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#10-30 MCNP-based study and validation of scattered neutrons for neutron metrology

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The CEZANE facility at the Micro-Irradiation, Neutron Metrology, and Dosimetry Laboratory (LMDN) is equipped with an irradiator using various neutron sources such as ^{241}Am-Be, ^{252}Cf, and (^{252}Cf+D_2O)/Cd. In the context of its accreditation activities, service provision, and R&D, the laboratory performs calibrations of ambient dose rate meters and individual dosimeters in accordance with ISO 8529 standards. One of the main challenges of these calibrations is the assessment and subtraction of neutrons scattered by the environment, a phenomenon that significantly influences detector response.

Standardized experimental methods, such as the shadow cone technique, are limited in certain specific detector or distance configurations. To address these limitations, a detailed model of the CEZANE installation was developed using the MCNP simulation code, allowing for precise evaluation of the influence of scattered neutrons at any calibration position.

The results for ambient dose equivalent rate showed good agreement between experimental data and simulations for a reference rate meter, with discrepancies of 4.7% for the ^{252}Cf source and 2.0% for the Am-Be source at a standard distance of 150 cm. The contribution of scattered neutrons to the ambient dose equivalent rate was also precisely quantified using the shadow cone method, with discrepancies of 2.3% and 0.9% for the ^{252}Cf and Am-Be sources, respectively.

A preliminary analysis of scattered neutron trajectories was conducted using MCNP's Particle Track Output (PTRAC) tool. Specifically, the origin of the last collision of neutrons before detection at the calibration point revealed that most scattering phenomena originate from elements near the source and the measurement bench, rather than from building structures like walls or concrete flooring. These observations have enhanced the understanding of scattered neutron contributions, offering promising insights for further simulations. Additionally, this work will be extended to study scattered neutrons involving the (^{252}Cf+D_2O)/Cd source to meet calibration requirements for individual dosimeters placed on a phantom at distances from the source where the shadow cone method cannot experimentally measure the contribution.

Overall, this work opens up new perspectives for improved measurement control on the CEZANE installation and for other neutron metrology devices, thus enhancing the reliability of calibrations in complex environments that require a fine understanding of the influence of scattered neutrons.

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