Special Talks

ST-1

Title: Compressed Baryonic Matter at FAIR

Author: Alberica Toia (Goethe Uni. Frankfurt & GSI, Germany)

The study of QCD matter in extreme conditions of temperature and density such as those existing in the core or in the merge of neutron stars brings many insights into the innermost structure of this matter and the forces between its building blocks.

The Compressed Baryonic Matter (CBM) experiment, currently under construction at the emerging Facility for Antiproton and Ion Research (FAIR), is designed to explore the QCD phase diagram at high net-baryon densities and moderate temperatures through heavy-ion and hadron collisions in the energy range of sqrt(sNN) = 2.9 - 4.9 GeV.

Designed to explicitly access rare observables sensitive to the medium, CBM aims to high-statistics measurements of rare probes, and therefore targets event rates of up to 10 MHz. To meet these demands, the CBM experiment uses fast and radiation hard detectors, self-triggered detector front-ends and a free streaming readout architecture.

Several of the CBM detector systems, the data read-out chain and the online event reconstruction are commissioned and already used in experiments during the FAIR Phase-0, and also within a full-system setup at GSI SIS18 (mCBM). In this presentation the physics program of CBM will be presented and the current status of the experiment construction and operation will be reported.

Oral Presentations

Commission: Nuclear Analytical Techniques and Applications (NAT)

NAT-1

Title: Study of radiation resistance of materials at the IBR-2 reactor in 2025-2032.

Author: M.V. Bulavin (Joint Institute for Nuclear Research, Russia)

In the spring of 2025, the IBR-2 pulsed fast research reactor will continue its work on a physical experiment at the Frank Laboratory of Neutron Physics of the Joint Institute for Nuclear Research after a planned shutdown.

The unique characteristics of a pulsed reactor make it possible to study not only the radiation resistance of electronic components or semiconductors (nanoheterostructures etc) for tokamaks, colliders, and other megascience-class facilities, but also to conduct various studies of a wide range of materials and equipment for power and research nuclear reactors, as well as to conduct research in the field of radiochemistry, radiobiology, archaeology, mineralogy, etc.

Currently, the Joint Institute for Nuclear Research continues to collect applications for conducting such experiments in broad collaboration with the participating countries of the Institute, scientific and any other organizations interested in using neutrons to study the structure and properties of materials.

NAT-2

Title: Mobile installation for determining carbon concentration in soil.

Author: Yu.N. Kopach (Joint Institute for Nuclear Research, Russia)

Co-autores: A.V. Andreev, I.E. Chirikov-Zorin, N.A. Fedorov, D.N. Grozdanov, I.F. Lensky, E.A. Razinkov, Yu.N. Rogov, I.N. Ruskov, M.G. Sapozhnikov, V.R. Skoy, T.Yu. Tretyakova.

Determination of the elemental composition of soil, especially its organic carbon content, is an important task for both agronomy and ecology. Soil carbon sequestration can play an important role in the field of global climate change, in the development and implementation of measures aimed at reducing greenhouse gas emissions [1].

Existing methods of soil analysis [2] mainly involve the selection of bulk samples and work in the laboratory, which leads to significant complications, and in some cases to the unreliability and insufficient accuracy of the results.

The tagged neutron method (TNM) [3] uses neutrons with an energy of 14.1 MeV, which have high penetrating power and can be used for non-destructive analysis of various objects. An important advantage of the method is the use of portable tagged neutron generators, which allows for field measurements.

A mobile installation for non-invasive analysis of carbon content in soil, based on the TNM is being developed at JINR. We present the parameters of this installation and some results of test measurements and model simulations, which assess the performance and accuracy limits of device.

This work was supported by the Russian Science Foundation (grant no. 23-12-00239).

[1] Lal, R.: Soil carbon management and climate change, Carbon Manage., 4 (2013) 439–462.
[2] England J.R. and Viscarra Rossel R.A., SOIL, 4 (2018) 101–122.
[3] Kopach Yu. N. Sapozhnikov M.G., Physics of Particles and Nuclei, 2024, Vol. 55, No. 1, pp. 55–102.

NAT-3

Title: Portable Hybrid Energy dispersive X-ray diffraction - fluorescence system: Complementary performance for archeomaterial and material science applications.

Author: Ariadna Mendoza Cuevas (University College San Geronimo de la Habana, Cuba)

A portable hybrid Energy dispersive X-ray Diffraction system has previously developed and applied to inorganic pigment and mineral stone identification. Here we exemplified complementary performance of such a system for critical archaeometrical and material science applications in the identification of organo-metallic pigment, characterization of nanomaterial composition and depth profile analysis in layered samples. The identification of Prussian blue, characterization of

nano ferrite and depth profile of Egyptian sarcophagus samples are discussed and compared with laboratory or synchrotron analogue XRD analysis.

NAT- 4

Title: First Results of Determination of Absorbed Dose of Irradiated Samples After Run8 (2022-2023)

Author: Marcela Perez Tapanes (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)

Co-author: Nelli Pukhaeva

A method for analysis of the intensity and profile data of the 3.8 GeV/nucleon 124 Xe 54+ ion beam is presented, which contributes to precise determination of the absorbed dose for irradiated materials. The beam profile and intensity distributions together with overall intensity and fluency are analyzed for the set of samples of different geometry and chemical composition. The raw data were taken in the long-term exposure mode, which is the unique option currently available at the ARIADNA target station of the NICA facility. The intensity is measured before collision with the target that requires additional study on how the intensity decreases after passing through each detector and approximation of the intensity, which reaches a particular sample. Distributions of beam intensity and profile versus exact duration of irradiation were obtained for each investigated sample. Each sample was at the beam sequentially in series that results in individual profile for particular sample. The result of the fluence obtained will be used for further precise calculation of energy losses and absorbed dose in irradiated materials.

The study is performed within the ARIADNA Collaboration.

NAT- 5

Title: Characterization of filter aerosols samples by EDXRF fundamental parameters for a PM10 and PM2.5 source apportionment.

Author: Elieza Meneses Ruiz (Centro de Gestión de la Información y Desarrollo de la Energía, CUBAENERGÍA, Cuba)
Co-authors: Yoelvis Bolaños Álvarez, Yasser Morera Gómez, Alina Roig Rassi, Armando Villavicencio Machado

The correct characterization of particulate matter is of great importance for epidemiological studies. From this, the sources of particle emissions can be identified and from there, mitigation measures can be proposed and established, thus achieving a reduction in pollution and guaranteeing a healthier environment.

This work aims to identify the main sources of aerosols, as well as to quantify their contributions to particulate air pollution, at an air quality monitoring station located in Havana. To achieve this, data obtained from PM2.5 and PM10 monitoring were used, in the period from April 2019 to January 2020, combined with energy-dispersive X-ray fluorescence (EDXRF) spectrometry analysis and positive matrix factorization (PMF) source distribution modeling.

The results show that the air quality at the monitoring site are not good. For PM2.5 particles, the values established in NC 2010:2014 are exceeded on 63% of the days of measurement, while for PM10 particles, on 34% of the days. Four main sources of particulate pollution are identified: industrial and fugitive dust emissions; sources of oil combustion, African dust and marine aerosol; and traffic emissions. This study confirms that the identification and quantification of air pollution sources using techniques such as PMF and XRF are an effective tools to develop air quality management strategies, especially in developing countries.

Keywords: particulate matter, air pollution, XRF, PMF

Commission: High Energy Physics, Astrophysics and Cosmology (HEP)

HEP- 1

Title: Constraints on Bose–Einstein condensate stars as neutron stars models from new observational data.

