DEEPLY VIRTUAL COMPTON SCATTERING AT 6.5 GEV AND 7.5 GEV POLARIZED ELECTRON BEAM WITH CLAS12

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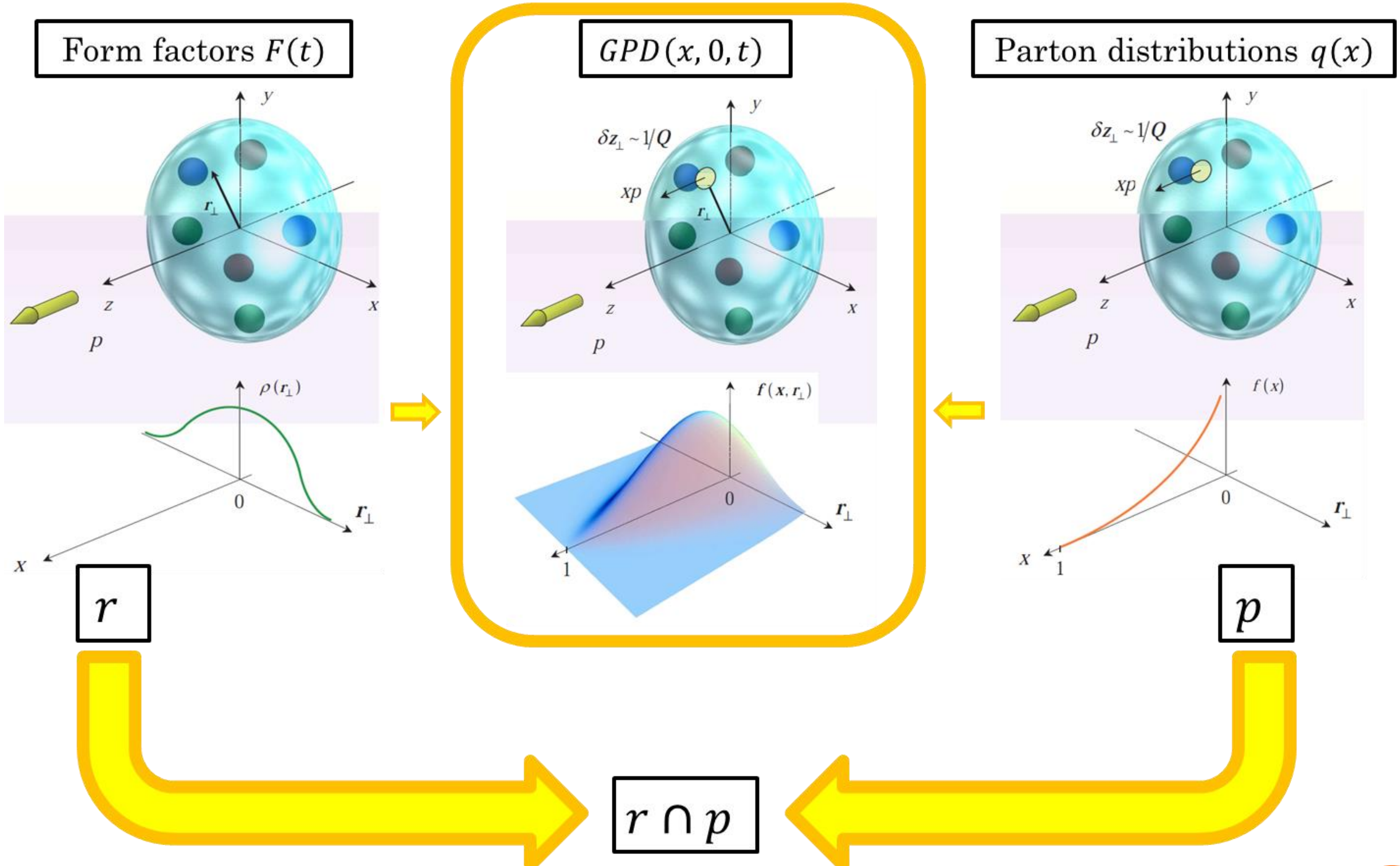
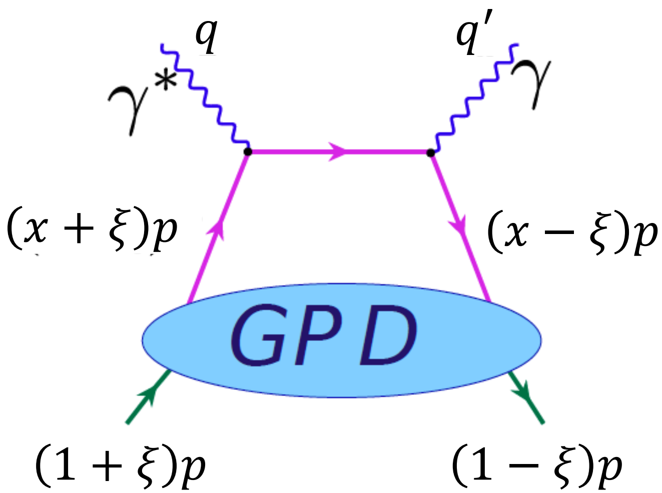
I. Introduction

Generalized Parton Distributions

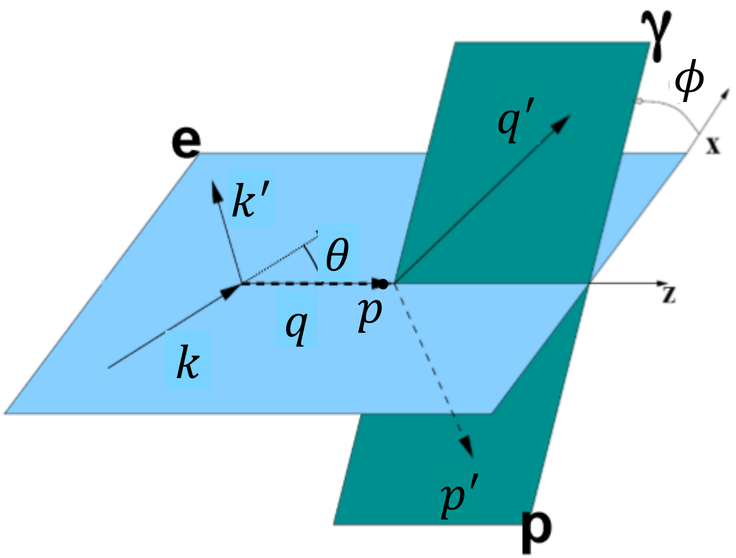


GPDs map the 3D nucleon structure as the quark's longitudinal momentum correlated with its transverse spatial distributions.

Deeply Virtual Compton Scattering



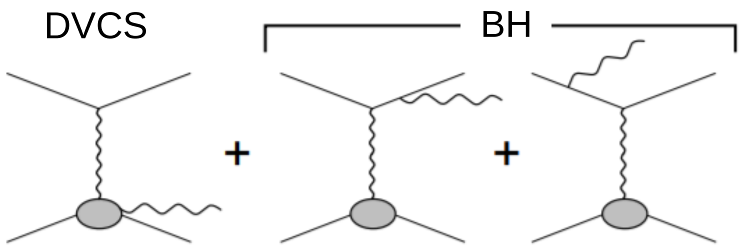
DVCS accessing GPDs



DVCS kinematics:
scattering plane (light blue)
and reaction plane (cyan)

Deeply virtual Compton scattering (DVCS) provides the cleanest access to chiral-even GPDs: H^q primarily, $\widetilde{H}^q$ and E^q.

