Hybrid setup for neutron imaging and prompt-gamma activation analysis at research reactor IEA-R1

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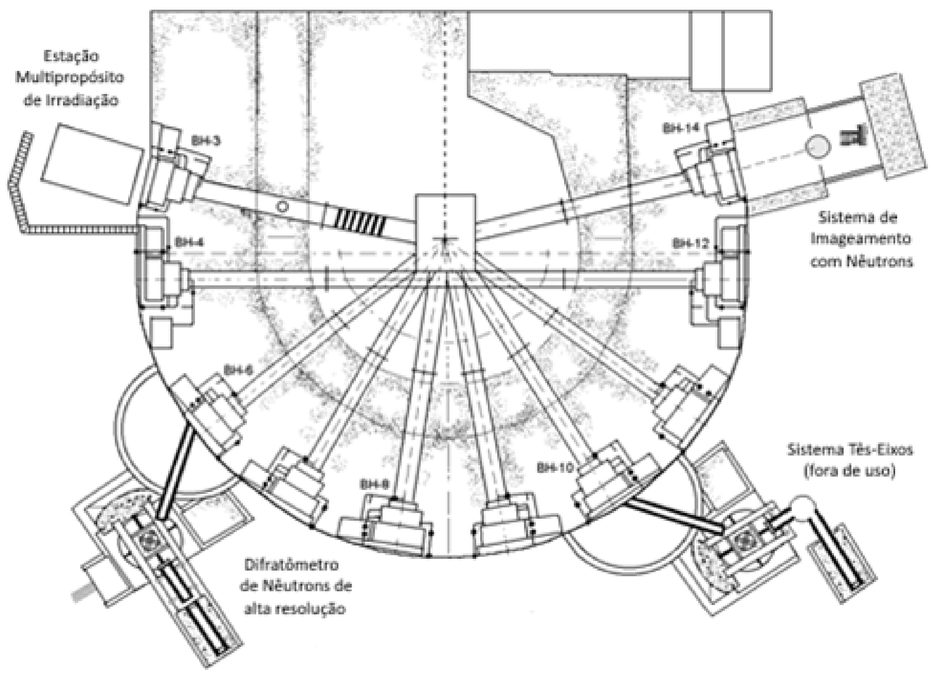
Abstract

The neutron imaging facility situated within the IEA-R1 research reactor at IPEN/USP offers a potent means of investigating hydrogen-based substances and visually discerning sample structures [2].Additionally, the prompt-gamma activation analysis (PGAA), reliant on neutron beams, presents a non-destructive approach for both quantitative and qualitative analysis of various objects [1]. However, the implementation of PGAA comes with considerable costs associated with filter installation, construction of shielding, and colimator integration to facilitate neutron beam management. This project aims to enhance the neutron imaging system to accommodate PGAA capabilities, while also characterizing neutron flux within the imaging setup through the employment of the multiple foil activation method. The simulation phase employs the MCNP6 code to model these adaptations and their effects. Through this endeavor, the feasibility and potential benefits of synergizing neutron imaging and PGAA techniques are explored, paving the way for advanced analytical opportunities.

Introduction

The prompt gamma activation analysis (PGAA) consists in a powerful technique to studies about elemental composition of different samples. However, the installation of the PGAA is very expensive, it's necessary adaptation in the place like collimator the neutron flux, shield the place to protect the people, shield the detector to neutrons and background gamma rays and a neutron beam intensity in order of 10^6 - $10^8 n.cm^{-2}.s^{-1}$ [3]. These necessities are supply doing an adaptation in a neutron tomography setup, this setup is called PGAI-NT in the literature [1]. The beam hole 14 in the reactor IEA-R1 has the ideal conditions to PGAA, this beam hole was installed the neutron tomography, the order of neutron intensity is $8.10^6 n.cm^{-2}.s^{-1}$ and the flux is more thermal than other beam holes in the reactor.

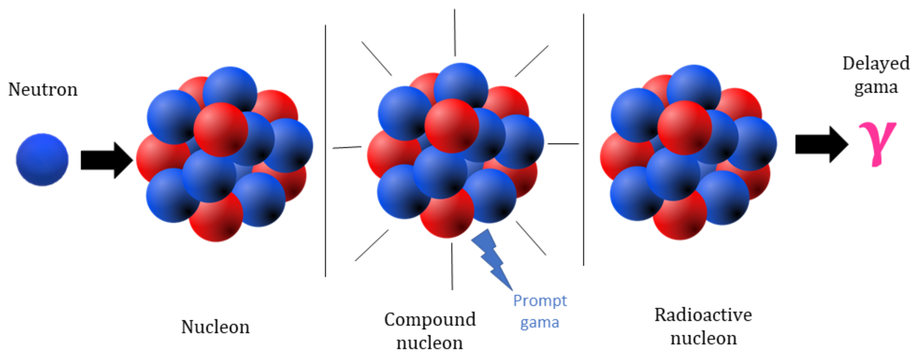


Research objectives

The present study investigates the following objectives:

- **Objective 1:** Simulating the necessaries adaptations in the neutron tomography setup using MCNP6 code.
- **Objective 2:** Simulating the design of HPGe's shield.
- **Objective 3:** Installing and testing the PGAA in the reactor.

