Cerium and Yttrium Distributions in LSO crystals and their Influence to Optical and Scintillation Properties

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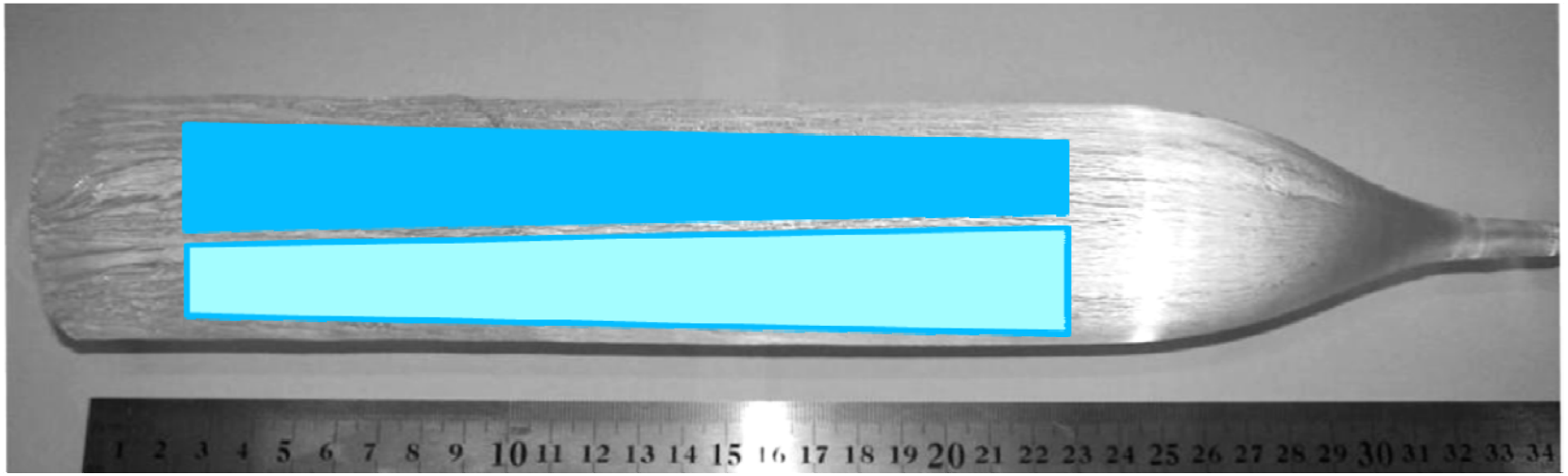
Motivation of this Work

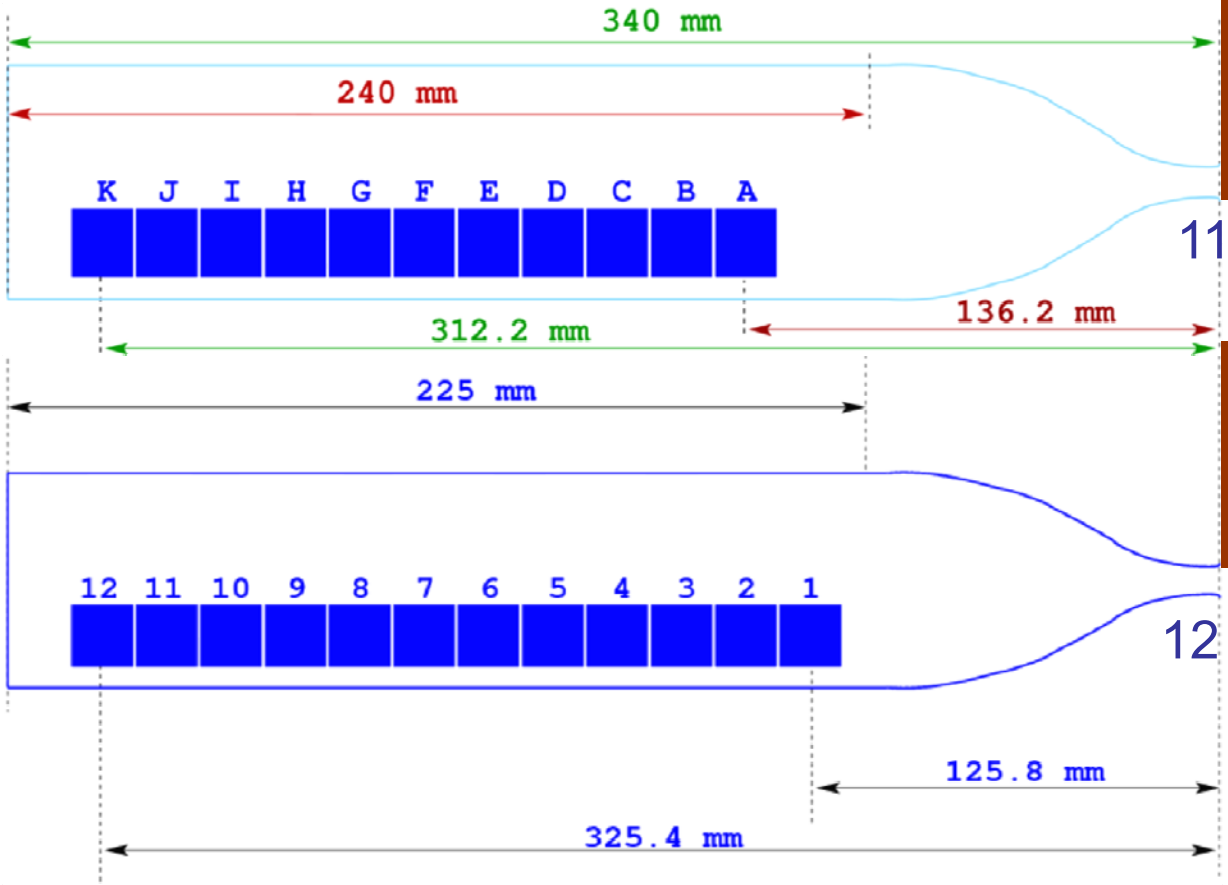
- Good light response uniformity is crucial for a crystal calorimeter to achieve its designed energy resolution. This study aims at developing longitudinally uniform LYSO crystals for HEP applications.



- Sipat's Φ60 x 250 mm ingot may be cut to two SuperB crystals, thus significantly increasing the ingot usage. The key issue: longitudinally uniformity.

Two Ingots with Different Cerium

Ingots grown by Czochralski method at Sichuan Institute of Piezoelectric and Acousto-optic Technology (SIPAT), China.



