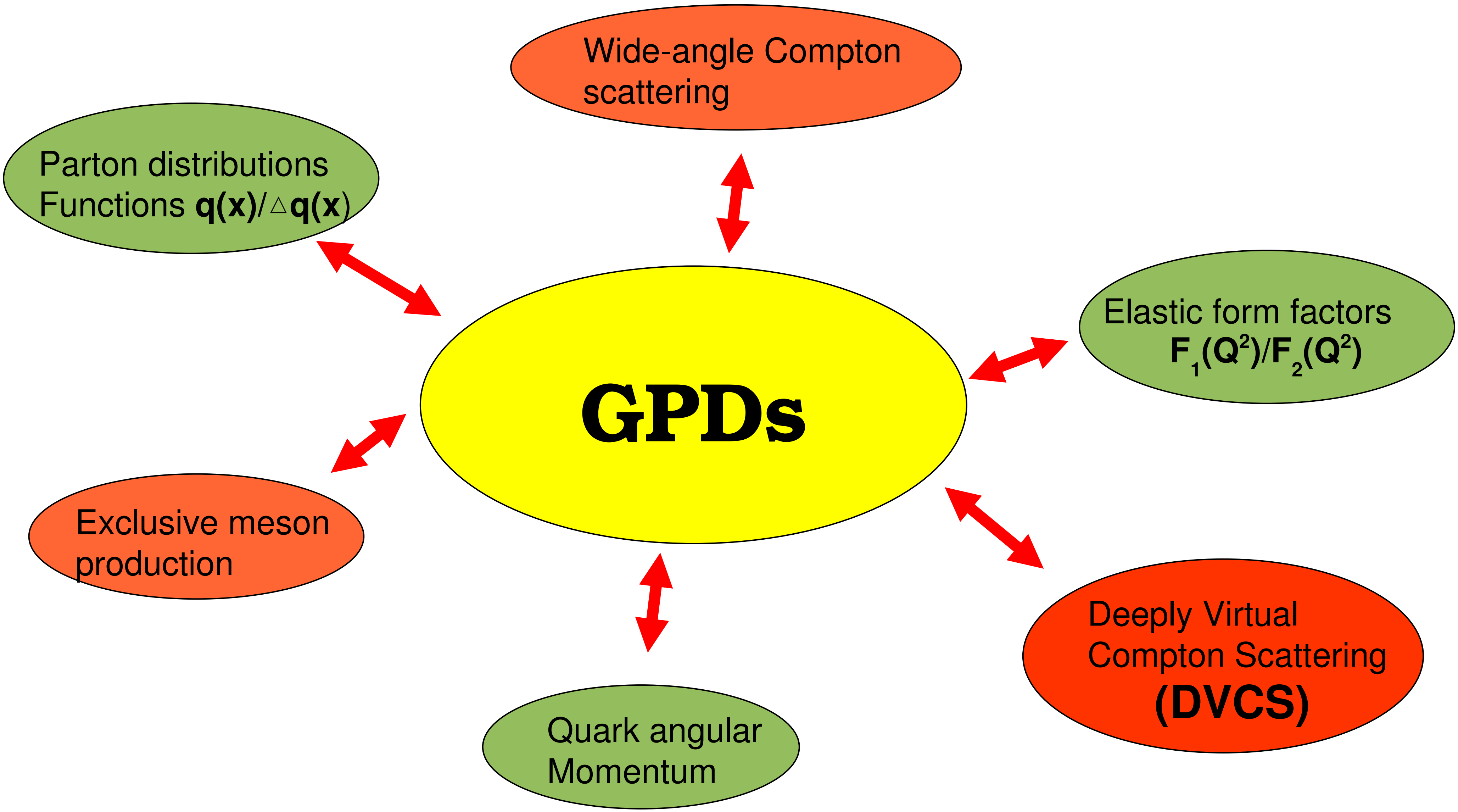
First Measurement of Deeply Virtual Compton Scattering with a Polarized Proton Target

Shifeng Chen
Florida State University
On behalf of CLAS collaboration

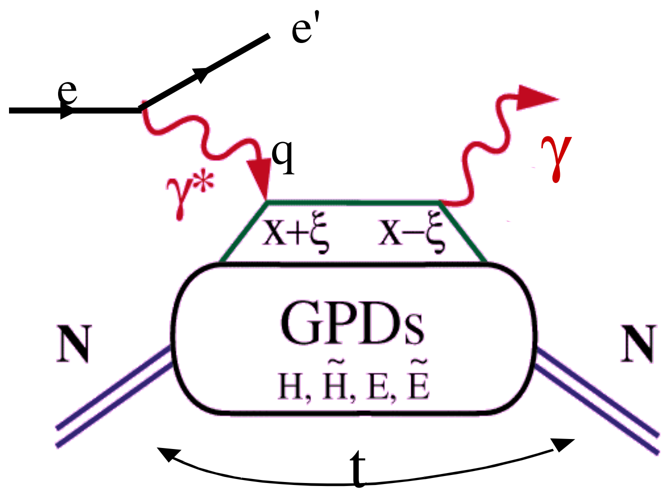
- Introduction
- Experimental setup
- DVCS Analysis
- π^0 Background Study
- Results
- Summary

