q_T weighted single spin asymmetries at PAX

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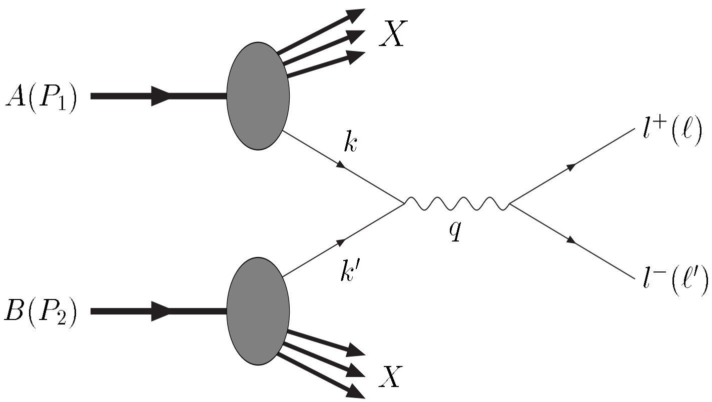
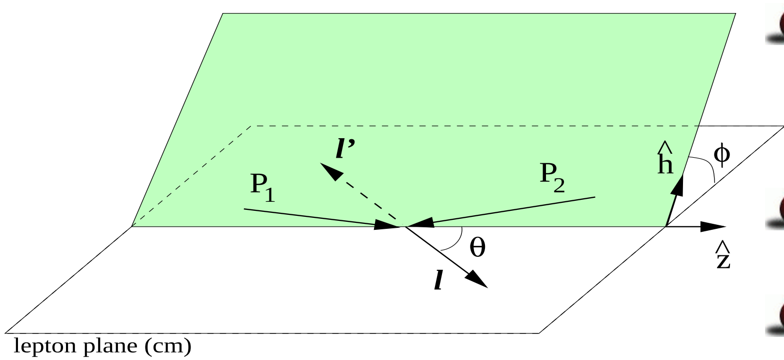
Kinematics





- $s = (p_1 + p_2)^2 \simeq 2p_1p_2$ **– the center of mass energy squared**

  $Q^2 = M^2 \simeq x_1x_2s \equiv \tau s$

  $y = \frac{1}{2}\ln\frac{x_1}{x_2}$

  $x_f = x_1 - x_2$

  $x_1 = \frac{\sqrt{x_f^2+4\tau}+x_F}{2} = \sqrt{\tau}\mathrm{e}^{y}$

  $x_2 = \frac{\sqrt{x_f^2+4\tau}-x_F}{2} = \sqrt{\tau}\mathrm{e}^{-y}$

- θ **– production angle in the dilepton rest frame – polar angle of the lepton pair in the dilepton rest frame**

- ϕ **– azimuthal angle of lepton pair**

- ϕ_S **– azimuthal angle of the hadron polarization measured with respect to lepton plane**

Main formulas

$$\hat{A}_h = \frac{\int d\Omega d\phi_{S_2} \int d^2\mathbf{q}_T (|\mathbf{q}_T|/M_1) \sin(\phi+\phi_{S_2}) [d\sigma(\mathbf{S}_{2T}) - d\sigma(-\mathbf{S}_{2T})]}{\int d\Omega d\phi_{S_2} \int d^2\mathbf{q}_T [d\sigma(\mathbf{S}_{2T}) + d\sigma(-\mathbf{S}_{2T})]}$$

$$\hat{R} = \frac{\int d^2\mathbf{q}_T [|\mathbf{q}_T|^2/M_1 M_2][d\sigma^{(0)}/d\Omega]}{\int d^2\mathbf{q}_T \sigma^{(0)}},$$

$$\hat{R} = \frac{3}{16\pi}(\gamma(1+\cos^2\theta) + \hat{k}\ \sin^2\theta \cos 2\phi)$$

$$\hat{k}(x_1,x_2)\Big|_{\bar{p}p\to l^+l^-X} \simeq 8\frac{h_{1u}^{\perp(1)}(x_1)h_{1u}^{\perp(1)}(x_2)}{f_{1u}(x_1)f_{1u}(x_2)},$$

$$\hat{A}_h(x_1,x_2)\Big|_{\bar{p}p^{\uparrow}\to l^+l^-X} \simeq -\frac{1}{2}\frac{h_{1u}^{\perp(1)}(x_1)h_{1u}(x_2)}{f_{1u}(x_1)f_{1u}(x_2)}.$$

