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Imaging performance dependence on crystal absorption properties: the CRY018 and CRY019 comparison

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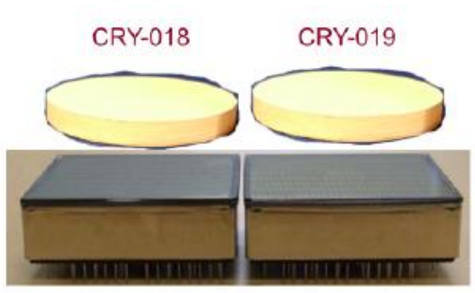
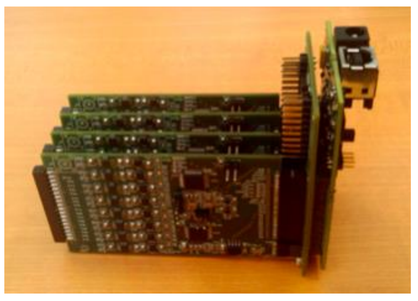
AIM

The **purpose** of this work is a quantitative comparison of two recently released scintillation crystals named CRY018 and CRY019, in terms of detected light distributions, position linearity, uniformity, energy and spatial resolution. They are non hygroscopic, have similar short decay time (45 ns), high light yield (28 kph/MeV leading to a good energy resolution) and low refraction index (1.8). CRY018 and CRY019 show similar responses, in terms of radiation absorption, to those of YSO and LYSO respectively.

MATERIALS

- **CRY018** and **CRY019**, released by Crytur Company, have been studied. They have a round shape (52.0±0.1 mm diameter and 6.25±0.05 mm thickness), both coated with a 0.2 mm TiO_2 white paint (full reflective treatment);
- Crystals are optically coupled to a Hamamatsu multi anode PMT (MA-PMT) series H10966A-100 with metal channel dynodes structure, a segmented anode pad of 8×8 array (6.05 mm pitch), a gain of $3 \cdot 10^5$, 60% first dynode efficiency and 35% of Q.E. @400 nm and an anodic gain variability 1:2.





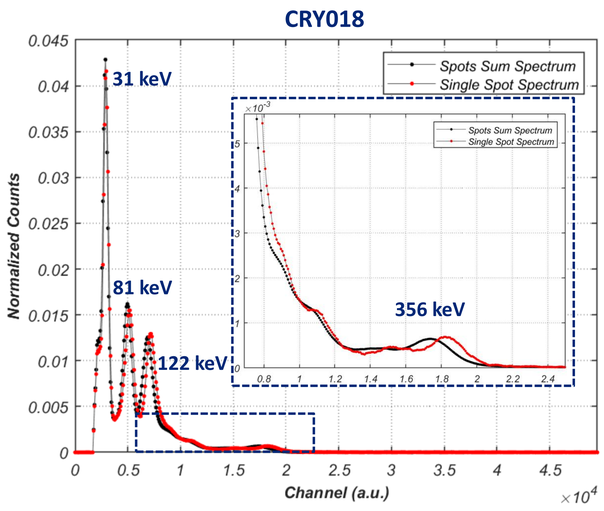
Detector overview and 64 independent channel electronics read out.

