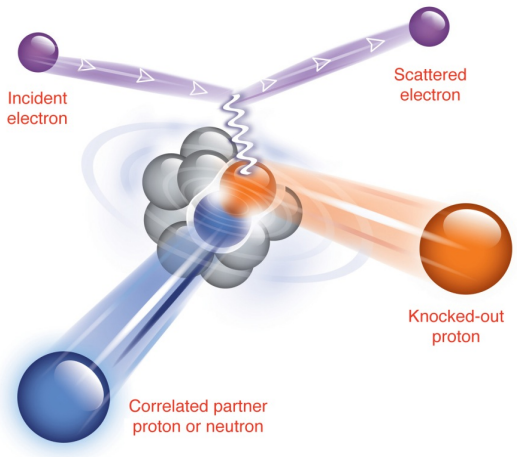
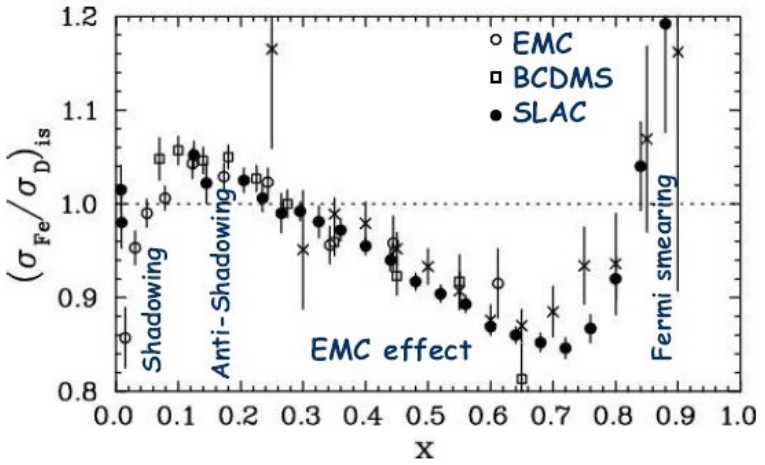
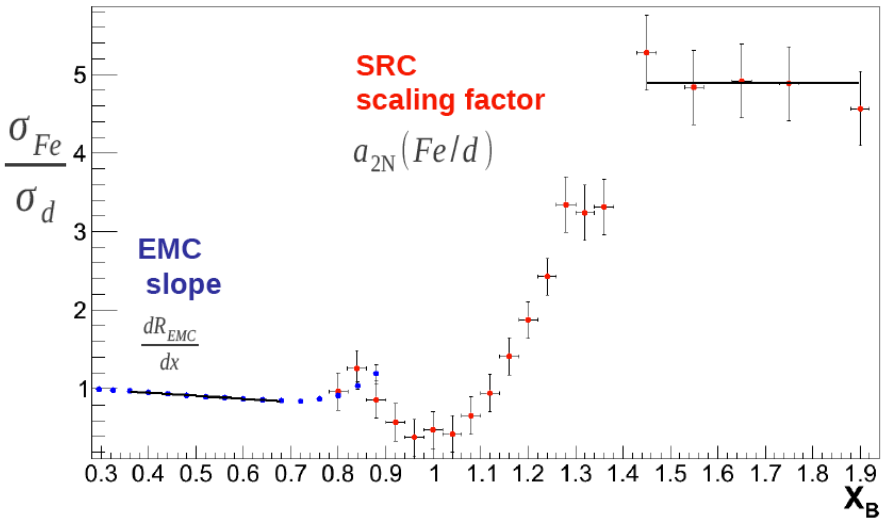
Future Program of Short-Range Correlations and the EMC Effect

- Linear Correlation between SRC and EMC
- Hypothesis: both effects are related to high-momentum (high-virtuality) nucleons
- Are high-momentum (virtuality) nucleons modified?
- Future studies





Correlations Between EMC and SRC!



SRC

- High local density
- High nucleons momenta

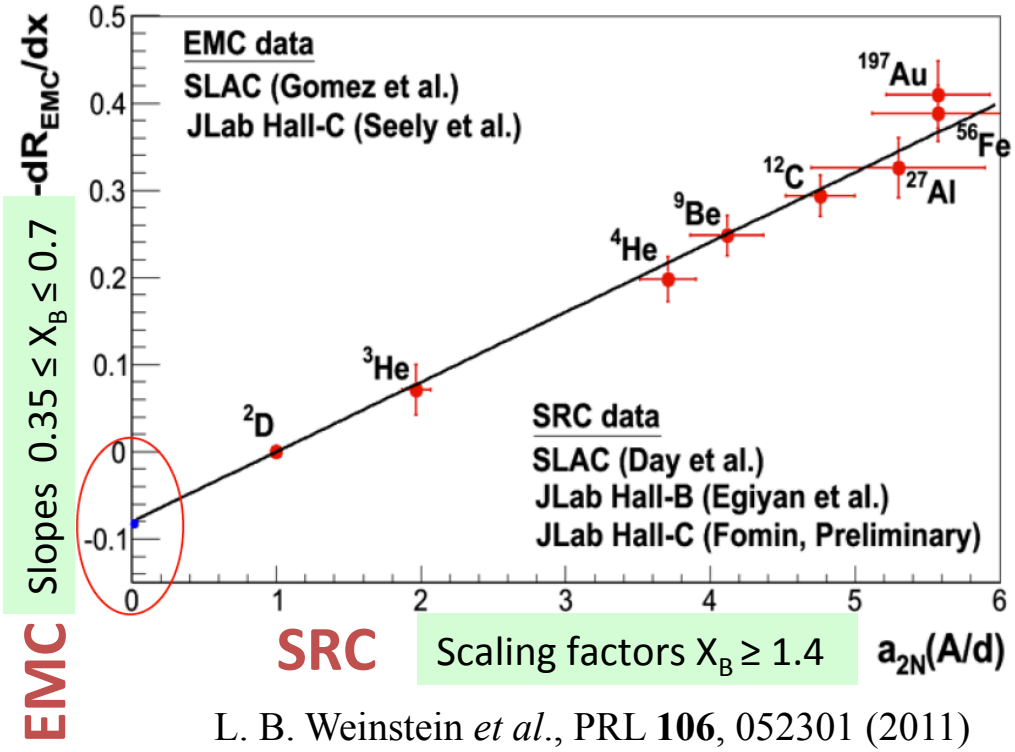
EMC

- Is EMC related to high-momentum nucleons?

