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PreLude® 420

It's what's Inside that Counts!

Scintillation Material

PreLude™ 420 ($Lu_{1.8}Y_{.2}SiO_5$:Ce) is a Cerium doped lutetium based scintillation crystal that offers high density and a short decay time. It has an improved light output and energy resolution compared to BGO ($Bi_4Ge_3O_{12}$), which has a similar density. Applications that require higher throughput, better timing and better energy resolution will benefit from using PreLude 420 material.

PreLude 420 scintillator has shown up to three to four times the light emission of BGO. The measured energy resolution for 662 keV photons for a 30mm diameter x 15mm long crystal is 7.1% (see the energy spectrum below). A typical value for BGO is 12%.

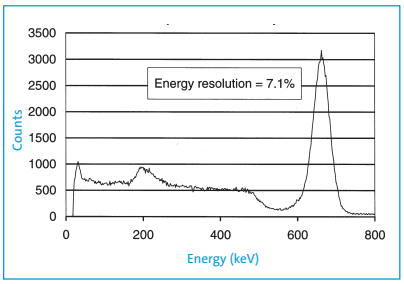

Figure 1. PreLude™ 420 Response to 662 keV Photons

The 1/e decay time of PreLude 420 crystal is 41ns, which is much shorter than the decay time of BGO. It is a single exponential with no long components present. This allows for higher rates, greater throughput and better timing.

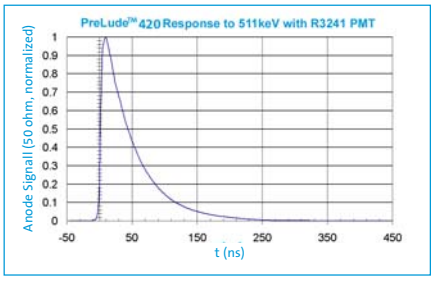

Figure 2. PreLude™ 420 response to 511 keV with R3241 PMT

The emission of scintillation light matches well with the sensitivity spectrum of most PMTs. The quantum efficiency (Q.E.) of a standard bialkali ETI 9266 PMT is 25% at the peak of the emission.

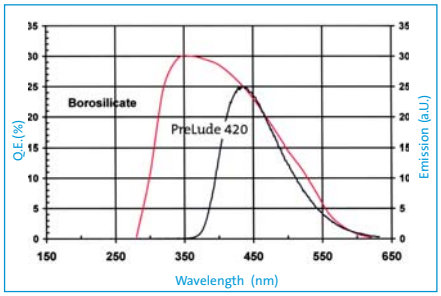

Figure 3. PreLude™ 420 Emission & ETI 9266 Q.E.
(Q.E. data courtesy of Electron Tubes, Inc.)

PET applications have traditionally used arrays of BGO. PreLude 420 crystal competes directly on density and surpasses BGO on energy resolution, timing and throughput.

The PreLude 420 material is a lutetium-based scintillator which contains a radioactive isotope ^{176}Lu, a naturally occurring beta emitter. ^{176}Lu beta decays to ^{176}Hf 99.66% of the time to the 597 keV excited state. This state decays with a 3 gamma ray cascade of 307, 202 and 88 keV. The 1" diameter by 1" long PreLude 420 crystal absorbs

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Properties –

Density [g/cm³]:	7.1
Hygroscopic	no
Attenuation length for 511keV (cm):	1.2
Wavelength of emission max.[nm]	420
Refractive index@emission max.	1.81
Decay time [ns]:	41
Energy resolution [%]:	8.0
Light yield [photons/keVγ]:	32
Average temperature coefficient from 25 to 50° C (%/°C):	-0.28
Photoelectron yield [% of NaI(Tl)] (for γ-rays)	75

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PreLude™420
Scintillation Material

nearly 100% of the beta particles. However, some of the photons escape leading to four sets of beta+gamma distributions. These four sets of beta distributions, based on which gamma rays are detected in coincidence, are identified in Figure 4. The total rate for this activity is 39 cps/g.

The light yield as a function of temperature was measured with ^{137}Cs excitation at 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. Results are shown in Figure 5.

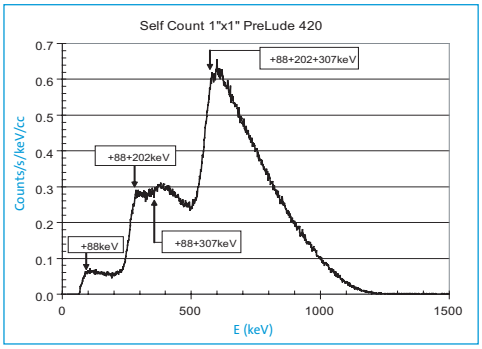


Figure 4. Beta distributions

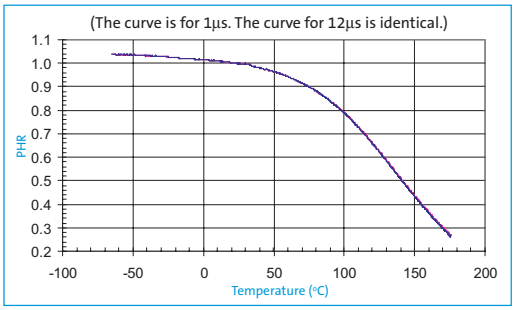
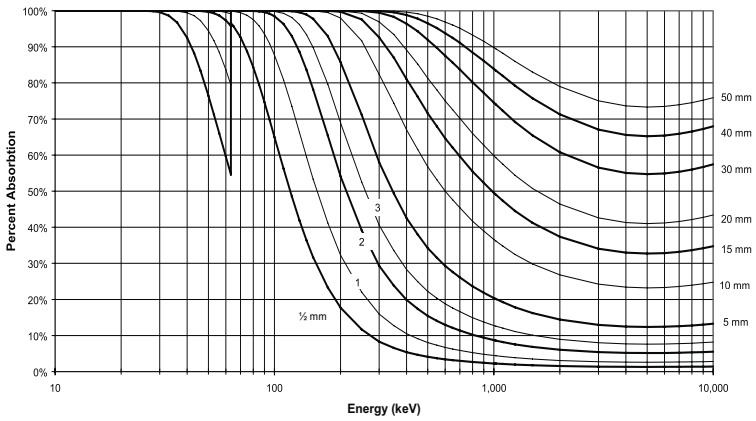


Figure 5. Temperature response



Absorption Efficiency of PreLude®420

Figure 6. Gamma and X-ray absorption efficiency for various thicknesses of PreLude 420 material. Data compiled by C. M. Rozsa (presented in Saint-Gobain Crystals brochure "Efficiency for Selected Scintillators.")

Table comparing principal properties of PreLude™420 versus BGO and LSO

Property	PreLude 420	BGO	LSO
Density [g/cm³]	7.1	7.1	7.4
Attenuation length for 511 keV (cm)	1.2	1.0	1.15
Decay time [ns]	41	300	40
Energy resolution	8.0	12.0	10.0
Light output, photons per keV	32	9	26
Average temperature coefficient 25 to 50°C (%/°C)	-0.28	-1.2	-1.3

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