Result of 18 2021 BTL LYSO Bars after 3.2×10^{14} n_{eq}/cm^2

Chen Hu, Liyuan Zhang, Ren-Yuan Zhu,

Adi Bornheim, Maria Spiropulu, Jason Trevor

California Institute of Technology

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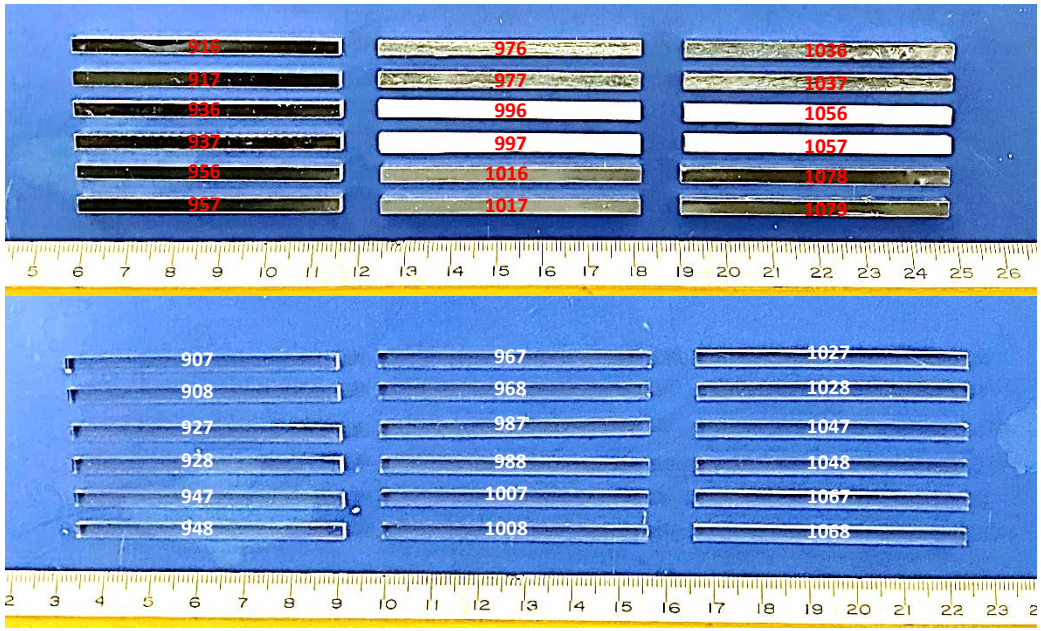
36 BTL LYSO Bars with & w/o ESR



ID	Dimension (mm^3)	#	Polishing
BTL LYSO-907~1079	3.00×3.12×56.3	36	All faces
All were received on April 6th, 2021. 18 bars were shipped to Lowell on May 7th.			
Irradiation to 3.2×10^{14} n_{eq}/cm^2 with ɣ-ray background of 42 krad			

Experiments

Properties measured before and after irradiation at room temperature:

Longitudinal Transmittance (LT), Light Output (LO) & Decay Time (τ)

Cross Link of LYSO Sample ID

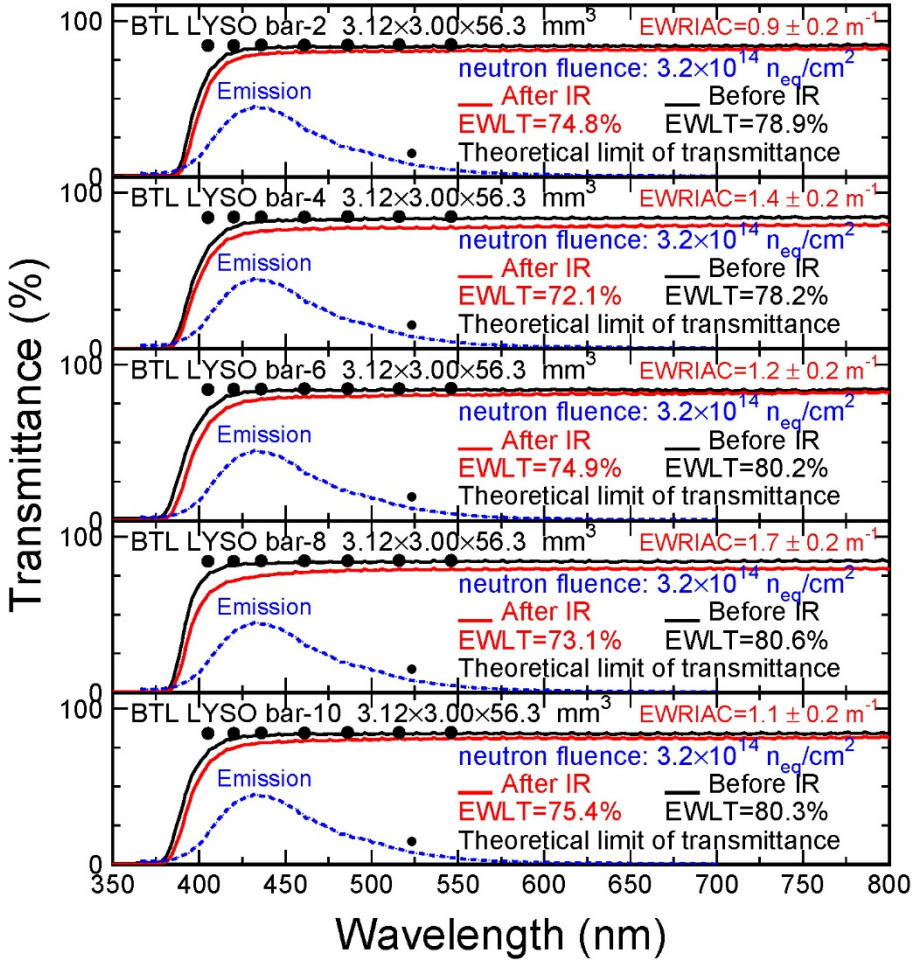
18 samples each went to ITA/Lowell for proton/neutron irradiation

