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# Report on the Twelve Mu2e LYSO Crystals from SIC

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# Samples and Experiment



ID	Dimension (mm <sup>3</sup> )	Received Data	Polish
SIC-1	30 × 30 × 130	1/13/2014	All faces
SIC-2	30 × 30 × 130	1/13/2014	All faces
SIC-3	30 × 30 × 130	1/13/2014	All faces
SIC-4	30 × 30 × 130	1/13/2014	All faces
SIC-5	30 × 30 × 130	1/13/2014	All faces
SIC-6	30 × 30 × 130	1/13/2014	All faces
SIC-7	30 × 30 × 130	1/13/2014	All faces
SIC-8	30 × 30 × 130	1/13/2014	All faces
SIC-9	30 × 30 × 130	1/13/2014	All faces
SIC-10	30 × 30 × 130	1/13/2014	All faces
SIC-11	Hexagon 18.6 × 130	1/13/2014	All faces
SIC-12	Hexagon 18.6 × 130	1/13/2014	All faces

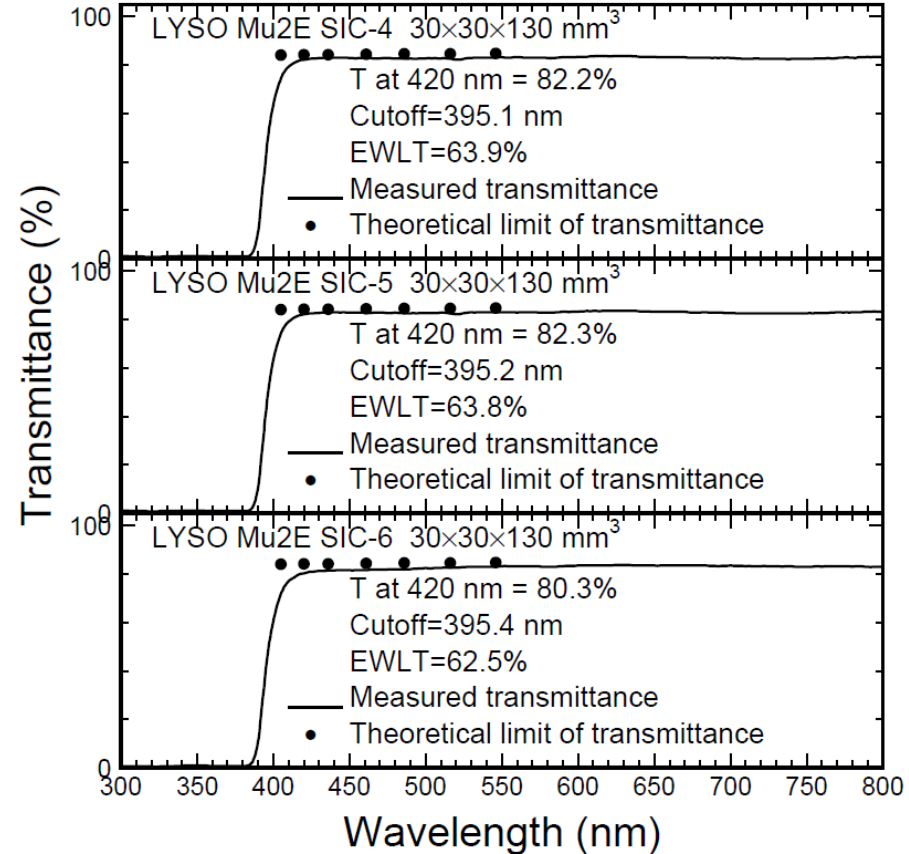
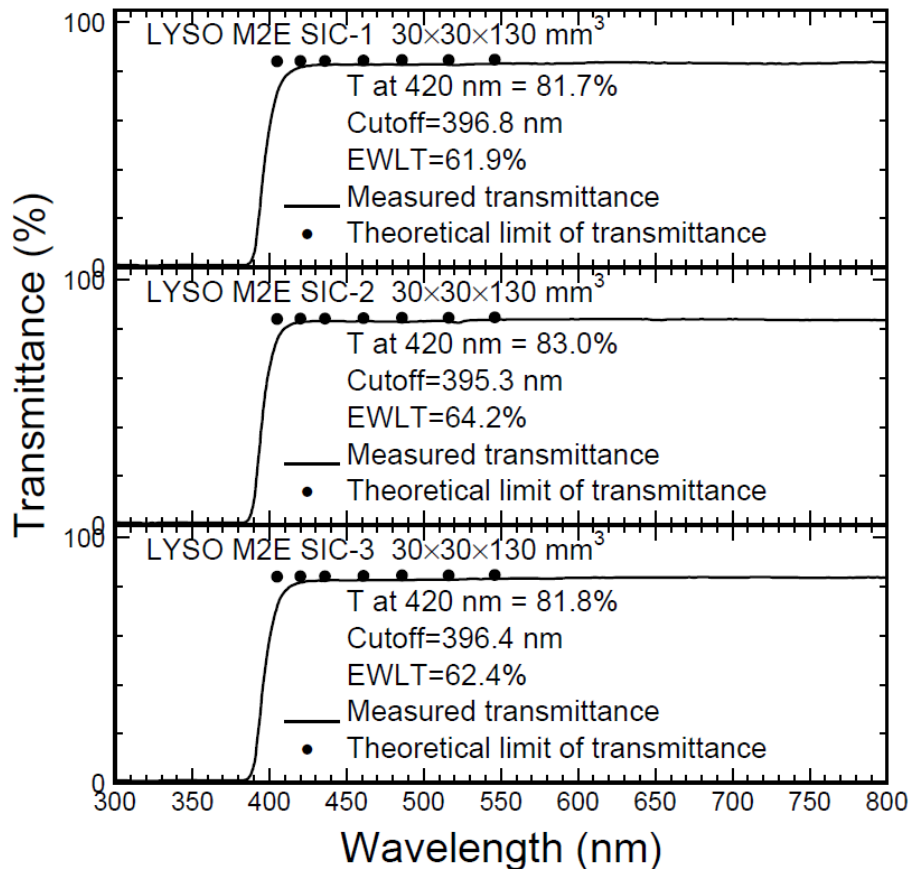
- Properties measured at room temperature: LT , LO, LRU and Decay;
- Crystal ID is marked at the A end (coupling end for better uniformity);
- Decay time was measured at the 1<sup>st</sup> point to the A end coupled to PMT.

# Optical and Scintillation Specification

1. All faces shall be optically polished with a roughness  $R_a < 0.02 \mu\text{m}$ .
2. The longitudinal transmittance (130 mm path length) shall be  $> 75\%$  at 420 nm.
3. The energy resolution shall be  $< 12.5\%$  (FWHM) at 511 keV, measured with a  $^{22}\text{Na}$  source and a large area photomultiplier tube (Hamamatsu R1306 or equivalent) coupled to the crystal with optical grease.
4. The decay time constant for the scintillation light shall be 50 ns or less.

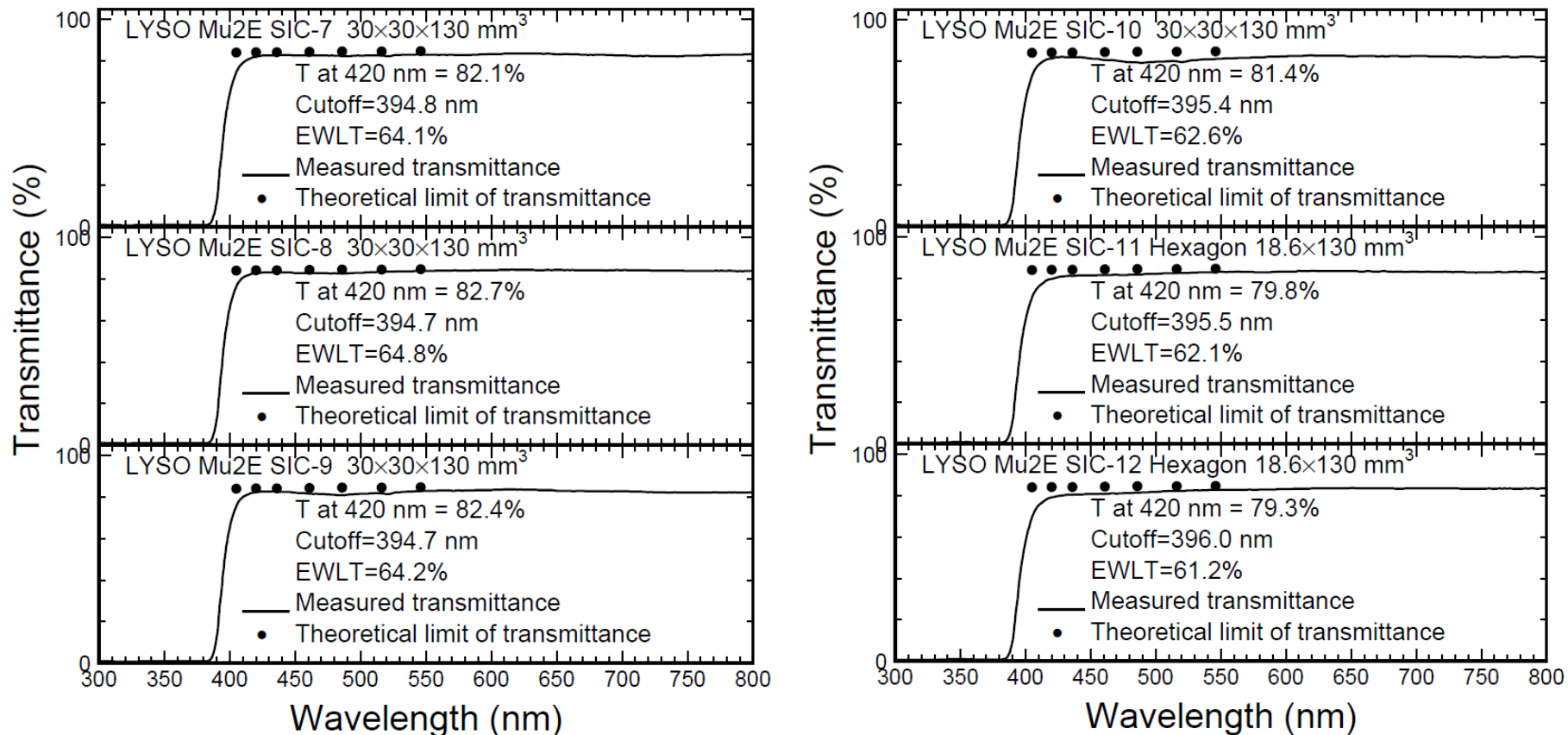
# Longitudinal Transmittance (LT)

All crystals approach theoretical limit, indicating good optical quality



# Longitudinal Transmittance (LT)

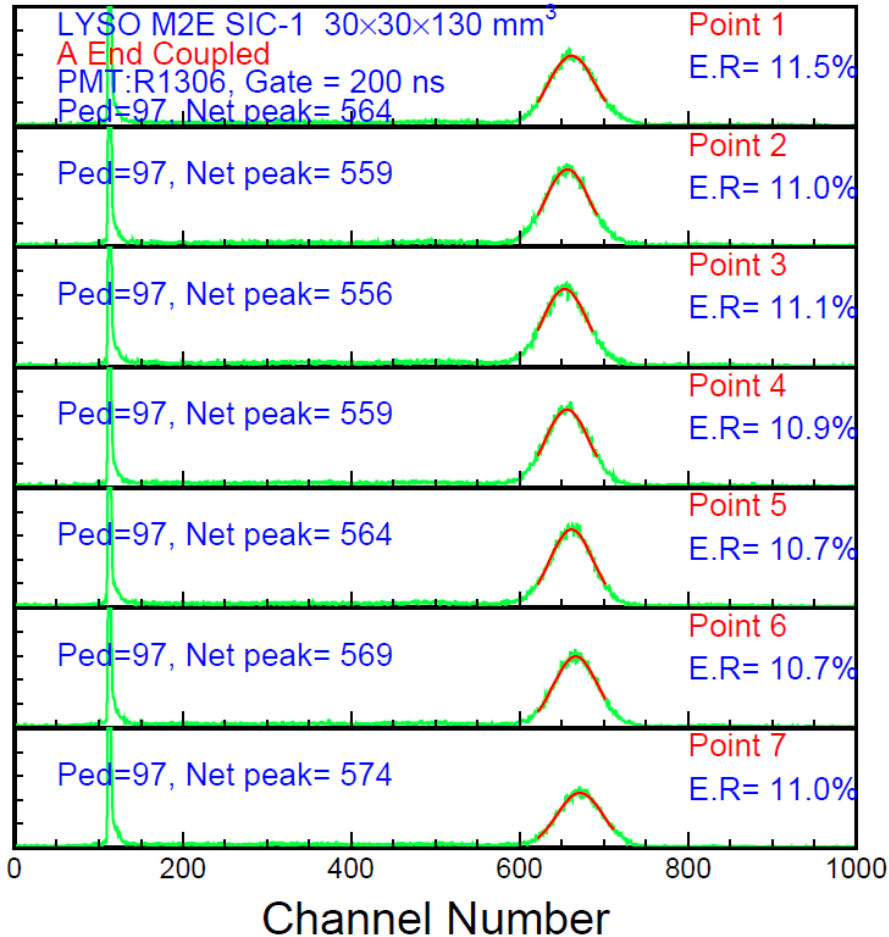
All crystals approach theoretical limit, indicating good optical quality



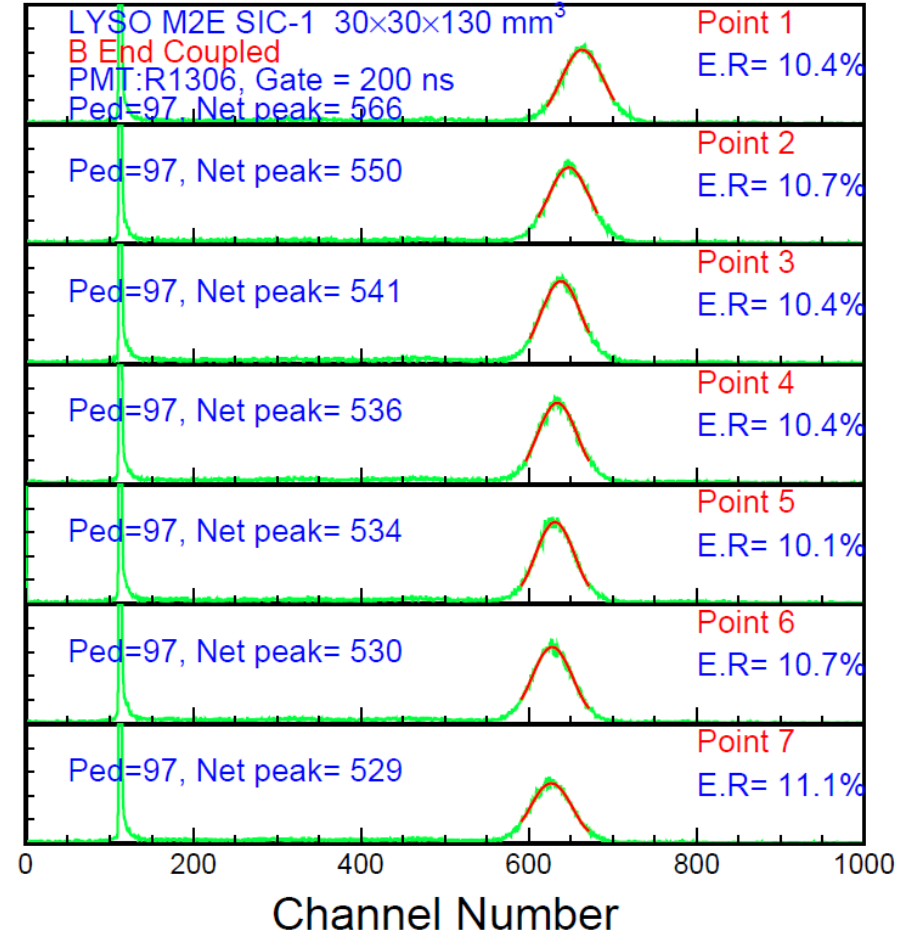
Hexagonal crystal SIC-12 has the lowest LT, but meets 75% specification