DVCS and Bethe-Heitler



Amplitude of photon production:

$$\mathcal{T}^2 = |\mathcal{T}_{\mathrm{DVCS}} + \mathcal{T}_{BH}|^2 = |\mathcal{T}_{\mathrm{DVCS}}|^2 + |\mathcal{T}_{BH}|^2 + \mathcal{I}$$

Beam spin asymmetry for unpolarized target:

$$A_{\mathrm{LU}}(\phi) \propto s_{1,\mathrm{unp}}^{\mathcal{I}} \sin(\phi)$$

$$A_{\mathrm{LU}}(\phi) = \frac{d\sigma^{\uparrow}(\phi) - d\sigma^{\downarrow}(\phi)}{d\sigma^{\uparrow}(\phi) + d\sigma^{\downarrow}(\phi)} = \frac{1}{P}\frac{N^{\uparrow}(\phi) - N^{\downarrow}(\phi)}{N^{\uparrow}(\phi) + N^{\downarrow}(\phi)}$$

$$A_{\mathrm{LU}}(\phi) \propto \Im\mathfrak{m}\left\{F_1\mathcal{H} + \frac{x_B}{2 - x_B}(F_1 + F_2)\widetilde{\mathcal{H}} + \frac{t}{4M^2}F_2\mathcal{E}\right\}\sin(\phi)$$

Compton form factors $\mathcal{H}$, $\widetilde{\mathcal{H}}$ and $\mathcal{E}$:

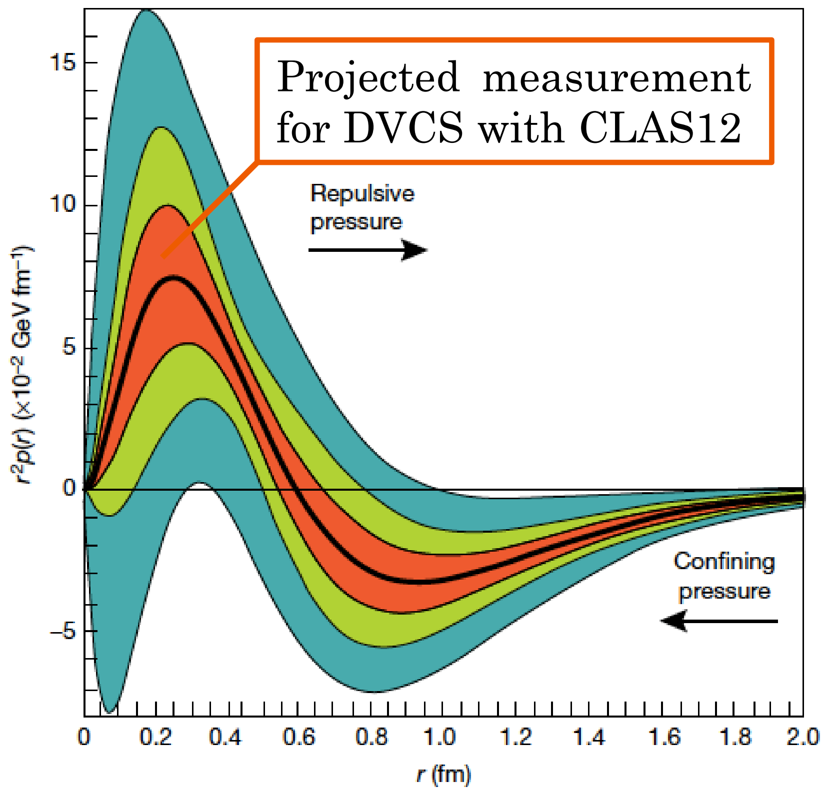
$$\{\mathcal{H}, \mathcal{E}\}(\xi, t, Q^2) = \sum_q \int_{-1}^{1} dx C_q^{(-)}(\xi, x)\{H^q, E^q\}(x, \xi, t, Q^2)$$

$$\widetilde{\mathcal{H}}(\xi, t, Q^2) = \sum_q \int_{-1}^{1} dx C_q^{(+)}(\xi, x)\widetilde{H}^q(x, \xi, t, Q^2)$$

DVCS measured at different beam energies allows the extraction of $|\mathcal{T}_{\mathrm{DVCS}}|^2$ for which GPD enters through the Compton form factor $\mathcal{H}(\xi, t)$.

DVCS at Multiple Beam Energies

Nucleon Pressure Distribution



V.D. Burkert, L. Elouadrhiri, & F.X. Girod, Nature,557 396 (2018)

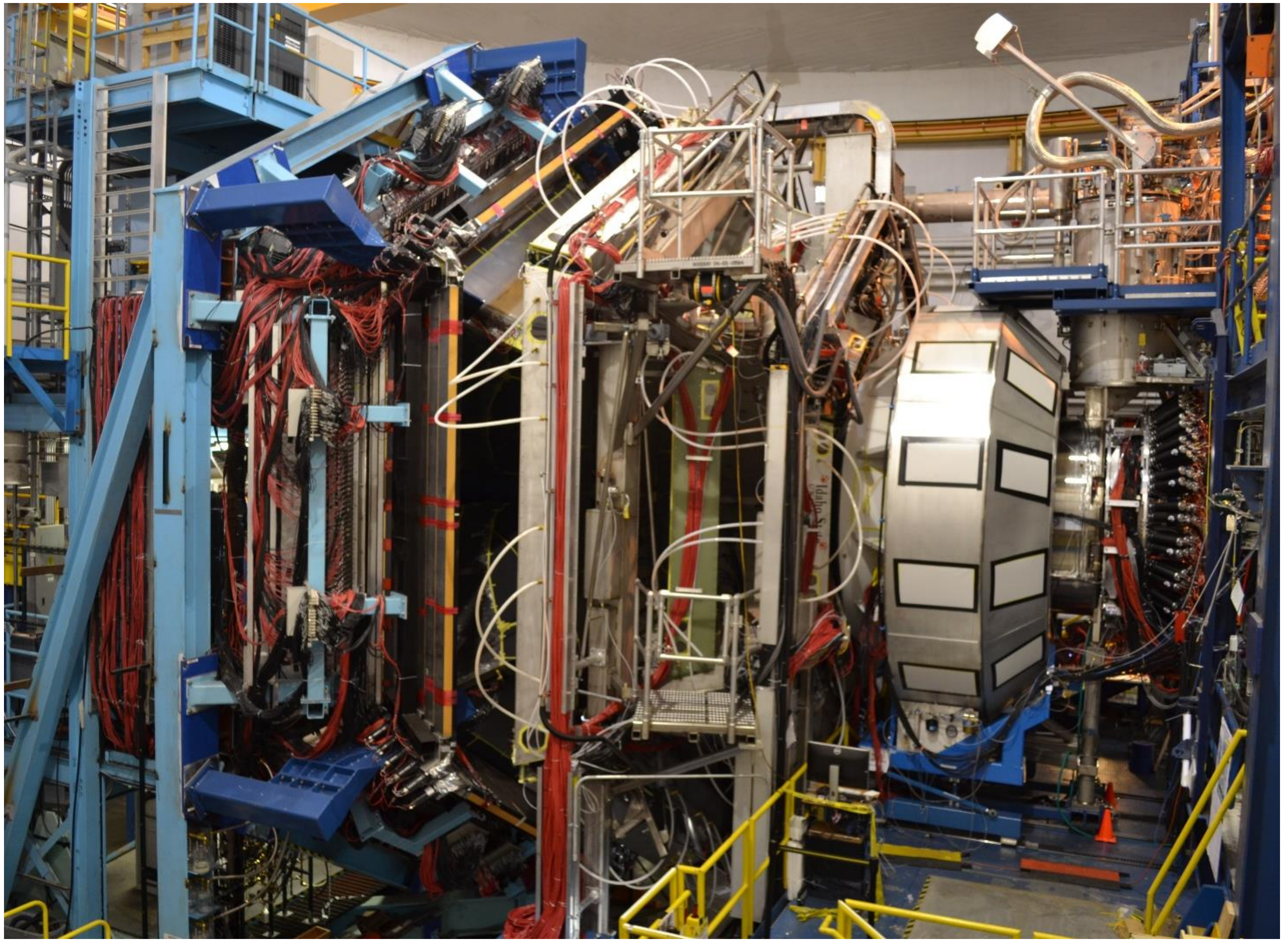
With $H(x,\xi,t)$, the Dispersion Relations allow access to $D(t)$ term and eventually to the form factor d_1:

$$d_1(t) = 15M_N \int d^3r \frac{j_0(r\sqrt{-t})}{2t} p(r) = 5M_N \int d^3r \frac{j_2(r\sqrt{-t})}{t} s(r)$$

Pressure $p(r)$ and shear force $s(r)$ distributions inside the nucleon may shed light on confinement mechanism.

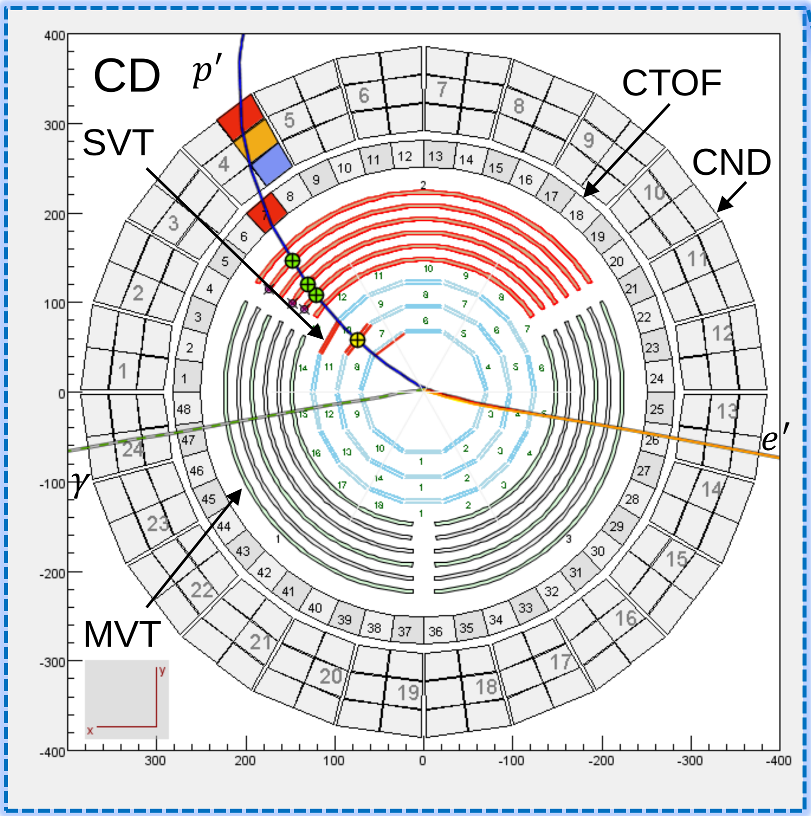
II. Experiment

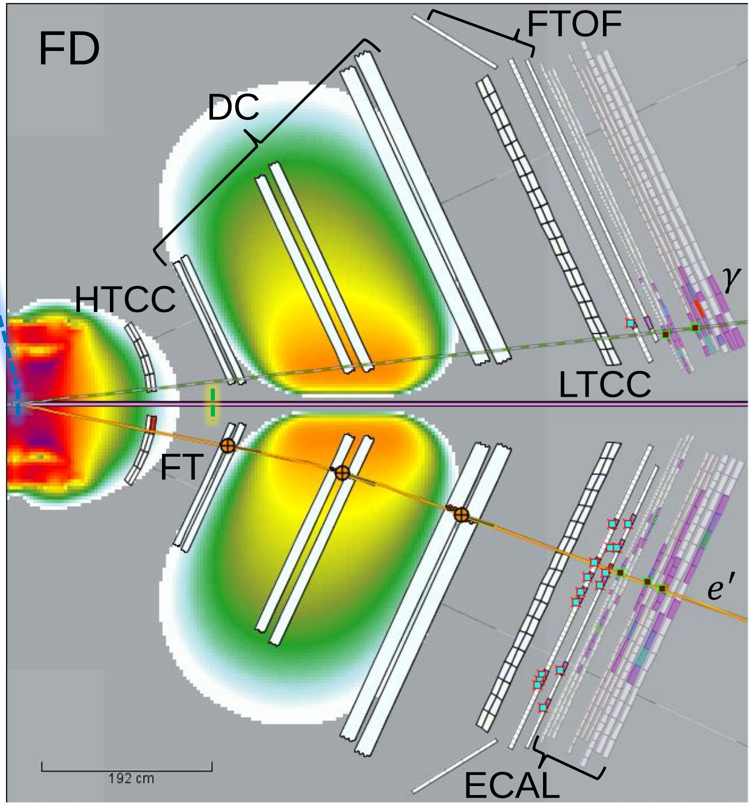
CEBAF AT 12 GEV AND CLAS12



First DVCS experiment with CLAS12 was performed in of 2018 at 6.5 GeV, 7.5 GeV, and 10.6 GeV polarized beam energies with ~87% average polarization, employing liquid hydrogen as production target.

