

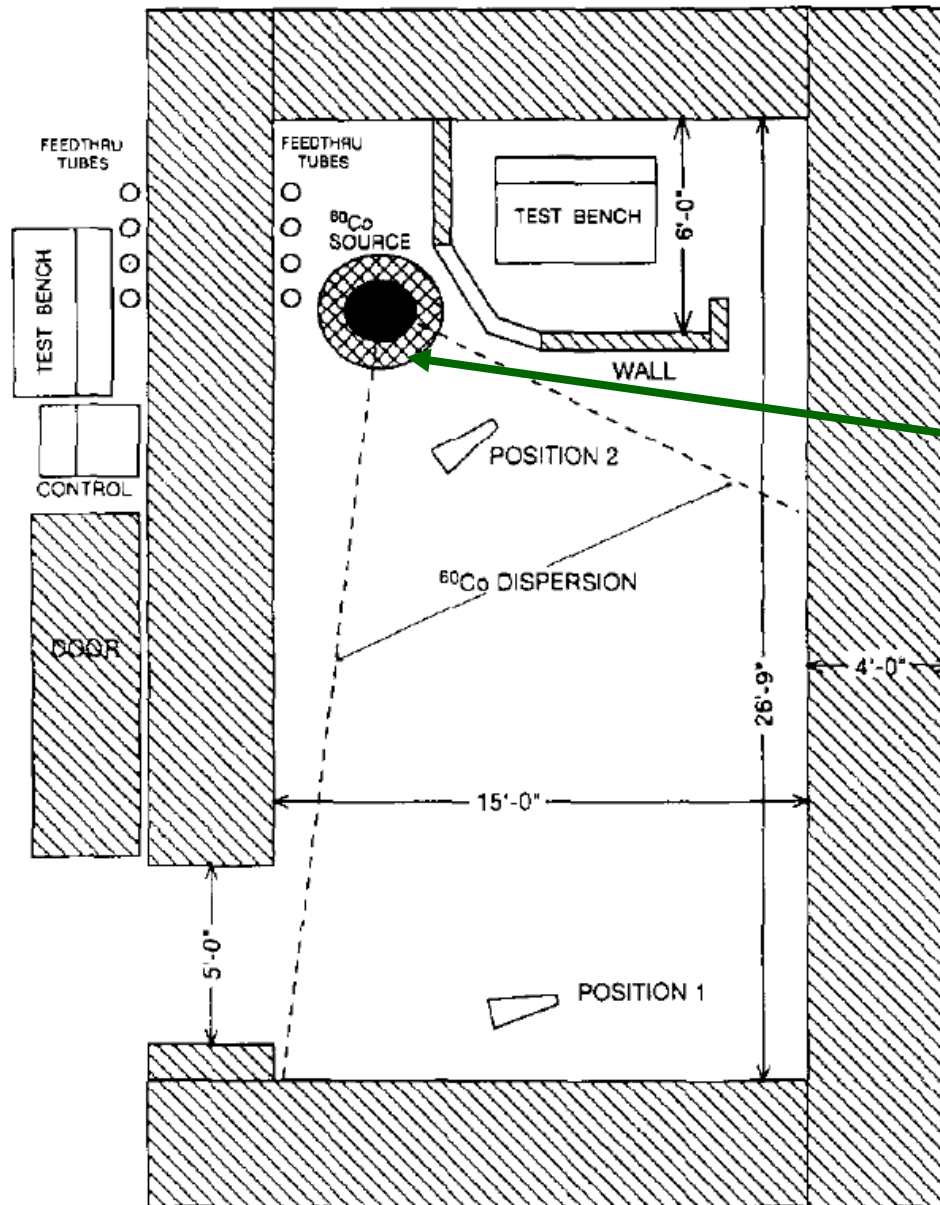
Gamma-ray Induced Radiation Damage up to 100 Mrad in a LYSO/W Shashlik Cell and Various Scintillation Crystals

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The Total Absorption Dose Facility of JPL



Two high intensity ^{60}Co sources provide variable dose rates up to 1 Mrad/h in an opening throat of 10" x 10" x 13.5".

Irradiations were carried out in two steps: 10 Mrad first, followed by a long weekend for additional 90 Mrad to reach 100 Mrad.

The time between the end of each irradiation and the measurement at Caltech is less than 30 minutes.

Samples Irradiated at JPL

10 Mrad @ 180 krad/h



90 Mrad @ 1 Mrad/h

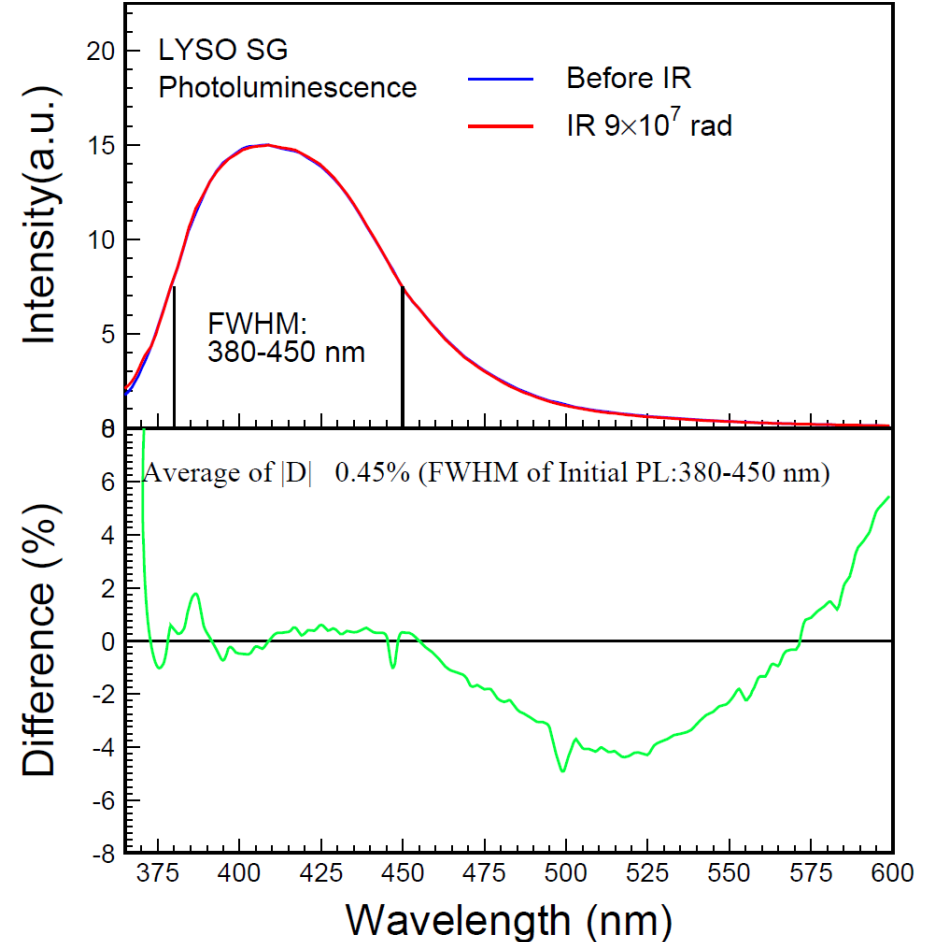
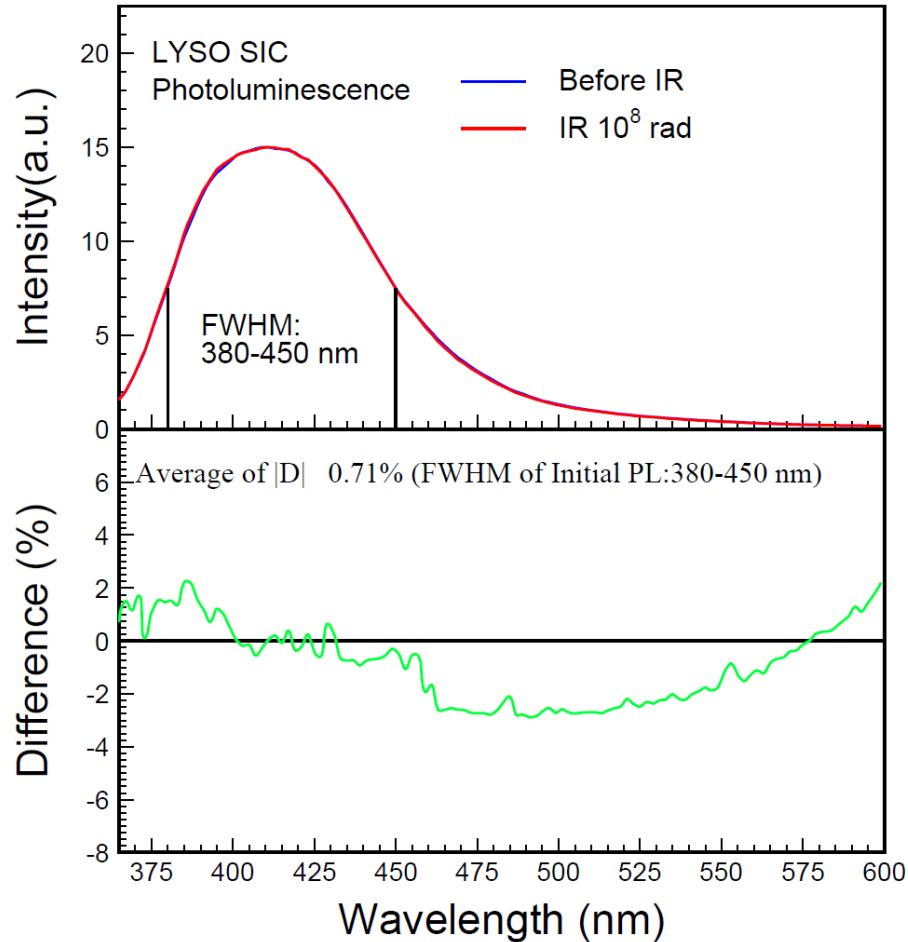