$$x \equiv x_1 \simeq x_2\ (x_F \simeq 0 \pm 0.4)$$

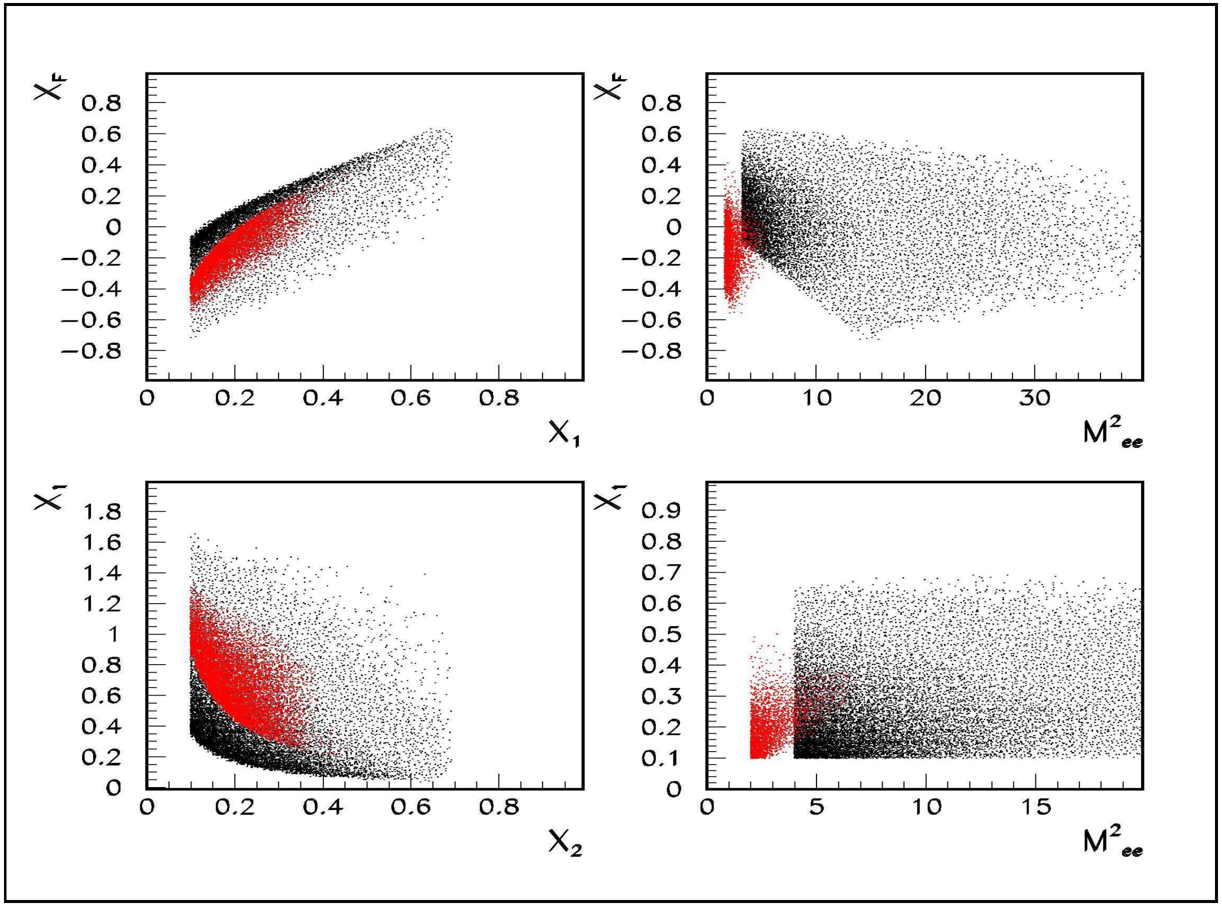
$$h_{1u}^{\perp(1)}(x) = f_{1u}(x)\sqrt{\frac{\hat{k}(x,x)}{8}}$$

$$h_{1u(x)} = -4\sqrt{2}\frac{\hat{A}_h(x,x)}{\sqrt{\hat{k}(x,x)}}f_{1u}(x)$$

Simulation conditions

The simulations are performed with PYTHIA within scattered and polar angles of PAX detector. Two data samples (100k events each) of Drell-Yan events:

- **collider mode: 15 GeV antiproton beam from collides with a 3.5 GeV/c proton beam,**
- **fixed target mode: 22 GeV antiproton beam collides with a internal hydrogen target,**

