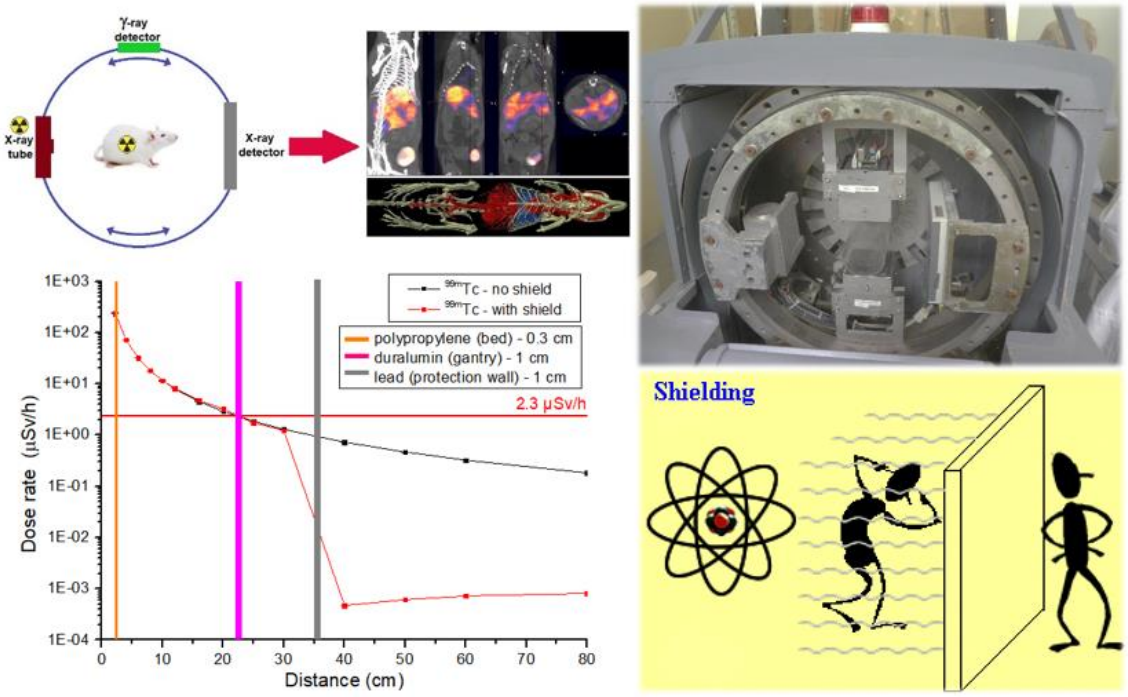
Investigation of radiation shielding in a preclinical SPECT/CT scanner using Monte Carlo-based code systems.



- Applied Research Using Nuclear Physics Methods
- 2 students

A code system based on the Monte Carlo method will be used to simulate the interaction of radiation with matter, with the aim of studying the characteristics of the radiation shielding in a preclinical SPECT/CT scanner prototype. In the simulation, the most important components of the scanner, with their typical materials and dimensions, will be taken into consideration. Some of the most widely used radioisotopes in SPECT imaging (^{201}Tl, ^{133}Xe, ^{99m}Tc, ^{131}I, etc.) will be used as gamma ray sources. Interesting will be the simulation in the CT geometry of a Roentgen X-ray tube emitting strictly with the characteristic spectrum that corresponds to the selected anode (W) and the tube operating parameters. Taking into consideration that the handling and medical use of the scanner must comply with the radiation protection requirements demanded at international level, the calculated dose rates for different conditions will be compared with the limit values of safe dose rates established for each group of people. The results will be analyzed in detail in the project.

Tasks

- Study of methods for mathematical modeling of radiation interaction with matter.
- Familiarization with SPECT and CT imaging techniques.
- Determination from literature of the safe exposure dose limits for occupationally exposed personnel and patients.
- Study and, if necessary, adjust the geometry of the scanner system.

- Calculation by mathematical modeling of the spatial distribution of particles fluencies in the experimental system for typical sources and geometries.
- Conversion of the obtained data to dose units.
- Analysis of the results.
- Preparation of final report.

Preliminary schedule by topics/tasks

The expected project duration is 5-6 weeks.
The work schedule will follow the order of the tasks indicated above, admitting the student initiative. Most of the time will be dedicated to calculating and analyzing the results, leaving the last week for the report preparation. The final schedule will be agreed directly with the student.

Required skills

General Physics, courses on Nuclear Physics.
Knowledge of the mechanisms of ionizing radiation interaction with matter.
Knowledge of the Monte Carlo Method and its use in Nuclear Physics.
Some experience utilizing any version of MCNP or GEANT4 code systems.
Satisfactory communication in English, Russian or Spanish language.

Acquired skills and experience

Understanding of the fundamentals of some advanced medical imaging techniques based on Nuclear Physics applications.
Deepening of the knowledge of the interaction mechanisms of radiation with matter.
Application of mathematical simulation techniques to solve applied problems of radiological protection.
Familiarization with radiation terms and units.
Improved knowledge in the use of Office Excels and OriginPro softwares for processing and presentation of experimental results.
Increased experience in the preparation and defense of scientific reports.

Recommended literature

- Hooshang Nikjoo, et al., Interaction of Radiation with Matter, CRC Press, 1st edition (September 30, 2020).
- C-K Chris Wang, Atoms, Nuclei, and Interactions of Ionizing Radiation with Matter, (1st edition), Cognella Academic Publishing, (2016).
- Brian F. Hutton, The origins of SPECT and SPECT/CT, European journal of nuclear medicine and molecular imaging 41(1), 3, (2014).
- John S. Hendricks, et. al. LA-UR-08-2216, MCNPX 2.6.0 Extensions, Los Alamos National Laboratory, April 11 (2008).
- International Commission on Radiological Protection, ICRP-103 The 2007 Recommendations of the International Commission on Radiological Protection, JAICRP 37, (2007).
- International Commission on Radiological Protection, Conversion coefficients for use in radiological protection against external radiation, ICRP publication 116, Annals of the ICRP 40, Pergamon Press Oxford (2010).