New Results Of SIDIS Kaon SSA and Inclusive Hadron SSA For Transvesity(E06010) Experiment

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Outline

- **Introduction of Transversity(E06010) experiment at Jefferson Lab Hall A**
  - Physics motivation
  - Setup of the experiment
- **Preliminary results of SIDIS Kaon SSA**
  - PID : electron@Bigbite kaon@LHRS
  - Collins and Sivers asymmetry
- **Preliminary results of Inclusive Hadron SSA**

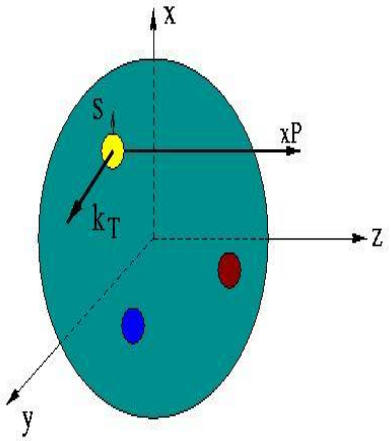
Introduction of Transversity(E06010) experiment at Jefferson Lab Hall A

- Physics motivation
- Setup of the experiment

Unified View of Nucleon Structure

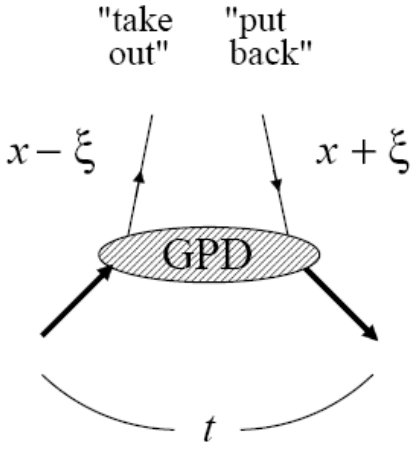
$W_p^u(x,k_T,r)$ *Wigner distributions* (X. Ji)

6D Dist.



d^3r

$d^2k_T\,dr_z$



TMD PDFs

$f_1^u(x,k_T)$, .. $h_1^u(x,k_T)$

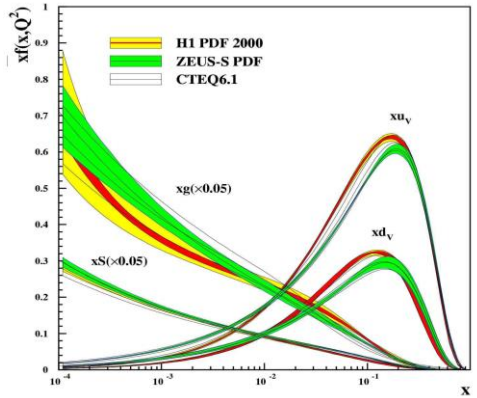
3D imaging

GPDs/IPDs

d^2k_T

d^2r_T

dx &
Fourier Transformation



PDFs

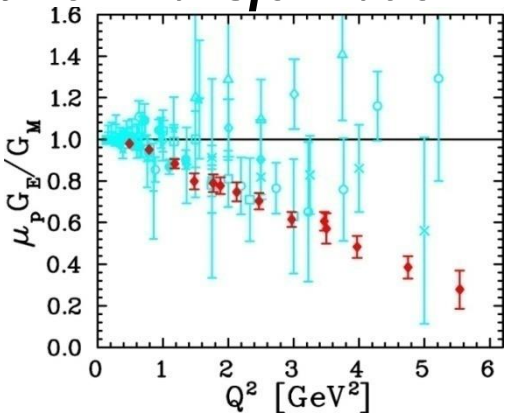
$f_1^u(x)$, .. $h_1^u(x)$

1D

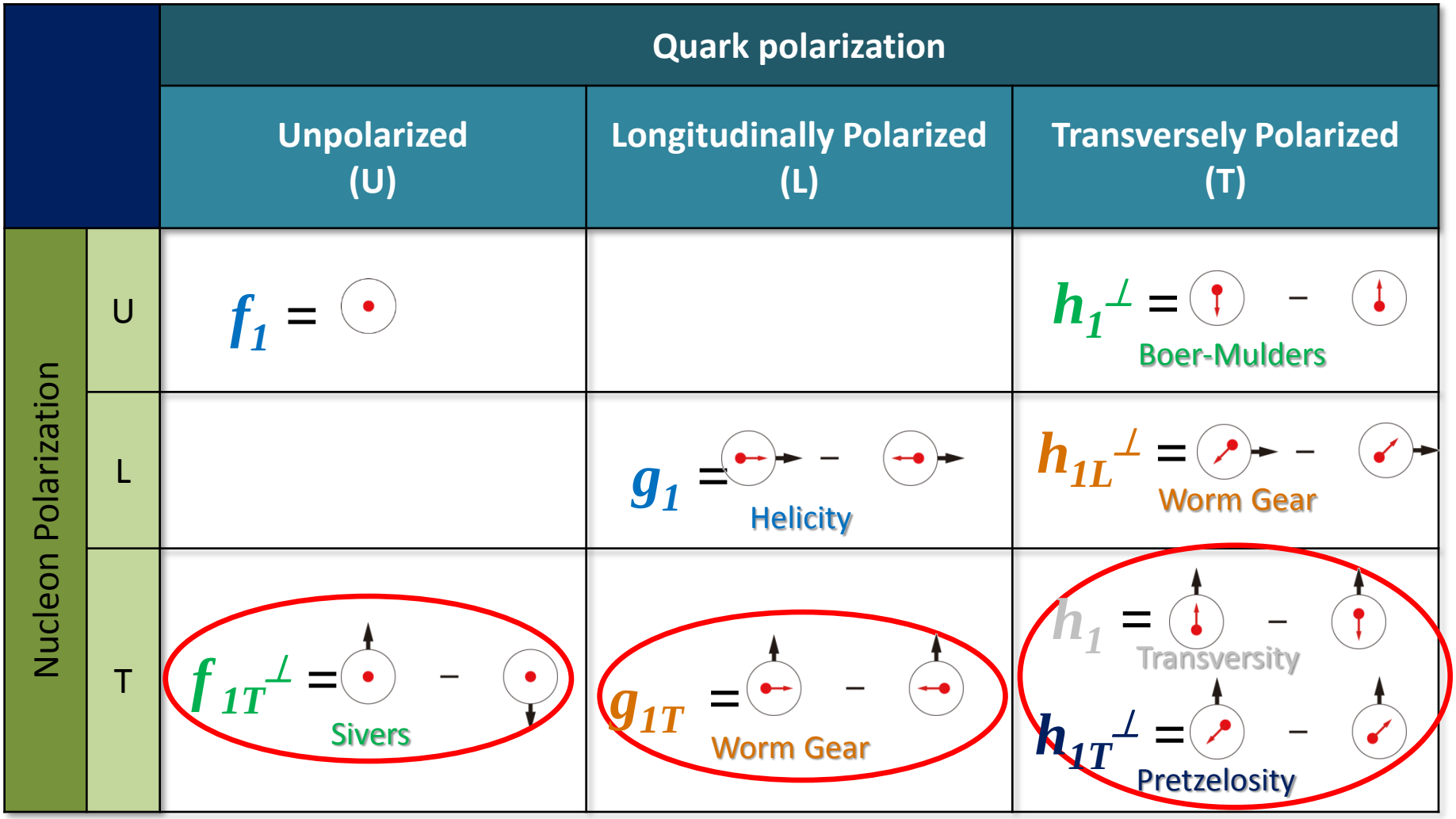
Form Factors

$G_E(Q^2)$,

$G_M(Q^2)$



Leading-Twist TMD PDFs(TMDs)



