

Measurement of $\Delta G/G$ from high transverse momentum hadron pairs in COMPASS

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The new COMPASS $\Delta G/G$ result obtained from high transverse momentum hadron pairs in the $Q^2 > 1$ (GeV/c)² region is presented. Comparing to the previous analysis in this region the statistical error of $\Delta G/G$ is reduced by a factor 3 to 0.10. A weighted method of the $\Delta G/G$ measurement based on neural network approach is used. In addition, the formula for the $\Delta G/G$ extraction used in the analysis has been updated. The contributions coming from the leading order and QCD Compton processes are no longer neglected. Slides can be found in [1].

1 Introduction

COMPASS is an experiment at CERN focusing on the spin structure of the nucleon and hadron spectroscopy. Between 2002 and 2004, a 160 GeV/c polarized muon beam and a two cell polarized ⁶LiD target were used for spin studies. For the 2006 data taking major updates of the spectrometer were made.

Here we present results for $\Delta G/G$ extracted from high transverse momentum hadrons pairs. The selection of these events increases the fraction of the *photo-gluon fusion* (PGF) in the sample, therefore increases sensitivity to the gluon polarization. So far data from 2002-2004 years were analyzed. The analysis of the 2006 data is in progress. The $\Delta G/G$ value was extracted for both the $Q^2 > 1$ (GeV/c)² and the $Q^2 < 1$ (GeV/c)² regions. In this paper we present the new result for the $Q^2 > 1$ (GeV/c)² analysis. For the low Q^2 data the obtained result is $\Delta G/G = 0.016 \pm 0.058 \pm 0.054$ *c.f.* [2]. Similar analyzes were performed in SMC [3] and HERMES [4]. In addition, COMPASS measured $\Delta G/G$ for open charm events, which are believed to be a clean source of PGF. The description of that analysis can be found in this proceedings, *c.f.* contribution by Florent Robinet.

2 Data selection

An incoming and a scattered muon as well as an interaction vertex in the target are required for each event. The kinematic cuts $0.1 < y < 0.9$ and $Q^2 > 1$ (GeV/c)² are applied. The latter cut ensures that scale of the hard process is high enough so that pQCD can be used. We require at least two charged hadrons in the interaction vertex with transverse momentum above 0.7 GeV/c each, their x_F as well as z have to be larger than 0. In addition, is also required that the sum of the energy fraction of the two hadrons is $z_1 + z_2 < 0.95$ and that their invariant mass is > 1.5 GeV/c². The total number of selected events is about 500k.

3 Extraction of $\Delta G/G$

In the leading order QCD there are three sub-processes which contribute to the total cross-section: leading order (LO), QCD Compton (QCDC or C), and photo gluon-fusion (PGF). The cross-section asymmetry for high transverse momentum hadrons pair can be expressed as

$$A_{LL}^{2h}(x_{Bj}) \approx \frac{\Delta G}{G}(x_G) a_{LL}^{PGF} R_{PGF} + A_1^{LO}(x_C) a_{LL}^{\hat{C}} R_C + A_1^{LO} D R_L; \quad A_1^{LO} \equiv \frac{\sum_i e_i^2 \Delta q_i}{\sum_i e_i^2 q_i}$$

where $a_{LL,i}$ are analyzing powers and R_i are the fractions of sub-processes in the sample. In a similar way the cross-section asymmetry A_1^d can be decomposed. Combining the two asymmetries, the following relation holds:

$$\begin{aligned} \frac{\Delta G}{G}(x_G) &= \frac{A_{LL}^{2h}(x_{Bj}) + A^{corr}}{\beta} \\ \beta &= a_{LL}^{PGF} R_{PGF} - a_{LL}^{PGF, incl} R_{PGF}^{incl} \left(\frac{R_L}{R_L^{incl}} + \frac{R_C}{R_L^{incl}} \frac{a_{LL}^C}{D} \right) \\ A^{corr} &= -A_1(x_{Bj}) D \frac{R_L}{R_L^{incl}} - A_1(x_C) \beta_1 + A_1(x'_C) \beta_2 \\ \beta_1 &= \frac{1}{R_L^{incl}} \left(a_{LL}^C R_C - a_{LL}^{C, incl} R_C^{incl} \frac{R_L}{R_L^{incl}} \right) \quad \beta_2 = a_{LL}^{C, incl} \frac{R_C R_C^{incl}}{(R_L^{incl})^2} \frac{a_{LL}^C}{D}. \end{aligned}$$

