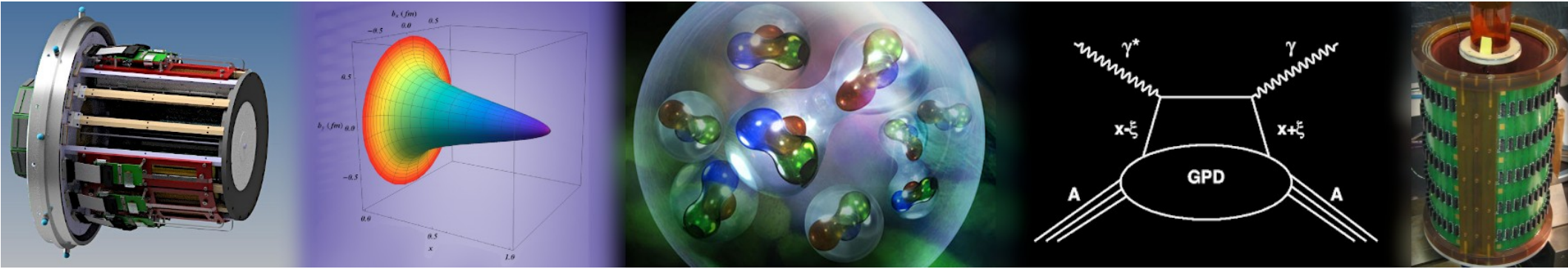
Nuclear Physics Working Group



Raphaël Dupré

Univ. Paris-Saclay

Disclaimer

I had very little time to prepare the session

- Many collaborators are travelling or otherwise unavailable today
- I will present quickly all projects, but the discussion can allow for exchanges with the people that could make it today

I will present the main projects brewing in CLAS NPWG

- Some are approved, some are still in development
- I was surprized by the number of projects
  - **The number of weeks of running will be an important issue**
  - **CLAS12 high luminosity will play an important rôle in this regard**
- Several require construction of new equipments (mainly targets)

Nuclear Spin Structure Functions

Study the EMC effect

- Look into the polarized structure function
  - **Searching for nuclear modifications and polarized EMC effect**
- Completely new approach to the problem

Runs with RG-C in FY28

- Should start the setup by the time CEBAF 2037 exercise is completed
- Yet, it is still a very important project in the short term

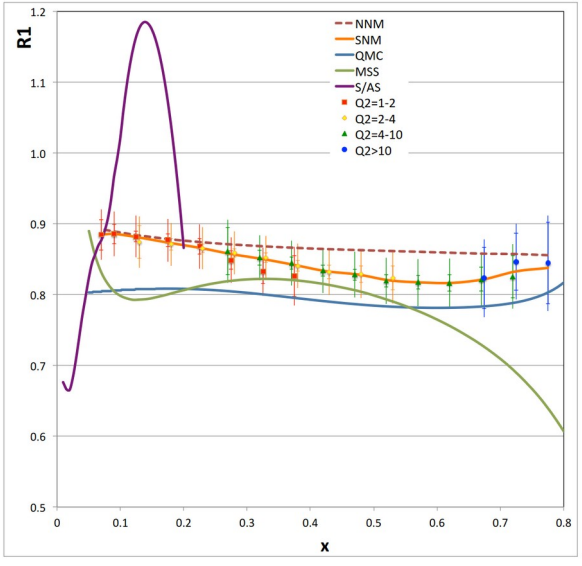
The EMC Effect in Spin Structure Functions

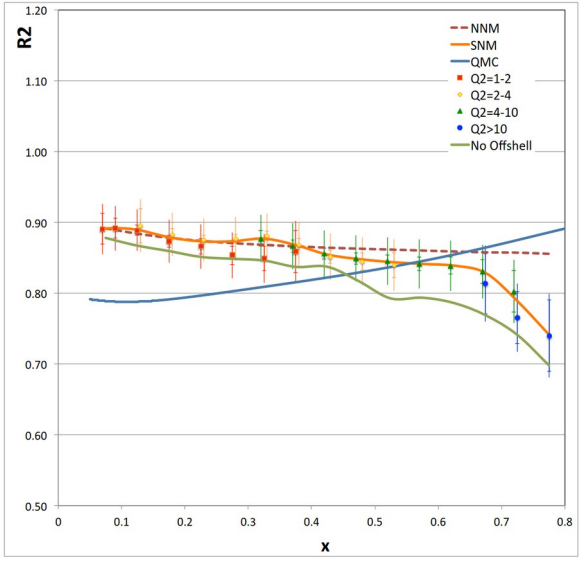
A 12 GeV Proposal to Jefferson Lab PAC 42