SLAC data

L. Frankfurt, M. Strikman, D. Day, M. Sargsian, Phys. Rev. **C**48, 4251 (1993)
Q^2=2.3 GeV/c^2

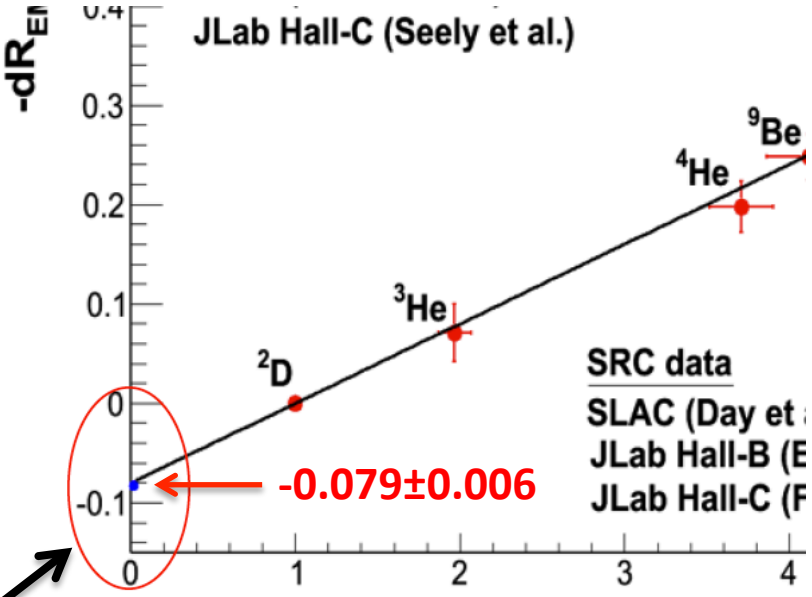
J. Gomez *et al.*, Phys. Rev. **D**49, 4348 (1983)
Q^2=2,5,10, 15, GeV/c^2 (averaged)



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

Explore Connection between EMC and SRC

If so, we should measure a large EMC effect by selecting high-momentum nucleons!?



Deuteron

- Is there an "EMC" effect in the deuteron?

$$\sigma_d^{DIS} \neq \sigma_p^{DIS} + \sigma_n^{DIS}$$

$$\frac{\sigma_d}{\sigma_p + \sigma_n} = 1 - (0.079 \pm 0.006)(0.6 - 0.31 \pm 0.04) \approx 0.975$$

- Is there a large "EMC" effect in the high-momentum tail of deuterium?

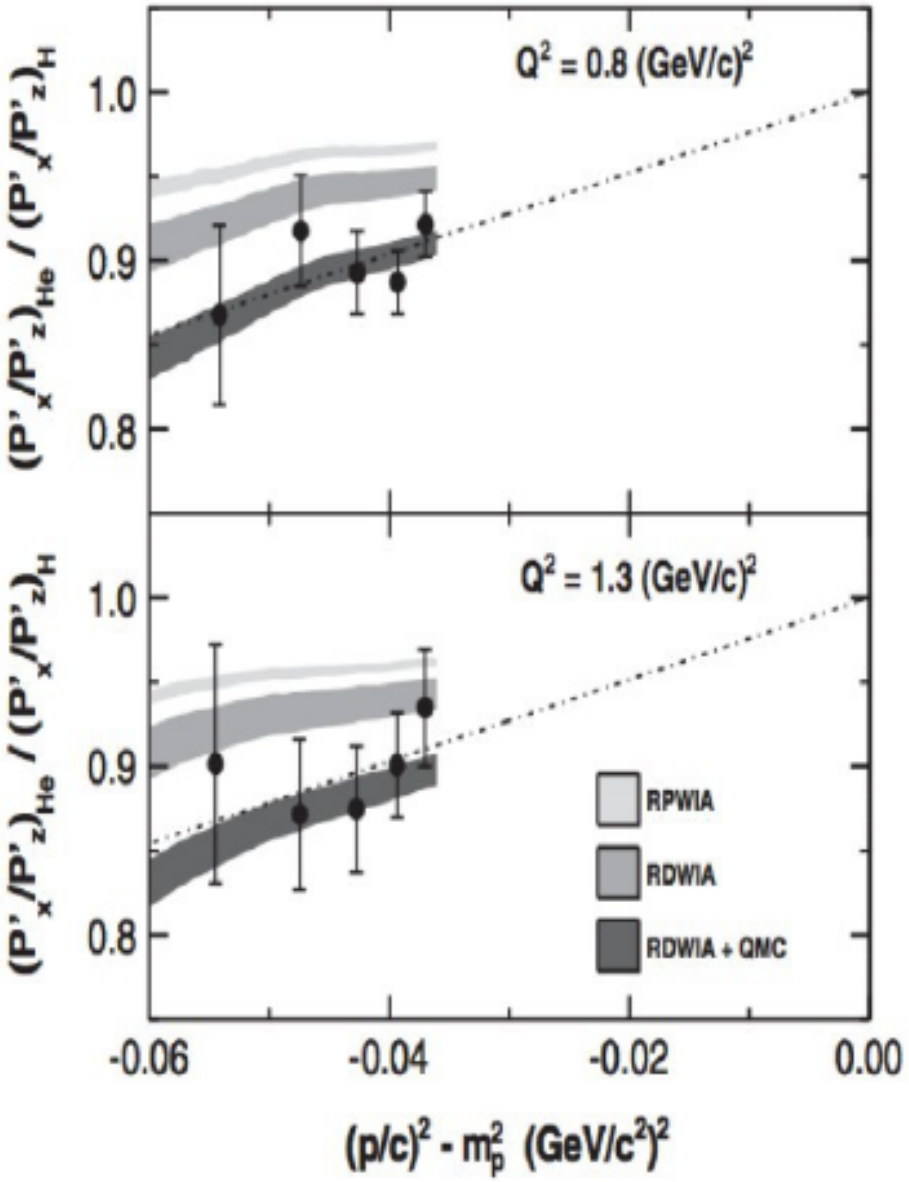
$$\frac{\sigma_d}{\sigma_p + \sigma_n}(x_B = 0.6) = 0.975$$