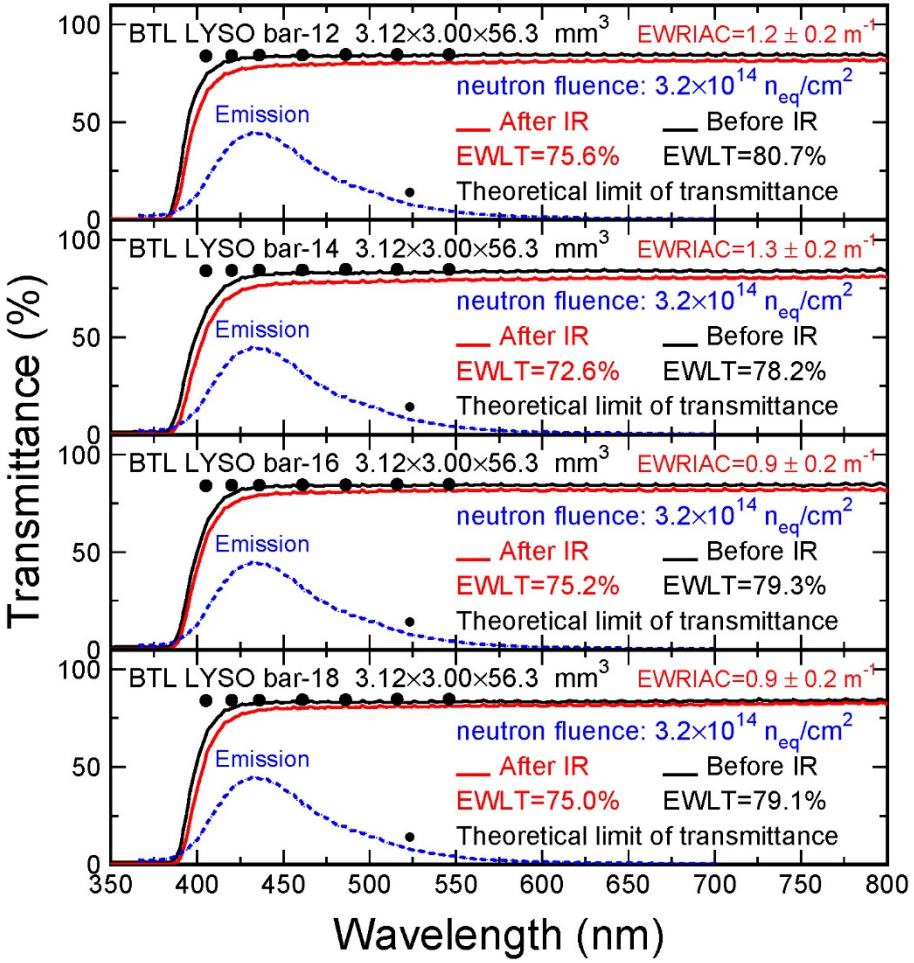
Caltech ID	Barcode	Producer	Test
1	907	1	Proton
2	908	1	Neutron
3	927	8	Proton
4	928	8	Neutron
5	947	5	Proton
6	948	5	Neutron
7	967	10	Proton
8	968	10	Neutron
9	987	3	Proton
10	988	3	Neutron
11	1007	9	Proton
12	1008	9	Neutron
13	1027	6	Proton
14	1028	6	Neutron
15	1047	4	Proton
16	1048	4	Neutron
17	1067	2	Proton
18	1068	2	Neutron

Caltech ID	Barcode	Producer	Test
ESR 1	916	1	Proton
ESR 2	917	1	Neutron
ESR 3	936	8	Proton
ESR 4	937	8	Neutron
ESR 5	956	5	Proton
ESR 6	957	5	Neutron
ESR 7	976	10	Proton
ESR 8	977	10	Neutron
ESR 9	996	3	Proton
ESR 10	997	3	Neutron
ESR 11	1016	9	Proton
ESR 12	1017	9	Neutron
ESR 13	1036	6	Proton
ESR 14	1037	6	Neutron
ESR 15	1056	4	Proton
ESR 16	1057	4	Neutron
ESR 17	1078	2	Proton
ESR 18	1079	2	Neutron

Transmittance: 9 LYSO Bars w/o ESR

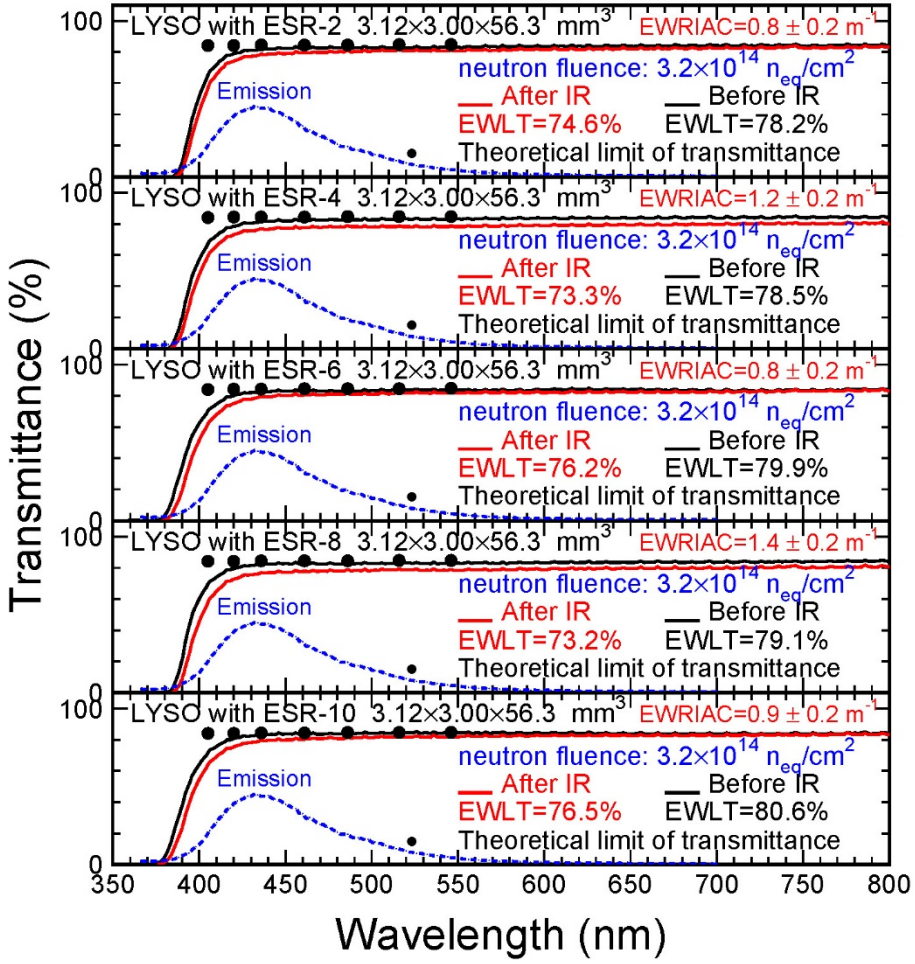
Radio-luminescence weighted LT (EWLT) and radiation induced absorption coefficient (EWRIAC) measured with a spectrophotometer

