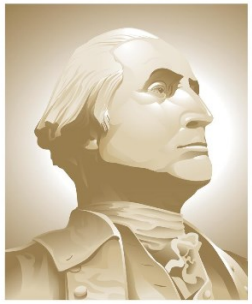
LAD Experiment:
Testing the EMC-SRC Hypothesis

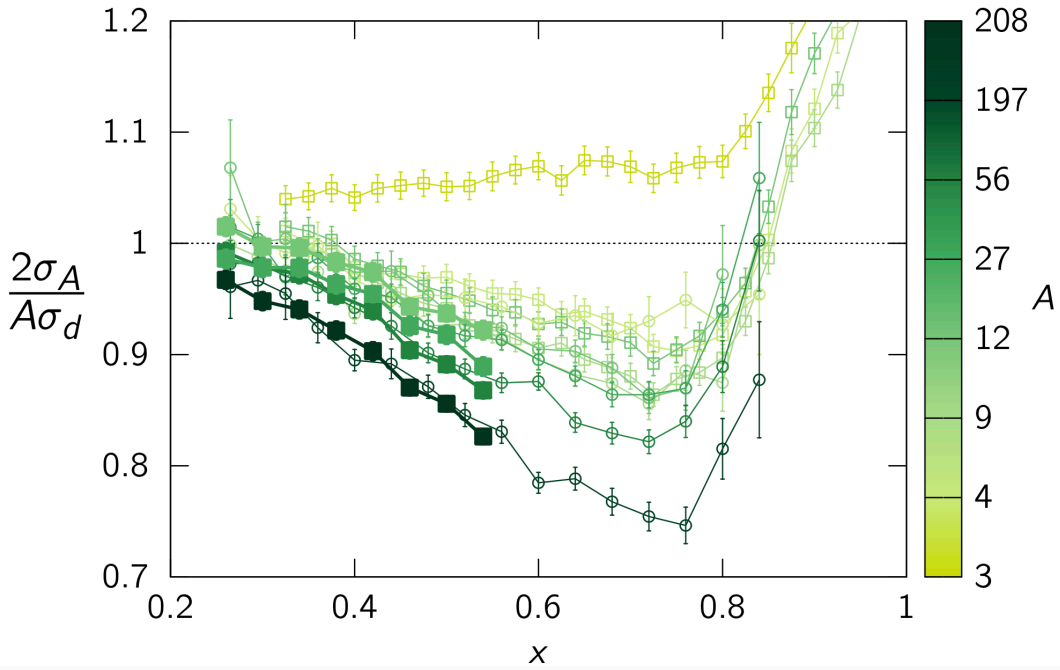
Sara Ratliff
The George Washington University
HUGS 2022



THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

The EMC Effect

Bound nucleons have different quark structure



J. Gomez et al., *Phys. Rev. D* **49** (1994) 4348.

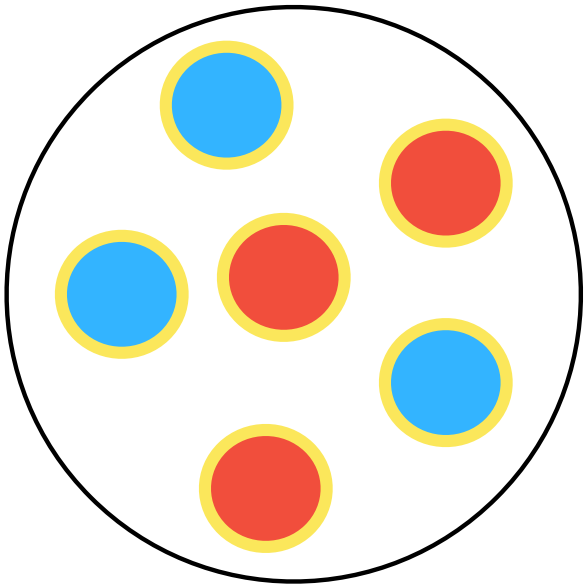
EMC: Mean Field v. Few Nucleon Explanation

Free Nucleons

EMC: Mean Field v. Few Nucleon Explanation

Free Nucleons

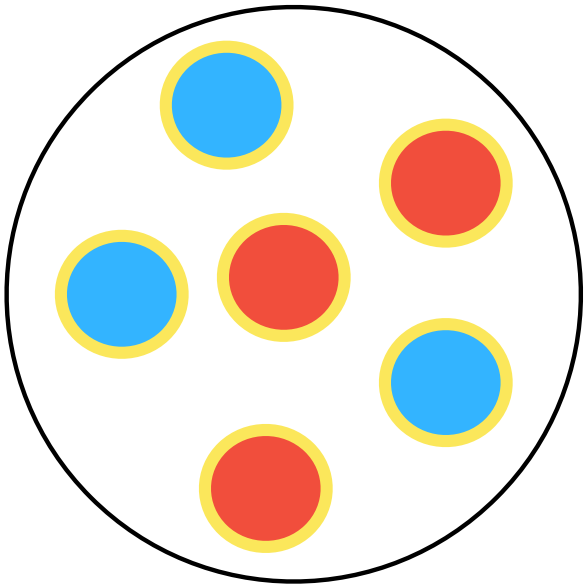
Mean-Field



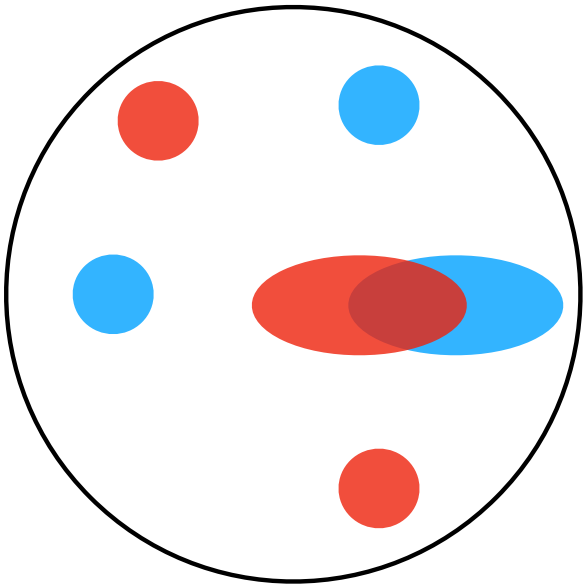
EMC: Mean Field v. Few Nucleon Explanation

