In vivo B10 imaging and dose rate measurement for BNCT using Single Photon Emission Comptuted Tomography (BNCT-SPECT)

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Boron Neutron Capture Therapy (BNCT) is an experimental form of binary radiotherapy based on the neutron capture reaction $^{10}B + n_{th} \rightarrow$ alpha + ^{7}Li. Thanks to the high LET secondary particles and their short ranges in tissue (4-9 um, to be compared with the mean cell diameter of few tens um) it is possible to selectively destroy cancer cells sparing the surrounding normal tissues.
BNCT cell-level selectivity depends on the dose deposited locally by ^{10}B capture reactions whose rate is proportional to the product between the local concentration of ^{10}B nuclei and the thermal neutron fluence inside the cancer cell at the irradiation time.
To date there are no real time and direct means to evaluate ^{10}B concentration in cancer cells during BNCT, and the same limitation affects thermal neutron flux measurements. Several clinical trials based on identical BNCT protocols reported outcomes significantly different which can be explained by a lack of precision in dosimetry assessment, thus requiring the development of a real time and *in vivo* strategy to measure boron dose rate during a BNCT session. To this scope, a useful tool is the 478 keV gamma-ray emitted by the 94% of ^{7}Li ions, which naturally opens the route for a BNCT-dedicated SPECT system. Because the dose due to boron capture reactions is proportional to the product of the local ^{10}B concentration and the thermal neutron fluence, the measurement of the 478 keV gamma-ray would allow a direct estimation of the delivered dose avoiding the difficulty of measuring boron concentration and neutron flux as separated quantities.
INFN has recently founded a 2-year project named 3CaTS (high performance 3D Cadmium-Zinc-Telluride spectro-imager for X and gamma-ray applications) whose goal is to develop and build an innovative fully functional highly segmented prototype of a CZT solid state photon detector to prove and evaluate its performance as spectrometer with 3D spatial resolution capabilities suitable for different spectroscopic imaging application in the range from few tens of keV up to MeV, including the aforementioned BNCT-SPECT research topic. In particular, the BNCT research group active at Pavia University and Pavia Unit of INFN is dealing with the feasibility and effectiveness studies of BNCT as treatment against diffuse lung cancers (including malignant pleural mesothelioma). The on-going experiments use tumour models induced in rats and mice and the BNCT application of 3CaTS project has the development of a small animal BNCT-dedicated SPECT as short term objective.
After a brief presentation of the state of the art of BNCT-SPECT research worldwide, the talk will focus on the CZT technology chose to carry out 3CaTS project and on the first results of the characterization and spectroscopic performance of a 1D CZT prototype for BNCT-SPECT obtained at the thermal neutron facility of Pavia University.