Contribution ID: **213** Type: **Oral Presentation**

#4-213 Characterization of thermal and epithermal contributions in a neutron field using Neutron Activation Analysis, the NFM detector, and MCNP simulations

Wednesday, June 11, 2025 10:20 AM (20 minutes)

The Laboratoire National de Métrologie et d'Essais (LNE) coordinates French metrology and represents it internationally across various domains. To fulfill this mission, LNE collaborates with several associated laboratories, including the Laboratoire de micro irradiation, de Métrologie et de Dosimétrie des Neutrons (LMDN) from IRSN/Cadarache/France, which is responsible for the national reference standards in neutron dosimetry. As part of its activities, the LMDN has an experimental facility for generating reference neutron fields, comprising irradiators that produce neutron fields from 241Am-Be and 252Cf sources. This facility also includes a plateform named CARAT, which includes an accelerator, the SAME T400. In combination with various moderators, this accelerator can generate realistic neutron fields representative of those encountered at nuclear industry workstations, as well as fields with a strong thermal component (En < 0.025 eV). Additionally, a second facility, AMANDE, is an accelerator producing reference monoenergetic neutrons fields with energies ranging from 2 keV to 20 MeV.

To expand the range of reference neutron fields available and meet emerging needs, such as Accelerator-Based Boron Neutron Capture Therapy (AB-BNCT) development, the LMDN is developing an epithermal neutron field with energies from 0.5 eV to 10 keV. The 7Li (p, n)7Be reaction was chosen for this purpose due to its threshold reaction at 1.880 MeV, which allows neutrons to be emitted at energies close to 10 keV. A moderator was designed to decelerate these neutrons to epithermal energies when threshold-level proton energies initiate the reaction at the AMANDE facility.

Since the neutron energies generated are close to the epithermal range, a few centimeters of high-density polyethylene suffice to moderate these neutrons to epithermal levels. After modeling and constructing this moderator, an experimental campaign was conducted in January 2024 to characterize the generated neutron field and to establish a characterization method for epithermal fields. Two detection systems were selected: the gold foil activation method and a new Neutron Field Monitor (NFM) detector. The activation method, which uses two 197Au foils, one covered with natural cadmium, enables the measurement of both thermal and epithermal fluxes. The NFM detector, based on neutron capture by 10B, was developed by the LPSC in Grenoble, France. Using these two systems enabled the determination of the thermal and epithermal fluxes of the neutron field in complementary ways. Experimental and simulated results were compared using Monte Carlo simulations on MCNP6.

The LMDN aims to establish a high-flux epithermal neutron field capable of delivering a dose of 1 mSv within six hours of irradiation. A new accelerator, expected to arrive at the LMDN facility in 2025, will generate neutrons through a deuteron-on-deuterium reaction. With neutron energies reaching 3 MeV, a larger multi-material moderator will be necessary. While the larger dimensions of the moderator will reduce particle flux due to the thermalization of fast neutrons, this will be compensated for by a high beam intensity of 6 mA, in contrast to the AMANDE accelerator's 5 µA.

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Session Classification: #04 - Research Reactors and Particle Accelerators

Track Classification: 04 Research Reactors and Particle Accelerators