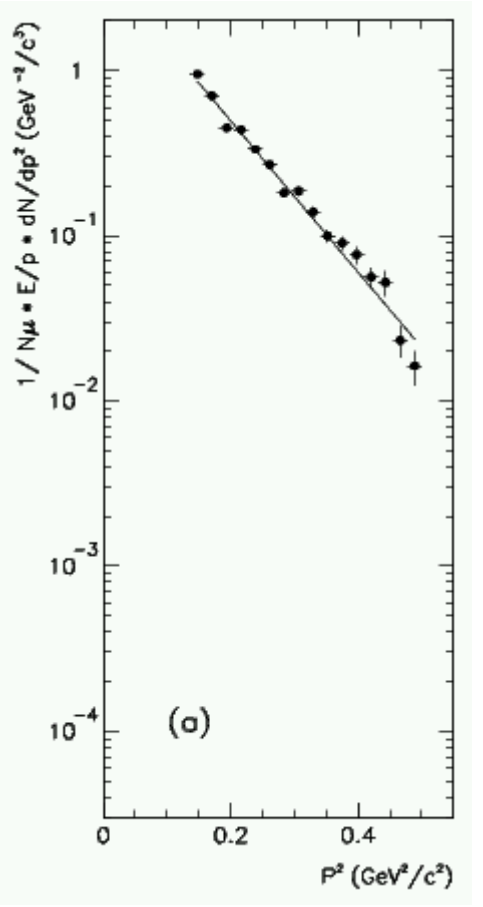
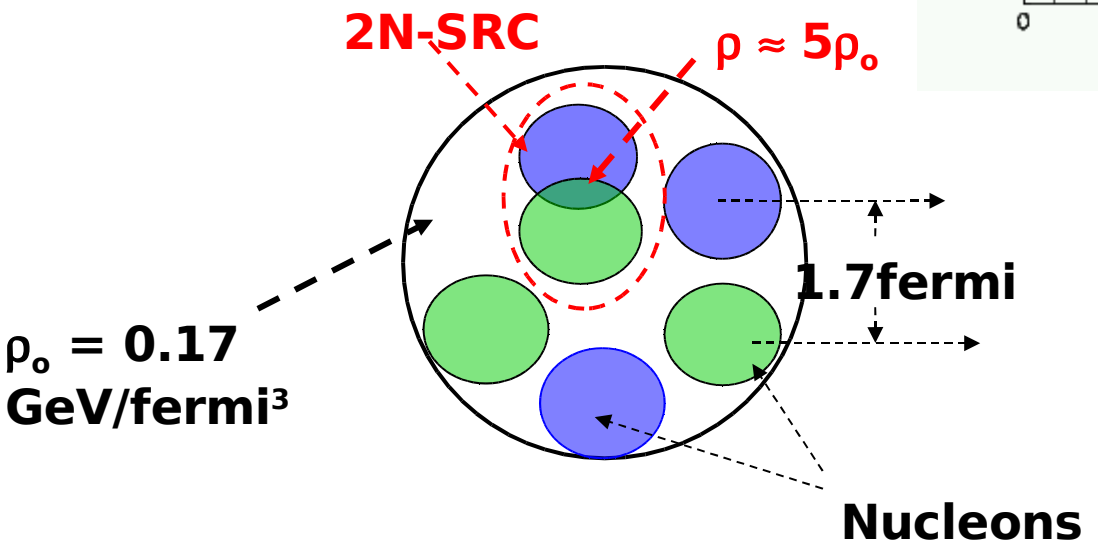
Short Range Correlations

JLab ^{12}C(e,e'pN) experiment

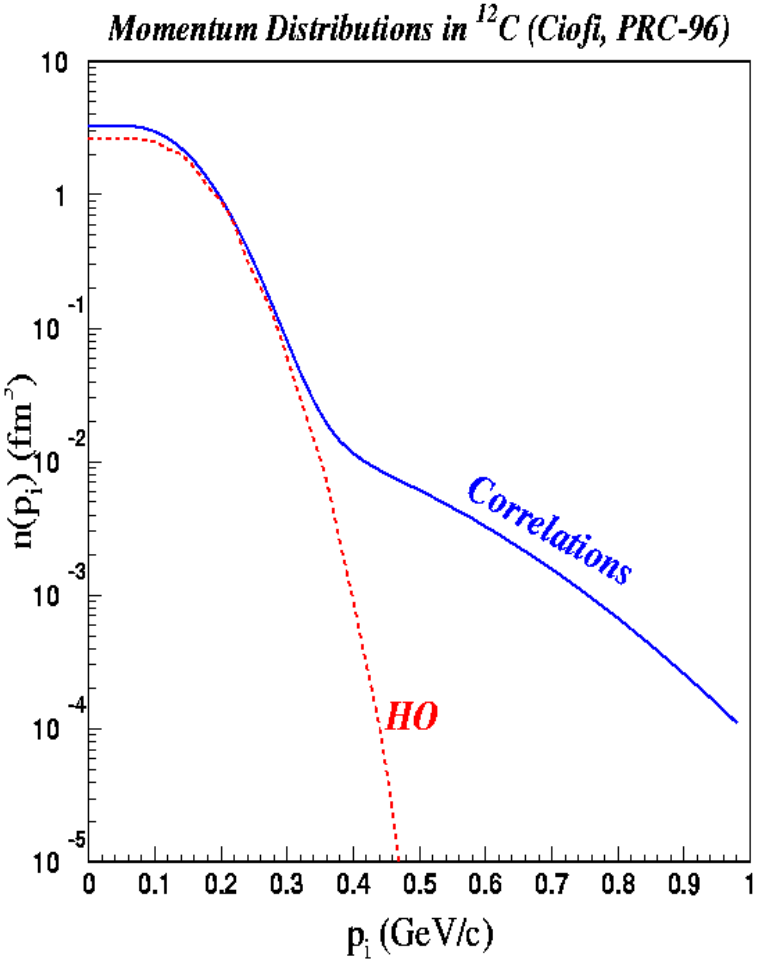
- NUINT01 – Personal observations
  - Nuclear Physics <=> Neutrino Physics
  - Backward Protons (*Bp*)
    - NOMAD (Veltri-NUINT01)
    - *Bp* interpreted as nu interaction with nucleon cluster
- Triple coincidence exp had been recently approved at JLAB.
  - ^{12}C(e,e'pp)
  - ^{12}C(e,e'pn)





