March 26, 2008
at Osaka, JPS

HERMESによるTransversity測定結果と他の高エネルギー反応過程へのimpact

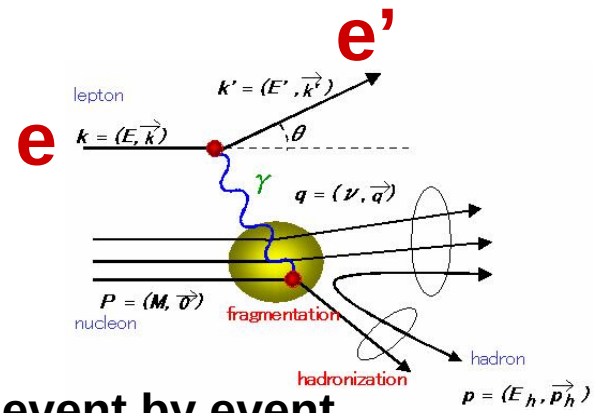
Transversity Measurement by HERMES and Its Impact On Other High Energy Reaction Processes

東工大理　柴田利明, 宮地義之, 長谷川大樹, 今津義充, 呂暁睿,
小林慶鑑, 他HERMES Collaboration

Contents:

- Longitudinal Spin Measurement and its Impact
- Transversity Measurement and Its Impact
- Conclusion

e -N, or μ*-N* deep inelastic scattering



x_B, Q^2 **event by event**

Inclusive measurement:

$$\sigma(x_B, Q^2) \propto F_2(x_B, Q^2) = x_B \sum_q e_q^2 \, q(x_B, Q^2)$$

Semi-inclusive measurement:

$$\sigma_h(x_B, Q^2, z) \propto x_B \sum_q e_q^2 \; q(x_B, Q^2) \; D_q^h(z, Q^2)$$

$$z = E_h / \nu$$

$$A_1 \propto g_1(x_B, Q^2),$$

Inclusive

semi-inclusive

$$\begin{pmatrix} A^{\pi^+} \\ A^{\pi^-} \\ A^{K^+} \\ A^{K^-} \\ .. \end{pmatrix} = \begin{pmatrix} u \to \pi^+, \\ ... \\ \\ \\ \\ \end{pmatrix} \begin{pmatrix} \Delta u / u \\ \Delta d / d \\ \Delta s / s \\ \Delta \bar{u} / \bar{u} \\ \Delta \bar{d} / \bar{d} \\ .. \end{pmatrix}$$

