The seal of the Massachusetts Institute of Technology (MIT) is visible in the background. It features a circular design with the text "MASSACHUSETTS" at the top and "INSTITUTE OF TECHNOLOGY" at the bottom. Inside the circle, there are two figures: one on the left holding a book and a quill, and one on the right holding a book and a staff. A central shield contains the text "SCIENCE AND ARTS" and the year "1861". Below the shield is a banner with the motto "MENS ET MANUS".

Measurement of Double Spin Asymmetry A_{LT} in Semi-Inclusive Pion Electroproduction on a Transversely Polarized ^3He Target

Jin Huang
M.I.T.

For 2009 APS April Meeting
May 04, 2009 @ Denver

Experiment E06-010 in Jefferson Lab Hall A

Single Target-Spin Asymmetry in Semi-inclusive DIS

- Measuring Collins, Sivers and Pretzelosity Asymmetry
- See Yi Qiang's Talk (Q3.2)

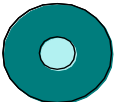
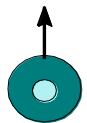
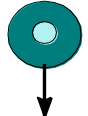
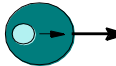
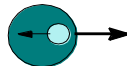
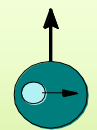
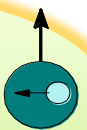

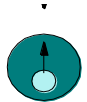

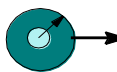
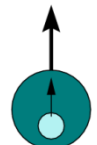
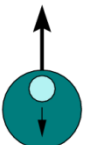
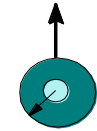
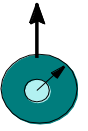
Single Target-Spin Asymmetry in Inclusive DIS

- Using Two Photon Exchange Effects to Probe GPD
- See Joe Katich's talk (Q3.6)

Double Target-Beam Spin Asymmetry in Semi-inclusive DIS

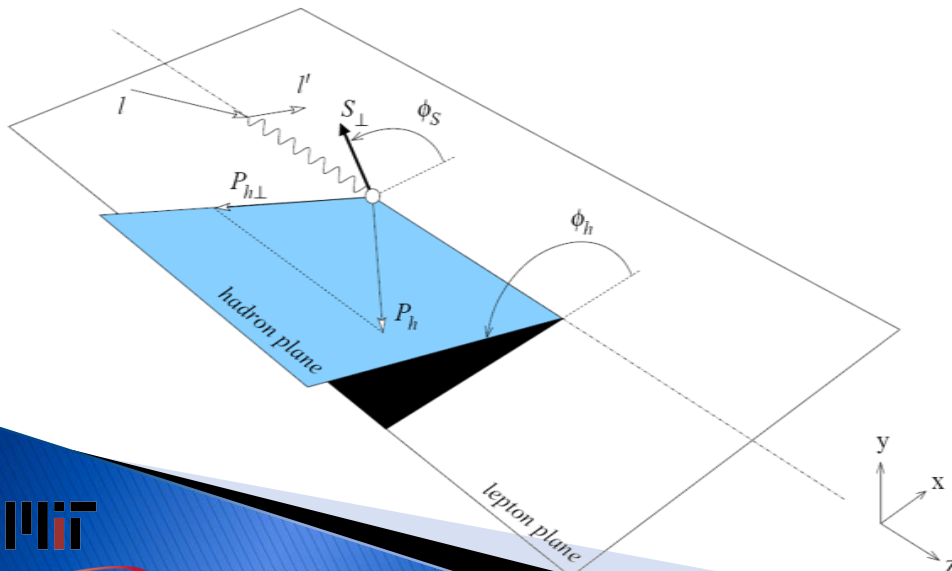
- Target-Beam Double-Spin Asymmetry, A_{LT} , in Semi-Inclusive ${}^3\text{He}^\uparrow(\vec{e}, e'\pi^\pm)X$ Reaction on a Transversely Polarized ${}^3\text{He}$ Target
- Extracting g_{1T} Distribution Function
- To Be Discussed in this talk

“Leading-Twist” TMD Quark Distributions

Nucleon Quark	Unpol.	Long.	Trans.
Unpol.	$f_1 =$ 		$f_{1T}^\perp =$  - 
Long.		$g_{1L} =$  - 	$g_{1T} =$  - 
Trans.	$h_1^\perp =$  - 	$h_{1L}^\perp =$  - 	$h_{1T} =$  -  $h_{1T}^\perp =$  - 

g_{1T} Distribution Function

- ▶ g_{1T} DF describe quark longitudinal polarization in a transversely polarized nucleon
- ▶ Such polarization can be non-vanishing only if the **Orbital Angular Momentum is non-zero**
- ▶ Extractable from Double Beam-Target spin asymmetry in SIDIS with transversely polarized target: A_{LT}



