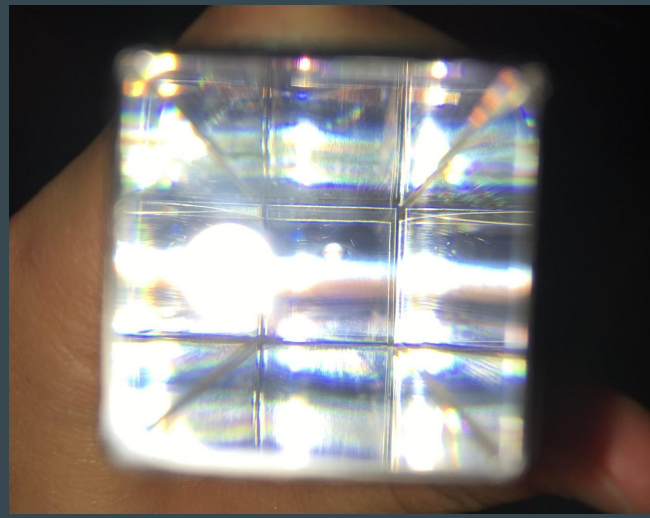
Characterization of Lead Tungstate Crystals for Application in the Neutral Particle Spectrometer and Electron Ion Collider

Abby and Dannie

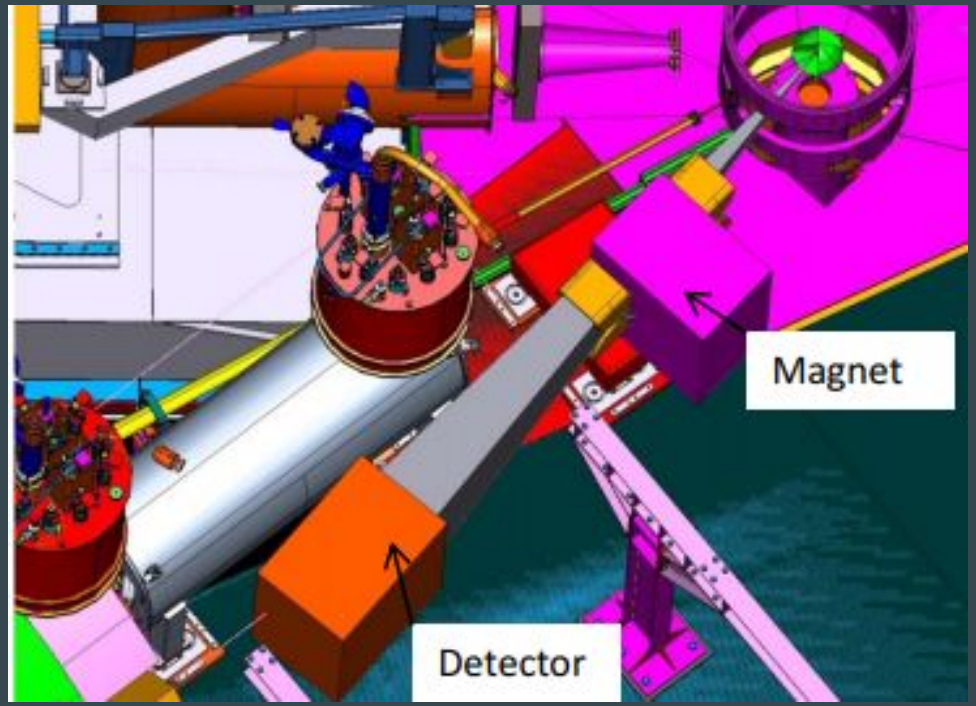


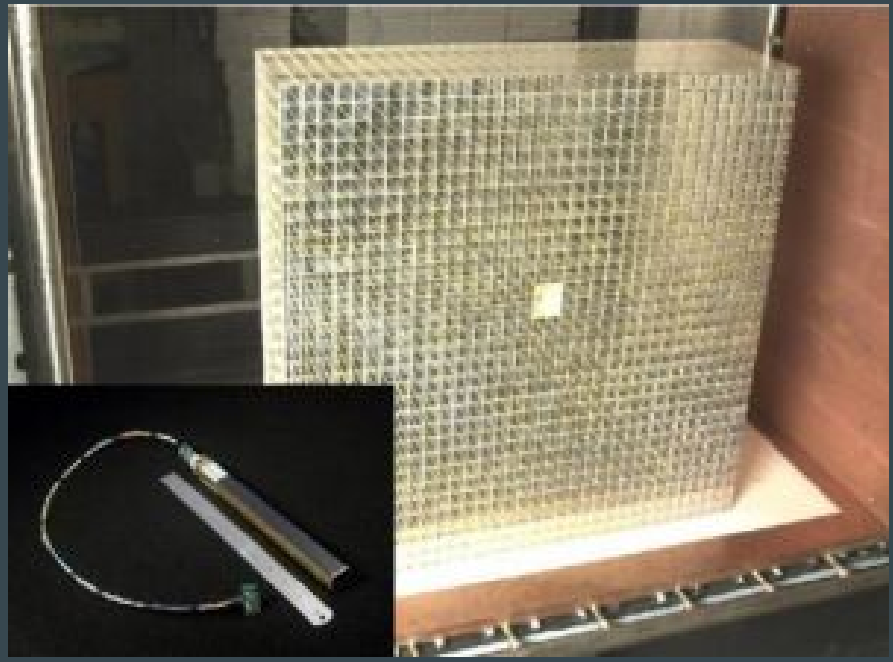
Why is PWO important?

- Lead Tungstate Crystals (PWO) are ideal for use in a compact electromagnetic calorimeter
  - Small Moliére Radius
  - Short Radiation Length = high stopping power
  - Higher light yield than other heavy crystals
  - Radiation hard
- HOWEVER, recent measurements have shown considerable variation of crystal properties
- Necessary to measure and understand the origin of variation

Ideal Parameters

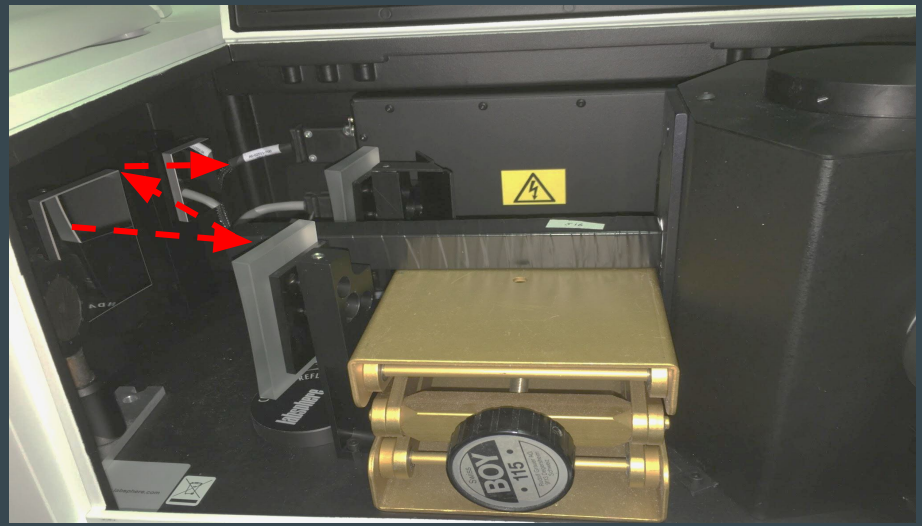
Parameter	Unit	EIC	NPS
Light Yield	pe/MeV	15	10-15
Transmittance @420nm	%	>60%	>60%
dk	m^-1	<1.5	


