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# **Result of the LYSO Sample SIPAT-LYSO-L15 and 16**

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# Introduction

Two type 6 crystals (15 and 16) were received on 9/13, which were shipped via FedEx on 9/2. The last type 6 crystal (17) was received on 9/24, which was shipped via FedEx on 9/17.

Revised schedule: Two type 7 were shipped via FedEx on 9/21. Three type 7 and one type 8 are scheduled to be shipped via FedEx on 10/8 because of the national holiday in China. To catch the beam test they will have to be shipped to CERN directly.

The following properties of SIPAT-15 and 16 were measured and is compared with other accepted samples.

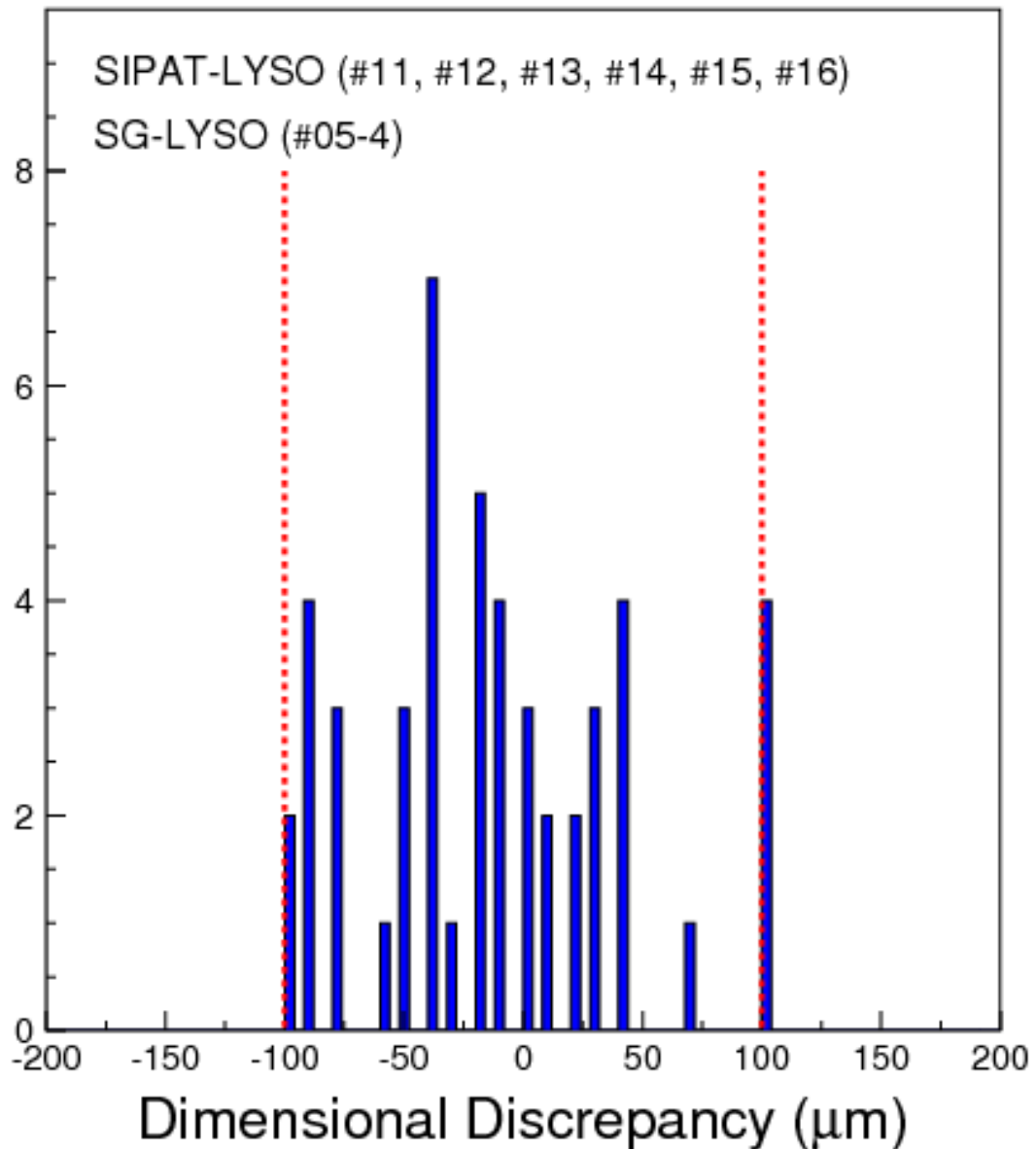
- (1) Dimension;
- (2) Optical transmittance;
- (3) Light yield and resolution measured by R1306 PMT and 2 x S8664-55 APD.

# Dimension: Measured by Dial Caliper

Meet the  $\pm 100 \mu\text{m}$  tolerance requirement

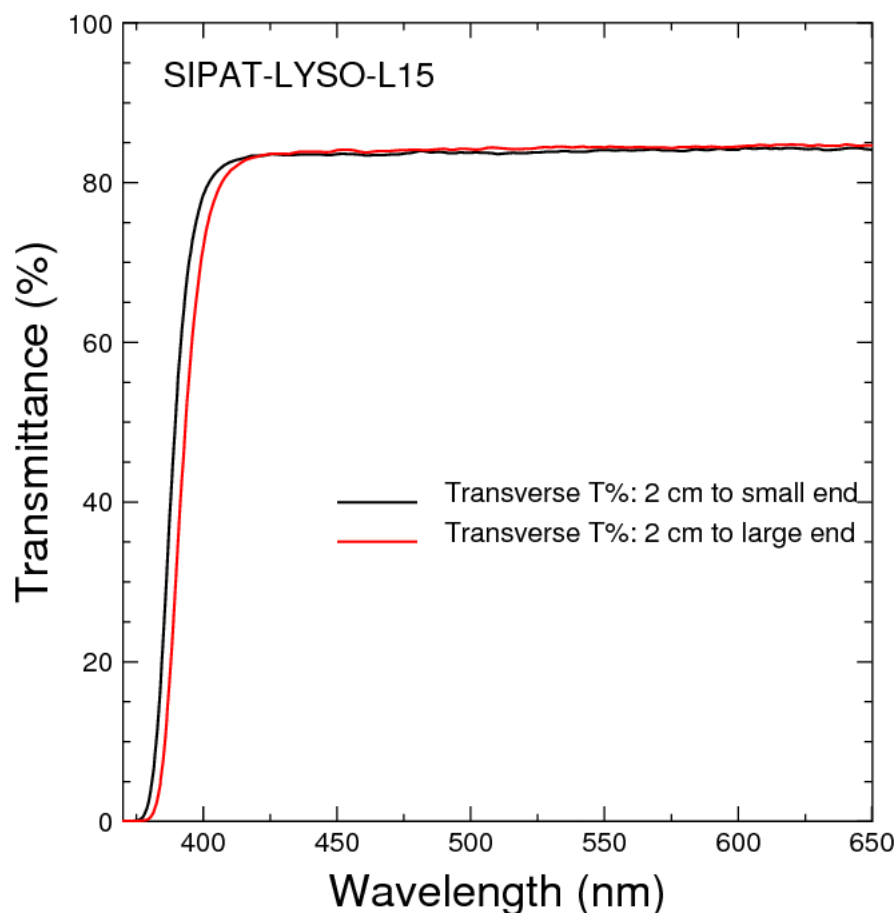
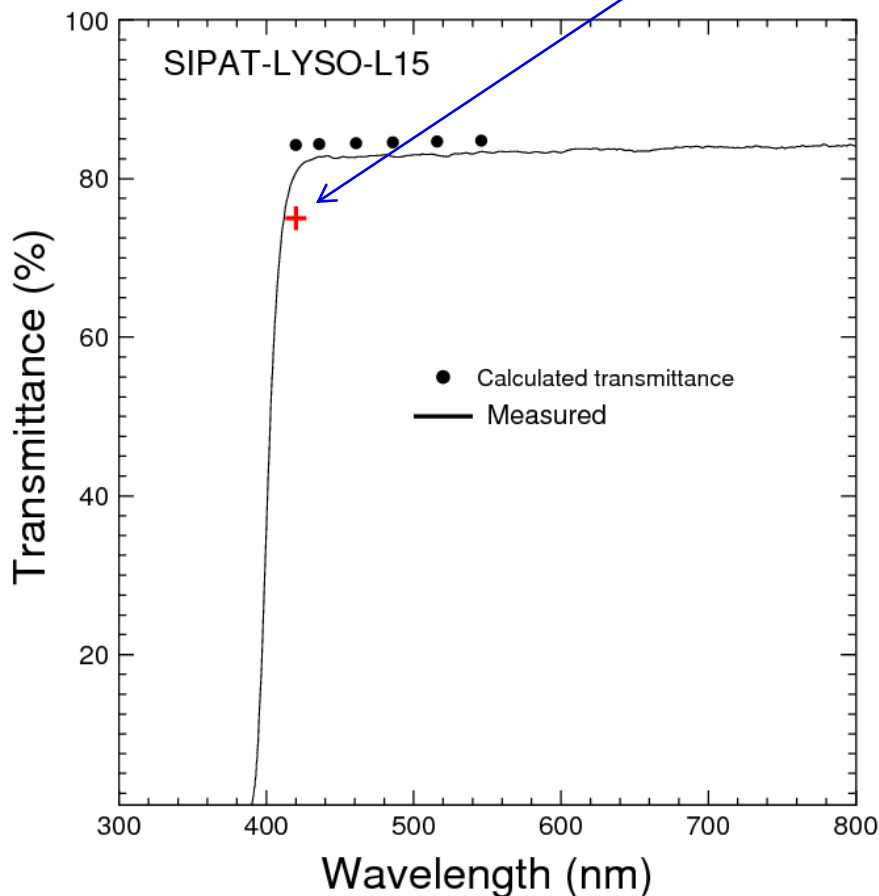
Samples	Front face (mm)	Length (mm)	Back Face (mm)
Type-6	19.28 X 23.12 X 19.94	200.00	21.24 X 25.65 X 21.96
SIPAT-15	19.28 X 23.08 X 19.90	199.97	21.31 X 25.56 X 22.00
SIPAT-16	19.24 X 23.07 X 19.89	199.96	21.34 X 25.55 X 22.06

