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

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HERMES

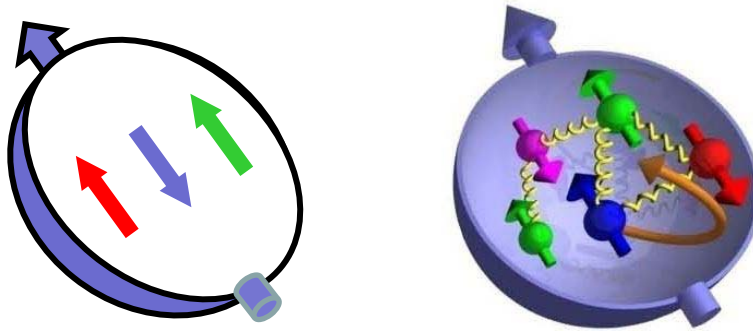
Phys. Lett. B 728 (2014) 183 'Transverse target single-spin asymmetry in inclusive
electroproduction of charged pions and kaons'

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1. Introduction

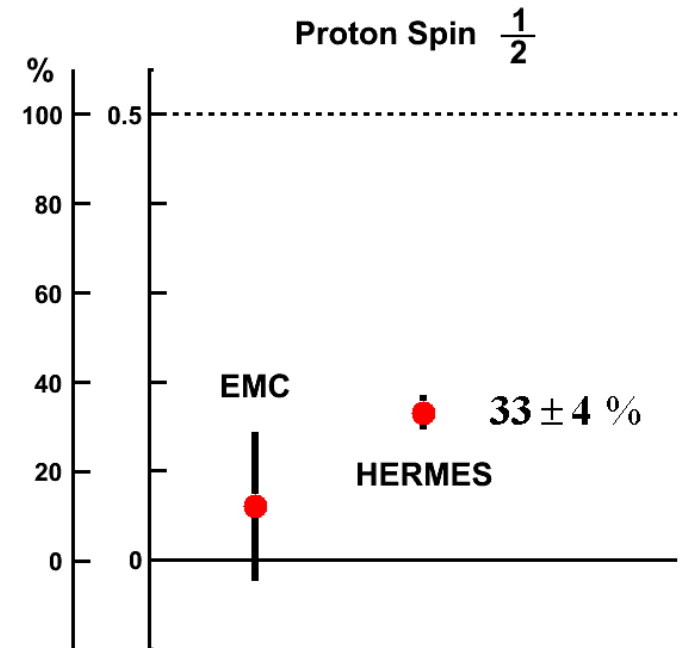
Spin Structure of the Nucleon



• Longitudinal Spin

1st moment. Integration of $g_1^d(\mathbf{x})$ over x

-- Quark spin contributions to the proton spin
 $33 \pm 4 \%$, 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

