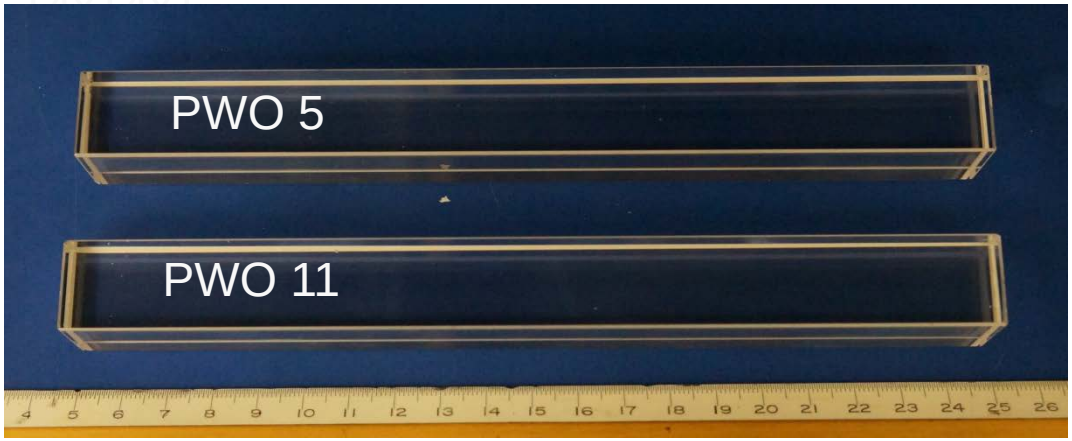
Report on Two SIC PWO Crystals from JLAB



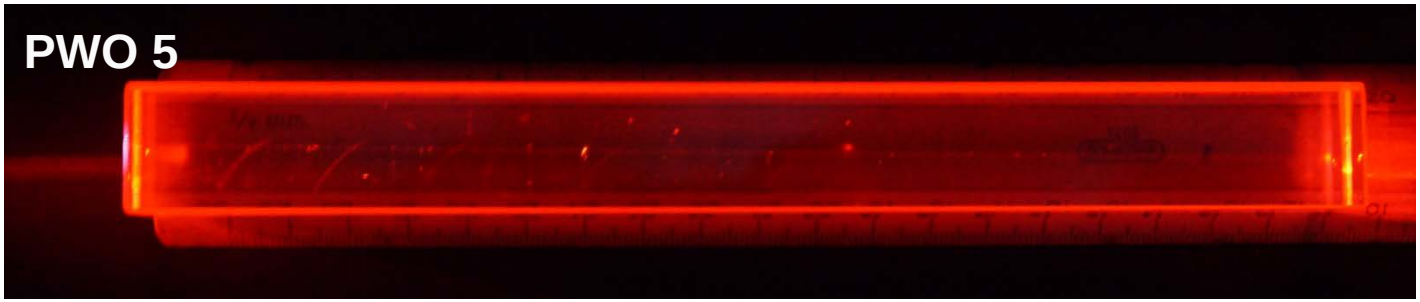
ID	Dimension (mm^3)	Polishing
PWO 5	20x20x200	All faces
PWO 11	20x20x200	All faces

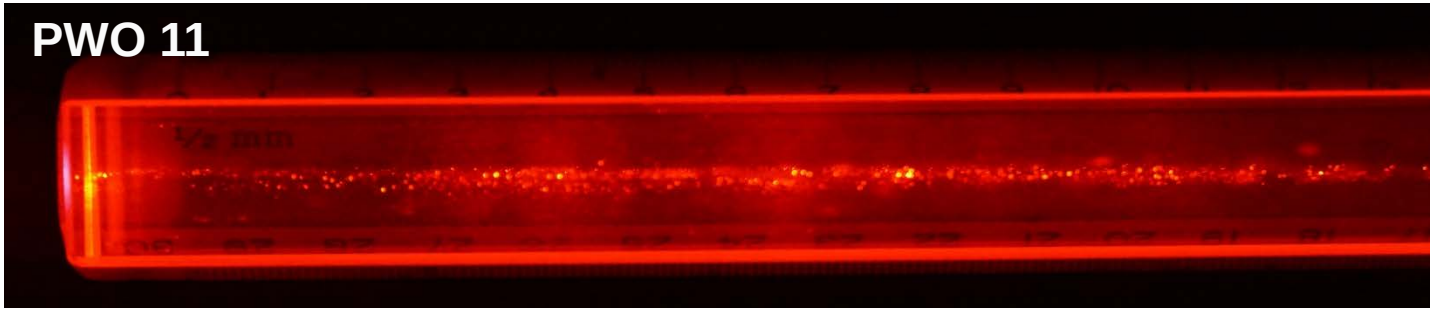
Experiments

- Two crystals were annealed at 200^{o}C for 240 minutes before measurements.
- Properties measured at room temperature : LT, PHS, LO & Decay Kinetics.
- Properties were also measured in equilibrium under ɣ-ray irradiation at 2, 8, 30 and 7k rad/h, and compared to CMS and Panda PWO crystals.

Scattering Centers

Laser beam goes through crystals, showing scattering centers

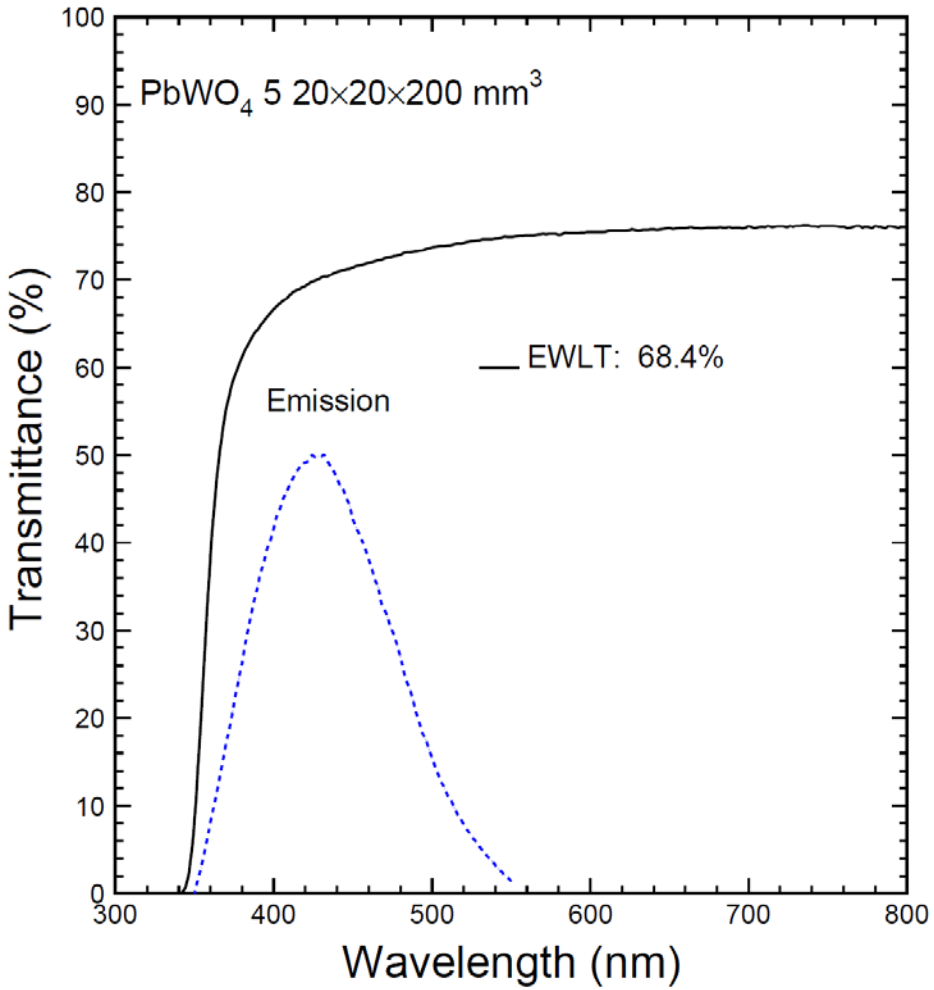


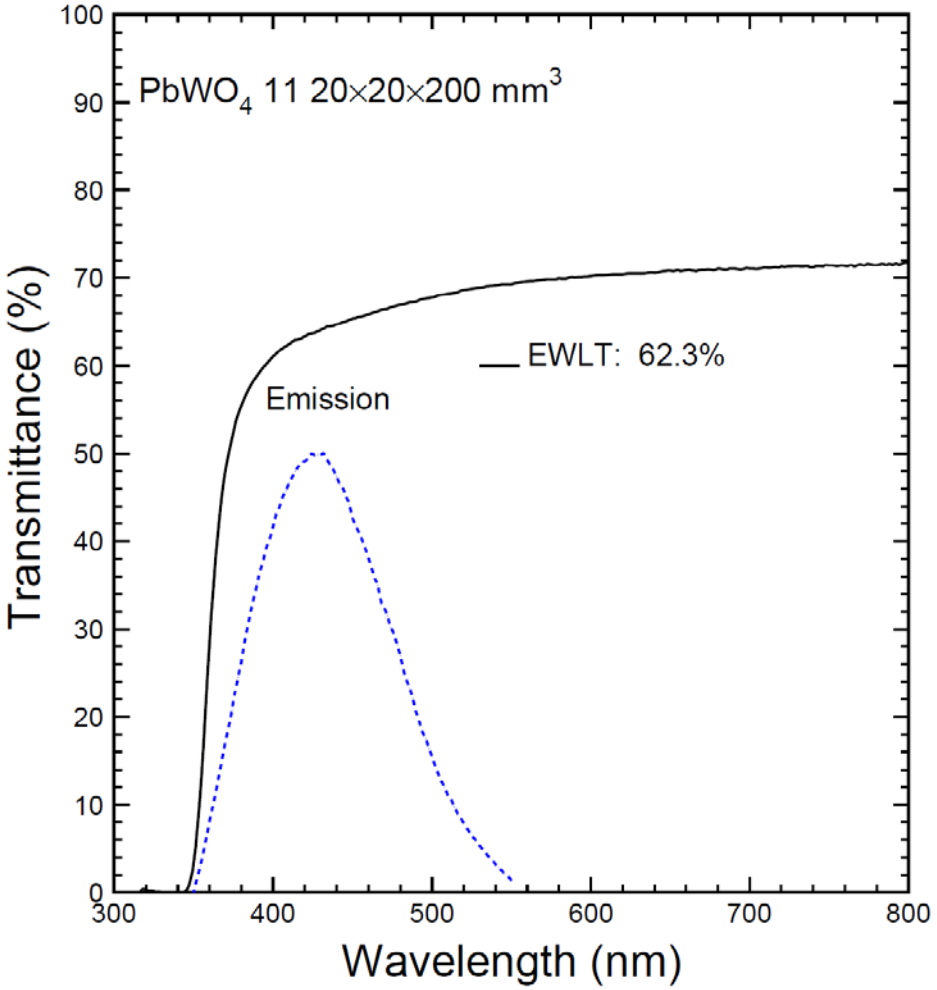


Sample 11 has significant scattering centers in the bulk

Longitudinal Transmittance

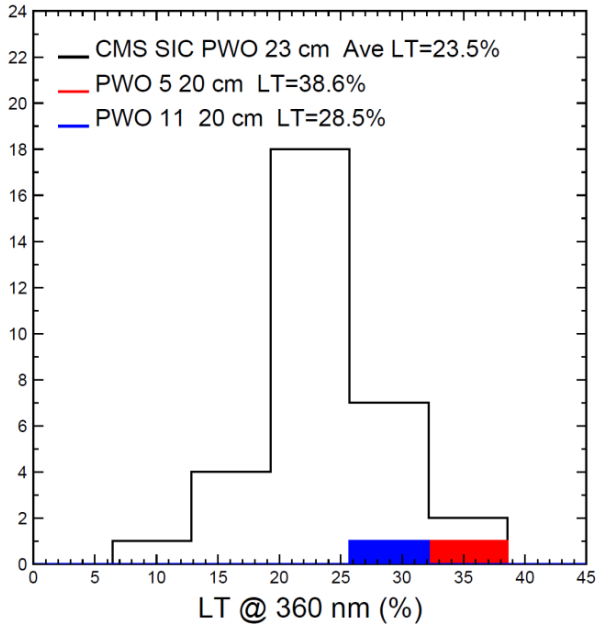
Significant lower transmittance in PWO 11

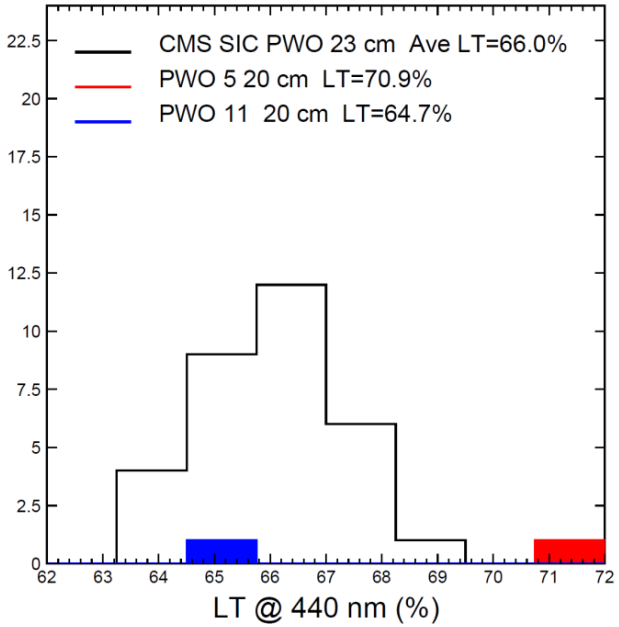


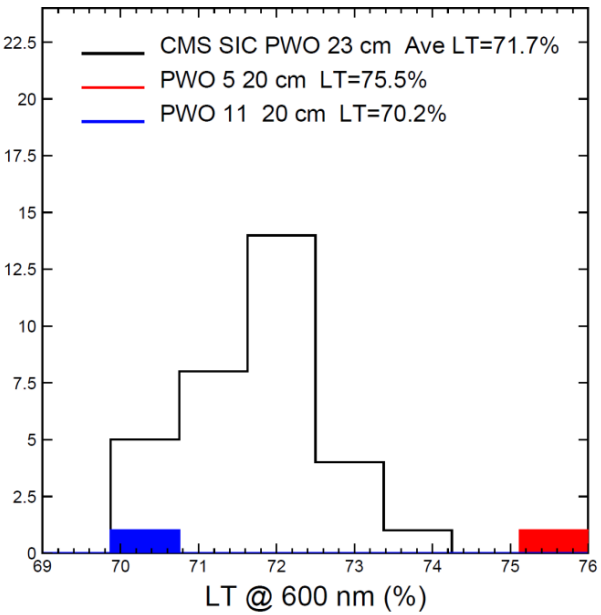


Comparison with CMS Batch

Longitudinal transmittance of sample 5/11 is better/worth that the average of CMS crystals as published in IEEE Trans. Nucl. Sci. NS-51 1777



