RCS Compton Update

Dave Gaskell
Jefferson Lab
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RCS Compton Rates

$$\mathcal{L} = f_{coll} N_\gamma N_e \frac{\cos\left(\alpha_c/2\right)}{2\pi} \frac{1}{\sqrt{\sigma_{x,\gamma}^2 + \sigma_{x,e}^2}} \frac{1}{\sqrt{\left(\sigma_{y,\gamma}^2 + \sigma_{y,e}^2\right)\cos^2\left(\alpha_c/2\right) + \left(\sigma_{z,\gamma}^2 + \sigma_{z,e}^2\right)\sin^2\left(\alpha_c/2\right)}}$$

1-2 Hz

$N_\gamma = \langle P \rangle / (f_{laser}\, E_{laser})$

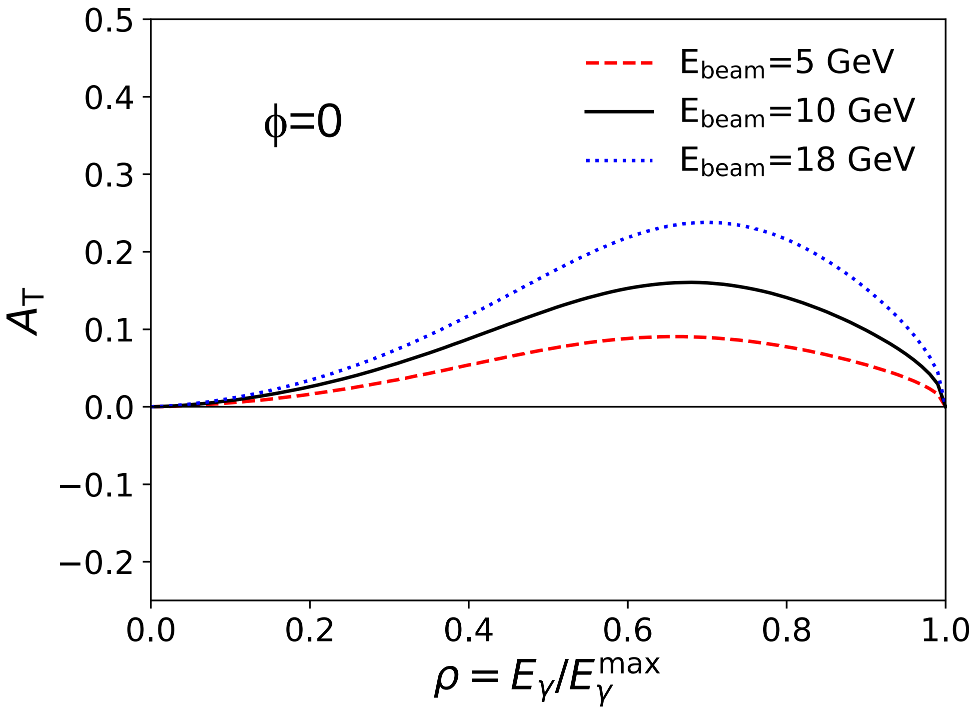
RCS Compton will use low duty cycle, higher peak power laser (similar to HERMES LPOL)
→ Example system from RPMC lasers: Pulse energy = 30 mJ @ 2 Hz (<P>=60 mW) → 8.0E16 photons/pulse

For 15 ns pulses, backscattered photon rate is 240 kHz, “ideal” measurement times on the order of a few seconds

Transverse Analyzing Power and Measurement

$$A_{\mathrm{T}} = \frac{2\pi r_o^2 a}{(d\sigma/d\rho)} \cos\phi \left[\rho(1-a) \frac{\sqrt{4a\rho(1-\rho)}}{(1-\rho(1-a))} \right]$$

In contrast to longitudinal measurement, measurement of transverse polarization requires sensitivity to spatial dependence of asymmetry