Free Nucleons

Mean-Field

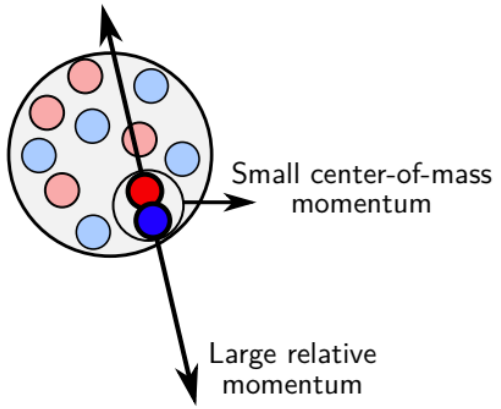


Few-Nucleon: SRCs



Short Range Correlations

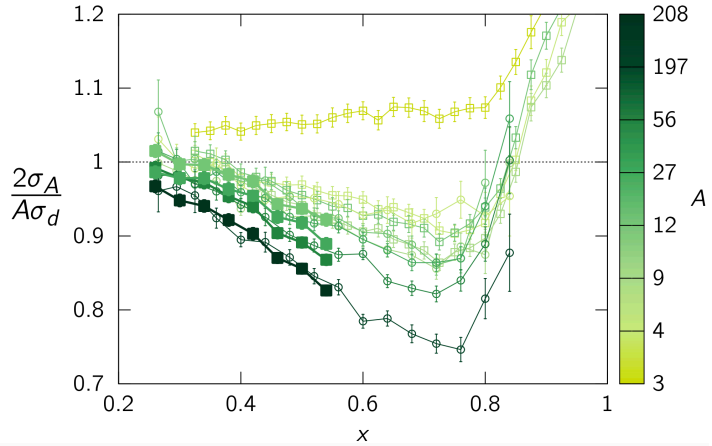
- ~20% of nucleons
- Closely associated nucleons
  - Closer than average nucleon radius



- Large relative momentum ($> k_F$), lower CM momentum
- ~90% of SRCs in nuclei are neutron-proton (np) pairs

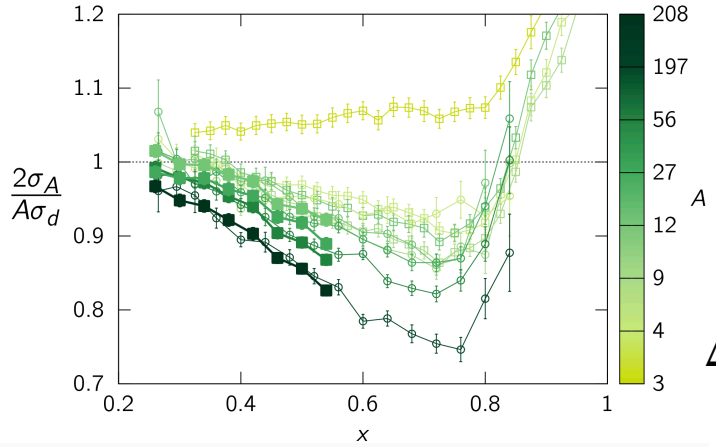
SRC-EMC Hypothesis

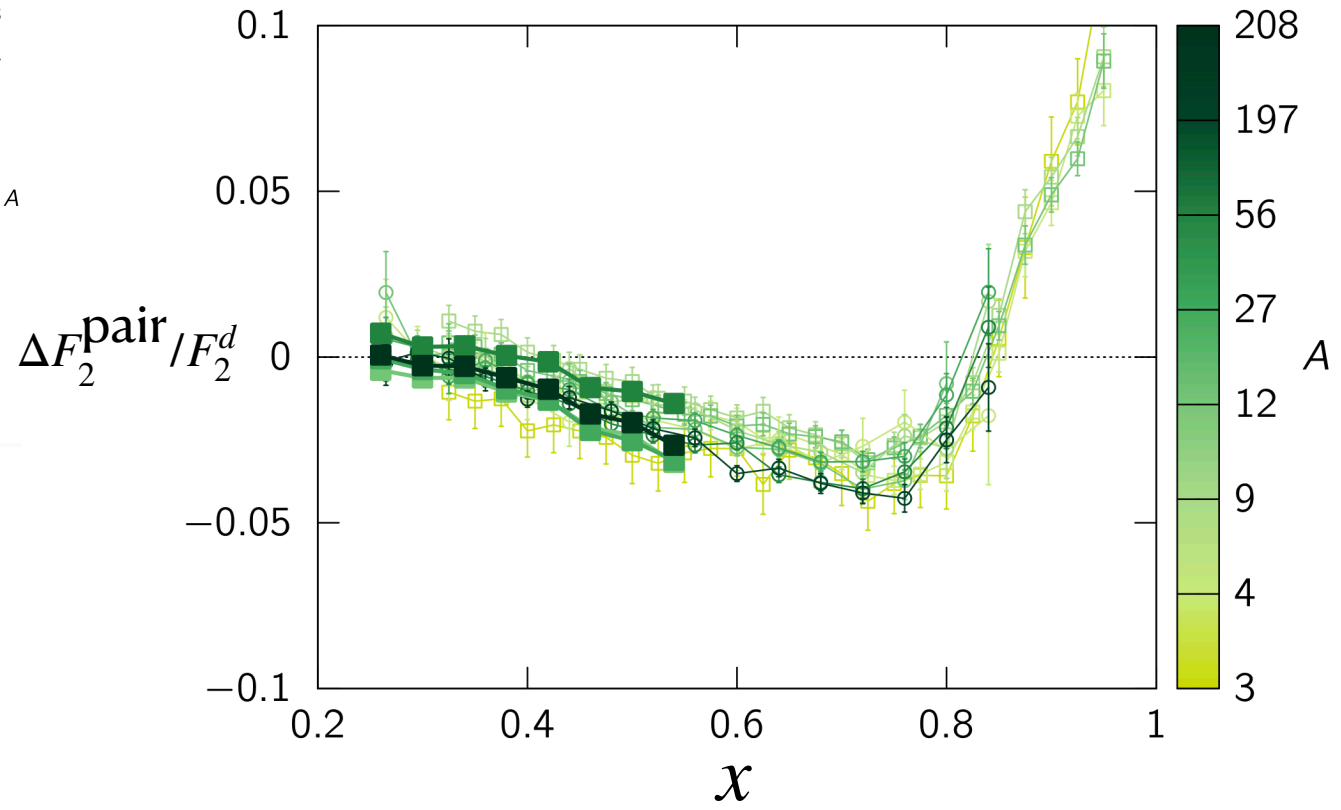
The prediction that the modification of the EMC effect is due to interactions within SRCs



