Investigation of single spin asymmetries in semi-inclusive pion electroproduction

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The azimuthal single target-spin asymmetries for π^+ production in semi-inclusive deep inelastic scattering of leptons off longitudinally polarized protons are evaluated using two main approaches available in the literature (see, e.g. Ref. [1]). It is shown that the approximation where the twist-2 *transverse* quark spin distribution in the *longitudinally* polarized nucleon is small enough to be neglected leads to a consistent description of all existing asymmetries observed by the HERMES experiment. A possibility to access the transverse distribution function through the measurement of single spin azimuthal asymmetry in semi-inclusive single pion leptoproduction on a transversely polarized target is also discussed.

There are two main approaches in the literature which aim at explaining the experimental data:

(i) The approximation where the twist-2 *transverse* quark spin distribution in the *longitudinally* polarized nucleon, $h_{1L}^{\perp(1)}(x)$, is considered small enough to be neglected [2–5]. This results in good agreement with the Bjorken-x behavior of the $sin\phi$ and $sin2\phi$ asymmetries observed at HERMES. Note, that this does not require the twist-3 interaction-dependent part of the fragmentation function, $\tilde{H}(z)$, to be zero.

(ii) The approximation where the contribution of the interaction-dependent twist-3 term, $\tilde{h}_L(x)$, in the distribution function $h_L(x)$ is assumed to be negligible, but $\tilde{H}(z)$ is not constrained [3].

Another approximation, where only the twist-2 distribution and fragmentation functions are used, i.e. the interaction-dependent twist-3 parts of distribution and fragmentation functions are neglected, was proposed earlier [7,8]. For certain values of parameters this results in good agreement with the HERMES data [9]. However, it leads to the inconsistency that all T-odd fragmentation functions would be required to vanish [10,11]. Thus, we do not consider it.

The transversity distribution $h_1(x)$ measures the probability to find a transversely polarized quark in a transversely polarized nucleon (see, e.g., Ref. [12]). One of the possibilities to access the transversity in one-hadron inclusive deep inelastic scattering off

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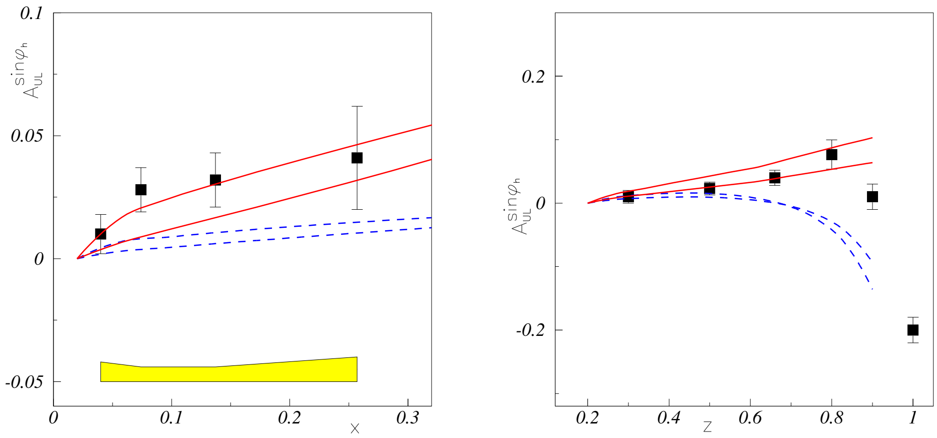

Figure 1. The single target-spin asymmetry $A_{UL}^{\sin\phi}$ for π^+ production as a function of Bjorken-x and z, evaluated using $M_C = 2m_\pi$ and $\eta = 0.8$. The results obtained within approaches (i) and (ii) are denoted by pairs of full and dashed lines, respectively. For each approach two curves are presented corresponding to $h_1 = g_1$ (lower curve) and $h_1 = (f_1 + g_1)/2$ (upper curve). HERMES data are from Ref. [9,13].

transversely polarized nucleons is to measure the azimuthal angular dependences in the production of spin-0 or (on average) unpolarized hadrons, which shows up as $\sin(\phi_h + \phi_S)$ dependence [14], where ϕ_S is the azimuthal angle of the target spin vector.

In Fig. 2 the curves have been calculated by integrating over the HERMES kinematic range. From Fig. 2 one can see that the single transverse-target-spin asymmetry expected to be quite large. At HERMES kinematics ($\langle x\rangle \approx 0.1, \langle z\rangle \approx 0.4$) it amounts to $(4 \div 7)\%$. The HERMES experiment using a transversely polarized proton target will be able to extract $h_1(x)$ in a simple way proposed in Ref. [15]. Actually, the combined results of HERMES (on transversely polarized target) and COMPASS should give quite precise information on transverse distribution functions soon.

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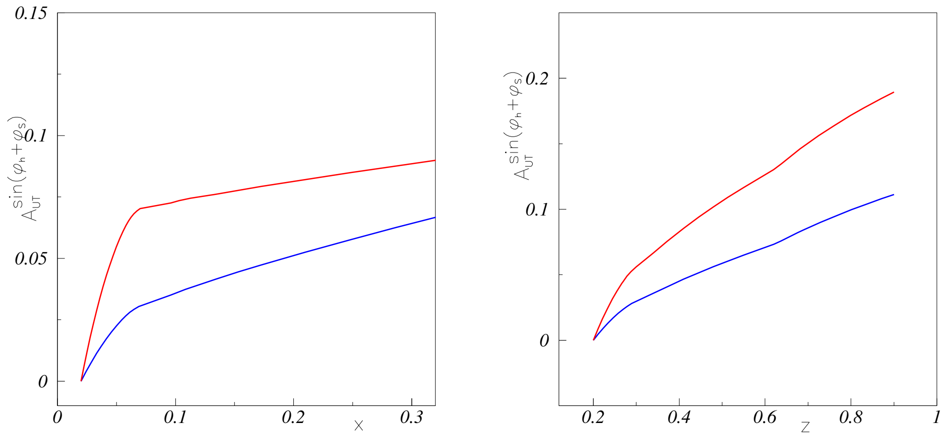

Figure 2. The single target-spin asymmetry $A_{UT}^{\sin(\phi_h+\phi_S)}$ for π^+ production as a function of Bjorken-x and z, evaluated using $M_C = 2m_\pi$ and $\eta = 0.8$. Two curves are corresponded to $h_1 = g_1$ (lower curve) and $h_1 = (f_1 + g_1)/2$ (upper curve).

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