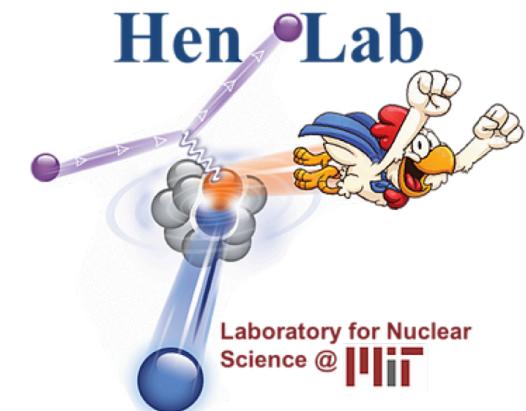


Inclusive DIS and SIDIS measurements on Triton and polarized ^3He in CLAS12

Dien Nguyen

CLAS Collaboration meeting



Outline:

- ❑ Two Experiments: A=3 ; Polarized ^3He

Outline:

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- A=3 Quasielastic:
 - (e,e') : Neutron form factor
 - $(e,e'p)$: Few-Body nuclear Structure
 - $(e,e'pN)$: SRCs
- A=3 DIS:
 - (e,e') : Neutron structure function
 - $(e,e'\pi^\pm)$ & $(e,e'K^\pm)$: EMC flavor dependence

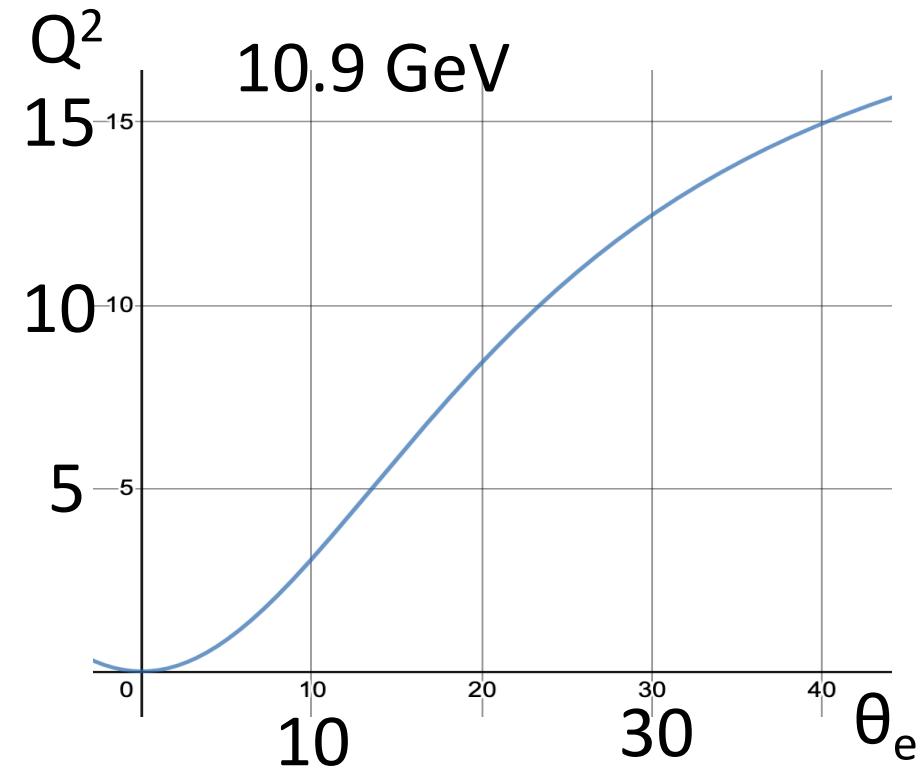
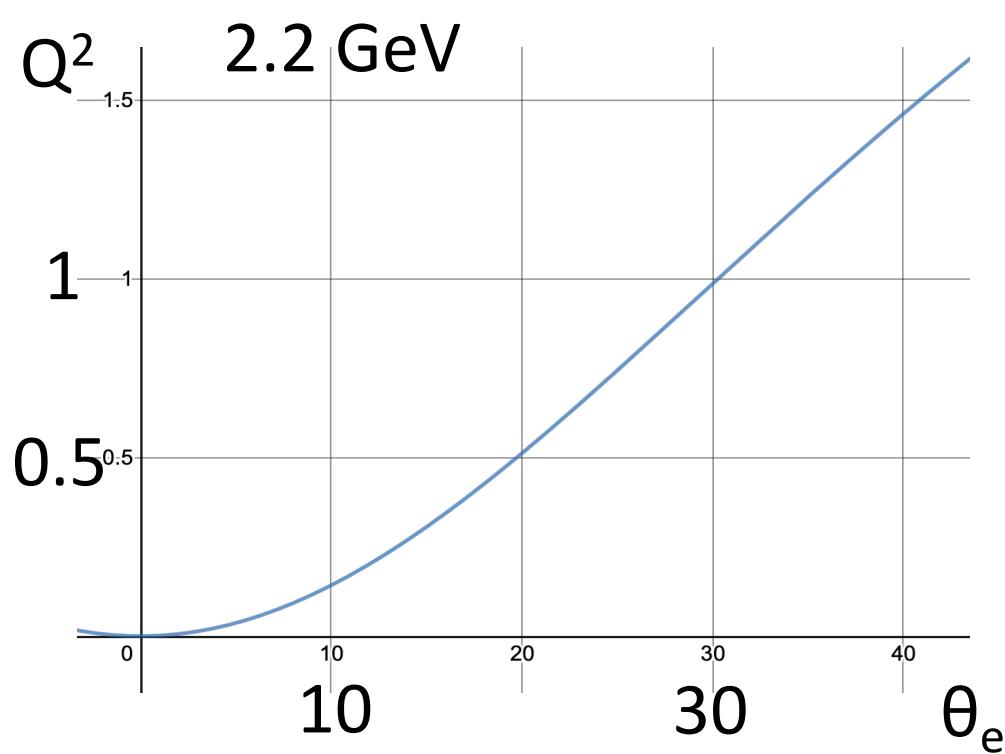
Outline:

- ❑ Two Experiments: $A=3$; **Polarized ^3He**
- ❑ $A=3$ Quasielastic:
 - ❑ (e,e') : Neutron form factor
 - ❑ $(e,e'p)$: Few-Body nuclear Structure
 - ❑ $(e,e'pN)$: SRCs
- ❑ $A=3$ DIS:
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- ❑ SIDIS on Polarized ^3He

A=3: Helium-3 + Tritium @ CLAS12

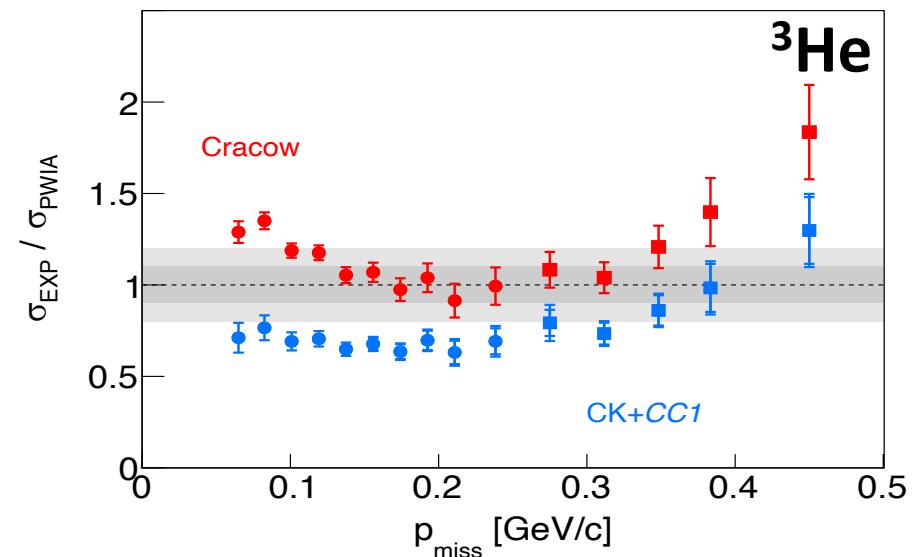
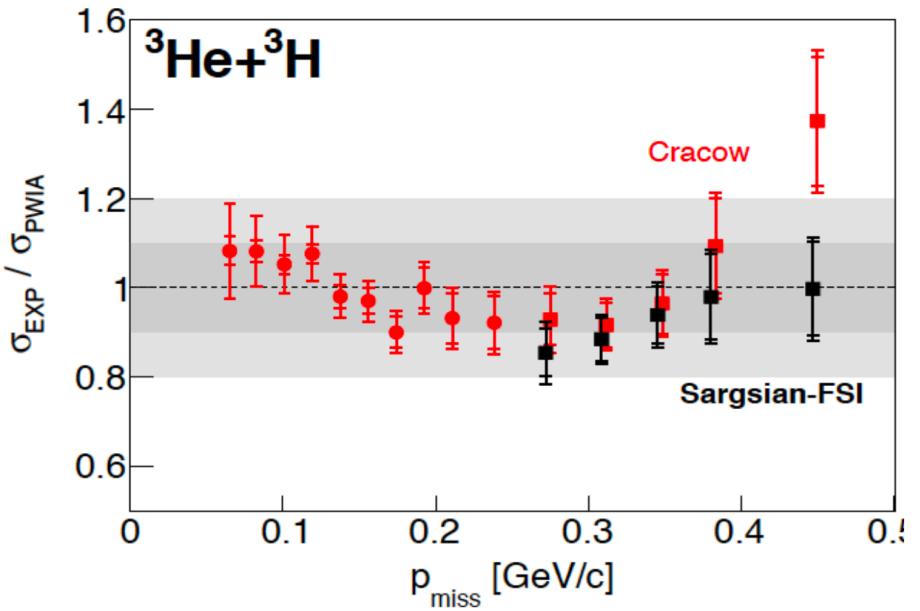
(e,e'): Neutron Form Factor

- ${}^3\text{He}(e,e') / {}^3\text{H}(e,e')$ @ $x_B = 1$ sensitive to σ_n / σ_p
- Measured @ Hall A \w limited Q^2 coverage
- CLAS12 covers $Q^2 = 0.1 - 14 \text{ GeV}^2$ (complementing RG-B)
- Only measurement sensitive to very low Q^2



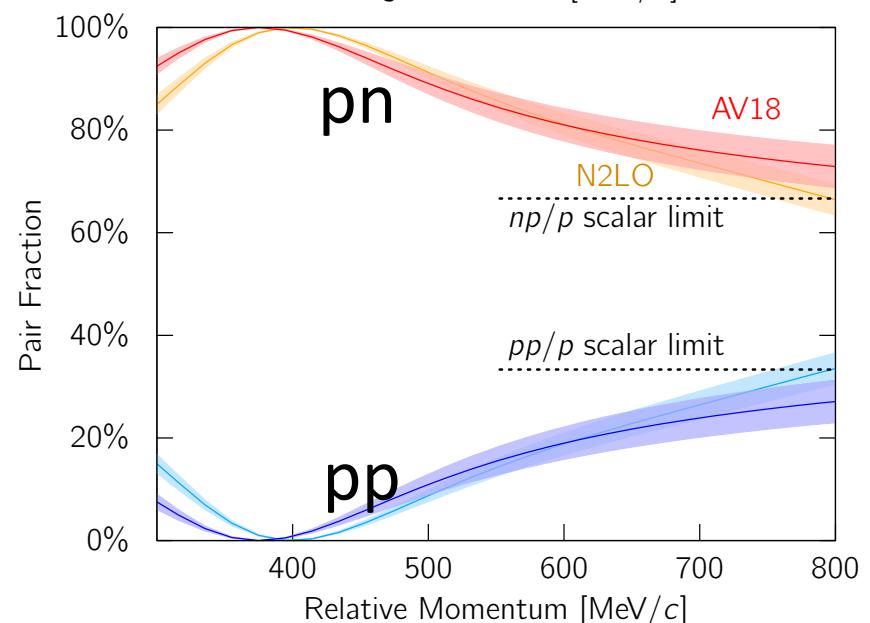
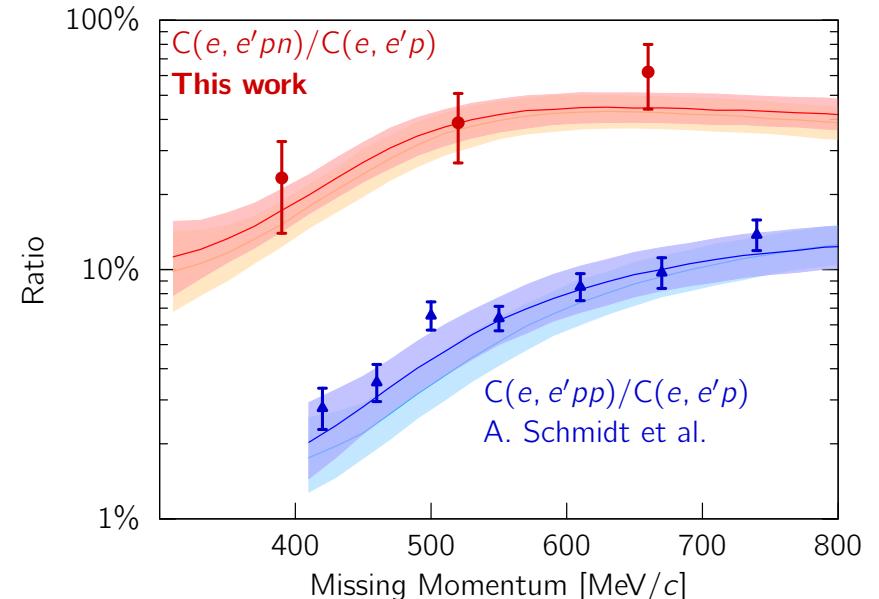
(e,e'p): Few-body nuclear structure

- Unique test of few-body nuclear structure.
- Hall A showed importance of using Helium & Triton BUT \w limited statistics
- CLAS12:
 - x0.1 luminosity
 - x100 acceptance
 - => x10 statistics + larger kinematical coverage!

