A Program of Spin-Dependent Electron Scattering from a Polarized ^{3}He Target in CLAS12

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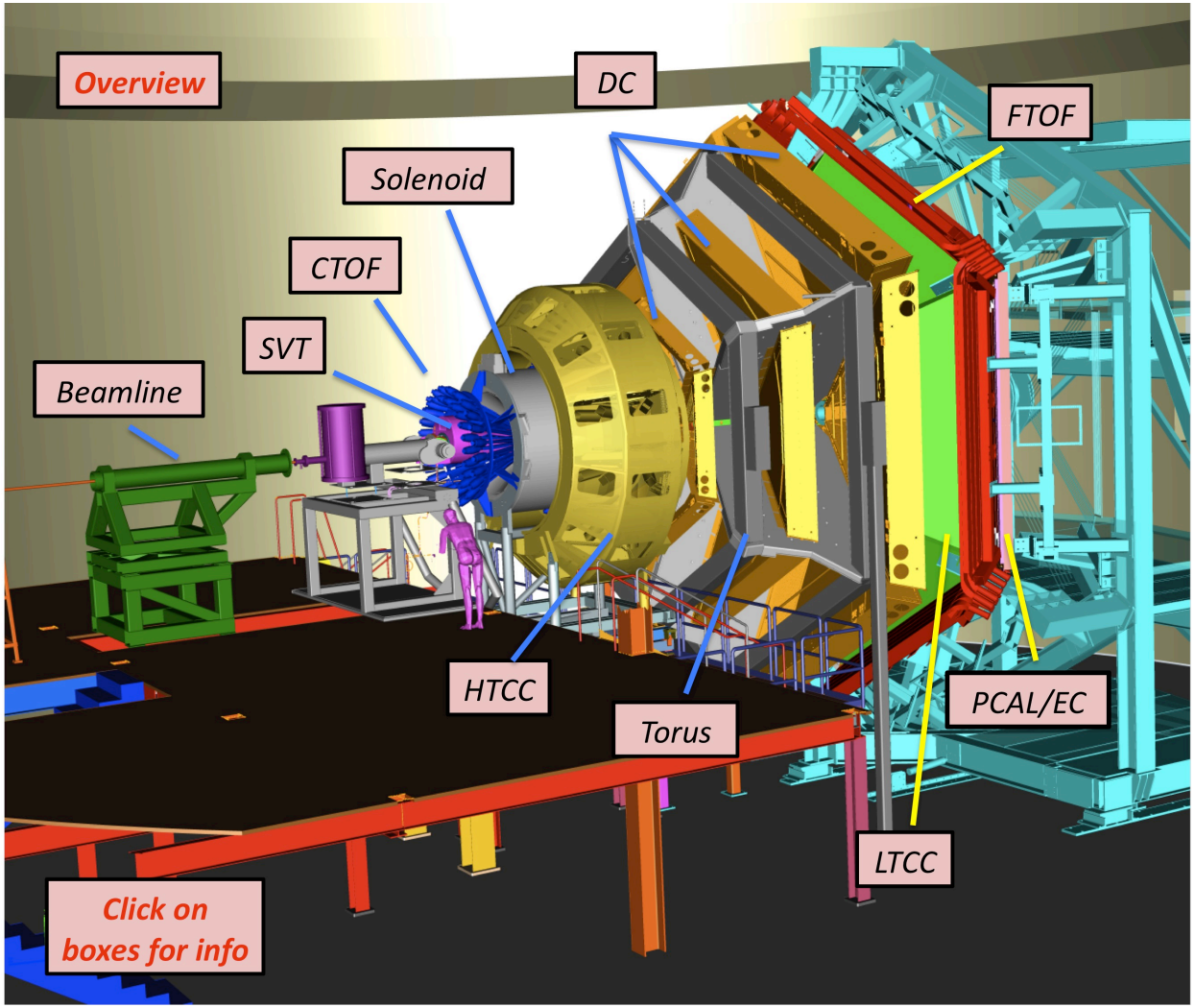
Abstract

We propose a program of spin-dependent electron scattering using a polarized electron beam of intensity 2 μA at an energy of 10.6 GeV incident on a polarized ^{3}He gas target taking data at a luminosity of 3×10^{34} ^{3}He/cm^2/s located within the central solenoid of the CLAS12 spectrometer in Hall B. In this initial proposal, we request 60 days of beamtime to carry out precision measurements of spin-dependent inclusive and semi-inclusive DIS ($\pi^\pm$ and K$^\pm$) directly from a longitudinally polarized neutron over a large kinematic range: $0.05 < x < 0.8$, $1 < Q^2 < 6$ (GeV/c)^2, $0.2 < z < 0.9$, $0 < p_T < 1$ GeV/c with the purpose of extracting the flavor dependence of the quark polarizations and, in particular, determining their transverse momentum dependence.