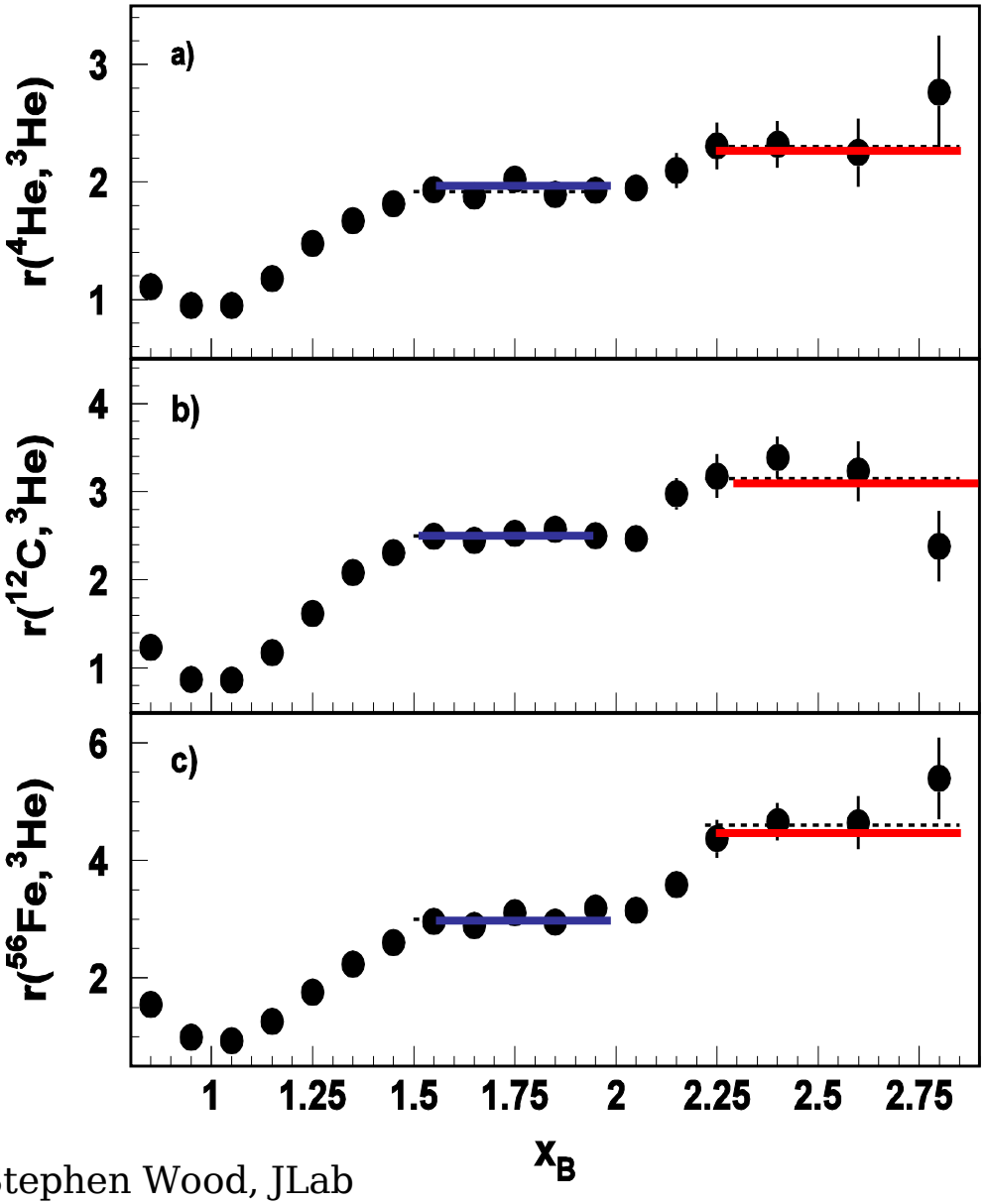
Short Range Correlations Questions

- What fraction of the high missing momentum tail is due to 2N-SRC?
- What is the relative momentum between the nucleons in the pair?
- What is the pair CM momentum distribution ?
- What is the ratio of pp to pn pairs?
- Are these nucleons different from free nucleons (shape, mass, etc.)?



CLAS A(e,e') Data

Egiyan et al. PRC 68, 014313, PRL 96, 082501.



$$x_B = \frac{Q^2}{2M\nu} > 1.5,$$

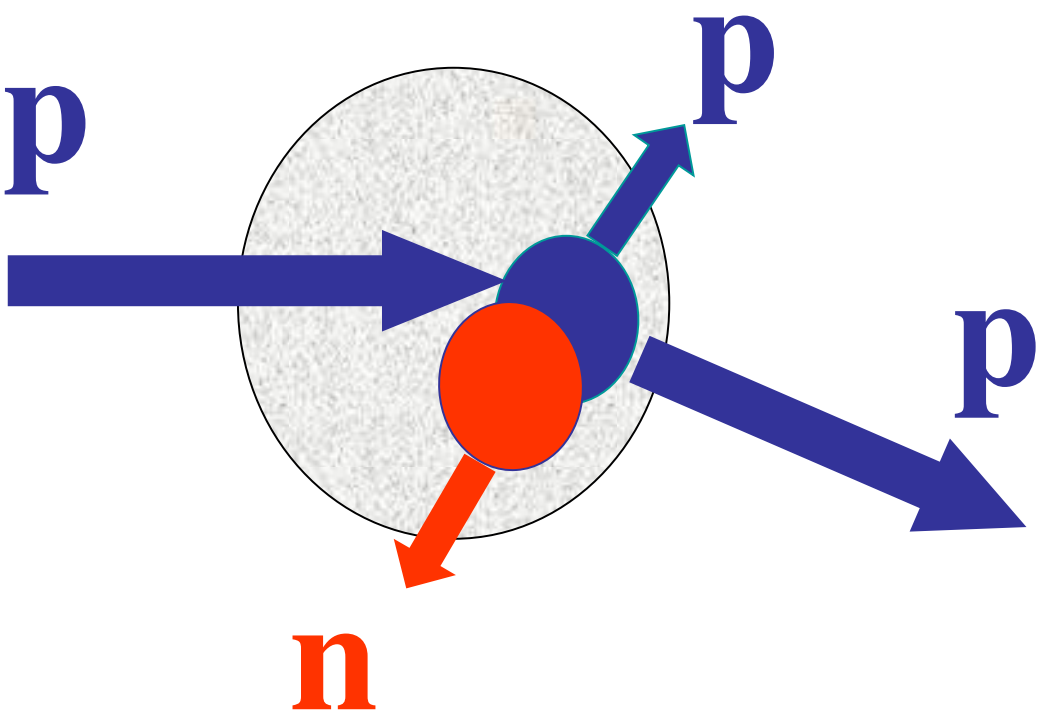
$$Q^2 > 1.4 GeV^2$$

suppresses the otherwise dominant contribution from single nucleons with momentum smaller than 275 MeV/c (as can be obtained from the kinematics of electron scattering from single nucleons

From ratios, determine that C12 is 20+/-5% 2N SRC, ~1% 3N SRC.

Triple – coincidence measurements:

BNL



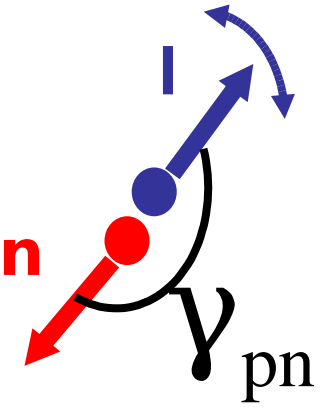
If beam scatters of single nucleon in nucleus:

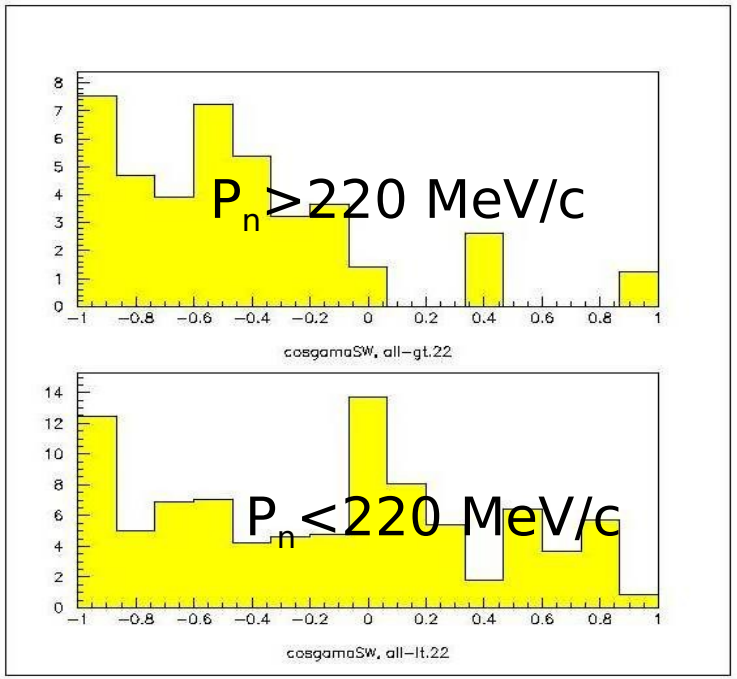
$$\vec{p}_i = \vec{p}_1 + \vec{p}_2 - \vec{p}_b$$

If “initial proton” correlated with a neutron, neutron should be emitted opposite to “initial proton” direction.