To leading twist:

$$A_{LT}^{\cos\phi_s^h} \equiv 2 \frac{\int d\phi_s^h (d\vec{\sigma} - d\vec{\sigma}') \cos\phi_s^h}{\int d\phi_s^h (d\vec{\sigma} + d\vec{\sigma}')}$$

$$\propto g_{1T}^q \otimes D_{1q}^h$$

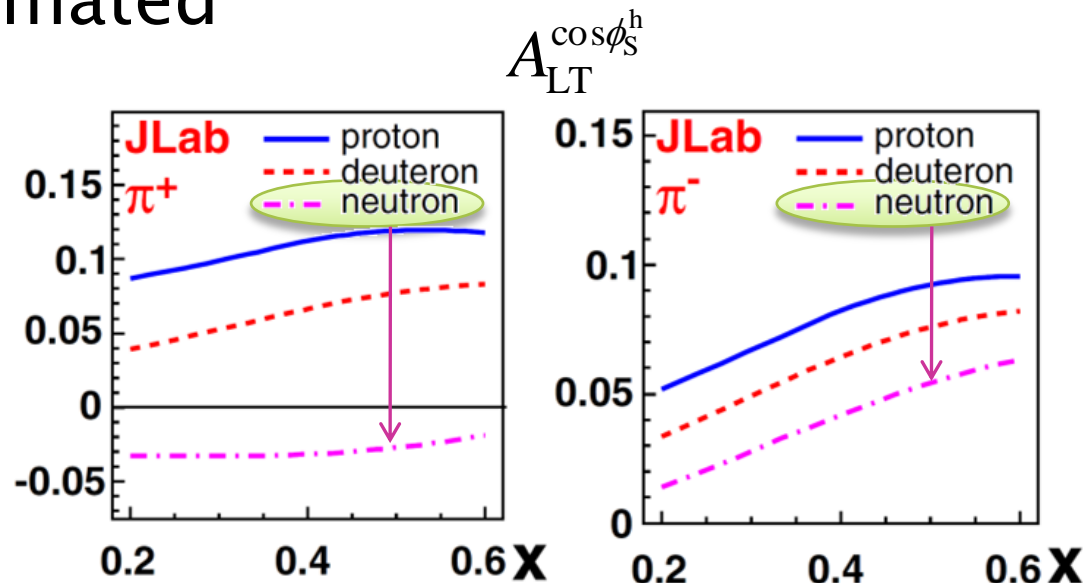
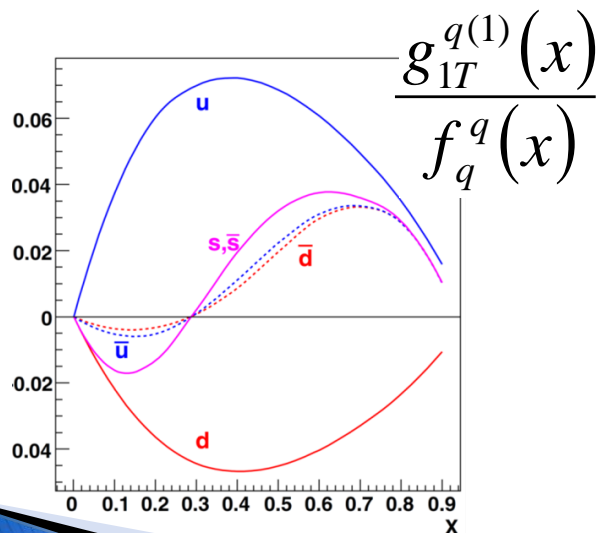
$$\phi_s^h \equiv \phi_h - \phi_s$$

One Prediction of g_{1T} and A_{LT}

- ▶ p_T weighted $g_{1T}^{q(1)}$ could be estimated from data of g_1 DF through Lorentz Invariance Relations and Wandzura and Wilczek Relations

Ref to A. Kotzinian and P. J. Mulders, Phys. Rev. D 54, 1229 (1996)

