

MEASUREMENT OF DEEPLY VIRTUAL COMPTON SCATTERING AT HERMES

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FOR THE HERMES–Collaboration

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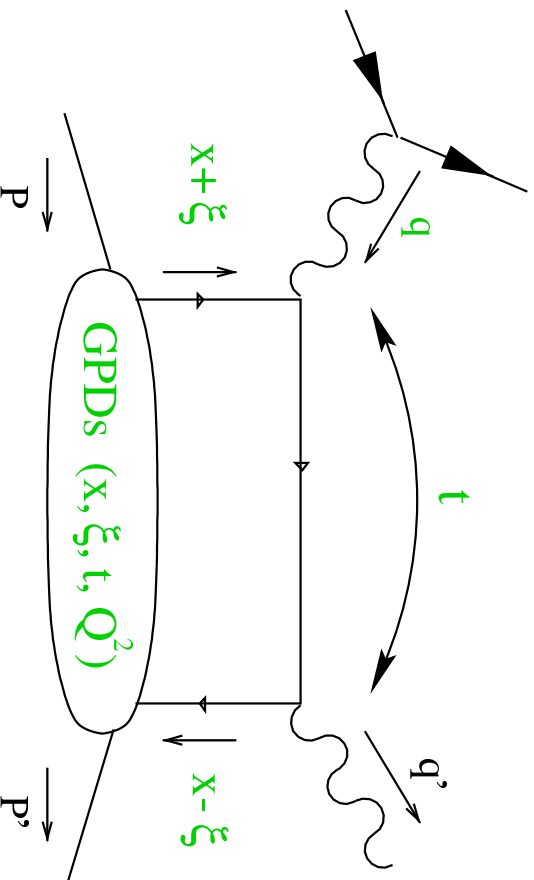
- DEEPLY VIRTUAL COMPTON SCATTERING (DVCS)
- DVCS MEASUREMENT AT HERMES
- HERMES RESULTS ON SPIN AND CHARGE AZIMUTHAL ASYMMETRIES
- SUMMARY AND OUTLOOK

DEEPLY VIRTUAL COMPTON SCATTERING (DVCS)

HARD PHOTOPRODUCTION OF A REAL PHOTON: $\gamma^* N \rightarrow N' \gamma$

HIGHLY VIRTUAL PHOTON GENERATED BY LEPTON SCATTERING

$\Rightarrow e N \rightarrow e' N' \gamma$ (DVCS)



TOTAL ANGULAR MOMENTUM:

$$J^q = \lim_{t \rightarrow 0} \frac{1}{2} \int_{-1}^1 dx x [H^q(x, \xi, t) + E^q(x, \xi, t)]$$

NUCLEON STRUCTURE:

GPDs: $H, \tilde{H}, E, \tilde{E}$

GPDs \rightarrow *PDFs*

$$\tilde{H}(x, 0, 0) = q(x)$$

$$\tilde{H}(x, 0, 0) = \Delta q(x)$$

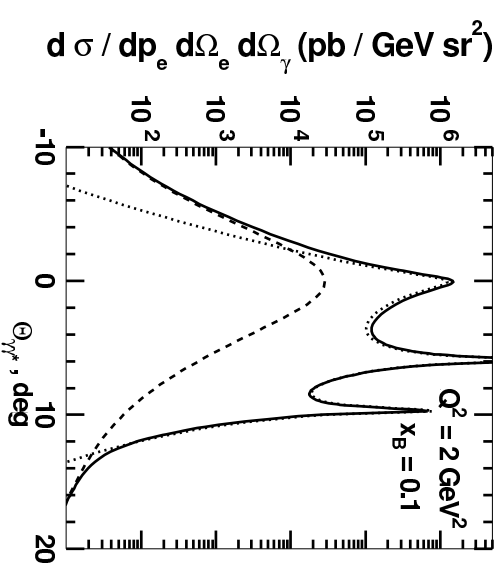
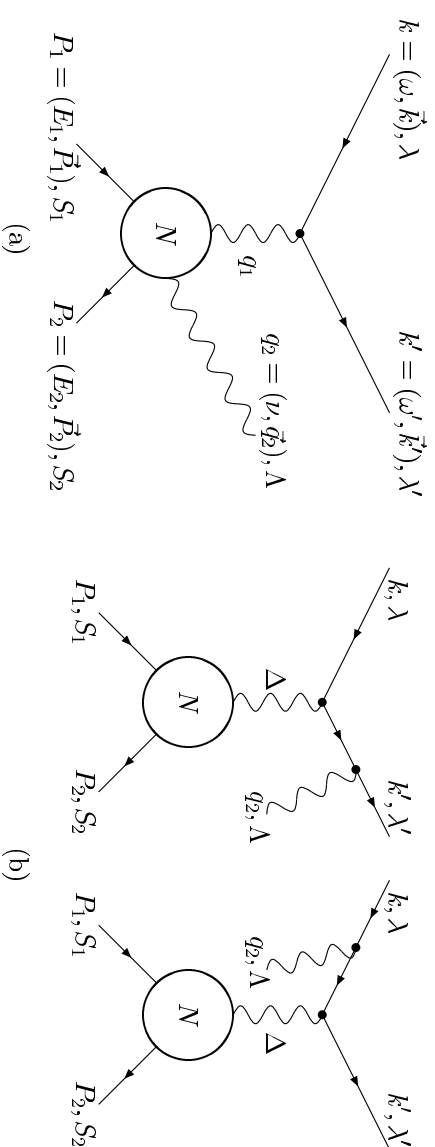
GPDs \rightarrow *FFs*

