Scintillator Light Yield and Aging Study

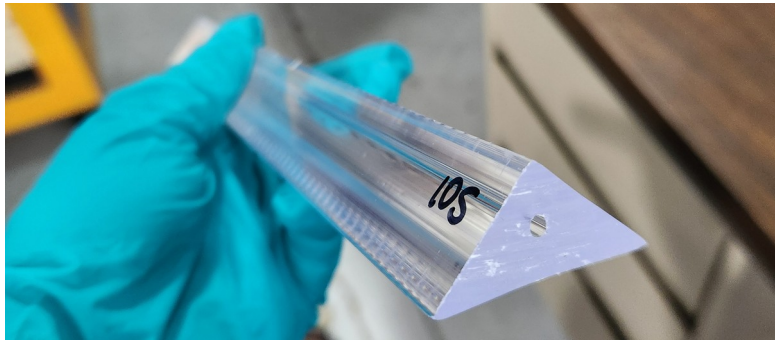
Samuel Turnberg

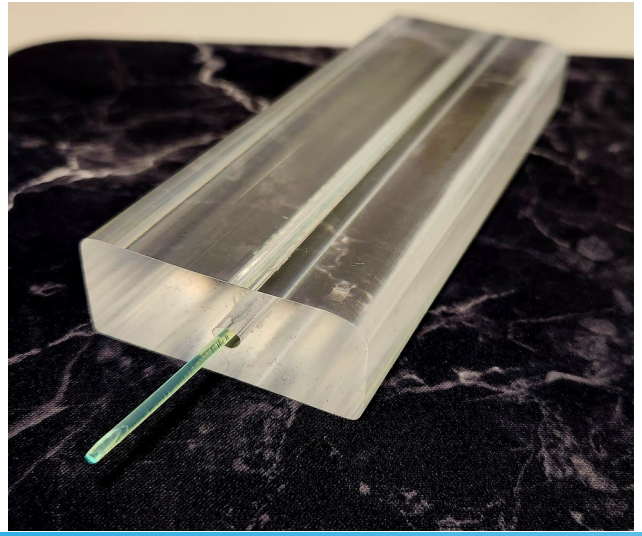
10/17/2024

ILLINOIS TECH

Samples

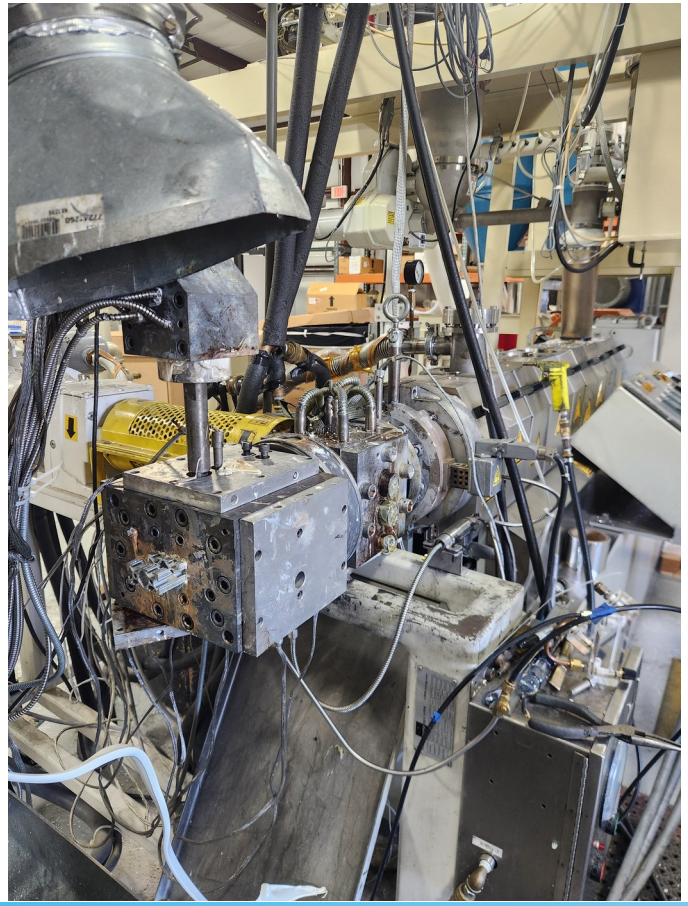
- Geometry
  - Triangular: EGP (2cm x 4cm)
  - Rectangular: Mu2e (2cm x 5cm)
- Polystyrene
  - AmSty 665 (Nominal)
  - Taita 808
- Cladding
  - TiO_2 (Nominal)
  - Teflon
  - BN