ID	Dimension (mm)
Shashlik (LYSO/W)	14x14x150
LYSO SIC Plate	14x14x1.5
CeF ₃ SIC	33x32x191
BaF ₂ SIC2012	20x20x250
PWO SIC	28.5 ² x220x30 ²
BGO SIC2011	25x25x200
LYSO SIC L2	25x25x200
CsI SIC2013	50x50x200

ID	Dimension (mm)
Shashlik (LYSO/W)	14x14x150
LYSO SIC Plate	14x14x1.5
LYSO SIC Plate	14x14x2
LYSO CPI Plate	14x14x2
CeF ₃ SIC	33x32x191
BaF ₂ SIC2012	20x20x250
PWO SIC	28.5 ² x220x30 ²
LYSO SIC L2	25x25x200
BGO SIC2011	25x25x200
LYSO SG L2	25x25x200
BGO NIIC	25x25x200

25 x 25 x 200 mm LYSO Crystals

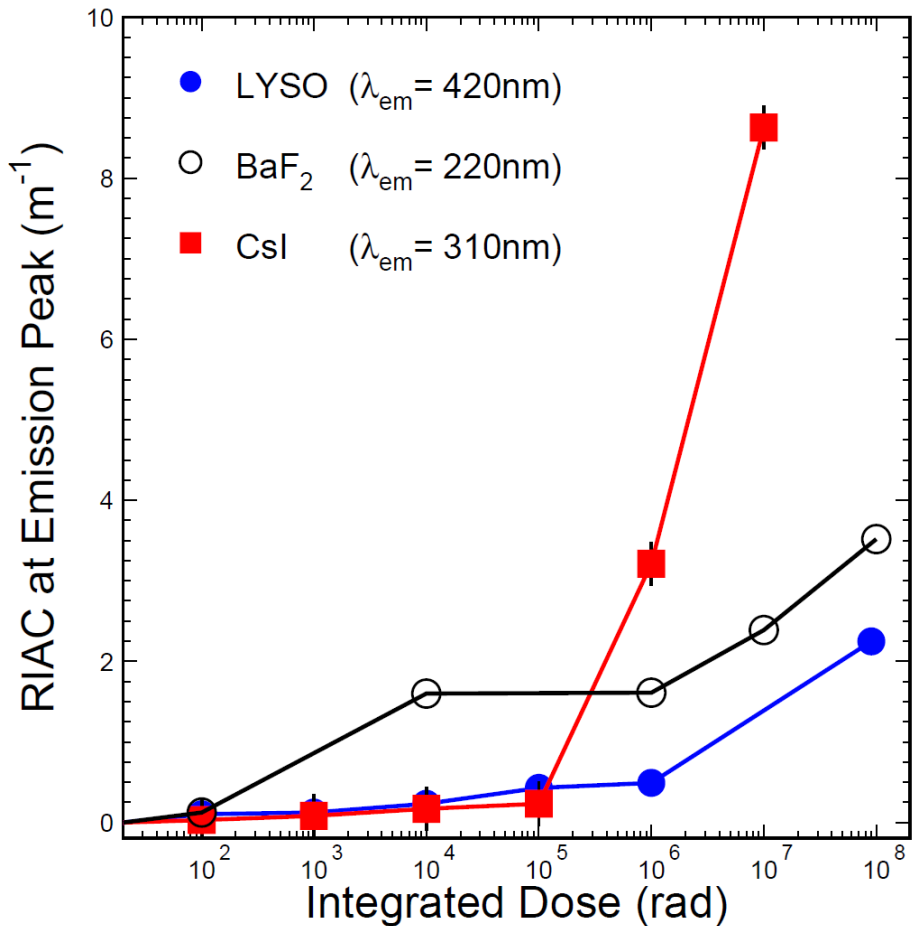
Photo-Luminescence



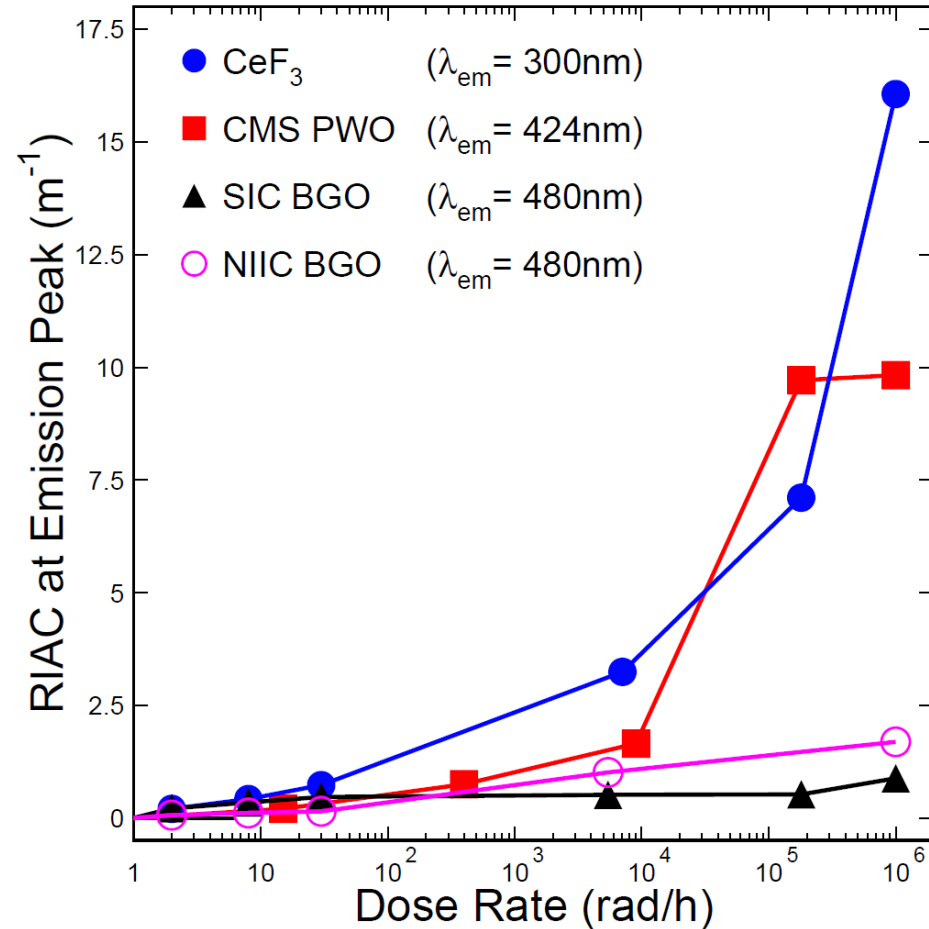
Both samples were grown about ten years ago

Radiation Induced Absorption Coefficient (RIAC)

Crystals with no recovery



Crystals with recovery



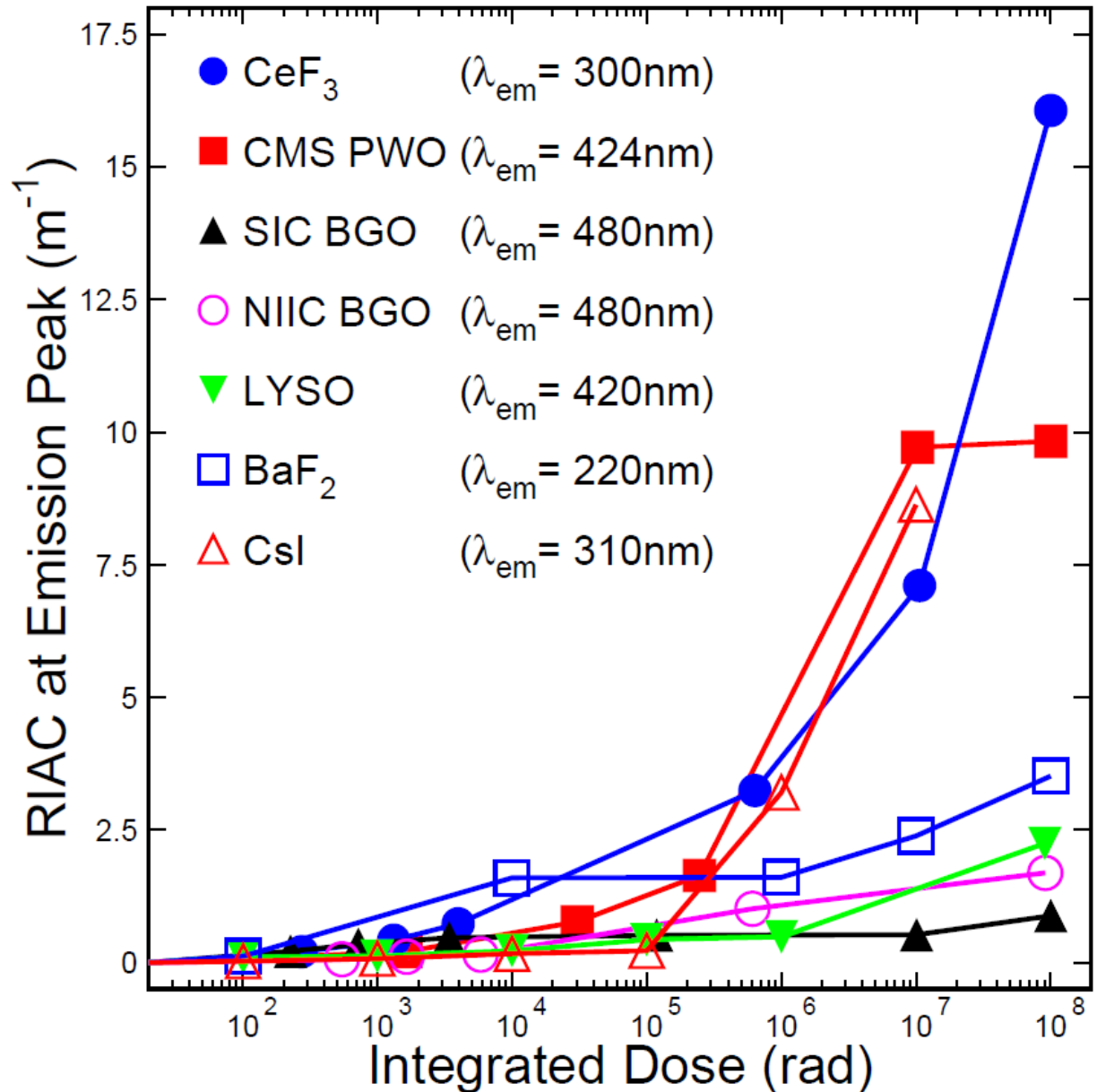
$\sim 2 \text{ m}^{-1}$ measured in LYSO and BGO after 100 Mrad