May 22, 2014

W. K. Brooks[1], H. Hakobyan, B. Kopeliovich, S. Kuleshov, S. Mancilla, and R. Mendez
Universidad Técnica Federico Santa María, Valparaíso, Chile

K. Adhikari, G. Dodge, L. El Fassi, S. Kuhn[2], and L. Weinstein
Old Dominion University, Norfolk, VA 23529





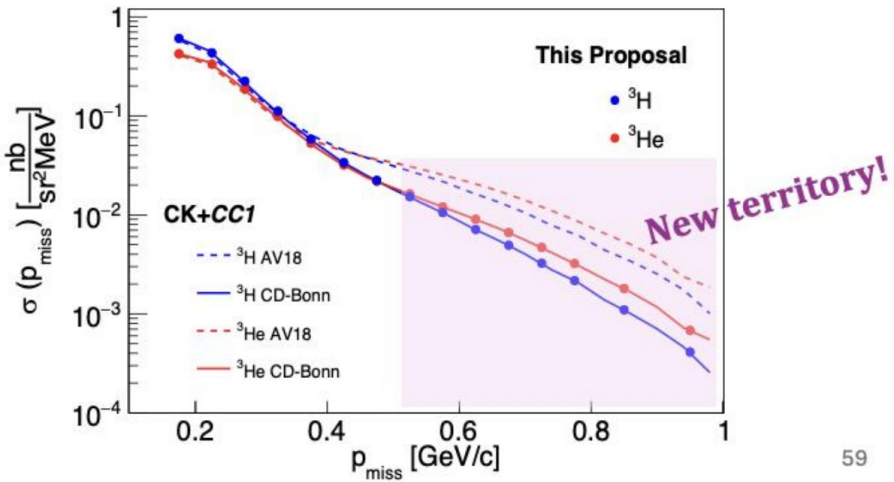
Bringing Tritium to Hall-B

Raise complex technical issues

- Using a tritium target

Set of measurements

- Test FSI in light nuclei
- Measure SRC in A=3
- Measure of Gmn



59

Precision measurements of $A = 3$ nuclei in Hall B

A. Denniston, O. Hen (spokesperson), J. Kahlbow, D. Nguyen (spokesperson),
J. R. Pybus, E.P. Segarra,
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

W. Briscoe, T. Kutz, S. Ratliff, A. Schmidt (spokesperson), P. Sharp, I. Strakovsky
The George Washington University, Washington DC 20052, USA

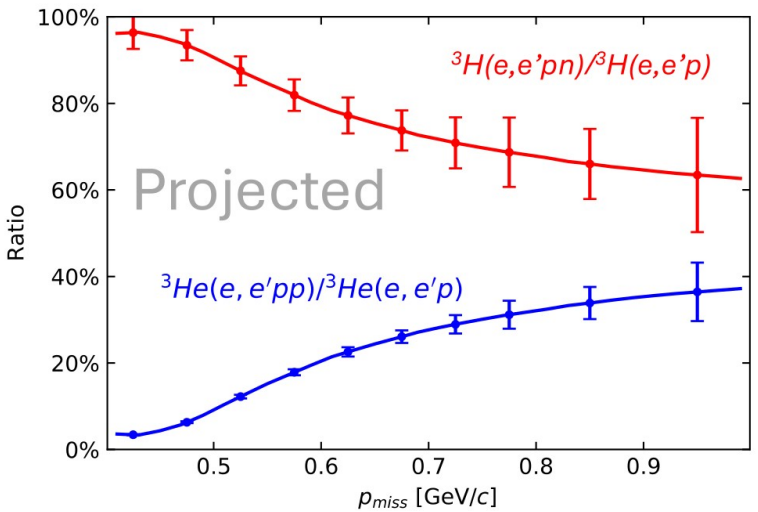
C. Fogler, F. Hauenstein, C. Hyde, L.B. Weinstein (spokesperson)
Old Dominion University, Norfolk, Virginia 23529, USA

