

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

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## Context and applications

### Key problems to solve :

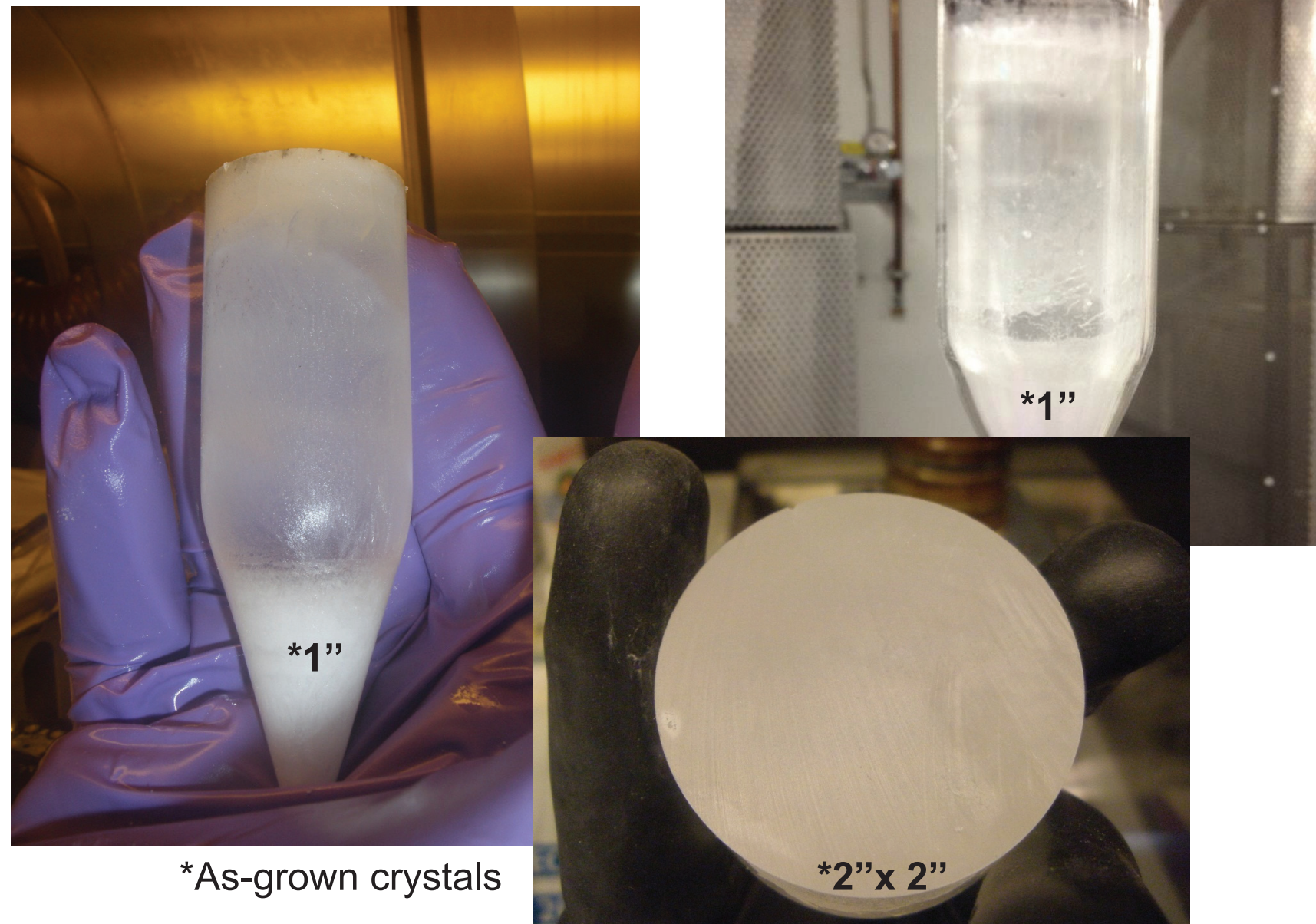
Bubbles, inclusions and cracks are known growth issues. Although CLYC and CLLB are cubic, they do not melt congruently. This can form unwanted material phases in the grown crystal.

