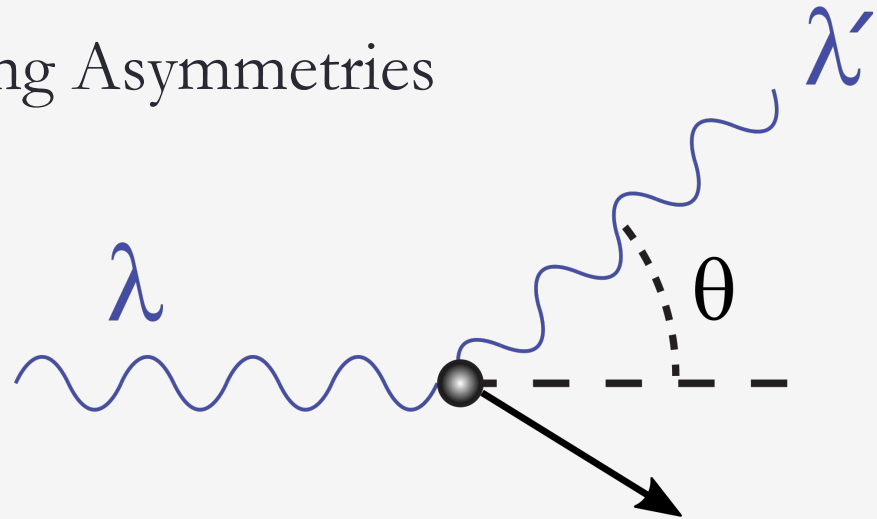


ASYMMETRIES, USING ACCUMULATORS

Calculating Compton Scattering Asymmetries



Larisa Thorne (CMU)

16 June 2016

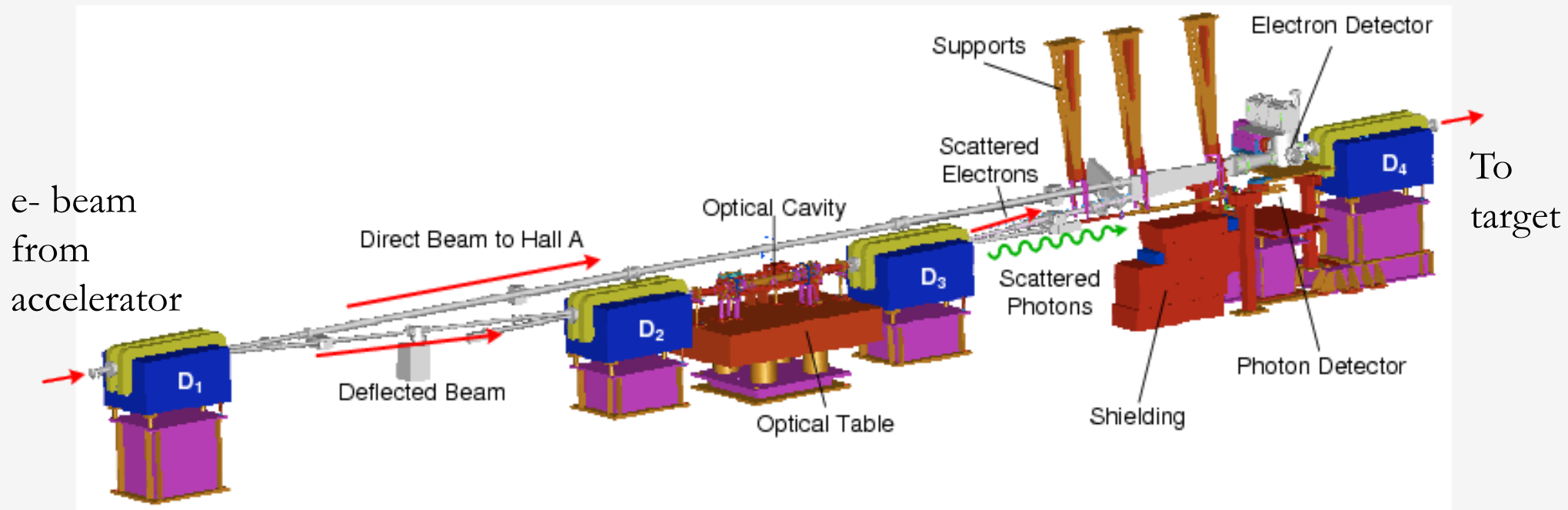
HUGS 2016 Student Seminars @ JLab

Outline

- General: Compton Scattering
 - Experimental setup and motivation
 - Formula
 - Sample Compton spectra at different energies
- Asymmetry calculation
 - Cuts, corrections & scalings
 - The search for afterglow effects
 - Comparison to Monte Carlo results
- Results (thus far)
- Acknowledgements

