responses under controlled laboratory conditions. The results demonstrate trophic-level-specific and medium-dependent effects of REE–containing nanoparticles in freshwater systems, affecting autotrophic algae, filter-feeding invertebrates, and vertebrate early life stages. Observed biological responses varied depending on both exposure duration and environmental matrix, indicating that nanoparticle behavior in the surrounding medium plays a critical role in determining exposure dynamics and biological outcomes. Given their expanding biomedical application and potential environmental dissemination, incorporation of nanoparticle transformation processes and environmentally realistic exposure conditions into ecotoxicological hazard assessment frameworks is essential for robust risk evaluation of lanthanide-based nanomaterials.

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Aerotechnogenic transfer of potentially toxic elements in an industrial city in the Middle Urals: Sources and influence of the orographic factor

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During the summer of 2025, according to the standard Moss survey protocol, 44 moss (Pleurozium schreberi и Hylocomium splendens) samples were collected in the Gubakha City and its vicinities, on the pre-prepared 2.5 x 2.5 km grid. The concentrations of 16 potentially toxic elements (PTE), namely Al, P, S, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Cd, Ba, Hg, and Pb were determined in mosses using inductively coupled plasma optical emission spectrometry method and direct mercury analyzer DMA-80 evo.

Based on the obtained data, the minimum, maximum, average, and median values of PTE concentrations were determined. Next, statistically processing (factor and correlation analyses) of the data was carried out. The results of the statistical processing were compared with spatial analysis performed using GIS.

It was established that for two groups of PTE (Hg – S – Cu and Al – V – Cr – Fe – Co – Ni) there is a set of features that allows their elevated concentrations to be assessed as anthropogenically induced. Thus, the PTE groups are combined into two sets of elements: Factor 3 and Factor 1, respectively. A strong statistical relationship is observed between the effects of factors and the spatial distribution of these PTEs: 0.75-0.89 for Factor 3; and 0.88-0.97 for Factor 1. Factor 3 and Factor 1 had the strongest impact on sites located near the Gubakha City's two largest chemical plants.

The spatial distribution of PTE deposition also indicates that the process of aerotechnogenic transfer in the study area depends not only on the prevailing wind direction (south and south-south-west), but also on the pronounced local topographic features. The city is located in cis-mountain part of the region and is divided by the valley of the Kosva River, which flows here from east to west. From north to south, the Kosva valley is intersected by the folded structure of the Bely Spoy Ridge. The terrain is quite rugged, with elevation differences varying from 40-160 m for the Bely Spoy Ridge, to 120-250 m for the Kosva River valley. Such pronounced altitude differences lead to a significant imprint on the movement of air masses in a surface layer of the atmosphere, leading to a predominance of wind directions along (and not across) elongated low landforms – along river valleys and inter-ridge depressions.

The industrial sites of two large chemical plants have significant differences in terms of their orographic position.

One plant is located in the lower part of the deeply incised Kosva River valley. This facilitates the predominant movement of pollutants along a low landforms over relatively short distances (up to 1.5-2 km): to the east – along the Kosva River bed; to the north – along the depression of the meridionally elongated folded structure of the Bely Spoy Ridge.

The industrial site of the second chemical plant is situated 150-180 meters above the first, at a significant distance from the Kosva River valley floor. Furthermore, the plant was built not at the bottom of an elongated depression (like the first), but in the middle part of a slope. This orographic position creates objective preconditions for the spread of emissions over relatively longer distances (3-5 km) along elongated low landforms and valleys, and also facilitates the periodic overcoming (by the emissions of the plant) of the upper part of the slope and their spread to the east, and not only to the north and south.

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Validation of an OpenFOAM toolbox to simulate 3D diffusive and advective 222Rn transfer in multiphasic variably saturated LNAPL contaminated porous media

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The contamination of soils and groundwater by Light Non-Aqueous Phases Liquids (LNAPLs), such as petroleum products, is a widespread environmental problem. In order to improve efficiency of the remediation processes, it is crucial to precisely assess the distribution and to quantify the subsurface LNAPL contamination. It is thus of great importance to develop tools to ease and accelerate the contaminated site diagnostic. The use of naturally occurring Radon-222 (^{222}Rn) is particularly interesting as an alternative option as it can be a possible indicator for LNAPL localization and quantification in both vadose and saturated zones. The ^{222}Rn deficit can therefore be used to localize NAPL contamination as part of a soil gas survey but its field application is often confronted to the complexity of natural systems and transient transport phenomena. Several models have been developed but few include the effects of ^{222}Rn partition into the water and NAPL phases during diffusive transfer. Among them, only two models allow the investigation of advective phenomena, one of them beeing an analytical solution which can only apply to steady-state simple (3 layers) conditions. Thus, it is necessary to develop a theoretical model of production, transfer (including diffusive and advective phenomena), as well as partitioning and decay in the different phases (solid, aqueous, gas and NAPL) of ^{222}Rn in order to discriminate the potential influence of all the confounding factors on ^{222}Rn profile and being able to discriminate uncontaminated vs LNAPL contaminated areas in real site applications.

A new 3D model was developped with OpenFOAM. The porous medium was described at the Darcy scale as a multiphase system composed of two mobile fluid phases (gas and water) and an immobile oil (NAPL) phase, all of them assumed incompressible. Gas–water flow is governed by Darcy's law and includes capillary pressure effects between the gas and aqueous phases, while the oil phase occupies a fixed fraction of the pore space and does not participate in advective transport. ^{222}Rn transfer is modeled as the migration by advection and/or diffusion of a naturally occurring compounds produced by the solid matrix and redistributed among the different phases where it decays. The code was first validated against the analytical solutions for diffusive condition in homogeneous contaminated porous media. Then, it was confronted to complex heterogeneous porous media in diffusive conditons. Finally, the code code was confronted to an analytical solution for advective cases configuration.

The comparison of the results obtained with the code with the ones obtained with the analytical solutions for diffusive homogeneous cases shows that the code can perfectly simulate the production, partitioning, decay and diffusive transfer of ^{222}Rn in homogeneous conditions. It can also deal with heterogenous conditions. Concerning advective transfer, the comparison of the results obtained with the code with the ones obtained with an analytical solution globally shows good agreement but few differences can be observed, which can be explained by differences in both model formulations.

The code developped here with OpenFOAM is able to simulate ^{222}Rn production, partitioning and decay in the different phases of heterogeneously saturated porous media as well as its transfer by diffusion and/or advection. It opens new insights for the identification and the quantification of LNAPL contamination in soils to optimize remediation of LNAPL polluted sites as well as a better understanding of gas transfer in heterogenous variably saturated porous media.

Non-invasive detection of explosives with a thermal-to-epithermal neutron station

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The growing scale of the devastation that even a single terrorist attack can cause requires more effective methods for the detection of hazardous materials. In particular, there are no effective solutions for monitoring threats at sea, both for offshore infrastructure and ports. Currently, state-of-the-art detection methods determine the density distribution and the shapes of tested subjects, but only allow for a limited degree of substance identification. This work aims to present a feasibility study of the potential application of several methods available at the thermal-to-epithermal neutron station, VESUVIO, located at the ISIS neutron and muon spallation source in the UK, for the detection of hazardous materials. I will present the results of a series of experiments performed concurrently using neutron transmission and Compton scattering with melamine, a commonly used explosive surrogate, to characterise its chemical dynamics and establish the limits of detection and quantitation. The experiments are supported by first-principles modelling, providing detailed scrutiny of the material structure and the nuclear dynamics behind the neutron scattering observables.

An ESG-based framework as one of the possible pathways for nuclear strategy development in Serbia

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Serbia is currently in the early stages of pre-decision-making following the lifting of the long-standing ban on nuclear energy use as part of Serbia's strategic plan. At this stage, the country is reviewing the potential role of nuclear technology in the broader framework of its commitments to energy transition and decarbonization by 2050. Regardless of the chosen energy path, it is necessary to monitor radiation, report regularly, comply with regulations, and raise social awareness. But these steps alone do not create a complete decision-making system. This time of change is an excellent opportunity to establish an Environmental, Social and Governance (ESG) framework that integrates technical controls, social issues, and institutional accountability into a single governance structure. Institutional practices often include environmental protection, social responsibility, and governance without being explicitly labelled as ESG strategies. Countries that are just beginning to develop a nuclear policy must contend with a lack of institutional experience, altered public confidence, and the absence of a defined strategic vision. In these cases, a clear ESG framework can help address the lack of institutional continuity by providing coordinated means to address radiological risks, societal acceptance, and long-term responsibilities. The proposed approach views nuclear energy as a low-carbon technology aligned with aspirations to reduce carbon emissions. It also says that radiation safety, long-term waste management, and compliance with international safety standards must be respected. The social aspect emphasizes the importance of public communication, education, and workforce development as key steps before significant technology investments. There must be a clear vision for the state, regulatory independence, and a link with international norms and review mechanisms in governance. The European Union, through initiatives such as the EU taxonomy for sustainable development, conditionally accepts nuclear energy as a contribution to climate goals, subjecting it to strict environmental and management norms. This makes the proposed framework even more compelling. Early adoption of the ESG framework in nuclear management is not a deviation but a reasonable step that will help make essential decisions and attract long-term investment for sustainable projects. In this context, ESG-based governance is not proposed as a replacement for existing regulatory bodies; instead, it serves as an integrated decision-support framework that improves coherence, transparency, and credibility. The paper proposes an approach in which the initial incorporation of ESG principles does not hinder nuclear growth; instead, it promotes responsible, investment-ready, and institutionally sound pathways for future nuclear energy initiatives in Serbia.

Assessment of metal levels in urban snow from asphalt road surfaces in Novi Sad, Serbia

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Urban snow can serve as an efficient short-term reservoir for airborne and road-related particles, especially in densely populated areas with intensive winter maintenance. In this study, snow samples were collected at 22 locations across Novi Sad (Serbia), including high-traffic crossroads, low-traffic streets, and traffic islands, during a representative snowfall event. The aim was to evaluate the concentrations of ten metals (Al, Ca, Cu, Fe, K, Mn, Na, Ni, Pb, and Zn) in melted snow, compare concentration patterns among locations, and identify potential contributions from traffic activity, de-icing salt, and urban dust. Total metal concentrations were determined by ICP–OES. Across all locations, sodium exhibited the highest concentrations, reflecting the intensive use of road de-icing salt, followed by Ca and Fe, while Ni showed the lowest levels. Differences between high- and low-traffic sites were moderate, with Na and Pb showing somewhat elevated values near busy crossroads. Metal concentrations measured on traffic islands were consistently lower than those recorded directly on asphalt surfaces, likely due to mechanical snow relocation during winter maintenance. Despite spatial variability, the broadly consistent elemental composition suggests the influence of similar sources across the study area. To complement chemical analyses, selected samples were examined using SEM–EDS to observe the morphology and microchemical signatures of particles retained in snow. Microscopy revealed mixtures of mineral grains, combustion-derived spherical particles, and fragments of road-origin materials, supporting the interpretation that both natural dust and traffic-related emissions contributed to the observed composition. Overall, the results indicate that winter road maintenance, urban soil dust, and vehicular activity jointly shape the metal content of short-lived urban snow cover. Although the snowpack typically persists only for a short period, its meltwater may temporarily increase local loads of Na and, to a lesser extent, traffic-related metals, yet without strong spatial gradients attributable solely to traffic density.

Microplastics in soils – Challenges and concerns

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Microplastics (MPs) are recognized as one of the most important global pollutants. Their distribution is largely attributed to the extensive production of polymeric materials characterized by high chemical stability, durability, plasticity, and corrosion resistance. Defined as plastic particles smaller than 5 mm, MPs can be transported over long distances via oceanic currents and atmospheric circulation. Recent studies identify soil as a predominant environmental sink for MPs, where polymer additives enhance their persistence. Estimates suggest that the annual input of MPs into terrestrial ecosystems 4–23 times exceed their loads in marine ecosystems. The impact of MPs on soil ecosystems has emerged as an important since MPs can influence not only soil composition and properties but also biological processes, including microbial diversity, enzyme activity, and the cycling of key elements – carbon, nitrogen and phosphorus. Physical and chemical changes, such as fragmentation, increased surface area, roughness, and formation of additional adsorption sites, may enhance MPs' capacity to interact with other soil contaminants. For instance, heavy metals (HMs) can be immobilized through adsorption and complexation on MPs, potentially either mitigating or exacerbating HM-related environmental risks. The accumulation of MPs in the soil occurs via multiple pathways, most of which are related to human activities. The increasing production and widespread use of plastic materials, particularly packaging, and the generation of municipal waste, driven by low-cost production, contribute substantially to environmental contamination. With global plastic production projected to continue rising, the load of MPs in the environment is unlikely to decline without mitigation measures. In agriculture, the application of sewage sludge, wastewater irrigation, fertilizers, and plastic-based coverings has been identified as a major source of MPs in soils. Once present in soils, MPs may enter crops and subsequently the food chain. Although the presence of MPs was first noted in the 1970s, the term was first mentioned in 2004 by R. Thompson. Since the 2010s, scientific interest and understanding of MP pollution have grown rapidly; however, some important knowledge gaps remain. The environmental fate of MPs is governed by multiple degradation mechanisms, including physical weathering, photo, and thermal oxidation, biological degradation processes, etc. Importantly, different types of plastics do not have identical effects on soil systems. Conventional, biodegradable, and aged MPs can influence soil properties in different ways, particularly biogeochemical cycling, reflecting complex interactions in soil environments. Recent studies indicated that MP type plays a key role in shaping soil microbial diversity, whereas MP concentration primarily affects the overall microbial community composition. Biodegradable MPs may undergo enzymatic fragmentation by soil microbiota, eventually producing mineralization end-products (CO_2, CH_4, H_2O), whereas conventional MPs predominantly generate physical changes in soils, including reduced porosity and water retention capacity, which ultimately can disrupt biogeochemical cycling. Dissolved organic matter (DOM) is the most dynamic and bioavailable fraction of soil organic carbon, which interacts with MPs. Consisting of low-molecular-weight organic compounds, microbial metabolites, and humic substances formed during organic matter transformation, DOM represent an additional but still insufficiently understood aspect of MP behaviour in soils. Therefore, future research should focus on the fate and transformation of MPs in different soil types, as the replacement of conventional with biodegradable plastics is unlikely to mitigate contamination in terrestrial ecosystems, as critical components of the global plastic pollution cycle.

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Radioecological assessment of soil to crop transfer of natural radionuclides in rice and cassava from a high background natural radiation area in India using gamma spectrometry and ICP-MS

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Soil to crop transfer of primordial radionuclides, such as ^{238}U, ^{232}Th, and ^{40}K, in high background natural radiation areas (HBNRAs) constitutes a key pathway for the entry of naturally occurring radionuclides into the human food chain. However, these radionuclides in staple crops are typically present at very low activity concentrations, posing analytical challenges for their reliable determination. This study presents a radioecological assessment of rice and cassava samples collected from Kanyakumari HBNRA, India using high-purity germanium (HPGe) gamma spectrometer and inductively coupled plasma mass spectrometer (ICP-MS). Single (n = 4) and double (n = 4) polished rice samples and cassava samples (n = 2), were analyzed by gamma spectrometry under varying counting times, and an optimal measurement duration of 160,000 s was established to improve detection sensitivity. Measurable ^{226}Ra activities in polished rice samples ranged from 3.8 – 5.3 Bq kg^{-1}, whereas ^{228}Ac and ^{40}K were below detection limits (BDL) and cassava samples exhibited detectable ^{226}Ra and ^{40}K activities. Soil to crop transfer factors (dry weight) for ^{226}Ra ranged from 0.09 – 0.26 for rice. The same samples along with the rice with husk (n = 4), were subjected to acid digestion and analyzed by ICP-MS for rare earth elements (REEs), uranium (U), and thorium (Th). ICP-MS method accuracy was validated through triplicate analysis of the standard reference material (SRM) NIST 1570a trace elements in spinach leaves, and the recoveries of As, Eu, Th, and U were found to be in good agreement with 90 – 110%. The U and Th concentrations across rice and cassava samples ranged from 0.14 – 6.71 ng g^{-1} and 1.48 – 49.5 ng g^{-1}, respectively. Polishing the rice resulted in reduction of U and Th concentrations by 55 to 87% and 45 to 86%, respectively, relative to husk. The study highlights the influence of sample processing, counting geometry, and detection limits on radionuclide quantification and demonstrates the complementary roles of gamma spectrometry and ICP-MS in assessing radionuclide transfer in food crops.

U-235 in sediment and groundwater samples of two Brazilian sites

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The natural radioelement uranium is lithophile, widely distributed in crustal rocks, being concentrated preferentially in acid igneous rocks compared with intermediate, basic, and ultrabasic varities. There are three natural isotopes of uranium: ^{238}U, ^{235}U, and ^{234}U. ^{238}U is the principal isotope of natural U in a mixture (about 99.3% abundance) and is the parent nuclide in the mass number (4n+2) decay series of radionuclides, the longest known series. ^{235}U is the primary nuclide in the mass number (4n+3) decay series of radioelements, and its proportion in a mixture of natural U is 0.72%. ^{234}U is radiogenic, being the fourth member of the ^{238}U radioactive decay chain; its abundance in a mixture of natural U is 0.0054%, whereas its average crustal abundance corresponds to 2-3´10^{-8}%. The $^{234}U/^{238}U$ activity ratio (AR) is unity (condition of secular radioactive equilibrium between the U-isotopes ^{238}U and ^{234}U) in all minerals and rocks that are closed systems for U over a time-scale greater than 10^6 years. On the other hand, AR values for uranium dissolved in waters are frequently above 1 when they interact with rocks and soils. AR´s and U concentration data measured in groundwater coupled to isotope dilution approaches have been utilized for deducing the proportions of groundwater masses mixing in different aquifer systems, among other applications. However, only a few studies have reported ^{235}U data in water resources due to its lower abundance compared to ^{238}U in nature, with exceptions referring to investigations focusing on past U-mining activities or occasional releases related to accidents involving nuclear power plants. This paper describes the characterization of the natural U-isotopes, specially highlighting the ^{235}U determined in samples of bottom sediments collected the Caldas Uranium Mine (CUM), located at the Poços de Caldas Plateau, Minas Gerais State, Brazil, inside a 30-35 km diameter alkaline volcanic caldera, where mining at the site started in 1982 and ceased in 1995. Also, ^{235}U has been found in groundwater samples providing from six deep tubular wells drilled at Campinas city, São Paulo State, Brazil, which exploit three different aquifer systems: CA-Crystalline Aquifer, TAS-Tubarão Aquifer System, and SGA-Serra Geral Aquifer. The samples of sediment and groundwater were submitted to a radiochemical process of extraction of the U-isotopes, involving several analytical steps such as co-precipitation with $Fe(OH)_3$, Fe^{3+} extraction with organic solvent, ion exchange, and electrodeposition on stainless steel planchets. The radioactive sources were submitted to analysis by alpha spectrometry utilizing four Si(Au) surface barrier detectors, each one possessing 450 mm^2 area and 0.1 mm depletion depth. The electronic signals were recorded on an EG&G ORTEC 919 Spectrum Master Multichannel Buffer, which converted them into spectra displaying the peaks associated to the recovered natural U-isotopes and ^{232}U tracer initially added to check the chemical yield. For sediment samples, the $^{234}U/^{238}U$ ratio ranged from 0.86 to 1.22, whose mean of 1.06 corresponds to unity, within experimental errors, as a consequence of the radioactive equilibrium condition between ^{234}U and ^{238}U in minerals/rocks that remained closed systems for U. The $^{235}U/^{238}U$ ratios in the sediment samples were 0.0051-0.0192, deviating of the expected natural value of 0.0072. Inputs of effluents providing from CUM and enriched in several heavy metals and radionuclides may have affected those $^{235}U/^{238}U$ ratios. The $^{235}U/^{238}U$ ratios found in the groundwater samples are between 0.018 and 0.062, with the highest ratio being almost 10 times higher than the natural expected value in U-mineralized rocks (0.0072), possibly indicating a preferential ^{235}U-transport into solution compared to ^{238}U, in a similar way as verified for ^{234}U. However, this is a subject for more detailed laboratorial tests, which is beyond the scope of this study.

Results and experience from the area dosimeter intercomparison NDS2025area: Performance assessment of passive $H^*(10)$ dosemeters at the Vinča Institute of Nuclear Sciences

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The accurate measurement of ambient dose equivalent, $H^*(10)$, is essential for ensuring a safe workplace and the environment. $H^*(10)$ provides a foundation for the graded approach, triggering different protective actions; providing the data necessary to estimate population exposure; and ensuring that workers remain within safe dose limits. This paper presents the results of Vinča Institute of Nuclear Sciences (VINS) in the regional NDS2025area Intercomparison for passive area dosimeters. The intercomparison, organized by the Laboratory for Dosimetry Standards of Jožef Stefan Institute (NDS), provided a unique opportunity to benchmark dosimeter performance across different radiation qualities and dose ranges, fostering international harmonization and quality assurance. Five organizations from three countries, with in total eight dosimetry systems, took part in the exercise between May and August 2025.

Vinča Institute of Nuclear Sciences, participated with TLDCARD-27P, TLD-700H two-element dosimeters (Thermo Fisher Scientific, USA) housed in holder type 8857 for environmental monitoring. Dosimeters contain 7LiF:Mg,Cu,P crystals and are calibrated in a ^{137}Cs reference field (662 keV) according to ISO 4037-3:2019 standard at secondary standard dosimetry laboratory at VINS. During irradiation, dosimeters were positioned with reference points at the geometric center or along the axis of rotation for rotational irradiations. Irradiations followed NDS-DN-04 and NDS-DN-05 procedures, with reference standards traceable to national and international standards. NDS estimated the measurement uncertainties of the reference values obtaining a 95% confidence interval. Readouts of 22 dosemeters were conducted with a Harshaw 6600 Plus automated TL reader (Thermo Fisher Scientific, USA).

The results obtained by the Vinča Institute of Nuclear Sciences demonstrate highly precise measurements for all radiation qualities and incident angles, and remarkable agreement for ^{137}Cs irradiations, with measured-to-reference ratios of 1.00-1.06 across tested dose levels, ranging from 0.2 to 20 mSv. For X-ray qualities: N-30 (24.6 keV) and N-60 (47.9 keV) the underresponse was recorded of 0.77-0.97, while mid-energy N-120 (100 keV) and N-300 (248 keV) qualities, yielded 0.56-0.61 and 0.80-0.82, respectively. These responses are in line with the previous results of the type test of various passive dosimetry systems used in environmental radiation monitoring done in 2021 during EMPIR 16ENV04 Preparedness project. Additionally, dosimeters that were subjected to constant rotation around vertical axis, while being in N-30 field gave excellent result of 0.96, in average.

The VINS participation in regional intercomparison highlights the capabilities of passive dosimetry system, based upon TLD-700H dosimeters, in routine environmental $H^*(10)$ monitoring and its reliability across a range of radiation qualities. Beyond confirming technical performance, this intercomparison underscores the value of international collaborative exercises in enhancing regional capabilities and confidence in measurement results, while advancing in radiation protection monitoring harmonization.

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The urban flora of East Sarajevo, Bosnia and Herzegovina

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The paper presents a taxonomic, ecological and phytogeographical study of the urban flora of East Sarajevo. Urban flora is mainly related to human settlements, but it is also found in other environments that are under more or less anthropogenic influence. East Sarajevo is located in the central part of Bosnia and Herzegovina. During the two-year research (2023 and 2024) has established the presence of 528 vascular plant species, belonging to 74 families and 304 genera. The families represented by the highest number of taxa are *Asteraceae* (15.15%), *Poaceae* (7.95%), *Lamiaceae* (7.01%) and *Fabaceae* (6.63%). The most frequent genera are *Veronica* (1.70%), *Geranium* (1.70%), Juncus (1.51%), Trifolium (1.51%), Euphorbia (1.14%), Crepis (1.14%) and *Carex* (0.95%). The most common phytogeographical elements were Euroasian (24,38%), Boreal and SubMediterranean (13,63%). A significant number of adventitious taxa (9,02%) and widespread taxa (8,83%) in the flora of East Sarajevo is an indicator of human impact. The analysis of life forms presence in the urban flora of East Sarajevo has proved their hemicryptophytic (51,63%) and terophytic (26,49%) character, which reflects the climatic conditions and the intensive urbanisation of the surveyed area. Regarding the ecological temperature index, dominating in the city area are mesothermophilic plants TB5 (37,62%), an indication of temperate-continental climate character of the city area. Dominating in terms of the humidity index are WB5 (25,5%) and WB4 (20,4%) plants that prefer moderately dry habitats. Dominant in terms of soil reaction are neutrophilic RB6 (32,8%) and in terms of nutrients mesotrophic NB5 (19,7%) and submesotrophic NB4 (16,8%) plants. Prevalent in terms of the light index are heliophyllic plants LB7 (38,6%) and LB8 (25,1%). These are plants of open and sunny habitats.

Recent developments in radiation based advanced chemical processes for degradation of organic pollutants in water and wastewater treatment applications

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Hybrid RADiation based technologies are the most promising type of Advanced Chemical Processes (ACPs). ACPs include both Advanced Oxidation Processes (AOPs) and Advanced Reduction Processes (ARPs) and are widely used for challenging water and wastewater treatment applications. These systems are frequently aided by ultrasounds (for acoustic cavitation) and UV or VISible light radiation. Cavitation intensifies reaction conditions by generating localized hotspots, extreme pressures, and enhancing mass transfer. UV-VIS is utilized for light-driven processes, mainly photolysis and photocatalysis. The core mechanism of these hybrid approaches lies in the in-situ generation of highly reactive radical species, including hydroxyl radicals (•OH) in AOPs and hydrated electrons (e^-_{aq}) or hydrogen atoms (H•) in ARPs. These radical species ensure effective transformations of a broad spectrum of recalcitrant and emerging organic pollutants, resulting in formation of low-molecular and less toxic compounds [1-3].

This presentation will provide a comprehensive discussion on the scientific fundamentals governing these synergistic technologies, delving into the specific chemical and physical interactions—such as radical's formation, improved catalyst utilization, and the breakdown of pollutants—that are responsible for their observed synergistic effects. Furthermore, it will detail recent advancements in their application for targeted treatment scenarios, including the removal of pharmaceuticals, endocrine-disrupting compounds, and persistent industrial chemicals from complex aqueous matrices. A significant achievement of these integrated systems is not only the high-efficiency mineralization or conversion of pollutants in both municipal water and industrial effluents but also the potential for process redesign to valorize waste streams, thereby enabling the co-generation of useful chemicals and supporting a circular economy approach [4-7].

Finally, the presentation will critically examine the existing challenges that remain before large-scale implementation, such as energy optimization, catalyst stability, and the formation of potentially toxic transformation by-products. It will conclude by highlighting innovative and emerging process configurations that hold potential for solving these existing limitations and addressing the evolving landscape of environmental contamination.

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Keywords: cavitation, ultrasounds, ultraviolet, oxidative radicals, reductive radicals.

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Diversity and distribution of *Gerbillinae* rodents in different habitats of the Ghardaïa Region, Northern Algerian Sahara

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Gerbillinae rodents constitute a major component of Saharan ecosystems and play important roles in trophic networks and ecosystem functioning. However, information on their distribution and abundance remains limited in several regions of the Algerian Sahara. The present study aimed to investigate the species composition and spatial distribution of *Gerbillinae* communities in different habitats of the Ghardaïa region (Northern Algerian Sahara).

Field surveys were conducted between October 2025 and May 2026 in agricultural, desert, natural and wadi habitats. The trapping campaign resulted in the capture of 60 individuals belonging to five taxa. *Gerbillus campestris* was the most abundant species recorded in the study area (36.7%), followed by *G. nanus* (25.0%), *G. gerbillus* (21.7%), *G. pyramidium* (15.0%) and *Pachyuromys duprasi* (1.7%). The highest abundances were recorded in the two wadi sampling sites, with 23 and 18 captured individuals, respectively. Species abundance varied among habitats, highlighting differences in habitat preferences and local ecological conditions.

These findings provide new information on the diversity and distribution of *Gerbillinae* in the Ghardaïa region and contribute to a better understanding of rodent communities inhabiting Saharan ecosystems. The results may serve as a baseline for future ecological monitoring and biodiversity conservation programs in arid environments.

Chemical fingerprinting and chemoinformatics in cereal-based food authentication

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Ensuring the authenticity of cereal-based food products has become a global priority due to rising cases of food fraud, mislabeling and economically motivated adulteration. Such practices not only undermine consumer confidence but also pose risks to public health, disrupt fair trade and complicate regulatory enforcement. Cereals, pseudocereals, flours and bakery products are vulnerable to substitution with cheaper ingredients or false claims regarding origin and composition. To address these challenges, combining chemical analysis with multivariate statistics and machine learning provides robust solutions for food authentication and traceability.

This mini-review summarizes recent methodological advances in chemoinformatics applied to cereal-based foods, emphasizing how chemical fingerprints can be extracted and interpreted using advanced data-driven tools. Key instrumental platforms include GC-MS for volatile and carbohydrate profiling, NIR and FTIR spectroscopy for rapid and non-destructive screening and ICP-MS for multi-elemental fingerprinting and geographical origin verification. Data generated from these analytical techniques are typically processed using principal component analysis (PCA), partial least squares discriminant analysis (PLS-DA), support vector machines (SVM) and clustering algorithms, enabling high-throughput classification and authentication in complex food matrices.

Representative case studies highlight the versatility of chemoinformatics across diverse cereal-based systems. For example, GC-MS profiling combined with PCA and clustering successfully determined buckwheat content in composite breads, while non-targeted metabolomics using GC-TOFMS and machine learning distinguished Tunisian durum wheat landraces based on organic acid and phenolic profiles. NIR spectroscopy coupled with multivariate regression accurately predicted mineral composition in lentil-fortified flours, whereas ATR-FTIR combined with SIMCA enabled differentiation of Andean pseudocereals and portable field authentication. Multi-element fingerprinting with ICP-MS has proven effective in tracing geographical origins of wheat and rice through robust markers such as Sr, Ba and Na. In addition, antibody-based microarray assays demonstrate promising high-throughput strategies for gluten detection and allergen screening in bakery products.

Despite clear progress, several challenges remain to translate this to standardized practice. Food matrix complexity, particularly in thermally processed bakery products, complicates fingerprint reproducibility. Lack of harmonization across chemometric models hinders cross-laboratory comparability, while sensitivity to sample handling and pre-processing introduces variability. Moreover, the adoption of advanced analytical and computational tools requires significant investment in instrumentation and expertise, limiting accessibility for small-scale laboratories and industry stakeholders.

The integration of validated reference databases, multimodal sensing platforms, and cloud-based data sharing will be essential to enable harmonized global traceability systems. Artificial intelligence and portable spectroscopic devices hold particular promise for scaling authentication to field and industrial applications, offering rapid, cost-effective and decentralized solutions. As consumer demand for transparency grows and regulatory frameworks tighten, chemoinformatics will play an increasingly central role in safeguarding the integrity of cereal-based foods.

***Keywords**:* chemoinformatics; authentication; cereals and pseudocereals; flour and bakery

Melatonin-induced changes in Merlot wine phenolics and antioxidant activity during early aging

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Melatonin has recently attracted interest as a winemaking additive due to its strong antioxidant activity, its ability to enhance phenolic synthesis, and its protective role against oxidative degradation of phenolic compounds. This study investigated the effects of three pre-fermentation melatonin concentrations (0.05, 0.1, and 0.5 mg/kg must) on the phenolic composition and antioxidant capacity of Merlot wine during early aging. Samples were coded as 1 (0.05 mg/kg), 2 (0.1 mg/kg), and 3 (0.5 mg/kg), and K which served as control. The experiment was carried out in two stages: immediately after fermentation (stage a) and after three months of aging (stage b). Total phenolic content (TPC), total flavonoid content (TFC), antioxidant (AO) activity determined by the DPPH assay (anti-DPPH), and individual phenolic acids were analyzed.

In both a and b aging stages, sample 1 exhibited the highest TPC, TFC, and anti-DPPH values, indicating a strong positive relationship between total phenolics and AO capacity. The highest TPC and anti-DPPH values were recorded in sample 1_a, whereas TFC was highest in sample 1_b. Although the control sample (K_a) showed moderate TPC and relatively high TFC, its lower anti-DPPH activity suggests that AO potential depends more on the overall phenolic profile than on flavonoid content alone. Immediately after fermentation, p-coumaric acid content decreased compared to the control (Ka). However, three months of aging resulted with its increase in sample 1_b, which may indicate the hydrolysis of bound phenolic compounds or the release of phenolic acids from previously formed complexes during wine maturation. Furthermore, the highest concentration of caffeic acid was measured in sample 1_a. Ferulic acid showed an initial increase in sample 1_a compared to control, but declined during aging, particularly in sample 2_b, likely due to oxidation, binding interactions, or polymerization processes. The most pronounced change was observed for gallic acid, whose concentration was significantly higher in melatonin-treated wines, particularly in stage a, compared to the controls. This increase may be attributed to gallotannin hydrolysis, improved extraction from skins and seeds, and enhanced AO protection during fermentation.

Overall, the treatment with the lowest melatonin concentration (0.05 mg/ml) showed the best balance of phenolic extraction and AO capacity in both stages. Considering its important role in AO activity and aging potential, gallic acid appears to have been a key contributor to the enhanced functional profile of the treated wines. This result clearly demonstrates that melatonin supplementation, particularly at lower doses, effectively modulates phenolic composition and improves the AO properties of wine.

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Keywords: Merlot wine, melatonin, wine aging, anti-DPPH radical activity, phenolic acid content

Maternal–fetal relationship of chromium concentrations in low-risk pregnancies in the context of metabolic adaptations

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Background: Low-risk pregnancy (37–41 weeks of gestation) is associated with dynamic metabolic adaptations, including progressively increasing insulin resistance in the third trimester, which may influence micronutrient homeostasis. Chromium, as an element modulating insulin action, may play a significant role in maintaining metabolic balance within the maternal–fetal unit. Its concentration is presumed to be regulated by placental mechanisms. In its trivalent form, chromium may indirectly attenuate oxidative stress by improving insulin sensitivity and glycemic control, whereas deficiency may contribute to enhanced pro-oxidative processes.

Objective: The aim of the study was to assess chromium concentrations in maternal venous blood and umbilical cord blood and to evaluate their associations with maternal dietary quality and selected antioxidant parameters.

Material and Methods: The study included 121 mother–newborn pairs from low-risk pregnancies with chromium concentrations within the reference range (2.3–40 nmol/dm^3). Chromium was measured by atomic absorption spectrometry (AAS), while SOD and GPx activities were determined colorimetrically. Maternal diet quality was assessed using the Diet Quality Score (DQS) and analyzed across extreme quartiles (Q1 vs Q4). Due to non-normal data distribution, non-parametric tests and Spearman's rank correlation were applied ($p < 0.05$).

Results: The mean chromium concentration was 22.25 nmol/dm^3 in maternal blood and 21.30 nmol/dm^3 in umbilical cord blood ($p = 0.177$). No significant differences were observed between extreme DQS quartiles ($p = 0.767$). A moderate positive correlation was identified between maternal and neonatal chromium concentrations ($p < 0.001$). In mothers, chromium levels were significantly associated with SOD activity ($p < 0.001$) and showed a weaker association with GPx activity ($p = 0.013$). No significant relationships between chromium concentration and antioxidant enzyme activity were observed in newborns ($p > 0.05$).

Conclusion: A moderate positive correlation between maternal and neonatal chromium concentrations suggests the involvement of regulated placental transfer mechanisms, in the absence of an association with dietary quality in the studied group.

Keywords: chromium, nutrition, oxidative stress, mother, newborn, pregnancy

„Smart“ system for cloud point extraction - determination of copper

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Cloud point extraction (CPE) has emerged as an efficient and sustainable preconcentration technique in analytical chemistry that exploits the phase separation behavior of surfactants as a more environmentally friendly alternative to organic solvents. To overcome the traditional limitations and further increase the efficiency and versatility of extraction, various modifications of CPE have been introduced to improve the procedure, including the integration of auxiliary energy sources to accelerate phase separation, the addition of auxiliary solvents to enable extraction at ambient temperatures, the use of mixed micelle systems, or the implementation of new detection methods [1–3]. This study presents a new, smart analytical approach of CPE for the determination of copper using neocuproine. The system is based on performing CPE at room temperature using 1-pentanol as an auxiliary solvent in a syringe as an alternative extraction vessel. After phase separation, the surfactant-rich phase is detected in two modes: (1) using a smartphone camera under controlled lighting conditions and (2) by directly dipping an optical probe into the tip of a syringe. Under optimized conditions (pH 5; 0.003% neocuproine; 0.1% ascorbic acid; 10^{-4} mol L^{-1} SDBS; 1% Triton X-100 and 0,35 ml 1-pentanol for 10 ml total volume of sample), the method exhibits high sensitivity with a detection limit of 4.7 µg L^{-1} Cu. The proposed syringe-based platform represents a versatile tool that is easy to apply in laboratory routine and offers a green alternative to traditional laboratory spectroscopic techniques.

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Keywords: cloud point extraction; copper; in-syringe; smart, green analytical chemistry

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Rapid and green preconcentration of ultra-trace lead using hydrophobic deep eutectic solvent–enhanced cloud point extraction

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The determination of lead at ultra-trace concentration levels in environmental waters remains a significant analytical challenge, particularly when high sensitivity, operational simplicity, and environmental sustainability are simultaneously required. Growing concerns related to heavy metal contamination demand reliable monitoring tools capable of detecting lead at concentrations well below regulatory limits while minimizing chemical consumption and energy input. In response to these requirements, this study presents a rapid, efficient, and environmentally responsible analytical procedure for the separation, preconcentration, and quantification of lead in water samples.

The proposed method is based on hydrophobic deep eutectic solvent–assisted rapid synergistic cloud point extraction (HDES-RS-CPE) combined with electrothermal atomic absorption spectrometry (ETAAS) for final quantification. A hydrophobic deep eutectic solvent composed of L-menthol and 1-octanol in a 1:1 molar ratio was employed as the extraction medium. Lead ions were converted into hydrophobic complexes using ammonium pyrrolidine dithiocarbamate (APDC), followed by efficient phase transfer into a surfactant-rich phase formed in the presence of Triton X-114. The entire extraction process was performed at room temperature and required only two minutes of vigorous shaking, eliminating additional heating or cooling steps and thus enabling high sample throughput.

Critical experimental variables affecting extraction efficiency (including solution pH, concentration of the chelating agent, surfactant amount, and volume of the hydrophobic deep eutectic solvent) were systematically investigated and optimized. Under optimal conditions, the method achieved a limit of detection of 0.04 μg/L and a limit of quantification of 0.12 μg/L, together with an enrichment factor of 38. The accuracy and precision of the procedure were evaluated using spiked environmental water samples, providing recoveries in the range of 94–104% and demonstrating satisfactory repeatability.

The environmental profile of the method was assessed using established green analytical metrics, confirming its compliance with the principles of Green Analytical Chemistry. The use of a low-toxicity hydrophobic deep eutectic solvent, minimal reagent consumption, short extraction time, and the absence of external heating collectively contribute to reduced environmental impact.

Overall, the developed HDES-RS-CPE–ETAAS approach represents a sustainable, robust, and analytically reliable strategy for ultra-trace lead quantification in environmental water matrices. Its simplicity, rapidity, and eco-friendly character make it a promising tool for routine environmental monitoring.

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Assessment of the cytoprotective and genoprotective activities of subcritical water extract of *Rosa alba* L. flowers in two different types of test-systems

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Rosa alba L. is a primary oil-bearing rose species cultivated in Bulgaria, renowned for its essential oils and extracts used extensively in cosmetics and perfumery. The biological efficacy of these products is highly dependents on the extraction method, which determines their phytochemical profile. Recently, subcritical water extraction has emerged as an eco-friendly, cost-effective, and efficient alternative for isolating biologically active compounds.

The present study was focused on the investigation of the cytoprotective and genoprotective activities of subcritical water extract of *R. alba* L. flowers (SWE) against alkylating mutagen N-methyl- N-nitro- N-nitrosoguanidine (MNNG) using cytogenetic tests in plant and human lymphocyte test-systems. Two experimental designs were employed:(i) a conditioning treatment with non-toxic concentrations of SWE followed by a 4-hour recovery period before MNNG exposure, and (ii) a co-treatment of SWE and MNNG without an inter-treatment period. Cytotoxicity was assessed via the mitotic index (MI) and nuclear division index (NDI), while genotoxicity was measured through chromosome aberrations (CA) and micronuclei (MN) induction. Prior GC-MS analysis identified the major components of the SWE as monoterpene alcohols (geraniol, citronellol, nerol, linalool), phenylethyl alcohol, eugenol, methyl eugenol, and aliphatic hydrocarbons.

Our cytogenetic studies showed that under both treatment schemes—conditioning with *R. alba* L. SWE and 4-hour recovery period as well as immediate co-treatment with MNNG restored mitotic activity (MI) in both test systems and proliferative activity (NDI) in lymphocyte cells which were reduced by treatment with the mutagen alone. This indicates a robust anti-cytotoxic effect of the *R. alba* L. flowers SWE. Furthermore, the extract demonstrated remarkable genoprotective efficiency, reducing MNNG-induced chromosomal aberrations by 2- to 3-fold across both test systems. A significant reduction in MN frequency ($p<0.001$) was also observed, with the protective effect being slightly more pronounced in human lymphocytes than in the plant model.

The discussion of these findings suggests that the high concentration of monoterpene alcohols and phenolic compounds in the SWE plays a key role in neutralizing the alkylating action of MNNG. The observed genoprotection in both conditioning and co-treatment schemes indicates that the extract may act through multiple mechanisms: both as a direct desmutagen and by potentially stimulating cellular repair processes. In conclusion, *R. alba* L. flowers subcritical water extract exhibits potent anti-cytotoxic and anti-genotoxic activity in diverse cell types. These findings reveal that SWE is not only a promising green technology for industrial production but also a source of high-quality extracts with robust defense potential against DNA-damaging agents.

Electromagnetic field in the modern environment – Between risk and therapeutic potential

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Rapid technological advances have increased both the number and variety of electromagnetic field (EMF) sources in human environments. Of particular concern are extremely low-frequency fields from power systems and radiofrequency/microwave fields from wireless technologies. Exposure is widespread, long-term, and often only partially managed, raising questions about potential effects on the organism, especially the nervous system, and possible links to neurodegenerative diseases.

Despite decades of research, EMF effects remain complex and variably reported, due to inconsistent exposure definitions, methodological limitations, and lack of standardisation. While often viewed as a risk factor, EMF also shows potential for controlled therapeutic use.
This presentation focuses on neurobiological effects, highlighting stress responses as a key mechanism. Laboratory studies reveal neurohormonal, behavioural, and cellular changes, which may not be uniformly detrimental and suggest phenomena such as hormesis and the influence of placebo/nocebo mechanisms.

The talk will integrate findings from our own laboratory research with epidemiological data and current therapeutic applications, including neurodevelopmental disorders such as ADHD. This perspective frames EMF both as a potential hazard and as a modulator of biological processes with therapeutic potential, highlighting the need for interdisciplinary studies to inform risk assessment and safe medical applications.

Acute exposure to environmental-level 3.5 GHz 5G signals in healthy young adults: Effects on brain activity, autonomic function, electrodermal responses, and skin temperature

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The rapid rollout of fifth-generation (5G) wireless networks, particularly the mid-band around 3.5 GHz, has prompted public concern regarding potential acute health effects at current environmental exposure levels. However, controlled human experimental evidence remains limited, and findings from earlier radiofrequency (RF) technologies (2G–4G, Wi-Fi) have been inconsistent and often based on non-representative exposure scenarios. This study aimed to comprehensively evaluate the acute physiological effects of far-field 3.5 GHz 5G exposure at levels comparable to contemporary outdoor environments in healthy young adults.

Using a triple-blind, randomized, counterbalanced crossover design, 44 participants (mean age ~26 years) underwent real and sham exposure sessions separated by up to one week. RF exposure was delivered via a horn antenna, producing mean electric field strengths of approximately 2 V/m at the head and 1–1.5 V/m at the trunk, corresponding to specific absorption rates far below international safety limits. Each session comprised baseline, exposure (~26 min), and post-exposure periods. Multimodal physiological assessments included electroencephalography (EEG), electrocardiography (ECG), electrodermal activity (EDA), skin temperature measurements, and salivary biomarkers of stress.

Results showed no robust or consistent effects of 5G exposure on resting EEG spectral power across frequency bands, global cardiac autonomic regulation, or stress-related salivary markers. Expected modulations related to eye condition and time validated the protocol. A small, isolated exposure-related change was observed in the heart rate variability parameter RMSSD during the final exposure phase, but this was not corroborated by other parasympathetic indices. Minor late-emerging differences were also detected in certain electrodermal and thermographic measures, all remaining within normal physiological ranges.

Overall, acute exposure to environmental-level 3.5 GHz 5G signals did not induce meaningful alterations in central nervous system activity, autonomic function, or peripheral physiological regulation. These findings support the short-term safety of current 5G exposure levels while underscoring the need for larger and longer-term studies to assess potential chronic effects and individual susceptibility.

Assessment and spatial analysis of nitrate contamination in drinking water sources in the Pleven region, Bulgaria

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One of the major challenges facing water supply utilities in Bulgaria is ensuring compliance of drinking water with regulatory standards for nitrate concentrations. Out of the 28 administrative regions in the country, 11 are significantly affected by elevated nitrate levels in groundwater used for drinking water supply.