- ▶ With assumption of p_T dependence, then A_{LT} could also be estimated

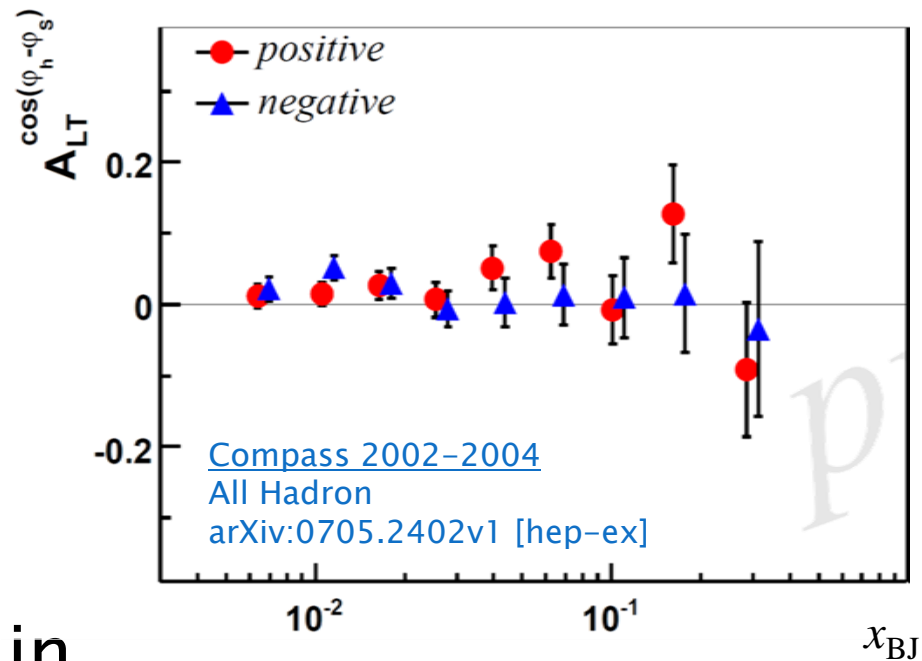


From A. Kotzinian, B. Parsamyan, and A. Prokudin, Physical Review D 73 114017 (2006)

Existing Data

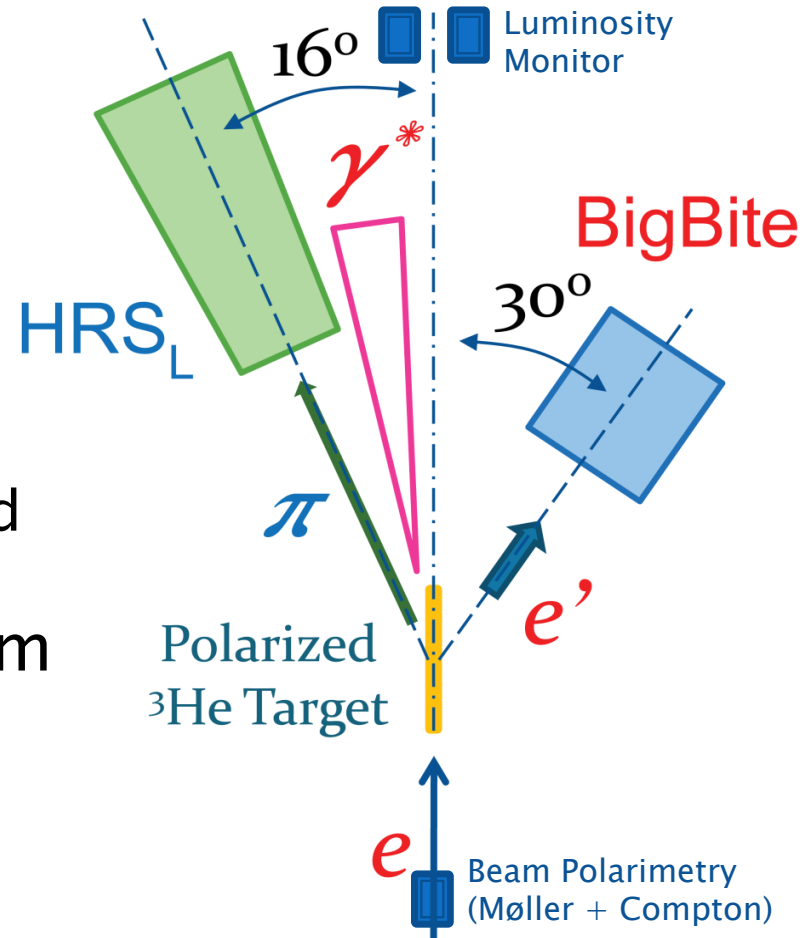
- ▶ No SIDIS A_{LT} Measurement until recent years
- ▶ Compass
 - A_{LT} on Deuteron (p+n)
 - Base on 2002–2004 runs
- ▶ Hermes could also measure A_{LT} on Proton Target
- ▶ Possible measurement in Drell–Yan Process

Zhun Lu, etc. PRD 75, 094012 (2007)