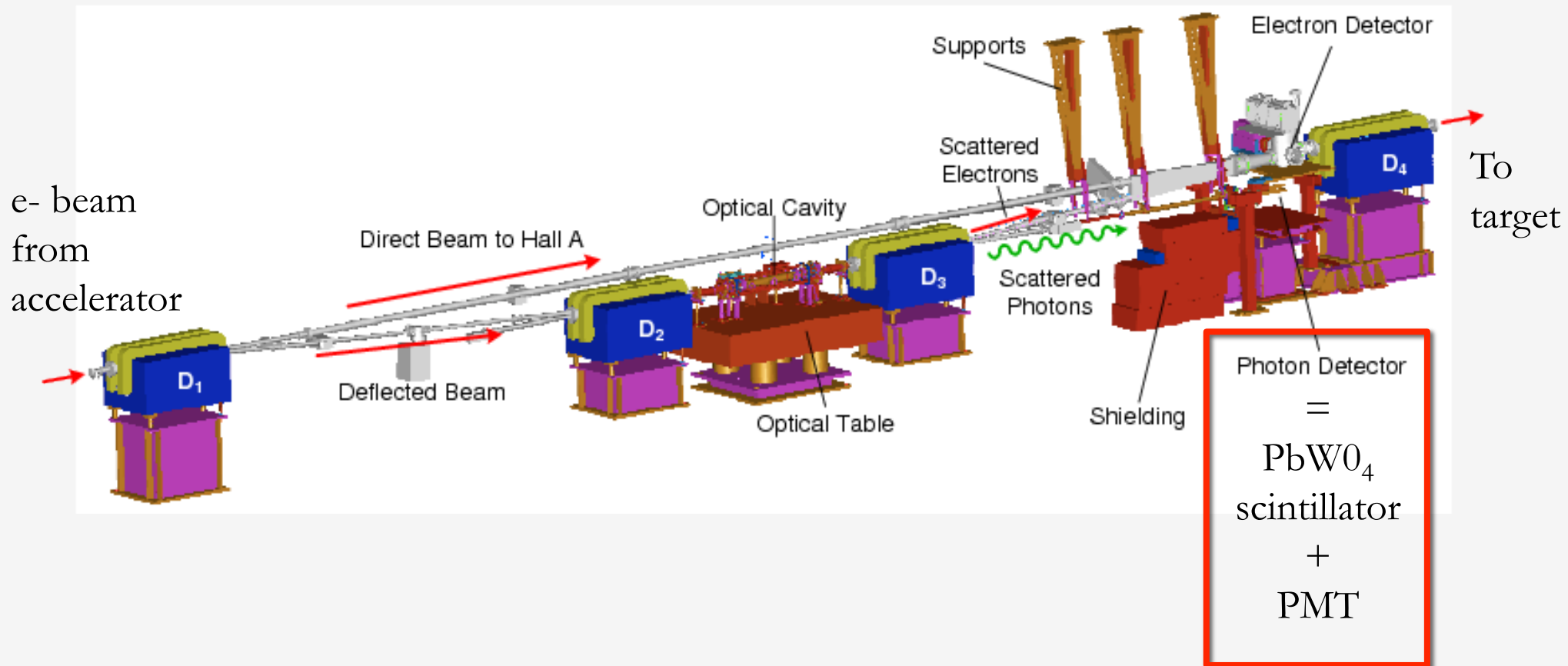
General: Compton Scattering

JLab's Hall A Compton chicane:



General: Compton Scattering

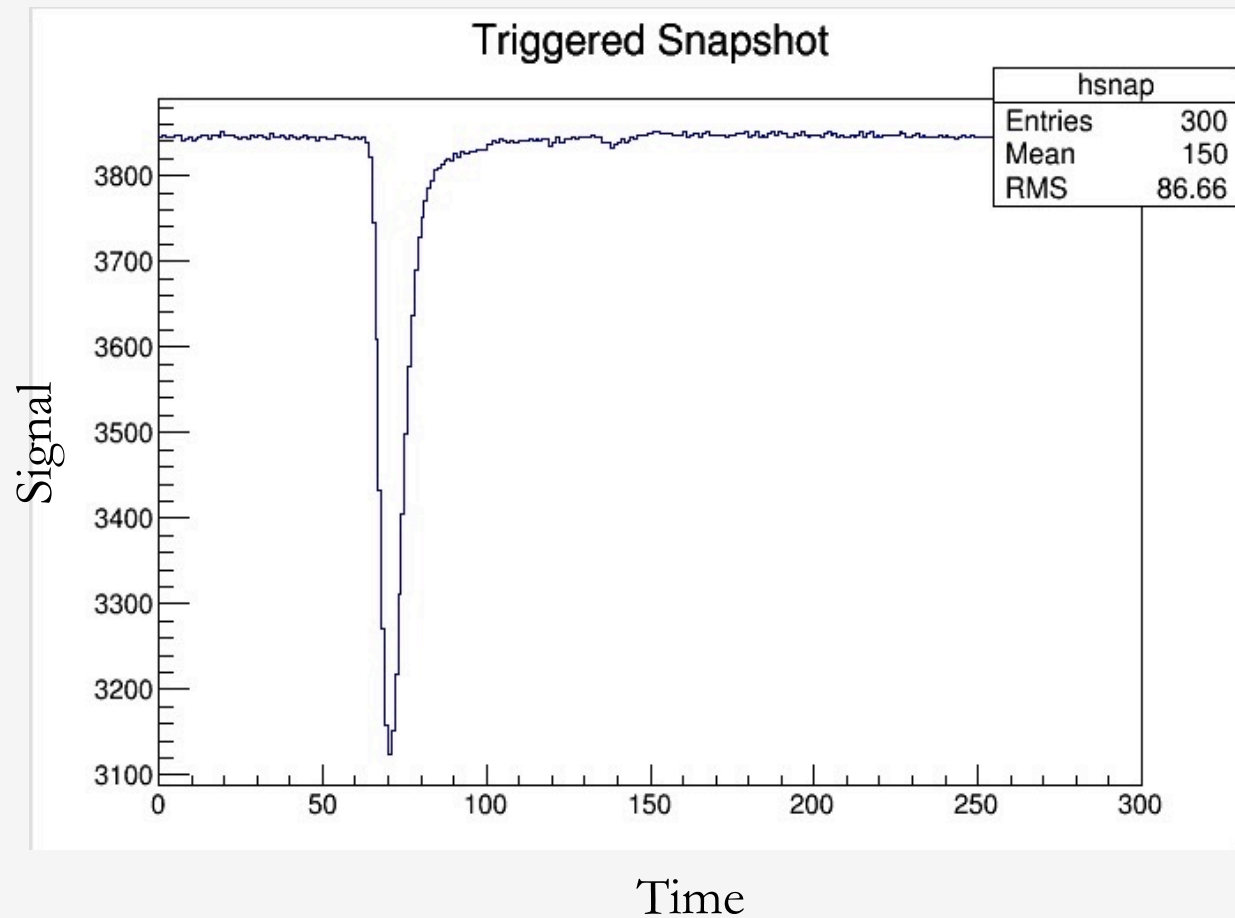
JLab's Hall A Compton chicane:



General: Compton Scattering

Two accumulator types:

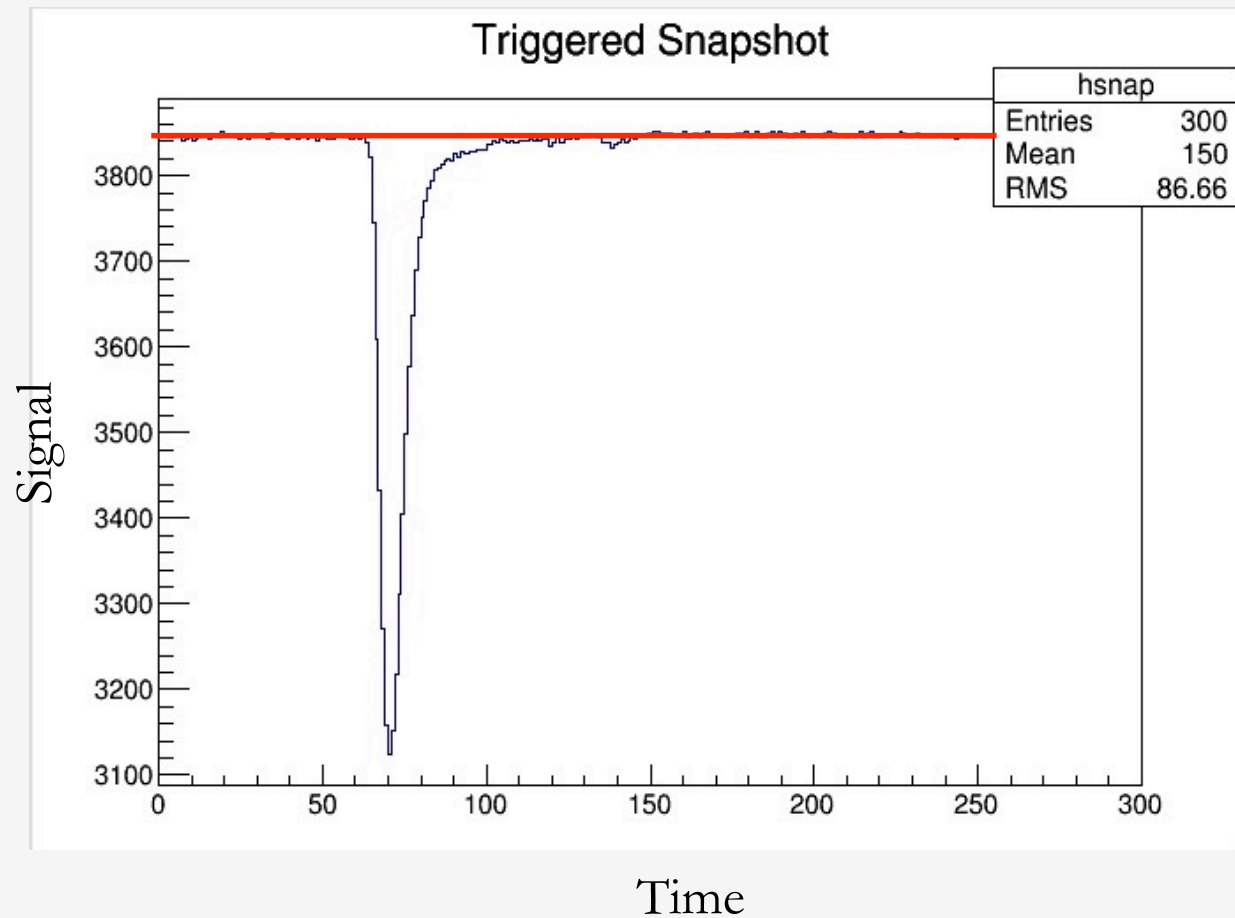
- *Acc0*
- *Acc4*



General: Compton Scattering

Two accumulator types:

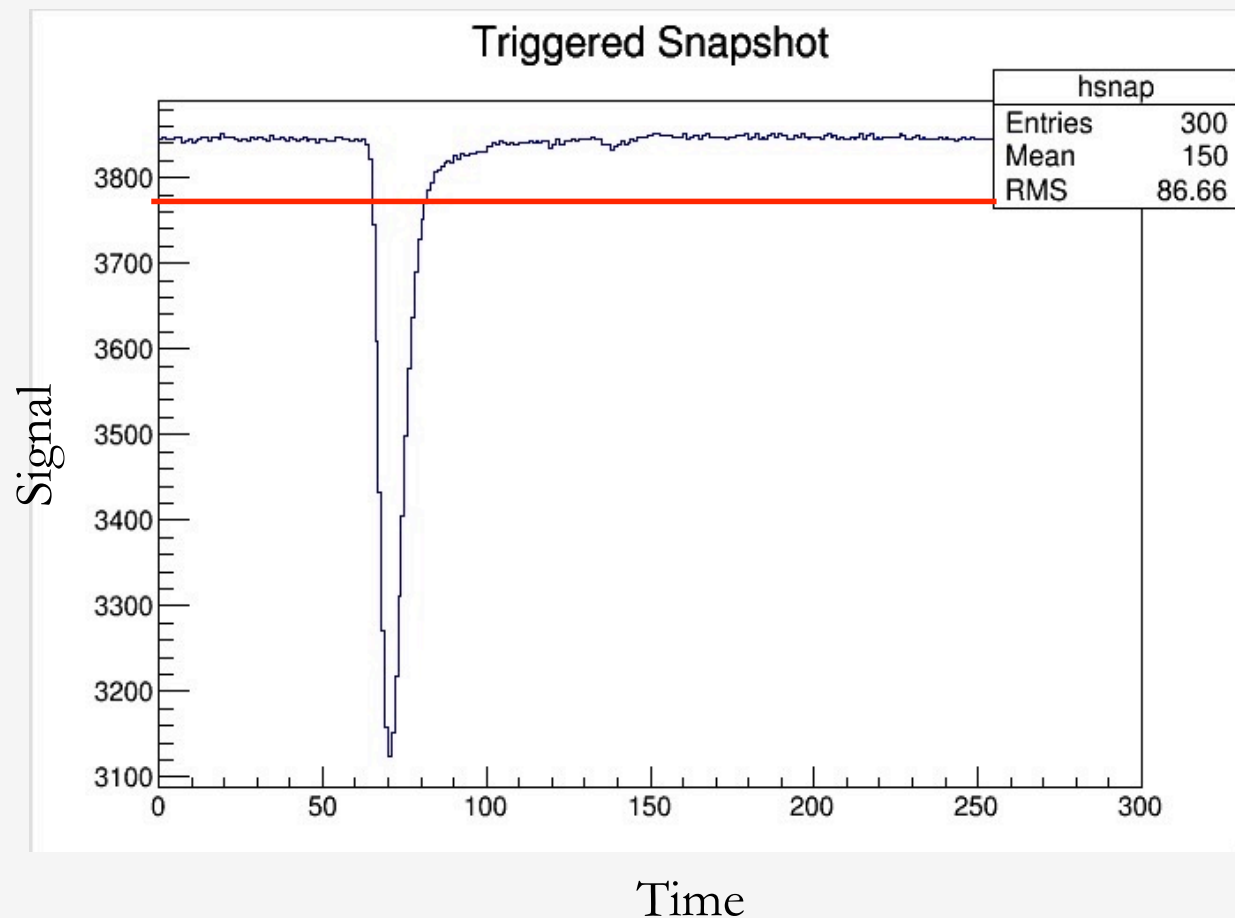
- **Acc0**
 - No threshold
 - Sensitive to various effects (synchrotron radiation, afterglow, etc)
- **Acc4**



General: Compton Scattering

Two accumulator types:

- **Acc0**
 - No threshold
 - Sensitive to various effects (synchrotron radiation, afterglow, etc)
- **Acc4**
 - Threshold value set by difference between observed pedestal and ped_value in .flags file



General: Compton Scattering

To calculate asymmetry:

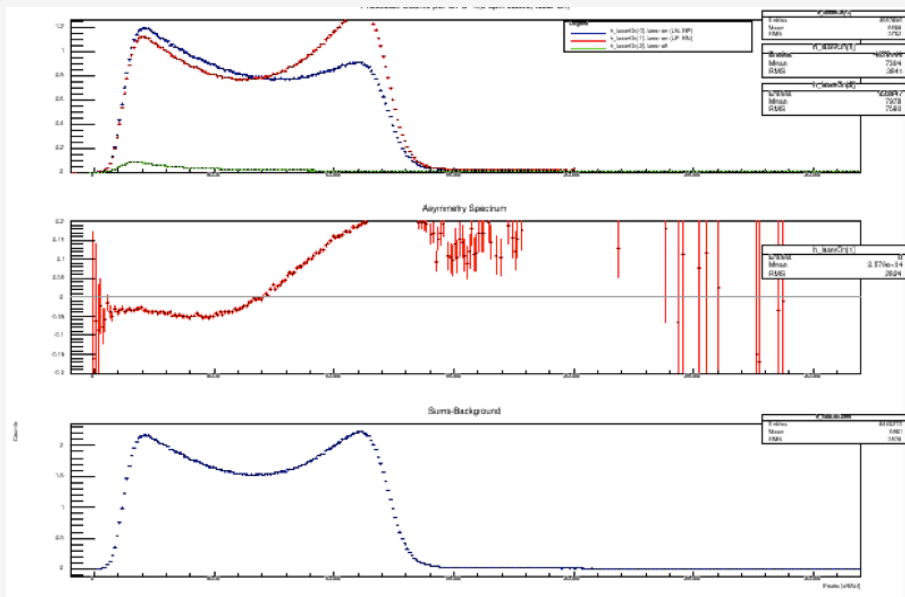
1. Sort accumulator values for unique states, by “quartet” event
 - Helicity, Accumulator, Beam, Laser
2. Fill histograms for a unique state (beam off/laser on) and (beam off/laser off)
 - h^{sum} : add both (+/-) helicity accumulator values
 - h^{diff} : add (+), subtract (-) helicity accumulator values
3. Fit with Gaussians to get at the mean, then calculate:

$$A_{exp} = \frac{\bar{h}_{on}^{diff} - \bar{h}_{off}^{diff}}{\bar{h}_{on}^{sum} + \bar{h}_{off}^{sum}}$$

