
IRRMA X
10th International Topical Meeting on Industrial Radiation
and Radioisotope Measurement Applications
July 9–13, 2017
Swissôtel | Chicago, Illinois | USA
conferences.illinois.edu/irrma2017

Monday, July 10, 2017

* denotes invited speaker

Plenary I: Vevey Room, 09:00-10:00

General Chair and Committee Welcome
C.J. Sullivan, General Chair, IRRMA-X

IRPS Welcome
C. Chantler, President, International Radiation Physics Society

Plenary II - Inaugural Pratt Lecture: Vevey Room, 10:30-12:00

Overview and Accomplishments of the Consortium for Nonproliferation Enabling Capabilities (CNEC)
Yousry Y. Azmy and John Mattingly
Department of Nuclear Engineering, NC State University

Presenter: Yousry Y. Azmy*
Department of Nuclear Engineering, NC State University (yyazmy@ncsu.edu)

The Consortium for Nonproliferation Enabling Capabilities (CNEC) is a five-year, $25M project funded by the National Nuclear Security Administration (NNSA). CNEC's mission is focused on developing new capabilities and new talent to meet the future challenges to nuclear nonproliferation. This is being accomplished by assembling a multidisciplinary team from the physical sciences, data science, and political science working together to instill in their students the requisite skills via integration of the education and research aspects of the academic endeavor. Approaching the end of its third budget period, CNEC has made great strides towards this goal along its four Thrust Areas (TA) covering traditional areas in nonproliferation research as well as novel research areas that open new frontiers in the pursuit of robust and reliable nuclear nonproliferation regimes. The goal of CNEC's Signatures and Observables (S&O) TA is to exploit signatures and observables that enable the phenomenological detection of proliferation activities. Faculty and students involved in S&O exploited spatial correlation in sensor responses to locate sources in fluctuating background, and developed methods to predict background from a time-series of measurements. CNEC's Simulation, Analysis, and Modeling (SAM) TA is multifaceted, pushing the envelope on several traditional nuclear computational science problems while venturing into some unchartered territories. SAM contributors have developed a platform for evaluating alternative methods to locate a point source using a sensor network in a cluttered, noisy urban environment, and are developing computationally efficient deterministic and stochastic radiation transport simulations in heterogeneous environments. The Data Fusion and Analytic Techniques (DFAT) TA is founded on recent advances in big data research applied to a multitude of commercial and security purposes and seeks to extend these to relevant problems in nuclear nonproliferation. Members of CNEC's DFAT team developed cooperative pursuit strategies for an evasive adversary, developed methods to data-mine the Bitcoin network to detect illicit transactions, and are exploiting social media to enhance detection of natural disasters. The latter two applications recognize that information and data regarding actual nonproliferation activities are classified hence the surrogate applications adopted are intended to test the underlying methods and algorithms. Replacement of Dangerous Radiological Sources (RDRS) that are prevalent in industrial and medical instruments with short-lived radioisotopes or machine sources is at the core of CNEC's fourth TA. The key to accomplishing this objective is to provide scientific evidence to the user community that viable alternatives are capable of delivering comparable performance. To this end the RDRS group is completing the construction of a prototype, accelerator-based oil-well logging tool to benchmark Monte Carlo simulations and is developing advanced inverse analyses that enable replacement of AmBe and ^{137}Cs with a DT generator. In addition to these tangible technical accomplishments, CNEC has a robust outreach program that includes an open, highly competitive fellowship program, summer internships at national laboratories, a new Graduate Certificate in *Nuclear Nonproliferation Science and Policy*, and a variety of distinguished lectures and special events designed to educate professionals and the public on the challenges of nuclear nonproliferation. CNEC organizes an annual experimental campaign at the Nevada National Security Site where CNEC faculty and students conduct experiments with Cat 1 SNM and use the measured data in their research projects.

Consortium for Verification Technology Research Activities

Sara Pozzi, University of Michigan, Department of Nuclear Engineering and Radiological Sciences

Presenter: Sara Pozzi*
University of Michigan, Department of Nuclear Engineering and Radiological Sciences

Since the discovery of fission, nuclear chain reactions, and nuclear weapons, preventing the spread of nuclear weapons has become a top priority for our nation and the world. Several international treaties have been put into place to curb the expansion of nuclear capabilities. Nevertheless, there are states that may be pursuing elements of an overt or covert nuclear weapons program. New science and technology developments are needed to verify the existing or proposed treaties in this area and to ensure that nuclear weapons are never used again.

In this presentation, I will discuss these challenges and the recent advances in science and technology that contribute to solving them. I will present our Consortium for Verification Technology, a consortium of 12 universities and 9 national laboratories working together on these issues. I will describe our studies on the fundamental emissions from nuclear fission, and the development of new detection systems for nuclear materials detection, localization, and characterization. Finally, I will touch upon the detection and characterization of nuclear explosions, with reference to the events in North Korea.

Thermo- and Radioluminescence Dosimetry Using Doped Silica Forms

D.A. Bradley
Department of Physics, University of Surrey, Guildford, GU2 7XH, UK
Institute for Healthcare Development, Sunway University, 46150 PJ, Malaysia

Presenter: D.A. Bradley*
Department of Physics, University of Surrey, Guildford, GU2 7XH, UK
Institute for Healthcare Development, Sunway University, 46150 PJ, Malaysia

We discuss development of novel dosimetric media, most particularly Ge-doped silica. The defects giving rise to electron trapping are the focus of interest, readout of the radiation sensitive signal being obtained through use of one or other of the related stimulated luminescence phenomenon, thermoluminescnce (TL) and radioluminescence (RL). During the course of our studies, various manipulations of the media have been made in an attempt to improve their radiation sensitivity, as an example starting from simple use of standard Ge-doped silica telecommunication fibres (SMF) through to tailor-made Ge-doped flat fibres (FFs) as well as Ge-doped photonic crystal fibres (PCF) co-doped with boron. The FFs and PCFs are formed of capillaries that at high temperatures and under vacuum are made to collapse inwards, the internal walls fusing and generating strain-related defects. Currently in use of such glassy media, we have made successful measurements of terrestrial natural radiation dose (eg 1 or 2 mGy per year), the very low doses of dental radiography (~ 10s μGy delivered in a few ms) and the tens of Gy doses of radiotherapy. In use of RL, we have compared the signal originating from Ge-doped silica optical fibres and commercial nanoDot Al_2O_3:C dosimeters, the RL signal being guided through PMMA optical fibre cables to obtain real-time measurements. For the Ge-doped fibre the manifest absence of an appreciable memory effect favours its preferential use in real-time evaluations.

Biological and Medical Applications of Radiation, Vevey Room, 13:30-15:10

Development of a Breast Phantom for Phase Contrast Imaging Study

J. C. Badelli, Federal University of Technology - Paraná, S. Ribeiro, Federal University of Paraná, M. Antoniassi, Federal University of Technology - Paraná, A. L. C. Conceição, Federal University of Technology - Paraná

Presenter: A. L. C. Conceição
Federal University of Technology - Paraná (UTFPR), alconceicao@utfpr.edu.br

Because of the large number of cases of breast cancer and its increasing incidence rate, new techniques of imaging are being studied. With the aim to provide better conditions for visualization and detection of this disease, in complement of the information obtained by mammography, the techniques of phase contrast imaging have been studied. Thus, the objective of the present study was to develop a breast phantom for application in phase contrast images. The breast phantom consists in a cylinder of polymethylmethacrylate (PMMA) with 22 mm in diameter and 50 mm in height, representing fibroglandular tissue, with some inserts filled with equivalent materials to adipose tissue (dimethylformamide) and malignant breast tissues (glycerol). These materials were chosen due to the similarity in the attenuation and scattering properties with healthy and pathological breast tissues. The in-line phase contrast microtomography imaging technique was used. An in-house experimental setup was built. This experimental arrangement consists basically of a microfocus x-ray source, a rotation/translation table where the sample was positioned and a flat panel detector with pixel size of 200μm. Microtomographic images were acquired by transmission and by phase contrast mode and then compared. The comparison between the analyzed images showed significant improvements in the contrast, mainly in the edges of the cylinders present in the phantom for phase contrast images. Therefore, the phantom developed in this work can be used to optimize the acquisition parameters for tomographic phase contrast images. Furthermore, the reference materials used were radiographically similar to normal and pathological human breast tissues. Thus, it contributes to corroborate the use of phase contrast imaging for future application in breast cancer screening.

Evaluation of glandular dose with breast deformation using Monte Carlo Simulation

Yan-Lin, Liu[1], Yun-Xuan, Tang[2,3], Hsin-Hon Lin[4,5], Keh-Shih Chuang[5], Cheng-Ting Shih[6]
[1]Institute of Nuclear Engineering and Science, National Tsing Hua University, Hsinchu, Taiwan
[2]Department of Biomedical Imaging and Radiological Sciences, National Yang-Ming

University, Taipei, Taiwan
[3]Department of Diagnostic Radiology, Shin Kong Wu Ho Su Memorial Hospital, Taipei, Taiwan
[4]Medical Physics Research Center, Institute for Radiological Research, Chang Gung University/Chang Gung Memorial Hospital, Taoyuan, Taiwan
[5]Biomedical Engineering and Environmental Sciences, National Tsing Hua University, Hsinchu, Taiwan
[6]3D Printing Medical Research Center, China Medical University Hospital, Taichung, Taiwan

Presenter: Yan-Lin Liu, National Tsing Hua University, s100013805@m100.nthu.edu.tw

Mammography is the front-line tool for diagnosing breast cancer, but the deformations of the breast during examinations are affected by glandularity, breast volume, and compression force. In addition, the glandular distribution will also change accordingly, causing difficulties in clinical evaluations of the glandular dose. This study uses magnetic resonance imaging (MRI) of the breast, and covers three categories of breast volumes (200-400 mL, 400-600 mL, and 600-800 mL) and three glandular/adipose composition ratios (20%, 30%, and 40%). These images are imported into a finite element analysis software (Abaqus) to simulate the clinical compressed breast thickness. The final geometries of the simulated compression-induced deformations are then imported into the FLUKA software to simulate the glandular dose with 27 kVp/39 mAs. The results indicate that for breast volumes of 200-400 mL, the glandular dose can vary as much as 26% depending on the glandular/adipose composition ratio, while this difference is 18% and 11% for breasts with volumes in the 400-600 mL and 600-800 mL ranges, respectively. When the glandular/adipose composition ratio is set to 30%, the maximum difference in the glandular dose for different breast volumes can reach 31%. This technique can be used to simulate the glandular distribution accurately and improve the accuracy of glandular dose evaluations. These findings will also serve as a useful reference for determining the conditions for clinical mammography.

Dosimetric analysis and experimental setup design for in vivo irradiation with a Plasma Focus device

Marco Sumini, Industrial Engineering Dept., University of Bologna, Italy
Lorenzo Isolan, Industrial Engineering Dept., University of Bologna, Italy
David Bradley, Department of Physics, University of Surrey, Guildford, GU2 7XH, United Kingdom
Sunway University, Institute for Health Care Development, Jalan Universiti, 46150 PJ, Malaysia
Shakardokht Jafari, Department of Physics, University of Surrey, Guildford, GU2 7XH, United Kingdom

Presenter: Marco Sumini
Industrial Engineering Dept.
University of Bologna, marco.sumini@unibo.it

Looking at possible clinical applications of the Plasma Focus (PF) technology as medium-low energy extremely fast radiation source, aiming at the treatment of skin cancer pathologies, in vivo experiments on mice are a due step. To properly design the experiments, a dosimetric analysis on a set of PMMA mice phantoms has been devised and carried out. The dose on the phantoms has been evaluated in experiments using Gafchromic films, standard TLD chips and TL glass beads and optical fibres to be able to reconstruct at best the radiation field produced by the PF at various depths in the phantoms. The whole setup has also been analysed with a Monte Carlo model using the MCNP6 code to produce a correlation between the results obtained from the various dosimetric technologies.

Developing a novelty method to estimate radon doses in a Waste Water Pre-Treatment Plant

Javier Enrique Martinez Ferri, Instituto de Seguridad Industrial, Radiofísica y Medioambiental (ISIRYM).
Belen Juste Vidal, Instituto de Seguridad Industrial, Radiofísica y Medioambiental (ISIRYM).
Rafel Miró Herrero, Instituto de Seguridad Industrial, Radiofísica y Medioambiental (ISIRYM).
Josefina Ortiz Moragón, Laboratorio de Radioactividad Ambiental. Universitat Politècnica de València.
Gumersindo Verdú Martin, Instituto de Seguridad Industrial, Radiofísica y Medioambiental (ISIRYM).

Presenter: Gumersindo Verdú Martin, Instituto de Seguridad Industrial, Radiofísica y Medioambiental (ISIRYM), gverdu@iqn.upv.es

This work is focused on a Waste Water Pre-Treatment plan (WWPT) with radon concentration above Spanish action level (600 Beccquerel per cubic meter). A Matlab© algorithm (UPVDose) has been developed based on the ICRP 66 (Human Respiratory Tract Model for Radiological Protection). This Matlab© software uses the compartimental model to describe each human respiratory compartments. This work is focused on the inhalation of the three main isotopes of the radon progeny; Po-218, Pb-214 and Bi-214. The majority of the radon inhalation dose is due to these three radioisotopes. The equilibrium factor between radon and short-lived progenies is of special importance for dose assessment from radon inhalation and it should be determined in each radon monitoring. In order to measure the equilibrium factor, an air sample has been used. This air sample has been filtered and a gamma and an alpha gamma spectrometry measurements have been performed, which have measured the concentración activity of radon in the WWPT. A Matlab program has been developed to solve the Bateman equations, with this program, the concentrations of the radon descendants as well as the equilibrum factor are obtained. The preliminary results show that the Matlab program based on the ICRP 66 are in good agreement with the results obtained with LUDEP Software for inhalation doses of Po-218 and Pb-214. In addition, the Po-218,Pb-214, Bi-214 and the equilibrum factor results are presented. With these results, the lung equivalent dose per month (BB, bb, AI and LNTH) can be obtained (we have supposed a worker, light exercise (ventilation rate 1.5 m3 h-1), working 40 hours per month): for Po-218 3.1 μSv, for Pb-214 0.172 μSv and for Bi-214 0.0335 μSv.

DEVELOPMENT OF A PHYSICAL BRAIN PHANTOM OF ÁGAR-ÁGAR FOR INTERNAL DOSIMETRY 18F

K. D. Vitala; B. M. Mendesb,c; M. A. S. Lacerdab; T. Camposc; T. C. F. Fonsecaa ; T. A. da Silvab
a Programa de Pós-Graduação em Ciências e Tecnologia das Radiações, Materiais e Minerais – CDTN/CNEN
b Centro de Desenvolvimento da Tecnologia Nuclear – CDTN/CNEN – Belo Horizonte, MG, Brasil
c Departamento de Engenharia Nuclear da Universidade Federal de Minas Gerais – DEN/UFMG, Belo Horizonte/MG, Brasil

Presenter: Telma C. F. Fonseca, Centro de Desenvolvimento da Tecnologia Nuclear – CDTN/CNEN, tcff01@gmail.com

The research group of the Laboratory of Internal Dosimetry (LDI) of the Nuclear Technology Development Center (CDTN) in Minas Gerais, Brazil developed a monitoring methodology for Occupationally Exposed Individuals (IOEs) working on the production of 18F-FDG. The monitoring system uses a Physical Head Simulator (SiCab) to obtain the calibration factor (CF) that is used to determine the 18F activity incorporated into the brain. The SiCab consists of a latex bag containing water solution and 22Na, which is a positron emitter, inserted into a plastic resin skull. Recently, the computational model of the skull monitoring system was developed using the MCNPx computational code. The voxelized computational model of the SiCab was generated from Computed Tomography (CT) images. Simulations were performed for several voxel phantoms available in the literature included the SiCab voxel phantom to obtain the CF and compare to the experimental CF value The results show a variation of up to 38% in the CF for the different skull geometries used [3]. Due to an inhomogeneity distribution of the radioactive material into the skullcap and inside of the latex bag of the voxelized SiCab model a difference in the CF value was found when compared to the reference phantom i.e., the male adult Voxel phantom of the ICRP 110. This work aims to present a physical solid brain simulator developed for internal dosimetry of 18F-FDG. This is based on materials with characteristics suitable for the simulation of human tissues and especially taking into account the homogeneous distribution of the radioactive material within the skullcap. Computational studies were also performed to evaluate the effectiveness of the proposed compositions.

Radiation Sources and Measurements for Applications I, Montreaux Room, 13:30-15:10

Experimental efforts to benchmark oil-well logging simulation codes

William L. Dunn, Kansas State University, J. Kenneth Shultis, Kansas State University, Walter J McNeil, Kansas State University, Maria Pinilla, Kansas State University, Long Vo, Kansas State University, Aaron Hellinger, Kansas State University, Alan Reinke, Kansas State University, Ryan Ullrich, Kansas State University

Presenter: William L. Dunn, Kansas State University, dunn@ksu.edu

A daunting challenge that faces rational societies is how to protect against construction and use of unconventional weapons such as “dirty bombs,” which use chemical explosives in order to disperse radioactive material. The Consortium for Nonproliferation Enabling Capabilities (CNEC) is directly addressing this challenge by considering methods for replacement of dangerous radiological sources (RDRS). One of the first issues being considered under RDRS is the replacement of Curie-sized radioisotope sources by machine sources in oil-well logging tools. The two most common well logging tools use Cs-137 for density logging and Am-Be for porosity measurement and, to a lesser extent, composition analysis. These tools are distributed around the world in large numbers and generally are not well protected from theft. CNEC is investigating the use of deuterium-tritium (D-T) generators, which produce 14.1-MeV neutrons in high abundance, to replace the radioisotope sources. A variant of the Monte Carlo Library Least Squares (MCLLS) procedure, already established for some applications, offers considerable promise as a technique to measure density, porosity, and composition using only D-T generators as radiation sources. In order to benchmark Monte Carlo codes used to address this problem, Kansas State University (KSU) has constructed a well-logging prototype tool that contains a D-T generator, two neutron detectors, and two gamma-ray detectors and a test enclosure in which to conduct benchmarking tests. The enclosure is filled with known materials—such as water, sand, and limestone—and the prototype tool is inserted and used to collect data for simulation code benchmarking. The tool, the test enclosure, and early tests will be described.

Investigation of Lithological Logging Tool Employing a D-T generator

L.K. Vo, A.C. Hellinger, M.I. Pinilla, A.J. Reinke, R. Ullrich, W.L. Dunn, W.J. McNeil, all from Kansas State University

Presenter: Long Vo, Kansas State University, longv@ksu.edu

In an effort to replace dangerous radioisotopes sources used in industry and medicine, Kansas State University has been collaborating with several other universities and national laboratories to investigate methods to substitute machine sources for the prominent radioisotopes, when feasible, and to enhance security where substitution is not feasible. The oil and gas industry employ a large amount of radioisotopes sources used in well-logging tools so the first task is directed at replacement of Cesium137 and Americium-Beryllium sources. Toward this end, Kansas State University has constructed an oil well logging prototype tool that is similar in size to those currently employed in the industry. The prototype utilizes two standard 3x3 Sodium Iodide doped with Thallium and two Helium-3 tubes. Georgia Institute of Technology is working on novel detectors which may be integrated into the prototype in the future. The prototype is capable of housing the detectors in various configurations and also has the ability to mount shielding when needed. A test facility, housing a 6ftx8ftx8ft sample holder, has been constructed to hold samples such as water, sand, limestone, and crude oil. A Thermofisher A3062 tube houses a B322 Deuterium-Tritium (D-T) neutron source. The D-T neutron source emit 14 MeV neutrons, which are used for porosity, density, and elemental composition measurement. Monte Carlo Library Least-Square (MCLLS) approach developed at North Carolina State University (NCSU) will be employed. Theoretically, this approach may give better results than conventional logging tools. Measurements collected at Kansas State University are analyzed and used to benchmark the MCLLS code from NCSU.

A Passive Strain Transducer Based on the Alpha-N Reaction

Diego Laramore, Kansas State University, Walter McNeil, Kansas State University, Amir Bahadori, Kansas State University

Presenter: Diego Laramore, Kansas State University, dlaramo@ksu.edu

Strain measurement may be achievable with a device which is entirely passive by utilizing energetic alpha particle transport through a fluid, incident on a neutron producing target such as Beryllium. With careful design in micro-fabrication, elongation on a microscopic scale can be made to influence the production rate of neutrons. Fast neutrons emitted from the device are highly penetrating and lend well to reading-out the strain sensor remotely at significant stand-off distances by means of a neutron counting system. This sensing concept may have unique advantages in applications such as strain sensing within non-penetrable mechanical systems, or deeply-embedded sensing within large dense structural members. The mechanism of strain-to-neutron

transduction is described here using Americium-241 and Beryllium as an example. The conceptual example is supported with particle transport simulations in a simple geometry.

Experimental Radon Exhalation Measurements: Comparison of different techniques.

A. Noverques[1], G. Verdu[1], B. Juste[1], M. Sancho[1]
[1] Instituto Universitario de Seguridad Industrial, Radiofísica y Medioambiental (Universitat Politècnica de València)

Presenter: Gumersindo Verdú, gverdu@iqn.upv.es

Radon is a radioactive gas produced by the radioactive disintegration of radium and uranium. Its presence in soils and construction materials, in conjunction with the incredibly concern which exists regarding pollution and safety of the population in present time, makes it necessary to investigate the methodologies to measure radon exhalation. Moreover, according to the Directive 2013/59 / EURATOM which should be incorporated into Spanish law in 2018, this kind of measures will increase in the next future.
To measure radon exhalation rate, four specific methods have been selected among all the different existing technologies: soil gas probe connected to a continuous radon detector, surface emission chamber connected to the radon detection monitor, chamber H connected to an electret and active charcoal canister measured with a sodium iodide scintillation detector.
Radon exhalation field measurements have been performed at a location where the exhalation values of radon are in the range of 850 to 27.000 Bq/m3. This work shows the results of measurements carried out with these different technologies and its comparison. The study of radon exhalation techniques is an important work to comply with the next future legislative requirements in terms of radon exhalation.

60Co irradiation effects in Gd2O3 and Er2O3 nanoparticles

Correa, E.L., Nuclear and Energy Research Institute, University of Sao Paulo; Bosch-Santos, B., Nuclear and Energy Research Institute; Pereira, L.F.D., Nuclear and Energy Research Institute; Carbonari, A.W., Nuclear and Energy Research Institute; Potiens, M.P.A., Nuclear and Energy Research Institute

Presenter: Correa, E.L., Nuclear and Energy Research Institute, University of Sao Paulo, eduardo.correa@usp.br

Enhanced radiosensitization in tissues using high-Z materials has been observed since 80’s, and the application of nanoparticles (NPs) for this purpose has been widely

studied in the past years. NPs use in radiotherapy procedures implies to submit them to high dose radiation beams which might cause damage to these particles resulting in the release of toxic material to the biological environment. In order to verify radiation effect in Gd2O3 and Er2O3 NPs doses from 3 Gy to 20 Gy produced by a 60Co source were tested. The study with X-ray diffraction (XRD) showed, for Gd2O3-NP samples, a change in peaks positions featuring a decrease in the lattice parameter as function of dose increase up to 5 Gy. From this point lattice parameter presented no significant change. For Er2O3-NP the lattice parameters do not present a behavior in function of dose. A peak change can be noticed for samples irradiated with 5 Gy and 20 Gy, and samples irradiated with 3 Gy, 7 Gy and no irradiated presented no significant peak displacement. Perturbed angular correlation (PAC) gamma-gamma spectroscopy was performed using 111In(111Cd) as probe nuclei. Despite non-symmetric site C parameters presented no substantial change results showed a slight variation of eta parameter for the symmetric site D for both samples, which may indicate a distortion at that site caused by the radiation. This study showed that radiation doses used in radiotherapy procedures may cause damage to nanoparticles structures. However, this damage is not great enough to break the nanoparticle and liberate toxic Gd3+ or Er3+ into patient organism.

Poster Session I, St. Gallen Room, 15:40-17:30

Estimation of the Radiation induced cataract and cancer effects in CT brain Procedures

M. Alkhorayef [1]: [1]Department of Radiological Sciences, College of Applied Medical Sciences, King Saud University, PO Box 10219 Riyadh 11433, Saudi Arabia
A.Sulieman [2]: [2]Prince Sattam Bin Abdulaziz University , College of Applied Medical Sciences, Radiology and Medical Imaging Department ,Alkharj, Saudi Arabia
F. Alonazi[2]: [2]Prince Sattam Bin Abdulaziz University , College of Applied Medical Sciences, Radiology and Medical Imaging Department ,Alkharj, Saudi Arabia
M. Al-Nuaimi[4]: [4]Medical Physics unit, Kuwait Cancer Control Center (KCCC), Kuwait
M. Alduaij[4]: [4]Medical Physics unit, Kuwait Cancer Control Center (KCCC), Kuwait
D. Bradley[5,6]: [5]Department of Physics, University of Surrey, Guildford, Surrey GU2 7XH, UK.,
[6]Sunway University, Institute for Health Care Development, Jalan Universiti, 46150 PJ, Malaysia

Presenter: M. Alkhorayef:Department of Radiological Sciences, College of Applied Medical Sciences, King Saud University, PO Box 10219 Riyadh 11433, Saudi Arabia, malkhorayef@ksu.edu.sa

The use of a CT scan in medical diagnosis has become of paramount importance proportion, because it has privileges diagnostic character, such as high speed and accuracy in imaging tissues, high quality of the picture and take the picture from different angles, but this device works by X-rays, which may cause some cancers or opacity of the lens of the eye when the exposure quantities is larger than threshold dose recommended by the International Commission on Radiological Protection. The purpose of this research was to measure the lens dose during brain CT scans with multidetector row CT and to assess methods for estimating the lens dose and related risks to thyroid and female breast. .A total of 85 patients were examined using four multi detector CT machines. The radiation dose parameters were presented in terms of CTDIw and CTDIvol and DLP. The overall mean CTDIW I this study 45.7±15.6 mGy for brain and 6.84 The eye lens dose is same values of 1.47 mSv per procedure. In the current study, the ratios of lens dose to CTDIvol were 90.6%–110%, and the lens doses tended to be smaller than the CTDIvols during whole-brain CT including the orbit.In this study radiation dose is considered low compared with previous studies, with few cases received high doses. A patient radiation risk for a particular exam proportional to the dose delivered during the exam. This dose will depend on the size of patient, the type of scanner and the imaging protocol used.

Characterization of breast tissues combining X-ray fluorescence and scattering spectroscopy: A Monte Carlo computational study

K. F. R. Maciel, Universidade Tecnológica Federal do Paraná
F. A. Manfre, Universidade Tecnológica Federal do Paraná
A. C. F. Fagundes, Universidade Tecnológica Federal do Paraná
A. L. C. Conceição, Universidade Tecnológica Federal do Paraná
M. Antoniassi, Universidade Tecnológica Federal do Paraná

Presenter: A. C. F. Fagundes, Universidade Tecnológica Federal do Paraná

The study of spectroscopic techniques that allow obtaining information about the breast tissues can be useful for the verification of the relationship between tissue composition and the carcinogenic process. In addition, the study of these techniques can serve as a basis for the development of imaging techniques to complement the diagnosis of breast cancer. Therefore, the objective of this work is to study computationally by Monte Carlo simulation the determination of information on the chemical composition of breast tissues through the fluorescence and x-ray scattering spectra and to verify its application in the production of images of breast tissues. Fluorescence spectra obtained by the simulations were used to mapping the spatial distributions of trace elements (Ca, Fe Cu, Zn) in the sample (a cylindrical phantom composed of regions of different types of breast tissues). In addition, the scattering spectra were used to produce images based on Rayleigh to Compton scattering ratio (R/C) and on the Full width at half maximum (FWHM) of the Compton scattering spectrum. The results show that the fluorescence and scattering techniques can produce images that allow

differentiating the various breast regions inside the sample. The R/C and FWHM scattering images showed that the higher the incident energy of the beam the higher the contrast. The R/C and FWHM images showed a strong correlation with the composition of the tissues presenting higher intensities in regions of tissues with higher effective atomic number.

