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COMPASS measurement of g_1 and QCD fits

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We present the latest COMPASS results on the proton spin structure function $g_1^p(x)$ at 200 GeV. The data improve the statistical precision by a factor of ~2 at low x. A reevaluation of the Bjorken sum rule based on COMPASS proton and deuteron data confirms its validation to a 9% accuracy. Finally, results from a global NLO QCD fit of g_1 world data are shown. The extracted spin singlet distribution leads to an integrated value of $0.26 < \Delta\Sigma < 0.34$ at $Q^2 = 3$ $(GeV/c)^2$. The large uncertainty is mainly driven by the unknown shape of the distribution.

Keywords: nucleon spin structure; QCD fit; Bjorken sum rule.

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1. Measurement of the proton spin structure function g_1^p at 200GeV

The 1/2 nucleon spin can be decomposed as follows along the longitudinal projection as

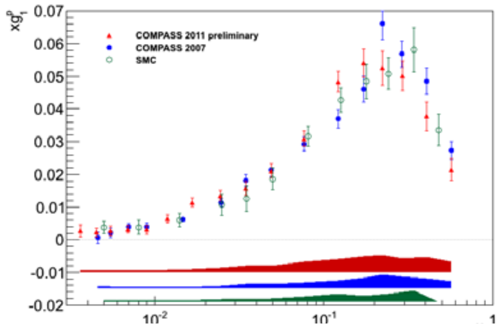

Fig. 1. Proton longitudinal spin structure function: COMPASS 200 GeV (red), 160 GeV (blue) and SMC data

1/2 = ½ ΔΣ + ΔG + L_z, where ΔΣ represents the quark spin contribution, ΔG the gluon spin one and L_z the contribution from the orbital angular momenta of quarks and gluons. We present here COMPASS latest results on the proton longitudinal spin structure function $g_1^p(x)$. The measurements were performed [1] using 200 GeV polarized muons from the CERN SPS (tertiary beam), scattered off a longitudinally polarized NH_3 target. Preliminary results [2] are shown in Fig.1 together with previous results taken at 160 GeV [3] and earlier results from SMC. The new data cover smaller x values, down to 0.0036. They improve the statistical precision of previous COMPASS data by a factor of about 2.

2. Test of the Bjorken sum rule

The Bjorken sum rule is a fundamental QCD prediction relating the first moment of the proton and the neutron spin structure functions to the ratio of the axial-vector to vector weak coupling constants g_A/g_V assuming SU(2) flavour symmetry. It can be tested by combining the COMPASS proton and deuteron results to calculate the non-singlet spin structure function $g_1^{NS}(x)$, and compare its first moment to the prediction.

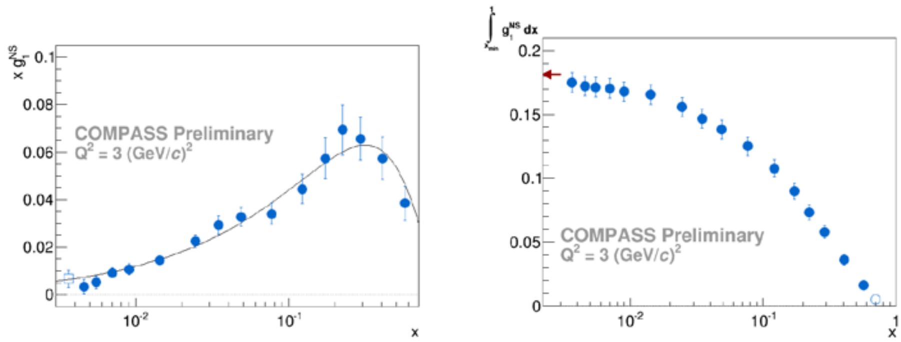

Fig. 2. *Left:* The nucleon non-singlet spin structure function g_1^{NS} vs *x*, measured from COMPASS p and d data. *Right:* truncated integral of g_1^{NS} from x_{min} to 1, vs x_{min}. The arrow shows the value extrapolated to x_{min}=0.

Preliminary results for $g_1^{NS}(x)$ are shown in Fig.2 *left*, and the corresponding truncated integral values (integrated from the minimum x=x_{min} to 1), are shown versus x_{min} in Fig.2 *right*. The full integral corresponds to a value of g_A/g_V = 1.220 ± 0.053(stat) ± 0.095(syst). Comparing this result [4] to the value obtained from neutron decay measurements, 1.2701 ± 0.0025 [5], we can say that the Bjorken sum rule is validated within 9% accuracy. The dominant uncertainty comes from systematic uncertainties on beam and target polarisation and target dilution factor (amount of polarisable material in the target). Note that the data cover 94% of the integral range, a remarkable feature compared to other evaluations.