General: Compton Scattering

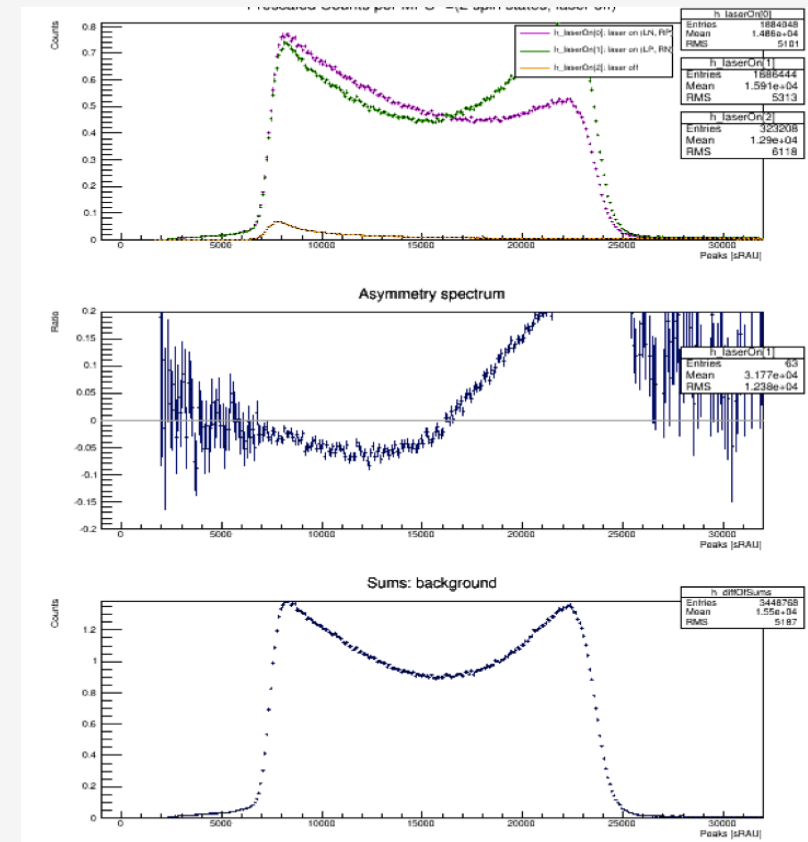
Compton spectra:

4-pass (8.8GeV)



Source: Larisa Thorne (plotAsymSpectrum.C)

5-pass (11GeV)



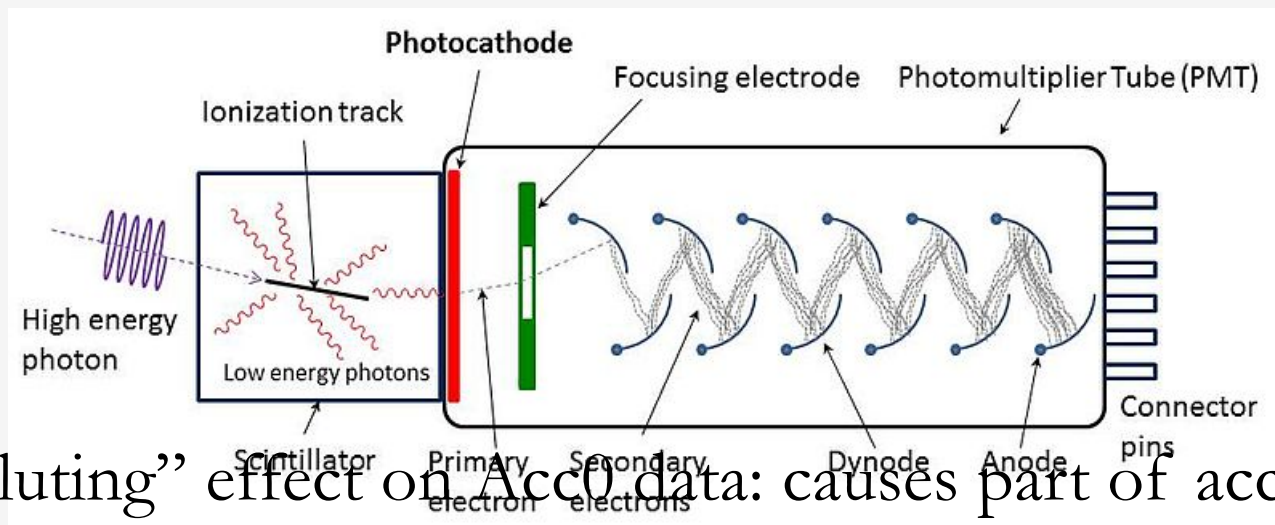
Source: Larisa Thorne (plotAsymSpectrum.C)

Asymmetry Calculations

- Cuts:
 - Laser cavity power (min/max)
 - BCM (cuts out beam trips)
 - Epics (timeout in data stream)
- Corrections:
 - Run-by-run effects due to inserting HWP, changing Wien angle, etc (accelerator physics domain)
 - Within a given run: afterglow
- Scaling:
 - BCM values fluctuated during run, needed to normalize relative to nominal value