Evaluation of Radiation Dose in Patients Admitted at Pediatric Intensive Care Unit

A.P. Bunick [1], H.R. Schelin [1], V.Deniyak [1,2], D. Filipov [3], A. Legnani [4], S.A. Paschuk [3], P. Vosiak [3], N. Cerniak [3], J.A. Ledesma [4]
[1] Pelé Pequeno Príncipe Research Institute, Curitiba, Brazil
[2] National Science Center 'Kharkov Institute of Physics and Technology', Ukraine
[3] Federal University of Technology – Paraná, Curitiba, Brazil
[4] Pequeno Príncipe Children's Hospital, Curitiba, Brazil

Presenter: Hugo R. Schelin
Pele Pequeno Príncipe Research Institute, schelin2@gmail.com

Determining radiation exposure and resulting risks is more complicated for children than for adults due to children's rapid development and associated physiological changes in children. Several factors contribute to this such as: size, mass, the developmental dynamics of the individual including organs, tissues, etc. The aim of this study is to evaluate the radiation dose at the entrance of the skin received by patients submitted to radiographic examinations in a Pediatric Intensive Care Unit. The patient's effective dose accumulated during their hospitalization at the unit is also monitored. 455 radiographic examinations performed in patients between the ages of 0 and 15 years were evaluated. The patients studied had been admitted to intensive care at an exclusively pediatric hospital in Curitiba – Brazil. The dose at the entrance of the skin in all the exams was verified with TLDs (Thermoluminescent Dosimeters). The effective dose was estimated through calculations with the online software Caldose_X. Technical information was collected such as: kVp, mAs, focus-patient distance and focus-detector distance of each exam. Patient information was also collected such as: gender, age, mass and gestational age of each patient examined. Considering the results were obtained, the greatest concern is the exposure of neonates and children less than one year old since their organs and tissues are more sensitive towards ionizing radiation; also, this is the largest demographic of patients in this study. The radiation dose at the entrance of the skin resulting from the present study was compared to results obtained by similar studies and major international dose reference levels. The estimated cumulative effective dose was compared to results obtained by similar studies and by studies that recommend regional DRLs or at specific places.

Study of the concentration of Cu, Fe and Zn in benign and malignant canine mammary tumour by ED-XRF

T. C. Cozer, Universidade Tecnológica Federal do Parana´, A. L. C. Conceição, Universidade Tecnológica Federal do Parana´, A. C. F. Fagundes, Universidade Tecnológica Federal do Parana´, A. S S. Rocha, Universidade Tecnológica Federal do Parana´, M. Antoniassi, Universidade Tecnológica Federal do Parana´

Presenter: André L. C. Conceição, alcconceicao@gmail.com

Canine mammary tumors represent around 50% of all tumor types affecting dogs. From this, half of them are malignant. It is known that tumor development depends on chemical and biochemical changes in the tissues. Then, researchers are focused in measuring the concentration of trace elements present in these tissues. In this sense, the quantification of trace elements can be performed by ED-XRF technique. Therefore, this work performed quantitative measurements of trace elements present in healthy and pathological canine tumors samples. A total of 56 canine breast samples were used in this study. The ED-XRF experimental setup consists, basically, an x-ray tube with silver anode, an energy dispersive detector and a computer to control and data. The sample was irradiated during 1500s. In order to determine the concentration of trace elements, Fe, Cu and Zn in the canine breast samples, it was previously prepared standards samples. The standard samples were composed by salt diluted in deionized water which concentration cover the range reported. Moreover, the XRMC Monte Carlo code was used to validate the experimental approach. Although the concentration of Fe, Cu and Zn were higher in malignant tumours, only the zinc concentration was statistically different ($p<0{,}05$) those in benign tumours. This fact may be related to the presence of this element in the matrix metalloproteinases (MMP9), which is associated to the invasive behavior of the tumour. Moreover, by analyzing the central region of the malignant tumour and its periphery, it was not verified significant difference in those trace elements concentration. The results of in this work allow us to correlated changes in trace elements concentration with the pathological process of canine mammary tumor. Furthermore, studies in this area are of great potential since the trace elements information can be used for the development of new drugs to control cancer dissemination.

STRUCTURAL CHARACTERIZATION OF CANINE MAMMARY TISSUE BY X-RAY DIFFRACTION

A.C.F. Fagundes, Universidade Tecnológica Federal do Paraná, L.M. Lopes, Universidade Tecnológica Federal do Paraná, K.A. Sato, Universidade Tecnológica Federal do Paraná, R.S. Sousa, Universidade Federal do Paraná, I. Mazzaro, Universidade Federal do Paraná, M. Antoniassi, Universidade Tecnológica Federal do Paraná, A.L.C. Conceição, Universidade Tecnológica Federal do Paraná

Presenter: Alana Caroline França Fagundes, Universidade Tecnológica Federal do

Paraná, alanacarolinef@gmail.com

The life expectance in canines are increasing due to the improvement in healthy care. However, some age diseases are arising, among them the mammary cancer, which represents about 50% of the cancers diagnosed in females. The mammary glands are formed by different types of tissues. Nowadays, researches are focusing efforts to identify structural changes into canine mammary tissues due to cancer progression. In this sense, X-ray diffraction is a powerful tool for this purpose. Therefore, this study aims to characterize structurally the normal and cancerous canine mammary tissue by X-ray diffraction.

A total of 83 canine mammary samples histopathologically classified as normal, benign and malignant, were used in this study. The samples were cut in disc shape with 21.0mm diameter and 4.0mm depth. A commercial diffractometer Shimadzu XRD-7000 with copper anode (Z=29; Kα=8,04 keV) was used. Scattering profiles were acquired between 6° and 76° with step of 0,33° and 20s of exposure time resulting in a momentum transfer interval of 4.27nm-1≤q(=4.sin(/2)/)≤50.18nm-1. The scattering profiles were corrected by spurious contribution, self-attenuation and polarization.

The corrected scattering profiles for each type of tissue were determined. In general, two broad peaks were identified. The first one at q=13.9nm-1 representing an electronic correlation distance of 4.5Å which is associated to fatty acids. The second peak arise at q=20.1nm-1 corresponding to a correlation distance of 3.0Å being related to water content of the tissues. The ratio both peaks intensities allows to distinguish between normal, benign and malignant tissue. Additionally, comparing to breast tissue of human beings, the scattering profiles are very similar.

From the results, it's possible to characterize the normal and neoplastic canine mammary tissues by X-ray diffraction. Moreover, due to similarity between canine and human mammary tissues, these animals can be used as model for future investigations.

Evaluation of limits and advantages of gadolinium in NCT

G. Gambarini[1,2], D. Bettega[1,2], A. Gebbia[1], M. Felisi[1], E. Artuso[1,2], G. Colombo[1], G. Camoni[1], E. Cesaroni[1], E. Durisi[3], V. Monti[3], V. Klupak[4], L. Viererbl[4], M. Vins[4], G. Kulabdullaev[5], A. Kim[5], A. Nebesniy[5], R. Kadirbekov[6], N. Kadirbekov[6], J. Alimov[6], R. Egamberdiev[6], I. Mavlyanov[7]
[1]Department of Physics, Università degli Studi di Milano, Italy
[2] INFN - National Institute of Nuclear Physics, Section of Milan, Milano, Italy
[3] Department of Physics, University of Torino and INFN, Torino, Italy
[4] Department of Neutron Physics, Research Centre Řež, Czech Republic
[5]Institute of Nuclear Physics, Tashkent, Uzbekistan
[6]Republican Scientific Center of Neurosurgery, Tashkent, Uzbekistan
[7]Tashkent Medical Academy, Tashkent, Uzbekistan

Presenter: Grazia Gambarini
Department of Physics, Università degli Studi di Milano and INFN, Milano, Italy,

grazia.gambarini@mi.infn.it

Neutron Capture Therapy (NCT) is a radiotherapeutic technique still in experimental phase, that exploits the high thermal-neutron cross section of some isotopes and the ability to selectively accumulate in tumor cells such isotopes chemically bound to suitable tumor-seeking compound. The first choice was the isotope 10B (thermal neutron cross section σth = 3837 b) for the short range of the high-LET particles generated in reactions with thermal neutrons. 157Gd (σth = 255000 b) has been considered too, owing to the Auger-electron-induced DNA damages. In the reaction of 157Gd with thermal neutrons, prompt gamma rays of various energies are emitted. The disadvantage of GdNCT over BNCT is just the long-range gammas emitted by 157Gd reactions that deliver dose also far from the reaction position, with damage to healthy tissue. In this work, Monte Carlo (MC) calculations concerning radiation transport and gamma dose distribution in a cubic water phantom with 14 cm side were carried out. MCNPX has been used to run simulations about neutron fluence and gamma dose in various configurations. The neutron-source input file contains the information of the epithermal beam designed for BNCT at the LVR-15 reactor (Řež), where many irradiations were made (with fluence rate about 8•108 cm-2 s-1) in previous experiments. Calculations were performed with 10B or/and 157Gd. Considering that suggested concentrations in tumor tissue are 35 ppm for 10B and 100 ppm for 157Gd and that the conventional carrier selectivity is around 3.5, for calculations suitable concentrations of the two isotopes in the water phantom were taken. The following simulations were performed: (i) water phantom (in order to evaluate fluence and gamma dose coming from epithermal neutron thermalization in water, as reference data); (ii) water phantom containing 10 ppm of 10B; (iii) water phantom containing 28.6 ppm of 157Gd; (iv) water phantom containing 5 ppm of 10B and 14.3 ppm of 157Gd. Results show that 10 ppm of 10B give low depression both on fluence and gamma dose. On the opposite, 28.6 ppm of 157Gd reduce significantly the thermal neutron fluence and increase substantially the gamma dose. The simulation with both 10B and 157Gd (in the halved amounts) shows lower reduction of thermal neutron fluence and lower gamma dose; moreover, it highlights a more advantageous condition because it joins an acceptable gamma dose in healthy tissue to the ability to perform Boron-Gadolinium imaging. No drastic changes have been found by introducing volumes with limited extension containing 100 ppm of 157Gd or/and 35 ppm of 10B.
The problem of the high absorbed dose in healthy tissue could be overcome by using, instead of conventional BNCT carriers, a Gd pharmaceutical with very high tumor-to-tissue uptake ratio. For additional investigation of above mentioned effects we developed and carried out experimental study with use of Magnevist® (Gadopentetate Dimeglumine), a paramagnetic contrast agent for magnetic resonance imaging. For this study we developed new model for analysis in vitro, using survival slices of glial tumours of human brain [1]. We carried out pilot study in which we use for irradiation the epithermal neutrons beam having fluence rate of 107 cm-2 s-1. Samples were analyzed before and after irradiation, in order to evaluate the induced tissue necrosis. Preliminary results revealed that despite of low flux density at absorbed doses 20-40 Gy about 10-20% of tumor cells died 24 hours after irradiation. Dosimetry calculations are

complex owing to the multiplicity of secondary radiation emitted during Gd reactions: electrons and photons with many possible energies and then many different ranges in tissue [2]. At present time study is still in progress.

[1] Kim A.A, Kulabdullaev G.F, Nebesniy A.F., Juraeva G.T et al Method of using of survival slices of human brain tumors for estimation in vitro of influence of radiation of neutron-capture reaction of gadolinium irradiated by epithermal neutrons. Patent application from 23.08.2016 № IAP 20160330
[2] Enger S.A., Giusti V., Fortin M., Lundqvist H., Munck af Rosenschöld P. Dosimetry for gadolinium neutron capture therapy (GdNCT). Radiat. Meas. 59 (2013) 233-240

Feasibility of employing thick microbeams from superficial and orthovoltage kVp x-ray tubes for radiotherapy of superficial cancers.

Pedrum Kamali-Zonouzi,Medical Physics, The Royal Surrey County Hospital, Guildford, Surrey, GU2 7XX, United Kingdom
Arron Shutt, Department of Physics, University of Surrey, Guildford, Surrey, GU2 7XH, United Kingdom & Radiation Hazards and Emergencies Department, Public Health England, Didcot, OX11 0RQ, United Kingdom
Andrew Nisbet, Medical Physics, The Royal Surrey County Hospital, Guildford, Surrey, GU2 7XX, United Kingdom & Department of Physics, University of Surrey, Guildford, Surrey, GU2 7XH, United Kingdom
David Bradley, Department of Physics, University of Surrey, Guildford, Surrey, GU2 7XH, United Kingdom & Sunway University, Institute for Health Care Development, Jalan Universiti, 46150 PJ, Malaysia

Presenter: Pedrum Kamali-Zonouzi, Medical Physics, The Royal Surrey County Hospital, Guildford, Surrey, GU2 7XX, United Kingdom, p.kamali@nhs.net

Preclinical investigations of thick microbeams show these to be feasible for use in radiotherapeutic dose delivery. To create the beams we access a radiotherapy x-ray tube that is familiarly used within a conventional clinical environment, coupling this with beam-defining grids. Beam characterisation, both single and in the form of arrays, has been by use of both MCNP simulation and direct Gafchromic EBT film dosimetry. As a first step in defining optimal exit-beam profiles over a range of beam energies, simulation has been made of the x-ray tube and numbers of beam-defining parallel geometry grids, the latter being made to vary in thickness, slit separation and material composition. For a grid positioned after the treatment applicator, and of similar design to those used in the first part of the study, MCNP simulation and Gafchromic EBT film were then applied in examining the resultant radiation profiles. MCNP simulations and direct dosimetry both show useful thick microbeams to be produced from the x-ray tube, with peak-to-valley dose ratios (PVDRs) in the approximate range 8.8 to 13.9. Although the potential to create thick microbeams using radiotherapy x-ray tubes and a grid has been demonstrated, Microbeam Radiation Therapy (MRT) would still need to be

approved outside of the preclinical setting, a viable treatment technique of clinical interest needing to benefit for instance from substantially improved x-ray tube dose rates.

A study of Irradiation Side Sampling Flat panel Detector with Crystal Silicon based X-ray CMOS Image Sensor

Myung Soo Kim, Korea Advanced Institute of Science and Technology, Yewon Kim, Korea Advanced Institute of Science and Technology, Kyung Teak Lim, Korea Advanced Institute of Science and Technology, Gyuseong Cho, Korea Advanced Institute of Science and Technology,

Presenter: Myung Soo Kim, Korea Advanced Institute of Science and Technology, myungsoo@kaist.ac.kr

In recent devices for radiography, In-direct X-ray imaging method, which use the scintillator for photon converter, is most widely spread method. The conventional FPD system had structure so that scintillators and photodiodes were combined in front-and-back to the incident X-ray, respectively. An FDR D-EVO, which is structured by an irradiation side sampling (ISS) FPD system, was presented by FUJIFILM. The ISS FPD has a scintillator in the opposite direction of an incident X-ray and has advantages in better light yield and better modulation transfer function (MTF) comparing with conventional FPD system. In mammography and high resolution non-destructive test, the device need smaller size of pixel pitch. The blurring effect during photon transfer in scintillators, such as cesium iodide and gadolinium oxysulfate, is major limited factor for making small pixel pitch under 80 um considering the energy of X-ray. Moreover, it is difficult to make a small photodiode pitch under 100 um on a glass with a thin film transistor. By using both ISS structure and crystal silicon based CMOS image sensor, we can make better performance FPD in high resolution and fast frame rate, which are related with MTF and light yield of scintillator. The crystal silicon based CMOS image sensor can make the pixel pitch smaller until 10 um and the ISS structure can support this small size pixel pitch sensor. We have simulated and fabricated the system of adaption both ISS structure and CMOS image sensor in order to verify the crystal silicon based CMOS image sensor with ISS structure. The sensor has 55 um pixel pitch and 2304x2304 pixel array but has a fully opened area is 1600 x 1600. It have been fabricated on 1P3M CMOS logic process. We will measure MTF, NNPS, and DQE of this test sensor for comparing conventional and ISS structure.

HIGH-SENSITIVITY COLOR INDICATOR OF THE ABSORBED DOSE OF EPITHERMAL NEUTRONS RADIATION.

Kulabdullaev G. A, Kim A.A., Nebesniy A.F., Djuraeva G. T, Saytjanov Sh.N.
Institute of Nuclear Physics, Academy of Sciences of Uzbekistan

Presenter: Kulabdullaev G. A,Institute of Nuclear Physics, Academy of Sciences of Uzbekistan, gkulabdullaev@inp.uz

In our study the high-sensitivity colour indicator of the absorbed dose of radiation of epithermal neutrons with energy 0 to 10 keV for dosimetry of low energy neutrons was developed. We had been developed the indicator on the basis of dye solution of arsenazo III and gadopentetic acid, allowing precisely define of absorbed dose in range 2 to 10E3 Gy. The properties of arsenazo III as metallic indicator, which change colour after binding of free ions of metals was used. Colour of the indicator solution before irradiation and after it is stable enough in time at storage in the dark or at artificial illumination or at scattered sunlight. The developed indicator, consisting of solution of arsenazo III and gadopentetic acid, allows to estimate the absorbed dose of epithermal neutron irradiation with good accuracy and reduces the error of measurement related to changing colour of dye under the influence of other factors (light, temperature etc.) Dosimeter is tissue-equivalent and possesses high sensitivity to neutron radiation due to content of gadolinium in solution, which has great neutron capture cross-section. The developed dosimeter maintains spectrophotometric characteristics after irradiaion within few weeks that allows to use it for measurement of the absorbed dose, both in mode of real time, and with the delayed measurement within few weeks.

Evaluation of Dose-Area Product in Pediatric Patients Subjected to Fluoroscopy Barium Meal

S.O. Machado ; H.R. Schelin; V. Deniyak and J. Ledesma 1, Pelé Pequeno Príncipe Research Institute 1
D. Filipov 2, Federal University of Technology – Paraná 2

Presenter: Hugo R. Schelin - Pele Pequeno Principe Research Institute, schelin2@gmail.com

Barium meal procedures are used in the diagnosis of gastro-intestinal disorders. The fluoroscopic imaging employed in these types of diagnosis result in a longer patient exposure than conventional x-ray imaging. It is crucial to minimize unnecessary exposure to children as they are more radiosensitive and more likely to develop mutations due to the radiation exposure during their lifetime.
This work measures the dose area product (DAP) of 45 patients from an accredited public pediatric hospital in Brazil and compared with the limits recommended by the Europian Commission and others recent studies. Aside the dose area product other information was gathered about the patients including age, gender, weight, and reason for procedure. The technical parameters collected included exposure time, mean fluoroscopy kVp and mAs, mean radiographs kVp and mAs, quantity of radiographs, focus-detector distance to the patient, ambient temperature and atmospheric pressure. The results show kVp ranging from 70 to 100 and a fixed focus-detector distance of 1.5

m. The average DAP was calculated for the following age groups: 0-1, 1-5, 5-10 and 10+ years. The average values for these groups were 78.58, 193.59, 115.73 and 1057.66 µGy.m², respectively. The doses found in this study are consistently larger than values published in recent literature. The dose can be reduced by raising awareness to the operators and investing in new technologies that greatly improve imaging efficiency.

Human Factor in Exposure from Conventional Radiographic Examinations in Very and Extremely Low Birth Weight Patients

M.L.C. Gois[1], H.R. Schelin [1], V. Denyak [1,2], A.P. Bunick[1], J.A. Ledesma [1], S.A. Paschuk [3]

[1] Pelé Pequeno Príncipe Research Institute, Av. Silva Jardim, 1632, Curitiba – PR 80250-060, Brazil
[2] National Science Center ‘Kharkov Institute of Physics and Technology’, Akademicheskaya 1, Kharkiv 61108, Ukraine
[3] Federal University of Technology, Av. Sete de Setembro, 3165, Curitiba – PR 80230-90, Brazil

Presenter: Hugo R. Schelin - Pele Pequeno Principe Research Institute, schelin2@gmail.com

The survival of very premature neonates has improved significantly at the last decades owing to the utilization of modern intensive care interventions. Such interventions are usually accompanied by frequent radiographic examinations. Elevated radiosensitivity of preterm patients combined with numerous examinations performed during their stay in intensive care units raise the issue of high risk for future radiation-induced malignancies considering their greater remaining lifetime. Absence of the examinations capable to substitute conventional radiography and not involving radiation exposure stimulates the investigations on a hospital’s routine practices aimed to minimise the dose received by neonates. In this work, we present the results of an investigation on the influence of radiographer strategies on radiation exposure of patients with birth weight lower than 1500 g in one paediatric hospital in Brazil. We analyse the radiographic techniques applied by 17 radiographers and their impact on patient dose. The analysis include accounting of patient weight and comparison between different examination types.

Characterization of materials used for 3D printed neck phantom for thyroid cancer treatment

Jaroslav Solc [1], Tomas Vrba [2,] Ludmila Burianova [1]
[1] Czech Metrology Institute, Okruzni 31, 638 00 Brno, Czech Republic
[2] Czech Technical University, Brehova 7, 110 00 Prague 1, Czech Republic

Presenter: Jaroslav Solc, Czech Metrology Institute, Okruzni 31, 638 00 Brno, Czech

Republic, jsolc@cmi.cz

One source of uncertainty related to dose assessment in nuclear medicine therapy is quantitative imagining. This is caused by a calibration which, if exists, is based on simplified phantoms that mimic real patient in limited way. These issues are addressed inside a larger joint research project “Metrology for clinical implementation of dosimetry in molecular radiotherapy” (MRTDosimetry). One of its objectives is to research applicability of 3D printing for the development of fillable quasi-realistic anthropomorphic phantoms. This paper describes characterization of materials for 3D printing with regards to photon attenuation. Printed rectangular samples of different printing materials (ABS, HiPS, NYLON, PET, PLA, PVA, PMMA, Polycarbonate) were obtained. Density, linear attenuation coefficient (LAtC), and Hounsfield units (HU) were assessed for the samples. LAtC was obtained by a collimated photon beams from Eu-152 and Am-241 radionuclide sources and covered photon energy range from 40 to 1400 keV. The main focus was given to the results obtained for energies 59.5, 122.0, and 344.5 keV since treatments with I-131 are the most frequent. Average HU were calculated from DICOM images acquired on Philips Brilliance CT Big Bore radiotherapy simulator. Obtained characteristics of the materials were compared to water and soft tissue. The material with the LAtC and HU closest to water was NYLON. However, it should be noted that up to 15% difference was found between LAtC of the same material printed by different companies on different printers. Therefore, printer and/or printing settings may have significant effect on the quality of the phantom.

A comparison of longitudinal and lateral range for protons traversing complex media using GATE, MCNP6 and FLUKA Monte Carlo simulations

Jarle Rambo Sølie, Western Norway University of Applied Sciences,
Helge E.S. Pettersen, Haukeland University Hospital,
Ilker Meric, Western Norway University of Applied Sciences,
Odd Harald Odland, Haukeland University Hospital,
Håvard Helstrup, Western Norway University of Applied Sciences,
Dieter Röhrich, University of Bergen

Presenter: Jarle Rambo Sølie, Western Norway University of Applied Sciences, jars@hvl.no

A prominent application area of Monte Carlo (MC) simulations is the design and development of detector systems, for instance, a detector system used for real-time verification and monitoring of the Bragg peak in particle therapy. Bergen pCT is a newly established collaboration focusing on the development of a digital proton tracking calorimeter for radiography and CT purposes using large-area Monolithic Active Pixel Sensor chips interleaved with energy-reducing absorbers. The development is based on MC simulations to determine proton range, straggling and tracking efficiencies. To this end, the accuracy with which these parameters can be determined in MC simulations constitutes important knowledge in the early development efforts. In this work, a comparison of the relevant parameters obtained using MC codes, GATE, MCNP6 and FLUKA is presented. Parameters such as mean proton range, the fraction of primary protons lost due to nuclear interactions and longitudinal- and lateral range straggling of monoenergetic protons with energies varying between 50 MeV and 250 MeV are calculated in homogeneous materials such as water and aluminum, in addition to the more complex geometry of the digital tracking geometry. The results indicate that proton ranges calculated with all three codes agree to within ± 1σ of each other. All three codes studied produce similar proton ranges as well as longitudinal and lateral straggling values over a wide proton energy region. The proton removal rate due to nuclear interactions does not seem to depend on the choice of nuclear models used in the simulations.

Improving Image Quality of Rhodnius prolixus head using different types of staining methods and Synchrotron Radiation Phase Contrast Microtomography

Gabriela Sena, Federal University of Rio de Janeiro, Delson Braz, Federal University of Rio de Janeiro, Marcos Colaço, State University of Rio de Janeiro, André Almeida, State University of West Zone, Patricia Azambuja, Oswald Cruz Foundation, Marcelo Gonzalez, Federal University Fluminense, Izabella Soares, Federal University of Rio de Janeiro, Regina Barroso, State University of Rio de Janeiro, Liebert Nogueira, State University of Rio de Janeiro

Presenter: Gabriela Sena, Federal University of Rio de Janeiro, gabisenaa@gmail.com

The application of microtomography for the study of insects is quite recent and its transposition to the Synchrotron Radiation Phase Contrast Microtomography is even more recent. A detailed knowledge of insect’s anatomical structures is crucial for a better understanding of their function and evolution. Some studies have shown that with an appropriate fixative and sample mounting, Synchrotron Radiation Phase Contrast Microtomography can produce high-quality images of insects, enhancing the contrast of images. In this work, the measurements using Synchrotron Radiation Phase Contrast Microtomography were performed in the new beamline IMX at LNLS (Brazilian Synchrotron Light Source) to study the internal structures of the head of the blood-sucking hemipteran, Rhodnius prolixus (Hemiptera: Reduviidae), the main insect vector of Chagas’ disease, endemic in Central and South America. About 7 million to 8 million people worldwide are estimated to be infected with this disease and understanding the behavior of the nervous system of Rhodnius prolixus is of great importance in vector control. In this work, two fixatives were chosen and combined with different types of staining, and the results obtained were compared using image quality parameters (contrast and signal-ratio noise). This work demonstrates that staining the sample with appropriate chemical agents is a simple way of increasing the contrast of relevant low-absorbing features in the specimen. The results showed that only a few staining for Synchrotron Radiation Phase Contrast Microtomography has been

demonstrated to be a valid tool for increasing the contrast in insects.

Patient Effective Doses and Radiation Risks in Cardiac catheterization Procedures

A. Abdelrazig[1]: [1]College of Medical Radiologic Science, Sudan University of Science and Technology, P.O.Box 1908, Khartoum 11111, Sudan
A.Sulieman[2]:[2] Radiology and Medical Imaging Department, , College of Applied Medical Sciences, Prince Sattam bin Abdulaziz University, Alkharj, Kingdom of Saudi Arabia
M.Alkhorayef[3]: [3]Department of Radiological Sciences, College of Applied Medical Sciences, King Saud University, PO Box 10219 Riyadh 11433, Saudi Arabia
E. Babikir[3]: [3]Department of Radiological Sciences, College of Applied Medical Sciences, King Saud University, PO Box 10219 Riyadh 11433, Saudi Arabia
H. Al-mohammed[4]: [4]College of Health and Rehabilitation Sciences, Princess Nora Bint Abdulrahman University, PO Box 84428, Riyadh 11671, Saudi Arabia
D.Bradley[5, 6]: [5]Department of Physics, University of Surrey, Guildford, Surrey GU4 8JU, UK.,
[6]Sunway University, Institute for Health Care Development, Jalan Universiti, 46150 PJ, Malaysia

Presenter: A. Sulieman:Prince Sattam Bin Abdulaziz University , College of Applied Medical Sciences, Radiology and Medical Imaging Department ,Alkharj, Saudi Arabia, abdelmoneim_a@yahoo.com

Cardiac catheterization is an interventional procedure used for the diagnosis and treatment of coronary arteries diseases. Patients are exposed to prolong radiation exposure during the procedure. Tissue reaction (erythema) effects are now well documented as one of the serious complications of extended radiation exposure procedures. Radiation dose up to 18 Gy were reported. No previous studies reported erythema incidence in dark –skinned patients. Therefore, accurate dose optimization is recommended to keep the radiation dose as low as reasonably achievable. The objectives of this work are to measure patient radiation dose and effective doses during eight type of cardiac catheterization. A total of 110 patients were examined for different clinical indication. A calibrated X ray machines was used to perform all the procedures. Patient dose measurements were performed using Kerma Area Product (KAP) meter. The mean and range of patient age (year), weight (kg)were 51.9 (22.0-80.0)and 70.1 9(49.0-86.5), respectively. While the mean and range exposure parameters were 84.1 kVp, 338 mA and 0.3 s for tube potential, tube current and time, respectively. The mean number of films per procedure is 7.5 and the mean fluoroscopic time was 5.6 min. The mean cumulative average dose (CAD) was 3342.8 cGy.cm2. Radiation induced erythema was noticed in some patients. Patients exposed to different dose values based on their clinical indications. Although, no patients developed tissue reaction effect, optimization of patient doses in important especially for young patients.

A study on possible gamma ray interferences from 60mCo, 139Ba and 56Mn formed in the direct thermal neutron irradiation of LaBaCo2O6 e LaBaMn2O6 perovskites to produce 140La(140Ce) probe nuclei for PAC spectroscopy

B. Bosch-Santos, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP) and Universidade de São Paulo (USP), M. Saiki, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP), N. M. Nascimento, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP) and Faculdades Oswaldo Cruz , SP, Brazil, D. S. Silva, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP), T. S. N. Sales, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP) and Universidade de São Paulo (USP), L. F. D. Pereira, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP), A. W. Carbonari, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP).

