Light Response Uniformization

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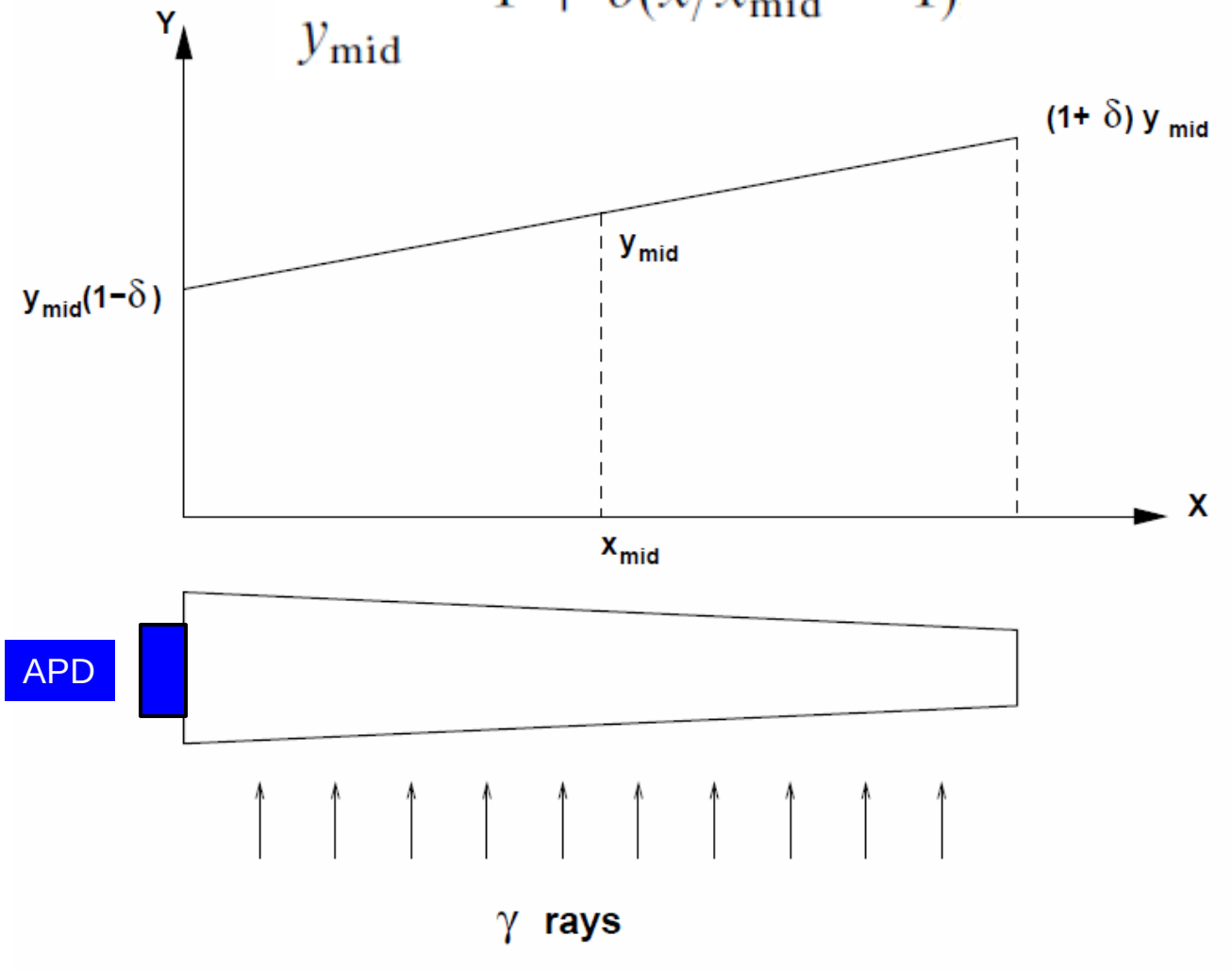
Light Response Uniformity

$$\frac{y}{y_{\mathrm{mid}}} = 1 + \delta(x/x_{\mathrm{mid}} - 1)$$



Introduction

Light response uniformity for LYSO crystals is affected by the following factors:

(1) Geometry (optical focusing for tapered crystal): δ = 17%;
(2) Self-absorption (emission, transmittance and QE): δ = 13%;
(3) Cerium concentration may be used to compensate: δ ~ 10%.