DETECTOR-BASED $e'p'\gamma$ SELECTION





p' in CD Subsystem and γ Hit in FT

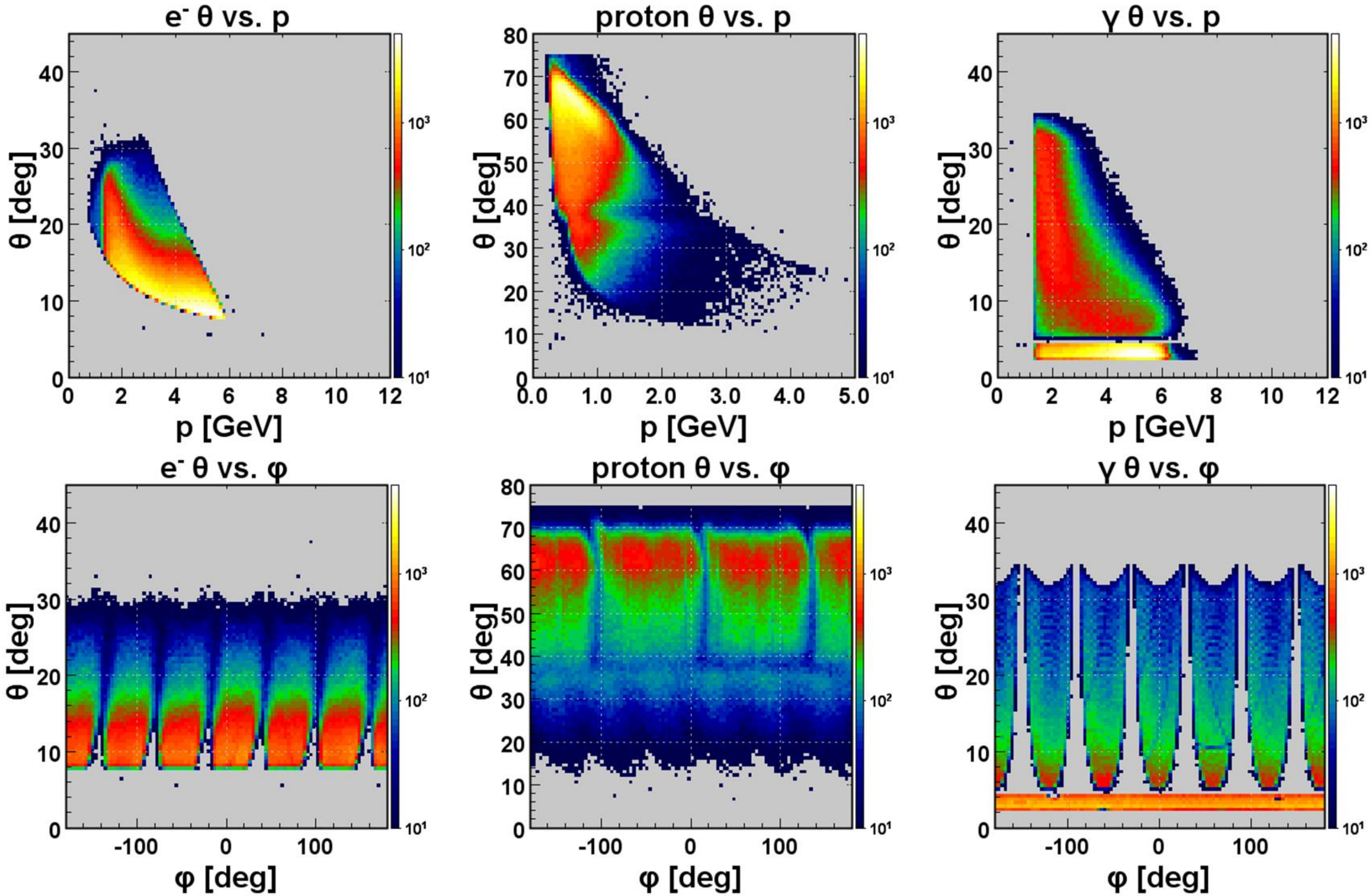
$e'\gamma$ in FD Subsystem

CLAS event display for a simulated DVCS event

DVCS sample selection requires 1 electron, 1 proton, and 1 photon as reconstructed in the Event Builder.

III. Analysis

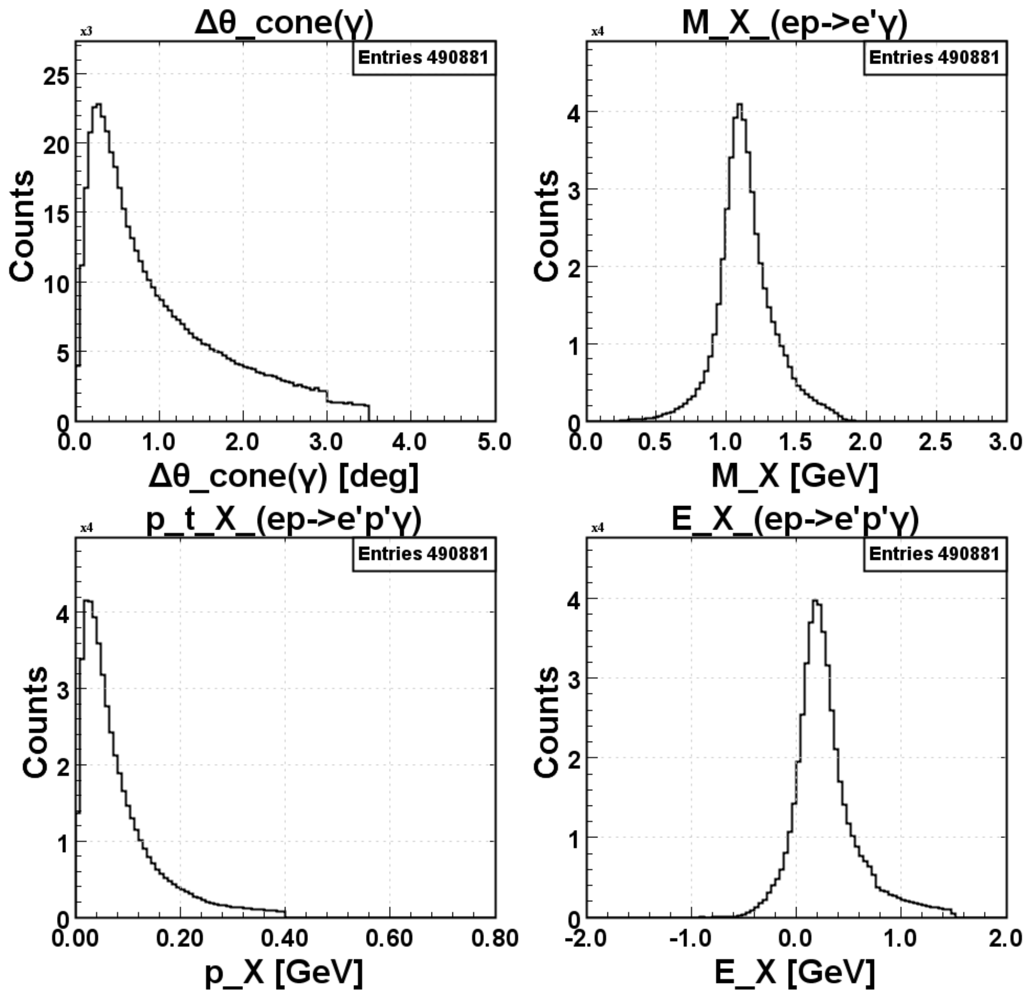
$e'p'\gamma$ Event Selection



Kinematic distributions of the selected particles reflect the detector topology.

$ep \rightarrow e'p'\gamma$ Exclusivity Cuts

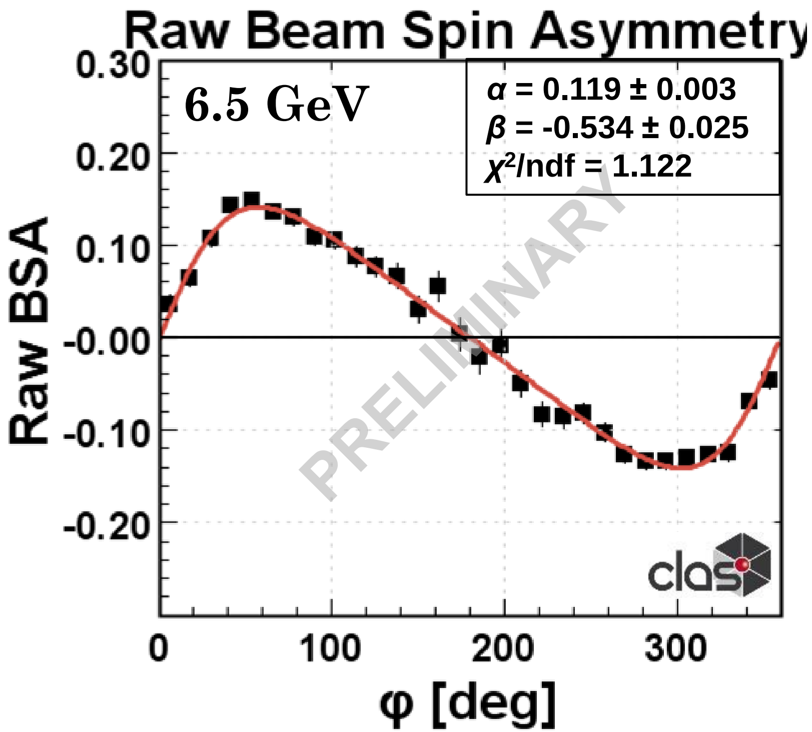
$$\Delta\theta_{\text{cone}(\gamma)} = \cos^{-1}(\vec{q'} \cdot \vec{X_\gamma} / |\vec{q'}||\vec{X_\gamma}|)$$