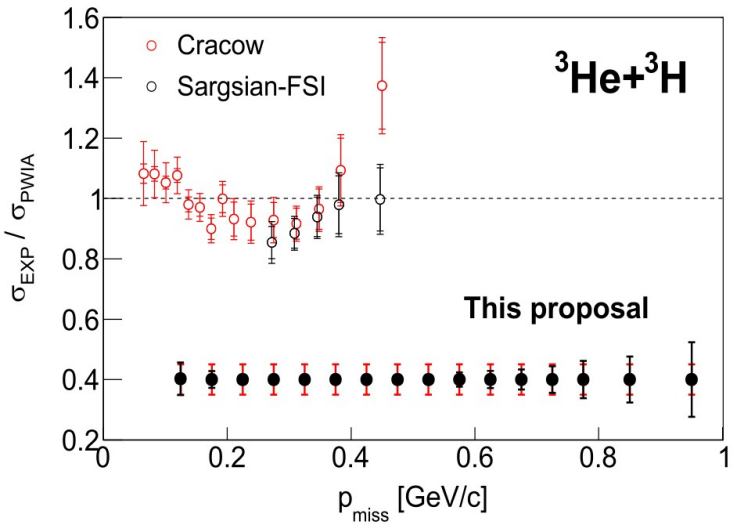
G. Johansson, C. Neuburger, E. Piasetzky (spokesperson)
Tel-Aviv University, Tel Aviv 69978, Israel

D.W. Higinbotham, C. Keith, C. Keppel, J. Maxwell, D. Meekins (spokesperson),
S. Stepanyan, H. Szumila-Vance (contact person)
Thomas Jefferson National Accelerator Facility,
Newport News, Virginia 23606, USA

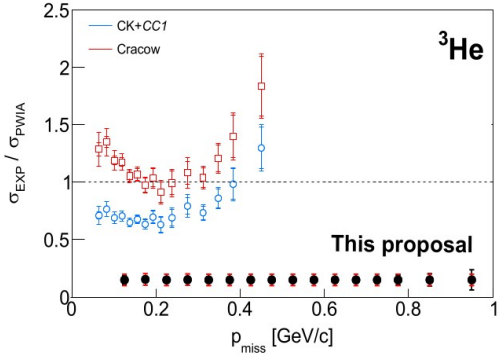
Beam time requirement

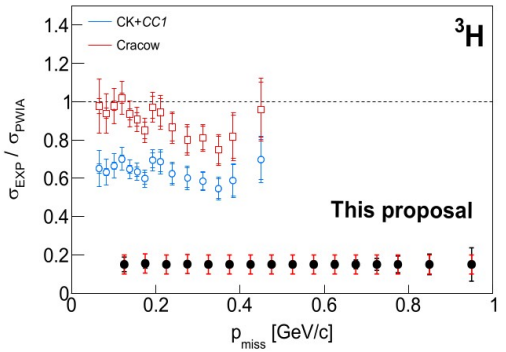
Energy	H	d	^{3}He	^{3}H	Measurement	Calibr.	Target changes	Total
6.6 GeV	1	10	20	20	**51 days**	1	2	**54 days**
2.2 GeV	0.5	0	1	1	**2.5 days**	1	2	**5.5 days**
Total time requested								**59.5 days**