# Dimension: Measured by Dial Caliper



# Optical Transmittance: SIPAT-15

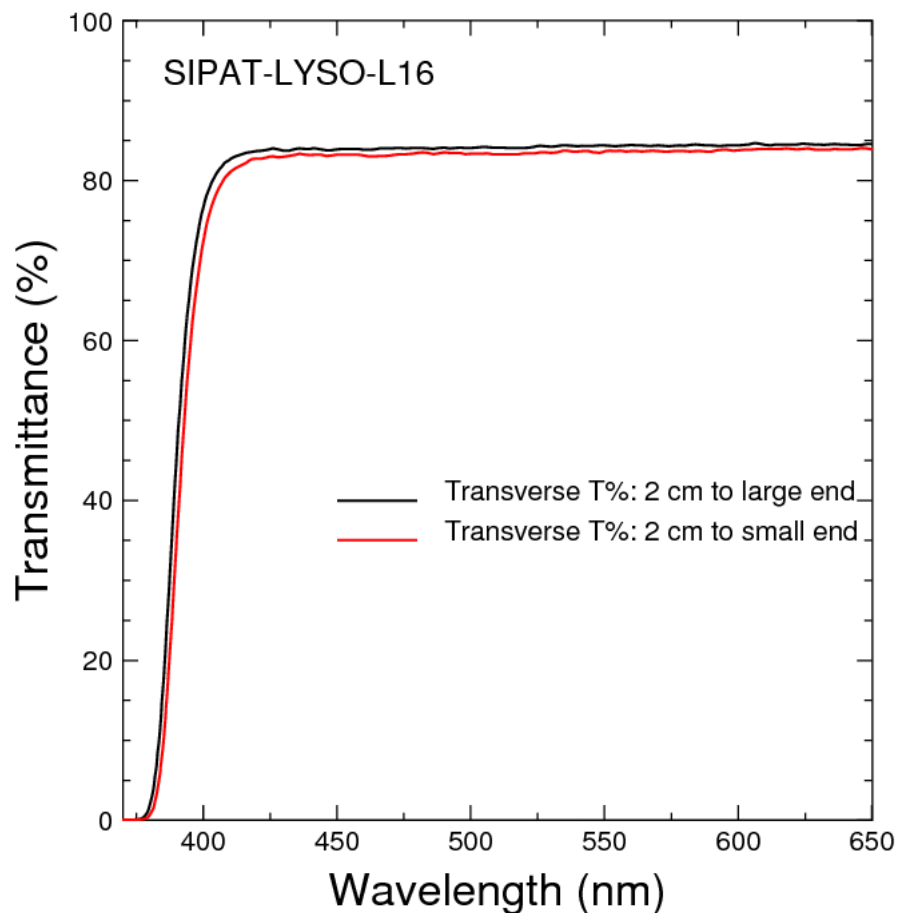
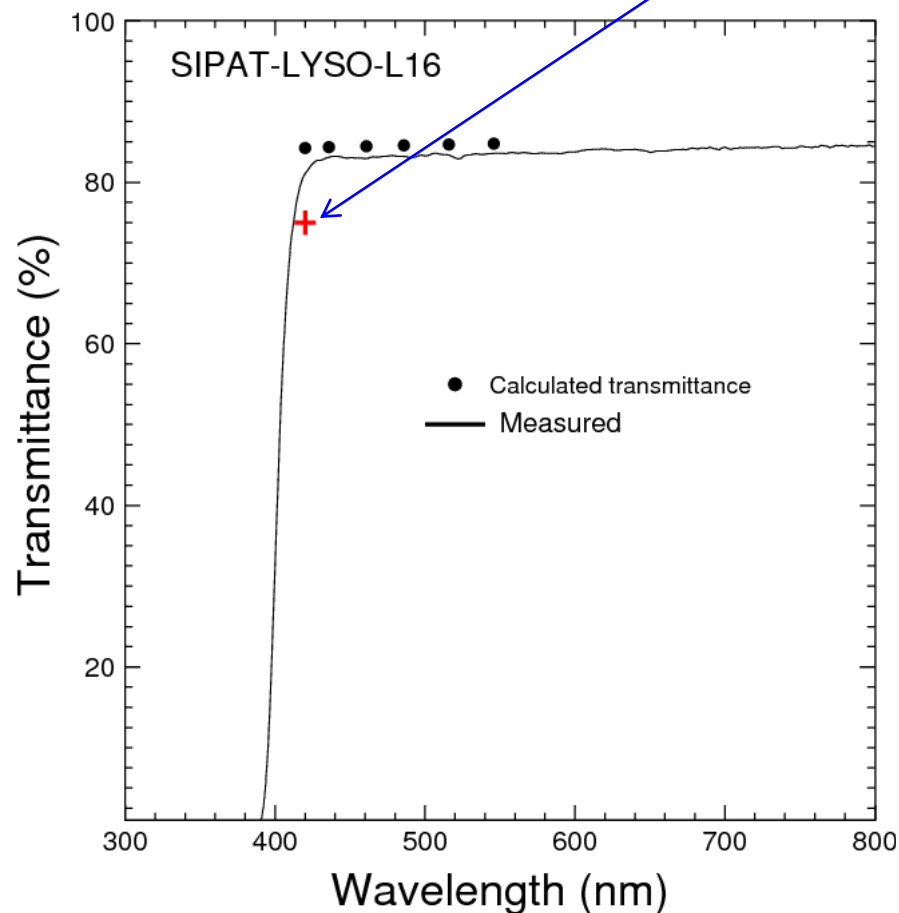
T% specification: 75% @ 420 nm