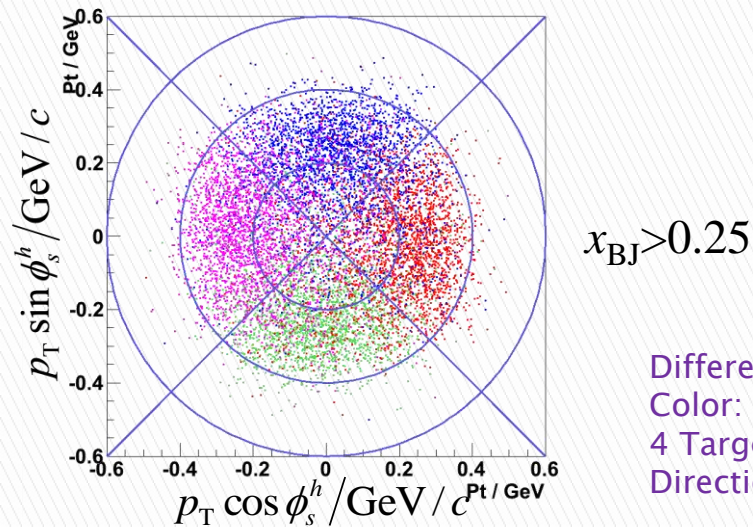
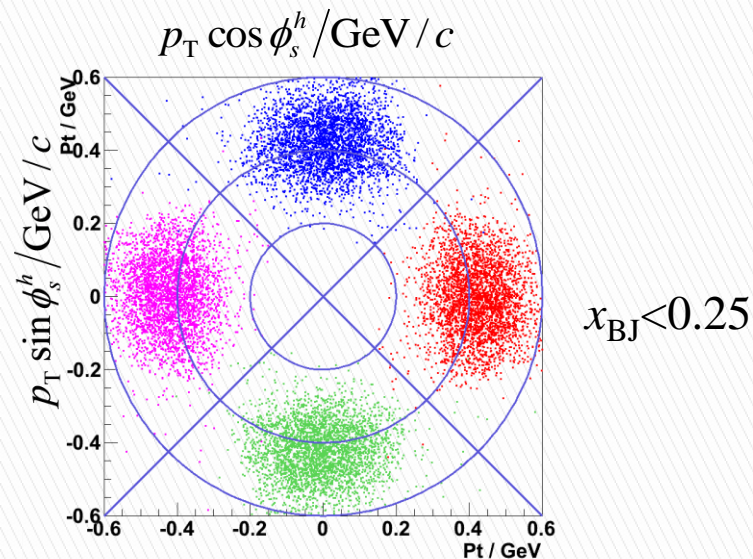
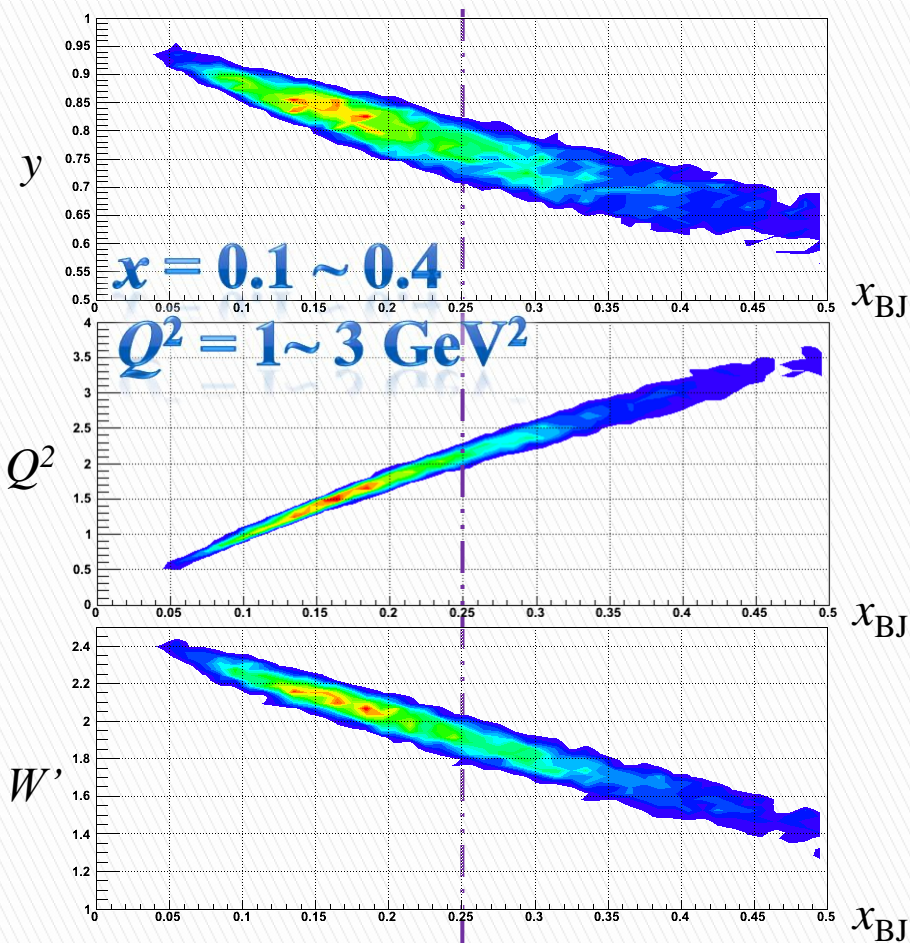