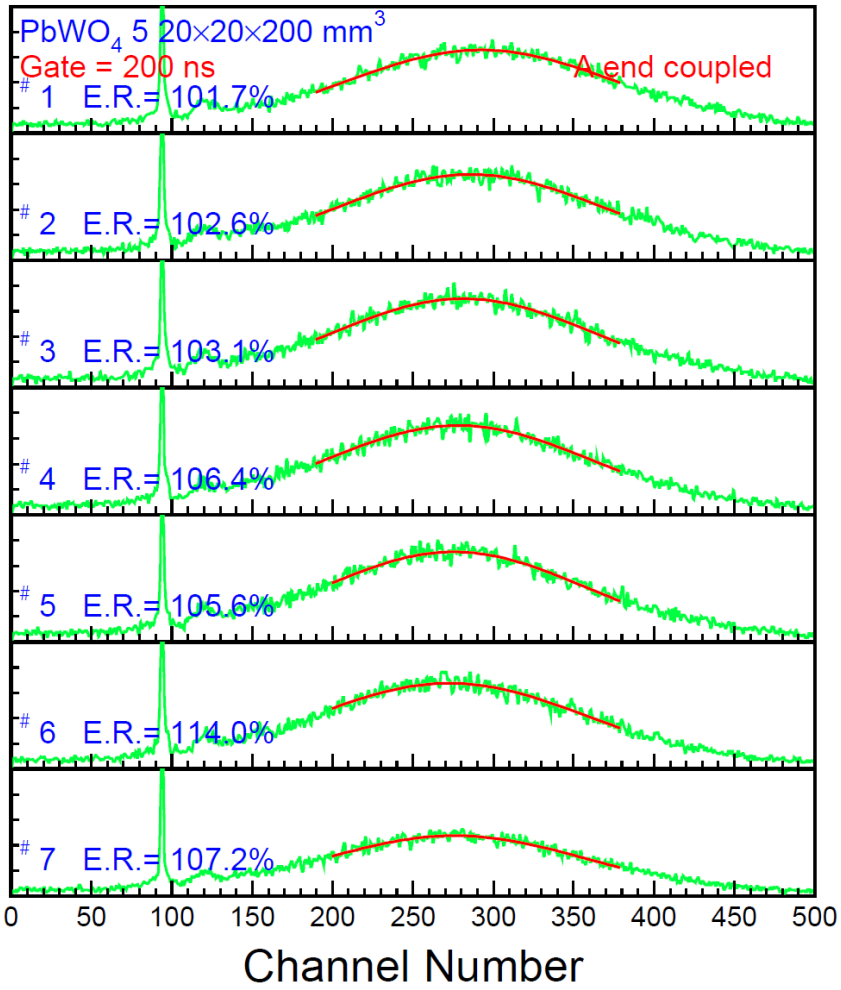


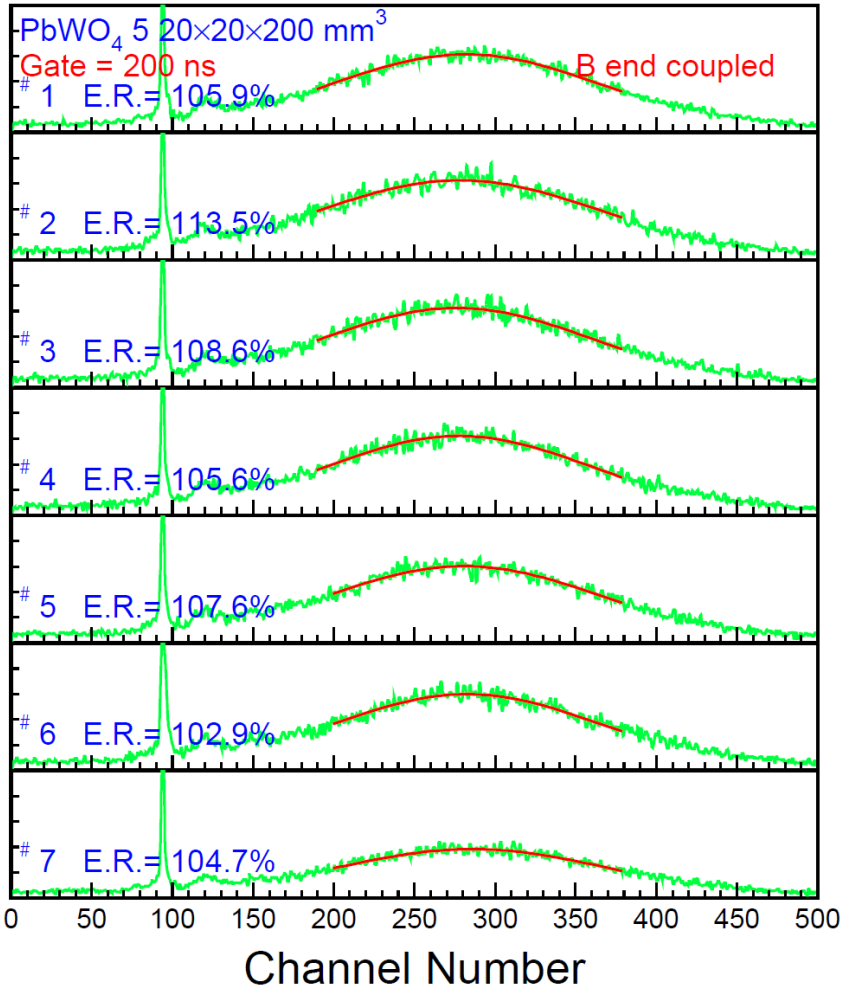


Sample 5 shows better LT than sample 11 because of less scattering centers

Pulse Height Spectra of PWO 5

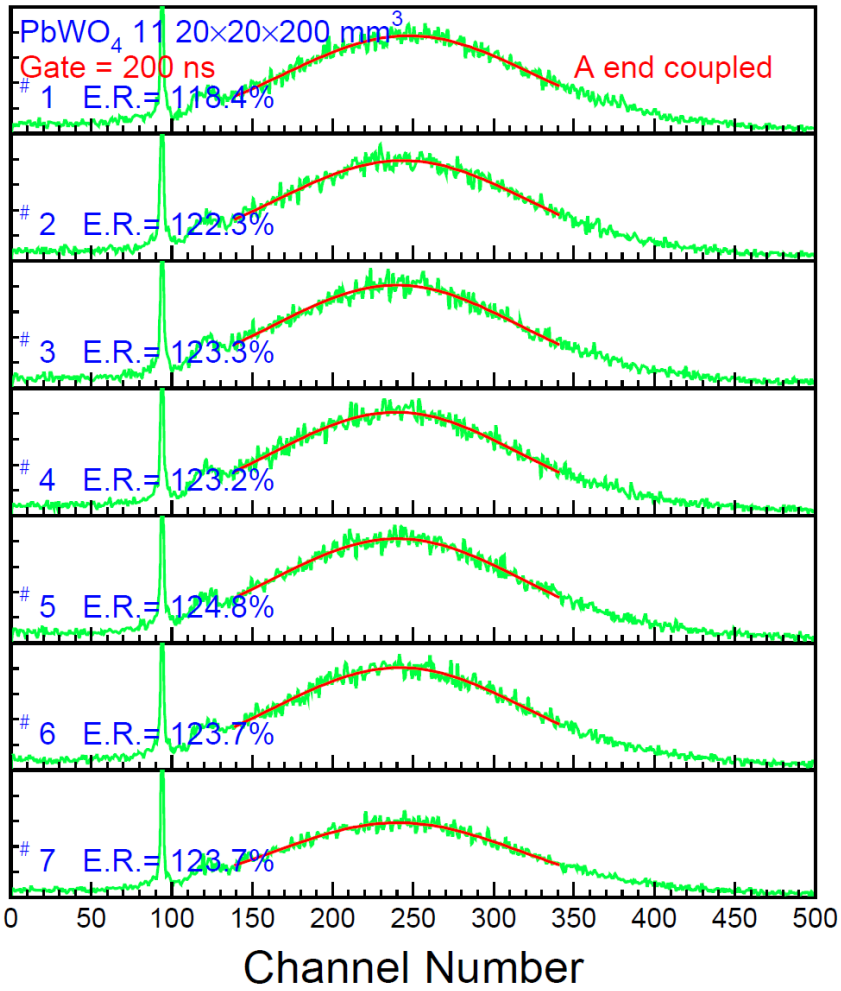
Measured with Cs-137 source and Hamamatsu R2059 PMT with grease coupling

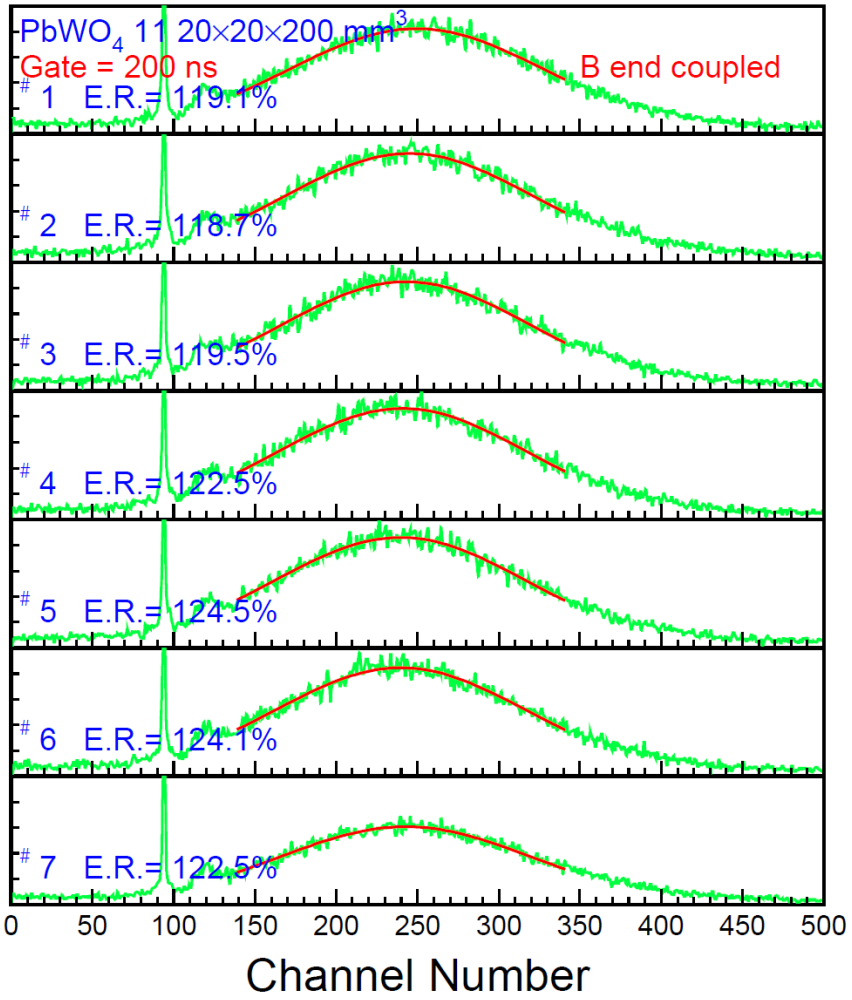




Pulse Height Spectra of PWO 11

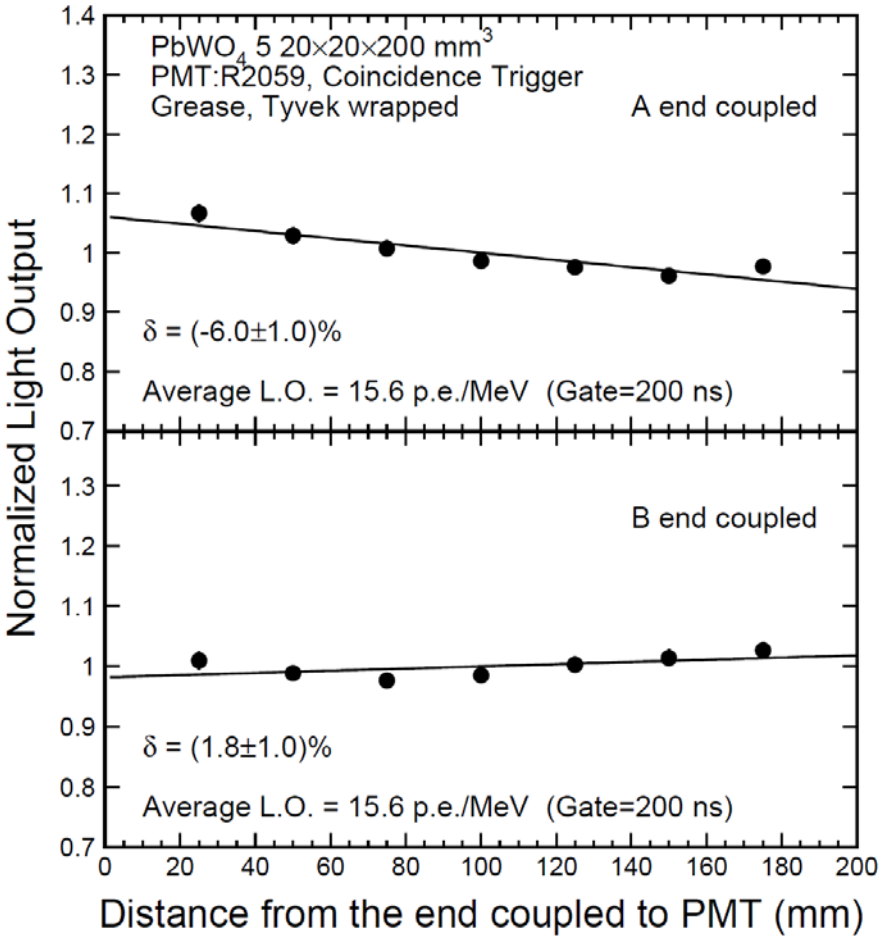
Measured with Cs-137 source and Hamamatsu R2059 PMT with grease coupling