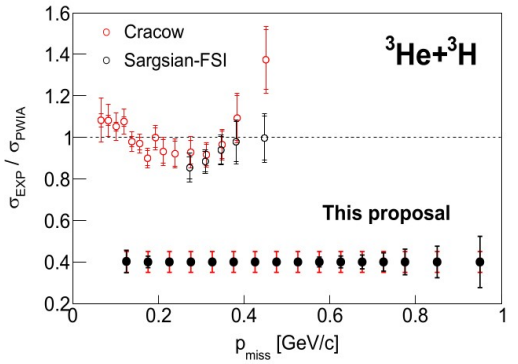


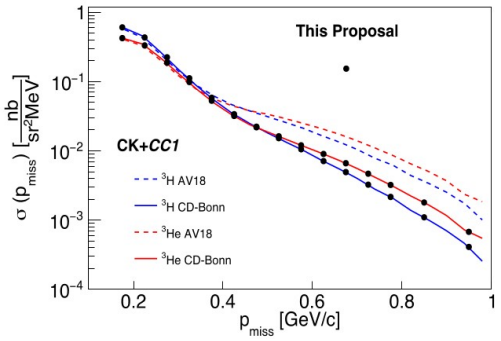


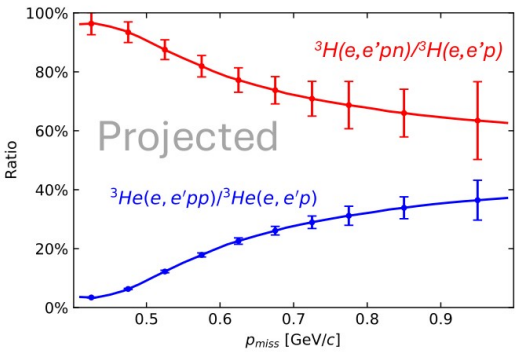
This measurement will produce many high-impact results!

