Single Spin Azimuthal Asymmetries from Deeply Virtual Compton Scattering at HERMES

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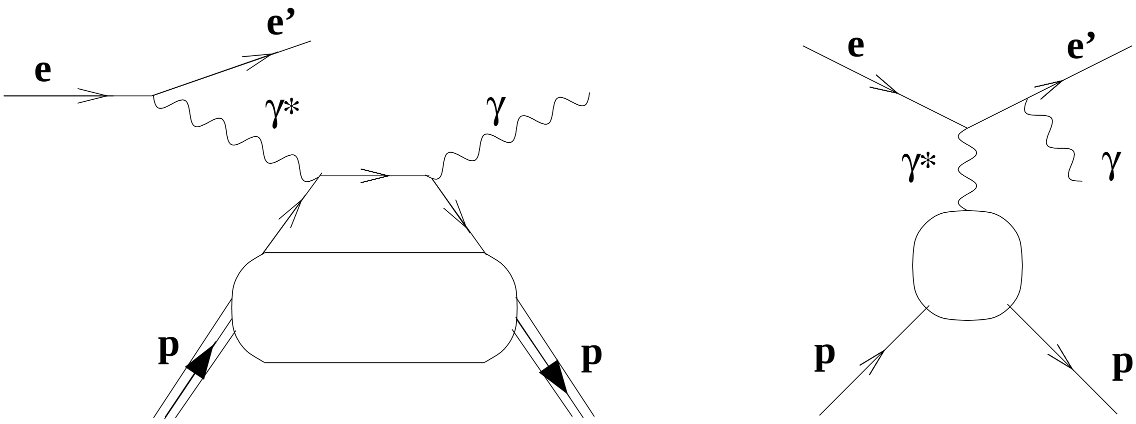
on behalf of the

