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Poster Discussion

A compact gamma-ray detector coupled with a pinhole collimator for real-time dose monitoring in BNCT

Anita Caracciolo[1,2], Tommaso Ferri[1,2], Giacomo Borghi[1,2], Marco Carminati[1,2], Nicoletta Protti[3,4], Saverio Altieri[3,4], Carlo Fiorini[1,2]

[1]Politecnico di Milano, DEIB, Milano, Italy. [2]Istituto Nazionale di Fisica Nucleare, Sezione di Milano, Milano, Italy. [3]Università di Pavia, Dipartimento di Fisica, Pavia, Italy. [4]Istituto Nazionale di Fisica Nucleare, Sezione di Pavia, Pavia, Italy

Purpose/Objective:

We present a compact gamma ray detector, combined with a lead pinhole collimator and a cadmium shielding housing, as a basic element for a Single Photon Computed Emission Tomography (SPECT) system for dose monitoring in Boron Neutron Capture Therapy (BNCT). BNCT is a targeted radiotherapy technique where tumor cells are loaded with ^{10}B-enriched molecules and then irradiated with thermal neutrons. Reactions following neutron capture by ^{10}B produce damage limited to the diameter of the single tumoral cell [1]. Although BNCT is really promising in terms of killing selectivity, it is still not established as common technique due to many limitations, as the limited availability of accelerator-based neutron sources and the lack of real-time dose monitoring techniques. Real time dose monitoring can be achieved by detecting the 478 keV prompt gamma rays that are emitted in 94% of the ^{10}B(n,α)^{7}Li reactions. The intensity of the 478 keV gamma rays is proportional to the boron local dose, thus a SPECT system can be used to monitor the 3D treatment effect in real time [2]. However, the detection of these gamma rays is very challenging because of the high intensity neutron sources required in BNCT, that leads to a severe background of neutrons and secondary gamma rays.

Material/Methods:

The proposed detector is based on a $LaBr_3$(Ce+Sr) scintillator crystal, with dimensions 5x5x2 cm^3, coupled with a matrix of 8x8 Silicon Photomultipliers (SiPMs). The outputs of the SiPMs are processed by very compact readout electronics, which consists of an assembly of three printed circuit boards (PCBs), resulting in a total encumbrance of around 6.2x6.2x3 cm^3. This detector represents a new version, characterized by a more compact design, in comparisons to our previous prototypes [3]. The detector is combined with a dedicated lead pinhole collimator and a cadmium shielding housing. The collimator has been designed by performing ANTS2 simulations, in order to find the best trade-off between spatial resolution and detection efficiency [4]. The cadmium shielding housing is required to lower the neutron activation of the detector, in particular of the printed circuit boards, which contain a not negligible amount of boron in their FR-4 material. The detection unit was characterized inside the Prompt Gamma Neutron Activation Analysis (PGNNA) facility of TRIGA Mark II (Pavia, Italy). Samples loaded with 0.5 g and 1 g of boron powder were irradiated with a neutron flux of the order of 2x106 n/cm^2/s. The detector was placed perpendicular to the neutron flux direction, at 40 cm from the sample, with the collimator in between. To evaluate the imaging capabilities of the system the vial was shifted 1 cm away from its initial position, while ensuring it remained aligned with the beam direction.

Results:

The good energy resolution of the detector (<3% FWHM at 662 keV) allowed to identify the BNCT photopeak despite the significant background. The linear response of the detector was verified, since the number of events at 478 keV was found to double as the boron concentration doubled (Fig. 1). Moreover, a fully connected Artificial Neural Network was implemented for estimating the gamma ray position of interaction on the monolithic crystal. The network has 64 input neurons to process the signals coming from the 64 SiPMs and an output layer with two neurons for the x and y position coordinates. The reconstructed images are represented as 64x64 matrices (Fig. 2). The detector was able to detect and reconstruct 1 cm lateral displacements in the borated sample's position.

