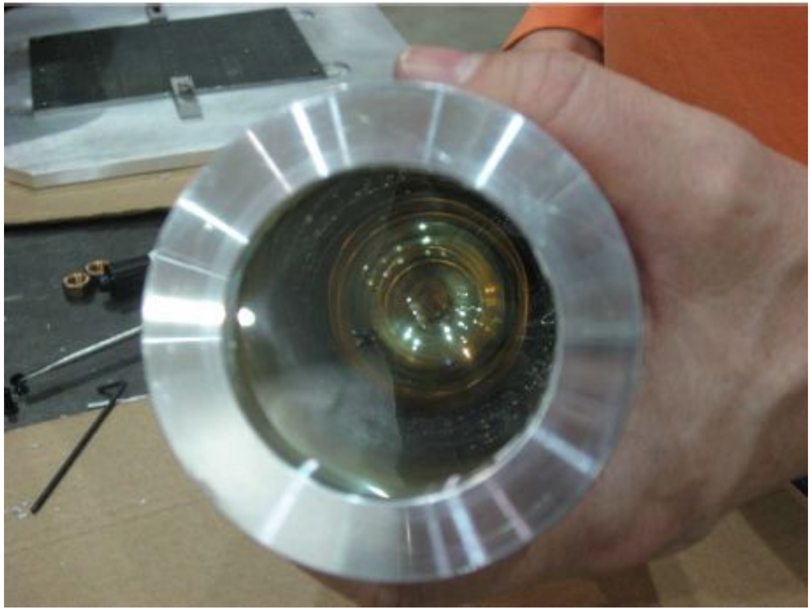
# Compton Photon Detector for PREX2/CREX

Juan Carlos Cornejo

PREX2/CREX Collaboration Meeting

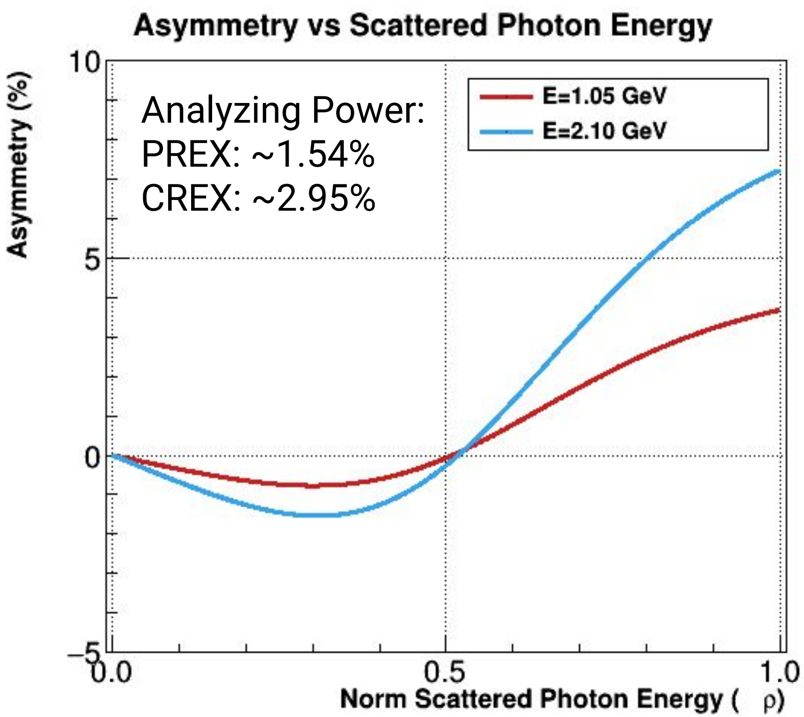
July 25, 2018

# Talk Outline



- Requirements for a γ-detector & summary of GSO detector
- Preparations for PREX/CREX2
  - Optimising PMT+base @ CMU
- Summary of commissioning plans