# Pulse Height Spectra & FWHM: SIC-1

A: Average ER = 11.0 %



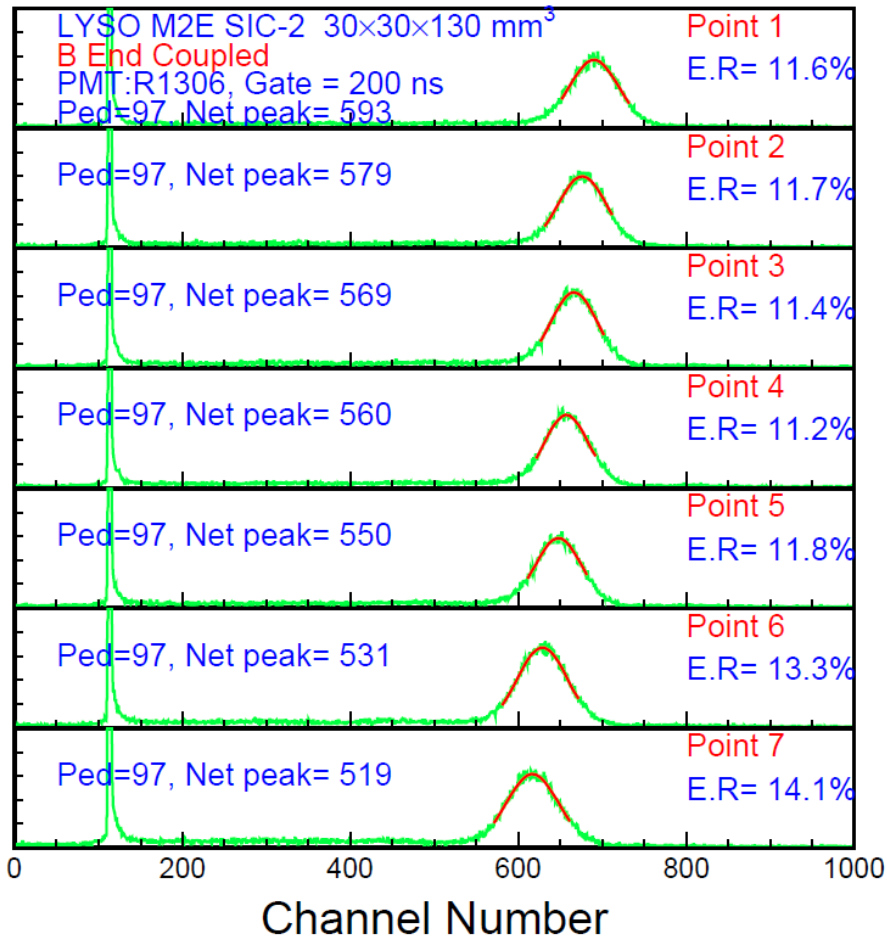
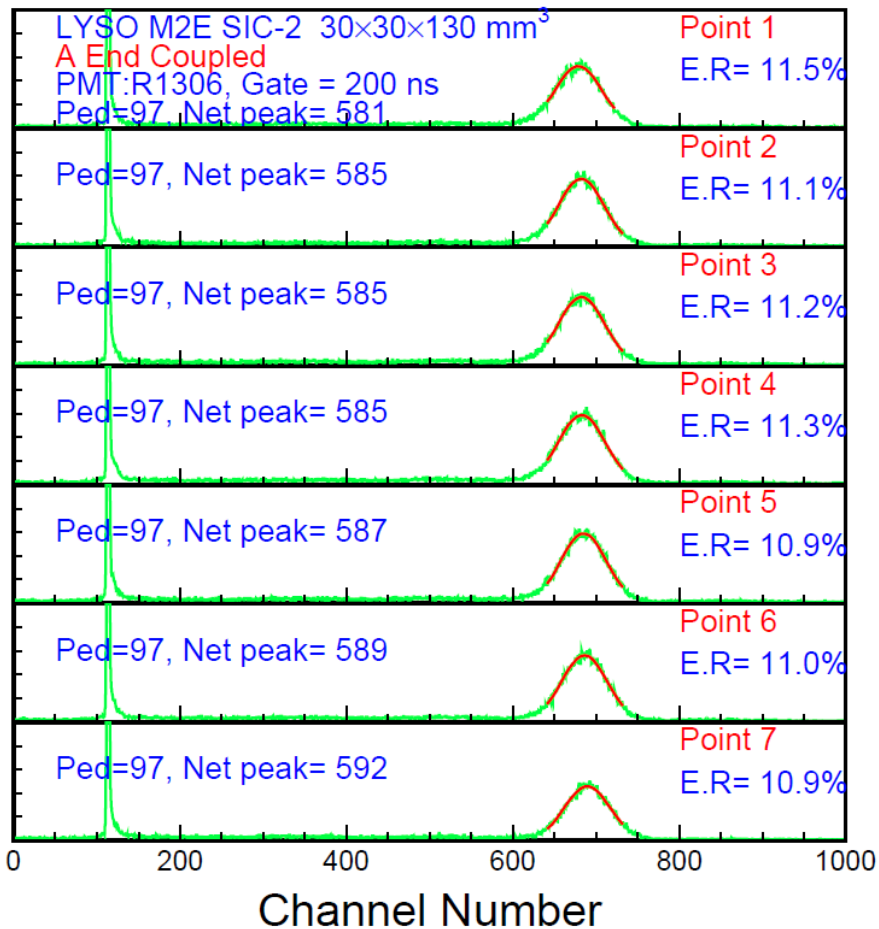
B: Average ER = 10.5 %



