Exclusive processes and GPDs with EIC:
Status report

C. Weiss (JLab), ELIC Science Meeting 21–Mar–08

- Exclusive processes: Physics interest
- Collider energies ($W > 10$ GeV):
  “Diffractive” vs. “non–diffractive” channels
- Cross section parametrization for $ep \to e'\pi^+n$
- First counting rate estimates for EIC  
  [→ Presentation by T. Horn]
- Work in progress, future plans
Exclusive processes: Physics

- Study of high-$Q^2$ exclusive processes
  essential part of physics program for $ep$ collider

  $e + p \rightarrow e' + \gamma + p \quad W^2, Q^2 \gg 1 \text{GeV}^2$
  $e' + \text{meson} + N \quad |t| < 1 \text{GeV}^2$

  $\rightarrow$ Reaction mechanism: QCD factorization
  $\rightarrow$ Information about GPDs, meson wave functions
  (baryon/meson structure)

- Experimental challenge
  - Small cross sections, \( \sigma(\text{meson} + N) \sim 1/Q^8 \)
  - Detection of recoil nucleon
  - Differential measurements in $x, Q^2, t$

\[\text{[cf. GPD White Paper for NSAC Long-Range Plan,}
\text{presented at Rutgers Town Meeting Jan–07]}\]
## Exclusive processes: Collider energies

<table>
<thead>
<tr>
<th>Channel</th>
<th>“diffractive” (vacuum exchange)</th>
<th>“non-diffractive” (quantum number exchange)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GPDs</strong></td>
<td>$\gamma p, \rho^0 p, J/\psi p, \ldots$</td>
<td>$\pi^+ p, \pi^0 p, K\Lambda, \rho^+ n, \ldots$</td>
</tr>
<tr>
<td><strong>Cross section</strong></td>
<td>rises with energy</td>
<td>drops with energy</td>
</tr>
<tr>
<td><strong>Interest</strong></td>
<td>gluon imaging of nucleon</td>
<td>spin/flavor structure of quark GPDs</td>
</tr>
<tr>
<td></td>
<td>“one channel”</td>
<td>“many channels”</td>
</tr>
</tbody>
</table>
Exclusive processes: EIC potential and simulations

- Diffractive channels
  - Data/experience from HERA: $\gamma p$ (DVCS), $\rho^0 p$, $\phi p$, $J/\psi p$
  - DVCS simulations [A. Sandacz 06/07; cf. GPD/EIC White Paper]
  - Certainly feasible even with modest luminosity ($10^{33}$cm$^{-2}$s$^{-1}$)
    Discussion about “quantitative” issues

- Non-diffractive channels
  - New territory for collider!
  - Much more demanding in luminosity
  - Physics interest closely related to JLab 6 + 12 GeV program:
    Quark spin/flavor distributions, nucleon/meson structure
  - Feasibility study of $\pi^+ n$, $\pi^0 p$, $K \Lambda$
    [A. Bruell, T. Horn, C. Weiss, V. Guzey, in progress]
\( \pi^+ n \) at EIC: Cross section parametrization

- Phenomenological parametrization based on
  - Regge parametrization of \( Q^2 = 0 \) data [cf. Guidal, Laget, Vanderhaeghen 98]
  - Vector meson dominance (\( Q^2 < 1 \text{GeV}^2 \))
  - QCD scaling (\( W^2, Q^2 \gg 1 \text{GeV}^2 \))

- Correct asymptotic behavior at large \( W, Q^2 \)

- Describes \( \sigma_T \) and \( \sigma_L \) (\( \leftrightarrow \) GPDs)

- Simple analytic forms, suitable for MC

[C. Weiss, Technical Report 08]
\( \pi^+ n \) at EIC: First estimates

\[ \frac{d\sigma}{dt}(ep \rightarrow e'n\pi^+) \]

\[ s_{ep} = 4000 \text{ GeV}^2, \ L = 10^{34} \text{ cm}^{-2} \text{ s}^{-1}, \ 16 \text{ weeks} \]

- Luminosity \( 10^{34} \text{ cm}^{-2} \text{ s}^{-1} \)
- Running time \( 16 \) weeks
- Energy \( 10 \) on \( 100 \) GeV
- Detection \( 100\% \)

[C. Weiss, EIC Collaboration Meeting, Stony Brook University, 07–Dec–07]

- Many uncertainties (model dependence, extrapolations)
- No proper integration \( (d\sigma \times \text{ bin size}) \)
- Seems feasible at not too small \( x \) (\( \sim 0.05 - 0.1 \))
Work in progress [→ EIC Collaboration meeting May–08]

• Extend parametrization to \( \pi^0 p, K \Lambda \)

• Full MC simulations [→ T. Horn]

Future extensions

• Develop GPD–based parametrizations, extract nucleon structure information from simulated data

• Other non-diffractive channels \( (\rho^+ n, K^* \Lambda, \ldots) \), polarization observables

• Diffractive channels at high luminosity: DVCS + BH, \( \rho^0 p, \phi p, J/\psi p \).