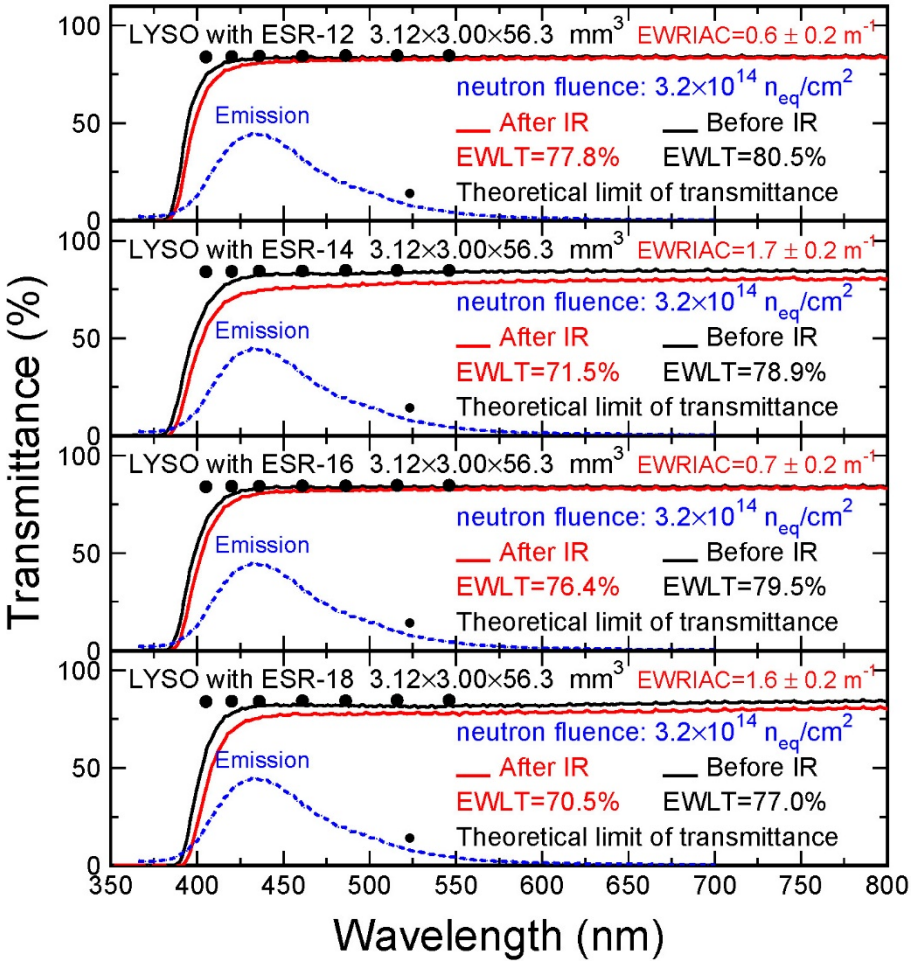




Transmittance: 9 LYSO Bars with ESR

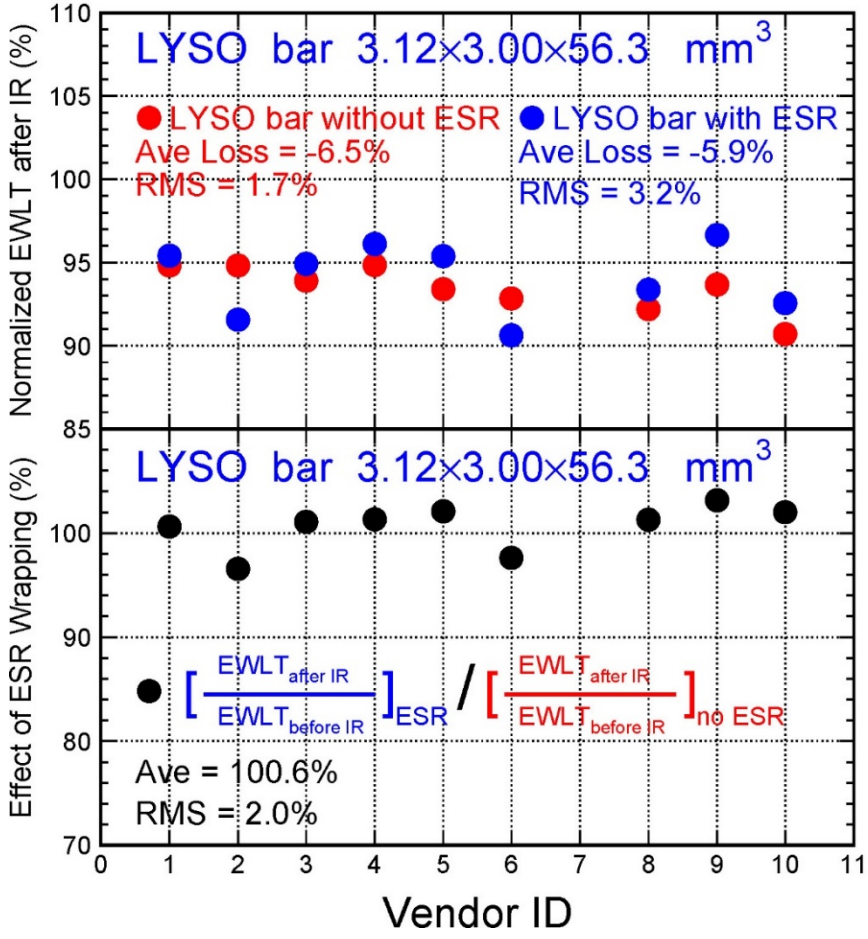
Radio-luminescence weighted LT (EWLT) and radiation induced absorption coefficient (EWRIAC) measured with a spectrophotometer

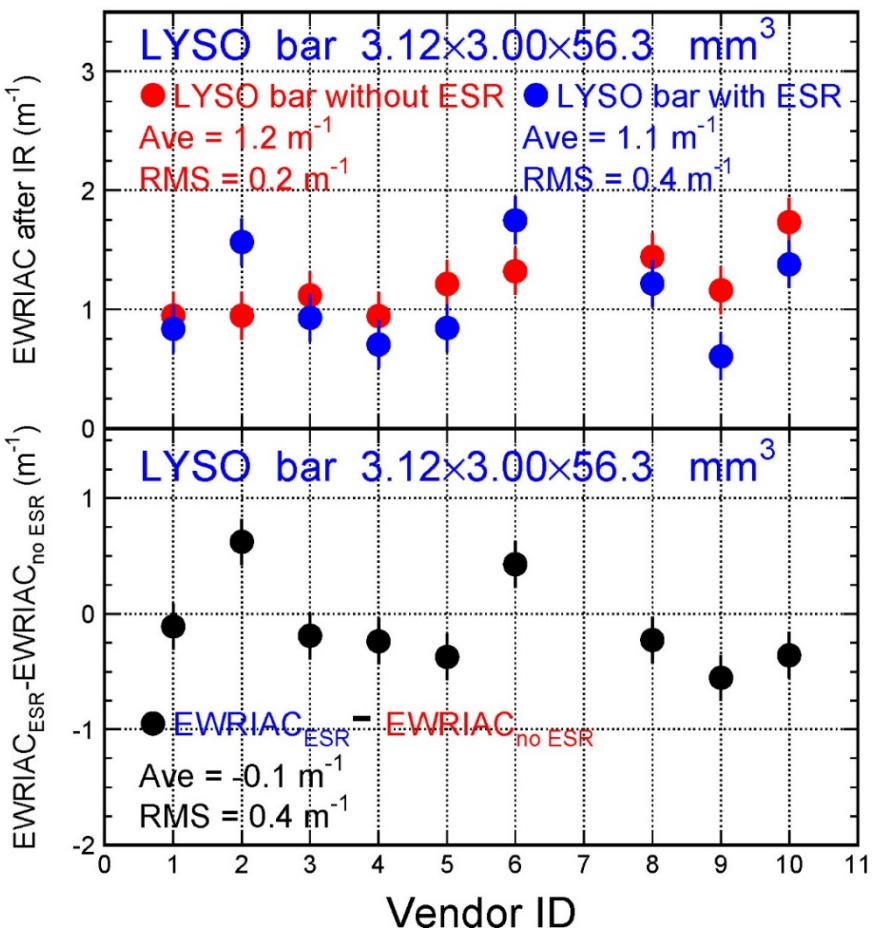




EWLT & EWRIAC after 3.2×10^{14} n_{eq}/cm^2

Average EWLT loss: 6.5 & 5.9 %, EWRIAC: 1.2 &1.1 m^{-1} for LYSO bars without & with ESR respectively

