

Transverse Spin Effects in MC Generators

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- **Sivers and Cahn effects in MC generators**
 - mLEPTO
 - mPYTHIA
- Collins effect in fragmentation

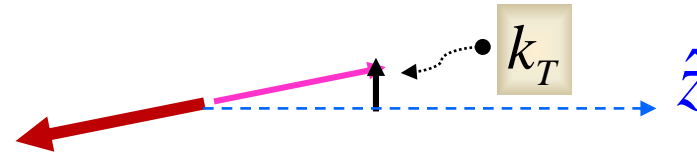
Initial quark k_T in MC generators PYTHIA and LEPTO

- Generate virtual photon – quark scattering in collinear configuration:



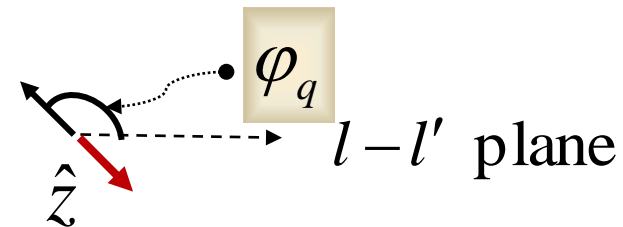
- Generate intrinsic transverse momentum of quark (Gaussian k_T)

- Rotate in $l-l'$ plane



- Generate **uniform** azimuthal distribution of quark

- Rotate around virtual photon



mLEPTO – modified LEPTO, includes Sivers modulation of the quark intrinsic transverse momentum in the transversely polarized nucleon

A.K. hep-ph/0504081, 0510359

Generate initial quark azimuth according

$$1 + |S_T| \frac{f_{1T}^\perp(x, k_T)}{f_1(x, k_T)} \frac{k_T}{M} \sin(\phi_q - \phi_S)$$

