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Poster abstracts

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Poster number 01

UKHSA RCCE Emergency Response Exercise 2025 - Biological and physical dosimetry

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Under the Civil Contingencies Act (CCA) 2004, the UK Health Security Agency is designated as a Category 1 responder, responsible for leading the public health response to radiological and nuclear incidents. In alignment with this role and to ensure readiness for such emergencies, a series of comprehensive emergency response exercises were conducted to evaluate the effectiveness and integration of multiple biodosimetry and physical dosimetry methods in assessing ionising radiation (IR) exposure. These exercises aimed to replicate realistic exposure scenarios and assess the capability of existing and emerging technologies to rapidly and accurately triage affected individuals during a real life emergency scenario.

In this study, multiple research groups employed a range of assays to evaluate their ability to triage and categorise potentially overexposed individuals in a timely and effective manner. Therefore, to simulate a real-life emergency scenario, five of each sample type were irradiated using an X-ray irradiator at doses of 0.3 Gy, 0.8 Gy, 1.2 Gy, 1.5 Gy, and 2.4 Gy. This included five 2 mL lithium heparin blood samples (for H2AX, DCA manual, and DCScore), five 1.5 mL EDTA blood samples (for gene expression), five 6 mL EDTA blood samples (for Tachyon device), five mobile phones, five alanine pellets, and twenty-five (5x5) TLD badges. Standard triage categories in radiation emergencies are low (<1 Gy), medium (1–2 Gy), and high (>2 Gy).

Biological dosimetry methods included the 'gold standard' dicentric chromosome assay (DCA), the γ-H2AX assay—a rapid approach suitable for initial triage—and FDXR gene expression analysis, a molecular biomarker of IR exposure. Additionally, Tachyon, a portable molecular diagnostic device, was deployed to assess radiation exposure in real time using nanopore sequencing and advanced bioinformatics, offering a rapid and scalable solution in emergency contexts.

In parallel, physical dosimetry approaches included Thermoluminescent Dosimeters (TLDs), smartphone-based dosimetry, and alanine chip dosimetry. All analyses have been completed and results show promising implications of a multi-assay approach to real life emergency scenarios. Results confirmed the accuracy and effectiveness of each method in assigning individuals to triage categories based on estimated dose.

These exercises underline the importance of integrating multiple dosimetry approaches to strengthen emergency preparedness and ensure robust public health responses in the event of radiological incidents. The outcomes underscore the importance of developing multi-assay strategies that can be adapted to different operational contexts, ensuring that the UK remains well-prepared to respond effectively and appropriately. The results provide promising evidence for future guidance on preparing for and responding to IR emergencies.

Poster number 02

Testing the use of alanine-based chip cards for emergency personal dosimetry following ionising radiation exposures

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Alanine is often used in medical dosimetry, and allows dosimetric estimates by measuring the number of radicals produced through Electron Paramagnetic Resonance (EPR) spectroscopy. However, it could also potentially find application as an emergency dosemeter following a large-scale radiological incident, to provide dose estimates to patients in order to triage them, and support limited biodosimetric methods.

The postulation of an alanine pellet embedded within identity cards (an ‘alanine card’) carried by the general public is one that would greatly improve emergency preparedness, provided a sufficient minimum detectable dose can be achieved. A deployable reader with sufficient sensitivity would be able to undertake a clinically relevant dosimetric reading of such a card immediately after an incident within the timescale of minutes.

This study aims to demonstrate the feasibility of alanine-card-based emergency dosimetry. Novel electronic hardware that will allow an alanine card to be measured through EPR measurements was designed in a high frequency electromagnetic simulation software (Ansys HFSS), and will be built and tested on alanine cards irradiated with varying doses. Simulations suggest that the use of this resonator could improve on the sensitivity of the current transmission line method by a factor of ~1,000.

Computational modelling was performed in MCNP using a voxel phantom to estimate the uncertainty in dose estimates from a worn alanine card, due to the attenuation of a person between the source and the pellet. By modelling an alanine pellet worn in various positions on the body, the relative change in dose received by a pellet as a function of source orientation around the phantom was simulated for various photon energies. Further simulations were done for isotropic and rotational sources. Together, these studies provide insight into the limits on the potential reliability of alanine cards for providing accurate dosimetry for individuals following a radiological incident.

Poster number 03

Impact of Thick Range Shifters on Neutron Dose in Conformal Proton FLASH Therapy

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Introduction

FLASH radiotherapy employing ultra-high dose rates (UHDR) has shown significant healthy tissue sparing while maintaining tumor control comparable to conventional dose rates [1]. Achieving UHDR with protons typically requires cyclotrons operating at maximum energy without a degrading system. To produce conformal depth-dose distributions under these conditions, 3D range modulators (3DRM) can be used in combination with thick range shifters [2, 3]. However, introducing these additional beamline components near the patient increases secondary neutron production and thereby elevate the risk of secondary malignancies [4]. This study examines how neutron production is affected by thick range shifters through comprehensive Monte Carlo (MC) simulations. A preliminary experimental benchmarking was performed with a commercial neutron rem counter detector.

Material and Methods

MC simulations were performed with TOPAS v3.9. Using the Marburg Ion Beam Therapy Center (MIT) as a real-world reference, the MC model incorporated a full implementation of the MIT nozzle and treatment room walls to facilitate experimental comparison. A proton pencil-beam of maximal machine energy (222.7 MeV) was directed at a water phantom placed at isocenter, with the range shifter placed upstream (Fig. 1).

Various thicknesses of Aluminum (5, 10, 14 cm) and PMMA (9.3, 18.6, 26 cm) were modelled and compared. Neutron spectral fluence was scored at four out-of-field positions at 0°, 45°, 90°, and 225° relative to the beamline. Scoring filters were applied to determine component-specific contributions to neutron production. Neutron ambient dose equivalent H*(10) was calculated from the spectra using ICRP-74 [5] conversion factors, and simulation results were compared to H*(10) measurements performed at MIT with a Berthold LB6411 neutron rem counter for all investigated setups.

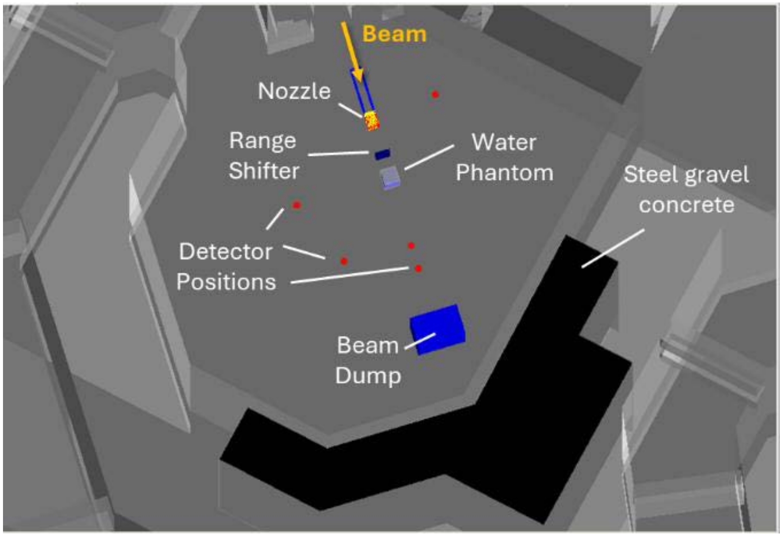

Figure 1: Simulation geometry in TOPAS.

Results

Range shifters substantially increased neutron dose, with enhancement factors of 1.2–6.1 for PMMA and 1.2–10.5 for Aluminum depending on range and detector position (Fig. 2). Neutron-origin analysis identified the range shifter as the dominant source, followed by the water phantom. Room-scattered neutrons accounted for 8–25% of the total, indicating that room modeling must not be neglected. Measured and simulated H*(10) values showed acceptable agreement across all investigated setups.