$$\int_{-1}^1 dx H(x, \xi, t) = F_1(t), \dots$$

GPDs ACCESSIBLE IN **EXCLUSIVE** REACTIONS \Rightarrow **DVCS** IS THE SIMPLEST AND ONE OF THE CLEANEST PROCESSES TO PROBE *GPDs*

DVCS-BH INTERFERENCE

DVCS AND BETHE-HEITLER (BH) PROCESSES HAVE THE SAME INITIAL AND FINAL STATES \Rightarrow TWO SUBPROCESSES INTERFERE



PHOTON LEPTOPRODUCTION CROSS SECTION:

$$d\sigma \propto \tau_{\text{DVCS}} + \tau_{\text{BH}} \ll \tau_{\text{DVCS}}^2 + \tau_{\text{BH}}^2 + \underbrace{(\tau_{\text{DVCS}}^* \tau_{\text{BH}} + \tau_{\text{BH}}^* \tau_{\text{DVCS}})}_I$$

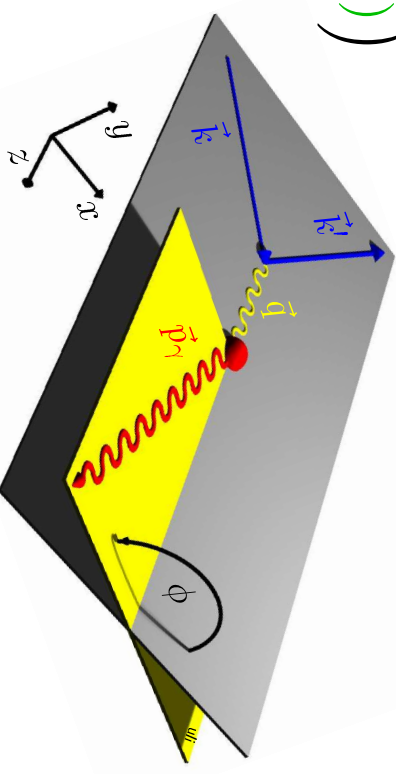
DVCS AMPLITUDES: ACCESSIBLE THROUGH AZIMUTHAL ASYMMETRIES VIA I (GPDs ENTER IN LINEAR COMBINATIONS IN AMPLITUDES)

AZIMUTHAL ASYMMETRIES AT HERMES

$$|\tau_{DVCS}|^2 \propto c_0^{DVCS} + \sum_{n=1}^2 c_n^{DVCS} \cos(n\phi) + \lambda s_1^{DVCS} \sin(\phi)$$

$$I \propto \pm \left(c_0^I + \sum_{n=1}^3 c_n^I \cos(n\phi) + \lambda \sum_{n=1}^2 s_n^I \sin(n\phi) \right)$$

$$|\tau_{BH}|^2 \propto c_0^{BH} + \sum_{n=1}^2 c_n^{BH} \cos(n\phi)$$



BEAM-CHARGE ASYMMETRY (BCA) AND BEAM-SPIN ASYMMETRY (BSA)

AT LEADING TWIST:

$$\text{BCA : } d\sigma(e^+p) - d\sigma(e^-p) \sim c_1^I \cos(\phi) \sim \cos(\phi) \times \text{Re } M^{1,1}$$

$$\text{BSA : } d\sigma(\overrightarrow{e^+p}) - d\sigma(\overleftarrow{e^+p}) \sim s_1^I \sin(\phi) \sim \sin(\phi) \times \text{Im } M^{1,1}$$

\Rightarrow **REAL AND IMAGINARY PART** OF THE HELICITY CONSERVING AMPLITUDE $M^{1,1}$ CAN BE ACCESSED VIA **BEAM-CHARGE AND BEAM-SPIN ASYMMETRY**

(OTHER AMPLITUDES $\rightarrow \cos 2\phi, \cos 3\phi, \sin 2\phi$)