# Compton Scattering and Beam Polarization

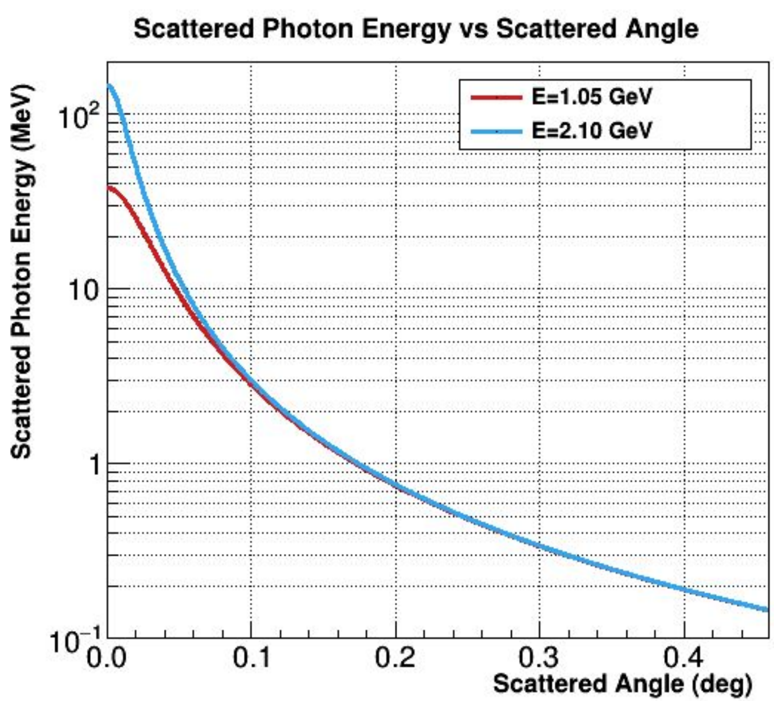


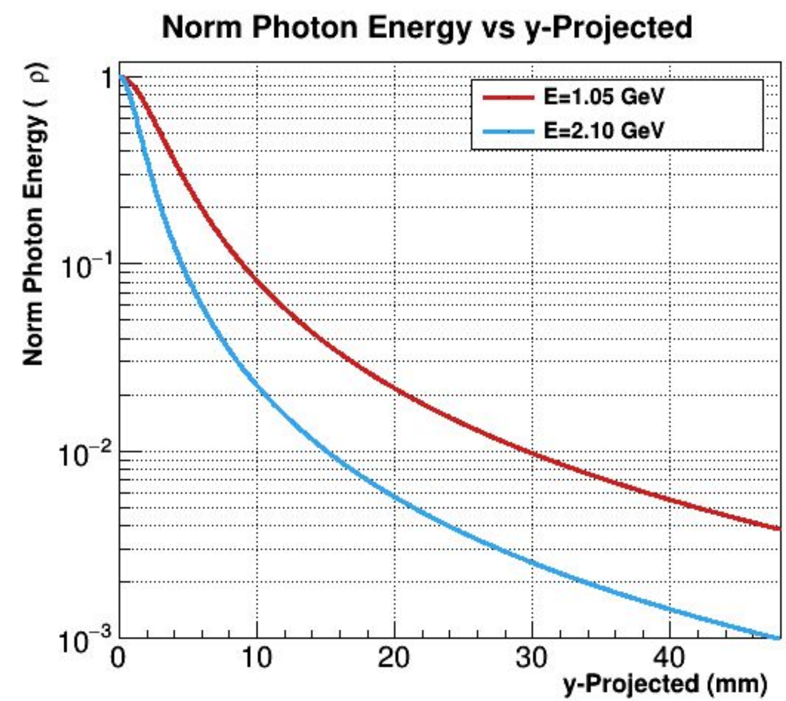

Polarization determined from:
$A_{th} = A_{exp} P_e P_\gamma$

- $\rho = E_\gamma / E_\gamma^{max}$ where $E_\gamma^{max}$ is the maximum kinematically allowed scattered photon energy → we call this the "Compton Edge"
  - $E_\gamma^{max} \propto E^2_{beam}$
  - For PREX: ~38 MeV
  - For CREX: ~146 MeV
- Since asymmetry is larger at larger scattered energies → need to use detector capable of capturing most of the γ's shower.

# Compton Scattering and Beam Polarization (cont.)

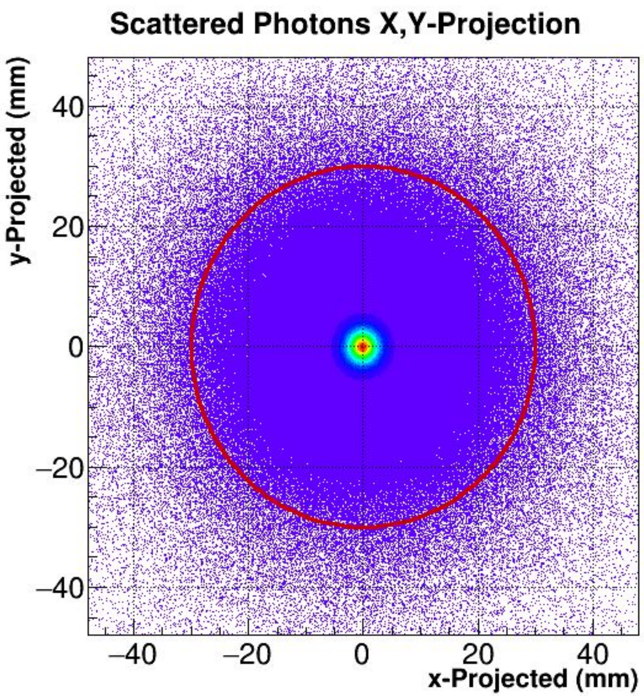
Most photons backscatter with very small angles. The fraction of scattered photons with given ρ scattering at small angles increases with beam energy.