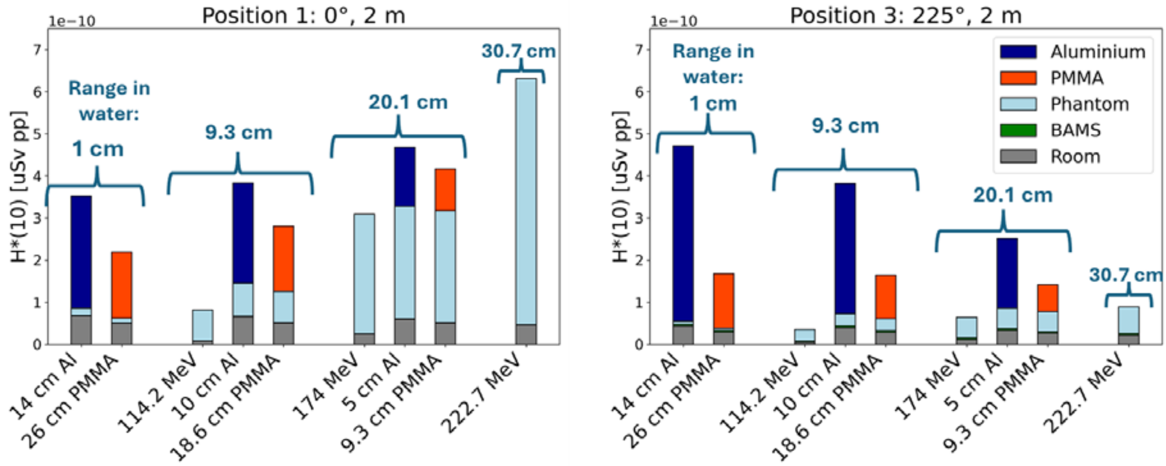

Figure 2: Neutron ambient dose equivalent H(10) for setups with and without range shifter.*

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Poster number 04

LinPAS: a passive neutron dosimeter for radiation protection applications in medical and nuclear fields

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Neutron dosimetry continues to face major challenges across various high-radiation sectors. Wellknown difficulties affect complex fields, including pulsed and quasi-continuum regimes encountered in hadron therapy centers and FLASH therapy; however, similar critical issues persist in the nuclear energy sector. In Nuclear Power Plants, ambient neutron dosimetry is frequently constrained by the limited portability. Furthermore, current passive area monitoring frequently relies on suboptimal solutions, due to the absence of specific, dedicated regulations. There is an urgent need for accurate, easily to operate tools capable of providing reliable integral dose measurements. Such tools are essential for corroborating actual worker doses and simplifying the reporting process to regulatory authorities. To overcome these shortcomings across medical and industrial fields, a Spanish initiative has developed a suite of innovative solutions for neutron area dosimetry and spectrometry. This initiative includes patented active dosimeters designed for specific high-dose rate environments,

LINrem, with sensitivity up to 10 MeV, and the extended-range LINremext, with a response until 10 GeV, expecially designed for hadrontherapy facility. From the LINrem tecnology, a passive solution is proposed in this work: the LinPAS.

Based on ThermoLuminescent Detectors (TLD) enriched with 6Li and 7Li, the LinPAS provides the necessary response to fast neutrons often missing in conventional passive systems. Although it offers a solution for areas where ionizing radiation is too intense for active instruments (leading to saturation, as in pulsed beam/FLASH therapy), its primary strategic value lies elsewhere. Being passive, the LinPAS is specifically focused as a robust tool for routine dose monitoring in clinical environments and an area monitor in Nuclear Power Plants. It is designed for performing precise integral dose evaluations over significant periods, rather than acting merely as a direct alternative to instantaneous active dosimeters.

This work presents preliminary results from calibration at the Universidad Politécnica de Madrid (UPM) using a moderated AmBe neutron source, together with its application at the CERN High Energy Neutron Source (CERF) above the IT iron roof.

Poster number 05

Development of a BaF - Plastic Phoswich Detector for Particle Identification and Dosimetry in Mixed Fields

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This poster presents the development of a Phoswich detector for fast neutron detection and particle discrimination in mixed radiation fields. The detector consists of a Barium Fluoride (BaF) crystal optically coupled to a thin plastic scintillator. Measurements were performed at the Marburg Ion Beam Therapy Center, where a water phantom was irradiated with 300 MeV/u carbon ions. Additionally in November 2025, the Phoswich joined the follow-up experiment of November 2023 at the Heidelberg Ion Beam Therapy Center aiming to measure the ratio between charged fragments and neutrons when irradiating a water phantom with different ion beams. Particle discrimination and identification were achieved using pulse shape discrimination (PSD) techniques, allowing the relative abundances of particles produced in the irradiation to be extracted. The measurement setup was replicated in a Geant4 simulation to validate the particle identification and to compare the relative particle yields. This work is part of the ADMIT consortium under Project Part A, which focuses on estimating spectral neutron fluxes for flash therapy in tumor treatment applications.

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Poster number 06

New Calculation of Fluence-to-Dose Conversion Coefficients for $H_p(10)$ Using Monte Carlo Simulations

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The Calibration Laboratory of the Paul Scherrer Institute (PSI) hosts a newly renovated neutron irradiation facility (NI-07), which provides well-characterised reference neutron fields generated by ^{252}Cf, D_2O-moderated ^{252}Cf, and ^{241}Am–Be sources. These fields have been characterised in terms of ambient dose equivalent $H^*(10)$ using a secondary standard LB6411 probe calibrated at a primary laboratory (Physikalisch-Technische Bundesanstalt, PTB). To extend this characterisation to the operational quantity personal dose equivalent (10), which is required for individual dosemeter calibration, validated Monte Carlo (MC) methods are essential. This is relevant not only for the characterisation of the currently available reference fields, but also in view of the planned development of a thermal neutron calibration facility at PSI, which is part of the present doctoral research project.

Current evaluations of (10) rely on analytical calculations using fluence-to-dose conversion coefficients $h_{p\Phi}(10; E, \alpha)$, which were calculated in the 1990s for expanded and aligned neutron fields and for a limited range of incidence angles (0° – 75°). Existing coefficients $h_{p\Phi}(10; E, \alpha)$, available in several references, can serve only as a first approximation, since in real reference fields factors such as anisotropy, finite source–phantom distances and room-scatter contributions play a significant role. Even when the double differential fluence is known, an analytical calculation of the (10) is not possible due to the lack of $h_{p\Phi}(10; E, \alpha)$ coefficients exceeding 75°. Moreover, existing conversion coefficients may no longer reflect improvements in modern MC transport algorithms and nuclear data libraries.

In this work, a validation of two state-of-the-art MC codes, MCNP and FLUKA, was performed by recalculating fluence-to-dose conversion coefficients for both monoenergetic neutrons and ISO 8529-1 reference spectra (^{241}Am–Be and ^{252}Cf). The simulations reproduce existing ISO coefficients with good agreement: deviations below 10% for broad neutron spectra and up to ~20% for monoenergetic fields, with the largest differences observed for thermal neutrons. These discrepancies are consistent with differences in transport models and cross-section libraries between modern codes and those used in the original calculations. Given that the development of a thermal neutron calibration facility at PSI is a core component of the present PhD project, a detailed investigation of these discrepancies at thermal energies is of particular importance.

The validated methodology will be applied to directly compute $(10; l, \alpha)$ in the full mass model of the PSI irradiation room for several distances l and irradiation angles α, enabling accurate characterisation of neutron fields.

Poster number 07

The points of accuracy management for the whole-body counting system - The lessons learned from the Fukushima Daiichi nuclear power plant accident

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After the Fukushima Daiichi nuclear power plant (FDNPP) accident in 2011, more than 50 whole-body counting (WBC) systems were installed in Fukushima Prefecture to monitor internal exposure of residents to radiation. However, these systems are still not readily available worldwide, and there is limited information on their accuracy. Therefore, it has been difficult to ensure their accuracy when used in Fukushima Prefecture. This study aimed to identify parameters that affect the accuracy of WBC systems when used to monitor internal radiation exposure, lessons learned from the FDNPP accident. The study included a longitudinal survey of the installation environment for WBC systems in Fukushima Prefecture and a cross-sectional survey of installation environments across Japan. This information was collected by survey questionnaires.

The longitudinal component of the study examined room temperature and humidity at WBC installation sites in Fukushima Prefecture and monitored total gain fluctuations over time. The survey included 18 WBC systems at 13 facilities. All facilities were equipped with air conditioners. Measurements were obtained on-site twice a year during the winter and summer seasons between February 2017 and March 2025. The mean room temperature (and standard deviation) was 236°C ± 2.2°C in winter and 24.8°C ± 1.6°C in summer. Humidity was 28.9% ± 8.5% in winter and 60.4% ± 10.1% in summer. Room temperature and humidity were identified to be factors affecting remarkable total gain fluctuations over time.

In the cross-sectional component of the study, 44 facilities housing WBC systems across Japan were invited to complete a questionnaire between July 2018 and August 2018. Completed questionnaires were returned by 32 facilities, giving a response rate of 72.7%. The responses indicated that environmental background and calibration checks were performed more frequently at facilities in Fukushima Prefecture (at least once weekly) than at those in other prefectures.

The NaI (Tl) scintillation detector in the WBC system is generally sensitive to temperature and humidity. Therefore, users need to maintain both the indoor environment using air conditioners and the accuracy of the WBC systems by calibration checks and adjustment for total gain fluctuations. In an environment contaminated by a nuclear disaster, the environmental background of WBC devices is influenced by the physical half-lives of various radioactive materials, necessitating frequent background measurements at short intervals. The results of this study may help to improve the accuracy of the WBC systems used to monitor internal radiation following a nuclear disaster.

We thank Ms Ayaka Sato and Ms Nozomi Tamura, both of whom are fourth-year students in the Department of Radiological Sciences, Fukushima Medical University, for their cooperation with this research. This study was supported by the Research Project on the Health Effects of Radiation (JFY 2025) organized by the Ministry of the Environment in Japan.