06/13/2006

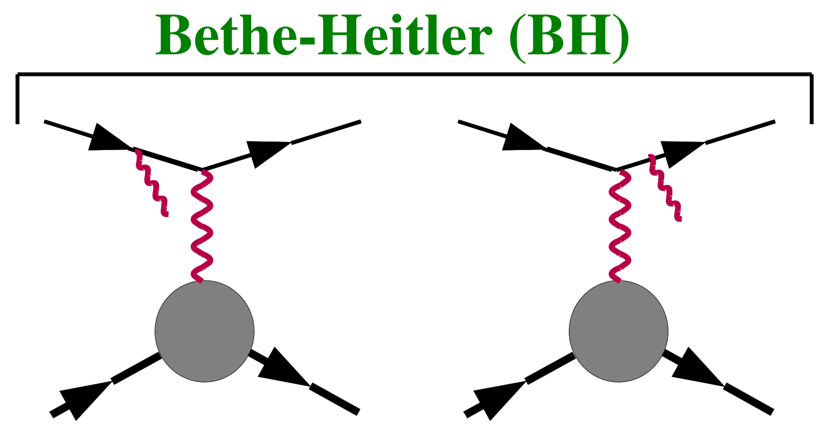
Generalized Parton Distributions (GPDs)



Deeply Virtual Compton Scattering (DVCS): Direct Access to GPDs



ep → e'p' γ



$$\frac{d^4\sigma}{dQ^2\, dx_B\, dt\, d\phi} \sim \left|\tau_{DVCS} + \tau_{BH}\right|^2$$

τ_{DVCS} **: derived from GPDs** τ_{BH} **: derived from form factors**

DVCS is one of the key reactions to determine GPDs experimentally
It is the simplest process that can be described in terms of GPDs

Target Spin Asymmetry for DVCS

Unpolarized electron beam

Longitudinally polarized proton target

$$e\vec{p} \to e' p \gamma$$

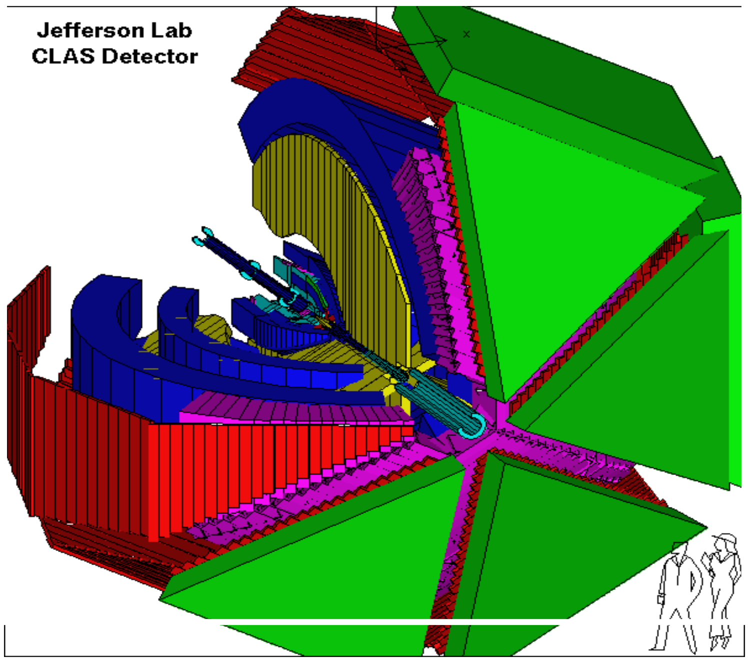
Goal: measuring the target spin asymmetry (A_{UL})

$$A_{UL}(\phi) = \frac{d\sigma^{\uparrow}(\phi) - d\sigma^{\downarrow}(\phi)}{d\sigma^{\uparrow}(\phi) + d\sigma^{\downarrow}(\phi)}$$

$$\propto \left\{ F_1 \widetilde{\mathrm{H}} + \xi (F_1 + F_2)(\mathrm{H} + \frac{\xi}{1+\xi}\mathrm{E}) - \xi(\frac{\xi}{1+\xi}F_1 + \frac{t}{4\mathrm{M}^2}F_2)\widetilde{\mathrm{E}} \right\} \sin\phi$$