RIAC as a Function of Integrated Dose

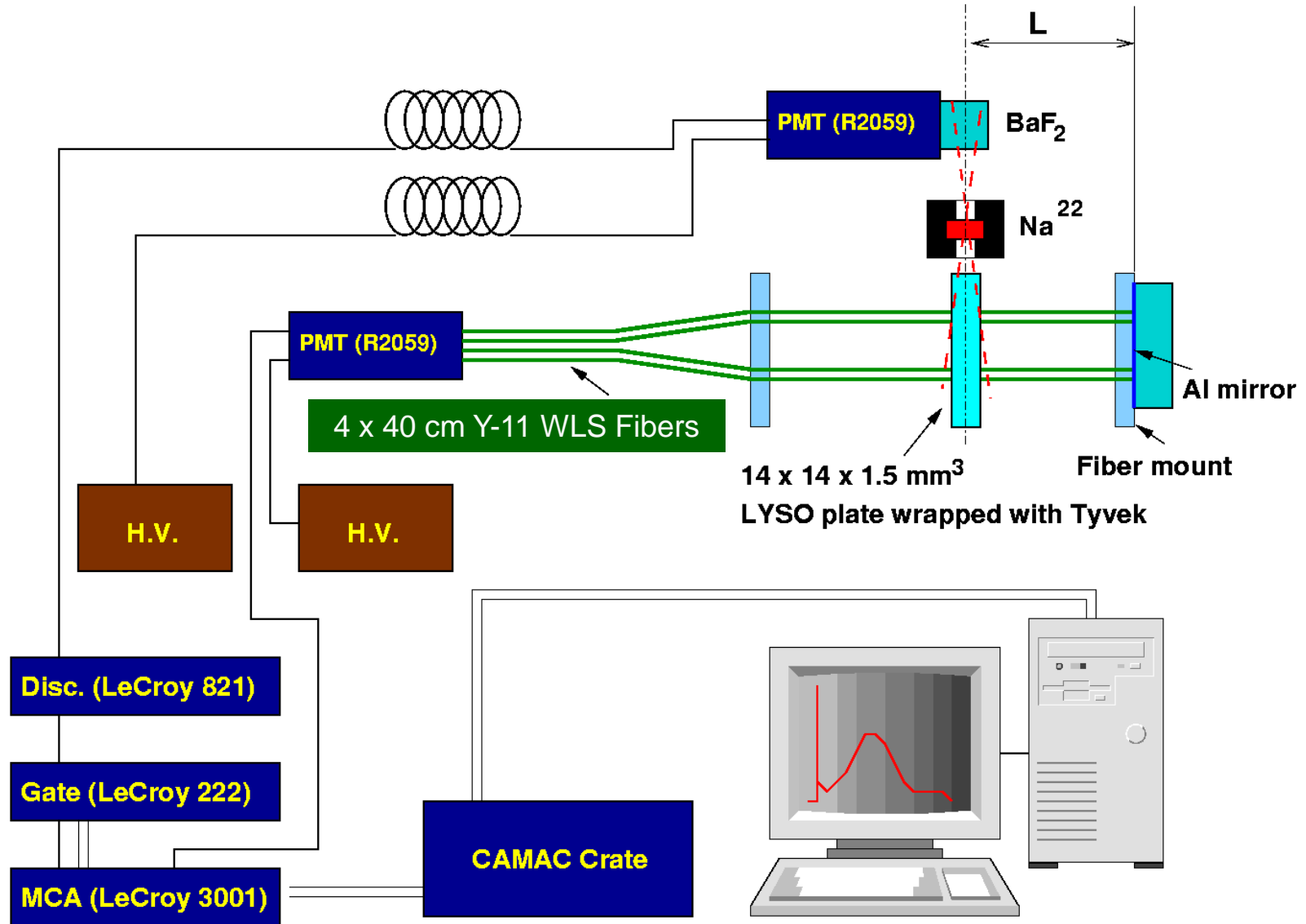
Ignoring the dose rate dependence, the RIAC values are shown as a function of integrated dose for all crystals.

The RIAC values are probably overestimated for crystals have shallow color centers with dose rate dependent damage.

Two CeF_3 crystals were grown about twenty years ago. High quality crystals grown recently need to be tested.

