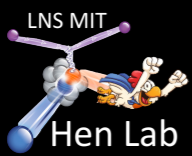


# Investigating the EMC effect in highly-virtual nucleons at Jefferson Lab





Hen Lab



## The BAND Experiment

### The EMC Effect in Highly-Virtual Nucleons

Efrain Segarra, Massachusetts Institute of Technology

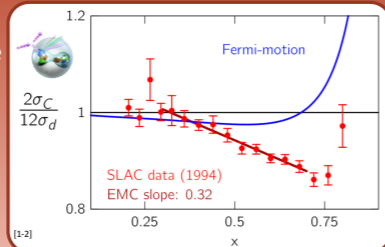
Jefferson Lab  
Thomas Jefferson National Accelerator Facility

#### The EMC Effect

Deep-Inelastic Scattering off Quarks in Nuclei:

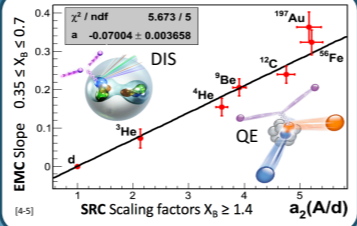
- Quarks in bound nucleons behave differently than in free nucleons
- No accepted theoretical explanation



SLAC data (1994)  
EMC slope: 0.32

#### EMC Effect & Short Range Correlations

Suggests EMC effect follows local nuclear density (SRCs!)

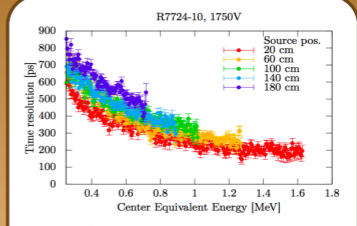


$\chi^2 / \text{ndf} = 5.673 / 5$   
 $a = -0.07004 \pm 0.003658$

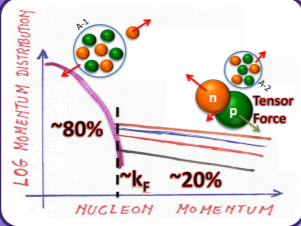
#### BAND Neutron Detector R&D Work

Requirements and Challenges

- ~40% efficiency
- 2MeVee threshold
- Large angular coverage
- 200 ps time resolution



#### NN Short Range Correlations (SRC)

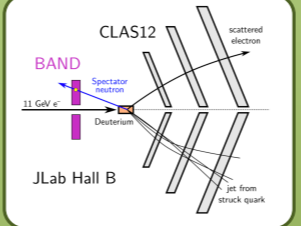


LOG MOMENTUM DISTRIBUTION  
~80%  
~20%  
NUCLEON MOMENTUM

#### The Backward Angle Neutron Detector (BAND)

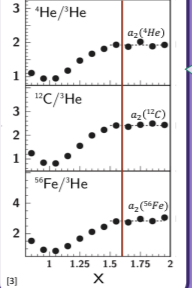
Recoil Tagging  $d(e, e' n) X$

- Minimizes final state interactions
- No residual system
- Recoil has exact opposite momentum of struck



#### Finding SRC Pairs in Nuclei in $e^-$ QE Scattering

$A(e, e' p) \sigma$  Ratios



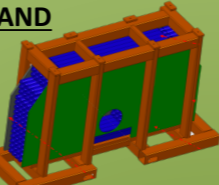
Nucleon momentum  
3  $k_F$   
2  $k_F$   
1  $k_F$   
Interesting  
Forbidden  
x → more momentum transfer

Probability to find nucleon in 2N-SRC!  
 $a_2(A) = \frac{2 \sigma_A(x_B, Q^2)}{A \sigma_{He}(x_B, Q^2)}$

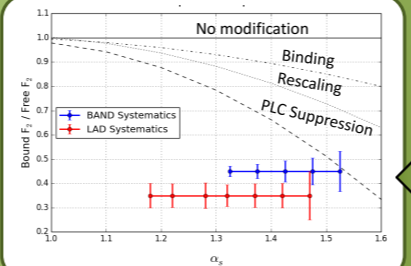
See my talk on Thursday to hear about the first fully exclusive 2N-SRC measurement!

