Quality of 28 cm Long LYSO Crystal and Progress on Optical Properties

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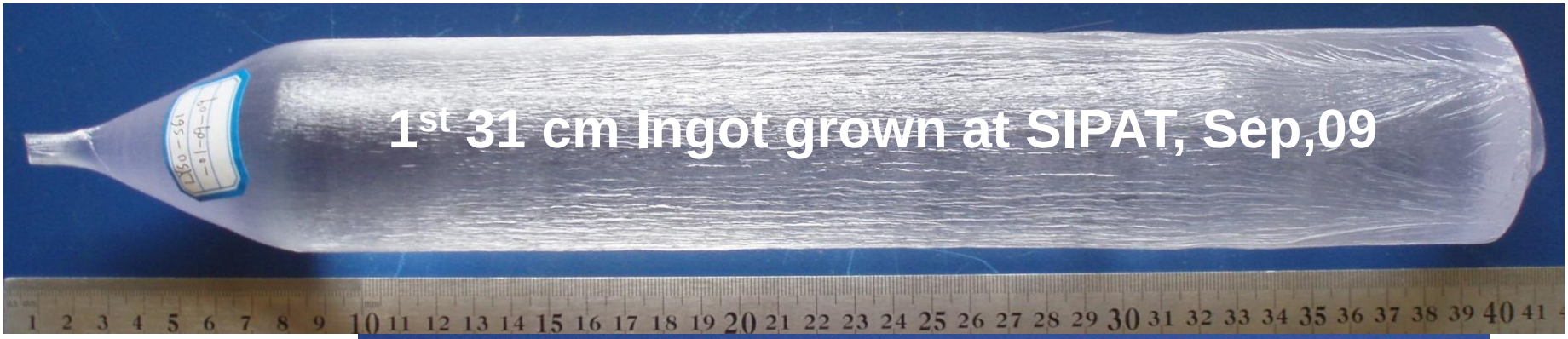
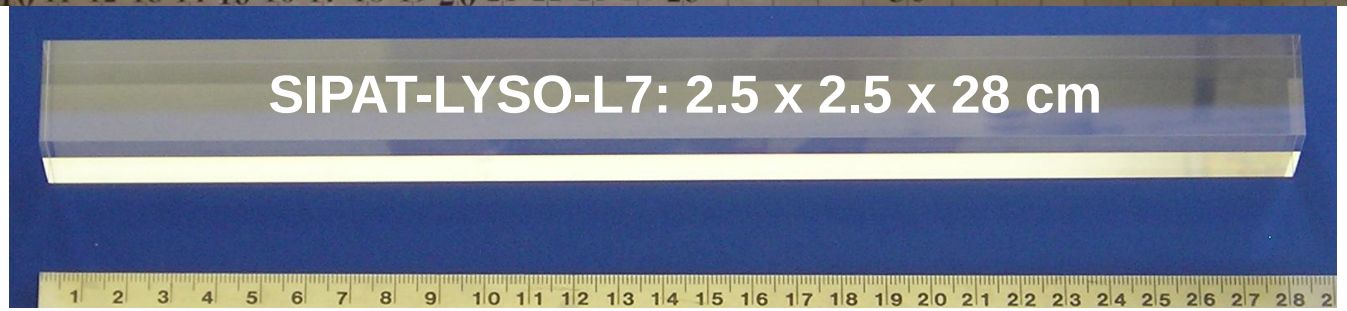
Samples

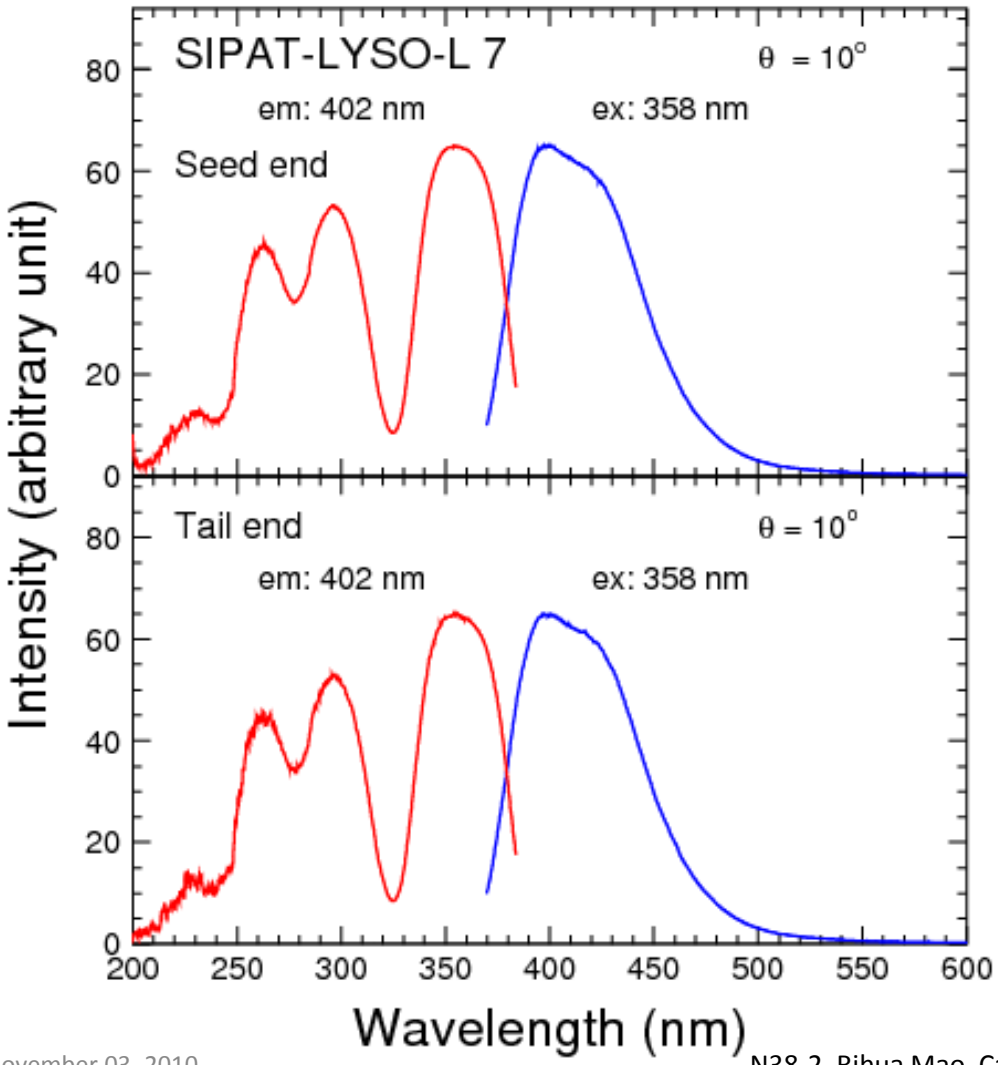


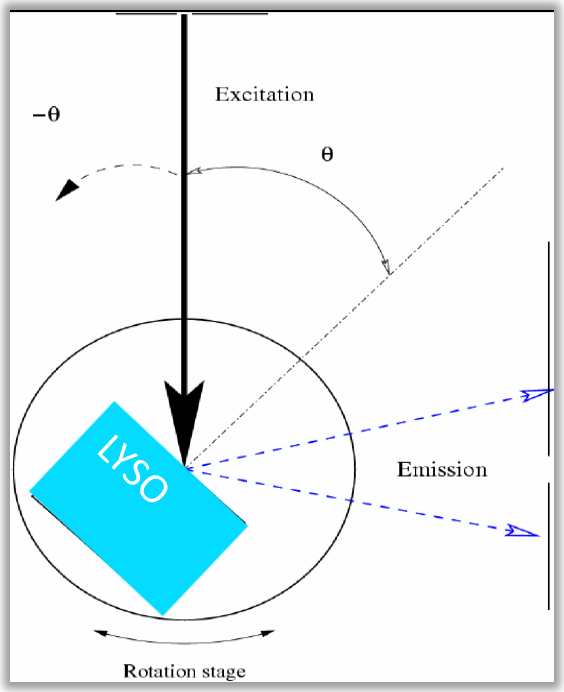


- A large size ingot of Φ60 x 310 mm was grown at SIPAT in 2009 and a 2.5 x 2.5 x 28 cm LYSO sample was obtained.
- Photo-luminescence, transmission, light output and light response uniformity (LRU) were evaluated.
- Radiation hardness against ^{137}Cs γ-rays up to 1 Mrad @ 7.5k rad/h were measured.
- Progress on optical transmittance for large size LYSO will be addressed

