The LAD Experiment in Hall C

Axel Schmidt

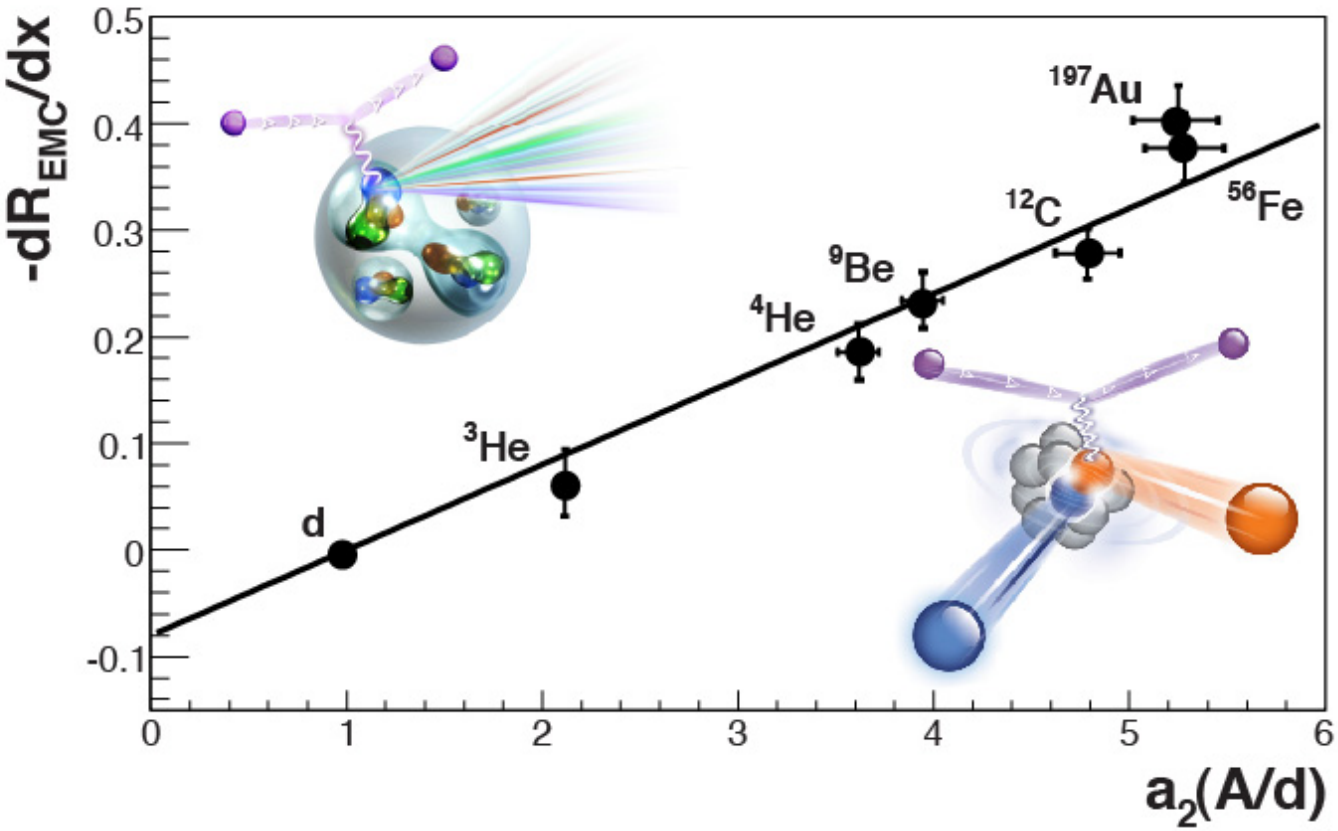
Workshop Exploring QCD with Tagged Processes

October 19, 2021

THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

The EMC Effect correlates with SRC pairing.

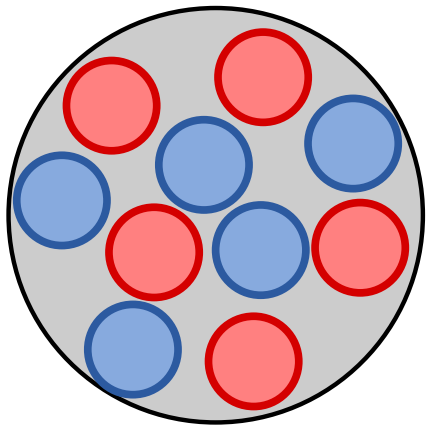


L. B. Weinstein et al., PRL 106, 052301 (2011)

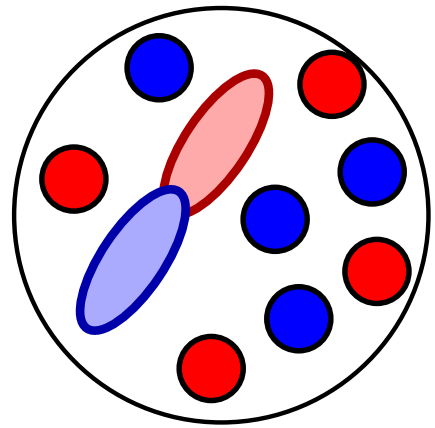
O. Hen et al., PRC 85, 047301 (2012)

The SRC-EMC correlation suggests an alternate hypothesis.

Free



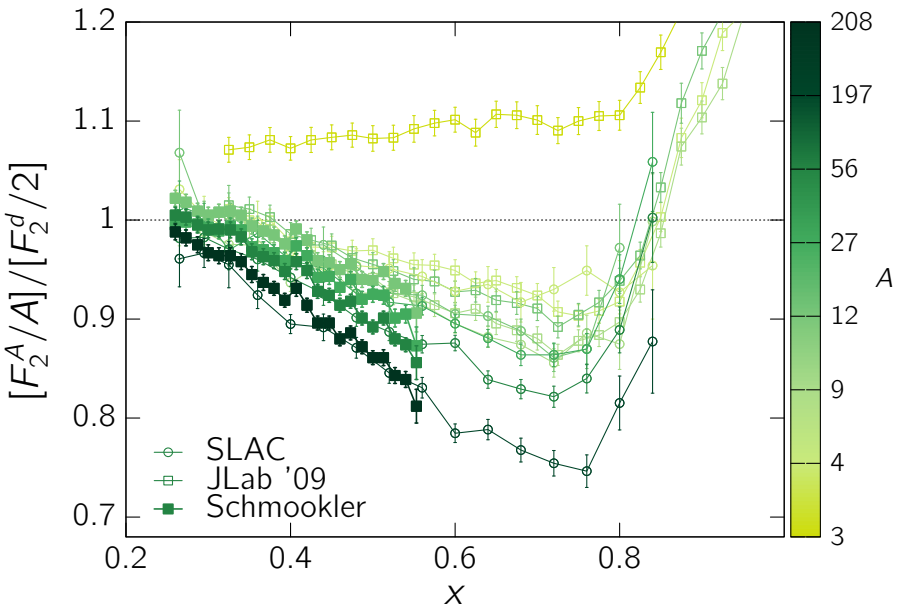
Medium Modification Hypothesis



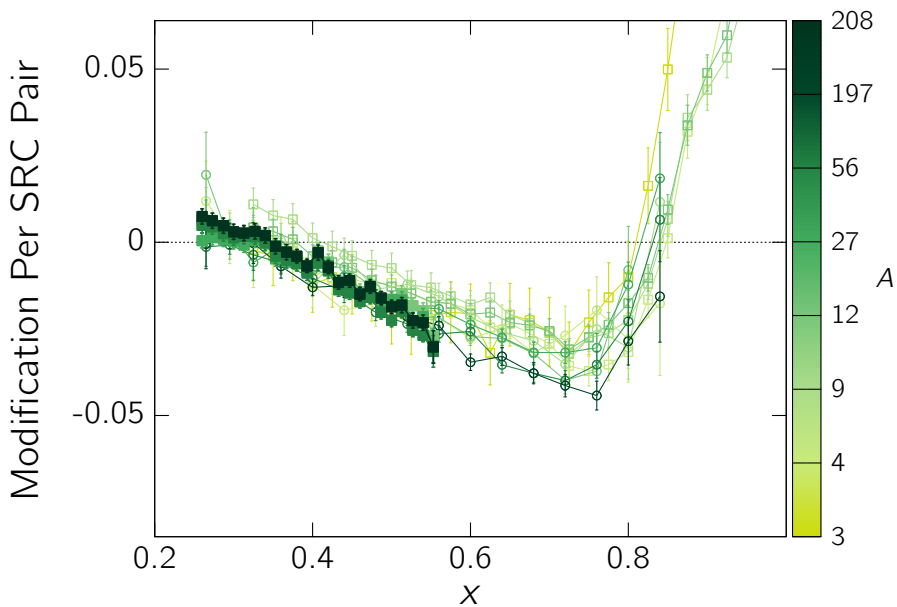
Short-Range Correlation Hypothesis

The modification per pairs appears universal.

Modification per nucleon



Modification per SRC pair



B. Schmookler et al., Nature 566 p. 354 (2019)

In my talk today:

The **Large Acceptance Detector** (LAD) Experiment

- Spectator Tagging
  - Measure the structure of short-range correlated nucleons.
- The Apparatus
  - Tag recoil protons, suppress background.
- Why now?
  - Charge-dependence of the EMC Effect
  - Tagging will be mainstay of EIC

The LAD team

Spokespersons

- O. Hen
- F. Hauenstein
- N. Liyanage
- E. Piasetzky
- A. Schmidt
- L. B. Weinstein
- S. Wood

Sara Ratliff

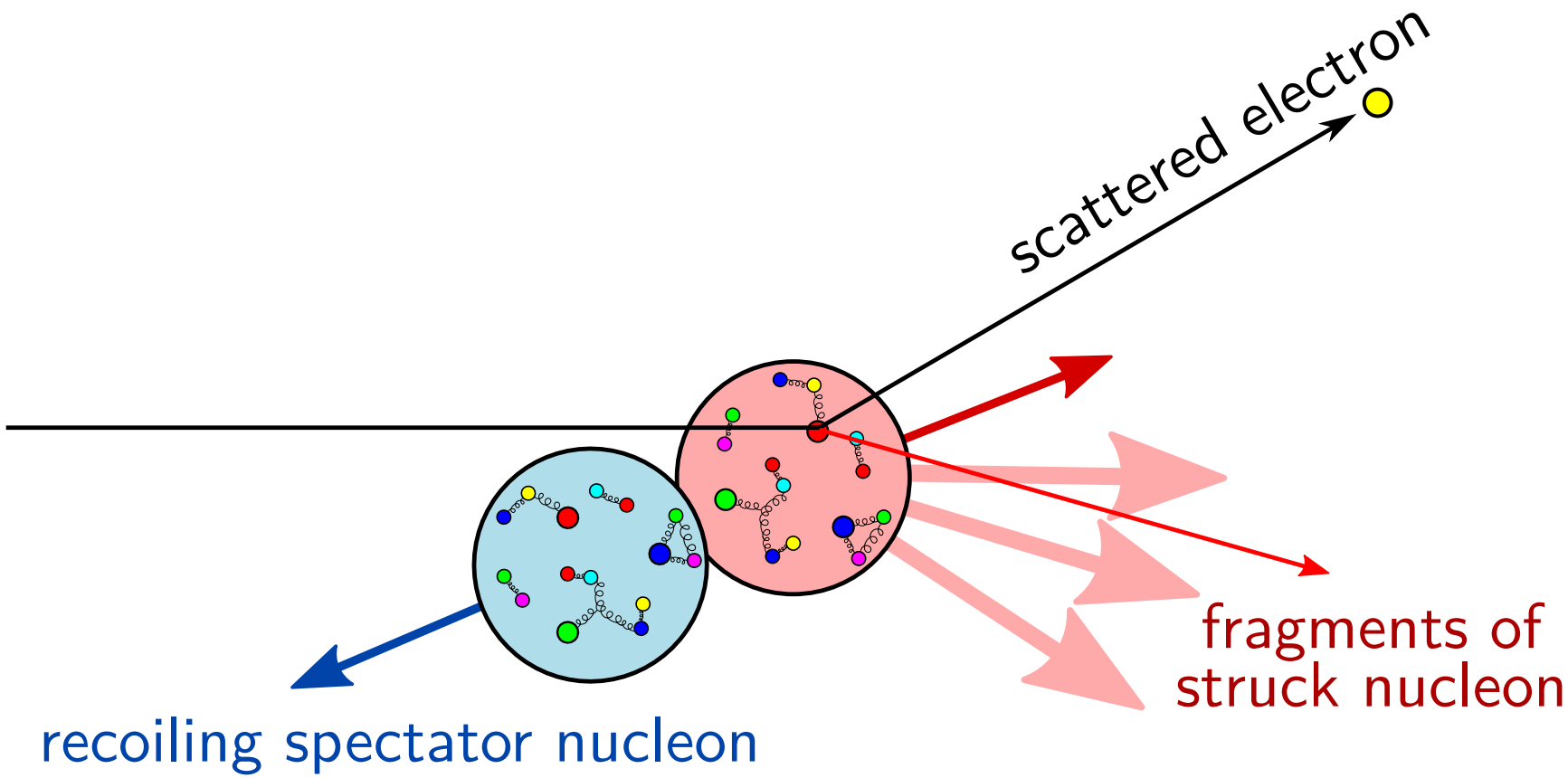
Dien Nguyen

Holly Szumila-Vance

Tyler Kutz

Florian Hauenstein

Spectator tagging can reveal how the nuclear configuration affects partonic structure.