HERMES EVENT SELECTION

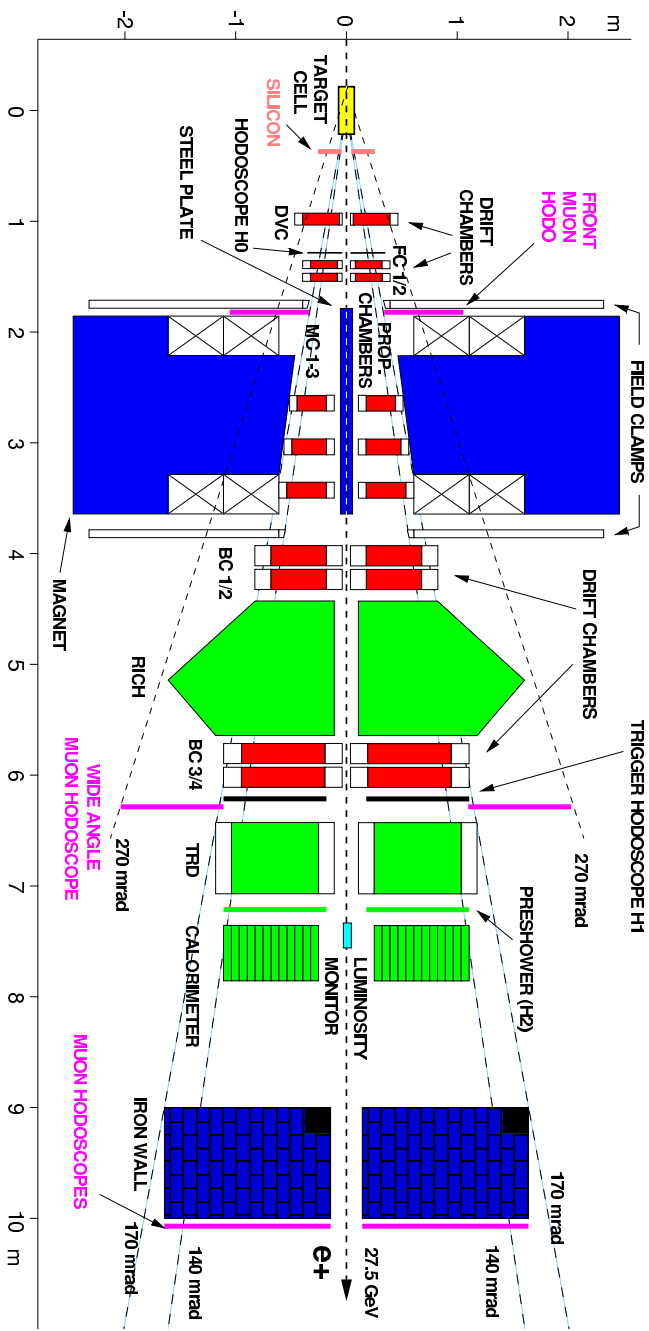
FIXED TARGET:

BEAM:

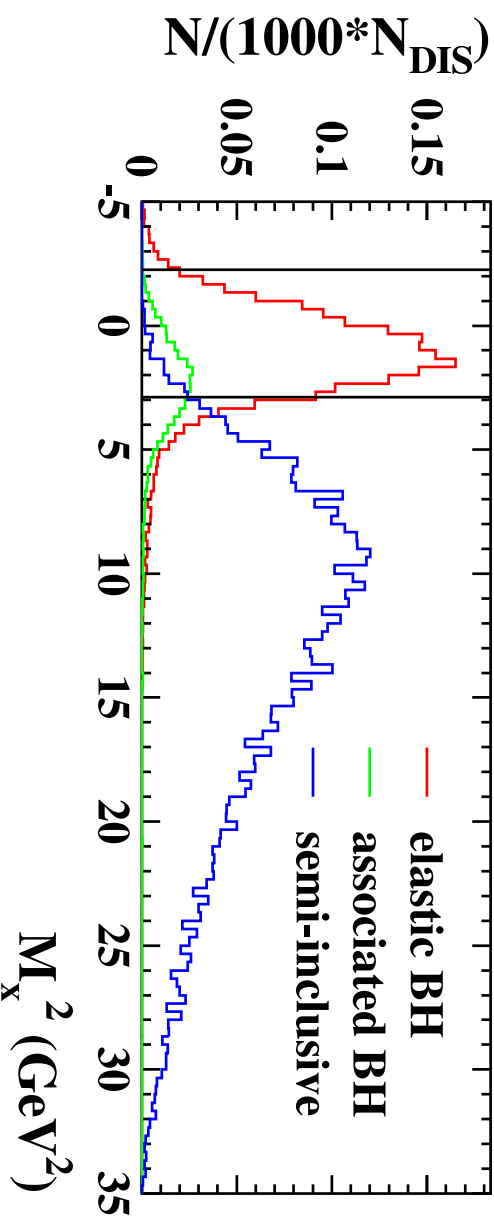
27.6 GEV

e^+ AND e^-

$\langle P \rangle \approx 55\%$

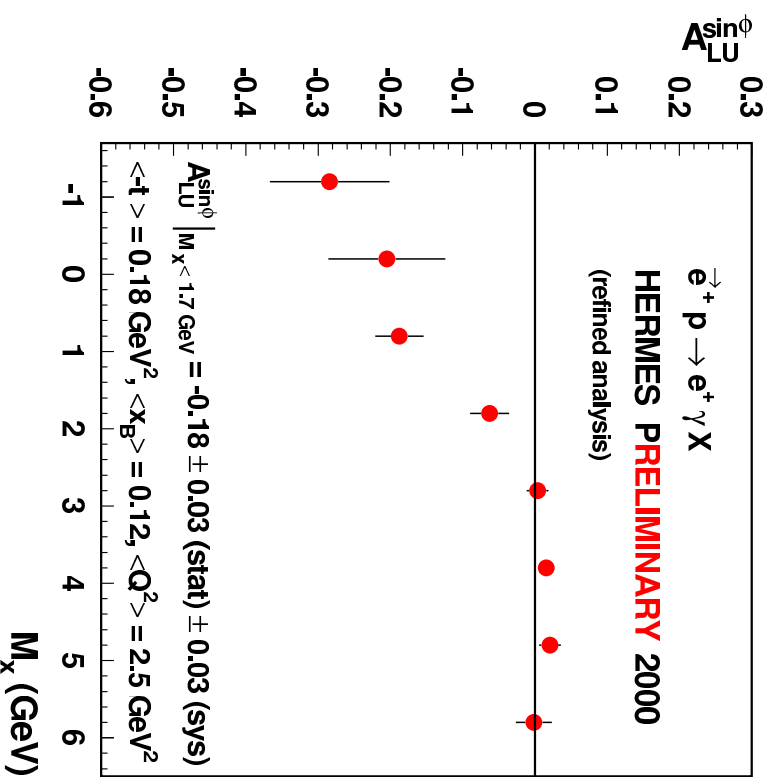
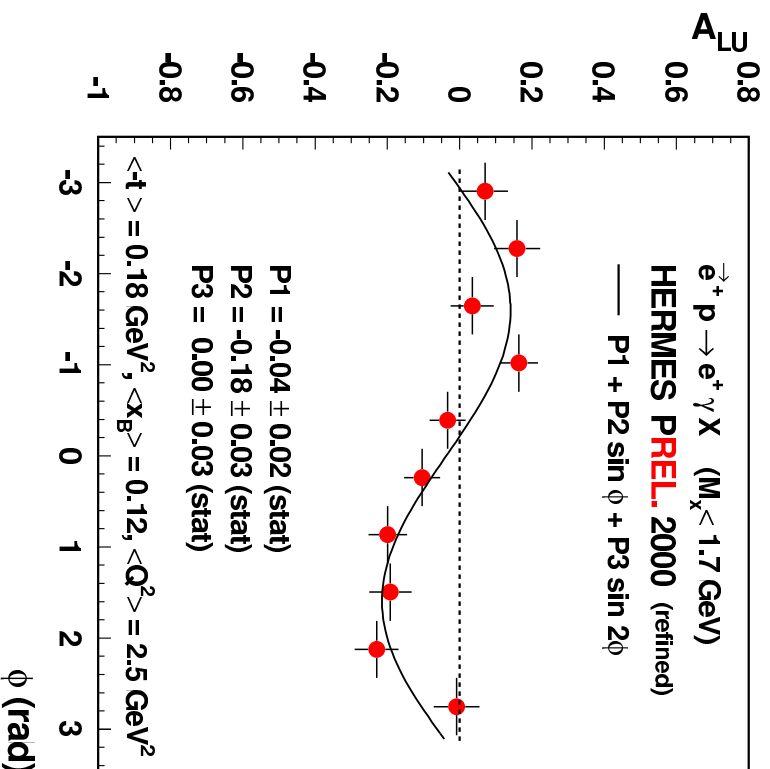


NO RECOIL
 DETECTION \Rightarrow
 EXCLUSIVITY VIA
 MISSING MASS
 $M_x^2 = (q + P - q')^2$



BEAM-SPIN ASYMMETRY ON PROTON

$$A_{LU}(\phi) = \frac{1}{\langle |P_b| \rangle} \frac{\vec{N}(\phi) - \overleftarrow{N}(\phi)}{\vec{N}(\phi) + \overleftarrow{N}(\phi)}$$



A_{LU} IN EXCLUSIVE BIN:

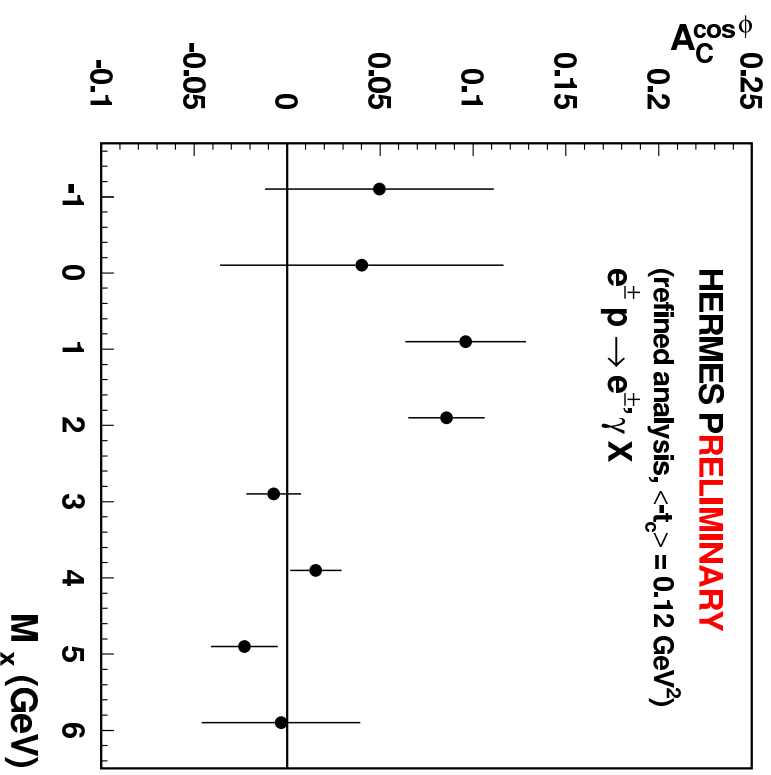
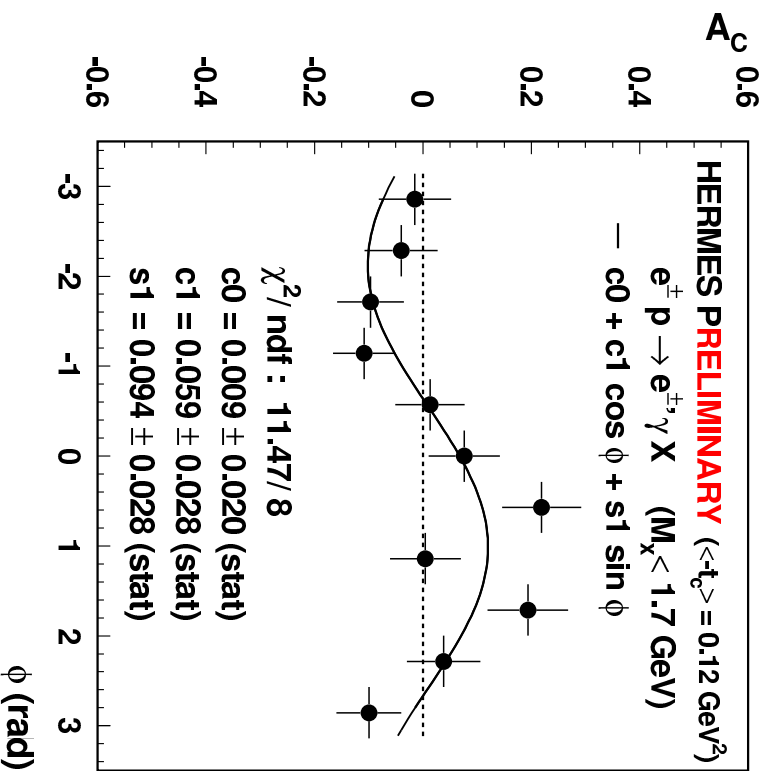
EXPECTED $\sin(\phi)$ DEPENDENCE

$\sin(\phi)$ -MOMENT IN NON-EXCLUSIVE REGION: SLIGHTLY POSITIVE ($\rightarrow \pi^0$)

PUBLISHED RESULTS: HERMES-PRL **87**, 182001 (2001), CLAS-PRL **87**, 18202 (2001)

BEAM-CHARGE ASYMMETRY ON PROTON

$$A_C(\phi) = \frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)}$$



A_C IN EXCLUSIVE BIN:
 EXPECTED $\cos(\phi)$ DEPENDENCE

$\cos(\phi)$ -MOMENTS ZERO AT HIGHER
 MISSING MASS

DVCS ON DEUTERIUM TARGET

- DEUTERIUM IS A **SPIN 1** NUCLEUS ($m = \pm 1, 0$)
- \Rightarrow **9** COMPTON FORM FACTORS (**CFFs**) REQUIRED
- \Rightarrow **9** **GPDs** ($H_1-H_5, \tilde{H}_1-\tilde{H}_4$)

$$ed \rightarrow e\gamma X$$

CONTRIBUTED PROCESSES:

- $ed \rightarrow ed\gamma$, COHERENT PROCESS
- $ed \rightarrow epn\gamma$, INCOHERENT PROCESS
- $eN \rightarrow eN^*\gamma$, RESONANT STATES