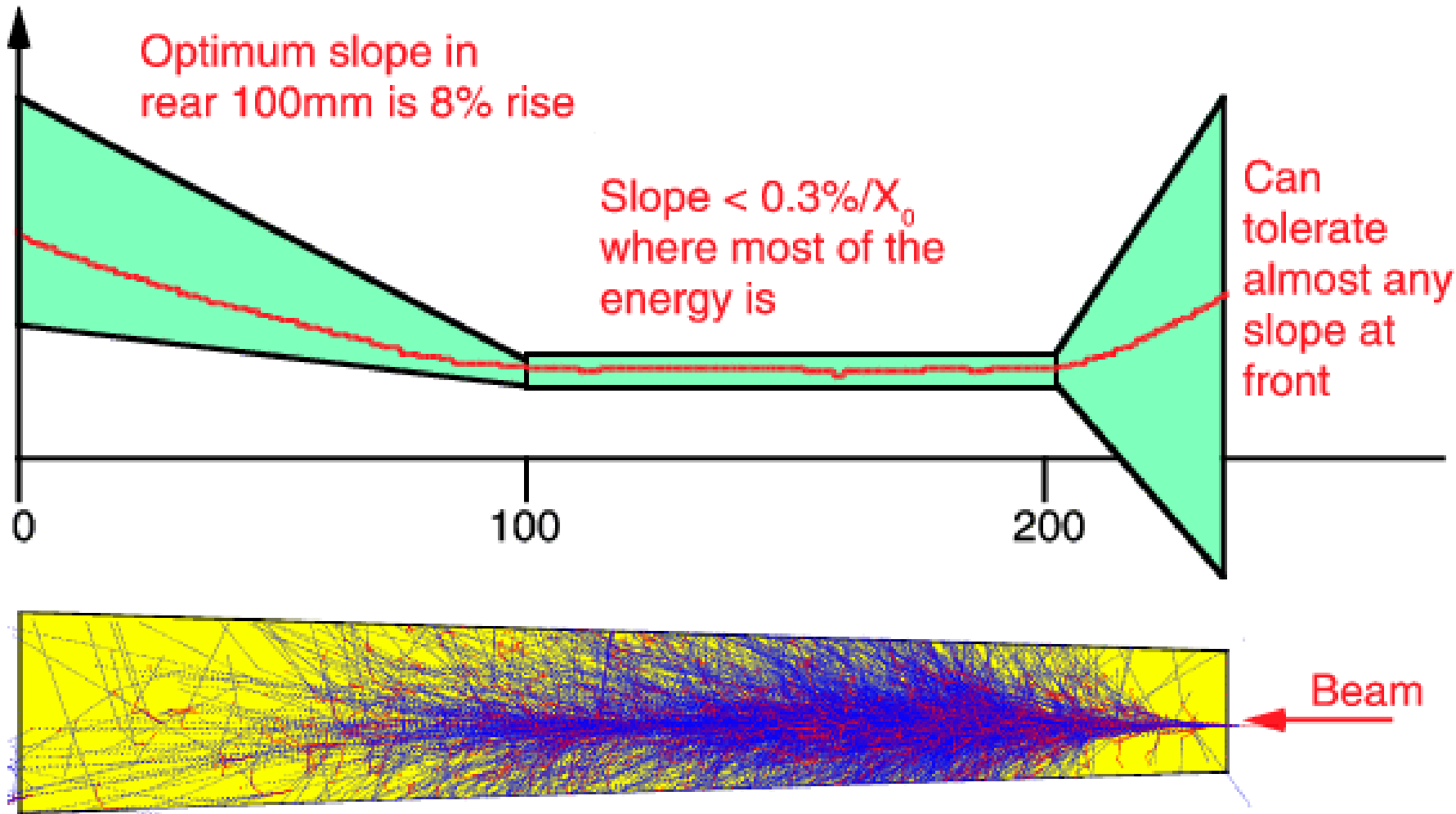


Shashlik Light Response Uniformity



CMS Uniformity Specification

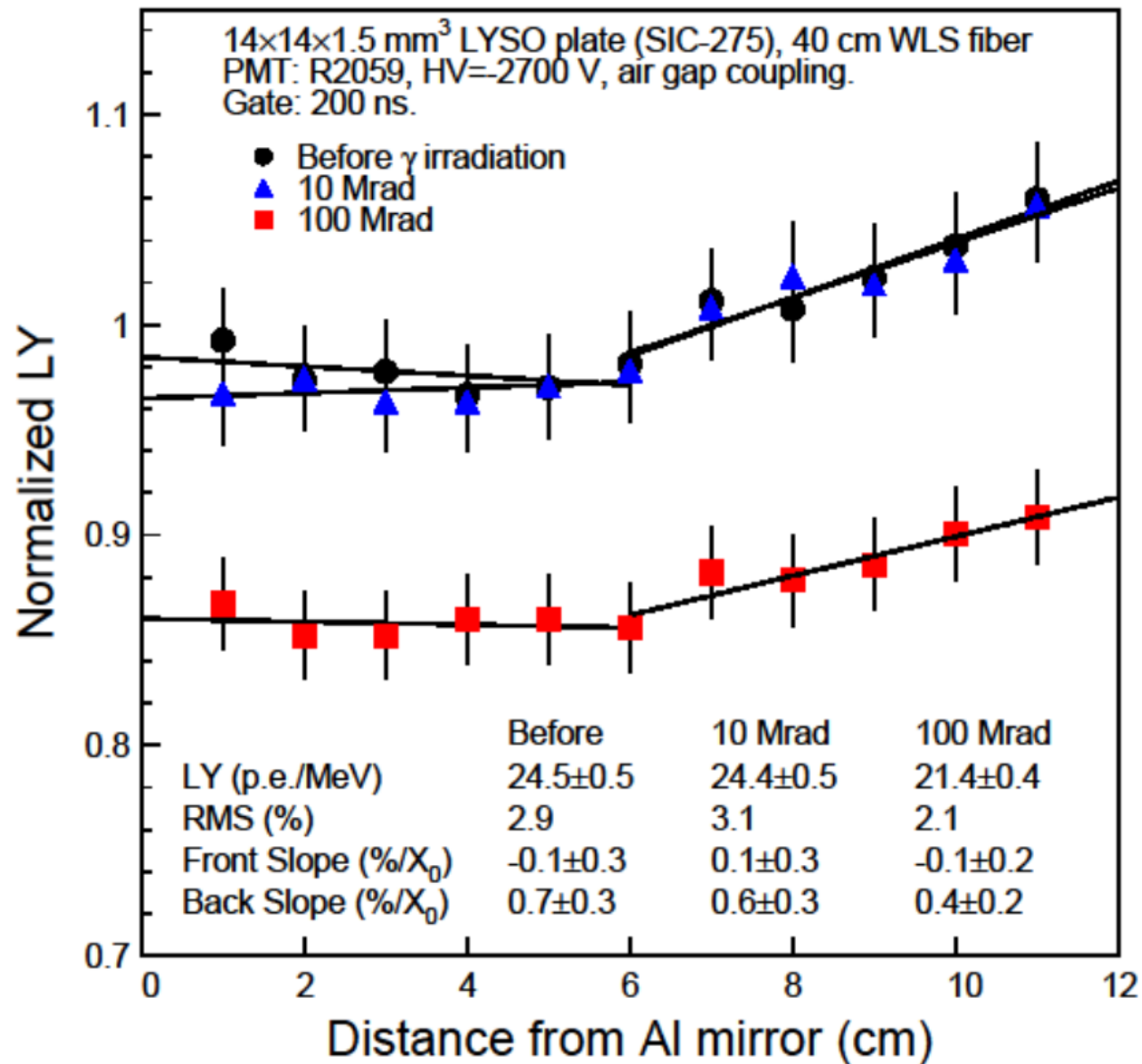
D. Graham & C. Seez, CMS Note 1996-002



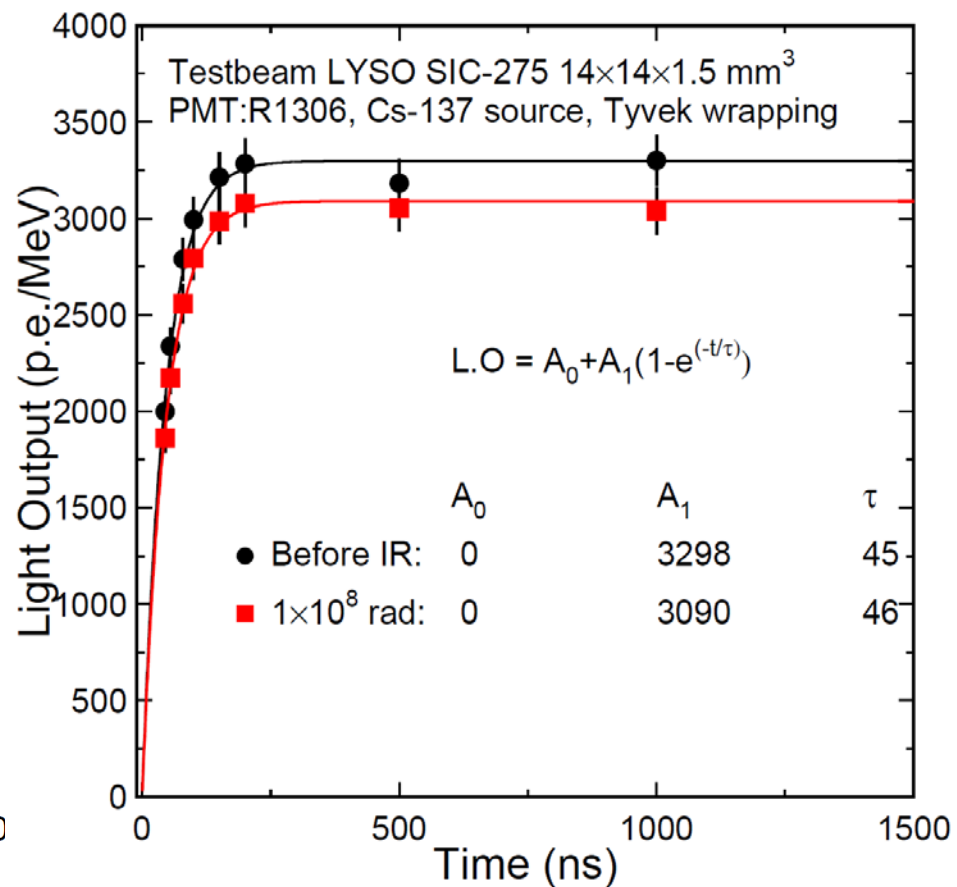
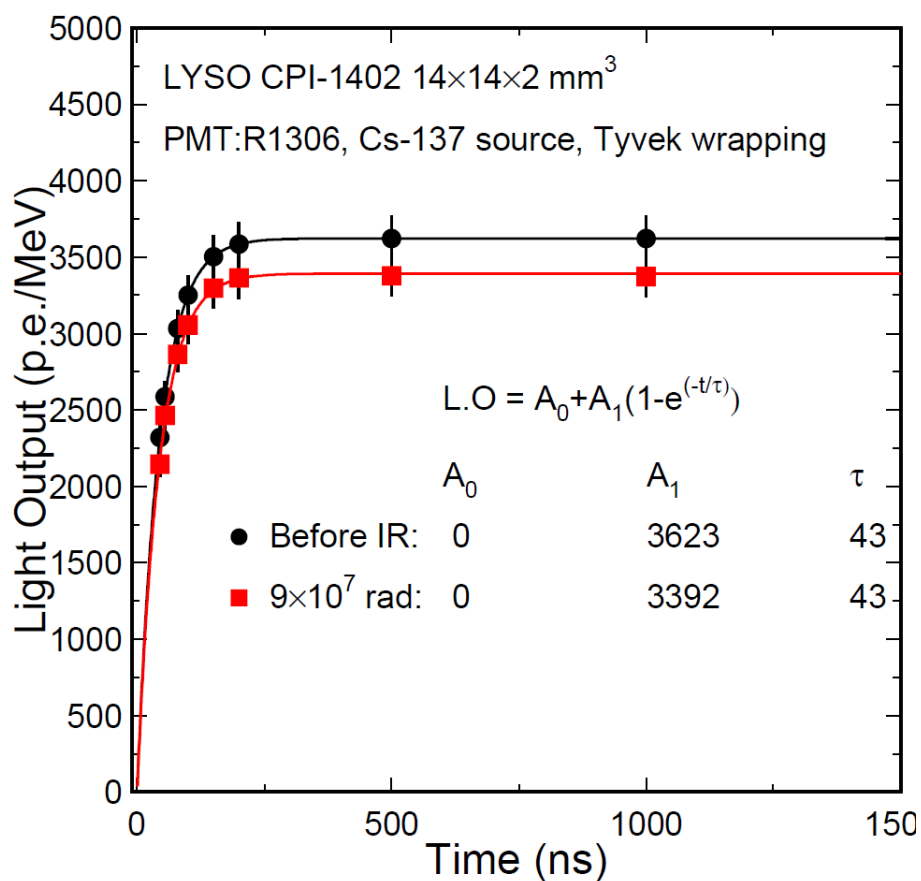
1%/12% Light Output Loss after 10/100 Mrad

Intrinsic light response uniformity of LYSO/W Shashlik cells is good for EM resolution.

Radiation damage to WLS fibers will be investigated: 20 cm long Y-11 and DSP fibers are irradiated at JPL.