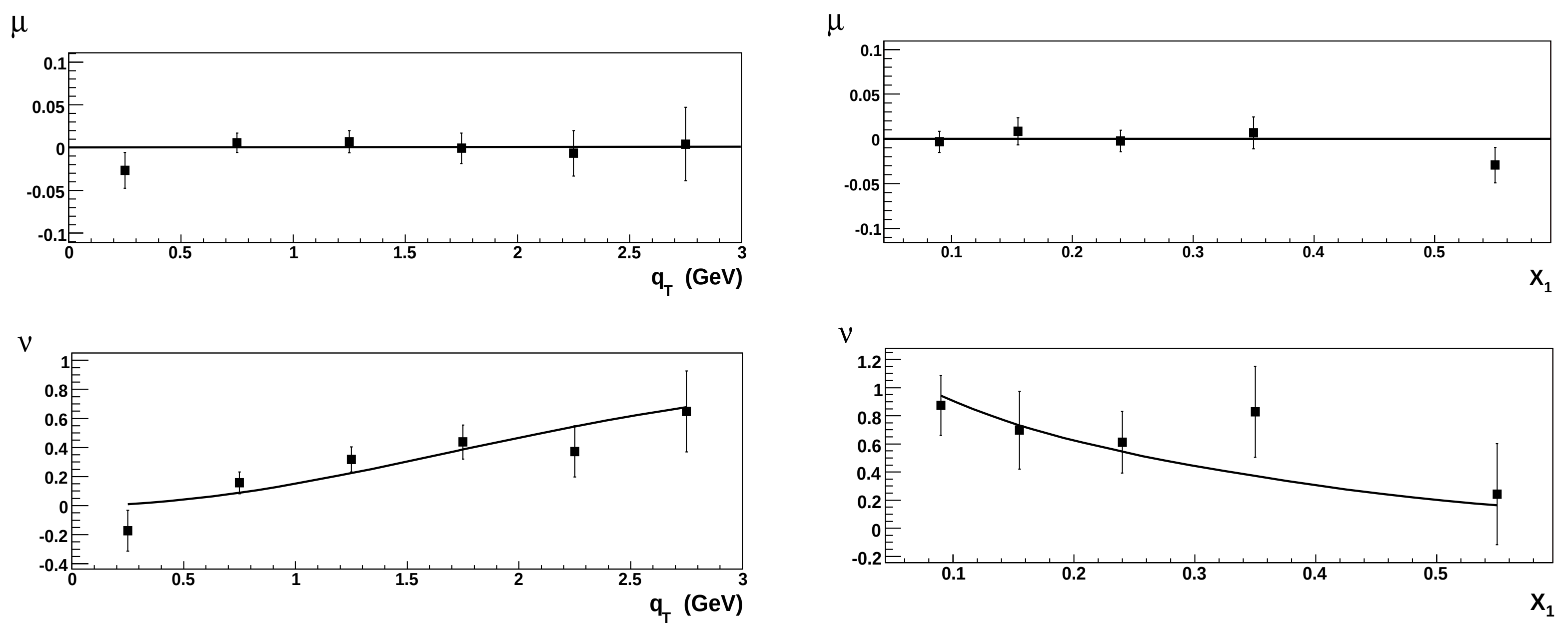


Tests of simulations

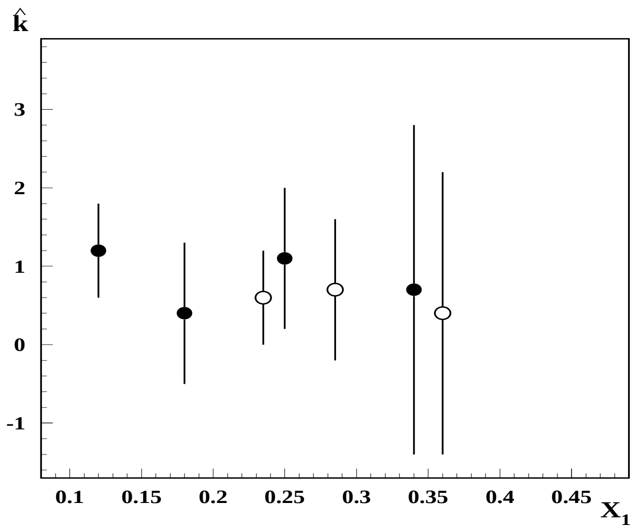
Experiments on unpolarized DY: J.S. Conway et al, PRD **71** (2005) 074014; NA10 Collaboration, Z. Phys. C 31 (1986) 513, Z. Phys. C **37** (1988) 545