Nucleon Spin

Quark Spin

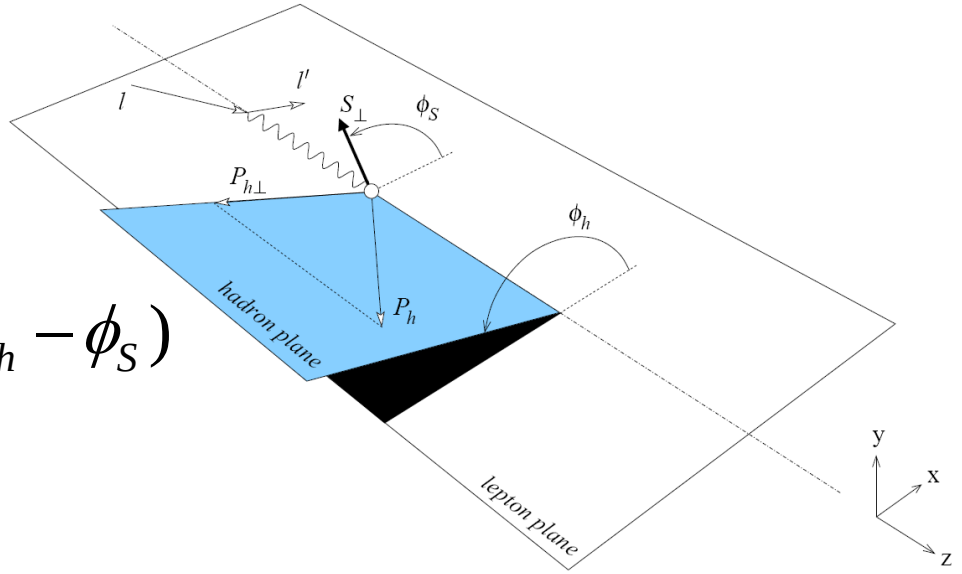
: Probed with transversely polarized target
HERMES, COMPASS, JLab E06-010

Separation of Collins, Sivers and pretzelosity effects through azimuthal angular dependence

$$A_{UT}(\varphi_h^l, \varphi_S^l) = \frac{1}{P}\frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

$$= A_{UT}^{Collins} \sin(\phi_h + \phi_S) + A_{UT}^{Sivers} \sin(\phi_h - \phi_S)$$

$$+ A_{UT}^{Pretzelosity} \sin(3\phi_h - \phi_S)$$



UT: **U**npolarized beam + **T**ransversely polarized target

$$A_{UT}^{Collins} \propto \langle \sin(\phi_h + \phi_S) \rangle_{UT} \propto h_1 \otimes H_1^{\perp}$$ →TMD: Transversity

$$A_{UT}^{Sivers} \propto \langle \sin(\phi_h - \phi_S) \rangle_{UT} \propto f_{1T}^{\perp} \otimes D_1$$ →TMD: Sivers

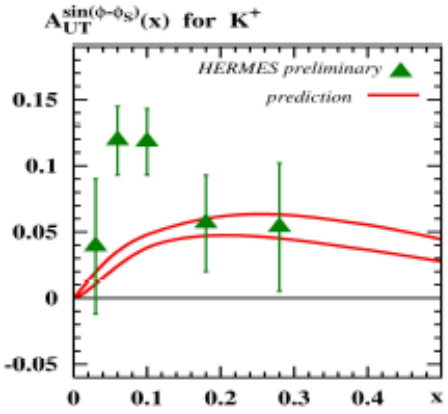
$$A_{UT}^{Pretzelosity} \propto \langle \sin(3\phi_h - \phi_S) \rangle_{UT} \propto h_{1T}^{\perp} \otimes H_1^{\perp}$$ →TMD: Prezelosity

Why kaon result is interesting I ---Sivers effect

- Only explicit kaon results from **HERMES**(preliminary, target: hydrogen, arXiv:0706.2242v2 [hep-ex] 19 Jun 2007) and **COMPASS** (preliminary, target: ^{6}LiD)
- Difference between π^+ and K^+: $\bar{d} \leftrightarrow \bar{s}$ "Sea quark effect"
- Differences in FF $D_1(z)$ for π^+ and K^+ and quark masses cancel in ratio!

→ Expectation: Kaon-SSA ≈ Pion-SSA in Sivers effect

But:



red solid line: prediction (Efremov, Goeke, Schweitzer)
data points: prelim. HERMES (Diefenthaler et al.)

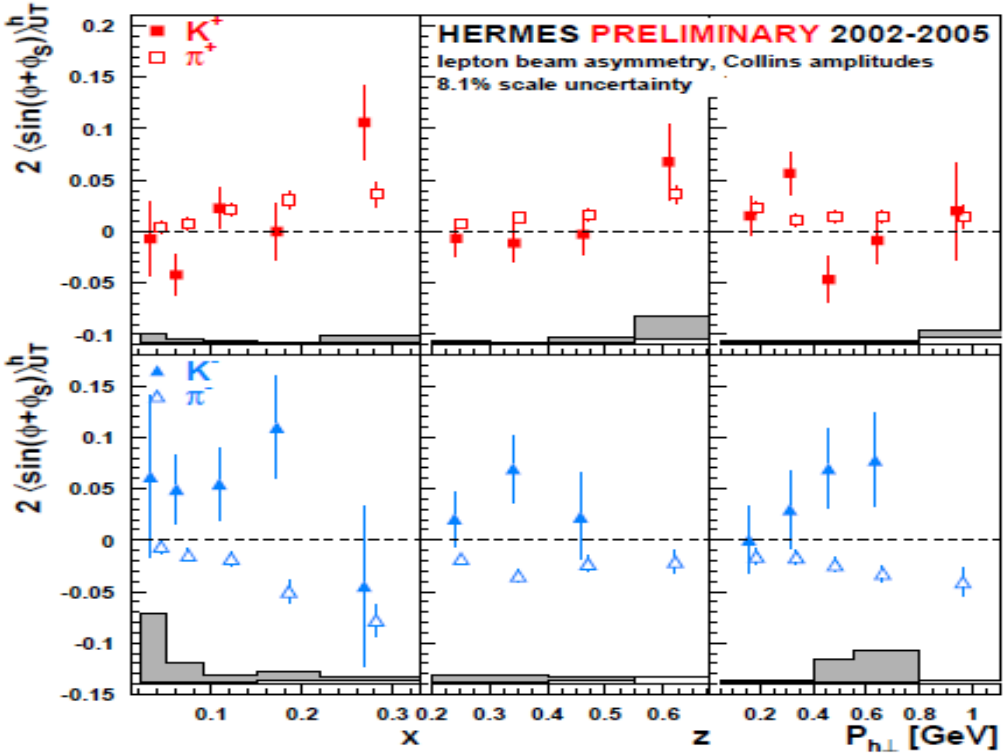
x>0.2: "sea-quark" effect small

x≈0.15: Kaon-SSA≈2 × Pion-SSA

Open question: How large can the effect of anti/Strange quarks be?