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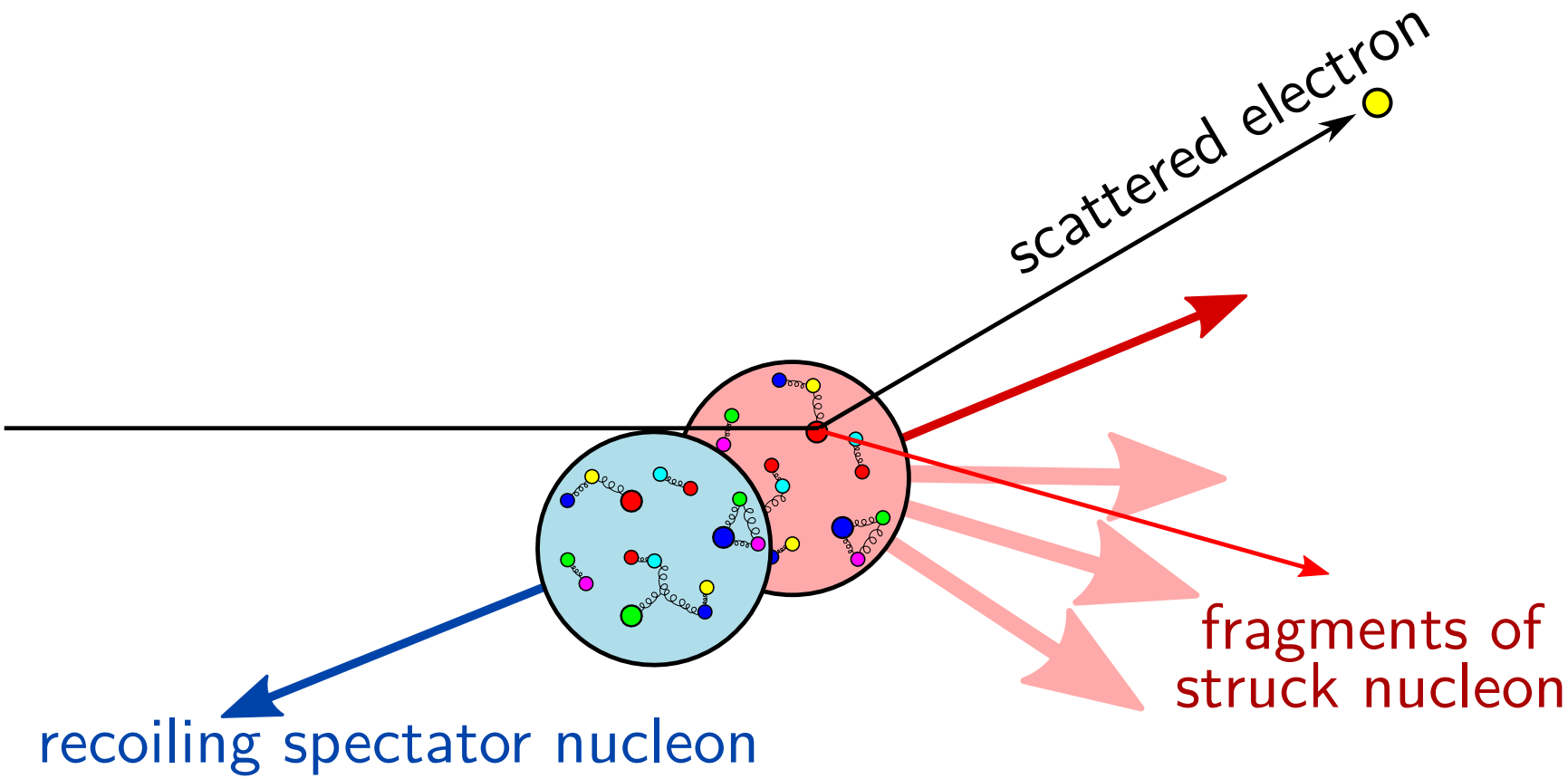
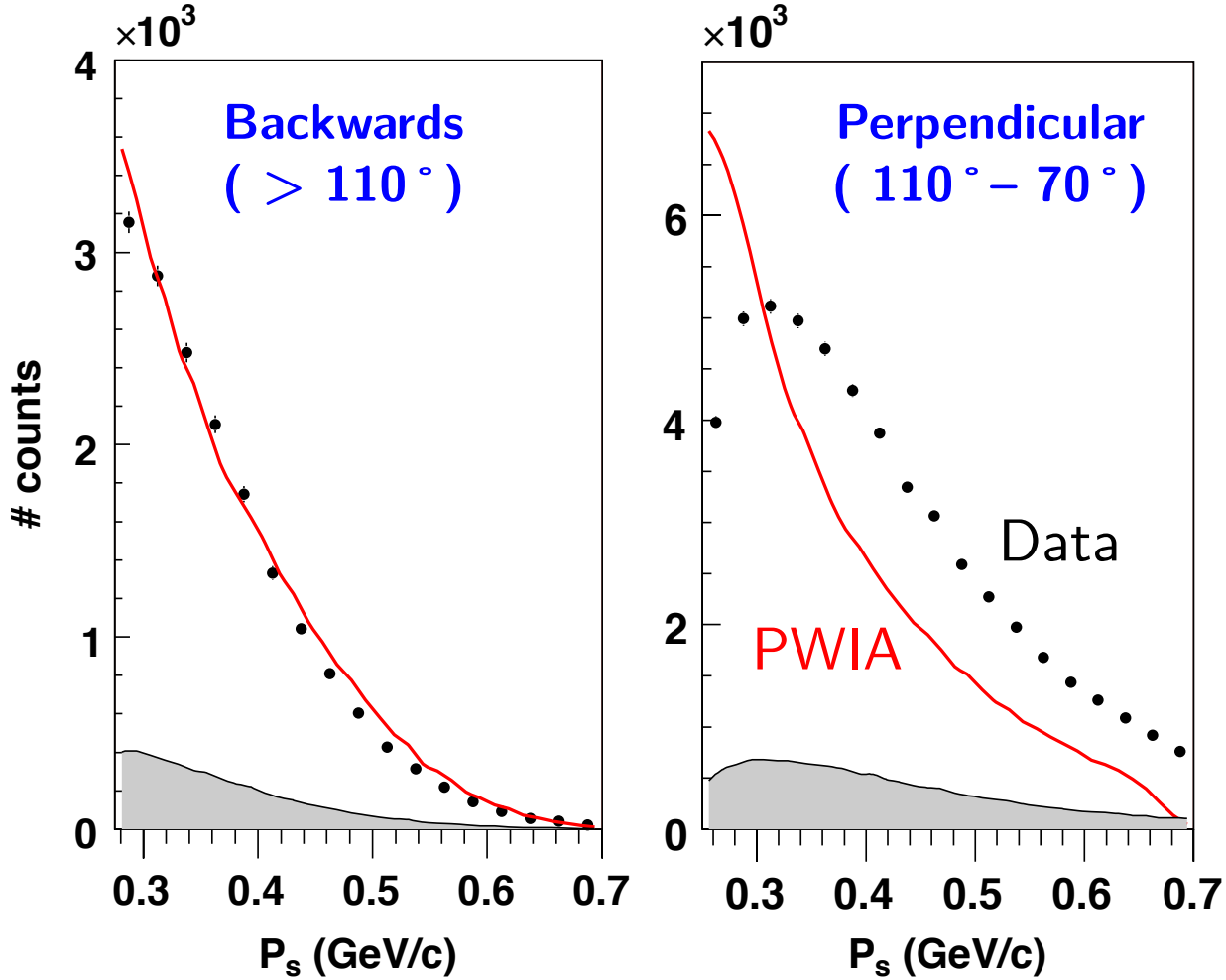


Kinematics with backwards-going spectators are less susceptible to FSIs.



A. V. Klimenko et al., PRC 73, 035212 (2006)

Spectator-tagged DIS

Tagging variables

- Scaling variable $x' = \frac{Q^2}{2q_\mu(p_d^\mu - p_s^\mu)}$
- Light cone momentum fraction $\alpha_s = \frac{E_s - \vec{p}_s \cdot \hat{q}}{m_N}$

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Tagged cross section

$$d^4\sigma(Q^2, x', \alpha_s, p_{s,\perp}) = K \cdot F_2(Q^2, x') \cdot P(\alpha_s, p_{s,\perp})$$

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Measure in two kinematics settings

- High x': $(x' > 0.5, \langle x' \rangle \sim 0.6)$ EMC Effect is large
- Low x': $(x' = 0.3)$ EMC Effect is small

Reduce sensitivity to FSI with double ratio: High-x' / Low-x', Tagged / Inclusive

$$\frac{F_2(x', Q^2, \alpha_s)_{\text{bound}}}{F_2(x, Q^2)_{\text{free}}}$$

Reduce sensitivity to FSI with double ratio: High-x' / Low-x', Tagged / Inclusive

$$\frac{F_2(x', Q^2, \alpha_s)_{\text{bound}}}{F_2(x, Q^2)_{\text{free}}} \approx \frac{d^4\sigma(x', Q^2, \alpha_s, p_{s,\perp})}{d^4\sigma(x'_0, Q^2_0, \alpha_s, p_{s,\perp})}$$

Tagged DIS measurement

Reduce sensitivity to FSI with double ratio: High-x' / Low-x', Tagged / Inclusive

$$\frac{F_2(x', Q^2, \alpha_s)_{\text{bound}}}{F_2(x, Q^2)_{\text{free}}} \approx \frac{d^4\sigma(x', Q^2, \alpha_s, p_{s,\perp})}{d^4\sigma(x_0', Q_0^2, \alpha_s, p_{s,\perp})} \times \frac{d^2\sigma(x_0, Q_0^2)}{d^2\sigma(x, Q^2)}$$

Tagged DIS measurement Input

Reduce sensitivity to FSI with double ratio: High-x' / Low-x', Tagged / Inclusive

$$\frac{F_2(x', Q^2, \alpha_s)_{\text{bound}}}{F_2(x, Q^2)_{\text{free}}} \approx \frac{d^4\sigma(x', Q^2, \alpha_s, p_{s,\perp})}{d^4\sigma(x_0', Q_0^2, \alpha_s, p_{s,\perp})} \times \frac{d^2\sigma(x_0, Q_0^2)}{d^2\sigma(x, Q^2)} \times R_{\text{FSI}}$$

