LYSO Scintillation Material

$Lu_{1.8}Y_{.2}SiO_5:Ce$

LYSO is a Cerium doped Lutetium based scintillation crystal that offers several benefits compared to many common scintillation materials.

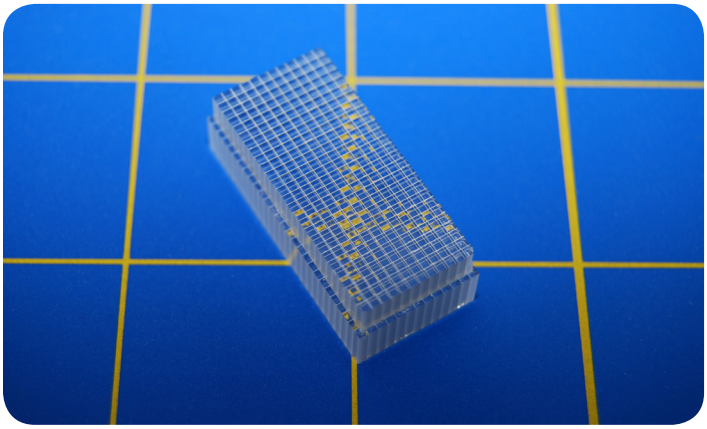
Compared to NaI(Tl) it has a high density (7.1 vs 3.67 g/cm^3), very fast decay time (36 ns), comparable light yield (33200 ph/MeV), and is non-hygroscopic. With a peak wavelength emission of 420 nm, the output is well matched to the sensitivity curve of photomultiplier tubes (PMTs) with bialkali photocathodes, as well as silicon photomultipliers (SiPMs).

- **High density**
- **Fast, single exponential decay time**
- **Non-hygroscopic**

High density and fast decay time make LYSO an excellent scintillator for positron emission tomography (PET), calorimetry in high energy physics, security scanners, and other applications where high stopping power, high throughput and excellent timing are critical. Compared to other high density scintillators such as BGO, LYSO crystal competes directly on density and surpasses BGO on energy resolution, timing and throughput.

Compared to BGO:

- **3-4x the light yield**
- **6-7x faster decay time**
- **Better energy resolution**



LYSO double layer array
Pixel size 1.094mm, pitch 1.17mm
"X"-ray thickness for each layer was 13mm

compared to traditional LYSO, offers up to:

- **6% improvement in energy resolution**
- **20% higher light yield**
- **20% faster decay time**

LYSO Properties	
Density [g/cm^3]	7.1
Hygroscopic	no
Attenuation length for 511keV (cm)	1.2
Energy resolution [%] @ 662 keV*	8
Wavelength of emission max [nm]	420
Refractive index @ emission max.	1.81
Decay time [ns]	36
Light yield [photons/MeV]*	33200
Average temperature coefficient from 25 to 50° C (%/°C)	-0.28

**Typical values tested using 1 cm^3 material against a calibrated standard; actual results may vary depending upon crystal size, shape and other factors.*

Currently in per-commercialization phase and material performance subject to change.

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Table comparing principal properties	LYSO	BGO	LSO
Density [g/cm^3]	7.1	7.1	7.4
Attenuation length for 511 keV (cm)	1.2	1.0	1.15
Decay time [ns]	36	300	40
Energy resolution @ 662 keV	8.0	12.0	10.0
Light output, photons per keV	33	9	26
Average temperature coefficient 25 to 50°C (%/°C)	-0.28	-1.2	-1.3