Presenter: B. Bosch-Santos, Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP) and Universidade de São Paulo (USP), brianna@usp.br

In this work, a method to introduce radioactive 140La nuclei with a half-life (t1/2) of 40.8 h, into samples of LaBaTM2O6 (TM = Mn, Co) double perovskites is described to carry out perturbed gamma-gamma angular correlation (PAC) spectroscopy measurements using 140La(140Ce) as probe nuclei. There are several methods to insert this probe nucleus in the samples and the present paper presents a new methodology to obtain the 140La(140Ce) in the compounds. These compounds were submitted to short irradiations with thermal neutrons in the rabbit station of IEA-R1 nuclear reactor of the IPEN/CNEN-SP. This method could be used because natural La is present in samples. Natural La contains the 139La isotope which, when irradiated with neutrons produces the 140La radioisotope, the parent radioisotope of 140Ce used for PAC measurements. However, other elements present in the compounds are also activated, in particular the isotopes 56Mn, 139Ba and 60mCo. In order to verify if these radioisotopes are presents in the PAC measurements, the gamma ray spectra of these irradiated samples can be measured at different decays times using a high resolution HPGe spectrometer. Samples were irradiated with thermal neutrons for 3 minutes. After short irradiation, the gamma ray spectra were acquired, one hour, 18 h, 24 h and 48 h after irradiation. The gamma ray energies of 328.8 keV and 487.0 keV of 140La (measured in the PAC spectroscopy) can be identified. Besides this, gamma-rays peaks of 56Mn (Eγ of 847.3 and 1812.9 keV and t1/2 of 2.57 h), 139Ba (Eγ of 166.04 keV and t1/2 of 84.63 min) and 60mCo (Eγ of 58.75 and 1333.30 keV and t1/2 of 10.47 min) are identified too. The results indicate that PAC measurements can be started after at least 48 h of decay time when there is in interference of other radioisotopes.

Determination of gadolinium and erbium in Gd2O3 and Er2O3 nanoparticle samples by neutron activation analysis

E.L. Correa, Nuclear and Energy Research Institute, University of Sao Paulo; B. Bosch-Santos, Nuclear and Energy Research Institute; M. Saiki, Nuclear and Energy Research Institute; N.M. Nascimento, Nuclear and Energy Research Institute, Faculdades Oswaldo Cruz; F.B. Effenberger, Faculdade de Engenharia Industrial; A.W. Carbonari, Nuclear and Energy Research Institute; M.P.A. Potiens, Nuclear and Energy Research Institute

Presenter: Eduardo Correa, Nuclear and Energy Research Institute, University of Sao Paulo, eduardo.correa@usp.br

Along these years the applications of nanoparticles (NPs) in medicine as radiosensitizers have been widely studied, so several methods for its syntheses are presented. One of the best synthesis methods for this application is by thermal decomposition, which produces small NPs size (3-5 nm) with a narrow size distribution. On the other hand NPs synthetized by this method are covered by an organic material, hence making their mass measurement impossible by conventional means. In this study neutron activation analysis (NAA) was applied to determine Gd and Er concentrations in their NP oxides. The analysis of NPs composition is not commonly carried out. However these determinations are of great importance when the NPs are used in radiosensitization tests and magnetization measurements. NPs were synthetized by the method of thermal decomposition, which consisted in adding and mixing Gd and Er acetate in an organic solution by stirring and heating at high temperature (about 573 K) for about six hours. After cooling at room temperature the solution was centrifuged to obtain the NPs that were separated from the liquid. For NAA about 5 mg of post-synthesis and 873 K annealed samples of Gd2O3-NP and Er2O3-NP were irradiated together with their respective element standard. One-minute irradiations were carried out at the IEA-R1 research nuclear reactor. Element concentrations were determined by measuring 159Gd and 171Er gamma ray activities (energy of 363.56 keV and 308.3 keV respectively). Concentration of (19.88 ± 0.43) % of Gd and (23.53 ± 0.82) % of Er were obtained in the Gd2O3-NP and Er2O3-NP samples, respectively. These results are useful and have been used to establish experimental conditions for NPs magnetization and irradiation in radiotherapy beams for dose enhancement factor determination.

Inverse Analysis of Irradiated Nuclear Material Gamma Spectra via Nonlinear Optimization

Garrett Dean, NCSU, John Mattingly, NCSU

Presenter: Garrett Dean, NCSU, gjdean@ncsu.edu

This work applies nonlinear optimization to the inverse analysis of gamma spectra measured from pulse irradiated nuclear materials. The algorithm described is used to estimate the fluence, cooling time, and sample composition to help in determining the

irradiation history and provenance of a sample. The forward model uses the SCALE module ORIGEN as a nuclide inventory calculator, the ENDF decay sublibrary to convert the nuclide inventory to a list of gamma emission energies and intensities, and detector response function. The predicted photopeak areas from the forward model are compared to the photopeak areas in the measured spectrum. A combination of a genetic algorithm and Levenberg-Marquardt use the differences between the predicted and measured areas to change the parameters until the difference is minimized. The inverse solver algorithm has been tested against gamma spectroscopy measurements of small SNM samples irradiated in the Washington State University TRIGA reactor and found good agreement with the traditional analysis methods.

Detector Resolution Effects on Spectral Uncertainty in Gamma-Ray Elemental Analysis

Aaron Feinberg, North Carolina State University
Dr. Robin Gardner, North Carolina State University

Presenter: Aaron Feinberg, North Carolina State University, apfeinbe@ncsu.edu

In performing Gamma-Ray Elemental Analysis, detector resolution is often a property of great consideration. While one’s intuition might lead them to believe that resolution is of the utmost importance, this is not necessarily the case. This is especially true when performing gamma-ray elemental analysis using the Library Least Squares technique on well-posed problems. This work shows how resolution affects uncertainty in gamma-ray elemental analysis through spectral composition uncertainty propagation and fitting parameter sensitivity.

Digital Neutron-Gamma Discrimination Performance of Stilbene in Comparison with Plastic Scintillators

Michal Cieslak, Kelum A.A. Gamage
Engineering Department, Lancaster University, UK

Presenter: Kelum A.A. Gamage
Engineering Department, Lancaster University, UK, k.gamage@lancaster.ac.uk

Digital pulse shape discrimination performance of single stilbene crystal in comparison with two plastic scintillators has been investigated. Simplified Digital Charge Comparison discrimination algorithm has been exploited for each scintillator sample, assessing their quality of neutron-gamma separation. In this study each scintillator sample was exposed to a Cf-252 neutron source, which was placed in a water tank. A bespoke fast digitiser system was used to collect the data allowing detailed offline examination of the sampled pulses. A pile-up rejection algorithm as well as moving

average filter were applied to the digitised samples, to reject pulses with more than one peak and to reduce high frequency noise respectively. The figure-of-merit was then estimated to compare the discrimination quality of the collected events, with respect to each sample investigated. Single stilbene crystal exhibits significantly better neutron-gamma separation performance compared to each plastic scintillator.

Radiological characterisation using radiation imaging and ground penetrating radar

Ikechukwu Ukaegbu, Kelum A.A. Gamage
Engineering Department, Lancaster University, UK

Presenter: Kelum A.A. Gamage
Engineering Department, Lancaster University, UK, k.gamage@lancaster.ac.uk

Radiological characterisation involves the identification of the location, type and other physical properties of radioactive wastes. It is a critical aspect of decommissioning potential nuclear contaminated sites and facilities as it provides input to all stages of the decommissioning process. However, some of these wastes are often located in hard to access areas such as below the ground. These include contaminated pipeline networks used to transport high level liquid wastes to underground storage tanks, and leaked effluents from these pipelines and storage ponds. Traditional methods of characterising such wastes e.g. gamma logging, involves excavation which leads to the generation of secondary wastes and increases the risks of exposure of personal and equipment to ionising radiation. Radiation imaging techniques are also used to obtain ground level images of the location of these underground wastes. However, such two dimensional (2D) images are limited to the ground surface and provide no information on how deep the waste is buried. However, since these wastes are usually solids and liquids, their physical presence below the ground can be detected using non-destructive techniques such as ground penetrating radar (GPR). And the information from the GPR can be combined with the 2D radiation image for non-destructive three-dimensional localisation of the underground waste. This has been demonstrated in this work using data from radiation transport and electromagnetic wave simulations.

Rapid method for gross alpha and gross beta determination in water samples in emergency situation.

M. Sáez Muñoz [1], J. Ordóñez [2], J. Ortiz [1], S. Carlos [2], S. Martorell [1]
[1] Laboratorio de Radiactividad Ambiental. MEDASEGI Research Group. Universitat Politècnica de València
[2] MEDASEGI Research Group. Universitat Politècnica de València

Presenter: José Ordóñez Ródenas, MEDASEGI Research Group. Universitat Politècnica de València., joorro1@etsii.upv.es

The Laboratorio de Radiactividad Ambiental of the Universitat Politècnica de València (LRA-UPV) participates as a support laboratory in case of radiological emergency within the emergency preparedness plan of the Valencian Community (Spain). Gross alpha and gross beta determination in water samples is an important indicative of the radiological quality of the water and a screening method in an emergency situation. The LRA-UPV developed a rapid procedure for the determination of gross alpha and gross beta activity in water samples based on the direct counting of the sample by liquid scintillation in Quantulus 1220. The procedure is applicable to waters with different salt content (from 5 g/L of continental and drinking water, to 35 g/L of sea water) and pH, since different corrections are applied in the measurement and calculation according to the characteristics of the sample. All samples were prepared by mixing 8 mL of the filtered sample and 12 mL of Ultima Gold LLT in a 20 mL polyethylene vials. The Pulse Shape Discriminator parameter (PSA) was optimized to minimize the total interference (α + β) and allow the simultaneous measurement of alpha and beta emitters for different quenching values (SQP(E)). Standard solutions of 241Am and 90Sr/90Y were prepared at the LRA-UPV in order to establish the optimum PSA and the alpha and beta efficiencies for different SQP(E). Finally, the method was tested for different alpha-beta ratios (1:1, 1:10, 10:1) and validated with spiked samples prepared by the laboratory and intercomparison samples. The measurement procedure is based on a screening measurement of 10 minutes to determine the quenching parameter and identify the active samples. A second measurement of 60 minutes is performed to calculate the activity of the sample with low uncertainty and get better limits of detection (LD). The LD goes from 6.3 Bq/L to 1.3 Bq/L for gross alpha, and from 30.3 Bq/L to 5.1 Bq/L for gross beta.

Neutron field study of p(35)+Be source reaction at the NPI Rez

Milan Stefanik, NPI CAS Rez / FNSPE CTU in Prague
Pavel Bem, NPI CAS Rez
Mitja Majerle, NPI CAS Rez
Jan Novak, NPI CAS Rez
Eva Simeckova, NPI CAS Rez
Jan Stursa, NPI CAS Rez

Presenter: Milan Stefanik
Inst.1: Nuclear Physics Institute of The Czech Academy of Sciences (NPI CAS Rez)
Inst.2: Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering (FNSPE CTU in Prague), milan.stefanik@fjfi.cvut.cz

The cyclotron-based fast neutron sources of the white- and quasi-monoenergetic spectra are operated at the NPI Rez Fast Neutron Facility utilizing the variable proton

(up to 36 MeV) and deuteron (up to 20 MeV) beams delivered by the U-120M isochronous cyclotron and target stations with the Be(thick), D2O(thick), and 7Li(C) neutron production targets. The upgraded beryllium target station provides the high intensity neutron field of broad spectra up to 33 MeV with mean energy of 14 MeV. The energy range corresponds to the main energy part of IFMIF (International Fusion Material Irradiation Facility) neutron spectrum. This IFMIF-like source is appropriate for the radiation hardness tests of materials and electronics, validation of activation cross-section data within the fusion relevant research programs, and fast neutron activation analysis experiments. At the NPI CAS, the neutron field of p+Be source reaction was studied for proton beam energy of 35 MeV using the multi-foil activation technique. Neutron spectra were measured at several target-to-sample distances using the large sets of dosimetry foils. The modified version of SAND-II deconvolution tool was used for neutron spectrum reconstruction up to 33 MeV (i.e. energy region with a lack of experimental neutron spectral data), and obtained spectra were validated against the Monte Carlo MCNPX calculations. Neutron characteristics of p+Be neutron source and neutron field distribution will be discussed in the article.

Chemical composition of mediaeval ceramic glazes studied by the means of XRF and micro-XRF

Martin Hložek, Masaryk University - Department of Archaeology and Museology Brno,
Tomáš Trojek, Czech Technical University in Prague,
Irena Loskotová, Masaryk University - Department of Archaeology and Museology Brno

Presenter: Martin Hložek, Masaryk University - Department of Archaeology and Museology Brno, mhlozek@seznam.cz

Unfortunately, glazes of mediaeval pottery and tiles are only seldom in the focus of scientists applying analytical approaches in archaeology. In the presented research, X-ray fluorescence (XRF) analysis was used for the examination of the effect of chemical composition on the colour of glazes and chemical characterisation of underlying layers in mediaeval stove tiles. Besides the chemical composition, furnace atmosphere affects the final colour. Mediaeval vessels are usually covered with dark green glazes, which are incorrectly been determined as lead – tin by archaeologists. Using XRF it was proved that so called lead – tin glazes almost do not occur in mediaeval artifacts, but green glazes coloured with lead and copper oxides are common. Except for lead oxides, other shades were produced by the addition of antimony, iron or manganese oxides. The set of ceramic artifacts from Opava, Czech Republic, is characteristic by semitransparent green glaze containing white grains inside. It was assumed that these grains are relics of galena ore impurities. Using analytical methods, it was found out that the grains are galls rich in phosphorus and, hence, it is an undecomposed opacifier. The composition of underlying layers under glazes was studied by XRF scanning. During melting down of glaze on the ceramic body, reactions leading to the formation of an interstitial layer proceed. This layer is macroscopically been mistaken for a deliberately coated layer of a whitish enamel. In some cases, even 3 - 4 mm thick interstitial layer of fine white clay between glaze and ceramic body occurs in stove tiles. Sometimes, several layers of underlying enamels and clays were illogically coated on each other. Based on XRF scanning across the layers we show that the sherd is not decolorized due to chemical reactions, but the individual layers are formed by completely chemically different materials.

Mediaeval metal threads and their identification using micro-XRF and confocal XRF

Martin Hložek, Masaryk University - Department of Archaeology and Museology Brno,
Tomas Trojek, Czech Technical University in Prague,
Radek Prokeš, Czech Technical University in Prague

Presenter: Martin Hložek, Masaryk University - Department of Archaeology and Museology Brno,, mhlozek@seznam.cz

Fabrics with metal threads were discovered in mediaeval well during excavations in the Mečová 2 Street in Brno. These are thin braids woven of metal threads using a small loom and sewed together into a broader strip. The textile materials are in a relatively good state, because the environment of the well preserved organic materials (fabrics, leather, wood). Furthermore, the positive effect of metal corrosion on the preservation of organic parts of the fabric occurred here. If metal threads are found in graves or dwelling backfills, only spiral-shaped metal fragments with microscopic relics of organic fibres are preserved. Based on microphotographs, we assume that metal threads were made by cutting or scissoring thin strips of metal sheets. The strips were spirally wound on a textile thread. The excavated fabric was deposited in a museum collection storage room for 20 years unnoticed, because its surface was covered with a layer of sediment and corrosion products. During the systematic research of mediaeval fabrics from Brno, it was found out that relics of gold are present in the ends of some of the threads. The fabrics were examined by non-destructive analytical methods. Metal threads covered with sediment and corrosion products were studied using confocal XRF. The concentrations of elements in the individual layers show that the center of the metal thread is formed by a silver strip. A thin layer of gold was laid on the silver strip. Silver was alloyed with copper, which corrosion products covered the whole metal strip and solidified the layer of sediments in the surface. XRF elemental mapping was employed to find out whether the metal threads pass through the whole braid. The results show that the braids are composed of silver threads with gold deposited on their rims and some central parts only.

Experimental Data for Benchmarking Monte Carlo Simulations of a Nuclear Well Logging Prototype Tool

R.M. Ullrich, Aaron Hellinger, Long Vo, Maria Pinilla, Walter McNeil, and W.L. Dunn

Presenter: Ryan Ullrich
Kansas State University, ryanmu42@ksu.edu

The well logging industry currently uses radioisotope sources in many of their tools for analyzing the geologic formations around potential oil wells. Often Cs-137 sources are used in density tools and Americium-Beryllium sources are used in porosity tools. Because these tools use Curie-level radioisotope sources and are deployed at remote locations, there is an incentive to investigate the use of particle accelerator sources to replace the radioisotopes currently applied because these radioisotopes could be employed in so-called "dirty bombs." Experimental tests using one of these machine sources, a deuterium-tritium (D-T) based fusion accelerator, are being conducted in order to gather benchmark data in a test facility designed to simulate the conditions encountered within oil wells. Various gamma-ray and neutron detectors are being used to measure the responses due to neutrons and induced gamma rays in the media surrounding the tool in the test facility. These experiments will be benchmarked against Monte Carlo simulations to validate the potential that accelerators possess as a possible radiological source replacement for the well logging industry.

Trace elemental concentrations in road dust and impact on the environment

Abdullah Alsubaie [1]Department of Physics, University of Surrey Guildford , [2]Department of Physics, Taif University, Saudi Arabia. Maisarah Jaafar [3]Department of Chemistry, University of Surrey, Guildford, Abdullah N. Al-Dabbous [4]Kuwait Institute for Scientific Research, Amjad. R. Alyahyawi [1]Department of Physics, University of Surrey, Guildford GU2 XH, UK, Abdulaziz Alanazi [1]Department of Physics, University of Surrey, Guildford GU2 XH, UK, S Alomairy [2]Department of Physics, Taif University, Saudi Arabia, Yasir Altowairqi [2]Department of Physics, Taif University, Saudi Arabia, Eman Daar [1] Department of Physics, University of Surrey, Guildford,GU2 XH, UK, [5]Department of Physics, The University of Jordan, Amman, Jordan, Mohammed Alkhorayef [6]Department of Radiological Sciences, King Saud University, Riyadh, Saudi Arabia, L Alsulaiti [7]Qatar Environment and Energy Research Institute, P.O. Box 5825, Doha, Qatar, KS Almugren [8]Dept. of Physics, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia, NI Ward [3]Department of Chemistry, University of Surrey, Guildford GU2 XH, UK, DA Bradley [1]Department of Physics, University of Surrey, Guildford GU2 XH, UK, [9]Sunway University, Institute for Health Care Development, Jalan Universiti, 46150, PJ, Malaysia,

Presenter: Abdullah Alsubaie [1]Department of Physics, University of Surrey Guildford , [2]Department of Physics, Taif University, Saudi Arabia., a.alsubaie@surrey.ac.uk

The monitoring of metal concentrations in road dust can be used in evaluating vehicular contributions to the environment. Here we compare the efficacy of several analysis techniques for such samples: XRF, SEM/EDX, ICP-MS. To-date we have made evaluation of pollution levels from roadside dust in up to three different sites within the University of Surrey and the Kuwait Research Institute, also investigating the influence of engine size (Kuwaiti vehicles tending to be of larger engine capacity) and climate, maritime and arid. With 36 street dust samples collected to-date, 18 have now been analysed, elemental concentrations being reported for Mg, Al, Ti, Mn, Fe, Co, Zr, Mo, Ba, Tl, V, Rb, Pb, Cu, Zn, Ni, Cr, Cd, As, Hg and Au. For Surrey samples, obtained at three different times of the year, SEM/EDX findings range from below the lower limit of detection for Ag, 4.7 E-6 mg/m2 for Co, up to 3.6 E-2 mg/m2 for Fe. Using ICP-MS and sieved Surrey road dust samples of average dimension < 45 micron (i.e. respirable dust), elevated elemental concentrations in units of mg/kg (ppm), were observed for Cu (70.4 mg/kg), Zn (288 mg/kg,) Al (3081 mg/kg) and Fe (14133 mg/kg). These can be compared with Co (3.5 mg/kg), V (12.3 mg/kg), a primary source of which are vehicle tyres, and 78.0 mg/kg (Pb). Other toxic metals found in the Guildford and Kuwait samples in different concentrations were Ti, Cr, and Ba. The concentrations of Pb were found to be low compared to previous analyses, attributable to restrictions on Pb in fuel. Au and Ag were detected in low concentrations in both countries, with size ~ 0.5 micron. Present study shows a number of elemental elevated concentrations contributed to by vehicular emissions, a major source being motor parts debris resulting from wear.

Determination of Environmental Levels of Radium in Groundwater Samples by Gamma and Alpha Spectrometry Using Barium Sulphate Co-precipitation Method

Huda Al-Sulaiti[1], K.S. Al Mugren[2], Peter Ivanov[3], Andy Pearce[3], Cyrus Larijani[3], Sean Collins[3], Maria Garcia Miranda[3], Ben Russell[3], Jaber Al-Marri[1], Ibrahim Al Sadig[4], Rifaat K. Babiker[4], Maha Al-Mari[4], S. Bukhari[5]
[1]Environmental and Chemical Sciences, Qatar Environment and Energy Research Institute (QEERI), HBKU, Qatar foundation, P.O. Box 5825 Doha, Qatar
[2] Physics Department, Faculty of Sciences, Princess Nora Bint Abdul Rahman University, Riyadh, KSA
3 Radioactivity group, National Physical Laboratory, Hampton Rd, TW11 0LW Teddington, UK
[4] Radiation Measurements Laboratory, Central laboratories, Radiation measurements laboratory, Ministry of Environment, Doha, Qatar, P. O. Box: 36390
[5] Information Technology Department, Ministry of Environment, Doha, Qatar, P. O. Box: 7634

Presenter: Huda Al-Sulaiti, Qatar Environment and Energy Research Institute (QEERI), halsulaiti@qf.org.qa

Previous studies which were conducted on Naturally Occurring Radioactive Materials (NORM) in soil in the State of Qatar have shown elevated levels of enhanced radioactivity [1]. An anomalously high value of 226Ra activity had been also observed for a number of measured samples in our last work on NORM [2]. An investigation for radium concentrations in the groundwater in that specific area has become an essential issue to estimate the environmental impact of the measured concentrations in current study. The main pollutant in this case is “radium” and specifically 226Ra. Typical levels of 226Ra in groundwater are usually very close to the detection limits in small size of water samples when using gamma spectrometry, therefore pre-concentration and chemical preparation for enrichment of radium is necessary to eliminate the effect of 235U interferences at the line 186 keV. In this study, a method has been developed to radiochemically separate the radium from the interfering elements in the samples. Two different analytical techniques, γ-spectrometry and α-spectrometry, for the quantification of radium have been used. The measured quantities of 226Ra in the water samples were in the range from 0.10 ± 0.008 to 18.39 ± 0.01 Bq L-1 with a mean concentration of about 7.44 ± 0.40 Bq L-1.

References:

[1] Al-Sulaiti, H. (2010). NIM-A. 619(1-3): p. 427-431.
[2] Huda Al-Sulaiti, (2012). Appl. Radiat Isot. 70, Issue 7, p 1344–1350.

Retrospective Electron Paramagnetic Resonance (EPR) Dosimetry of Radiation Accidents Using Environmental Biological Samples

C.C. Lu [1], Y.C. Liu [2,3], K.S. Chuang [1,2,] C.F. Wang [1,2], H.H. Lin [4*], Y.X. Zhang [5], L.H. Lai [1], J.P. Lin [6]
[1] Department of Biomedical Engineering and Environmental Sciences, National Tsing Hua University, Hsinchu, Taiwan
[2] Institute of Nuclear Engineering and Science, National Tsing Hua University, Hsinchu, Taiwan
[3] Department of Radiation Oncology, Wei Gong Memorial Hospital, Miaoli, Taiwan
[4] Medical Physics Research Center, Institute for Radiological Research, Chang Gung University/Chang Gung Memorial Hospital, Taoyuan, Taiwan
[5] Department of Electronics Engineering, National Chiao Tung University, Hsinchu, Taiwan
[6] Department of Medical Imaging and Radiological Technology, Yuanpei University of Medical Technology, Hsinchu, Taiwan

Presenter: C.C. Lu / Department of Biomedical Engineering and Environmental Sciences, National Tsing Hua University, Hsinchu, Taiwan, ccnlu1991@gmail.com

In response to large-scale radiological incidents and nuclear mass-casualty events, it is essential to develop a retrospective dosimetry framework towards the estimation of the environmental dose for a risk assessment. Electron Paramagnetic Resonance (EPR) dosimetry provides measurements of absorbed dose in a variety of materials through the measurement of the radiation damage therein induced. Therefore, materials contained in creatures from sea or land can be collected and potentially used as dosimeters for a retrospective dose analysis. Here, we propose the retrospective dose assessment based on the use of EPR measurement of free radicals from environmental biological samples. The biological samples include human tissue (enamel and fingernail), ox bone, cyclina shell, clam shell, and chitin from squid. All materials are dehydrated and grinded to powder with different size. EPR spectra of all materials, irradiated with the dose ranging from 0.5Gy to 50Gy using 6MV LINAC, were obtained from the addition of peak-to-valley amplitudes under a static magnetic field. The signals were estimated with linear regression (R2: 0.98~0.99) to derive signal-to-dose conversion factors. The signals of unpaired free radicals such as PO42- (from the bone and cyclina), CO3- or CO33- (from the clam, cyclina and enamel), R-CO2- (from the fingernail and chitin) can be measured using EPR techniques. Under the same irradiated dose, the signal ratios relative to enamel were about 0.16 for chitin, 0.173 for bone, 2.87 for cyclina, 3.43 for clam, 0.87 for fingernail; the signals ratios relative to fingernail were about 0.18 for chitin, 0.197 for bone, 3.6 for cyclina, 3.9 for clam, and 1.138 for enamel. We conclude that the developed relationships between human tissue and creatures can retrospectively give a fast rough estimate of radiation dose under the environment when radiation accidents occur.

CHARACTERIZATION OF RADIONUCLIDES PRESENT IN PORTLAND CEMENT, GYPSUM AND PHOSPHOGYPSUM MORTARS

Danielle Cristine Narloch [1], Sergei Anatolyevich Paschuk [1], Janine Nicolosi Corrêa [1], Juliana Machado Casali [2], Wellington Mazer [1], Catarina Alzira Montenegro Peddis Torres [1], Flávia Del Claro [1], Alessandro de Lara [3], Hugo Reuters Schelin [4]
[1] Federal University of Technology - Paraná, Av. Sete de Setembro, 3165, Curitiba – PR 80230-90, Brazil,
[2] Federal Institute of Santa Catarina State, Brazil,
[3] São Paulo University – USP, Brazil,
[4] Pelé Pequeno Príncipe Research Institute, Av. Silva Jardim, 1632, Curitiba – PR 80250-060, Brazil

Presenter: Hugo R. Schelin Pele
Pequeno Principe Research Institute, schelin2@gmail.com

Portland cement is the main ingredient of concrete and various types of finishing materials. It is considered as the main and most consumed building material in the world, which is used for all type of construction, including residential and commercial buildings, dwellings, offices, and industrial facilities. Portland cement is made from the chemical composition of major oxides, such as CaO, SiO2, Al2O3, and Fe2O3, and minor oxides, which include MgO, SO3 together with alkali oxides (K2O and Na2O) and other compounds such as P2O5, TiO2, MnO3, among others. Being produced from different type of natural raw materials, such as limestone, chalk, marl, clays, slags and shale among other, the manufacturing of Portland cement involves the crushing rocks, their mixture with different ingredients such as iron ore or/and fly ash, grounding, homogenizing of this mixture, and then its calcination and fusion at a temperature about 1450°C. As result of such industrial process the Portland cement could contain rather significant quantity of natural radionuclides such as 226Ra, 232Th and 40K. Therefore, the aim of present study was qualitative and quantitative analysis of the constituents of Portland cement, natural gypsum and phosphogypsum mortars using the EDXRF technique and gamma spectrometry. The radiological risk of studied building materials was evaluated by calculating the values of the radium equivalent activity (Raeq), absorbed gamma dose rate (Din), the annual effective dose (Ein), the alpha hazard index (I), the gamma hazard index (I), as well as external hazard index (Hex) and the internal hazard index (Hin). Obtained values of hazard indexes were found below the recommended limits. The results of quantitative analysis of chemical composition of studied construction materials using EDXRF, shows that the Ca, S and Si, in the case of gypsum, phosphogypsum and cement mortars are in agreement with standards for Brazilian building materials.

THE NATURAL RADIOACTIVITY OF ISTRIA, CROATIA

Vanja Radolic, Department of Physics, J. J. Strossmayer University of Osijek, Osijek, Croatia,
Igor Miklavcic ,Department of Physics, J. J. Strossmayer University of Osijek, Osijek, Croatia,
Marina Poje Sovilj, Department of Physics, J. J. Strossmayer University of Osijek, Osijek, Croatia,
Denis Stanic, Department of Physics, J. J. Strossmayer University of Osijek, Osijek, Croatia,
Branko Petrinec, Institute for Medical Research and Occupational Health, Radiation Protection Unit, Zagreb, Croatia,
Branko Vukovic, Department of Physics, J. J. Strossmayer University of Osijek, Osijek, Croatia

Presenter: Branko Vukovic,
Department of Physics, J. J. Strossmayer University of Osijek, Osijek, Croatia,
branko@fizika.unios.hr

Because of the geological structure of Istrian peninsula which mainly consists of a limestone that is characterized by karstic topography on its surface, it is expected that there are areas with elevated radon levels in soil gas as well as inside buildings (e.g. houses, kindergartens, schools). Recently, from autumn 2013 until spring 2015, radon measurements at more than 1000 randomly selected locations (in houses as well as in schools and kindergartens) were investigated. The average value of indoor radon in homes is 102 Bq m-3 while the average radon concentrations in kindergartens and schools are two times higher than in homes. In fact, 24% of kindergartens and 40% of schools have, at least, one room/classroom with radon value higher than 300 Bq m-3 which is the maximum reference level in EU and Croatia. Radon concentrations in soil

gas in Istrian peninsula were measured from 2013 to 2015 with the AlphaGUARD and RM-2 measuring systems. The obtained average value of 103 kBq/m3 classifies the soil of Istria County into soil of high geogenic radon potential. It is important to emphasize that there are areas with radon concentrations up to 500 kBq m3. Soil samples were collected according to the standard procedures of the IAEA at 55 different locations. Activity concentrations of selected radionuclides were determined by means of gamma spectrometry by using an ORTEC HPGe detector system. The correlation between radon and thoron soil gas and their parents radium/uranium and thorium were investigated. In accordance with the obtained results, areas with elevated indoor radon levels as well as levels of radon in soil gas were identified and radon maps were generated by using different geostatistical approaches.