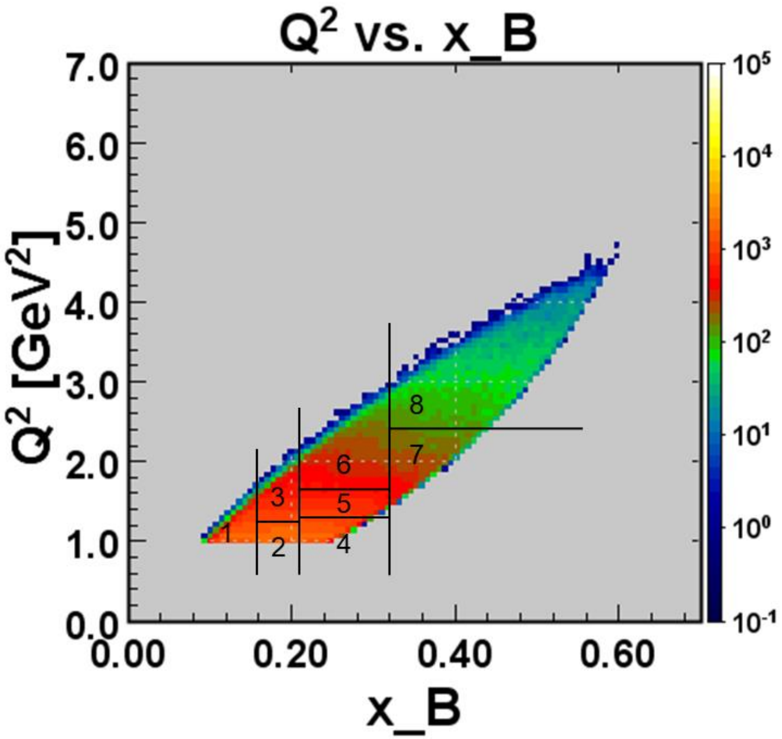


$Q^2 = -q^2$ above 1 GeV² and $W = \sqrt{(q+p)^2}$ above 2 GeV conditions are implemented as deep inelastic scattering (DIS) cuts.

IV. Preliminary Results

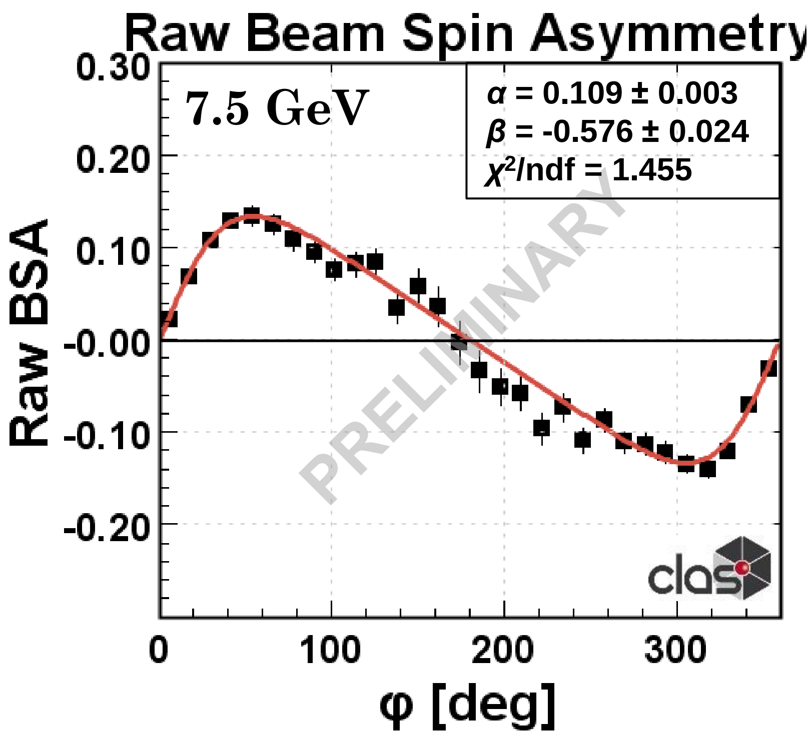
Integrated Raw Beam Spin Asymmetry I

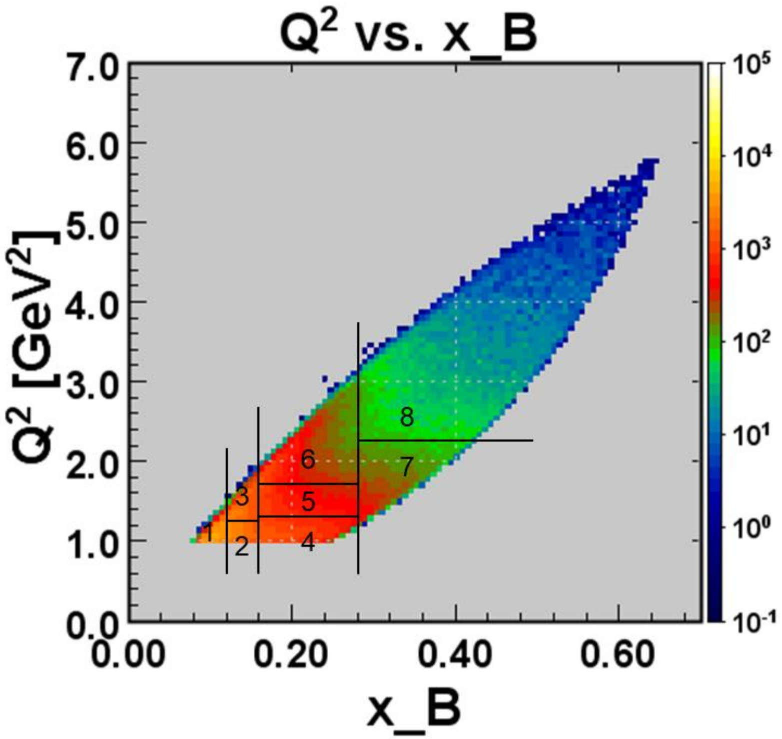




Raw Beam Spin Asymmetry (BSA) is fitted with $BSA = \frac{\alpha \sin\phi}{1+\beta\cos\phi}$ and statistical errors (only), at 6.5 GeV beam energy.