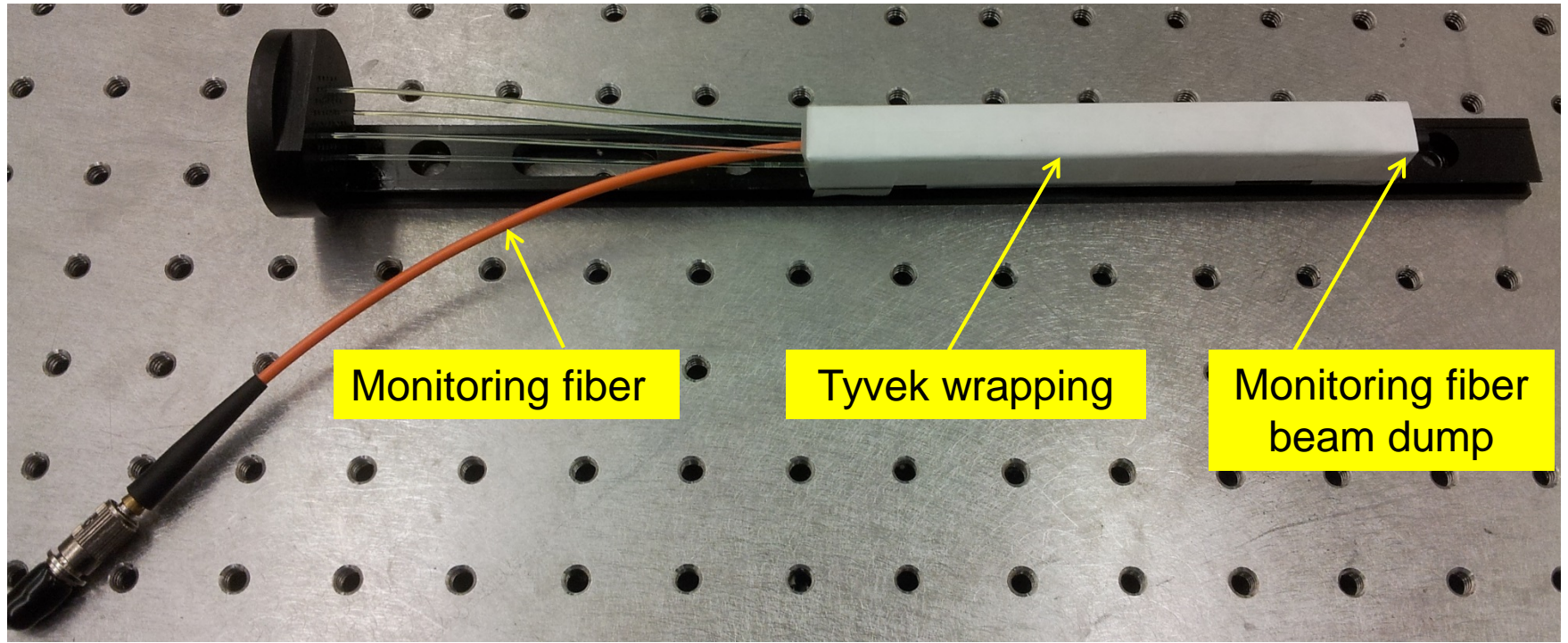
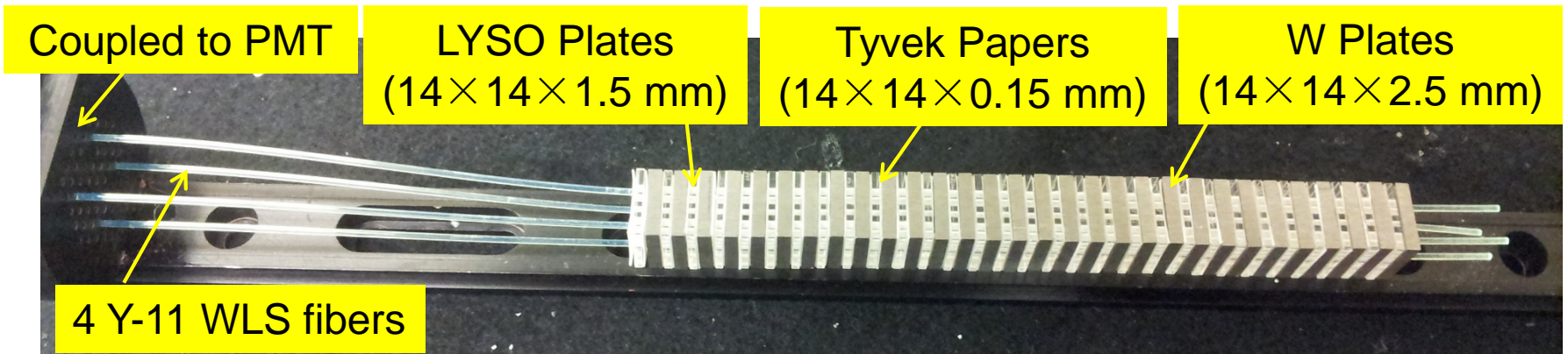


A Cross Check with Direct PMT Readout



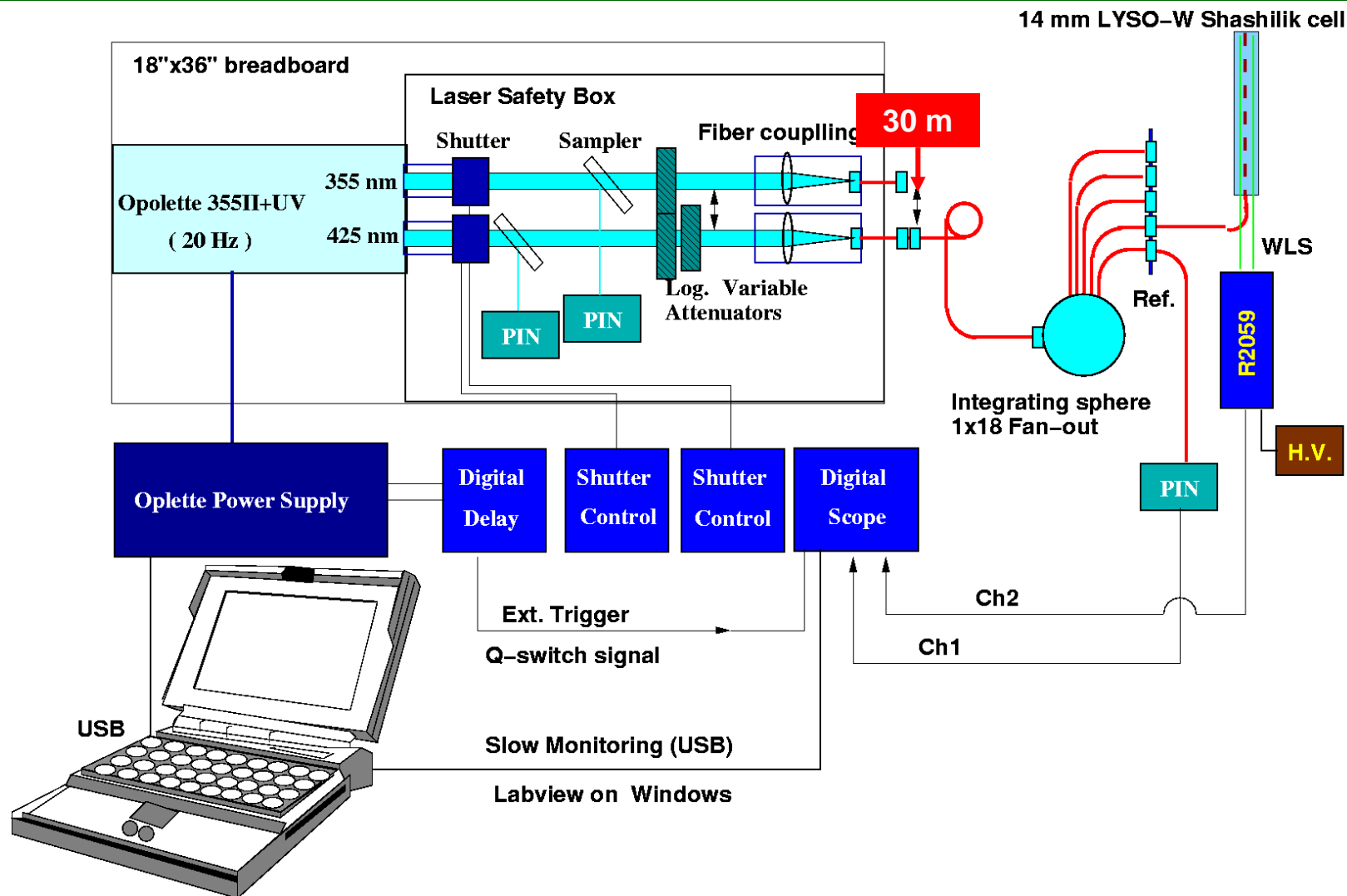
~6% losses after 100 Mrad consist with Y-11 readout

A Shashlik Cell Irradiated at JPL



An Opolette Laser Based Monitoring Setup

Two channels from the ½ inch integrating sphere were read out by a R2059 PMT through Shashlik and a PIN diode (Thorlabs DET10A) as a reference

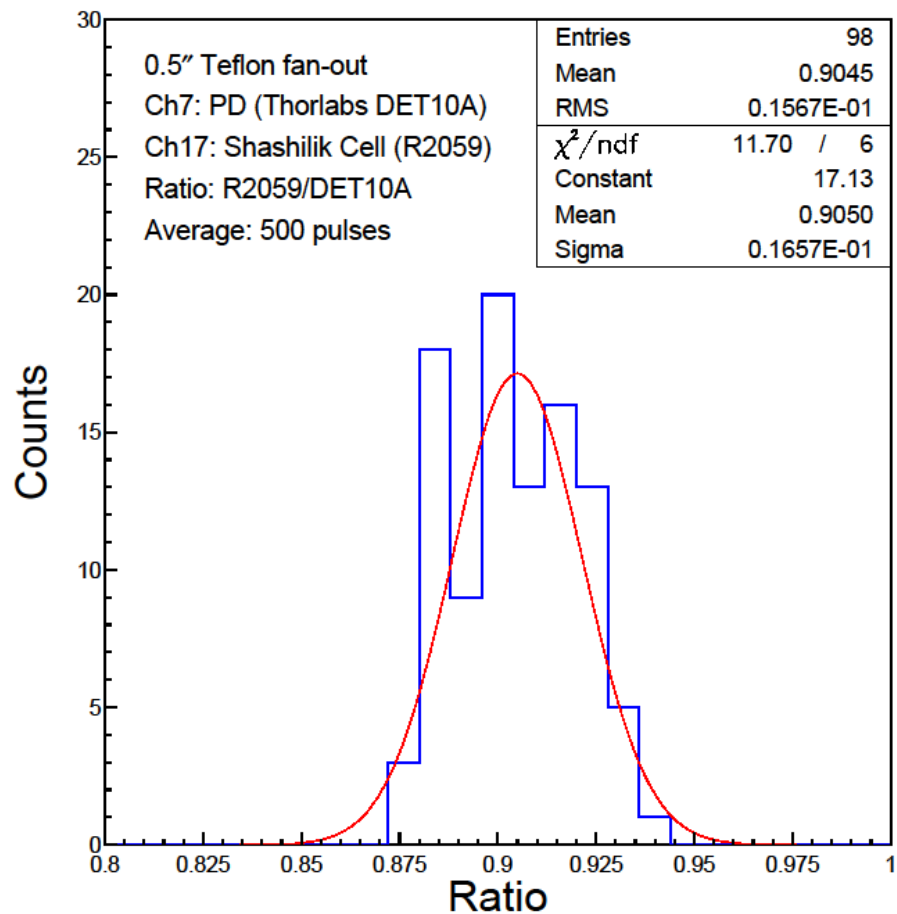
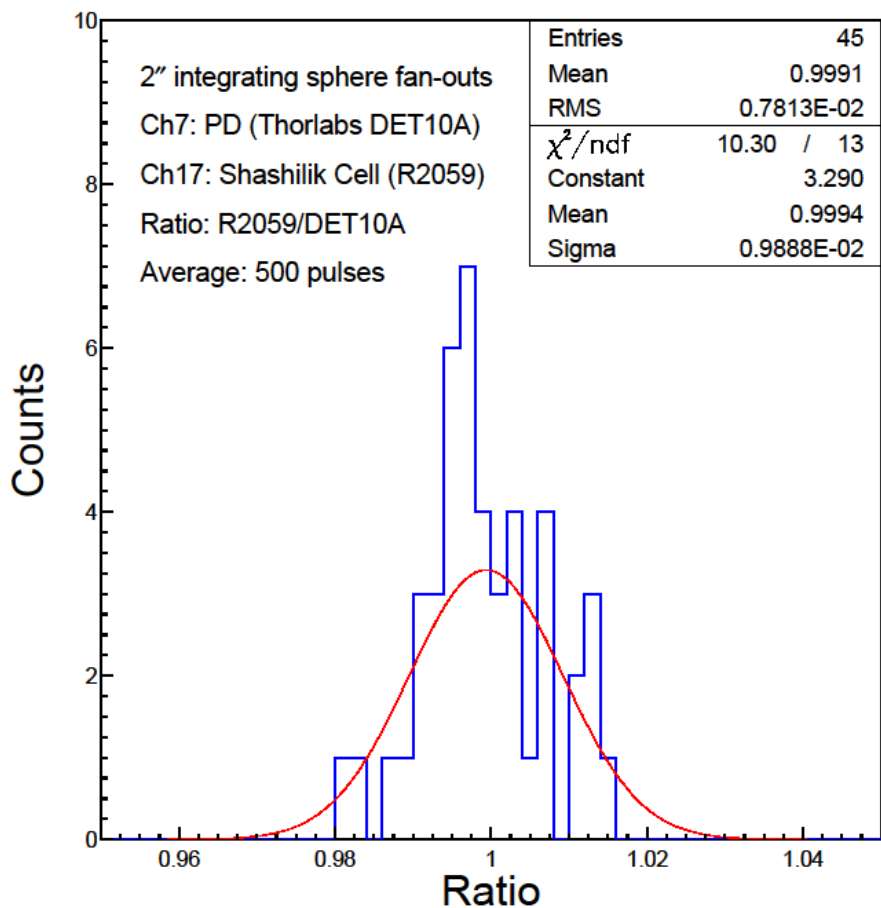


