Results of Radiation Damage in Two SIC Pre Series Crystals and Six Saint-Gobain Cubes

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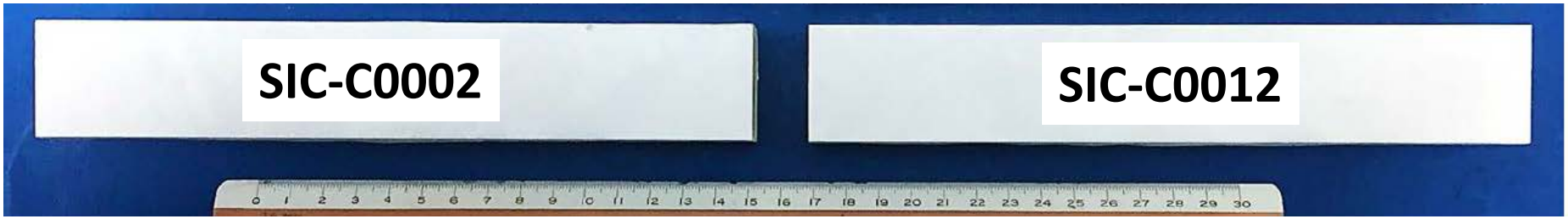
Introduction

- Two SIC pre series CsI crystals and six Saint-Gobain 1” cubes were irradiated by Cs-137 sources to 10 and 110 krad.
- Their LO, energy resolution and F/T ratio were measured before and after 10 and 110 krad. Light response uniformity was also measured for two SIC crystals.
- Performance is compared to Mu2e radiation hardness spec: > 85%/60% after 10/100 krad.

Two SIC Pre Series CsI Crystals



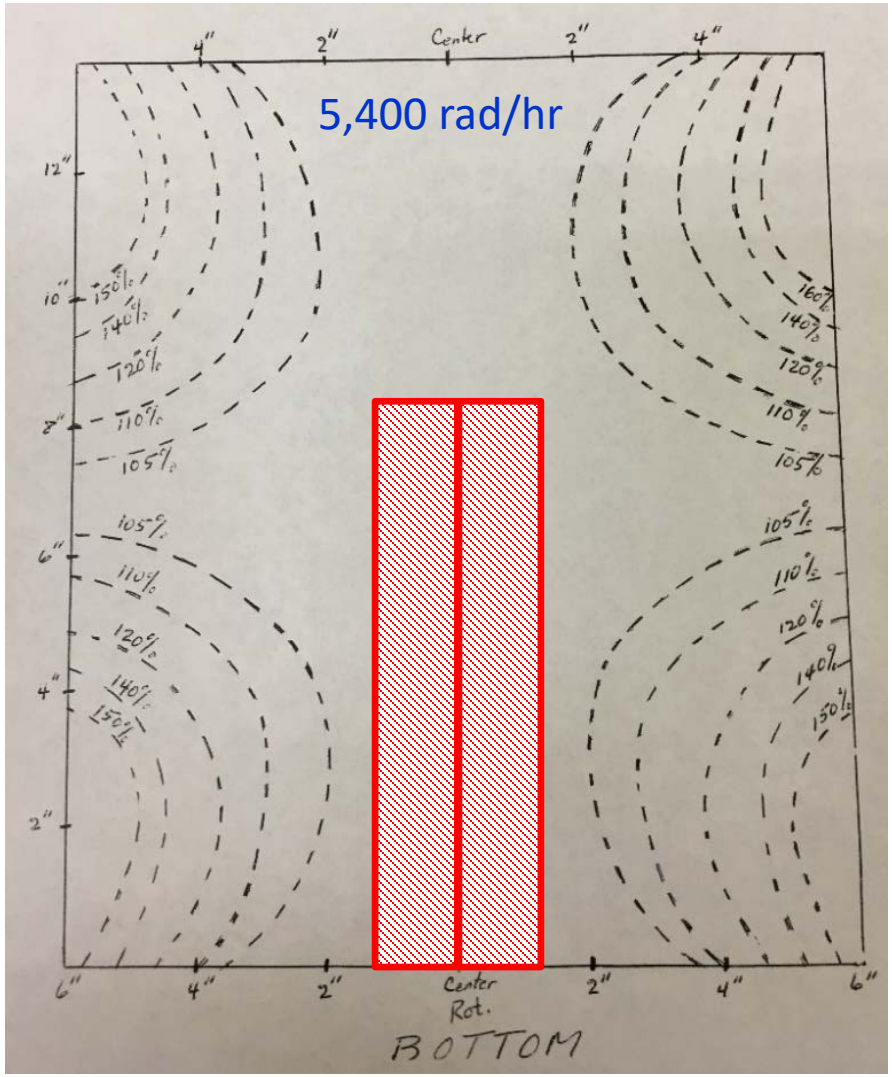
ID	Dimension (mm^3)	Polishing
SIC-C0002,3,5,6,11,12	34x34x200	All faces

