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#9-265 Validation of a Scintillator-Based SPECT Tomographic Imaging System for Boron Neutron Capture Therapy

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Boron Neutron Capture Therapy (BNCT) is a cancer treatment technique that combines the power of radiation therapy with targeted therapy. In this technique, patients are administered a targeted pharmaceutical containing 10B that selectively accumulates in tumor tissues and are then irradiated with a beam e [epi-]thermal neutrons. These neutrons interact with 10B through a large-cross-section neutron-capture reaction [n (10B, 7Li) α] whose products are high linear-energy-transfer particles that release their energy locally killing tumor cells. Differently from other radiotherapy techniques, the beam does not need to be focused and the patient can be irradiated by a wide neutron field in order to treat diffused (metastatic) tumors. Despite being known since decades, BNCT is gaining new momentum thanks to the advancements in the development of clinical neutron production facilities based on compact accelerators.

During BNCT treatments, the 478-keV gamma photons emitted in 94% of the reactions by 7Li could be used to localize and estimate in real-time the delivered dose using SPECT technique. The main challenges come from the low 478-keV gamma signal, the strong secondary gamma-ray background field (including the 511-keV annihilation peak), the required system spatial resolution (<10 mm), and the constraints given by the integration with the neutron irradiation facility.

During the past years, we have developed a dedicated detection module for BNCT-SPECT application based on a wide scintillator detector and a channel-edge pinhole collimator. When combined with artificial neural network for planar image reconstructing, it provides a geometrical resolution of 8.2 mm. The detector is built using a square LaBr3(Ce+Sr) scintillator (5cm side, 2cm thick) coupled to an array (8 by 8) of SiPM (NUV-HD by FBK) readout but a custom-designed ASIC, allowing energy discrimination at ASIC level to reject background events and avoid count rate saturation. This crystal offers a suitable field of view and achieves a high efficiency (better than 60% at 478keV) and a good energy resolution (better than 3% FWHM at 662 keV).

Two measurement campaigns were recently carried out to test the performance of the BNCT-SPECT module during neutron irradiations, both of which were prepared and designed performing extensive Monte Carlo (MC) simulations. The results of these campaigns will be presented at the conference. The first one was carried out at the Prompt Gamma Neutron Activation Analysis (PGNNA) facility of TRIGA Mark II reactor of the applied Nuclear Energy Laboratory (LENA) in Pavia (Italy). During this campaign a tomographic acquisition of two vials containing an aqueous solution of 10B (~7000 ppm) at a distance of about 1 cm was acquired. The acquisition was performed with the SPECT detection module measuring four different projections of the sources at four different angles with respect to the beam direction and was repeated for two reactor powers (70 kW and 250 kW). In both cases, the results of the measurements significantly matched with the predictions obtained with the MC simulations and the two sources could be visualized and resolved in the reconstructed tomographic images (using 10 iterations of the MLEM algorithm in the STIR reconstruction software).

The second measurement campaign has been performed at the newly constructed BNCT facility of Nagoya University (Japan), which is a more relevant validation environment being an actual clinical facility. Here the major challenge is the abundant presence in the walls of the treatment room of borated polyethylene used to shield thermal neutrons, which create a large background at 478keV demanding additional shielding from the surrounding gamma rays. Data are being acquired and results will be presented at the conference.

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