New Results from the HERMES Recoil Detector

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Exclusive DIS Measurements at HERMES

Without Recoil Detector
- Exclusivity via missing mass
- ~ 11% background

With Recoil Detector
- Improved exclusivity
- < 1% background
- Improved t resolution
Recoil detector installed for the last two years of data taking at HERA

- 49.3M DIS events off Hydrogen target (21.5M DIS events 1996-2005)
- 12.4M DIS events off Deuterium target
The HERMES Recoil Detector

- **Superconducting Solenoid (1T)**
- **Photon Detector (PD)**
  - 3 layers of Tungsten/Scintillator sandwich
- **Fiber Tracker (SFT)**
  - 2 barrels with 4 layers of scinillating fibers
  - 2 parallel and 2 stereo layers per barrel
- **Silicon Detector (SSD)**
  - 16 double-sided sensor in 2 layers
  - Inside HERA vacuum
  - 5 cm close to beam

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

**Target cell**

30 cm
Low-energy protons
• Momentum via sum of energy deposits

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

**Low-energy protons**
- Momentum via sum of energy deposits

**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 energy deposits

**Medium-energy protons**
- Momentum via dE/dx

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

125 MeV/c $< p < 145$ MeV/c
145 MeV/c $< p < 250$ MeV/c
$p > 200$ MeV/c
Momentum Reconstruction

- Energy loss is taken into account for "long" tracks ($p > 200\ MeV/c$)
- Each track is reconstructed twice
  - Pion
  - Proton
- Significantly improves momentum resolution

![Graph showing momentum resolution vs. momentum](image-url)
Particle Identification

- $p/\pi^+$ separation via energy deposits and parent distributions
- Information from up to 9 layers can be used (2 SSD, 4 SFT and 3 PD)
- $p < \approx 0.6$ GeV/c: SSD & SFT
- $p > \approx 0.6$ GeV/c: SSD & SFT & PD
Particle Identification

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

- $p/\pi^+$ separation via energy deposits and parent distributions
- Information from up to 9 layers can be used (2 SSD, 4 SFT and 3 PD)
- $p < \approx 0.6 \text{ GeV/c} : \text{SSD & SFT}$
- $p > \approx 0.6 \text{ GeV/c} : \text{SSD & SFT & PD}$
Particle Identification Performance

- Extract parent distributions from reconstructed MC data
  - Same method as for real data
- Combine individual PID values: \( PID_{total} = \sum PID_i \)
- Proton: \( PID_{total} > PID_{cut} \)
- Pion: \( PID_{total} < PID_{cut} \)
- Use true particle ID from MC to study PID performance

**p Efficiency**

**p Purity**
• 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 in first quadrant
• \( \varphi < \pi / 2 \) : \( \langle \varepsilon \rangle \approx 98.5\% \)
• \( \varphi > \pi / 2 \) : \( \langle \varepsilon \rangle \approx 99.5\% \)
A first look at DVCS with Recoil

- „Classic“ style HERMES DVCS analysis
- Scattered beam lepton and one photon in forward spectrometer
  ➡ DVCS event candidate

- Calculate kinematics of recoiling proton
- Look for correlated track in RD
  - Use track with highest momentum and positive charge
  - No PID information used to select protons
    - $\Delta p = p_{\text{measured}} - p_{\text{calc}}$.
    - $\Delta \phi = \phi_{\text{measured}} - \phi_{\text{calc}}$. 

\[ e \rightarrow e' \gamma^* \rightarrow e' \gamma \]

\[ \text{GPDs}(x, \xi, t) \]

\[ p, p', e, e' \]

\[ \Delta \phi = \phi_{\text{measured}} - \phi_{\text{calc}}. \]

\[ \Delta p = p_{\text{measured}} - p_{\text{calc}}. \]
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  - \( \Delta \phi = \phi_{\text{measured}} - \phi_{\text{calc}} \)
  - \( |\Delta p| < 1 \text{ GeV/c} \)
A first look at DVCS with Recoil

- Correlated track in recoil detector exists
- $|\Delta p| < 1 \text{ GeV}/c$
- Good agreement between Data and MC
Summary and Outlook

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

- First look at physics using Recoil Detector tracks looks promising
  - Deeply Virtual Compton Scattering
  - Exclusive $\rho^0$ - production

- Exclusive physics
  - Improve event selection
  - Use PID to select recoiling proton
  - Include single hits in inner SSD to extend to even lower $t$

- Extract neutron structure function via spectator proton tagging

- Refinement of SSD energy calibration
- Fine-tuning of track reconstruction