1st ingot with high cerium

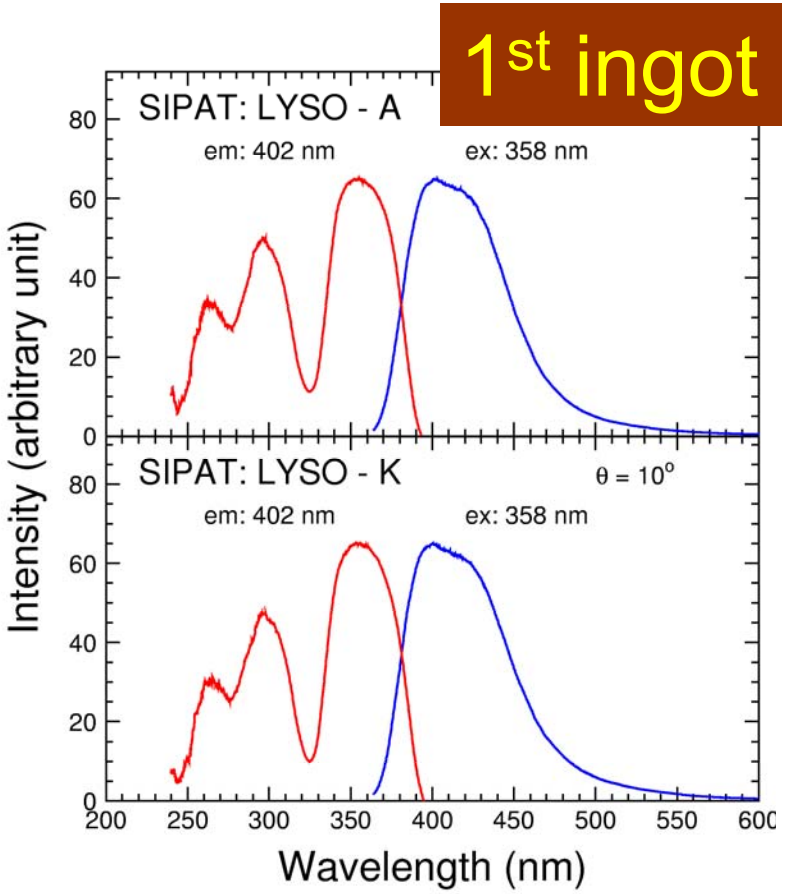
11 cubes of 17 ($1.5\ X_0$) mm^3

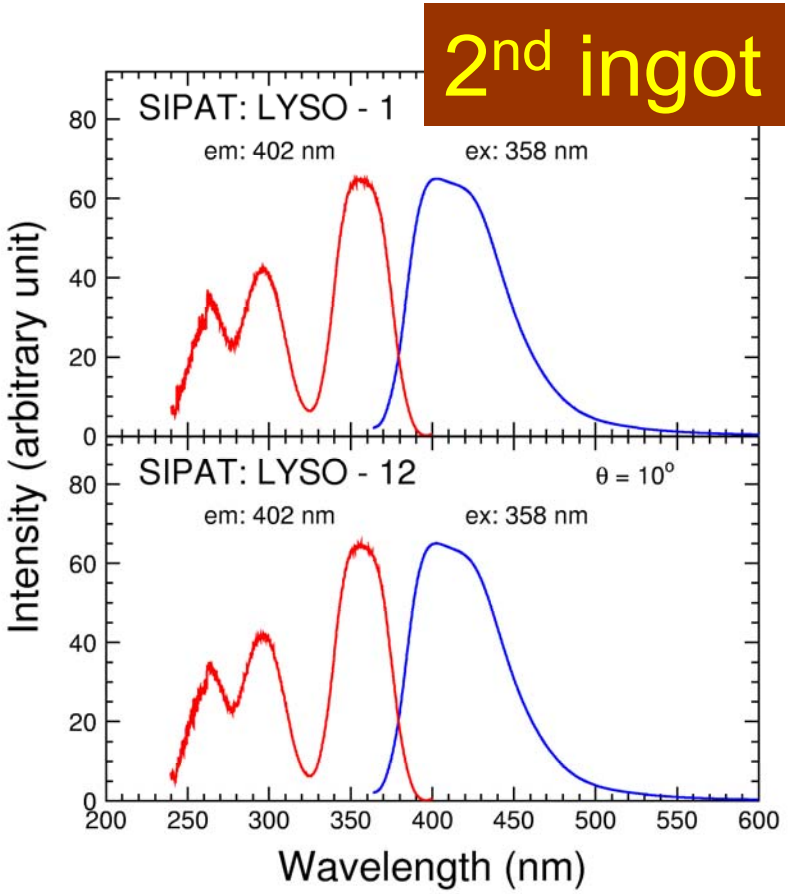
2nd ingot with low cerium

12 cubes of 17 ($1.5\ X_0$) mm^3

UV Excitation and Emission Spectra

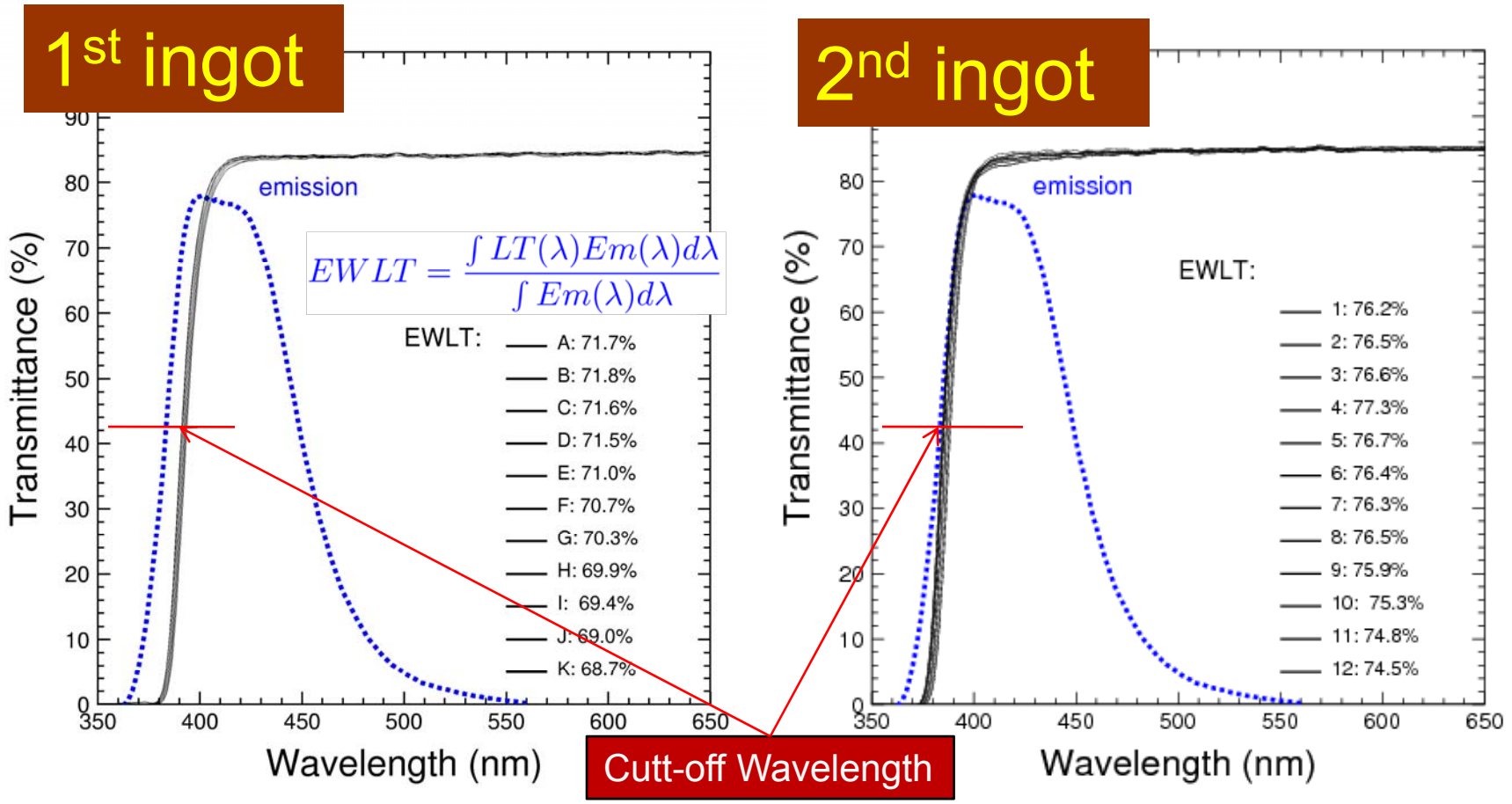
Consistent excitation (red) and emission (blue) spectra observed from seed to tail for both ingots.





