

CHERNE 2024 Workshop

Sunday, 26 May 2024 - Thursday, 30 May 2024

CTU in Prague, Faculty of Nuclear Sciences and Physical Engineering



Book of Abstracts

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Estimation of the influence of beaver constructions on environmental contamination in the area of the former Zadní Chodov uranium mine

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Hydrothermal-metasomatite uranium deposit Zadní Chodov is situated in metamorphic rocks (gneisses and metagranites) between the villages of Zadní Chodov and Broumov, Czech Republic. The deposit was discovered in 1952 and mined until the year 1992. In the time period 1992-1995 the deposit was flooded in a controlled manner. The change in the oxidation-reduction environment in the underground resulted in high concentrations of U and Ra in the water that rose to the surface. Consequently, mine water had to be cleaned at a treatment plant. The purified water was discharged into a surface stream, which flows through a pond and, after 2 km, joins the Hamerský stream. After the cessation of treatment in 2010, the concentration of radionuclides in surface water and stream sediments began to increase; therefore, in 2012, it was decided to divert part of the overflowing water (1/3) through an experimental wetland. Contamination of water and stream sediments is monitored annually by DIAMO, s. e. as part of the Monitoring Program, approved by SONS; and the impact on the population from this old burden has not been significant so far. In 2023, beavers appeared on the stream, built 25 dams and caused the surrounding pastures to be permanently flooded. Based on the H*(10) measurements carried out in the years 2022, 2023 and 2024, it is possible to evaluate the influence of the flooding on contamination of the area and estimate the impact of higher radionuclide concentrations on grazing beef cattle. Assessing the situation is important to decide if it will be necessary to resume the treatment process.

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Cocaine: COMMUNICATIOn In Nuclear Engineering for non-nuclear experts

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Our previous 3 Erasmus+ SPs have revealed that blended activities improve the intensive programs we offer to our students and that soft skills are key competences for nuclear engineers in a sustainable future.

Integrating these aspects however asked a lot of efforts of the academic and technical staff to cope and integrate it in the practical activities. But it also offered new opportunities in collaboration and outreach. From student's perspective the relevance of the activities was not always clear and the quality of the output during the trainings was strongly influenced by degree of durability competences of the group members. These competences compromise inclusive collaboration, ethical and sustainable reflection, system thinking and sustainable actions. Among international student groups good communication is key to work on and improve these competences.

There are many formats of communications where engineers are involved in going from technical

meetings, ICT tools, instructive video's, mobile applications, written reports to even social media. Also, the target public can differ from experts in different disciplines to general public, from junior to senior, from one region to another even within Europe. The combination of both should be optimized in order to send and receive the correct message to a specific audience.

Recently, in many universities the role of AI in education is discussed on a high level and probably students are more exploring it than the professors. The applications of AI are numerous and can help certain communication goals or not.

In this new SP idea, we aim that students and professors learn from and with each other what the impact can be of a certain communication strategy for sending and receiving the right message, to explain the data and experiences they learned in the technical workshops correctly and to explore the opportunities of tools like AI, GIS, ... in scientific communication to non-nuclear experts. This will be done during an intensive staff training, pre-training activities and F2F training for students in different disciplines (Environmental radioactivity, Security/RP, waste management, nuclear energy and nuclear medical applications). At the end of each F2F training a communication session/event to a non-expert audience (dissemination) will be organized.

We reach out for partners and associate partners to be involved in this SP.

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Research at the Nuclear Technology Centre NuTeC at Hasselt University

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The Nuclear Technological Centre (NuTeC) is a research group of Hasselt University (UHasselt) and connected to the master program in Nuclear Technology at the Faculty of Engineering Technology. The research group NuTeC is integrated in the larger research institute the Centre for Environmental Sciences (CMK).

This research group operates at the intersection of several crucial areas in the field of radiological sciences, focusing on radiological analysis, reuse and management, and medical dosimetry.

NuTeC is specialised in low-level radiological analysis of materials containing enhanced concentrations of natural and artificial radionuclides. Through rigorous research and collaboration, we strive to enhance our understanding of radiological phenomena and develop novel approaches to address emerging challenges. Our commitment to sustainability drives our efforts in reuse and management, where we explore innovative strategies for the immobilisation of radioactive waste, the decommissioning of NORM sites, reuse and management of NORM residues, and nuclear decommissioning. Lastly, our group is actively involved in advancing medical dosimetry, focussing on dosimetry auditing service for radiotherapy departments and R&D regarding medical dosimetry e.g. dosimetry audits, dosimetry for biological experiments, micro dosimetry, nanoparticles, small animal irradiations and dosimetry in small fields and kV X-rays.

