Jefferson Lab
Exploring the Nature of Matter

Double spectators tagging from unpolarized and Polarized ^{3}He at EIC

Dien Nguyen

SRC-EMC workshop, 03/26/2021

In collaboration with I. Ivica, J. R. Pybus, E. P. Segarra, A. Jentsch, M. Baker, Or Hen, D. Higinbotham, Zhoudunming Tu, A.S. Tadepalli.

Physics motivation

Nucleon spin question:

$$S_z^N = S_z^q + L_z^q + J_z^g = \frac{1}{2}$$

-> Spin structure function

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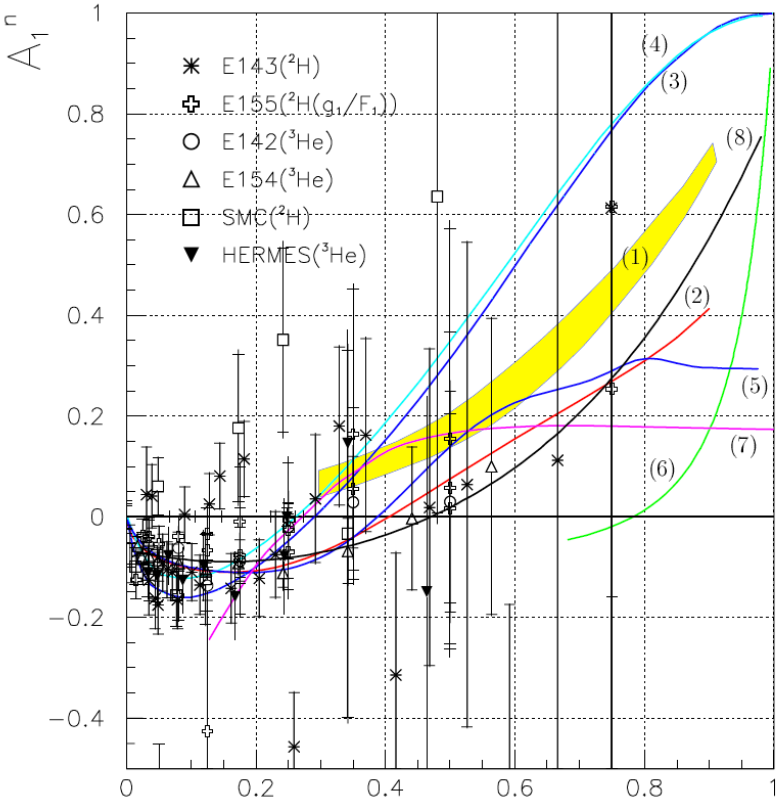
Asymmetry A1n measurement:

$$A_1(x,Q^2) = \frac{\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow}}{\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow}} \approx \frac{g_1(x,Q^2)}{F_1(x,Q^2)}$$

An example: A1n measurement



Xiaochao's thesis

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$$A_1^n = \frac{1}{P_n}\frac{F_2^{^3\mathrm{He}}}{F_2^n}(A_1^{^3\mathrm{He}} - 2P_p\frac{F_2^p}{F_2^{^3\mathrm{He}}}A_1^p)$$

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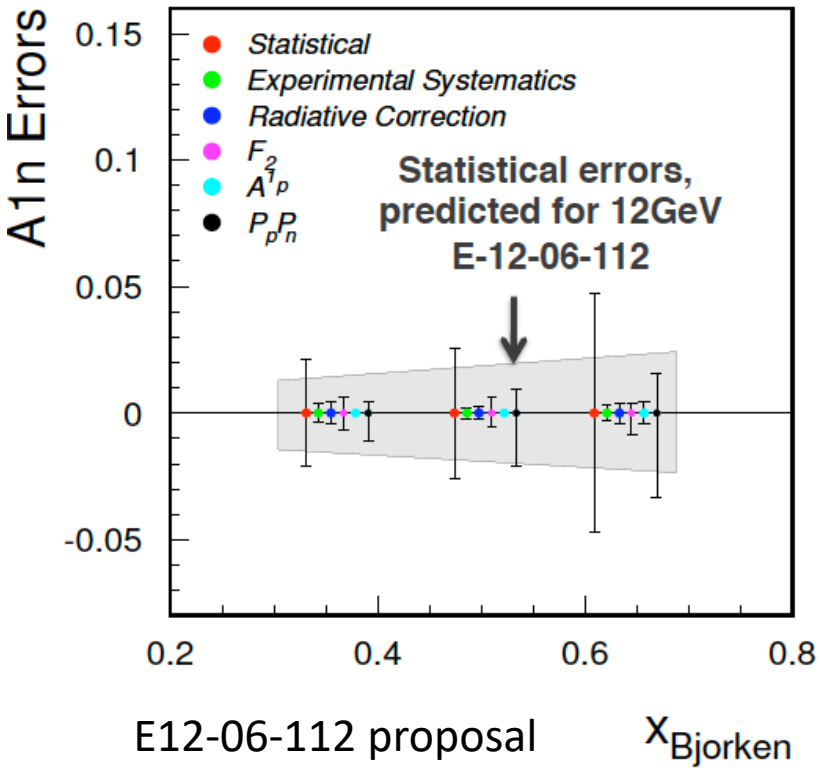

Talks: Efrain, Kuhn, Simon,

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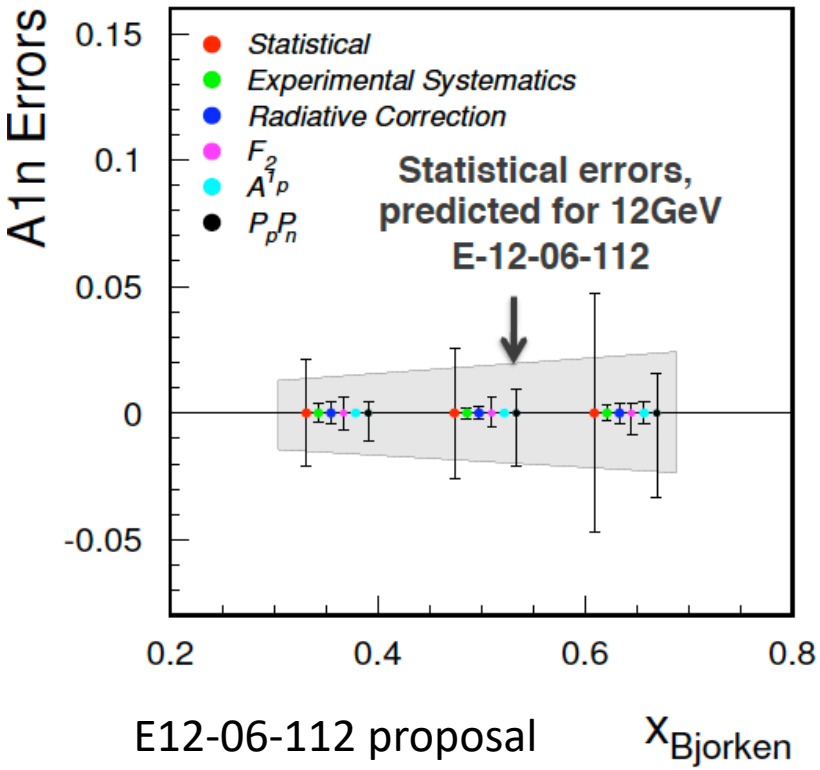
- Effective neutron, proton polarization
- Structure functions F2
- A1p uncertainty.