Excitation, luminescence and lifetime of CaO – Al2O3 – H3BO3 – Yb3+ and CaO – Al2O3 – H3BO3 – Ce3+ rare earth-doped borate glasses

A.L.F. Novais [1], L.F. Souza [1] , C.M. Abreu [1], G. R. Barrera [1,2] and D.N. Souza [1]
Universidade Federal de Sergipe [1]
Corporación Universitaria del Huila [2]

Presenter: A.L.F. Novais. Universidade Federal de Sergipe., deafisica@yahoo.com.br

This work aims to investigate the characteristics related to the excitation, luminescence and lifetime spectra of both borate glasses CaO - Al2O3 - H3BO3 and CaO - Al2O3 - H3BO3 doped respectively with 1.0% of Yb3+ and Ce3+. These glasses were produced by melt and rapid cooling method and their structural and spectroscopic properties were studied. The characterization tries to define the ideals levels of rare-earth ions that do not compromise the spectroscopic properties of these glassy matrices. Such glasses can be useful as optical fibers doped and in solid-state lasers. The spectral characteristics of Yb3+ and Ce3+ ions in borates are important to optical applications. To structural and optical properties was studied using different spectroscopic techniques, including density, refractive index, optical absorption, excitation, luminescence, time life, x-ray diffractometry (XRD), differential thermal analysis (DTA), scanning electron microscopy (MEV), infrared spectroscopy (FT-IR) and Raman. The XRD standard confirms the amorphous nature of the prepared glasses. Excitation and luminescence spectra of rare earths were also detected. From the luminescence spectrum the lifetime of the glasses under study was measured. It was verified from the FT-IR spectroscopic technique that different groups of structural borates are present in glasses. The TL and OSL characterization were also investigated.

Test of biological shielding of hot cells with high active source 60Co (300 TBq)
Ondřej Srba, Research centre Řež, Petr Švrčula, Research centre Řež, David Zoul,

Research centre Řež.

Presenter: Ondřej Srba, Research centre Řež, ondrej.srba@cvrez.cz

The purpose of the paper is to present a test of biological shielding of hot cells facility constructed as a part of the project SUSEN. In our facility we have 10 hot cells and 1 semi-hot cell. The hot cells are used for preparatory and auxiliary operations with irradiated materials, (receiving of irradiated materials, unloading of containers), but also for mechanical testing and determination of structure characteristics. Semi hot cell is used for microstructure analyse of samples (scanning electron microscope, nanoindenter). Biological shielding of the hot cells is made by steel plates having a thickness between 300 mm - 500 mm. This biological shielding allows us to work with activity of up to 300 TBq for 60Co. Semi hot cell is suitable for 250 GBq for 60Co.
The purpose of this test was to demonstrate that the biological shielding of the hot cells has the desired efficiency and the measured values at selected points correspond to the contractual values, which were mandatory for supplier of biological shielding. The results are also used as a proof of the optimization of radiation protection for the State Office for Nuclear Safety. Which shows that radiation protection is optimized and allowed to work safely work in the facility of hot cell. During this test of biological shielding was revealed that radiation protection in the hot cells facility is optimized for nominal activities of samples.

Acknowledgements
The presented work was financially supported by the Ministry of Education, Youth and Sport Czech Republic Project LQ1603 (Research for SUSEN). This work has been realized within the SUSEN Project (established in the framework of the European Regional Development Fund (ERDF) in project CZ.1.05/2.1.00/03.0108).

The New External Dose Rate Factor Generator of the GENII-LIN Health Physics Code

Francesco Teodori. University of Bologna

Presenter: Francesco Teodori, University of Bologna, francesco.teodori@unibo.it

The GENII-LIN software package has been developed with the aim of providing a reliable tool to be used for calculating dose and risk to individuals and populations from radionuclides released to the environment. The code has capabilities to handle: acute and chronic releases to air from ground and elevate sources; acute and chronic releases to water; chronic releases to deep soil from waste form degradation; pre-existing contamination of soil and surfaces. The code considers exposure pathways that include: internal exposure from consumption of terrestrial foods, aquatic foods, drinking water, animal products, and inadvertent intake of soil; internal exposures from inhalation; external exposure from finite or infinite atmospheric plumes; external exposure from contaminated soil, sediments, and water; and external exposure from special geometries. It is not feasible to develop an external dosimetric methodology that applies to arbitrary distributions of radionuclides in the media. In environmental radiation protection, it is common practice to consider simplified and idealized exposure geometries: submersion in a semi-infinite cloud, exposure to ground surface contamination and exposure to soil contaminated to an infinite depth. In this vein, GENII-LIN offers pre-built dose rate factor libraries for commonly used standard geometries:submersion in a semi-infinite cloud of radioactive materials; immersion in contaminated water; direct exposure to surface ground contamination; and direct exposure to top soil contaminated to an infinite depth. For scenarios where these generalized geometries are to be considered not adequate, the GENII-LIN software system provides its own external dose rate factor generator that allows for the creation of special dose rate factors for arbitrarily shaped sources. The GENII-LIN external dose rate factor generator is a modified and enhanced version of the well-known shielding code ISOSHLD. In this work, we want to describe its latest development and its improved capabilities.

Tuesday, July 11, 2017

Plenary III, Vevey Room, 09:00-10:00

Organic Materials for Next-Generation Radiation Detectors

Paul Sellin, Department of Physics, University of Surrey, Guildford UK

Presenter: Paul Sellin*
Department of Physics, University of Surrey, Guildford UK

There is increasing interest in the application of organic materials for use in radiation sensors, driven during the last decade by the rapid development and sustained growth of these materials for electronic applications. Organic materials possess a unique set of electronic and physical characteristics that have been applied across a range of consumer electronics and photovoltaic applications. The growing interest in the use of electronic-grade organic materials as radiation sensors is due to their ability to realize low cost, large area detectors with particular applications in medical imaging and dosimetry. However as these device technologies become more mature there are numerous other potential application areas for these detectors including neutron physics, high energy physics, and security applications. In this talk I will give an overview of the various classes of organic detector materials which are of interest for radiation detectors, focussing initially on thick-film polymer X-ray detectors which have been developed as tissue-equivalent X-ray dosimeters and X-ray imaging detectors [1,2], including the addition of high-Z nanoparticles to enhance X-ray detection efficiency [3]. The use of hybrid organic materials where traditional inorganic scintillator nanoparticles are embedded within an organic photo-sensor will also be discussed. An important recent development is the first demonstration of organic detectors operating in a pulse counting mode, as evidenced by recent reports of alpha particle spectroscopy using large-volume organic single crystals [3,4].

References:

[1] A. Intaniwet, J.L. Keddie, M. Shkunov, P.J. Sellin, High charge-carrier mobilities in blends of poly(triarylamine) and TIPS-pentacene leading to better performing X-ray sensors, Organic Electronics 12 (2011) 1903-1908.
[2] C.A. Mills, H. Al-Otaibi, A. Intaniwet, M. Shkunov, S. Pani, J.L. Keddie, P.J Sellin, Enhanced x-ray detection sensitivity in semiconducting polymer diodes containing metallic nanoparticles, Journal of Physics D: Applied Physics 46 (2013) 275102.
[3] C.A. Mills, Y.G. Chan, A. Nisbet, J.L. Keddie, P.J. Sellin, M. Shkunov, A. Intaniwet, Direct detection of 6 MV x-rays from a medical linear accelerator using a semiconducting polymer diode, Physics in Medicine and Biology, 58 (2013) 4471-4482.

[4] A. Ciavatti, E. Capria, A. Fraleoni-Morgera, G. Tromba, D. Dreossi, P.J. Sellin, P. Cosseddu, A. Bonfiglio, B. Fraboni, Toward Low-Voltage and Bendable X-Ray Direct Detectors Based on Organic Semiconducting Single Crystals, Advanced Materials 27/44 (2015) 7213.
[5] A. Ciavatti, P.J. Sellin, L. Basirico et al, Charged-particle spectroscopy in organic semiconducting single crystals, Applied Physics Letters 108/15 (2016) 153301.

'Drifting Light'- Using an Optical Time Projection Chamber and Cherenkov Light to Reconstruct Reactor and PET Event Topologies in Water-based detectors.

Henry Frisch, High Energy Physics, Enrico Fermi Institute, University of Chicago

Presenter: Henry Frisch*
High Energy Physics, Enrico Fermi Institute, University of Chicago
(frisch@hep.uchicago.edu)

By reconstructing the arrival position and time of photons produced in water or liquid scintillator on highly segmented photodetectors one can reconstruct tracks by using the `drift time' of photons, much as one does with electrons in Nygren's Time Projection Chamber. An additional wrinkle is that photocathode coverage can be multiplied up by the use of mirrors, as the time dimension allows distinguishing two photons that arrive at the same point but with one by reflection (in Liouville Theorem terms, we have expanded the 4-dimensional phase space at the cathode surface to 6-dimensions, with much more volume to play in.) I will present Fermilab testbeam data, and simulations of whole-body Positron-Electron Tomography scanners and large liquid detectors for neutrinoless double-beta decay.

Radiation Data Science and Analytics I, Vevey Room, 10:30-12:00

Learning to Detect and Characterize Radiation Threat

Artur Dubrawski, Carnegie Mellon University

Presenter: Artur Dubrawski*, Carnegie Mellon University

Machine Learning has been a game changing technology in multiple data-rich domains of practical interest. We will show a few examples of how it can help address key challenges prevalent in radiation threat detection applications, while extracting operationally useful information from data collected using various types of gamma-ray spectrometers and secondary sensing modalities.

Detection and Parameter Estimation of Radioactive Sources with Mobile Sensor Networks
Jifu Zhao, University of Illinois at Urbana-Champaign, Clair J. Sullivan, University of Illinois at Urbana-Champaign

Presenter: Jifu Zhao, University of Illinois at Urbana-Champaign, jzhao59@illinois.edu

The concept of mobile radiation sensor networks has been proposed to detect the presence of possible illicit radioactive materials in a large area. It is important to develop efficient approaches to estimate the location and activity of potential radioactive sources. In this paper, a sensor fusion technique based on mobile sensor networks that combines kernel density estimation (KDE), maximum likelihood estimation (MLE) and a Bayesian framework is proposed to solve this problem. Simulation results show that the proposed method can give some good estimation of the radioactive sources parameters, especially the location of sources.

Bayesian Metropolis Methods for Source Localization in an Urban Environment
Jason Hite, North Carolina State University
John Mattingly, North Carolina State University

Presenter: Jason Hite, North Carolina State University, jmhite@ncsu.edu

We apply Bayesian techniques to determine the location and intensity of a gamma radiation source in an urban environment using count rates taken from a distributed detector network. A simplified model of the radiation transport process is used to construct a statistical model for the detector count rates in the presence of a random background. Markov Chain Monte Carlo is then used to generate samples from the Bayesian posterior density, which can be used to inform search and interdiction efforts. We demonstrate this approach for a simplified 3D representation of concrete buildings using detector responses simulated via analog Monte Carlo (MCNP) with an added contribution from background sources. The resulting posterior samples are shown to correctly determine the source location and intensity while accounting for the uncertainties associated with the detector measurements and background.

Simultaneous Detection of Fast Neutron and Thermal Neutron with Superheated Droplet Detector and Real-Time Readout System

Yi Liu, University of Illinois at Urbana-Champaign
Clair Sullivan, University of Illinois at Urbana-Champaign
Francesco d'Errico, Yale School of Medicine

Presenter: Clair Sullivan, University of Illinois at Urbana-Champaign, cjsulli@illinois.edu

A neutron detection system is presented for simultaneous fast neutron and thermal neutron detection. The detection system is composed of two superheated droplets detectors (SDD) and a live imaging readout system. One of the SDDs is doped with 3.4% 6LiCl for measuring both fast neutrons and thermal neutrons. The second detector, containing no $^{6}LiCl$, is used for fast neutron flux measurement. The thermal neutron flux is calculated through response difference of the two detectors. Also, in the real-time imaging read-out system, machine learning algorithms were developed for image analysis. The algorithms are more robustness and accurate than traditionally-used algorithms.

Radiation Sources and Measurements for Applications II, 10:30-12:00, Montreaux Room

Production of ^{236}Pu of suitable purity as a chemical yield tracer by proton irradiation of uranium targets

C. Larijani[1,2,] P. Ivanov[1], G. Lorusso[1], A.K. Pearce[1] and P.H. Regan[1,2]
[1]AIR Division, National Physical Laboratory, Teddington, TW11 0LW, UK
[2]Department of Physics, University of Surrey, Guildford, GU2 7XH, UK

Presenter: C. Larijani*
AIR Division, National Physical Laboratory, Teddington, TW11 0LW, UK
(cyrus.larijani@npl.co.uk)

The radionuclide ^{236}Pu has a half-life of t½: 2.858(8) y; (Browne and Tuli, 2006) and is of interest as a chemical yield tracer for the radiochemical analysis of ^{238}Pu, ^{239}Pu, ^{240}Pu and ^{241}Pu from nuclear fuel. Radiochemical analysis of plutonium in nuclear fuel is complicated by the few radionuclides suitable for tracing: ^{236}Pu, ^{242}Pu and ^{244}Pu. A limited supply of ^{242}Pu and ^{244}Pu are available, making ^{236}Pu as the most convenient radiotracer. Currently, a widely used production mechanism for ^{236}Pu is through the photon irradiation of $^{237}Np(\gamma,n)^{236}Pu$ (Efurd, 1990). According to Dmitriev, (et al,1994) the purest form of ^{236}Pu was obtained by Efurd et al(1991), by $^{235}U(d,n)^{236}Np \rightarrow ^{236}Pu$, with a very thick (1.3 g cm^{-2}) target of 99.75% ^{235}U and a beam energy of 20 MeV; the yield was ~0.3 kBq/μA-h and, relative to ^{236}Pu, the activities of ^{238}Pu and ^{239}Pu from reactions in ^{238}U were 5 × 10^{-4} and 1 × 10^{-5}, respectively. Various production mechanisms of ^{236}Pu involving charged-particle irradiation of uranium targets ^{236}Np have been studied at the National Physical Laboratory using the University of Birmingham Cyclotron(Jerome, et al, 2012), in order to find a suitable production method for ^{236g}Np, as a mass spectrometric tracer for ^{237}Np (Jerome, et al, 2014). Significantly for the purposes of this paper, ^{236}Np through both its metastable state (^{236m}Np ($t_{½}$: 22.5(4) h; Chechev and Kuzmenko, 2012b) and ground state (ground state half-life of 1.55(8) × 10^{5} years (Chechev and Kuzmenko, 2012a)) decay to ^{236}Pu ($t_{½}$: 2.858(8) y; Browne and Tuli, 2006) and ^{236}U ($t_{½}$: 2.343(6) × 10^{7}y; Luca, 2012). The ^{236}Pu daughter subsequently decays to ^{232}U ($t_{½:}$ 70.6(11) y; Pearce, 2008). The primary challenge of this work will be firstly to produce isotopically pure ^{236}Pu and also to then to chemically separate ^{236}Pu from the production target material and fission products produced during irradiation (Larijani, et al, 2015).The two reactions outlined in this paper are the ^{nat}U(p,3n)^{236}Np and ^{236}U(p,n)^{236}Np. The ^{236}U ($t_{½}$: 23.43(6)×10^{6} years) irradiation is compromised by the availability of the nuclide in a suitably pure state, however the irradiation was carried out using 99.74% enriched uranium, making it of significant to recover the target material, while natural uranium is much more widely used, making it much less significant to recover the target material after irradiation. After chemical separation the ^{236}Pu will be 'standardised' and certificated in a manor traceable to primary standards at the National Physical Laboratory using a combination of liquid scintillation counting, α-particle and γ-ray spectrometry.

REFERENCES:

DDEP Decay Data Evaluation Project, http://www.nucleilde.org/DDEP_WG/DDEPdata.htm

S.M. Jerome et al., Journal of Environmental Radioactivity 138(2014) p.315-322C.

Larijani et al., Radiation Physics and Chemistry, 116(2015) p.69-73. Proceedings from IRMMA 9 conference.

Measurement of fast neutron spectra in radial channel of VR-1 research reactor

Zdeněk Matěj [1], Michal Košťál [2], Ondřej Huml [3], Milan Štefánik [3], Evžen Losa [2,3], František Cvachovec [4], Václav Přenosil [1]
[1]Masaryk University
[2]Research Center Rez Ltd.
[3]Dept. of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering
[4]University of Defence

Presenter: Zdeněk Matěj, Masaryk University, Botanická 15, Brno 612 00, Czechia, matej.zdenek@gmail.com

Knowledge of the fast neutron spectra in reactors irradiation position is important information for many types of experimental topics. Provided it is well described, such a spectrum can also be employed as a reference neutron field that is suitable for validating and testing measuring devices of detector. The present paper aims to compare calculations and measurements of well-defined spectra in the research reactor VR-1 with the fast neutron measuring device NGA-01. Fast neutron spectra were measured in radial channel of the reactor with using stilbene scintillator detector. The neutron spectra were calculated with the MCNP6 code using ENDF/B-VII.0 nuclear data libraries. Only notable discrepancy in neutron spectra were found between calculated and measured value in region 2 – 3 MeV. In other regions the differences between calculated and experimental values are comparable with discrepancies. As the detector is relatively far from core, the neutron beam can be assumed as parallel one. This condition eliminates possible problems with stilbene anisotropy, thus this type of experiment can be used for validation of reactor leakage spectra in energies over 10 MeV what is under auspices of IAEA.

Characterization of the Anisotropic Scintillation Response of Stilbene Using Monoenergetic Neutron Beams

Robert Weldon, North Carolina State University
Jonathan Mueller, North Carolina State University
John Mattingly, North Carolina State University

Presenter: Robert Weldon, North Carolina State University, raweldon@ncsu.edu

Stilbene is a crystalline organic scintillator known to have an anisotropic scintillation response to neutrons dependent on the proton recoil direction in the crystal. We have conducted two experiments using the Triangle Universities Nuclear Laboratory (TUNL) tandem Van de Graaff accelerator with the goal of characterizing the anisotropic scintillation response. In the first experiment the response for 12 proton recoil directions in two 1 cc stilbene crystals was measured with an 11.4 MeV neutron beam. The second experiment measured the response for 7 proton recoil directions in the same stilbene crystals with a 5 MeV neutron beam. The results of the experiments provide the characterization of the anisotropic scintillation response of stilbene in the a-b plane and the a-c’ plane for 21 distinct proton recoil energies between 400 keV and 10 MeV.

Calibration of Handheld X-ray Fluorescence Spectrometer for Identification and Semi-quantitative Analysis of Objects with Stratified Structure

Tomas Trojek, Czech Technical University in Prague,
Hana Bartova, Czech Technical University in Prague

Presenter: Tomas Trojek
Czech Technical University in Prague, tomas.trojek@fjfi.cvut.cz

Handheld, portable, and stationary laboratory X-ray fluorescence (XRF) analyzers are used for non-destructive analysis of materials because the irradiation of material and the consequently induced changes are negligible. At present, the aim of a lot of investigators is to perform the XRF also non-invasively, i.e. without taking any samples because taking even a micro-sample represents a partial damage to an investigated object. Our current investigation is focused on quantitative or rather semi-quantitative evaluation of XRF data obtained in the case of measurements of objects with stratified structure. The aim of this paper is to introduce relatively easy feasible procedure for identification of stratified structure and determination of approximate abundance of an element and its mean depth under the surface. It requires calibration of the XRF spectrometer with the sets of homogenous standard reference materials and at least a couple of thin and intermediate thick foils. Application of Monte Carlo method is possible. The calibration should not be significantly dependent on matrix composition otherwise its application would be limited. The principle of this method is based on the ratio of two X-ray lines of a certain element, typically the Kα/Kβ ratio. The value of this ratio for the given chemical element depends on depth distribution of this element in material. Since the Kα line has lower energy that is usually more absorbed in materials than the X-ray line Kβ, the Kα/Kβ ratio decreases for elements located deeper under surface. So, we propose to draw calibration diagrams that include also this Kα/Kβ ratio of the corresponding element. The current experiments are performed with handheld XRF device NITON XL3t GOLDD+. The calibration diagrams make us possible to recognize the stratified structure and estimate the approximate concentration and the mean depth of this element under the surface.

Radiation Data Science and Analytics II, Vevey Room, 13:30-15:00

X-ray and electron data science and analytics

Christopher T Chantler
University of Melbourne

Presenter: Christopher T Chantler
University of Melbourne, chantler@unimelb.edu.au

X-ray interaction cross-sections for isolated atoms and complex molecules show a complex pattern of structure, reflected in recent and current databases but in general incomplete in each and requiring new theory and new experiment to add to our understanding and utility. Further, photon and electron transport codes require such, usually theoretical, packages to predict efficiency and optimisation of detectors or signals. A new area of research lies in electron inelastic scattering where combined techniques of Density Functional Theory, high-accuracy experiment, low-energy electron transport, high-accuracy X-ray absorption spectroscopy and overlayer experiments need to be brought to bear and compiled to produce a novel understanding for all applications.

Prediction of Weather Induced Background Radiation Fluctuation with Machine Learning Method

Zheng Liu, University of Illinois Urbana-Champaign, Erik Medhurst, University of Illinois Urbana-Champaign, Clair J. Sullivan, University of Illinois Urbana-Champaign

Presenter: Zheng Liu, University of Illinois Urbana-Champaign, zliu86@illinois.edu

Background radiation estimation plays an important role in the anomalous radiation detection. Accurately estimating temporal and spatial fluctuations of background radiation can reduce the false alarm rate and improve the estimation accuracy of anomalous source location. It has been long observed that background radiation is positively correlated with precipitation due to the scavenging effect of rain and snow. Studies have used background radiation measurements and radon decay chain equations to derive the background radiation level as a function of time. In this paper, machine learning algorithms are studied to predict the background radiation level based on previous weather and radiation data. Preliminary results show that by using radiation and weather data, machine learning algorithms outperform the traditional moving-window average algorithm. Machine learning methods correctly estimate background radiation fluctuating trends and capture the radiation fluctuation peaks induced by precipitation.

An Automated Isotope Identification and Quantification Algorithm for Isotope Mixtures in Low-Resolution Gamma-ray Spectra

Mark Kamuda, University of Illinois UIUC, Clair J. Sullivan, University of Illinois UIUC

Presenter: Mark Kamuda, University of Illinois UIUC, kamuda1@illinois.edu

There is a need to develop an algorithm that can quickly perform radioisotope identification and quantification in low-resolution gamma-ray spectra that contain a mixture of many isotopes. While algorithms for this task exist, they operate too slowly to use on a very large dataset of spectra in a small time-frame. Pattern recognition algorithms such as artificial neural networks (ANNs) are prime candidates to solve this problem due to their ability to model complicated functions. In this paper an algorithm for mixtures of radioisotopes based on neural networks is presented and evaluated against a series of measured spectra.

Dosimetry and Detector Applications I, Montreaux Room, 13:30-15:00

Double-Sided Microstructured Semiconductor Neutron Detectors

Douglas S. McGregor[1], Steven L. Bellinger[2], Ryan G. Fronk[1], Taylor R. Ochs[1], Luke C. Henson[2]
[1]SMART Laboratory, Dept. Mechanical and Nuclear Engineering, Kansas State University, Manhattan, KS 66506
[2]Radiation Detection Technologies, Inc., Manhattan, KS 66506

Presenter: Douglas S. McGregor*
SMART Laboratory, Dept. of Mechanical and Nuclear Engineering, Kansas State University, Manhattan, KS 66506 (mcgregor@ksu.edu)

Planar semiconductor diode detectors coated with neutron reactive materials, such as ^{10}B or ^{6}LiF, have been investigated as neutron detectors for many decades. Unfortunately, these planar detectors are limited to less than 5% intrinsic thermal neutron detection efficiency. Microstructured semiconductor neutron detectors (MSND) have microstructures etched deeply into the substrates, backfilled with neutron reactive material, and have much higher efficiencies that typically exceed 30% thermal neutron detection efficiency. In recent years, double-sided microstructured semiconductor neutron detectors (DS-MSND) have been produced with >54% thermal neutron detection efficiency. These double-sided detectors operate on the built-in pn junction potential of the contact interface and do not require a bias voltage. These DS-MSNDs have been integrated with compact low-noise and low-power electronics, thereby, allowing for ruggedized instruments to be fashioned from the devices. A discussion on the physics, performance and instrumentation of these MSNDs will be presented.

The development of a dosimetry protocol for X-ray microbeam radiotherapy: Testing the limits of high-resolution dosimetry and Monte Carlo modelling

Richard Hugtenburg[1], Dimitri Reynard[1,2], Paolo Pellicioli[1,2], Francois Esteve[2], Elke Bräuer-Krisch[3]
[1.] Swansea University, Swansea, U.K.
[2.] Université Grenoble Alpes, Grenoble, France
[3.] European Synchrotron Radiation Facility, Grenoble, France

Presenter: Richard Hugtenburg
Swansea University, Swansea, U.K.

X-ray microbeam radiotherapy is a promising new modality, offering the possibility of dramatic dose escalation, whilst achieving excellent normal tissue-sparing. Microbeams are typically 50 micron in width and need to be delivered at extremely high dose-rates to avoid smearing from the motion of the patient; currently only viable at 3rd generation X-ray synchrotron, such as at the ID17 beamline at the ESRF. Animal and human trials are being considered for alternative methods of delivering radiosurgery of epilepsy and for the treatment of highly radioresistant tumours, such as glioma. Research into establishing an accurate dosimetry protocol is the subject of a collaboration between Swansea University and Université Grenoble Alpes.

High spatial-resolution dosimetry (of the order of microns) is needed to determine treatment parameters including the microbeam dose relative to open fields, which quantifies primary dose in relation to reference fields and the peak-to-valley ratio, which quantifies the dose between microbeams, due to scattered photons. Use has been made of radiochromic film and microdiamond (PTW) detectors, where both dosimetry systems are expected to offer excellent tissue-equivalence. Models using a variety of Monte Carlo codes, EGSnrc, EGS5, GEANT4 and PENELOPE, have been compared to measurements. The codes are tested by the challenging nature of the problem, given that considerable doses are due to scattered radiation, which must also be determined accurately.

Significant differences (in the range 5-10%) have been observed between the experimental data and models, and also between modelling codes. This has motivated a careful analysis of the implementation of Compton scattering in the kilovoltage energy range. The work has lead to improvements in the precision of measurements and models and better quantification of treatment parameters suggesting that accurate dosimetry, comparable to conventional radiotherapy techniques, is viable.

Performance Characterization and Optimization of Suspended Foil Microstrip Neutron Detectors

Nathaniel S. Edwards, Kansas State University, Benjamin W. Montag, Kansas State University, Luke C. Henson, Radiation Detection Technologies Inc., Steven L. Bellinger, Radiation Detection Technologies Inc., Daniel M. Nichols, Kansas State University, Ryan G. Fronk, Kansas State University, Michael A. Reichenberger, Kansas State University, Douglas S. McGregor, Kansas State University

Presenter: Nathaniel S. Edwards, Kansas State University, nedwards@ksu.edu

Suspended foil microstrip neutron detectors (SFMNDs) have recently been investigated as a potential alternative neutron-detection technology to 3He proportional counters and offer a mechanically and electrically robust alternative to to multi-wire-proportional-counter-based 3He alternative technologies. Previously, SFMNDs fabricated with silicon-based microstrip electrodes were tested in which the microstrip electrode contained a 3-μm thick SiO2 layer on both surfaces of the silicon substrate. Due to suspected ionic charging of the microstrip electrode SiO2 layer and poor signal-to-noise ratio stemming from a measured microstrip electrode capacitance of 757 pF, microstrip electrodes were subsequently fabricated using 500-μm thick Schott Borofloat® 33 with the same size, strip geometry, and strip metals as were used for the silicon substrate. Once fabricated, the capacitance of the Schott Borofloat® 33 microstrip electrodes was measured to be 67 pF before characterizing the electrodes using a collimated-241Am alpha-particle source to study microstrip-electrode-substrate charging phenomena and drift-electric-field strength distribution. The Schott Borofloat® 33 microstrip electrode appeared to be electrically-stable over the course of approximately 20 hours after a 1.5 hour initial electrode stabilization period, while the signal amplitude of the silicon-based microstrip electrode continuously degraded over the same course of time after approximately the same initial electrode stabilization period. The drift-electric-field strength distribution was also studied by monitoring the peak channel from energy deposited using a collimated-241Am at various vertical positions along the drift-electric-field length. The study was performed using a planar-type drift electrode coupled separately with two different anodes: a microstrip (microstrip-planar) electrode and a planar-type (planar-planar) electrode. The microstrip-planar scenario exhibited a non-uniform drift-electric-field strength distribution indicated by the increase in peak channel number as the source was positioned closer to the microstrip electrode surface. Conversely, the planar-planar scenario exhibited a drift-electric-field strength distribution with slight non-uniformities and resembles the position-sensitive nature of a parallel-plate ionization chamber.