# Pulse Height Spectra & FWHM: SIC-2

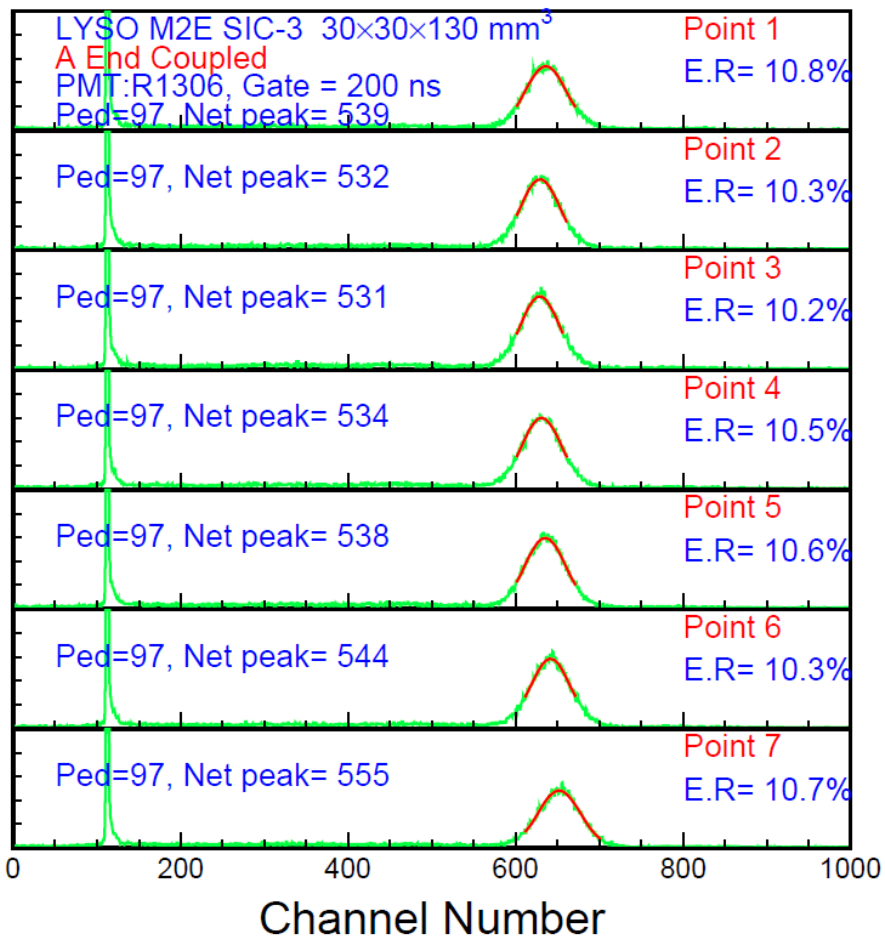
A: Average ER = 11.1%

B: Average ER = 12.2 %

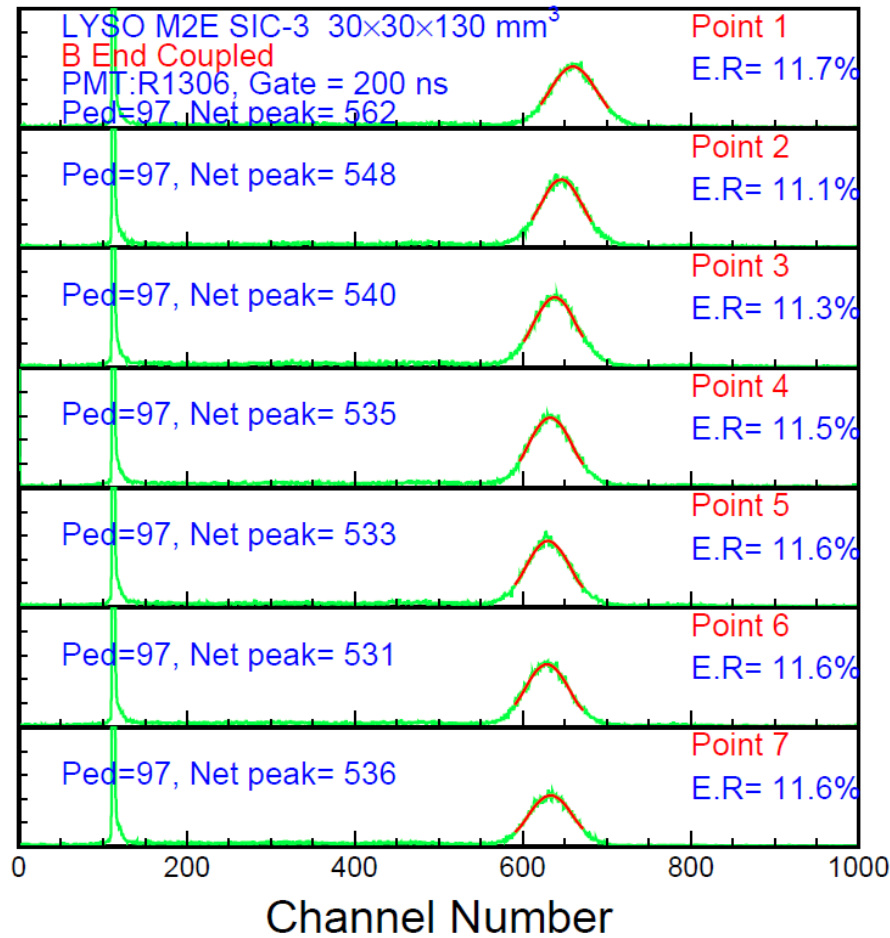


# Pulse Height Spectra & FWHM: SIC-3

A: Average ER = 10.5 %



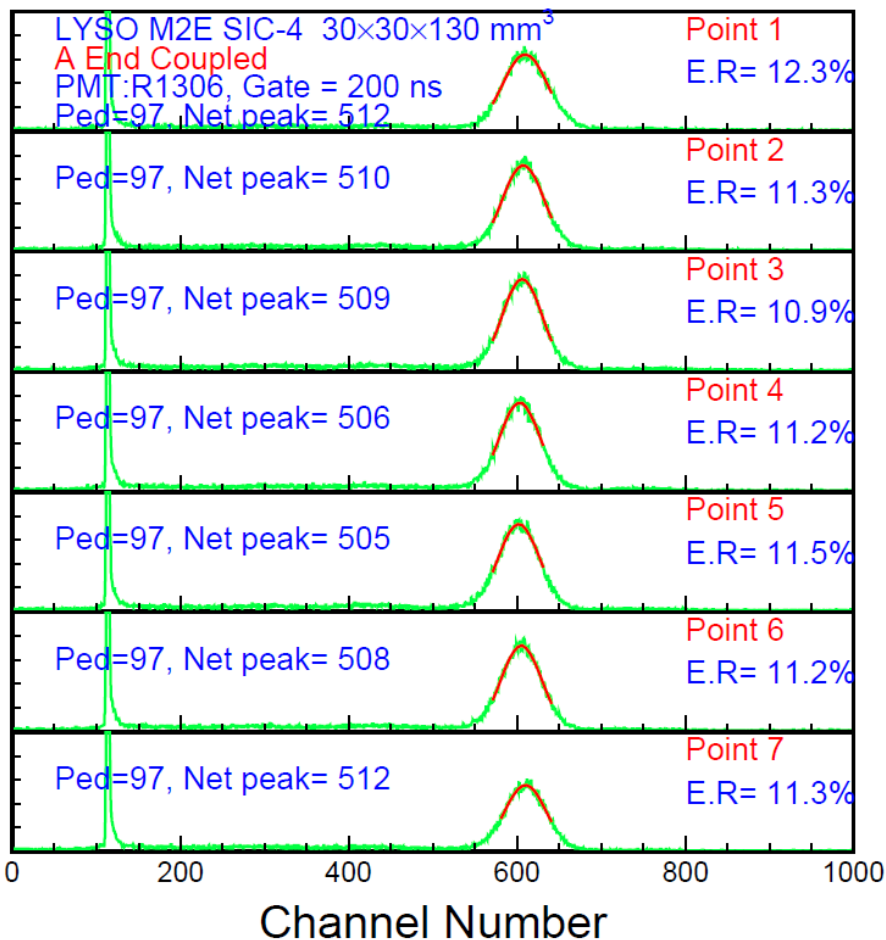
B: Average ER = 11.5 %



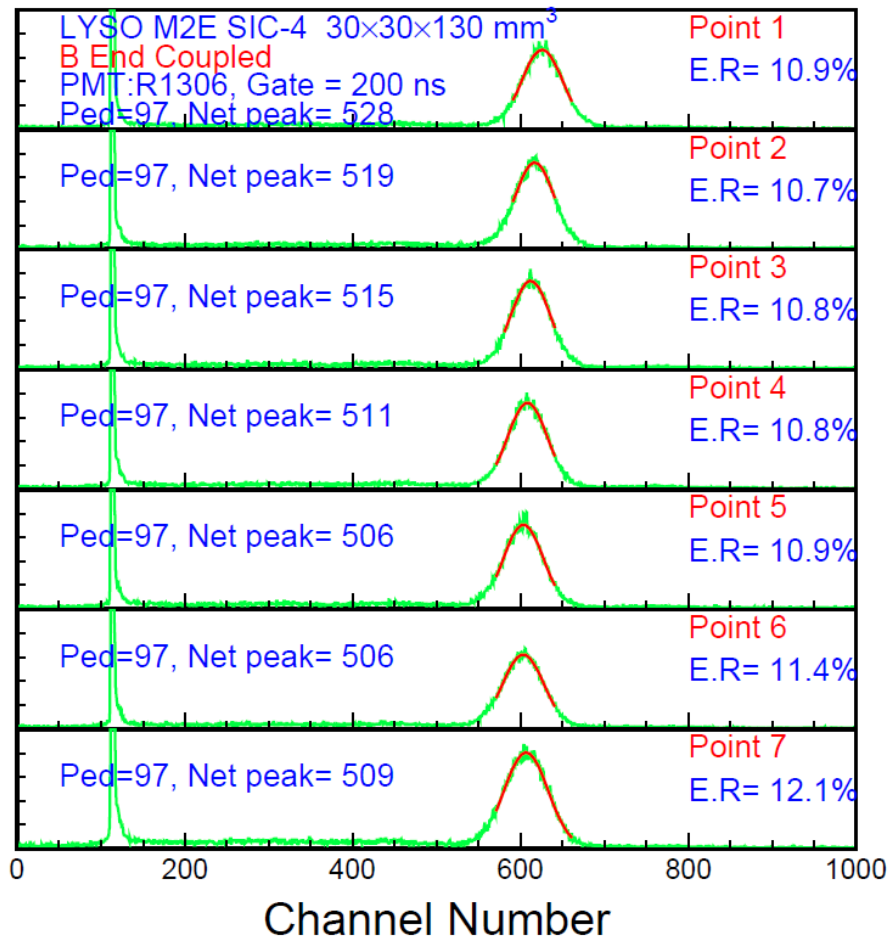


# Pulse Height Spectra & FWHM: SIC-4

A: Average ER = 11.4 %

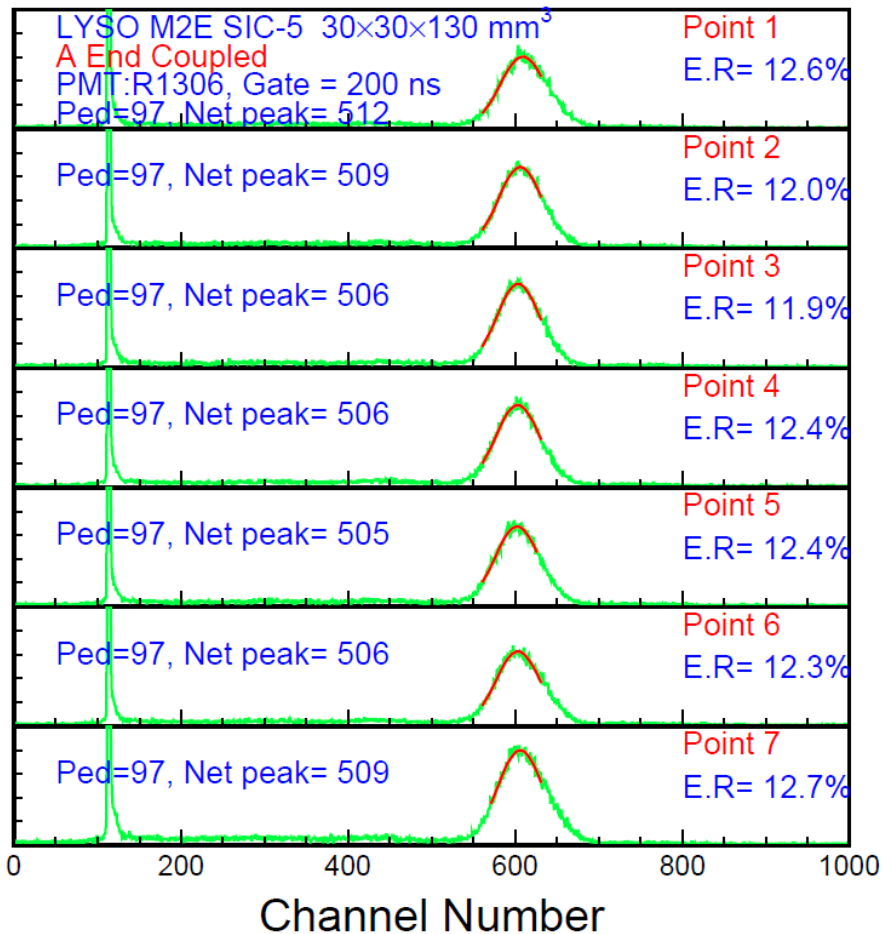


B: Average ER = 11.1%

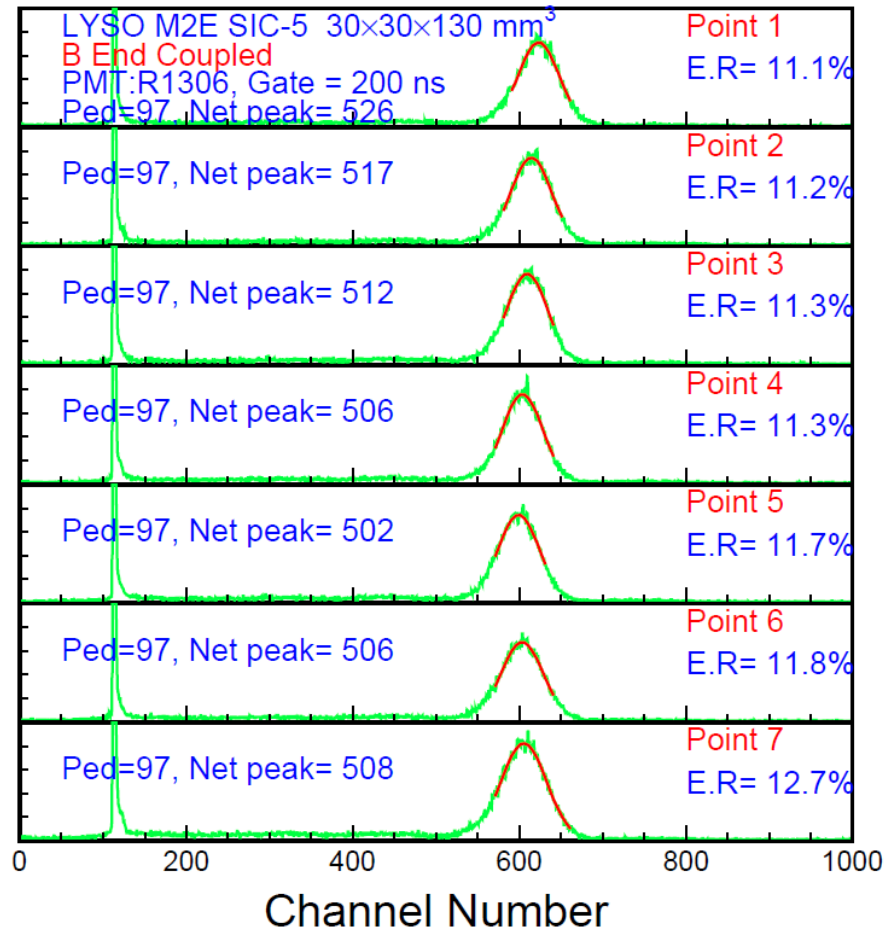


# Pulse Height Spectra & FWHM: SIC-5

**A: Average ER = 12.3%**



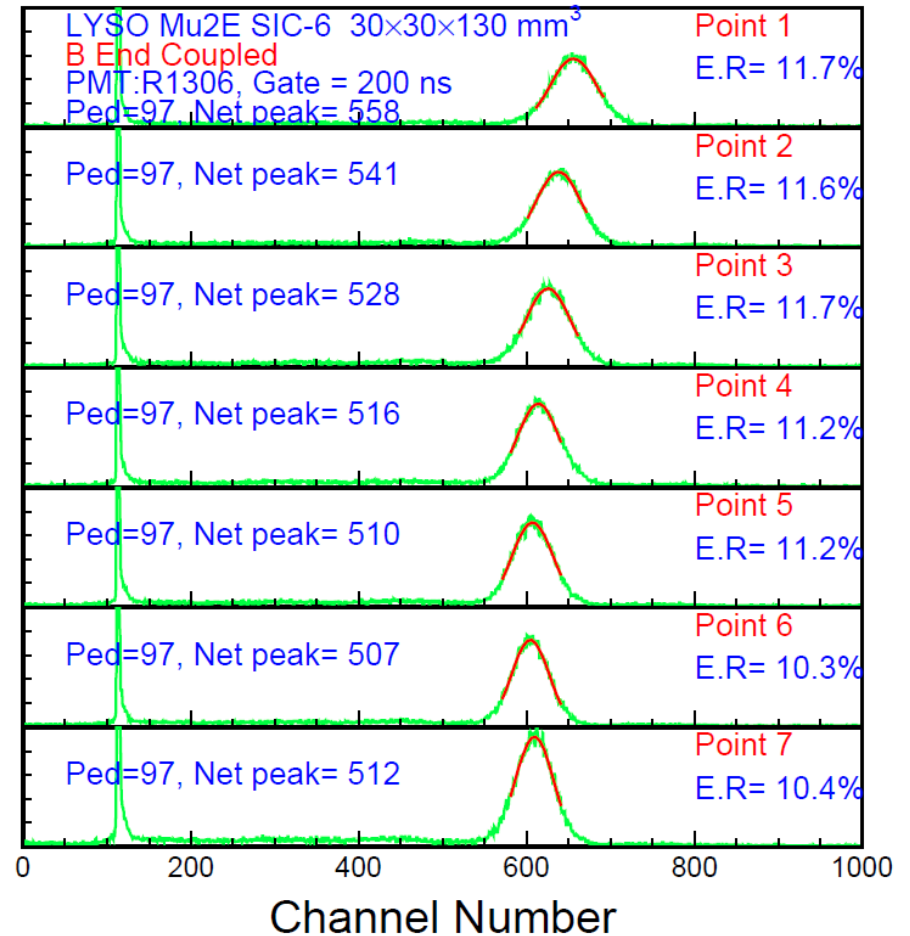
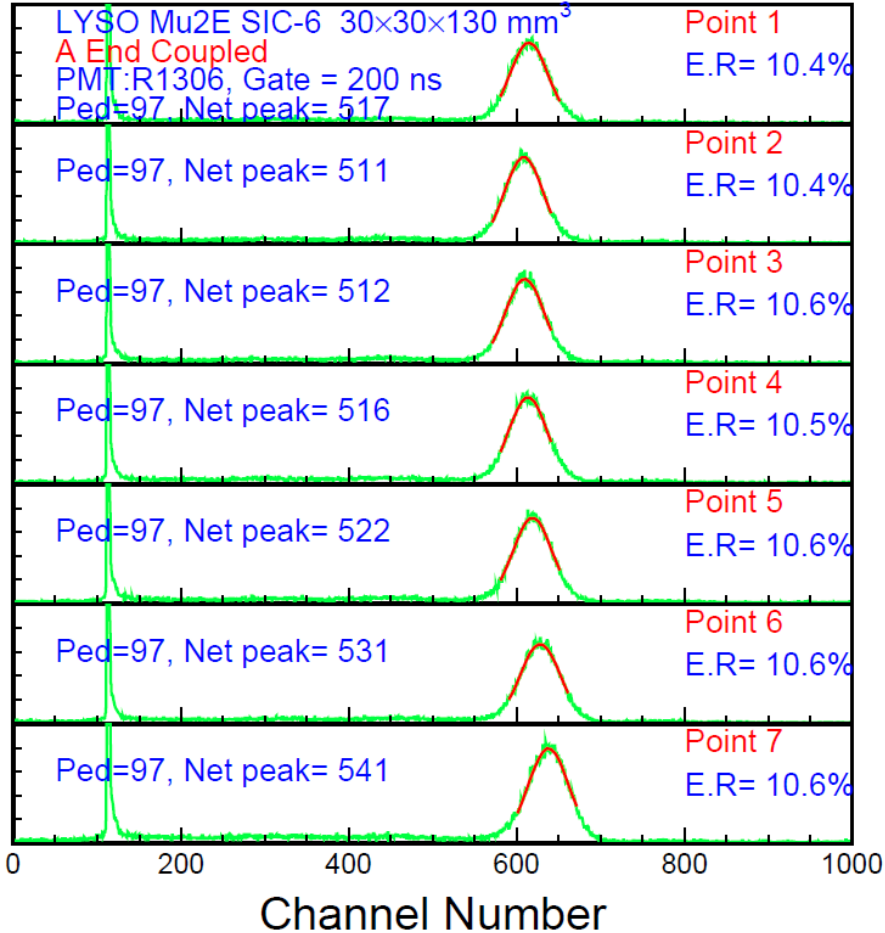
**B: Average ER = 11.6%**



