BOOK OF ABSTRACTS

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IN PHYSICS, CHEMISTRY, BIOLOGY, MEDICAL SCIENCES, ENGINEERING AND ENVIRONMENTAL SCIENCES

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INVITED TALKS

CONFERENCE ABSTRACTS

Radiometric time series – why, what for, how. Plus, some examples

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Generation of time series of environmental quantities is a tool to explore the dynamic nature of the physical phenomenon that manifests in these quantities. In the radiometric context, this includes investigation of the notoriously complicated dynamic of radon in various environmental media, of ambient dose rate or following radiologically relevant events such as the passage of contaminated clouds and fallout after the Chernobyl and Fukushima accidents. The objectives are detection, quantification and classification of "signals" contained in the series, or the "volume" of an event that has caused the signal. The former is typical for tracer studies and studies intended to understand the physical nature of a process, the latter for quantifying radiological impact. Importantly, also the observation process, i.e., measuring, induces variability that has to be accounted for.

More often than not the phenomena or processes to be assessed are variable in time and space. One is interested in both – the temporal aspect to assess its evolution and the spatial one for mapping or to assess the regionally different evolution. Sometimes surveys are performed with moving monitors which entails the additional task to disentangle the two variability components. For example, in surveys of ambient dose rate by moving G-M monitors one has to consider that the dose rate changes with fluctuation of cosmic radiation or ambient radon concentration that in turn are subject to temporal changes.

Methodologies for assessing spatial and temporal variability are different. Here we are interested in the temporal aspect in the first place. If the task consists in identifying signals and understanding the epistemic chain from their generators over their propagation in the environment to the observation process, the task consists in decomposing the series. Components may be a constant or stationary background, a trend, periodic and aperiodic fluctuation in different time scales, instrumental noise and statistical noise due to the stochastic nature of a process. Mathematical procedures are available to separate the components, such as low/high pass filtering, Fourier, autocorrelation and Hurst analyses. Phase space exploration can serve to investigate the complexity of a process; chaotic analysis can indicate its predictability. Some examples derived from radon time series are shown. Also examples of observational variability are given.

As examples of studies that consider spatio-temporal effects, we address ground-borne surveys of ambient dose rate, geographical transects of outdoor radon concentration (now possible with simple, easily transportable radon monitors) and ambient dose rate measurements after Chernobyl and Fukushima. A novel project targeting possible differences of the radon dynamic in different climatic zones (temperate, Mediterranean, tropical) is currently in its initial stage.

Keywords: time series, statistical analysis, radon, ambient dose rate

Radioactivity in the Environment in the Republic of Serbia – 40 years after Chernobyl, 15 years after Fukushima

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Beside the natural sources of radiation present throughout the environment, human activities, nuclear weapons testing and major nuclear accidents such as those occurred at Chernobyl in 1986 and Fukushima in 2011, have introduced additional radioactive materials into the environment and increased environmental radiation levels, traces of which can still be detected today.

Radioactive substances released into the atmosphere during the Chernobyl accident were widely dispersed and mostly settled across the land areas of Europe. In contrast, about 80% of the atmospheric releases from the Fukushima Daiichi nuclear disaster spread over and were deposited in the Pacific Ocean. As a result, the impact on human populations, in terms of radiation exposure and health effects, was significantly lower than in cases where contamination occurs over land (*UNSCEAR 2020/2021 Report*).

This paper presents an overview and assessment of radioactivity in environment in the Republic of Serbia, four decades after the Chernobyl nuclear accident and fifteen years after Fukushima Daiichi nuclear disaster. The study examines long-term trends in radionuclide activity concentrations in key environmental compartments including air, soil, water, and food products. Particular attention is given to the persistence of artificial radionuclides especially ^{137}Cs, which remains the dominant anthropogenic contributor in radioactivity. In addition to ^{137}Cs, nuclear accidents release other artificial radionuclides in atmosphere. One of the particular biological importance is ^{90}Sr. It is mainly taken into the human body through ingestion especially via milk and dairy products. Due to its chemical similarity to calcium, ^{90}Sr tends to accumulate in bones, where its concentration in the human body is the highest. Tritium (^{3}H) is also an important radionuclide released during nuclear accidents. It is typically found in the form of tritiated water (HTO), which easily mixes with natural water and can enter the human body through drinking water, food, and inhalation.

Monitoring data collected over several decades indicate decline in radioactive concentrations due to radioactive decay and environmental processes such as migration dilution and fixation in soil layers. Current activity levels are generally within regulatory limits and do not pose a significant risk to human health or the environment. Radioactivity monitoring in the Republic of Serbia is regulated, among other regulations, by the Rulebook on the Establishment of a Programme for Systematic Environmental Radioactivity Assessment (*Official Gazette of RS, No. 100/2010*).

Results of radioactivity monitoring in the Republic of Serbia were previously presented in the monograph *Chernobyl – 30 Years After, 2016* (https://dzz.org.rs). Here, we provide updated findings after forty years of continuous monitoring, including the impacts of the Chernobyl accident and the Fukushima Daiichi nuclear disaster. These data highlight the importance of ongoing environmental surveillance and provide an overview of artificial radioactivity trends over four decades.

Keywords: radioactivity monitoring, environment, Chernobyl, Fukushima, artificial radionuclides

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Metal-ligand coordination and microbial management: From radioprotection of the microbiome to PET imaging of MDR infections

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The interaction between ionizing radiation and the human microbiota presents a dual challenge in modern oncology. While radiotherapy is a primary treatment modality, it frequently induces systemic dysbiosis, compromising patient health. Concurrently, the rise of multidrug-resistant (MDR) bacterial infections in immunocompromised patients necessitates faster, high-precision diagnostic tools. This work explores the pivotal role of metal-complexed small molecules, metabolites and metallophores, in both protecting commensal bacteria and detecting pathogenic threats. The work presented herein is the result of a multidisciplinary study from two projects, integrating coordination chemistry, microbiology, and molecular imaging.

On TrypGut we intended to address the radioprotective potential of the tryptophan metabolite 8-hydroxyquinoline-2-carboxylic acid (8-HQA) and its metal complexes. Inactivation kinetics were performed on individual and co-cultured human microbiota isolates (e.g., *Actinomyces viscosus*) exposed to ionizing radiation. Preliminary results demonstrate a significant radioprotective effect of the Ga^{3+}/8-HQA complex on A. *viscosus*, with evidence of a symbiotic survival advantage in oral co-culture models compared to individual assays. This suggests that specific metabolites can preserve the structural integrity of the microbiome during radiotherapy.

Parallelly, on SuperOpTyMe project our focus is the synthesis and chemical speciation of radiolabeled opine-type metallophores (OpTyMe) designed to exploit bacterial metal-uptake pathways for selective PET imaging of MDR infections.

By leveraging the chemical properties of metal-ligand complexes, we can transition toward a "theranostic" microbial strategy. While 8-HQA-based complexes offer a path to mitigating radiotherapy-induced dysbiosis, optimized OpTyMe probes provide the precision required to identify and monitor resistant infections.

Acknowledgments: The authors would like to thank the financial support from the National Science Centre (NCN), Poland, under the scope of the research project number 2020/39/B/ST4/03060, and the Portuguese funding agency, FCT – Fundação para a Ciência e a Tecnologia, and by the European Regional Development Fund (FEDER, "Regional Program of Lisbon") through the project LISBOA2030-FEDER-00786200. https://doi.org/10.54499/2023.16636.ICDT.

Sub-cellular delivery of auger electron emitters for improved radiotheranostics of prostate cancer

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In the past few years, theranostic radiopharmaceuticals targeting the Prostate-Specific Membrane Antigen (PSMA) opened new avenues for the treatment and management of prostate cancer (PCa). In particular, a variety of PSMA inhibitors were labelled with different imaging and therapeutic radionuclides, leading to the development of the β^- emitting ^{177}Lu-PSMA-617 (Pluvicto), approved by the FDA and EMA for targeted radionuclide therapy of PSMA-positive metastatic castration-resistant PCa (mCRPC). More recently, ^{161}Tb started to be considered a promising therapeutic radionuclide and an attractive alternative to ^{177}Lu. ^{161}Tb is a β^- emitter but also emits conversion electrons and Auger electrons (AE) and thus is expected to allow a combined beta and AE therapy with improved therapeutic index, particularly for disseminated cancer disease. AEs show a high linear energy transfer over a nanometric range. Thus, the specific targeting of highly radiosensitive organelles in tumoral cells, like the nucleus or the mitochondria, might enhance the therapeutic effects of AEs at lower administered doses, while minimizing undesirable side effects. Having this in mind, we have embarked on the study of dual-targeted ^{161}Tb-radiocomplexes, carrying a PSMA derivative and acridine orange (AO) or triphenyl phosphonium (TPP) groups to promote selective uptake by PCa cells and accumulation in the nucleus or mitochondria, respectively. The study was also extended to congener complexes with the AE emitter ^{111}In.

In this communication, we describe the preclinical evaluation of the above mentioned dual-targeted radiocomplexes in cellular and animal models of PCa, aiming to assess their interest as PCa radiotheranostics. These dual-targeted radiocomplexes were obtained with DOTA-based chelators carrying PSMA and AO and TPP derivatives. Their *in vitro* biological evaluation included cellular uptake, internalization and PSMA-blocking studies in PSMA-positive PC3 PIP and PSMA-negative PC3 FLU cells, nuclear and mitochondrial uptake studies, and assessment of radiobiological effects (e.g., clonogenic survival and gamma-H2AX assays). μSPECT/CT imaging studies in mice with PSMA-positive PCa xenografts were also performed for selected ^{161}Tb- and ^{111}In-complexes. The designed dual-targeted ^{161}Tb- and ^{111}In-radiocomplexes had a favourable biological performance, showing high and specific cellular uptake and internalization in PSMA-positive PCa cell lines, and higher radiotoxicity than the corresponding single target complexes ^{161}Tb- and ^{111}In-PSMA-617. Our results highlight the potential of the devised dual-targeted strategy to optimize the biological performance of radiotheranostics for Auger therapy of cancer.

Self-absorption of low energy gamma rays in various sizes and densities in neutron activation analysis

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Self-absorption of gamma rays in large size samples is very well known especially for environmental radioactivity measurements needing 100 or more grams. There have been a multitude of analytical methods used to correct for this physics phenomenon. In neutron activation analysis (NAA) which samples sizes may be only 0.2 – 3 grams self-absorption of gamma rays in routine analysis is usually neglected. In the recent past, our group has focused on rare earth elements in phosphates using photons between 69 keV – 103 keV. These NAA reactions include the following: $^{102}Sm(n,\gamma)^{103}Sm$ [69.2 keV and 103 keV); $^{165}Ho(n,\gamma)^{166}Ho$ [80 keV]; $^{169}Tm(n,\gamma)^{170}Tm$ [84 keV]; $^{146}Nd(n,\gamma)^{147}Nd$ [91 keV] and $^{164}Dy(n,\gamma)^{165}Dy$ [96 keV]. We have constructed with additive manufacturing several sizes of typical NAA irradiation/counting vials and performed these gamma-ray self-absorption experiments. A detailed presentation of the results will be given.

Keywords: self-absorption of gamma rays, neutron activation analysis

Angular dependence of a hybrid dosimeter for individual monitoring according to IEC 61526:2024

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Technological advancements in the design of radiation protection instruments are, among others, aimed towards constructing dosimeters suitable for various applications of ionizing radiation. Such devices should exhibit a flat energy response, minimal dependence on the applied dose (rate), and limited variation of response due to varying angle of incidence. State-of-the-art technologies include hybrid dosimeters, which incorporate the properties of both active and passive dosimetry systems, providing the end-users benefits of on-demand personal dose reporting. However, comprehensive performance evaluation in a broad range of radiation conditions is required prior to their widespread implementation. Therefore, in this research the performance characteristics of a novel hybrid dosimeter were evaluated in terms of its angular dependence, according to the IEC 61526:2024 standard. Dosimeter response was examined in the N-60 radiation quality (47.9 keV mean photon energy), established according to the ISO 4037-1:2019 standard, for a wide range of angles of incidence, spanning from 0° to ±75°. Although these irradiation conditions exceed the standard defined minimum rated range, they present unfavorable irradiation conditions, which can be encountered in real workplace exposure scenarios. Therefore, it is expected that the performance of dosimeters would significantly deteriorate under such conditions. Despite that, the hybrid dosimeter exhibited a stable response, across the entire evaluated range, in line with the standard stated limits of variation (-29%; +67%). The presented findings indicate that the dosimeter is suitable for use even in radiation fields of low energy and high angles of incidence, characteristic for interventional radiology procedures.

Keywords: individual monitoring, hybrid dosimeter, angular dependence, radiation protection

Acknowledgments: The research was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia under the contract 451-03-33/2026-03/200017.

A comparative analysis of methods for measurement uncertainty evaluation in soil gamma spectrometry in accordance with ISO 18589-3

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The accurate evaluation of measurement uncertainty (MU) is crucial for the reliable interpretation of results in environmental gamma spectrometry. The implementation of the new ISO 18589-3 standard necessitates a critical reassessment of existing measurement uncertainty evaluation practices. This study presents a comparative analysis of three distinct approaches to MU estimation, applied to a soil sample with typical radionuclide content, measured using an HPGe detector and processed with GammaVision software.

The analyzed approaches are:

Software-Based Approach. Relies directly on the output from GammaVision software, where uncertainties are derived from counting statistics, efficiency calibration, and library data, but does not explicitly account for laboratory-specific effects such as self-absorption or coincidence summing.

Conservative Laboratory Budget. Represents a previously established, conservative methodology where efficiency uncertainty was estimated based on the maximum deviation of calibration curves obtained from certified reference materials, while additional contributions were introduced based on practical experience.

Refined Approach (ISO-Compliant). Introduces a methodology aligned with ISO 18589-3 recommendations. Efficiency uncertainty is treated as energy-dependent, and the potential influence of self-absorption and coincidence summing, based on literature, is reflected through corresponding contributions to the uncertainty budget; activity is determined by combining multiple gamma lines through inverse-variance weighting for enhanced statistical robustness.

Although all three methods yielded statistically comparable activity results, the refined approach offers a more transparent and physically grounded uncertainty model, reducing unnecessary conservatism while preserving metrological reliability. The findings strongly support the adoption of structured, standards-aligned approaches to measurement uncertainty evaluation in routine environmental measurements.

Keywords: gamma spectrometry, soil, measurement uncertainty, ISO 18589-3, HPGe detector, uncertainty budget, environmental radioactivity

Dosimetric accuracy of reference cylindrical ionization chamber in radioprotection field

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The implementation of a new reference ionization chamber in a secondary standards dosimetry laboratory is a rigorous process designed to ensure traceability to international measurement standards and maintain high-accuracy calibration services. The process includes the stability tests, checking leakage current, determining ion recombination factors and polarity effects. The vented cylindrical chamber of 30 cm^3 has been designed as a reference chamber for absolute dosimetry in calibration services by providing an accuracy in dose measurements for public and occupational safety.

This work will present the dosimetric accuracy performance of the new ionisation chamber PTW 23361 implemented as reference dosimeter in radioprotection field at calibration laboratory in Institute of Applied Nuclear Physics, Albania.

Keywords: secondary standard laboratory, ion chamber, reference fields

Acknowledgments: The authors are acknowledged to National Agency for Scientific Research and Innovation in Albania for financial support providing the ionization chamber.

Methods for measuring neutron contamination in proton and ion beam radiotherapy

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Secondary neutron contamination from particle radiotherapy contributes to out-of-field doses and radiation risks. Carbon-ion beam therapy generates high-energy neutron spectra via nuclear fragmentation, unlike the extensively studied proton therapy. This study evaluated methods for measuring secondary neutron contamination in proton and ion-beam radiotherapy, emphasizing the performance of the detectors. This review of neutron measurement techniques focuses on detector systems in clinical and research settings, which are categorized into spectral, dosimetric, and microdosimetric approaches. The performance of each detector type, including energy response, sensitivity, photon discrimination, and operational practicality, was evaluated in mixed radiation fields of particle therapy. The assessed detectors included Bonner sphere spectrometers (BSS), neutron rem meters, bubble detectors, CR-39 nuclear track detectors, activation foils, and tissue-equivalent proportional counters (TEPCs). No single detector comprehensively characterizes the neutron energy spectrum in proton and ion beam therapies. Bonner Sphere Spectrometers provide detailed spectral information but are complex and slow. Neutron rem-meters are suitable for radiation protection surveys but respond differently in high-energy fields. Passive detectors, such as bubble detectors and CR-39, offer photon-insensitive measurements, whereas activation foils enable energy-selective validations. Tissue-equivalent proportional counters provide microdosimetric insights relevant to the radiation quality and biological effectiveness in ion beam therapy. The measurement of secondary neutron contamination in particle therapy requires multiple detectors and complementary techniques. Detector selection should be based on the application, such as shielding design, patient dosimetry, or radiobiological assessment. The growth of ion beam therapy has highlighted the need for better neutron detection systems and standardized protocols.

Keywords: proton therapy, carbon ion therapy, secondary neutrons, neutron dosimetry, bonner sphere spectrometer, TEPC

Optimization of neutron activation analysis of rare-earth elements

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A weighting factor was constructed based on seven characteristics of the properties of the lanthanides: thermal cross section, resonance integral, natural abundance of the element itself, half-life of the activation product, the branching ratio, the Igamma (relative) value, and relative detector efficiency of the photon spanning from 80 keV – 1596 keV. The seven individual characteristics were then added together and divided by the total possible value to get their total weighting factor. In addition, the application of gamma-gamma coincidence and Compton suppression was also evaluated to determine which radionuclides may be better determined.

Keywords: rare earth elements, neutron activation analysis

The effects of the ICRU 95 quantities for whole body exposure on active dosimeter performance

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The International Commissions on Radiation Units and Measurements (ICRU) and on Radiological Protection (ICRP) introduced a set of new operational quantities for radiation protection in their joint report ICRU 95. One aim of the newly proposed quantities is to reduce the overestimation of dose, which is observed with current operational quantities and is particularly prominent in the low photon energy range relevant to diagnostic radiology applications. The transition to these operational quantities is expected to have a major impact on dosimeter and instrumentation design, and subsequently on dosimeter response. Therefore, the effect of new conversion coefficients on active area and personal dosimeter performance was evaluated in this research. Dosimeter performance data obtained in the scope of the 22NRM07 Joint Research Project GuideRadPROS was used to recalculate dosimeter relative response with respect to the newly proposed conversion coefficients, h_k (Behrens and Otto, J. Radiol. Prot., 2022. 42(011519)). Dosimeter response was assessed in a broad photon energy range, exceeding both the minimum rated range stated in commonly used standards, as well as manufacturer stated specifications. The energy dependence test was performed in the reference N-series radiation qualities, from N-40 to N-200, and in Cs-137 and Co-60 radionuclide radiation fields established according to ISO 4037:2019. The relative energy response curve was determined by normalizing the response value at a specific energy to the reference value obtained for S–Cs. The obtained relative responses were evaluated using the limits of variation for the energy dependence test (-29 %, +67 %) specified in the IEC 60846-1:2009 and the IEC 61526:2024 standard. The results demonstrate the influence of the new conversion coefficients on dosimeter relative response, particularly in the low-energy photon range, and allow assessment of compliance of existing instrumentation with the IEC performance criteria within the revised framework.

Keywords: new operational quantities, active area dosimeter, active personal dosimeter, type testing, energy dependence

Acknowledgments: The project (22NRM07 GuideRadPROS) has received funding from the European Partnership on Metrology, co-financed by the European Union's Horizon Europe Research and Innovation Programme and by the Participating States. Funded by the European Union. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or EURAMET. Neither the European Union nor the granting authority can be held responsible for them. The research was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia under the contract 451-03-33/2026-03/200017.

Three-dimensional localization of radiation sources and estimation of radioactivity using a teleoperated robot equipped with a directional gamma ray sensor during motion-based data acquisition

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In decommissioning sites of nuclear facilities, including the Fukushima Daiichi Nuclear Power Station, accurately measuring the locations and spatial distribution of radiation sources is crucial. Such data are essential for reducing worker exposure and for planning operational tasks. By carrying out these measurements remotely using robots instead of human workers, it goes without saying that worker radiation exposure can be reduced, and it also holds the potential to further shorten the duration of the work.

To address this need, we are developing a method that generates three-dimensional maps visualizing the locations of radiation sources, using a teleoperated robot (Robotis Co., Ltd., TurtleBot3 Waffle Pi) equipped with a directional gamma-ray sensor and a laser range finder. The radiation sensor employs a BGO scintillator combined with lead pixels arranged in a specific pattern to provide directional sensitivity to gamma rays. The method also estimates the radioactivity of the visualized radiation sources.

The localization of radiation sources and the estimation of their radioactivity are performed using a response function of the radiation sensor that has been pre-derived through Monte Carlo simulations. More specifically, the response function describes how each BGO sensor element responds, in terms of count rate, when gamma rays enter the detector from a given incident angle.

The robot moves while performing self-localization based on the laser range finder, and gamma-ray responses are measured at multiple positions. Using the pre-derived response function, we perform an inverse estimation to determine the radiation source locations and their radioactivity levels that best reproduce the measured data obtained at these multiple positions. This inverse estimation is carried out using the ML-EM algorithm. The visualized source positions and the estimated radioactivity levels are displayed on a three-dimensional map of the work area acquired with a laser range finder. We will present the proof-of-principle results obtained by measuring a ^{137}Cs test radiation source in the laboratory using the developed gamma-ray imaging system at RAP2026.

Keywords: directional gamma-ray sensor, source localization, radioactivity estimation, teleoperated robot, nuclear decommissioning

Acknowledgments: We would like to express our sincere gratitude to the engineers at CLEAR-PULSE CO., LTD. for their support in the fabrication of the radiation sensor used in this study.

The development of an on-line gaseous radioactive xenon monitoring system for nuclear facilities

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Nowadays, radioactive xenon ^{131m}Xe, ^{133m}Xe, ^{133}Xe and ^{135}Xe isotopes in the atmospheric environment mainly come from the operation of various reactors and the leakage of major accidents of reactors. In order to improve the online monitoring capability of xenon in nuclear facilities, a highly sensitive xenon online monitoring system was developed for monitoring, warning, and alarming the activity concentration of radioactive xenon in nuclear facility sites and gaseous effluents. The on-line monitoring system for radioactive xenon in nuclear facilities was established based on xenon membrane separation and concentration technology, xenon high efficiency selective adsorption technology and low background gamma ray spectrometry analysis method. Under the operation mode of one hour sampling and one hour measuring, the minimum detectable activity concentration of the on-line monitoring system for radioactive xenon was about 1.5 Bq/m^3. This system can be effectively used for online monitoring of xenon activity concentration in nuclear facilities such as nuclear power plants and isotope production reactors, as well as in gaseous effluents, which could be conducive to improve the safety level of personnel, environment and nuclear facilities.

Keywords: membrane separation, selective adsorption, low background measurement, xenon on-line monitoring

An FPGA-based digital twin for sustainable modernization of radiation portal monitors

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The reliable operation of Radiation Portal Monitors (RPMs) is critical for a country's nuclear security architecture. This work, conducted under IAEA CRP J02015, addresses the dual challenges of maintaining aging RPM infrastructure and developing robust anomaly detection algorithms. For example, in Albania, nuclear security infrastructure includes several aging RPMs, some deployed for more than 20 years at major border crossing points. We performed field inspections, laboratory diagnostics, and in-situ performance testing on these systems to identify failure modes and pursue cost-effective restoration. Root-cause analysis revealed that systemic factors—including rising maintenance costs, dependence on obsolete proprietary components, gaps in operator nuclear security culture, and environmental stress—had degraded system operation.

This paper presents a comprehensive failure analysis of these old RPM systems, identifying common failure modes in analog front-ends, data acquisition hardware, and processing units. In response, we propose and demonstrate a novel, sustainable modernization path centered on Field-Programmable Gate Array (FPGA) technology. The core of our methodology is a high-fidelity digital twin of the RPM's detection system, implemented in VHDL, which accurately replicates the analog pulse response of plastic scintillators. We detail an FPGA-centric architecture that leverages this digital twin not only for development and testing but also for ongoing system diagnostics and predictive maintenance. This approach replaces multiple proprietary, obsolete subsystems with a single vendor-free digital core, enhancing system reliability, scalability, and repairability while mitigating supply chain vulnerabilities.

Our work concludes that an FPGA-based digital twin strategy offers a technically superior and economically viable solution for extending the operational lifespan of aging RPM networks. This blueprint provides a sustainable path for modernizing detection infrastructure. Furthermore, it serves as a vital testbed for developing and validating the advanced anomaly detection algorithms central to the coordinated research program.

Keywords: Radiation Portal Monitor (RPM), FPGA, digital twin, nuclear security, aging infrastructure, sustainable maintenance, VHDL, modernization

Acknowledgments: The authors would like to thank the International Atomic Energy Agency for supporting this work through Coordinated Research Projects CRPJ02014 and CRPJ02015. They also gratefully acknowledge the Albanian General Directorate of Customs for their continued cooperation.

Evaluation of the response and the resistance of the RaSens IoT based radiation measuring board to high levels of radiation

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The methodology of radiation surveillance has been transitioning from a manual, high-risk endeavor to a sophisticated, data-driven discipline. The current trend is to move beyond static, ground-based measurements, carried out by human personnel, toward a dynamic, autonomous Internet of Things (IoT) framework. This shift represents a fundamental evolution of the Unmanned Aerial Vehicles (UAV) from its military origins into intelligent practical solutions within a collaborative IoT ecosystem. By combining UAVs with IoT technologies, multi-level monitoring systems can be developed to mitigate human exposure while enabling access to hazardous environments previously deemed unreachable. The STU team has responded to this transition by developing the RaSens IoT based radiation monitoring device as part of the STU-GUARD and STU-RMS projects. The RaSens modules are designed for measurements from an UAV as well as for deployment via UAV to radiation-affected areas as independent nodes, providing real-time monitoring, mapping the airborne radioactivity, and forming a network of nodes sharing measured data and performing independent assessments. Tha RaSens modules utilize one ore more GM detectors, which are calibrated by the manufacturer, but need to be verified for the target application. In this paper we are presenting the results of two specific measurements conducted in cooperation with the Slovak Institute of Metrology and the Research Centre Řež in Czechia. In these measurements we evaluated the response of the RaSenS modules to gamma radiation ranging from natural background up to 10 Sv/h and the resistance to radiation damage caused by X-rays and gamma radiation as well as fast neutrons.

Keywords: RaSens, radiation detection, IoT, modular measurement nodes, environmental monitoring

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The impact of field size on air kerma measurements in mammography

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Quality control (QC) test procedures in mammography consider the determination of different X-ray tube parameters such as air kerma, tube voltage, and half-value layer (HVL). Ionization chambers (ICs) and X-ray multimeters (XMMs) are used for QC measurements. ICs are used, historically, for air kerma and HVL measurements. These parameters can also be measured directly with XMMs. In mammography, mean glandular dose (MGD) is a risk-related quantity calculated as the product of air kerma and HVL dependent conversion coefficients. When air kerma is measured with an IC, there might be a contribution of backscattered radiation from the image detector since ICs are usually more sensitive to radiation from all directions compared to XMMs. XMMs are less sensitive to radiation scattered from the sides and the back due to their construction and geometry (e.g., collimation and shielding). Backscattering conditions can be harmonized by covering the image detector with a copper plate which is often used to protect the image detector. Besides the backscattered radiation, the scattering contribution to air kerma may originate from the forward scatter from the compression paddle (CP) which is an essential part of the mammography unit and typically measurements are performed when the compression paddle is in the primary beam. The forward scatter is dependent on exposure geometry (field size and distance).

QC mammography protocols provide guidelines for air kerma measurements with no specific requirements regarding the field size except that the radiation field should completely cover the active volume of the detector. Mammography field sizes are typically predefined however, in clinical measurements sometimes an additional collimator is placed in the primary beam to achieve the narrow beam geometry necessary for the HVL measurements. The impact of field size on measured air kerma was studied for one IC and three XMMs. Measurements were done in an open field (18 cm x 24 cm at the plane of the image receptor) without additional collimator in the beam and the smallest achievable field (5 cm x 5 cm at the reference plane of the dosimeter).

Most of the dosimeters showed an increased air kerma value of 2 to 4 % for the open field compared to the narrow field setup. When the CP was not in the beam, the impact of field size was less pronounced.

Keywords: field size, air kerma, mammography

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Assessment of X-ray multimeter performance for measuring half-value layer, total filtration and tube voltage

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Dosimeters which are based on solid-state detectors incorporated in X-ray multimeters (XMMs), are commonly used in diagnostic radiology quality control tests. These devices are designed to measure several relevant quantities and parameters of X-ray beams, such as the X-ray tube output in terms of air kerma (rate), X-ray tube voltage, half-value layer (HVL), total filtration (TF) and exposure time. Assessment of XMM performance was undertaken according to standards published by the International Electrotechnical Commission (IEC). IEC 61674:2024 and IEC 61676:2023 standards provide test methods and define the criteria of acceptability for the measurement of air kerma and practical peak voltage. These standards apply to the X-ray multimeters since they can measure air kerma and X-ray tube voltage non-invasively. In the case of other quantities and parameters measured by XMMs there is no current standard which provides limits of variation and minimum rated ranges for the relevant influence quantities. In this study, the performance of several XMMs for measuring HVL, TF and maximum peak voltage ($kV_{p,max}$) in terms of their variation in response to the change in photon energy, angle of incidence and air kerma rate was examined. These results are a part of a larger study within the TraMeXI project with the aim of proposing the limits of variation for different influence quantities as a potential input for future standardization.

Keywords: diagnostic radiology, X-ray multimeter, solid-state detector, half-value layer, total filtration, X-ray tube voltage

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Field of capture gamma radiation with energy up to 10 MeV for metrological support of spectrometry and dosimetry instruments

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The use of dosimeters calibrated in reference fields with corresponding energies for correct estimation of dose loads for personnel working in high-energy gamma-radiation fields with energies above 3 MeV is required. The creation of reference fields with gamma-radiation energies up to 7 MeV is essential for photon radiation dosimetry at nuclear power plants, where a significant gross dose rate component is stipulated by the radiation with an energy of 6.13 MeV associated with the $^{16}O(n, p)^{16}N$ reaction in the water cooling loop. Apart from nuclear power plants, such tasks occur on electron accelerators, widely used for therapeutic, industrial and other purposes.

The state verification schedule stipulates the use of ^{241}Am (0.06 MeV), ^{137}Cs (0.662 MeV) and ^{60}Co (1.250 MeV) radionuclides for reference dosimetry measurements of gamma radiation in the range from 0.06 to 3 MeV. No standard calibration and verification is performed for nuclear physics equipment in bremsstrahlung with an energy above 3 MeV generated by accelerators. Dosimeters calibrated in the radionuclide sources fields may not measure the dose rate from high-energy gamma radiation correctly. At the same time, there is a nomenclature list of instruments with various detector types, where the energy range has to be expanded to 7 MeV or 10 MeV following the relevant research is carried out.

High-energy capture gamma-radiation fields with energies up to 7 MeV (titanium target) and up to 10 MeV (nickel target) to calibrate the energy scale and verify the energy dependence of developed spectrometric and dosimetric measuring instruments were generated by AT140 Neutron calibration facility for radiation monitoring instruments according to the requirements of international standard ISO-4037:2019.

The report presents the results of experimental studies. The standard dosimeter AT5351with a highly sensitive ionization chamber TM32002 was used to determine the air kerma rate and ambient dose equivalent rate of gamma radiation.

Keywords: high-energy capture gamma-radiation fields, AT140 neutron calibration facility, titanium target, nickel target

Metrological equipment for calibration of environmental dosimeters

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Calibration of dosimetric radiation monitoring instruments: dosimeters, dosimeter-radiometers, dosimeter-spectrometers, dose rate meters, detection units, multichannel systems with detection units designed to determine the air kerma rate, ambient and directional dose equivalent rates of X-ray and gamma radiation is performed in calibration laboratories.

In order to recognise the calibration results and the calibration certificates provided at the international level, the laboratories undergo a conformity assessment procedure with a national accreditation body. National accreditation bodies that have been peer reviewed as competent sign agreements with international accreditation organisations (European Accreditation Organisation (EA), International Laboratory Accreditation Organisation (ILAC), International Accreditation Forum (IAF)) to demonstrate their competence. National accreditation bodies then assess and accredit the conformity assessment bodies to the relevant standards.

When calibration laboratories are accredited, they are assessed against the requirements of ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories. The report provides information on the provision of calibration laboratory, carrying out calibration of environmental dosimeters, with calibration facilities (working standards, auxiliary equipment), discusses the following issues.

Keywords: calibration, dosimeter, dose rate, air kerma rate, gamma radiation, calibration facility

Immersion spectrometer for automated radiation monitoring of aquatic environment and bottom sediments

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"ATOMTEX" SPE has developed the AT6104DM spectrometer, designed to search and detect gamma radiation sources and neutron flux in aquatic environments, measure energy distribution of detected gamma radiation, identify gamma-emitting radionuclides, perform In SItu radiation monitoring of fresh and sea water in 4Pi measurement geometry and bottom sediments in 2Pi measurement geometry.

The spectrometer is a multifunctional system consisting of a detection device, an electromechanical winch (EMW) with a deep-sea cable-rope installed on it, a power supply for EMW, a spectrometer control module, a global navigation satellite system receiver, power cables, data transmission cables, and specialized software. The spectrometer's detection device is submersible to depths of up to 100 m. The spectrometer's detection unit (measuring channel) based on a 63 x 63 mm NaI(Tl) spectrometric detector and a photomultiplier tube, equipped with an LED stabilization system for the measuring path and an automatic temperature compensation system.

This paper presents the results of a Monte Carlo simulation of the spectrometer's detection efficiency in the 70–3000 keV energy range for 4Pi measurement geometry, as well as the results of a study examining the spectrometer's ability to detect neutron flux by registering gamma radiation generated by the neutron capture reaction on H, O, Na, and Cl nuclei (Prompt Gamma Rays Neutron Reaction).

Keywords: immersion spectrometer, *in situ*, Monte Carlo simulation, gamma radiation, radiation monitoring

Universal digital spectrometric system for fast neutron field characterization

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This paper presents a versatile digital spectrometric system designed for the characterization of unknown fast neutron fields. The system combines a digital multichannel analyzer, a stilbene scintillation detector, and advanced signal-processing algorithms to provide a flexible tool suitable for a wide range of neutron measurement tasks.

The hardware is based on an FPGA platform, which integrates programmable logic with an embedded Linux system. This architecture enables real-time digital pulse processing while also providing convenient remote access, control, and data management via a standard Linux environment. Digital pulse shape discrimination (PSD) is implemented to ensure reliable neutron–gamma separation across varying radiation conditions.

The system has been configured with a (25 × 25) mm stilbene detector. The functionality of the system has been verified through measurements of a Cf-252 neutron irradiator in a calibration laboratory. The results demonstrate that the proposed solution provides a robust, remotely accessible, and adaptable platform suitable for neutron field characterization, detector testing, and metrological applications.

Keywords: neutron irradiator, fast neutrons, FPGA (Field Programmable Gate Array), Pulse-shape discrimination (PSD), digital-signal processing

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Neutron time-of-flight measurements at the U-120M cyclotron

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This work presents preliminary results from neutron time-of-flight (TOF) spectroscopy measurements conducted at the U-120M cyclotron facility, focusing on the characterization of fast neutron sources using a compact, digitizer-based acquisition system. Neutrons with maximum energies of 20–25 MeV were generated via proton bombardment of both lithium and beryllium targets, producing quasi-monoenergetic spectra from lithium reactions and broad continuous spectra from beryllium. The experimental configuration utilized short flight paths under 5 meters. Measurements were done at several distances for each target.

Neutron detection was performed using a 10×10 mm stilbene organic scintillator coupled to a fast photomultiplier tube. Signal digitization was accomplished using a Picoscope 6426E USB oscilloscope at a sampling rate of 1.25 GS/s. Full pulse waveforms were recorded for each experimental run for subsequent offline processing. Neutron and gamma events were separated using pulse shape discrimination (PSD). To improve timing resolution, a constant fraction discriminator (CFD) algorithm was applied to interpolate pulse arrival times. These separated spectra were used to determine the time-zero (impact of protons on target) via analysis of gamma-ray arrival times. Additionally, the cyclotron RF periodicity was exploited to maximize the measurable neutron energy.

The preliminary results demonstrate good agreement with both simulated spectra and measurements conducted using other acquisition chains and methods.

Keywords: time-of-flight, neutron, cyclotron, u-120m, picoscope, scintillator

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Beta irradiation facility BSS 2: An update

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Introduction. The irradiation facility for beta radiation, Beta Secondary Standard BSS 2, has been developed and continuously improved by PTB [http://www.ptb.de/cms/en/ptb/fachabteilungen/abt6/fb-63/information/results-of-research.html#c38376] and is commercially available [https://www.ezag.com/de/produkte/isotope-products/isotrak-calibration-sources/instruments/beta-secondary-standard-2-bss-2/]. For several years, it has been in worldwide use to perform irradiations with calibrated beta sources traceable to PTB in terms of the operational quantities in radiation protection.

Main characteristics of the BSS 2, including its most recent hard- and software update:

1. beta sources ^{147}Pm, ^{85}Kr, ^{90}Sr/^{90}Y, and ^{106}Ru /^{106}Rh with mean energies from (0.07…1.2) MeV;
2. operational quantities $H_p(0.07)$, $H_p(3)$, $H'(0.07)$ and $H'(3)$;
3. dose rates of ~ (10…1000) mSv/h;
4. PTB-traceable dosimetry in accordance with ISO 6980-1, -2 and -3:2023;
5. fully software-controlled irradiation of dose and dose rate;
6. sensors for all parameters relevant for the dose (rate), such as radio nuclide, beam-flattening filter, angle of radiation incidence, distance, ambient conditions etc.;
7. ISO rod and slab phantom;
8. recent addition of energy reduced ^{90}Sr/^{90}Y radiation field (0.54 MeV instead of 0.8 MeV) [doi.org/10.1088/1748-0221/19/07/P07003].

Conclusion. The BSS 2 remains a modern and fully quality assured irradiation facility for beta radiation.

Keywords: irradiation facility, beta radiation, dose rate, dosimetry

Application of TDCR method in radioluminescence studies

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The TDCR method is based on the triple to double coincidence ratio in order to determine the activity of a radionuclide. In this technique, the TDCR counter detects scintillation photons generated by alpha or beta particles interacting within a scintillator, typically a liquid cocktail. Radioluminescence in air has been investigated as an indirect approach for the imaging and remote detection of alpha particles. Several radioluminescence scanning systems have been developed and successfully applied in environmental studies for alpha particle detection. In the present work, the TDCR counter from the Ionizing Radiation Metrology Laboratory (LMRI) from Horia Hulubei National Institute for Research and Development in Physics and Nuclear Engineering (IFIN-HH) was employed to detect radioluminescence photons produced in air. For validation of the method under air conditions, standard sources of Am-241 were used.

Keywords: TDCR method, alpha sources, radioluminescence

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Recent advances in high-k MOS based radiation sensors

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Conventional RadFETs with SiO_2 sensitive regions/gate oxide layers are widely used in many fields, from medical applications to space. Their major disadvantages are the inability to accurately measure doses below 10 mGy and their inability to be reused. On the other hand, extending the dose measurement range can both increase the lifetime of the sensor and make it more resistant at high radiation doses. In recent years, advancements in high-k dielectric materials have significantly enhanced the performance and durability of RADFETs. High-k dielectrics such as HfO_2, Al_2O_3, and ZrO_2 are essential in modern electronics due to their excellent electrical performance and low leakage at small scales. This study discusses recent advancements in materials, device designs, and fabrication methods that improve radiation resistance, focusing particularly on high-k dielectric materials and RADFETs. Tests conducted up to a gamma irradiation dose of 20 Gy have shown that the threshold voltage shifts in high-k RadFETs remain within values that preserve dose measurement accuracy while also extending the dose measurement range.

Keywords: high-k dielectrics, RADFET, gamma irradiation, radiation sensors

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High-velocity SHI effects in pre-damaged Ga_2O_3

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Gallium oxide (Ga_2O_3) has emerged as a promising addition to the class of polymorphic materials, where ion-beam modification can be used to tune functionality. While it is well established that atomic-level defects are created by elastic energy transfer (S_n) from ions to atomic nuclei, leading, for example, to a monoclinic-to-orthorhombic phase transition, the effects of inelastic energy loss (S_e) to electrons are more complex, especially in the presence of pre-existing defects. More specifically, the balance between swift heavy ion (SHI) driven defect creation, defect recovery, and possible phase transformations remains insufficiently understood compared to other materials in its class [Kamarou et al., NIM-B, 2004, 225, 129–135]. In this work, we investigate whether competitive (damage reduction) and synergistic (damage enhancement) mechanisms can coexist by subjecting β-Ga_2O_3 to controlled pre-damage followed by high-velocity SHI irradiation. Samples were first pre-irradiated with 1.2 MeV Au ions at fluences of 0.3, 1.0, and 10.0 nm^{-2} to generate distinct initial disorder levels. Subsequently, all samples were exposed to 8.6 MeV/u Au ions ($S_e \approx 43$ keV/nm), and the resulting structural modifications were quantified by Rutherford Backscattering Spectrometry in channeling geometry.