Magnet
Detector



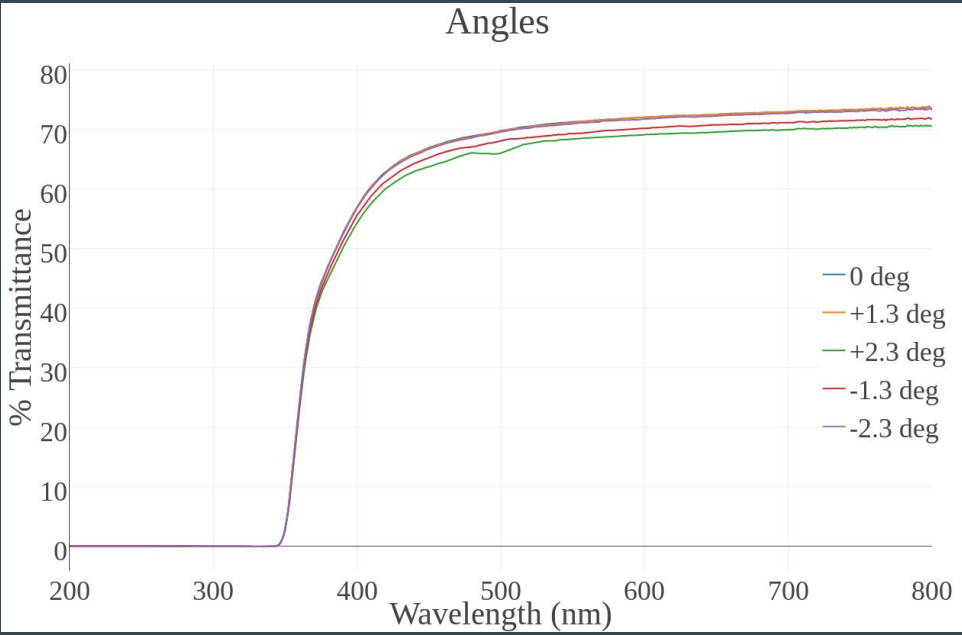
Characteristic 1: Longitudinal Transmittance

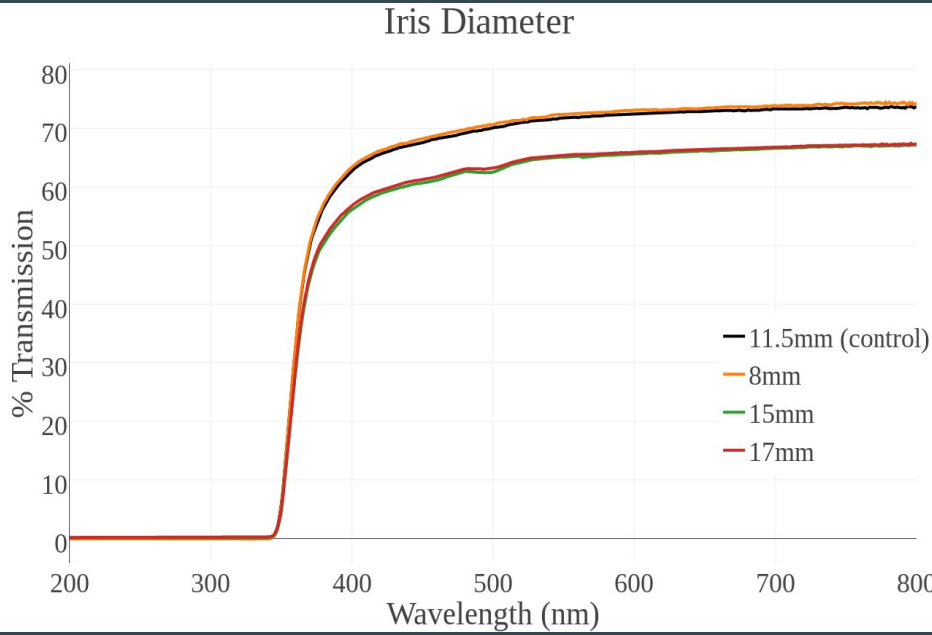
- Lambda 950 Photospectrometer



Characteristic 1: Longitudinal Transmittance

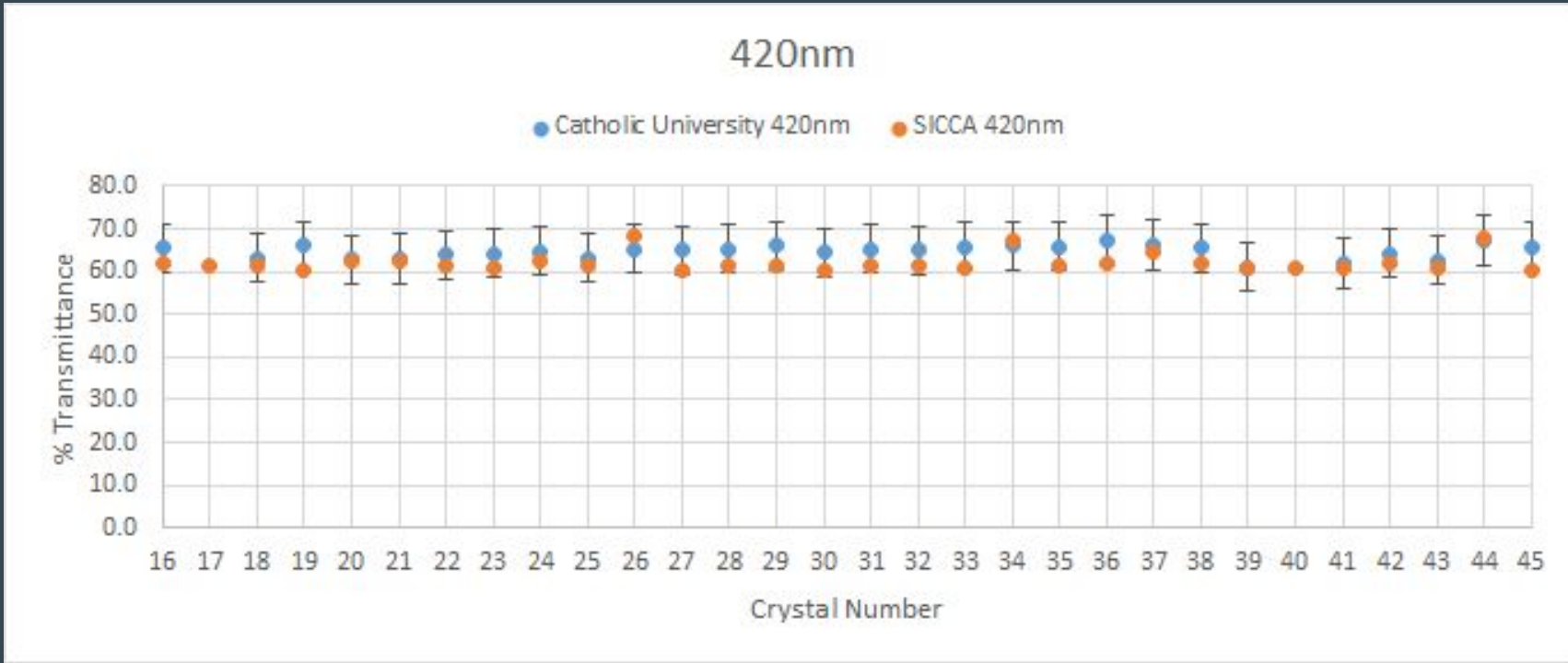
- Uncertainties from crystal preparation and placement were reduced