Author: Adriel Rodríguez. (University of Havana, Cuba)
Co-author: Gretel Quintero Angulo

We evaluate the feasibility of Bose–Einstein condensate stars (BECS) as models for the interior of neutron stars (NSs). BECS are compact objects composed of bosons, formed through the spin-parallel pairing of neutrons. Here, we utilize the astronomical data from GW170817, XMMU J173203.3-344518 (the lightest NS known), and a novel lower limit on NS core heat capacity to scrutinize the

compatibility of BECS with these recent observations of NSs. Our specific focus is to constrain the values of the scattering length a, parameter determining the strength of particle interactions in the model. Our analysis suggests that if the stars involved in GW170817 were BECSs, the scattering length of their constituent bosons should fall within the 4 to 10 fm range. Additionally, at a scattering length of $a \sim 3.1-4$ fm, stars with mass and radius characteristics akin to XMMU J173203.3-344518 are identified. Moreover, we find that the heat capacity depends on the mass and temperature of BECS, and surpasses the established lower bound for NS cores when $a > 2-5$ fm. In summary, our results endorse BECS models with $a \sim 4$ fm, providing NS observables in agreement with diverse observations and contributing to the understanding of NS interiors.

HEP- 2

Title: Tracker Alignment: Early 2024 performance and Phase 2 calibration.

Autor: Karla Figueredo Rodríguez (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)

The DESY CMS tracker alignment group is a team responsible for developing and operating the software tools to align the CMS silicon tracker detector. The CMS Phase-2 Upgrade will significantly improve the CMS detector to tackle the more challenging conditions of high luminosity LHC (HL-LHC). The installation of some of the components of the upgraded detector systems started in the Long Shutdown 2 (LS2) and is planned to be completed during the Long Shutdown 3 (LS3). The new CMS Silicon-Tracker constitutes one of the pillars of the upgrade with a significant increase in the number of channels and improved spatial resolution. In the context of this project, the tracker alignment performance in 2024 is studied and the track-based alignment of the Phase 2 tracker geometry is performed using simulated events under the HL-LHC pileup conditions with the MillePede-II algorithm.

Commission: Nuclear Instrumentation and Facilities (NI)

NI-1

Title: Remarks on LINAC-200 electron accelerator operational parameters and its new control system development status

Author: Aleksei Trifonov (Joint Institute for Nuclear Research, Russia)
Co-authors: Aleksander Brukva, Vladimir Glagolev, Mikhail Gostkin, Valery Kobets, Mikhail Nozdrin, Vladimir Shabratov, Dmitry Shokin, Konstantin Yunenko, Pavel Zhuravlyov

The linear accelerator LINAC-200 at JINR is a new facility constructed to provide electron test beams to carry out particle detectors R&D, to perform studies of advanced methods of electron beam diagnostics, and for applied research. The core of the facility is a refurbished MEA accelerator from NIKHEF. Commissioning is underway at the accelerator, during which a complete modernization of the accelerator control system is ongoing. The new control system is being developed based on the TANGO Controls framework. Both software and hardware are being developed to automate individual accelerator subsystems.

Currently, two test beam channels are available for users: the first one with electron energy in range 5–25 MeV, and the second one with electron energy in range 60–200 MeV. A test beam channel with energy in range 60–120 MeV has been assembled and needs to be tested; another channel with beam energy in range 25–60 MeV is under development. The pulse current varies smoothly from 80 mA down to almost zero (single electrons in a bunch). This report will discuss the status and operation parameters of the facility, the prospects for future upgrades, as well as the design and current status of the control system of the LINAC-200 machine.

NI-2

Title: Characterization of a EJ-200 plastic scintillator array for experiments with 14-MeV tagged neutrons using the carbon and polyethylene samples

Authors: P.S. Prusachenko. (Joint Institute for Nuclear Research, Russia)
Co-authors: D.N. Grozdanov, N.A. Fedorov, Yu.N. Kopatch, I.N. Ruskov, T.Yu. Tretyakova, P.I. Kharlamov, C. Hramco, P.G. Filonchik, V.R. Skoy, and TANGRA collaboration

Investigation of the interaction of 14.1 MeV neutrons with the different nuclei is the main aim of the TANGRA project at the Frank Laboratory of Neutron Physics. One of the experimental setups within the framework of the project consisting of an array of EJ-200 plastic scintillators was designed to study the angular distributions of neutrons and γ-rays from elastic and inelastic scattering of 14.1 MeV incident neutrons.

The main aim of the work was to determine and verify the neutron detection efficiency of EJ-200 scintillators in a wide energy range. The existing datasets on the light outputs for the secondary particles produced by interaction of neutrons with EJ-200 scintillator are insufficient and contradictory, leading to a large uncertainty in the efficiency predicted by a Monte-Carlo simulation. The experimental verification of the efficiency above 8 MeV is quite a difficult problem too because the yield of neutrons with energies above 7 MeV from 252Cf source commonly used for this is very low.

In this work the light outputs for both protons and alpha-particles were experimentally determined. Scattering of the 14.1 MeV neutron beam on the graphite and polyethylene samples were used to obtain the neutrons with known energies at different angles. A GEANT4 simulation of both the EJ-200 response function and the intrinsic efficiency was performed based on the data obtained. The simulated efficiency curve was experimentally verified using the 1H(n,n)1H reaction as a standard.

This work was carried out with financial support from the Russian Science Foundation (grant no. 23-12-00239).

NI-3

Title: Progress in development of the TANGRA project

Author: Nikita Fedorov (Joint Institute for Nuclear Research, Russia)
Co-authors: C. Hramco, A.P. Zuev, A.V. Andreev, P.I. Kharlamov, T.Yu. Tretyakova, I.N. Ruskov, V.R. Skoy, P.G. Filonchik, Pavel Prusachenko, Yu.N. Kopatch, D.N. Grozdanov

Information about neutron-induced reactions is very important both for fundamental and applied research. To date, a significant attention is paid for reactions with 14 MeV neutrons because they could be produced using very compact sources – neutron generators that allows creation of very compact devices for elemental analysis and well logging [1,2]. Parameters of these neutron sources and implementation of the tagged neutron method (TNM) makes they usage quite prospective for fundamental research.

The TANGRA (TAgged Neutrons and Gamma RAys) project at FLNP JINR in Dubna (Russia) is dedicated for nuclear reaction research using the TNM [3]. It was started in 2014 and during 10 years of its operation a list of experiments was carried out, including measurements of γ-ray emission cross-sections and angular distributions [4], correlations between inelastically scattered neutrons and subsequent γ-quanta, differential cross-sections for elastic and inelastic neutron energy for 14.1 MeV neutrons [5]. Software for nuclear data handling and TALYS calculation processing was developed [6,7]. Current status of the TANGRA project and directions of further work will be reported.

[1] V Valkovic. 14 MeV Neutrons. Physics and Applications. CRC Press, New York, 2015.
[2] G. Yakubova et al., Vadose Zone Journal 15 (2015) 1
[3] I.N. Ruskov et al. Physics Procedia, vol. 64, 2015, pp. 163-170, ISSN 1875-3892, https://doi.org/10.1016/j.phpro.2015.04.022.
[4] Fedorov N. A. et al. EPJ A 6 (2021) 194
[5] Dashkov I.D. et al., Bull. RAS: Physics. 86 (2022) 893
[6] https://github.com/terawatt93/talyslib
[7] https://github.com/terawatt93/indc-ccp-0413-JSON

NI- 4

Title: Development and optimization of data processing methods in the TANGRA project experimental setups

Author: Petr Kharlamov (Joint Institute for Nuclear Research, Russia)
Co-authors: A.V. Andreev, Nikita Fedorov, P.G. Filonchik, D.N. Grozdanov, C. Hramco, Yury Kopach, G.V. Pampushik, Pavel Prusachenko, I.N. Ruskov, V.R. Skoy, T.Yu. Tretyakova

In order to conduct research on γ-radiation, the TANGRA project [1] utilizes two semiconductor detectors made of high-purity germanium, as germanium possesses a small band gap and the lowest energy of formation of an electron-hole pair in comparison to other semiconductors. In TANGRA experiments, customized digitizers are applied, with the resulting signals fed into the Romana software developed as part of the project. The software is used for the recording and processing of signals from the detectors. The Romana software employs a specialized approach to obtain spectrometric measurements. However, the energy resolution (FWHM) is observed to degrade significantly as the detector load increases. One potential solution to this resolution loss is an increase in the processing area of the signal. Unfortunately, this approach may result in a situation where the processing system is unable to maintain the required rate of data processing, leading to the loss of the data. Therefore, alternative methods of digital signal processing were developed and the optimal parameters were identified with respect to the best energy resolution and high detector load. The following report presents the latest studies on the optimization of parameters for a set of methods used for processing digitized signals from semiconductor detectors made of high-purity germanium.