INTEGRATED RAW BEAM SPIN ASYMMETRY II

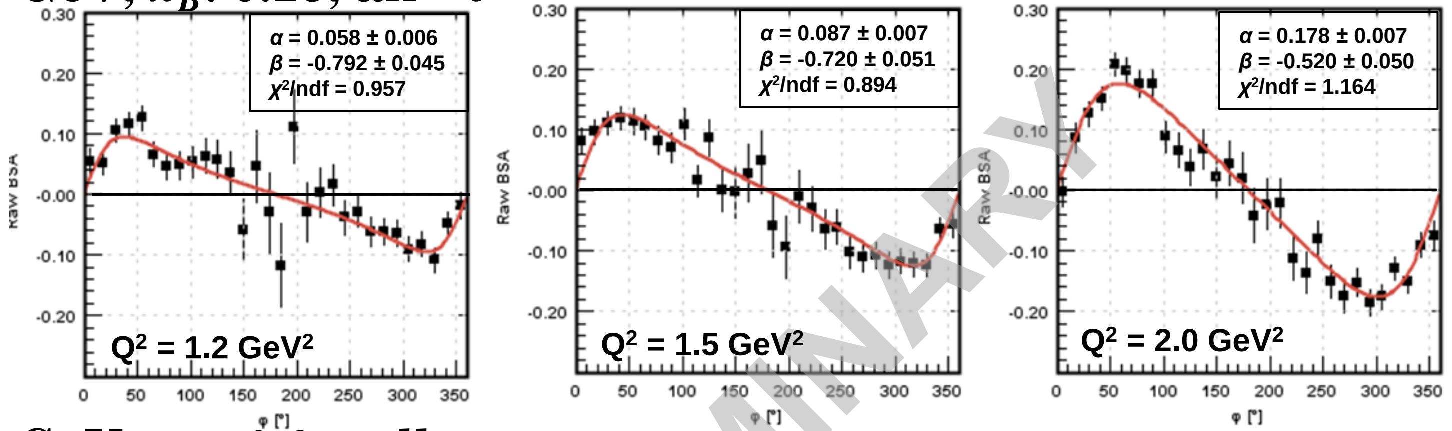




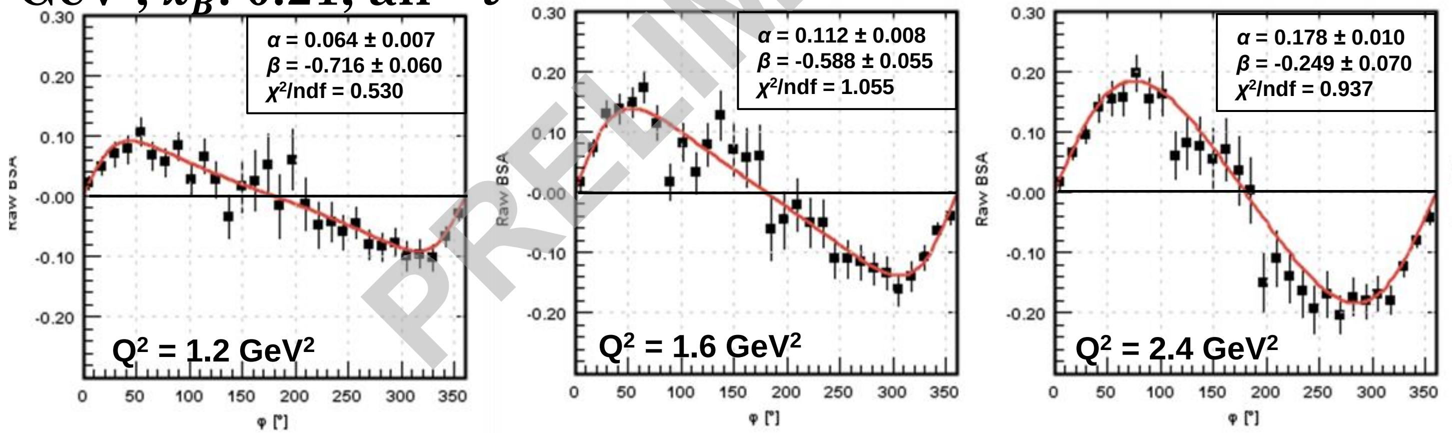
Raw Beam Spin Asymmetry (BSA) is fitted with $BSA = \frac{\alpha \sin\phi}{1+\beta\cos\phi}$ and statistical errors (only), at 7.5 GeV beam energy.

Raw Beam Spin Asymmetry and Beam Energy

6.5 GeV, x_B: 0.25, all $-t$

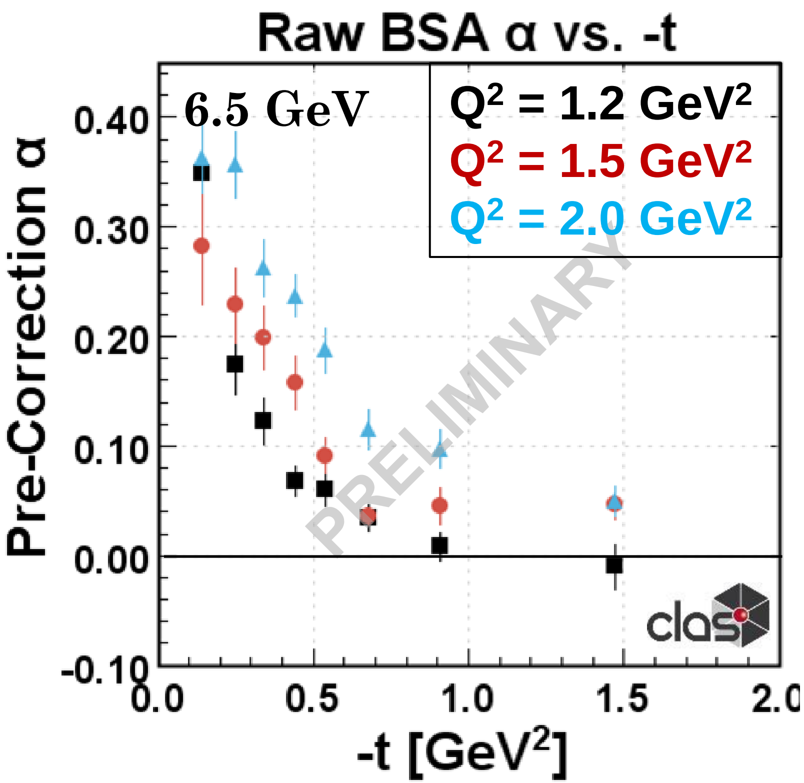


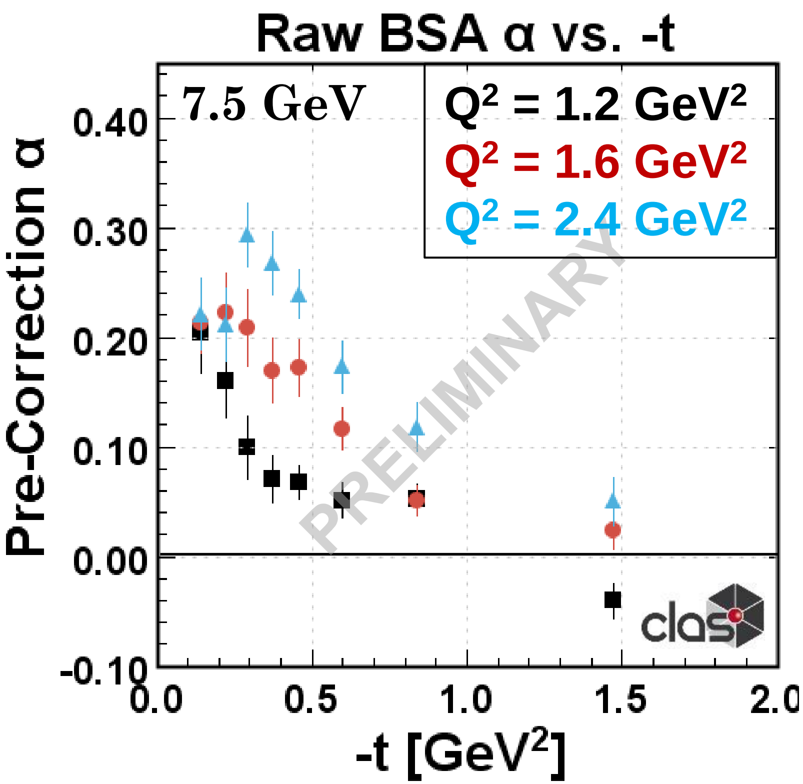
7.5 GeV , x_B: 0.21, all $-t$



Results for sample bins show raw BSA dependence on beam energy.