No 1/Q suppression for Sivers effect

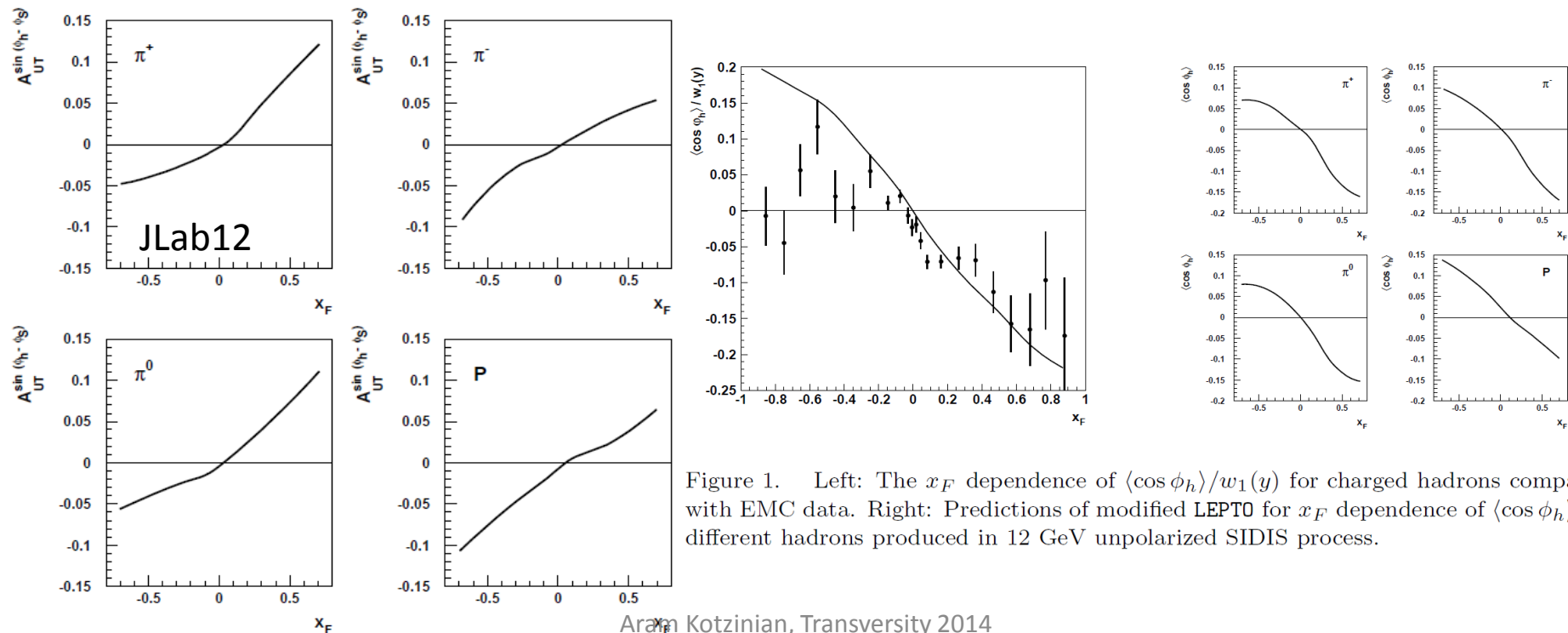