E06-010 Experiment Setup and Preliminary Performance

- ▶ Polarized ^3He Target
 - 10 atm pressure; $L(n) \sim 10^{36}\text{cm}^{-2}\text{s}^{-1}$
 - Record* High 65% Pol. In Beam
- ▶ Polarized Electron Beam
 - ~80% Polarization
 - **Fast Flipping at 30Hz**
 - **PPM** Level Charge Asymmetry controlled by online charge feed back
- ▶ BigBite at 30° as Electron Arm
 - See Kalyan Allada's talk
- ▶ HRS_L at 16° as Hadron Arm
 - $P \sim 2.35$ GeV
 - Tracking/Timing/PID detectors



Data Coverage



Different
 Color:
 4 Target Pol.
 Direction

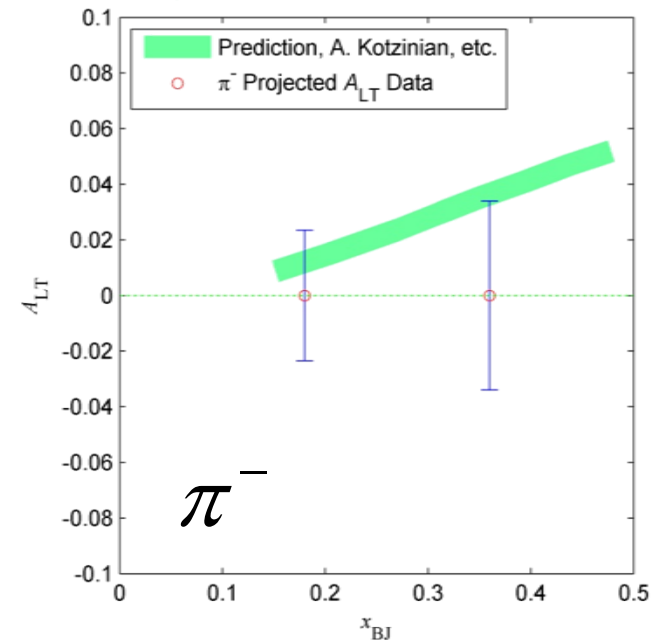
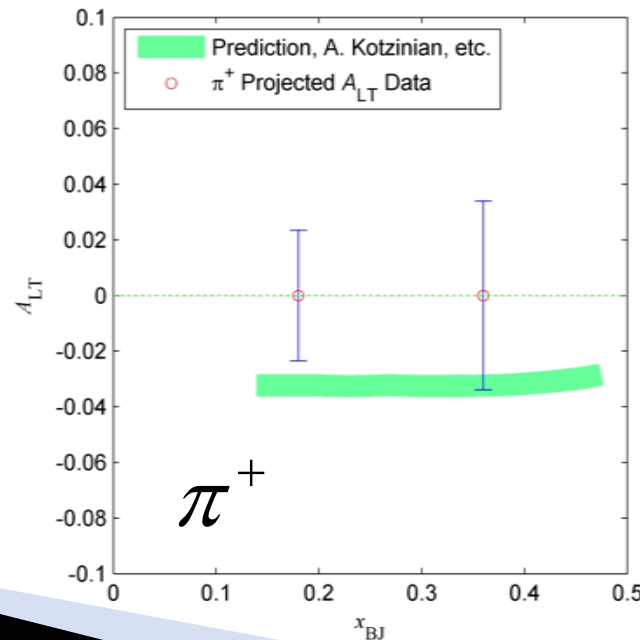
Kinematics Coverage