This work was supported by the RSCF grant 23-12-00239.

[1] Ruskov I.N., Kopatch Y.N., Bystritsky V.M. et al. TANGRA-Setup for the Investigation of Nuclear Fission induced by 14.1 MeV neutrons //Physics procedia. - 2015. - T. 64. - S. 163-170.

NI- 5

Title: Performance of hit, track, and vertex reconstruction of the CBM Silicon Tracking System at mCBM@SIS18.

Author: Dario Alberto Ramirez Zaldivar (GSI Helmholtzzentrum für Schwerionenforschung gmbh, Germany)

The Compressed Baryonic Matter (CBM) experiment is one of the experimental pillars at the Facility for Antiproton and Ion Research (FAIR).

The Silicon Tracking System (STS) is the central detector for track reconstruction and momentum measurement. It is designed to measure heavy ion collisions at interaction rates up to 10 MHz. It comprises approximately 900 double-sided silicon strip sensors with 1024 strips per side, arranged in 8 tracking stations in a magnetic field of 1 Tm. In the context of the FAIR Phase-0 program, the mCBM setup at SIS18/GSI is a small-scale precursor of the full CBM experiment, consisting of pre-series productions of all major CBM detector subsystems aiming to verify CBM's concepts of free-streaming readout electronics, data transport, and online reconstruction. The mini-STS (mSTS) setup consists of 11 sensors arranged in 2 stations and no magnetic field.

Heavy ion collisions in the 1−2AGeV/c range were measured with an average collision rate of 500kHz. The primary and secondary vertexes are reconstructed using the two layers of the mSTS detector, with tracks reconstructed as straight lines. Hit reconstruction efficiency was estimated using correlations with downstream detectors. This contribution will present the performance of hit, track, and vertex reconstruction from measurements of heavy ion collisions.

NI-6

Title: The Silicon Tracking System of the E16 experiment at J-PARC: commissioning and results from the test beam

Author: Dairon Rodriguez Garces (GSI and Goethe University of Frankfurt, Germany)

The J-PARC E16 experiment has the goal to search for signatures of the spontanoeusly broken chiral symmetry and its (partial) restoration, through the study in-medium modification of the vector mesons, particulary the phi meson, decaying via di-electron channel, with a high intensity 30 GeV proton beam interacting with C and Cu targets at rates up to 10 MHz. For this purpose, the experiment will use

modules constructed using the same technology and procedures as the modules of the Silicon Tracking System (STS) of the CBM experiment.

A total of 10 modules were assembled, tested, characterized and then; installed in the E16 detector setup. For preparation the detector for the beamtest, we commissioned the detectors by measuring ENC and calibration performance. In the beamtime 3 modules operated and were iluminated by electron beam of 3 GeV momentum.

This work will show the results of commissioning and operation of the E16 modules, as well as the status of the data analysis and the insights that we have gained from it, in view the upcoming series production of STS modules.

NI-7

Title: Detailed Geometric Simulation of the Zero-Degree Calorimeter for the Spin Physics Detector Using Geant4.

Authors: Thalia Rodriguez (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)
Co-authors: Katherin Shtejer Diaz, Fernando Guzman, Mayvi Pedraza

Accurate geometric modeling of detector components is essential for optimizing performance and ensuring the reliability of experimental setups in high-energy physics. This report details the geometry simulation of the Zero-Degree Calorimeter (ZDC), a key component of the Spin Physics Detector (SPD) at the Nuclotron-based Ion Collider facility (NICA) currently under construction at the Joint Institute for Nuclear Research (JINR), Dubna. Using the latest version of the Geant4 toolkit, this work aims to replicate the particular design of the ZDC, which was engineered to be located at 13 m from the Interaction Point (IP) and placed in between the two beam pipes that are not parallel in that specific position. Strong magnetic fields will allow the ZDC to selectively filter charged particles to facilitate the accurate detection of neutral particles. Its finely segmented calorimeter design incorporates plastic scintillator tiles, tungsten absorber plates, and advanced SiPM readout systems, which collectively ensure high precision in luminosity measurements, neutron tagging, and time resolution. This simulation meticulously models the ZDC's geometry, taking into account its electromagnetic and hadronic modules, material composition, and the innovative "growing" design that enhances particle containment. The study also evaluates the detector's response to photons and neutrons with different energies. These results are benchmarked against the

specifications outlined in the Technical Design Report (TDR) of the SPD collaboration.

NI-8

Title: Software program for calculating the dynamics of a fast pulsed reactor.

Authors: Tatiana Dikova. (Joint Institute for Nuclear Research, Russia)
Co-authors: Alexander Verkhoglyadov, Maksim Bulavin, Mikhail Rzyanin

Research reactors of the IBR-2 type (Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna) provide efficient generation of high-intensity slow neutron fluxes for structural studies of materials due to short neutron pulses and high level of average flux [1]. The dynamic characteristics of IBR-2 depend on feedbacks acting on short time intervals comparable to the repetition period of power

pulses (5-10 Hz) [2]. These feedbacks can change during reactor operation, affecting its dynamics in both transient and steady-state operational modes. A software program capable of quickly predicting the most stable reactor operation modes is being developed. The C++ programming language is used to create the application under development, and the Qt framework is used to specify the graphical shell using the Qt Creator development environment.The program allows making reactor stability predictions based on the following parameters: reactor power, amplitudes of "impulse functions", relative rates of reactivity feedback reduction.

NI-9

Title: Managing the accelerator complex network infrastructure (using the DC-140 as an example at FLNR) using the Telegram application.

Author: Andrey Baginyan (Joint Institute for Nuclear Research, Russia)

No matter how convenient the WEB interface of the network management system is, it will still not be as convenient as using the Telegram messenger, where everything is in one application: from communicating with friends and receiving a weather forecast to managing network devices. In addition, the convenient API interface of the Telegram platform allows you to get the desired service with minimal effort. In this paper I will give the simplest example of one of these

solutions. The implementation of this solution is planned to be carried out using the example of the creation of the latest network architecture, the DC-140 accelerator under construction at the Flerov Laboratory of Nuclear Reactions.

NS-1

Title: The measurements of the gamma-ray emission cross sections and angular distributions from (n,xγ) reactions with 14.1 MeV neutrons with chromium and titanium nuclei.

Authors: Dimitar Grozdanov. (Joint Institute for Nuclear Research, Russia)
Co-authors: N.A. Fedorov, Pavel Prusachenko, Yu.N. Kopatch, C. Hramco, I.N. Ruskov, P.G. Filonchik, P.I. Kharlamov, T.Yu. Tretyakova, V.R. Skoy, TANGRA collaboration, A.P. Zuev, A.V. Andreev, G.V. Pampushik

The study of inelastic scattering of fast neutrons by atomic nuclei is of great importance for fundamental and applied neutron-nuclear physics. Reactions induced by neutrons are the unique source of information for describing the processes of strong interaction between nucleons. Inelastic scattering processes are used to study the characteristics of excited states of target nuclei. The practical use of the (n,n'γ) reaction requires the expansion and refinement of experimental data on this process. Research on the inelastic scattering of fast neutrons has recently become more active in connection with new prospects for the production of nuclear energy using fast neutron reactors.

The purpose of the experiment was to refine the available data on emission cross sections and angular distributions from inelastic scattering of 14.1 MeV neutrons by natural composition of chromium and titanium nuclei. The work was carried out within the framework of the scientific program of the international TANGRA project at FLNP of the JINR in Dubna (Russia).

Inelastic scattering was studied by the Tagged Neutron Method, in which neutrons with an energy of 14.1 MeV produced in the d(t,a)n reaction are “tagged” by detecting alpha particles. Gamma quanta from the (n,n'γ) reaction were recorded by

the new multidetector system [1]. Experimental data are shown and discussed in comparison with previously published data.