Locate Polarized ^{3}He Gas Target in CLAS12 Central Solenoid



Running Assumptions

- Incident electron beam
  - energy = 10.6 GeV
  - intensity = 2 μA (upgrade beam dump)
  - polarization = 80%
- Target – see talk by James Maxwell
  - thickness = 3 x 10^{21} /cm^2/s
  - polarization = 50%
- Luminosity: 4.5 x 10^{34} ^{3}He/cm^2/s
- 30 days continuous, 100% efficient data taking

Physics Overview

- DIS and SIDIS, long. polarized target
  - extract $\Delta u_V(p_T)$, $\Delta d_V(p_T)$ and sea polarization using neutron and proton for the first time
- Di-hadron SIDIS
- SIDIS, transversely polarized target
  - transverse structure of neutron
- Deeply Virtual Exclusive Processes
  - transverse structure of neutron
- Tagged DIS (spectator proton, deuteron) BONUS, ALERT
  - spin-dependent EMC effect in calculable nucleus
- Quasielastic Spin-Dependent Scattering
  - comprehensive study of the spin structure of the ^{3}He ground state

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Dien Thi Nguyen
Harut Avakian

Simulation

Dien Nguyen
Harut Avakian

- CLASDIS generator was used

  - To generate the SIDIS event, the LUND STRING cross section model was used
  - The generated event was passed to the full GEMC
  - Care was taken to include acceptance and reconstruction (inbending)
  - Using the reconstructed event, the rate was estimated
  - The simulation was run on the proton and neutron and the yields then combined as $2p + n$ to obtain the ^3He rate estimation.

- The simulation was run with different helicities

  - Run Proton (+/-) and Neutron(+/-)
  - These files are used to extracted A_1^n

- The extracted asymmetry uncertainties are corrected for dilution and P_t and P_b.

- Simulation events of order 2M.

Large Number of Events

Dien Nguyen
Harut Avakian

Apply general DIS cuts: $Q^2>1$ and $W^2>4$

(e,e’)	~4000 M
(e,e’π-)	~1200 M
(e,e’π+)	~2300 M
(e,e’K-)	~60 M
(e,e'K+)	~295 M

If we also require z>0.3

(e,e’π-)	~ 238 M
(e,e’π+)	~ 650 M
(e,e'K-)	~ 25 M
(e,e'K+)	~ 175 M

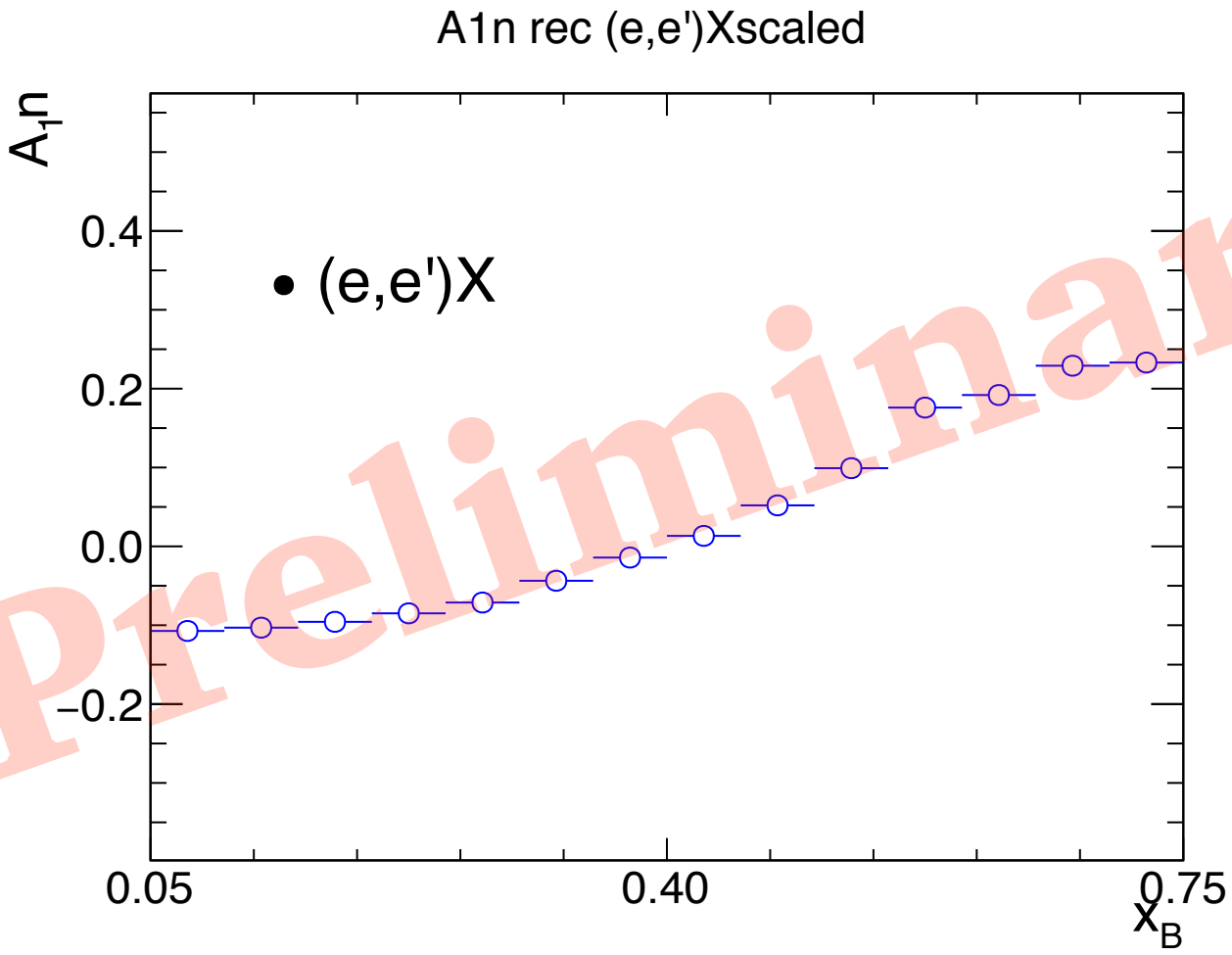
Unprecedented precision!

