Testing the EMC-SRC Hypothesis with the BAND Experiment

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Frontiers and Careers in Nuclear and Hadronic Physics

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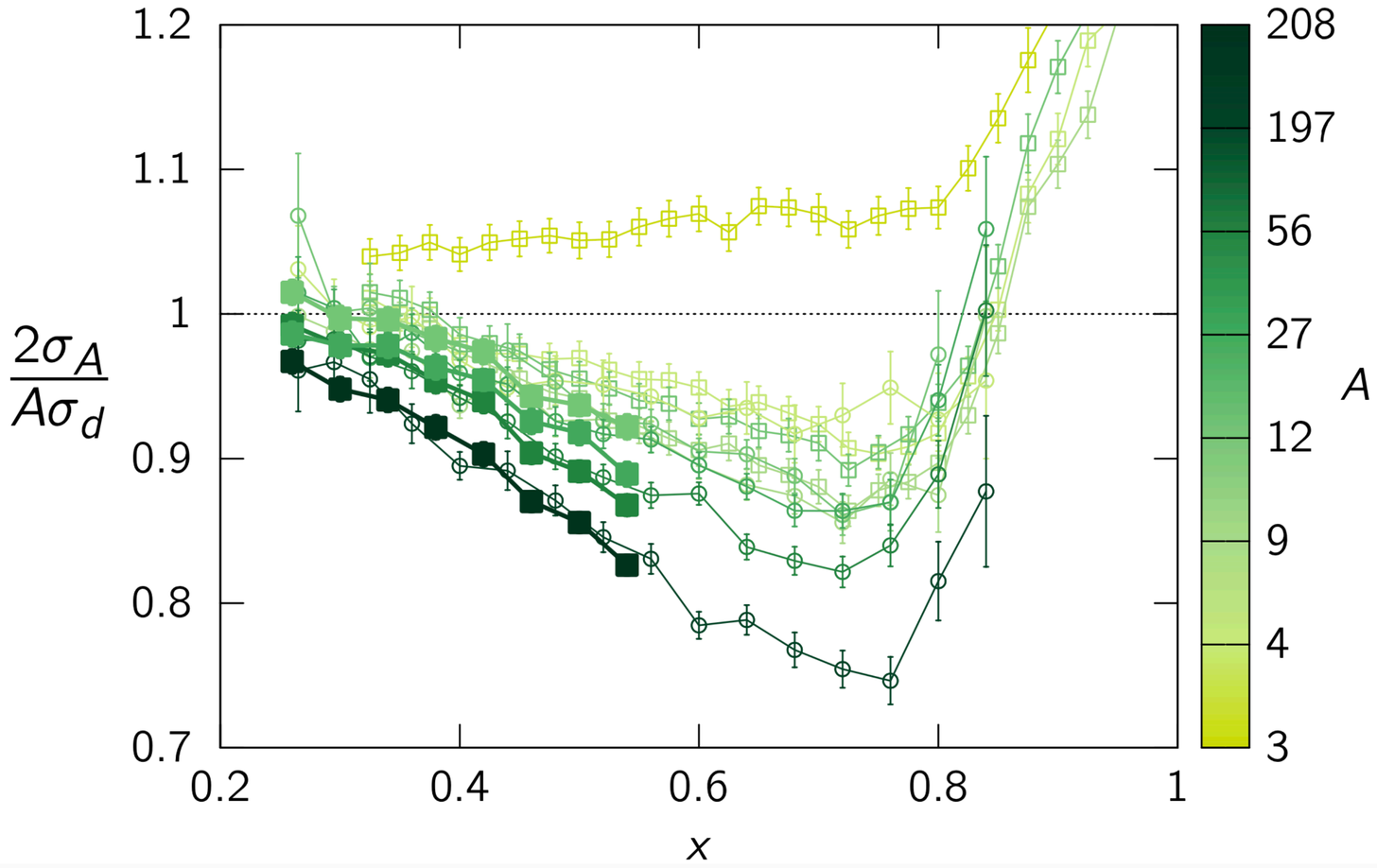
The EMC Effect

DIS cross sections on nuclei differ from those on free nucleons



Schmookler, *Nature* **566** (2019)

EMC: Mean Field v. Few Nucleon Explanation

Free Nucleons

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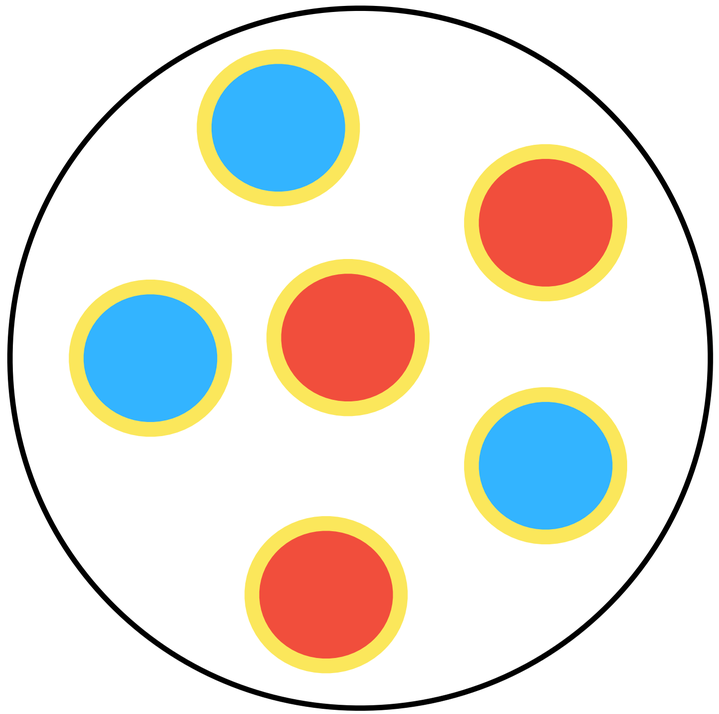
Free Nucleons