This work was carried out with financial support from the Russian Science Foundation (grant no. 23-12-00239).

[1] Yu.N. Kopatch, et al. Moscow University Physics Bulletin vol.79, No3, pp. 308-317, 2024.

NI-10

Title: Thermo-hydraulic analysis of a small modular reactor of type IPWR

Authors: Daniel Perdigon Cuellar (Instituto Superior de Tecnologías y Ciencias Aplicadas, Havana, Cuba)
Co-author: Carlos Rafael García Hernandez

Small Modular Reactors (SMRs) are an innovative option for power generation. This type of reactor offers numerous benefits and uses. The implementation of Fully Ceramic Microencapsulated fuel (FCM) in an integral pressurized water reactor (iPWR) with SMR characteristics has been studied previously. FCM has excellent thermal and irradiation resistance properties and comprises a SiC matrix with dispersed TRISO fuel particles. A computational model was built using CFD codes to perform the thermo-hydraulic analysis of the core of an SMR using FCM as fuel. The model describes a typical fuel assembly of the reactor and the main thermo-hydraulic parameters are calculated for the increased power values of 65, 80, and 100 MWt. To improve the thermo-hydraulic behavior of the core, it was considered to vary the values of mass flow, core inlet temperature, and system pressure. In addition, calculations were performed for different values of the packing fraction of TRISO particles in the matrix, and this variable's influence on heat transfer was analyzed. In all the cases analyzed, the reactor conditions were found to meet the safety parameters from the thermo-hydraulic point of view.

Commission: Medical Physics and Radiation Protection (MP)

MP-1

Title: ALFIM: Continuing Education Strategy for Medical Physicists in the Region.

Author: Adlin López Díaz (Departamento Ciencias Físicas, Centro de Excelencia en Física e Ingeniería en Salud, Universidad de la Frontera, Chile)
Co-authors: Daniel Coiro da Silva, Erick Hernández, Patricia Mora, Nahuel Díaz Giunta, María Sol Gallo

This work evaluates the results of the strategy developed by ALFIM (Latin American Association of Medical Physics) to generate and strengthen continuous education (CE) actions in medical physics. The activities carried out, the results obtained, and their impact were analyzed from June 2022 to June 2024. The strategy was based on creating the ALFIM Continuing Education and Training Committee, composed of 41 experts, and the approval of the Policy for the Education and Accreditation of Latin American Medical Physicists. The committee approved the work plan and generated manuals for accreditation and recognition of CE courses and activities. The organization's new website, quarterly newsletter, social networks such as LinkedIn, Facebook, Instagram, as well as WhatsApp, Telegram, and X groups were used as basic elements for the CE work plan. The ALFIM YouTube channel was an indispensable CE tool, growing from 12 to 421 followers. Other successful results of this CE strategy included the Virtual Conferences for Medical Physics Day (viewing range 26-223) and the Video Match "This is how we do it," featuring 26 educational videos (viewing range 44-168). The six asynchronous seminars from April to June 2024 showed 92-201 views. The first Asynchronous Virtual Course "Diagnostic Reference Levels in MN" was developed, with 316 registered participants, 91 graduates of the theoretical activities, and 42 of the practical activities. Conclusions: The balance of the CE strategy of ALFIM was positive. However, increasing the dissemination work and the impact and recognition of the planned and developed actions is necessary.

MP-2

Title: Optimizing CT component in Hybrid Nuclear Medicine Studies: first steps at national levels.

Author: Adlin López Díaz (Departamento Ciencias Físicas, Centro de Excelencia en Física e Ingeniería en Salud, Universidad de la Frontera, Chile)

Co-authors: Carlos F Calderón, Caridad Casacó, Juan Cárdenas, Mayka Guerrero Cancio, Adalberto Machado Tejeda, Juan Miguel Martín Escuela, Ilén O´Farril Mérida, Lissette Pérez Mejías, Yudmila Reyes, Jeniffer Reyes Garrido, Leonel A Torres Aroche

This work aimed to critically analyze the strategy for optimizing the CT component of hybrid studies during the national project PS211LH02-064 (2022-2026). The activities from June 2022 to June 2024, the results obtained, and their impact were analyzed. The results included a calibration study on Philips PET/CT and Mediso SPECT/CT hybrid equipment (88% of available in Cuba), comparing the results using different phantom/dosimetric available sets and their combinations. This exercise led to training personnel on dosimetric CT assessment, to strengthen the dosimetric measurement infrastructure and quality control programs. Initial baseline studies of typical exposures of the CT components were carried out in hybrid studies, using computational tools developed and tested during the project, consolidating the knowledge of the available equipment and its exposure characteristics. Next, the study of image quality and its relationship with dose was carried out, using physical and anthropomorphic phantoms. These tasks allowed the characterization of the available protocols and tools and served as a basis for studying and implementing metrics for their objective evaluation. Finally, the clinical images and their relationship with the doses were studied, using quality metrics and the observer criteria, which let us identify the available optimization potentials. Taking these results into account, specific strategies were drawn up in each center to optimize the protocols. Conclusions: in this first stage, solid results were achieved that allowed specific strategies to be drawn up in each center, taking into account the characteristics and particularities found in each case.

MP-3

Title: Establishing reference levels for diagnosis for computed tomography examinations in Costa Rica: preliminary results.

Author: Dagoberto E. González López (Hospital México-CCSS. San José, Costa Rica)
Co-authors: Simone Kodlulovich Renha, Adlin López Díaz, Lourdes Salvador Hernández, Fredys Santos Gutiérrez, Leonel A Torres Aroche

Diagnostic reference levels (DRLs) are an important tool for optimizing the medical exposure of patients in computed tomography (CT). Costa Rica is part of a working group of the IAEA-RLA6091 project that aims to design strategies to generate, implement, and monitor DRLs in the region.

A preliminary study was performed in the country's public health centers that perform CT examinations. The volumetric dose index in CT (CTDIv) and the dose-length product (DLP) medians of anatomical areas: head, chest, abdomen-pelvis protocols in adult patients were collected. The value of the third quartile (75th percentile) of the distribution of the medians was determined and analyzed for these parameters.

This investigation comprised 26% of all CT scans in Costa Rica. From the preliminary results collected, the 75th percentile for CTDIvol (mGy) and DLP (mGy cm) was for head CT (52 and 1197 respectively), chest CT (9 and 664 respectively), and abdomen-pelvis CT (16 and 1568 respectively).

CTDIvol values in the different anatomical areas were similar to international studies. However, a wide variation in DLP values was identified between national CT scanners, confirming the need to develop strategies to optimize CT protocols in Costa Rica.

MP-4

Title: Implementation of 3D-Printed Bolus Technique Using Structure from Motion in Radiotherapy.

Authors: Jorge Luis Dominguez Martinez (JLDM Technology and Commissioning Entity, Trinidad and Tobago)
Co-authors: Courage Mahuvava, Nikolay Zyuzikov

The implementation of low-cost camera-assisted processing to obtain radiotherapy bolus using the surface of motion technique and a 3D printer can improve the superficial tumour treatment in the patient. The issue of air gap is produced due to lack of perfect contact between the commercial flat bolus and the irregular surface. The use of 3D printed customized bolus improve the radiotherapy variables such as dose-volume histogram, conformity index, and homogeneity index. A comparison of the 3D structure obtained from CT images and the camera is presented. 3D-printed bolus for the specific patient instead of the commercial bolus improves the delivery of patient treatment ensuring adequate irradiation dose. This has not been previously reported in the regional literature and includes a brief discussion of the challenges of 3D printing regarding its related materials.