p-p collision

$$p + p \to \pi + X$$

$$\to particle\ cluster + X$$

$$\to \gamma + X$$

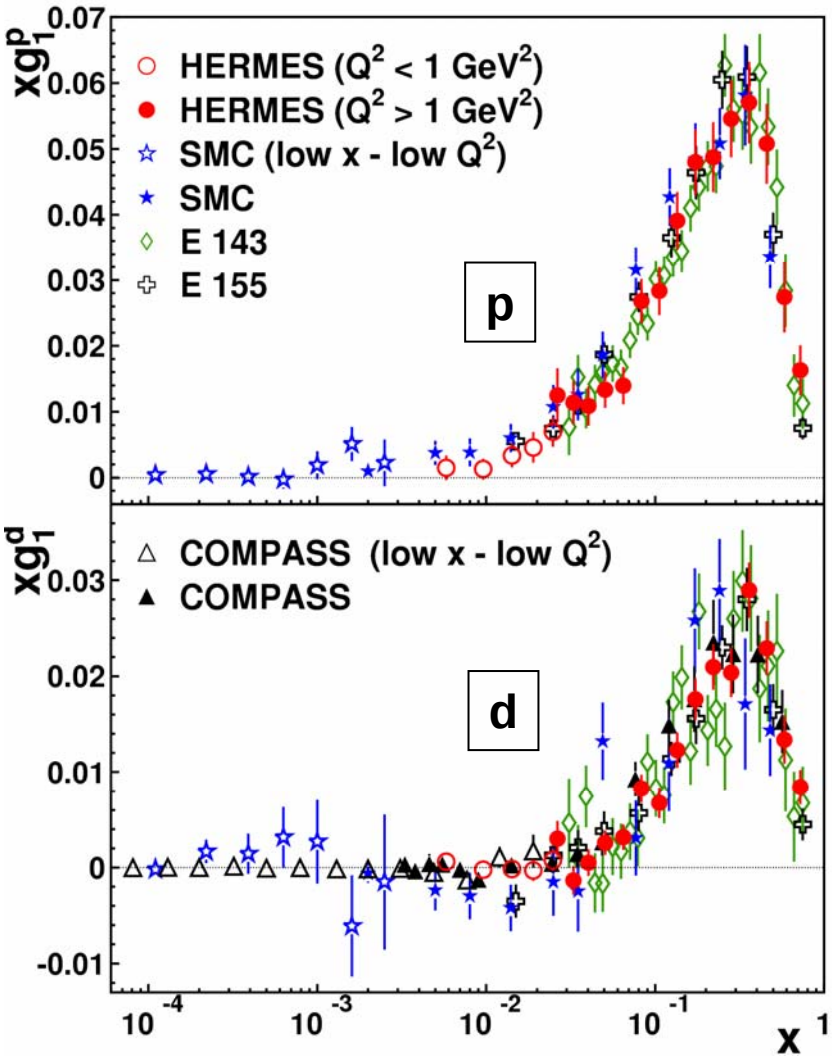
$$\to jet + jet$$

$$\to \mu's$$

$$\frac{d\sigma(p_T)}{dp_T} \propto \sum_{q1,\,q2} \int q_1(x_{B_1}, Q^2) \, q_2(x_{B_2}, Q^2) \bullet D(z, Q^2)$$

$$A_{LL}(p_T) \propto \sum_{q1,\,q2} \int \hat{\sigma}\,\hat{a} \, \frac{\Delta q_1}{q_1}(x_{B_1}, Q^2) \, \frac{\Delta q_2}{q_2}(x_{B_2}, Q^2) \bullet D(z, Q^2)$$

$g_1(x_B,Q^2)$ from Lepton-Nucleon Deep Inelastic Scattering



$g_1(x,Q^2)$

and also semi-inclusive data

GRSV parameterization 12 parameters

$$\Delta u(x) = N_u\, x^{\alpha_u} (1-x)^{\beta_u}\; u(x)$$
$$\Delta d(x) = N_d\, x^{\alpha_d} (1-x)^{\beta_d}\; d(x)$$
$$\Delta \bar{q}(x) = N_{\bar{q}}\, x^{\alpha_{\bar{q}}} (1-x)^{\beta_{\bar{q}}}\; \bar{q}(x)$$
$$\Delta g(x) = N_g\, x^{\alpha_g} (1-x)^{\beta_g}\; g(x)$$

GS parameterization

$$x\,\Delta g(x) = \eta_g A_g x^{\alpha_g} (1-x)^{\beta_g}\; (1+\gamma_g\, x + \rho_g\, x^{1/2})$$

....

The parameters are fitted to the DIS data with a condition of

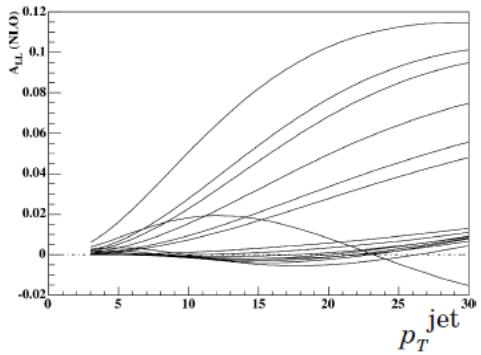
$$\int_0^1 \Delta g(x)dx = \int_0^1 N_g\, x^{\alpha_g} (1-x)^{\beta_g}\, g(x)\; dx = 0.5$$

