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How to improve timing performance in TOF-PET with segmented SiPMs coupled to BGO and LYSO

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Fast timing in ToF-PET improves signal-to-noise ratio for better patient comfort through either a lower dose or a shorter measurement time. Currently, lutetium-based crystals in clinical PET scanners achieve a coincidence time resolution (CTR) of around 200 ps, which is limited by the scintillation process. Therefore, BGO with its Cherenkov radiation is being investigated as an alternative. However, it cannot reach its full potential due to a too low bandwidth of the electronics and time resolution of the photosensors. Segmenting the photosensor into an array of μSiPMs, which can be read out individually, allows to better utilize the prompt time information of the Cherenkov photons through an effectively higher bandwidth and thus is a promising approach to improve timing. In this work, we simulated the optical photon production with Geant4 and applied a signal model with a leading-edge threshold to determine timestamps and calculate the CTR from the first timestamp. Two detectors using either 3 mm long BGO or LYSO crystals, were investigated with varying segmentations of the photosensor. Segmenting the photosensor resulted in a 2.6-fold improvement of the CTR for BGO, reducing it to 39 +/- 20 ps. Segmentation is beneficial to BGO with its higher Cherenkov-to-scintillation ratio, while LYSO does not show an improvement due to its lower Cherenkov yield, which is additionally spoiled by its higher scintillation photon yield.

Field

Detectors and electronics

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