Poster number 08

Assessment of radiation exposure of clinical staff during radioligand therapy and patient dosimetry

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Targeted alpha therapy (TAT) with [^{225}Ac]Ac-PSMA has emerged as a promising treatment for metastatic castration-resistant prostate cancer. Despite encouraging clinical results, the assessment of pharmacokinetics and absorbed doses remains challenging because ^{225}Ac cannot be directly imaged and because alpha decay leads to recoil-induced release and redistribution of radioactive progeny. These processes complicate internal dosimetry and raise concerns regarding off-target organ toxicity and potential external exposure. This work addresses both challenges by combining pharmacokinetic modelling of the complete [^{225}Ac]Ac decay chain with experimental investigation of radionuclide release from patients.

In the first part, a population pharmacokinetic model originally developed for [^{177}Lu]Lu-PSMA-617 was adapted to predict the systemic behaviour of [^{225}Ac]Ac-PSMA and its radioactive daughters. The compartmental model was implemented in SAAM II and supplemented with ICRP systemic transfer coefficients to describe the biokinetics of the free progeny. Short-lived daughters were assumed to decay at their site of origin in accordance with ICRP recommendations. The model generated time-activity curves for [^{225}Ac]Ac and its decay products, enabling the calculation of time-integrated activity coefficients and, subsequently, the determination of absorbed dose coefficients using MIRDCalc. Simulations demonstrated a dominant tumour dose while revealing relevant contributions to kidneys and salivary glands, reflecting both PSMA affinity and progeny redistribution. This approach provides a practical framework for individualized dosimetry of [^{225}Ac]Ac-PSMA without relying on direct imaging or extensive patient-specific measurements.

The second part explores potential external release of radionuclides by patients undergoing targeted radionuclide therapy. Breath samples were collected from prostate cancer patients treated with [^{225}Ac]Ac- or [^{177}Lu]Lu -labelled compounds and analysed using high-resolution gamma spectrometry. Trace activities of [^{177}Lu]Lu were detected in some samples, likely associated with saliva droplets, whereas no [^{225}Ac]Ac or short-lived progeny were observed above detection limits. Although preliminary, these findings indicate that breath collection is feasible for investigating minor excretion pathways and may support improved assessments of occupational exposure for clinical staff.

Together, these complementary studies enhance the understanding of both internal pharmacokinetics and potential external release associated with [^{225}Ac]Ac-PSMA therapy. They contribute to improving internal dosimetry methodologies and radiation protection practices, supporting safer and more effective implementation of targeted alpha therapies.

Monte Carlo characterisation of the neutron reference fields of the Calibration Laboratory at PSI

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The Calibration Laboratory for ionising radiation (CL) at the Paul Scherrer Institute (PSI) provides calibration services for neutron dose-rate meters, personal dosimeters, and other neutron-sensitive devices using reference fields according to ISO 29661 and ISO 8529. These fields are generally characterised in terms of both neutron fluence Φ and ambient dose equivalent H∗(10). The presented project focuses specifically on the characterisation of the fields in terms of H∗(10) using Monte Carlo (MC) methods, aiming to improve its accuracy and deepen the understanding of the scattered neutron component that influences calibration results.

Since certain field properties - particularly room-scatter - are difficult to quantify, detailed MC simulations were carried out. A high-fidelity mass model of the CL irradiation room was developed in MCNP 6.3 and FLUKA to predict neutron scattering from all elements within the room.

Validation of the model was performed by calculating H∗(10) from the simulated neutron fluence using internationally agreed conversion coefficients h∗(10; E), and further comparing with experimental measurements carried out at multiple source-to-detector distances with a secondary standard calibrated at a primary laboratory (National Metrology Institute, PTB, Braunschweig, Germany). These measurements were conducted with an LB 6411 (Berthold Technologies GmbH) neutron dose rate meter together with its display unit UMO LB 123.

The simulated dose rate values agree with the measurements within 10% for all distances, with better agreement for larger distances. Additionally, using the flagging option in MCNP, the scattering contribution of all relevant elements within the irradiation room was evaluated. Close to the source, the principal contributors are the irradiator shielding, materials surrounding the source, as well as the elements in the calibration benches. These results provide a solid basis for refining PSI's neutron calibration procedures. Next steps consist of investigating the appropriate geometry corrections to reduce the discrepancy between the measured and simulated values at short distances and performing field characterisation measurements with more stable instruments that do not need conditioning before usage (e.g. SmartREM from Freiberger Sensortechnik).

Poster number 10

Fetal doses for diagnostic radiology and radiotherapy procedures on pregnant patient: in phantom measurements within the SONORA project

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Introduction

Each year a certain number of pregnant patients have to undergo radiology or radiotherapy procedures exposing the fetus to unwanted ionizing radiation. To weigh in the risk compared to the benefit of such procedures, a proper fetal dose estimate is needed. One of the aims of the SONORA project (Towards Safe, Optimized and PersoNilized RadiOlogy and RAdiotherapy procedures for Pregnant Patients) is to improve the accuracy of fetal dose estimation in diagnostic and interventional radiology (DIR) and radiotherapy (RT).

Material and methods

Within SONORA project three physical pregnant phantoms corresponding to three stages of pregnancy (TENA-I, TENA-II and TENA-III) have been developed and with them 14 measurement campaigns in 5 institutions in Croatia, France, Greece and Italy have been completed so far.

Fetal doses were measured for three DIR procedures: CT Abdomen+Pelvis, CT Polytrauma, and RTG Abdomen. These were chosen specifically as they are the most common procedures for which the fetus would be in the primary beam. Fetal doses during photon radiotherapy were measured for three photon techniques; 3D-CRT, IMRT, and VMAT, and left breast irradiation was simulated. Simulated target volumes included whole left breast (WB), breast boost (BB), and breast + supraclavicular lymph nodes(B+LNF). Each participating center created treatment plans with the same dose prescription, ensuring consistency across measurements.

Doses to the fetus were measured with radiophotoluminescent dosimeters (RPLD) placed within the TENA phantoms. RPLD type GD-352M was used, which consists of a silver activated phosphate glass rod encased in a plastic holder with an energy compensating filter. TENA-I has one, TENA-II two, and TENA-III seven RPLD measurement points within the fetus.

Preliminary results

The measured doses have been in the range 0.2 to 3.2 mGy for RTG, and from 2.1 to 47.4 mGy for CT protocols. Variability in dose for the same protocol can be seen depending on the unit as well as between institutions and pregnancy stages.

For breast RT, the total doses measured at points in fetus were from 0.9 mGy to 186 mGy. Lowest doses were measured for BB plans, which have a lower target dose, while highest are usually for B+LNF. Doses depend on pregnancy stage, technique used but also on measurement point location. Specifically, in TENA-III for the same irradiation, due to the size of fetus, measured doses span over an order of magnitude.

Conclusions

The results of SONORA measurements will give an overview of how fetal doses vary depending on the pregnancy stage, unit and protocol or technique used as well as from one institution to another. This ongoing research will provide evidence for safe use of DIR and RT during pregnancy and enhance our understanding of its impacts on fetal exposure.

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Poster number 11

IndAccDos: investigation of novel methods for INDividualised ACCident DOSimetry

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Household salt (NaCl) has been proposed as a dosemeter for the public, when measured with optically stimulated luminescence (OSL) in connection with radiological or nuclear (R/N) emergencies [1], [2]. NaCl in various forms has proven to be an excellent luminescent dosemeter. However, as the effective atomic number of NaCl is almost twice as high as tissue, the energy dependence of NaCl needs to be compensated for, if used for dosimetry [3].

In this project, the aim was to design a holder for a dosimetric badge incorporating NaCl pellets, based on a 3D-printed badge and appropriate filters, aiming to distinguish photons of different energies. Furthermore, the filters allow for correction of the overresponse at lower photon energies.

Based on Monte Carlo simulations, prototype-kits were tailored, and measurements were conducted at UKHSA, utilizing ISO Narrow Series X-rays (N-20 – N-300), and gamma-ray radiation sources. Results regarding the energy dependence of the dosemeters and the effect of the filtering materials is presented. Also, the dependence of NaCl pellets for various air kerma rates was investigated. The use of the NaCl pellets is verified through a dose reconstruction study, based on three luminescence stimulation modes.

This project was financially supported by the Swedish Radiation Safety Authority [SSM2022-5450] and the EURADOS young scientist grant 2024.

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Poster number 12

Proton Beam Dosimetry for Electronics Radiation Hardness Tests

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The AIC-144 cyclotron in the Institute of Nuclear Physics, Polish Academy of Sciences produces a 60 MeV proton beam with intensity up to about 80 nA. The proton irradiation station for radiation hardness testing of electronics is being developed at this facility.

The irradiation station contains an optical bench of 180 cm length and beam forming and monitoring elements installed on the bench. The irradiation station has an irradiation field formed by the single scattering method with a diameter from 10 mm to 120 mm and uniformity better than +/- 15%.

A special XY scanner was built to precisely position and move irradiated samples within a 200 mm x 300 mm radiation field. This allows for the irradiation of larger numbers of samples without entering the room and without the need for extended irradiation breaks.

Beam monitoring (dose measurement and calculation of delivered fluence) is based on ionization chambers and electrometers as well as measurement of residual current from selected elements of the beam forming system.

Reference dosimetry is based on measurements made with ionization chambers connected to reference-class electrometers (according to IAEA TRS-398) or by measuring the charge using a Faraday cup. The choice of method depends on the proton flux at which the irradiation is performed. In addition, the lateral dose distributions are verified by measurements using radiochromic (Ashland Gafchromic) films.