SRC-EMC Hypothesis

The prediction that the modification of the EMC effect is due to interactions within SRCs

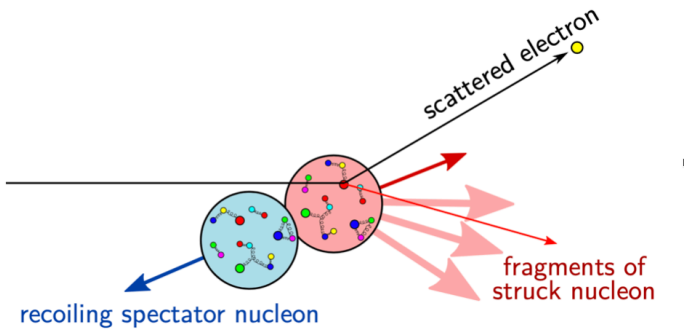




B. Schmookler, *Nature* **566** (2019) 354.

Recoil-Tagged DIS

- Deep inelastic scattering from a member of an SRC pair
- The correlated partner of the struck nucleon will recoil



- By detecting this recoiling nucleon, information about the state of the correlated pair can be extracted

Recoil-Tagged DIS
New Variables

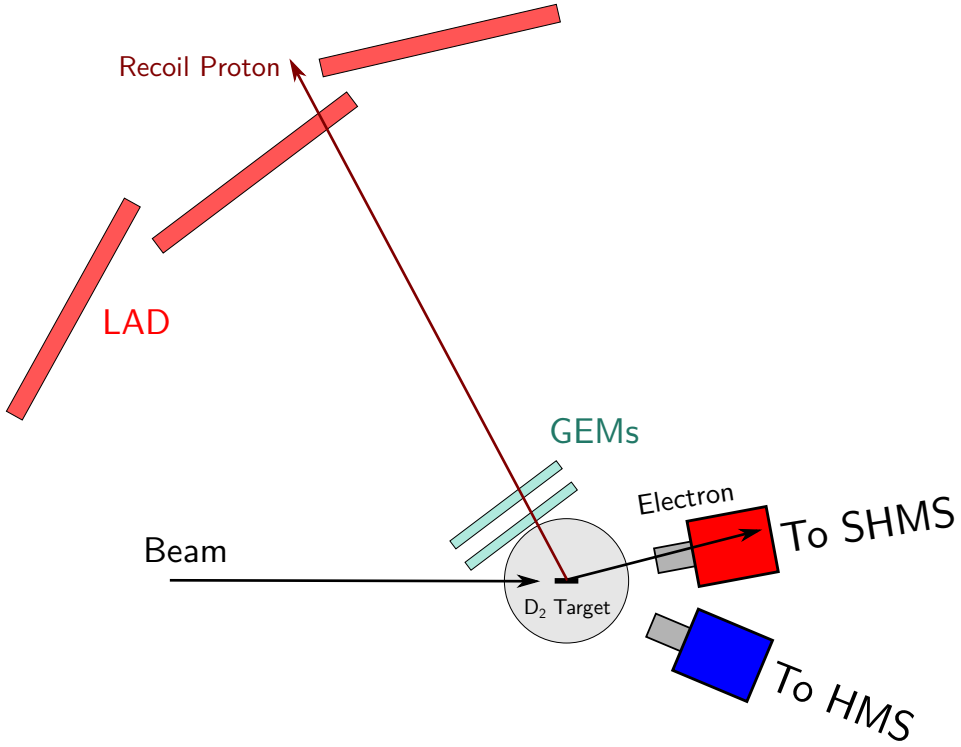
- Spectator light-cone momentum fraction
  "Degree of Correlation"

$$\alpha_s = (E_s - p_s^z)/m_s$$

- Updated value of x for a moving nucleon
  "Quark Motion"