An example: A1n measurement



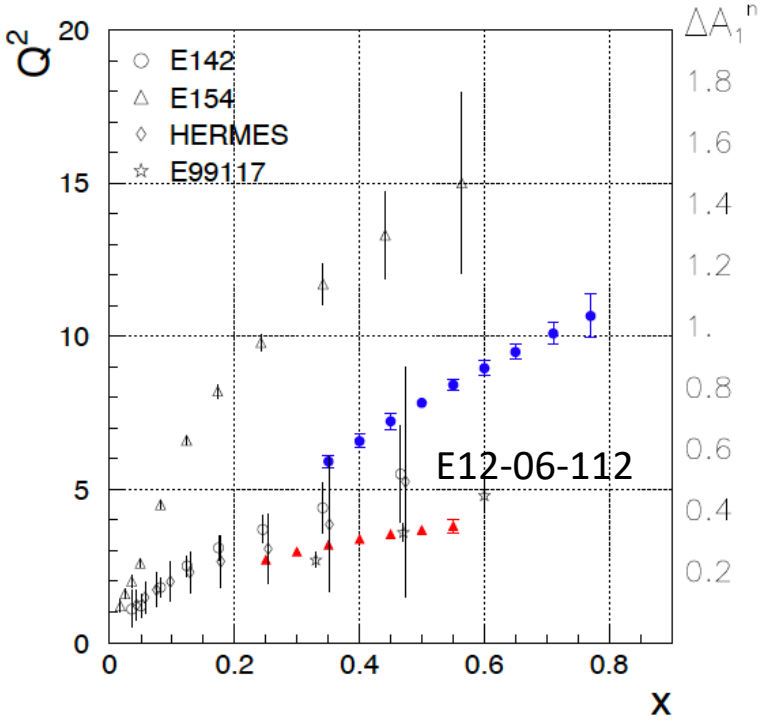
E12-06-112 proposal

➡ Tagging measurement from He3

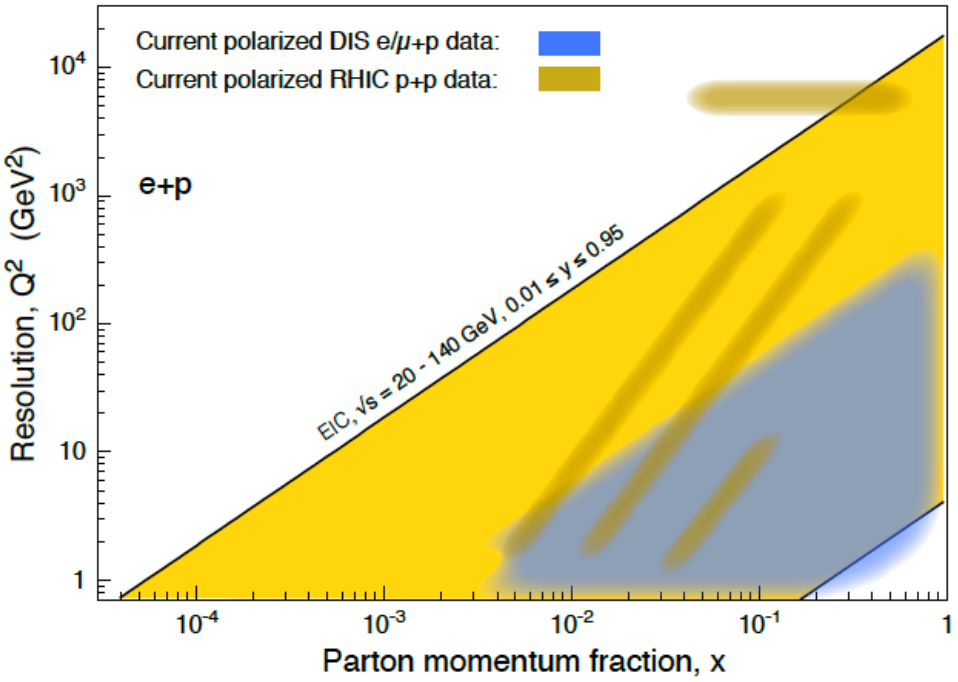
Talks: Weiss, Kuhn, Cosyn, Simon

Q2 dependence study

A1n world data



EIC x:Q2 coverage

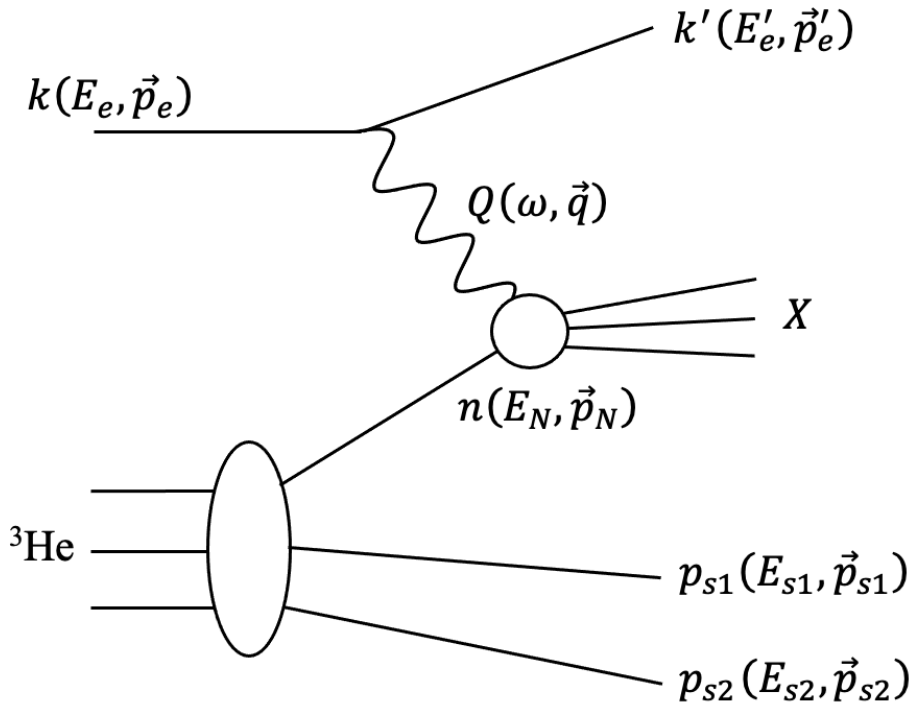


EIC yellow report

EIC gives:

- Unique opportunity for tagging measurement
- Large coverage in x and Q2

Double spectators tagging from ^{3}He at EIC

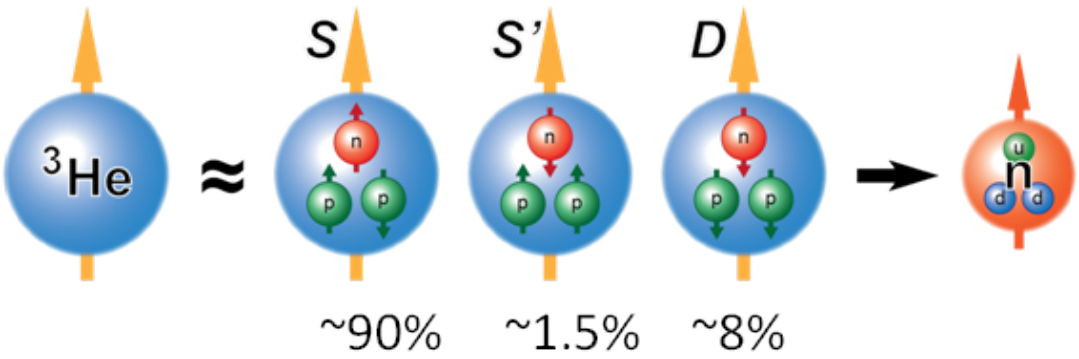


Talks: Weiss, Wim, Kuhn,

- Select the active nucleon in the reaction and break up channel
- Suppress the contribution of non-nucleonic degree of freedom
- “Effective” free neutron target

Polarized ^{3}He Ion is possible for EIC

Talks: Simon



Neutron polarization: Pn ~ 87%
Proton polarization: Pp ~ 2.7%

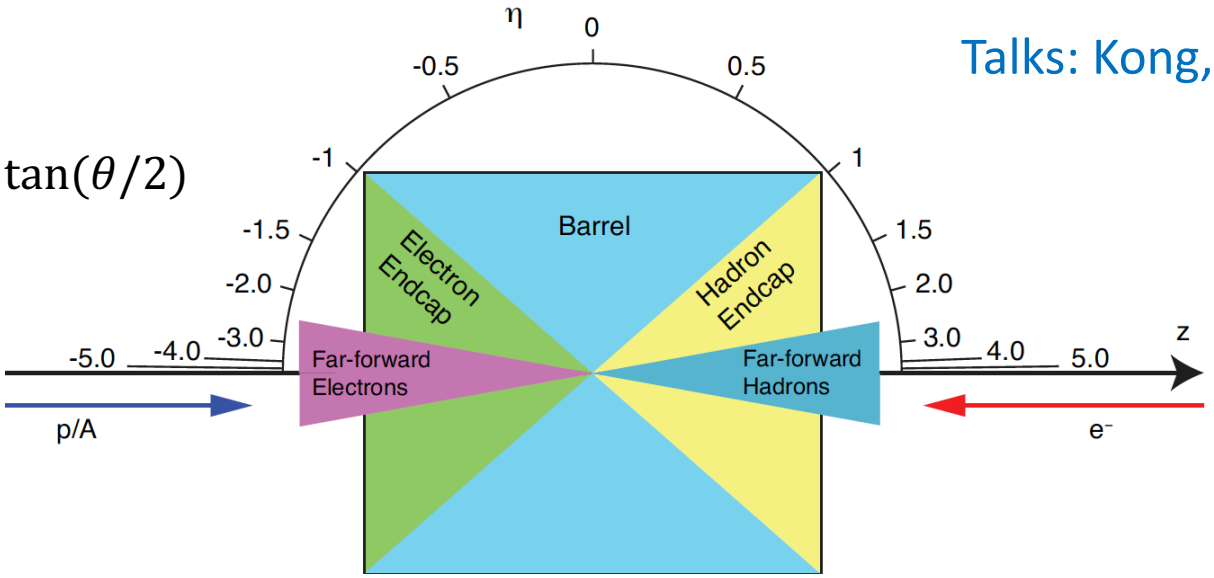
- ❑ Effective polarized neutron target
- ❑ Crucial for neutron spin structure study

Double tagging can provide “Effective” free polarized neutron

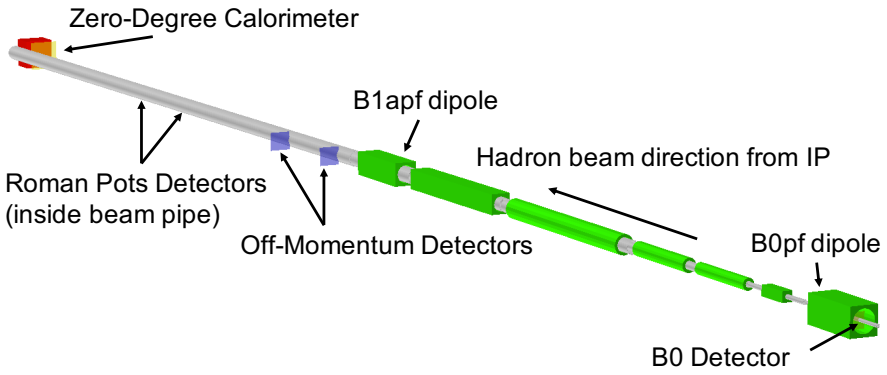
Far forward detector at EIC

Talks: Kong, Florian, Doug

$$\eta = -\ln\tan(\theta/2)$$



- Particles outside the main detector: θ < 35 mrad
- Protons and light nuclei: B0 tracker, Off-momentum detectors and Roman Pots
- Neutrons: Zero-Degree-Calorimeter (ZDC)



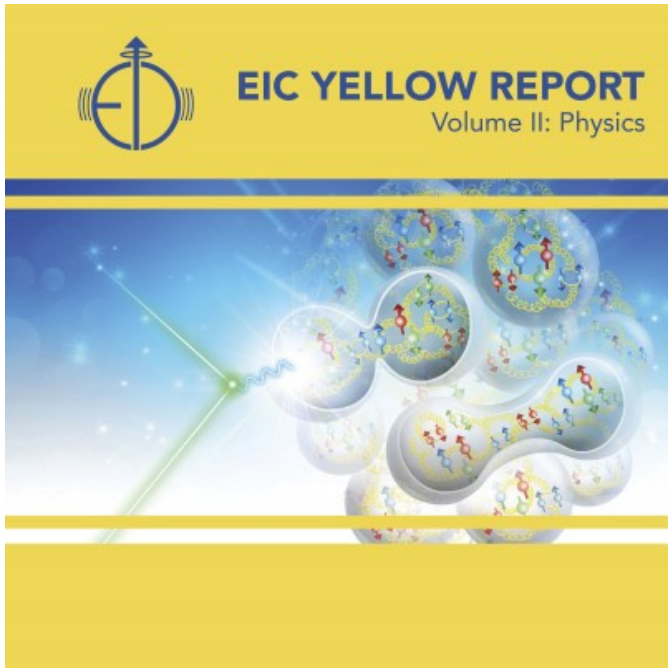
Event generator and processing

Generator:

- CLASDIS for inclusive and SIDIS based on PEPSI
- Unpolarized and polarized PDFs
- Generate event at fixed target frame
- No nuclear effect

➡ Boosted to collide frame

Section: 7.3.8



Many Many thanks to: A. Harut, I. Ivica, J. R. Pybus, E. P. Segarra, A. Jentsch, M. Baker, Or Hen, D. Higinbotham, Zhoudunming Tu, A.S. Tadepalli.