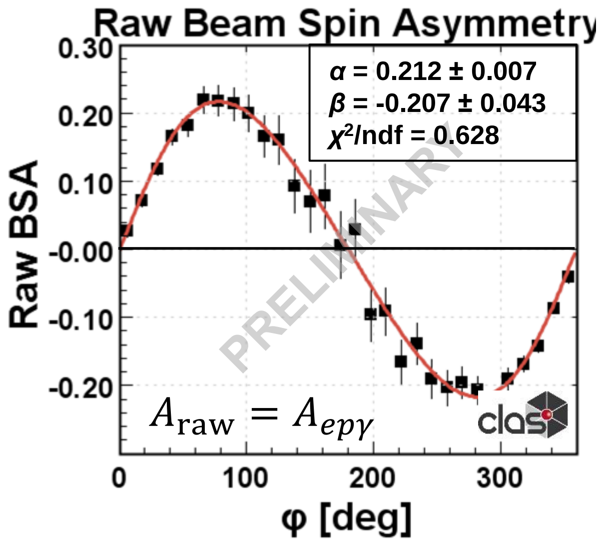
Raw Beam Spin Asymmetry Observables

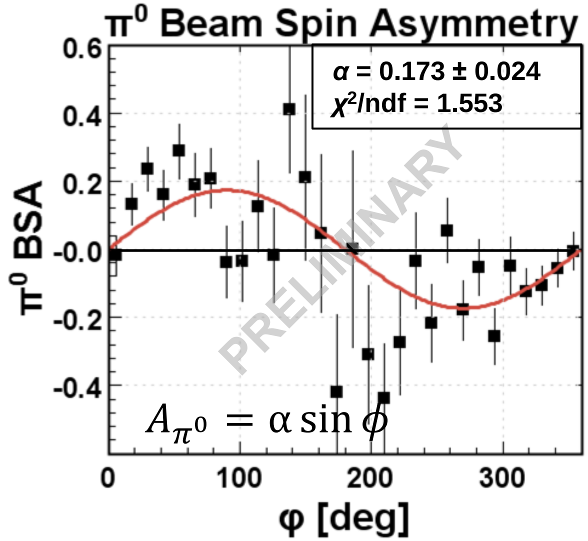


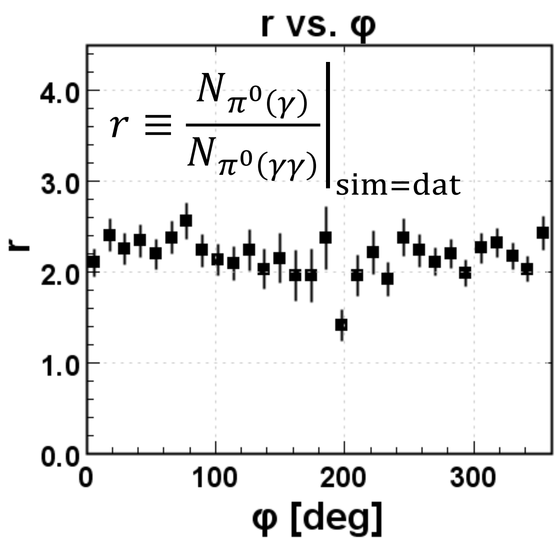


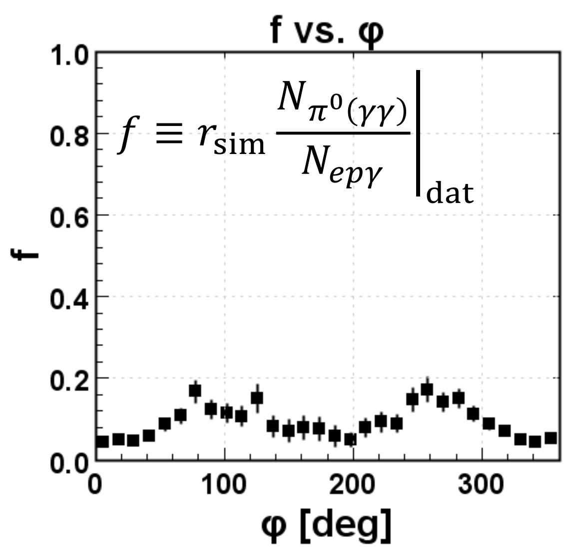
Together with the information from cross-section measurements, BSA observables eventually leads to the extraction of $D(t)$ term.

