Longitudinal spin physics at COMPASS

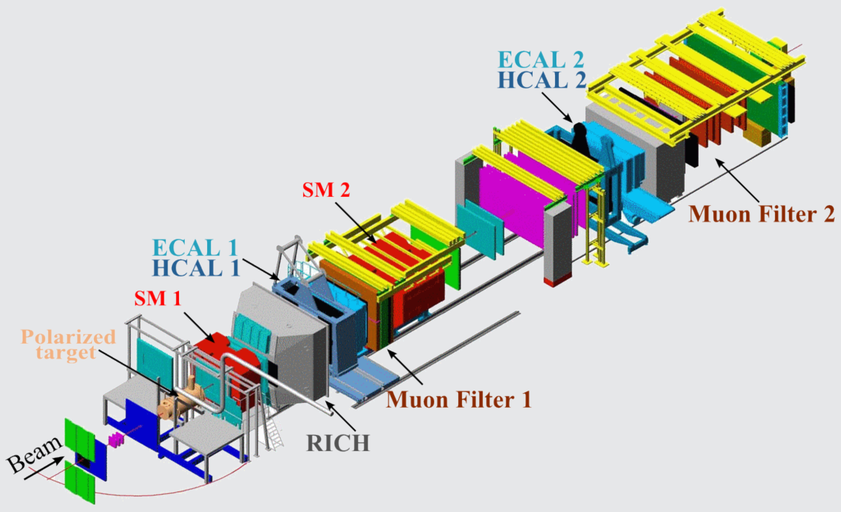
Malte Wilfert

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

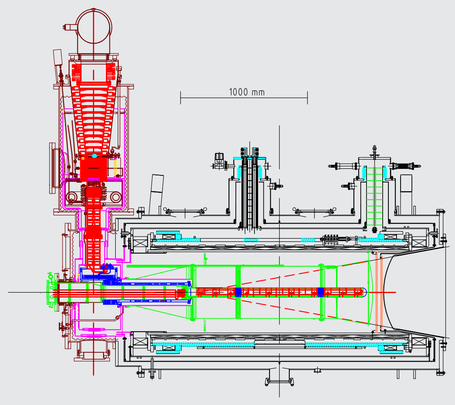
Symmetry Breaking

COmmon Muon and Proton Apparatus for Structure and Spectroscopy

- Fixed target experiment
- Located at CERN SPS
- Data taking since 2002
- Physics program
  - Nucleon spin structure
  - Hadron spectroscopy
- Two types of beams
  - Polarized μ beam ($\sim 80\%$): 160 GeV/c, 200 GeV/c
  - Hadron beam (π, K, p): 190 GeV/c
- Spectrometer
  - Two magnets
  - Tracking ($p > 0.5$ GeV/c)
    SciFi, Silicon MicroMega, Gem MWPC, Drift, Straws, Driftubes
  - PID: RICH (π, K, p)
    ECAL, HCAL, muon filters

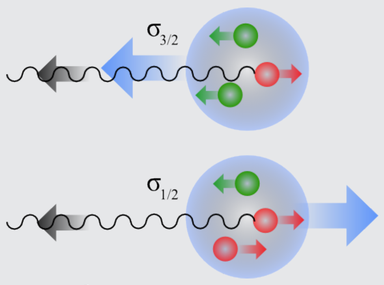


Polarized Target



- Upgrade of the target system in 2005
- Three target cells, oppositely polarized
- 180 mrad geometrical acceptance
- Regular polarization reversals by field rotation
- NH_3 (Longitudinal proton polarization: $\sim 90\%$)

Polarized Deep Inelastic Scattering



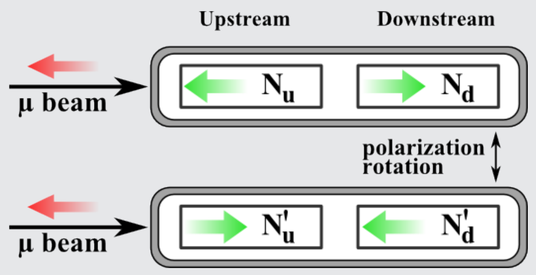
- Absorption of polarized photons
  $\sigma_{1/2} \sim q^+$
  $\sigma_{3/2} \sim q^-$
- $q(x) = q(x)^+ + q(x)^-$
  $\Delta q(x) = q(x)^+ - q(x)^-$
- Photon nucleon asymmetry