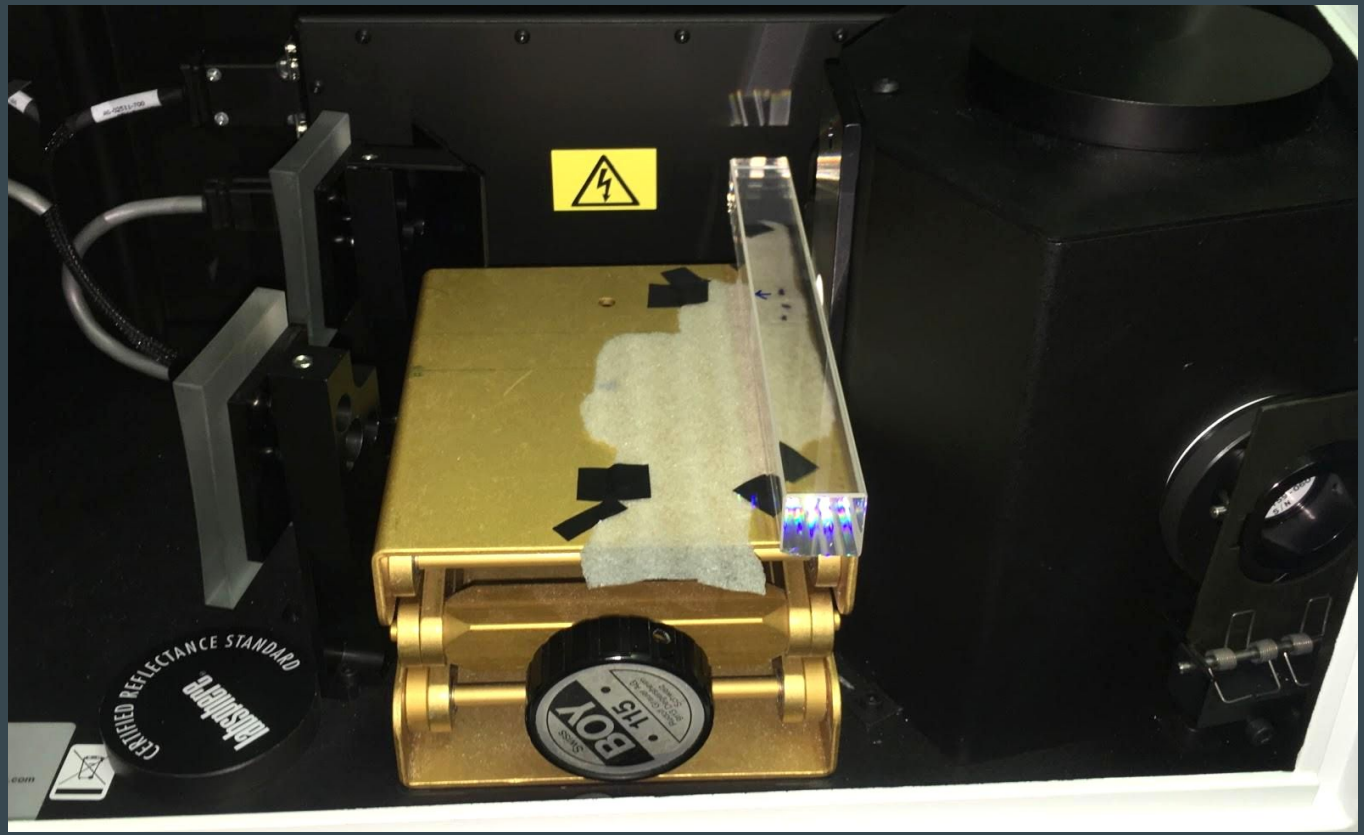


Characteristic 1: Longitudinal Transmittance

- Comparison against manufacturer's data

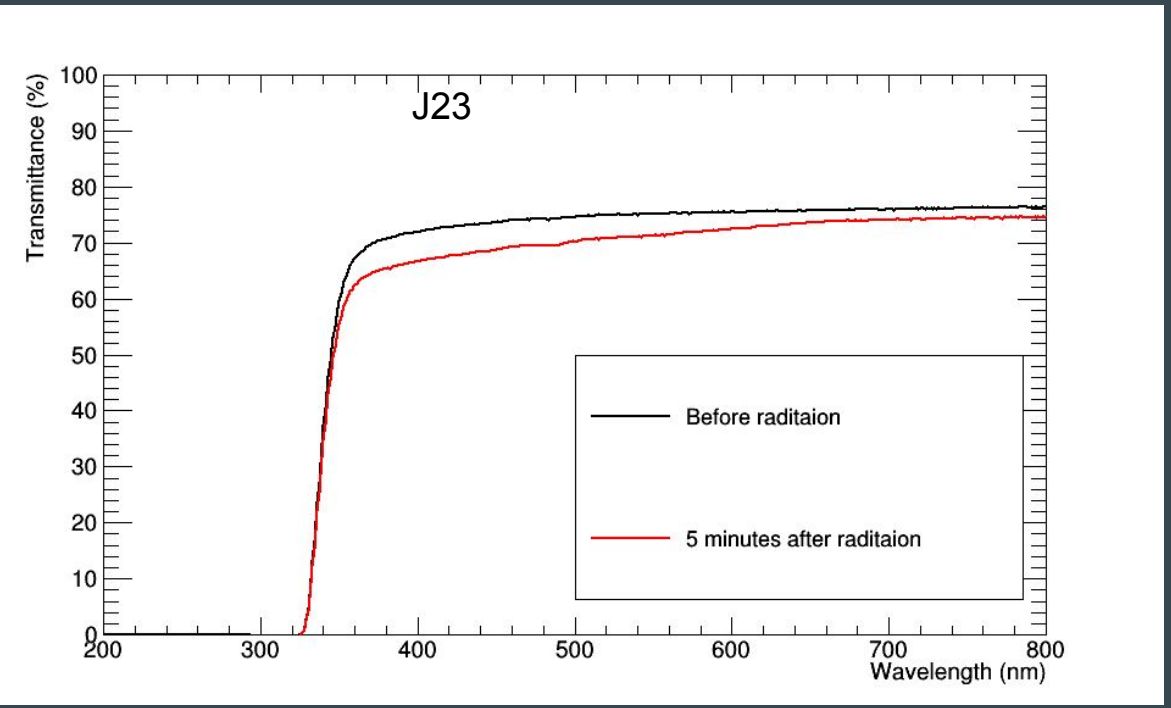


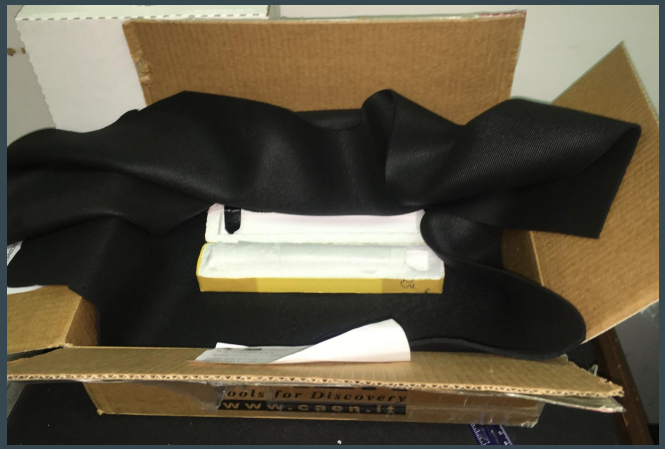
Characteristic 2: Transverse Transmittance