10% Degradation Observed after 100 Mrad

By using 425 nm laser pulses

Before irradiation

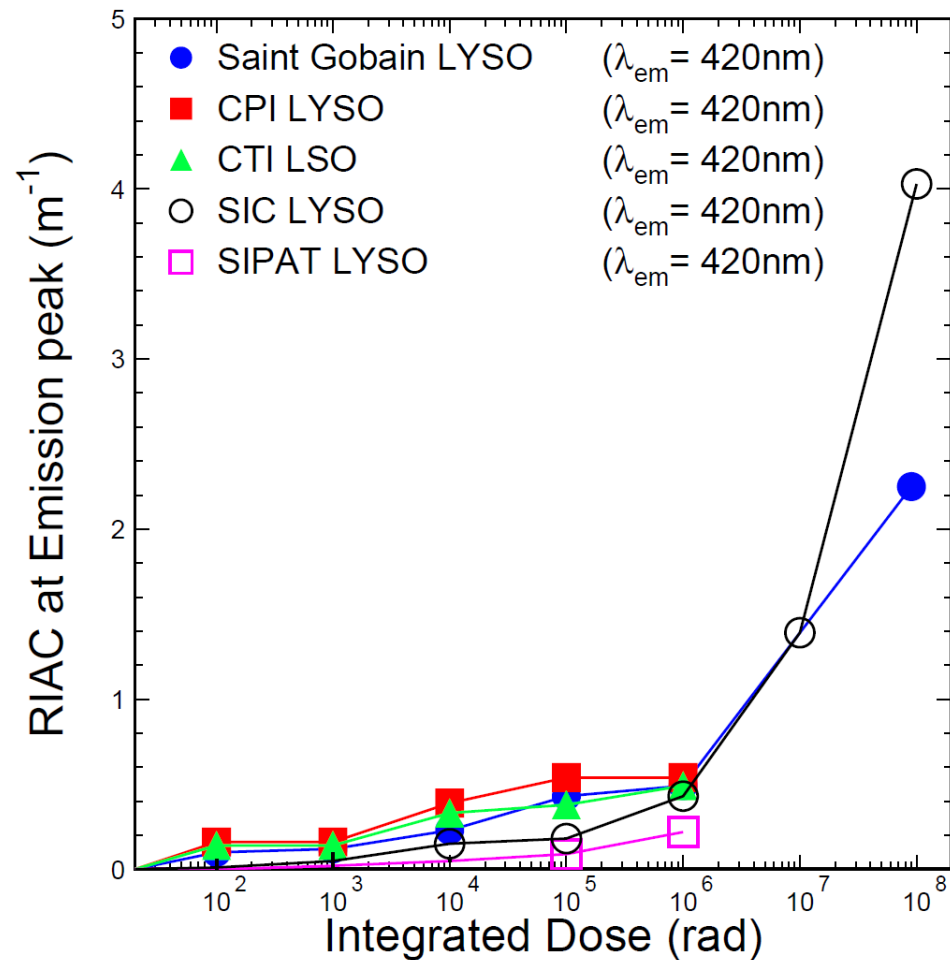
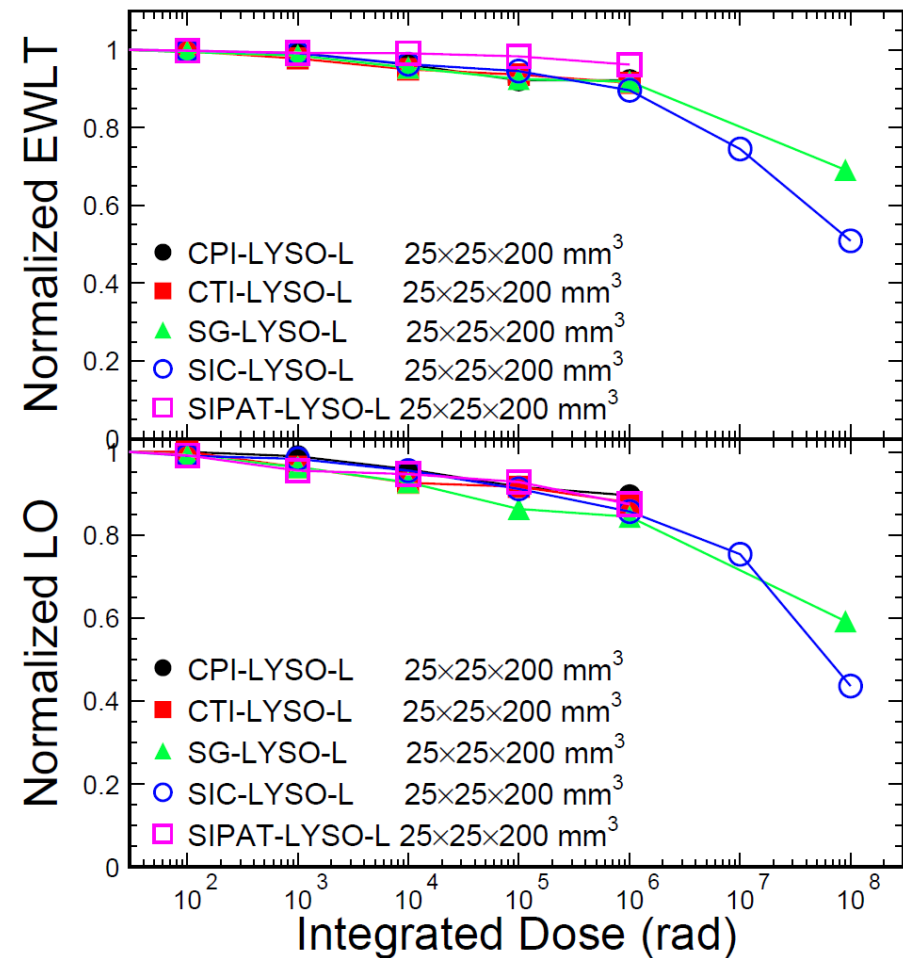
After 100 Mrad



Summary

- 1st round irradiation with ^{60}Co source up to 100 Mrad was carried out for a LYSO/W Shashlik cell and various crystals at the TAD facility of JPL. No scintillation mechanism damage was observed in LYSO.
- Radiation induced absorption coefficient of $\sim 2 \text{ m}^{-1}$ was measured for 20 cm LYSO:Ce and BGO samples after 100 Mrad.
- Light output loss of an LYSO plate with Y-11 readout was measured to be 1%/12% after 10/100 Mrad. This 12% degradation after 100 Mrad is consistent with 6% observed by direct PMT readout and 10% observed in the LYSO/W Shashlik cell by monitoring pulses at 425 nm.
- Light response uniformity of LYSO/W Shashlik cell with Y-11 readout is ideal for excellent EM resolution. To be investigated: damage in WLS.
- 2nd round of 100 Mrad irradiation was carried out at JPL last weekend. Y-11 and DSB fibers as well as wrapping materials were irradiated. Results will be presented in future Shashlik meetings.
- Irradiation with 800 MeV protons (experiment 6501 at LANL) will be carried in October at the Weapons Neutron Research facility of the Los Alamos Neutron Science Center.