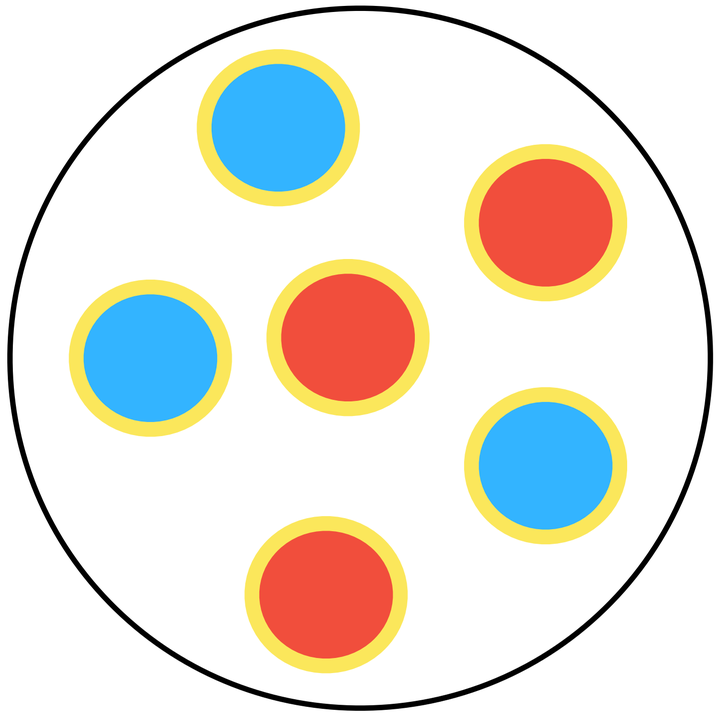
Mean-Field



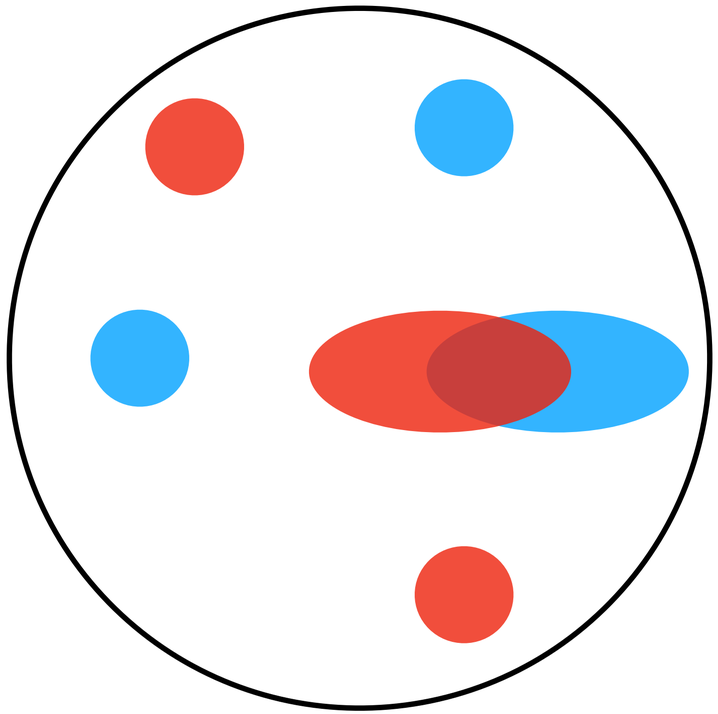
EMC: Mean Field v. Few Nucleon Explanation

Free Nucleons

Mean-Field

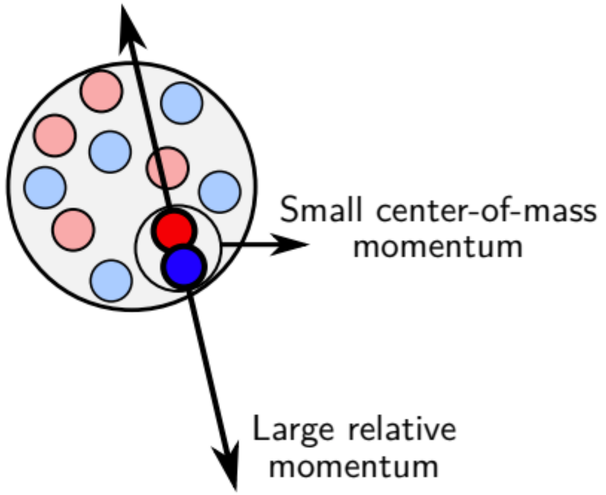


Few-Nucleon



Short Range Correlations

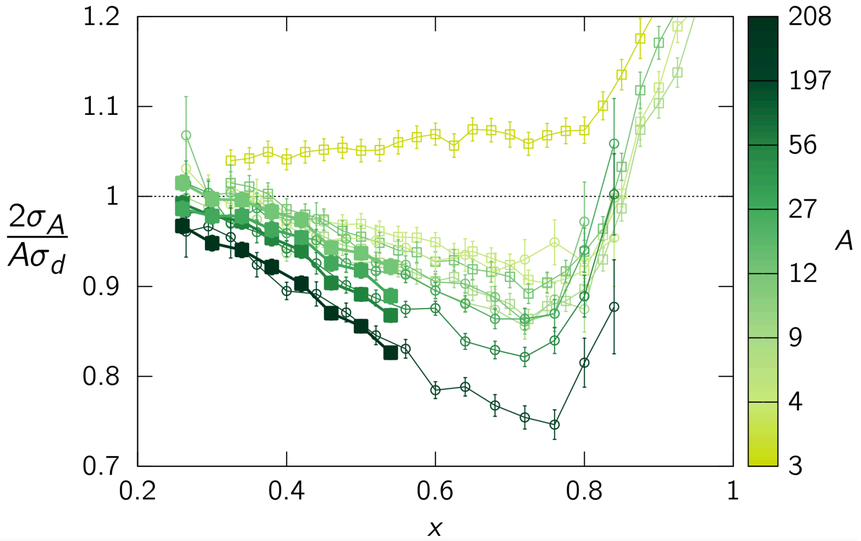
- ~20% of nucleons
- Closely associated nucleons
  - Closer than average nucleon radius