The irradiation station is currently intensively used to test the radiation hardness of electronics designed and built for the space industry and to test semiconductor elements used in particle physics detectors, providing the possibility of irradiating samples with energies in the range of 10 MeV - 60 MeV and depositing total fluences up to 1e14 proton/(cm2s) during a single irradiation.

Poster number 13

Performance Assessment and Adaptation of a Mobile NaI(Tl) Anthropogammametry System for Lung and Whole-Body Monitoring in Radiological Emergencies

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Internal contamination monitoring is essential for the radiological protection of occupationally exposed workers, particularly in radiological emergency situations requiring rapid screening. The Laboratory of Internal Dosimetry at CNESTEN, Morocco, operates a mobile anthropogammametry system based on a collimated 2"×2" NaI(Tl) detector, which is routinely used for thyroid monitoring. This study presents an experimental and Monte Carlo based performance assessment of this mobile system to evaluate its feasibility for lung and whole-body monitoring, using the thyroid geometry as a reference configuration.

Experimental calibrations were carried out with an anthropomorphic phantom and standard gamma-emitting radionuclides (^{241}Am, ^{137}Cs, and ^{60}Co), covering an energy range from 59 keV to 1332.5 keV. Monte Carlo simulations were used to optimize detector positioning for lung measurements, by simulating detection efficiency at various detector-phantom distances. The study specifically evaluated the system's dosimetric performance for a targeted set of radionuclides relevant to emergency scenarios:

- For Lung monitoring : ^{57}Co, ^{58}Co, ^{60}Co and ^{235}U.
- For Whole-Body monitoring : ^{57}Co, ^{58}Co, ^{60}Co, ^{59}Fe, ^{85}Sr and ^{134}Cs, ^{137}Cs.

The system performance was evaluated in terms of photopeak efficiency, energy resolution, Minimum Detectable Activity (MDA), and Minimum Detectable Committed Effective Dose (MCED). Monte Carlo simulations were specifically used to compare efficiencies between thyroid, lung, and whole-body geometries. The results indicate that the system is capable of detecting all studied radionuclides in whole-body configurations, with MCED values below regulatory monitoring thresholds. However, the use of a single collimated detector limits its applicability for operational quantitative whole-body monitoring. For lung monitoring, after geometric optimization, the system is able to assess committed effective doses below the regulatory thresholds for all studied radionuclides except uranium isotopes, for which detectable doses remain above the limits due to intrinsic physical constraints.
This work demonstrates that an existing mobile NaI(Tl) anthropogammametry system can be effectively adapted for lung contamination screening in radiological emergency situations, while clearly identifying its limitations for whole-body monitoring and uranium detection.

Poster number 14

Estimating Spatially Resolved Radiation Fields Using Neural Networks

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We present neural networks to estimate the spatial distribution of scattered radiation fields in real-time for radiation protection dosimetry in medical radiation fields, such as those found in Interventional Radiology and Cardiology.

Additionally, we present three different synthetically generated datasets with increasing complexity for their training, using a Monte-Carlo Simulation application based on Geant4. On those datasets, we evaluate convolutional and fully connected architectures of neural networks to demonstrate, which design decisions work well for reconstructing the fluence and spectra distributions over the spatial domain of such radiation fields.

Poster number 15

Comparative study of secondary neutron doses in coplanar and non-coplanar proton therapy for a pediatric brain tumor

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Background and purpose

Treatment plan parameters, such as beam incidence angles, strongly influence out-of-field doses (OOF) in proton therapy (PT). These OOF doses need to be characterized, especially for pediatric patients, who have a longer life expectancy and a higher radiosensitivity.

This study evaluates and compares neutron OOF doses from coplanar and non-coplanar brain treatment plans for a pediatric case and assesses their impact on radiosensitive organs.

Materials and methods

Two PT treatment plans were generated for a centrally located brain tumor, a coplanar plan consisting of 3 coplanar beams and a non-coplanar plan consisting of 2 coplanar beams and 2 non-coplanar beams (Figure 1). Topas Monte Carlo (MC) simulations were conducted for both treatment plans, while measurements were conducted for the coplanar plan to validate the simulations using a 5-year-old CIRS ATOM anthropomorphic phantom.

Neutron dose equivalent was measured using Bubble Detector Personal Neutron Dosimeter (BD-PND) at six different OOF locations at increasing distances from the target (Figure 1). Detectors were calibrated with a Cf-252 reference source to obtain neutron dose equivalent by applying new fluence-to-dose equivalent conversion coefficients calculated specifically for BD-PNDs (Van Hoey et al., *in preparation*). Measurements were then corrected for their detector energy response (Lewis et al., 2021) by using the simulated neutron energy spectra of each measurement position.

Within the MC simulations, the full-body CT of the anthropomorphic phantom was imported, and the RT plans were modeled using a validated beam model (Colson et al., 2023). BD-PND volumes were modeled within the phantom geometry to score the neutron fluence energy spectra, which were converted to neutron dose equivalent by using the fluence-to-dose equivalent conversion factors mentioned above.

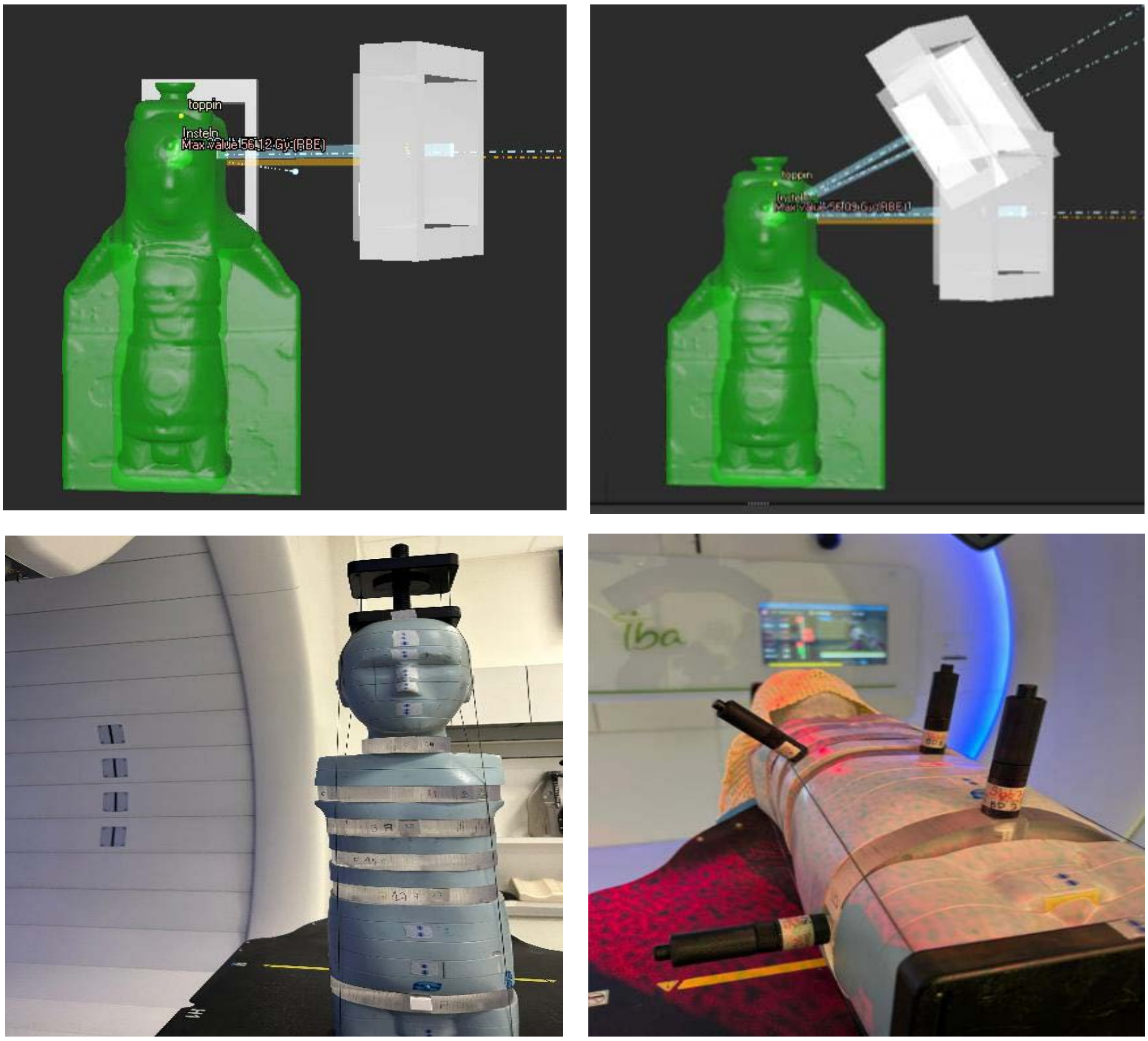

Figure 1: Top Left: coplanar treatment plan beam configuration visualized in Raystation. Top Right: non-coplanar treatment plan beam configuration visualized in Raystation. Bottom left: anthropomorphic phantom with PMMA slabs. Bottom right: anthropomorphic phantom with BD-PNDs placed to measure doses in the thoracic and pelvic regions.