Experiments

- Properties measured at room temperature : LO, ER, F/T, and LRU

^{137}Cs γ-ray Irradiation Facility

5.4 krad/h at the center with 10% uniformity



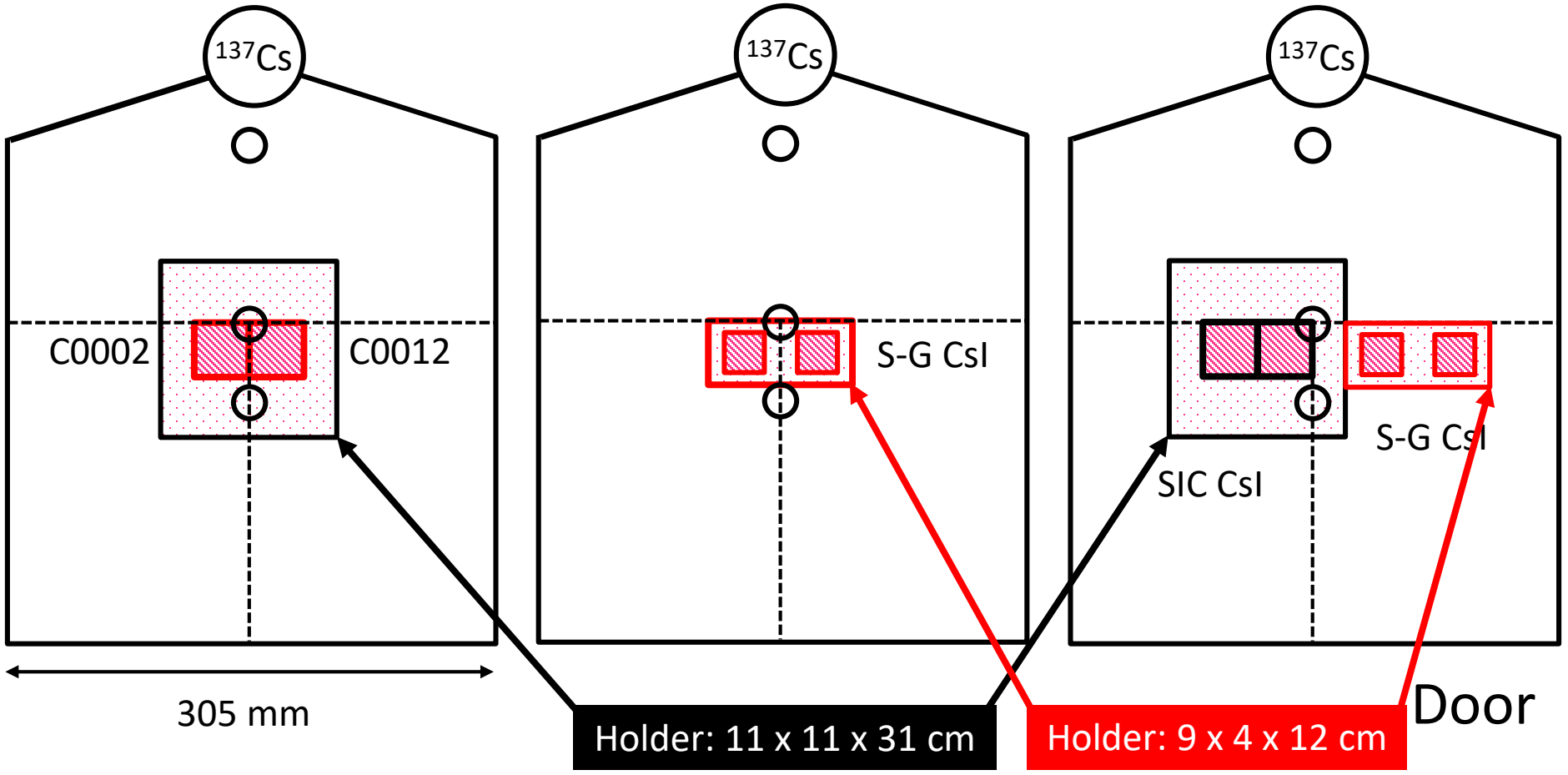
Sample Holder Locations: Top View

Front face of samples are at the center of the irradiation chamber

