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Single Spin Asymmetries on a transversely polarised proton target at COMPASS

S. Levorato on behalf of COMPASS collaboration

Physics Department, INFN Trieste and Trieste University,
Trieste, 34100, Italy

E-mail: stefano.levorato@ts.infn.it

COMPASS is a running fixed-target experiment at the CERN SPS with a rich physics program focused on nucleon spin structure and on hadron spectroscopy. One of the main goals of the spin program is the measurement of the transverse spin effects in semi-inclusive DIS on transversely polarised nucleons. In the years 2002, 2003 and 2004 data have been taken using a 160 GeV=c naturally polarised $^+$ beam and a deuterium target ($^6\text{Li d}$) transversely polarised respect to the beam direction. In 2007 the run year has been devoted to collect data with a proton (NH_3) target. The preliminary results for the Collins and Sivers asymmetries, extracted from the 2007 data with transverse target polarisation, are presented here. Results are also compared with existing model predictions.

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1. Single Spin asymmetries

The cross-section for polarised deep inelastic scattering¹ of leptons on spin $l=2$ hadrons can be expressed, at leading twist, as a function of three independent quark distribution functions: $q(x)$, $\bar{q}(x)$ and $\Delta_T q(x)$. The latter, which describes the probability of finding a quark with spin parallel to the nucleon spin in a transversely polarised nucleon, is chiral-odd and can be measured in transversely polarised nucleon (anti)-nucleon hard scattering or in semi-inclusive deep inelastic scattering (SIDIS) on a transversely polarised target.

In SIDIS $\Delta_T q(x)$ can be measured in combination with the chiral odd Collins fragmentation function $\bar{T}_0^h D_q^h$, via azimuthal single spin asymmetries (SSA) in single hadron production. According to Collins,² the fragmentation of a transversely polarised quark in unpolarised hadrons presents

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an azimuthal modulation with respect to the plane defined by the quark momentum and the quark spin. In SIDIS the hadron yield can be written then as:

$$N = N_0 (1 + f_t P_t D_{nn} A_C \sin(\phi_C)) \quad (1)$$

where f is the target dilution factor, P_t the target polarisation and $D_{nn} = (1 - y)/(1 - y + y^2)$ the transverse spin transfer coefficient from the initial to the struck quark. The angle ϕ_C is known as "Collins angle" and is conveniently defined in the system where the z -axis is the virtual photon direction and the x - z plane is the muon scattering plane. In this frame $\phi_C = \phi_h + \phi_s$, where ϕ_h is the hadron azimuthal angle, and ϕ_s the azimuthal angle of the transverse spin of the initial nucleon. Finally A_C is the Collins asymmetry resulting from the convolution between the Collins fragmentation function and the transverse spin distribution:

$$A_C = \frac{\sum_q e_q^2 \int_0^1 q(x) D_q^h(z; p_T^h)}{\sum_q e_q^2 \int_0^1 q(x) D_q^h(z; p_T^h)} \quad (2)$$

where e_q is the quark charge, $D_q^h(z; p_T^h)$ is the unpolarised fragmentation function, $z = E_h/(E_1 - E_1')$ is the fraction of available energy carried by the hadron, and p_T^h is the hadron transverse momentum with respect to the virtual photon direction. As is clear from eq.1, the Collins asymmetry A_C is revealed as a $\sin \phi_C$ modulation in the number of produced hadrons. A second source of azimuthal asymmetry is related to the Sivers effect³, arising from a possible coupling of the intrinsic transverse momentum \vec{k}_T of unpolarised quarks to the spin of a transversely polarised nucleon. In this case the number of produced hadrons can be written as:

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2. Data sample and analysis

The Collins and the Sivers asymmetries have been measured by COMPASS from 2002 to 2004 on a transversely polarised deuterium target; both the asymmetries turned out to be small, compatible with zero.^{5,17} In 2007 COMPASS took data with a proton target (NH_3) and a 50% sharing between longitudinal and transverse target configuration, accumulating $40 \cdot 10^6$ and $42 \cdot 10^6$ on tape respectively.