There are two points worth mentioning about the formulas. Firstly, a A_{corr} cannot be neglected for the $\Delta G/G$ extraction. It was found that the average value of x_C in the sample is about 0.14. For such a high x value A_1^d and therefore A_{corr} are no longer zero. Secondly, β determines the precision of the measured $\Delta G/G$. In the first approximation it is proportional to a difference between the PGF fractions for the high- p_T and the inclusive samples. If the difference between the two fractions is small the statistical error of $\Delta G/G$ will be large. Neglecting the impact of PGF events from the inclusive sample would lead to underestimation of the statistical error of $\Delta G/G$.

To increase the statistical precision of the gluon polarization measurement a weighted method of asymmetry extraction was used. The weight is $f D P_b \beta$, where f is the dilution factor D is the depolarization factor, P_b is the beam polarization. The weight has to be known on the event by event basis. This means that for every event we have to know: $R_{PGF}, R_C, R_L, R_{PGF}^{incl}, R_C^{incl}, R_L^{incl}, a_{LL}^{PGF}, a_{LL}^C, a_{LL}^{PGF, incl}, a_{LL}^{C, incl}, x_G, x_C, f, D, P_b$. Only the last three quantities are calculated from data, all others have to be obtained from MC. A Neural Network (NN) trained on MC samples was used for the parametrization of these quantities. As an input to the NN training for the inclusive sample, x_{Bj} and Q^2 were selected while for the high- p_T sample in addition transverse and longitudinal momenta of the two hadrons were used. This method of $\Delta G/G$ extraction depends largely on MC. Good data description with the MC as well as good NN parameterizations are the ‘‘key points’’ of this analysis.

4 MC and NN parameterizations

To extract $\Delta G/G$ two MC samples are needed: an inclusive and a high- p_T . The LEPTO generator and full simulation of the COMPASS spectrometer were used. MRST04 LO was used for the parton distribution functions given the very good description of F_2 in COMPASS kinematics. The gluon radiation in the initial and final state were allowed in the generator (the so called parton shower ON). This simulates part of NLO corrections. The parton shower OFF was used to estimate systematics. To improve the data and MC agreement the LEPTO parameters were tuned (k_T and parameters of fragmentation). Standard LEPTO tuning was used for systematic studies. In Figure 1 examples of data-MC comparison are shown for the transverse momenta of the first and the second hadron respectively. In the right-most plot the comparison between standard and tuned LEPTO is shown for $\sum p_T^2$. We observe good agreement between data and MC, also necessity for LEPTO tuning is clearly visible.

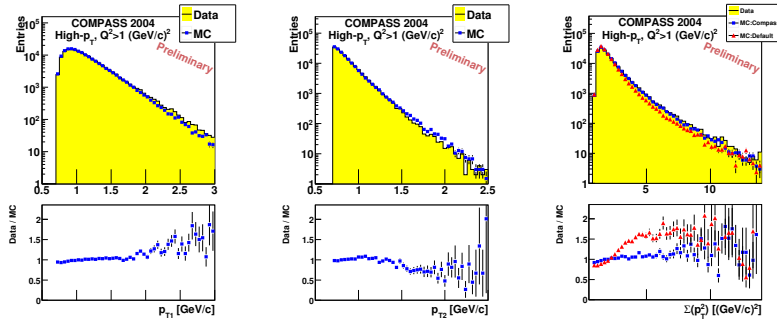


Figure 1: Data and Monte Carlo comparison for transverse momenta of the hadrons.

The NN parameterizations of the variables used in the weight were compared with original MC samples and good agreement was found. As an example we show in Figure 2 the comparison between the fractions of the processes as a function of $\sum p_T^2$.