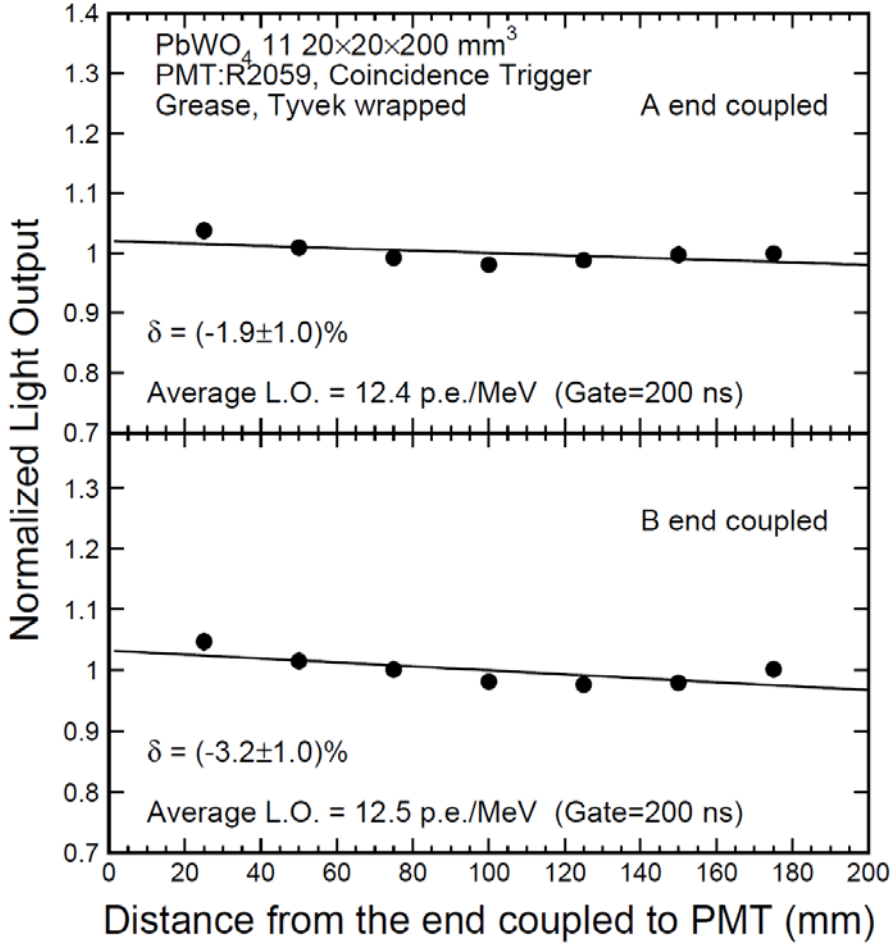




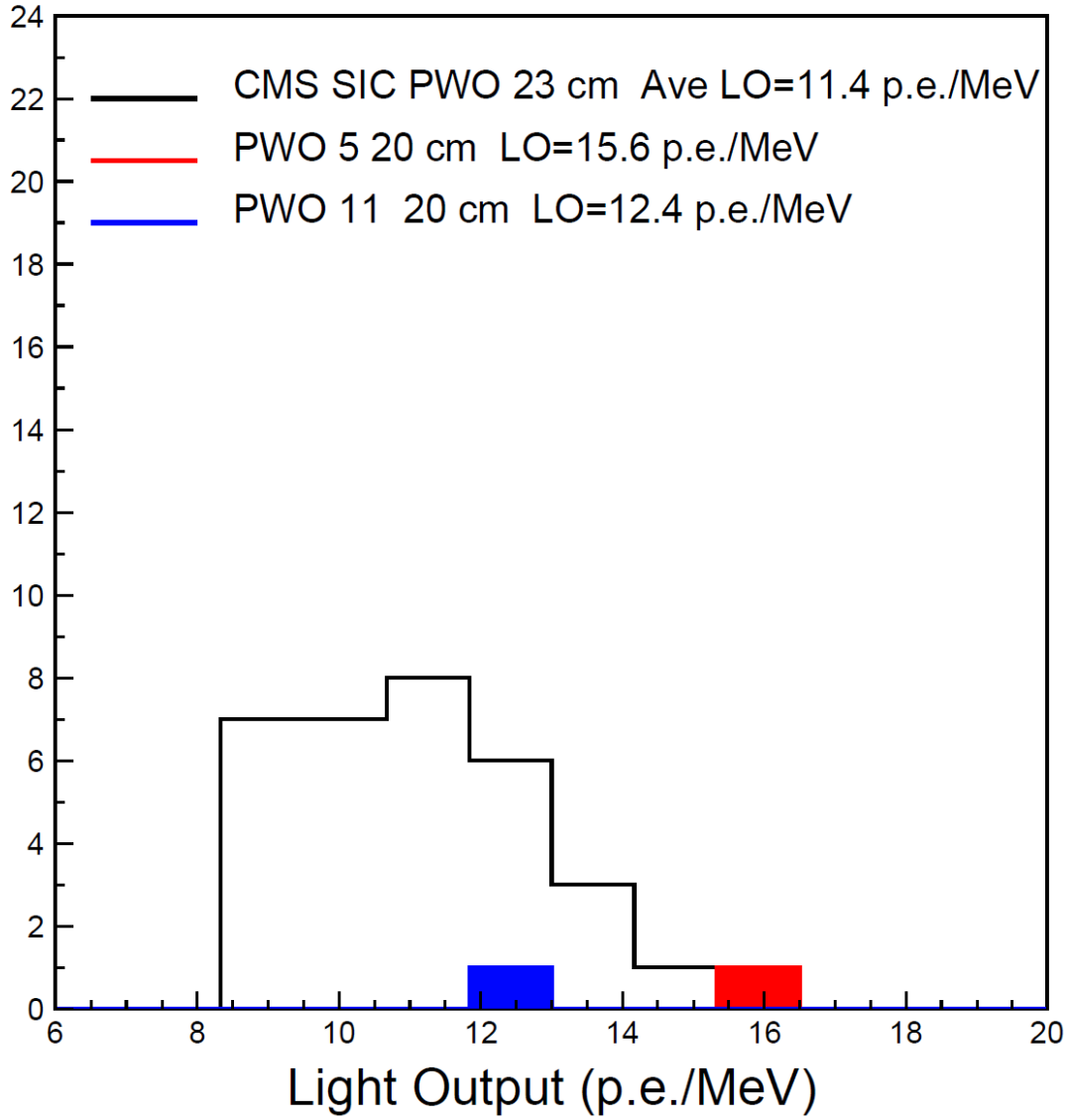
Light Response Uniformity and Light Output

Sample 5/11 with B/A end coupling to PMT provide good LRU





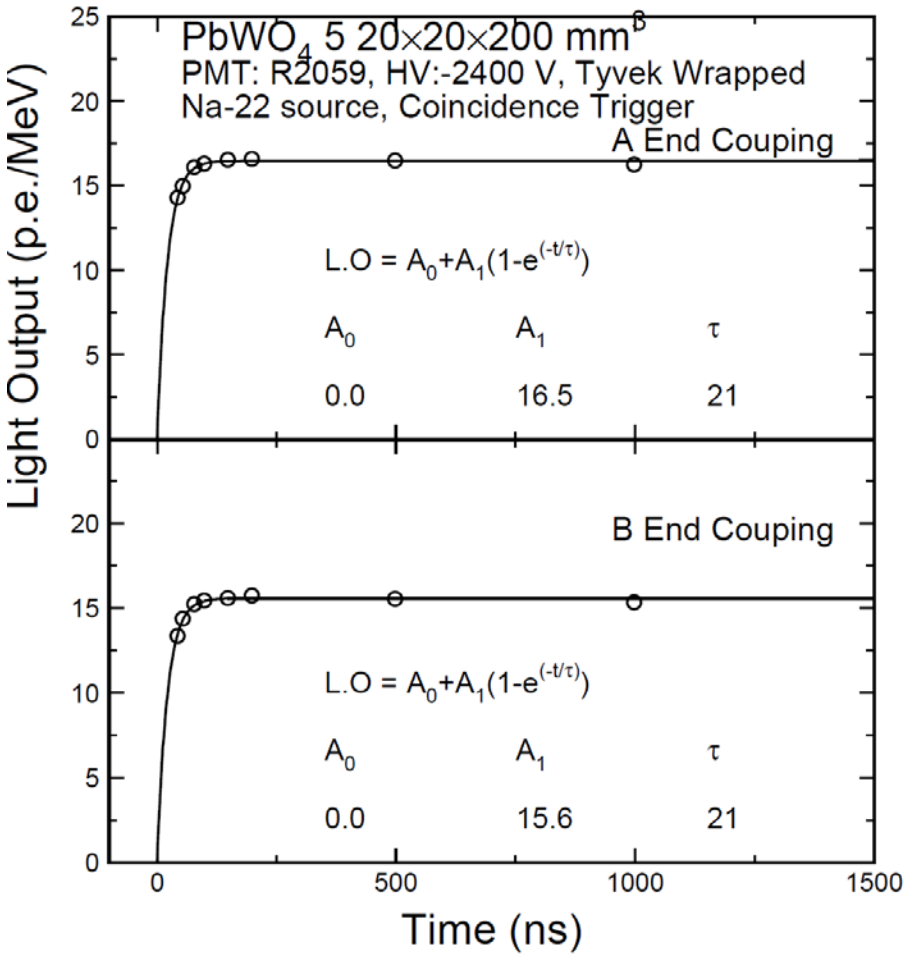
Comparison with CMS SIC PWO Crystals

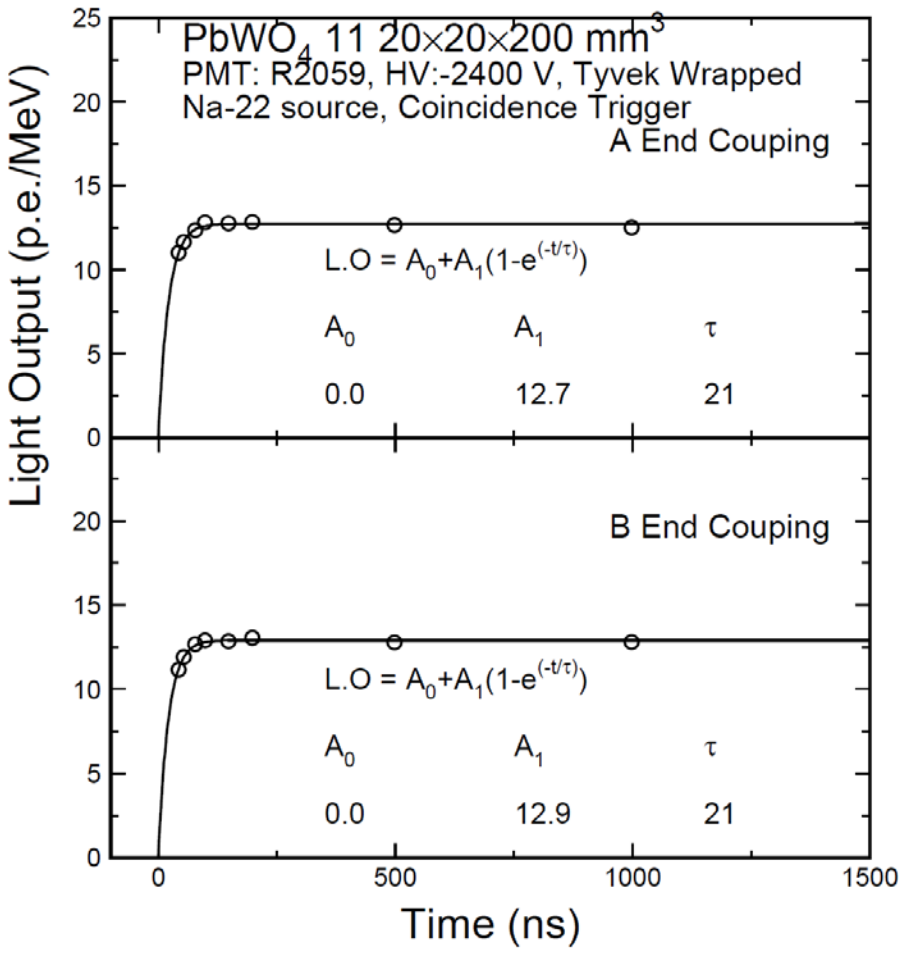


Light output of both 20 cm long samples are larger than the average of 23 cm long CMS PWO crystals as published in IEEE Trans. Nucl. Sci. NS-51 1777.

