G. Schnell (DESY Zeuthen)
67. DESY PRC Meeting, May 5th, 2009
[conclusions at DIS 2009]

\[ \frac{1}{2} = \frac{1}{2} \Delta \Sigma + \Delta G + L_q + L_g \]

“the spin crisis is solved but ...”
\[ \frac{1}{2} = \frac{1}{2} \Delta \Sigma + \Delta G + L_q + L_g \]

“the spin crisis is solved but ... the proton spin is still a puzzle”
Longitudinal Spin/Momentum Structure, Hadronization

DVCS

GPDs
“Nucleon Tomography”

Exclusive Meson Production

Strange-Baryon Production

Transverse Spin/Momentum Structure

Transversity TMDs
Physics Highlights since last PRC Mtg.

- SDMEs in exclusive $\rho^0$ electro-production on H and D targets [arXiv:0901.0701 (accepted by EPJC)].

- Preliminary results released:
  - Transverse SDMEs in exclusive $\rho^0$ production
  - Transverse SSA in exclusive $\omega$ production
  - Nuclear-mass dependence of transverse $\Lambda$ polarization
  - Structure function $F_2$ on H and D targets
Longitudinal Spin/Momentum Structure, Hadronization

Transverse Spin/Momentum Structure

Strange-Baryon Production

Exclusive Meson Production

GPDs "Nucleon Tomography"

DVCS

Transversity TMDs

Strange-Baryon Production
Probing GPDs in Exclusive Reactions

Accessible through hard exclusive reactions:

<table>
<thead>
<tr>
<th></th>
<th>unpolarized</th>
<th>polarized</th>
</tr>
</thead>
<tbody>
<tr>
<td>photon: ( J^P = 1^- ) (DVCS)</td>
<td></td>
<td></td>
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<tr>
<td>H</td>
<td></td>
<td>( \tilde{H} )</td>
</tr>
<tr>
<td>E</td>
<td></td>
<td>( \tilde{E} )</td>
</tr>
</tbody>
</table>

\( J^P = 1^- \) mesons | \( J^P = 0^- \) mesons

Different mesons provide different sensitivity to quark flavors
ρ^0 SDMEs from HERMES

\[ A: \gamma_L^* \rightarrow \rho_L^0, \quad \gamma_T^* \rightarrow \rho_T^0 \]

\[ B: \text{Interference} \quad \gamma_L^* \rightarrow \rho_L^0 \& \gamma_T^* \rightarrow \rho_T^0 \]

\[ C: \gamma_T^* \rightarrow \rho_L^0 \]

\[ D: \gamma_L^* \rightarrow \rho_T^0 \]

\[ E: \gamma_T^* \rightarrow \rho_T^0 \]

Target-polarization independent SDMEs

\[ 1 - r_{00}^0 \]
\[ 2 r_{11}^0 \]
\[ -2 \text{Im} r_{00}^1 \]
\[ 2\sqrt{2} \text{Re} r_{10}^1 \]
\[ -2\sqrt{2} \text{Im} r_{10}^1 \]
\[ 2\sqrt{2} \text{Im} r_{10}^6 \]
\[ 2\sqrt{2} \text{Re} r_{10}^8 \]
\[ 2 \text{Re} r_{00}^4 \]
\[ -2 \text{Re} r_{10}^1 \]
\[ 2 \text{Re} r_{10}^2 \]
\[ 2 \text{Im} r_{10}^2 \]
\[ 1/\sqrt{2} r_{00}^5 \]
\[ -r_{00}^1 \]
\[ 2 \text{Im} r_{10}^3 \]
\[ -1/\sqrt{2} r_{00}^6 \]
\[ \sqrt{2} r_{11}^5 \]
\[ -\sqrt{2} r_{11}^5 \]
\[ -\sqrt{2} r_{11}^5 \]
\[ -\sqrt{2} r_{11}^5 \]
\[ \sqrt{2} r_{11}^5 \]
\[ -\sqrt{2} r_{11}^5 \]
\[ r_{00}^5 \]
\[ r_{11}^5 \]
\[ \text{Im} r_{11}^3 \]

Proton: ■
deuteroton: •

scaled SDME
\( \rho^0 \) SDMEs from HERMES

Results on Meson SDMEs at Average Kinematics

Resulting SDMEs shown according to suggested hierarchy of helicity amplitudes:

- **scaled SDME**
  - proton
  - deuteron

A: \( \gamma^*_L \rightarrow \rho^0_L \)
- \( \gamma^*_T \rightarrow \rho^0_T \)

B: Interference \( \gamma^*_L \rightarrow \rho^0_L \) & \( \gamma^*_T \rightarrow \rho^0_T \)

C: \( \gamma^*_T \rightarrow \rho^0_L \)

D: \( \gamma^*_L \rightarrow \rho^0_T \)

E: \( \gamma^*_T \rightarrow \rho^0_T \)

helicity non-flip much larger than helicity-flip and double helicity-flip

target-polarization independent SDMEs
ρ₀ SDMEs from HERMES

A: $\gamma_L^* \rightarrow \rho_L^0$
$\gamma_T^* \rightarrow \rho_T^0$

B: Interference $\gamma_L^* \rightarrow \rho_L^0$ & $\gamma_T^* \rightarrow \rho_T^0$

C: $\gamma_L^* \rightarrow \rho_L^0$

D: $\gamma_T^* \rightarrow \rho_T^0$

E: $\gamma_T^* \rightarrow \rho_T^0$

target-polarization independent SDMEs

“transverse” SDMEs

8.1% scale uncertainty

HERMES PRELIMINARY
ρ⁰ SDMEs from HERMES

target-polarization independent SDMEs

“transverse” SDMEs

HERMES PRELIMINARY

GPD E

8.1 % scale uncertainty

dominant transitions

single spin flip

double spin flip

SDME values
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Transverse Spin/Momentum Structure
HERMES Physics Highlights since last PRC Mtg.