Results

MC simulations are consistently higher than measurements across all detector positions (Figure 2). The simulations differ from the measurements between 6% and 42%, with an average of 22%. These discrepancies may originate from differences in phantom material definition between the physical and modelled phantom (Hounsfield Unit-based material conversion), as well as from the physics module selected in the TOPAS simulations. Moreover, the measurements with BD-PNDs present an average uncertainty of 20% (k=1).

Coplanar and non-coplanar plans yield nearly identical neutron doses close to the target. However, at further distances (>25cm from the edge of the Clinical Target Volume), the non-coplanar plan shows higher neutron dose equivalent compared to the coplanar plan (Figure 3). This was 14% higher at 27 cm and 18% higher at 47 cm. These elevated doses can be attributed to the specific beam orientation of the non-coplanar plan.

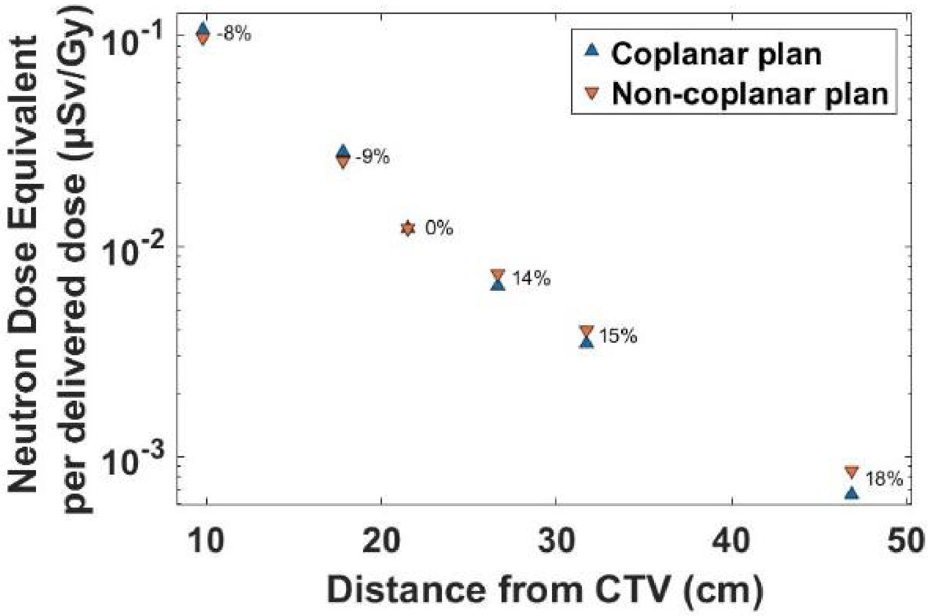

Figure 2: Coplanar treatment plan measured and simulated neutron dose equivalent per delivered dose, as measured by BD-PND and calculated by TOPAS MC simulations. Percent differences relative to measurements indicated at each position.

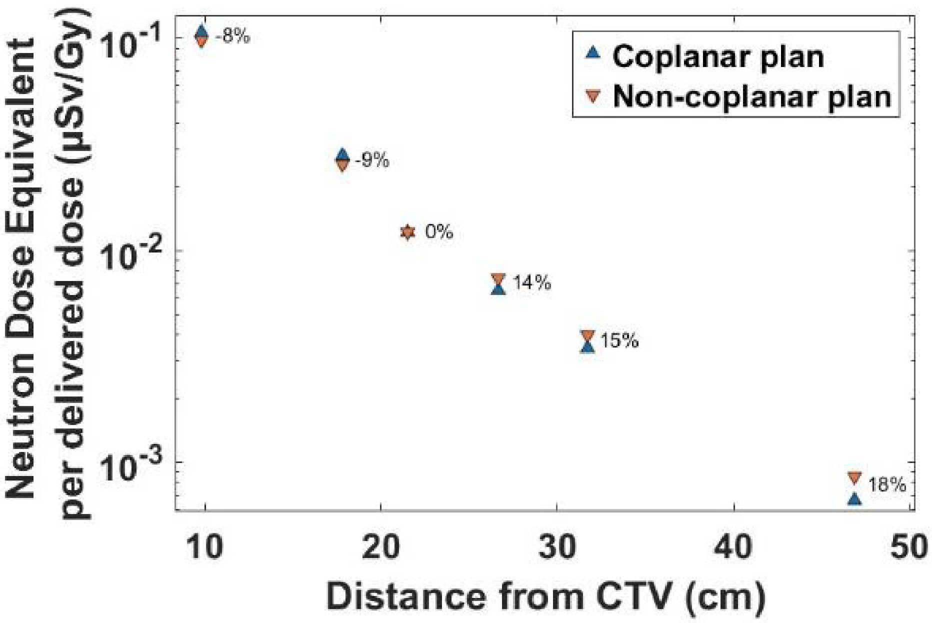

Figure 3: Simulated neutron dose equivalent for coplanar and non-coplanar PT treatments. Percent differences relative to the coplanar plan indicated at each measurement position.

In this study, similar thyroid doses were observed for both plans of 107 µSv/Gy, while lower doses were measured in the thoracic and pelvic regions, with maximum values between the two plans of 12 μSv/Gy and 0.9 μSv/Gy, respectively. These values will be further recalculated with higher precision.

Conclusion

Non-coplanar plans produced up to 18% higher distal neutron doses due to their couch–gantry geometry and associated high-energy neutron production. This study also provides experimental validation of the TOPAS ProteusOne beam model for out-of-field dose assessment in a pediatric phantom with an agreement that falls within uncertainties. These findings highlight the importance of beam-angle selection on neutron exposure.

Poster number 16

Towards a model for track-etched detectors to improve neutron dosimetry

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Neutron dosimetry plays a crucial role in ensuring radiation protection across multiple domains, including nuclear power generation, medical diagnostics and therapy, and high-energy physics experiments. Nevertheless, obtaining precise neutron dose measurements remains difficult due to the wide energy range of neutrons - spanning more than ten orders of magnitude - which influences both the reaction types and the corresponding cross-sections. Similarly, the fluence-to-dose conversion coefficients can vary up to an order of magnitude depending on neutron energy.

This work is dedicated to developing a predictive model for PADC detectors and the entire dosimetry procedure, which includes exposure, etching, read-out, and dose estimation. The goal is to systematically address each step of the process, accounting for all factors that could potentially affect the accuracy of neutron dosimetry. By integrating a Monte Carlo simulation of the detector's irradiation conditions with a semiempirical model for track formation and evolution, and by developing new algorithms for track recognition that overcome the limitations of current commercial read-out systems, we seek to predict the detector's efficiency for any neutron spectrum and irradiation geometry.

The model is currently under development and validation under standard conditions through both simulations and experimental measurements using well-characterized neutron sources such as ^{241}AmBe and ^{252}Cf. Future work aims to extend the model's applicability to a wider range of neutron energies and incident angles, with additional testing to be carried out in realistic workplace neutron fields.

Our objective is to enhance the energy response and efficiency of one of the most widely used personal neutron dosimeters while enabling predictive modeling of its response in complex or poorly characterized neutron fields. This capability is particularly important in environments such as nuclear reactors or high-energy accelerators, where neutron spectra can significantly differ from calibration conditions, thereby increasing measurement uncertainty and inaccuracy.

Poster number 17

PENELOPE/penEasy Validation in Internal Dosimetry with Respiratory Motion

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This study investigates four-dimensional internal dosimetry by incorporating respiratory motion effects into absorbed dose calculations using a 4D XCAT phantom. A complete respiratory cycle was simulated and divided into 13 phases, during which specific absorbed fractions (SAFs) were evaluated for several energies using Monte Carlo simulations based on the PENELOPE/penEasy code. PENELOPE/penEasy has been shown to provide highly accurate results in internal dosimetry for nuclear medicine applications. The results demonstrate that SAFs vary significantly with respiratory phase, exhibiting higher values during exhalation than inhalation, particularly in the lungs, liver, and stomach. Respiratory motion also affects cross-irradiation between adjacent organs. Self-irradiation from photons in the lungs was estimated at approximately 11.5%, while in the liver it remained below 3%. These findings highlight the importance of accounting for respiratory motion with realistic 4D phantoms in Monte Carlo simulations to achieve more accurate absorbed dose assessments in internal dosimetry.

Poster number 18

Development of an Experimental Setup for Flash Effect Studies at the FLUTE Electron Accelerator

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Investigating dose-rate–dependent effects in radiotherapy requires irradiation platforms that allow access to both conventional and ultra-high dose-rate regimes under well-controlled conditions. At the Karlsruhe Institute of Technology (KIT), the FLUTE facility (Ferninfrarot Linac- und Test-Experiment) provides such capabilities by enabling the generation of ultra-short electron bunches and flexible beam delivery. This makes it possible to realize irradiation scenarios relevant for FLASH radiotherapy (> 40 Gy/s) as well as direct reference irradiations at conventional dose rates (0.1 Gy/s). The implementation of these regimes relies on precise adjustment of bunch charge, repetition rate, and lateral beam spot size, which in turn introduces specific challenges for dosimetric measurements.