Why kaon result is interesting **II** ---Collins effect

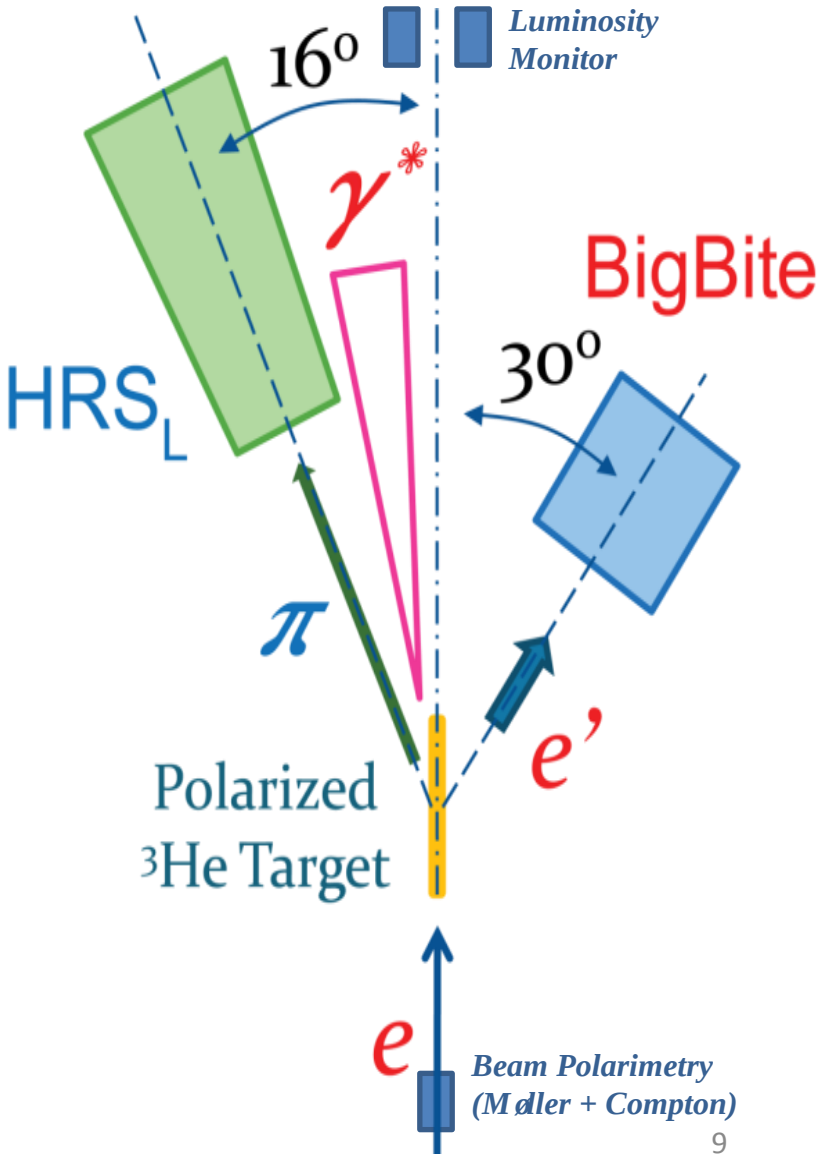
- Only explicit kaon results from HERMES(P. L. B, Target:hydrogen) and **COMPASS** (Preliminary,target: ^{6}LiD)
- From pion results: Unfavored $H_1^{\perp}$ > Favored $H_1^{\perp}$ (π^->π^+)
- From HERMES kaon results: Unfavored $H_1^{\perp}$ > Favored $H_1^{\perp}$ (k^->k^+)



E06010 Experiment Setup

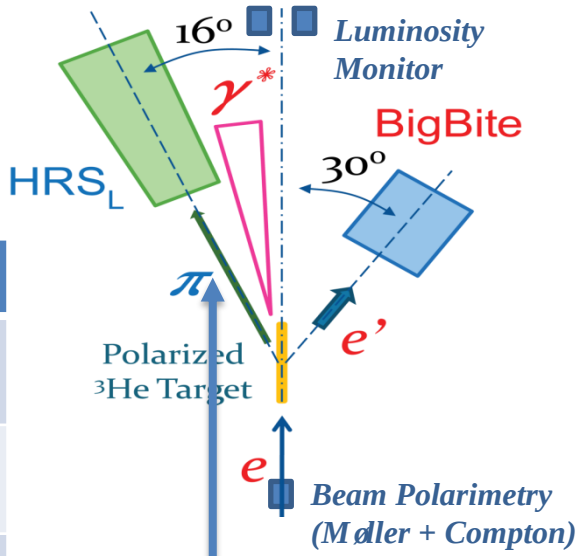
- First measurement on n (^{3}He)
  - $^3He^{\uparrow}(\vec{e}, e'\pi^{\pm})X$
  - $^3He^{\uparrow}(\vec{e}, e'K^{\pm})X$
- Transversely Polarized ^{3}He Target
  - 10 atm pressure, L(n) ~10^{36}cm^{-2}s^{-1}
  - ~60% polarization in Beam
  - Spin flips every 20 minutes

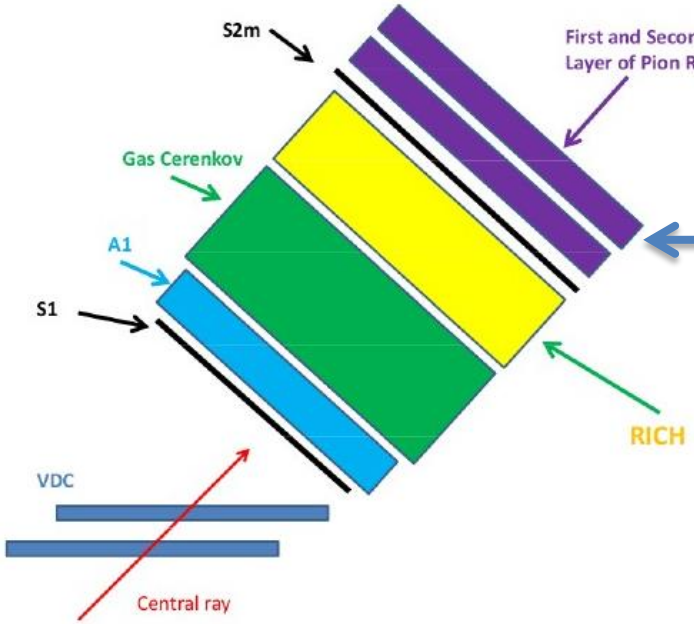
    (World Record !!!)
- Polarized Electron Beam, 5.9 GeV
  - Helicity Flips at 30Hz
- Bigbite at 30^0 as electron arm
  - P_e =0.6~2.2GeV/c
- LHRS at 16^0 as hadron arm(π/k/p)
  - P_h=2.35GeV/c
  - Excellent PID for π/k/p

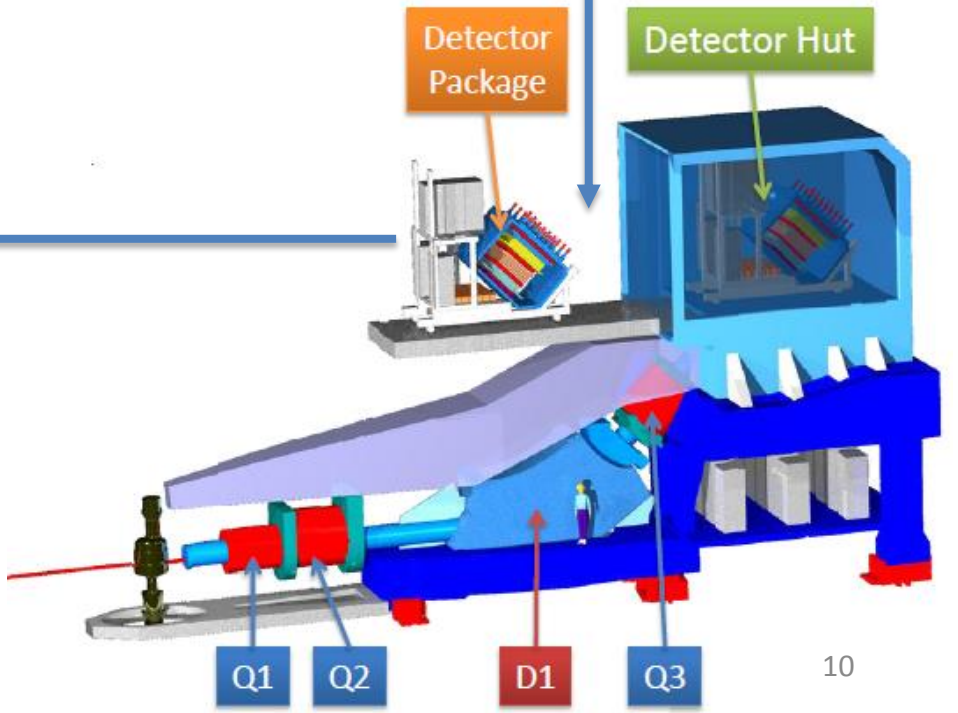


High resolution spectrometer(HRS)