MP-5

Title: Improvement of breast micro-calcification contrast through spectral image analysis

Author: Steven Cely Iza (Universidad de los Andes, Colombia)
Co-autores: Simon Procz, Gerardo Roque, Sebastian Useche, Carlos Arturo Ávila Bernal

The limited visibility of breast lesions underlying silicone implants has hampered the early detection of breast cancer, highlighting the need for imaging methods that provide enhanced contrast for features behind the implant. An experimental study of spectral material decomposition to improve the contrast of aluminum oxide micro-calcifications (μC) in a breast implant mammographic setting is presented. The phantom Mammo-156 (with 400 μm diameter μCs) was partially shielded with a 250 cc breast silicone implant compressed to 2 cm. Additional PMMA slabs were included to emulate a standard breast tissue of 5 cm. The experimental setup consisted of a microfocus X-ray source and the hybrid photon counting detector Timepix3, which allows to determine the energy of the incident photons. The X-ray exposure time was set to get standard entrance radiation doses in mammography (~ 4 mGy). Four different polychromatic X-ray spectra were considered, where images in different energy bins were used as input to obtain energy-independent maps (projected thicknesses) of two reference materials for each spectrum. By applying the Beer-Lambert equation to the energy with the highest contrast-to-noise ratio (CNR) identified from the binarized images, and using the obtained projected thicknesses, a new image with an improved CNR was constructed. After applying this method, the highest CNR improvement was 49% for μCs not shielded by the implant, and 39% for μCs shielded by the implant. Enhancement of μCs contrast was also verified with Monte Carlo simulations using the GATE software.

MP-6

Title: Application of speckle X-ray phase contrast imaging to mammography.

Author: Cristian David Tibambre (Universidad de los Andes, Colombia)
Co-authors: Carlos Arturo Avila Bernal, Edilio Steven Cely Iza

The use of X-ray phase contrast techniques has gained great relevance in recent years due to their ability to identify low-attenuation tissues in X-ray images. In the present study, we use two widely reported phase contrast methods: the free propagation (In-line) method and the speckle X-ray tracking (SBI) method to obtain images of the accreditation Mammo-156 phantom. We concentrate our attention on the phantom region with 0.4mm diameter microcalcifications (μCs) composed of Alumina (Al 2 O 3). The experimental setup consists of a Tungsten anode X-ray micro-focus source (operated at 28kVp) with 50μm Rhodium filter and a Timepix3 detection with CdTe sensor. By using phase retrieval algorithms it is possible to obtain multimodal signals from the SBI method, providing additional information in a diagnostic process, compared to the In-line method.

Additionally, the dose absorbed by the phantom in each of the methods is estimated with the Timepix3 detector, finding that the In-line method offers a higher Contrast-to-noise ratio in the phase image compared to the SBI method at the same dose. However, the latter offers two additional signals: the laplacian signal and the dark-field signal, which can also be used in the early diagnosis of breast lesions. On the other hand, the versatility of the Timepix3 detector is demonstrated in this medical application, producing images with high-resolution and measurements of the dose received by the sample in the same acquisition process.

MP-7

Title: Use of radiation transport modeling in source-detector arrangement optimization for medical imaging application.

Author: Elizabeth Vega Moreno (Center for Technological Applications and Nuclear Development, Cuba)
Co-authors: Carlos Manuel Cruz Inclán, Antonio Leyva Fabelo

Using the MCNPX code system, based on the Monte Carlo statistical method, a simulation of a preclinical SPECT/CT micro-scanner was carried out. All the geometric details inherent to a conventional tomograph were meticulously considered. The X-ray spectra were modeled and intercompared for different tube potentials, both at the output and in the proximity to the detector. The influence of the lateral displacement of the detector and its inclination with respect to the beam axis on the number of photons from the source reaching the detector was investigated. In this context, the detector efficiency was also evaluated as a function of the electron current in the Roentgen tube for three different acceleration potential values. The impact of the semiconductor detector material in the micro-scanner on the attenuation of radiation from the X-ray tube was demonstrated and notably manifested in the estimated dose rate values. The simulation confirmed that the number of photons reaching the detector from the tube, using the two proposed conventional primary source variants, the photon and the electron, exhibits a percentage difference between them of less than 3.03% in all cases, supporting the accuracy of the simulation.

MP-8

Title: Visualization and Quantitative Analysis of High-Molecular Biopolymers In Vivo Using Energy-Sensitive Computed Tomography (eCT) with Nanocomposite Contrast Agents.

Authors: V.A. Rozhkov. (Joint Institute for Nuclear Research, Dubna, Russia)(Lomonosov Moscow State University, Moscow, Russia)
Co-authors: G.A. Chelkov, D.A. Shashurin, R.V. Sotenskii, E.V. Suslova

Within the project, new contrast agents (CA) for eCT were developed, based on Ln-containing nanoparticles (La, Nd, Gd) stabilized on carbon nanomaterials and silicon dioxide. The primary objective of the first phase was to obtain stable nanocomposites with high contrast properties for their subsequent use in biomedical research.
Nanocomposites based on few-layered graphite fragments (FLGF) and SiO2 were synthesized and their physicochemical properties were studied. These composites demonstrated the ability to precisely control particle size and morphology. Energy-sensitive CT using phantom studies showed that such contrast agents allow for accurate differentiation of high atomic number elements.
Preliminary studies of the pharmacokinetics and toxicological profile of the contrast agents revealed the need for further optimization for in vivo applications. Ongoing work is focused on improving suspension stability and enhancing the sensitivity of the method.

Acknowledgments
This research was funded by the Russian Science Foundation, grant number 22-15-00072.

MP-9

Title: Optimization design of medical exposures in PET studies: First experience in Cuba.

Authors: Daniel Alejandro Izquierdo (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)
Co-authors: Ernesto Corona González, Mayka Guerrero Cancio.

The objective of this work is to design a methodology to optimize medical exposures of the most common and dosimetrically relevant procedures in FDG studies for the PET component of the Philips Ingenuity TF128 RoHS multimodal system installed at the cedt-CIMEQ. The study was divided into three stages: 1) evaluation of medical exposure optimization methods in phantoms to simulate different activity levels, 2) Retrospective analysis of FDG studies in patients, and 3) Planning optimized studies in a select group of patients. In both, the first and second stages, it was found that: • SNR improves with increased acquisition time per bed • Lower activity concentrations with longer acquisition times per bed have comparable or superior

image quality to routine studies with higher activity concentrations. • Varying certain processing parameters in the equipment can improve factory clinical protocols • Reconstruction tools available in modern systems such as iDOSE and PSF can improve image quality with lower dose concentrations. • The activity concentration in certain studies could be reduced to half of what is established in international protocols. In the last stage, these results were verified with patients in real-time. This work developed over two years allowed characterizing the PET/CT system installed at the cedt. A methodology was designed to optimize medical exposures of the most common and dosimetrically relevant procedures in PET studies with FDG and served as a reference for the rest of the country's services that have this technology.

MP-10

Title: Deep learning for bone scintigraphy images denoising for patient dose optimization.

Authors: Joaquín González. (Institut of Oncology and Radiobiology, Cuba)
Co-authors: Carlos Calderón, Raisa Ledesma, Yudmila Reyes, Leonel Torres

Optimizing medical exposures is a topic of great interest in radiation medicine to improve patient safety. Bone scintigraphy is one of the diagnostic studies in nuclear medicine where patients receive a higher dose of radiation. Identification of processing methods that contribute to reducing radiation exposure levels while preserving the quality of diagnostic images is currently of great interest.

This work shows the preliminary results of the use of a convolutional auto-encoder network for bone scintigraphy images denoising with the aim of reducing the activity to be administered to patients without affecting the images diagnostic quality. The preliminary results obtained show the potential of convolutional auto-encoder networks could contribute to significantly reduce the amount of activity to be administered in bone scintigrapic studies.

MP-11

Title: Quantitative pattern of administered activity release by patient in bone scintigraphy study.

Author: Francisco Pérez Gonzalez (Teaching General Hospital "V. I. Lenin", Holguin, Cuba)

Bone scanning is important element in the staging and monitoring of cancer patients. The quality and effectiveness of this study, depends on several factors related to preparation administration and pharmacokinetics in each patient. The result of the behavior of the activity in urine of the patient is presented as indicator to be considered when evaluating study result. For a sample of 8 prostate cancer patients all of their urine was collected from the moment of administration until study end.