METHODS AND MEASUREMENTS

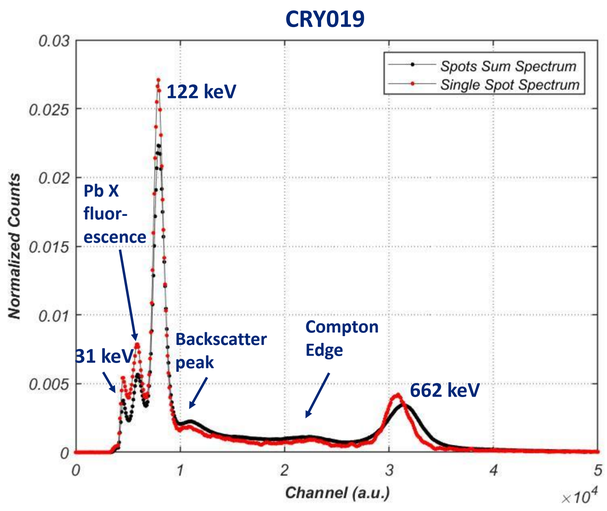
- 6mm-step scanning on crystals surface was performed with 2.5 mm ^{133}Ba and ^{57}Co collimated sources for CRY018 and 2.5 mm ^{57}Co and ^{137}Cs collimated sources for CRY019, in order to irradiate each anode center;
- 1.5mm-step scanning on both crystals along a maximum diameter with 1 mm ^{99m}Tc collimated source;
- 6mm-step scanning on CRY018 crystal surface was performed with 1 mm ^{241}Am collimated source;
- Pulse height uniformity response, ER, position linearity and SR were investigated;
- A new position method for image construction (RTP method) was used to correct strong position non linearities generated by the wider scintillation light distribution of full reflective coating:

$$X_{centroid} = \frac{\sum_j n_j' x_j}{\sum_j n_j'} \rightarrow n_j = \left(\sum_k n_{k,j}\right)^{\alpha} \quad \alpha = 1,2,3,\ldots$$

RESULTS



CRY018 ^{133}Ba and ^{57}Co Spots Sum Spectrum and a central Single Spot Spectrum.



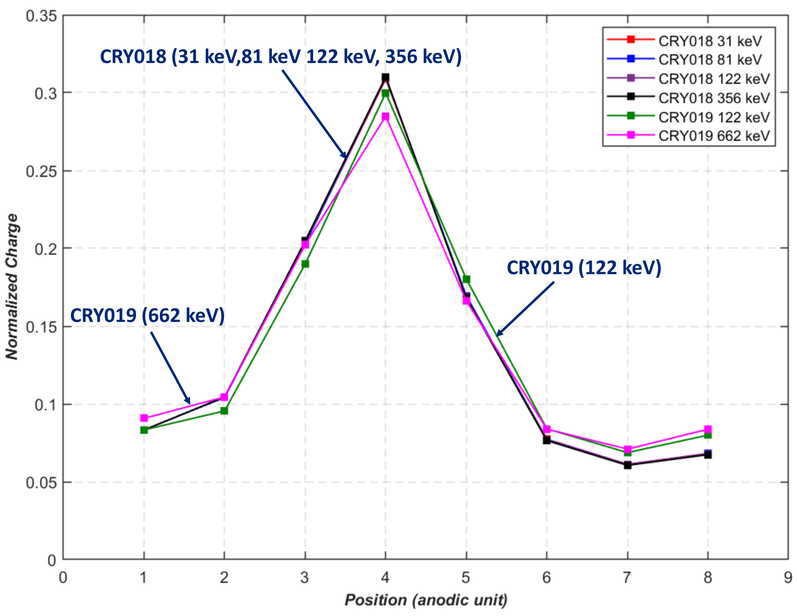
CRY019 ^{57}Co and ^{137}Cs Spots Sum Spectrum and a central Single Spot Spectrum.

Energy (keV)	PMT		Single Spot min		Single Spot max		64 Spots Sum		Anodic gain correction		Flood	
	CRY18	CRY19	CRY18	CRY19	CRY18	CRY19	CRY18	CRY19	CRY18	CRY19	CRY18	CRY19
31	13.0	23.0	24.3	/	37.6	/	27.8	/	/	/		
81	13.5	16.2	19.0	/	25.3	/	20.1	/	/	/		
122	12.7	15.3	15.9	20.7	17.5	23.7	17.3	22.5	16.5	21.5	17.1	21.0
356	8.5	10.07	8.0	/	12.4	/	12.0	/	/	/		
662	6.5	7.6	/	9.4	/	12.6	/	12.5	/	/	10.5*	15.1*