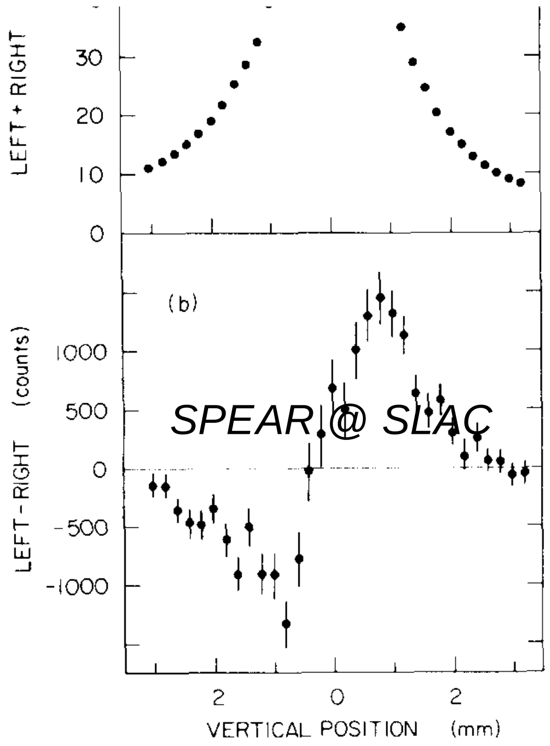


Fig. 10. (a) Sum and (b) difference distributior
positron beam at 3.60 GeV. The resulting v
(2.55±0.14)%.

circular polarization is switched from l
a frequency of about 20 Hz by s

Simple rate, measurement time estimates

$$t^{-1} = \mathcal{L}\sigma \left(\frac{\Delta P}{P}\right)^2 P^2 A^2_{method}$$

Average analyzing power: $A^2_{method} = \langle A \rangle^2$ → Average value of asymmetry over acceptance

Energy-weighted: $A^2_{method} = \left(\frac{\langle EA \rangle}{\langle E \rangle}\right)^2$ → Energy deposited in detector for each helicity state

Differential: $A^2_{method} = \langle A^2 \rangle$ → Measurement of asymmetry bin-by-bin vs. energy, etc.

Assuming 80% polarization, $\langle P_{laser} \rangle$= 6mW, 300 μm beam spot size…, → time for 1% measurement

E_{beam}	A_{avg}	T_{avg}	A_{energy}	T_{energy}	A_{diff}	T_{diff}
5	4.51%	243 s	5.78%	148 s	5.48%	164 s
10	7.79%	92 s	10.15%	54 s	9.56%	61 s
18	11.29%	51 s	14.91%	29 s	13.96%	33 s

Toy Monte Carlo

- Used toy Monte Carlo to look at asymmetries, energy/per bunch etc.
- Generated events for 240 bunches (i.e., 2 minutes of running)
  - For each bunch/crossing, generated number of backscattered photons based on simple luminosity estimates
  - Assumed luminosity 10x smaller than previous slide → 6 mW average laser power
  - 12,000-15,800 backscattered photons/bunch crossing
- Assumed detector 25 m away from laser-beam collision point
  - No realistic simulation of detector – just a point in space to look at distributions
- Event generator ignores hourglass effect, assumes all events generated at (0,0) → does incorporated finite beam sizes, but only at that point

Detector Distributions

LEP polarimeter measured difference in vertical position for h+ and h- induce by transverse analyzing power