Status of Fast-Neutron Detector Development at KSU for the TREAT Hodoscope

Jeremy A. Roberts,

Mark J. Harrison,
Wenkai Fu,
Priyarshini Ghosh,
Douglas S. McGregor
Dept. of Mechanical and Nuclear Engineering, Kansas State University, Manhattan, KS 66506

Presenter: Douglas S. McGregor
Dept. of Mechanical and Nuclear Engineering, Kansas State University, Manhattan, KS 66506, mcgregor@ksu.edu

Recent progress in the development of fast-neutron detectors for use at the Transient REActor Test (TREAT) facility hodoscope is presented. The hodoscope provides line-of-site viewing of nuclear reactor fuel samples subject to immense irradiation through reactor pulsing. The fast neutrons emitted from fission of the fuel sample stream through a large steel collimator and impinge on an array of over 300 detectors. Originally, the TREAT hodoscope was outfitted with Hornyak buttons. These detectors are ZnS(Ag)-based devices used mainly for their relativell high gamma-ray discrimination properties. However, they suffer from low neutron detection efficiency and significant background noise from Cherenkov radiation produced in the surrounding plastic light waveguide. Three alternative technologies are under consideration at Kansas State University to replace these Hornyak buttons: a modified ZnS(Ag) device with significantly reduced light waveguide mass coupled with overall improved neutron detection efficiency; a micro-structured semiconductor neutron detector (MSND) based on a hydrogenous reactant; and a hydrogen-loaded, scintillating gas detector. Computational modeling of the three detector configurations suggest that each provides intrinsic efficiencies of over 2% with excellent gamma-ray rejection.

Poster Session II, St. Gallen Room, 15:30-17:30

Development of Radioisotope Identification algorithm for a Radiation Detection Portal Monitor

Yewon Kim, Myung soo Kim, Kyung Taek Lim, Gyuseong Cho, Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, Myungkook Moon, Korea Atomic Energy Research Institute

Presenter: Yewon Kim, Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, yewonkim@kaist.ac.kr

Radioisotope identification with spectroscopy for a radiation detection portal monitor(RPM) is difficult. Because the limited measurement time of RPM for a vehicle and the relatively low light output of a polyvinyl-toluene(PVT) based plastic scintillator

used in the RPM system are not allow to obtain sufficient energy spectrum. Therefore, the gross counting and energy windowing algorithm are broadly used in current RPM system instead of spectroscopic analysis. The gross counting algorithm is able to screen radioactive material contained cargos but cannot distinguish special nuclear materials(SNM), and naturally occurring radioactive materials(NORM) and cannot identify radioisotope. To overcome this limitation of gross counting algorithm, new method, energy windowing algorithm, distinguishing SNM and NORM has been developed but there are still false or nuisance alarms. Because energy windowing algorithm is not spectroscopic analysis but simply compare the ratio of high and low energy counts. Thus this algorithm cannot identify radioisotope of radioactive material and caused a lot of nuisance alarms.In this paper, new approach to identify energy spectra using inverse matrix(IM) algorithm and classify nuclide is suggested. To evaluate this method, various gamma energy spectra of four calibration gamma sources were measured by four photomultipliers(PMTs) attached RPM system with measurement time from 0.01 to 50.00 seconds. As a result, IM algorithm could perfectly identify spectra of 133Ba, 137Cs, 60Co, 22Na, background radiation and 40K included potassium fertilizer measured from 0.1 to 20.0 seconds.

Dosimetric characteristics of Lithium Borate glass doped dysprosium oxide as a solid TL detector

M.H.A. Mhareb, Department of Physics, Faculty of Science, Isra University, 11622 Amman, Jordan.
S. Hashim, Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, UTM, 81310 Skudai, Johor, Malaysia
S.K. Ghoshal, Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, UTM, 81310 Skudai, Johor, Malaysia
Y.S.M. Alajerami,Department of Medical Radiography, Al-Azhar University, Gaza Strip, Palestine

Presenter: Mohammad Abu Mhareb, mmhareb@hotmail.com

The dosimetric characteristics of recently developed borate glass dosimeter modified with lithium oxide (LB) and doped with Dy2O3 are reported. A simple glow curve of Dy doped LB is seen with a single prominent peak (Tm) at 190 ºC. The TL intensity response displays an enhancement of ~160 times due to the addition of Dy2O3 (0.5 mol%) to LB composite. The proposed dosimeter displays good linearity up to 4 Gy, excellent reproducibility and tissue equivalent effective atomic numbers ~7.99 are attained. The trap parameters, including geometric factor (μg), activation energy (E) and frequency factor (s) associated with LB:Dy are also calculated. These favorable dosimetric characteristics of prepared glasses may donate towards the development of Li2O-B2O3:Dy2O3 radiation dosimeters.

Novel Dosimetric Study of SP2 to SP3 Irradiation hybridisation Ratio in Free –Standing CNTs

Abdulaziz H Alanazi[1,2], Izabela Jurewicz[1], Amjad Alyahyawi[1,4], Abdullah Alsubaie[1,5], Steven Hinder[6], Jorge Bañuls-Ciscar[6], Mohammed Alkhorayef[1,7], J.F. Watts[6] and D.A. Bradley[1,8]
[1] Centre for Nuclear and Radiation Physics, Department of Physics, University of Surrey, Guildford, Surrey, GU2 7XH, UK.
[2] Medical Physics Department, Cancer Centre, Prince Mohammed Medical City, P.O. Box: 2254 Sakaka Aljouf 42421, Saudi Arabia.
[3] Physics Department, Faculty of Applied Sciences, Umm AL-Qura University, Makkah, P.O. Box 175, Saudi Arabia.
[4] Department of Diagnostic Radiology, University of Hail, Hail, Saudi Arabia
[5] Physics Department, Taif University, Al-Taif, PO Box 888, Saudi Arabia.
[6] The Surface Analysis Laboratory, Department of Mechanical Engineering Sciences, University of Surrey, Guildford, Surrey. GU2 7XH, UK.
[7] Department of Radiological Sciences, King Saud University, P.O. Box 10219, Riyadh 11433, Saudi Arabia.
[8] Sunway University, Institute for Health Care Development, Jalan Universiti, 46150 PJ, Malaysia

Presenter: Abdulaziz H Alanazi, University of Surrey, a.alanazi@surrey.ac.uk

Over the past decade a considerable amount of research has focussed on the adaptation of carbon nanotubes (CNTs) for a wide range of applications, including gas detectors, photonics, radiation sensors and energy storage. In previous studies by this group, investigating the thermoluminescent (TL) properties of CNTs, their sensitivity towards ionising radiations has been observed using beta radiation, delivered at dose levels of a few Gy. Strain and impurity defects in CNTs have been noted to give rise to substantial TL yields, providing an initial measure of the extent to which electron trapping centres exist in various qualities of CNT, from super-pure to raw. In present study the contribution to TL of irradiated CNTs is investigated with respect to changes within the atomic orbitals in the lattice, pointing to a possible new method in radiation dosimetry. The surface-sensitive method, one highly suited to the thin (few µm thick) CNT samples that have been produced through buckypaper fabrication, is based on use of the X-Ray Photoelectron Spectroscopy (XPS) technique (operated at 1.4 kV), evaluating the ratio of sp2 to sp3 hybridisation. Various CNT samples have been examined subsequent to their irradiation to a variety of sources and dose, use being made of high (90Sr beta, 0.546 MeV) and low electron energies (the latter supplied by electron microscope operated at 20 keV). Increased sp2 to sp3 hybridisation is observed with increase in dose deposition. The use of the 1.4 kV source (in the process of XPS) has also shown to increase the TL signal, with more detailed study of this being currently undertaken. Considerable advantage is seen in making use of the TL properties of CNTs in dosimetry, not least in terms of the effective atomic number, being similar to that of adipose tissues, making them suitable for soft tissue dosimetry.

COMPARATIVE STUDY OF THE TL RESPONSE OF LiF:Mg,Ti AND CaSO4:Dy IN THE CLINICAL ELECTRON BEAMS DOSIMETRY APPLIED TO TOTAL SKIN IRRADIATION – TSI TREATMENTS

[1-]Shirlane Barbosa de Almeida, Letícia Lucente Campos (Radiation Metrology Center - Instituto de Pesquisas Energéticas e Nucleares – IPEN/CNEN).
[2-]Roberto Kenji Sakuraba, Ana Carolina Pires de Rezende (Radiotherapy department of the Hospital Israelita Albert Einstein).

Presenter: Letícia Lucente Campos (Radiation Metrology Center - Instituto de Pesquisas Energéticas e Nucleares – IPEN/CNEN)., lcrodri@ipen.br

Dose verification in the patient has become an important part of quality radiotherapy programs in the departments. The thermoluminescent dosimeters have become essential for the determination of the dose applied to the patient; these detectors present a great accuracy and precision in the measurements, thus enabling the detection of various types of errors in the dosing process. High energy electron beams (> 5 MeV) have wide use in the medical field mainly in the treatment of various types of cancer, or in the irradiation of all skin - TSI. TSI dosimetry is difficult because of the complexity of the treatment in assessing dose uniformity and measuring the absorbed dose at shallow depths throughout the cutaneous surface area, resulting in wide variation in the dose distribution. TLDs have proven to be very useful for the distribution and verification of the dose prescribed for the patient, since the dose may differ from place to place due to the geometry of the patient's body, overlapping of structures and asymmetries of the radiation field. In this work the results obtained from the comparative study and the performance of the LiF:Mg,Ti and CaSO4:Dy detectors used in the clinical electron beams dosimetry applied to total irradiation of the skin treatment are presented. Other factors were analyzed in this study such as the homogeneity of the field and the dose at the calibration point (ZRef), where the detectors were located in the regions anterior, posterior, right anterior oblique, right posterior oblique and right side.

Characterization of Lithium Diborate, Sodium Diborate and Commercial Glass Exposed to Gamma Radiation via Linearity Analyses

[1]Lucas N. de Oliveira, Instituto Federal de Educação, Ciência e Tecnologia de Goiás-IFG, 74055-110, Goiânia-GO, Brazil
[2]Eriberto O. do Nascimento, Instituto Federal de Educação, Ciência e Tecnologia de Goiás-IFG, 74055-110, Goiânia-GO, Brazil
[3]Patrícia L. Antonio, Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear-IPEN/CNEN-SP, 05508-000, São Paulo-SP, Brazil
[4]Marcello R.B. Andreeta, Universidade Federal de São Carlos-UFSCar, 13565-905, São Carlos-SP, Brazil

[5]Linda V.E. Caldas, Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear-IPEN/CNEN-SP, 05508-000, São Paulo-SP, Brazil

Presenter: Patrícia L. Antonio,
Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear, IPEN/CNEN-SP, patrilan@ipen.br

The linearity characteristic in radiation dosimetry presents a growing interest in medical physics. In this work, the lithium diborate, sodium diborate and commercial glass were irradiated with doses from 10 Gy to 10 kGy using a 60Co Gamma-Cell system 220, and then they were evaluated with the UV-Vis technique. The linearity analyses were applied through four methodologies, which the objetive to find linear regions in their response. The results show that all four analyses indicate linear regions for the studied radiation detectors. The samples with higher linearity range, in descending order, were lithium diborate, sodium diborate and commercial glass. In conclusion, the materials may be promising in dosimetry for intermediate and high doses of radiation.

Evaluation of the thermally and optically stimulated response of as Italian Silicate irradiated in 60Co beams

Patrícia L. Antonio [1],
Raquel A.P. Oliveira [2],
Helen J. Khoury [3],
Linda V.E. Caldas [1]
[1]Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear, IPEN/CNEN-SP
[2]Instituto de Pesquisa em Ciência dos Materiais, IPCM, Universidade Federal do Vale do São Francisco, UNIVASF
[3]Departamento de Energia Nuclear, DEN, Universidade Federal de Pernambuco, UFPE

Presenter: Patrícia L. Antonio,
Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear, IPEN/CNEN-SP, patrilan@ipen.br

In this work, pellets were manufactured in a proportion of 2:1 of powdered samples of Obsidian black:Teflon (dimensions of 6.0 mm in diameter and 0.8 mm in thickness). The pellets were irradiated using a Gamma-Cell 220 System, model 200, Atomic Energy of Canada LTD (60Co). The TL and OSL responses were analyzed using the reader system composed by the TL/OSL meter Risø, model TL/OSL-DA-20, and the TSEE response was obtained using a homemade reader system developed at the Calibration Laboratory, at IPEN. After the TL, OSL and TSEE measurements, the pellets were thermally treated at 400 °C during 1 h, for reutilization. The physical and chemical characterization of powdered Obsidian was also investigated using the X-ray diffraction, XRD (using a diffractometer Equinox 1000, Inel), scanning electron microscope, SEM,

and energy dispersive X-ray spectroscopy, EDX (the last two using a scanning electron microscope with an energy dispersive X-ray microanalyser Vega 3 SEM, Tescon) techniques. The results proved, basically, that Obsidian is a natural glass and composed mainly of silica (82.4%). The TL glow curve revealed a dosimetric peak at the temperature of 220 °C, and the TSEE emission curve showed a peak at about 300 °C. The results obtained in the reproducibility of response test were: 2.9% (TL), 3.0% (TSEE) and 3.1% (OSL). The lower detection limits were: 48.1 Gy (TL), 18.1 Gy (TSEE) and 79.3 Gy (OSL). The dose-response curves showed, in the case of TL, a supralinearity behavior between only 500 Gy and 2 kGy with a following saturation of the response. For the TSEE response, a sublinearity was seen with a following saturation of the response. For the OSL technique, linearity could be observed in the interval from 500 Gy to 2 kGy and then a tendency to saturation.

Estimative of conversion coefficients for absorbed and effective doses in pediatric CT examinations in two different PET/CT scanners

1. Ana P. Perini, Instituto de Física, Universidade Federal de Uberlândia (INFIS/UFU), Uberlândia, MG, Brazil;
2. William S. Santos, Instituto de Física, Universidade Federal (INFIS/UFU), Uberlândia, MG, Brazil;
3. Lucio P. Neves, Instituto de Física, Universidade Federal de Uberlândia (INFIS/UFU), Uberlândia, MG, Brazil;
4. Walmir Belinato, Departamento de Ensino, Instituto Federal de Educação, Ciência e Tecnologia da Bahia (IFBA), Vitória da Conquista, BA, Brazil;
5. Linda V. E. Caldas, Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear (IPEN/CNEN), São Paulo, SP, Brazil

Presenter: Linda V. E. Caldas
Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear (IPEN/CNEN) São Paulo, SP, Brazil, lcaldas@ipen.br

The use of computed tomography (CT) in pediatric patients has grown substantially in recent years. As a result, there is an increase to maintain the radiation doses as low as possible, in order to avoid long-term effects, as cancer. In this work, the radiation doses on radiosensitive organs of pediatric patients undergoing head, chest and abdomen CT examinations, utilizing Monte Carlo simulations, were evaluated. In this sense, a new set of pediatric virtual anthropomorphic phantoms with Monte Carlo simulation was employed to determine the conversion coefficients for absorbed and effective doses. Two CT equipment were simulated, taking into account the main characteristics of those commercially available. The F6 tally (MeV/g) was employed to compute the absorbed organ doses. The obtained results were converted to conversion coefficients for all radiosensitive organs, considering all applied beams. The highest conversion coefficients for effective dose were for the newborn virtual anthropomorphic phantom. Therefore, this work provides a useful tool regarding the risks involving ionizing

radiation in pediatric patients, employing a reliable technique.

RELIABILITY OF AN X-RAY SYSTEM FOR CALIBRATING AND TESTING PERSONAL RADIATION DOSIMETERS

M.C. Guimarães, Centro de Desenvolvimento da Tecnologia Nuclear, CDTN, Belo Horizonte, MG, Brazil
P.H.G. Rosado, Instituto de Radioproteção e Dosimetria, IRD, Rio de Janeiro, RJ, Brazil.
P.G. Cunha, Instituto de Radioproteção e Dosimetria, IRD, Rio de Janeiro, RJ, Brazil
T. A. Da Silva, Centro de Desenvolvimento da Tecnologia Nuclear, CDTN, Belo Horizonte, MG, Brazil

Presenter: Teogenes A. Da Silva, Centro de Desenvolvimento da Tecnologia Nuclear, CDTN, Belo Horizonte, MG, Brazil, silvata@cdtn.br

Metrology laboratories are expected to maintain standardized radiation beams and traceable standard dosimeters to provide reliable calibrations or testing of detectors. A characterization of an X-ray system for performing calibration and testing of radiation dosimeters used for individual monitoring was done. Stability and traceability of the standard ionization, reliability of the calibration procedure in terms of air kerma in air and ability to provide Hp(10) calibrations were studied. Results proved that the X-ray calibration was reliable.

Neutron spectra from Neutron Standards Laboratory (LPN/CIEMAT) sources with two Bonner sphere spectrometers

Marco Aurélio de Sousa Lacerda [1], Roberto Méndez-Villafañe [2], Xandra Campo Blanco[2], Alfredo Lorente [3], Sviatoslav Ibañez [3], Eduardo Gallego [3], Hector René Vega-Carrillo [4].
Institution 1: Laboratório de Calibração de Dosímetros, Centro de Desenvolvimento da Tecnologia Nuclear, CDTN/CNEN, Belo Horizonte, Brazil.
Institution 2: Laboratorio de Patrones Neutrónicos, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, CIEMAT, Madrid, España.
Institution 3: Departamento de Ingenieria Energética, Universidad Politécnica de Madrid, UPM, Madrid, España.
Institution 4: Unidad Academica de Estudios Nucleares, Universidad Autónoma de Zacatecas, UAZ, Zacatecas, Zac, Mexico

Presenter: Marco Aurélio de Sousa Lacerda
Institution: Laboratório de Calibração de Dosímetros, Centro de Desenvolvimento da Tecnologia Nuclear, CDTN/CNEN, Belo Horizonte, Brazil, madslacerda@gmail.com

The Neutron Standards Laboratory (LPN: Laboratorio de Patrones Neutrónicos) is the newest facility of the Ionizing Radiation Metrology Laboratory (LMRI) of the CIEMAT (Centro de Investigaciones Energéticas Medioambientales y Tecnológicas). LPN has two calibration neutron sources, 241Am-Be and 252Cf, as recommended by International Organization for Standardization, ISO 8529-2 standard, for monitor and dosimeter calibration purposes. Studies have been performed to verify the shielding of the installation and to characterize the neutron field in the irradiation room, by means of Monte Carlo method. In this study, we measured total neutron spectra at 115 cm from each neutron source, using two different Bonner Sphere Spectrometers (BSS): (a) LPN/CIEMAT BSS system, constituted of 12 spheres with a spherical 3He SP9 counter (Centronic Ltd., UK) and; (b) the BSS system of the Neutron Measurements Laboratory of Universidad Politécnica de Madrid (LMN-UPM), with 6 spheres and a small cylindrical 4 mm-diameter x 4 mm-height 6LiI(Eu) scintillator (Ludlum Measurements). Data obtained with the CIEMAT BSS system were unfolded with the MAXED computer code, from the UMG 3.3 package, and specific response matrix, with 221 energy bins, determined in the Physikalisch-Technische Bundesanstalt (PTB). Data obtained with the LMN-UPM BSS system were unfolded with the BUNKIUT code with the response matrix UTA-4, with 31 energy bins. Additionally, a new response matrix, with 221 energy bins, was used to unfold the LMN-UPM BSS data. Good agreements were observed for the total spectra obtained with the different BSS system/unfold codes. Good agreements were also observed for the integral quantities, such as total fluence and fluence components (thermal, epithermal and fast), ambient dose equivalent (H*(10)) and average energy.

Study of the influence of atmospheric air climatic parameters on the air kerma measurements in low energy X reference radiation fields

Marcus Tadeu Tanuri Figueiredo [1], Marco Aurélio de Sousa Lacerda [1], Teógenes Augusto da Silva [1]
Institution 1: Laboratório de Calibração de Dosímetros, Centro de Desenvolvimento da Tecnologia Nuclear, CDTN/CNEN, Belo Horizonte, Brazil.

Presenter: Marco Aurélio de Sousa Lacerda
Institution: Laboratório de Calibração de Dosímetros, Centro de Desenvolvimento da Tecnologia Nuclear, CDTN/CNEN, Belo Horizonte, Brazil., madslacerda@gmail.com

The control of climatic conditions in a radiation metrology laboratory is very important. Air pressure, temperature and humidity affect the value of the air density, and, consequently, alter the absorption of the photon radiation. Then, the values of the air kerma Ka, conversion coefficients from Ka to the dose equivalent quantities (hp,K(10,) and h*K(10)) and their product (Hp(10) and H*(10)) are affected by climatic changes. For low energy X radiation fields, changes in climatic conditions are more critical. The International Organization for Standardization (ISO), by mean the ISO 4037-4, specifies corrections for air density for all quantities defined in 10 mm depth in tissue for nominal tube potentials varying from 10 kV to 30 kV (inclusive). In this work, we used Monte Carlo method to evaluate the influence of atmospheric air climate parameters on the air kerma measurements, for the ISO low energies, series N and L. Simulations were performed using the MCNPX code version 2.7.d, running under MPI (Message Passing Interface) on a computational cluster. We simulated the air with different humidity levels, and consequently, different densities and elemental compositions. The ISO 4037 reference beams of the Dosimeters Calibration Laboratory of the Nuclear Technology Development Center (LCD / CDTN) were used to validate the Monte Carlo simulations. The correction factors, calculated in this work, for the majority of the ISO qualities, were more sensitive to the density variations than the factors provided by the ISO 4037-4.

Performance of TL and OSL Techniques Using CaSO4 and Al2O3 Dosimeters for Mean Glandular Dose (MGD) and Entrance Surface Skin Dose (ESD) Determination in a Digital Mammographic Unit as Alternative Dosimeters

Felícia Del Gallo Rocha
Instituto de Pesquisas Energéticas e Nucleares/CNEN-SP
Daniel Villani
Instituto de Pesquisas Energéticas e Nucleares/CNEN-SP
Vicente de Paulo de Campos
Instituto de Pesquisas Energéticas e Nucleares/CNEN-SP
Maria do Socorro Nogueira
Centro de Desenvolvimento da Tecnologia Nuclear/CDTN-CNEN/MG
Maurício Eduardo Goulart
Instituto de Pesquisas Energéticas e Nucleares/CNEN-SP
Valter Sichito
VAS Radiologia
Letícia Lucente Campos
Instituto de Pesquisas Energéticas e Nucleares/CNEN-SP

Presenter: Felícia Del Gallo Rocha
Instituto de Pesquisas Energéticas e Nucleares/CNEN-SP, fdgrocha@uol.com.br

The mammography is the most important and simple tool in the diagnosis of breast diseases in women. In digital mammography, the process of image acquisition, display and storage are separated which allows optimization of each. Despite the innumerous advantages of this technique, such as an accurate diagnosis for women with dense breast, it was noticed an increase of radiation doses to obtain the images by the new system. As with any examination that includes x-rays, there is always a small stochastic risk of inducing cancer. It is therefore important to evaluate the risk from the dose delivered to the patient during the screening process. The mean glandular dose within the breast is the recommended quantity to evaluate the risk from radiation to the breast. To guarantee proper conditions of protection for patients, the radiation dose should be as low as reasonably achievable possible and simultaneously compatible with image

quality requirements. Thus, this work proposes the use of the thermoluminescent (TL) CaSO4:Dy sintered discs, produced at IPEN, widely used in individual, environmental and area monitoring in Brazil, and Al2O3:C optically stimulated luminescence (OSL) ‘dot’ dosimeters, manufactured by Landauer® Inc., as application as easy-to-use and low cost alternative dosimeters to evaluate the entrance skin doses (ESD) delivered to patients, the half value layer (HVL) and the mean glandular doses (MGD) in a mammographic digital unit, comparing these two techniques with the results obtained using an All-in-one QC meter. The results obtained demonstrated that the TL and OSL dosimetry systems and the CaSO4 and Al2O3 dosimeters used are able to evaluate the entrance skin dose as well as mean glandular doses in a digital mammographic unit accurately within the requirements, and they can be considered a practical, simple, easy-to-use and low cost tools for verification of these items in a Quality Assurance Program.

Application of a Tandem System for HVL evaluation in Computed Tomography
Ladyjane Pereira Fontes, Instituto de Pesquisas Energéticas e Nucleares, IPEN – CNEN/SP. Av. Prof. Lineu Prestes, 2242 - Cidade Universitária – 05508-000. São Paulo - SP – Brasil Maria da Penha A. Potiens, Instituto de Pesquisas Energéticas e Nucleares, IPEN – CNEN/SP. Av. Prof. Lineu Prestes, 2242 - Cidade Universitária – 05508-000. São Paulo - SP – Brasil, Eduardo Lima Corrêa,
Instituto de Pesquisas Energéticas e Nucleares, IPEN – CNEN/SP. Av. Prof. Lineu Prestes, 2242 - Cidade Universitária – 05508-000. São Paulo - SP – Brasil

Presenter: Ladyjane Pereira Fontes, lpfontes@ipen.br

Computed Tomography (CT) is a method of imaging used for diagnosis and diseases treatment. In CT equipment due to its geometry, the determination of the HVL is a difficult task and is usually determined only by the manufacturer. By definition, the energy of a beam is determined by the value of HVL. When HVL values are not easily determined, as in the case of CT, it is possible to evaluate the effective energy of the beam through a system consisting of the use of different energy dependent dosimeters, where the ratio between the calibration curve responses in Energy can provide the effective energy of the beam (Tandem System). The application of this system was proposed by Kenney and Cameron1 and Gorbics and Attix2 that used thermoluminescent materials to determine energy of gamma and X radiation. In 2004, Maia3 studied the application of a Tandem System obtained through a set formed by an ionization chamber of the Type pencils and cylindrical absorber sleeves made of aluminum, PMMA and copper, as a non-invasive method for the determination of HVL values in computed tomography beams. Although the proposed Tandem System initially consists of two dosimeters with different energetic dependencies, the sets formed by the ionization chamber and the cylindrical absorber layers of different materials can also be considered a Tandem System. Taking as a reference the System built by Maia3, a Tandem System was developed at the Institute of Energy and Nuclear Research

(IPEN), formed by cylindrical absorber layers of aluminum and PMMA. The thickness of the aluminum layers was chosen from the HVL values of the standard RQT beams, implemented in 2010 by Dias4 in IPEN's Instrument Calibration Laboratory (LCI).

Using 6MV photon to evaluate the effect of surface dose under different thickness of bolus with different gaps

Hsiao-Ju Fu ; Yuk-Wah Tsang ; Chih-Chia Chang ; Cheng-Yen Lee
Departament of Radiation Oncology, Dimanson Medical Foundation Chia-Yi Christian Hospital, Taiwan

Presenter: Hsiao-Ju Fu;Departament of Radiation Oncology, Dimanson Medical Foundation Chia-Yi Christian Hospital, Taiwan, evelynhjf@gmail.com

6 MV photons are commonly used for treatment of head and neck cancer due to their physical properties and penetration. Superflab was selected for superficial lesions. This research focused on the results of the surface dose in phantom with different gaps measured by Markus parallel chamber and ISP Gafchromic EBT3 film. The points on the calibration curve of the Gafchromic film are within 1% variation. Three measurements were taken on phantom. The measured mean surface doses between Markus parallel chamber and ISP Gafchromic EBT3 film are within 5% deviation. All ionizations were normalized to the reference point of 10×10 ㎝2. The relative doses of field size 5×5、10×10 and 15×15 were 65.07%、48.85% and 29.27%；94.92%、79.47% and 54.18%；98.6%、91.72% and 75.21%under air gap of 3㎝、5.5㎝ and 9 ㎝, respectively. If Superflab use leads to poor contact with the skin, the results of this suggest that small field sizes would induce more significant decreased magnitude of surface dose.