# PHS & FWHM of SIC-6

A: Average ER = 10.5%

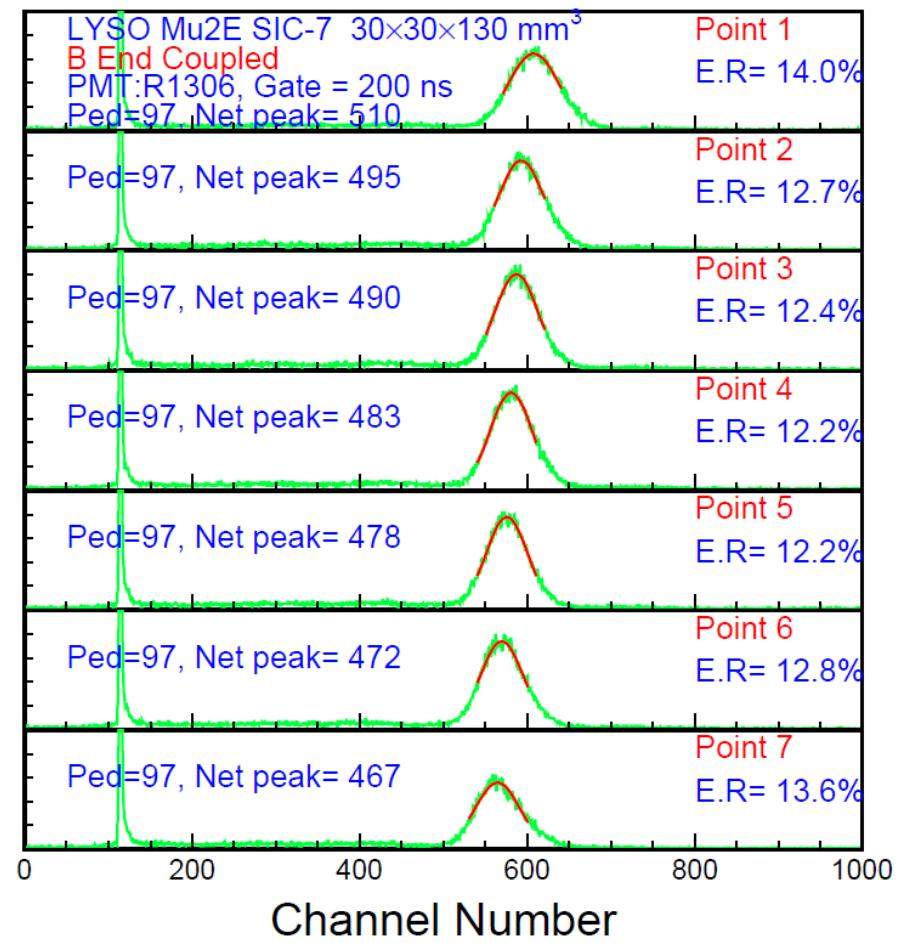
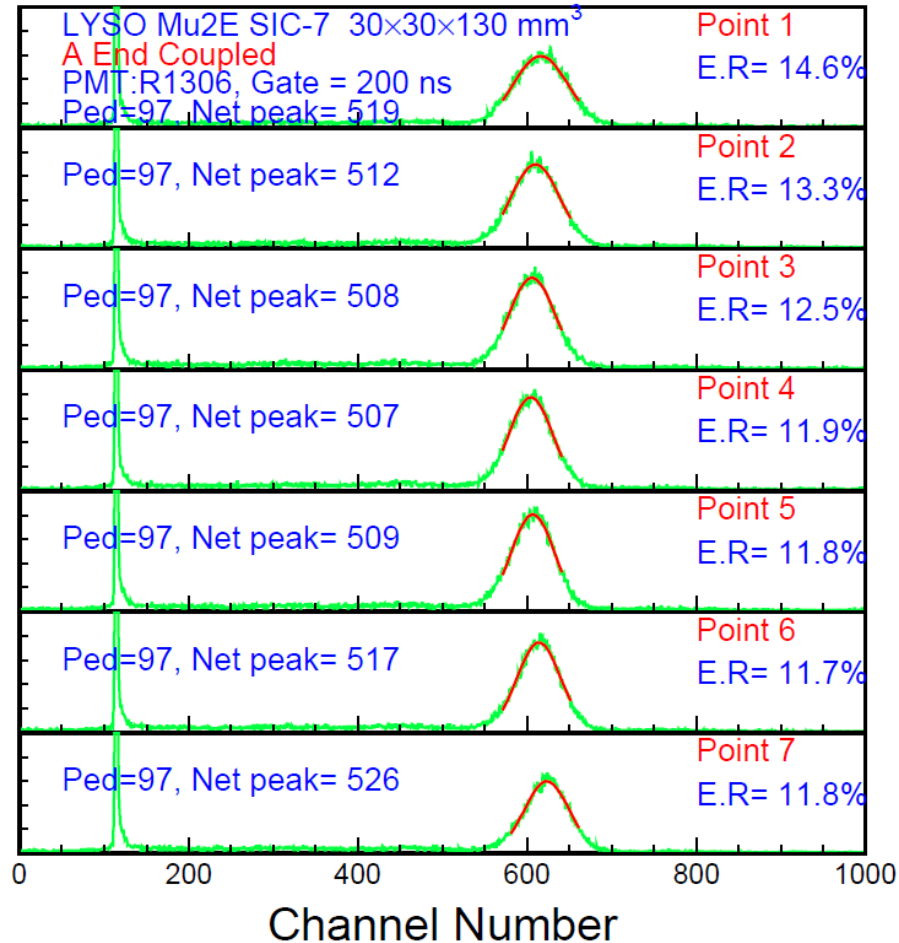
B: Average ER = 11.2%



# PHS & FWHM of SIC-7

**A: Average ER = 12.5%**

**B: Average ER = 12.8%**

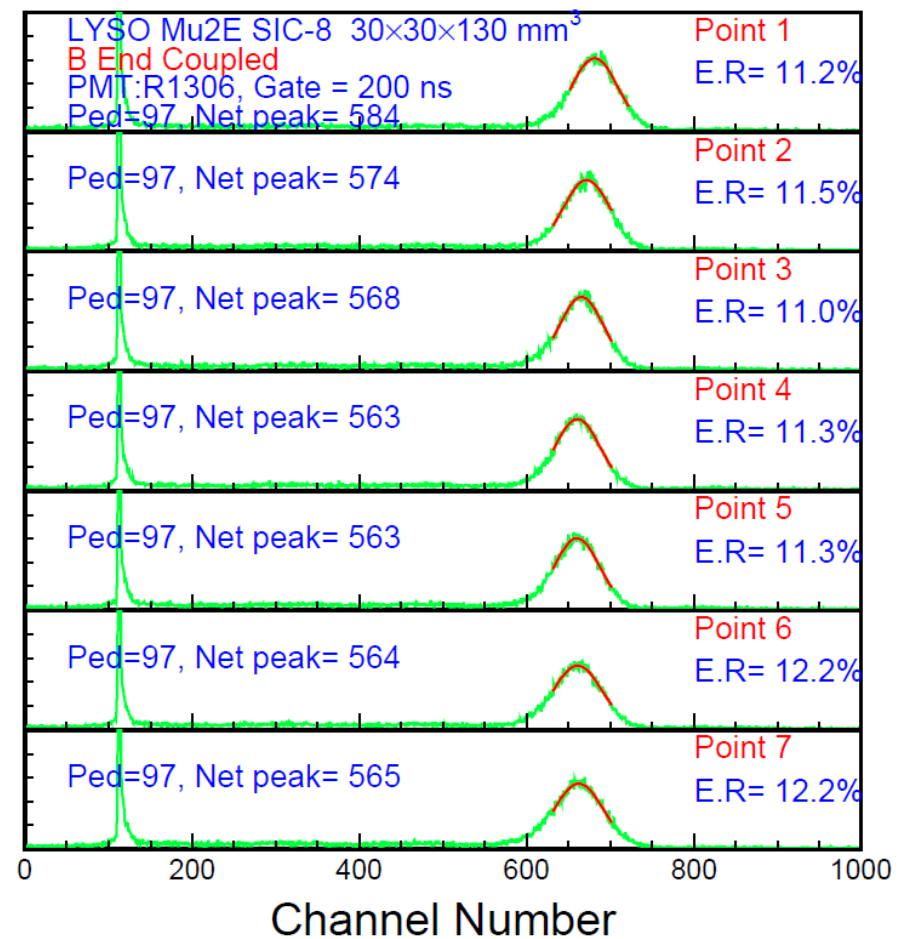
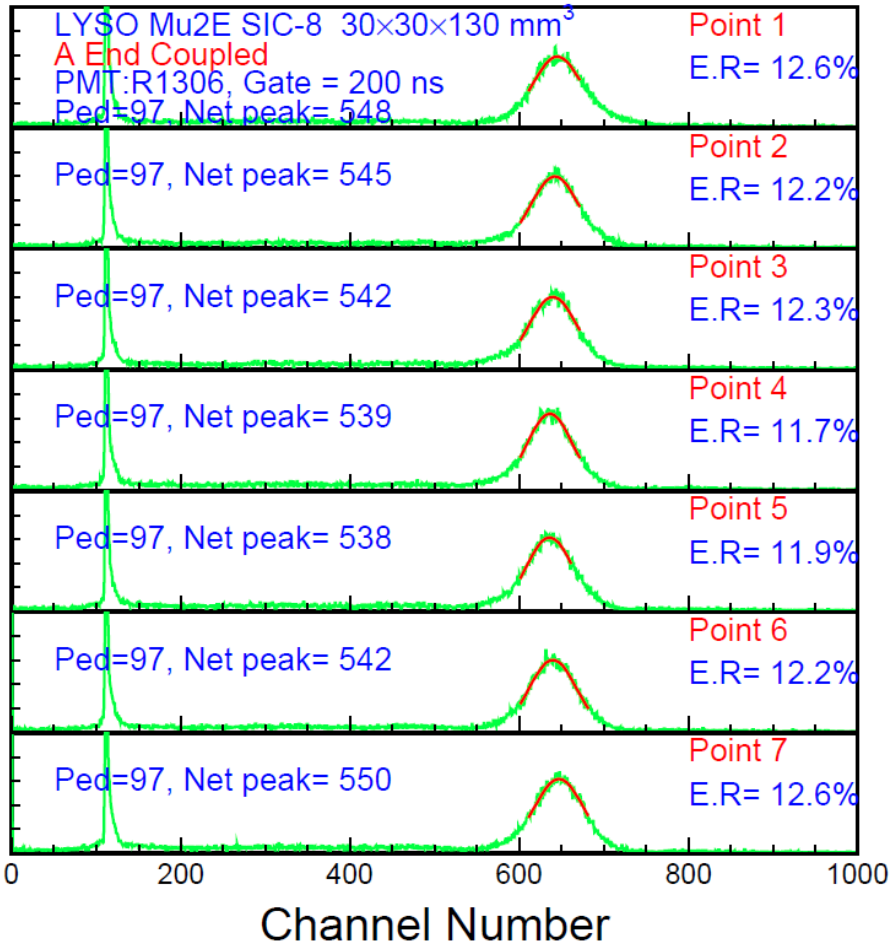


**Crystal SIC-7 has the B end coupling missing 12.5% specification**

# PHS & FWHM of SIC-8

A: Average ER = 12.2%

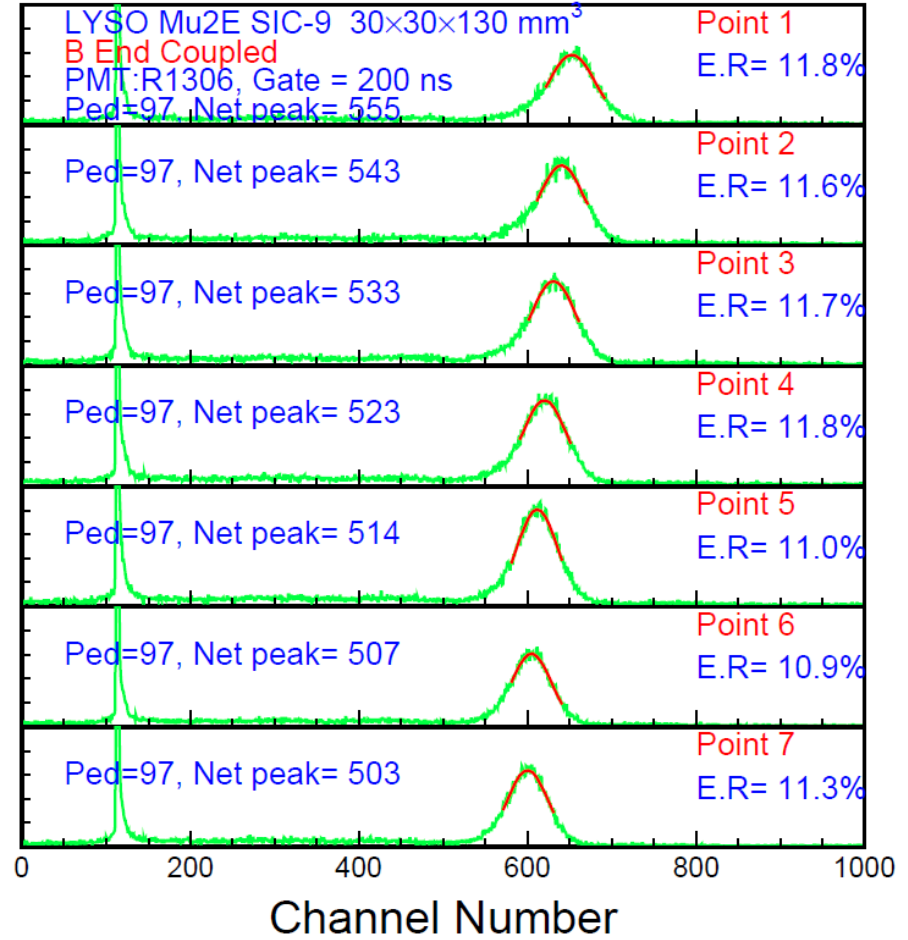
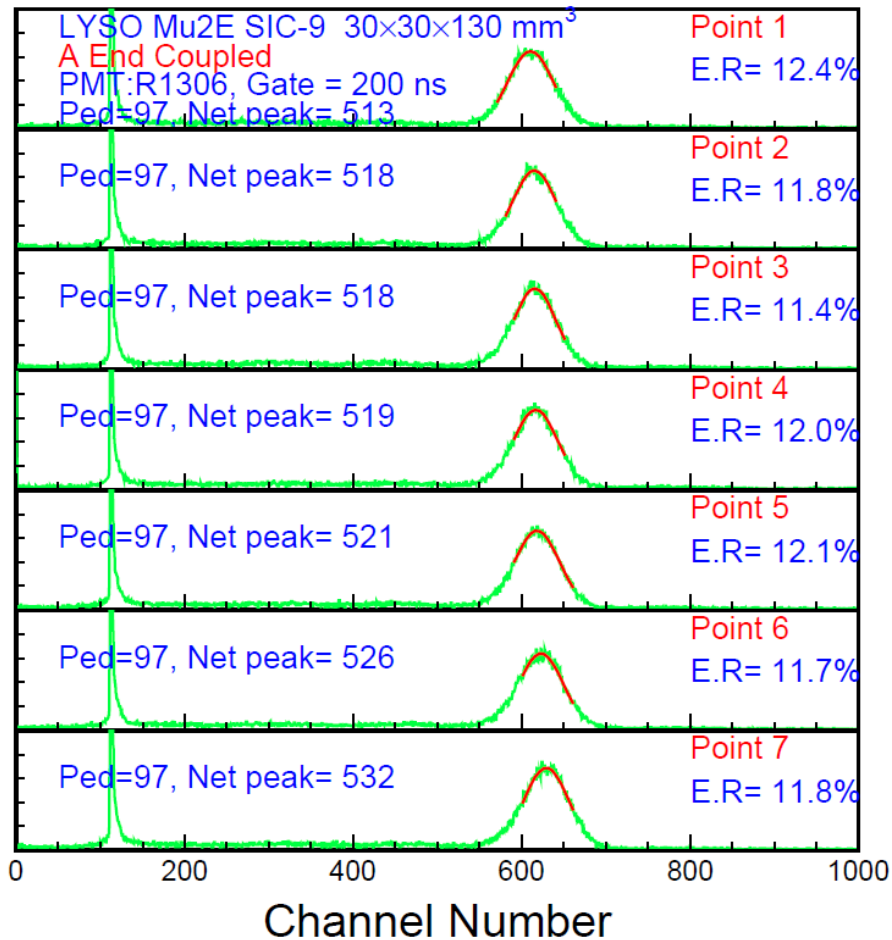
B: Average ER = 11.5%