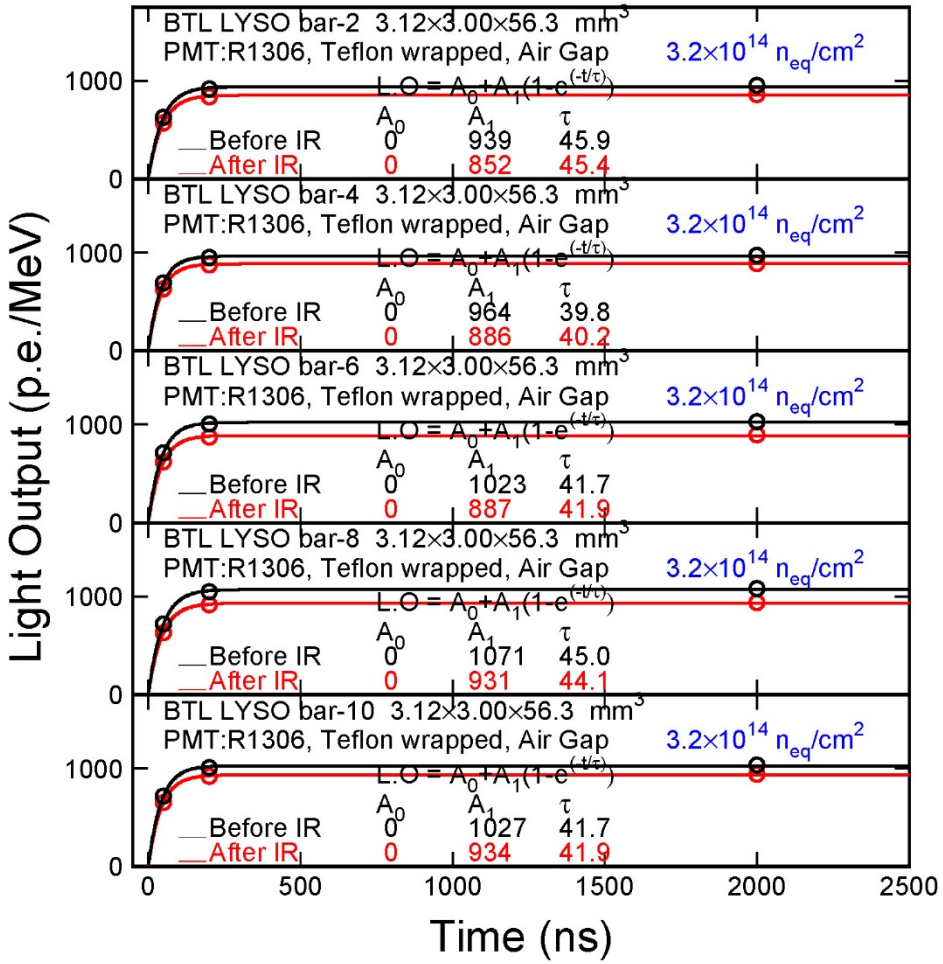


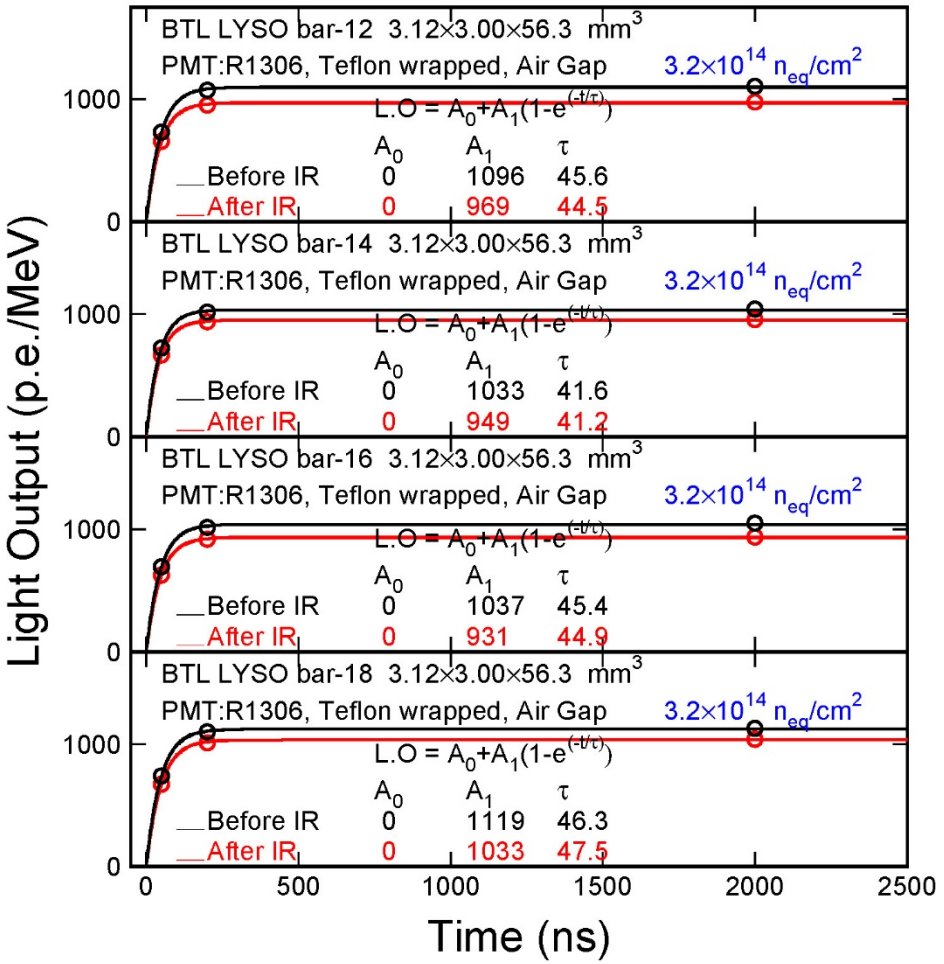


LYSO bars with ESR show a larger divergence

Light Output: 9 LYSO Bars w/o ESR

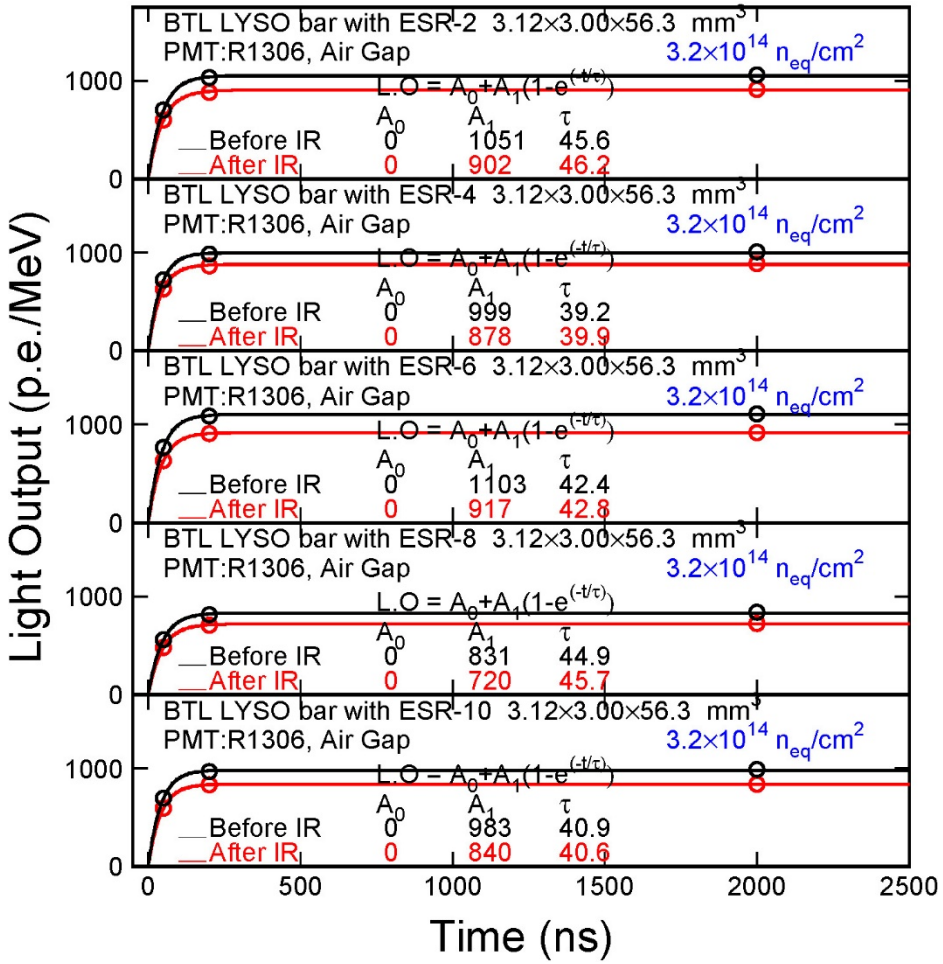
LYSO bars were surrounded by a Teflon block, coupled to an R1306 PMT with an air gap, and triggered by a Na-22 source at the center

