Compton Polarimetry: Photon Analysis

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OUTLINE

1. PHOTON DETECTOR

2. FADC DAQ

3. CALCULATING BEAM POLARIZATIONS
   - Theoretical Asymmetries
   - Experimental Asymmetries
   - Beam Polarizations

4. PREPARATION FOR PREX

5. CONCLUSION

PHOTON DETECTOR

- 15cm long, 6cm diameter GSO crystal
- "Linear" tube and base
  - Specially designed LED pulser for linearity testing
- Adjustable collimator
- Synchrotron radiation filters of different thicknesses
- 1mm thick W converters and light-guide "fingers" to determine horizontal and vertical beam position
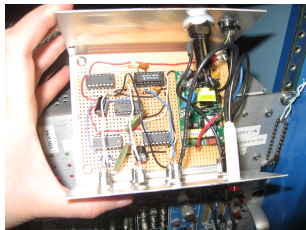
FADC DAQ

- Two simultaneous modes
  - Accumulator mode
    - Integrates all pulses over MPS
    - No dead time
  - Triggered mode
    - Look at pulse structure and Compton spectrum
- Can also run with FADC and EDET simultaneously (CompSimple)
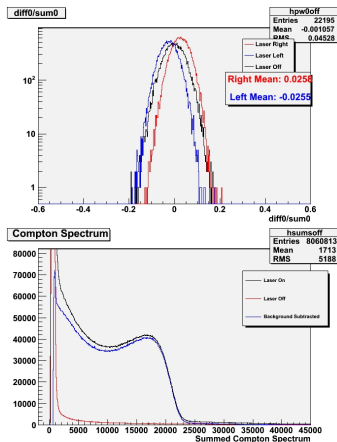
CALCULATING A POLARIZATION

The beam polarization is:

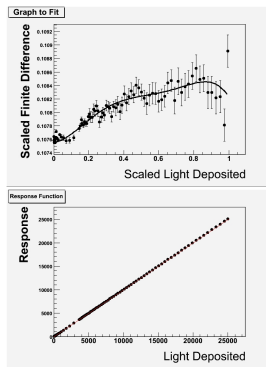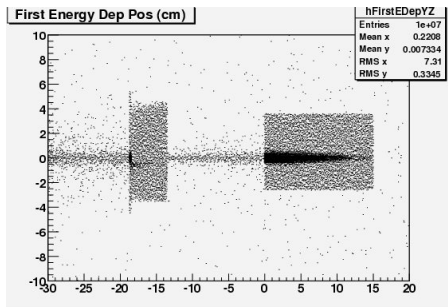$$P_{elect} = \frac{A_{exp}}{P_{phot} * A_{th}}$$

The experimental asymmetry is:

$$A_{exp} = \frac{S_n^+ - S_n^-}{S_n^+ + S_n^-}$$

Where S_n^+ (S_n^-) is just the FADC accumulator signal for a positive (negative) helicity MPS

THEORETICAL ASYMMETRY

- Calculated using Geant 4 simulation (Gregg Franklin)
  - Generate Compton photons
  - Let them interact with lead filter/collimator/GSO
  - 5% smearing factor
  - Include PMT nonlinearity

THEORETICAL ASYMMETRY, CONT.

- Fit simulation to triggered data
- Get triggered data asymmetry (independent measurement of A_{th})
  - Gives $P_{elect} = 83.8 \pm 1\%$ for laser left and $80.1 \pm 1\%$ for laser right
- Calculate energy weighted asymmetry (A_{th}) – used to calculate final beam polarization
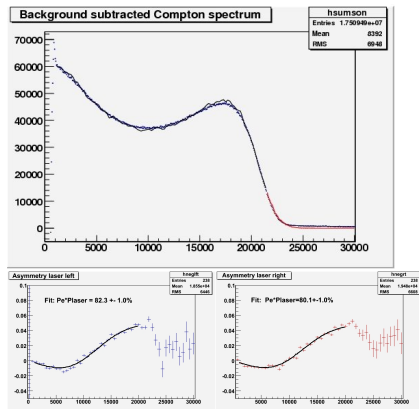
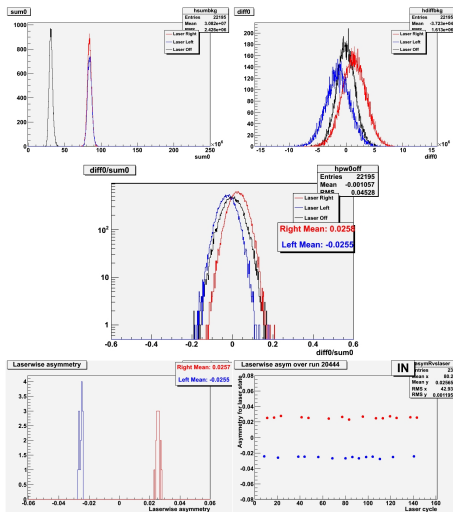# EXPERIMENTAL ASYMMETRIES

