



CAEN Educational Handbook

Nuclear and Particle Physics Experiments



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A COMPARISON OF DIFFERENT SCINTILLATING CRYSTALS: LIGHT YIELD, DECAY TIME AND RESOLUTION

SG6115A

SP5600C - EDUCATIONAL GAMMA KIT

Difficulty



Execution Time



Purpose of the experiment

Compare the basic characteristics of different scintillating crystals, namely the light yield and the decay time of the scintillation light. Verify the effect on the energy resolution.

Fundamentals

Scintillating materials exhibit various characteristics related to light yield and the characteristic time of emission. The CAEN spectrometer is equipped with three different crystals: BGO (Bismuth Germanate), LYSO(Ce) (Cerium-doped Lutetium Yttrium Orthosilicate), CsI(Tl) (Thallium-doped Cesium Iodide). All of them have the same volume ($6 \times 6 \times 15 \text{ mm}^3$), are polished on all sides, and coated with a white epoxy on 5 faces. One $6 \times 6 \text{ mm}^2$ face is open to be coupled with the Silicon Photomultiplier. The main characteristics

of the crystals are summarized in the table alongside. The light yield affects the energy resolution. This is also influenced by the decay time, which constrains the integration time and implies a different effect of the sensor's stochastic effects (dark counts and afterpulses).

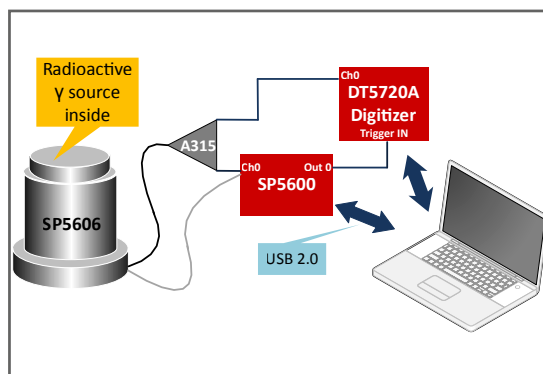
	BGO	LYSO(Ce)	CsI(Tl)
Density (g/cm^3)	7.13	7.4	4.51
Decay Time (ns)	300	40	1000
Light Yield (ph./MeV)	8200	27000	52000
Peak emission (nm)	480	420	560
Radiation length (cm)	1.13	1.14	1.85
Reflective index	2.15	1.82	1.78

Requirements

Gamma Radioactive Source. 

Carrying out the experiment

The scintillator crystal shall be coupled to the SiPM in the SP5607, through a thin layer of index matching grease to maximize the light collection. In order to avoid saturation, the output of the SiPM is divided using the A315 splitter: one branch is connected to the DT5720A and will be digitized. The other branch will be amplified by the SP5600 module, generating the trigger for the integration signal by the on-board leading edge discriminator. The discriminator threshold shall be defined looking at the spectrum and evaluating the dark count rate. Once this is set and the radioactive source is properly positioned, the spectrum can be recorded. The procedure shall be repeated for every crystal.

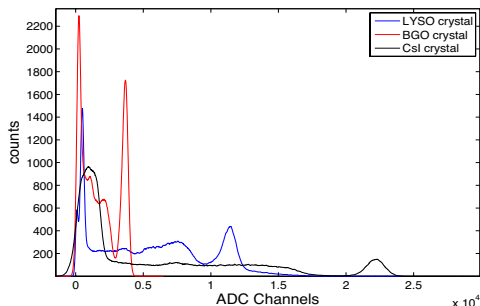


Block diagram of the experimental setup that makes use of the "Educational Gamma Kit".

Results

The crystal characteristics are investigated recording a source spectrum (for example ^{137}Cs) with the three different crystals, optimizing the integration time as a function of the scintillation decay time.

According to table, the Light Yield of the three crystal is very different. LYSO(Ce) has a light yield three times greater than the BGO, and CsI(Tl) light yield is twice than LYSO(Ce). The analysis of the signal waveform or the trend of the charge vs integration time leads to the measurement of the time characteristics of the scintillator.



^{137}Cs energy spectra. Blue spectrum corresponds to the acquisition through LYSO crystal, the red and black ones respectively with BGO and CsI crystals.

	Light Yield Ratio (from datasheet)	Peak Position Ratio
LYSO/CsI	0.52	~0.51
LYSO/BGO	3.29	~3.11
BGO/CsI	0.16	~0.16

Experimental results of Light Yield Ratio.