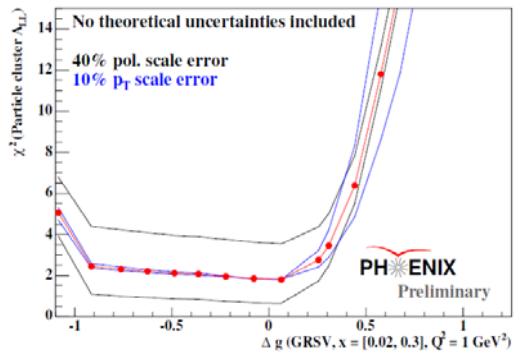
, and calculate $A_{LL}(p_T)$

$$\int_0^1 \Delta g(x)dx = \int_0^1 N_g\, x^{\alpha_g} (1-x)^{\beta_g}\, g(x)\; dx = 1$$

.....

at Q^2 = 1 GeV^2





Calculate χ^2 with A_{LL} data of π or particle cluster from pp collision

one parameter fit χ^2 increase by 1 $\longleftrightarrow$ $1\,\sigma$

Shape of gluon distribution: rely on the DIS data

Transversity: with a Transversely polairzed target

spin-$k_\perp$ correlation

orbiting quarks

Transverse momentum dependent distribution functions

Space (position) dependent distribution functions

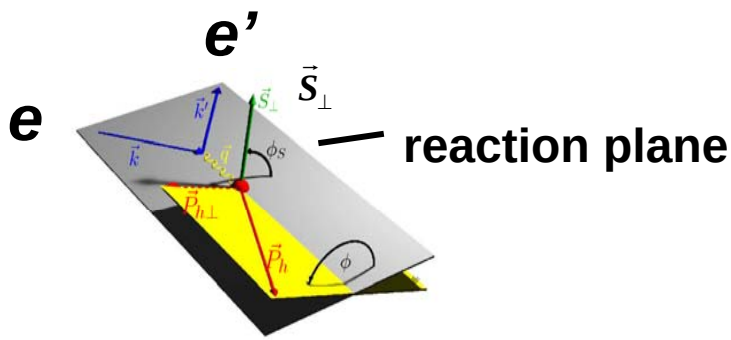
$$q(x, \boldsymbol{k}_\perp; Q^2)$$

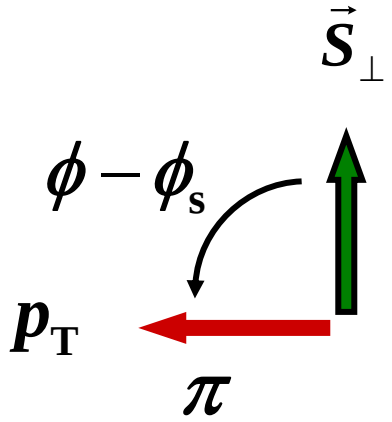
$$q(x, \boldsymbol{b}; Q^2)$$

Transverse Spin Measurements:

Azimuthal Single Spin Asymmetry: UT

Asymmetry around the virtual photon direction





Fit in 2-dimension (ϕ, ϕ_s) **in each x bin**

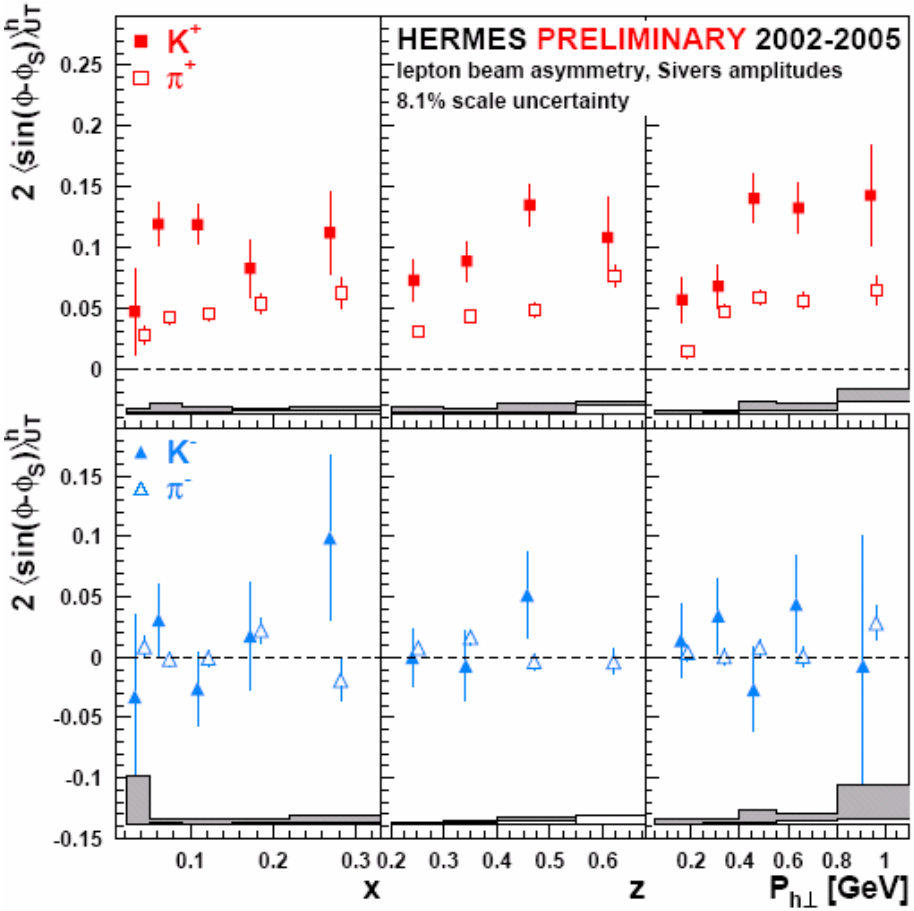
$$A_{UT}(\phi,\phi_s) = 2 < \sin(\phi+\phi_s) >_{UT}^{1} \sin(\phi+\phi_s) + 2 < \sin(\phi-\phi_s) >_{UT}^{1} \sin(\phi-\phi_s)$$

Collins

Sivers

Fourier Amplitudes

Sivers Amplitudes for π, K



non-zero Sivers function

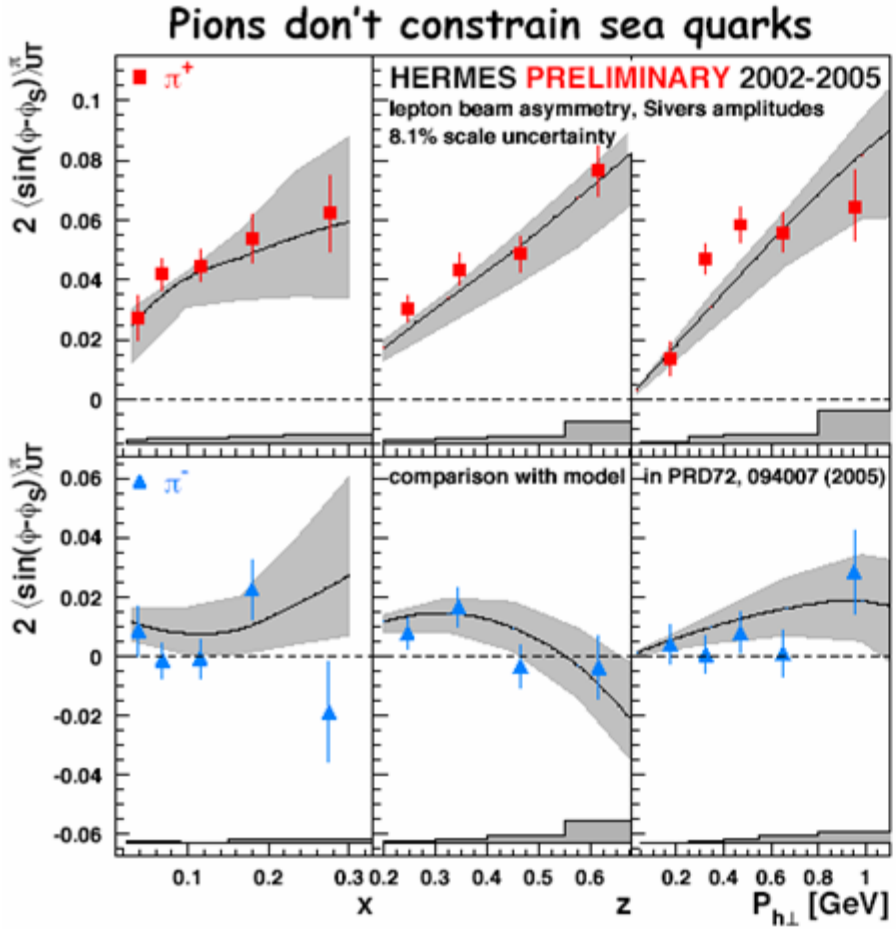
π^+, K^+ amplitudes significantly positive