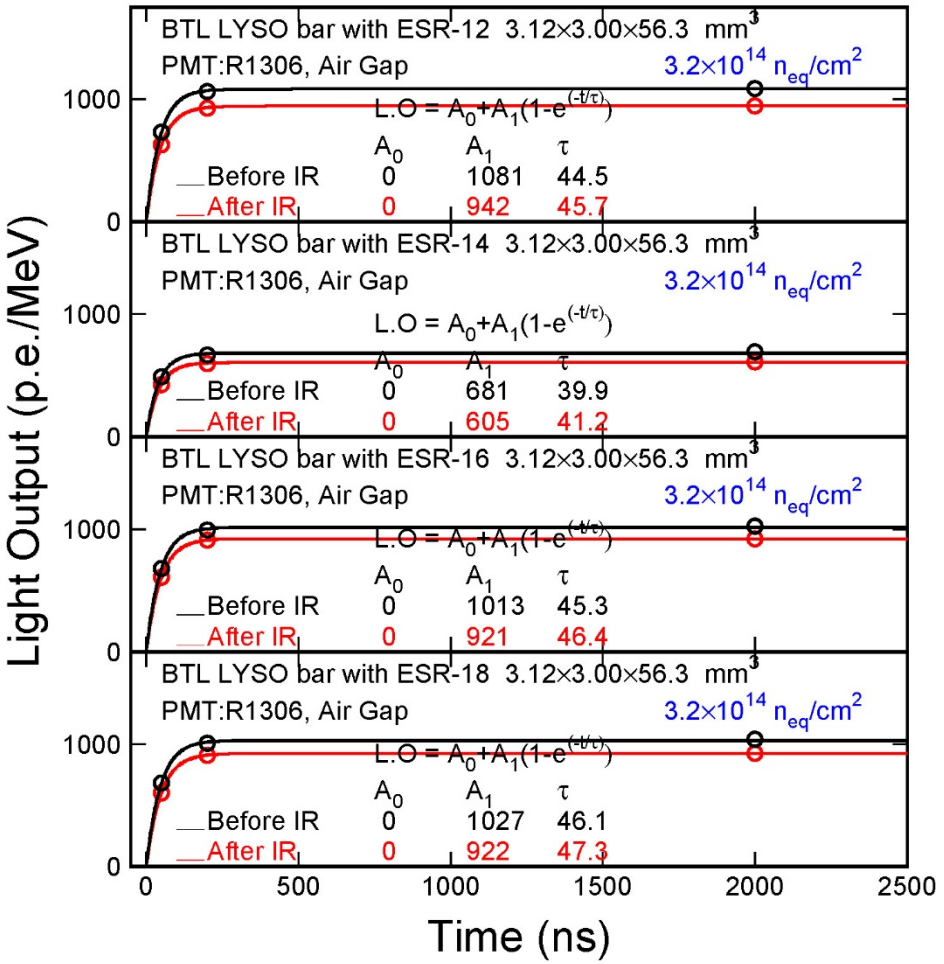




Light Output: 9 LYSO Bars with ESR

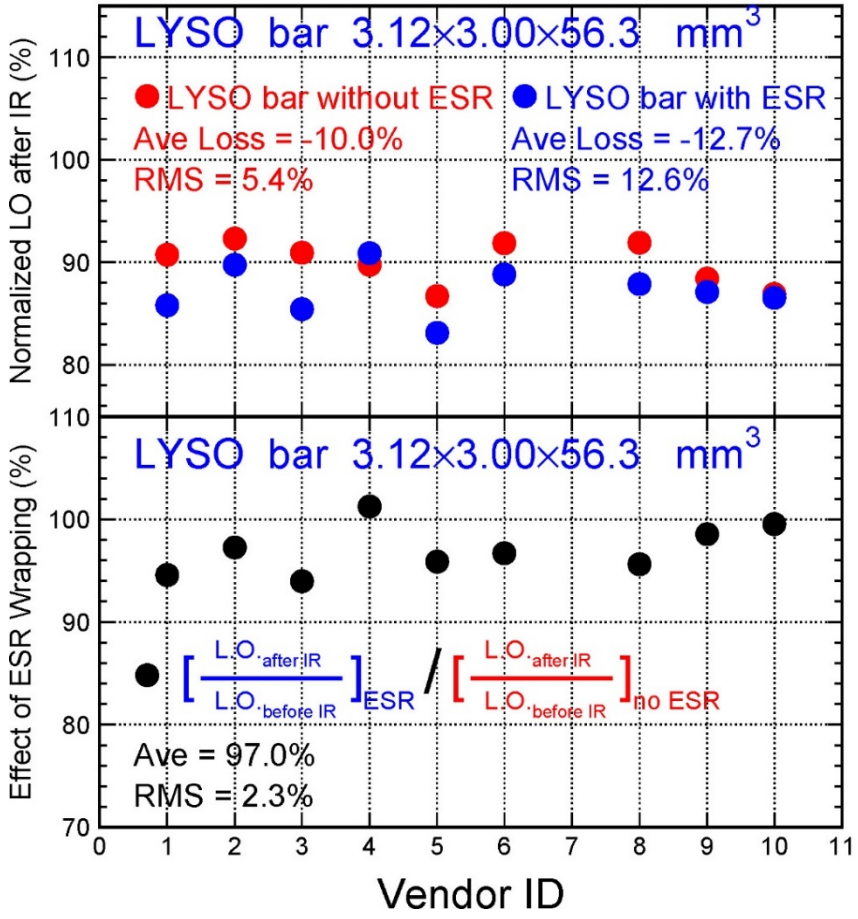
LYSO bars surrounded by ESR/Teflon at side/end faces, coupled to an R1306 PMT with an air gap, and triggered by a Na-22 source at the center