Decay Kinetics

Fraction of LO in 50/100 ns is 91/99%, which is larger than 84/96% for CMS PWO crystals as published in IEEE Trans. Nucl. Sci. NS-51 1777

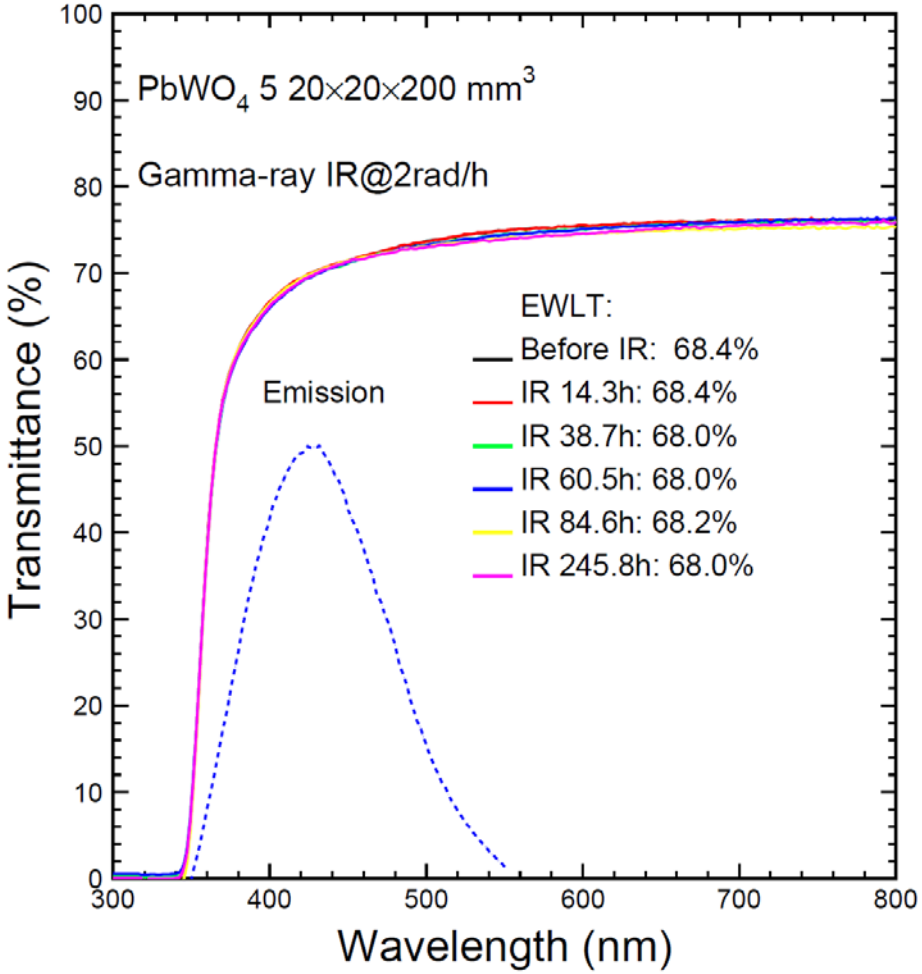


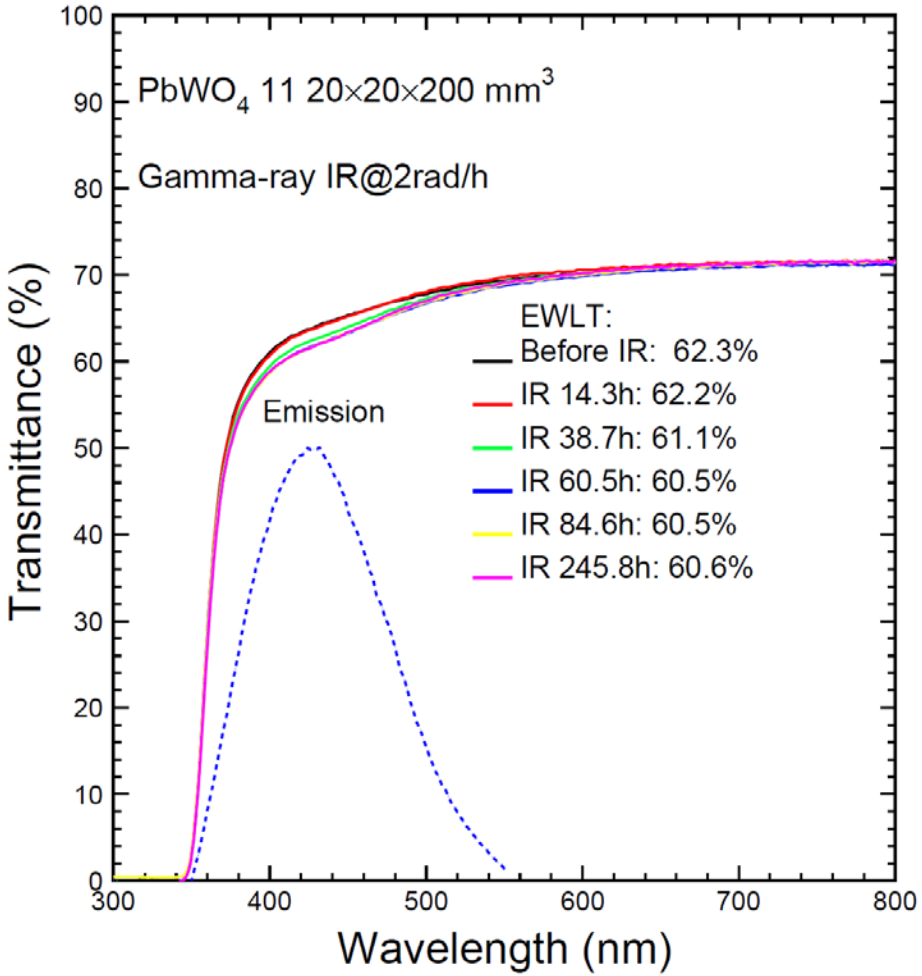


Both samples are faster than CMS PWO crystals

Longitudinal Transmittance: 2 rad/h

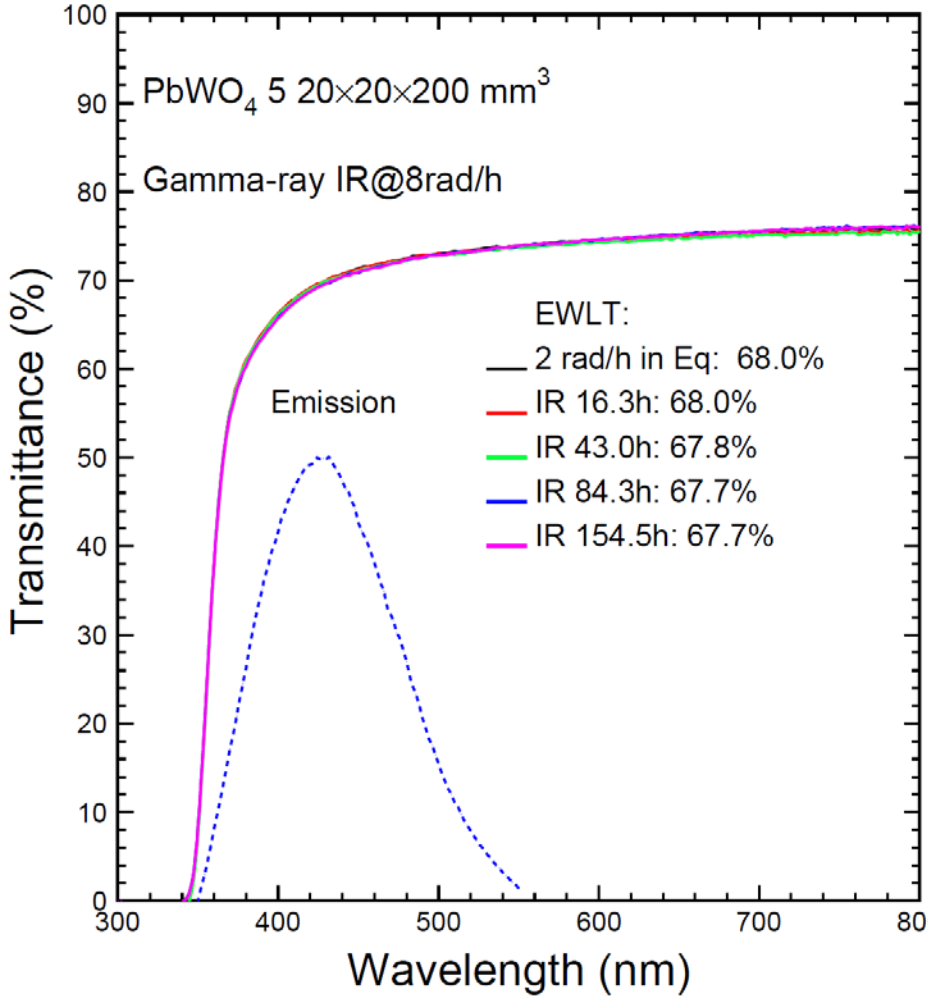
Irradiation carried out until equilibrium

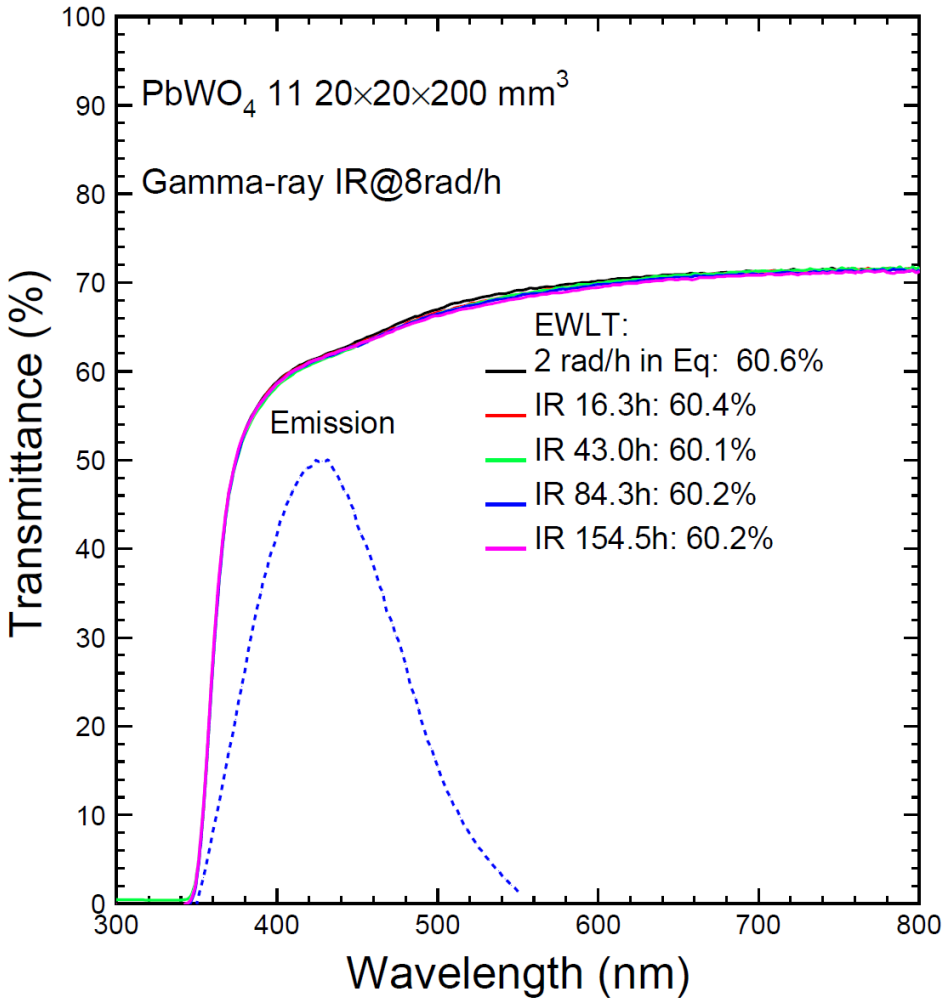




Longitudinal Transmittance: 8 rad/h

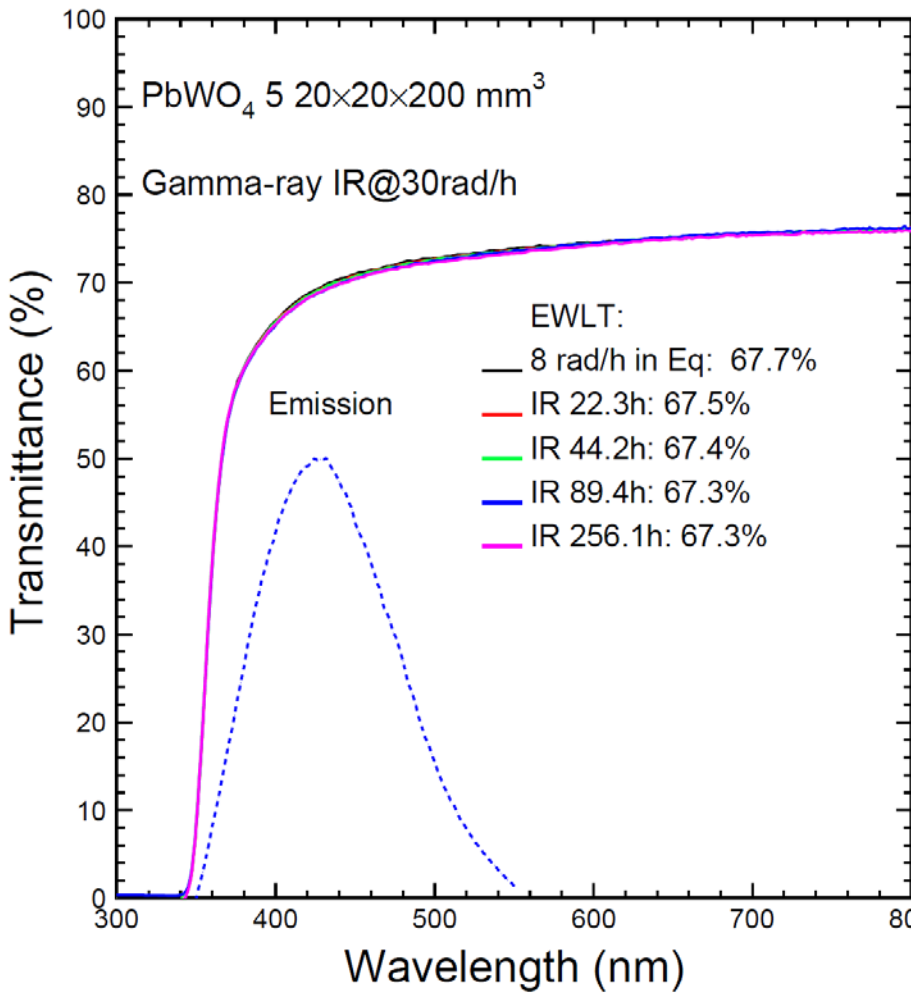
Irradiation carried out until equilibrium

