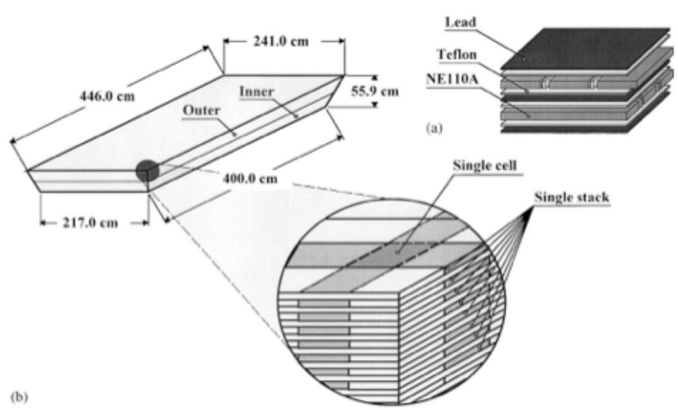
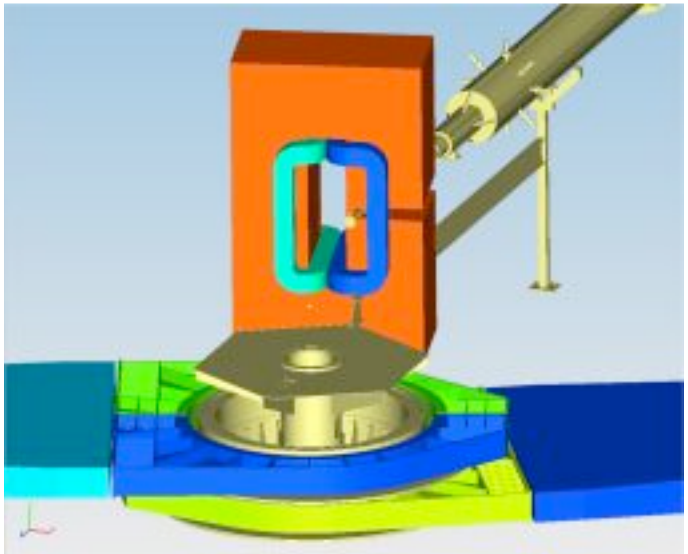
A(*e*,*e'pN*)*X*
Measuring SRC with the LAC + SuperBigBite

Larry Weinstein, Old Dominion University

With E. Piasetzky, S. Gilad, O. Hen, and Your Name Here



Large Angle Calorimeter



SuperBigBite Dipole

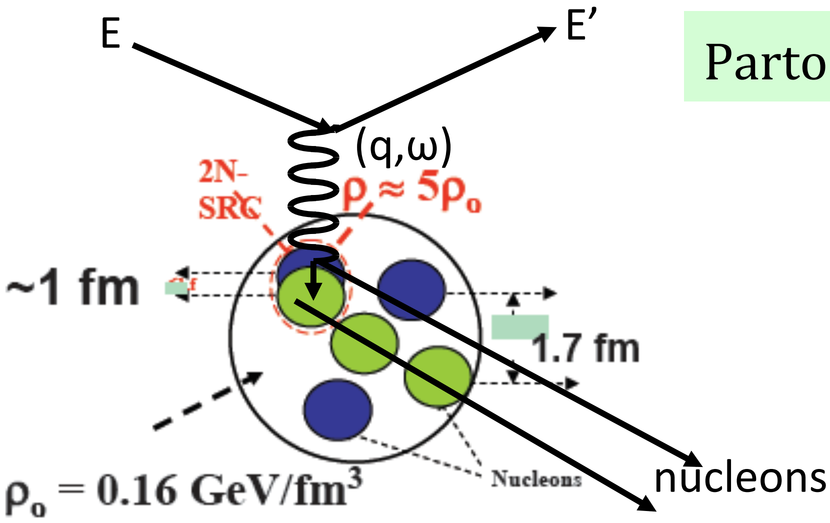
Jefferson Lab EXPLORING THE NATURE OF MATTER

Old Dominion UNIVERSITY

MIT

TEL AVIV UNIVERSITY

Short-Range Correlations (SRC)



