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New COMPASS results on the proton spin-dependent structure function g_1^p

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Recent COMPASS results on the spin asymmetry A_1 and the spin-dependent structure function of the proton g_1^p as a function of x_{Bj} and Q^2 are presented. The data have been recorded with a polarised muon beam at 200 GeV scattered off a polarised NH_3 target. The high energy of the beam allows for A_1 measurements down to x_{Bj} = 0.0036 for the first time and extends the Q^2 range to higher values, which brings new inputs for QCD global fits of world data.

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PoS(DIS 2013)207

1. Introduction

The COMPASS spectrometer [1], located at CERN, is dedicated to the study of spin structure of the nucleon and hadron spectroscopy using the SPS beam. We present here new results on the proton spin-dependent structure function extracted from deep inelastic scattering (DIS). A polarised muon beam with an energy of 200 GeV is scattered off a longitudinally polarised NH_3 target. These new data complement the previous COMPASS proton results measured at 160 GeV [2]. The increase of the beam energy allows us to explore a wider kinematic domain. It contributes to a better knowledge of the scaling violation of g_1^p which constitutes an indirect measurement of ΔG. This new set of data improves the statistics on the spin dependent structure function in the whole x_{Bj} range of measurement and especially in the low x_{Bj} region. The kinematic domain covered by the data is extended to 100 (GeV/c)^2 in Q^2 and down to 0.0036 in x_{Bj} . Figure 1a shows the available kinematic domain and the effect of the rise of the energy.

2. Measurement & Event Selection

The data were recorded in 2011. The muon beam comes mostly from the weak decay of beam pions and is hence naturally polarised. Its polarisation is 80%. The target is embedded in a solenoid producing a 2.5 T field. The ammonia which composes the target material is then polarised by dynamic nuclear polarisation. The target structure has been optimised to record simultaneously data with the two spin states, therefore it has been divided into three cells with the central one polarised oppositely to its two nearby cells. The track of the incoming muon is required to cross all the cells to have the same flux for each cell. Moreover the central cell is twice as long as the upstream and downstream cells to keep the same acceptance for the two spin state on average. The NH_3 polarisation is about 85% with a fraction of polarisable nucleons of 16%. The DIS regime is assured by a cut on $Q^2 > 1 GeV/c^2$. Only events with a photon fraction of the energy, y, within the range [0.1,0.9] are kept. This selection removes events which are hardly reconstructible (y<0.1) and the region the most affected by the radiative corrections (y>0.9).

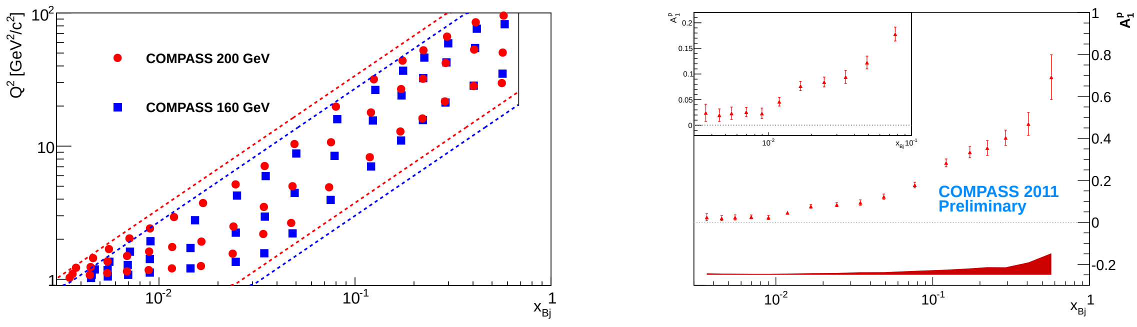
3. Spin asymmetry, A_1^p, and spin structure function, g_1^p, extraction

The asymmetry of longitudinally polarised cross-section $A_{\parallel}^p$=$(\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow})/(\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow})$ is related to a combination of the virtual photon-nucleon asymmetries A_1 and A_2 weighted by some kinematic factor: $A_{\parallel}^p = D(A_1 + \eta A_2)$. The η factor is always small within the COMPASS kinematic, moreover A_2 has been found to be small [3], thus the ηA_2 term is neglected. Hence A_1^p and g_1^p are expressed as :

$$A_{\parallel} \simeq DA_1 \qquad (3.1) \qquad\qquad g_1^p = \frac{F_2^p}{2x_{Bj}(1+R)} A_1^p \qquad (3.2)$$

where D is the depolarisation factor. F_2^p and R are spin-independent structure functions taken from [4] and [5] respectively. The data have been corrected for radiative effects [6], [7]. A correction for ^{14}N contribution in the target material has also been performed according to a model described in [8].