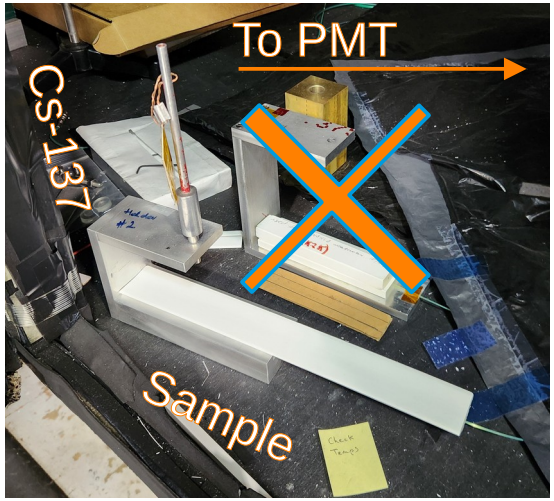
Lab 5 Procedure

- Scintillator extruded on July 15 (EGP) and July 16 (Mu2e)
  - Samples cut from every 5th extrusion
  - ~6 to 15 pieces for each sample population
- EGP
  - Uncladded 665
  - TiO_2 / 665
- Mu2e
  - Uncladded 665
  - TiO_2 / 665
  - TiO_2 / 808
- Measurements (counts over 60s for 70mV and 180mV threshold)
  - Background in reference (K2K) without Cs-137 source
  - K2K reference with Cs-137 source
  - Each sample with Cs-137 source