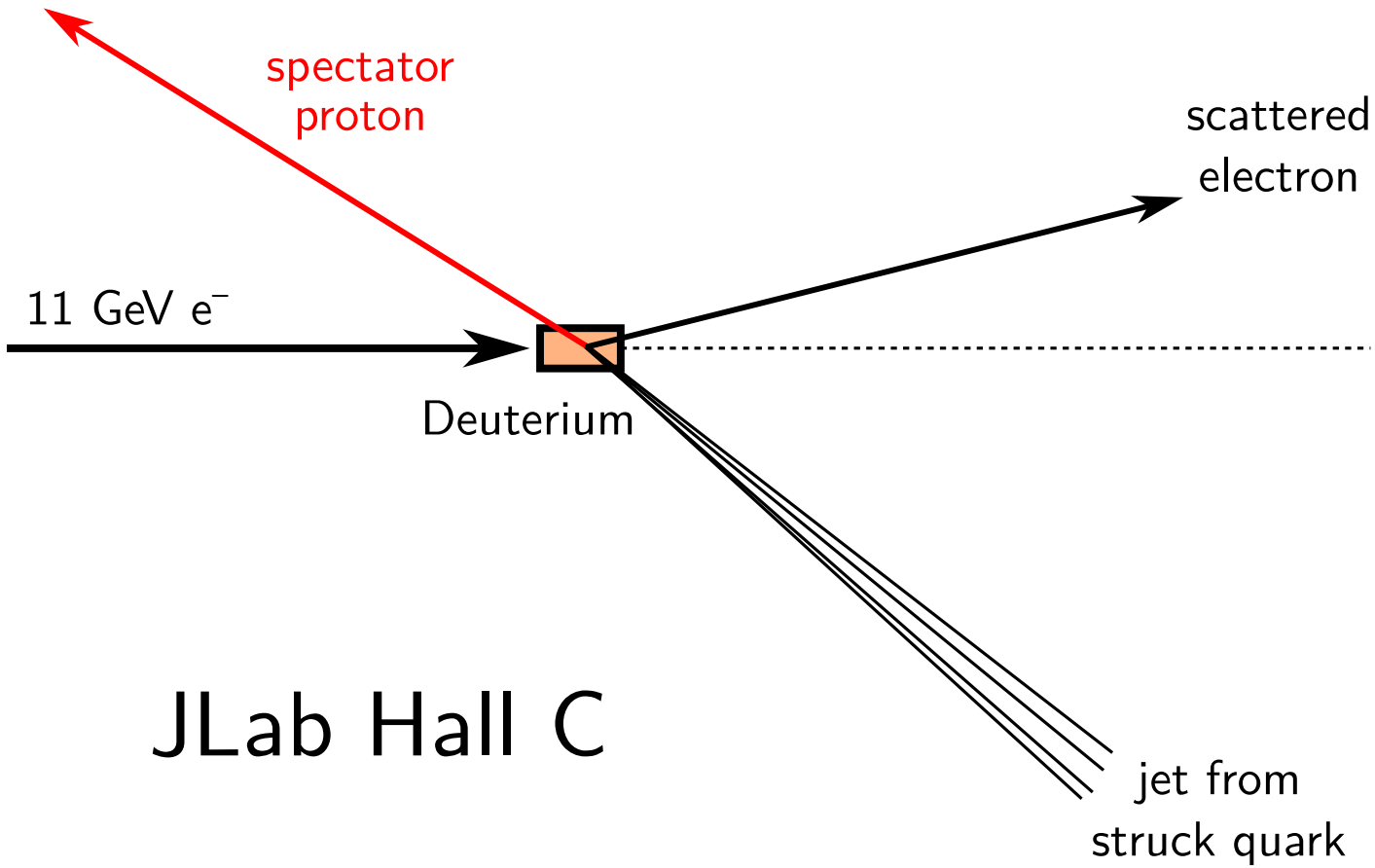
Tagged DIS measurement Input ≈ 1

JLab experiments measuring tagged DIS on deuterium

- **BAND**
  - Tagging spectator neutrons to measure proton structure
  - Collected data in 2019/2020 with CLAS12

- **LAD**
  - Tagging spectator protons to measure neutron structure
  - Approved to run, but not yet scheduled

The LAD Experiment



Jefferson Lab Hall C

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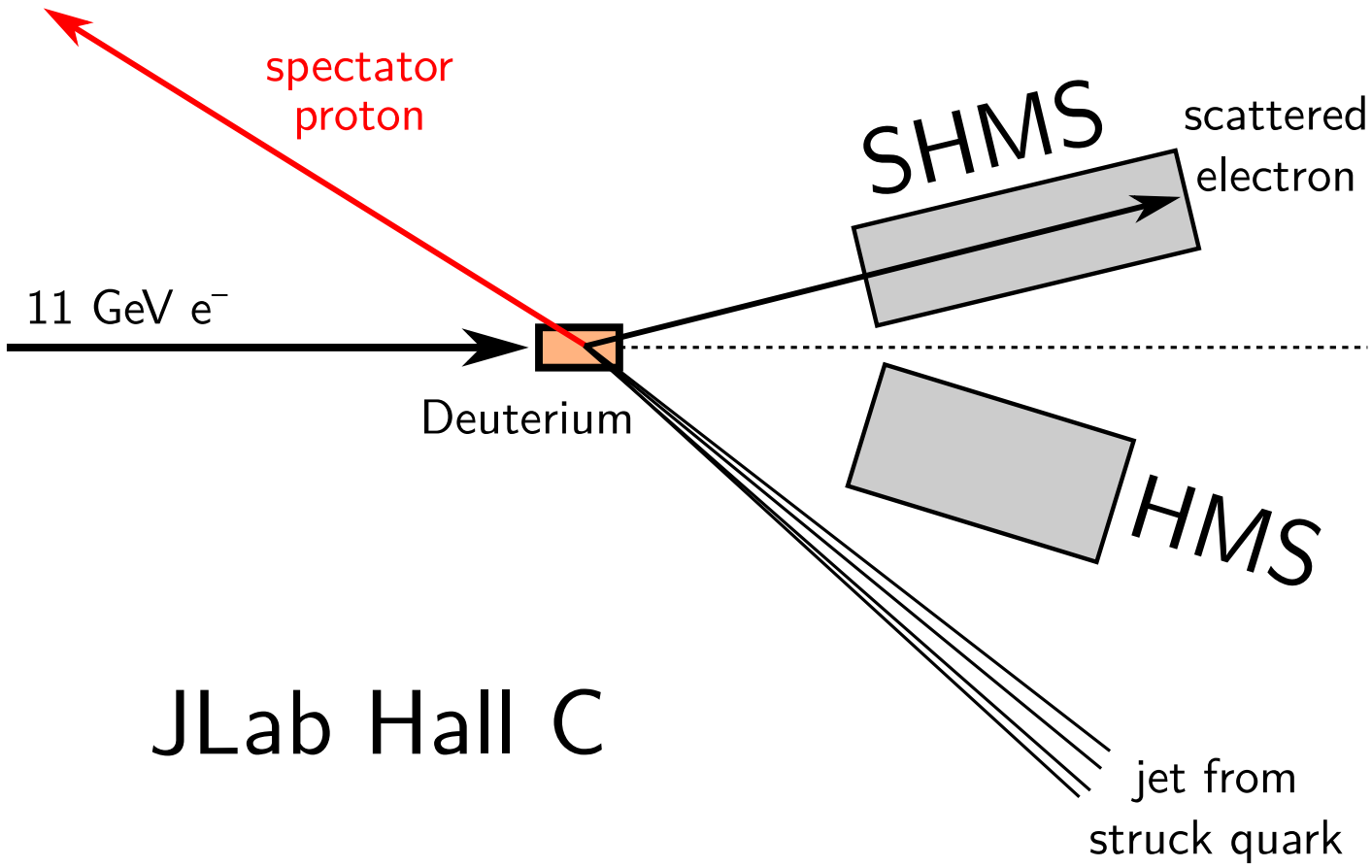

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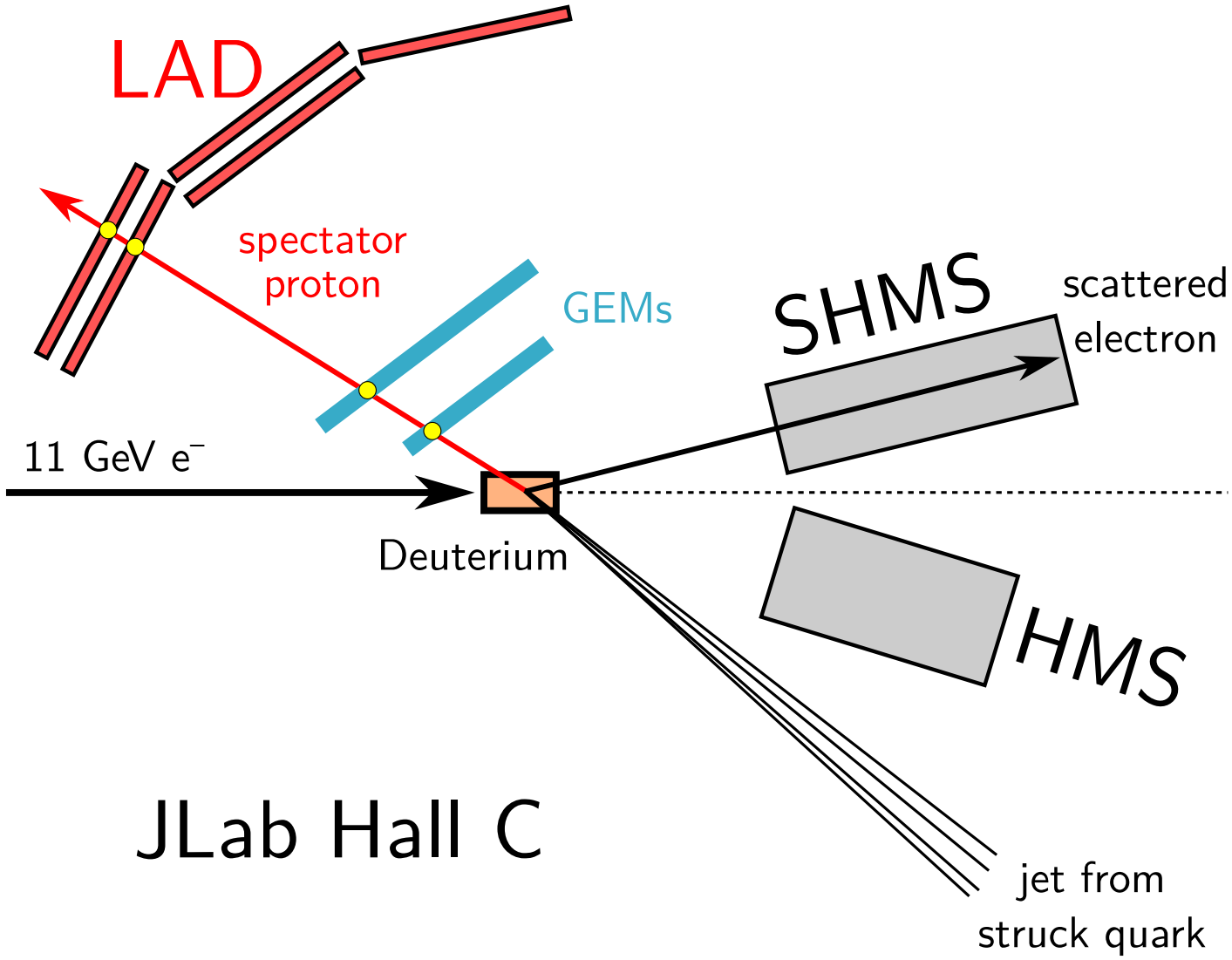
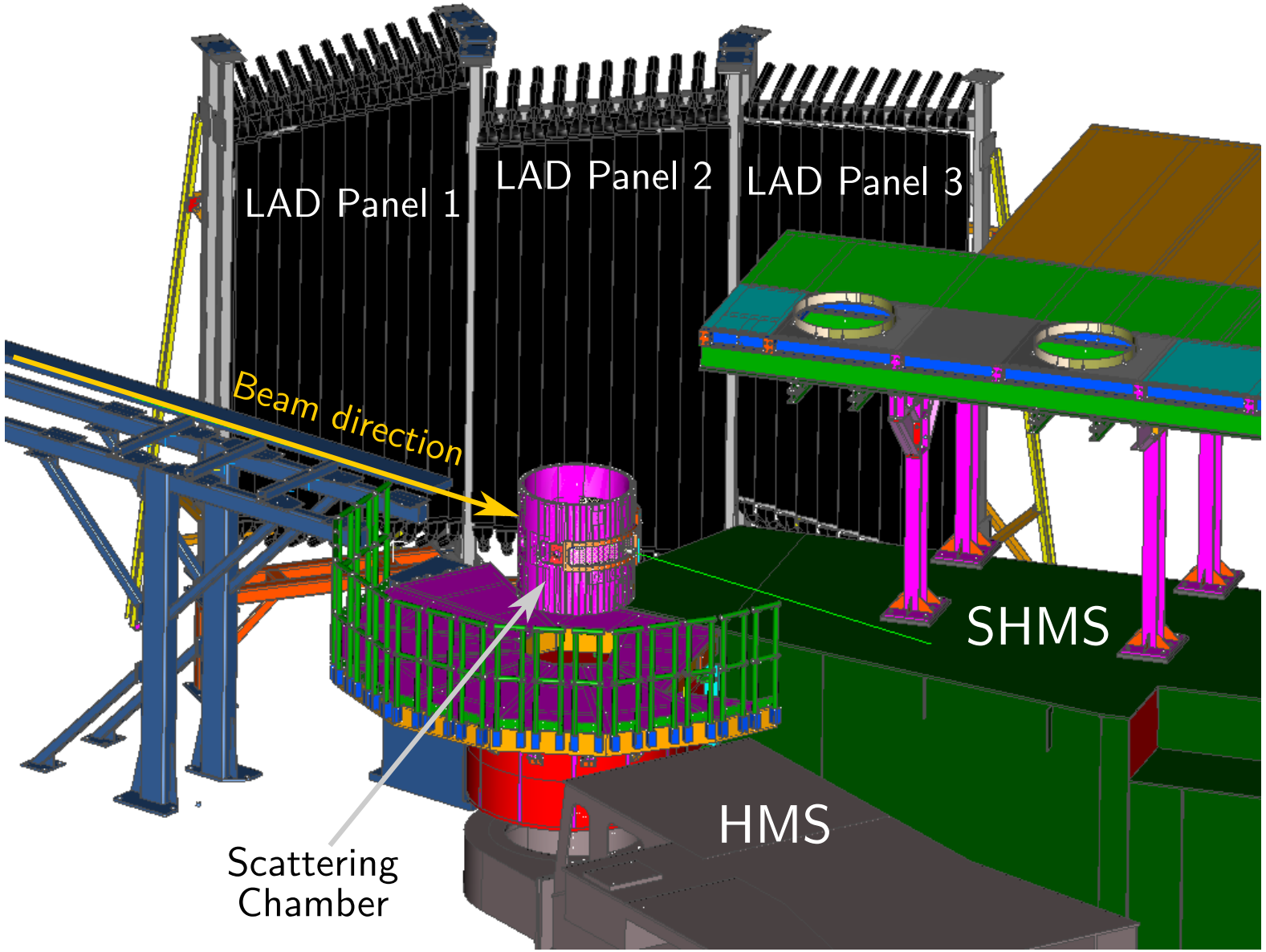
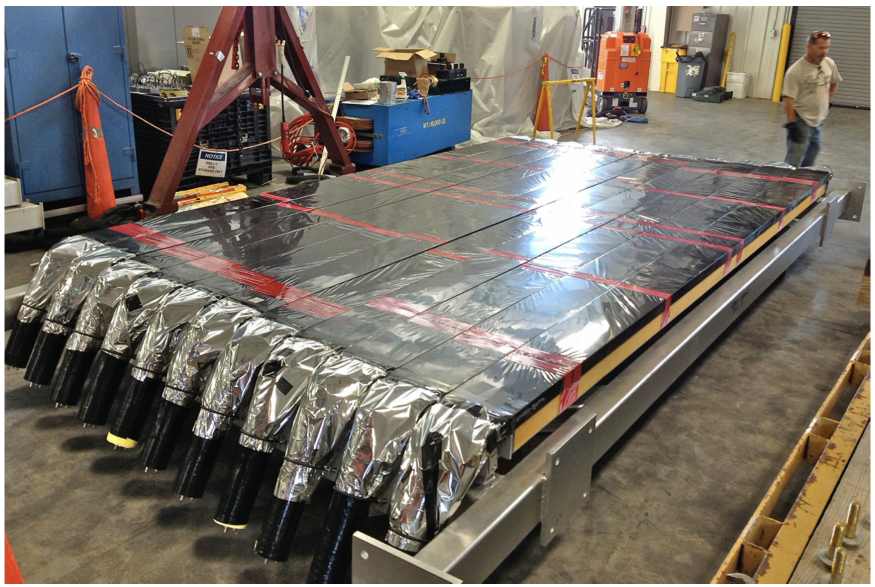