Characteristic 3: Radiation Hardness

6970 R/min

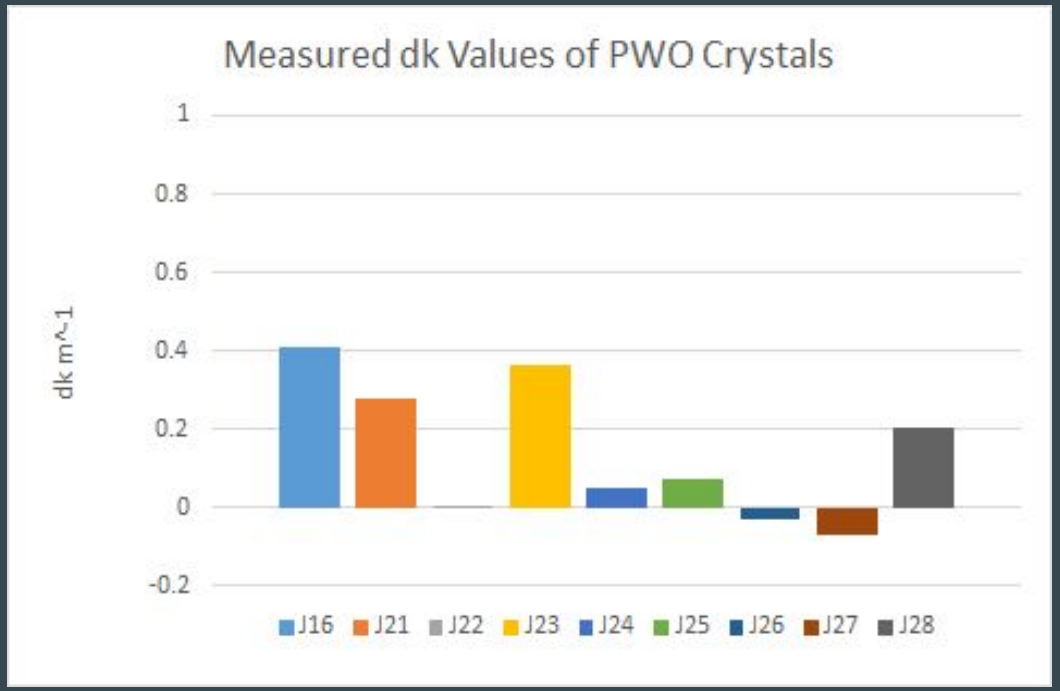




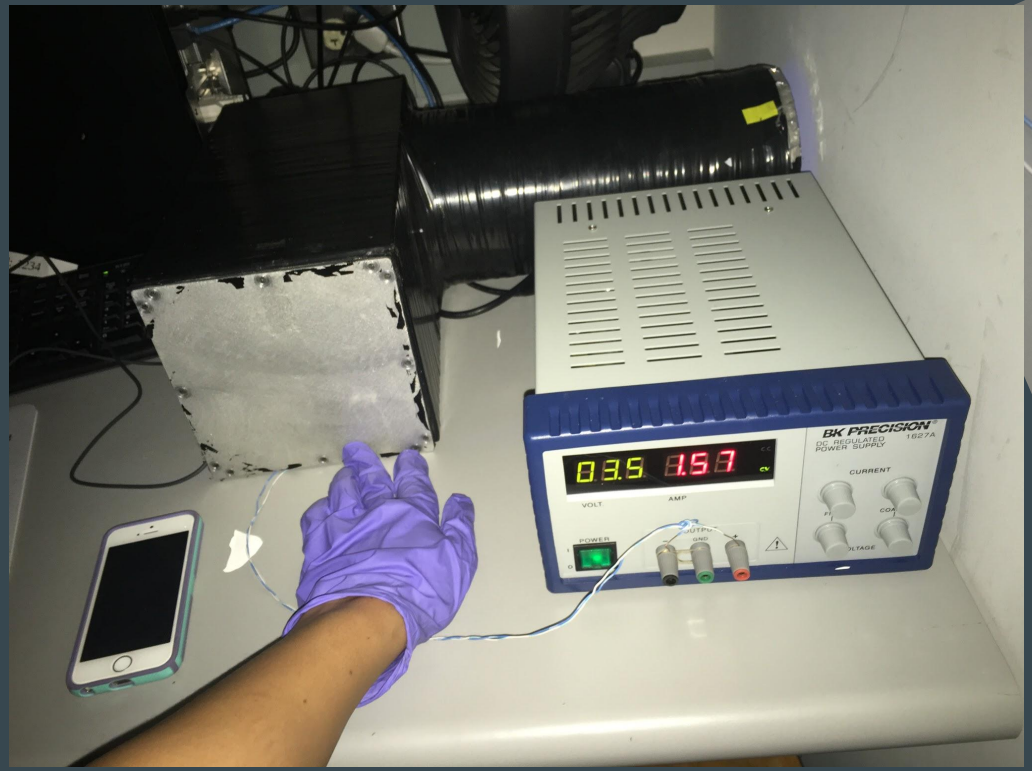
dk = absorption coefficient, 420nm

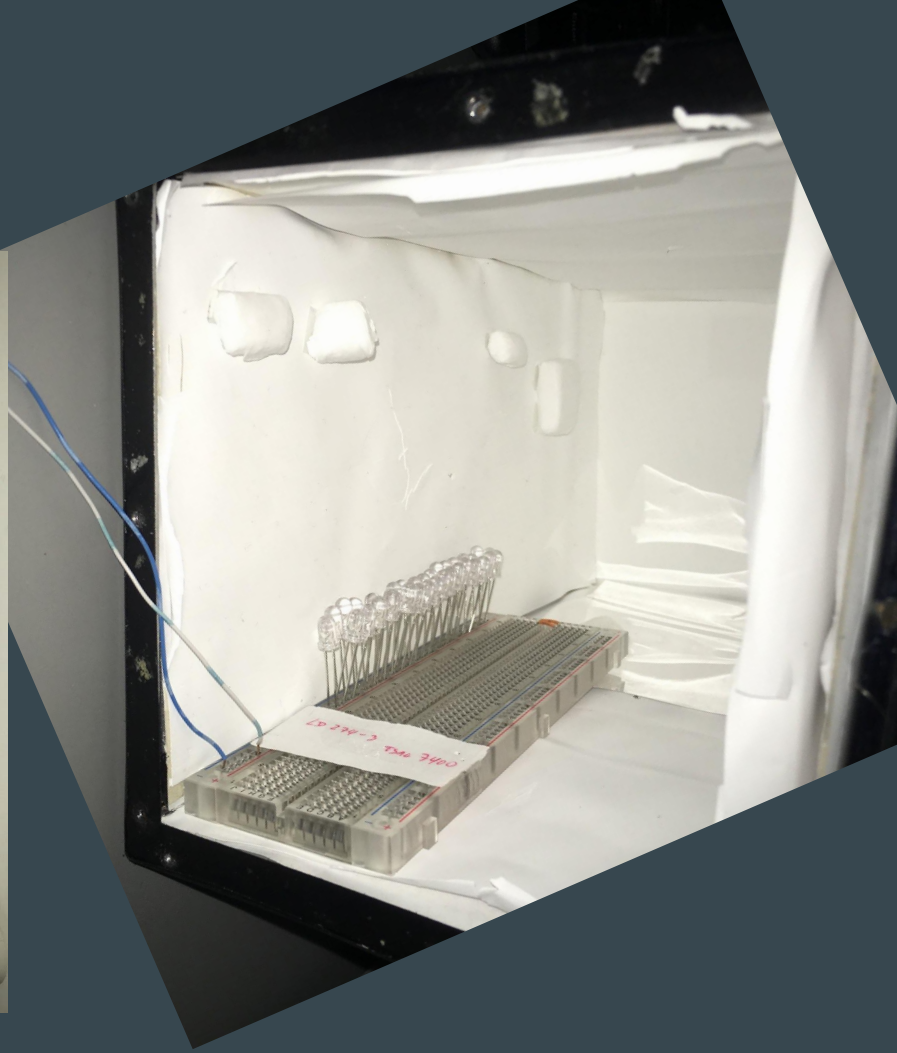
- Closer to 0 = better radiation hardness