The response of Ga_2O_3 to SHI is found to depend strongly on the initial disorder state. The least pre-damaged sample (defective β-Ga_2O_3) exhibits partial recovery of the pre-existing defects, consistent with electronic-excitation-induced annealing [Iancu et al., Scripta Materialia, 2025, 268(116858)]. In contrast, the most heavily pre-damaged sample displays clear signatures of ion-track formation, indicating that increased pre-existing disorder, or the presence of γ-phase regions, sensitizes the material to latent track creation. The observed behavior also suggests the possibility of localized phase transformation around the track core, in line with recent reports [Han et al., Adv. Sci., 2025, 12]. The present results enable leveraging a new variable (initial disorder state) for selective activation of these ionization-induced processes under the same experimental conditions. This lays the groundwork for a novel strategy to tune the properties and functionalities of Ga_2O_3 that are vital in oxide electronics and spintronics applications.

Keywords: gallium oxide, polymorphic materials, swift heavy ions, defect creation and recovery, phase transformations, electronic-excitation-induced annealing, ion-track formation

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3D IME-CAS pixel produced in 8-inch CMOS technology with geometrical gain: Depth profiling of gain and timing using 2PA-TCT on non-irradiated and 3PA-TCT on irradiated samples

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3D Si devices recently gained significant attention. In particular, they are interesting devices for X-ray spectroscopy, microdosimetry in radiotherapy and as fast timing devices (radiation hard) in the HEP experiments under extreme radiation fluency conditions, such as future FCChh. However, they are not yet fully understood. Device under test (DUT) was a small pixel 3D sensor, produced by IME-CAS in 8-inch CMOS technology, on p-type wafers of 700 Ωcm. The 30 μm thick silicon microdetectors have trench walls (ohmic p+) and very narrow n-column columns with a diameter of only 0.5 μm (and length of 25 μm). A 5 × 5 matrix of 35 ×35 μm2 was measured with Two Photon Absorption Transient Current Technique (2PA-TCT). The holding substrate is 600 μm tick. For the first time, n this contribution, we will compare the results measured on irradiated and non-irradiated devices. They are fully characterized in terms of charge collection uniformity and time resolution performance across the cell at different bias voltages. Moreover, depth profiling of gain and timing parameters was systematically and comprehensively studied. Since the Single Photon Absorption (1PA) can contribute to the 2PA due to by radiation induced defects in irradiated device, we cross-checked the results using more advanced, Three-Photon Absorption TCT technique.

Keywords: 3D Si pixel, geometrical gain, depth profiling of gain, depth profiling of Time of Arrival, extreme fluency, micro-dosimetry. X-ray, fast timing, radiation hard device, 3PA- and 2PA-TCT, FCChh

AI-enhanced self-calibrating platinum RTD system for intelligent fault detection and energy optimization in domestic ovens

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This study presents a physics-informed artificial intelligence (AI) enhanced thin-film Pt1000 resistance temperature detector (RTD) system designed for intelligent thermal control in domestic ovens. Conventional oven control architectures suffer from thermal overshoot, energy inefficiency, long-term sensor drift, and inability to detect heating element degradation. The proposed system integrates a Pt1000 sensor (R_0 = 1000 Ω at 0°C, TCR = 0.385 Ω/°C) with embedded machine learning algorithms capable of real-time self-calibration, drift compensation, anomaly detection, and predictive heater failure diagnostics. A hybrid modeling framework combining Callendar-Van Dusen physics-based modeling and lightweight neural networks was implemented on an ARM Cortex-M4 microcontroller platform. Experimental validation across 300 cooking cycles and 40 induced fault scenarios demonstrates 38-52% reduction in overshoot, 8-14% energy savings per cycle, and heater fault detection within 4-12 seconds with 96% accuracy. The results indicate a paradigm shift from passive sensing to intelligent embedded thermal management systems suitable for next-generation smart appliances.

Keywords: Pt1000 RTD, self-calibration, fault detection, energy optimization, machine learning, smart appliances, predictive maintenance

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Electrical response of natural diamond under Cs-137 and Co-60 ionizing radiation

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Diamond has emerged as a promising material for radiation detection due to its wide bandgap, high carrier mobility, radiation hardness, and chemical stability. These properties make diamond-based sensors suitable for applications in nuclear environments, medical dosimetry, and high-energy physics. In particular, natural diamond offers a low-cost alternative for exploratory radiation sensing studies. This work presents a preliminary investigation of the electrical behavior of a natural diamond sample exposed to ionizing radiation. The objective was to evaluate the material's sensitivity to radiation through changes in its electrical conduction properties. The diamond sample, obtained from a natural source, was positioned between two electrical probes and characterized using a semiconductor parameter analyzer. Current–voltage (I–V) measurements were performed in the voltage range from 0 to 10 V under ambient air conditions. The sample was exposed to controlled radioactive sources of Cs-137 and Co-60, with dose rates of approximately 0.60 µSv/h and 0.27 µSv/h, respectively. Electrical measurements were conducted both in the absence and presence of radiation, as well as during successive measurements after exposure. The results showed a clear perturbation in the electrical response of the diamond at the moment of radiation incidence. After the radiation source was removed, the material gradually returned to its original electrical behavior. Additionally, successive measurements revealed a temporary increase in electrical resistance, indicating a cumulative radiation effect consistent with the Total Ionizing Dose (TID) phenomenon. This effect was observed for both Cs-137 and Co-60 sources, suggesting that the radiation modifies the charge transport mechanisms within the diamond. Over time, the electrical characteristics partially recovered, indicating a dissipative process associated with trapped charges or defect states. The experimental results demonstrate that natural diamond exhibits measurable electrical sensitivity to ionizing radiation, even under low-dose and ambient conditions. These findings indicate the feasibility of using natural diamond as a passive radiation-sensing material and provide a basis for future studies involving controlled atmospheres, higher radiation doses, and device-structured detectors.

Keywords: natural diamond, ionizing radiation, electrical characterization, Cs-137, Co-60

Multi-arrays of 3D-cylindrical microdetectors with internal gain: Toward next-generation fast timing devices for HEP and medical applications

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The 3D silicon (Si) detector has demonstrated excellent spatial and temporal resolution under extreme radiation conditions. It is therefore considered a strong candidate for the upgrade of pixel systems in LHC experiments such as ATLAS and CMS (innermost layers), as well as LHCb (VELO), and represents a promising technology for the future development of the FCC-hh.

The primary research direction for 3D pixel detectors in the coming years is the improvement of spatial and temporal resolution. In this context, the IMECAS technology offers a significant advantage, enabling the fabrication of 3D silicon devices with electrode diameters as small as 0.5 µm. This allows for aspect ratios (depth-to-diameter) exceeding 70, which is substantially higher than what can be achieved with CNM and FBK technologies. A higher aspect ratio enables shorter device geometries, while the small diameter of the central n+ electrode leads to the formation of a strong electric field in its vicinity. This facilitates electron impact ionization, making it possible to achieve internal gain without the need for a dedicated highly doped gain layer, as is required in Low Gain Avalanche Diodes (LGAD).

In this work, we present the performance of multi-arrays of 3D cylindrical silicon microdetectors designed for fast timing applications in both high-energy physics (HEP) and medical research.

The device under test (DUT) consists of an array of 10 × 10 individual 3D cylindrical silicon microdetectors, each with a diameter of 10 µm and an active thickness of 30 µm. The array is fabricated on a 600 µm thick supporting substrate. The devices were produced using an 8-inch CMOS-compatible process at the Institute of Microelectronics of the Chinese Academy of Sciences (IMECAS). The design is based on the 3D cylindrical architecture developed at the National Microelectronics Center (IMB-CNM, CSIC), Spain. Each detector features a central n+ electrode with a diameter of 1 µm and a depth of 20–25 µm, while the surrounding circular p+ electrode has a width of 1 µm and a depth of 43.5 µm. The unit cells are electrically isolated, each defining a well-confined three-dimensional radiation-sensitive volume. The pitch between adjacent detectors is 200 µm in both horizontal and vertical directions.

These structures are particularly suitable for studying impact ionization effects under high radiation fluence and high bias conditions. Furthermore, the device is well suited for microdosimetry applications. Therefore, understanding the detector performance and the conditions required for achieving internal gain in the presence of radiation-induced defects is essential for future research and development of fast timing devices with intrinsic gain, with applications in both high-energy physics and medical fields. As characterisation tool we use the Two-Photon Absorption Transient Current Technique, at ELI ERIC in Prague.

Keywords: multi-arrays of 3D-cylindrical microdetectors, 3D Si with internal gain, 8-inch CMOS technology, IMECAS, impact ionisation, gain, TPA-TCT

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Design and simulation of a Bragg spectrometer for soft X-Ray diagnostics

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X-ray spectroscopy is a key diagnostic for laser-produced plasmas, providing access to parameters such as electron temperature, density, and ionization state. These non-equilibrium systems, generated at density of 10^{11}–10^{13} Wcm^{-2}, reach energies of 0.1–1 keV and densities up to 10^{23} cm^{-3}, making them relevant to fusion, astrophysics, and high-energy-density physics. Within this framework, this work focuses on the design, modeling, and optimization of a soft X-ray spectrometer to study ion stopping power in dense plasmas.

A spectrometer based on a 45° flat Bragg crystal coupled to a high-performance CCD has been designed and simulated. Different crystals enable access to selectable soft X-ray spectral ranges. The core of this work is a 3D Monte Carlo simulation model that replicates the spectrometer geometry and an extended source. The model analytically describes the photon path, from generation according to a given spectral distribution to impact on the detector, organically integrating structural parameters (geometries, distances, and orientations) and physical laws (Bragg's law and the rocking curve as a model for the crystal's angular selectivity). This integration makes it possible to probabilistically determine the diffraction of each photon and geometrically reconstruct its interaction with the detector, establishing a direct correspondence between the detected position and the specific energy-geometry history of the event.

The model provides the theoretical basis for calibration and position-energy correlation. Simulations map accessible energy ranges on the CCD, assess spectral selectivity, and optimize geometry for coverage and resolution. The intrinsic selectivity, governed by crystal lattice and system geometry, defines the observable window and enables resolution of continuum (bremsstrahlung, recombination) and characteristic lines (Kα, Lα) as function of crystal choice and alignment. The ultimate goal is a robust, calibrated diagnostic tool, based on the systematic comparison between experimental measurements and simulations, with automated procedures for spectral analysis and parameter extraction. This integrated approach — combining analytical models, numerical simulation, and high-resolution spectroscopy — constitutes a powerful paradigm for the study of plasmas under extreme conditions, with significant implications for fundamental physics and applied technologies.

Keywords: X-ray spectroscopy

Optimization of a remote fibre-optic scintillation detector for real-time cyclotron radiation monitoring

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Real-time radiation monitoring in the surroundings of particle accelerators is crucial for safety and operational diagnostics. Fibre-optic coupled scintillation detectors offer a promising solution for remote sensing in harsh environments with strong electromagnetic interference. However, their deployment requires careful evaluation of signal integrity, particularly due to parasitic radiation-induced luminescence generated within the optical fibre. This study presents the initial experimental testing and subsequent optimization of a prototype fibre-optic detector designed to verify its basic functionality and signal transmission in a real cyclotron radiation field. Measurements were conducted at the U-120M isochronous cyclotron facility. To evaluate the system's response to different radiation components, two distinct scintillators were tested: an inorganic LYSO(Ce) crystal (highly sensitive to γ-rays) and an EJ-200 plastic scintillator (sensitive to fast neutrons via proton recoil). Scintillation light was guided to a photomultiplier tube via a multi-mode optical fibre. The initial prototype (30 m segmented fibre, Ø 1.5 mm) was later upgraded to an optimized continuous 50 m fibre (Ø 1.0 mm) coupled with diameter-matched scintillators (Ø 1.0 x 10 mm).

The first testing campaign revealed significant radiation-induced fibre luminescence, which formed a considerable background and degraded the signal-to-noise ratio, especially for the less luminous EJ-200 scintillator. In the second iteration, reducing the fibre diameter to 1.0 mm and eliminating optical joints successfully suppressed this parasitic background to negligible dark-count noise levels. The LYSO(Ce) detector demonstrated a strong, stable response to the radiation field. Interestingly, orienting the longitudinal axis of the EJ-200 scintillator parallel to the beam axis increased the signal by 10% compared to a perpendicular alignment, indicating a geometric dependence of the fast-neutron interaction probability. The optimized 50 m fibre-optic system proved highly functional for remote, real-time radiation monitoring at a cyclotron facility. The successful suppression of fibre-induced background and the distinct responses of the tested scintillators demonstrate the prototype's excellent potential for future development.

Keywords: fibre-optic sensor, scintillation detectors, radiation monitoring, radiation-induced luminescence, cyclotron, remote dosimetry

Performance of n-type Low Gain Avalanche Detectors under impact of low-energy carbon ion implantation

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Low Gain Avalanche Detectors (LGADs) are silicon sensors that combine moderate internal gain with excellent time resolution (tens of picoseconds), making them attractive for particle detection. While conventional LGADs are typically p-type and optimized for high-energy particle detection, the n-type LGADs (nLGADs), designed for low-energy ion detection, with potential applications in medical imaging systems and radiation therapy environments, have been investigated.

The studied nLGADs were fabricated at IMB-CNM, together with PIN sensors without the gain layer. The devices were investigated before and after irradiation with 900 keV and 2.15 MeV carbon ions at fluences of Φ=(1-10)×10^{10} cm^{-2}. Current-voltage (IV) and capacitance-voltage (CV) measurements were performed to evaluate leakage current and effective doping profiles, respectively. A custom transient current technique (TCT) setup with a 405 nm picosecond laser and optical delay line was used to determine detector gain and time resolution. Gain was determined by comparing collected charge in LGADs to that in reference PIN diodes at reverse biases in the range of 50-500 V. Time resolution was determined from Gaussian standard deviation σ of the time difference distribution between signals of two consecutive laser pulses, where one pulse was delayed relative to the other. The dependence of gain and time resolution on irradiation fluence and temperature was analyzed.

Based on IV characteristics, irradiated samples were grouped by leakage current levels. In unirradiated sensors with lower leakage current, time resolution ranged from 45 ps at 300 V reverse bias to 40 ps at 500 V, while higher leakage current samples showed degraded performance (75 ps at 300 V improving to 50 ps at 500 V). Time resolution degraded with increasing irradiation fluence in both groups. The gain in irradiated LGADs remained around 4 at 500 V, independent of leakage current grouping, although a decrease in gain was observed with increasing irradiation fluence. Temperature dependent measurements further revealed post-irradiation evolution of detector performance.

These results provide valuable insight into the radiation tolerance and operational limits of nLGADs under low-energy carbon ion exposure, relevant for applications requiring precise timing in radiation environments. Measurement results and detailed analysis will be presented at the conference.

Keywords: silicon detectors, n-type LGAD, Low Gain Avalanche Detectors, carbon ion irradiation, time resolution, detector gain, radiation hardness, transient current technique, low-energy particle detection

Monte Carlo simulations of a custom-made neutron probe based on the SI-19N proportional ^{3}He counter

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Proportional ^{3}He counters of the SI-19N type are widely used and readily available, making them suitable candidates for neutron detection systems. When combined with an appropriate electronic readout and a well-optimized high-density polyethylene (HDPE) moderator, these detectors can serve as highly effective neutron probes with a broad range of applications. The design presented here is tailored to meet the operational requirements of the Centre of Nuclear Technology and Applications (CeNTA), specifically for characterizing neutron fields produced by a d–D neutron generator. The probe is intended for use both as an absolute neutron counter and as a rate meter, while also maintaining adequate sensitivity to neutron fields from common radioisotopic sources such as ^{252}Cf and ^{241}Am-Be. To support the design process, Monte Carlo simulations of the neutron fluence response were performed. Response functions were calculated using the MCNP6 radiation transport code for multiple moderator-thickness configurations. The simulations employed the well-validated ENDF/B-VII nuclear data library. The results of this study provide the basis for determining the optimal probe configuration for versatile neutron field measurements at CeNTA. Finally, the calibration of newly constructed detector was performed and is documented in the paper.

Keywords: custom-made neutron probe, fluence response, Monte Carlo simulations

Behaviour of CVD diamond detectors under ion irradiation

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The development of radiation-hard particle detectors is essential for next-generation nuclear physics experiments within the Facility for Antiproton and Ion Research (FAIR) framework. Among candidate materials, Chemical Vapor Deposition (CVD) diamond stands out due to its wide bandgap, high carrier mobility, and excellent radiation hardness, enabling operation in extreme environments [T. Shimaoka et al., Functional Diamond 1(1):205-220, 2021, DOI: 10.1080/26941112.2021.2017758]. In this work, we present a complementary study to the development of CVD diamond detectors carried out by the CRYRING (GSI) group, with a focus on their application in beam diagnostics [R. Wallny et al., 10th International Workshop on Semiconductor Pixel Detectors for Particles and Imaging (Pixel2022), 2022, https://cds.cern.ch/record/2870194/files/document.pdf].

CVD diamond samples were irradiated with 1.2 MeV Au ions, reaching fluences up to 10^{14} ions/cm^2 at the 3 MV Tandetron™ accelerator, from IFIN-HH, Romania. Between irradiation steps, defect density profiles were obtained using Rutherford Backscattering Spectrometry in channeling mode (RBS-C), allowing identification of threshold fluences where detector performance degrades. Positron Annihilation Spectroscopy (PAS) analyses were also applied to probe the level of vacancies and lattice damage. Electrical characterization was performed using planar contacts deposited on the sample, with charge collection efficiency (CCE) monitored as a function of fluence. By correlating PAS and RBS-C, while assessing the electrical response enabled us to find a direct link between defect evolution and detector performance.

Post-irradiation with 12 MeV oxygen ions, at fluences up to 10^{16} ions/cm^2, revealed partial recovery of defects and an improved electrical response, confirming the presence of electronic-excitation-assisted defect recombination processes. These results support the in-situ optimization of CVD diamond detectors for high-radiation environments relevant to future FAIR experiments.

Keywords: CVD diamond detectors, radiation damage, Rutherford backscattering spectrometry - channeling (RBS-C), defect density, ion irradiation, annealing effects, beam diagnostics

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Orientation cutting of TlBr crystals via pole figure measurements for gamma-ray detector fabrication

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TlBr semiconductor crystal, which has a BCC structure similar to that of CsI, is considered promising gamma-ray detector material. In previous studies on TlBr detector fabrication, TlBr wafers were cut from TlBr single crystals grown by non-seeded growth methods, and TlBr detectors have been investigated for their application in gamma-ray spectrometry. Although crystal orientation estimated to affects for electric properties of the detectors, the TlBr detectors were fabricated from TlBr wafers obtained from TlBr ingots without regarding the orientation. This study developed the pole figure measurement and crystal cut procedure using an originally designed gonio instrument were combined to obtain TlBr wafers with specific orientation. Using the alpha and beta angles obtained from the (100), (110), and (111) pole figure measurements, the orientation of the TlBr crystals was adjusted with the goniometer instrument, and around 1 mm-thick TlBr wafers with (100), (110), and (111) orientations were sliced using a diamond wire saw. After the cutting process, the alignment of the normal direction and the intended orientations were evaluated by measuring the pole figures of the sliced TlBr wafers.

Keywords: TlBr, semiconductors, crystal orientation, gamma-ray detectors

Metrological preflight preparation of a NaI(Tl) 2×2″ scintillation detector for UAV-based gamma spectrometry

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The use of unmanned aerial vehicles (UAVs) equipped with gamma-ray spectrometers for radiological mapping and orphan source detection has gained increasing attention. While considerable research focuses on UAV platform integration and flight algorithms, less attention has been given to the systematic laboratory preparation of the detector system that underpins the reliability of subsequent field measurements. A NaI(Tl) scintillation detector (2×2 inch) coupled with an ORTEC DigiBase MCA is a practical choice for airborne applications due to its favourable balance of detection efficiency, energy resolution, weight, and digital signal processing. However, UAV deployment introduces requirements beyond routine calibration: short acquisition times dictated by flight speed, variable source-to-detector distances corresponding to flight altitudes, and environmental factors such as temperature variation and vibration. This work presents a calibration and characterisation methodology developed specifically for preparing a NaI(Tl) detector system for airborne gamma spectrometry, designed as an integrated framework linking laboratory parameters directly to UAV operational constraints. Energy calibration is performed using ^{137}Cs (661.7 keV), ^{60}Co (1173.2 and 1332.5 keV), and ^{241}Am (59.5 keV), covering the energy range of the target radionuclides. Energy resolution (FWHM) is evaluated at each energy, emphasising the ability to resolve ^{137}Cs and ^{60}Co photopeaks — critical for spectral identification in field conditions. A laboratory background measurement is conducted to establish baseline count rates and assess ambient interference. Detector count rate response is characterised at representative source-to-detector distances without performing absolute efficiency calibration, as the operational objective is anomaly identification rather than activity quantification. A key element is the investigation of spectral quality as a function of acquisition time. Peak identification reliability is assessed using a 3σ detection criterion to determine the minimum exposure required for radionuclide discrimination at operational distances — directly constraining flight speed and altitude planning. Statistical uncertainties are estimated from counting statistics under the Poisson approximation. The methodology establishes a reproducible and traceable procedure bridging laboratory detector preparation and airborne survey design, and will be validated through planned field experiments with known-activity sources.

Keywords: NaI(Tl) scintillation detector, energy calibration, airborne gamma spectrometry, UAV

Experimental validation of true coincidence summing correction factors for ^{60}Co and ^{152}Eu using EFFTRAN in point source geometry

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Gamma-ray spectrometry is a widely used technique for the qualitative and quantitative analysis of radionuclides in environmental, industrial, and nuclear applications. It provides high energy resolution and detection sensitivity, particularly for multi-gamma-emitting radionuclides with complex decay schemes. However, the accuracy of quantitative measurements is affected by several factors, including true coincidence summing (TCS), self-attenuation, geometry-dependent efficiency variations, pile-up effects, peak interferences, and uncertainties in efficiency calibration and nuclear decay data. Among these, true coincidence summing (TCS) is one of the most significant sources of error, especially in close-geometry measurements involving cascade-emitting radionuclides.

In this study, TCS correction factors for point source geometry were determined for ^{152}Eu and ^{60}Co using both experimental method and the EFFTRAN code. Gamma-ray spectra were acquired using a p-type coaxial high-purity germanium (HPGe) detector with 40% relative efficiency and an energy resolution of 1.8 keV at 1332 keV (^{60}Co). All measurements were conducted at a fixed source-to-detector distance of 10.24 cm, at which random summing effects are negligible, with the detector connected to a digital spectrometer.

For the experimental approach, full-energy peak efficiency values were first determined using standard gamma-emitting sources (^{241}Am, ^{57}Co, ^{137}Cs, ^{54}Mn, and ^{65}Zn) to establish a TCS-free efficiency calibration. The efficiency data were fitted using a logarithmic polynomial function to obtain a continuous efficiency curve. TCS-free efficiency values (ε) for ^{152}Eu and ^{60}Co were derived from this fitted curve. Subsequently, TCS-affected efficiencies (ε_{exp}) were calculated from the measured spectra of these radionuclides. The TCS correction factor was then determined as $TCS=\varepsilon/\varepsilon_{exp}$. Furthermore, TCS correction factors were calculated using EFFTRAN by incorporating detector specifications provided by the manufacturer and the experimental geometry into the model.

The comparison of experimental and EFFTRAN results showed good agreement, with deviations ranging from 0.1% to 7.6%. These findings indicate that the applied experimental method provides reliable estimation of TCS effects, even without detailed detector modelling.

Keywords: HPGe, true coincidence, point source, EFFTRAN

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Gamma scintillation detector with a Si-PM array and Arduino Due processor

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2x2 Si-PM NUV-MT silicon photomultiplier array from Broadcom with an area size of 8x8mm^2 in connection with an Arduino Due processor and an YAG:Ce (from China, Hangzhou Yong Hee Photonics Co., Ltd) 18x18x10mm^3 inorganic scintillator crystal is ensembled. This detector system is used for gamma-ray spectroscopy with different applications in nuclear physics (high energy physics and medical imaging). It was obtained an energy resolution of 8.0 % at the energy 661keV of Cs^{137}. This value is better than the energy resolution of 12.0% obtained for 661 keV of Cs137 with the same volume YAG:Ce crystal and a PIN photodiode readout, type S3204-08(from Hamamatsu, Japan). Three different radioactive sources are used to test this readout system: Na^{22}, Ba^{133} and Cs^{137}.

Keywords: silicon photomultiplier, scintillator, energy resolution

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Defect tailoring in low dimensional structures by radiation

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Low dimensional structures are among the most relevant building blocks of (opto)electronic devices and nanodevices such as lasers, transistors and sensors. However, the scaling down poses several problems to obtain homogeneous compositions and defect free structures. Indeed, even the presence of a reduced number of defects or composition fluctuation, especially in compound materials, could destroy or inhibit device operation.

Ionizing radiation like ion beams provide excellent tools to control dopants and defect distributions and has been successfully applied to manipulate nanostructures like nanowires (NWs) and multiple quantum wells (QWs). In this contribution we will show and discuss results of NW and QW structures implanted with rare earth (RE) ions, correlating the damage role on the optical behavior of the implanted samples. The possibility to use defects to release interface strain in multiple QW through ion mixing will be also analyzed. The damage build-up and RE incorporation and activation in NWs and QWs were studied by Rutherford Backscattering/Channeling Spectrometry (RBS/C), high resolution X-ray diffraction (HRXRD) and photoluminescence (PL). The effect of subsequent annealing on the activation of the dopants and defect recovery will be discussed.

Keywords: radiation effects, nanomaterial structures, ion beam techniques and optical and X-ray spectroscopies

Testing the neutron defectoscopy system on the D–T generator

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Fast neutron defectoscopy is a promising non-destructive testing method currently under development. This method utilizes a fast neutron beam to investigate the internal structure of materials and industrial components and to detect defects that are inaccessible to conventional techniques such as X-ray imaging. Due to the high penetration capability and sensitivity to different nuclides, fast neutrons can complement standard radiography methods. The main challenges of this technique lie in fast neutron detection and the reconstruction of radiographic images from measured data. The developed defectoscopy system consists of a neutron-sensitive organic scintillator, a CMOS camera, and dedicated image-processing software. The system feasibility was evaluated using a compact heat exchanger mock-up composed of stainless-steel tubes filled with demineralized water. The long-term objective is the development of a portable system for in situ measurements, requiring the use of a compact neutron generator. This work presents experimental results obtained using a D–T neutron generator at the Centre of Research in Řež (CVR). The relatively large neutron emission area of the generator is advantageous for imaging applications. A small-scale mock-up was first used to optimize the experimental setup, including the arrangement of the neutron source, the mock-up, and the detection system. Various generator power levels and irradiation times were investigated to define suitable measurement conditions. Subsequently, measurements were performed with a full-scale mock-up in both reference and defected configurations. Neutron flux and generator power were verified using a scintillator-based detector, and the neutron emission rate, flux distribution, and energy spectra were evaluated. Additionally, measurements with reactor neutron spectra were conducted using both fast neutron and thermal neutron imaging systems. For fast neutron measurements, the beam port was shielded with cadmium foil to suppress thermal neutrons. A qualitative comparison of the obtained images and the capabilities of both methods is presented in this paper.

Keywords: neutron defectoscopy, neutron generator, industrial mock-up, NDT, neutron measurements

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Long-time analysis of the activity concentration of $^{234,238}U$ isotopes in atmospheric precipitation in Silesian Voivodeship, Poland

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Uranium is an element widely distributed in nature. Uranium can be released into the atmosphere through both natural and anthropogenic pathways. Measurements of radionuclide content in atmospheric precipitation primarily focus on anthropogenic radionuclides and radionuclides released during nuclear incidents. On the other hand, there is little data in the literature on the concentrations of the long-lived ^{234}U and ^{238}U isotopes in atmospheric precipitation. The present study aimed to determine the activity concentrations of ^{234}U and ^{238}U in atmospheric precipitation. The sampling station was located in the Silesian Voivodeship in Poland. Atmospheric precipitation was collected semi-monthly or monthly, depending on rainfall volume, using a stainless steel open-surface tray with a surface area of 1.6 m^2. After rainfall, the water was acidified, filtered through ash-free filters, and evaporated to about 0.5 L. The collector was wiped with ash-free filters and combined with filters after rainwater filtration. Rainwater samples were subjected to radiochemical preparation, as routinely used in the laboratory for water samples. The filters were calcined and then processed according to routine radiochemical procedures for soil samples. Uranium was separated from other alpha emitters using ion exchange chromatography. The samples were measured using 7401VR and the Alpha Analyst™, the alpha spectrometers equipped with semiconductor detectors. The concentrations of ^{234}U and ^{238}U isotopes in both fractions (rainwater and dry precipitation) will be presented. The sampling period lasted over 9 years, enabling long-term assessment of uranium level in atmospheric precipitation. Based on the results, the uranium content and the $^{234}U/^{238}U$ activity ratio in both fractions will be presented, and the uranium origin in atmospheric precipitation will be discussed. Uranium present in fine airborne particles can be inhaled, potentially leading to adverse health effects from chemical and radiological toxicity.

Keywords: ^{234}U, ^{238}U, air precipitation, $^{234}U/U^{238}$ activity ratio

Natural and artificial radionuclides in wood pellets and derived ashes

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This study presents a radiological assessment of wood pellets and their combustion ashes, with a focus on the activity concentrations of caesium-137 (Cs-137) and potassium-40 (K-40). A total of 24 commercial pellet samples and 16 corresponding ash samples from domestic appliances in Greece were analyzed using high-resolution gamma-ray spectrometry. The results reveal that K-40 activity concentrations in pellets (10–80 Bq/kg) are consistent with values typically reported for wood biomass. In contrast, Cs-137 levels show strong geographical dependence, ranging up to 60 Bq/kg in pellets from Eastern Europe—particularly Ukraine and Romania—reflecting the heterogeneous Chernobyl fallout distribution. Combustion resulted in a marked radionuclide concentration in the ash, with mean activities of 2751 Bq/kg for K-40 and 281 Bq/kg for Cs-137, corresponding to average enrichment factors of 76 and 33, respectively. These values indicate radiological concerns for densely populated areas that burn pellets for heating and align with enrichment ranges reported in comparable European studies. From a regulatory perspective, this concentration effect is of particular significance. Although none of the analyzed pellet samples exceeded the exemption limit of 100 Bq/kg for Cs-137 several ash samples surpassed this threshold due to combustion-induced enrichment. This finding indicates that fuels considered radiologically safe at the point of use may produce ashes requiring controlled management or disposal. Spatial mapping of Cs-137 activity, measured in pellets and the corresponding ash from different countries, highlights a clear east–west gradient consistent with Chernobyl deposition models, underscoring the long-term persistence of radiocaesium in forest ecosystems.

Keywords: wood pellets, biomass, ash enrichment factor, Chernobyl accident, natural radioactivity, potassium-40, radiocaesium, Germanium detectors, γ-spectroscopy, forest radioactivity

Radioecological and radiobiological consequences of the Chornobyl accident for aquatic ecosystems: 40 years later

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Despite the four decades that have passed since the accident at the Chornobyl Nuclear Power Plant (CNPP), natural self-purification processes in the water bodies of the Exclusion Zone (EZ) continue to progress extremely slowly. In this regard, the ecosystems of most floodplain and oxbow lakes, and backwaters are still characterized by high levels of radionuclide contamination of all components. Under conditions of a no-drainage regime and relatively large catchment areas with a high density of contamination by artificial radionuclides, these water bodies are capable of accumulating significant amounts of radioactive substances in biotic and abiotic components, which, in turn, causes an increased dose rate to aquatic biota. The results obtained during last 10 years in the most radionuclide-contaminated water bodies of the EZ are presented. Representatives of higher aquatic plants, fish and invertebrates were studied at various levels of biosystem organization. The current gradient of radiation dose rate for different species was in range of 0.05-180 μGy/h. A direct relationship has been registered between the absorbed dose rate and the frequency of chromosomal aberrations in cells of root meristems of aquatic plants. It has been established that against the background of a certain stabilization of chromosomal mutagenesis, which is 2-3 times higher than the spontaneous level, an increase in the number of cells with multiple aberrations is observed. The hematopoietic system of fish reacts to chronic radiation exposure by activating compensatory-adaptive processes, which are manifested in changes in the number of leukocytes, leukocyte indices, as well as the redistribution of individual types of cells in the leukogram. At the same time, a significant increase in pathological changes in the structure of the nuclei and cytoplasm of erythrocytes was noted. In juveniles of various fish species of the EZ an increased level of axial skeleton disorders was detected, localized mainly in the caudal and abdominal parts. Analysis of pollen grains of aquatic plants revealed a significant proportion of sterile grains, as well as changes in their morphometric indicators in the most contaminated reservoirs. Species richness and diversity, as well as indicators of abundance and biomass of benthic invertebrates of the reservoirs of the EZ are quite low. In general, the assessment of the abundance indicators of all studied water bodies may indicate a depressed state of aquatic invertebrate communities. However, no significant relationship was found between these indicators and the external dose. It is also assumed that the chronic radiation exposure to higher aquatic plants did not cause significant changes in the species and coenotic composition of macrophytes in the studied water bodies.

Keywords: Chornobyl exclusion zone, aquatic ecosystems, radionuclide contamination, absorbed dose rate, radiation effects

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Skeletal abnormalities in juvenile fish from the Chornobyl Exclusion Zone

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Skeletal abnormalities were studied in juveniles of *Rhodeus amarus* (European bitterling), *Leucaspius delineatus* (sunbleak), *Rutilus rutilus* (roach), and *Scardinius erythrophthalmus* (rudd). Samples were collected from water bodies with different levels of radioactive contamination, including Lakes Pidbirna, Glyboke, and Azbuchyn, the Yaniv backwater, and the cooling pond of the Chornobyl NPP. Reference fish were collected from Pidbirna Lake near Kyiv. All specimens were cleared and stained for bone with alizarin red according to the method of T. Potthoff. The absorbed dose rate ranged from 0.07 μGy/h in the reference water body to 58 μGy/h in Glyboke Lake.

Fifteen types of skeletal abnormalities were identified, mainly in the caudal and abdominal regions. The most frequent abnormalities included additional arch and bifurcations of neural and haemal processes (18–68%), vertebral fusion (up to 10%), vertebral deformities and deformities of the terminal vertebra (up to 25%), axial skeletal deformities (kyphosis, lordosis, scoliosis), and rib deformities. In the reference lake, the number of abnormalities did not exceed four per individual, whereas in contaminated water bodies, especially the cooling pond of the Chornobyl NPP and Glyboke Lake, it reached 40 per individual. The highest frequency of multiple and severe deformities was recorded in *R. rutilus*, which also showed the highest proportion of rib deformities (93–98%) and complex axial skeletal deformities. In *S. erythrophthalmus*, up to 23 abnormalities per individual were found, predominantly deformities of neural and haemal processes. In *L. delineatus* from Azbuchyn Lake, the number of abnormalities reached six per individual, with deformities of the terminal vertebra and additional processes predominating. In *R. amarus*, 10–33% of individuals had one to three abnormalities, and the frequency of deformities was higher in contaminated water bodies. A positive association was found between the absorbed dose rate in parent fish and the total number of abnormalities in juveniles.

The study identified the skeletal abnormalities that are most informative for detecting radiation-related effects in juvenile fish. Morphological abnormalities, particularly those affecting the caudal and abdominal regions, the axial skeleton, and the ribs, may serve as sensitive indicators of the ecological status of aquatic ecosystems in the Chornobyl Exclusion Zone.

Keywords: radioecology, radiobiology, fish juveniles, skeletal anomalies, radioactive contamination, Chornobyl Exclusion Zone, absorbed dose rate, freshwater ecosystems, morphological abnormalities, bioindicators

Analysis of environmental background radiation and public exposure in Shkodra District, Albania

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The natural background radiation levels in North Albania are mostly influenced by the geological composition of this region of Albania, including sedimentary and metamorphic rocks, and the presence of natural radionuclides such as uranium, thorium, and potassium-40. The mountainous terrain, particularly in areas like the Albanian Alps and Shkodra region, contributes to variations in environmental background radiation. Background radiation levels in Shkodra district are within global natural ranges, and slight variations may occur due to soil composition, altitude, and cosmic radiation. Regular monitoring is essential for establishing baseline data and ensuring environmental and public health safety.

The study presented in this paper focuses on the analysis of ambient radiation levels in Shkodra district. Institute of Applied Nuclear Physics with the support of the National Agency for Scientific Research and Innovation of the Ministry of Education and Sport conducted this study for the analysis of ambient radiation levels and associated public exposure in Shkodra District. The average dose rate levels in Shkodra district were 0.044 (μSv/h), maximum 0.093 (μSv/h) and minimum 0.017 (μSv/h).

The calculated annual dose received from the public is 0.0915 mSv which is within the allowed dose limit of 1 mSv in a year. As conclusion the dose received from various natural sources for Shkodra district population does not constitute any risk on the health of the population and is within the dose limit for the population described in annex II of Regulation No.801 dt.11.12.2019 “On the protection of the public and professionally exposed employees to ionizing radiation”.

Keywords: geological composition, radiation levels, background radiation, annual dose

Acknowledgments: The authors are grateful to the National Agency for Scientific Research and Innovation of the Ministry of Education and Sport for the financial support in the implementation and realization of this study and its continuous support. Thankful Tirana University and the Institute of Applied Nuclear Physics for supporting and the infrastructure made available for this study.

Radiological characterization, car-borne survey and radioecological risk assessment of soils and air in El Kala National Park, Eastern Algeria

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Human exposure to ionizing radiation, both indoors and outdoors, is primarily due to natural background radiation. This radiation is emitted by radionuclides found in the Earth's crust, along with their decay products, and by cosmic rays.

Humans can also be exposed to artificial radioactivity, such as caesium-137 (^{137}Cs), which is primarily generated through nuclear fission. Understanding exposure pathways is essential for evaluating health risks.

This research aims to assess levels of natural background gamma radiation in air and soils, analyse concentrations of natural and man-made radionuclides in surface soils, and conduct a radiological risk assessment.

Natural background gamma radiation in soils at a depth of 1 m was measured along roads in the vicinity of El Kala (eastern Algeria) using a car-borne spectrometer system (FHT 1376 Mobysis).

A total of 7289 background gamma dose rate data were collected in February 2022. The background gamma dose rate was mapped using MapInfo software.

Long-term radiological monitoring of the air was conducted at the El Kala Station over a period of 28 months, from 13 December 2020 to 11 April 2023. The ambient gamma dose rate was continuously recorded using an AMES MFM 202, with a total of 9 412 data collected.

Seventeen (29) surface soil samples were collected from the eastern region in August 2022. The detailed methodology applied to the HPGe gamma spectrometry treatment and analysis was described by Taieb Errahmani et al. (2020) [Taieb Errahmani et al., *Quat. Geochr., 2020 (56)*].

The measured dose rate at a depth of 1 m was found to be in the range of 6.95–39.7 nSv h^{-1}, with a mean value of 15.6 nSv h^{-1}. The measured ambient gamma dose rate in air was found to be in the range of 35–107 nSv h^{-1}, with a mean value of 43.31 nSv h^{-1}. The radionuclides analysed in the soil by gamma spectrometry were the ^{238}U daughters (^{210}Pb, ^{234}Th, ^{226}Ra, ^{214}Pb and ^{214}Bi), the ^{232}Th daughters (^{212}Pb, ^{208}Tl and ^{228}Ac), ^{137}Cs and ^{40}K. The activity concentrations of ^{137}Cs and ^{40}K in the soil were found to be 12.95 ± 2.66 Bq/kg – 307.57 ± 50.02 Bq/kg and 0.57 ± 0.24 Bq/kg – 21.80 ± 1.42 Bq/kg, respectively.

The average activity concentration of ^{137}Cs (8.98 Bq/kg) is low compared to that detected in soils from a high-altitude site [Taieb Errahmani et al., *J. of Env. Rad.*,2022.242 (106799)].

The radiological risk was assessed by calculating radiological parameters and using the ERICA tool. The results obtained for dose rate and radionuclide activity concentrations were similar to those of other sites in the country where there are no nuclear installations.

Keywords: gamma radiation, soils, air, radioecological risk assessment, ERICA tool, Eastern Algeria

Acknowledgments: The authors would like to thank the Centre de Recherche Nucléaire d'Alger for funding the PR2/2022 research project.

Uranium concentrations in groundwater in a uraniferous region: Case of Santa Quitéria, Ceará State, Brazil

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The main uranium deposit in Brazil is located in the Itataia Mine, between the municipalities of Santa Quitéria and Itatira, State of Ceará, with estimated resources of around 142,000 tons.