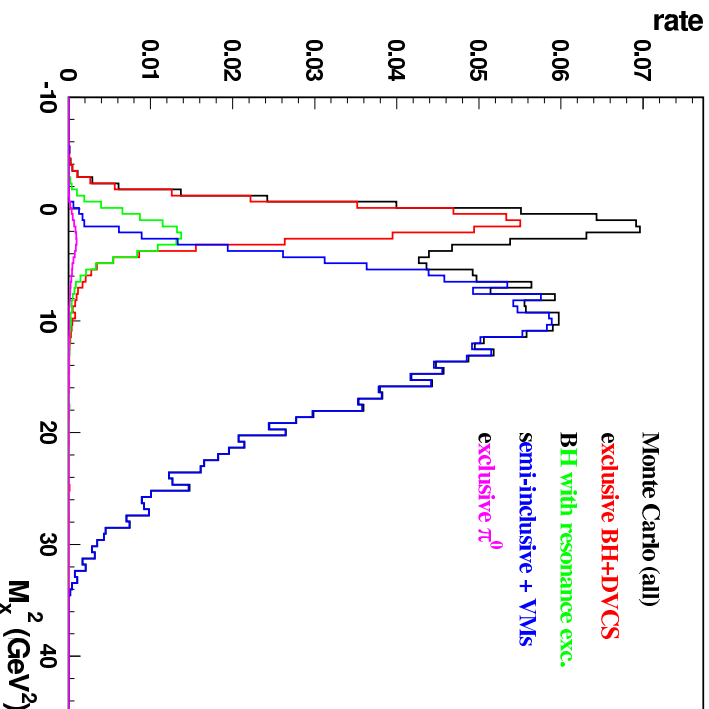
$-t < 0.7 \text{ GeV}^2 \Rightarrow$ COHERENT $\approx 20\%$

$\Rightarrow M_x$ CALCULATED VIA PROTON MASS

SMALLER $-t \Rightarrow$ COHERENT ENHANCED

BACKGROUND \Rightarrow DECAY PHOTONS FROM:

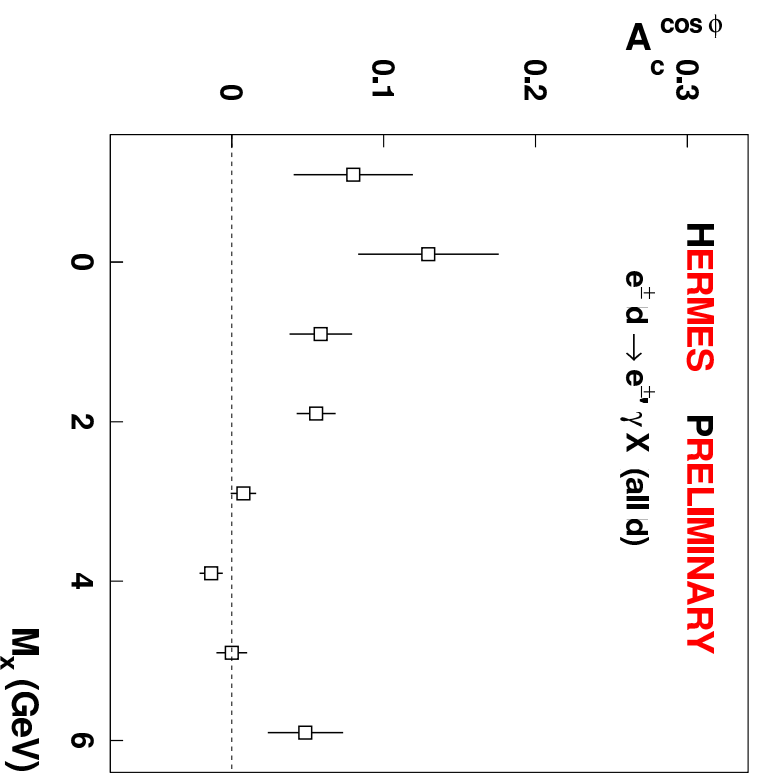
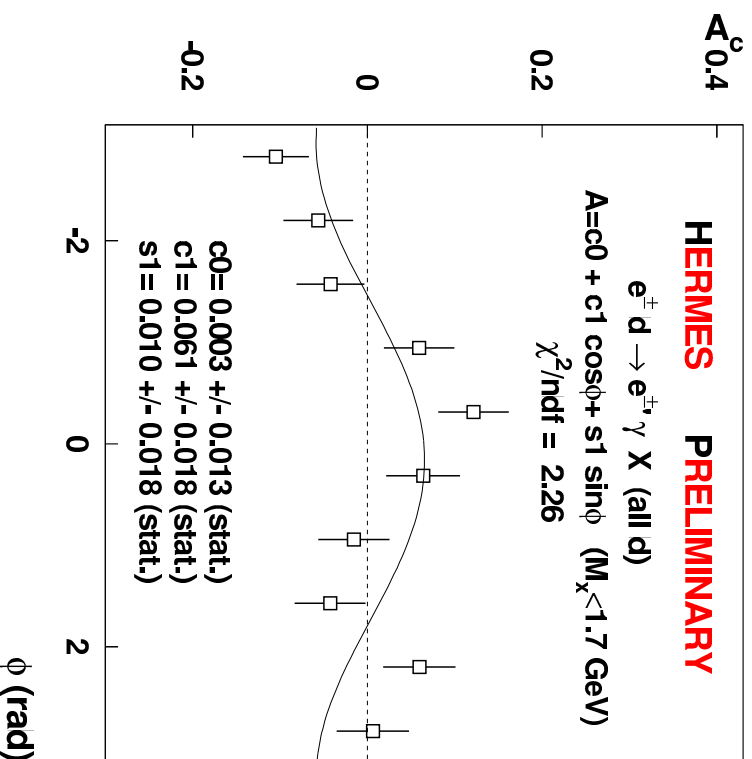
- SEMI-INCLUSIVE π^0
- EXCLUSIVE π^0