Partonic (nucleonic) structure of nuclei

$$Q^2 = -q_\mu q^\mu = q^2 - \omega^2$$

$$\omega = E' - E$$

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

$E, E' \approx$ 3-5 GeV

$Q^2 \geq 1.5$ GeV^2

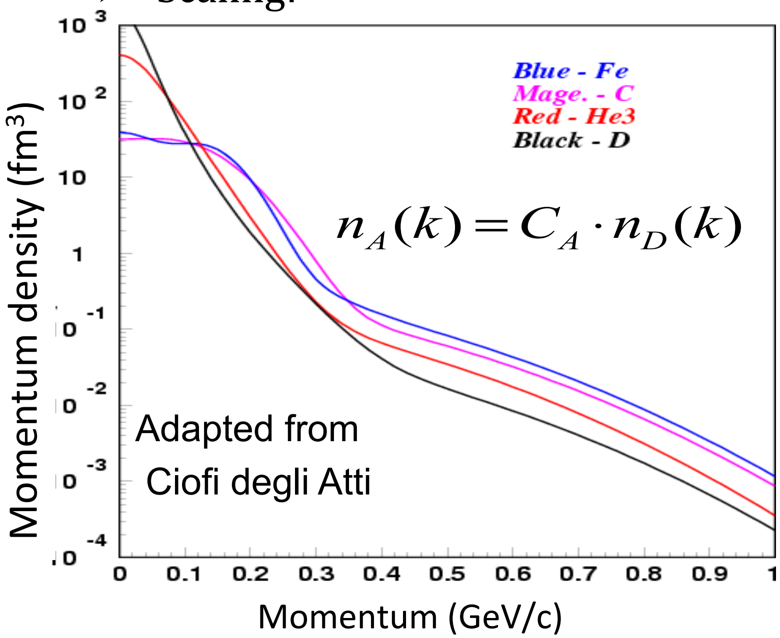
$0 \leq x_B \leq A$

x_B counts the number of nucleons involved : $x_B > n$ ==> at least $n+1$ nucleons

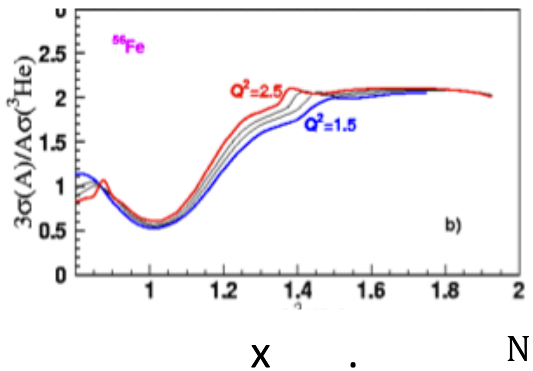
x_B and Q^2 also determine the minimum momentum of struck nucleon in nucleus (the y of y-scaling)

$A(e,e')$ ratios: Universality of SRC (Scaling)

- At high nucleon momenta, strength is different but shapes of distributions are similar
- Scaling!