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

SRC-EMC Hypothesis

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



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SRCs: SRC-EMC Hypothesis

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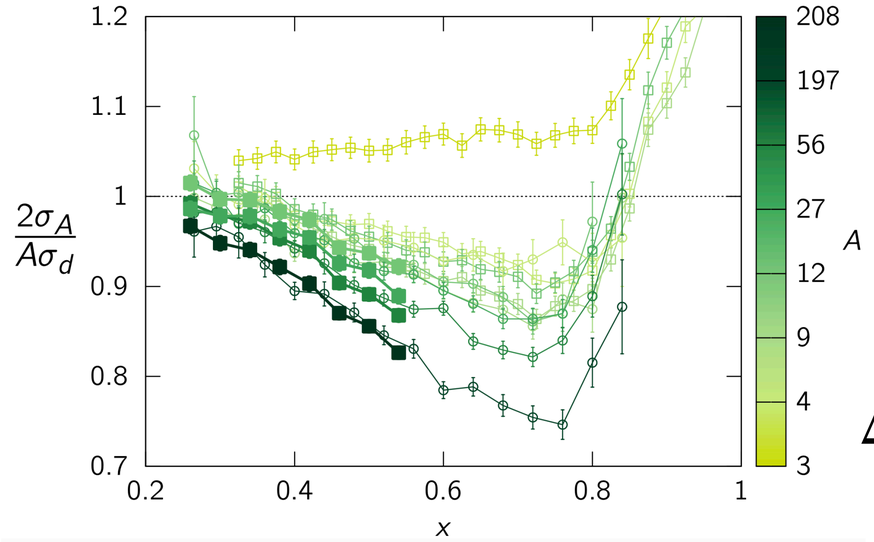

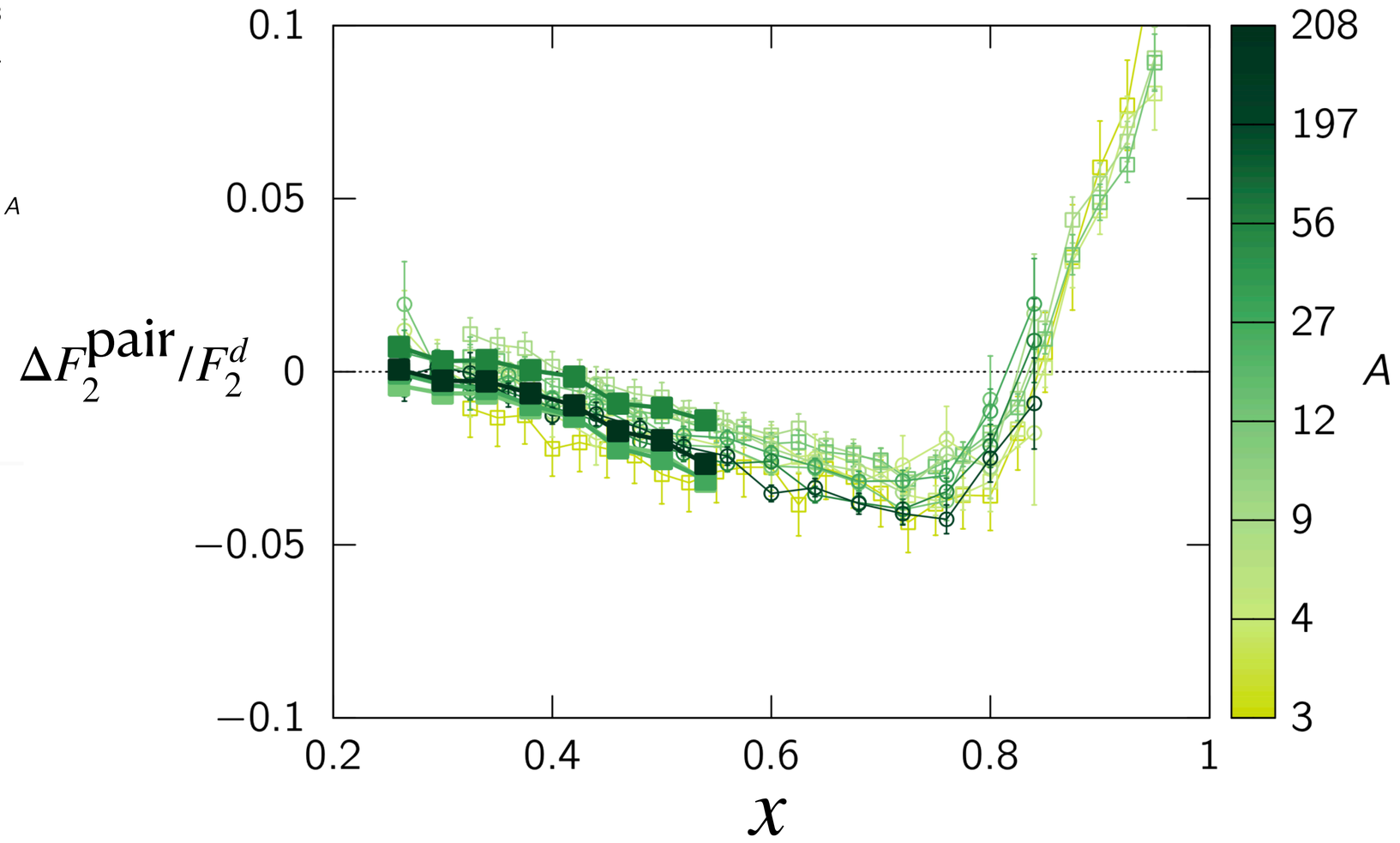

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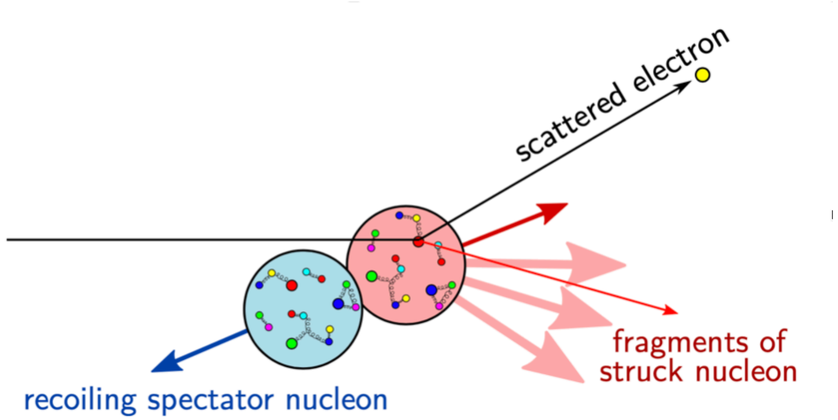
SRCs: Recoil-Tagged DIS