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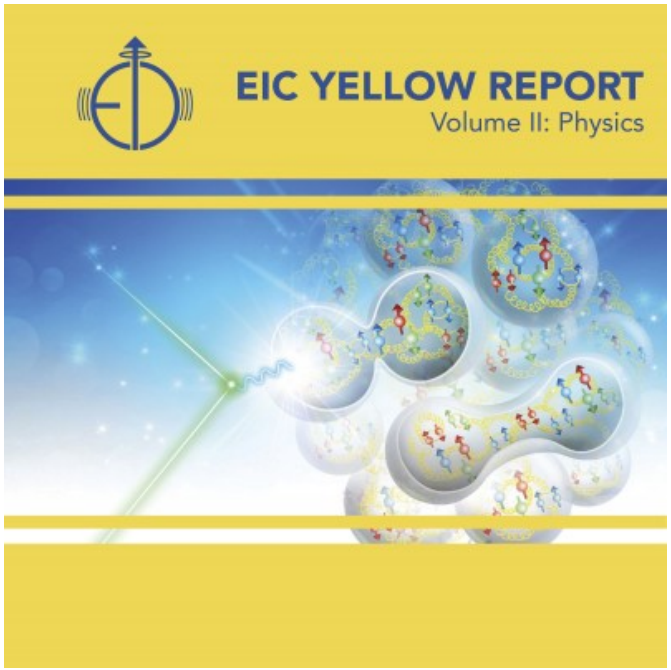

Fermi-correction:

- Using the light-cone spectral function
- Adding the motion of active nucleon
- Determine kinematic of spectators
- 2BBU, 3BBU, SRCs

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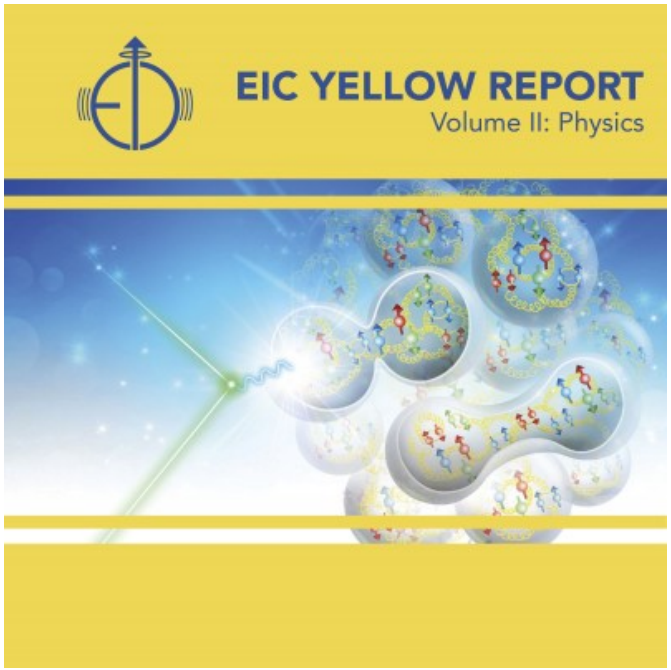

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EIC simulation: EIC smear and EIC root

- Acceptance and resolution

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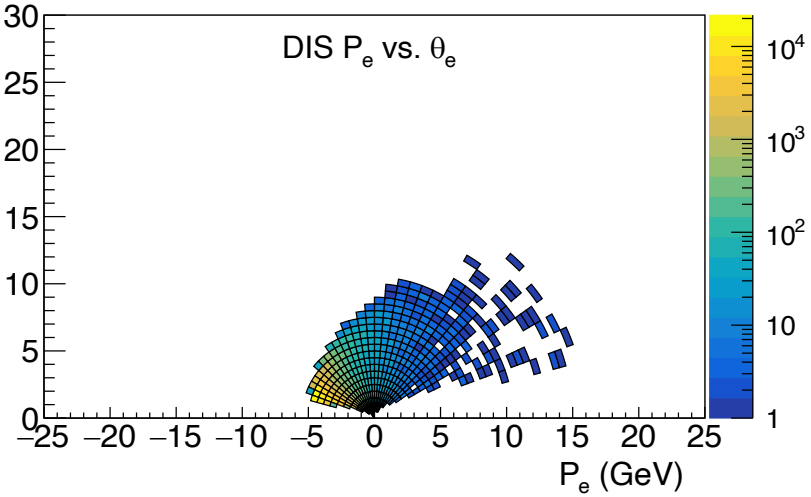
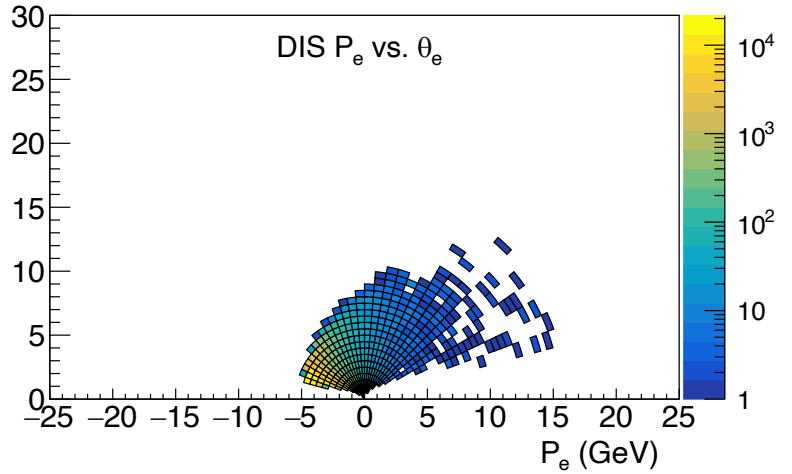
DIS ^{3}He(e, e'pp)X: Electron kinematic