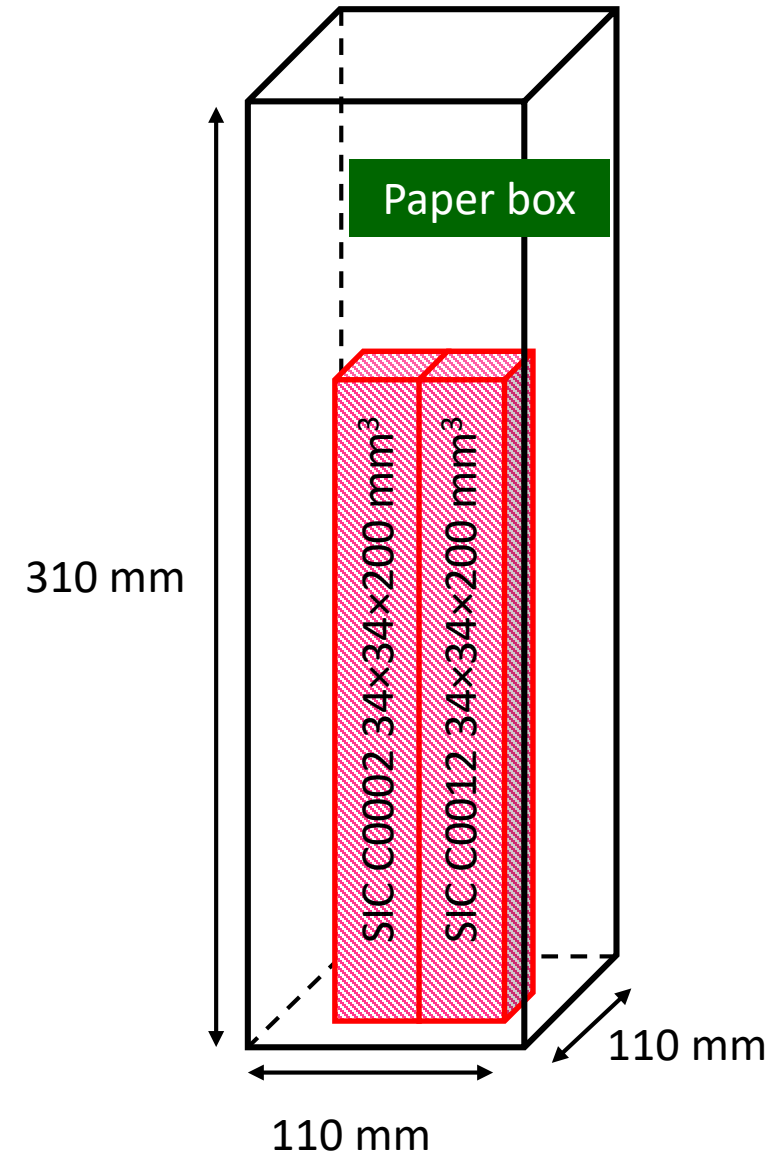
10 K (111 min) for SIC

10 K (111 min) for S-G

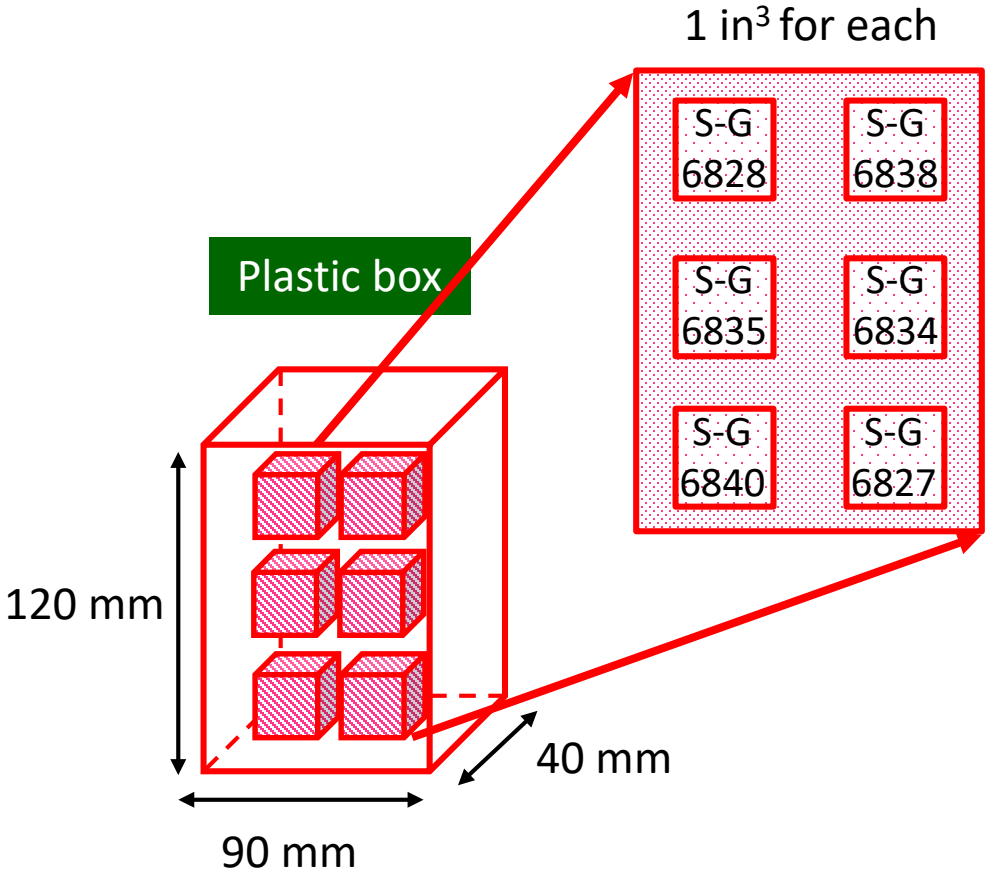
100 K (1110 min) for SIC & S-G



Two Sample Holders

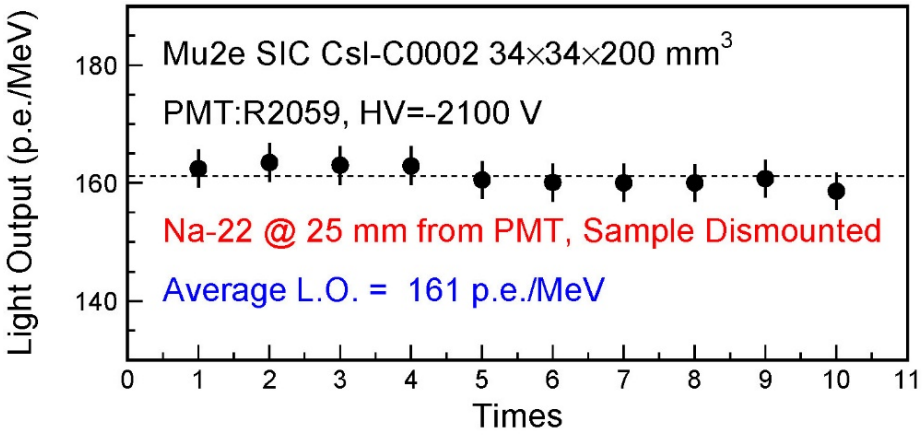


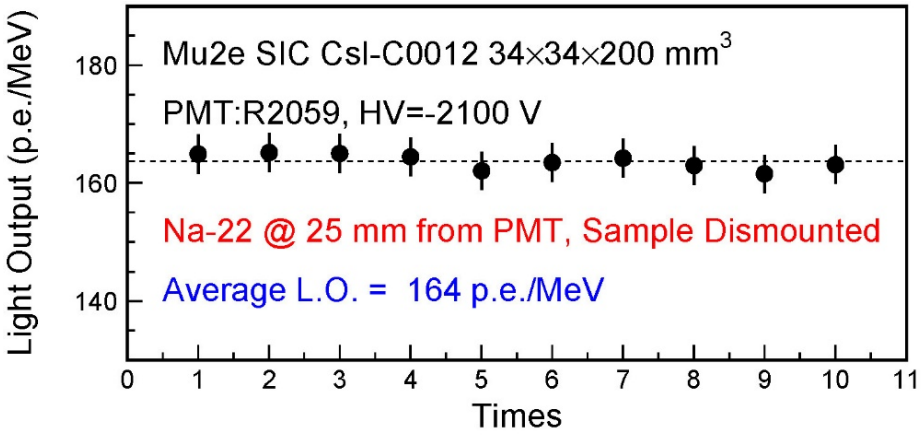
Space filled with soft plastic foam