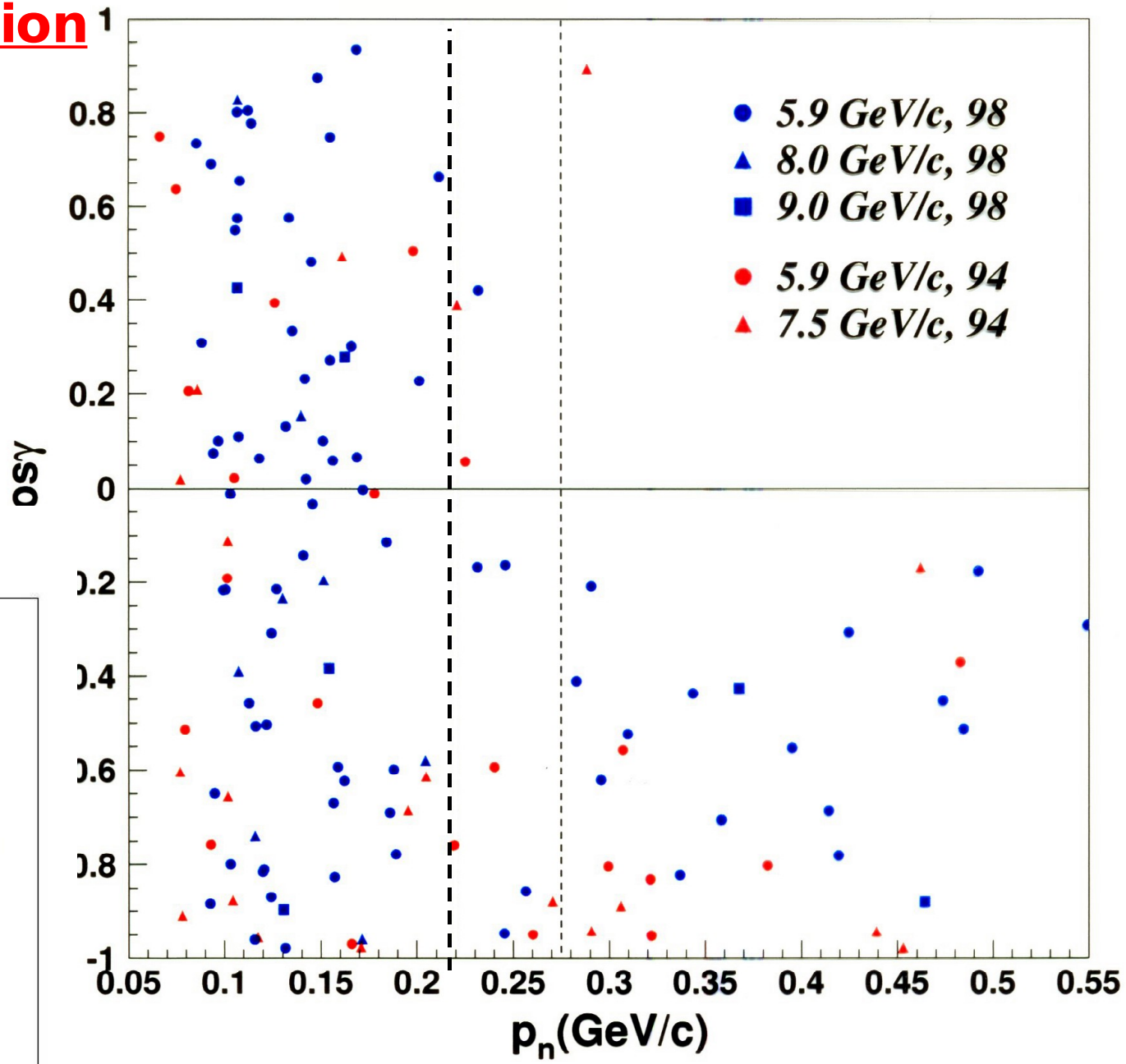
Directional correlation

(p,2pn)





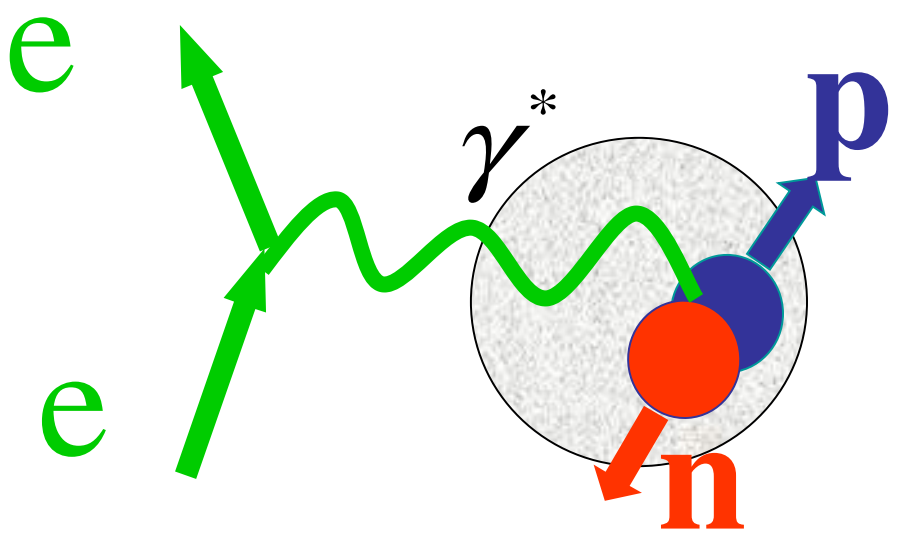
PRL 90, 042301 (2003)

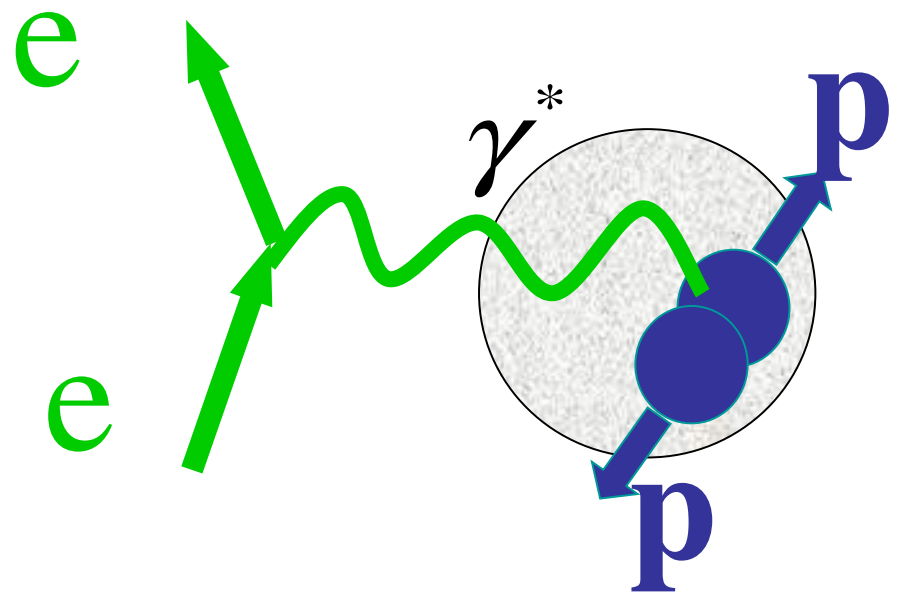


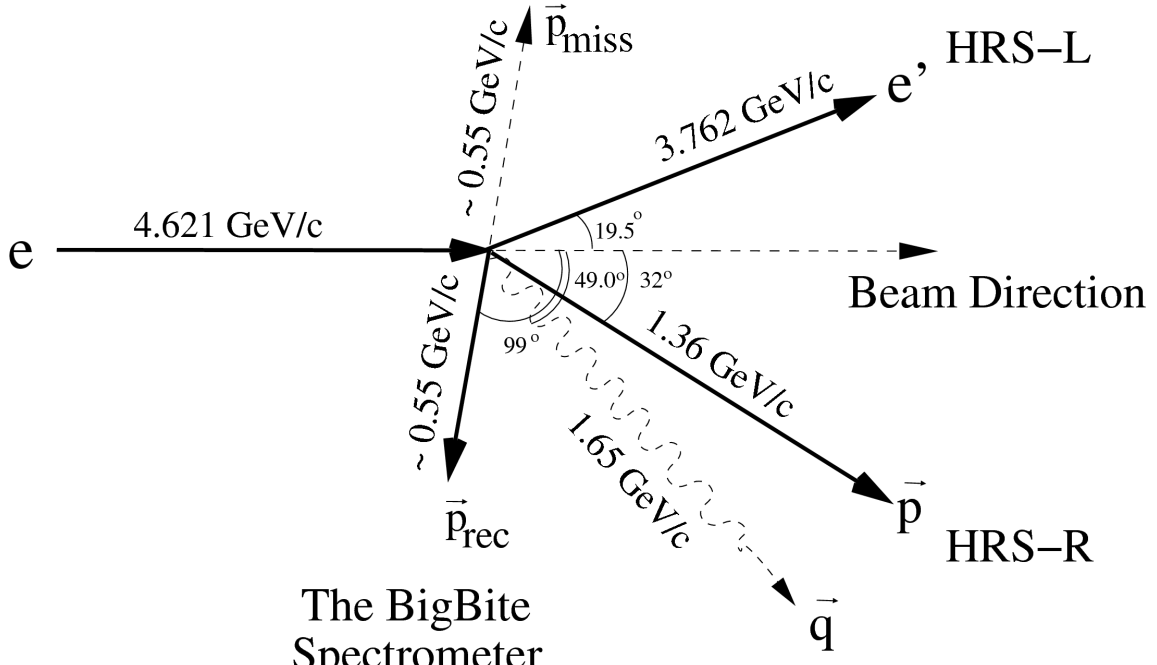
The EVA/BNL collaboration

Triple – coincidence measurements:

JLab







The BigBite Spectrometer Neutron Detector

$$\vec{p}_m = \vec{p}_e + \vec{p}_p - \vec{p}_b = \vec{p}_p - \vec{q}$$

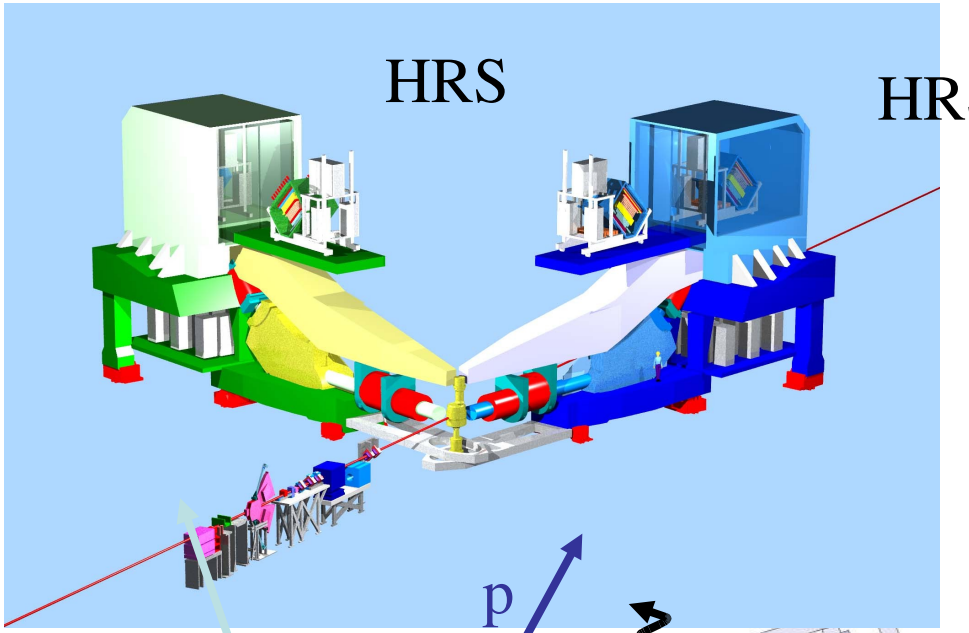
Choose p_m >=300 MeV/c

$Q^2 \sim 2$ (GeV/c)^2

$X_B \sim 1.2$

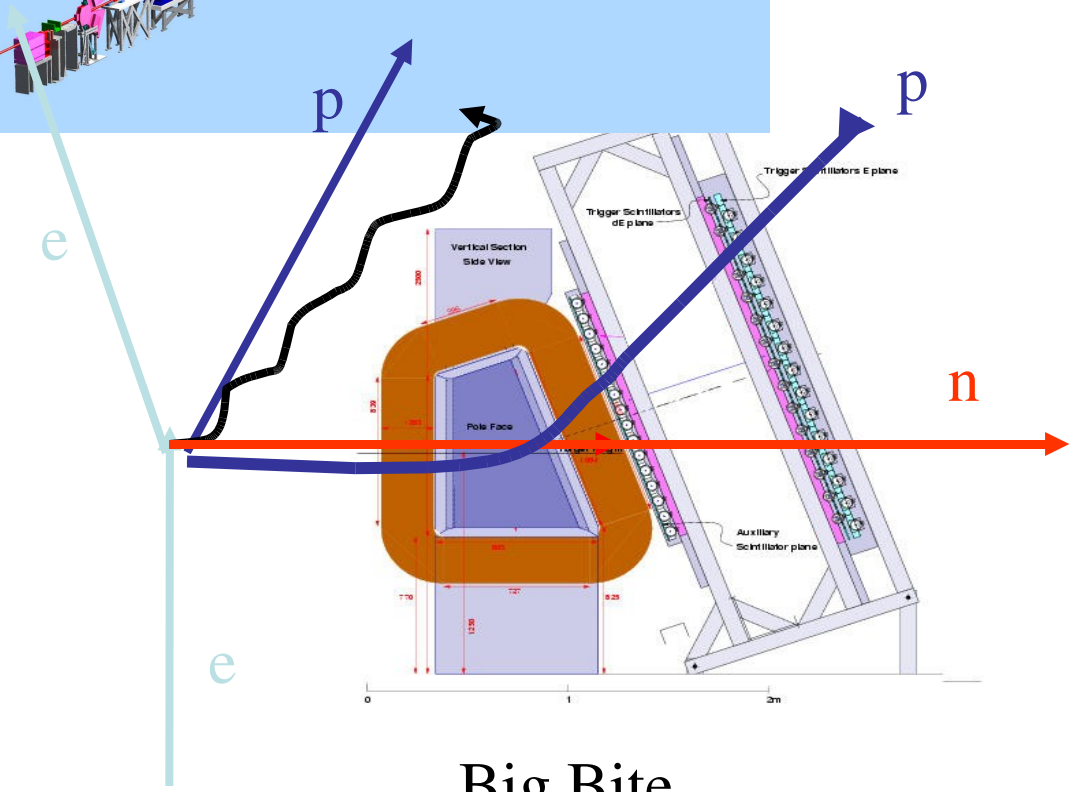
^{12}C(e,e'pN)
Experimental setup

EXP 01-015 / JLab - Hall A

