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 3×3 mm\(^2\) 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 200 ps. 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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