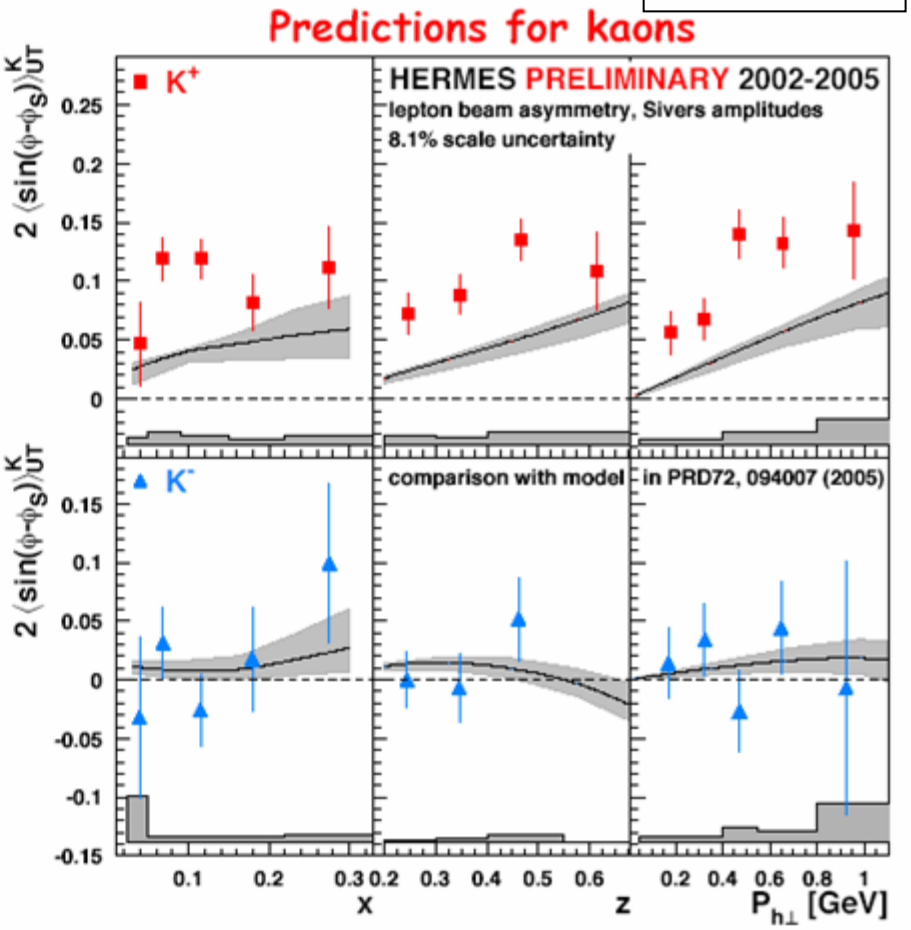
π^-, K^- amplitudes consistent with zero