Scintillation Emission

Consistent Photo-luminescence





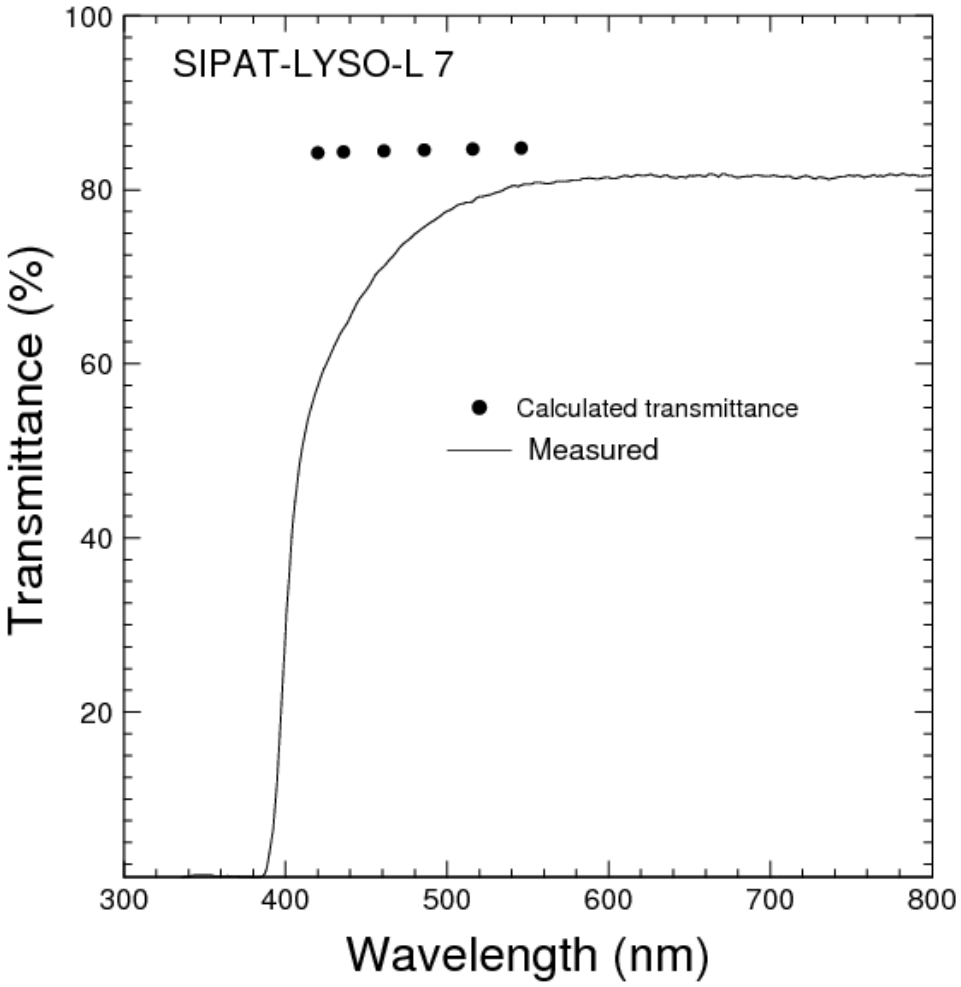
Hitachi F-4500 fluorescence spectrophotometer.

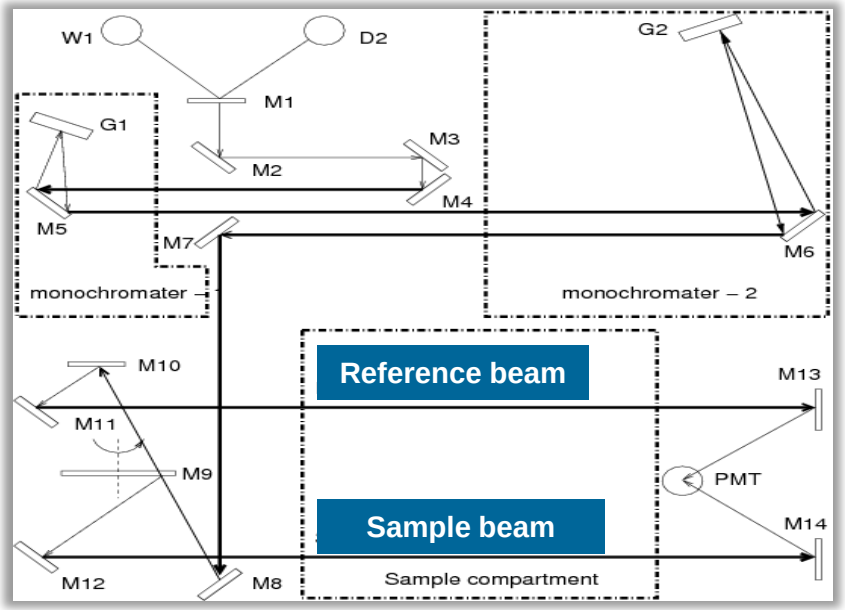
Θ set to be 10° to avoid internal absorption.

For details see: *IEEE TNS Vol.55 No.4 (2008) p 2425.*

Optical Transmittance

Poor longitudinal transmittance observed between 400 and 600 nm



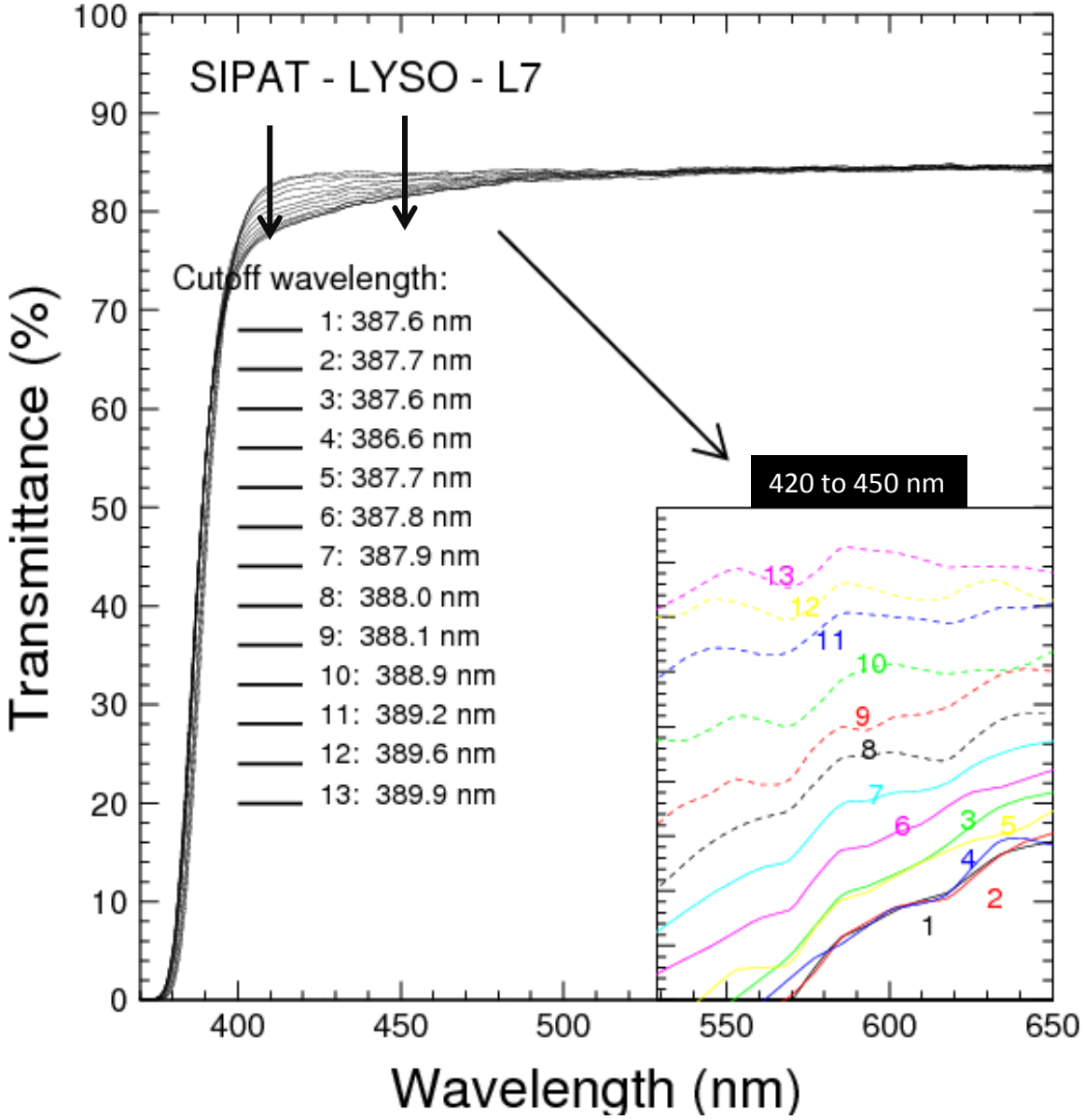


Perkin Elmer Lambda-950 spectrophotometer with double beam, double monochromator and GPOB for large samples.