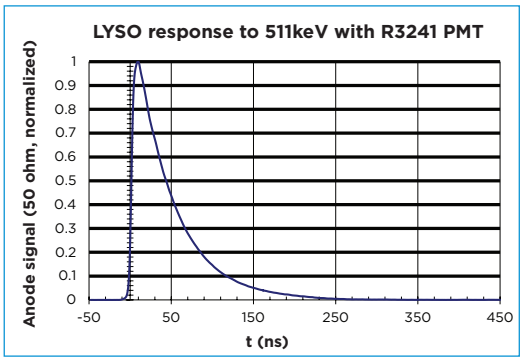

Figure 1. LYSO response to 511 keV

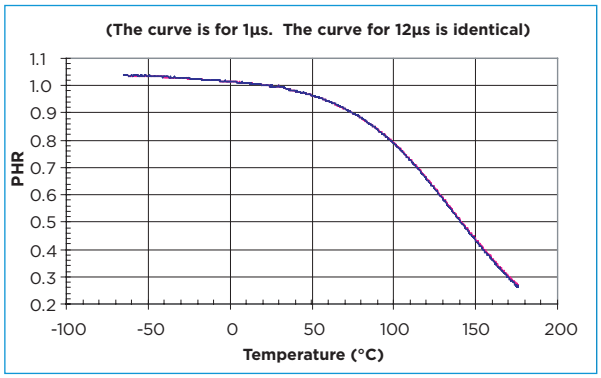

Figure 2. Light yield as a function of temperature. A 137Cs excitation was used, with two amplifier shaping times of 1µs and 12µs. The temperature of the PMT was maintained constant while the temperature of the scintillator was varied from -65°C to +175°C.

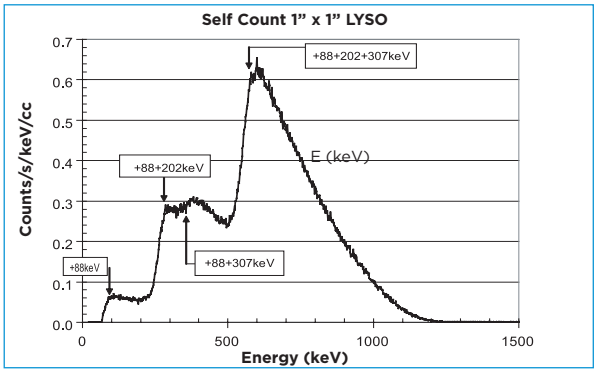

Figure 3. LYSO is a Lutetium-based scintillator which contains a naturally occurring radioactive isotope 176Lu, a beta emitter. The decay results in a 3 gamma ray cascade of 307, 202 and 88 keV, where self-absorption of these photons results in the above spectra in a 1"x1" cube. Total rate for this activity is 39 cps/g.

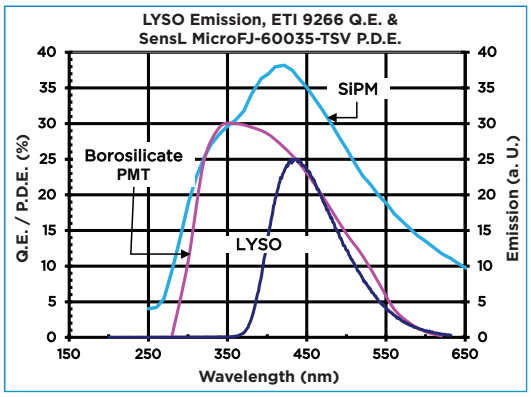

Figure 2. LYSO Emission, ETI 9266 Q.E. & SensL MicroFJ-60035-TSV P.D.E.
(Q.E. data courtesy of Electron Tubes, Inc.)

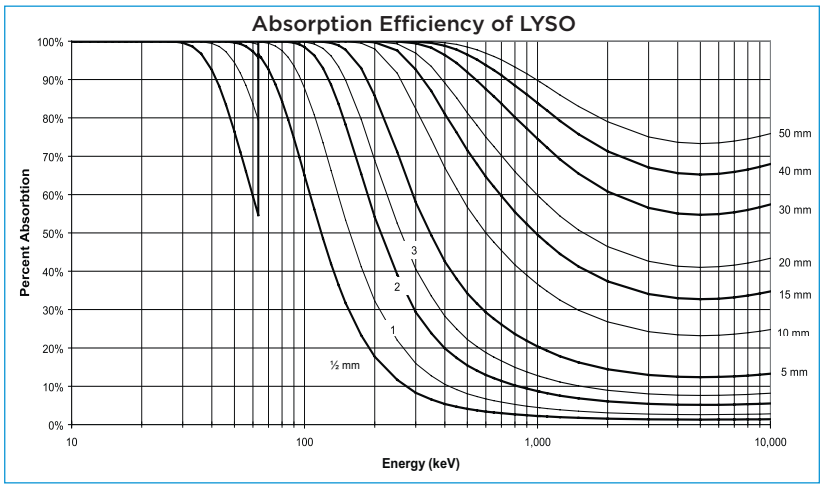

Figure 5 Gamma and X-ray absorption efficiency for various thicknesses of LYSO material.