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Measurement of Collins asymmetries in the inclusive production of hadron pairs

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Summary. — Transversity distribution, which describes the quark transverse polarization inside a transversely polarized nucleon, is the last leading-twist missing piece of the QCD description of the partonic structure of the nucleon. Transversity can be extracted from semi-inclusive deep inelastic scattering (SIDIS) where it couples to a new, unknown fragmentation function, called Collins function. The aim of the analysis is a measurement of the azimuthal xasymmetries in $e^+e^- \to \pi\pi X$ (inclusive hadron production), based on the full BaBar data sample in order to extract the Collins fragmentation function from the measured asymmetries.

PACS 13.66.Bc – Hadron production in e^-e^+ interactions.

1. – Motivation for extraction of Collins function in e^+e^- annihilation

Transversity (h_1) is the less known function [1] of the three parton distribution functions needed for a complete description of the momentum and spin distribution of the quark inside the nucleon. We can measure h_1 in SIDIS experiment where, thanks to factorization theorem, we have

$$\sigma^{ep\to ehX} = \sum_q DF \times \sigma(eq \to eq) \times FF, \tag{1}$$

where DF is the unpolarized Distribution Function and FF is the Collins Fragmentation Function which is yet unknown. In e^+e^- annihilation experiment we can write the cross section for inclusive hadron production in the reference frame of thrust (see fig. 1):

$$\frac{\mathrm{d}\sigma(e^+e^- \to h_1h_2X)}{\mathrm{d}z_1\mathrm{d}z_2q\Omega\mathrm{d}\phi_1\mathrm{d}\phi_2} = \sum_{q,\bar{q}} \frac{3\alpha^2}{Q^2}\frac{e_q^2}{4}z_1^2z_2^2\Big[(1+\cos^2\theta)D_1^{q(0)}(z_1)\bar{D}_1^{q(0)}(z_2) + \sin^2(\theta)\cos(\phi_1+\phi_2)H_1^{\perp,(1),q}(z_1)\bar{H}_1^{\perp,(1),q}(z_2)\Big], \tag{2}$$

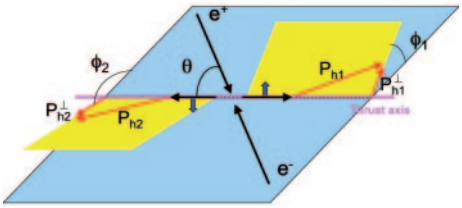

Fig. 1. – (Colour online) Thrust reference frame: θ is the angle between lepton axis and thrust axis (pink in figure) and $\phi_{1,2}$ is the azimuthal angle between the scattering plane and the transverse momenta $P_h^\perp$ of the hadron around the thrust axis. Assuming the thrust axis as $q\bar{q}$ direction and selecting pions in opposite hemispheres with respect to the thrust axis, we can measure the corresponding azimuthal angles (ϕ_1 and ϕ_2) and fit these raw asymmetries taking into account the detector acceptance.

where D_1 is the unpolarized Fragmentation Function (FF), $H_1^\perp$ is the Collins FF, $z_{1,2}$ is the fractional energy of the hadron and Q^2 is the center-of-mass energy. In conclusion, the Collins asymmetries ($\cos(\phi_1 + \phi_2)$ modulation in the formula (2)) are proportional to $H_1^\perp(z_1) \times H_1^\perp(z_2)$ and we can obtain an independent measure of this FF.

2. – Analysis strategy

We can access the Collins asymmetries by measuring the $\cos(\phi)$ modulation of the pions on top of the flat distribution due to unpolarized part of FF (normalized distribution). These raw asymmetries are affected by detector acceptance. We can construct the double ratio of the raw asymmetries for like sign pions pair (R_L) over the raw asymmetries for unlike sign pions pair (R_{UL}) in order to eliminate the detector affects and the first order of radiative effects [2]. Fitting the double ratio with a cosine function

$$\frac{R_L}{R_{UL}} = \frac{N^L(\phi)/\langle N^L\rangle}{N^{UL}(\phi)/\langle N^{UL}\rangle} = P_0 + P_1 \cdot \cos(\phi), \tag{3}$$

the P_1 parameter (proportional to $H_1^\perp(z_1) \times H_1^\perp(z_2)$) contains only the Collins effect. We need to study and eventually subtract the charm contributions and the systematic effects.

3. – Conclusion

The Collins FF at 10.58 GeV has been already measured by Belle Collaboration [3] and we expect to have the first result with the full BaBar data sample as soon as possible.

REFERENCES

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