#### Detecting Recoil Neutrons with BAND

- Covers backward recoil angles 160°-175°
- 5 layers of 24 scintillation bars – 36cm thick
- Veto layer & lead shield to reject background

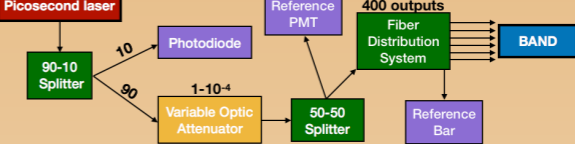


#### Expected Experimental Impact

$$\frac{F_2(\text{high } x', Q^2, \alpha_S)_{\text{bound}}}{F_2(\text{high } x', Q^2)_{\text{free}}} \approx \frac{\sigma_{DIS}(\text{high } x', Q^2, \alpha_S)_{\text{bound}}}{\sigma_{DIS}(\text{low } x', Q^2, \alpha_S)_{\text{bound}}} \times \frac{\sigma_{DIS}(\text{low } x', Q^2)_{\text{free}}}{\sigma_{DIS}(\text{high } x', Q^2)_{\text{free}}} \times R_{FSI}$$


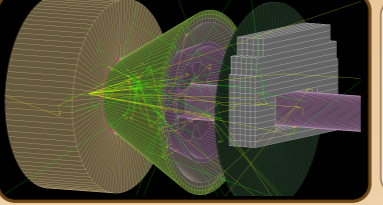
Experiment E12-11-003A  
Approved for 90 days  
Extended LD<sub>2</sub> target  
11 GeV  $e^-$  beam  
 $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

#### Laser Calibration System:



Picosecond laser  
90-10 Splitter  
Photodiode  
Reference PMT  
400 outputs  
Fiber Distribution System  
BAND  
Variable Optic Attenuator  
1-10<sup>-4</sup>  
50-50 Splitter  
Reference Bar

#### Simulation Efforts in Geant4



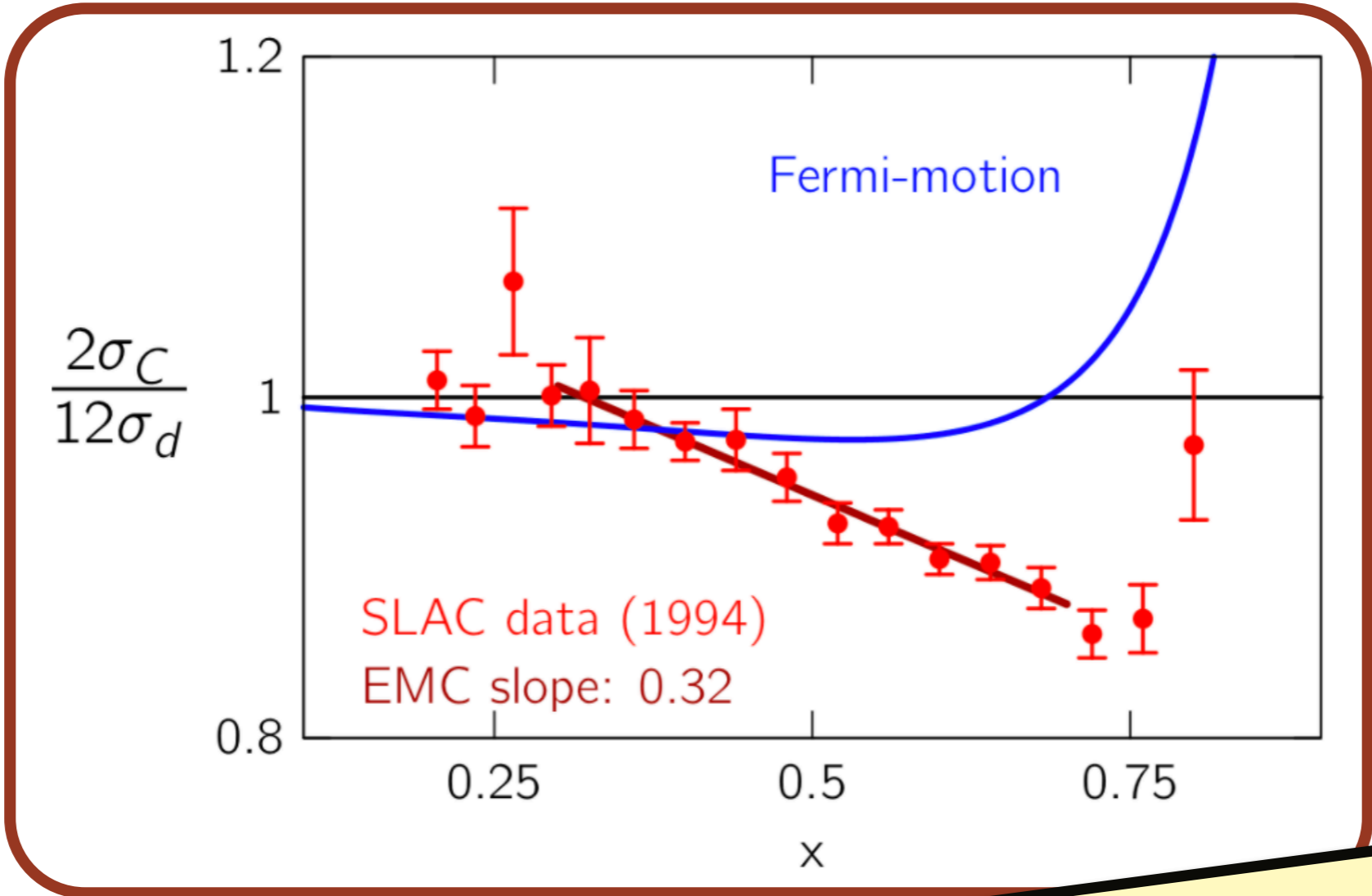
- Jefferson Lab Hall B geometry
- Random neutron background