Asymmetry Calculations

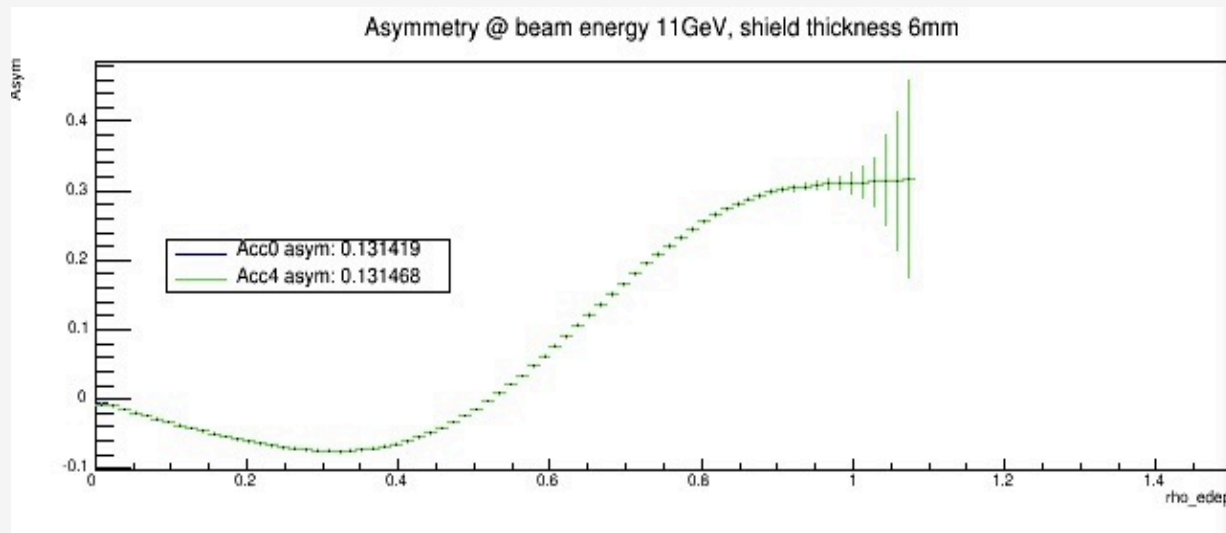
- Afterglow (induced phosphorescence)
 - “A study on the properties of lead tungstate crystals”, by Zhu et al describes methods for measuring afterglow in scintillator, depending on its construction
 - Lifetime of effect: 15 – 127 ms after irradiation



- Has “diluting” effect on Acc0 data: causes part of accumulator data near start of laser cycle to be pushed into next event
- Software testing hasn’t found significant effects (yet?), even at high E

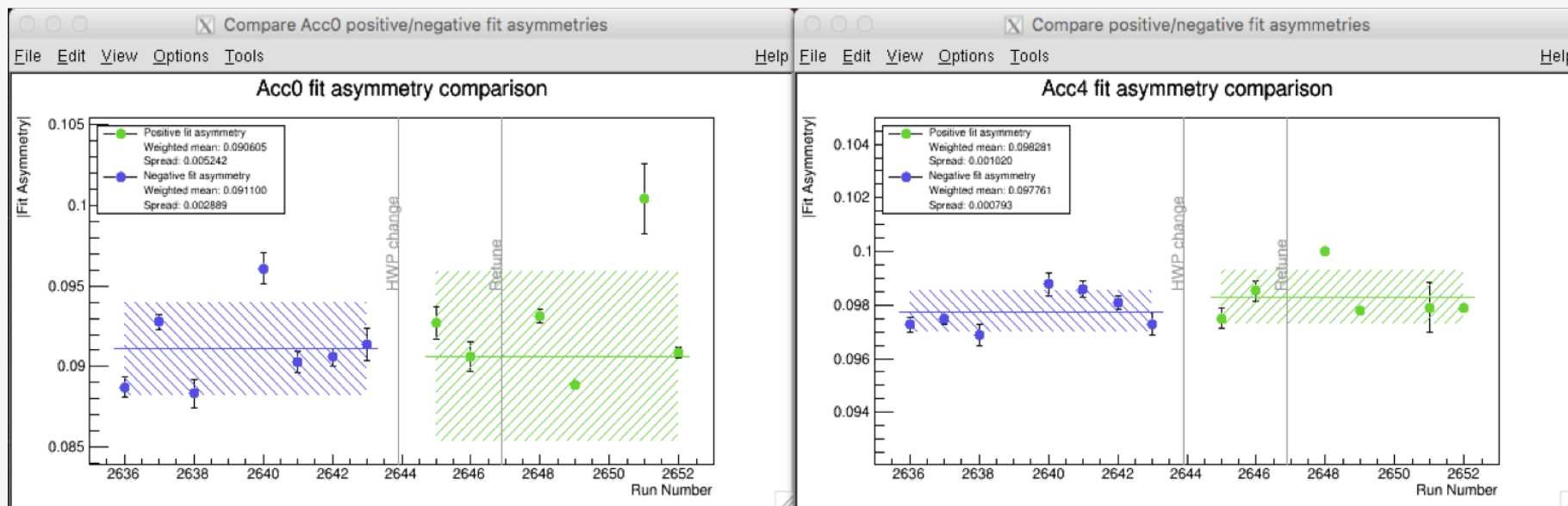
Asymmetry Calculations

- Monte Carlo simulation of “ideal” asymmetry, A_{theo}
- $A_{theo} ==$ “analyzing power”
- Uses GEANT4 to simulate high energy photons impinging on Compton photodetector (PbWO₄ scintillator + PMT)
- Energy, geometry, cutoff (i.e., accumulator) dependent