The present study aims to assess nitrate concentrations in drinking water in the Pleven region through a detailed analysis of monitoring data provided by the Regional Health Inspectorate – Pleven for the period 2018–2024. The results indicate a persistent exceedance of the maximum permissible concentration for nitrates (50 mg/L) in approximately 12% of the settlements within the region, with average concentrations in some locations exceeding the regulatory limit by nearly three times. A comparison with a similar study covering the previous eight-year period reveals an approximately twofold increase in the number of affected settlements and their associated water sources.

Spatial analysis in a GIS environment was applied to characterize the specific environmental and anthropogenic conditions surrounding selected water sources and to assess the potential future development of nitrate contamination in drinking water sources.

Charge transport in organic semiconductors for device applications

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Interest to optoelectronic properties of organic crystalline and amorphous semiconductors has been steeply growing in the last decades. This is caused by successful current applications of such materials in thin-film-transistors, light-emitting diodes, solar cells, sensors, photorefractive devices, and by their promise for future applications [1,2].

The nature of charge transport mechanisms in organic semiconductors is still under debate. Various models for charge transport in organic materials can be found in the literature varying from the classical bandlike conduction to the incoherent hoping of charge carriers between localized states created by the static and dynamic disorder and by the electron-phonon interactions [3,4].

Theoretical models for description of charge transport in organic materials will be reviewed in the presentation. Particular attention will be given to material parameters responsible for the dependencies of charge carrier mobility on the intrinsic properties, such as molecular structure, on the extrinsic properties, such as the nature of defects and their concentration, and on the external parameters, such as electric field and temperature [5,6].

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The corrosion properties of $Ni/Al_2O_3/PTFE$ composite coatings in NaCl and CMA solutions

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The paper describes the microstructure and corrosion investigations of nickel-nano-alumina-polytetrafluoroethylene ($Ni/Al_2O_3/PTFE$) composite coatings produced by the electrochemical method in a Watts bath modified with saccharin and in its base variant. The main purpose of this paper was to examine the corrosion properties of $Ni/Al_2O_3/PTFE$ coatings. The structure studies were performed by Scanning Electron Microscopy, Transmission Electron Microscopy, X-ray Diffraction. The nickel and Ni/Al_2O_3 composite coatings were also analysed for the purpose of comparison. The coatings were subjected to corrosion studies by the potentiodynamic method in two anti-icing environments: sodium chloride (NaCl) and calcium magnesium acetate (CMA). The completed studies have shown that the Ni/Al2O3/PTFE composite coatings produced in the base Watts bath are characterized by higher corrosion resistance in a NaCl solution compared to the other investigated coatings nickel and Ni/Al_2O_3 and $Ni/Al_2O_3/PTFE$ coating obtained in Watts bath with saccharin. The microstructure studies performed by the Scanning Electron Microscopy method before and after the exposure to corrosion environments have shown that all the coatings tested in NaCl were characterized by pitting corrosion. In contrast, the coatings exposed to the CMA environment have shown the slight change in morphology. Saccharin because of the adsorbsion on the substrate surface (which blocks grain growth) as well as Al_2O_3 nanoparticles reduce the size of the nickel crystallites and smooth the boundaries between the nickel grains. The presence of saccharin in a Watts bath increases the amount of built-in PTFE and reduces the residual stress in $Ni/Al_2O_3/PTFE$ coatings, from tensile to compressive residual stress because of the partly incorporation of organic substances in the coating which affects on the stresses. Nickel and composite coatings in a NaCl environment have demonstrated pitting corrosion on all the coatings, with the exception of the $Ni/Al_2O_3/PTFE$ coating deposited in the base Watts bath. Inversely, the $Ni/Al_2O_3/PTFE$ coatings produced with saccharine are characterized by the largest pitting area, which may be caused by a high degree of the PTFE incorporation. It is crucial to determine the optimal PTFE content in the coating; as too high or too low content would deteriorate their properties. In a CMA environment, a slight corrosion degradation occurs on the surface, which confirms that these chemicals do not cause structural changes of the studied materials and can be used to increase the lifespan of vehicles.

New in-situ capabilities of X-ray imaging and microanalysis for inspection and materials analysis in forensic science field

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Microanalytical, multispectral and X-ray imaging methods are widely established in the forensic field and materials testing for non-destructive analysis and inspection. Existing systems have certain limitations: difficulties with large-sized objects, challenges posed by irregularly shaped items, some methods requiring micro-sampling, the need to transfer objects between instruments, among others. One approach to cover a broad spectrum of analysed objects at high resolution is the utilisation of robotic arms with different detectors. The maximum size of the object is consequently limited only by the reach of the robotic arms used. In collaboration with the Institute of Criminalistics and Radalytica Ltd., a unique analytical multimodal analytical and imaging device is being developed, which combines spectral X-ray imaging with a range of other analytical techniques (X-ray fluorescence (XRF), X-ray diffraction (XRD), computed tomography, multispectral analysis, and more) and is easily adaptable. Unlike conventional systems, the integration of imaging technologies on six-axis robotic arms provides significant flexibility in imaging with regard to both the size and shape of the sample. The system can non-destructively inspect a wide array of objects with complex curvature and is fully mobile, allowing expert examinations to be performed directly at the incident site. The device is equipped with precise geometric calibrations, enabling accurate yet arbitrary positioning of both robots. One robot carries an X-ray tube, with power tailored to the application, or various lighting sources for multispectral imaging. The other robot carries an X-ray imaging detector, an XRF detector, or detectors for multispectral capture. Rapid exchange of sources and detectors is facilitated by specially developed mounts. The robots are mobile, mounted on wheeled bases, allowing relocation as necessary. For coordinate calibration, the robots do not need direct line-of-sight but can be separated by the analysed object. The robotic arms are employed to their full potential as functional scanning elements, moving along and around six different axes: X, Y, Z, and three rotational axes. The robotic scanner has been extended with a module for XRF mapping. The XRF signal is generated by a primary X-ray beam emitted from the same X-ray tube used for transmission X-ray imaging, which is mounted on one of the robotic arms. For XRF operation, the tube is equipped with a removable lead collimator with a 1 mm aperture that defines the excitation spot on the sample. The collimator assembly is mounted on precision locating pins and held in place by magnets, enabling repeatable, accurate, and straightforward installation and removal. The second robotic arm carries the XRF detector - compact energy-dispersive spectrometer based on a silicon drift detector (SDD). The XRF mapping mode fully benefits from the robotic scanner's advanced motion capabilities, including the ability to follow curved and complex surfaces. As a result, XRF scanning is not limited to planar objects, such as paintings, but can also be applied to objects with complex geometries. In such cases, the surface curvature is first acquired using a laser distance measurement probe, after which the robots are navigated to follow the measured surface while maintaining a constant relative distance, orientation, and mutual alignment of the X-ray tube and detector with respect to the scanned surface. The system finds wide applications across various fields of forensic analysis – chemical and physical expertise, ballistics, analysis of electronic devices, trace analysis, forensic metallography, defectoscopy, and others, in investigation the causes of industrial accidents and explosions, traffic and aviation incidents, fire cause analysis, examination of unidentified objects, detection of improvised explosive devices, as well as authentication of artworks and other areas.

Development of fast perovskite scintillators for high-energy physics tasks

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Today, the need to develop new scintillation materials with short decay times is more urgent than ever. This is due to the increased demand for such materials in high-energy physics. The increase in the power of accelerators such as the LHC-HL (CERN, Sweden), where the planned particle collision energy will reach 7 TeV, requires faster scintillation materials, on which new types of detectors will be based. Also, an important property is the radiation-resistance of these materials, as this requirement is now set at 100 Mrad (1 MGy) or higher. Unfortunately, standard organic scintillation materials (crystals or plastic scintillators) have low radiation resistance below 20 Mrad (0.2 MGy). Inorganic single crystals have higher radiation resistance and longer decay times than organic scintillation materials.

One option for fast inorganic scintillation materials is YAP:Ce. The decay time of Ce-doped YAP is 25 ns, and the density is 5.4 g/cm^3. Its structure can also be modified by adding appropriate rare-earth metal oxides, which can form the $REAlO_3$ structure, forming a solid solution (mixed crystal).

Growing bulk perovskite crystals is somewhat more difficult than, for example, growing garnets, due to their tendency to crack during cooling after growth. This is due to their orthorhombic lattice, which causes anisotropy in their properties along different crystallographic directions. The solution to this problem may lie in heterostructured materials, namely composite perovskite-based materials. By creating a composite material, it will be possible to obtain a large-sized scintillator from grains of perovskite crystals, which may exhibit properties similar to those of single crystals.

In this work, the technological principles for growing single crystals of rare-earth perovskites were developed, and crystals of $YAlO_3$ (YAP), $Y_{0.5}Gd_{0.5}AlO_3$ (YGAP), and $GdAlO_3$ (GAP) activated with 1% Ce were grown. Preliminary studies of optical transmittance, luminescence, light output and decay time of samples of grown crystals were carried out. After that, composite scintillators based on grains of perovskite single crystals were developed and their properties were investigated. Also, in this work, a radiation resistance investigation of these composite scintillators is presented.

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Modified self-seeding vertical Bridgman technique for p-terphenyl single crystal growth

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Due to the high hydrogen content in organic substances, organic scintillation materials are effective for detecting short-range radiation and for the selective detection of fast neutrons in the presence of gamma radiation.

p-Terphenyl is one of the most commonly used organic scintillation materials. The single crystals of *p*-terphenyl possess a monoclinic symmetry with the space group $P2_1/a$, with lattice parameters: a = 8.12 Å, b = 5.62 Å, and c = 13.62 Å. The only non-right angle, b = 92.4°, is formed between the (a,b) plane and the c axis [1]. The single crystal of *p*-terphenyl has a *pi*-stacked crystal structure, which largely determines its properties. The potential application of a compact detector based on a *p*-terphenyl single crystal in space research equipment with signal registration by a silicon photomultiplier is highlighted in [1]. A small prototype of a high-resolution TOF detector based on a silicon photomultiplier and a *p*-terphenyl crystal was described in [2]. The development of a medical device for radiosurgery using a detector based on a single crystal of *p*-terphenyl as a *b*-particle counter is presented in [3]. The high efficiency of neutron detection and neutron/gamma discrimination by single crystals of *p*-terphenyl was noted in the results of research presented in [4].

In this work, a single crystal of *p*-terphenyl with high scintillation and optical characteristics was obtained using a simplified Bridgman-Stockbarger method, and no information on the growth of organic crystals using this method could be found. In the classical methods, the single crystal grows from a single point due to the sharp conical bottom of the ampoule, or the single crystal growth begins from an oriented seed [5]. In the method we use, spontaneous nucleation of the single crystal occurs on the crystallization front plane.

The proposed method significantly simplifies the growth of organic single crystals, as it does not require the fabrication of a complex growth ampoule, greatly reduces the risk of contamination of the raw materials, and other similar aspects. Therefore, this method is promising for obtaining *p*-terphenyl single crystals, and possibly other organic single crystals as well.

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Correlation analysis of thermal resistance and structural parameters in fibrous materials

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Heat resistance of fibrous structures is an important property that describes how effectively a material regulates the heat transfer, which directly affects energy efficiency, thermal comfort, and protection from extreme temperatures. Materials made of different fibre bases are expected to provide varying resistance to heat transfer because of their morphology, thermal conductivity, and moisture behavior. This further directs how the heat is retained, transferred, or dissipated within the material. In this investigation, two sets of materials were selected – one composed of regenerated fibres and the other one composed of natural fibres. All materials were tested for heat resistance. In order to observe the influential parameters on the observed property of heat resistance, materials were additionally tested for surface mass, thickness and porosity. The values of linear modulus, surface modulus and cover factor were calculated to assess structural influence.

Based on the obtained results, the correlation analysis showed that thermal resistance of the regenerated materials had strong positive correlation with surface mass and porosity, as well as strong negative correlation with calculated indices of linear modulus and cover factor. For the natural based materials dataset, the correlations with thermal resistance reveal a behavior pattern that differs from the regenerated group. In this case, among the measured material properties, only the surface mass showed strong positive correlation with the heat resistance. As far as the calculated parameters are considered, strong correlation remains with the linear modulus and cover factor, as it was shown for the regenerated materials. This investigation showed weaker influence of thickness on the heat resistance. Overall, the results indicate a material-origin effect on the structural parameters governing heat resistance, suggesting distinct mechanisms of thermal behavior and highlighting which properties should be considered most influential when comparing different fibre-based materials.

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Keywords: thermal resistance, material, modeling, fibrous, structure

Polyethyleneimine-directed GaN-Au hybrid nanoarchitectures for high-performance electrochemical sensing interfaces

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The design of hybrid nanomaterials that combine structural stability, tunable surface chemistry, and efficient electron-transport pathways is central to advancing next-generation electrochemical interfaces. Herein, we report the preparation and physicochemical/electrochemical evaluation of a polymer-directed gallium nitride-gold (GaN-Au) hybrid nanoarchitecture obtained via polyethyleneimine (PEI)-mediated assembly. Branched PEI plays a multifunctional role: it disperses and stabilizes GaN nanoparticles in aqueous media, creates an amine-rich reactive interphase, and directs the *in situ* nucleation and controlled growth of Au nanoparticles on the GaN surface.

Systematic variation of the Au(III) precursor permitted precise tuning of gold loading while preserving colloidal stability. Dynamic light scattering and ζ-potential measurements showed that intermediate precursor amounts yield optimized dispersions with reduced hydrodynamic diameters and strongly positive surface charge, consistent with compacted polymer shells and minimized aggregation. UV-vis spectroscopy confirmed Au nanoparticle formation via a localized surface plasmon resonance band at 520-525 nm, while limiting the red-shift and band broadening associated with interparticle coupling. These results highlight the importance of polymer-metal coordination and nucleation kinetics in controlling nanoscale organization and dispersion quality.

Scanning transmission electron microscopy provided direct evidence of nanoarchitectures composed of ~100 nm GaN cores decorated with ~5 nm Au nanoparticles, generating a high density of discrete conductive nanodomains attached to a chemically robust semiconductor scaffold.

The presented GaN-PEI-Au platform constitutes a modular interface in which each component contributes complementary functionality: GaN provides chemical stability, mechanical rigidity, and favorable electronic properties; PEI ensures electrostatic stabilization, surface functionalization, and efficient metal-ion coordination; and Au nanoparticles form conductive nanojunctions that accelerate heterogeneous electron transfer. The synergistic coupling of semiconductor support, polymer interphase, and metallic nanodomains yields a robust conductive network with increased electroactive surface area and enhanced interfacial charge-transfer kinetics.

When applied as a drop-cast coating on gold electrodes, the hybrid material noticeably amplified electrochemical oxidation signals compared to bare and non-metallized interfaces. This enhancement is attributed to increased nanoscale roughness, higher active-site density, adsorption promoted by the amine-rich interphase, and efficient electron transport through Au nanodomains. Calibration studies demonstrated a linear analytical response from the nanomolar to micromolar range with stable baselines under repeated measurements, confirming mechanical integrity and electrochemical robustness.

The presented GaN-PEI-Au concept offers a versatile platform for developing stable, high-response, and structurally tunable nanostructured interfaces for electrochemical technologies.

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Study of silver reduction with medicinal plant extracts and of their cytotoxicity and antimicrobial properties

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To increase the biocompatibility of silver nanoparticles and improve their antimicrobial properties, some medicinal plants were used as green reductants, being chosen for their antioxidant capacity and low cost. Optimization of the synthesis conditions was followed by the characterization of the microstructural properties (by transmission electron microscopy, energy dispersive X-ray spectroscopy, as well as dynamic light scattering), which revealed good crystallinity and granulation. The study of the optical and spectral properties (by dark-field microscopy, UV-Vis spectra and FTIR) revealed the appearance of the characteristic band due to the LSPR (Localized Surface Plasmon Resonance) phenomenon specific to nanostructured noble metals and the chemical modification of the surface of the nanoparticles, which ensures the stability of the prepared suspensions. The antimicrobial activity was demonstrated on standard Gram-positive and Gram-negative germs through microbiological tests that allowed the measurement of the zones of inhibition of microbial growth, the minimum inhibitory concentration and the minimum bactericidal concentration which suggested their usefulness in the case of possible antibiotic-resistant microbial strains. Given that the fate of nanoparticles after the applications in which they are used is determined by their release into the environment, a study was carried out on their nanotoxicity through cytogenetic investigations that revealed chromosomal changes in the plants in the environment. The results suggest the continuation of experiments to synthesize new silver nanoparticles with various biomedical applications.

SANS investigation on irradiated reactor vessel steels

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The high ernergy neutron irradiation (>1MeV) changes the mechanical properties of structural materials These changes in microstructure are takes place in three different ways, i.e. the additional componets are dissolved in the lattice structure, migrate to the grain boundary and create dislocations. Precpitates can be nano sized and their sizes strongly affects to the reactor material's mechanical feature. Because of this the investigation of nanoclusters are important.

The macroscopical mechanical properties and their changes are due to irradiation are strongly affected by chemical composition of steel. It is well known tha some additional componenst (Cu, Ni, Mn) are the base of precipitation and increase the sensitivity of steels against the radiation damage. In order to investigate these feature a SANS investigation has been carried out on the neutron irradiated reactor vessel steel samples, in order to determine the material embrittlement rate. The quantity of the precipitation in the range of 0.5-10 nm measured. The specimens had been irradiated in the HFR reactor in Petten, the irradiation temperature was 286°C, the nominal fluency was 11.1×10^{23} $n.m^{-2}$ (E>1MeV).

Non-irradiated samples were used as reference, to separate the precipitates created during the steel production. The measurement carried out at the small angle scattering facility of the Budapest Research Reactor. The purpose was to determine the radiation damage of the reactor vessel steels in function of Ni and Mn content.

These results shown that Ni and Mn are creating 1.2-1.4nm diameter stress centres during irradiation. The result achieved by inverse Fourier transformation of SANS scattering pattern.

Cobalt-based catalysts for electrochemical water splitting

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Electrochemical water splitting represents an effective route for sustainable hydrogen production, motivating the development of efficient and economical electrocatalysts. In this work, cobalt–phosphorus (Co–P) and cobalt–boron (Co–B) coatings were prepared as non-precious metal catalysts for the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) in alkaline media. Co–P coatings were deposited on copper substrates via an electroless deposition method using sodium hypophosphite as the reducing agent, while Co–B coatings were synthesized under similar conditions employing morpholine borane as the reducing agent. The surface morphology and elemental composition of the catalysts were examined by scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), and inductively coupled plasma optical emission spectroscopy (ICP-OES). Their electrocatalytic activities were evaluated by linear sweep voltammetry (LSV) in 1 M KOH solution. Among the investigated cobalt-based catalysts, the Co–P coating containing 11 wt% P showed the highest HER activity, delivering a current density of 10 mA cm^{-2} at an overpotential of approximately 115 mV. For OER, the Co–P coating with 8 wt% P exhibited the best performance, requiring an overpotential of approximately 391 mV to achieve 10 mA cm^{-2}. These results demonstrate the significant influence of phosphorus content on catalytic behavior and highlight the potential of Co–P and Co–B coatings as cost-effective, bifunctional electrocatalysts for alkaline water splitting.

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Gold nanoparticle–modified nickel–rhenium alloy coatings as advanced anode materials for sodium borohydride–water reduction fuel cells

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Sodium borohydride ($NaBH_4$) is considered a promising alternative fuel for direct liquid fuel cells due to its high energy density and convenient handling. The development of efficient electrocatalysts for the borohydride oxidation reaction (BOR) is therefore of considerable interest. In this study, flexible nickel–rhenium (Ni_xRe_y) binary alloy coatings were successfully deposited onto stainless-steel mesh substrates (denoted Ni_xRe_y/SS) using a simple and cost-effective electroless deposition method with sodium hypophosphite as the reducing agent. To further enhance catalytic performance, the Ni_xRe_y/SS electrodes were modified with gold nanoparticles via a galvanic displacement method, yielding AuNPs–Ni_xRe_y/SS catalysts. The morphology, structure, and chemical composition of the prepared catalysts were characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), and inductively coupled plasma optical emission spectroscopy (ICP-OES). The electrocatalytic activity and stability toward BOR in alkaline media were evaluated using cyclic voltammetry and chronoamperometry. In addition, the performance of a borohydride oxidation–water reduction fuel cell employing these materials as anodes/cathodes was assessed through polarization and power density measurements. Hydrogen evolution reaction (HER) at the cathode was used instead of oxygen reduction (ORR) to couple anode BOR for the concurrent electricity generation and hydrogen production. The AuNPs–Ni_xRe_y/SS catalysts with varying gold loadings exhibited significantly enhanced electrocatalytic activity and stability compared to both bare Ni_xRe_y/SS and pure Au electrodes. The improved performance is attributed to the synergistic interaction between Au nanoparticles and the Ni_xRe_y alloy. These findings demonstrate that AuNPs–Ni_xRe_y/SS catalysts are promising flexible anode materials for high-performance BOR–HER fuel cells.

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Radioprotective potential of Aryl-hydrazone derivative on synthetic phospholipid

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The integrity of cellular membranes is highly susceptible to radiation-induced damage. Synthetic phospholipids are well-established and widely used model systems for investigating simplified physical cell models. They provide a highly controllable environment to study fundamental interactions between the membrane matrix and various embedded inclusions or environmental factors. In this context, aryl-hydrazone derivatives are investigated as potential membrane stabilizers against oxidative stress induced by slow neutron irradiation. To assess these effects, Differential Scanning Calorimetry (DSC) and Infrared Spectroscopy (FTIR) were employed, as they represent classical and well-proven biophysical methods for monitoring phase transitions and molecular order in lipid systems.

ASIF: Italy's national space irradiation network for radiation effects testing and component qualification

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The space radiation environment — encompassing trapped particles in the Van Allen belts, solar particle events, and galactic cosmic rays — poses severe challenges to electronic components and onboard systems. As device geometries shrink and functional integration increases, susceptibility to radiation-induced failures such as Total Ionizing Dose (TID), Total Non-Ionizing Dose (TNID), Single Event Effects (SEEs), latch-up, burnout, and cumulative degradation becomes increasingly critical. Reliable access to well-characterized ground-based irradiation facilities is therefore essential for space mission success.

ASI Supported Irradiation Facilities (ASIF) addresses this need through a nationally coordinated, multi-particle, multi-energy network operating under common access rules, shared data standards, and quality assurance procedures aligned with ESA/ECSS/ESCC requirements. Active since 2015, ASIF federates Italy's leading irradiation infrastructures through a distributed network model, ensuring comprehensive coverage of particle types and energy ranges, complementarity and redundancy in testing capabilities, and scalability for future facility integration.

The ASIF network encompasses a broad portfolio of irradiation sources. A ^{60}Co gamma source (up to ~5 kGy/h) covers TID qualification; a neutron generator and two research reactors support TNID, SEE, and displacement damage studies; an electron linac up to 5 MeV enables TID testing and functionalization for quantum technology development; and a proton linac (7–71 MeV) is dedicated to SEE and TID investigations. Light and heavy ion beams up to hundreds of MeV allow SEE testing with micrometric resolution mapping, while high-energy electron beams (300–750 MeV) support displacement damage studies and functional testing and calibration of advanced detectors. Clinical-range proton beams (70–230 MeV) complete the portfolio for component and sensor qualification. A dedicated web portal — the ASIF Gateway — provides unified user access, technical support and computational modelling tools, including SR-NIEL, HelMod, and GeoMagSphere.

A key current application is the EU-funded ACDC_Q project, in which one of the network facilities supports the optimisation of nitrogen-vacancy centres in diamond for quantum magnetometry in the space environment, demonstrating ASIF's capability to enable the qualification of cutting-edge technologies beyond conventional space electronics.

ASIF's distributed architecture, combined with harmonised dosimetry, real-time diagnostics, and coordinated multi-facility test campaigns, delivers performance comparable to large centralised irradiation centres, while advancing Italy's technological autonomy and supporting international research on radiation effects for space applications.

Hydrogels: Past, present, and future perspectives with advances in swelling kinetics, drug delivery and field-assisted processes

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Hydrogels have been extensively studied over the past decades due to their unique physicochemical properties, including high water content, tunable structure, and responsiveness to external stimuli. These materials have found widespread applications in biomedicine, environmental engineering, and advanced material systems.

This work provides a comprehensive overview of the evolution of hydrogel research, from early developments to current trends and future perspectives. Particular emphasis is placed on recent advancements in modeling and process understanding, including improved descriptions of swelling kinetics beyond conventional approaches. Novel modeling strategies are discussed in terms of their ability to more accurately capture diffusion, relaxation, and coupled transport phenomena.

In the field of drug delivery, new modeling frameworks are highlighted that enable more reliable prediction of release kinetics under complex conditions. In addition, dehydration processes are addressed as an emerging and increasingly relevant research area, particularly in relation to hydrogel stability and performance.

Special attention is given to hydrogel synthesis under non-conventional conditions, including microwave- and ultrasound-assisted methods. The influence of external fields, such as microwave (MW) and ultrasonic (US) irradiation, on swelling behavior and drug release kinetics is critically analyzed, with emphasis on enhanced transport rates and structural modifications induced by these fields.

Looking toward future trends, hydrogels are expected to play an increasingly important role in environmental protection, energy-related applications, and advanced functional systems, including batteries and solar technologies. Emerging directions also include their potential use in gas adsorption and separation processes, as well as in radiation-related applications such as shielding, sensing, and radioactive waste management, bridging soft matter science with emerging energy and radiation technologies.

Finally, the contribution of the author's research to these advancements is outlined, particularly in the development of extended kinetic models and field-assisted processing approaches. The presented overview identifies key challenges and future directions for the design of next-generation hydrogel systems with improved functionality and predictive modeling capability.

Functional biopolymer hydrogels based on carrageenan and gellan gum with encapsulated thyme oil for controlled release applications

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Biopolymer-based hydrogels are increasingly explored as functional materials for biomedical and cosmetic applications due to their biocompatibility, biodegradability, and tunable physicochemical properties. In this study, hydrogel films based on carrageenan and gellan gum were developed as carriers for encapsulated thyme essential oil, aiming to obtain systems with improved stability and controlled release of bioactive compounds.

Thyme oil, known for its antimicrobial and antioxidant activity, was encapsulated using β-cyclodextrin to enhance its stability and reduce volatility. The obtained microcapsules were incorporated into hydrogel matrices prepared at different carrageenan/gellan gum ratios, with sorbitol as a plasticizer. The materials were further crosslinked using calcium ions to improve structural integrity.

The resulting hydrogel films were characterized in terms of morphology (SEM), swelling behavior, stability, mechanical properties, and chemical structure (ATR-FTIR). The incorporation of encapsulated oil influenced the matrices' microstructure, resulting in heterogeneous but well-integrated systems, depending on the polymer composition. The carrageenan–gellan system with balanced polymer ratios exhibited the most favorable structural and functional properties.

Biological evaluation demonstrated that the developed materials were non-cytotoxic and exhibited antibacterial activity against selected strains, confirming their potential as active biomaterials. The results indicate that combining biopolymer hydrogels with encapsulated essential oils is a promising strategy for designing multifunctional materials with controlled release properties.

The study of the pharmacokinetics and contrast properties of gadolinium-based nanoparticles using the methods of neutron activation analysis and photon-counting CT: R&D project of JINR

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The report presents a joint interlaboratory project on the study of the pharmacokinetics and contrast properties of gadolinium-based nanoparticles, carried out within the framework of R&D program of Joint Institute for Nuclear Research. The nanoparticles under study have been developed and synthetized by Department of Chemistry of Lomonosov Moscow State University as potential contrast agents for photon-counting computed tomography and MRI. Neutron activation analysis was used to assess the migration and accumulation of nanoparticles in the organs of small laboratory animals. The contrast properties of the nanoparticles were studied using the SARRP facility and experimental facility for X-ray spectroscopy. Behavioral responses and toxicity were evaluated in accordance with standard histological procedures. The presented project demonstrates a set of methods that can serve as a basis for external collaboration aimed at exploratory pilot studies of new contrast agents, metal-containing compounds, and nanoparticles.

The accumulation and pharmacokinetics of the particles differed significantly depending on their size, structure, shell characteristics, and hydrophilic properties. Apparently, migration within the body occurred primarily via lymphatic drainage and transport within macrophages. Within the framework of the project, optimal CT scanning parameters were determined for both standard (energy-integrative) and photon-counting CT.

MRI monitoring in ovarian endometrioma – From physicist to radiologist: A case presentation

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This study presents the case of a patient with an ovarian endometrioma who underwent serial MRI examinations over a one-year period. Using a dual physicist-radiologist approach, the study highlights the value of integrating technical expertise with clinical interpretation.

Physicist perspective. In this case, particular attention was given to maintaining consistency in MRI equipment and acquisition parameters, as technical variations may mimic or obscure true pathological changes. Variations in field strength, sequence parameters, or signal-to-noise ratio (SNR) may modify image contrast on conventional and advanced MRI sequences potentially influencing the apparent cyst size without representing actual disease progression. Furthermore, spatial resolution plays a critical role in volumetric assessment and accurate lesion delineation, directly impacting measurement reproducibility over time.

Radiologist perspective. Under standardized imaging conditions, the right ovarian endometrioma demonstrated a marked volumetric increase compared with the prior examination. Despite this significant growth, the lesion preserved stable signal characteristics across all sequences. No mural nodules, solid components, diffusion restriction, or pathological post-contrast enhancement were identified. These findings support benign progression of a known endometrioma in the absence of imaging features suggestive of malignant transformation.

In conclusion, this work emphasizes that a solid understanding of how acquisition parameters affect image quality and quantitative consistency is fundamental for meaningful longitudinal assessment. When combined with careful clinical interpretation, these considerations contribute to more accurate and confident diagnostic evaluations.

Tomosynthesis as a dose-efficient modality with extended functional potential

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Digital tomosynthesis is rapidly developing as an intermediate imaging modality positioned between digital radiography (DR) and computed tomography (CT). From the perspective of radiation exposure and spatial resolution, tomosynthesis remains much closer to DR, while in terms of diagnostic sensitivity and 3D imaging it approaches certain capabilities of CT, particularly in the detection of overlapping structures and subtle contrast variations.

This balance makes tomosynthesis highly consistent with the ALARA principle. By providing quasi-three-dimensional information at a significantly lower radiation dose compared to CT, it enables improved visualization without proportionally increasing patient exposure. In clinical practice, this advantage has primarily been exploited for structural assessment.

However, the informational potential of tomosynthesis projections is not yet fully utilized. During acquisition, a sequence of angular projections is recorded over a limited arc. In thoracic imaging, these projections inherently contain temporal variations associated with physiological motion, including cardiac activity. Traditionally, such motion is considered a limiting factor or a source of artifacts. Nevertheless, it may also represent an additional diagnostic signal embedded within already acquired data.

If projection data are analyzed not only for structural reconstruction but also for inter-projection intensity variations, it becomes possible to extract information related to cardiac mobility without increasing radiation dose or modifying the acquisition protocol. In this context, tomosynthesis may provide complementary functional insights alongside anatomical information.

Such an approach directly aligns with the ALARA principle: maximizing diagnostic yield from already acquired data instead of increasing exposure. The concept is based on reinterpreting existing projection sequences as a source of dynamic information rather than solely as input for slice reconstruction.

Therefore, tomosynthesis should be viewed not only as a structural imaging modality positioned between radiography and CT, but also as a platform with underexplored functional capabilities. Expanding the analytical use of projection datasets may further enhance its clinical value while maintaining dose efficiency.

Digital tomosynthesis for chest screening application

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Tomosynthesis mammographs are currently the "gold standard" for breast cancer screening. They combine high diagnostic sensitivity with a low dose rate.

Tomosynthesis is equally suitable for chest screening. However, there are significant differences between mammography screening and chest screening. First and foremost, there are the screening targets. For countries with a high standard of living, screening is primarily aimed at detecting lung cancer in smokers. This requires a small-scale screening, which can be accomplished using a network of expensive, low-dose LDCT scanners.

For countries with middle and low standards of living, there is a risk of tuberculosis epidemics. The fight against tuberculosis requires mass screening using relatively inexpensive equipment. Traditional use of roentgenographic chest X-ray machines is currently ineffective due to low diagnostic sensitivity, which ranges from 0.3 to 0.4 relative to the CT scan at the early stage of the disease. At the same time, using CT scans for mass chest screening is not economically feasible. Such CT screening is also unjustified due to its non-compliance with the ALARA principle, as it is diagnostically excessive. Therefore, for countries with medium and low living standards, the use of tomosynthesis in chest X-ray screening, with a diagnostic sensitivity of 0.8 to 0.9 and a dose load of 0.1 relative to the CT scan, is arguably the "gold standard" of screening. This is consistent with the ALARA principle. There is another reason to have a large network of chest tomosynthesis machines for screening in countries with both high and low living standards: viral lung epidemics. Experience with the COVID-19 epidemic has shown the low effectiveness of chest X-rays in detecting the disease. Only CT scans and tomosynthesis machines were reliable diagnostic tools. CT scanners had waiting lists of over a week. Patients underwent 3-4 CT scans per week during treatment. This created conditions for the development of tumors due to X-ray exposure.

Tomosynthesis is the best screening solution among the currently available diagnostic methods. Thus, the experience of the last decade using chest-screenning X-ray methods indicates the end of the era of radiology imaging. A transition from X-ray radiology imaging to tomosynthesis, which has a diagnostic sensitivity 2-3 times greater than radiology X-ray imaging, is necessary. Due to the dose burden being significantly lower than the threshold of 1 mSv per examination, this opens up broad prospects for the use of tomosynthesis in screening networks.

A versatile low-dose organ-targeted PET platform for cancer and neurological imaging

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One of the primary barriers to the widespread clinical adoption of Positron Emission Tomography (PET) is the significant radiation exposure associated with whole-body (WB) PET/CT scans, as well as their limited spatial resolution. Here we report on the Radialis low-dose organ-targeted PET technology, specifically designed to overcome these limitations and to serve a range of emerging clinical tasks in diagnostic and therapeutic settings.

The Radialis PET employs two planar SiPM (Silicon Photomultipliers)-based detector heads with adjustable separation and rotational capability, allowing them to be positioned directly adjacent to an organ of interest on both sides. This geometry enhances solid angle coverage of the organ while minimizing unwanted signals from surrounding body areas. The combination of geometric efficiency with high-yield scintillation crystals and ASIC-based SiPM signal readout delivers superior detectability of small lesions (with a demonstrated in-plane spatial resolution of 1.3 mm and a 3D reconstructed spatial resolution of 3 mm) while enabling a tenfold reduction in the administered radiotracer activity compared to commercial WB PET scanners. Compared to other organ-dedicated PET systems with similar spatial resolution, the Radialis camera demonstrated improved contrast recovery and spill-over ratio, attributed to optimized count rate performance and image reconstruction workflow. The technology supports low-dose imaging of multiple organs including the breast, brain, prostate, and extremities.

Clinical breast imaging results demonstrate the system's capability in visualizing abnormal metabolic tissue across multiple cancer types. The system identified false-negative X-ray mammography and false-positive MRI findings at 1/10 of a standard dose of ^{18}F-FDG (2-deoxy-2-[^{18}F]fluoro-D-glucose) radiotracer. Its ability to reconstruct 3D metabolic volumes based on tissue uptake thresholds makes it well-suited for image-guided assessment of response to neoadjuvant systemic treatment (NST) in lesions smaller than 2 cm. Early results further indicate that, with detectors repositioned around the head, the same system enables clinical brain imaging with a 12-angle step-and-shoot acquisition protocol and fully 3D brain image reconstruction, extending its clinical utility to neurological applications.

Insights into the physics and imaging of BNCT: A Monte Carlo approach

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Purpose: Boron neutron capture therapy (BNCT) is biologically selective, but its clinical accuracy is limited by the inability to measure the spatial distribution of boron-capture reactions during irradiation. Current boron assessment relies mainly on blood sampling, pharmacokinetic assumptions, PET-based boron uptake estimation, and treatment-planning neutron-flux calculations. These methods provide important pre-treatment information but do not directly image the in-field reaction distribution. This work reviews the imaging gap in BNCT and proposes a Monte Carlo and Compton-camera imaging framework to reconstruct reaction gammas from neutron capture using extended back-projection (EBP).

Methods: A Geant4-based simulation workflow is developed to model neutron irradiation of boron-loaded tissue and head-phantom geometries. Spatially varying boron-10 concentrations is assigned to tumor and normal tissues to generate a ground-truth neutron-capture reaction map. The principal imaging signal is the 478 keV gamma emitted following the boron-10 neutron capture reaction. A Compton-camera detector is modeled to record interaction position and deposited energy. Detected events are reconstructed using EBP and compared with the simulated reaction map.

Results: This work identifies a clear translational opportunity: BNCT requires in vivo verification of the boron-capture reaction distribution, while Compton-camera-based gamma imaging and Monte Carlo modeling provide a pathway to non-invasive reaction monitoring. The BNCT problem shifts the imaging target from a beam-range surrogate to a reaction-rate distribution governed by neutron fluence, boron concentration, and capture probability. The proposed framework may quantify gamma yield, detection efficiency, reconstructed hotspot localization, kernel based spatial resolution, and sensitivity to boron tumor-to-normal concentration ratio. These outputs potentially support selection of detector geometry and reconstruction parameters for 478 keV reaction-gamma imaging.

Conclusion: A EBP-based Compton-camera framework for BNCT reaction-gamma imaging may provide a practical route toward treatment verification by directly reconstructing the spatial distribution of boron-capture events. This work provides the basics for optimizing detector geometry and image reconstruction for future patient-specific BNCT monitoring.

Pits and pitfalls with Gafchromic film dosimetry

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Introduction: Radiochromic films produce permanent visible colour change when irradiated. The desirable characteristics of radiochromic film include: sensitivity to ionizing radiation, ease of use, tissue equivalence, no dose-rate dependence, no light dependence, environmentally stable, rugged, of a reasonable size and not too thick, as well as a uniform response to radiation over the whole film.

Method and Materials: Gafchromic EBT2 film was used in this study. Film calibration was done using doses from 0.1 – 5 Gy, with at least 8 data points per calibration. Density values were extracted from the red colour channel of the film, scanned on a 48-bit scanner.

Inconsistencies in dosimetric testing were investigated. These include: different optical densities when different scanners were used; differences in optical densities between portrait and landscape mode scanning for the same film; film response over time; dependence on positioning of the film on the scanning surface.

Results: Significant differences were observed in optical densities when different scanners were used. Scanning the film in portrait mode reduced the greyscale value by an average of 9.0 % when compared to the landscape mode. Post-irradiation darkening was observed with time. Scanning one film at 11 different time-points over 166 hours post irradiation indicated that the most significant contributor to relative response was if the scanner had warmed up or not. Relative responses with different film scanning positions on the scanner bed varied from 0.991 – 1.026.

Conclusion: Gafchromic film dosimetry can be a very useful tool in radiotherapy. Film must be scanned on the same scanner, at the same position, under the same conditions and at the same time post-irradiation as the calibration films, to reduce uncertainties.

The impact of high dose rate and detector volume on beam profile acquisition: A comparative study of continuous and step-by-step dosimetry for WFF and FFF beams

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Precise beam characterization is of fundamental importance to the realm of radiotherapy Quality Assurance (QA). In the context of the escalating clinical utilization of Flattening Filter Free (FFF) beams, which proffer considerably elevated dose rates, the selection of data acquisition mode — namely, continuous scanning (CONT) versus step-by-step (STEP) — assumes paramount importance. It is important to note that higher dose rates may have a detrimental effect on the temporal resolution of the scanning system and the stability of the detector response.

The objective of this study is to evaluate the dosimetric equivalence of CONT and STEP acquisition modes. The investigation will focus on the interplay between detector volume and beam delivery characteristics (WFF vs. FFF).

The measurements were conducted at the Provincial Integrated Hospital in Płock with the use of a Varian TrueBeam accelerator and an IBA BluePhantom2 water tank. The analysis focused on three beam energies: 6 MV, 15 MV (600 MU/min), and 6 MV FFF (1400 MU/min). Four detectors with varying active volumes were utilized: The following values are to be considered: CC13 (0.13 cm^3), CC04 (0.04 cm^3), Razor (0.011 cm^3), and Razor Nano (0.003 cm^3). A range of field sizes was encompassed in the study, with profiles acquired for areas ranging from 4×4 cm to 40×40 cm. Key parameters, including penumbra width, flatness, and symmetry, were extracted in accordance with IAEA TRS-395 protocols using a bespoke Python tool. The statistical validation was conducted by applying a 1D Gamma Index (1%/1 mm).

The study demonstrates that, while continuous scanning is a time-efficient solution, its accuracy is dependent on a synergistic combination of detector type, scanning speed, and beam dose rate. The results of the study provide optimized QA guidelines for both conventional and high-dose-rate stereotactic beam deliveries.

Independent dose verification in HDR brachytherapy: A comparative evaluation of Mobius3D and treatment planning systems for gynecological applications using the BrachyVision

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The delivery of precise doses is of fundamental importance to the safety and efficacy of High Dose Rate (HDR) brachytherapy. In the context of the increasing complexity of Image-Guided Adaptive Brachytherapy (IGABT), the implementation of a robust independent dose verification system (secondary dose check) assumes paramount importance to mitigate potential errors within the Treatment Planning System (TPS) or during data transfer. Conventional manual point-dose calculations are being superseded by automated, software-based systems that facilitate efficient point-by-point analysis at specific anatomical coordinates. It is imperative to emphasise that the reliability of such systems must be rigorously validated against established clinical standards and physical formalisms.

The objective of this study is to evaluate the dosimetric accuracy and clinical utility of the Mobius3D system (v4.0.2) as a tool for automated, independent Quality Assurance (QA) in gynecological HDR brachytherapy. The investigation focuses on the dosimetric agreement between doses calculated in the Eclipse TPS (v18.0, Brachytherapy Planning) and Mobius3D independent verifications for plans executed on the Bravos afterloading system.

The study utilised a cohort of clinical treatment plans for patients with gynecological malignancies, treated with a GammaMed Plus HDR source (Varian Medical Systems) and various gynecological applicators. Independent dose calculations in Mobius3D were performed based on the AAPM TG-43 formalism, which serves as the physical foundation for Ir-192 source modelling. A series of reference points, encompassing both target volumes and Organs at Risk (OARs), were analysed in order to assess dosimetric consistency. All evaluations were conducted in accordance with GEC ESTRO recommendations. The statistical validation process entailed the calculation of the mean percentage difference, the standard deviation (SD), and the distribution of deviations within the established clinical tolerance thresholds of 3% to 5%.

The study demonstrates that Mobius3D provides a highly reliable platform for independent plan verification. For the group that was analysed, the mean percentage difference between TPS and Mobius3D was -2.59% (SD = 0.94%), with a maximum recorded deviation of 4.18%. It is noteworthy that the majority of the points fell well within the 3% tolerance limit, with 100% of the evaluated points remaining within the 5% threshold that is generally considered to be within the bounds of clinical acceptability. These results indicate a high level of consistency between the secondary calculation engine and the primary TPS.

The findings indicate that while minor systematic deviations exist, they remain well within international safety standards and are consistent with recent literature reporting on secondary dose check systems. The automation of the QA process using Mobius3D has been demonstrated to engender significant time efficiency and enhanced patient safety, thus providing a robust framework for routine clinical quality assurance in adaptive gynecological brachytherapy.

Impact of source orientation on cellular-scale dose distribution in high-dose rate brachytherapy

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In high-dose rate (HDR) brachytherapy, the investigation of angular dose distribution becomes important due to the complexity of the source encapsulation and internal geometry. Although macroscopic dosimetric characteristics have been widely reported, dose heterogeneity at the cellular scale remains a critical factor for radiobiological response assessment. Such small-scale dose perturbations can have significant implications for radiobiological modeling and the refinement of precision treatment planning.

The aim of this work is to investigate how the orientation of the source influences microscopic dose deposition using the Geant4 Monte Carlo simulation toolkit. A Flexi-type Iridium-192 cylindrical source, together with its AISI 316L stainless steel encapsulation, was modeled in this simulation. The source was placed at the center of a water-equivalent phantom. The low-energy electromagnetic physics models were activated to describe photon transport in the energy range relevant to HDR brachytherapy. Simulations were carried out for three source orientations—0° (longitudinal), 45° (tilted), and 90° (horizontal) using 2×10^7 primary particle histories. Two-dimensional isodose distributions and axial dose profiles were obtained and analyzed for these source orientations. The results show orientation-dependent dose heterogeneity around the source, characterized by asymmetric high dose regions.

Histopathological validation of high-frequency ultrasound imaging of cutaneous melanoma: methodological justification

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Introduction: Cutaneous melanoma is a malignant tumor associated with a high risk of both lymphatic and hematogenous metastasis, which is a negative prognostic factor for affected patients. Although melanoma accounts for only about 1% of all skin cancers worldwide, it is responsible for more than 80% of skin cancer-related deaths, largely due to delayed or inaccurate diagnosis. Given the increasing incidence of melanoma, particularly among fair-skinned individuals (Fitzpatrick skin phototypes I–II), timely and accurate diagnosis, including reliable preoperative assessment of tumor characteristics, is of critical importance for selecting the optimal treatment strategy.