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

- 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:
  $A_{exp} = \frac{N_u - N_d}{N_u + N_d}$
- Needed:
  - Flux cancellation
  - Acceptance cancellation
    → Polarization rotation
    → 3 target cells
- $A_{exp} = A \cdot P_B \cdot P_T \cdot f$
- Averaging:

$$A_{exp} = \frac{A + A'}{2} = \frac{1}{2}\left(\frac{N_u - N_d}{N_u + N_d} + \frac{N'_u - N'_d}{N'_u + N'_d}\right)$$

Aim: Improve Results on

- Bjorken Sum Rule
- NLO QCD Fit
- Polarized quark distributions (LO)

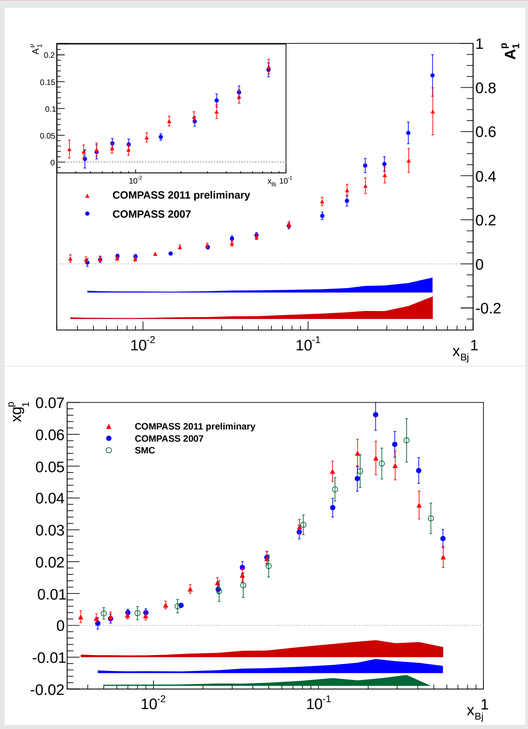
2007 and 2011 data taking

- Target: NH_3
- Increased beam energy
  160 GeV → 200 GeV
- Higher Q^2
- Smaller x