- 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

SRCs: Recoil-Tagged DIS
New Variables

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

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

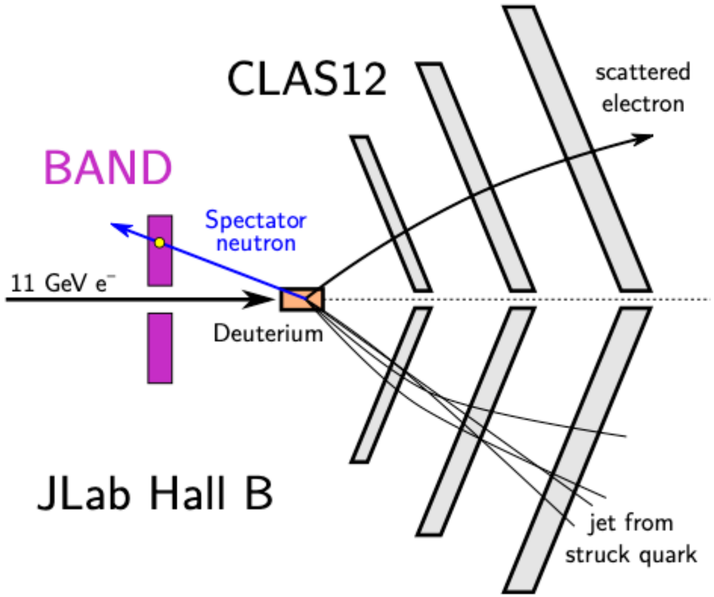
- Updated value of x for a moving nucleon
  "Quark Motion"

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

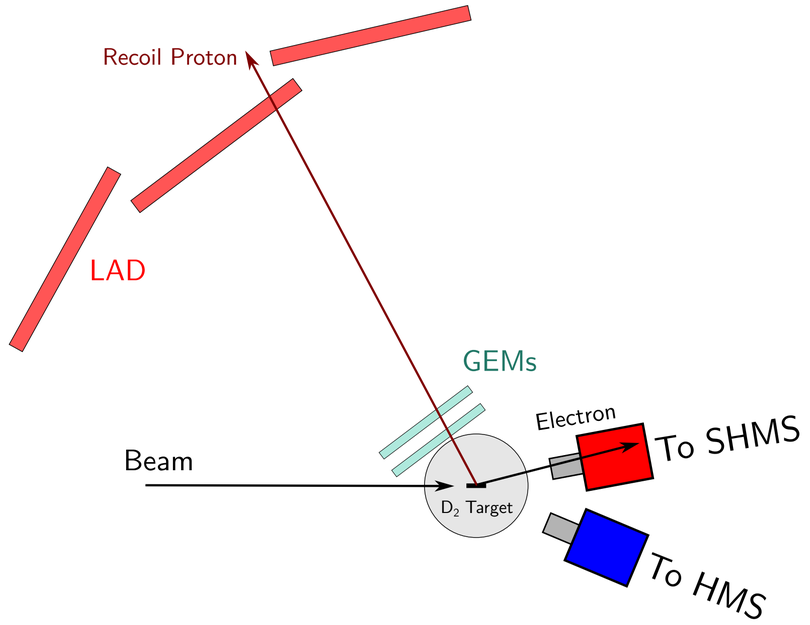
BAND Experiment

JLab Hall B
Run Group B (2019-2020)

