

$A_{LL}(p_T)$ for single hadron photoproduction at high p_T

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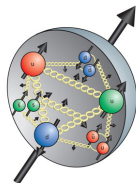
CEA Saclay - SPhN

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Nucleon Spin Structure

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

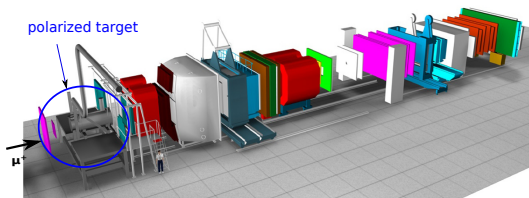


$$\Delta\Sigma \approx 0.3 \Rightarrow -0.1 \leq \Delta G \leq 0.3 \text{ ??}$$

\Rightarrow Purpose: Extraction of ΔG from $A_{LL}(p_T)$ at high p_T and low Q^2

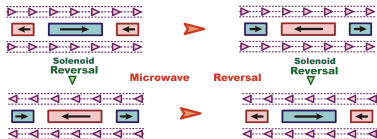


COMPASS Spectrometer and Target



- ▶ polarized target with 2 (2002-2004) or 3 (2006-2011) cells
- ▶ 2 types of polarization reversal
- ▶ target material:
 - ▶ deuterons (${}^6\text{LiD}$) from 2002 to 2006
 - ▶ protons (NH_3) from 2007 to 2011

- ▶ μ^+ polarized beam from SPS at 160 or 200 GeV
- ▶ 2 stages spectrometer with large acceptance

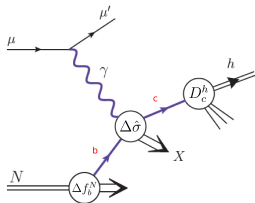


Theoretical Framework

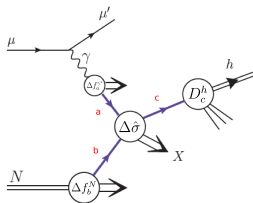
- Collinear pQCD analysis at NLO:

$$\frac{d\Delta\sigma^h}{d\sigma^h}(p_T, \eta) = \frac{\sum_{a,b,c} \Delta f_a^\mu \otimes \Delta f_b^N \otimes d\Delta\hat{\sigma}_{a,b \rightarrow c, X} \otimes D_c^h}{\sum_{a,b,c} f_a^\mu \otimes f_b^N \otimes d\hat{\sigma}_{a,b \rightarrow c, X} \otimes D_c^h} = \frac{d\Delta\sigma_{dir} + d\Delta\sigma_{res}}{d\sigma_{dir} + d\sigma_{res}}$$

direct γ -contribution



resolved γ -contribution

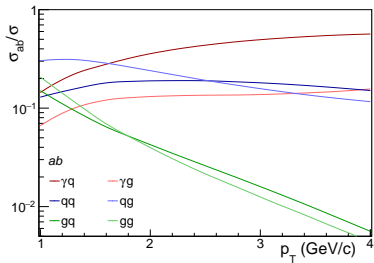


- $\Delta f_a^\mu(x_a, \mu_f) = \int_{x_a}^1 \frac{dy}{y} \Delta P_{\gamma\mu}(y) \Delta f_a^\gamma(x_\gamma = \frac{x_a}{y}, \mu_f)$
allows to take into account both γ -contributions
- Uncertainty for the polarization of the hadronic fluctuation of the virtual photon