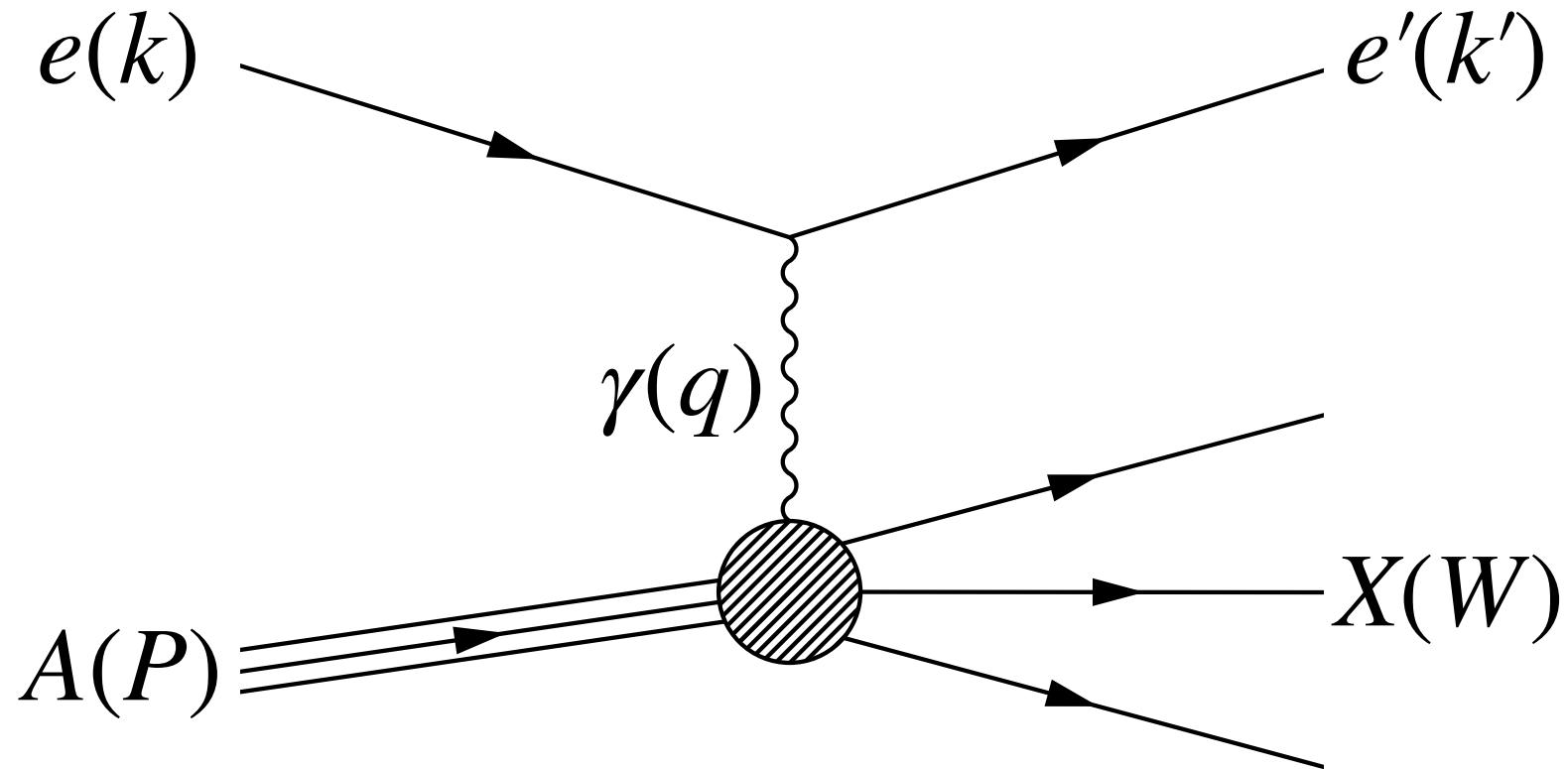


$(e, e' p N)$: SRCs

- Recent CLAS6 Nature paper relate SRCs to NN interaction @ short-distance.
- Data analyzed using the GCF factorized cross-section approximation.
- $A=3$ systems exactly calculable => Precision tests of $2N$ interactions!

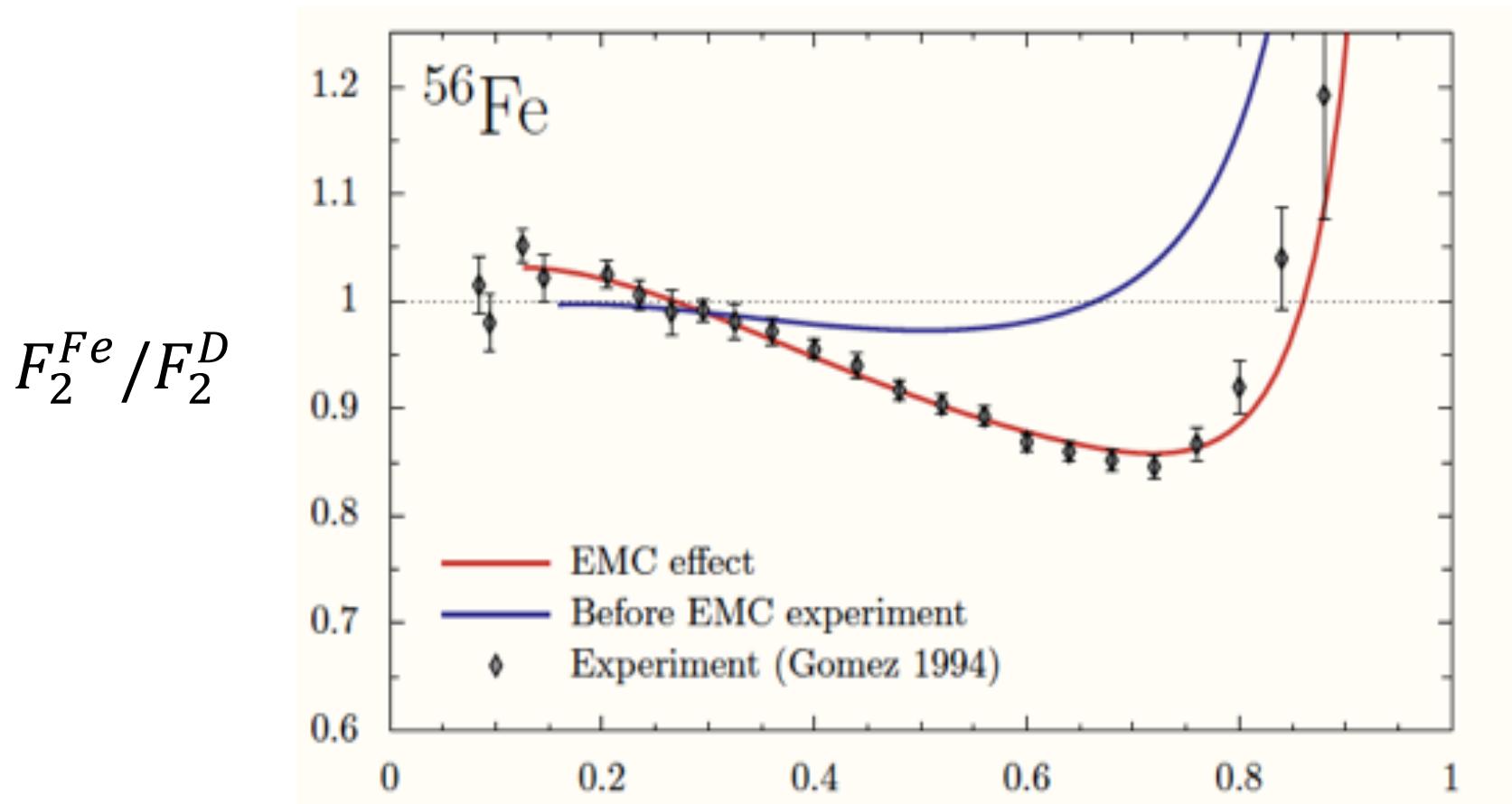


DIS & SIDIS



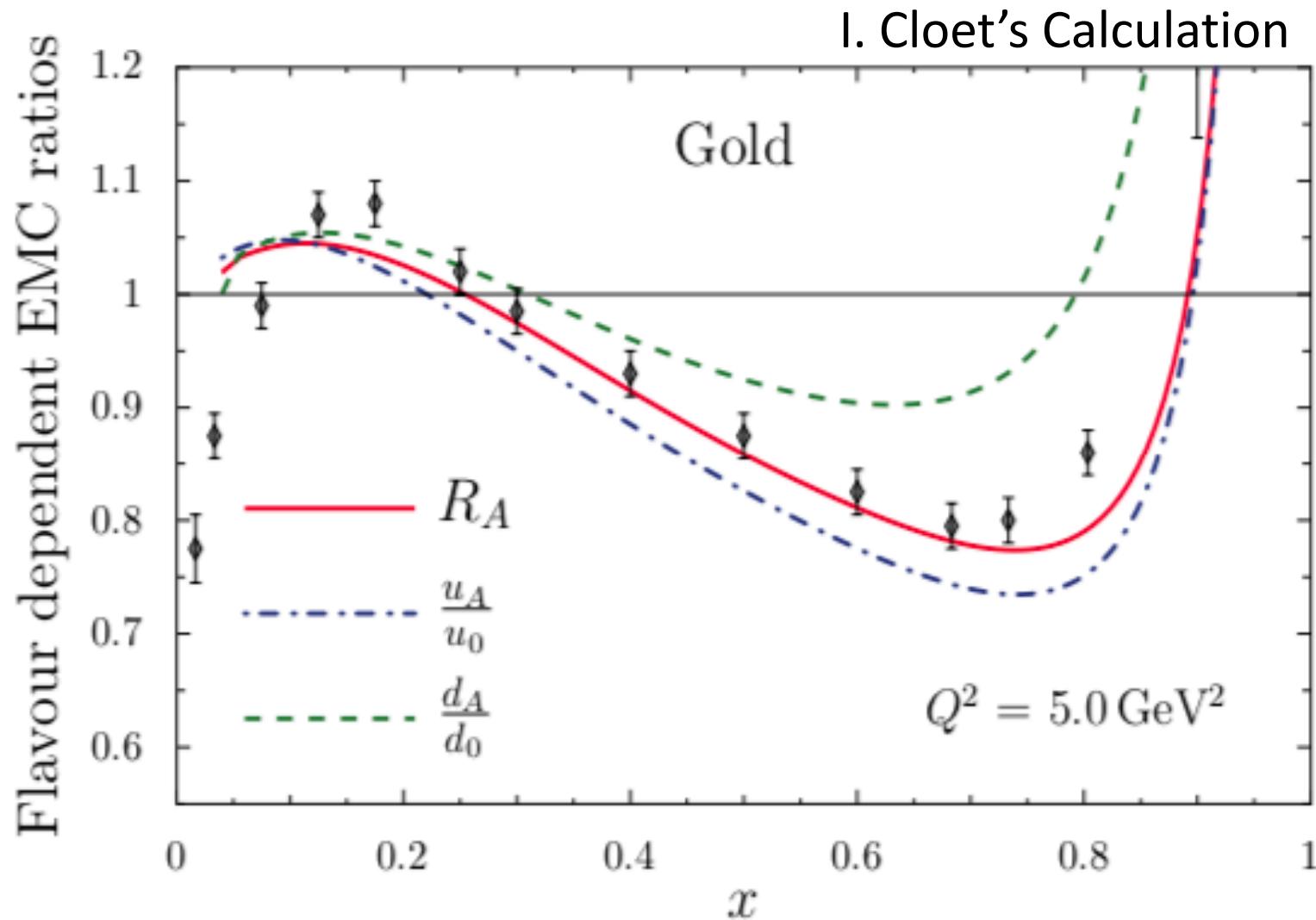
- ❑ Sensitive to the nucleon structure and modification

EMC effect in Deep inelastic scattering



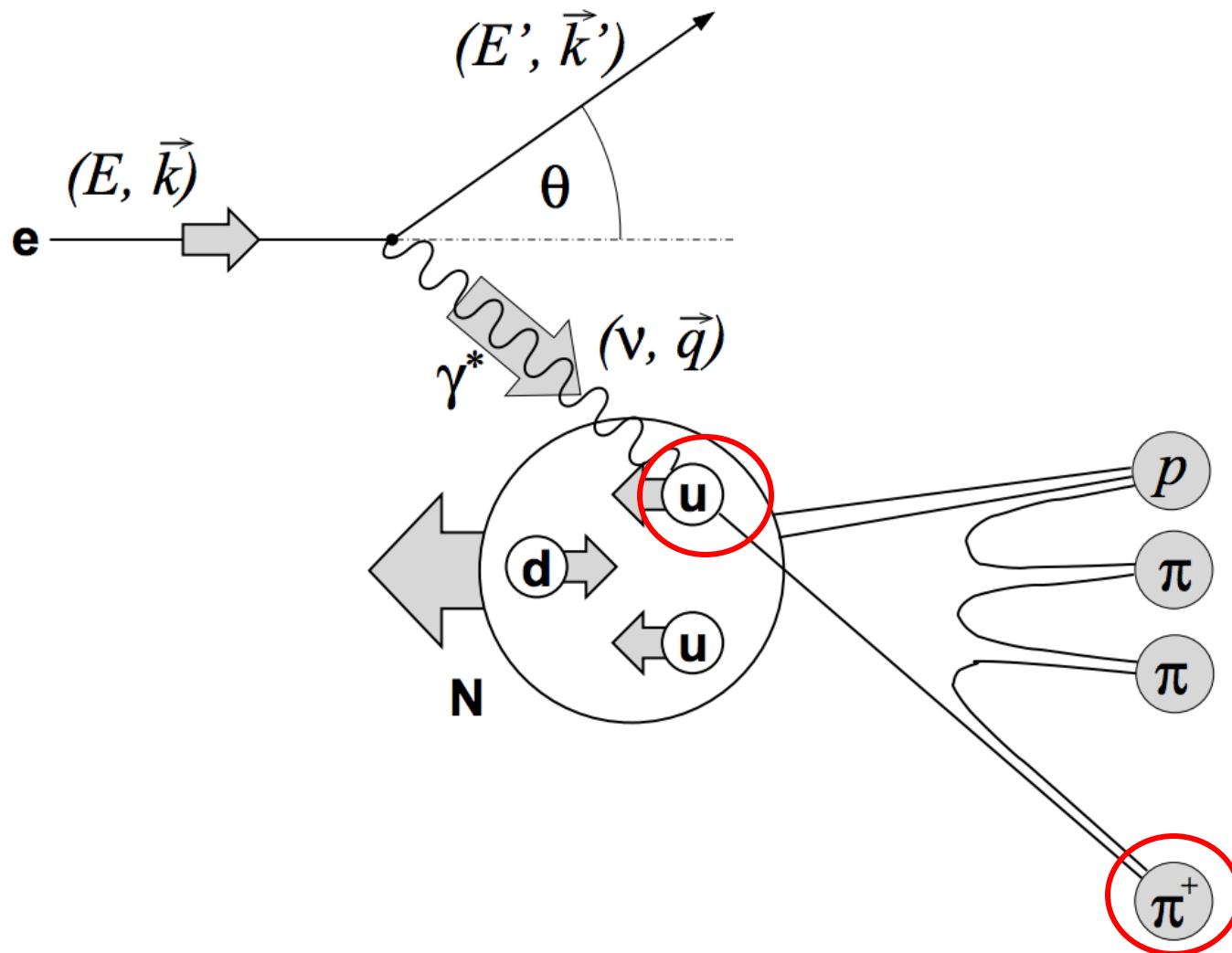
- Bound nucleons behave different from free nucleons

Flavor Dependence of the EMC



□ Different flavors cause different modifications

Semi-Inclusive DIS: Flavor Tagging



A = 3 Observables

Yield sum

$$\frac{Y(\pi^+ + \pi^-)_A}{Y(\pi^+ + \pi^-)_D}$$

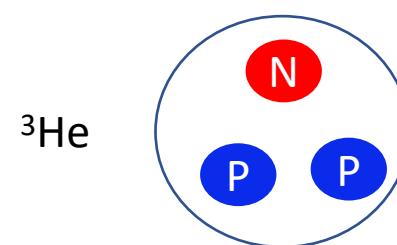
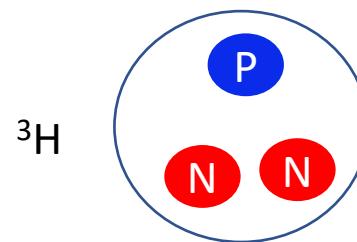
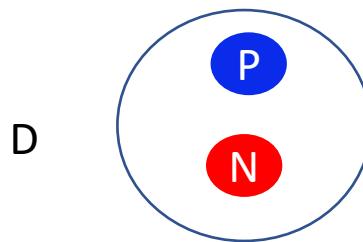
Yield difference

$$\frac{Y(\pi^+ - \pi^-)_A}{Y(\pi^+ - \pi^-)_D}$$

Double ratio

$$\frac{Y\left(\frac{\pi^+}{\pi^-}\right)_A}{Y\left(\frac{\pi^+}{\pi^-}\right)_D}$$