$p_{hT} \ll Q$ TMD distributions

$\Lambda_{QCD} \ll p_{hT} \ll Q$ Intermediate region

$\Lambda_{QCD} \ll p_{hT} \sim Q$ Multi-parton correlation functions

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

HERMES



Beside the longitudinally-polarized spin program,

2014 Transverse target single-spin asymmetry in inclusive electroproduction of charged pions and kaons

Phys. Lett. B 728 (2014) 183

2013 Extraction of Azimuthal Angle Dependence with Unpolarized Targets

Phys. Rev. D 87 (2013) 012010

2009 Extraction of Sivers Asymmetry

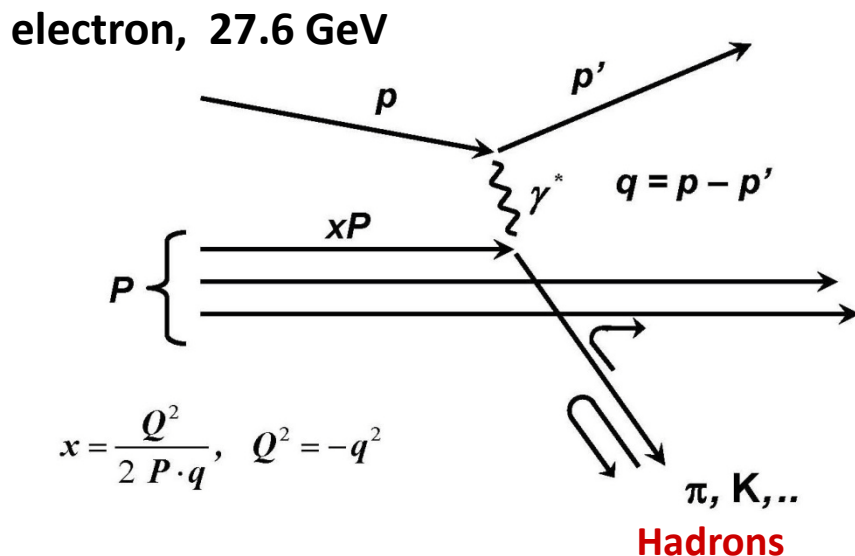
Phys. Rev. Lett. 103 (2009) 152002

2005 Extraction of Collins Asymmetry

Phys. Rev. Lett. 94 (2005) 012002

and deeply virtual Compton scattering and exclusive meson productions

Deep inelastic scattering



Typical cuts when electron is detected:

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

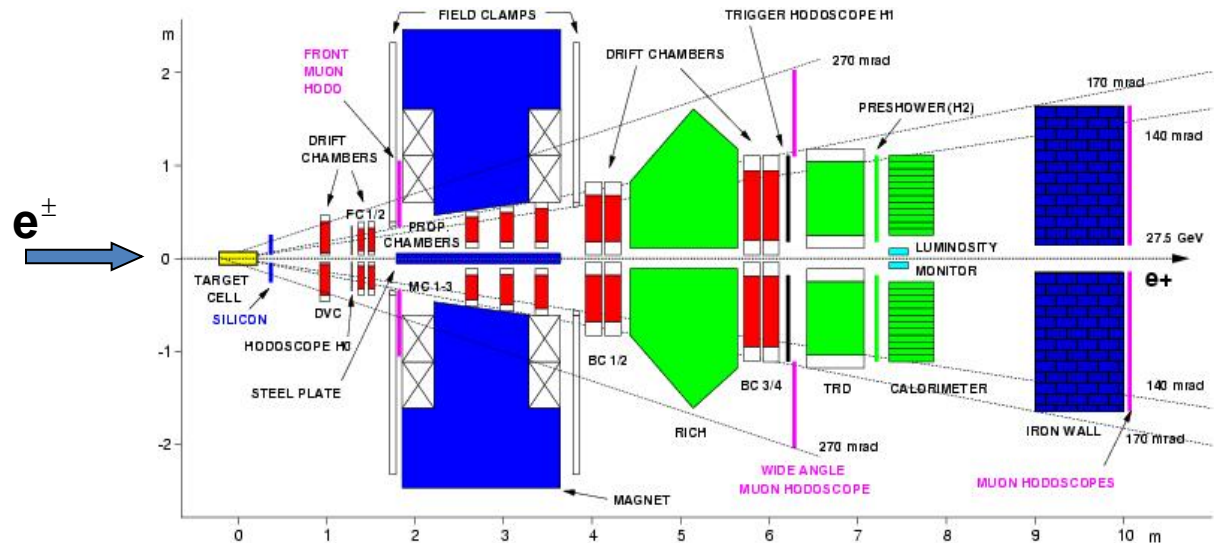
$$0.023 < x < 0.6, \quad 0.2 < y < 0.85$$