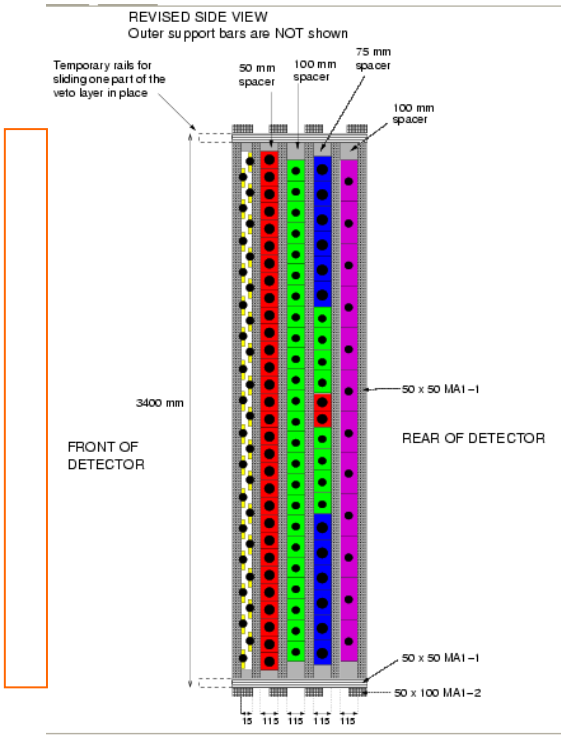


Students:
P. Monaghan, R. Shneor, R. Subedi

n array

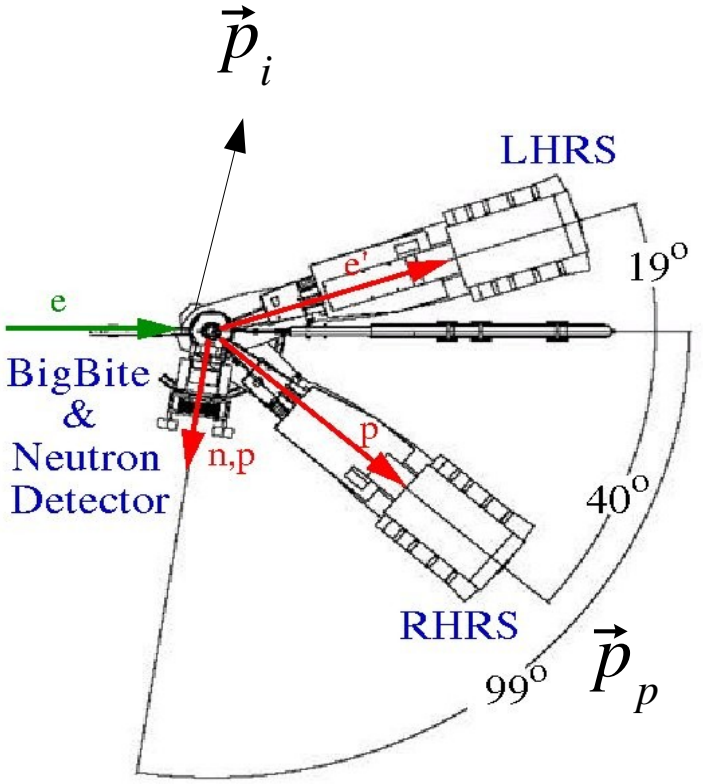


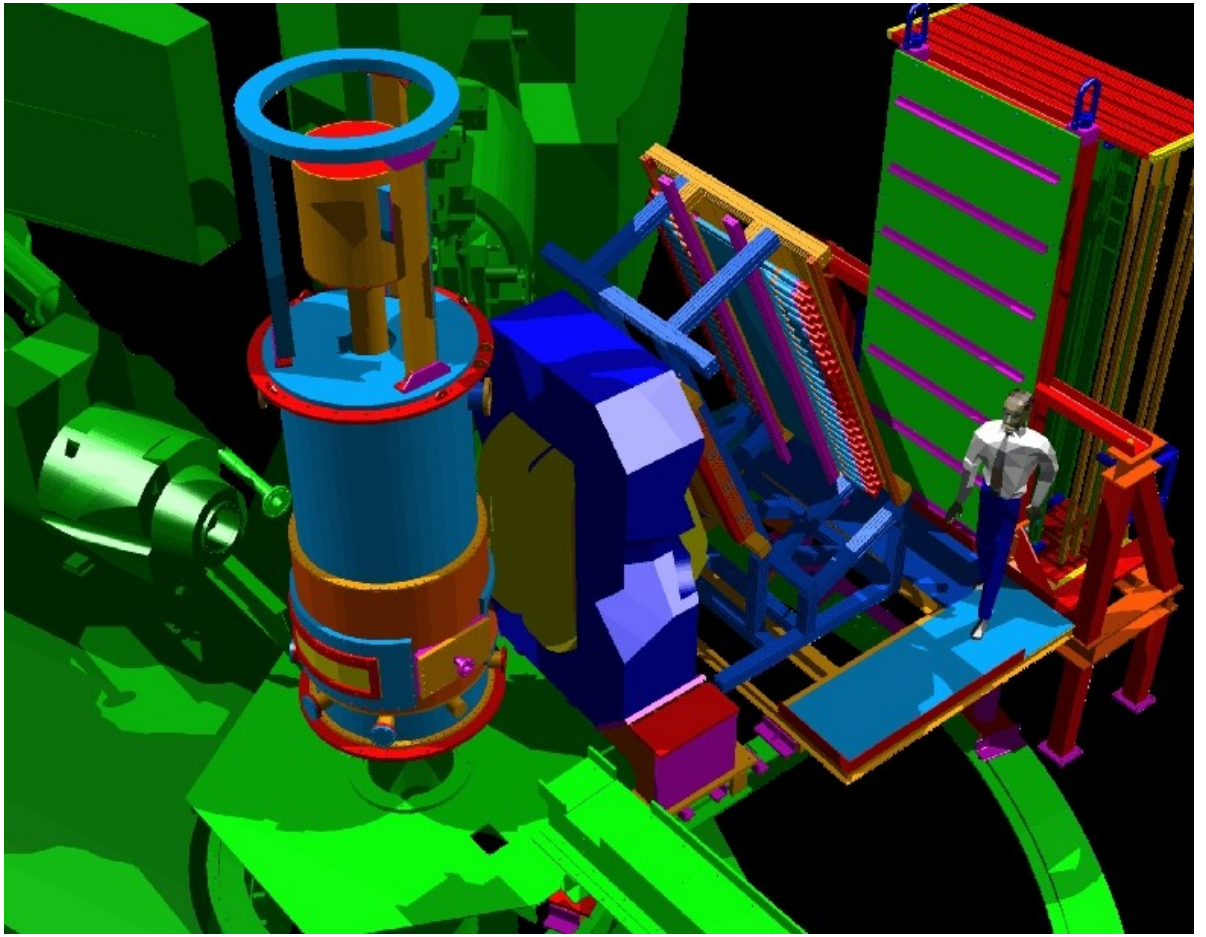
Big Bite



Lead wall

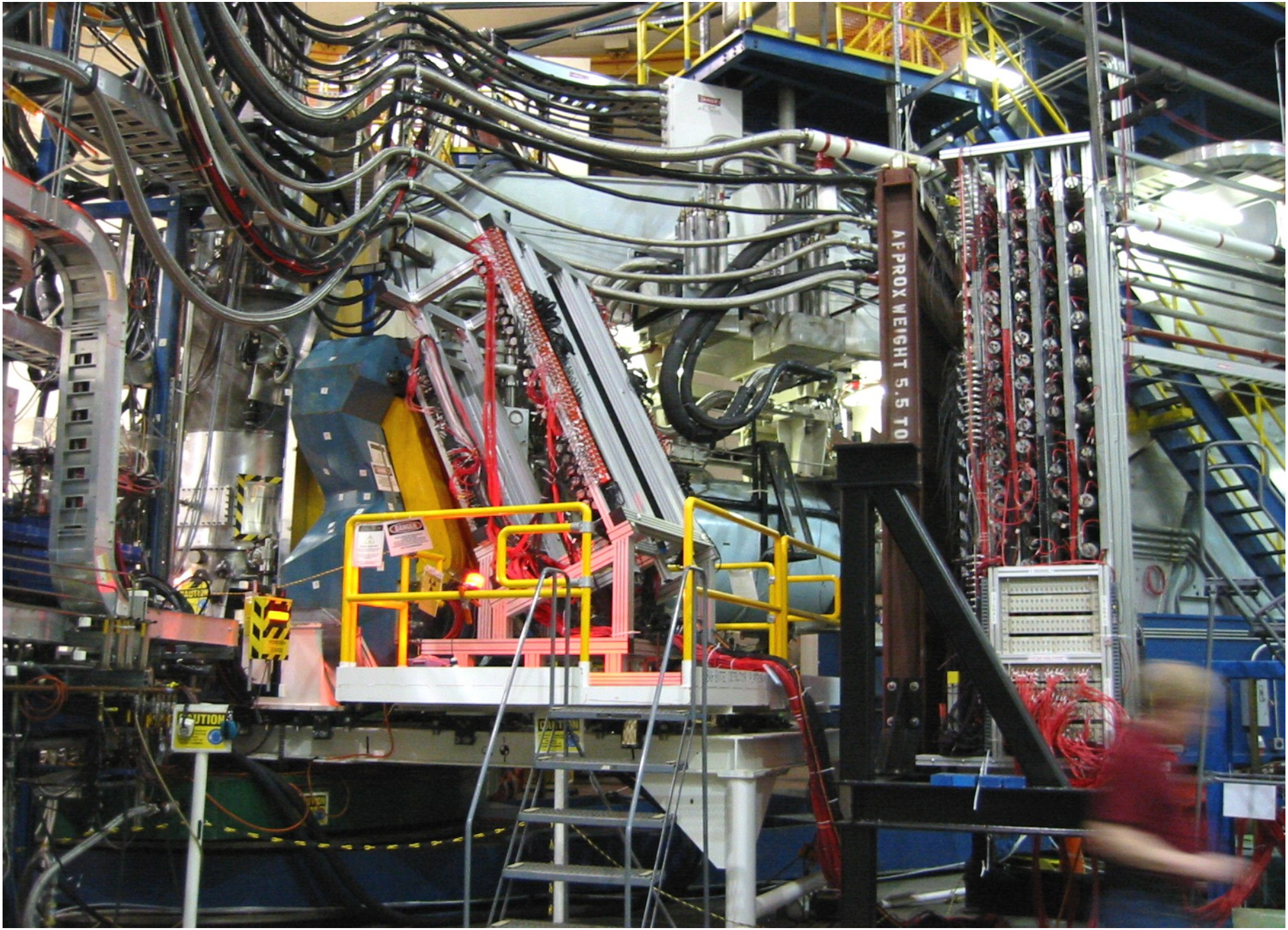
(e,e'pN) setup





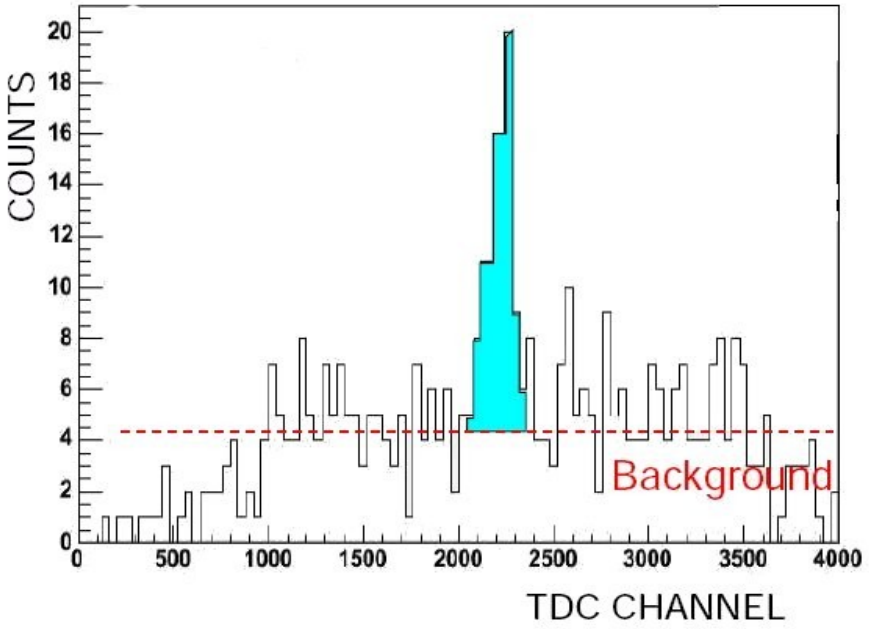
$$\vec{p}_i = \vec{p}_p - \vec{q}$$

