New COMPASS Results on Polarised Parton Distributions inside Nucleon

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A selection of COMPASS results obtained in polarised deep inelastic scattering of polarised muons off longitudinally polarised proton and deuteron targets is presented. A LO flavour separation and two new measurements of the gluon polarisation $\Delta g/g$ are discussed.

1 Introduction

COMPASS is an experiment at CERN focusing on the spin structure of the nucleon and hadron spectroscopy. For analyses presented in this paper, a 160 GeV/c polarised muon beam and a two (three) cell polarised ^{6}LiD or NH_3 targets were used. The LO flavour separation is discussed with emphasis on ΔS distribution. The new $\Delta g/g$ results obtained in the open charm and in High-p_T hadron pairs analyses are also shown.

2 Flavour separation

COMPASS analysed the semi–inclusive asymmetries for kaons and pions on both proton and deuteron targets. In the LO approximation the hadron asymmetry can be expressed as

$$A_1^h(x, Q^2, z) = \frac{\sum_q e_q^2 \Delta q(x, Q^2) D_q^h(z, Q^2)}{\sum_q e_q^2 q(x, Q^2) D_q^h(z, Q^2)} \quad (1)$$

where e_q is quark electric charge, $(\Delta)q$ (polarised) parton distribution function and D_q^h is fragmentation functions (FF) of quark q into hadron h. With inclusive and semi-inclusive asymmetries one has 10 measured asymmetries and 5 unknown parameters $(\Delta u, \Delta d, \Delta\bar{u}, \Delta\bar{d}, \Delta s)$, The flavour separation of quark helicity distributions is possible using just a linear algebra. Some results were already published in [1] using FF from DSS parametrisation [2]. The results are summarised in Fig. 1. In general good agreement is observed between COMPASS results and DSSV parametrization [3].

From the inclusive asymmetries it is known that the strange sea polarisation is negative. This tend is so far not observed in COMPASS and HERMES semi-inclusive analyses where, in the measured rage of x, the value of ΔS is consistent with zero. However, as pointed out in [1], the ΔS obtained in semi-inclusive analysis strongly depends upon the choice of the fragmentation functions used. COMPASS try to extract these FF from data alone $cf.$ [4].

3 Gluon polarisation

Information about gluon polarisation can be obtained indirectly from scaling violations in the structure function g_1 or in direct measurement studying photon-gluon fusion processes (PGF). Here only direct COMPASS measurements are discussed: *i*) open charm studies and *ii*) in the analysis of hadrons produced with high transverse momenta (HipT). In the former case the analysis is free from any physical background in the Leading order approximation. Unfortunately due to the large charm mass, in the COMPASS energy range the production cross section for charm mesons is small, and also branching ratio for the $D^0 \to K\pi$ is below 4%. Therefore the analysis has limited statistical precision. The HipT method has an advantage over open charm that the production cross-section is larger therefore the statistical error of $\Delta g/g$ will be reduced. On the other hand the HipT analysis is not background free.

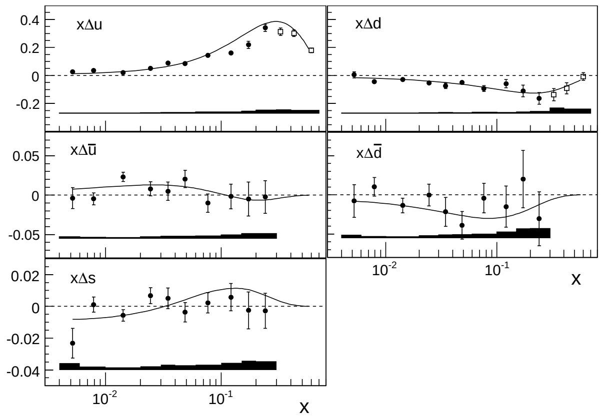

Figure 1: Results of LO flavour separation using COMPASS data [1]. The curves are from [3].

