



October 29, 2013
Pacific Spin 2013
at Shandong University

Transverse Spin Physics by HERMES

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Tokyo Institute of Technology



HERMES

arXiv: 1310.5070

'Transverse target single-spin asymmetry in inclusive electroproduction of charged pions and kaons'

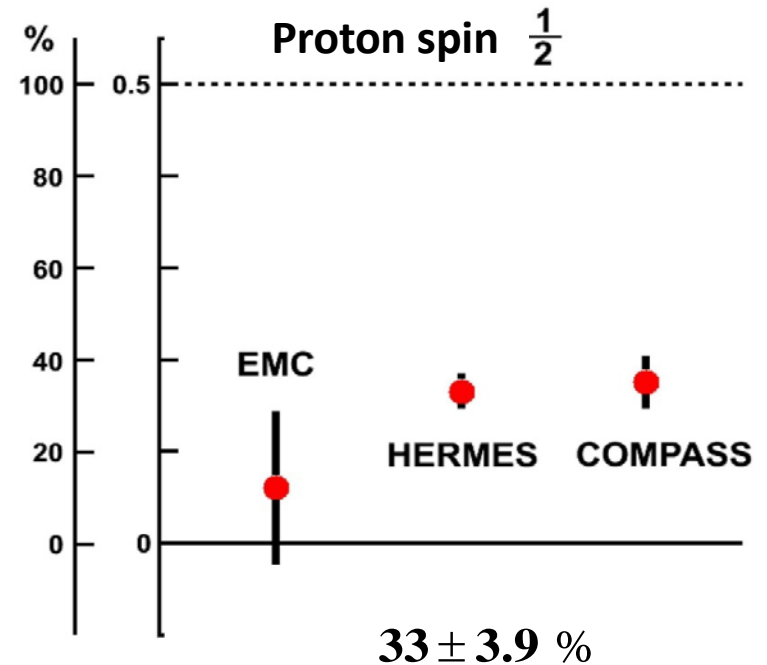
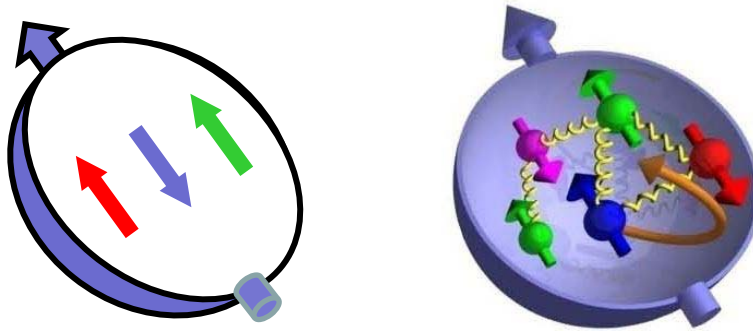
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Also, C. Van Hulse's general talk on HERMES on October 30

1. Introduction

Spin Structure of the Nucleon



Quark spin contributions to the nucleon spin
1st moment. Integration over x

- Longitudinal Spin
 - Quark spin contributions to the proton spin $33 \pm 3.9 \%$, HERMES (2007)
- Transverse single-spin asymmetries
 - They originate from correlations of transverse spin of the nucleon and/or transverse spins of quarks with transverse quark momentum

