Characterization and first test of an i-TED prototype at CERN n_TOF

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Abstract Neutron capture cross section measurements are of fundamental importance for the study of the slow process of neutron capture, so called s-process. This mechanism is responsible for the formation of most elements heavier than iron in the Universe. To this aim, installations and detectors have been developed, as total energy radiation C_6D_6 detectors. However, these detectors can not distinguish between true capture gamma rays from the sample under study and neutron induced gamma rays produced in the surroundings of the setup. To improve this situation,

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we propose [1] the use of the Compton principle to select events produced in the sample and discard background events. This involves using detectors capable of resolving the interaction position of the gamma ray inside the detector itself, as well as a high energy resolution. These are the main features of i-TED, a total energy detector capable of gamma ray imaging. Such system is being developed at the ”Gamma Spectroscopy and Neutrons Group” at IFIC [2], in the framework of the ERC-funded project HYMNS (High sensitivitY and Measurements of key stellar Nucleo-Synthesis reactions). This work summarizes first tests with neutron beam at CERN n_TOF.

1 i-TED concept and first tests at CERN n_TOF

Compton cameras are widely used in various fields such as astronomy, medicine, and the treatment of radioactive waste. In this work we explore the possibility to apply them also in the field of neutron capture experiments. The detector consists of two stages, scatter and absorber, operated in temporal coincidence. This allows us to apply the Compton principle to obtain information on the direction of origin of the gamma ray. Each stage is composed of $LaCl_3$(Ce) scintillation crystals (thinner in the scatter than in the absorber), coupled to pixelated silicon photomultipliers (SiPM) readout by a fronted electronics from PETSyS [3].
On the left part of the Fig.1, the experimental setup for the first tests of the detector in n_TOF at CERN it shown. This facility provides pulsed and intense neutron bunches over a broad every range [4]. In order to obtain the neutron energy, an external trigger input was implemented on the electronic system.

2 Characterization

The energy resolution is relevant because the uncertainty in this quantity leads also to an uncertainty on the Compton cone. i-TED achieves resolutions of around 5% at 662 keV [5]. On the other hand, we obtain spatial information of the gamma ray hits by means of a pixelated SiPM photosensor coupled to the crystal. The information from the SiPM basically allows us to trace the vertex and the axis of the Compton cone for each detected event.
For the position reconstruction, we have investigated different algorithms in order to recover the 3D spatial coordinates of the gamma ray hit in each crystal. These characterization studies will be reported in a separate work [6]. For example, on the right part of Fig.1 one can see the charge distribution of a gamma event centered in the the crystal fitted by an analytical form. The accuracy in the reconstructed position ranges between 1 mm and 3 mm FWHM depending on the method used.

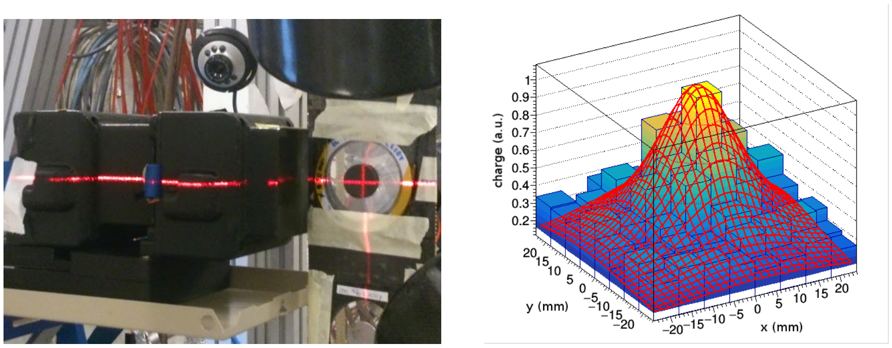

Fig. 1 Experimental setup with an i-TED prototype (left). Charge distribution of a gamma event fitted with one analytical formula (right).

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