Uranium in Itataia does not occur in isolation but is associated with phosphate. The project plans to separate the phosphate and uranium. Phosphate will be used for fertilizers and animal nutrition, while uranium will be used for nuclear fuel for power reactors installed in Brazil. When operational, it is expected to produce approximately 2,300 tons of uranium concentrate and more than 1 million tons of phosphate fertilizers annually.

The project faces resistance from local communities due to high water consumption in a semi-arid region and risks of radioactive contamination. Tests carried out in deep wells in the town of Trapiá, in Santa Quitéria, identified uranium concentrations seven times higher than the limit allowed for human consumption in Brazil (0.03 mg/L). The uranium concentrations in groundwater observed in the region are related to the local geology, which is rich in uranium and phosphates, and not to the operation of a mine, which has not yet begun operations.

About 40 groundwater samples were collected in the municipalities of Santa Quitéria and Itatira, from residences and public buildings. The uranium concentration ranged from <0.001 to 0.186 mg/L, with a median of 0.014 mg/L. The observed maximum value was consistent with previously reported data. Of the total samples collected, 24 were also analyzed for major cations and anions, as well as trace elements. The main issue observed was the hardness, with 90% of the samples exceeding the limit established in Brazilian legislation of 300 mg/L.

Keywords: Brazil, uranium, groundwater, Santa Quitéria

Natural radioactivity characterization in the Vesuvius National Park: Baseline levels and dose assessment for non-human biota

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Radiation protection of the ecosystems is a topic of increasing relevance as criteria traditionally applied to humans are being extended to the entirety of non-human biota [ICRP, Ann ICRP, 2007, 37(2–4)].

In the context of environmental releases of radionuclide-containing materials, particularly of anthropogenic origin, it becomes essential to establish baseline exposure levels to which the biota is locally subjected, which is mainly due to natural radioactivity, prior to performing a risk assessment. Such baseline studies are important when addressing potential contamination in site-specific evaluations [Guillén et al., Environ Sci Pollut Res, 2024, 31].

This study is aimed at characterizing natural radioactivity in the Vesuvius National Park, an area of volcanic origin with Mediterranean climate, where geological features might significantly influence radionuclide distribution and bioavailability. The limited literature data for geologically comparable areas highlights the need for a comprehensive assessment in representative matrices to improve radioecological evaluations.

Gamma-ray spectrometry results will be reported for soil samples and relevant local bioindicators, selected both for their bioaccumulation properties and environmental availability (lichens, mosses, holm oak leaves). These data will be used to calculate transfer factors to biota and to assess the baseline background radioactivity for the area. Dose rates will be estimated using ERICA Tool, a widely recognized software in the literature, and compared with background reference values from its internal database [Brown et al., J Environ Radioact, 2016, 153].

Additionally, a nearby non-volcanic area will also be examined to assess potential differences in environmental radioactivity levels due to geological characteristics.

This will contribute to improving datasets for similar environments, supporting the shift in environmental monitoring of non-human biota in the field of radiation protection.

Keywords: environmental radioactivity, non-human biota, dose assessment, ERICA tool

Atmospheric deposition fluxes of ^{210}Pb and ^{210}Po at Lisbon, Portugal

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The surface deposition of the atmospherically derived 210 Pb and 210 Po was measured in rain collector samples at Lisbon, over a 5-year period. The average annual fluxes were, respectively, 55.7 ± 11.9 Bq yr -1 and 8.3 ± 2.8 Bq m -2 yr -1, with a ^{210}Po/^{210}Pb ratio of 0.15 ± 0.06. The ^{210}Pb flux was positively correlated with the rainfall ($p<0.001$) while the ^{210}Po atmospheric flux showed a lower probability of correlation ($p<0.05$). Based on the annual deposition flux values, the years of higher rainfall correspond to lower ^{210}Po and ^{210}Pb deposition ratios due to the shortening of the ^{210}Po ingrowth time in the atmosphere. The annual ^{210}Pb flux, determined by direct measurement of atmospheric deposition, was confirmed by the computed deposition rates based on the analysis of ^{210}Pb-excess repository in soils. The positive correlation between ^{210}Pb-excess and fallout ^{137}Cs measured in surface soils indicates the similarity of the atmospheric processes operating in the deposition of both radionuclides, in spite of their different origin. The flux of ^{210}Pb reported herein is lower than other measurements made in western Europe due to the strong influence of oceanic air masses in the Lisbon area, at the edge of the European landmass.

Keywords: radioactive lead, polonium, atmospheric deposition, radionuclides in soil

Radioactivity of surface waters in a region with old radium and uranium mines, Portugal

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Radionuclides from uranium, actinium and thorium series were determined in drainage from old uranium mine sites, in water from surface streams receiving such drainage, in main rivers, and water for human consumption in the catchment basins of rivers Mondego and Zêzere, center-north of Portugal. Radionuclide concentrations were high, particularly in association with the suspended particulate matter in mine drainage and in surface streams near mine water discharges. Radionuclide solid-water distribution coefficients (Kd) were generally of 10^5-10^6 for U, Th, Ra, Pb and Po in these freshwater systems and allowed for contaminated sediments being carried downstream for many km. Water for human consumption, distributed through public networks, is supplied from artificial lakes in the region. Radionuclide concentrations in this water were relatively low and not significantly enhanced by uranium mine discharges meeting water quality standards. However, conservation of water resources requires adequate and long-term uranium waste management and regular water quality monitoring.

Keywords: natural radionuclides, uranium mines, environmental radioactivity, drinking water

Irradiation method for insect population control

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The Ionizing Radiation Calibration Laboratory (IRCL) of the Greek Atomic Energy Commission (EEAE) is a national secondary standard calibration laboratory, that performs calibrations in the field of ionizing radiation. It is accredited according ISO 17025 and participates in national and international research programs.

In recent years, in cooperation with the Laboratory of Efficacy Control of Pesticides at the Benaki Phytopathological Institute, a number of Sterile Insect Technique (SIT) irradiations have been performed in IRCL. SIT is available and environmentally friendly method for controlling insect populations not as immediate control strategy but a as gradual population suppression process. It is based on the mass rearing and release of sterilized, yet biologically competitive, male insects into the environment, thereby increasing the ratio of sterile to fertile males. Ionizing radiation damages reproductive cells while maintaining male mating competitiveness. For the technique to be successful, the released sterile males must outnumber fertile males in the target population.

In the present study, a new irradiation method was proposed by the Ionizing Radiation Calibration Laboratory of the Greek Atomic Energy Commission (EEAE) to address the lack of an adequate SIT irradiator in Greece. Irradiations were carried out using a PICKER Co-60 radiotherapy unit, providing a dose rate of approximately 100 mGy/min at a depth of 5 cm in water-equivalent material.

The experimental setup was similar to that used for calibration procedures, and a suitably designed plexiglass irradiation box was constructed to ensure reproducible irradiation conditions. Dose verification was performed using both an ionization chamber and Gafchromic HD-MD-V3 films, following the International Atomic Energy Agency (IAEA) protocol. The films were calibrated against a SCANDITRONIX secondary standard ionization chamber, which ensures traceability to the Bureau International des Poids et Mesures (BIPM).

Adult males were irradiated at doses of 20, 50, 60, and 80 Gy and the results were evaluated for the effectiveness of the irradiation method in terms of male sterility and survival in relation to absorbed dose.

Keywords: Cobalt-60 (Co-60), male sterility & survival, radiotherapy unit, secondary standard calibration laboratory, Sterile Insect Technique (SIT)

Radiological analysis of soil samples: The physicochemical characteristics of the soil and radionuclide migration

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The physical and chemical characteristics of the soil, along with other environmental conditions, affect the migration of radionuclides in the soil and, therefore, their absorption by the plants growing there. In this paper, soil samples from three locations (Aleksinac, Despotovac, and Stara Pazova) were analyzed. The specific activities of ^{137}Cs, ^{40}K, and ^{210}Pb were determined, and the obtained values were discussed and related to the soil's characteristics. At the Aleksinac location, where a temperate continental valley climate prevails, smonica (clay-rich soil with hygroscopic properties) dominates. The Despotovac location is characterized by more acidic soils (cambisol) and a temperate continental-mountainous climate that is cooler and wetter. At the Stara Pazova location, within the Pannonian temperate-continental climate, chernozem (dark, humus-rich soil with neutral to alkaline pH) prevails.

As a result of nuclear accidents, artificial radionuclides (primarily ^{137}Cs) are present in our environment. The ^{137}Cs activity concentrations at Aleksinac and Stara Pazova were (6.1±0.4) Bq/kg and (4.2±0.3) Bq/kg, respectively, while at the third location, Despotovac, the highest concentration was detected (54.2±2.8) Bq/kg. The reason for this may be the soil type (cambisol), which has a lot of silt, and silt has been shown to have the greatest affinity for retaining ^{137}Cs.

For ^{40}K, the measured values at the three locations were: (604±32) Bq/kg for Aleksinac, (733±37) Bq/kg for Despotovac, and (634±33) Bq/kg for Stara Pazova. Soil pH, texture, and moisture strongly influence the availability of potassium, with higher moisture, favorable structure, and organic matter improving mobility, while different soil types show different patterns of potassium supply. In the Aleksinac area, the soil is rich in minerals, and its clayey structure, combined with frequent dry periods, limits the availability of ^{40}K. At the Stara Pazova site, the soil contains abundant humus and potassium. Its alkaline pH reduces ^{40}K uptake, while the recurring summer droughts characteristic of this region further limits the diffusion of potassium ions to the roots.

Along with ^{40}K, ^{210}Pb is a natural radionuclide that originates from the decay of ^{222}Rn in the ^{238}U series and accumulates in the upper soil horizons due to its strong binding to organic matter and fine minerals. The following specific activities of this radionuclide were determined in the analyzed soil samples: Aleksinac - (69.3±5.0) Bq/kg, Despotovac - (41.5±3.1) Bq/kg, and Stara Pazova - (74.3±4.6) Bq/kg. Neutral, clay-rich soils effectively immobilize lead at neutral pH, thereby limiting its mobility towards plant roots. On the other hand, acidic, loose soils increase lead mobility. Based on the above, it can be expected that plants from smonica soil will have the lowest ^{210}Pb uptake, whereas plants from chernozem and cambisol soils will have higher ^{210}Pb accumulation.

Keywords: artificial radionuclides, natural radionuclide, soil

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Natural sorbents for remediation of ^{137}Cs-polluted aquatic environments

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This study is dedicated to the ability to use natural mineral sorbents for remediation of waters, contaminated with ^{137}Cs. ^{137}Cs is an anthropogenic radionuclide ($T_{1/2}$ = 30.17 years) and is synthesized as a fission-product in nuclear reactors and aboveground nuclear weapons explosions. It is released into the environment through nuclear accidents or improper management of radioactive waste. As an alkali metal, it displays high aqueous mobility due to its negligible hydrolysis, persisting predominantly as free Cs^+ ions (>95%) that mimic K^+ ions. Radiocesium demonstrates weak sorption onto inorganic phases (Fe/Mn oxides, $CaCO_3$) which facilitates its rapid dispersion and bioaccumulation risks via trophic transfer. Micaceous minerals are known to have high affinity to retain Cs at the frayed edge sites, which provides an ability for effective remediation of contaminated waters. The efficiency of kaolinite as a Cs sorbent is worth to be considered due to its wide distribution in soils and sediments, offering cost-effective abundance for large-scale applications. In our work we present the sorption degree of ^{137}Cs from waters in wide pH interval, using muscovite, kaolinite and rock, consisted of mineral mixture of muscovite, chlorite, quartz and albite. The sorption of ^{137}Cs was measured by its daughter product ^{137m}Ba at 661.5 keV, by means of gamma-spectrometry. HPGe detector Canberra 7221 coupled to a 16000-channel analyzer DSA-1000 was used. The effects of the mechanochemical activation on the sorption ability of kaolinite was examined. The results showed that the natural rock and muscovite provide better and faster retention of radiocesium, while kaolinite demonstrated the least efficient and most time-dependent uptake. The mechanochemical activation, particularly in organic media, was found to transform kaolinite into a highly effective sorbent for ^{137}Cs retention in a wide pH range.

Keywords: radiocesium, sorption, waters, kaolinite, muscovite, mechanochemical activation

Acknowledgments: This research was funded by the Sofia University Fund, Contract № 80-10-23/01.04.2026, entitled: Ecologically compatible natural and modified minerals and mineral mixtures for water purification and remediation of soils contaminated with Am-241 and Cs-137.

Investigation of the sorption of ^{241}Am by natural minerals for water purification

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The study presents the effectiveness of natural sorbents, such as kaolinite, muscovite and rock, for the purification of water contaminated with americium across a wide pH range for a contact time from 15 to 45 min. ^{241}Am has a half-life of 432.2 years and α-emission, and poses a serious threat to the environment due to its high radiotoxicity and long-term mobility in natural waters. In the context of potential contamination from nuclear incidents or waste, studying its sorption onto natural minerals and modified surfaces is critically important for developing effective remediation strategies. Particularly relevant are natural clays such as kaolinite ($Al_2Si_2O_5(OH)_4$) and micas like muscovite ($KAl_2(AlSi_3O_{10})(OH)_2$), as well as their mixtures with other minerals, since they are widespread in soils and groundwater in Bulgaria and globally. This study aimed to evaluate the sorption efficiency of muscovite, kaolinite and mineral mixtures for ^{241}Am in contaminated waters in acidic, neutral and alkaline media. Mechanochemical activation of kaolinite in different media aiming to increase its sorption efficiency, was performed in planetary ball mill. Measurements of ^{241}Am were performed by gamma-spectrometer Canberra 7221 coupled to a 16000-channel analyzer DSA-1000 with HPGe detector, using its gamma line at 59.9 keV. The results showed that ^{241}Am sorption on kaolinite remains relatively stable between 59% and 72% across the pH range 2.5–11.3. The retention of ^{241}Am on muscovite increased from 61% at to 97% while raising pH from acidic to alkaline. Mechanochemical activation of kaolinite significantly enhanced its sorption efficiency for ^{241}Am, reaching to 99-100 % in alkaline media.

Keywords: Americium, waters, sorption, minerals, mechanochemical activation

Acknowledgments: This research was performed by the financial support of the Sofia University Fund, Contract № 80-10-23/01.04.2026, entitled: Ecologically compatible natural and modified minerals and mineral mixtures for water purification and remediation of soils contaminated with Am-241 and Cs-137.

Determination of natural and artificial radionuclides (^{40}K, ^{137}Cs) activities in freeze-dried foods of plant origin

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During freeze-drying (lyophilization) of food products, the water contained in them in solid form turns into vapor due to the sublimation process. Food products processed in this way become porous, preserving their biological, nutritional and sensory properties. After removing water from food products, dry matter, including radionuclides contained in food products, becomes concentrated. The initial content of radionuclides (^{40}K, ^{137}Cs) in plant-based food products depends on the content of radionuclides in the soil of the growing place and their chemical form. The article presents a study that investigated the amounts of radionuclides (^{40}K, ^{137}Cs) in raw and freeze-dried food products of plant origin: forest mushrooms wrinkled ceps (*Rozites caperata,* growing area – Varėna district, forest near village Puvočiai), Jerusalem artichokes (*Helianthus tuberosus*, growing area – Ukmergė district, Jogvilai village), carrots (*Daucus carota*), beets (*Beta vulgaris* L.) (Molėtai district, Alanta village)). The results of the studies showed that only in mushrooms which were collected at the Varėna district, the specific activity of artificial ^{137}Cs (ceps sample - 144 ± 18 Bq/kg) and natural ^{40}K (ceps sample - 87 ± 17 Bq/kg) radionuclides was determined. In raw samples of food products from other growing areas, only ^{40}K specific activity was determined: Jerusalem artichokes – 165 ± 15 Bq/kg, beets – 90 ±9 Bq/kg, carrots – 149 ±13 Bq/kg. The specific activity of ^{137}Cs during lyophilization of plant-based food products increased by 13.5 times. The specific activity of ^{40}K during lyophilization of plant-based food products increased by an average of 6.8 times. The amount of radionuclides determined in lyophilized plant-based food products was influenced by the density of the initial product and the amount of water.

Keywords: radionuclides, ^{40}K, ^{137}Cs, food products, lyophilization, freeze dried food

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Design of permanent magnetic tubes for use in agriculture for irrigation water magnetization

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In recent years, the number of published research papers that are related to the beneficial use of magnetic field in agriculture has significantly increased. The static magnetic field (SMF), as a type of non-ionizing radiation, is widely perceived as a natural radiation due to its eco-friendliness and because it is of the same type as is the omnipresent geomagnetic field. These advantages of SMF compared to the standard chemical treatments used in agriculture, make it the method of choice when it leads to the comparable improvements of plant health, development, and growth.

The two main methods of application of SMF in agriculture are pre-sowing irradiation of seeds and irradiation of irrigation water. Seed exposure to SMF is shown to improve water and nutrient absorption, resilience, enzyme activity, growth, germination rate, and immune response of plants. These effects are attributed to destabilization, type change, and increase of dipole moments of fatty acids and changes in the structure of proteins and carbohydrates in seeds. Growth and development of plants can as well be improved by irrigation with magnetized water. In this case, faster germination, better root development, and increased biomass result from the improved photosynthesis, nutrient uptake, and efficiency of water usage. Magnetized water also affects the soil by breaking it up, enhancing infiltration, water retention, and decrease of soil pH, which makes nutrients more available. These effects result from the changes that SMF induces in structural, physical, and chemical properties of water. Due to its diamagnetism, in SMF water molecule tends to reorient itself, to shift electrons, and to create opposing weak magnetic field. At the intermolecular level, SMF disrupts hydrogen bonds and reduce cohesion. Consequently, conductivity and evaporation rate of water increase, whereas, its viscosity and surface tension decrease.

The reported experiments with magnetized irrigation water, undertaken in laboratories as well as in fields, were conducted on a wide variety of plants, with SMFs that range from 70 mT to 1.45 T and are most often perpendicular to the water flow.

Our goal is to design modular magnetic tubes that can easily be mounted to commonly used irrigation systems pipes. Each module is composed of neodymium magnets embedded in a plastic tube. Within the tube, water is exposed to relatively homogeneous SMF that can be either perpendicular or parallel to the water flow. The magnetization intensity is defined by the number of modules used.

Keywords: Nd magnets, magnetized water, irrigation, plants, agriculture

Effect of gamma irradiation as a physical mutagen on sunflower seeds

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This study aims to investigate the dose-dependent effects of gamma irradiation on germination, survival, height, and leaf number of sunflowers (Helianthus annuus). A dual-environment study was conducted using a wide spectrum of gamma-ray doses. In a controlled laboratory setting, irradiated seeds (0, 5,10, 30, 60, 90, 200, and 500) Gy were sown in pots. In the field, another group of irradiated seeds (0, 5, 10, 30, 60,100, 200, 500, and 1000) Gy was sown.

The data reveals a classic hormetic response, characterized by low-dose stimulation and high-dose inhibition. Specifically, lower irradiation levels appeared to bolster physiological vigor before reaching a critical inflection point. Laboratory results showed that irradiation at a dose of 90 Gy was close to LD50, and irradiation at doses of 200 Gy and higher caused a lethal effect. Field results showed that irradiation at 200 Gy was close to LD50, while irradiation at 500 Gy and higher caused lethal effects.

Keywords: dose, gamma irradiation, physical mutagen, sunflower seeds, lethal effect

Quantification of the impact of natural ventilation on indoor radon concentrations in schools

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Radon is a naturally occurring radioactive gas that poses significant health risks and is recognised as the second leading cause of lung cancer. Schools are the most important indoor environment for children, apart from home, where they spend a great part of their time. Therefore, monitoring and mitigating indoor radon concentrations in these settings is of utmost relevance. The COVID-19 pandemic reinforced the importance of evaluating indoor air quality (IAQ) in schools and led to the widespread implementation of preventive measures to reduce airborne transmission, including enhanced natural ventilation. This study aimed to quantify the impact of this preventive measure on radon concentrations in nursery and primary schools in an urban area of Porto (Portugal).

The study was carried out in early 2020 (before the COVID-19 pandemic) and early 2021 (during the COVID-19 pandemic) in 13 selected microenvironments (ME), including 10 classrooms and 3 lunchrooms, in two nursery and two primary schools. The ME presented a similar school timetable between the two periods; however, natural ventilation practices were substantially intensified during the pandemic, with windows and doors kept open whenever possible. Radon and CO_2 concentrations were continuously monitored using professional-grade instruments (Radim 5B and Haz-Scanner IEMS, respectively) for 2 to 5 consecutive days. Descriptive statistical analyses and significance tests (Wilcoxon Signed Rank Test) were performed, focusing on the occupancy period.

Median concentrations ranged from 41 to 241 Bq/m^3 (radon) and 1993 to 3759 mg/m^3 (CO_2) in classrooms and from 45 to 54 Bq/m^3 (radon) and 1501 to 2631 mg/m^3 (CO_2) in lunchrooms before pandemic, decreasing to 15 - 68 Bq/m^3 (radon) and 1017 - 2919 mg/m^3 (CO_2) in classrooms and to 37 - 39 Bq/m^3 (radon) and 858 - 1627 mg/m^3 (CO_2) in lunchrooms during the pandemic. These results demonstrate a consistent reduction in both radon and CO_2 concentrations following the implementation of enhanced natural ventilation during occupancy. Moreover, statistically significant decreases (p-value < 0.05) in radon concentrations were observed in 7 out of the 13 studied ME, with reductions of up to 94%.

Although not specifically designed to reduce radon, the findings indicate that simple, low-cost measures such as increased natural ventilation can substantially reduce children's indoor radon exposure in schools without requiring structural modifications. Nevertheless, the short-term nature of this study represents a limitation, highlighting the need for long-term monitoring.

Keywords: indoor air quality, exposure, children, natural ventilation, mitigation, monitoring, COVID-19

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Indoor radon in school buildings of a European radon prone region

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Radon is a recognised carcinogenic indoor air pollutant and a major public health concern in educational settings, where children and staff may be exposed for prolonged periods. This study characterised indoor radon concentrations in school buildings across different provinces/districts of the radon-prone Galicia–Norte de Portugal Euroregion and quantified the relative contribution of specific building and classroom determinants (location, type of management, construction material, season, and floor within the building). Continuous radon measurements were conducted in 416 classrooms across nursery, primary, secondary and higher education facilities, considering urban and rural contexts, public and private management, construction materials, floor level and occupants' age group. Mean and median radon concentrations were 332 Bq·m^{-3} and 181 Bq·m^{-3}, respectively, with approximately 30% of classrooms exceeding the European Union reference level of 300 Bq·m^{-3}, and around 75% exceeded the action level recommended by the World Health Organisation of 100 Bq·m^{-3}. Multivariate linear regression models showed that around 50% of the variability in indoor radon levels could be explained by room/building characteristics, namely location and construction material being the most influential determinants, followed by occupants' age group, floor level and type of management. These findings highlight that elevated radon concentrations are widespread across educational facilities in radon-prone regions and are not confined to specific school types or levels. Systematic radon testing in all school buildings is therefore essential, alongside the development of dedicated sampling protocols and targeted mitigation strategies to reduce exposure and protect vulnerable populations such as children.

Keywords: indoor air, exposure, children, educational facilities, monitoring, building characteristics

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Comparing low-cost and professional radon continuous monitors for real-time monitoring in schools

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Radon is a naturally occurring radioactive gas and one of the leading causes of lung cancer after smoking, representing a significant public health concern. Continuous monitoring of indoor radon concentrations is essential for risk assessment and mitigation, particularly in regions with high geogenic potential. In Portugal, several areas are classified as radon-prone, reinforcing the need for effective and accessible monitoring strategies. In this context, low-cost continuous radon monitors have emerged as a promising alternative due to their affordability, ease of use, and potential for large-scale deployment. This study aimed to compare the performance of two continuous radon instruments: a low-cost device and a professional-grade instrument (considered as reference in the present study). The instruments used were Corentium Pro (professional-grade monitor) and RadonEye Plus 2 (low-cost monitor). Both detectors were co-located and operated simultaneously under identical conditions. The study was carried out in 21 classrooms, from 9 school buildings in the city of Porto (Portugal), a radon-prone area. The mean and median radon concentrations obtained from the professional monitor were 160.2 Bq/m³ and 88 Bq/m³, respectively, with a maximum of 1531 Bq/m³. While the central tendency values (means and medians) are generally below the European Union reference level of 300 Bq·m^{-3}, they exceed the action level recommended by the World Health Organization of 100 Bq·m^{-3}, highlighting the relevance of continuous monitoring in school indoor environments. Moreover, the maximum values observed are substantially higher than both reference thresholds, indicating significant radon peaks that would not be captured by integrated measurements alone and reinforcing the importance of continuous monitoring to identify periods of elevated exposure. The mean and median radon concentrations obtained from the low-cost monitor were higher than those from the professional-grade monitor (191.3 Bq/m³ and 118 Bq/m³, respectively), with maximum values up to 1585 Bq/m³, suggesting that the low-cost monitor tends to overestimate radon concentrations. A strong correlation was observed between the two datasets (Spearman's ρ = 0.932), indicating a high degree of agreement between the low-cost monitor measurements and those of the professional-grade instrument. Bland–Altman analysis revealed a mean difference of -31.16 Bq/m³ and a standard deviation of 66.15 Bq/m³, with 93.8% of the observations within the limits of agreement. This negative bias also indicated that the low-cost monitor tended to overestimate radon concentrations compared to the professional-grade monitor. Overall, the results indicated that, due to the strong correlation observed, low-cost monitors have significant potential for continuous radon monitoring when properly calibrated. Thus, future research should focus on training and testing calibration models for these devices.

Keywords: radon, indoor air, monitoring, exposure, low-cost sensors

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Identifying the primary source of error in the determination of radon activity concentration in water

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Accurate determination of radon (^{222}Rn) activity concentration is important; however, the transition from field sampling to laboratory analysis introduces sources of measurement uncertainty. This study investigates the robustness of standard sampling and storage protocols by analysing how environmental conditions and handling procedures, specifically: temperature fluctuations, mechanical shaking, and sampling techniques, affect ^{222}Rn concentrations in well water samples. Sampling was conducted at a single private groundwater well in the city of Valpovo (Osijek-Baranja County, eastern Croatia) to eliminate hydrogeological influence. Measurements were performed using liquid scintillation counting (LSC) with a TriCarb 2900TR device. The experimental design simulated various field scenarios, including seasonal temperature extremes ("winter" at 5 °C, "spring" at 25 °C, and "summer" at 35 °C), high mechanical shaking during transport, and direct versus indirect (submerged) sampling methods. Statistical analysis included using Shapiro-Wilk tests for normality, followed by parametric (t-test) and non-parametric (Mann-Whitney U-test) evaluations at a significance level of $\alpha = 0.05$. The results indicated that temperature stability during transport—comparing thermally insulated containers with non-insulated bags—showed no statistically significant difference ($p = 0.384$). Similarly, simulated seasonal storage temperatures (5 °C to 35 °C) yielded no significant variations, with p-values ranging from 0.102 to 0.589, suggesting the method's resilience to thermal fluctuations. Intense mechanical shaking during transport also failed to produce a significant loss of radon compared to samples kept in a stable, vertical position ($p = 0.455$). Likewise, no significant difference was observed between samples collected directly into vials and those collected using a submerged hose-and-bucket method ($p = 0.441$). These findings demonstrate that standard sampling, storage and transport protocols for ^{222}Rn in water measurements are remarkably robust against common field stresses, provided that hermetic sealing is maintained. While moderate temperature fluctuations and mechanical shaking do not statistically compromise the results, the study identifies the formation of air bubbles under the vial septum (improper sampling quality) as the most critical potential source of degassing and measurement error. Consequently, while the procedure is robust, strict adherence to airtight sampling techniques remains the primary requirement for ensuring high-quality data in environmental radon monitoring.

Keywords: radon, liquid scintillation counting, water, sampling, storage, transport, measurement uncertainty

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Radon activity concentration and effective dose assessment in two Slovak tourist mines

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Underground workplaces (caves, mines, tunnels) are characterized by an increased health risk from exposure to radon. Several historic mines and galleries in Slovakia now serve as technical monuments and museums. In two of them (Bear Gallery and Salvátor Gallery) radon survey started in December 2024 and is planned for two years. Both galleries are situated in the Northern part of Central Slovakia and are open to the public all-year long with a guide. The aim of the research is to assess spatio-temporal variations of radon and estimate the effective doses for the tourist guides from radon inhalation. The monitoring is performed using CR-39 track detectors, changed in one month and three-months periods. In the Bear Gallery (Western Tatras, Mts.) four monitoring stations were established close to the tourist route. The results obtained during the year 2025 confirmed significant spatial and temporal changes of radon concentration. The lowest radon levels, monthly up to 450 Bq/m^3, were found at the first station situated close to the entrance. On sites 2 and 3, situated further into the gallery, radon values were similar, with monthly levels up to 1000 Bq/m^3. Significantly higher radon levels were measured at site 4, reaching up to 2200 Bq/m^3. On sites 2 and 4 also continuous radon monitoring is carried out from March 2025, using RPP semiconductor detector (Piketronic, CZ) with one hour resolution, showing also significant short-term radon variations. In the Salvátor Gallery (Low Tatras, Mts.) three monitoring stations were established directly on the tourist route and are situated on the dead-end corridors. Radon levels on all sites were similar, reaching monthly up to 600 Bq/m^3. Annual variation of radon was observed with maximum in the spring and summer season. Considering the number of the visits per year, the limit for effective dose equal to 20 mSv per year was not exceeded in both tourist galleries.

Keywords: radon, mine, activity concentration, variation, effective dose

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Development of a Radon-222 primary standard using Defined Solid Angle (DSA) alpha spectrometry: Thermo-Mechanical optimization

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Radon-222 (Rn-222) is a major contributor to natural radiation exposure and represents a well-established health risk due to its alpha-emitting progeny. Ensuring regulatory compliance in radiation protection requires highly accurate and traceable radon measurements, posing significant metrological challenges, particularly with respect to metrologically traceable calibration of monitoring instruments and measurement uncertainty reduction. A key task of National Metrology Institutes (NMIs) is therefore the realization of primary standards for radon gas to guarantee traceability in radiation protection 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 RAP 2025 (submitted to *EPJ Special Topics*). In the DSA method, radon gas is condensed in an ultra-high vacuum (UHV) chamber onto the top of a cryogenically cooled nickel rod, which is enclosed by a thin metal membrane sealed via micro-laser welding; this deposition area is referred to as the cold surface. Solidification occurs below 100 K. Only alpha particles emitted within a well-defined solid angle are detected. This solid angle is geometrically defined by a precision circular diaphragm positioned at a known axial distance from the cold surface.

A critical parameter is the source–diaphragm distance z, defined as the axial separation between the condensation surface and the diaphragm plane. Experimental observations indicate that strong thermal gradients during cryogenic cooling induce mechanical stresses, leading to axial displacements of the cold surface of up to 0.3 mm. Such thermally induced displacements cannot be directly traced using conventional coordinate measuring machines under operational conditions. Since the standard uncertainty of z contributes between 88 % and 97 % of the total variance of the normalized defined solid angle (Geometry Factor) under typical NMI conditions, thermo-mechanical stability represents the dominant uncertainty component.

Finite-element simulations performed in COMSOL Multiphysics are applied to model coupled thermal–structural effects and predict distance variations under realistic cryogenic boundary conditions. The results demonstrate a strong correlation between axial displacement and the effective length of the nickel rod supporting the cold surface; shorter rod geometries significantly reduce displacement magnitude and hysteresis effects. Preliminary findings further indicate that even small thermo-mechanical effects can noticeably influence high-precision configurations and must be explicitly included in the uncertainty budget.

These combined design optimizations and simulation-based corrections enable micrometer-level control of the source–diaphragm distance and support a substantial reduction of the combined standard uncertainty of the geometry factor. The findings strengthen the metrological robustness of the PTB radon primary standard and support the development of harmonized and traceable procedures across NMIs.

Keywords: Radon-222, primary standard, Defined Solid Angle alpha spectrometry, COMSOL Multiphysics, measurement uncertainty, thermo-mechanical effects

Superposed epoch analysis of radon time series associated with seismic swarm activity in the Korçë Basin (Albania)

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A seismic swarm developed along the western and southern margins of the Korçë Basin, a tectonically active half-graben characterized by strong structural interaction with adjacent horst-type blocks. The sequence consisted of more than 20 earthquakes, including the largest event of magnitude M4.1 followed by M3.9 and M4.0 events, displaying clustered swarm-like behavior rather than a classical mainshock–aftershock pattern. This study investigates short-term radon variations associated with this seismic activity using continuous indoor radon measurements recorded at the Sheqeras monitoring station.

The radon time series was analyzed using Superposed Epoch Analysis (SEA), treating earthquake origin times as impulsive key events. Relative radon anomalies were computed with respect to a pre-event baseline and aggregated over a fixed temporal window around each earthquake. Bootstrap resampling was applied to assess the statistical stability of the SEA results. Event-based metrics were also evaluated to examine the dependence of radon variations on epicentral distance and earthquake magnitude.

The analysis reveals a consistent radon anomaly developing in the hours to days preceding the earthquakes, with the strongest contribution associated with the largest-magnitude events of the swarm. The amplitude of the radon response increases with decreasing distance between the monitoring station and the earthquake sources, indicating a clear spatial control on signal detectability.

These results demonstrate that SEA provides an effective statistical framework for identifying systematic radon responses associated with clustered seismic activity and highlight the importance of basin-scale tectonic structure and station–source distance in radon-based investigations of short-term crustal processes.

Keywords: radon monitoring, seismic swarm, Superposed Epoch Analysis, tectonic basin

Assessment of geogenic radon potential in the cities of Yerevan and Gyumri, Armenia

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Radon (^{222}Rn) is a radioactive gas and a leading cause of lung cancer. Because approximately 60–80% of indoor ^{222}Rn accumulation stems from soil gas infiltration, assessing Geogenic Radon Potential (GRP) of urban areas has become a critical priority for public health.

Armenia is a mountainous country characterized by diverse geology. Majority of the territory is dominated by igneous rocks, including both extrusive and intrusive types such as andesites, basalts, dolerites, and granites. In contrast, the south-western plateau is primarily composed of sedimentary formations, such as alluvial and deluvial deposits, sands, and breccias. The territory is characterized by active faults; so, radon risk is expected. Although Armenia has implemented a National Radon Action Plan since 2009, radon mapping has not yet been completed.

In 2022 and 2025 ^{222}Rn measurements in soil gas was implemented in order to outline possible radon prone areas in the major cities of Armenia: capital Yerevan and Gyumri.

In total, 32 measurement points were surveyed in Yerevan and 29 in Gyumri. Activity concentrations of ^{222}Rn in soil gas were measured using DURRIDGE RAD8 electronic detector at a depth of 30-90 cm (depending on the thickness of the soil layer), soil permeability was measured using RADON JOK device. The geogenic radon potential (GRP) was calculated using the internationally accepted formula: $GRP=C_{\infty}-\log_{10}(k)-10$, where C_{∞} is the equilibrium radon concentration (kBq/m^3) and k is the soil gas permeability (m^2).

Measurements of ^{222}Rn activity in urban soils of Yerevan showed significant variability, ranging from 483.0 to 38,375 Bq/m^3, with an average value of 5,347.7 Bq/m^3. Spatial analysis revealed local "hotspots", especially in the central-eastern and southern parts of the city, which mainly coincide with volcanic-sedimentary formations. GRP values ranged from 0.2 to 41.4, with an average of 7.8. High GRP values are found in the Malatia-Sebastia administrative district. ^{222}Rn activity in urban soils of Gyumri ranged from 272 to 39,000 Bq/m^3, with an average value of 7,932 Bq/m^3. GRP values ranged from 0.3 to 36.1, with an average of 8.4. High GRP values are found in the east of the city. The results of the correlation test showed that the potential for ground-source radon depends mainly on the depth of measurement, ^{222}Rn activity in the soil, and gas permeability. The study found a weak positive correlation between radon and carbon dioxide in soil gas.

The data obtained confirm that urban areas of Armenia are classified as low and normal in terms of ^{222}Rn risk, but there is a high GRP in certain areas. The results of this study support the implementation of radon-resistant construction practices in areas with high GRP, which will reduce the collective risk of lung cancer in the population.

Keywords: geogenic radon potential, soil gas, permeability, radon action plan

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Indoor radon as an unmonitored source of radiation dose in healthcare settings

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Occupational exposure to ionizing radiation among healthcare workers is routinely monitored by personal dosimetry and managed within established radiation protection frameworks. In contrast, indoor radon exposure in healthcare workplaces is rarely assessed, although it may contribute non-negligibly to annual effective dose. This study aimed to compare monitored occupational doses with estimated annual effective doses from indoor radon exposure in order to highlight the importance of considering natural radiation sources in healthcare environments.

Occupational dose records obtained from thermoluminescent dosimeter (TLD) monitoring over a six-year period were reviewed for at least 20 occupationally exposed healthcare workers. These data were compared with annual effective doses estimated for indoor radon exposure using standard dose conversion methodology and regional radon data derived from previous indoor surveys and published studies. The analysis aimed to determine whether indoor radon may represent an additional source of radiation dose not captured by routine occupational monitoring.

The results indicate that, under certain indoor conditions, radon-related annual effective doses may be comparable to, and in some cases exceed, the occupational doses recorded by personal dosimetry. This suggests that reliance solely on occupational dose monitoring may not provide a complete picture of the total radiation dose received by healthcare staff when indoor radon is not taken into account.

These findings underline the need to include indoor radon assessment in radiation protection strategies for healthcare facilities, particularly in buildings where staff spend prolonged periods indoors. Integrating occupational dosimetry with indoor radon assessment would provide a more complete basis for dose evaluation and workplace radiation protection.

Keywords: indoor radon, occupational exposure, TLD, effective dose, radiation protection, healthcare environments

Validation of the Portuguese radon gas exposure risk map using workplace measurements

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Radon (Rn-222) is a naturally occurring radioactive and potentially carcinogenic gas, produced by the decay of Ra-226 present in rocks, soils, and water. In Portugal, Decree-Law No. 108/2018 establishes 300 Bq/m³ as the national reference level (RL) for indoor radon concentrations. In 2021, the Laboratory of Natural Radioactivity (LRN) developed the Portuguese Radon Gas Exposure Risk Map (RGERM), based on 1:1M-scale geological units and 3,084 household measurements, complemented by predictors such as Ra-226 activity, uranium concentration in rock samples, Rn-222 activity in soils, and gamma radiation exposure rate. Three risk categories were defined: low, medium, and high.

Over the subsequent five years, the LRN conducted more than 26,000 indoor Rn-222 measurements, mostly in workplaces, using CR-39 passive detectors in accordance with ISO 11665-4:2021. Of these, 10,906 measurements were geocoded and correspond to floors –1, 0, or 1. The national median concentration obtained (36 Bq/m³) is lower than the 139 Bq/m³ median estimated in 2021. Radon distributions differ significantly across floors ($p < 0.05$): on floor –1, 10% of locations exceed 439 Bq/m³, whereas on floors 0 and 1 the 90th percentile remains below the RL.

For the validation of the RGERM, low- and medium-risk units were aggregated, as fewer than 10% of locations exceed the RL, in contrast with high-risk units. Geological units with at least 10 observations were classified based on the new measurements, according to whether the 90th percentile exceeded (1) or was equal to or below (0) the RL.

The risk index correctly classified 81% of the units, with a sensitivity of 63% and a specificity of 86%. The negative predictive value reached 89%, indicating that areas classified as low or medium risk are unlikely to have more than 10% of monitored locations above the RL. Cohen's kappa coefficient (0.46) reflects moderate agreement between classifications. Units classified as high risk show a nine-fold higher probability of exceeding the defined threshold (10%) compared with lower-risk units ($p < 0.05$).

Overall, the results confirm the validity of the RGERM, originally developed using dwelling measurements, even when assessed using a dataset predominantly composed of workplace measurements, which differ in occupancy.

Keywords: risk mapping, radon

Radon in groundwater and radiological characterization under different geological conditions in Kosovo

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Radon in drinking water represents an important source of internal radiation exposure. This study presents a comparative assessment of radon concentration and radiological parameters in groundwater from two locations in Kosovo with different geological characteristics: Stublla (Vitia) and Gelanca (Suhareka).

The results showed significantly higher radon concentrations in Stublla (210–284.3 Bq/L) compared to Gelanca (8.65–12.70 Bq/L). Groundwater samples from Stublla also exhibited elevated radiological parameters, including total alpha activity, total beta activity, residual beta activity, and tritium concentration, whereas most parameters in Gelanca remained below detection limits, indicating low radiological activity. Additional analyses showed relatively low concentrations of uranium isotopes and Ra-226, while Pb-210 activity exceeded the recommended reference level (0.376 ± 0.052 Bq/L), suggesting that the observed radiological signal was mainly associated with radon decay products.