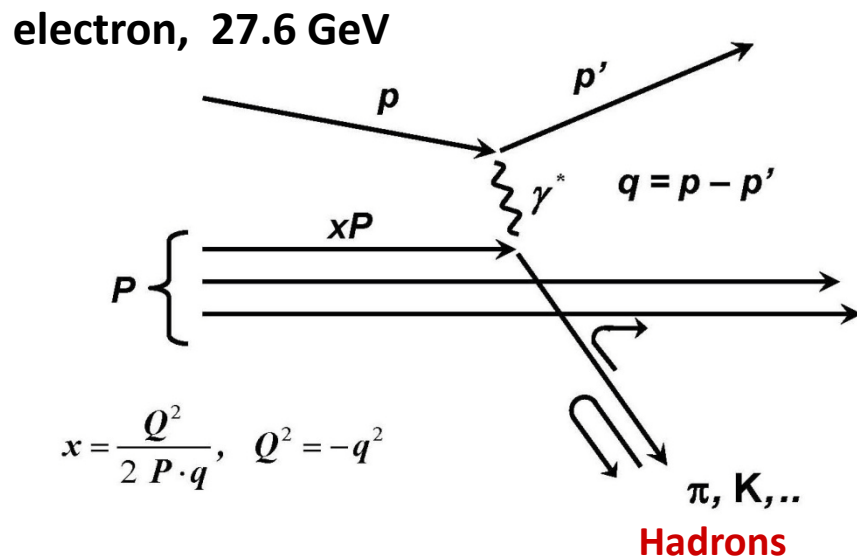
Spin-orbit effects and orbital motion of partons within the nucleon in models

HERMES



- 2005** Extraction of Collins Asymmetry Phys. Rev. Lett. 94 (2005) 012002
- 2009** Extraction of Sivers Asymmetry Phys. Rev. Lett. 103 (2009)152002
- 2013** Extraction of Azimuthal Angle Dependence with Unpolarized Targets
Phys. Rev. D 87 (2013) 012010
- 2013** **Transverse target single-spin asymmetry in inclusive electroproduction of charged pions and kaons**
arXiv: 1310.5070

Deep inelastic scattering



Typical cuts when electron is detected:

$$Q^2 > 1 \text{ GeV}^2, \quad W > 3.3 \text{ GeV},$$

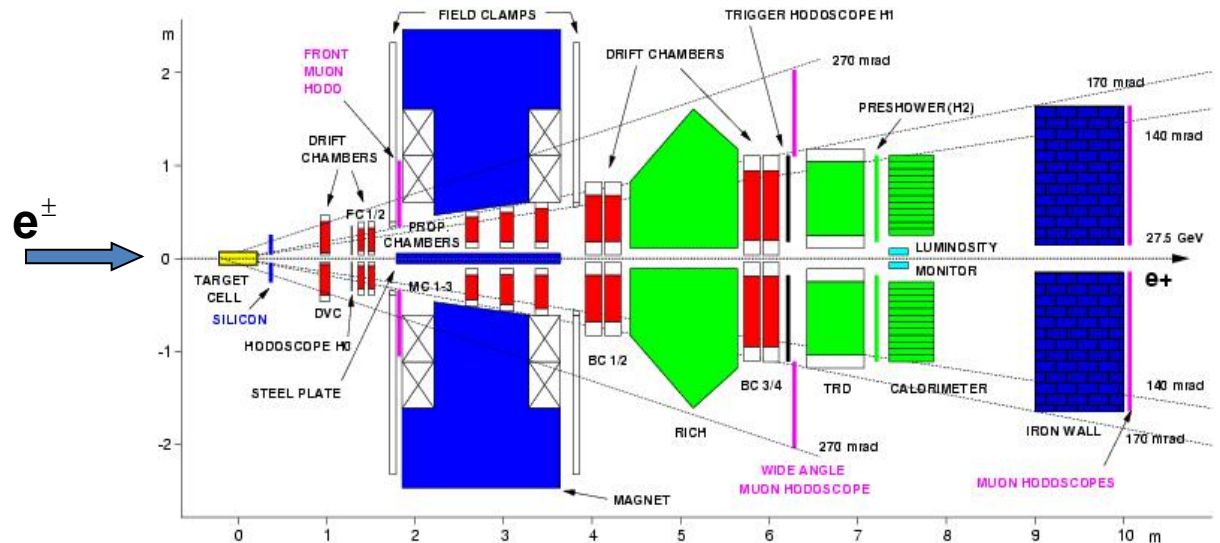
$$0.023 < x < 0.6, \quad 0.2 < y < 0.85$$