FINALLY THE **RESULTS** ARE CORRECTED FOR THE FRACTIONAL CONTRIBUTION OF THE BACKGROUND

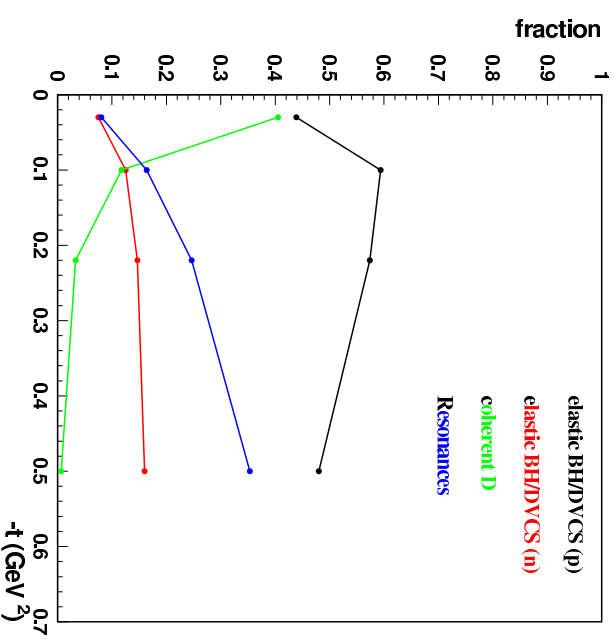
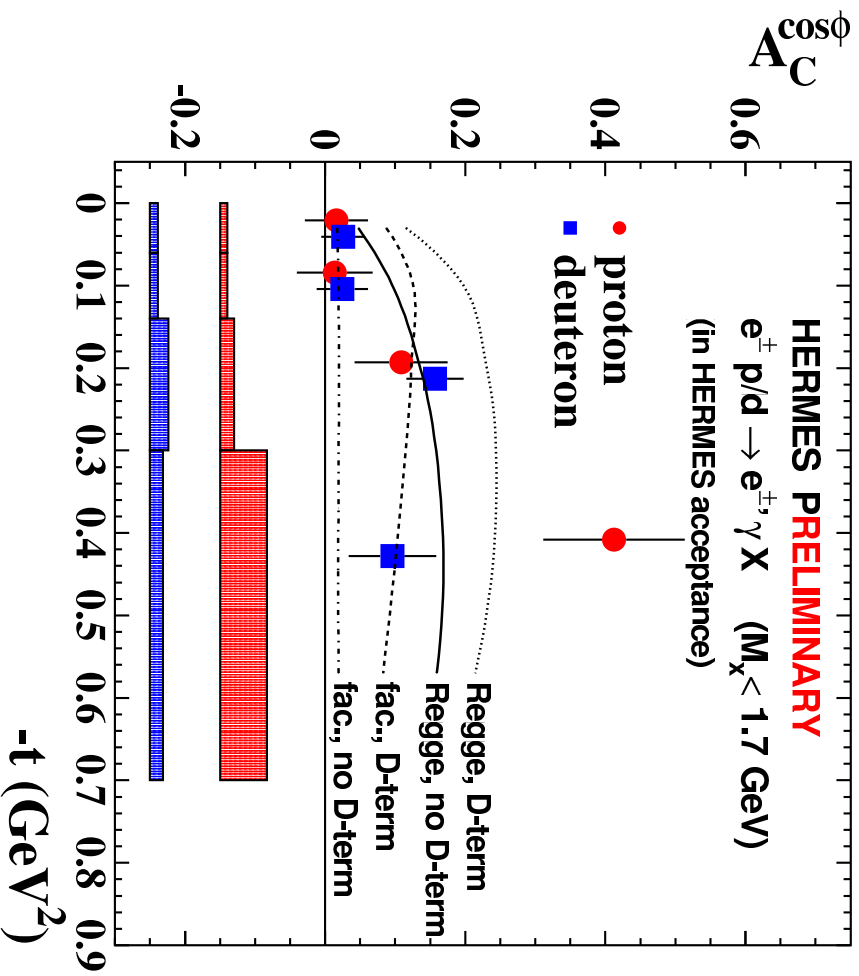
BCA ON DEUTERIUM TARGET