HERMES Collaboration

- DVCS process
- Single Spin Asymmetry
- HERMES DVCS Analysis
- Result
- Outlook

Deeply Virtual Compton Scattering

$$e + p \rightarrow e' + \gamma + X$$

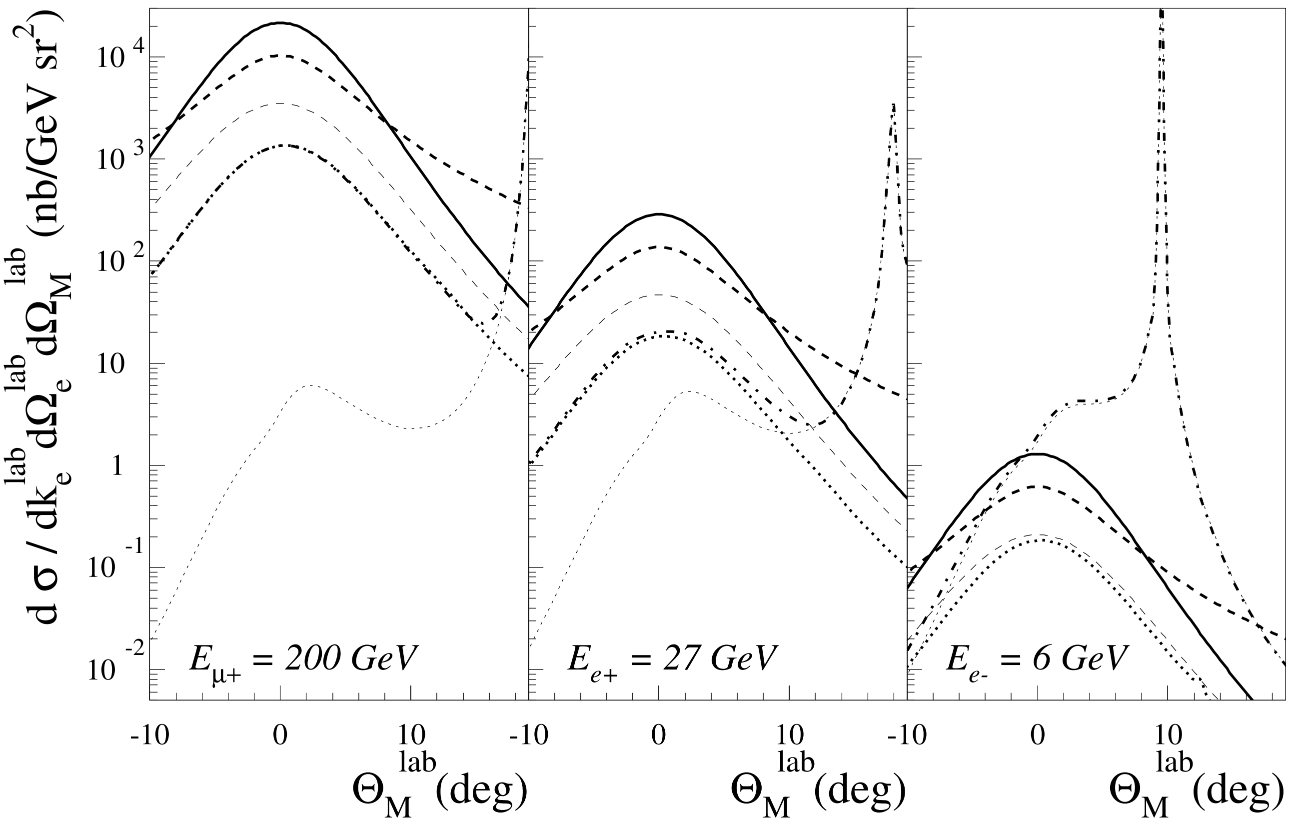


- processes: exclusive and associated DVCS (p or Δ in the final state), exclusive case of primary interest
- background from Bethe-Heitler process calculable from QED and proton structure functions
- DVCS and BH indistinguishable $\rightarrow$ amplitudes add up coherently
- DVCS process factorizes at high Q^2 and low $-t$ $\rightarrow$ handbag diagram
- simpler than meson electroproduction because produced particle is elementary particle
- in terms of Skewed Parton Distributions, DVCS depends on polarized and unpolarized SPD's, vector and pseudoscalar meson production only on one or the other (more detail in talk of W.-D. Nowak on monday)

Cross Section Estimates

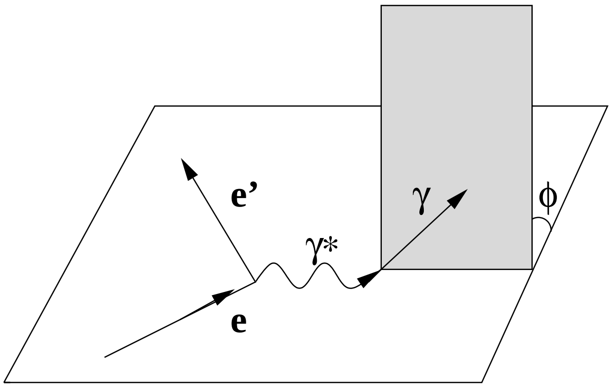
$$l + p \rightarrow l + \ \rho_L^0 \, p, \ \ \pi^+ \, n, \ \ \gamma \, p$$

$$Q^2 = 2.5 \ GeV^2, \ x_B = 0.3$$



leading order calculation and plot by Vanderhaeghen, Guichon and Guidal, Phys. Rev. **D60** (1999) 094017