At 5 GeV, average position difference for h+ and h- is

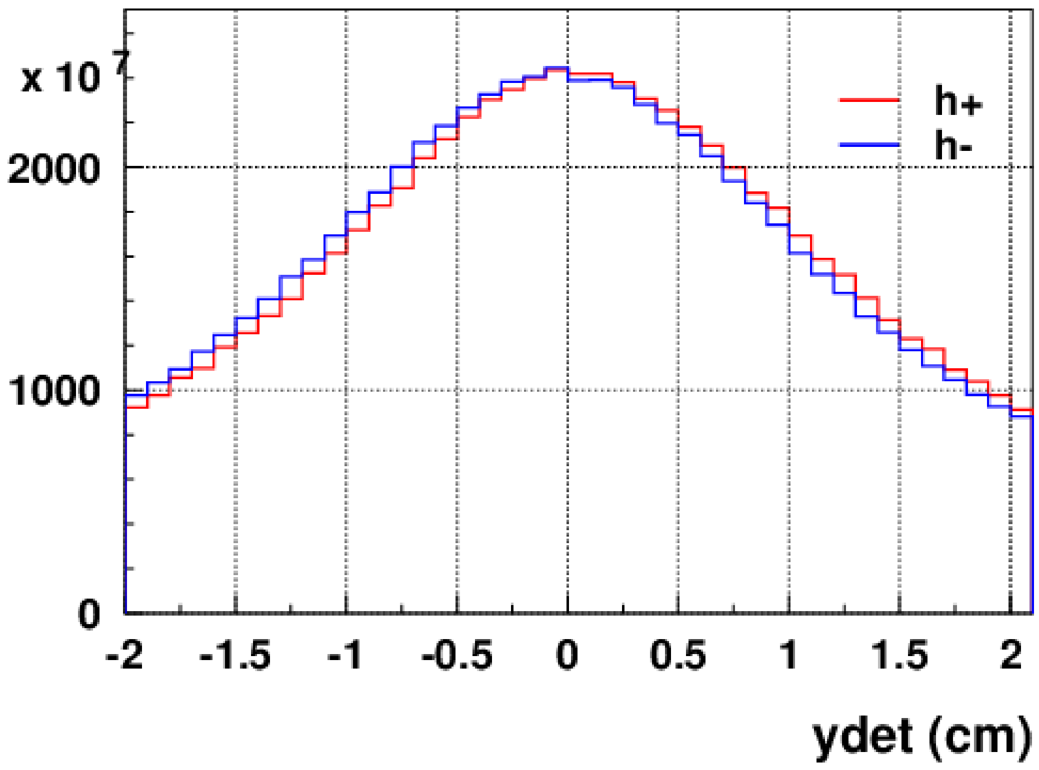
$Y_{h+} - Y_{h-} = 0.49$ mm

At 18 GeV, difference is similar magnitude:

$Y_{h+} - Y_{h-} = 0.38$ mm

While measurable, this quantity extremely sensitive to knowledge of absolute detector position and laser-beam collision point