Targets:



- Minimize hadron attenuation effects
- Maximizing nuclear asymmetry

CLAS12 Rates

^3He

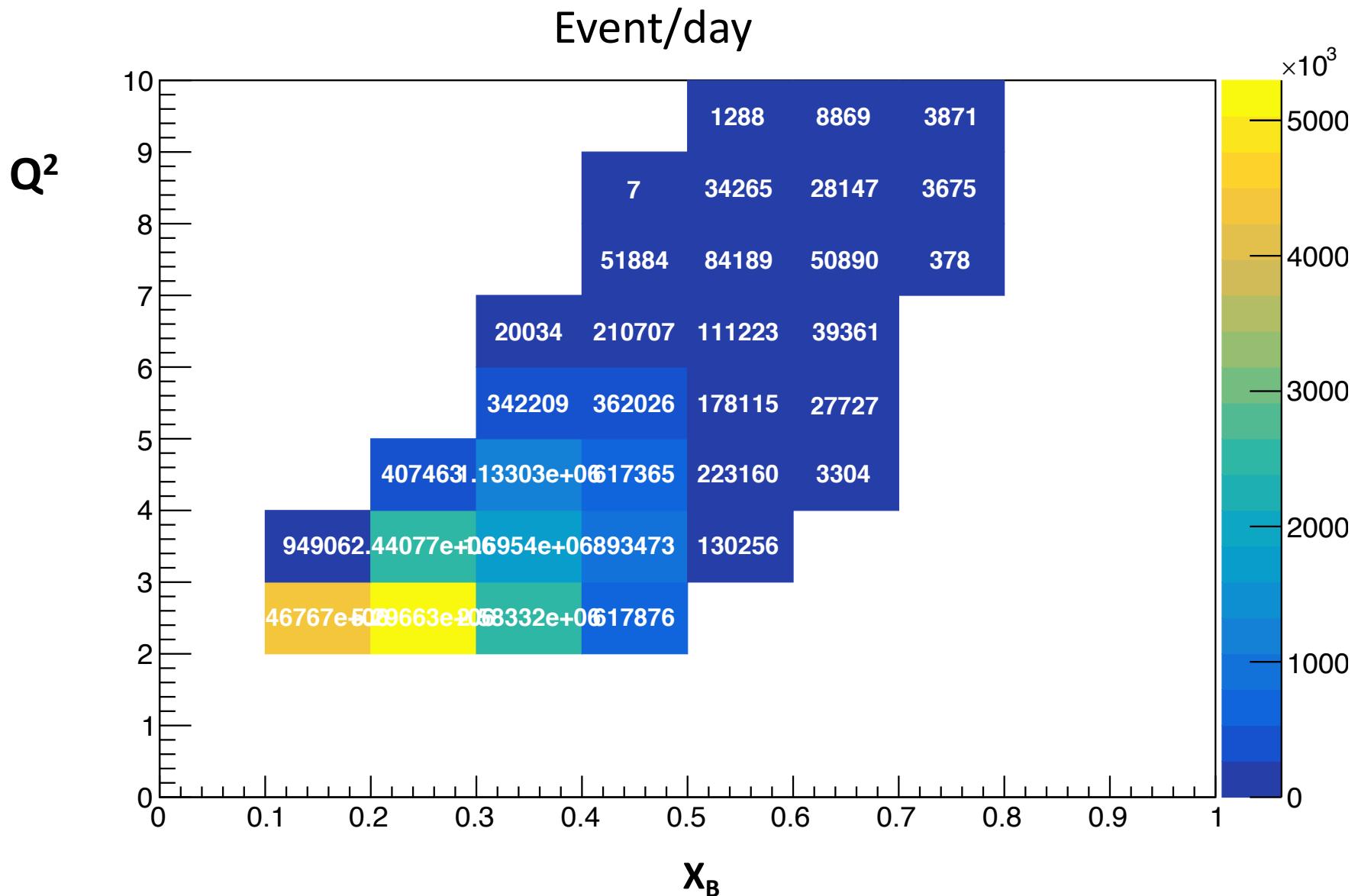
Measurement	Rate (event/second)
Inclusive (e,e')	257
SIDIS ($e,e'\pi^-$)	8
SIDIS ($e,e'\pi^+$)	17
SIDIS ($e,e'K^-$)	0.5
SIDIS ($e,e'K^+$)	6

Luminosity: 3.5×10^{34}

Inclusive (e,e'):
 $x_B > 0.1, Q^2 > 2, W^2 > 4$

SIDIS ($e,e'\pi^\pm$):
 $x_B > 0.3, Q^2 > 2, W^2 > 4, Z > 0.3$
Acceptance match for π^+ and π^-

${}^3\text{He}(e,e')$ DIS Rate

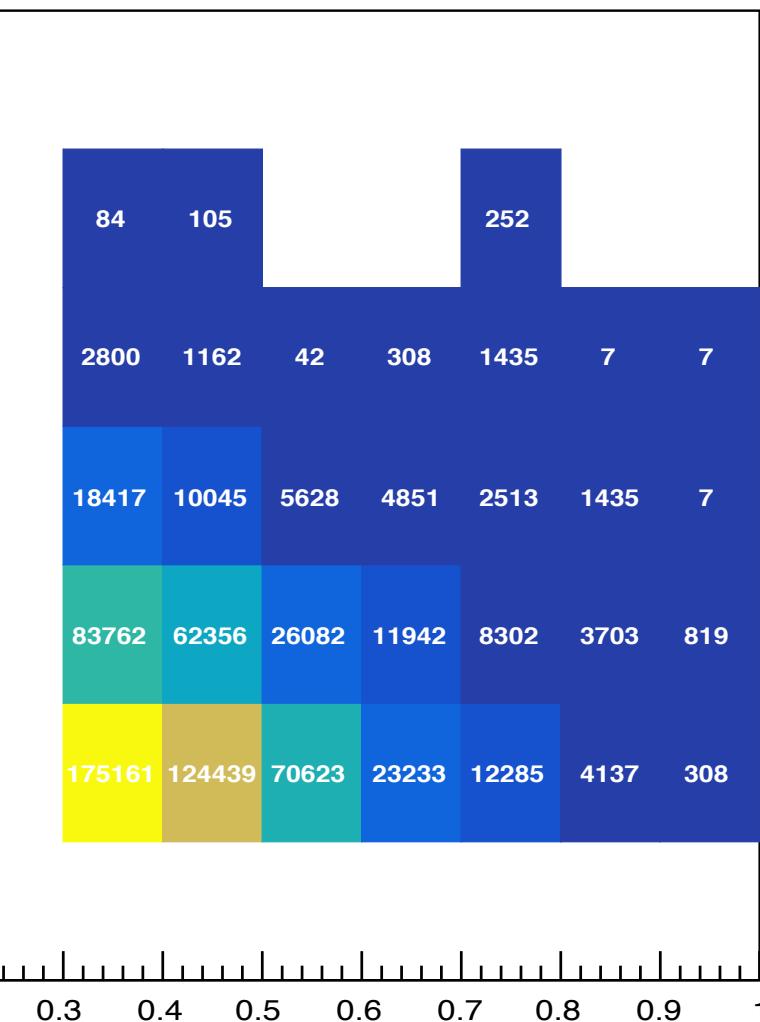


${}^3\text{He}(e,e'\pi^-)$ SIDIS Rate

X_B

Event/day

0.8
0.7
0.6
0.5
0.4
0.3
0.2



P_\perp

Event/day

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0



0.3

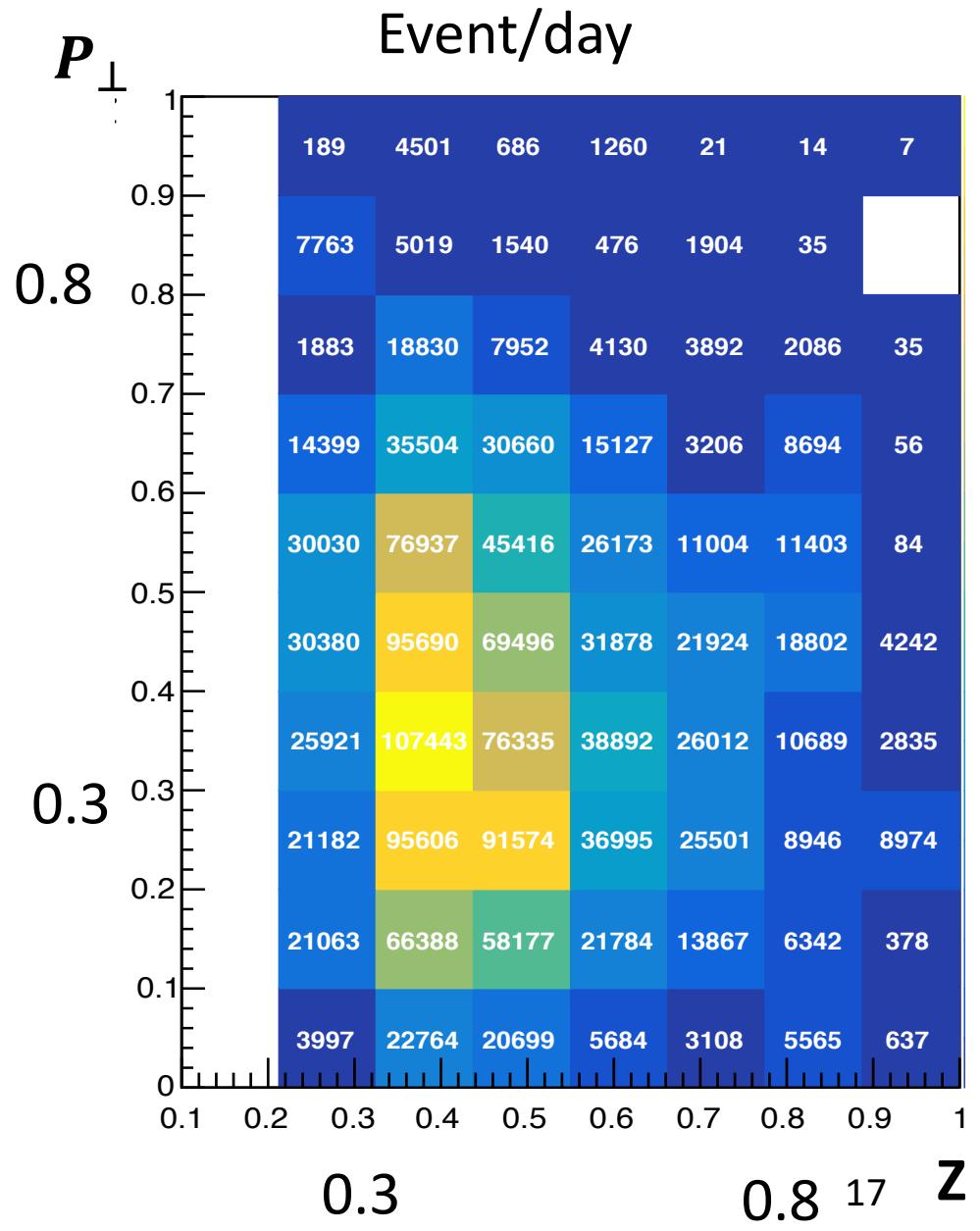
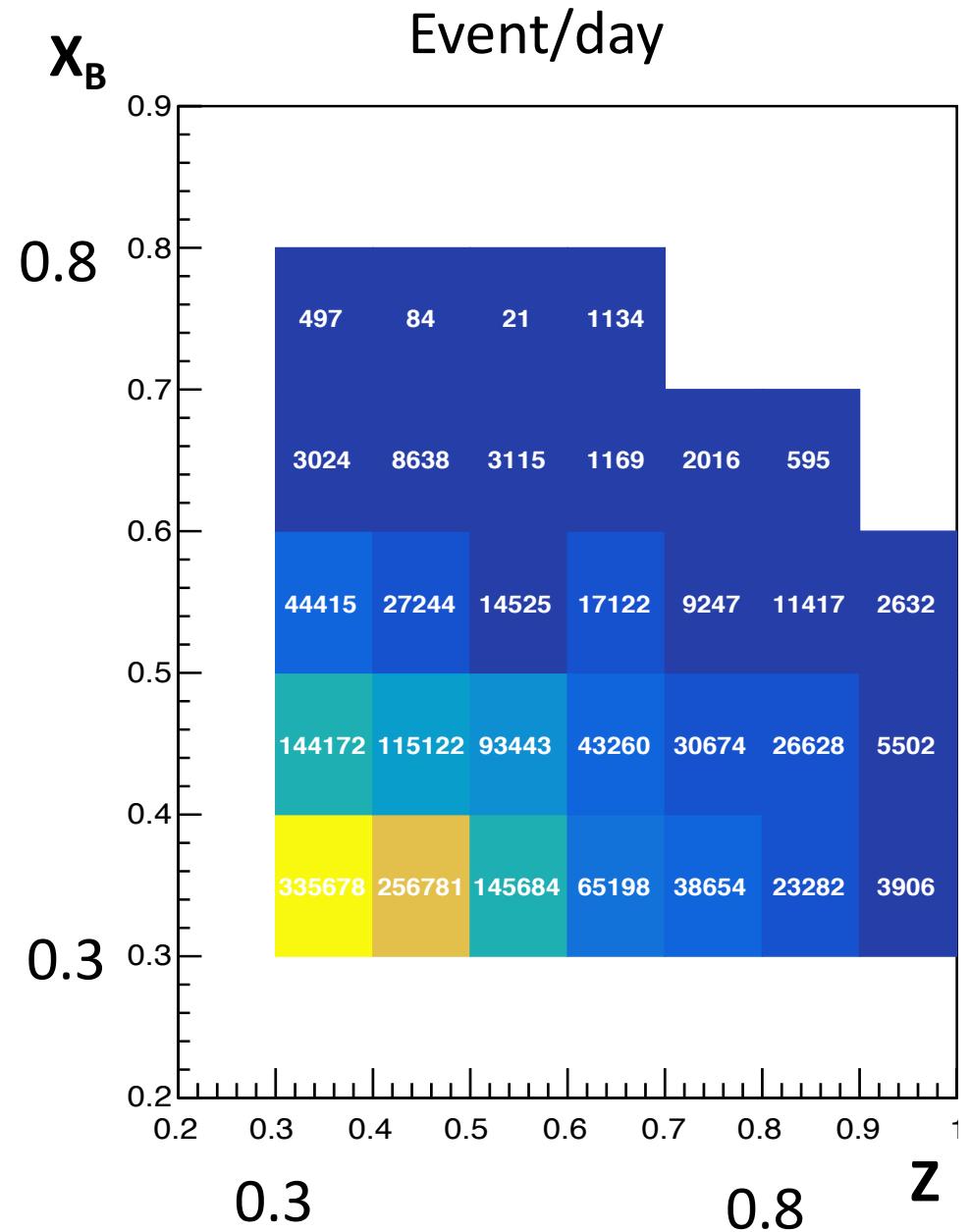
0.8