Objectives: High-frequency ultrasound (HFUS) is a non-invasive and safe imaging modality that enables preoperative assessment of tumor invasion depth and skin architecture. The aim of this study was to evaluate the diagnostic performance of high-frequency ultrasound using a 20–22 MHz probe for the preoperative visualization and assessment of cutaneous melanoma and to validate the findings by comparison with histopathological examination (HPE) data, recognized as the reference standard. Specifically, the study evaluated the performance of a linear ultrasound probe with a frequency range of 10-22 MHz on the General Electric LOGIQ E R8 (USA) system, in comparison to the 22 MHz DUB Skinscanner (Germany), for determining tumor invasion depth.

Materials and Methods: Ultrasound examinations were performed in 22 patients using the DUB ultrasound system, while 68 examinations were conducted using the GE ultrasound system. The primary objective was to compare the frequency of cases in which the ultrasound-based diagnosis did not coincide with the histopathological examination (HPE) results, with complete concordance between HFUS and HPE considered the desired outcome. Histopathological examination is considered the reference method (gold standard) for diagnostic verification, particularly when assessing the accuracy of diagnostic modalities such as ultrasound.

Results: A total of 90 patients with dermoscopically suspected melanoma were examined. The results of preoperative HFUS obtained using two systems (GE and DUB) were validated against HPE data. Frequency analysis showed that for the DUB ultrasound system, the incidence of discrepancies between ultrasound and HPE data was 63.6% (95% CI: 42.9%-80.3%), while for the GE ultrasound system this figure was significantly lower –14.7% (95% CI: 8.2%-25.0%). To assess the strength of the association between particular HFUS use and the likelihood of detecting differences, the odds ratio (OR) was calculated. The odds of discrepancies between HFUS and HPE based diagnoses were 10.1 times higher when using the DUB ultrasound system than when using the GE ultrasound system (OR 95% CI: 3.4-30.4). Additionally, the study established the statistical correlation between HFUS and histopathological findings, to justify the integration of HFUS into clinical diagnostic algorithms for melanoma as a non-invasive tool for preoperative assessment. The analysis showed that the Spearman rank correlation coefficient between the data obtained on GE ultrasound system and HPE data is 0.929 ($p<0.001$), which indicates a very strong relationship between the studied variables, even in the case of possible deviations of the data distribution from the normal law. Based on the results of the biostatistical analysis, the GE ultrasound system demonstrated a high level of concordance with histopathological reference data. These findings support the incorporation of high-frequency ultrasound into the diagnostic algorithm for patients with cutaneous melanoma as a non-invasive and informative method for preoperative evaluation.

An estimation of the outfield patient exposure during radiotherapy for painful shoulder tendonitis measured using TLDs: A preliminari study on a single patient

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Introduction: Radiotherapy is an accepted treatment for several inflammatory, proliferative and degerative benign muscle-skeletal diseases, such as inflamed bursa (bursitis), calcified or inflamed tendon (tendonitis), etc. when other methods fail. The therapy dose is low in a range 6-10 Gy applied in 6-10 fractions, two to three times per week using an ortovoltage X-ray therapy unit (energy range 240-300 keV) or conformaly at a linear accelerator (6 MeV maximum photon energy).

Material and methods: The patient aged 66 years, high 168 cm, with an averaged constitution was irradiated at the Institute for Oncology and Radiology of Serbia for painful inflamed and calcified tendon in right shoulder using X-strahl ortovoltage unit (United Kingdom), celling mounted. Total dose of 6 Gy (1 Gy per fraction, every other day) was applied using two opposite 10x10 cm fields with energy of 300 keV.

Outfield equivalent dose (Hp10 and Hp3) was measured only at antero-posterior patient position using TLD-100 (Harshaw, England) placed in cassette holder and positioned near patient gonads (approximately 0,9 m from the unit cone end), and above right eye/lens (approximately 0,3 m from the unit cone end). The Harshaw manual reader 4000 was used for dose readings.

Result: Maximum equivalent dose registered was about 0,09 mSv (Hp10) per 1 Gy for patient gonads and 0,27 mSv (Hp3) per 1 Gy for right eye/lens, that was highly acceptable considering patient exposure safety. However, outfield dose could slightly vary with energy applied, treatment field area, patient constitution, patient position and treatment room design, since scatter component is predominant.

Advancing real-time light dosimetry in interstitial photodynamic therapy of prostate cancer

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Photodynamic therapy (PDT) is a promising minimally invasive approach for cancer treatment. It is based on the interaction between three components – light, a photosensitizing (PS) drug, and oxygen – whose combined action generates cytotoxic singlet oxygen and leads to tissue destruction. While none of these components is harmful on its own, their interaction determines the treatment efficacy. The goal is to cause cell death only in malignant tissue, and it is necessary to spare the surrounding healthy tissue. In interstitial PDT of prostate cancer with PS verteporfin, the drug is administered intravenously, oxygen is naturally present in tissue, and light is delivered through optical fibers inserted into the targeted region. Light delivery can be monitored in real time, which has already been applied in clinics. However, complete feedback requires not only information on delivered light dose and tissue absorption, but also knowledge of the spatial distribution of the PS concentration and the level of tissue oxygenation.

Prostate cancer is the most common cancer among men in the "western world" (around 600 000 cases are diagnosed annually in European Union and United States of America combined). Although the established treatment methods achieve high cure rates, they often lead to adverse effects by damaging surrounding organs and tissues. PDT provides a targeted, minimally invasive alternative. To fully exploit its potential, real-time information about the key quantities for light dosimetry is needed to adapt the treatment to patient-specific conditions, enabling more personalized and effective therapy.

In this work, we focus on real-time monitoring of the PS distribution during interstitial PDT of prostate cancer. We present models and methods based on diffuse fluorescence tomography (DFT), which exploits fluorescence emitted by the PS upon excitation with visible or near-infrared light (in our case around 690 nm, in the so-called “therapeutic optical window”, and matching the PS verteporfin absorption peak). Interstitially placed optical fibers, inserted into prostate tissue through brachytherapy needles, are used to deliver and collect light, enabling tomographic measurements. From detected signals at the excitation and fluorescent wavelengths, by solving the inverse problem of diffuse optical tomography (DOT), we can estimate the spatial distribution of the PS drug concentration, in real time during treatment.

To validate our developed mathematical models and computational reconstruction algorithms and evaluate their performance, we developed tissue-mimicking phantoms for laboratory experiments. Phantoms mimicking human prostate in shape, size, and optical properties, contained the fluorescent PS verteporfin. The accuracy and robustness of the proposed reconstruction methods were evaluated in different scenarios in numerical simulations and in laboratory experiments using phantoms with various concentrations and sizes of fluorescent PS inclusions. The experiments demonstrate that the quantitatively accurate DFT reconstruction of PS distribution is possible in realistic geometries using the clinical PDT system. This establishes an important step towards incorporating PS distribution monitoring into real-time PDT dosimetry.

Future work will extend these methods to include estimation of tissue oxygen saturation, using absorption measurements at wavelengths sensitive to haemoglobin oxygenation. By integrating information on light dose, PS distribution, and oxygenation, our long-term goal is to develop a comprehensive real-time feedback system for PDT, capable of supporting fully personalized prostate cancer treatments.

Application of thermoluminescent detectors based on garnet crystals for monitoring the activity of liquid radioactive sources

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This work demonstrates the application of Ce^{3+}-doped garnet crystals as effective thermoluminescent (TL) and optically stimulated luminescence (OSL) detectors for measuring the activity of liquid radioactive solutions of radiopharmaceuticals used in nuclear medicine at Oncology Centers in Bydgoszcz, Poland. The TL/OSL detectors were prepared from $Y_3Al_5O_{12}$:Ce (YAG:Ce) single crystals, with low density and effective atomic number (ρ= 4.5 g/cm^3, Z_{eff}= 35); $Gd_3Al_{5-x}Ga_xO_{12}$:Ce (x=2.5–3) (GAGG:Ce) crystals, with high density (ρ = 6.6–6.7 g/cm^3) and medium effective atomic number ($Z_{eff} \approx 52–54$); and $Lu_3Al_5O_{12}$:Ce (LuAG:Ce) crystals, with high density (ρ = 6.7 g/cm^3) and high effective atomic number (Z_{eff}=61).These garnet crystals, previously employed in radiotherapy applications at this Oncology Center [1, 2], also exhibit high chemical resistance to direct contact with liquids and vapours, including aggressive chemical agents, making them suitable for monitoring radioactive sources in nuclear medicine facilities.

The radiopharmaceuticals used in the experiments were ^{99m}Tc (a 140.5 keV γ-ray emitter for scintigraphy), ^{90}Y (a 2279 keV β-particle emitter for the treatment of liver cancers), and ^{223}Ra (a 5.78 MeV α-particle emitter for the treatment of prostate cancers), as well as mixed β and γ radiation from ^{177}Lu (β: 490 keV; γ: 113 and 208 keV, for the treatment of gastrointestinal tract and prostate cancers) and ^{153}Sm (β: 0.632, 0.702, and 0.805 MeV; γ: 103 keV, for the treatment of cancer pain caused by bone metastases).

Our results indicate that YAG:Ce detectors are most effective for detecting high γ-ray activities from ^{99m}Tc (29.6–2.3 GBq), whereas LuAG:Ce detectors, due to their higher density and effective atomic number, show superior sensitivity for medium and low activities (256–6.6 MBq), with YAG:Ce approaching background levels below ~70 MBq. Both crystals exhibited strong TL responses to β particles from ^{90}Y (19.6–6.2 MBq) and α particles from ^{223}Ra (2.23–2.13 MBq). Within the tested activity ranges, TL intensity both detectors correlated nearly linearly with source activity. The stability of TL signals during direct contact with liquid radioactive solutions confirms the chemical robustness and durability of these garnet crystals. Furthermore, LuAG:Ce detectors also displayed radiation-type-dependent TL glow-curve shapes, suggesting the potential to discriminate between γ, β and α-radiation using a single material.

Furthermore, all Ce^{3+}-doped garnet crystals possess strong OSL luminescence under infrared stimulation [3]. The best OSL properties were observed in GAGG:Ce crystals [3]. These findings demonstrate significant potential for YAG:Ce, GAGG:Ce, and LuAG:Ce detectors in radiopharmaceutical dosimetry and radiation monitoring in nuclear medicine using both TL and OSL methods.

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Effects of methylphenidate and caffeine on procrastination phenomenon in adults with ADHD

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Background: Adult attention-deficit/hyperactivity disorder (ADHD) remains far less studied than its childhood form, particularly regarding procrastination. Existing research has focused mainly on pediatric populations, leaving a major gap in understanding the efficacy and safety of stimulants in adults. Many adults with ADHD self-medicate with caffeine (CAF) or combine it with prescribed methylphenidate (MPH) in an attempt to enhance focus, motivation, and task initiation, yet this widespread practice has never been systematically investigated.

Methods: A two-week observational study including 75 men aged 18–55 years was conducted, assigned to control, MPH, or MPH+CAF groups (n=25 each). Participants completed daily diaries assessing attention, organization, memory, and state procrastination during everyday activities.

Results: MPH significantly improved attention, organization, and reduced procrastination compared to controls. The MPH+CAF combination further shortened task initiation delays and enhanced vigilance but was associated with a modest memory decline and higher frequency of activation-related adverse events.

Conclusions: This study provides the first systematic evidence on how methylphenidate and caffeine, alone or combined, affect cognitive performance and procrastination in adults with ADHD. Findings emphasize the need for individualized monitoring when considering combined psychostimulant use in clinical and everyday settings.

Injuries from industrial noise among metallurgical workers in Bulgaria

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Introduction: Sound represents mechanical vibrations transmitted through an elastic medium. When sound is perceived as unpleasant, irritating, or without informational value, it is defined as noise. In most manufacturing industries, occupational exposure to high noise levels remains a significant health risk.

Prevention of diseases associated with excessive occupational noise requires continuous monitoring and systematic risk assessment, particularly in metallurgical production. Major noise sources in metallurgy include electric arc furnaces, sintering processes, and ore preparation units.

In 2006, Bulgaria adopted Regulation No. 6, which sets the minimum requirements for ensuring the health and safety of workers exposed to noise-related risks. This regulation introduced hygienic standards defining exposure limit values and action levels. The upper exposure action value is set at 85 dB (A). The actual exposure level of workers must be assessed, taking into account the attenuation provided by personal protective equipment.

The aim of the study is to clarify the impact of industrial noise on metallurgical workers and to propose measures for the prevention of health damage in the professional group under consideration.

Material and methods: The subject of the study are 170 people working in a steel production company in Bulgaria. In view of the aural and extraaural effects of industrial noise, the study used clinical, laboratory, functional and instrumental diagnostic methods. Hearing impairment and accompanying diseases in the studied individuals were examined.

Results and discussion: Damage to the investigated workers, exposed to industrial noise is manifested by decreased hearing and tinnitus. In 70% of the examined persons with more than 10 years of work experience, socially significant diseases were found.

Conclusions: Injuries from industrial noise are a current healthy problem for metallurgical workers. Professional experience and the characteristics of the working conditions in the cases discussed are a prerequisite for the presence of occupational hearing loss. A hearing test should be performed during periodic preventive examinations.

The role of diagnostic imaging in HIV-associated diseases

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Introduction: Diagnostic Imaging, mainly MRI and CT, are essential for identifying HIV-associated opportunistic infections, malignancies and neurological damage, especially in patients with low CD4 cell counts. Common applications include brain imaging for neurocognitive disorders, chest imaging for inflammatory diseases such as pneumonia/tuberculosis and assessment of cardiovascular complications. Advanced techniques such as MRI provide detailed data on brain metabolism and structure.

Clinical cases: We present a series of clinical cases of patients diagnosed with HIV infection. In most cases, there is a serious immunological deficiency, with clinical and laboratory evidence of advanced AIDS. This is a variation of HIV-associated diseases - primary CNS lymphoma, cerebral toxoplasmosis, pulmonary tuberculosis, Pn. jirovecii pneumonia, CMV encephalitis - some of the most common pathologies in this group of patients. The work of clinical specialists, in some cases even the diagnosis, as well as the adequate assessment and follow-up of the patient, would be impossible without imaging methods. Conclusions: In some cases, the clinical diagnosis of HIV-associated diseases would be impossible without the establishment of specific and characteristic findings from imaging modalities. This defines diagnostic imaging d as an essential part of the assessment of these patients in support of the clinical specialist.

Keywords: CT, MRI, AIDS, HIV-associated diseases

Analysis of erythrocyte granular bodies

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Erythrocyte granular (Heinz, etc.) bodies are intracellular inclusions in erythrocytes. The leading hypothesis is that Heinz bodies are formed under conditions of oxidative stress and structural damage to hemoglobin. Current data suggest that in addition to chemical factors, representatives of the blood microbiota may also participate in the process of their formation. We conducted infrared spectroscopy and X-ray powder analysis (XRD/SAXS) of erythrocyte granular bodies. A difference was found in the infrared spectra of erythrocyte granular bodies from whole blood and from lysed blood. The infrared spectrum of erythrocyte granular bodies from whole blood gave strong absorption bands for hemoglobin, indicating that the bodies are enveloped and/or co-precipitated with denatured (water-insoluble) hemoglobin. The infrared absorption bands of bodies obtained from lysed blood showed a different profile, which is an indication of their different composition. Characteristic absorption bands for hemoglobin were at 1500–1700 cm^{-1} (different vibrations of the amide bond), 1200–1300 cm^{-1} (vibrations of the porphyrin/heme ring and C–N/Fe–N bonds associated with heme), 900–950 cm^{-1} and 970–980 cm^{-1} (vibrations associated with the bonds in heme). For comparison, the infrared spectra of two different commercial human hemoglobins were investigated, which were practically identical, despite differences in UV spectra and water solubility. SAXS analyses also confirm the presence of denatured hemoglobin in the erythrocyte bodies obtained from whole blood. All samples were amorphous when examined by X-ray powder analysis. Our studies showed that granular bodies obtained from whole blood and those obtained from lysed blood show clear morphological differences when observed with a scanning electron microscope. Erythrocyte granular bodies obtained from whole blood were larger and could be observed with an optical microscope, most effectively in the interference phase contrast mode.

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Blood microbiota in healthy indidviduals

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Indirect evidence supports the presence of living microbial forms within erythrocytes. We analyzed both uncultured and cultured blood samples from clinically healthy individuals under stress conditions (43°C for 24 h). We quantitatively measured the culturable part of blood microbiota of healthy individuals by culturing freshly drawn blood in Brain Heart Infusion medium supplemented with 10% sucrose and a high concentration of Vitamin K (1 mg/mL) and incubated at 43°C for 24 h. The explosive growth of microbial structures was observed by light microscopy on Gram-stained slides. To discriminate the culturable part of the blood microbiota we applied targeted sequencing of 16S rDNA and internal transcribed spacer markers. Dominant bacterial phyla among non-cultured (i.e. native blood) samples were Proteobacteria 93%, Firmicutes 2%, Actinobacteria 2% and Planctomycetes 2%, while among cultured samples Proteobacteria were 48%, Firmicutes 26%, Actinobacteria 17%, Bacteroidetes 4%, Cyanobacteria 3%. Our studies fill a knowledge gap and provide an analysis of the cultivability of circulating blood microbiota. In summary, our findings indicate high biodiversity and distinct mechanisms of propagation of eukaryotic and prokaryotic microbiota inhabiting the blood.

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The effect of light on the melanocyte unit and the skin; Clinical observations and implications

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Melanocytes form a pigmentary unit with keratinocytes of the hair (hair bulb unit) or the skin. Melanin, which can be further subdivided into two subgroups, phaeo and eumelanin, protects us against UV and visible light irradiation. We have opsins, light sensitive proteins, in the eyes and the skin; melanopsins, in the cones and rods are responsible for pupillary constriction and circaclian rhythm adjustment. Melanin, transferred to keratinocytes binds to the nucleus and is a physical shield against UV and VL irradiation. The skin, equipped with a light detecting system, similar to that of the eye therefore protects us against irradiation. In vitiligo, an autoimmune desease, there are areas of the skin completely devoid of pigmentation. Red light irradiation (630 *nm*) stimulates melanocytes from neighboring areas and repigment those areas.

Ceria nanoparticles with vitamins D/K: A combined approach to targeting osteosarcoma cells

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Osteosarcoma is the most common primary malignant bone tumor, predominantly affecting children and young adults. Although diagnostic techniques and multimodal treatment strategies have improved, survival rates for metastatic or recurrent cases have shown little progress over the past decades. Conventional therapies remain burdened by considerable toxicity, poor selectivity, and drug resistance. In this work, we examined how ceria nanoparticles (CeO_2 NPs) interact with human osteosarcoma SaOS-2 cells and how these effects may be influenced by vitamins D and K. CeO_2 NPs have attracted attention due to their ability to switch between Ce^{3+} and Ce^{4+} states, a property linked to cellular behavior in several cancer models. Vitamins D and K were included as additional biological modulators, as both have been associated with pathways regulating cell growth and apoptosis.

To understand how material characteristics, relate to cellular responses, CeO_2 NPs were first evaluated using transmission electron microscopy to assess particle morphology and size distribution. Their crystalline structure was verified by X-ray diffraction. The biological experiments were designed to capture multiple aspects of the cellular response. Cell viability and metabolic activity were assessed using the MTT assay across a range of concentrations and treatment combinations. Confocal laser scanning microscopy was used to visualize structural and morphological changes. To explore whether the treatments affected the expression of selected genes related to oxidative stress (SOD1) and apoptosis (BAX, BCL2, CASP3), quantitative PCR was performed. In addition, intracellular ROS levels were evaluated using CellROX to provide complementary insight into treatment-related cellular changes.

By combining detailed nanoparticle characterization with functional assays, imaging, and gene expression analysis, this work offers a thorough insight into how CeO_2 NPs influence osteosarcoma cells and how vitamins D and K may further shape these cellular responses. Together, the results provide a broader understanding of the potential role of nanoparticle-based approaches in the development of future osteosarcoma therapies.

Fiber-optic dosimetry for in situ electron beam dose measurements in conventional and FLASH radiotherapy

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This work presents the review on development and experimental validation of a fiber-optic dosimeter (FOD) system for real-time, in situ dose measurements of ionizing radiation generated by linear electron accelerators. The proposed solution extends the applicability of FOD detectors beyond photon radiation (X and γ) [1-3] to include charged particle beams such as electrons and protons.

Experimental studies were carried out using a clinical linear accelerator TrueBeam (Varian Medical Systems, Palo Alto, USA) at the Oncology Center in Bydgoszcz, operating in conventional mode with nominal electron beam energies of 6 MeV and 9 MeV. The detector system consisted of a GAGG:Ce scintillation crystal coupled to a 4 m optical fiber. Measurements performed in the dose range of 0.25–3 Gy demonstrated an almost perfectly linear relationship between radioluminescence (RL) signal and absorbed dose, with excellent repeatability. In clinical conditions, the deviation between FOD measurements and reference dosimetry based on radiographic films was below 1%. Additionally, the proposed system enables significantly faster and simpler in situ dose measurements compared to conventional passive (film) and active (ionization chambers, semiconductor detectors) techniques.

Further investigations were conducted for ultra-high dose rate (FLASH) radiotherapy using an electron accelerator developed at the National Centre for Nuclear Research (NCBJ, Poland), tested at the Greater Poland Cancer Center in Poznań. For high dose rates (~10^3 Gy/s), limitations of the GAGG:Ce-based FOD were observed due to signal saturation above 1 Gy, even at minimal acquisition times of 5.2 ms. This indicates the necessity of optimizing scintillator size, type, and optical fiber length of FOD for FLASH applications.

In contrast, an FOD system based on an Al_2O_3:C crystal (2 × 2 × 1 mm) exhibited a stable and linear RL response for FLASH type radiotherapy with very good agreement with radiographic film measurements up to 40 Gy. These results demonstrate the strong potential of GAGG:Ce and Al_2O_3:C-based fiber-optic dosimeters for accurate, real-time dose monitoring in both conventional and FLASH electron radiotherapy.

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In silico early developability and liability screening of new steroidal heterocycles

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Steroidal drugs play an important supportive role in cancer therapy, including treatment protocols involving radiotherapy. Steroidal derivatives continue to attract attention as potential scaffolds in anticancer drug research due to their favorable membrane permeability and biological compatibility. In continuation of our previous studies focused on drug-likeness as well as absorption and distribution properties, the present work extends the *in silico* evaluation toward metabolism- and toxicity-related parameters of three steroidal triazoline-3-thione derivatives differing in their parent steroidal skeleton (androstenedione, progesterone, and testosterone).

Pharmacokinetic and toxicity-related properties were predicted using pkCSM and ADMETlab 2.0 tools and compared with those obtained for dexamethasone, a steroid widely used in oncological clinical practice. As commonly observed for steroidal compounds, the investigated derivatives were predicted to exhibit possible hepatotoxicity and interactions with certain CYP enzymes. Nevertheless, favorable predictions were obtained regarding AMES mutagenicity and hERG-related cardiotoxicity, suggesting absence of major genotoxic or cardiotoxic risks.

Total clearance predictions indicated high clearance for the progesterone-based derivative, moderate clearance for the androstenedione- and testosterone-based compounds, whereas dexamethasone showed low predicted clearance. Although dexamethasone displayed a somewhat more favorable overall pharmacokinetic profile, the predicted properties of the investigated derivatives remained within the range observed for clinically used steroidal drugs.

These findings indicate that the studied derivatives possess pharmacokinetic characteristics comparable to therapeutically relevant steroidal agents and provide a basis for further structural optimization and experimental evaluation of their anticancer potential.

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Evaluation of the antitumor activity of novel berenil complexes with gold(III) in a cell-based model of breast cancer

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Breast cancer remains one of the most frequently diagnosed malignancies worldwide and continues to represent a major therapeutic challenge due to tumor heterogeneity, systemic toxicity of currently used drugs, and the progressive development of chemoresistance. Although platinum-based agents such as cisplatin have significantly improved clinical management, their severe side effects and limited selectivity have prompted intensive research into alternative metal-based anticancer compounds. Among them, gold complexes — particularly gold(I) and gold(III) derivatives — have attracted considerable attention owing to their structural versatility, tunable coordination chemistry, and mechanisms of action distinct from classical platinum drugs. Gold(III) compounds are especially promising because of their enhanced chemical stability and ability to interfere with redox homeostasis, mitochondrial function, and key signaling pathways involved in cancer cell survival.

In the present study, novel berenil complexes of gold(III) were synthesized and structurally characterized, and their anticancer potential was evaluated in MCF-7 and MDA-MB-231 breast cancer cell lines. Cytotoxicity analysis performed using the MTT assay demonstrated pronounced antiproliferative activity of the tested compounds, with IC_{50} values after 24 h incubation significantly lower than those of cisplatin. The gold(III) derivatives markedly reduced cancer cell viability even at relatively low concentrations and exhibited strong activity in both molecular subtypes of breast cancer. To elucidate the mechanism of cell death, apoptosis was assessed by Annexin V-FITC/propidium iodide double staining followed by flow cytometric analysis. The tested gold(III) complexes significantly increased the percentage of early and late apoptotic cells compared with the reference compound. This proapoptotic effect was accompanied by a pronounced loss of mitochondrial membrane potential ($\Delta\Psi m$), indicating involvement of the intrinsic apoptotic pathway. Furthermore, activation of caspase-8 was observed, suggesting engagement of the extrinsic apoptotic signaling cascade. Importantly, the gold(III) complexes induced stronger apoptotic changes, greater mitochondrial depolarization, and higher caspase-8 activation than cisplatin, highlighting their enhanced proapoptotic potency.

Collectively, these findings demonstrate that pyridineberenyl gold(III) complexes exert potent antiproliferative and proapoptotic effects in breast cancer cells and represent promising candidates for further development of innovative metal-based anticancer therapies.

Keywords: breast cancer, gold(III) complexes, organometallic compounds

Comparison of the biological activity of related Co(II)/Cu(II) complexes

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Aim: New two cationic binuclear Cu(II) and Co(II) complexes of *tpmc = N,N',N'',N'''-tetrakis(2-pyridylmethyl)*-1,4,8,11-tetraazacyclotetradecane) and co-ligand S-phenylalanine with general formulas $[Cu_2(S\text{-}Pheala)tpmc](ClO_4)_3 \cdot 7H_2O$ and $[Co_2(S\text{-}Pheala)tpmc](ClO_4)_3$ were tested against three human cancer cell lines. Complexes were tested for its antimicrobial activity against Gram (+), Gram (-) bacteria and the yeast.

Materials and methods: The antimicrobial activity of the Cu(II) and Co(II) complexes were assayed using the broth-microdilution method against: Gram-positive bacteria *M. lysodeikticus, Staphylococcus aureus* and *Bacillus subtilis*, Gram-negative bacteria *Escherichia coli* and one strain of the yeast *Candida albicans*.

In vitro cytotoxicity of the free ligands (tpmc, S-phenylalanine, free salts), complexes and cis-platin were evaluated against four cancer cell lines: human cervix adenocarcinoma (HeLa), human melanoma (FemX), K562 (human myelogenous leukemia) and human colon carcinoma (LS174). The effect of compounds on cancer cell survival were determined by the MTT test. Cell survival were determined by the MTT test according to the method of Mosmann [1] and modified by Ohno and Abe [2] at 72h after the test compound additions.

Conclusion: Both complexes have moderate bactericidal effect on Gram-(+) bacteria: *S. aureus* and *B. subtilis*. No compound showed antifungal activity. Compounds have promoted decrease in metabolic activity of the HeLa (human adenocarcinoma), FemX (human melanoma), K562 (human myelogenous leukemia) and LS174 (human colon carcinoma), which occurred in a dose-dependent fashion. Co(II) complex generally showed higher activity then Cu(II) analogue. Under the same conditions and the same concentrations, the control group showed no activity.

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Keywords. Copper (II) complex, Cobalt (II) complex, antimicrobial and cytotoxic activity

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Poloxamers as versatile components of semi-solid matrices: the influence of the system microstructure on the release of active substances

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Poloxamers, nonionic block copolymers of ethylene oxide and propylene oxide, are widely used as components of modern semisolid systems applied in dermal and pharmaceutical formulations. Their amphiphilic nature enables the formation of complex microenvironments, including micellar structures and interfacial regions at the boundaries between hydrophilic and hydrophobic domains. This structural versatility allows modulation of carrier properties and control over the release of active substances.

In the present study, the properties of hydrogel, oleogel, and emulsion systems containing poloxamers were compared, with the polymers playing different roles depending on the matrix type. Koliphor® 407 was employed as the main structure-forming component in hydrogel systems, while Synperonic® F108 was used as a microstructure-modifying additive in oleogels and emulsions. The diversity of the investigated systems enabled analysis of the influence of both the carrier type and the mode of poloxamer incorporation on the performance of the delivery system.

Vitamin E and berberine were selected as model active compounds characterized by distinct yet formulation-challenging physicochemical properties, which limit their effective incorporation and controlled release from conventional hydrogel matrices. The high lipophilicity of vitamin E and the cationic nature of berberine, combined with their limited aqueous solubility, justify the use of poloxamers as components facilitating stabilization and solubilization of both compounds within semisolid matrices of complex microstructure.

The aim of this study was to determine the impact of the carrier type and the poloxamer's functional role in the formulation on the structural–mechanical properties of the systems and on the release profiles of the active substances. The results demonstrated that the presence of poloxamers significantly affects the microstructural organization of the matrices, leading to distinct release mechanisms and kinetics for the investigated compounds. These findings confirm the potential of poloxamers as versatile components for designing flexible carrier platforms tailored to the properties of the active substance and specific application requirements.

Methods for assessing radio frequency (RF) electromagnetic exposure in front of building facades using drone mounted instruments and radio wave propagation model

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Assessing RF exposure from outdoor sources is challenging at certain types of locations. For instance, it is difficult to perform measurements in every apartment of a multi-storey building. At the same time, higher levels of public RF exposure are typically observed in such locations due to the proximity of mobile base station antennas, which represent a dominant source of outdoor exposure in general.

Exposure from outdoor sources inside apartments can be more easily estimated by accounting for the attenuating effect of building materials. Based on this attenuation, it can be assumed that indoor exposure from outdoor sources does not exceed the levels measured or calculated in front of the building facade.

It is therefore important to compare the assessment methods that enable large-scale exposure evaluation in these areas. The following three methods appear to be the most suitable for determining exposure levels in front of building facades:

- Measurement using drone-mounted instruments,
- Calculation based on a radio wave propagation model,
- Artificial intelligence-based estimation.

Conducting drone-based measurements near apartment buildings can face several practical obstacles. For example, flights can only be performed under suitable weather conditions. In addition, obtaining the consent of all building residents may present a further challenge.

Wave propagation calculations can provide accurate exposure estimates without the need for physical measurements. However, such calculations require detailed radio station and building data, which can be costly to collect. Furthermore, the computational processing time of the simulation software may be considerable.

Artificial intelligence-based methods generally do not require a detailed specification of building materials. However, developing such models requires a training database with a large number of samples as well as the evaluation of multiple computational approaches.

The objective of our study is to compare two of the aforementioned methods: drone-based measurement and wave propagation modelling. In addition to the results obtained from these two methods, the comparison is supported by reference measurements performed at the windows of educational buildings.

Characterization of a cell culture incubator used as a reverberation chamber for in vitro 26 GHz 5G (FR2) experimental studies

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Next-generation telecommunications networks, such as fifth-generation (5G) systems, support numerous novel and high-speed mobile applications. In addition to the mid-frequency band (FR1) at 3.5 GHz, 5G also operates in the high-frequency band (FR2) around 26 GHz. For laboratory investigations, new experimental apparatus capable of generating well-controlled 26 GHz exposure conditions is required to ensure reproducible in vitro biological experiments. Previously, a reverberation chamber (RC) designed for operation inside a cell culture incubator at 3.5 GHz (FR1) was developed [1]. In the present work, a similar RC-based exposure system operating at 26 GHz in the FR2 millimeter-wave band is introduced, and several radiofrequency (RF) measurements are presented to characterize and evaluate the RF performance of the system.

The modified cell culture incubator functioning as a reverberation chamber consists of a patch antenna and a specially designed mechanical stirrer installed inside the incubator (CB-S170, Binder, Germany). The stirrer rotates at a speed of 16 rpm, producing a statistically homogeneous spatial distribution of the RF field within the chamber. The patch antenna was connected to a continuous-wave (CW) signal generator (SG Compact 24-40 GHz, SAF Tehnika AS, Latvia) and a millimeter-wave amplifier (AMP3033, Exodus Advanced Communications, USA).

The S11 reflection coefficient of the radiating antenna placed inside the incubator was measured using a single-channel vector network analyzer (VNA; MS46131A, Anritsu, Japan) at different stirrer positions. The RF field strength was recorded at multiple locations within the incubator using a small isotropic RF field meter (PMM 604, Narda-PMM, Italy) with a sampling rate of 0.1 s. The maximum RF field strength at 26 GHz achieved inside the incubator was 160 V/m. The overall standard deviation of the spatial RF field distribution within the exposure region—where the cell culture holders (3.5 mm Petri dishes) were positioned—was below ±12%.

A four-channel fiber-optic thermometer (Luxtron STB probe, LumaSense Technologies, CA, USA) was used to measure the sample temperature. The fiber-optic probe did not perturb the RF field and enabled continuous temperature monitoring throughout the experiment.

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Assessment of consecutive UV and 26 GHz 5G RF-EMF exposure on DNA photolesions and oxidative stress markers in HaCaT keratinocytes

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The fifth generation of mobile communication systems, 5G, is expected to markedly enhance wireless connectivity by enabling higher data throughput, reduced latency, and improved network capacity. Commercial deployment has already begun worldwide, underscoring the importance of evaluating potential biological effects associated with human exposure. Within the European Union, the 26 GHz high-frequency band has been authorized for telecommunication use. While radiofrequency fields applied in earlier generations such as 4G have been extensively investigated, considerably fewer experimental data are available regarding millimeter-wave (MW) frequencies. Because tissue penetration decreases as frequency rises, radiation at 26 GHz is absorbed predominantly within superficial skin layers.

Ultraviolet (UV) radiation represents a segment of the electromagnetic spectrum subdivided into UVA (315–400 nm), UVB (280–315 nm), and UVC (100–280 nm). Solar UVA and a fraction of UVB reach the Earth's surface, whereas UVC and most UVB are filtered by atmospheric ozone. In addition to solar exposure, artificial UVC sources used for disinfection can contribute to human exposure. UV photons, particularly within the UVB and UVC ranges, induce direct DNA damage by forming covalent linkages between adjacent pyrimidine bases and by triggering the production of reactive oxygen species (ROS). Longer wavelengths such as UVA primarily act through oxidative mechanisms, generating radicals including hydroxyl, superoxide, and peroxyl species. These processes promote oxidative stress, potentially resulting in mutagenesis or apoptosis. Due to its well-established carcinogenic potential, solar UV radiation has been classified as carcinogenic to humans (Group 1) by the International Agency for Research on Cancer. Since both 26 GHz millimeter waves and solar UV radiation deposit their energy mainly in the epidermis, investigating their combined biological impact is scientifically justified.

The objective of the present study was to determine whether exposure to 26 GHz radiofrequency electromagnetic fields (RF-EMF), either alone or together with UV radiation, induces non-thermal biological responses in human skin cells. Specifically, we assessed oxidative stress markers and cyclobutane pyrimidine dimer (CPD) formation in immortalized human keratinocytes (HaCaT).

HaCaT cultures were first subjected to UV doses ranging from 40 to 400 J/m², followed immediately by exposure to 26 GHz RF-EMF at power densities of 5–10 W/m² for two hours, using both continuous wave (CW) and time-division duplex (TDD) modulation schemes. UV irradiation was delivered by a solar simulator providing a near-continuous emission spectrum closely resembling natural sunlight and encompassing both UVA and UVB components. Radiometric output was verified before each experiment with a calibrated spectroradiometer, and radiant exposure was adjusted according to the erythemal weighting function recommended by ICNIRP.

Millimeter-wave exposure was produced with a horn antenna (10 dB gain). The upconverted 26 GHz signal was continuously tracked using a spectrum analyzer operating between 24 and 40 GHz (Spectrum Compact, SAF Tehnika, Latvia) connected through a 20 dB directional coupler (PE2CP1122-20; Pasternack, USA). Signal amplification was achieved with a 38 dB microwave amplifier. To limit unwanted reflections, the entire exposure assembly was housed in a chamber lined with microwave-absorbing material (Eccosorb HR-25; Laird Technologies, UK) and placed within a temperature-controlled incubator.

DNA photoproduct formation was quantified using a T4 endonuclease V-modified comet assay capable of detecting strand breaks and UV-induced pyrimidine dimers. Oxidative DNA lesions were evaluated by the FPG-modified comet assay, while intracellular ROS generation was determined using the H_2DCFDA fluorescence assay.

Determination of exposure duration and power density parameters in a 26 GHz thermostat-based reverberation chamber for in vitro studies

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The 26 GHz frequency band will be introduced for the future operation of 5th generation mobile technologies. The near-millimeter wavelength frequency is absorbed at a different depth than the current 3.5 GHz. This difference highlights the need for well-characterized in vitro exposure systems and optimized experimental parameters. This study is part of a research project. Its aim is to determine the appropriate irradiation duration and incident power density for subsequent biological experiments.

The exposure system is based on a modified CO_2 culture incubator functioning as a reverberation chamber. This design enables controlled 26 GHz irradiation of biological samples in standard Petri dishes and 96-well plates under stable incubation conditions. The reverberation-like configuration promotes improved field uniformity and reproducible exposure across the sample volume while maintaining physiological temperature. The system allows precise adjustment of different power density levels.

Since the 26 GHz radiofrequency is mainly absorbed by the skin, human immortalized keratinocytes (HaCaT cell line) are used as an in vitro model. To simulate environmental electromagnetic radiation, the cells are first exposed to ultraviolet (UV) radiation and then to RF treatment. RF exposure is applied for four different durations, ranging from 2 - 24 hours, allowing for a systematic evaluation of time-dependent effects. Four different intensity levels are used: 0.1, 1, 10, and 20 W/m^2.

The primary goal of the study is to determine an exposure matrix (time × power density) that adequately models exposure from mobile phones while allowing for the monitoring of changes in cells. The temperature of the samples was continuously monitored with optical thermocouples to record possible RF-induced heating, and cell viability was also examined.

The results may contribute to the establishment of a well-defined exposure range that can serve as a basis for further studies, and the test protocol may help in determining doses for similar experiments.

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Comparison of internal dosimetry estimation of ^{177}Lu-DOTA-Trastuzumab in metastatic states (OLINDA vs IDAC)

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This study aimed to compare the dosimetry of ^{177}Lu-DOTA-trastuzumab in patients with HER2-positive breast cancer, using IDAC 2.1 (Internal Dose Assessment by Computer), and to compare the results with those obtained by OLINDA EXM v2.1.1. Results from previously published research are used to obtain the mean absorbed doses for the liver, spleen, kidneys, heart, red marrow, and tumor, applying IDAC 2.1. Then the results are compared to those obtained from OLINDA EXM v2.1.1.

For kidneys, liver, and spleen, mean absorbed doses estimated by IDAC 2.1 are lower than OLINDA EXM by ~20–30%. This can be attributed to differences in anatomical phantoms and S-factors used by the two software systems. Heart wall shows a significant discrepancy (+110%), likely due to differences in activity distribution models. Red marrow differs by nearly -95%, reflecting the different skeletal and marrow models implemented in IDAC compared to OLINDA. The effective dose is lower in IDAC (~47%), consistent with the stricter ICRP reference models. Overall, both methods identify the same high-dose organs (liver, kidneys, spleen, heart), but the magnitude differs due to software modeling.

Risk analysis of using ^{223}Ra and ^{224}Ra for pain relief in ankylosing spondylitis

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An assessment of absorbed doses and radiation risks to human organs and tissues during the treatment of ankylosing spondylitis pain syndrome with intravenous injections of $^{223}RaCl_2$ and $^{224}RaCl_2$ was made. Expected radiation risks are compared with lifelong non-radiation risks.

Absorbed doses to human organs and tissues during intravenous administration of ^{223}Ra and ^{224}Ra dichloride were calculated taking into account the independent biokinetics of the decay products of radium isotopes, both those formed in the human body and those administered intravenously in equilibrium with parent radionuclides. Radionuclide dynamics in the human body were assessed using WinAct software in accordance with ICRP Publication 137. Absorbed dose values in tissues (bone surfaces, red bone marrow, liver, kidneys, etc.) were obtained using IDAC 2.1 software. Radiation risk calculations were performed using the BEIR VII, UNSCEAR, and RERF models, as well as models for plutonium production workers and patients who received ^{224}Ra injections.

Absorbed doses to bone surfaces of 1.1–1.3 Gy is less than the threshold dose of 9–10 Gy, so the occurrence of skeletal tumors can be neglected. Calculated values of the radiation risk for liver cancer of ~ (1–3) x 10^{-2} were also ignored as they contradict direct epidemiological data on liver cancer incidence following exposure to high levels of ^{224}Ra and ^{226}Ra. Calculated radiation risks for kidney cancer are not statistically significantly supported by published epidemiological data. The relative risk estimates for leukemia of 1.3–1.6, obtained for an RBE of 2, is consistent with the value of 1.75 reported in the literature. The estimated absolute risk of radiation-induced leukemia with radium therapy is (5.0–5.6) x 10^{-3}. The additional absolute lifetime risk of leukemia with 10 MBq of ^{224}Ra, according to published data, is 9.6 x 10^{-3}, which is consistent with our estimates.

Radiation-related risks are relatively small compared to the lifetime risks of spontaneous cancer and mortality from causes unrelated to radiation exposure. The use of proven therapies using $^{223}RaCl_2$ and $^{224}RaCl_2$ will significantly improve patients' conditions without exposing them to unacceptable levels of radiation risk.

Experimental determination of radiation dose levels in female urogenital system organs using a dynamic phantom in nuclear medicine applications

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Determining radiation dose levels in radiosensitive organs is important for radiation protection and for improving nuclear medicine procedures. Organs of the female urogenital system may be exposed to significant radiation during the administration of radiopharmaceuticals because these substances are distributed in the body and excreted through the urinary system. However, experimental data about organ-specific radiation dose levels in these tissues are still limited.

In this study, radiation dose levels in organs of the female urogenital system were experimentally investigated using a dynamically designed phantom. The phantom representing a 50-kg female anatomy was developed using computed tomography images and produced with three-dimensional (3D) printing technology. The system includes major urogenital organs such as the ovaries, fallopian tubes, uterus, vagina, adrenal glands, kidneys, ureters, bladder, and urethra. Special cavities were created in the phantom to place thermoluminescent dosimeters (TLDs) for measuring radiation dose at the organ level.

As a preliminary stage of the study, measurements were performed using fluorine-18 fluorodeoxyglucose (^{18}F-FDG). The radiopharmaceutical solution was introduced into the dynamic phantom to simulate physiological transport and urinary excretion. Radiation doses to individual organs exposed to the radiopharmaceutical were measured using calibrated TLD detectors.

Selected medicinal plants and natural products as immunostimulators

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Immunomodulators represent a group of exogenous factors which can affect the immune system. They can be divided into immunosuppressants, immunoadjuvants and immunostimulators. Among the latter, various natural and (semi)synthetic compounds are used with the purpose of stimulating the human immune system. Further on, among the products of natural origin, medicinal plants, fungi and various other products derived from them, can be used precisely for aiding the immunity against both exogenous harmful noxae, but also in the regulation of internal pathological processes. Natural products can modify the immune system in several aspects, targeting components of both innate and adaptive immunity. Besides immunostimulatory effects, natural products can have other biological and pharmacological activities, such as antioxidant, anti-inflammatory, antiviral, antimicrobial, and adaptogenic activities.

Astragalus (*Astragalus membranaceus,* Fabaceae), also known as milkvetch, is a plant commonly used in traditional Chinese medicine, with growing interest in its application for immunostimulatory properties. The main active ingredients of astragalus are polysaccharides and triterpene saponins. The first are considered responsible for stimulatory properties on natural killer cells, while the latter regulates the levels of cytokines in inflammation. It can be used even in small children, for respiratory infections. Coneflower (*Echinacea* spp., Asteraceae) is another plant commonly used for these purposes (prevention and treatment of common cold), although its application is not recommended in children under the age of 12. Besides derivatives of caffeic acid, main active compounds are alkamides, being active in enhancing the process of phagocytosis, and increasing the number of T-cells. Beta-glucan represents a dietary fiber, commonly found in various grains, algae, lichen etc. – however, the highly branched polysaccharides with the best activity toward innate immune system are obtained from various mushrooms, mainly oysters (*Pleurotus* spp.) and shiitake (*Lentinula* spp.). Beta-glucan is generally considered safe; it can be used even in children (at the eighth month of age), however, the application should be at least one month long for effects to take place. Bee products have a long history of application, with immunostimulatory properties being one of the most prominent ones, primarily in the reduction of proinflammatory cytokines. The products can be divided into collected ones (such as honey, propolis, pollen and bee bread) and secretions of specialized glands (bee wax, royal jelly and bee venom). Bee products are generally considered safe- caution is required in infants due to the possible risk of botulism. Lacquered bracket (*Ganoderma lucidum*, Ganodermataceae), also named Reishi, is a mushroom of medicinal importance, known precisely for its immunomodulating properties. Various dosage forms can be used, and it finds its place as adjuvant therapy in patients with various types of carcinomas. Besides polysaccharides, lanostane-type triterpenes are considered responsible for the increased number of lymphocytes. Cat's claw (*Uncaria tormentosa*, Rubiaceae) is another plant often used as an aid in combating various infections, via stimulating effects on leukocytes and regulatory effects on cytokine levels. Pentacyclic oxindole alkaloids are the main active compounds.