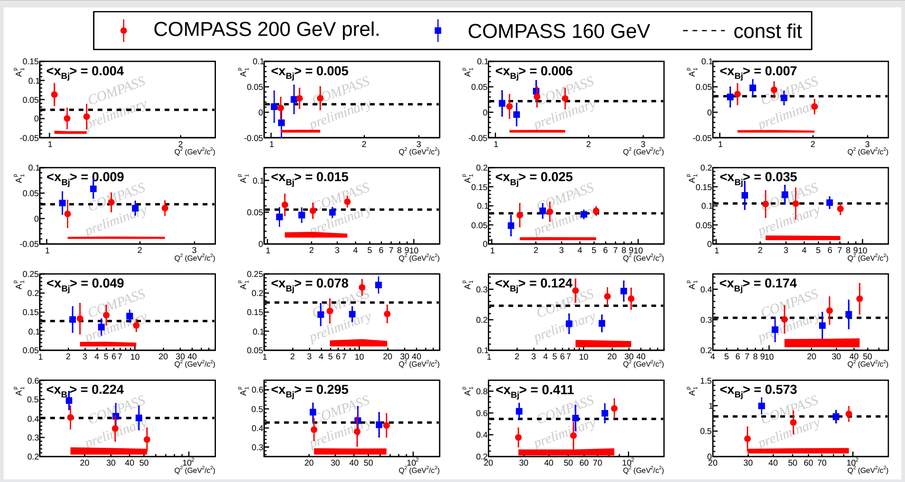
Event selection

- 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
  → Flux cancellation

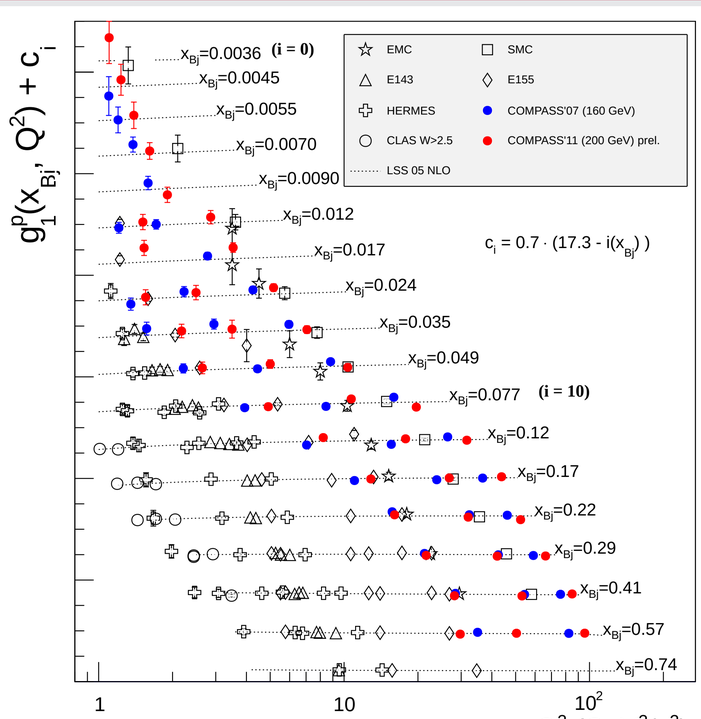
First results



In bins of x and Q^2



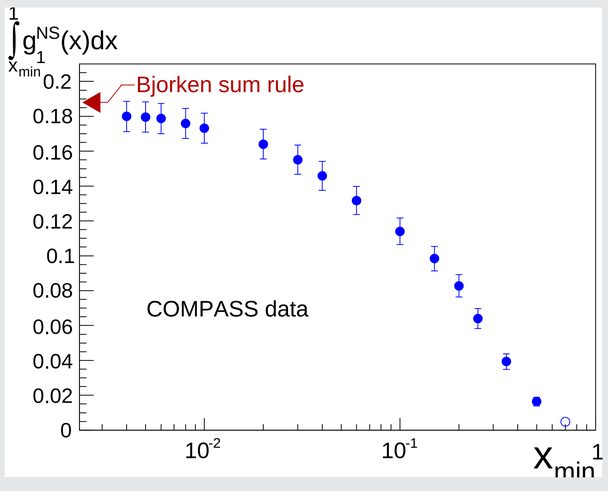
- No Q^2 dependence observed
- New data point at very low x
- New input for global QCD fit
- Indirect ΔG extraction



Outlook

Bjorken Sum Rule

$$\int_0^1 g_1^{NS}(x,Q^2)dx = \int_0^1 \left(g_1^p(x,Q^2) - g_1^n(x,Q^2)\right) dx = \frac{1}{6} \mid \frac{g_A}{g_V} \mid C_1^{NS}(Q^2)$$



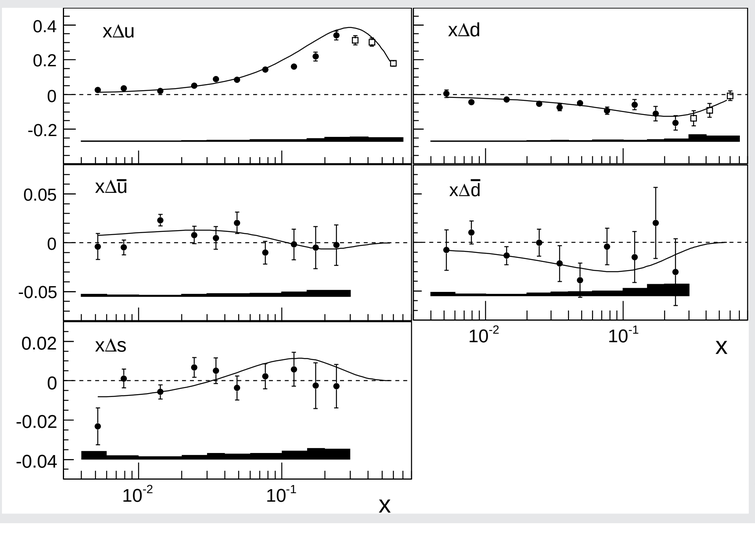
Previous results

- g_1^{NS} determined only from COMPASS data
- $\mid \frac{g_A}{g_V} \mid = 1.2694 \pm 0.0028$ obtained from neutron β-decay.
- COMPASS result:
  $\mid \frac{g_A}{g_V} \mid = 1.28 \pm 0.07 \pm 0.10$
- Verification of the Bjorken sum rule

PLB 690 (2010) 466-472

Polarized PDFs from LO fit

$$A_1^h(x,z) = \frac{\sum_q e_q^2 (\Delta q(x) D_q^h(z) + \Delta\bar{q}(x) D_{\bar{q}}^h(z))}{\sum_q e_q^2 (q(x) D_q^h(z) + \bar{q}(x) D_{\bar{q}}^h(z))}$$



Previous results

- Measured:
  $A_{1p}, A_{1p}^{\pi+}, A_{1p}^{\pi-}, A_{1p}^{K+}, A_{1p}^{K-}$,
  $A_{1d}, A_{1d}^{\pi+}, A_{1d}^{\pi-}, A_{1d}^{K+}, A_{1d}^{K-}$
- Input:
  - unpolarized PDF $q(x)$, $\bar{q}(x)$
  - Fragmentation function D_q^h, $D_{\bar{q}}^h$ describing $q \to h$
- Flavor asymmetry of the sea

PLB 693 (2010) 227-235