T% measured by Perkin-Elmer 950 spectrophotometer

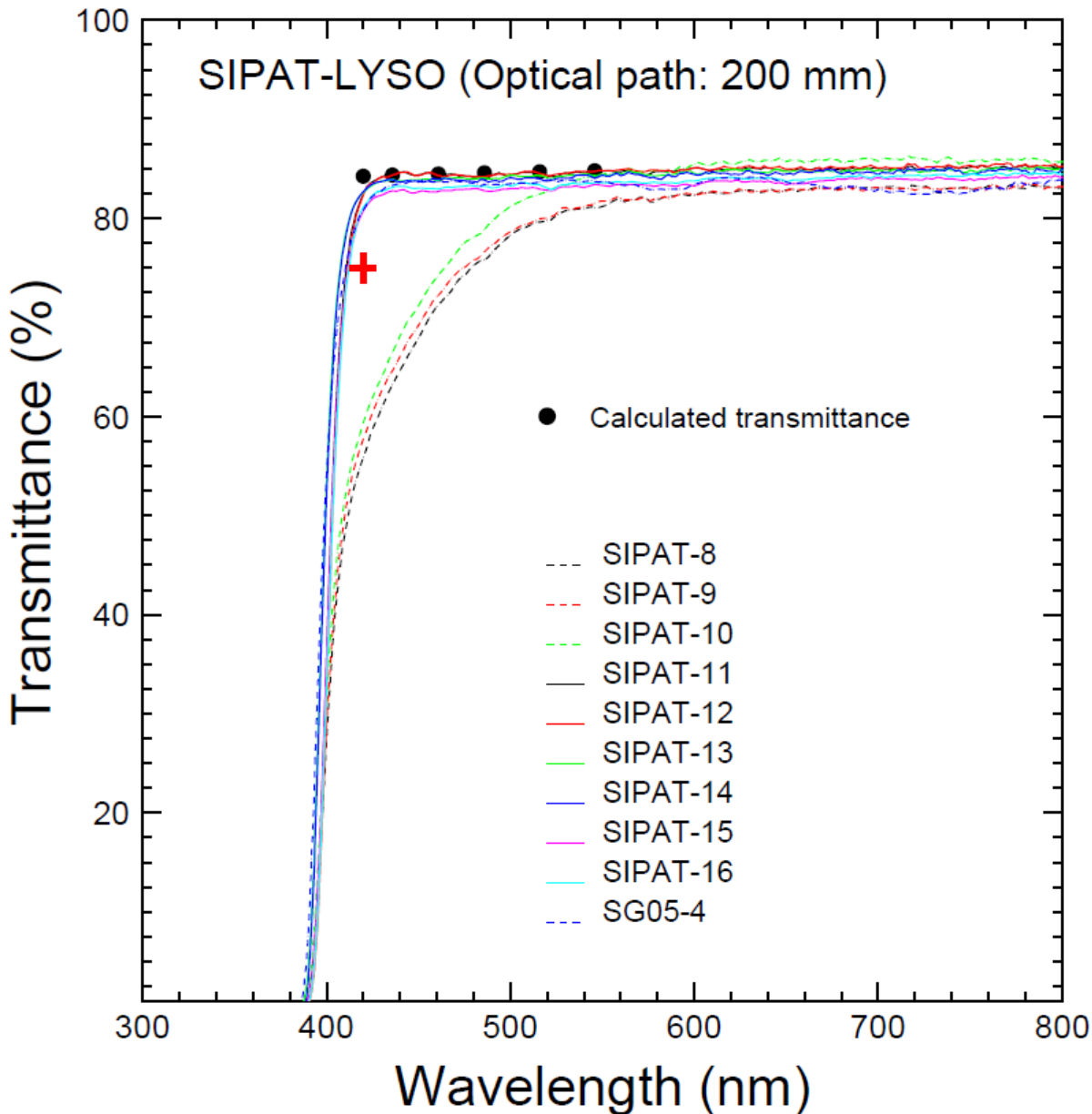
# Optical Transmittance: SIPAT-16

T% specification: 75% @ 420 nm



T% measured by Perkin-Elmer 950 spectrophotometer

# Longitudinal Transmittance

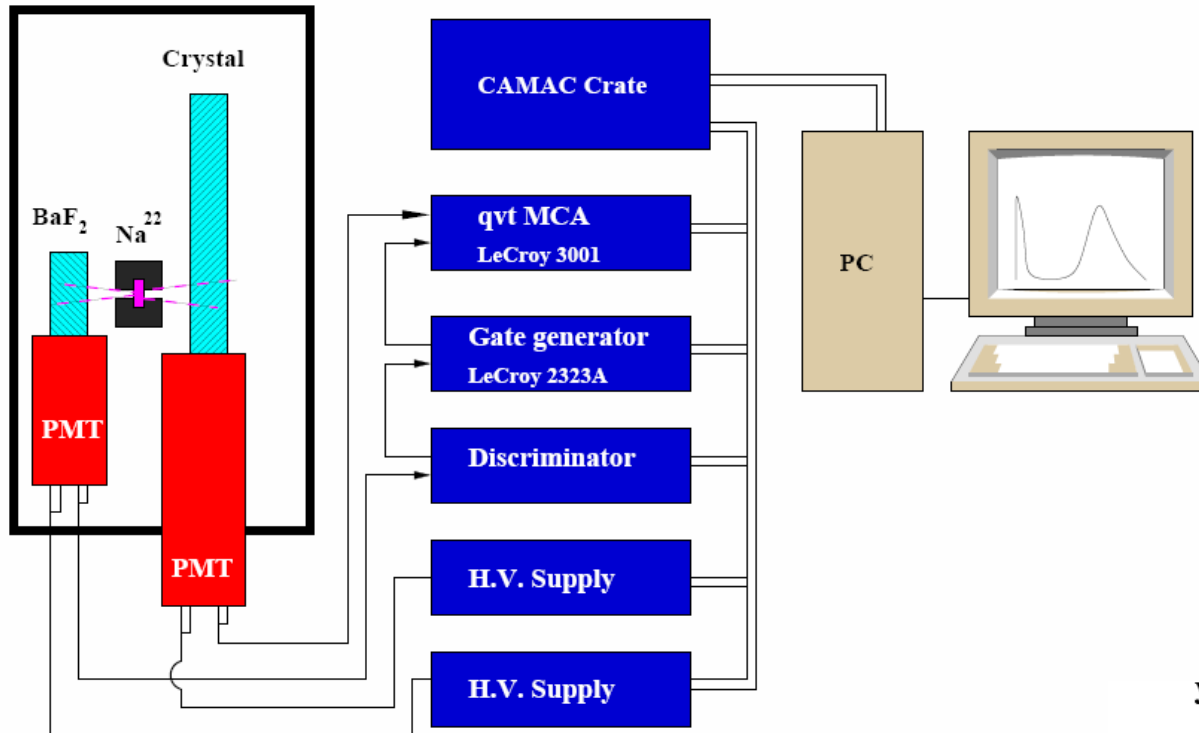


After several iterations and a site visit to SIPAT in late May, the origin of the absorption was correlated to the poor quality of a seed crystal used.

A specification for the longitudinal transmittance (+) was added:  
> 75% @ 420 nm

All SuperB test beam crystals accepted satisfy this specification and show no absorption band.

# L.O. & FWHM: by R1306 PMT

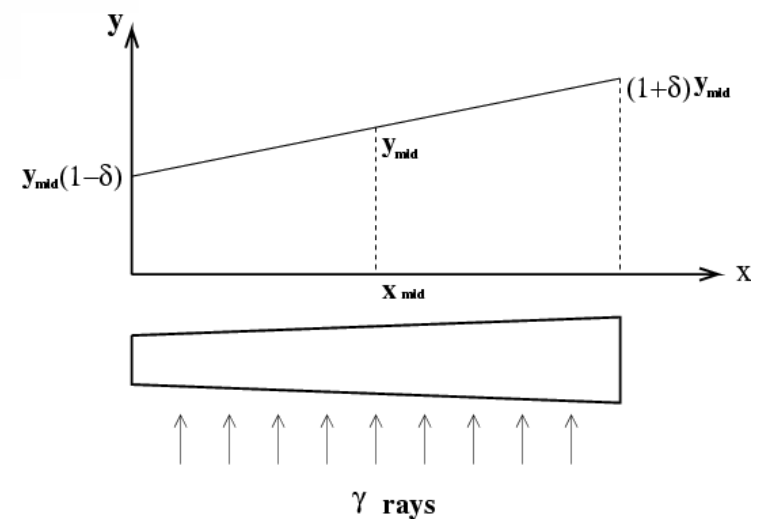


Two layers of Tyvek paper wrapping with the large end coupled to PMT

Hamamatsu R1306 PMT  
HV = -1050V  
Air gap (L.O.)  
DC-200 grease (E.R.)

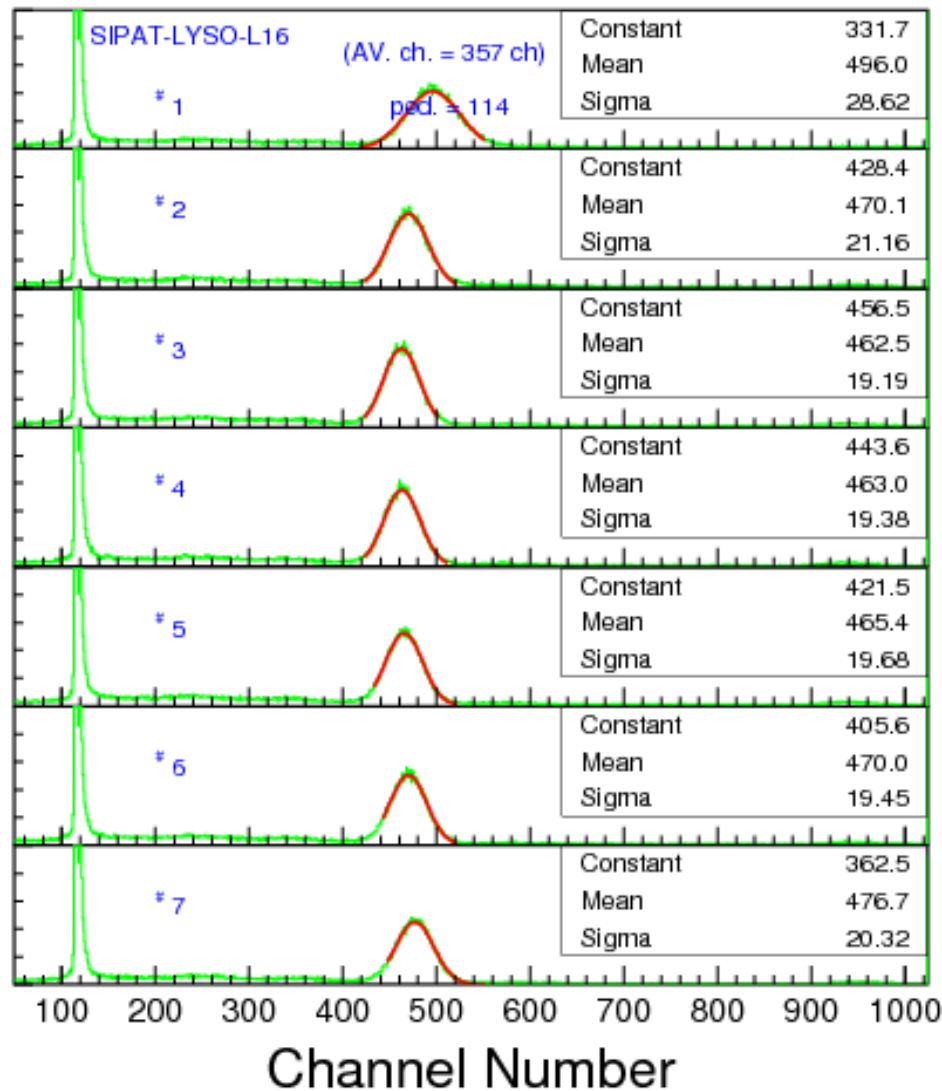
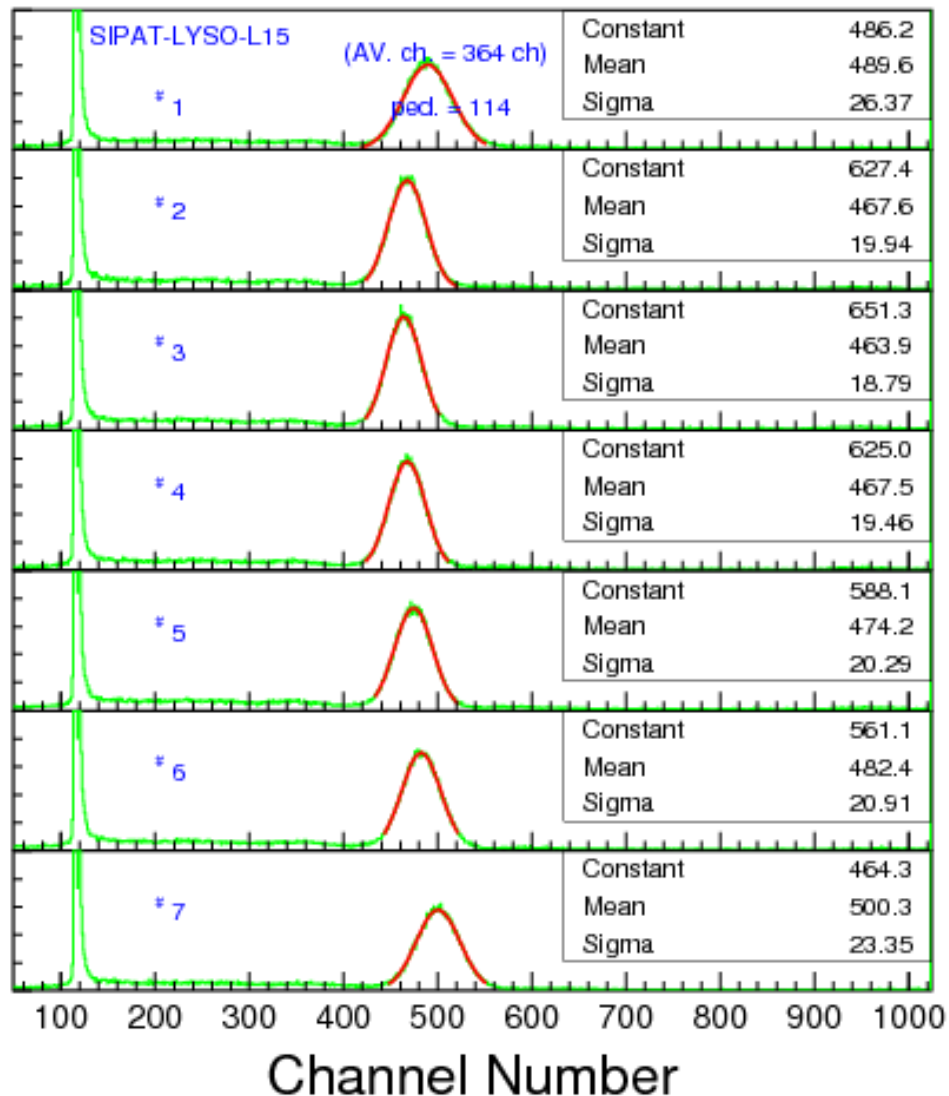
200 ns integration gate  
Coincidence trigger from a Na-22 source

A test bench for the light output and FWHM resolution measurement at seven points along the crystal.