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

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

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

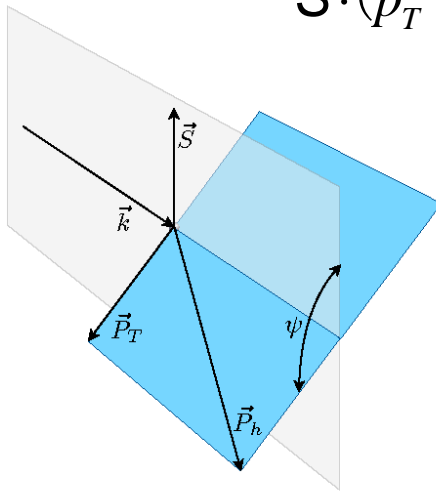
Azimuthal Angle Dependence



$$l P^\uparrow \rightarrow h X$$

Hadron inclusive measurements

$$S \cdot (p_T \times k)$$

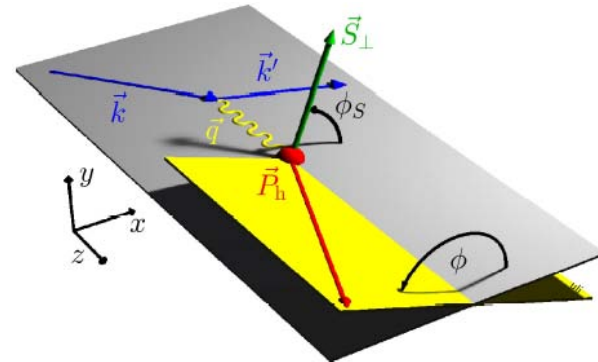


$$d\sigma = d\sigma_{UU} \left[1 + S_T A_{UT}^{\sin \psi} \sin \psi \right]$$

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

$$l P^\uparrow \rightarrow l' h X$$

Electron - hadron coincidence measurements:
semi-inclusive measurements



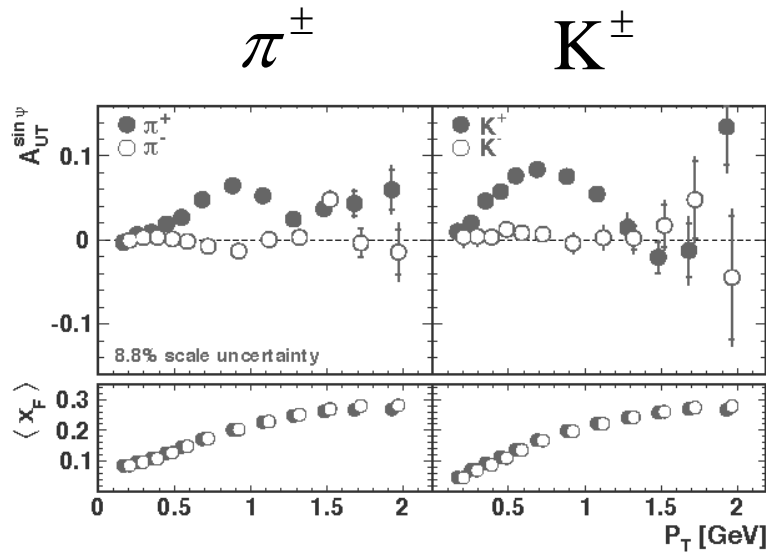
$$\sin(\phi - \phi_s), \sin(\phi + \phi_s)$$