3BBU

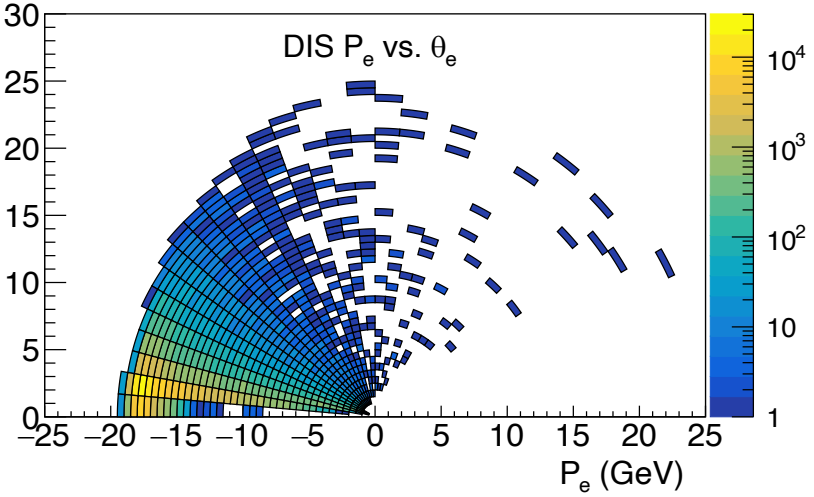
SRC

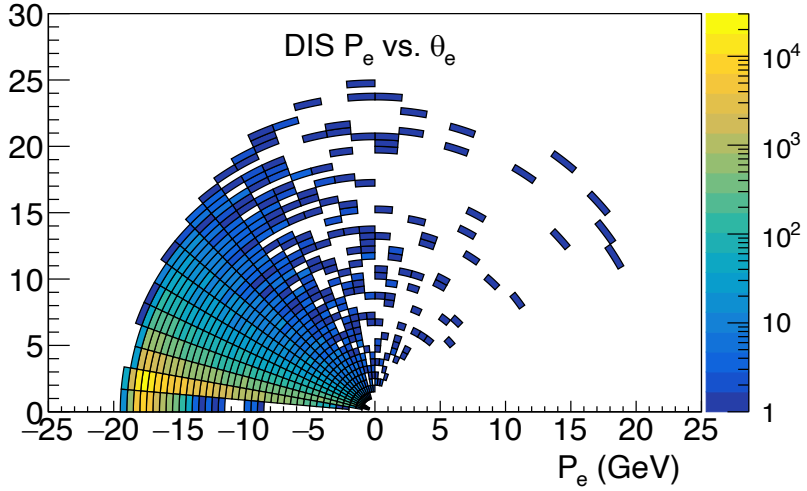
41x5





110x18

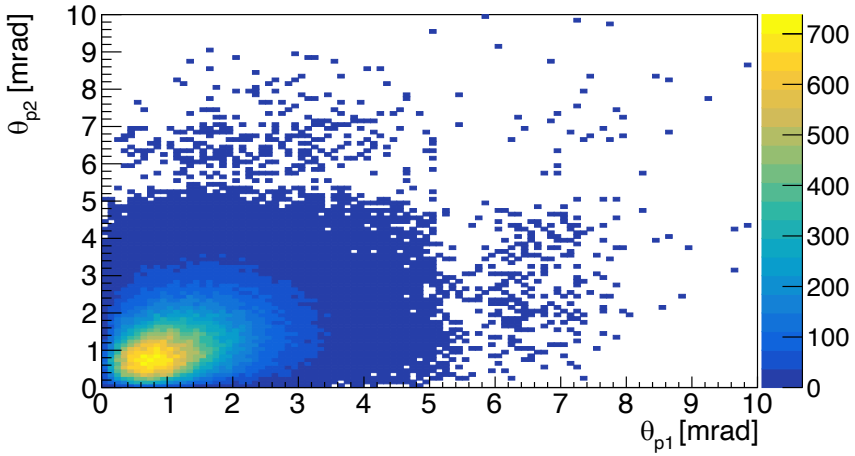


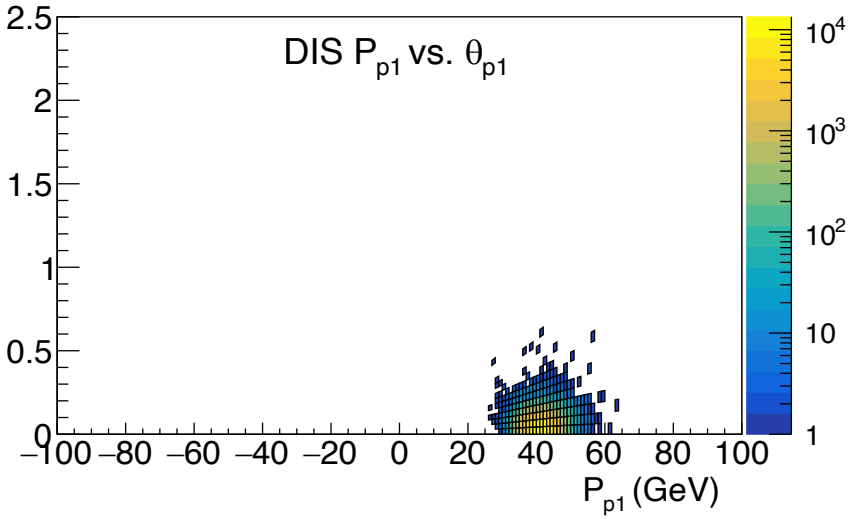


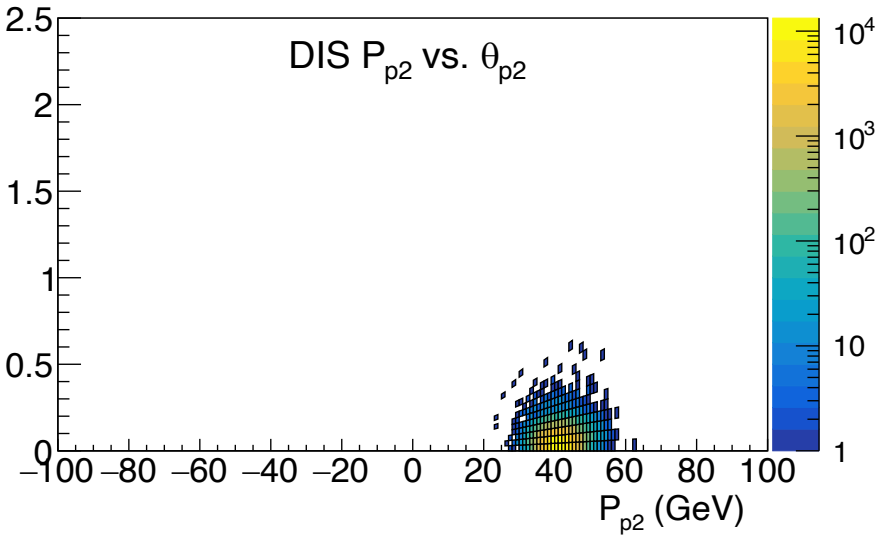
DIS ^{3}He(e, e'pp)X: Spectator protons

eN: 5x41

3BBU

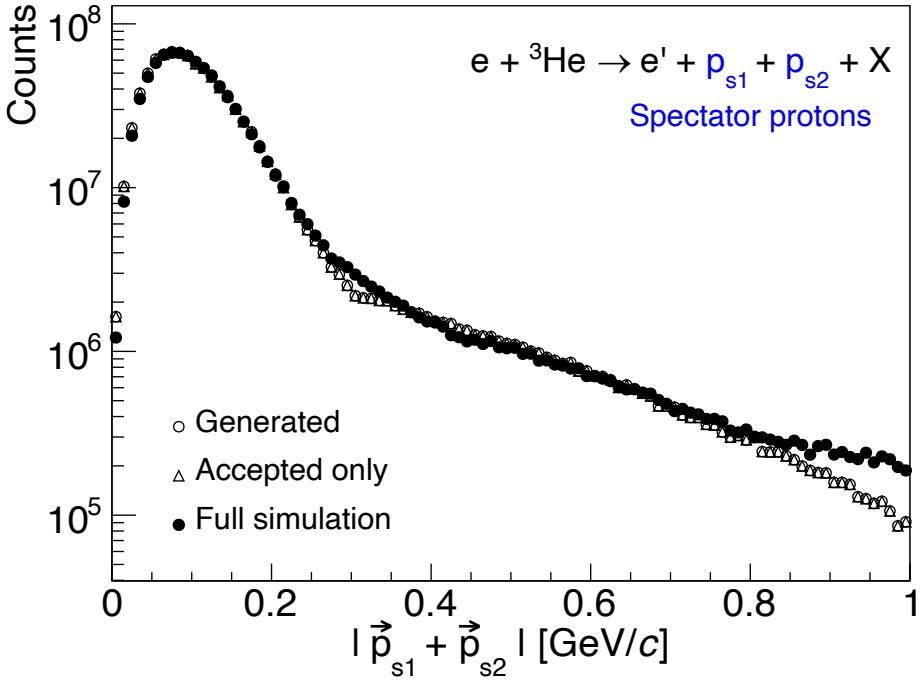




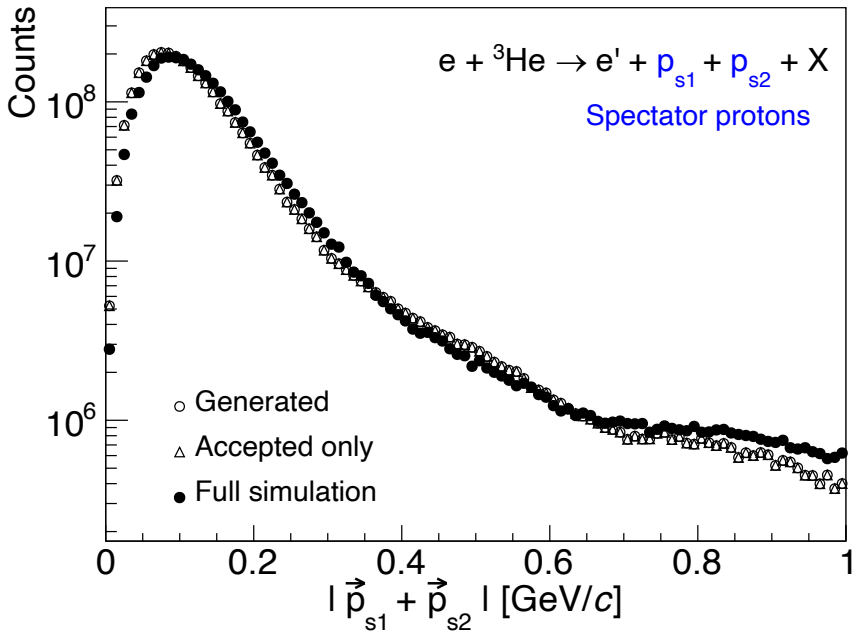