These findings highlight the influence of geological and tectonic conditions on radon occurrence and suggest that radon enrichment is primarily controlled by radon emanation and migration processes from surrounding geological formations. The study also emphasizes the need for regular groundwater monitoring in areas with favourable geological conditions for radon accumulation.

Keywords: radon in groundwater, groundwater radioactivity, radiological characterization, Pb-210, tritium, gross alpha activity, gross beta activity, geological influence, Kosovo groundwater

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Spatiotemporal distribution of dissolved Rn-222 in Yerevan drinking water and associated health risk assessment

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Introduction. Radon (Rn-222) has been identified as the most significant source of natural radiation, accounting for approximately 47% of the annual effective dose for the general population. In Armenia tap water of underground origin constitutes a primary factor in the internal and external exposure to radon, which has the potential to affect the human body in three distinct ways: ingestion, inhalation of the gas released during water use, and through the dissolution of radon in the blood.

Purpose. The aim of this study was to evaluate the spatiotemporal distribution of Rn-222 activity dissolved in tap water in Yerevan, the capital of Armenia, during the period 2023-2025, and to assess the associated health risk.

Methods. During the research, 354 tap water samples were measured and taken from 12 administrative districts. Water samples were collected from all administrative districts of Yerevan and measured with DURRIDGE RAD7 and RAD8. The data obtained were compared with the water consumption habits of different population groups, which were revealed through the Food Frequency Questionnaire (FFQ).

Results and Conclusion. The results of the study showed significant variations in Rn^{-222} activity between the administrative districts of Yerevan. According to statistical data, the highest average radon activity was recorded in Ajapnyak (5.92 Bq/L) and Arabkir (5.46 Bq/L) administrative districts. The lowest average indicators were observed in Shengavit (1.62 Bq/L) and Kanaker-Zeytun (1.72 Bq/L). These differences are due to the peculiarities of the water supply network and different sources of water located in regions with different geological structures. A clear seasonal trend was observed in the monitoring results, with higher concentrations in winter and spring.

Although the measured concentrations did not exceed the regulatory limit of 60 Bq/L, risk modeling showed that consumers with large water volumes could approach the WHO individual dose criterion (0.1 mSv/year) at the highest concentration and highest consumption.

Conclusion. The results highlight the importance of integrating probabilistic risk assessment into national drinking water regulations and the importance of establishing an action level framework for the presence of radon in water in Armenia.

Keywords: radon, risk, tap water, drinking water

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Uncertainties in indoor radon risk assessment: Field insights from Kosovo

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Accurate assessment of indoor radon exposure is essential for reliable evaluation of radiation related risk; however, significant uncertainties remain in both measurement and dose estimation. This study presents a critical analysis of the main sources of uncertainty in indoor radon risk assessment, combining evidence from literature with field observations from hospital measurement campaigns in Kosovo.

The analysis identifies three main categories of uncertainty: (i) measurement related factors, including detector placement, calibration conditions, and counting procedures; (ii) environmental variability, illustrated by temporal fluctuations observed in active monitoring data; and (iii) dosimetric assumptions, including equilibrium factors, occupancy time, and dose conversion coefficients. Attention is given to the difference between long-term average concentrations and short-term temporal variations, which are not resolved by passive measurement techniques.

Field observations indicate that practical constraints and non-standardized measurement conditions may significantly affect the reliability of reported radon concentrations and derived dose estimates. In addition, the use of simplified assumptions in dose calculations may lead to under or overestimation of actual exposure.

The study highlights the importance of quality assurance, standardized measurement protocols, and transparent reporting of assumptions and uncertainties in radon studies. These findings contribute to a more realistic interpretation of risk related to radon and support the development of more robust assessment frameworks, particularly in regions with evolving monitoring infrastructure.

Keywords: indoor radon, uncertainty, measurement error, dose estimation, environmental variability, radiation protection

Determination and analysis of radon activity concentration in Albanian groundwater

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In many countries, groundwater represents the main source of drinking water. As these waters remain in continuous contact with geological formations, the presence of elevated uranium concentrations in rocks can lead to the release of radon gas, which subsequently dissolves into the water. Although the amount of radon inhaled through breathing is greater than that ingested through drinking water, it remains important to raise awareness among national authorities and the general public regarding the risks associated with radon exposure.

According to Decision of the Council of Ministers No. 957, dated December 2, 2015, entitled "Regulation on guideline levels of radon concentration in indoor environments and radionuclide concentrations in goods affecting the general public," Article 6, point 2, a reference level of 100 Bq/L is established for radon concentration in water intended for public consumption. Currently, no monitoring plan exists for radon gas concentrations in water samples in Albania.

The aim of this study was to determine the activity concentration of radon gas in groundwater at the most frequented locations in Albania. Two parallel measurements were performed for each location.

The measurements were carried out using the Sarad RTM 1688-2 instrument at the Institute of Nuclear Physics in Tirana, in close collaboration with the Faculty of Geology and Mining. This work was conducted within the framework of the project entitled "Chemical, radiological, and microbiological characterization of geothermal waters used for therapeutic purposes in Albania" (AKKSHI).

The results showed that the levels of radon gas activity level in the water samples were within the reference level of 100 Bq/l.

Keywords: radon gas, drinking water, Rn-222, radioactivity

Indoor radon levels in residential dwellings in Suhareka, Kosovo

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Indoor radon concentrations were assessed in nine residential dwellings of different construction ages to evaluate the influence of floor level, room type and building characteristics. Measurements were carried out using CR-39 passive detectors and RadonEye active monitors over an 88-day period during the winter season, in dwellings with levels ranging from the basement (–1) to the second floor (2).

The mean annual indoor radon concentration was 59.7 Bq m^{-3}, corresponding to an average annual effective dose of 2.8 mSv $year^{-1}$. The highest values were observed in basements and ground floors, with a gradual decrease at higher levels. Older dwellings exhibited higher radon concentrations, whereas newer buildings showed lower levels, with intermediate values observed in mid-age constructions. A slightly higher radon concentration was observed in bedrooms compared to living rooms. These findings indicate a low radiological health risk, as the observed levels are well below the reference level of 300 Bq m^{-3} established by Kosovo legislation for dwellings.

Keywords: indoor radon, residential dwellings, CR-39 detectors, active radon monitors, vertical distribution, annual effective dose

Acknowledgments: I thank all co-authors for their valuable contribution.

Implementation of building practices for radon protection in Germany – DIN/TS 18117-1 and 18117-2 as guides to mitigate radon concentrations in buildings

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Balancing radon mitigation with mandatory laws to reduce lung cancer involves multi-sectoral stakeholders. In Germany, the Radiation Protection Act establishes a reference level (RL) for assessing indoor radon in common rooms and workplaces. If more than 10% of buildings in an area might exceed this RL, it's labeled radon-prone, requiring protective measures in new constructions and workplaces. Private owners of existing buildings aren't obliged to make modifications, though it's encouraged voluntarily. According to Ordinance/§154, new private constructions must implement radon reduction methods alongside standard moisture protection. Despite many regions not meeting the 10% RL exceedance, a significant number of buildings nationwide likely face elevated radon levels due to environmental or human-caused anomalies. Preventive measures in building practices, as outlined in the new DIN/TS 18117-1/2, provide structural and ventilation guidelines for radon protection. These prestandards aim to inform and encourage voluntary implementation among stakeholders, potentially reducing radon health risks nationwide.

Keywords: radon, radon mitigation, buildings, Radiation Protection Act, preventive measures, DIN/TS 18117-1/2

Comparative analysis of RadonEye monitors for radon activity measurements in laboratory conditions

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The RadonEye+2 (RD200P) and RadonEye RD200 were monitored for radon activity measurements in a semi-underground, poorly ventilated laboratory. During a one-month intercomparison, environmental parameters remained relatively stable, with temperature and humidity ranging from 17.5–26.5°C and 31–45%, respectively. While both monitors showed a strong correlation (r = 0.941) in tracking radon trends, distinct numerical differences were observed. During the study period, the average radon concentrations measured by the RadonEye+2 and RadonEye RD200 were 524 Bq/m³ and 400 Bq/m³, respectively. The RadonEye+2 consistently reported higher values, with an average relative percent difference (RPD) of 26.9%. High variability was noted at lower levels (< 200 Bq/m³), reaching up to 43%. Conversely, at very high levels (> 1000 Bq/m³), the monitors consistently diverged, with the RD200 trailing the RadonEye+2 by 25–35%. The readings were most synchronized when radon levels were between 500 and 750 Bq/m³. These discrepancies are likely due to internal calibration offsets or inherent differences in sampling sensitivities. Data suggest that the measured radon concentrations were not influenced by temperature or humidity, as correlations with these parameters were negligible.

Keywords: Intercomparison, RadonEye+2, RadonEye RD200, Relative Percent Difference (RPD), correlation

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Radon levels in energy-renovated schools in North Kosovo and Metohija

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Energy-efficient buildings are designed to provide comfort and a pleasant working and living atmosphere. However, renovation processes can sometimes make a building airtight, trapping radon indoors and leading to long-term exposure risks. It is crucial to test for radon before, during, and after energy renovations, especially in radon-prone areas.

This research presents radon concentrations in 20 energy-renovated schools in North Kosovo. The study was conducted in 76 classrooms that underwent full or partial renovation, including facade improvements, wall insulation, and the replacement of roofs, windows, and floors. Charcoal canisters were placed on tables in the center of the classrooms over a weekend (for approximately 48 hours), at the beginning of July 2025.

Radon concentrations in the classrooms ranged from 8 ± 2 to 639 ± 22 Bq/m³, with an overall average of 144.2 Bq/m³. On average, radon levels in half of the schools exceeded 100 Bq/m³. The highest mean radon level (590 Bq/m³) was recorded in a ground-floor school in the settlement of Grabovac, where high radon concentrations in dwellings had been previously documented. Since energy renovations often reduce natural air exchange, there is a need to re-introduce controlled airflow by mechanical ventilation with heat recovery, active soil depressurization, and structural sealings.

This study highlights a critical conflict between energy efficiency and indoor air quality of schools in North Kosovo and Metohija. While renovations have improved thermal comfort, the resulting airtightness has led to radon accumulation. These findings, underscore the need for integrated radon protection in building retrofits. To ensure a healthy learning environment, it is essential to move beyond passive energy saving and implement active mitigation strategies. Future energy renovations in radon-prone regions must include pre- and post-intervention monitoring to prevent long-term radiological risks to students and staff.

Keywords: radon, school, energy-renovation, health risk, mitigation, Kosovo and Metohija

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Radon in drinking waters from local natural sources of monasteries in Kosovo and Metohija, Serbia

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Numerous studies indicate that the presence of radon in drinking water leads to internal exposure, both directly (through the processes of radioactive decay, ingestion and inhalation) and indirectly (when combined as part of the food chain). In the area of Metohija, the research covered 11 monasteries, which are supplied with drinking water exclusively from natural underground water sources in the immediate vicinity of the buildings. Water from natural sources is used not only for drinking, but also for wider use, so we can consider them as alternative sources of supply. During the research, water was sampled from 13 measuring points - one well, two natural springs and ten public fountains. The concentration of radon activity in water was measured using the alpha spectrometric method with a RAD7 device (Durridge Co.). The measured radon concentration in all 13 samples is in the interval from 2.2±1.0 Bq/l to 18.7±4.5Bq/l, with a mean value of 6.6±2.0 Bq/l. If the measured radon concentrations are compared with the recommended WHO value of 100Bq/l, and with the recommended USEPA value of 11.1 Bq/l, it can be concluded that the waters from these localities are radiologically correct. During sampling, water temperatures and pH values were measured, the average values of which are 17.8 ^{o}C and 7.2, respectively. The rate of ambient dose equivalent of gamma radiation was measured at the sampling site using the RADEX RD1503+ device, with mean value is 114 nSv/h.

The carcinogenic effect of radon, in the long-term sense, refers to the determination of the annual effective dose by ingestion of radon present in water, which ranges from 0.5±0.2 μSv/y to 3.9±0.9 μSv/y, with a mean value of 1.4±0.4 μSv/y. If we start from the assumption that during ingestion the stomach tissue is most exposed to radiation, the mean value of the dose received by the organ on an annual level is 0.17 μSv/y. ELCR is a quantity that defines the probability that people will develop cancer during their lifetime due to chronic direct exposure to radon in water, the mean value of which in these studies is 0.006 × 10^{-3}.

Keywords: radon, drinking water, natural sources, annual effective dose by ingestion

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The contribution of waterborne radon to indoor radon in residential homes in the region of Kosovsko Pomoravlje, Southern Serbia

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In rural, semi-urban and urban areas where there is no regular supply of water from central waterworks, the population is supplied from alternative sources, primarily from underground mineral water sources. The concentration of radon in water, which is widely used in households, is a function of various parameters, such as the geomorphological characteristics of the aquifer, the way water moves, water-rock interaction, and the mineral content in rocks. To protect the population from the consequences of excessive exposure to radon in their environment, it is necessary to assess the level of radon in every source, including household water, especially water from alternative sources. Ingestion of radon can cause stomach cancer even at low concentrations, while water with elevated radon levels can cause radon diffusion into rooms and increase the total radon level and thus indirectly lead to an increased risk of lung cancer. Here are presented the results of research at 14 locations in rural and semi-urban areas in the Kosovsko Pomoravlje region. The concentration of radon in natural mineral water, which is traditionally used for drinking, but also for other household needs, was measured. The measured concentration of radon in water ranges from 2.2±0.5 kBq/m^3 to 340.7±35 kBq/m^3, with an average value of 38.2±3.9 kBq/m^3. The mean value of the contribution of waterborne radon from water to total indoor radon in the premises of family houses is 13.6±1.4 Bq/m^3. The mean annual effective inhalation dose is 317.6±32.4 μSv/y, while the mean effective ingestion doses of different age groups are as follows: for infants - 202.1±20.6 μSv/y, for children - 74.4±7.6 μSv/y and adults - 97.6±9.9 μSv/y. If we exclude the high value of radon concentration in the water at one locality, the calculated effective doses of inhalation and ingestion at other localities are below the recommended value of 100 μSv/y, which leads to the conclusion that from a radiological point of view the water is correct and can be used both for drinking and for other needs from all the investigated measuring localities.

Keywords: waterborne radon, contribution to indoor radon, health risk

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Continuous radon measurements and environmental correlations in the “Trepča” Mining District

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This paper presents the results of continuous indoor radon measurements conducted in a semi-underground laboratory in Kosovska Mitrovica, situated within the “Trepča” mining district. Measurements were performed using Corentium Home detectors (method - alpha spectrometry) from September 16, 2022, to July 11, 2023. Diurnal radon concentrations ranged from 90 to 1446 Bq/m³, with a long-term average of 475 Bq/m³. These values significantly exceed the World Health Organization (WHO) reference level of 100 Bq/m³ and the European Union limit of 300 Bq/m³ (Directive 2013/59/EURATOM).

The study also analysed the relationship between radon levels and meteorological parameters. Comparative analysis of mean monthly values revealed a moderate negative correlation between indoor radon and precipitation ($r = -0.5$), while the correlation with outdoor temperature was negligible ($r = 0.08$). Additionally, the high radon concentrations may be attributed to the laboratory’s proximity to a deep fault zone, facilitating radon transport through permeable soil, and potential influence from underground activities in the nearby “Stari Trg” mine. The results confirm that the study area qualifies as a radon-prone area (RPA), consistent with previous research in the region.

Keywords: indoor radon, geogenic radon potential, mine, meteorological parameters

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Determination of radon activity concentration in indoor air at groundwater source facilities in Albania

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Groundwater is the main source of drinking water in many countries. Owing to its continuous interaction with geological formations, high uranium concentrations in rocks may result in the release of radon gas, which can dissolve into the water. Part of this dissolved radon is then released into the environment when the water first comes into contact with air, as well as during its flow and agitation at the source. For this reason, increasing awareness among national authorities and the general public about the risks associated with radon exposure is of considerable importance.

The regulatory framework in Albania, defined by Decision of the Council of Ministers No. 957, dated December 2, 2015, titled "Regulation on guideline levels of radon concentration in indoor environments and radionuclide concentrations in goods affecting the general public," specifies in Article 6, a reference level of 300 Bq/L for radon concentration indoor.

This study aims to determine the activity concentration of radon gas in air at the most frequented groundwater source locations in Albania. For each location, two parallel measurements were conducted.

The measurements were carried out using the RADON EYE+2 instrument at the Institute of Nuclear Physics in Tirana, in close collaboration with the Faculty of Geology and Mining. This work was conducted within the framework of the project entitled "Chemical, radiological, and microbiological characterization of geothermal waters used for therapeutic purposes in Albania" (AKKSHI).

Keywords: radon gas, drinking water, Rn-222, radioactivity

Analysis of the proteomic profiles in serum of mice treated with RadioDefender, a novel radiation medical countermeasure

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Exposure to high doses of ionizing radiation arising from nuclear attacks or radiological emergencies can result in the development of acute radiation syndrome (ARS). Current treatments for ARS are limited to radiomitigators that help restore immune cell and platelet production along with bone marrow function. However, there are no radioprotectors available for use as a prophylaxis for military and first responders, although many are under investigation. RadioDefender is a candidate radioprotective agent derived from amifostine, a limited use drug with radioprotective properties. Previous investigations in pre-treated human hematopoietic stem cells exposed to γ-radiation and mouse survival studies have shown that this candidate drug improves cell viability, supporting its potential for further development as a radioprotector. In this study, mice were treated with a single dose of either RadioDefender (250, 500, 600, or 700 mg/kg) or vehicle 24 hours prior to 9.2 Gy total-body γ-irradiation. Blood was collected at 30 days post-irradiation and serum was isolated for proteomic analysis. As part of a larger investigation into the safety of RadioDefender, this study was performed to assess the efficacy of selected doses in combination with radiation exposure. Vehicle-treated animals were compared to each drug group in addition to a healthy control group to assess any protective effects of RadioDefender and the acute effects of ionizing radiation, respectively. At 30 days post-irradiation, minimal proteomic changes were observed between any of the groups, suggesting that both irradiation- and drug-induced changes subsided by this time point and no evidence of lasting toxicity was observed.

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. XL and JZZ are employees of Zymeron Corporation. The remaining authors declare no conflict of interest.

Keywords: acute radiation syndrome, radioprotector, proteomic analysis

Ensuring radiation protection through strict regulations in Australia: Clinical and industrial perspectives

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Strict regulatory frameworks are fundamental to enhancing radiation safety and protection in Australia, particularly in clinical and industrial settings where ionising radiation is routinely used. Across all states and territories, legislation governs the safe use, management, and control of radiation sources to protect patients, workers, and the environment from the harmful effects of unnecessary or inappropriate exposure. These frameworks emphasise licensing, compliance, monitoring, and enforcement as central mechanisms through which safety and protection objectives are achieved.

In Australia, each jurisdiction has enacted specific radiation protection legislation that aligns with nationally consistent principles and standards. Central to these regulatory frameworks is the requirement that radiation practices, whether clinical (such as diagnostic imaging, nuclear medicine, and radiotherapy) or industrial (such as industrial radiography and non-destructive testing), be conducted under appropriate licences. Licences are granted only when applicants demonstrate adequate safety management plans, qualified personnel, and radiation protection measures. Monitoring of compliance is undertaken through a combination of inspections, audits, reporting requirements, and radiation dose monitoring to ensure ongoing adherence to safety standards and legal requirements. Regulatory authorities, including state environment protection agencies and health departments, are empowered to impose enforcement actions for non-compliance, ranging from warnings and improvement notices to licence suspension, cancellation, fines, and prosecution [www.health.vic.gov.au].

Penalties for breaches of radiation legislation are deliberately stringent to deter unsafe practices. In Victoria, for instance, individuals and companies face penalties equivalent to hundreds of thousands or even millions of dollars if they conduct radiation practices without licences or contravene licence conditions, while other jurisdictions impose fines and potential imprisonment for serious offences.

By requiring licences, enforcing compliance, and prescribing penalties, these regulatory frameworks ensure that radiation sources are used only by competent professionals and within controlled environments, thereby minimising the risk of unintended exposures. In clinical settings, this results in safer diagnostic and therapeutic procedures, the implementation of quality assurance programs, and robust systems for incident reporting and investigation. In industrial contexts, compliance with radiation protection plans, equipment testing, and environmental monitoring safeguards workers and the public. In this paper, I will discuss how Australia's strict radiation regulations create a culture of accountability and continuous improvement that underpins both clinical and industrial radiation safety.

Keywords: radiation safety, radiation protection, radiation regulation, radiation licensing and enforcement, risk management

Pediatric CBCT in radiotherapy: Dosimetric evaluation and national practice variability

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Introduction. Cone-beam computed tomography (CBCT) is widely used in image-guided radiotherapy for patient positioning. In pediatric patients, increased radiosensitivity and longer life expectancy require careful management of imaging dose. This study aimed to quantify CBCT dose in pediatric and adult settings and to characterize pediatric CBCT acquisition practices across Portuguese institutions [Bryce-Atkinson et al., Clin. Oncol., 2020, 32(12); Olch & Alaei, J. Appl. Clin. Med. Phys., 2021, 22(2)].

Methods. A national survey was conducted to collect CBCT acquisition parameters (kV, mAs, and number of projections) used in pediatric radiotherapy. In parallel, an experimental dose assessment was performed using a linear accelerator-mounted CBCT system. The weighted Cone Beam Dose Index (CBDIw) was measured using a 100 mm pencil ionization chamber and CTDI phantoms representing pediatric and adult anatomies. Head, thorax, pelvis, and Image Gently protocols were evaluated.

Results. The survey revealed substantial inter-institutional variability, particularly in thorax and pelvis protocols, with large differences in mAs and number of projections. Dosimetric results showed consistently higher CBDIw values in pediatric phantoms compared to adult phantoms for equivalent protocols. For pediatric phantoms, CBDIw reached up to 44.37 mGy in pelvis protocols, while adult values were approximately half for comparable configurations. Image Gently protocols yielded the lowest doses, ranging from approximately 1.23 to 1.65 mGy in pediatric settings and below 1.23 mGy in adults.

Conclusion. CBCT contributes a non-negligible imaging dose in radiotherapy, particularly in pediatric patients. The observed variability in clinical practice and the higher dose levels in smaller phantoms highlight the need for size-adapted protocols. The implementation of optimized acquisition strategies and systematic dose monitoring is essential to improve radiation protection and promote harmonization of clinical practice.

Keywords: cone-beam computed tomography, pediatric radiotherapy, image-guided radiotherapy, imaging dose, dose optimization

Radiological impact of prolonged outage on neutron activation: A case study of Kori Unit 2 in Korea

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Long-term operation of nuclear power plants often involves regulatory review periods that may lead to a prolonged outage prior to restart. Such interruptions can significantly influence activation inventories and associated radiation fields, thereby affecting maintenance planning, occupational exposure, and radioactive waste management.

This work investigates the radiological consequences of a prolonged outage of approximately 950 days at Kori Unit 2, the pressurized water reactor (PWR) of Korea. Radiological inventories are evaluated using FISPACT-II code, enabling neutron activation analysis for representative corrosion and structural materials. A comparative analysis with a continuous operation scenario was performed to identify key differences in isotope dominance and dose-rate behavior.

The results show a pronounced reduction in radionuclides with short and intermediate half-lives, shifting the radiological spectrum toward longer-lived isotopes. While this transition may reduce near-term dose rates, it does not necessarily translate into proportional reductions in collective dose due to expanded inspection scopes during restart preparation.

This study highlights the importance of incorporating outage duration into activation assessments and demonstrates how physics-informed evaluations can support risk-informed maintenance planning for reactors approaching or undergoing long-term operation.

Keywords: pressurized water reactor, neutron activation, radiological inventory, prolonged outage, FISPACT II

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A comparative study on neutron energy spectrum evaluation methodologies for radiological inventory analysis between CANDU-type and PWR reactors

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Accurate estimation of the radiological inventory is a key element in the planning and implementation of nuclear reactor decommissioning, particularly in relation to safety analysis, waste classification, and cost optimization. These assessments largely depend on neutron flux and energy spectrum information, which are crucial for predicting activation products in reactor structural components. However, existing methodologies for radiological inventory evaluation often lack standardization and reproducibility, especially for CANDU-type reactors, which exhibit fundamentally different core geometries and neutron moderation characteristics compared to pressurized water reactors (PWRs).

This study presents a methodological approach aimed at standardizing the radiological inventory assessment process in the context of CANDU-type reactor decommissioning. A comparative analysis was conducted between PWR and CANDU-type neutron energy spectrum distributions in bioshield regions, with particular attention to spatial resolution and spectral shift behavior.

The results reveal significant spectral variations that necessitate tailored evaluation strategies when applying computational codes for radionuclide generation analysis. Based on these insights, this work proposes a standardized neutron spectrum evaluation methodology, including optimized spatial differencing and energy group structures suited to the characteristics of CANDU reactors.

The proposed approach is expected to improve the accuracy and consistency of radiological inventory predictions, contributing to more reliable activation product estimations and providing a basis for regulatory guidance in decommissioning projects.

Keywords: nuclear reactor decommissioning, radiological inventory, neutron energy spectrum, CANDU, PWR

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Radiological characterization of activated materials at CERN using synthetic data and statistical learning

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Activated materials generated during the operation, maintenance, and dismantling of high-energy particle accelerators require reliable radiological characterization for radiation protection and waste management. At CERN, this task is complicated by the wide variability of irradiation fields, material compositions, irradiation times, and cooling times. Traditional approaches based on the most penalizing activation scenario are robust, but can become overly conservative in such complex activation environments.

We present a characterization approach based on statistical models trained on synthetic activation scenarios generated from deterministic activation calculations. In particular, irradiation and material parameters are sampled from probability distributions derived from operational experience, generating more than 100,000 representative activation scenarios. For each scenario, the radionuclide inventory and measurable indicators, such as dose rate, gamma-spectrometry observables, and total gamma-counting signals, are then calculated with ActiWiz, a CERN-developed code based on FLUKA Monte Carlo simulations and neutron libraries.

These datasets are used to derive statistical models that relate measurable quantities to the underlying radionuclide inventory. The method supports both the derivation of decision thresholds for radiological classification and the estimation of difficult-to-measure radionuclides from routine measurements. It is benchmarked against more than one thousand gamma-spectrometry measurements on waste packages and several hundred radiochemical analyses, showing that the synthetic populations reproduce the main radiological properties observed in practice.

Its application to CERN waste-characterization workflows shows fewer false positive classifications and reduced measurement effort compared with more traditional approaches, while maintaining a conservative basis for radiological decisions. This method can be transferred to other accelerator or nuclear facilities by adapting the input parameter distributions to local operational conditions.

Keywords: radiological characterization, activated materials, radioactive waste management, particle accelerators, synthetic data, statistical learning, activation calculations radionuclide inventory gamma spectrometry decision thresholds

Radiological protection aspects: Radiostrontium in agroecosystem

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Radiostrontium has been released to the environment since the development of the nuclear industry in the beginning of the last century, and after 1950 researchers recognized the importance of the uptake of radiostrontium by chain "plant-animal-human". After the accidents in nuclear power plants Chernobyl in 1986 and Fukushima in 2011, the need for extensive research of Sr-90 has emerged. Since it has a long half-life and participates in the mineral metabolism of organisms, is one of the most hazardous radionuclides. Consequently, this study focuses on the radiological protection aspects of Sr-90 in agricultural soil-crop system.

Research was conducted at the experimental agricultural farm "Radmilovac" near Belgrade, Serbia. Content of Sr-90 in investigated soil and crop samples (winter wheat and maize) is determined by validated radiochemical method, accredited according to requirements ISO/IEC: 17025. The detection was performed by beta spectrometry using a low-level gas proportional counter *Thermo Eberline FHT 770T*. To determine Ca concentration in samples, ICP-OES analytical technique, was applied and samples were measured using *iCAP6500 duo* spectrometer. Based on the measured values of Sr-90 activity and Ca concentration in the investigated samples, assessment of the following radioecological parameters is performed: soil-crop transfer factor (*TF*), strontium unit number (*SU*), discrimination coefficient (*DC*), protection coefficient (*PC*), and K-parameter. The TF values, calculated as ratio of Sr-90 activity in crop and soil, confirmed that resuspension from the soil is the main mechanism of accumulation of this radionuclide in crops, as well as that the major part of the activity accumulates in the crop root, and a smaller part translocates to other plant organs. The SU factor, value that shows the level of Sr-90 activity related to its metabolic analogue Ca, indicates that the rate of accumulation of Sr-90 relative to Ca from the soil depends on the type of crop. The values of the DC (transfer degree of Sr-90 and Ca from soil to crop) and PC (reciprocal value of DC) indicate the dependence on the type of crop. Also, these parameters depend on the type of soil and on the Ca content in the soil and crops. The effect of deposition of the radionuclide Sr-90 expressed via K-parameter (ratio of Sr-90 activity in investigated soil profiles) showed a negative gradient in the investigated soil profile. The results of this study contribute to the expansion of the database on radiological protection aspects of Sr-90 in the agroecosystem, which is of great importance for decision making in agriculture.

Keywords: radiostrontium, agricultural soil, crops, radioecological parameters

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Total personal risk assessment corresponding to multiple exposures to two or more CBRN agents

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In some cases, more than one CBRN agent can expose a person. The total risk may be assessed as the sum of the risks across all exposure components. However, it is difficult to quantify these individual contributions with a single number, making it almost impossible to assess total risk as the sum of individual risks. Moreover, we must assess risks from internal and external exposure and also account for the distinct nature of risks arising from stochastic and deterministic effects. The paper presents a comprehensive overview of the current approach to evaluating the total risk from multiple exposures to all CBRN agents involved. Special attention is given to inconsistencies in the definitions of radiation quantities and their corresponding units.

Keywords: CBRN, individual agents, risk, total risk, multiple exposure

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Enhanced biosorbents: Green direction for radionuclide removal

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Radionuclide immobilization technologies have undergone significant transformations over the past few years due to the increasing demand for effective removal methods. With an emphasis on sustainable systems and green environment development, a new path of the sorption technique that includes sorbents derived from predominantly natural sources has emerged. Unlike traditional biosorbents for wastewater purification (algae, bacteria, yeast, fungi, and agricultural and industrial wastes), the biopolymer matrix provides tunable properties and sorption capacity by adding reinforcing particles. Incorporation of nano- or micro-sized fillers into the polymer carrier creates hybrid materials, known as polymer composites. Nano-sized fillers result in improved sorptive properties due to increased ion-particle interaction and a higher surface-area-to-volume ratio. Subsequently, the polymer nanocomposite materials are capable of efficiently eliminating radionuclide ions through an adsorption process. A step forward to advanced sustainable biosorbent design should consist of combining biopolymers derived from natural sources, incorporated with biowaste materials. Further investigation is required to adequately estimate the suitable ratio between the biopolymer matrix and filler content, as well as the structural integrity of the nanocomposite. An additional drawback is related to obtaining the desired nanofiller size, which is a high-energy operation. Assessing the cost-benefit of both the biopolymer nanocomposite synthesis and the overall technological process is one of the most crucial aspects for an optimized scale-up plan.

Keywords: radionuclides, biopolymers, nanocomposites, wastewater treatment

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Natural radioactivity and radiological hazards in the most widely consumed nuts in West Africa

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The presence of naturally occurring radioactive materials (NORMs) in foodstuffs, particularly nuts, has raised concerns due to potential health risks associated with prolonged ingestion. The presented study aims to investigate the activity concentrations of ^{40}K, ^{226}Ra, and ^{232}Th radionuclides in three widely consumed nuts in West Africa: kola nuts (Cola nitida), bitter kola (Garcinia kola), and African walnut (Plukenetia conophora). Samples from the Iyana-Iba market in Lagos, Nigeria, were collected and analyzed with gamma spectrometry. The mean activity concentrations of ^{40}K, ^{226}Ra, and ^{232}Th were 108.6 (BDL-163.5) Bq/kg, 33.4 (BDL-72.2) Bq/kg, and 74.5 (BDL-74.5) Bq/kg, respectively. The annual effective dose (AED) and excess lifetime cancer risk (ELCR) were estimated to assess radiological health risks. The obtained values are well below the international safety limits of 1 mSv/year for AED and 0.29 x 10^{-3} for ELCR, as recommended by the International Commission on Radiological Protection (ICRP) and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The study concludes that consuming these nuts does not pose significant radiological health risks. However, continuous monitoring is recommended due to the high consumption rates of these nuts in Nigeria.

Keywords: kola nut, bitter kola, walnut, nuts, activity concentrations, gamma spectrometry

Radiological risk assessment of selected teas and medicinal herbs commonly used in Albania

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This study presents a radiological risk assessment of commonly consumed teas and medicinal herbs in Albania. Teas and medicinal herbs have been widely used for centuries and continue to play an important role in daily consumption and traditional medicine. The activity concentrations of natural and artificial radionuclides were determined using gamma-ray spectrometry with a high-purity germanium (HPGe) detector.

Based on the measured activity concentrations, several radiological parameters were evaluated, including radium equivalent activity (Raeq), internal hazard index (Hin), and excess lifetime cancer risk (ELCR). The average values obtained for these parameters were 49.46 Bq kg-1 for Raeq, 0.17 for Hin, and 4.97×10^{-5} for ELCR.

The calculated values for all radiological parameters were found to be lower than the corresponding worldwide average limits recommended for radiological safety. These results indicate that the evaluated radiological parameters in the analyzed tea and medicinal herb samples do not pose significant radiological hazards.

Consequently, the consumption of these teas and medicinal herbs can be considered safe from a radiological perspective and does not present a considerable health risk to consumers.

Keywords: radiological risk, gamma-ray spectrometry, HPGe detector, radium equivalent

Problems of radiation exposure risk communication with the public, workers and patients under normal conditions and emergency situations

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It is well known that radiation exposure to people from various applications of radiation and nuclear technologies may be underestimated or overestimated. In both cases, it is undesirable, as such an extreme assessment of radiation health effects may lead to adverse consequences. In the first case, the actual health effects are not fully accounted for, whereas in the second case, measures to reduce the potentially exaggerated risk may prove unnecessarily stringent and costly. In some situations, this may affect applications of ionising radiation, particularly those involving nuclear reactors. It is obvious that there are quite big differences regarding the impact of the perception of radiation and nuclear technologies by different groups of persons, where it depends largely on their familiarity with the field. Those knowledgeable about the details of individual applications and their relationship to exposure to affected individuals will be more pragmatic than the general public's perception of this risk, which does not fully understand the situation. This also applies to patients, but they typically rely on radiologists and are less concerned about diagnostic radiation examinations or radiation therapy treatments. It is essential to systematically inform the population about the actual situation so that they can understand radiation risk and compare it with the risks associated with other industrial or medical applications of nuclear technologies, as well as the risks they face in everyday life. The paper summarises the current situation in this area, emphasising the need to keep people regularly informed, in a simple, understandable manner, about the actual health risk associated with various radiation and nuclear technologies.

Keywords: radiation exposure, risk communications, radiation workers, patients, general public, normal and emergency situations

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Failure analysis of radiation portal monitors in Albania: A case study for sustainable nuclear security infrastructure

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Albania's nuclear security infrastructure includes several aging Yantar radiation portal monitors (RPMs) deployed at strategic border crossing points. Under the framework of IAEA CRP J02014, we performed comprehensive field inspections and laboratory diagnostics on these systems to identify specific failure modes and implement cost-effective restoration. The root-cause analysis primarily focused on the hardware degradation of the Yantar-specific BPO (processing and power units) and the PVC (digital remote control panels). We found that environmental stressors—specifically temperature fluctuations and humidity—combined with systemic aging of electronic components to compromise power stability, signal processing integrity, and operator interface functionality. To quantify system reliability, we measured key engineering metrics including Mean Time Between Failures (MTBF), Mean Time To Repair (MTTR), and overall availability before and after restorative interventions and hardware repairs. Our findings reveal that the most critical vulnerabilities lie within the legacy BPO power electronics and the communication/display circuitry of the PVC units. Based on this analysis, we propose design modifications targeting these units, including the implementation of redundant power supplies, modular electronics, and embedded self-diagnostics to eliminate single points of failure. Institutional recommendations include formalizing a national maintenance program and transferring technical responsibility to the Institute of Applied Nuclear Physics (IANP) and the Polytechnic University of Tirana in accordance with IAEA guidance. This research provides a scalable model for the sustainable modernization of legacy Yantar systems in other member states.

Keywords: failure analysis, Yantar RPMs, BPO, PVC unit, MTBF, MTTR, hardware degradation, nuclear security, Albania

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A study on radiological impact of natural radioactivity in bottled drinking water in Albania

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The objective of this study is to obtain the concentrations of natural radionuclides from drinking water samples, considering various sources of water by using the gamma-ray spectrometry (HPGe detector). Ten water samples were collected from different locations, with the samples categorized into bottled water and public drinking water systems. The mean activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in the studied water samples were calculated to be 1.12 ± 0.18 Bq/L, 0.06 ± 0.02 Bq/L and 5.76 ± 0.64 Bq/L. Also, annual effective dose equivalents from the intake of these radionuclides in the bottled water were calculated for infants, children and adults and the found results were compared with the values recommended by international organizations. The results of this study show that the annual effective doses calculated for the three age categories were much lower than the average worldwide ingestion exposure of 0.29 mSv/y. In addition, the present study concludes that the bottled mineral water produced in Albania is safe for daily human consumption.

Keywords: radioactivity, bottled water, gamma spectrometry, annual effective dose

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A preliminary study of gross alpha-beta radioactivity in Albanian thermal water sources

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As part of a cooperation project with the Faculty of Geophysics of the Polytechnic University of Tirana and the Institute of Applied Nuclear Physics, University of Tirana implemented to study the quality of thermal waters from a health perspective, we conducted a study of the concentration of total alpha beta radioactivity and radon in these sources for the first time in Albania.

The study was conducted in several thermal water points that are widely used for therapeutic purposes by the Albanian population over the years. One of the important indicators, among others, of the quality of these waters is the concentration of gross alpha beta radioactivity that is in contact with the human body.

The measured activity concentrations in the collected samples in the autumn season range from LLD to 322 mBq/L and from 340 to 4751 mBq/L for gross alpha and beta, respectively.

The data obtained can provide information for authorities regarding the quality of thermal water and a baseline for future activities.

Keywords: gross alpha/beta activity, gas-flow proportional counter, thermal water sources

A study on concrete as an ionizing radiation shielding material

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When designing an X-ray facility, normal concrete is often used for the walls. In shielding design, a transmission factor is widely used, defined by a parametric equation as a function of the thickness, L, of the material, T=T(L). Although it seems like a relatively simple problem, the design of concrete shielding can become more complex than one would expect. In fact, in a literature search we found significantly different values for the fitting parameters. Furthermore, barite concrete is also frequently used as a shielding material, applying some simplified conversion rules to determine the required thickness from normal concrete thicknesses. For this reason, this work was developed using a Monte Carlo code designed to determine the transmission factor for normal and barite concretes. Transmission in lead was also determined as a reference material. Voltages of 100 kV, 150 kV and 300 kV (covering medical and industrial applications) were studied. A conservative geometry was determined. The transmission factor parameters for lead, normal concrete and barite concrete were determined, as well as the relationship between the thicknesses of normal concrete and barite concrete.

Keywords: X-ray, lead, concrete, barite concrete, shielding, transmission factor

X-ray spectrometry for radiation protection metrology

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This work addresses the application of X-ray spectrometry in radiation protection metrology, with a focus on the characterization of radiation fields used in dosimeter calibration. Operational quantities are traditionally derived from air kerma using tabulated conversion coefficients, such as those provided in ISO 4037:2019. However, these coefficients are limited to specific energy and geometric conditions, motivating the development of alternative approaches based on photon energy distributions.

The main objective of this work was to implement and validate an X-ray spectrometry methodology at the Ionizing Radiation Metrology Laboratory of Instituto Superior Técnico, enabling the experimental determination of radiation spectra used for calibration purposes. A Cadmium Telluride (CdTe) semiconductor detector was employed, and its response was modeled using Monte Carlo simulations with the PHITS code.

The developed model incorporates relevant physical effects affecting detector response, including charge trapping, incomplete charge collection, and energy resolution, allowing the construction of a detector response matrix. The system was experimentally calibrated using standard sources to establish the channel-to-energy relationship and to characterize detector performance.

For the first time in this context, X-ray spectra from the narrow series available at the laboratory were measured. Spectrum reconstruction was performed through a deconvolution process based on the GRAVEL code, using prior information from theoretical spectra to ensure physically consistent solutions.

The results demonstrate the feasibility of X-ray spectrometry as an alternative to conventional methods based on tabulated conversion coefficients, enabling a more flexible and accurate characterization of radiation fields and contributing to improved calibration procedures in radiation protection.

