Large CLYC:Ce and CLLB:Ce crystals for gamma-neutron detection systems

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Context and applications

Key problems to solve :

Bubbles, inclusions and cracks are known growth issues
Although CLYC and CLLB are cubic, they do not melt congruently. This can form unwanted material phases in the grown crystal.

Our goals :

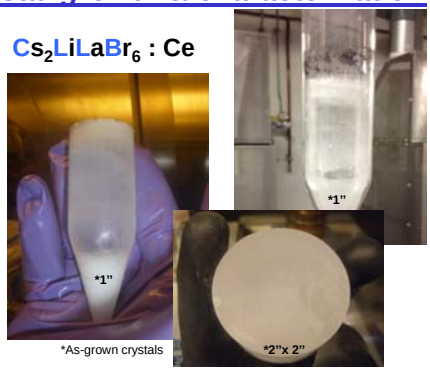
1. Develop growth methods to produce uncracked crystals free of bubbles and inclusions.
2. Improve scintillation performance with improved quality
3. Create a scalable growth method capable of producing high quality crystals with 3" diameter and larger
4. Improve energy resolution and pulse shape discrimination through adjustment of dopants

Applications :

- Dual γ/n handheld scanners for security
- Baggage and cargo screening
- Oil well logging (CLLB only)

Crystal growth & characterization

$Cs_2LiLaBr_6$: Ce



*As-grown crystals

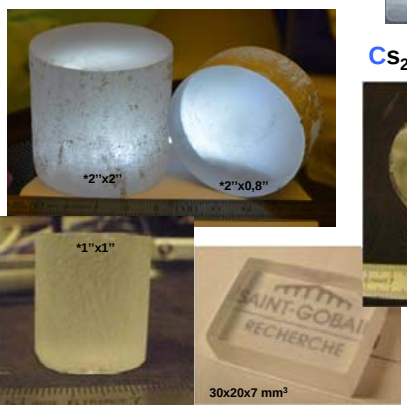
Problems solved:

solutions to non-congruent melting have been developed

Crystals are crack free & bubble free
High transparency with no inclusion

Bridgman Growth (cubic matrix)

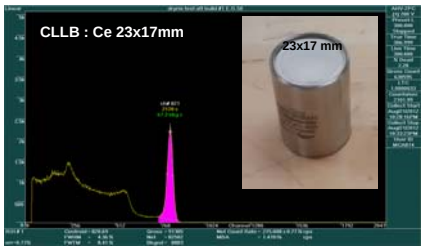
1" process complete
2" process reliable
Scaling to 3" process (currently at 65mm)

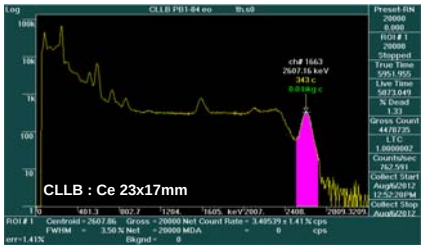


Cs_2LiYCl_6 : Ce

*As-grown crystals

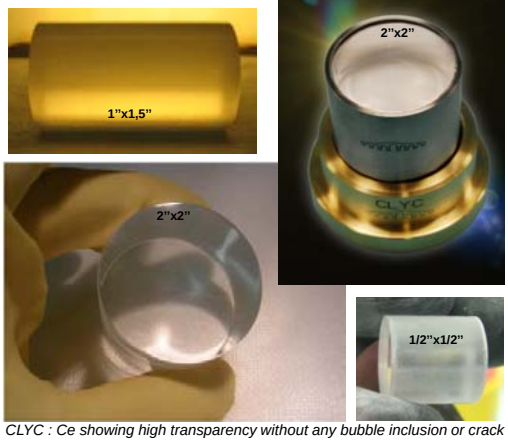
Detectors & performances





CLLB : Ce pulse height spectra @662keV (top) and 2.6MeV (bottom)

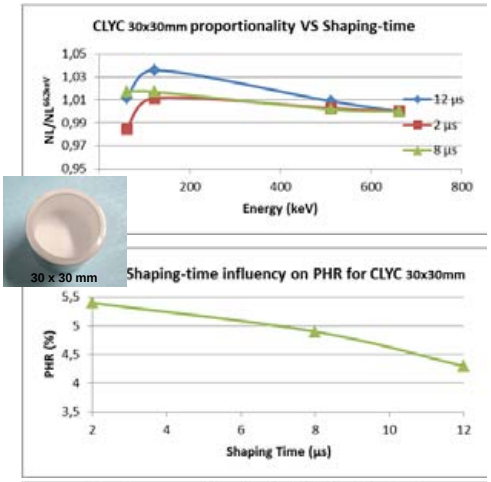
CLYC detectors

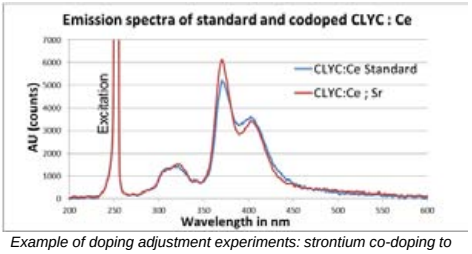


CLYC : Ce showing high transparency without any bubble inclusion or crack

Matrix	Dimensions (mm)	Shaping time (µs)	Energy Resolution (% @662keV)
CLYC	41 x 39	4	5,15
	30 x 30	8	4,9
		12	4,3
	25 x 38	8	4,58
	25 x 25	8	4,45
	13 x 13	8	4,39
CLLB	*23 x 17 *Secondary phase inside.	4	4,37
		8	3,5 @ 2,6MeV
	25 x 12	4	4,09

Tab: No significant systematic degradation between small and larger crystals





Example of doping adjustment experiments: strontium co-doping to improve growth and scintillation properties

References :

[1] C. M. Combes, P. Dorenbos, C. W. E. van Eijk, K. Krämer, and H., U. Güdel, J. Lumin., vol. 82, pp. W. 299–305, 1999

[2] Saint-Gobain Patent Appl: WO2013041251

[3] US Patent: US7525100B2

Conclusions

CLYC : Ce

Saint-Gobain **successfully developed 2" CLYC** with improved scintillation parameters and Pulse shape discrimination
Same process **can be scaled to larger diameter** such as 3"

CLLB : Ce

Good scintillation properties (approaching $LaBr_3$:Ce) and capabilities for neutron detection
process for growing high quality 2" diameter crystals is mature
same process can be scaled to larger diameters such as 3"
we are improving PSD properties (approaching CLYC) with Ce doping *(see SG Crystals poster: K.Yang & all.)*

Perspectives

2" Crystals are capable of being industrialized
Methods to improve the scintillation and PSD properties are being investigated through changes in doping

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