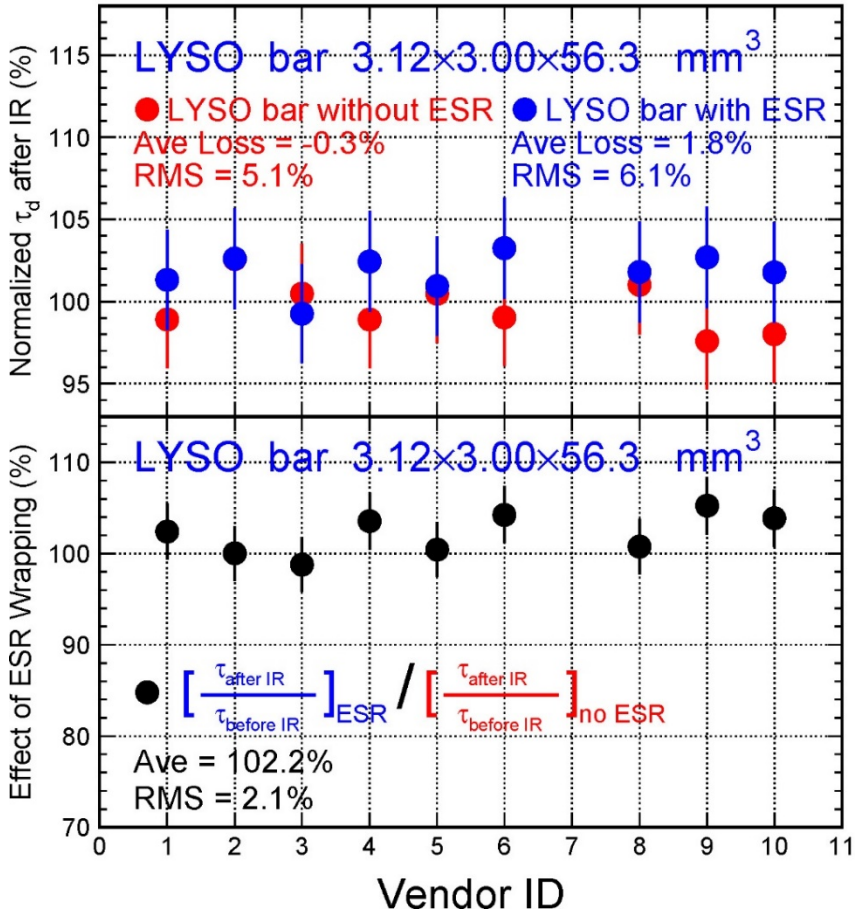




LO & τ after 3.2×10^{14} n_{eq}/cm^2

Average LO loss: 10.0 & 12.7 %, τ variation: -0.3 & 1.8 % for LYSO bars without & with ESR, respectively





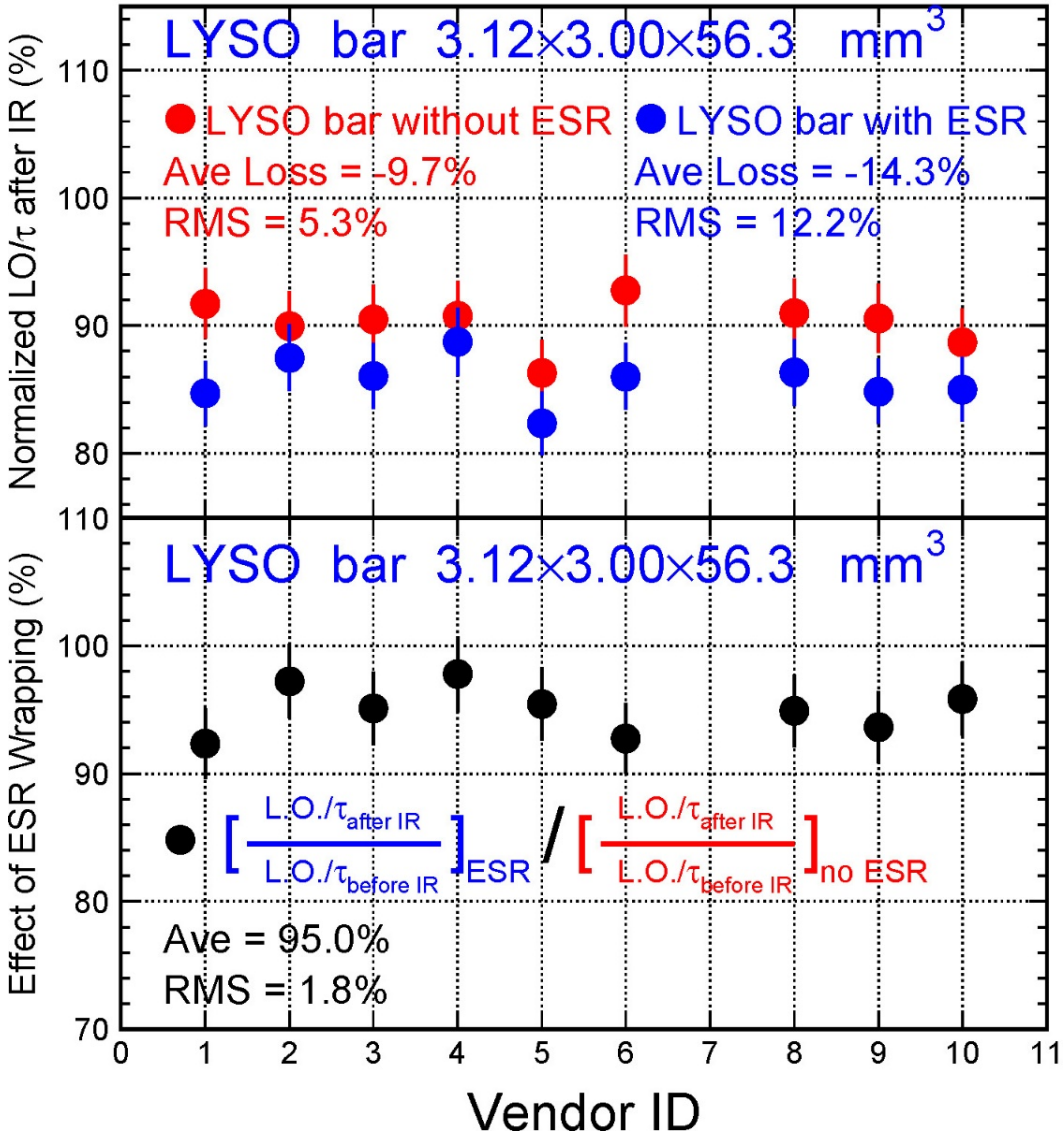
LYSO bars with ESR show a larger divergence