# Relative L.O.: SIPAT-15 & 16



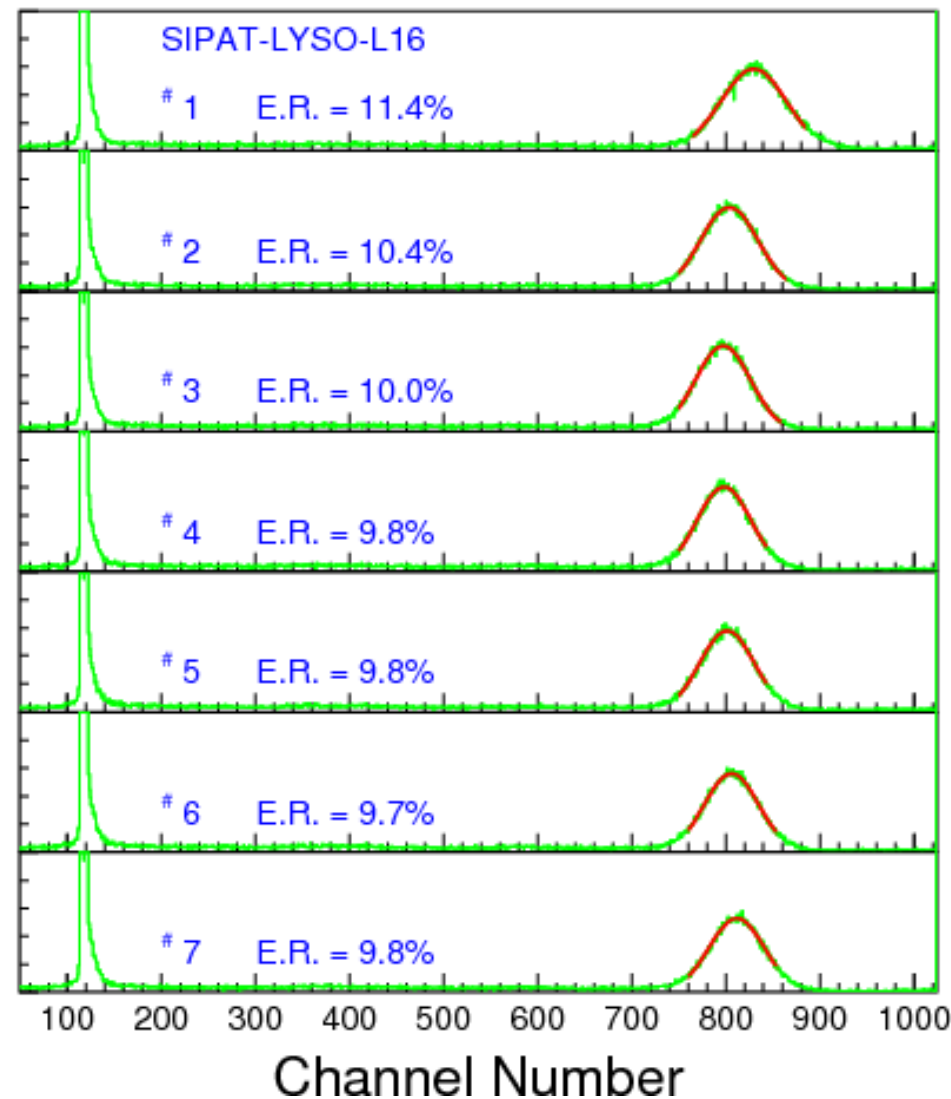
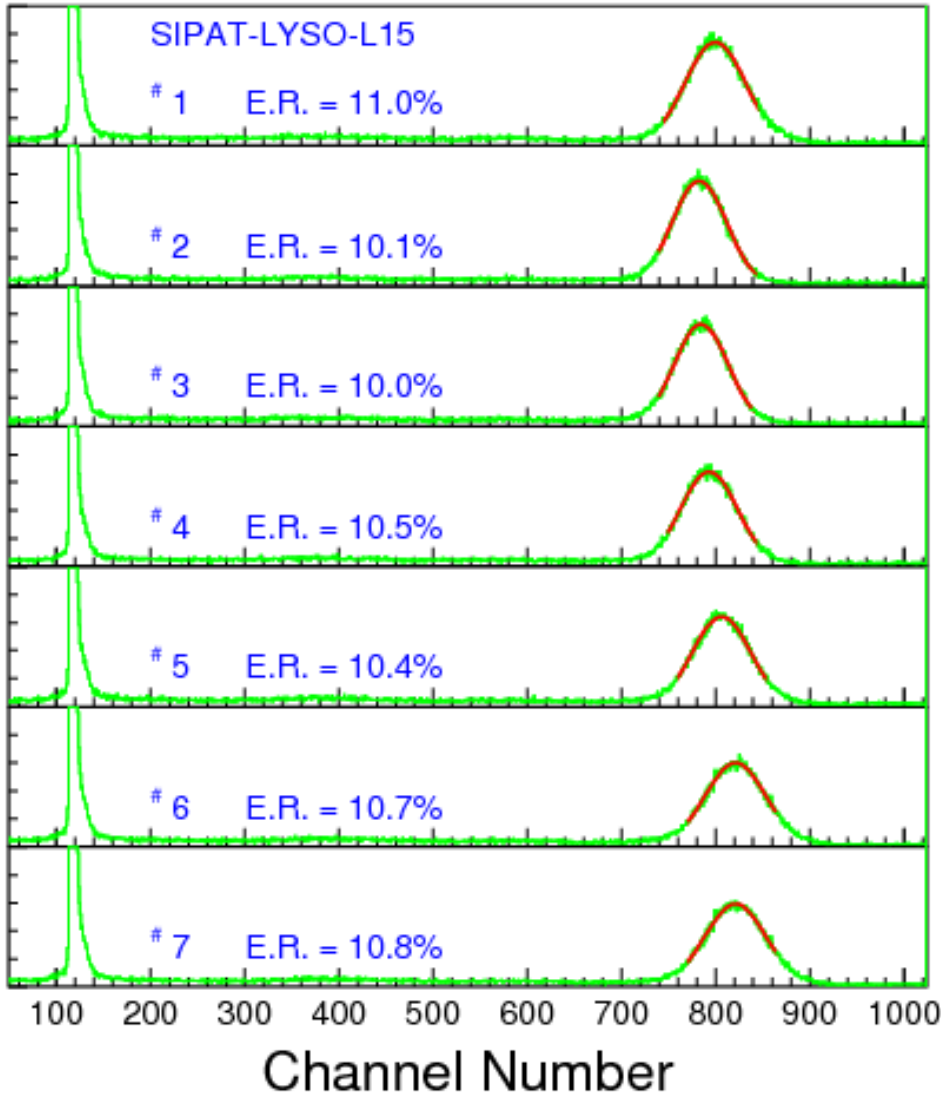
# Summary of Relative L.O. (Air gap)

	Relative L.O. = 100 x L.O. (large sample) / L.O. (candle) (%)
Sample ID	Candle-1 (618ch)
SIPAT-11 (329ch)	53.2
SIPAT-12 (321ch)	51.9
SIPAT-13 (362ch)	58.6
SIPAT-14 (383ch)	62.0
SIPAT-15 (ch364)	58.9
SIPAT-16 (ch357)	57.8
SG-LYSO-05-04 (366ch)	59.2