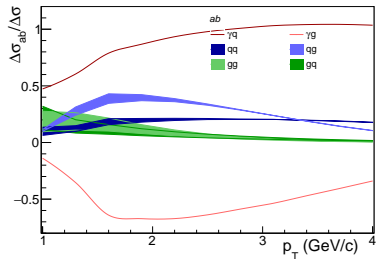


Contributions of the Different Processes at NLO

Unpolarized Cross-sections



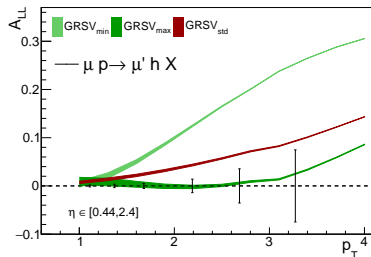
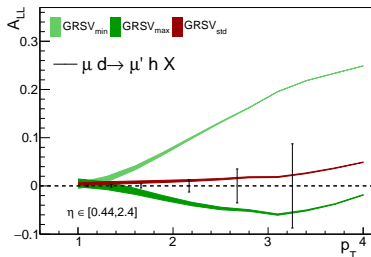
Polarized Cross-sections



- ▶ QCD Compton (γq) dominating over PGF (γg)
→ Some discrepancies with results based on the Pythia model (analyses with different kinematics and final states)
- ▶ Still a good sensitivity on ΔG through the PGF

Theoretical Estimations

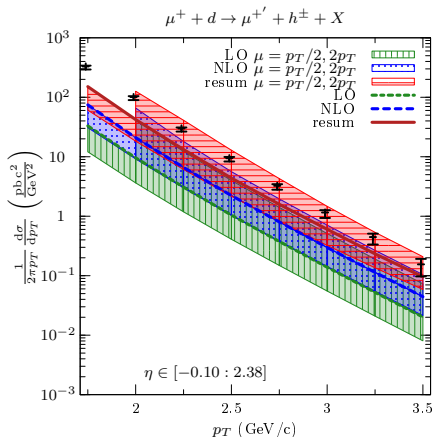
- ▶ Estimation of COMPASS A_{LL} for deuteron and proton target, with COMPASS error projection (EPJC 44 (2005) 533)



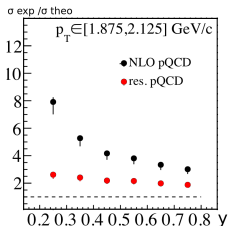
- ▶ Small impact of the resolved photon polarized structure uncertainty (only at low p_T)
- ▶ **Discriminating power on ΔG**

Unpolarised Cross-sections Preliminary Study

- ▶ COMPASS measurement (PRD 88 (2013) 091101)
- ▶ Comparison with theoretical calculations with gluon resummation (PRD 88 (2013) 014024)



- ▶ close to threshold given a low energy range: $\sqrt{s} \approx 18 \text{ GeV}$ (RHIC: $\sqrt{s} \approx 200 \text{ GeV}$)
- ▶ needs gluon resummation to explain unpolarized cross-section



Systematics Study

- ▶ Qualitative study of unphysical asymmetries (supposed to be zero) and comparison of asymmetries from equivalent parts of the data
- ▶ Multiplicative uncertainties coming from measurement uncertainties on beam and target polarization and on the dilution factor

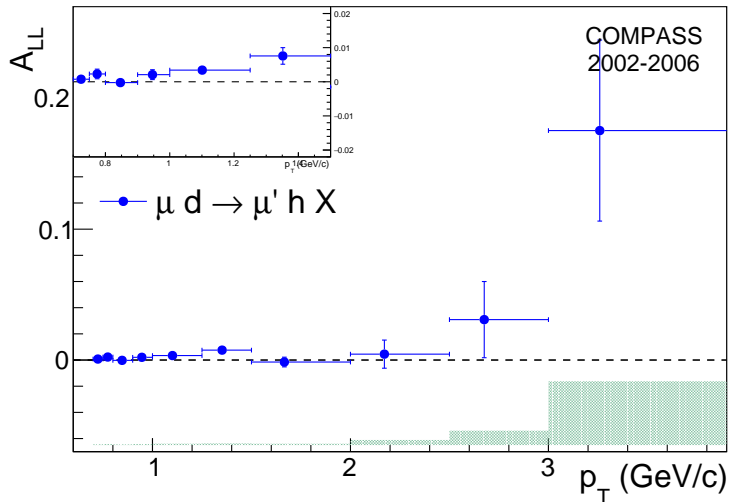
$$\rightarrow 0.07 \cdot A_{LL}$$

- ▶ Study of false asymmetries (dominant systematics) through a *pulls* analysis ($(A_i - \bar{A})/\sigma_{A_i}$ distribution for i sub-sample)