Transverse Transmittance

Transverse transmittance measured every 2 cm

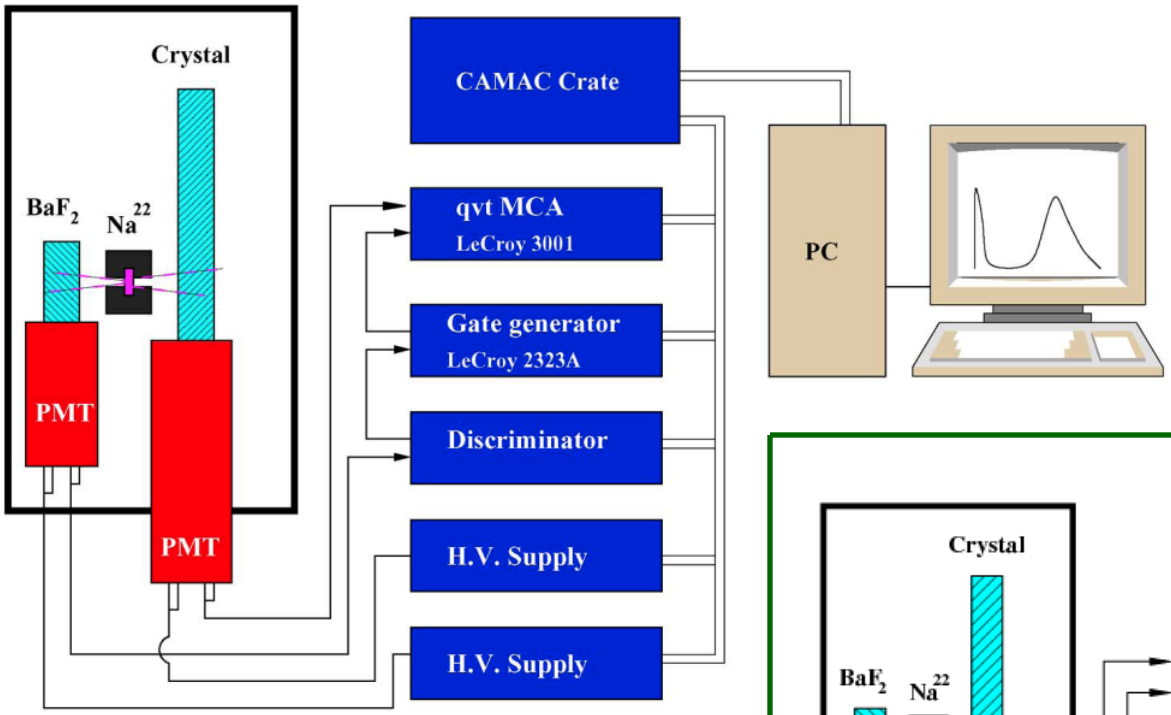
Transverse Transmittance



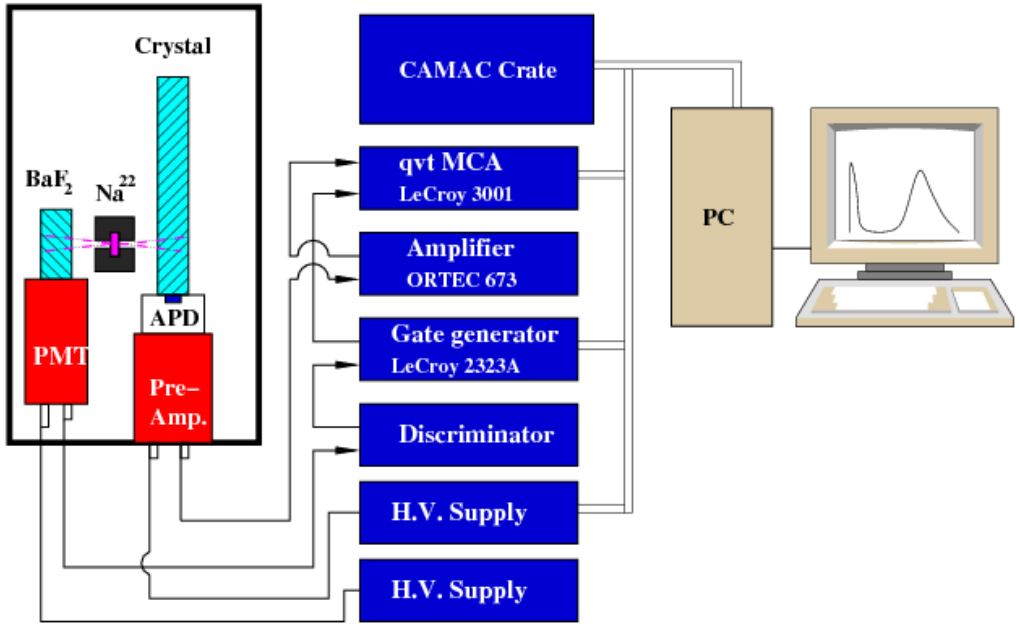
Poor transverse transmittance observed at the seed end of the crystal sample.

Is it caused by absorption or scattering?