Single Spin and Azimuthal Asymmetries



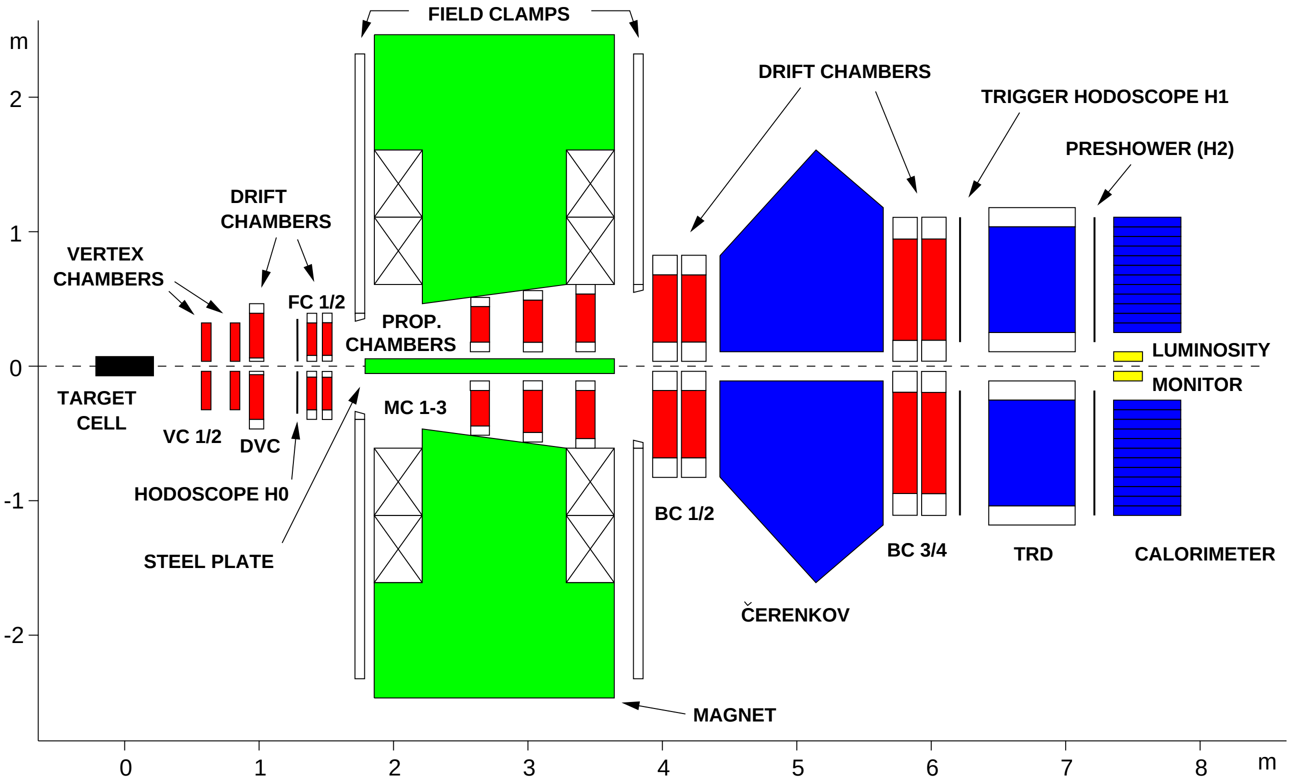
Photon production cross section:

$$d\sigma \propto |\tau_{\rm DVCS} + \tau_{\rm BH}|^2 = |\tau_{\rm DVCS}|^2 + |\tau_{\rm BH}|^2 + (\tau^*_{\rm DVCS}\tau_{\rm BH} + \tau^*_{\rm BH}\tau_{\rm DVCS})$$

- Bethe-Heitler contribution calculable with the knowledge of QED and the proton structure functions
- Real part of interference term is asymmetric with respect to reversal of lepton charge:
  $d\sigma_{e^+} - d\sigma_{e^-} \propto \mathrm{Re}\,(\tau_{\rm DVCS}\tau_{\rm BH})$
  $\rightarrow$ exhibits $\cos(\phi)$ dependence in leading twist
- Imaginary part of interference term is asymmetric with respect to reversal of beam helicity (single spin asymmetry, or SSA):
  $d\sigma_{\leftarrow} - d\sigma_{\rightarrow} \propto \mathrm{Im}\,(\tau_{\rm DVCS}\tau_{\rm BH})$
  $\rightarrow$ exhibits $\sin(\phi)$ dependence in leading twist