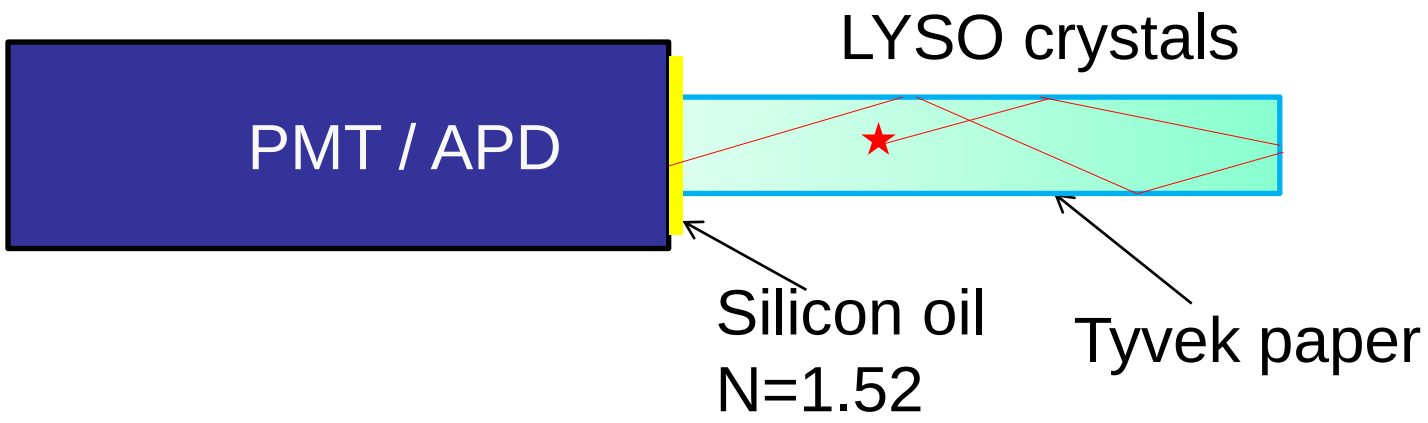
Approaches used to uniformize crystal response:

(1) De-polishing one side surface: L3 BGO and CMS PWO;
(2) Black dots on Tyvek wrapping papers: BaBar CsI(Tl);
(3) Black strips on Tyvek wrapping papers: BES III CsI(Tl).

In this investigation black bands were painted directly on a side surfaces by using a Sharpie permanent marker

http://www.officedepot.com/a/products/203349/Sharpie-Permanent-Fine-Point-Markers-Black/