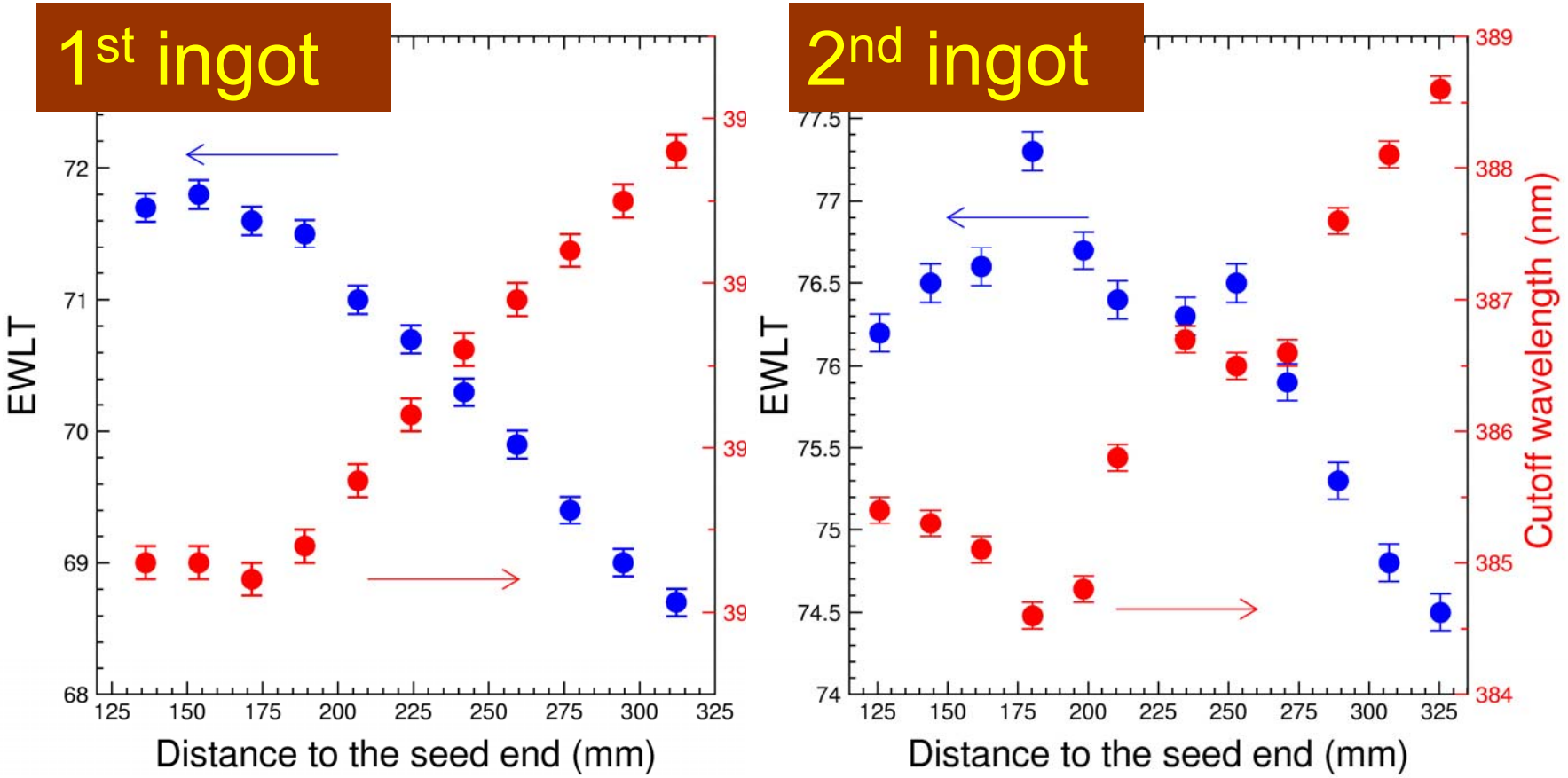
Transmission Spectra

Transmissions are position dependent, indicating possible correlation with dopant concentrations.



EWLT and Cut-off versus Position

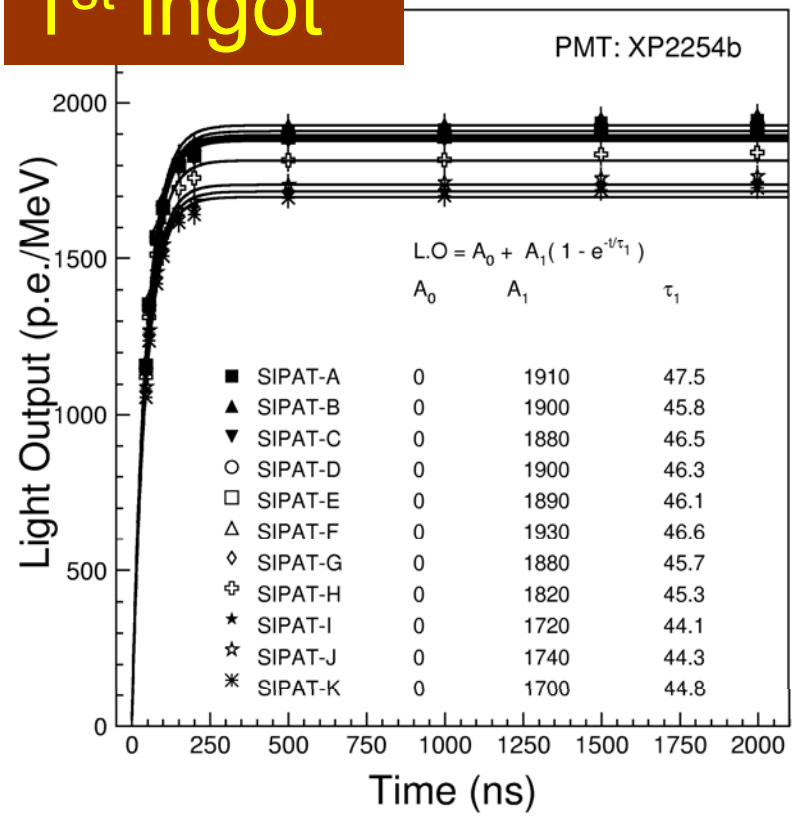
Correlations exist between EWLT/cut-off and cube position