$$z > 0.2, \quad x_F > 0.2, \quad 1 < P_h < 15 \text{ GeV}$$

2. HERMES Experiment at DESY—HERA



$$E_e = 27.6 \text{ GeV}$$



< 170 mrad horizontally, 40-140 mrad vertically

Transversely polarized proton target $P = 0.713 \pm 0.063$

Pion, Kaon, Proton Identification with RICH

$$L = 146 \text{ pb}^{-1}$$

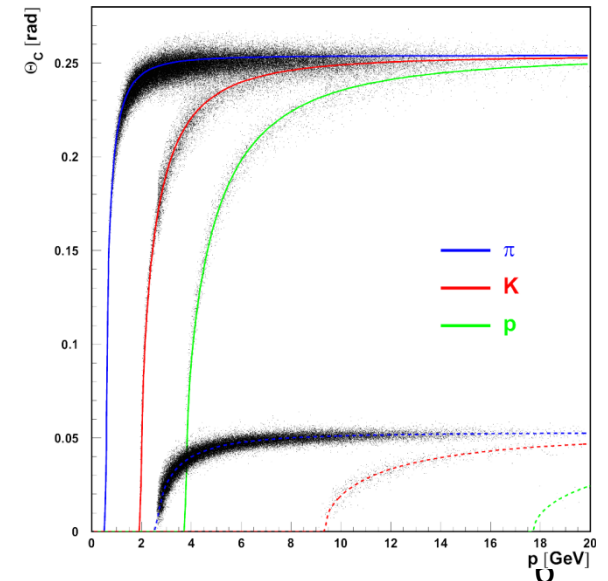
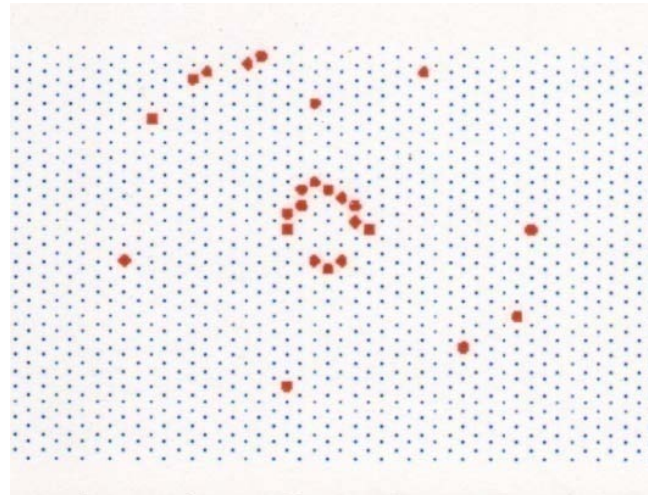
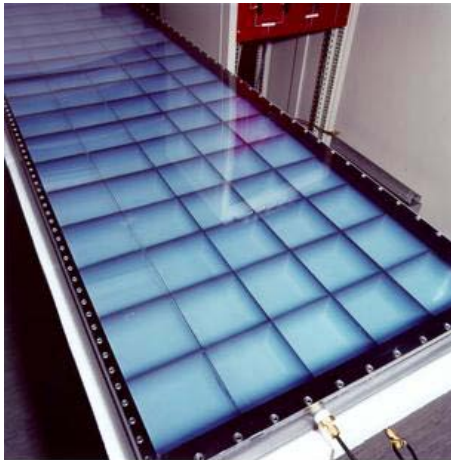
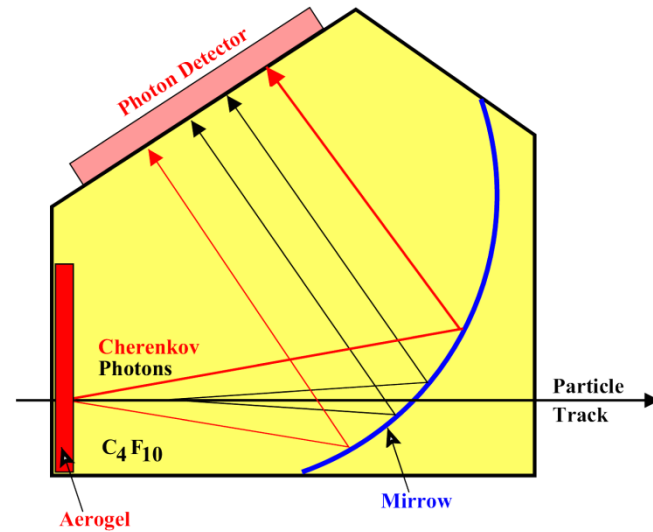
Hadron Identification