SLAC E-142	**300 M**
SLAC E-154	**100 M**
HERMES	**3 M**
COMPASS 2011	**77 M**

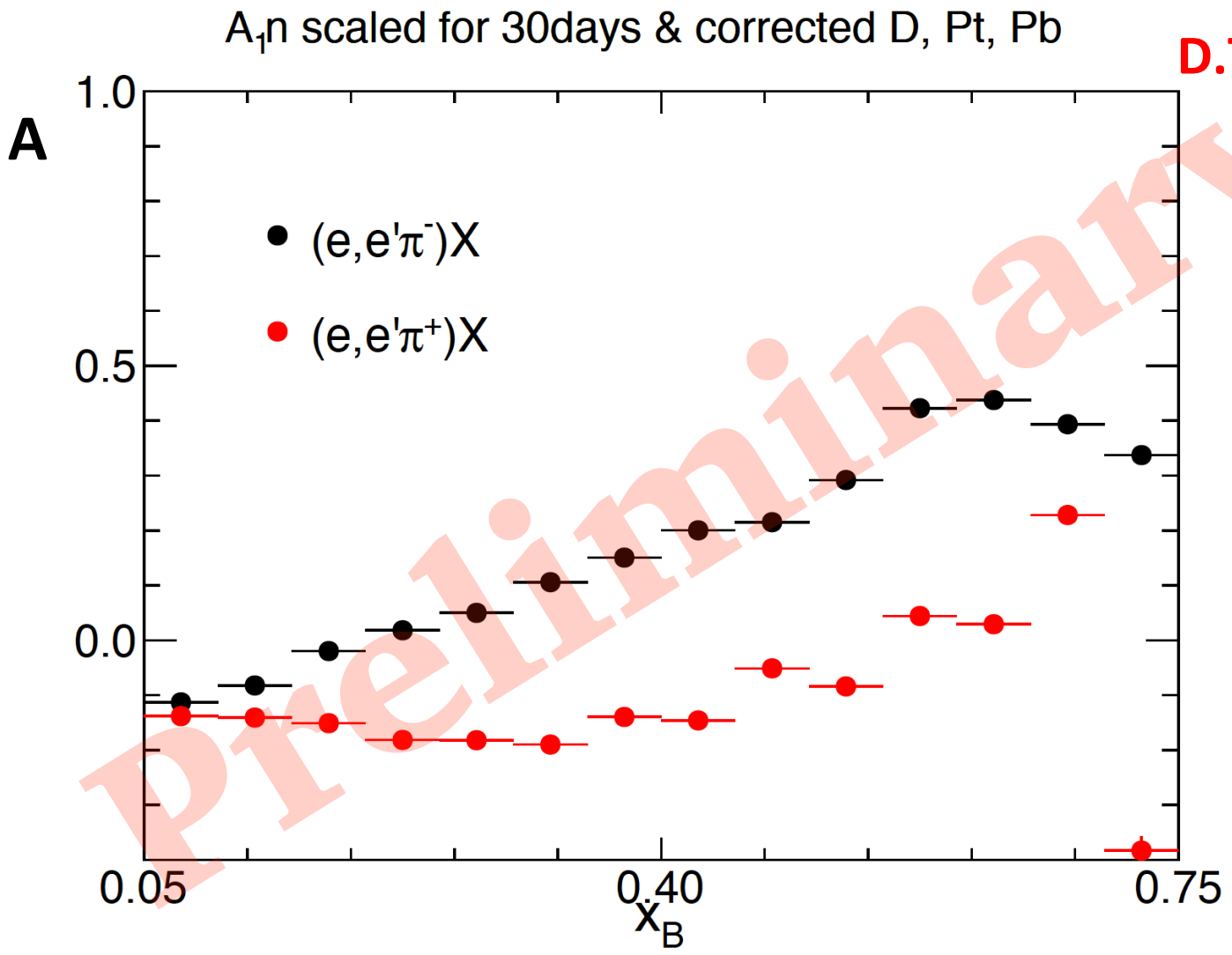
With SIDIS over a large kinematic range

Inclusive Asymmetry A_1^n

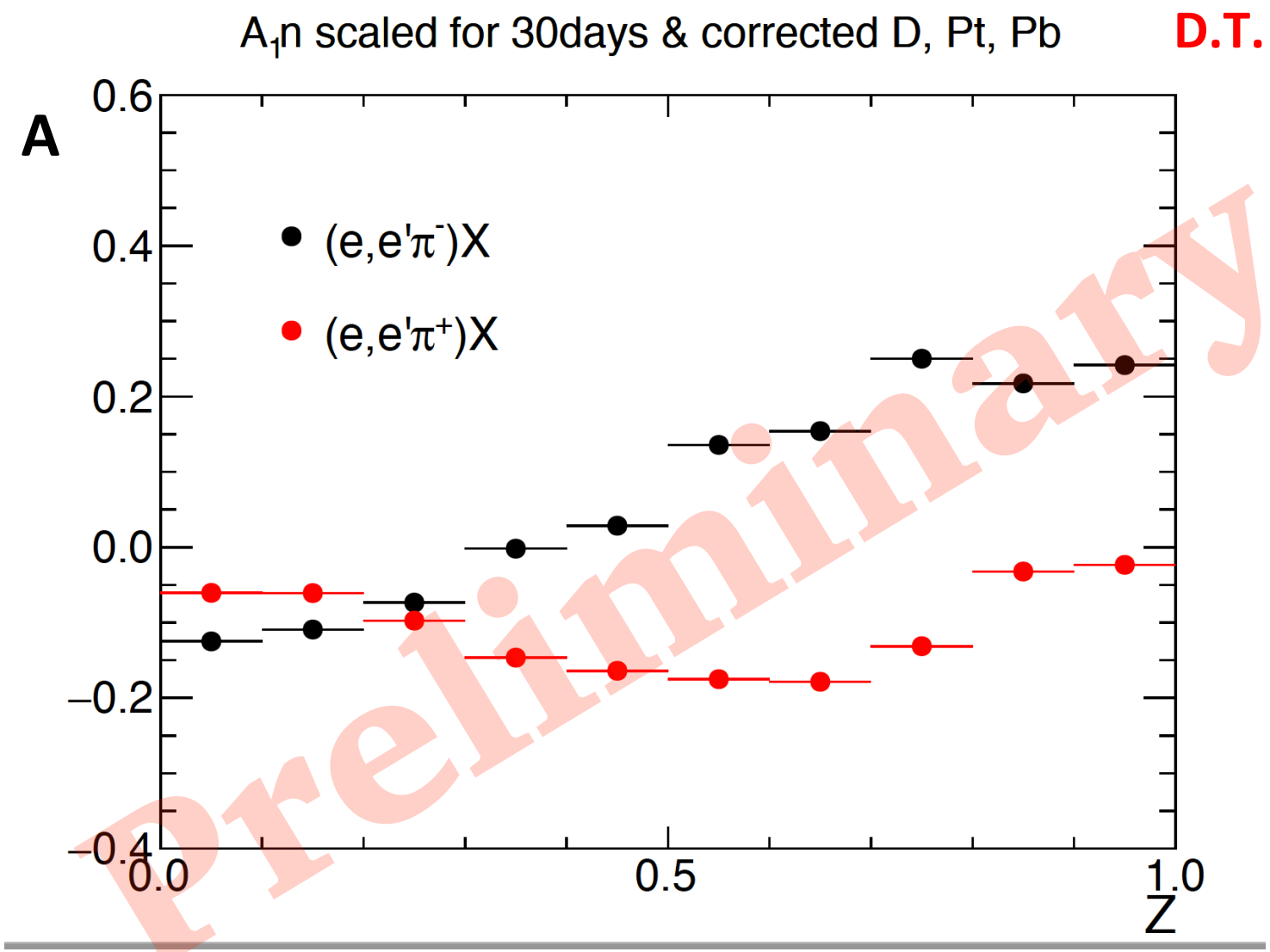
D.T. Nguyen



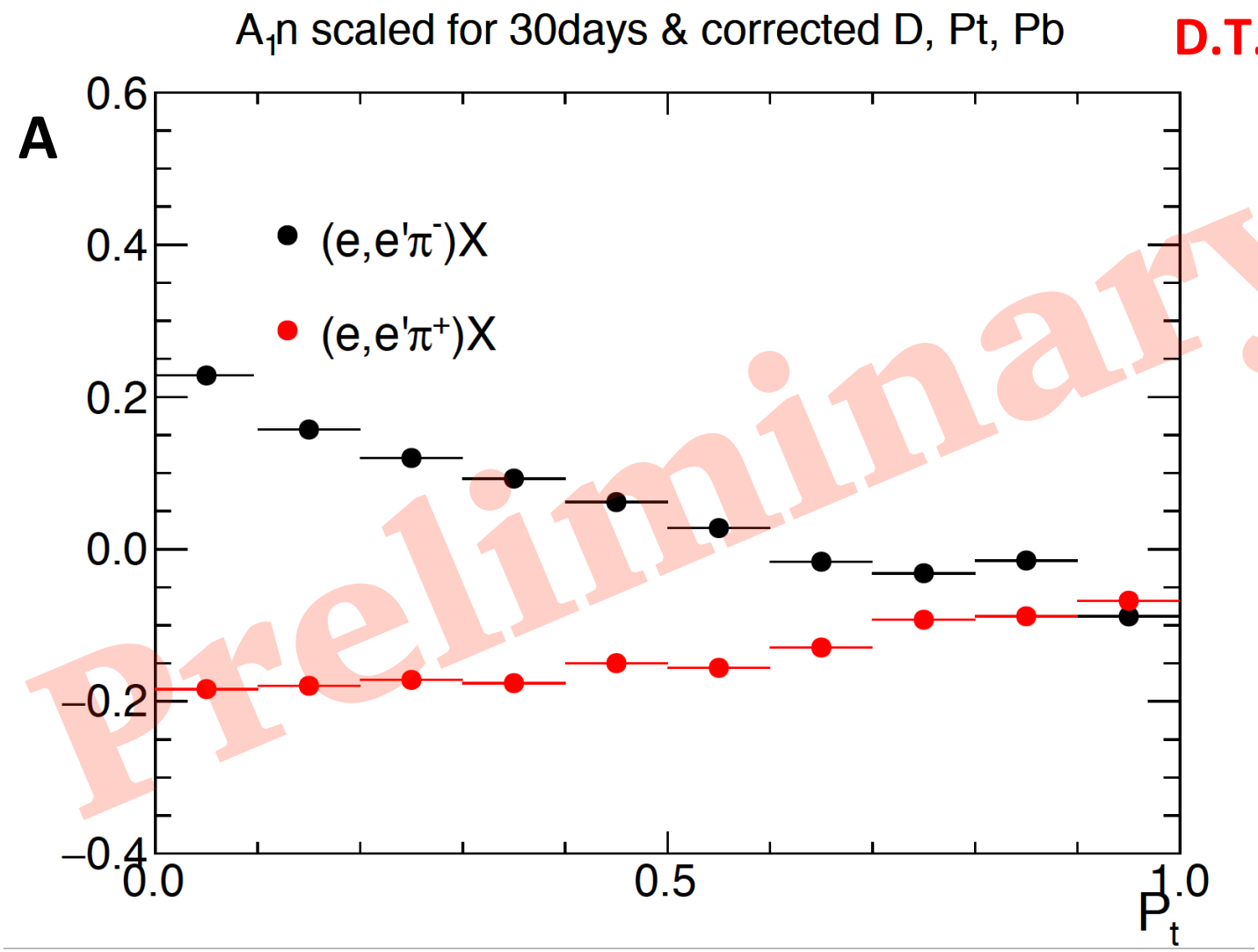