M. Anselmino, M. Boglione, U. D'Alesio, A. Kotzinian, F. Murgia, A. Prokudin

A fit of HERMES + COMPASS pion data, information on u and d Sivers funtions

- Pacific SPIN07 -





no sea contribution

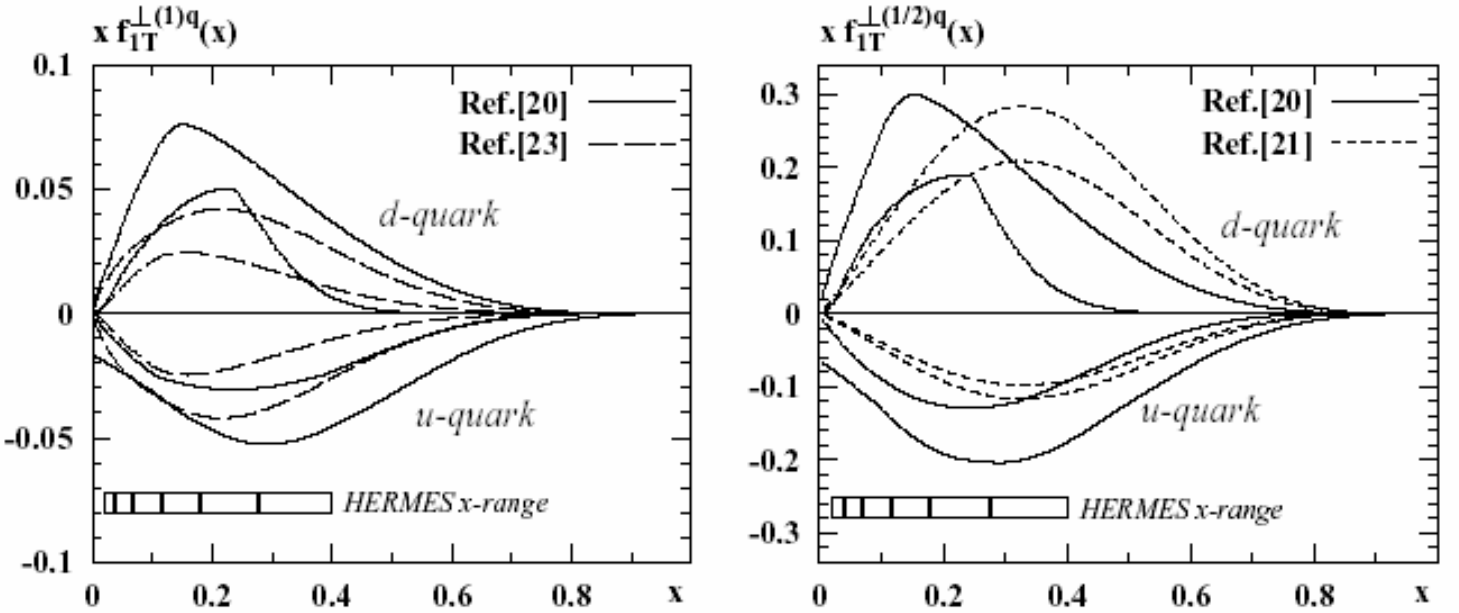
sea contribution?

(Kretzer fragmentation functions)

Present knowledge of Sivers function (u,d)

M. Anselmino, M. Boglione, J.C. Collins, U. D'Alesio, A.V. Efremov, K. Goeke, A. Kotzinian, S. Menze, A. Metz, F. Murgia, A. Prokudin, P. Schweitzer, W. Vogelsang, F. Yuan