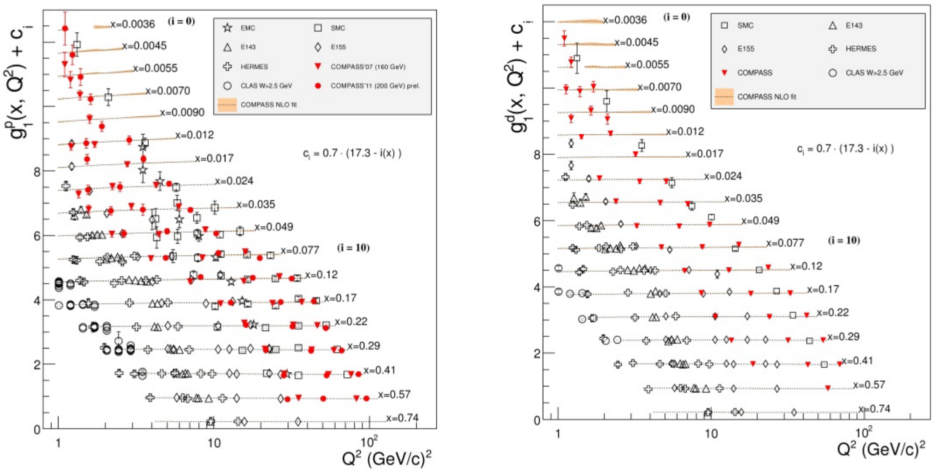

Fig.3: World data on g_1 proton *(left)* and deuteron *(right)* vs Q^2, for various x. COMPASS data are in red. The dotted lines represent the solutions of a COMPASS global NLO QCD fit (see text).

3. NLO QCD fit of g1 world data

The COMPASS g_1^p and g_1^d measurements are shown in Fig. 3 as a function of Q^2 for various x values, together with other world proton and deuteron data. The COMPASS coverage is very significant in the low x and large Q^2 regions. All these data, plus the existing neutron data, are included in a global QCD fit performed at NLO. The goal is to extract the helicity distributions of quarks and gluons. A functional form is assumed at an initial Q_0^2 scale for the singlet, the triplet and the octet SU(3) flavour combinations of the quark distributions as well as for the gluon distribution. The first moments of the non singlet distributions are fixed to the values of the axial-vector weak coupling constants measured in neutron and hyperon β-decay. The x-Q^2 evolution are made in the MS factorisation scheme (program #1 taken from [6]). Depending on the choice of the functional forms at the initial Q_0^2 scale, three classes of equally possible solutions are found. They correspond to a positive, compatible with zero and negative ΔG value, that ranges from -1 to 0.5 at $Q^2 = 3$ (GeV/c)^2. Consequently, the value of $\Delta\Sigma$, correlated to ΔG, ranges between 0.26 and 0.34 at the same scale. The dominant uncertainty in the extraction comes from the choice of the functional forms chosen at the initial Q_0^2 scale. Results for the three solutions are shown in Fig.4 at $Q^2 = 3$ (GeV/c)^2. On top are shown the quark singlet helicity $\Delta q^S(x)$ (the integral of which gives $\Delta\Sigma$) and the gluon helicity $\Delta G(x)$ distributions. In Fig.4 *bottom*, the quark helicities are shown separately for the u, d and s flavours. The dashed, solid and dotted lines correspond to positive, compatible with zero and negative ΔG solutions of the NLO QCD fit. The dark and light bands correspond respectively to the propagation of the statistical error from the data and to the combined statistical and systematic uncertainties, the latter dominating largely and being mainly attributed to the choice of functional forms.

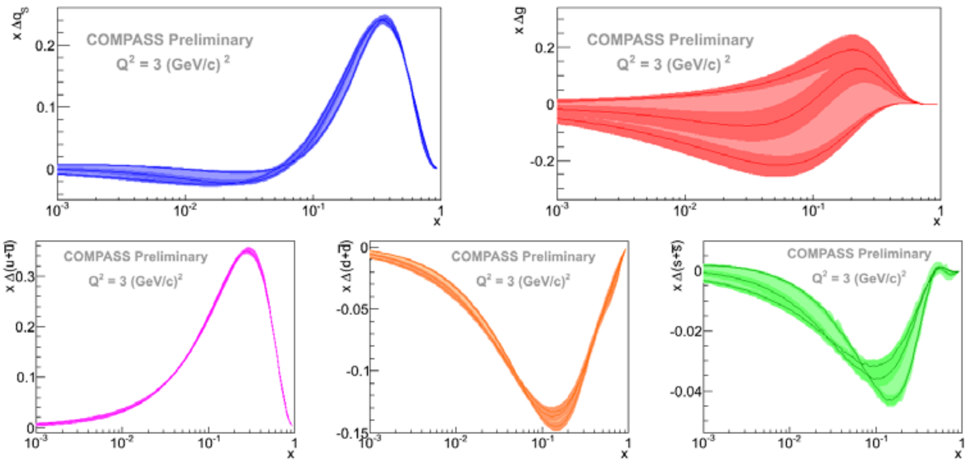

Fig.4. *Top:* Helicity distributions of the quarks *(left)* and the gluons *(right)* at 3 $(\mathrm{GeV}/c)^2$ in MS scheme. *Bottom:* Helicity distributions per flavour. Dashed, solid and dotted lines correspond to the three solutions with positive, compatible with zero and negative DG. Dark bands correspond to propagation of statistical errors, and the light bands to the combined statistical and systematic uncertainties (dominating and mainly attributed to choice of functional forms).

References

1. P. Abbon et al., COMPASS Collab., NIM A **517**, 455 (2007).
2. V.Andrieux, COMPASS Collab., PoS DIS2013, 207 (2013)
3. M. G. Alekseev et al., COMPASS Collab., Phys. Lett. B690, 466 (2010)
4. J. Beringer et al.,, Particle Data Group, Phys. Rev. D86, 010001 (2012)
5. M. Wilfert, COMPASS Collab., PoS DIS2014, 206 (2014)
6. M. Hirai, S. Kumano, T.-H. Nagal and K. Sudoh, *Phys. Rev.* **D 75**,094009 (2007)