# Energy Resolution

SIPAT-15: 10.0~11.0%

SIPAT-16: 9.7~11.4%

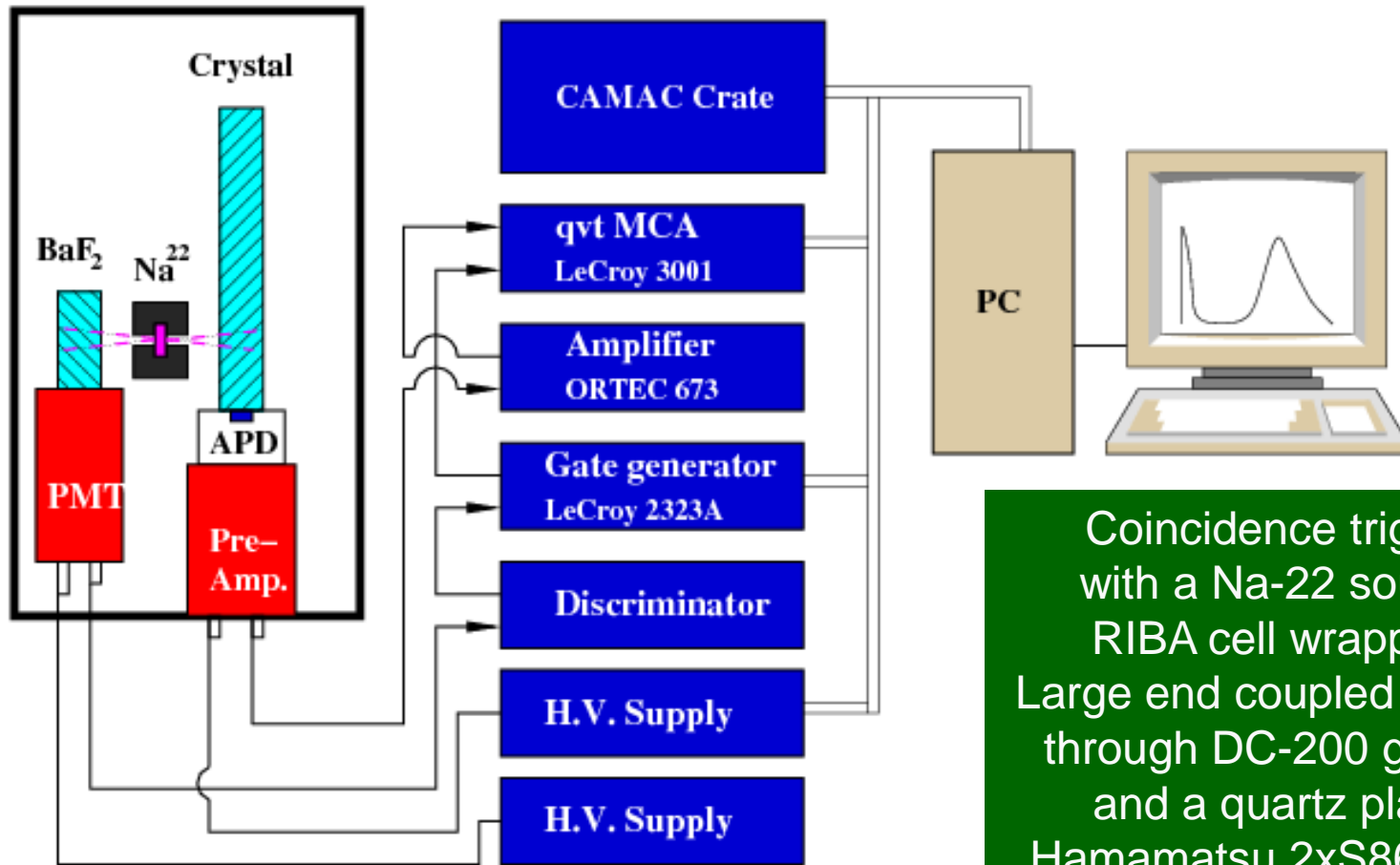


# Summary of FWHM Resolution by PMT

	FWHM Energy Resolution at different points (%)							Mean value (%)
Sample ID	1	2	3	4	5	6	7	
SIPAT-11	10.1	10.0	10.3	10.6	11.0	11.4	11.8	10.7
SIPAT-12	10.3	9.9	10.0	10.4	10.5	11.0	11.0	10.4
SIPAT-13	12.0	11.0	10.9	11.2	11.5	11.8	12.2	11.5
SIPAT-14	12.4	11.3	10.8	10.3	10.7	10.4	10.5	10.9
SIPAT-15	11.0	10.1	10.0	10.5	10.4	10.7	10.8	10.5
SIPAT-16	11.4	10.4	10.0	9.8	9.8	9.7	9.8	10.1
SG-LYSO-05-04	12.0	10.0	9.7	10.7	10.3	10.5	10.4	10.5

# Setup for LRU Measurement by APD

APD: Hamamatsu 2xS8664-55

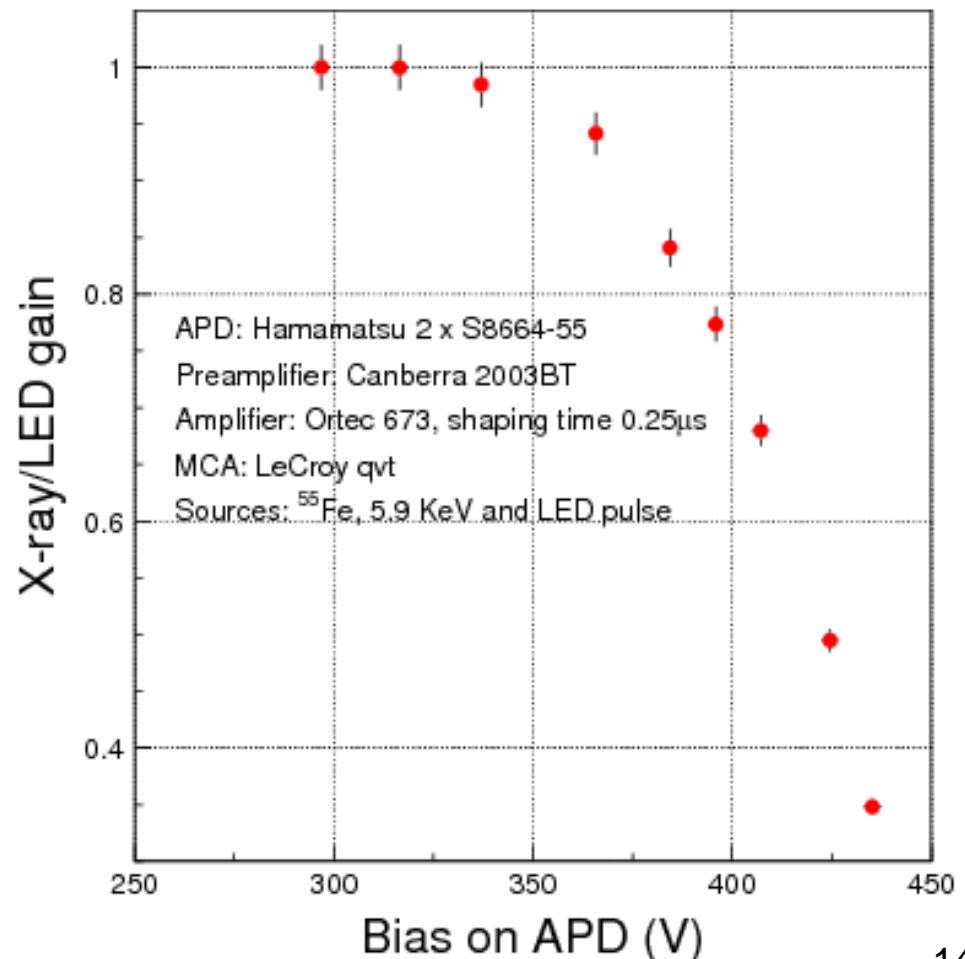
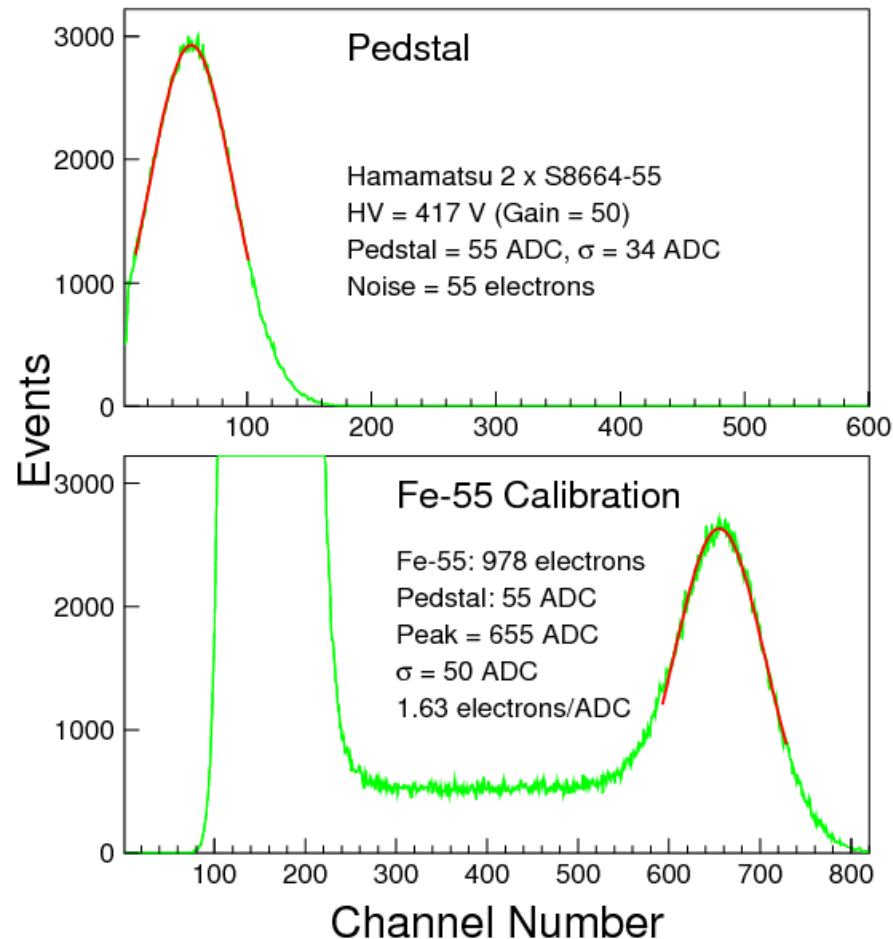


Coincidence trigger  
with a Na-22 source  
RIBA cell wrapping  
Large end coupled to APD  
through DC-200 grease  
and a quartz plate.  
Hamamatsu 2xS8664-55  
with bias at 417V for gain  
of about 50.

# Calibration of APD Using Fe-55

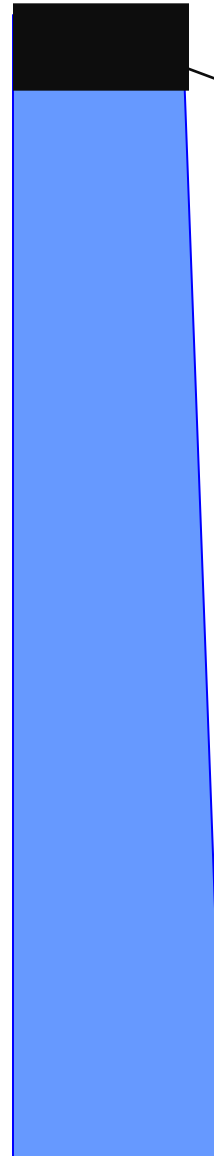
Calibration with Fe-55 X-ray  
Noise: 55 electrons

Correction factor: the ratio of APD responses between 5.9 keV X-ray and blue LED pulse: 0.72 @ 417 V