# PHS & FWHM of SIC-9

A: Average ER = 11.9%

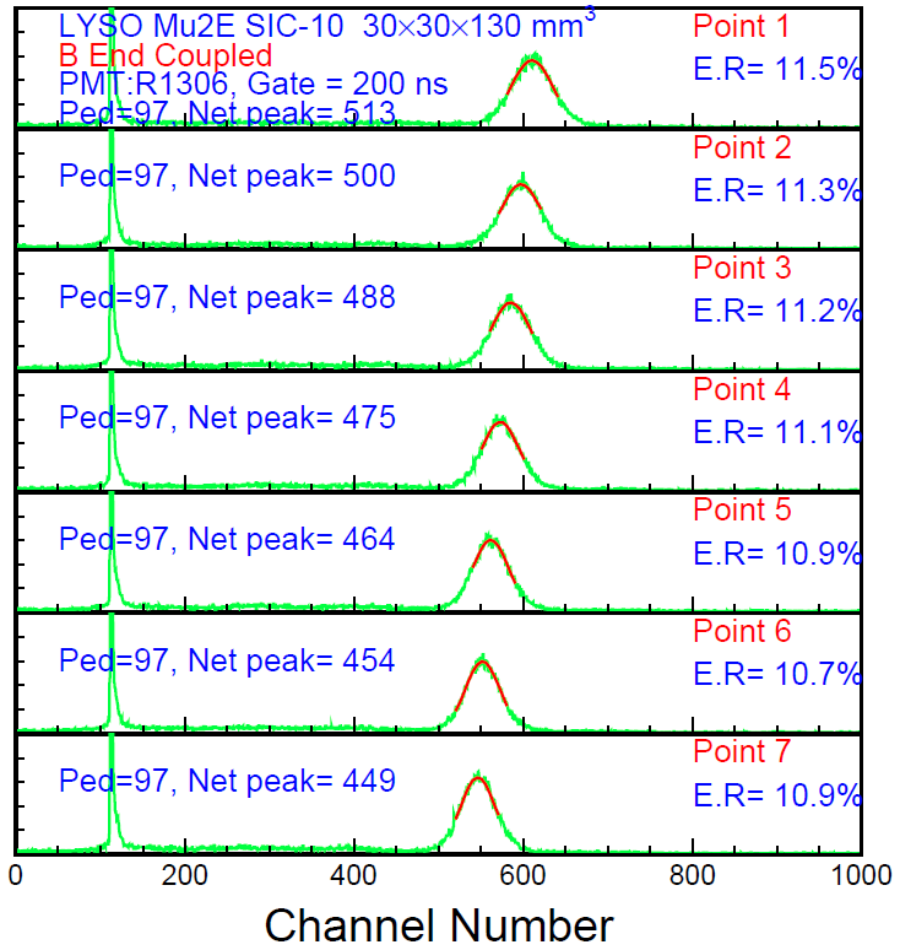
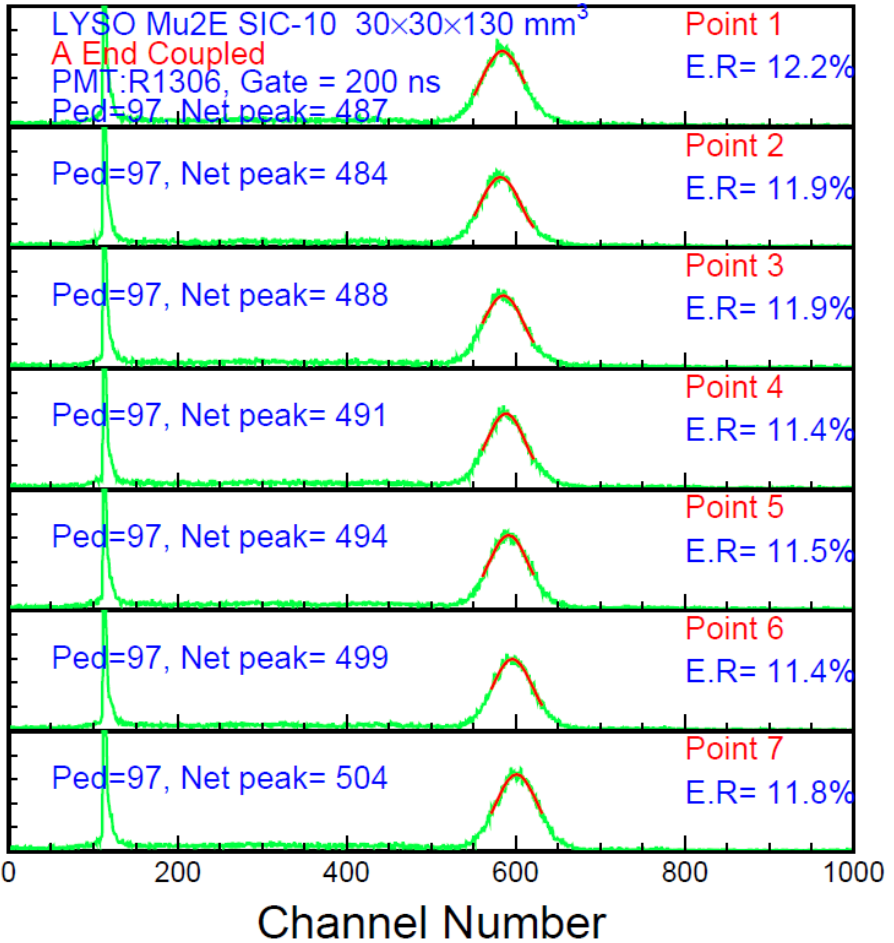
B: Average ER = 11.4%