$$\rightarrow \leq 0.6 \cdot \sigma_{A_{LL}}^{stat}$$

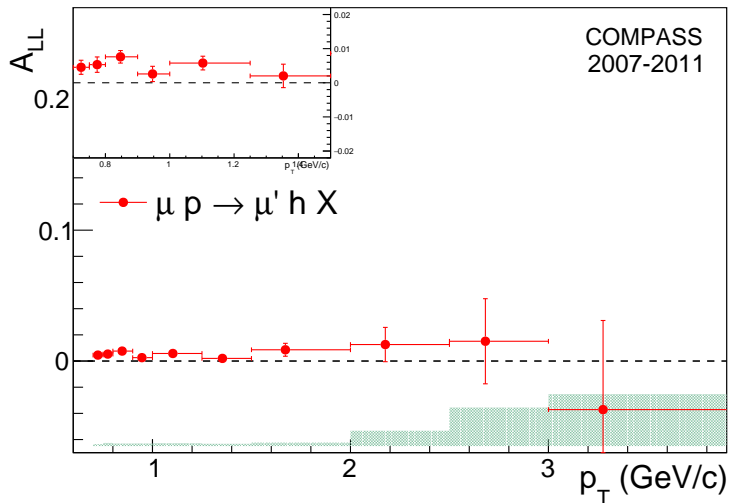


Deuteron Results (2002-2006)



- ▶ A tendency to go positive at high p_T




Proton Results (2007,2011)