- $A$-dependence of transverse $\Lambda^0$ polarization in $eN \rightarrow \Lambda^0 X$:

![Graph showing $P_\Lambda$ versus $A$ for different nuclei.](image)
HERMES Physics Highlights since last PRC Mtg.

- A-dependence of transverse $\Lambda^0$ polarization in $eN \rightarrow \Lambda^0 X$:

![Graph showing the A-dependence of transverse $\Lambda^0$ polarization for different nuclei.]
Longitudinal Spin/Momentum Structure, Hadronization

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HERMES Physics Highlights since last PRC Mtg.

- \( F_2 \) structure function off H and D targets:

\[
F_2 \propto x^{-\alpha} F_{2p} \propto \frac{1}{Q^2} \sum_q f_q^2(x) \frac{1}{1 + \frac{Q^2}{4 M^2}} \]

\[
\langle x \rangle \approx \frac{1}{F_2} \int_0^1 x F_2(x) dx
\]

\[
F_{2p} = F_{2d} = 0.679 \left( \frac{Q^2}{\text{GeV}^2} \right)^{1.6^{36}}
\]

\[
F_{2d} \approx 0.018 \left( \frac{Q^2}{\text{GeV}^2} \right)^{1.6^{30}}
\]

\[
\frac{F_{2p}}{F_{2d}} \approx 36.4 \left( \frac{Q^2}{\text{GeV}^2} \right)^{-1.6^{38}}
\]

\[
\frac{F_{2d}}{F_{2e}} \approx 0.18 \left( \frac{Q^2}{\text{GeV}^2} \right)^{-1.6^{32}}
\]

\[
\frac{F_{2p}}{F_{2e}} \approx 0.679 \left( \frac{Q^2}{\text{GeV}^2} \right)^{1.6^{18}}
\]
HERMES Physics Highlights since last PRC Mtg.

- $F_2$ structure function off H and D targets:

![Graph showing $F_2$ structure function data points for NMC, BCDMS, SLAC, and HERMES.](image)
Publications & Physics Analyses

- 1 paper accepted
- 8 paper drafts in circulation stage
- 12 paper drafts in preparation stage
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- around 25 key analyses
  - around 15 important analyses
  - around 10 interesting analyses looked into
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~80% manpower “secured”
Publications & Presentations

Major conferences:
- 12 talks at Spin 2008 (3 invited talks)
- 11 talks at DIS 2009
- 10 talks at ENPC 2009

HERMIES Publications

in average about **70 citations per paper**
Progress on Recoil-Detector Analysis

- calibrations silicon, SciFi, and photon detectors … done
- particle identification … (almost) done
- tracking … done
- fine tuning (ghost-track suppression, etc.) … in progress
- efficiencies … in progress
- Monte Carlo … (almost) done

refinements:
- calibration fine tuning, kinematic fitting, tracking with photon detector
DVCS Event selection

- Missing φ: \( \Delta \phi = \phi_{\text{meas}} - \phi_{\text{calc}} \)
- Missing \( p \): \( \Delta p = p_{\text{meas}} - p_{\text{calc}} \)

\[ M^2_X = (p + p_{\gamma^*} - p_{\gamma})^2 \]

**Hermes 2007 data**

- Traditional DVCS analysis \( (E_{\gamma} > 5 \text{ GeV}) \)
- \(|\Delta p| < 1 \text{ GeV/c} \)
- \(|\Delta p| > 1 \text{ GeV/c} \)

measured with RD
inferred from forward spectrometer
Exclusive VM Event Selection

HERMES 2007 data

Rho candidates

$p_{\text{meas}}(\text{Recoil}) - p_{\text{calc (miss)}} \ [\text{GeV}/c]\]

Herpes 2007 data

Traditional $\rho^0$ analysis

Traditional $\omega$ analysis

Recoil momentum cut

Recoil acceptance

HERMES Data 2007

$\Delta p \leq 0.8\text{GeV}/c$

$\Delta p > 1$
Data Processing

- most of data productions foreseen to be done end of 2010
- data until 2005 ("pre-Recoil") by middle of 2009
- 2006/07 ("Recoil") data still requires several iterations (fine tuning of calibrations, tracking etc.)
  ➤ “physics production” ready Fall 2009
  ➤ final productions expected to be finished end of 2010
- Monte Carlo productions running in parallel
  - with end of processing of experimental data, much increased computing power available on HERMES PC farm
  - in the meanwhile use of GRID when necessary
Summary

- five new results became available since last PRC and have been presented at the main conferences
- many more results expected to come
- first physics analyses using the recoil detector underway