Large Acceptance Detector



LAD scintillators were refurbished from CLAS-6 time-of-flight system.



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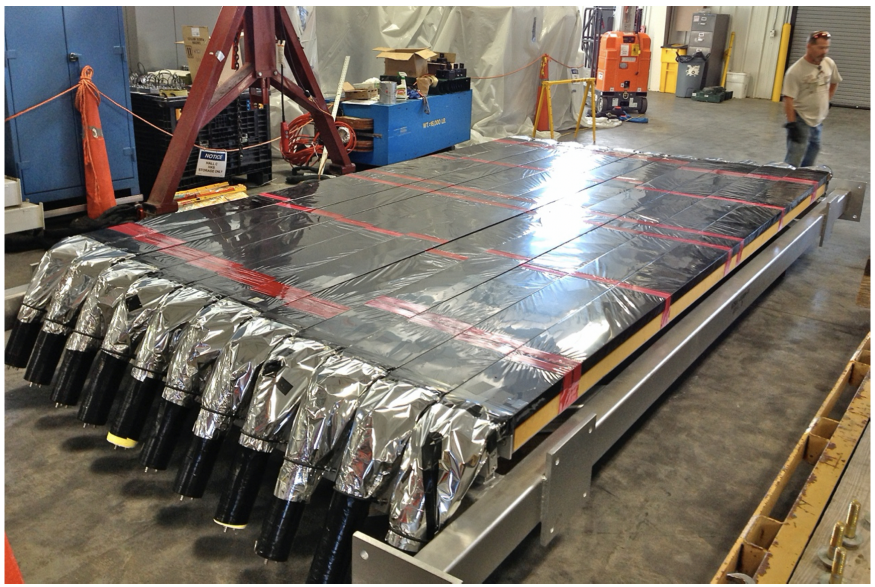

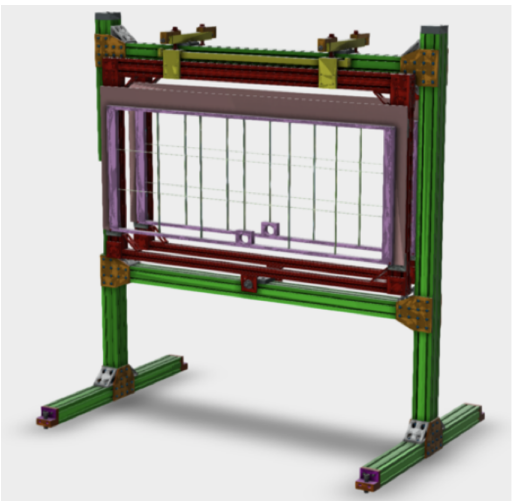

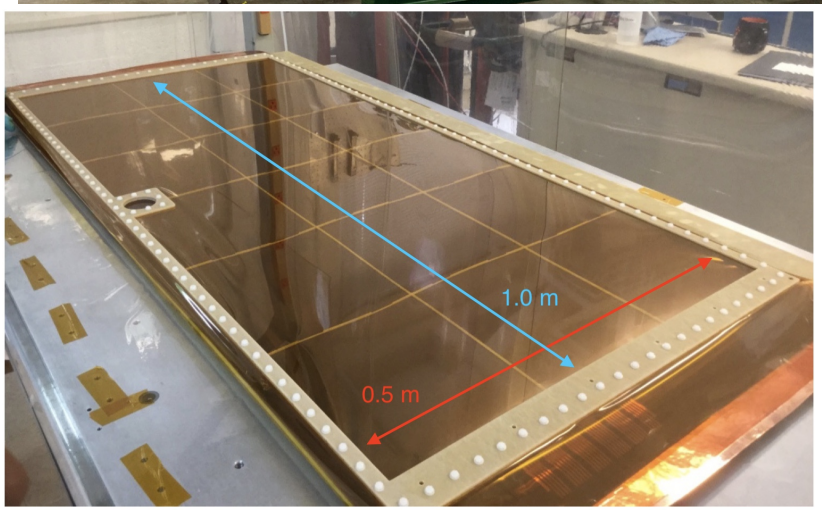

Experimental Details

Jefferson Lab E12-11-107 (LAD)

Beam Energy	11 GeV
Current	1 μA
Target	20 cm liquid D_2
Luminosity	1.2×10^{37} cm^{-2} s^{-1} per nucleon
Duration	34 PAC days

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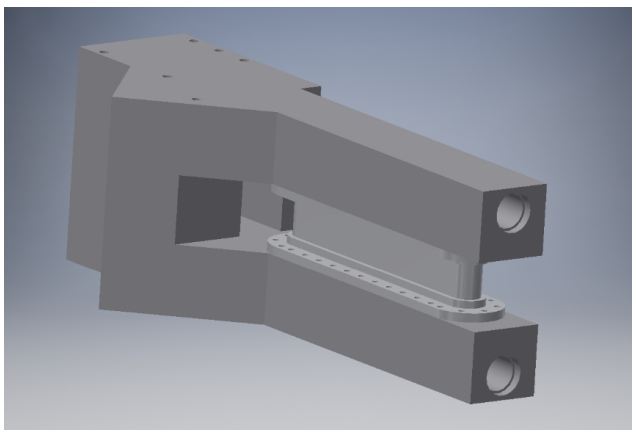

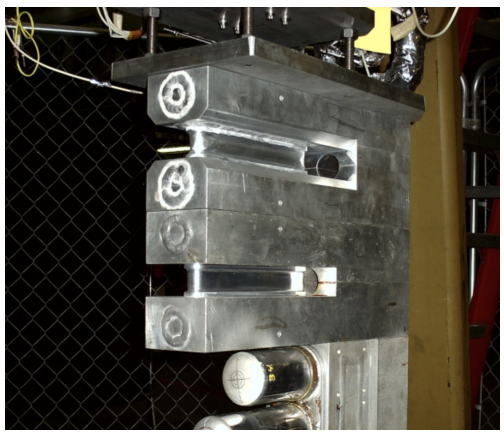

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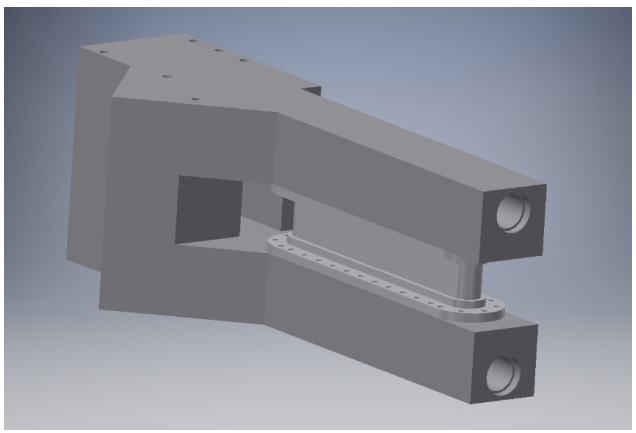
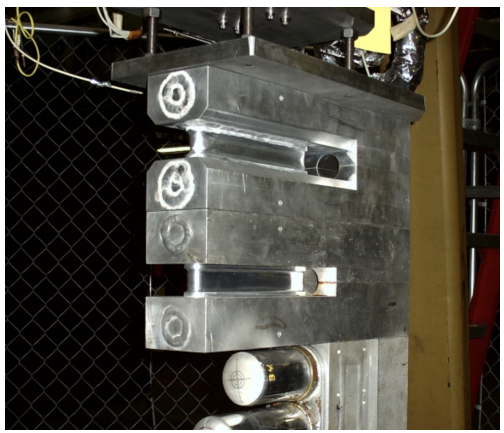
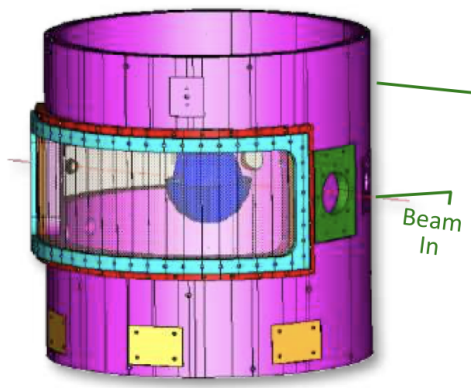
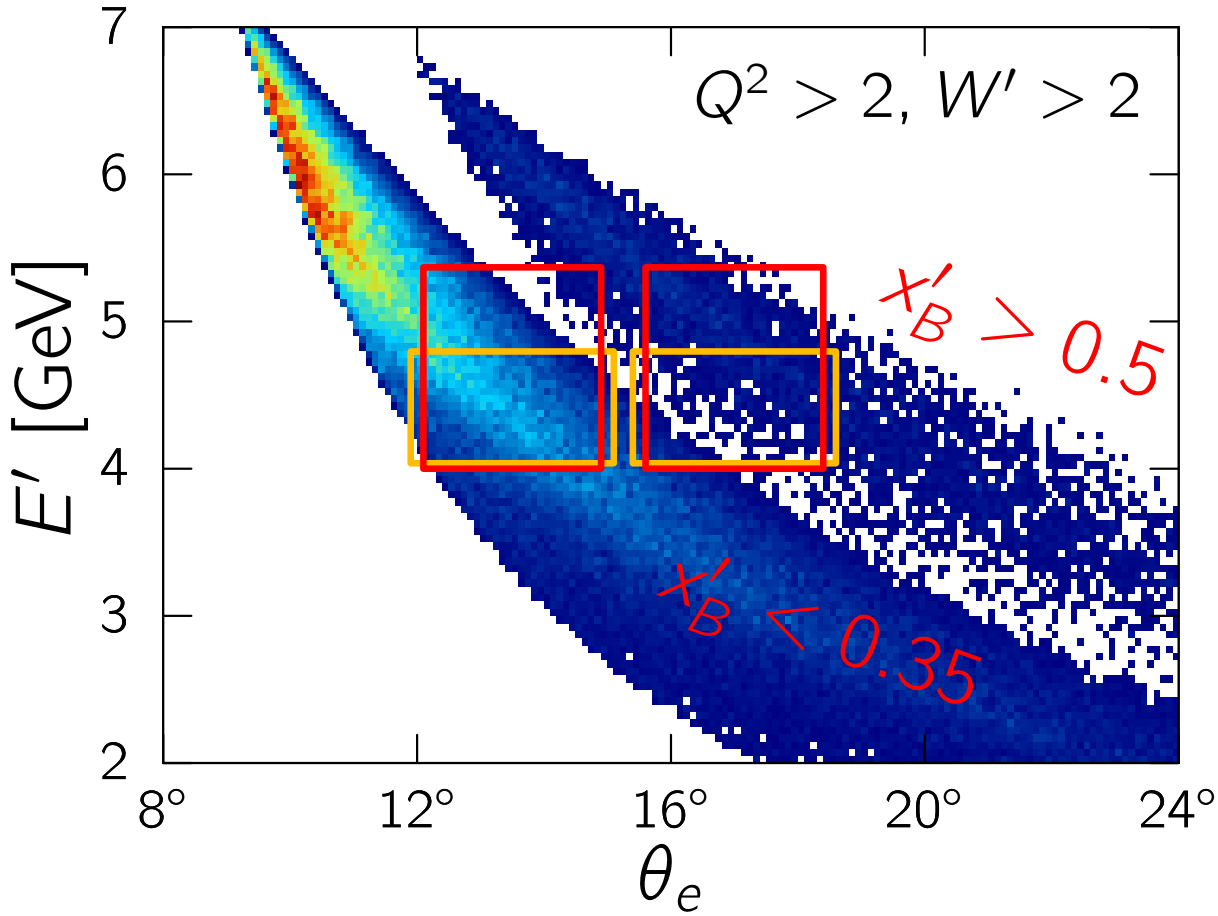