RICH

radiators: Aerogel, C_4F_{10}

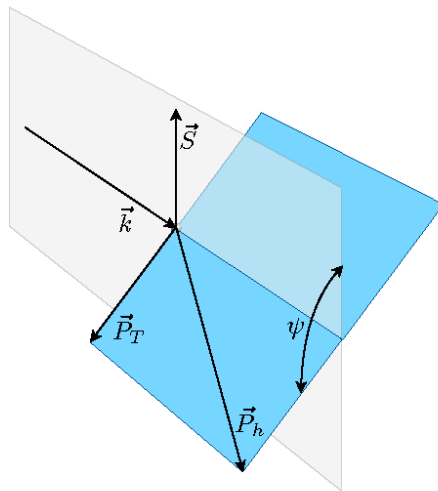
$n = 1.03, 1.0014$

2 – 15 GeV/c



Azimuthal Angle Dependence

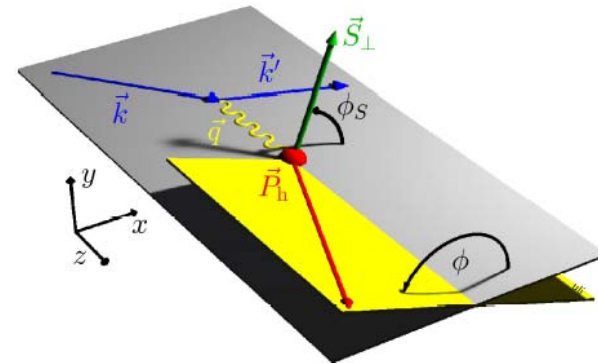
Hadron inclusive measurements



$$d\sigma = d\sigma_{UU} \left[1 + S_T A_{UT}^{\sin \psi} \sin \psi \right]$$

$$A_N \equiv \frac{\int_{\pi}^{2\pi} d\psi d\sigma - \int_0^{\pi} d\psi d\sigma}{\int_{\pi}^{2\pi} d\psi d\sigma + \int_0^{\pi} d\psi d\sigma} = -\frac{2}{\pi} A_{UT}^{\sin \psi}$$

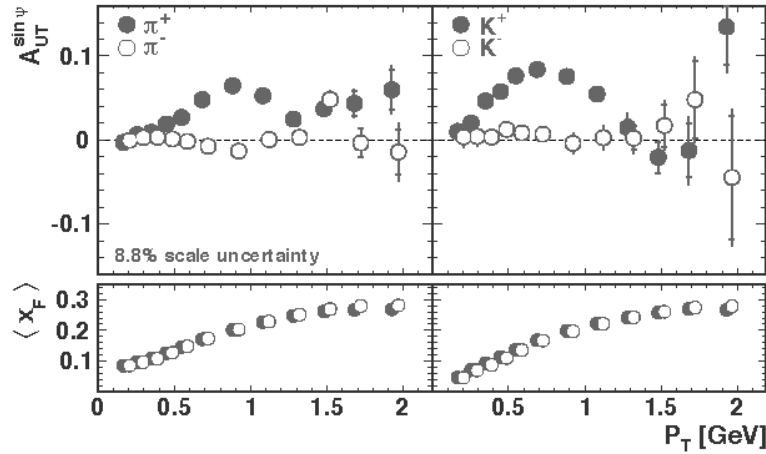
Electron - hadron coincidence measurements:
semi-inclusive measurements