$\pi^{+/-}$ SIDIS Asymmetries - x_B



$\pi^{+/-}$ SIDIS Asymmetries - z

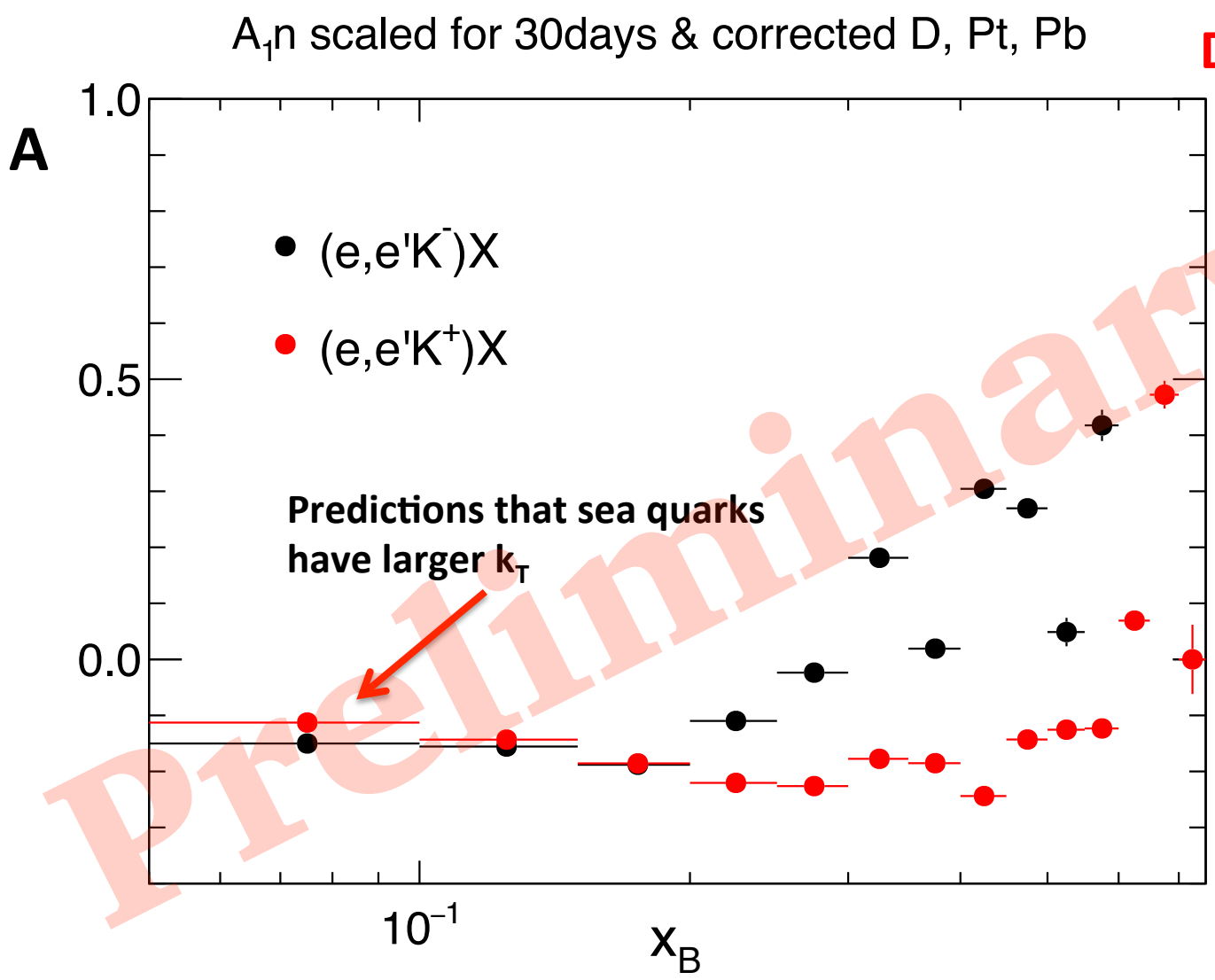


$\pi^{+/-}$ SIDIS Asymmetries - p_T

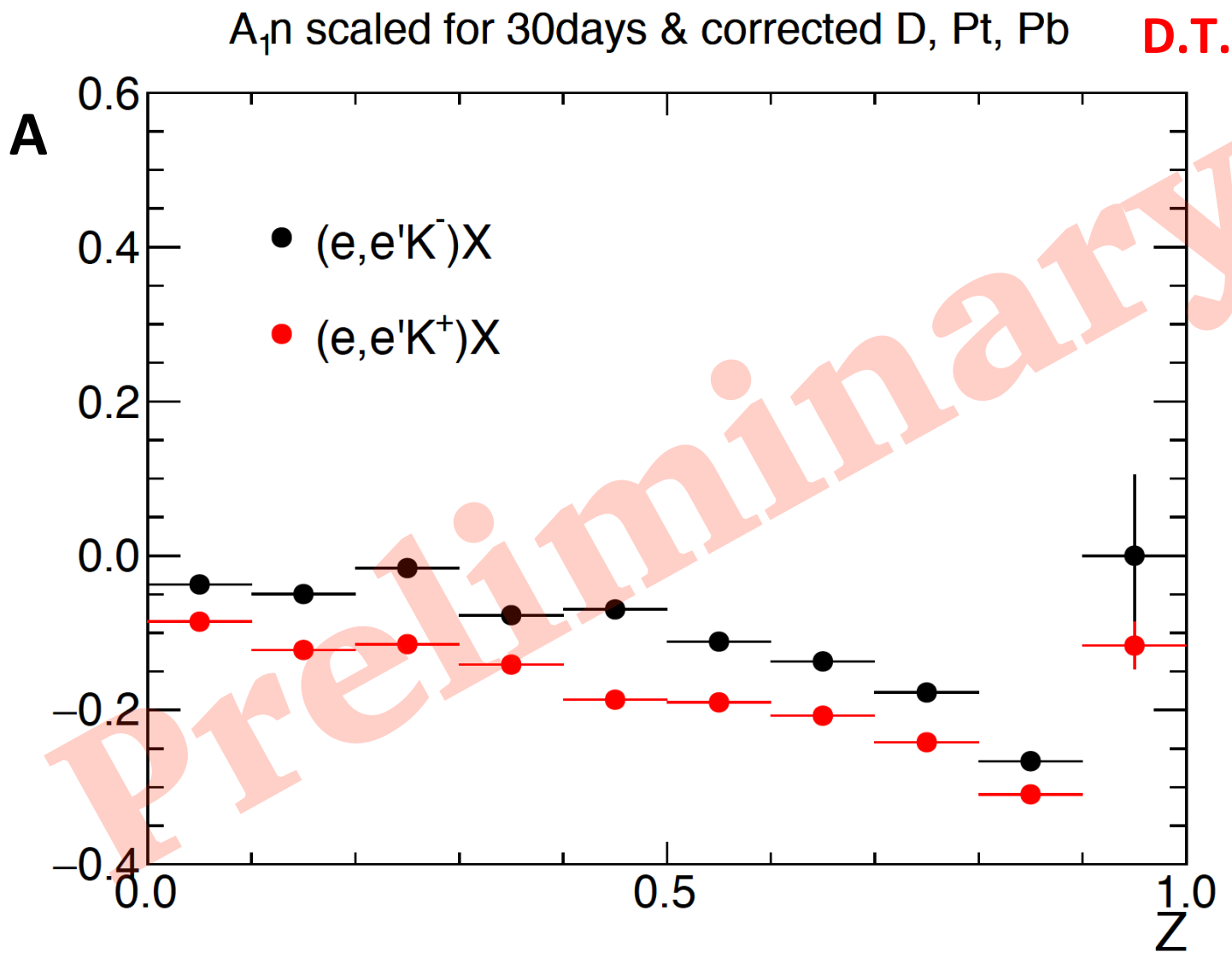


$K^{+/-}$ SIDIS Asymmetries - x_B

D.T. Nguyen