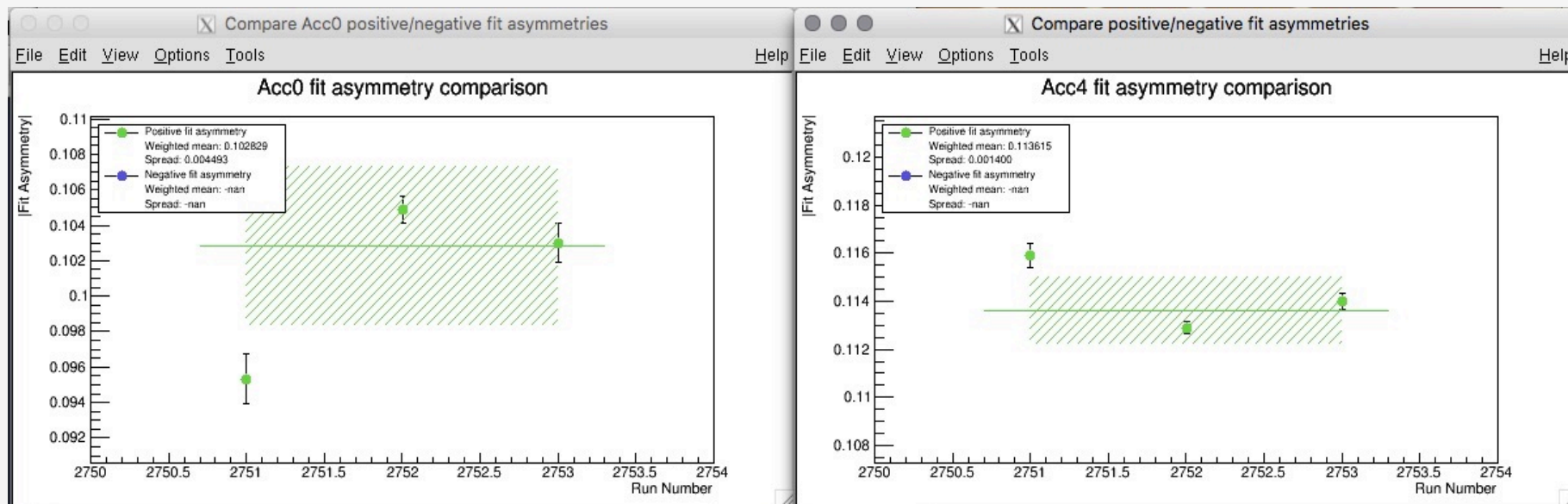


Results*:

4-pass (8.8GeV)

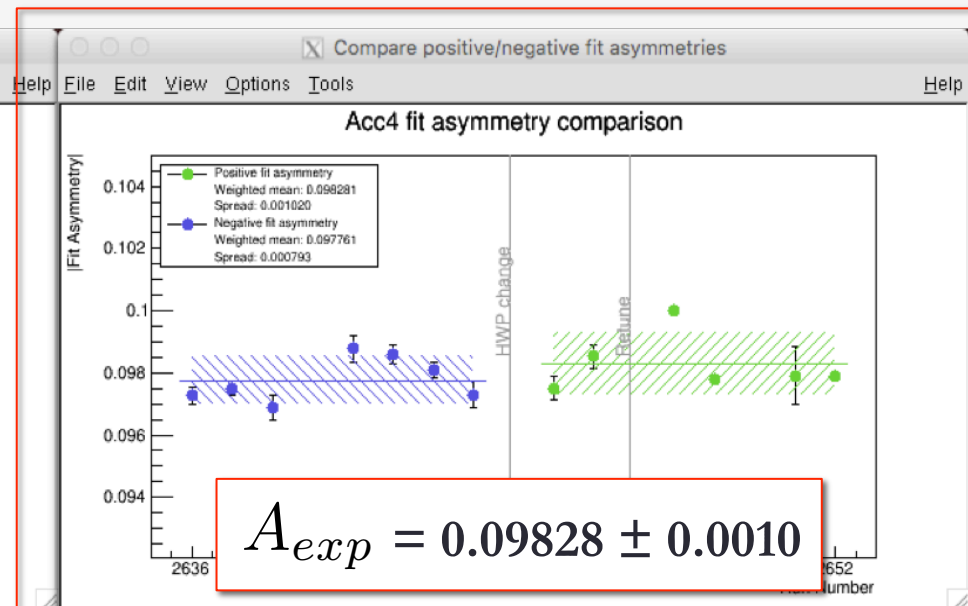
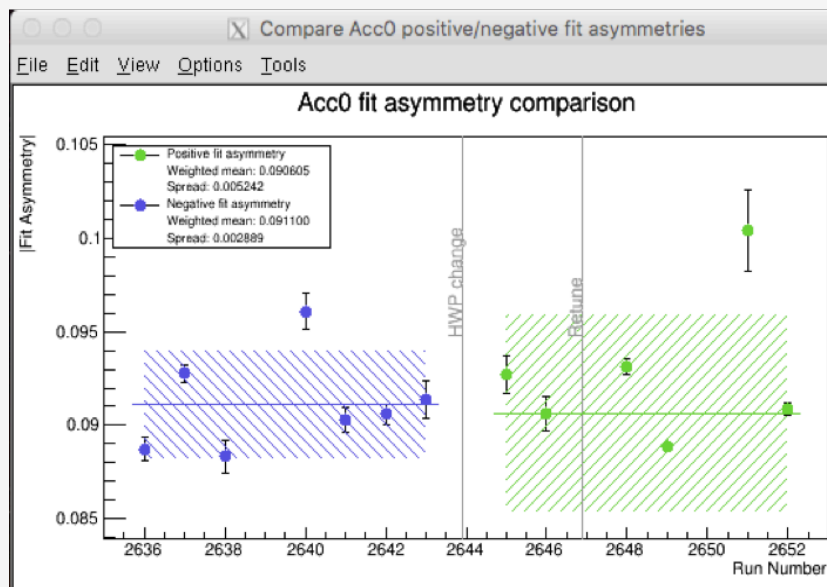


5-pass (11GeV)