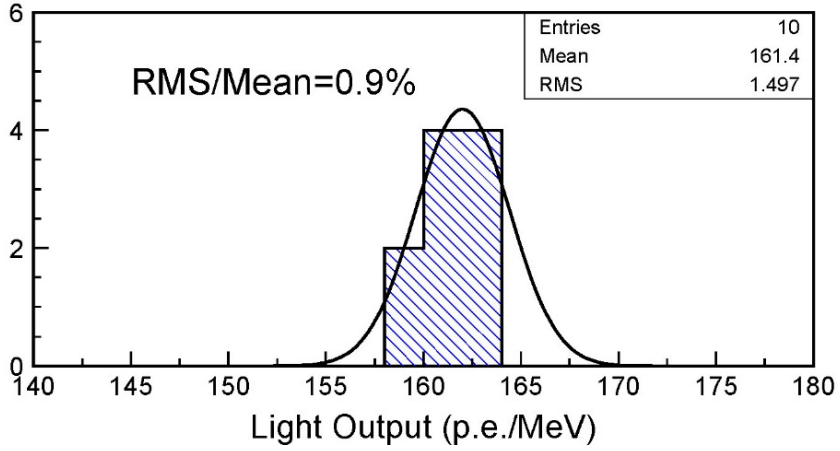


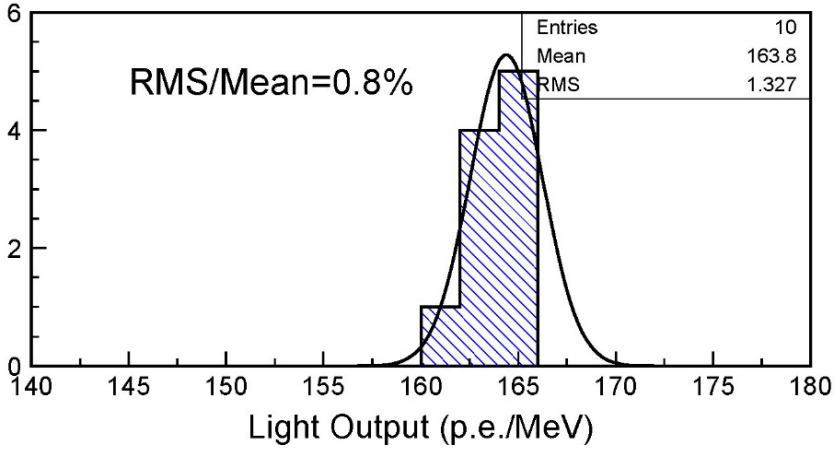
Systematics in LO Measurement

1% uncertainties determined by 10 repeated measurements









Results of Two SIC Samples

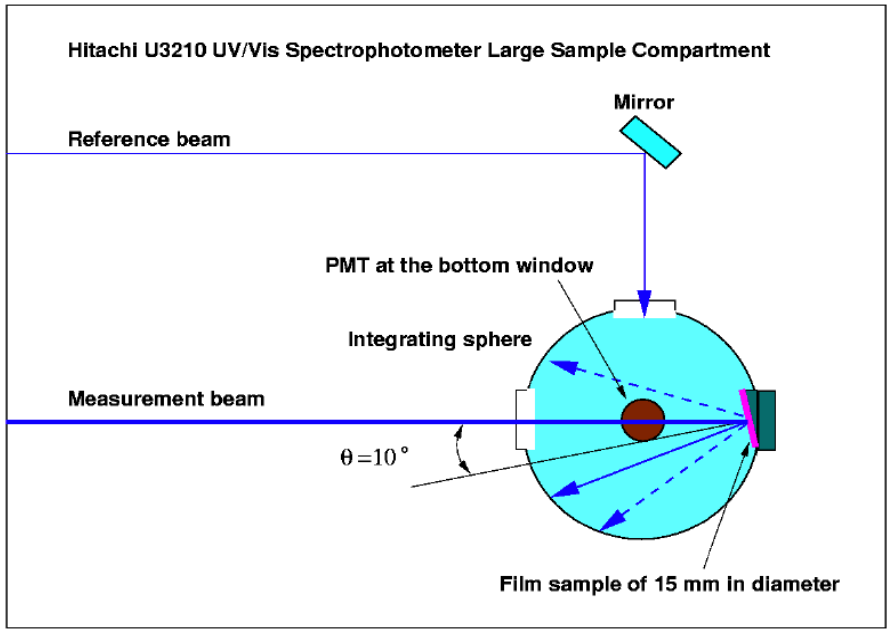
Damages, including Tyvek, meet Mu2e spec after 110 krad, but not after 10 krad