Sivers asymmetry, Collins asymmetry

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



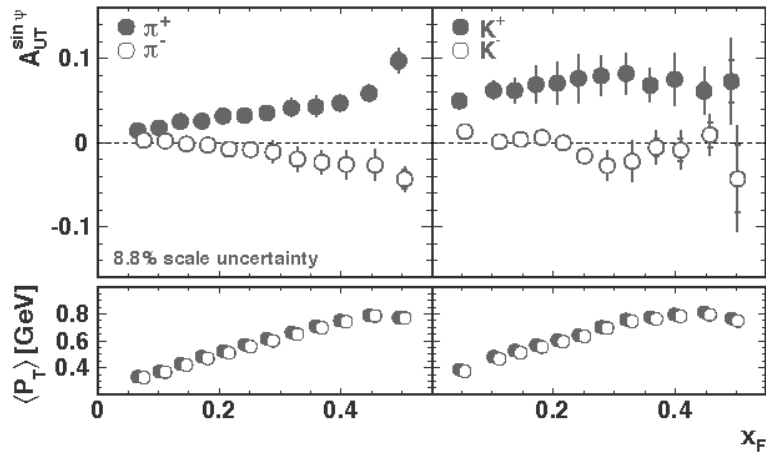
$A_{UT}^{\sin\psi}$



π^+ 60 Millions, π^- 50 Millions
 K^+ 5.1 Millions, K^- 2.8 Millions

P_T

$A_{UT}^{\sin\psi}$

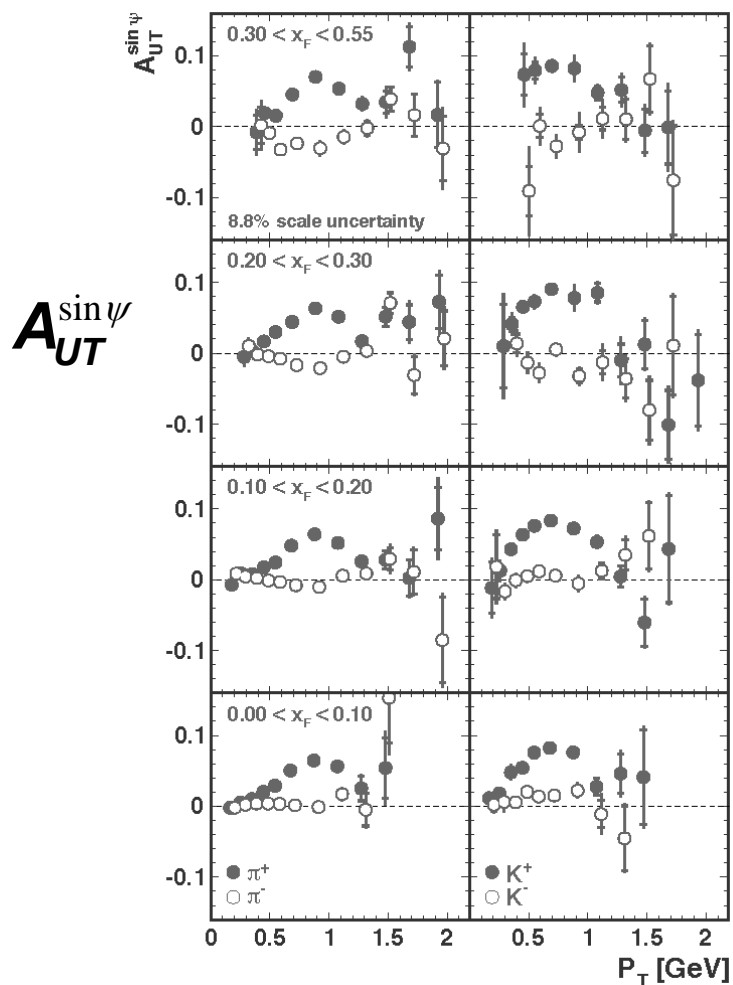
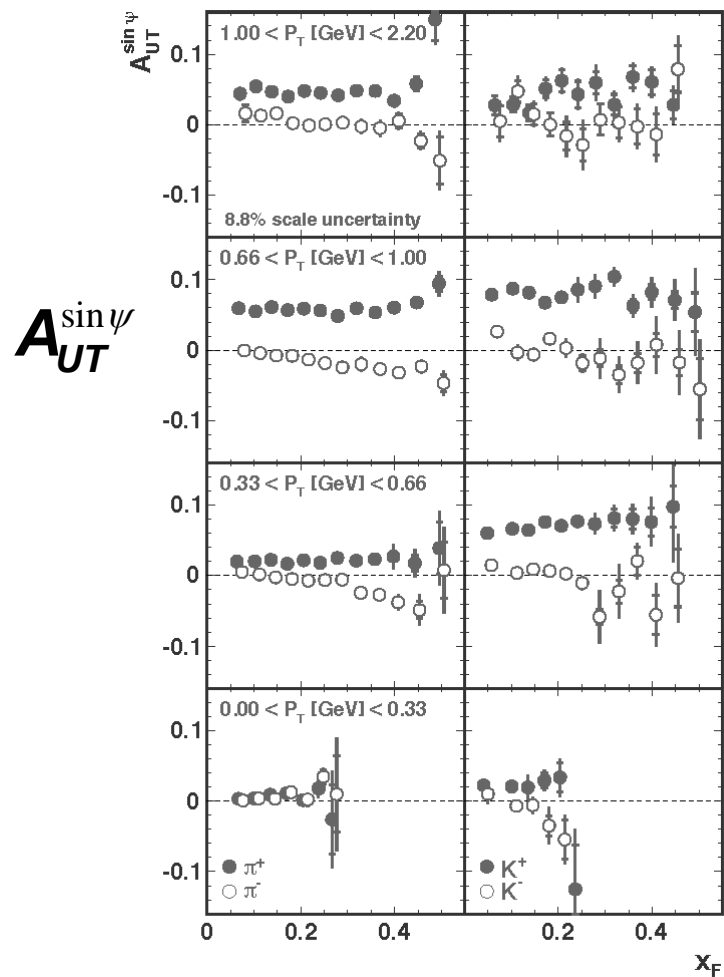