Setup for L.O. Measurement

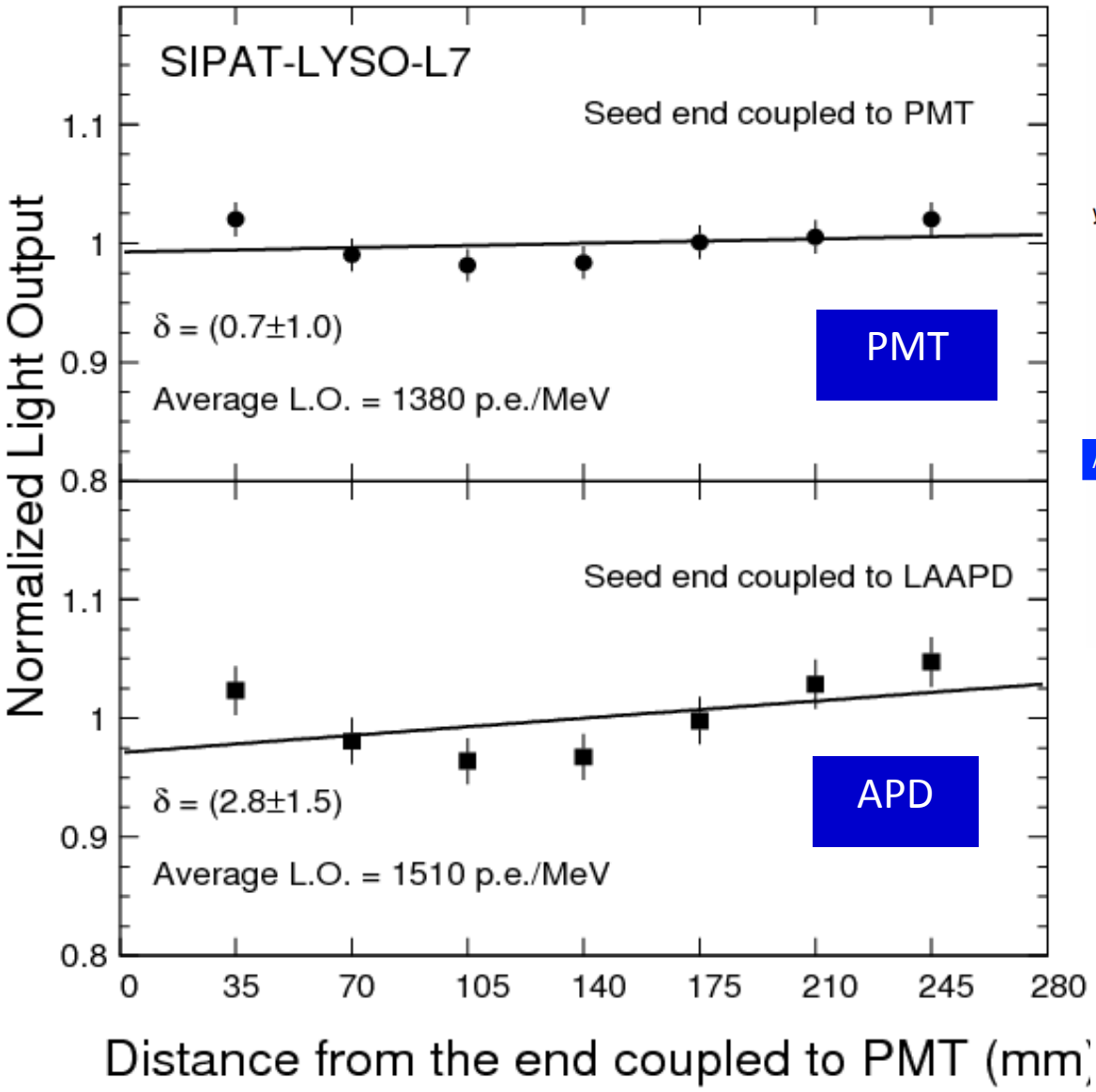


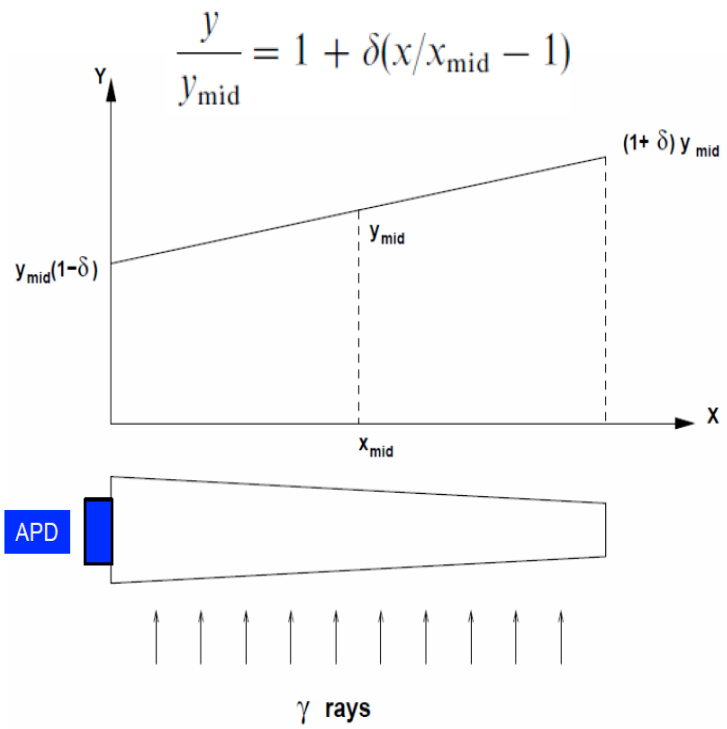
Na^{22} source and BaF_2 provided coincidence trigger to reduce intrinsic natural radioactivity in LYSO.



IEEE TNS, VOL. 54, NO. 3, JUNE 2007 P718.

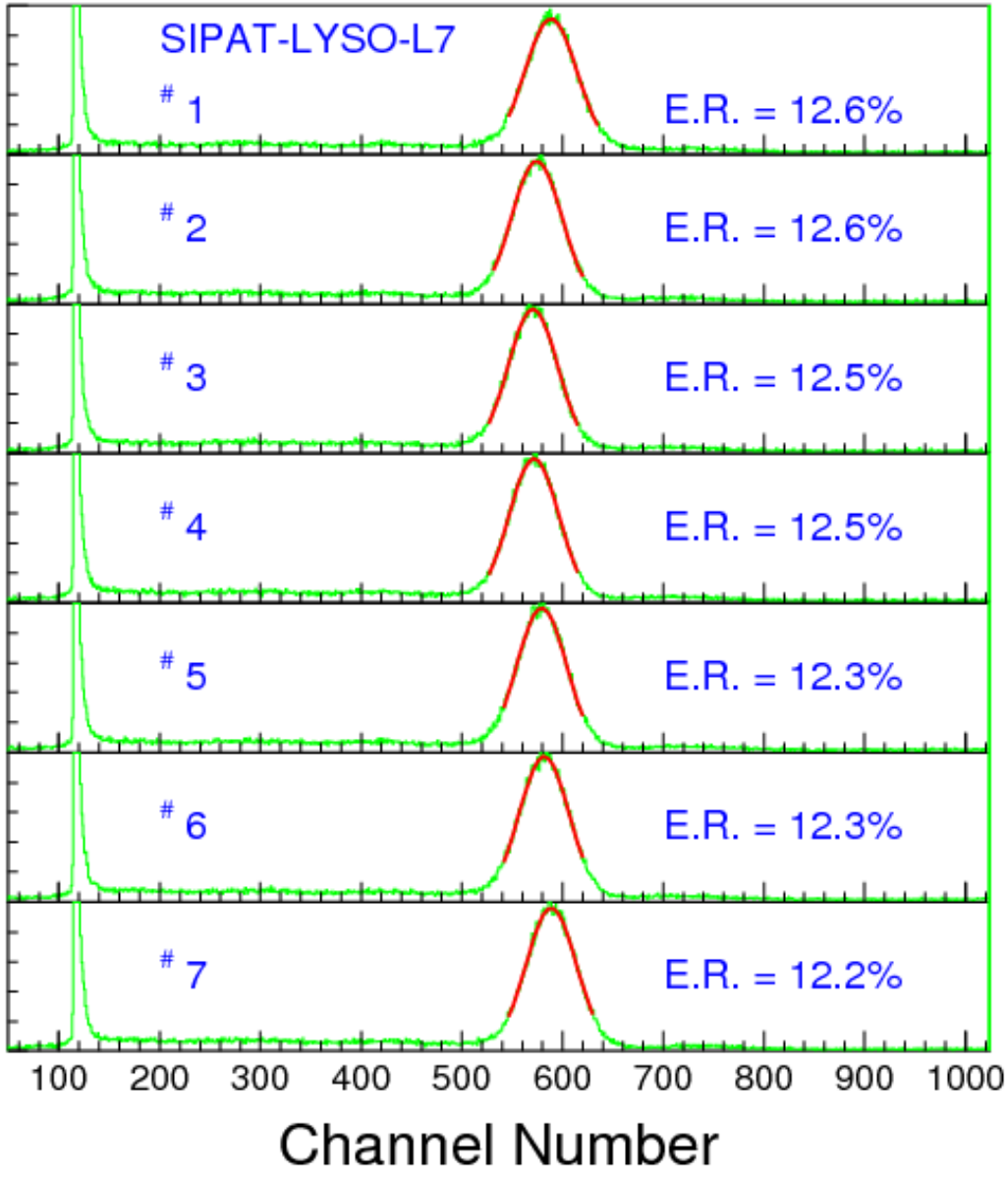
L.O. & Response Uniformity





Light response uniformity at a few percents observed for both PMT and APD readouts.