References: [1] J. Gomez et al., PRD 49 4348 (1994) [2] Miller + Smith, PRC 65 015211 (2001) [3] K.S. Egiyan et al. PRL 96, 082501(2006) [4] L.B. Weinstein et al., PRL 106, 052301 (2011) [5] O. Hen et al., PRC 85, 047301 (2012)

Collaboration: MIT, TAU, ODU, Jefferson Lab, GSI, TUD, Mainz, JINR, CEA, UTSM, Fermilab, and many theory collaborators...  
JLab Experiment E12-11-107

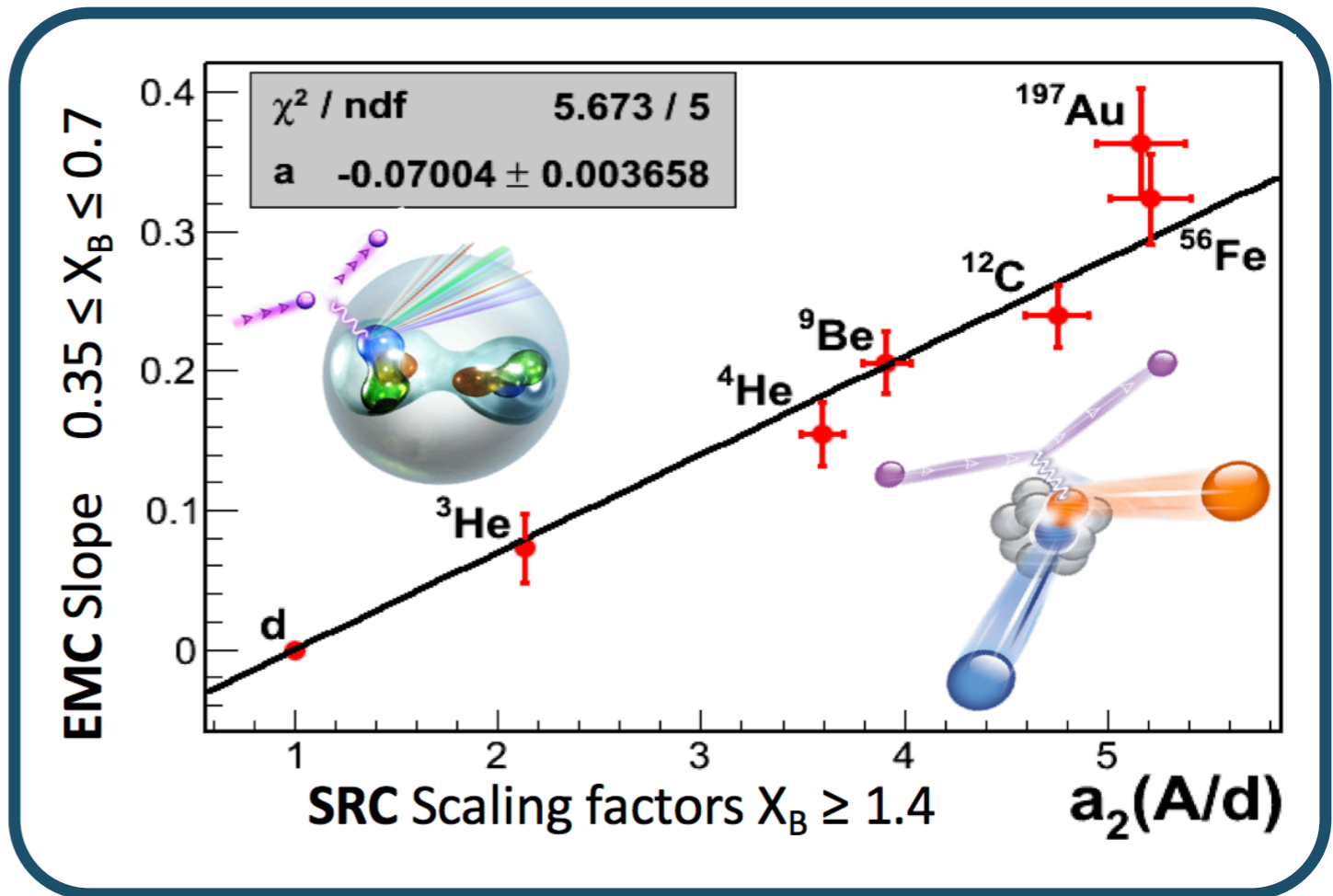
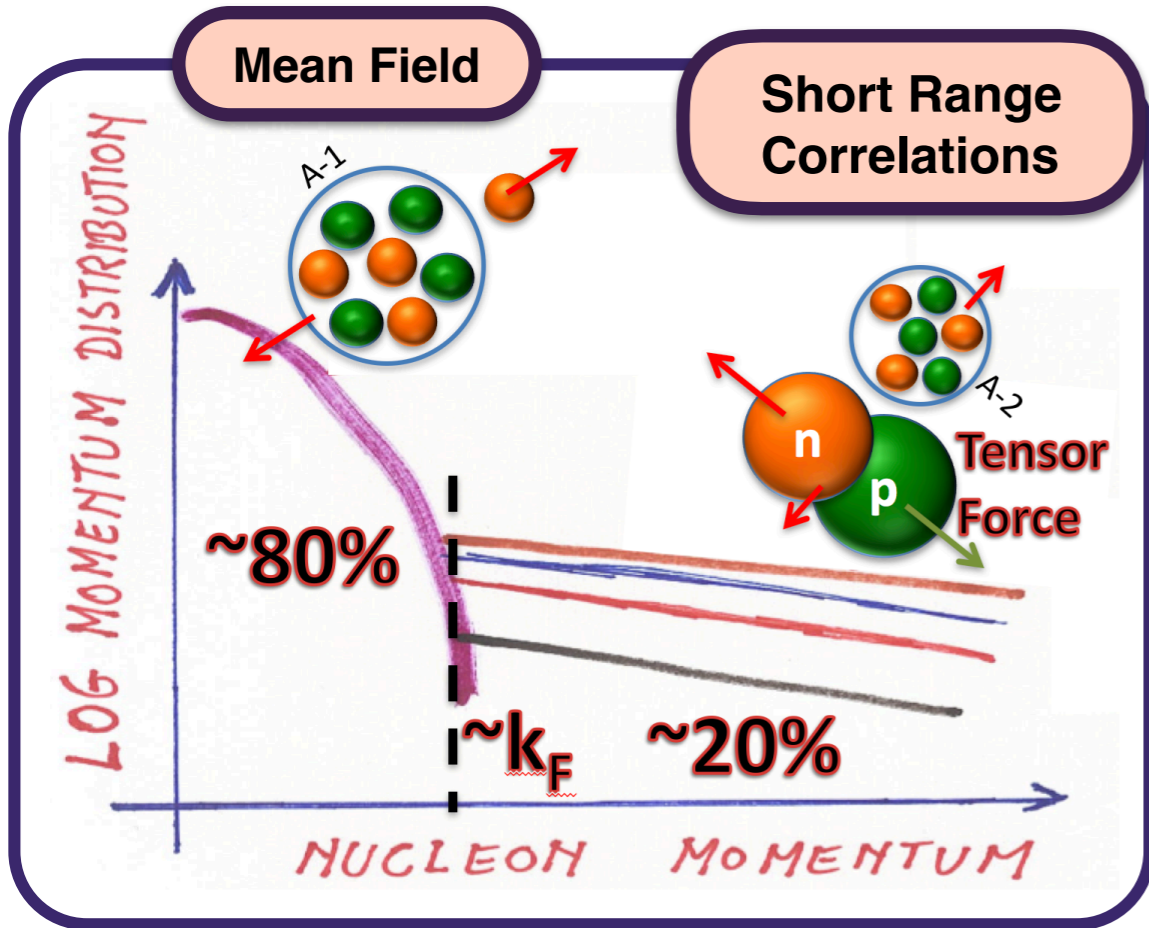
Efrain Segarra  
Massachusetts Institute of Technology  
Advisor: Or Hen (MIT)

