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Performance of monolithic BGO crystals as gamma ray detectors using a neural network event decoding algorithm

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We compare the performance of gamma-ray detectors based on monolithic BGO crystals versus LYSO ones, using a novel neural-network event characterization algorithm. LYSO represents the gold standard in applications such as Positron Emission Tomography and is considered a key component for time-of-flight (ToF) photon detection. On the contrary, BGO has been used so far only for non-ToF applications because of its long scintillation decay time and low light yield.
The setup consists of a 22Na point source between two detectors composed of a 25.9 mm x 25.9 mm x 12 mm scintillating crystal coupled to Hamamatsu MPPC arrays. The acquired events are reconstructed using a neural network trained with both experimental and simulated data. The experimental data are acquired by moving the detector on a 2 mm step grid, so as to irradiate a regular mesh. The simulated data are obtained by modeling the photon interactions and the optical tracking using Geant4, and subsequently using the timestamp of each detected optical photon to simulate the response of the SiPM arrays. In each scan, about 500 coincidence events are acquired for each point, equally divided between the training and the test sets.
The x and y positions of the interactions in both crystals can be reconstructed with a full width at half maximum (FWHM) of 0.8 mm with either crystal. An energy resolution of 20.2% and 12.7% is obtained for BGO and LYSO, respectively. The time difference distribution between the monolithic and the coincidence detector shows an average coincidence time resolution (CTR) of 320 ps FWHM for BGO and 160 ps for LYSO.
The obtained results show that the performance gap between BGO and the more performant LYSO in terms of CTR can be reduced significantly to the level that BGO becomes a valid alternative for time-of-flight applications.

Collaboration

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