Ray-Tracing Simulation

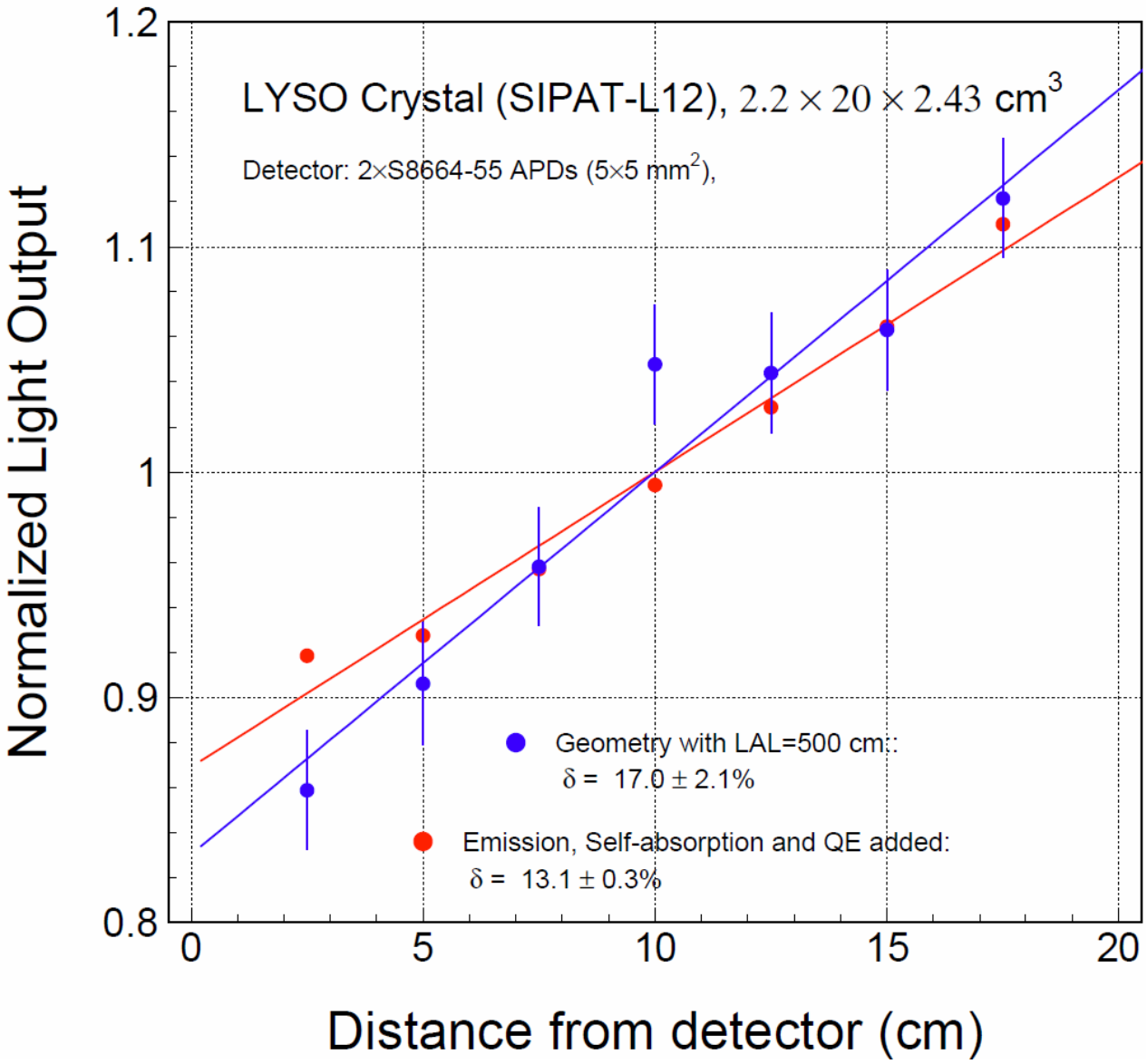


Processes included:

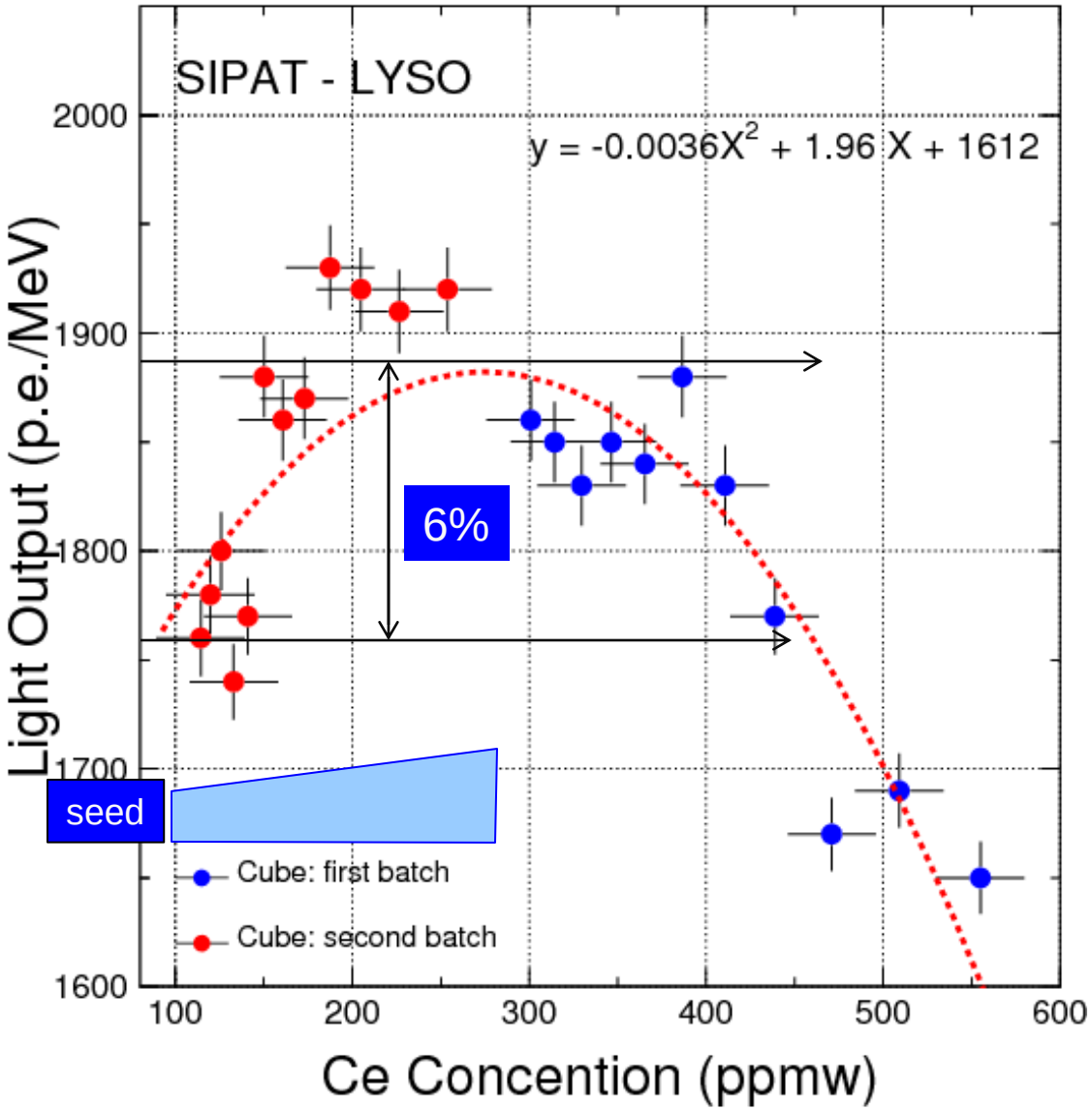
1. Homogeneous bulk absorption (λ or LAL);
2. Light reflection and refraction on six surfaces;
3. Diffused reflection on the surface of Tyvek paper.