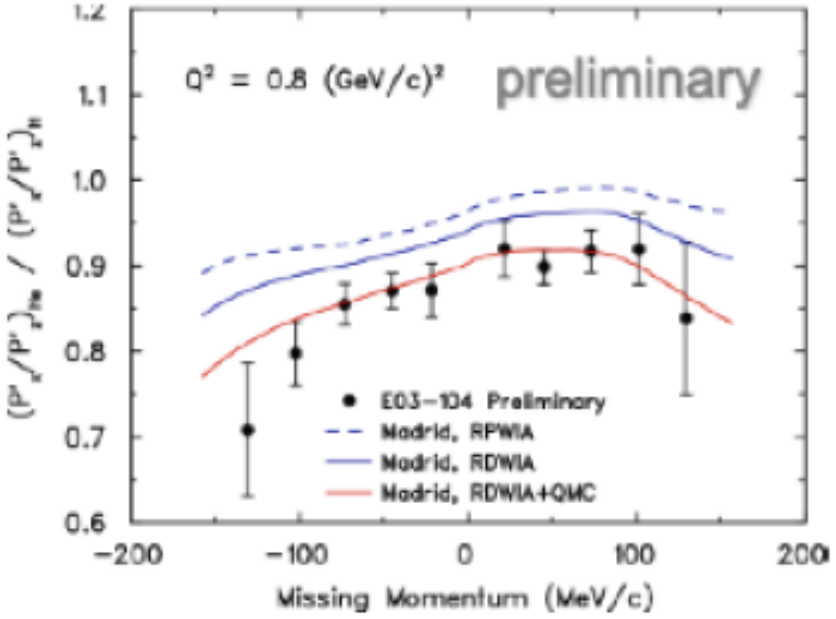
- Is the structure function F_2 momentum (virtuality) dependent?

$$\frac{\sigma_p^*}{\sigma_p} \approx \frac{\sigma_n^*}{\sigma_n} \approx \frac{2.5\%}{5\%} \approx 0.5$$

Nucleons Modified at High Momentum

M. Paolone *et al*. PRL **105**,072001 (2010)





This is quasi-elastic scattering, not DIS!

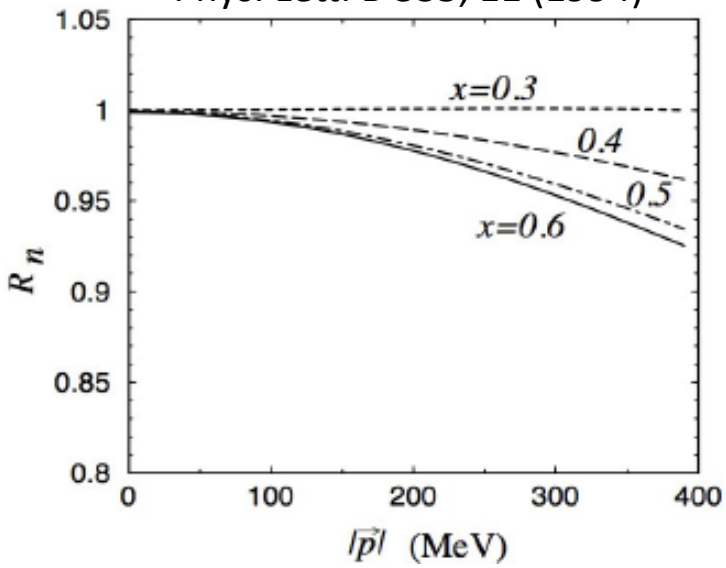
Our experiment will cover the range of virtuality 0.2 – 0.5

Dependence of Nucleons SF on Momenta

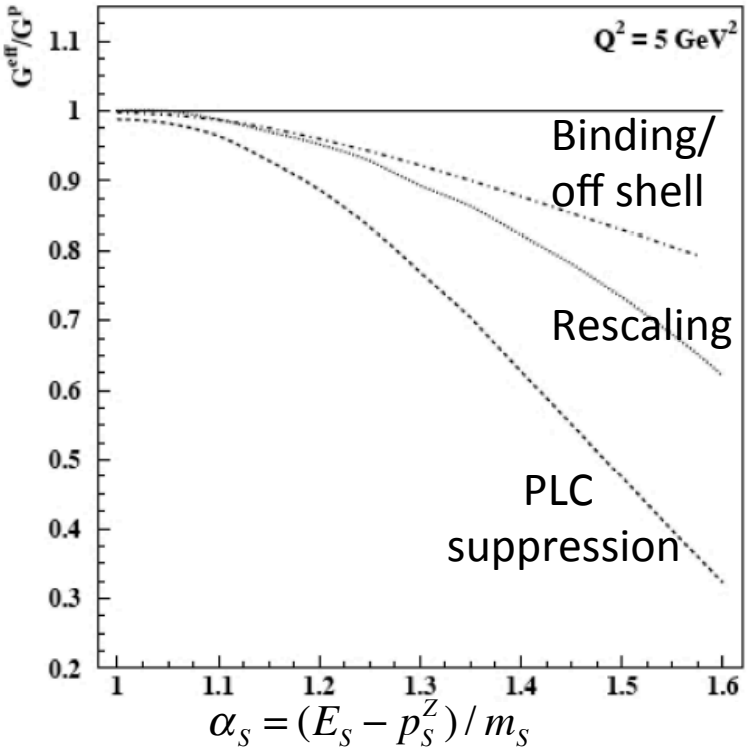
Dependence on

- Models
- Nucleon's momentum and x_B
- Nucleon's momentum, not x_B

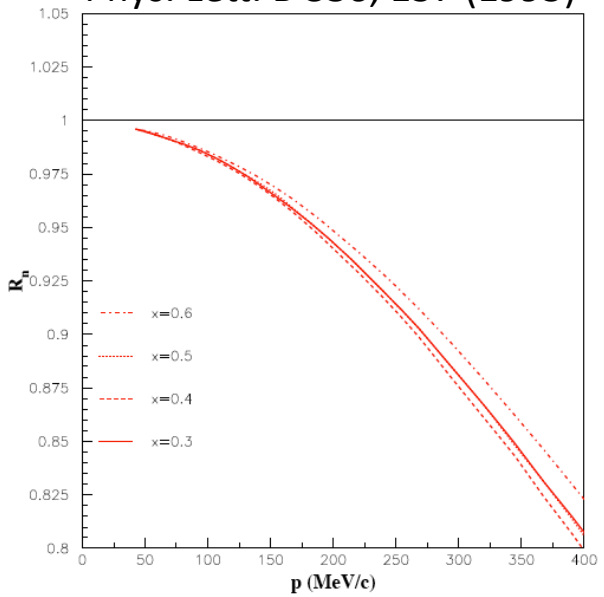
Phys. Lett. B **335**, 11 (1994)



Z. Phys. A **359**, 99 (1997)



Phys. Lett. B **356**, 157 (1995)



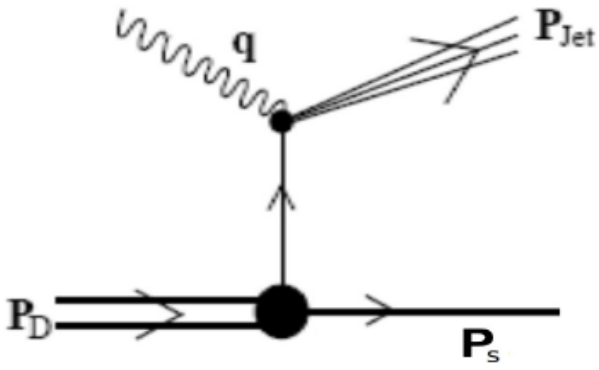
Experimental Program at JLAB

Compare F_2 in DIS off high-momentum nucleons to F_2 of free nucleons

E12-11-107 – TAU, ODU, MIT JLAB

Experimental method

- Use deuteron as a target in DIS
- Tag high-momentum nucleons with high-momentum recoiling ("spectator") partner fast, backwards recoiling nucleon as in SRC using the reaction $d(e,e'N_S)$



Experimental Method (cont.)