LO/τ after 3.2×10^{14} n_{eq}/cm^2

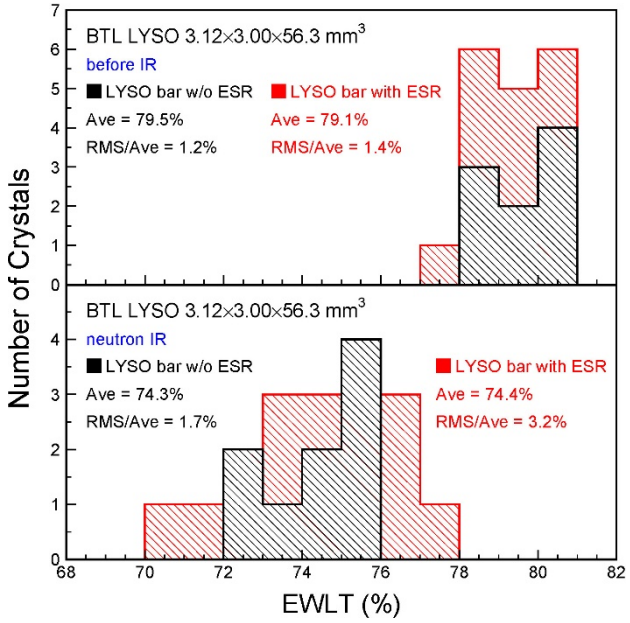
All vendors show consistent result

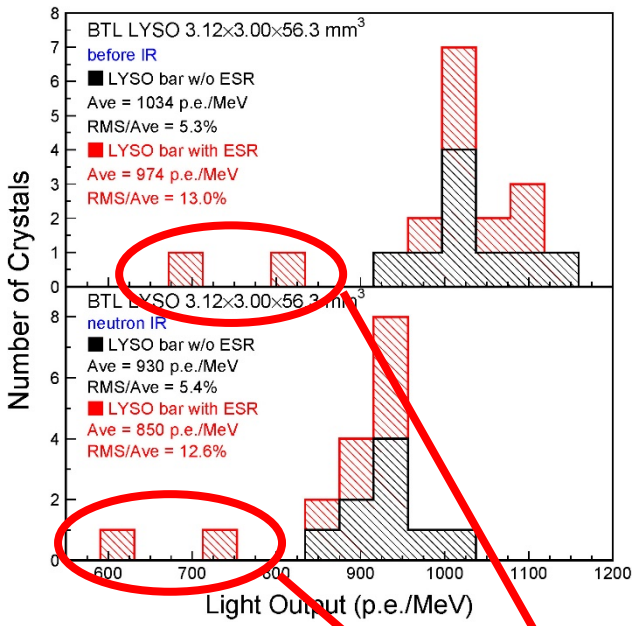
Average LO/τ loss: 9.7 & 14.3 % for LYSO bars without & with ESR respectively, indicating a less than 5 & 8 % degradation in timing resolution

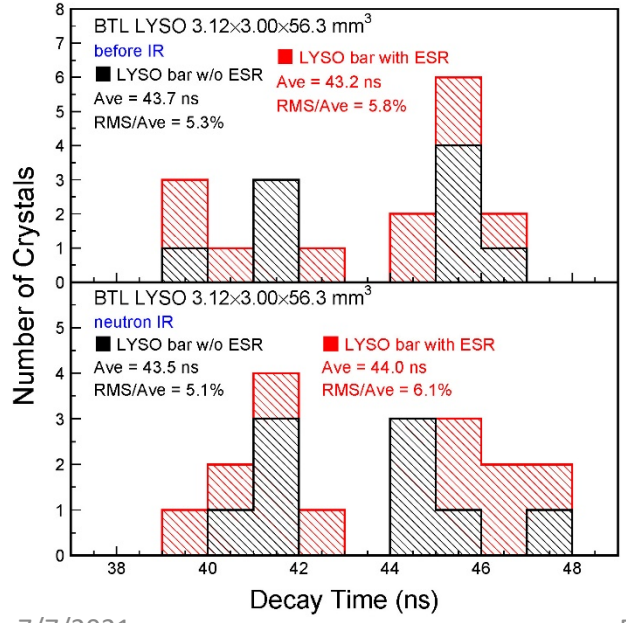
LYSO bars with ESR show a larger divergence