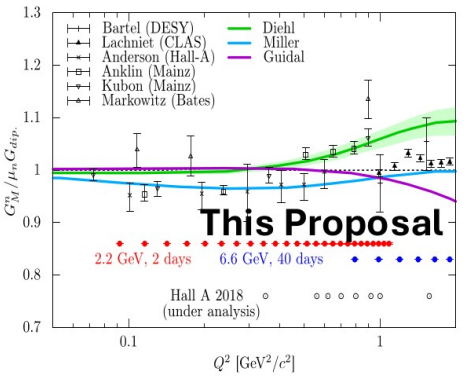






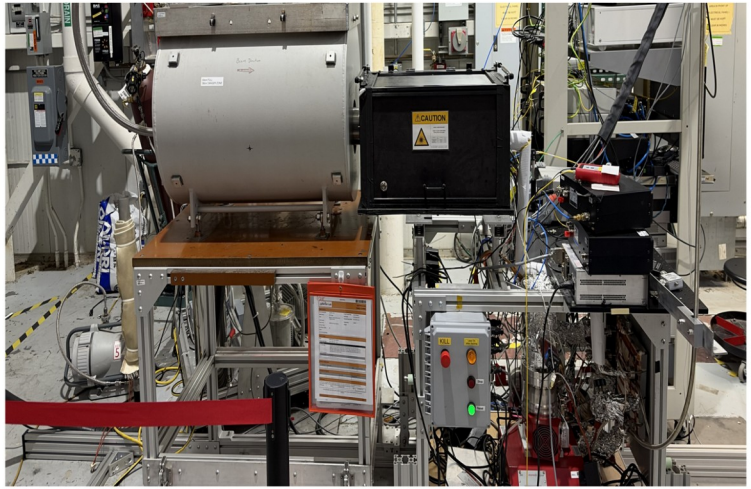


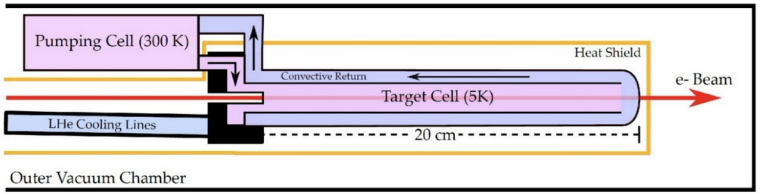


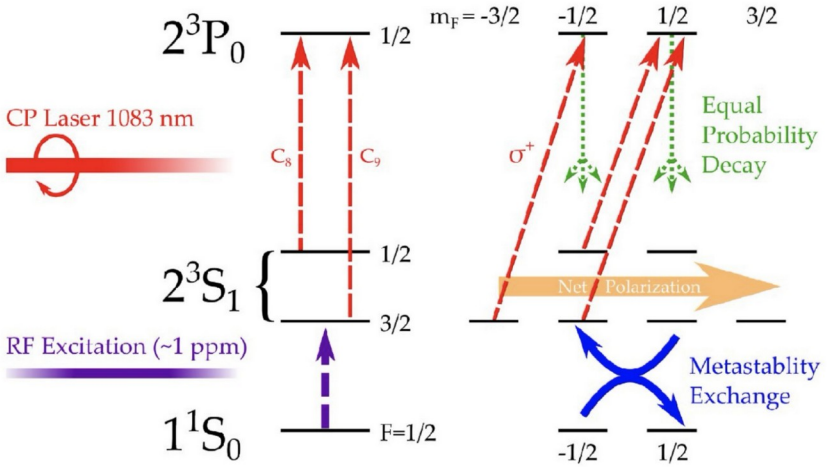


Polarized ^{3}He Target

MEOP Polarized ^{3}He Target







MEOP Polarized ^{3}He Target Working Group

MIT: Richard G Milner, Pushpa Pandey, Yijie Wang

JLab: Harut Avagyan, James Maxwell, Christopher Keith, Hao Lu

UTK: Dien Nguyen, Jordan O'Kronley

Shandong: Xiaqing Li, Jinglun Cheng

High-field MEOP: Polarize ^{3}He in the CLAS12 5T solenoid.

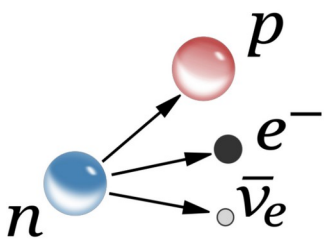
Double-cell design: 300 K pumping cell → 5 K target cell.

Design goals: ~60% polarization; run current 0.5μA.

Conditionally approved by PAC48 (2020), with an A− scientific rating and 30 PAC days. (PR12-20-002: A Program of Spin-Dependent Electron Scattering from a Polarized ^{3}He Target in CLAS12)

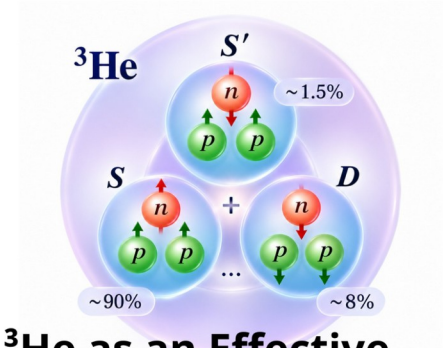
Why Polarized ^{3}He?

Polarized ^{3}He Physics



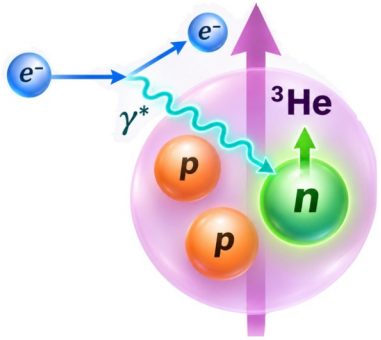
No natural pure neutron target:

Free neutron lifetime is only ~870s.



^{3}He as an Effective Polarized Neutron

Dominant S-state (~90%)
Nuclear spin carried primarily by the neutron

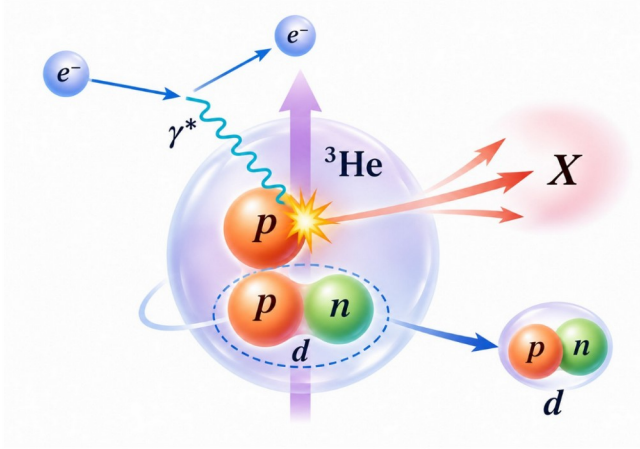


Probing Neutron Structures

DIS: Longitudinal spin structure (g_1^n)

SIDIS: Momentum and spin structure (TMDs)

DVEP: Spatial and spin structure (GPDs)



Nuclear Modifications

Investigate the polarized EMC effect and few-body nuclear dynamics through spectator-tagged DIS