$$x' = \frac{Q^2}{2q \cdot (p_{\text{pair}} - p_s)}$$

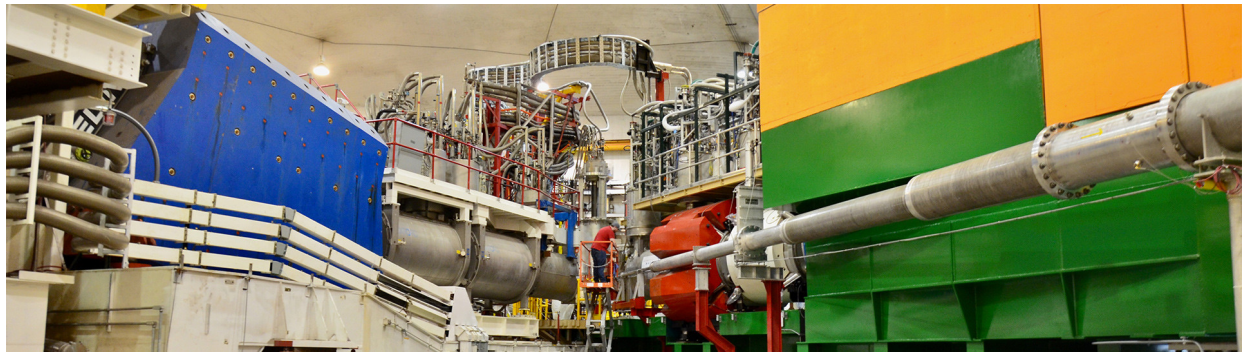
LAD Set-Up



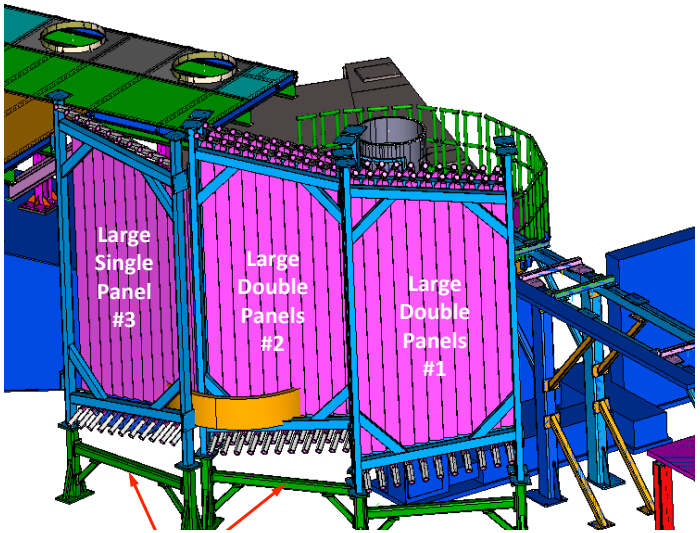
Components:

Electron Beam
Deuterium Target
Large Acceptance Detector (LAD)
GEM detectors
High momentum spectrometers

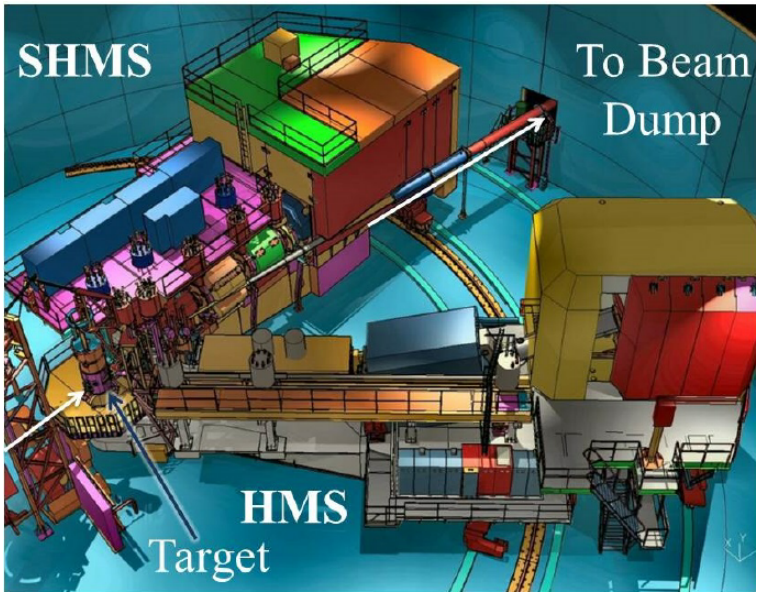
Jefferson Lab Hall C



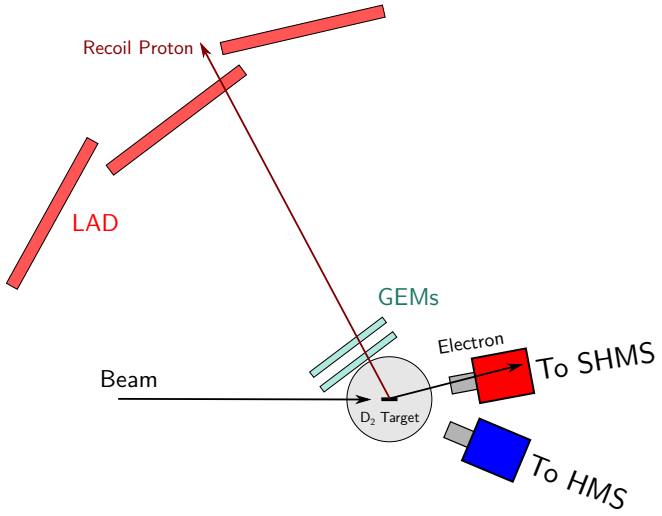
Large Acceptance Detector (LAD)



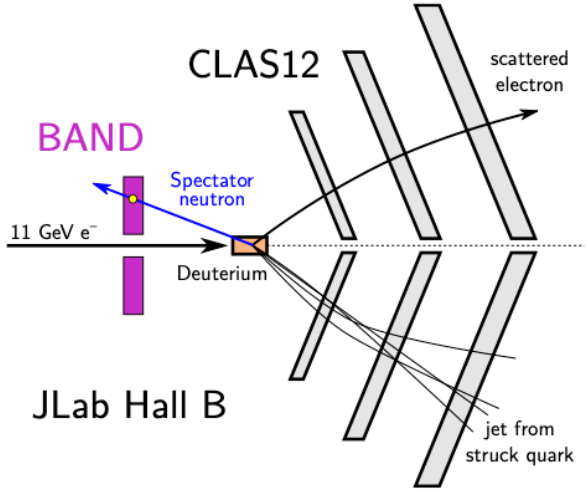
Spectrometers



LAD



BAND



- Jefferson Lab Hall C
  - Prioritizing Resolution over Acceptance
- Recoiling Protons
- Quarks in Neutrons
- New Avenue for background suppression:
  - GEMs