For each urination, volume, specific activity and total activity eliminated from patient were determined. At the end of the waiting period for the study, total activity eliminated was calculated. The percentage of activity eliminated compared to that administered was calculated.

It was possible to corroborate that although the activity evacuated is at relatively low values, it is very specific for each patient, showing considerable fluctuations. The greatest amounts of activity are eliminated in first and second urinations. A pattern of relationship could not be established between eliminated activity and patient's bone metastasis magnitude and distribution. This information is of great importance for individualized internal dosimetry.

As a conclusion, quantitative estimate of activity eliminated in urine should be considered as complementary criterion when evaluating study quality. Collection and measurement of all urine from all patients, or a void, preferably first or second, can give sufficient information about it. Sample size, oncological location and radiopharmaceutical diversity are limitations that authors recommend to extend.

Poster session

Ps-1

Title: Assessment of the radiological safety on vegetables from Cienfuegos city, Cuba.

Author: Rita Ivelice Sibello Hernández (Centro de Estudios Ambientales de Cienfuegos, Cuba)
Co-authors: Héctor Alejandro Cartas Aguila, Yusdiany Pereira Cuellar

One of the current challenges is to achieve food security, to guarantee a varied and nutritious diet for the population. In addition, it is important that food is safe, it means that it is not associated with risks to the health of consumers. In this sense, from the radiological point of view, it is necessary to guarantee that the presence of radionuclides in food is as low as possible. That is why the main objective of this research was to determine the concentrations of the radionuclides cesium (Cs) - 137 and potassium (K) - 40 in vegetables grow in urban agricultural in Cienfuegos city, Cuba, and to evaluate their safety. The measurement method used was low background gamma spectrometry. The results showed that the levels of Cs-137 correspond to those existing due to global radioactive deposition for our geographical position and those of K -40 correspond to the natural concentrations reported for food. It was concluded that the monitored vegetables are radiologically harmless. These results were obtained within the framework of the territorial project SEGAL related with the food safety, run by Environmental Studies Center of Cienfuegos, Cuba.

Keywords: safety food; cesium – 137; potassium – 40

Ps-2

Title: The effect of helium implantation on the structural properties of disordered tin oxide films.

Author: Anastasiya Kruglyak (Joint Institute for Nuclear Research, Russia)

Co-authors: P.L.Tuan, R.S. Isayev, V. K. Ksenevich, V. A. Dorosinets, M.A. Samarina, D.V. Adamchuk, A.S. Doroshkevich

One method for modifying the properties of SnO_2 films and other metal oxide semiconductors to enhance the sensory properties of gas sensors is ion implantation [1]. In this study, He^+ ion implantation was used to modify the structural properties of tin oxide films, with the goal of further developing moisture sensors based on these films.

The synthesis of tin oxide films was conducted via magnetron sputtering of a tin target, followed by oxidative annealing in air within a temperature range of 350–450°C (Minsk, Belarus). He+ ion implantation, with energy of 2.4 MeV, was performed on the tin oxide films at the EG-5 accelerator (FLNP JINR, Dubna, Russia) by three radiation doses ranging from 3.75×10^{14} to 1.1×10^{16} cm^{-2}.

X-ray diffraction analysis and Raman scattering techniques revealed that both the initial and ion-implanted films possess a multiphase structure, including SnO, SnO_2,

and Sn_2O_3 phases. It was determined that He^+ ion implantation leads to disordering of the crystal structure of tin oxide films only at high radiation doses (~10^{16} cm^{-2}).

[1] S.M. Majhi, A. Mirzaei, S. Navale, H.W. Kim and S.S. Kim // Nanoscale, 2021, Vol. 13, №11, P. 4728-4757.

Ps-3

Title: Effects on fluorescence and chemical structure of carbon quantum dots, induced by neutrons from a plutonium-beryllium source.

Author: Janser Hernández Ojeda (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)

Carbon quantum dots (CQDs) are quasi-spherical nanoparticles with a radius of no more than 10 nm, which show absorption of photons in the near UV or visible range and a strong adjustable emission throughout the visible range. Recent research has evaluated the effects of gamma radiation on the fluorescence of CQDs, finding certain doses for which the fluorescence intensity can be increased. Regarding the interaction with neutrons, this has not been widely studied for CQDs, although studies have been reported on other carbon-based nanomaterials such as nanotubes and inorganic quantum dots. Therefore, the present research has proposed the objective of evaluating the effects on the fluorescence and chemical structure of CQDs, as a result of the interaction with neutrons from a plutonium-beryllium source. CQDs were synthesized from extracts of Bursera simaruba bark by applying ultrasound at 488.32 W of power for 1 hour. The CQD solutions were exposed to a plutonium-beryllium neutron source for 1, 2 and 5 days; a decrease in fluorescence intensity and variation in certain functional groups were found, without experiencing shifts in the excitation and emission wavelengths. Therefore, it is concluded that the interaction with neutrons mainly causes the destruction of the carbonized amorphous core of the CQD, instead of influencing the excited states and functional groups as occurs with gamma radiation.

Ps-4

Title: A sustainable approach in the application and efficiency evaluation of irradiation for preservation of cultural heritage.

Author: Ariadna Mendoza Cuevas (University College San Geronimo de la Habana, Cuba)

A biocide treatment in a gamma irradiation Plant (0.8 -1.2 kGy/h average dose rate) and its combination with a previous stage of essential oil or argon atmosphere during irradiation was evaluated with a proposal methodology, as sustainable treatment for their economic and environmental advantages, with respect to the traditional chemical biocide treatments (toxic and affect the environment) used for microbiological decontamination of cultural heritage. The massive irradiation treatment of contaminated books and documents requires economic and sensible methodology to determine treatment effectiveness, to record doses and dose rates received by the materials. Here, 0.5 mm diameter silica glass beads are used as a routine dosimeter. Viability methods, independent or dependent on culture medium, are experimented in the search for a quantitative, sensitive and sustainable method to evaluate the efficiency of massive antifungal treatments on documentary material. The proposal of an economic method of limited dilution in multiple inoculums in culture medium, as viability fungi determination method, is evaluated, with a statistical (probabilistic) model developed for this purpose. The materials used were the same constituents of the contaminated books of the Historical Library of the Havana City Historian Office (OHH). Gamma irradiation was also used as a sustainable procedure for sterilization of plastic materials (24- or 96-well plates) used in the proposed viability methods and 3D printer and its filament materials were useful for sample holder.

Ps-5

Title: Non-invasive quantitative X-ray fluorescence analysis of antique organ metal pipes.

Author: Ariadna Mendoza Cuevas (University College San Gerónimo de la Habana, Cuba)

A musical organ created by the master Merklin-Schutze in 1856, is currently exposed at the San Francisco church in Old-Havana. The metal compositions of the organ pipes were examined with the purpose to replicate them, procuring the original sound register. Performance of quantitative XRF methods and algorithms implemented in QXAS and PyMCA software were compared regarding the determination of alloy composition. The best calibrations were obtained with reference materials prepared from pure metal powder of the pipes constituents, and pure metal sheets. The algorithm of the Fundamental Parameters method, implemented in the PyMCA, was fed with an energy distribution representative of a polychromatic beam of the X-ray tube used. This proved to be the most accurate provision for the quantitative analysis of the pipes, according to the quality control criteria Z-score. The concentration of Pb varies between pipes accounting for distinct implicated sounds.

Ps-6

Title: Impact of missing transverse energy resolution in searches for Dark Matter in dileptonic $t\bar{t}$ final states.

Author: Yeirys Caballero (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)

Dark Matter remains one of the greatest mysteries in modern science. At the Large Hadron Collider, the primary indicator of Dark Matter is missing transverse energy in the final state, due to the particles invisible nature, making them impossible to detect directly as they pass through the detectors. Therefore, accurately and precisely measuring the missing momentum in the transverse plane is crucial for identifying these particles. One of the primary goals of this project is to re-evaluate how the resolution of measurements affects our ability to distinguish between the Standard Model background and the Dark Matter signal in final states featuring two leptons produced from the decay of two top quarks.