Dose re-evaluation in personal dosimetry by using PTTL method of LiF:Mg,Cu,Si TLD

Hyoungtaek Kim, Korea Atomic Energy Research Institute(KAERI), Min Chae Kim, KAERI, Jungil Lee, KAERI, In-Su Chang, KAERI, Seung Kyu Lee, KAERI, Jang-Lyul Kim, KAERI

Presenter: Hyoungtaek Kim, Korea Atomic Energy Research Institute(KAERI), kht84@kaeri.re.kr

PTTL characteristics of LiF:Mg,Cu,Si which is developed by Korea Atomic Energy Research Institute were presented to provide a simple and reliable method for a dose re-evaluation compatible with routine personal dosimetric service. A diameter of 4.5 mm and thickness of 0.8 mm pellet type TLD was used after a dual step thermal anneal of 300˚C for 10 min followed by 260˚C for 10 min to obtain a thermal stability. For optimal

UV illumination, samples were placed under 254 nm UV lamp for 90 min. The signal of PTTL is only around 2 % of the TL's due to a low density of high temperature deep traps. A signal difference of PTTL between samples showed up to 2 times which indicate a high variation in a density of deep trap between samples. Various thermal treatments after each PTTL measurement were carried to remove the residual PTTL signals. A condition of 250˚C / 20 min with the UV exposure fully resets the residual signal to the same level of the dual-step annealing and 8 repeat measurements were assured without TL peak degradation. Dose response of PTTL in the range of 1.14 to 51.3 mGy was measured. Zero dose and minimal detectable dose (MDD) were also verified using the PTTL signal after dual-step thermal anneal.

Influence of the vials radioactive residue in Nuclear Medicine procedure applied to a new "in situ"activimeter calibration methodology

Lilian Toshie Kuahara , Instituto de Pesquisas Energéticas e Nucleares, Universidade de São Paulo., Eduardo Corrêa,Instituto de Pesquisas Energéticas e Nucleares,Universidade de São Paulo., Maria da Penha Albuquerque Potiens,Instituto de Pesquisas Energéticas e Nucleares, Universidade de São Paulo.

Presenter: Maria da Penha Albuquerque Potiens, mppalbu@ipen.br

A safe and efficient Nuclear Medicine Services (NMS) performance depends, among other factors, on a complete quality assurance program, mainly in the case of the activity meters. Many elements may influence this equipment response, being the major errors related to vials characteristics, such as volume and geometry, as presented in other studies [1,2]. Correction factors must be applied in order to avoid patient exposure to excessive doses.However, another aspect that should be taken into account is how much radioactive material is lost during the radioisotope labeling, a process that includes many recipient changes.In this study we present the estimated activity lost during 99mTc labeling process and show how important is to add this value to the total activity measured in a new "in situ" calibration procedure, in which the activity meter is not removed from its place of use. For the radioactive residue determination99mTc labeling procedure was reproduced under laboratorial conditions, resulting in losses of up to 40 %. However greater errors are expected in a NMS. Activity meter calibration using two methodologies: the first consists in a direct comparison between the two systems with the same vial (P6-P6 and 10R-10R), and the second is a comparison made using two different vials (P6-10R), with and without geometry and residual activity corrections. A calibration factor of 0.999 was obtained in the reference situation. The same procedure performed without the application of the necessary correction factors resulted in a variation of almost 3 %, which is high considering the test was made under controlled conditions and less residue was left inside vials. The "in situ" calibration procedure worked well and was important to present the need of correction factors application, including the residue activity measurement.

Establishment of Conversion Coefficient of Whole Body Effective Dose by Human Tissue of Electron Paramagnetic Resonance (EPR)

L.H. Lai[1], Y.C. Liu[2,3], K.S. Chuang[1,2], C.F. Wang[1,2], H.H. Lin[4*], Y.X. Zhang[5], C.C. Lu[1], J.P. Lin[6]
[1] Department of Biomedical Engineering and Environmental Sciences, National Tsing Hua University, Hsinchu, Taiwan
[2] Institute of Nuclear Engineering and Science, National Tsing Hua University, Hsinchu, Taiwan
[3] Department of Radiation Oncology, Wei Gong Memorial Hospital, Miaoli, Taiwan
[4] Medical Physics Research Center, Institute for Radiological Research, Chang Gung University/Chang Gung Memorial Hospital, Taoyuan, Taiwan
[5] Department of Electronics Engineering, National Chiao Tung University, Hsinchu, Taiwan
[6] Department of Medical Imaging and Radiological Technology, Yuanpei University of Medical Technology, Hsinchu, Taiwan

Presenter: Lu-Han LAI/Department of Biomedical Engineering and Environmental Sciences, National Tsing Hua University, Hsinchu, Taiwan, soneynice@gmail.com

Electron paramagnetic resonance (EPR) dosimetry is a physical method for the assessment of absorbed dose from ionizing radiation. It can be used to detect and measure free radicals, its concentration is proportional to radiation dose the sample has absorbed. The purpose of the research is to establish the conversion coefficient relation between absorbed dose (Gy) of enamel, fingernail and whole body effective dose (Sv). Enamel powder and fingernail are placed in the Rando phantom, the absorbed dose of the samples can be estimated with EPR methods. Thermoluminescent dosimeters (TLD) are placed in critical organs of the Rando phantom to evaluate the whole body effective dose. The Rando phantom will undergo radiation by linear accelerator, the irradiation condition was as follows: photon beam (6, 10 MV), electron beam (6, 9, 12MeV) and accumulate dose (2, 10 Gy) for each fraction. The directions of irradiation come from anteroposterior, posteroanterior, bilateral. The signal-to-dose conversion factors can be obtained from calibration curves, and derive whole body effective dose with International Commission on Radiological Protection publications (ICRP-60 and ICRP-103). The conversion factor (Sv/Gy) between enamel, fingernails absorbed dose (Gy) and whole body effective dose (Sv) can be obtained. All experiments have regression with R square 0.99, the TLD charge and enamel, fingernail signal are all proportional to respective dose. The conversion factor between fingernails and whole body is all 0.89 times of that of enamel. The absorbed dose of human organs is lower on electron beam irradiation, but that of teeth, fingernails is obviously higher, the contribution of dose may come from scattering dose. In this experiment, tissue absorbed dose could be conversed to whole body effective dose. As the same accident happens, injury could be rapidly estimated, classified, and treated if excessive dose is accepted.

Photoluminescence and optically stimulated luminescence of PbO–H3BO3 and PbO–H3BO3–Al2O3 glasses

A.L.F. Novais [1], C.M. Abreu [1], L.F. Souza [1], G. R. Barrera [1,2] and D.N. Souza [1]
[1]Universidade Federal de Sergipe
[2]Corporación Universitaria del Huila

Presenter: A.L.F. Novais. Universidade Federal de Sergipe., deafisica@yahoo.com.br

In this study, we examined the basic thermoluminescent (TL) and optically stimulated luminescence (OSL) properties of PbO:H3BO3 and PbO:Al2O3-H3BO3 glasses for dosimetric applications. These glasses were produced by melting and rapid cooling method and their structural and spectroscopic properties were studied. This report focuses on lead-borate glasses due to their intense thermoluminescence and OSL properties. The TL and OSL characterization were combined with the techniques of optical and structural analyses, including density, refractive index, absorption, luminescence, X-ray diffractometry (XRD), differential thermal analysis (DTA), scanning electron microscopy (MEV), infrared spectroscopy (FT-IR) and Raman spectroscopy. The XRD standard confirms the amorphous nature of these glasses, and FT-IR spectroscopic technique showed that different groups of structural borates are present in them.

Reconstruction of X-rays spectra of clinical linear accelerators from transmission data with generalized simulated annealing

John Peter Oyardo Manrique, Physics Department, Ribeirão Preto School of Philosophy, Science and Literature (FFCLRP), São Paulo University, Alessandro Martins da Costa, Physics Department, Ribeirão Preto School of Philosophy, Science and Literature (FFCLRP), São Paulo University, National Institute of Science and Technology in Radiation Metrology at Medicine, Brazil

Presenter: John Peter Oyardo Manrique, Physics Department, Ribeirão Preto School of Philosophy, Science and Literature (FFCLRP), São Paulo University., johnp067@usp.br

The spectral distribution of megavoltage X-rays used in radiotherapy departments is a fundamental quantity from which, in principle, all relevant information required for radiotherapy treatments can be determined. The direct measurement is difficult to achieve clinically and analyzing the transmission is a clinically viable indirect method for determining clinical linear accelerators photon spectra. In this method, transmission signals are acquired after the beam passes through different thicknesses of attenuators.

The objective of this work was the establishment and application of an indirect method that used a spectral model based on generalized simulated annealing algorithm to determine the spectrum of clinical linear accelerators photons based on the transmission curve. Analysis of the spectra was made by analytical determination of dosimetric quantities and related parameters.

Equivalence between Solid Water and printed PLA plates for 6 MV clinical photon beam - An assessment using thermoluminescent dosimetry

VALERIANO, C.C.S., Instituto de Pesquisas Energéticas e Nucleares – IPEN.
MORENO, C.S., Hospital Israelita Albert Einstein
CORRÊA, E.L., Instituto de Pesquisas Energéticas e Nucleares – IPEN.
SAKURABA, R.K., Hospital Israelita Albert Einstein
CAMPOS, L.L., Instituto de Pesquisas Energéticas e Nucleares – IPEN.

Presenter: CAMPOS, L.L., Instituto de Pesquisas Energéticas e Nucleares – IPEN., lcrodri@ipen.br

Three dimensional models of anatomical structures, produced by rapid prototyping are being adopted for medical application as hemodynamics studies and maxillofacial surgery planning. Models with geometrical accuracy can be achieved using medical images as MRI or CT and produced using polyurethane, polylactic acid and epoxy resins[1]. When a volume of tissue equivalent material is used to simulate an interaction of radiation, this volume is given by the name phantom [2]. Plates with different thickness were printed using a 3D printer using a filament of PLA. As the standard material it was used plates of Solid Water RMI-457. The plates of PLA and Solid Water were irradiated using a Linear Accelarator of 6 MV. For each material were performed irradiations for the same thickness of material, in each of them were used thermoluminescent dosimeters of LiF:Mg,Ti to measure the absorbed dose. This work aims to compare the thermoluminescent (TL) dosimetric behavior of PLA plates printed using a 3D printer and solid water plates in the absorbed dose evaluation using clinical photon beams.

COMPARISON BETWEEN AAA AND ACUROS XB CALCULATION ALGORITHMS FOR VMAT TREATMENT PLANNING OF BRAIN MULTIPLE METASTASES USING OSL DOSIMETRY

Daniel Villani, Instituto de Pesquisas Energéticas e Nucleares - IPEN/USP, Carolina dos Santos Moreno, Hospital Israelita Albert Einstein, Vinicius Demanboro Gonçalves, Hospital Israelita Albert Einstein, Roberto Kenji Sakuraba, Hospital Israelita Albert Einstein, Letícia Lucente Campos, Instituto de Pesquisas Energéticas e Nucleares - IPEN/USP.

Presenter: Letícia Lucente Campos, Instituto de Pesquisas Energéticas e Nucleares - IPEN/USP., lcrodri@ipen.br

The “Alabama Technique” demonstrates plan quality and provide a practical, systematic approach to the treatment planning technique for single isocenter cranial radiosurgery with volumetric modulated arc therapy (VMAT) used in metastatic carcinoma treatments. The Optically Stimulated Luminescence dosimetry has become one of most used techniques for radiation dosimetry now days, especially after the improvement of Landauer’s Luxel™ and creation of Landauer’s Inlight™System, initially for individual monitoring radiation protection, and now it has been tested and validated for radiation therapy dosimetry with good results. This work aims to compare Varian AAA and Acuros XB dose calculation algorithms for treatment planning of multiple brain metastases using “Alabama Technique” with a 3D printed anthropomorphic phantom and the OSL InLightTM system for dosimetric validation. An anthropomorphic skull 3D printed phantom was submitted to a CT scan and planed five target volumes. In order of comparison, two dose calculations were performed in the Varian Eclipse with VMAT planning with "Alabama technique", using the Varian’s AAA and Acuros XB and treatment was delivered with a VARIAN True Beam linear accelerator with Multileaf Collimator HD and 6 MV photon beam were used. Landauer nanoDot dosimeters were positioned inside each of the five target volumes planned and the experimental dosimetric results were compared with the two calculation algorithms. The experimental results using the OSLDs show agreement of 97.26 %, 99.12 %, 99.99 %, 95.94 % % and 98.79 % for the targets 1 to 5 respectively for the ACUROS XB calculated doses.The findings of this work indicate that ACUROS XB calculates more accurate doses compared with AAA, with all the experimental agreements better than 96 %. The intrinsic precision and uncertainty of the InLight system device is sufficient to sustain the dosimetric uncertainties below 2 %, validating the results.

The influence of soil cover on pore distribution and connectivity density in a Ferralssol evaluated by 3D computerized microtomography

Author 1: Marcelo Wermelinger Lemes, Universidade Federal Fluminense;
Author 2: Alessandra Silveira Machado, Universidade Federal do Rio de Janeiro;
Author 3:Gustavo M. Vasques, Empresa Brasileira de Pesquisa Agropecuária, EMBRAPA;
Author 4: Ricardo Tadeu Lopes, Universidade Federal do Rio de Janeiro;
Author 5: Reiner O. Rosas, Universidade Federal Fluminense

Presenter: Alessandra Silveira Machado - Universidade Federal do Rio de Janeiro, UFRJ, alessandramachado192@gmail.com

The pores of the soil are represented by cavities with different sizes and shapes, determined by the arrangement of solid particles which constitute a volumetric fraction of the soil filled with air, water and nutrients solution. The soil porosity influences in

aeration, water conduction and retention, resistance to penetration and branching of the roots in the soil and, consequently use of available water and nutrients. Several techniques can be used to obtain soil porosity index. In the search for new techniques aimed at complementing and adding new data on Ferralsols, high resolution computer microtomography (microCT) appears as a non-destructive and fast analytical technique. Analyzing a soil sample by microCT allows obtaining knowledge, in microscale, on shape, size, distribution, volume, area and pore connectivity and having a 3D visualization of the soil sample and its structure. The objective of this work is to use microCT to compare the porosity distribution and pore connectivity density between a soil without vegetation cover and a soil with grass cover, both Ferralsols. Four undisturbed samples of each soil were collected. Grass cover soil presented the following percentages of total porosity: 21.1; 24.6; 27.3 and 36.7 %. Since the soil without vegetation cover had porosities: 13.6; 20.5; 21.8 and 30.8 %. The pore connectivity densities in the grass cover soil were: 46.7; 76.7 and 155.4 (connectivity density was so high in one of the sample that extrapolated algorithm's limit). While in the samples without vegetation cover were of 19.9; 45.8; 76.7 and 511.3 (Table 1). The values for soil porosity presented higher values in the soil covered with grass in relation to the same pairs of soil samples without vegetation cover. This trend was also observed in the connection density values between pores.

CHARACTERIZATION OF METEORITES WITH RELEVANCE TO ASTROBIOLOGY USING NON-DESTRUCTIVE X-RAY TECHNIQUES

Bruno L. Nascimento Dias, Physics Institute, State University of Rio de Janeiro.
Olga M. O. Araujo, Nuclear Instrumentation Laboratory, Federal University of Rio de Janeiro.
Alessandra S. Machado, Nuclear Instrumentation Laboratory, Federal University of Rio de Janeiro.
Joaquim T. Assis, Polytechnique Institute, State University of Rio de Janeiro.
Ricardo T. Lopes, Nuclear Instrumentation Laboratory, Federal University of Rio de Janeiro.
Davi F. Oliveira, Physics Institute, State University of Rio de Janeiro.
Marcelino J. Anjos, Physics Institute, State University of Rio de Janeiro.

Presenter: Davi F. Oliveira, Physics Institute, State University of Rio de Janeiro., davifoliveira82@gmail.com

Meteorites have been arousing the curiosity of mankind since antiquity. The interest in these objects goes far beyond mere curiosity in the study of such materials, which has great importance due essentially to the information they can provide. Since meteorites have a primitive character, this type of rock is essential for studying and understanding the primordial material that formed the planets, which quickly evolved into different phases. This study aims at the application of non-destructive techniques for the structural characterization of meteorite samples in order to provide relevant information

to planetary science and astrobiology. Fragments of a Martian and of a Lunar meteorites were analyzed through X-ray microCT and µXRF techniques. The microCT images showed encrusted structures within both samples. However, while in Lunar meteorites spheroidal structures very similar to small grains internally grouped in clusters were found, in the Martian meteorite a very peculiar structure was identified. Through microCT it was also possible to evaluate the different density materials that compose the samples. The µXRF results accounted for the presence of the chemical elements Si, Ca, Ti, Cr, Mn, Fe, Ni and Sr in the Lunar sample, as well as of Si, K, Ca, Ti, Cr, Mn, Fe, Cu, Zn, Sr, Y and Zr in the Martian sample. The results obtained through microCT and µXRF are effective for the characterization of meteorites by non-destructive techniques, proving thus that it is possible to obtain important information about the chemical composition of the meteorite, as well as about the distribution and the internal structure of these materials, evaluating aspects such as density, porosity and vesicles. Furthermore, with such information at hand, a whole window of opportunity opens itself in terms of deriving relations which have a big relevance in certain astrophysical processes that occurred before the formation of the solar system.

INVESTIGATION OF MULTI- AND SINGLE-SCATTERING PEAKS BASED ON MONTE CARLO CODES WITH EXPERIMENTAL VALIDATION

Sy Minh Tuan Hoang, Korea Atomic Energy Research Institute
Gwang Min Sun, Korea Atomic Energy Research Institute
Jiseok Kim, Korea Atomic Energy Research Institute
Han Rim Lee, Korea Atomic Energy Research Institute
Hani Baek, Korea Atomic Energy Research Institute

Presenter: Sy Minh Tuan Hoang, Korea Atomic Energy Research Institute, hsmtuan@gmail.com

Monte Carlo simulations (MCNP6 and EGS5) have been performed to simulate the spectra of the photon-backscattered from the aluminum alloy by rotating the detector collimator from 60 to 120 degrees using 137Cs source at 661.6 keV. Based on the simulated results, the single- and multi-scattering peaks were investigated and experimentally validated with the experiments. The results showed that the single backscattering photons increase while the multiple backscattering photons decrease according to the scattering angle relative to the incident beam. When the aluminum thickness was increased, the single and multiple backscattering photons increased and reached saturation values at a thickness of approximately 20 mm. With the validation results, the simulation codes can be applied extensively to other geometrical cases and materials.

ALPHACAL: A new user-friendly tool for the calibration of alpha-particle sources

Author 1: A. Fernández Timón
Institution 1: Universidad Rey Juan Carlos, 28933 Móstoles-Madrid, Spain,
Author 2: M. Jurado Vargas
Institution 2: Departamento de Física, Universidad de Extremadura, 06071 Badajoz, Spain
Author 3: P. Álvarez Gallardo
Institution 3: Universidad Rey Juan Carlos, 28933 Móstoles-Madrid, Spain,
Author 4: J. Sánchez-Oro
Institution 4: Universidad Rey Juan Carlos, 28933 Móstoles-Madrid, Spain
Author 5: L. Peralta
Institution 5: Departamento de Física, Faculdade de Ciências, Universidade de Lisboa, Portugal & Laboratório de Instrumentação e Física Experimental de Partículas, Portugal

Presenter: M. Jurado Vargas, Departamento de Física, Universidad de Extremadura, 06071 Badajoz, Spain, mjv@unex.es

The activity measurement of sources for alpha-particle spectrometry requires several corrections to the counting rate, due especially to the scattering and self-absorption of alpha particles in the source substrate and in the backing material. Although these corrections can be estimated experimentally for each particular backing, it requires a great number of measurements using sources with a wide range of thicknesses and similar chemical composition to the source of interest. An alternative method to this laborious task is the use of Monte Carlo procedures to simulate the interaction of alpha particles in the source and backing. However, the available MC codes are of general-purpose and generally spend a high computational time, resulting in very slow calculations.
In this work, we developed the program ALPHACAL, specifically designed for the particular task of source calibration in alpha-particle spectrometry. It is therefore more user-friendly and less time-consuming than multipurpose codes that are intended for a wide range of applications. ALPHACAL is based on the recently developed MC code ALFAMC, which simulates specifically the transport of alpha particles, and it is optimized to allow the implementation of complex geometries. ALPHACAL has been implemented in C++ language using QT library, so it is available for Windows, MacOs and Linux platforms. Both cylindrical and point sources can be simulated. In addition to efficiency calculation, some advanced tools are available to the user, like the visualization of energy spectrum, use of energy cut-off or low-energy tail corrections.

The validity of the program was tested by comparing efficiency values and backscattering coefficients obtained by ALPHACAL with those obtained experimentally using sources deposited on polished backings.

The optimization of coal on-line analysis system based on SNR through Monte Carlo simulation

1, Jiatong Li, Department of Nuclear Science and Engineering, College of Materials Science and Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 211106, China
2, Daqian Hei, Department of Nuclear Science and Engineering, College of Materials Science and Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 211106, China; Collaborative Innovation Center of Radiation Medicine of Jiangsu Higher Education Institutions, Suzhou 215000, China
3, Pingkun Cai, Department of Nuclear Science and Engineering, College of Materials Science and Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 211106, China
4, Can Cheng, College of Astronautics, Nanjing University of Aeronautics and Astronautics, Nanjing 211100, China
5, Wenbao Jia, Department of Nuclear Science and Engineering, College of Materials Science and Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 211106, China; Collaborative Innovation Center of Radiation Medicine of Jiangsu Higher Education Institutions, Suzhou 215000, China

Presenter: Jiatong Li, Department of Nuclear Science and Engineering, College of Materials Science and Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 211106, China, lijiatong@nuaa.edu.cn

When Prompt Gamma-ray Neutron Activation Analysis (PGNAA) technology is used for elements detection, Signal-to-Noise Ratio(SNR) is an important indicator for evaluating the detection performance of analysis system. In the present study, a definition of SNR is proposed, the moderator of a coal on-line analysis system has been improved, and the position of NaI detector and D-D neutron generator has been optimized based on SNR evaluation. The results based on the Monte Carlo simulations indicate that polyethylene with a thickness of 3 cm as the moderator is the better alternatives for the intended purposes. The better direction of NaI detector is perpendicular to the axis of the D-D neutron generator, comparing with the parallel between the axes of detector and neutron generator. The better axis spacing between NaI detector and D-D neutron generator is chosen as 47 cm, meanwhile, the overall position of them in coal on-line analysis system is discussed.

Evaluation of the Response of a Bonner Sphere Spectrometer with a 6LiI detector using 3D meshed MCNP6.1.1 models.

S. Morató, L. Martínez, B. Juste, R Miró, G. Verdú, ISIRYM (Institute for Industrial, Radiophysical and Environmental Safety) UPV (Universitat Politècnica de València).

Presenter: G. Verdú, ISIRYM (Institute for Industrial, Radiophysical and Environmental Safety) UPV (Universitat Politècnica de València), gverdu@iqn.upv.es

Present work is a previous step to obtain neutron measurements generated by a

Medical Linear Accelerator (LinAc) Varian TrueBeam using a multisphere spectrometer, also called Bonner Spheres System (BSS). Response detector curves have been obtained by Monte Carlo (MC) simulation with MCNP6.1.1, where the use of unstructured mesh geometries is introduced as a novelty. The aim of these curves was to study the theoretical response of a widespread neutron spectrometer exposed to neutron radiation generated after using high megavolts treatment beams.

Dose Calculation in Computerized Tomography

S. Morató, C. García, B. Juste, R.Miró, G. Verdú , ISIRYM, Institute for Industrial, Radiophysical and Environmental Safety. Universitat Politècnica de València

Presenter: G. Verdú, ISIRYM, Institute for Industrial, Radiophysical and Environmental Safety. Universitat Politècnica de València, gverdu@iqn.upv.es

The purpose of this work is to develop an automated methodology to obtain the dose received by a patient, classified by organs, after being subjected to the use of ionizing radiation for the CT images acquisition. The methodology starts from CT images, these images are automatically segmented and voxelized taking into count the CT numbers in order to obtain a 3D model used in Monte Carlo Simulations to calculate the dose inside the patient. Monte Carlo codes used in this work are MCNP.6.1.1 whose results will be taken as a reference values and MC-GPU, which appears to be a good candidate to be implemented in the methodology because its GPU parallelization is reflected in a high speed calculation. Results show a good fit between simulated values obtained by MC-GPU and MCNP6.1.1.

QUALITY CONTROL OF RADIOTHERAPY TREATMENT PLANS WITH ELECTRONS BEAMS

Author 1: Luciana Tourinho Campos. Institution 1: Universidade Estadual do Rio de janeiro (UERJ), Rio de janeiro, RJ, Brasil
Author 2: Luiz Antonio Ribeiro da Rosa Insitution 2:Instituto de Radioproteção e Dosimetria (IRD/CNEN), Rio de janeiro, RJ, Brasil
Author 3: Delson Braz Institution 3: Programa de Engenharia Nuclear (COPPE/UFRJ),Rio de janeiro, RJ, Brasil
Author 4:Delano Batista Institution 4: :Instituto de Radioproteção e Dosimetria (IRD/CNEN), Rio de janeiro, RJ, Brasil

Presenter: Luciana Tourinho Campos (DFAT/UERJ), tc_luciana@yahoo.com.br

In this work the quality of the treatment planning generated by Eclipse commercial treatment planning system for electron beams of energy 9 and 20 MeV was verified and their accuracy in the calculation of dose distributions for several clinical situations was

evaluated. Tests cases had been developed according to the Brazilian reality, having as reference the radiotherapy treatments carried out in the National Institute of the Cancer. The system developed for checking the quality of treatment planning systems with electrons was efficient in evaluating the Eclipse planning system by identifying the failures of their algorithms, especially in planning the isodose. The verification system has been validated against the Monte Carlo method and the experimental data with an ionization chamber and showed the shortcomings of generalized pencil beam and eMC algorithms.

Using the Monte Carlo Library Least Squares (MCLLS) Approach for the PGNAA Measurement of Chromium in Aqueous Solution

Yan Zhang [1,2,3], WenBao Jia [1, 3], Robin Gardner [2], Qing Shan [1, 3], Daqian Hei [1, 3]
[1] College of Materials Science and Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China.
[2] Center for Engineering Application of Radioisotopes (CEAR), Department of Nuclear Engineering, North Carolina State University, Raleigh, NC 27695, USA.
[3] Collaborative Innovation Center of Radiation Medicine of Jiangsu Higher Education Institutions, Suzhou 215000, China

Presenter: Yan Zhang
[1] College of Materials Science and Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China.
[2] Center for Engineering Application of Radioisotopes (CEAR), Department of Nuclear Engineering, North Carolina State Univ, 296295220@qq.com

A prompt gamma neutron activation analysis (PGNAA) setup, with a 300 mCi 241Am-Be neutron source and a 4×4 inch BGO detector, was developed for chromium detection in aqueous solutions. In the present work, a series of standard samples were prepared by dissolving lead compounds in deionized water. Quantitative spectrum analysis was done by using Monte Carlo-Least-Squares (MCLLS) approach to measure the standard samples. The simulates of element libraries were in-silico by utilizing a CEARCPG code, developed in the Center for Engineering Application of Radioisotopes (CEAR) of North Carolina State University. Simulation results were presented that are in good agreement with experimental results. The correlation coefficients were very close to 1 by comparing the fitted spectrum with the experiment spectrum. By applying the MCLLS approach, relative deviation (%D) of the chromium measurement accuracy was less than 4.09%.

Improvement of Sievert Integration Model in Brachytherapy via Inverse Problems and Artificial Neural Networks

1. Eriberto O. Nascimento, Instituto Federal de Educação, Ciência e Tecnologia (IFG), Goiânia, GO, Brazil;
2. Lucas N. Oliveira, Instituto Federal de Educação, Ciência e Tecnologia (IFG), Goiânia, GO, Brazil;
3. Linda V.E. Caldas, Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear (IPEN/CNEN), São Paulo, SP, Brazil.

Presenter: Linda V. E. Caldas
Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear (IPEN/CNEN), São Paulo, SP, Brazil, lcaldas@ipen.br

Increasing the radial distance, the accuracy of the Sievert Integration Model (SIM) decreases in a non-linear manner, adding errors up of 10% into the dose rate calculations; a similar fact occurs to the 2D anisotropy function where the errors may achieve 30% as already related. For that reason, this paper sought an innovative approach to optimize the error variance and its biases of dose rate calculations around a Nucletron brachytherapy source of 192Ir from 0 to 10 cm taken in the radial distance, using an improved SIM through a hybrid coupling of Artificial Neural Networks (ANN) and Inverse Problem Theory (IPT). Since the traditional approach relies into the use of a small data set of dose rate, the ANN generalized these doses, making possible to search more broadly optimum parameters to SIM using the IPT. The results showed excellent accuracy evaluated with the Root Mean Square Percentage Error (RMSPE). In conclusion, the low RMSPE values indicate that the methodology is a consistent methodology, showing an excellent agreement with the state of art of dosimetric measurement techniques.

Determination of Si content in Fe-doped HfSiO4 nanoparticles by neutron activation analysis

T. S. N. Sales[1], B. Bosch-Santos[1], M. Saiki1, L. F. Pereira[1] , A. W. Carbonari[1], R. N. Saxena[1]. A. Burimova[1,2].
[1]Nuclear and Energy Research Institute (IPEN-CNEN/SP) University of São Paulo, São Paulo, SP, Brazil.
[2]Federal University of ABC, Santo André, SP, Brazil.