# Uniformization

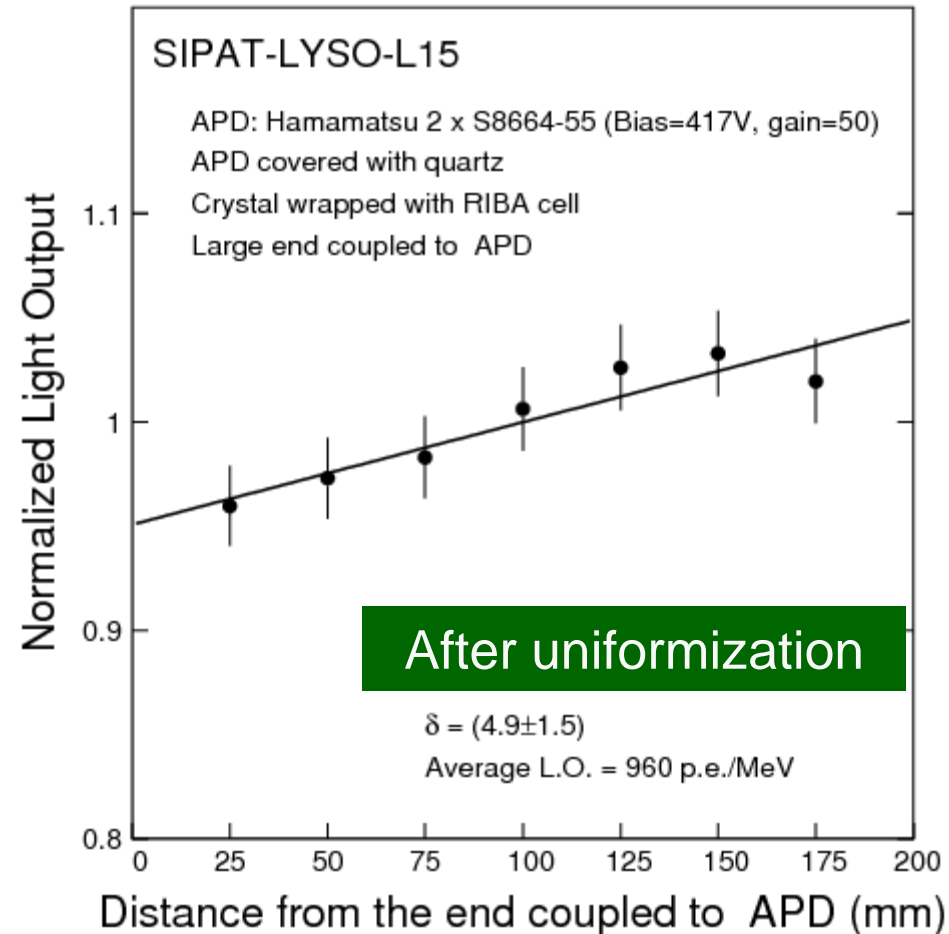
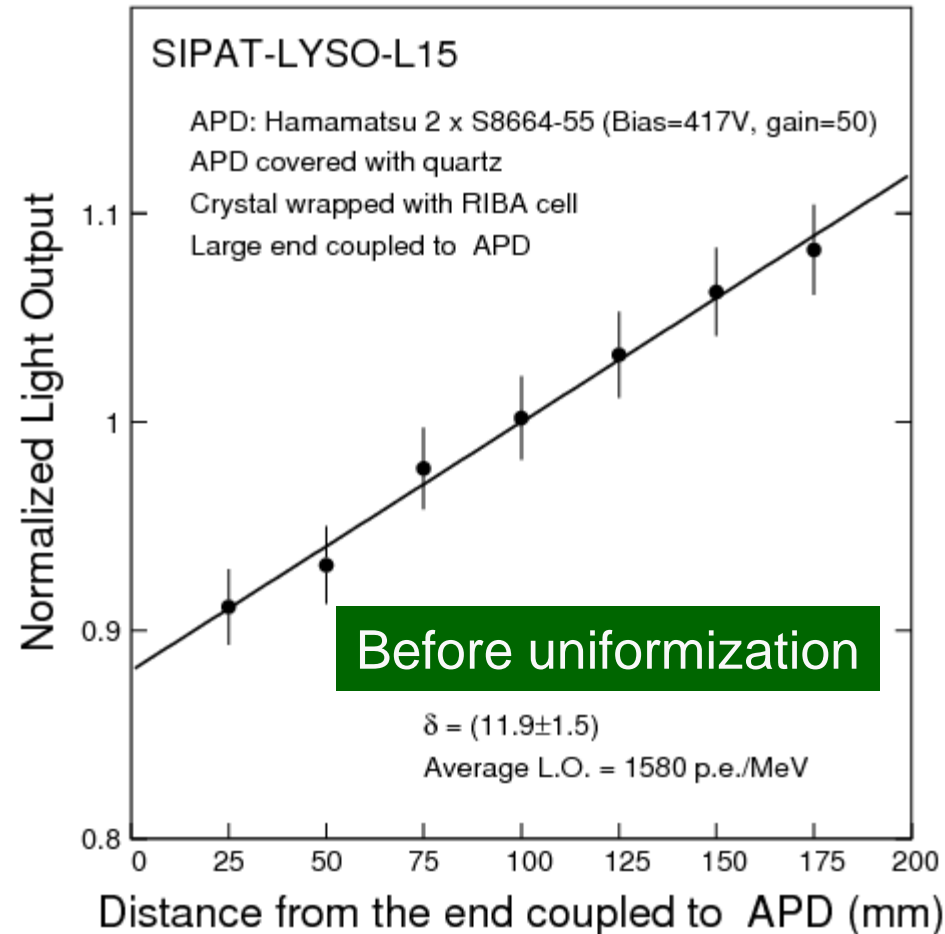
A black band is painted at the end of the smallest side surface of the crystal: 0-15 mm from front face.



A black band with Length of 15 mm

# Uniformization: SIPAT-15

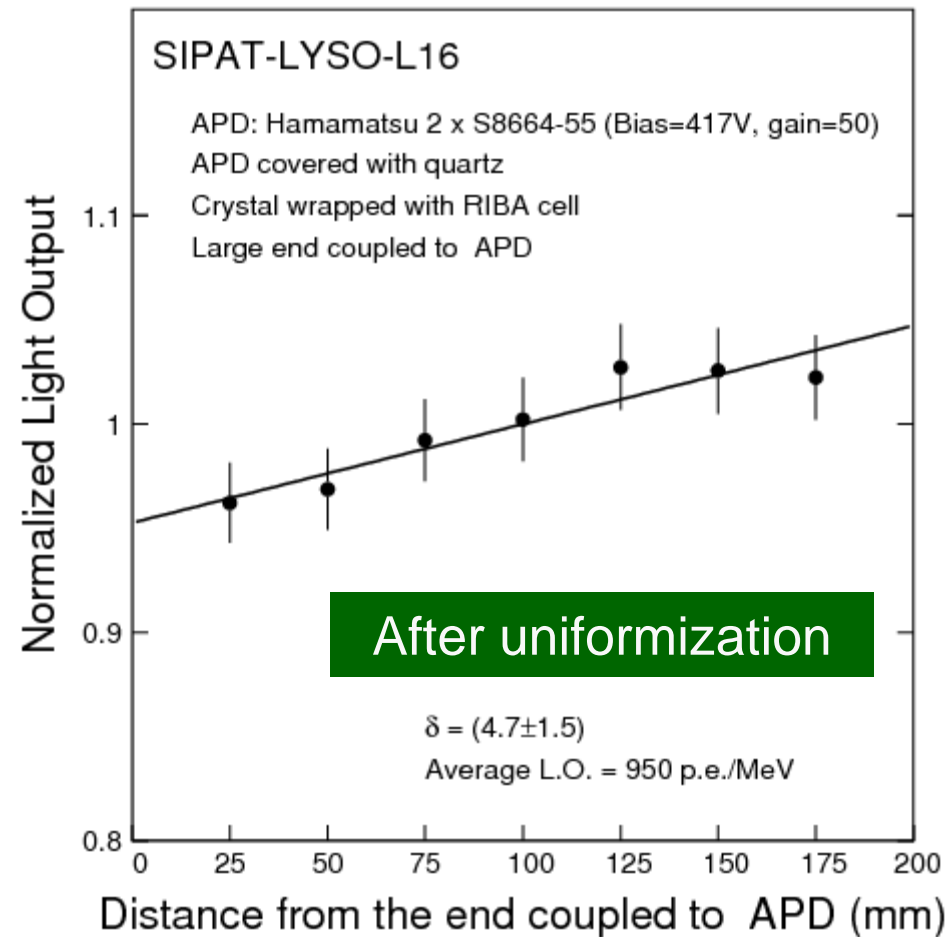
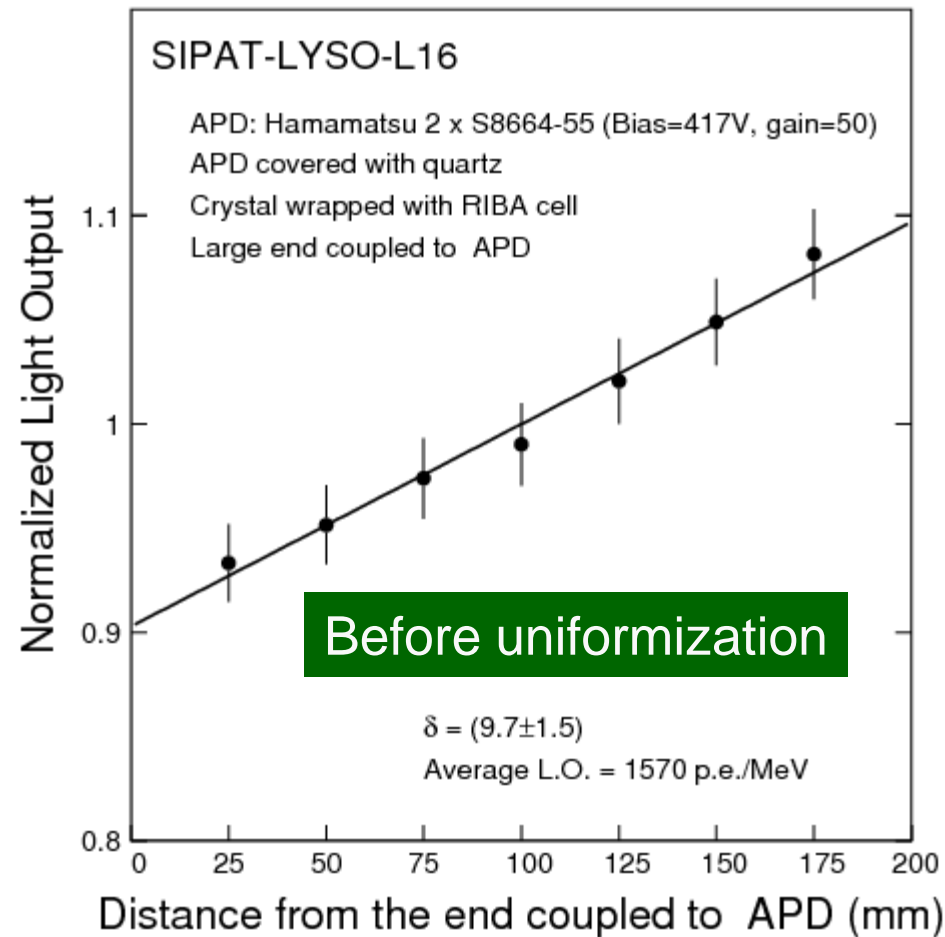
A good light response uniformity of  $< 5\%$  can be achieved with black paint with a price of losing 40% of the light output.





# Uniformization: SIPAT-16

A good light response uniformity of  $< 5\%$  can be achieved with black paint with a price of losing 40% of the light output.