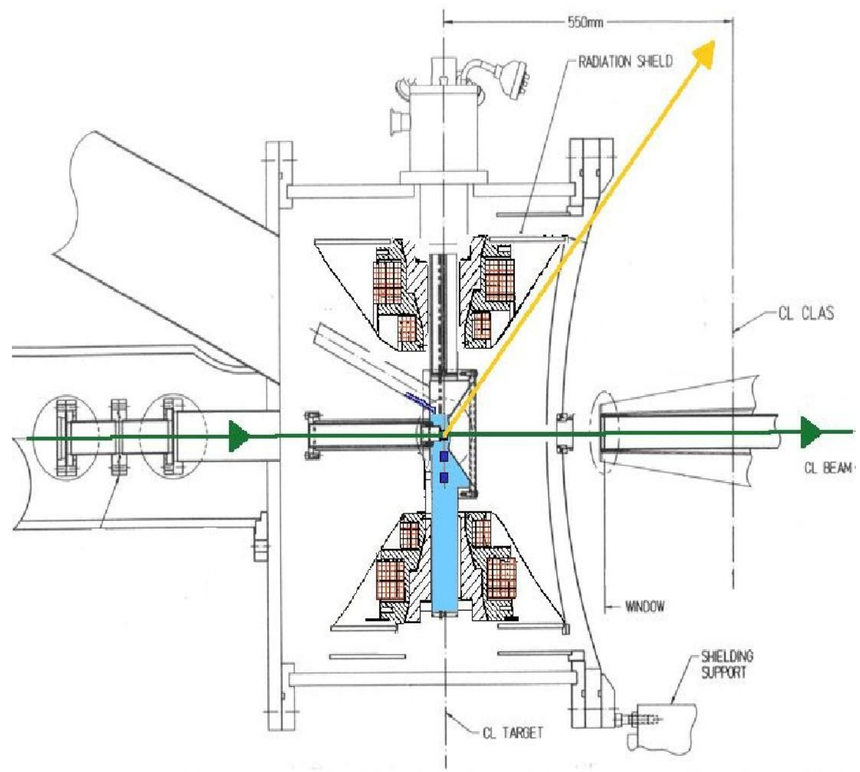
Kinematically Suppressed

CLAS EG1b Experiment



Longitudinally Polarized Target

- 5 Tesla magnetic field, $\delta B/B \approx 10^{-4}$
- 1K LHe cooling bath
- Dynamically polarized $^{15}NH_3$ target
- Polarization ~ 75%

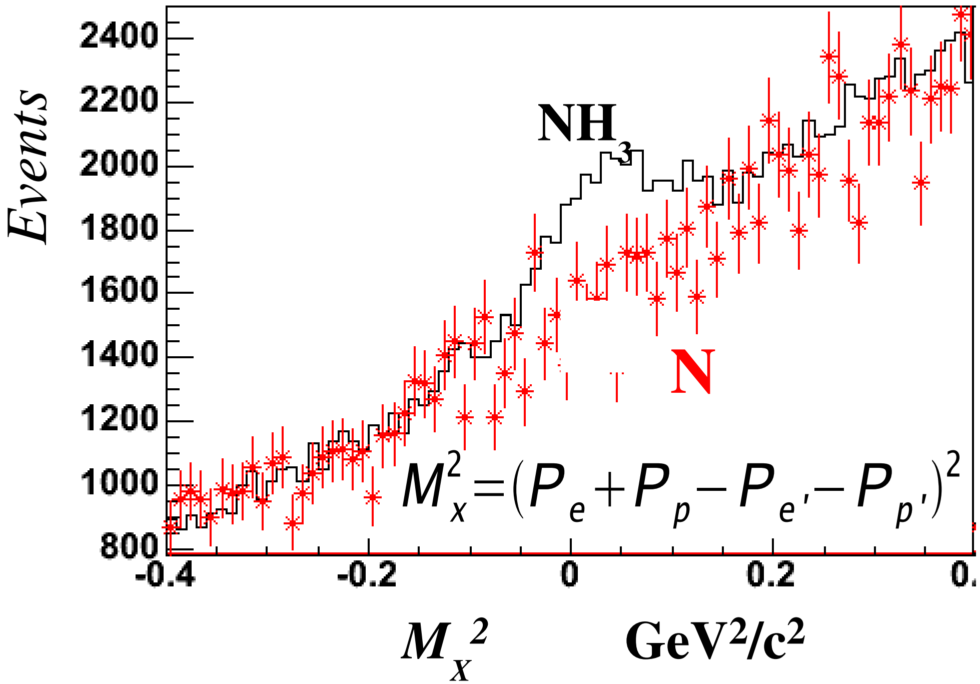


- 2000/2001 run
- 5.7 GeV electron beam
- Polarized $^{15}NH_3$ target
- Unpolarized ^{12}C , ^{15}N and ^{4}He targets

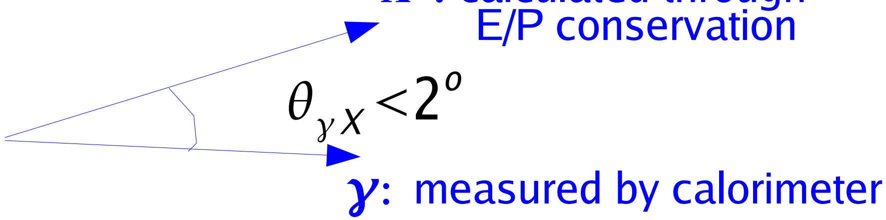
DVCS Events Selection

W > 2 GeV/c ,   -t < 0.6 GeV^2/c^2 , Q^2 > 1 GeV^2/c^2

e+p->e'+p'+γ + ...