(2.35GeV)	Electron	Pion	Kaon	Proton
Aerogel 1(n=1.015)	√	√	x	x
CO2 Gas Cherenkov	√	x	x	x
RICH	Large ring	Large ring	Middle ring	Small ring
Lead Glass	Large signal	Small signal	Very small	Very small

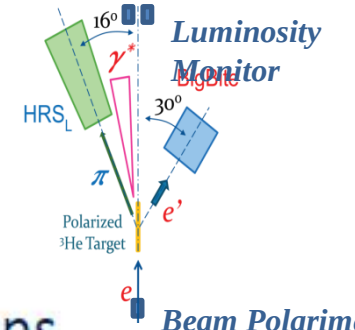


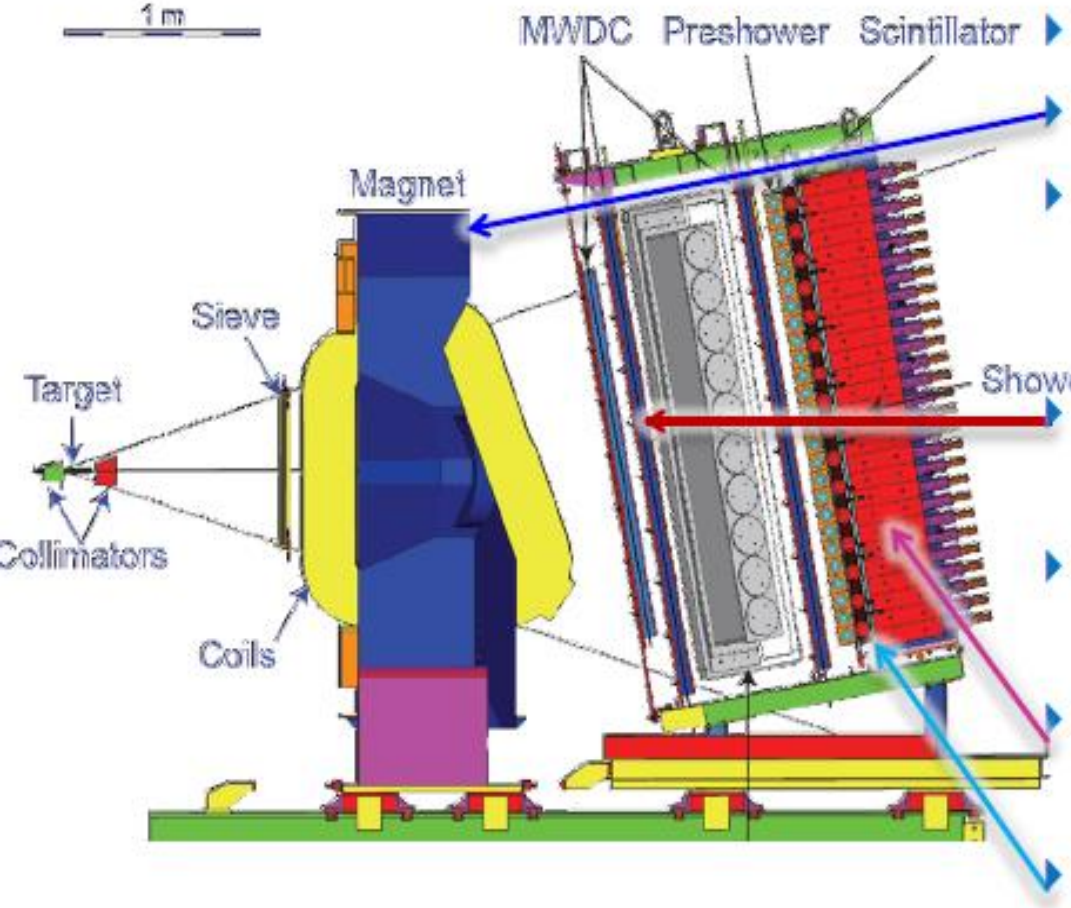




2.35GeV particles

Bigbite spectrometer





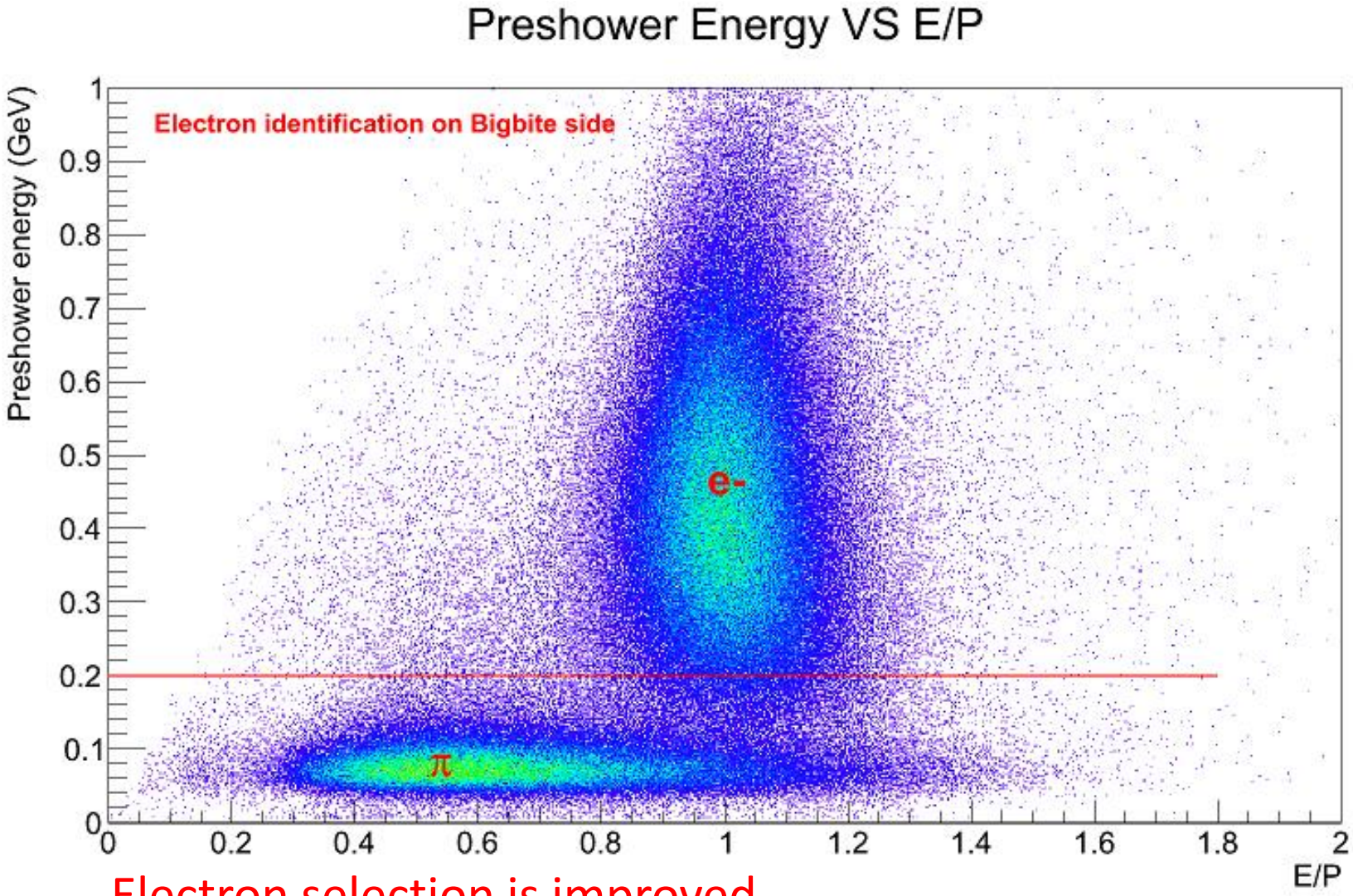
- Detects electrons
- Single dipole magnet
- A "big bite" of acceptance
  - $\Delta\Omega = 64$ msr
  - P : 0.6 ~ 2.2 GeV/c
- 3 wire chambers: 18 planes for precise tracking
- Bipolar momentum reconstruction
- Pre-shower and shower for electron PID
- Scintillator for coincidence with left HRS