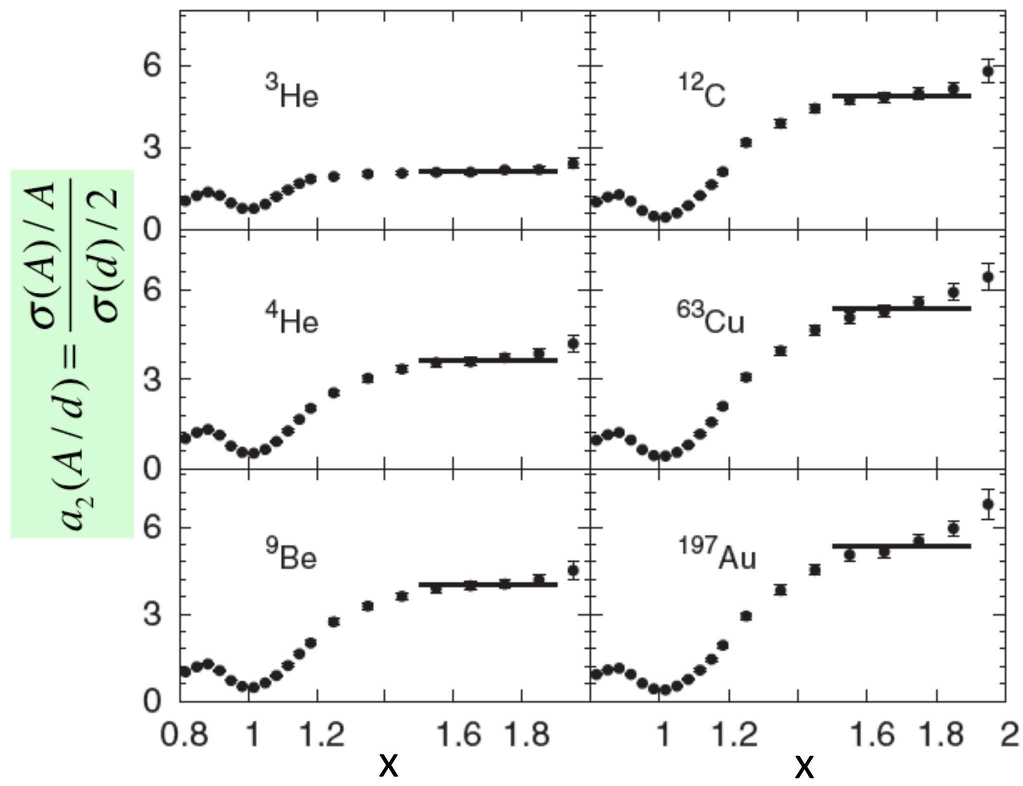


Nucleus	% 2N corr.
d	4.1 ± 0.8
^{3}He	8.0 ± 1.6
^{4}He	15.4 ± 3.2
^{12}C	19.8 ± 4.4
^{56}Fe	23.9 ± 5.3



Ratio predictions by Frankfurt, Strikman, and Sargsian

N. Fomin et al., Phys. Rev. Lett. **108** (2012) 092502



JLAB Hall A Experiment E01-015

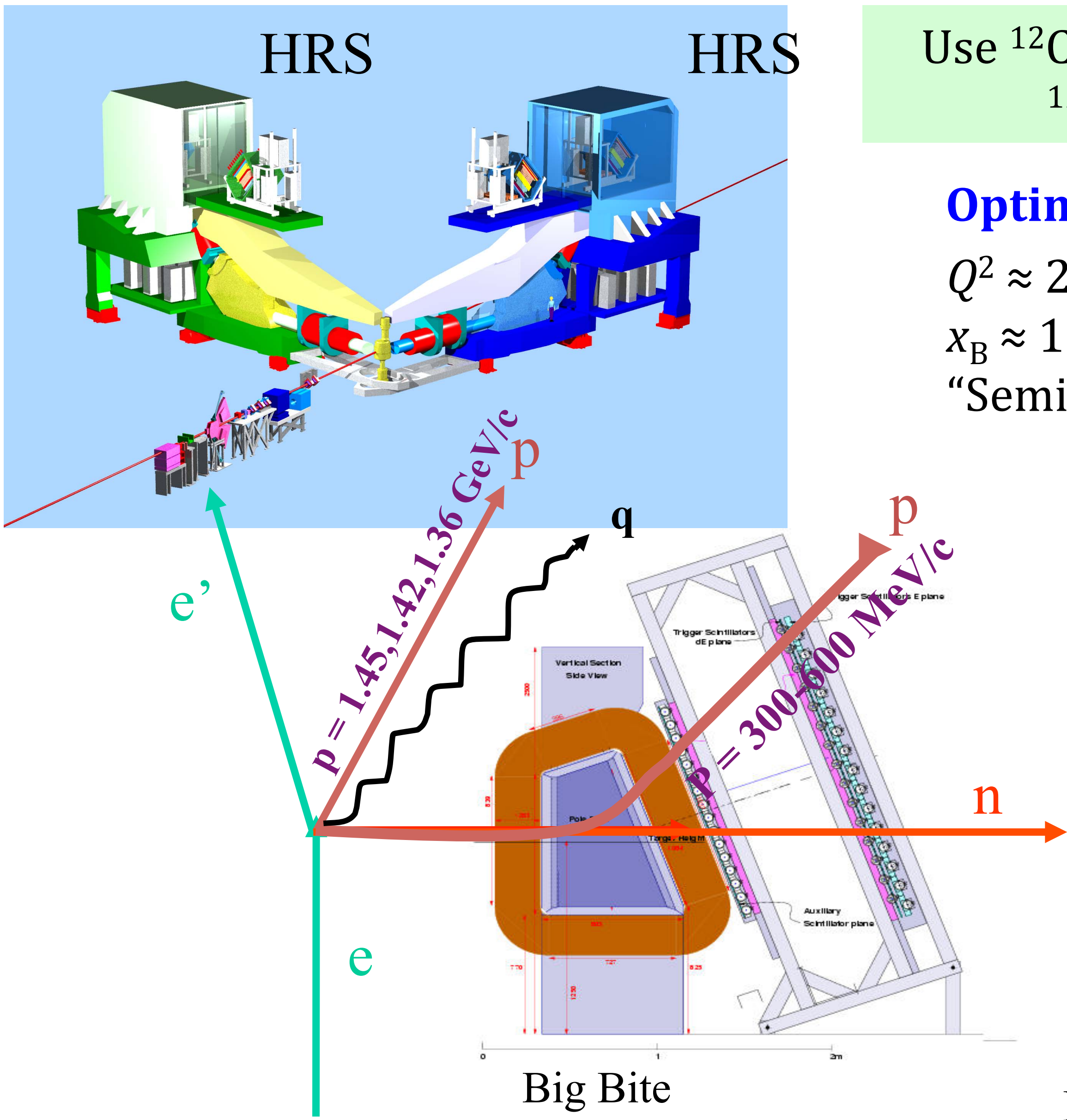
Use ^{12}C($e,e'p$) as a tag to measure ^{12}C($e,e'pN$)/^{12}C($e,e'p$)