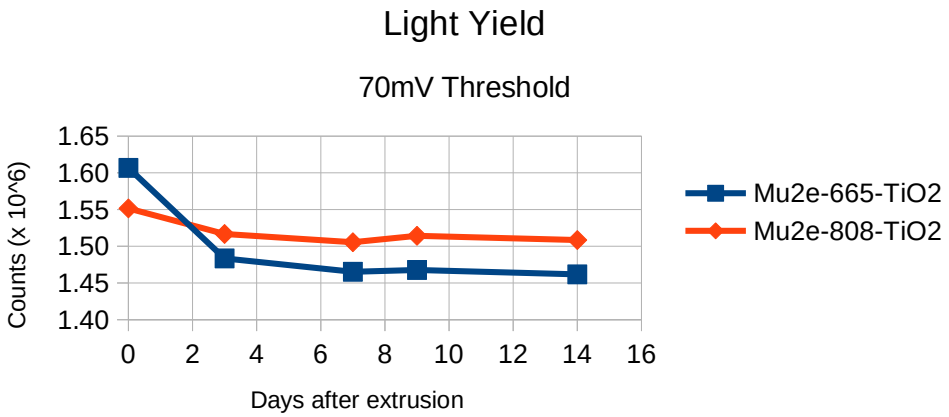
Lab 5 Setup

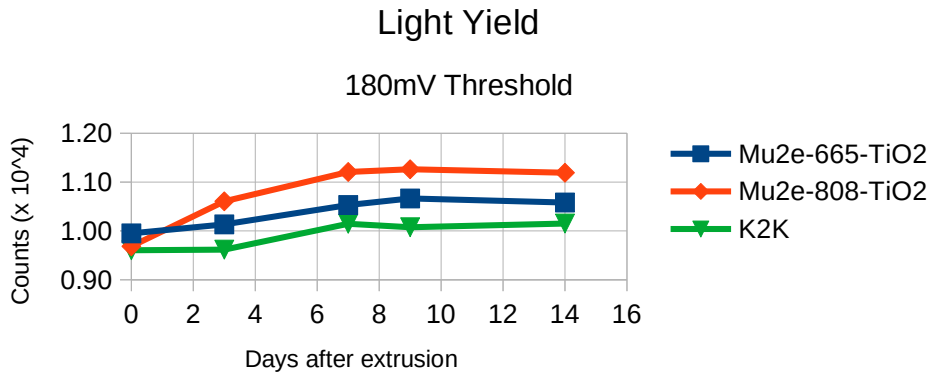
- Photomultiplier Tube
  - Hamamatsu R2165-01 CC3 87.1 @ 1300V
- LeCroy PMT Amplifier
- LeCroy Quad Discriminator
- Ortec Counter
- Wavelength shifting fiber “mirrored” by Al holder
- Cesium-137 Source (0.837mCi) e^- 0.514MeV(94%) 1.176MeV 6%



Lab 5 Measurements (Cs-137)

- Background (negligible) subtracted counts
- Day 0 data point taken immediately after extrusion while warm
- Increase in counts in first 3 days (rest corresponds to increase in K2K) not understood
- Slightly higher yield in Taita (808)
  - Mean counts +3.2% (70mV)
  - Mean counts +5.7% (180mV)
- K2K is flat at 0.7×10^6 counts for the 70mV plot (is not shown)
- Trend for both thresholds shows higher light yield for Taita (808)





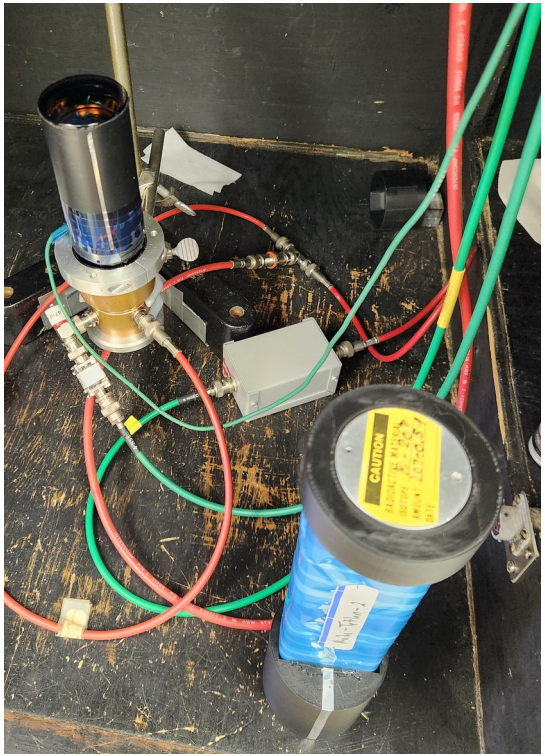
Lab 6 Procedure

- First measurement is July 26
  - 11 days after EGP extrusion
  - 10 days after Mu2e extrusion
- Measure blue and green reference scintillators for 60s
- Measure each sample 3 times (total of 6 between both samples) and average the results