$\rightarrow$ possibility to study absolute value and complex phase of the DVCS amplitude

HERMES Spectrometer



- large solid angle acceptance: $|\theta_x| < 170$ mrad, $40 < \theta_y < 140$ mrad
- momentum resolution for charged particles $\sim 1\%$ from 1 to 27 GeV
- hadron/lepton contamination $\leq 1\%$
- calorimeter energy resolution on the order of 5%

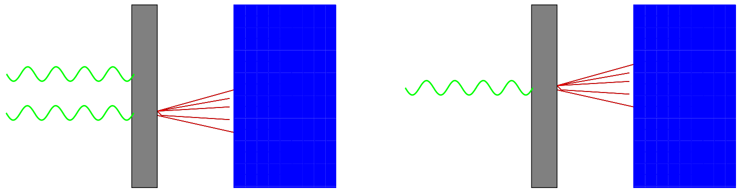
HERMES DVCS data

- 1996/97: 27.5 GeV longitudinally polarized positrons with positive and negative helicity
- $I_{\rm beam}$ up to 30 mA
- average beam polarization $\sim$ 50%
- polarized and unpolarized H_2 target
- target thickness 10^{13} - 10^{15} atoms/cm^2
- approx. 6 million DIS events
- approx. 400.000 events with one positron and one untracked cluster in the calorimeter
- kinematic requirements:
  * $Q^2 > 1$ GeV^2
  * $W^2 > 4$ GeV^2
  * $15 < \theta_{\gamma^*\gamma} < 70$ mrad

  (cut on $\theta_{\gamma^*\gamma}$ to avoid false asymmetries from bias on reconstruction of small angles)

Background Contaminations to DVCS and Bethe-Heitler

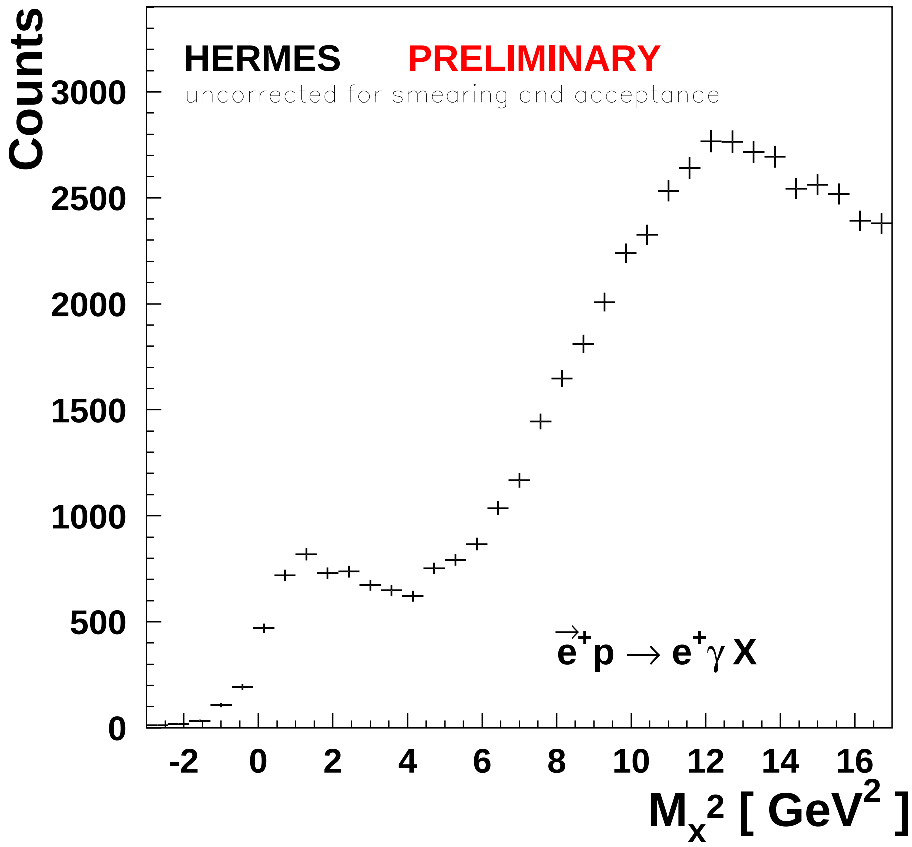
- $\pi^0 \to 2\gamma$ decay misidentification due to calorimeter granularity, use preshower to estimate 2 γ contamination: response for 1 photon $\sim$ 80%, for 2 photons $\sim$ 95%
  (result consistent with $< 5\%$ π^0 contamination)