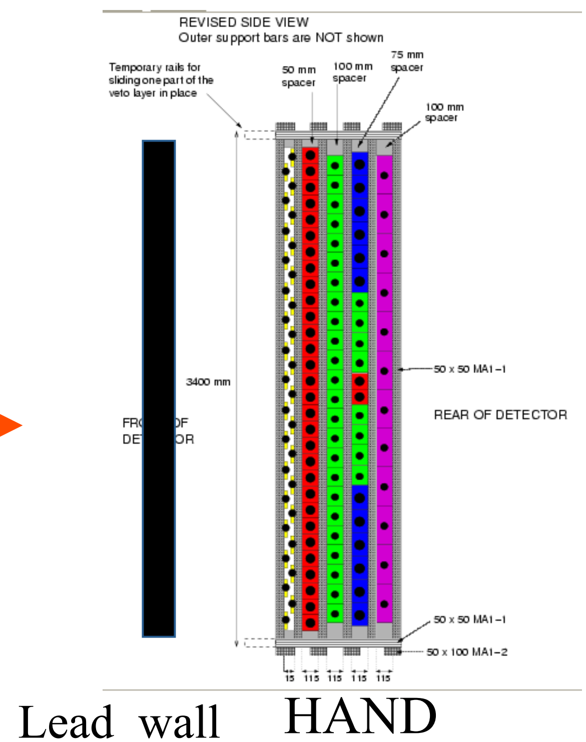
Optimized kinematics:

$Q^2 \approx 2.0$

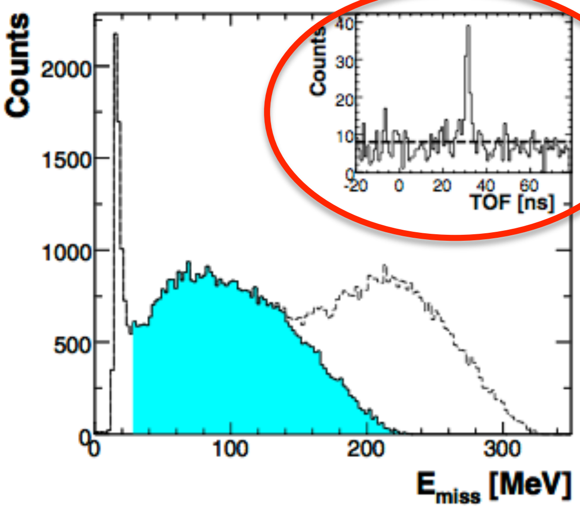
$x_B \approx 1.2$

“Semi anti-parallel” kinematics





JLAB Hall A Experiment E01-015

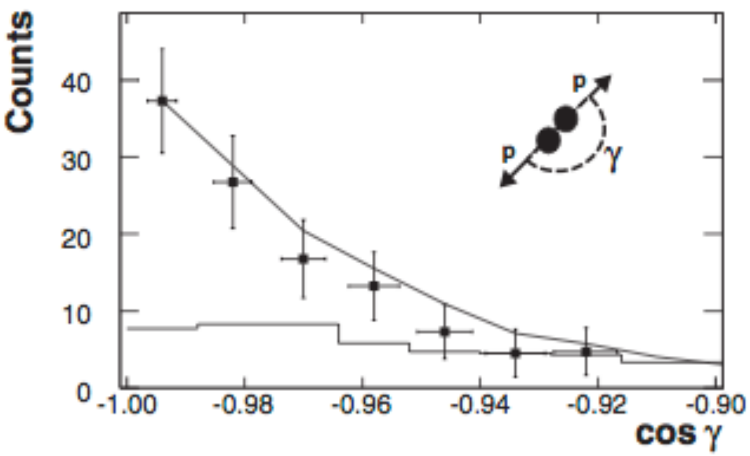


C(*e,e'pp*) yield
~100 events

C(*e,e'p*) yield

Measured:

1. Missing momenta 300 < p_{miss} < 600 MeV/c
2. Opening angle distribution of *pp* pairs
3. Proportion of high p_{miss} protons with a correlated partner
   1. Yield ratio of C(*e,e'pp*)/C(*e,e'p*)
   2. Yield ratio of C(*e,e'pn*)/C(*e,e'p*)



pp opening angle distribution

Follow-up experiment E07-006
(see Tai's talk earlier this morning)
^{4}He(*e,e'pN*) at higher missing momenta
Looking for central correlations

Both experiments are very statistics limited

Hall A : E07-006

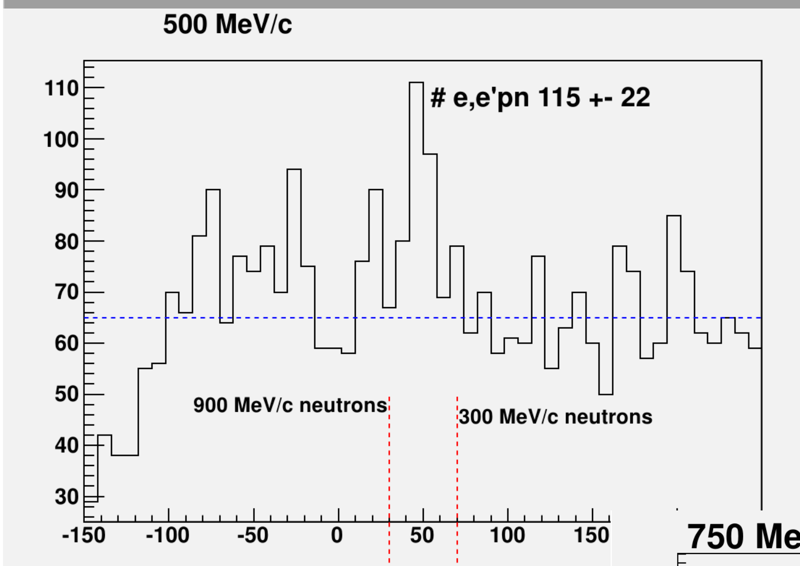
$^{4}\text{He}(e,e'pn)$

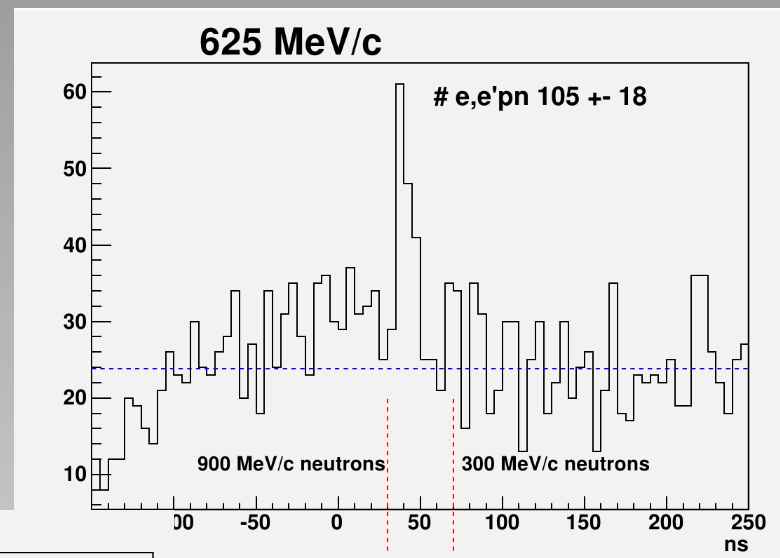
$Q^2 \approx 2\ \text{GeV}^2$ $\quad x_B > 1.05$

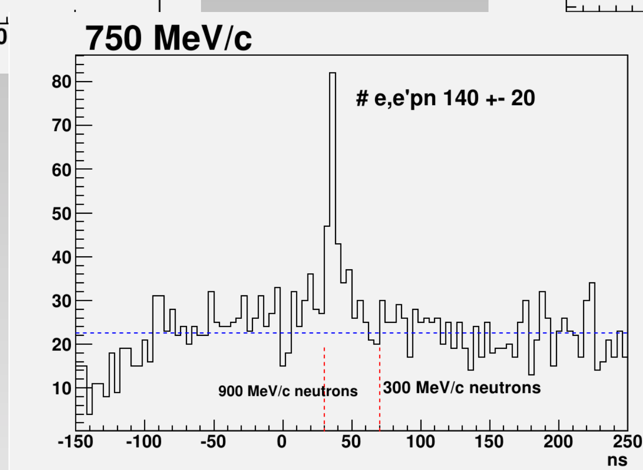
3 kinematical set up in each:

~2000 (*e,e'p*) events

100-150 (*e,e'pn*) events







PRELIMINARY

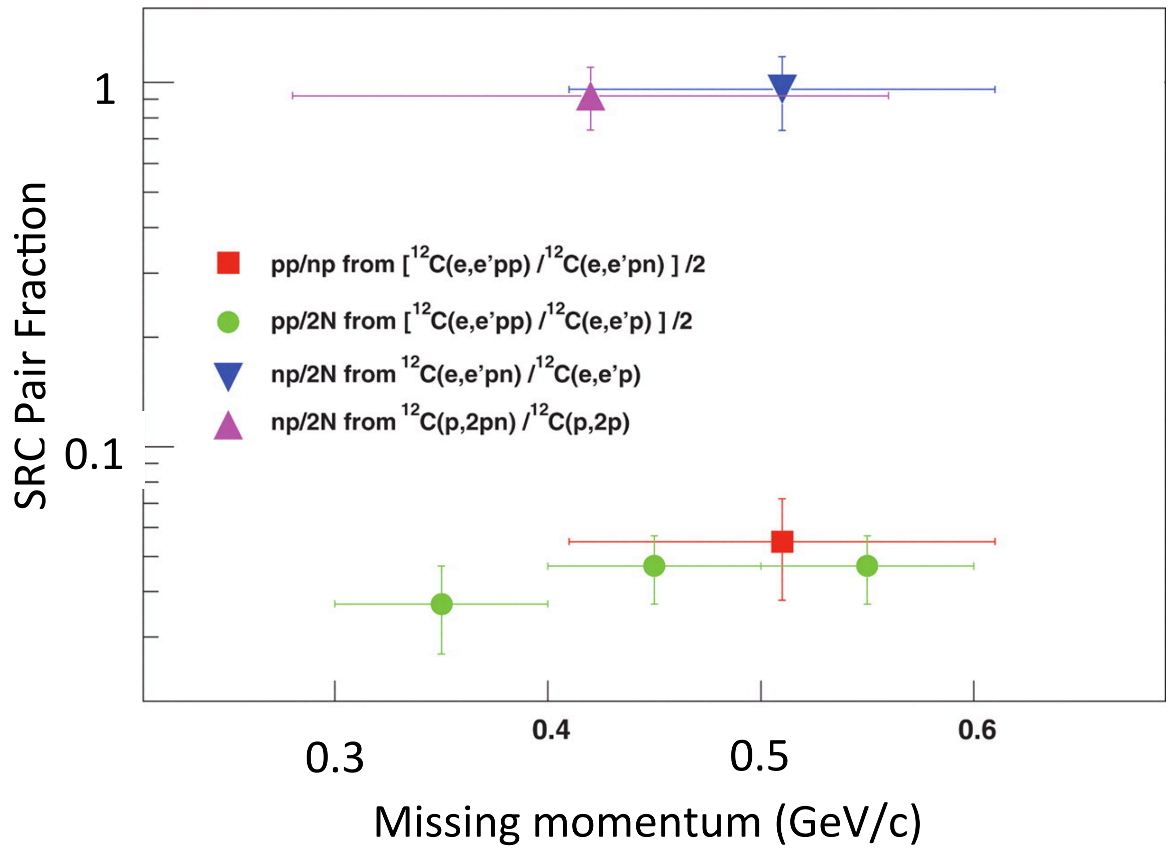
Results from Hall A (*e,epN*) SRC experiments

- Almost **all** protons with p_{miss} > 300 MeV/c in ^{12}C(*e,e'p*) have a paired proton or neutron with similar momentum in opposite direction

$$\frac{^{12}C(e,e'pn)}{^{12}C(e,e'p)} = 96^{+4}_{-23}\%$$

$$\frac{^{12}C(e,e'pp)}{^{12}C(e,e'p)} = 9.5 \pm 2\%$$

- *np* SRC is ~18 times larger than *pp* or *nn* SRC



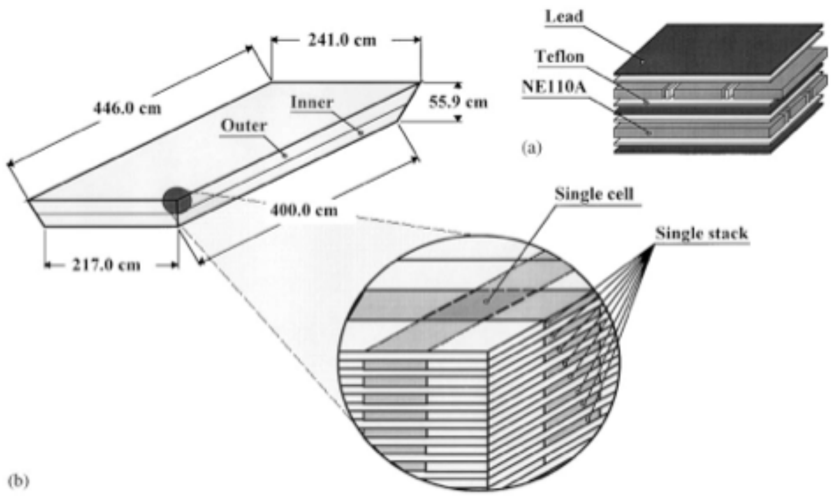
R. Subedi *et al*., Science **320** (5882), 1476 (2008)