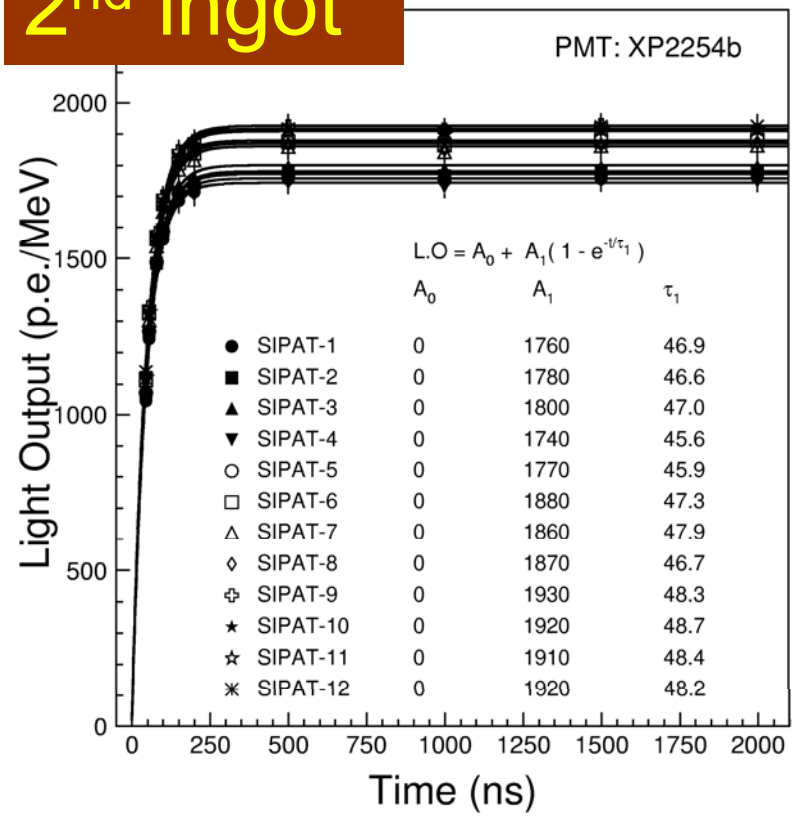
Light Output

Light Outputs are position dependent, indicating possible correlation with dopant concentrations.