### 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

## Crystal growth & characterization

### Cs<sub>2</sub>LiLaBr<sub>6</sub> : Ce



### 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)

### Applications :

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



### Oil well logging

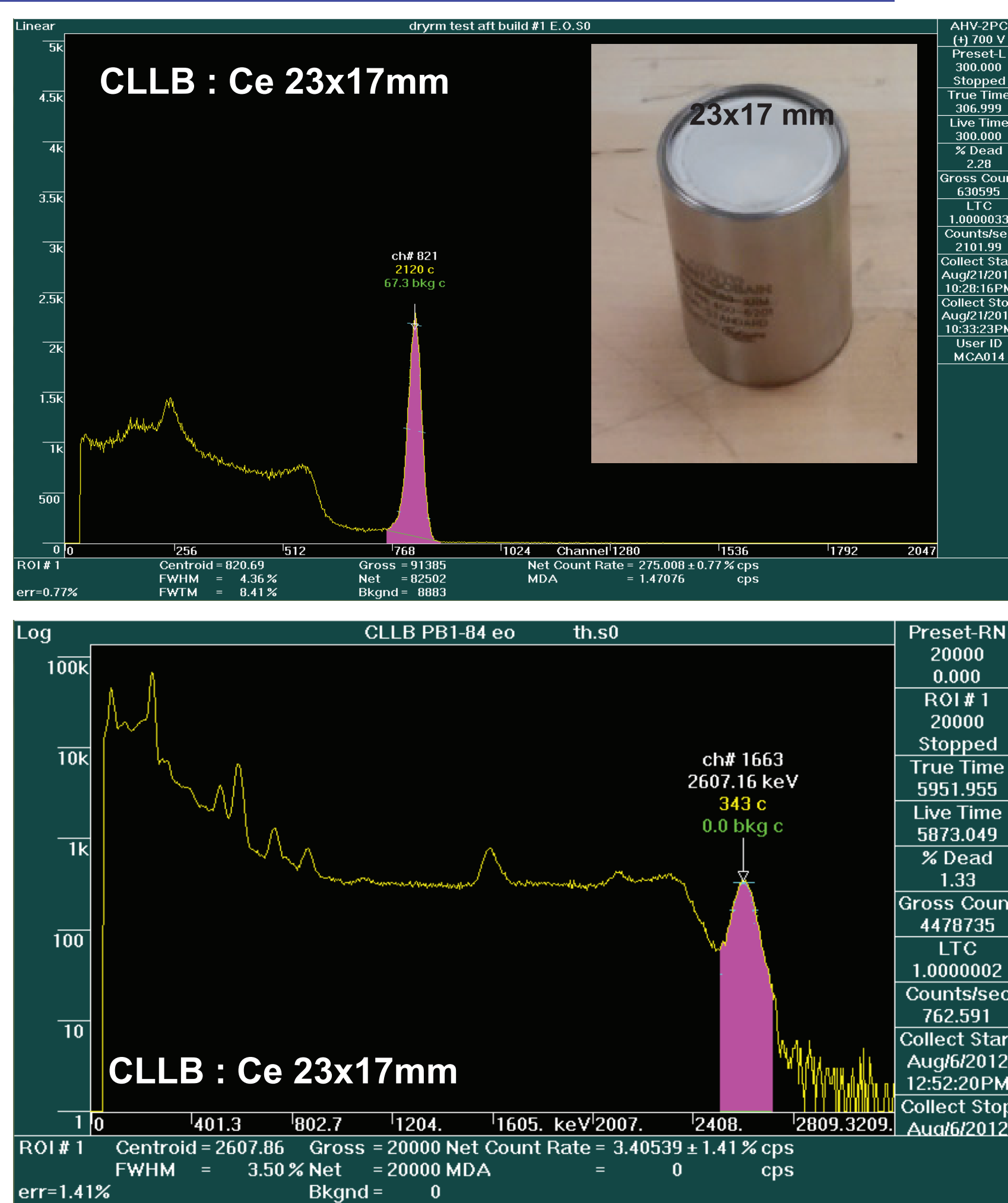


### Cs<sub>2</sub>LiYCl<sub>6</sub> : Ce



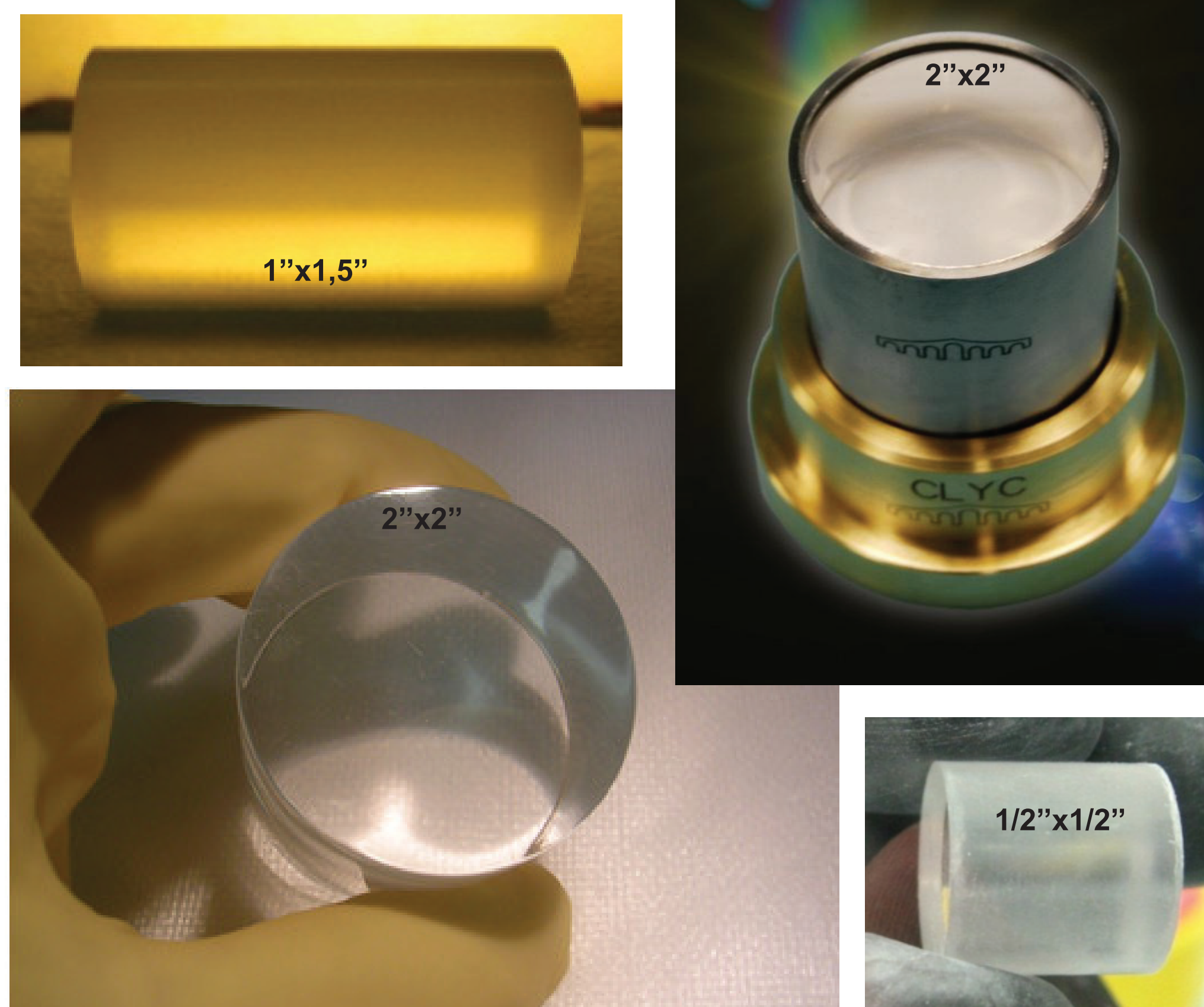
\*As-grown crystals

## Detectors & performances

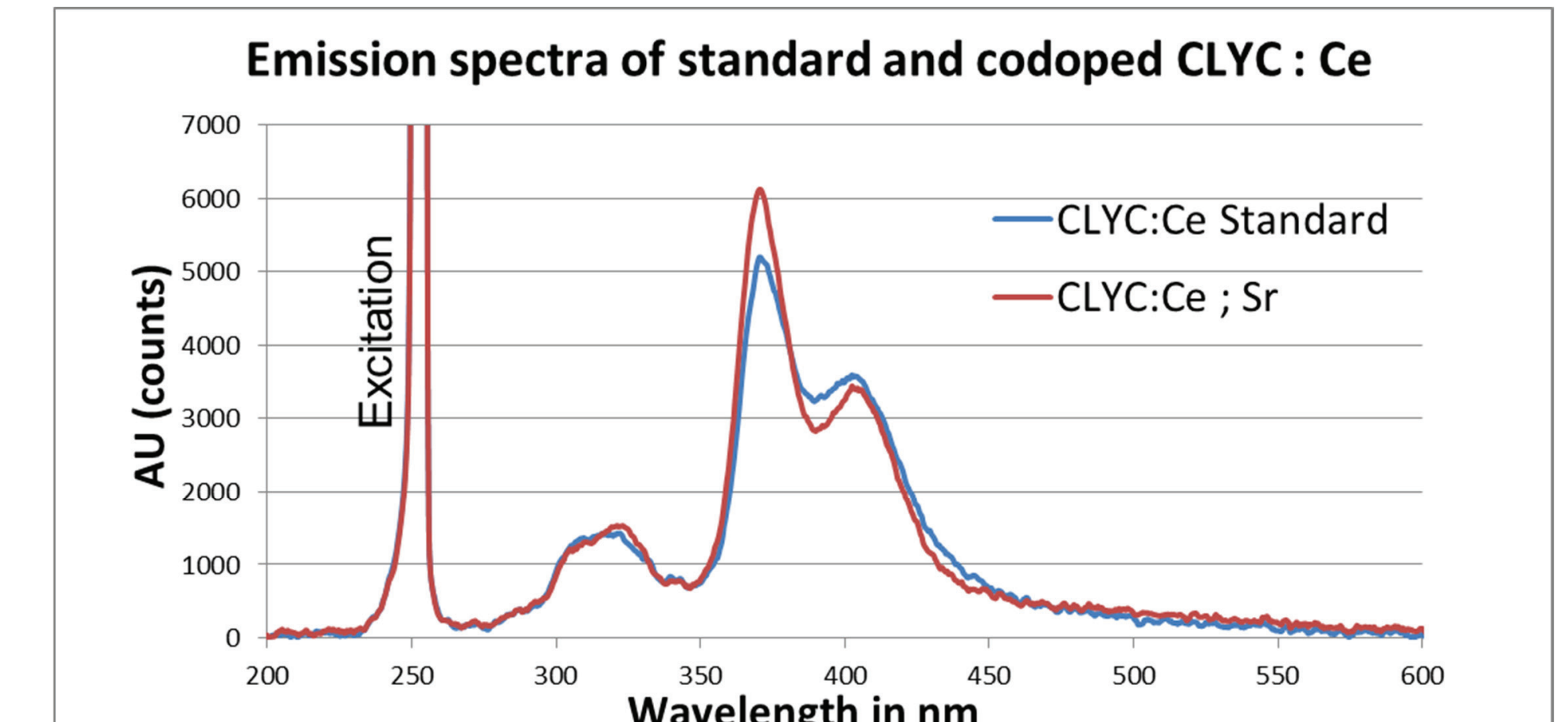