Presh. Response ~95% ~80%

- negligible contamination from photons from proton beam line, collimators, radiation in spectrometer

Exclusivity of Reaction



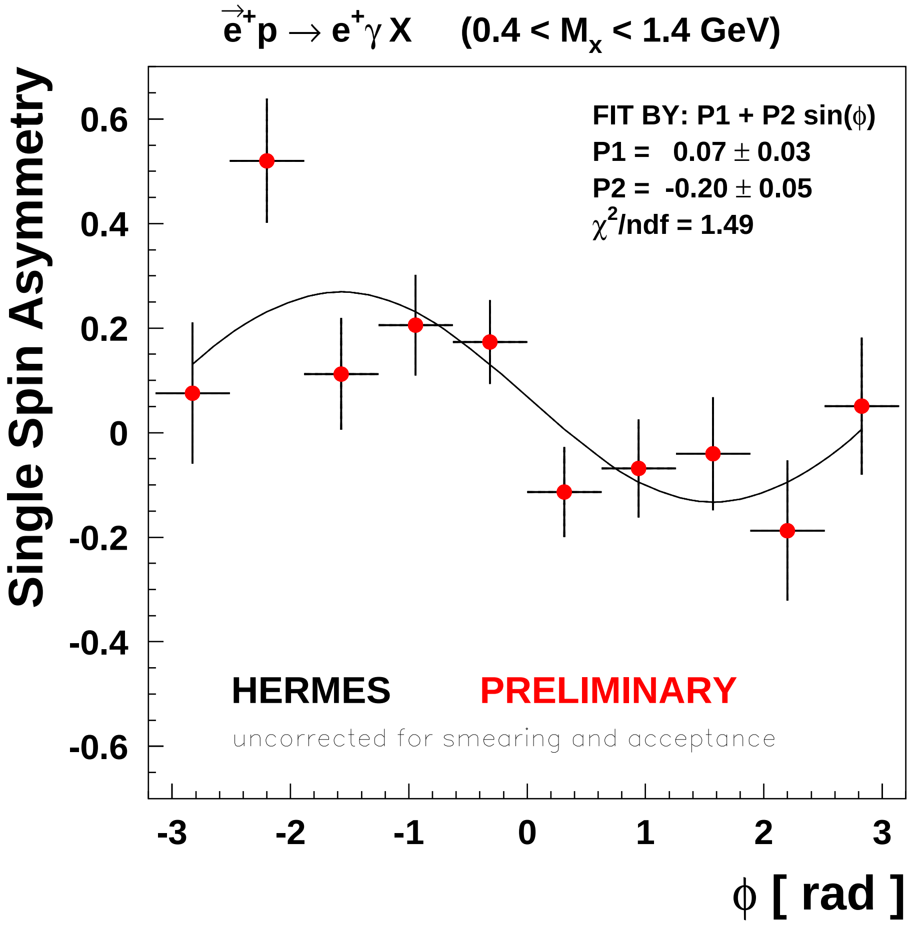
in exclusive DVCS: $M_x^2 = (q + p - p_\gamma)^2 = M_p^2$