**Quarks in bound nucleons != quarks in free nucleons**

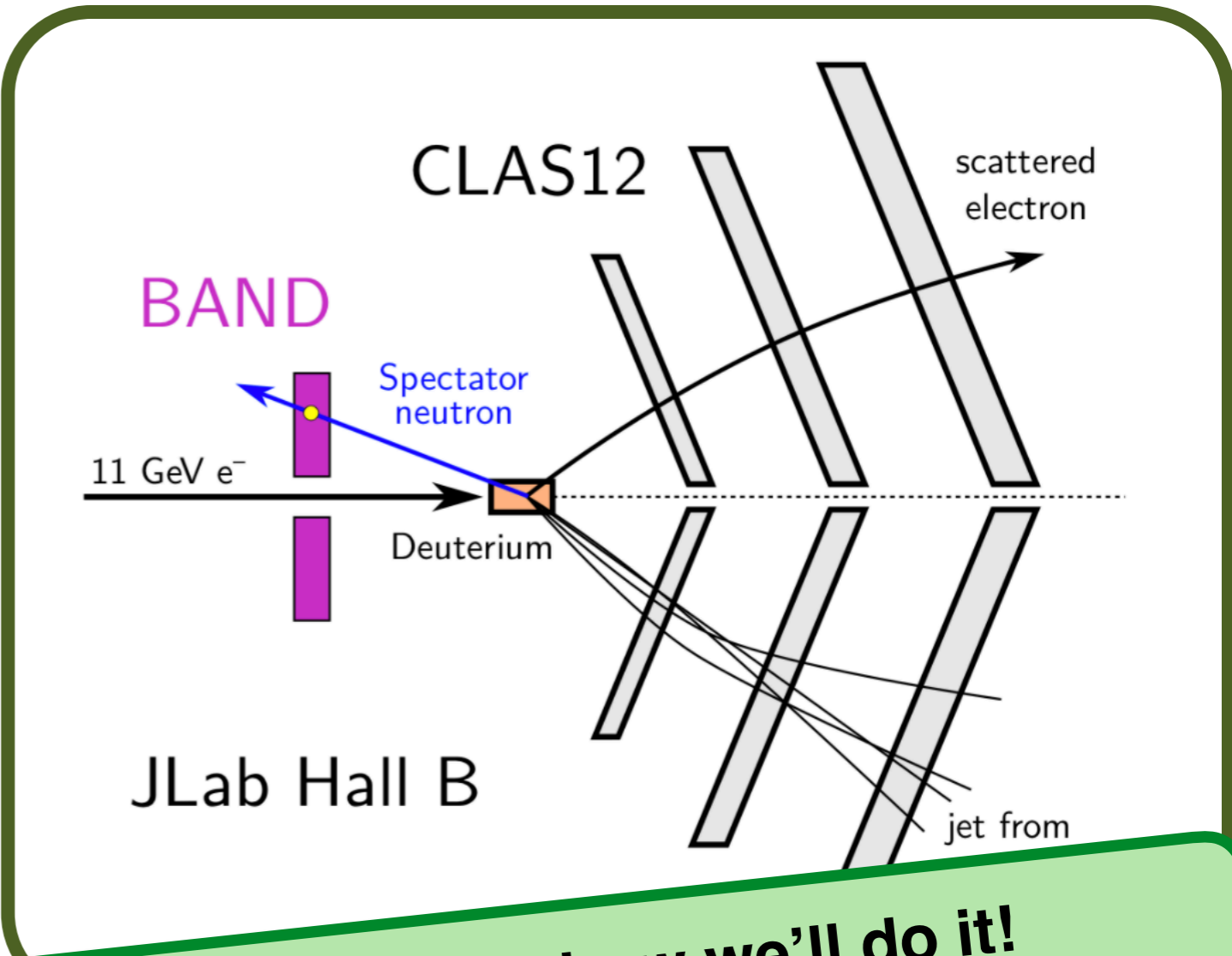
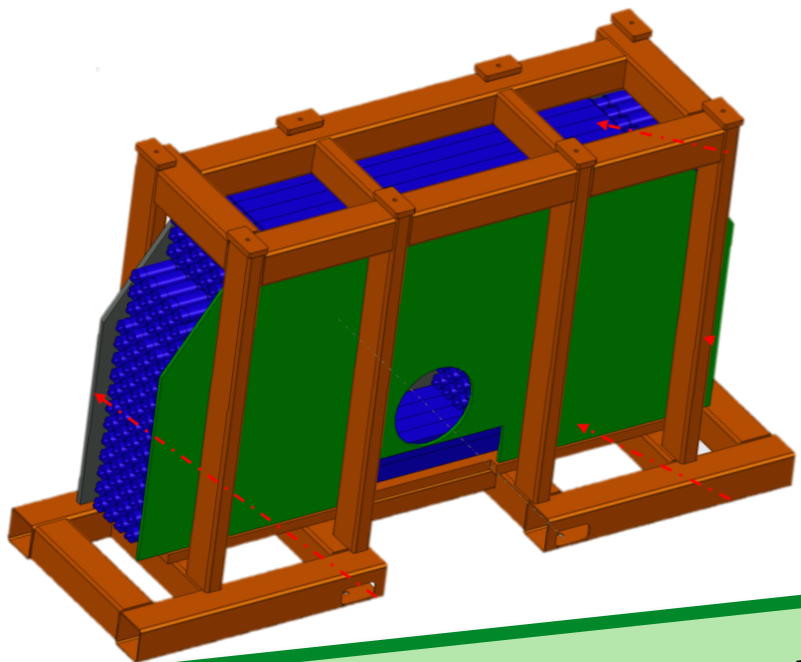
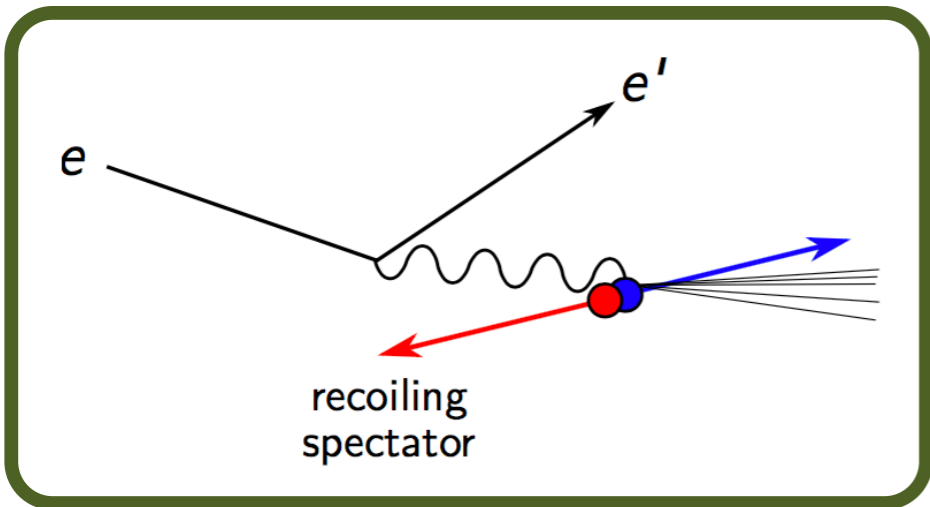


No accepted theoretical explanation

**We believe NN-short-range correlations may be involved**



**We have an upcoming experiment that will be able to study the two**



**Come see my poster and talk to me to see how we'll do it!**