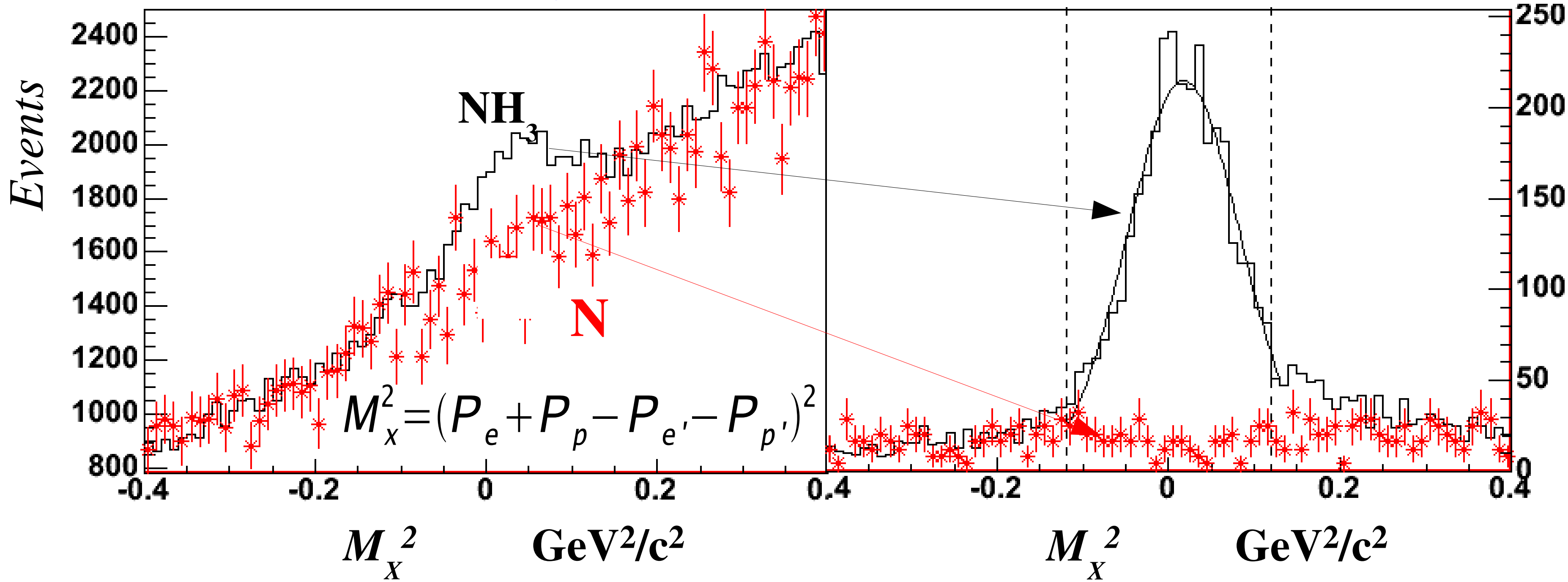
e+p->e'+p'+X



DVCS Events Selection

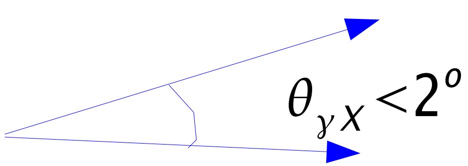
W > 2 GeV/c , -t < 0.6 GeV^2/c^2 , Q^2 > 1 GeV^2/c^2

e+p->e'+p'+γ + ... e+p->e'+p'+γ



e+p->e'+p'+X

X : calculated through E/P conservation



γ: measured by calorimeter

dilution factor:

$$f=\frac{N_h}{N_{nh_3}}=1-\frac{N_n}{N_{nh_3}}$$

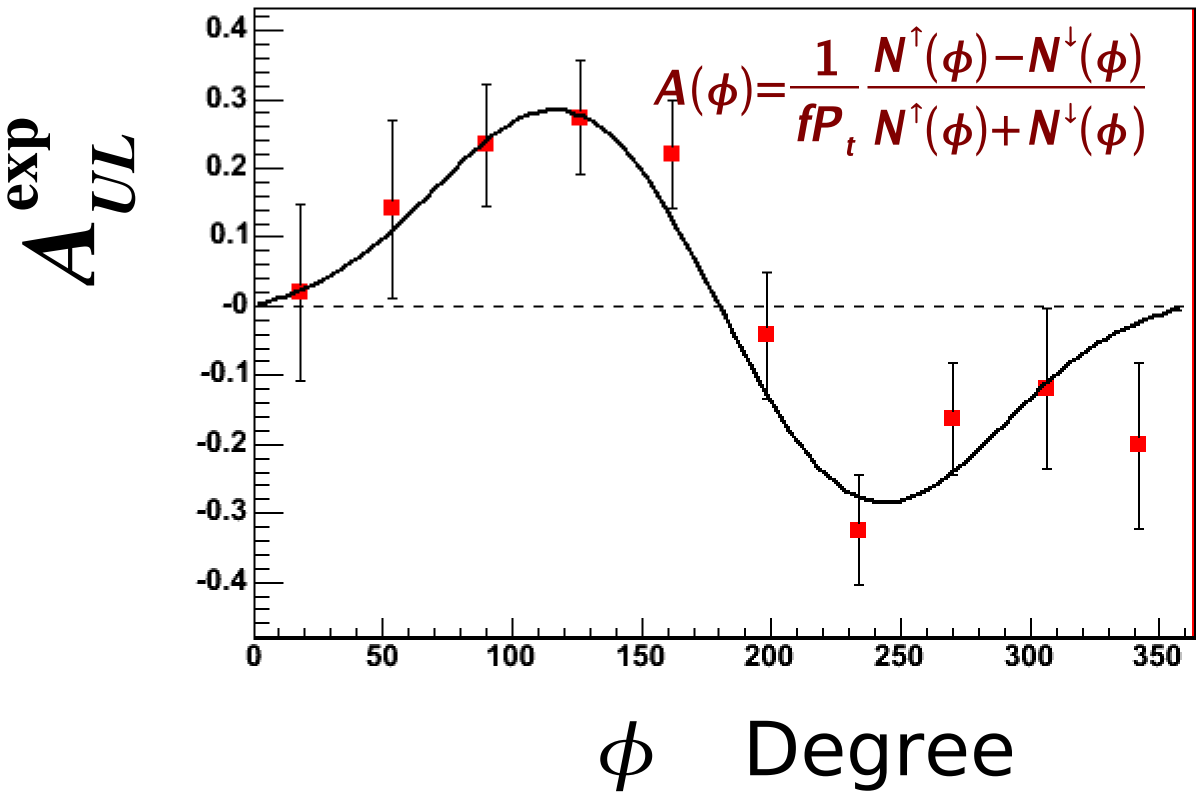
Measuring Target Spin Asymmetry

$$A(\phi)=\frac{1}{fP_t}\frac{N^{\uparrow}(\phi)-N^{\downarrow}(\phi)}{N^{\uparrow}(\phi)+N^{\downarrow}(\phi)}$$

- $N^{\uparrow(\downarrow)}$ is the luminosity-normalized and acceptance corrected number with positive (negative) target helicity
- P_t is target polarization
- f is dilution factor
- ϕ is the angle between reaction plane and scattering plane

"Observed" Single Photon Target Spin Asymmetry

Due to detector acceptance, the observed 1γ events can be contaminated by π^0



$$A_{UL}^{exp}(\phi)=\alpha\sin\phi+\beta\, sin2\,\phi$$

$$\alpha=0.240\pm0.042$$

$$\beta=-0.087\pm0.045$$

ϕ is the angle between the scattering plane and the reaction plane

We used observed π^0 data and Monte Carlo Studies to determine the π^0 Background