LAD will measure at two settings: high-x' and low-x' setting.



Tagged DIS simulation, c.s. from W. Cosyn, M. Sargsian, PRC 84, 014601 (2011)

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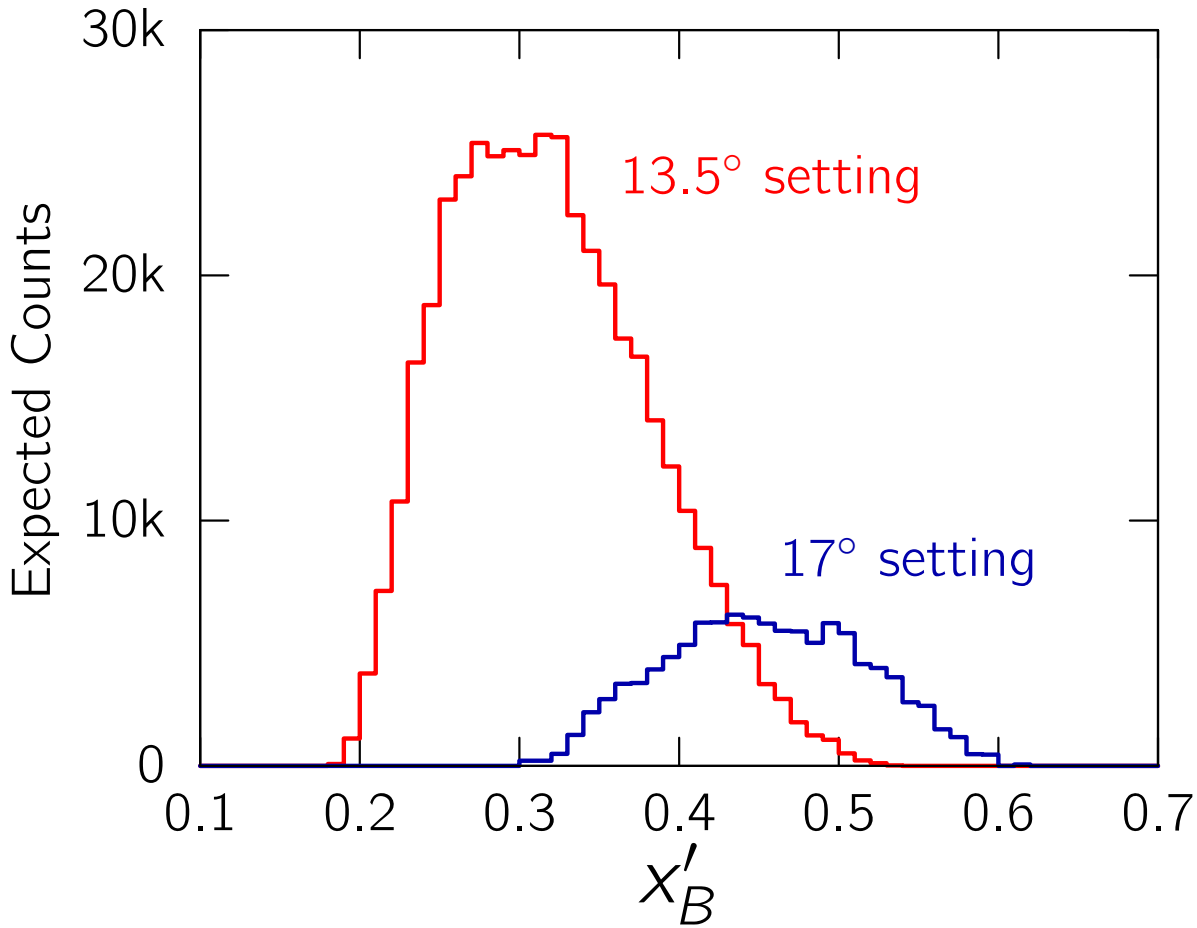

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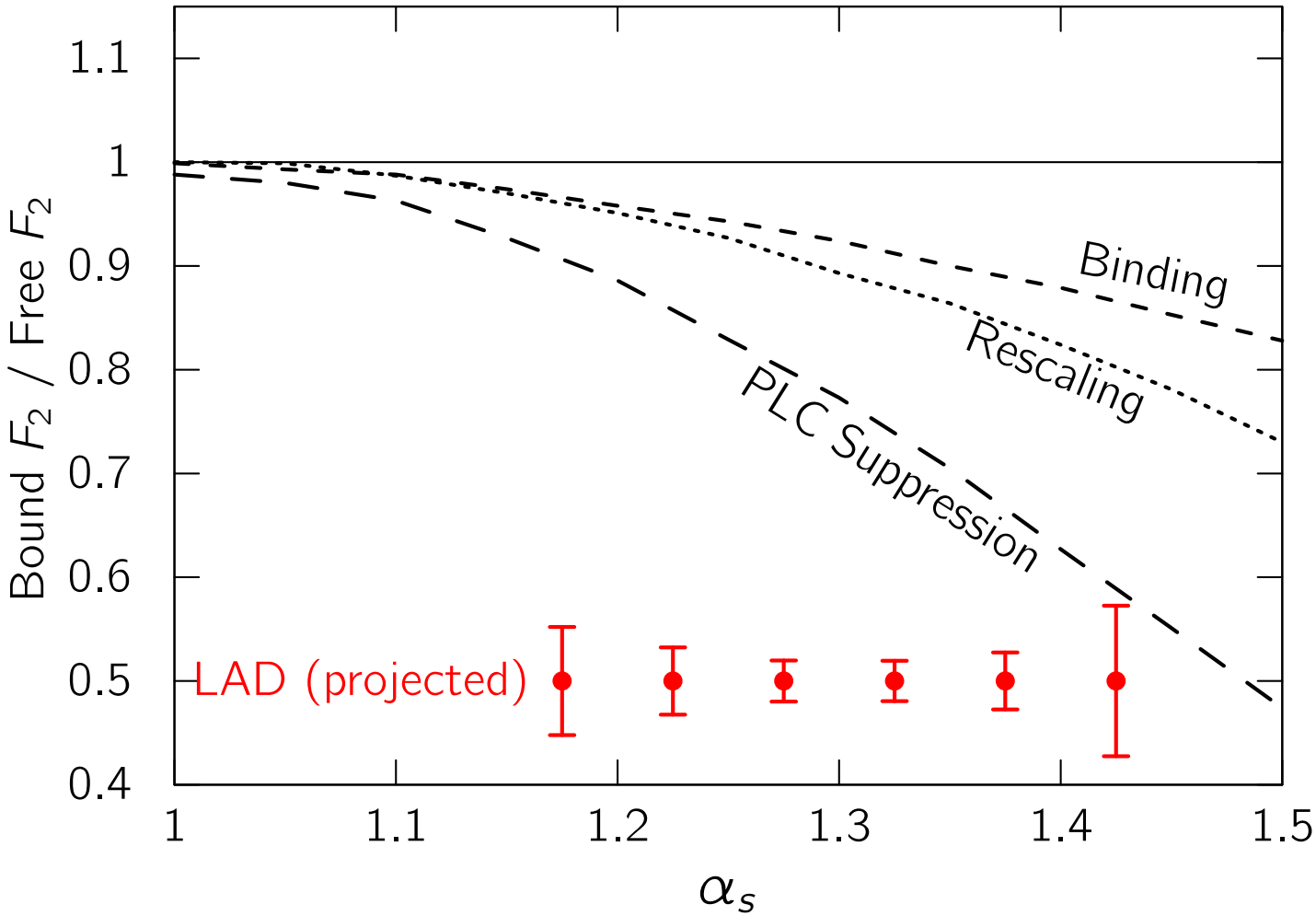
LAD will distinguish between modification models.



Melnitchouk, Sargsian, Strikman, Z. Phys. A 359, p. 99 (1997)