BAND



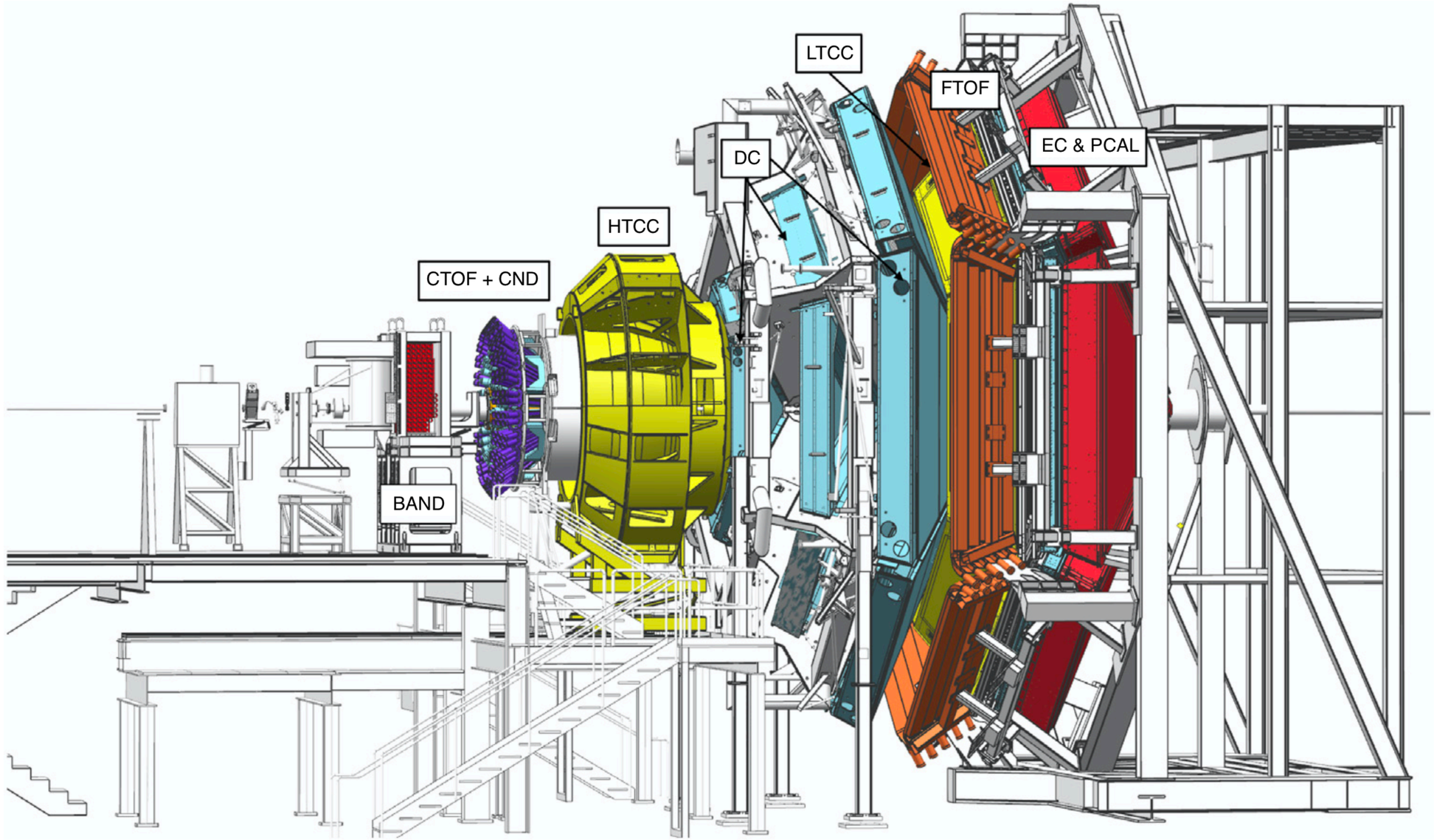
LAD



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

- Jefferson Lab Hall C
  - Prioritizing High Resolution
- Recoiling Protons
- Quarks in Neutrons

CLAS12 Detector System



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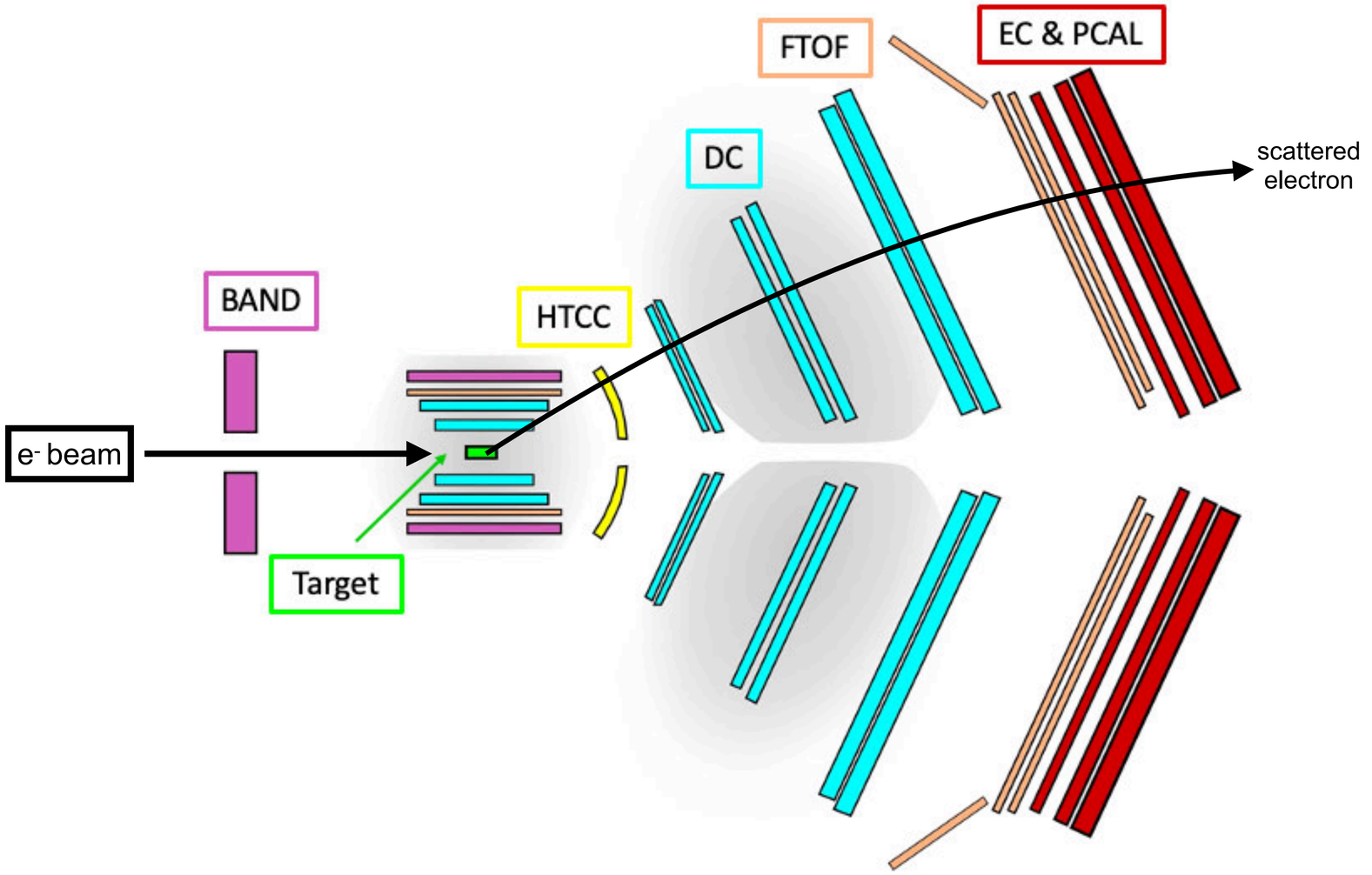