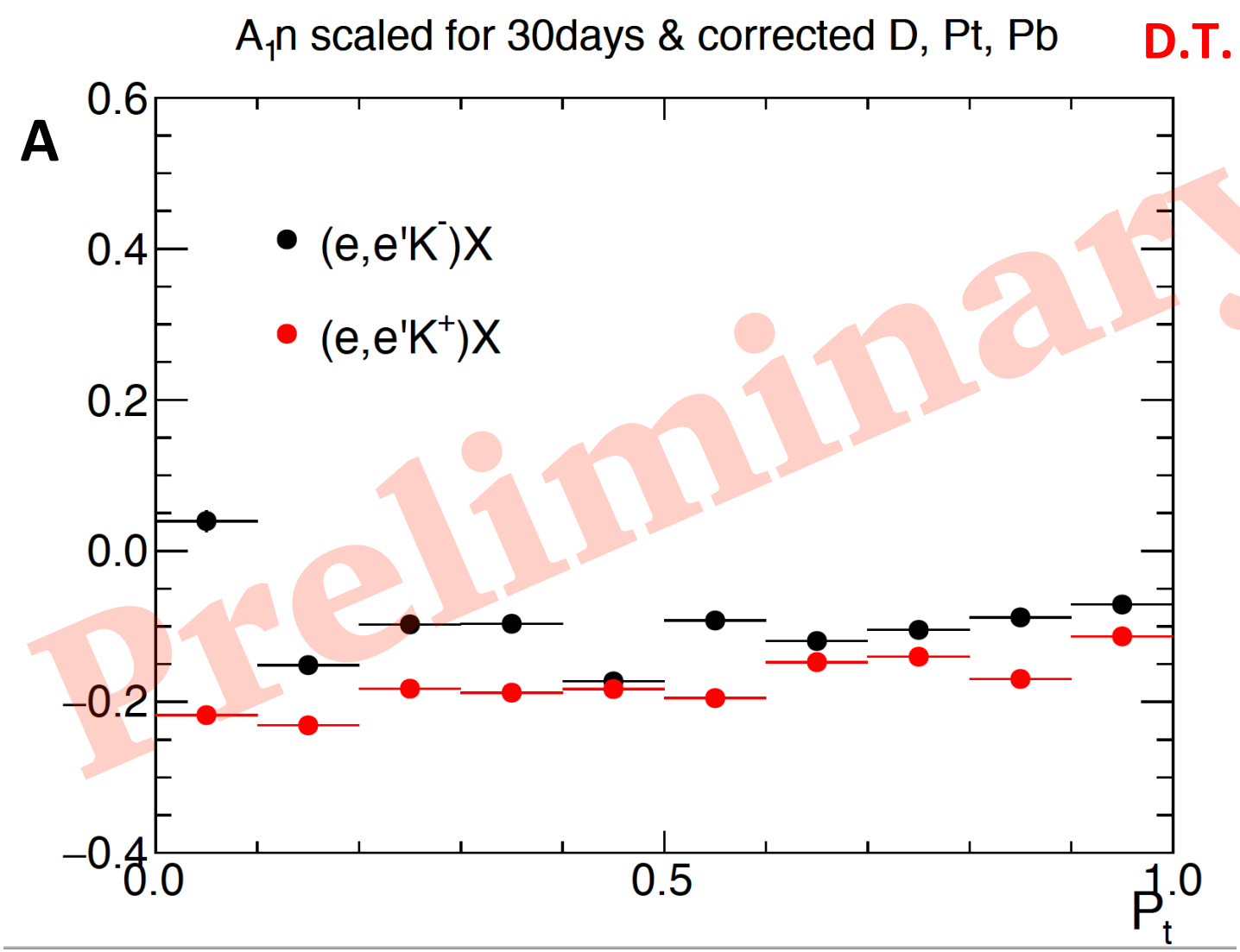


$K^{+/-}$ SIDIS Asymmetries - z



$K^{+/-}$ SIDIS Asymmetries - p_T

D.T. Nguyen



SIDIS Spin-Dependent Cross Section

$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_T^2} =$$

$$\frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{F_{UU,T}+\varepsilon F_{UU,L}+\sqrt{2\,\varepsilon(1+\varepsilon)}\,\cos\phi_h\,F_{UU}^{\cos\phi_h}$$

$$+\varepsilon\cos(2\phi_h)\,F_{UU}^{\cos 2\phi_h}+\lambda_e\sqrt{2\,\varepsilon(1-\varepsilon)}\,\sin\phi_h\,F_{LU}^{\sin\phi_h}$$

$$+S_\parallel\left[\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_h\,F_{UL}^{\sin\phi_h}+\varepsilon\sin(2\phi_h)\,F_{UL}^{\sin 2\phi_h}\right]$$

$$+S_\parallel\lambda_e\left[\sqrt{1-\varepsilon^2}\,F_{LL}+\sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_h\,F_{LL}^{\cos\phi_h}\right]$$