p_t & $\phi_h - \phi_s$ Coverage

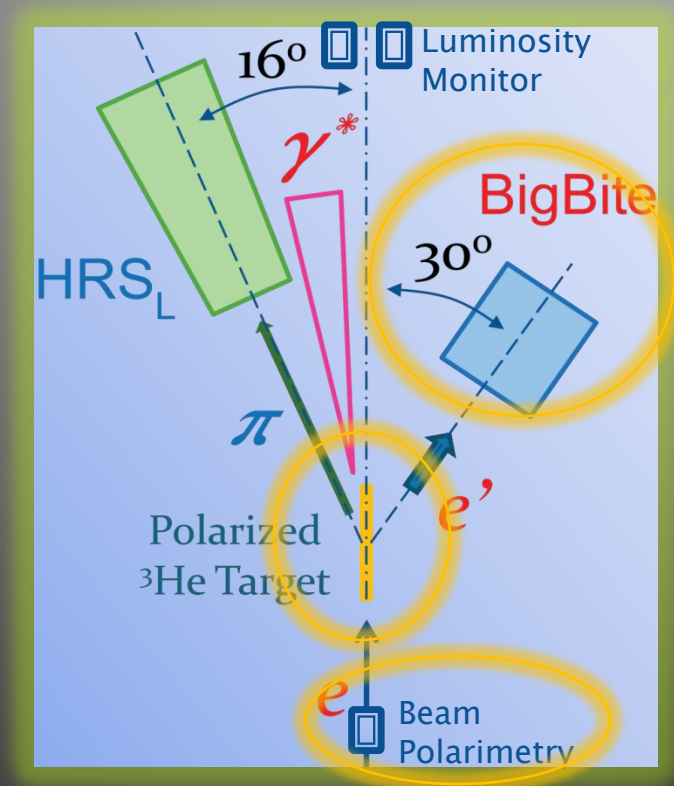
Data Projections

- ▶ First Neutron (^3He) Measurement
- ▶ With Fast Beam Helicity Flip (30Hz)
- ▶ Projected Uncertainties (Stat. Only):
 - 2.3% at low x
 - 3.4% at high x

Theory Estimation by A. Kotzinian, etc. Physical Review D 73 114017 (2006)

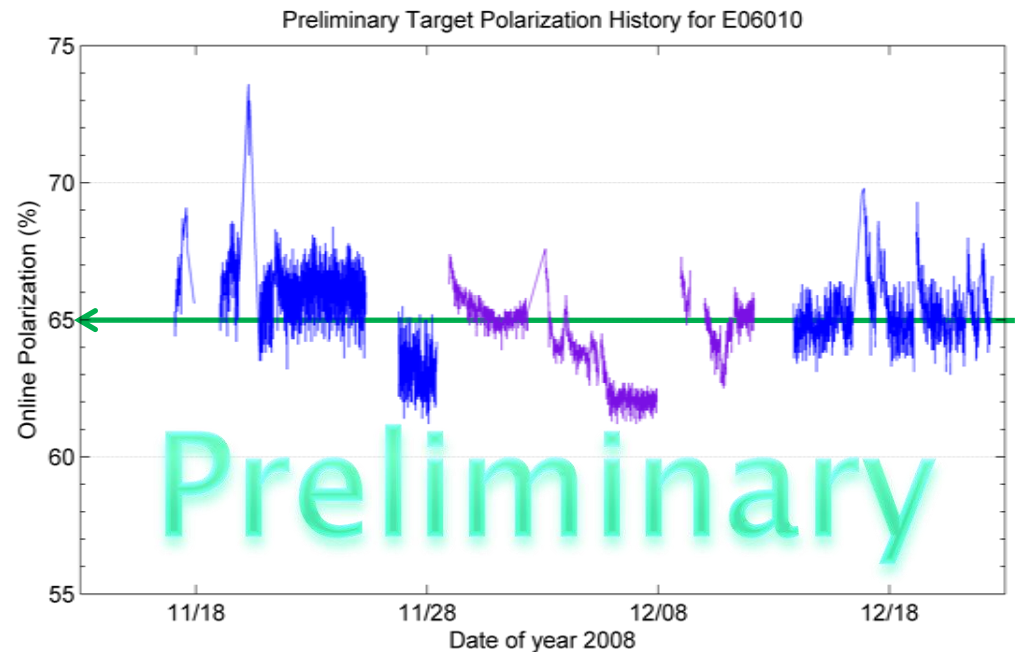
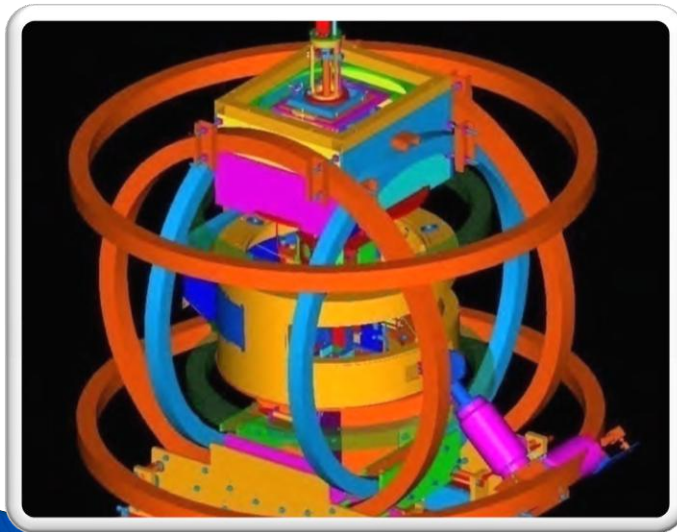
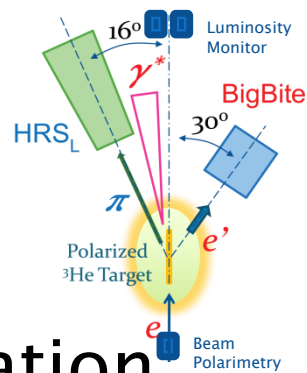