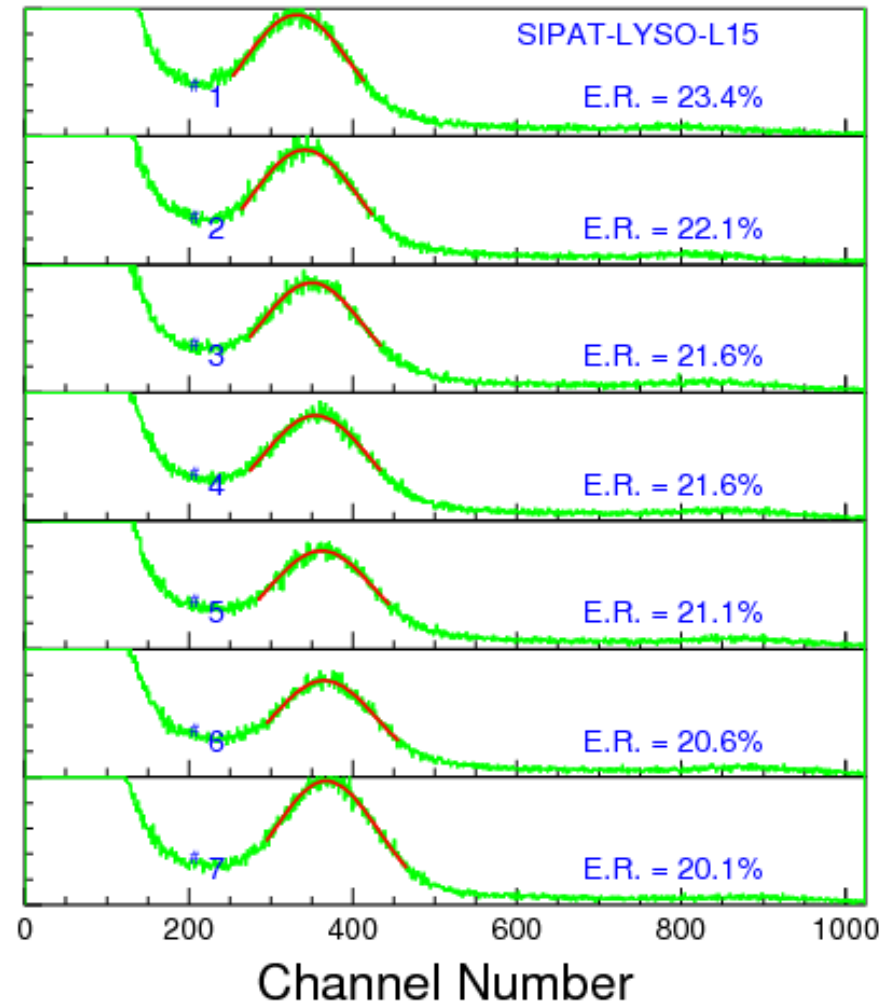
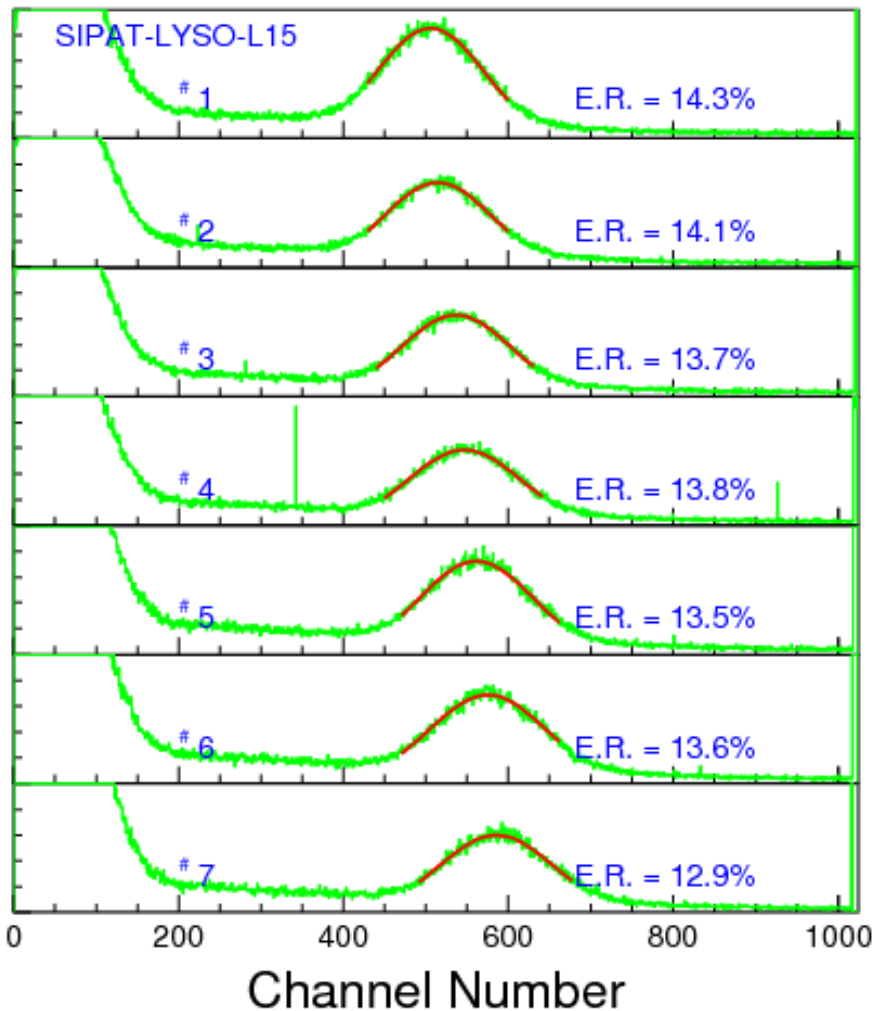
# Uniformization Summary

ID		LRU		Light output (p.e./MeV)		L.Y. Loss (%)
		$\Delta$ (%)	RMS (%)	LY <sub>mid</sub>	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	

# E.R. ( $\sigma$ ) by APD: SIPAT-15

Before uniformization:  
12.9~14.3%

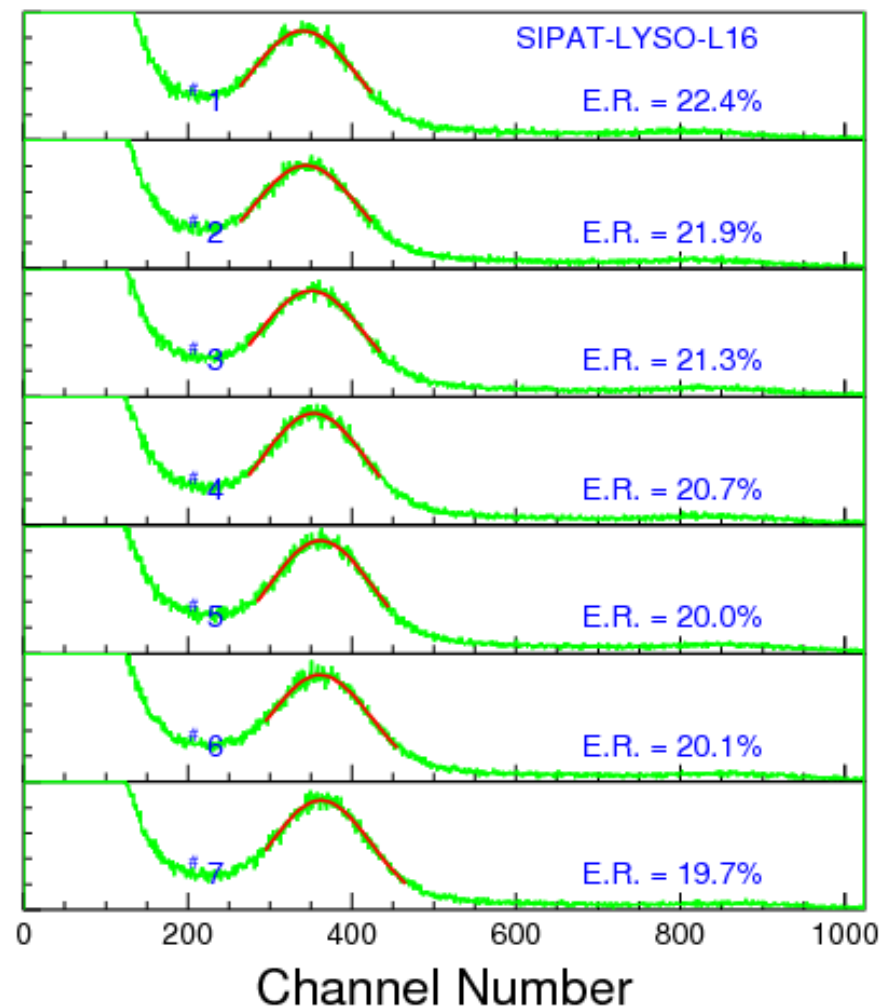
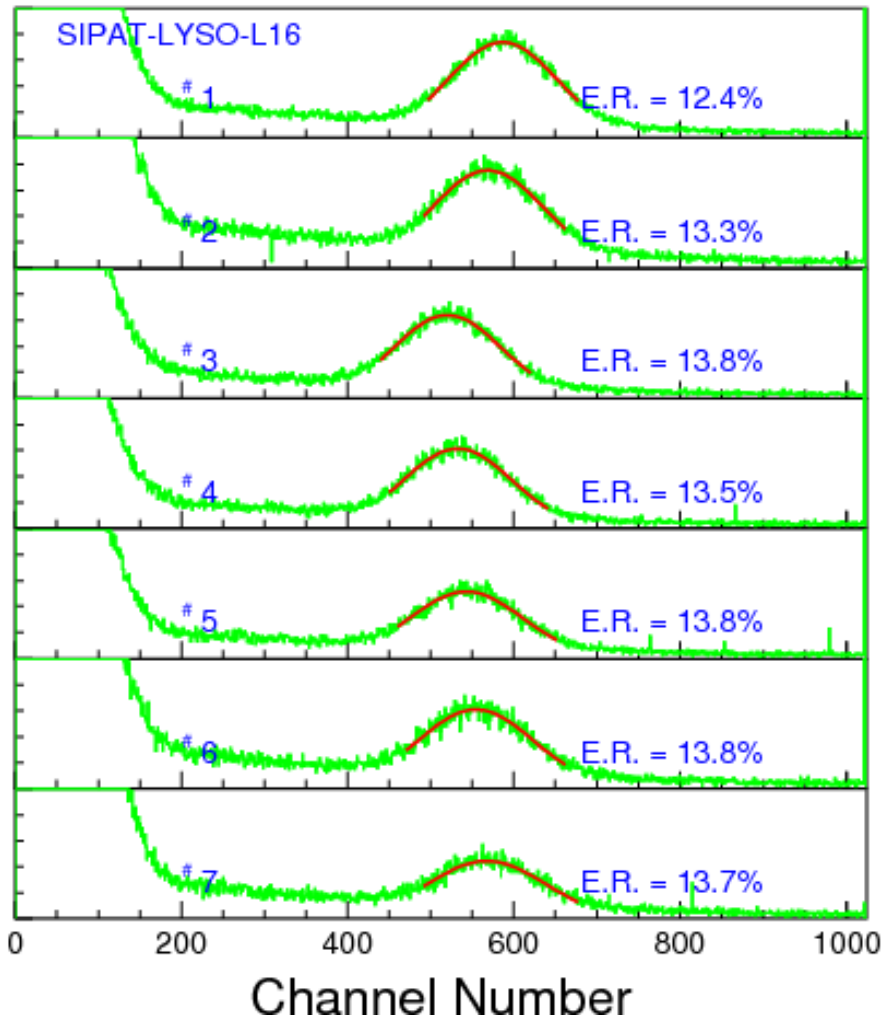
After uniformization:  
20.1~23.4%