The poster presents first dosimetric characterizations of the biomedical irradiation setup at FLUTE. Measurements were performed using an Advanced Markus electron ionization chamber and a flashDiamond detector, both of which exhibited saturation effects due to the extremely high instantaneous dose rates ($\approx 10^{11}$ Gy/s). In addition, passive dosimetric systems, including radiochromic films and optically stimulated luminescence dosimeters (OSLDs), were investigated.

The poster further outlines initial steps toward establishing a three-dimensional clonogenic-type organoid assay. These preparatory studies form the basis for upcoming biological experiments aimed at a retrospective characterization of radiation-induced damage.

Poster number 19

Experimental assessment of neutron background generated by 60 MeV proton beam irradiations

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Proton beams are used in a wide range of applications, from proton radiotherapy and isotope production to radiation-hardness testing of electronics for the physics and space industries. During proton beam irradiations, intensive scattered radiation is produced, depending on the beam configuration and the irradiation target. After the beam is switched off, residual radiation persists due to activation by protons and secondary neutrons. The aim of this research was to determine the spatial distribution of neutron and gamma doses (dose rates) during 60 MeV proton beam irradiations under different beam configurations.

The measurements were conducted at the Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN) using a 60 MeV horizontal proton beam from the AIC-144 isochronous cyclotron. Proton beam dosimetry was performed using a PTW TM 34045 Advanced Markus chamber connected to a PTW Unidos Romeo electrometer. The beam current was measured using the Faraday cup and this current was applied to calibrate the PTW TM 7861 monitor chamber. Neutron doses were measured with a Thermo Fisher Scientific FHT 762 Wendi-2 wide-energy neutron detector connected to an FH 40 G survey meter. Gamma doses were measured with Thermo Fisher Scientific FHT 192 ionization chamber connected to an FH 40 G survey meter.

Neutron dose rates, as well as background gamma-radiation dose rates, were systematically collected as a function of beam configuration, target type, proton beam intensity, and integrated proton current. The time dependence of the decrease in background gamma dose rates after beam shutdown will be presented. The resulting database of neutron dose rates will be used for experimental benchmarking of Monte Carlo calculations.

Poster number 20

Internal dosimetry of European Spallation radionuclides

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This poster presents an overview of ongoing PhD research aimed at identifying key knowledge gaps and reducing uncertainties in the internal dosimetry of radionuclides produced at the European Spallation Source (ESS). The ESS, currently under construction near Lund, Sweden, is a neutron research facility based on spallation reactions, in which 2 GeV protons from a high-power linear accelerator strike a rotating tungsten target. While routine releases are expected to be negligible, radiological protection assessments must also consider postulated worst-case accident scenarios, such as a loss-of-coolant event followed by a hydrogen explosion, potentially resulting in airborne releases of radionuclides in particulate form. Previous consequence analyses performed by the Swedish Radiation Safety Authority (SSM) identified inhalation as the dominant exposure pathway during the early phase following such a release, particularly under low wind speed conditions. Among the radionuclides considered, 148Gd (a pure α emitter with a physical half-life of approximately 84 ± 4 years) was shown to contribute more than half of the effective dose during the first seven days, assuming respirable aerosol formation. Despite its importance, large uncertainties remain in the biokinetic behaviour and dose coefficients of this radionuclide, particularly for refractory metal oxides.

The central research questions addressed in this work are therefore: (i) which biokinetic parameters most strongly influence internal dose estimates for ESS radionuclides, and (ii) how experimental data can be used to reduce uncertainties in these parameters. Dose coefficients for key radionuclides are currently under development using biokinetic models implemented in the AFRY Intelligent Systems modelling framework (previously known as Ecolego). To support this work, sensitivity analyses were performed to identify the most influential parameters for both lung retention and urinary excretion at 1, 7, 30, and 365 days post-intake. For the lungs, the fractional deposition in the alveolar–interstitial region (f_d,AI) consistently dominated at all times, followed by the rapid alveolar fraction (f_r,ALV) at later times. Additional influential parameters included transfer coefficients between alveoli and bronchioles, as well as rapid and slow transfer rates from alveoli to blood. For urinary excretion, f_d,AI and the transfer coefficient from blood to urinary bladder content were dominant at all times, while longer-term sensitivity increasingly depended on transfers from blood to trabecular and cortical bone surfaces. These results highlight which parameters should be prioritized for experimental characterization.

To address these priorities, lung dissolution experiments for gadolinium oxide (Gd_2O_3) aerosols are being conducted in collaboration with Linköping University using validated in vitro models. Dissolution kinetics in synthetic phagolysosomal fluid indicate solubility behaviour closer to ICRP Type S than the provisionally assumed Type M. Model-derived respiratory uptake parameters exhibit a particle-size dependency not assumed in current ICRP models, although firm conclusions are limited by remaining uncertainties

and the lack of in vivo validation. For an AMAD of 5 µm, the derived committed effective dose coefficient exceeds

Type M estimates by more than a factor of three, underscoring the importance of correct solubility classification. Gastrointestinal dissolution studies suggest that ingestion contributes only marginally to overall dose due to low solubility and probable precipitation. Overall, this work demonstrates how targeted sensitivity analysis combined with experimental dissolution data can systematically reduce uncertainties in internal dosimetry for spallation-produced radionuclides, thereby supporting more robust dose assessments and emergency preparedness for ESS and similar facilities.

Poster number 21

Inorganic Scintillator micro-dosimeter for radiation therapies under small fields

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We have developed inorganic scintillating detectors (I.S.D.), based on the conversion of ionizing radiation into visible light in a passive sensitive part, grafted at the extremity of an optical fiber. This fiber, made of glass, has a core diameter of 100µm and the volume of the sensitive part is much lower than 1 mm3. This fiber guides the visible light to a photodetector, allowing measurements at a great distance without signal loss.

To improve the reproducibility of the fabrication process, a LabVIEW program has been developed, allowing us to have a semi-automatic fabrication test-bench. Different I.S.D.s, made before and after this improvement demonstrate that the reproducibility has been achieved. Various scintillators emitting in the visible range have been used in the process. I.S.D.s were tested under X-rays and show good sensitivity.

Also, in the focus of developing an entire independent acquisition chain, measurements have been held with the same I.S.D. in association with a Silicium PhotoMultiplier (SiPM), or a PhotoMutiplier in tube, and compared with the association with a Single Photon Detector (SPD) from Aurea-Technologies used as reference. Results obtained with the SPD and with the PMt are in good agreement.

Coating the scintillating part of the detector was considered to protect this delicate part and decrease the background level recorded during the measurements (dark noise). For this purpose, a silver coating of the ISD was performed. Comparison between measurements under X-rays with and without metallization will be compared and discussed.

Poster number 22

The EURADOS HIT campaign 2025: experimental characterization of secondary particle mixed fields generated by carbon and oxygen ion irradiation of a water phantom

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The previous EURADOS measurement campaign conducted in 2023 at the Heidelberg Ion Therapy Center (HIT) demonstrated that the stray radiation field downstream of a water phantom irradiated with clinically relevant protons, helium ion, carbon ion and oxygen ion beams contains a substantial contribution from secondary charged hadrons of about 70 % in comparison to neutrons [1]. In the angular range 0° to 45° with respect to the primary beam direction, this mixed radiation field was shown to significantly affect the response of moderator-type neutron instruments, including rem counters and Bonner Sphere Spectrometers. Secondary charged particles may either deposit energy directly in the sensitive volumes of these detectors or generate additional neutrons through interactions in the moderator material. Both processes produce signals that are indistinguishable from neutron-induced events, potentially leading to an incorrect estimate of the neutron ambient dose equivalent if the charged-particle contribution is not properly accounted for.

To further investigate this effect, a dedicated follow-up experiment was performed under identical irradiation conditions, with a field size of 10 cm x 10 cm and a spread out Bragg peak with a depth of 10 cm to 20 cm in a water phantom. The objective was to characterize the mixed radiation field inside and outside of the phantom and to discriminate secondary charged fragments from neutrons. A comprehensive set of active and passive detectors was deployed, including a LUPIN rem counter, Timepix hybrid pixel detectors, tissue-equivalent proportional counters, CR-39, radiophotoluminescent dosimeters (RPLs), the AlphaBeast CMOS-based detector, LINrem dosimeters with extended and non-extended neutron energy response, a Phoswich detector, and a silicon telescope. The detectors were installed at multiple locations within the HIT experimental room, with Position 1 and 2 inside the water phantom and Position 3 to Position 9 outside (Fig. 1).

The data analysis and cross-comparison of the various detectors and dosimeters is currently underway. Preliminary results from the silicon telescope placed inside the water phantom indicate the presence of multiple secondary ions at Position 1, ranging from protons up to boron fragments for primary carbon beams and from protons up to nitrogen fragments for primary oxygen beams. Measurements performed with the AlphaBeast detector at Position 8 showed a clear thermal neutron signal. At the same time, a strong contribution from secondary charged particles was observed, partially masking the recoil-proton signals associated with neutron interactions.

