First results on the longitudinal double spin asymmetry $A_1^p$ and $g_1^p$ from the 2011 COMPASS data

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M2 beamline

Polarized $\mu$ beam ($\sim 80\%$)
160 GeV/c, 200 GeV/c

Solid polarized target (1.2m)

Spectrometer

- Two magnets
- Tracking ($p > 0.5$ GeV/c)
  SciFi, Silicon MicroMega, Gem
  MWPC, Drift, Straws, Driftubes
- PID: RICH($\pi, K, p$)
  ECAL, HCAL, muon filters
Polarized target

- Upgrade of the target system in 2005
- Three target cells, oppositely polarized
- 180 mrad geometrical acceptance
- Regular polarization reversals by field rotation
- \( \text{NH}_3 \) (Longitudinal proton polarization: \( \sim 90\% \))
Deep Inelastic Scattering

- 4-momentum of the virtual photon: $q = k - k'$
- Energy of the virtual photon:
  $$\nu = \frac{Pq_{\text{lab}}}{M} = E - E'$$
- $Q^2 = -q^2_{\text{lab}} \approx 4EE' \sin^2 \frac{\theta}{2}$
- Bjorken scaling variable:
  $$x_{\text{lab}} = \frac{Q^2}{2M\nu}$$
  $$y_{\text{lab}} = \frac{\nu}{E}$$

Inclusive cross section:

$$\frac{d^2\sigma}{d\Omega dE'} \sim c_1 F_1(x, Q^2) + c_2 F_2(x, Q^2) + c_3 g_1(x, Q^2) + c_4 g_2(x, Q^2)$$

- spin independent
- spin dependent
Polarized Deep Inelastic Scattering

Absorption of polarized photons

\[ \sigma_{1/2} \sim q^+ \]
\[ \sigma_{3/2} \sim q^- \]

\[ q(x) = q(x)^+ + q(x)^- \]
\[ \Delta q(x) = q(x)^+ - q(x)^- \]

Photon nucleon asymmetry

\[ A_1(x, Q^2) = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}} \approx \frac{\sum_q e_q^2 (q(x)^+ - q(x)^-)}{\sum_q e_q^2 (q(x)^+ + q(x)^-)} = \frac{g_1(x, Q^2)}{F_1(x, Q^2)} \]

Spin structure function

\[ g_1(x, Q^2) = \frac{1}{2} \sum_q e_q^2 \Delta q(x) = A_1(x, Q^2) \cdot \frac{F_2(x, Q^2)}{2x(1 + R(x, Q^2))} \]
Method

Aim:
\[ A = \frac{\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow}}{\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow}} \]

Measured:
\[ A_{\text{exp}} = \frac{N_u - N_d}{N_u + N_d} \]

Needed:
- Flux cancellation
- Acceptance cancellation
  → Polarization rotation
  → 3 target cells

Averaging:
\[ A_{\text{exp}} = A \cdot P_B \cdot P_T \cdot f \]

\[ A_{\text{exp}} = \frac{A + A'}{2} = \frac{1}{2} \left( \frac{N_u - N_d}{N_u + N_d} + \frac{N'_u - N'_d}{N'_u + N'_d} \right) \]
2011 Data

2007 and 2011 data taking
- Target: NH$_3$
- Increased beam energy 160 GeV → 200 GeV
- Higher $Q^2$
- Smaller $x_{Bj}$

Improve results on
- Bjorken sum rule (systematic error)
- QCD fit
- Flavor asymmetry

Event selection
- Kinematic cuts:
  - $Q^2 > 1$ (GeV/c)$^2$
  - $0.1 < y < 0.9$ remove radiative events
  - $0.0025(0.0040) < x < 0.7$
- Extrapolated beam track crosses all target cells
  $\rightarrow$ Flux cancellation
Systematic studies

- Determination of the exact target position
- Checking the data quality
  → e.g. Influence of small detector movements, detector problems,...
- Most important contribution to the systematic error
  → False asymmetries
    - Microwave reversal
    - Fake configuration (same spin orientation)

![Graph showing systematic studies results]

COMPASS 2011 Preliminary
2011 results

- **78 \cdot 10^6** Events
- Dilution factor includes radiative corrections
- Higher $Q^2$ in 2011
- Field reversals
2011 results

- Good agreement between COMPASS 2011/07 and SMC
- 2011: Small $^{14}$N corrections missing
- $g_1^p(x, Q^2) = \frac{F_2^p(x, Q^2)}{2x(1+R(x, Q^2))} A_1^p$
- $F_2^p$ parameterization from SMC
- Same parameterization for R as in depolarization factor
Summary and Outlook

- New measurement at 200 GeV/c
- Measurement of $A_1^p$ and $g_1^p$
  - New value at small $x$
  - 2011 data improve the precision of the COMPASS results

Outlook

- Identified hadron asymmetry
- Include our results in a NLO pQCD fit
- Improve the results on the test of the Bjorken sum rule