The choice of immunostimulatory agent primarily depends on the cause of impaired immunity, but also on the characteristics of the patient, e.g., age, general health, other comorbidities, use of other conventional and alternative medicines, etc. It is possible to combine these natural products; however, the combination should be carefully evaluated for potential interactions and adverse effects. Only rational (phyto)therapy can bring the most benefits for patients and their health.

Keywords: immune system, immunostimulatory, medicinal herbs, phytotherapy

Reduced mobility for Ar^+ ions in argon gas

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Understanding plasma distribution, characteristics and phenomena is important for the development and optimization of semiconductor device manufacturing plasma equipment, such as etching and deposition tools. For this reason, plasma simulation is currently being utilized at every stage of equipment design, development and improvement.

In this work we present a complete cross sections dataset and transport properties for Ar^+ ions in argon gas. These data are needed for modeling in numerous applications of technological importance. A Monte Carlo simulation method is applied to accurately calculate transport parameters in hydrodynamic regime. We discuss new data for Ar^+ ions in argon gas where the drift velocity, characteristic energy, specially flux and bulk values of reduced mobility and rate coefficients are given as a function of low, moderate and high reduced electric fields E/N (E-electric field strength, N-gas number density). Ion mobility (K) is defined as the proportionality factor between the ion drift velocity and the electric field. One often exploits the reduced or standard mobility defined as:

$$K_0 = \upsilon_d / N_0 EN$$

where is the drift velocity of the ion, N is the gas density at elevated temperature T, $N_0 = 2.69 \cdot 10^{25}$ m^{-3} and E is the electric field. Agreement with experimentally determined values is more than satisfactory.

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Four Wave Mixing (FWM) in alkali atom vapors - Numerical method

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Four Wave Mixing (FWM) in alkali atom vapors exists only under very specific conditions, it is necessary that density of alkali vapor, intensities and frequencies of pump and probe laser beams, have their values within rather narrow ranges. FWM is nonlinear phenomena that can be regarded as scattering of laser beams on nonlinear index grating, generated by the same laser beams. Such scattering results in conversion of two pump photons to additional probe photon, and to conjugate photon at frequency (much) different form the pump and probe frequencies.

The interaction of coherent radiation with atomic pairs was analyzed using the Maxwell-Bloch equations. Codes have been developed to numerically solve this system, including the Doppler effect and relaxation processes. Added to them are the effects created by the quantum treatment of the electromagnetic field, the so-called Langevin equation. This created the conditions for the theoretical analysis of quantum effects such as the appearance of trapped states under conditions that provide four-wave mixing of coherent radiation.

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Development of apparatus and measurement procedures for measurement of thermal conductivity of metals

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The aim of this work is to present a new apparatus developed in our laboratory for measuring thermal conductivity in metallic materials. Apparatus is constructed using 3D printed parts, mini hot plate, EU-aluminum profiles, aluminum vessel and digital thermometers. The construction of the apparatus makes it possible to measure the thermal conductivity of metals in four different ways. The results of thermal conductivity measurements are in good agreement with tabular data for the metals used.

Heavy-ion based infrastructure for applied research at the NICA injection complex

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An injection complex for the heavy-ion collider NICA (Nuclotron-based Ion Collider fAcility) has been constructed at the Joint Institute for Nuclear Research (JINR, Dubna, Moscow Region, Russia). The heavy-ion collider NICA is currently being commissioned. On the basis of the injection complex, specialized stations for applied research have been established and integrated into a unified infrastructure called ARIADNA (Applied Research Infrastructure for Advanced Developments at the NICA Facility). This infrastructure is focused on studying radiation effects in microelectronics induced by heavy charged particles over a wide energy range (3.2 MeV/nucleon and 150 – 500 MeV/nucleon), as well as on conducting radiobiological experiments using heavy-ion beams in a broad energy range (400 MeV/nucleon to 1000 MeV/nucleon).

The paper presents the concept, equipment, and current status of three specialized experimental stations: Station of Chip Irradiation (SOCHI), Irradiation Setup for Components of Radioelectronic Apparatus (ISCRA), and Setup for Investigation of Medical Biological Objects (SIMBO). The SOCHI and ISCRA stations are designed for studying single-event radiation effects in modern microelectronic devices exposed to heavy charged particles over a wide energy range – from 3.2 MeV/nucleon to 500 MeV/nucleon. This includes irradiation of both decapsulated and packaged integrated circuits. Special attention is given to the most recent irradiation sessions of decapsulated integrated circuits performed at the SOCHI station using pulsed heavy-ion beams extracted from the heavy-ion linear accelerator. The SIMBO station is aimed at modeling the effects of galactic and solar cosmic rays for radiobiological studies in the energy range of 400 – 1000 MeV/nucleon.

Physics aspects of pulsed reactors

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The IBR-2M pulsed research reactor has been in operation at the Frank Laboratory of Neutron Physics (FLNP) in Dubna since 2011. As one of the world's most powerful neutron sources for physical experiments, this reactor achieves unique characteristics due to its pulsed operation mode. With an average power of only 2 MW and a compact core, it develops a peak power of about 2 GW during a pulse, a value comparable to that of large power reactors.

The IBR-2M's operational lifetime is expected to be exhausted by 2040, necessitating the development of a new neutron source to replace it. The FLNP team working on the new source is investigating the physics of pulsed reactors and is focused on creating the next generation of such facilities. This presentation will showcase the Laboratory's recent advancements in the pulsed reactor dynamics program. This program is based on a comprehensive approach involving thermophysical and neutronic calculations, as well as mathematical modeling. During the campaign, the parameters of both the fuel and structural materials change due to continuous radiation exposure. The development of a comprehensive dynamics program will make it possible to account for subtle yet significant processes occurring in the reactor core, which could potentially lead to operational issues.

Understanding the physics of processes in a pulsed reactor will enable the development of a new generation of such facilities. This new generation will surpass the IBR-2M in terms of pulse parameters, neutron flux density, and operational reliability. Currently, several fuel options are being considered: plutonium dioxide, neptunium, and mixed nitride fuel, each with its own set of advantages and disadvantages regarding key performance parameters.

3He-4He Dilution Refrigerator, used to obtain ultra-low temperature

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This method, based on dissolving He^3 in He^4, has proven very successful in experimental nuclear physics. This method has proven very successful in experimental nuclear physics and as well as some leading cryogenic companies (S.H.E., Lake Shore, Oxford Instruments....) produced commercial plants to produce ultra-low temperature.

First Attempts: In about 1964, two Moscow State University students, N. S. Borisov and M. Yu. Liburg, joined Neganov's group and were given an opportunity to put into practice a fresh idea of producing ultralow temperatures by a new method which was published in 1962. This publication was brought just in time by Czechoslovakian Physicist S. Safrata, who worked in the journal Cryogenics for a long time and had access to information like that clearly, there were many who knew about it, and two more attempts to implement the idea were made in different places at approximately the same time.

- **1952:** The principle of the method of dissolving ^{3}He in ^{4}He was proposed by **Heinz London**
- **1962: H. London, G.R. Clarke and E. Mendoza** proposed a design for a continuously operating ^{3}He/^{4}He dilution refrigerator
- **1965:** The world's first dilution refrigerator was created at Leiden University. **Das P., Ouboter R.B., Taconis K.W. (Tmin≈ 220 mK)**
- **1966: Neganov B.S., Borisov N.S. and Liburg M.Yu.** created a dilution refrigerator at JINR that allows obtaining a temperature of **25 mK** in circulation mode, and in 1968 they managed to get **5.5 mK** in single-shot mode, which was a world record for that time.
- **Today:** Modern dilution refrigerators allow obtaining temperatures in the range of 5 – 50 mK. The lowest temperature obtained with a dilution refrigerator is **Tmin ≈ 2 mK**

The results showed that Neganov's group was the best. Even at their earliest steps the record temperature of 50 mK was achieved!

The cooling power of the dilution refrigerator is defined by $Q = 8n^2$ (1), where Q is the cooling power (in Watts) at the mixing chamber, n3 is the 3He molar circulation rate, TM is the mixing-chamber temperature and TM_{min} is the minimal temperature in the mixing chamber at $Q = 0$.

International Cooperation: In 1977, an ultralow-temperature setup for studying short-lived nuclei was developed at DLNP with the decisive participation of V. N. Pavlov. It allowed the LNP Radiochemical Laboratory (RCL) to implement its vast research program. Surprisingly soon, in 1978, the second polarized target of the frozen type, was made specially for the research at the Institute of High-Energy Physics (IHEP) in Protvino. The real international collaboration began for Low Temperature Department with the proposal of Czechoslovakian scientists and physicists from LNP to develop a frozen polarized target especially for experiments at low energies of —15 MeV. That was the energy of the polarized neutron beam from the Van de Graaff (VdG) accelerator at Charles University in Prague.

Now about the main and new among our scientific activities: The Low Temperature Department researchers currently participate in development of the precision Möller polarimeter for MESA, the new superconducting accelerator of polarized electrons at the University of Mainz. There will have to face highly sophisticated problems of precision measurement of the electron beam 1this is just the area of the Low Temperature Department unique experience and best methodological practices. A team of experts from the Laboratory of High-Energy Physics (former Laboratory of High Energies) led by V. V. Fimushkin is also engaged in the development of the polarimeter for MESA.

Conclusion: Presently, a number of commercial companies ("Oxford Instruments", "JANIS", "BlueFors", ...) offers the laboratory facilities produced ultra-low temperatures using ^{3}He / ^{4}He dissolution method with quite good parameters.

Modeling of vacuum conditions and ion beam losses in the design of the vacuum system of the SCIF-D magnetic spectrograph at the U400R cyclotron complex

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The results of numerical modeling of vacuum conditions and ion beam losses during the design of the vacuum system of the SCIF-D magnetic spectrograph are presented. The developed method for estimating ion beam losses is based on both numerical simulation of the pressure distribution in vacuum chambers of virtually any arbitrary geometry and on calculating the cross sections for charge-exchange reactions of accelerated ions on residual gas molecules. This method was implemented using the GENAP and VACLOS computer codes, which provide good agreement with experiments conducted during long-term heavy-ion acceleration experiments at the FLNR cyclotron complexes. These computer programs were used to design vacuum systems for accelerator complexes, including the DC-72 cyclotron in Slovakia, the CYTREC cyclotron complex in Dubna, the DC-60 cyclotron complex at Astana University in the Republic of Kazakhstan, the DC-110 cyclotron complex at the Dubna Center for Nano- and Nuclear Technologies, the DC-280 heavy ion cyclotron complex, and the modernized U400R cyclotron complex at JINR. The conducted research and the developed calculation methodology enable the optimal design of vacuum systems for accelerator complexes and physical irradiation facilities.

Neutron tomography and specific methods of its application

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Neutron tomography is an important method for non-destructive investigation of the internal structure of materials and engineering components. Unlike the classical approach based on integral beam attenuation, specialized neutron tomography methods employ additional physical selectivity related to wavelength, phase, diffraction response, polarization, and time. This enables characterization of object geometry, phase composition, texture, stress state, microstructure, magnetic properties, and process dynamics.

Introduction: Neutron tomography reconstructs the internal structure of an object from projections recorded at different angles [1, 2]. Owing to the specific character of neutron–matter interaction, the method is especially effective for detecting light elements, primarily hydrogen, lithium, and boron, even inside heavy metallic casings [1, 2]. In many cases, however, a conventional attenuation map is insufficient. Therefore, specialized neutron imaging methods are used, in which the detected signal is additionally selected according to a specific physical parameter [2, 3].

Specialized Methods: These methods are based on wavelength-dependent attenuation, diffraction in polycrystals, the neutron magnetic moment, phase effects, and small-angle scattering [1–3]. The principal groups include energy-selective, phase-contrast, diffraction-sensitive, polarization-based, and time-resolved methods [2, 3]. Energy-selective techniques, particularly Bragg-edge imaging, provide information on phase composition, texture, and residual stresses [1, 2]. Phase-contrast and interferometric methods detect interfaces, cracks, porosity, and sub-pixel microstructure [1, 5]. Diffraction-sensitive methods reveal crystallographic structure, phase transformations, and residual stresses [2]. Polarization methods visualize magnetic fields in bulk objects [1, 6]. Time-resolved methods enable observation of water transport, battery and fuel-cell operation, phase transitions, and crack propagation [1, 4].

Applications and Conclusion: For metals and alloys, the most informative approaches are energy-selective and diffraction-based methods [3, 4]. In energy-related systems, neutron tomography is especially valuable due to its sensitivity to hydrogen [1, 2]. In porous media and geomaterials, dynamic and phase-contrast methods are useful for observing saturation, capillary transport, and hidden damage [1, 5]. For magnetic materials, polarized neutrons are essential for mapping internal magnetic-field distributions [6]. Thus, specialized neutron tomography methods significantly expand the capabilities of classical neutron imaging and transform it into a tool for functional and structural diagnostics [1, 2].

Keywords: neutron tomography, neutron radiography, energy-selective imaging, Bragg-edge imaging, phase contrast, diffraction tomography, polarization tomography.

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Multi-valence-band effects in orientation-resolved high harmonic generation in ZnO

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We present a joint theoretical and experimental investigation into the electronic mechanisms governing orientation-resolved high-harmonic generation (HHG) in zinc oxide (ZnO). Using a 100 kHz high-power laser system, (0001)-cut and (112¯0)-cut ZnO samples were subjected to intense 3.2 μm, 45 fs mid-infrared pulses. The resulting non-perturbative harmonic spectra extend into the XUV region and exhibit a sensitive dependence on the crystal orientation relative to the laser polarization.

To interpret the experimental results, we performed detailed theoretical calculations of the orientation-dependent yields. Our findings show that the observed angular modulation is fundamentally shaped by multi-valence-band effects. Specifically, the intrinsic anisotropy of the ZnO band structure supports multiple coupled valence bands that undergo tunnel transitions into the conduction band, a process that significantly dictates the harmonic emission intensity. By accounting for this complex band interaction—a factor often overlooked in standard theoretical treatments—we provide a more comprehensive description of the nonlinear optical response in hexagonal semiconductors. These results highlight the essential role of multi-band dynamics in solid-state HHG and demonstrate the potential of harmonic yields as a sensitive probe of anisotropic band structures.

Three-body boundary-corrected methods for single-electron capture in fast H^++$Li^+(1s^2)$ and He^{2+}+$He^+(1s^1)$ collisions

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The process of single electron capture in fast H^++$Li^+(1s^2)$ and He^{2+}+$He^+(1s^1)$ collisions has been investigated. Four three-body boundary-corrected methods were employed: the three-body boundary-corrected first-Born eikonal-final-state (CB1-EFS-3B) and eikonal-initial-state (CB1-EIS-3B) methods, the three-body boundary-corrected continuum-intermediate-states (BCIS-3B) method, and the three-body boundary-corrected first-Born approximation (CB1-3B). Total cross sections were calculated for electron capture from the ground state of the target into the ground state of the projectile. The contribution of excited states was taken into account using the Oppenheimer scaling law. The influence of intermediate electronic continuum states included in the BCIS-3B approximation, as well as their eikonal forms incorporated in the CB1-EFS-3B and CB1-EIS-3B methods, was examined. The obtained results were compared with available experimental measurements.

Double aliovalent codoping as a tool for improving properties of YAG:Ce scintillators for fast detectors of ionizing radiation

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The combination of fast scintillation response, sufficient light yield, and radiation hardness is the main figure of merit for the material to be exploited as scintillator in the future high-luminosity particle physics experiments. Cerium-doped gadolinium aluminum gallium garnet (GAGG:Ce) currently stands out due to its exclusively high light yield. However, GAGG:Ce single crystals have to be grown in expensive iridium crucibles, whereas the emission decay is too slow for certain applications.

We report on the development of Ce-doped yttrium aluminum garnet (YAG:Ce) as a cost-effective alternative, since YAG:Ce can be grown using tungsten or molybdenum crucibles. It is known that YAG:Ce performance as a scintillator is deteriorated by carrier trapping that slows down the scintillation decay, whereas this effect can be partially mitigated by aliovalent codoping with Mg^{2+} or Ca^{2+} ions. In this work, we study the properties of YAG:Ce simultaneously codoped with Mg and Ca at different ratios.

Single YAG:Ce crystals codoped with different amounts of Mg and Ca were grown by the Czochralski method in Ar+CO atmosphere in tungsten crucibles. The crystals were studied under two different excitation conditions. In cathodoluminescence (CL) experiments, multiple electron–hole pairs were generated and migrated to emitting Ce centers, so that cerium ions in both valence states, Ce^{3+} and Ce^{4+}, were excited. Photoexcitation enabled selective excitation to specific Ce^{3+} levels. Time-resolved photoluminescence (PL) and CL spectroscopies, and transient absorption measurements performed over a temperature range from 80 to 750 K were exploited.

Our study revealed specific influences of Mg- and Ca-codoping on the scintillation performance. The introduction of Mg results in a moderate conversion of Ce^{3+} to Ce^{4+} and slightly accelerates of the luminescence decay. The enhancement of low-temperature PL intensity evidences a reduced influence of shallow electron traps in Mg-codoped samples. Meanwhile, Ca-codoping facilitates the conversion of a substantial part of Ce^{3+} to Ce^{4+} and strongly accelerates the luminescence decay at the expense of luminescence efficiency by channeling trapped electrons to nonradiative recombination centers and by the modification of the local Ce environment. Time-resolved PL spectroscopy in a wide temperature range revealed coexistence of two types of emitting Ce ions: regular Ce ions with a thermal depopulation barrier of 0.8 eV and Ce ions affected by Ca in their close proximity and having the depopulation barrier reduced to 0.36 eV.

We demonstrated that the reduction of the product of the rise and decay times of the luminescence response at increasing level of codoping overcompensates the decrease in the light yield, thus, making this approach useful for the improvement of timing properties of doubly codoped YAG:Ce scintillators. The current study demonstrates that codoping of YAG:Ce with Mg and Ca have specific influences on the properties of this scintillator, so that double codoping offers an efficient tool to tailor the combination of the emission decay rate and the light yield.

Monte Carlo simulation of full-energy peak efficiency of a coaxial HPGe detector using PHITS in point-source geometry

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High-purity germanium (HPGe) detectors are fundamental instruments in radiation measurements and gamma-ray spectrometry due to their superior energy resolution and ability to identify and quantify radionuclides accurately. Precise determination of full-energy peak efficiency (FEPE) is essential for reliable activity calculations. However, experimental efficiency calibration may be limited by the availability of certified calibration sources, geometric constraints, or long-term detector aging. In such cases, the Monte Carlo method provides a powerful complementary and validation tool.

In this study, the full-energy peak efficiency of a p-type coaxial HPGe detector (ORTEC GEM-C40) was investigated using the PHITS code under point-source measurement geometry. The detector has a relative efficiency of 40% and an energy resolution of 1.8 keV at 1332 keV for ^{60}Co. The detector geometry, including crystal dimensions, end-cap structure, and internal components, was initially modelled based on manufacturer specifications.

Efficiency values were evaluated in the photon energy range of 59.5–1332.5 keV using ^{241}Am, ^{57}Co, ^{60}Co, ^{137}Cs, ^{54}Mn, and ^{65}Zn point sources. Both experimental measurements and Monte Carlo simulations were conducted at source-to-detector distances of 5 cm and 10 cm to assess geometric consistency and model robustness. Consideration was given to the thickness of the dead layer in the detector, as it has a substantial effect on the attenuation of low-energy photons and, consequently, on the calculations of efficiency. This parameter was systematically increased within realistic limits to achieve optimal agreement between simulated and measured efficiency values. The optimal dead-layer thickness was determined by minimizing relative deviations across the fully investigated energy range.

With the optimized detector model, the relative deviations between simulation and experiment were below 5% at both measurement distances. The agreement demonstrates that PHITS-based Monte Carlo modelling, combined with careful dead-layer optimization, enables accurate efficiency prediction and supports detector characterization beyond nominal manufacturer data.

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Keywords: HPGe, efficiency, point source, PHITS, Monte Carlo

Life expectancy following childhood exposure to low-moderate doses of ionizing radiation to the head and neck: 70 years of follow-up of the Tinea Capitis cohort

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The health implications of exposure to ionizing radiation (IR) have been predominantly studied in the context of risk of cancer and other diseases. However, only limited attention has been given to the overall impact of such exposure on life expectancy itself. This analysis aims to evaluate the effects of childhood exposure to low-moderate doses of IR to the head and neck on mortality risk throughout lifetime, considering selected clinical and demographic covariates.

The study population comprised 10,834 individuals treated in childhood (ages 1-15 years) with IR for Tinea Capitis and 10,834 individually matched non-exposed subjects derived from the National Population Registry. The mean dose of radiation to the brain and breast were 1.5 Gy (range, 1-6) and 0.017 Gy (range, 0.0007-0.0074), respectively. The median age at end of follow-up of the study group was 67 years (range, 1-83). Data on mortality and causes of death was obtained from official national records. Poisson regression models controlling for sex and age at irradiation were applied and Excess Relative Risks (ERRs) and ERRs/Gy for major causes of death were estimated using a linear dose-response model. In addition, the average years of life lost among the exposed (up to age 75) and the attributable risks associated with radiation exposure were estimated.

Until December 2017, a total of 3,527 study subjects died (1,897 (17.5%) and 1,630 (15.1%) among irradiated and non-exposed population, respectively; $p<0.001$) yielding an overall ERR of 20%, (95%CI 0.07, 0.33) and ERR/Gy of 0.14 (95%CI 0.09, 0.19). Higher mortality rates were observed in both irradiated males and females, compared to non-exposed individuals (21.7% vs. 19.1% in males, $p=0.001$ and 13.5% vs. 11.2% in females, $p=0.001$, respectively). Elevated risks were additionally seen for malignant neoplasms as well as for non-neoplastic diseases, particularly circulatory diseases with an increased mortality ERR of 18% and 20% for heart disease. Mortality risks for most categories of causes of death were found to be inversely associated with age at exposure. Overall, we found a significant 10-month shortening in life expectancy, with a 17-month reduction for those irradiated at age < 5 years (95%CI 10.4-24.4) and a 12.4-month reduction for those irradiated at ages 5-9.9 years (95%CI 7.9-16.7). No difference between the study groups was observed for those irradiated at age 10 years and above. In addition, a 17% attributable risk for mortality due to radiation was found.

The results of the current study show that exposure to IR in childhood, even at relatively low doses and when restricted to specific anatomical area (head and neck), is associated with life shortening which is not attributed to cancer only. The finding that exposure to such doses of radiation might shorten life expectancy as a result of circulatory diseases might be considered among the long-term implications of radiation on public health.

Radiation testing of COTS-based safety infrastructure: from analogue acoustic chains to GaN and LED testing for signalling systems

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The deployment of safety and monitoring infrastructure in nuclear particle physics facilities, such as CERN large-scale accelerators, presents unique challenges for electronic systems. While high-energy physics experiments focus on beam-related radiation effects, ancillary infrastructure—including emergency communication systems and visual signalling equipment—must operate reliably in high-dose environments (exceeding 100 kGy) where traditional radiation-hardened components are often cost-prohibitive or unavailable. This paper investigates the radiation tolerance of Commercial-Off-The-Shelf (COTS) systems and components and proposes a development path for specialized radiation-hardened devices.

The first part of this study details the qualification of an emergency telephone system. The investigation covers the entire analogue signal chain, located within the device, including the microphone, speaker, and the analogue hybrid control board. Unlike standard digital electronics, acoustic and analogue components are expected to exhibit specific degradation patterns under Total Ionizing Dose (TID). We present a methodology for evaluating voice clarity and signal integrity, providing a "pass/fail" screening framework for infrastructure maintenance.

The second part focuses on the development of high-reliability beacons for emergency signalling systems. To overcome the obsolescence of xenon discharge lamps beacon and limitations observed in general purpose LED alternatives, a prototype utilizing Gallium Nitride (GaN) transistors was characterized. GaN devices were tested up to 100 kGy to evaluate their resilience to ionization and displacement damage. In parallel, high-power LEDs were monitored for luminous flux degradation and spectral shifts up to 40 kGy.

The results demonstrate that while certain COTS analogue acoustic components show surprising resilience, the electronic components for lighting beacons require specific hardening strategies. By combining system-level testing of existing telephones with component-level characterization of GaN-based sub-modules, this work provides an early introduction to hardness assurance in nuclear infrastructure. This study concludes by proposing design guidelines that bridge the gap between low-cost COTS deployment and the necessity for robust, Rad-Hard device development in critical safety applications.

High-entropy alloys for nuclear fuel cladding: a comparison on nitrides, silicides, carbides and metallic alloy of (CrNbTiVZr)X

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Materials used in nuclear fuel cladding must withstand simultaneous exposure to high temperature, corrosive environments, and intense neutron irradiation while maintaining low neutron absorption. The search for alternatives to conventional alloys has therefore shifted toward compositionally complex materials that can provide improved irradiation tolerance and thermodynamic stability. High-entropy alloys and ceramics are particularly attractive due to their severe lattice distortion, high configurational entropy, and enhanced resistance to radiation-induced defect accumulation. In this work, a radiation-informed compositional design strategy is proposed for multicomponent systems based on Cr, Mn, Nb, Ti, V, and Zr. These elements were selected due to their comparatively low neutron-capture cross sections, refractory nature, and ability to form protective oxide scales under reactor operating conditions. To further enhance high-temperature stability and oxidation resistance, selected light elements (C, Si, N, and Al) are incorporated to enable the formation of high-entropy carbides, nitrides, and silicides. First-principles simulations based on density functional theory (DFT) and molecular dynamics (MD) are used to investigate phase stability, mixing energetics, lattice distortion, and point-defect formation energies within the proposed compositional space. Particular emphasis is placed on vacancy and interstitial defect energetics, which are key indicators of irradiation tolerance in high-flux neutron environments. In parallel, a Monte Carlo radiation-interaction approach is employed to estimate neutron attenuation behavior, including the total macroscopic cross section and fast neutron removal cross section for representative alloy and ceramic compositions. The simulations indicate that Cr–Nb–Ti–V–Zr-rich systems exhibit favorable thermodynamic stability, moderate lattice distortion, and relatively low defect formation energies, suggesting improved resistance to radiation-induced damage accumulation. The incorporation of light elements strongly affects the stabilization of complex ceramic phases with enhanced oxidation resistance while maintaining low neutron interaction probabilities.

Radiation effects in spatially confined amorphous pnictochalcogenides: A computational insight through cluster modeling code CINCA

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Phenomenology of radiation induced effects in amorphous pnictochalcogenides A_xB_{1-x} (where pnictogen A = P, As, Sb, Bi; and chalcogen B = S or Se) is critically reexamined with respect to intrinsic free volume available for their realization. Destruction of covalent chemical bonds in these alloys under above bandgap irradiation is accompanied by relaxation in a new structural state. When such relaxation occurs via switching of heteronuclear (A-B) bonds into homonuclear (A-A) and (B-B) ones, like under intrinsic decomposition in amorphous stoichiometric $As_2(S/Se)_3$, an additional volume appears resulting in a red shift of optical absorption edge. Assuming that double-bond based $B{=}As(B_{1/2})_3$ units are stabilized due to inner pressure because of nanoconfined spatial geometry, a blue shift is expected. This analysis based on ab-initio quantum-chemical modeling of atomic clusters clarify misunderstanding with double bond based $B{=}As(B_{1/2})_3$ units as principal structural species facilitating self-organization in binary pnictochalcogenide A-B compounds.

A SEU detection and monitoring tool for radiation-sensitive FPGAs in the ATLAS Muon Barrel trigger upgrade

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In view of the ATLAS experiment upgrade for the High Luminosity LHC (HL-LHC) phase, several sub-detectors will undergo significant improvements to cope with the new operating conditions expected at HL-LHC. For example, in the Muon Spectrometer, the main upgrade will involve the installation of a new generation of Resistive Plate Chambers (RPC) detectors.

For the Level-0 Muon Barrel Trigger system, which relies on RPC detector signals, a new high-speed bidirectional serial link is foreseen between the new Data Collector and Transmitter (DCT) boards - installed in the experimental cavern (on detector) - and the new Sector Logic (SL) boards, located in the USA15 counting room outside the cavern (off detector). The optical serial link is based on the lpGBT (low power GigaBit Transceiver) chipset, developed at CERN and designed for high-radiation environments.

In this framework, the DCT boards collect the RPC detector signals and send them to the SL boards (uplink) at a data rate of 10.24 Gb/s; in addition to the detector signals, system monitoring information is also transmitted on the uplink. The link section from SL to DCT (downlink) operates at 2.56 Gb/s and is mainly used for configuration and slow control.

Since the radiation level expected in the USA15 area allows the use of commercial electronics, the lpGBT link section on the SL boards has been implemented using the Serializer/Deserializer (SerDes) transceivers integrated in commercial AMD Xilinx Kintex7 FPGAs, while the lpGBT ASIC will be installed on the DCT boards located in the cavern.

On the FPGA mounted on each DCT board - which is subject to Single Event Upsets (SEUs) in its configuration memory - a dedicated system for monitoring radiation-induced effects has been designed and integrated. In this contribution, we describe the design and validation of this radiation-effect monitoring system.

The SEU detection and monitoring system uses the AMD Xilinx Soft Error Mitigation (SEM) controller, integrated into the FPGA, which continuously scans the configuration memory and reports any detected or corrected errors. To enable reliable operation of the SEM controller in a radiation environment and to integrate it into the experiment's control infrastructure, a custom firmware module was developed. This module autonomously manages communication with the controller, formats diagnostic and status packets according to the lpGBT uplink protocol, and provides a remote interface for issuing configuration and diagnostic commands.

The system also includes a controlled error-injection mode, which allows specific configuration memory frames to be intentionally altered to validate the SEM controller's response and to verify the robustness of the firmware under simulated SEU conditions. The entire infrastructure - monitoring, control, and diagnostic channel - makes use of the high-speed link developed for the trigger system, demonstrating the flexibility of this link for remote maintenance and diagnostic tools.

The system was successfully tested both on the DCT prototype in the laboratory and later in the ATLAS experimental cavern, demonstrating its ability to reliably detect, handle, and report SEUs, and confirming the effectiveness of the developed firmware architecture and communication flow.

Total ionizing dose characterization of MOSFET-based voltage translators using impedance spectroscopy

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Voltage translators are widely used in modern digital systems to interface circuits operating at different logic voltage levels. These devices are also required in radiation environments such as nuclear instrumentation, space electronics, and medical imaging systems. Their reliable performance under ionizing radiation is essential, as degradation in threshold voltage, leakage currents, or internal parasitic elements can affect data transmission and system stability. In this work, we investigate Total Ionizing Dose (TID) effects on a MOSFET-based voltage translator (LSF0102, Texas Instruments) exposed to 100 Gy of ^{60}Co gamma irradiation. The study combines conventional electrical measurements with impedance spectroscopy (IS), a frequency-domain technique that is widely used in electrochemistry but underexplored in the study of radiation effects on microelectronic devices.

Standard characterization techniques included current and voltage monitoring during irradiation, analysis of transfer characteristics, and extraction of key MOSFET parameters. Throughout the irradiation, current consumption remained stable in both the high- and low-voltage domains, indicating that no macroscopic degradation occurred. Threshold voltage was extracted using the linear extrapolation method from Id–Vg curves, and only a small shift of approximately 6 mV was observed after exposure. The maximum transconductance did not change, further confirming that the device retained its operating capability under the applied dose.

To complement these measurements, impedance spectroscopy was performed to study subtle internal changes that are not easily detectable with standard methods. The device behavior was successfully modeled using an equivalent circuit composed of an RC parallel network in series with a resistor. IS showed that the oxide capacitance remained unchanged at around 14 pF, and the series resistance exhibited no measurable variation after irradiation. However, a moderate reduction of about 23% in the parallel resistance was observed, suggesting a slight increase in leakage mechanisms within the MOSFET structure. Importantly, this change did not affect the device functionality or its ability to translate digital signals between voltage domains.

Overall, the investigated voltage translator demonstrated stable performance and maintained all operational characteristics after exposure to 100 Gy of TID. While conventional measurements indicated negligible degradation, impedance spectroscopy revealed small variations in internal resistive elements that provide insight into underlying radiation-induced processes. These results highlight the value of IS as a sensitive and non-destructive tool for analyzing radiation effects in digital interface components. By identifying changes in parasitic and lumped elements that may precede functional degradation, impedance spectroscopy offers an important complement to traditional testing methods and supports the qualification of voltage-level-translation devices intended for use in radiation environments.

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Effects of X-ray exposure on white blood cell and systemic inflammatory indices in occupationally exposed healthcare workers: A pilot study

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Background: Increasing attention in contemporary research has been directed toward sterile inflammation induced by ionizing radiation (IR), which arises as a consequence of cellular damage rather than infection. Damaged cells release danger-associated molecular patterns, which activate the immune response and initiate an inflammatory cascade. This process may lead to alterations in hematological parameters and systemic inflammatory indices, which serve as indicators of the intensity of this response.

Objective: The aim of this study was to investigate the possible effects of occupational low-dose x-ray exposure on white blood cell subpopulations and systemic inflammatory indices in healthcare workers.

Materials and Methods: Data were obtained from mandatory periodic medical examinations of 66 healthcare workers occupationaly exposed to IR, which were provided in January 2026 at the Serbian Institute of Occupational Health. Workers were divided into two groups according to their annual effective dose (<1 mSv and ≥1 mSv). The routine complet blood count analysis and the following systemic inflammatory indices were calculated: neutrophil-to-lymphocyte ratio (NLR), derived neutrophil-to-lymphocyte ratio (dNLR), platelet-to-lymphocyte ratio (PLR), lymphocyte-to-monocyte ratio (LMR), systemic immune-inflammation index (SII), and systemic inflammation response index (SIRI). Data distribution was assessed using the Kolmogorov–Smirnov tests. Continuous variables were expressed as median (minimum-maximum), and differences were assessed using Mann-Whitney U test. The correlation was analyzed using Spearman's rank correlation coefficient and multivariate linear regression including age, sex, annual effective dose, and duration of occupational exposure as independent variables. All analyses were performed using SPSS version 17 (IBM Corp, Armonk, NY, USA).

Results: The study included 66 healthcare workers of both sexes, with a median age of 43 years (ranging: 23-63 years), who had been exposed to x-rays for a median of 10 years (ranging: 1-37 years) at various hospital departments, and with median annual effective dose of 0.88 mSv (ranging: 0.07-1.76 mSv). No significant difference was observed with regard to age, time of occupational x-ray exposure, white blood cells and investigated systemic inflammatory indices between two groups. In the present study, we observed a statistically significant negative correlation between lymphocyte count and time of occupational x-ray exposure. Although the correlation in the
overall sample was weak (rho = −0.264, p = 0.032), it reached statistical significance, suggesting that prolonged exposure may be associated with a gradual decline in lymphocyte levels.

Interestingly, when the analysis was restricted to healthcare workers receiving annual effective doses <1 mSv, the negative correlation became stronger (rho = −0.411, p = 0.013). This finding suggests that even within dose limits considered low and occupationally safe, cumulative exposure duration may still be associated with measurable biological changes. No significant association was found between time of occupational radiation exposure and systemic inflammatory indices in either univariate or multivariable analyses, suggesting that chronic low-dose exposure within regulatory limits may not substantially affect composite inflammatory indices.

Conclusion: Although inflammatory indices such as NLR, PLR, SII, and SIRI are widely used in clinical practice, their role in assessing biological effects of occupational exposure to IR remains insufficiently explored. The relatively small sample size and the lack of a control group may have limited the statistical power to detect subtle associations. Newertheless, our study contributes to filling this gap by systematically assessing these indices in the context of chronic occupational exposure to IR.

Keywords: Healthcare Workers; Ionizing Radiation; Hematopoietic Cells; Systemic Inflammatory Indices

Radiation hardness qualification of commercial electronic components for the Data Collector and Transmitter board of the ATLAS Experiment

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The electronics of the muon system of the ATLAS experiment at the CERN Large Hadron Collider (LHC) will be upgraded to withstand the increased radiation doses expected after the High-Luminosity upgrade (HL-LHC). The on-detector trigger and readout electronics of the RPC detectors will be replaced by the new Data Collector and Transmitter (DCT) boards. The radiation requirements for the selection of electronic components for the DCT are: a total ionizing dose (TID) of 80 Gy, a non-ionizing energy loss (NIEL) equivalent to 4x10^{12} n_{1{\rm MeV}} cm^{-2}, and a high-energy hadron (HEH) fluence exceeding 1.2x10^{12} cm^{-2}. We report the results of an irradiation campaign evaluating the radiation tolerance of various commercial off-the-shelf (COTS) components intended for the DCT. The tests were performed at the CERN CHARM mixed-field facility and included low-dropout (LDO) voltage regulators, SFP+ optical transceivers, LVDS receivers, and voltage translators. A full DCT prototype was also tested. The tests highlighted some unexpected single-event effects, which had not been observed for the same components in previous irradiations at other facilities. The results demonstrate that, by implementing measures to mitigate single-event effects (SEE), the selected components are suitable for the ATLAS upgrade.

Compact modeling of irradiation induced MOSFET threshold voltage shift using artificial neural networks

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Compact modeling is one of the types of modeling that tends to simplify otherwise complex physical processes dependent on multiple factors. Unlike physics-based analytical modeling, which relies on solving a large set of equations to describe specific processes or phenomena, this approach takes a different path. In environments where multiple conditions—such as bias, temperature, radiation, humidity, or magnetic field—vary simultaneously, solving equations at the particle level or at the charge carriers level becomes extremely challenging, even for advanced simulators. As a result, one strategy is to develop a model based on simpler premises that concentrates on just one device parameter, thus significantly cutting down the computational time required for parameter modeling.

Threshold voltage, which is one of the key parameters of MOS devices, shifts with applied radiation. This effect is more emphasized in p-channel devices than in n-channel devices. Among others, a radiation-induced shift in threshold voltage (ΔV_T) is also observed in devices with thicker oxide layers, such as p-channel power Vertical Double-Diffused MOS transistors (VDMOS), where the oxide thickness is estimated to be around 100 nm, as well as in p-channel transistors of CMOS circuits like CD4007, where oxide thickness is estimated to be around 90 nm. Since the threshold voltage shift in some of these devices can be significant even for low irradiation doses, there are many reports on using mentioned devices as dosimeters. On the other hand, different types of annealing following irradiation lead to recovery of degradation. Thermal annealing proved as efficient in degradation recovery, but can also impose some limitations in dosimetry applications of these devices. Therefore, there is a need to model threshold voltage shift after irradiation and during subsequent thermal annealing to make a valid assumption about whether the change is induced with irradiation on thermal annealing.

Modeling these processes can be very demanding from the analytical modeling standpoint, but can be relatively simplified with compact modeling using artificial neural networks. The ANN is designed using scikit-learn and trained using a combination of experimentally measured data (dose of 40 Gy, thermal annealing on T = 125 °C) and SPICE simulated datasets from multiple devices. Input feature for the ANN training is a vector composed of experiment conditions parameters (T, V_G and dose). Output data is a vector composed of coefficients of logarithmic expression, used to describe the shift of ΔV_T. The entire algorithm is implemented in Python. The trained model demonstrates good predictive capability, but with present errors in the range of relative error up to 13.6 %. It leads to a conclusion that more training data is needed to deliver more precise results. On the other hand, complexity of the simulation program is reduced drastically and the model offers greater versatility in the terms of modeling conditions.

The proposed approach bridges the gap between detailed physical simulations and practical parameter monitoring, offering a viable accurate solution for some dosimetry applications of the analyzed devices.

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Keywords: modeling, VDMOSFET, irradiation, annealing

Seasonal variation of radon levels in groundwater: Impact of weather conditions in a hot spot area

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This study investigates the seasonal variation of radon (Rn-222) concentrations in groundwater within an area identified as a radiological hot spot. The primary objective is to evaluate the influence of seasonal weather conditions, particularly summer and winter, on radon behavior in groundwater systems and to assess potential implications for environmental and public health risk.

Groundwater samples were collected from ten boreholes during both summer and winter seasons and analyzed for radon activity concentrations. The results demonstrated notable seasonal fluctuations in radon levels, indicating a strong influence of meteorological and hydrogeological conditions. Significant variations were observed among the studied boreholes, reflecting localized geological and environmental controls on radon release and transport.

For example, Sample 1 recorded a radon concentration of 10.9 Bq/L in summer, which decreased sharply to 0.778 Bq/L in winter. In contrast, Sample 903 exhibited an increase from 7.99 Bq/L in summer to 17.3 Bq/L in winter. Similarly, Sample 2940 showed a rise in radon concentration from 3.67 Bq/L during summer to 11.66 Bq/L in winter. Conversely, Sample 4587 demonstrated exceptionally high radon levels of 178 Bq/L in summer, which decreased significantly to 29.6 Bq/L in winter. These contrasting trends suggest that radon mobility and accumulation are strongly controlled by seasonal changes in groundwater recharge, soil moisture, temperature, and gas solubility.

The findings indicate that seasonal weather conditions exert a substantial influence on radon concentrations in groundwater, potentially driven by changes in aquifer recharge rates, groundwater flow patterns, and radon emanation from surrounding geological formations. Elevated radon levels observed in some boreholes exceed international guideline values for drinking water, highlighting potential radiological health concerns.

This study emphasizes the importance of continuous and seasonal monitoring of groundwater radon in hotspot areas to accurately characterize exposure risks. Furthermore, understanding the mechanisms controlling seasonal radon variability will support the development of more effective groundwater management strategies and enhance public health protection in regions affected by naturally occurring radioactive materials.

Radiological dosimetric assessment of soils in Ulaanbaatar city, Mongolia

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This study investigates soil radiation levels in the densely populated areas of Ulaanbaatar city based on the analysis of soil samples collected from 180 locations at approximately one-kilometer intervals. Gamma spectrometry was employed to determine the activity concentrations of naturally occurring radio nuclides, including radium-226, thorium-232, and potassium-40, as well as the mane-made radionuclide cesium-137. Based on the measured activity concentrations, the radium equivalent activity was calculated to assess the combined radiological impact of the radio nuclides present in the soil. In addition, ambient gamma dose rates were measured in situ at each sampling location using a portable dosimeter in order to evaluate background radiation levels across the city.

The main objective of the study was to assess radiological hazard parameters, including external and internal hazard indices, absorbed dose rates for outdoor and indoor environments, annual outdoor and indoor effective dose rates, and excess lifetime cancer risk for the selected locations. Gamma spectrometric measurements were carried out at the accredited laboratory of the Nuclear Physics Research Center (NPRC), National University of Mongolia (NUM), ensuring the reliability and traceability of the obtained results.

Spatial analysis and mapping of the results were performed to visualize the distribution of radionuclide activity concentrations and radiological indices across Ulaanbaatar city. The results indicate that the measured activity concentrations of both natural and man-made radio nuclides, as well as the calculated hazard indices and dose rates, are generally within internationally recommended safety limits. These findings provide a comprehensive baseline dataset for assessing soil radiation in Ulaanbaatar. In the future, this research will be expanded to develop an ecological atlas of soil radiation for the capital city, supporting long-term environmental radiation monitoring and risk assessment.

Keywords: Soil radioactivity; Gamma spectrometry; Natural radionuclides; Man-made radionuclide (Cesium-137); Radiological hazard

Anomaly in atmospheric ionizing radiation field below ten kilometers altitude

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In this study, measured vertical ionization profile showed a peaking in ionizing radiation intensity in the atmosphere registered below 10 km altitude, exceeding more than 20 times the values at these heights from previous measurements by meteorological balloons (or in any other way lifted detectors into the atmosphere). We confirmed these findings by three independent measurements performed by detectors equipped with ultra-thin mica windows. The registered peaking in ionizing radiation intensity was observed at altitude ranging from 5-8 km, in a very narrow altitude region (~300 m). Furthermore, Monte Carlo simulations of propagation of cosmic rays through the atmosphere were performed, searching for possible increase in number of detected events at certain altitudes (10 km, 8 km, and 5 km) due to air-shower developments. Unlike our experimental results, the simulation results did not show an enhance in the number of cosmic ray-produced secondary particles at certain altitudes (5 km or 8 km) relative to the 10 km altitude. A form of anomaly in atmospheric ionizing radiation field at lower altitudes has been seen in ARMAS (Automated Radiation Measurements for Aerospace Safety) data and measurements performed by the National University Corporation, Fukushima University.

The presented results in this study are important for better understanding of the ionizing radiation production mechanism in the atmosphere, as well as of its dose consequences.