Effective “Free Neutron” target

IRF eN: 5x41



IRF eN:18x110

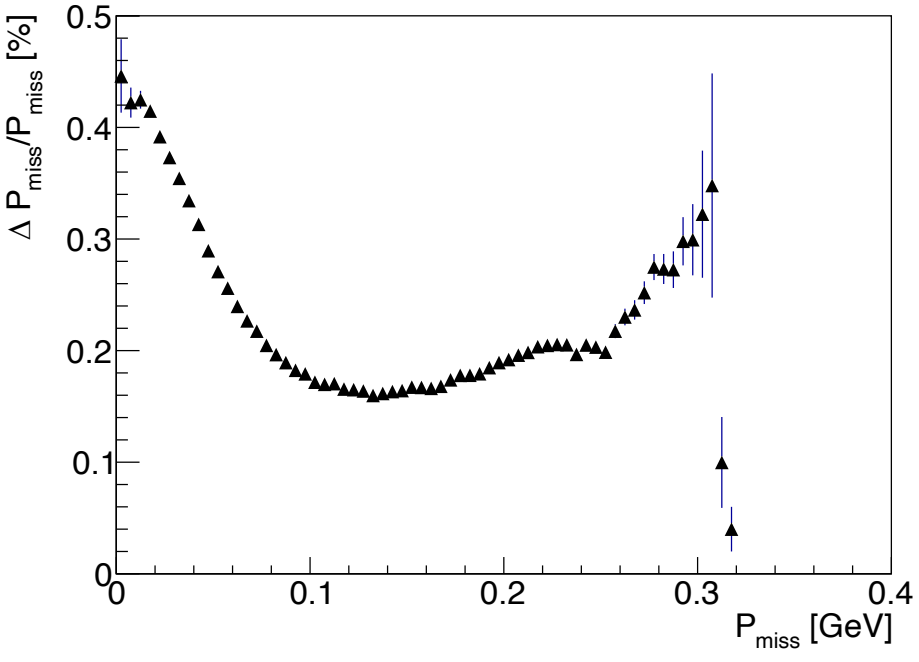


<u>Advantage of the double tagging measurements:</u>

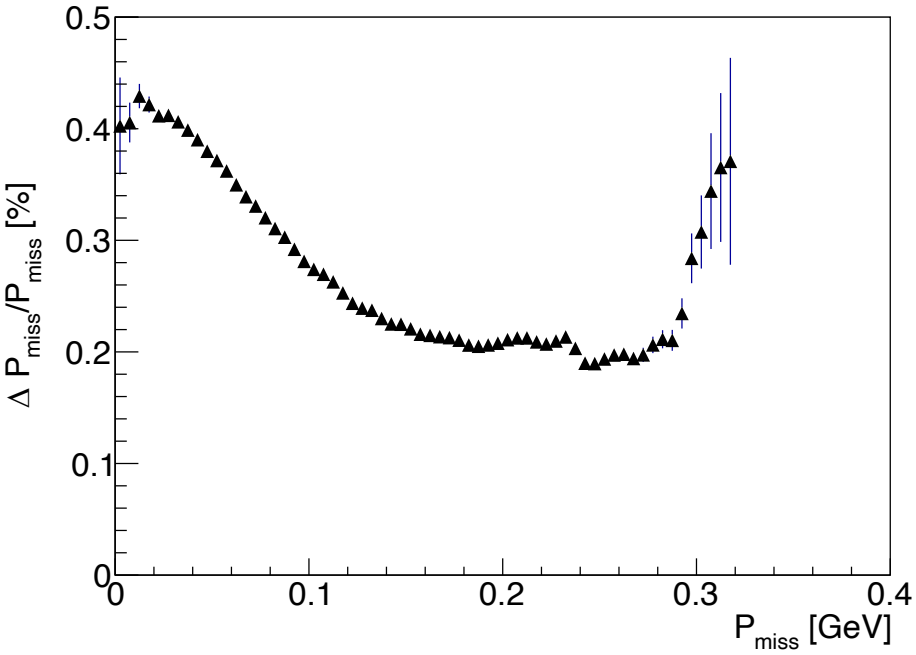
- ❑ In Ion Rest Frame (IRF): Constraint the total momentum of two spectator nucleons to low momentum provides almost “Free neutron” target.
- ❑ Minimize the nuclear correction model effects.