Photons are propagated in the crystal until: (1) entered into the detector; (2) absorbed in the bulk crystal; (3) escaped on a side surface with no detector coverage, or (4) trapped in edges and corners of the crystal (cut-off path length: l = 10 λ). The weight of each photon is exp(-l/λ).

Ray-Tracing Result



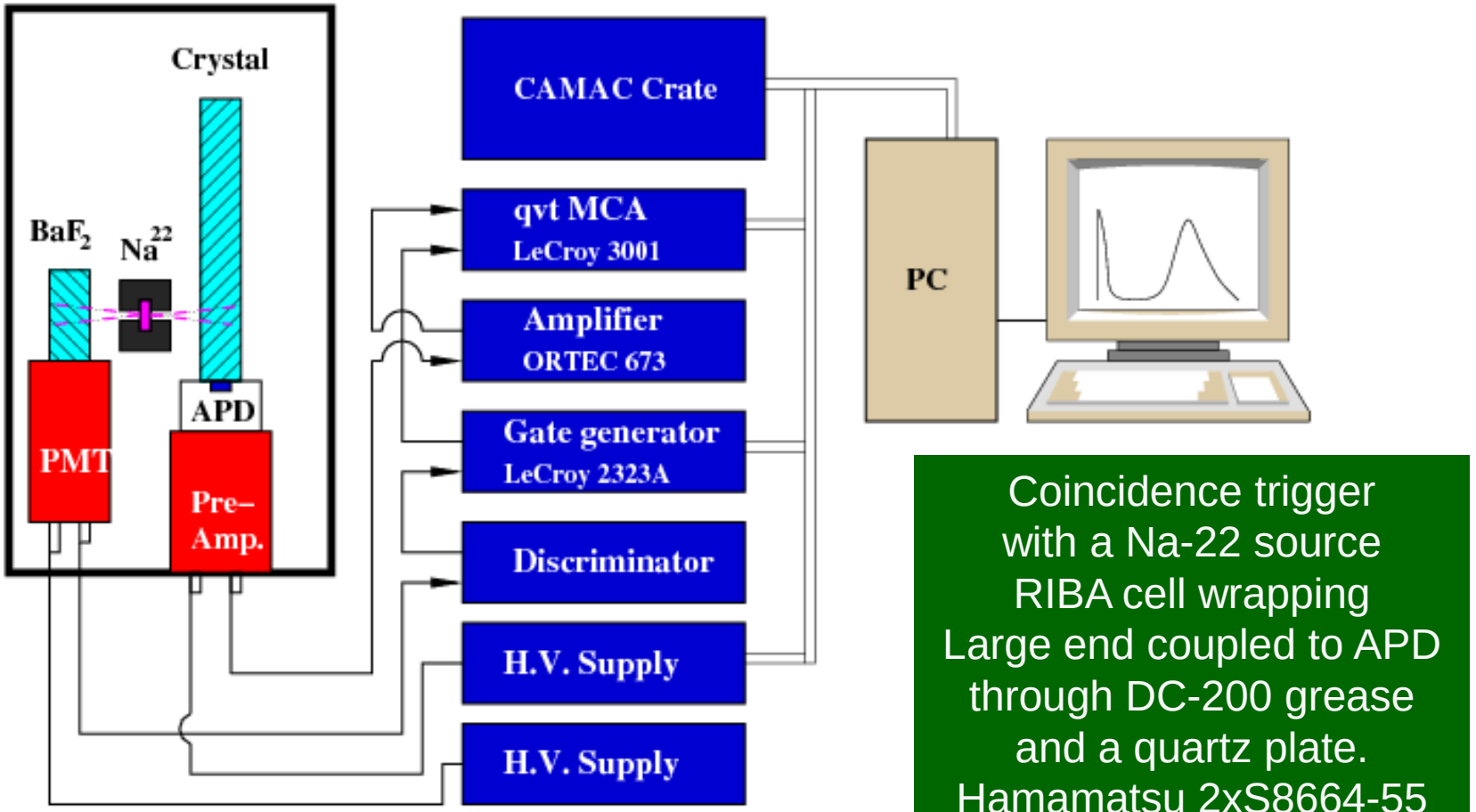
[Ce] in SIPAT-11 & 12



Non uniformity caused by Ce segregation is about 6% at two ends, indicating a compensation of 3% in δ is possible.