Samples of Analysis Progress

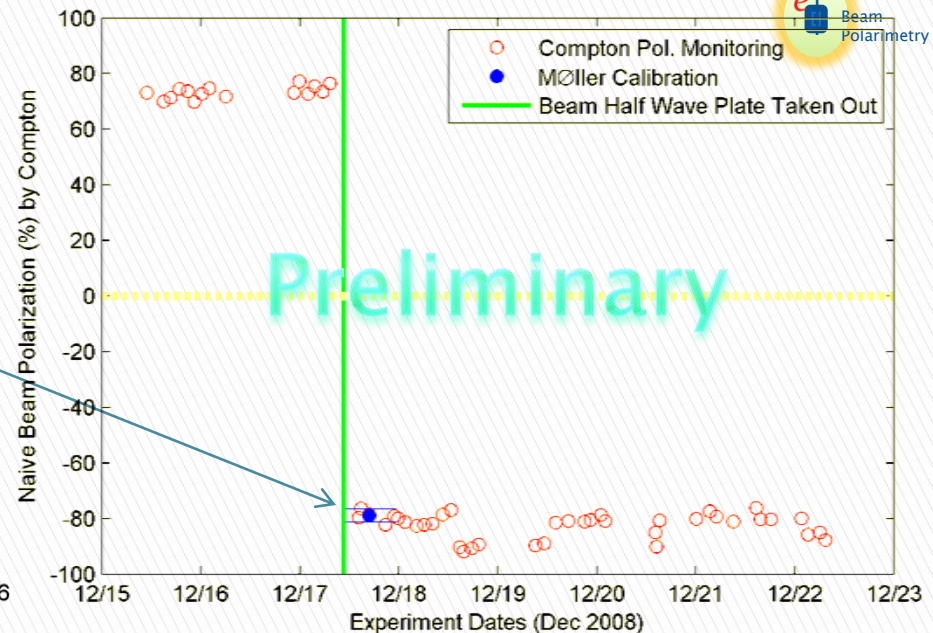
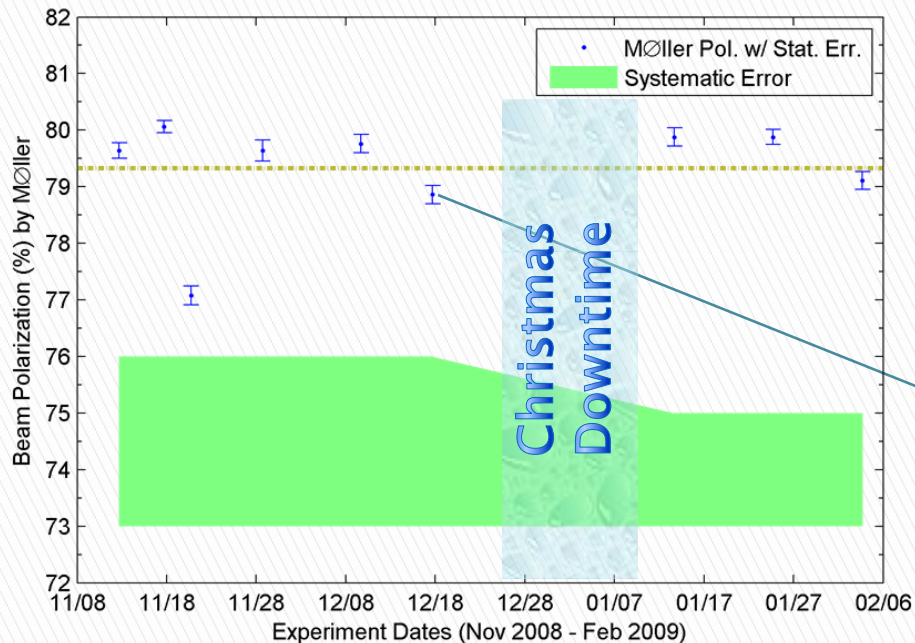
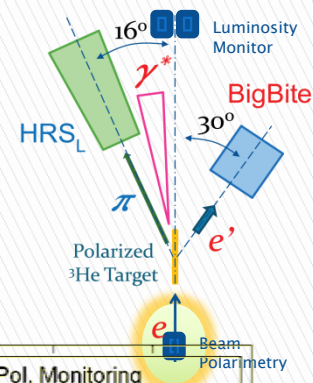