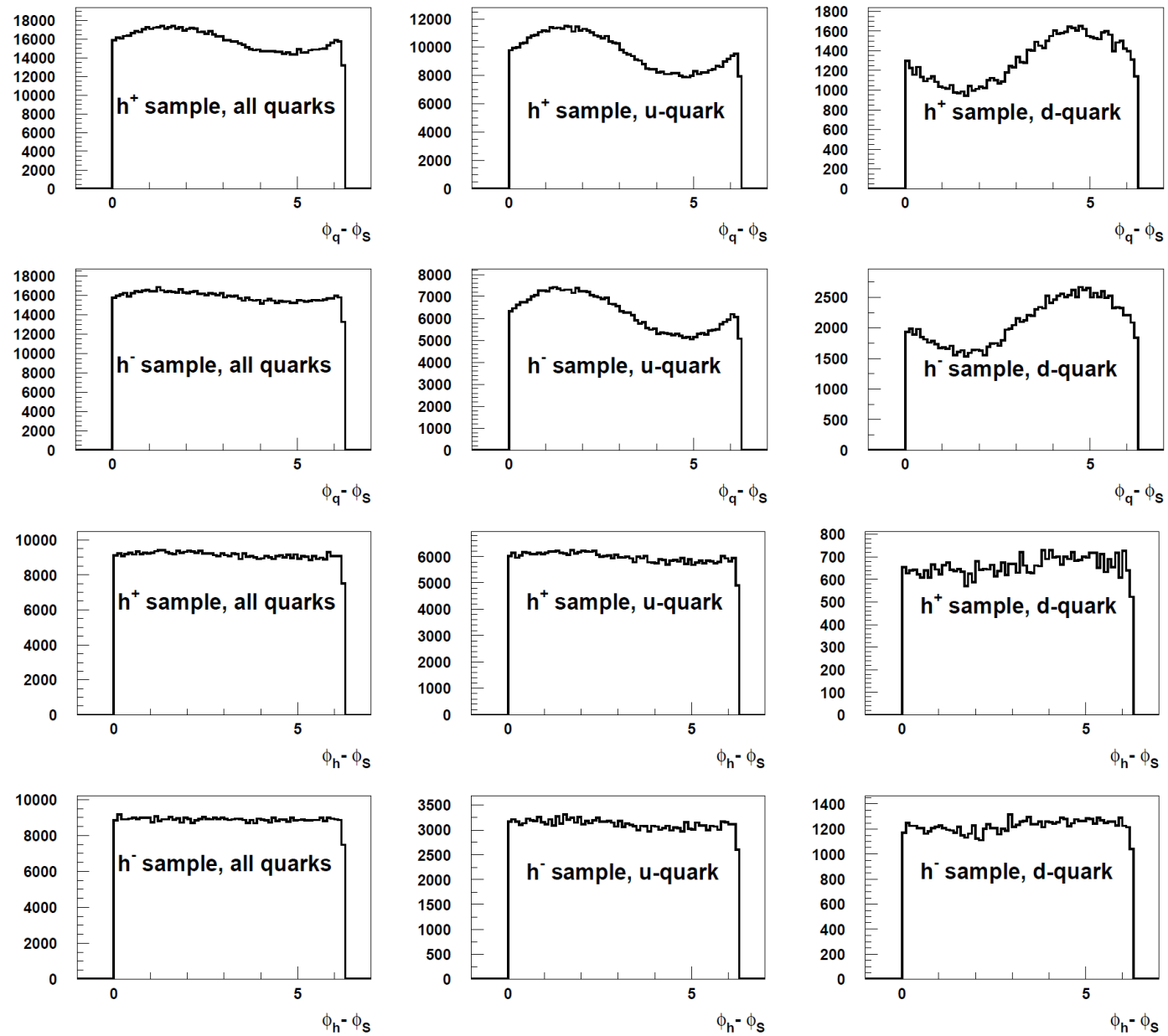
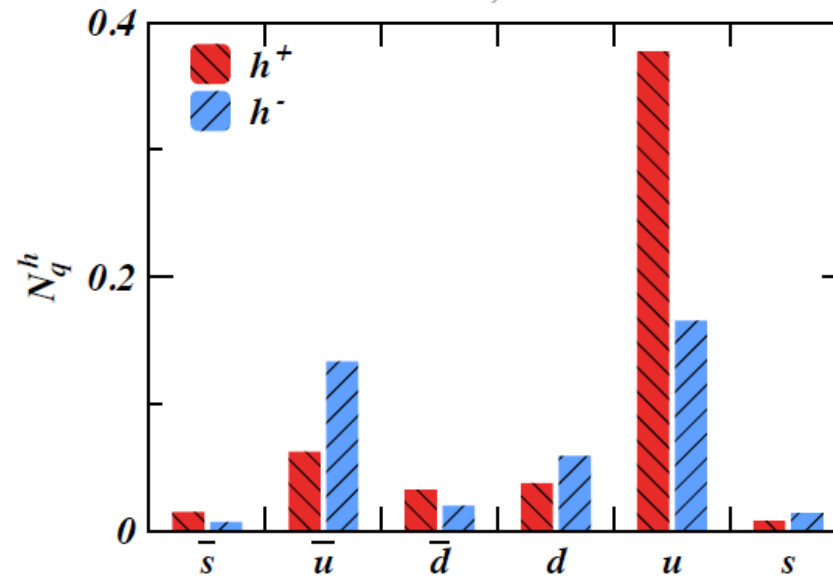
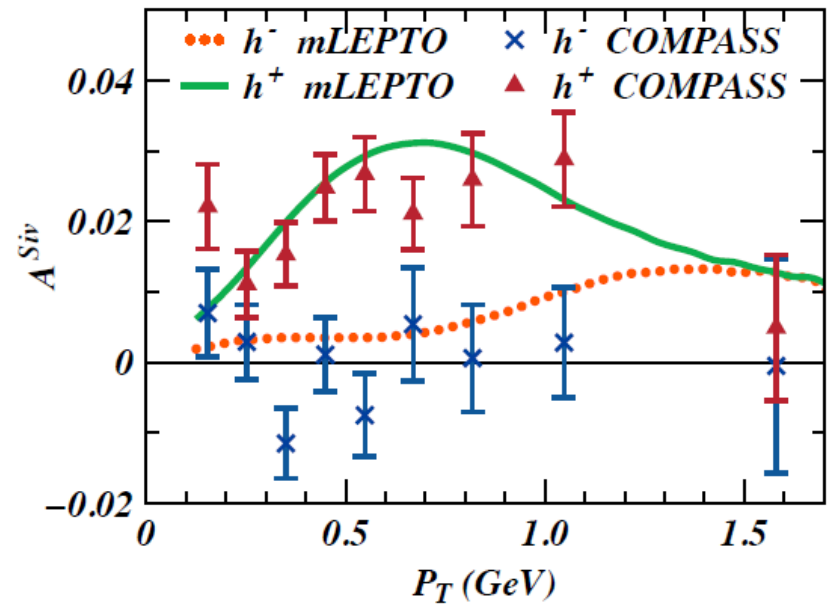