Setup for LRU Measurement by APD

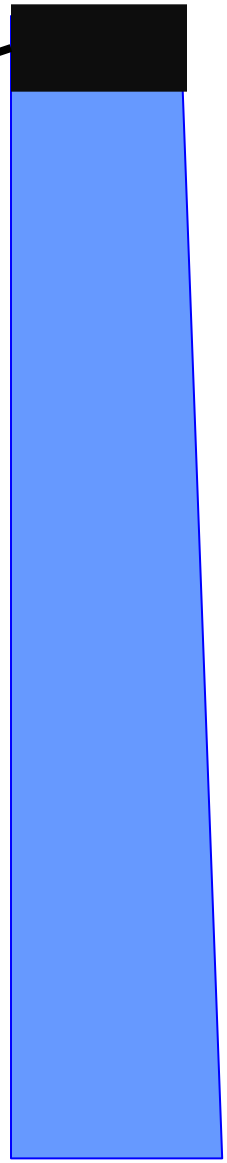
APD: Hamamatsu 2xS8664-55

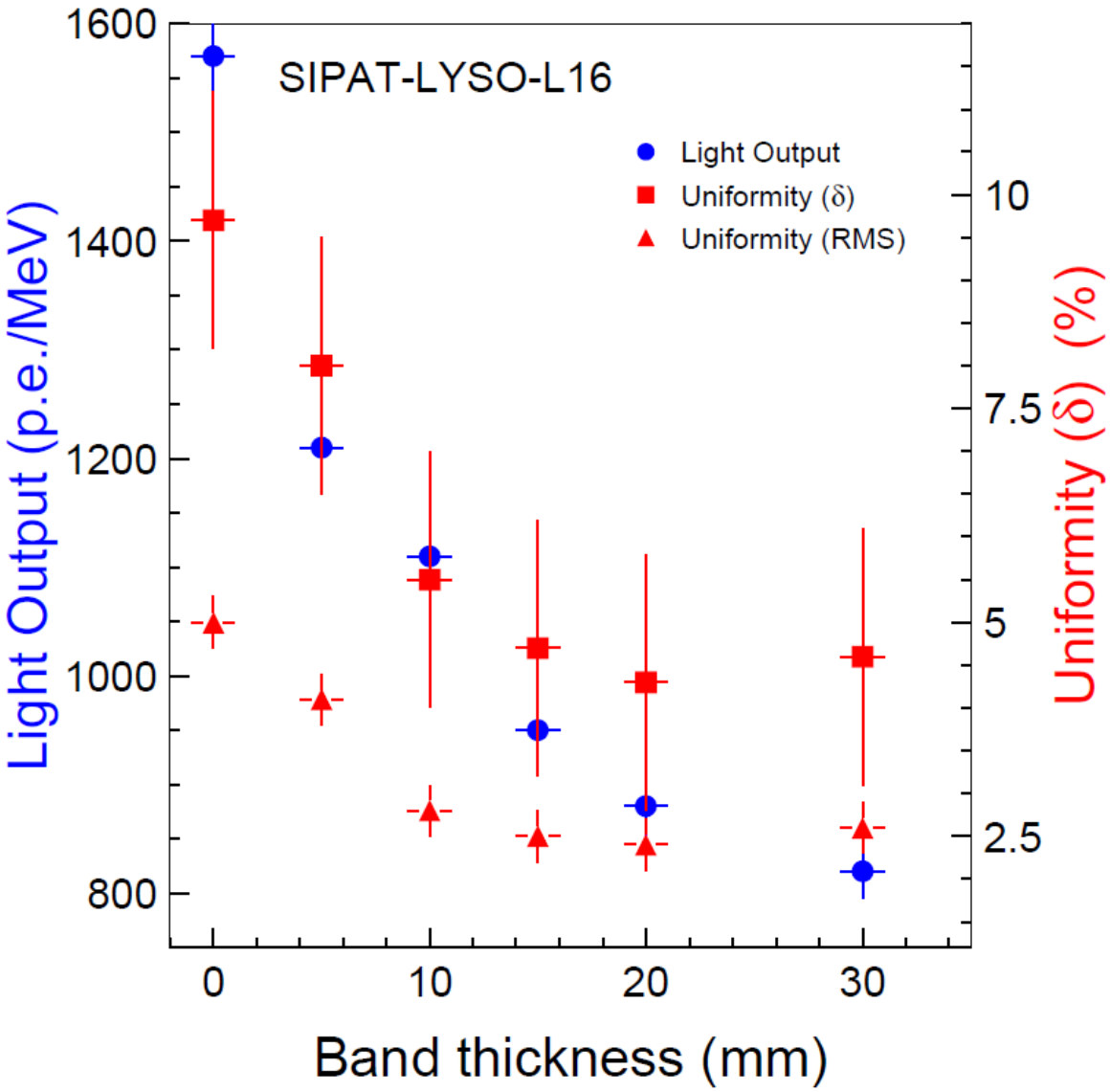


Coincidence trigger with a Na-22 source
RIBA cell wrapping
Large end coupled to APD through DC-200 grease and a quartz plate.