$$dk = \frac{1}{\text{length}} \ln\left(\frac{T_{bef}}{T_{irr}}\right)$$



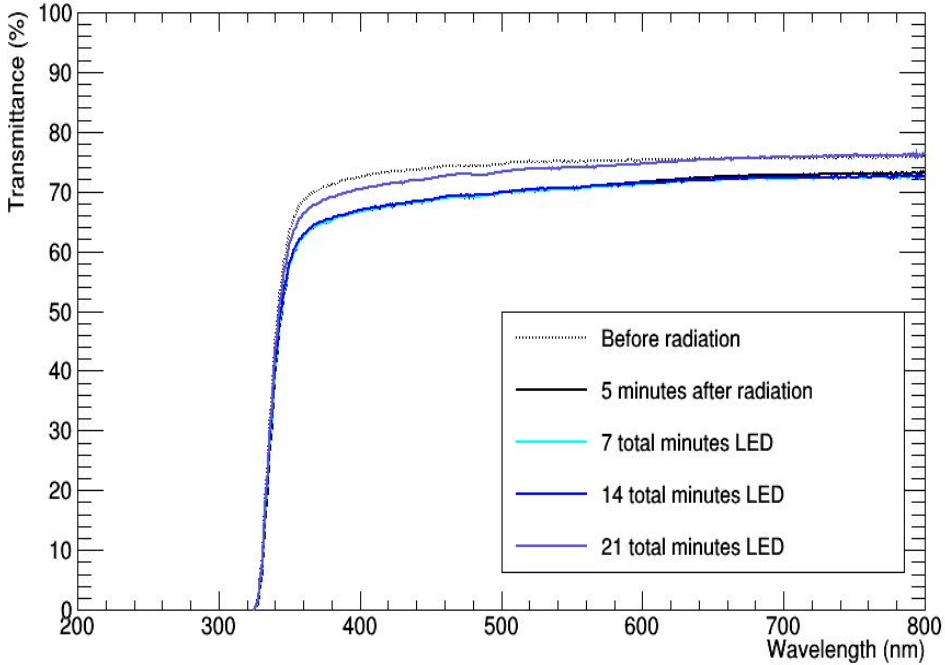
LED Curing

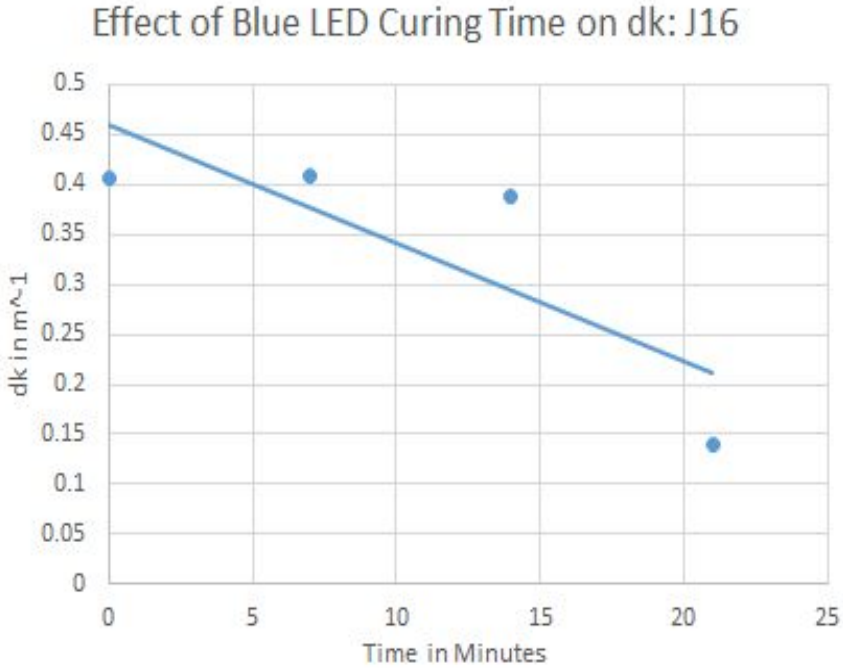

BK PRECISION
DC REGULATED
POWER SUPPLY
1627A
VOLT
AMP
CURRENT
POWER



LED Curing

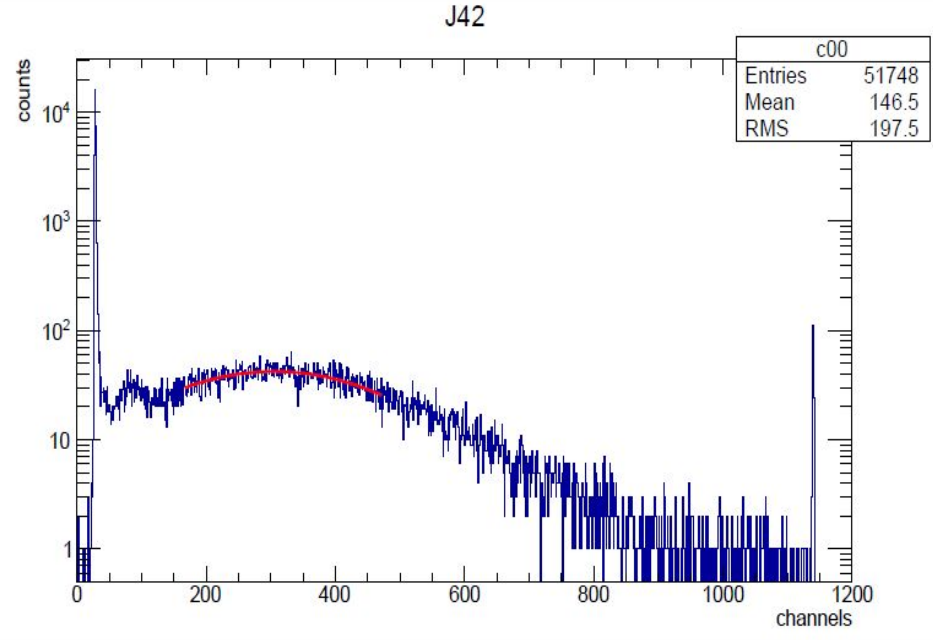
J16

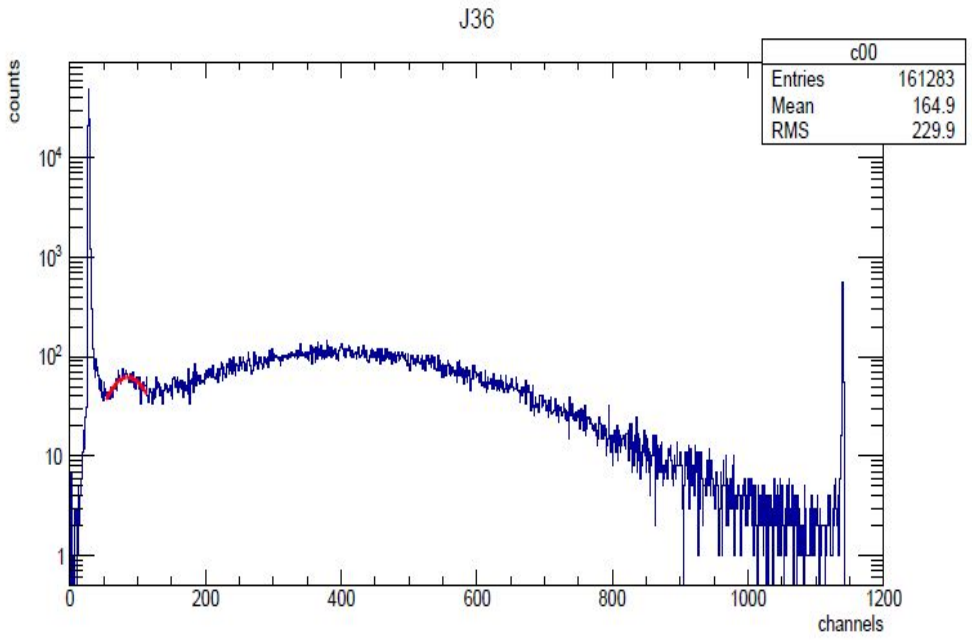