Bssunfold - A python package for neutron spectrum unfolding using Bonner sphere spectrometer

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The bssunfold python package has been developed for solving the ill-posed inverse problem of unfolding neutron spectra (φ) from measurements of a Bonner multisphere spectrometer (b). This inverse problem is formalized as a system of linear equations with additive noise: $b = A\varphi + \varepsilon$ (where A is the detector sensitivity matrix and ε is the measurement noise). The package implements a set of numerical methods, including Landweber iterative algorithm and the Tikhonov regularization method with minimization of a smoothing functional using convex optimizers under the constraint that the solution should be non-negative. The uncertainty of spectrum unfolding is accessed by introducing a random error into the original data. Tests on reference spectra (calculated using Monte Carlo simulation software) showed that combination of the regularization method with the iterative algorithm provides a more accurate and stable solution compared to use of the one method separately. The iterative algorithm stabilizes the solution, and significantly reduces the uncertainty of the unfolding. With a measurement uncertainty of 1%, the uncertainty of estimation the effective dose rate from the spectrum is also about 1%. The developed package is applicable to neutron dosimetry at the accelerators and nuclear facilities and for solving a broad class of inverse problems described by Fredholm integral equations of the first kind.

Simulation of stochastic jittering in liquid scintillation counters

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Liquid Scintillation Counting (LSC) is a key technique for analyzing difficult-to-measure nuclides in the environment, particularly beta and low-energy particle emitters such as ^{3}H, ^{14}C, ^{35}S, ^{36}Cl, ^{45}Ca, ^{55}Fe, ^{63}Ni, ^{89}Sr, ^{90}Sr, ^{99}Tc, ^{147}Pm, and ^{241}Pu, which cannot be quantified using gamma spectrometry. To function effectively, LSC devices must mitigate thermionic noise generated by photodetectors. This is typically achieved by implementing a coincidence architecture utilizing two or three photodetectors to filter uncorrelated noise.

Within this architecture, the coincidence window is a crucial parameter, set relative to the scintillation pulse length. Previous studies [1,2] have demonstrated that this window must be increased for low-energy emitters to avoid significant event losses. These losses arise from two concomitant phenomena: signal quantization and the increase of delayed fluorescence. Quantization decomposes the ideal exponential pulse shape—where the trigger time theoretically matches the decay event—into a train of single-electron pulses. Consequently, there is a non-negligible probability that the first triggered charge appears with a delay, introducing stochastic jitter.

To analyze this stochastic jittering (cross-correlation), previous works have developed parametric models based on Poisson statistics [1] and fitted experimental time distributions using exponentially modified Gaussian distributions [2]. In the present study, this jittering effect is investigated via Monte-Carlo computation using the **ScintiPulses** program. This software emulates scintillation pulses by modeling the quantization effect (shot noise) as an inhomogeneous Compound Binomial-Binomial process.

Finally, the signal loss as a function of the coincidence window is estimated. Based on these simulations, recommendations are proposed to optimize the measurement of difficult-to-measure environmental nuclides using liquid scintillation.

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Thermoluminescence characteristics of natural epidote under beta irradiation

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Natural epidote samples were studied in order to examine their thermoluminescence (TL) response under controlled beta irradiation. All measurements were carried out using a Lexsyg Smart TL/OSL reader coupled with a $^{90}Sr/^{90}Y$ beta source operating at a dose rate of 0.097 Gy s^{-1}. Before applying laboratory irradiation, the natural TL (NTL) signal was recorded to evaluate the presence of intrinsic trapping centers associated with the crystal structure of the mineral. Following the initial characterization, beta doses within the range of 0.1–200 Gy were delivered to the samples. The resulting TL glow curves were monitored to track changes in luminescence intensity as a function of absorbed dose. Changes in TL intensity and glow curve profiles were evaluated as a function of absorbed dose. To examine signal reusability (RU), ten consecutive irradiation readout cycles were conducted using identical experimental parameters. Each cycle involved controlled beta exposure followed by TL measurement under a fixed heating rate. Maintaining constant thermal conditions ensured that variations in the glow curves were attributable to irradiation history rather than measurement inconsistencies. The obtained experimental data provide an experimental overview of the TL behavior of natural epidote under beta irradiation and establish a basis for subsequent indepth analyses of its luminescence properties.

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Performance of the TDCR system from IFIN-HH

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The triple to double coincidence ratio (TDCR) method for liquid scintillation measurement is used in national metrology institutes (NMIs) and designated institutes (DI) as a primary technique to standardize pure beta emitters. The TDCR system from IFIN-HH has been developed and commonly used for the last two decades with its associated electronics to measure different radionuclides. IFIN-HH has participated in several international intercomparisons for the following radionuclides - ^{3}H, ^{55}Fe, ^{89}Sr, ^{68}Ge, ^{222}Rn, ^{99}Tc - obtaining very good results using the TDCR method. The PMTs threshold values are very important for achieving low noise and high detection efficiency. In this paper, we will present the TDCR liquid scintillation measurement system along with the performance of the device obtained for few radionuclides.

Evolution of radon concentration in the MicroBq laboratory at Unirea Mine, Slănic Prahova

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Radon is a noble gas produced in the decay chains of ^{238}U, ^{235}U, and ^{232}Th, with a half-life of 3.82 days. Due to its radioactive nature and its proven link to lung cancer, radon represents an important environmental and occupational health concern, being the second leading cause of lung cancer after smoking. Monitoring radon levels is therefore essential, especially in underground environments where accumulation may occur.

This study investigates the evolution of radon concentration in the MicroBq underground laboratory located in the Unirea Salt Mine, Slănic Prahova, Romania. The mine is excavated in a large salt deposit approximately 5 km long, 3 km wide, and 500 m thick, with the laboratory situated at a depth corresponding to more than 600 m water equivalent. The underground salt environment provides extremely low natural radioactivity and strong shielding against cosmic radiation, making the site suitable for ultra-low background radiation measurements.

Radon concentration measurements were performed in the gamma spectrometry laboratory using an AlphaGUARD D2000 radon monitor. The instrument recorded radon activity in air with a sampling cycle of 3600 seconds (one hour). Measurements were carried out during several monitoring campaigns: March–April 2018, May–December 2020, December 2022–May 2023, and July–October 2025.

The results highlight the temporal variation of radon concentration within the underground laboratory and contribute to the characterization of the radiological environment of the MicroBq facility. Understanding radon behavior in this ultra-low background setting is essential for maintaining optimal experimental conditions for high-sensitivity nuclear radiation measurements and for ensuring accurate low-activity detection in environmental and biological samples.

Natural radionuclides in soils from three different geological regions of Brazil

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Determination of the elemental and mineralogical composition is crucial when studying The Earth's crust contains naturally occurring radioactive materials, whose concentrations vary with local geology and altitude, contributing to an average annual dose of 2.8 mSv/year (UNSCEAR, 2025). Brazil possesses the sixth largest uranium reserves in the world, although only 25% of its territory has been prospected. The country's main uranium deposits are located in the states of Bahia and Ceará. Ceará borders Rio Grande do Norte and Paraíba, in the easternmost region of South America, where economic activities are strongly associated with tourism, the oil industry, and sea salt production.

Objective: The present study aimed to assess radioactive contamination in soil samples collected in these four regions. The goal was to compare activity concentrations of ^{226}Ra (^{238}U), ^{232}Th and ^{40}K in soils samples collected both from uranium rich regions (Caetité U-mine; Santa Quitéria) and, for comparison, semi-arid, not rich in uranium ore region of Parelhas.

Material and methods: In total, about 40 soil samples were examined. Samples were dried and weighed and placed in Marinelli containers for 28 days for radioactive equilibrium to be reached. Then, samples were measured using gamma-spectrometer equipped with HPGe detector.

Results and discussion: Activity concentrations of ^{226}Ra (^{238}U), ^{232}Th and ^{40}K varied widely from MDA values to over 35,9 kBq/kg, 536 Bq/kg and 2700 Bq/kg, respectively. The highest concentration of these isotopes were obtained for soil samples collected in the area of Parelhas.

Conclusions: The presence of radionuclides in soil samples is independent of the exploitation of the U ore, since all points in the uraniferous region of Caetité and Santa Quitéria have concentrations in very similar values and the highest results were obtained for the region not connected with uranium exploitation.

Quantitative dosimetric assessment of external exposure from patients after ^{18}F-FDG administration as a methodological framework for the development of ^{161}Tb-based radiopharmaceuticals for theranostics (using the Drosophila melanogaster biomodel)

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The development of a 161Tb-based theranostic radiopharmaceutical requires the development of a methodology for the quantitative dosimetric assessment of external radiation exposure during preclinical studies. In this study, clinical dose rate measurements from patients following 18F-FDG administration (activity 200-335 MBq) and the experimental Drosophila melanogaster biomodel were used as such a methodological basis. The equivalent dose rate was shown to decrease from 184.3±30.3 μSv/h (immediately after administration) to 96.4±11.3 μSv/h (after 60 minutes), which is approximated by an exponential model with an effective decay constant $H(t)=Hoe-\lambda efft$. The low correlation of the initial dose rate with the administered activity ($R^2 \approx 0.002$) confirms the need for personalized dosimetry, which is critical for 161Tb with its half-life of 6.89 days. The 18F-FDG data serve two functions: 1) Methodological – the protocol for measuring the time dependence of the dose rate and exponential modeling, validated in patients, will be adapted for 161Tb, taking into account its longer half-life (6.89 days against 110 minutes). 2) Experimental – using a biomodel – in parallel with clinical measurements, the patterns of 18F-FDG accumulation and elimination were studied in Drosophila melanogaster. The same biomodel will be used to assess the biodistribution and dosimetric characteristics of 161Tb, allowing for a direct comparative study of the two nuclides under identical conditions.

The developed protocol for time measurements and exponential modeling has been adapted for 161Tb, and the patterns of radiopharmaceutical accumulation/elimination have been validated in Drosophila melanogaster, enabling a direct comparative dosimetric analysis of 161Tb and 18F-FDG under identical conditions. Thus, clinical data on 18F-FDG and experiments on Drosophila serve as a methodological foundation for the subsequent development of methods for the production and dosimetric evaluation of radiopharmaceuticals based on 161Tb.

Medical calibrators quality assurance and testing

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Radionuclides commonly used in nuclear medicine in Romania include Tc-99m, I-131, and F-18. These radionuclides are measured at Ionizing Radiation Metrology Laboratory (LMRI) from National Institute for R&D in Physics and Nuclear Engineering “Horia Hulubei” (IFIN-HH) using an ionisation chamber that serves as a secondary standard. LMRI ensures the national metrological traceability and its international equivalence through regular participation in international comparisons of activity measurement, the most recent of which took place in 2023. Following calibration at LMRI, the activity of the radioactive solutions is measured using the dose calibrators available from the customers. The stability of the chamber functioning is verified using a Cs-137 standard radioactive solution. The radionuclides used in nuclear medicine have relatively short half-lives which makes them well suited for diagnostic and therapy applications, as they result in reduced exposure to ionising radiation. In this study, various types of calibrators are evaluated by assessing their performance regarding two main criteria: the relative deviation of the measured activity compared to the true conventional values and the linearity check.

Determination of absolute gamma-ray emission probabilities in the decay of ^{241}Am

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Gamma rays of ^{241}Am are used in the MGA and FRAM software packages to construct the relative efficiency calibration curve for determining the isotopic composition of plutonium and for age dating of plutonium samples. This requires accurate values of the absolute gamma-ray emission probabilities in the decay of ^{241}Am. This is particularly important when measuring heavily shielded samples, where the high-energy region of the spectrum is used and only a limited number of gamma peaks with well-known emission probabilities are available. In this work, we performed measurements of the absolute gamma-ray emission probabilities in the decay of ^{241}Am.

The gamma spectrum of ^{241}Am was measured using a high-purity germanium (HPGe) semiconductor detector manufactured by CANBERRA, specifically the BE6530 model.

A ^{241}Am source with an activity of 10^8 Bq was measured at a distance of 40 mm from the detector crystal, ensuring a high counting rate in gamma lines within the studied energy range. To significantly reduce the load on the spectrometric system caused by X-rays and 59 keV gamma rays, as well as to minimize the effects of random and cascade summing, a system of Pb, Cd and Cu filters was placed between the detector and the source. The gamma spectrum was measured over a period of 17 days.

Based on a mathematical model of the measurement geometry implemented in the Geant4 environment, the relative detection efficiencies for gamma-ray transitions in the decay of ^{241}Am were calculated and normalized to the 662 keV gamma peak. The model was validated using experimentally measured relative detection efficiencies for well-known gamma lines of ^{241}Am and ^{233}Pa. The validation results show a discrepancy of less than 2% between the model and experimental efficiencies.

Using the gamma peak intensities obtained from spectrum analysis and the calculated relative detection efficiencies, we determined the absolute gamma-ray emission probabilities in the decay of ^{241}Am. The resulting emission probabilities were compared with evaluated data from Nuclear Data Sheets, revealing deviations of up to 90%.

Nitroimidazole-based radiosensitizers: Effect of halogenation on X-ray driven fragmentation

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Radiosensitizers are compounds that enhance the effectiveness of cancer radiotherapy by increasing the sensitivity of tumor cells to ionizing radiation. Despite their clinical importance, the fundamental molecular response of radiosensitizers to core- and inner-shell ionization, particularly the buildup and redistribution of charge and the magnitude of the resulting fragmentation, remains insufficiently understood. Prediction of these processes is, however, essential for elucidating why certain radiosensitizers outperform others[1–3] and for guiding the design of next-generation radiosensitizers.

Here, we present the results of gas-phase experiments exploring the photofragmentation dynamics of nitroimidazole-based radiosensitizers functionalized with iodine and/or bromine[2,4], providing neccessary data (ion yields and ion kinetic energies) for benchmarking theoretical models. The experiments were carried out using electron-multi-ion coincidence spectroscopy at the FinEstBeAMS beamline of MAX IV synchrotron (Sweden) and at the GALAXIES beamline of the SOLEIL synchrotron (France). This approach enables the reconstruction of site-specific fragmentation pathways and provides insight into the earliest steps of molecular breakup following X-ray absorption.

The photofragmentation dynamics of nitroimidazoles were investigated using both soft X-rays to ionize electrons from the C 1s, N 1s, I 4d, Br 3d and I 3d orbitals and tender X-rays to access the deeper I 2p orbital. We demonstrate how both the presence and the identity of halogen substitutes modulate the response of nitroimidazole radiosensitizers to X-ray absorption.

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Photoactivation yields of indium and tin long-lived isomer states

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The isotopes of indium (In, Z=49) and tin (Sn, Z=50) span a wide range of nuclei with shapes varying from near-spherical to deformed. Vicinity to the proton shell closure at Z=50 determines existence of a large number of In and Sn isomer states with different half-lives. The long-lived isomers play an important
role in the cosmic nucleosynthesis serving as β-decay waiting points [1]. The data about photoactivation reactions of indium and tin nuclei are necessary for modelling of abundances of several A~100 region p-nuclei ^{112}Sn, ^{113}In, ^{114}Sn, ^{115}Sn.
The ^{nat}In and ^{nat}Sn targets were irradiated by the microtron MT25 produced bremsstrahlung photon beams at several end-point energies in the range from 7.17 MeV to 22.82 MeV. The γ-spectra of activated samples were measured with HPGe detector after different cooling times. The lines corresponding to the decay of indium and tin long-lived isomer states ^{113m}In (391.7 keV; $T_{1/2}$=1.7 h), ^{114m}In (190.3 keV; $T_{1/2}$=49.5 days), ^{115m}In (336.2 keV; $T_{1/2}$=4.5 h), ^{116m}In (127.3 keV; $T_{1/2}$=54.3 min), ^{117m}In (315.3 keV; $T_{1/2}$=116.2 min), ^{117m}Sn (314.6 keV; $T_{1/2}$=13.9 days) have been identified. The measured intensities allowed to determine experimental yields of photonuclear reactions ^{113}In(γ,γ')^{113m}In, ^{115}In(γ,γ')^{115m}In, ^{115}In(γ,n)^{114m}In, ^{114}Sn(γ,p)^{113m}In, ^{117}Sn(γ,γ')^{117m}Sn, ^{118}Sn(γ,n)^{117m}Sn, ^{118}Sn(γ,p)^{117m}In at several bremsstrahlung end-point energy values in the range from close to the reaction threshold up to GDR. The experimental results are compared with literature data [2] as well as with the results of theoretical predictions in the frameworks of Hauser-Feshbach nuclear reaction theory.

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Radon measurements in Zametska Cave in the city of Rijeka, Croatia

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Radon concentration in cave systems is an important subject of study due to its impact on health [1, 2], especially in regions with significant karst areas such as those near the city of Rijeka in Croatia. Radon-222 is an inert, alpha-emitting gas formed from the uranium series, one of the three decay series observed in nature. It tends to accumulate in poorly ventilated areas, underground spaces, and caves. The presence of radon is influenced by geological, meteorological, and hydrological factors. In this study, we present preliminary results of radon concentration monitoring in Zametska Cave in Rijeka, Croatia.

Zametska Cave is located in the city of Rijeka, within the Zamet district, surrounded by several residential buildings, very close to the road, and only a few metres from a parking area and kindergarten. Despite its distinctly urban setting, it is a geomorphologically interesting cave, 224 m long and 23 m deep, protected as a geomorphological natural monument since 1981 and managed today by the Public Institution "Priroda". Zametska Cave was first explored and described by Guido Depoli, a Rijeka's speleologist, and entomologist, in 1920. Further research was carried out in 1928 by speleologist and geologist Josip Poljak [3]. In his articles, he described the cave, provided new microclimatic measurements, and took black-and-white photographs of the interior. During the Second World War, it served as a shelter. Today, metal stairs allow access to a large chamber, and due to its geological and geomorphological features, the possibility of arranging the cave for educational visits has been considered several times. To enable the cave to be opened to visitors in the future, preliminary measurements of radon concentration in the air are necessary to determine whether it is safe for visitors.

In this study, continuous year-round monitoring of radon concentrations was conducted in the cave for the first time using a portable AlphaE device (Saphymo GmbH). Measurements were carried out from July 2024 to July 2025, with data recorded every 30 minutes. Average radon concentrations of about 4000 Bq/m^3 were recorded during August and September, and the lowest average values between April and June (around 2000 Bq/m^3), while the maximum instantaneous value reached 13 000 Bq/m^3 in December. Unlike other caves in the region (Šparožna Pećina and Biserujka) [4, 5], Zametska Cave did not show pronounced seasonal variations. This pattern may be related to its urban position and the potential influence of natural gas heating systems in surrounding buildings on air circulation within the subsurface. The obtained radon concentrations do not exceed values that would limit visits to Zametska Cave. With the application of basic protection measures, Zametska Cave could be used for educational and scientific purposes, further highlighting its geological and speleological value within the urban area of Rijeka.

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Photoraser, a new effective technology for the decontamination & reducing radioactive waste

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The presentation presents the operating principle and feasibility of a new decontamination technology. One of the very important parameters for the storage of radioactive waste is volume. Due to the ablation technology, the surface contamination of the solids can be eliminated by collecting the detached particles, thus maximizing the volume / impurity volume ratio of the purified material. Most technologies produce large amounts of secondary contamination, the ablation process is not, inexpensive, fast, and can be deployed almost anywhere.

In this presentation I present the results of my radioactive material decontamination process, during which the contaminated surface was treated three times.

GANIL facility regime: Scientific approach for future evolutions

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GANIL is the unique nuclear accelerator in France classified as INB (Basis Nuclear Facility) in the same level as nuclear reactors, uranium enrichment facilities and nuclear fuel facilities. Many constraints are induced by this classification for the operation, the nuclear safety and the risks management. These constraints involve big costs in both human resources and operating budget with considerable time-consuming. The discussion, recently initiated by French nuclear safety authorities with all French accelerator facilities focuses on the possibilities to create a new regime for accelerators facilities, including GANIL. This evolution would induce a declassification of GANIL as INB for the new one which will be less constraining and especially more adequate with the real risks levels considerably weaker than those of traditional INB facilities.

A new criterion for nuclear facilities classification will be introduced. It deals with the level of the radioactivity contained in the facility. This concerns radioactive matter currently or that will be included in the future into the facility induced by research activities (irradiated targets …) or needed for the operating (calibration sources …). Each isotope activity in Becquerel is compared to its exemption activity fixed by the competent environmental and health authorities. We speak then about Q factor, which is the quotient of the radioactivity contained in the facility on its exemption activity. Regarding these calculation, one can evaluate the radioactive level of each nuclear facility, which will be considered as one of the criteria of the classification regime.

In this talk we will present the methodology used to perform these calculation for each radioactive source in all GANIL facilities: the existing ones and the under-construction or conception ones.

Radioactive elements transfer factors in the plant Helianthus tuberosus l (sunchoke)

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Research on biomass use for energy purposes is an important topic for sustainable development and the application of renewable energy sources in an area with developed agricultural production. As a basis of use of renewable energy sources in technology, planned cultivation of fast-growing crops that have a high yield of biomass per hectare is considered to be of great importance. Usage of renewable energy sources can be achieved by obtaining a large amount of organic matter for the production of biogas, which is then used in the cogeneration process for the production of heat and electricity. Fast growing culture, the Helianthus tuberosus L. plant (sunchoke), is an example of a culture that can be used for a high yield of biomass, because it grows with a yield of 140 to about 220 tons per hectare per year, thus obtaining a considerable amount of biomass where the carbon in the structure of the biomass was created entirely from CO_2 from atmosphere.

Sunchoke accumulates significant amounts of nutrients, including radionuclides from the soil. After biogas production, biomass is separated into liquid fertilizer and solid residue, in which the radionuclides remain. Since both products return to the soil and potentially re-enter the food chain, it is necessary to assess the transfer factors of radionuclides from the soil to individual parts of this industrial plant grown on this land.

The research included two plots of land. Several sunchoke plants were sampled in the post-flowering period, along with the soil in which the crop was grown, in order to determine radionuclide, transfer factors. After sampling, the plants were separated into tubers, stems, leaves, and flowers, and the radionuclide content was measured using an ORTEC HPGe GMX detector system. The measured activity concentrations of detected radionuclides were in the following ranges: Cs-137, 2.84–12.5 Bq/kg in soil and 0.6–1.67 Bq/kg in tubers; Ra-226, 21.7–37.3 Bq/kg in soil and 4.8–17.9 Bq/kg in stems; and K-40, 399–553 Bq/kg in soil and 705–1330 Bq/kg in flowers and leaves.

Based on the ratios of the measured activity concentrations, radionuclide transfer factors for all samples were calculated according to the IAEA TRS-472 methodology. The most important result of this research is that the plant reconcentrates potassium (K-40) in all of its parts, which may affect food production safety and population exposure through ingestion.

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Modelling of radionuclide migration in a generic deep geological repository in granitic host rock considering engineered and natural barrier interaction

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An important step in the design process of a deep geological repositories (DGRs) includes an extensive safety assessment. These safety assessments have to take into account a number of factors that can affect the capability of the waste disposal facility and its surroundings to retain dangerous materials, this can include the assessment of radionuclide sorption change in various engineered and natural barriers. A common approach is to use sorption coefficients for materials of each barrier, to determine the retardation of radionuclide flux into the environment. The evolution/change of barriers properties, e.g., physio-chemical degradation of concrete barriers can affect its sorption capabilities.

The aim of this study is to assess the concentration distribution of three representative radionuclides in a generic DGR for intermediate-level waste (ILW), considering interactions between engineered and natural barriers. The repository consists of cemented waste packages and cementitious backfill placed in a granitic host rock [1]. The radionuclides evaluated are Ni-59 (moderately sorbing), I-129 (weakly sorbing), and Pu-239 (strongly sorbing). Water percolation leaches cementitious components from the engineered barriers, decreasing pH inside the cell and increasing it in the surrounding rock matrix. Modelling chemical transport is essential to determine the pH front, as pH controls radionuclide sorption (Kd) values in each material. Leaching-induced pH changes in concrete waste packages and engineered barriers are used to define corresponding Kd coefficients in both concrete barriers and granite host rock, which are then applied in reactive transport models to evaluate radionuclide migration. Three cases are modelled: (1) no physical or chemical property changes are considered in granite and engineered barriers; (2) pH and Kd changes in both natural and engineered barriers are considered in two steps based on high-pH front propagation; and (3) pH and sorption changes in natural and engineered barriers are assessed over five steps. Reactive transport modelling is performed using HYDRUS 1D software [2] in all cases.

The results of the evaluation demonstrate, that radionuclide concentrations in all cases, for each radionuclide follows a similar distribution pattern in the system. However, differences in concentrations are noticeable. In case 1, radionuclide Ni-59 propagates deeper into the granitic rock layer and the concentration is higher, when compared to case 2 and 3. The differences between cases 2 and 3 are very low, and follow the exact same distribution pattern. In the case of a strongly sorbing radionuclide Pu-239, the differences in modelling approach led to a negligible difference in radionuclide distribution: Pu-239 does not leave the concrete barrier system. Similarly, for the weakly sorbing radionuclide I-129, the differences in modelling approach led to negligible difference in radionuclide distribution: I-129 has very low sorption on both concrete and on granitic rock, and pH change in surrounding material does not impact the Kd of the radionuclide.

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Insights from the EURADOS eye lens dosemeter intercomparison IC2025eye: Evaluation of results from the Department for Radiation and Environmental Protection at the Vinča Institute of Nuclear Sciences, Serbia

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This paper presents the results of the EURADOS Eye Lens Dosemeter Intercomparison IC2025eye, focusing on the measurements performed at the Department for Radiation and Environmental Protection, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade. The intercomparison was coordinated by the EURADOS WG2 Intercomparison Organization Group, which established the irradiation plan, including photon energy and dose ranges, and managed all logistics, from participant registration to the return of dosemeters. A total of 46 institutes with 49 dosemeter systems participated, following standardized irradiation procedures in September-November 2025. At the Vinča Institute of Nuclear Sciences, the Department for Radiation and Environmental Protection participated in the intercomparison using passive thermoluminescent dosimeters (TLDs) with LiF:Mg,Cu,P crystals, commercially designated DXT-100H, selected for their high sensitivity and ergonomic suitability, enabling routine monitoring of occupational eye lens doses without compromising operator comfort. Readouts were performed using a Harshaw 6600 Plus automated TL reader (Thermo Fisher Scientific, USA), calibrated in a ^{137}Cs reference field (S-Cs radiation quality) with a 1 mSv reference Hp(3) dose at 0° incident angle. Participants applied readout procedures and reported measured doses, which were compared with reference values to assess performance. Expanded uncertainties (k = 2, 95.4% confidence) were calculated according to the GUM framework (ISO/IEC Guide 98-3:2008). The results achieved by the Vinča Institute of Nuclear Sciences demonstrated good overall agreement with reference doses, with measured-to-reference ratios ranging from 0.87 to 1.16. Analysis by radiation quality showed that ^{137}Cs irradiations slightly underestimated doses (ratios 0.87-0.88), N-40 X-ray irradiations slightly overestimated doses (ratios 1.13-1.16), and W-80 X-ray irradiations showed excellent agreement across both low- and high-dose configurations and at different angles of incidence (ratios 0.95-1.06). These variations are consistent with expected TLD energy responses and are within acceptable intercomparison criteria. In conclusion, the results achieved by the Department for Radiation and Environmental Protection at the Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade within IC2025eye intercomparison of passive eye lens dosemeters were generally satisfactory, confirming the suitability of DXT-100H dosimeters for routine eye lens dose monitoring.

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The response of solid-state nuclear track detectors exposed at 3 MV Tandetron accelerator from IFIN-HH

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The scientific motivation behind this study is to evaluate the performance of CR-39 materials, in this case from Radosys, to achieve calibration factors from exposure to protons at 3 MV Tandetron accelerator from IFIN-HH, Romania. This study arises from the wide range of applications and the importance of CR-39 plastic detectors, also known as solid state nuclear track detectors (SSNTDs), particularly in fields such as radiation dosimetry. These detectors can register the damage produced by various charged particles at the molecular level. The resulting tracks can be revealed by chemically degrading the detector material through a process known as etching. SSNTDs are widely used for applications including radiation fluence determination, particle identification, classification of energetic particles, and reconstruction of particle trajectories [1].

Thus, in one experimental setup, several SSNTDs were exposed to protons with energy of about 3.5 MeV, to doses that varied between 1.60mGy and 6.42 mGy, and different time of exposure, from 1 ms to 20 ms. After the exposure, the solid-state nuclear track detectors are chemically treated, in order to reveal and count the tracks of the particles.

In general, the proton dosimetry using SSNTDs is commonly based on the evaluation of track density (e.g., tracks/cm^2) and on the assumption of a linear relationship between track density and the personal dose equivalent Hp(10), where the calibration factor is given by calculating the ratio between the value of the reference dose H_0 and the mean track density of these SSNTDs [2]. However, from this first experimental setup the response of solid-state nuclear track detectors did not show linearity response to dose, but rather of polynomial response (2nd order) of the track density as function of the personal dose equivalent Hp(10).

Further investigations are considered, regarding the diameter of the tracks on the SSNTD as a function of the proton energy, as well as the dip angles. Exposure to lower and higher energy proton are under investigation in order to validate the method for the data used and the experimental methodology involved.

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Comparative analysis of the response of SSNTDs under accelerator-based and high-power-laser–generated particle beams

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In this work, track morphology, track density, etch-pit dimensions, and sensitivity curves of solid-state nuclear track detectors (SSNTDs) were analyzed and compared for 60 MeV protons obtained from a 1 PW laser-driven proton source with the response obtained from protons produced in a conventional accelerator. The experiments were performed at ELI-NP (Extreme Light Infrastructure – Nuclear Physics), which hosts one of the most advanced high-power laser systems dedicated to photonuclear research.

High-power laser–target interactions generate pulsed ionizing radiation fields characterized by ultra-short duration, high instantaneous dose rates, and broad particle spectra, making their characterization challenging for conventional active detectors [1]. In this context, passive detectors such as SSNTDs, which are inherently insensitive to pulse structure, represent a suitable alternative.

The aim of the present study was to evaluate the detector response under laser-driven irradiation conditions and to assess the feasibility of establishing a dosimetric method based on SSNTDs combined with automated track analysis. Particular emphasis is placed on the use of laser-driven 60 MeV proton beams for detector calibration and material-response investigations.

The results indicate that, despite broader energy distributions and shot-to-shot fluctuations, petawatt laser sources can provide suitable irradiation environments when appropriate spectral filtering and beam selection techniques are applied. This comparative analysis highlights the complementary roles of accelerator- and laser-based proton sources and provides guidance for detector characterization in high-intensity laser facilities.

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From contamination to reuse: A practical methodology for assessing health risks in radioactive contaminated buildings

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Radioactive contamination of internal building surfaces arising from historical industrial practices presents ongoing radiological protection and regulatory challenges, particularly in the context of decommissioning and building reuse. Robust and practical approaches are needed to assess potential health risks from such contamination.

This work presents a methodology for estimating effective dose to current and future building users from internally contaminated surfaces. The approach considers a variety of plausible exposure scenarios and contamination profiles. These range from localised surface contamination to more embedded activity, allowing both realistic and worst-case dose estimates to be calculated.

The methodology assumes the contaminated room was repurposed as an office. Key exposure pathways include external radiation from fixed surface contamination, as well as inhalation and ingestion associated with dust generated during renovation activities. The methodology adopts cautious but reasonably realistic assumptions to account for uncertainties in future building use.

The methodology is used to calculate screening levels, expressed as activity per unit mass (Bq g^{-1}). These levels can be compared to monitoring data to determine whether future reuse of an internally contaminated room could result in doses exceeding a specific dose criterion. The criterion used in this work is 10 μSv y^{-1}, the level used by the UK Office for Nuclear Regulation to represent "no danger" for delicensing nuclear sites.

The methodology provides a transparent and proportionate framework to support regulatory decision-making, enabling the safe and sustainable reuse of historically contaminated buildings.

An urgent need to optimise and reduce the number of currently in use quantities in radiation protection

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The system of radiation protection quantities has been evolving for years, with definitions often changed to reflect the latest progress in the field, and thus, many new quantities have been introduced. The old quantities were usually employed alongside newly introduced ones, leading to too many quantities being used at the same time and making their definitions difficult to interpret, thereby often complicating the correct interpretations and applications of such quantities. In addition to two physical quantities, which present a basis for radiation protection quantities, namely absorbed dose (D) and kerma (K), several protection quantities were introduced, serving for the assessment of biological effects: dose equivalent (H), equivalent dose (H_T), effective dose (E), and committed effective dose (E50). Since these quantities cannot be measured directly, operational quantities for assessing external exposure have been introduced to overcome these difficulties. The originally introduced operational quantities included ambient dose equivalent, directional ambient dose equivalent, and personal dose equivalent. Later, the original operational quantities began to be replaced by new operational quantities, namely personal dose (H_p), ambient dose (H*) and directional absorbed dose (D'). New operational quantities are defined as the product of the field quantity (fluence) and relevant conversion coefficients. The simultaneous use of old and new operational quantities poses some obstacles in their applications. Other problems encountered in the current system of radiation protection concern units used for numerous quantities, where only three such units are available: Gy, Sv, and Gy-Eq. These units are often used without clearly specifying the quantity they refer to. The paper will present and discuss the current system of radiation protection quantities and units, including the difficulties in their use and in interpreting results obtained with various dosimeters or monitors, where it is often unclear which quantity is intended to be measured.

Importance of radiation exposure quantification for the risk assessment and its communication with the public

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The radiation risk assessment is based on radiation quantification, which is used to estimate health effects on exposed persons. Their doses should be kept at very low levels where only stochastic effects are expected. However, in exceptional cases, such as accidents or terrorist attacks, exposure may be considerably high, leading to deterministic effects. In any case, applications of radiation and nuclear technology should be fully justified, and exposure of personnel and the public should be kept as low as possible, but it must not exceed the limits recommended by relevant international and national radiation safety standards. The population, including persons who encounter radiation sources and materials (workers, patients), should be aware of the possible effects of radiation exposure and possess basic knowledge of radiation protection. This is usually achieved through information from the public mass media and lectures by specialists who explain, in a simple and understandable manner, the health effects of radiation and basic recommendations for protection against radiation exposure. In understanding the consequences of radiation exposure and assessing the relevant health risks, quantifying these effects using appropriate units is crucial.

There are, however, some problems in the implementation of these tasks: 1. Existence of different quantities and units for the assessment of stochastic and deterministic effects. 2. Too many quantities (more than ten) are currently in use to quantify radiation-induced health effects, and only three units. 3. Confusions arising from inconsistencies concerning the use of units without specifying to which quantities they belong. 4. Since the radiation quantification is continuously developing, aiming at the introduction of further new quantities which are then used in parallel with the old quantities. 5. The wrong use of quantities, e.g., the unit Sv is often used also for the assessment of deterministic effects, also contributes to some problems, which complicate the communication of radiation risks based on the information and results from various published materials.

It seems that an excessive number of radiation quantities is used in routine radiation protection. It looks desirable to reduce the number of radiation protection quantities intended for routine use and leave other specific quantities for their scientific and, especially, medical applications.

The paper discusses the present rather complex situation in using radiation protection quantities and units, including the relevant inconsistencies which may affect the risk communication to the public and other persons, including patients and those who are engaged in radiation and nuclear applications, but they may not be specialists in the present rather complicated system of radiation protection and its applications.

An attack where the use of radioactive or nuclear material may significantly frighten the public could be considered a particular case. This poses challenges for communicators, who must swiftly disseminate information following an assault while ensuring their statements are clear and likely to be received by the public. Communicators may increase the likelihood that their communications will have the desired impact by anticipating what people want to know, where they will obtain information, and how to follow such instructions.

Thymoquinone as a new radioprotective drug with mitochondria-targeted action

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The study of methods for modifying radiosensitivity is a crucial fundamental problem both from the standpoint of reducing the consequences of exposure to ionizing radiation (IR) on the body and from the standpoint of increasing the effectiveness of radiotherapeutic approaches to the treatment of tumor diseases. It is known that the radiosensitivity of living organisms is largely determined by the activity of endogenousprotective and reparative systems. The efficiency of repair systems depends not only on their completeness but also on the amount of induced DNA damage, its complexity, and energy supply. The functioning of DNA repair systems is an energy-dependent process. Repair of one DNA double-strand break (DSB) requires approximately 10000 ATP molecules. As is known, only when exposed to rare-ionizing radiation at a dose of 1 Gy can up to 40 DSB be formed in the DNA of a mammalian cell. ATP is also necessary for the implementation of cell death programs (apoptosis, autophagy, parthanatosis, etc.).

5'-AMP-activated protein kinase (AMPK) plays a key role in maintaining energy homeostasis in cells irradiated with low and sublethal doses of IR. Activated AMPK triggers a cascade of intracellular events, primarily enhancing mitochondrial biogenesis, autophagy, and stimulating energy production. Many studies have shown that additional activation of AMPK, mitochondrial biogenesis, and autophagy in cells can be achieved using compounds of different classes. Among them, thymoquinone is of considerable interest – a component of black cumin (Nigella sativa), which does not have toxic properties and has a positive effect on various endogenous and exogenous human pathologies. Black cumin and its active component, thymoquinone, exhibit various pharmacological activities against many diseases (viral, bacterial, as well as cardiopathology and tumor formation). Owing to its antioxidant properties, this drug is characterized by neuroprotective, nephroprotective, gastroprotective, hepatoprotective, and anticarcinogenic effects.

In this study, various markers were used to analyze tissue damage in mice with different proliferative activity and radiosensitivity (brain, spleen). The degree of damage modulation was also assessed when thymoquinone (2-isopropyl-5-methyl-1,4-benzoquinone, Nigella sativa) was administered to mice after exposure to X-rays. The results of the study showed that nuclear DNA (nDNA) reparation was more active in the spleen of mice irradiated and given thymoquinone than in brain tissue. This was accompanied by activation of mitochondrial biogenesis with the synthesis of new copies of mitochondrial DNA (mtDNA). A significant proportion of newly synthesizedmtDNA molecules contained mutant copies, which contributed to an increase in oxidative stress. Thymoquinone reduced the number of mutant mtDNA copies in the spleen and brain tissues. In the tissues of mice exposed to X-rays, an increase in the level of malondialdehyde (MDA) and a decrease in the level ofreduced glutathione (GSH) were observed. The concentration of MDA was higher in the tissue of the cerebral cortex than in the tissue of the mouse spleen, and the content of GSH in the spleen was more than two times lower than in the brain. Nevertheless, thymoquinone contributed to the restoration of their levels. Thus, despite the fact that the tissues of the spleen and brain of mice differed in the values of the analyzed markers, the radioprotective potential of thymoquinone was observed in both tissues.

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Radionuclide dispersion in complex urban environments: A hybrid CFD framework

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Atmospheric dispersion of radioactive clouds in urban areas generated, for instance, by the operating cycles of particle accelerators employed in nuclear medicine and oncological therapy centres typically situated near residential areas requires the development of accurate modelling. This represents a crucial challenge for radiation protection and environmental impact assessment.

The presence of buildings and obstacles significantly alters wind velocity fields, generating complex local aerodynamic phenomena that traditional operational models, such as the Gaussian Plume Model (GPM), fail to fully describe. These stationary analytical models rely on extremely simplified assumptions that are often inadequate for short-range evaluations in contexts characterised by irregular geometries. To overcome these limitations, the present work proposes an advanced methodological framework based on Computational Fluid Dynamics (CFD), continuing the research activity previously initiated [1]. Specifically, the Large Eddy Simulation (LES) technique is employed to capture the unsteady and three-dimensional nature of contaminant transport, resolving the energetic scales of turbulence with high fidelity. To ensure a correct representation of the incident atmospheric boundary layer, an advanced approach for inlet turbulence generation has been implemented, surpassing the approximations of traditional synthetic methods. Numerical simulations are performed on standard geometries, consisting of an emitting stack placed on its own supporting structure and a building located downwind along the flow direction.

The proposed model aims to calculate concentration fields for future integration with Monte Carlo codes. This will allow for the formulation of dosimetric evaluations based on the accurate spatial distribution of the radionuclide, accounting for the attenuation effect produced by the influence of buildings. Consequently, the approach serves as a modular and state-of-the-art reference framework for optimising radiological safety and emergency management in real-world scenarios. The results of this work will focus on the analysis of the spatial distributions of the contaminant, employing a LES approach coupled with a precursor domain capable of developing velocity profiles and turbulence parameters of the atmospheric boundary layer (ABL) that are physically consistent with the site roughness. The work includes a critical comparison between the CFD results and the profiles derived from Gaussian models, currently in use within the field of radiation protection, validating the effectiveness of the framework in complex urban environments.

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Cellular and molecular mechanisms which diversify alpha radiation inflicted killing of various cancer cells: The role of DNA damage, cell cycle arrest, and TP53

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High–linear energy transfer (high-LET) alpha-particle radiation presents a potent candidate for radiotherapy, particularly for photon-based radiation radioresistant tumors. We developed an alpha radiation-based radiotherapy designated as *Diffusing alpha radiation therapy* (Alpha DaRT). DaRT involves the use of intra-tumoral wires loaded with Ra-224, which spread alpha emitting atoms inside the tumor. DaRT efficiently destroys various solid tumors which subsequently induces systemic antitumor immunity. Clinical studies proved the efficiency of DaRT in the eradication of squamous cell carcinoma (SCC) cancers in patients.

Currently we examine *in vitro* the killing of tumor cells of various histotypes by alpha particles and attempted to elucidate the cellular and molecular mechanisms attributed to the differences in sensitivity to radiation. Previous in vivo studies revealed that SCC derived tumors (SQ2) are the most sensitive to alpha radiation (DaRT) compared to murine breast (4T1), and pancreatic (Panc02) carcinoma cell lines. Comparable in vitro studies indicated that among the three cell lines, SCC cells were the most sensitive to alpha radiation (0-7 Gray) as determined by clonogenic assays and exhibited the highest number of Double strand DNA breaks (DSB) as quantified by phosphorylated H2A.X (gamma-H2AX). The sensitivity of the three cell lines to photon radiation was similar. A most pronounced effect of alpha radiation was G2/M-arrested cells in all cell-lines, but mainly in SQ2 cells, a phenomenon related to Mitotic Cell Death (MCD). DNA compactness does not seem to affect the sensitivity.

Further investigation was conducted to reveal if the differences found among tumors of different histotypes, also exist among tumors from the same tissue origin. Four human-derived cutaneous melanoma cell lines: YDFR.C, DP.C, M12.C and M16.C, were irradiated *in – vitro* using Am-241 as alpha-particle source [0-2.8 Gray (Gy)]. Cell viability assays revealed a correlation between the number of DSB and the size of the nucleus. The most sensitive cell, DP.C, had the largest nucleus area and the highest number of DSB. Melanoma cell variants were significantly more susceptible to the cytotoxic effect of alpha radiation compared to photon radiation. Chromatin condensation does not seem to affect alpha radiation-inflicted damage.

Next, we examined if TP53 status shapes the radiosensitivity of human derived sarcoma cells to alpha radiation. Sarcoma cell lines: U2OS (TP53 wild type), SAOS-2 (TP53 null), RD-18 (TP53 R248W), SK-LMS-1 (TP53 M237K/G245S), and A673 (TP53 frameshift), were irradiated by alpha particles (Am-241 source) at doses ranging from 0 to 4.2 Gy. Alpha-particle radiation reduced clonogenic survival, caused dose-dependent suppression of proliferation, and induced double-strand breaks in all sarcoma cell lines. Evidently TP53 wild-type, U2OS cells, were the most sensitive cells (D_0=0.55 Gy), whereas TP53-null (D_0=0.82) and mutated cells retained clonogenic survival at higher doses, with A673 displaying the greatest resistance (D_0=1.642 Gy). Furthermore, post-irradiation treatment with p53-reactivating compound, APR-246, reduced clonogenic survival in TP53-altered cell lines, indicating that resistant cells can be rendered more sensitive by manipulating p53 expression.

Summary:

- Various mouse and human tumor cell succumb to the destructive force of high-LET alpha particles which was more effective than photon radiation.
- DNA Double strand breaks are a major event induced by alpha particles and related to nucleus size in melanoma.
- Proliferation arrest was involved in cell death following alpha particle attack.
- Long-term survival and DNA damage in sarcoma cells differed markedly by TP53 status. TP53 wild type cells were more sensitive compared to TP53 null or mutated cells exposed to alpha-particles.
- The findings support the rationale for combination of alpha-based radiotherapy with p53-reactivating and stress-amplifying agents.

The early assessment of tumor response after carbon ion irradiation using radionucleic acid derivatives

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Carbon-ion radiotherapy is a minimally invasive treatment that preserves organ function and improves quality of life, owing to its superior dose distribution and higher biological effectiveness than that of conventional photon therapy. However, in current clinical practice, tumor response is generally evaluated using anatomical imaging several months after treatment initiation, limiting early assessment of therapeutic effectiveness. Moreover, relative biological effectiveness (RBE) is often assumed to be constant in clinical dose prescriptions, despite evidence that it varies with dose and linear energy transfer (LET). Therefore, developing biologically relevant early-response markers is essential for improving treatment evaluation and optimization.

In this study, we evaluated the potential of 2-[14C]-thymidine as a direct DNA synthesis tracer for early tumor response assessment following carbon-ion radiotherapy. Syngeneic NFSa fibrosarcomas were implanted subcutaneously into C3H mice and irradiated with carbon-ion beams at low (14 keV/μm) or high (74 keV/μm) LET using the Heavy-Ion Medical Accelerator in Chiba. Tumor growth was monitored longitudinally, and tumor growth delay (TGD) was calculated as the gold-standard endpoint for treatment efficacy. Isoeffect doses corresponding to a TGD of 15 days were derived to estimate RBE under different LET conditions. To assess early biological changes after irradiation, 2-[14C]-thymidine was administered intravenously 12 h post-irradiation, and tumor uptake was quantified as percentage injected dose per gram of tissue. These measurements were used to examine dose- and LET-dependent changes in thymidine uptake, and to compare early tracer responses with subsequent tumor growth outcomes.