z

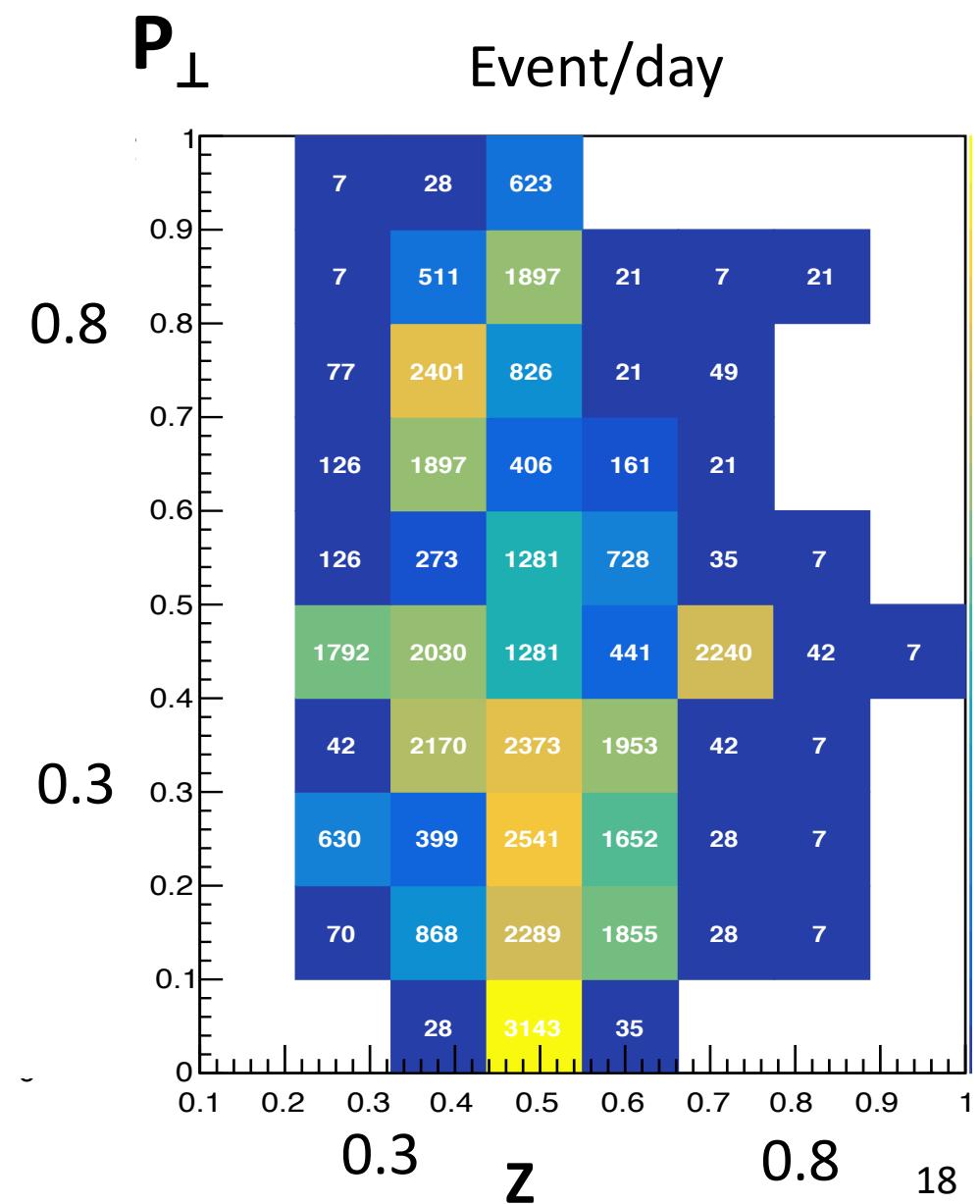
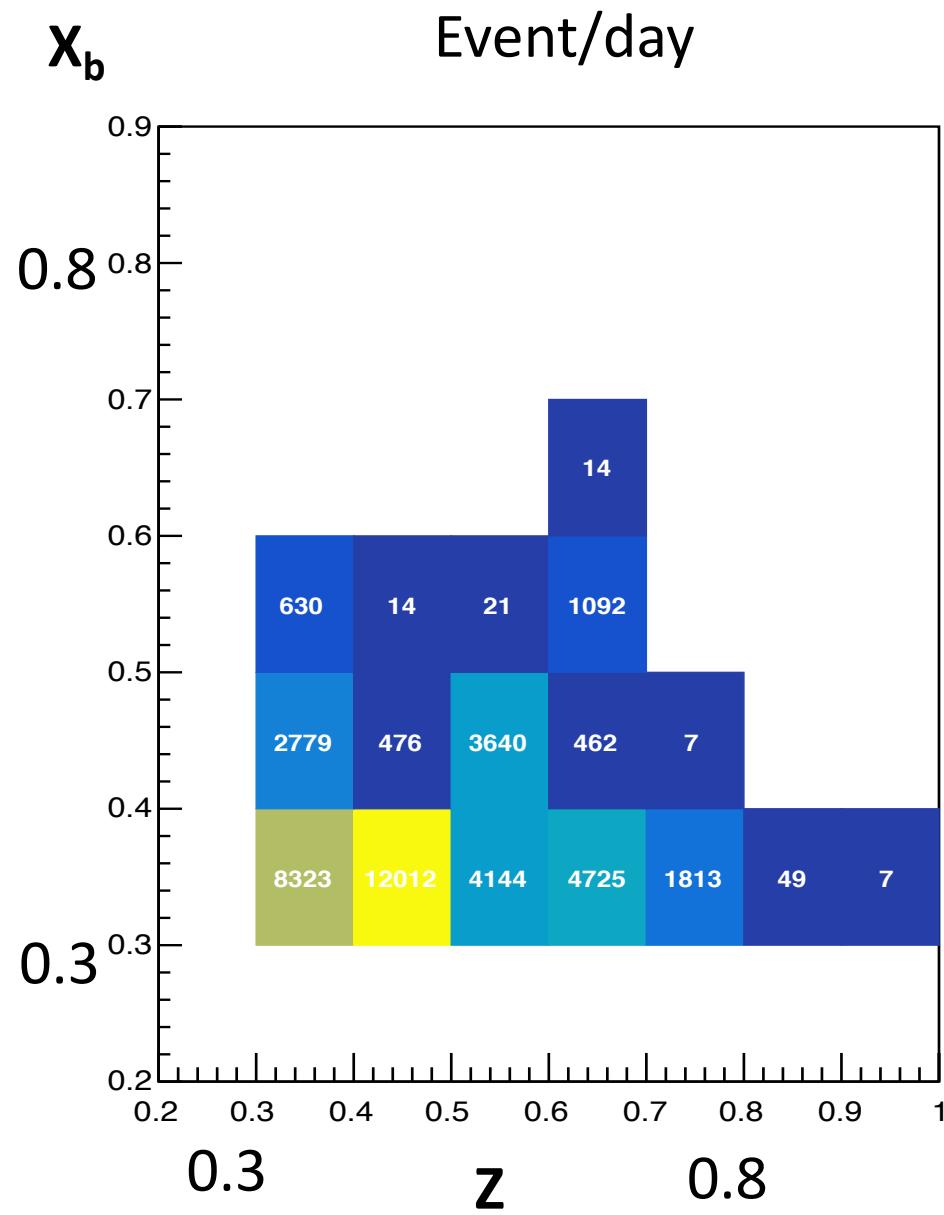
z

16

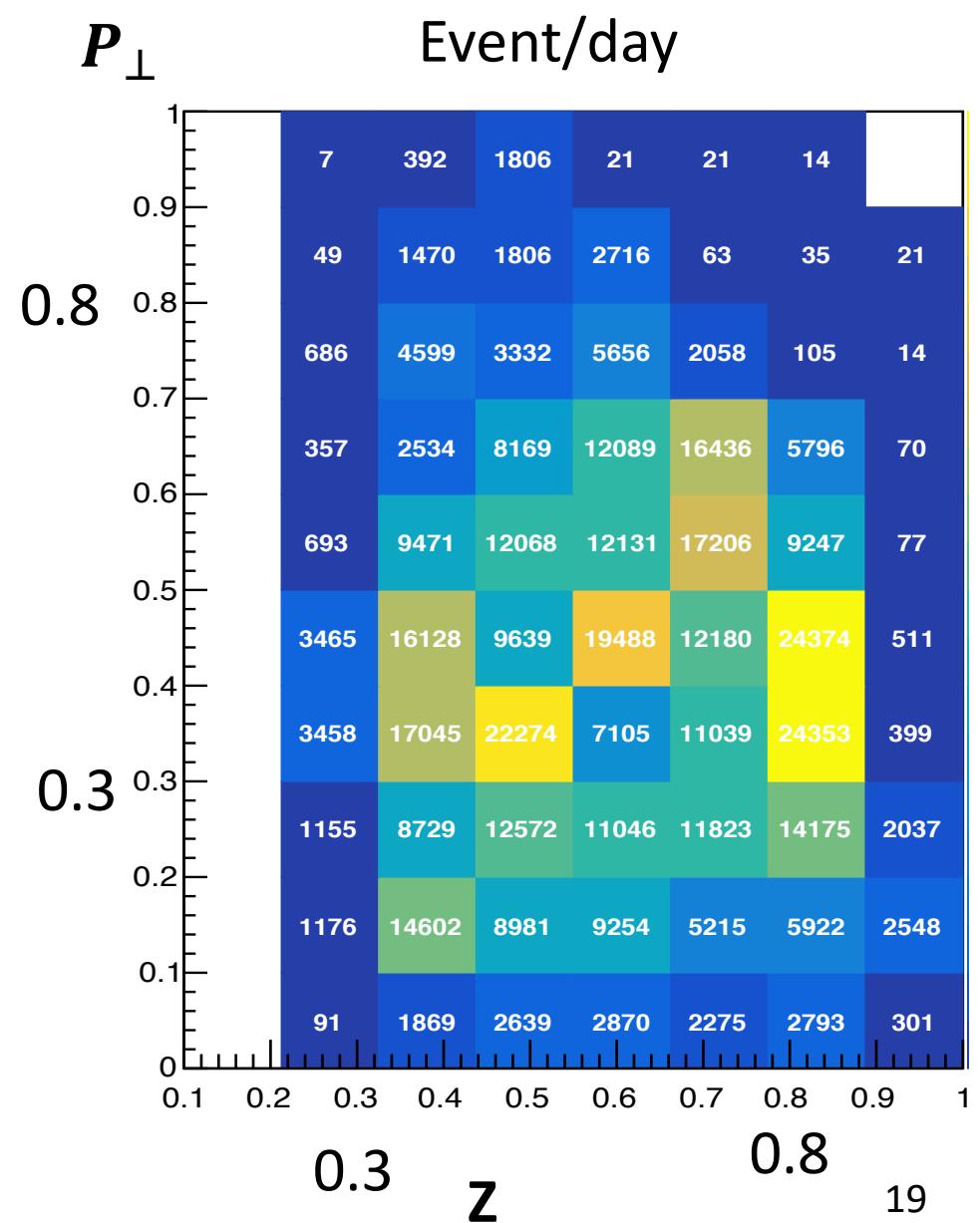
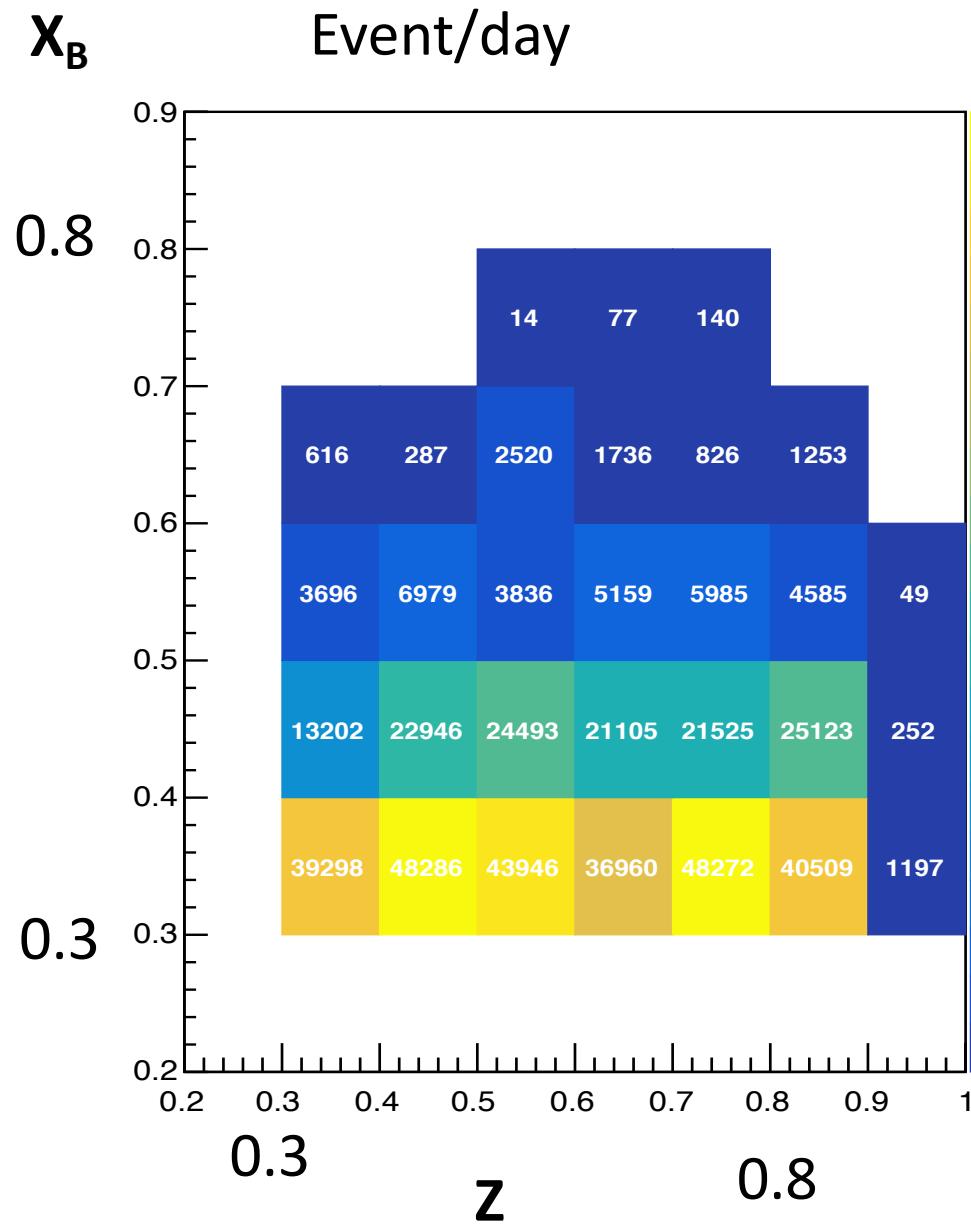
${}^3\text{He}(e,e'\pi^+)$ SIDIS Rate