Presenter: T. S. N. Sales, Nuclear and Energy Research Institute (IPEN-CNEN/SP) University of São Paulo, São Paulo, SP, Brazil., tatianenas@usp.br

New synthesis method of Fe-doped hafnium silicate nanoparticles (NPs) with tetragonal structure is reported. The procedure implies auto-controlled incorporation of Si from the quartz to the iron-doped hafnium oxide NPs. X-ray diffraction data has shown that lattice parameters of Fe-HfSiO4 thus obtained are very close to those previously known for hafnon. It was established that the hafnon-like phase has stabilized at T=1173K which is ~500K lower than the corresponding transition of bare bulk hafnium silicate. The

fractions of Si and Fe in the composite matrix were evaluated via neutron activation analysis (NAA). Delayed gamma NAA results allowed to assume that (i) Fe initially substituted Hf in the HfO_2 lattice; (ii) there was no migration of iron atoms from Hf to Si sites throughout the formation of hafnon-like phase; (iii) Fe-doped hafnium oxide has taken as much Si from the quartz as was needed for the arrangement of $Fe_{1-x}Hf_x SiO_4$ tetragonal system. Our results are consistent with those observed for similar materials, such as metal (Fe,V) doped zircon, where metal has also demonstrated catalytic effect on phase stabilization.

Structural characterization of a novel anti-inflammatory parent compound

Isadora T. S. Bastos, State University of Rio de Janeiro, Fanny N. Costa, Federal University of ABC, Miguel D. Rocha, Federal University of Rio de Janeiro, Eliezer J. Barreiro, Federal University of Rio de Janeiro, Carlos A. M. Fraga, Federal University of Rio de Janeiro, Delson Braz, Federal University of Rio de Janeiro, Fabio F. Ferreira, Federal University of ABC, Regina C. Barroso, State University of Rio de Janeiro

Presenter: Gabriela Sena Souza, Laboratory of Nuclear Instrumentation/COPPE, Federal University of Rio de Janeiro, Brazil, gabisenaa@gmail.com

LASSBio-1860 is an inhibitor of phosphodiesterase type 4 (PDE4). This enzyme plays a major role in modulating the activity of virtually all cells involved in the inflammatory process acting in the control of cAMP levels [1]. This compound was planned and synthesized in Laboratory of Evaluation and Synthesis of Bioactive Substances – LASSBio® as part of a research program to develop a series of compounds with anti-inflammatory activities. As important as the planning and synthesis of new drugs is its structural characterization, since its structure may be related to a biological activity. In many cases suitable single crystals cannot be prepared, and the most used technique that is the single crystal X-ray diffraction (XRD) is not a viable approach for structure determination. Under such circumstances, structure determination must be tackled instead from X-ray powder diffraction (XRPD) data and that is considerably more challenging than structure determination from single-crystal XRD data. In this work we determined the crystal structure of LASSBio-1860 compound using XRPD that has been a very important tool in the structural determination of new synthesized compounds. LASSBio-1860 crystallized in a monoclinic system ($P2_1/c$) and the crystal structure consists of four formula units per unit cell (Z = 4), thus accommodating one molecule in the asymmetric unit (Z' = 1). The Rietveld method was used to refine the crystal structure and the goodness-of-fit indicator as well as R-factors were $\chi^2 = 1.131$, $R_{Bragg} = 0.856\%$, $R_{wp} = 4.174\%$ and $R_{exp} = 3.692\%$.

Test enclosure design, construction, and tests for the CNEC well-logging benchmark tool

Aaron Hellinger, Long Vo, Maria Pinilla, Ryan Ulrich, Alan Reinke, Walter McNeil, Bill

Dunn

Presenter: Aaron Hellinger, Kansas State University, aaron523@ksu.edu

Kansas State University (KSU) has constructed a facility that allows testing of a well logging tool in order to validate Monte Carlo Library Least-Squares codes created by North Carolina State University and others. Two rooms have been occupied inside a chemical storage building at KSU. The borehole facility has been constructed in one room and a control center is located in the second room. A five-inch well-logging benchmark tool will be inserted into this facility which will be surrounded by various types of media commonly found during a realistic well-logging process, such as limestone, sand, water, and crude oil. The solid media will be purchased from a quarry, dumped on-site, and transferred using a large vacuum conveying system while the liquid media will be immediately transported into the simulated borehole environment from their original storage containers. Due to safety concerns, shielding has been placed in multiple areas. A ventilation system will be installed and a lid will also be constructed in order to test crude oil. Preliminary tests using the borehole facility will also be described.

Activation Analysis of Tibetan Coins and Thermal Neutron Flux Measurement at the VR-1 Training Reactor

Milan Stefanik, Ondrej Huml, Jan Rataj, Lubomir Sklenka,
Institution: Czech Technical University in Prague (Faculty of Nuclear Sciences and Physical Engineering)

Presenter: Milan Stefanik
Czech Technical University in Prague (Faculty of Nuclear Sciences and Physical Engineering), milan.stefanik@fjfi.cvut.cz

The VR-1 training reactor of the Czech Technical University in Prague served mostly to train the students; however, owing to the presence of the experimental channels, it can be utilized for the particular research tasks such as the irradiation experiments, neutron radiography, and neutron activation analysis (NAA). Within the presented experiments, the samples of historical Tibetan coins were irradiated in the experimental channel at maximum power, and the amount of the copper and silver was investigated using the NAA. The irradiated samples were repeatedly measured by the calibrated semiconductor HPGe detector; saturated activities were obtained by means of the gamma-ray spectrometry, and subsequently the composition of the samples was determined. Moreover, the activation measurements using the dosimetry foils were performed as well, and the reaction rates and cadmium spectral indexes in the vertical experimental channel were determined utilizing the gold foils. Afterwards, the thermal neutron flux for the relevant position was extracted employing the Westcott formalism and activation cross-section from the ENDF/B-VII.1 database. The results presented in

this paper show clearly that the low-power VR-1 training reactor (ca. 80 W) is suitable for the neutron activation analysis of the samples from the everyday life.

Wednesday, July 12, 2017

Detection of Threat and Contraband Material, Vevey Room, 09:00-10:20

Exploiting Fission Chain Reaction Dynamics to Image Multiplying Assemblies of Fissile Materials

Pete Chapman, North Carolina State University
Jonathan Mueller, North Carolina State University
Jason Newby, Oak Ridge National Laboratory Nuclear Material Detection and Characterization Group
John Mattingly, North Carolina State University

Presenter: Pete Chapman, North Carolina State University, p_chapman@ncsu.edu

Radiation imaging is one potential method to verify nuclear weapons dismantlement. The neutron coded aperture imager (NCAI), jointly developed by Oak Ridge National Laboratory (ORNL) and Sandia National Laboratories (SNL), is capable of imaging sources of fast (e.g., fission spectrum) neutrons using an array of organic scintillators. North Carolina State University (NCSU) has developed a method to discriminate between non-multiplying (i.e., non-fissile) neutron sources and multiplying (i.e., fissile) neutron sources using the NCAI. This method exploits the dynamics of fission chain-reactions; it applies time-correlated pulse-height (TCPH) analysis to identify neutrons in fission chain reactions. TCPH analyzes the neutron energy deposited in the organic scintillator vs. the apparent neutron time-of-flight. Energy deposition is estimated from light output, and time-of-flight is estimated from the time between the neutron interaction and the immediately preceding gamma interaction. Neutrons that deposit more energy than can be accounted for by their apparent time-of-flight are identified as fission chain-reaction neutrons, and the image is reconstructed using only these neutron detection events. We applied this analysis to measurements of weapons-grade plutonium (WGPu) and 252Cf performed at the Nevada National Security Site (NNSS) Device Assembly Facility (DAF) in July 2015. Our initial results demonstrate it is possible to eliminate the non-fissile 252Cf source from the image while retaining the fissile WGPu source.

Wearable Detector Device (WDD) Based on Microstructured Semiconductor Neutron Detector (MSND) Technology

T. R. Ochs, Kansas State University, S. L. Bellinger, Radiation Detection Technologies, Inc., R. G. Fronk, Kansas State University, L. C. Henson, Radiation Detection Technologies, Inc., D. E. Huddleston, Kansas State University, T. J. Sobering, Kansas State University, R. D. Taylor, Kansas State University, A. Van Beergeijk, Kansas State University, and D. S. McGregor, Kansas State University

Presenter: Taylor R. Ochs, Kansas State University, Semiconductor Materials and Radiological Technologies (S.M.A.R.T.) Laboratory, trochs@ksu.edu

A Wearable Detector Device (WDD) has been outfitted with Microstructured Semiconductor Neutron Detectors (MSNDs) to aid in the search and localization of Special Nuclear Materials (SNMs). The system operates by detecting the neutrons emitted during the spontaneous fission of SNMs. The WDD is composed of 16 Modular Neutron Detectors (MND), each populated with a 6 x 4 array of 1-cm^2 MSNDs. The MSNDs were calibrated to an intrinsic thermal-neutron detection efficiency of approximately 30% using a calibrated He-3 counter. Each MND is enclosed in a 5-in. by 3-in. by 0.6-in. HDPE moderator case, and is connected to a wired communications board. The output of the communications board is fed upstream to a master control board via passive USB Type C. The master control board houses all power and power conditioning systems and connects the network of MNDs to an Android smartphone where real-time count rates and alarm levels are displayed. The operation lifetime of the battery powered WDD is estimated to be greater than 12 hours on three 18650 batteries. The WDD reported 10.1 ± 0.1 cps and 13.0 ± 0.1 cps for a bare and moderated 27.4-ng Cf-252 source at a distance of 1.5 m, respectively, which was greater than 40 times the background count rate of 0.24 ± 0.01 cps. The gamma-ray rejection ratio of the WDD for Co-60 measured at a dose rate of 30mR/h was 5.8x10^-7.

Technical-Performance Standards for Radiation Inspection Systems

Larry Hudson
National Institute of Standards & Technology, Gaithersburg, MD, USA

Presenter: Larry Hudson, National Institute of Standards & Technology, Gaithersburg, MD, USA, larry.hudson@nist.gov

Technical-performance standards operate within the homeland-security enterprise to save significant time and money while increasing safety to the public. This is illustrated through the lens of the standards infrastructure that is being developed to ensure the imaging performance and radiation safety of security-screening systems in the United States that use active radiation probes to detect explosives and other contraband. The products of this effort include standard test objects, test methods, objective scoring algorithms, minimum performance requirements, technical guidance documents, and dosimetry protocols, supported by NIST measurement science and computational modeling. This project responds to government requirements for 100 % screening of transnational cargo and airline passengers and baggage while also establishing the means to harmonize national standards across disparate agencies and with international norms. This talk will show how standards gaps are identified and anticipated, and outline the standards-development process, especially highlighting issues unique to technical-performance standardization. Five use cases are offered that document the impact of measurement standards when applied across the life cycle of radiation inspection systems in ways that complement and inform threat-based and operational testing and evaluation (T&E).

Recent Progress in the Commercialization of the Li-Foil Multiwire Proportional Counter Neutron Detectors

Benjamin W. Montag, Kansas State University, Steven L. Bellinger, Kansas State University, Nathaniel S. Edwards, Kansas State University, Jackson Lage, Kansas State University, Luke C. Henson, Kansas State University, Douglas S. McGregor, Kansas State University

Presenter: Benjamin W. Montag, Kansas State University, bmontag@ksu.edu

The scarcity and rising cost of 3He gas has initiated a push in alternative neutron detector technologies. The Li Foil Multi-wire Proportional Counter Neutron Detectors (Li Foil MWPC) has shown promise as a 3He replacement technology. Large gas-filled proportional counters with five layers of 75 micron thick 6Li foils have been built and characterized, yielding over 55% thermal neutron detection efficiency, with the possibility of increasing the efficiency above 70% with ten 6Li foil layers. Most recently, a backpack radiation detector (BRD) was fabricated, equipped with four Li Foil MWPC devices. This study not only explored the performance of the Li Foil MWPC in the backpack instrument configuration, but also many advancements were introduced to the Li Foil MWPC device to increase the device manufacturability and commercial ability. These advancements included weight reduction, new hermetic sealing techniques, optimizing active area, and anode wire cost reduction. The Li Foil MWPC BRD was evaluated for neutron sensitivity where 0.36 cps/ng of 252Cf at 1.5 meters was measured. The BRD was also evaluated for gamma-ray rejection where 3.1 x 10-8 for 137Cs at 50 mR/Hr was measured. The construction, design considerations, advancements, and performance of the new backpack radiation detector with Li Foil MWPC neutron detectors will be presented and reported.

Dosimetry and Detector Applications II, Montreaux Room, 09:00-10:20

Advancements with Micro-Pocket Fission Detectors for Nuclear Reactor Power Monitoring

Michael A. Reichenberger,
Daniel M. Nichols,

Sarah R. Stevenson, Tanner M. Swope, Caden W. Hilger, Jeremy A. Roberts, Douglas S. McGregor
Department of Mechanical and Nuclear Engineering, Kansas State University, Manhattan KS 66506
Troy Unruh
Idaho National Laboratory, Idaho Falls, ID 83415

Presenter: Daniel M. Nichols
Department of Mechanical and Nuclear Engineering, Kansas State University, Manhattan KS 66506, danmarcnichols@ksu.edu

Micro-pocket fission detectors (MPFD) has been fabricated as a linear 4-node detector array for in-core power monitoring of research nuclear reactors. The miniaturized fission chambers have gas pockets on the order of 2 mm3 with a small concentration of uranium electrodeposited inside the gas chamber. The detectors are assembled without adhesives, and are stacked such that each device signal is separately acquired. Spacers are placed to separate the detectors by a vertical distance of approximately 11 cm each. The MPFD array was coupled to an electronic support system developed to support pulse-mode operation. The detectors were tested near the central thimble of the Kansas State University TRIGA Mk. II nuclear reactor, and neutron-induced pulses were observed on all four sensor channels. Stable device operation was confirmed by testing under steady-state reactor conditions. Each of the four sensors in the array responded to changes in reactor power between 10 kWth and full power (750 kWth). Reactor power transients were observed in real-time including positive transients with periods of 5, 15, and 30 seconds. Design details and performance of the MPFD four-node array will be presented.

Computed Tomography dose estimation using Monte Carlo simulation (MC-GPU)

S. Morató, C. García, B. Juste, R.Miró, G. Verdú
ISIRYM, Institute for Industrial, Radiophysical and Environmental Safety. Universitat Politècnica de València, Camí de Vera s/n 46022 Valencia

Presenter: Sergio Morató Rafet, ISIRYM, Institute for Industrial, Radiophysical and Environmental Safety. Universitat Politècnica de València, Camí de Vera s/n 46022 Valencia, smorato@iqn.upv.es

The purpose of this work is to develop an automated methodology to obtain the dose received by a patient, classified by organs, after being subjected to the use of ionizing radiation for the CT images acquisition. The methodology starts from CT images, these images are automatically segmented and voxelized taking into count the CT numbers in order to obtain a 3D model used in Monte Carlo Simulations to calculate the dose inside

the patient. Monte Carlo codes used in this work are MCNP.6.1.1 whose results will be taken as a reference values and MC-GPU, which appears to be a good candidate to be implemented in the methodology because its GPU parallelization is reflected in a high speed calculation. Results show a good fit between simulated values obtained by MC-GPU and MCNP6.1.1.

Comparative Studies of Coloured Silica Beads for Dosimetry

Author 1: Katie Ley
Institution: 1- Radiation and Medical Physics, Department of Physics, University of Surrey, Surrey, UK
Author 2: S. Jafari
Institution:1- Radiation and Medical Physics, Department of Physics, University of Surrey, Surrey, UK
2- QA Hospital, Portsmouth, Hampshire, UK
Author 3: A. Lohstroh
Institution: 1- Radiation and Medical Physics, Department of Physics, University of Surrey, Surrey, UK
Author 4: A. Alyahyawi
Instiution: 1- Radiation and Medical Physics, Department of Physics, University of Surrey, Surrey, UK
Author 5: A. Alanazi
Institution: 1- Radiation and Medical Physics, Department of Physics, University of Surrey, Surrey, UK
Author 6: D. A. Bradley
Instiution: 1-Radiation and Medical Physics, Department of Physics, University of Surrey, Surrey, UK
3- Sunway University, Institute for Health Care Development, Jalan Universiti, PJ, Malaysia

Presenter: Katie Ley - Radiation and Medical Physics, Department of Physics, University of Surrey, Surrey, UK, k.ley@surrey.ac.uk

In recent years the key advances that have been made in dose delivery techniques have led to considerable challenges to the measurement of dose deposition, including the spatial resolution demands of external beam small-field dosimetry and the steep dose gradients of brachytherapy. Present investigations concern the thermoluminescence (TL) yield of coloured silica beads for use in for instance in vivo radiotherapy measurements, providing high spatial resolution (typically 1 to 2 mm) dosimetry. The work makes use of commercially manufactured silica beads for the measurements of dose, typically in the range cGy to kGy, covering radiotherapy doses, extending beyond this into industrial dosimetry. The study focuses on comparing the TL

response of different coloured silica beads, with the aim of tailoring the use of different types of beads, guided by their response for specific dose ranges. Results from study of the TL yield with different coloured beads and a dose of 10 Gy show that the colourless beads provided significantly greater response than the coloured beads. The range of linearity of the TL response will be presented.

Development of a procedure for quenching-effect correction in images of absorbed dose
from protons or carbon ions acquired with Gafchromic EBT3 films

G. Gambarini [1,2], D. Bettega [1,2], G. Camoni [1], E. Cesaroni [1], M. Felisi[1], A. Gebbia[1], E. Massari [1], V. Regazzoni [1,2], A. Mirandola [3], M. Ciocca [3]
[1] Department of Physics, Università degli Studi di Milano, Milano, Italy
[2] National Institute of Nuclear Physics, Section of Milan, Milano, Italy
[3] Medical Physics Unit, Centro Nazionale di Adroterapia Oncologica (CNAO), Pavia, Italy

Presenter: Grazia Gambarini, Department of Physics, Università degli Studi di Milano and INFN, Milano, Italy, grazia.gambarini@mi.infn.it

For dose verification in conformal radiation therapy with protons or carbon ions, great benefits can be obtained from the use of Gafchromic EBT3 films, because of their high spatial resolution.These dosimeters, as in general all solid-state detectors, have the disadvantage of having a sensitivity that is reduced with increasing the linear energy transfer (LET) of the radiation. After a preliminary method, based on large approximations, for correcting the measured dose images [1], a more exhaustive procedure was proposed [2] and subsequently developed. Those studies were limited to protons. Now the interest has been focused also to carbon ions. The method evaluates a correction coefficient in each position of the acquired image by multiplying the measured dose value to a calculated ratio of the absorbed by the measured dose. Dedicated software in MATLAB has been developed for achieving such a correction of the measured images. The software takes as input the data concerning the initial energy, intensity and spatial coordinates of each pencil beam (PB) utilized for the treatment. Then, both the absorbed and measured doses are evaluated, in each position of the image, taking into consideration all the pencil beams that contribute to the absorbed dose. The software is provided with information that allows deducting the in-depth profiles of the absorbed dose and of the measured dose along the axis of each PB and also the in-depth variation of the transversal profile of PBs, in order to estimate the dose both on and out of the beam axis. In order to achieve suitable data for the correctness of the calculations, the behaviour of in-depth profiles and of the broadening of PBs in solid water (RW3, PTW, Freiburg, Germany) has been studied. For some energies, transversal dose images have been measured at various depths up to the Bragg peak. For the same energies, the profiles of the absorbed dose have been calculated and compared with the measured values. From these results, a trend of the

absorbed and measured doses as a function of the initial energy has been estimated. This estimation is necessary, because the number of the energies utilized for a treatment is very large, and it is not possible to determine and store specific information for each PB energy. The software is continuously implemented according to the results of the experiments. The optical analysis of EBT3 films was performed by means of two devices: a conventional scanner (Epson) and a laboratory-made instrument for transmitted light detection. Such an instrument consists of a plane and uniform source of white light and a CCD camera provided with a band-pass filter around 630 nm. Suitable software in MATLAB has been developed to get, from the light transmittance images, the images of optical density difference and, by means of the calibration function, of absorbed dose. Exposures were carried out at the synchrotron of the Italian National Center for Oncological Hadron Therapy (CNAO) in Pavia (Italy).

[1] Gambarini G, Regazzoni V, Giove D, Mirandola A., Ciocca M, 2015. Measurements of 2D Distribution of Absorbed Dose in Protontherapy with Gafchromic EBT3 Films. Appl. Radiat. Isot. Vol. 104, pp. 192-196.
[2] Gambarini G., Bettega D., Camoni G., Felisi M., Gebbia A., Massari E., Regazzoni V., Veronese I., Giove D., Mirandola A., Ciocca M. Correction method of measured images of absorbed dose for quenching effects due to relatively high LET. Radiat. Phys. Chem. (in print)

Monte Carlo Applications I, Vevey Room, 11:00-12:20

MCNP - a review of our 40 year history, current status, and upcoming future

Avneet Sood, Los Alamos National Laboratory

Presenter: Avneet Sood*, Los Alamos National Laboratory

The Monte Carlo method for radiation particle transport has its origins at LANL dating back to the 1940's. The creators of these methods were Drs. Stanislaw Ulam, John von Neumann, Robert Richtmyer, and Nicholas Metropolis. Monte Carlo methods for particle transport have been driving computational developments since the beginning of modern computers; this continues today. In the 1950's and 1960's, these new methods were organized into a series of special-purpose Monte Carlo codes, including MCS, MCN, MCP, and MCG. These codes were able to transport neutrons and photons for specialized LANL applications. In 1977, these separate codes were combined to create the first generalized Monte Carlo radiation particle transport code, MCNP. In 1983, MCNP3 was released for public distribution to the Radiation Safety Information Computational Center (RSICC). The upcoming release of MCNP (version 6.2) is expected in June 2017. Approximately 20,000 copies of MCNP have been distributed to users in government institutions, academia, and private industries worldwide. This talk will review our history, current status, and future directions.

Avneet Sood

Characterizing Scintillator Detector Response for Correlated Fission Experiments with MCNP and Associated Packages

M.T. Andrews, LANL, M.E. Rising, LANL, K. Meierbachtol, LANL, P. Talou, LANL, A. Sood, LANL, C.R. Bates, LANL, E.A. McKigney, LANL, C.J. Solomon, LANL.

Presenter: Madison Andrews, Los Alamos National Laboratory, madison@lanl.gov

Neutron emissions created in the fission process are correlated in energy and angle, however these correlations are often not included in radiation transport codes. The upcoming release of MCNP6.2 includes the incorporation of interfaces to the fission event generators FREYA and CGMF to reproduce correlated fission emissions. Accompanying this release will be associated packages which make it easier to process event data recorded by MCNP (MCNPTools) and simulate detector response (DRiFT). Several experiments utilizing scintillator detectors to measure neutron correlations are currently underway or planned at LANL and will be compared to MCNP6.2 output.

Correlated Fission Simulations with MCNP6.2 and MCNPX-PoliMi

Michael E. Rising, Los Alamos National Lab, Madison T. Andrews, Los Alamos National Lab, Avneet Sood, Los Alamos National Lab, Matthew J. Marcath, University of Michigan, Shaune D. Clarke, University of Michigan, Sara A. Pozzi, University of Michigan

Presenter: Michael E. Rising, Los Alamos National Lab, mrising@lanl.gov

For some time there has existed a need for improved simulation capabilities in the area of nuclear nonproliferation and safeguards applications where multiple detectors are often employed with time-coincidence detection systems. With this application in mind, the expected-value approach to secondary particle emissions from nuclear fission events present in the majority of Monte Carlo codes, including MCNP version 6.1, can lead to highly inaccurate results due to the lack of event-by-event correlations within each simulated fission event. To address this lack of detailed physics, the MCNPX-PoliMi code was created for the special purpose of simulating advanced detector designs and particle coincidence experiments. Similarly, in the latest release of MCNP6.2, two new correlated fission event generators, CGMF and FREYA, have

been integrated into the code to address this need specifically for use in fixed-source special nuclear material (SNM) detection and coincidence experiment simulations. The primary objective of this work is to provide a quantitative comparison between the various correlated fission simulation capabilities in both the MCNPX-PoliMi and MCNP6.2 codes. Beyond the fission event generator choice and the particle transport done in both codes, the full detector response and post-processing of the simulations are also compared in the present work making use of the MPPost and DRiFT codes. Ultimately, by applying both of these detector response tools to a variety of transport calculations a direct comparison is made between the simulations and experimental measurements.

MCNP & DRiFT Simulation of the NEUANCE Detector Array

M.I. Pinilla, Kansas State University and LANL, M.T. Andrews, LANL, C.R. Bates, LANL, M.E. Rising, LANL, W.L. Dunn, Kansas State University

Presenter: Maria I. Pinilla, Kansas State University, mpinilla@ksu.edu

The NEUtron detector Array at DANCE (NEUANCE) is a new stilbene detector array that is currently under development at Los Alamos National Laboratory. It is designed to fit inside the Detector for Advanced Neutron Capture Experiments (DANCE), a very high-efficiency gamma-ray calorimeter used to measure prompt fission and capture gamma rays. These measurements afford the opportunity to validate new MCNP6.2 correlated fission and DRiFT stilbene detector simulation capabilities. The first step taken in this project was to fit MCNP's Gaussian Energy Broadening (GEB) function to attain an accurate stilbene gamma-ray detector response function to compare to measurements already taken at NEUANCE. Work is currently being done to add stilbene processing capabilities to the Detector Response Function Toolkit for MCNP (DRiFT). These additions include pulse shape simulations for incident neutrons and gamma radiation and light output curves for stilbene crystals. Improvements to MCNP6/DRiFT modeling and analysis of the NEUANCE detector array will also provide much needed validation of the new fission event generator models recently integrated into MCNP6. The scope of this project includes understanding the nuclear physics simulations of secondary particle emissions from fission, modeling and simulating both differential and integral experiments using the new MCNP6 features, and finally comparing code predictions to the latest real-world measurements of special nuclear materials (SNM) at the Los Alamos Neutron Science Center (LANSCE).

Industrial Applications of Radiation, Montreaux Room, 10:50-12:20

Backscatter Radiography As a Non-Destructive Examination Tool
James E Baciak, University of Florida, Shuang Cui, University of Florida, Gabriel Sandler, University of Florida, and Travis Barker, University of Florida

Presenter: James E Baciak, University of Florida, jebaciak@mse.ufl.edu

Backscatter radiography by selective detection is a form of Compton backscatter imaging that allows for sub-surface imaging of flaws and features of interest in applications in which traditional transmission radiography is impractical or impossible. Backscatter radiography by selective detection can utilize x-ray energies up to 1 MeV, although practical limitations of the backscatter signal normally limit use to below 600 kVp. While most backscatter imaging techniques use a highly collimated pencil beam of x-rays to provide position information, this limits acquisition speeds and reduces application space. The use of x-ray fan beam geometries and high frame-rate linear detector arrays allows one to overcome these challenges and produce images over large areas. Advanced, custom-built linear detector arrays have the potential to acquire images at rates of 5 meters per second or higher. In this paper, the principles or backscatter radiography by selective detection are reviewed. The use of linear detector arrays with x-ray fan beams is discussed. We present preliminary results for a system that can be used for detection and identification of wood railroad crossties that are experience subsurface degradation that cannot by identified by other inspection techniques, with significantly improved acquisition times of exceeding 3.5 m2/s. Finally, we will discuss how the fan-beam backscatter x-ray radiography translates to other applications such as land mine detection, imaging of root structure in soil, and flaw identification in composite materials.

High-Power Commercial X-ray Sources Driven by Superconducting Linacs
Chase H. Boulware, Niowave, Inc., Terry L. Grimm, Niowave, Inc., Valeriia Starovoitova, Niowave, Inc., Jerry L. Hollister, Niowave, Inc.

Presenter: Chase H. Boulware, Niowave, Inc., boulware@niowaveinc.com

Commercial x-ray sources need to operate reliably with high average x-ray flux, but must also be reasonably compact and affordable. High-energy electron accelerators create beams that produce x-rays at high flux. Superconducting radio-frequency accelerators can sustain very high electric fields at high duty factors up to continuous-wave, enabling high-average-power beams in compact systems. This contribution will give an overview of commercial superconducting accelerator technology along with four important commercial markets for superconducting electron linear accelerators. The commercial opportunity, advantages of superconducting systems, and the current status and plans for commercialization will be reviewed.