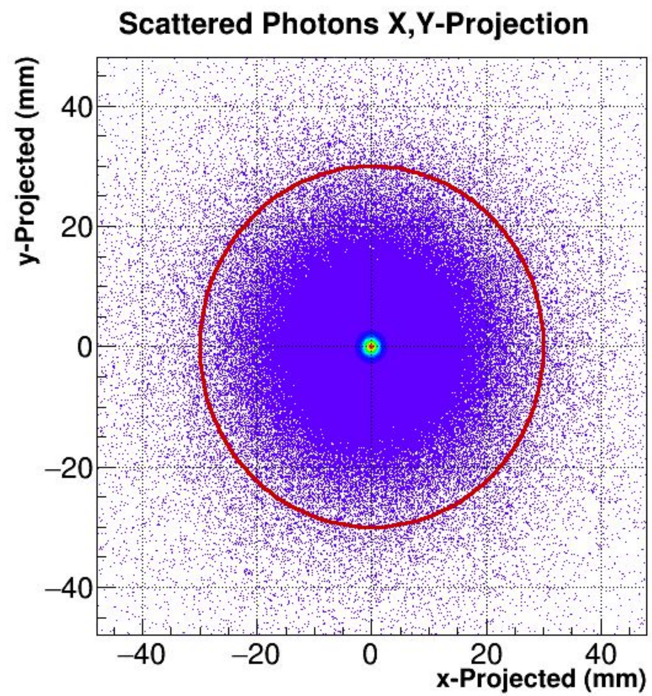


# Scattered Photons Projected onto γ-detector

- ~6 m downstream of interaction point, >99% of scattered photons are within a 3 cm radius → Place γ-detector downstream