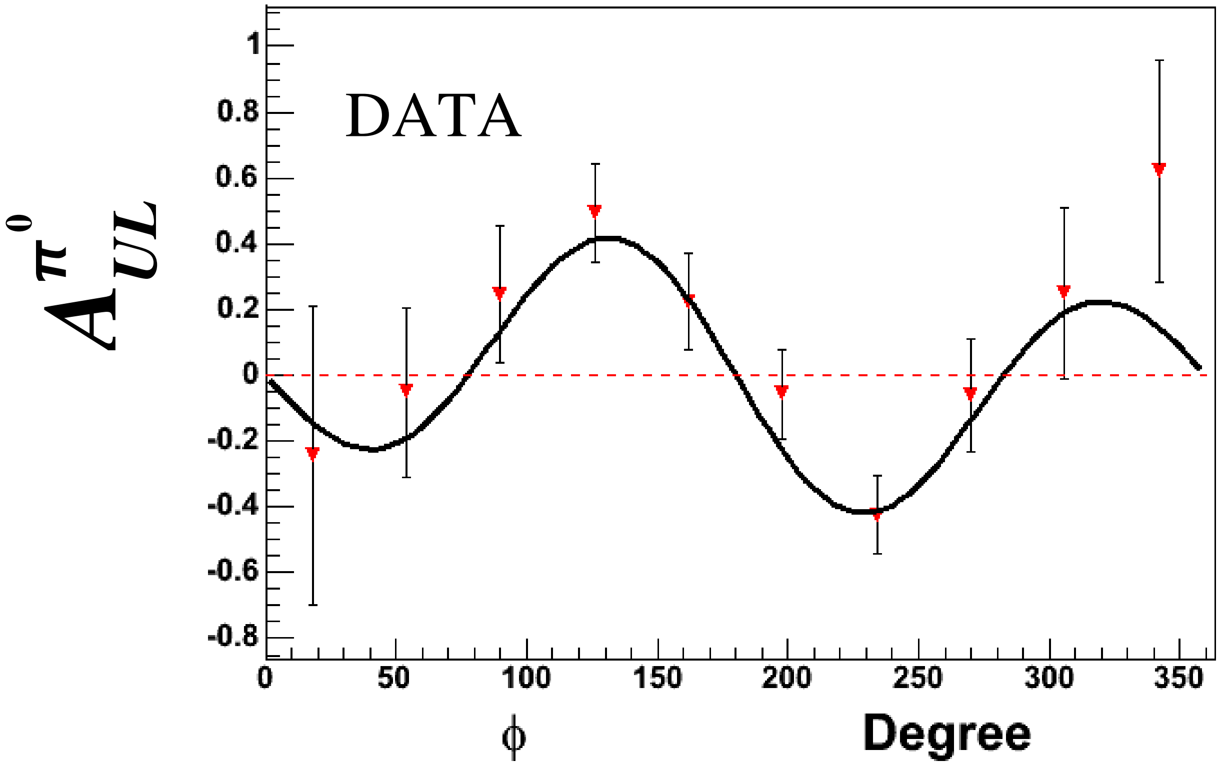
Will be measured

$$A_{UL}^{exp} = A_{UL}^{DVCS} F_{DVCS} + A_{UL}^{\pi^0} F_{\pi^0}$$

Measured

MC

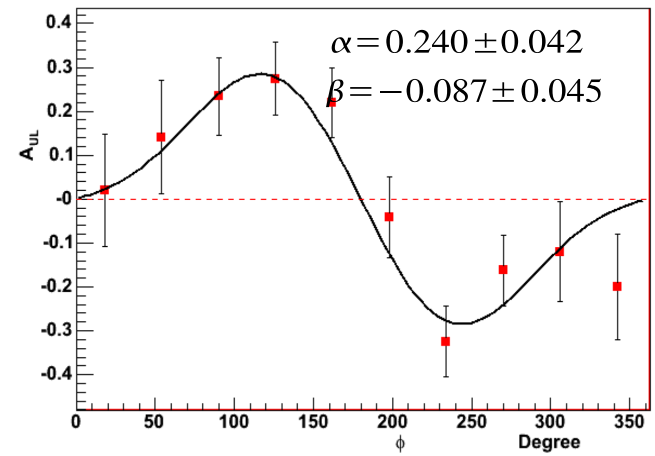
Target Spin Asymmetry for π^0



$$A_{UL}^{\pi^0} = \alpha \sin\phi + \beta \sin 2\phi$$

$$\alpha = 0.109 \pm 0.0561$$

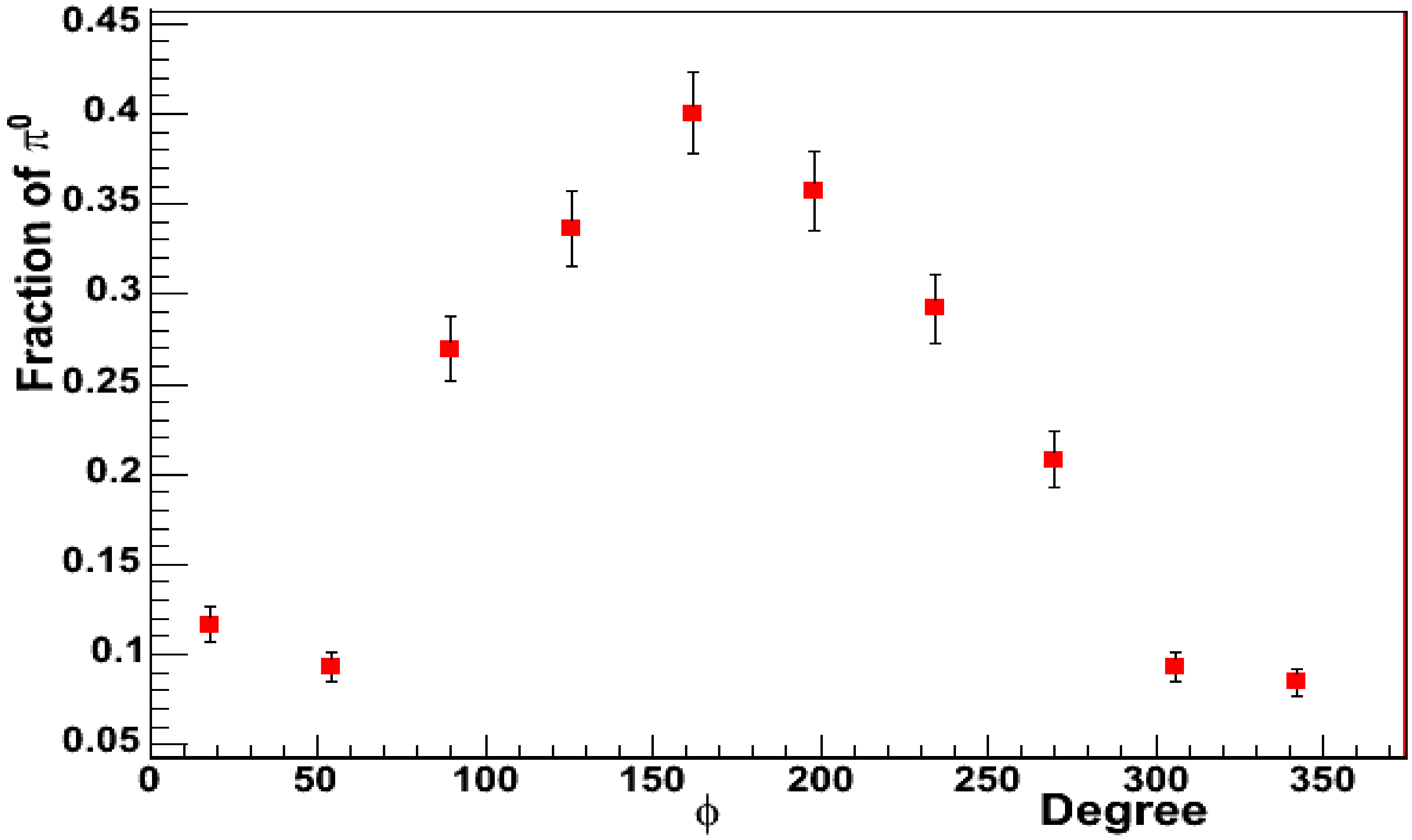
$$\beta = -0.319 \pm 0.0606$$



