Characterization of a HR-GAGG(Ce) crystal coupled to an avalanche photodiode for HYPATIA project

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One of the main tasks of the HYPATIA project[1)] is testing high-resolution cerium-doped $Gd_3(Ga,Al)_5O_{12}$ scintillator crystals, known as HR-GAGG(Ce), to determine the optimal choice of readout and electronics. The avalanche photodiodes (APDs) and silicon photomultiliers (SiPMs) are the most immediate readout options because of their availability. In this study, we assembled and tested a HR-GAGG crystal coupled to an APD readout.

The crystal used is a $35 \times 35 \times 100$ mm^3 HR-GAGG(Ce) supplied by C&A.[2)] For readout, we tested two devices: a Hamamatsu S8664-1010[3)] with 1 cm^2 effective sensitive area, and an array of two S8664-1010 assembled by the same supplier. These are referred to as single APD and double APD, respectively. The signals from each cell in the double APD are summed, and the array has a single signal output. In both cases, optical grease was applied between the crystal and readout, and the assembly was wrapped in Teflon.

To amplify the signal, we used the Cremat CR110 charge sensitive preamplifier[4)] with the CR-150-R5 Cremat evaluation board.[5)] For digitization, a FASTER digitizer supplied by LPC Caen[6)] with trapezoidal-spectro module was used. This digitizer has two modules, QDC-TDC and trapezoidal-spectro. Using the first module, the digitizer integrates the charge of the signal to obtain the energy of the detected particle. Using the second module, the digitizer estimates the energy of the detected particle based on the amplitude of the signal. The trapezoidal-spectro module was employed because the preamplifier's output signal tends to be too long in duration to be processed in QDC mode.

Because of the high sensitivity of APDs to external electromagnetic fields, the analog part of the setup, consisting of the crystal, APD, and evaluation board, was initially placed inside a metallic shielding box. This required housing makes APDs less practical for use in an array such as the one proposed for HYPATIA. For this reason, the setup was improved by introducing of a coaxial cable between the APD and the board, and using a shielding case to place the board outside the metallic box without significantly affecting the detector performance.

The results of the tests performed show 1% better resolution for double APD than for single APD. Spectra from a ^{60}Co source, taken with both detectors, are displayed in Fig. 1. The energy resolution at the two characteristic emission lines of the source is shown in Table 1.

For the measurements conducted so far, the ^{60}Co source was positioned to point at one of the long faces of the crystal. For a detector with this prism-like geometry, better resolution is achieved by having the source point at one of the small faces of the detector, which is also the configuration proposed for HYPATIA. Notably, the size of the HR-GAGG crystals proposed for HYPATIA is smaller than the one tested here, which usually results in better resolution.

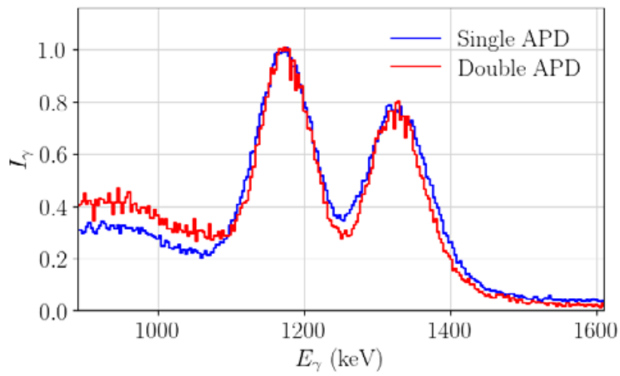

Fig. 1. ^{60}Co spectra with single and double APD. The spectra are calibrated, rebinned, and normalized to the height of the first peak, calculated from the Gaussian fit.

Table 1. Detector resolution, calculated as FWHM/E_γ (%), with the source positioned to point at one of the long faces of the crystal.

Photodetector	E_γ (MeV)	
	1.173	1.332
Single APD	7.42(5)	7.53(5)
Double APD	6.49(7)	6.43(7)

References
1) HYPATIA Project, SUNFLOWER Colaboration.
2) C&A Corporation, Sendai, Japan.
3) Hamamatsu S8664-1010, Hamamatsu Photonics K.K., Japan.
4) Cremat CR-110 Preamplifier, Cremat Inc., USA.
5) Cremat CR-150-R5 Evaluation Board, Cremat Inc., USA.
6) FASTER Digitizer, LPC Caen, Caen, France.

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