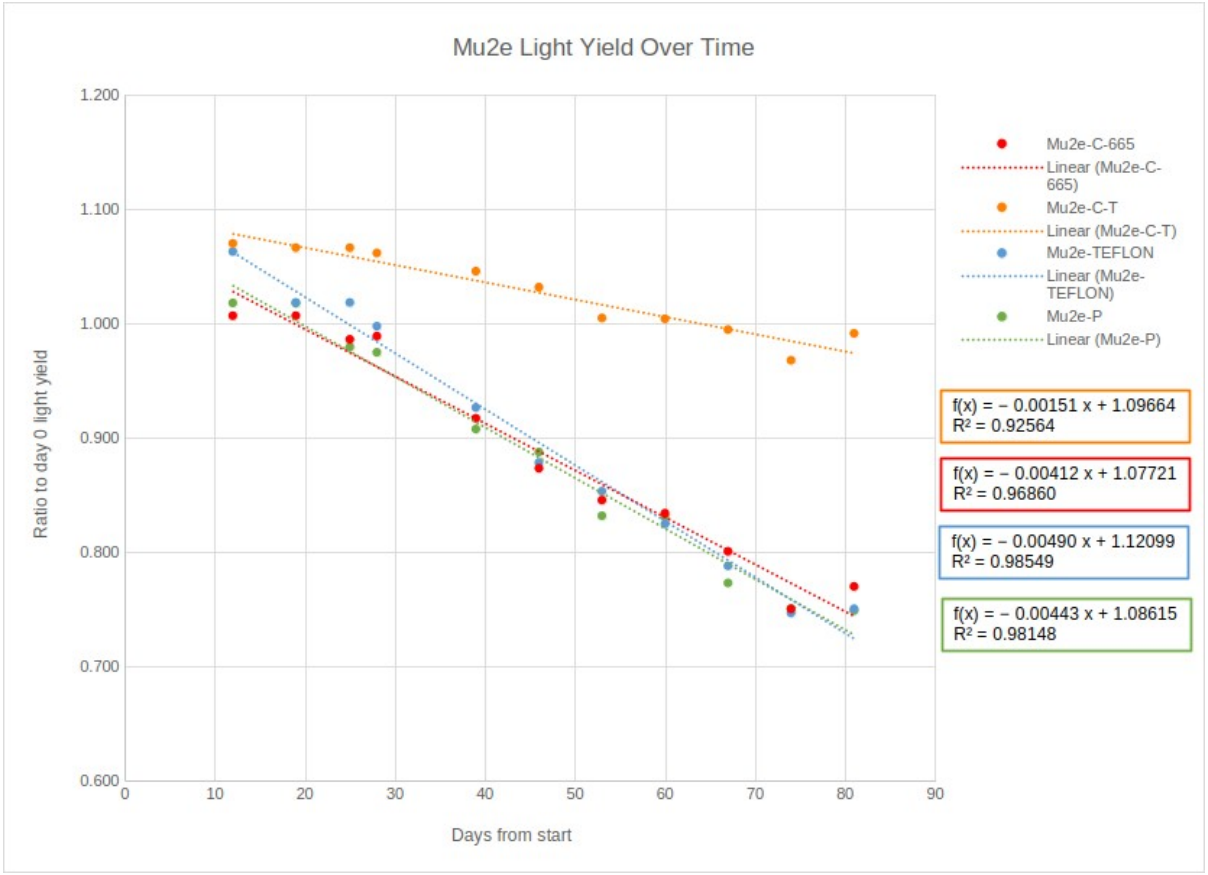
- Prepared samples with 3D printed source holder at top and PMT attachment on bottom
- 2 samples for each configuration
- EGP-665-TiO2 and EGP-665-Teflon
- Mu2e-665-TiO2, Mu2e-808-TiO2, Mu2e-665-Teflon, Mu2e-665-BN

Lab 6 Setup

- Photomultiplier Tube
  - Hamamatsu R669 @ 1300V
- Ortec Spectroscopy Amplifier
- Ortec Multi-channel Analyzer
- Maestro MCA Software
- Bismuth-207
- Measure 3x per sample
- Average between both copies