# PHS & FWHM of SIC-10

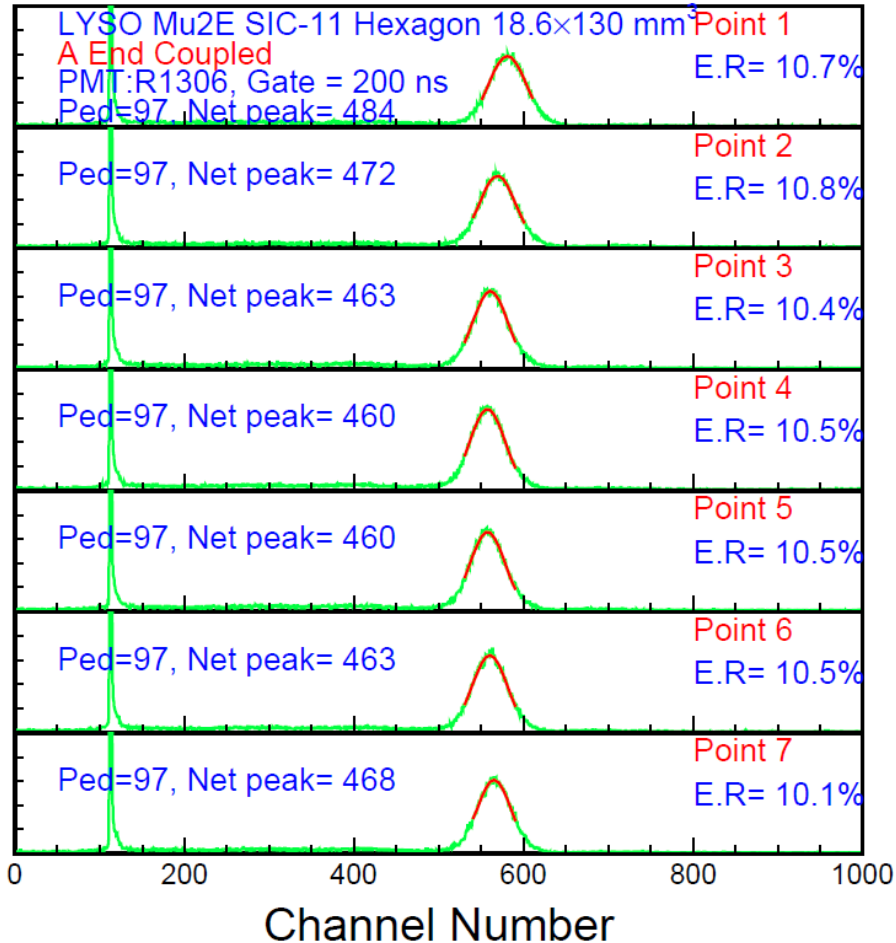
**A: Average ER = 11.7%**

**B: Average ER = 11.1%**

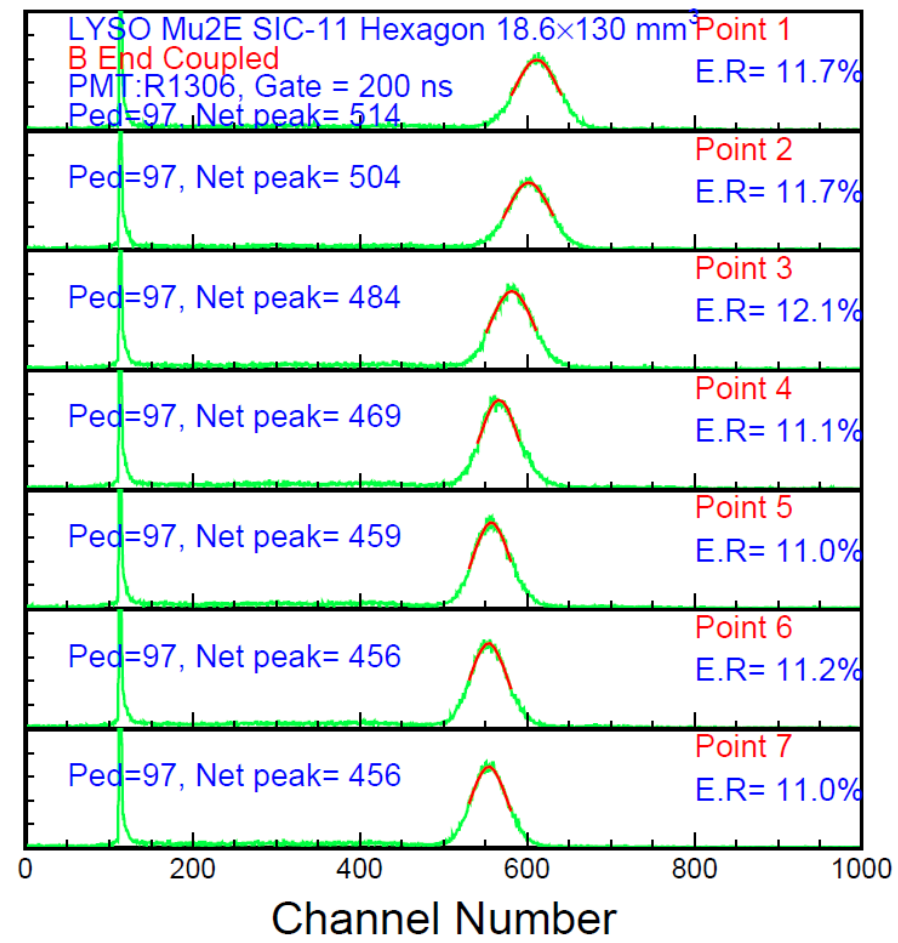


# PHS & FWHM of SIC-11

A: Average ER = 10.5%



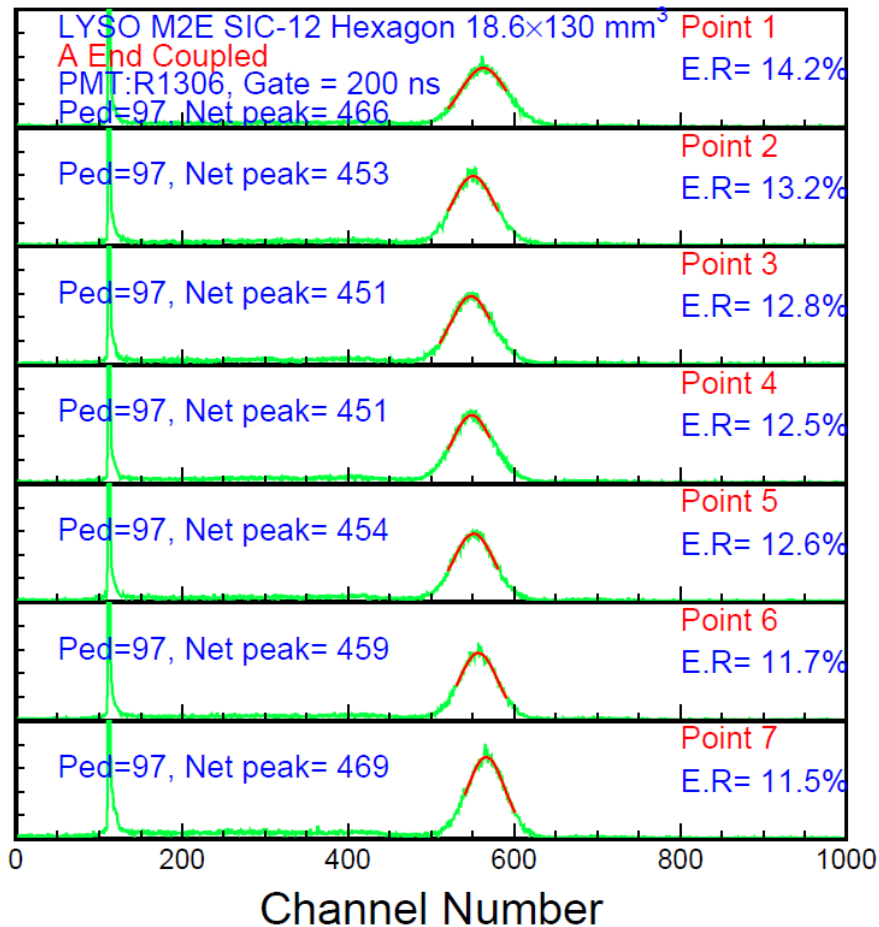
B: Average ER = 11.4%



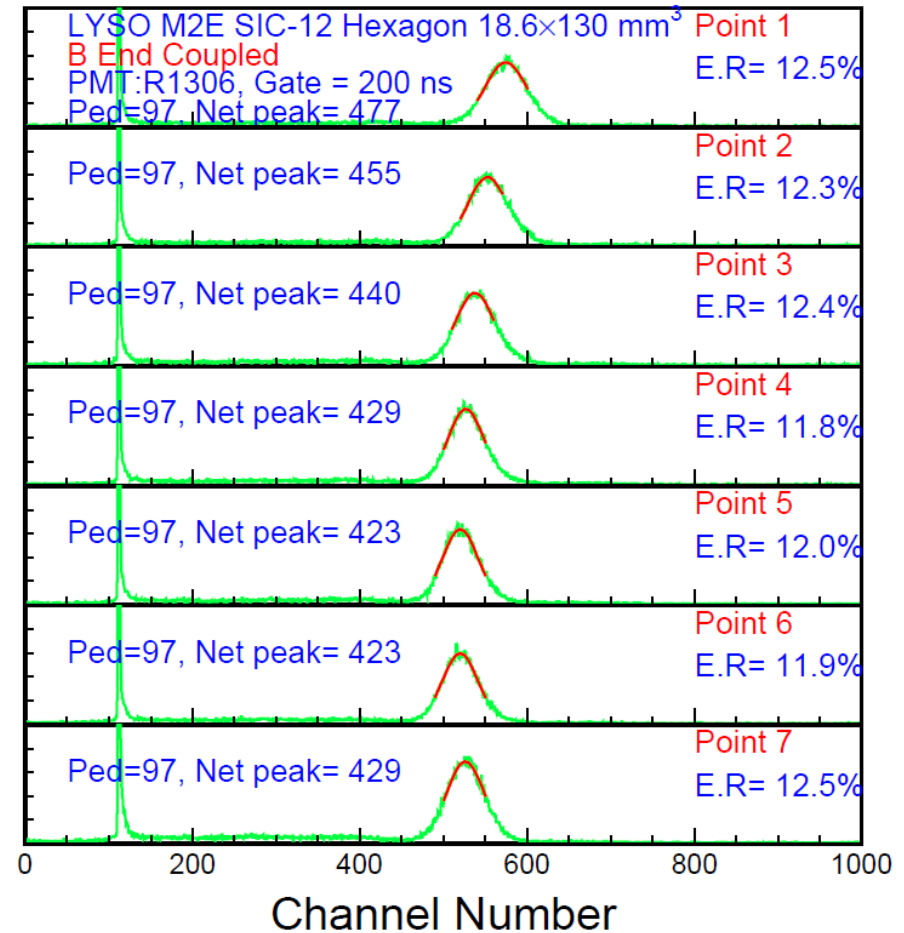


# Pulse Height Spectra & FWHM: SIC-12

A: Average ER = 12.6 %



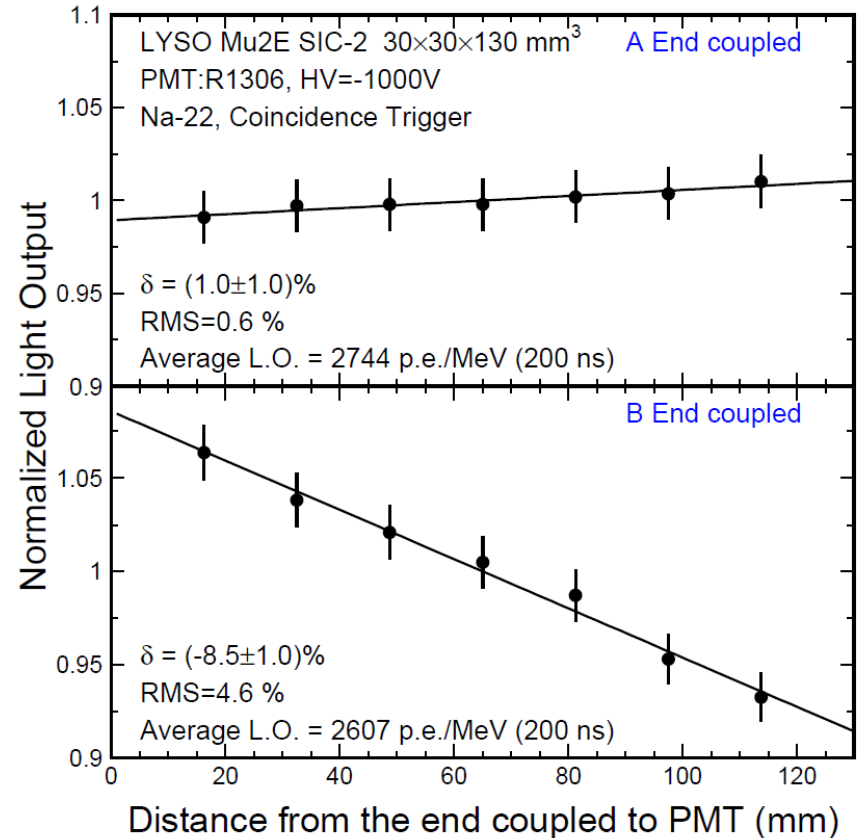
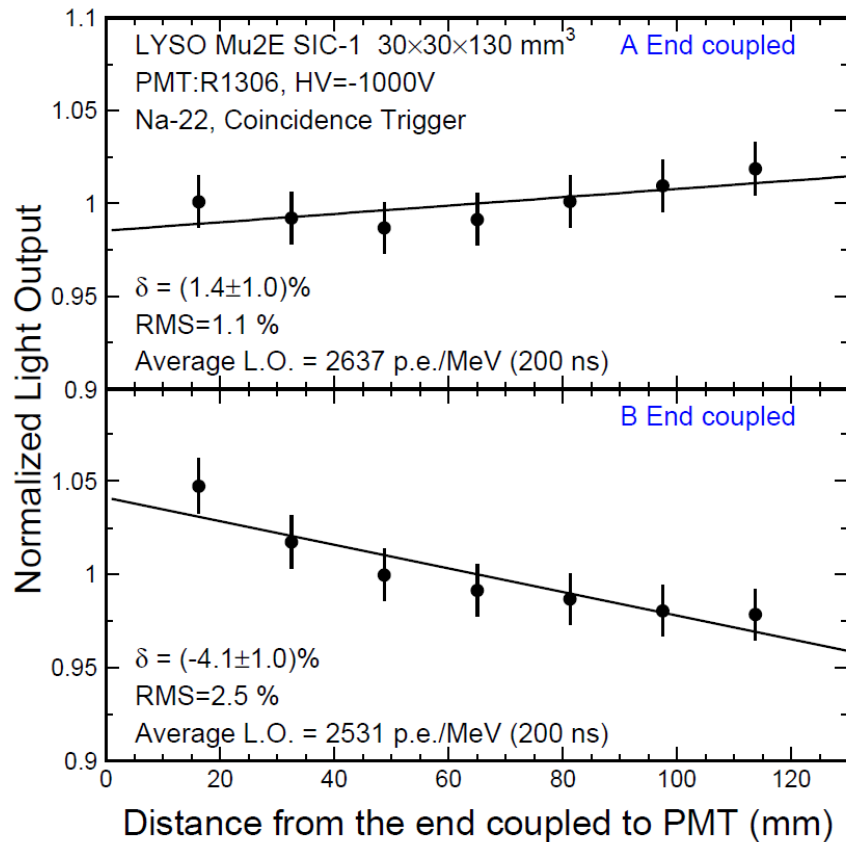
B: Average ER = 12.2 %



Hexagonal crystal SIC-12 has the A end coupling missing 12.5% specification

# Light Output and Response Uniformity

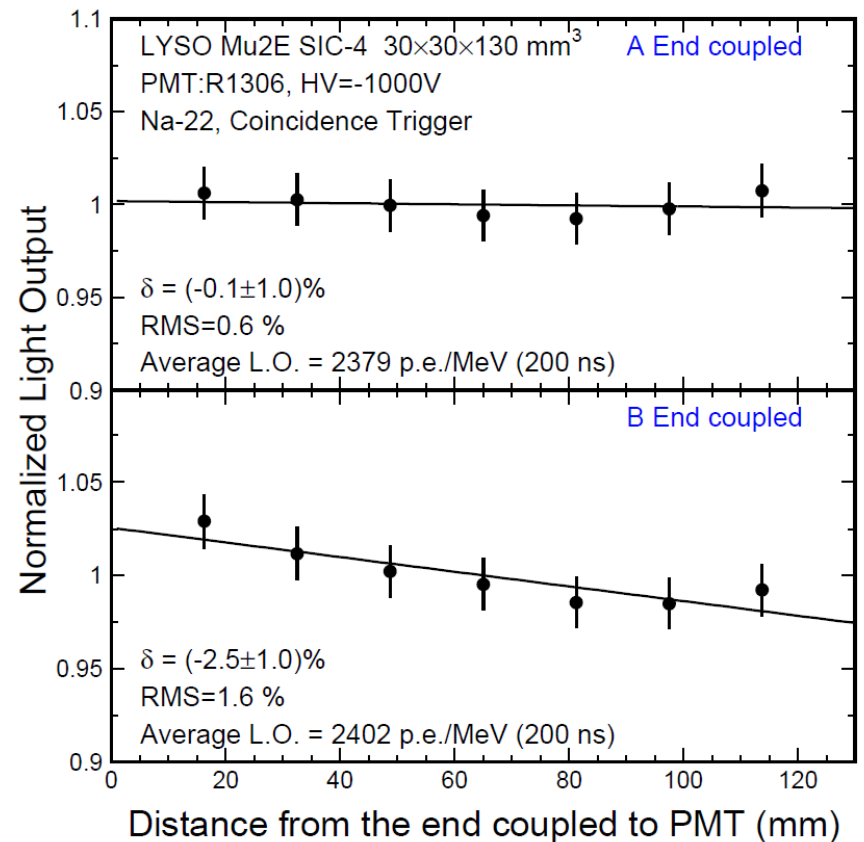
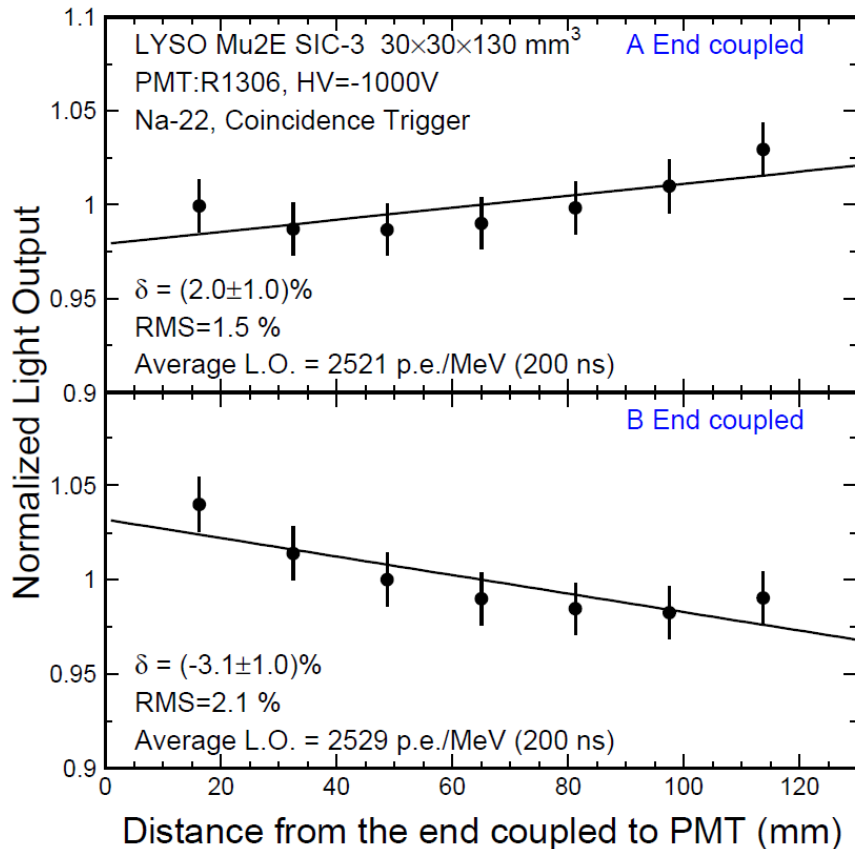
$\delta$  & rms of 1.4 & 1.1/1.0 & 0.6 % observed with the A end coupling



LRU is not good with the B end coupling to the PMT

# Light Output and Response Uniformity

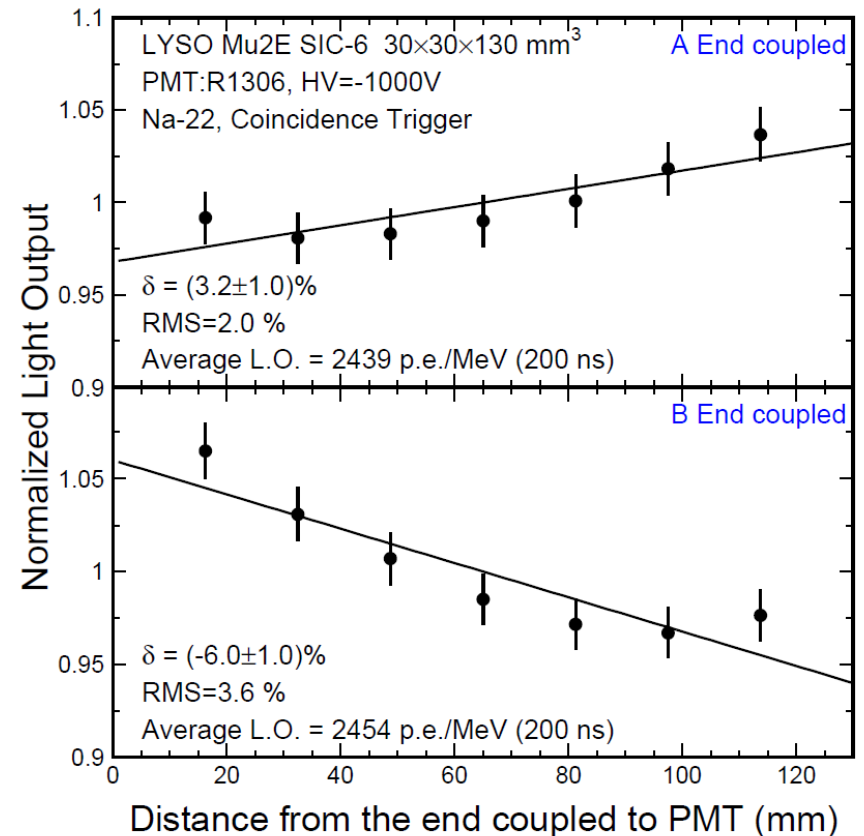
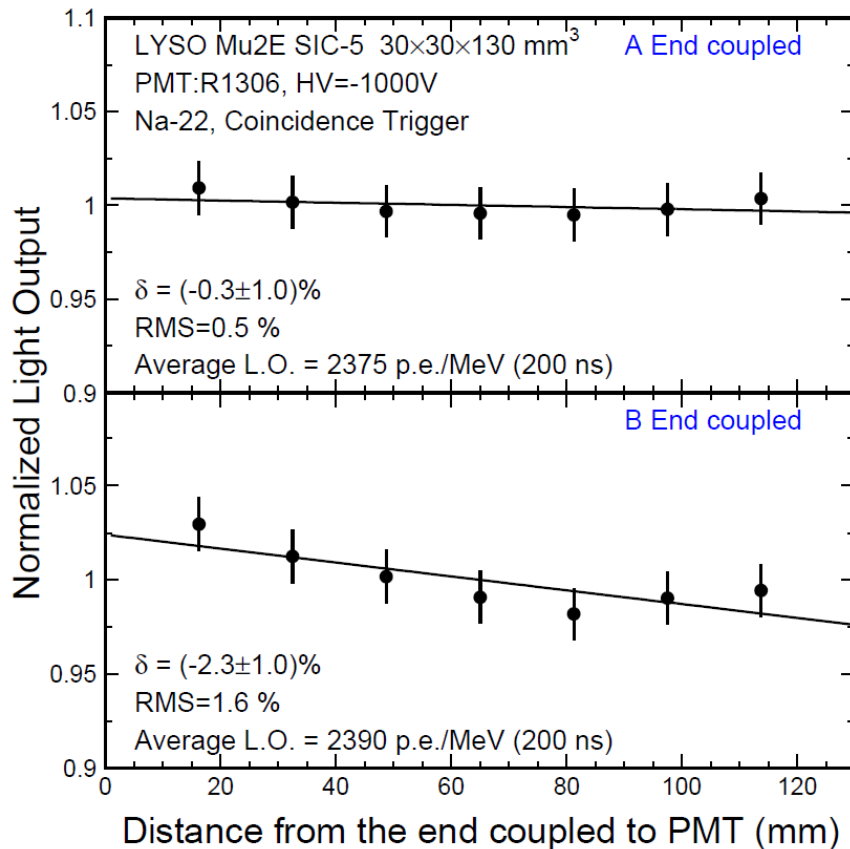
$\delta$  & rms of 2.0 & 1.5/-0.1 & 0.6 % observed with the A end coupling



