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Status of the LINrem project: validation in reference fields

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Neutrons are a highly penetrating type of radiation that can significantly contribute to the total absorbed dose in the human body. Monitoring neutron dose rates is essential for assessing the risk to workers, patients, and the public, particularly in particle therapy centers. Such treatments, often recommended for young and pediatric patients, offer the benefits of a reduced overall dose and high radiobiological effectiveness. Proton beams are typically used, though recent advancements are focusing on light ions such as carbon, helium, and oxygen. Since the primary beam energy ranges in the hundreds of MeV, nuclear interactions between high-energy particles and beam-shaping elements—or even the patient—result in the production of secondary neutrons. Additional factors influencing neutron production include the accelerator technology, room design and treatment plan.

For instance, modern compact proton therapy units, such as those based on superconducting synchrocyclotron technology, produce pulsed neutron fields characterized by intense bursts of neutrons within a short time frame. In this scenario, many commercial dosimeters underestimate neutron ambient doses by up to a factor 10 [1]. A similar situation is expected occur in innovative treatment approaches such as the Ultra-High Dose Rate Radiation (FLASH therapy) [2]. As accelerator technology advances, so must the instrumentation used to measure radiation [3]. To address this gap, we propose the LINrem project as a potential solution. LINrem dosimeters are specifically designed to provide accurate neutron dose measurements under challenging conditions, such as those found in particle therapy facilities.

This contribution discusses the status and future directions of the LINrem project. We outline the design of a new passive LINrem dosimeter, developed by replacing the active sensor in the LINrem moderator with thermoluminescent dosimeters (TLDs). We also present the validation of LINrem dosimeters in a high-energy reference neutron field, with measurements conducted at CERN's CERF facility [4,5]. This facility simulates both, cosmic-ray neutron spectra at altitudes of 10–20 km and the secondary spectra found in particle therapy environments. Furthermore, regarding clinical applications, we provide preliminary results from an ongoing intercomparison campaign at the West German Proton Therapy Center (WPE) in Essen. This study, conducted in close-to-clinical conditions, includes measurements using Pencil Beam Scanning with setups for both, pristine Bragg peaks [6] and range-modulated beams [7].

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Abstract

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