Through multidisciplinary collaboration and a commitment to excellence, our research group continues to make significant strides in the field of radiological sciences, driving innovation and fostering a safer, more sustainable future.

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Reference sites for aerial unmanned radiometric survey

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Spectrometers on board unmanned aerial systems are increasingly used for monitoring and surveying missions, both for security applications and studies related to natural resources. Compared to ground surveys as well as traditional helicopter/aircraft aerial surveys, the application of UAS has numerous advantages –and presents different challenges. To enable cross-comparisons and testing of the full data acquisition and evaluation chain, well described reference sites are required.

This contribution will present the progress in establishing reference sites for aerial gamma spectrometry in Czech Republic and provide an overview of the technical methods used in the process.

This work has been supported by the TA CR project SS06010467.

Technical workshop part IA / 15

Comparison of different detectors for small field output factor measurements in photon radiotherapy with a focus on long rectangular fields

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In the Varian environment (TrueBeam linear accelerator and Eclipse treatment planning system, Varian Medical Systems, Palo Alto, USA), beam data acquisition for radiation fields smaller than 3 cm x 3 cm involves measurements of long and narrow rectangular fields such as 1 cm x 40 cm. The beams must be collimated by jaws with fully retracted MLC (multileaf collimator). Output factors (OF) of such small fields are not comprised in the standard golden beam data package. There is very little literature on OF measurements in small rectangular fields and the IAEA document TRS 483 does not report correction factors for OF measurements in narrow rectangular fields collimated by jaws. In our clinic, we use this type of long, narrow fields for breast treatment plans (two IMRT tangential fields with jaw tracking) and stereotactic radiation therapy plans. There was a need to measure the small field beam data carefully and evaluate the impact on patient plans.

We compared three commercially available detectors that can be used for small field OF measurement: plastic scintillation detector Exradin W1 (Standard Imaging, Inc., Middleton, WI, USA), ionization chamber PinPoint 3D (PTW Freiburg, Germany) and ionization chamber IBA Razor Nano Chamber (IBA Dosimetry GmbH, Schwarzenbruck, Germany). We studied the effect of detector orientation and the collimator exchange effect in order to obtain accurate output factors into the beam data table. We considered the plastic scintillator as reference and we aimed to determine correction factors for OF measurements for the other two detectors including long and narrow rectangular fields collimated by jaws. These are not reported in the IAEA TRS 483 recommendation.

Marawas: Erasmus BIP in management of radioactive waste at UHasselt

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In the framework of a Erasmus+ BIP and DIOS-UHasselt project, UHasselt (Diepenbeek, Belgium) will organise a new edition of the training school in Management of Radioactive Waste 'MaRaWas' (3ECTS) from 13-20 November 2024.

A maximum of 16-18 students, master in nuclear engineering from Cherne and Eureka Pro partners, can register for this course. The training comprises a week with expert lectures, experimental sessions, technical visits and presentations of the work done during lab sessions and prepared in the pretraining task. This pre-training will involve the preparation of a round table discussion dealing with radioactive waste in different aspects and contexts in view of the SDGs. Lab exercises will focus on techniques like HPGe, Rn exhalation, LSC and nuclear decontamination and GIS data treatment. Technical visits to the Euridice/Hades facilities, industrial partners for nuclear waste management will be organised.

The pretraining coaching and information sessions will be organised using google meets. Teams or a shared google drive folder will be used in order to distribute a study guide and background course material, subjects for groups tasks and practical information.

The enrolled students will be divided in groups of 4-5 students of at least 3 different nationalities. Next to the specialised radioactive waste management skills, communication and collaboration are key evaluation factors. The pretraining phase will be evaluated for 1 of the 3 ECTS.

A preliminary program will be presented. As Bilateral Agreements need to be established well in advance between the host and home universities the registration and administration will start in June 2024, moreover after selection of registered students all IDs of students and extra information needs to be collected for access approval to nuclear facilities.

