Status and Prospects of the HERMES Recoil Detector

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for the HERMES collaboration

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Exclusive DIS measurements at HERMES

- Status of Recoil Detector
- First Look at Physics
• Recoil detector installed for the last two years of data taking
• 23M DIS events off Hydrogen target
• 5.6M DIS events off Deuterium target
The HERMES Recoil Detector

Superconducting Solenoid (1T)

Photon Detector (PD)
- 3 layers of Tungsten/Scintillator sandwich

Fiber Detector (SFT)
- 2 barrels with 4 layers of scintillating fibers
- 2 parallel and 2 stereo layers per barrel

Silicon Detector (SSD)
- 16 double-sided sensors in 2 layers
- Inside HERA vacuum
- 5 cm close to beam

Lepton beam
- 10.4 MHz bunch frequency
- 30 ps bunch length
- 25 mA avg. beam current

Target cell
Momentum Reconstruction

- Low-energy protons
  - Momentum via sum of deposited energies

125 MeV/c < \( p \) < 145 MeV/c
Momentum Reconstruction

- Low-energy protons
  - Momentum via sum of deposited energies
- Medium-energy protons
  - Momentum via dE/dx

125 MeV/c < p < 145 MeV/c
145 MeV/c < p < 250 MeV/c
Momentum Reconstruction

- **Low-energy protons**
  - Momentum via sum of deposited energies
  
- **Medium-energy protons**
  - Momentum via $dE/dx$

- **High-energy particles (protons/pions)**
  - Momentum via bending in magnetic field

\[
\begin{align*}
125 \text{ MeV/c} &< p < 145 \text{ MeV/c} \\
145 \text{ MeV/c} &< p < 250 \text{ MeV/c} \\
p &> 200 \text{ MeV/c}
\end{align*}
\]
Particle Identification

- \( p/\pi^+ \) separation via energy deposits and parent distributions
- \( p < \sim 0.6 \text{ GeV/c} \): SSD & SFT
- \( p > \sim 0.6 \text{ GeV/c} \): SSD & SFT & PD
Particle Identification ($p > 0.2$ GeV/c)

$PID = \log_{10} \frac{P_p(dE,p)}{P_{\pi^+}(dE,p)}$

- $\pi^+/\pi^+$ separation via energy deposits and parent distributions
- $p < \sim 0.6$ GeV/c: SSD & SFT
- $p > \sim 0.6$ GeV/c: SSD & SFT & PD
• Drops in statistics related to acceptance holes and dead strips in other silicon layer

• $\langle \varepsilon \rangle > 99\%$ for all 16 sensors
- Lower statistics and lower efficiency for first quadrant
- $\varphi < \pi / 2$: $\langle \varepsilon \rangle \approx 98.5 \%$
- $\varphi > \pi / 2$: $\langle \varepsilon \rangle \approx 99.5 \%$
### ep - Elastic

- Single lepton in forward spectrometer \((p > 25 \text{ GeV/c})\)
- Use Recoil Detector track with highest momentum and positive charge
- Will be used for Recoil alignment relative to HERMES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>(\chi^2 / \text{ndf})</td>
<td>247.8 / 244</td>
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<tr>
<td>(p_0)</td>
<td>(-708.5 \pm 4.5)</td>
</tr>
<tr>
<td>(p_1)</td>
<td>(598.2 \pm 1.9)</td>
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<tr>
<td>(p_2)</td>
<td>(-113.6 \pm 0.4)</td>
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<tr>
<td>(p_3)</td>
<td>(992.3 \pm 12.6)</td>
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<tr>
<td>(p_4)</td>
<td>(3.145 \pm 0.000)</td>
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<tr>
<td>(p_5)</td>
<td>(0.008711 \pm 0.000079)</td>
</tr>
</tbody>
</table>
A first look at DVCS with Recoil

- “Classic” style HERMES DVCS analysis
  - Exactly one lepton and one photon in forward spectrometer

- Calculate kinematics of recoiling proton

- Look for a correlated track in Recoil Detector
  - Use track with highest momentum and positive charge
  - No PID used to select protons
  - All track types: SSD-only & “long” tracks
  - $\Delta \phi = \phi_{\text{measured}} - \phi_{\text{calc}}$
  - $\Delta p = p_{\text{measured}} - p_{\text{calc}}$

\[ 
\begin{align*}
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  - $\Delta \phi = \phi_{\text{measured}} - \phi_{\text{calc}}$
  - $\Delta p = p_{\text{measured}} - p_{\text{calc}}$
  - $|\Delta p| < 1 \text{ GeV/c}$

DVCS event candidates

$M_x^2 \times (\text{GeV/c})^2$
A first look at DVCS with Recoil

Data and MC agree very well
A first look at DVCS with Recoil

Ji Relation: \( J_q = \lim_{t \to 0} \int_0^1 dx \ x \left( H_q + E_q \right) \)
Exclusive $\rho^0$ - Production

- “Classic” style HERMES $\rho^0$ analysis
- Calculate kinematics of recoiling proton
- Look for correlated track in Recoil Detector

![Graph showing $\Delta E_{\pi\pi}$ distribution with cuts for positive recoil track](image-url)
Summary and Outlook

- Great progress in understanding the detector
  - All three sub-detectors calibrated
  - PID and efficiencies look very good

- First look at physics using Recoil Detector tracks looks promising

- Exclusive physics
  - Improve event selection
  - Use PID to select recoiling proton
  - Separation of associated background by using PD
  - Include single hits in inner SSD to extend to lower $t$

- Extract neutron structure function via spectator proton tagging

- A bit more work needed for the SSD energy calibration
DVCS Event

HERMES Recoil Detector
DVCS event candidates

Exists positive Recoil Track

Recoil $\Delta p<1$ cut

Traditional DVCS analysis

$M_p^2$

2.89

$M_x^2$ [ (GeV/c)$^2$ ]