PoS(DIS 2013)207



(a) (b)

Figure 1: (a): The mean values of Q^2 versus the mean values of x_{Bj} for the new COMPASS at 200 GeV and compared to previous COMPASS data at 160 GeV. (b): A_1^p as a function of x_{Bj} for the COMPASS. The bottom band shows the systematic errors.

4. Results

The proton spin asymmetry A_1^p measured by COMPASS at 200 GeV is shown as function of x_{Bj} in Fig. 1b. The corresponding proton spin structure function g_1^p for COMPASS 200 GeV is shown versus x_{Bj} and integrated over Q^2 in Fig. 2. The results from the previous COMPASS and SMC proton data are also shown.

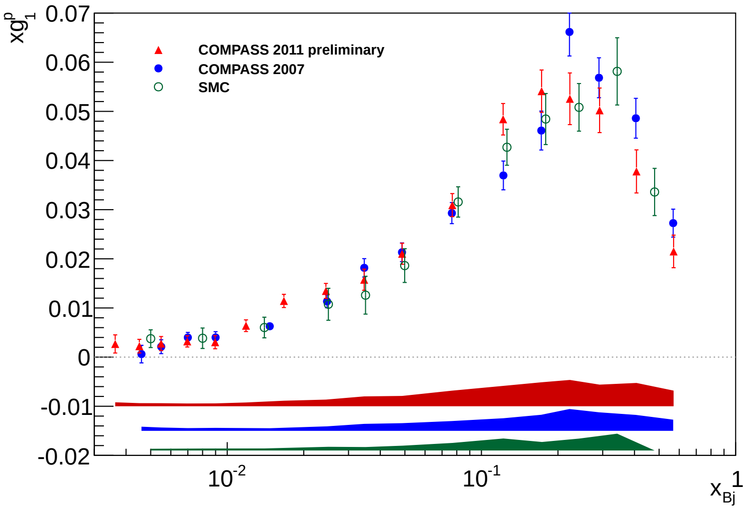


Figure 2: The proton structure function xg_1^p as measured at COMPASS at 200 GeV is plotted as a function of x_{Bj}. The previous results from COMPASS 160 GeV and SMC are also shown for comparison. COMPASS 200 GeV systematics are the top band, followed by COMPASS 160 GeV and SMC 190 GeV.

PoS(DIS 2013)207

For the new 200 GeV data, the main components of the preliminary systematic errors come from the beam polarisation, the target polarisation and the limit to a possible false asymmetry. The latter is estimated by a statistical test performed on the distribution of asymmetries extracted from 78 subsamples. For each x_{Bj} value the asymmetry distribution is fitted to a Gaussian distribution and the width parameter with its error are used to set a limit to the false asymmetry. All the results are consistent with each other and the COMPASS data improve the statistical accuracy by a factor two to three in comparison with the SMC data. Furthermore, an additional point at very low x_{Bj} has been measured and brings more constraints in the fit and the determination of the integral of g_1 which the low x_{Bj} region is the greatest source of uncertainties.

To better make use of the wider kinematic domain, each x-bin of A_1^p has been split into three bins of Q^2 and shown in Fig. 3.