Runwise

- Over the entire run

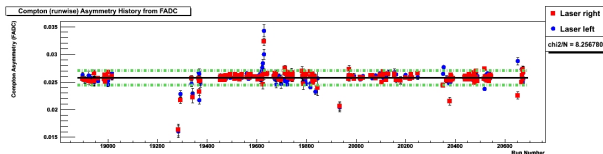Pairwise

- Pair by pair
- Locally stable

Laserwise

- For each laser cycle
- Local background subtraction

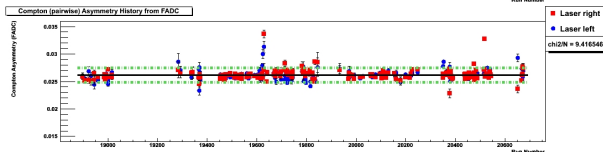# STABILITY OF EXPERIMENTAL ASYMMETRIES DURING HAPPEX-III
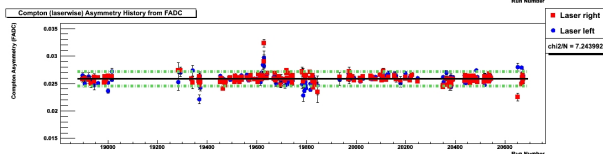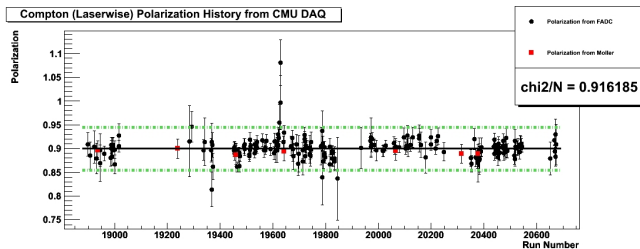

Runwise

χ^2/N
8.26

Pairwise

9.42

Laserwise

7.24

HAPPEX-III BEAM POLARIZATIONS

Preliminary HAPPEX-III results

- Calculated using laserwise asymmetries
- Geant 4 simulation data
  - Includes collimator/filter, PMT nonlinearity, photon beam offset
- Does not include
  - Run-by-run laser polarization
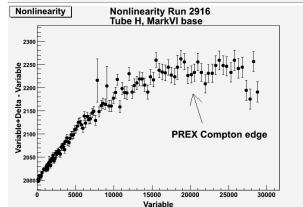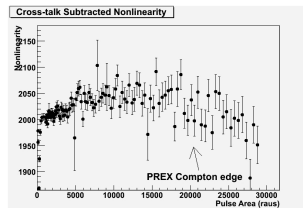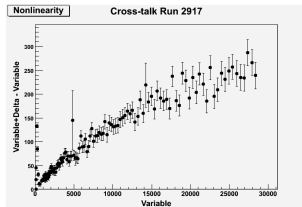 - Laser transfer function
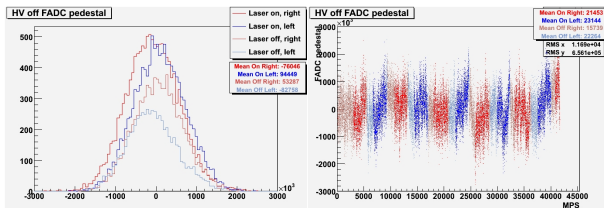

Wt Mean:
Compton:
$90.00 \pm 0.11\%$
Moller:
$89.28 \pm 0.76\%$

PREX PMT SELECTION

- Linear tube and base selected
- Currently there are cross-talk issues with the LED pulser

ISSUES

- DAQ needs to work at 240Hz (not tested yet) – shouldn't be difficult
- Pedestal problem? – needs more testing

- Ratty (helicity-dependent) MPS signal – maybe doesn't matter

  0 -1 1 1 0 -1 1 0 0 1 0 -1 1 1 0 0

- Beamline kinks/photon beam position
- BCM asymmetries are NOT a problem for the FADC DAQ

CONCLUSION

- HAPPEX-III analysis is progressing well
  - Preliminary laserwise analysis gives a beam polarization with a weighted mean of $90.00 \pm 0.11\%$ with $\chi^2/N = .92!$
  - In good agreement with Moller measurements
  - Triggered data results do not match accumulator results yet – it's a work in progress
- Things are looking fine for PREX, although we still need to:
  - Test FADC DAQ at 240Hz
  - Look into laserstate dependant pedestal shifts
  - Fix photon beamline
  - Fix LED pulser
  - Minor DAQ tweaks