

Characterization of a semi-monolithic detector with DOI and TOF capabilities for preclinical PET

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A semi-monolithic scintillator crystal consists of a monolithic block segmented in only one direction in different pieces called slabs. This approach is intended to combine the benefits of both pixelated and monolithic crystals, which are usually employed in PET detectors, preserving the good timing resolution of pixelated crystals, and the high sensitivity and good spatial resolution of monolithic crystals.

In this work, a semi-monolithic block consisting of 24 LYSO slabs of $25.4 \times 12 \times 1$ mm³ coupled to a matrix of 8×8 SiPMs of 3×3 mm² active area each with 50 μ m cell size and 3.2 mm pitch has been characterized. The 64 individual signals are read out by the TOFPET2 ASIC. Different treatments have been applied to different surfaces of the detector block in order to assess their impact on the detector performance. In “All ESR” configuration, all the faces of the slabs are polished and ESR is employed as separator between the slabs and also on the lateral and top faces. In “ESR+B+RR”, all the faces of the slabs are polished, ESR is employed as separator between the slabs and also on the two monolithic outer faces, retroreflector (RR) is applied on the top face and black (B) painting on the two pixelated outer faces. “ESR+B+RR unpolished” configuration is identical to “ESR+B+RR”, but the two pixelated outer faces have been mechanically unpolished.

The energy, spatial and MAE resolutions are, respectively, 13.1%, 1.7 mm and 0.8 mm for the “All ESR”, 13.8%, 1.6 mm and 0.7 mm for the “ESR+B+RR” and 15.5%, 1.5 mm and 0.7 mm for the “ESR+B+RR unpolished”. The DOI resolution has been evaluated for the “ESR+B+RR unpolished” detector showing 2.0 mm FWHM and 1.0 mm MAE. The coincidence time resolution (CTR) for two identical blocks of the “All ESR” configuration is 336 ps when the first timestamp is used and it improves to 276 ps when energy-weighted averaging of the timestamps belonging to the same event is applied.

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