# Preliminary Measurement of Transversity at COMPASS

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COMPASS is a new fixed target experiment presently running at CERN. Using a 160 GeV polarised muon beam coming from the SPS and scattered off a $^6$LiD polarised target, the spin structure of the nucleon is determined from polarised semi-inclusive DIS (p-SIDIS) reactions. In particular the $h_1$ structure function can be measured via the so-called Collins effect. In 2002 we collected SIDIS data in transverse spin configuration for a total integrated luminosity of about $1.9 \times 10^{38} cm^{-2}$. The expected statistical error coming from these data has been compared with existing QCD-based phenomenological calculations.

## 1 The COMPASS experiment

COMPASS [1] is a fixed target experiment presently running at the CERN SPS accelerator. The experiment makes use of a high energy, intense, polarised muon beam coming from the SPS and scattered off a $^6$LiD target which provides deuterium nuclei (longitudinally or transversely polarised with respect to the incoming muon momentum).

COMPASS is presently running and, in 2002, has devoted 3 weeks of the beam time to transversity. The collected data amount to 30 TBytes and correspond to about $1.9 \times 10^{38} cm^{-2}$ in integrated luminosity.

## 2 Probing transversity by a lepton beam: the Collins effect

The three independent Parton Distribution Functions (PDF) $q\,(x)$, $\Delta q\,(x)$ and $\Delta_T q\,(x)$ fully describe the nucleon structure at the leading twist [2]. The parton density $q\,(x)$ and the parton helicity distribution $\Delta q\,(x)$ can be measured in ordinary inclusive polarised DIS. This is not the case for $\Delta_T q\,(x)$, the transverse

spin distribution, which is chiral odd, requiring more detailed information from the associated hadronic final state.

In the definition of the experimental observables, one usually does not quote the PDF but the corresponding functions summed upon the flavours (weighted on their electric charge): $f_1$, $g_1$ and $h_1$.

Since helicity is conserved in all hard processes, a possibility of measuring transversity is offered by those phenomena in which two helicity flips are required.

The opportunity is provided by polarised Semi-Inclusive Deep Inelastic Scattering (p-SIDIS) where the chiral odd fragmentation function $H_1^\perp$ is coupled to $h_1$. This coupling only affects the azimuthal dependent cross-sections and can be measured via the Collins effect [3].

Deriving the polarised part of the cross-section as a function of the Bjorken variables $x$ and $y$, of the transverse momentum of the leading hadron $\vec{P}_{h\perp}$ and of $z$ (the fraction of the available energy carried by the selected hadron), one should observe the effect at the leading twist for transversely polarised nucleon targets [4]:

$$\frac{d\sigma_{OT}}{dx\,dy\,dz\,d^2\vec{P}_{h\perp}} \propto \; x\,h_1(x)\,H_1^\perp(z,\vec{P}_{h\perp}^{\,2}) \cdot sin(\Phi_C) \tag{1}$$

where $\Phi_C$ is an event-dependent variable, function of the spin vector and the leading azimuthal angles defined in the Breit frame. For longitudinally polarised targets, the contribution of $h_1$ should be suppressed by $1/Q$, what makes it an effect of order twist-3, hard to detect. COMPASS will look for the Collins effect in both configurations. We focus on the transverse one where, theoretically, its amplitude should be larger.

## 3 The 2002 run

In the COMPASS run of 2002, 80% of the data have been collected using a longitudinally polarised target, and 20% with a transversely polarised target, to allow to perform exploratory transversity measurements.

The COMPASS target is divided into two $^6$LiD cells polarised in opposite direction. To minimise the systematic effects in the asymmetry measurements (due to acceptance difference for upstream and downstream target cells), a spin

rotation is performed by microwaves every few days to pass from $\Downarrow\Uparrow$ configuration to $\Uparrow\Downarrow$.

During the DAQ a polarisation of the order of 50% has been reached in both the target cells. The nominal value for the target dilution factor ($f$) is 0.5.