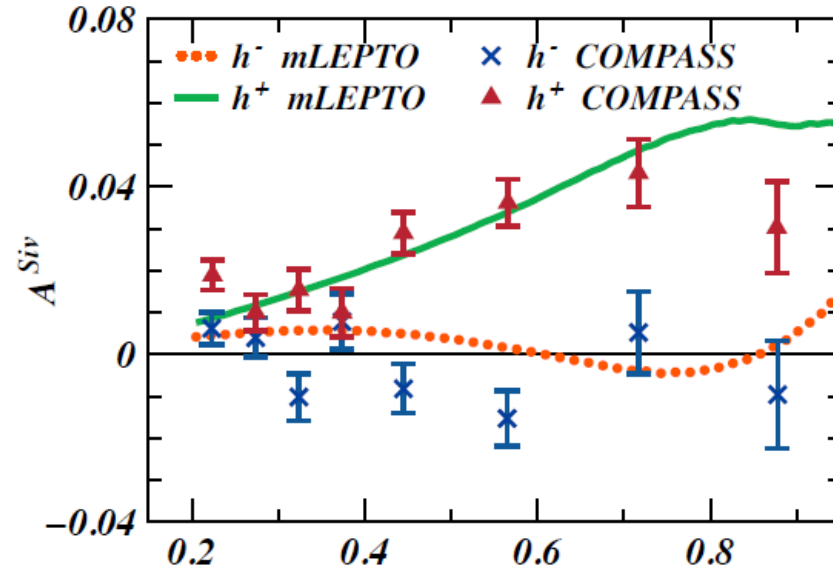
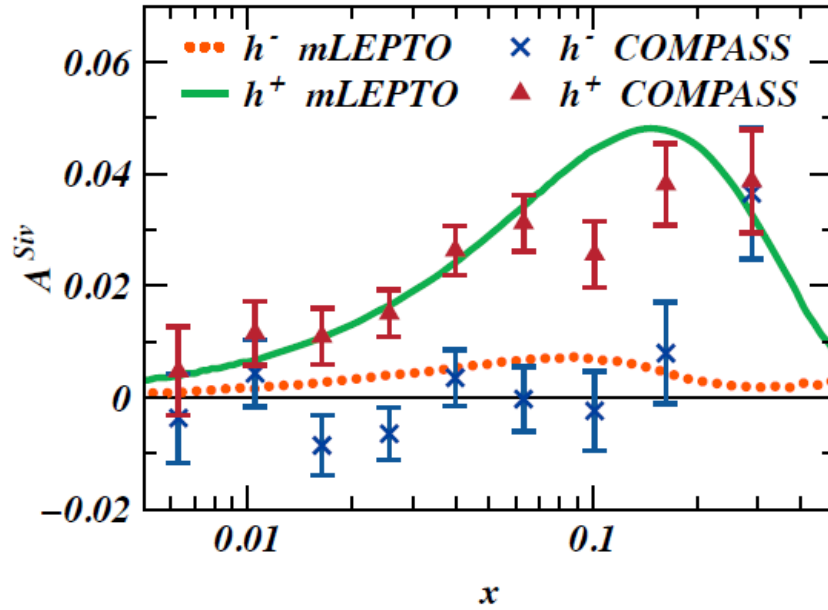