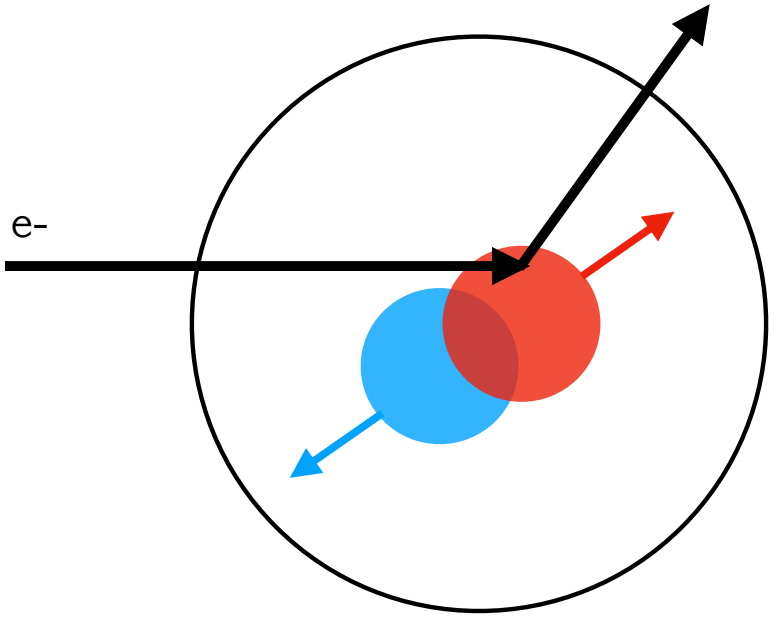
- Jefferson Lab Hall B
  - Prioritizes High Acceptance
- Recoiling Neutrons
- Quarks in Protons

LAD Experiment Timeline

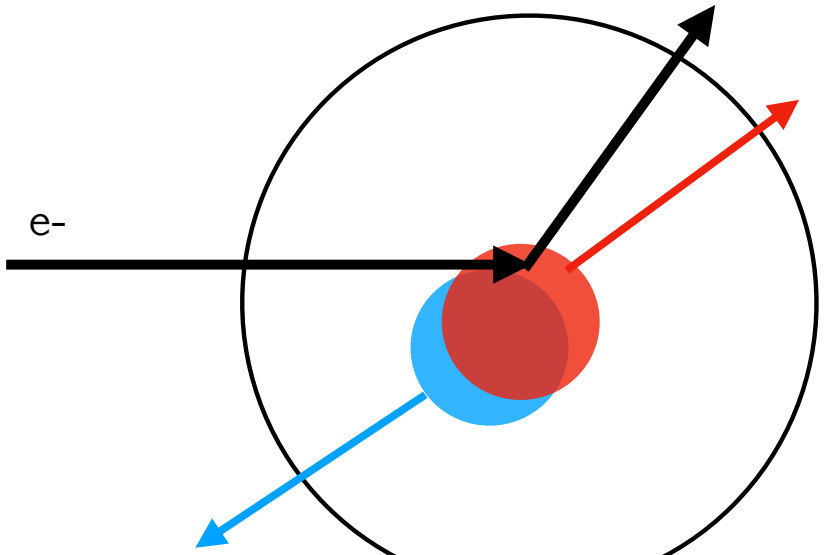
- Proposed in 2011
- Passed the Experiment Readiness Review in 2020
- Faced “Jeopardy” in 2021, Approved
- Hopefully will run in 2024