$$A_C(\phi) = \frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)}$$



$$A_{C, Deuteron}^{\cos\phi} \approx A_{C, Proton}^{\cos\phi}$$

COMPARISON TO MODEL CALCULATIONS



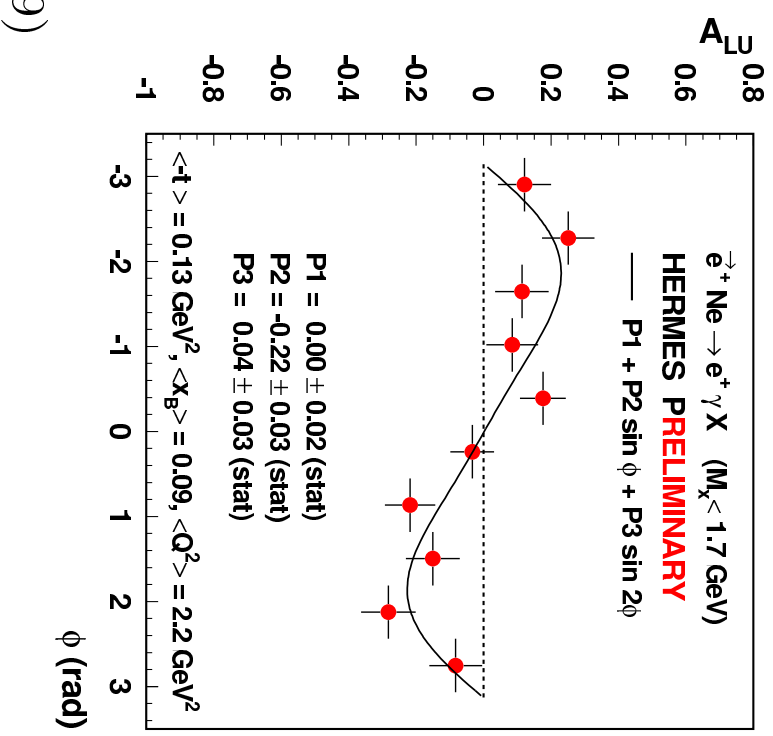
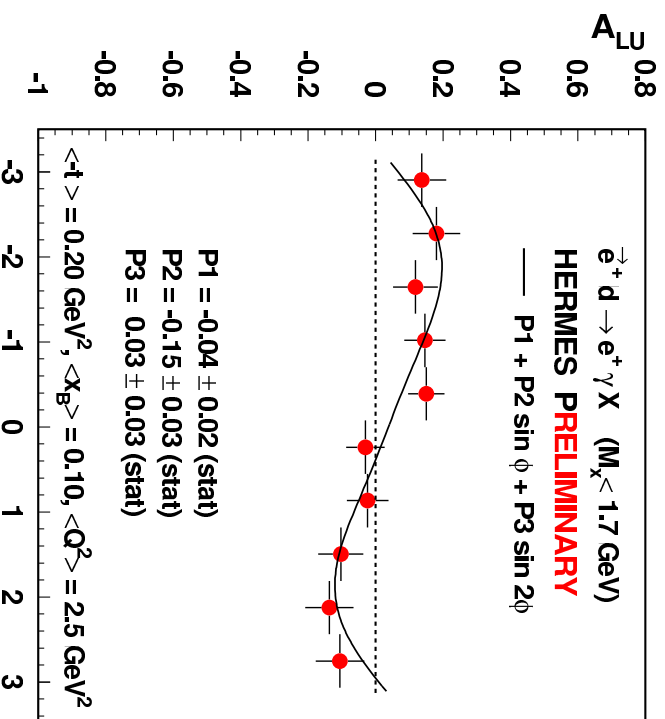
COHERENT PRODUCTION
 IN FIRST t -BIN ($\approx 40\%$)
 \rightarrow NO EFFECT SEEN
 DIFFERENCE IN LAST BIN
 (NEUTRON RESONANCES,
 NEUTRON)

SMALL $e^- p$ SAMPLE ($L \approx 10$ PB⁻¹)

\Rightarrow t -DEPENDENCE OF BCA \rightarrow POSSIBLE TOOL TO CONSTRAIN GPDs

BEAM-SPIN ASYMMETRY ON DEUTERIUM AND NEON

INVESTIGATE THE INTERNAL STRUCTURE OF NUCLEI



(HEP-EX/02012019)

CALCULATIONS FOR DVCS ON (HEAVIER) NUCLEI (KIRCHNER, MÜLLER, HEP-PH/0302007, GUZEY, STRIKMAN, HEP-PH/0301216, ...)

- PRELIMINARY RESULT OF BSA ON KR

SUMMARY AND OUTLOOK

- FIRST MEASUREMENT OF THE T-DEPENDENCE OF THE BEAM-CHARGE ASYMMETRY ON PROTON \Rightarrow ACCESS TO THE GPD H
- FIRST MEASUREMENTS OF THE BEAM-CHARGE ASYMMETRY ON DEUTRON
- \tilde{H}, E AND \tilde{E} ACCESSIBLE INVOLVING TARGET-SPIN ASYMMETRY (ANALYSIS IN PROGRESS) ON LONGITUDINALLY POLARIZED TARGETS AND TRANSVERSELY POLARIZED PROTON TARGET (HERA II)
- DVCS ON NUCLEI: NEW DATA ON KR, XE
- LARGE-ACCEPTANCE RECOIL DETECTOR FOR HERMES (2005/2006)
|| RUNNING PERIOD) ||