${}^3\text{He}(e,e'K^-)$ SIDIS Rate



${}^3\text{He}(e,e'K^+)$ SIDIS Rate

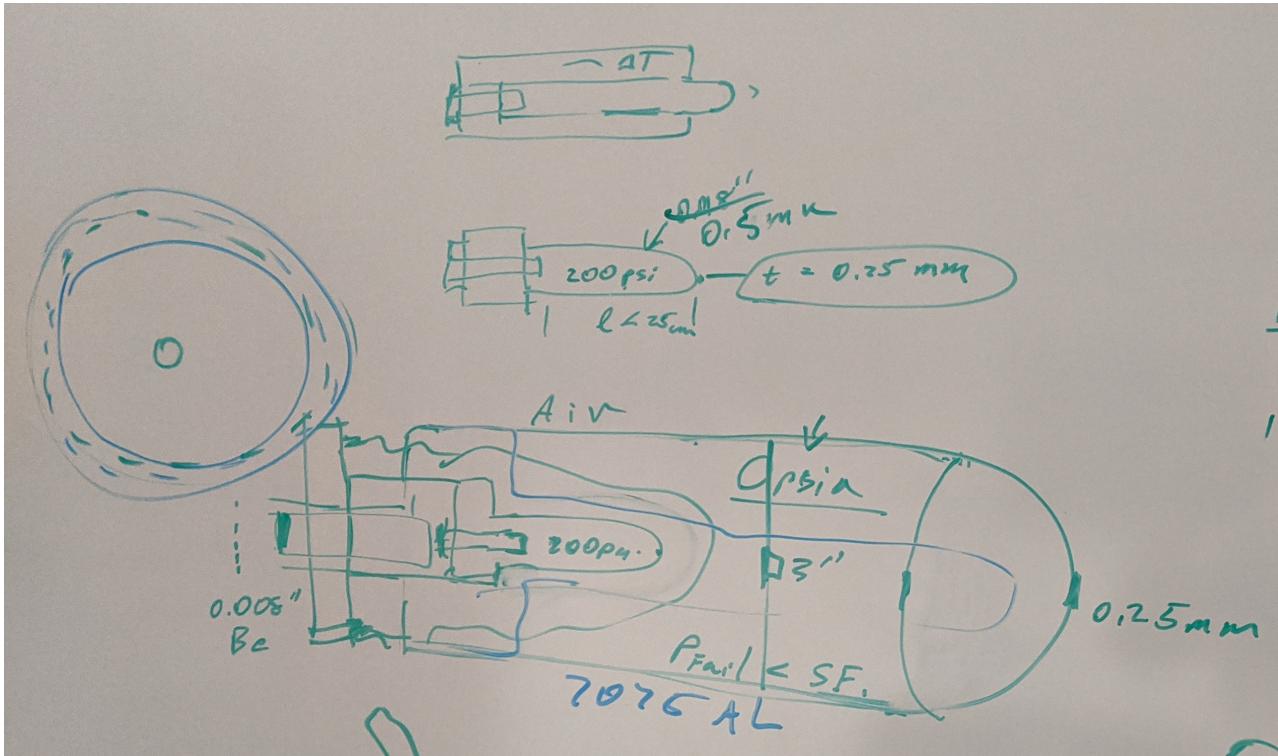


A=3: Helium-3 + Tritium @ CLAS12

Current Status:

- Developing proposal for 60 PAC days. **Looking for more collaborators!**
30 @ 10.9, 25 @ 6.6, 5 @ 2.2
- 6.6 GeV simulations taken from on RG-M.
10.9 GeV simulations presented today.
- Will finalize in the coming weeks.

A=3: Helium-3 + Tritium @ CLAS12



Tritium target in Hall B

Tritium: 0.085 g/cm²

Al window: 0.075 cm

Be window: 0.02 cm

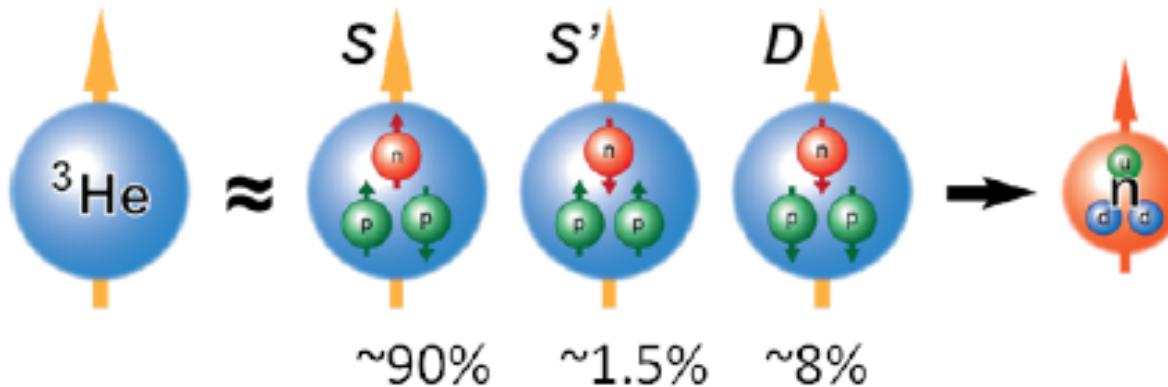
Tritium luminosity:

3.5×10^{34}

*Initial setup by target group. Will be improved ☺

Polarized ^3He in CLAS12

Polarized ^3He in CLAS12



Neutron polarization: 87%

Proton polarization: 2.7%

- Neutron spin structure: $g_1^n(x, Q^2)$, A_1^n , $\Delta u/u$, $\Delta d/d$?
- Spin structure functions of deuteron and proton in ^3He ?
- Spin- dependent EMC effect ?

Conceptual Design of a Polarized ^3He Target for the CLAS12 Spectrometer

James Maxwell¹ and Richard Milner²

¹Jefferson Lab, Newport News, VA

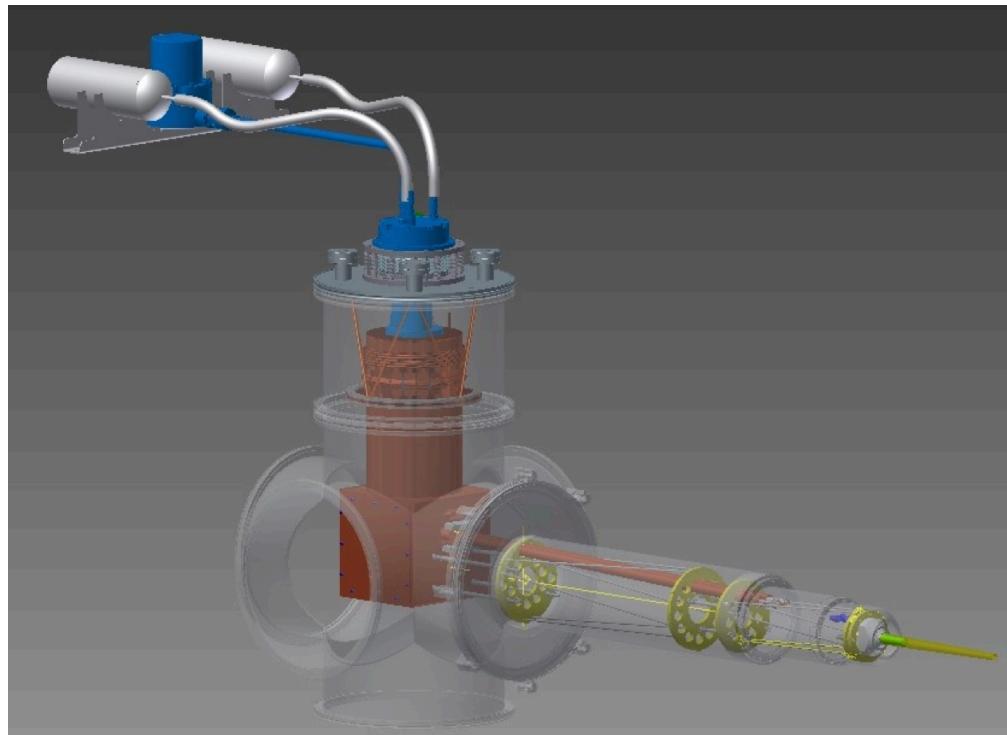
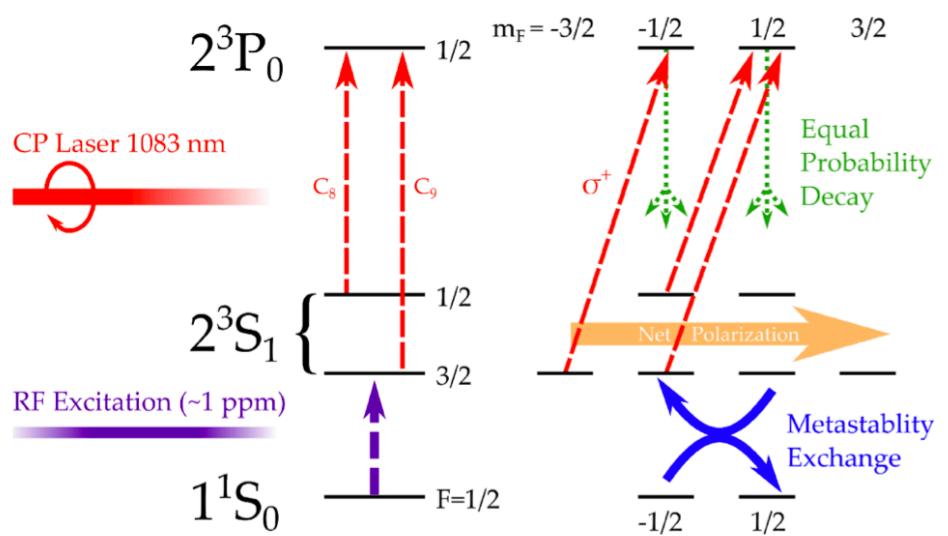
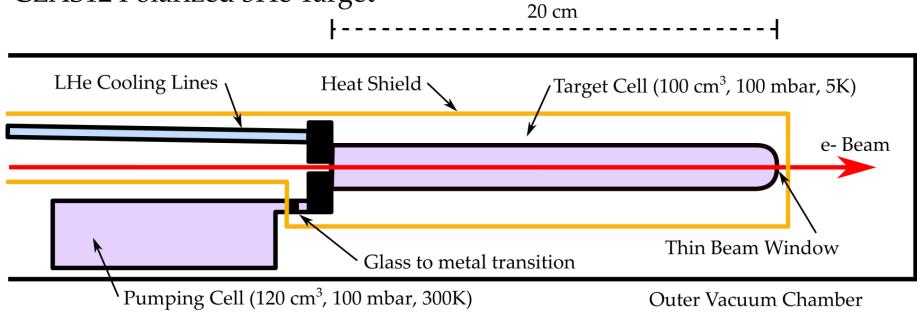
²Laboratory for Nuclear Science, MIT, Cambridge, MA

November 14, 2019

Abstract

We present a conceptual design for a polarized ^3He target for Jefferson Lab's CLAS12 spectrometer in its standard configuration. This two-cell target will take advantage of advancements in optical pumping techniques at high magnetic field to create 60% longitudinally polarized ^3He gas in a pumping cell inside the CLAS12 5 T solenoid. By transferring this gas to a 20 cm long, 5 K target cell, a target thickness of $3 \times 10^{21} \text{ } ^3\text{He}/\text{cm}^2$ will be produced, reaching the detector's specified maximum luminosity with a beam current of $2.5 \mu\text{A}$.

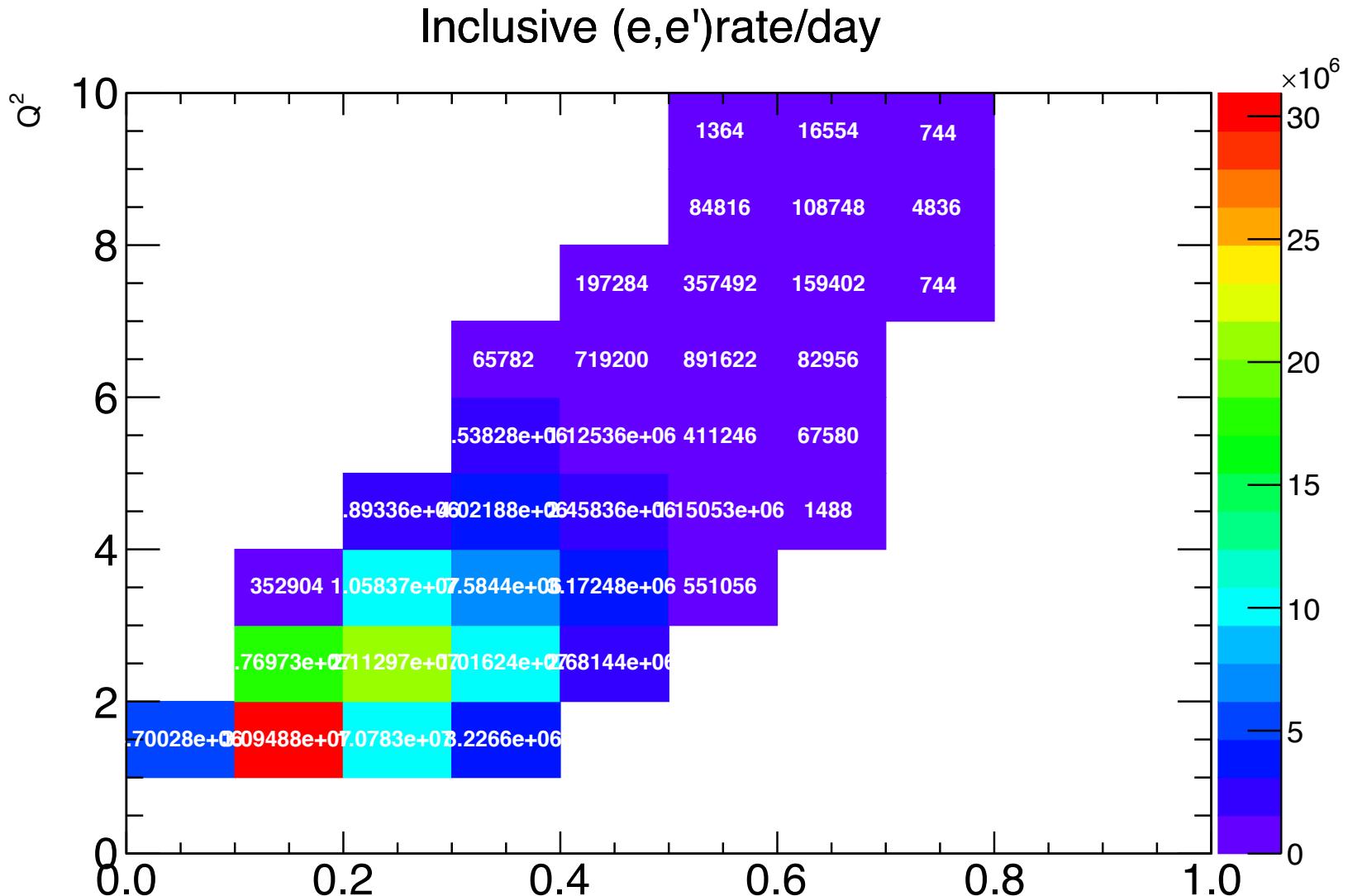
CLAS12 Polarized 3He Target



physics \w polarized ^3He in CLAS12

Process	Reaction	Physics Focus	Issues
Inclusive DIS	$e + ^3\text{He} \rightarrow e'$	$g_{1n}(x, Q^2)$	
Tagged Structure Functions	$e + ^3\text{He} \rightarrow e' + p$ $\rightarrow e' + d$	$g_{1p}(x, Q^2) g_{1d}(x, Q^2)$ for p,d in ^3He Spin-dependent EMC effect	Detecting spectator p/d Coexistence of tagger and polarized target in central detector
Semi-Inclusive DIS	$e + ^3\text{He} \rightarrow e' + \pi^{+/0/-}$ $e + ^3\text{He} \rightarrow e' + K^{+/0/-}$	Flavor dependence of quark polarizations in neutron	Good particle ID
Deeply Virtual Processes	$e + ^3\text{He} \rightarrow e' + ^3\text{He} + \pi^0/\gamma/\phi.....$	Neutron GPDs	Detection of recoil ^3He