Observable of Interest

Low α_s: slightly correlated



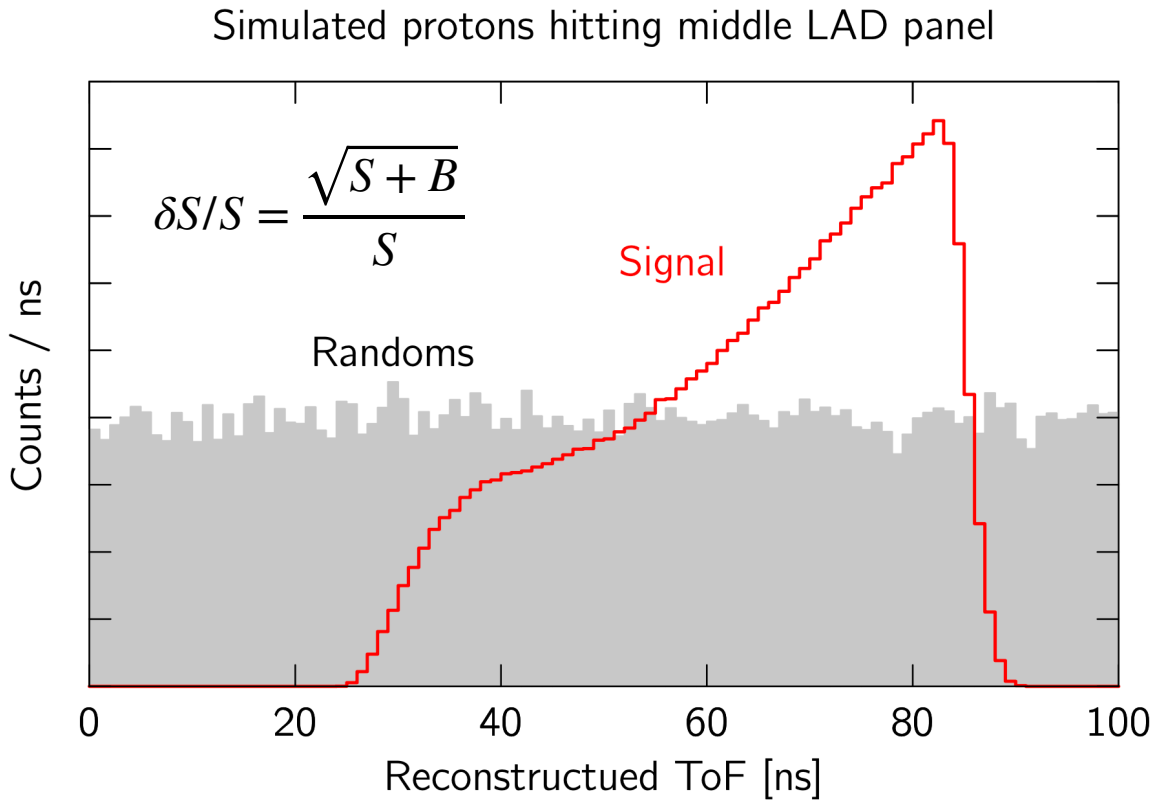
High α_s: highly correlated



Measure $F_2^{\text{bound}}/F_2^{\text{free}}$ via cross section ratios against α_s to determine if modification increases with increased strength of correlation

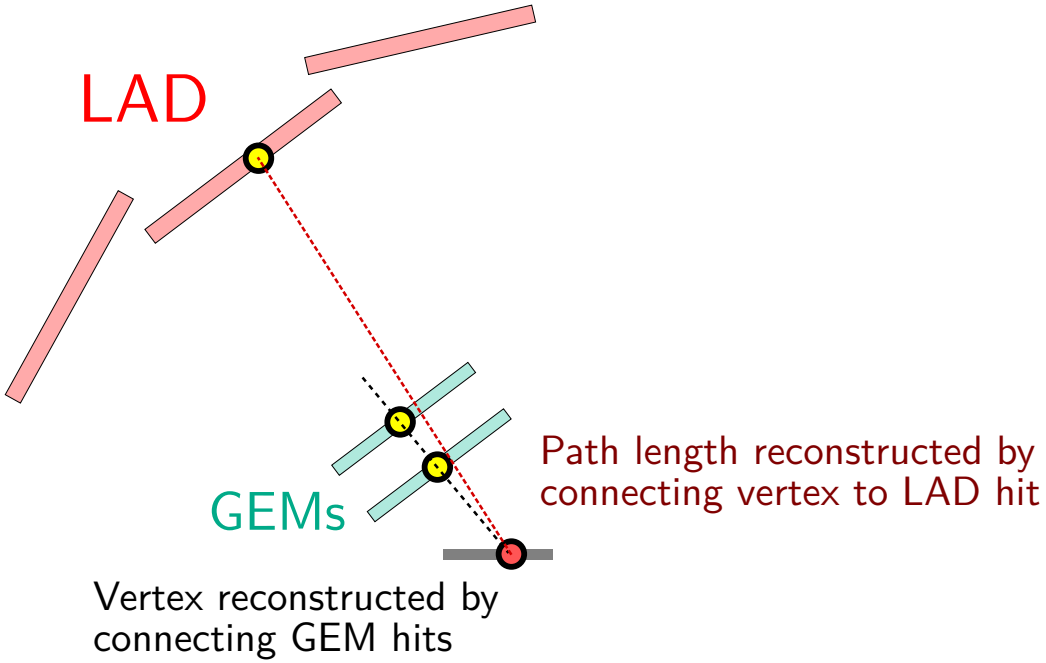
Random Coincidence Background

The experiment will be limited by random coincidence background



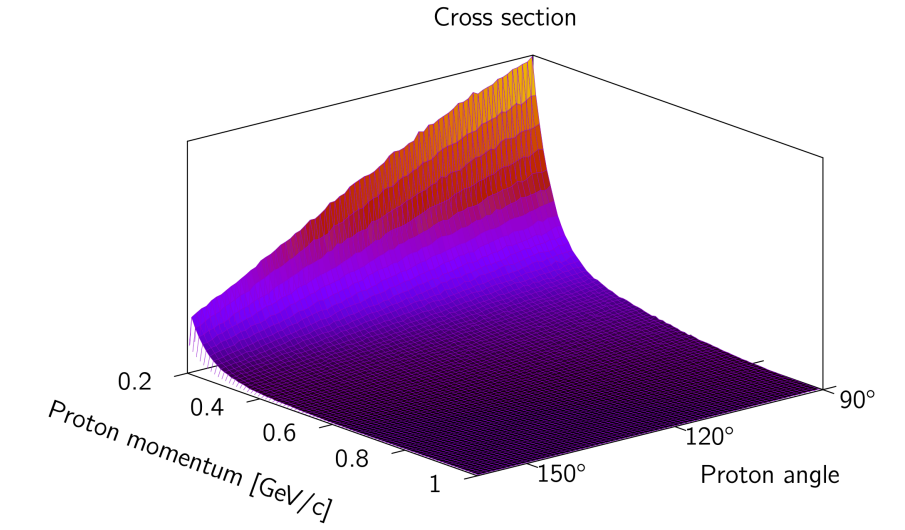
GEM Detectors

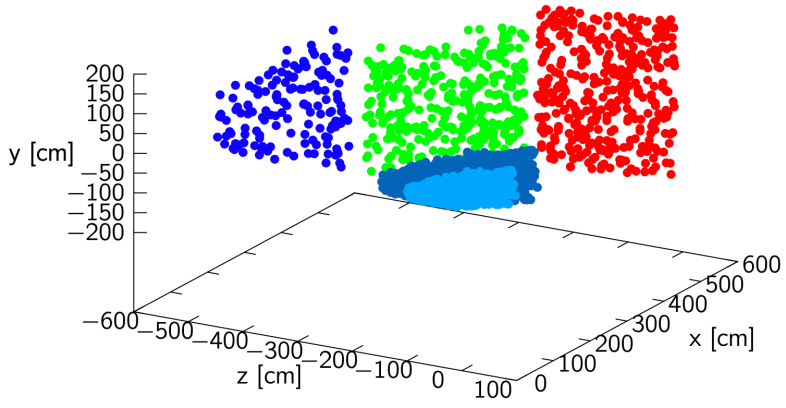
GEM detectors provide crucial background suppression