The study will focus on the transverse mass variable, which typically exhibits a high value in processes involving invisible decays and may be influenced by the resolution of missing transverse energy. The goal of the project is to assess the impact of different resolutions between experiments on searches for the associated production of Dark Matter with top quarks using this variable.

Ps-7

Title: Investigation of pulse shape discrimination characteristics of EJ-309 liquid scintillators for the experiment to study prompt neutron emission in nuclear fission.

Autor: Deniel Rodríguez Almora (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)

Understanding the fission process, especially how energy is shared between fission fragments, is crucial for both fundamental science and practical applications. Investigations into prompt fission neutron (PFN) emission offer a window into this complex process. Research conducted at the Joint Institute for Nuclear Research (JINR) has been at the forefront of this field for over two decades, investigating the

correlation between fission fragment characteristic (such as mass and kinetic energy) and neutron energy. These studies have uncovered complex patterns in how these variables fluctuate, shedding light on the stochastic nature of the fission process. Notably, recent experiments measuring PFN multiplicity have yielded unexpected results, suggesting that our current understanding of neutron emission mechanisms may be incomplete.

These surprising findings have reignited scientific interest and underscored the necessity for more refined experimental investigations. As a result, advanced experimental setups are being developed to explore these phenomena. At the Frank Laboratory of Neutron Physics, the ENGREN facility, comprising 32 liquid scintillators and a fission chamber, is being constructed to facilitate these studies. This facility aims to provide high-resolution data on neutron and gamma-ray emissions, allowing for a more nuanced understanding of the fission process. The present work focuses on rigorously testing various components of this experimental setup to ensure their optimal performance. This includes calibrating the scintillators for accurate neutron detection and refining techniques for distinguishing between neutrons and gamma rays. Achieving optimal discrimination is critical for minimizing background noise and enhancing the precision of measurements.

Ps-8

Title: Deep-inelastic scattering of leptons in protons using the MIT Bag Model.

Author: David Chávez Mesa (Instituto Superior de Tecnologías y Ciencias Aplicadas, Cuba)

Co-author: Fernando Guzmán Martínez

The deep-inelastic scattering is a method of study that allowed to explore the internal composition of hadrons. In the QCD is usually uses the lattice QCD model to calculate the structure functions, however this method implicates large compute facilities. The current work gives an alternative using a phenomenological model of the behaver of the QCD, first introduces by the Massachusetts Institute of Technology, call the MIT Bag Model, which describe the behaver of quarks inside protons. With this, in the framework of lepton scattering, it was possible to obtain the wave functions corresponding to the quarks and to construct with it the corresponding structure functions for the ground state of the protons, as well as an expression for the interaction cross section of the themselves.

Ps-9

Title: High doses estimation exercise by the Latin-American Biological Dosimetry Network (LBDNet).

Author: Ivonne Romero Aguilera (Universidad de La Frontera, Temuco, Chile).
Co-authors: Tania Mandina, M. Cabitto, M. Deminge, J. Fernández Rearte, H. Vaquero, F.F. Lima, M.E. Mendes, M.L. Silva, E.F. Lafuente-Álvarez, A. Rada-Tarifa, V.A. Verdejo, A. Radl, N.R. Saavedra, M. Santibañez, F.A. Chaves-Campos, F. Ortiz, L. Valle, J.E. Gonzalez, A. Bastidas, G. Muñoz-Velastegui, C. Arceo-Maldonado, Y.C. Guerrero-Carbajal, S. Aguilar-Coronel, N. Mongigata, M. Espinoza, W. López-Martinez, B. Mechoso, M.V. Di Tomaso, A. Falcón de Vargas, O. García

When a radiological accident occurs, it is highly important to estimate the doses received by the overexposed people. The estimations of doses over 5Gy, through the biodosimetry, it is a still of main concerns for doctors and Biodosimetry specialists. For these high doses estimations, it was developed the Dicentric plus caffeine (D+C) assay. Recently, the Latin-American Biological Dosimetry Network (LBDNet) organized a high-dose estimation exercise using the D+C Assay. Objective: To obtain dose-response curves for D+C Assay from 13 LBDNet laboratories and evaluate their performance for high dose estimation.

Peripheral whole blood was irradiated in vitro between 5–25Gy. The D+C assay was carried out. The laboratories analyzed codified images of the metaphases, and the results were sent to the exercise organizers. Two dose-response models (linear, Gompertz-type) were adjusted for each laboratory with its individual data. Then these curves were tested through the estimation of three doses (7.5, 15, 20Gy) using the Frequentist (Freq-ap) and the Bayesian (Bay-ap) approaches.

The results between both approaches are in agreement for dose and adjusted model. The highest accuracy in dose estimation was obtained with the linear model (Trueness: Freq-app: 0.9%, 4.4%, 9.6%; Bay-ap: 0.2%, 4.2%, 8.3%, for 7.5, 15, 20Gy, respectively). The lowest interlaboratory variations was obtained with the linear model (Coefficient of Variation: Freq-app: 14.5%, 16.1%, 17.8%; Bay-ap: 14.5%, 15.7%, 17.8%, for 7.5, 15, 20Gy, respectively).

In our experimental and scoring conditions, the linear adjustment is the better model for the high dose estimation.

Ps-10

Title: Optimization of Medical Exposure in Whole-Body Bone Scintigraphy Using the Trio AnyScan Gamma Camera**.**

Author: Yudmila Reyes (CENTIS, Cuba)
Co-authors: Raisa Ledesma, Yolaine Sánchez González, Leonel Torres Aroche.

Nuclear medicine employs various radiopharmaceuticals for diagnosing and treating diseases, maintaining minimal risk from ionizing radiation exposure. Whole-body studies significantly contribute to population doses. This work aims to optimize whole-body bone scan procedures, balancing image quality and radiation dose. The proposed strategy involves dynamic mode acquisition, performing four scans at different speeds to ensure the same statistics and image quality as the original (12 cm/min). This dynamic approach also allows simulating different administered activity levels.

Validation showed a linear relationship between total counts and simulated activity levels. The procedure was tested on 30 patients, with results and image metrics analyzed for correlation.

Experts concluded that images representing 60% of current activity are highly useful for diagnosis with the Trio AnyScan. This finding will help reduce radiation doses for patients and the population, impacting current reference levels.

Ps-11

Title: Optimization of Medical Exposures in Myocardial Perfusion Studies with 99mTc-MIBI Using Artificial Intelligence Techniques: Preliminary Results.

Author: Raisa Ledesma Maura (Centro de Isótopos, Havana, Cuba)

Co-authors: Carlos Calderón, Joaquín Gónzalez, Yudmila Reyes González, Leonel A. Torres Arocha

The present work focuses on optimizing myocardial perfusion studies to minimize radiation exposure without affecting diagnostic quality, using Artificial Neural Networks (ANN), specifically denoising autoencoders. For this purpose, a 3D

convolutional autoencoder model was programmed and trained with studies obtained at low dose and their high-dose counterparts.

Twenty-three myocardial perfusion studies acquired with 99mTc MIBI, with administered doses between 20 and 25 mCi, were used to simulate images equivalent to a 50% dose reduction. The ANN was implemented using TensorFlow and Keras in Python, configured with 2 convolutional blocks in the encoder and decoder of the autoencoder. Each block includes 2 layers with 16 filters, a kernel size of (3,3,3), strides of (1,1,1), MaxPooling of (2,2,2), the "ReLU" activation function, and the "Adam" optimizer.

Training resulted in low loss values (≈0.00008) and mean absolute error (0.0011). However, the model still presents limited accuracy (accuracy = 0.5579) due to the insufficient number of images used for training.

The proposed methodology was confirmed to allow for radiation dose reduction while maintaining image quality at acceptable levels for clinical diagnosis. Efforts are underway to increase the database to improve network training and method accuracy.

Ps-12

Title: A tool for automatic registering of dose indicators, evaluation of DRL compliance and data quality management in diagnostic nuclear medicine using DICOM metadata.