- BigBite Proton Spectrometer
- Low Energy Neutron Detector
- 100 msr solid angle

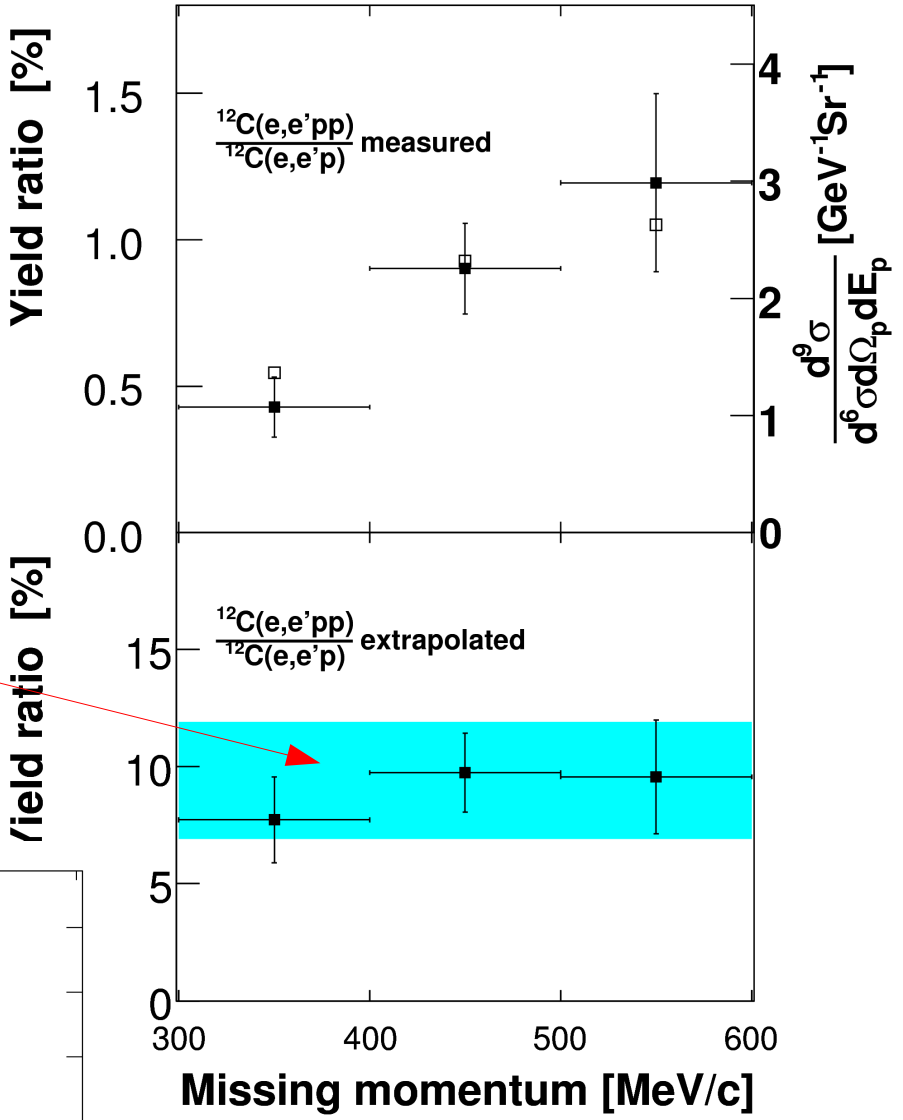


EXP. 01-015 **Jlab / Hall A** Dec. 2004 – Apr. 2005

^{12}C(e,e'pp) *Ran Shneor (Tel Aviv University)*

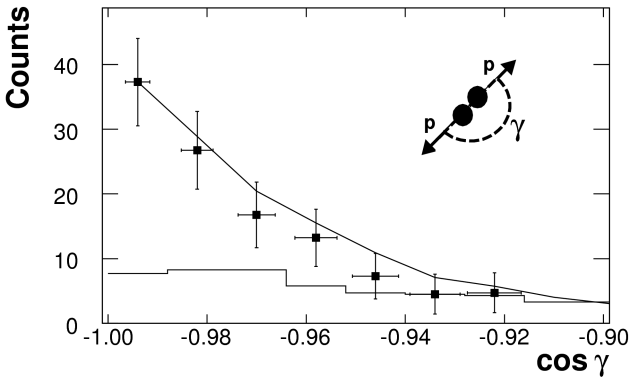


Raw ratio of detected recoiling protons.