Keywords: X-ray spectrometry, radiation protection, metrology, CdTe detector, Monte Carlo simulation, PHITS, spectrum unfolding, GRAVEL

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Methods in radiation safety assessment

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For many years, the LPSR ("Laboratório de Proteção e Segurança Radiológica") has been conducting radiological safety assessment work for facilities and activities involving the use of ionizing radiation sources. The technical and scientific framework is based on recommendations from international bodies such as the ICRU, ICRP, and IAEA, which are used to establish methodologies for radiological safety assessment. As Portugal is a member of the European Union, the implementation of European directives is mandatory. The progressive transposition of Directive 2013/59/Euratom into national law has consolidated Portuguese legislation and some regulations. Although some gaps and ambiguities remain, this process has forced changes in our radiological safety assessment methods to ensure recognition by the national regulatory authority. The objective of this work is as follows: focusing on ionizing radiation sources, namely linear accelerators (LINAC), X-ray tubes, sealed and unsealed radioactive sources used in medicine, industry, and research, it aims to present and discuss the similarities and differences in the methods implemented at the LPSR for carrying out radiological safety assessments of those facilities and activities.

Keywords: radiation safety assessment, ionizing radiation, facilities and activities

Radiological risk assessment to indoor radon concentration and gamma dose rate in southeast region of albania

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This study investigates indoor radon concentration and gamma dose rate levels in the South-East region of Albania, aiming to establish a regional radiological baseline. The study area is part of the Outer Albanides, within the Albanian-Thessialan tectonic zone (ATT), characterized by terrigenous sedimentary formations that may influence indoor radon accumulation and gamma dose rate. Gamma dose rates were measured across urban, suburban, and rural locations using a high-sensitivity portable gamma spectrometry system (Atomtex AT6101C), while indoor radon concentrations were assessed using passive measurement techniques. The measured gamma dose rates ranged from 0.022 to 0.129 μSv/h, with a mean value of 0.052 μSv/h, while indoor radon concentrations varied from 13 to 420 Bq/m^3 with an average value 123±82 Bq/m^3. These findings are essential for environmental radiation surveillance, public health risk assessments, and will serve as a reference for future monitoring.

Keywords: radiological risk, indoor radon, gamma dose rate, environmental monitoring, effective dose

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Establishment of X-ray spectrometry at the Portuguese ionising radiation metrology laboratory

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Ensuring accurate metrological verification of ionizing radiation monitoring equipment is a crucial task in the area of radiological protection of exposed workers and patients exposed to ionizing radiation. This work aims to enhance the metrological verification of X-ray capabilities of the Portuguese Metrology Laboratory of Ionizing Radiation (Laboratório de Metrologia de Radiações Ionizantes, LMRI), located at the Technological and Nuclear Campus of Instituto Superior Técnico, University of Lisbon.

The present study explores the application of X-ray spectrometry employing cadmium telluride detectors to perform systematic studies on the properties of the X-ray beams available at LMRI allowing for the implementation of the recommendations of the ISO 4037:2019 standard published by the International Standardization Organization.

The energy spectra of the beams were measured as a function of the distance from the source, tube current and acceleration potential. Monte Carlo methods were employed to assess the detector's response to monoenergetic radiation and to build a response function matrix subsequently employed on the reconstruction of the continuous X-ray spectra from the measured data using deconvolution algorithms.

As an additional asset, methods for determining the spectral endpoint were implemented based on a machine learning algorithm offering an alternative, deconvolution-free approach to precisely determine the acceleration potential of the X-ray tube.

Keywords: X-ray spectrometry, metrology, radiological protection, radiology Monte Carlo simulations, deconvolution algorithm, X-ray detector response, calibration conditions

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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%.

Keywords: americium-241, absolute gamma-ray emission probabilities, gamma spectroscopy, plutonium isotopic analysis, plutonium sample age determination

Deep learning-based segmentation in MicroCT imaging: A robust protocol for the digital extraction of neogene fossils

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The application of microcomputed tomography (microCT) has transformed the field of palaeontology by enabling the non-destructive visualization of internal structures within fossil specimens. However, precise differentiation between the sedimentary matrix and biological material remains a significant challenge, particularly in samples with low density contrast or complex diagenetic alterations. This study presents an integrated methodological framework for the digital recovery of fossils, drawing upon research conducted on Neogene fish fossils and microfossils (foraminifera) from South and Central America. The proposed methodology focuses on the optimization of X-ray acquisition parameters and, crucially, the implementation of neural network-based segmentation algorithms for the extraction of volumes of interest (VOIs). Moving beyond conventional thresholding methods, the use of deep learning allows for the automated identification of complex morphologies, such as embryonic chambers in diagenetically altered foraminifera and delicate cranial structures in Teleostean fishes. The results demonstrate that neural network segmentation significantly mitigates image artifacts and reduces processing time while preserving the morphological integrity essential for accurate taxonomic and palaeoecological analysis. This workflow establishes a robust standard for tomographic data processing in palaeontology, facilitating the creation of high-resolution 3D models for both digital curation and the detailed study of marine biodiversity evolution.

Keywords: MicroCT, digital palaeontology, neural networks, deep learning, image segmentation, microfossils, neogene

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RTD modeling of flow-rig column using DTS-pro

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RTD modeling is widely used in various industries, including, chemical processing for optimizing reactor performance, ensuring consistent product quality, and preventing undesirable reactions [Bhalode et al, 2021, International Journal of Pharmaceutics 610: 121248]. The aim of the present study is RTD modeling obtained by radiotracer method of flow-rig column using DTS-pro software [Djoudi et al,2012, Chemical Engineering Research and Design 90: 582–1589]. The radiotracer method is used to determine the RTD for three flow rate 4,12 and 20 L/min and the radiotracer 99MTc with 2mCi activity was selected for this work because of its chemical properties and its suitable half-life [Gitau et al, 2019, Applied Radiation and Isotopes 154:108902]. The results obtained have shown that if the flow rate increases, the dead volume decreases and eliminates at Q = 20 L/min. The plug flow open to the diffusion and two mixing cells in series with exchange seems most suitable to characterize the hydrodynamics of the column, for a flow rate of 4 L/min. The combination of plug flow and plug flow open to the diffusion best describes the hydrodynamic behavior of the studied column for the two flow rates 12 and 20 L/min. The experiments were carried out safely without any kind of contamination.

Keywords: radiotracer, DTS-Pro4, RTD, modeling, column, flow rate, reactor, flow-rig, hydrodynamic, process

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Autoresonance pulse-periodic plasma accelerator for radiation sterilization of specialized feeds

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In recent years, there has been a growing interest in the effects of bremsstrahlung in the orthovolt energy range with a relatively low dose on biological objects. Modern sources of hard X-ray radiation - industrial accelerators and radioisotopes widely used. However, in the majority of them the energy price of radiation photons is enormously high. For non-destructive control methods, technologies, a number of biological and genetic research, medical purposes and so on there is a need in compact sources of X-radiation within orthovolt energy range. In the present work a pulse-periodic plasma accelerator based on the principle of gyromagnetic autoresonance was used [Physics of Plasmas, 2017. 24(093518), Physics of Plasmas, 2021. 9(092507)].

The feeds of the Altromin brand are the world standard in laboratory practice in the care and breeding of laboratory animals. The enhanced regime in SPF-vivariums (Specific Pathogen Free) provides for a set of barrier measures aimed at eliminating accidental infection, which can distort the results of biological research. The applied sterilization method, autoclaving, can lead to starch gelatinization, vitrification, and destruction of vitamin supplements, proteins, and amino acids.

Radiation sterilization is the "gold standard" for high-quality feed because it does not change the physical and chemical properties of the granules. Sterility of feed is critically important when conducting biomedical research with immunodeficient animals.

Pilot experiments on the sterilization of rodent feed (Altromin 1324) by bremsstrahlung of plasma accelerator have been completed. Sterilization was carried out with a variation of the target material, the radiation spectrum and the absorbed dose in four modes: 1 – gas target (Kr), 350 keV, 0.03 G; 2 – gas target (Kr), 500 keV, 0.07 G; 3 – solid–state target (W), 350 keV, 0.3 G; 3 - solid-state target (W), 500 keV, 0.8 G. Irradiation of 0.5 kg portions of feed in modes 1-3 led to complete sterilization, confirmed by microbiological studies. A comparative study of feeding laboratory mice with irradiated and autoclaved food has been conducted. It is shown that the feed sterilized by radiation has not lost its mechanical and nutritional properties.

Keywords: plasma accelerator, X-ray, sterilization

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Comparative analysis of linear and non-linear blending in dual-energy microCT for microplastic detection in soil

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The pervasive nature of microplastics (MPs) in terrestrial ecosystems is a critical environmental concern, yet their identification within soil matrices remains a significant challenge. Although Micro-computed tomography (microCT) is an established non-destructive tool for 3D characterization of MPs, traditional monochromatic scans often struggle to distinguish low-density polymers from intricate mineral backgrounds. The high-energy X-rays required to penetrate dense soil result in suboptimal contrast, hindering the detection and characterization of plastic particles. To address this, this study investigates Dual-Energy Micro-CT (DECT) combined with digital image fusion. The methodology exploits energy-dependent attenuation coefficients: low-energy photons enhance material sensitivity via the photoelectric effect, while high-energy photons interact primarily through Compton scattering. Samples were scanned at 50, 70, 90, 110, and 130 kV using a BRUKER 1273, generating a multi-spectral dataset. Acquisitions were processed via a custom Python script to evaluate all possible voltage pairings and their respective blending outcomes. Based on established frameworks, fusion was performed using linear and non-linear algorithms. The linear approach utilized standard weighted averaging, while the non-linear method employed sigmoid-based functions to modulate pixel weights individually. This allowed selective fusion where data from low-voltage scans was prioritized for MP particles, whereas high-voltage scans defined the dense soil background with reduced noise. This dual-pathway processing ensures that the final image retains structural integrity and enhanced material discrimination. Image quality was evaluated through Signal-to-Noise (SNR), Contrast-to-Noise (CNR) ratios, and Gray Value (GV) variation at boundaries. Results demonstrate that DECT fusion methods significantly enhance material contrast compared to single-energy scans. The combinations of low and high energy spectra proved effective for identifying small MPs, providing sharper boundary transitions and improving segmentation accuracy. The increase in CNR allowed for reliable automated identification in complex porous media. Ultimately, this research establishes DECT as a potential robust framework for MP detection in soil. By optimizing the visualization of low-density materials within dense substrates, this method offers a tool to understand the distribution and impacts of microplastics in soil systems.

Keywords: dual-energy microCT, microplastic detection, soil

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Calibrating Bragg Edge Neutron Transmission analysis for characterising the elemental composition of archaeological bronzes

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The study of ancient metallurgy, with particular emphasis on bronze and copper alloys, is fundamental for reconstructing the technological and artistic developments of past civilisations. In this context, neutron-based techniques represent a highly effective approach for the non-invasive characterisation of elemental, isotopic, and phase composition in archaeological objects [A. De Palmas *et al.*, Archaeol Anthropol Sci 13, 101 (2021); G. Marcucci *et al.*, European Physical Journal Plus, 139 (2024) 475].

The present study is conducted within the INFN CHNet_BRONZE project, whose objective is to develop and quantitatively calibrate neutron-based methods for the analysis of copper-based archaeological artefacts. Three bulk investigation techniques are considered: Time-of-Flight Neutron Diffraction (ToF-ND), Neutron Resonance Transmission Imaging (NRTI), and Bragg-Edge Neutron Transmission analysis (BENT).

This contribution focuses on measurements performed using the BENT technique, which enables non-invasive determination of elemental and phase composition, as well as microstructure, texture, and other properties of crystalline materials [H. Sato *et al.*, Materials Research Proceedings 15, 214-220 (2020)]. The method relies on the coherent elastic interaction between an incident neutron beam and the crystal lattice of the sample. By employing a 2D detector, position-resolved Bragg-edge transmission spectra can be collected, allowing reconstruction of the spatial distribution of phases.

A set of purposely prepared copper-based reference samples, both in powder and cast form with well-defined composition and structure, are used to establish experimental and analytical methodologies. This also helps interpreting data from historical bronze artefacts. Particular attention is given to the analysis of BENT spectra aimed at extracting compositional information, including the derivation of calibration curves that correlate spectral features to the concentration of Cu, Sn, and Pb in the material. The results can help to answer questions of historical and cultural interest on archaeological bronzes, allowing to extract compositional information from the bulk of the objects non-invasively.

Keywords: neutron analysis, BENT, calibration, elemental composition, ancient bronzes

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Chemical composition of bronze weapons from Bronze and Iron age Illyrian territories: A portable X-ray fluorescence study

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Bronze weapons continued to be produced and used in the western Balkans during the Iron Age, despite the increasing dominance of iron for weaponry, reflecting both technological traditions and cultural preferences within Illyrian communities. This study provides a non-destructive chemical characterization of 85 bronze weapons originating from Illyrian territories dating to the Bronze Age and Iron Age. The analyzed artefacts include spearheads, swords, daggers, knives, arrowheads, and armor components, examined using portable X-ray fluorescence spectrometry. Elemental concentrations of major alloying elements (Cu, Sn, Pb) and minor elements (Sb, Zn, Fe, Ni) were determined to assess alloy composition, technological practices, and potential patterns of production and recycling. The assemblage is dominated by copper-based alloys, primarily tin bronzes with variable tin contents generally below 7%, as well as near-pure copper objects. Lead is present in several samples, occasionally reaching elevated concentrations, suggesting either deliberate addition to improve casting properties or incorporation through recycling practices. Minor and trace elements typically occur at low levels and are interpreted as ore-related impurities or by-products of repeated metal recycling rather than intentional alloying strategies. Principal Component Analysis (PCA) reveals greater compositional variability among Middle and Late Bronze Age weapons, whereas 3rd–2nd century BC and Iron Age objects display more compact compositional clusters, indicating increased standardization and technological continuity over time. When grouped by object type, the samples show substantial compositional overlap between different weapon categories, suggesting that alloy composition was not primarily determined by functional requirements. Overall, these results highlight long-term continuity in bronze-working traditions and provide new archeometallurgical data for Illyrian territories in the western Balkans, contributing to a better understanding of technological organization and metal circulation in this region.

Keywords: weapons, alloy composition, tin bronze, Bronze Age, Iron Age, Illyrian territories, western Balkans, X-ray fluorescence, Principal Component Analysis, technological continuity

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Gamma irradiation optimization for the decontamination of 19th century Tuareg artifacts: Species identification and minimum inhibitory dose assessment

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The preservation of organic cultural heritage materials remains a major challenge due to biodeterioration induced by fungal colonization under fluctuating microclimatic conditions. Traditionally vegetable-tanned leather artifacts are particularly vulnerable despite the protective effect of tanning. In this study, gamma irradiation was evaluated as a reliable radiosterilization method to ensure the microbiological safety and long-term preservation of 19th century TUAREG leather objects conserved at the Bardo National Public Museum.

Four ethnographic artifacts were investigated: a camel equestrian saddlebag, an artisanal wooden leather bottle cover, an artisanal travel bag, and a goatskin bucket. Microbiological sampling was performed by surface swabbing, followed by incubation on selective media and macroscopic and microscopic identification. The isolated fungal species were Penicillium spp., Aspergillus flavus, Alternaria spp., and Chaetomium spp. Penicillium spp. was the most frequently detected contaminant, while Alternaria spp. exhibited the highest persistence.

To determine radiation sensitivity, standardized fungal suspensions at 10^6 CFU/ml were exposed to cobalt-60 gamma irradiation at doses ranging from 0.15 to 6 kGy, with a dose rate of 18.32 Gy/min. Survival curves were established to calculate D_{10} values, defined as the dose required to achieve a one-log reduction of the initial population. The D_{10} values ranged from 0.11 kGy for Penicillium spp. to 0.49 kGy for Alternaria spp., indicating significant interspecies variability in radioresistance. Based on a six-log reduction approach, the minimum inhibitory doses (Dm) were determined as 0.66 kGy for Penicillium spp., 1.20 kGy for Aspergillus flavus, 0.80 kGy for Chaetomium spp., and 2.94 kGy for Alternaria spp.

Validation tests were performed on inoculated traditionally tanned leather samples irradiated between 2 and 12 kGy. Complete fungal inhibition was achieved at 5 kGy, including for the most radioresistant strain, Alternaria spp. No regrowth was observed after incubation at 30°C for 14 days. The selected dose ensured total decontamination while preserving the physical appearance, color, and texture of the artifacts.

These findings confirm that optimized cobalt-60 gamma irradiation at 5 kGy represents a safe, efficient, and non-destructive strategy for the decontamination of historically valuable leather objects. The study provides a scientific basis for implementing radiation processing in Algerian museums and contributes to international efforts promoting ionizing radiation technologies for cultural heritage conservation.

Keywords: gamma irradiation, radiosterilization, cultural heritage conservation, leather artifacts, fungal biodeterioration, D10 value and radioresistance

Machine learning surrogate modeling of multilayer concrete-FeB-soil shielding in a 250 MeV proton accelerator tunnel based on FLUKA Monte Carlo Simulations

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In proton accelerator environments, neutrons produced through proton-target interactions constitute the dominant secondary radiation component and play a critical role in shielding design due to their high penetration capability and broad energy spectrum. In this study, a hybrid Monte Carlo-Machine Learning (MC–ML) framework was developed to enable rapid and reliable prediction of ambient dose equivalent distributions in a multilayer concrete-FeB-soil shielding system for a 250 MeV proton accelerator tunnel.

The secondary neutron field was modeled in a three-dimensional tunnel geometry using the FLUKA MC particle transport code for a monoenergetic proton beam incident on a copper target. Dose data obtained along horizontal and vertical directions were used to train surrogate models based on linear, distance-based, and tree-based ensemble learning algorithms, including Linear Regression, K-Nearest Neighbors, Random Forest, Gradient Boosting, HistGradientBoosting, and Extra Trees Regressors.

The results demonstrate that tree-based ensemble methods provide the highest prediction accuracy. In particular, the Extra Trees and Random Forest models achieved R^2 values of 0.9970 and 0.9964 along the x-direction, and 0.9832 and 0.9815 along the y-direction, respectively. The developed surrogate models successfully capture the highly nonlinear dose-distance relationship and offer significant computational efficiency compared to full Monte Carlo simulations.

These findings highlight the strong potential of hybrid MC–ML approaches for fast evaluation and optimization of complex multilayer shielding systems in proton accelerator applications.

Keywords: proton accelerators, neutron shielding, FLUKA, Monte Carlo simulation, machine learning, surrogate modeling, multilayer shielding, ferroboron, dose prediction, hybrid MC–ML approach

An artificial intelligent automation of neutron activation analysis via language-driven workflow

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Accurate prediction of radiological inventories is a critical component of nuclear facility decommissioning, radioactive waste classification, and long-term safety assessment. Activation and transmutation codes provide robust physics-based calculations; however, their practical application remains heavily dependent on expert knowledge due to complex input structures and labor-intensive interpretation of large output datasets. This reliance introduces workflow bottlenecks and limits scalability in modern decommissioning analyses where numerous materials, irradiation histories, and cooling scenarios must be evaluated.

This study presents a language-driven artificial intelligent framework designed to automate the generation and interpretation of FISPACT-II input–output workflows. The proposed approach reformulates activation analysis as a semantic translation problem, converting natural language descriptions of irradiation scenarios into structured computational inputs while simultaneously transforming raw numerical outputs into physically meaningful insights. A constrained decoding strategy incorporating domain rules is implemented to ensure that generated inputs remain physically valid and consistent with established activation modeling practices. The framework is evaluated through multiple case studies, including reactor pressure vessel steel and bioshield concrete subjected to representative neutron irradiation environments.

Results demonstrate that the AI assisted workflow achieves high agreement with expert-generated models while significantly reducing preparation and analysis time from hours to minutes. Furthermore, the system successfully identifies dominant radionuclides, temporal activity trends, and waste-relevant radiological indicators without manual postprocessing.

The proposed method introduces a paradigm shift in activation analysis by embedding domain knowledge within a language-driven computational layer. This enables more adaptive, scalable, and accessible radiological assessments while preserving the rigor of physics-based simulation.

Keywords: neutron activation analyses, radiological inventory, artificial intelligence, language driven framework

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Feasibility of a language-based AI framework for radiation transport modeling

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Radiation transport analysis for neutron and gamma fields is essential in numerous nuclear engineering and radiation technology domains, including radiological inventory assessment for nuclear decommissioning, medical physics treatment planning, industrial NDT and shielding design, RI and fusion research environment validation, and regulatory safety verification for radiation facilities. Despite its technical importance, current Monte Carlo transport codes such as MCNP, GEANT4, PHITS, and FLUKA rely on complex input structures and expert-oriented configuration procedures, which impose limitations on automation, scalability, and accessibility for new or non-expert users. These challenges create a technical need for a framework that can interpret user intent, translate natural-language descriptions into structured input data, and support iterative analysis without extensive manual intervention.

This study discusses a language-based model (LBM) as an artificial intelligence (AI) approach to initiate radiation transport automation. The development framework includes: (1) constructing an AI-trainable dataset by tokenizing and parsing existing transport-code input decks into structured representations of geometry, materials, source terms, and tallies; (2) designing an inference module that interprets natural-language problem descriptions and generates candidate input configurations for geometry construction, material composition assignment, and irradiation/source condition specification; (3) implementing an automated pipeline for transport-code execution, result extraction, and consistency checking between predicted and calculated outcomes; and (4) integrating feedback routines for model refinement through comparative evaluation of simulation accuracy and configuration validity.

The resulting language-based AI model is expected to enable natural-language-driven transport workflow automation, reduce input configuration errors, shorten repetitive modeling tasks, improve accessibility, and narrow the usability gap between expert and non-expert users. Ultimately, this approach is anticipated to support future extensions toward intelligent analysis advisors, semi-autonomous modeling assistants, and domain-specific large language models applicable to radiation transport analysis.

Keywords: radiation transport, Monte Carlo code, artificial intelligence, language-based model

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Regulatory improvements for clearance of decommissioning waste in Korea

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Korea has entered the era of nuclear power plant decommissioning following the permanent shutdown of Kori Unit 1 Nuclear Power Plant (NPP). Unlike the operational phase, decommissioning generates large volumes of waste within a short period, limiting the applicability of waste management frameworks and regulatory systems developed for normal operation, particularly clearance regulations. Such limitations have become more apparent in preparing for the decommissioning of Kori Unit 1 NPP, indicating the need for regulatory improvements suited to decommissioning conditions. This study proposes two regulatory improvements for the effective clearance of waste generated during nuclear power plant decommissioning.

First, for decontaminated structures, a graded survey approach based on site-specific conditions should be applied. In Korea, clearance assessments have traditionally relied on destructive sampling proportional to surface area or material mass. However, decommissioning generates large volumes of waste, making a contamination-based approach more practical and risk-informed. In this context, the Final Status Survey (FSS) methodology of MARSSIM, which integrates surface scanning with statistically based random sampling, provides an effective framework while maintaining statistical rigor and regulatory confidence. In the Fort St. Vrain decommissioning project, an area-proportional sampling approach required 474 samples, whereas a MARSSIM-based approach achieved an equivalent level of confidence with only 13 samples [E. W. Abelquist, 1999].

Second, for waste generated from dismantling decontaminated structures with negligible radiological risk, new radiological concentration criteria should be introduced to allow classification as non-contaminated waste rather than applying existing clearance requirements. Site-specific Derived Concentration Guideline Levels (DCGLs), derived using conservative exposure scenarios such as continuous occupancy and subsistence farming, can be applied. In the case of Kori Unit 1 NPP, DCGLs for unrestricted reuse were more conservative than current clearance criteria for most radionuclides, providing a quantitative basis for regulatory decision-making.

The proposed regulatory improvements support the development of a rational and efficient regulatory framework that reflects large-scale decommissioning realities while adhering to the ALARA principle. Experience gained during preparation for Kori Unit 1 NPP decommissioning indicates that direct application of operational-phase regulations can result in excessive survey efforts beyond actual radiological risk. The findings of this study may serve as practical references for future nuclear power plant decommissioning regulatory frameworks.

Keywords: decommissioning, waste, clearance

Data digitalization methodology for radiological characterization of a cyclotron U-120-1 type under decommissioning

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The present paper describes a methodology developed for data digitalization in radiological characterization of Cyclotron U-120-1 particle accelerator from IFIN-HH, Romania, under decommissioning. The purpose is to consolidate and optimize the decommissioning process, minimize the worker exposure, the amount of waste as well as the impact on the environment. By data digitalization a detailed and easy retrieval of radioactive inventory is obtained and increases the accuracy, efficiency and reliability of radiological characterization workflows. Data digitalization is an effective tool for subsequent planning of decommissioning work, dose and risk assessment for different working scenarios. The methodology designed according with the Holistic Digital Strategy aims to eliminate legacy system limitations, ensures data security and regulatory compliance. Data accuracy and accessibility are increased, by routine tasks automation, sensor networks integration and advanced data analytics. The personnel are trained with skills needed to operate new technologies and adapt to digital workflows. Methodology was developed and implemented based on a DigiWASTE type Platform used for easily identification of radioactive sources and waste tracking from the earliest possible phase of the D&D cycle. Radiation measurement is done with RADHAND 600 PRO, innovative handheld instrument, provided with a high-efficiency 2"x2" NaI detector and advanced digital pulse processing (DPP) algorithms, who ensures an accurate radionuclide identification and continuous dose rate monitoring and with a read/write UHF RFID tagging component for radioactive materials. Instrument is acting as a pre-screening tool in sampling processes, by optimizing the representative samples selection and identifying hotspots in the radiological interest areas. The information produced in subsequent D&D activities are loaded, collected and processed by the customizable database framework, RadBASE, used for development, tracking and integration of information critical to D&D and waste management.

Keywords: radiological characterization, digitalization, decommissioning

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Rare earth elements in phosphogypsum as a challenge for the transition to green economy: Review of the state of the art

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Phosphogypsum is a waste material generated during the processing of phosphate rocks in the fertilizer industry, specifically in the production of phosphoric acid. To date, large phosphogypsum stockpiles exist worldwide, occupying potentially valuable land and posing environmental and public health risks. In recent years, the increasing investment in the green economy has renewed interest in this by-product due to its potential for reuse. In fact, phosphogypsum has been investigated for various applications, including the use as a construction material, fertilizer and soil amendment. Among the proposed applications, the extraction of Rare Earth Elements from phosphogypsum has emerged as a particularly promising, although still developing, research field. Rare Earth Elements are critical components in modern technologies and are therefore of significant economic and strategic importance. Despite their name, they are relatively abundant in the Earth's crust; however, economically exploitable deposits have limited Rare Earth Elements concentrations, are geographically constrained and the extraction from the mineral is quite difficult. This combination of high demand and restricted availability makes phosphogypsum a potentially valuable secondary resource of Rare Earth Elements. In addition, the recovery of Rare Earth Elements has recently attracted increasing attention due to their critical role in the transition to sustainable technologies and for the continuously growing global technology demand. This paper first outlines the general geology of phosphate rocks and Rare Earth Elements deposits and then summarises and compares reported Rare Earth Elements concentrations in phosphogypsum, providing an updated and extensive overview of the available data. In conclusion, this review paper aims to summarize the current state of knowledge regarding Rare Earth Elements concentrations in phosphate rocks and in phosphogypsum from different geographical regions.

Keywords: phosphogypsum, phosphogypsum recovery, green-economy, Rare Earth Elements geology, Rare Earth Elements extraction, responsible consumption and production, sustainable cities

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Analysis of trade flows for heavy water and deuterium in South Korea and its implications for export controls

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Heavy water and deuterium have traditionally been regulated as Trigger List items under the NSG guidelines. However, deuterium has recently emerged as a critical material for advanced industries, including AI semiconductor annealing, OLED organic materials, and precision chemicals, transforming into a "strategic bottleneck asset". Heavy water, as an essential precursor for extracting deuterium gas, is also gaining significance across the value chain, aligning with the global trend where critical minerals are used as leverage in techno-hegemonic competition under protectionist policies. This study analyzes South Korea's trade trends for these items from 2021 to 2025 using K-stat and UN Comtrade statistics and examines the impact of shifting industrial demand on the existing export control framework.

Statistical analysis reveals a clear upward trend in both heavy water and deuterium trade across both datasets, despite numerical discrepancies caused by time lags in reporting and differences in Cost, Insurance, and Freight (CIF) / Free on Board (FOB) valuation. For deuterium (HS 2845.90), K-stat imports surged 3.3-fold from $68,919k in 2021 to $225,685k in 2025, with trade highly concentrated toward the U.S. and China. Notably, the average export unit price for deuterium skyrocketed from approximately $9.4/kg in 2022 to $6,958/kg in 2025, demonstrating a complete transition from low-value nuclear materials to high-value advanced industrial assets. Heavy water (HS 2845.10) also recorded an unusual export of approximately $3,203,878 (80,033 kg) in 2023 per UN Comtrade, reflecting a structural pattern where imported precursors are re-exported after domestic processing. In response to these shifting trade patterns, the U.S. transferred the authority for non-nuclear deuterium to the Department of Commerce (BIS) under the Export Administration Regulations (EAR) in 2021, reclassifying it as a dual-use item (ECCN 1C298). In South Korea, heavy water has been designated as an Economic Security Item under the Supply Chain Basic Act since December 2023. This expansion of management reflects high import dependency and the significant impact these items have on national economy and security during supply chain crises.

In conclusion, the trade data from the past five years confirm that heavy water and deuterium have evolved beyond their conventional role as non-nuclear materials into critical industrial assets for the AI and semiconductor sectors. This transformation introduces regulatory ambiguities, as rapidly growing non-nuclear demand increasingly falls outside the scope of traditional nuclear export control frameworks. From the perspective of nuclear non-proliferation and trade security in the AI and semiconductor era, this study concludes that more effective and meticulous export control measures—based on international precedents—are required to reduce regulatory "gray zones." To enhance national security and prevent the diversion of industrial materials for nuclear purposes, it is essential to consider strengthening controls by regulating these Trigger List items regardless of their intended end-use.

Keywords: deuterium, heavy water, nuclear export control, non-nuclear materials, trade flow analysis

Nuclear energy perspective in Serbia

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First and main step towards the future use of nuclear energy in the Republic of Serbia was taken in late 2024, when the National Assembly lifted the 35-year moratorium on nuclear power plants, originally imposed after the 1989 Chernobyl accident. This legislative breakthrough opened the door to serious strategic planning. By early 2026, the Serbian government had already taken concrete steps. A preliminary technical study, prepared in cooperation with a French consortium led by EDF, was presented in March 2026. The document follows the International Atomic Energy Agency's (IAEA) three-phase methodology and identifies 19 key infrastructure areas that Serbia must develop — ranging from legal and regulatory frameworks, through workforce training and public communication, to waste management and emergency preparedness.

This paper provides a deeper analysis of both small modular reactors (SMRs) and conventional Generation III+ power plants currently available on the market. It includes a comprehensive SWOT analysis aimed at offering a clearer understanding of the opportunities and challenges on Serbia's nuclear path.

Keywords: nuclear energy, small modular reactors, generation III+ reactors, international cooperation

Synthesis, structural and magnetic behaviour of undoped and doped $Ba_{0.5}Sr_{1.5}Zn_2Fe_{12}O_{22}$ Y-type hexaferrites

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Y-type hexaferrites, in particular $Ba_{0.5}Sr_{1.5}Zn_2Fe_{12}O_{22}$ and its Al-substituted analogue $Ba_{0.5}Sr_{1.5}Zn_2Al_{0.08}Fe_{11.92}O_{22}$, have emerged as promising single-phase multiferroics owing to their large room-temperature magneto-electric coupling, which originates from non-collinear spiral magnetic structures. This work presents a comparative study of the microstructure, crystal structure and magnetic properties of these materials prepared by two soft-chemistry routes — citric-acid sol-gel auto-combustion and ultrasonic co-precipitation — followed by annealing at 1170 °C.

X-ray and neutron diffraction confirmed the formation of the main Y-type phase (space group R-3m) in all samples, accompanied by only minor traces (< 2 wt.%) of spinel $ZnFe_2O_4$. The ultrasonic co-precipitation route produced powders with significantly higher crystallinity, sharper diffraction peaks and well-defined hexagonal platelet morphology (average diameter ~1 μm, thickness ~170 nm). In contrast, the sol-gel auto-combustion yielded agglomerated particles of non-uniform shape and smaller average size (~550 nm). Scanning electron microscopy showed that high-power ultrasound promotes three-dimensional grain growth and markedly reduces agglomeration, resulting in a more homogeneous microstructure.

Magnetic characterization revealed clear differences between the two preparation methods. The sonochemically synthesized powders exhibited higher saturation magnetization (reaching 50 emu g^{-1} at 300 K) and larger coercivity compared with the auto-combustion samples. Both undoped and Al-substituted materials displayed characteristic triple hysteresis loops at room temperature in moderate magnetic fields (up to 6 kOe), indicating the coexistence of two ferrimagnetic states associated with an intermediate phase between the collinear ferrimagnetic and proper-screw spin orders. Temperature-dependent magnetization and AC susceptibility measurements (4.2–300 K, 1 kHz) identified several magnetic phase transitions: the collinear ferrimagnetic structure transforms into a proper-screw spin order near 285–326 K, followed by a longitudinal conical phase below ~150 K and an alternating longitudinal conical ordering at lower temperatures. Al substitution slightly lowers the transition temperatures and modifies the stability range of the intermediate phases. AC susceptibility anomalies in both the real and imaginary parts confirmed the metamagnetic character of these transitions, with their positions shifting to higher temperatures as the AC field amplitude increased.

The results demonstrate that ultrasonic co-precipitation is a superior single-step route for obtaining monophase Y-type hexaferrite powders with well-developed hexagonal morphology, enhanced magnetization and clearly resolved magnetic phase transitions near and above room temperature. The stabilization of non-collinear spin structures in polycrystalline form and the persistence of magneto-electric-relevant phases up to 300 K highlight the critical role of synthesis conditions in tuning the magneto-electric performance. The findings open promising perspectives for the development of polycrystalline magneto-electric materials suitable for room-temperature spintronic and sensor applications without the need for single-crystal growth.

Keywords: Y-type hexaferrite, ultrasonic co-precipitation, sol-gel auto-combustion, magnetic phase transitions, magneto-electric coupling, microstructure

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Novel miniature microwave plasma source for thin film deposition: Application in packaging industry for reduction of plastic waste

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Plastic waste reduction in the packaging industry can be achieved through material minimization, substitution, reuse, recyclability, and the implementation of advanced surface technologies. Plasma-Enhanced Chemical Vapor Deposition (PECVD) of ultra-thin protective SiO_x coatings provides durable functional layers on polymer surfaces, enabling the multi-use of plastic bottles.

A Miniature Microwave Inductively Coupled Plasma (MMWICP) source is a small and versatile device characterized by excellent plasma properties, such as high electron densities, making it well suited as a source of reactive species. In this work, the MMWICP is used as a highly efficient source of atomic oxygen. The oxygen plasma effluent is employed to dissociate silicon-containing precursors—hexamethyldisiloxane (HMDSO) or tetraethyl orthosilicate (TEOS)—and to deposit thin SiO_x films on silicon substrates. Furthermore, the use of a high flux of oxygen atoms enables optimization of the film composition and stoichiometry, which is essential for achieving excellent barrier properties.

The quality of the deposited films is analyzed using Fourier-transform infrared spectroscopy (FTIR), atomic force microscopy (AFM), and X-ray photoelectron spectroscopy (XPS). The objective of this study is to quantify process parameters of MMWICP, such as gas temperature, electron and atomic oxygen density for the deposition of high-quality SiO_x barrier coatings.

Keywords: thin SiOx film, PECVD, microwave plasma, barrier coating, atomic oxygen

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Role of high-k materials in developing advanced photodetector modules

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This research investigates the use of high-k dielectric materials in developing advanced photodetector modules for MRI-PET systems. High-k materials enhance charge collection, reduce noise and improve overall detector sensitivity. These benefits address key challenges like electromagnetic interference and size limitations in hybrid imaging systems. The results highlight the potential of material-driven innovation to improve performance in nuclear medicine applications.

Keywords: high-k materials, photodetectors, MRI/PET, imaging, dielectric

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Microstructural and high-frequency dielectric characterization of Sc-doped $NiMn_2O_4$ spinel ceramics

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Sc-doped $NiMn_2O_4$ spinel oxide was successfully synthesized via conventional solid-state reaction method. The Structural, microstructural, and frequency-dependent dielectric properties of the material were investigated systematically. X-ray diffraction (XRD) analysis confirmed the formation of a cubic spinel phase with Fd-3m space group, characteristic of NiMn2O4-type structure. Fourier-transform infrared spectroscopy (FTIR) revealed the characteristic of the metal-oxygen vibrational bands in the 400-700 cm^{-1} region, confirming successful oxide formation. Scanning electron microscopy (SEM) micrographs exhibited a dense, polygonal grain morphology with grain sizes ranging from 1 to 5 μm and visible porosity typical of solid-state synthesized ceramics. Energy-dispersive X-ray spectroscopy (EDS) analysis confirmed the elemental composition with successfully incorporated Sc (19.6 wt%) into the spinel lattice, showing good stoichiometry and homogeneous elemental distribution.

The dielectric properties were investigated as a function of frequency (100 Hz - 1 MHz) at room temperature. The dielectric constant (ε') exhibited frequency-independent behavior with stable ranges between 2.5 and $2.85x10^{-7}$ across a wide frequency region (1 kHz - 1 MHz). Most remarkably, the dielectric loss factor (tan δ) decreased dramatically with increasing in frequency and stabilized at an exceptionally low value of approximately 0.01 above 1 kHz, indicating minimal energy dissipation at higher frequencies. AC conductivity (σ_{ac}) analysis followed Jonscher's universal power law, revealing a transition from DC to AC conduction mechanisms attributed to electron hopping between Mn^{3+}/Mn^{4+} ions in octahedral sites, with Sc^{3+} incorporation modifying the local charge dynamics. Impedance spectroscopy suggested that grain interior (bulk) conduction is the dominant transport mechanism.

The combination of the stable spinel structure, homogeneous microstructure, frequency-independent dielectric constant, and ultra-low dielectric loss at high frequencies positions this Sc-doped $NiMn_2O_4$ ceramic as a highly promising candidate for high-frequency electronic applications, particularly in multilayer ceramic super capacitors (MLCSCs) and microwave dielectric devices.

Keywords: spinel oxide, $NiMn_2O_4$, Sc doping, solid-state reaction, dielectric properties, dielectric loss, AC conductivity, SEM, EDS, high-frequency applications, super capacitors

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A radiation-based strategy for the development of functional coatings on military textiles

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Ionising gamma irradiation is an effective method for textile activation, as it induces the formation of free radicals in the bulk and on the surface of fibres, leading to the disruption of existing chemical bonds and increased surface reactivity. These newly generated active sites enable efficient and durable attachment of functional compounds to textile fibres without the use of harsh chemicals (Gunenc and Yavas, Fibers Polym., 2025, 26). The process is carried out at ambient temperature and does not require toxic reagents, making it an environmentally friendly and energy-efficient approach to textile functionalisation.

Natural polyphenolic acids have attracted increasing attention as functional additives due to their beneficial properties. Phytic acid, which is non-toxic and biodegradable, exhibits pronounced flame-retardant behaviour owing to its high phosphorus content and its ability to promote char formation. Tannic acid, by contrast, acts as an effective UV absorber and possesses antimicrobial activity, further enhancing the safety and hygienic performance of treated fabrics [Wen et al., Prog. Org. Coat., 2023, 175]. The combination of gamma irradiation with natural polyphenolic acids enables the development of multifunctional textiles with improved durability, safety, and sustainability, making them suitable for military applications.

This study presents an innovative approach to functionalising various textile fabrics (cotton, nylon, polyester, and nylon-cotton composites) using gamma irradiation combined with the application of environmentally friendly tannic acid coordinated with iron ions and phytic acid. Gamma irradiation was applied under different conditions and doses. Following functionalisation via a one-pot synthesis method and through layer-by-layer deposition, colour was determined by colorimetric measurements, and the intensity of coloration was visually evaluated. The materials were further analysed by water contact angle measurements, while coating uniformity was confirmed using energy-dispersive X-ray spectroscopy. The results demonstrate that irradiation conditions and dose significantly influence coating adhesion to textile surfaces. The applied radiation-assisted method resulted in a uniform atomic distribution across the fabric surfaces, accompanied by changes in the textile surface properties.

Keywords: textile functionalisation, gamma irradiation, phytic acid, tannic acid

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Radiation-crosslinked fatty acids for biocompatible stainless steel implant functionalisation

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Biomedical stainless steel implants are extensively used in the medical applications owing to their favorable mechanical properties and established biocompatibility. However, the corrosion resistance of stainless steels in physiological environments remains limited, making surface functionalisation essential for improving long-term performance. Fatty acids (FAs) have the ability to form highly ordered and densely packed self-assembled monolayers (SAMs) on metal surfaces. While such monolayers can initially act as and effective protective barrier, their long-term stability is restricted by gradual desorption from the metal surface under physiological conditions. To overcome this limitation, ionising gamma irradiation can be employed to induce polymerisation within the SAMs. This radiation-driven process, known as radiation crosslinking, transforms the monolayers into robust polymer nanocoatings (PNCs), offering a promising approach toward durable functionalisation of biomedical stainless steel implants.