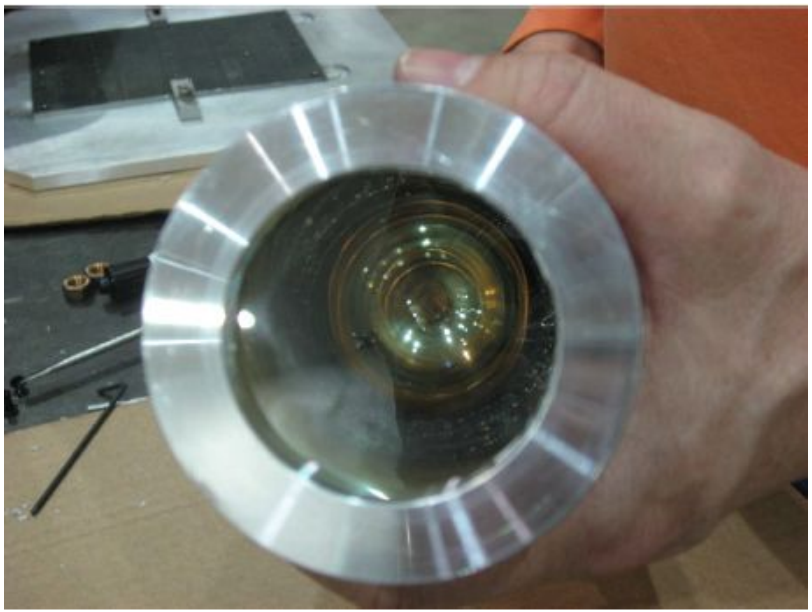


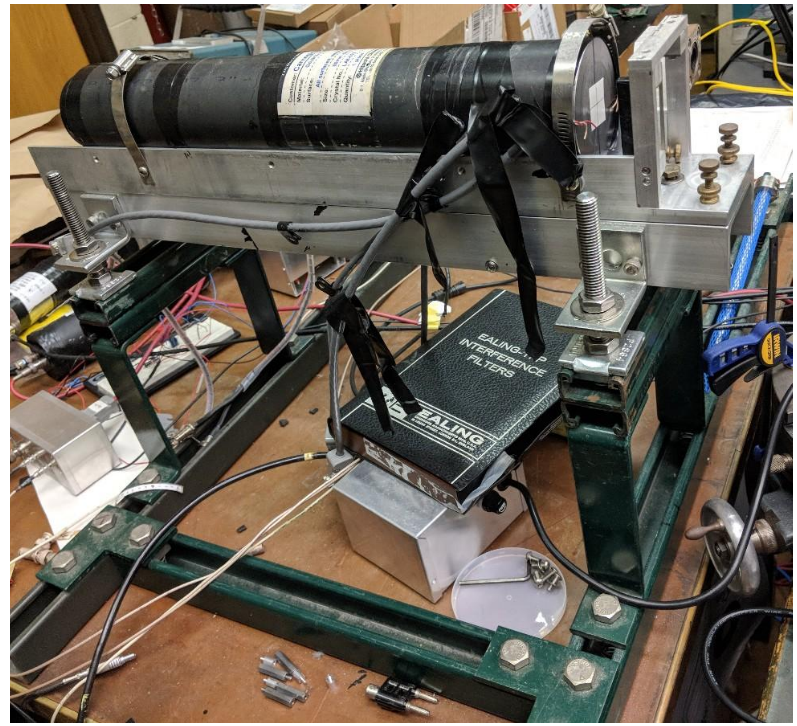
# γ-Detector for PREX2 & CREX

Single GSO crystal manufactured by Hitachi Chemical

- 0.5% Ce-doped $Gd_2SiO_5$
- 6 cm diameter x 15 cm length



A view of how the almost-complete detector sitting in lab bench @ CMU

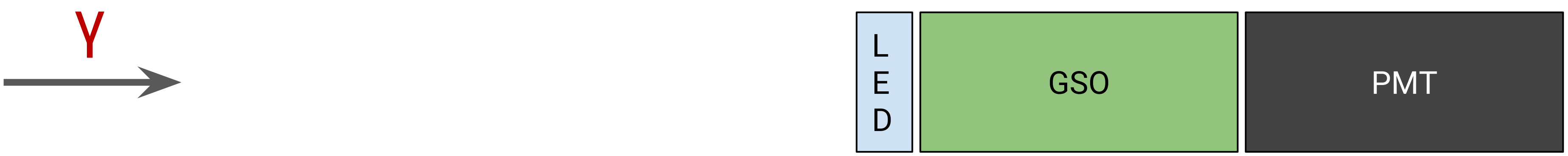


# Layout of γ-Detector

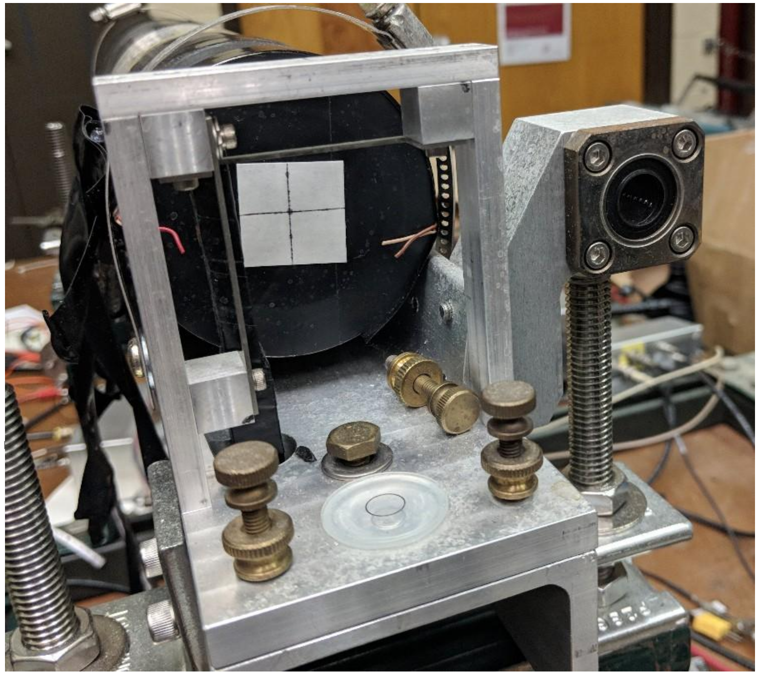
Photon detector is positioned downstream of interaction point

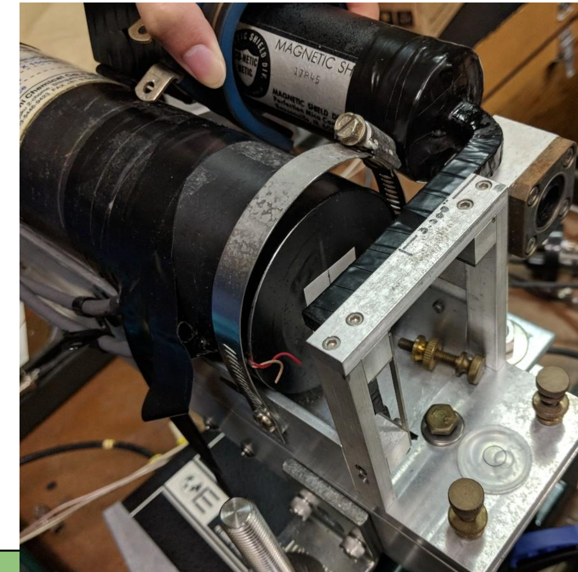
# Layout of γ-Detector

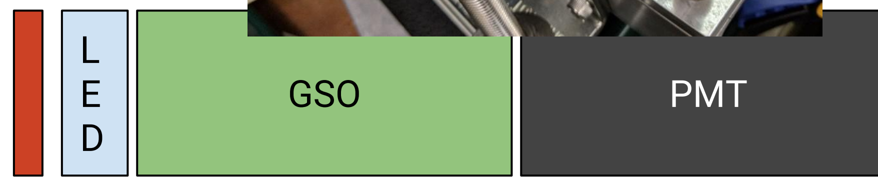
Several LED's are positioned at the front of the GSO → Used to monitor detector linearity