1st ingot

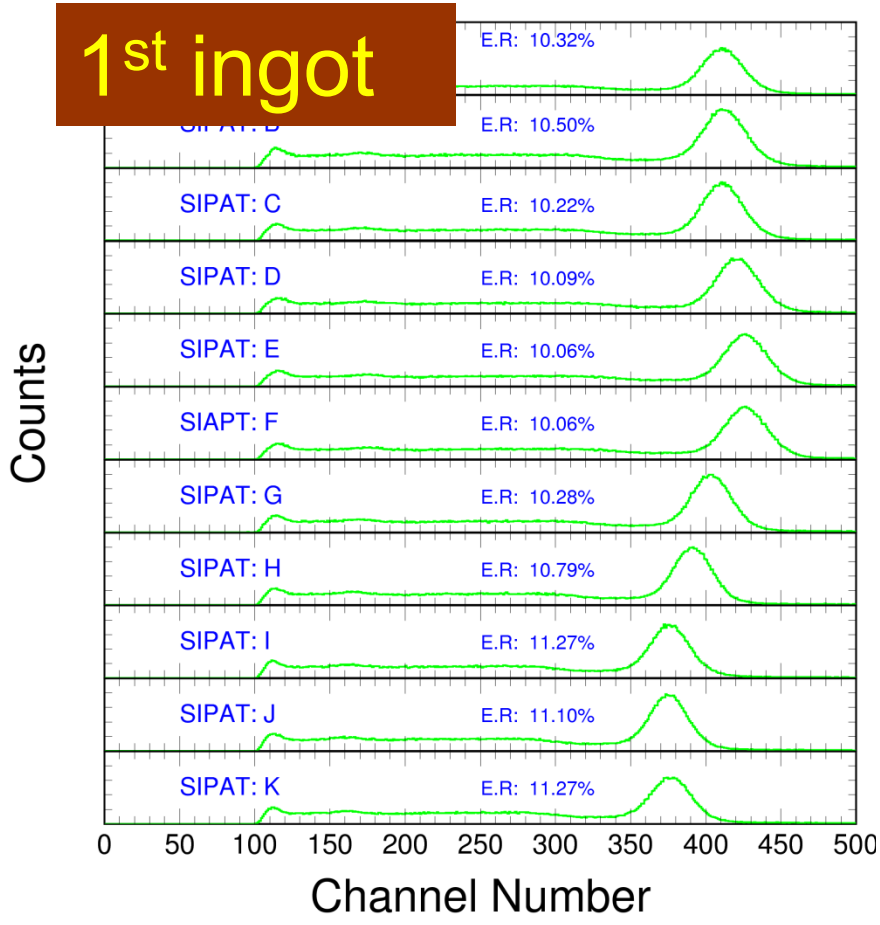


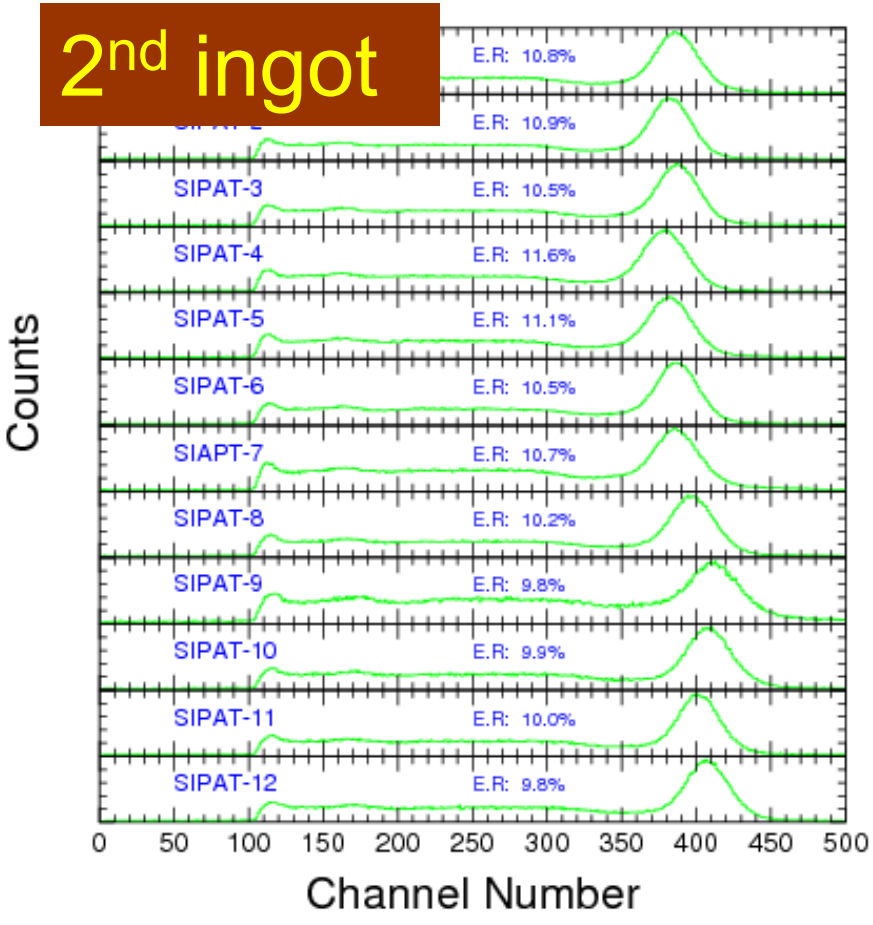
2nd ingot



FWHM Energy Resolution

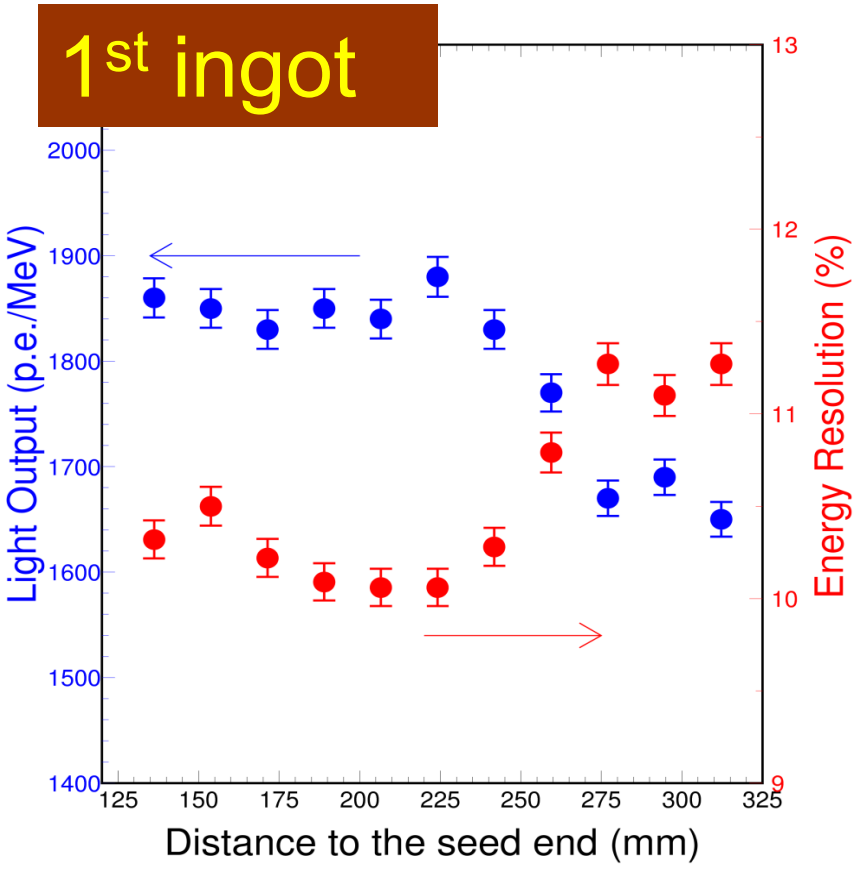
Energy resolution are position dependent, indicating possible correlation with dopant concentrations.