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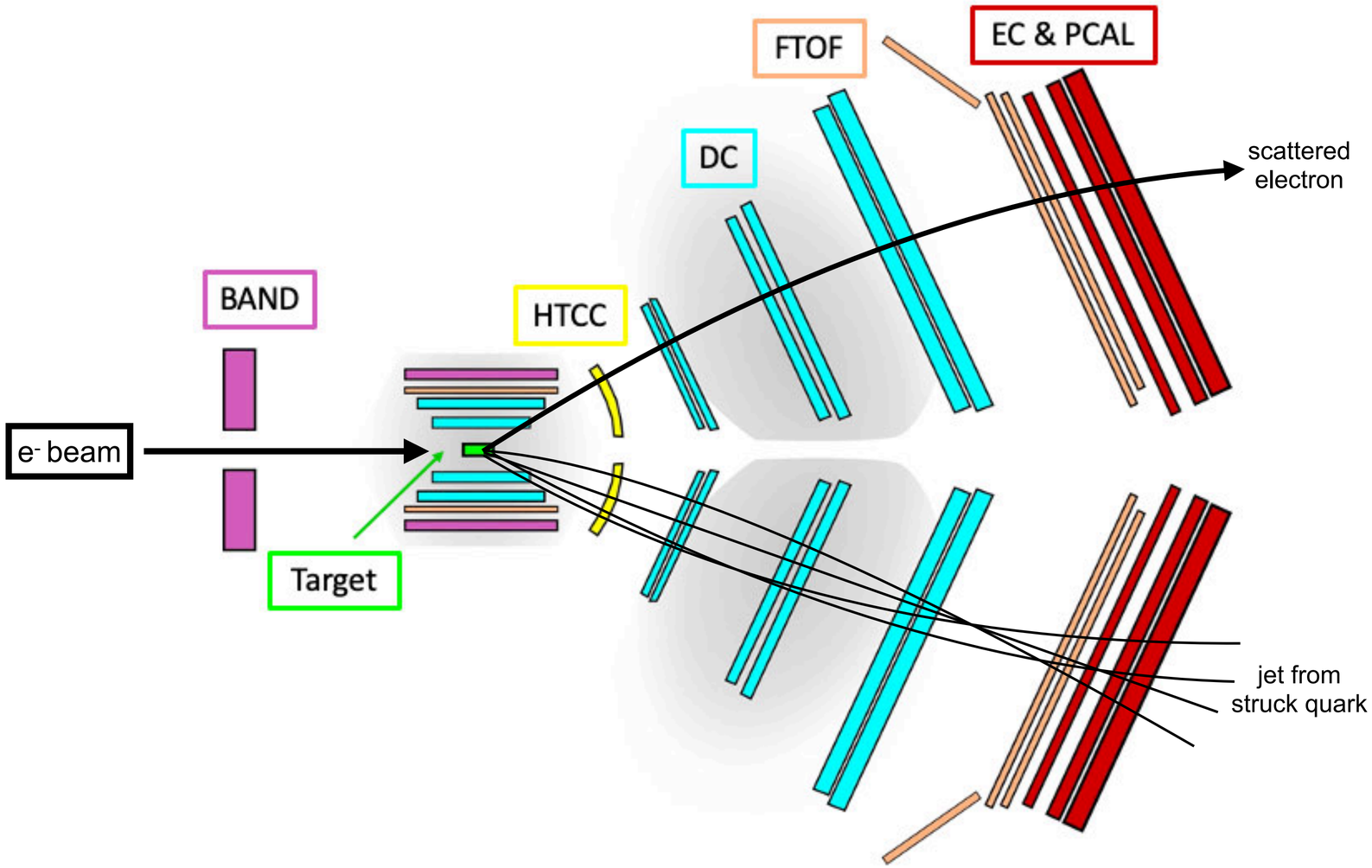