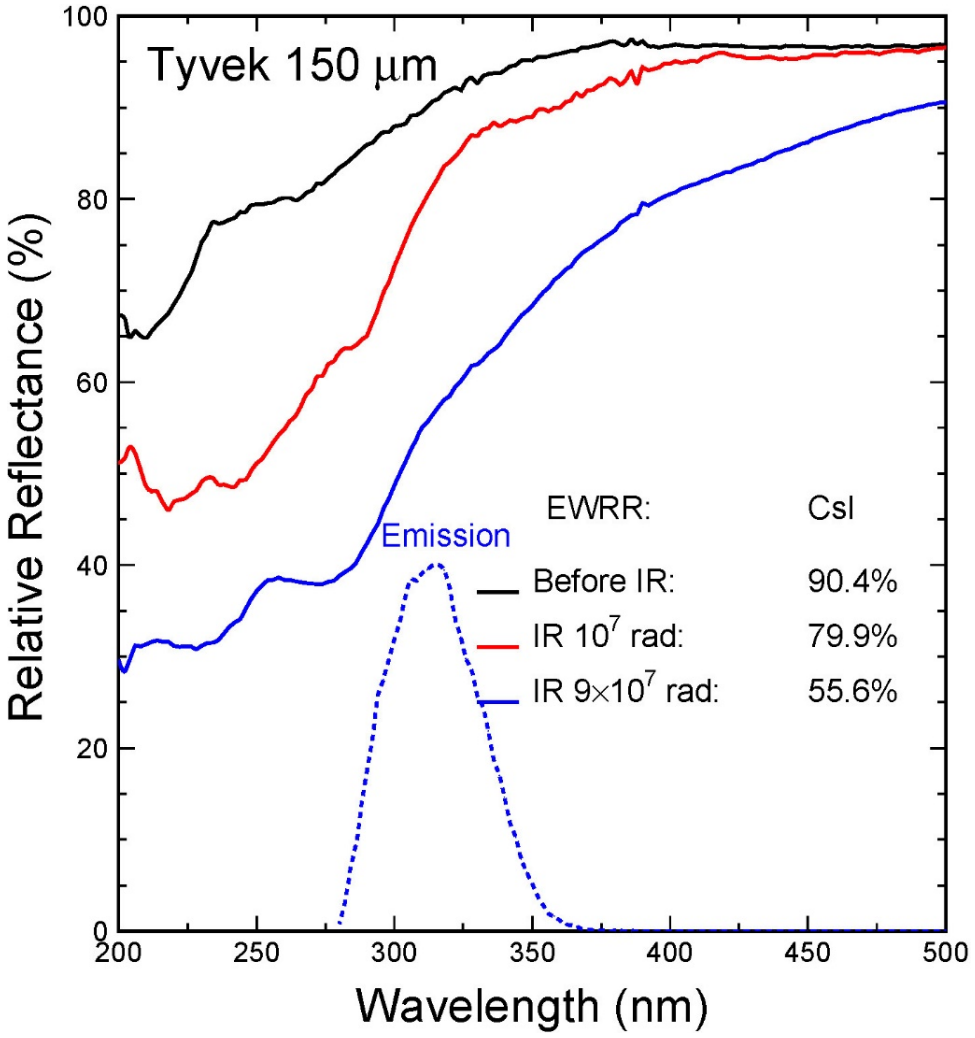
Crystal ID	Dose	L.O. (p.e./MeV)	E.R. (%)	F/T (%)	LRU (%)	δ (%)
SIC-C0002	-	164	34	90.5	2.20	4.7
	10 krad	**135 (82.3%)**	35	89.8	0.83	1.0
	110 krad	115 (70.1%)	36	91.7	1.88	-3.4
SIC-C0012	-	169	33	88.6	2.71	6.0
	10 krad	**133 (78.7%)**	35	88.5	1.21	1.5
	110 krad	104 (61.5%)	37	89.6	1.49	-2.5

Reflectance Damage in Tyvek

2014 data: 88.4%/61.5% after 10/90 Mrad for CsI emission

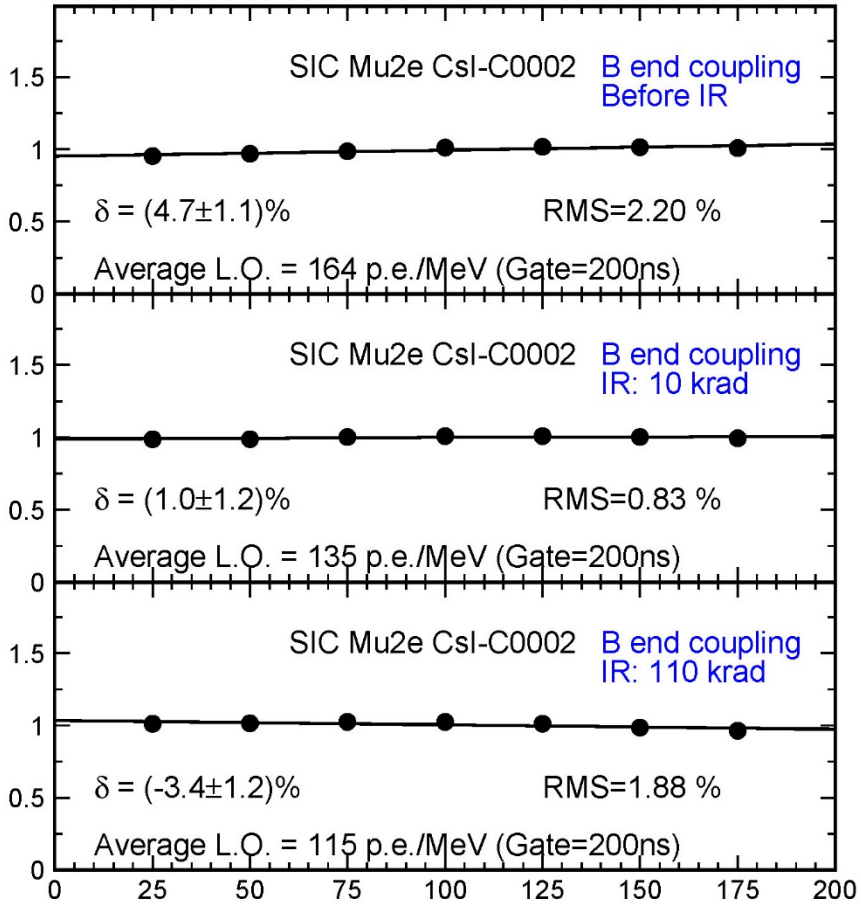
To be investigated: reflectance damage in Tyvek and its consequence to CsI LO.