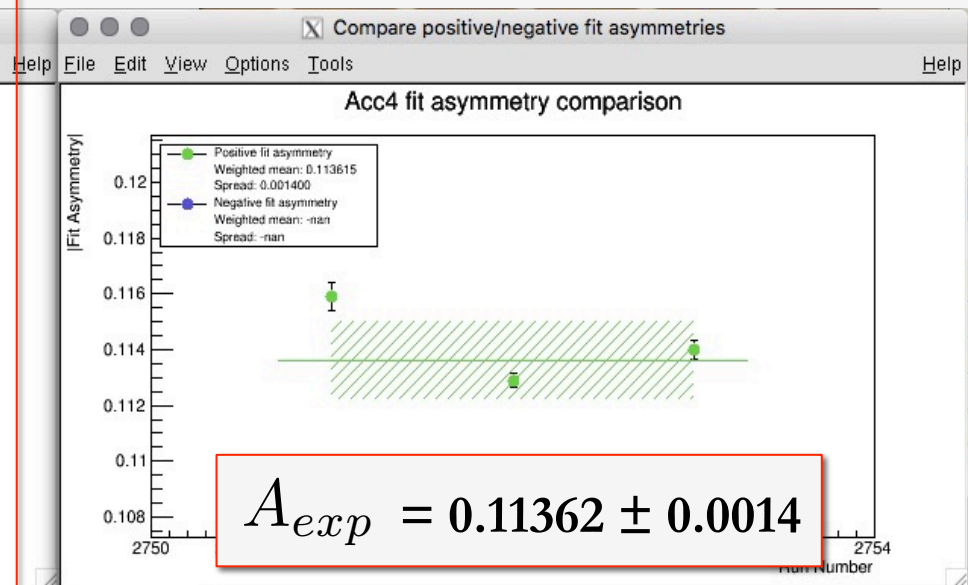
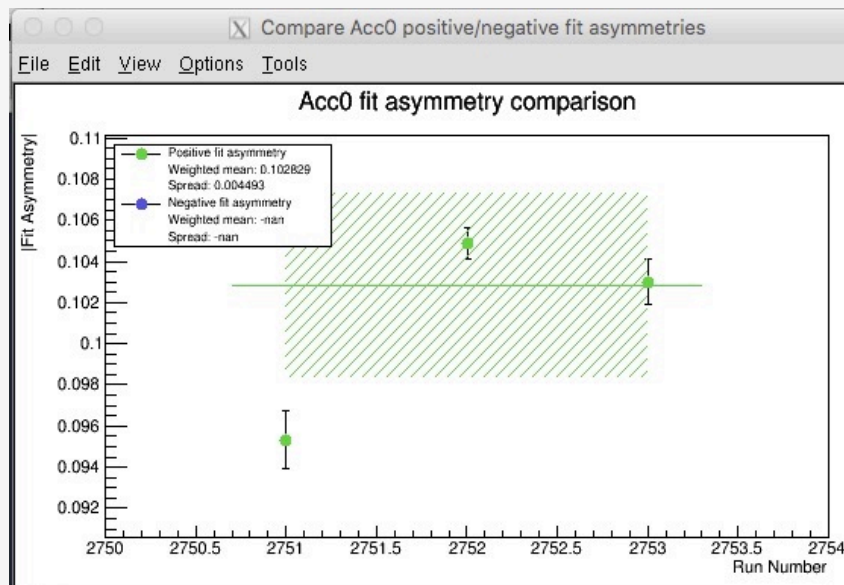


Results*:

4-pass (8.8GeV)



5-pass (11GeV)



Results:

Can use Compton Scattering asymmetries to calculate electron beam polarization:

$$P_{exp} = \frac{A_{exp}}{P_{theo} \times A_{theo}} \longrightarrow \left\{ \begin{array}{l} \sim 85.0\% \text{ at } 8.8\text{GeV} \\ \sim 86.4\% \text{ at } 11\text{GeV} \end{array} \right.$$

Of interest to groups who care about beam polarization

Acknowledgements

- Thanks to:

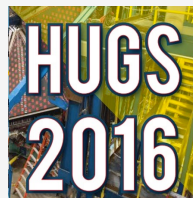
- Hall A Compton team (Dave Gaskell)



- CMU (Gregg Franklin, Alexa Johnson)



- HUGS 2016



Backup: Histogram Pedestals

- Care about pedestals when constructing sum/diff histograms:

```
acc0Sum = PosHelAcc[0] + NegHelAcc[0] + beamOffZero0;  
acc0Diff = PosHelAcc[0] - NegHelAcc[0];  
  
Double_t pedestal = beamOffZero0 / (PosHelNSamples0 + NegHelNSamples0);  
Double_t posContrib = PosHelAcc[4] + pedestal * PosHelNSamples4;  
Double_t negContrib = NegHelAcc[4] + pedestal * NegHelNSamples4;  
acc4Sum = posContrib + negContrib;  
acc4Diff = posContrib - negContrib;
```

Backup: Afterglow



ELSEVIER

Nuclear Instruments and Methods in Physics Research A 376 (1996) 319-334

NUCLEAR
INSTRUMENTS
& METHODS
IN PHYSICS
RESEARCH
Section A

A study on the properties of lead tungstate crystals

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Received 5 February 1996

Abstract

This report summarizes the results of a study on the properties of five large and five small size lead tungstate (PbWO_4) crystals. Data are presented on the longitudinal optical transmittance and light attenuation length, light yield and response uniformity, emission spectra and decay time. The radiation resistance of large crystals and possible curing with optical bleaching are discussed. The result of an in depth materials study, including trace impurities analysis, are also presented. The general conclusion from this investigation is that further research and development is needed to develop fast, radiation-hard PbWO_4 crystals for the CMS experiment at the CERN LHC.