Missing Momentum resolution

5x41: 3BBU



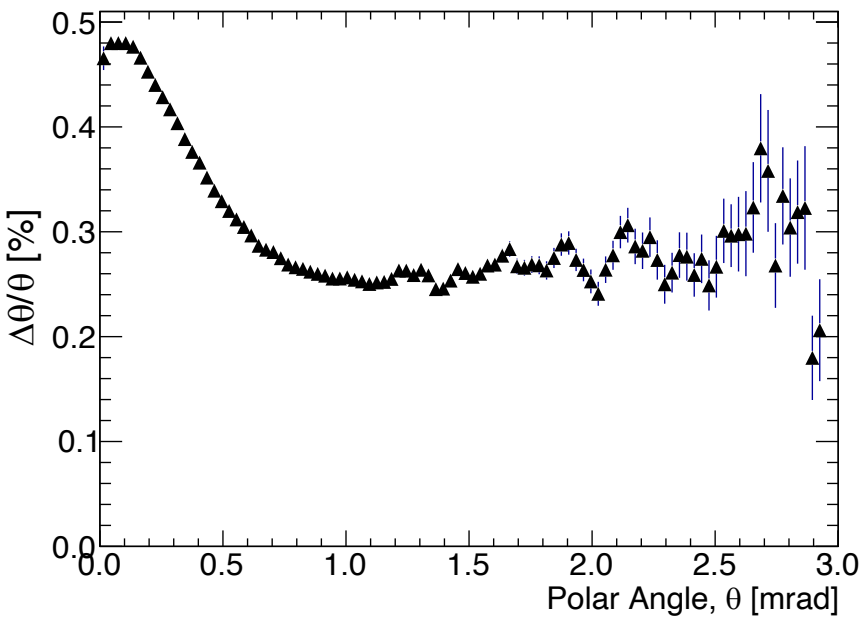
18x110: 3BBU



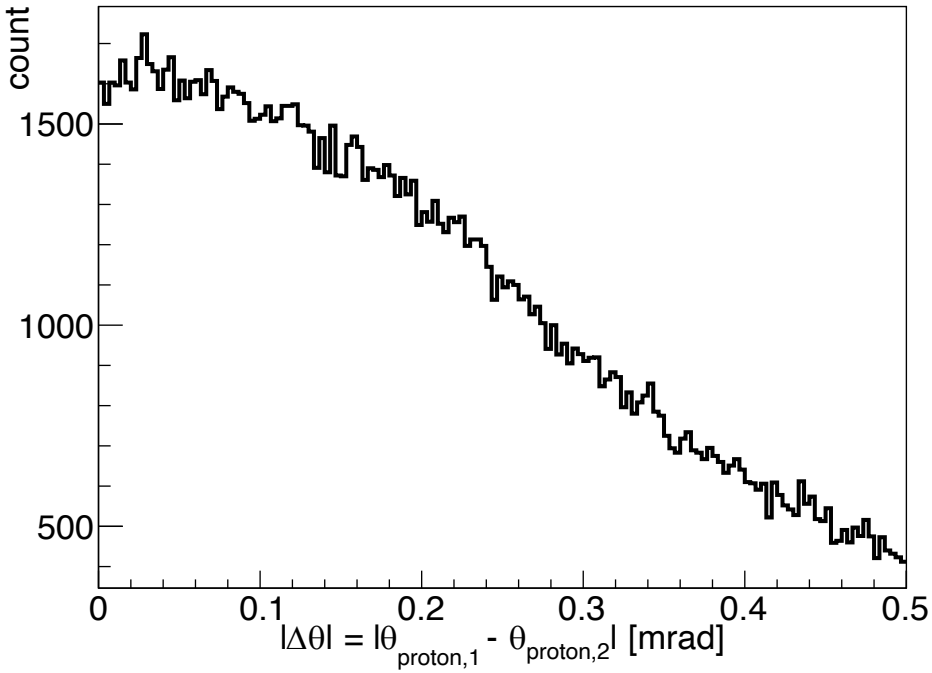
$$P_{miss} = \overrightarrow{P_{s1}} + \overrightarrow{P_{s2}}$$