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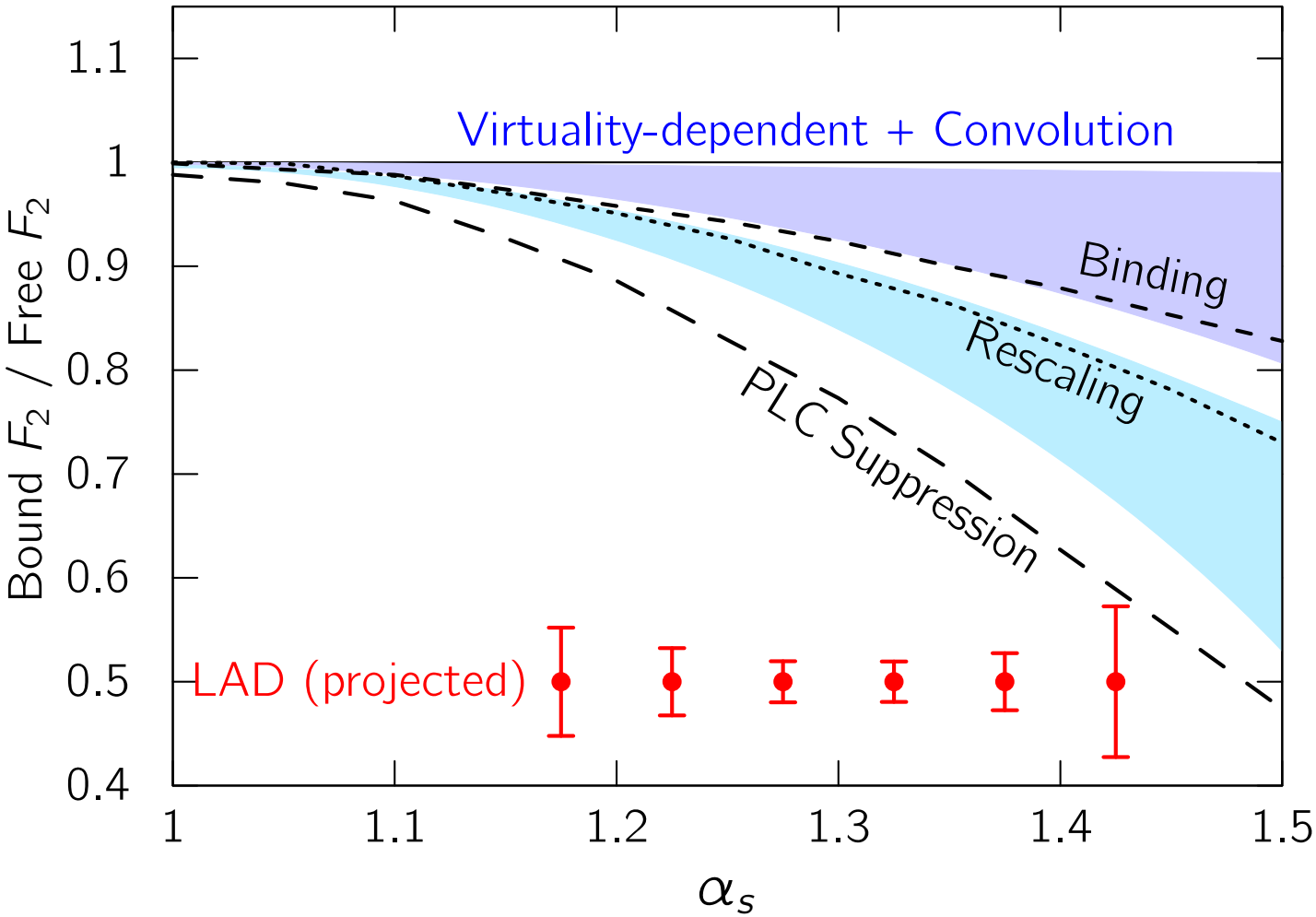
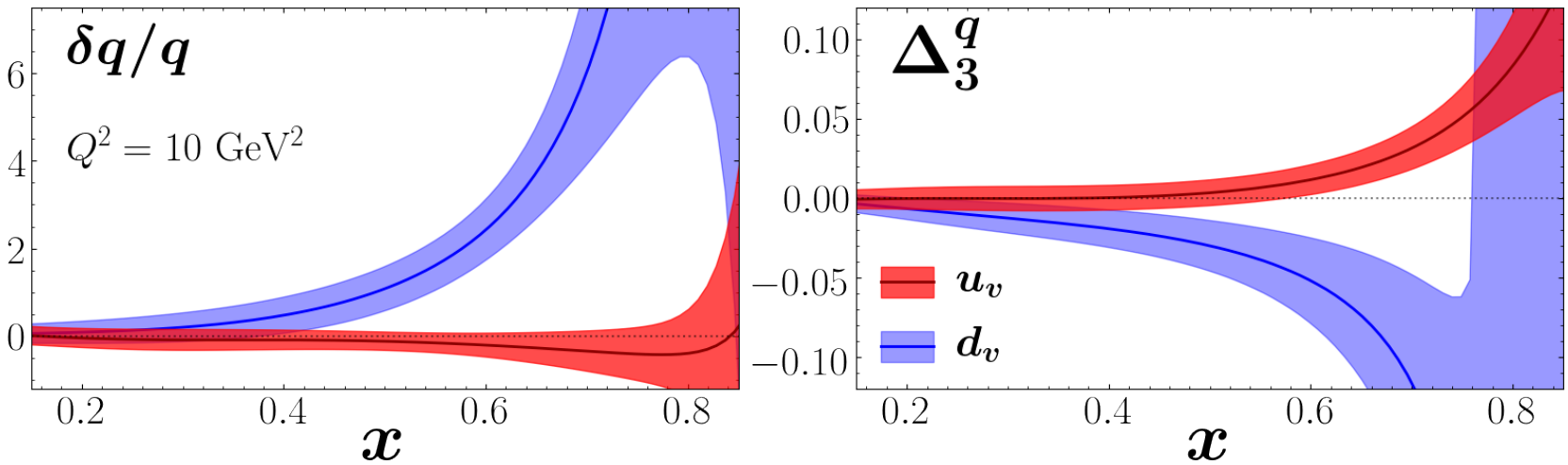


Melnitchouk, Sargsian, Strikman, Z. Phys. A 359, p. 99 (1997)
E. P. Segarra et al., Phys. Rev. Research 3, 023240 (2021)

Evidence suggests EMC Effect is different in protons and neutrons.



C. Cocuzza et al., JAM Collaboration, arXiv:2104.06946 [hep-ph] (2021)

Evidence suggests EMC Effect is different in protons and neutrons.

Convolution Framework

$$F_2^A = \frac{1}{A}\int_x^A \frac{d\alpha}{\alpha}\int_{-\infty}^0 dv \left[Z\rho_p(\alpha,v)F_2^p(x') + N\rho_n(\alpha,v)F_2^n(x')\right] \times \left[1 + v f_{\text{off}}(x')\right]$$

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Protons Neutrons Modification

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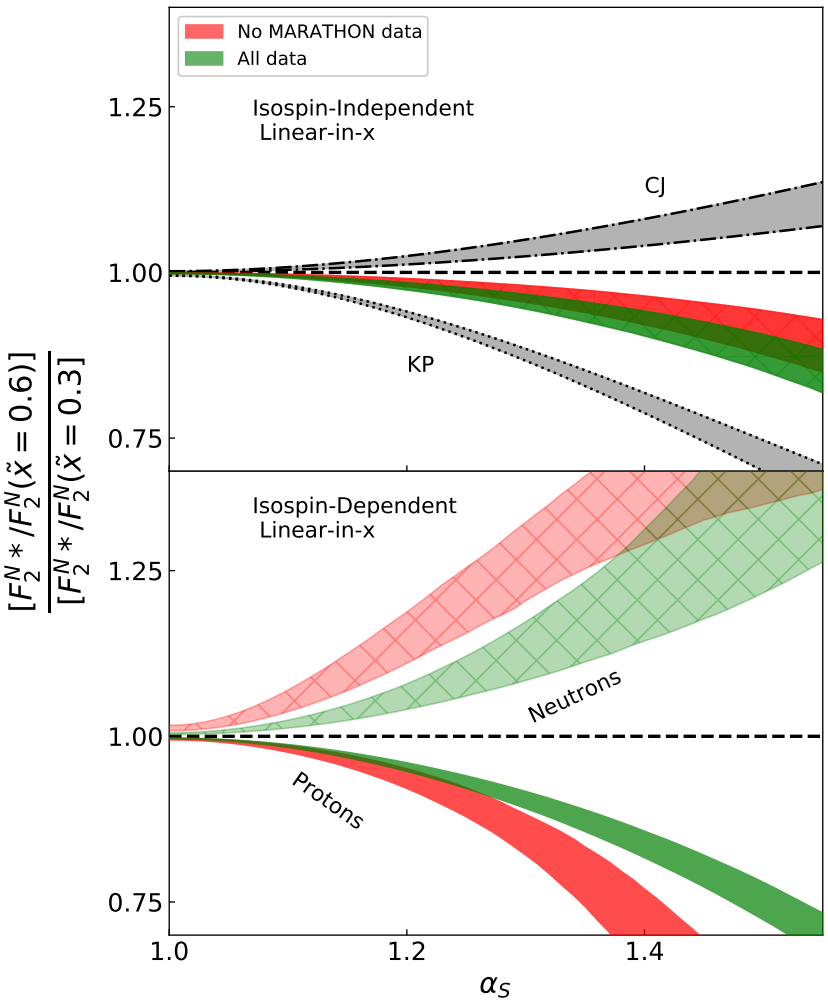
E. P. Segarra et al., arXiv:2104.07130 [hep-ph] (2021)



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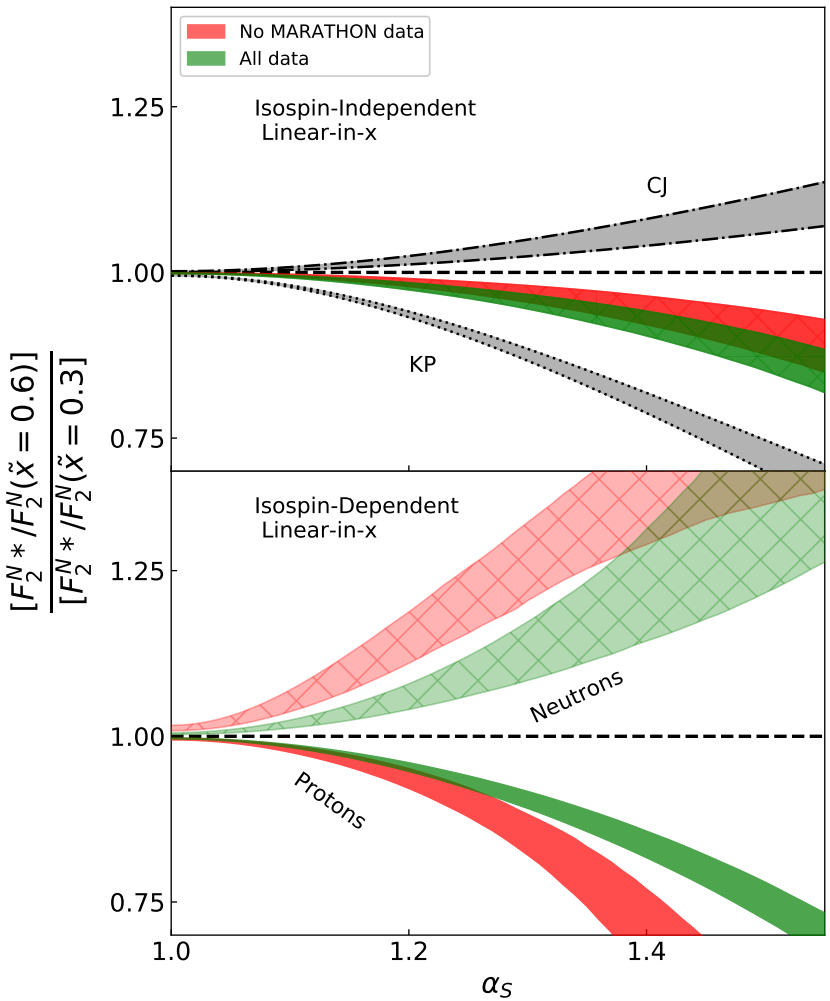
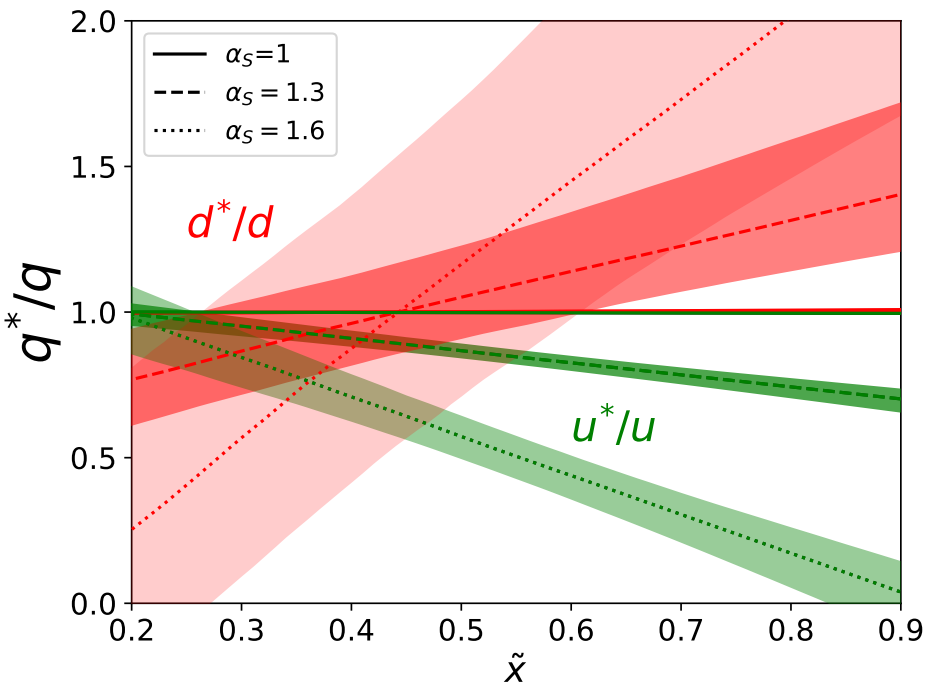
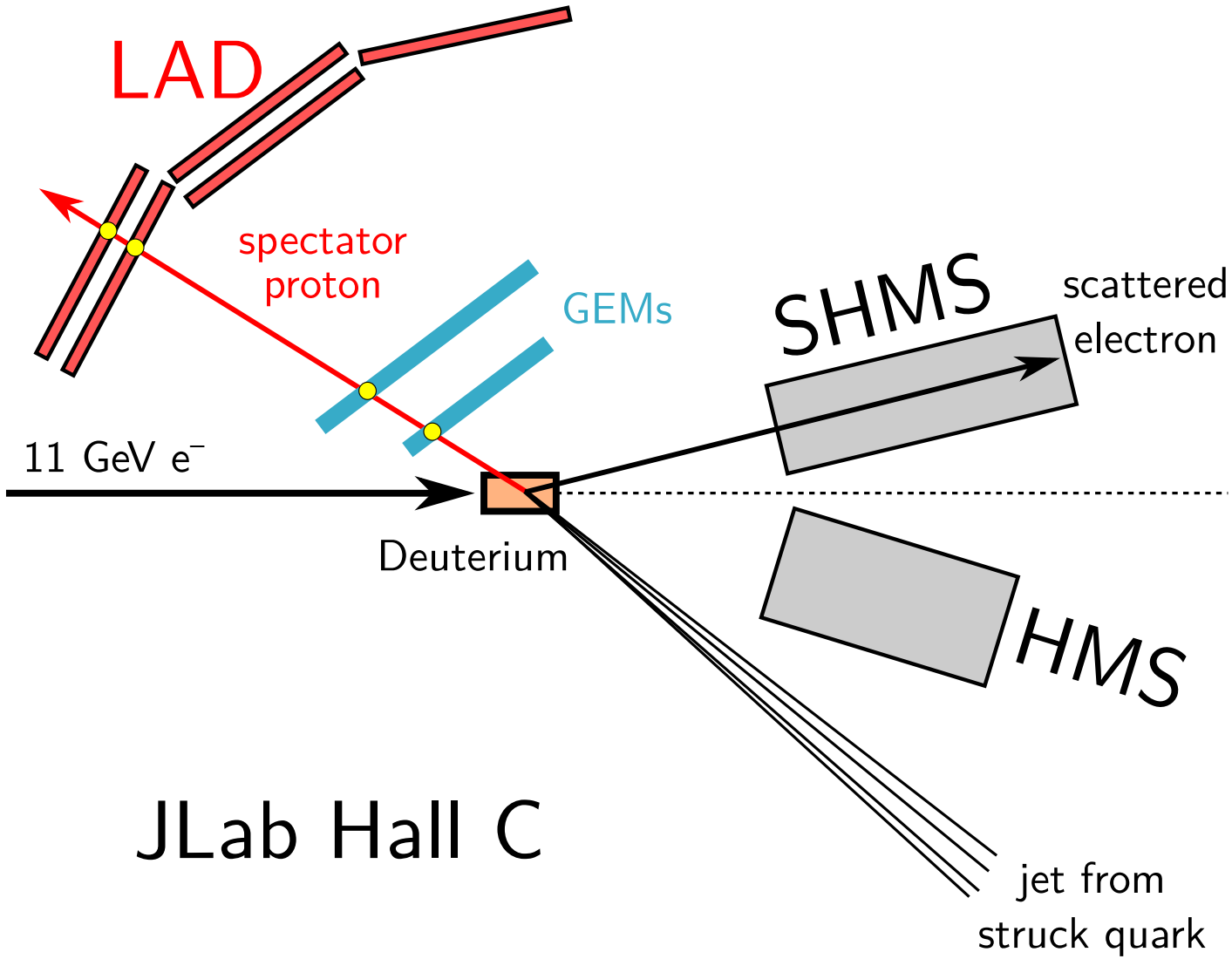