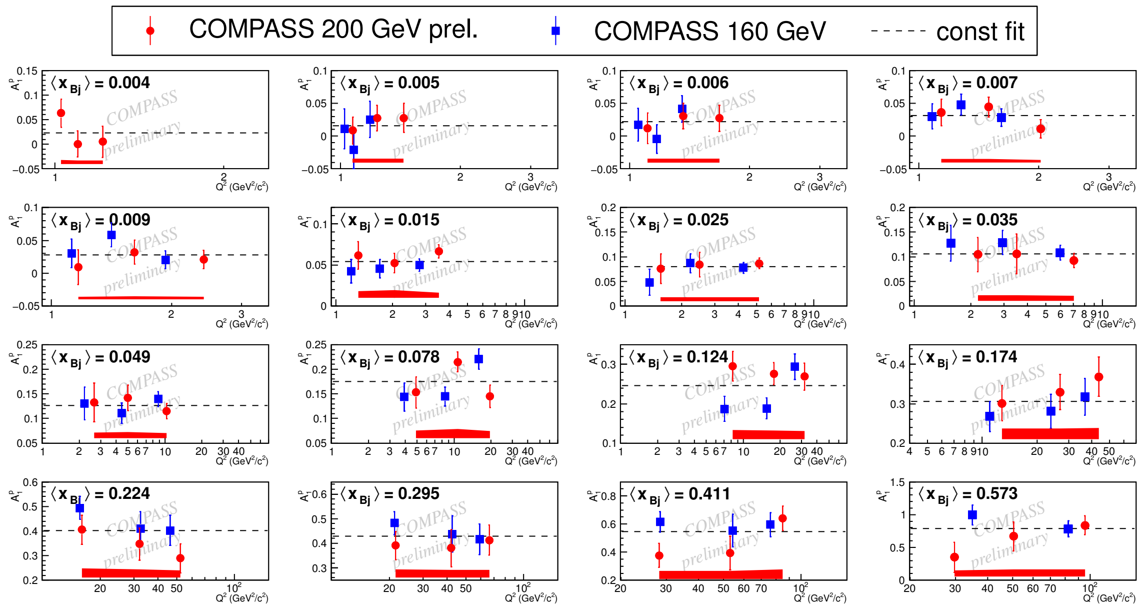


Figure 3: COMPASS A_1^P results versus Q^2 for the different x_{Bj}-bin. Only the systematics for 200 GeV data are shown by the band at the bottom of each pad. The upper left pad shows only 200 GeV data since its value of x_{Bj} has been accessed for the first time. The dashed lines show a fit of the data points to a constant.

The results of the world measurement of the proton spin structure function as a function of Q^2 for different values of x_{Bj} are shown in the Fig. 4. The data points for the different experiments are slightly readjusted to the same value of x_{Bj} according to formula 4.1, based on the LSS parametrisation of world data [9].

$$g_1^p(x_{Bj}, Q^2_{meas}) = g^p_{1(data)} + g^p_{1(LSS)}(x_{Bj}, Q^2_{meas}) - g^p_{1(LSS)}(x^{meas}_{Bj}, Q^2_{meas}) \tag{4.1}$$

PoS(DIS 2013)207

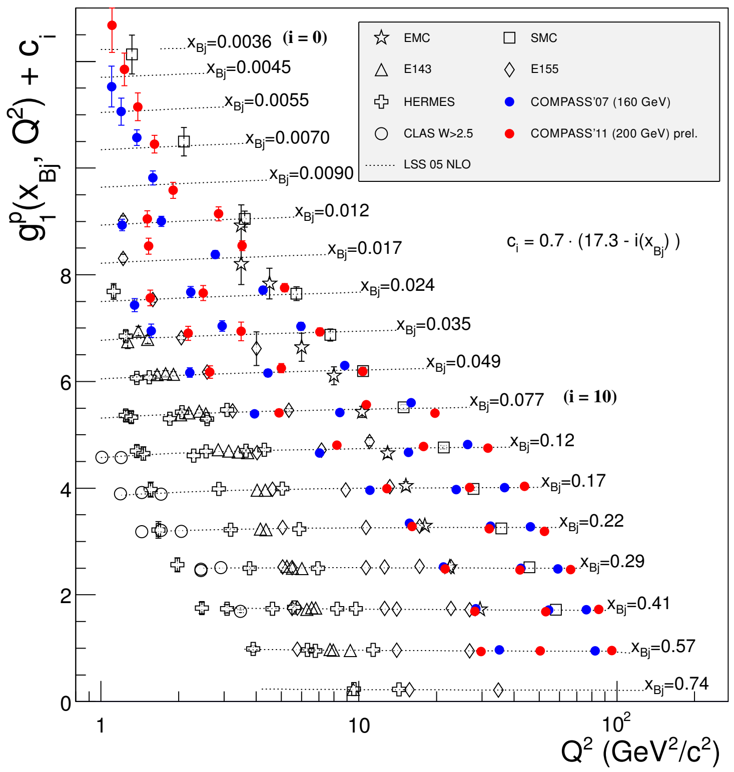


Figure 4: World data measurements of the proton spin structure function versus Q^2 in bins of x_{Bj}. The dashed line shows the LSS05 fit at NLO.

5. Summary

New results of the proton spin structure function g_1^p measured at COMPASS at 200 GeV have been presented. They complete the previously existing data at 160 GeV, enlarging the x_{Bj} and Q^2 coverage. In most x_{Bj}, they provide a result at the highest Q^2 value. They constitute an important input for global QCD fits at NLO.

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PoS(DIS 2013)207