MEOP Polarized ^{3}He Physics Working Group

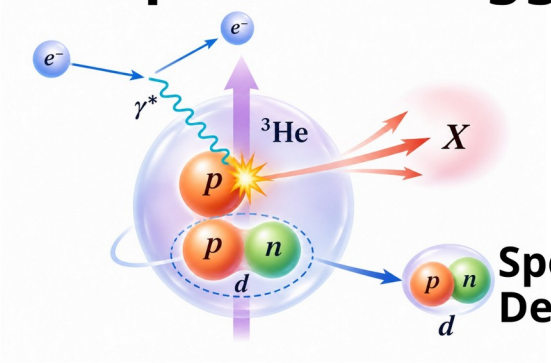
PhD. Student: Yijie Wang, Abhishek Abhishek

Postdoc: Jackson Pybus, Timothy Hayward

PI: Richard G Milner, Dien Nguyen, Barak Schmookler, Xuan Li, Harut Avagyan, Hao Lu

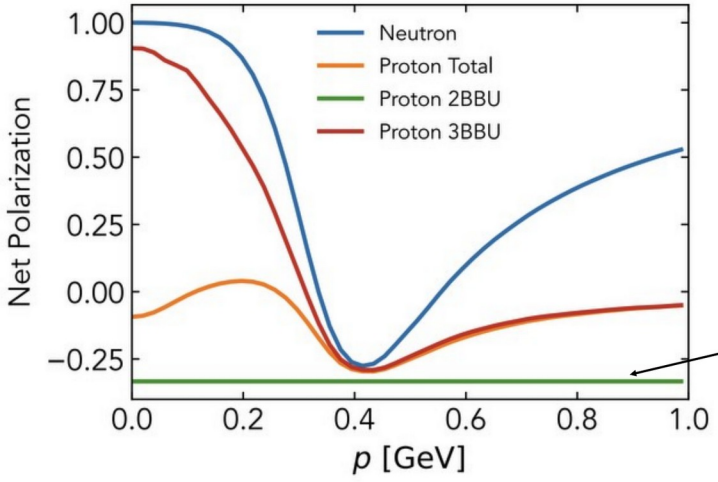
Nuclear Modification

^{3}He spectator-tagging DIS



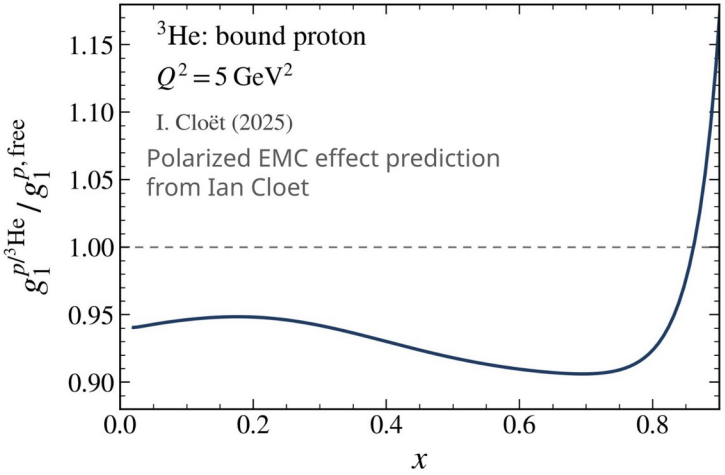
Spectator Detector

Spectator deuteron provides access to the struck proton's initial momentum and virtuality.