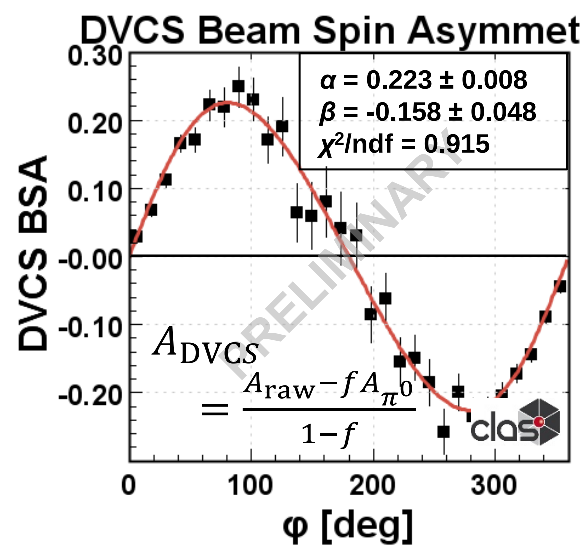
π^0 Contamination Subtraction I





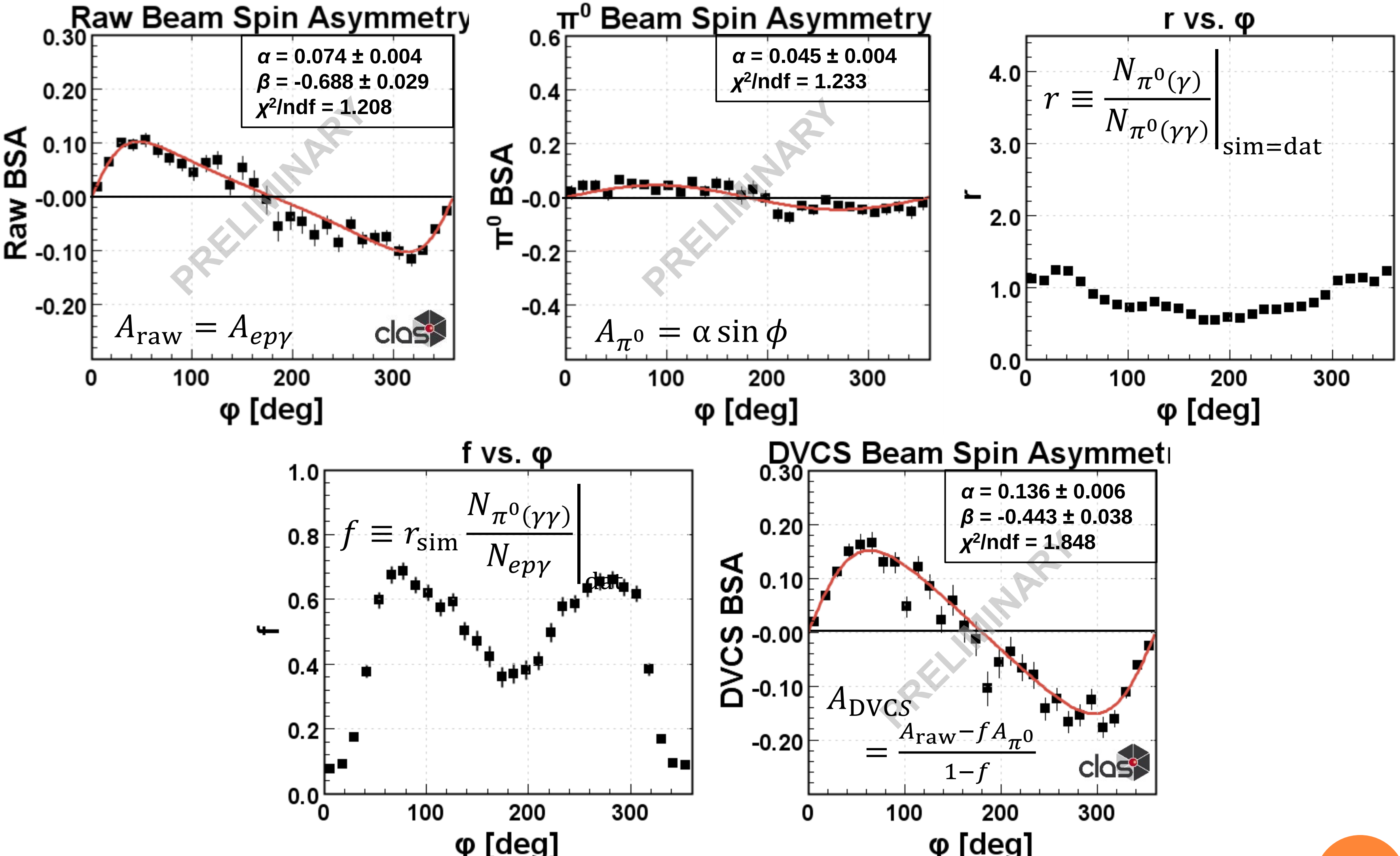






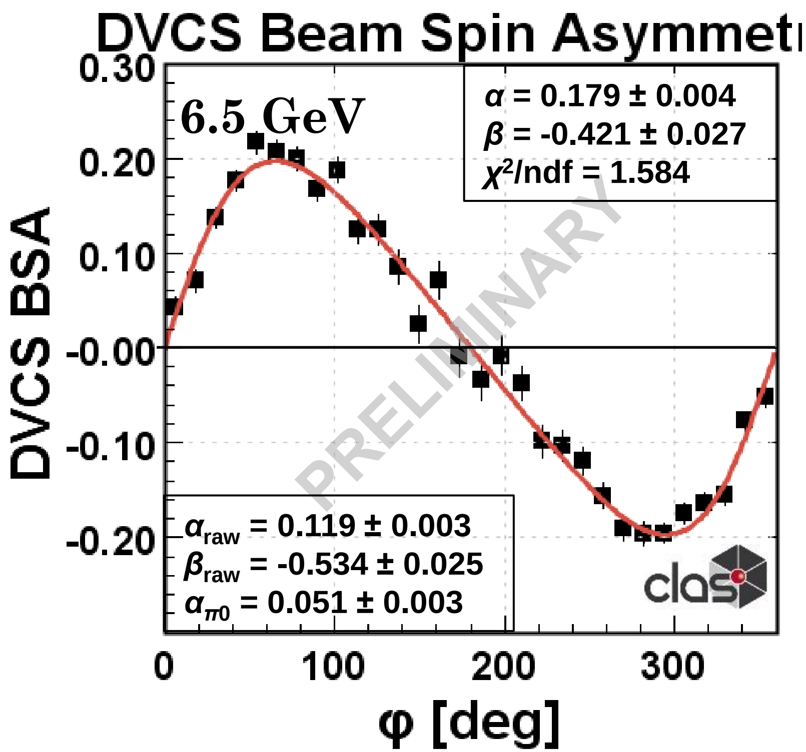
Shown is subtraction of DVπ^0P contaminants from raw $ep\gamma$ events at 7.6 GeV bean energy and $\frac{-t}{Q^2}$ less than 0.25.

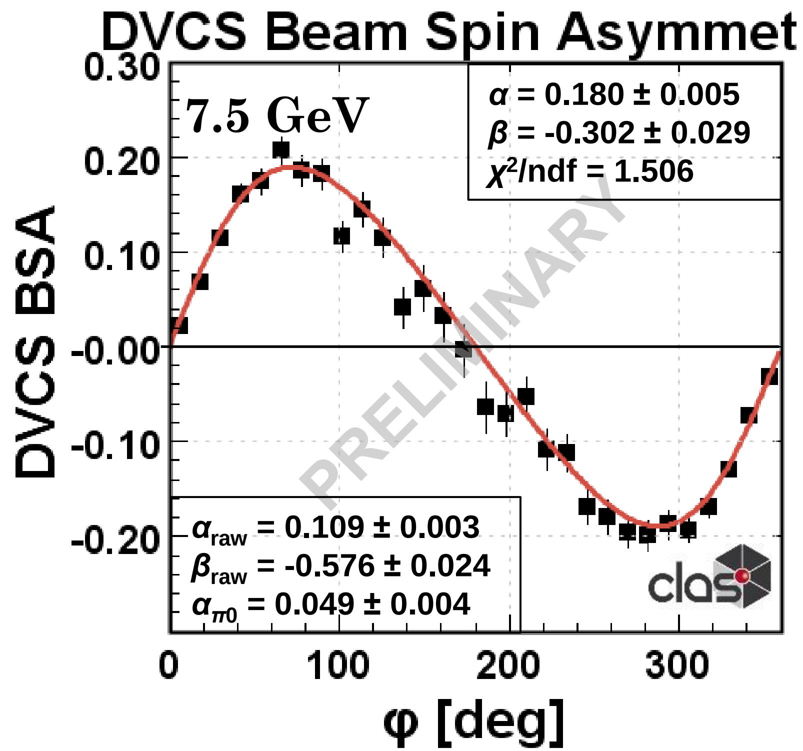
π^0 Contamination Subtraction II



Shown is subtraction of DVπ^0P contaminants from raw $ep\gamma$ events at 7.6 GeV bean energy and $\frac{-t}{Q^2}$ greater than 0.25.

Integrated DVCS Raw Beam Spin Asymmetry





Integrated DVCS BSA after π^0 contaminant subtraction.

V. Summary

Summary

- First DVCS beam spin asymmetry at 6.5 GeV and 7.5 GeV was measured with the goal of deepening our understanding on the GPD-modelled 3D structure of the proton and its mechanical properties.

- Raw BSA was extracted from $ep\gamma$ sample after implementing exclusivity cuts and correction was performed by eliminating DVπ^0P contamination; bin by bin implementation will follow.

- Kinematic and finite bin size corrections will be implemented after which, systematic errors will be estimated for the final BSA results.

- Dependance of BSA to various kinematic observables will be studied in detail.

- Together with DVCS cross-section measurements, the results of this analysis will be used to extract GPDs and map the proton pressure and shear force distributions.

Thank You!!!