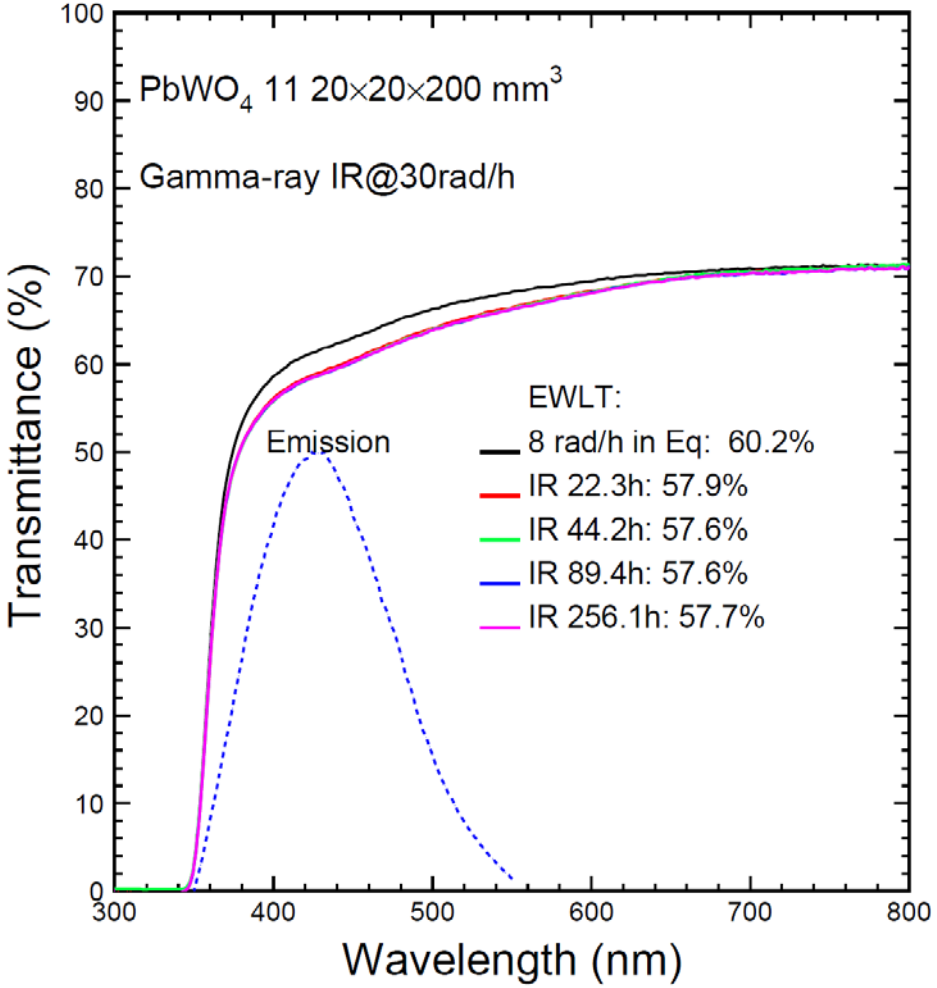




Longitudinal Transmittance: 30 rad/h

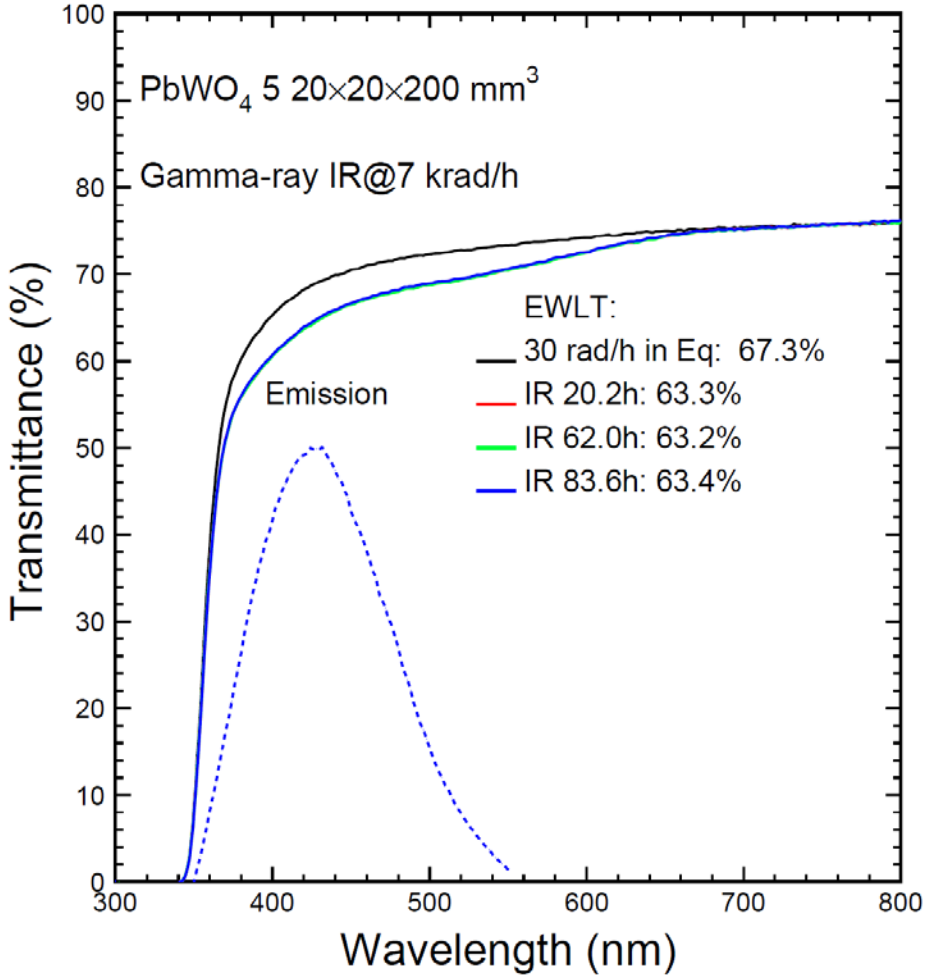
Irradiation carried out until equilibrium