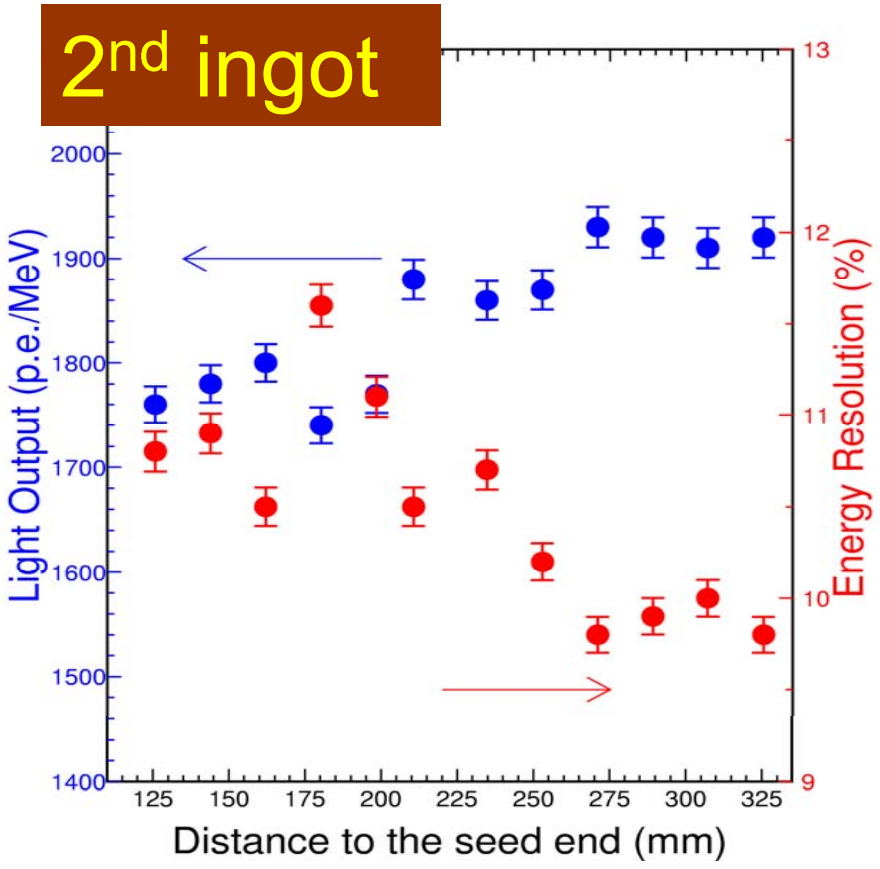




L.O. and E.R. versus Position

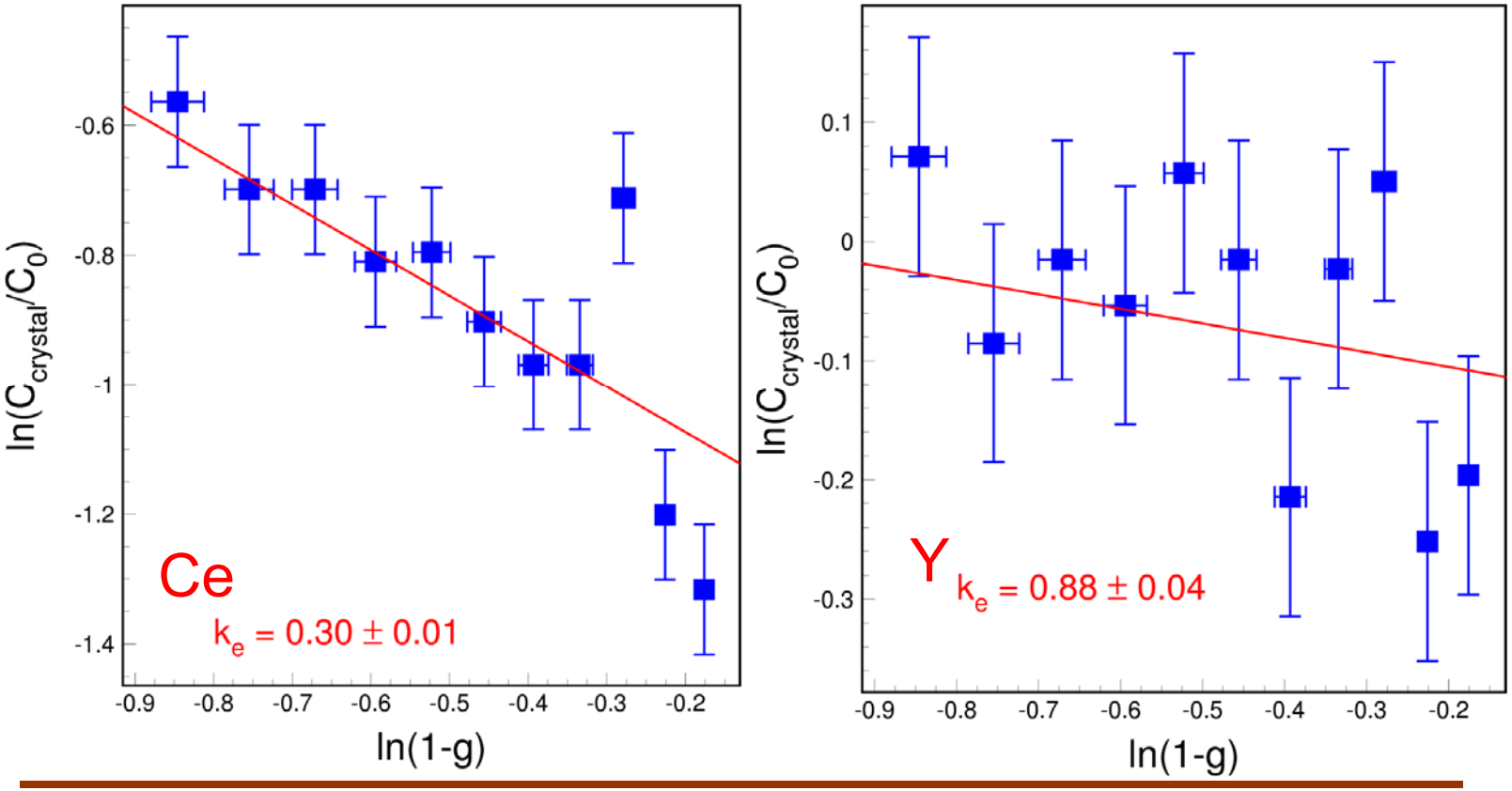
Correlations exist between L.O./E.R. and cube position





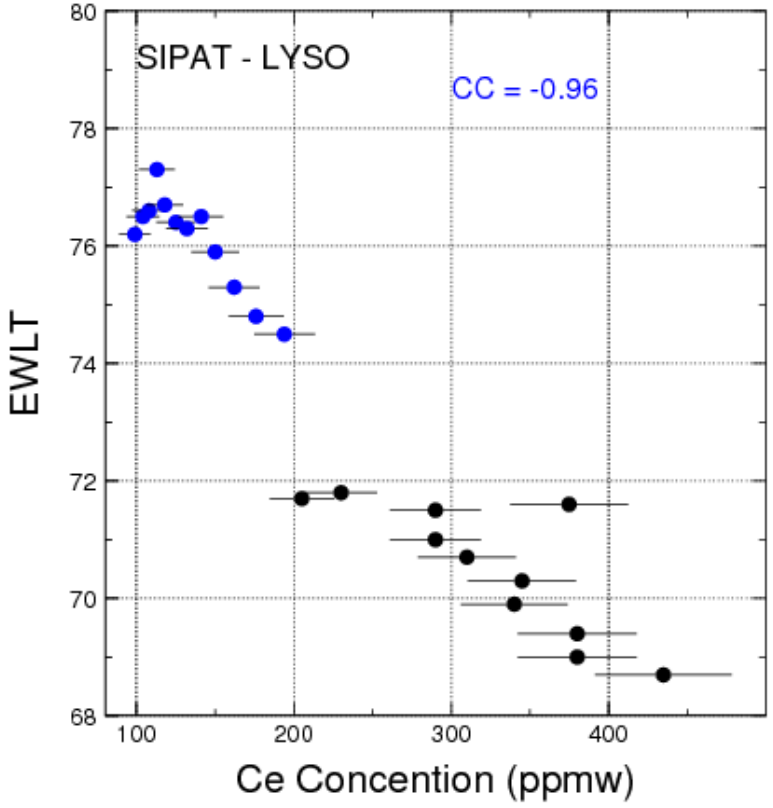
Segregation Coefficient of Cerium and Yttrium

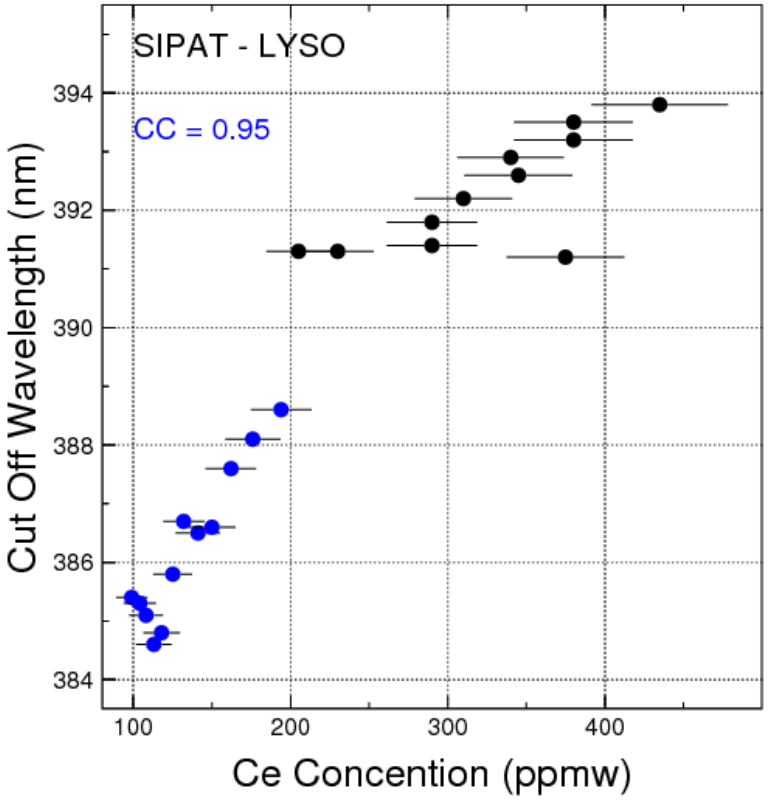
- Concentrations of cerium and yttrium were measured by using Glow Discharge Mass Spectrometry (GDMS) analysis.
- Segregation coefficients of cerium and yttrium in LSO were fitted to be 0.30 and 0.88 respectively.