- Minimize experimental and theoretical uncertainties by measuring cross-section ratios

$$\frac{\sigma_{DIS}(x'_{high},Q_1^2,\vec{p}_s)}{\sigma_{DIS}(x'_{low},Q_2^2,\vec{p}_s)}\cdot\frac{\sigma_{DIS}^{free}(x_{low},Q_2^2)}{\sigma_{DIS}^{free}(x_{high},Q_1^2)}\cdot R_{FSI}=\frac{F_2^{bound}(x'_{high},Q_1^2,\vec{p}_s)}{F_2^{free}(x_{high},Q_1^2)}$$

FSI correction factor

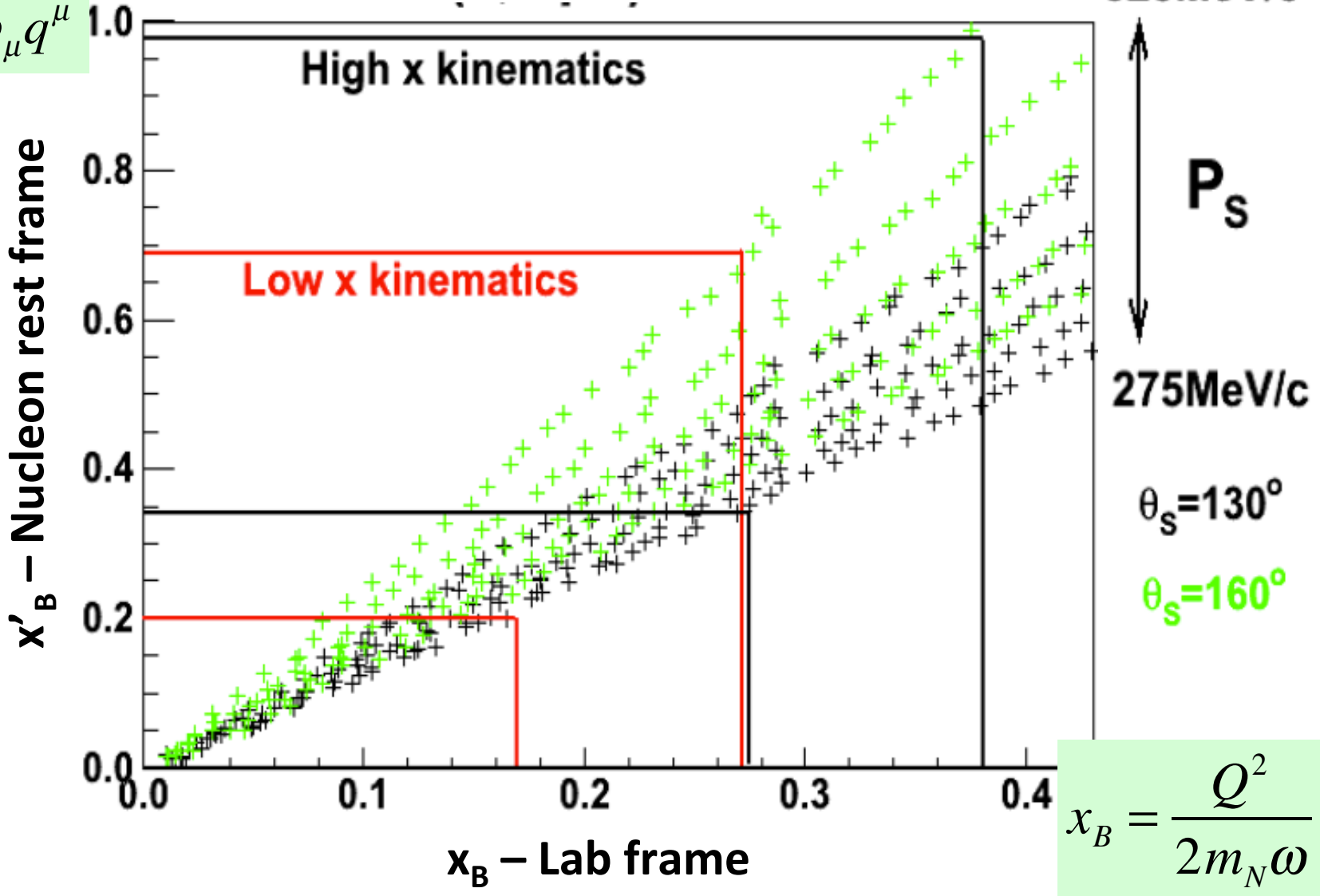
$$x'_B=\frac{Q^2}{2p_\mu q^\mu} \qquad x_B=\frac{Q^2}{2m_N\omega}$$

$$x'_{high}\geq 0.45$$

$$0.25\geq x'_{low}\geq 0.35$$ No EMC is expected

x_B' vs. x_B (Why x'?)

$$x_B' = \frac{Q^2}{2 p_\mu q^\mu}$$



$$x_B = \frac{Q^2}{2 m_N \omega}$$

How to Deal with FSI?