Tumor growth analysis revealed clear dose- and LET-dependent inhibition of tumor regrowth, supported by a significant dose × time interaction in linear mixed-effects modeling ($p < 0.001$). TGD increased with dose under both LET conditions, and the dose–TGD relationship was well approximated by linear regression ($R^2 = 0.91$ for 14 keV/μm and $R^2 = 0.98$ for 74 keV/μm). The isoeffect doses required to produce a TGD of 15 days were 39.52 Gy at 14 keV/μm and 22.29 Gy at 74 keV/μm. Previous studies have shown that the RBE of 14 keV/ μm carbon ions relative to Cs-137 γ-rays is approximately 1.4.TGD-based isoeffect dose analysis indicated that the RBE of 74 keV/μm carbon ions relative to ^{137}Cs γ-rays was approximately 2.48.

Tumor uptake of 2-[14C]-thymidine at 12 h post-irradiation decreased in a dose- and LET-dependent manner, with statistically significant reductions in all irradiated groups compared with controls ($p < 0.05$). The dose–thymidine uptake relationship was also well approximated by linear regression ($R^2 = 0.84$ for 14 keV/μm and $R^2 = 0.72$ for 74 keV/μm). At TGD-defined isoeffect dose pairs (40 Gy at 14 keV/μm and 22 Gy at 74 keV/μm), comparable suppression of thymidine uptake was observed, and the 95% confidence interval of the difference included zero. Notably, significant reductions in thymidine uptake were observed even under low-dose irradiation conditions, for which tumor volume-based assessment failed to show clear differences.

These findings indicate that early changes in thymidine uptake reflect biologically relevant dose- and LET-dependent tumor responses and suggest that thymidine uptake may serve as a sensitive early biomarker for evaluating tumor proliferation and treatment response following carbon-ion radiotherapy.

Changes in serum homeostasis under the action of gamma radiation in a wide range of doses and time, detected by Laser Correlation Spectroscopy (LCS)

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Health risks associated with therapeutic or occupational radiation exposure, and the causal relationship between such exposure and subsequent diseases, can only be identified through longitudinal radiobiological and epidemiological studies. The search for new integral biomarkers to assess radiation-induced alterations remains a pressing problem. Changes in the physiological status of the body induced by environmental factors modulate metabolic processes, which in turn alter the composition of biological fluids. Evaluation of the subfraction composition of samples provides information on the proportions of biosubstrate constituents and yields integral characteristics reflecting the function of systems and their readiness for adequate protection of the body. This study aimed to assess the dynamics of radiation-induced changes in the subfractional composition of blood serum across a wide dose range and at different time intervals after exposure.

The study was conducted on 2–2.5-month-old male C57BL/6 mice. The animals were subjected to whole-body gamma irradiation from a ^{60}Co source (GUT-200M; NRC «Kurchatov Institute») at mean absorbed doses of 0.5, 2.5, 5, 7.5, 10, and 15 Gy, respectively (6 mice per dose). Controls (n=7) were not irradiated. On day 3 post-irradiation, the blood was collected via cardiac puncture under anesthesia, and the serum was separated.

To assess the dynamics of the observed changes, the mice were irradiated at the mean absorbed doses of 0.5 Gy and 7.5 Gy (7 mice per dose). Controls (n=7) were not irradiated. Three and 30 days after irradiation, the animals were anesthesized, the blood was collected, and the serum was separated.

Measurements were performed on an LCS-03 laser correlation spectrometer (INTOX, Saint Petersburg). The samples were diluted 1:10 with physiological saline and 0.2 ml was transferred into an LCS cuvette. The data was averaged over 2000 runs at a sampling frequency of 16,384 MHz.

Analysis of the obtained spectra yielded histograms representing the contribution of various particles present in the serum into light scattering. The following dose-dependent changes were revealed. On day 3, a shift in the light-scattering maximum from 250 to 100 nm, a dose-dependent decrease in the contribution of large particles in the range of 100-250 nm, and an increase in the contribution of small particles (12-30 nm) were observed, which indicates progressive destructive processes in cells.

When analyzing the dynamics of radiation-induced shifts we found that on day 3 post-irradiation, particles with a diameter of 27-50 нм predominated in mice exposed to 0.5 Gy, whereas after irradiation at 7.5 Gy, the predominant particle sizes ranged from 67 to 223 nm. On day 30 after exposure to 7.5 Gy, a pronounced prevalence of particles sized 4-12 nm was observed, indicating destructive processes in cells. These findings are consistent with our previous data obtained on mice irradiated at a dose of 7.5 Gy.

The study demonstrates the informativeness of LCS for dynamic assessment of changes in serum homeostasis induced by radiation exposure across a wide dose range and over an extended time interval. The proposed approach allows pre-nosological detection of metabolic shifts in workers in potentially hazardous industries and evaluation of the risk of complications in patients undergoing therapeutic radiation treatment.

This work was conducted within the framework of the State Assignment for Institute of General Pathology and Pathophysiology (FGFU-2025-0003), and the State Assignment for the National Research Center "Kurchatov Institute", Moscow, Russia.

Comparative study on biochemical and morphophysiological changes induced by UV-C exposure of *Triticum aestivum* and *Cucurbita pepo* plant embryos

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An experimental study was carried out with controlled irradiation of germinated seeds of common wheat and pumpkin using high-energy ultraviolet radiation to study the changes induced at the biochemical and morphophysiological level in young seedlings of the two species. The seeds were selected to present uniform features, integrity and healthy appearance. Irradiation occurred for 1-2-3 hours and the analyses were performed after seven days. The antioxidant activity of catalase and superoxide dismutase were determined biochemically as well as the total protein content and malondialdehyde, as an indicator of lipid peroxidation, and also the concentrations of photosynthetic pigments (chlorophyll A, chlorophyll B and total carotenes) while the lengths of the roots and stems were measured in the same samples. The variations of the parameters related to the antioxidant capacity were statistically greater in pumpkin while the variations of the parameters related to the photosynthetic processes were more pronounced in wheat. In wheat, pronounced decreases in the dimensions of the roots and stems were highlighted by the statistical box-plot representation. In general, it can be concluded that the greater radiosensitivity of pumpkin compared to wheat was highlighted, which may be of interest for for plant breeding, crossing irradiated and non-irradiated plants of to obtain varieties with better properties.

Advancing radiotherapy outcomes: Ginkgo biloba extract as a potential radiosensitizing adjuvant in breast cancer

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Despite the established efficacy of ionizing radiation in oncology, the clinical utility of chemical radiosensitizers is often limited by acute and chronic toxicities. Consequently, there is an urgent need to identify plant-derived phytochemicals that can selectively enhance tumor radiosensitivity while maintaining a favourable safety profile. This study investigates the radiosensitizing potential of *Ginkgo biloba* extract (GB) in breast cancer management. The in vitro radiosensitizing effects of GB were evaluated in MDA-MB-231 breast cancer cells. Cells were treated with varying concentrations of GB (10–350 µg/mL) prior to exposure to ionizing radiation. Cell viability was assessed using the MTT assay at 24, 48, and 72 hours' post-irradiation. Preliminary findings indicate a dose-dependent response. While lower concentrations exhibited negligible effects, higher concentrations significantly enhanced radiation-induced cytotoxicity. Cells pre-treated with higher concentrations of GB exhibited enhanced susceptibility to radiation-induced damage, resulting in further reductions in survival compared to either modality administered independently. In particular, high-dose GB pre-treatment markedly reduced cell viability across all evaluated time points, suggesting a pronounced radiosensitizing effect. These results indicate that GB extract may enhance the therapeutic efficacy of radiotherapy in breast cancer cells. Further research will assess selected high concentrations in combination with clinically relevant radiation doses and investigate associated molecular biomarkers of DNA damage and cellular response.

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Keywords: Radiotherapy, Breast Cancer, Phytochemicals, Ginkgo biloba, Radiosensitizers, Cell viability.

Biomarkers of individual radiosensitivity of cancer patients

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Breast cancer (BC) is the most prevalent cancer among women worldwide. Radiotherapy (RT) is a major treatment modality; however, 1–5% of patients develop severe acute or late normal tissue toxicities. Early identification of radiosensitive (RS) patients could enable treatment individualization and toxicity prevention.

Despite extensive research on biomarkers of individual radiosensitivity, including DNA repair foci, apoptosis, and cytogenetic assays, no clinically applicable marker with sufficient sensitivity and specificity has been established.

This study evaluated in vivo and in vitro radiation-induced γH2AX/53BP1 DNA repair foci and apoptosis as potential biomarkers of individual radiosensitivity. In addition, EDA2R gene expression was investigated using a biodosimetric approach.

γH2AX/53BP1 foci and apoptosis were analysed in 50 BC patients before RT, during RT (after 10 Gy), and after RT (1 month and 1-year post-treatment). RS patients showed a significantly higher baseline level of DNA repair foci compared to patients with a normal response (NOR), indicating an altered DNA damage response. In vitro experiments confirmed increased primary 53BP1 and γH2AX/53BP1 foci (30 min post-irradiation) in RS patients, while repair kinetics were comparable between groups. No differences in apoptosis were observed.

EDA2R expression was analysed after irradiation with 0, 5, 10, and 50 cGy to establish a dose–response relationship. Both EDA2R expression and γH2AX/53BP1 foci were sensitive in detecting radiation-induced damage at doses ≥5 cGy. In patients, EDA2R expression increased after the 6th and final RT fractions compared to pre-treatment levels.

In conclusion, DNA damage response is altered in RS patients; however, γH2AX/53BP1 foci are insufficient for individual prediction of radiosensitivity. EDA2R represents a promising biomarker candidate, functioning as an upstream regulator of the NF-κB pathway involved in the response to ionizing radiation. Further validation in larger patient cohorts, particularly including more RS patients, is required.

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Extremely low frequency and static magnetic fields emitted by mobile phones: Measurements, mechanisms and possible biological implications

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While research on mobile phone exposure has predominantly focused on radiofrequency (RF) radiation, mobile devices simultaneously emit extremely low frequency (ELF) magnetic fields and static magnetic fields (SMF). These non-RF components remain largely overlooked in risk assessment despite experimental and epidemiological evidence demonstrating biological activity within the microtesla range. ELF magnetic fields were classified by IARC (2002) as possibly carcinogenic to humans (Group 2B), mainly based on associations with childhood leukemia above 0.3–0.4 μT. Accumulating data also suggest that ELF exposure may contribute to brain tumor promotion under specific exposure conditions.

In our recent studies (2021–2023), we quantified ELF and SMF emitted by commercial mobile devices. ELF magnetic fields were measured in two frequency bands (5 Hz–200 Hz and 120 Hz–10 kHz) during standby, speaking and listening modes. Peak RMS values reached 70.03 μT (2G, listening mode, front side) in the lower band and 12.67 μT in the higher band. Numerical simulations using anatomical head and body models showed induced magnetic flux densities in the midbrain up to 8.45 μT (10 Hz), 7.5 μT (50 Hz) and 6.09 μT (200 Hz), with lower but measurable values in thoracic and pelvic regions. These levels exceed those reported in epidemiological studies to be associated with increased leukemia risk.

In addition to ELF fields, smartphones and earphones emit non-uniform SMF originating from permanent magnets integrated in speakers and other components. Two-dimensional surface mapping revealed local hot spots ranging from microtesla to millitesla levels with pronounced spatial gradients. Exposure modelling indicated non-negligible SMF exposure of superficial tissues during realistic use. Although these values remain within regulatory limits, static fields are key parameters in several physical models describing bioeffects of weak RF and ELF fields.

Experimental evidence indicates that SMF can significantly modify RF and ELF biological responses. Superposition of weak magnetic noise may inhibit microwave-induced DNA damage, oxidative stress and receptor clustering, whereas specific combinations of static and alternating fields can shift resonance conditions or invert biological effects. These findings support theoretical models based on ion interference, magnetic moment precession and chromatin rotational mechanisms, predicting dependence on both AC and DC components of exposure.

ELF and SMF exposures have been linked to modulation of reactive oxygen species, calcium signalling and chromatin conformation—processes directly relevant to genomic stability and tumor promotion. Many ELF-induced effects occur below current ICNIRP reference levels and exhibit non-linear “window” characteristics depending on frequency, amplitude and background static magnetic field.

Our results indicate that ELF magnetic fields emitted by mobile phones may exceed exposure levels associated with leukemia risk, while co-emitted static magnetic fields can modulate both ELF and RF bioeffects. Comprehensive health risk assessment of mobile phone exposure should therefore address combined RF, ELF and SMF components and their potential synergistic interactions, particularly in long-term and developmental exposure scenarios.

Study of cereal radiosensitivity to fast neutron irradiation

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Determination of radiosensitivity for plant species is important to obtain desirable plant characteristics. As a rule, the median lethal dose (LD50) is considered the appropriate dose to achieve the highest mutation frequency. Such a task for fast neutrons (FN) is a complex challenge due to the unique properties of neutron radiation, biological variability of the plants, difficulties in accurate dosimetry, and the intricate nature of radiation-induced damage. Even for gamma radiation, LD50 values vary widely across cereal crops. Although many authors consider neutron irradiation a promising mutagen for plant breeding, there is still no clear information on dose-response relationships. Researchers use different fast neutron sources and crop varieties, with inconsistent reports on effective doses. As specific results may vary depending on experimental conditions, crop variety, and radiation source, the aim of our research was to study radiosensitivity of rice, triticale, and barley based on seedling growth reduction (GR) and median lethal dose (LD50). The seeds were irradiated by fast neutrons at the EG-5 in the Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research (Dubna, Russian Federation). It was found that GR50 and LD50 doses differ across these cereals, providing baseline data for further plant mutagenesis studies at the EG-5 and applicable to other cereals.

Low-frequency electric field exposure in sleeping areas in Austria: Measurement-based assessment, radiobiological relevance and mitigation

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Artificial low-frequency electromagnetic fields (ELF-EMF) generated by electrical installations and household devices contribute to continuous indoor exposure in modern living environments. Current statutory exposure limits are primarily derived from acute stimulation thresholds and short-term biophysical effects, whereas potential long-term biological interactions at lower field strengths remain a subject of ongoing radiobiological research. Environmental medicine guidelines therefore propose substantially lower precautionary reference levels, particularly for sensitive microenvironments such as bedrooms, where adults typically spend 2,600–3,300 hours per year and where essential physiological recovery, neuroendocrine regulation and immune-related processes predominantly occur during sleep. Against this background, the present study aimed to quantify low-frequency alternating electric fields under real residential conditions and to evaluate practical mitigation strategies in relation to precautionary guideline values. Ten randomly selected sleeping areas in Austria were investigated. Electric fields in the frequency range 1 Hz–100 kHz were measured according to the EUROPAEM EMF Guideline and established building biology protocols using calibrated isotropic field meters (EFA-3 and 3D-EFM). A standardized nine-point measurement grid was applied at each bed location, resulting in 90 measurement points collected by a single investigator following a consistent protocol to ensure comparability. Maximum electric field strengths ranged from 14 V/m to 124 V/m, and minimum values from 2 V/m to 20 V/m. In all examined sleeping areas, precautionary reference levels recommended for night-time environments (≤1 V/m; ≤0.3 V/m for sensitive individuals) were exceeded, and daytime precautionary levels (10 V/m) were also surpassed in every case. Although measured values remained well below statutory ICNIRP limits for low-frequency electric fields (5,000 V/m), consistent exceedance of precautionary thresholds was observed across all sites. On-site identification of relevant emission sources demonstrated contributions from building wiring systems, fuse circuits, extension cords, lamps, chargers and nearby installations. Targeted mitigation measures, primarily selective deactivation of fuse circuits, resulted in substantial exposure reduction; excluding one infrastructural outlier with outdated electrical installation, an average of four circuits required deactivation to achieve precautionary levels. Additional experimental shielding measures reduced electric field strengths to below 0.1 V/m in all cases. The effect of a grounding (earthing) mat was assessed in one sleeping area and revealed an increase in measured electric field strength from 61 V/m in the disconnected state to 94 V/m when connected, attributable to field concentration effects at grounded conductive surfaces under real residential conditions. The findings demonstrate that elevated low-frequency electric field exposures can occur in sleeping areas when evaluated against precautionary guideline values, while also showing that measurement-based identification of emission sources enables effective exposure reduction through relatively simple technical interventions. These results underscore the radiobiological relevance of systematic exposure assessment in sleeping environments and support further interdisciplinary investigation of chronic low-level ELF-EMF exposure in relation to biological regulation processes.

Multiparametric assessment of systemic radiation response in glioblastoma during concomitant radiochemotherapy

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Glioblastoma (GBM) is the most aggressive primary brain tumor and is associated with poor prognosis, with a median overall survival of approximately 15 months despite maximal treatment. Reliable differentiation between true tumor progression and pseudoprogression remains a major clinical challenge, as conventional imaging lacks sufficient specificity. Therefore, minimally invasive liquid biopsy–based biomarkers may provide additional tools for treatment monitoring and individualized therapeutic decision-making.

The aim of this preliminary prospective study was to evaluate the feasibility and potential predictive value of an integrated panel of cytogenetic, molecular, oxidative stress, and immune biomarkers in patients with newly diagnosed GBM undergoing standard concomitant radiochemotherapy according to the Stupp protocol.

Peripheral blood samples were collected longitudinally at four defined time points: before treatment initiation, after the first radiotherapy (RT) fraction, after six fractions, and at completion of the concomitant phase. Chromosomal aberrations and micronuclei in peripheral blood lymphocytes were assessed as indicators of baseline genomic instability and radiation-induced genotoxicity. Expression of a panel of 10 microRNAs together with the EDA2R gene was quantified using RT-qPCR to explore transcriptional radiation responses. Plasma malondialdehyde (MDA) levels were measured as a marker of systemic oxidative stress, and CD38 expression on CD4+ and CD8+ T lymphocytes was analyzed by flow cytometry to evaluate immune activation. Neurocognitive performance was assessed longitudinally to explore potential associations between biological responses and functional outcomes.

Preliminary findings suggest elevated baseline genomic instability in GBM patients compared to controls and heterogeneous cytogenetic responses during early phases of radiotherapy, indicating interindividual variability in systemic radiosensitivity. Most analyzed microRNAs remained relatively stable throughout treatment; however, a subset of patients demonstrated a trend toward increased miR-34 expression at later treatment stages, although statistical significance was not retained after false discovery rate correction. Systemic oxidative stress parameters and proportions of CD38+ T-cell subsets did not demonstrate pronounced dose-dependent modulation during the concomitant phase.

These data demonstrate the feasibility of integrated multiparametric biomarker monitoring during radiochemotherapy and support further validation of combined cytogenetic, molecular, and immune profiling as a tool for individualized radiobiological assessment and early detection of treatment-related dynamics in glioblastoma.

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From X-ray tubes to FLASH therapy: How does dose rate affect DNA damage?

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Exposure of cells to ionizing radiation can cause DNA damage, which threatens the cell's genetic stability. This mechanism underlies the radiotherapy strategies used in cancer treatment. FLASH therapy, which is being studied widely in radiotherapy, is based on the delivery of ionizing radiation at an ultra-high dose rate. It has been shown that with such rapid dose delivery, damage to healthy tissue is significantly reduced, while the cytotoxic effect on cancer cells remains unchanged. For the patient, this translates into a single, short irradiation session, significantly improving the comfort and convenience of treatment. Despite these promising observations, the mechanism behind the FLASH effect has not yet been fully elucidated.

The aim of the experiment was to investigate how changes in dose rate—within the range achievable using a standard X-ray tube—affect the profile of double-strand DNA damage, and whether these differences can provide insights into the nature of radiation effects at varying delivery rates. Characterizing these fundamental dose-rate effects within conventional radiotherapy limits serves as a necessary foundation for understanding the complex radiobiology underlying ultra-high dose therapies.

To achieve this, three experimental setups yielding dose rates of 0.00467, 0.0413, and 0.0602 Gy/s were used. For each setup, dosimetry was performed using Gafchromic EBT3 films. The study was conducted on a human osteosarcoma U2OS cell line—the cells were irradiated with 2.3 Gy (within the range of fractional dose), which required exposure times of 493, 56, and 38 seconds, respectively. Quantitative damage analysis was conducted 15 minutes post-irradiation by observing the NBS1 protein, which participates in the cellular response to double-strand DNA breaks by forming repair foci. The foci were visualized using a Green Fluorescent Protein tag to the NBS1 protein. In addition, cell nuclei were stained with DAPI. The biological assay was performed using a fluorescence microscope, and both the number of repair foci per nucleus and the size of foci were assessed.

Analysis of the data for the three different dose rates showed no significant differences in the number of repair foci, suggesting that the duration of the dose exposure did not affect the radiosensitivity of the cells. However, higher dose rates lead to the formation of larger repair foci. It can be hypothesized that the extended duration of dose delivery at lower rate allows early DNA repair mechanisms to act during the exposure itself, thereby mitigating lesion clustering. In contrast, shorter delivery times at higher rates likely overwhelm immediate repair capacity, leading to more direct and complex damage. Future experiments are planned to use ultra-high dose rates to further investigate the variability and complexity of the resulting DNA damage.

Cytogenetic effect of radon in water: A study of bioindicator cells

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Radon, a naturally occurring radioactive gas, emits ionizing radiation capable of causing DNA damage and chromosomal instability. To reliably assess its biological effects, its physicochemical properties, including mobility, solubility in water, and migration potential, were considered. The aim of this study was to investigate the cytogenetic effects of radon in water on meristematic cells of ***Allium cepa* L.** roots, using the Allium bioassay as a sensitive bioindicator system. Meristematic cells were treated with twenty different radon concentrations in water, ranging from 100.62 to 2,515 Bq/L, for a defined exposure period. Cytogenetic analysis included the evaluation of chromosomal aberrations (*CA*), nuclear alterations, and cell cycle indices. The most frequently observed chromosomal and nuclear abnormalities were polyploidy, sticky chromosomes, C-mitosis, chromosomal bridges, micronucleus formation, irregular segregation, multipolar mitoses, necrosis, apoptosis, and binucleated cells. In addition to cytogenetic evaluation, cytotoxic effects were assessed based on root growth inhibition, mitotic index (*MI*), and phase index (*PI*). All radon concentrations caused dose-dependent reductions in root growth, decreased *MI*, and a significant increase in the frequency of aberrant cells, indicating concurrent cytotoxic and genotoxic effects. Statistical analysis confirmed that all treatments differed significantly from the negative control. These results demonstrate that radon in water can induce significant cytogenetic damage in ***Allium cepa* L.** meristematic cells, confirming the sensitivity of this species as a bioindicator for monitoring environmental radioactive contamination. The findings provide valuable information on the potential health risks associated with radon exposure and highlight the importance of regular monitoring of radon concentrations in water sources to protect public health.

Comparative evaluation of cellular responses to proton flash irradiation in B16-F10 melanoma and L929 fibroblast cells

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Melanoma is a type of malignant lesion that has as its starting point the uncontrolled division of melanocytes. The best method of treatment for this condition is radiotherapy, but melanoma cells have the ability to repair non-lethal damage to cellular DNA caused by photon radiation.

Proton radiotherapy is an innovative method of cancer treatment that, due to the specific mechanisms of interaction with matter as well as linear energy transfer (LET), is able to target the tumor volume, minimizing the damage to surrounding healthy tissues. To enhance tumor control, the FLASH method is developed, which involves administering treatment doses with dose rates higher than 40 Gy/s. Due to the biological mechanisms of the FLASH effect, following the administration of a high dose over a very short period of time, healthy cells experience depletion of their oxygen reserves and become radioresistant to radiation, while tumor cells are exposed to a high concentration of reactive oxygen species, which cause extensive and rapid damage.

To study the effects of FLASH proton therapy on B16-F10 melanoma cells and normal L929 fibroblasts cells, they were irradiated at dose rates of 1500, 1000, 250, and 50 Gy/s, with doses of 1 and 3 Gy, using the Tandetron particle accelerator at the DFNA department of IFIN-HH, Romania. Subsequently, a series of assays was conducted to evaluate their responses to the treatment. Cell viability was tested using the MTS assay, cell proliferation capacity was analyzed by post-treatment clonogenic assay, and treatment-induced genotoxicity was evaluated by micronuclei identification.

The experimental results obtained suggest the protective effect of FLASH proton therapy on L929 fibroblast cells while the therapeutic effects on B16-F10 melanoma cells have been identified.

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Analysis of DNA repair protein foci in radiobiology: advantages, limitations, perspectives

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During DNA repair process, complex dynamic microstructures are formed, consisting of hundreds and thousands of copies of various proteins involved in these processes. These microstructures are visualized using immunocytochemical staining or fluorescent proteins in the form of bright fluorescent dots or tracks localized at DNA repair sites. In the literature, they are called radiation-induced foci, DNA damage foci, DNA repair foci, or DNA repair protein foci. In terms of its importance for radiobiology, the development of the method for analyzing DNA repair protein foci can be compared to the invention of the Wilson cloud chamber, which made it possible to visualize the tracks of accelerated particles (Nobel Prizes in Physics in 1927 and 1948). This presentation, using our own and published data, examines in detail the advantages, limitations, and prospects of usage and further development of the method. The advantages include: 1) extremely high sensitivity, allowing detection of the effects of irradiation in low and ultra-low doses; 2) the ability to analyze the spatial distribution of DNA repair sites throughout the volume of each cell nucleus; 3) precise analysis of DNA repair mechanisms and cellular response to DNA damage; 4) the ability to study the response to irradiation of each cell in asynchronous/heterogeneous cell populations; 5) the ability to work with both fixed and living cells. The results obtained using this method requires correct interpretation. It is important to clearly understand that the number and post-radiation changes of specific protein foci may differ significantly from the number and repair kinetics of radiation-induced DNA damage. The foci of a particular DNA repair protein that are studied, not the DNA damage itself. Technical limitations include high cost, low productivity (no more than 1000 cells/sample), and large time costs for microscopy and analysis (from 30 min/sample). However, the method is constantly being improved, the number of proteins studied is constantly increasing, automated systems are being developed using artificial intelligence technologies to recognize foci. Currently, the method is actively used not only in radiobiology, but also in oncology, toxicology, pharmacology, gerontology and related fields of science.

Chronic low-dose neutron exposure on plants in agro-space applications

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Future crewed missions to the Moon and Mars will expose biological organisms to significant levels of cosmic radiation, including secondary neutrons produced by primary cosmic rays. Plants will play a crucial role in these missions, providing both fresh food, through microgreen cultivation, and oxygen for life-support systems. Microgreens offer an important nutritional advantage for long-duration space missions because, despite their small size, they are rich of vitamins, minerals, and antioxidants, providing higher nutrient concentrations than their mature plant counterparts. Moreover, microgreens can contribute to psychological well-being of astronauts due to the interaction with living plants. This study investigates the damage and physiological response of plants subjected to neutron flux produced as secondary radiation by primary cosmic rays, comparable to those expected in deep-space environments. Dose-rate values derived from literature, measurements and simulations range between 15 and 40 μSv/h. Seeds of two *Raphanus sativus* cultivars, Rioja and Daikon, were irradiated for different periods ranging from few weeks to several months using calibrated Am–Be neutron sources at the ENEA Casaccia Research Centre, with the support of the National Institute for Metrology of Ionising Radiations (ENEA-INMRI). The energy spectra of these sources partially reproduce the characteristics of cosmic-ray-induced neutrons. Following irradiation, germination performance and early seedling development were assessed through morphological analyses, flow cytometry evaluation of ploidy level in roots and cotyledons, and metabolomic profiling. Some distinct dose and time dependent responses were observed following the different approaches. The results provide insights into plant resilience under space-relevant neutron fields and contribute to the development of biological systems for future long-duration space missions. Selected findings will be presented.

Effect of ionizing radiation on circrna0085439 in human bronchial epithelial cells

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Radiation-induced pulmonary fibrosis represents a frequent and clinically significant complication in patients undergoing radiotherapy. Due to the limited availability of effective preventive strategies and therapeutic interventions, fibrotic lung damage remains largely irreversible and poorly controlled. Previous studies have identified epithelial–mesenchymal transition (EMT) as a key driver and critical step in the development of pulmonary fibrosis. Importantly, EMT is accompanied by substantial alterations in the expression profile of circular RNAs (circRNAs), which are increasingly recognized as important regulators of fibrotic processes.

In this study, we investigate the expression levels of circRNA0085439 in the human bronchial epithelial cell line HBE135-E6E7 following exposure to ionizing radiation at doses of 2, 4, 6, and 8 Gy, as well as over time points of 24, 48, and 72 hours. This circRNA was selected based on previous findings demonstrating its responsiveness to radiation. Notably, overexpression of circRNA0085439 has been shown to effectively reverse radiation-induced downregulation of the epithelial marker E-cadherin and upregulation of the mesenchymal marker N-cadherin, suggesting its involvement in EMT regulation.

Our results aim to elucidate whether circRNA0085439 contributes to the progression of radiation-induced pulmonary fibrosis and to improve the understanding of circRNA-mediated responses to ionizing radiation.

Ultimately, this research could contribute to the identification of novel biomarkers for early detection of radiation-induced lung injury and potential therapeutic targets. Such advances may improve patient stratification, enable more personalized radiotherapy approaches, and reduce the risk of long-term pulmonary complications, thereby enhancing the overall quality of life of cancer patients.

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Circular RNAs as emerging regulators of radiation response in tumor and normal tissues

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Radiotherapy (RT) remains a cornerstone of cancer treatment; however, its clinical efficacy is limited by tumor radioresistance and radiation-induced normal tissue toxicity. A deeper understanding of regulatory mechanisms underlying cellular responses to ionizing radiation (IR) is therefore essential for improving therapeutic outcomes.

Circular RNAs (circRNAs) have recently emerged as a novel class of highly stable non-coding RNAs involved in cellular stress responses. In this work, we provide an integrated overview of IR-induced circRNA dynamics and their functional roles in modulating radiation responses in both tumor and normal tissues.

Accumulating evidence indicates that IR induces dose- and tissue-specific alterations in circRNA expression profiles. Functionally, circRNAs are implicated in the regulation of key radiation response pathways, including DNA damage repair, apoptosis, metabolic reprogramming, epithelial–mesenchymal transition, and inflammatory signaling. Several circRNAs, such as circRNA_100367, circATRNL1, circFIP1L1, and circZNF208, have been shown to influence radiosensitivity through circRNA–miRNA–mRNA regulatory networks.

Importantly, circRNA-mediated responses exhibit distinct patterns in tumor versus normal tissues. In tumors, circRNAs contribute to the development of radioresistance, whereas in normal tissues they are associated with radiation-induced injury as well as regenerative processes.
Together, these findings identify circRNAs as an important and previously underappreciated regulatory layer in radiation biology. Targeting circRNA-associated networks may represent a promising strategy to enhance tumor radiosensitivity while mitigating normal tissue toxicity.

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Construction and validation of a γ-H2AX calibration curve for retrospective biodosimetry

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Organic scintillators have gained popularity due to their high pulse-shape discrimination This study presents the development and validation of a calibration curve for radiation dose estimation based on the quantification of γ-H2AX foci in human peripheral blood lymphocytes. DNA double-strand breaks (DSBs) represent one of the most severe types of radiation-induced damage, as they involve disruption of both strands of the DNA helix and may result in chromosomal aberrations, genomic instability, or cell death if not accurately repaired. One of the earliest cellular responses to DSB formation is the phosphorylation of histone H2AX at serine 139, leading to the formation of γ-H2AX foci at the sites flanking DNA lesions. These foci can be visualized by fluorescence microscopy and serve as a sensitive and widely used biomarker for the detection and quantification of DNA damage. For the preparation of a calibration curve suitable for retrospective biodosimetric analysis, peripheral blood samples were obtained from two healthy donors (one male and one female). Blood was collected into heparinized vacutainers in volumes of 2–2.5 mL and subsequently irradiated with defined doses of ionizing radiation using a linear accelerator (LINAC) at the Faculty Hospital Bulovka in Prague, Czech Republic. Irradiation was performed using 6 MV X-ray beams, and doses up to 4 Gy were applied alongside a non-irradiated control sample. Immediately following irradiation, samples were incubated for 2 hours at 37 °C in a CO_2 incubator to simulate physiological conditions and enable efficient induction of γ-H2AX formation as part of the cellular DNA damage response. Lymphocytes were then isolated using density gradient centrifugation with Histopaque-1077. Prior to use, the separation medium was equilibrated to room temperature to prevent clot formation and ensure optimal separation efficiency. After centrifugation, the lymphocyte layer was carefully collected, washed in phosphate buffered saline (PBS), and subjected to repeated centrifugation steps to obtain a clean cell pellet. The isolated lymphocytes were subsequently deposited onto Superfrost Plus microscope slides using a cytospin centrifuge and fixed with 4% paraformaldehyde. Following fixation, cells were permeabilized with Triton X-100 and non-specific binding sites were blocked prior to immunocytochemical staining. Detection of γ-H2AX foci was performed using a primary mouse polyclonal anti-γH2AX (Ser139) antibody, followed by visualization with a goat anti-mouse secondary antibody conjugated to Alexa Fluor 488. Nuclear counterstaining was achieved using DAPI, allowing clear discrimination of lymphocytes from morphologically distinct monocytes. Fluorescence imaging was carried out using an upright fluorescence microscope, with cells captured in multiple focal planes to ensure accurate detection of foci throughout the nuclear volume. The acquired image stacks were subsequently merged into single composite images for analysis. γ-H2AX foci were quantified manually, with approximately 150 lymphocytes evaluated per dose point. The number of foci per nucleus was then correlated with the applied radiation dose to construct a dose–response calibration curve using Biodose Tools. The resulting calibration curve demonstrated a clear dose dependent increase in γ-H2AX foci formation across the analyzed dose range, confirming the suitability of this method for biodosimetric applications. The quality and robustness of the curve were further assessed in a blind validation experiment, which revealed notable variability in foci scoring. This finding led to refinement of the scoring criteria and repetition of the calibration procedure to improve reproducibility and accuracy. Overall, this study highlights the potential of γ-H2AX foci analysis as a rapid and reliable approach for radiation dose estimation based on cellular responses to DNA damage.

Non-coding RNAs as a marker of radiation response in mononuclear cells of pediatric leukemia patients and healthy probands

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Pediatric leukemia accounts for approximately one-third of all pediatric tumor cases. Amongst them, acute lymphoblastic leukemia (ALL) is the most frequent with approximately 80 %. Despite the advances in the treatment and diagnostic procedures there is still a need for new biomarkers for the monitoring of disease and treatment response.

In our study, we analyzed the copy numbers of selected long non-coding RNAs (lncRNAs) MALAT1, GAS5, and circular RNA circPVT1 using real-time quantitative PCR (RT-qPCR). We studied radiation response (0 Gy or 2 Gy *in vitro*) of these ncRNAs in mononuclear cells (MNC) isolated from bone marrow (BM) of pediatric ALL patients and in umbilical cord blood (UCB) of healthy probands.

We analyzed 6 frozen MNC samples – 3 samples from leukemic patients (LP) samples and 3 samples from healthy UCB. Our results showed that the number of copies of lncRNA GAS5 was significantly higher in LP as compared to healthy probands in both irradiated and non-irradiated samples ($p = 0{,}004$ and $p = 0{,}019$, respectively). Interestingly, these levels were significantly decreased after *in vitro* irradiation ($p = 0{,}042$). In healthy UCB the trend to the decreased level of lncRNA GAS5 was present, but was not significant. Other studied non-coding RNAs (lncRNA MALAT1 and circRNA circPVT1) were neither significantly affected by *in vitro* irradiation, nor differed between LP and healthy probands.

In our study, we investigated the effect of ionizing radiation (0 Gy or 2 Gy) on the expression levels of selected ncRNAs. Among studied ncRNAs – lncRNA MALAT1, lncRNA GAS5, circRNA circPVT1 – lncRNA GAS5 demonstrated statistically significant differences. We observed higher copy numbers of lncRNA GAS5 in bone marrow of leukemic patients, whereas a significant decrease in expression was observed after 2 Gy irradiation. Based on the results of our study we concluded, that lncRNA GAS5 could be a promising biomarker of both radiation response and also childhood leukemia, but needs to be validated on bigger cohort.

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In vitro evaluation of novel thiazolyl-methyl-thio-thiadiazolyl-quinazolinone hybrid compounds as potential radiosensitizers on breast cancer cell lines

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Background. Two novel synthesized thiazolyl-methyl-thio-thiadiazolyl-quinazolinone hybrid compounds (5a and 5b) were synthesized and tested for their potential anticancer effects on two human breast cancer (BC) cell lines: a triple negative (MDA-MB-231) and a Cisplatin (Cis) resistant adenocarcinoma (MCF-7), in the context of irradiation of the cells with ionizing radiation. The thiazole heterocycle is present in several anticancer agents (bleomycin, dabrafenib, alpelisib etc). Thiadiazole is a central heterocycle for the development of anticancer drugs, due to its facile crossing of the cellular membranes and *in vivo* stability, present in filanesib and litronesib drugs. Quinazolinones have been extensively used in recent years in the development of EGFR, VEGFR and tubulin polymerization inhibitors, cell cycle arrest initiators, apoptosis inducers, and PI-3K inhibitors. **Material and methods.** *The cytotoxicity of the compounds* was assessed by AlamarBlue™ Cell Viability assay. Briefly, cells were seeded at a cell population density of $2x10^4$/well, in 96-well plates. A range of concentrations (0-2000 µM) of the tested compounds were added to the cells after 24 h of plating (at 37 °C, 5% CO2). An additional 24 h of incubation followed, afterwards the cytotoxicity was assessed by adding the AlamarBlue reagent and fluorescence was recorded using a spectrophotometer. Based on the calculated IC_{50} values, the working concentrations were established for each compound and cell line (as 75% of IC_{50}). *The DNA lesions induced by the compounds and the ionizing radiation* were evaluated by Comet Assay (CA). For this purpose, the cells were seeded at a cell population density of $3x10^5$ cells/well, into 6-well plates and incubated (24 h, at 37 °C, 5% CO2). Afterward, the cells were treated with 5a or 5b or Cis, then another 24 h of incubation followed. The re-seeding of the cells for irradiation (I) was performed in 96 wells plates, at a cell populations density of 3-$4x10^5$ cells. Then the plate for irradiation was inserted in a polymethacrylate phantom and irradiated with a Clinac iX Silhouette Linear Accelerator (E=16 MV, field= 6x6 cm, distance from the source 97 cm, irradiation dose: 4 Gy). For the CA the cells were embedded in low melting point agarose and spread on microscope slides precoated with normal melting agarose then lysed in alkaline solution. Electrophoresis followed (20 min, 1 V/cm, 300 mA), then neutralization and fixation. Ethidium bromide was used to stain the disrupted DNA which were analyzed with a fluorescent microscope (510-560 nm excitation, 590 nm barrier filters). Comets were assigned in classes (0 – undamaged DNA, no tail; 4 - severely damaged, long diffuse tails) and two parameters were calculated: Lesion score (LS) and Tail factor (TF). Finally, the dynamics of the repair process of the induced DNA lesions was also assessed at 2 h and 24 h after irradiation. **Results.** *Cytotoxicity assessments.* Notable cytotoxicity of both compounds was registered on the Cis resistant BC cell line (MCF-7) (*** $p<0.0001$). *DNA lesions assessments.* For the MCF-7 cell line: higher LS values were obtained at 24 h as compared to immediately post-irradiation. Also, the persistent DNA lesions after treatment with 5a and 5b suggests impaired repair capacity. For the MDA-MB231 cell line partial repair was registered at 24 h after pretreatment with 5a or 5b. The highest levels of persistent DNA lesions were observed after pretreatment with Cis. Also, a differential repair behavior was observed between the two cell lines. **Conclusions.** Both, 5a and 5b compounds exhibit radiosensitizing activity, however, compound 5a is more effective on MCF-7 (Cis resistant), while 5b on MDA-MB231 (triple negative) BC cell line. Results suggest potential therapeutic relevance of the newly synthesized compounds in BC radiosensitization.

Radiological assessment of imported edible mushrooms and ingestion risk assessment

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Monitoring of food safety is one of the key tasks in public health protection. In the Republic of Serbia, various foodstuffs are routinely analyzed, including the determination of radionuclide content, with the results compared to the limits prescribed by national legislation. Mushrooms are a common component of the diet in Serbia, and in 2024, approximately 1,054 t of mushrooms (fresh and frozen) were imported [1]. It is well-known that the fungi, in general, including edible mushrooms, are bioaccumulators of both natural and anthropogenic radionuclides, particularly ^{137}Cs and ^{40}K [2-4], due to their extensive mycelial systems and the chemical similarity of cesium to potassium.

In this paper, 22 samples of edible mushrooms are analyzed using a low-level gamma spectrometry method. The activity concentration of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were in the range <8–89 Bq kg^{-1}, <4–20 Bq kg^{-1}, <40–890 Bq kg^{-1}, and <3–186 Bq kg^{-1}, respectively. Based on the measured activity concentration, the annual committed effective dose due to ingestion was estimated and found to be below the worldwide average ingestion dose [5]. Additionally, gross alpha and gross beta activity were determined in five selected different types of mushrooms, and their correlation with the activity concentrations of detected radionuclides was examined. The gross alpha activity was in the range from 12 Bq kg^{-1} to 36 Bq kg^{-1}, while the gross beta activity ranged between 69 Bq kg^{-1} and 148 Bq kg^{-1}.

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Soil radioactivity and radon exhalation in agricultural areas of Vojvodina

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Living organisms are inevitably exposed to radiation from various natural sources. Natural radionuclides are taken up by plants and animals due to the similar chemical properties between radionuclides and essential nutrients. Radionuclide concentrations in plant depend primarily on the radioactivity of the source media, particularly soil. Since radionuclides enter the food chain, dietary intake is the most significant pathway of radionuclide exposure for the general population. Therefore, detailed knowledge of radionuclide activity concentrations in soil is essential. The global population receives 10% of the average annual radiation dose due to radionuclides of natural origin in the diet [1]. In addition, doses due to food consumption vary depending on the food type, highlighting the importance of monitoring radioactivity levels in food and informing consumers about potential health risks.

In the recent decades, the trend of using agricultural land for the built of urban areas has emerged as an additional concern. The amount of land occupied by urban areas is projected to increase, from 213 million ha in the year 2000 (1.6% of ice-free land) to 621 million ha (4.7%) by the 2040 [2]. While the urbanization of agriculture land has significant environmental and socioeconomic consequences, from radiological perspective it also raises concerns regarding potential exposure to radon exhaled from the soil beneath buildings.

In this paper, the study area was Vojvodina region in Republic of Serbia, well known for its highly fertile soil and favorable agricultural conditions. A total of 38 agriculture soil samples were collected and analyzed. Radionuclide content was determinated using low-level gamma spectrometry method. Activity concentration of *226Ra*, *232Th*, *40K*, *238U*, and *137Cs* were in the range: (20.7-87) Bq kg^{-1}, (23.5-95) Bq kg^{-1}, (340-1600) Bq kg^{-1}, (15.0-98) Bq kg^{-1}, (<1.0-11.8) Bq kg^{-1}, respectively.

The release of radon from soil and building materials into the atmosphere, known as the radon exhalation rate, was determined using an active radon monitor (RAD7) with the closed-chamber method [3]. Measured radon exhalation rates were in the range (34–92) mBq kg^{-1} h^{-1}. Based on the measured radionuclide activity concentrations in soil and radon exhalation rate, the radiological health risk to the population was assessed.

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Forensic processing of a scene contaminated with depleted uranium

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Armed conflicts over the past three decades have left a significant number of depleted uranium (DU) penetrators dispersed in various environmental settings. Incidents involving DU contamination represent a complex challenge at the intersection of forensic science, radiological protection, environmental safety, and public health. Depleted uranium, primarily composed of uranium-238 ($^{238}U \approx 99.27\%$) with a reduced fraction of uranium-235 ($^{235}U \approx 0.72\%$), is characterized by relatively low specific radioactivity dominated by alpha emissions. However, it poses considerable chemical toxicity, particularly nephrotoxicity. During impact events, especially involving military penetrators, DU may oxidize and form fine aerosolized particles (UO_2 and U_3O_8), creating inhalation hazards and potential long-term environmental contamination.

The forensic processing of a DU-contaminated scene requires a structured, multidisciplinary approach integrating radiological survey techniques, contamination control, evidence preservation, and isotopic analysis ($^{238}U/^{235}U$ ratio determination). One of the initial operational steps following identification and marking of a potentially contaminated site involves comprehensive risk assessment and establishment of controlled operational zones (hot, warm, and cold zones) in accordance with radiological protection principles, including the ALARA concept. The use of appropriate personal protective equipment (PPE), particularly respiratory protection, is essential due to the predominance of internal exposure pathways.

Radiological mapping is conducted using gamma survey meters (dose rate meters) and alpha/beta contamination probes to identify hotspots and guide targeted sampling. Although DU is primarily an alpha emitter, gamma spectrometry is employed to detect accompanying gamma photon emissions and to quantify activity concentrations. Environmental sampling typically includes surface and subsurface soil, vegetation, water, structural swabs, and metallic fragments. Strict chain-of-custody procedures must be maintained to ensure evidentiary integrity.