LAD covers both backward and perp. kinematics, help us understand FSIs in advance of EIC.



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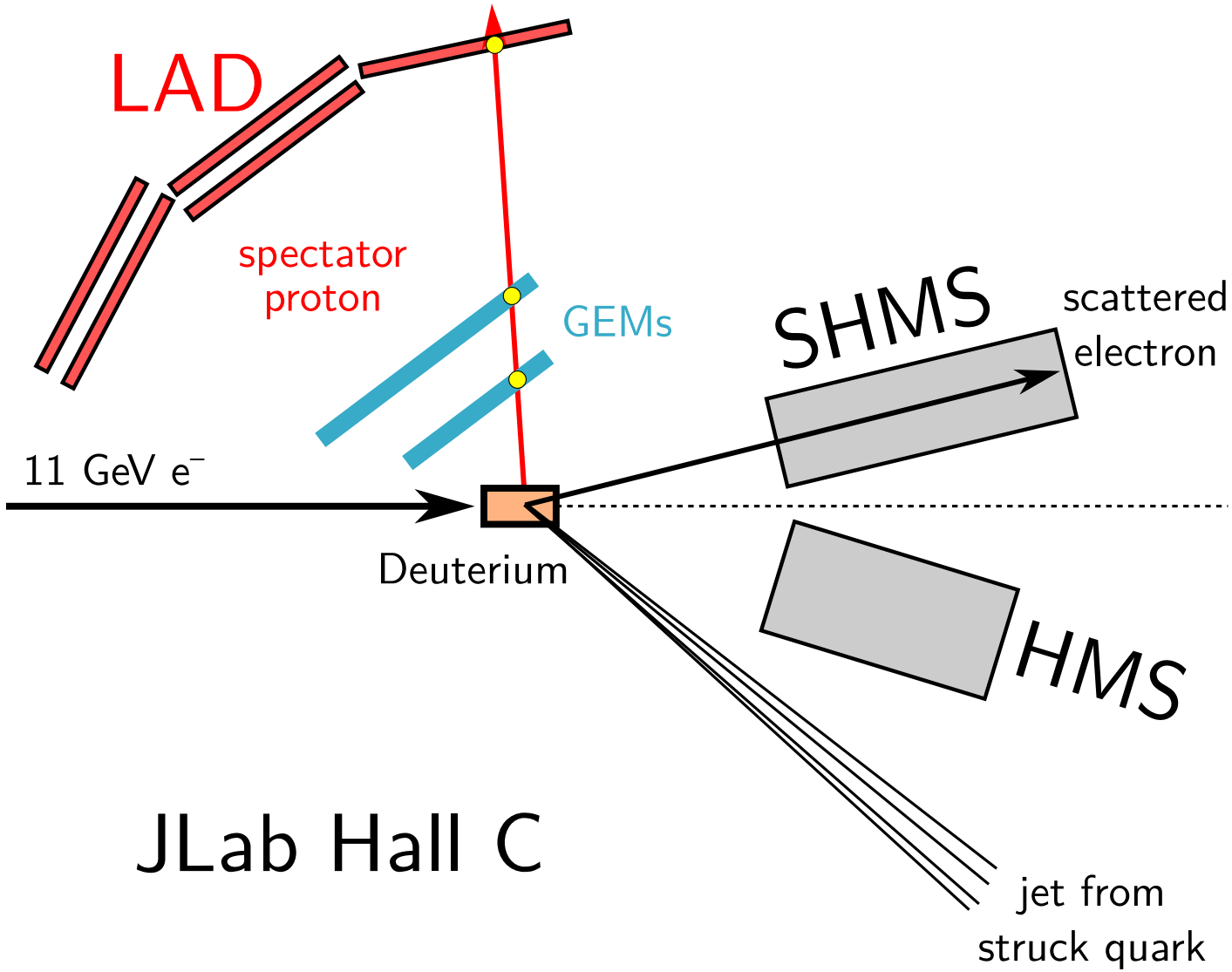

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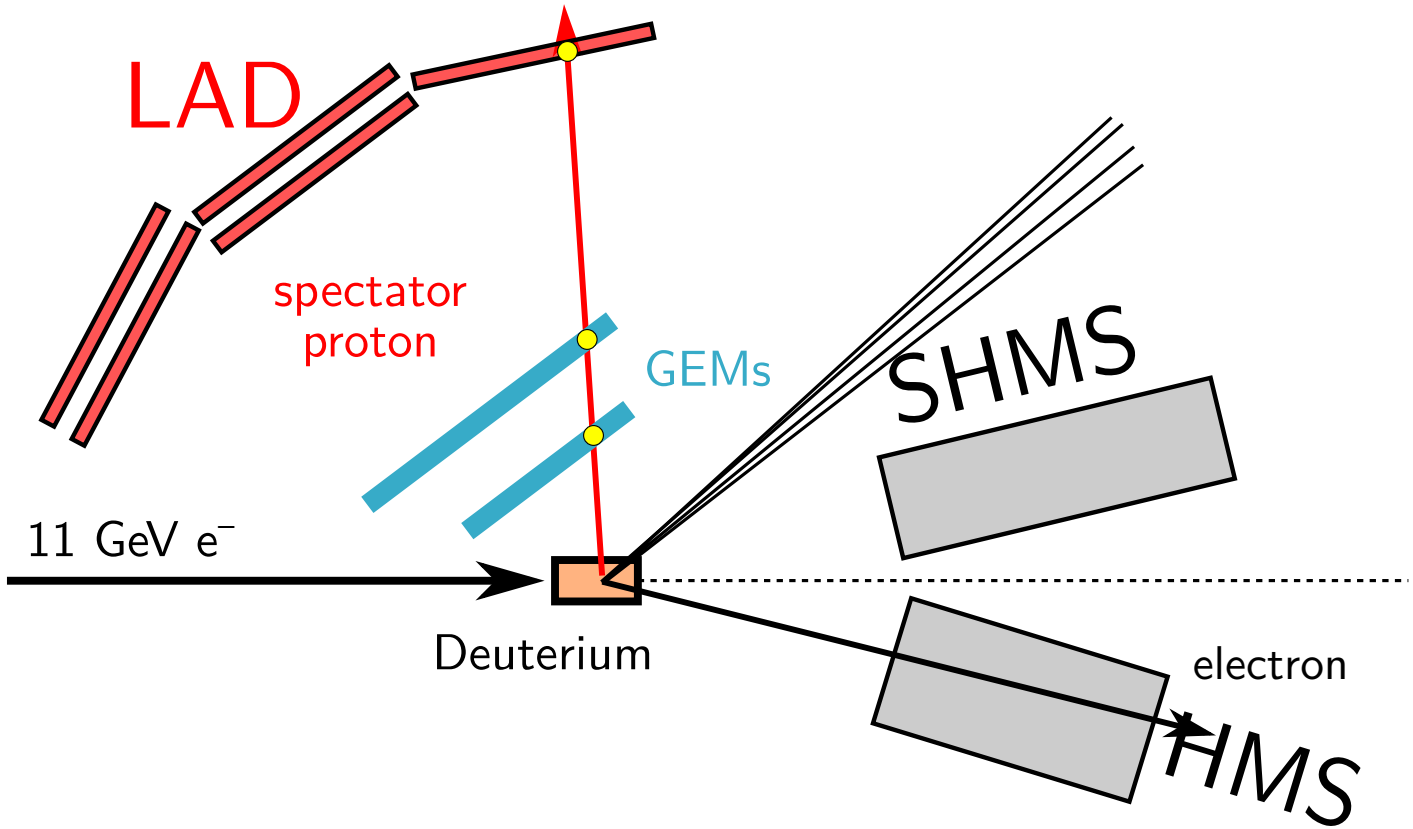