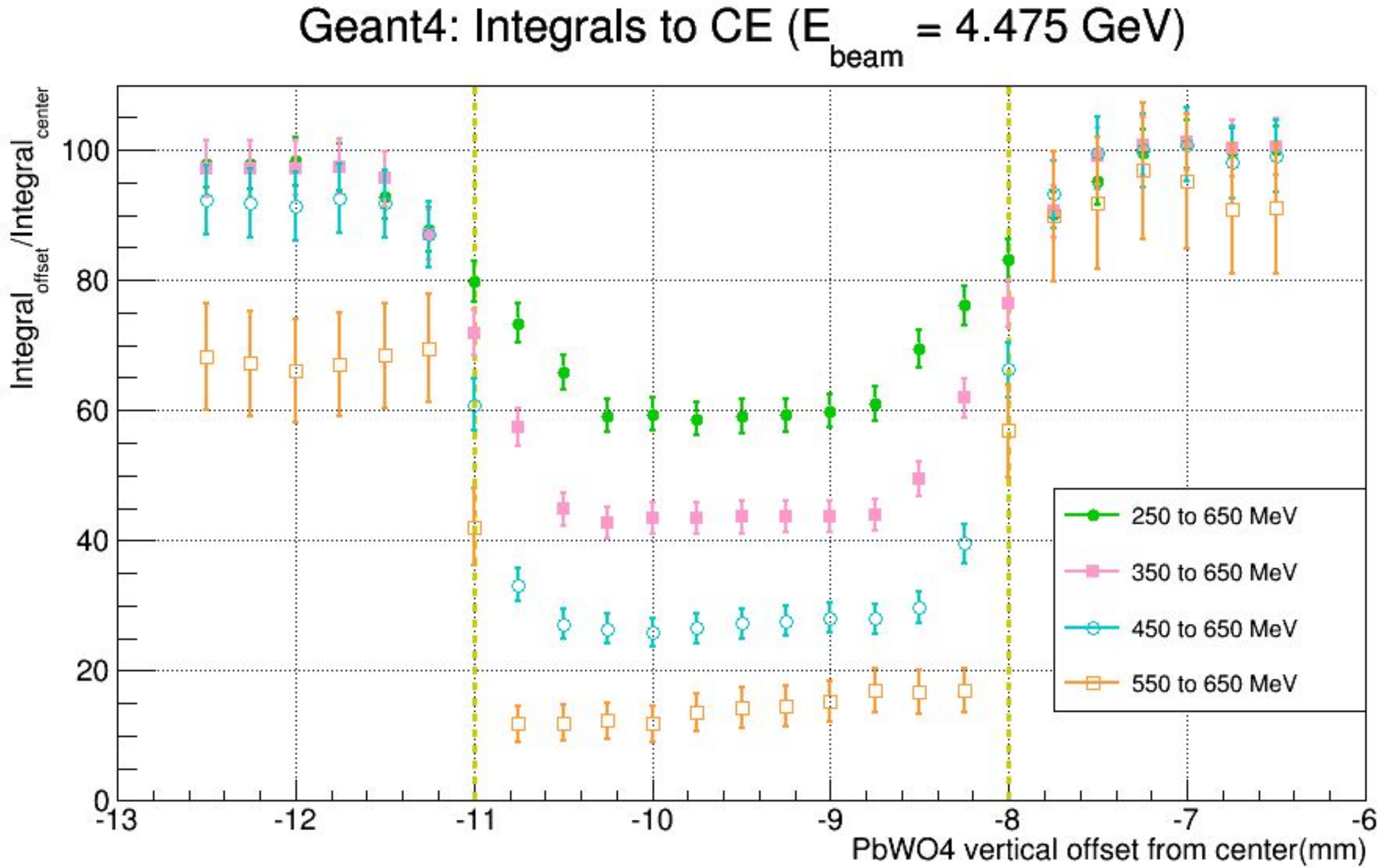
# Layout of γ-Detector





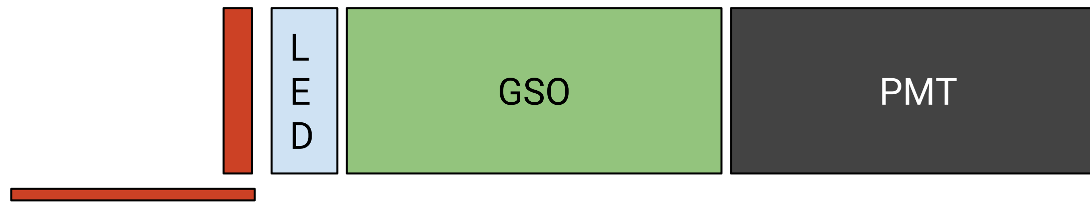



Two “finger” scintillators positioned in front of main detector and behind tungsten “fingers” → Used to center scattered photons on detector.



