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Advancements in DOI-capable TOF-PET modules based on High-Frequency Readout

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High-frequency (HF) front-end electronics are an attractive solution for exploiting fast light production mechanisms in crystals and achieving excellent performance in TOF-PET applications. They have demonstrated improved time resolution by allowing the lowering of the leading-edge detection threshold. This enables the use of the fastest photons produced in the crystals, such as Cherenkov emission, and facilitates event discrimination in heterostructures made of a combination of fast and dense scintillators.

Heterostructured scintillators are emerging as a trade-off between the high sensitivity and fast timing of TOF-PET detectors. They consist of stacks of alternating layers of two materials with complementary properties: high stopping power (BGO) and ultrafast timing (plastic). However, layering is a limiting factor for the best achievable time resolution, as it worsens light transport. This effect can be mitigated by retrieving depth-of-interaction (DOI) information. To address this issue, a double-sided readout method or a light-sharing mechanism in single-side readout using a matrix of scintillators coupled to an array of SiPMs can be employed to identify the DOI and correct for the induced bias. For the light-sharing method to work, readout integration in a multi-channel scheme is required.

We present the achievement of 174 $\pm$ 6 ps coincidence timing resolution (CTR) and 6.40 $\pm$ 0.04 mm DOI resolution in single-pixel heterostructured scintillators of 3x3x20 mm^3 using double-sided HF readout. Additionally, the integration of a multi-channel HF readout board to a matrix of 4x4 LYSO 3.1x3.1x15 mm^3 allows to achieve a CTR lower than 130 ps. Finally, we outline the steps toward the implementation of this readout to a heterostructured scintillator matrix.

Collaboration

Role of Submitter

I am the presenter

Primary author: TERRAGNI, Giulia (CERN / Technical University of Vienna)

Co-authors: TRIBBIA, Elena (Organization for Nuclear Research (CERN) and University of Milano-Bicocca, Italy); LOWIS, Carsten (Organization for Nuclear Research (CERN) and RWTH Aachen University, Germany); PAGANO, Fiammetta (Organization for Nuclear Research (CERN) and University of Milano-Bicocca, Italy); Dr CATES, Joshua W. (Lawrence Berkeley National Laboratory, CA, USA); Dr PIZZICHEMI, Marco (Organization for Nuclear Research (CERN) and University of Milano-Bicocca, Italy); Prof. MARTON, Johann (Technical University of Vienna (TU Wien), Austria); Dr AUFFRAY, Etiennette (Organization for Nuclear Research (CERN))

Presenter: TERRAGNI, Giulia (CERN / Technical University of Vienna)

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