This research focuses on the functionalisation of biomedical stainless steel 316L with different fatty acids. The corrosion behaviour of SAMs and radiation-crosslinked PNCs formed on the stainless steel 316L surface was investigated using electrochemical impedance spectroscopy and Tafel extrapolation methods. Direct contact experiments on the human endothelilal cell line Ea.hy926 were conducted to asses the biocompatibility of the SAM- and PNC- functionalised stainless steel 316L surfaces.

Keywords: stainless steel, self-assembled monolayers, fatty acids, polymer nanocoatings, gamma irradiation, biocompatibility

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EPR study of the dynamic processes and structural phase transitions in liquid crystal systems

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We present a comprehensive investigation into the relationship between molecular structure and mesophase dynamics in thermotropic liquid crystal (LC) systems. The LC compounds studied included: NLCs*:* C_7H_{15}-C_6H_4-COO-C_6H_4-CN; C_5H_{11}-C_6H_4-C_6H_4-CN; C_4H_9-C_6H_4-COO-C_6H_4-OC_6H_{13} and their systems of different concentrations, as well as SmC LCs*:* $C_5H_{11}O$-$(OH)C_6H_3$-CH=N-C_6H_4-C_5H_{11}; $C_{10}H_{21}O$-C_6H_4-CH=CH- C_6H_4-$OC_{10}H_{21}$; and ferroelectric SmC*LCs*:* $C_7H_{15}O$-C_6H_4- C_6H_4- COO-$CH_2C^*H(CH_3)C_2$; $C_8H_{17}O$-C_6H_4- C_6H_4-$C_2H_4C^*H(CH_3)C_2H_5$.

Employing electron paramagnetic resonance (EPR) spectroscopy with nitroxyl spin probe TMOPO, we quantified values of key dynamic parameters—orientation relaxation time, anisotropy parameters, local viscosity, and order parameters across nematic (N) and smectic (SmA, SmC*) phases. EPR measurements were performed in the microwave region at 9 GHz. The magnetic parameters were measured with an accuracy of ±0.4 G. The accuracy of the temperature measurements was ±0.1 °C. Our analysis of the EPR spectra line shapes was based on the well-developed spin relaxation theory [S.A. Goldman et al., J. Chem. Phys., 1972. 56/2, (716)].

The study demonstrates that variations in molecular length, polarity, and substituent architecture modulate both pre-transitional anomalies and the effective rotational diffusion tensor of probe radicals.

Special attention is given to the nature of phase transitions between isotropic, nematic, and smectic phases. EPR-derived order parameters combined with analysis of pretransitional anomalies, hysteresis phenomena, and critical behavior near phase transitions within the frameworks of McMillan's microscopic theory, Landau phenomenology, and scaling theory elucidate the first- or weakly first-order character of the N ↔ Sm phase transitions and highlight the emergence of cybotactic clusters in the nematic phase. It is shown that the nematic–isotropic transition in the studied systems is close to tricritical behavior, while the smectic–nematic transition predominantly exhibits first-order characteristics. These findings provide mechanistic insight into the molecular origins of phase behavior and dynamic properties, offering predictive guidance for the design and development of advanced liquid crystal materials with controlled functional parameters.

Keywords: EPR spectroscopy, thermotropic liquid crystal, nematic, smectic, ferroelectric, phase transition

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Gel vs. suspension: radiolytic synthesis of magnetic CMC–based hydrogels in one– and two–step approaches

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At the Ruđer Bošković Institute, using γ-irradiation from a ^{60}Co source we synthesized magnetic nanocomposites based on biocompatible semi-synthetic polymer carboxymethyl cellulose (CMC). Our research systematically explores the critical conditions such as precursor concentration, pH, polymer concentration, and scavenger concentration that determine whether the process yields stable ferrofluid suspensions or crosslinked hydrogel networks.

In our previous work we successfully synthesize magnetic poly(ethylene oxide) (PEO)/magnetite nanocomposite hydrogels using one-step gamma irradiation technique [I. Marić et al, Nanomaterials, 2020, 10(9)] starting from PEO and Fe^{3+} aqueous solutions, by optimizing parameters such as 2-propanol and Fe^{3+} concentration, polymer molecular mass, dose etc., and on such way finding optimal balance between reductive conditions needed for reduction of Fe^{3+} and oxidizing conditions (hydroxyl radical) needed for crosslinking of polymer chains.

In this work, the additional challenge lies in the fact that natural polymers like polysaccharides are known to degrade on irradiation in aqueous solution. In the one–step synthesis approach – trying to obtain simultaneous reduction of Fe^{3+} and formation of CMC network – stable ferrofluids with controlled iron oxide nanoparticle phase composition and excellent colloidal stability, or orange-colored non-magnetic gels derived from high-density, highly viscous precursors were obtained. The main parameter that directed the system toward the formation of either gels or suspensions was the concentration of aqueous CMC solution, followed by the concentration of 2-propanol. The limited water content in viscous systems, required for gel formation, restricts Fe^{3+} reduction to magnetite, leaving primarily ferrihydrite-like phases. Even in a case when certain reduction occurred these gels exhibit rapid oxidation upon air exposure. In contrast, ferrofluids from the one–step route served as excellent precursors for formation of magnetic hydrogels by radiation induced crosslinking in the second step. This yielded dark, homogeneous magnetic hydrogels with uniform nanoparticle distribution throughout the polymer matrix.

This dual–strategy approach enables precise tuning from flowable ferrofluids to magnetic hydrogels, opening new possibilities for targeted drug delivery, magnetic hyperthermia, and tissue engineering applications.

Keywords: nanocomposite, hydrogels, magnetic nanoparticles, biocompatible, CMC, radiolytic synthesis, magnetite

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Influence of sintering temperature on porosity and crystallization in recycled glass piezoelectric glass ceramics: A correlative study using X-Ray MicroCT, MicroXRF and XRD

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Piezoelectric glass-ceramics are advanced materials that combine the functional properties of crystals with the processability of glasses, making them attractive for industrial, medical, and energy-related applications. Producing these materials from recycled glass offers a promising route for environmental sustainability. However, the functional performance of such materials is critically dependent on their microstructure, and the relationship between the sintering parameters and the resulting physico-chemical properties – such as porosity, crystallinity, and elemental distribution changes – in recycled-glass systems remains poorly understood. Establishing this link is essential to optimize the manufacturing process and enable the technological valorization of recycled glass into high-performance devices.

In this work, we investigate how the sintering temperature influences porosity, crystallization, and the spatial distribution of chemical elements in a piezoelectric glass-ceramic fabricated from recycled glass. We employed X-ray microcomputed tomography (microCT) to quantify pore morphology in 3D, micro X-ray fluorescence (microXRF) to map elemental distributions across the material, and X-ray diffraction (XRD) to assess the crystallinity of glass-ceramic samples sintered at 650, 750, and 800 °C under controlled conditions. MicroCT analysis revealed that while the total pore volume fraction remained stable between 1 and 2%, the number of individualized pores decreased by approximately 39.5% as temperature increased from 650 to 800 °C, indicating significant microstructural densification. MicroXRF analysis identified 14 elements (including Al, Ca, Ti, and Pb) and showed that both the bulk composition and the spatial homogeneity of these elements remained unchanged across all sintering temperatures. XRD analysis revealed progressive structural changes in the SiO_2-based matrix, with crystallinity percentages of 6.7%, 12.8%, and 33.6% for the samples sintered at 650, 750, and 800 °C, respectively. These findings demonstrate that sintering temperature primarily governs pore coalescence and crystallization rather than bulk chemical redistribution, providing critical processing-structure correlations for the development of sustainable piezoelectric glass-ceramics from recycled waste.

Keywords: glass-ceramic, sintering, microCT, X-ray fluorescence, X-ray diffraction, porosity, nondestructive characterization, crystallization

Carrier lifetime variations in neutron-irradiated high resistivity silicon across wide fluence range

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Silicon is the dominant semiconductor material used in the production of high-sensitivity particle detectors for high-energy physics applications. Consequently, the characterization of radiation-induced defects and the prediction of material radiation hardness are critical for the development of next-generation radiation-hard detectors and for ensuring reliable operation in extreme environments. Charge carrier dynamics are sensitive to concentration and to the parameters of defects, making carrier lifetime analysis a powerful probe of radiation-induced damage. Additionally, thermal annealing offers a pathway for partial recovery and further insight into defect evolution.

In this work, two sets of high-resistivity silicon samples were investigated after neutron irradiation at the TRIGA reactor in Ljubljana. Irradiations were performed in two channels over a wide fluence range of 10^{12}-10^{17} n/cm^2. To examine radiation-induced changes in charge carrier dynamics, two complementary contactless techniques of microwave probed photoconductivity (MW-PC) and the differential absorption (DA) in the pump-probe configuration were employed. For samples irradiated with lower fluences (10^{16} n/cm^2), MW-PC transient method was employed. Here excess carriers are generated by a 1064 nm laser pulse, and the resulting transient photoconductivity is monitored via microwave probing. However, due to limitations imposed by the RC circuits of the measurement system, this method has a temporal resolution above 1 ns. For measurements of shorter carrier lifetime values, the DA technique was utilized. Here, carriers are excited using a 1030 nm pump pulse and probed by a 2300 nm pulse, delivered to the sample with a variable delay. This method is sensitive to changes in optical absorption caused by variations of excess carrier concentration. The combined use of MW-PC and DA techniques enabled measurements of carrier lifetimes ranging from hundreds of microseconds to tens of picoseconds. It was determined that the carrier lifetime decreased from hundreds of microseconds to tens of picoseconds over a fluence range of 10^{12}-10^{17} n/cm^2.

Following irradiation, isochronal thermal annealing was performed in 30-minute steps over the temperature range of 80–400 °C. An increase in carrier lifetime with annealing temperature was observed, indicating partial recovery of radiation-induced damage. These changes are attributed to defect transformation and annihilation processes, which will be discussed.

Keywords: silicon, carrier lifetime, radiation defects

High-entropy oxides with spinel structure-preparation method, structural and microwave properties

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High-entropy spinel oxides (HE-SOs) have rapidly emerged as advanced electromagnetic wave (EMW) absorbers owing to their multicomponent tunability, severe lattice distortion, abundant oxygen vacancies and synergistic “cocktail effect”. These features enable excellent impedance matching, multiple dielectric and magnetic losses, and strong interfacial polarization, providing broadband absorption while maintaining lightweight and thin profiles. Such properties make HE-SOs particularly promising for 5G interference suppression, electromagnetic compatibility and stealth technologies.

In this work, the equimolar high-entropy spinel $Co_{0.6}Mn_{0.6}Ni_{0.6}Cr_{0.6}Fe_{0.6}O_4$ was synthesized via a simple solution-combustion route using metal nitrates as oxidizers and sucrose as fuel. The starting materials acting as oxidizers were $Co(NO_3)_2{\cdot}4H_2O$, $Mn(NO_3)_2{\cdot}4H_2O$, $Fe(NO_3)_3{\cdot}9H_2O$, $Ni(NO_3)_2{\cdot}6H_2O$, and $Cr(NO_3)_3{\cdot}9H_2O$. All metal nitrates were mixed in equimolar proportions (1:1:1:1:1). Sucrose ($C_{12}H_{22}O_{11}$) served as the fuel and reducing agent. Following the combustion principles, the quantities of fuel and oxidizers were adjusted to maintain a 1:1 ratio. The as-combusted powder was calcined at 400 °C, 700 °C and 900 °C for 1 h. The resulting materials were characterised by powder X-ray diffraction, X-ray fluorescent analysis, X-ray photoelectron spectroscopy (XPS), and Electron (SEM, TEM) and Mössbauer spectroscopy methods.

Powder X-ray diffraction revealed that the 400 °C product is poorly crystalline (crystallite size < 5 nm). Annealing at 700 °C yielded a well-defined cubic spinel phase (a = 8.356(1) Å, crystallite size 28 nm), while treatment at 900 °C produced a more ordered structure (a = 8.3412(6) Å, crystallite size 73 nm).

The controlled increase in crystallinity and crystallite size with annealing temperature demonstrates that post-combustion thermal treatment effectively tailors microstructure while preserving the single-phase high-entropy character. These tunable structural features directly enhance lattice distortion and defect engineering, thereby optimizing impedance matching, dielectric/magnetic losses and interfacial polarization for superior EMW attenuation.

The results highlight solution-combustion synthesis as a scalable, energy-efficient route to high-performance HE-SOs. Combined with their intrinsic “cocktail effect”, these materials offer sustainable solutions for next-generation broadband microwave absorbers in 5G interference suppression and electromagnetic shielding applications.

Keywords: high-entropy spinel oxides, microwave absorption, electromagnetic wave absorbers, impedance matching, dielectric losses, lattice distortion, 5G interference suppression, solution combustion synthesis

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Effect of synthesis temperature on the rearrangement of hydroxyapatite microsphere beds characterized by microcomputed tomography and digital volume correlation

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Hydroxyapatite (HA) microspheres are a versatile class of biomaterials widely used in bone tissue engineering and controlled drug delivery due to their bioactivity and flowability. However, non-destructively resolving how particle morphology and local packing constraints govern bulk settlement under mechanical perturbation remains challenging. Addressing this issue is important for engineering particulate scaffolds with controlled porosity and predictable mechanical stability. In this work, we investigated whether the synthesis temperature modifies settlement kinematics by shifting the system from discrete particle rearrangement toward more constrained collective motion. Micro-computed tomography combined with Digital Volume Correlation (DVC) was used to map and compare the three-dimensional displacement fields and 3D morphometrics in HA90 (synthesized at 90°C) and HA37 (synthesized at 37°C) hydroxyapatite microsphere beds. For a standardized comparison of packing states, identical watershed separation parameters were applied to both datasets. Quantitative morphometric analysis showed that the HA90 system exhibited an apparent fivefold increase in segmented object volume and an 87% increase in equivalent diameter relative to HA37. While synthesis conditions influence crystal growth and primary particle morphology, these apparent increases, together with a 24% higher mean neighbor count and a 4 times higher area fraction, are consistent with stronger packing and enhanced boundary sharing, which hindered full watershed separation in HA90. Analysis of the DVC displacement-magnitude field further showed that HA90 exhibited a mean displacement magnitude approximately 4.1 times higher than HA37, a median displacement magnitude 4.5 times higher, and a 10-fold higher displacement variance, indicating a more heterogeneous resolved rearrangement pattern under identical mechanical stimulation. In contrast, the HA37 bed preserved clearer particle discreteness, consistent with more independent local rearrangements. These results demonstrate that micro-computed tomography combined with Digital Volume Correlation and segmentation-based analysis provides a non-destructive framework to distinguish discrete particle rearrangement from more constrained, jammed-like packing states dictated by synthesis conditions in hydroxyapatite particulate beds.

Keywords: microcomputed tomography, non-destructive characterization, segmentation, Digital Volume Correlation, displacement characterization, particular kinetics, hydroxyapatite microspheres, granular materials, morphometric analysis

Estimation of the accuracy of generic NaI(Tl) and $LaBr_3$ models used in the LabSocs and ISOCS calibration software

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The gamma ray spectroscopic measurement of the radioactive content of the foodstuff always poses the problem of the efficiency calibration of the detectors used. In many situations, the wide combinations of geometries and type of samples that are to be measured renders the experimental efficiency calibration virtually impossible without compromising the accuracy of the measurement and this is why many of the laboratories in the field are resorting more and more to methods of mathematical efficiency calibrations.

Many users of gamma ray spectroscopy systems use the software LabSocs or ISOCS for the efficiency calibration of their systems. The MCNP code or other Monte Carlo simulation codes can be an alternative for the efficiency calibration. While the usage in conjunction with a germanium detector (HPGe) usually involves a Monte Carlo characterisation of the detector used, if the laboratory uses a scintillator detector – be it NaI(Tl) or $LaBr_3$ – all the software offers is a generic description of these detectors. Within a research project which aims to develop a new method for measuring the radioactive content of foodstuff, we set up to estimate the accuracy of these generic descriptions of scintillation detectors.

Point source measurements have been made with 3x3 and 2x2 inch NaI(Tl) detectors as well as with 1.5x1.5 inch $CeBr_3$ and $LaBr_3$ detectors and the efficiencies calculated from the measurements were compared with the efficiencies calculated from LabSocs and MCNP code. Correction factors were then applied and the implications for the accuracy of measurements in real geometries were also evaluated. A few recommendations for gamma ray spectroscopy users are presented, too.

Keywords: foodstuff radioactivity, detector efficiency, mathematical efficiency calculation

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Multidirectional secondary radiation fields in multilayer proton accelerator shielding: A comparative Monte Carlo analysis of concrete, FeB, and hybrid designs

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In high-energy proton accelerators, secondary radiation fields generated by proton interactions with target materials constitute a critical engineering challenge in shielding design, primarily due to the high penetration capability of neutrons. In this study, the secondary particle field produced by the interaction of 1000 MeV protons with a copper target was investigated using the FLUKA Monte Carlo particle transport code for three different multilayer shielding configurations: layered concrete shielding (Design 1), layered ferroboron (FeB) shielding (Design 2), and an asymmetric concrete–FeB hybrid shielding (Design 3).

The analyses were performed based on secondary particle production and two-dimensional dose distributions expressed in terms of ambient dose equivalent H*(10). The results indicate that neutrons are the dominant secondary component in all configurations and play a dominant role in determining the spatial characteristics of the radiation field. In FeB-based shielding systems, the presence of high atomic number constituents leads to an increase in hadronic and electromagnetic interactions, resulting in enhanced neutron and photon production. In contrast, concrete-based shielding systems exhibit more effective neutron moderation due to their hydrogen content, with a relatively more pronounced contribution from charged particles.

The asymmetric hybrid shielding configuration effectively combines the advantages of both materials by optimizing neutron moderation and absorption processes, thereby providing a more balanced particle distribution and a more controlled dose field. These findings demonstrate that, in multilayer shielding design, not only the total thickness but also the material selection, layer sequencing, and geometric configuration play a decisive role in determining shielding performance.

Keywords: proton accelerators, neutron shielding, FLUKA, ferroboron, multilayer shielding, dose distribution, H*(10), secondary particles, Monte Carlo, hybrid shielding system

Effect of molecular excitation under irradiation on the local structure and thermodynamic. Properties of liquids: A computer simulation study

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The effect of ionising radiation on liquids is traditionally considered in terms of radiolysis and local heating. Within these approaches, the main attention is paid to changes in the chemical composition of the system and non-equilibrium thermal effects. At the same time, it is usually not taken into account that molecular excitation leads to a change in the nature of intermolecular interactions with surrounding non-excited molecules. Meanwhile, the transition of a molecule to an excited state can qualitatively modify the interaction potential and, consequently, affect the structure and properties of a liquid even at low concentrations of such particles.

In our previous work (Ukr. J. Phys. 70, 769 (2025)), a model potential describing the interaction between excited and non-excited molecules was proposed, taking into account the change in the character of intermolecular forces. In the present study, an irradiated liquid is treated as a two-component system consisting of excited and non-excited molecules interacting via different potentials.

Computer simulations were performed using the Monte Carlo method in the canonical ensemble. Non-excited molecules interact via the Lennard-Jones potential, while the interaction between excited and non-excited molecules includes an anisotropic dipole-like contribution. Systems with the same density and number of particles but different concentrations of excited molecules were considered. The local structure was analysed using Steinhardt bond-orientational order parameters.

It is shown that the distributions of Steinhardt parameters characterising the environment of non-excited molecules remain almost unchanged upon the addition of excited particles, indicating that the structure of the main liquid matrix is preserved. At the same time, in the vicinity of excited molecules a pronounced temperature dependence is observed, along with the formation of structurally distinct local configurations.

The calculated thermodynamic properties demonstrate that even a small concentration of excited molecules leads to an increase in the heat capacity and pressure of the system. In the reduced temperature range of 1.3 – 1.5, anomalies in the form of a heat capacity maximum and a non-monotonic behaviour of the pressure difference are observed, correlating with the restructuring of the local environment around excited molecules.

The obtained results indicate that the change in the character of intermolecular interactions due to molecular excitation can act as an independent mechanism of radiation effects on liquids, complementing the conventional concepts based on radiolysis and thermal effects.

Keywords: radiation effects in liquids, radiation-induced modification of intermolecular interactions, local structural heterogeneity, steinhardt bond-orientational order parameters, thermodynamic signatures of local structural rearrangements

Comparison of the static neutronics and sensitivities of the ESFR-SMART and derived ESFR-SMR fresh cores

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The sodium-cooled reactors offer multiple advantages over more commercial alternatives. Utilization of fast neutron spectra together with sodium coolant leads to inherent safety features, improved fuel and thermal efficiency and the possibility of closing the fuel cycle. In Europe, the development of SFR technology has a long history, including notable projects such as Phénix and Super Phénix. In recent years, European SFR research endeavors were consolidated in projects such as EFR, CP-ESFR etc., resulting in the ESFR-SMART reactor concept at 3600 MW_{th}. The most recent goal of this line of R&D is the ESFR-SIMPLE project, focused on experimental validation of the proposed design features and power, economics, safety and flexibility optimization. To improve the power and deployment flexibility, smaller and fully transportable and modular ESFR-SMR design was proposed at 360 MW_{th}. Since the ESFR-SMR is directly derived from the ESFR-SMART, the objective of this work is to evaluate whether key characteristics remain comparable under static conditions. The compared parameters include reactivity coefficients, power distribution and sensitivity coefficients calculated using IFP and direct perturbation methodology. Additionally, the overall similarity of the designs is quantified using the TSUNAMI-IP similarity indices.

Keywords: ESFR, sensitivity analysis, similarity indices

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Design and construction of a neutron activation system for a DD neutron generator at STU Bratislava

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The contribution outlines the design and optimisation of a neutron activation system developed for a newly installed deuterium–deuterium neutron generator at STU. The system supports both prompt and delayed neutron activation analysis, with its configuration guided by Monte Carlo simulations performed using the MONACO code within the ORNL SCALE suite. The potential integration of available radioisotope sources is assessed to enhance analytical capability. The paper presents the system architecture together with initial performance measurements.

Keywords: neutron activation system, simulations, construction, neutron generator, radioistope sources

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Dose measurements during 4DCT scans on radiotherapy CT simulators using LD-V1 GafChromic™ film

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Purpose. We measured surface dose during 4DCT scans on radiotherapy CT-simulator used for planning stereotactic body radiotherapy (SBRT) in lung cancer patients. This modality requires precise targets and organs at risk contouring using 4DCT scans with elevated imaging dose levels. Following AAPM TG-180 [C. M. Ma, et al., Med. Phys. 28, 868–893 (2001)] request for imaging dose estimation in radiotherapy patients, we measured surface dose on humanoid Rando phantom with GafChromic™ LD-V1 film, designed for the 40–160 kVp and dose range 20 - 200 mGy. While the reflectance responses produce non-linear calibration curves [O. Masella, et al., J Appl Clin Med Phys. 25:1453 (2024)], we evaluated a linearized function to characterize LD-V1 dose response.

Methods. Calibration of LD-V1 film was carried on Philips Big-Bore CT-simulator, in Service mode with X-ray tube in stationary mode, using 120 kVp with body bow-tie filter and measured half-value layer (HVL) of 8.41 mm Al. Air-kerma in air (Kairair) and HVL were measured using RaySafe X2 dosimeter. We placed film pieces (1″×3″) on Styrofoam at the center of scanner bore, and irradiated them with Kairair values 30-200 mGy. For surface dose measurements during 4DCT scans, we attached film pieces to chest and pelvis Rando phantom surfaces and repeated measurements three times. Films were scanned 24 hours post-irradiation with Epson Expression 11000XL scanner in reflective mode (127 dpi and 48-bit RGB). With MATLAB script we extracted red-channel mean pixel value (PV) within 5×5 pixels ROI at the center of each film piece from tiff images. Film response was expressed as: Kairair =A[(PV0/PV)n-1], where A and n are fitting parameters, and PV0 and PV are pixel values of unexposed and exposed films, respectively. Surface dose to water was obtained by multiplying measured air-kerma by the mass energy-absorption coefficient ratio (water/air) for the measured HVL, following AAPM TG-61 [Ding GX, et al., Med. Phys. 45(5) (2018)].

Results. We obtained the LD-V1 calibration curve which demonstrates linear dose response across 30–200 mGy range, with fitting parameters found A=66.7 and n=1.8. At chest and abdomen anatomical levels, per 1000 mAs, commonly used for SBRT 4DCT scan, the measured doses are in the range from 91.1 mGy for lateral, to 115.0 mGy for anterior surface dose. Overall measurement uncertainty was estimated 5–8%.

Conclusions. Surface dose during 4DCT simulations in our clinical 4DCT scans is considerably higher than for diagnostic CT scans of the same anatomical regions (2–6 cGy), which must be balanced against clinical benefit of improved target localization and motion management for high-precision radiotherapy of moving targets.

Keywords: LD-V1 films, 4DCT, refence dosimetry

Analysis of production methods for the medical isotope ^{124}Sb

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The development of nuclear medicine has increased the demand for cost-effective and reliable production routes for medical radionuclides with high radiochemical and chemical purity. Antimony–124 (^{124}Sb) is a β^- – emitting radionuclide with a half-life of 60.2 days and accompanying γ–ray emissions. Its relatively high–energy β^- particles (≈1–2 MeV) enable localized radiation delivery, while the γ–rays allow imaging and dosimetric monitoring. Owing to these characteristics, ^{124}Sb has been investigated as a potential radionuclide for intravascular brachytherapy (IVBT) aimed at preventing restenosis after angioplasty or stent implantation.

This analysis, based on both our experimental results and those reported in the literature, will help identify the most suitable rout for producing high–purity ^{124}Sb by comparing the yield of photonuclear, proton–, deuteron–, neutron–, and alpha–induced reactions.

Experimental data show that the cross section for ^{124}Sb production via the ^{124}Sn(p,n)^{124}Sb reaction is significantly higher than that for deuteron-induced reactions on natural tin. Reported maxima are 472.8 ± 39.4 mb at 8.5 MeV (Elmaghraby et al., 2008) and 330 ± 16.5 mb at 8.2 MeV (Miyazawa et al., 2021), compared with 57.5 ± 6.3 mb at 13.3 MeV for ^{nat}Sn(d,x)^{124}Sb (Tárkányi et al., 2011). Although the cross section can increase to about 977.5 mb when using enriched ^{124}Sn targets, this route is not optimal due to the co-production of long-lived ^{125}Sb ($T_{1/2}$ = 2.7 y).

Experimental results for the reaction ^{124}Te(n,p)^{124}Sb have also been reported in the literature F. Zhou et al., 2007. The small cross-section values (a maximum of 10.51 ± 0.88 mb at 14.6 MeV) make production by this reaction unlikely. The main industrial production route for ^{124}Sb is ^{123}Sb(n,γ)^{124}Sb, favored by the high natural abundance of ^{123}Sb and reactor neutron flux. However, it is less suitable for nuclear medicine due to co-production of long-lived ^{122}Sb ($T_{1/2}$ = 2.72 d), requiring extended cooling (for about 20 days).

Rebeles et al. (2007) studied excitation functions for α-induced reactions on natural tin, including the ^{nat}Sn(α,xnp)^{124}Sb reaction, in the energy range 12–38 MeV. The measured cross sections for ^{124}Sb were relatively low (a maximum of 2.39 ± 0.19 mb at 36.31 MeV), and the production involves contributions from multiple radioactive isotopes, making this route less suitable for efficient production.

We investigated photonuclear production of ^{124}Sb using the LUE-75 linear accelerator at the A. Alikhanian National Science Laboratory (Yerevan) with bremsstrahlung endpoint energy of E_{gmax} = 40 MeV. The low yield from ^{nat}Te (0.71 ± 0.03 mb) and significant co-production of long-lived radionuclides make this route impractical, even with enriched targets.

Summarizing we can say that the high–purity ^{124}Sb reasonable to produce in proton- induced reaction at incident energy of protons should be lower than 17 MeV and cooling of the target should last 6.5 h.

Keywords: nuclear medicine, production routes, medical radionuclides, Antimony–124

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A new generalized approach to beta-gamma radioxenon analysis

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Comprehensive Nuclear-Test-Ban Treaty Organization, Vienna, Austria

The Comprehensive Nuclear-Test-Ban Treaty Organization is in a preparatory phase to implement the required systems and analysis techniques for States to verify if a nuclear weapons test has been conducted. The Treaty encompasses geophysical measurements (seismic, hydroacoustic, infrasound) and environmental radiation measurements using aerosol filters and whole air samples of concentrated radioxenon. It is the analysis of radioxenon samples that is the focus of this work.

Radioxenon analysis involves the collection of whole air samples (approximately 40 m^3 over 24 hours for HPGe measurement or between 20-30 m^3, depending on the system manufacturer, over 6-12 hours for beta-gamma coincidence spectroscopy). The samples are concentrated and purified using silver zeolites or charcoal adsorpers before activity concentrations of ^{131}Xe, ^{133}Xe, ^{133m}Xe, and ^{135}Xe are determined. The total activity and more importantly, the relative amounts of the radioxenon species present can indicate that a nuclear test has occurred.

Historically, two analytical approaches have been applied for activity determination. The first is the Net Count Calculation (NCC) method, which relies upon 2D counting in various Regions of Interest (ROI) and performing a series of corrections for decay, interferences, ingrowth etc. The second approach, called BGM (Beta-Gamma Matrix) converts the NCC method to a matrix formulation and proceeds to solve the system simultaneously.

Recently, new beta-gamma coincidence systems have been developed that replace the NaI detector with a HPGe detector. This simplifies the analysis as both metastable isotope gamma and conversion electrons signals are no longer in the contained in the same ROI as the 30 keV x-ray from ^{133}Xe. This greatly simplifies the analysis and quantification as there are fewer interferences to consider. However, the initial formulation of the BGM algorithm is not flexible enough for analysis with HPGe detectors.

This poster will describe the features of radioxenon beta-gamma coincidence spectroscopy, and present comparisons and results of the Generalized BGM (GBGM) approach.

Keywords: radioxenon, Comprehensive Nuclear-Test-Ban Treaty

EPR investigation of dose–response characteristics of radiation-induced stable radicals in biomolecules under clinically relevant doses gamma radiation

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Ionizing radiation is widely applied across numerous areas of human activity. This necessitates careful monitoring of irradiation processes and rigorous dosimetric control. Accurate dosimetric measurements are essential both in industrial settings and in cases of radiation accidents, requiring reliable dosimetry systems. It is well established that exposure to highly ionizing radiation generates free radicals in materials. Electron paramagnetic resonance (EPR) spectroscopy is extensively used for dosimetric purposes and for the detection of radiation-induced free radicals in various materials. A specialized branch, known as EPR dosimetry, focuses on quantifying absorbed doses using this method. The main advantages of EPR dosimetry include rapid dose assessment and its non-destructive nature, allowing repeated measurements. Over the past three decades, EPR spectroscopy has seen substantial growth in practical applications.

Understanding the formation and stability of radiation-induced radicals in biomolecules is critical for applications ranging from radiotherapy to radiation protection. In this study, we investigated the generation of stable radicals in selected biologically relevant molecules, including sulfur-containing amino acids (cysteine and taurine), vitamins (Vit C and Vit B12), and mineral salts of vitamin C (Ca and Na ascorbates), exposed to clinically relevant gamma irradiation doses (1–20 Gy). EPR spectroscopy was employed to detect and characterize the radicals formed in powder samples at room temperature. Dose–response curves were obtained, and the linearity and slope of radical yield versus absorbed dose were analyzed. Spectral parameters, including g-factors and line shapes, were used to infer the chemical nature of the radicals and their dependence on molecular structure.

The yield and stability of radiation-induced radicals in biomolecular samples irradiated with clinically relevant gamma doses (1–20 Gy) are strongly dependent on molecular structure and functional groups, resulting in distinct dose–response characteristics. Sulfur-containing molecules showed the highest radical formation efficiency, whereas molecules lacking reactive centers exhibited comparatively lower yields. The radicals remained stable over the observation period, because of their trapping in the solid matrix.

Keywords: EPR spectroscopy, dosimetry, irradiation, clinical dose, free radicals, biomolecules

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EPR identification and kinetics study of the decay of gamma-induced free radicals in Physalis

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Physalis, also called the "golden berry," is a healthy fruit that is increasingly gaining popularity. This small, golden fruit, wrapped in a thin shell, not only impresses with its taste, but also offers numerous health benefits. The main ones among them are a wealth of nutrients and trace elements, improves the immune system, regulates blood sugar levels and many others. The opportunity to treat foods with high energy radiation can provide microbiologically stable products. It is known that gamma irradiation prevents foodstuffs from quickly spoiling and prolong their shelf life. Furthermore, irradiation by doses less than 10 kGy does not damage the taste of foodstuffs as well as the health of the consumers. Plants of different origins from South America and Europe were studied, as well as different parts of the fruit - shell, peels, seeds and defatted powder after seed oil extraction. In physalis, the ions of manganese, copper and iron are detected by EPR spectroscopy. Before gamma-sterilization, free radicals of the semiquinone type are registered. After irradiation, characteristic EPR spectra are detected, proving the radiation treatment, according to European Standards EN 1787 and EN 13708. One of them is due to gamma-induced free radicals in cellulose – shell, seeds and defatted powder, and the other in saccharides – peels. Kinetics study of the decay of gamma-induced free radicals shows that identification of previous irradiation is possible for 100 days and long period after that in peels samples.

Keywords: physalis, gamma-irradiation, EPR

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Gamma-irradiation effects on free radical formation and antioxidant activity of *Prunella vulgaris L.*

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Gamma irradiation is widely used for microbial decontamination and preservation of plant-derived materials used in the food, pharmaceutical, and cosmetic industries. Due to increasing consumer concerns, further studies on radiation-induced changes in medicinal plants are required. *Prunella vulgaris L.* (PV) is a medicinal and edible plant rich in biologically active compounds, including polysaccharides, phenolic acids, flavonoids, terpenoids, sterols, and volatile constituents, responsible for its diverse pharmacological activities and therapeutic applications.

In this study, Electron Paramagnetic Resonance (EPR) spectroscopy was applied to characterize free radical species in non-irradiated and gamma-irradiated samples exposed to doses of 1, 5, and 10 kGy. Free radical scavenging activity (FRSA) was evaluated using the stable DPPH radical. The characterization of selected polyphenolic groups, including flavan-3-ols, phenolic acids, and quercetin glycosides, in leaves and fruit spikes with flowers (FSF) was carried out by High-Performance Liquid Chromatography (HPLC). Total phenolic content was determined spectrophotometrically. EPR spectra revealed semiquinone radicals whose intensity increased after irradiation. A naturally occurring Mn^{2+} signal was observed and used as an internal marker for irradiation identification. Gamma irradiation did not significantly affect the FRSA of leaves, whereas FSF samples showed dose-dependent behavior, with increased antiradical activity at 10 kGy and decreased activity at 5 kGy. HPLC analysis showed that gamma irradiation induced both degradation of certain polyphenolic compounds and formation of new phenolic derivatives.

In conclusion, gamma irradiation leads to measurable changes in radical formation and polyphenolic composition of Prunella vulgaris L., while its antioxidant capacity remains largely preserved or dose-dependent.

Keywords: irradiation, *Prunella vulgaris L.*, free radicals, antioxidant activity, EPR, HPLC

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Model-based approach of low frequency magnetic field distribution along high voltage power lines

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Assessment of population exposure to low-frequency (LF) electric and magnetic fields (EMFs) from high-voltage power lines has traditionally relied on standardized in situ measurements. While such methods provide reliable data at specific locations, they are limited in their ability to describe the field's spatial distribution along transmission line routes. This creates a need for approaches capable of providing spatial characterization of LF EMF components.

This work focuses on the development and application of a model-based approach for predicting the distribution of electric and magnetic fields along transmission line corridors. The model is grounded in classical electromagnetic theory. Particular attention is given to the realistic representation of the system, including conductor geometry, phase configuration, and sag, which are critical for accurate field prediction.

Numerical simulations were carried out using a dedicated electromagnetic field calculation tool, enabling detailed modeling of extended line sections. The model is constructed using known technical parameters of the transmission line, including conductor arrangement, geometrical characteristics, and nominal operating voltage. Within this framework, field measurements measured at selected representative locations are not treated as primary results, but as reference data used to validate the model, particularly with respect to magnetic field levels influenced by load current.

The results demonstrate good agreement between measured and simulated values within the combined expanded uncertainty, confirming the reliability of the modeling approach. The analysis shows that the model's predictive capability depends primarily on the quality of the input data, particularly the conductor geometry and load conditions.

The proposed methodology allows the electromagnetic field distribution to be described along the entire transmission line route, rather than only at measurement locations, supporting corridor scale assessment of population exposure.

Keywords: model, power lines, low frequency magnetic field, safety protection, methodology

Determination of Po-210 in bottled mineral waters in Korea by alpha-spectrometry

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Po-210 is a highly radiotoxic alpha emitting radionuclide in the U-238 decay series and is ubiquitously present in environmental matrices as a decay product of Rn-222. Due to its strong alpha particle energy and biokinetic behavior in humans, ingestion of Po-210 through drinking water can cause continuous internal exposure and is therefore considered important from a radiological protection perspective. The World Health Organization (WHO) recommends that gross alpha activity in drinking water should not exceed 0.5 Bq/L.

Alpha-spectrometry is mainly used for determining Po-210, and a thin, uniform, and flat detection source is essential for precise alpha particle measurement. Among various preparation methods, spontaneous deposition is widely adopted worldwide. A newly designed deposition kit was developed in our laboratory to improve the conventional method, and physicochemical factors affecting deposition efficiency were experimentally optimized [Lee et al., Appl. Radiat. Isot., 2023]. Analytical reliability was verified through continuous participation in the IAEA ALMERA proficiency tests for Po-210 in water.

Using this optimized method, Po-210 in bottled mineral waters distributed in Korea was measured by alpha-spectrometry. Ten samples were analyzed with Po-209 as a yield tracer. The average chemical yield was 95 %, and the minimum detectable activity ranged 0.34–0.45 mBq/L. Measured Po-210 concentrations ranged 0.44–11.3 mBq/L, generally lower than those reported for bottled waters in other countries such as Hungary, Italy, and Spain.

Keywords: Po-210, bottled mineral water, alpha-spectrometry, spontaneous deposition

Statistical evaluation of the toxic elements content in urban soils

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Soil pollution caused by industrial activities results in the deterioration of soil quality, the loss of essential ecological functions, and poses considerable environmental and public health risks. Heavy metals enter soils through multiple pathways, including mining operations, energy production, the application of fertilizers and pesticides, wastewater discharge, and atmospheric emissions. Although some metals occur naturally, elevated concentrations can present serious hazards to human health.

Soil radioactivity arises from natural radionuclides (such as those in the uranium and thorium decay series, as well as potassium-40), cosmic radiation, and anthropogenic sources including strontium-90 and cesium-137. Monitoring soil contamination requires measuring gross alpha and beta activity, since radionuclides can migrate from soil into plants and animals, thereby affecting ecosystems and human well-being.

A thorough understanding of soil radioactivity and heavy metal content is crucial for building reliable databases, tracing their movement through ecosystems, and assessing potential risks. Continuous monitoring of both natural and anthropogenic toxic elements is essential to safeguard environmental integrity and protect public health.

To identify sources of toxic elements in soil, statistical approaches such as Pearson's correlation coefficient and principal component analysis are commonly employed. Pearson's correlation reveals relationships among different elements, while principal component analysis helps determine the likely sources of contamination within the study area.

This study presents observations derived from statistical analyses of experimentally measured concentrations of toxic elements in urban soils within the municipality of Novi Sad.

Keywords: radionuclides, heavy metals, statistical analysis

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Refractory elements in the rivers of the Paraguayan Chaco

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Refractory elements, such as metal or incompounds, have high melting points. They are of great importance in the hypermodern electronics as well as cutting edge technology. Here we studied the distribution of selected refractory elements in river sediments from the Paraguayan Chaco of western Paraguay. We also included the results from studies of the Paraguay and Paraná Rivers, the two largest rivers of the country. Samples were analyzed by X-ray fluorescence (XRF) and results checked in arachnograms with of the primordial mantle (PM) and upper crust (UC) values. This work is the second part of the previously published study.

Keywords: river sediments, refractory elements, XRF, Paraguayan Chaco

Assessment of natural radioactivity of fossil bones using Gamma-Ray Spectrometry and Scanning Electron Microscopy: Significance and implications

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This study analyzes fossil bones of Mammuthus Meridionalis from the Irimeşti site, estimating the concentrations of natural radioactive elements (^{238}U, ^{232}Th, and ^{40}K) and investigating the relationship between the site's geological characteristics, the mineralogy of the bones, and radioactivity levels. The site is part of the Plio-Pleistocene mammalian succession in the western Dacian Basin, characterized by a 100m thick fluvio-lacustrine sequence that has produced various mammalian faunas from its sediment layers. Each depositional cycle begins with erosional gravels or pebbles, followed by cross-bedded sands, and evolves into finer materials, ending with silty clay or clay levels [Rădulescu C. & Samson P., Quartärpaläontologie, 1990, 8, 225 -232].