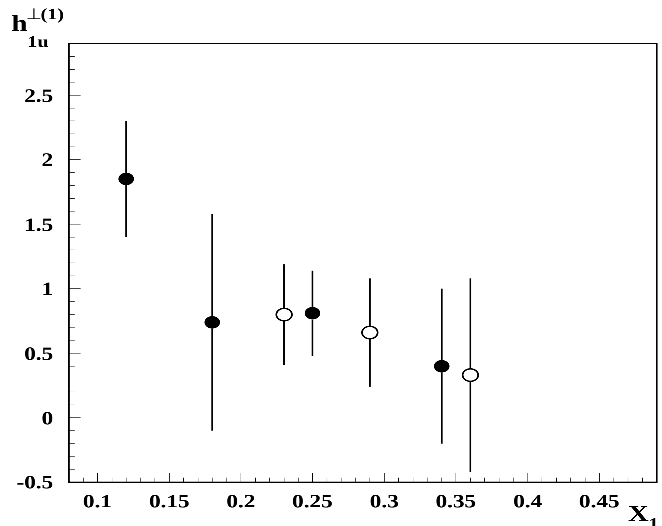
$$R = \frac{3}{16\pi}(1 + \lambda \cos^2\theta + \mu \sin 2\theta \cos\phi + k \sin^2\theta \cos 2\phi),$$

$$(\lambda \simeq 1, \mu \simeq 0, k \equiv \nu/2)$$



Results for $\hat{k}$ at $x_F = 0 \pm 0.04$

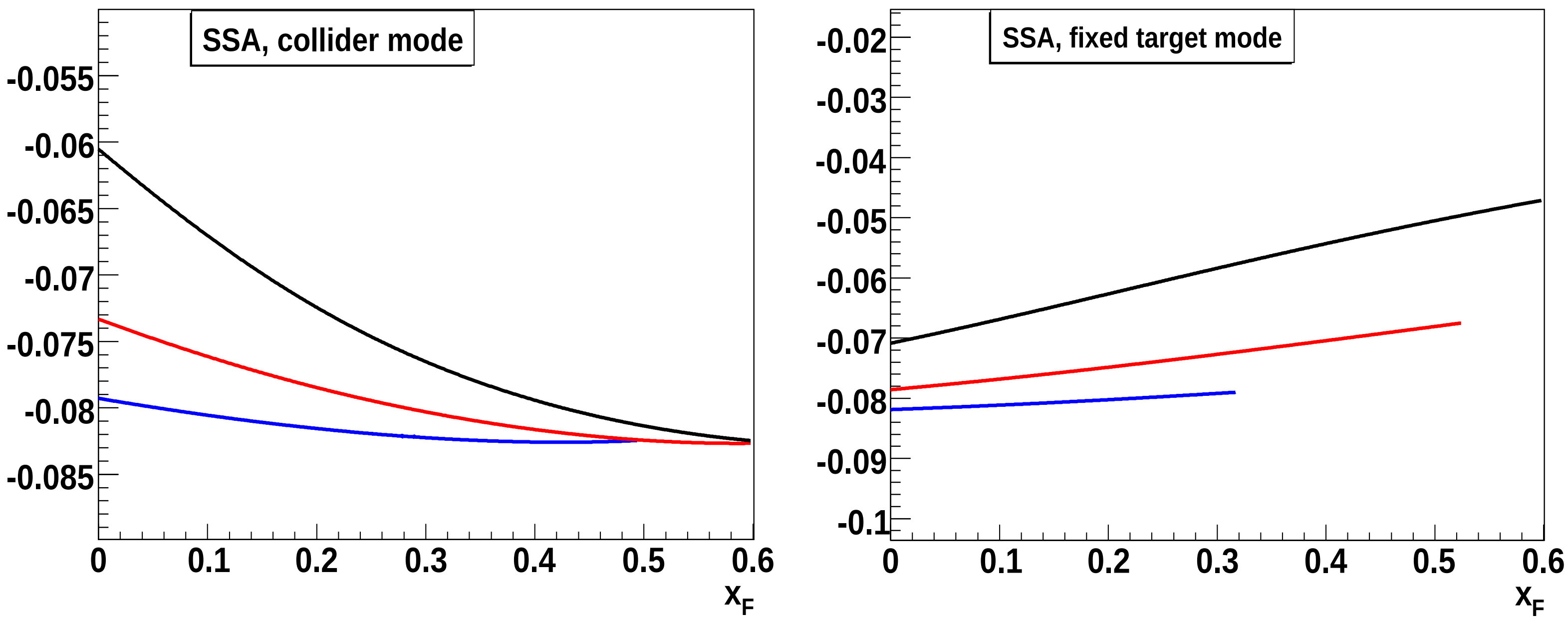




closed circles: collider mode; ($Q^2_{\text{average}} = 8.6 GeV^2$)

open cirles: fixed target mode;($Q^2_{\text{average}} = 2.8 GeV^2$)

Estimation of asymmetry $\hat{A}_h$ (single-polarized DY)