Summary of LYSO Crystals

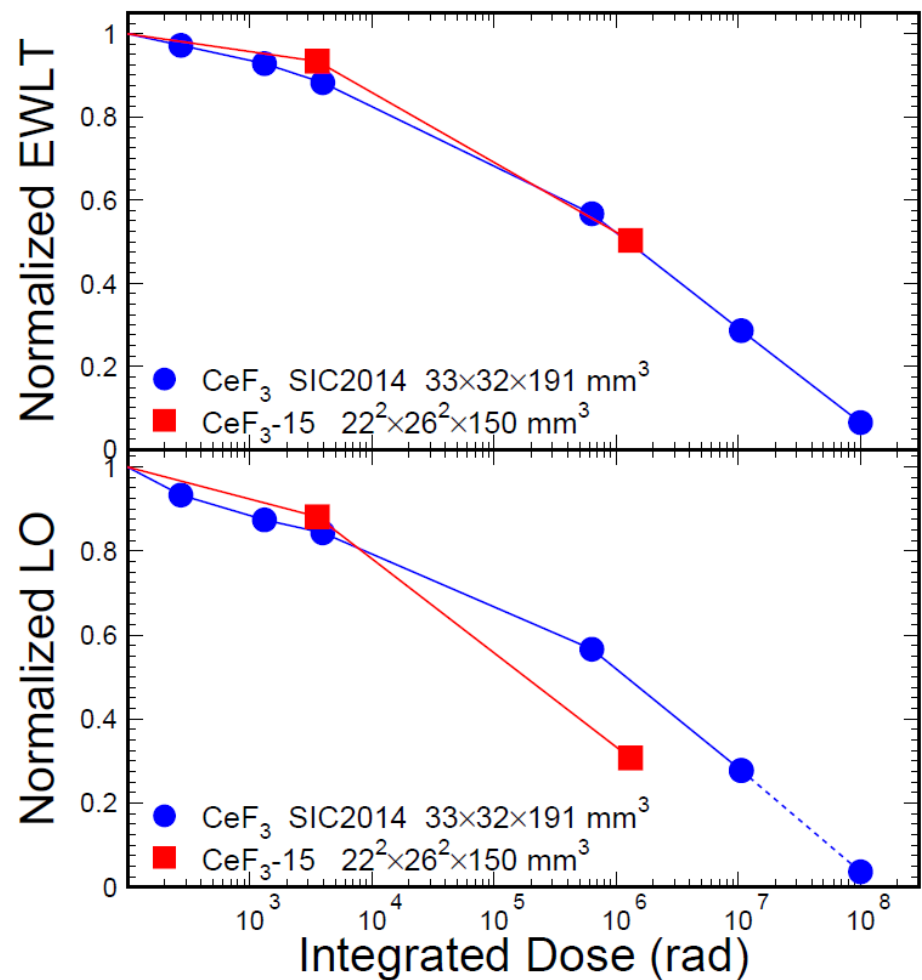
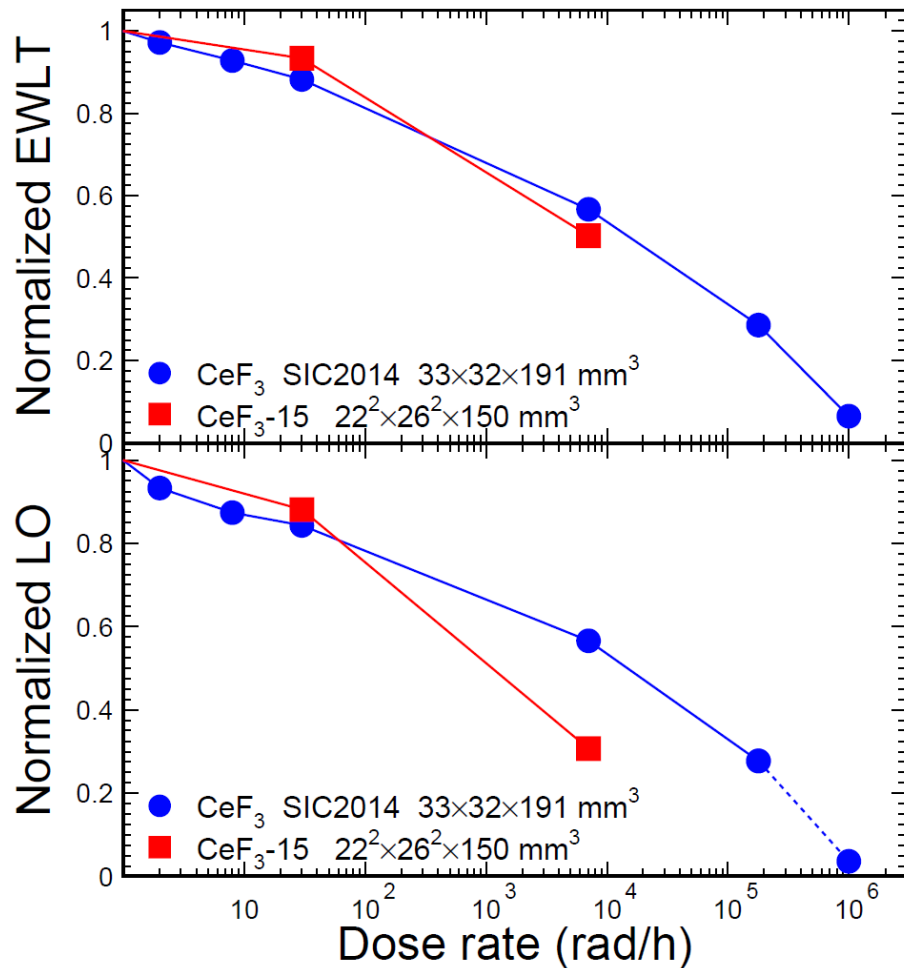


All samples were grown about ten years ago

Summary of CeF₃ Crystals

Dose Rate

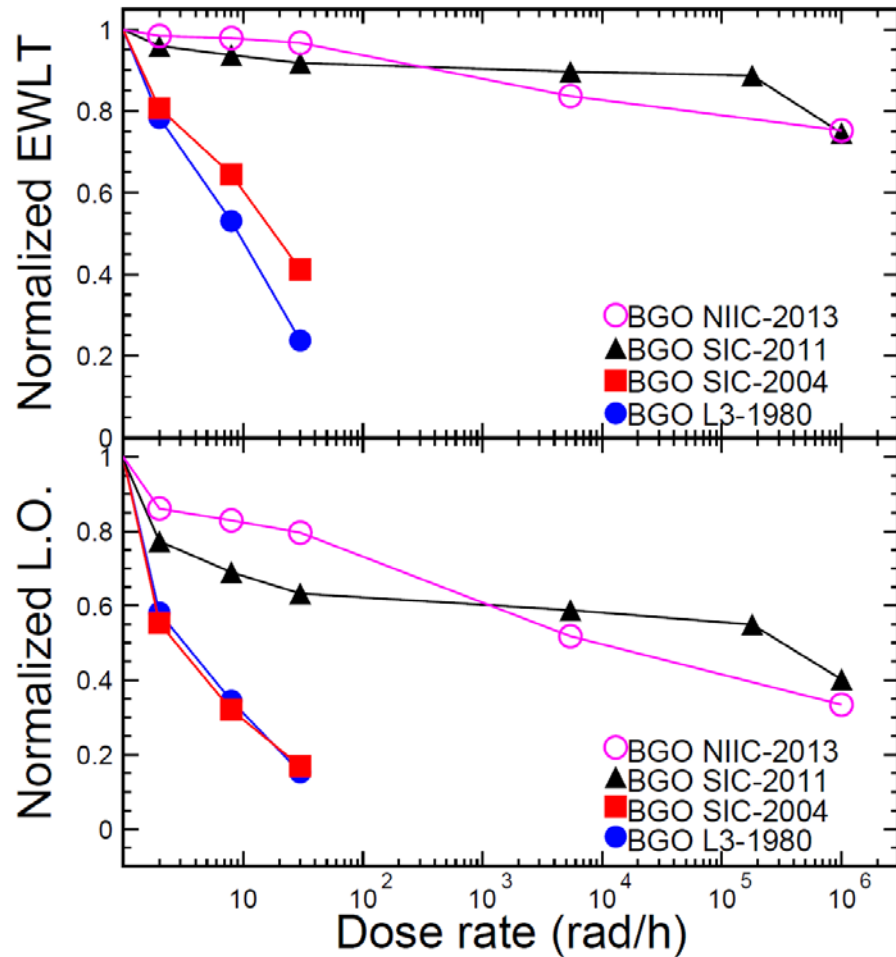
Integrated Dose



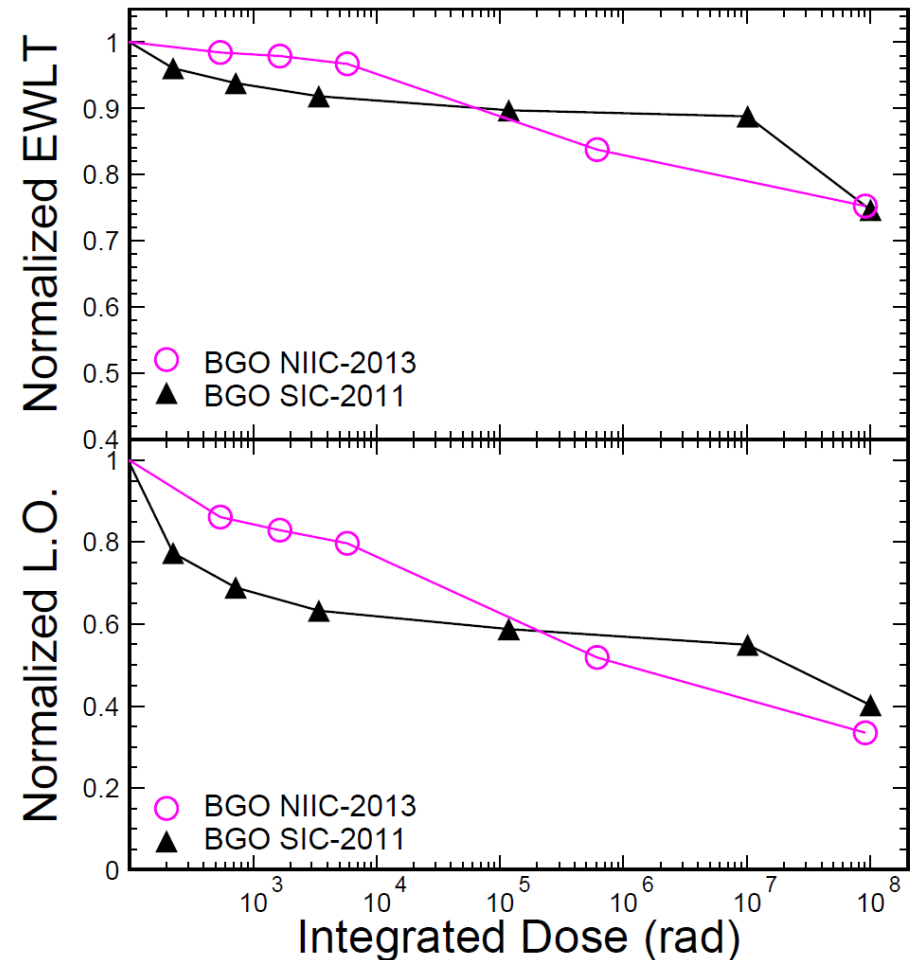
Both samples were grown about twenty years ago

