BSA from Deeply virtual $\pi^0$ electroproduction measurements with CLAS12

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Generalized Parton Distributions (GPDs)

<table>
<thead>
<tr>
<th>Quark polarization</th>
<th>U</th>
<th>L</th>
<th>T</th>
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<tbody>
<tr>
<td>Nucleon polarization</td>
<td>U</td>
<td>$H$</td>
<td>$\bar{E}_T$</td>
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<tr>
<td></td>
<td>L</td>
<td>$\tilde{H}$</td>
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<tr>
<td></td>
<td>T</td>
<td>$E$</td>
<td>$H_T$, $\tilde{H}_T$</td>
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Chiral-odd GPD results:
- Deeply virtual meson production
- Lattice QCD by Göckeler et al

Chiral even GPDs:
- DVCS on unpolarized and polarized targets with polarized beam by HERMES, JLAB and COMPASS
GPDs in deeply virtual exclusive reactions

\[ \langle F \rangle = \sum_{\lambda} \int_{-1}^{1} dx H_{0,\lambda,\mu} (x, \xi, Q^2, t) F(x, \xi, t) \]

**Generalized Form Factor (GFF)** \( \langle F \rangle \) is a convolution of hard subprocess with GPD \( F \)

- 4 parton helicity conserving (chiral even) GPDs: \( H, \tilde{H}, E, \tilde{E} \)
- 4 parton helicity flip (chiral odd) GPDs: \( H_T, \tilde{H}_T, E_T, \tilde{E}_T \)
- functions of three kinematic variables: \( x, \xi \) and \( t \)
Experimental setup

- CEBAF Large Acceptance Spectrometer
- 10.6 GeV longitudinally polarized electron beam
- 85% average polarization
- Liquid hydrogen target
- First CLAS experiment since 12 GeV Upgrade
- The analysis uses 3% of approved beam time
\[ \frac{2\pi}{\Gamma} \frac{d^4\sigma}{dQ^2 dx_B dtd\phi_\pi} = \sigma_T + \epsilon\sigma_L + \epsilon\sigma_{TT} \cos 2\phi + \sqrt{\epsilon(1 + \epsilon)}\sigma_{LT} \cos \phi \]

unpolarized terms

longitudinally polarized target

longitudinally polarized beam

+ \! P_b \! \sqrt{\epsilon(1 - \epsilon)} \sigma_{LT} \sin \phi

+ P_{tg} \left( \sqrt{\epsilon(1 + \epsilon)}\sigma_{UL}^{\sin \phi} \sin \phi + \epsilon\sigma_{UL}^{\sin 2\phi} \sin 2\phi \right)

longitudinally polarized beam and
longitudinally polarized target

+ P_b P_{tg} \left( \sqrt{1 - \epsilon^2} \sigma_{LL} + \sqrt{\epsilon(1 - \epsilon)}\sigma_{LL}^{\cos \phi} \cos \phi \right)
Particle identification

- All final state particles are detected: electron, proton and two photons from $\pi^0$ decay
- Invariant mass of two photons is used to select $\pi^0$ candidates
Exclusive event selection

With all final state particle detected we can consider multiple combinations which allow us to isolate clean exclusive event sample and reject background:

- $\vec{e}p \rightarrow epX$
- $\vec{e}p \rightarrow e\gamma\gamma X$
- $\vec{e}p \rightarrow ep\gamma\gamma X$
Exclusive variables [sector 1]: $e, p, \pi^0$ detected and $MM^2_{epx} < 1 \text{ GeV}^2$
$MM_{epx}^2$ for $\theta_{X\pi} > 2^\circ$
Exclusive variables [sector 1]: $e, p, \pi^0$ detected, $M_{e\pi x}^2 < 1$ GeV$^2$, $\theta_{X\pi} < 2^\circ$
$\pi^0$: Kinematic coverage: $W > 2$ GeV, $Q^2 > 1$ GeV$^2$
Beam spin asymmetry

\[ BSA = \frac{1}{P_b} \frac{N^+ - N^-}{N^+ + N^-} \]

where \( P_b = 85\% \) is an average beam polarization

- Statistically significant beam spin asymmetry was observed
The preliminary results are compatible with previous measurements.
Summary

- CLAS12 preliminary results indicate a promising future for Deeply Virtual $\pi^0$ Electroproduction measurements
- 10.6 GeV electron beam extend our reach to the higher kinematic regions
- 85% beam polarization allows us to extract the beam spin asymmetry moments
- These data will provide further insight into chiral-odd GPDs and constrain their parameterizations