A new target with a larger diameter (4 cm) and three cells (upstream, central, downstream, 30, 60, and 30 cm long respectively) have been used: the three cells setup is meant to reduce the difference in acceptance between the two polarisations. The upstream and the downstream cells are polarised along the same direction, which is opposite to the central cell. The Ammonia material is characterized by a dilution factor $f = 0.15$ and a very high polarisation: 90%. As in 2006 the target is inside the new large acceptance Superconducting magnet. The transverse run has been divided in 12 "periods", each of them corresponding to about 5 full days of data taking. Consecutive periods correspond to opposite polarisation of each of the three target cells. Asymmetries are extracted using at the same time the informations coming from cells in two consecutive periods with opposite configuration.

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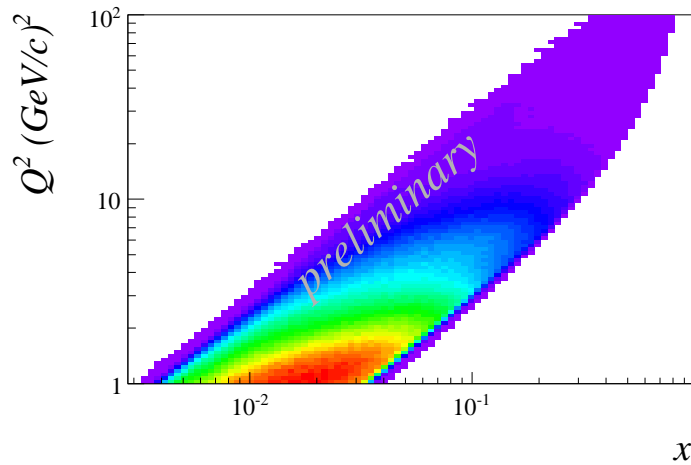


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From all these tests the systematic errors have been estimated to be 0.3_{stat} for the Collins asymmetries and 0.5_{stat} for the Sivers asymmetries.

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The Collins and Sivers asymmetries were evaluated as a function of x , p_T^h , and z dividing the corresponding kinematical range in bins (with variable width, in order to have a comparable statistics in each of them), and

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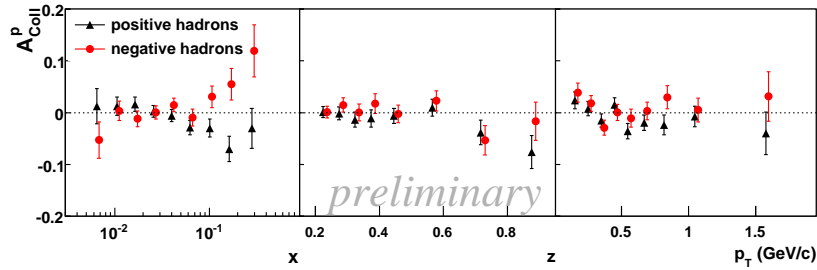


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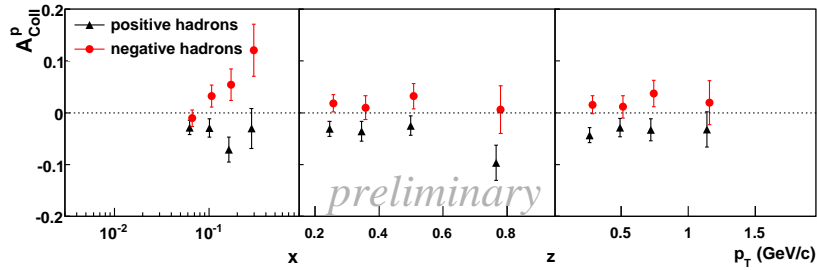


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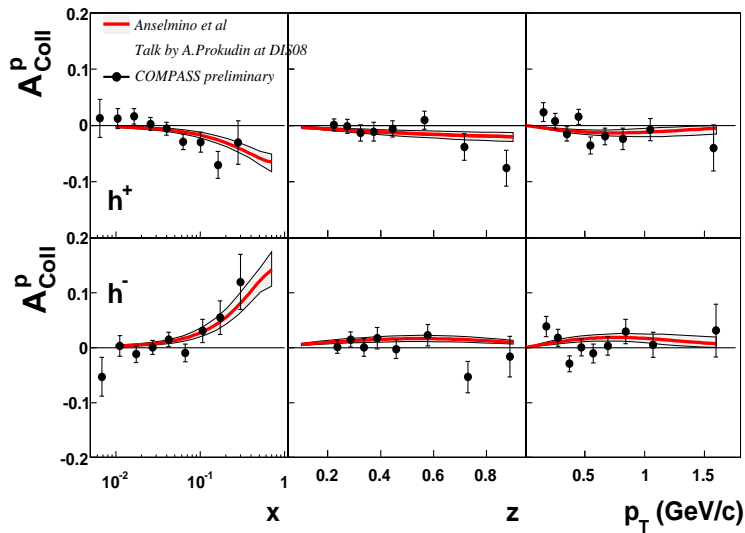