Analysis Progress Sample I/ Polarized ^3He Target

- ▶ Cell characterization & pol. cross Calibration underway; Preliminary Pol. $\sim 65\%$
- ▶ 20min / spin flip provide pol. monitoring
- ▶ See C. Dutta Talk for details



Analysis Progress Sample II/ Beam Polarization



- ▶ High Precision Møller Polarimetry \rightarrow $\sim 80\%$
- ▶ Performed every 1–2 weeks

- ▶ Polarization Mentoring
- ▶ Calibrated by Møller
- ▶ Under Upgrading Work

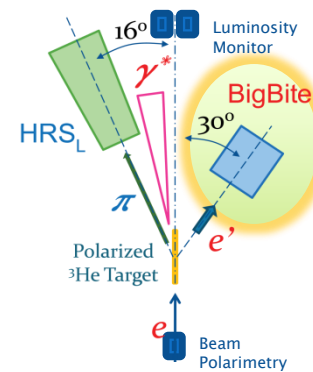
Møller Polarimetry

<http://www.jlab.org/~moller/e06-010.html>

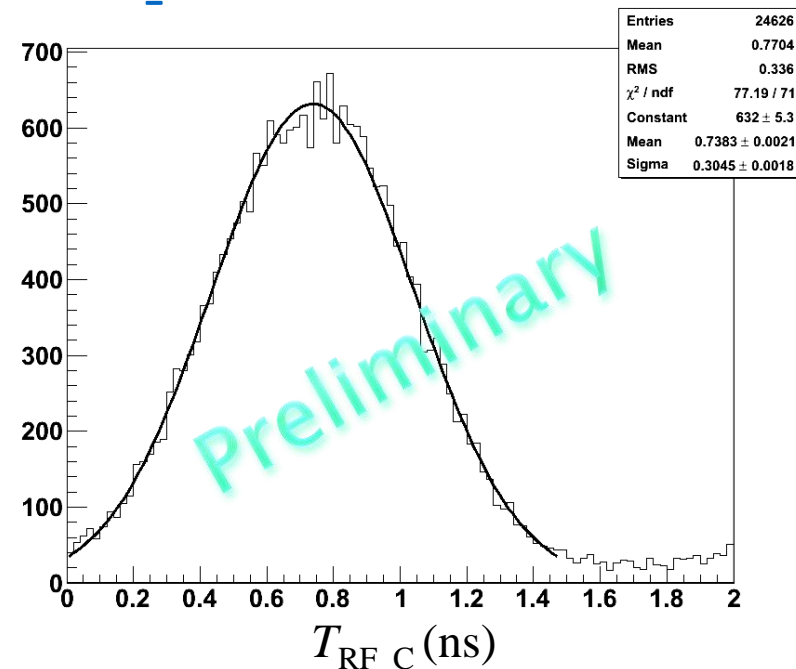
Compton Polarimetry

Analysis Progress Sample III/ BigBite Spectrometer Timing

- ▶ Scintillator plane in BigBite Spectrometer provides timing information
- ▶ BigBite Spectrometer timing resolution $\sim 300\text{ps}$
- ▶ Promising $K-\pi$ separation, combined with Timing information from Hadron Arm (as redundant approach to hadron arm PID)
- ▶ Possible to measure Kaon A_{LT} too



Reconstructed Beam Bunch Time $\delta T_{RF_C} \approx 300\text{ps}$



Conclusion

- ▶ **First measurement** of neutron A_{LT} from polarized ^3He Target
- ▶ Systematic uncertainties is improved by **Fast Beam Helicity Flip**
- ▶ Data will cover **valence range**
- ▶ Absolute uncertainty is **2%~3%**.
- ▶ Promising **Kaon A_{LT}** Data
- ▶ Preliminary result coming soon!
Please stay tuned
- ▶ **Precision 3D mapping** possible after Jefferson lab 12GeV upgrade