Laboratory analysis focuses on determining uranium activity concentrations and isotopic ratios. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) plays a crucial role in distinguishing depleted uranium from natural uranium through precise measurement of the $^{235}U/^{238}U$ ratio, particularly because gamma spectrometry often lacks sufficient sensitivity due to minimal detectable activity limitations. Complementary analytical techniques such as alpha spectrometry and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS) enable detailed characterization of particle morphology and elemental composition.

Dose assessment includes evaluation of external gamma exposure as well as potential internal contamination via inhalation or ingestion. Although external doses from DU are generally low, internal exposure assessment may require bioassay analysis (e.g., urinary uranium concentration) and application of biokinetic models. In addition to radiological risk, the chemical toxicity of uranium must be incorporated into the overall health risk assessment.

The integration of forensic methodology with radiological and toxicological evaluation provides a comprehensive framework for managing DU-contaminated scenes, supporting environmental assessment, evidence documentation, and expert interpretation in both civilian and post-conflict contexts.

Comparative analysis of ^{137}Cs and ^{90}Sr concentrations in milk from the Serbian market and an assessment of their contribution to the effective dose for 2025

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The nuclides ^{137}Cs and ^{90}Sr represent the two most radiologically significant artificial radionuclides in the environment, which entered ecosystems mainly as a consequence of the Chernobyl accident. As a staple food, milk represents a key pathway for their transfer into the human food chain. Due to their different metabolic behaviors — ^{137}Cs being a potassium analogue and ^{90}Sr a calcium analogue — their continuous comparative monitoring is essential for a comprehensive assessment of radiological risk. The aim of this study is to determine and compare the specific activity levels of ^{137}Cs and ^{90}Sr in milk samples from the market of the Republic of Serbia during 2025, by the cities where sampling was conducted, as well as to assess their combined contribution to the average annual effective dose for the adult population. Measurements were performed using a low-background alpha-beta proportional gas counter, as well as a semiconductor (HPGe) detector manufactured by ORTEC. The measured specific activities are within the average values for Serbia, and the estimated annual effective dose from milk consumption is significantly below the dose limit for the general population. The results of the analyses are presented in a table, categorized by the cities where sampling was conducted: Belgrade, Zaječar, Novi Sad, Niš, Subotica, Vranje, and Užice. These seven cities were defined by the Regulation on Monitoring of Radioactivity of the Republic of Serbia by the Serbian Radiation and Nuclear Safety and Security Directorate with the aim of representing the regions of Serbia and thus providing insight into the population's diet and food supply at the national level.

Radioactivity monitoring and radiation risk assessment in the vicinity of thermal power plants in the Republic of Serbia in 2025

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The Laboratory for Radioactivity Measurement of the Institute of Occupational Health of Serbia "Dr Dragomir Karajović" in Belgrade performs regular annual radioactivity monitoring in the vicinity of the "Nikola Tesla B" thermal power plant in Obrenovac and the "Morava" thermal power plant in Svilajnac. The primary process of electricity production in thermal power plants generates large quantities of ash and slag, which are products of the combustion of various types of coal. The operation of thermal power plants is the main source of technologically enhanced radioactivity, which can affect the exposure to ionizing radiation of workers and the population living in the vicinity of the power plants. This paper presents the results of radioactivity measurements in the thermal power plants in 2025.

Gamma-spectrometric measurements were performed using HPGe detectors with resolutions of 1.95 keV and 1.85 keV, and relative efficiencies of 25% and 40% at 1332 keV, respectively, from the "ORTEC" company. Gross alpha and gross beta activity measurements were conducted using a low-background alpha-beta proportional gas counter PIC-WPC-9550 with efficiencies of 31% and 42%, respectively. Samples of coal, slag, ash, soil, crops, wastewater, and river water were analyzed.

The results of the gamma-spectrometric analysis for environmental samples (excluding coal, ash, and slag) are at the level of average values for the territory of the Republic of Serbia. The results of gross alpha and gross beta activity in the Sava and Velika Morava river water samples (gross alpha < 0.08 Bq/kg and gross beta from 0.027 to 0.073 Bq/kg), and in water from the overflow and drainage landfills (gross alpha < 0.02 Bq/kg and gross beta from 0.202 to 0.372 Bq/kg) are within the permissible levels for drinking water.

Based on the measured concentrations of radionuclides Ra-226, Th-232, and K-40 in the soil, the absorbed gamma dose rate in the air (35–129 nGy/h), the annual effective dose (0.04–0.16 mSv/year), and the radiation hazard index (0.2–0.8) due to external exposure for the population were calculated. Simultaneously with the sample collection at the thermal power plants, the ambient dose equivalent rate was measured at 1 m above the ground. The obtained results range from 0.05–0.13 μSv/h.

The obtained results indicate that there is no significant risk as a consequence of external exposure to ionizing radiation for the workers and the population living in the vicinity of the thermal power plants.

^{137}Cs in small mammals in the Chornobyl exclusion zone: Assessment of the role of radioactive contamination and biological factors

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Over the past 40 years, ^{137}Cs has remained the primary radionuclide determining the level of internal contamination in biota in areas affected by nuclear weapons testing and nuclear accidents such as the Chornobyl Exclusion Zone (CEZ) and the Fukushima Difficult-to-Return Zones. However, spatial variability in ^{137}Cs uptake by animals is difficult to interpret without considering animal behavioral patterns and contamination levels in the environment they inhabit.

This study aims to evaluate a relationship between β- and γ-contamination levels in the CEZ and ^{137}Cs activity in rodents (*Apodemus flavicollis, Apodemus sylvaticus, Clethrionomys glareolus*). β- and γ-contamination were assessed at each study site (n=15): eight sites had contamination levels ranging from 0.5 to 41.6 μSv·h^{-1} (188 to 23,000 β-part.·cm^{-2}·min^{-1}); seven "control" sites had contamination levels below 0.25 μSv·h^{-1} (62 β-part.·cm^{-2}·min^{-1}). The dependence of ^{137}Cs activity on β and γ indicators was analyzed, accounting for biological factors (species, sex, and body weight).

- Significant differences in ^{137}Cs levels were observed between sites with high and low contamination – ^{137}Cs contamination was higher in rodents collected at highly contaminated sites than at control sites (60,000 versus 2,100 Bq/kg – approximately 28.6 times higher).
- Correlations between ^{137}Cs activity and local β- and γ-radiation levels were weak. At sites with high β- and γ-contamination, rodents showed higher ^{137}Cs activity, but this relationship remained limited (for β $p=0.26$; for γ $p=0.23$). Our results suggest that β and γ contamination levels in the environment may indicate the direction of ^{137}Cs changes but explain only a small part of its variations.

None of the biological factors had a statistically significant effect ($p > 0.05$) on the concentration of ^{137}Cs in rodents, and variation in ^{137}Cs concentrations might therefore be mainly affected by environmental conditions. We conclude that β and γ activity measurements may serve as informative predictors of internal ^{137}Cs contamination variations in small mammals, but their explanatory power is limited. A significant part of the variation is likely due to environmental heterogeneity and other uncontrolled factors. Our results may optimize future monitoring designs and interpretation of differences in biota contamination in areas like the Chornobyl Exclusion Zone.

Keywords: Chornobyl, small mammals, rodents, ^{137}Cs, beta contamination, gamma contamination

^{137}Cs in freshwater fish, based on the example of carp (*Cyprinus carpio*) – monitoring studies

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Introduction. One of the environmental areas contaminated after the Chernobyl nuclear accident in 1986 was a water area in Poland. Radioactive fallout from the reactor explosion contaminated the surface layers of soil and surface water. Due to their affinity for potassium, cesium radioisotopes have the ability to accumulate mainly in muscle tissue and constantly enter the food chain of animals living in the aquatic environment. Carp can accumulate harmful chemicals such as heavy metals (mercury, lead, cadmium), organochlorine pesticides, dioxins and polychlorinated biphenyls (PCBs) and radioactive radionuclides, especially when bred in polluted waters.

Objective. In order to assess the current level of radioactive contamination of the aquatic environment, the reference laboratory at National Veterinary Research Institute (NVRI) has been systematically testing the content of caesium radioisotopes in fish, including the muscle tissue of carp (*Cyprinus carpio*), for many years.

Material and methods. The research material consisted of samples weighing approximately 1 kg, collected randomly every quarter in each voivodeship, originating from fish farms or processing plants. A total of 1,306 samples were analyzed between 2015 and 2025. Detection was performed using gamma radiation spectrometry using a semiconductor (germanium) detector (HPGe) and a scintillation detector (NaI(TI)). After grinding and homogenization, the samples were transferred to Marinelli-type measuring vessels (450 cm^3), maintaining the geometry of the multinuclide calibration source used to calibrate the detectors. The collected gamma radiation spectra were analyzed using Genie 2000 software.

Results and discussion. Evaluating the obtained test results, it can be concluded that radioactive concentrations of cesium radioisotopes are low. Approximately 96% of the samples had ^{137}Cs radioactivity concentrations below the MDA of 1–2 Bq/kg. In some carp samples, radioactivity concentrations ranging from 3 to 7 Bq/kg were observed. The highest measured ^{137}Cs radioactivity concentration in carp muscle was 9.21 Bq/kg. The average concentration of ^{137}Cs has remained stable over the years and is significantly below the permissible limits established in EU and national regulations.

Conclusions. Alimentary tract is the primary route of exposure to ^{137}Cs from potentially contaminated fish. Monitoring studies indicate the presence of ^{137}Cs in fish, with carp being an example. However, measured ^{137}Cs concentration levels in freshwater fish are low, well below established permissible limits, making carp safe for consumption.

Keywords. ^{137}Cs, Chernobyl, contamination, freshwater fish.

Tritium measurement in the surface and subsurface waters of the Carpathian Basin (EU) and Fukushima Hamadori-Nakadori (Japan) mountain ranges

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Mountain ranges have numerous surface and subsurface water resources, including a variety of springs as well as permanent and transitory lakes that offer a potential interest for tritium radionuclide with half-life of 12.32 years. Anthropogenic tritium is released during normal operation of nuclear power plants while natural tritium is generated in the upper atmosphere by cosmic rays. This way, we can improve our understanding of the hydrodynamics of the study area by establishing baseline data for water circulation and climate change research and for assessing the potential effects of nuclear facilities.

In this study, we focused on Carpathian Basin of Hungary and Transylvania, Romania mountain ranges and of the Hamadori-Nakadori area in Fukushima Prefecute, Japan and collected water samples of natural freshwater and thermal springs. Furthermore, we collected rainwater sample from Kézdivásárhely, a town in the Carpathian mountain ranges. All samples were collected in 2 l plastic containers and sealed for transportation. Tritium activity concentration measurements were carried out by Liquid Scintilation Counting (LSC) at the International Atomic Energy Agency (IAEA) Isotope Hydrology Laboratory in Austria. A preconcentration step was performed via electrolytic enrichment using a solid polymer electrolyte membrane (PEM) system, following the procedure of enrichment factor determination via the deuterium-based measurement method for highest efficiency and accuracy in low-level analyses.

As a result, the tritium activity concentrations of the thermal and fresh water springs range between 0.04±0.004 and 0.98±0.01 Bq/L. The highest tritium activity concentration was measured the rain water sample, 1.05 ± 0.02 Bq/L, which suggests an elevated level of isotope content but correlates with the general range of worldwide results.

Keywords: tritium, surface water, Carpathian Basin, Fukushima Prefecture

Natural radioactivity and Cs-137 in the soils of the Trans-danubian region in Hungary

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Natural and artificial radionuclide concentrations in the environment are important parameters for assuring public health, with soil being one of the most important sources of natural radiation exposure either directly or indirectly, however they are often investigated and reported compartmentalised, so complex analysis often requires matching disparate datasets.

In the 2022-2023 period, the University of Pannonia carried out a larger scale survey, 1139 soil samples were collected in settlements from counties west of the Danube river, using a population weighted sampling method based on the 10x10 km standardised European grid, and were evaluated for Ra-226, Th-232, K-40 and Cs-137 content by gamma spectrometry, in conjunction with massic radon exhalation and emanation measurements. Corresponding field measurements were carried out for soil radon concentration, permeability and geogenic radon potential.

The arithmetic mean, SD and range of the observed activity concentrations were Ra-226 29.3±12.7 Bq/kg (4.0-122.2), Th-232(Ra-228) 27.0±10.7 (1.2-154.6), K-40 394.5±107.8 Bq/kg (98.0-1008.7 Bq/kg), Cs-137 8.3±7.5 Bq/kg (n.d.-105.8 Bq/kg), respectively.

Correlation between the measured parameters was investigated. Soil radon concentration had high correlation with permeability, with very low permeability soils disregarding the general trend. Soil radon concentration was also weakly correlated to K-40 content and massic exhalation. GRP was only strongly correlated to soil radon concentration and permeability; the parameters it is calculated from. K-40 had a strong correlation with Th-232, and a moderate correlation with Ra-226, while Cs-137 had a weak correlation with Ra-226. Massic exhalation naturally had a strong correlation with Ra-226 concentrations and the emanation coefficient, however only a weak correlation with soil radon concentration, and a very weak correlation to GRP. The gamma dose rates calculated based on activity concentrations were moderately correlated to the massic exhalation, with Cs-137 providing 2.7±2.4% (0-22.6%) of the estimated dose rate.

The data was also assessed in comparison to soil and geological classifications. Mean activity concentrations tended to be similar across the soil types for Ra-226, Th-232(Ra-228), K-40 and Cs-137, with leptosols having higher Ra-226 concentrations, fluvisols higher K-40 concentrations, arenosols lower K-40 concentrations and umbrisols higher Cs-137 and K-40 concentrations than the general trend. Elevated Ra-226 is associated with limestone, sandstone and deep magmatic formations, elevated Th-232(Ra-228) with deep magmatic formations, while K-40 with sandstone and deep magmatic formations.

The survey will be expanded to additional sampling points, and the incorporation of other soil related measurements and their results on the already existing sample base, as well as their geostatistical analysis is in progress.

Comparative distribution and bioaccumulation of ^{210}Po in three shallow coastal lagoons of Uruguay

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Polonium-210 (^{210}Po) is a naturally occurring alpha-emitting radionuclide with a strong affinity for particulate matter and organic material. In aquatic systems, its distribution is controlled by adsorption onto suspended particles, sedimentation and resuspension processes. Although ^{210}Po has been widely studied in marine environments, fewer studies have comparatively investigated its behavior in shallow coastal lagoons under similar geological and atmospheric conditions, considering both abiotic partitioning and biological accumulation.

This study compares ^{210}Po distribution in three shallow coastal lagoons of eastern Uruguay (Castillos, Briozzo and Rocha). The lagoons are geographically close and receive similar atmospheric inputs but differ in hydrology and internal dynamics. Seasonal sampling was conducted at different sites within each lagoon to determine ^{210}Po activity concentrations in dissolved water, surface sediments and representative biota.

Dissolved ^{210}Po activities ranged between 0.4–34 mBq L^{-1} in Castillos, 1.1–3.5 mBq L^{-1} in Briozzo and 1.9–3.5 mBq L^{-1} in Rocha. Surface sediment concentrations varied from 24–129 Bq kg^{-1} (dry weight) in Castillos, 17–540 Bq kg^{-1} in Briozzo and 13–118 Bq kg^{-1} in Rocha. Solid–water distribution coefficients (Kd) generally ranged between 10^3 and 10^5 L kg^{-1}, with consistently higher values observed in Briozzo and greater variability in Castillos. In biota, ^{210}Po activity concentrations varied depending on the organism and tissue analyzed. Calculated concentration ratios (CR) relative to water were of similar magnitude across lagoons (typically 10^4–10^5 for primary producers and bivalves and 10^3–10^4 for zooplankton and crustaceans) and remained within internationally reported ranges for comparable aquatic environments.

Overall, the results show that, even within a shared regional setting, solid–water partitioning of ^{210}Po may differ among lagoon systems, likely because of differences in internal hydrodynamic and sedimentary processes. However, these differences are not clearly reflected in the observed patterns of biological accumulation. This study contributes to a comparative radioecological understanding of ^{210}Po behavior in nearby shallow coastal lagoons.

Features of technogenic tritium distribution in the surface waters of the Shagan River and its transfer into the milk of farm animals in the zone of influence of the Semipalatinsk test site

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As part of IRN project AP22783154, "Comprehensive radioecological study of the Shagan River basin and development of recommendations for minimizing the negative impact on the environment and population," a comprehensive study of the distribution of the technogenic radionuclide ^{3}H in the surface waters of the Shagan River and the parameters of its transfer into livestock products was conducted. A pronounced uneven distribution of tritium was found both across the width and depth of the watercourse in sections 2 km and 5 km downstream of the "Atomic Lake." The horizontal distribution over a short section of the channel (3–5 m) varies by more than 11 times: from 6,000 Bq/L near one bank to 70,000 Bq/L and higher near the other. Vertical stratification in the water column (up to 35 cm deep) shows differences between the surface and bottom layers ranging from 3 to 13 times, with maximum values of up to 200,000 Bq/L in the bottom layer. In the "5 km" section, the most pronounced excess was recorded at a point 5,100 m from the source.

The studies were conducted by collecting water samples layer by layer using a special sampler with horizontal tubes (5 cm apart) to prevent mixing. Laboratory analysis was performed using liquid scintillation spectrometry on a TRI-CARB 2900 TR β-spectrometer after sample distillation (error of ±10%). Reynolds number calculations confirmed the turbulent flow regime of the river (Re from 240×10^{3} to 615×10^{3}), which should ensure mixing under normal conditions. However, the direct discharge of contaminated groundwater and fissure water from the Atomic Lake zone and the Balapan site disrupts this equilibrium.

Additionally, the parameters of ^{3}H transfer into milk were studied after a single introduction via contaminated water and hay in field experiments with mares and cows. When introduced via water, the transfer coefficient (Kp) in the first cow's milk sample reached 3.8×10^{-3}, decreasing by half by the eighth day. When tritium was introduced with hay, its tritium concentration was significantly higher-up to 1.7×10^{-2} in cow's milk and 5.7×10^{-3} in mare's milk, with slower elimination (halving by day 13). By day 18, up to 0.8% of the incoming tritium remained in milk.

These results indicate that the uneven distribution of tritium is due to groundwater discharge across the entire floodplain, possible sorption processes in bottom sediments, and hydrodynamic characteristics. This requires strict control of the location and depth of sampling during monitoring. For populations using the resources of the Shagan River basin for economic purposes (including the production of kumiss and other dairy products), the development of practical recommendations for minimizing the influx of tritium into agricultural products and ensuring the radioecological safety of the region is relevant.

Speciation of artificial radionuclides in soils of the natural steppe zone of the Republic of Kazakhstan

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The problem of nuclear power development in the Republic of Kazakhstan is currently one of the most relevant on the agenda. The construction and operation of a nuclear power plant are inseparably linked to radiation safety and environmental issues. The assessment of the impact of nuclear fuel cycle facilities on the environment is impossible in the absence of up-to-date information on the background level of radioactivity. The existing levels of global radioactive contamination in Kazakhstan could have arisen from incidents and accidents at nuclear fuel cycle facilities, nuclear weapon tests at the Semipalatinsk Test Site located in the territory of the Republic of Kazakhstan. The natural steppe zone occupies about 26% of the total area of Kazakhstan stretching from west to east and covers the northern and northeastern country. Of the soils in the steppe zone, black earth (in the north) and chestnut soils (in the central part) dominate.

The research sites were prepared along meridians 65, 70 and 75 of eastern longitude, uniformly distributed latitudewise in the steppe zone of the Republic of Kazakhstan from the northern to the southern border of the zone. The total length of each meridian section varied from 486 to 544 km. There were 15 research sites (points) located in each section with the distance in-between of 24 to 53 km. As reported by previous research, the activity concentrations of artificial radionuclides in the top soil (0-5 cm) of the steppe zone were found to range for ^{137}Cs – 2.4-61 Bq/kg, ^{241}Am – <0.1-0.8 Bq/kg, ^{90}Sr – 1- 21 Bq/kg, $^{239+240}$Pu – 0.1-2.5 Bq/kg. To study the speciation of artificial radionuclides in the soil in each of three meridians, 4 or 5 points were selected, uniformly distributed all along, and which were characterized by the maxima of artificial radionuclide activity concentrations. The speciation was researched by sequential extraction under the Pavlotskaya procedure.

The distribution of ^{137}Cs speciation is classical for this radionuclide – its content was mostly determined in a tightly bound form. Due to the low content of ^{241}Am in soils, figures on its speciation could be derived only in 3 samples in a tightly bound form. The distribution trend of ^{90}Sr, which is prone to the exchange type of uptake by soils, is classical for the global fallout. The bulk of ^{90}Sr is distributed between an exchangeable and mobile form. $^{239+240}$Pu in soils is mainly distributed between a tightly bound and mobile form. In general, the research findings on the speciation of artificial radionuclides in soils of the steppe landscapes of the Republic of Kazakhstan match the data on the speciation of radionuclides that were brought by the global fallout. The findings are usable in the future as basic indices in assessing the impact of radiation-hazardous sites on the radioecological state within the Republic of Kazakhstan.

Vertical distribution of radionuclide speciation in the soil of the test location of radiological warfare agents of the Semipalatinsk Test Site

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A vertical distribution of radionuclides in soils is an indicator reflecting the processes of migration, distribution and fixation in natural ecosystems. The vertical distribution pattern of radionuclides in the soil profile is defined by conditions of their input, physic-chemical soil properties, as well as the time that passed immediately upon contamination Under the conditions of a growing man-made impact, related to nuclear power activities, to develop rehabilitation measures for radioactively contaminated areas and predict the behavior of radionuclides in the soil profile, the study of the regularities of the vertical migration of radionuclides in soils becomes particularly relevant.

The pattern of the vertical distribution of artificial radionuclides (ARN) in the Semipalatinsk Test Site(STS) soils essentially differs depending on a test type. Most of the STS's area is marked by surface contamination of the soil cover attributed to the fallout from atmospheric blasts. However, there are objects at which a different type of contamination occurs, which is characterized by the vertical migration of radionuclides into layers of 20 cm and deeper. The 4a site is one of such objects whose contamination is driven by tests with a view to design a radiological weapon. As a combat ammunition, liquid and powdered radiological warfare agents (RWA), were applied, which represented nuclear radioactive waste, as well as the products irradiated with neutrons from an operating nuclear reactor, i.e. by way of generating an induced activity. Liquid radioactive formulations were dispersed by means of aviation (air bombs, AST- airborne spray tanks) and artillery (conventional and missile). Single warheads containing RWA were also detonated at dedicated sites fitted out with the target layout.

The paper's goal was to research into ARN speciation in the soil profile of the test location of radiological warfare agents (4a site) with various patterns of the vertical distribution of artificial radionuclides. The objects of research were two spots of a various vertical distribution pattern. A classical distribution of radionuclides in the soil is specific to spot 1, which is accompanied by reduced activity concentrations of ARN as the depth increases. The occurrence depth of ^{137}Cs varies within 0-10 cm, that of ^{241}Am – 0-20 cm, $^{239+240}$Pu and ^{90}Sr are marked by the maximum research depth of 30 cm. At spot 2, the pattern of radionuclide distribution is different–as the depth rises, radionuclide activity concentrations first increase to the maximum as deep as 15-20 cm. Next, in the 20-25 cm layer, the ARN activity concentrations begin to gradually drop, and in the lowermost survey layer of 25-30 cm, they reach the layers lower than in the top 0-5 cm soil.

The research findings suggested that at spot 1, as of the test date, the RWA penetration was initially superficial (0-10 cm). As time passed, under gravity and diffusion, the vertical migration of more mobile ^{90}Sr, $^{239+240}$Pu continued into deeper layers by the exchangeable and acid-soluble forms. Initially after testing RWA, deeper layers at spot 2 were exposed to contamination, which correspond to the points currently marked by the maxima of ARN activity concentrations(15-20cm). Over time, the vertical migration of ^{137}Cs, ^{241}Am, ^{90}Sr into deeper layers persisted, as proven by the content of these radionuclides on the mobile forms and the vertical distribution pattern of mobile forms in the spot profile. A significant relationship was established between the indicators of the particle-size composition and the content of organic matter in the soil and the mobility of ^{90}Sr and $^{239+240}$Pu in soils of spot 2. Nevertheless, the influence of soil physico-chemical properties on the pattern of ARN vertical distribution in soils is not paramount. A varying pattern the vertical distribution at two spots could have been attributed to a variety of characteristics of the RWA test.

Development and standardization of a kit-based FAPI-04 radiopharmaceutical: Chelator exchange strategy enabling dual labeling with lutetium-177 and technetium-99m

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Introduction: Fibroblast activation protein (FAP) is overexpressed in cancer-associated fibroblasts in many solid tumors, making it an important target for both diagnostic and therapeutic applications. FAPI-04, a quinoline-based inhibitor, has demonstrated high specificity and affinity for FAP, supporting its application in theranostic approaches in nuclear medicine.

Aim: The aim of this study is the development of a kit-based formulation for dual radiolabeling of a single FAPI-04 molecular scaffold for both therapeutic and diagnostic use.

Materials and Methods: The original FAPI-04 molecule, functionalized with a DOTA chelator, was radiolabeled with Lutetium-177 (^{177}Lu). Radiochemical purity was evaluated using three independent ITLC chromatographic systems.

For diagnostic application, the molecule was modified by replacing the DOTA chelator with hydrazinonicotinamide (HYNIC). Radiolabeling with Technetium-99m (^{99m}Tc) was performed using tricine and EDDA as co-ligands and stannous chloride ($SnCl_2$) as a reducing agent. Labeling conditions, including pH, ligand concentration, and reducing agent stability, were systematically evaluated.

Results and Discussion: Radiolabeling of DOTA-FAPI-04 with ^{177}Lu showed high efficiency, with radiochemical yields exceeding 98%, as confirmed by three ITLC systems.

In contrast, radiolabeling of HYNIC-modified FAPI-04 with ^{99m}Tc demonstrated variable yields depending on reaction conditions. This variability highlights the importance of the coordination chemistry environment. The balance between HYNIC, co-ligands (tricine/EDDA), and the reduction efficiency of technetium was identified as the critical factor influencing labeling efficiency. Additionally, parameters such as pH, ligand ratios, and $SnCl_2$ stability were found to significantly affect reproducibility.

Conclusion: This study demonstrates the feasibility of developing a kit-based, single-molecule theranostic platform using FAPI-04. While ^{177}Lu labeling with DOTA shows high stability and reproducibility, optimization of the HYNIC-based system is essential for consistent ^{99m}Tc labeling. Further work is required to standardize coordination conditions and develop a robust, clinically applicable kit formulation.

X-ray induced fragmentation and charge release in halogenated radiosensitizers: A first electron–multi-ion coincidence study

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Absorption of high-energy X-rays by molecules initiates a cascade of electronic relaxation processes that redistribute charge and energy on femtosecond timescales. These ultrafast steps determine how the system evolves from a localized excitation to widespread ionization of the molecular framework and, ultimately, to fragmentation through Coulomb explosion. Despite their central role in X-ray science and radiation chemistry, the pathways of charge buildup and energy flow at the molecular level remain poorly understood.

Molecules containing High-Z atoms such as bromine or iodine are of particular interest because their large inner-shell ionization cross sections make them efficient X-ray “antennas”, or absorption hotspots, triggering rich decay cascades that drive rapid and extensive molecular damage. Beyond their fundamental significance for ultrafast radiation-matter interactions, these processes are also relevant for X-ray-based cancer therapy, where halogenated nucleoside analogs act as radiosensitizers in hypoxic tumor cells. Current biological models of radiation damage mainly emphasize low-energy secondary electrons and radicals from water radiolysis, while largely overlooking the direct contributions of the radiosensitizer molecules themselves.

To address this gap, we developed MUSTACHE, a high-resolution electron–multi-ion coincidence setup optimized for tender and hard X-ray studies [1]. By correlating energy-resolved electrons with multiple ionic fragments, MUSTACHE enables detailed probing of charge redistribution and fragmentation pathways in complex molecules.

Our first coincidence experiments [2] on halogen-containing uridine derivatives – 5-iodo-4-thio-2′-deoxyuridine and 5-bromo-4-thio-2′-deoxyuridine – performed at the GALAXIES beamline of the SOLEIL synchrotron (France), reveal that absorption of a single hard X-ray photon can trigger a violent Coulomb explosion, producing predominantly small and multiply charged fragments. These results demonstrate that such molecules release not only cascades of Auger electrons but also energetic ionic fragments, including H+, capable of inflicting localized chemical and mechanical damage – species not accounted for in existing radiobiological models. Together, these insights can help advancing our understanding of the molecular-scale mechanisms underlying radiosensitizer action and their potential impact in X-ray-based therapies.

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A novel theoretical approach for determining the effective atomic number in medical physics applications

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Effective atomic number (Zeff) is a key parameter in radiotherapy dose calculations and tissue-equivalence studies, as it enables the energy-dependent characterization of photon-matter interactions. In this work, a novel theoretical approach for determining Zeff is proposed and systematically compared with several widely used Zeff calculation methods reported in the literature. The comparisons were performed for 6 MV and 18 MV LINAC photon beams using both photon spectrum and monoenergetic beam representations. Analyses were also performed for low, medium, and high-energy photons. The approach was applied to materials commonly used in radiotherapy and phantom studies, including water, PMMA, RW3, and various glass materials.

This study presents a comparative evaluation of spectral and monoenergetic approaches for clinical LINAC beams and demonstrates the applicability and material-discrimination capability of a new Zeff calculation methodology across a broad energy range.

Three approaches for determining imaging dose during intrafractional cone beam computed tomography in radiotherapy

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Purpose: One of the parameters monitored during teleradiotherapy is patient positioning and internal organs motion. Pre- and post-treatment cone beam computed tomography (CBCT) is typically performed for this purpose. Intrafractional CBCT (intraCBCT) allows for the assessment of set-up variations simultaneously with irradiation. Introducing intraCBCT into clinical routine requires comparing it with standard CBCT. To this end, the computed tomography dose index (CTDI) is measured. This work proposes CTDI measurement paths for intraCBCT and the corresponding ranges of variability of CTDI values for intraCBCT ($CTDI_{intra}$) compared to CTDI for CBCT ($CTDI_{CBCT}$).

Methods: CTDI determination was performed in accordance with IAEA recommendations [1]. Measurements were taken for the chest preset on two Elekta Versa HD linacs: V1 and V2.

During $CTDI_{intra}$ determination, the dose rate (DR(ß)) was recorded at 0.5 second intervals for a full rotation (the angle ß ranges from 0 to 360 degrees) at constant gantry speed. DR(ß) measurements were performed under the following conditions: in a phantom (DR_r(ß)) and in air (DR_ra(ß)), both for a 20mm beam width, and in air for a standard beam (DR_a(ß)). Using a proprietary program, gantry angles (ß) and times corresponding to DR(ß) were extracted from the system files. For each angle ß with an accuracy of 1°, DR(ß) was determined.

$CTDI_{intra}$ was determined for five plans with energies of 6MV and 6FFF, and MU (monitor unit) ranging from 264.3 to 3920.5. For the selected beam, the angles ß which the kilovolt beam was exposed were extracted from the system file for each plan.

Additionally, $CTDI_{intra}$ was calculated for five plans in the treatment and QA modes. For two plans, the measurements were repeated 10 times (once daily) and 3 times a day. The results were compared with the $CTDI_{CBCT}$ for both linacs.

Results: $CTDI_{intra}$ compared to $CTDI_{CBCT}$ varied from 5.6% to 7.1% for V1 and from 10.8% to 15.4% for V2. All $CTDI_{intra}$ values were higher than $CTDI_{CBCT}$. $CTDI_{intra}$ values performed in the treatment mode and in the QA mode did not differ by more than 1% for both linacs. The $CTDI_{intra}$ value for all plans did not change by more than 0.6% for measurements 10 times once a day and 3 times a day. The difference between $CTDI_{CBCT}$ for V1 compared to V2 was 12%.

Conclusion: The performed measurements made it possible to propose three approaches for determining $CTDI_{intra}$ with defined variability ranges.

Path 1: Performing $CTDI_{intra}$ measurements for a set of typical plans enables determination of $CTDI_{intra}$ with variation of less than 16% for a single intraCBCT compared to $CTDI_{CBCT}$. This result is comparable to difference between $CTDI_{CBCT}$ for twin machines.

Path 2: Performing a $CTDI_{intra}$ measurement for a single plan in QA mode allows assuming a $CTDI_{intra}$ variation of less than 2% compared to $CTDI_{CBCT}$. This takes into account the variability resulting from the measurement in QA mode and occurring in subsequent fractions.

Path 3: Performing a measurement in treatment mode allows for determining a $CTDI_{intra}$ with a variability of less than 1%, which results from the variability of CTDI during subsequent fractions.

Presented values may differ for different linac machines, but the research carried out allows for the selection of a course of action in order to adopt the appropriate procedure.

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Capabilities and application experiences of low-cost active radon-detectors

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The contribution of indoor radon-inhalation to the natural radiation exposure has been increasing significantly in recent decades due to multiple reasons. This increasing importance of radon has initiated extended radon monitoring campaigns worldwide. Such campaigns require increasing number of detection equipment. In recent years, several types of low-cost radon measuring devices have been introduced in the product-line of instrument manufacturers.

The price of several low-cost active detector is comparable to the annual cost of a monitoring campaign with passive detectors involving seasonal detector replacement. However, the advantage of low-cost active detector is their typical hourly time resolution which enables the measurement of daily oscillations and other time-dependent variations of radon levels. Therefore, these detectors can be applied cost-effectively in extended monitoring campaigns involving multiple sites, particularly when the number of available instruments is limited by the available budget. Another potential application is the long-term monitoring of a specific site, which requires a dedicated device over an extended period.

However, their properties, performance characteristics and limitations are not sufficiently documented. Consequently, their application for a specific purpose should be preceded by testing and pilot measurements. A few types of these low-cost active radon detectors have been tested in our laboratory and initial experiences have been evaluated. A calibration procedure was developed to check the manufacturer's calibration of these devices. Based on the test results, low-cost radon-detectors can be effectively used for several purposes. Our preliminary experiences, test results and example applications will be presented.

Defined Solid Angle (DSA) alpha spectrometry for absolute Radon-222 activity determination: Thermal modelling of the cryogenic source

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Radon-222 (Rn-222) is a major contributor to natural radiation exposure and presents a significant health risk due to its alpha-emitting progeny. Accurate and traceable radon measurements are critical for radiation protection, posing metrological challenges related to uncertainty reduction and calibration of monitoring instruments. Primary standards for radon gas, realized at National Metrology Institutes (NMIs), ensure traceability in such measurements.

In preparation for a new primary standard for absolute radon activity determination at the Physikalisch-Technische Bundesanstalt (PTB), this work further develops the Defined Solid Angle (DSA) alpha-spectrometry method previously presented at RAD 2025. In DSA, radon gas is condensed in an ultra-high vacuum (UHV) chamber onto the top of a cryogenically cooled nickel rod enclosed by a thin metal membrane sealed via micro-laser welding (the cold surface). Solidification occurs below 100 K. Only alpha particles emitted within a well-defined solid angle are detected, defined geometrically by a precision circular diaphragm at a known axial distance from the cold surface.

A central challenge is the determination of the effective condensation radius, which depends on the local cold surface temperature. Radial and axial temperature gradients along the cold surface and nickel rod affect the condensation boundary, yet direct measurement of the cold surface is not feasible. Finite-element thermal simulations in COMSOL Multiphysics quantify temperature distributions on the cold surface and surrounding membrane, enabling accurate correction of sensor readings and precise calculation of the condensation radius.

The results demonstrate that temperature gradients can significantly influence the effective condensation radius and, consequently, the normalized defined solid angle (Geometry Factor). Thermal modelling provides guidance for optimizing cryogenic design and boundary conditions, supporting reduced uncertainty in the DSA primary standard and harmonized procedures across NMIs.

Assessment of geogenic radon potential and preparation of GRP maps in the Transdanubia region of Hungary

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The primary geological contributors to public radiation exposure are radon and its decay products. In addition to certain building materials, soil is a major source of radon. The Geogenic Radon Potential (GRP) index evaluates the risk of indoor radon originating from surface soils, independent of building characteristics or lifestyle factors, as it is determined by soil permeability and radon concentration in soil gas. GRP-based radon risk maps therefore help identify areas that are more prone to elevated indoor radon levels.

In the Transdanubian region of Hungary, soil permeability and soil gas radon concentration were measured at 1311 sites. The study area is largely characterized by low to moderate GRP values, with only a limited number of high-risk locations. Specifically, 985 sites were classified as low risk, 315 as medium risk, and 11 as high risk. Following the current European Union radon survey framework, the data were transformed into a raster map using 10 × 10 km grid cells. Each grid cell included three to five measurement points, preferably situated near inhabited areas. After aggregation, no grid cells were classified as high risk, 82 were classified as medium risk, and 282 were classified as low risk.

Geographic Information System (GIS) software was applied to generate GRP maps Several spatial interpolation techniques were tested to determine the most suitable method for interpreting the measured data. However, when interpolated datasets are displayed, the spatial resolution may decrease, as local anomalies can be obscured or exaggerated.

A method for assessing the radon diffusion potential of soils

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It is well known that radon (^{222}Rn) in buildings accounts for the largest contribution to the population's radiation dose and is the leading risk factor for lung cancer among nonsmokers [1]. The primary source of ^{222}Rn entering buildings is the soil beneath them, which contains ^{226}Ra, the parent nuclide of radon. To regulate radon, an assessment of geogenic radon hazard is conducted during the land-use planning stage. This allows for the adoption of preventive measures to avoid radon exposure in buildings. There are various methods for assessing geogenic radon hazard, each with its own advantages and disadvantages. In this work, we proposed a method for assessing geogenic radon hazard based on in-situ measurements of radon diffusion length and 226Ra concentration, which we termed the "diffusion radon potential" (DRP) [2].

$$DRP = (C_{Ra} \cdot \exp(L)) / 100$$

Where: C_{Ra} – ^{226}Ra concentration, Bq/m^3; L – radon diffusion length in shallow soil, m.

The proposed parameter is effective for assessing the radon hazard in areas composed of loose, porous soils where radon transport is predominantly by diffusion.

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Geochemical criteria for the radon potential of groundwater in granite massifs

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Radon in groundwater is one of the most significant natural radiation hazards. Direct measurements of radon are laborious; therefore, the search for reliable indirect predictive criteria is highly relevant. The aim of this work is to analyze together trace-element composition and thermodynamic indicators of water–rock interaction for radon potential prediction.

We studied 126 natural water samples from various granitoid provinces: the Caucasus Mineral Waters region (Beshtau, Zheleznovodsk, Pyatigorsk, Kislovodsk, and hot and cold springs of the Elbrus region (Northern Caucasus)) as well as the Belokurikha granite massif (northern face of the Altai mountains). The investigated radon activities range from background values up to 700 Bq/L; most radon-rich waters contain 100–200 Bq/L, and the Belokurikha thermal waters contain 150–280 Bq/L. ICP-MS analysis of 70 trace elements (with DL down to 0.1 ng/L) was performed; major ions were determined by ion chromatography, and pH, Eh, DOC, O_2 and T were measured. Saturation indices (SI) for aluminosilicate minerals — albite, microcline, kaolinite, Na- and Ca-montmorillonite, and quartz — were calculated using the Visual MINTEQ software.

All waters with radon concentrations above 100 Bq/L are distinguished by high kaolinite saturation indices, SI ≥ +4.5, and, as a rule, supersaturation with montmorillonite (SI > +5.0). Background and low-radon waters have SI(kaolinite) ≤ +3.8. An exception is the thermal waters of Pyatigorsk (e.g. *Narodnye Vanny (free public thermal pools)*), which have kaolinite SI up to +5.0 but are in equilibrium with albite (SI ≈ 0) and contain uranium <200 ng/L, indicating exhaustion of the radioactive source.

However, thermodynamic indicators alone do not distinguish between actively leached and “exhausted” aquifers. The key indicators of present-day leaching intensity are U > 2000 ng/L, Mo > 300 ng/L, and Be > 2000 ng/L (for ultra-fresh waters) or >150 ng/L (for more mineralized waters). In the Belokurikha thermal waters, which have low U (~5–35 ng/L), evidence of continuing activity comes from extreme Mo concentrations (up to 45,000 ng/L) against a background of SI(montmorillonite) > +6. Molybdenum and Be, primarily released from accessory phases, are poorly co-precipitated and remain conservative tracers of hydrothermal alteration even at low uranium concentrations.

Based on their macro-component composition, waters with elevated radon are divided into ultra-fresh (Na <15 mg/L, Cl <10 mg/L — springs in Beshtau mountain) and more saline waters with Na/Cl ≥5–10 (Zheleznovodsk, Belokurikha). Cl >100 mg/L with Na/Cl ≈1 always corresponds to low radon in the water.

A complex Radon Index (RI) is proposed that incorporates the concentrations of macro-components (Na, Ca, Mg, Cl), trace components (U, Mo, Be), and the saturation indices of kaolinite and montmorillonite. The index correctly classifies 91% of the samples, including difficult cases (high-radon waters with low U but anomalous Mo; thermal springs with high SI of clay minerals but without radon; and others).

Notably, the index identifies waters that are geochemically predisposed to radon accumulation but does not predict its level qualitatively; the concentration itself is governed by fracture permeability, local uranium enrichment (up to ore-grade bodies) as well as water-rock interaction time.

Published datasets on granitic waters from Russia, the USA, Norway, China, Korea, and Brazil confirm the same correlations of radon with U, Mo, Be, Si, and supersaturation with kaolinite/montmorillonite. The developed index, for the first time, integrates trace-element and thermodynamic parameters into a single predictive criterion suitable for the rapid assessment of radon hazard in granitoid provinces worldwide.

The study was supported by the Russian Science Foundation (project No. 24-17-00217).

Uranium occurrences and radon potential in Poland: A review of their geological and radiological significance

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Uranium occurrences in Poland are usually discussed in the context of mining history, resource potential and nuclear fuel supply. However, uranium-bearing formations and abandoned mining sites may also be important from the perspective of environmental radioactivity, especially in relation to radon generation, migration and exposure in underground spaces.

This review summarizes selected uranium-bearing regions in Poland and evaluates their geological and radiological significance, with particular emphasis on locations where radon measurements have been reported in the literature.

Historical uranium mining in Poland was carried out mainly between 1948 and 1968, with total production estimated at approximately 650 tonnes of uranium. Five uranium mines operated in the country, including four in the Sudetes and one in Rudki in the Holy Cross Mountains. The Sudetes are therefore of particular interest, as they combine documented uranium mineralization, post-mining underground workings, fractured crystalline rocks and tourist use of former mining spaces.

The radiological relevance of these areas is demonstrated by published radon studies from selected post-mining sites. In Kletno, measurements in the Old Uranium Mine recorded elevated radon activity concentrations, reaching several thousand Bq/m³ in the underground tourist route. In Kowary, measurements in adits of the abandoned Podgórze uranium mine showed reported average levels of radon activity concentration of 350-400 kBq/m³.

These examples indicate that former uranium mining areas should be considered not only as geological and mining heritage sites, but also as objects for radioecological assessment, radon monitoring and radiation protection education.

The review highlights the need to interpret uranium occurrences not only as mineral resources, but also as geological indicators of radon-prone environments.

Keywords: uranium occurrences, radon monitoring, uranium mine, radon activity concentration, Kowary, Kletno, Poland

Pulse waveform measurement using a laser-induced graphene sensor and ADS1220 readout

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Accurate pulse waveform acquisition is essential for the development and validation of wearable cardiovascular monitoring systems. Laser-induced graphene has emerged as a promising material for flexible biosensors due to its electrical conductivity, mechanical compliance, and scalable fabrication. A laser-induced graphene (LIG) resistive sensor was used to measure the pulse waveform generated by the BT-CEAB2 Pulse Assessment Simulator. The LIG was fabricated on Kapton tape with an active area of 2 × 0.5 cm. Electrical connections were formed directly on the LIG using flexible silver conductive paste (Sigma-Aldrich, USA), and the sensor was interfaced with an ADS1220 (24-bit delta-sigma ADC) and an ATmega328P microcontroller. Since the tested LIG sample exhibits a low resistance (approximately 235 Ω), excitation was provided by the integrated ADS1220 current source (IDAC) set to 1.5 mA.

The sensor was placed at the radial site of the simulator and mechanically fixed using adhesive tape to ensure stable coupling with the artificial skin. The measurement was performed at a heart rate of 80 bpm. Data acquisition was carried out in real time using a custom PC-based real-time plotter application, which receives the serial data stream from the microcontroller, stores the measurements in a user-selected file, and simultaneously plots the signal in a separate window. A hardware timer on the microcontroller was used to maintain a stable sampling rate of 200 Hz. Each transmitted sample includes a timestamp in milliseconds generated by the ATmega328P microcontroller from the start of acquisition, followed by a separator character and the corresponding ADC voltage value expressed in millivolts. Timestamping is therefore not performed on the PC side, reducing potential timing errors and improving the reliability of post-processing and filtering.