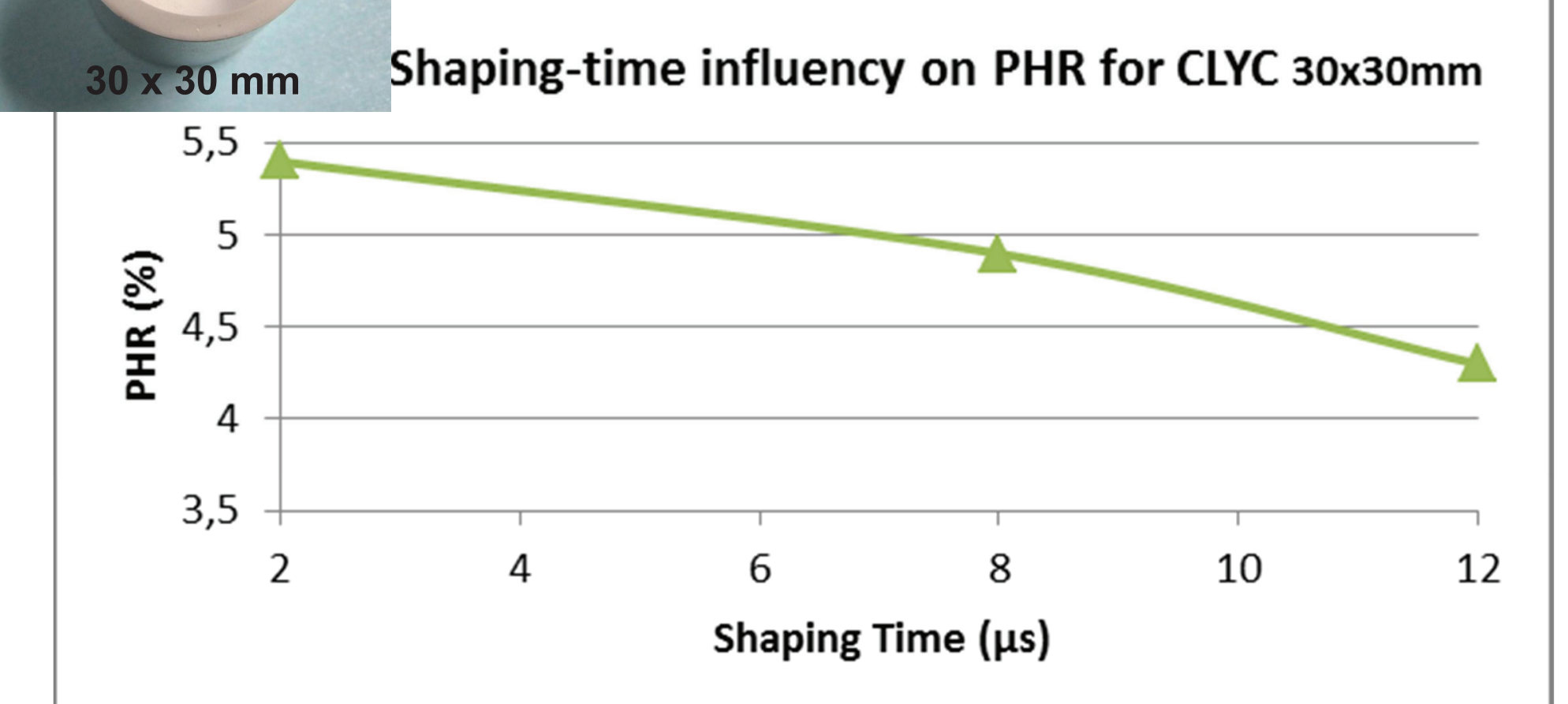
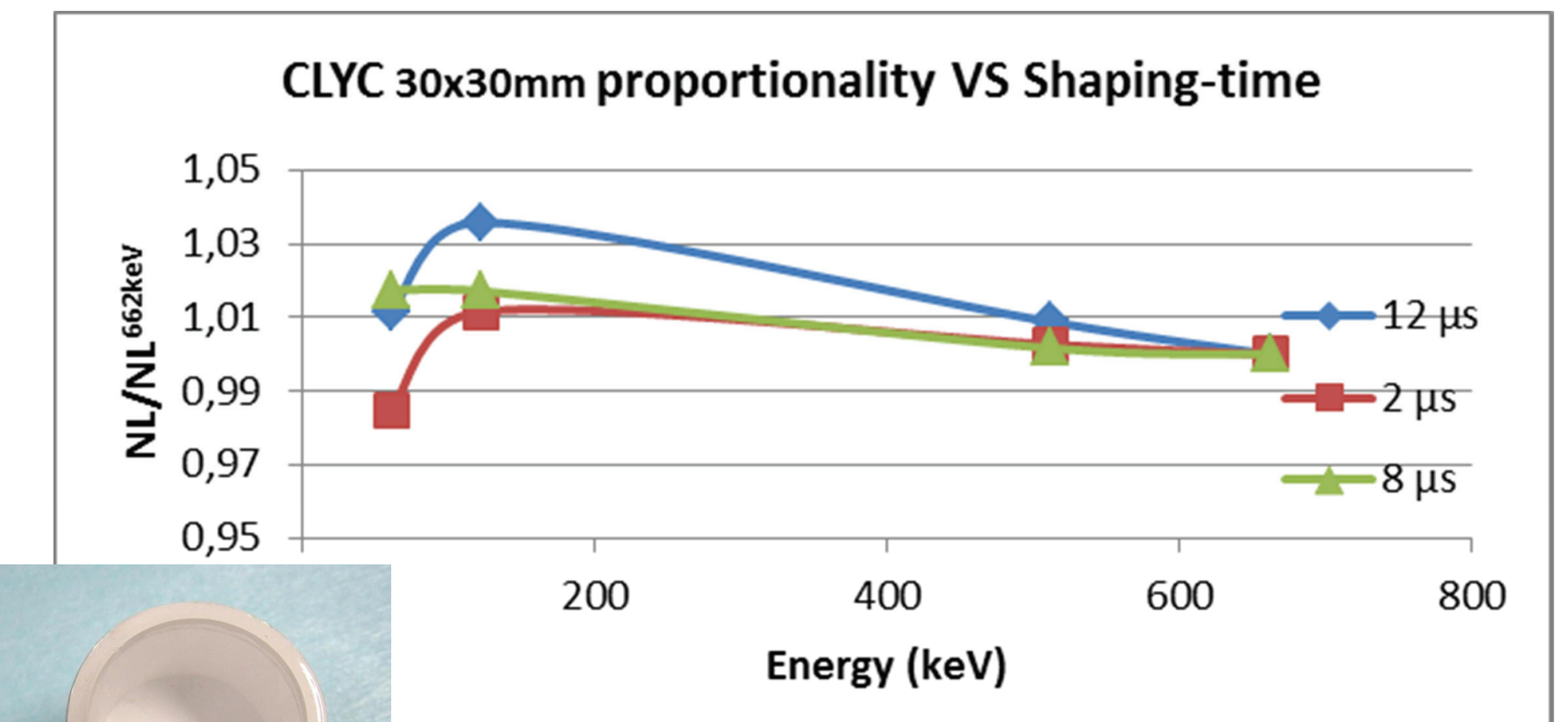


CLLB : Ce pulse height spectra @662keV (top) and 2.6MeV (bottom)

### CLYC detectors



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



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. W. Krämer, and H. U. Güdel, J. Lumin., vol. 82, pp. 299–305, 1999
- [2] Saint-Gobain Patent Appl: WO2013041251
- [3] US Patent: US7525100B2

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
CLLB	13 x 13	8	4,39
	*23 x 17	4	4,37
	*Secondary phase inside.	8	3,5 @ 2,6MeV
	25 x 12	4	4,09

Tab: No significant systematic degradation between small and larger crystals

## 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<sub>3</sub>: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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