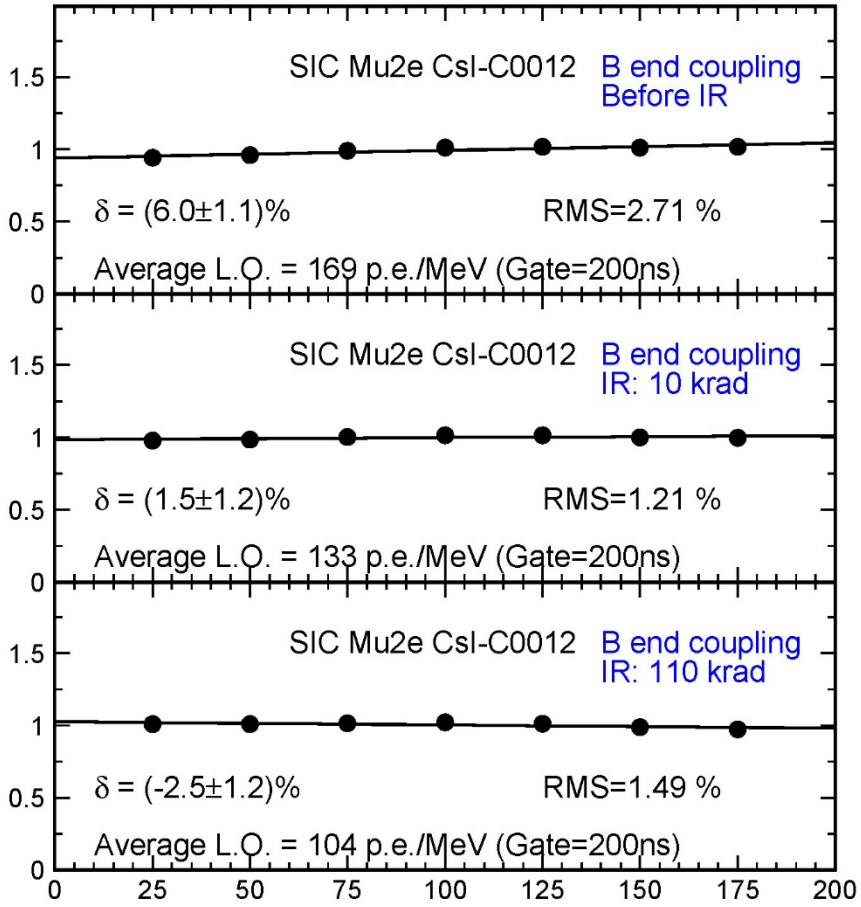




LRU of Two SIC Samples

Good LRU maintained after 10 and 110 krad





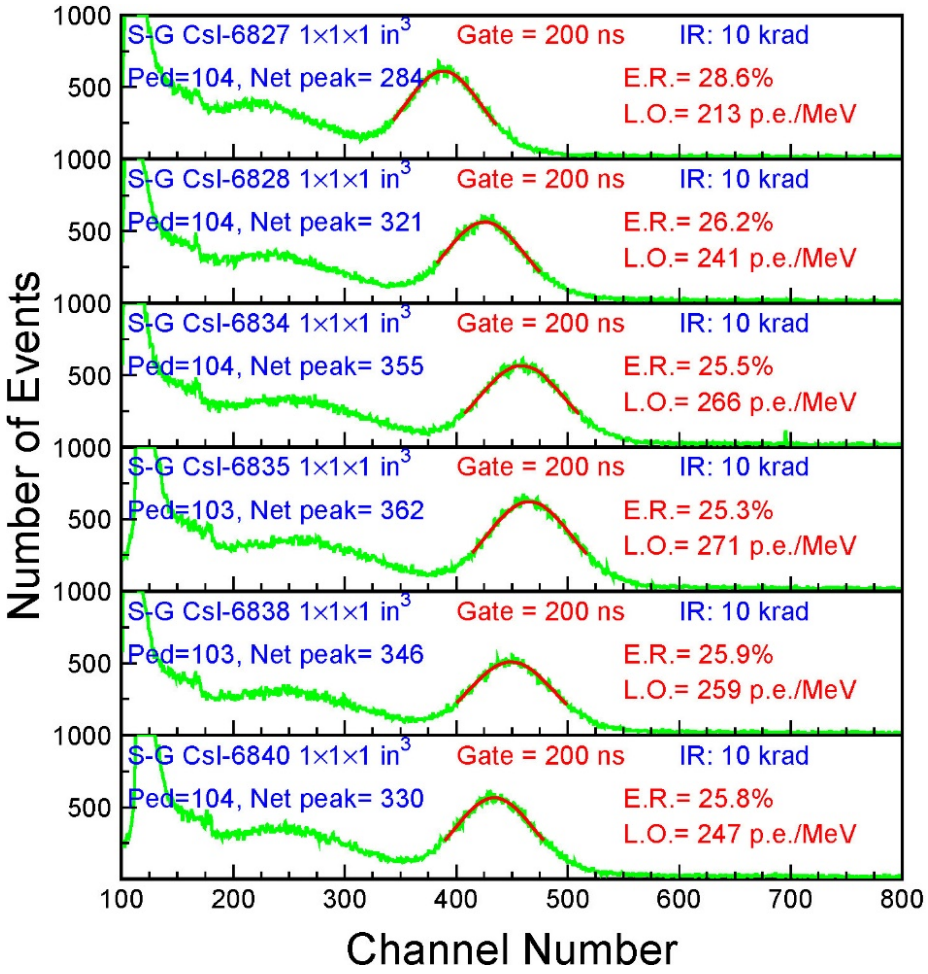
Results of Six S-G Samples

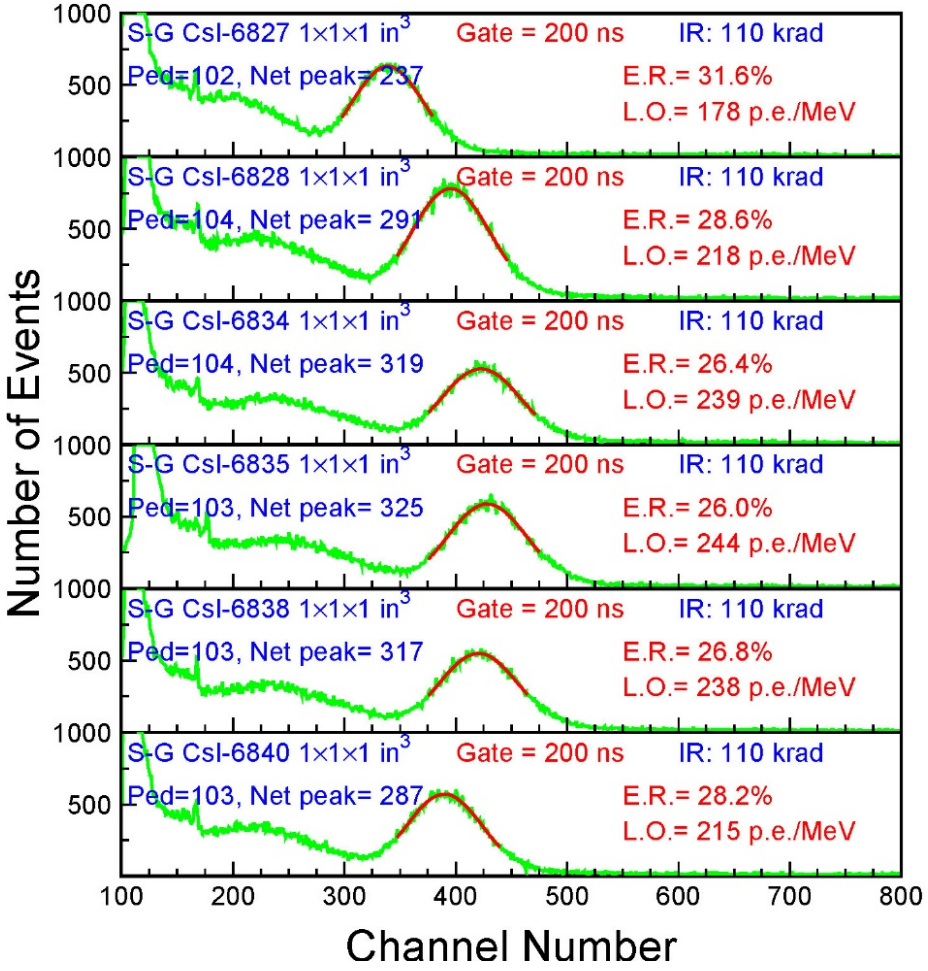
Damages meet Mu2e spec after 110 krad, but not after 10 krad

Crystal ID	Dose	L.O. (p.e./MeV)	E.R. (%)	F/T (%)
SG-6827	-	266	26.9	97.4
	10 krad	**213 (80.1%)**	28.6	95.5
	110 krad	178 (66.9%)	31.6	96.2
SG-6828	-	279	25.3	98.8
	10 krad	241 (86.4%)	26.2	99.6
	110 krad	218 (78.1%)	28.6	98.8
SG-6834	-	315	25.8	96.6
	10 krad	**266 (84.4%)**	25.5	98.3
	110 krad	239 (75.9%)	26.4	99.5
SG-6835	-	379	22.7	97.5
	10 krad	**271 (71.7%)**	25.3	98.7
	110 krad	244 (64.3%)	26.0	97.7
SG-6838	-	316	24.5	97.5
	10 krad	**259 (82.0%)**	25.9	99.2
	110 krad	238 (75.3%)	26.8	99.9
SG-6840	-	298	24.4	98.5
	10 krad	**247 (83.2%)**	25.8	100
	110 krad	215 (72.1%)	28.2	99.7