Preliminary results of SIDIS Kaon SSA

- PID : electron@Bigbite kaon@LHRS
- Collins and Sivers asymmetry on ^{3}He

Analysis by Y. Zhao(USTC), Y. Wang(UIUC)

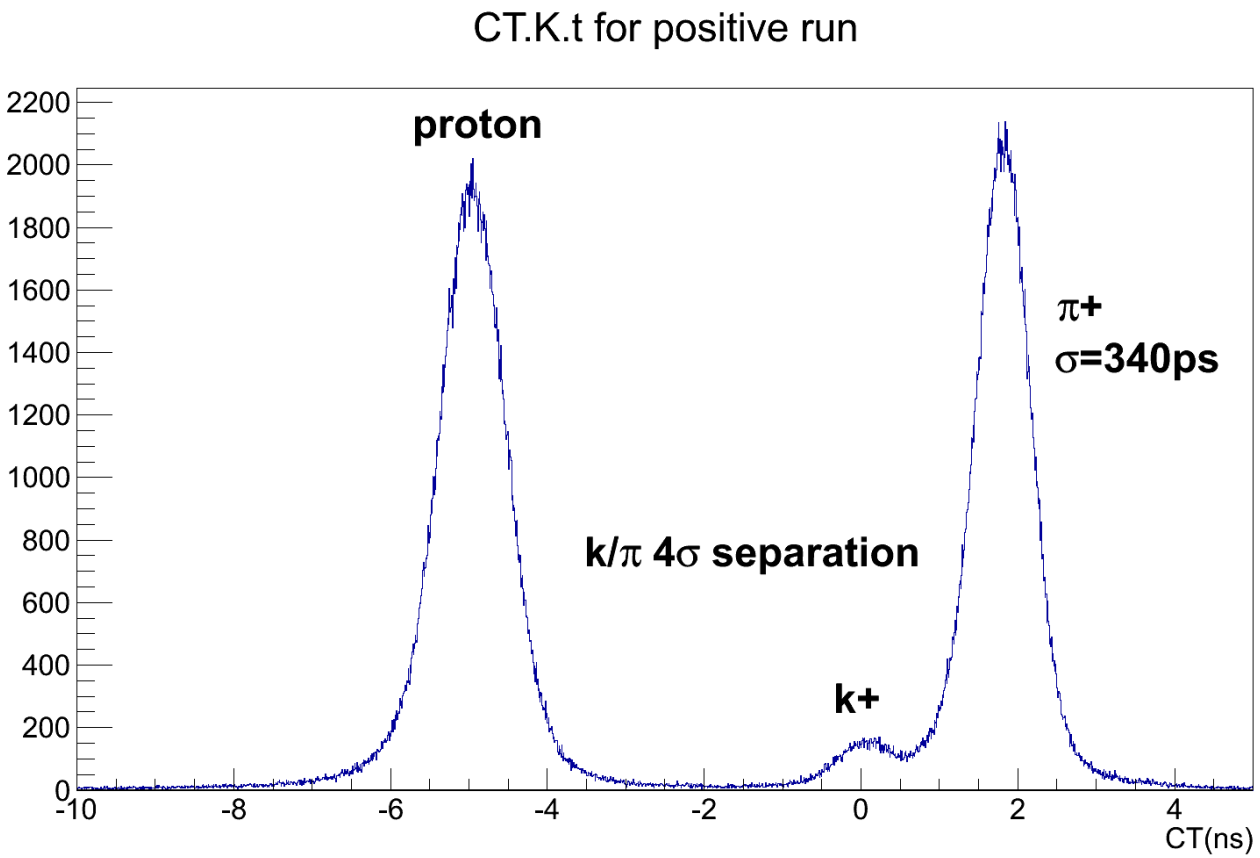
Electron(BB) PID for SIDIS



Electron selection is improved
by additional momentum dependent E/P cut

Kaon(LHRS) PID for SIDIS

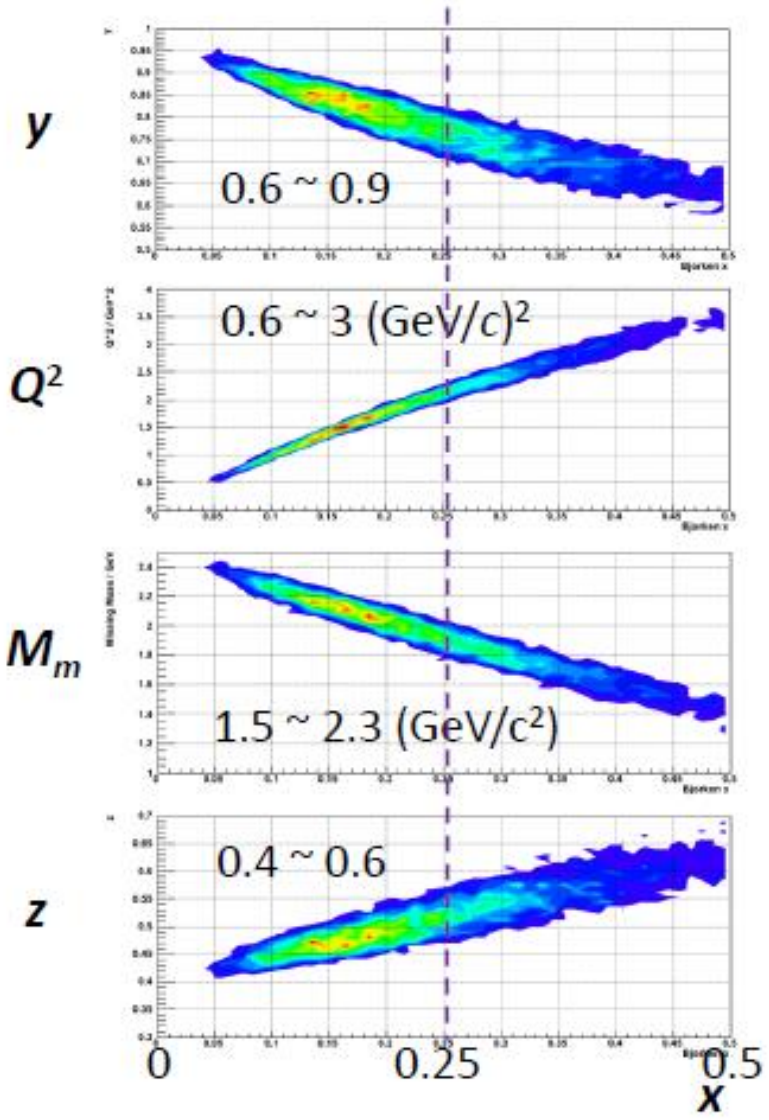
Cross checked with RICH detector

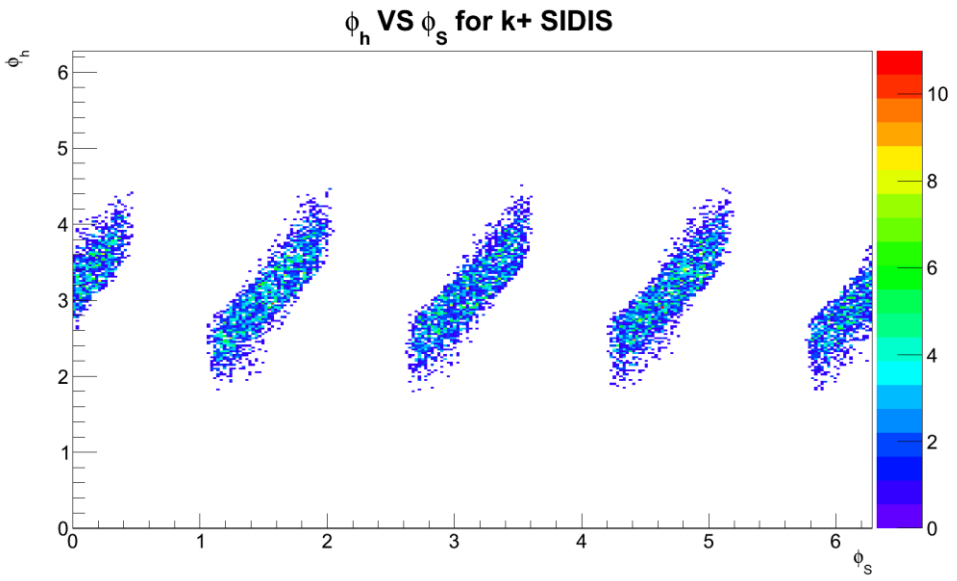


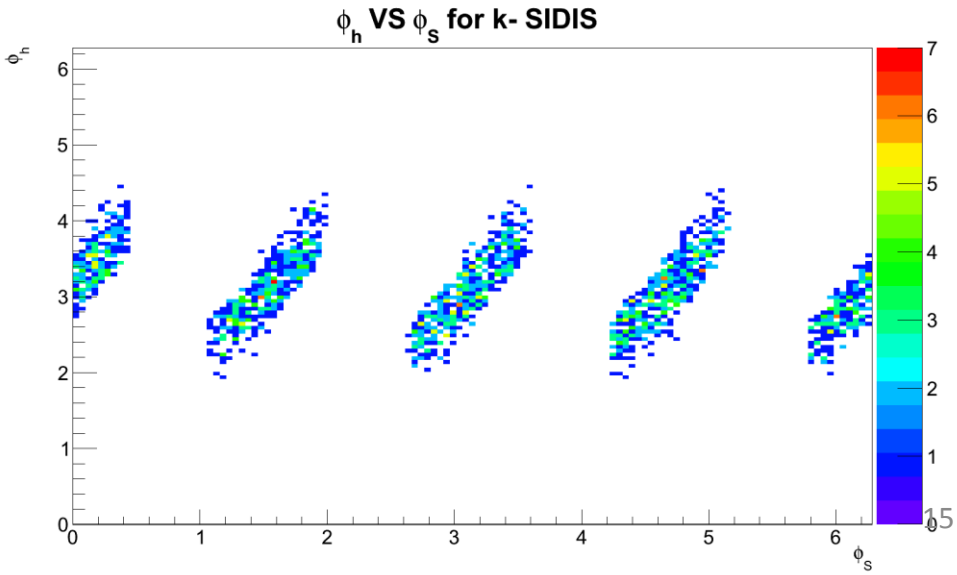
K+/π+ ratio: ~5% **K-/π- ratio: ~1%**

Pion contamination in kaon sample is suppressed by using gas Cerenkov and Aerogel detector