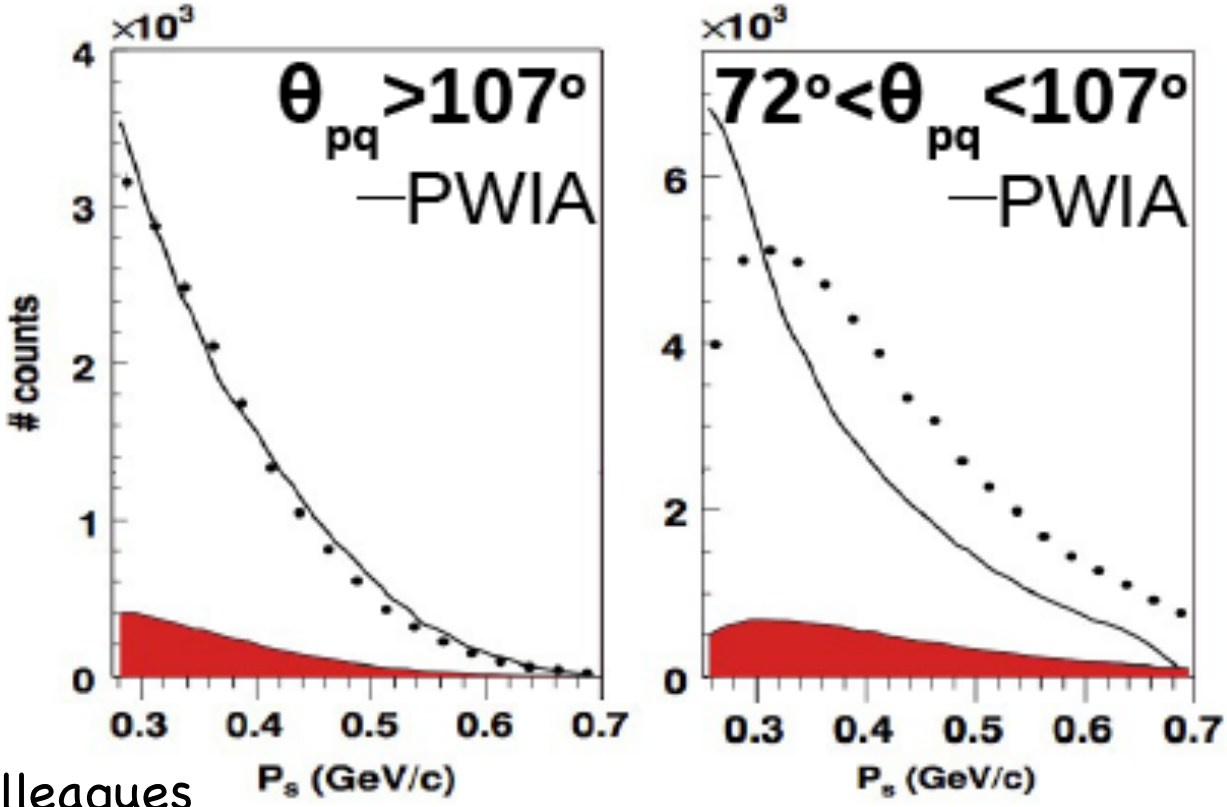
We know that FSI:

- Decrease with Q^2
- Increase with W'
- Not sensitive to x'_B
- Small for θ_{pq}>107°

We shall:

- Involve theoretical colleagues
- Take data at large recoil angles
- Take data at 90°
- Take data at two x'
- Use low x' data to study FSI dependence on Q^2, W'^2, θ_{pq}

D(e,e'p_S)

