TDA measurements based on hard exclusive pion electroproduction with CLAS at JLAB

Stefan Diehl

for the CLAS collaboration

Justus Liebig University Giessen
University of Connecticut
Hard exclusive $\pi^+$ electroproduction $ep \rightarrow en \pi^+$

collinear factorization theorem

**GPD based description**
- Large $Q^2$ and $s$
- Small $t$ channel contribution
- $\pi^+$ in forward region

**TDA based description**
- Large $Q^2$ and $s$
- Small $u$ channel contribution
- $\pi^+$ in backward region
**Aim:**
Investigate the GPD and TDA kinematic regime and study the transition

<table>
<thead>
<tr>
<th><strong>GPDs:</strong></th>
<th>describe hadronic structural information in terms of quark and gluon degrees of freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>➔ tool to study the nature and origin of the nucleon spin</td>
</tr>
<tr>
<td></td>
<td>➔ impact parameter space: spatial femto-photographs of the hadron structure in the transverse plane</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Baryon to meson TDAs:</strong></th>
<th>encoded physical picture close to GPDs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>➔ probe partonic correlations between states of different baryonic charge</td>
</tr>
<tr>
<td></td>
<td>➔ access to non-minimal Fock components of baryon light-cone wave functions</td>
</tr>
<tr>
<td></td>
<td>➔ impact parameter space: Femto-photography of hadrons from a new perspective</td>
</tr>
<tr>
<td></td>
<td>➔ spatial imaging of the structure of the pion cloud inside the nucleon</td>
</tr>
</tbody>
</table>
Hard exclusive $\pi^+$ electroproduction

\[ ep \rightarrow en\pi^+ \]

Cross section (longitudinally pol. beam and unpol. target):

\[ d\sigma = d\sigma_0 (1 + A_U^{\cos(2\phi)} \cos(2\phi) + A_U^{\cos(\phi)} \cos(\phi) + h A_L^{\sin(\phi)} \sin(\phi)) \]

\[ BSA = \frac{d\sigma^+ - d\sigma^-}{d\sigma^+ + d\sigma^-} = \frac{A_L^{\sin(\phi)} \sin(\phi)}{1 + A_U^{\cos(\phi)} \cos(\phi) + A_U^{\cos(2\phi)} \cos(2\phi)} \]
Experimental Setup

- CLAS (e1f run period)
- 5.5 GeV longitudinally polarized electron beam
- unpolarized hydrogen target

- **Electron ID** based on electromagnetic calorimeter and Cherenkov counters
- **π⁺ ID** based on a maximum likelihood particle selection from TOF based β vs p correlation
Kinematic coverage and exclusivity cuts

**DIS cuts:**
- $W > 2$ GeV
- $Q^2 > 1$ GeV²

**forward region „small t“**
- $-t < 1.5$ GeV²
- $\cos(\theta) > 0$

**backward region „small u“**
- $-u < 2.0$ GeV²
- $\cos(\theta) < 0$

**missing mass**

Stefan Diehl, JLU + UCONN

Fall Meeting of the APS DNP, Crystal City, VA

10/15/2019
Beam spin asymmetry

$$BSA_i = \frac{1}{P_e} \cdot \frac{N_i^+ - N_i^-}{N_i^+ + N_i^-}$$

$P_e = 75\%$ : average e$^-$ beam polarisation

Integrated over all kinematic variables in forward / backward region:
BSA for different -t bins

- **0.11 GeV²**
- **0.26 GeV²**
- **0.56 GeV²**
- **0.96 GeV²**

- **1.55 GeV²**
- **2.34 GeV²**
- **3.34 GeV²**
- **4.45 GeV²**

- **5.44 GeV²**
- **6.64 GeV²**
-t dependence of $A_{LU}^{\sin(\phi)}$

- The background has been subtracted.
$Q^2$ and $x_B$ dependence of $A_{LU}^{\sin(\phi)}$
• $A_{LU}^{\sin(\phi)}$ moment from the hard exclusive $\pi^+$ channel has been extracted for the first time over a large range of kinematics.

• The results show a clear sign change from forward to backward angles, which may indicate a transition from the GPD to the TDA regime.

• Measurements with higher statistics will be performed with CLAS12.

• The crossed reaction $\bar{N}N \rightarrow \gamma^* \pi$ will be accessible with PANDA at FAIR.