due to Calorimeter energy resolution, M_x resolution > 0.5 GeV

$\rightarrow$ no separation of exclusive and associated DVCS

$\rightarrow$ leakage into negative M_x^2 region

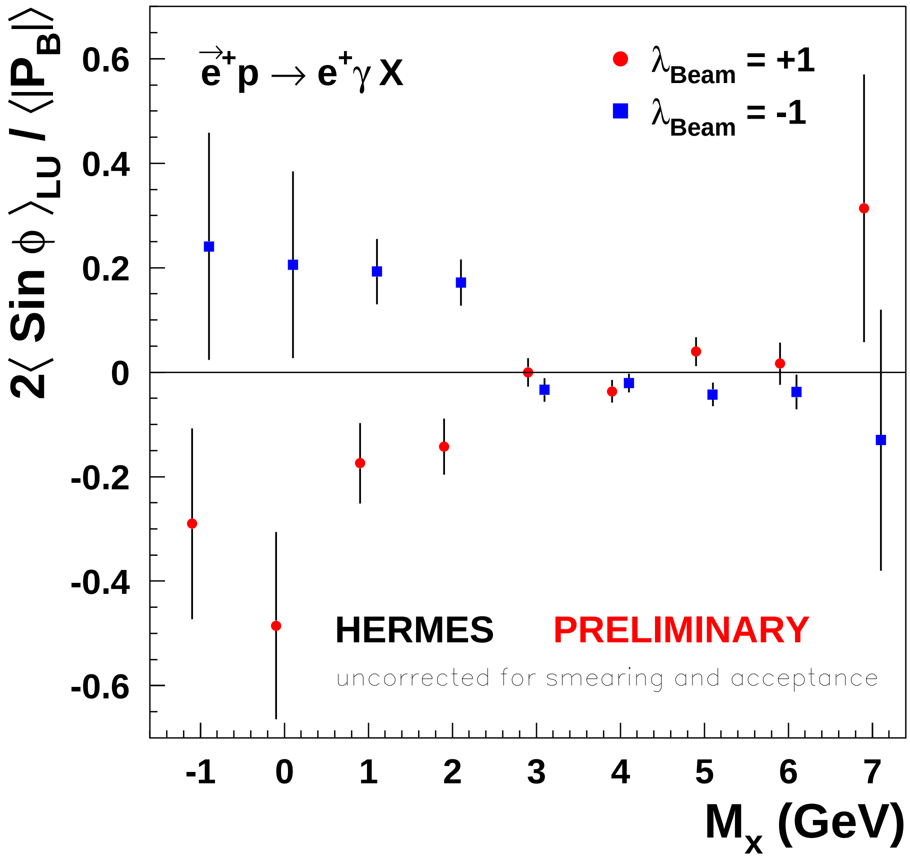
Single Spin Asymmetry



$$A_{\mathrm{LU}}(\phi) = \frac{2[N^{+}(\phi)-N^{-}(\phi)]}{<|P_b|>[N^{+}(\phi)+N^{-}(\phi)]}$$

in the exclusive bin 0.4 $< M_x <$ 1.4 GeV A_{LU} exhibits $\sin(\phi)$ dependence, no such behaviour seen at higher missing mass