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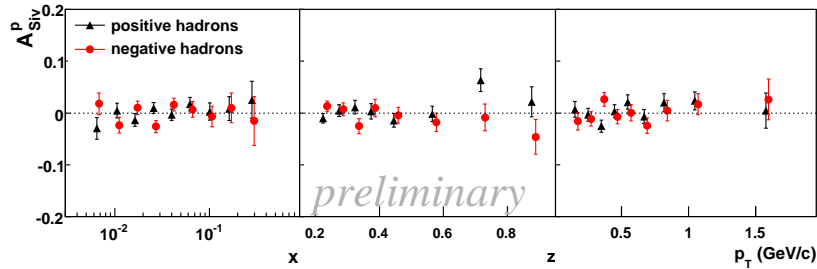


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Preliminary results of Collins and Sivers asymmetries for 2007 COMPASS proton data have been presented. Collins asymmetries for positive and negative hadrons are different from zero and of opposite sign for the two charges and agree with the previous HERMES results. In the Sivers case the measured asymmetries are compatible with zero, within the present statistics, both for positive and negative hadrons, at variance with the HERMES result.

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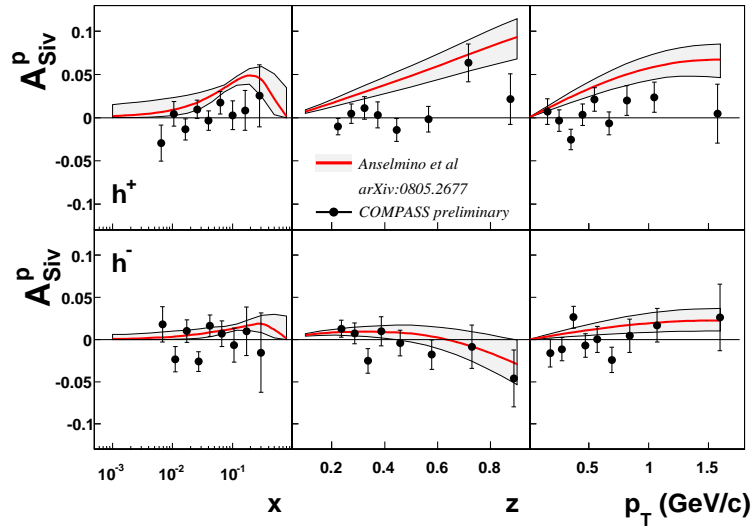


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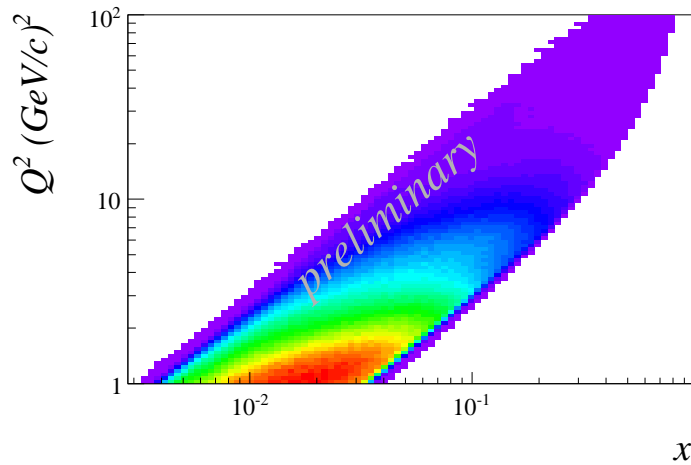


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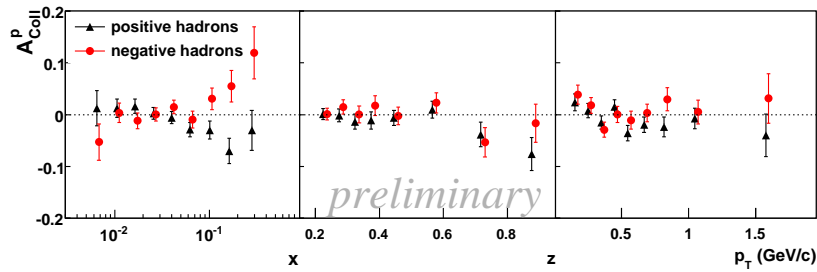