Geant4: Integrals to CE (E_beam = 4.475 GeV)
Integral_offset/Integral_center
PbWO4 vertical offset from center(mm)
0
20
40
60
80
100
-13
-12
-11
-10
-9
-8
-7
-6
250 to 650 MeV
350 to 650 MeV
450 to 650 MeV
550 to 650 MeV

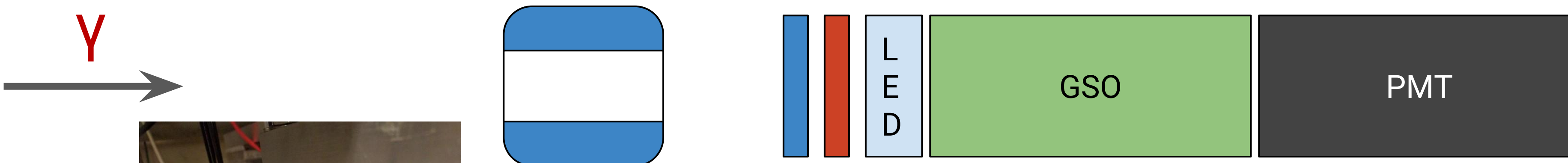
# Layout of γ-Detector

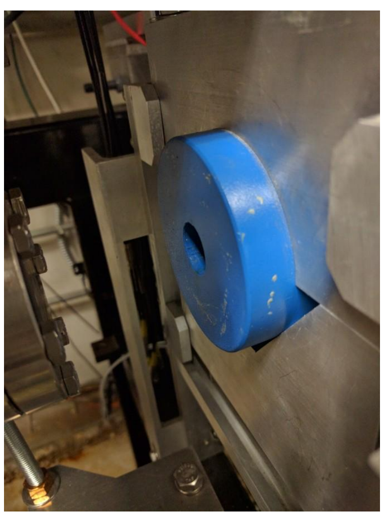



A metal cylinder is used to center (visually) the detector. It also provides a reference point for surveys. Due to interferences, it will be mounted only for installation.

# Layout of γ-Detector

Synchrotron shielding: Lead collimator with apertures of 0.5 cm - 2 cm permanently mounted in front of detector. Changing aperture on collimator requires Hall Access...

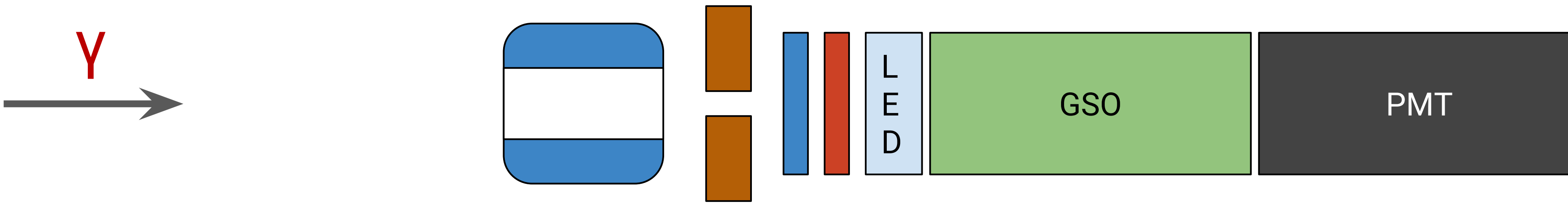


Additional pieces of thin pb plates (of a few mm's each) placed in front of detector.