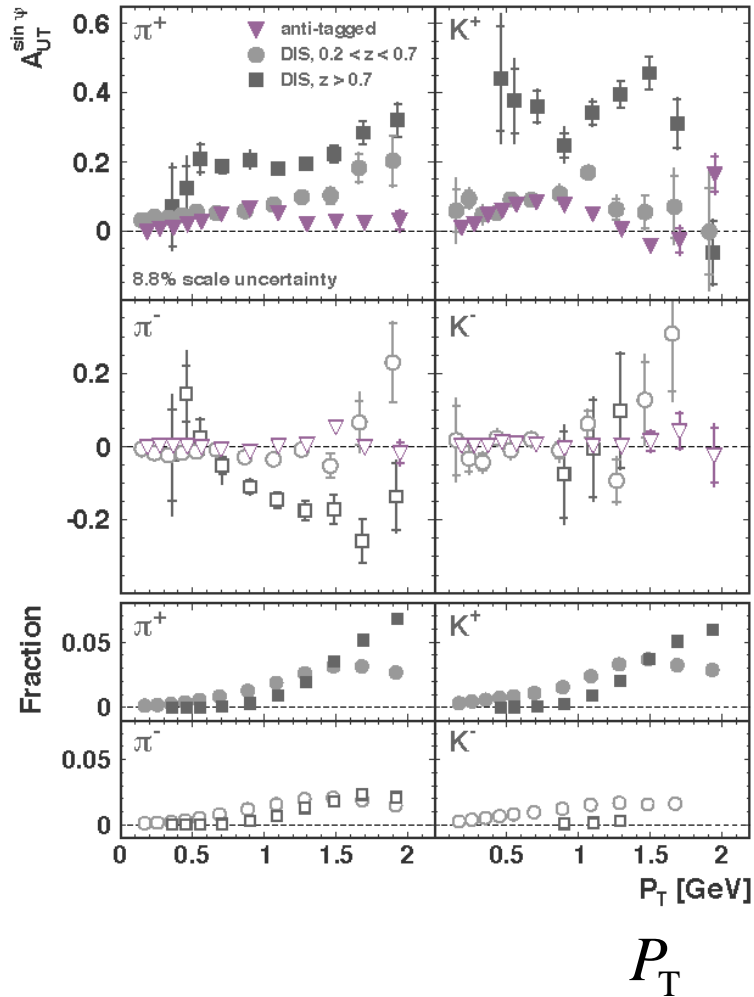
P_T ,

Q ,

$\Lambda_{\text{QCD}} \cong 0.3 \text{ GeV}$

x_F

π^\pm K^\pm

 P_T
 π^\pm K^\pm

 x_F

π^\pm
 K^\pm


Q^2 small
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

DIS $Q^2 > 1 \text{ GeV}^2, \dots$
 $\langle Q^2 \rangle = 2.2 - 4.3 \text{ GeV}^2$



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
- High statistic results in
'Transverse target single-spin asymmetry in inclusive electroproduction of charged pions and kaons' Phys. Lett. B 728 (2014) 183 were presented.
- $A_{UT}^{\sin\psi}$ up to 0.1 was observed in inclusive hadron measurement.
up to 0.4 was observed in coincidence measurement.
- Two-dimensional analysis on p_T, x_F is important.
- p_T dependence and control on Q^2 will be inputs to theoretical studies.