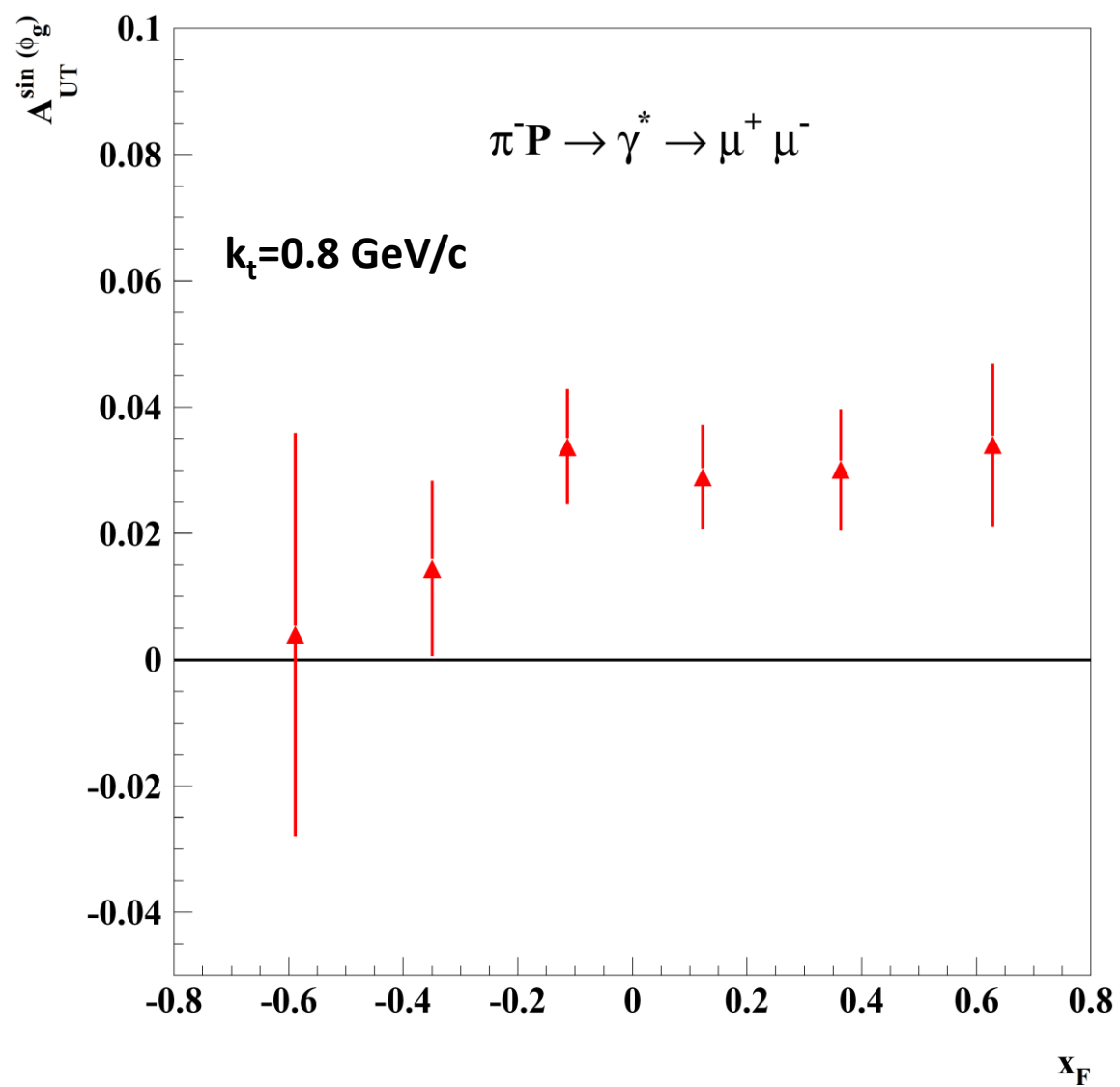
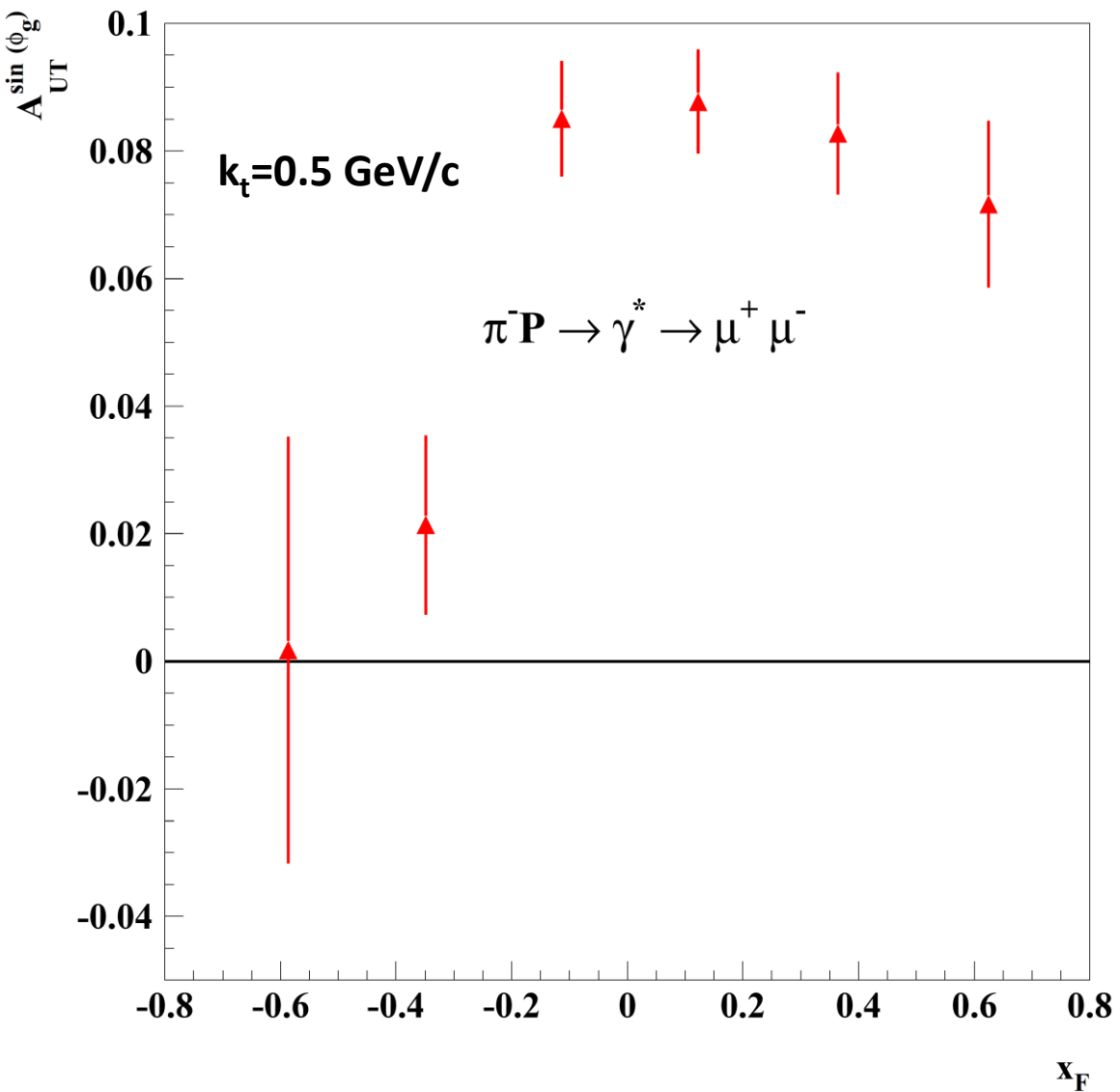