EWLT & Cut-off versus Ce Concentration

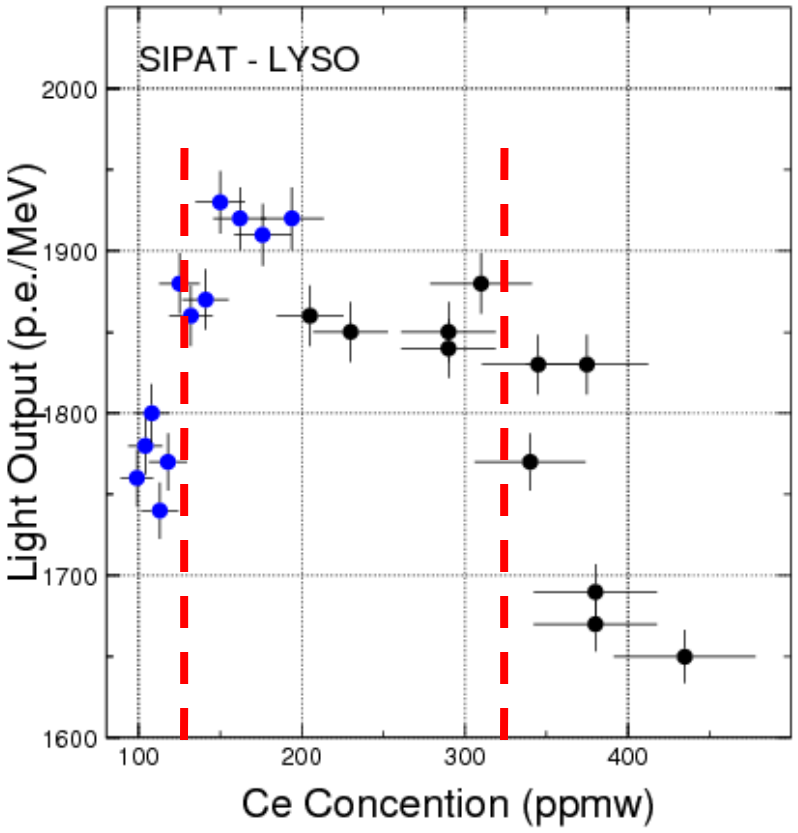
Strong correlations observed between EWLT and the cut-off wavelength versus the Ce concentration.

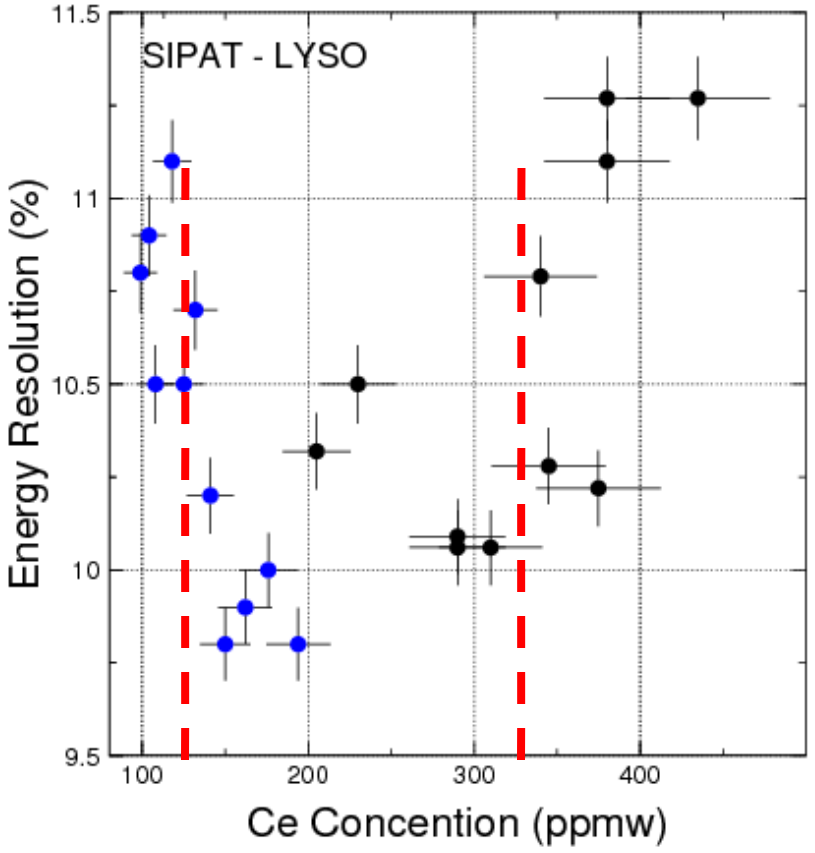




L.O. and E.R. versus Ce Concentration

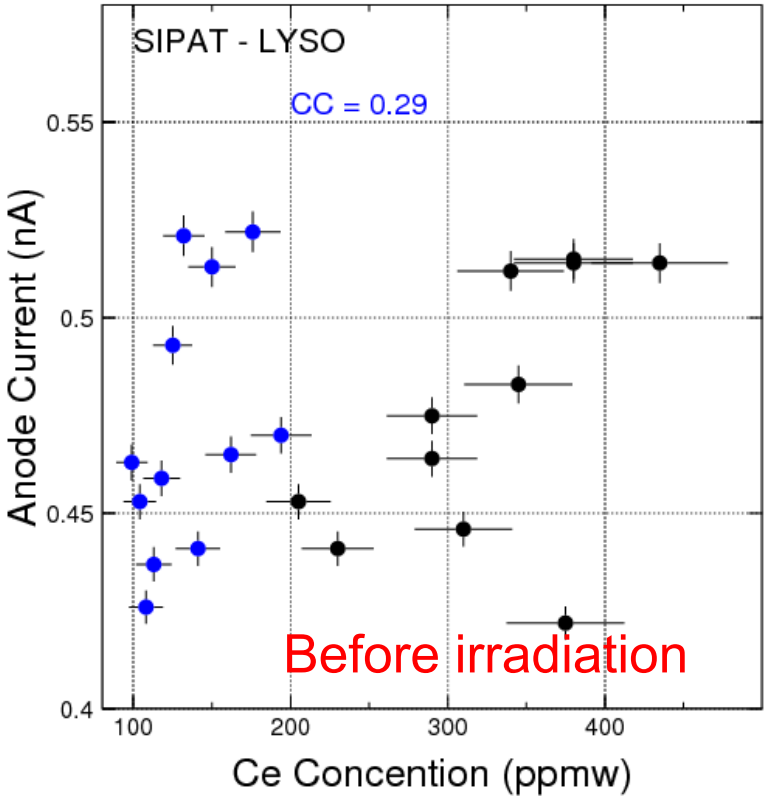
A ‘plateau’ observed between 125 ~ 325 ppm, indicating a possibility to grow uniform crystal with optimized Ce doping.