5 GeV

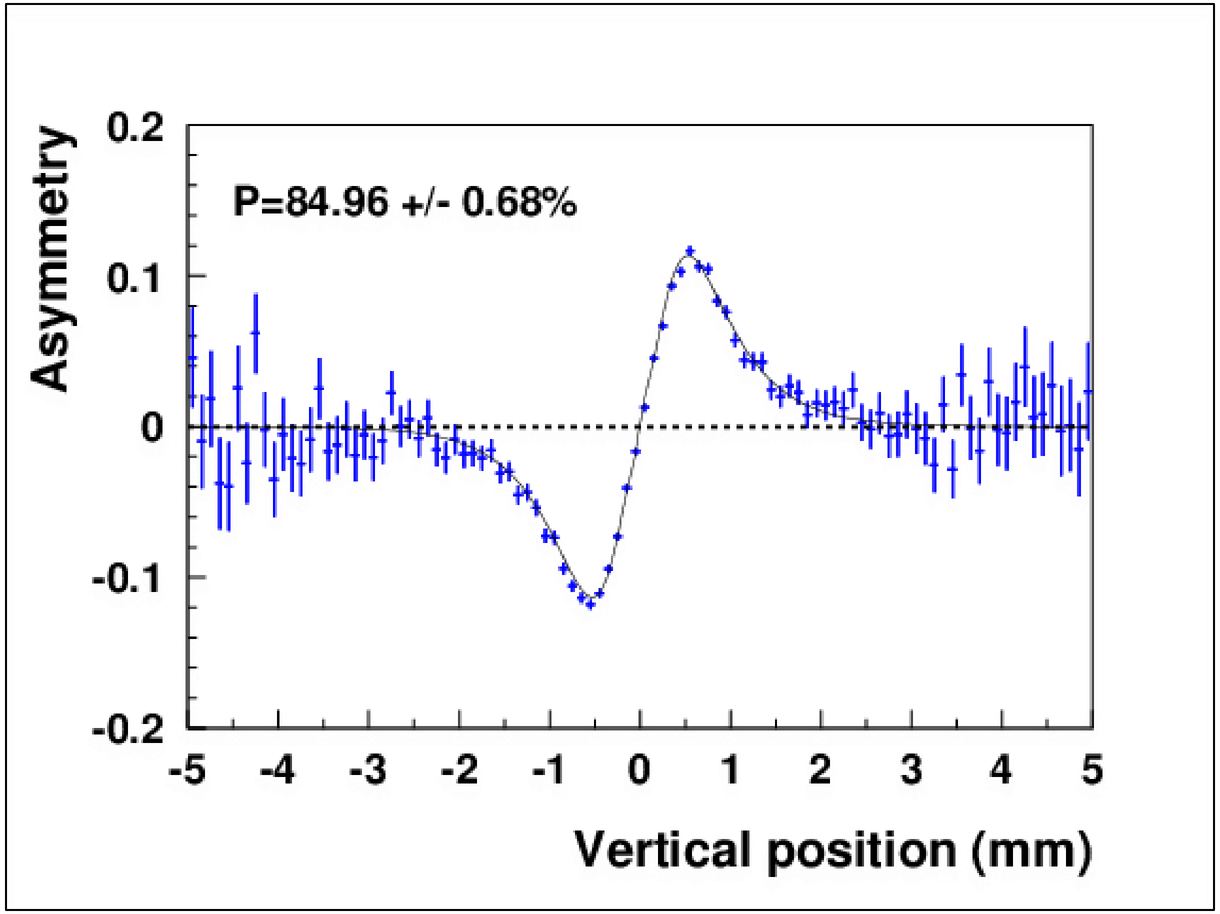


Differential Asymmetry measurement

Differential measurement of asymmetry vs. position at detector allows us to incorporate offsets in the fit

Example using Toy MC for counting-mode asymmetry vs. y assuming 0.1 mm segmentation
(240 bunches)

→ Requires detector operated in integrating mode (~10,000 photons/bunch) with signal proportional to number of photons in each channel



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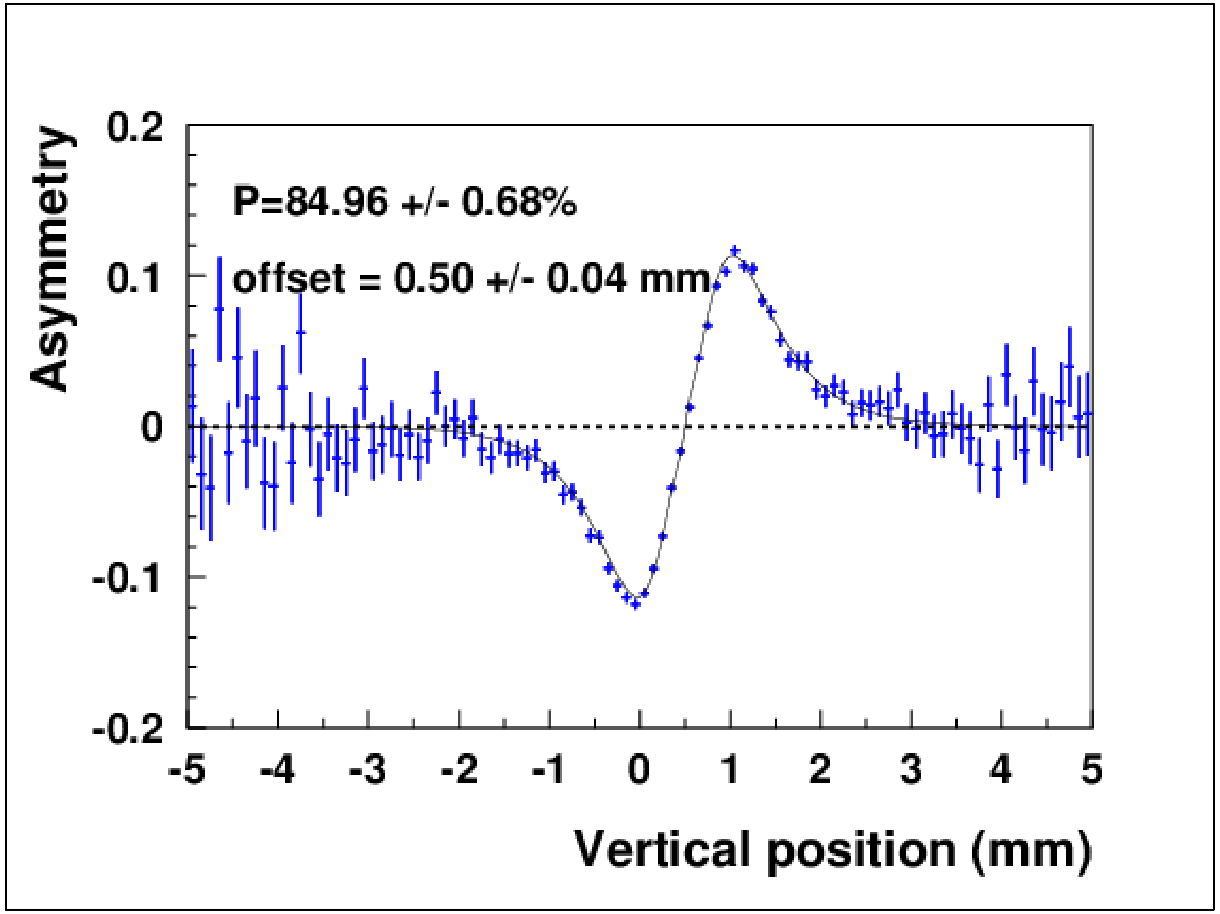