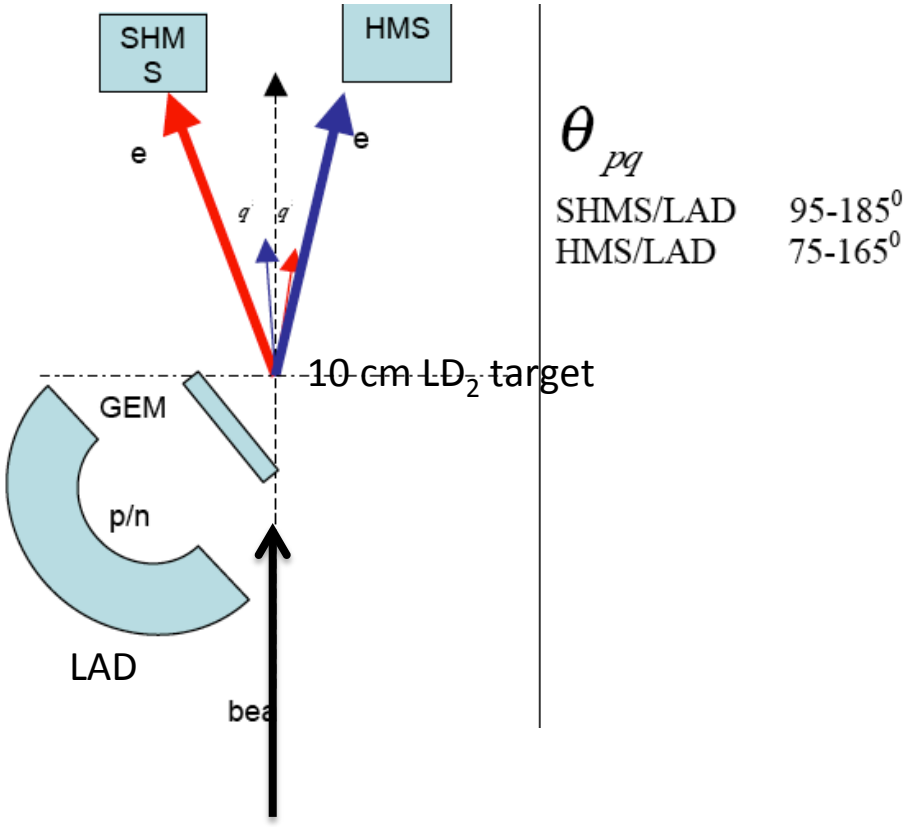


A. V. Klimenko *et al.*, PRC **73**, 035212 (2006)

Experimental Setup – Hall C

HMS and SHMS detect electrons

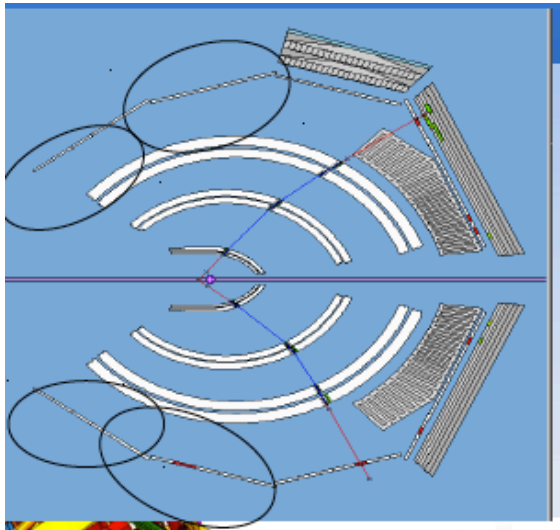
LAD detect recoiling nucleon



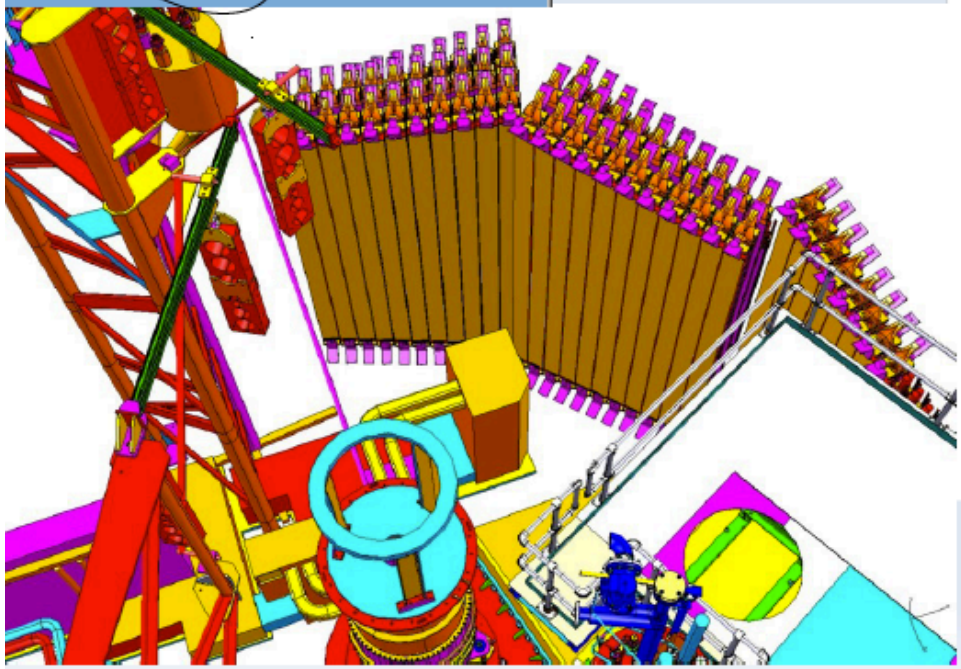
Central values of kinematics

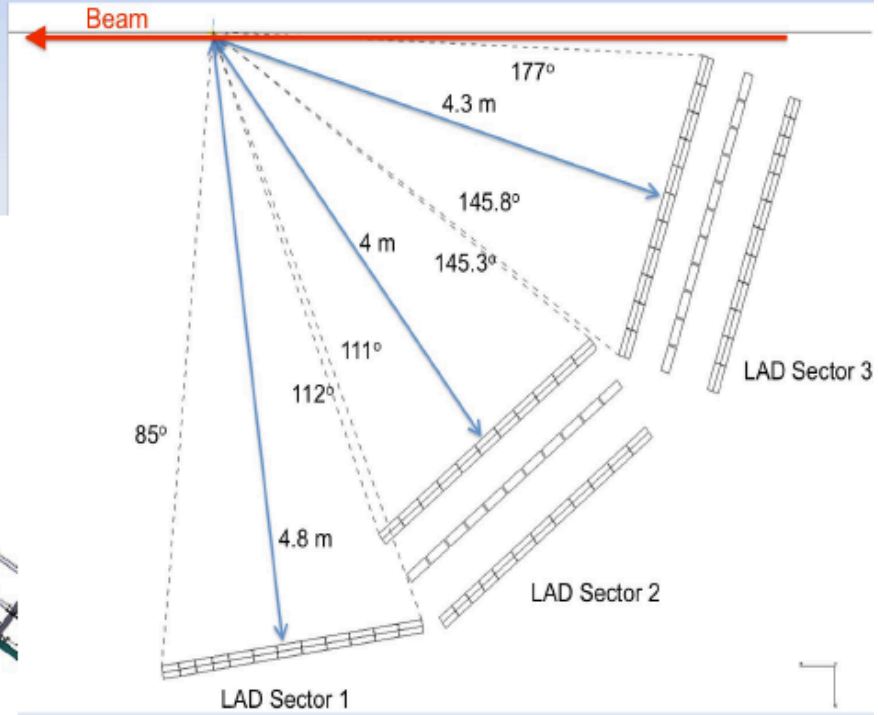
Low x'	High x'
$E_{in} = 10.9$ GeV	$E_{in} = 10.9$ GeV
$E' = 4.4$ GeV	$E' = 4.4$ GeV
$\theta_e = 13.5^o$	$\theta_e = -17^0$
$Q^2 = 2.65$ GeV^2	$Q^2 = 4.19$ GeV^2
$\lvert\vec{q}\rvert = 6.7$ GeV/c	$\lvert\vec{q}\rvert = 6.8$ GeV/c
$\theta_q = -8.8^0$	$\theta_q = 10.8^0$
$x = 0.217$	$x = 0.34$

Large acceptance Detector (LAD)



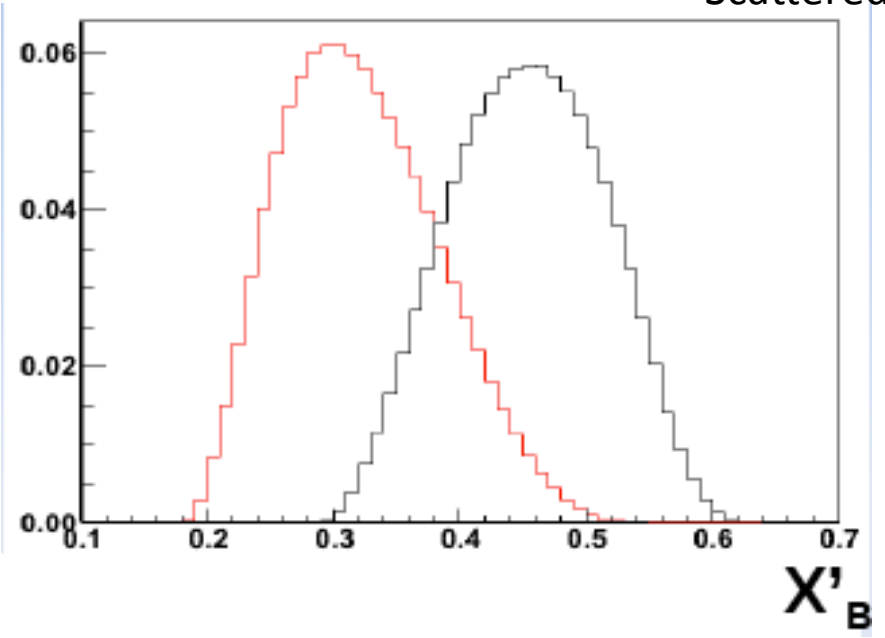
Use retired CLAS-6 TOF counters.
132, 5-cm thick counters in 12 panels.
1.5 sr, ~20% neutron detection efficiency