ϕ is the angle between the scattering plane and the reaction plane

The ϕ dependence of the asymmetry is dominated by sin2ϕ moment
Different with the ϕ dependence of the asymmetry for DVCS

π^0 Fraction in "observed" Single Photon Events

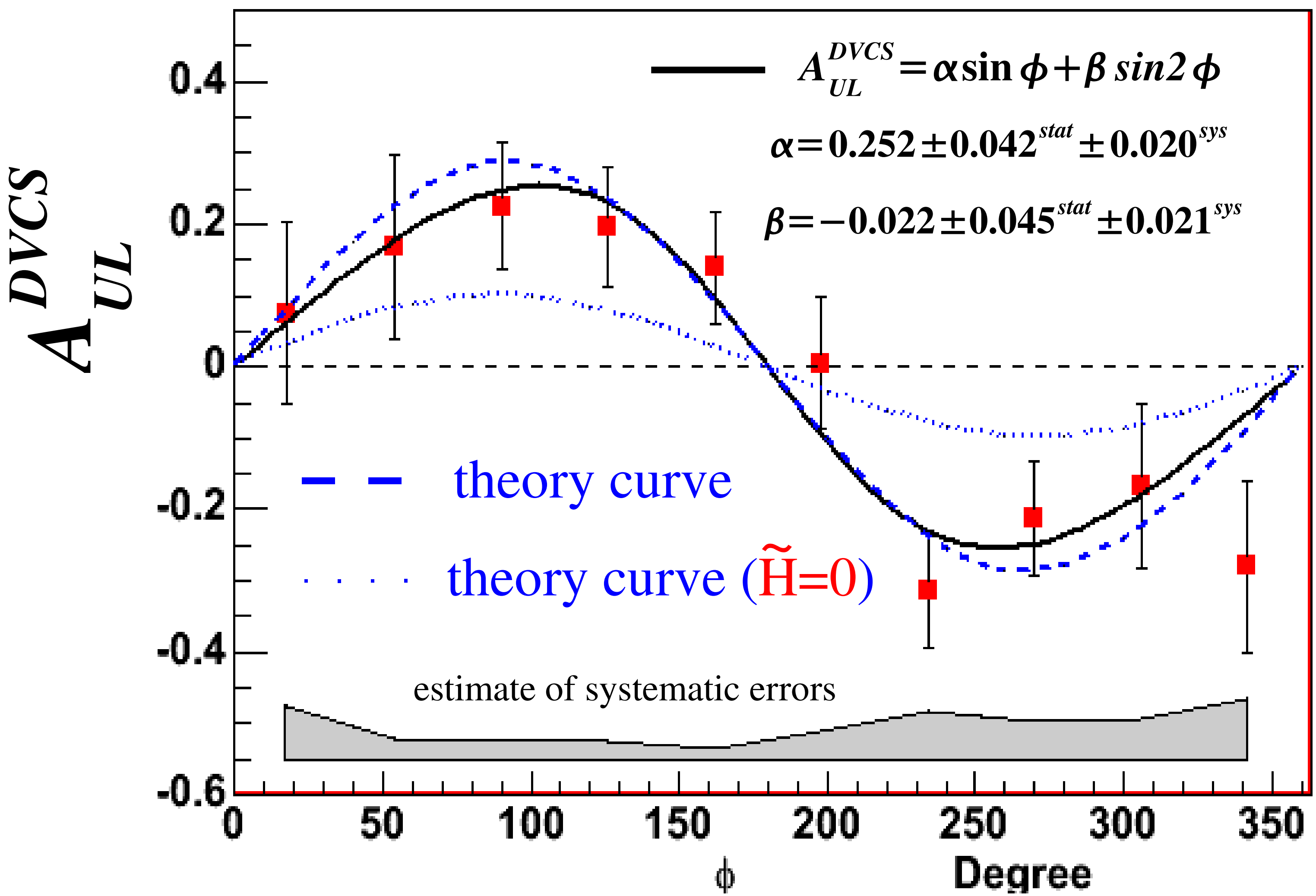


Target Spin Asymmetry for DVCS

$$A_{UL}^{\exp}(\phi) = A_{UL}^{DVCS}(\phi)\, F_{DVCS}(\phi) + A_{UL}^{\pi^0}(\phi)\, F_{\pi^0}(\phi)$$