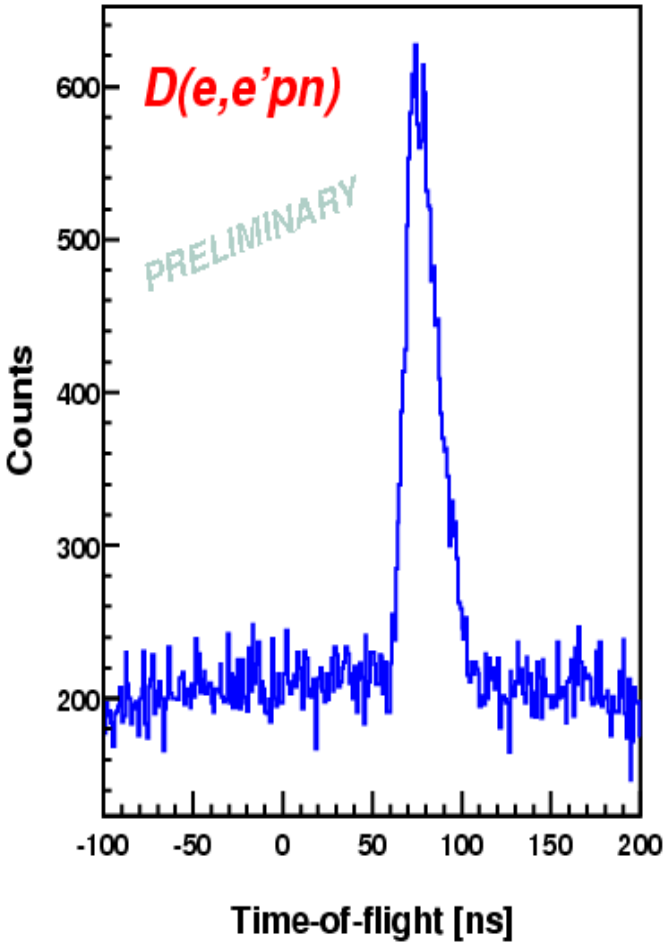


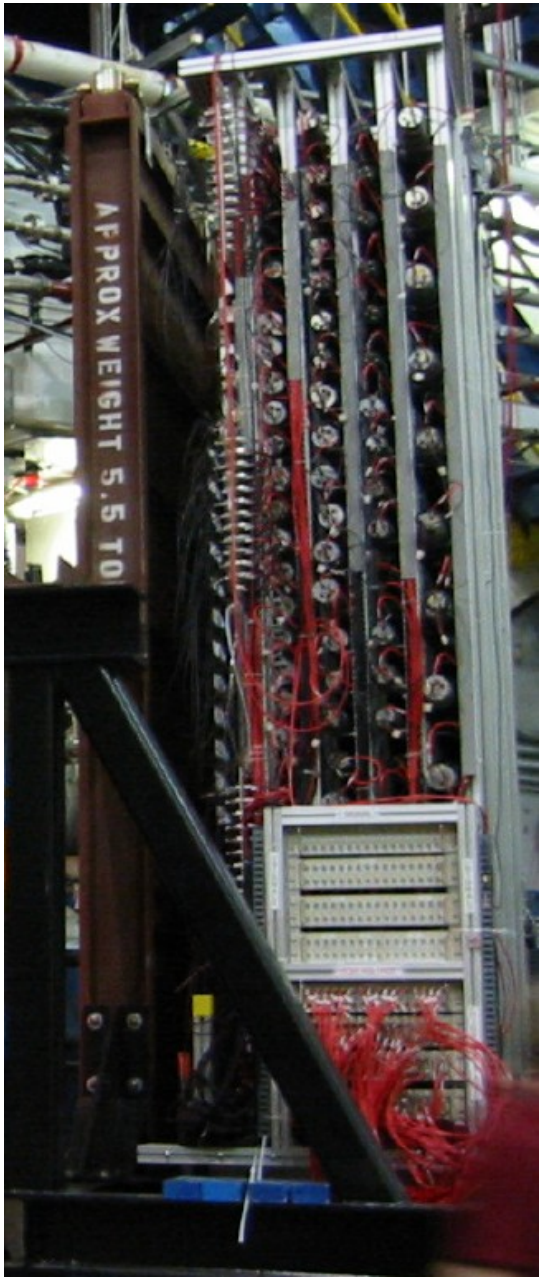
Correcting for the finite acceptance of BigBite yields approx. 10% for the ratio of (e,e'pp)/(e,e'p).

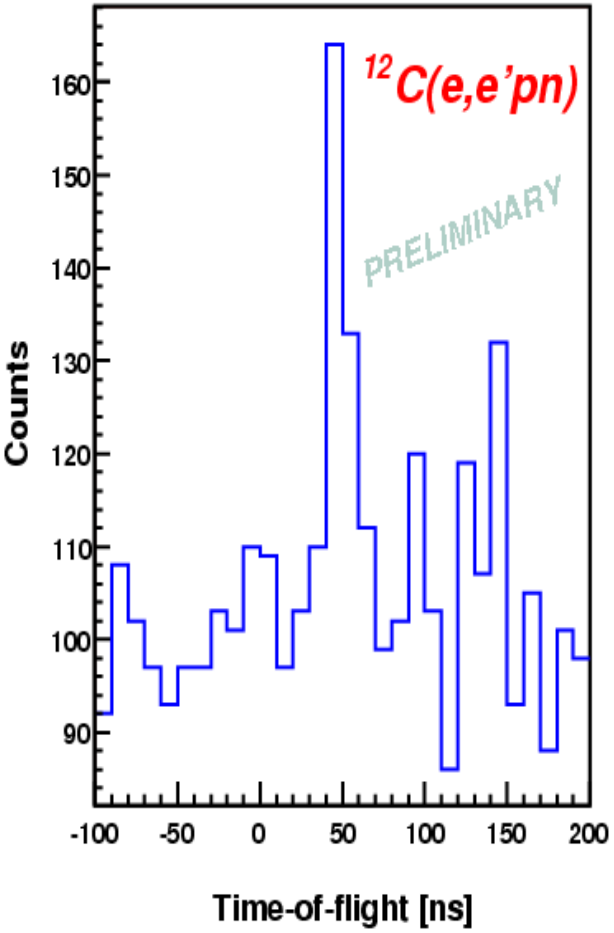
Angular correlation between pm and "backward" proton. Pair cm momentum width 135 MeV/c.



$^{12}C(e,e'pn)$ *Ramesh Subedi (Kent State University)*

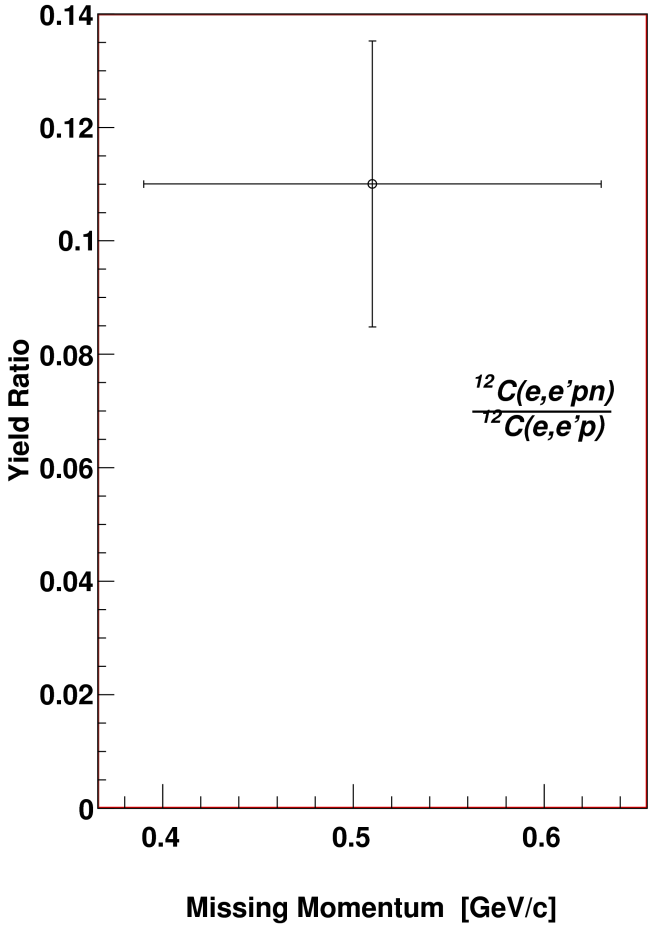




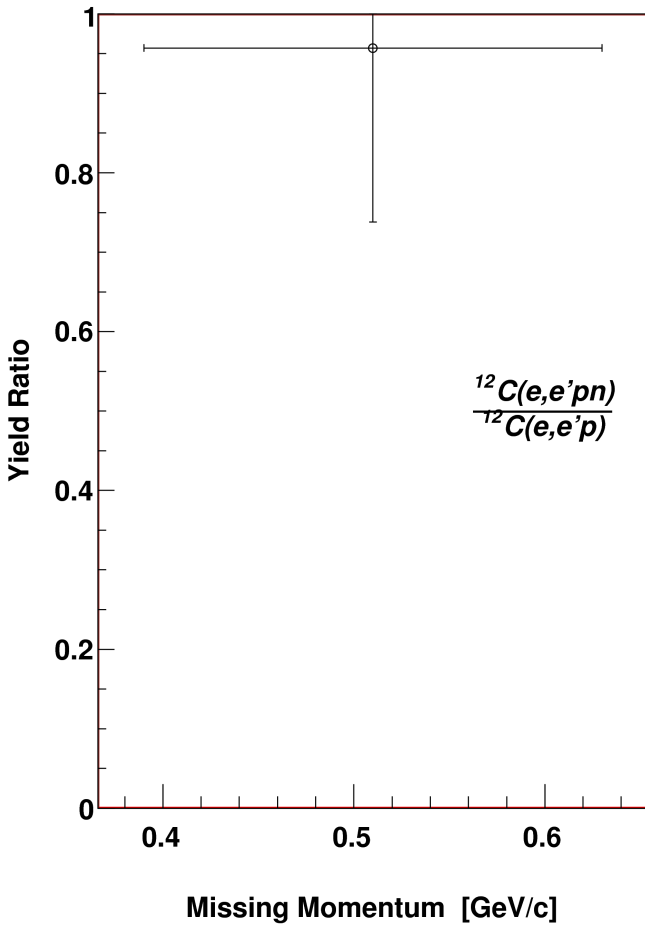


Deuterium was used to determine the absolute neutron detection efficiency.