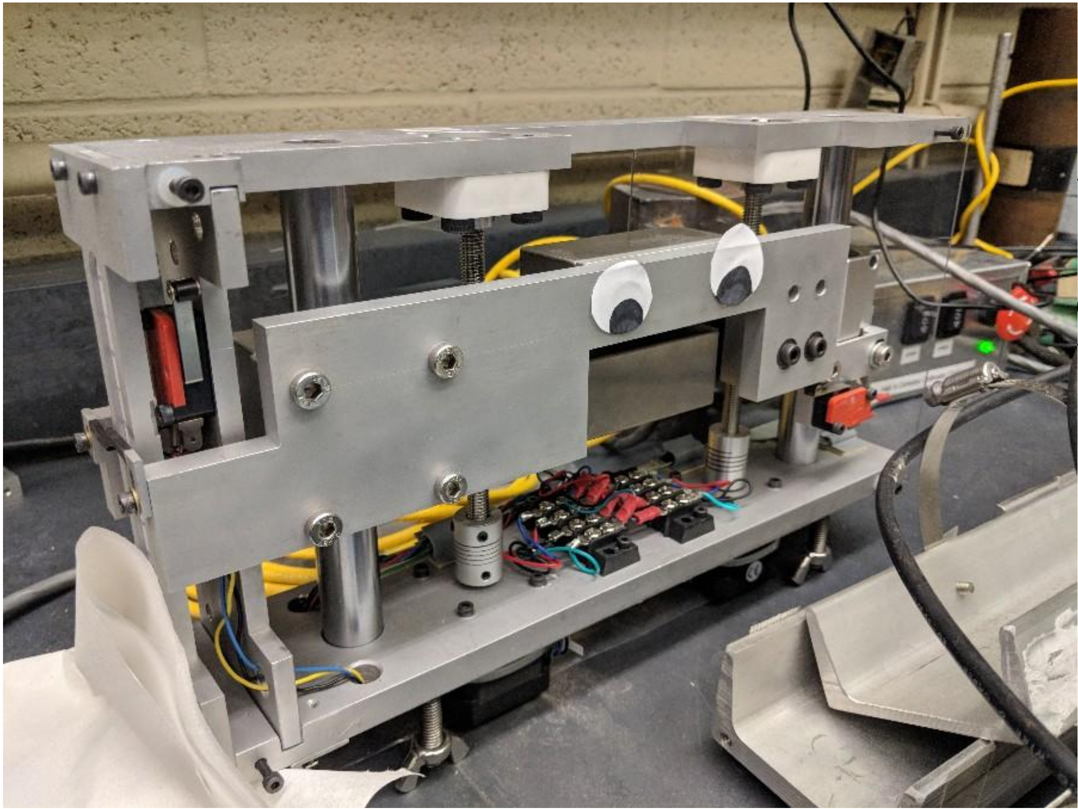
# Layout of γ-Detector

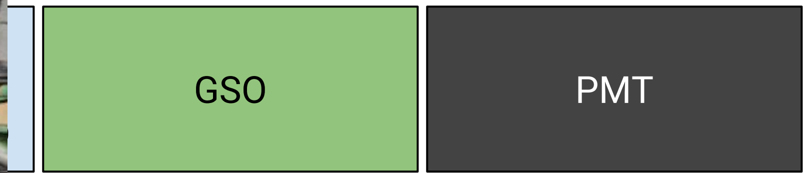
Add a remote-controllable Tungsten collimator. Aperture contrable from ~1 mm to ~5 cm.



# Layout of γ-Detector

Add a remote-controllable Tungsten collimator. Aperture contrable from ~1 mm to ~5 cm.

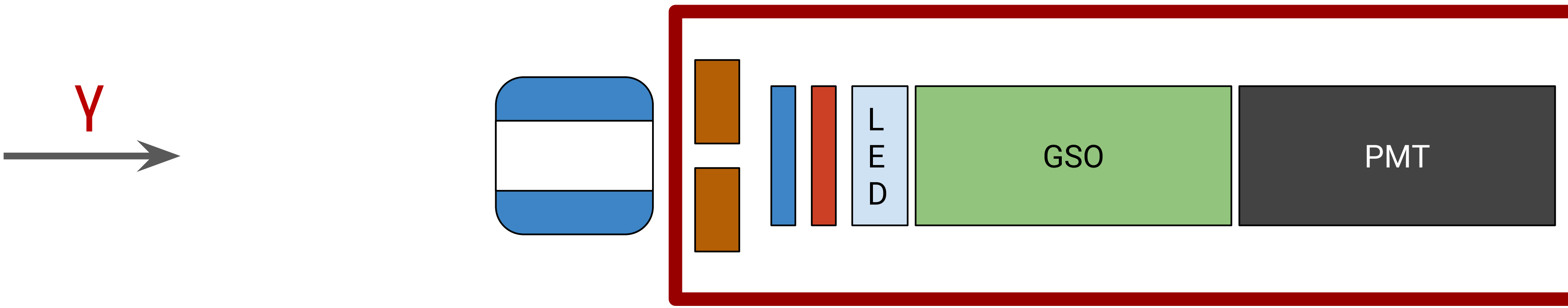





Can also be used to center scattered photons on detector.