Polarized ^3He Inclusive rate estimate

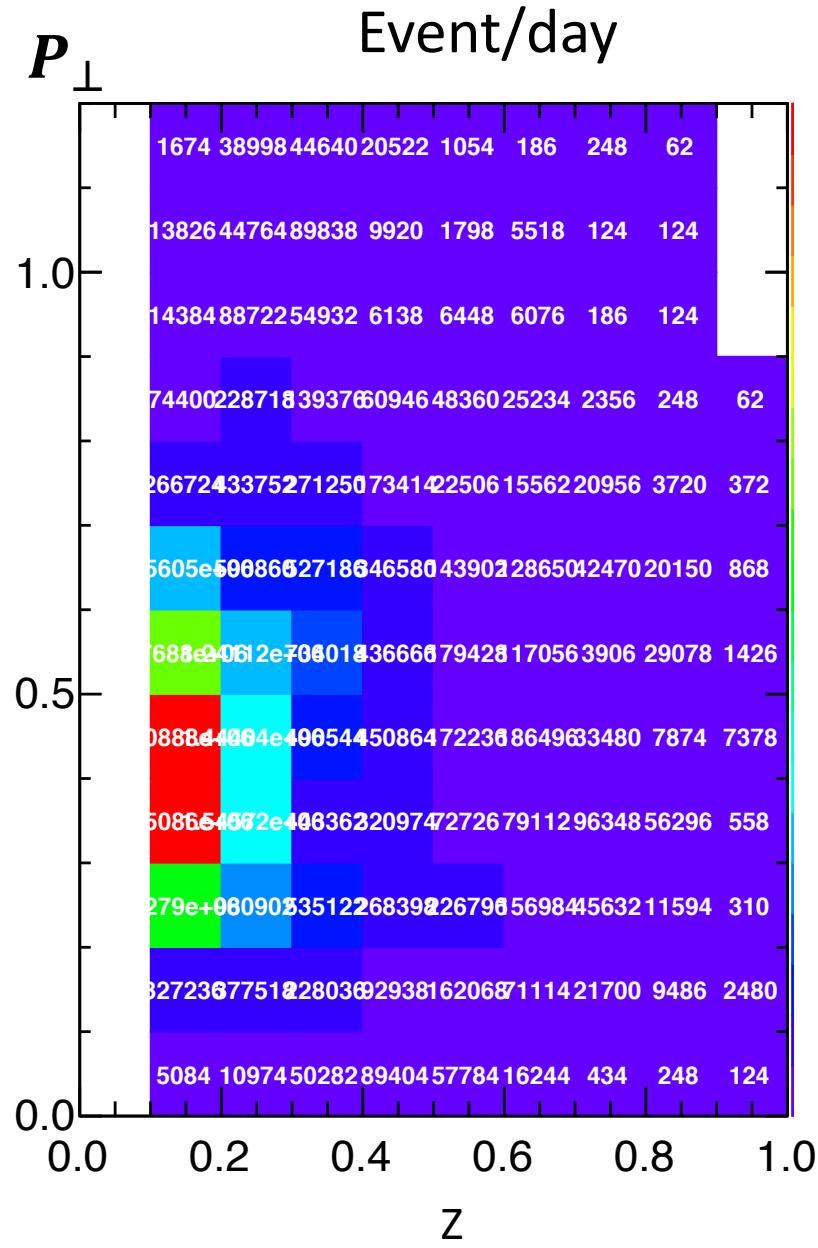
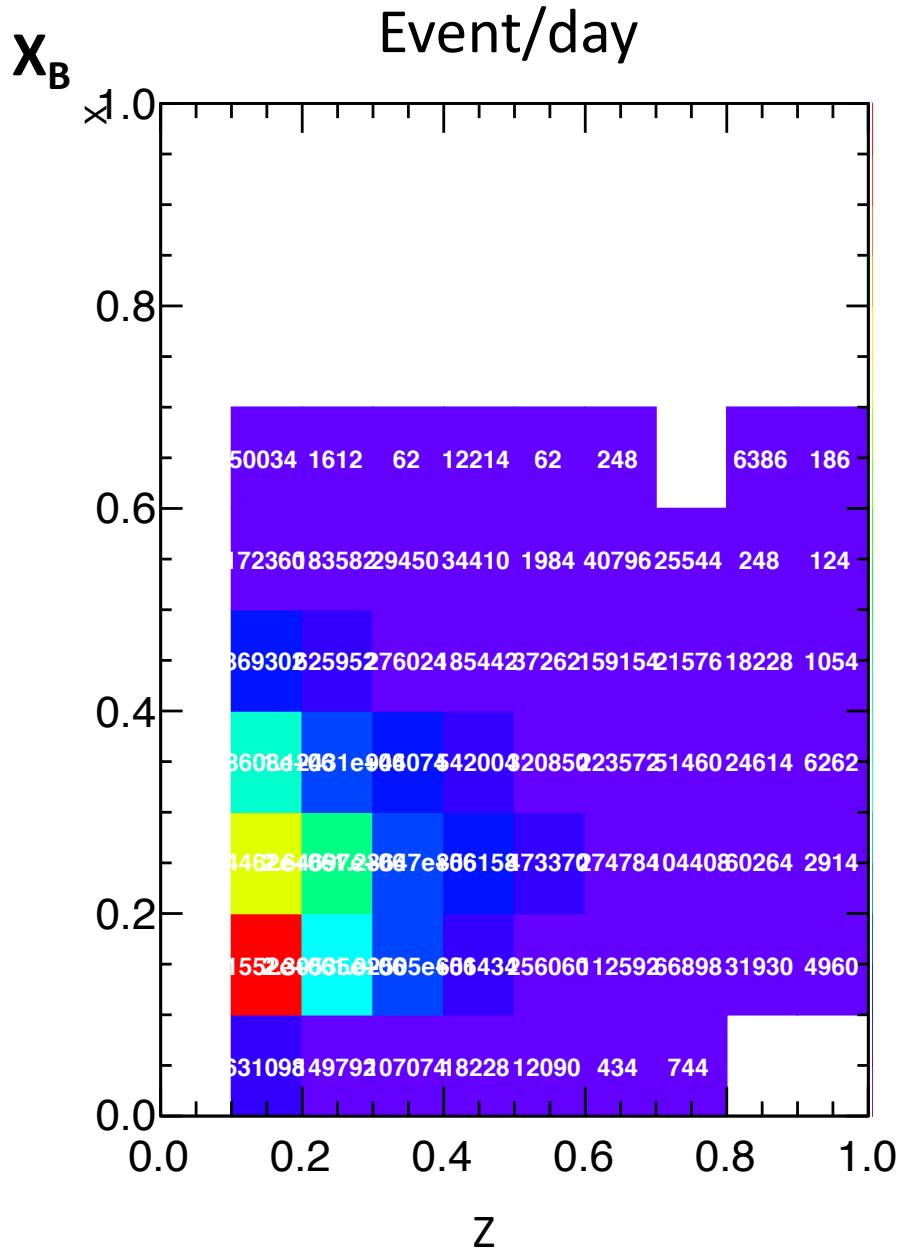


Luminosity: 1.35×10^{35}

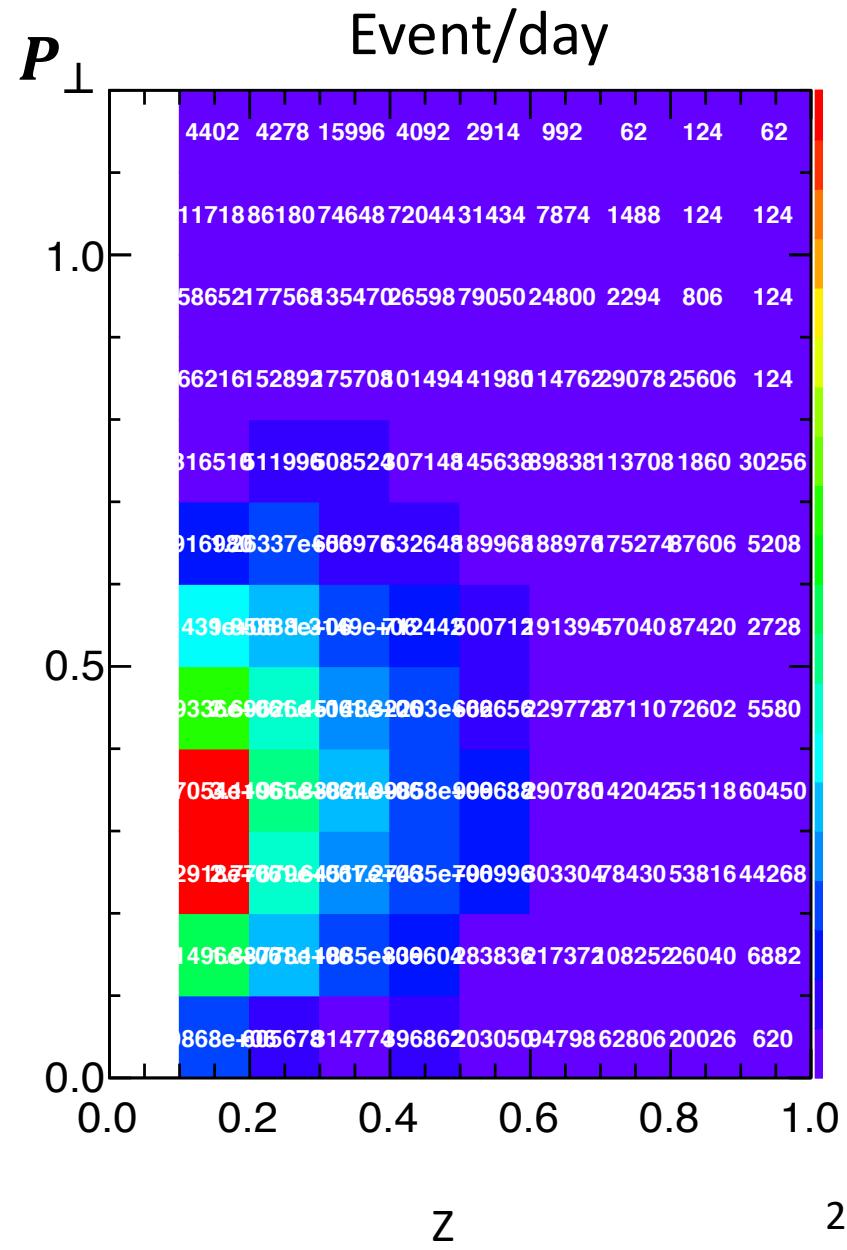
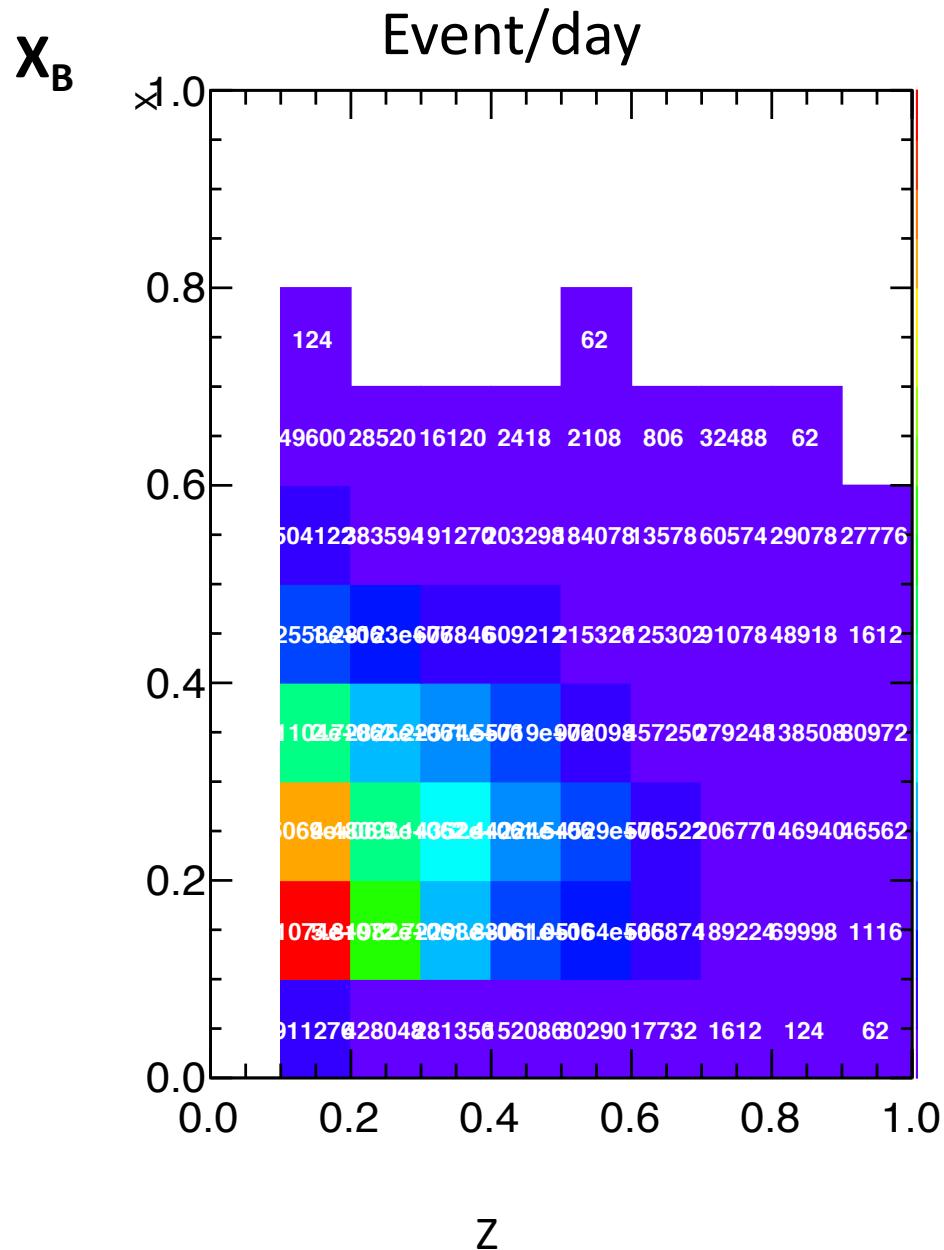
$Q^2 > 1$ and $W^2 > 4$

