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# Monolithic crystals with SiPMs read-out: optical coupling optimization

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In this work we present a method to efficiently collect scintillation light at the time to reduce photosensor active area. We have applied this procedure on gamma detectors for PET devices based on continuous crystals and SiPM detectors.

The use of continuous scintillation crystals preserves the spatial distribution of scintillation light for each γ-ray event, which can be reconstructed with a small number of statistical moments, reducing the number of analogue-to-digital conversion channels. However, in contrast to pixelated crystals, they account for moderate edge effects which specially depend on the crystal thickness. Several configurations for crystal surface treatment have been studied aiming at preserving the original scintillation light distribution. The initial tests suggested, in order to optimize the light collection, a reduction of the acceptance angle of the scintillation photons in order to keep a compromise between small edge effects and statistically good light transmission. Optical devices positioned between the scintillation crystal and the photosensor, like the so-called faceplates or some light guides, make possible to reduce the acceptance angle of the incoming light.

Since it is part of this research also to design a detection block compatible with magnetic fields, we have chosen SiPM which are suitable to work under the fields of for instance magnetic resonances. However, due to their main components, they present a number of dark counts that squarely increase with their active area size and could degrade the impinging photon position determination when using multiplexing read-out approaches. Therefore, we have designed an array of SiPMs with 1 mm2 detection area. In order to satisfy both requirements small acceptance angle and reduce individual detection area, we have proposed to use light guides to efficiently transfer the scintillation light to each SiPM.

The optical design of a light guide has been optimized using the ZEMAX simulation program that is based on light propagation within the crystal and guides. An optimal configuration that represents a balance between light detection efficiency and cross talk between channels was found. This configuration has already been implemented by developing a special cast for an array of 8 light guides using PMMA as material. A final matrix of 256 light guides is foreseen to be built by gluing 32 of those arrays with the help of a plastic grid, ensuring a very low cross-talk (12 dB) and good transmission of nearing 70%.

In this work we will present the first results of monolithic LYSO crystals coupled to an array of 64 and 256 SiPMs. We have tested different LYSO thicknesses, and we have found that our design allows using crystals blocks with a thickness of more than 18 mm without degrading the spatial resolution caused by edge effects.

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