Single Spin Asymmetry - $\sin(\phi)$ Moment

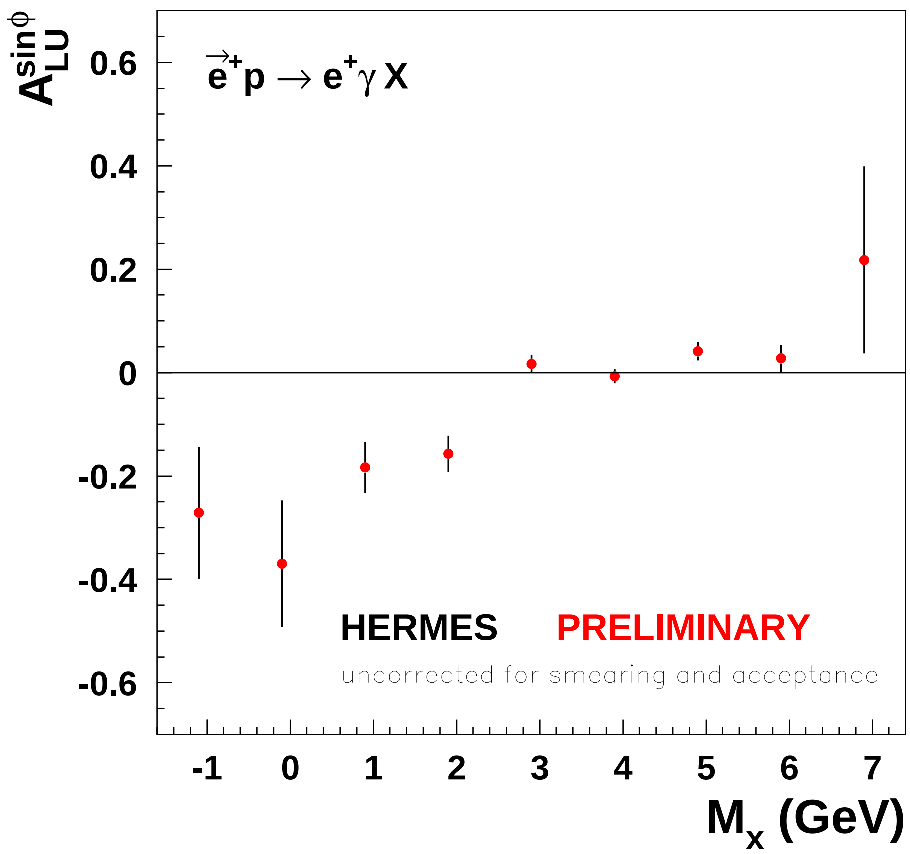


$\sin(\phi)$ Moment of the SSA:

$$A_{\mathrm{LU}}^{\sin\phi^{\pm}} = \frac{2\sum^{\pm} \frac{\sin(\phi_i)}{|P_l|_i}}{N^{\pm}}$$

- use $\sin(\phi)$ moment to extract amplitude
- average gives estimate of false asymmetry
- observed error on average limits systematic error in exclusive bin to $< 5\%$

Single Spin Asymmetry - $\sin(\phi)$ Moment



$$A_{\mathrm{LU}}^{\sin\phi} = \frac{2\sum\left(\frac{\sin(\phi_i)}{(P_l)_i}\right)}{N}$$

$$< Q^2 >= 2.6 \text{ GeV}^2$$
$$< x >= 0.11$$
$$< -t >= 0.25 \text{ GeV}^2$$

Conclusions and Outlook

- First measurement of a DVCS SSA performed at HERMES
- DVCS can be accessed through DVCS-BH interference
- Value of SSA is $-0.18 \pm 0.05(\mathrm{stat}) \pm 0.05(\mathrm{syst})$ in "exclusive" missing mass bin

- Near future: further analysis of HERMES data in progress:
  - ongoing work on Monte Carlo simulation for smearing and acceptance effects, systematics
  - more statistics from 2000 running
  - extract lepton charge asymmetry from electron runs in 1998 (low statistics)
- Farther future:
  - possible additions: running with longitudinally and transversely polarized target (low density), electron and positron beams, high-density unpolarized target running
  - Large-Acceptance Recoil Detector planned for HERMES to ensure the exclusivity of measured events

More information on DVCS and SPD's and on the planned Recoil Detector given in talk by W.-D. Nowak, Monday, 14.55h