Summary of BGO Crystals

Dose Rate



Integrated Dose

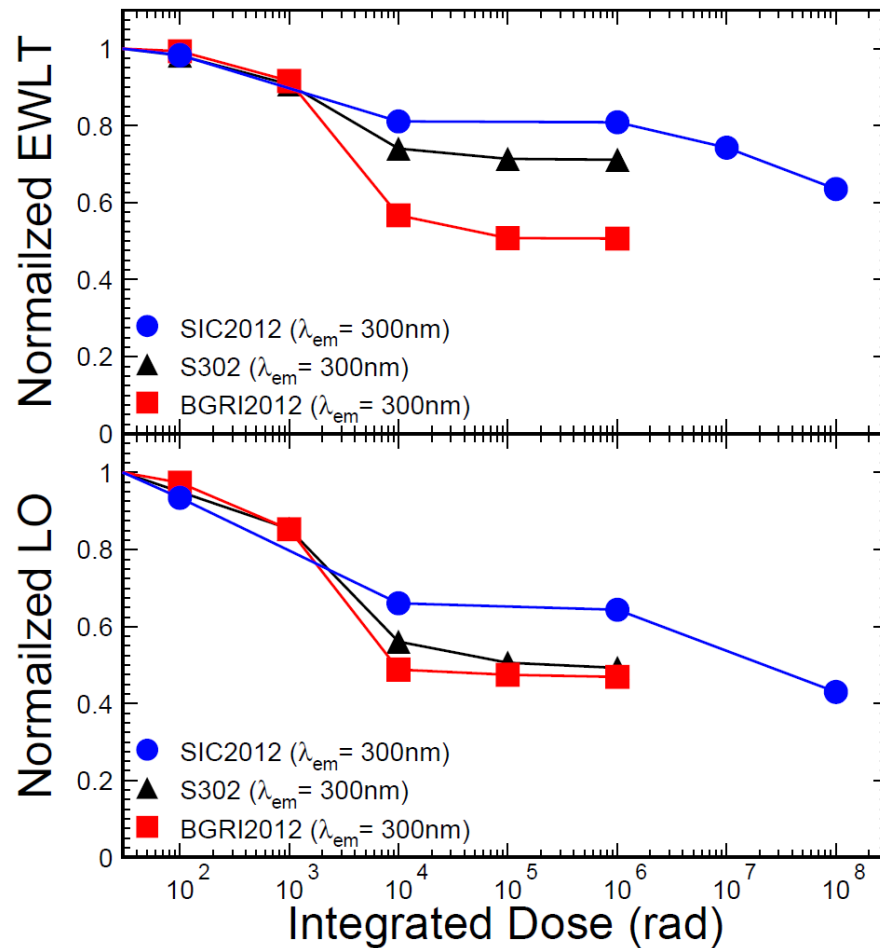
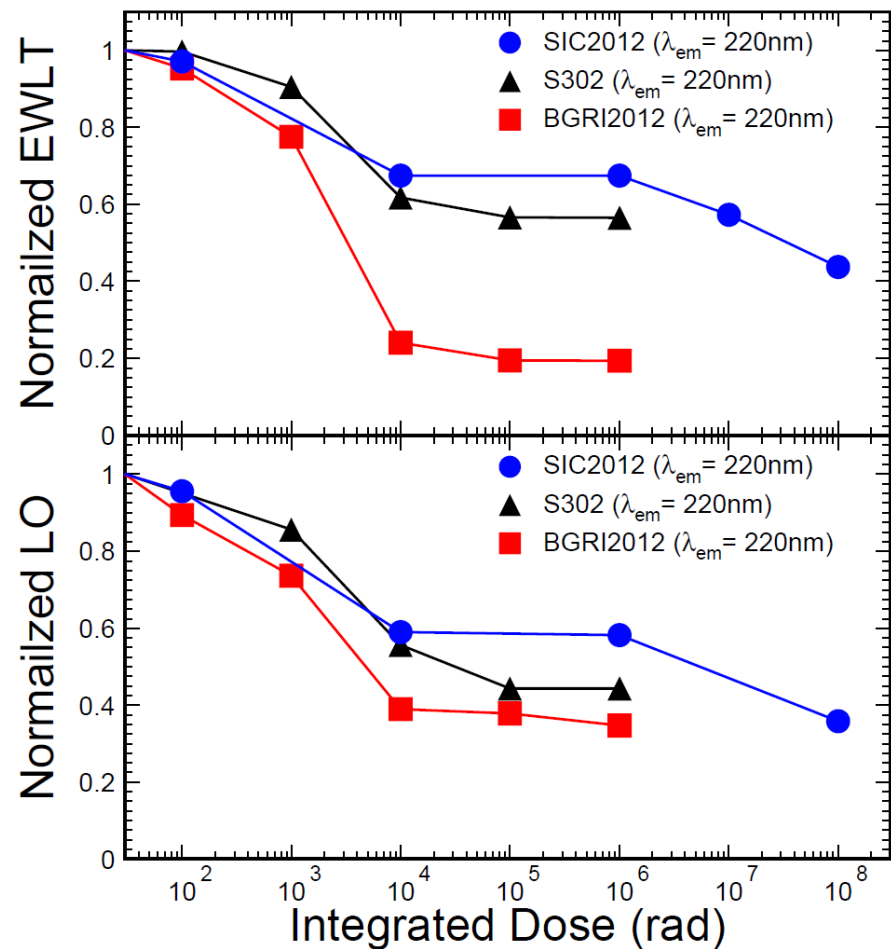


Sample L3/SIC-2004 were grown about thirty/ten years ago

Summary of BaF₂ Crystals

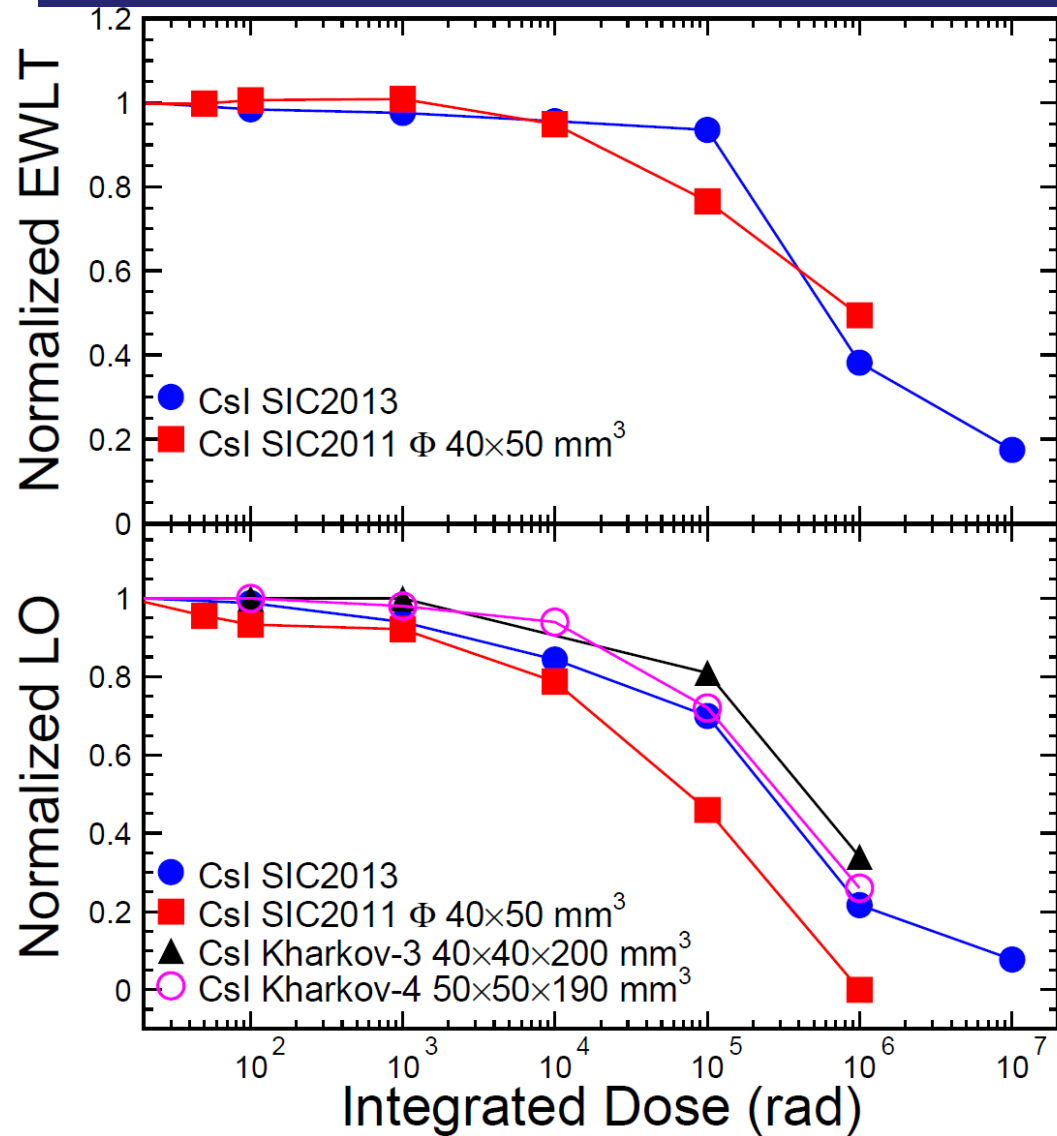
Fast Component

Slow Component



Sample S302 and BGRI2012 were grown about twenty year ago

Summary of CsI Crystals



Kharkov samples were grown about twenty years ago