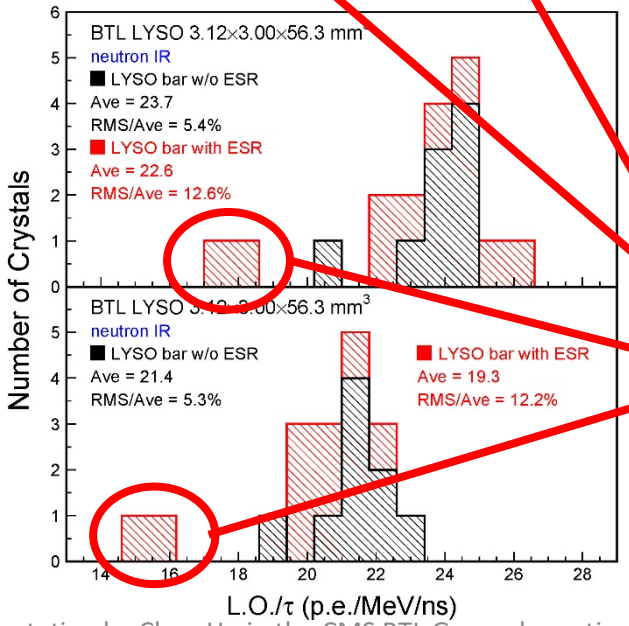


Damage after 3.2×10^{14} n_{eq}/cm^2







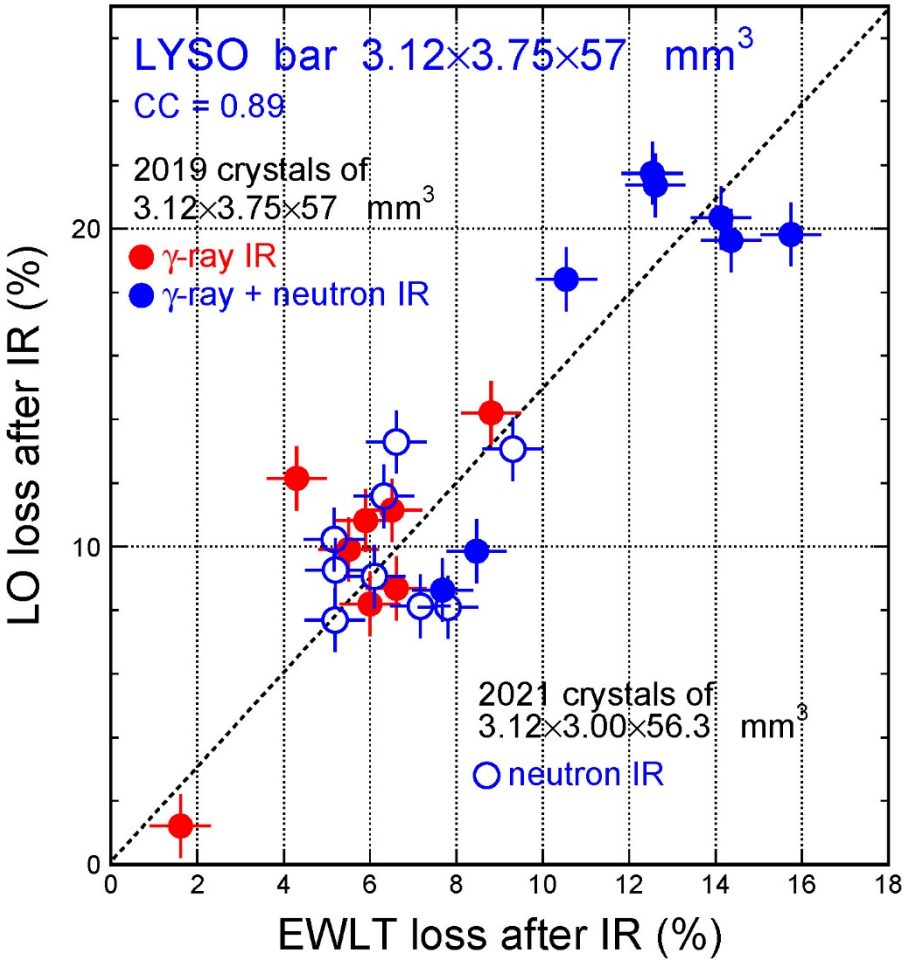


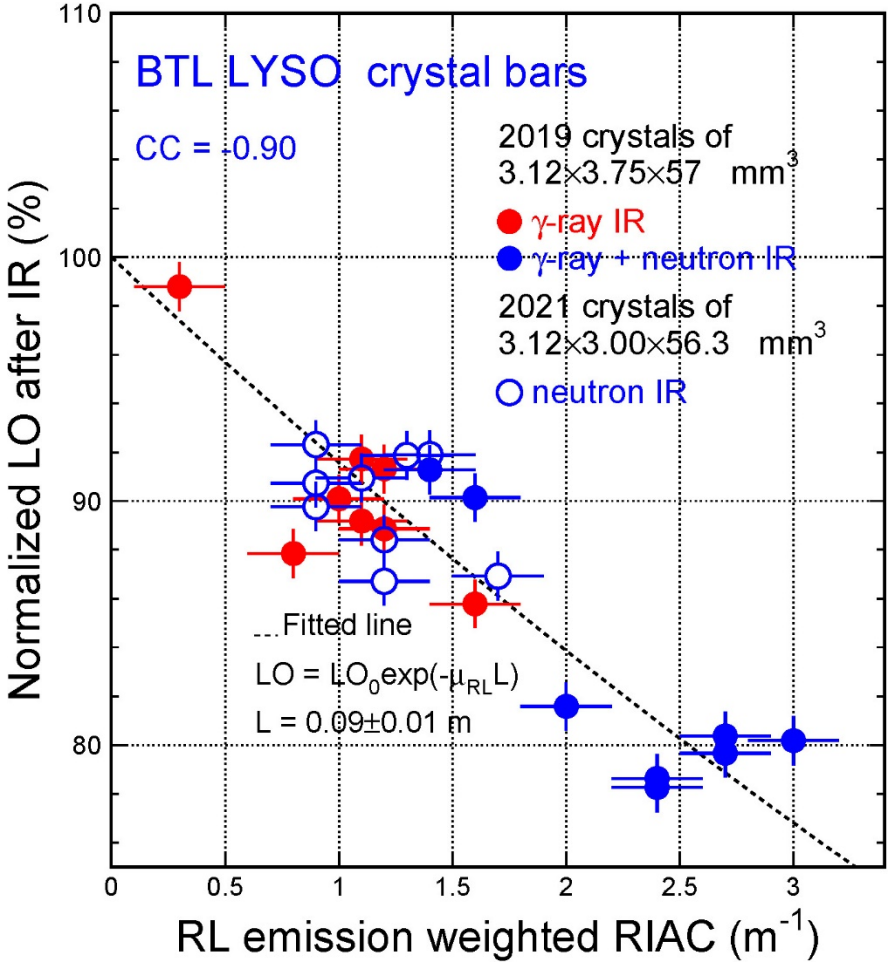
Average variations of EWLT, LO, τ and LO/τ: -6.5% & -5.9%, -10.0% & -12.7%, -0.3% &1.8% and -9.7% & -14.3% for LYSO bars without & with ESR, respectively

Two vendors (6 and 10) have poor ESR wrapping as shown on slide 12 in the 5/19/21 report

Light Output vs EWLT & EWRIAC

Good correlations between LO, EWLT and EWRIAC indicate that LO loss is due to radiation induced absorption with a mean light path of 9 cm





Summary

We measured LT, LO and τ for 18 2021 BTL LYSO bars w/o and with ESR wrapping before and after 3.2×10^{14} n_{eq}/cm^2.

LYSO bars from nine venders show consistent damage. The average variation of LT, LO, τ and LO/τ after 3.2×10^{14} n_{eq}/cm^2 is -6.5% & -5.9%, -10.0% & -12.7%, -0.3% &1.8% and -9.7% & -14.3% respectively for LYSO bars without & with ESR.

Average variation induced by ESR is -3.0%, 2.2% and -5.0% respectively for LO, τ and LO/τ. Timing resolution is expected to degrade by 5% and 9% for LYSO bars w/o and with ESR. A larger divergence observed in LYSO bars with ESR.

Similar to ɣ-rays, neutrons induced LO loss is due to induced absorption with a mean path of 9 cm in BTL LYSO bars.

Acknowledgements: DOE HEP Award DE-SC0011925