Hamamatsu 2xS8664-55 with bias at 417V for gain of about 50.

Uniformization: < 5% Possible

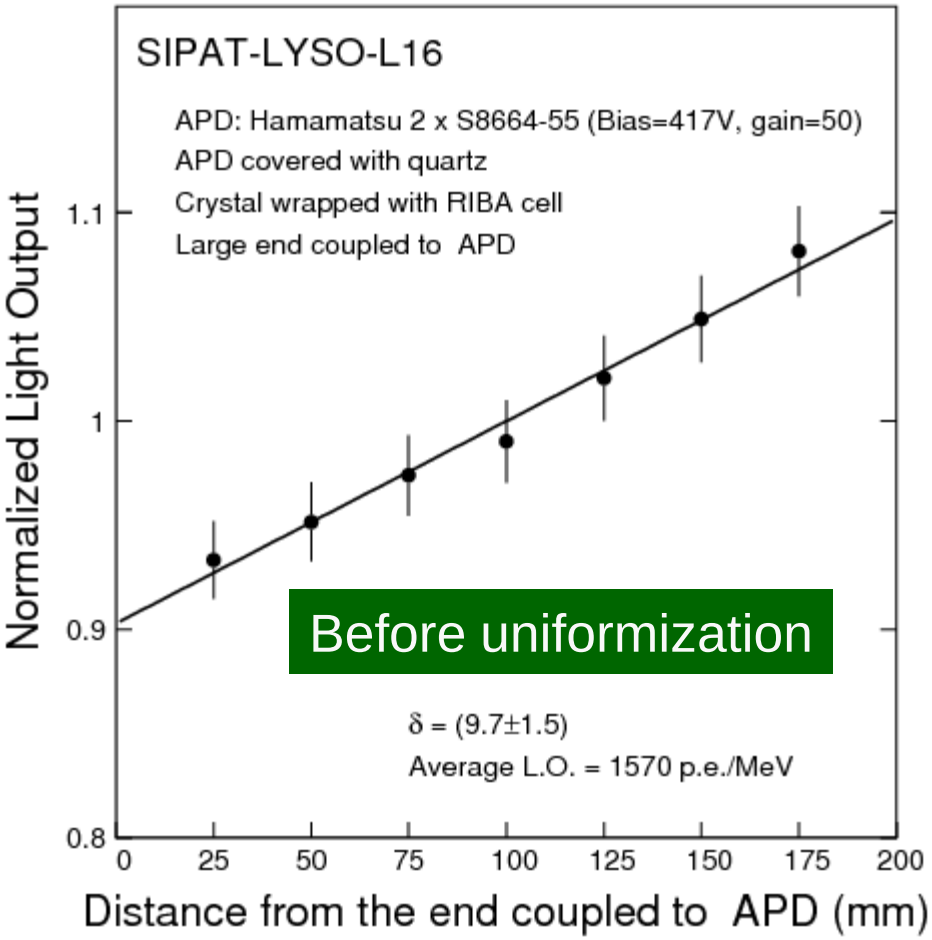
A black band is paint on the smallest side surface of the crystal with a width up to 30 mm from the small end.