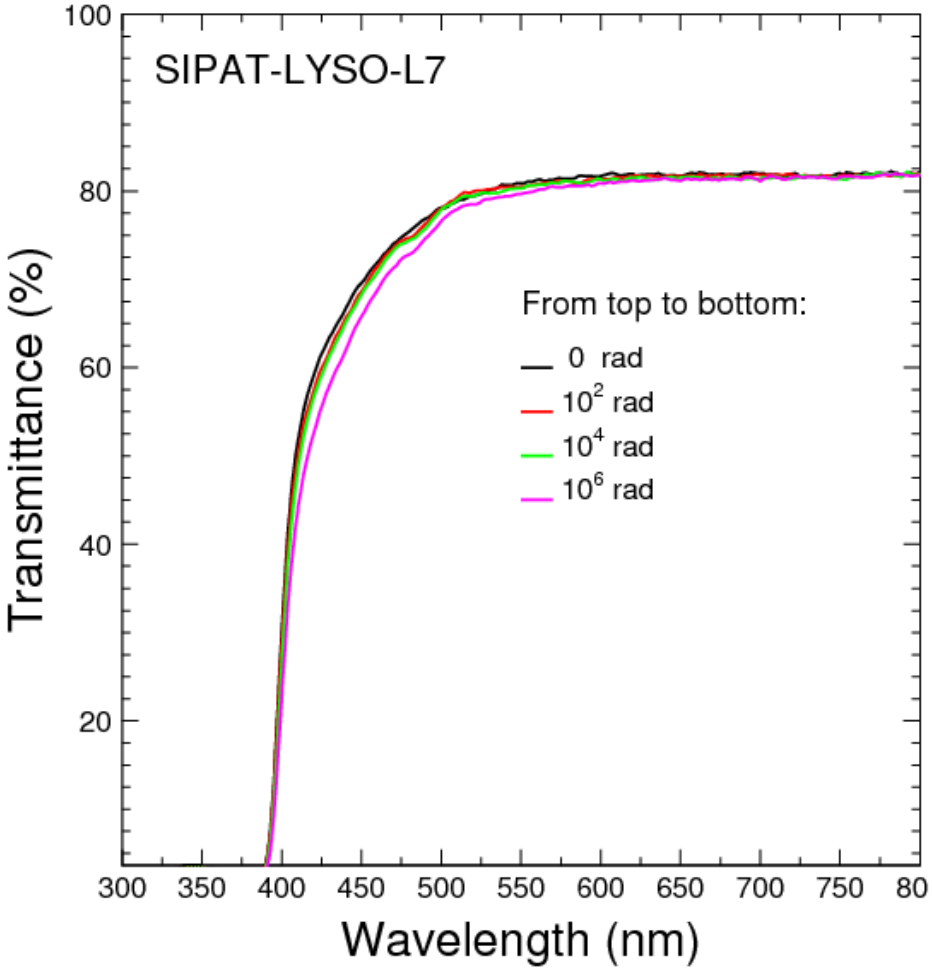
Energy Resolution for 0.511 MeV γ-rays



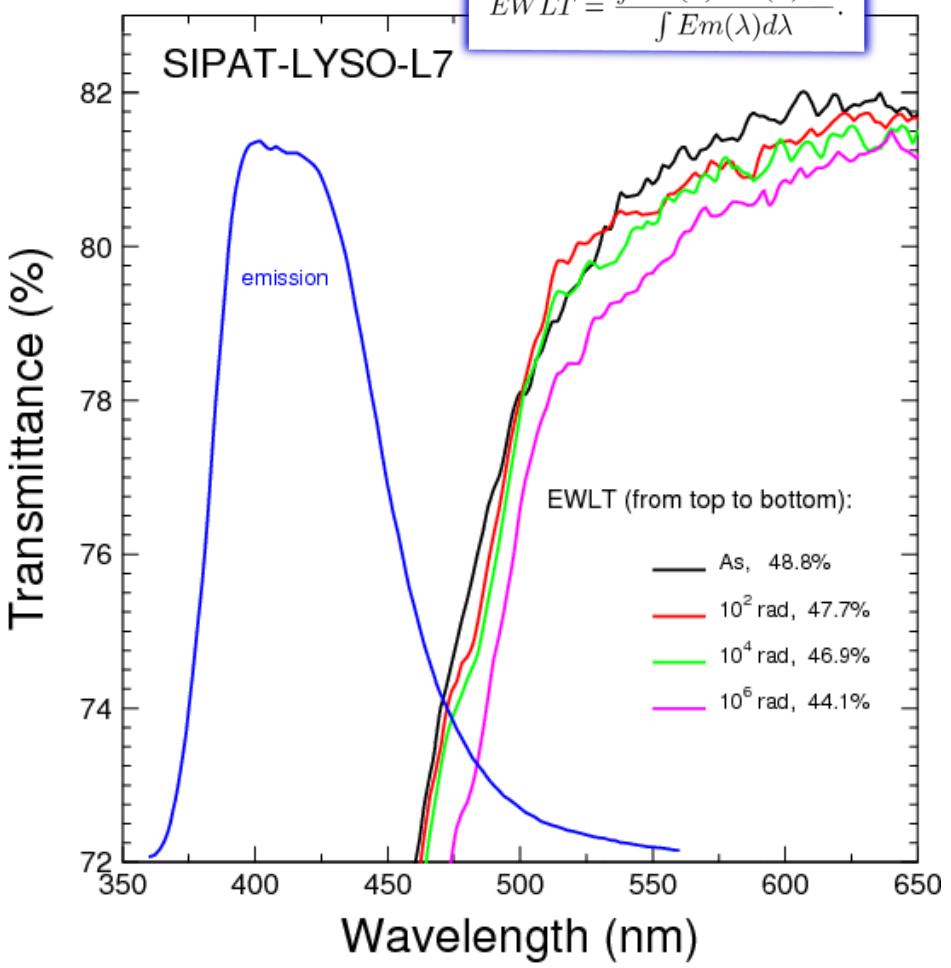
Corresponding FWHM energy resolution at seven points along the crystal was measured by using an R1306 PMT to be 12.4% in average.

γ-Ray Induced Damage in LT & EWLT

^{137}Cs γ-rays up to 1 Mrad @ 7.5k rad/h: 9.6%

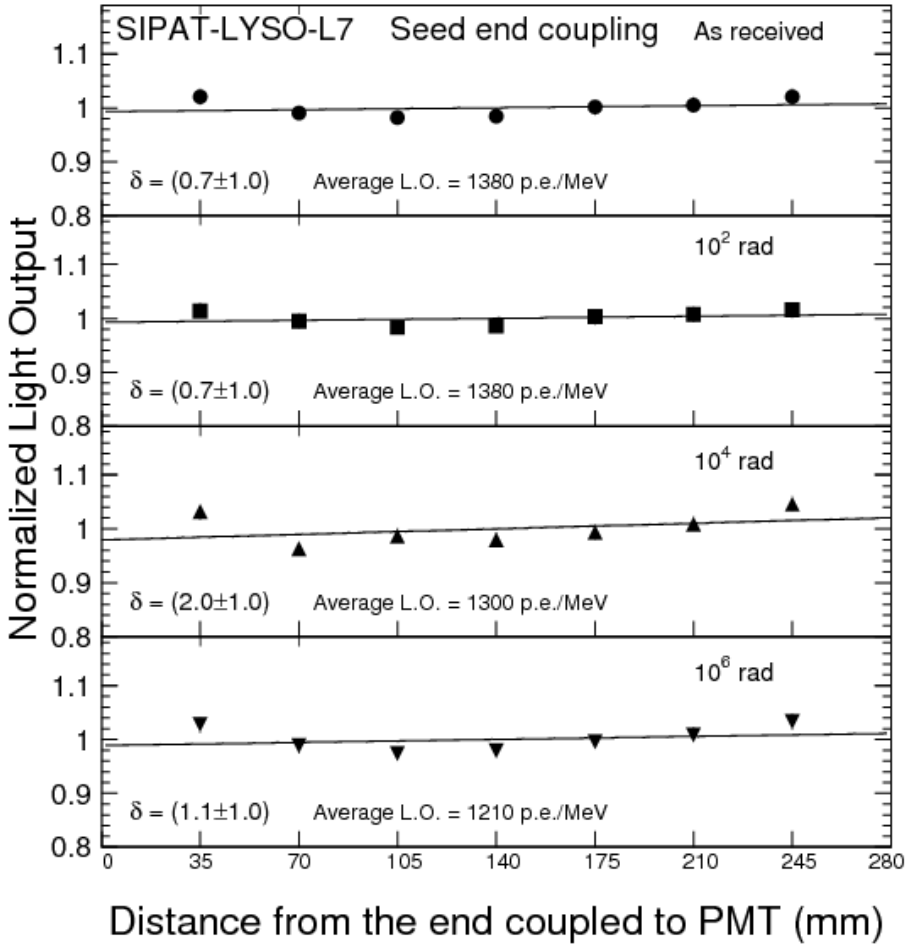


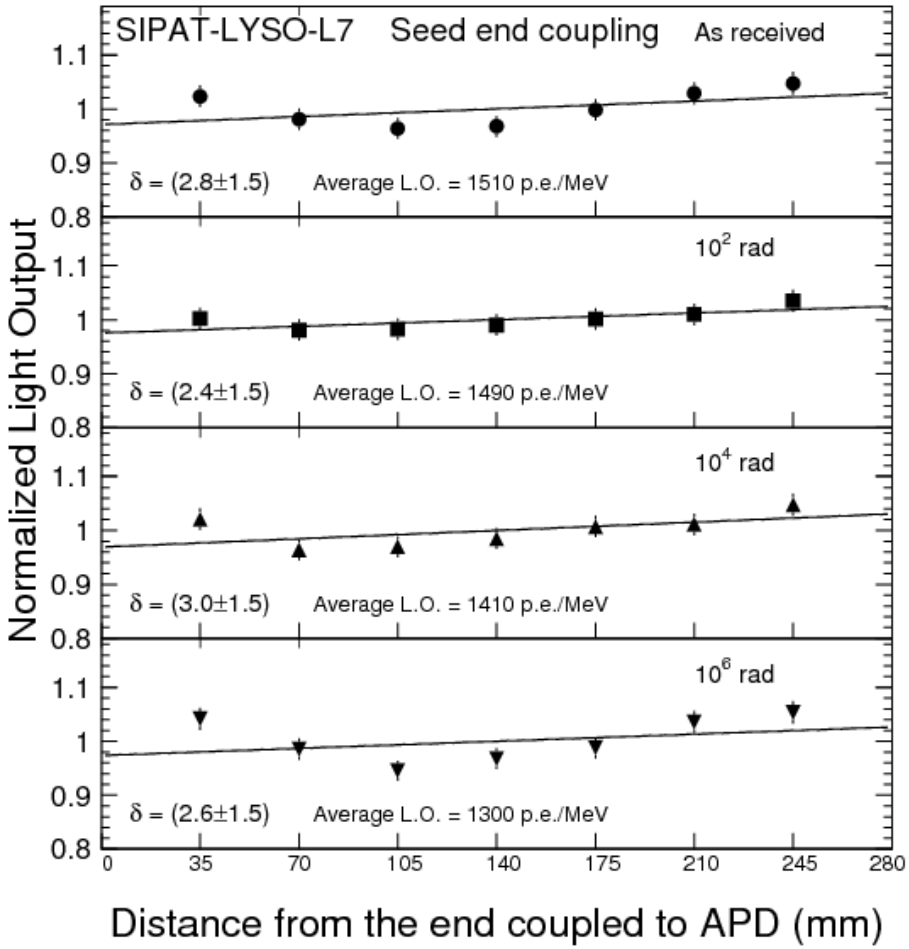
$$EWLT = \frac{\int LT(\lambda)Em(\lambda)d\lambda}{\int Em(\lambda)d\lambda}.$$