The presented measurement campaign should enable a detailed assessment of the charged-particle component and its impact on neutron detector readings. These results would provide insight into the limitations and applicability of moderator-type neutron dosimeters in complex mixed radiation fields relevant to ion therapy.

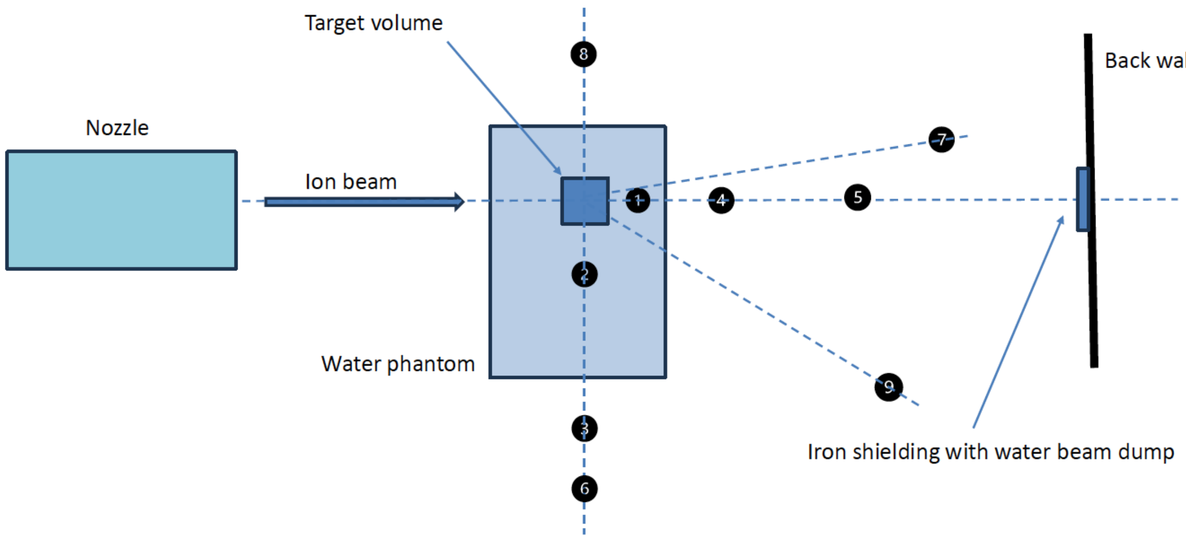

Figure 1: Experimental setup of the EURADOS HIT campaign, indicating the detector positions 1-9.

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Poster number 23

Full dose range testing of a machine learning-based pit-counting model for electrochemically etched neutron dosemeters

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For a neutron dosimetry system to be approved for use in the UK, it must pass a performance test defined by the regulatory organisation, the Health and Safety Executive (HSE). In the tests for routine monitoring, neutron dosemeters are in groups where the smallest Hp(10) doses are between 0.6 and 1 mSv, and the largest doses are between 30 and 50 mSv. The dosimetry service must determine the dose to within 20 % of the value given by the test laboratory. The UK Health Security Agency's (UKHSA) personal dosimetry service will typically ask the National Physical Laboratory (NPL) to perform these tests.

There are a few recent examples of machine learning (ML) being applied to chemically etched particle track dosemeters [1-3]. Mostly, existing deep neural network architectures are being leveraged to identify pit features and then classify them as pit or not. Other work attempts to classify the energy of pits resulting from heavy ions as encountered in space dosimetry [4]. However, the performance of these models has only been explicitly tested to a maximum dose of 5 mSv [2]. For such systems to be used for routine personal monitoring in the UK, the full dose range needs to be considered.

The size of electrochemically etched pits is much larger than chemically etched pits. This causes much more overlap between pits, especially at high dose, creating large variation in the appearance of pit features. Therefore, the model developed here to assess electrochemically etched dosemeters attempts to estimate pit counts without directly identifying and classifying the individual features. This model is small compared to those used in other work and is built and trained locally using Python with Tensorflow [5].

The dose linearity of the ML model is shown in the range 0.6 – 46 mSv from a recent HSE performance test. The model is compared to UKHSA's current analysis software as well as being assessed for consistency when applied to images which have undergone transformations. Additionally, a pragmatic approach to uncertainty assessment is considered.

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Poster number 24

Development of a Tracking System for Caregivers of Patients Treated with I-131

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Patients undergoing nuclear medicine therapy (NMT) with I-131 are discharged when the residual activity level is low enough to guarantee respect of dose constraints to the population and caregivers set based on criteria established by Council Directive 2013/59/Euratom. At discharge from hospital the specialist provides the patients with information on the precautions they need to take and recommendations on radiation-safety behavior, to avoid exceeding such dose constraints, but the dose they receive in the real world is difficult to estimate. Also, data on radiation exposure of caregivers resulting from caring for a radioactive patient is relatively limited [1, 2]. The project has two objectives: (i) provide caregivers with an informative visual tool to help them understand radiological risk and good practices to adopt (ii) provide hospital radiation protection experts with data on distance, time, and average dose that can help refine discharge criteria and hospital procedures.

In the SIREN project [3], we have developed a system to estimate the dose received by NMT operators without the use of physical dosimeters, using radiation maps and AI algorithms to track human exposure. This approach is extended to dose estimation for caregivers.

Compared to the hospital, implementation in the domestic setting presents certain difficulties: it must be as non-invasive as possible, adaptable to changing scenarios, and more respectful of privacy. The system will provide real-time tracking of the caregiver's body pose to estimate exposure time as a function of distance from the patient’s neck. This is based on a stereo camera combined with Computer Vision algorithms for human pose estimation (Fig. 1(a)).

The acquired data are integrated into the simulated radiation map using deterministic and/or Monte Carlo codes, which describe the radiation field due to the movement of the patient treated with I-131 [4]. This allows the dose absorbed at specific points on the caregiver's body to be calculated over time.

A prototype of a web-based application, which will allow caregivers to receive information on the distance from the patient and the exposure time during interaction, has been developed (Fig. 1(b)). The distances are shown using a distance vs. time graph and five different interaction zones, as different hospitals provide specific guidelines on interaction time in these specific zones. This will help caregivers to understand how long they actually spend in these zones, as the interaction time in each zone is also shown.

The tracking system developed in this study has the potential to become a valuable information tool for the caregivers of NMT patients. Preliminary results, carried out in a laboratory room set up to simulate a domestic setting, are promising. In the future, the complete system will enable hospitals to be provided with dosimetric data acquired in the home setting where physical dosimeters are not used.

