Contribution ID: **61** Type: **not specified**

Evaluation of a PET detector with ultra-high spatial and timing resolution suitable for preclinical systems

Friday 3 June 2022 16:00 (15 minutes)

In Positron Emission Tomography (PET), depending on the scintillator type and geometry, many events undergo Compton interactions before photoelectric absorption. If these interactions are not properly identified, an image blurring is observed. In this report, the main components of the scatter ring of a Compton-PET system for mice brain imaging with high timing and spatial resolution are described. We have carried out a performance study in terms of energy, spatial and timing resolutions.
Two detector blocks composed of 8×8 SiPM arrays of 3×3 mm2 elements and cell sizes of 50 μm have been employed. The scintillation material was LYSO:Ca crystal array of 12×12 with 0.95×0.95×3 mm3, the array is placed at the center of the SiPM array covering 4×4 photosensors. All surfaces of each pixel of the array were polished and all but the face coupled to the photosensor, covered with ESR. The crystal array was designed such that groups of 3×3 pixels match one photosensor active area (9-to-1 coupling). The frontend electronics used was the TOFPET2 ASIC.
All pixels were identified using CoG method, furthermore Voronoi diagrams were applied to identify each pixel. After applying a custom energy equalization procedure, the energy resolution decreases from 35% to 19% in arbitrary ADC units
The Detector Time Resolution (DTR) values for different energy windows (EW) applied to the energy spectra of both detectors were studied. The energy spectrum was divided into 4 different windows from low, medium to high Compton energies and the photopeak. For low EW, the measured DTR is around 275 ps. Better performance is observed at the photopeak energies, finding values of 130 ps DTR considering 9 pixels matching 1 SiPM, and an improved 112 ps at crystal pixel level.
In next steps, the size of the crystal array will increase covering the 8×8 SiPM array with 24×24 pixels. Moreover, we also will scale the system to 8 detectors forming a rectangular parallelepiped and fully characterize the system

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Session Classification: System considerations for TOFPET CTR resolution ≤100ps

Track Classification: System considerations for pushing TOFPET CTR ≤ 100ps