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Characterization of Ca co-doped LSO: Ce scintillators coupled to SiPM for PET applications

Scintillators suitable for PET applications must be characterized by a high efficiency for gamma-ray detection, determined by a high density and atomic number of the crystal; a fast light signal that allows to achieve a good time resolution and to cope with high counting rates; a high light yield for a good energy and time resolution; a good linearity of the light output as a function of the energy to preserve the intrinsic energy resolution of scintillator.
Recently developed LSO:Ce scintillators, co-doped with Ca, have been produced by the University of Tennessee group. They are characterized by the improved performance of all the above mentioned characteristics. The crystals, initially tested with PMTs, showed a higher light output, faster light pulse, improved energy resolution and reduced afterglow, as compared to the standard LSO:Ce crystals. Even though the PMTs still represent the gold standard photodetectors, the recently available SiPMs are now valid candidate to replace PMTs in the next generation PET scanners thanks to their compactness, high spatial resolution performances, low bias operating voltage and, most important for combined PET/MRI systems, insensitivity to static and RF fields.
In this work we present the performance of Ca co-doped LSO:Ce samples coupled to SiPMs from different manufacturers. In particular we have assessed their performances by evaluating the energy and time resolution.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

Inorganic scintillators are employed in most of the current medical imaging techniques [1], thanks to their good detection efficiency in the energy range of radiology and nuclear medicine (from 20 keV of mammography to 511 keV annihilation radiation used in PET).
Different imaging modalities pose different requirements to be fulfilled by the radiation detectors and not all these requirements are met by the crystals developed up to date. This is a reason why the R&D on the scintillators is always in progress.
As for the scintillators to be used in PET detectors, the requirements are:
• A high efficiency for ⊠-ray detection, associated with a high density and atomic number of the detector elements;
• A fast light signal that allows to achieve a good time resolution and to sustain high counting rates;
• A high light yield in order to achieve a good energy and time resolution;
• A good linearity of the light yield as a function of the energy to preserve the intrinsic energy resolution of the scintillator.
LSO:Ce doped was introduced in the 90's as a high resolution and fast scintillator [2][3] and in 2001 Siemens /CTI introduced the first LSO:Ce based high resolution research tomograph (HRRT) for brain studies [4]. LSO is particularly appealing for PET thanks to its high efficiency (high density and atomic number) and to the ionic dopant Ce3+, which significantly improves the light output and the time response.
Recently developed LSO:Ce scintillator, co-doped with Ca, has been produced by the University of Tennessee group guided by Prof. C. Melcher. These crystals, tested with PMTs, showed a higher light output, faster light pulse, improved energy resolution and reduced afterglow, as compared to the standard LSO:Ce crystals.
The development and the optimization of the scintillators proceed in parallel with the research on new photodetectors. Even though the PMTs still represent the gold standard photodetectors, the recently available SiPMs are valid candidates to replace PMTs in the next generation PET scanners thanks to their compactness, high spatial resolution performances, low bias operating voltage and, most important for combined PET/MRI systems, insensitivity to static and RF fields.
In this work we present the performance of Ca co-doped LSO:Ce scintillator samples coupled to SiPMs from different manufacturers. The spectroscopic capabilities of the crystals and the timing performances have been assessed by using a Na-22 source. As an example, in figure 1 we show the energy spectrum of the Na-22source obtained with an LSO:Ce(Ca) sample of 4x4x5 mmˆ3 coupled to a MPPC Hamamatsu 3x3 mmˆ2, in time coincidence with another detector. The energy resolution is 8.5% (FWHM) at 511 keV.

Figure 1 Energy spectrum of the Na22source obtained with an LSO:Ca sample of 4x4x5 mmˆ3 coupled to a MPPC Hamamatsu 3x3 mmˆ2, in time coincidence with another detector. The energy resolution is 8.5% (FWHM) at 511 keV

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