R. Shneor *et al*., PRL**99, 072501 (2007)**

How can we do better?

- Higher beam energy ➔ higher Mott cross section
  - Q^2=2 GeV^2, x_B=1.2 and E_{beam}=11 GeV ➔ E_f=10 GeV
  - ➔ cannot use HRS at large x_B and large E_{beam}
- Use SuperBigBite to get larger electron momenta and larger solid angle
  - But no electron identification
- Use the CLAS6 Large Angle Calorimeter for SBB electron ID
- Detect primary proton in HRS
- Detect spectator nucleon in BigBite/HAND

The Large Angle Calorimeter (LAC)



Active area: 2.2 m by 4 m

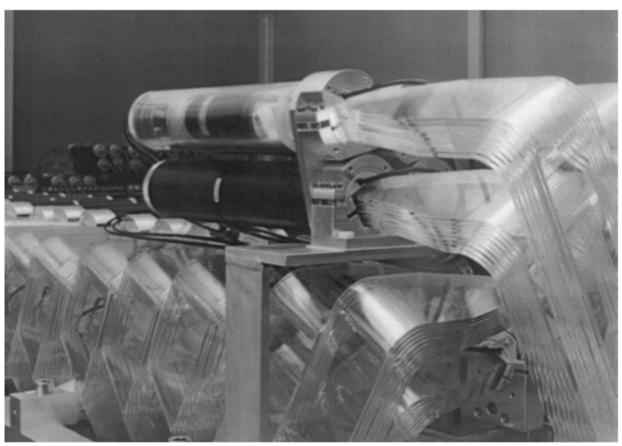
33 layers

- 0.20 cm Pb foil
- 1.50 cm NE110A scintillator

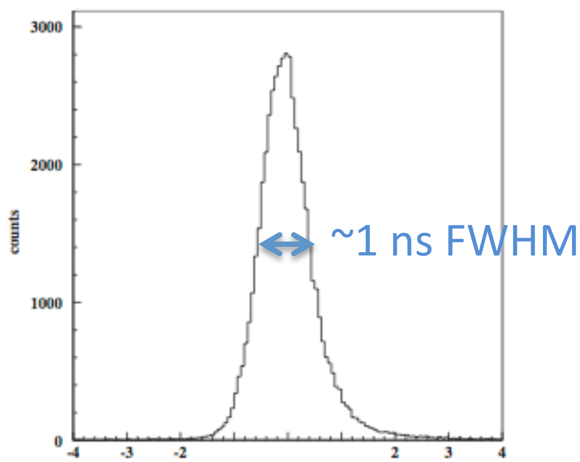
Readout segmentation:

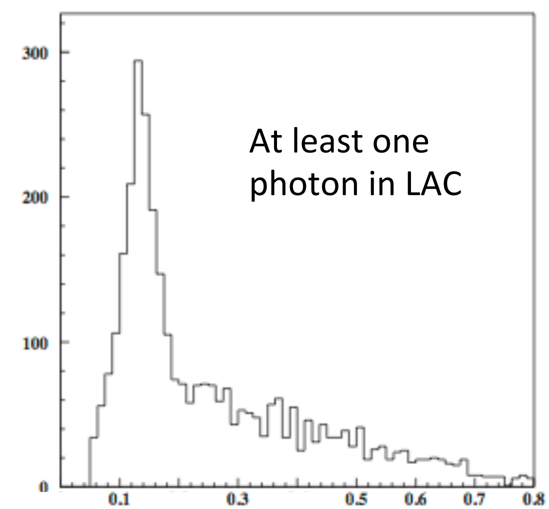
- 40 strips in *X* (each ~ 10 cm)
- 24 strips in *Y* (each ~ 10 cm)
- "Inner" (17 layer) vs "outer"