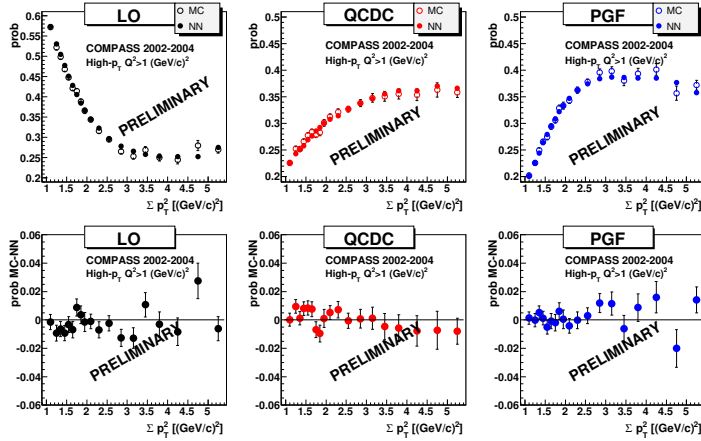


Figure 2: Comparison of R_i from MC and NN parameterization.

5 Systematic studies

Various systematic studies were performed to estimate the systematic uncertainty of the extracted $\Delta G/G$. Summary is given in Table 1. The main contribution comes from the MC, other contributions like false asymmetries, uncertainties of the beam/target polarization, dilution factor, radiative correction, simplification of the formula for $\Delta G/G$ extraction, A_1^d parametrization and NN parametrization stability were found to be much smaller.

$\delta(\Delta G/G)_{NN}$	0.006
$\delta(\Delta G/G)_{MC}$	0.040
$\delta(\Delta G/G)_{f,P_b,P_t}$	0.006
$\delta(\Delta G/G)_{false}$	0.011
$\delta(\Delta G/G)_{A1}$	0.008
$\delta(\Delta G/G)_{formula}$	0.013
TOTAL	0.045

Table 1: Contributions to the systematic error of $\Delta G/G$

Since the MC error gives the largest contribution to the systematic error its estimation will be described in more details. For these studies we were using four MC samples: tuned LEPTO with parton shower ON/OFF and standard LEPTO tuning with parton shower ON/OFF. This way we estimated the impact of the MC tuning and partially the impact of NLO corrections. In addition, we made three extraction of $\Delta G/G$ with each of MC samples. In the first one we were using samples as they were, in the second one using NN we selected events from regions of phase space where data and MC agrees well in the last one variation we re-weighted MC events so that ratio data over MC is equal to 1. This way we obtained 12 values of $\Delta G/G$. From their distribution we estimated the MC systematic error to be about 0.04.

6 Results

The preliminary result for $\Delta G/G$ for high transverse momentum hadron pairs with $Q^2 > 1$ (GeV/c)² is $\Delta G/G = 0.08 \pm 0.10 \pm 0.05$. The average $\langle x_G \rangle$ for the data was about 0.08, and average scale of the process about 3 (GeV/c)². The result is consistent with zero. The statistical precision with respect to the previous measurement from COMPASS in the $Q^2 > 1$ (GeV/c)² range increased by factor 3. The presented result is also in good agreement with the $\Delta G/G$ result obtain for low the Q^2 high- p_T analysis.

7 Summary and Outlook

The preliminary result for $\Delta G/G$ for high transverse momentum hadron pairs with $Q^2 > 1$ (GeV/c)², was presented: $\Delta G/G = 0.08 \pm 0.10 \pm 0.05$. The result is compatible with zero as well as with other direct measurements of $\Delta G/G$ from COMPASS, HERMES and SMC. The presented data used 2002-2004 data. With additional 2006 data and future upgrade of the analysis method we expect to at least double available statistics.

References

- [1] Slides: <http://indico.cern.ch/contributionDisplay.py?contribId=256&sessionId=22&confId=24657>
- [2] COMPASS, E.S. Ageev *et al.*, Phys. Lett. B **633** (2006) 25.
- [3] SMC, B. Adeva *et al.*, Phys. Rev. D **70** (2004) 012002.
- [4] HERMES, A. Airapetian *et al.*, Phys. Rev. Lett. **84** (2000) 2584; recently a smaller preliminary value from another method has been reported in P. Liebig, AIP Conf. Proc. 915 (2007) 331 (arXiv:0707.3617).