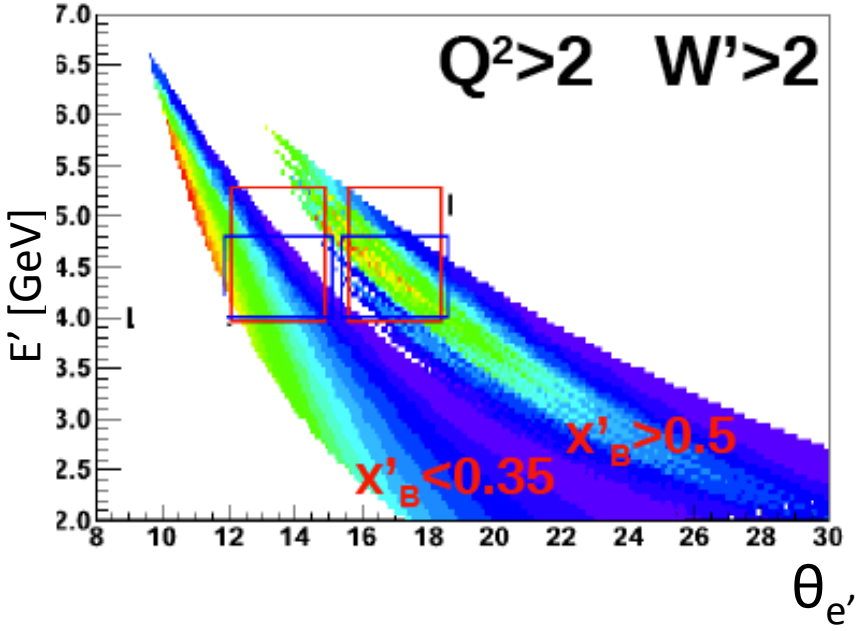




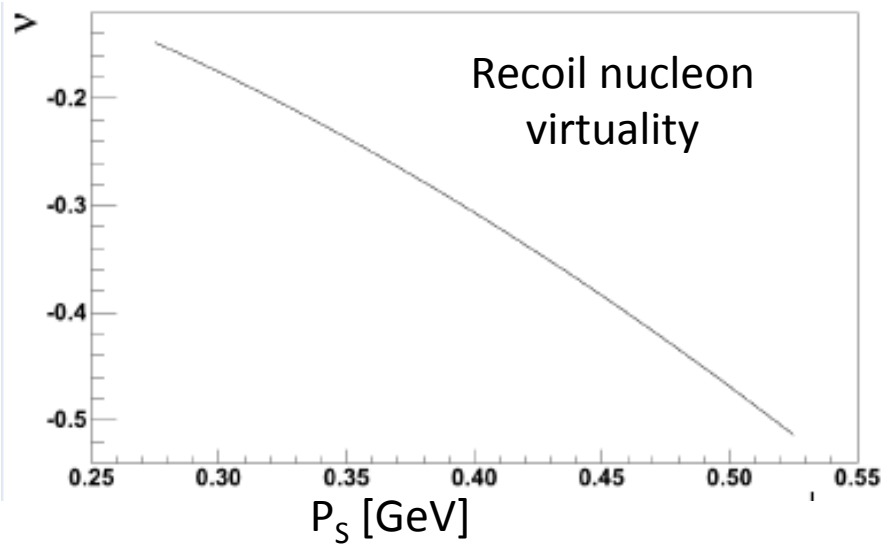
Kinematic Coverage

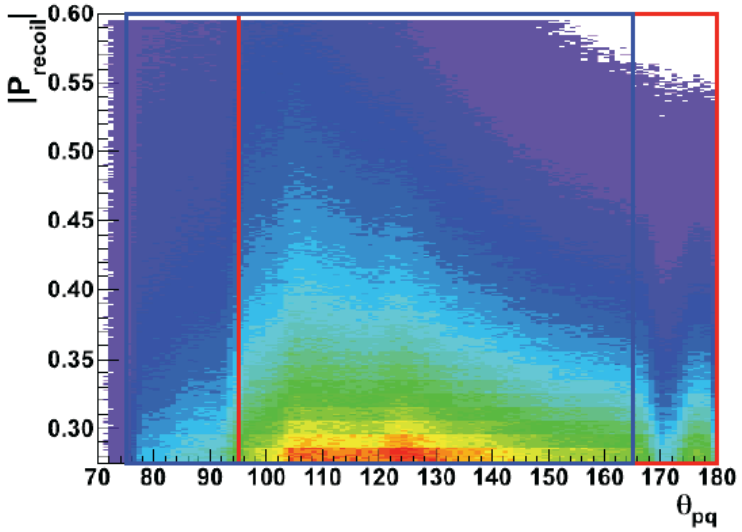
Scattered electrons



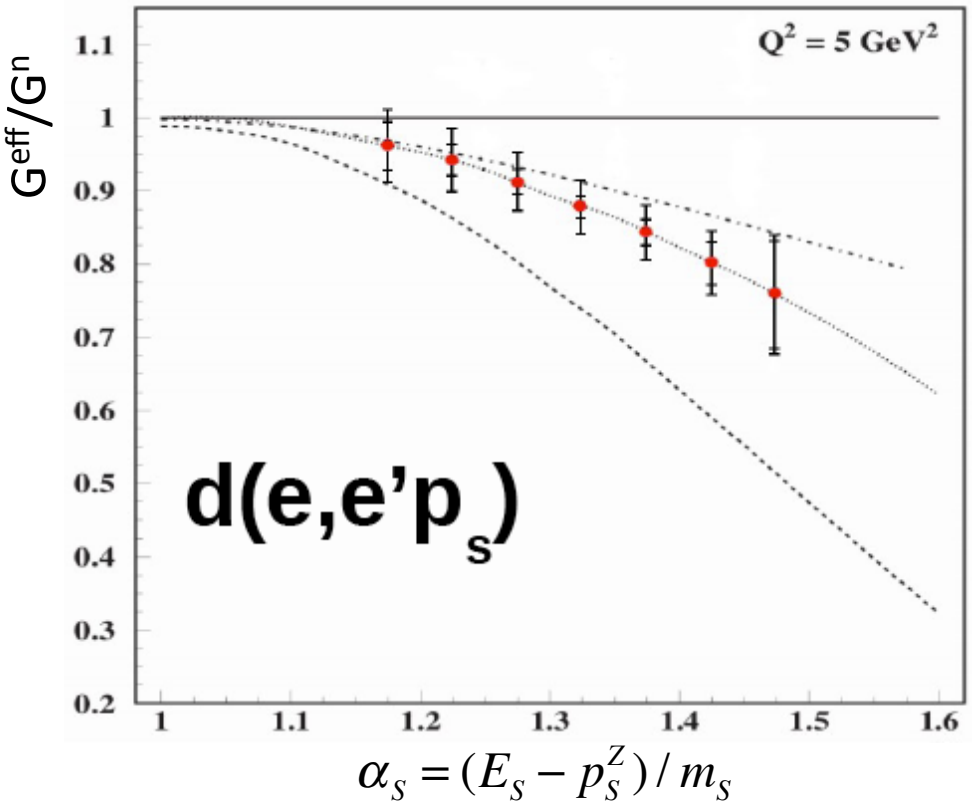


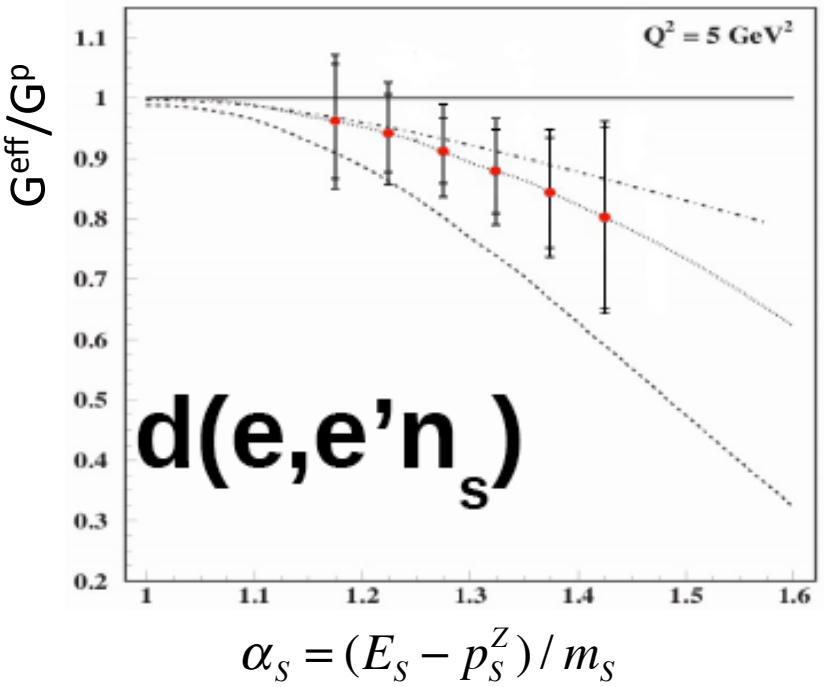
Recoiling nucleons





Expected Results





Systematic uncertainty (4-7% total)

- SHMS and HMS efficiency and acceptances (1-2%)
- LAD efficiency (3% protons, 5% neutrons)
- Al walls subtraction (1%)
- FSI ratio (4%)
- Free nucleons structure functions ratio (1% protons, 4% neutrons)

Second Stage - EMC

Measuring EMC with Tagged High-Momentum Recoil Nucleons

LOI-11-104 - TAU, ODU, MIT, JLAB

Basic idea of measurement

- Perform DIS ($Q^2 > 2$; $W > 2$) on high-momentum (vituality) nucleons by tagging the high-momentum recoiling nucleons
- Remember, almost all high-momentum nucleons have a SRC partner!!
- Measure per-nucleon x-sections ($p_S > 275$ MeV/c; $\theta_{pq} > 110°$) ratio of ^{4}He to deuteron, $\sigma[^4He(e,e'p_S)]/\sigma[d(e,e'p_S)]$, $f(0.3 < X_B < 0.6)$

Signal

- If EMC depend on virtuality, $\sigma[^4He(e,e'p_S)]/\sigma[d(e,e'p_S)]$ should not depend on x_B
- Magnitude of ratio should be $a_{2N}(^4He/d) \approx 4$

Basic Idea of Measurement (cont.)

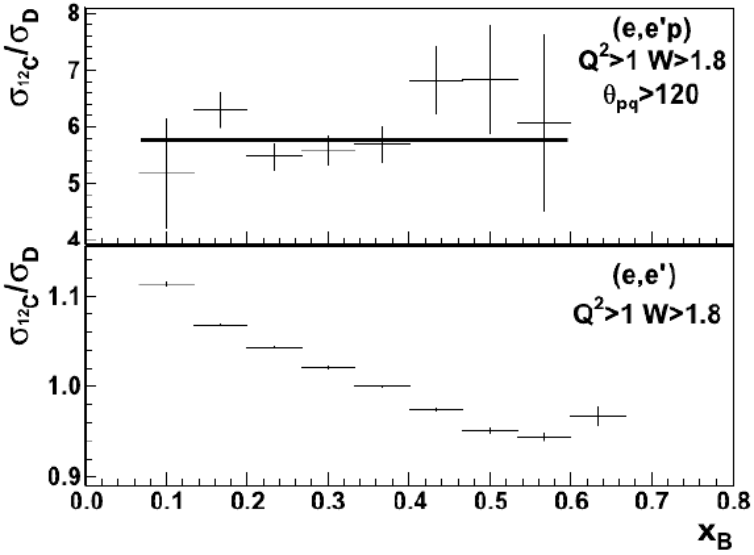
Second Measurement

- Ratio of per-nucleon cross section, $\sigma[^4He(e,e'p_S)]/\sigma[d(e,e')]$, at the same kinematic range