Figure 1. Left: The x_F dependence of $\langle \cos \phi_h \rangle / w_1(y)$ for charged hadrons compared with EMC data. Right: Predictions of modified LEPTO for x_F dependence of $\langle \cos \phi_h \rangle$ for different hadrons produced in 12 GeV unpolarized SIDIS process.

Quark Sivers angle distribution







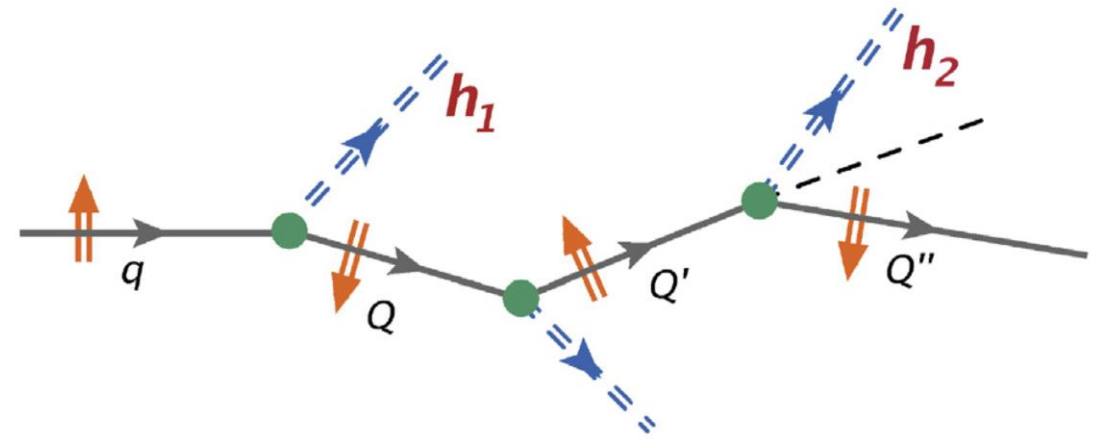
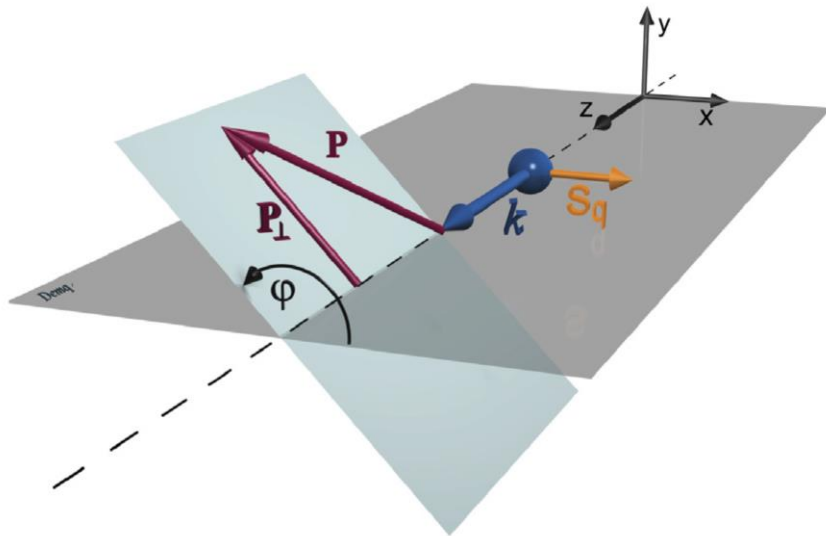
Transversely polarized quark fragmentation (Collins effect)

