Contribution ID: **38** Type: **Talk**

Challenges and developments in neutron metrology for high energy workplace radiation fields

Tuesday 8 July 2025 10:35 (35 minutes)

Neutron spectra found in typical workplace environments, especially in the high-energy (>20 MeV) domain, of particle accelerators, accelerator-driven spallation sources, and at cruising altitudes onboard aircraft, often differ significantly from those produced by standard radioactive sources defined in the ISO 8529 series. This discrepancy poses a substantial challenge in neutron metrology, as the energy-dependent response of dosimeters and survey instruments can lead to inaccurate measurements if they are calibrated using reference fields that do not reflect actual workplace conditions. In addition, above 20 MeV, neutron interaction cross-sections are derived from theoretical models with limited experimental verification. This introduces significant uncertainties and complicates the validation of detector response functions in high-energy fields. ISO 12789 highlights the need for well-characterized and application-specific radiation fields to ensure meaningful calibration and performance evaluation of radiation protection instruments.

This presentation will provide an overview of representative workplace radiation fields and their critical role in advancing neutron metrology, particularly for radiation protection applications. It will illustrate the unique challenges involved in establishing and characterizing reference workplace fields in the high-energy radiation environments. These include the need to replicate complex, mixed radiation fields with broad energy spectra, and the difficulty in accurately modeling and measuring neutron fluence and energy distributions.

An emerging aspect with significant implications is the introduction of the new operational quantities –ambient dose and personal dose –as recommended by the ICRU and the ICRP. These quantities are intended to provide a more meaningful link to protection quantities across a broader energy range, particularly at high energies where traditional quantities such as H*(10) and Hp(10) may not remain conservative. Their adoption will likely require the redefinition of reference fields and recalibration procedures, particularly for workplace environments, to ensure consistent and accurate dose assessments.

To progress in this respect, several essential advancements are required: the development of standards how to characterise different high-energy reference fields, improved physics models that are benchmarked against experimental data, advanced spectrometric techniques for real-time field characterization, and internationally coordinated efforts to update and expand the ISO framework (including ISO 12789). These efforts seem essential to improve the traceability and reliability, and relevance of neutron measurements in the complex radiation environments.

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Session Classification: HE Neutron Fields: Broad Energy, Workplace, etc

Track Classification: Day 2: Neutron metrology, high energy neutron facilities and reference standards: High energy neutron facilities (present and planned)