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Experiences of working SDGs in Radiological Protection

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The achievement of Sustainable Development Goals (SGD) defined in 2015 by the United Nations, is nowadays an issue of great concern for Governments and International Organizations and affect all aspects of human activities. The International Atomic Energy Agency (IAEA) is fully involved in the achievement of SDGs. Thus, in the IAEA's newsletter of March 2016, a review of how Nuclear Radiation Protection can help to achieve different SDGs, in areas such as industry, health and environmental protection, is presented. Moreover, the Universitat Politècnica de València (UPV) involvement in SDGs and for Degree Thesis, or Master Thesis, as well as for the different courses offered in UPV's Degrees and Masters the related SDGs must be specified. In this framework, it is relevant that the students of the Master's Degree in Nuclear Safety and Radiation Protection of the UPV, develop the necessary skills to contribute to the achievement of the SDGs. Thus, in Radiation Protection in Radioactive and Nuclear Installations, which is a compulsory subject of the Master's Degree in Nuclear Safety and Radiation Protection, three SDGs are identified based in the course contents and the IAEA's recommendations, as more relevant. The SDG linked with the course contents are: SDG 3: Health and well-being, SDG 6: Clean water and sanitation, SDG 9: Industry, innovation and infrastructure. In this context, students are expected to be aware that their training in Radiological Protection is not

limited just limited to the installation work. On the contrary, by including SDGs they are contributing to solve actual and specific problems that now are of concern in the whole society. Innovation focuses on making these relationships explicit and making them evident in the development of activities performed in the course.

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Preliminary Findings in the Study of Radon Gas Absorption Capacity in Aromatic Plants

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Radon is a naturally occurring radioactive noble gas emitted from rocks containing uranium. This study aimed to analyse the absorption capacity of this gas in aromatic plants exposed to an aerosol-rich radon environment. Additionally, it sought to determine the presence of radionuclides from the decay chain of ²³⁸U or ²³²Th. Aromatic plants, commonly used in both cuisine and interior decoration, were represented by the widely utilized species *Mentha spicata* L. This plant, extensively studied for its medicinal properties, exhibited promising results. High specific activities of certain radionuclides were found when compared to non-exposed plants. This preliminary outcome underscores the promising nature of investigating radon absorption capacity in *Mentha spicata* L., suggesting a need for further exploration into the chemical, medicinal, and morphological alterations undergone by this plant.

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Car-borne monitoring for NORM residue surveying

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Car-borne gamma spectrometry and dose rate measurement are useful tools in various situations, such as geological surveys, searching for orphan sources, or surveying in the aftermath of an incident. The method can also be successfully applied for surveying large masses of NORM residues, since a great amount of NORM residue can be further reused, for example, as construction material. This usage, however, may be conditional on the necessity of effective dose rate estimation, which is where the car-borne survey can be extremely helpful.

Our presentation will introduce an experiment in which we compared different types of cars in order to assess the impact of different types of vehicle construction on the measured dose rate above a large mass of NORM residue. The experiment combines field measurement with Monte Carlo simulation. We compared the data obtained in various positions inside three different cars that were parked on a large source of NORM residue. The main point of the Monte Carlo simulations was to estimate the correction for a real-life situation, since our experimental source was notably smaller than real sources (such as roads built using NORM residues).

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Indirect estimation of airflow inside uranium waste rock dumps using ground surface temperature measurements

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Uranium waste rock dumps contain residual uranium mineralization, resulting in increased concentrations of radon within the dump body. Depending on the structure of the stored material as well as on the surface properties and environmental parameters, radon is released from the waste rock dump body and the radon concentration in vicinity of the dump increases.

Areas of release vary during the year, depending on external temperature, cloud cover and atmospheric pressure. Radon release is coupled with airflow through the dump body, resulting in two typical vertical airflow regimes –up from base to top during winter, down with radon release near the base during hot weather.

Release areas in both regimes can be localized using ground or UAV thermography, providing hot and cold spots, and aiding in optimization of placement of the measurement instruments. However, surface radon exhalation measurements and radon concentration measurements above the surface are risky in terms of equipment damage and loss and do not provide inflow data.

Therefore, we propose method and instrumentation for evaluation of the airflow in the waste rock dump body using thermal dataloggers at above surface (control) and sub-surface positions. Such measurements provide indication of inflow and outflow at selected points and provide data to identify a critical “characteristic temperature” at which the natural airflow changes direction, resulting in sharp change in radon exhalation.

Results from an in-situ pilot campaign will be presented.

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X-ray Fluorescence Analysis of Pigments in Coats of Arms on the Lauf castel in Bavaria

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Pigments in the paints used for the coats of arms, polychromy on sculptures, and pigments in frescoes characterize not only the epoch but also individual creators or groups of artists involved in their creation. X-ray fluorescence analysis is a non-destructive method suitable for determining the chemical composition of these artefacts. This article covers the results of measurements of coats of arms on the Lauf castel in Bavaria and compares them with similar objects from the territory of the Czech Kingdom in the 14th century.