3.1 Open charm analysis

In the current open charm analysis all available data from 2002-2007 are used. In order to improve the statistical error of $\Delta g/g$ five different D mesons decay modes are studied. In total there are about 65000 D^0 candidates and about 29000 D^* candidates out of which 13000 are in the golden channel $D^* \to K\pi\pi_{slow}$. In a simplified approach the gluon polarisation $\Delta g/g$ can be obtained from:

$$\frac{\Delta g}{g} = \frac{1}{P_T P_b f a_{LL} \frac{S}{S+B}} A^{\mu N \to D^0 + X} \qquad (2)$$

where $P_{T,b}$ are the target and beam polarisation, respectively, f is the dilution factor of the material which takes into account the fraction of polarisable nucleons in the target, including radiative corrections. a_{LL} is the so called analysing power which represents the polarisation transfer from muon to photon and from gluon to charm quarks. The $\frac{S}{S+B}$ is the ratio between signal and signal plus combinatorial background, and finally the $A^{\mu N \to D^0 + X}$ is the measured asymmetry. The method which is actually used in the analysis is much more complex *e.g.* it allows the simultaneous extraction of signal and background asymmetries, details can be found in [5]. To increase the statistical significance of the results the events are weighted on an event by event basis using a Neural Network approach. The preliminary result is $\Delta g/g = -0.08 \pm 0.21 \pm 0.11$. at average $x_g = 0.11$ and scale $\mu^2 = 13$ (GeV/c)^2.

The gluon polarisation in NLO approximation, based on [6], was recently extracted in COMPASS. The AROMA generator is used with active parton shower option. The parton shower simulates the phase-space for NLO correction, which can be calculated on the event by event basis. Large differences are observed between a_{LL} and x_g for LO and NLO order. In addition, in NLO part of the D^0 doesn't come from PGF process, but is sensitive to inclusive spin asymmetries $A_1^{p,d}$. This correction was found to be small, but it is included in the analysis. The preliminary result of the NLO analysis is $\Delta g/g_{NLO} = -0.20 \pm 0.21 \pm 0.08$ at average $x_g = 0.28$ and scale $\mu^2 = 13$ (GeV/c)^2.

3.2 High-p_T hadron pair analysis

The results of $\Delta g/g$ analysis form $Q^2 > 1$ (GeV/c)^2 high-p_T hadron pairs are presented. Data come from 2002-2006 years when COMPASS used LiD target. As the Q^2 ensures perturbative scale the cut on hadron p_T can be low, here $p_{T_1} = 0.7$ and $p_{T_2} = 0.4$ GeV/c, for the first and the second hadron respectively. The total number of events in the selected sample is about 7.3 millions. The sample is strongly contaminated by a non–PGF processes. This background is related to Leading Process (LP) *i.e.* photon-quark scattering and QCD Compton process (QCDC), where the scattered quark emits in addition a gluon. It is expected that for higher p_T of hadrons the PGF fraction will grow while LP decreases. The observed asymmetry in a two hadron sample can be written as:

$$A_{LL}^{2h}(x_{Bj}) = R_{PGF}\, a_{LL}^{PGF} \frac{\Delta g}{g}(x_g) + R_{LP}\, D\, A_1^{LO}(x_{Bj}) + R_{QCDC}\, a_{LL}^{QCDC} A_1^{LO}(x_C) \qquad (3)$$

where $A_1^{LO} \equiv \frac{\sum_i e_i^2 \Delta q_i}{\sum_i e_i^2 q_i}$, Rs are fractions of the sub-processes (LO, PGF, QCDC) and a_{LL}s - analysing powers for PGF and QCDC. Unfortunately Rs and a_{LL}s cannot be determined from data they have to be taken from elsewhere *e.g.* MC simulation. Therefore a good agreement between data and MC is crucial for this analysis. In the above equation there are two unknowns $\Delta g/g$ and A_1^{LO}, to be obtain $\Delta g/g$ additional information is needed. This information is taken from the inclusive sample, where inclusive asymmetry is described in a similar way as the asymmetry of two hadron sample. Finally,