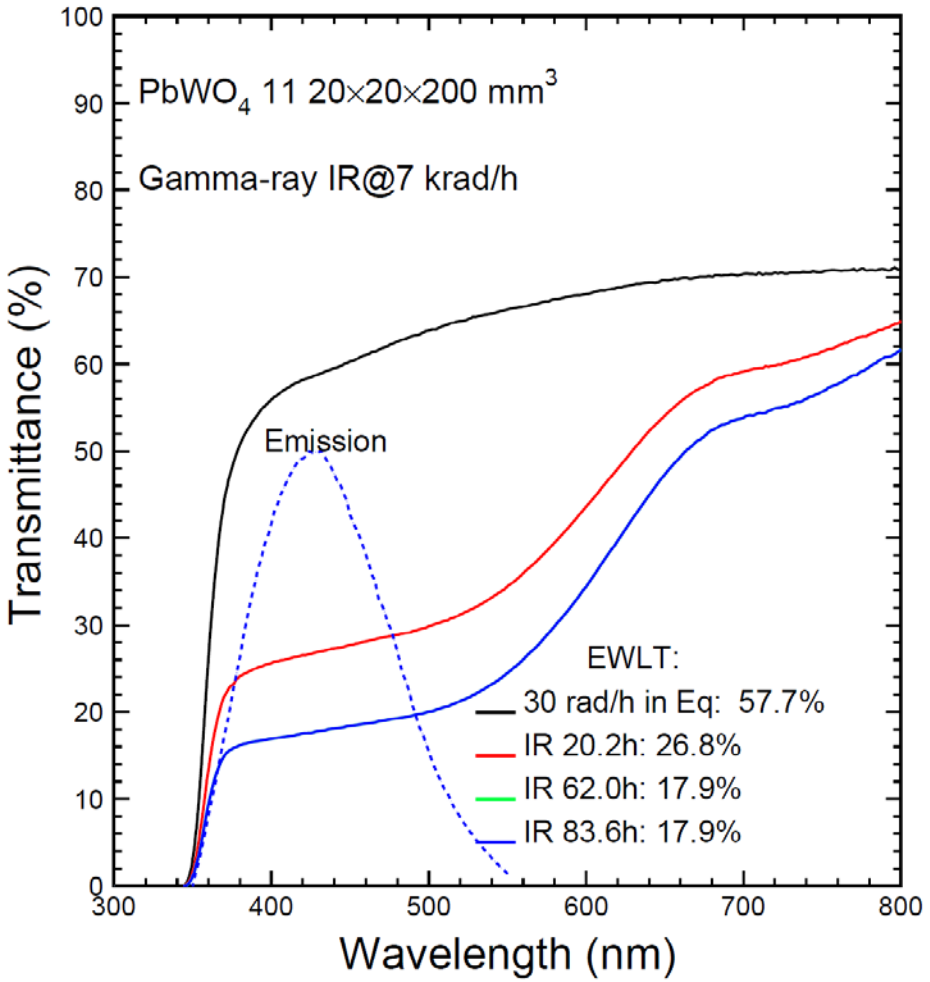




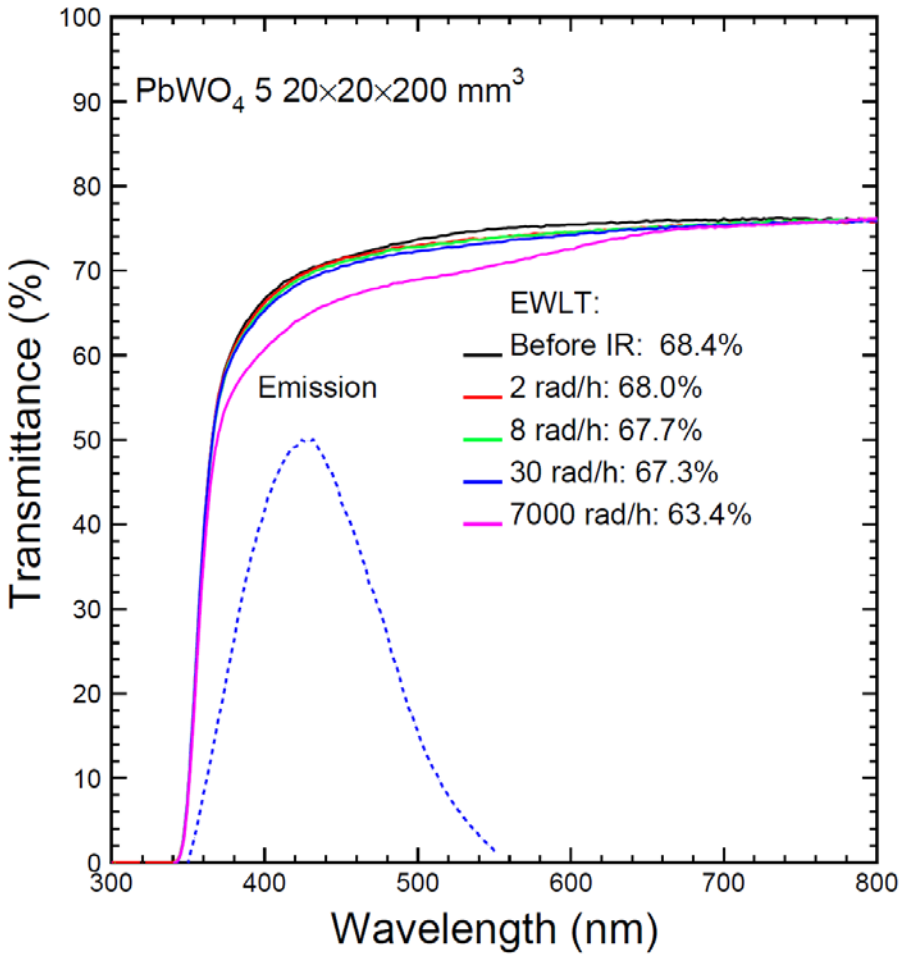
Longitudinal Transmittance: 7k rad/h

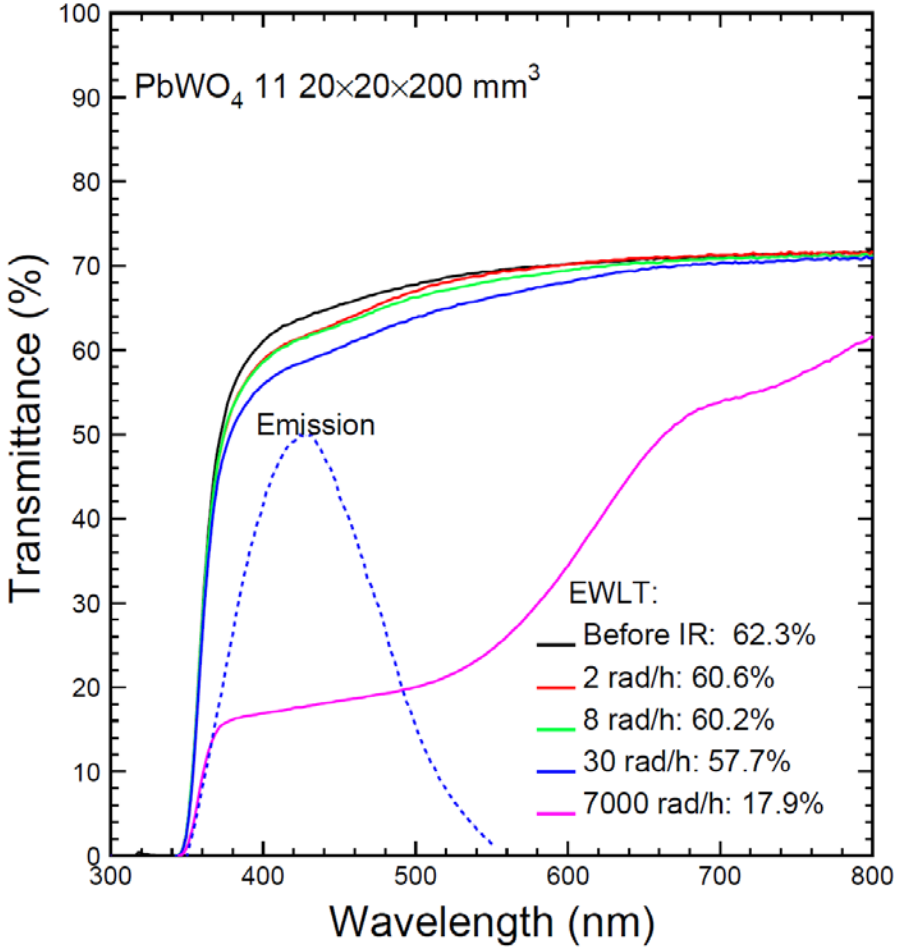
Irradiation until Equilibrium





LT @ 2, 8, 30 and 7k rad/h

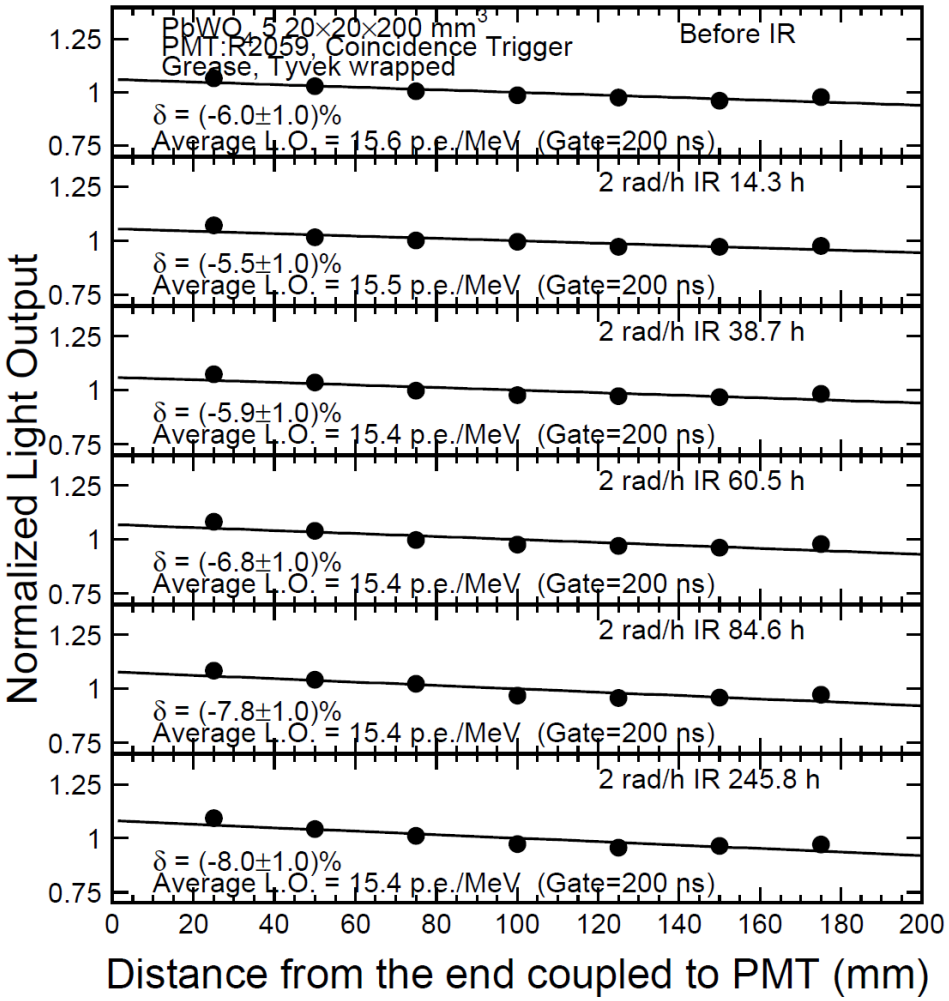


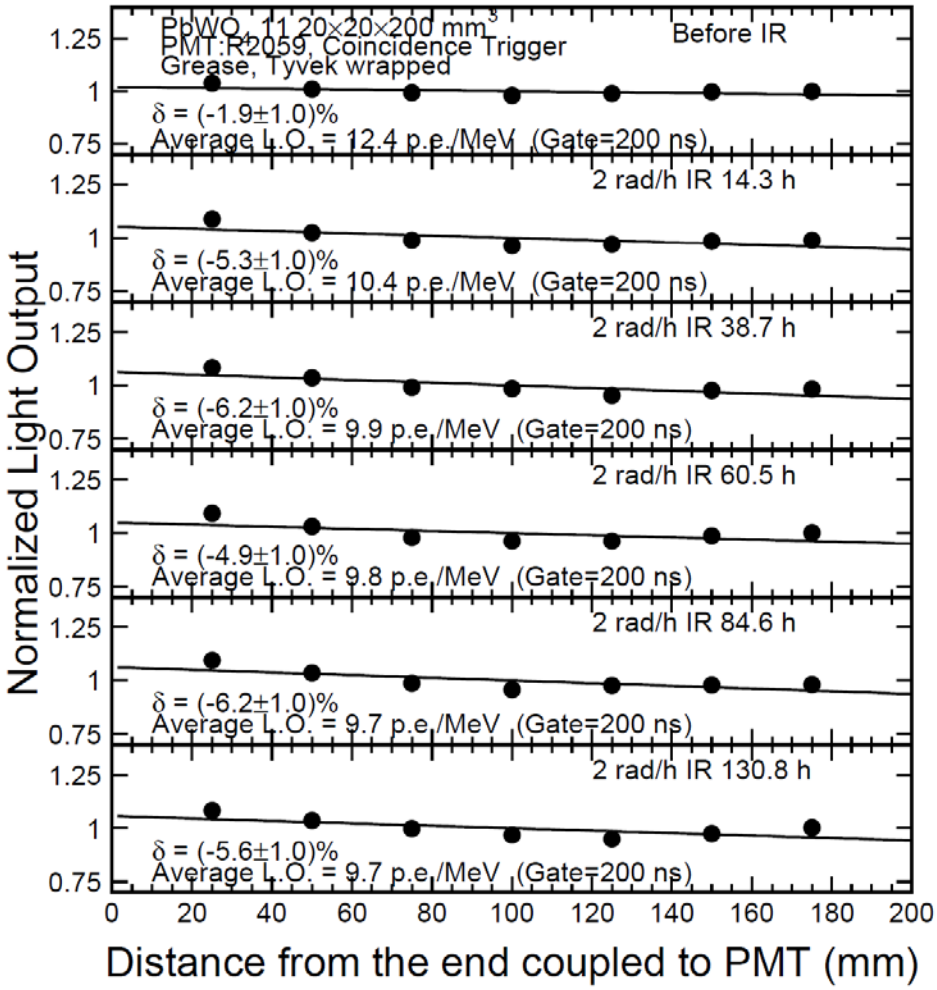


Sample 5 has good radiation harness

LO & LRU: 2 rad/h

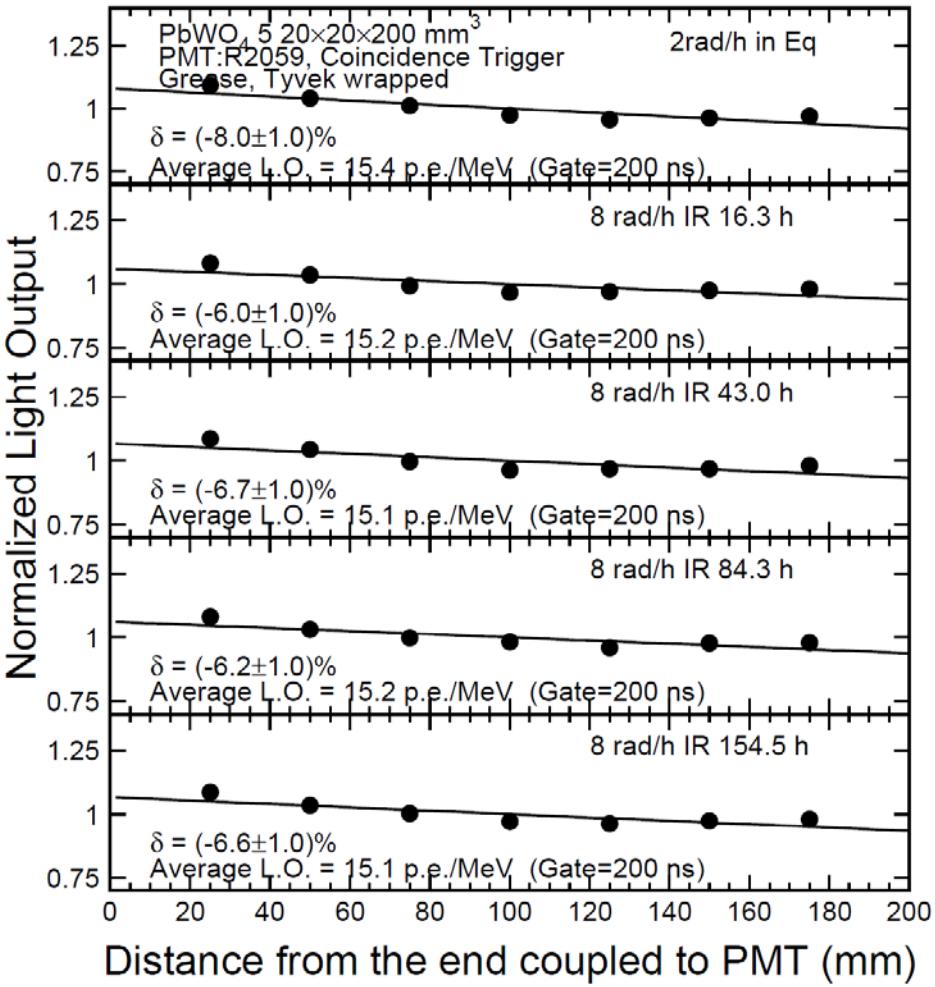
Irradiation until Equilibrium

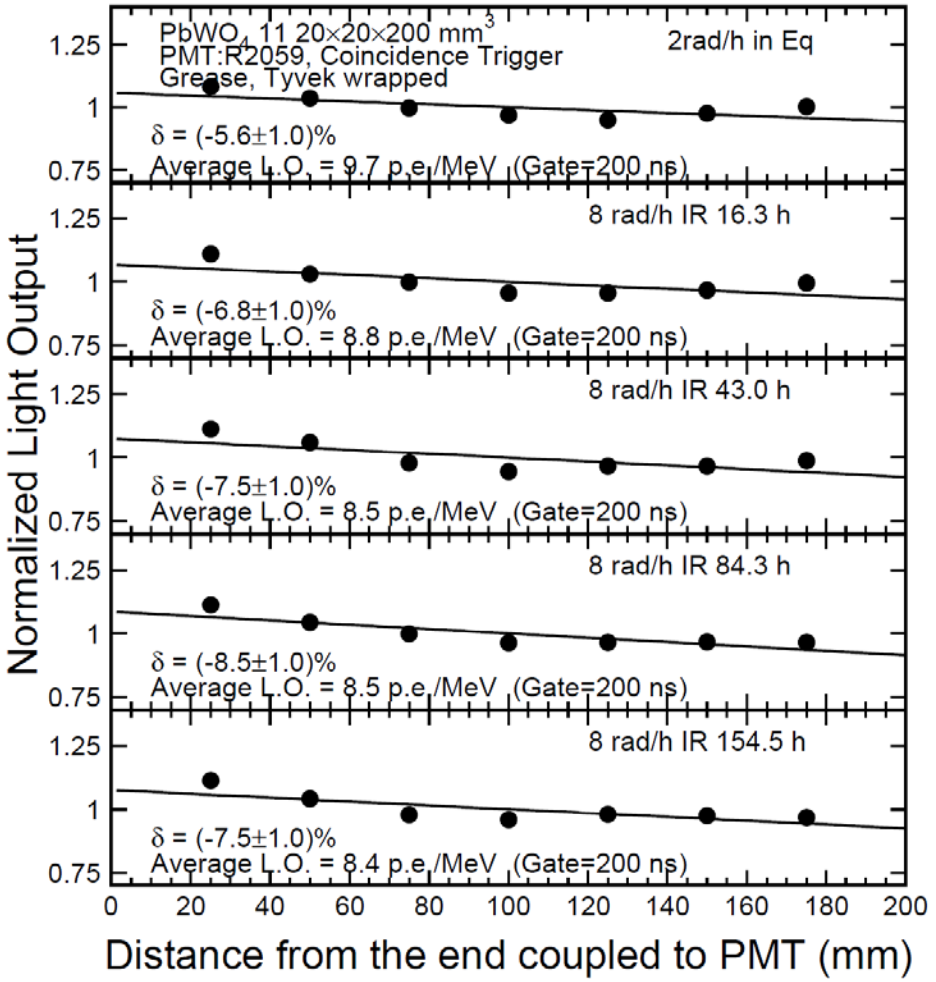




LO & LRU: 8 rad/h

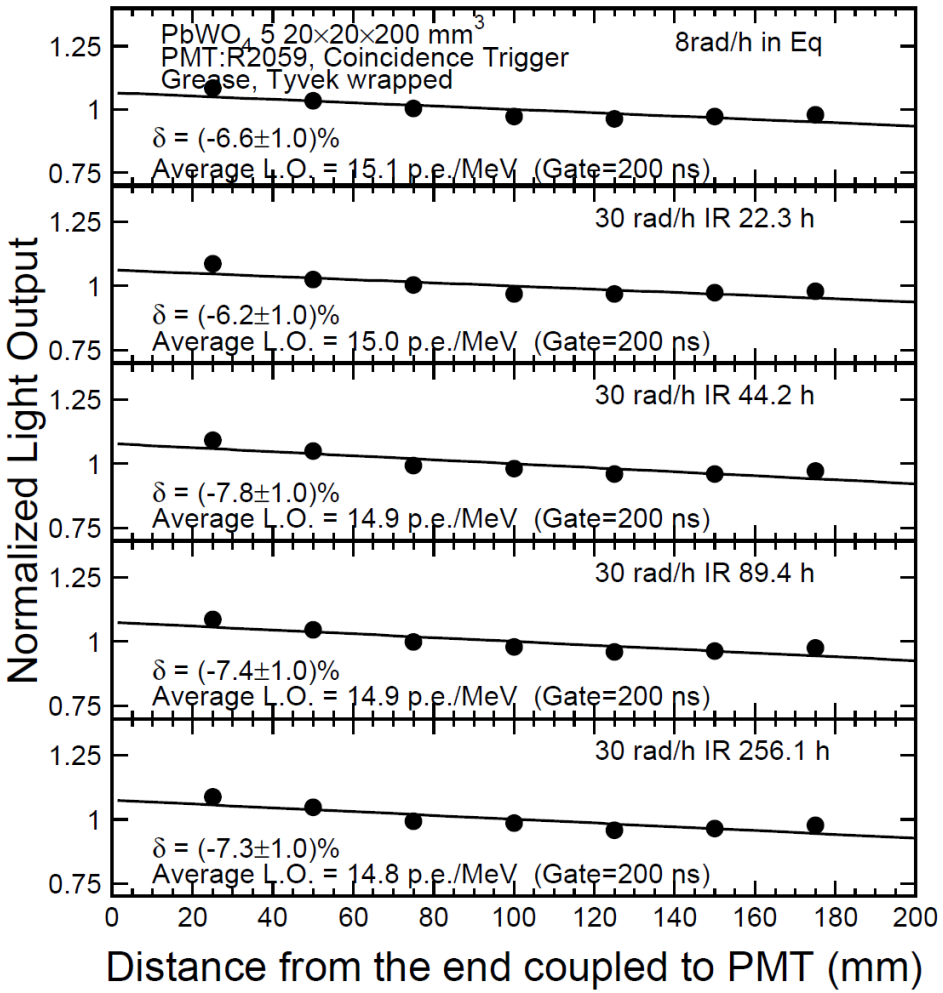
Irradiation until Equilibrium

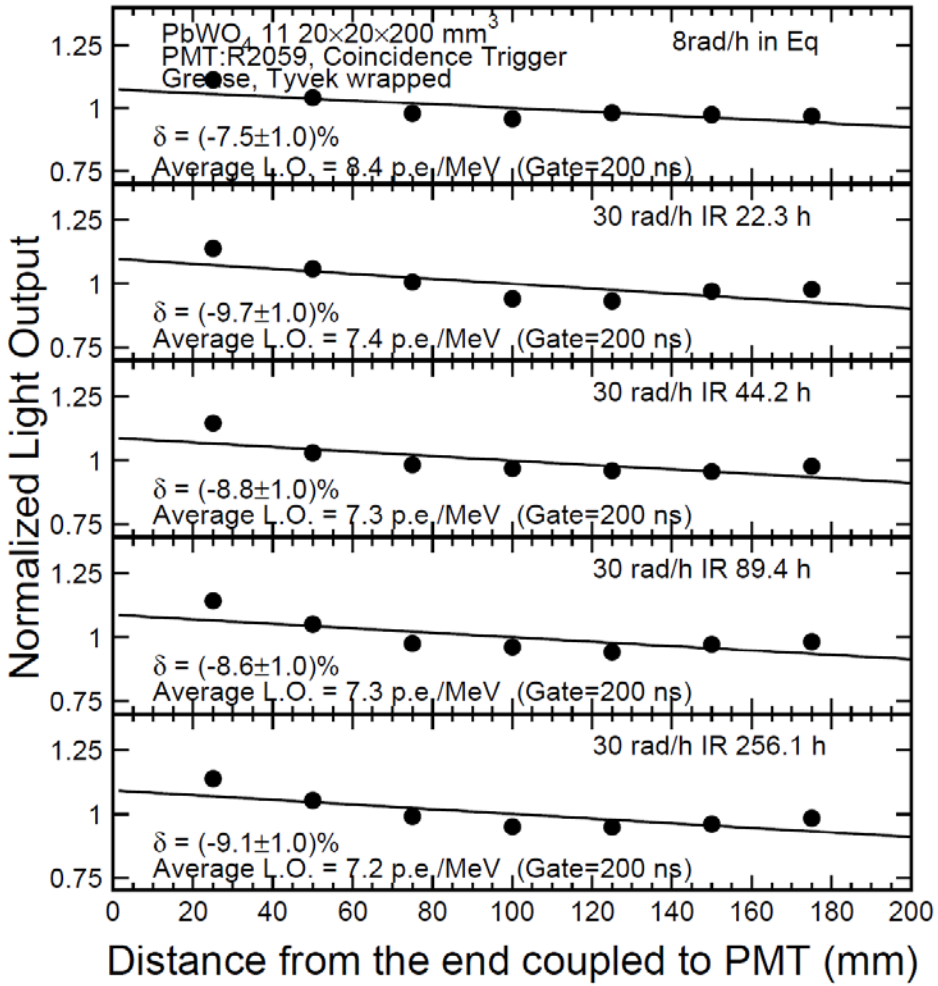




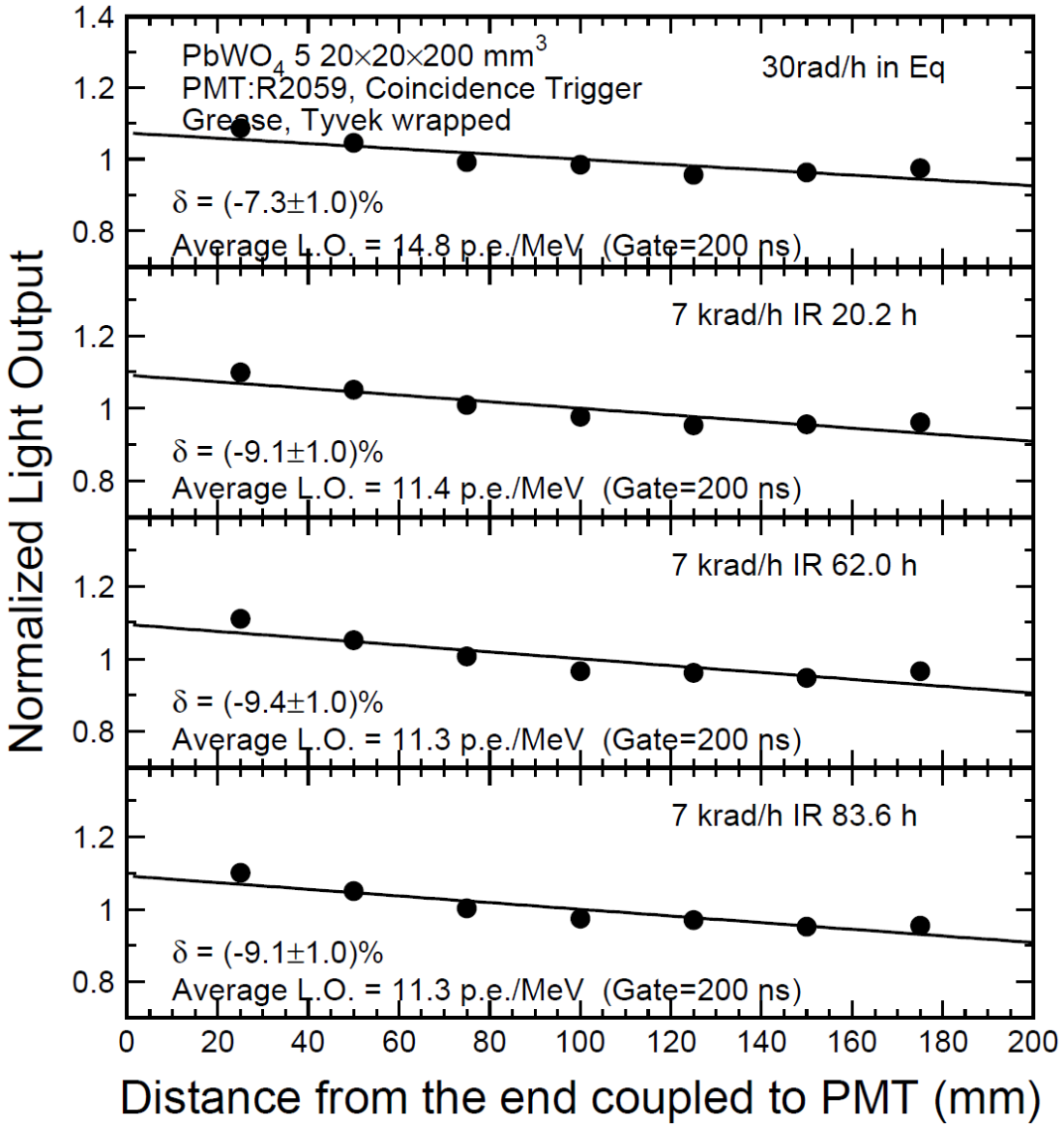
LO & LRU: 30 rad/h

Irradiation until Equilibrium





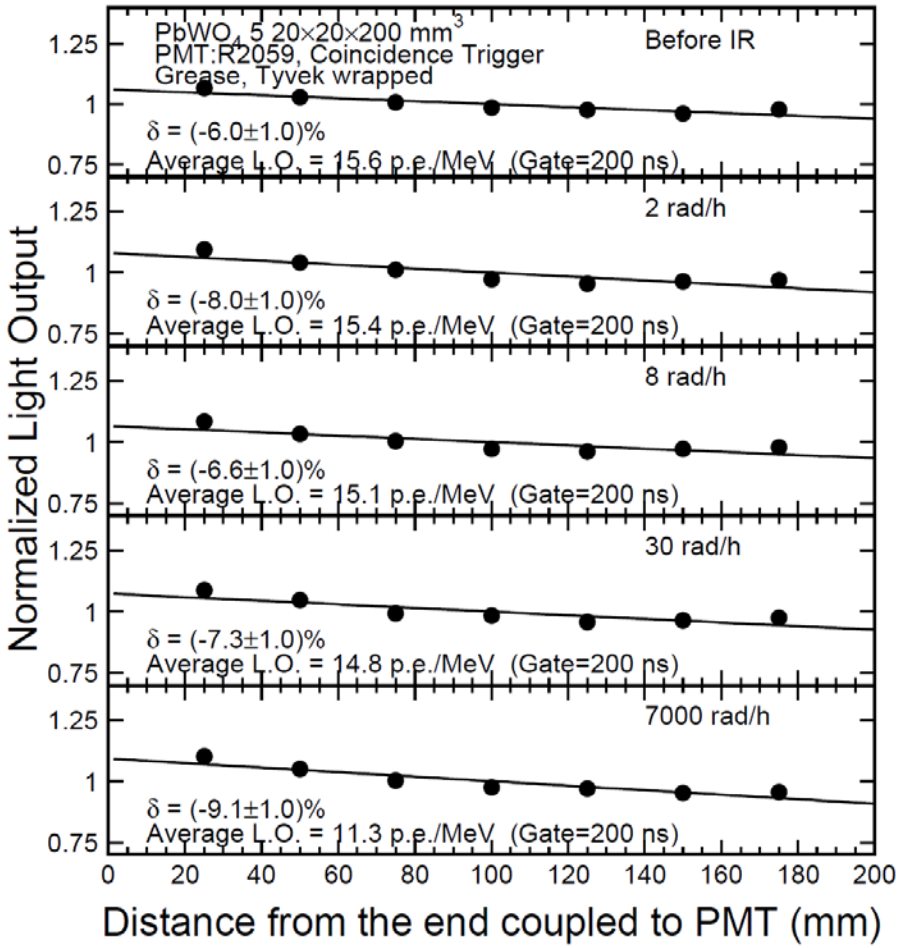
LO & LRU: 7k rad/h

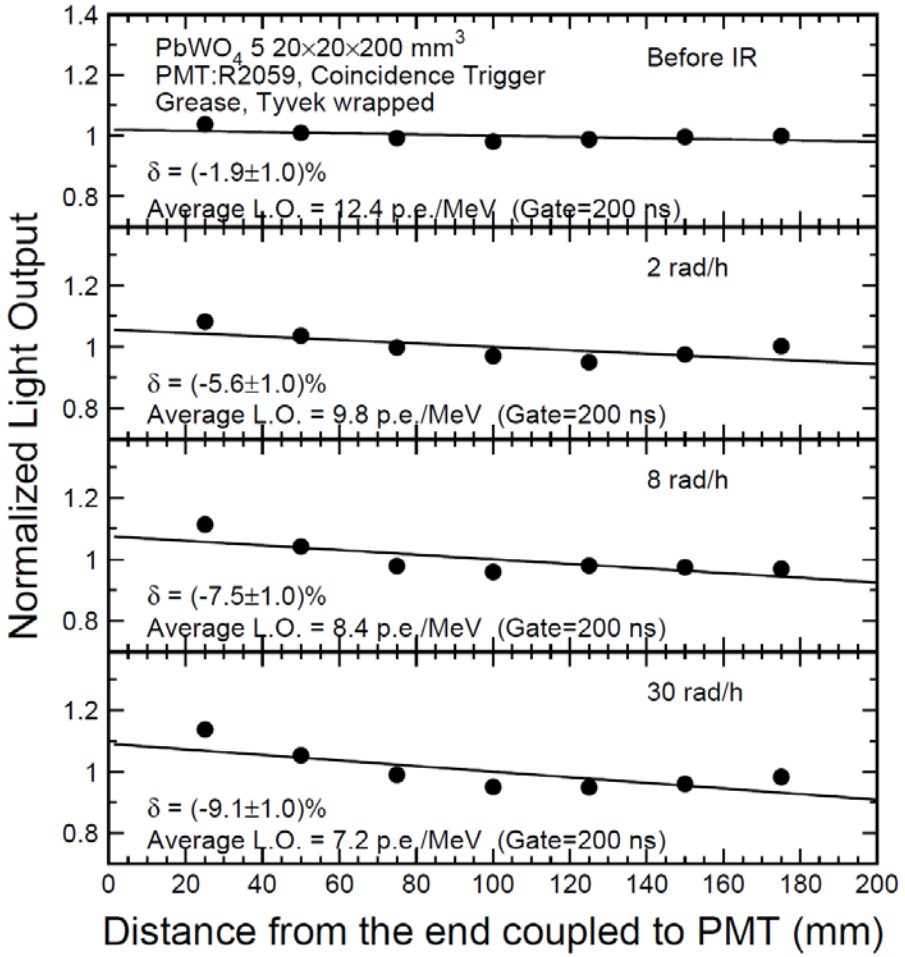


LO of PWO 11 under 7 krad/h is too low to be measured