Interaction of the Neutrons with the matter

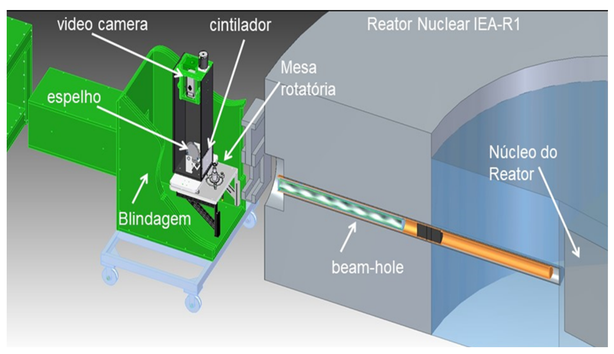


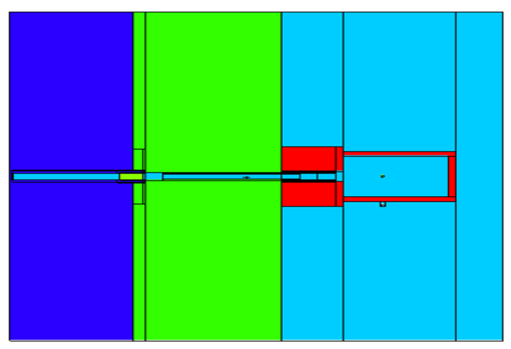
Methodology

The simulation was do using the monte carlo n-particle (MCNP6) code version 1 developed by Los Alamos National Laboratory, the specification about the neutron tomography in the reactor IEA-R1 is availability in Schoueri, R. M. [2].

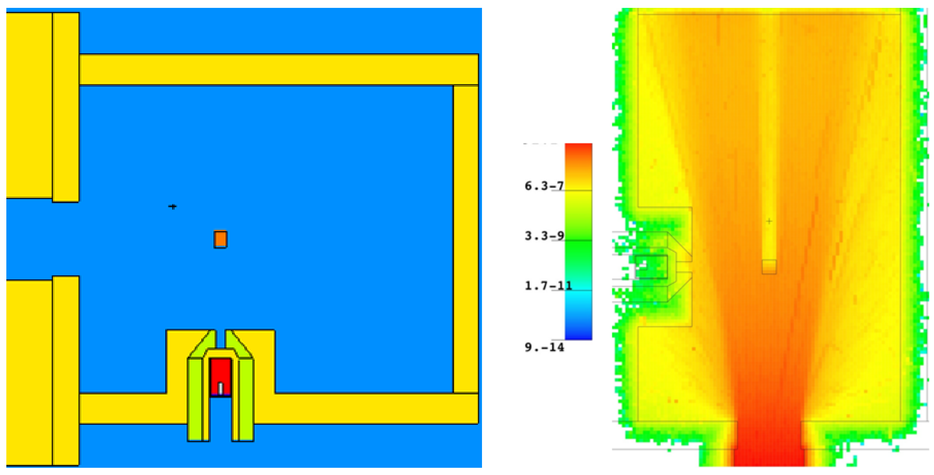
Results and discussion

Modeling of the PGAI-NT

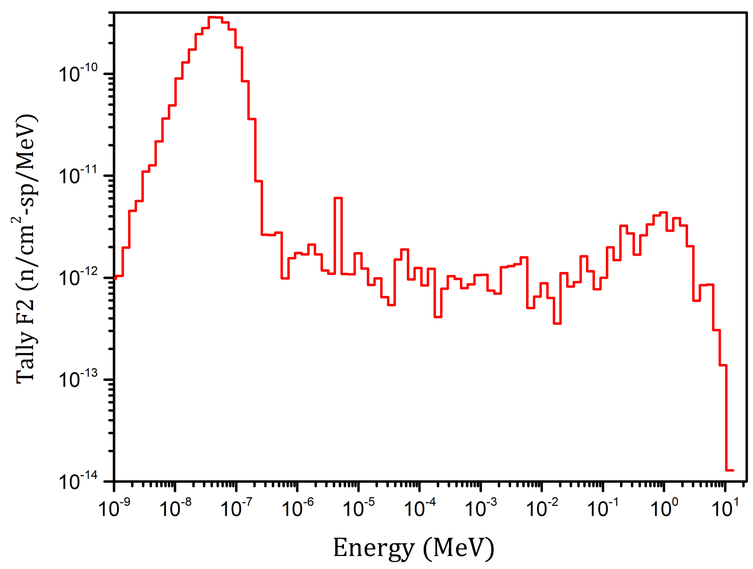




Detector's shield and thermal flux in the setup



Neutron spectrum after the bismuth filter



Future perspectives

- Obtain the neutron spectrum source of the BH14.
- Simulate the shield with different configurations.
- Optimize the input code.
- Efficiency determination of the prompt gamma collimator.
- Construction of the setup.

What does this study add?

- A first step to PGAA in Brazil.
- The characterization to the neutron tomography by simulation.
- To Auxiliary in the construction of a similar setup in the Brazilian Multipurpose Reactor (RMB).

Practical implications

- A new method to study elemental composition of different samples.
- Implementing a new method of discrimination.
- New possibilities of studies.

References

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