$$\Delta g/g = \frac{A_{LL}^{2h} + A^{corr}}{\beta} \qquad (4)$$

where β is a function of a_{LL}s, Rs and A^{corr} is in addition a function of inclusive A_1^d asymmetry. To reduce statistical error of $\Delta g/g$ the weighted method of the asymmetry extraction is used. All Rs and a_{LL}s have to be known on the event-by-event basis. We use a Neural Network trained on MC to obtain parametrizations of Rs and a_{LL}s.

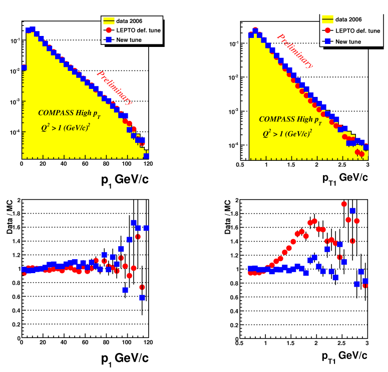

Figure 2: Data/MC agreement for different LEPTO tunings for longitudinal and transverse momenta of the first hadron.

The LEPTO generator is used with parton shower on, and MSTW08LO as a source of parton distribution functions. To improve data/MC agreement the intrinsic k_T of quarks inside nucleon and fragmentation parameters were adjusted. Example of data/MC agreement for p_{L_1}, p_{T_1} before and after adjustment is presented in Fig. 2. Clear improvement is seen for the HipT tuning.

COMPASS preliminary results of $\Delta g/g$ extracted in this analysis is $\Delta g/g = 0.125 \pm 0.060 \pm 0.065$ at average $x_g = 0.09$ and scale μ^2=3 (GeV/c)^2. The major contribution to the systematic error (0.045) comes from MC. In addition COMPASS for the first time obtained results in three bins of x_g. Within statistical errors these three results agree with each other.

The results of COMPASS $\Delta g/g$ analyses are summarised in Fig. 3. In all analyses extracted $\Delta g/g$ is small and consistent with zero. The results agree well with each other as well as with measurements from SMC and HERMES experiments. Currently the NLO analysis of a single high-p_T hadron is ongoing for $Q^2 < 0.1$ (GeV/c)^2 events *cf.* [7]. In the first step hadron cross-section as a function of p_T was compared with theoretical prediction [8].

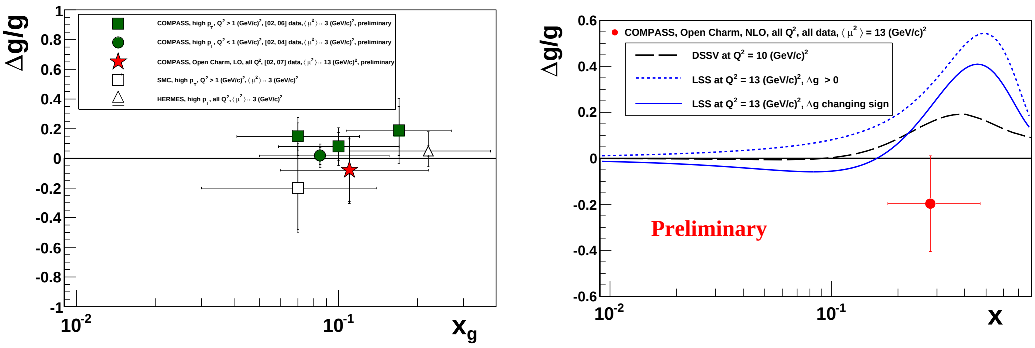

Figure 3: Summary of $\Delta g/g$ results obtained in LO and NLO analysis.

Acknowledgements

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