# E.R. ( $\sigma$ ) by APD: SIPAT-16

Before uniformization:  
12.4~13.8%

After uniformization:  
19.7~22.4%

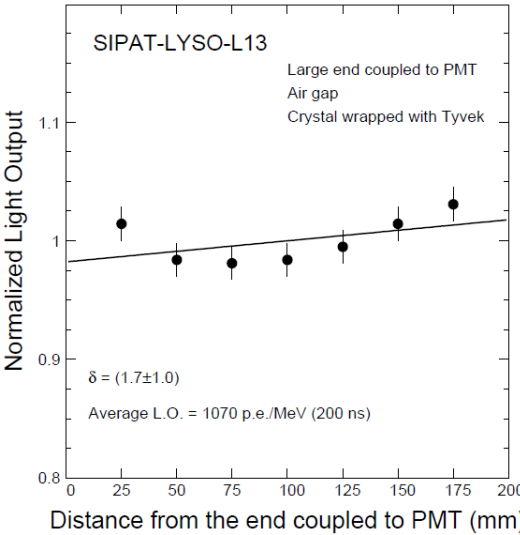


# Summary of Energy Resolution ( $\sigma$ ) by APD

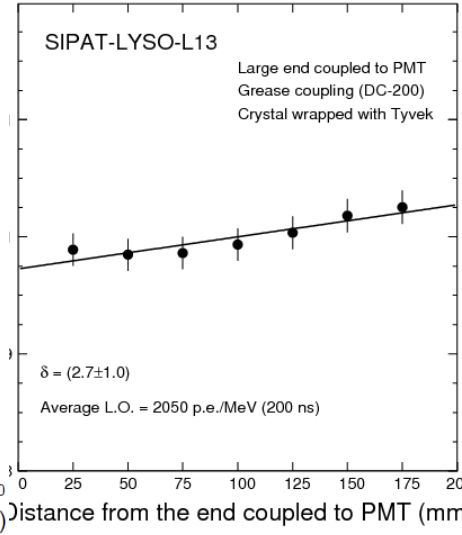
Sample ID		Energy resolution (%) (Mean value of $\sigma$ at 7 locations)
SIPAT-11	Before	15.5
	After	27.4
SIPAT-12	Before	15.1
	After	26.7
SIPAT-13	Before	14.9
	After	22.6
SIPAT-14	Before	14.9
	After	24.7
SIPAT-15	Before	13.7
	After	21.5
SIPAT-16	Before	13.5
	After	20.9
SG-05-04	Before	17.3
	After	23.8

# L.O. with Different Wrappings

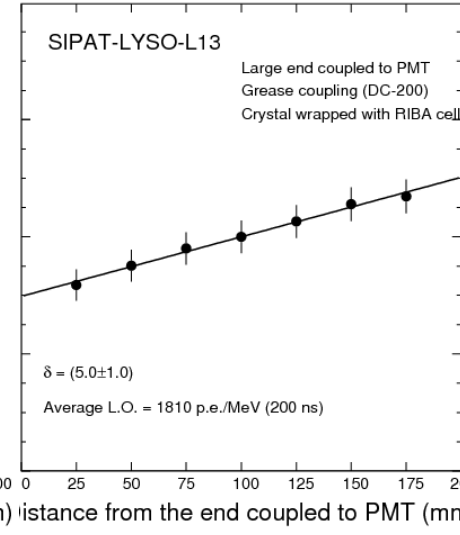
Tyvek, Air Gap



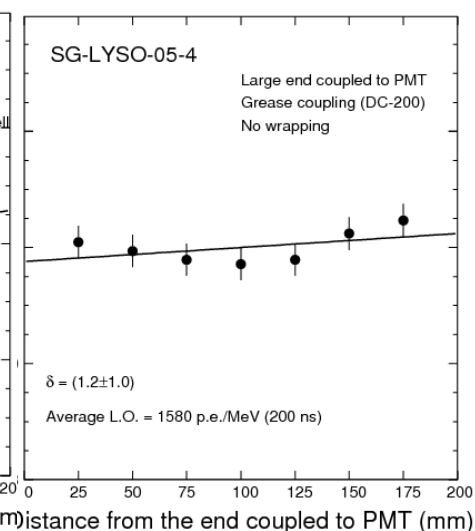
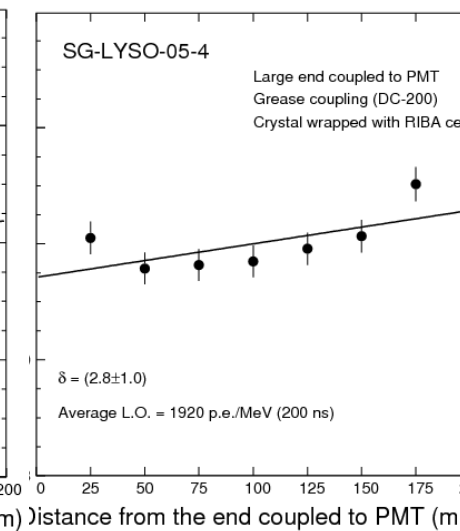
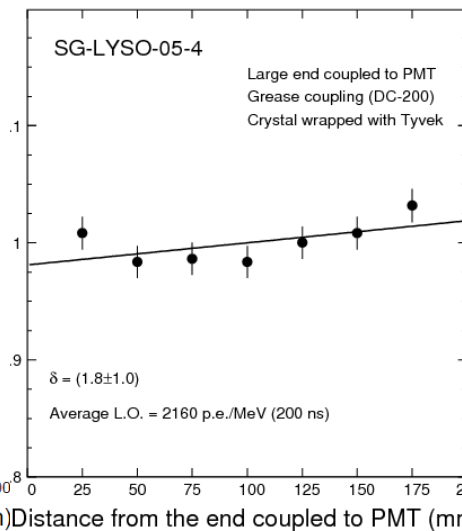
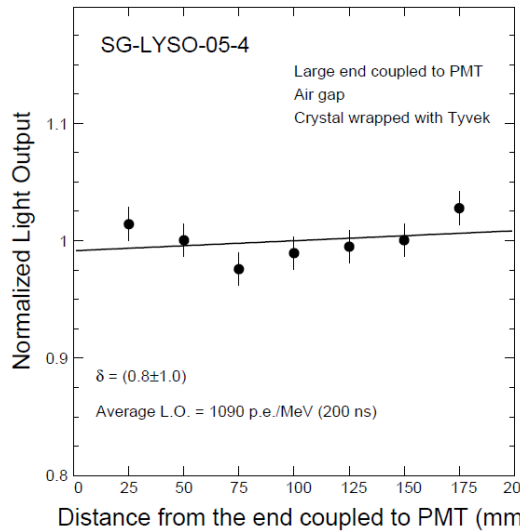
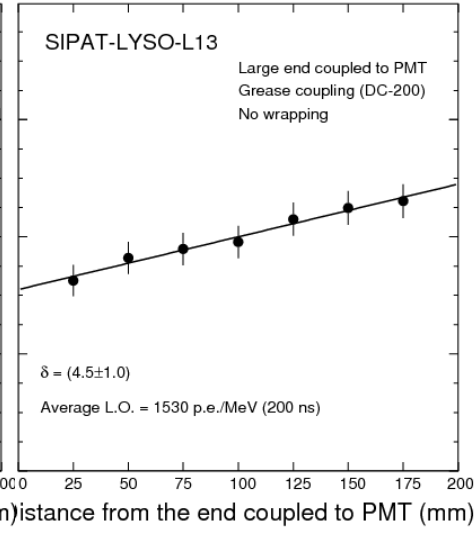
Tyvek, Grease



Riba, Grease



Bare, Grease



# L.O. with Different Wrappings: Summary

Tyvek and grease has the highest L.O  
50% loss for air gap coupling  
11% and 26% loss for Riba cell and bare crystals  
17% loss for bare as compared to Riba cell

ID	Tyvek & Air Gap	Tyvek & Grease	Ratio A-G/Grease	RIBA cell & Grease	Bare crystal & Grease	Ratio RIBA /Tyvek	Ratio Bare/Tyvek	Ratio Bare/RIBA
SIPAT-13	1070	2050	52%	1810	1530	88.3%	74.6%	84.5%
SG-05-4	1090	2160	50%	1920	1580	88.9%	73.1%	82.3%

# Summary

All crystals delivered meet specifications in dimension, longitudinal transmittance and resolution.

The light output and energy resolution are compatible between the SG sample and SIPAT samples.

900 p.e./MeV seems achievable for the APD readout with Riba cell, consisting with 4 p.e./MeV observed for CMS PWO crystals.

15% and 25% energy resolutions are achievable for 0.511  $\gamma$ -rays with the APD readout and Riba cell before and after uniformization respectively, where 55 electrons readout noise plays an role.

50% LO loss is observed for the air gap versus grease coupling. 11% and 26% losses are observed for Riba cell and bare crystals.

Additional loss for the uniformization with black paint at the small end is about 40%. Further investigation is needed to explore a better approach.



# EWQE for LYSO Crystals by PMT and APD