27

Polarized ${}^3\text{He}(e,e'\pi^-)$ SIDIS Rate



Polarized ${}^3\text{He}(e,e'\pi^+)$ SIDIS Rate



Asymmetry uncertainty estimation

$$\delta A = \frac{1}{\sqrt{N} \times P_{beam} \times P_{target}} \times 3$$

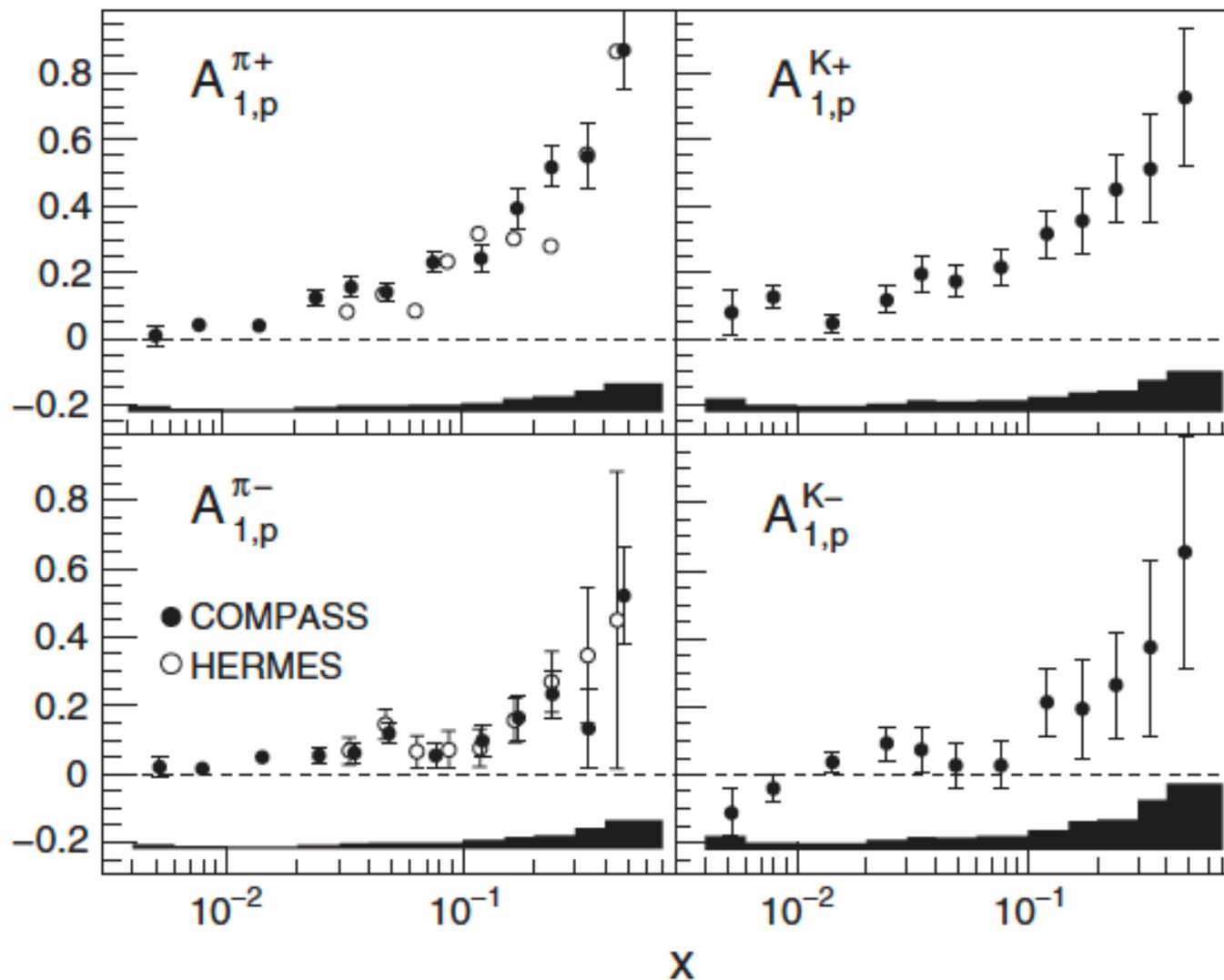
N: Number of events

P_{beam} : Beam polarization ~ 0.9

P_{target} : Target polarization ~ 0.5

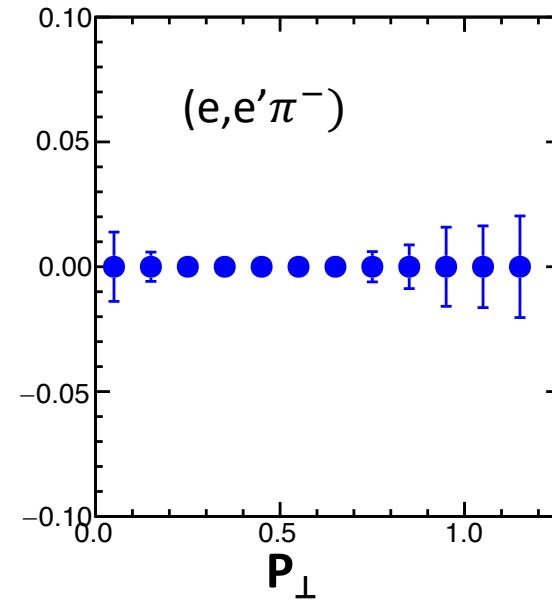
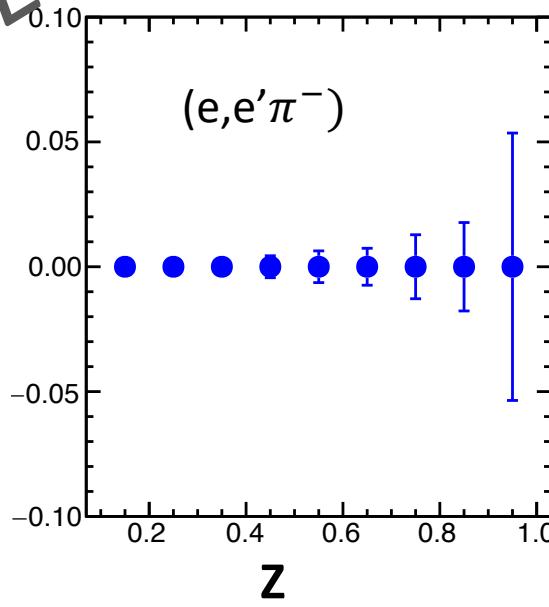
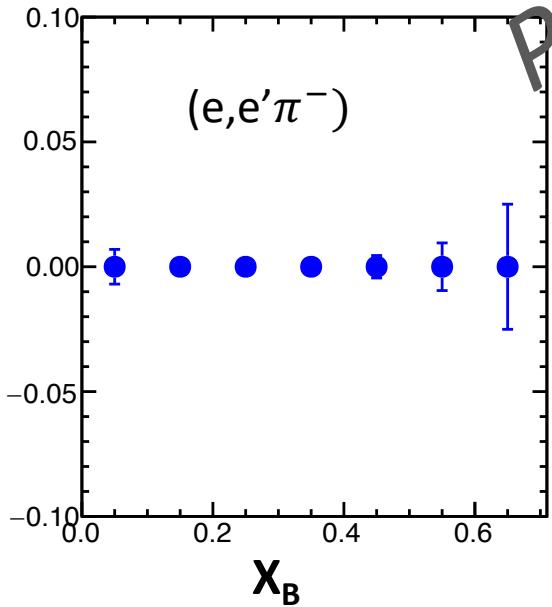
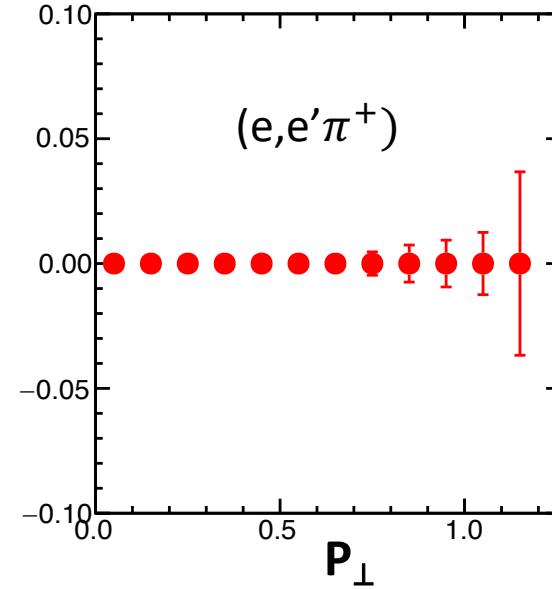
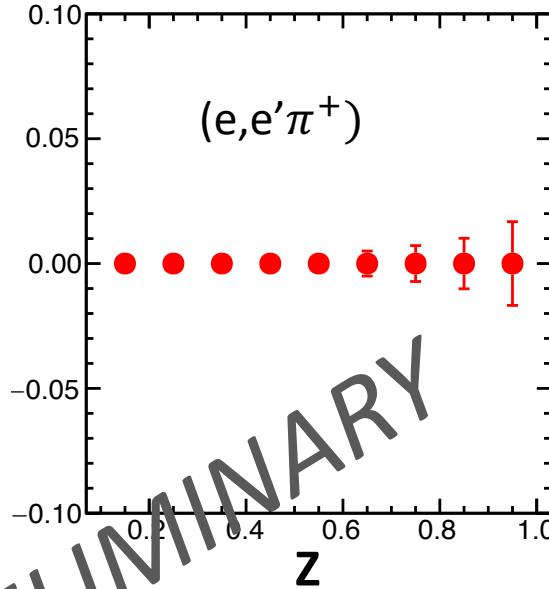
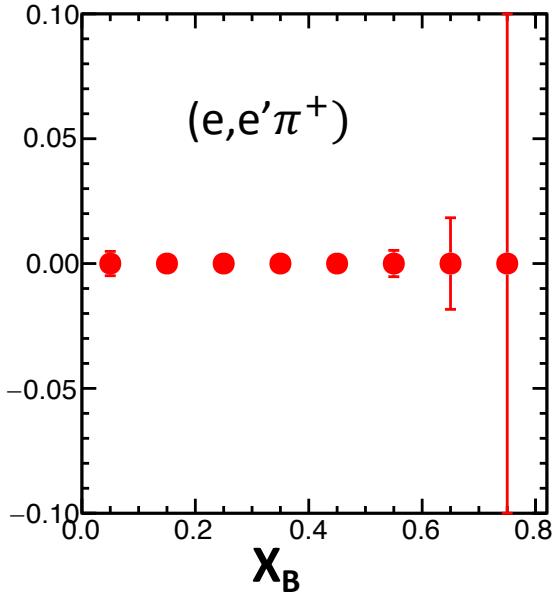
Luminosity: $1.35 \times 10^{35} / \text{cm}^2/\text{s}$

Existing Asymmetry Data on Proton



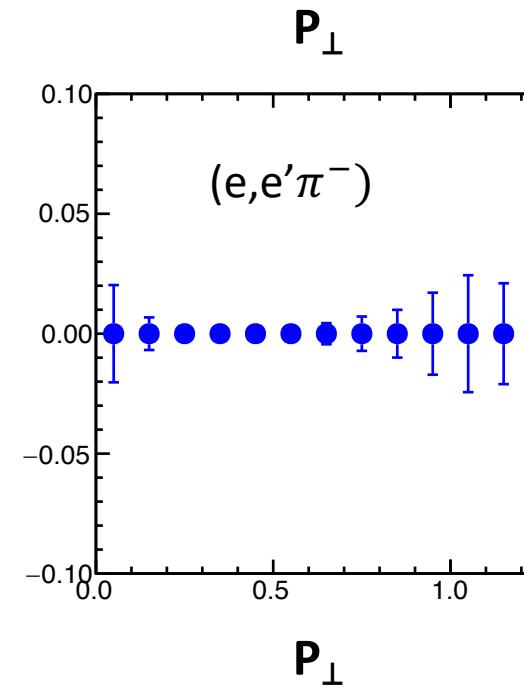
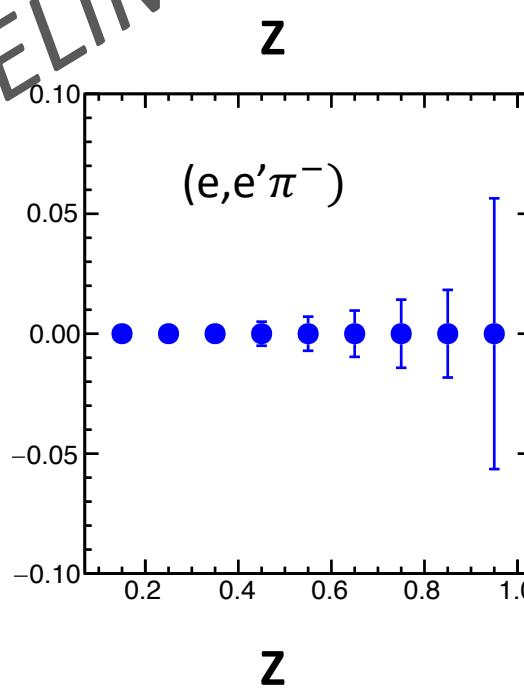
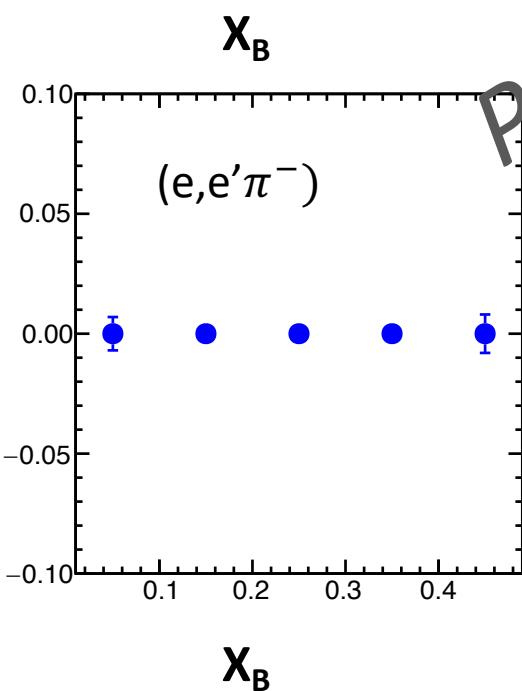
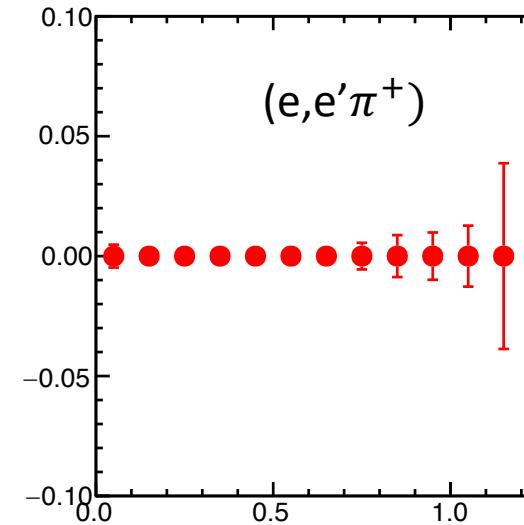
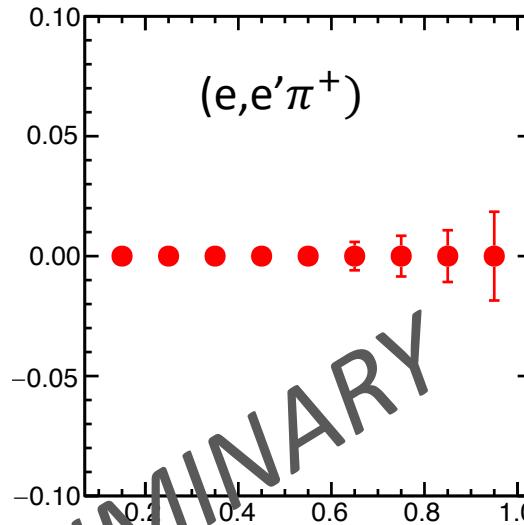
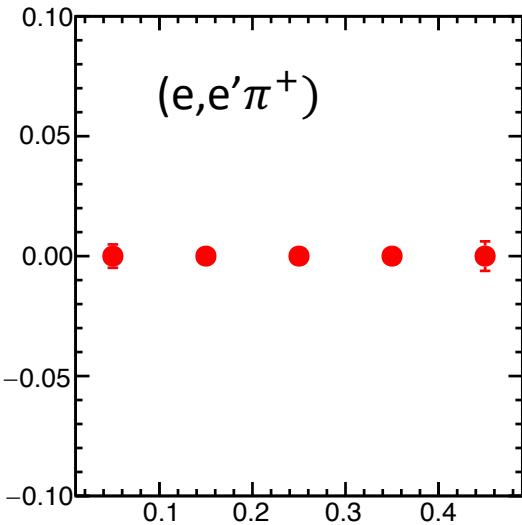
A. Aidala *et al* Review of Modern Physics (2013)