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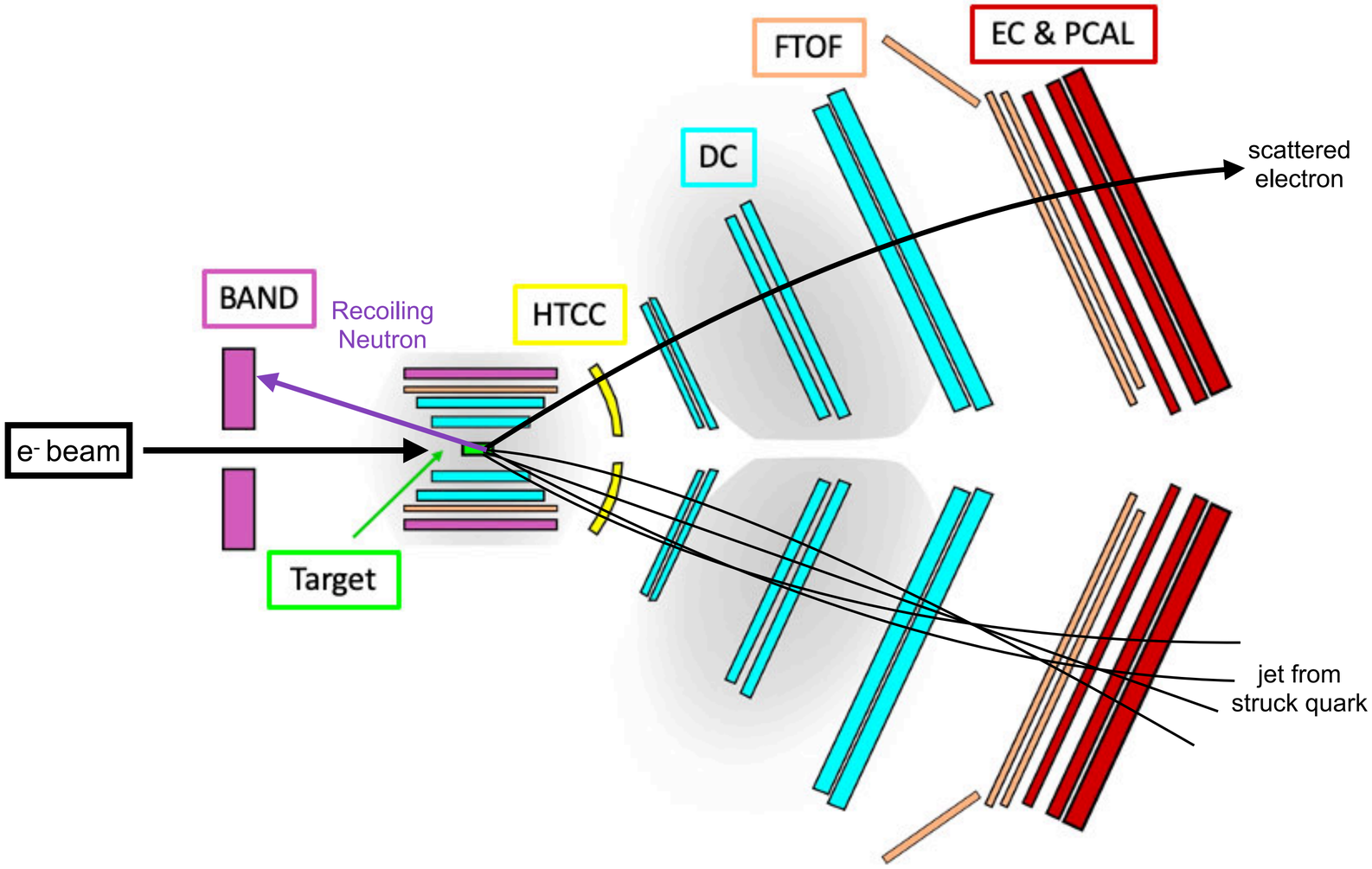
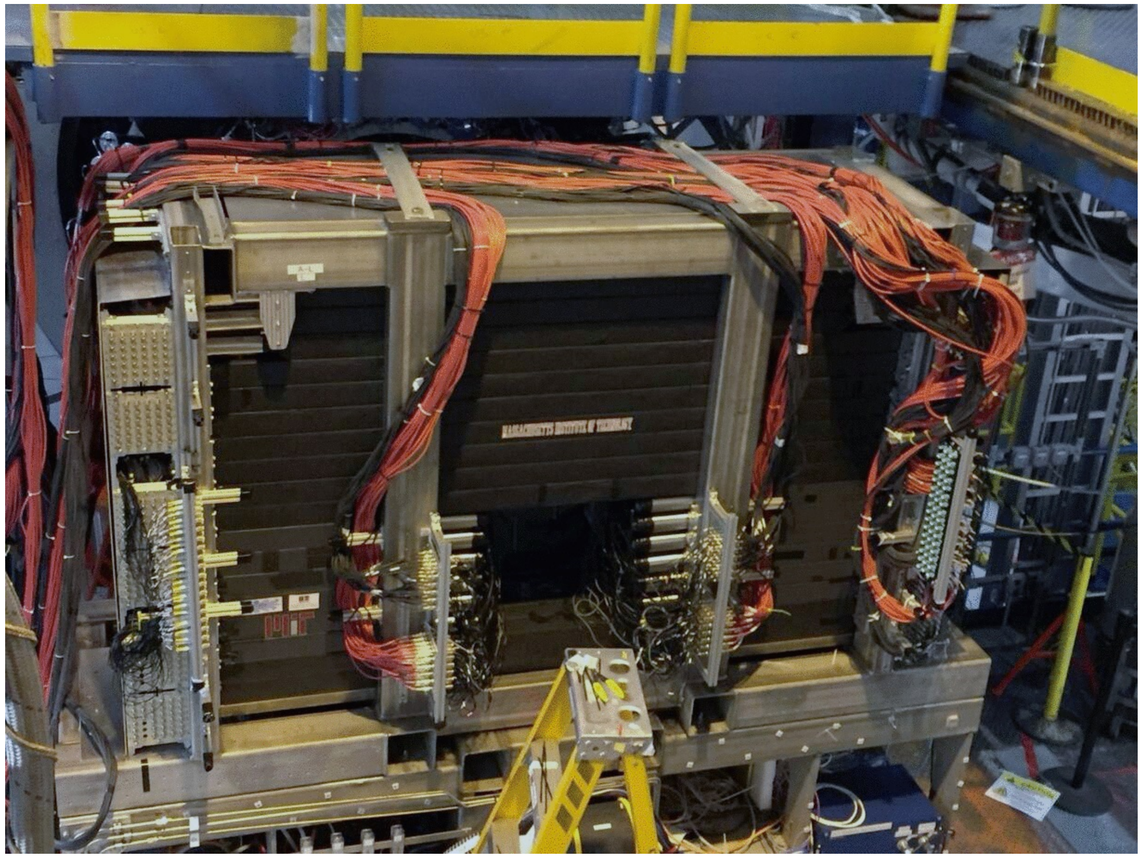


Backward-Angle Neutron Detector

- 2 m x 1.5 m
- Made of plastic scintillators, with a veto layer
- Placed upstream of the target to detect backward scattered neutrons



Observable of Interest

Want to look at bound/free structure

$$\mathscr{R} = \left(\frac{d\sigma^{data}(x', \alpha_s)}{d\sigma^{data}(x'_{ref}, \alpha_s)} \right) \Big/ \left(\frac{d\sigma^{sim}(x', \alpha_s)}{d\sigma^{sim}(x'_{ref}, \alpha_s)} \right)$$

Input from data:

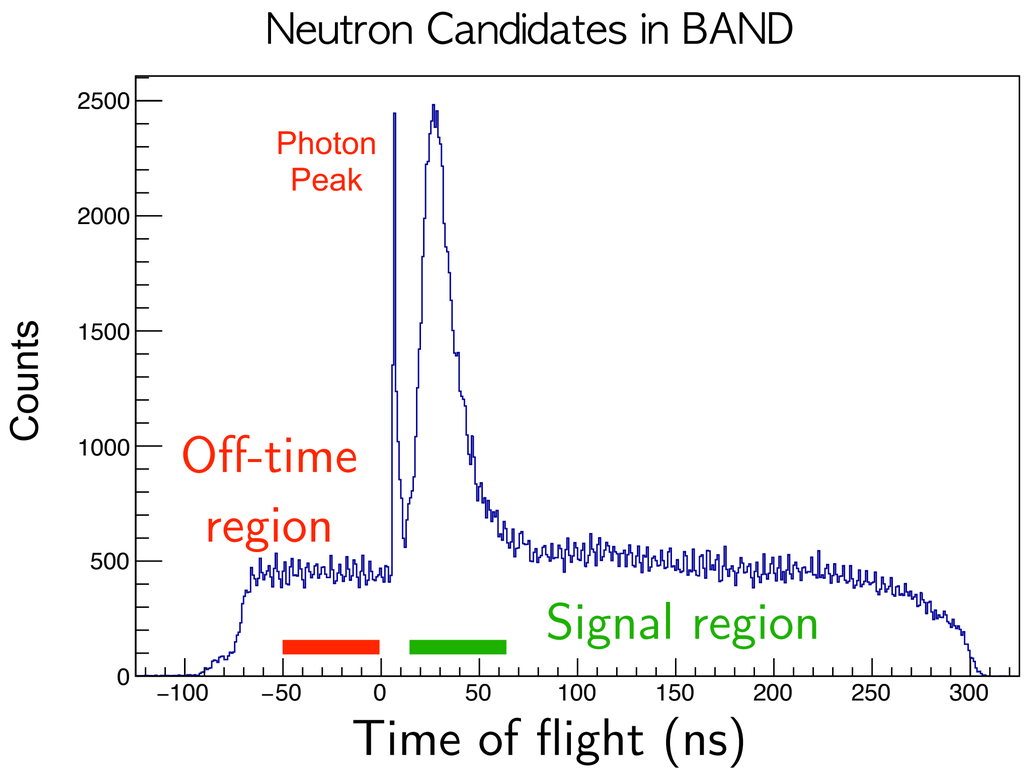
- Same target and beam: luminosity cancels
- Different kinematics: acceptance and radiative effects don't cancel

Input from simulation:

- Correct for acceptance, radiative effects

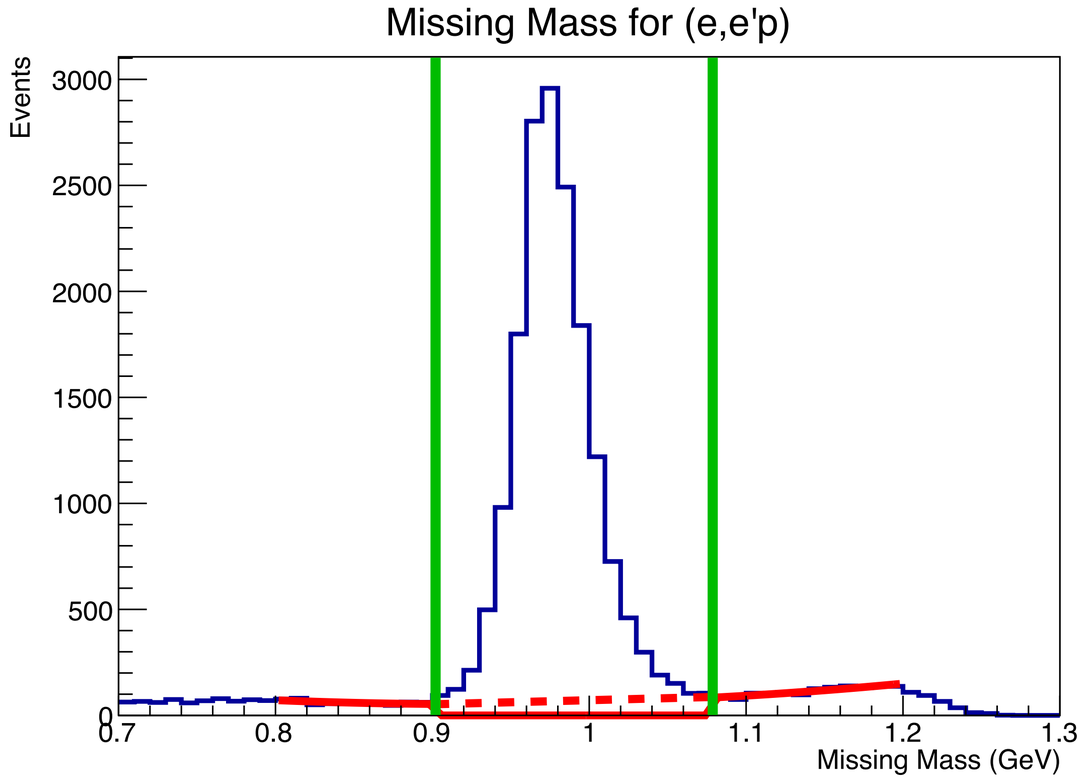
Background

- Significant contributions from random coincidence background
- Can be estimated from off-time region
- Look at background rates against kinematic variables using “event-mixing”



BAND Efficiency

- 2 GeV deuterium data collected in SRC-CLAS12 2021 Experimental run
- Quasielastic proton knock-out
- $(e, e'pn)/(e, e'p)n$ points-to-BAND



Current State of Analysis

- Finalizing results, going through CLAS review

- Preliminary results will be shown and discussed at GRC

Tuesday	
11:50 am - 12:10 pm	**Tyler Kutz** (Massachusetts Institute of Technology, United States) "Bound Proton Structure from Neutron-tagged DIS and SIDIS Measurements"

Conclusions

- BAND analysis results will be coming soon

- These results will help us definitively test the EMC-SRC Hypothesis