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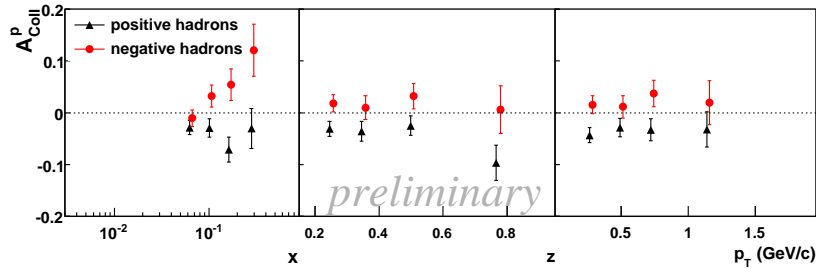


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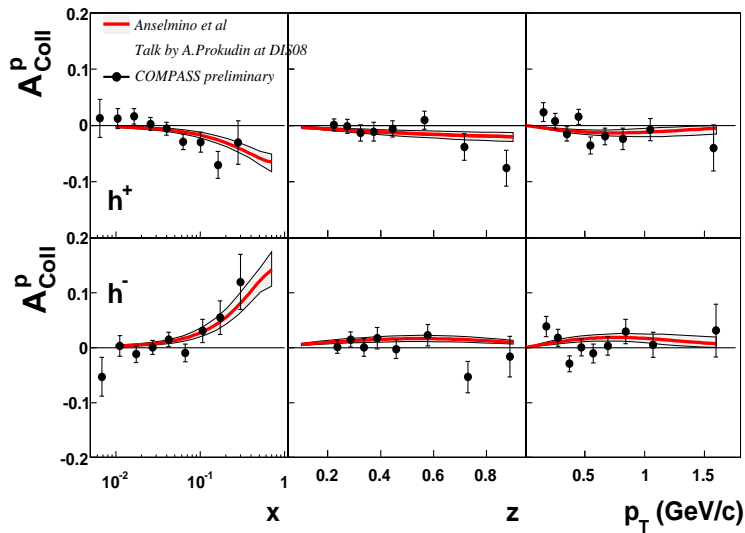


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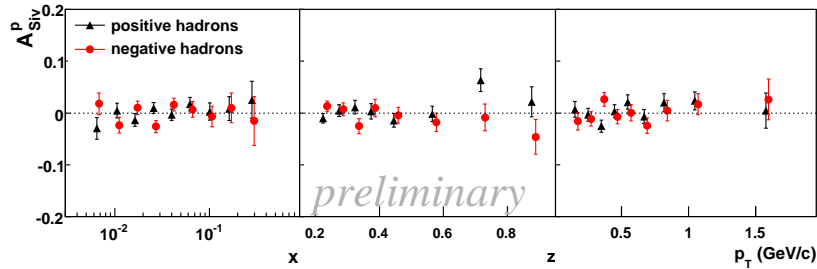


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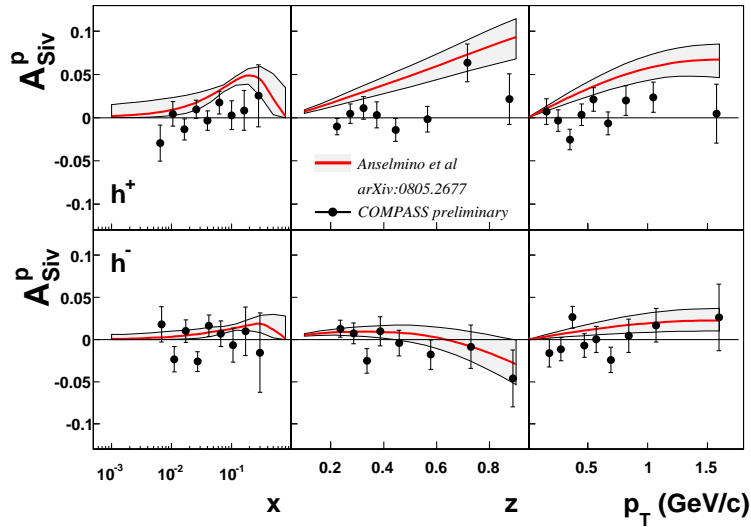


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