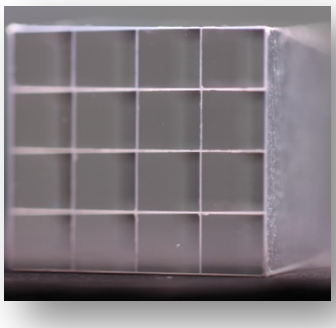
Master / Diploma thesis

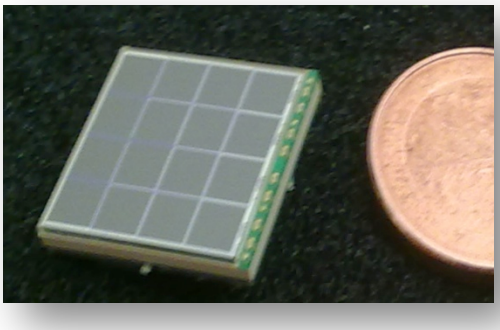
at the

Detector labororatory of the Institute for Experimental Physics

Optimization of a novel positron emission tomography detector

The aim of this thesis is to optimize the geometrical sizes of a single channel in a Time-of-Flight Positron Emission Tomography (TOF-PET) detector for best image, energy and time resolution. TOF-PET is a technique to reconstruct images exploiting the line of response in coincidence of two 511 keV photons emitted by electron-positron annihilation.
Each individual channel comprises a crystal (LuYAp[1] and LYSO[2] are considered) and a silicon based photo-detector (MPPC[3], Hamamatsu S10362-33-050C series 3×3mm^2 active area, 50×50 µm pixel size). The optimization of the crystal length has to maintain highest possible sensitivity and ensure a coincidence time resolution better than 200ps. The crystal size is optimized to ensure best possible image resolution.
The optimization is to be carried out using the GEANT 4 simulation tool. In order to validate the simulation, one measurement will be performed using one crystal out the possible geometries, coupled to the chosen photo-detector. For the proper comparison, the photo-detection efficiency and the non-linear response function of the MPPC need to be implemented in the simulation.





Discuss:

- The process of light generation and detection in a PET event.
- the plan for the simulation studies (give sensible range for the length and size of the crystal to be investigate, motivate the decision)
- the plan for the validation measurements (describe the observables to be measured, a possible measurement setup, and the analysis steps required)
- the properties of the photo-detector that need to be implemented in simulation

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. [2] A. Cutler, C. L. Melcher, M. A. Spurrier, P. Szupryczynski, and L. A. Eriksson, Scintillation Non-Proportionality of Lutetium and Yttrium-Based Silicates and Aluminates, IEEE Trans. Nucl. Sci., Vol. 56, No. 3, June 2009.

. [3] Discription of MPPC S10362-33 series from Hamamatsu, http: //jp.hamamatsu.com/resources/products/ssd/pdf/s10362-33_series_kapd1023e05.pdf