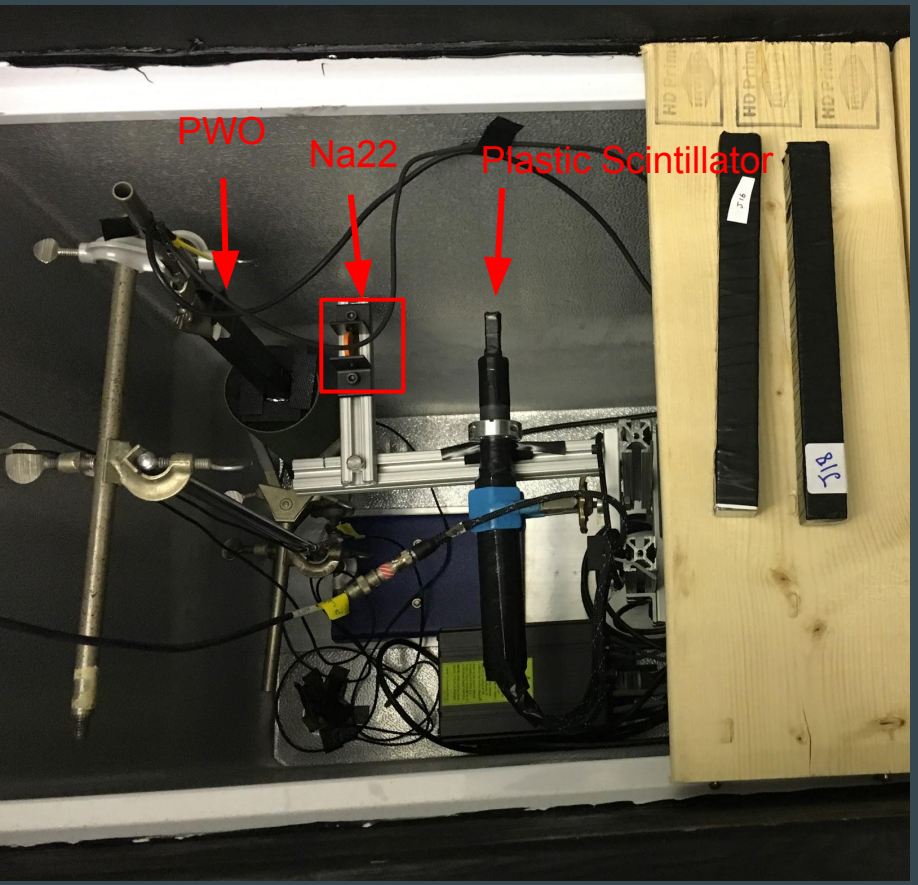
Characteristic 4: Light Yield

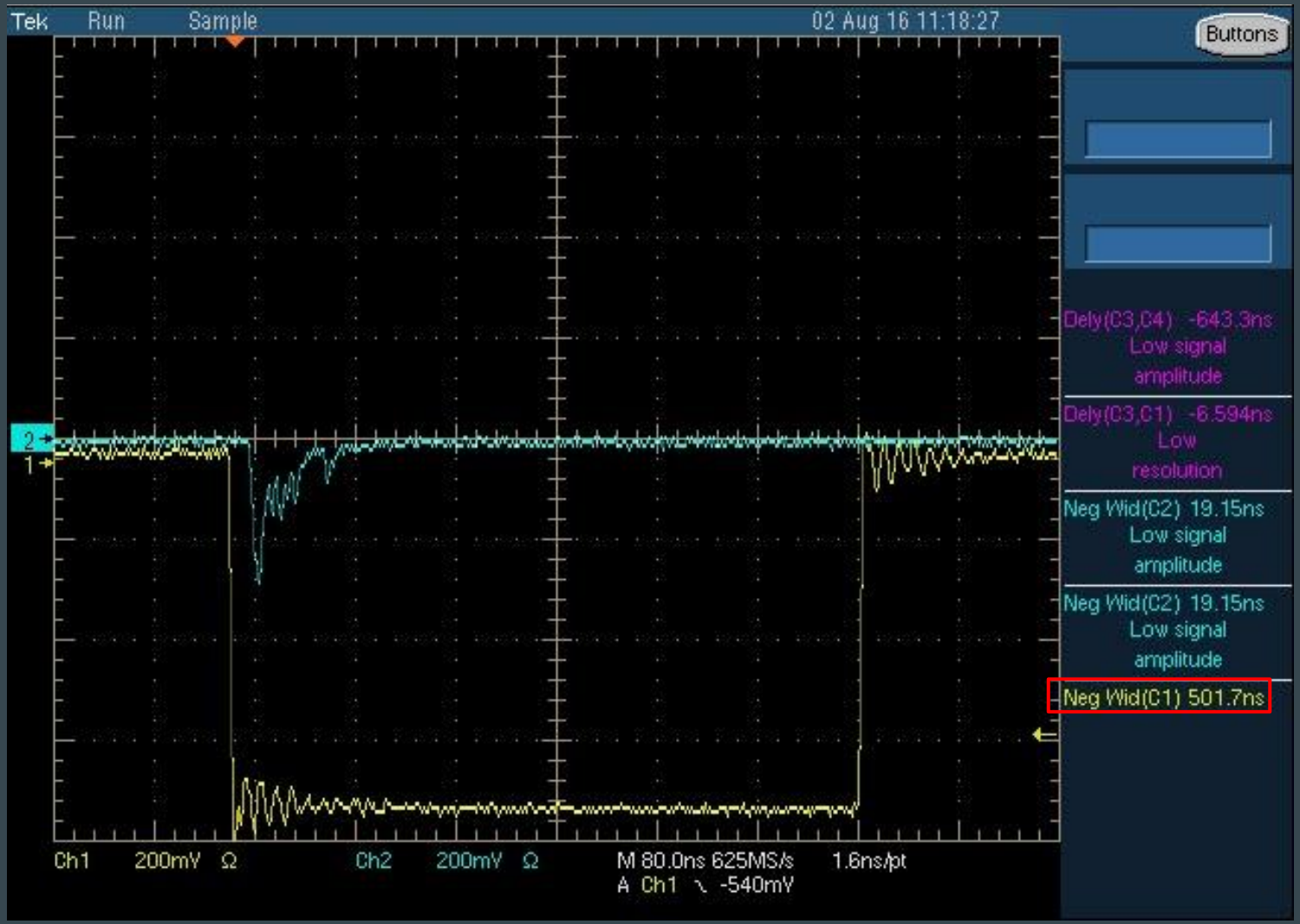
Light Yield: The amount of photoelectrons produced per 0.511 MeV (per electron)



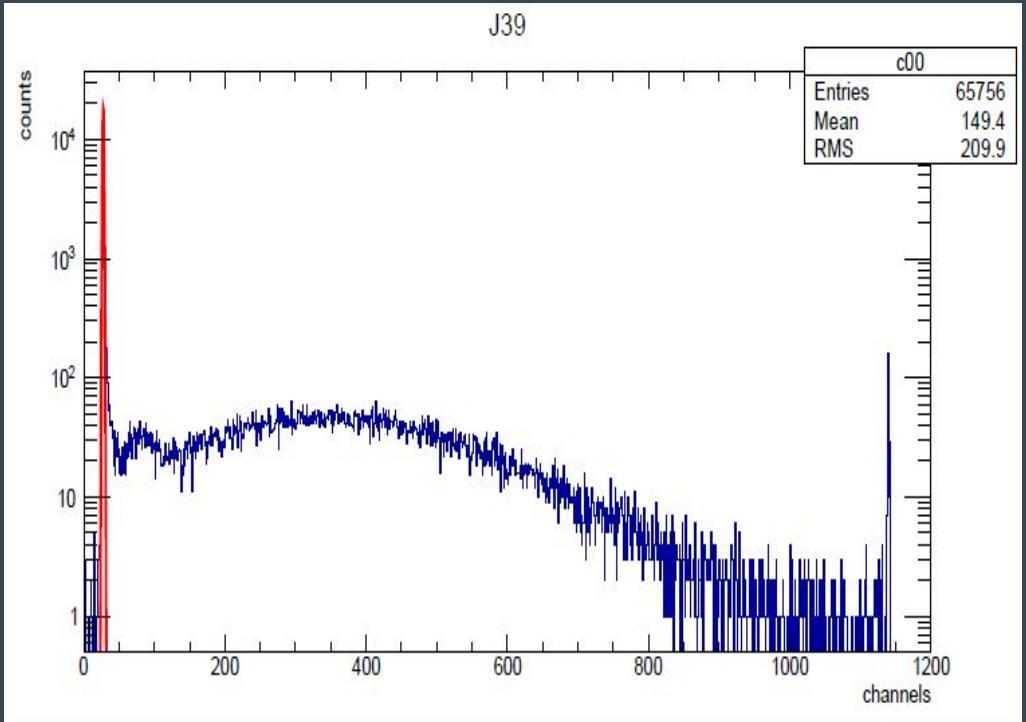


Light Yield Setup




Tek Run Sample
02 Aug 16 11:18:27
Buttons
Dely(C3,C4) -643.3ns
Low signal amplitude
Dely(C3,C1) -6.594ns
Low resolution