Utilization of integral ventilation rate measurement in practice

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The exchange of air between the indoor and outdoor atmosphere is a key physical process that affects, among other things, the behaviour of all types of aerosols and gaseous contaminants, including radon/ thoron and their decay products in buildings, and mediates their transfer from indoor to outdoor air and vice versa. Commonly used technique of tracer gases was implemented into SURO's measurement procedures in two modes, continuous and integral.

The integral air exchange rate measurement is more practical from the point of view of longer measurement time (i.e. improved coverage of user conditions), better comfort of the inhabitants of the building and tracer gas consumption. SURO utilizes integral air exchange rate measurement to objectify the results of radon measurement with respect to the minimum required hygienic air exchange rate (0.3 1/h), and as a radon diagnostic tool.

Practical use of integral air exchange measurement will be demonstrated through case studies.

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Blended Intensive Program - Assessment of radioactivity and Environmental radiological control in Belgium

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ISIB, the technical department of HE2B, is organizing a BIP in Brussels (Belgium) on the assessment of radioactivity and environmental radiological control in Belgium. A face-to-face training will follow an online pretraining.

The target audience is Bachelor students (3rd year) and Master students. 3 ECTS are delivered after evaluation of the learning outcomes.

The date of the face-to-face week will be discussed during the CHERNE workshop. The proposal is to organize the face-to-face training during the week of the 31st of March 2025.

We foresee trip on the field, laboratory work, technical visits and lecture.

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Assessment of radio cesium and natural radionuclides in mosses and study of their distribution in a mountainous region in Central Portugal

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Airborne transport is responsible for the long-range spreading of pollutants via atmospheric pathways. A fission product such as ^{137}Cs , serves as an effective tracer for studying the distribution of pollutants and its mechanisms through the atmosphere. Its propensity to be airborne transported on aerosols, combined with its half-life of 30 years, enables assessment over a timescale spanning several decades. Additionally, lithogenic radioisotopes are valuable indicators of transfer processes, especially in a region as Central Portugal, where the soil is naturally rich in these isotopes and their progeny.

Measurements of these radioisotopes were performed, among others, in mosses. These non-vascular and non-root plants are relevant for studying atmospheric contamination due to their capability to absorb nutrients from precipitation and dry deposition. Samples were collected from the Serra da Estrela and Beira Interior region in Portugal, at altitudes ranging from 400 to 1500 m. ^{137}Cs , ^7Be , and lithogenic isotopes such as ^{226}Ra , ^{228}Ra and ^{40}K were assessed using gamma spectrometry. The samples were geolocated using a dual frequency handheld GNSS receiver for subsequent Geographic Information System (GIS) data processing. The results were mapped to analyze the local distribution of radioactivity and to evaluate potential correlations with proxies linked to the region's morphology.

Results suggest that both artificial and local radioisotopes are distributed according to various mechanisms, indicating complex patterns of airborne transport and deposition.

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Methods for data evaluation from UAS gamma spectrometry – detector response models and data analysis methods

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As part of the ongoing “Reference sites for aerial unmanned radiometric survey” project, the CTU in Prague is developing data processing and analysis methods for data from gamma spectrometric scintillation detectors carried by an unmanned aerial system. The acquired data and developed methods shall improve calibration techniques for spectrometers and help characterize the chosen reference areas.

The scintillation spectrometer's gamma spectra provide quantitative and qualitative information on the presence of radionuclides producing the photon field at the measurement point, depending on peak position in the spectra. Quantitative information cannot be immediately obtained from the raw spectra due to the complex interaction and energy deposition processes of gamma photons in the detector, and mathematical analysis is required.

This contribution discusses methods for determining the detector response matrix for the D230A Georadis airborne spectrometer, calculation of air kerma rate, $H^*(10)$ and concentrations of ^{137}Cs and K , U , and Th in the surface layer of the soil. Additionally, model calculations for calibration factors enabling assessment of activity of a point source or circular contaminated hotspots for an identified radionuclide are presented, for different heights above the ground level. Spatial resolution assessment of the monitoring with an UAS is also discussed.

This work has been supported by the TA CR project SS06010467.

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Overview of HEP experiments of the Department of Dosimetry of CTU in Prague

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Over the last fifteen years, the staff and students of the Department of Dosimetry have participated in a number of experiments in the field of High Energy Physics. Individual experiments will be presented here and our activities will be mentioned.

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