Implementation of Monte Carlo Library Least-Squares (MCLLS) approach for quantification of the chlorine impurity in on-line crude oil monitoring system

Hao Ping Chang [1], Center for Engineering Applications of Radioisotopes (CEAR), North Carolina State University, Raleigh, NC 27695-7909, United States [1], Meric Ilker [1 2], Department of Electrical Engineering, Western Norway University of Applied Sciences, Inndalsveien 28, Bergen, Norway [2], Davorin Sudac [3], Ruder Boskovic Institutre, Bijeni\v{c}ka c. 54, 10000 Zagreb [3], Karlo Nad [3], Ruder Boskovic Institutre, Bijeni\v{c}ka c. 54, 10000 Zagreb [3], Jasmina Obhodas [3], Ruder Boskovic Institutre, Bijeni\v{c}ka c. 54, 10000 Zagreb [3], Robin P. Gardner [1], Center for Engineering Applications of Radioisotopes (CEAR), North Carolina State University, Raleigh, NC 27695-7909, United States [1]

Presenter: Hao Ping Chang
Center for Engineering Applications of Radioisotopes (CEAR), North Carolina State University, Raleigh, NC 27695-7909, United States, hchang11@ncsu.edu

In on-line measurement system, prompt gamma-ray neutron activation analysis (PGNAA) has been widely used for elemental analysis especially bulk samples since it provides a rapid and non-destructive method. The Monte Carlo Library Least-Squares (MCLLS) approach is one of the methods for quantitative analysis all elemental weight fractions via assuming that total gamma-ray spectrum is using linear combinations of contributions by the library from the individual composition in the sample. To generate prompt gamma-ray libraries for each element, a specific purpose Monte Carlo code called Center for Engineering Application of Radioisotopes Coincidence Prompt Gamma-Ray (CEARCPG) is under consideration. In this work, conditions of extremely low concentration of chlorine impurity in crude oil have faced, however, PGNAA results suffer by lager noise from neutron source and background in general. An approach of determining chlorine content in the severe environment and improving the accuracy of elemental quantification via MCLLS is presented. In addition to handle ill-conditioning cases, a method of stripping known background radiation counts from experimental spectra was implemented before executing MCLLS processes. This approximation has been applied for removing known libraries of isotopes from prompt gamma-ray spectra and preparing unknown background library for library least-squares approach. The results show the estimation of chlorine content in various fuel oil samples by constructing computer-generated elemental libraries and background library from experimental results with two different methods to deal with the ill-conditioning issue. Essentially, it indicates that the applicability of PGNAA in conjunction of MCLLS approach is workable in low chlorine concentration environment and modified MCLLS

approach offers accurate resolutions as comparing with normal one.

Implications of 3D Electronics for Radiation Detection Systems
Walter McNeil, Kansas State University, Amir Bahadori, Kansas State University, Tim Sobering, Kansas State University, Nathan Hines, Kansas State University,

Presenter: Walter McNeil, Kansas State University, wmcneil@ksu.edu

3-Dimensional design and fabrication of electronics may be soon achievable with additive manufacturing methods such as Voxel Printing. Design considerations are presented here including potential weight and space-savings, trace path optimizations, grounding, return-currents, electro-magnetic shielding, mechanical shock protection and heat extraction. A conceptual design comparison is presented regarding a generic amplifier circuit as an example with discrete components in 3-Dimensional layout compared to a more traditional printed-circuit-board layout.

Monte Carlo Methods and Applications II, Vevey Room, 13:50-15:10

FULL ENERGY PEAK EFFICIENCY OF AN HPGE DETECTOR. SIMULATION USING MCNP6 AND GEANT4
José Ordóñez Ródenas, Grupo de Medioambiente y Seguridad Industrial. Universitat Politècnica de València
Sergio Gallardo Bermell, Instituto Universitario de Seguridad Industrial, Radiofísica y Medioambiental. Universitat Politècnica de València
Josefina Ortiz Moragón, Laboratorio de Radiactividad Ambiental. Universitat Politècnica de València.
Sebastián Martorell Alsina, Grupo de Medioambiente y Seguridad Industrial. Laboratorio de Radiactividad Ambiental. Departamento de Ingeniería Química y Nuclear. Universitat Politècnica de València.

Presenter: José Ordóñez Ródenas, Grupo de Medioambiente y Seguridad Industrial. Universitat Politècnica de València, joorro1@etsii.upv.es

High Purity Germanium (HPGe) detectors are widely used in gamma-ray spectrometry for the determination of radionuclides and their activity in environmental samples. In order to obtain accurate measurements, a detailed characterization of the system efficiency response is required. Nevertheless, experimental efficiency calibration is a time-consuming procedure, requiring previous measurements of standard samples with the same geometry and density than those to be analyzed. This work is focused on studying the capacities of different Monte Carlo simulation programs to complement the calibration procedures of the environmental radioactivity laboratory from the UPV. In this context, knowing the capabilities of the programs and their potential to the laboratory is required. Accordingly, an inter-comparison ensures the model validation and improves the analysis of the physic phenomena involved. In this frame, two detailed models have been implemented using MCNP6 and GEANT4. The validation of the results is determined by a quantitative comparison between the simulated and the measured efficiencies over the entire energy range under study (59.54 keV – 1836.01 keV). The results show some discrepancies between both programs due to the fact that GEANT4 is able to simulate the entire spectrum of the radionuclide as well as the radioactive decay. Both codes are reliable for the full energy peak efficiency calibration, but only GEANT4 allows calculating the true summing correction factors and the efficiency for those radioisotopes presenting a more complex decay scheme.

Full Recovering of an X-ray Spectrum from Detector Influence

Jorge E. Fernandez [1,2]
[1] Laboratory of Montecuccolino-DIN, Alma Mater Studiorum University of Bologna, via dei Colli 16, 40136 Bologna, Italy
[2] Alma Mater Studiorum Università di Bologna Representación en la República Argentina, M. T. de Alvear 1149, Buenos Aires, Argentina

Presenter: Jorge E. Fernandez [1,2]
[1] Laboratory of Montecuccolino-DIN, Alma Mater Studiorum University of Bologna, via dei Colli 16, 40136 Bologna, Italy
[2] Alma Mater Studiorum Università di Bologna Representación en la República Argentina, M. T. de Alvear 1149, Buen, jorge.fernandez@unibo.it

It is well known that a measured X-ray spectrum differs from the original spectrum arriving to the detector. This is due to changes introduced by the detection device and by the pulse electronics during the measurement. The detection device contributes with a deformation attributed to the detector response function (DRF) which is well described in terms of physical processes of radiation diffusion inside the detector. The pulse electronics contributes in two different ways: (a) with a convoluted broadening due to an asymmetrical distribution at each recorded energy (resolution effect) which produces an uneven smoothing of the spectrum, and (b) with the pulse pile-up which introduces a distortion which changes the total counts and the shape of the spectrum. Once characterized the DRF comprising the resolution broadening effects, it is possible to recur to an unfolding algorithm to recover the original spectrum. In this paper it is introduced a detailed description of the four steps which are necessary to recover the source spectrum from a measurement by using a set of computer codes developed in Bologna. In first place, it is applied a PPU correction algorithm on the measured spectrum which renders a corrected measure having the proper number of counts in the proper energies. Then it is computed the combined effect of the DRF and the asymmetrical resolution for each energy of the source spectrum. By discretizing these single energy distributions it is possible to obtain the response matrix feeding the next step. The last step consists in the application of a robust unfolding procedure like UMESTRAT, the maximum entropy technique which takes advantage of the known a priori information and preserves the positive-defined character of the X-ray spectrum. The results obtained are very good and are illustrated with some paradigmatic examples involving popular SSDs like Si, Ge and CdTe.

UNFOLDING X-RAY SPECTRA USING A FLAT PANEL DETECTOR. DETERMINATION OF THE ACCURACY OF THE METHOD WITH THE MONTE CARLO METHOD

S. Gallardo, Polytechnic University of Valencia, J. Ródenas, Universitat Politècnica de València, E. Jabaloyas, Polytechnic University of Valencia, G. Verdú, Polytechnic University of Valencia

Presenter: J. Ródenas, Department of Chemical and Nuclear Engineering, Universitat Politècnica de València, jrodenas@iqn.upv.es

Accurate experimental measurements of X-ray spectra in the radiodiagnostic energy range present important difficulties especially due to the high fluence rate of photons. The X-ray spectrum can be assessed using Monte Carlo techniques, simulating the interaction between electrons and the anode material and considering collimators and attenuation of X-rays in the filters. Experimentally, the X-ray spectrum is difficult to be determined with acceptable accuracy because it is influenced by several uncertainties, especially those related with the geometrical features of the X-ray device, the attenuation material, the detector and the experiment itself. Flat panel detectors can be used to obtain experimentally the primary X-ray spectrum. They are based on transforming the absorbed X-rays into charge carriers by means of a scintillator material that absorbs the X-rays and converts them into visible light photons that pass onto a photodiode array. A semiconductor foil is used to convert visible light photons into charge carriers. In this work, it has been developed a MCNP model simulating the experimental equipment, including the X-ray tube focus, a PMMA wedge attenuator and a flat panel. When the flat panel is irradiated, the photon fluence can be calculated in the scintillator layer at different positions using a F4MESH tally in MCNP5. This photon fluence can be converted into dose using the mass energy-absorption coefficient ($\mu en/\rho$). Once the dose curve corresponding to a determined X-ray spectrum is obtained, the X-ray can be estimated using unfolding techniques. The primary X-ray spectrum strongly depends on different parameters such as high voltage, filament current, high voltage ripple, anode angle and thickness and filter material. Slight variations of these parameters can produce non-negligible modifications in the X-ray spectrum. The objective of this work is to determine whether this unfolding technique is accurate enough to estimate the X-ray spectrum when small changes in the operation variables are considered. In this frame, several X-ray spectra are generated varying the

operation variables of the X-ray tube. With those spectra, the corresponding dose curves are obtained by simulation with a MCNP5 model. Once the dose curves are simulated and applying the unfolding SVD technique, the unfolded spectrum is obtained, which is compared with the theoretical one. Discrepancies between unfolded and primary X-ray spectra can be explained by two different ways. The first one is due to fact that this is an ill-posed problem, and the unfolding of the spectrum is strongly affected by the method used to improve the conditioning of the response matrix. The second one is referred to the differences produced by slight changes in the operational parameters that affect the X-ray spectrum. In the paper, both sources of discrepancies are assessed and quantified, determining each relative importance.

Depth of layers in historical materials measurable by X-ray fluorescence analysis

T. Trojek, Czech Technical University in Prague, L. Musílek, Czech Technical University in Prague, H. Bártová, Czech Technical University in Prague, R. Šefců, National Gallery in Prague

Presenter: L. Musílek, Czech Technical University in Prague, musilek@fjfi.cvut.cz

X-ray fluorescence analysis (XRFA) is one of the most frequently used radioanalytical methods, and is sensitive to most elements of the Mendeleev's periodic table. It is of particular relevance for valuable artefacts in investigations of cultural heritage, as, e.g., paintings and frescoes, sculptures, objects of applied art, etc., as it is a non-invasive and non-destructive method, and as it can be applied in-situ with portable instruments. On the other hand, it also has some unpleasant disadvantages, one of them being the fact, that it uses relatively soft X-rays with limited penetration ability. This means that, without taking samples from the depth of analysed objects, it is in principle a "surface" method, analysing effectively only relatively thin surface layers of materials. However, these layers can be of key importance in many artefacts, e.g., layers of paints on paintings and frescoes, layers of inks on historic manuscripts, metal-plating on sculptures and other metal objects, enamel layers, etc. The maximum depth, from which analytical signal is still measurable, depends on the material composition and density, the element, which should be detected (the main factor being in this case the energy of excited X-rays), and on the geometrical arrangement of a measuring instrument (especially angle of impact of exciting radiation and angle of emission of excited radiation). The paper summarises results of Monte Carlo calculations of thicknesses of material layers used in fine and applied arts objects, which are reachable by XRFA measurements of selected material and elements contained in these materials. Examples chosen for these calculations are related to real practical investigations of artefacts in our laboratory.

Dosimetry and Detector Applications III, Montreaux Room, 13:50-15:10

TL Measurement of Eye-Lens Dose in a Multicentre Stereotactic Radiosurgery Audit

Author 1:, Amjad. Alyahyawi , Institution:, 1-Department of Physics University of Surrey, Guildford, Surrey, UK, 2-Department of Diagnostic Radiology, University of Hail, Saudi Arabia, Author 2:, A. Dimitriadis, Institution:, 1-Department of Physics University of Surrey, Guildford, Surrey, UK, 2-National Physical Laboratory, Teddington, UK, Author 3:, S. Jafari, Institution:, 1-Department of Physics University of Surrey, Guildford, Surrey, UK, 2-Radiotherapy Physics, Level B, Queen Alexandra Hospital, Portsmouth, Author4:, A. Lohstroh, Institution, 1-Department of Physics University of Surrey, Guildford, Surrey, UK, Author5:, A. Alanazi, Institution, 1-Department of Physics University of Surrey, Guildford, Surrey, UK, 2-Cancer Centre, Prince Mohammed Medical City, 2254 Sakaka Aljouf 42421, Saudi Arabia, Author6:, A. Alsubaie, Institution, 1-Department of Physics University of Surrey, Guildford, Surrey, UK, 2-Department of Physics, Taif University,At- Al Khurmah branch, Taif 888, Saudi Arabia, Author7:, C. Clark, Institution, 1-Medical Physics Department, Royal Surrey County Hospital, Guildford, UK, 2-National Physical Laboratory, Teddington, UK, Author8:, A. Nisbet, Institution, 1-Department of Physics University of Surrey, Guildford, Surrey, UK, 2-Medical Physics Department, Royal Surrey County Hospital, Guildford, UK, Author9:, D.A. Bradley, Institution:, Department of Physics University of Surrey, Guildford, Surrey, UK, Sunway University, Institute for Health Care Development, 46150 PJ, Malaysia,

Presenter: Amjad. Alyahyawi, Department of Physics University of Surrey, Guildford, Surrey, UK, a.alyahyawi@surrey.ac.uk

Stereotactic radiosurgery (SRS) is a non-invasive radiation-therapy technique delivering high doses of ionizing radiation to precisely defined targets while preserving surrounding tissue. Constantly being developed for treatment of various functional abnormalities, malignant and benign brain lesions, SRS commercial platforms include Gamma-Knife, and the Linac-based systems X- and Cyberknife. All demonstrate local tumour control for single and multiple brain metastases, maintaining low complication rates. Imaging techniques used for localizing SRS targets include CT or MRI, imported into planning software that allows simulation and assessment of the most effective treatment approach. With a number of such approaches, this is an area befitting greater investigation and standardization. Here we report on a multi-centre (19 in all) dosimetric audit, investigating the range of SRS practices for a single brain metastasis using various detectors and an anthropomorphic head-phantom. With the lens being one of the most radiosensitive tissues, one audit aim has been to determine scattered radiation doses received by the lens during SRS treatments, a further aim being to evaluate imaging doses received during CT-scans at the planning stage. In satisfying these aims, custom-designed holders have been fabricated for three types of thermoluminscent dosimeter: Ge-doped optical fibres, glass-beads and TLD-100, the latter adopted as reference. A bespoke 3D-printed goggle insert was produced for the head phantom for reproducible placement of the TLD holders. The National Council on Radiation Protection and the International Commission on Radiological Protection have pointed to a threshold dose capable of producing cataract formation of some 2 Gy in a single exposure and 5 Gy for fractionated or protracted exposure. Present guidance seeks reduction in the dose that can be received by the lens, to 0.5 Gy. Our preliminary results for the SRS procedure show doses of between 0.2 to 0.3 Gy.

Slowing and Stopping Charged Particles Cause Angular Dependence for Absorbed Dose Measurements

Amir A. Bahadori, Kansas State University; Rajarshi Pal Chowdhury, Kansas State University; Tom Campbell-Ricketts, University of Houston; Ana Firan, Leidos; Dan Fry, NASA Johnson Space Center; Ramona Gaza, Leidos; Stuart George, University of Houston; Martin Kroupa, Leidos; Lawrence S. Pinsky, University of Houston; Nicholas N. Stoffle, Leidos; Ryan R. Rios, Leidos; Cary Zeitlin, Leidos

Presenter: Amir A. Bahadori, Kansas State University, bahadori@ksu.edu

The space radiation environment is dominated by heavy charged particles with atomic numbers ranging from 1 to 58 and kinetic energies up to about 10 GeV per nucleon. Despite advances in space radiation modeling and transport, radiation detectors provide critical data for understanding the space radiation environment. In the past, NASA relied on tissue-equivalent proportional counters and passive devices for operational dosimetry; however, in recent years, pixelated array detectors providing detailed information about the radiation environment through analysis of charged particle tracks have been demonstrated in space. These next-generation detectors, based on Timepix read-out technology, require special analysis considerations that were not necessary or possible for previous dosimetry tools. The impacts of slowing and stopping ions on absorbed dose measurements must be explicitly modeled to understand variations with detector orientation. The purpose of the present study is to conclusively demonstrate that while absorbed dose measurements of penetrating charged particles are independent of detector orientation, slowing and stopping particles can result in charged particle absorbed dose measurements that are dependent on detector orientation. Monte Carlo simulations of an unshielded detector, irradiated at selected orientations by different kinetic energy domains with fluence spectra representative of two historical solar particle events, will be presented to demonstrate the dependence of absorbed dose measurements. Next, Monte Carlo simulations of the same energy domains and fluence spectra, isotopically impinging on an anisotropic shield configuration about the detector, will be shown, to exhibit the potential for observing varying absorbed doses under realistic environment and shielding conditions. Finally, slowing and stopping proton data acquired using the Timepix-based detectors at the Tandem Van de Graaff at Brookhaven National Laboratory will be presented to demonstrate the effect using accelerator-based measurements.

Radiation gradient assessment at the new CERN CHARM irradiation facility

Angelo Infantino, Chiara Cangialosi, Salvatore Danzeca, Markus Brugger.
European Organization for Nuclear Research (CERN), Geneva 23, Geneva CH-1211, Switzerland

Presenter: Angelo Infantino, European Organization for Nuclear Research (CERN), Geneva 23, Geneva CH-1211, Switzerland, angelo.infantino@cern.ch

CERN's CHARM facility provides a unique complex radiation environment characterized by particle energy spectra representative of high energy accelerators, ground and atmospheric conditions and space applications. CHARM is conceived to be an irradiation facility for the qualification of large electronic systems and components in a mixed field radiation environment generated from the interaction of a 24 GeV/c proton beam with a copper or aluminium target. A movable shielding made of layers of concrete and iron allows to change the hardness and the particle population (neutrons, protons, kaons, pions, muons, electrons, photons) in predefined test locations. To ensure a full representativeness and reproducibility of the tests, a detailed dosimetry of the complex mixed irradiation field is mandatory. The significant size of the available test area, the multiple facility configurations as well as the partly strong radiation gradient present in some of the test locations make the radiation monitoring a challenge, the latter however of utmost importance for the correct characterisation of the device under test. This work provides first an overview of the various radiation fields depending on the test location and provides a detailed evaluation and the characterization of the dose gradient in test locations downstream of the target position. The obtained measurements have been coupled with FLUKA Monte Carlo simulations where a first test campaign allowed evaluating the vertical and horizontal dose gradient, at a reference test location. The here presented set of measurements is based on RadFET dosimeters, which were previously qualified in multiple calibration facilities and where we also discuss the observed varying responses to different particle/energy fields. The concluding comparison of simulations and the measurements shows an overall good agreement. A second measurement campaign is currently ongoing for an even more detailed mapping of the area of interest and for a further benchmark of FLUKA simulations.

[CANCELLED] Evaluation of Equivalent Dose on the Hands of Professionals in Pediatric Voiding Cystourethrography Procedures

Author 1: F.Z. Severo
Institution 1: Federal University of Technology – Paraná
Author 2: D. Filipov
Institution 2: Federal University of Technology – Paraná

Author 3: H.R. Schelin
Institution 3: Pelé Pequeno Príncipe Research Institute
Author 4: V. Deniyak
Institution 4: Pelé Pequeno Príncipe Research Institute
Author 5: S.A. Paschuk
Institution 5: Federal University of Technology – Paraná
Author 6: J.A. Ledesma
Institution 6: Pelé Pequeno Príncipe Research Institute

Presenter: Hugo Reuters Schelin
Institution: Pelé Pequeno Príncipe Research Institute, schelin2@gmail.com

In the Voiding Cystourethrography (VCUG), a urinary fluoroscopic procedure to visualize the urethra and the urinary bladder during urination, especially when involving pediatric patients, usually two professionals stay inside the examination room, whether to immobilize the patient or to inject the contrast material. Besides that, the hands of these professionals may stay close to the primary X ray beam, which is a great concern since, according to the ICRP, there is an annual limit of equivalent dose at the extremities of 500 mSv. Based on this data, the aim of the present work is to estimate the equivalent dose on the hands of both professionals who accompany pediatric VCUG, in order to confront those results with ICRP guidelines and some similar studies results. The study was conducted in a Brazilian pediatric Hospital, where humanoid phantoms were used to simulate the 2 y, 5 y and 10 y patients. A parallel plates ionization chamber was positioned in the place where the hands of both professionals remain during the examination: ~20 cm (for professional 1 – who inject the contrast material) and ~30 cm (for professional 2 – who immobilize the patient). As a result, the annual equivalent doses verified for both professionals were 730,0±0,1 mSv and 210,0±0,1 mSv, respectively for professionals 1 and 2. The dose received by the professional 1 exceeds the ICRP guideline and both doses were much higher than the ones from the similar studies (which were up to 50 mSv/year). Taking into account the reduction of these doses, it is suggested the application of radiological protection measures, such as the use of lead gloves, the increase in the distance between the patient and the professional (since the increase in 10 cm was responsible to reduce the dose in ~70%) and the reduction of the exposure time and field size.

Monte Carlo Methods and Applications III, Vevey Room, 15:40-17:00

RadFET dose response under mixed-fields characterized by high thermal neutrons fluences.

Matteo Marzo, CERN, Matteo Brucoli, CERN, Markus Brugger, CERN, Francesco

Cerutti, CERN, Salvatore Danzeca, CERN, Ruben Garcia Alia, CERN, Angelo Infantino, CERN.

Presenter: Matteo Marzo, CERN, matteo.marzo@cern.ch

RadFETs integrated in the RadMON system at the CERN High energy AcceleRator Mixed-field (CHARM) test facility are used to perform micro-dosimetry and to characterize the mixed-field of the the facility, e.g. in terms of Total Ionizing Dose. Different radiation fields representative of accelerators, atmospheric and space radiation environments can be reproduced at CHARM, by means of the interaction of a 24 GeV/c beam extracted from the Proton Synchrotron (PS), with a copper target: the developing particles shower can be then further modified using a movable shielding and finally reaches a set of tests positions, where electronic components to be tested are placed. Simulations and measurements of the dose response of RadFETs in the facility's mixed-field have already been performed in copper target and no shielding configuration, providing a good agreement between simulated and experimental values (5÷25% difference, within statistical uncertainty). On the other hand, when the concrete/iron movable shielding is in place, the massive presence of neutrons (mostly thermal) populating the mixed-field produces a significant discrepancy between simulated and experimental values (~50% difference), possibly caused by a strong dependence of the RadFET response on neutrons energy. This paper focuses on both FLUKA Monte Carlo simulations and experimental results of a test campaign we are conducting to investigate the RadFET response, when irradiated by thermal neutrons. A first set of irradiations have been performed in Grenoble in early 2017, using monoenergetic beams of 0.025eV neutrons (ILL, Institut Laue-Langevin) and 14MeV neutrons (LPSC, Laboratoire de Physique Subatomique & Cosmologue). Further tests will be conducted at ILL and CHARM in March-April 2017. In parallel, FLUKA is used to improve the RadFET model and the physics settings of the simulations to investigate the causes of the present mismatch.

Dose estimate for cone beam CT equipment protocols using Monte Carlo simulation in computational adult anthropomorphic phantoms

1 - M. Rosangela Soares, Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear, IPEN/CNEN, SP, Brazil, 2 - William S. Santos, Instituto de Física, Universidade Federal de Uberlândia (UFU), MG, Brazil, 3 - Walmir Belinato, Instituto Federal de Educação, Ciência e Tecnologia da Bahia (IFBA), BA, Brazil, 4 - Ana F. Maia, Universidade Federal de Sergipe (UFS), SE, Brazil, 5 - Linda V.E. Caldas, Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear, IPEN/CNEN, SP, Brazil

Presenter: Maria Rosangela Soares / Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear, IPEN/CNEN and Universidade Federal de Rondônia, UNIR, mrs2206@gmail.com

Cone beam computed tomography (CBCT) has become essential for dental diagnosis in the last decade. The objective of this study was to estimate the effective dose and the absorbed dose in tissue and organ for CBCT protocols intended for dental use. Monte Carlo (MC) simulations were used to estimate the effective dose and absorbed dose in tissue / organ suggested by the International Commission of Radiological Protection (ICPR) in its report ICRP-103. Seven different fields of view (FOV) were simulated. Two CBCT equipment were used in this work: i-Cat Classic CBCT and ProMax 3D CBCT. The code used was MCNPX. Anthropomorphic phantoms FASH (Female Adult MeSH) and MASH (Male Adult MeSH) were used. The results were compared with measurements previously obtained, and they were satisfactory. The tissue and organ doses vary for different FOV. The effective dose was in the range 66-111 μSv for the i-Cat Classic CBCT equipment and 68 - 236 μSv for the ProMax 3D equipment. The ProMax 3D equipment presented absorbed doses of at least 34% higher than the i-Cat Classic equipment in all protocols with the same clinical objective image. For both devices, the largest single contribution to the effective dose was from the salivary glands (31%, between 27 – 36 %) and other tissues (36%, between 31 – 39 %). The highest dose range, using the protocols, was shown in the salivary glands and thyroid. For the i-Cat equipment, the conversion factor dose–area product (DAP) was more efficient. For the ProMax 3D equipment the conversion factor kerma was more effective. The effective dose and the dose absorbed in tissues / organs vary according to the FOV exposure parameters and the positioning of the beam relative to the radiosensitive organs. The conversion factors for the equipment used were satisfactory.

COINCIDENCE SUMMING CORRECTION FACTORS FOR 238U AND 232Th DECAY SERIES USING THE MONTE CARLO METHOD.

José Ordóñez Ródenas, Grupo de Medioambiente y Seguridad Industrial. Universitat Politècnica de València
Sergio Gallardo Bermell, Instituto Universitario de Seguridad Industrial, Radiofísica y Medioambiental. Universitat Politècnica de València
Josefina Ortiz Moragón, Laboratorio de Radiactividad Ambiental. Universitat Politècnica de València.
Sebastián Martorell Alsina, Grupo de Medioambiente y Seguridad Industrial. Laboratorio de Radiactividad Ambiental. Departamento de Ingeniería Química y Nuclear. Universitat Politècnica de València

Presenter: José Ordóñez Ródenas, Grupo de Medioambiente y Seguridad Industrial. Universitat Politècnica de València., joorro1@etsii.upv.es

A common application of the gamma ray spectrometry in laboratories is the quantification of the activity in environmental samples containing natural radionuclides such as 238U and 232Th. Those radionuclides are not gamma emitters and, therefore, it is not possible to obtain their activity directly by gamma spectrometry techniques.

Often, they are in secular equilibrium with their progeny and, therefore, it is possible to quantify indirectly their activity by measuring others gamma-emitting radionuclides. On the other hand, some of them emit photons in cascade within the resolving time of the detector and therefore, the spectrometer may detect one interaction with an energy equal to the sum of all of them. This effect implies an erroneous calculation of the efficiency and thus, the activity of the radionuclide. In order to obtain the true activity, a correction factor (True Summing Correction Factor, TSCF) must be applied. The aim of this work is to apply the Monte Carlo method to calculate TSCFs for natural decay series and for different sample configurations (geometry and matrix) using the GEANT4 toolkit. In addition, a quantitative analysis about the influence of the geometry/matrix on the TSCFs is included. Once the TSCF is calculated, the experimental efficiency curve can be corrected allowing obtaining the true activity of the radionuclide. If secular equilibrium within the decay series is assumed, it is possible to quantify the activity of the precursor as well as any other radionuclide of interest.

Bandwidth consideration for data acquisition electronics of radiation detectors: a simulation study

Mohan Li, Nuclear, Plasma, radiological Engineering, University of Illinois at Urbana-Champaign
Shiva Abbaszadeh, Nuclear, Plasma, radiological Engineering, University of Illinois at Urbana-Champaign

Presenter: Mohan Li, Nuclear, Plasma, radiological Engineering, University of Illinois at Urbana-Champaign, mohanli2@illinois.edu

In the development of radiation detection systems with a large number of channels there is a need for front-end electronics load balancing to prevent loss of photon detection efficiency due to data pile-up. Depending on the width of the electrodes and their location, they may be a large variation in photon interaction rate per channel. Hence, it is important to design the electronics to provide sufficient bandwidth for reading out of each channel in a high detection efficiency system. In this study we used the Monte Carlo Simulation (GATE) study to determine the required front-end data acquisition bandwidth to optimize the electronic design of a cadmium zinc telluride (CZT) detector based system. A maximum detection rate of 18.98 ×104 photon interaction/s was found in 4cm×4 cm×0.5cm CZT crystal closet to a 300 μCi point source. In a cross-strip electrode configuration, this translates to approximately 1.2×104 photon interaction/s for the detector’s anode strips and 9.8×104 for the detector cathode strips revealing an order of magnitude variation.