GEANT3 Simulations

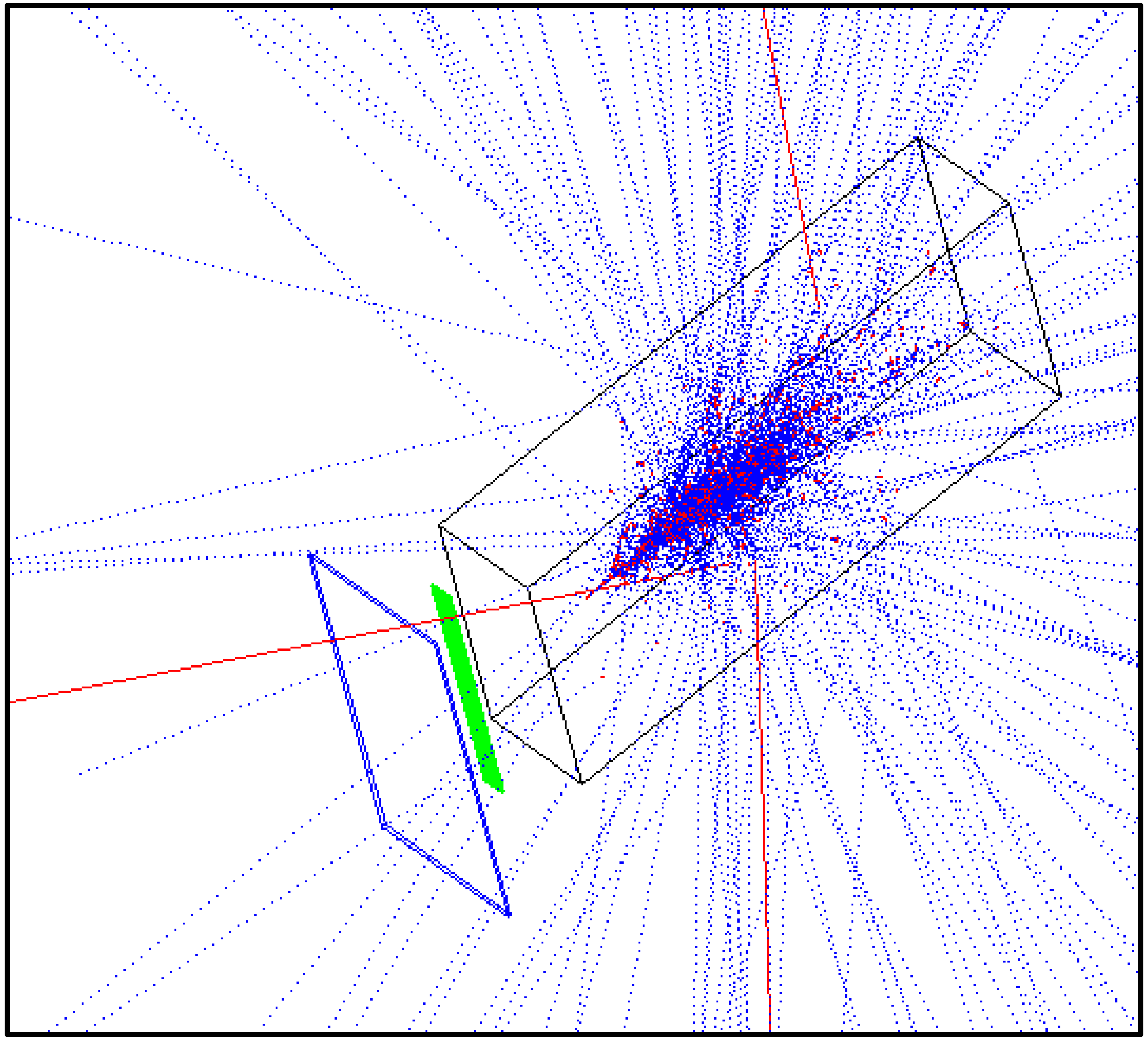
Originally assumed a Cherenkov-style detector with number of photoelectrons proportional to number of particles incident on detector
→ Not easy to build such a detector with needed granularity