Kinematics for E06010 kaon SIDIS

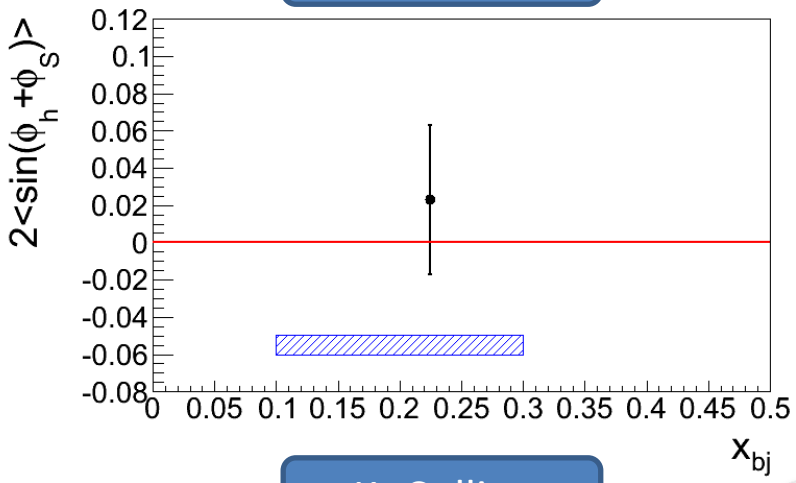




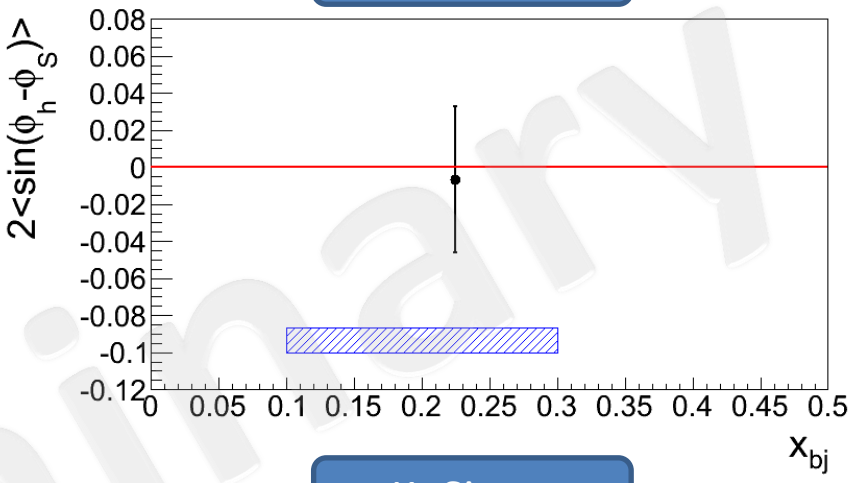


Preliminary K+/K- Collins and Sivers Asymmetries on ^{3}He

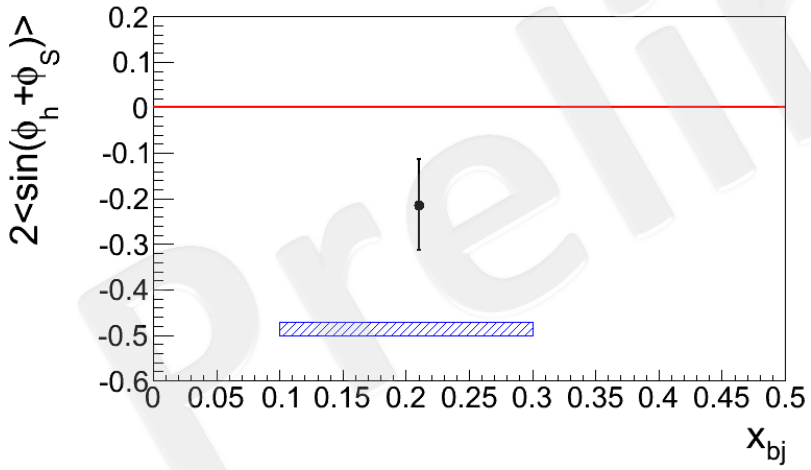
K+ Collins



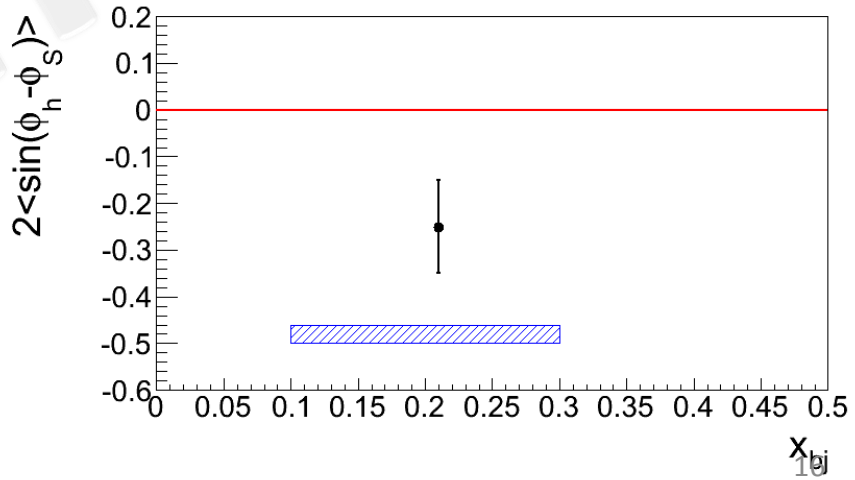
K+ Sivers



K- Collins



K- Sivers

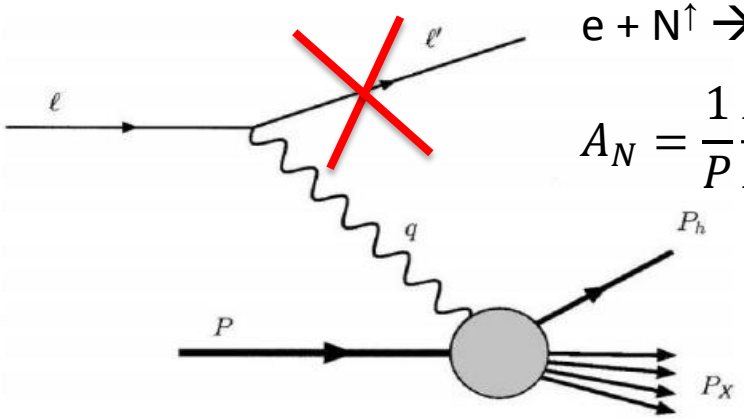


Preliminary results of Inclusive Hadron SSA

Trigger: LHRS(hadron) singles

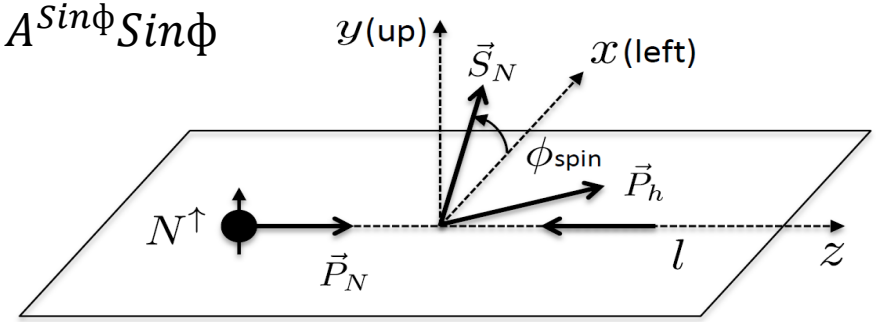
Analysis by K.Allada(JLab), Y.Zhao(USTC)

Inclusive Hadron Electroproduction



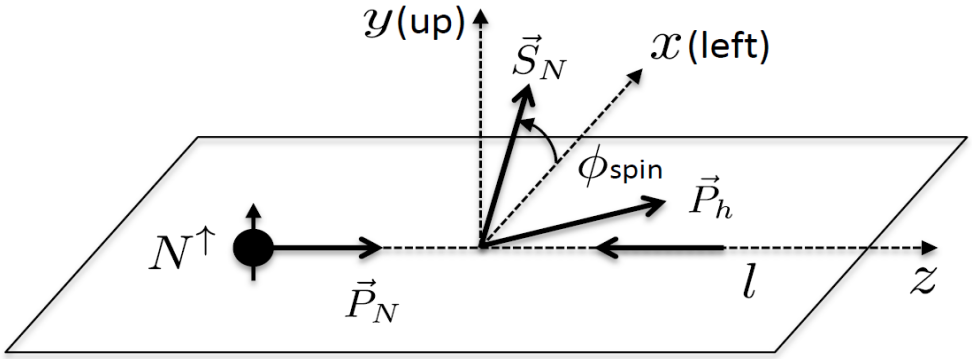