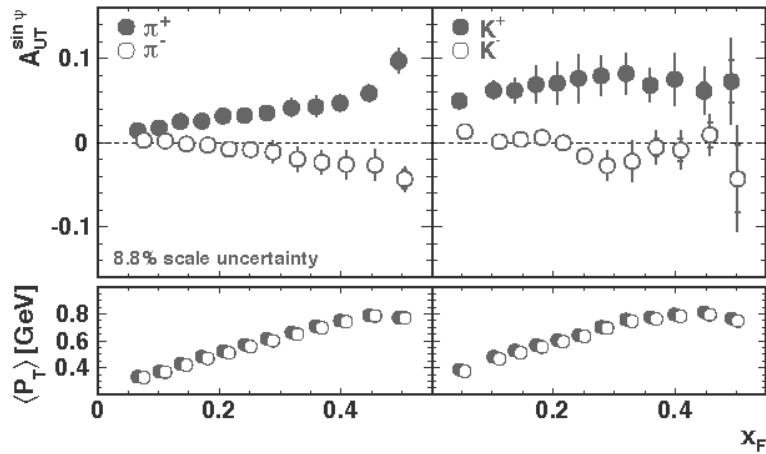
$$\sin(\phi - \phi_s), \quad \sin(\phi + \phi_s)$$

Sivers asymmetry, Collins asymmetry

3. Results of Azimuthal Amplitude $A_{UT}^{\sin\varphi}$

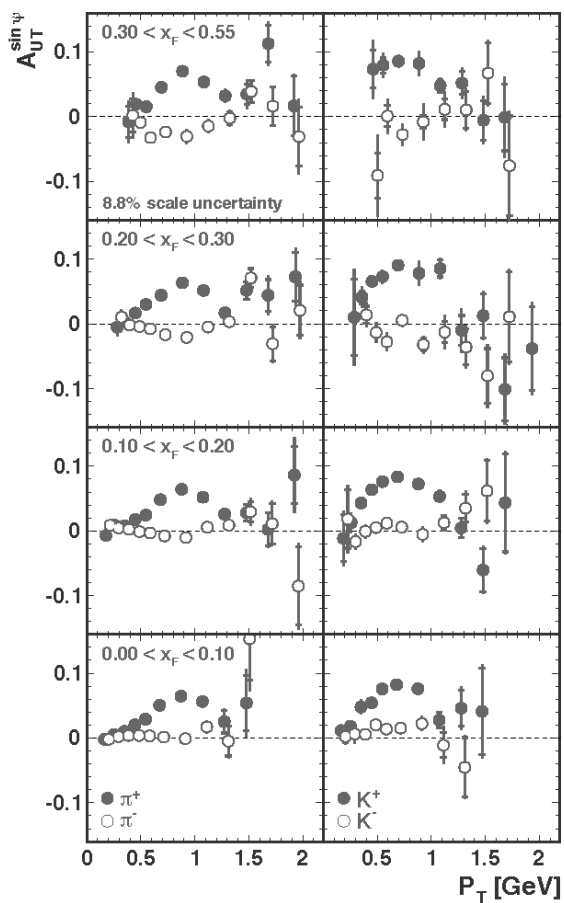
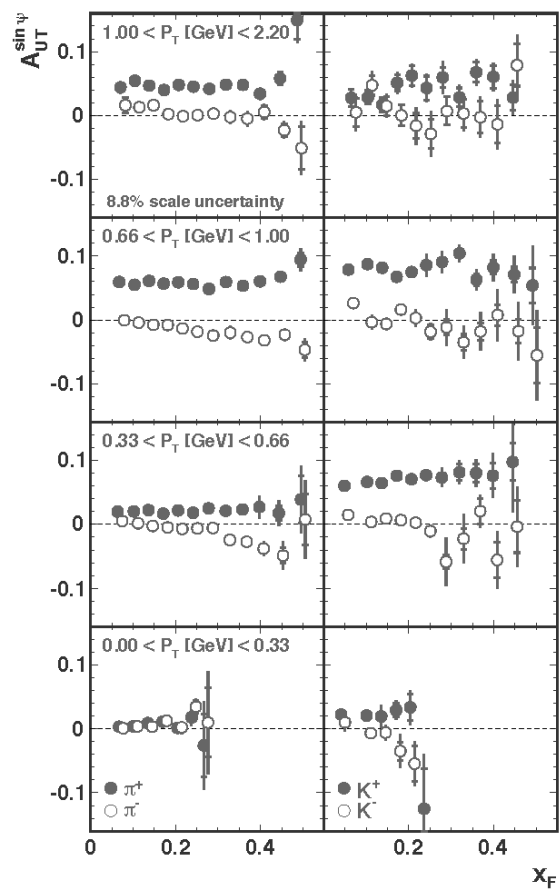