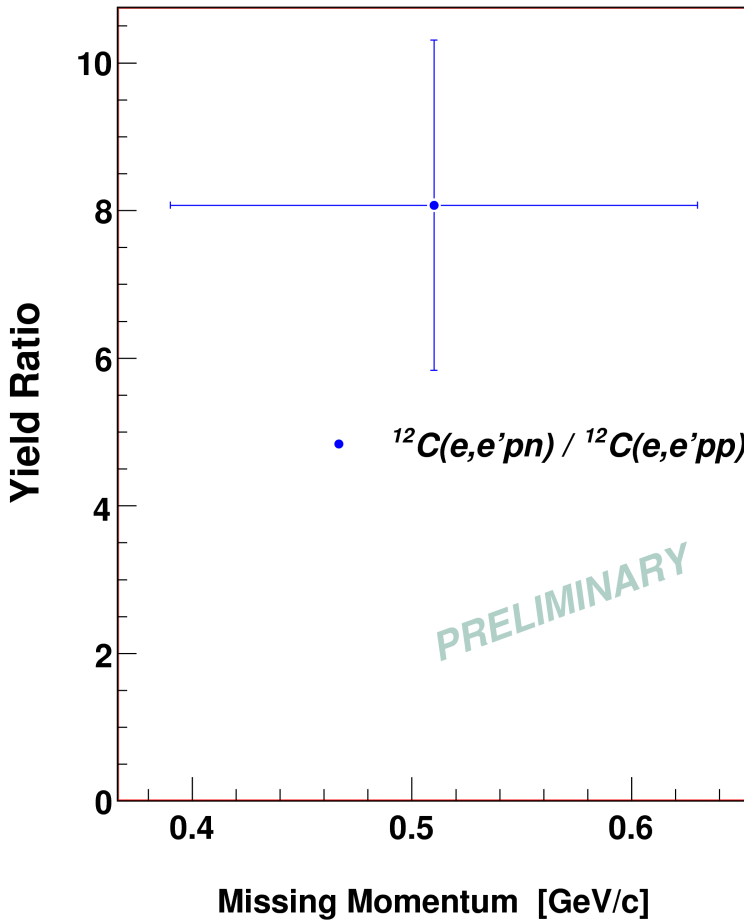
Raw ratio
(includes correction
for neutron efficiency)



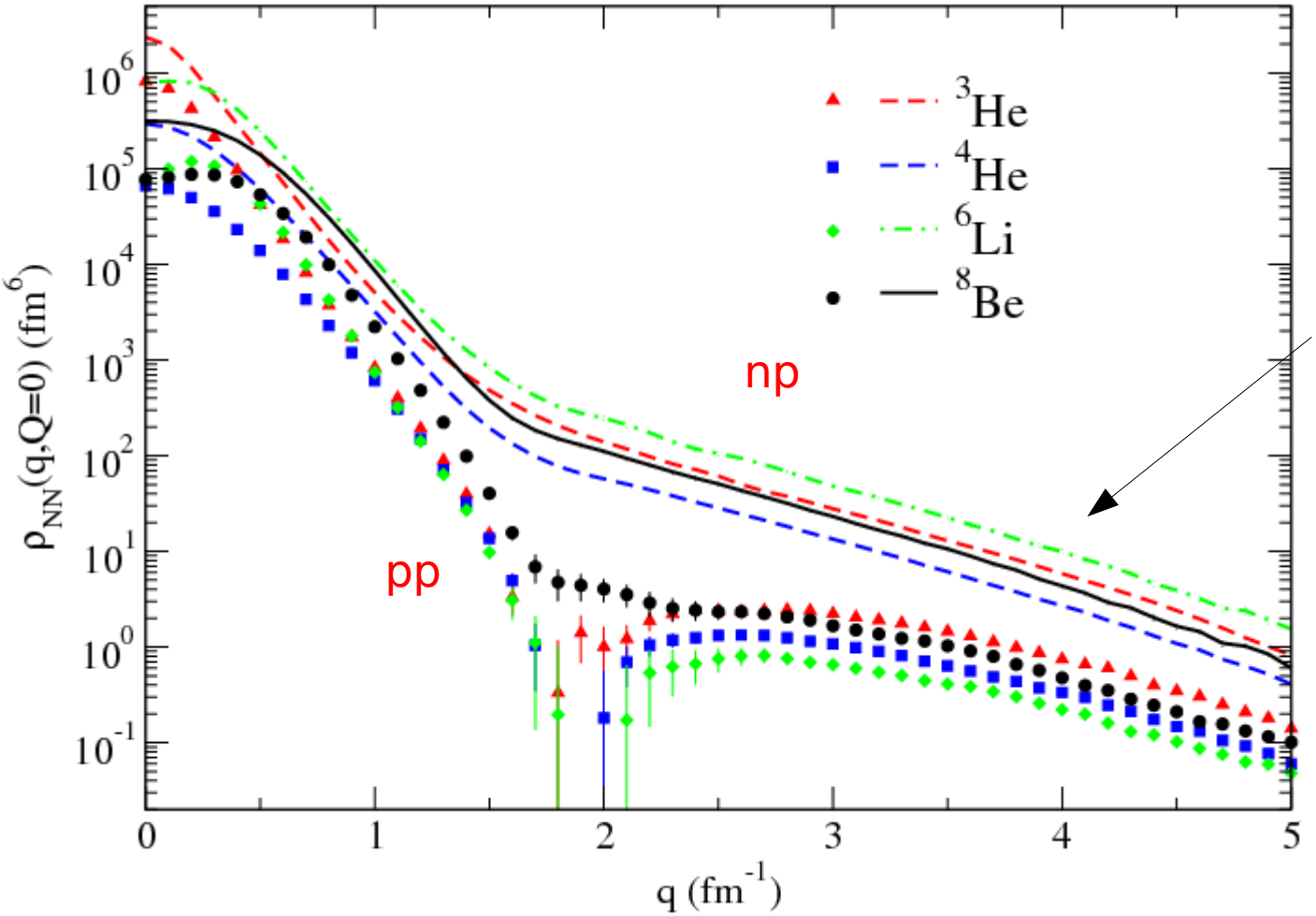
Acceptance corrected
(Moving deuteron
MC model)



Correlated pairs
much more likely
to be np than pp



Schiavilla et.al. PRL 98, 132501



Tensor correlations lead to ratio of np to pp momentum distributions of ~10 at high relative momenta

Helped to motivate new Jlab experiment:

4He(e,e'pN) with 400 < pm < 875 MeV/c

Look for momentum dependence in np/pp

Incorporate experiment lessons learned

From the (e,e'), (e,e'p), and (e,e'pN) Results

- 80 +/- 5% single particles moving in an average potential
  - 60 – 70% independent single particle in a shell model potential
  - 10 – 20% shell model long range correlations
- 20 +/- 5% two-nucleon short range correlations
  - from (e,e'pp) 1-2% pp SRC
  - exact ratio for (e,e'pn) / (e,e'pp) not final, but clear pn dominance observed with 10-20% pn SRC
  - combining preliminary results we can deduce 1-2% nn SRC
- less than 1% multi-nucleon correlations

Comments/Future SRC experiments with neutrinos

- Large accidental backgrounds make measurement difficult with electron beams, particularly ^{12}C(e,e'pn)
- Triple coincidence with MINERvA for “free”?
  - CC Sensitive to np (-> pp) and nn (-> np) pairs $\nu + {}^{12}C \rightarrow \mu + p + N + X$
  - Fully active CH target sensitive to low momentum protons
  - 4pi avoids model dependent acceptance correction for “N”
  - Using Benhar ^{12}C spectral function estimate several thousand events at interesting kinematics (x>1, p_m>300 MeV/c)
  - May be able to measure c.m. Motion of correlated pair by selecting roughly coplanar events
  - Looking forward to using event generators (i.e. NEUGEN) with spectral functions to model SRC triple coincidence events with MINERvA simulation