Switched to diamond detector – record total energy deposited in each strip for a single laser strip

Detector components:

1. 1 mm W converter
2. 500 strip diamond detector, 1 x 5 cm
3. W/ScFI calorimeter (not really relevant here)

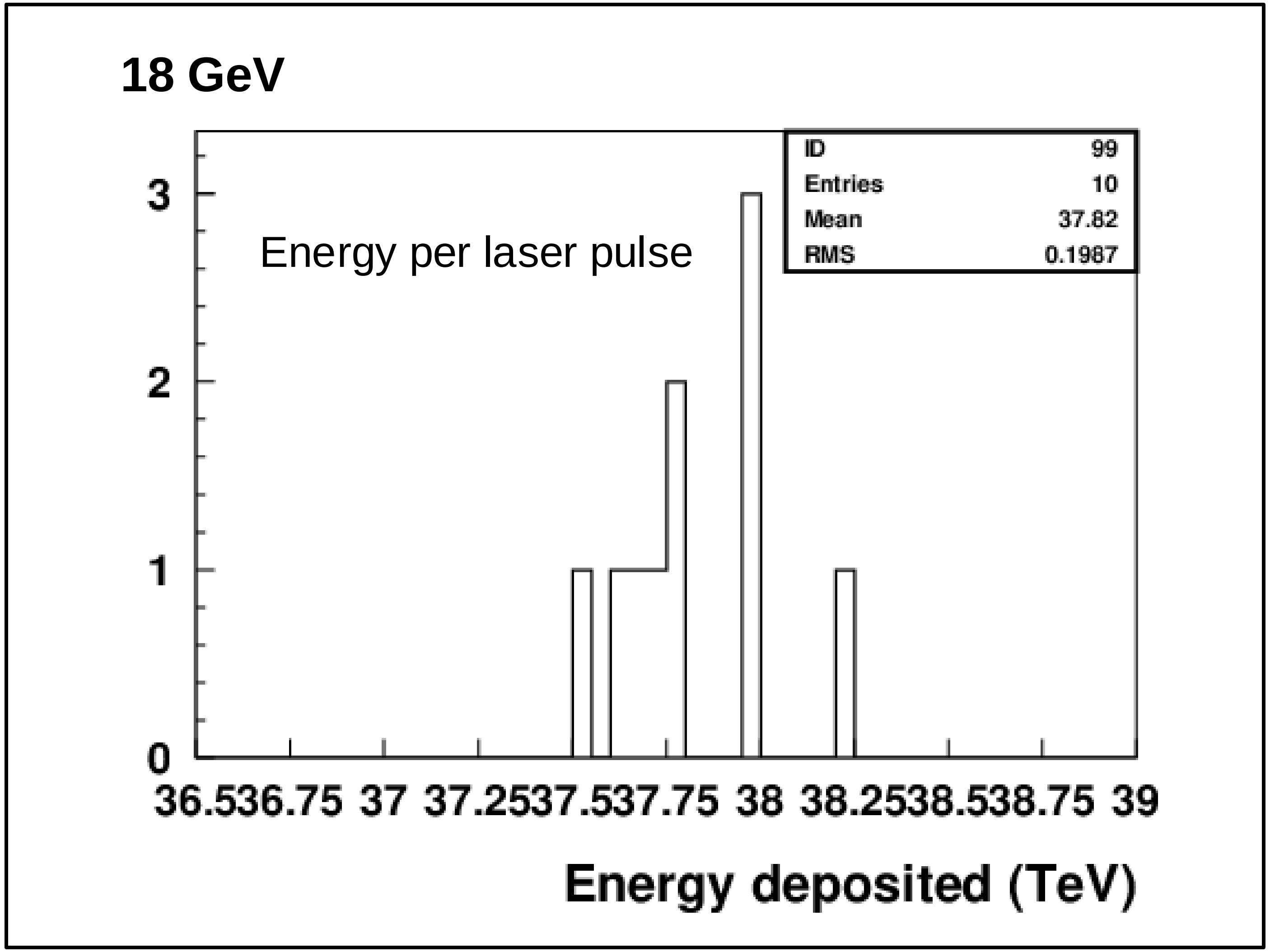
Simulation = 100,000 backscattered photons
Assuming 10,000 photons/laser pulse = 10 laser pulses



Energy deposited in Photon Detector

Assuming ~10,000 backscattered photons per laser pulse, large amount of energy deposited in photon calorimeter
→ 37 TeV!