LRU is not good with the B end coupling to the PMT

# Light Output and Response Uniformity

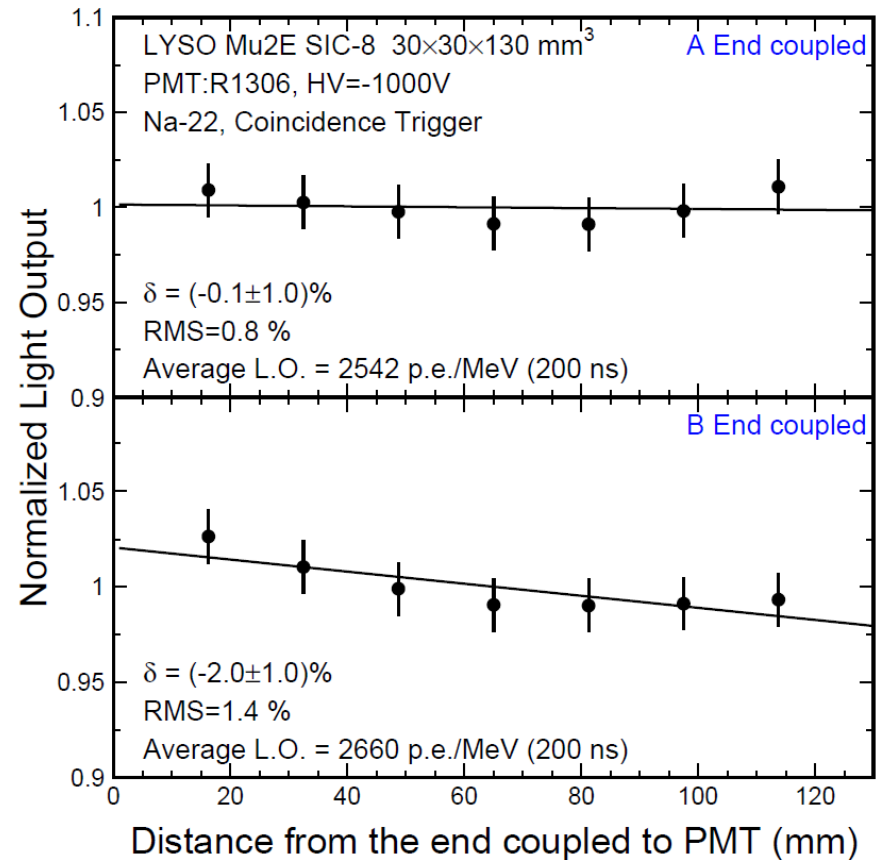
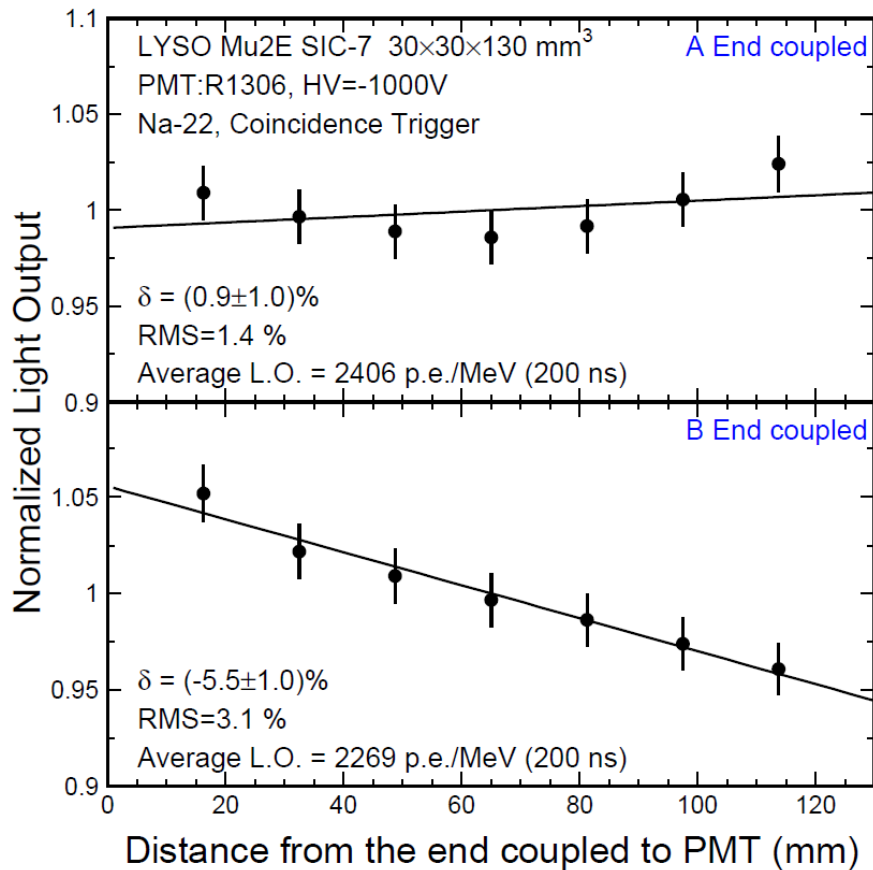
$\delta$  & rms of -0.3 & 0.5/3.2 & 2.0 % observed with the A end coupling



LRU is not good with the B end coupling to the PMT

# Light Output and Response Uniformity

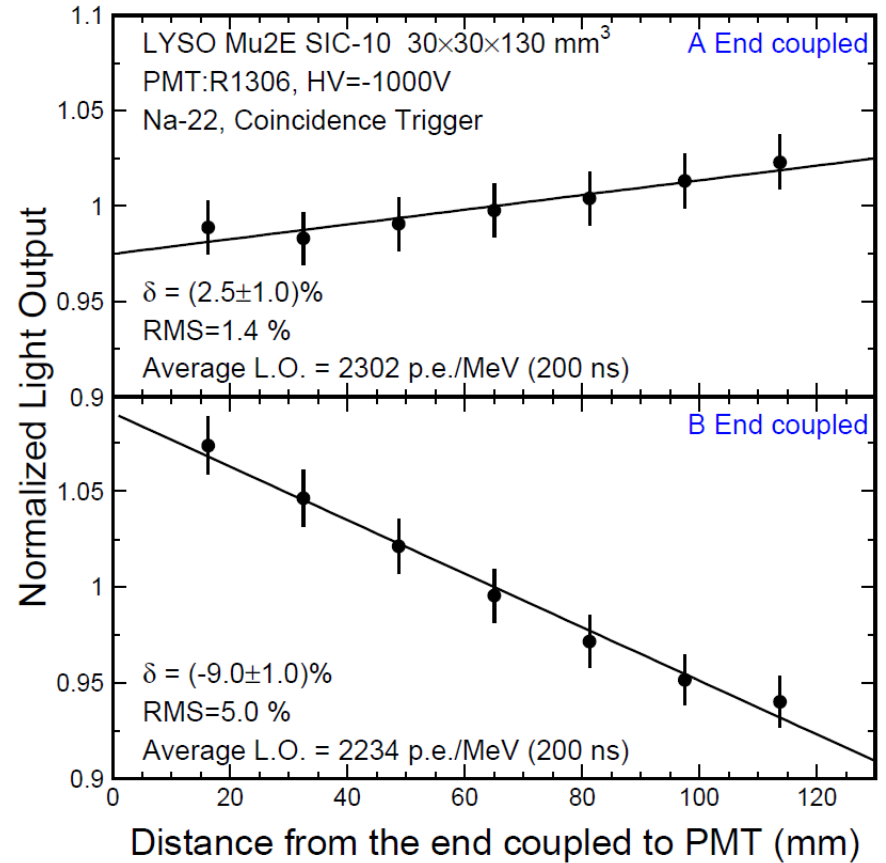
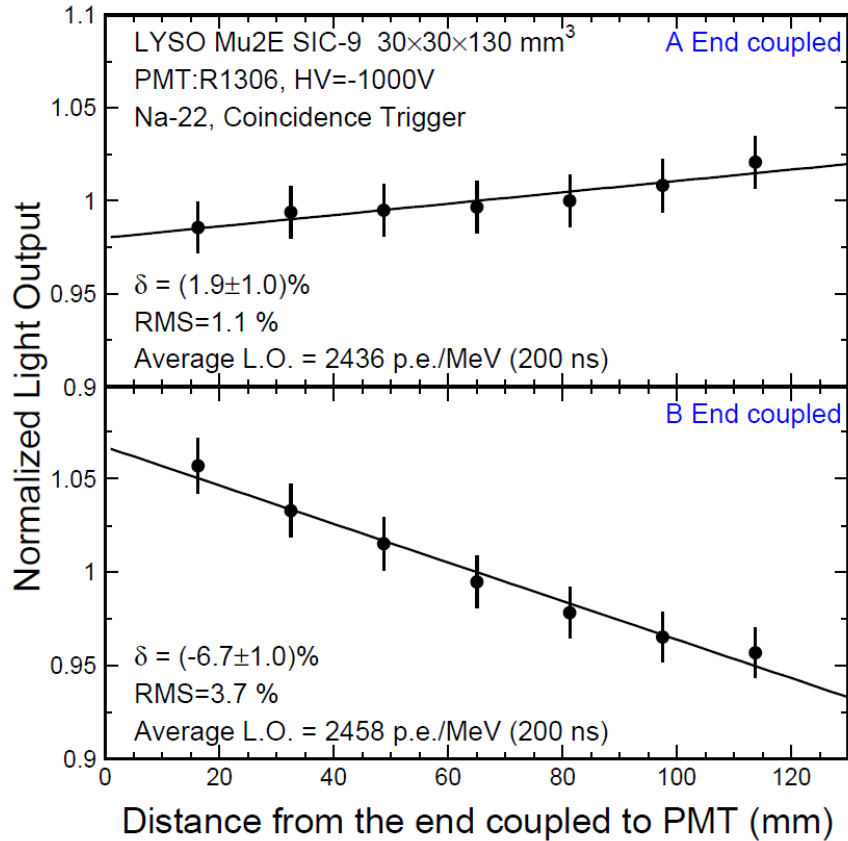
$\delta$  & rms of 0.9 & 1.4/-0.1 & 0.8 % observed with the A end coupling



LRU is not good with the B end coupling to the PMT

# Light Output and Response Uniformity

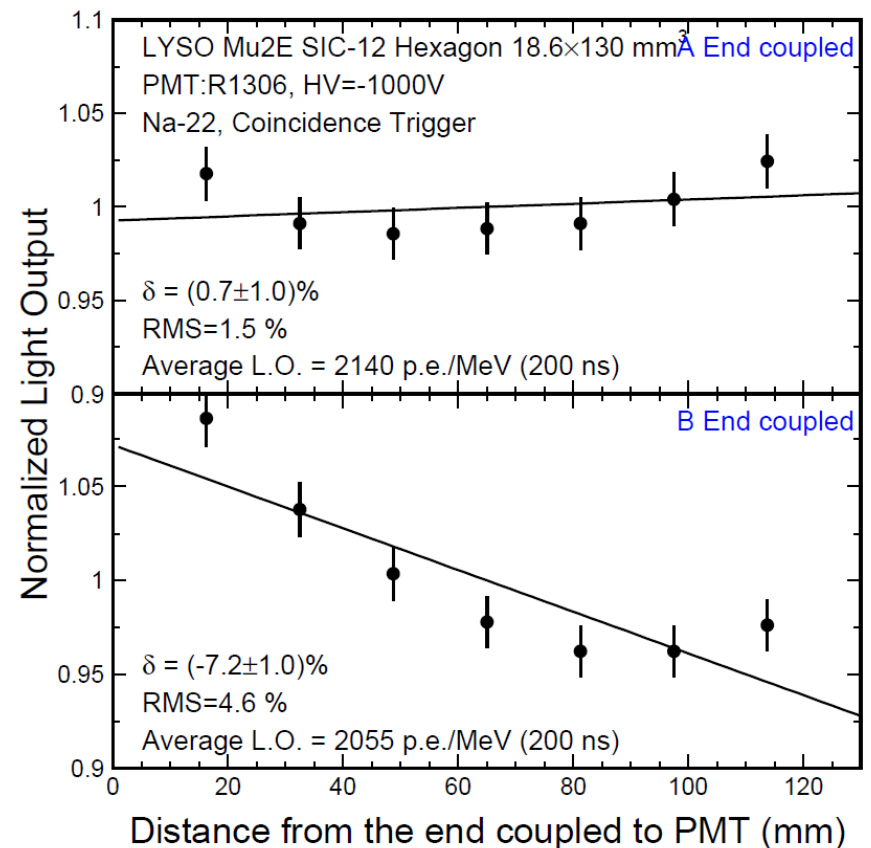
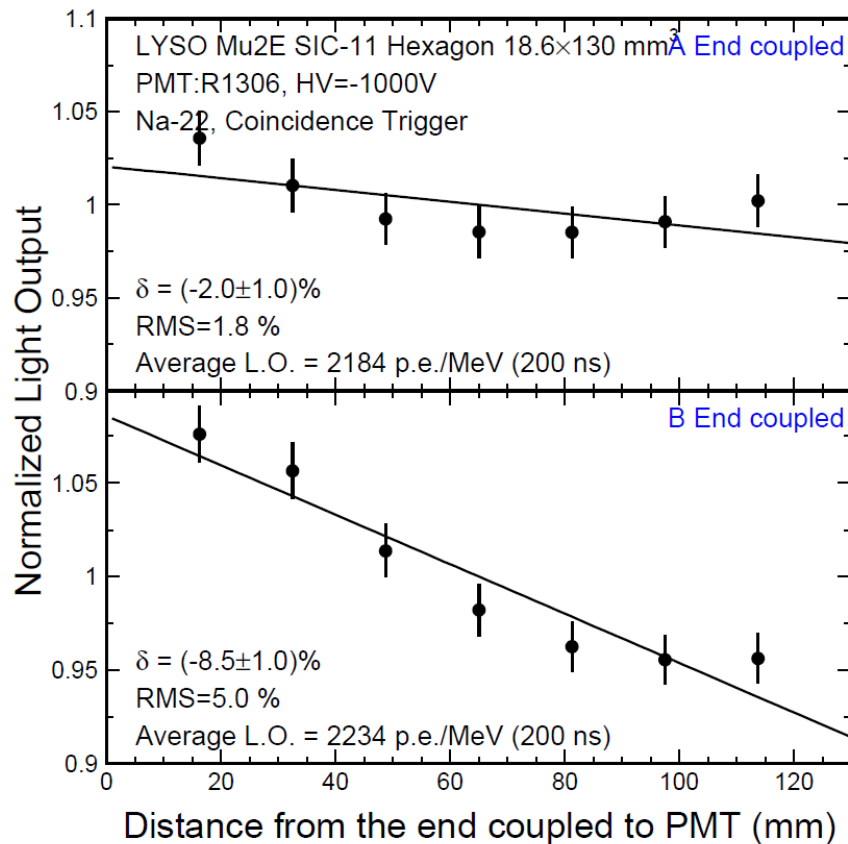
$\delta$  & rms of 1.9 & 1.1/2.5 & 1.4 % observed with the A end coupling