^{238}U, ^{238}Th, ^{40}K concentrations in selected fossil bones (skull, femur, and spinal column) were determined non-destructively using gamma-ray spectrometry with high purity germanium (HPGe) detector - (relative efficiency of 27%, resolution of 1.90 keV and peak/Compton ratio of 56:1 at 1.33 MeV). The texture and mineral contents of a selected specimen of fossil bone (femur) was examined using Scanning Electron Microscope (SEM).

The average of specific activity shows a preferential enrichment of ^{238}U in fossil bones (3340 Bq/Kg), whereas ^{232}Th (4.33 Bq/Kg), and ^{40}K (65.33 Bq/Kg) concentrations are insignificant. SEM analysis did not detect any U minerals in the bone fragment, contrasting with the high uranium content determined radiometrically, and the mineral matter contained. The fossil bones are apparently composed of a massive or cryptocrystalline variety of apatite or collophane, with fibrous and porous textures and cracks that occur locally. The Haversian canals are mineralized with authigenic calcite crystals, manganese oxide, iron oxide, and silicate. The U-bearing substance is evidently distributed together with organic bone material, probably associated with collophane, it is arguably secondary accumulated during fossilization, uranium being derived by leaching of the lignite deposits, mobilized as uranyl ion, and strongly absorbed by the organic matter from bones, being a marker for redox conditions during diagenesis. High concentrations of uranium have been noticed in some lignite seams belonging to Berbeşti coal deposits upstream from the fossiliferous site [Cosma C. et. al., J. Environ. Prot. Ecol, 2009, 10, 1, 192-200].

Keywords: fossil bones, radioactivity, minerals, diagenesis

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Optimization of integrated analytical procedures for essential beta-emitting radionuclides in complex low- and intermediate-level radioactive waste matrices

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Radioactive solid waste generated during the operation and decommissioning of nuclear facilities encompasses a wide range of physical forms and chemical compositions. These include inorganic matrices such as concrete and soil, as well as organic combustible materials like latex gloves and various polymers (e.g., PE, PVC). Effective management and safe disposal of these materials depend fundamentally on the precise characterization of their radiological content to ensure compliance with disposal facility acceptance criteria.

This study established and validated a comprehensive analytical framework for eight essential beta-emitting radionuclides (^{3}H, ^{14}C, ^{129}I, ^{55}Fe, ^{63}Ni, ^{59}Ni, ^{99}Tc and ^{90}Sr) within these diverse waste streams. Optimized pre-treatment protocols were developed for each matrix: acid digestion using HNO_3, HCl, and aqua regia was employed for concrete and soil, while high-temperature thermal decomposition with catalyst-aided combustion was utilized for organic wastes to capture volatile isotopes in specific trapping solutions. Following dissolution, target nuclides were purified through sequential extraction chromatography using specialized resins, including Sr resin, TEVA resin, and Ni resin, to achieve high chemical purity. Quantitative analysis was performed using a multi-instrumental approach: Liquid Scintillation Counting (LSC) for most beta emitters, ICP-MS for long-lived ^{129}I to achieve superior detection limits, and Low-Energy Germanium (LEGe) detectors for the characteristic X-rays of ^{59}Ni. To ensure data integrity, chemical yields were monitored using tracers Y, Fe, Ni, Re, Sr, and ^{127}I, and statistical outliers were managed through rigorous standard error evaluations. Validation results demonstrated exceptional performance, achieving analytical accuracy exceeding 90% across all matrices and radionuclides, with precision (RSD) maintained below 5% through automated pre-treatment systems. These optimized procedures reduce analytical time and secondary waste generation while providing the high-precision data required to minimize uncertainty.

Keywords: beta-emitting radionuclides, low- and intermediate-level waste, method validation, sequential extraction chromatography

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Historical trends of radionuclides and chemical substances in a sediment core at Cretan basin, Greece

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The study of sedimentary environments provides essential insights into the long-term cycling of physicochemical properties and the movement of tracers within marine ecosystems. Deep-sea sediments, which preserve environmental signatures across extended timescales, act as natural archives that record both natural processes and anthropogenic influences. Through the analysis of these deposits, it is possible to reconstruct past geological and environmental events, as well as to evaluate the historical dispersion of pollutants. In the present study, sediment core was collected from the Cretan Basin at the depth of 1070 m using a box corer sampler in order to determine sedimentation rate and assess the distribution of both natural and anthropogenic radionuclides. Particular attention was given to ^{137}Cs, as this isotope serves as a well-established marker of past nuclear activities. The core was sliced at 0.5 cm intervals, and sample preparation followed the International Atomic Energy Agency (IAEA) standard protocols to ensure analytical consistency and data reliability. Radionuclide activity concentrations were determined by high-resolution gamma spectrometry utilizing a high-purity germanium (HPGe) detector at the Marine Environmental Laboratory of HCMR. Chronological reconstruction was achieved through radiometric dating models employing both ^{210}Pb and ^{137}Cs radionuclides. A sedimentation rate of 0.02 cm/yr was determined for the sediment core. Distinct signals associated with global nuclear weapons testing and the Chernobyl fallout were identified and used to validate the ^{210}Pb-derived chronology, thus improving the accuracy and robustness of sedimentation rate estimates and the temporal reconstruction of depositional sequences.

Keywords: radioactivity, sedimentation rate, radionuclides, marine environment, HPGe

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Comparative Monte Carlo modeling of underwater gamma-ray spectrometry using MCNPX/6 and Geant4/GATE

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Understanding and protecting marine environments from the consequences of nuclear events is a key scientific goal. Accurate detection and characterization of gamma radiation are critical not only for nuclear safety but also for a range of applications, including environmental monitoring, seabed mapping, freshwater detection and analysis of human-made radionuclides in coastal waters. Developing robust measurement and simulation methodologies is therefore essential to support both scientific studies and operational activities in marine environment. This research focuses on advancing underwater gamma-ray spectrometry as a tool for detecting and analyzing radiation in aquatic systems. The study combines advanced computational simulations with experimental validation. Comparative Monte Carlo simulations are carried out using both MCNPX/6 and the Geant4/GATE codes in order to assess their performance under realistic underwater conditions. Simulation outputs from both frameworks are compared in terms of detector response functions, full-energy peak efficiency, spectral shape and photon interactions in water. Statistical uncertainties, along with differences in physics models, cross-section libraries, and particle transport schemes, are examined to evaluate the level of agreement between the two Monte Carlo codes. The Geant4/GATE software is applied for the first time by the Marine Environmental Radioactivity Laboratory at HCMR and, to our knowledge, represents one of the first implementations of GATE in marine gamma-ray spectrometry. Its results are benchmarked against the already calibrated MCNPX/6 model and validated using in situ measurements under controlled and field conditions. This comparative methodology establishes a dual-code verification strategy and assesses the suitability of Geant4/GATE, as an independent and complementary simulation platform for underwater gamma-ray detection and marine spectrometry applications.

Keywords: response function, full-energy peak efficiency, MCNPX/6 and Geant4/GATE, gamma-ray detectors, marine environment

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Characterization and analysis of microplastics (MPs) in beach sands

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The presence of microplastics in the environment has emerged as a critical concern on a global scale. The accumulation of microplastics in water bodies, beach sands, sediments and marine organisms poses a significant threat to ecosystems and the food chain. The identification of the chemical composition of microplastics is a critical step in comprehending the sources of plastic pollution and formulating reliable monitoring methods. In this study, the identification of microplastics present in the sand of the seashore was carried out using chemical and physical separation methods and spectroscopic analysis. The study was conducted on the sand of the Adriatic coast, in the Durrës area and in a sand sample prepared by the Marine Environment Laboratory of the International Atomic Energy Agency (IAEA). The samples represent material collected from a 25 cm × 25 cm quadrat at a depth of about 2 cm, corresponding to a surface area of 0.0625 m². The dimensions of microplastics range from 0.3 to 5 mm and microplastics separation was carried out through the sieving process. The separation of microplastics according to density was achieved by using a saturated NaCl solution. The resulting mixtures – the supernatant – were filtered using aluminium filters with 250 mm pore size. The filters were subjected to analysis under a stereomicroscope to identify various plastic particles according to size, shape and polymer type. Polymer identification was performed using Fourier Transform Infrared Spectroscopy (micro-ATR-FTIR), a method that enables the identification of polymers based on their characteristic absorption spectra. The results of the study indicated the presence of various types of polymers in different size and shape, primarily polyethylene (PE), polystyrene (PS), and polyethylene terephthalate (PET). The identification of these materials was based on the interpretation of ATR-FTIR spectra through characteristic molecular vibration bands, such as C–H stretching (~2920 and 2850 cm-1) for polyethylene (PE), C=O stretching (~1715–1735 cm-1) for polyethylene terephthalate (PET), and aromatic ring vibrations (~1450–1600 cm-1) for polystyrene (PS). The recovery efficiency was higher for particles in the 1–5 mm size range compared to the 300 µm–1 mm fraction. This is related to the greater difficulty in visualizing and isolating very small particles during the processing steps. The findings of this study demonstrate that the integration of separation methodologies and micro-ATR-FTIR spectroscopic analysis constitutes a reliable approach for the identification of microplastics in marine ecosystems.

Keywords: microplastics, beach sand, ATR-FTIR spectra, NaCl solution

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Gamma spectrometric analysis of radionuclide activity from soil and rock samples near Kosovska Mitrovica

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In general, the primary contribution to external exposure arises from gamma-emitting radionuclides present in soil and rocks, particularly in deeper layers of the Earth enriched in uranium. This study provides a statistical analysis and radiological characterization by analyzing the activity concentrations of natural and anthropogenic radionuclides in soil and rock samples collected near the Kosovska Mitrovica. The measurement focused on ^{226}Ra, ^{232}Th, ^{40}K,^{137}Cs, and uranium isotopes ^{238}U, ^{235}U. In rock samples, the mean activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K were respectively 85, 123 and 990 Bq/kg, while soil samples showed elevated values, with mean specific activity of about 66, 104 and 776 Bq/kg, respectively. The results show that rock samples generally exhibit higher concentrations of natural radionuclides compared to soil, which is typical for primary geological formations. According to UNSCEAR (2008), the worldwide average concentrations are 412 Bq/kg for ^{40}K, 32 Bq/kg for ^{226}Ra and 45 Bq/kg for ^{232}Th. The activity concentrations of ^{226}Ra and ^{40}K are 1.9 times higher than the world average, while ^{232}Th is 2.3 times higher. Average value of ^{137}Cs in rock is significantly lower, which is expected because cesium is retained in the surface layer of soil and humus, and does not penetrate deep into the compact rock mass. Soil serves as a reservoir for ^{137}Cs (mean value 75 Bq/kg). The presence of ^{137}Cs showed considerable spatial variability with elevated values reaching up to 183 Bq/kg at certain locations. The observed differences between soil and rock samples suggest that rocks represent the primary source of natural radioactivity, while soil reflects redistribution and accumulation processes.

The uranium isotope ratios provide further insight into the geological origin and potential environmental impact in ten surveyed locations. Average specific activity of ^{235}U in rock and soil are 4.4 and 142 Bq/kg, respectively, while ^{238}U content is 5 Bq/kg (rock) and 109 Bq/kg (soil). The activity ratio of ^{235}U/^{238}U ratio was found to be 0.031 for rock and 0.046 for soil samples. Although the natural mass ratio is fixed, the activity can vary slightly depending on geochemical processes. The ^{238}U/^{226}Ra ratio is 1.5, indicating a slight imbalance in favour of the parent uranium isotope. This finding indicates a higher relative presence of ^{235}U in soil compared to rock samples. The high activity concentrations of ^{238}U indicate a uranium-rich geological background.

Overall, the elevated concentrations of natural radionuclides, particularly ^{232}Th and ^{238}U, point to enhanced natural radioactivity in the investigated area. These findings imply potential for increased radon generation, which may be of radiological significance for environmental and public health.

Keywords: radionuclides, elevated specific activity, soil, rock, environmental exposure

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Gamma radiation for enhancing phenolic extraction and bioactivity in grape pomace

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Grape pomace, a widely available winemaking by-product, is a rich source of phenolic compounds with recognized antioxidant, antidiabetic and antimicrobial properties, supporting its valorization (Lopes et al., 2025). Gamma radiation has emerged as a sustainable processing technology capable of enhancing the extractability and functionality of bioactive compounds, contributing to greener recovery strategies (Madureira et al., 2020).

This study evaluated the impact of gamma radiation as a pre-treatment on the extraction efficiency of phenolic compounds from grape pomace and on the antioxidant and antidiabetic properties of the resulting extracts. The effectiveness of different radiation doses (5, 15 and 37 kGy) was assessed by comparing total phenolic content (TPC), total flavonoid content (TFC), antioxidant activity (DPPH and FRAP assays), and α-amylase and α-glucosidase inhibition with a non-irradiated control of grape pomace extracts.

Gamma radiation significantly increased phenolic extraction, with 15 and 37 kGy treatments showing higher TPC and TFC than the control. The treatment of grape pomace at 37 kGy produced extracts with the strongest antioxidant activity and α-amylase inhibition, while α-glucosidase inhibition was maximized at 15 kGy. These results demonstrate that gamma radiation effectively enhances both the recovery and bioactivity of grape pomace phenolics.

Overall, the study highlights gamma radiation as an efficient technology for producing high-value bioactive extracts with potential applications in the pharmaceutical, cosmetic and functional food sectors, while contributing to sustainability and resource valorization.

Keywords: gamma radiation, grape pomace, phenolic compounds, extraction efficiency, antioxidant activity, antidiabetic activity, sustainable valorization, circular economy

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The state of the rat skin mast cell population after exposure by pulsed periodic plasma accelerator bremsstrahlung radiation of orthovoltage range

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The active development of radiation technologies in the biomedical field necessitates flexibility in adjusting the intensity and spectral composition of ionizing radiation (IR), enabling the modulation of key properties of the tissue microenvironment, including tumor sensitivity to subsequent treatment regimens (Tubiana M. et al., 2006; Huber S. et al., 2013; Santos Ortega M. et al., 2025; Lach M. et al., 2025). In this context, the development of IR with parameters that exert targeted effects on the regulatory systems of local tissue homeostasis - specifically mast cells - is of paramount importance (Atiakshin D. et al., 2023; Heidarzadeh-Asl S. et al., 2025; Elieh-Ali-Komi D. et al., 2025).

In this work, bremsstrahlung (BR) with tunable spectrum and intensity in the orthovolt energy range generated by a compact plasma accelerator based on the gyromagnetic autoresonance phenomenon (Andreev V. et al., 2021) was used for radiation exposure to mast cells (MCs) in the skin of outbred Sprague-Dawley rats, female, aged 7–8 weeks. Mast cells were selected as the target of this study due to their critical roles in regulating the tissue microenvironment and their high radiosensitivity (Albrecht M. et al., 2007; Milliat F., François A. et al., 2018).

The animals (N=44) were divided into 5 groups with different parameters of BR exposure with a duration of 40 minutes, including the control group: 1) gas target - Xe, maximum energy in the spectrum of 500 keV, absorbed dose of 0.04 Gy; 2) Xe, 250 keV, 0.02 Gy; 3) solid-state target - W, 500 keV, 0.5 Gy; 4) W, 250 keV, 0.1 Gy; 5) control, without radiation exposure.

A post-radiation increase in the population of skin MCs in rats was observed, along with enhanced secretion of biologically active substances - including tryptase - targeting cellular and tissue structures, as well as an increased frequency of juxtacrine and paracrine interactions with cells of the fibroblastic differon. Changes in the colocalization of MCs with collagen and elastic fibers in the dermis indicate both post-irradiation alterations in collagen fibrillogenesis activity and tension of the tissue microenvironment, which may influence the development of biological effects of IR in this energy range. Further studies are planned to elucidate the biological effects of IR with these parameters on the condition of the dermis, including the architecture of the immune and stromal landscape.

Keywords: plasma accelerator, X-ray, mast cells, tissue microenvironment

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Natural compound curcumin mitigates DNA damage in lymphocytes after γ-irradiation

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Introduction. DNA double-strand breaks (DSBs) are recognized as a critical biomarker of radiation exposure, posing significant deleterious effects on cellular integrity. These breaks can be quantitatively assessed within the cell nucleus through the immunofluorescence co-localization of γ-H2AX/53BP1 repair proteins, which form DNA damage-repair foci (DRFs). Previous research has demonstrated a linear increase in DRFs in human lymphocytes corresponding to the radiation dose (Rothkamm, 2003). Concurrently, curcumin has garnered substantial scientific interest due to its antioxidant and anti-inflammatory properties, which may alleviate oxidative stress and subsequent damage induced by ionizing radiation in normal tissues (Zoi, 2022).

Aim. This study aimed to assess the impact of varying concentrations of curcumin on *ex vivo*-irradiated lymphocytes.

Materials and Methods. Peripheral blood samples were obtained from three healthy donors and pretreated with curcumin at concentrations of 0.5, 10, 20, and 100 μg/ml for one hour prior to irradiation with single doses of 0.05, 0.5, 1, and 2 Gy. Post-irradiation, lymphocytes were isolated, and DNA damage was evaluated through the immunofluorescence co-localization of γ-H2AX/53BP1 repair proteins. A manual microscopic analysis of 200 cells was conducted, and the frequency of DRFs was determined for each experimental condition.

Results. The findings indicated that curcumin pretreatment resulted in a reduction in the frequency of DRFs across all tested concentrations and doses ($p<0.05$). The most pronounced decrease, 38%, was observed in lymphocytes treated with 100 μg/ml curcumin and exposed to 0.5 Gy γ-radiation.

Conclusion. The reduction in DNA double-strand break frequency suggests that curcumin is a promising natural compound capable of mitigating DNA radiation damage in lymphocytes *ex vivo*.

Keywords: curcumin, irradiation, DNA damage, DNA double-strand breaks, γ-H2AX/53BP1 radiation foci, radiation mitigation

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Turning stress into value: Ionising radiation as a tool for selenium biofortification in *Chlorella sorokiniana*

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Selenium (Se) is an essential micronutrient for the human antioxidant system and strategies to enhance its bioavailability in food sources are of growing interest.

Ionising radiation has emerged as a promising tool to stimulate the production and accumulation of valuable compounds in microalgae, although the effects of electron beam (EB) irradiation in *Chlorella sorokiniana* (*C. sorokiniana*) remain unexplored. In this study, the impact of gamma and EB irradiation on *C. sorokiniana* growth and Se accumulation was evaluated across a range of doses (0.05-4 kGy) and applied at two distinct phases of microalgae growth (0 h and 24 h).

An absorbed gamma dose of 4 kGy inhibited growth, particularly when irradiation was applied at 0 h, while cultures irradiated at 24 h recovered faster. The maximum gamma doses tolerated by *C. sorokiniana* without growth reduction were 0.1 kGy at 0 h and 0.5 kGy at 24 h. EB irradiation (0.1–0.5 kGy) showed a stronger inhibitory effect for doses above 0.1 kGy.

Se accumulation was influenced by both irradiation dose and timing of growth, with higher values generally observed when irradiation was applied at the 24 h growth phase. Gamma irradiation at 1 kGy enhanced Se content by up to 48% compared to the control, while EB irradiation at 0.1 kGy resulted in a 19% increase, independently of the growth phase moment of irradiation (0 h or 24 h). Gamma irradiation promoted higher Se accumulation at higher doses, whereas EB exposure had a stronger inhibitory effect on microalgal cell growth.

Keywords: growth inhibition, ionising radiation, microalgal biotechnology, selenium biofortification

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Radiobiology-guided dose compensation after prolonged interruptions in postoperative breast cancer radiotherapy

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Introduction. Interruptions in radiotherapy may prolong overall treatment time, reduce treatment effectiveness, and adversely affect clinical outcomes. In breast cancer, prolonged treatment gaps represent a relevant clinical problem, particularly when compensation is required without exceeding tolerance doses to organs at risk (OARs). Although the linear-quadratic (LQ) model is widely used in radiobiological calculations, its limitations become more apparent in the setting of extended treatment interruptions.

Methods. We developed a radiobiology-based dose compensation algorithm designed for use in postoperative breast cancer radiotherapy after prolonged treatment pauses. The algorithm was based on the LQ model and generated approximate biological effective dose (BED) estimates for both target volumes and OARs. It was designed to provide multiple compensation options, allowing clinicians to evaluate alternative approaches for restoring the planned biological dose while minimizing unnecessary exposure to healthy tissues. In addition, the calculator included a generic OAR option, enabling individualized adjustment of the α/β ratio for specific organs or tumor characteristics. The algorithm was applied in five breast cancer patients who experienced radiotherapy delays longer than two weeks.

Results. The developed algorithm provided several feasible dose compensation strategies for each analyzed case and supported selection of the most appropriate option according to target coverage and normal tissue constraints. It proved most useful in patients with interruptions occurring before the final phase of treatment, where compensation remained biologically and technically achievable. Its applicability was more limited in cases of treatment interruption near the end of radiotherapy.

Conclusions. The algorithm may be a useful supportive tool in breast cancer radiotherapy planning when prolonged treatment interruptions occur. By offering multiple biologically informed compensation strategies, it may assist in balancing maintenance of tumor dose intensity with sparing of normal tissues. However, larger prospective studies are required to validate its clinical usefulness and confirm its impact on outcomes and toxicity.

Keywords: breast cancer, dose compensation, postoperative radiotherapy

Chromosomal aberration assay as a screening tool for emergency exposure situations: IST preliminary results of RESILIENCE project

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Introduction. The RESILIENCE-R-2023 project aims to establish a European collaborative ecosystem to address the growing threat of chemical, biological, radiological and nuclear (CBRN) agents. With the escalation of global conflicts there is a growing need to develop strategies to address these threats. The objective of the present study is to support medical diagnosis and treatment decision in case of RN emergencies, highlighting the importance of the triage between unexposed, and individuals developing a low and high severity degree of the acute radiation syndrome (ARS). Radiotherapy patients were studied to mimic different ARS severity degrees. The dicentric chromosome aberration (DCA) assay was used to evaluate the damage induced by ionising radiation in peripheral blood lymphocytes.

Methodology. Blood samples from breast and prostate cancer patients (BCP and PCP, respectively), as a simulation of mild-ARS, and from leukemia patients (LP), simulating a high-ARS, were studied using an optimized protocol. These samples were collected at different phases of radiotherapy: before, during and after the treatment for BCP and PCP; and only after treatment for LP. Briefly, the blood samples were preserved in liquid nitrogen, defrosted in a water bath and put in culture in a supplemented RPMI medium. Colcemid was added after 24h. The assay was performed at 48h. The slides were stained with Giemsa and analysed with an optical microscope. Whenever possible, a total of 250 metaphases, containing 46 centromeres, were scored for each sampling time.

Results and Conclusions. For LP, an absence of scorable metaphases was observed, possibly due to lymphocytopenia. For PCP, the number of metaphases in some samples were particularly low, while for BCP 250 metaphases were scored for each sampling time. Both groups demonstrated an increase in the number of dicentrics throughout the treatment. Our results suggests that DCA assay can be used as a screening tool to identify exposed/non-exposed individuals in case of a RN emergency, if a number of scorable metaphases is available. Further research with more samples is needed to acquire a more reliable triage.

Keywords: radiological and nuclear emergency, screening, dicentric chromosome

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An organotypic in vitro platform for physiologically relevant visualization of the spread out Bragg peak

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Organotypic tissue slices are thin, viable sections of tissue that retain the architecture and cellular composition of the original tissue. These slices can remain viable and functional for days to weeks during culturing, allowing for long-term investigations for the study of proton interactions and Bragg peak visualization in a setting that closely mimics in vivo conditions. Standardization of the organotypic tissue slices lead to the development of relevant flannic tissue culture with thickness of 200 μm [Shestakova et al. Int J Mol Sci., 2026. 27(6)]. The size of the flannics enables visualization of the heterogeneous dimensions of ionizing radiation dosage, including the Bragg peak in proton therapy in vitro models, using scanning laser confocal fluorescence microscopy. The experimental injections of micro-dosimetry radioluminescent particles sized 2-10 μm and based on the reaction of ionizing radiation-sensitive fluorescent probes with hydroxyl radicals after water radiolysis, and, thus, transition to compounds emitting strong fluorescence under ultraviolet excitation [Li et al. Chem Commun (Camb), 2019. 55(65)]. This reaction is based on the replacement reaction or addition reaction of masked fluorophores with hydroxyl radicals, and accumulation of clear fluorophores as a result. Unlike scintillation flashes, which can be observed for only seconds, the effect of radiofluorescence is much longer and can be detected after irradiation during the presence of organic conformations [Stepanenko et al. Radiat Environ Biophys, 2020. 59]. These dosimetric particles could be injected after premedication in large blood vessels, as portal vein (intrahepatic delivery), or pulmonary artery (intra-lungal delivery), for venule embolization, and are aimed to select radioluminophores with suitable characteristics for imaging and dosimetry. Additionally, it is hypothesized that using a backbone scaffold with non-covalent bonds for fluorescent proteins based on π-π stacking interactions with an external scaffold could alter the initial emission properties of the fluorescent protein. These properties could consequently be disrupted in a dose-dependent manner after ionizing irradiation, allowing in vitro visualization of the spread-out Bragg peak.

Keywords: biological dosimetry, ionizing radiation, fluorescent dosimetry, organotypic tissue culture, radiobiology, tissue slices

Application of diverse assay in cellular oncology with and without the use of radioactive nuclides

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Different assays are used in-vitro to study cancer cell death and cytotoxicity during application of diverse drugs. Labeling cells with short-lived radioactive nuclides such as 3H Thymidine is the gold standard in nuclear medicine and can demonstrate cell proliferation or cell inhibition following various cell treatments in-vitro.

In this study, we compared the findings obtained for the study cell death in Raji cells (isolated from patients with Burkitt lymphoma) in vitro conditions after treatment with high concentration cytotoxic cytokine using 3h Thymidine over time. In addition, we compared the findings obtained with other biochemical assays without the use of radioactivity, which are based on the examination of total LDH in cells, spontaneous enzyme release through the cell membrane and protein determination using the sulforhodamine B (SRB) test. All data were also correlated with cell death estimated by flow cytometry.

The findings showed a statistically significant correlation ($p< 0.05$) between cell assays based on the incorporation of 3H Thymidine into the nucleus with other assays showing changes reflecting intracellular protein synthesis in cells measured by the SRB assay, as well as with energy changes based on measured LDH in cancer cells.

Therefore, it was shown that there is a significant correlation between the different assays during the cell death analyses in-vitro. However, it must always be taken into account that each assay has its own specificities and shows changes in individual compartments of the cells, whether apoptosis, necrosis, or intracellular metabolism are being investigated. It must always be clearly indicated to which part of the cell the data obtained from the individual assay refer and the limitations of the applied test must always be taken into account.

Keywords: 3H thymidine, LDH, SRB, MTT

Results of treatment of endo-periodontal lesions using bioregulatory drugs

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Background. Endo-periodontal lesions are a complex pathology. The use of bioregulatory agents in the complex treatment of this condition may be justified, as inflammation is controlled by gently resolving the acute inflammatory process, which is essential for periodontal tissues.

Aim. To evaluate the results of therapy with Traumeel S and Echinacea compositum in patients with endo-periodontal lesions.

Methods. A total of 65 patients with apical periodontitis secondary to stage 1 and 2 periodontitis were examined. The control group (25 patients) received treatment according to the standard regimen. The study group (40 patients) supplemented the standard treatment regimen with injections of the bioregulatory agents Traumeel S and Echinacea compositum into the mucosal fold.

Results. Five days after treatment, patients in the study group demonstrated a 40% reduction in the severity of the inflammatory response compared to the control group. Patients in the study group reported a relatively rapid 22% reduction in pain without the use of nonsteroidal anti-inflammatory drugs, while pain complaints persisted in the control group. Exudation and inflammation in the study group were also 10 times less severe than in the control group.

Conclusion. After three months, 70% of patients in the control group showed clinical signs of periodontal inflammation. Notably, all patients in the study group showed sustained remission three and six months after treatment. The use of bioregulatory agents Traumeel S and Echinacea compositum is of interest for developing a rational treatment plan for combined endodontic and periodontal lesions.

Keywords: endo-periodontal lesions, Traumeel S, Echinacea compositum, bioregulatory agents

Artificial Intelligence – pros and cons

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Artificial Intelligence (AI) is different from every previous history. It is not a tool. It is an agent that it can make decisions by itself and it can invent new ideas by itself. Part of the reason for collapse of trust between humans and the crisis of democracies is that we have given control of the conversation to a non-human intelligence. Democracy is in essence a conversation between humans. We have the most sophisticated formation in history and people are losing the ability to talk each other. AI can help us create the best health care system. The best education system with children getting an AI tutor. On car accidents, every year more than a million people die in car accidents, many of them are caused by human error. By self-driving vehicles, we could save more than a million lives a year. There is a lot of positive potential and the question is how to stop the development of AI but how to make to develop AI for the future economic and future power for human beings.

Most information is actually fiction and fantasy. If the world is flooded with misinformation, the truth will sink to the bottom under ocean of fantasy. Humans have faced similar problems for thousands of years and we have developed mechanisms to deal with these problems by communication and trust. We need time to adapt the new condition. Every order has its own problems, but we should offer clear alternative to function in a different and better way. Then it will be easy to develop AI in a safe way. History tells us that human past is not all crimes and injustices but the cooperation between people and people's ability to build trustworthy relationship. We don't know the mystery of consciousness in science. We don't know whether we can do the same thing in computers in AI. Ultimately human beings are embodied beings. We cannot exist without a body. The brain is just one part of the body. So far as AIs have no bodies. We need to give more importance to the body and to feelings and consciousness. If the whole focus is just on developing intellect, we are bound to lose to AIs.

Keywords: Artificial Intelligence (AI), trust, democracy, misinformation, human consciousness

Digital planning of a customized navigation template for infraorbital anesthesia

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Background. The use of digital radiographic diagnostic methods ensures precision of intervention and adequate pain relief in the alveolar ridge area, and expands the possibilities for planning customized devices, such as intraoral templates for local conduction anesthesia.

Objective. To substantiate the need for radiographic diagnostics of the infraorbital foramen parameters to improve the efficacy and safety of maxillary conduction anesthesia through the development of a custom navigation template.

Materials and Methods. ***Digital:*** retrospective analysis of the jaw bones of 160 patients (80 men and 80 women) using cone-beam computer diagnostics (CBCT) with the Ez3D-I software for processing 3D studies and analysis of intraoral scans of the jaw bones of dry skulls using Primescan AC "Dentsplay Sirona (Germany), the program for digital planning of surgical templates "RealGide5" (Italy). ***Laboratory:*** production of a navigation template for conduction anesthesia in the area of the infraorbital foramen from the photopolymer resin "Dental Yellow Clear PRO" (Russia) using 3D printing "Elegoo Saturn 4 Ultra 16K". ***Statistical:*** StatTech 4.12.5 software.

Results. Based on a retrospective analysis of CBCT scans of 180 patients, it was established that there are 4 forms of PO: oval, round, crescent-shaped and triangular. The oval form of PO is most common among males and females in 53% of cases ($p = 0.058$), and crescent-shaped is rare in 3% ($p = 0.367$). The distance from the inferior margin of the orbit to the center of PO on the right and left sides was 20.09 ± 2.31. The longitudinal size of the infraorbital foramen on the right side did not have statistically significant differences between the right and left sides and amounted to 4.12 ± 0.97 (mm), the transverse size was 2.78 ± 0.67 (mm). According to the school of closeness of the relationship of Chaddock, a very high correlation was revealed between the value of the angles of individual convergence (AIC) formed between the base of the alveolar process and the body of the maxilla and (IIP) angle of insertion of the injection needle into the infraorbital foramen. With an increase in the UIC angle by 1 degree, an increase in the IIV angle by 0.979 degrees is expected ($p < 0.001$). Based on the analyzed data, a customized navigation template for conduction anesthesia in the PO area was developed.

Conclusions. Based on the morphometric analysis of cone beam computed tomography data and their systematization, a mathematical model for calculating individual craniometric parameters of the facial skeleton was proposed, providing a justification for the optimal trajectory and depth of needle insertion during infraorbital anesthesia, which made it possible to develop a digital planning protocol and a technology for manufacturing an individual navigation template, including the stages of CBCT analysis, segmentation, 3D modeling and additive manufacturing, which ensures individualization, safety and accuracy of conduction anesthesia in the infraorbital foramen.

Keywords: infraorbital foramen, cone beam tomography, navigation template

Giant pelvic ganglioneuroma in children: A rare pelvic tumor with diagnostic and surgical challenges

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Background. Ganglioneuroma is a rare, fully differentiated benign tumor of the sympathetic nervous system and represents the mature end of the neuroblastic tumor spectrum. Although typically slow-growing and asymptomatic, it may present in early childhood with significant mass effect. Pelvic localization is exceptionally rare and can mimic aggressive malignant tumors such as neuroblastoma, creating a major diagnostic challenge in pediatric imaging.

Case Presentation. We report the case of a 3-year-old girl presenting with progressive abdominal distension, irritability, and urinary obstruction symptoms. Physical examination revealed a firm, distended abdomen. Ultrasound demonstrated a large heterogeneous hypoechoic suprapubic mass with minimal Doppler vascularity, associated with severe left hydronephrosis and ureteral dilatation. Contrast-enhanced CT showed a 15 cm well-defined retrovesical mass with smooth lobulated contours and minimal heterogeneous enhancement. The lesion caused significant mass effect with displacement of the iliac vessels and urinary bladder without evidence of vascular encasement or invasion. Tumor markers and laboratory tests were within normal limits. After temporary urinary decompression with ureteral stenting and open biopsy, histopathology confirmed ganglioneuroma. The patient underwent complete surgical excision with uneventful recovery and resolution of hydronephrosis. Follow-up imaging at 6 months showed no recurrence.

Conclusion. Giant pelvic ganglioneuroma in children is rare and may closely mimic malignant retroperitoneal tumors. Recognition of key imaging features—well-circumscribed margins, minimal enhancement, absence of invasion, and displacement rather than encasement of adjacent structures—is essential for accurate diagnosis and appropriate surgical planning. Multimodality imaging combined with histopathological confirmation ensures optimal management and excellent prognosis following complete resection.

Keywords: Ganglioneuroma, pelvic tumor, retroperitoneal mass, CT imaging, pediatric oncology, hydronephrosis, neurogenic tumor

The importance of early radiological diagnostics in emergency medicine shown through two cases of ruptured ectopic pregnancy

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Introduction. Ectopic pregnancy involves the implantation of a fertilized ovum outside the uterine cavity with incidence of about 2% of all pregnancies. This condition is unfortunately a leading cause of maternal mortality in the first trimester, accounting 9%-14% of pregnacy-related deaths. Even the risk of overall mortality is low, it is significantly higher due to late diagnosis and treatment of massive hemorrhage. The main radiological diagnostic modalities used to confirm the presence of a ruptured ectopic pregnancy are Multidetector Computed Tomography and Magnetic Resonance Imaging.

Case presentation. We present two cases of well treated ruptured ectopic pregnancies in female patients. The first case involves a 36-year-old woman in whom the diagnosis of ectopic pregnancy was established after tubal rupture. The patient underwent emergency surgical intervention, during which a salpingectomy with extirpation of the associated gestational sac was performed. The second case involves a 34-year-old woman presenting with acute diffuse abdominal pain. Further evaluation revealed an ectopic pregnancy located in the left fallopian tube. Laparoscopic salpingectomy was subsequently performed.

Conclusion. Ruptured ectopic pregnancy represents a gynecological surgical emergency. Given that the clinical presentation is often non-specific and the consequences of delayed or inadequate treatment are serious and potentially fatal, thorough familiarity with Multidetector Computed Tomography and Magnetic Resonance Imaging findings of ruptured ectopic pregnancy is essential for diagnosis confirmation. The importance of this paper lies in raising awareness of this increasingly common pathological condition, as well as in presenting the key radiological diagnostic and visualization features characteristic of ruptured ectopic pregnancy.

Keywords: ectopic pregnancy, tubal rupture, multidetector computed tomography, magnetic resonance imaging

Assessment of quality of life in patients undergoing hyperbaric oxygen therapy

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Introduction. Hyperbaric oxygen therapy (HBOT) is a therapeutic procedure involving the inhalation of 100% oxygen for a limited period under increased pressure. This procedure has demonstrated effectiveness in treating bacterial infections and, given the growing problem of bacterial resistance, can be considered an alternative therapeutic modality for infections caused by resistant bacterial strains.

This study **aimed** to evaluate the effects of HBOT as an adjuvant therapy in the treatment of soft tissue infections.

Materials and Methods. Wound classification was determined using the Wagner classification scale, and the progression and regression of the wound (size and healing course) were descriptively monitored. Before and after treatment, patients completed the EQ-5D-VAS (Serbian version) questionnaire, which assesses quality of life.

Results and Discussion. The most common primary site of infection was the lower extremities (91.2%). According to the Wagner wound classification scale, grade 2 was most frequently recorded among respondents (53.7%). As expected, after 20 treatments, there was a significant increase in the self-assessed health level of the subjects. The median self-assessed health score before treatment was 50.0 (range, 10.0–100.0), and after 20 treatments it was 70.0 (range, 20.0–100.0), which is a statistically significant difference ($Z = 5.772$; $p < 0.001$). The median value of the EQ5D index, adjusted for our region (Slovenia), before treatment was 0.46 (range, -0.06 to 1.00), and after 20 treatments it was 0.58 (range, -0.04 to 1.00), which is a statistically significant difference ($Z = 4.666$; $p < 0.001$). There was a statistically significant increase in the EQ5D index value.

Conclusion. Following HBOT, a statistically significant improvement in self-assessed quality of life and self-assessed health status was observed in the subjects. This meta-analysis concludes that HBOT leads to an improvement in the quality of life of patients across various indication areas.

Keywords: quality of life, hyperbaric oxygen therapy, health condition, improvement

Effects of hyperbaric oxygen therapy on healing soft tissue infections

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Introduction. The most common clinical application of HBOT is the treatment of soft tissue infections of the skin and hypoxia-related osteomyelitis caused by anaerobic bacteria, as well as infections caused by resistant bacterial strains. The most common causes of superficial skin and soft tissue infections, which can only be treated by incision, are S. aureus and streptococci. Streptococcus spp. is the primary cause of erysipelas, while most infectious processes on the face are attributed to group A beta-haemolytic streptococcus (GABHS), and infections of the lower extremities are caused by non-GABHS.

This study **aimed** to evaluate the effectiveness of a standard protocol of 20 hyperbaric oxygen treatments in patients with confirmed soft tissue infection by microbiological analysis.

Material and Methods. A prospective study was conducted at the Special Hospital for Hyperbaric Medicine in Belgrade during 2020 and 2021. Fifty-seven patients who underwent hyperbaric treatment were included in the study. All data were processed using the IBM SPSS Statistics 22 (SPSS Inc., Chicago, IL, USA) software package.

Results and Discussion. During the observed period, there was a statistically significant reduction in wound length. The difference in wound length was statistically significant between all observed periods ($p<0.001$). The application of HBOT also resulted in a statistically significant reduction in wound width. The median wound width before treatment was 22.0 mm, after 10 treatments 20.0 mm, and after 20 treatments 13.0 mm, which represents a statistically significant difference (chi-square=113.8; DF=2; $p<0.001$). With the reduction in wound length and width, as expected, there was also a statistically significant reduction in wound area. In our study, the application of HBOT stimulated wound healing.

Conclusion. Based on the results obtained, we conclude that the use of HBOT as adjuvant therapy in the treatment of soft tissue infections is justified. The HBOT protocol, which includes 20 treatments with hyperbaric oxygen, in patients with soft tissue infection, promotes wound healing and reduces the symptoms of wound infection.

Keywords: soft tissue infection, hyperbaric chamber, oxygen therapy, chronic wounds, healing

Exceptional response to radiotherapy and Nivolumab in vaginal melanoma: A case report and insight into the abscopal effect

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Background. Primary mucosal melanoma of the vagina is a rare and aggressive malignancy with poor prognosis and no standardized treatment strategy. It predominantly affects older women and is often diagnosed at an advanced stage. The role of radiotherapy combined with immunotherapy remains insufficiently explored, particularly in inoperable cases.