Calorimeter response not crucial for RCS polarimeter, but would like to be able to measure absence of a longitudinal asymmetry



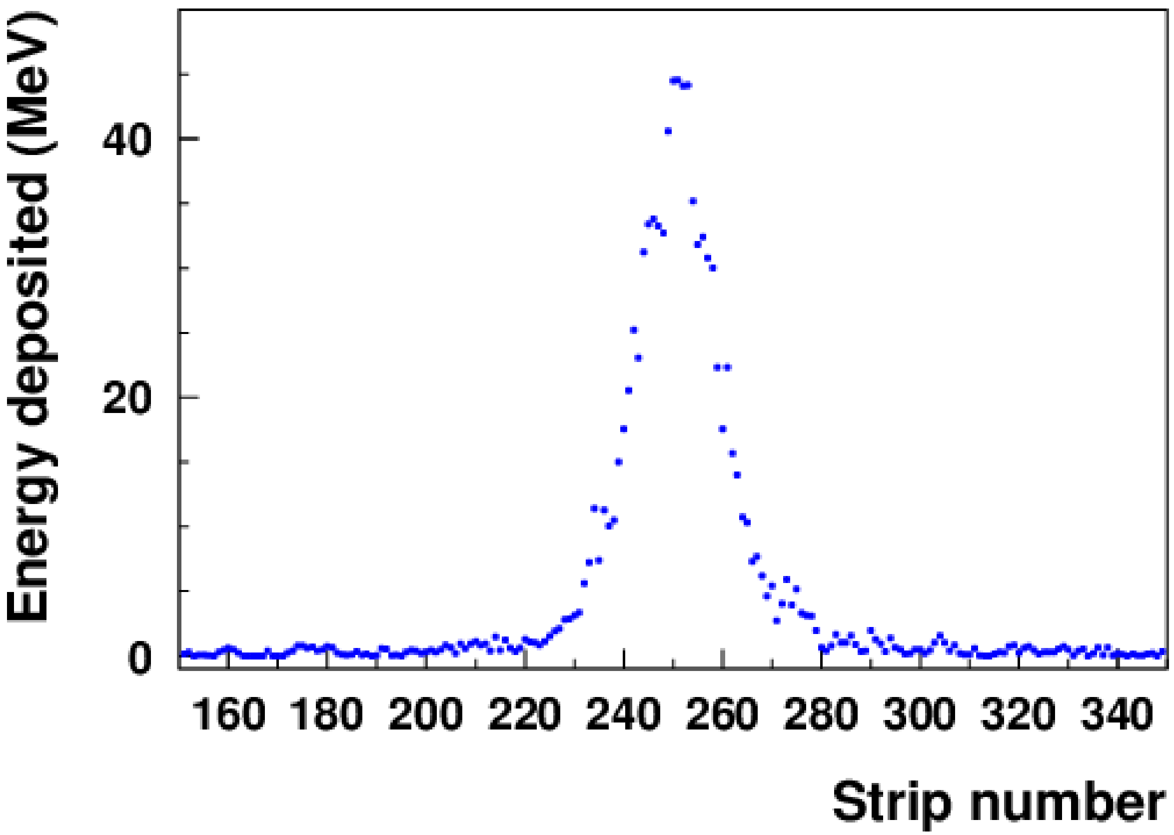
Energy Deposited in Diamond Strips

Diamond detectors assumed to be ~0.5 mm, much higher segmentation

→ More modest amount of energy deposited in each strip for a single laser pulse

Even though time response not crucial for this application, could use FLAT-32 ASIC here as well
→ Can choose analog pulse as opposed to discriminated signal (ESR Compton use)