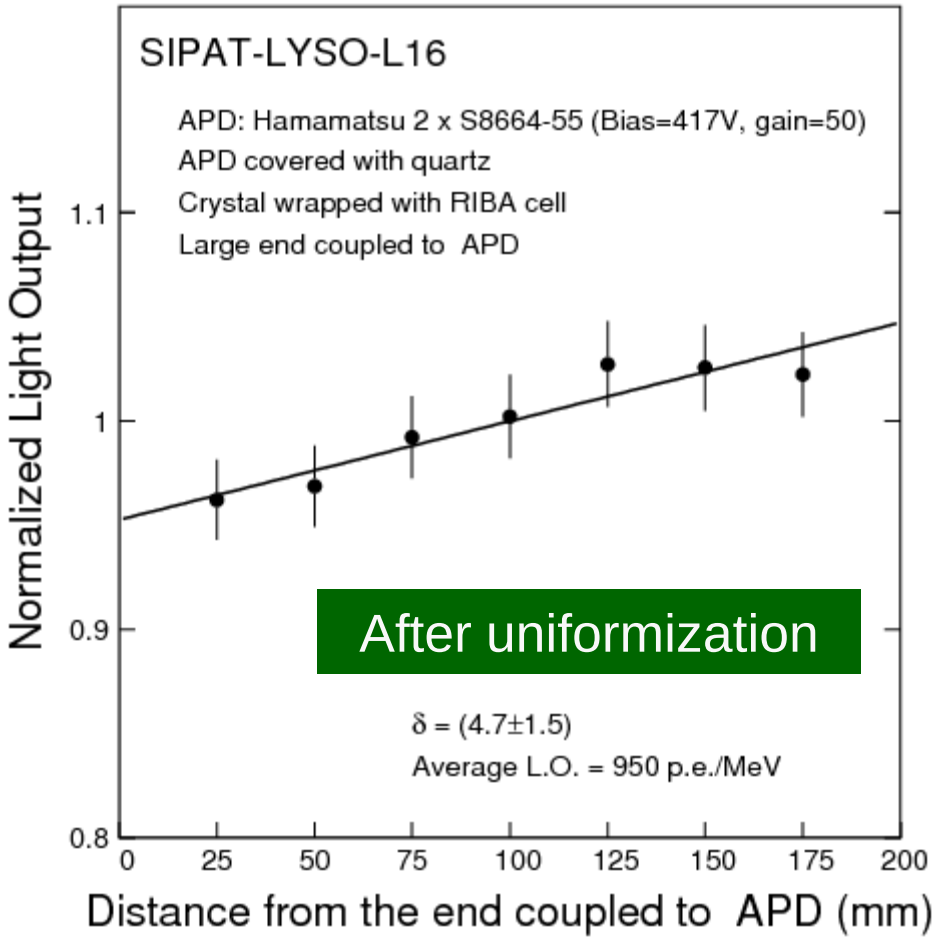




Uniformization: SIPAT-16

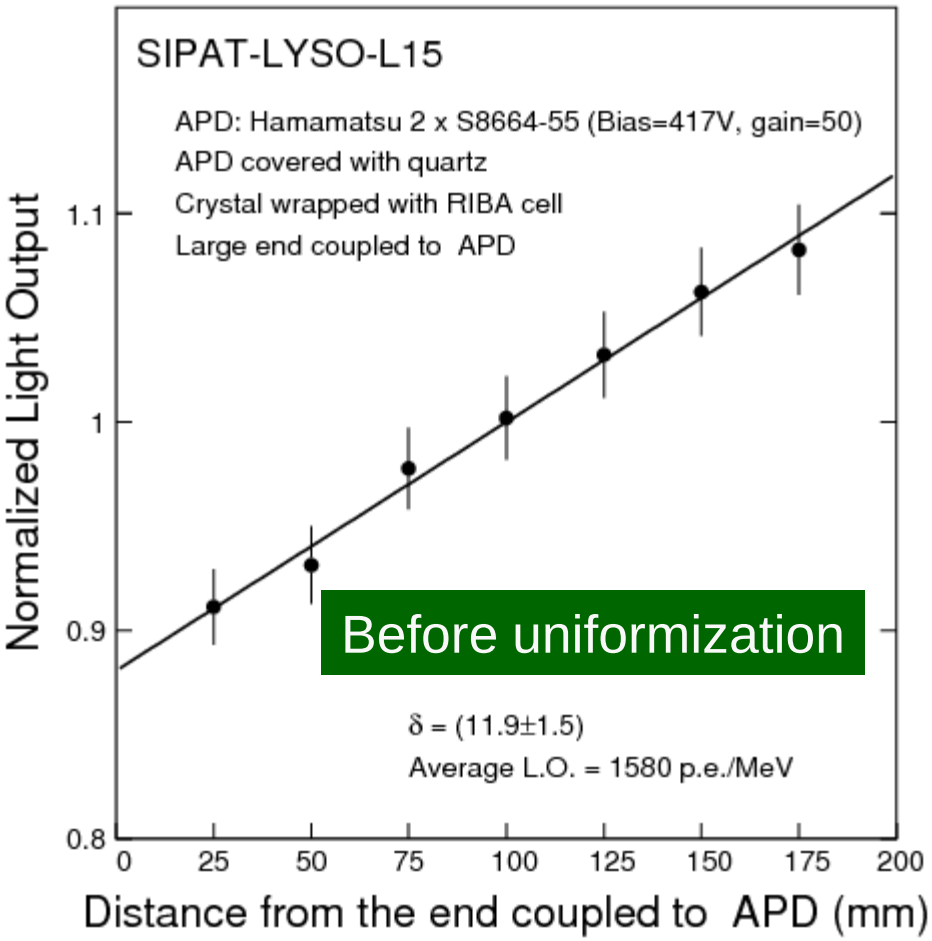
Uniformity of < 5% achieved by 15 mm black paint with 40% loss of the light output.

