Innovative 3D sensitive CdZnTe solid state detector for dose monitoring in Boron Neutron Capture Therapy (BNCT)

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Logo Conf

Project Aim

To characterise a prototype of drift strip CZT detector for an innovative SPECT system for BNCT application.

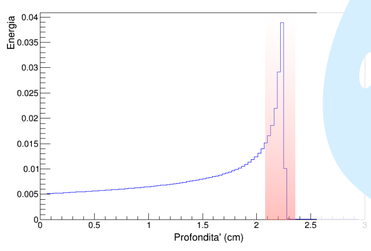
Boron Neutron Capture Therapy (BNCT)

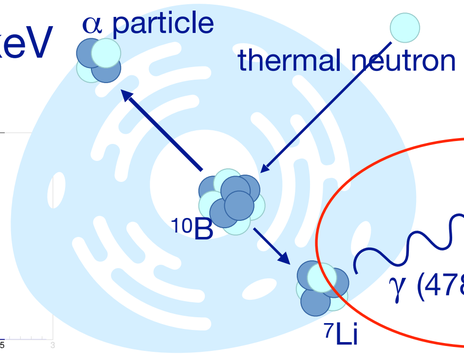
Binary form of experimental hadron therapy with cell level selectivity mainly determined by microscopic ^{10}B spatial distribution.

Presently there is no direct method to measure in vivo and in real time the therapeutic ^{10}B dose.

In 94% of capture reaction a 478 keV γ ray is emitted.

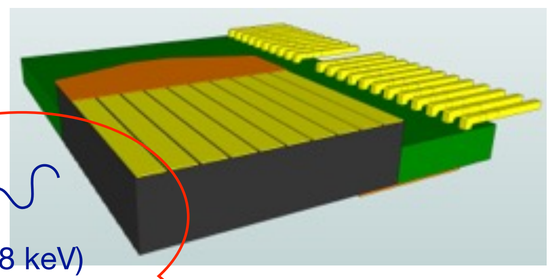
	E(MeV)		R(μm)
α	1.47	1.78	9-10
^{7}Li	0.84	1.01	4-5
γ	0.48	--	





Cadmium Zinc Telluride (CZT) solid state detector

CZT is an interesting material for innovative medical imaging thank to: broad energy band gap (room temperature operation), high atomic number (high photoelectric detection efficiency even with small volumes), very good energy resolutions.

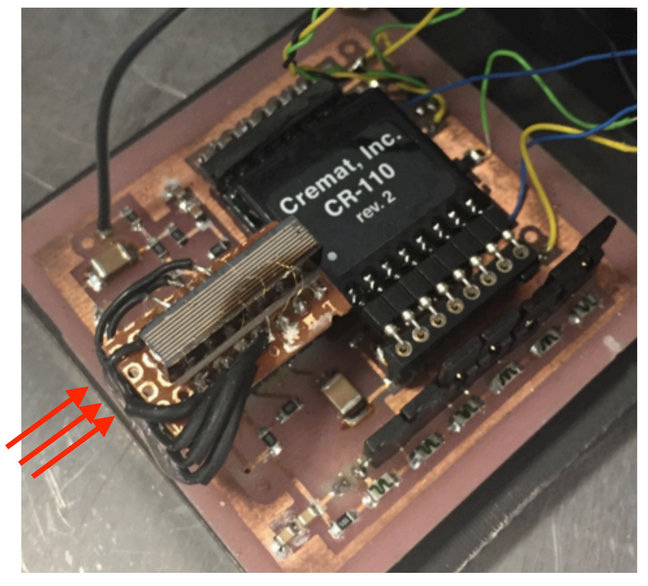


INFN 3CaTS project aims to develop a BNCT-dedicated SPECT using innovative 3D drift strip CZT detectors.

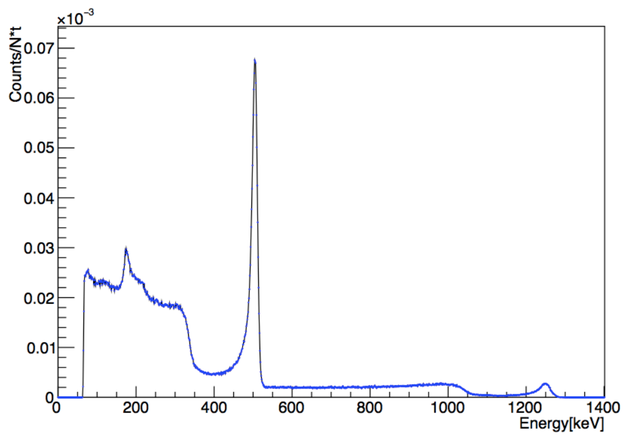
BNCT-dedicated SPECT for in vivo dose monitoring