Left: Collider mode, Right: Fixed target mode

Quantities h_1 and $h_1^{\perp(1)}$ entering SSA are estimated using two models:

- h_1 is estimated using so-called “evolution model”
- $h_1^{\perp(1)}$ is estimated using the Boer’s model

Sivers function from the single-polarized Drell-Yan

A. Efremov et al (Phys. Lett. B612 (2005))

q_T-integrated asymmetry

$$A_{UT}^{\sin(\phi-\phi_S)\frac{q_T}{M_N}} = \frac{\int d\Omega d\phi_{S_2} \int d^2\mathbf{q}_T (|\mathbf{q}_T|/M_1) \sin(\phi-\phi_{S_2})[d\sigma(\mathbf{S}_{2T}) - d\sigma(-\mathbf{S}_{2T})]}{\int d\Omega d\phi_{S_2} \int d^2\mathbf{q}_T [d\sigma(\mathbf{S}_{2T}) + d\sigma(-\mathbf{S}_{2T})]}.$$

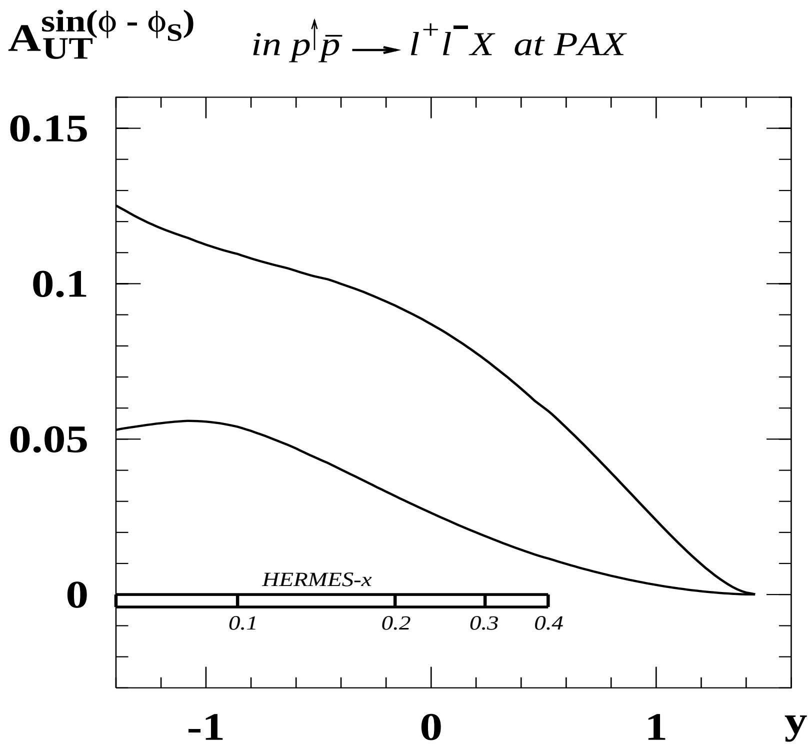
As a result:

$$A_{UT}^{\sin(\phi-\phi_S)\frac{q_T}{M_N}} = 2\,\frac{\sum_a e_q^2\, f_{1T}^{\perp(1)q/p}(x_1)\, f_1^{\bar q/\bar p}(x_2)}{\sum_a e_q^2\, f_1^{q/p}(x_1)\, f_1^{\bar q/\bar p}(x_2)},$$

$$f^{(n)}(x) \equiv \int d^2\mathbf{k}_T \left(\frac{k_T^2}{2M^2}\right)^n f(x, k_T^2)$$

Estimation of SSA $A_{UT}^{\sin(\phi-\phi_S)\frac{q_T}{M_N}}$

The estimated are based on the fit for the Sivers functions obtained from the HERMES data
A. Efremov et al, Phys. Lett. B612 (2005)233
J. Collins et al, hep-ph/0511272



Summary

- **Within the proposed direct (without any model assumptions) procedure of the transversity extraction the MC simulations corresponding to the PAX kinematics were performed.**
- **Preliminary estimations demonstrate that both the transversity h_1 and the first moment of Boer's function $h_1^{\perp(1)}$ can be (presumably) extracted from unpolarized $\bar{p}p \to l^+l^-X$ and single polarized $\bar{p}p^\uparrow \to l^+l^-X$ Drell-Yan processes**
- **At the same time the preliminary estimations (A. Efremov et al) demonstrate that it is quite real also to extract the Sivers function from the single-polarized Drell-Yan processes $\bar{p}p^\uparrow \to l^+l^-X$ at PAX**

At present the generators of unpolarized and polarized Drell-Yan events are constructed by Dubna team. To this end the existing PYTHIA generator is properly modified.