18 GeV

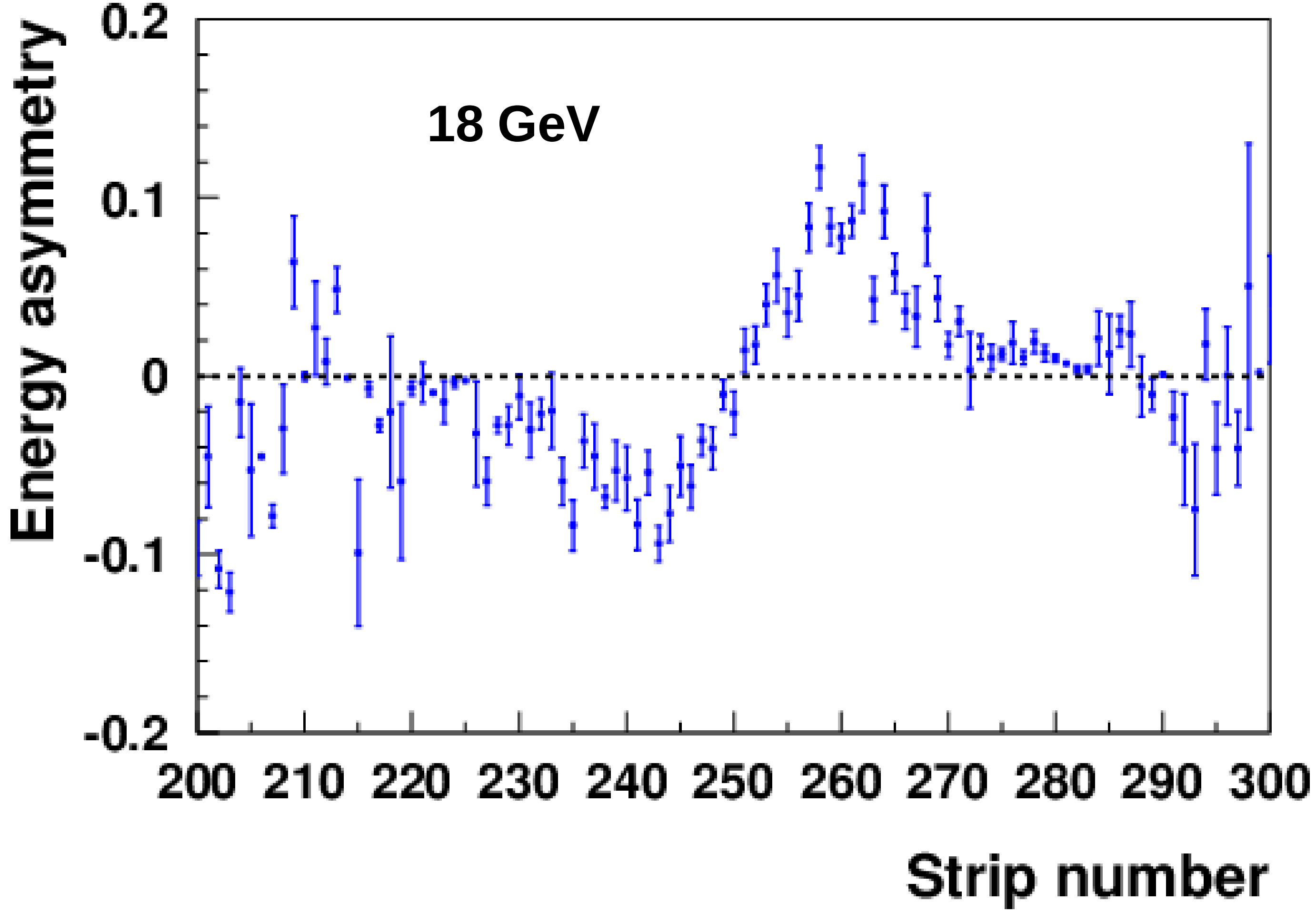


Energy Asymmetry

Transverse polarization will be extracted using asymmetry in energy deposited in each strip

$$A_{strip} = \frac{E^+_{strip} - E^-_{strip}}{E^+_{strip} + E^-_{strip}}$$

Since diamond planes are thin, energy deposited roughly the same for all photons
→ Resulting asymmetry similar to that from Cherenkov-type detector



Note: only 10,000 backscattered photons (simulation operator error)

RCS to-do list

- Get realistic beam parameters for RCS laser IP
- Add 5 GeV, 10 GeV
- Perform robust estimates of measurement times using this technique
- Add another plane for measurement of in-plane polarization
- Check sensitivity to residual longitudinal polarization