Materials and Methods

- The CZT detector used in this study has been developed by IMEM-CNR Parma and due2lab s.r.l starting from a Redlen crystal. The final volume is 20x5x5 mm^3. A full area contact was realised at the cathode side by gold electroless deposition in methanol solution. On the anode side, drift stripes were deposited using standard photolithographic techniques.
- The readout electronics is composed of two Cremat preamplifiers lodged in the same box as the detector, while the amplifier and power supply are separated in a different box.
- The measurements were carried out using the Planar Transversal Field (PTF) configuration, using the 5x5 mm^2 surface as the photon entrance side; the cathode and the external anode stripes were grounded, the anode collecting strip voltage was set at 150V, while the drift stripes voltages were set to 37.5, 75 and 112.5V.
- Spectroscopic characterisation has been carried out using standard gamma sources to evaluate the energy resolution and efficiency over the energy range 200-1350 keV. The distance between the source and the detector was 1 cm.
- Detection capabilities in a mixed (n+γ) field were studied under irradiation using a thermal neutron beam at the Pavia research nuclear reactor.



Results



Isotope	Energy (keV)	En. resolution (%)
Ba133	276	2.97
	303	2.53
	356	**2.81**
Cs137	**662**	**2.81**
Na22	**551**	**2.99**
	1275	2.09
Co60	1173	1.78
	1332	1.78

Fig. 1: (left) ^{22}Na spectrum (peak energies: 511keV, 1274.5keV)

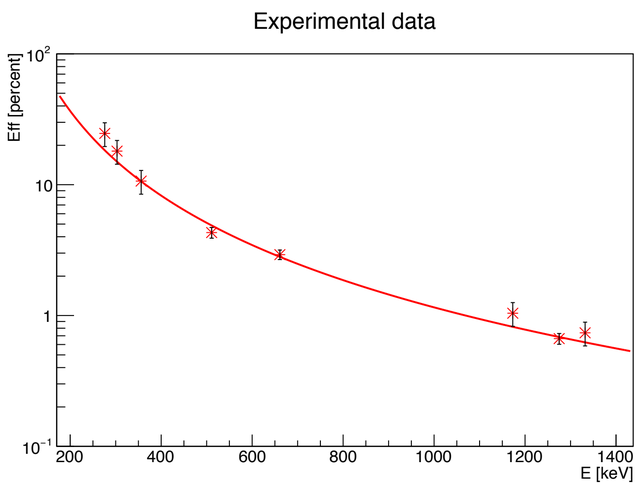


Fig. 2: detection efficiency curve

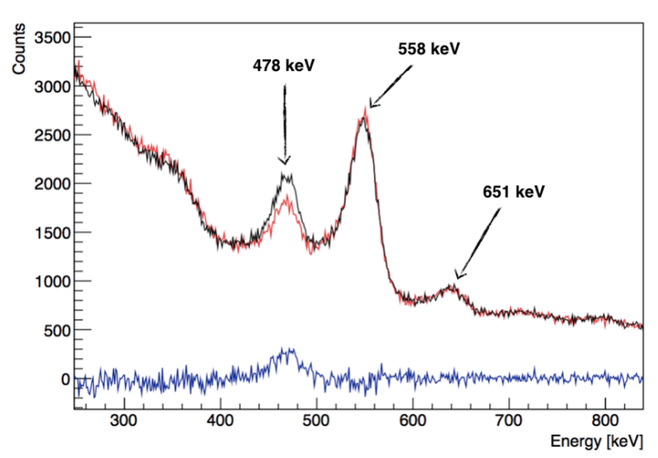


Fig. 3: preliminary spectrum of ^{10}B enriched vial irradiated by a thermal neutron beam

Discussion

- We obtained a 3.0% energy resolution at 511keV, while the expected efficiency at 478 keV is 6.1%
- Preliminary measurements inside the (n+γ) field at the Pavia nuclear reactor confirmed the possibility to discriminate the 10B signal from the 558 keV neutron activation peak of 113Cd.
- Further measurements at Pavia reactor are required to evaluate the detections limits and the reliability of the detector response under (n+γ) fluxes representative of a BNCT clinical irradiation.