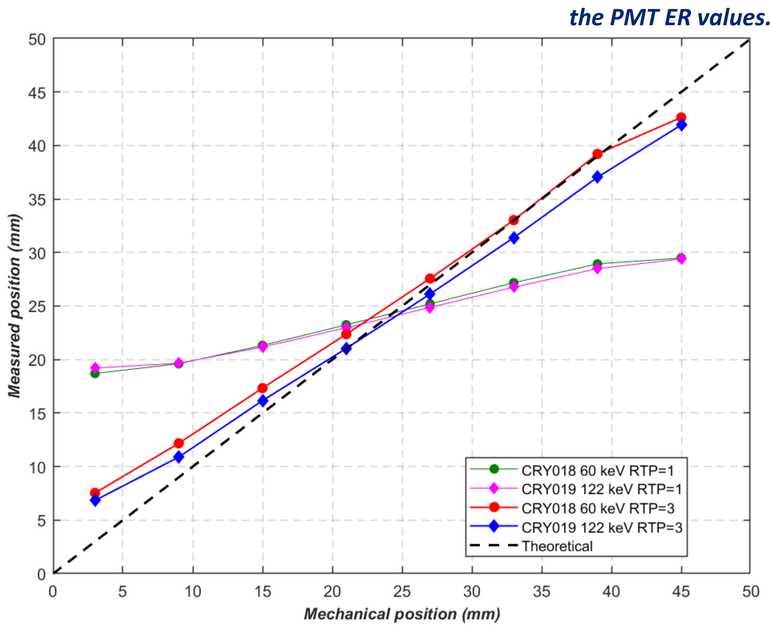
ER(%)=FWHM(%)

CRY018 and CRY019 ER values for Single Spot Spectrum, Spots Sum Spectrum with and without anodic gain correction and flood Spectrum obtained from MA-PMT compared with the PMT ER values.

*@551 keV



Scintillation light PSF Profile.



CRY018 and CRY019 position linearity for ^{241}Am and ^{57}Co respectively, evaluated with the standard Anger logic and corrected with the RTP method with α=3 compared with the theoretical curve.

1 mm COLLIMATED SOURCES

Energy (keV)	λ (mm)		totSR (mm)		iSR (mm)	
	CRY18	CRY19	CRY18	CRY19	CRY18	CRY19
60	1.0	0.63	2.30*	/	2.27÷1.87 *	/
140	7.7	1.6	1.87	2.25	1.79÷1.36	2.21÷1.81 *

**RTP α =3*

2.5 mm COLLIMATED SOURCES

Energy (keV)	λ (mm)		totSR (mm)		iSR (mm)	
	CRY18	CRY19	CRY18	CRY19	CRY18	CRY19
31	0.17	0.11	4.09*	/	3.49÷2.98 *	/
81	2.3	0.40	2.81	/	1.67÷0.75	/
122	5.9	1.1	2.49	2.70*	<1.5	<2.2*
356	22	9.5	2.62	/	<1.5	/
662	30	17	/	3.00	/	2.26÷1.99

**RTP α =3*

CRY018 and CRY019 totRS and iRS values evaluated from the scanning with 1 mm and 2.5 mm collimated sources using the RTP method (α=2) compared with their attenuation length .

CONCLUSIONS

- All ER values measured by MA-PMT are worse than the ones by standard PMT. ER values from flood irradiation are worsen in agreement with the MA-PMT anodic gain standard deviation of 3%.
- Thanks to crystals coating and optical treatment, the pulse height uniformity response is close within 6%. It allows the selection of a reasonable narrow energy window without any look-up-table gain correction.
- Mean scintillation light PSF profile seams mainly dependent on crystals coating, optical treatment and size.
- All iSR values are dependent on attenuation length and are confined within 2mm after RTP position linearity correction.

REFERENCES

[1] R. Pani et al 2016 JINST 11 P09010
[2] C. Polito et al 2017 JINST 12 C01055
[3] C. Polito et al 2017 JINST 12 C02034
[4] http://www.crytur.cz/materials/
[5] Hamamatsu, H10966A 64ch multianode PMT assembly webpage, http://www.hamamatsu.com/eu/en/product/alpha/P/3002/H10966A/index.html
[6] A. Fabbri et al., FPGA based readout electronics for multi anode PSPMT, IEEE Nucl. Sci. Symp. Conf. Rec. (2009) 357