e + N↑ → h + X (h=pion ,kaon, proton)

$$A_N = \frac{1}{P}\frac{N\uparrow - N\downarrow}{N\uparrow - N\downarrow} = A^{Sin\phi} Sin\phi$$



- Driven by the large inclusive hadron SSA A_N in pp↑→hX process
- Simpler than pp↑→hX due to only one quark channel
- Mechanism for A_N:
  - TMDs
  - collinear parton dynamics(higher-twist quark-gluon correlations)
- To help understand the mechanism behind large A_N in pp↑→hX process in the TMD framework

Systematic error is well controlled

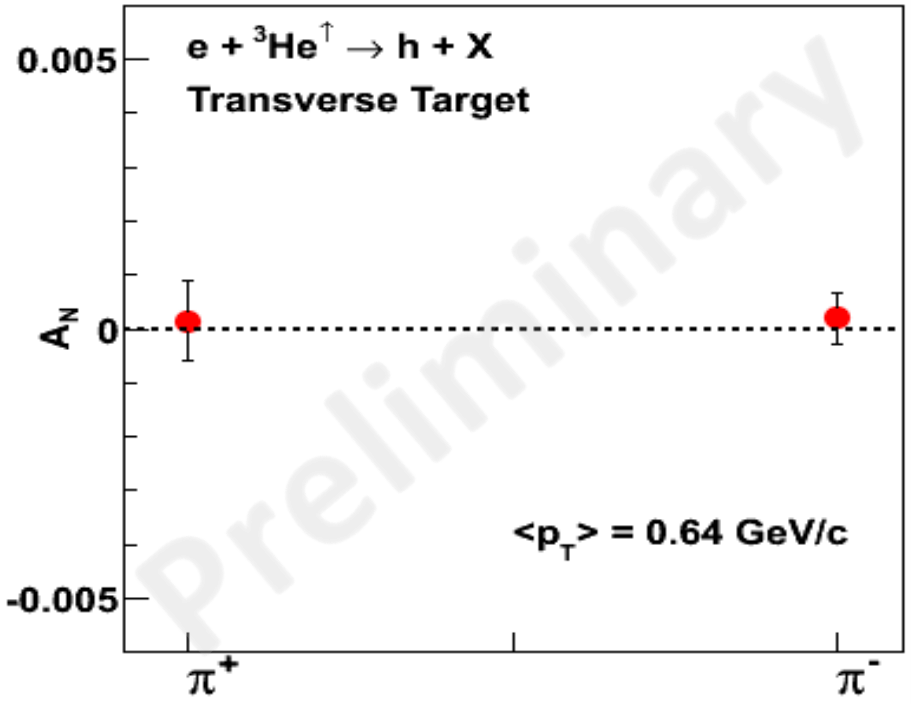


$$A_N = \frac{1}{P}\frac{N\uparrow - N\downarrow}{N\uparrow + N\downarrow} = A^{Sin\phi} Sin\phi$$