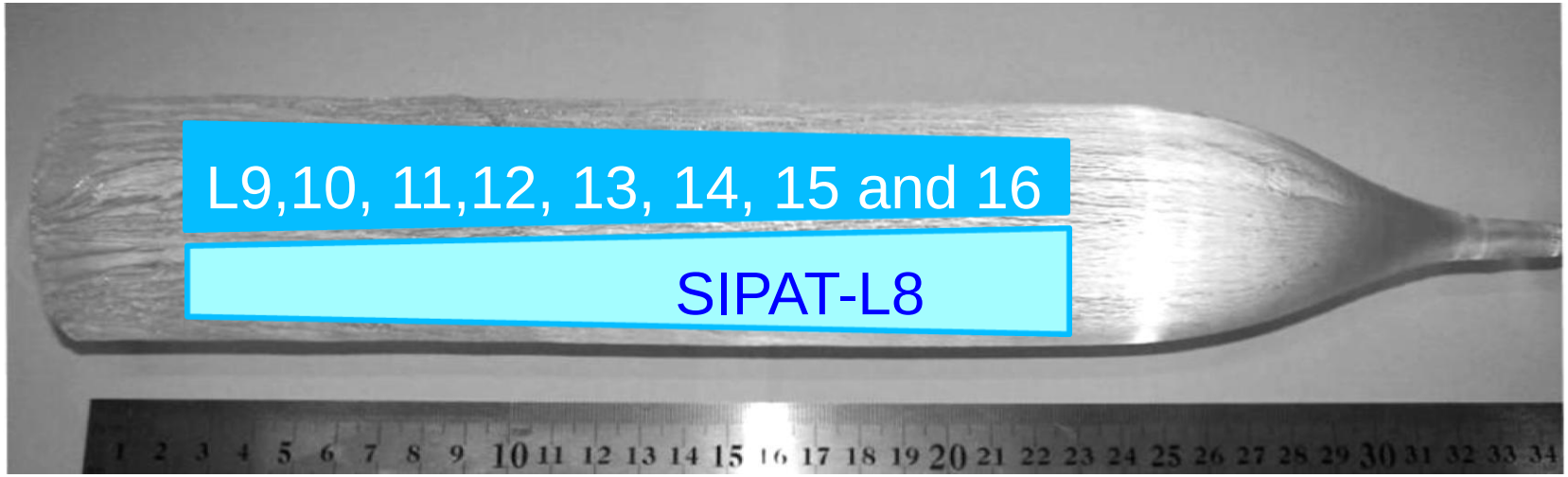
Damage in L.O. and Uniformity

^{137}Cs γ-rays up to 1 Mrad @ 7.5k rad/h: 12 ~14%
Light response uniformity is maintained





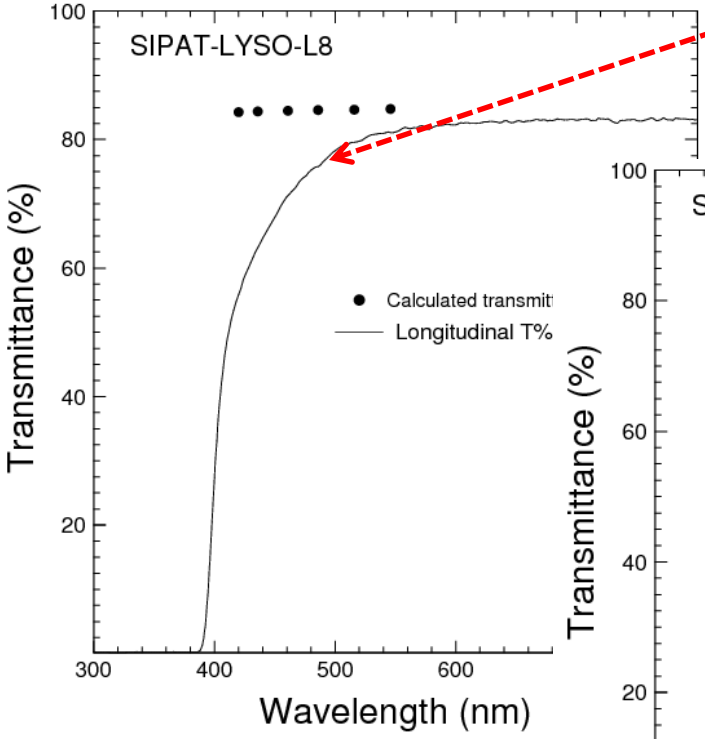
LYSO Batch: SIPAT-L8 to L16

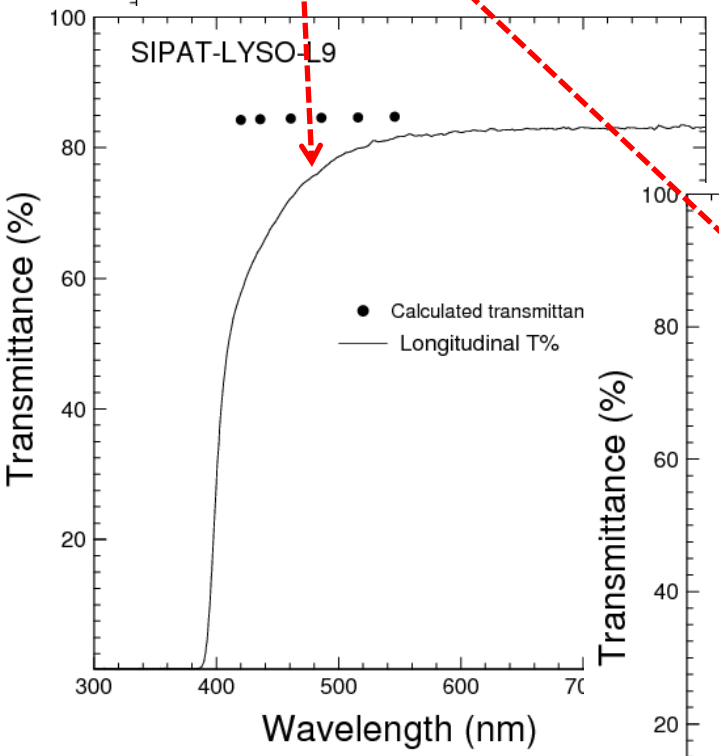


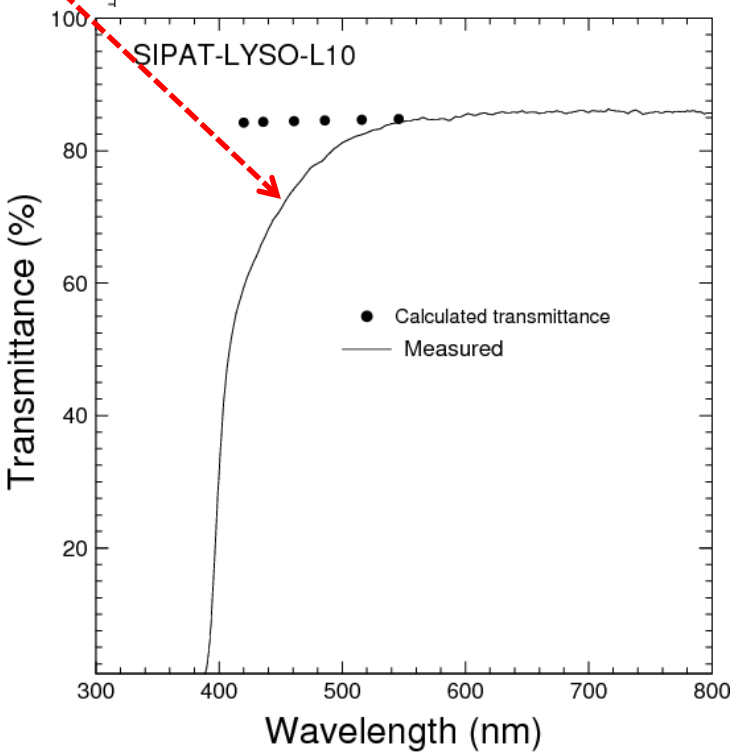
Sipat's Φ60 x 250 mm ingots are cut to two crystals for the SuperB beam test matrix. While crystals L11 to L16 are accepted, crystals L8, L9 & L10 were rejected because of poor optical transmittance.