Monte Carlo Simulation

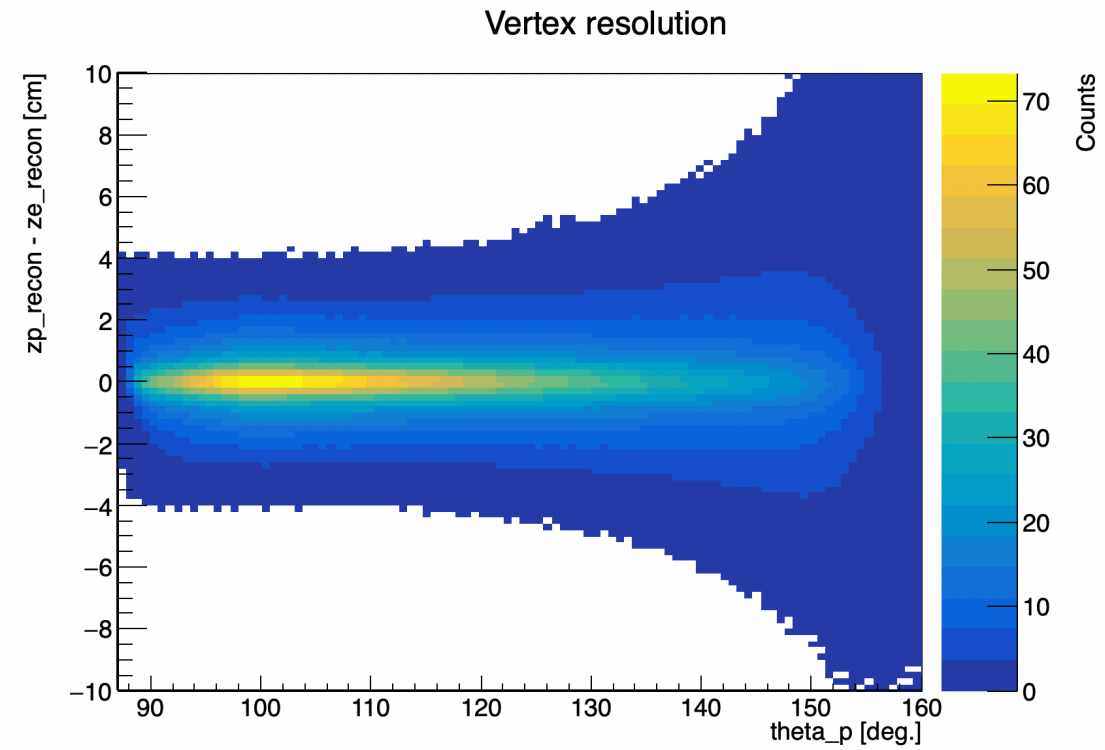
- Tagged-DIS event generator
- Random coincidence background generator
- Calculations by Wim Cosyn and Misak Sargsian