PHS for Six S-G Samples

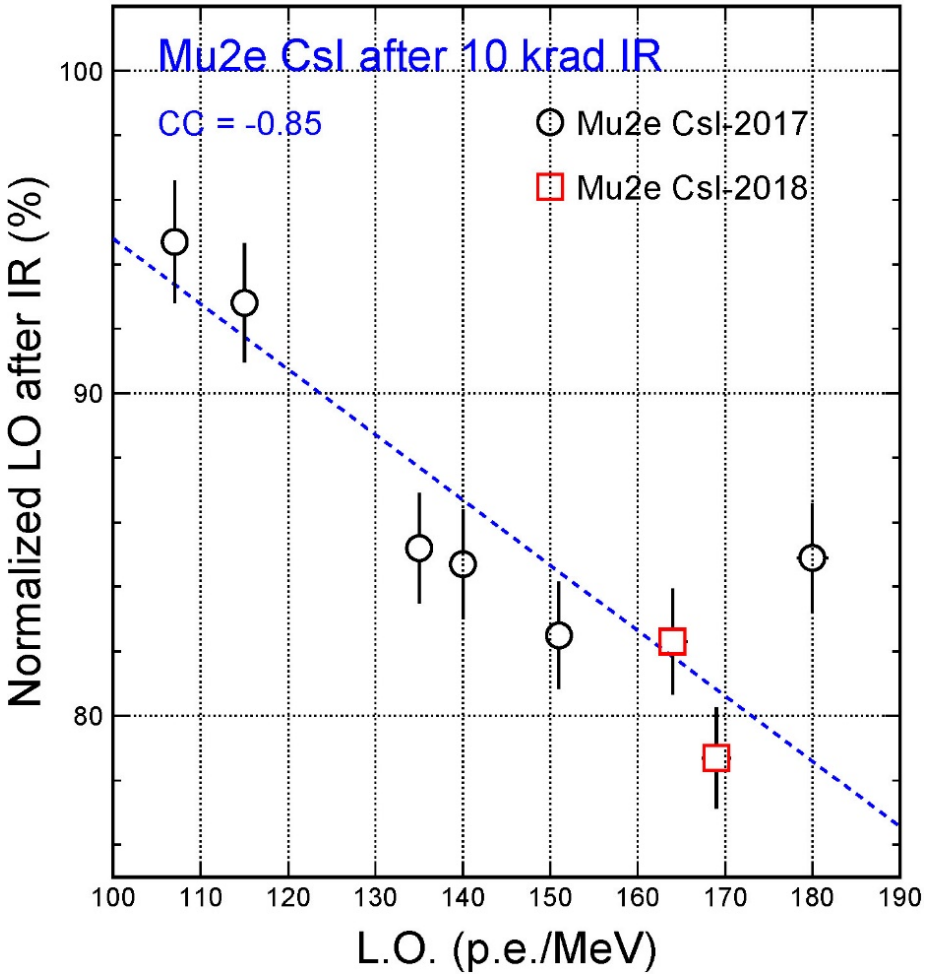
Good E.R. maintained after 110 krad

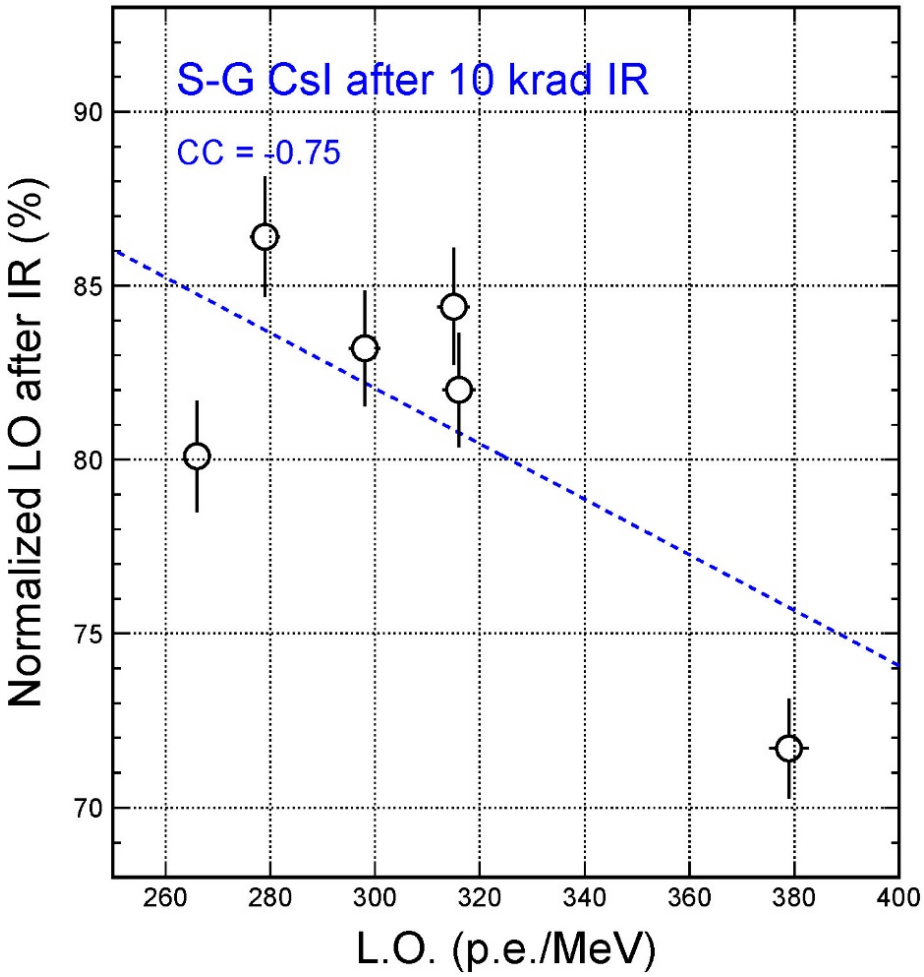




Normalized LO vs. Initial LO

Correlations exist between LO loss vs LO





Summary

- Two pre series SIC crystals with Tyvek wrapping were irradiated to 10/110 krad. They meet the Mu2e spec after 100 krad, but not after 10 krad.
- Since SIC crystals were irradiated together with the Tyvek wrapping, so the observed damages include reflectance damage in Tyvek. Further investigations will be carried out to understand Tyvek damage.
- Six Saint-Gobain 1” cubes were irradiated to 10/110 krad. They meet the Mu2e spec after 100 krad, but not after 10 krad. Given small sample size, the vendor will be reminded for radiation hardness.
- All CsI crystals measured so far meet Mu2e radiation damage spec after 100 krad.

Summary: F/T Ratio

ID	200 ns ER (%)	200 ns LO (p.e./MeV)	3000 ns LO (p.e./MeV)	LO(200) /LO(3000) (Caltech Data)	LO(100) /LO(1000) (S-G Data)	Conversion Factor (%)
S-G 6827	26.9	266	273	97.4	87.6	**89.9**
S-G 6828	25.3	279	283	98.8	87.9	**89.0**
S-G 6834	25.8	315	326	96.6	86.4	**89.4**
S-G 6835	22.7	379	389	97.5	88.3	**90.6**
S-G 6838	24.5	316	324	97.5	87.5	**89.7**
S-G 6840	24.4	298	301	98.5	88.5	**89.8**
Average	**24.9**	**309**	**316**	**97.7**	**87.7**	**89.8**
RMS/Ave	**5.2%**	**11.7%**	**12.0%**	**0.8%**	**0.8%**	**0.5**

Conversion factor: (89.8±0.5)% from the Mu2e data to the S-G data