Asymmetry uncertainty / 1 day: Full range Q^2



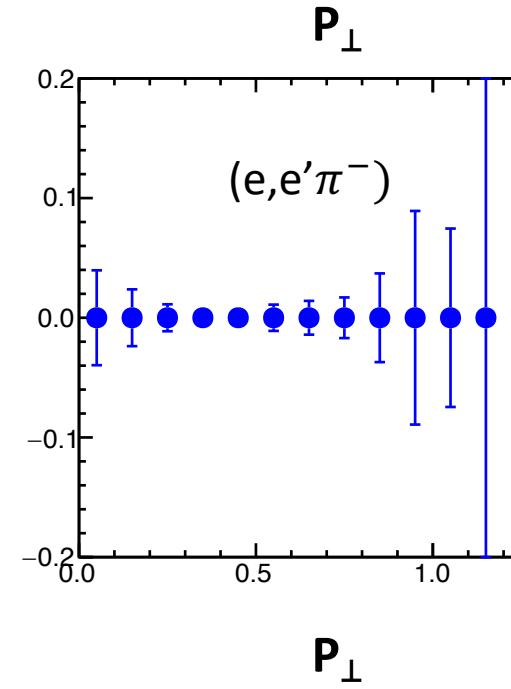
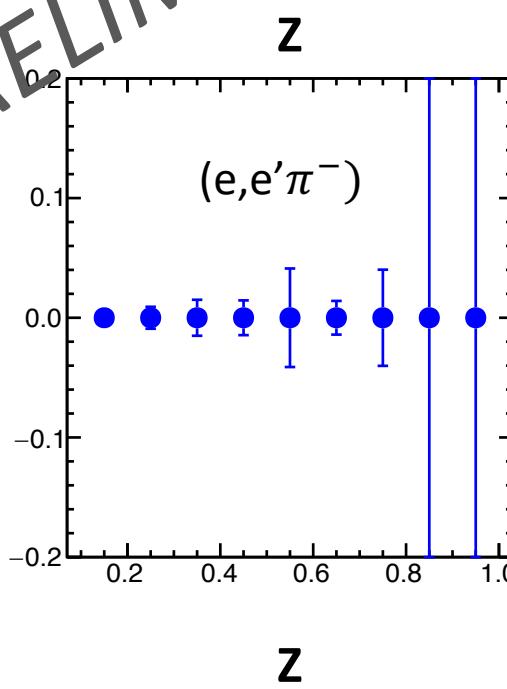
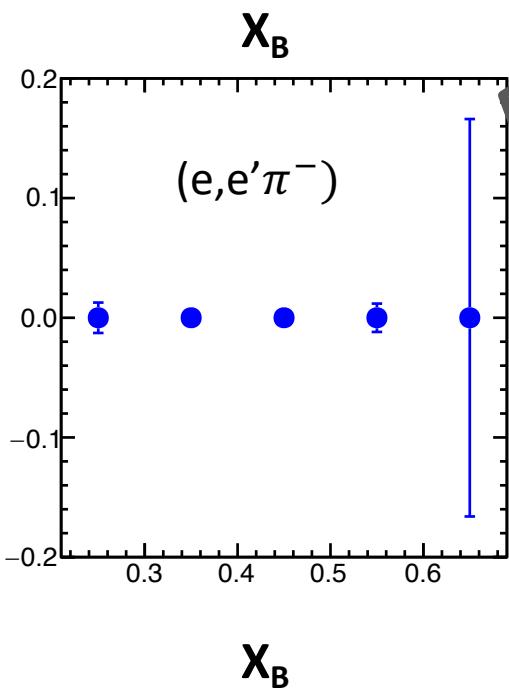
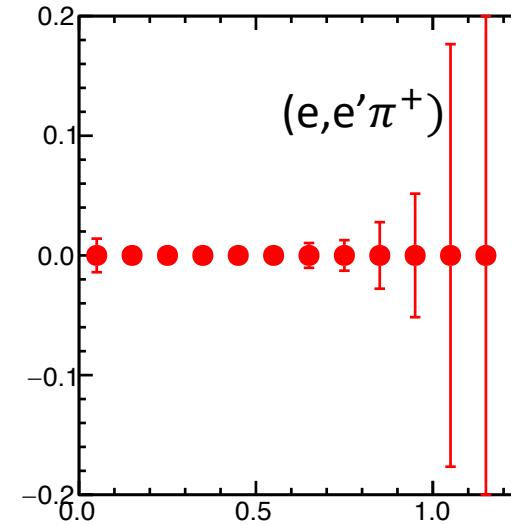
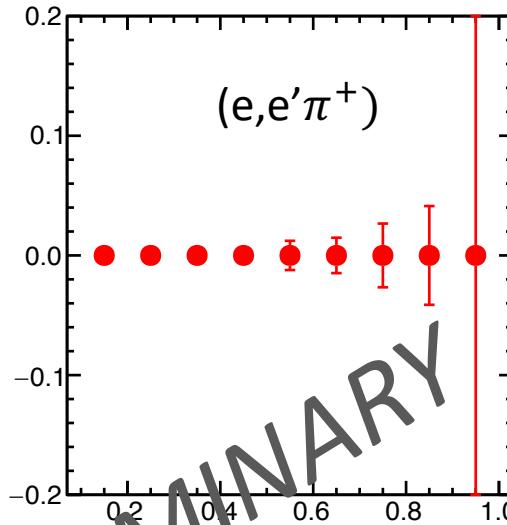
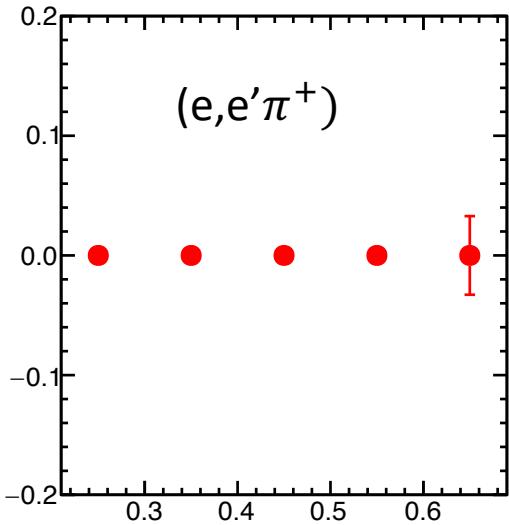
PRELIMINARY

Asymmetry uncertainty / 1 day: $1 < Q^2 < 3$



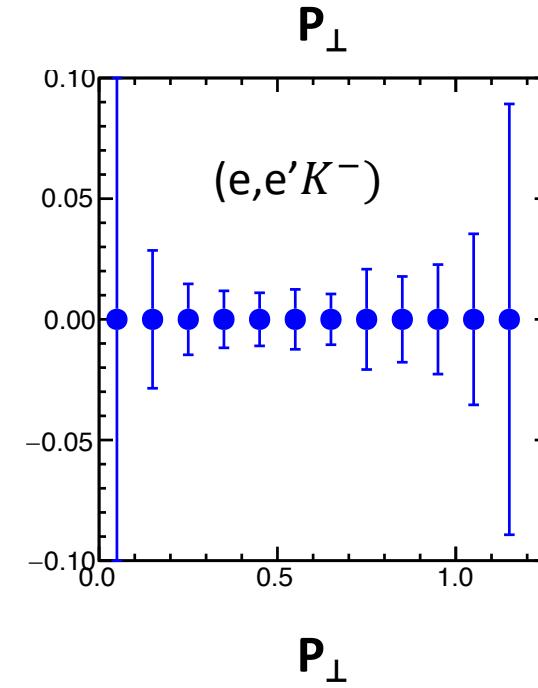
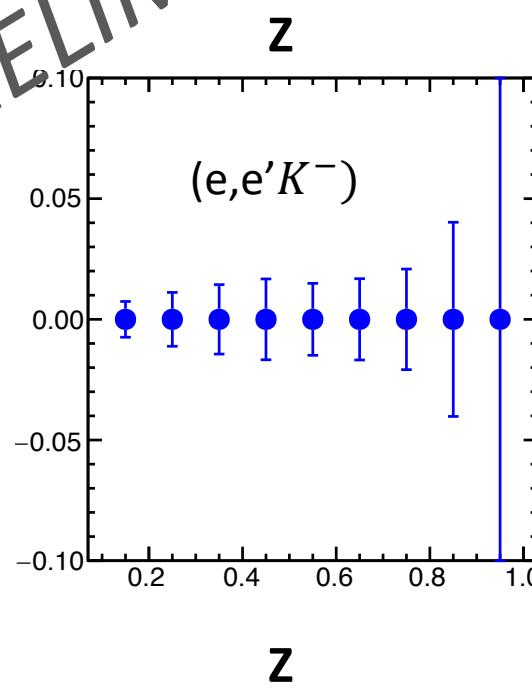
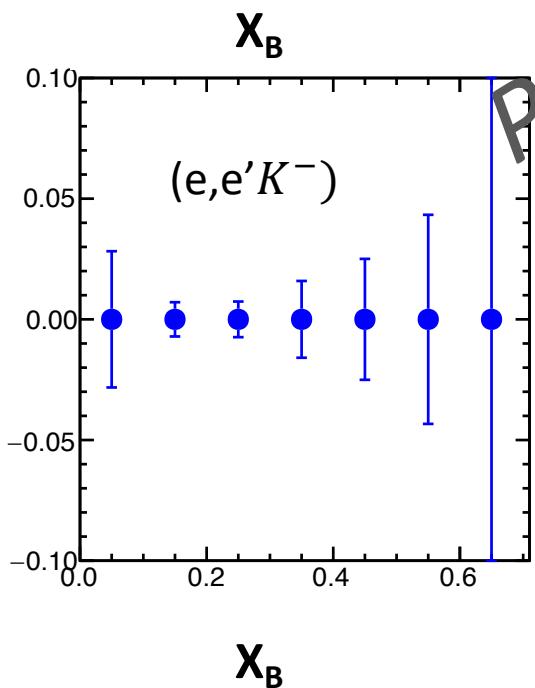
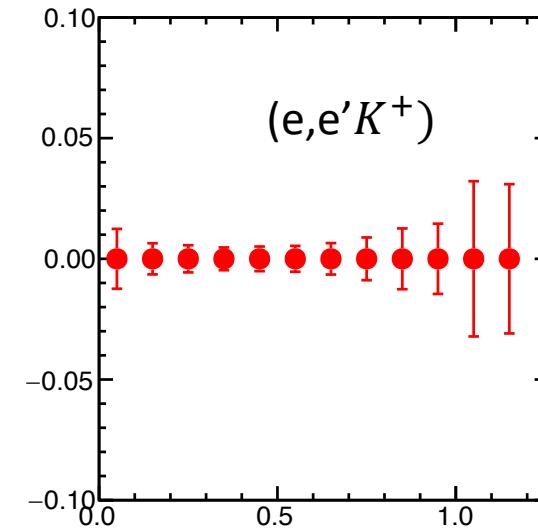
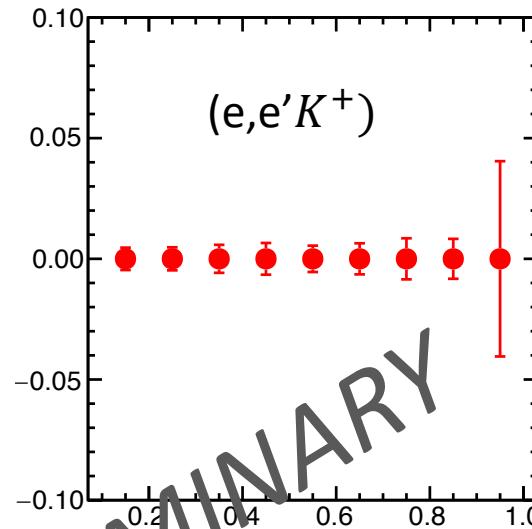
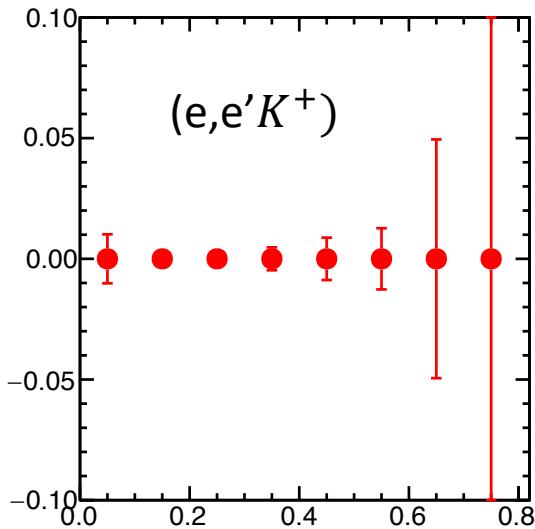
PRELIMINARY

Asymmetry uncertainty / 1 day: $4 < Q^2 < 6$



PRELIMINARY

Asymmetry uncertainty / 1 day: Full range Q^2



CLAS12 + polarized He3 target:

- Determine spin-dependent inclusive DIS and SIDIS from neutron with unprecedented
- Statistical precision over an unmatched kinematic range.
- Can uniquely explore TMDs and polarization of sea quarks in the nucleon

Thank you !