PROTTI-1: The BNCT-SPECT project at Pavia University and INFN: real time B^{10} dose monitoring and tomography by innovative CZT photon detectors

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We report on the results and on-going studies of the BNCT-SPECT project carried out at Pavia University and Pavia-INFN. The project wants to develop a SPECT system to monitor *in vivo* the dose delivered in patients during BNCT, in particular the component due to ^{10}B capture reactions. In addition, thanks to a highly innovative technology (3D CZT spectro-imager) under investigation, the preliminary data collected on a CZT based BNCT dedicated Compton Camera will be reported. CdZnTe (CZT) semiconductor detectors are presently under scrutiny for diagnostic and molecular imaging [Garcia et al., J Nucl Med 52(2), 210-217, 2011; C.B. Hruska et al., Am J Roent 191, 1805-1815, 2008]. For the named BNCT-SPECT, CZT technology has been chosen thanks to its high detection efficiency even using small sensitive volumes together with its extremely good energy resolution, greatly valuable inside the mixed $(n+\gamma)$-radiation field of a BNCT facility [Altieri et al., Il Nuovo Cimento C 41(208), 1-8, 2018]. In addition, the possibility of working at room temperature avoids a cumbersome cooling system thus facilitating patient positioning despite the close proximity of the photon sensor.

After a preliminary characterisation of the first CZT prototype [Fatemi et al., NIM A 903, 134-139, 2018], we evaluated the capability of this 5x5x20 mm^3 detector to discriminate the ^{10}B peak at 478 keV from the activation signals at 558 and 651 keV induced by thermal neutrons in ^{113}Cd, as well as from the annihilation signal. These studies, carried out inside the recently built Prompt Gamma Neutron Activation Analysis (PGNAA) facility of the TRIGA Mark II research nuclear reactor of Pavia University, confirmed the proper identification of the ^{10}B signal even when a significant neutron background is accounted. Due to its main application, the PGNAA facility is characterised by a very low photon background and by an almost complete absence of ^{10}B in the shielding and beam collimating structure. After some Monte Carlo simulations to know the neutron and photon backgrounds from which we evaluated the necessity of proper shields around the detector, we carried out the first spectroscopic measurements of ^{10}B-enriched materials (boronated water solutions), together with some sensitivity studies focusing on the lowest ^{10}B detectable threshold.

In parallel, a second CZT prototype has been developed and built. The sensitive volumes increased to 20x20x5 mm3 and thanks to the pattern of collecting electrodes arranged through orthogonal drift stripes, this detector is capable of 3D spatial sensitivity thus opening the route for the investigation of a BNCT-dedicated single stage Compton Camera. Preliminary data simulated by Geant4 Monte Carlo code will be presented as well as the first preliminary results obtained using point-like standard sources.