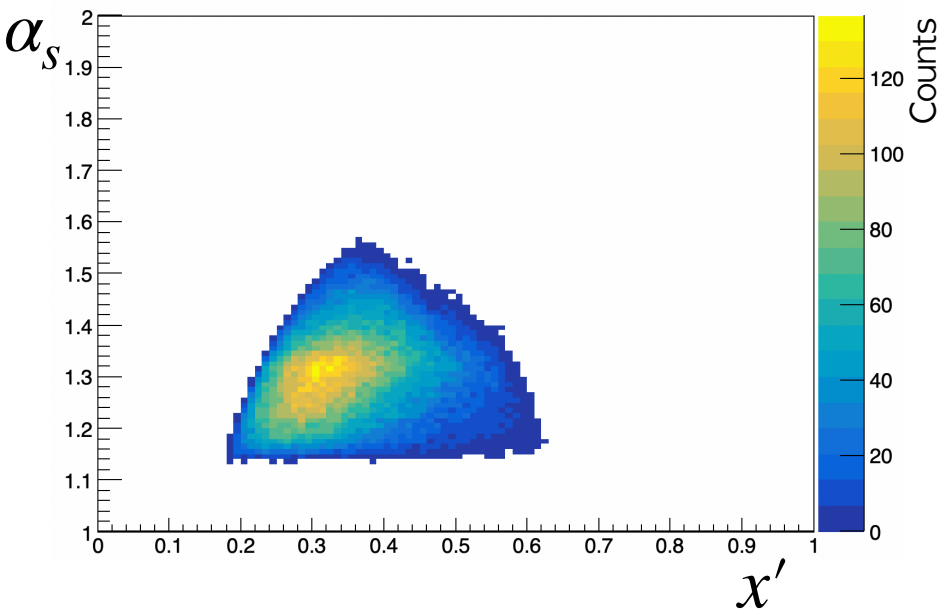


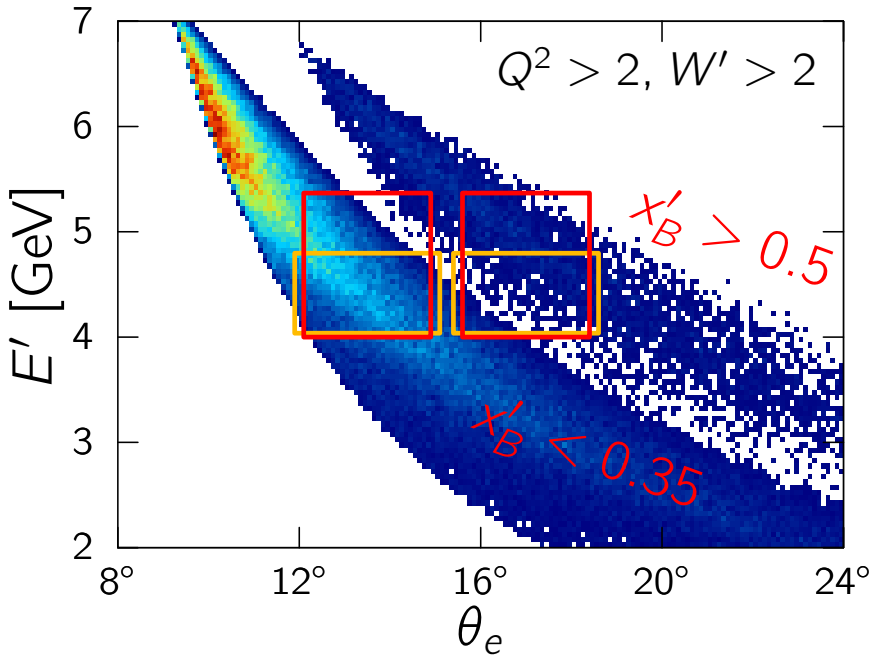
Monte Carlo Simulation

The GEM detectors will give centimeter-level vertexing



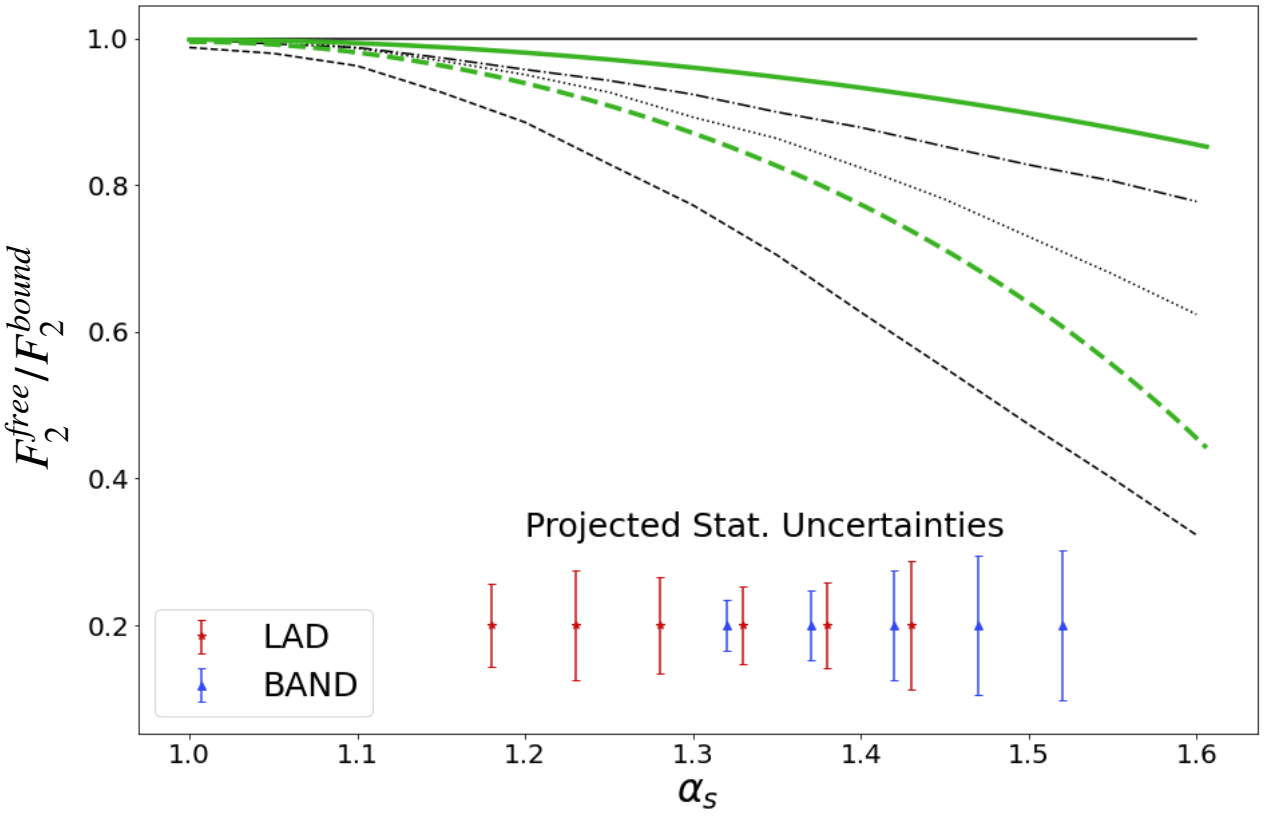
Kinematics


α_s
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x'
120
100
80
60
40
20
0
Counts


$Q^2 > 2, W' > 2$
$x'_B > 0.5$
$x'_B < 0.35$
E' [GeV]
7
6
5
4
3
2
8°
12°
16°
20°
24°
θ_e

Projected Uncertainties

LAD and BAND will definitively test the EMC-SRC Hypothesis



Segarra et al., arXiv:2006.10249 (2020)

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

Conclusions

- SRC-EMC ~exciting~ alternative to other hypotheses explaining EMC effect
- LAD is a necessary complement to BAND
- LAD will be scheduled soon and will provide a definitive answer to the SRC-EMC Hypothesis