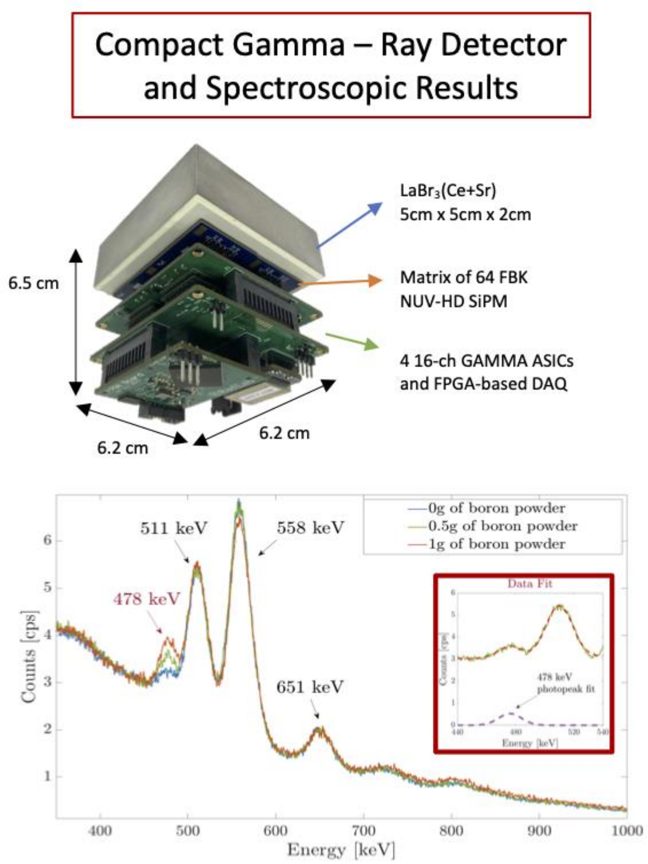

Fig. 1

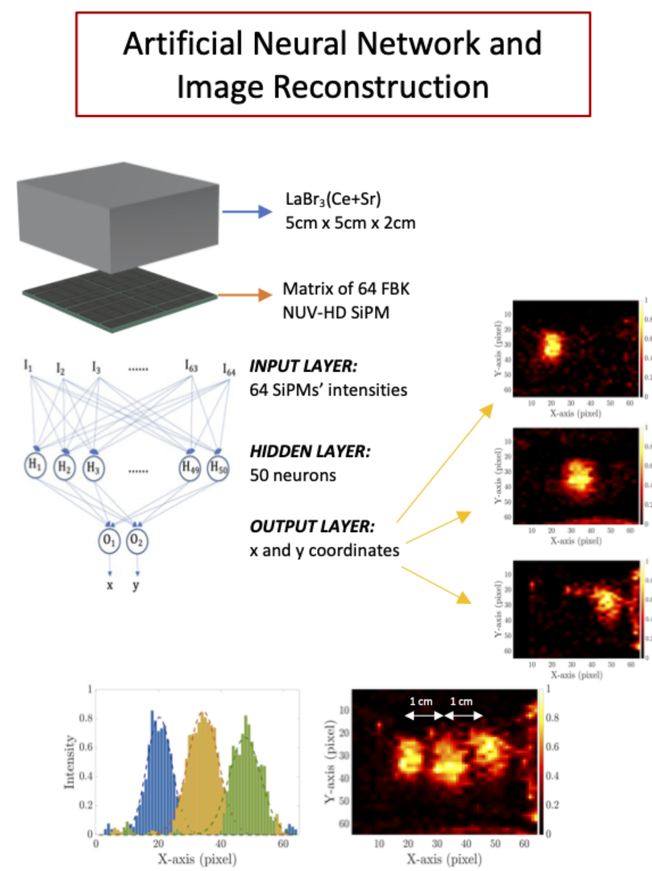

Fig. 2

Conclusion:

Our detection module has demonstrated feasibility for the development of a BNCT-SPECT system, both in terms of spectroscopic and imaging capabilities. Future measurements in a BNCT facility equipped with an accelerator-based neutron source are foreseen.

Keywords: BNCT, Gamma Rays, Artificial Neural Network

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Dosimetric verification of stereotactic multiple brain metastases treatment using 3D gel dosimetry

Sofie Ceberg[1], Thi Guldhill[1], Patrik Brynolfsson[2], Anneli Edvardsson[2,1], Crister Ceberg[1], Christian J Gustafsson[2,3], Sven Bäck[2,1]

[1]Medical Radiation Physics, Lund University, Lund, Sweden. [2]Radiation Physics, Department of Hematology, Oncology, and Radiation Physics, Skåne University Hospital, Lund, Sweden. [3]Department of Translational Medicine, Medical Radiation Physics, Malmö, Lund University, Malmö, Sweden

Purpose/Objective:

Recently developed radiation delivery techniques enable stereotactic treatment of multiple brain metastases using partial-arc gantry rotations, couch rotations, and high-definition (HD) multi-collimator leaves (MLC) [1]. When carrying out dose verification measurements for treatment quality control using a conventional pseudo-3D detector, there are not enough measurement points to cover all metastases with high spatial resolution. In this study we aim to demonstrate the use of highly resolved true 3D gel dosimetry [2] to verify the delivered absorbed dose from a stereotactic treatment of multiple brain metastases.

Material/Methods:

A HyperArc plan was optimized (Treatment Planning System (TPS) Eclipse, Version 15.6, Varian Medical System, CA) for a patient with two intracranial metastases, where the Gross Tumour Volumes (GTVs) were 3.0 cm^3 and 2.9 cm^3, respectively. The technique consisted of four 6 MV HD MLC modulated partial-arc rotations including four couch angles. The prescribed dose was 30 Gy/3 fractions. The treatment plan was recalculated on a 1.2 l gel phantom,