JLab Hall C

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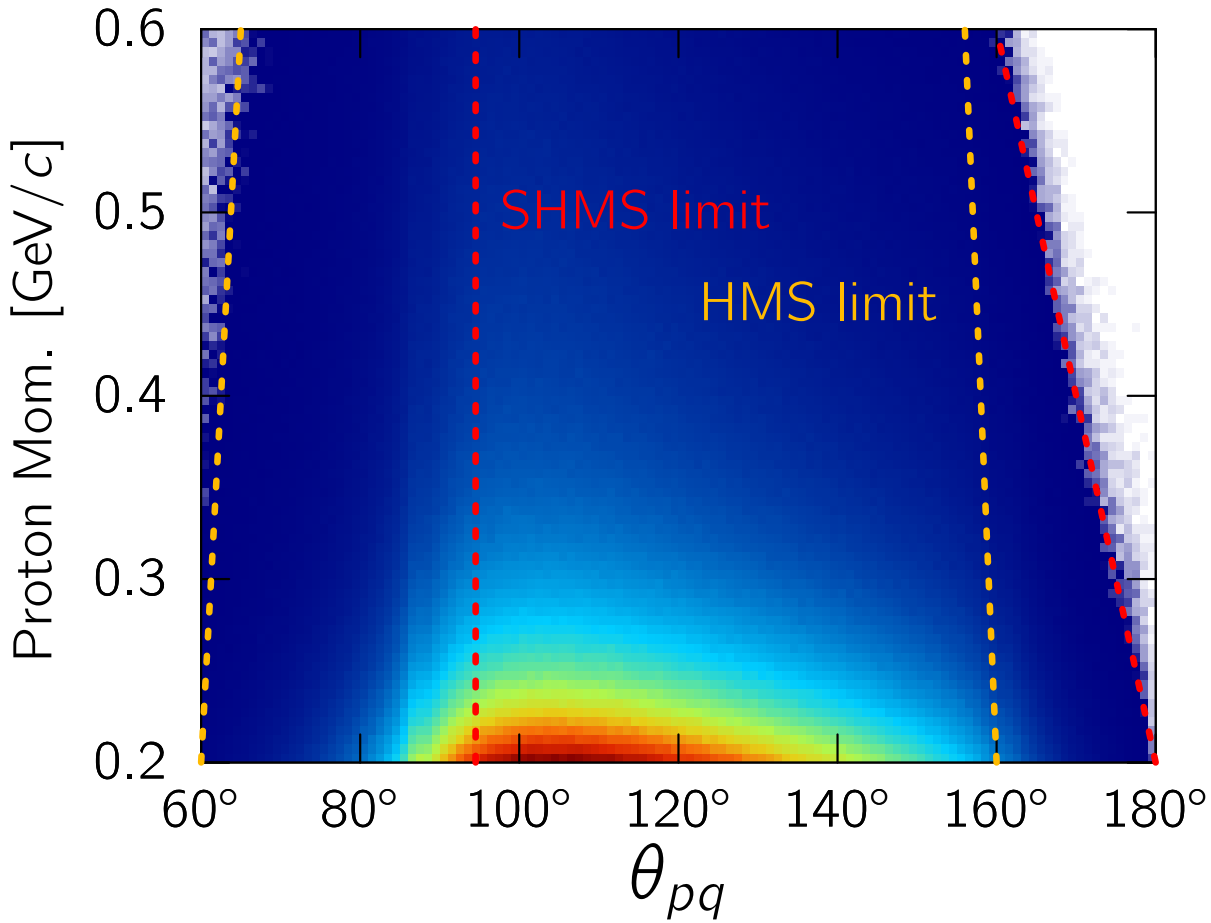
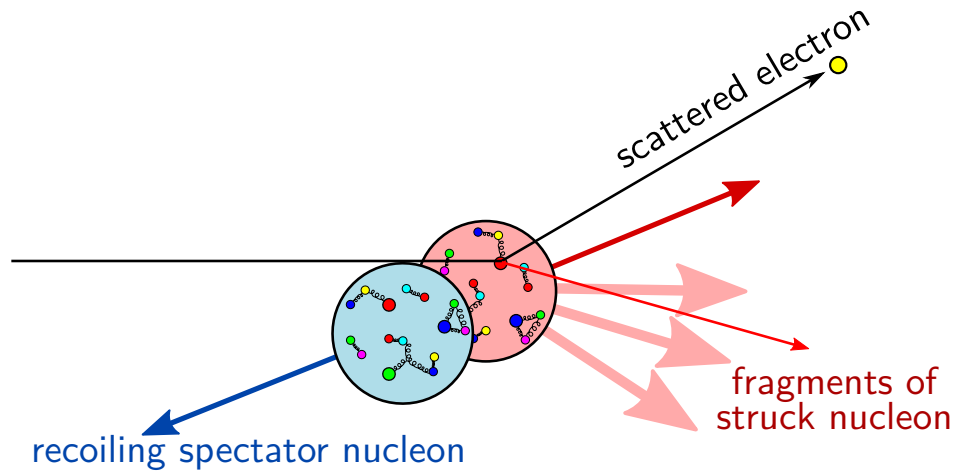


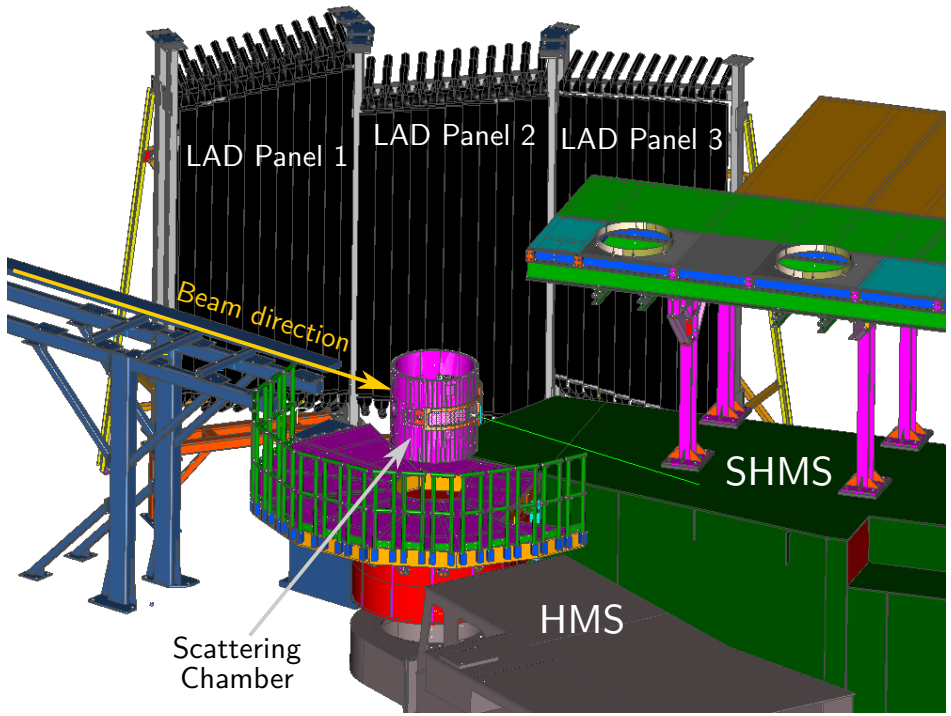
Summary

- **Spectator tagging** can test the SRC-EMC Connection.



Summary

- **Spectator tagging** can test the SRC-EMC Connection.
- **The LAD Experiment** will tag spectator protons.



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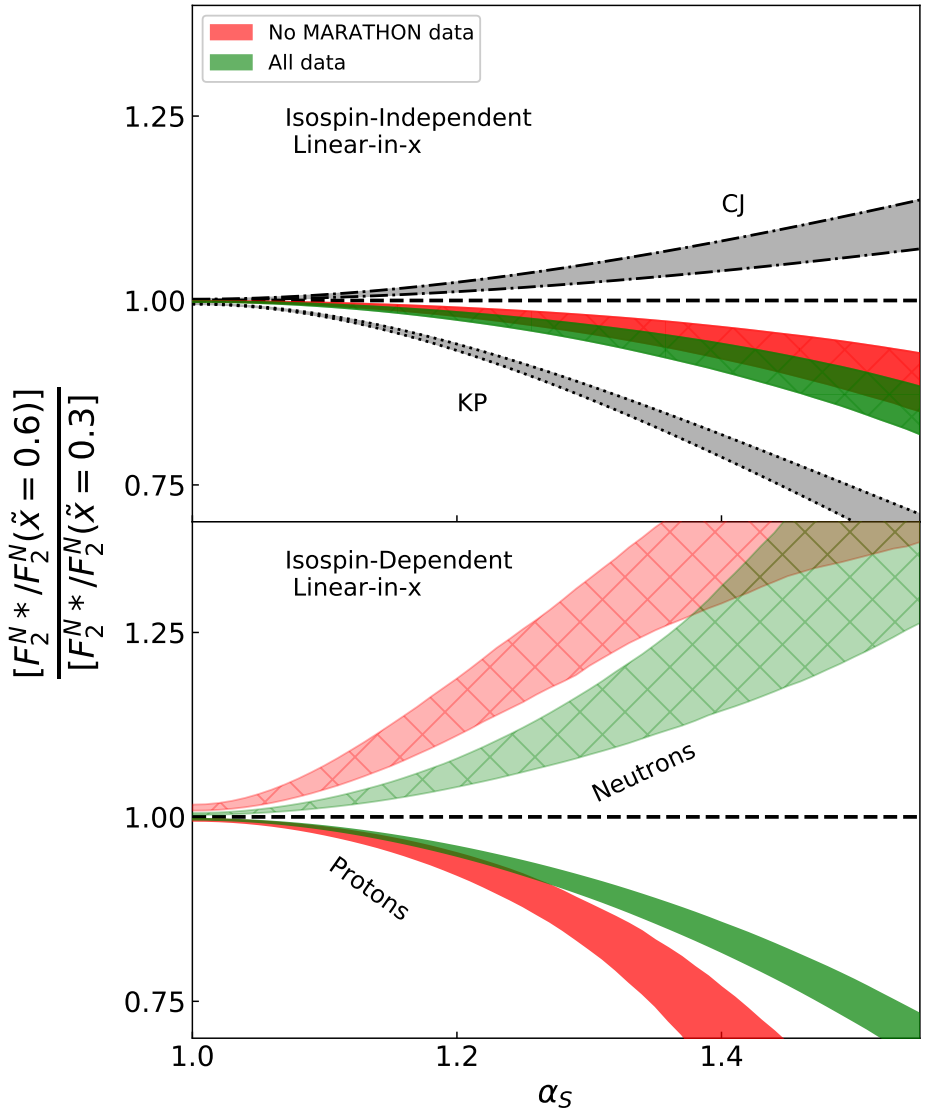
- **Linch pin experiment**
  - Test charge / isospin dependent EMC Effect



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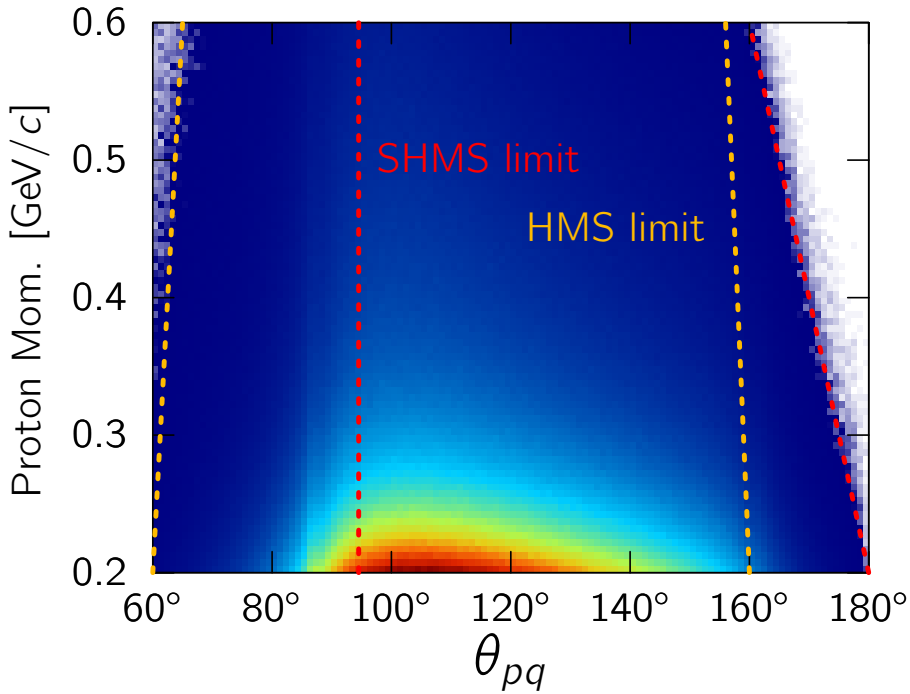

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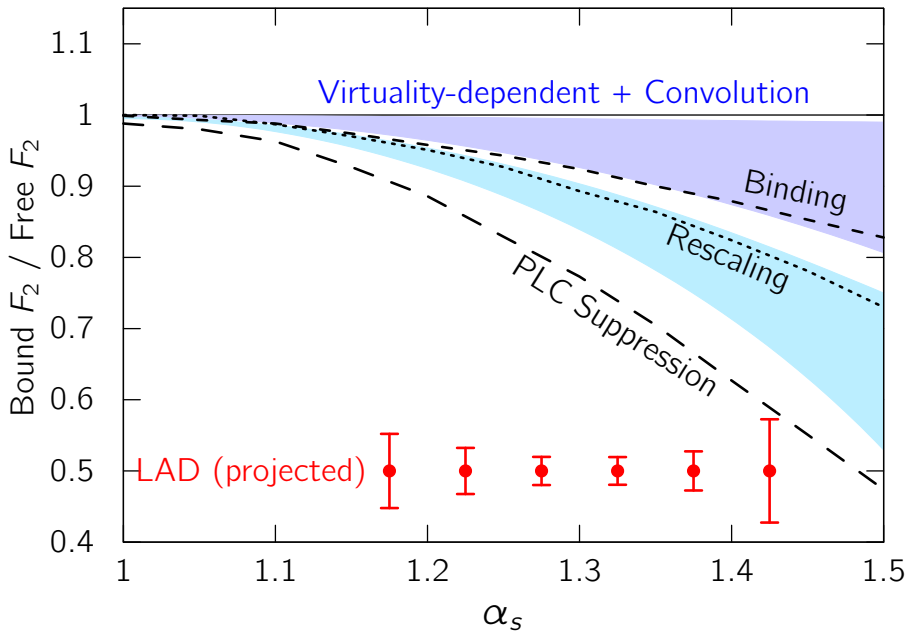
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