- Pacific Spin07-



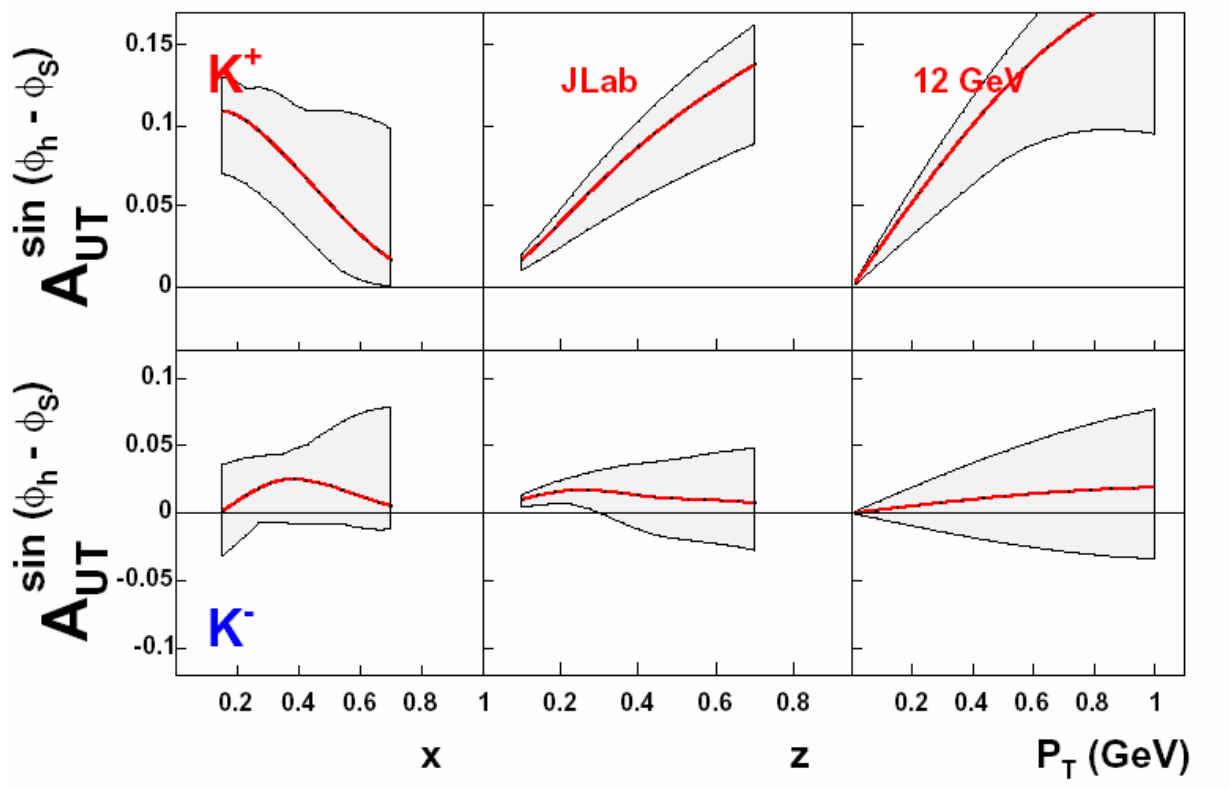
The first and 1/2-transverse moments of the Sivers quark distribution functions. The fits were constrained mainly (or solely) by the preliminary HERMES data in the indicated x-range. The curves indicate the 1-σ regions of the various parameterizations.

$$f_{1T}^{\perp(1)q} = \int d^2\boldsymbol{k}_\perp \frac{k_\perp^2}{2M^2} f_{1T}^{\perp q}(x,k_\perp) \qquad f_{1T}^{\perp(1/2)q}(x) = \int d^2\boldsymbol{k}_\perp \frac{k_\perp}{M} f_{1T}^{\perp q}(x,k_\perp)$$

M. Anselmino et al.

Predictions for JLab

- Pacific Spin07 -



Summary

Longitudinal spin measuements: inclusive and semi-inclusive, used to fit gluon distribution and to evaluate χ^2 of A_{LL} of π or particle cluster from pp collision

Increasing the data set helps to reduce the uncertainty of ΔG

Transverse spin measuements:

Sivers asymmetry

Non-zero Sivers function has been observed, u and d
Drell-Yan processes
pp collision, hadron production

Collins asymmetry

e^+e^- collision, Belle …