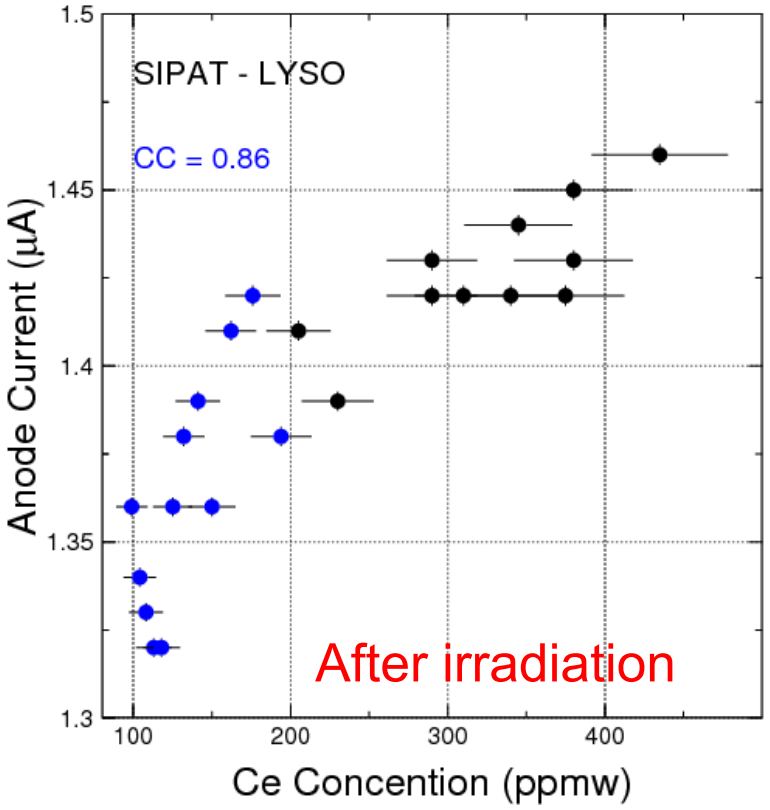




Phosphorescence versus Ce Concentration

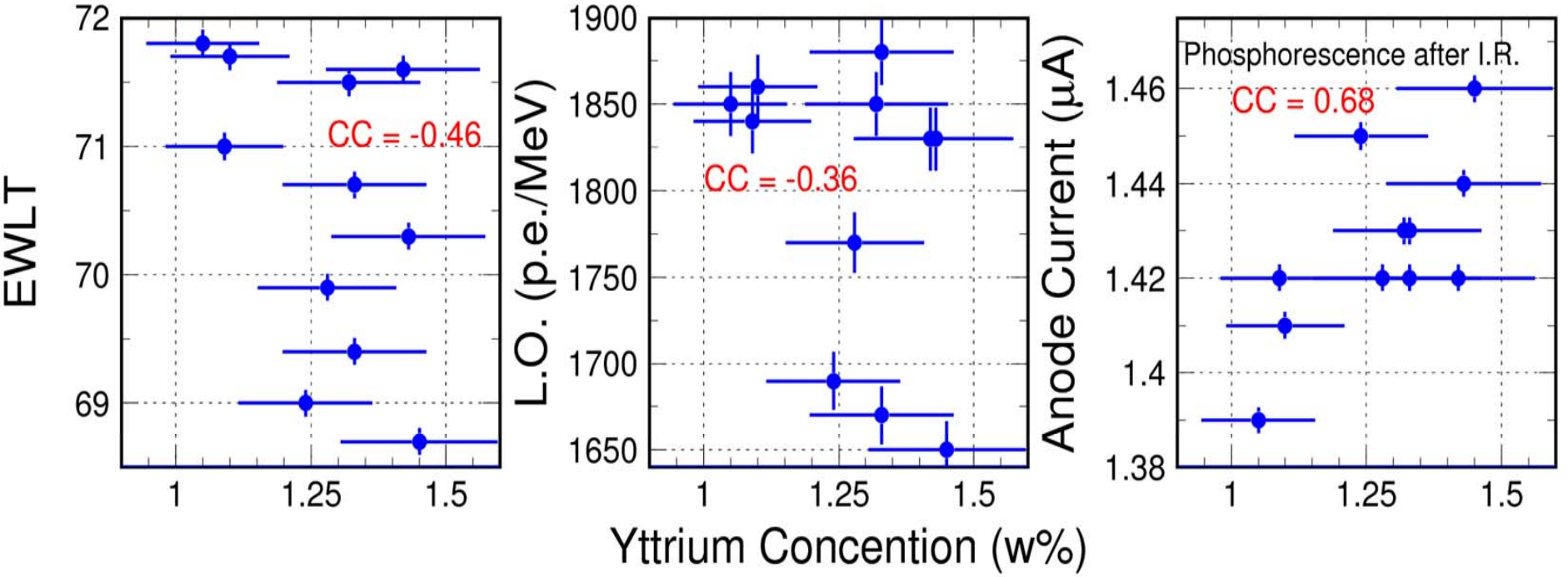
Correlation observed between radiation induced phosphorescence and the Ce concentration, but not before gamma-ray irradiation.





EWLT, L.O. and Phosphorescence versus the Yttrium Concentration

Very weak or no correlations were observed between the yttrium concentrations and EWLT, the light output and the intensity of phosphorescence after gamma-ray irradiations.



Summary

- Two LYSO:Ce ingots grown by Czochralski method at SIPAT were cut into cubes of 17 mm (1.5 X_0), of which the optical and scintillation properties were characterized.
- By using GDMS analysis the segregation coefficients of cerium and yttrium were determined as 0.30±0.01 and 0.88±0.04 respectively.
- Correlations were observed between EWLT, cut-off wavelength in transmission, light output, energy resolution and radiation-induced phosphorescence versus the cerium concentration, but not the yttrium concentration.
- The optimized cerium concentration in LYSO was found to be between 125 and 325 ppmw, providing a foundation for growing longitudinally uniform LYSO crystals for high energy physics applications.