# Layout of γ-Detector

These components are mounted on detector stand and sits on a remote-controllable table with x,y motion



# Modifications to the detector stand

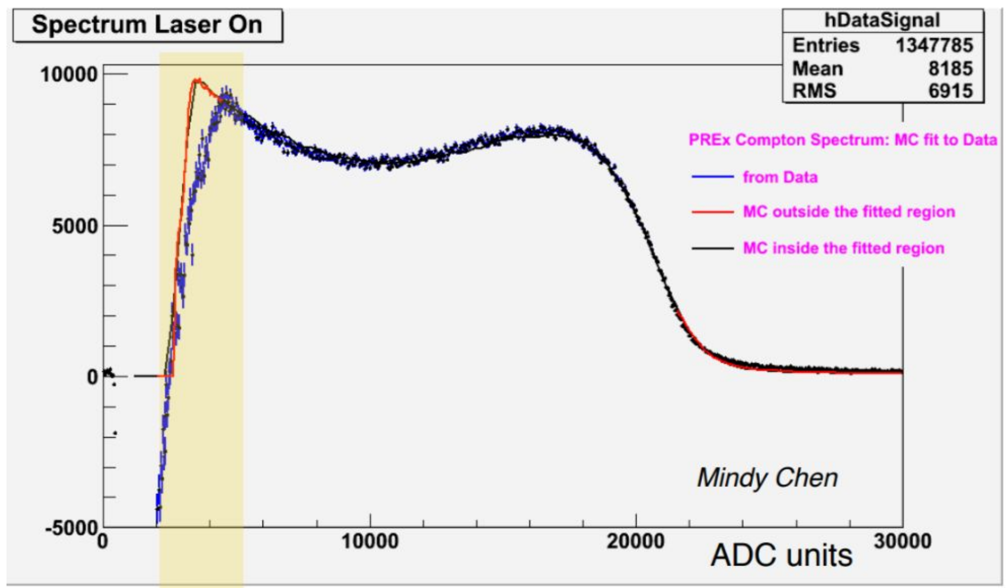
- The top “finger” scintillator PMT has been moved to the bottom
  - This is due to the beam height being smaller than during PREX-1
- Front of stand has to be modified so that Tungsten Collimator system and synchrotron shields can be mounted in front.
- Biggest concern right now is ensuring it all fits inside the table and that it has free mobility without bumping into a screw at the bottom of the electron detector stand.
- CMU machinist has taken measurements of the clearances in the table, and will modify the stand this Fall.

# Measuring Detector Linearity

- A system (mini-Megan) of 3 LEDs are used
  - LED1 is Delta: Fixed LED brightness of low intensity
  - LED2 is Variable: Brightness stepped through different intensities to mimic real Compton photon signals of various energies.
  - LED3 (bench tests): Either a fixed non-pulsing LED with minimum brightness (to mimic baseline shift when PMT under load). Second option is a rapidly pulsing LED.
    - This LED not necessary at JLab, and only used during bench tests at CMU
- Goal is to keep this relation as constant as possible: $y(x) = f(x+\delta) - f(x)$, where x is Variable setting.

# Measuring Detector Linearity @ CMU

- Data from previous experiments is used to establish Compton Edge and detector response
  - For example, Compton edge here at 20000 srau (1rau ~ 2mV)



# Measuring Detector Linearity @ CMU (cont.)

- Data from previous experiments is used to establish Compton Edge and detector response
  - For example, Compton edge here at 20000 srau (1rau ~ 2mV)
- This is used to estimate detector response at the Compton Edge for the given beam energies and laser wavelength used for PREX and CREX.
- Any non-linearities can be addressed by adding resistors, capacitors at the various dynode stages to minimize any voltage-sagging or space-charge effects.
  - Adding Zener diodes at the last stages helps

# Preparing Detector for PREX-II/CREX

- GSO and PMTs are @ CMU → have working DAQ and is available for bench tests.
- Plan is to have PMT+base for PREX and a separate PMT+base for CREX
- Work on PMT+base for PREX in advanced stage → have already seen nonlinearities of 1% or better, but work will continue this Fall.
- Brian + CMU student will work on PMT+base for CREX this fall
  - Student only committed for the Fall as her PhD project is non-JLab physics.
- DAQ presently @ TestLab for summer SBS work → linearity work can start when DAQ back @ CMU (no earlier than late August to early September).

# Commissioning Detector at experiment start

- Besides the ones Kent already mentioned, we also need:
- Need to identify level of Synchrotron radiation and necessary level of shielding.
  - Changing pieces of thin-lead require access to the hall → will try to choose the right level at the start of the experiment to minimize interference.
  - Tungsten Collimator can be controlled from upstairs → can be dynamically changed to address present conditions during running.
- Center scattered photons on detector and collimator
  - If beam is too far center of collimator → need to steer beam
  - If centered on collimator, γ-detector can be centered by Compton experts with no interference to the experiment. This is done by moving the table from upstairs in the Counting House.

# Summary

- GSO crystal being prepared @ CMU for use.
  - PMT+base in advanced stage for PREX already
  - Will start preparation of PMT+base for CREX this Fall @ CMU
- Slight modifications to detector stand are needed
  - Expect to be completed this Fall.
- Have plans already for commissioning of the detector