Neg Wid(C2) 19.15ns
Low signal amplitude
Neg Wid(C2) 19.15ns
Low signal amplitude
Neg Wid(C1) 501.7ns
Ch1 200mV Ω
Ch2 200mV Ω
M 80.0ns 625MS/s
1.6ns/pt
A Ch1 ∖ -540mV

The Equation



((365-27.6)/(87-27.6))= 6 electrons per photon

(6 electrons)/(.511MeV)=11.3pe/MeV

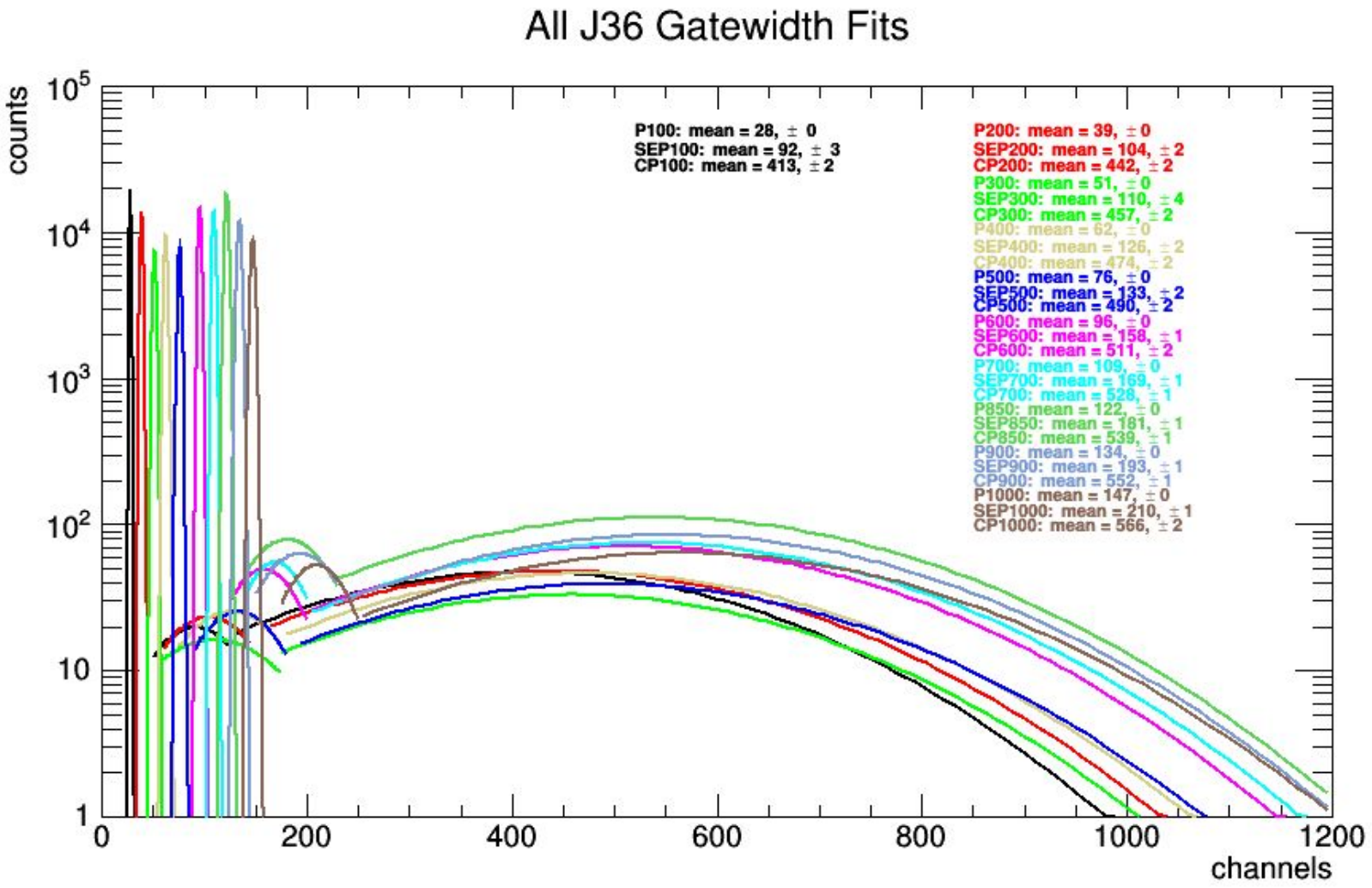
Variation in Light Yield due to Slow Components