Angle resolution, and separation

18x110: 3BBU: Resolution



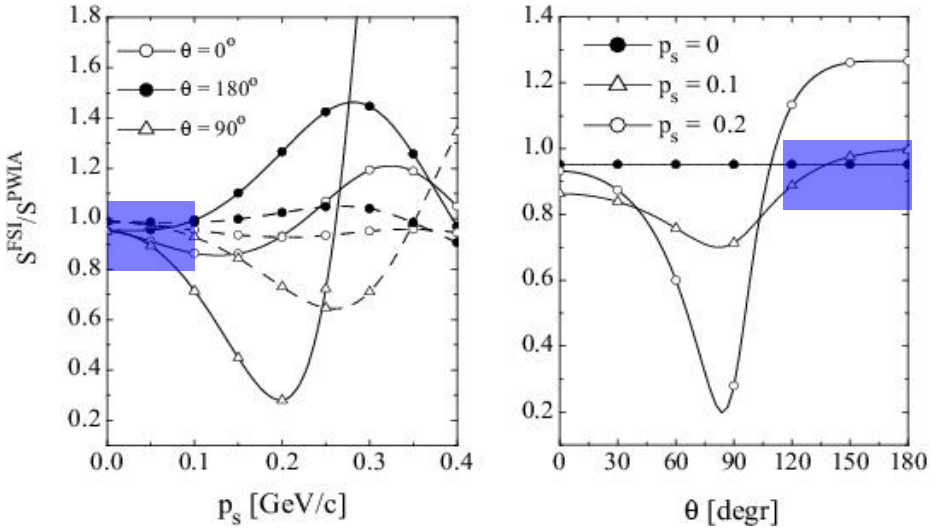
18x110: 3BBU: separation

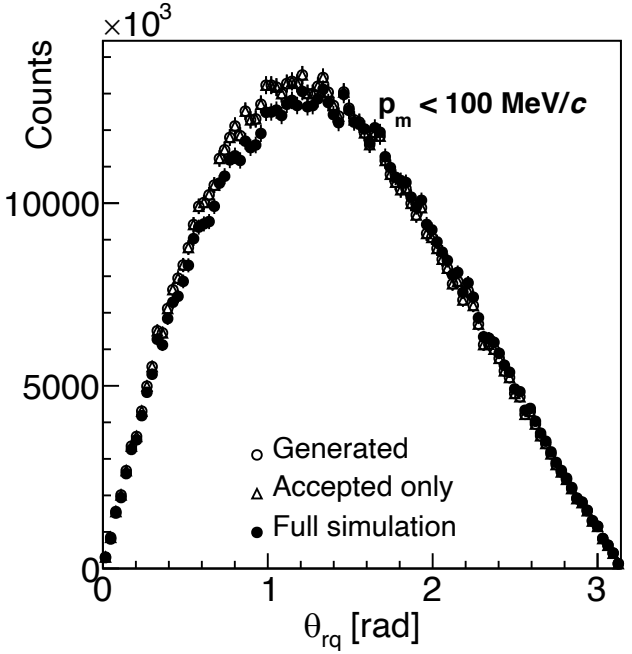


Angle distribution: θ_{rq}: FSI

eN: 5x41

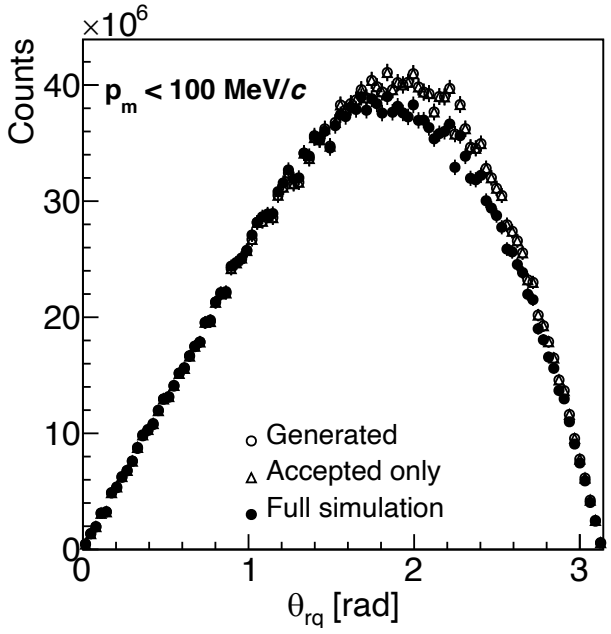
Ciofi degli Atti and Kopeliovich, Eur. Phys. J. A17(2003)133





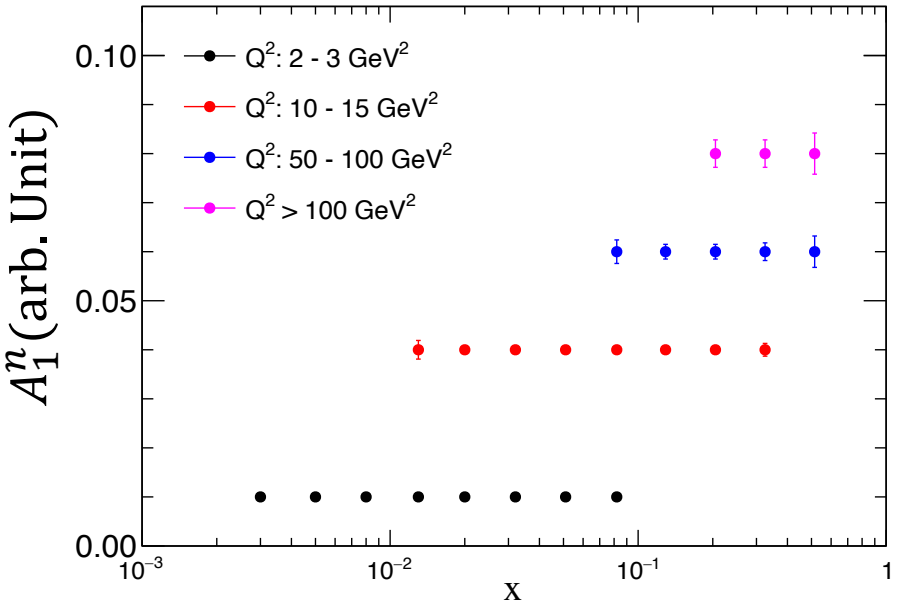
Talks: Weiss, Wim, Kuhn

eN: 18x110



Statistic Uncertainty projections

5x41, $\sqrt{s}$=



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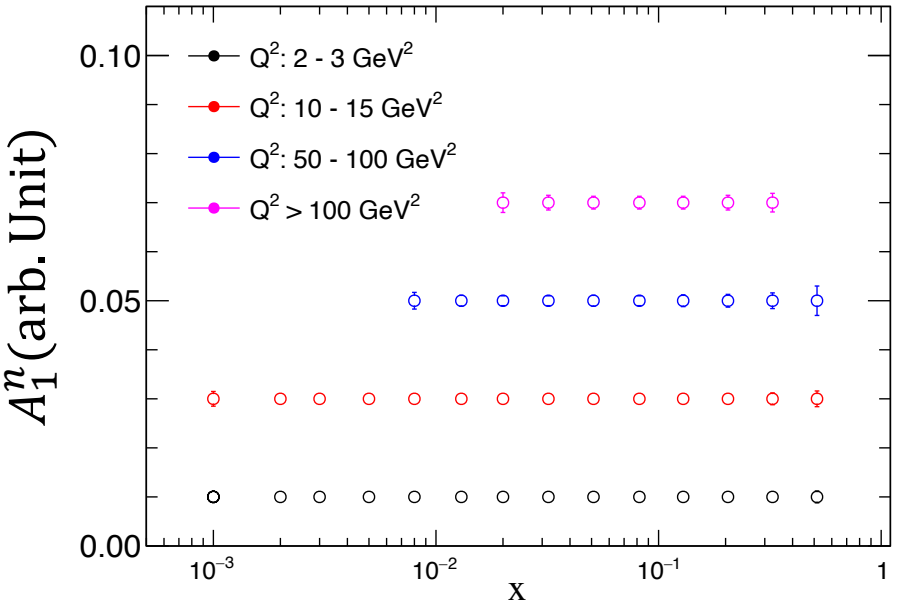

- DIS event: Q2 > 2, W2 > 4 with double protons
- Integrated luminosity: EIC 10 fb-1
- Polarization: Pe = 0.7 and Pn = 0.7
- Error bar: Only statistic absolute uncertainty

Other potential physics measurements

- Free neutron structure function
- SIDIS: flavor tagging, TMD
- DVCS: Neutron GPD
- Spin-EMC dependence
- QE ground states
- And More

Talks: Simon, Zhihong

Thank you