LT of SIPAT-L8, L9 & L10 (20 cm)

Poor longitudinal transmittance, similar to SIPAT-L7 (28 cm)

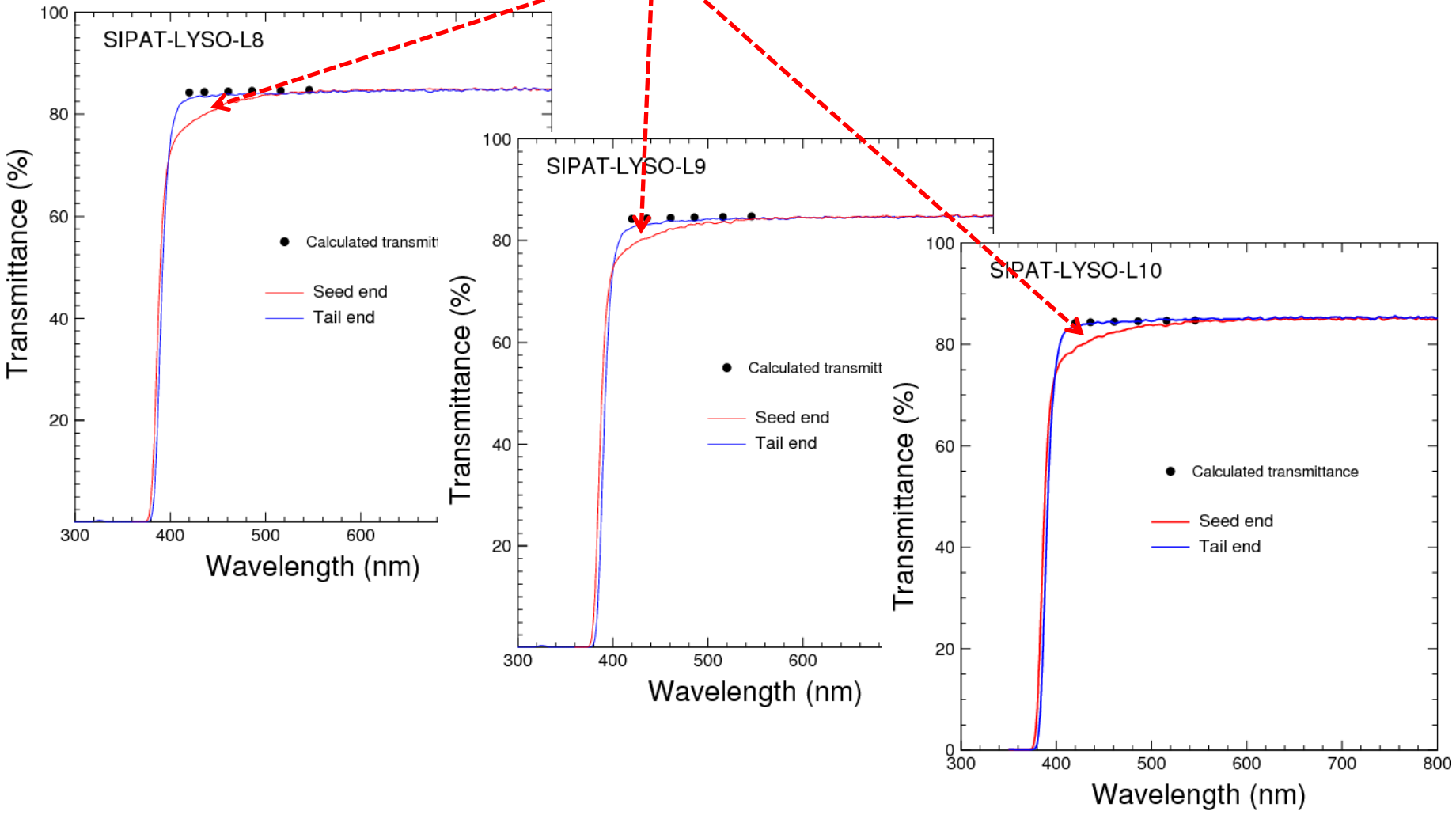






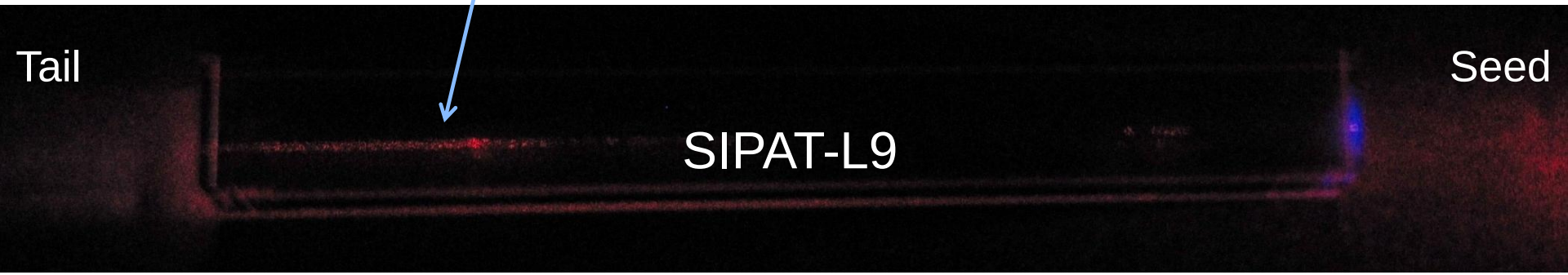
SIPAT-L8, L9 & L10: Transverse T%

Low transverse transmittance at the seed end



He-Ne Laser Shooting at Seed Ends

Scattering centers observed at the tail end



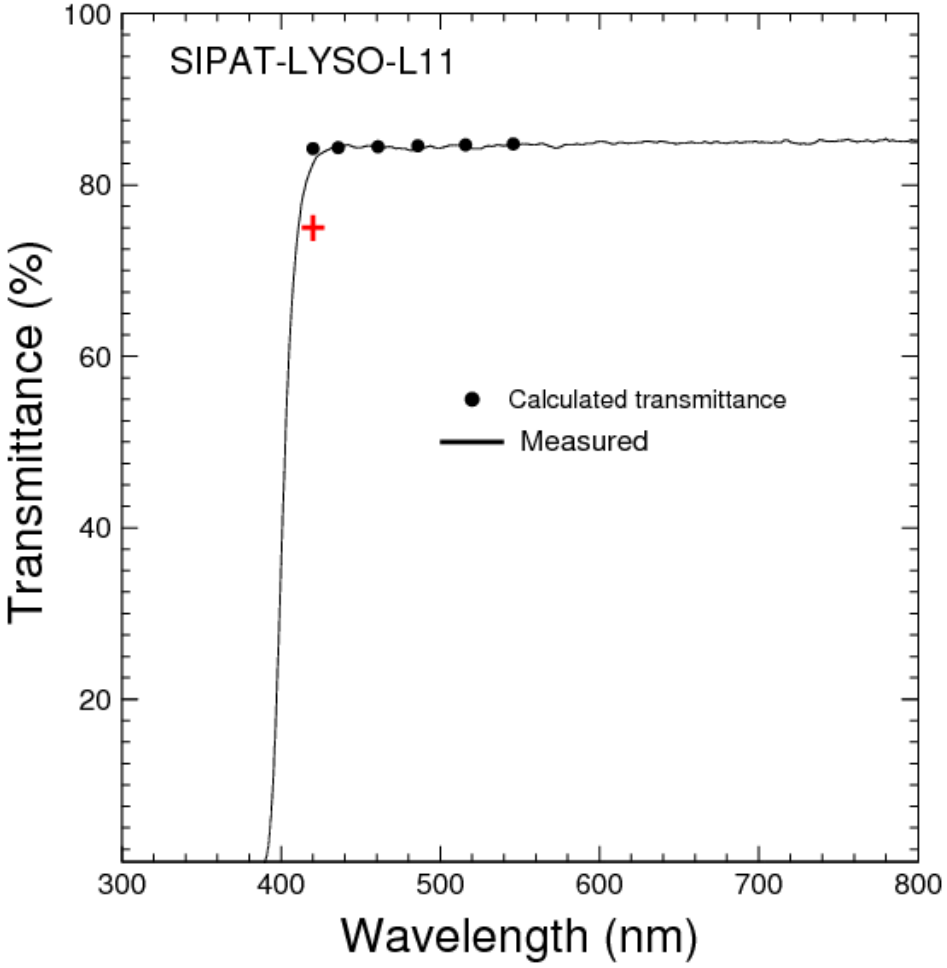
The low transmittance at the seed end is caused by absorption