✓ ? ✓ ✓ ✓

Target Spin Asymmetry for DVCS



$\langle Q^2 \rangle = 1.82$ GeV^2/c^2

$\langle -t \rangle = 0.31$ GeV^2/c^2

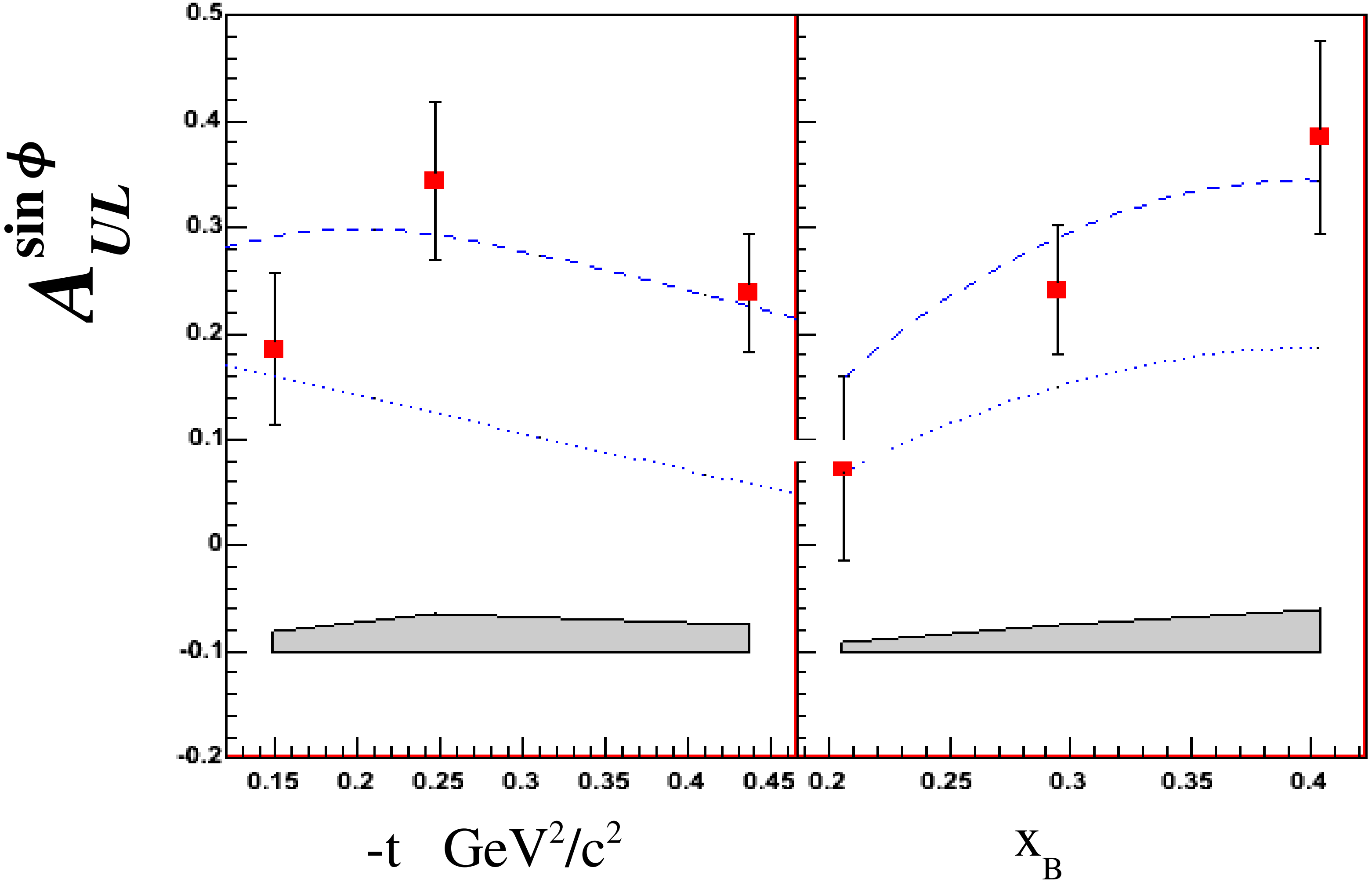
$\langle x_B \rangle = 0.28$

$$A_{UL}^{exp} = A_{UL}^{DVCS} F_{DVCS} + A_{UL}^{\pi^0} F_{\pi^0}$$

$$\alpha \propto F_1 \tilde{H} + \xi (F_1 + F_2) H$$

Model calculation is based on M. Vanderhaeghen, et al, Phy. Rev. D. (1999)

Kinematic Dependence



Model calculation is based on M. Vanderhaeghen, et al, Phy. Rev. D. (1999)

Summary

- First measured target spin asymmetry for DVCS shows asymmetry with approximate $\alpha\sin\phi+\beta\sin2\phi$ modulation
    - α= 0.252 ±0.042(stat)±0.020(sys)
    - β= -0.022 ±0.045(stat)±0.021(sys)
- DVCS asymmetry is dominated by $\sin\phi$ moment
- The measurements agree well with model calculations
- The asymmetry is sensitive to GPD $\tilde{H}$
- Combined with precision measurements of the beam spin asymmetry, these results will allow us to constrain different GPDs
- These results were submitted to *Phys. Rev. Lett.* (hep-ex/0605012)