$$A_{UT}^{\sin(\varphi_S)}(\varphi_S = 0)$$

Overall systematic check with A_N at $\phi_S = 0$

→False asymmetry < 0.1%

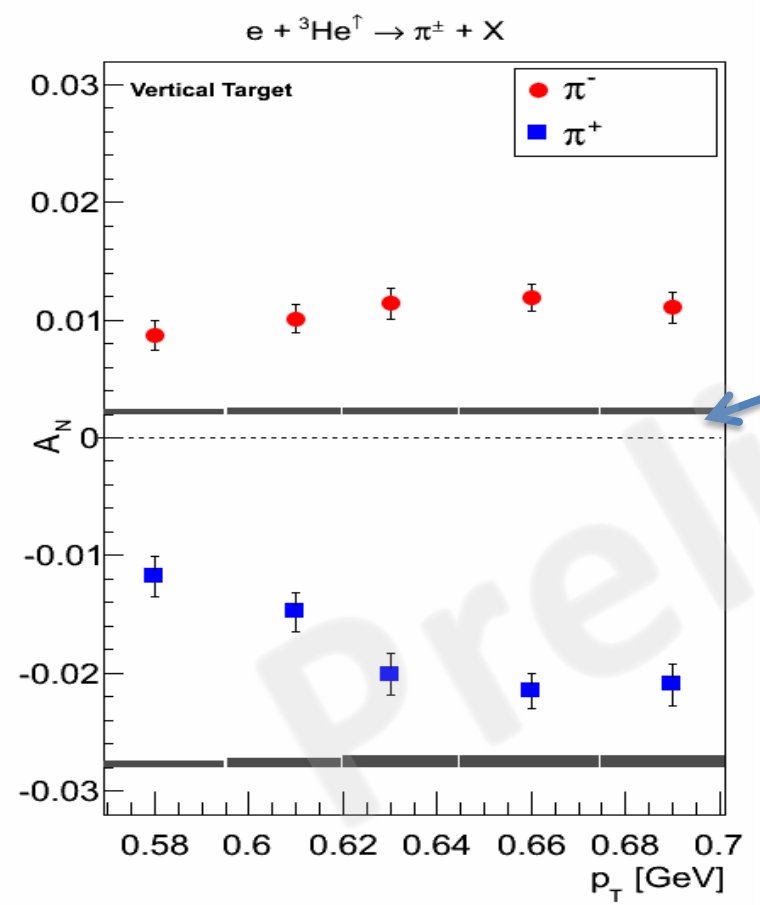


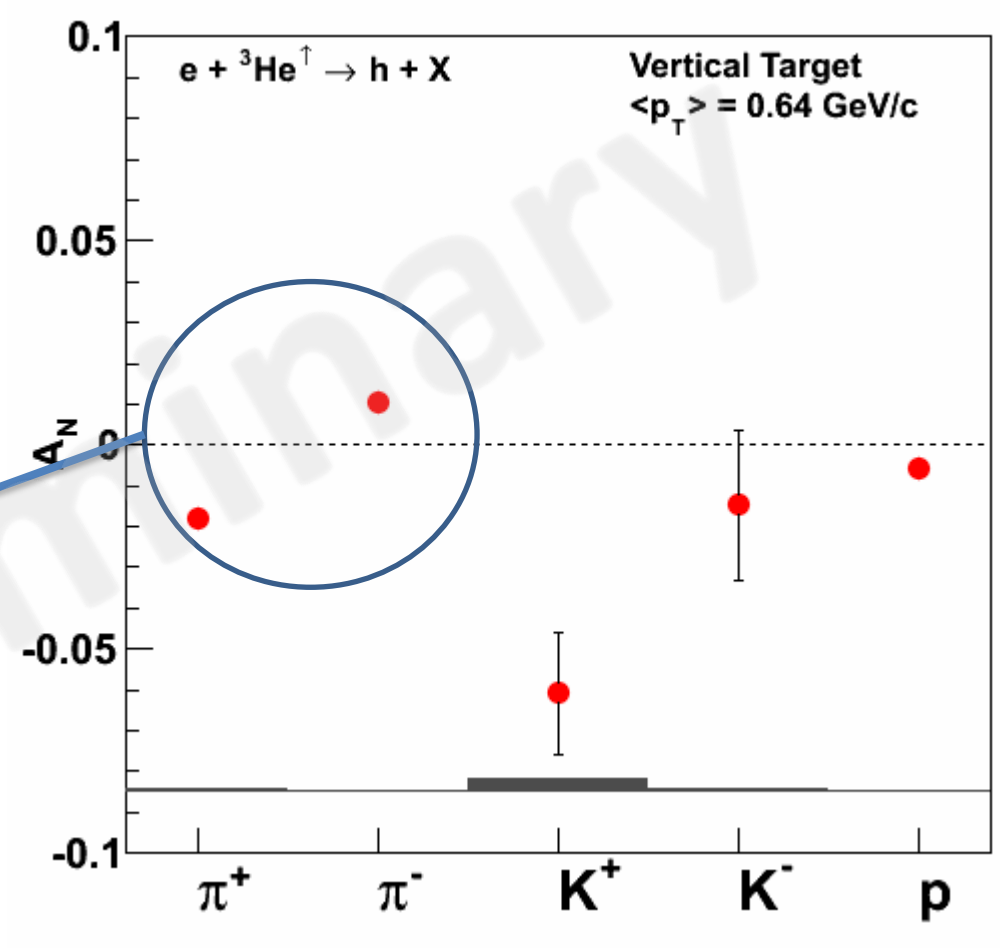
Preliminary results of inclusive hadron SSA for 3He

- For P_T ~0.64GeV/c , clear non-zero SSA is observed for π+, π-, K+, P

$$A_{UT}^{\sin(\varphi_S)}\left(\varphi_S = 90^0\right)$$

- Opposite sign for π+ ,π-





Summary

SIDIS Kaon SSA

- K+ Collins and Sivers effects are consistent with zero within error bar
- K- Collins and Sivers effects are negative

Inclusive hadron SSA

- Non-zero A_N asymmetry for π+, π-, K+, P at P_T ~0.64 GeV/c

Backup

Contamination for electron/kaon selection

- Electron sample @ Bigbite

	Pi- Contamination	Photon induced electron contamination
HRS k+	0.2%	4.9%
HRS k-	0.5%	14%

- Kaon sample @ LHRS

	Pion contamination	Random Coincidence Contamination
HRS +	1.5%	3.2%
HRS -	4.5%	0.3%