Beat detection was performed using the HeartPy software toolkit, and the heart rate set by the simulator was measured accurately (80 bpm), with no observable deviations over the acquisition period. The acquired pulse waveform clearly exhibits systolic and diastolic peaks typical of PPG-like signals. The systolic peak is consistently present and strongly pronounced across the entire recording, while the diastolic peak is visible only in certain signal segments. In intervals where the diastolic peak is not present, the waveform is dominated by a clean and sharply defined systolic component with very low noise, resulting in a signal-to-noise ratio of 20 dB. In contrast, segments in which the diastolic peak and the surrounding waveform features are expressed show increased signal complexity and higher noise levels, leading to a reduced signal-to-noise ratio of approximately 10 dB. These results demonstrate the suitability of LIG sensors for high-resolution pulse waveform acquisition using compact, low-power redout electronics.

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Underwater detection of hazardous substances with neutron beams: The SABAT project

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The Neutron Activation Analysis (NAA) plays an exceptional role in modern nuclear engineering, especially in view of hazardous substances. Especially in the aquatic environment, NAA has the potential to support threat detection by providing a fast and cheap tool to plan the utilization of munitions and fuel in sunken remnants of the II World War. They are a serious threat to the Navy, and the toxic substances contained in some munitions, such as combat gases, are a major environmental problem, and detecting and classifying them is still very costly. The use of neutrons is distinct from commonly used methods in that it enables the determination of not only the shape, but also the stoichiometry of the objects under investigation. However, in the aquatic environment, there are still many problems to be solved for effective usage of neutrons. In this contribution we present the status of the SABAT (Stoichiometry Analysis by Activation Techniques), one of the projects aiming at construction of an underwater device for non-invasive threat detection based on the NAA.

Diamond film thermistors for application in extreme environments

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Extreme environments such as very high or low temperatures, extreme pressure, intense radiation, corrosive media, strong electromagnetic fields, or heavy mechanical loads and vibrations, push materials and devices beyond the limits for which they were originally designed. Temperature monitoring is crucial in almost all areas of modern technology, including applications in extreme environments where current sensing devices have limited operational capabilities. Many such situations require these sensors to operate for long periods while maintaining their thermal sensitivity over a wide temperature range.

The novel temperature sensors presented in this work are NTC thermistors based on boron-doped diamond (BDD) and undoped diamond (UND) thin films grown on silicon nitride (Si_3N_4) ceramic substrates. The new sensor's planar geometry maximizes the thermal contact area and, since the temperature sensitive film is made of diamond, the best thermal conductor material, and is just a few micrometres thick, it gives fast response times to small temperature variations, with high thermal stability. Another innovative aspect of these diamond thermistors is their ability to measure temperature without contact. Our preliminary work has demonstrated the electrical response of these sensors to small temperature variations by infrared radiation. This feature is important in applications where thermal contact with the sensor is not possible or undesirable such as measuring the temperature of sensitive and rotating mechanical parts.

Time-structured radiochemical and radiobiological investigation of FLASH-RT using laser-driven proton beams

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FLASH radiotherapy (FLASH-RT), characterized by ultra-high dose rates (≥40 Gy/s), has demonstrated significant normal-tissue sparing while maintaining tumor control. Despite growing experimental evidence, the physical and chemical mechanisms underlying the FLASH effect remain unresolved, limiting rational optimization and clinical translation. Recent studies indicate that oxygen depletion alone cannot explain FLASH-induced tissue sparing at clinically relevant doses. Instead, growing evidence indicates that ultra-high instantaneous dose rates fundamentally alter radical reaction kinetics through enhanced radical–radical recombination, inter-track coupling, and strong dependence on the temporal structure of dose delivery. Despite these advances, most existing simulations rely on time averaged dose-rate descriptions, do not explicitly model pulse duration or pulse train structure, and are rarely benchmarked against experiments with matched temporal irradiation profiles. Laser-driven proton accelerators provide a unique platform for FLASH-RT due to their intrinsically ultrashort pulses, extreme instantaneous dose rates, and flexible pulse-train structures. This project proposes a pulse-resolved computational–experimental framework that explicitly models laser- driven proton pulse structures using Geant4-based toolkits, integrates chemically realistic radiolysis (including pH-dependent radical protonation and oxygen effects), and validates predictions against laser-driven proton beamline experiments. The validated framework will be used to investigate radical–radical recombination, inter- track coupling, and LET-dependent oxygen effects, and to optimize beamline parameters for mechanistic FLASH studies. This work will provide a physics- and chemistry-grounded understanding of FLASH-RT and establish a predictive tool for next-generation proton FLASH research.

Ultra-high dose rate radiobiological effects: Laser-driven radiation sources as complementary research tools

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Ultra-high dose-rate radiotherapy and the observation of the so-called FLASH effect have stimulated renewed interest in how the temporal structure of dose delivery influences the biological response to ionizing radiation. Although the FLASH effect has often been primarily associated with dose rate, recent studies indicate that dose per pulse, total irradiation time, pulse repetition structure, and beam delivery modality may also play important roles. Most current UHDR research is performed with conventional accelerators; however, laser-plasma sources provide radiation fields with intrinsically ultra-short bunch durations and very high instantaneous dose rates. These features make them attractive for dosimetry or detector development, but especially for radiobiology, as irradiation conditions that are difficult to reproduce with standard beam delivery systems may help to reveal new aspects of radiation response.

At ELI Beamlines facility, laser-driven radiation sources are being developed and used for multidisciplinary research, with a strong emphasis on radiobiology. The ELIMAIA-ELIMED platform, powered by the L3 HAPLS 1 PW-class laser system, enables controlled multi-shot irradiation with laser-driven protons, including energy selection and dedicated sample irradiation setups. Proton energies currently available for user experiments are typically in the range of 15–25 MeV. Although the mean dose rate is relatively low, the individual proton bunches have nanosecond-scale duration and very high instantaneous dose rates, creating irradiation conditions not usually achievable with conventional accelerators. In parallel, laser-accelerated electron beams are available at ELI Beamlines in both mid- and high-energy regimes, including high-repetition-rate electron beams from the L1-Allegra laser and emerging very-high-energy electron capabilities at the GeV level.

Laser-driven radiation sources can usefully complement current conventional accelerator-based UHDR approaches by broadening the accessible range of dose rates and enabling dedicated studies of the effects of dose per pulse, irradiation time, and pulse structure. Such complementary approaches may help to disentangle the physical and biological factors underlying the FLASH effect and related ultrafast radiation responses, ultimately contributing to the optimization of future radiotherapy strategies.

Optical properties of layered double hydroxide analysis for photodynamic therapy

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Photodynamic (PDT) and photothermal therapy (PTT) offer promising non-invasive alternatives for cance therapy using nanoparticles with photoluminescent properties as photosensitizers and photothermal agents, respectively.

Photosensitizers generate reactive oxygen species (ROS), while photothermal agents convert light to heat, destroying cancer cells with minimal resistance. These mechanisms may act independently or synergistically, depending on laser source, pH, oxygen, temperature, or structural defects.

Using bioinspired MgAl and CoAl layered double hydroxides (LDH), with or without structural defects, the aim of this work is to analyse the procedure to induce tumor cell death via ROS pathways.

Samples were synthesized by co-precipitation from Mg^{2+}, Co^{2+}, and Al^{3+} chlorides at a 2:1 M^{2+}/M^{3+} molar ratio. Structural defects were introduced via alkaline treatment with 2M NaOH. XRD confirmed typical LDH structures, while treated samples showed slight peak shifts indicating strain-induced lattice contraction [2]. FTIR spectra revealed strong CO_2 adsorption at ~1360 cm^{-1}, suggesting defect formation, such as Co^{+}–VO, which retain CO_2 through electron transfer from CO_2 to Co atom vacancies [3-4]. Additionally, micropores may contribute to CO_2 retention due to high surface area and stronger interactions. PL spectra (excitation at 380 nm) revealed structural defects with emissions at 400–500 nm for MgAl and 450–650 nm for CoAl. These findings support the potential of engineered defects in LDH for PDT applications.

The challenge of clinical translation for FLASH radiotherapy using RF-based accelerators

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The clinical translation of the FLASH effect—characterized by a significant sparing of normal tissue toxicity at ultra-high dose rates (UHDR)—is currently one of the most pressing challenges in radiation oncology. Among the various technological approaches, radiofrequency (RF)-based accelerators represent the most viable pathway toward widespread clinical implementation. RF-driven LINACs are already capable of providing the reliability and beam quality essential for medical standards. The fundamental definition of FLASH is inextricably linked to the delivery of a high total dose within an extremely compressed timeframe (~ 100 ms), resulting in mean dose rates exceeding 40–80 Gy/s. While conventional RF LINACs are already capable of delivering FLASH treatments for superficial tumors—often managed with single-fraction, high-dose delivery—treating deep-seated lesions is significantly more complex. The clinical requirement for multiple treatment fields and fractions, combined with the need to maintain UHDR thresholds across the entire target volume, pushes current RF technology to its absolute physical limits.

The current state of the art reveals critical trade-offs depending on the particle species used. Proton therapy can achieve FLASH rates, but current systems are limited by the time required to switch beam energies for a Spread-Out Bragg Peak. To deliver the entire dose within the necessary FLASH window, passive range modulators must be used; however, this compromise degrades the dose conformity. Very High Energy Electrons (VHEE) have emerged as a robust alternative; unlike protons, a single VHEE energy can cover deep-seated volumes without the need for complex modulation, allowing the entire dose to be delivered within the required FLASH window. However, VHEE technology is still in the developmental phase and remains distant from routine clinical use. Conversely, UHDR Photons can be generated by combining high-power LINACs with electron-to-photon converters, but they face a major "spatial" bottleneck: conventional Multi-Leaf Collimators are mechanically too slow to conform the beam during micro-second UHDR pulses.

In this presentation, I will discuss the inherent challenges of multi-particle delivery within the FLASH regime, with a specific focus on the technical and dosimetric requirements for VHEE and MV Photons. To ground this analysis, I will utilize the technological baseline of the SAFEST (SApienza Flash Electron Source for radioTherapy) project. Developed at Sapienza University in collaboration with INFN, SAFEST consists of a compact C-band linac designed for hospital integration, capable of delivering Low Energy Electrons, VHEE (<100 MeV), and UHDR photons. Starting from the SAFEST architecture, I will explore various machine configurations to define the conditions necessary for achieving a moderate FLASH sparing effect in the treatment of specific deep-seated tumors. These 'golden cases'—where tumor location, stringent dose constraints, and the technical limitations of conventional radiotherapy converge—represent the highest potential for therapeutic gain and serve as the primary benchmark for this feasibility study. The analysis demonstrates that achieving even moderate sparing of the main Organs at Risk is strictly dependent on surpassing specific operational thresholds. By exploring machine configurations beyond standard settings, I will show that such results are attainable only when the Pulse Repetition Frequency exceeds 500 Hz for both VHEE and photons, combined with a charge per pulse of approximately 5 uC for photon production. By quantifying these technical requirements, this work defines the necessary evolution for RF LINACs to successfully translate the FLASH effect from a laboratory phenomenon into a clinical reality.

Diamond detectors for real-time dosimetry and beam characterization in FLASH radiotherapy

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FLASH radiotherapy requires accurate, reproducible and real-time dosimetry under irradiation conditions that are far beyond those encountered in conventional radiotherapy. Ultra-high dose-per-pulse and ultra-high dose-rate electron beams pose severe challenges to standard active dosimeters, which typically suffer from recombination, saturation and dose-rate-dependent response. In this work, we present the development, validation and application of a diamond-based dosimetric approach specifically designed for FLASH electron beam dosimetry.

A novel diamond Schottky diode detector, named flashDiamond, was designed by optimizing the detector layout, active volume and series resistance in order to preserve response linearity under ultra-high dose-per-pulse conditions. The detector was tested using ElectronFlash linac beams and benchmarked against radiochromic films and established commercial dosimeters. Its response was investigated over a wide range of irradiation conditions, including dose-per-pulse values up to the ultra-high regime, conventional and FLASH modalities, different applicators, beam energies and pulse durations.

The flashDiamond showed a linear response up to at least 20 Gy/pulse during detector development, and was subsequently validated for commissioning measurements of 7 and 9 MeV ElectronFlash beams. Percentage depth doses, beam profiles and output factors measured with the detector were in very good agreement with reference dosimetry, demonstrating its suitability for fast and reproducible characterization of FLASH electron beams. In addition, a dedicated fast readout configuration further enabled time-resolved measurements of the instantaneous dose rate, with nanosecond-scale temporal response and no saturation up to about 2 MGy/s.

These results demonstrate that flash Diamond-based systems provide a robust solution for real-time dosimetry, commissioning and temporal characterization of ultra-high dose-rate electron beams, supporting the reliable implementation of preclinical FLASH radiotherapy studies.

A new underground laboratory for FLASH applications of laser-plasma VHEE accelerator at ILIL: Radioprotection measures at high repetition rate

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Radiotherapy via the FLASH effect is an upcoming modality of cancer treatment that requires high mean dose rate (>40 Gy/s). Very High Energy Electrons (>100 MeV), the so-called VHEE beams, are being considered in this context for future FLASH treatment of deep seated tumors.

VHEE beams can be generated from Laser Wakefield Acceleration (LWFA), a technique that uses ultra-short (fs), high intensity laser pulses focused on a gas target to accelerate high charge electron bunches of equivalent short duration and very high peak dose rate. To reach the required mean dose rate, laser repetition rates of 100 Hz and above are desirable. For this reason, the ILIL laboratory at CNR-INO, Pisa, is currently undergoing a significant upgrade, with the commissioning of a new laser system and gas target capable of 100 Hz repetition rate and a new underground bunker being constructed to house the target area for 100 Hz repetition experiments. The development of such a facility placed inside the area of CNR, requires careful consideration of radioprotection, both inside the bunker and in the area above it, as well as the possible activation of the surrounding soil, to ensure the safety of all personnel and the environment.

As such, extensive Monte Carlo simulations have been carried out with the code Fluka, evaluating prompt and residual radiation, during and after irradiation, using the actual architectural design of the area. Worst-case irradiation scenarios have been considered given the capabilities of the laser system and a proper beam dump has been designed and built to minimize radiation during such cases. We show that the yearly dose rate of all critical areas under consideration is of the order of few pSv/year and the generated radionuclides are of the order of kBq, which drop to Bq in less than 1 hour and are negligible after 24 hours. Given these results and the safety regulations implemented during irradiation, the new installation provides the ILIL lab at CNR-INO with the necessary infrastructure for VHEE beam operation up to 100 Hz repetition VHEE for experiments dedicated to FLASH radiotherapy, with the required radioprotection measures concerning working personnel and the surrounding environment.

Beam monitoring, dosimetry, and detector features in FLASH radiotherapy

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In FLASH radiotherapy, one of the biggest challenges is achieving accurate and precise dosimetry at the elevated dose rates. Reproducibility of dose delivery with precise beam monitoring is crucially important. Interrupting a FLASH treatment quickly enough to avoid a misadministration is another issue. To address the challenges with beam monitoring in FLASH UHDR, we will compare several solid state devices: thin silicon, diamond and SiC state-of-the-art devices.

Laser-driven electron acceleration with solid-state and microjet targets for FLASH radiation sources

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FLASH radiotherapy, therapeutic doses delivered at ultra-high mean dose rates (≥40 Gy/s) over sub-second timescales, spares normal tissue while preserving tumour control, but its dependence on instantaneous dose rate, pulse structure and pulse duration cannot be resolved by conventional clinical accelerators, whose temporal parameter space is intrinsically limited. Laser-driven electron sources, with femtosecond-scale bunch durations and instantaneous dose rates orders of magnitude beyond any conventional machine, open a region of this parameter space that is otherwise inaccessible. We present the establishment in Catania of a laser-driven electron source for the FLASH regime, built around the I-LUCE facility at INFN-LNS. The driver is a post-compressed Coherent Astrella system (6 fs after compression, kHz repetition rate, multi-mJ class), used to accelerate electrons from two complementary target classes. The first consists of solid-state targets, carbon nanotubes and hollow nanofoam channels, exploiting relativistic induced transparency and direct laser acceleration to produce charge-dense, broadband bunches at high accelerating gradients. The second consists of gas microjet targets operating in the LWFA / shock-injection regime, with negligible debris, no target-replacement deadtime and a duty cycle natively compatible with the kHz laser repetition rate, i.e. with realistic multi-shot operation. An integrated diagnostic suite (magnetic spectrometer, scintillator-based charge monitor, pulse-resolved transmission ionisation chamber and EBT-XD radiochromic film stacks) characterises absolute dose, spectrum and shot-to-shot stability at the sample plane for both target families, supporting downstream in vitro radiobiology in a regime inaccessible to clinical linacs. The co-located SIT ElectronFlash linac at the University of Catania provides a clinically validated reference against which laser-driven results can be cross-checked at matched mean dose. The combination, a laser-driven source covering the extreme end of the FLASH parameter space, co-located with a conventional FLASH linac on the same campus, positions Catania as a reference site for laser-driven electron-FLASH research in Southern Europe. The hub is conceived to be open to external users through INFN access procedures and to feed European initiatives in laser-driven particle acceleration (EuAPS, IMPULSE).

Sustainable valorization of the invasive crayfish *Faxonius limosus*: Integrating tradition and innovation

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This study examines the invasive freshwater spiny-cheek crayfish *Faxonius limosus*, explores its potential for sustainable valorization in culinary applications that balance tradition with innovation. Both meat and shell were analyzed for their nutritional composition and sensory properties to identify opportunities for traditional recipes and novel food products. Consumer acceptance was evaluated through structured sensory evaluations, highlighting how taste, texture, and familiarity influence willingness to consume products derived from this invasive crayfish. Results show that *Faxonius limosus* meat has favorable sensory qualities for traditional and innovative dishes, while the shell adds umami and supports sustainable valorization. These findings suggest that sustainable utilization of spiny-cheek crayfish can reduce ecological pressure on freshwater ecosystems, support biodiversity, and promote circular bioeconomy. By integrating traditional culinary practices with innovative approaches, this study provides a model for environmentally responsible use of invasive crayfish, offering both gastronomic and ecological benefits.

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Modelling local heat transfer of a cylinder in air crossflow

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This study presents the results of numerical modelling of local heat transfer of a heated circular cylinder in crossflow under the experimental conditions. The investigation was performed in the subcritical air flow regime for a heated circular cylinder of diameter d = 0.032 m at a blockage factor k_q = 0.16 (k_q = d/H, where H is the height of the test section), and with an air flow turbulence at the inlet of Tu = 1.2%.

The two-dimensional simulations were performed using the ANSYS Fluent code for a Reynolds number Re = 61000 based on the cylinder's outer diameter as the reference geometric parameter, the airflow velocity in the smallest cross-section of the channel (at 90° of the cylinder) as the reference velocity, and the air flow temperature at the inlet as the reference temperature. Three turbulent transfer models were used: the standard k-ε model (k - turbulent kinetic energy and ε - dissipation), the Reynolds Stress-Omega model and the k-ω SST (Menter) model (ω - specific dissipation and SST - turbulent shear stress).

To ensure the accuracy of the modelling results, the sensitivity analysis was performed using three different meshes. Finally, a 760 thousand computational node mesh was selected for modelling.

The modelling results of all three turbulent transfer models were compared with experimental data. In the case of the k-ε turbulent transfer model, simulated results showed an unsatisfactory agreement with the experimental data: the modelled heat transfer coefficients an over the cylinder perimeter in the frontal part of the cylinder were higher by up to 250 % compared to the ones obtained in the experiments. This was caused by an overestimation of the turbulent transport in the model, which resulted in the decrease in the wall temperature in the frontal part of the cylinder. However, the local heat transfer coefficients an around the rear part of the cylinder did not exceed the experimental ones more than 40 %. In the case of the Reynolds Stress-Omega model, the comparison showed a moderate agreement between the modelling results and the experimental data in the frontal part of the cylinder. Here, the heat transfer coefficients a was only 15–19 % higher than the experimental ones. However, in the rear part of the cylinder, heat transfer increased by up to 40 % compared with the experimental values. In the case of the SST k-ω turbulence model, the comparison showed a reasonable agreement with the experimental data in the frontal part of the cylinder. Here, the heat transfer coefficients a were higher than the experimental ones by 10–13 %, but at the vicinity of the separation point (90°), this difference increased to 30 %. A very good agreement of the data was noticed in the rear part of the cylinder, where the difference was only up to 2 %.

The methodology and results presented here can serve as a reference for future wider research of heat transfer of a cylinder in crossflow and not only of the circular shape.

Treatment of antibiotic fermentation residuals (AFR) by coupled ionizing radiation and fermentation

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Antibiotic fermentation residuals (AFR) has been categorized as hazardous waste, and the elimination of residual antibiotics and antibiotic resistance genes (ARG) is the key to AFR disposal. Erythromycin fermentation residual (EFR) is a kind of AFR formed during the erythromycin (Ery) production. EFR poses significant greater threat than the other AFR because of more stable chemical structure of Ery, and easier proliferation of ARG with the antibiotic selective pressure caused by residual Ery, making EFR disposal hard and costly.

Taking advantage of the high organic content of EFR and the unstable characteristic of Ery at acidic conditions, biological acidification process is recognized as a good option for removing Ery in EFR. In addition, with unique advantages in damaging gene materials, ionizing radiation exhibits great potential in eliminating ARG in EFR. In this study, anaerobic fermentation coupled ionizing radiation was adopted for EFR treatment, aiming to achieve multiple benefits: (1) Ery degradation by biological acidification; (2) ARG releasement by EFR hydrolyzation, facilitating ARG degradation by the subsequent ionizing radiation treatment; (3) consumption of rich organic components in EFR, facilitating the ARG elimination by subsequent ionizing radiation treatment; (4) additional environmental and economic benefits obtained with the bioproducts produced from EFR.

Results showed that, anaerobic fermentation achieved Ery degradation rate up to 85%, and the degradation rate was further increased to 100% with 50-150 kGy ionizing radiation aftertreatment. Anaerobic fermentation induced the decreased abundance of *mph*B, while abundances of *ere*A, *erm*B and *mef*A were increased, verified the risk of ARG propagation during biological processes. Ionizing radiation aftertreatment achieved effective ARG elimination, and the elimination rate of over 99% was achieved when the radiation dose reached 150 kGy. Besides EFR disposal, volatile fatty acids of over 5000 mg/L was recovered from the coupled treatment process. This study proved the feasibility of treating EFR by coupled anaerobic fermentation and ionizing radiation, and provided a new way for EFR disposal and resources recovery.

NVivo-based qualitative analysis of integrated pharmaceutical waste management for sustainable healthcare

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Introduction: Pharmaceutical waste represents a growing global challenge with significant implications for human health, animal health, and the environment. Inadequate disposal and management practices lead to the accumulation of pharmaceutical residues in water, soil, and ecosystems, causing long-term environmental degradation and disruption of ecological balance. Despite increasing recognition of pharmaceuticals as emerging pollutants, regulatory frameworks and management systems remain fragmented and insufficient. Addressing this issue requires an integrated, interdisciplinary approach, as emphasized by the *One Health* concept, which recognizes the interconnectedness of human, animal, and environmental health.

Goal: This pilot study aims to explore the current state of pharmaceutical waste management, identify key systemic barriers and opportunities for improvement, and contribute to the development of integrated, sustainable strategies. A particular focus is placed on the role of qualitative analysis in uncovering complex, context-specific dimensions of the problem.

Materials and Methods: The study employs a mixed-methods design, conducted in two parallel phases. The qualitative component is central to the research and involves semi-structured interviews analyzed using NVivo software. This approach enables systematic coding, thematic analysis, and identification of patterns related to institutional practices, barriers, awareness, and proposed solutions. The quantitative component consists of a structured survey targeting healthcare professionals, with data analyzed using descriptive and inferential statistical methods to assess knowledge, practices, and perceptions regarding pharmaceutical waste management.

Results and Discussion: Preliminary findings from the qualitative NVivo analysis reveal critical systemic issues, including institutional fragmentation, lack of standardized protocols, insufficient professional training, and practical implementation barriers. Importantly, the qualitative approach provides in-depth insights into stakeholder experiences, perceptions, and underlying causes of inefficiencies—dimensions that cannot be fully captured through quantitative data alone. The survey data further support these findings, indicating gaps in formal education and variability in practices across institutions, alongside a notable willingness among stakeholders to adopt improved measures. The integration of qualitative and quantitative findings highlights the complexity of pharmaceutical waste management as a system-level issue requiring coordinated intervention.

Conclusion: This study underscores the pivotal role of qualitative analysis, particularly NVivo-assisted thematic exploration, in understanding the multifaceted nature of pharmaceutical waste management. By revealing hidden patterns, institutional dynamics, and stakeholder perspectives, qualitative methods provide essential evidence for designing effective, context-sensitive interventions. Within the One Health framework, these insights contribute to advancing interdisciplinary, integrated, and sustainable approaches to pharmaceutical waste management, supporting the development of more resilient healthcare and environmental systems.

Determination of Ra-isotopes and Pb-210 using MnO_2-nanolayered polyamide for Quench-Free LSC

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The determination of naturally occurring radionuclides such as radium isotopes (Ra-224, Ra-226, Ra-228) and Pb-210 is of considerable importance in environmental studies, particularly in water samples, due to their radiological relevance and geochemical mobility. These radionuclides are widely used as tracers in hydrological and geochemical processes; however, their accurate determination remains analytically challenging. Beyond aqueous systems, their measurement is also relevant in matrices such as soils, peat, sediments, and biological materials.

In this study, an improved analytical approach is developed, in which Ra and Pb-210 radionuclides are not measured in conventional liquid scintillation counting (LSC), but are first deposited onto MnO_2-Nanolayered polyamide filaments. The solid carrier containing the immobilized radionuclides is then directly immersed into the scintillation cocktail, enabling measurement. This approach simplifies the analytical procedure and enables faster and potentially more accurate measurements.

Prior to deposition, radium and lead were radiochemically separated. Radium was precipitated as $Ba(Ra)SO_4$ with a recovery of 95.3 ± 4.1%, while lead was isolated as PbS with a recovery of 93.3 ± 7.6%, both determined gravimetrically. The precipitates were subsequently re-dissolved, and separate deposition experiments were performed on MnO_2-coated polyamide discs. The deposition efficiency was evaluated using tracer isotopes and verified by alpha spectrometry employing a PIPS detector.

The proposed method demonstrates a promising alternative for the determination of Ra and Pb-210 radionuclides, offering simplified sample preparation, reduced reliance on tracers, and applicability to a wide range of environmental matrices.

Radioactivity, radiation and radioactive waste in a neutron activation analysis laboratory

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There are more than 220 worldwide research reactors (RR) ranging from less than 1 KW to tens of MW, with several others being constructed. In many of these RR basic training and neutron activation analysis (NAA) comprise an important role. Unlike nuclear power plants where radiation levels are very well known and categorized, NAA laboratories are involved in a large variety of isotope production for research, tracers for industry and now more common for medical research in imaging and therapy. Also, NAA is employed by many undergraduate and graduate students who may stay from a few months to a few years. The pedagogical challenge arises from how to quickly and properly train a semi-permanent and transient population of users on NAA. Our own experience has shown that specfic unique training in not only the basic techniques of NAA but all ancillary important aspects in radioactivity, radiation, radioactive waste and health physics. We will give an educational presentation and offer an template that other research reactors can implement and improve.

Factors influencing the concentrations of atmospheric radionuclides and their predictive modeling

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Concentrations of both natural and artificial radionuclides in the atmosphere have been monitored in the Czech Republic for 40 years. Although the primary purpose of radiation monitoring networks is the early detection of potential radioactive contamination, data from these networks can also be used to study atmospheric processes, as certain atmospheric radionuclides serve as suitable tracers.

Under normal conditions, aerosol sampling is carried out continuously, and analyses are performed twice a week. Activities collected on filters are measured using gamma spectrometry or radiochemical methods at four facilities. These results are based on data from Prague, where the highest measurement sensitivity is achieved among all measuring sites (down to the level of tens of nBq/m^3), and the widest range of radionuclides is analyzed. Here, we focus on those nuclides present that are accessible by gamma spectrometry methods—Cs-137, Be-7, Na-22, K-40, and Pb-210.

Long-term trends in the concentrations of these nuclides are presented, along with the effective half-life of Cs-137, correlations between the activities of individual radionuclides and meteorological and environmental parameters, and a simple predictive model based on a multilinear regression of the atmospheric predictors.

Effect of particle size on distribution of radioactivity in oil scale

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Naturally occurring radioactive materials (NORM) and technologically enhanced naturally occurring radioactive materials (TENORM) are an ongoing problem in the oil and gas exploration industry. During oil extraction, mixtures of oil, gas, and water are removed from the ground. Water soluble radionuclides such as Ra-226 and Ra-228 are present in the water. These radionuclides can be incorporated into in the mud, sludge, slimes, and evaporation ponds present at the drilling site. The radioactivity can then be further concentrated as mineral deposits (scale) on the inside of pipes, storage tanks, and other equipment. The scale mineral deposits consist largely of iron (due to pipe corrosion) and calcium, with strontium and barium in excess of 10,000 μg/g. The significant presence of alkaline-earth metals leads to coprecipitation and concentration of the chemically similar radium along with these elements. [1]

In this work we report on the effect of particle size on the distribution of radioactivity of oil scale from West Texas. Approximately 600 g of scale was dried and sieved into fractions between 20 to 600 microns. Each fraction was weighed, sealed in petri dishes, and then counted using a High-Purity Germanium detector with Compton suppression. The counted oil scale was then compared to a multi-nuclide standard to determine the activity distribution of each oil scale fraction. Neutron activation analysis was performed using the UT Austin TRIGA Mk. II reactor to determine the fractionation of other select stable elements. An analysis of the effect of particle size on the distribution of radioactive and other elements present in oil scale is discussed.

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Comprehensive analysis of carbon sequestration and decomposition dynamics in peatlands using radiometric dating and FTIR spectroscopy

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Peatlands play a critical role in the global carbon cycle; therefore, understanding their function is essential for reconstructing paleoenvironmental changes and assessing the long-term stability of carbon storage. The peat samples investigated in this study were collected from an extensive geographical range, including Bosnia and Herzegovina, Serbia, Bulgaria, Romania, Poland, and Lithuania. Consequently, the sampling sites span a significant latitudinal gradient from approximately 43°N to 55°N, covering various climatic conditions across Central and Eastern Europe. Furthermore, the selected sites represent diverse land-use and management zones, ranging from natural protected national parks to peatlands located in the vicinity of intensive agricultural activities, allowing for a comparative analysis of anthropogenic and natural environmental impacts.

To establish a precise chronological framework for these diverse profiles, a dual radiometric dating approach was employed: Lead-210 (^{210}Pb) dating was used to determine the age of recent layers, while Radiocarbon (^{14}C) analysis was applied to older, deeper horizons. The vertical distribution of organic and inorganic fractions was determined using Loss on Ignition (LOI), which served as the fundamental proxy for calculating the total amount of sequestered carbon and estimating potential carbon loss over time. To further characterize the quality of the preserved organic matter and the degree of humification, UV-Vis spectroscopy was utilized to calculate specific humification indices.

A key component of the study involved the application of Fourier-Transform Infrared (FTIR) spectroscopy, which provided a refined molecular-level estimation of chemical structural changes within the peat matrix. This technique was utilized to quantify the aromatization index, carbohydrate loss, and carboxyl group content, offering a detailed view of the chemical stabilization of organic carbon. Furthermore, an oxidation index was calculated to differentiate between aerobic and anaerobic transformation pathways during the peat's developmental history. This multi-proxy approach provides a comprehensive insight into the efficiency of carbon sequestration and the specific environmental factors—such as latitude and land management—that influence organic matter stability across these European regions.

Microplastic archaeology in sediments: Reconstructing the history of plastic usage through ^{210}Pb-dated lacustrine profiles in three geologically distinct Romanian lakes

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This study investigates microplastic (MP) contamination in the sedimentary records of three limnologically distinct lakes in Romania: **Lake Pănăzii** (plain reservoir), **Lake Red (Gyilkos)** (natural dam lake), and **Lake Saint Anne** (volcanic crater lake). To focus on low-density polymers, MP particles were isolated using density separation in a saturated NaCl solution. The geochronology of the sediment cores was established using **^{210}Pb dating**, while polymer types were identified via **FTIR spectroscopy**.

This research represents the first study in Romania to establish a high-resolution chronological reconstruction of microplastic pollution within sedimentary archives.

The research adopts a **'plastic archaeology'** approach by analyzing the chemical evolution of particles through **polyethylene / polystyrene (PE/PS)** and **polyamide / polyethylene (PA/PE)** ratios, alongside the **Carbonyl Index** to assess degradation.

Our findings reveal a precise stratigraphic archive of the Plastic Age. While the upper layers reflect the recent surge in plastic usage—dominated by **polyethylene (PE)** and **polyethylene terephthalate (PET)**—the deeper strata, dated back to the **1940s**, contain early industrial markers such as **Bakelite** and synthetic fibers (Nylon). These results demonstrate that lake sediments serve as reliable environmental archives, documenting the historical transition from early synthetic innovations to the modern microplastic crisis.

Atmospheric and hydrological transport of radionuclides from an unrehabilitated uranium mine: A multi-matrix study in Băița-Plai, Romania

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This study investigates the environmental dispersion of radionuclides from the abandoned and non-rehabilitated Băița-Plai uranium mine in Romania. In the absence of proper ecological restoration, the site poses a continuous radiological risk through mine water discharge and the wind-driven resuspension of radioactive dust from tailings piles. To assess this impact, we analyzed a multi-matrix sample set including soil, surface water, well water, and epiphytic mosses as bioindicators for atmospheric deposition.

The methodology relied on high-resolution gamma spectrometry using a well-type HPGe detector. To ensure analytical precision, calibration for solid samples was performed using international standards (RGU, RGTh, and IAEA-312), while water samples were calibrated with a $Th(NO_3)_4$ solution. A key aspect of our research was the use of ^{210}Pb activity concentrations to determine the exposure time of the moss samples, with values corrected for radium fallout. This allowed for a precise comparison against a reference site located 200 km away.

Our results track the migration of ^{226}Ra into the local hydrological system and quantify the atmospheric transport of radioactive particles. The findings demonstrate how the lack of site remediation leads to the continuous spread of legacy mining waste into the surrounding environment, providing essential data for future radiological protection and site rehabilitation strategies.

Synthesis of chitosan-copper oxide nanocomposite surfaces for radionuclide adsorption

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The rapid development of nuclear technology and various industrial activities has led to the generation of wastewater containing long-lived and highly toxic radionuclides, posing severe threats to ecosystems and human health. Consequently, there is an urgent demand to develop eco-friendly, cost-effective, and easily separable adsorbents. While chitosan is a promising, sustainable biopolymer rich in amino and hydroxyl functional groups, its practical application in water treatment is often restricted by poor mechanical stability and significant phase-separation difficulties in complex aqueous media. To overcome these limitations, this study presents the fabrication of a novel macroscopic adsorbent by immobilizing a chitosan matrix modified with copper oxide (CuO) nanoparticles onto a solid macroscopic support. The synergistic integration of the biopolymer network and the inorganic metal oxide aims to significantly enhance structural integrity, radiation resistance, and adsorption affinity toward targeted radionuclides. This preliminary research evaluates the potential of this solid-supported eco-friendly nanocomposite to serve as a scalable, highly efficient, and sustainable platform for advanced radioactive wastewater remediation.

Science and progress in the context of modernist discourse in the Polish lands at the turn of the nineteenth and twentieth centuries

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The history of debates concerning the relationship between the natural sciences and theology has a long tradition in Western intellectual history. With the advent of the Enlightenment, religion and theology were increasingly marginalised as manifestations of backwardness and gradually excluded from the domain of science. In response, currents emerged within the Church aimed at renewal and adaptation to the profound transformations taking place in the modern world. In its struggle against the proponents of modernism, Pope Pius X issued the encyclical Pascendi Dominici Gregis in 1907, condemning modernists as enemies of the Church. This decision sparked several years of debate, including within the Polish context. A Polish advocate of modernism, the Capuchin Father Kajetan Wysłouch (Antoni Szech), argued that if the Church wished to emerge from stagnation, it needed to recognise the significance of the great advances in human thought and acknowledge that it was possible to be both a sincere Catholic and a supporter of progress. After leaving the Church, however, he described its teachings as Sisyphean labours, claiming that they were impossible for contemporary people to accept. Another cleric, Father Euzebiusz Stateczny, who concealed his modernist sympathies, proposed an integration of knowledge and faith whereby religion might find support in the achievements of biology and the exact sciences. Bishop Teodorowicz wrote: “If we wish to win over the modern individual to the Church, the faith of the Apostles must also be illumined by the aureole of science, in which the contemporary mind believes devoutly and unreservedly.” Idzi Radziszewski, in turn, observed: “Among the Church’s devoted adherents we find thousands of illustrious names that have rendered immense service to science. Impartial history teaches us that throughout the ages the Church has been a great patron of learning.” Shortly after the First World War, Bishop Pelczar expressed concern about the use of science as an instrument of destruction: “In the nineteenth and twentieth centuries, voices were increasingly raised calling for religion to be replaced by modern culture; yet that culture suffered a disgraceful bankruptcy in the recent war, for it did not restrain supposedly Christian nations from acts that were truly barbaric and inhuman, such as poisoning combatants with gas and bombing open cities.” This observation, which acknowledges the achievements of science while simultaneously recognising the threats it may pose to humanity, remains consistent with the position of the Catholic Church in the twenty-first century.

Nuclear or renewable energy?

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Electrification of the economies is getting momentum; the world's electricity demand is constantly growing [1]. This change coincides with new challenges facing us for political and environmental reasons, such as climate protection and the creation of a zero-emission economy. The need to cover the growing electricity demand from low-emission energy sources in a reliable, affordable, safe and, if possible, sustainable manner is becoming increasingly urgent. The currently available sources of such energy are renewables and nuclear energy. However, many green and civil society organizations, as well as some politicians, believe that the use of the two energy sources in one system is impossible, or at least hinders the development of each other. An extreme form of this view is green energy messianism, whose proponents claim that renewables will solve all our problems, and that there is no need for either fossil or nuclear energy.

In the presentation, an attempt was made to compare the properties of different energy sources, their integration into the system, and their economics. The results show that the artificial opposition between renewables and nuclear energy is unjustified, and that our energy strategy and climate policy goals could be successfully achieved by using them together.

The rapid technological development and growth of renewable energies – especially wind and solar – observed in the last two decades is likely to continue in the future. The further network penetration of weather-dependent (intermittent) renewables poses major challenges to system management, transmission and distribution networks, and electricity trading. At the current level of technological development, achieving 100% renewable energy production is not realistic – the technological conditions for this are not available, and it would not be economical. In order to ensure the security of energy supply, it is necessary to develop an electricity system where, in addition to renewables, we use reliable, affordable and emission-free energy technologies in the same system – nuclear energy is a real option for this. The responsible use of renewables will only be possible up to a specific and country-specific proportion (probably not even approaching 100%). In summary: Of course, renewables must be used, every opportunity must be seized to achieve emission-free energy production, but at the same time, recognizing the advantages of nuclear energy – mainly its climate neutrality and its ability to produce continuous, reliable electricity (line power) – we must strive for the widest possible application of this technology.

Potential of Castanea sativa Mill. catkins and leaves extracts for natural-based sunscreen formulation: Antioxidant and photoprotective activities

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Sunscreens contain chemical (organic) or physical (inorganic) compounds that act to block UV radiation. However, the efficacy and safety of conventional sunscreen formulations have raised concerns due to the potential adverse effects of synthetic ingredients. In light of these challenges, there is a growing interest in exploring alternative natural ingredients with enhanced photoprotective properties. One such promising candidate is Castanea sativa Mill., commonly known as European or sweet chestnut, which offers a valuable composition of bioactive compounds. In addition to vitamins and minerals, chestnuts are rich in polyphenols, flavonoids, and tannins. These compounds contribute to antioxidant, anti-inflammatory, and antimicrobial properties, making chestnuts beneficial for preventing numerous chronic diseases. Notably, the processing of this globally important commercial nut generates substantial amounts of residues, such as shoots, shells, and leaves. Typically discarded, these residues actually represent a promising source of biologically active compounds. Against this background, we aimed to analyse the antioxidant and photoprotective activity of chestnut catkins and leaves extracts obtained using 50% acetone.

The catkins and leaves of traditional sweet chestnut and the Italian Marrone cultivar were collected, allowed to dry at room temperature, and then ground into a powder. The plant material was extracted using 50% acetone as a solvent. Specifically, 10.0 g of the sample was mixed with 100 mL of 50% acetone (sample to solvent ratio 1:10; w/v). The liquid extract was obtained by filtration, followed by ultrasound-assisted extraction for 30 minutes. Finally, the solvent was completely removed by evaporation under vacuum at 40°C, yielding a dry extract. The yield of the dry extract was then calculated.

Total phenolic content (TPC) of extracts was measured by the Folin–Ciocalteu reagent method, while total flavonoid content (TFC) was measured by an aluminium chloride colorimetric method. The antioxidant activity of extracts was determined using two spectrophotometric methods: DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2′-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid)) assays. The Sun Protection Factor (SPF) calculation of the sample was done using the Mansur method.

The ultrasound-assisted extraction with 50% acetone provides efficient extraction of phenolic compounds. The extract of chestnut catkins exhibited the highest total antioxidant activity, with a DPPH radical scavenging IC50 value of 20.12 ± 0.19 μg/mL, and an IC50 value of 51.88 ± 0.28 μg/mL for ABTS activity. The same extract also showed the highest TPC of 454.10 ± 0.92 mg gallic acid equivalent (GAE)/g dry extract, TFC of 98.10 ± 1.54 mg catechin equivalent (CE)/g dry extract, and SPF at 0.20 mg/mL of 21.41 ± 0.06. The IC50 values of extracts, determined by DPPH and ABTS assays, were lower than 0.10 mg/mL. The light-protecting activity of C. sativa Mill. dry extracts, whose SPF at a concentration of 0.20 mg/mL varies between 16.01 ± 0.10 (catkins of Italian Marrone) and 23.98 ± 0.20 (leaves of Italian Marrone), suggest their possible further applications as natural UV photoprotectors. TFC in the extract of catkins and leaves of Italian Marrone were 78.03 ± 0.47 mg CE/g and 70.53 ± 0.55 mg CE/g, respectively. Natural flavonoids provide plant-based photoprotection by absorbing ultraviolet (UV) radiation and scavenging free radicals, acting as both chemical filters and antioxidants. Observed amounts of flavonoids are sufficient for significant antioxidant and photoprotective activity of extracts of catkins and leaves of traditional chestnut and Italian Marrone cultivar. They are a very promising source of natural sunscreen compounds.

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Energy loss in a moving viscoelastic functionally graded component with a lengthwise crack in it

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One of the main characteristics of functionally graded composite materials is the continuous change of their material properties in certain directions in the structural component. The very concept of functionally graded materials offers excellent opportunities for designing the distribution of material properties in order to satisfy certain requirements in terms of strength, stiffness, temperature resistance, wear resistance and others in certain parts of the structural component. All this makes functionally graded materials indispensable in engineering applications, where structural components are subjected to dynamic loads, temperature fields and chemical effects. The phenomenon of energy loss is characteristic of materials with viscoelastic behavior. In this article, the energy loss in a viscoelastic functionally graded component with a lengthwise crack in it is studied. The component performs mechanical movement according to a known law. The resulting solution for the energy loss is based on an analysis of the behavior of the moving structural component under the action of the inertial load, taking into account the viscoelastic properties of the functionally graded material. The total energy loss is obtained by summing the energy loss in both arms of the lengthwise crack and in the intact part of the structural component. An approach known from the literature is applied to verify the solution. The effect of various parameters of the moving structural component, the lengthwise crack and the material gradient on the energy loss is evaluated.

Delamination analysis of a multilayered structure with two rigidly joined members under bending and torsional shock load

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Multilayer structural materials are very popular among engineers working in various fields of modern technology. The explanation for this phenomenon should be sought in their good material properties, which significantly exceed those of classical homogeneous structural materials. A natural disadvantage of multilayer materials is their relatively low resistance to delamination. This is the reason for the more limited use of these materials, especially in load-bearing structures with more members. This article studies delamination in a multilayer structure formed by two rigidly connected members. The structure is under a bending and torsional shock load resulting from a body falling on it. Part of the structure is delaminated. The strain energy release rate (SERR) in the structure under shock loading conditions is determined. A check is made using formulas from the research literature. An analysis is carried out to establish the dependence of SERR on a number of parameters of the structure and on the bending and torsional shock load. Graphs are presented illustrating the characteristic features of the delamination behavior of the structure.

Influence of torsional shock on the longitudinal fracture of a functionally graded rod fixed by a spiral spring to a rotating structural system

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The very good properties of functionally graded engineering materials are an important prerequisite for their intensive use in more and more areas of modern technology. The wide application of these relatively new materials in mechanical engineering, aircraft engineering and instrument making leads to the need to study the various forms of destruction of moving functionally graded structural components. The present article studies the issue of the influence of a torsional shock on the longitudinal fracture of a functionally graded rod attached with a spiral spring to a structural system performing rotational movement. Additionally, there is a cylindrical disk at the left end of the rod. Torsional shock is generated when the rotation of the system is abruptly stopped. In fact, the inertial forces that appear during the abrupt stop in the cylindrical disk load the rod in shock torque. There is a longitudinal circular cylindrical crack in the rod. A solution for the strain energy release rate (SERR) in the rod under torsional shock is obtained. The obtained solution is verified using formulas from the scientific literature. The influence of the spiral spring, as well as the geometric and material parameters of the system on the longitudinal fracture, is investigated.

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