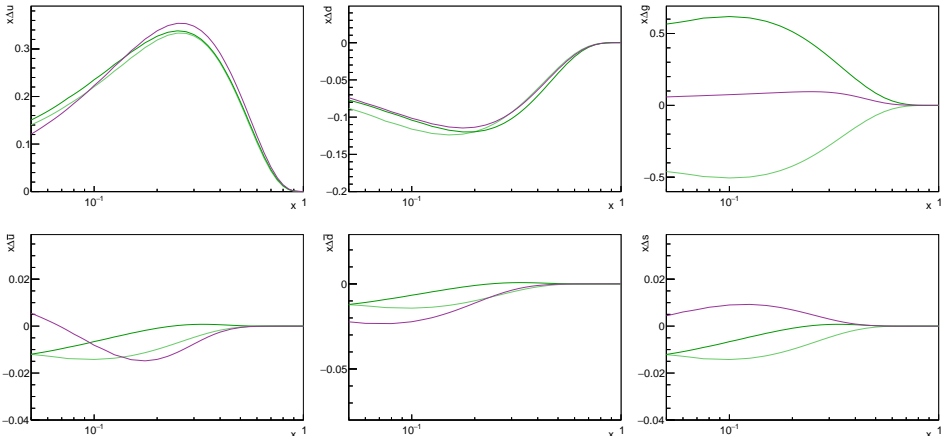


- ▶ Asymmetry compatible with 0, more positive at low p_T



PDFs Used in the Comparison

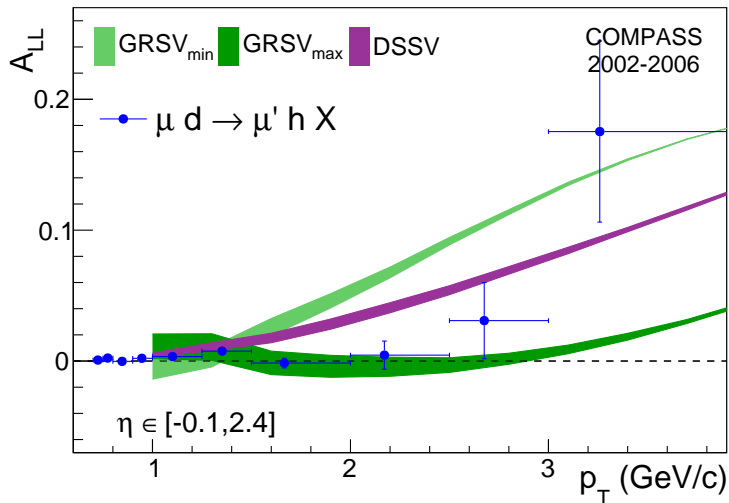
 GRSV_{min} $\Delta G \approx -0.3$  GRSV_{max} $\Delta G \approx 0.38$  DSSV $\Delta G \approx 0.09$



Polarized PDFs for $Q^2 = 5 \text{ GeV}^2$

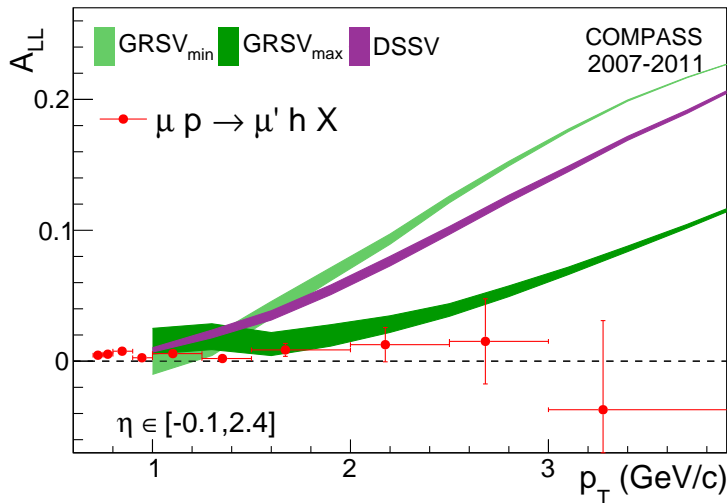
ΔG computed with a truncation for $x_g \in [0.15, 0.5]$

Deuteron Results with Theoretical Comparison



- Large positive ΔG is favored

Proton Results with Theoretical Comparison



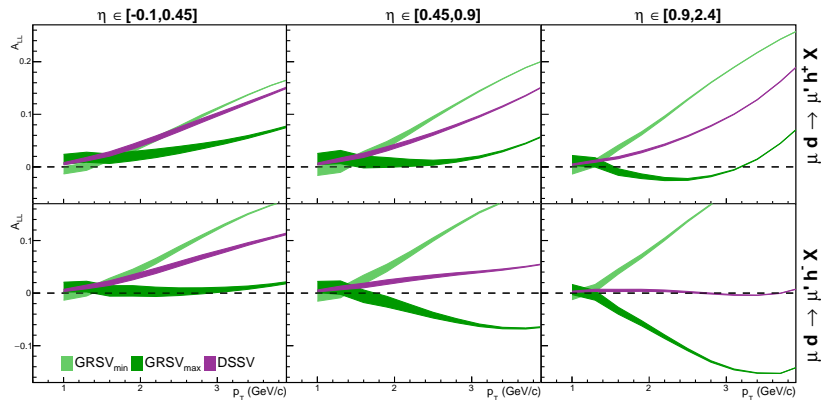
- Some discrepancy between theoretical model and experimental calculations.

Outlook

- ▶ Expecting theoretical calculations for the gluon resummation for the polarized case
- ▶ $A_{LL}(p_T, \eta)$ which are much more sensitive to ΔG
- ▶ $A_{LL}^{h^+}, A_{LL}^{h^-}, A_{LL}^{\pi^+}, A_{LL}^{\pi^-}, A_{LL}^{K^+}, A_{LL}^{K^-}$ which give various and more precise comparisons



Theoretical Results for Deuteron Target



Theoretical Results for Proton Target