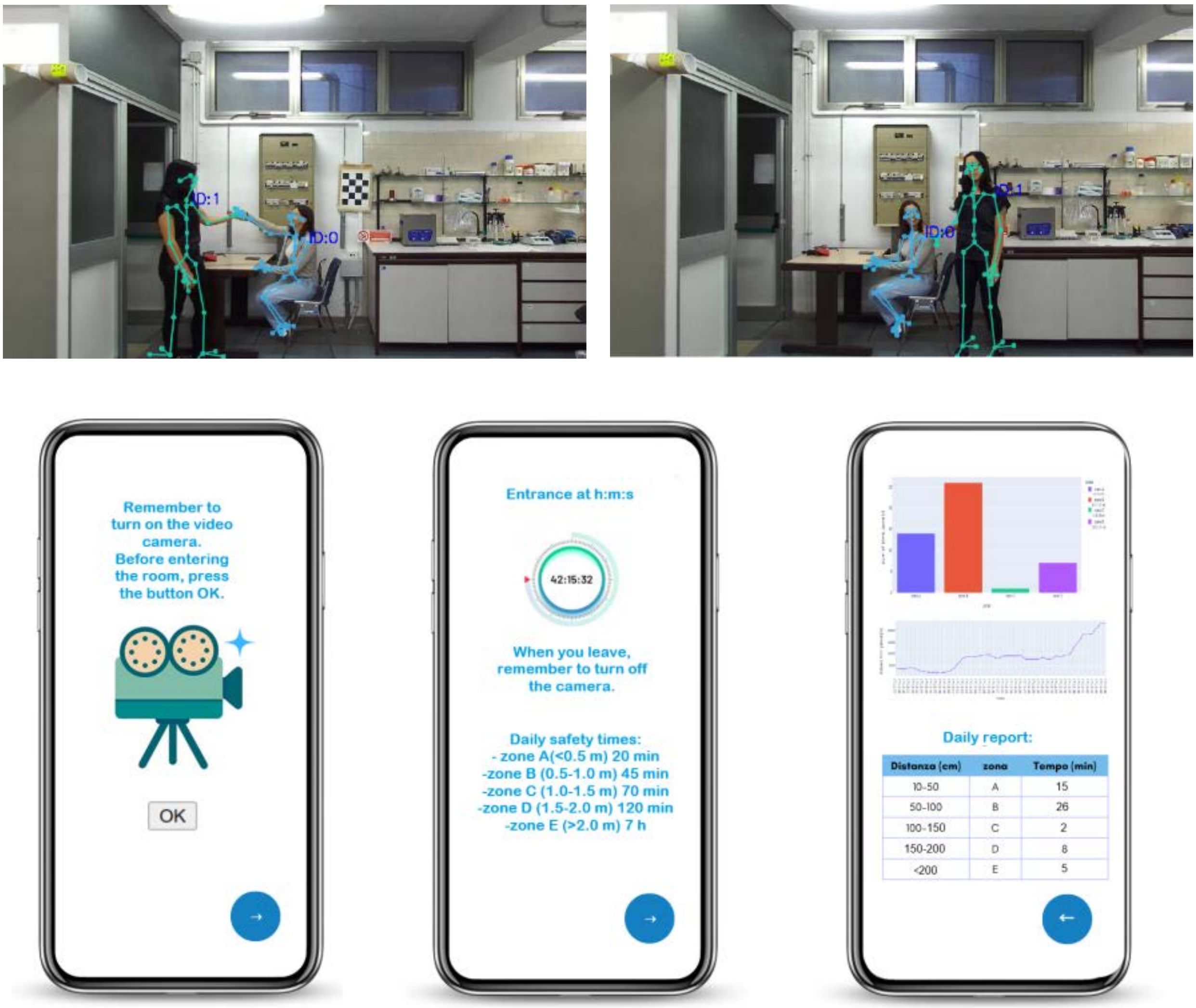

Figure 1: (a) Example of the body tracking of the patient (ID:0) and the caregiver (ID:1), (b) mock-up of the web-app for the caregiver.

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Poster number 25

Performance tests of the THYMON Portable Thyroid Monitor for Emergency Use employing different families of age-dependent thyroid and neck phantoms

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Introduction

In radiological emergencies, internal contamination assessment is central to exposure evaluation and medical triage. Among radionuclides of concern, ^{131}I is a major contributor to thyroid dose following accidental releases. Rapid and accurate quantification of thyroid ^{131}I activity is therefore essential both for individual dose assessment and for large-scale population screening.

Within the rescEU programme [1], a portable thyroid monitoring system (THYMON) has been developed and scientifically validated to ensure reliable operation in field conditions. The instrument combines rugged mechanics, low weight, simple deployment, high throughput (MDA < 100 Bq in 2 min measurement), and user-friendly operation, essential features for first responders in crisis scenarios. Dedicated algorithms for ^{131}I activity assessment were implemented, based on Monte Carlo-derived counts-to-activity conversion coefficients. Their calculation required the development of age-dependent numerical thyroid phantoms covering age groups from 1 year to Adult.

This work presents the development of the instrument with focus on the numerical phantom modelling and its validation against physical neck/thyroid phantoms.

Materials and Methods

THYMON employs a collimated 1.5" NaI(Tl) crystal coupled to a SiPM, compact electronics, and MCA. The mechanics of the probe (usable hand-held or mounted on a dedicated support) ensures reproducible positioning relative to the thyroid, minimizing alignment uncertainties (Figure 1). Counts-to-activity conversion coefficients were calculated via MCNP Monte Carlo simulations, using detailed models of both detector and neck/thyroid geometry. The thyroid numerical model was developed from ICRP Publication 89 organ reference volumes [2], while its mathematical definition follows the formulations by Ulanovsky et al. [3,4]. Modelling followed the recommendations of CAThyMARA [5] and EURADOS Report 2025-02 [6]. Five age groups were considered in accordance with ICRP 89: 1yo, 5yo, 10yo, 15yo, Adult. Experimental validation was performed at CIEMAT (Spain) and STUK (Finland) using two different families of age-dependent physical phantoms, loaded with either ^{133}Ba or ^{131}I.

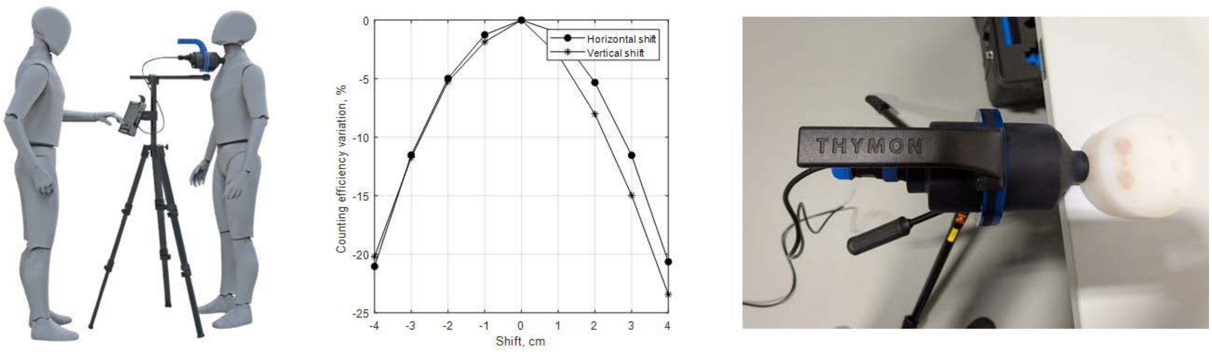

Figure 1: Rendering of the device used on the dedicated standalone support (left). Variation of the efficiency vs thyroid-to-detector misalignment (centre). Picture of the device measuring a thyroid phantom (right).

Results and Discussion

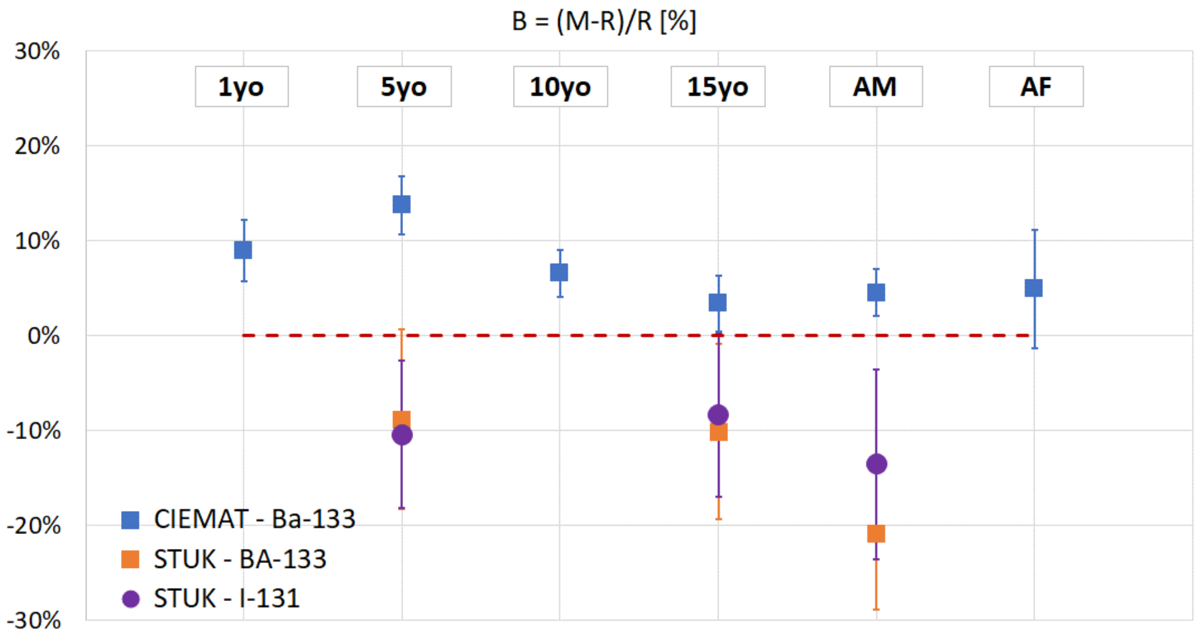

Figure 2: Results of the experimental campaign expressed in term of relative intrinsic error (IEC 61582), obtained across all age groups. The CIEMAT family of phantoms included 1yo, 5yo, 10yo, 15yo, Adult Male and Adult Female. The STUK family included child (corresponding to 5yo), teenager (corresponding to 15yo) and Adult Male.

Figure 2 presents the results in terms of the relative intrinsic error as defined in IEC 61582 [7]. Results for all age groups lie within the ± 30% acceptance criterion of the standard, confirming both the accuracy of the numerical thyroid model, and the suitability of the developed instrument as a portable device for in vivo measurement. No systematic over- or under-estimation trends are observed. The achieved performance is consistent with the uncertainties typically associated with thyroid modelling, as reported in EURADOS-related research [5,6,8].

<u>Conclusions</u>

This work demonstrates that THYMON provides accurate and reproducible quantification of ^{131}I thyroid activity across all relevant age groups. The results confirm the reliability of the Monte Carlo efficiency model, the strength of the calibration methodology, and the suitability of the instrument for deployment in emergency scenarios.

<u>Links to EURADOS activities</u>

The project aligns with EURADOS SRA Vision 3 – Challenge 1 [9], addressing efficient internal dose assessment after radiological emergencies. The instrument design followed EURADOS guidance documents [6] and modelling approaches developed in EURADOS-linked research [5,8]. The work involved direct participation of three EURADOS Voting Members: STUK, CIEMAT, and ELSE NUCLEAR. The work is of interest for WG7/TG "Internal Dosimetry for Emergency".

<u>References</u>

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