Under Proton 2 body breakup, the effective proton polarization is -1/3

Proton Polarized EMC Effect

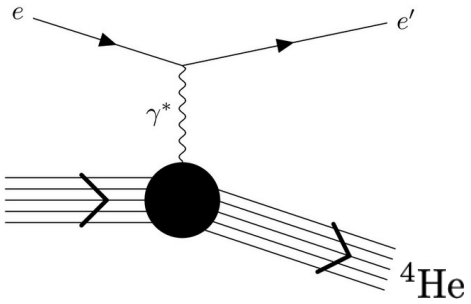


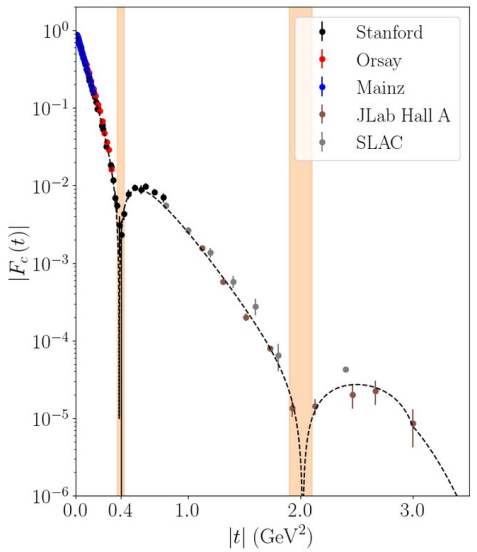
Nuclear modification for spin-dependent structure functions.

Provides new sensitivity to the spin-dependent quark structure of bound protons

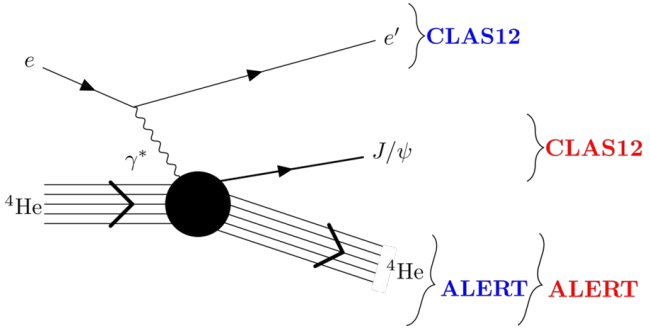
Does the gluon distribution inside the ^{4}He nucleus follow the charge?

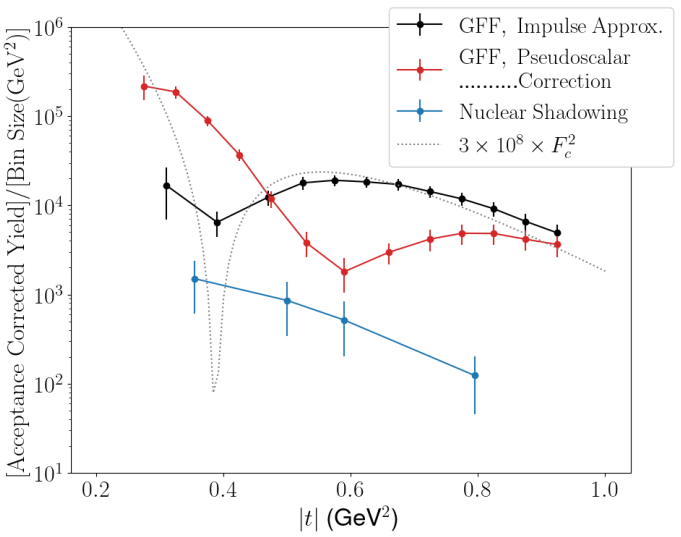
Charge





Gluon





C12-25-004: A Measurement of the Coherent J/ψ Electroproduction Cross Section off ^{4}He

First-of-its-kind experiment to directly compare mass distribution to charge! Conditionally approved (C2)

Other projects to extend the ALERT program

We have a set of propositions around running ALERT again

- Make more measurement along the previous proposal
  - **In particular, TCS measurement is envisionned (N. Pilleux)**
- Running medium sized nuclei (C, O,…)
  - **Letter of intent was submitted to look into alpha clustering (W. Armstrong)**
- Running larger nuclei (Ar for instance)
  - **Nothing proposed yet, but can be of particular interest for hadronization and to prepare for the EIC**

Will need to refurbish ALERT

- Upgrade to setup the proposed trigger
- Update the electronics protection to take the high luminosity

Summary

Many proposals in the Nuclear Physics Working Group

- What is left is mostly complex setups
- Leavs us with some difficult experiments to put together
  - **with some costs associated that may need to be evaluated for the 2037 exercise**

Much more can be done with high luminosity

- See the talk from Lamiaa El Fassi during the dedicated session on Thursday

Physics Opportunities with High Luminosity on Nuclear Targets

Probing In-Medium QCD Dynamics, Nuclear Modifications, and Hadron Tomography

Lamiaa El Fassi

Mississippi State University

November CLAS Collaboration Meeting

November 19, 2026