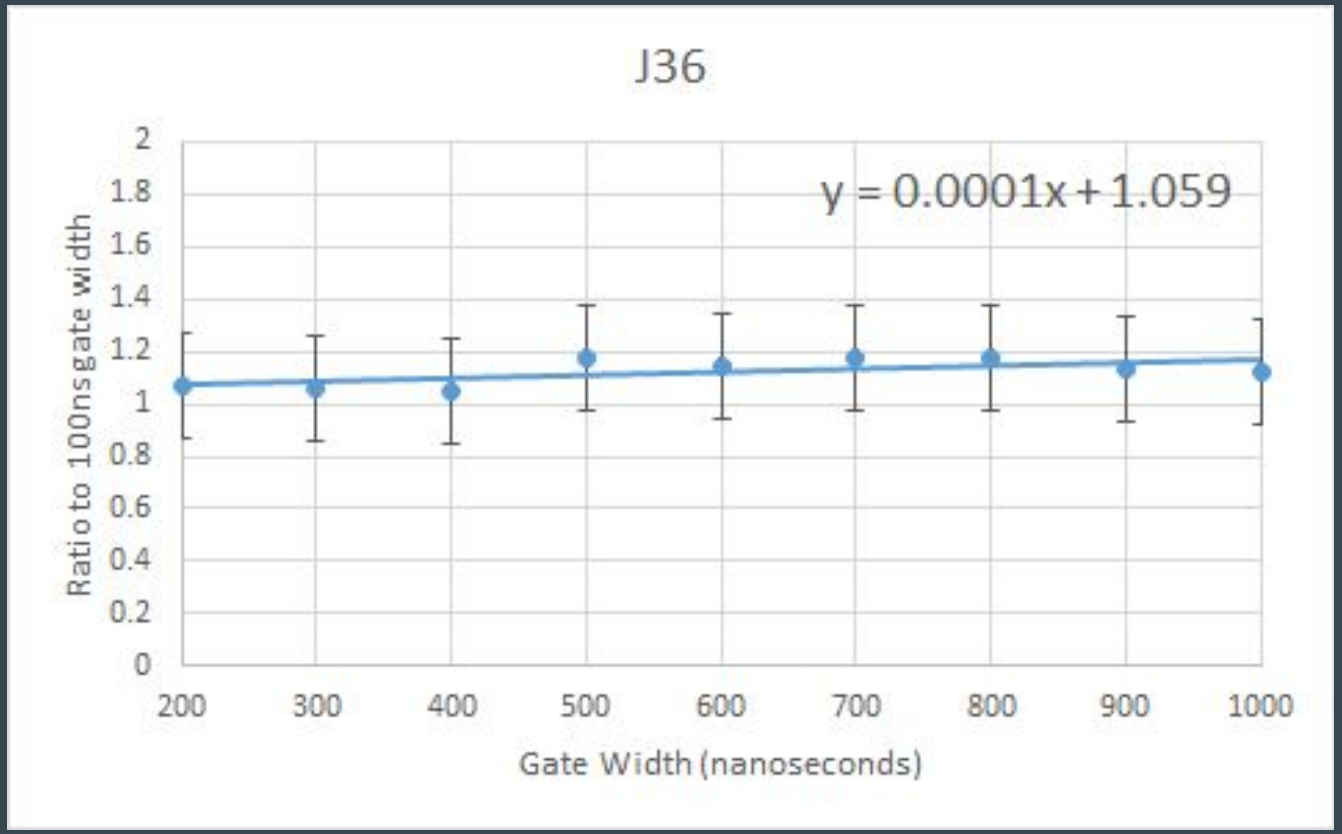
Fast Component: Electrons return to ground state rapidly after being excited, releasing energy via a photon

Slow Component: Electrons are “metastable” in high energy levels, take longer to return to their ground state/release photons

Ideally, light yield of slow components will not cause overall light yield to fluctuate.

To test, we measured light yield as a function of gate width.


All J36 Gatewidth Fits
counts
channels
P100: mean = 28, ± 0
SEP100: mean = 92, ± 3
CP100: mean = 413, ± 2
P200: mean = 39, ± 0
SEP200: mean = 104, ± 2
CP200: mean = 442, ± 2
P300: mean = 51, ± 0
SEP300: mean = 110, ± 4
CP300: mean = 457, ± 2
P400: mean = 62, ± 0
SEP400: mean = 126, ± 2
CP400: mean = 474, ± 2
P500: mean = 76, ± 0
SEP500: mean = 133, ± 2
CP500: mean = 490, ± 2
P600: mean = 96, ± 0
SEP600: mean = 158, ± 1
CP600: mean = 511, ± 2
P700: mean = 109, ± 0
SEP700: mean = 169, ± 1
CP700: mean = 528, ± 1
P850: mean = 122, ± 0
SEP850: mean = 181, ± 1
CP850: mean = 539, ± 1
P900: mean = 134, ± 0
SEP900: mean = 193, ± 1
CP900: mean = 552, ± 1
P1000: mean = 147, ± 0
SEP1000: mean = 210, ± 1
CP1000: mean = 566, ± 2



Ideally, ratio should be close to 1 regardless of gate width, so slope of the line should be close to 0 → ✔

100ns= Standard Gate Width

Conclusion

- From what we have seen so far, all crystals (J16-J45) are suitable for use in the NPS/EIC.
- No measurements violated the ideal parameters
- More measurements are needed