Intrinsic resolution (from MC) of 6%/√E



Coupling of scintillators to PMTs

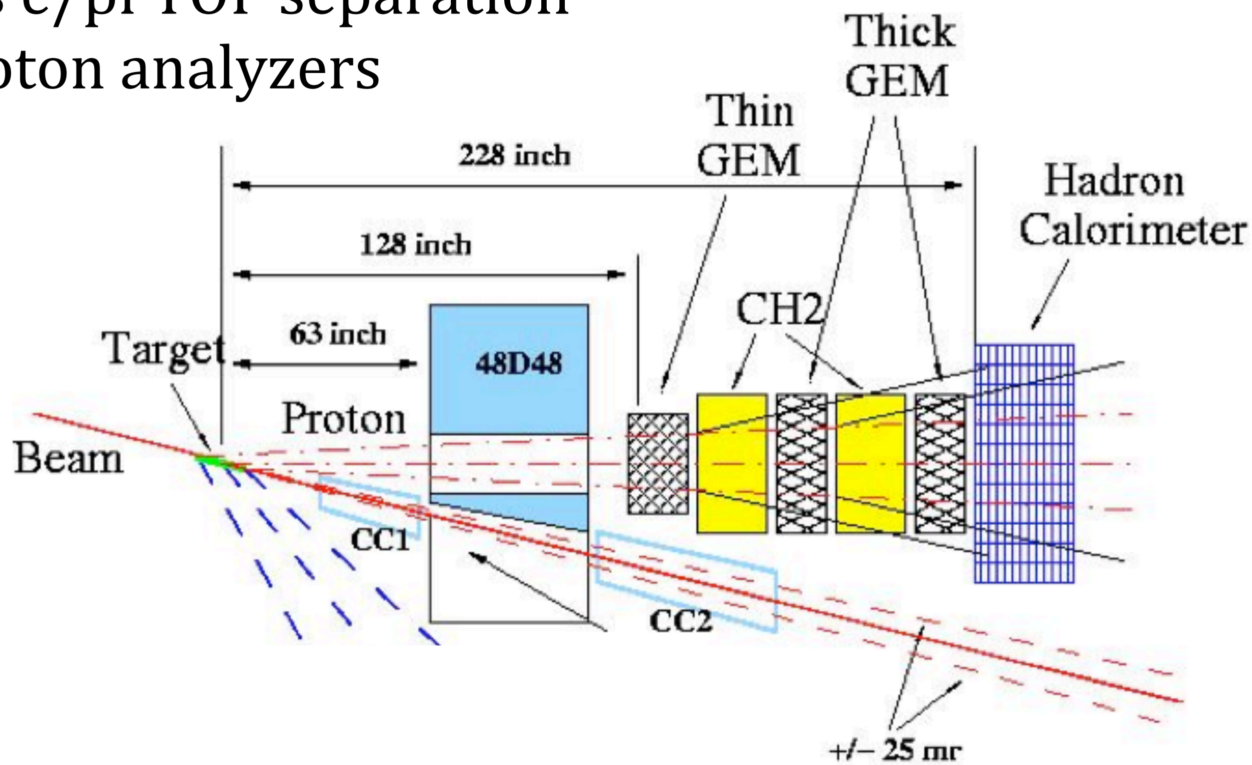




SBS + LAC

Using the SBS for electron detection:

- Replace Hadron Calorimeter with LAC
    - Similar sizes (5.5 m^2 vs 8.7 m^2)
    - Place the LAC as far back as possible to match the solid angle.
        - Improves angular resolution
        - Improves e/pi TOF separation
- Remove CH2 proton analyzers



Crude count rate comparison

- Previous measurements limited to $L = 10^{37}$ cm^{-2}s^{-1} by signal to noise ratios.
- The singles rate for the backward nucleon (detected in BigBite) should not depend strongly on incident electron energy.

At the same electron kinematics as E01-015 and E07-006 (Q^2 = 2 GeV^2 and x_B = 1.2) we can get 70 times more rate at the same luminosity:

$$\frac{\sigma_{Mott}(11\ \text{GeV})}{\sigma_{Mott}(5\ \text{GeV})} \cdot \frac{30\ \text{msr (SBB)}}{6\ \text{msr (HRS)}} = 14 \cdot 5 = 70$$

100 (*e,e'pn*) counts ➔ 7000 counts!

More Data!

- With 70 times more data (at the same kinematics), we can
  - Greatly improve our measurements of the probability that a high momentum proton has a correlated partner
  - Greatly improve our measurements of the angular distribution of the correlated partners
  - Refine our measurements of *pp* vs *pn* pairs
  - Extend the measurements to much larger proton momentum and explore the region of central correlations much better
- The LAC has been recovered from CLAS6
- It needs to be stored in climate controlled space
- We anticipate submitting a proposal to the next PAC.