H.H. Matevosyan, A.W. Thomas, W. Bentz,

Collins fragmentation function within NJL-jet model, PRD86 (2012) 034025.

H.H. Matevosyan, A.K., A.W. Thomas,

Studies of azimuthal modulations in two hadron fragmentation of a transversely polarized quark, PLB 731 (2014) 208



Elementary Collins effect in the string fragmentation

H.H. Matevosyan, A.K., A.W. Thomas, PLB 731 (2014) 208

$$\begin{aligned}
 &= \hat{D}_1 \otimes \hat{D}_2 \otimes \hat{D}_3 \otimes \hat{D}_4 + \hat{H}_1 \otimes \hat{D}_2 \otimes \hat{D}_3 \otimes \hat{D}_4 + \hat{D}_1 \otimes \hat{H}_2 \otimes \hat{D}_3 \otimes \hat{D}_4 + \\
 &+ \hat{D}_1 \otimes \hat{D}_2 \otimes \hat{H}_3 \otimes \hat{D}_4 + \hat{D}_1 \otimes \hat{D}_2 \otimes \hat{D}_3 \otimes \hat{H}_4
 \end{aligned}$$

$$\begin{aligned}
 d_{h/q\uparrow}(z, p_{\perp}^2, \varphi) &= \\
 &= d_{h/q}(z, p_{\perp}^2) - h_{h/q}(z, p_{\perp}^2) \frac{p_{\perp} s_q}{zm} \sin(\varphi)
 \end{aligned}$$

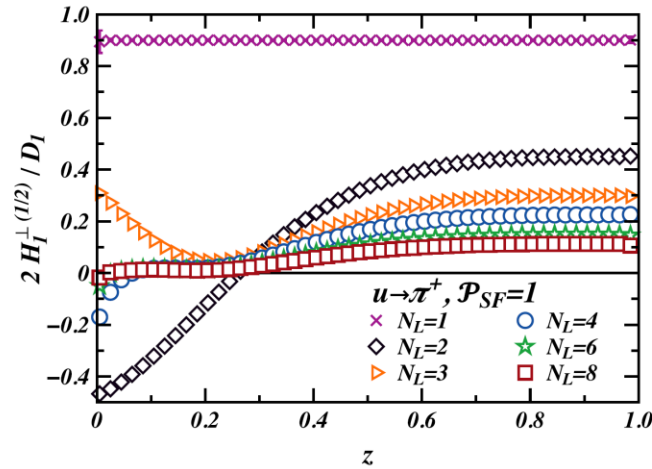
More realistic description of $h_{h/q}$ a la
 A. Bacchetta, L. P. Gamberg, G. R. Goldstein, and
 A. Mukherjee, (PLB659, 234 (2008))
 Spectator Model gives similar results