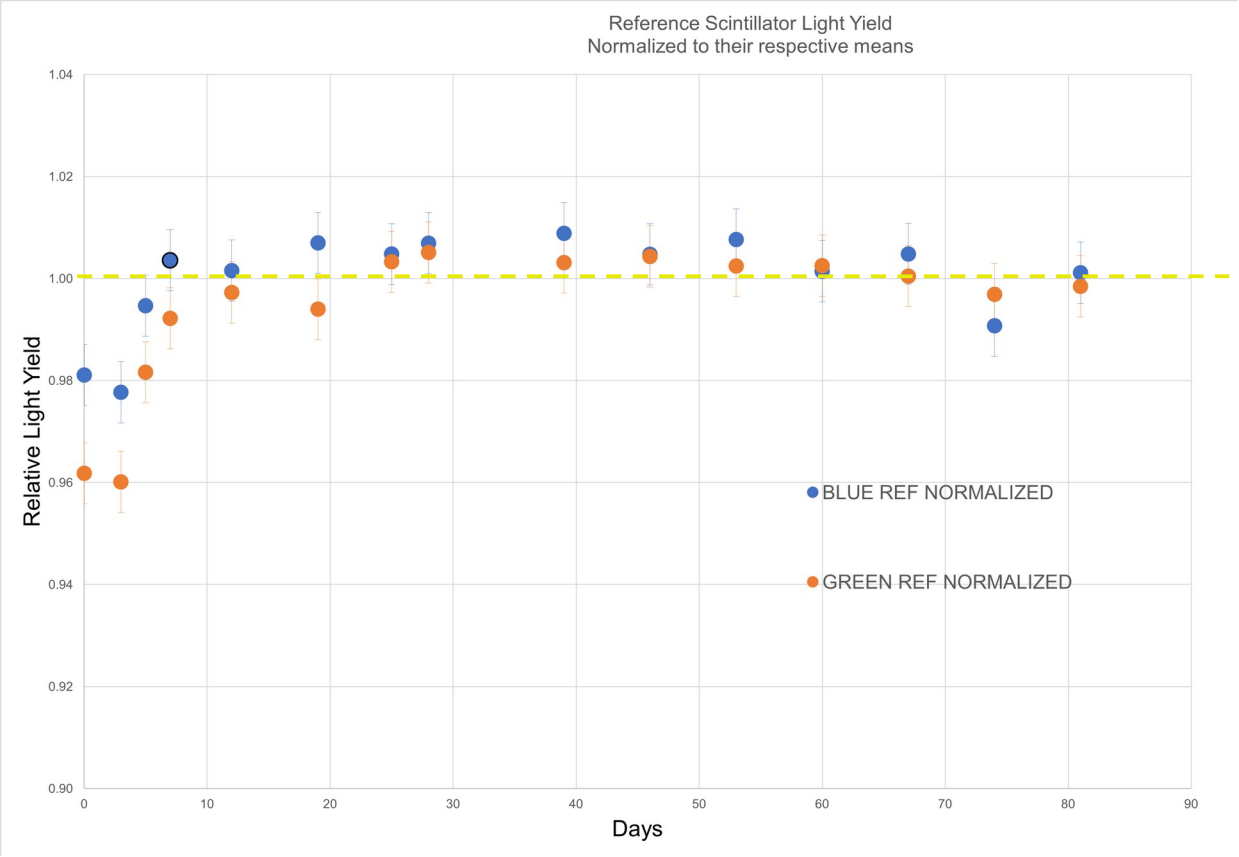
Lab 6 Measurements (Bi-207)



- Referenced to a blue scintillator
- Normalized to day 0 measurement
- Taita 808 polystyrene has ~23% more light after 81 days since first measurement
- AmSty 665 decreasing ~0.0045 per day (mean)
- Taita 808 aging more slowly

Reference Scintillators

- Vary by ~ ±1%
- Green is normalized to green mean
- Blue is normalized to blue mean



Conclusions

- Cladding doesn’t make a noticeable difference
- 808 has ~5% higher light yield within first 2 weeks
- 808 has ~23% higher light yield after 11 weeks
- 808 light yield drops off at a slower rate