## 4 The experimental asymmetries

In transverse polarisation, one can express the number of events as follows:

$$N_{\uparrow\downarrow}(\Phi_C) = \alpha(\Phi_C) \cdot N_0 \left(1 \pm \epsilon \sin \Phi_C\right) \tag{2}$$

where $\epsilon$ is the amplitude of the experimental modulation and $\alpha$ is an experimental systematic modulation coming from the apparatus. The former is function of the Collins asymmetry $A_{UT}$ (the spin dependent part in the RHS of equation (1)) through some parameters measured by independent dedicated analyses:

$$\epsilon = A_{UT} \cdot P_T \cdot f \cdot D_{NN} \,. \tag{3}$$

These parameters are the polarisation of the target ($P_T$), the spin transfer coefficient ($D_{NN}$), the dilution factor ($f$) (see [1]). Thus the $A_{UT}$ asymmetry can be factorized into a $z$ (and $\vec{P}_{h\perp}$) dependent part multiplying an $x$ dependent part, the latter measuring the transversity of the nucleon. To extract the experimental asymmetry, the best way is to combine the statistics coming from both the spin orientations (in order to get rid of the function $\alpha$), and to fit the distribution by a sinus wave function:

$$\frac{N_\uparrow \; - \; N_\downarrow}{N_\uparrow \; + \; N_\downarrow} \; = \epsilon \; \sin \Phi_C \tag{4}$$

## 5 The preliminary analysis

A preliminary analysis has been done on 2/3 of the available statistics. The p-SIDIS events have been reconstructed by identifying at least the incoming muon, the scattered muon, and one or more hadrons (with measured momentum). These events cover a large surface in the $x$-$Q^2$ plane (see Figure 1) for

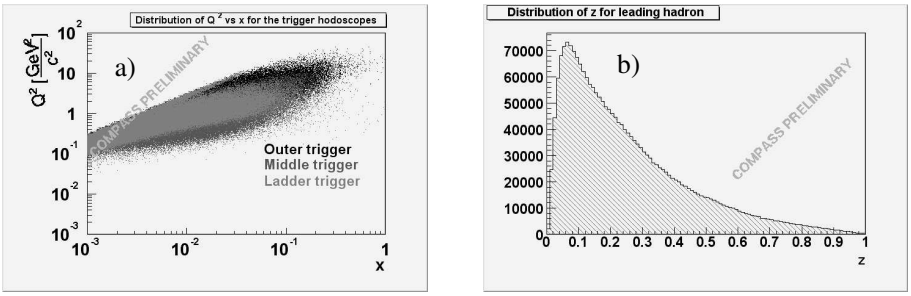


Figure 1: a) the $x$-$Q^2$ coverage of COMPASS semi-inclusive events; b) the $z$ distribution for the leading hadron.

different physics analysis purposes. In the same Figure the $z$ variable distribution is also shown.

In this analysis a preliminary version of the reconstruction program has been used, which did not permit an efficient reconstruction of the high $Q^2$ events. The selection of the events has been done on the basis of the following kinematical cuts:

- $\mathrm{Q}^2 > 1$ GeV$^2$ and $0.1 < \mathrm{y} < 0.9$;
- $\mathrm{z} > 0.25$ and $\mathrm{p}_t > 0.1$ GeV/c;

where $p_t$ is the transverse momentum of the leading hadron computed in the Breit frame.

In Figure 2 the statistical error bars expected from 2002 data are shown as a function of $x$ in the case of positive and negative leading hadron, and compared to the predictions by Efremov and collaborators [5].

## 6 Conclusions and outlook

This is the result of a first look at the transversity data collected by COMPASS in the run of year 2002. The algorithm to compute the Collins effect asymmetries has been developed and the preliminary measurements of $A_{UT}$ for $\pi^+$ and $\pi^-$ will be available soon and will allow to check the theoretical predictions.

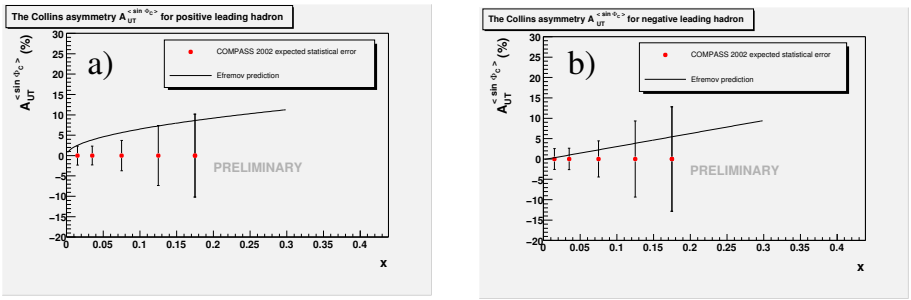


Figure 2: The statistical error bars expected from 2002 data as a function of $x$ for the case of positive (a) and negative (b) leading hadron.

A lot of work (not reported in the present paper) is presently ongoing to evaluate the systematic error. New transverse polarisation data will be taken by COMPASS in the years 2003 and 2004.

## References

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