- Only $\sigma[^4He(e,e'p_S)]$ is tagged by p_S > 275 MeV/c while $\sigma[d(e,e')]$ is not!

Signal

- Ratio depends on x_B
- Shape similar to universal EMC shape BUT more pronounced

Experimental setup of both measurements will be similar to that of E12-11-107



CLAS data, very preliminary!
Or Hen, TAU

Remember $a_{2N}(^{12}C/d) = 4.8 \pm 0.4$

Summary

- SRC and EMC are linearly correlated
- We suggest that this correlation is because both phenomena are related to high-momentum nucleons
- We assume that highly virtual nucleons are modified
- E12-11-107 is approved to measure at JLAB the ratio of F_2 for highly virtual nucleons to F_2 of free nucleons in the deuteron
- Use spectator tagging to select highly virtual nucleons in DIS
- Minimize systematic uncertainties by measuring ratios
- This is not (yet) an EMC measurement

Summary (cont.)

- LOI-11-104 plans to measure the doubly-tagged per-nucleon cross-sections ratio $\sigma[^4He(e,e'p_S)]/\sigma[d(e,e'p_S)]$ for $p_S > 275$ MeV/c, $\theta_{pq} > 110°$, and as $f(0.3 < X_B < 0.6)$
- LOI-11-104 plans also to measure the singly-tagged per-nucleon cross-sections ratio $\sigma[^4He(e,e'p_S)]/\sigma[d(e,e')]$ in the same conditions
- If the EMC effect is related to highly virtual nucleons, then both measurements will have a very unique signatures
- A full proposal will be submitted to the JLAB PAC
- This IS an EMC measurement

Experimental Setup for both measurements