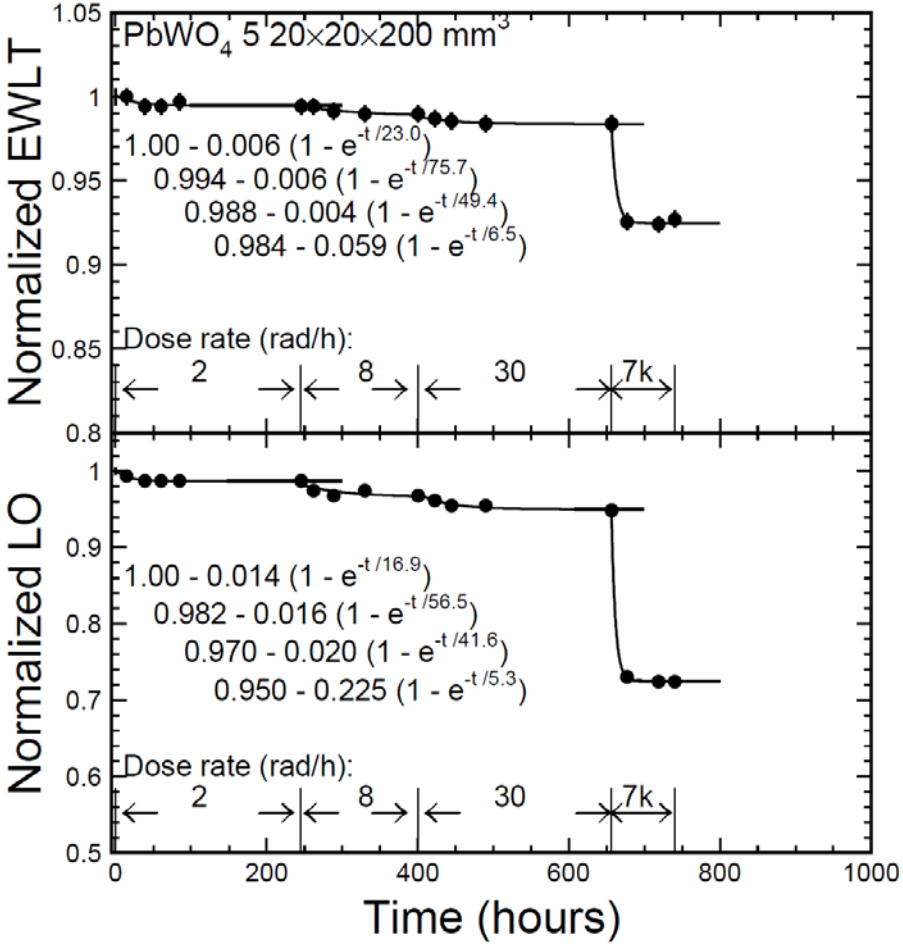
LO & LRU @ 2, 8, 30 and 7k rad/h

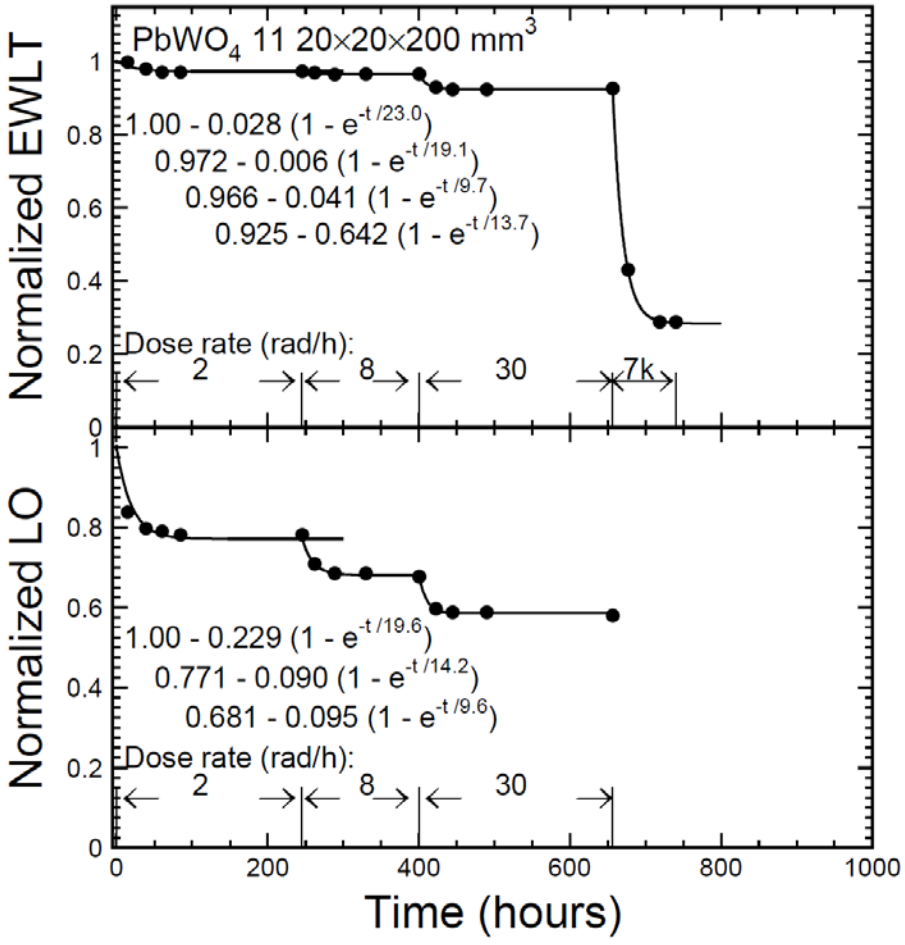
LO of PWO 11 under 7 krad/h is too low to be measured





History of Normalized EWLT and LO





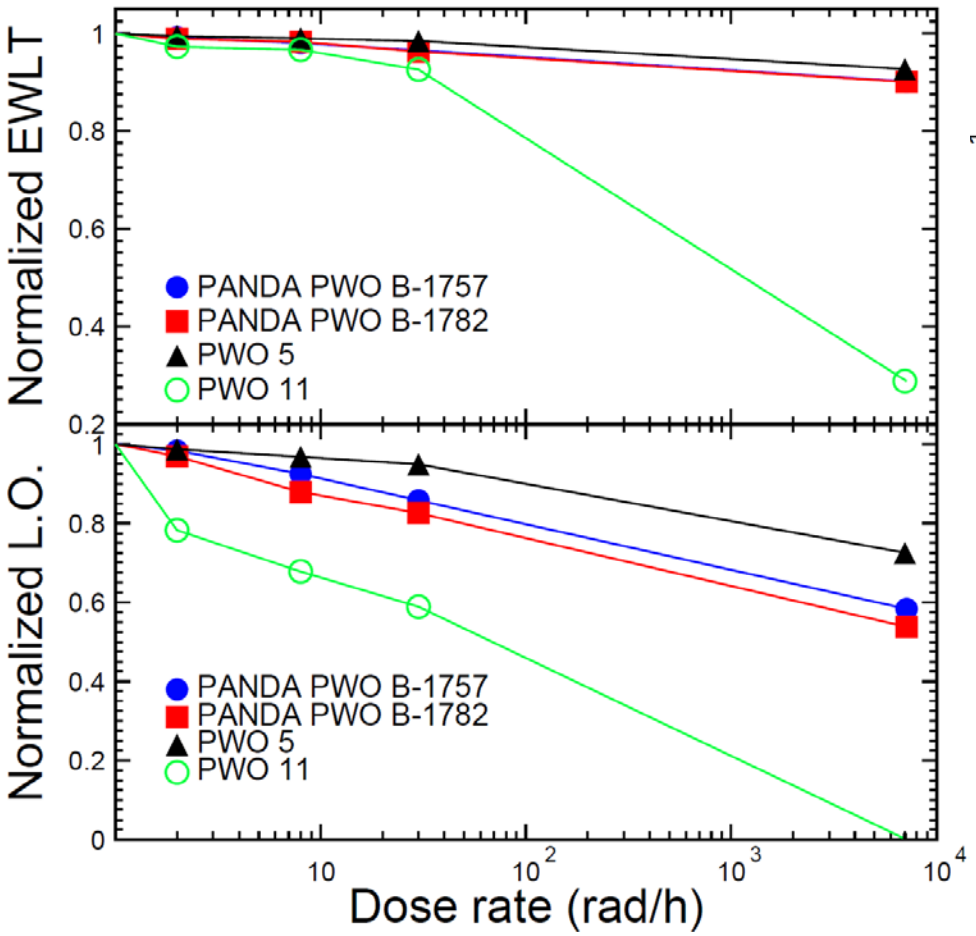
Dose rate dependent damage levels observed in both crystals

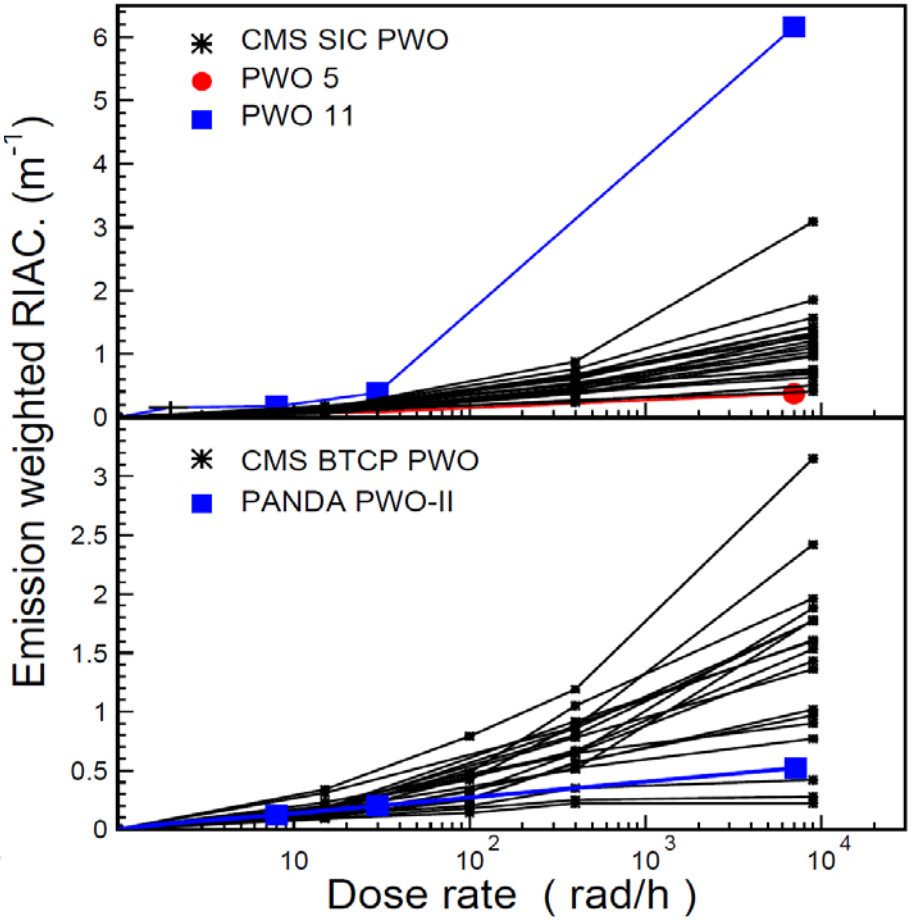
Comparison with Panda PWO-II

Samples	L.O. (p.e./ MeV)	L.O. loss (%)				EWLT loss (%)			
		2 rad/h	8 rad/h	30 rad/h	7,160 rad/h	2 rad/h	8 rad/h	30 rad/h	7,160 rad/h
PANDA PWO B-1757	12.0	2	8	14	42	0.8	2.0	2.9	9.9
PANDA PWO B-1782	13.2	3	12	17	46	1.1	1.7	2.9	10.0
		2 rad/h	8 rad/h	30 rad/h	7,000 rad/h	2 rad/h	8 rad/h	30 rad/h	7,000 rad/h
PWO 5	15.6	1	3	5	28	0.6	1.0	1.6	7.3
PWO 11	12.4	21	32	42	-	2.7	3.4	7.4	71

PWO 5/11 is better/much worse than two Panda PWO-II samples tested at Caltech

Comparison with Panda & CMS PWO





PWO 5/11 is better/much worse than the average of CMS PWO tested at Caltech

Summary

- Two PWO crystal samples of 2 x 2 x 20 cm grown at SIC were received from Jlab, and characterized at the Caltech HEP crystal laboratory.
- Initial measurements show that their longitudinal transmittance, light output and decay time are respectively compatible, higher than and shorter than PWO crystals grown at SIC for CMS. Significant scattering centers are observed in sample 11.
- Irradiation under ɣ-ray irradiation at 2, 8, 30 and 7k rad/h shows that samples 5 and 11 are respectively better and much worse than the average of CMS and Panda PWO samples tested at Caltech.
- Radiation hardness of SIC PWO crystals are diverse. Rigorous QC is required for applications in severe radiation environment.