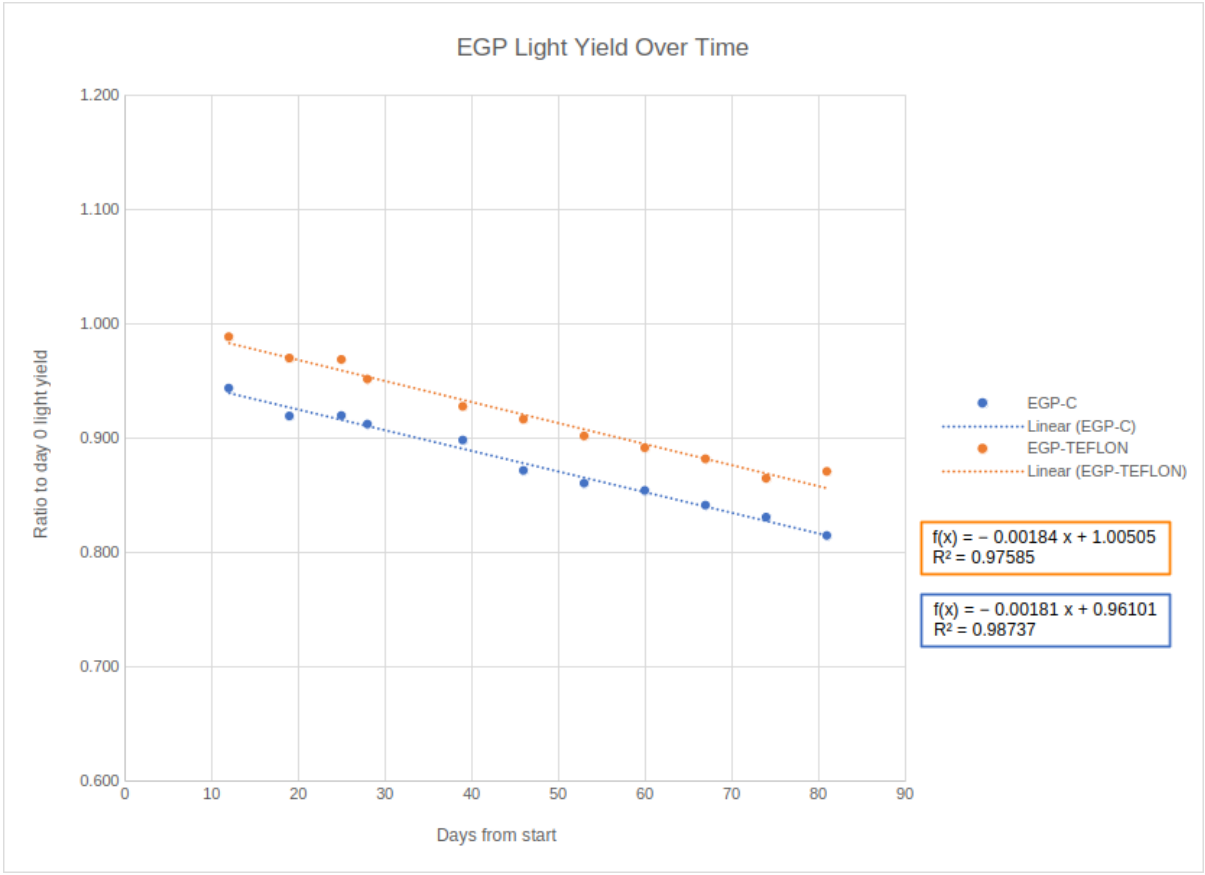
Next Steps and Questions

- Continue measurements for next several weeks/months
- Cosmic ray muon light yield measurements
- Repeat lab 5 measurements with a scope instead of counter
- Analysis of polystyrene by a lab to see possible differences

- Why does BN not do better?
- Why does the Taita 808 yield more light than AmSty 665?
- Why is Taita 808 aging more slowly?

Thank You

Lab 6 Measurements



- Referenced to a blue scintillator
- Normalized to day 0 measurement
- Teflon yields ~5% more light than TiO2
- Both age at about the same rate (as well as similar rate that Mu2e 808 aged)

Lab 6 (Strontium measurements)

- Only two days of measurements
- Both Taita 808 PS and the boron nitride cladding perform better, but this goes down after a week

Date	7/31/2024	8/6/2024
Mu2e-665-TiO_2	16,284,212	17,670,000
Mu2e-808-TiO_2	20,214,014	19,647,185
Mu2e-665-BN	25,560,231	23,498,115
Mu2e-665-TiO_2	100.000%	100.000%
Mu2e-808-TiO_2	124.133%	111.190%
Mu2e-665-BN	156.963%	132.983%