LRU is not good with the B end coupling to the PMT

# Light Output and Response Uniformity

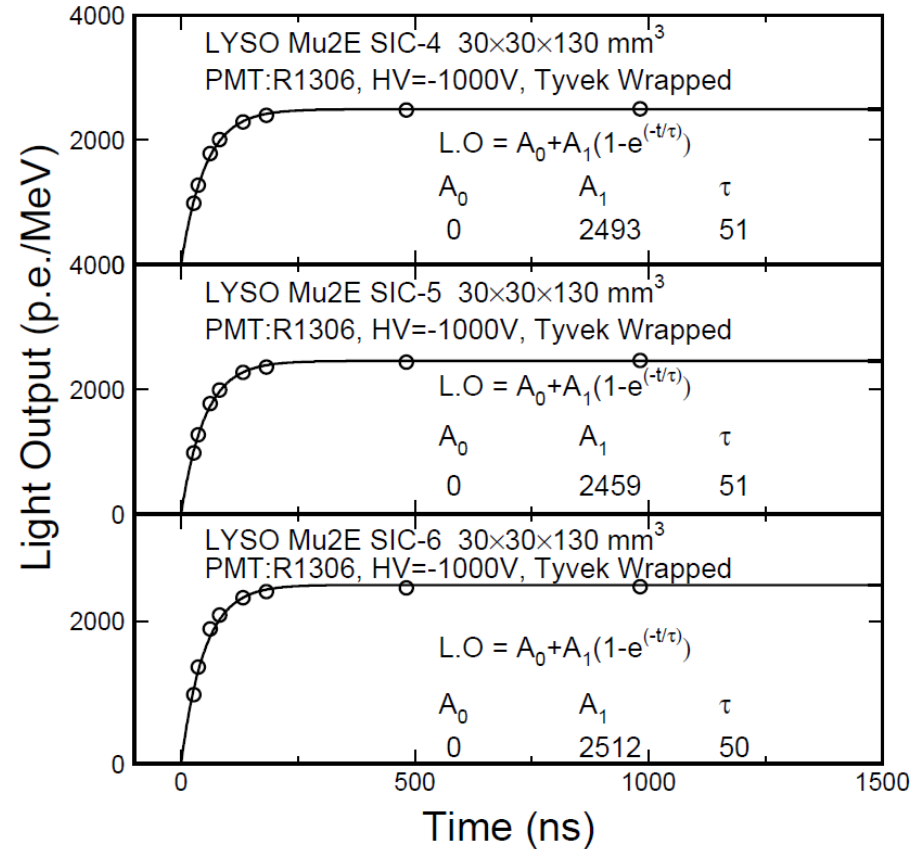
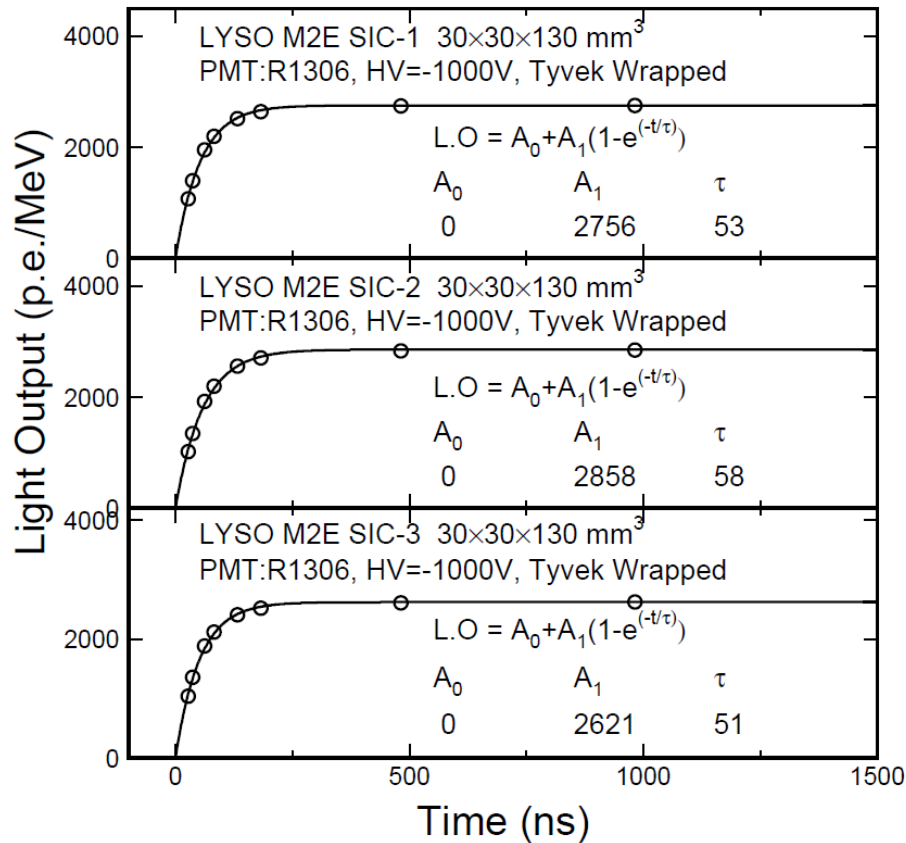
$\delta$  & rms of -2.0 & 1.8 & 0.7 & 1.5 % observed with the A end coupling



LRU is not good with the B end coupling to the PMT

# Decay Kinetics

Decay time of (50 to 58) ns observed

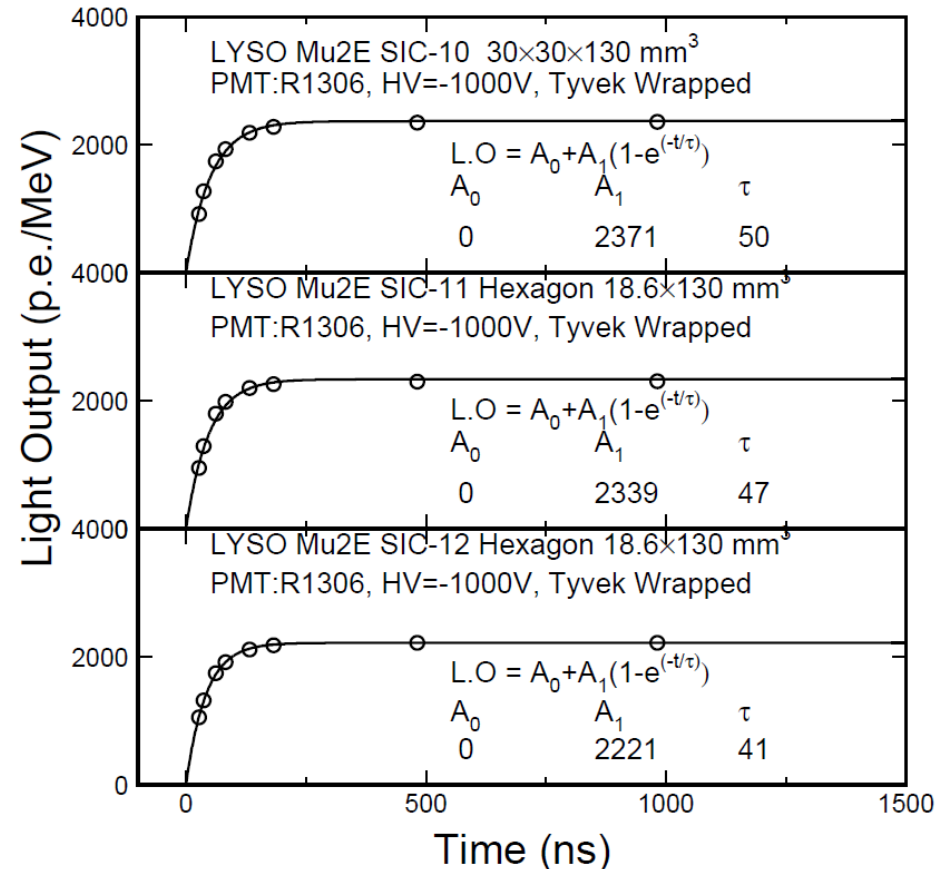
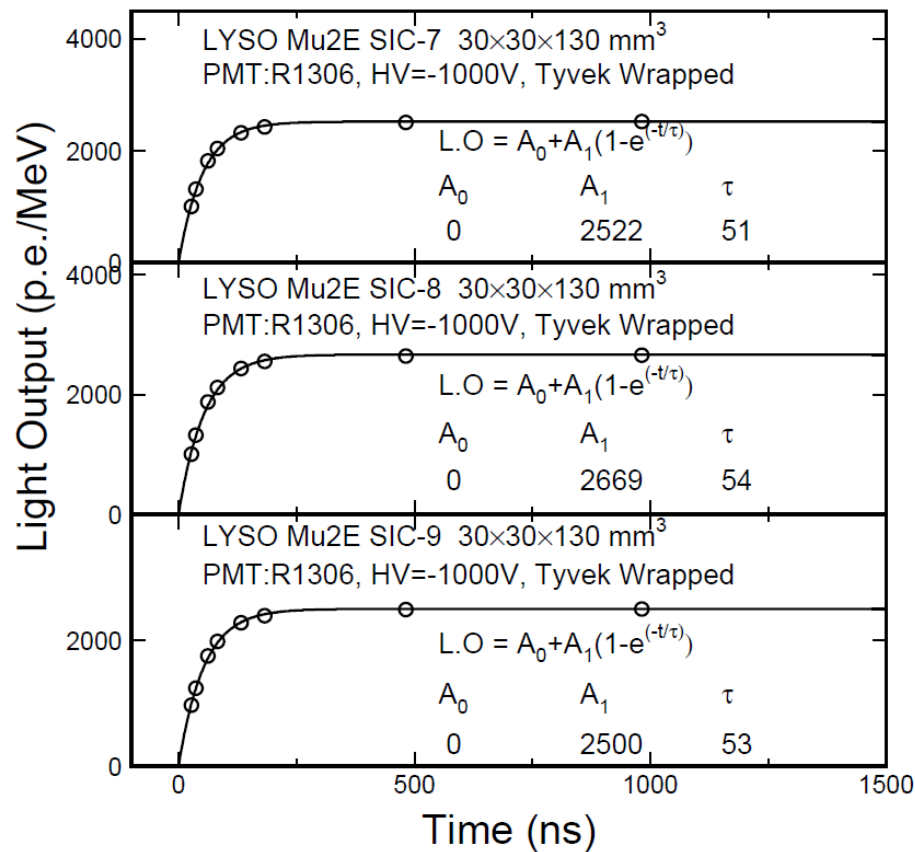


Plan to measure decay time with other method



# Decay Kinetics

Decay time of (41 to 54) ns observed



Plan to measure decay time with other method

ID	Dimension (mm <sup>3</sup> )	T@420nm (%)	UV Cutoff (nm)	EWL T (%)	Coupling End	Ave ER (%)	LO (p.e./MeV)	$\delta$ (%)	RMS (%)	Decay Time (ns)
SIC-1	30 × 30 × 130	81.7	396.8	61.9	A	11.0	2637	1.4	1.1	53
					B	10.5	2531	-4.1	2.5	
SIC-2	30 × 30 × 130	83.0	395.3	64.2	A	11.1	2744	1.0	0.6	58
					B	12.2	2607	-8.5	4.6	
SIC-3	30 × 30 × 130	81.8	396.4	62.4	A	10.5	2521	2.0	1.5	51
					B	11.5	2529	-3.1	2.1	
SIC-4	30 × 30 × 130	82.2	395.1	63.9	A	11.4	2379	-0.1	0.6	51
					B	11.1	2402	-2.5	1.6	
SIC-5	30 × 30 × 130	82.3	395.2	63.8	A	12.3	2375	-0.3	0.5	51
					B	11.6	2390	-2.3	1.6	
SIC-6	30 × 30 × 130	80.3	395.4	62.5	A	10.5	2439	3.2	2.0	50
					B	11.2	2454	-6.0	3.6	
SIC-7	30 × 30 × 130	82.1	394.8	64.1	A	12.5	2406	0.9	1.4	51
					B	12.8	2269	-5.5	3.1	
SIC-8	30 × 30 × 130	82.7	394.7	64.8	A	12.2	2542	-0.1	0.8	54
					B	11.5	2660	-2.0	1.4	
SIC-9	30 × 30 × 130	82.4	394.7	64.2	A	11.9	2436	1.9	1.1	53
					B	11.4	2458	-6.7	3.7	
SIC-10	30 × 30 × 130	81.4	395.4	62.6	A	11.7	2302	2.5	1.4	50
					B	11.1	2234	-9.0	5.0	
Average		81.6	395.4	62.3		11.1	2466	A: 1.2	A: 1.1	51.5
rms/Ave		0.3%	0.3%	0.8%		0.6%	12%	B: -5.0	B: 2.9	4%
SIC-11	Hexagon 18.6×130	79.8	395.5	62.1	A	10.5	2184	-2.0	1.8	47
					B	11.4	2234	-8.5	5.0	
SIC-12	Hexagon 18.6×130	79.3	396.0	61.2	A	12.6	2140	0.7	1.5	41
					B	12.2	2055	-7.2	4.6	
Average		79.6	395.8	61.7		11.4	2153	A: -0.7	A: 1.7	44
rms/Ave		0.4%	0.1%	1%		32%	4%	B: -7.9	B: 4.8	10%

Poor LO & FWHM of two hexagonal crystals seem caused by poor transmittance  
Overall good performance. To be understood: decay time of longer than 50 ns