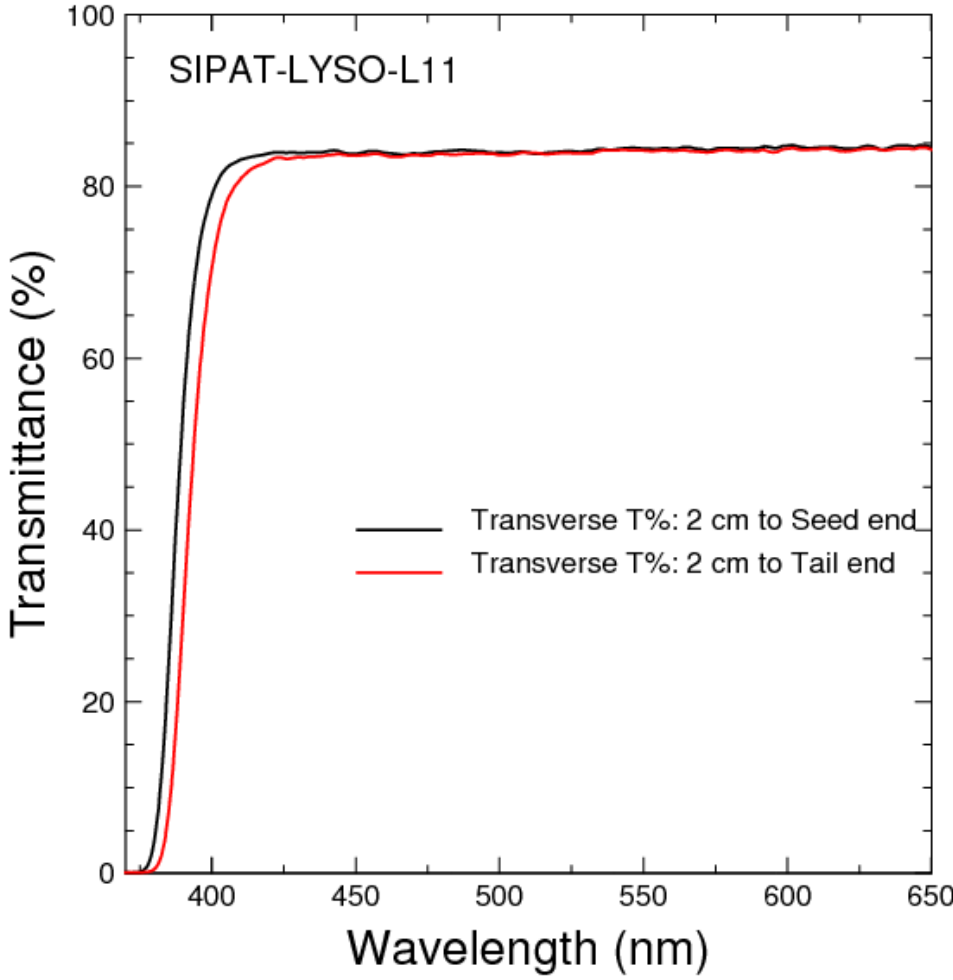
A Site Visit to SIPAT on May 20

The issue of the absorption band at the seed end of SIPAT-LYSO-L7, 8, 9 and 10 was brought to the attention of SIPAT, and was discussed in a site visit on May 20, 2010. The problem was traced back to a bad seed crystal used.

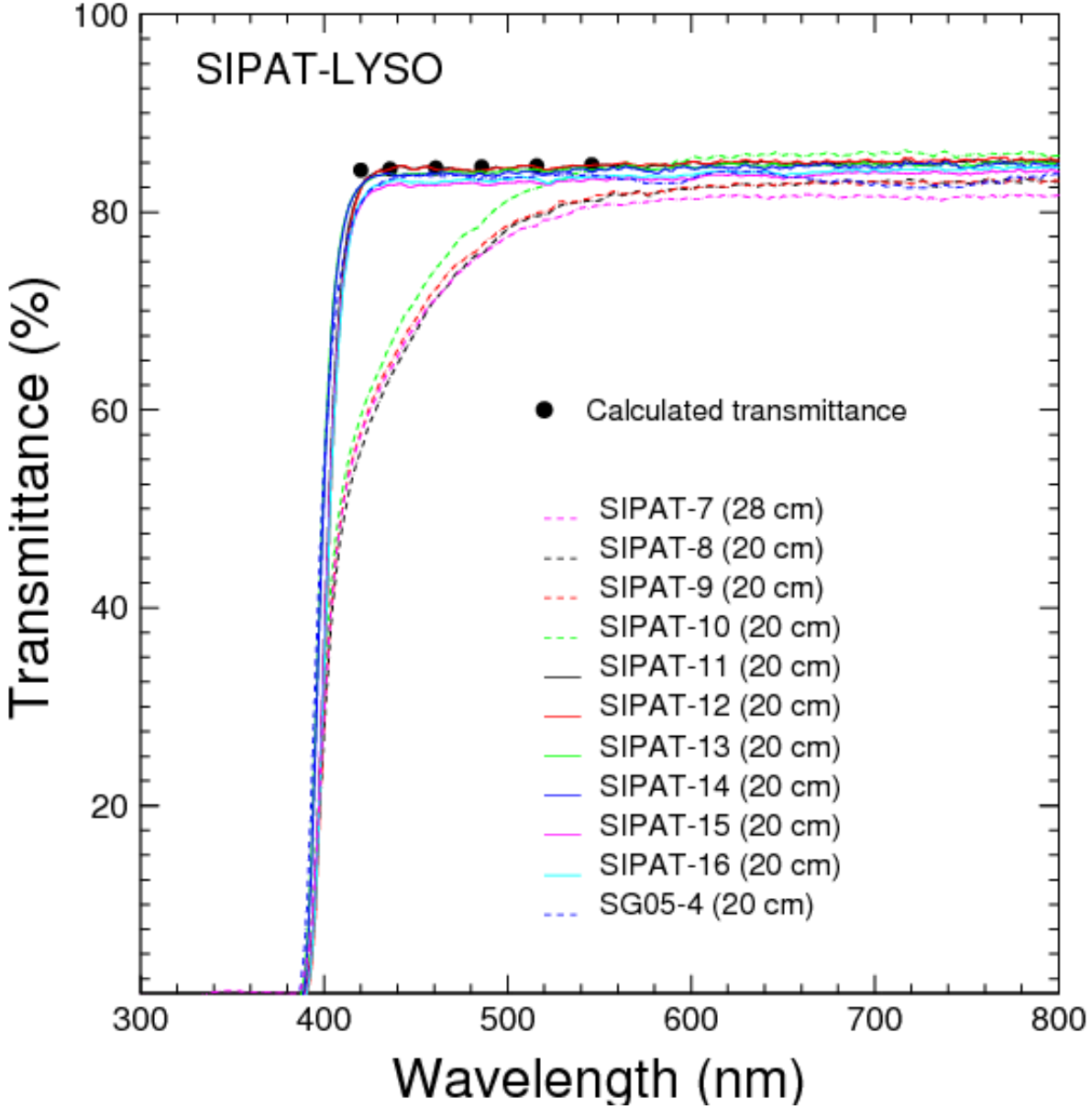
Progress in Transmittance

SIPAT-LYSO-L11: Absorption at the seed end eliminated





Progress in Transmittance



With rigorous control recently delivered LYSO crystals show no absorption band at the seed end.

Progress in Light Output & Resolution

ID	L.O (p.e./MeV)	FWHM (%)
SIPAT-7	1380	12.2
SIPAT-8	1330	13.1
SIPAT-9	1450	12.3
SIPAT-10	1490	12.3
SIPAT-11	2010	10.7
SIPAT-12	1970	10.4
SIPAT-13	2050	11.5
SIPAT-14	2100	10.9
SIPAT-15	2040	10.5
SIPAT-16	2050	10.1

The light output of recent LYSO crystals from SIPAT increased by 30% as compared to that with the absorption problem.

Summary

The 1st 2.5 x 2.5 x 28 cm (25 X_0) LYSO sample from SIPAT has consistent emission, adequate light response uniformity and good radiation resistance against γ-rays.

It and several 20 cm long LYSO samples, however, have an absorption band between 400 and 600 nm at the seed end, causing a relatively poor longitudinal transmittance and light output.

This absorption at the seed end was understood as caused by a bad seed crystal used in their growth. With rigorous control recently delivered LYSO crystals show no absorption band at the seed end and have 30% increase in light output as compared to those with this problem.

Thank you !