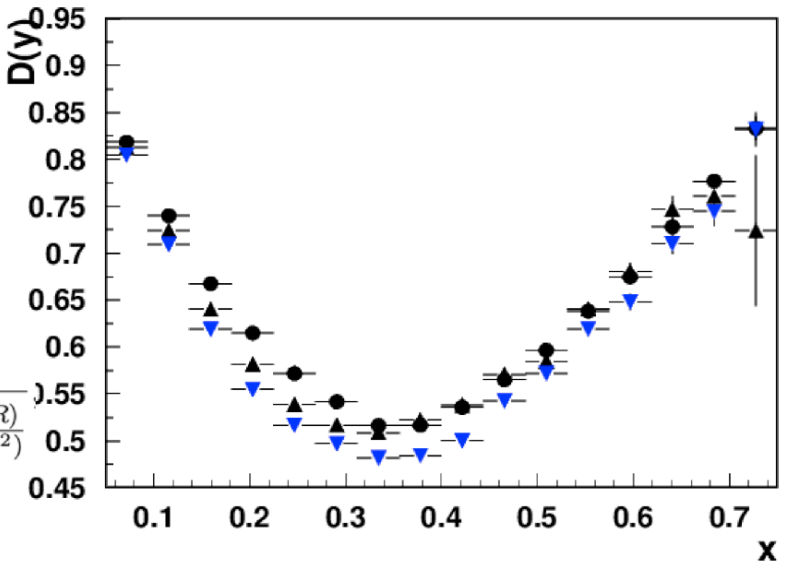
$$\varepsilon=\frac{1-y-\frac{1}{4}\gamma^2y^2}{1-y+\frac{1}{2}y^2+\frac{1}{4}\gamma^2y^2}$$

$$A_\parallel\approx\frac{(1-\varepsilon)(2-y)}{y\,(1+\varepsilon R)}\,\frac{g_1}{F_1}\equiv\frac{y(2-y)}{y^2+2\left(1-y-\frac{y^2\gamma^2}{4}\right)\frac{(1+R)}{(1+\gamma^2)}}\,\frac{g_1}{F_1}\equiv D'(y)\frac{g_1}{F_1}$$

R → the ratio of the longitudinal and transverse photo absorption cross sections

$$D'(y)=\frac{(1-\varepsilon)(2-y)}{y(1+\varepsilon R)}$$

$$\equiv\frac{y(2-y)}{y^2+2\left(1-y-\frac{y^2\gamma^2}{4}\right)\frac{(1+R)}{(1+\gamma^2)}}$$



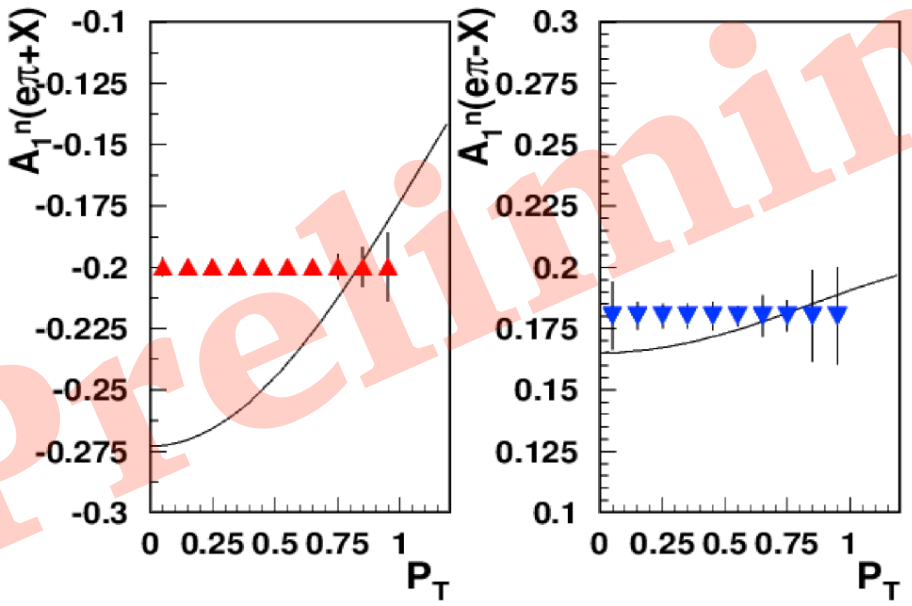
Projections for p_T Dependence of Neutron

https://arxiv.org/pdf/1011.1213.pdf

Assuming sea quark contributions are small at large x and factorization in x and k_T-dependences (using simple Gauss in k_T) we get for $A1(P_T)=F_{LL}/F_{UU}$

Curves calculated using LO DSS for D^{unf}/D^{fav}, LO GRV98 for quark PDFs

$x_B = 0.3$



H. Avakian

Significant effect expected for neutron target for pi+

Summary

- Recent technical developments make possible a polarized ^{3}He gas target in the central solenoid of CLAS12 well matched to the max. luminosity
- This enables precision measurements of spin-dependent electron scattering from ^{3}He (both long. and transverse poln.) across the complete kinematic response.
- We propose an initial 30 day run of DIS and SIDIS ($\pi^{+/-}$ and $K^{+/-}$) from the polarized neutron over the complete kinematic range accessible.
- The statistical precision over a large kinematic range is unprecedented. However, we need to
  - study outbending option
  - study kaon detection in CLAS12
  - expand binning.
- This is the natural starting point for any comprehensive program.
- A principal focus of the initial proposal is the k_T dependence of the quark polarizations: $\mathbf{g_1(x,Q^2,k_T)}$.
- All are welcome to join!