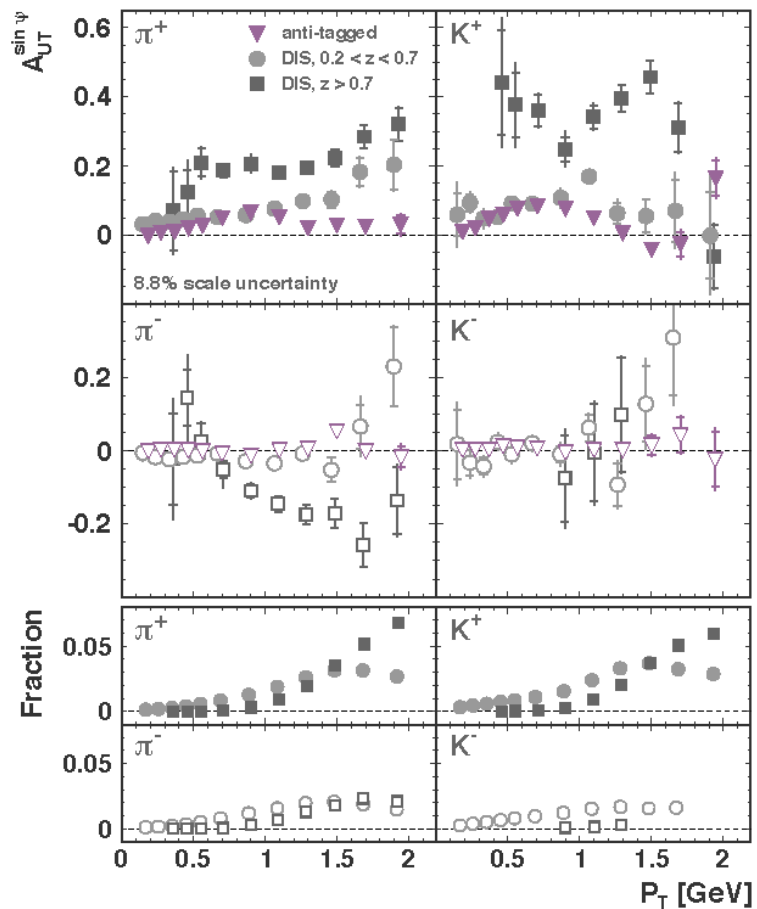
$P_T,$
 $Q,$
 $\Lambda_{\text{QCD}} \cong 0.3 \text{ GeV}$



P_T

x_F


 P_T

 x_F



$$P_T$$

$$Q^2 \approx 0$$

quasi-real photon

subsample	π^+	π^-	K^+	K^-
'anti-tagged'	170.5	140.7	14.3	7.2
'tagged'	1.93	1.49	0.26	0.13
DIS, $0.2 < z < 0.7$	0.69	0.49	0.12	0.05
DIS, $z > 0.7$	0.061	0.037	0.013	0.001



4. Summary

- HERMES is a deep inelastic scattering experiment with gas targets internal to the DESY-HERA electron/positron beam
- Electron/positron beam energy is 27.6 GeV. HERMES spectrometer has wide acceptance and a RICH for hadron identification
- In the series of measurements with the transverse polarized proton target, Collins asymmetry and Sivers asymmetry had been identified
- New result on
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was presented.
- Two-dimensional p_T, x_F analysis is important