Case Presentation. A 75-year-old female presented with prolonged postmenopausal bleeding, in good general condition. Diagnostic imaging and immunohistochemistry confirmed locally advanced, BRAF V600 wild-type primary mucosal melanoma. The tumor was deemed inoperable, and a multidisciplinary tumor board recommended palliative radiotherapy for hemostasis combined with immunotherapy using Nivolumab (480 mg every 4 weeks). Intracavitary brachytherapy with a vaginal cylinder was administered to a total dose of 6 Gy in 4 applications, doses prescribed 1cm from applicator surface. This was followed by external beam radiotherapy using volumetric modulated arc therapy (VMAT) with a total dose of 30 Gy in 10 fractions. Radiotherapy was well tolerated, with moderate radiation-induced mucositis managed symptomatically. Notably, Nivolumab was not administered on the same days as radiotherapy. After the first brachytherapy application, a significant reduction in bleeding was observed. During treatment, serial gynecological examinations demonstrated a progressive and marked tumor regression on a weekly basis.

Results. At the first post-treatment evaluation, complete clinical response (CR) was achieved according to Response Evaluation Criteria in Solid Tumours (RECIST) 1.1 criteria and confirmed by magnetic resonance imaging. At the last follow-up, CR persisted more than 12 months after completion of radiotherapy, with the patient continuing immunotherapy and maintaining good performance status.

Conclusion. This case highlights a remarkable and durable response to combined radiotherapy and immune checkpoint inhibition in an inoperable vaginal mucosal melanoma. The observed synergy between radiotherapy and immunotherapy suggests a potential therapeutic benefit beyond local control, possibly enhancing systemic antitumor immune response through Abscopal effect. These findings support further investigation of combined immuno-radiotherapy approaches in rare and aggressive malignancies such as mucosal melanoma.

Keywords: vaginal melanoma, immunotherapy, radiotherapy, abscopal effect

Features of the course of inflammatory periodontal diseases taking into account the types of nonspecific adaptive reactions and the level of body reactivity in patients with oncological pathology

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The article presents data on nonspecific adaptive reactions (NSAR) and reactivity levels (RL) of the body in 63 patients with catarrhal gingivitis and periodontitis. It is shown that in the context of stress response and reactivation combined with low reactivity levels in patients with oncopathology after courses of radiation and chemotherapy, as well as with certain types of somatic pathology. At the same time, in the context of training response, calm and increased activation, therapeutic and preventive measures proceed faster and clinical remission lasts longer.

Introduction. The main methods of treating malignant neoplasms are surgical treatment, radiation therapy, and chemotherapy. Combined antitumor therapy is accompanied by the development of severe complications, which limits the possibilities of its use, complicates psycho-social adaptation and rehabilitation of these patients. Pathology of the oral mucosa in cancer patients against the background of standard polychemotherapy reaches 90%. Any pathological process is determined by the current AR and NAO, which change under the influence of various irritating factors. Reactivity levels characterize the functional potential of the body at different time periods and determine the response to stimuli of varying strength. The current AR, as well as NAO, can be interpreted by the relative content of blood cells. Low, medium, and high levels of reactivity are distinguished.

Research Objective. To assess the characteristics of the course of the inflammatory process in the periodontium, taking into account the types of nonspecific adaptive reactions and the level of body reactivity in patients with cancer against the background of combined antitumor therapy.

Materials and Methods. The clinical-laboratory study included 63 patients with inflammatory periodontal disease aged 40 to 55 years. The patients were divided into 3 groups: the main group – 21 patients with inflammatory periodontal diseases and a history of oncopathology; comparison group 1 – 23 patients with inflammatory periodontal diseases with background pathology; comparison group 2 – 19 patients with inflammatory periodontal disease and no history of somatic diseases.

Results and Discussion. In the observed individuals (21 people) in the Main group, the history revealed that for 5 people the last course of chemotherapy (for 4 due to breast cancer, 1 for stomach cancer) was 5 months ago; 5 patients underwent radiation therapy for papillary thyroid carcinoma 3 months before their initial visit to the dental clinic. These patients were diagnosed with chronic catarrhal gingivitis (10 people). The remaining 11 patients were diagnosed with lip cancer (2 people) and papillary thyroid carcinoma (4 people). Among them, 3 patients had 2 courses of radiation therapy with a 3-month interval within a year before the visit, and 1 had a course of radiation therapy 8 months before the visit. Two patients were diagnosed with buccal mucosa cancer, and three with breast cancer (2 courses of chemotherapy with a 2-month interval 3-4 months prior to visiting the dental clinic). These patients exhibited more severe inflammatory periodontal disease: exacerbation of chronic generalized periodontitis of grades II and III severity. The overwhelming majority of patients (78%) reported general complaints: low work capacity, sleep and appetite disturbances, weakness, and psycho-emotional stress.

Conclusions. Traditional treatment of inflammatory periodontal disease is most effective in patients with favorable NARO (training, calm, and increased activation) against the background of medium and high reactivity levels. However, in patients with oncological pathology after courses of radiation and chemotherapy and certain types of somatic pathology, shorter periods of clinical remission were observed against the background of negative NARO (stress and overactivation) combined with low UR, which were detected. The obtained data indicate the need for monitoring NARO and UR to expand the range of therapeutic and preventive measures for inflammatory periodontal diseases in patients with various somatic pathologies.

Keywords: nonspecific adaptive reactions, reactivity levels, oncopathology, catarrhal gingivitis and periodontitis

Development and validation of a Monte Carlo model of the Portuguese national standard of activity for nuclear medicine

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Accurate measurement of radiopharmaceutical activity is essential in nuclear medicine, since the administered activity directly influences image quality and therapeutic outcome. As nuclear medicine evolves toward quantitative and personalized approaches including dosimetry-based theragnostics, high metrological quality and traceability in activity measurements has become increasingly critical. Radionuclide calibrators are routinely used to determine activity prior to patient administration. As their response depends on radionuclide emission spectra, source container, volume and positioning within the ionization chamber, deviations between calibration and clinical conditions are expected to introduce measurement errors that can exceed 10 % of the prescribed value, even within the same country.

In this context, the National Metrology Institutes (NMI) or Designated Institutes (DI) must provide accuracy and traceability to activity measurements through the calibration of radionuclide calibrators at an adequate uncertainty level. The LMRI (Laboratório de Metrologia das Radiações Ionizantes), the Portuguese DI for ionizing radiation, has recently acquired the Fidelis radionuclide calibrator, produced by Southern Scientific Ltd (Henfield, UK), to become the national standard for activity. This ionization well chamber was developed as a commercial version of the Vinten 671 chamber, used in many NMI as a secondary standard.

In the present work, the Monte Carlo (MC) simulation code EGSnrc was applied to create a model of Vinten 671 as a surrogate to Fidelis, which is important to validate calibrations and investigate the parameters affecting it. As a first step, a simplified model based on the literature was implemented for benchmarking and validating the computational methodology. Afterwards, a detailed model was successfully validated by comparison with results available in the literature and experimental measurements. The validated model can be used to support calibration services, uncertainty evaluation, and validate the establishment of subsidiary calibrations. These results and their impact on activity measurements performed with the national standard will be reported.

Keywords: radionuclide metrology, Monte Carlo, nuclear medicine, radionuclide calibrator

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Two different approaches to digital mammography

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In 2025, new DRLs came into force for a fairly wide variety of types of radiological examinations with ionizing radiation, including digital mammography with tomosynthesis (3D) and digital mammography without tomosynthesis (2D). According to the legal provisions for the implementation of DRLs in practical activity, each healthcare unit must estimate quarterly the average values of the dose amounts for each type of radiological examination with ionizing radiation and to annually analyze the quarterly values obtained in relation to the DRLs established at national level for the respective types of examinations, in order to optimize patient protection in medical exposures.

The data analyzed in this study come from two healthcare facilities, Hospital A in the private sector, with a Mammomat Inspiration Siemens equipment and Hospital B in the public sector with a Selenia Dimensions Hologic equipment. Both healthcare facilities belong to the category of medium hospitals, with 100-200 beds, such as municipal or specialized hospitals, capable of serving a significant local population.

Aspects regarding the number of mammographic exposures with and without tomosynthesis and the average doses obtained quarterly were analyzed, for a period of 8 quarters, respectively the years 2024-2025, so that the specific trends observed were consistent.

The average MGD values and the number of exposures performed for both hospitals were determined for periods of 3 months, and the dose values were compared with the national DRLs: 2.65 mGy for digital mammography with or without tomosynthesis, the value being valid in both situations for a single exposure only, in CC or MLO incidence and 10.73 mGy in the case of digital mammography with tomosynthesis, the value referring to the total medium glandular dose MGD obtained through four exposures, two in CC incidence and two in MLO incidence, in the case of bilateral mammography.

The results of the study are as follows:

- For the 2-years period studied, a general trend of a slight decrease in the number of medical exposures is observed, valid for both hospitals,
- The total number of exposures is much higher (40%) in Hospital A compared to Hospital B, although from the point of view of hospital capacity, the situation is the opposite,
- Hospital A presents an almost double number of 2D exposures compared to Hospital B,
- For Hospital A, 3D exposures are much fewer, representing only 30% of the number of 2D exposures,
- Hospital B presents equal weights for 3D and 2D exposures,
- All MGD values are below the DRLs established at national level, both for Hospital A and for Hospital B,
- All MGD values for Hospital A are lower than those for Hospital B,
- The highest MGD values, that are closest to the national DRLs, are those for digital mammography with tomosynthesis, in MLO projection, a situation valid for both hospitals.

Thus, two different approaches are observed, and the general conclusion is that the standard investigation procedure in Hospital B consists of the combined 2D + 3D examinations, thus the doses received by the patient are higher compared to the situation in Hospital A, where the standard investigation procedure is the 2D examination, and if certain abnormalities of the breast tissue are observed, the 3D examination is also performed, the radiation doses received by the patients being thus maintained at a lower level.

Keywords: digital mammography, tomosynthesis, patient doses, DRLs

From examination-based to acquisition-based DRLs: A paradigm shift in CT dose optimization and radiation protection

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The increasing exposure to ionizing radiation in medical imaging, particularly in Computed Tomography (CT), highlights the need for continuous optimization of radiological practices. Diagnostic Reference Levels (DRLs), recommended by Directive 2013/59/EURATOM, are a key tool for radiation protection and are traditionally defined at the examination level.

In this study, a retrospective analysis of dosimetric parameters from CT examinations in a hospital setting was performed to characterize current exposure levels and compare them with European reference values. The results showed mean CTDIvol values of 51.9 mGy for head, 57.7 mGy for neck, and 11.98 mGy for chest, with corresponding DLP values of 855.39 mGy·cm, 846.42 mGy·cm, and 273.01 mGy·cm, respectively, overall aligned with European benchmarks. Nevertheless, relevant variability was observed between different protocols and acquisitions.

These findings highlight limitations of the conventional examination-based approach, particularly in multi-acquisition protocols, where aggregated analysis may mask significant dose variations. In this context, the concept of Single Acquisition Diagnostic Reference Level (saDRL) is proposed as an alternative framework, based on defining reference levels per individual acquisition, enabling a more detailed assessment aligned with clinical practice.

The adoption of this approach may improve optimization and auditing processes in CT, promoting more effective radiation dose management. Future studies may further explore the application of the saDRL concept across different clinical settings and populations.

Keywords: computed tomography, diagnostic reference levels, saDRL, radiation protection, dose optimization

Effect of electron beam irradiation on DNA in the presence of porphyrins

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Porphyrins are widely studied for their applications in biology and medicine, notably as anti-viral and anti-tumor agents and potential radiosensitizers. This study investigates the effect of AgTOEPyP4 porphyrin on DNA damage induced by electron beam radiation, extending our previous work on radiation-induced degradation of macromolecules and their interactions with ligands.

The studies were carried out using calf thymus DNA (Sigma-Aldrich) under conditions of different relative concentrations of DNA and AgTOEPyP4 (r = 0.01, 0.02, 0.04, where $r=C_{porph}/C_{DNA}$). The samples were irradiated by electron beam at 2 Gy and 4 Gy doses. Thermodynamic analysis was performed using ultraviolet spectrophotometry (Agilent Cary 3500 Multizone). Melting curves were recorded at a heating rate of 1 °C/min, allowing determination of the melting temperature (T_m) and melting interval (ΔT). The quantitative analysis of the melting curves demonstrated that the thermal parameters of DNA in the investigated systems significantly depend on both the porphyrin concentration and the applied irradiation dose.

It was shown that an increase in the concentration of porphyrin leads to an enhancement of the thermal stability of DNA. At the same time, electron beam irradiation results in the formation of structural defects in the DNA double helix, which is reflected in changes in the T_m and ΔT parameters. The irradiated AgTOEPyP4/DNA systems showed Tm values ranging from 46.43 °C to 52.9 °C depending on the porphyrin concentration and the applied dose. At r = 0.04, the highest thermal stability was observed at both doses (T_m = 52.9 °C at 2 Gy and 51.45 °C at 4 Gy), indicating a pronounced stabilizing effect of porphyrin even under irradiation conditions. The effect of dose on T_m is concentration-dependent: at r = 0.01 and r = 0.04, increasing the dose from 2 Gy to 4 Gy results in a slight decrease in T_m (−1.74 °C and −1.45 °C, respectively), while at r = 0.02 Tm increases by 1.39 °C, suggesting a complex interplay between porphyrin binding and radiation-induced structural damage. The changes in ΔT further confirm that irradiation induces structural heterogeneity in the DNA double helix, the extent of which significantly depends on both the porphyrin concentration and the radiation dose. The obtained results suggest that irradiation induces both single-strand and double-strand breaks, the degree of which is modulated by the presence and concentration of porphyrin in the system.

Keywords: electron beam irradiation, DNA damage, porphyrins, radiosensitizers, DNA thermal stability, UV spectrophotometry

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Modeling of oxygen-dependent radio-modifying effects in bone tissue during combined radiation sterilization

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Modern radiation technologies for sterilizing bioimplants account for about 45% of the global medical services market. The traditional use of gamma quanta and accelerated electrons has a number of limitations related to the high dose rate or the need for complex protection [Silindir, M. and Özer, A.Y., FABAD // J. Pharm. Sci. – 2009, vol. 34, p. 43]. In this context, the use of X-ray radiation in combination with chemical radiosensitizers such as ozone is relevant, which makes it possible to implement a combined approach to sterilization.

In this work, the distribution of the absorbed dose in the cortical bone was studied, taking into account its porous structure and gradient saturation with ozone. The simulation was performed using the GEANT4 software package. The physical model under study is based on the experimental testing of the technology of combined radiation sterilization of bone implants at an electron accelerator at the Moscow State University Research Institute of Nuclear Physics [Alimov A.S., Bliznyuk U.A., Borchegovskaya P.U. et al. Using accelerated electron beams for the radiation processing of foodstuffs and biomaterials // Bulletin of the Russian Academy of Sciences: Physics. – 2017. – vol. 81. – no. 6. – p. 743-747]. As a result of the study, a computer system block with parameters from the GEANT4 biotech was identified with an integrated array created by a microcavity. Calculations were performed for electron radiation in the energy range 0.5-10 MeV and X–ray radiation in the energy range 0.26-10 MeV, taking into account secondary processes that are critically important in the interaction of radiation with bone tissue, by selecting the physical sheet G4EmStandardPhysics_option4 [Allison, J. Geant-4. Developments and Applications // IEEE Trans. Nucl. Sci. – 2006. – vol. 53. – no. 1. – p. 270-278].

To assess the effect of ozone, a model of the oxygen-dependent radio-modifying effect was implemented, taking into account the exponential decrease in gas concentration along the depth of the implant. Comparisons of the deep dose distributions in the presence and absence of oxygen have been made. The key efficiency factor is the oxygen enhancement coefficient (OER). A quantitative assessment of the degree of increased radiation exposure to a bone sample has been obtained in the presence of additional oxygen in its volume, which helps reduce the radiation load on bone grafts during radiation sterilization, preserving their biomechanical properties and the integrity of collagen structures.

Keywords: bone grafts, combined sterilization, radiation technology, ozone treatment, GEANT4, oxygen enhancement ratio

Radiological clearance assessment in a nuclear medicine department using integrated *in situ* measurements and RESRAD-BUILD Modeling

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This study presents a comprehensive radiological clearance and dose assessment of a former nuclear medicine department, based on a combination of in situ measurements and scenario-based modeling using the RESRAD-BUILD computer code. The model was applied to simulate the release, transport, and deposition of radionuclides in indoor environments, and to estimate potential radiation doses to occupants through relevant exposure pathways, including inhalation, ingestion, and external irradiation.

Measured data, including gamma dose rates, surface contamination levels, and smear (swipe) test results, were used to calibrate and validate the model predictions. The results demonstrate good agreement between measured and modeled values, confirming the reliability of the RESRAD-BUILD as both a predictive and verification tool. The assessed dose levels were found to be within acceptable regulatory limits for site clearance. The study highlights the utility of RESRAD-BUILD as a predictive and verification tool for radiological assessment and clearance evaluation, providing a robust framework for ensuring safety in environments with potential radioactive contamination and supporting decision making in decommissioning processes.

Keywords: RESRAD-BUILD, simulation, radiological clearance, surface contamination, decommissioning

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Integration of AI for dose optimization in diagnostic radiology and fluoroscopy

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Without proper optimization, diagnostic radiology and fluoroscopy procedures can cause risks because of radiation exposure. Popular ways to assess tracer doses such as MIRD, often do not take into account the unique anatomy of each patient or how much tracer is taken up for imaging. As a result, dose measurements may be inaccurate, especially when bones or lungs are involved.

Deep learning, an AI technique, is making a big difference in medical imaging today. Götz et al. presented a model that blends a deep U-net with Empirical Mode Decomposition (EMD) to determine how much radiation is absorbed in the body using CT images and SPECT data. The model was developed from data on 26 patients undergoing 177Lu-PSMA therapy. The system predicted personalised dose maps with high precision, demonstrated by much lower differences from MIRD-based estimates. Specifically, dose errors in kidneys and spleen were roughly −3.7% with AI, yet deviations of over −7% were seen when MIRD guidelines were used. Moreover, the model predicted for each patient in 1.3 seconds while Monte Carlo simulations took 6 hours, making its use useful for doctors' decisions. The U-net/EMD model underlines radiation protection by providing patient justification, minimising dose according to ALARA and enhancing accuracy in dose limitations. Notably, using intrinsic modes from CT data made the predictions more correct by lessening noise and useless details. The small dataset still showed that AI can bring great changes to dose planning and monitoring. More research is needed to enlarge datasets, combine data from several inputs and make sure all regulations are followed. Applying clinical validation, AI might enable real-time, safe and customised radiology imaging.

Keywords: Artificial Intelligence, dose optimization, fluoroscopy, personalized dosimetry, radiation protection, SPECT/CT imaging, ALARA principle, diagnostic radiology, U-Net, deep learning

From plan complexity to delivery accuracy: An MLC-based PSQA approach

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Introduction. In clinical radiotherapy practice, Patient-Specific Quality Assurance (PSQA) remains essential to ensure that the delivered dose accurately corresponds to the planned dose distribution. However, the increasing complexity of treatment techniques has substantially intensified the workload associated with QA procedures. Conventional approaches rely on global indices that summarize plan complexity into a single value, which may not adequately reflect actual delivery system behavior or capture clinically relevant uncertainties. In contrast, the proposed approach focuses on a detailed analysis of mechanical behavior, enabling a more realistic characterization of treatment delivery (Hernandez et al., 2018; Claessens et al., 2024). These limitations have also been highlighted in broader studies addressing variability in plan complexity assessment and its clinical implications (Kaplan et al., 2022). In this context, the present work investigates individual multileaf collimator (MLC) leaf motion characteristics, including mean speed, acceleration, and the number of motion reversals, together with aperture-related features such as the size, number, and temporal evolution of MLC-defined openings.

The aim of this work is to develop a method based on treatment plan MLC files to determine whether a treatment plan requires measurement-based validation. Furthermore, the proposed framework aims to support large-scale clinical implementation by enabling the assessment of whether individual treatment plans require PSQA. Applied to a cohort of approximately 1000 treatment plans, this approach has the potential to substantially reduce the overall PSQA workload while maintaining treatment safety.

Materials and Methods. A retrospective cohort of previously treated patient plans with available PSQA measurements was analyzed. Gamma analyses were performed using portal dosimetry combined with three-dimensional dose distribution evaluation. The mechanical descriptors included the mean absolute MLC leaf speed and acceleration, the number of leaf motion reversals, and aperture-based metrics such as the number of MLC apertures and the aperture open area per control point. In addition, aperture areas per control point were evaluated, with particular attention given to apertures smaller than 10 mm^2. Correlation analyses were performed to assess the relationship between these mechanical delivery parameters and PSQA performance.

Results. Based on the analysis of the collected data, a metric was developed to enable the omission of PSQA for at least 24% of treatment plans. Treatment plans were classified as non-complex when (1) more than 75% of MLC apertures had an area greater than 10 mm^2 and (2) the number of small islands per control point was less than or equal to 2.

Conclusion. The proposed tool enables a reduction in PSQA workload by characterizing treatment plan complexity using MLC-derived metrics, allowing the exclusion of plans that do not require measurement-based validation.

Keywords: radiotherapy, Patient-Specific Quality Assurance (PSQA), MLC motion, plan complexity, quality assurance optimization

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Utilization of ophthalmic B-scan ultrasonography to identify the etiology of impaired vision in diabetic retinopathy patients

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Background. Diabetic retinopathy (DR) is a major cause of low vision and blindness worldwide, with a steadily increasing prevalence in Sudan. Fundus examination in diabetic patients is frequently limited by ocular media opacities, underscoring the clinical value of ophthalmic B-scan ultrasonography for evaluating posterior segment complications associated with visual impairment.

Aim. This study aims to identify the underlying causes of low vision in Sudanese patients with DR using ophthalmic B-scan ultrasonography and to assess its diagnostic accuracy.

Methods. A prospective study was conducted on 100 Sudanese diabetic patients (200 eyes) with different grades of DR at Makkah Eye Hospital, Khartoum, between September 2020 and January 2023. All patients underwent comprehensive ophthalmologic examination in addition to B-scan ultrasonography performed with a 10-megahertz (MHz) probe. Demographic characteristics, duration of diabetes, Hemoglobin A1c (HbA1c) levels, and ultrasonographic findings were analyzed using Statistical Package for the Social Sciences (SPSS). The diagnostic performance of ophthalmic B-scan ultrasonography was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Results. The mean age of participants was 46.4 ± 1.4 years, and males represented 75% of the study population. Mild nonproliferative diabetic retinopathy (NPDR) was the most frequent stage (34%), accompanied by moderate to poor glycemic control. The predominant ultrasonographic causes of low vision were vitreous hemorrhage (57%), retinal detachment (21%), asteroid hyalosis (12%), posterior vitreous detachment (7%), and choroidal detachment (3%). More severe posterior segment complications were significantly associated with poor glycemic control and advanced stages of diabetic retinopathy. Ophthalmic B-scan ultrasonography demonstrated high diagnostic accuracy, with a sensitivity of 98.95%, specificity of 85.71%, PPV of 97.92%, and NPV of 92.31%.

Conclusion. Ophthalmic B-scan ultrasonography is a reliable, noninvasive, and highly sensitive imaging modality for identifying the causes of low vision in patients with DR, particularly when fundus visualization is compromised. Early detection of DR–related complications using ultrasound may improve clinical decision-making and contribute to the prevention of diabetes-associated vision loss.

Keywords: diabetic retinopathy, low vision, ophthalmic B-scan ultrasonography, retinal detachment, vitreous hemorrhage

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Automated quality assurance and dosimetry using artificial intelligence (AI): Insight into mammography and CT application

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Quality assurance (QA) and accurate dosimetry are essential for maintaining image quality and patient safety in digital mammography and computed tomography (CT). Conventional QA and dose assessment procedures are largely manual, time-consuming, and susceptible to inter-observer variability, limiting efficiency in high-throughput clinical environments. Recent advances in artificial intelligence (AI) provide powerful tools to automate and standardize QA and dosimetric workflows across X-ray–based imaging modalities.

This presentation reviews automated QA and dosimetry approaches in digital mammography using AI and discusses their translational relevance to CT applications. In mammography, AI models, particularly convolutional neural networks, can automatically evaluate key image quality metrics, including contrast-to-noise ratio, spatial resolution, uniformity, and artifact presence, while simultaneously estimating mean glandular dose from exposure parameters and image-derived features. Such systems enable near–real-time performance monitoring, early detection of equipment or protocol deviations, and consistent compliance with international QA requirements.

The same AI-driven paradigm can be extended to CT imaging, where automated assessment of image quality indicators and patient dose metrics, such as CTDIvol, dose–length product, and size-specific dose estimates, can be achieved. By integrating scanner output data with patient size and anatomical information, AI-based models support personalized dosimetry and protocol optimization, improving dose efficiency without compromising diagnostic accuracy.

Overall, AI-enabled QA and dosimetry offer a robust framework for reducing human workload, enhancing reproducibility, and supporting continuous quality improvement. The adoption of these intelligent systems represents a critical step toward data-driven imaging practice, strengthening radiation protection, optimizing clinical performance, and improving patient-centered care in mammography and CT globally worldwide.

Keywords: artificial intelligence, mammography, CT, radiation protection, patient safety

Preliminary results for highly sensitive AFET-based biosensor for early detection of cancer associated miRNAs

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The detection of cancer at an early stage requires sensitive techniques that are capable of detecting biomarkers at low concentrations. In this preliminary study, the authors present a biosensor based on a Highly Sensitive Avalanche Field Effect Transistor (AFET) for the label free detection of miRNAs associated with the early stages of lymphomas and lung cancer. Avalanche multiplication is used to amplify the signal from the hybridization of the miRNA probes. It provides greater sensitivity compared to the conventional FET biosensor. A biofunctional gate is used to detect the target miRNA. Initial results indicate the possibility of achieving extremely low detection limits.

Keywords: AFET, biosensor, miRNA, early stage cancer, label free detection, point care diagnostics

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Monte Carlo simulations of digital mammography using FLUKA

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Accurate dosimetry in breast tissues is essential for evaluating radiation risk during diagnostic imaging procedures such as mammography. This study employs Monte Carlo simulations using FLUKA to model photon transport and energy deposition in heterogeneous breast phantoms composed of varying proportions of glandular and adipose tissues, including skin layers. Seven breast models, ranging from 0% to 100% glandularity, were simulated under a monoenergetic photon beam of 25 keV. Detailed dose depth profiles were generated for each phantom. The absorbed dose by each individual tissue region was calculated using analytical integration methods based on the FLUKA output. The results demonstrate that glandular tissues absorbed significantly higher doses compared to adipose tissues. Moreover, a linear correlation between glandularity and absorbed dose was observed, emphasizing the need for personalized dosimetry in breast imaging. These findings contribute to optimizing mammographic protocols and minimizing radiation exposure to radiosensitive tissue with each mammography screening procedure.

Keywords: Monte Carlo simulation, FLUKA, mammography, absorbed dose, glandular tissue, radiation protection

Python-based study of accuracy in radiotherapy dose calculations

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Introduction. This study evaluates the practicability of applying standard clinical verification tools for patient-specific validation of advanced radiotherapy treatment plans.

Objectives: The objective of this study was to assess the accuracy of treatment plan verification and to investigate how plan complexity may influence the precision of dose delivery.

Methods. A series of radiotherapy plans was analyzed using conventional clinical equipment and planning software. The complexity of the plans was characterized by published plan complexity metrics and the agreement between the planned and delivered dose distributions was evaluated using the verification criteria routinely used for the clinical validation of the dose delivery.

Results. The agreement for the verification was found to decrease only slightly for plans with higher modulation factors in the range investigated, while the effectiveness of the system was clear even for highly modulated plans. Despite some variability, it was found that dose delivery agreed with planned distributions for all scales of plan complexity.

Conclusion. Confirmed reliable functioning of the verification procedure, as dose distributions were comparable for all levels of plan complexity, even at higher modulation factors.

Keywords: radiotherapy, VMAT, plan complexity, gamma index, Python

Method for range calculation based on empirical models in proton therapy in liquid water and DNA bases in hemodialysis patients with kidney cancer

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Proton therapy has emerged as a highly precise radiotherapy modality due to its unique ability to deposit maximum energy at a well-defined depth, known as the Bragg peak, thereby minimizing irradiation of surrounding healthy tissues. In this study, we develop a robust analytical and semi-empirical framework for the accurate determination of proton stopping power, energy loss, and Bragg peak position in liquid water and DNA bases. The model integrates ionization, excitation, and electron capture processes using well-established semi-empirical formulations, including the Rudd and Dingfelder models, complemented by original analytical developments from our laboratory.

A comparative analysis with Monte Carlo simulations performed using GEANT4 and SRIM demonstrates strong agreement, with discrepancies remaining below 5% across clinically relevant energy ranges. The model also accounts for secondary electron contributions, significantly improving accuracy in the low-energy region near the Bragg peak. Extension of the model to DNA bases reveals consistent energy deposition patterns, supporting the validity of liquid water as a biological surrogate while highlighting molecular-scale differences.

In addition, a clinical study conducted on hemodialysis patients with chronic kidney disease underscores the importance of precise dose delivery in fragile populations, where proton therapy offers clear advantages over conventional radiotherapy. This work contributes to advancing proton therapy optimization and offers new perspectives for radiobiological modeling in kidney cancer treatment.

Keywords: Bragg peak, liquid water, stopping cross sections, biological, proton therapy, albumin, calcium, phosphorus, nutrition

CT imaging criteria for predicting inoperability in pediatric abdominal tumors: A retrospective cohort study in Albania

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Background. Accurate preoperative identification of surgical inoperability in pediatric abdominal tumors is essential for optimizing treatment strategies, yet reliable imaging-based prediction models remain limited.

Purpose. To identify computed tomography (CT) imaging predictors of inoperability in pediatric abdominal tumors and to develop a quantitative risk stratification model.

Materials and Methods. This retrospective study included 43 pediatric patients (mean age, 3.9 years ± 2.1; 22 males, 21 females) with abdominal tumors evaluated between January 2023 and January 2026. Tumor types included neuroblastoma (n=16), nephroblastoma (n=8), and other malignancies (n=19). Contrast-enhanced CT examinations were independently reviewed for predefined imaging features, including vascular encasement, organ invasion, vascular thrombus, lymphadenopathy, multifocal disease, distant metastases, and tumor size. Operability status was determined by multidisciplinary consensus. Statistical analysis was performed using IBM SPSS Statistics, including univariate analysis, multivariate logistic regression, and receiver operating characteristic (ROC) curve analysis.

Results. Eighteen of 43 patients (41.9%) were classified as inoperable. Independent predictors of inoperability included vascular encasement (odds ratio [OR], 6.8; 95% CI: 2.1–21.3; p=0.001), organ invasion (OR, 5.4; 95% CI: 1.7–16.2; p=0.004), tumor size greater than 6 cm (OR, 3.9; 95% CI: 1.5–10.8; p=0.006), and multifocal disease (OR, 4.1; 95% CI: 1.2–13.5; p=0.02). Mean tumor size was significantly higher in inoperable compared with operable tumors (7.6 cm ± 2.4 vs 4.3 cm ± 1.2; p<0.001). The predictive model demonstrated excellent discrimination (AUC 0.91), with sensitivity of 88% and specificity of 84%. A CT-based operability scoring system achieved an overall accuracy of 86%.

Conclusion. CT imaging enables accurate prediction of surgical inoperability in pediatric abdominal tumors. Vascular encasement, organ invasion, and tumor size are the strongest independent predictors. A structured CT-based scoring system provides robust risk stratification and may improve preoperative planning and multidisciplinary decision-making.

Keywords: Pediatric abdominal tumors, computed tomography, inoperability, image-defined risk factors, vascular encasement, risk stratification, operability score, oncology imaging

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Digital planning of conduction anesthesia for various dental procedures in the maxilla

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Introduction. Conduction anesthesia in the maxilla remains one of the most complex and risky stages of dental treatment. Traditional methods of tuberal, palatal, infraorbital, and incisor anesthesia rely on palpation landmarks. However, the variability of the anatomical structure of the alveolar process, body, and tuberosity of the maxilla leads to insufficient needle positioning accuracy. Therefore, a technology for personalized 3D-printed templates has been developed, eliminating the risk of "blind" injection and ensuring accurate anesthetic delivery. Objective of the study. To improve the accuracy and safety of conduction anesthesia in the maxilla by developing and testing an individual navigation template created based on the analysis of anatomical and topographic features according to CBCT and intraoral scanning data.

Materials and Methods of the Study. A retrospective analysis of CBCT scans of 100 patients (45 men, 55 women) aged 25–55 years who met the inclusion criteria was performed; the average age of the patients was 40 ± 0.4 years. Morphometric parameters of the location of the infraorbital, greater palatine, and incisive foramina, as well as the maxillary tuberosity, were determined. At the prospective stage, intraoral scanning (Primescan, Dentsply Sirona) was performed on 30 patients (15 men, 15 women). Navigation templates were designed by superimposing CBCT data and digital models in the RealGide5 software. Manufacturing was carried out using 3D printing (Elegoo Saturn 4 Ultra printer, Elegoo and Dental Yellow Clear PRO photopolymers). Statistical processing was performed using StatTech 4.12.5.

Results. A database of anatomical and topographic features of the maxilla was compiled using CBCT scans of 100 patients. This database included variations in the position of the infraorbital foramen, greater palatine foramen, incisive foramen, and maxillary tuberosities. Key technical elements of a customized navigation template were developed: a basic mouthguard that tightly encloses the dentition; control windows on natural teeth for positioning verification; and guide axial holes in posts with stoppers that ensure the specified trajectory and depth of needle insertion. Thirty stereolithographic models of the maxilla and 30 mock-up navigation templates were produced for subsequent clinical trials. The proposed technology enables standardized access to target nerves and minimizes the risk of local complications, such as damage to the pterygoid plexus vessels (excluding the formation of hematomas) and injuries to nerve trunks (preventing paresthesia).

Conclusions. The developed method of digital planning and 3D printing of personalized navigation templates for conduction anesthesia in the maxilla takes into account individual anatomical features for the first time, based on a created CBCT database. This ensures high-precision positioning of the injection needle, allowing control over the trajectory and depth of its insertion, which can significantly reduce the risk of complications.

Keywords: infraorbital foramen, cone beam tomography, navigation template

Examining the noise power spectra of a dental detector for high kVp irradiation conditions

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Introduction. X-ray dental imaging is based on digital detectors which convert the absorbed X-rays into voltage and subsequently into imaging bits. Detection technology uses either direct detectors, where the absorbed X-ray energy is transformed into electron-hole pairs, or indirect detectors where the absorbed radiation is transformed into optical photons which in turn are detected by electronic optical sensors. The electric signals from the sensor are channeled to digitizers through gate drivers and multiplexers for the formation of the final digital image. A fundamental criterion of a good image is high spatial resolution and reduced noise. The latter is of importance since it provides the limit of low contrast tissues detectability. Dental imaging employs X-ray tube voltages of 60 kVp and 70 kVp. In this work, the noise properties of a dental detector were examined in terms of the Normalized Noise Power Spectrum (NNPS) for tube voltages of 100 kVp and 120 kVp.

Materials and Methods. In this study a SCHICK CDR indirect digital dental detector with a pixel size of 40 μm was irradiated with a CPI, series CMP 200DR 50kW, at X-ray tube voltages of 100 kVp and 120 kVp at a distance of 72.5 cm The tube current ranged from 25 mA to 50 mA. The irradiation time was 400 ms. The final image was obtained processed by the vendor software in 8-bit and 16-bit format. NNPS was evaluated by COQ, an ImageJ plug-in software (B. Donini et al, 2014, Med. Phys. 41 051903). A noise transfer function (NTF) was calculated as the square root of NNPS normalized to its maximum value. Entrance surface air KERMA (ESAK) was measured with a Piranha multimeter.

Results. ESAK ranged from 97.4 μGy to 256.1 μGy. NNPS was calculated higher for the 16-bit image presentation. For instance, at 100 kVp and 25 mA and at the spatial frequency of 2.34 lp/mm, the NNPS at 8 bit was $5x10^{-6}$ mm² while the corresponding NNPS at 16 bit was $6.7x10^{-6}$ mm². The differences were significantly reduced at higher spatial frequencies close to the resolution limit of the system. NNPS was found reduced with increasing ESAK. This is expected since NNPS can be considered as the spatial distribution of the relative statistical noise fluctuations. An increase in ESAK corresponds to a higher value of X-ray photons absorbed in the detector, thus providing better image clarity and reduced statistical uncertainty. The latter is expressed in the reduced NNPS. Similar results were obtained at 120 kVp irradiation conditions. The 16-bit image exhibited higher NNPS than the corresponding 8-bit images. In each kVp the corresponding NTF values were found comparable.

Conclusion. The noise properties of a commercially dental digital detector were evaluated. It was found that increasing the ESAK decreases the NNPS values. The 16-bit quantification was found to increase NNPS due to the larger available grey levels. In each case our results were affected by the vendor software imaging manipulation attributes.

Keywords: dental detector, noise, NPS, high kVp

Organ dose reconstruction in a cobalt-60 radiation accident using Geant4 Monte Carlo simulation

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Inadvertent exposure to high-activity sealed gamma sources is a key concern of radiation protection, especially when physical dosimetry is not accessible. The current study elaborates a computational approach of reconstruction of organ-specific doses in the historical real-world Cobalt-60 exposure event through the use of the Geant4 Monte Carlo simulation package (Agostinelli et al., 2003). The case under investigation is a documented case of radiation accident of an adult male (pseudonym BERT), which involved exposure to a Cobalt-60 source at acute distance but with a short period and then a long time staying in the range of irradiation. The exposure resulted in pronounced localized effects such as finger necrosis, which provided a relevant dose-effect basis. A computational human phantom based on the MIRD model was optimized in the Geant4 framework in this work through the implementation of explicit eye geometries, which allows an improved assessment of dose to organs by organ specificity. The Co-60 photon spectrum was simulated with normalisation consistent with international radiation protection recommendations (ICRP, 2007).

Simulations with high statistics, of order 10^9 primary histories, were done to determine energy deposition, which reported to cover many orders of magnitude, i.e. at least between 10^{10} and 10^{14} MeV per GBq, which are strong spatial dose gradients. The reconstructed whole-body dose was estimated at approximately 11.1 Gy, with relative statistical uncertainties on the order of 10^{-5}, indicating stable simulation convergence. The results reveal a very non-homogeneous distribution of dose, such that doses are very high in the superficial tissues and extremities compared to internal organs. The clinical outcomes that existed in the studied case are consistent with the reconstructed dose patterns. Significant deviation between the estimated physical doses that were reconstructed and the biological dosimetry value of about 28.8 Gy that was reported in the incident was found. Such a difference is mainly explained by non-uniform exposure. In addition, cytogenetic dose assessment based on chromosome aberration analysis is known to be less reliable at high doses, since calibration is typically established under in vitro conditions below ~2 Gy. At higher dose levels, saturation effects and increased cell lethality can lead to overestimation. The suggested methodology provides a reproducible system of retrospective organ dose assessment of radiation accidents, supporting improved interpretation of clinical outcomes and aiding emergency response and medical decision-making.

Keywords: cobalt-60, Monte Carlo simulation (Geant4), dose reconstruction, organ-specific dosimetry, radiation accident, computational phantom, non-uniform exposure, biological dosimetry, high-dose effects, retrospective dosimetry

AI-assisted scientific event management: Conference session design and chairperson selection

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The rapid adoption of artificial intelligence (AI) in scientific event management continues to expand beyond content generation and communication support. Building on our previous work, this study presents advanced AI-assisted approaches for organizing scientific conferences, focusing on session planning and chairperson selection while highlighting additional applications throughout the conference workflow.

During abstract submission, authors select the scientific topic that best matches their work from a provided list. Although these selections are generally appropriate, many abstracts are inherently multidisciplinary and may fit several thematic areas. Organizers must therefore occasionally adjust sessions to better match the expected audience's interests. Furthermore, technical constraints may prevent authors from presenting in their ideal session, causing reassignment to alternative sessions. To support this process, AI analyzes the scientific content of abstracts rather than relying solely on author-selected topics. Using the clearly representative "core" abstracts of each session as references, the system recommends the most suitable session for ambiguous or unassigned contributions while preserving thematic consistency and maximizing audience relevance.

A similar methodology is applied to chairperson selection for oral and poster sessions. AI first evaluates the scientific expertise of registered participants based on their publications, research interests, and submitted abstracts to identify suitable chair candidates. While assigning chairpersons to well-defined and largely attended sessions is generally straightforward, difficulties arise for sessions that lack candidates with a relevant scientific background. In these cases, AI generates optimized chairperson assignments together with ranked backup candidates, balancing scientific competence, availability, and overall program coherence.

Beyond these applications, AI can further assist conference organizers by detecting duplicate or highly similar submissions, recommending appropriate reviewers, identifying scheduling conflicts, generating personalized conference programs, predicting audience attendance for individual sessions, and supporting multilingual communication.

Although human oversight remains essential for final decision-making, these AI-assisted approaches significantly reduce organizational workload, improve consistency and transparency, and enable more efficient management of increasingly complex scientific conferences.

Keywords: artificial intelligence (AI), scientific conferences, conference organization, chairperson selection, abstract classification, reviewer recommendation, scientific communication

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