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Development of a DOI mini PET/SPECT prototype based on scintillation detectors in phoswich configuration

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Positron Emission Tomography (PET) scanners possess the capability to both delineate three-dimensional images of organs affected by different diseases and investigate the metabolic behavior of tumoral structures. This is accomplished by detecting the two 511 keV photons produced in positron annihilation emitted by a β+ radionuclide. On the other hand, Single Photon Emission Computed Tomography (SPECT) systems employ γ-emitting radionuclides to identify single-photon events and reconstruct three-dimensional images in a similar fashion to PET imaging.

In practical terms, the reconstruction of images in PET detection assumes that the two annihilation photons are emitted along a certain Line Of Response (LOR). However, uncertainties arising from the actual size of the detectors transform this LOR into a volume of response. Hence, it becomes imperative to introduce a third dimension, namely the Depth Of Interaction (DOI), to enhance sensitivity and spatial resolution. To address this issue, as an alternative to the typical single-crystal configuration in PET scanners, this study proposes the use of two scintillation crystals in phoswich configuration. This configuration relies on the utilization of two scintillators with different decay times, optically coupled and integrated into a single readout and acquisition system. These differences in the decay time of each crystal enable for a better discrimination of the depth of interaction within the crystal assembly.

In this work, we present a DOI mini PET/SPECT prototype for pre-clinical small animal studies using CsI(Tl) and ceramic GAGG(Ce) crystals in phoswich configuration, with a readout that primarily features a large area avalanche photodiode and an electronic chain inherited from CALIFA, a gamma-ray detector of the R3B experiment at FAIR, and designed for high-resolution gamma spectroscopy. We will present the state of the art of this innovative configuration, as well as the characteristics of the current setup, first results and future improvements for this proof of concept.

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