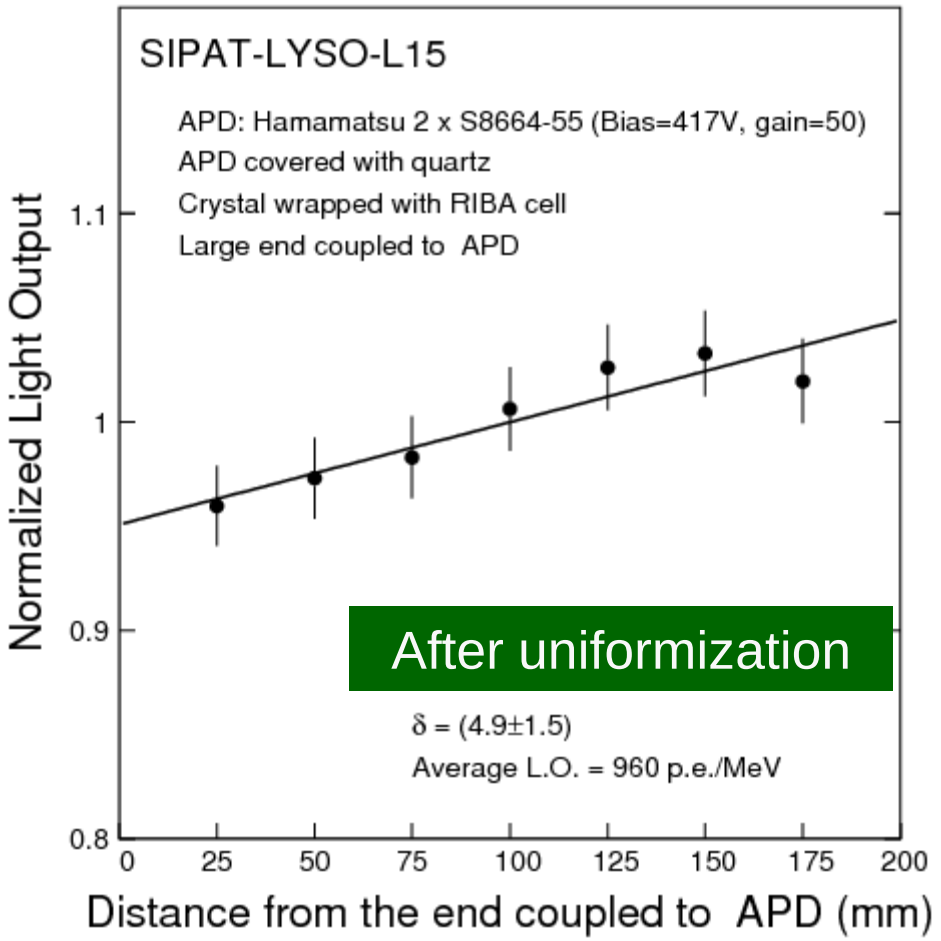




Uniformization: SIPAT-15

Uniformity of < 5% achieved by 15 mm black paint with 40% loss of the light output.





Uniformization Summary

ID		LRU		Light output (p.e./MeV)		L.Y. Loss (%)
		Δ (%)	RMS (%)	LY_{mid}	LY*	
SIPAT-11	Before	12.9	6.5	1430	1420	46
	After	4.1	2.5	780	770	
SIPAT-12	Before	14.2	7.1	1440	1440	48
	After	3.4	2.8	770	750	
SIPAT-13	Before	6.8	3.6	1430	1440	35
	After	4.6	2.4	940	940	
SIPAT-14	Before	14.4	7.4	1480	1500	45
	After	4.5	2.7	840	830	
SIPAT-15	Before	11.9	6.0	1580	1580	40
	After	4.9	2.7	960	960	
SIPAT-16	Before	9.7	5.0	1570	1550	40
	After	4.7	2.5	950	950	
SG-05-4	Before	9.7	5.2	1350	1360	34
	After	4.7	2.4	890	900	

* Average L.Y.

Summary

The dominate contribution to the light response non-uniformity is the geometry or optical focusing effect. Both self-absorption and non-uniform cerium concentration can be used to compensate the optical focusing effect, leading to an initial non-uniformity at a level of 10%.

A black band painted on the smallest side surface seems effective to reduce the non-uniformity to 5% for the band width of 15 mm. The loss of light output by taking this approach, however, is about 40%.

This approach seems simple enough to be applied to all crystals. Further investigation is needed to explore a better approach, such as de-polishing.