Collins effect in 1h and 2h fragmentation

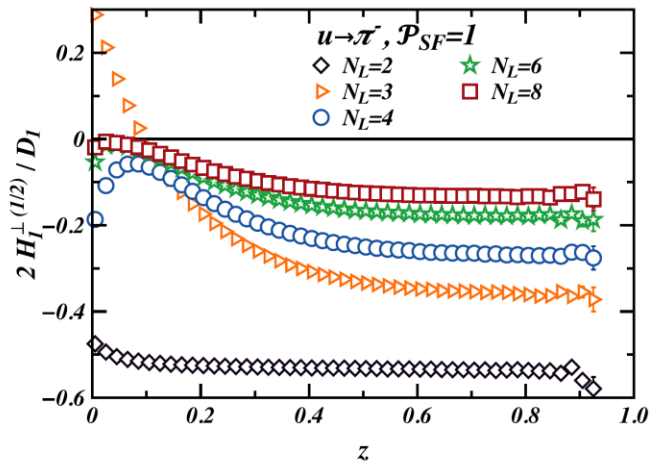
Toy model

$$d_{h/q^-}(z, p_\perp^2, \varphi) = d_{h/q}(z, p_\perp^2) (1 - 0.9 \sin(\varphi))$$

$$F(c_0, c_1) \equiv c_0 - c_1 \sin(\varphi).$$



(a)



(b)

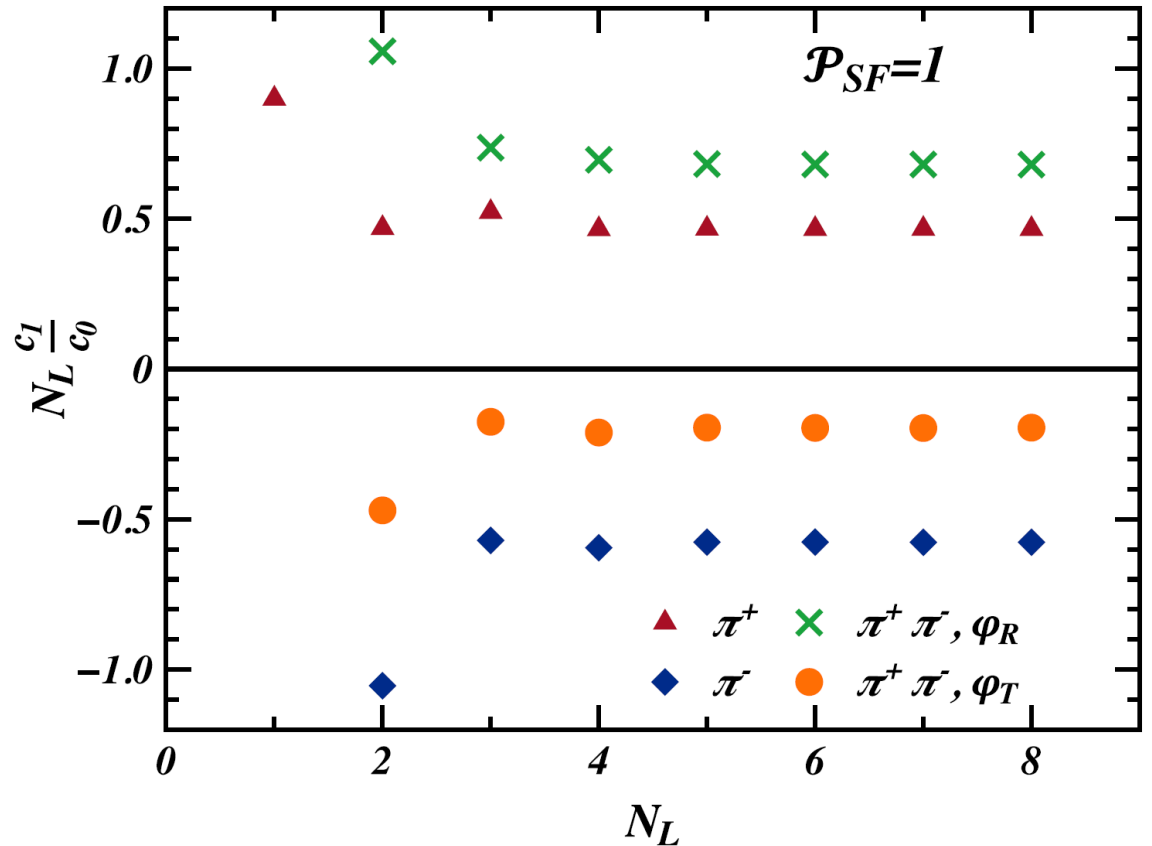


Fig. 4. Fitted values of the ratio $2H_1^{\perp(1/2)}/D_1$ for $u \rightarrow \pi^+$ (a) and $u \rightarrow \pi^-$ (b) as a function of z from MC simulations with several values of N_L , where $\mathcal{P}_{SF} = 1$.