Author: Carlos Calderón (Instituto de Oncología y Radiobiología, Cuba)
Co-authors: Joaquin J. Gónzalez González, Raiza Ledesma, Adlin López Díaz, Yudmila Reyes, Leonel Torres

The increasing number of diagnostic procedures in Nuclear Medicine (NM) and other modalities necessitates improved procedures for controlling medical exposure. This work aimed to develop a computer tool for automatic registration of dose indicators for emission images (injected activity (MBq) and injected activity per kg of body weight (MBq/kg)) and for CT images (CTDI (mGy) and DLP (mGy*cm)) by extracting information from DICOM metadata. The tool, MNDR, was developed under the IAEA RLA6091 project and consists of two modules: MNDR.read, implemented in Python (v3.10), and MNDR.analysis, implemented in VBA MS Excel. MNDR.read provides a user interface with search and modality filtering tools to retrieve information from DICOM metadata available on DICOM servers, DICOMDIR, or data folders. It generates a .csv report, which is then analyzed by the MNDR.analysis module to produce dose indicator reports sorted by study protocol. The MNDR.analysis module allows input of typical values or DRLs, issuing warnings when limits are exceeded and generating trend curves of dose indicators by protocol, operator, and equipment.

An evaluation of the quality of parameters recorded in the DICOM tags was performed using data from the patient database over one year. Errors detected included omissions in the patient identification field, heterogeneity in image series identification, additional acquisitions requested by physicians, and errors in the administered activity input due to different unit systems (mCi vs. MBq). MNDR automates dose indicator registration, optimizes medical exposures, verifies data quality, and ensures traceability, prompting procedural modifications and planning for further automation in diagnostic NM services.

Ps-13

Title: Typical diagnostic reference levels in nuclear medicine clinical protocols at INOR.

Author: Carlos Calderón (Instituto de Oncología y Radiobiología, Cuba)
Co-authors: Isidro González Rodríguez, Joaquin J. Gónzalez González, Karina Jimenez Rodríguez, Aldo Martínez Ramírez, Juan P Oliva González, Anilec Portales Oña, Leonel A. Torres Arocha

The ICRP highlights Diagnostic Reference Levels (DRLs) as essential for optimizing diagnostic imaging and controlling medical exposure. At the institutional level, DRLs are typical values based on available instrumentation and procedures. This study aimed to determine typical DRLs for various clinical nuclear protocols in adult patients at the Nuclear Medicine Department of INOR, including whole body Tc99m-MDP bone scans, Tc99m-MAG3 dynamic renal scintigraphy, Tc99m-DMSA renal scintigraphy, Tc99m-MIBI parathyroid scans, and F18-FDG PET/CT. Data from imaging procedures performed between 2019 and 2022 using a MEDISO AnyScan SC spect/ct system were analyzed. Samples of 30 adult patients (both genders, 70 ± 20 kg) were randomly selected. A Python script retrieved information from DICOM tags, and medical staff assessed image quality. DRLs were reported as median injected activity (MBq) and normalized by body weight (MBq/kg). For CT in PET/CT studies, the CT dose index (CTDIvol) and dose-length product (DLP) were reported. All images were deemed clinically adequate. Typical values were: whole body Tc99m-MDP bone scintigraphy (623MBq / 8.6MBq/kg), Tc99m-MAG3 dynamic renal scintigraphy (187.1MBq / 2.7MBq/kg), Tc99m-DMSA renal scintigraphy (189MBq / 2.9MBq/kg), Tc99m-MIBI parathyroid (747.3MBq / 9.4MBq/kg), and F18-FDG PET/CT (204.5MBq / 3.1MBq/kg). These values represent the typical diagnostic reference levels for adult patients at INOR.

Further work is ongoing to report typical values for pediatric patients. A methodology for reporting typical values was presented, and some tools are available. This is the first report of typical values at INOR.

Ps-14

Title: Strengthening the radiation protection of patients receiving NM diagnostic services in Cuba.

Author: Leonel A. Torres Arocha (Centro de Isótopos (CENTIS) Cuba)
Co-authors: Rosbel Bosh, Carlos Calderón, Caridad Casacó, Ernesto Corona González, Juan Miguel Escuela, Mayka Guerrero, Joaquin J. Gónzalez González, Raiza Ledesma, Adlin López Díaz, Lissete Mejias, Ilen O'farril, Yudmila Reyes, Daniel Rodríguez, Lester Rodríguez, Leonel A. Torres Arocha, Consuleo Varela

The objective of this work was to enhance the optimization of medical exposures during diagnostic studies using nuclear medicine (NM) techniques, aiming to improve medical care quality and patient safety in Cuba. This initiative was part of the PNOULO and IAEA project programs, involving five local NM services (INOR, CEDT, HHA, ICCCV, and DSB-CENTIS) as pilot institutions. Methods and procedures were implemented to optimize image quality versus radiation dose for the eight most common NM examinations in Cuba. Calibrations and evaluations were conducted on physical and anthropomorphic phantoms and patients. Typical values of administered radionuclide activities, CTDI, DLP, and SSDE from the CT component of hybrid NM studies were evaluated and reported, following ICRP recommendations 135. Intervention actions, based on G.L.Poli et al.'s methodology (EANM), were performed using a local tool for reading DRL magnitudes from DICOM identifiers.

Results showed optimization of medical exposures for PET-CT studies, bone scans, cardiac perfusion SPECT, cardiac amyloidosis studies, cerebral perfusion studies, and renal scans in at least two institutions per study type. The interventions included dynamic studies, list mode optimization, and image processing methods, yielding satisfactory results. Artificial intelligence was used to optimize image quality versus radiation dose in cardiac and bone studies, focusing on denoising analysis. Typical values for eight clinical studies were collected, involving each institution in at least two procedures. Preliminary results show improved image quality and diagnostic value with reduced radiation levels. These findings are being extended nationwide, with on-going analysis and coordination with local authorities.

Ps-15

Title: Evaluation of the Typical values for the most common nuclear medicine examinations at the DSB-CENTIS NM service.

Author: Leonel Torres (Division of Clinical Reserach, Isotope Center)
Co-authors: Carlos Calderón, Raiza Ledesma, Yudmila Reyes, Leonel Torres

The calculation and establishment of typical values at the institutional level is crucial for optimizing medical exposures during diagnostic nuclear medicine procedures. This process enhances patient radiation protection and aids in setting local and national dose reference levels. A survey was conducted to gather raw data on DRL magnitudes used in nuclear medicine, including administered activity during conventional procedures and CTDI, DLP, and SSDE values from hybrid SPECT-CT examinations. Additional patient and clinical study information was also recorded. Data collection, processing, and analysis followed methods and procedures from ICRP 135 and IAEA publications. A spreadsheet developed by local and regional working groups was used to automate and standardize data management during the DRL process. Typical values were collected for common studies in the NM service from adult patients aged 50-70 years, covering the period from 2020 to 2024. Basic statistical analysis was performed to obtain and report the DRL values.

Typical values for nuclear medicine procedures were reported. The most relevant findings were as follow. For myocardial perfusion imaging (MPI) with 99mTc-MIBI using SPECT (2020-2023): Act=1050.4MBq, ActConc=13.3MBqKg^-1. MPI with SPECT-CT (2023-2024): Act=781.5MBq, ActConc=8.7MBqKg^-1, DLP=35.6mGycm, CTDIvol=1.7mGy, SSDE=1.8mGy. Whole-body bone scans (2020-2023): Act=930.1MBq, ActConc=12.7MBqKg^-1. Bone scans with SPECT-CT: Act=900MBq, ActConc=13.2MBqKg^-1, DLP=166.8mGycm, CTDIvol=3.2mGy, SSDE=4.6mGy. Interventions for optimizing NM examinations yielded positive results, reinforcing the optimization principle. Follow-up evaluations showed a significant decrease in DRL values for bone and cardiac exams with adequate clinical value. A follow-up study is planned for 2025, and the next step includes a detailed analysis of pediatric NM studies.