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Characterisation of an AI-enhanced TOF-PET detector module with monolithic BGO crystals

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We present an autonomous, monolithic scintillator-based PET detector that incorporates our newly developed artificial intelligence algorithm for real-time, on-board event characterization. This new design achieves state-of-the-art performance metrics including spatial resolution, depth-of-interaction (DOI), coincidence time resolution (CTR), and maximum event rate capabilities while maintaining scalability, low costs and the ability to process all data internally.

We present two detector designs equipped with 16- and 20-mm-thick monolithic BGO crystals coupled to a 8 x 8 SiPM matrix with a 6 mm pitch. Each SiPM is individually read by an HRFlexToT ASIC with 16 channels apiece, for a total of 4 ASICs. The detector incorporates an internal artificial intelligence algorithm that effectively consolidates the digital outputs from each sensor into 3D position, time of interaction, and amount of energy deposited.

Both variants achieved spatial resolutions below 2 mm FWHM and timing resolutions below 450 ps. The data acquisition architecture is able to sustain an event rate of up to 1.1 Mcps over a 50 mm x 50 mm active area. Notably, the design confines the entire detector volume within the 50 mm x 50 mm footprint of the crystal, enabling a completely tileable architecture with no loss of space on the two planar sides.

Field

Detectors and electronics

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