Short-Range Correlations

by

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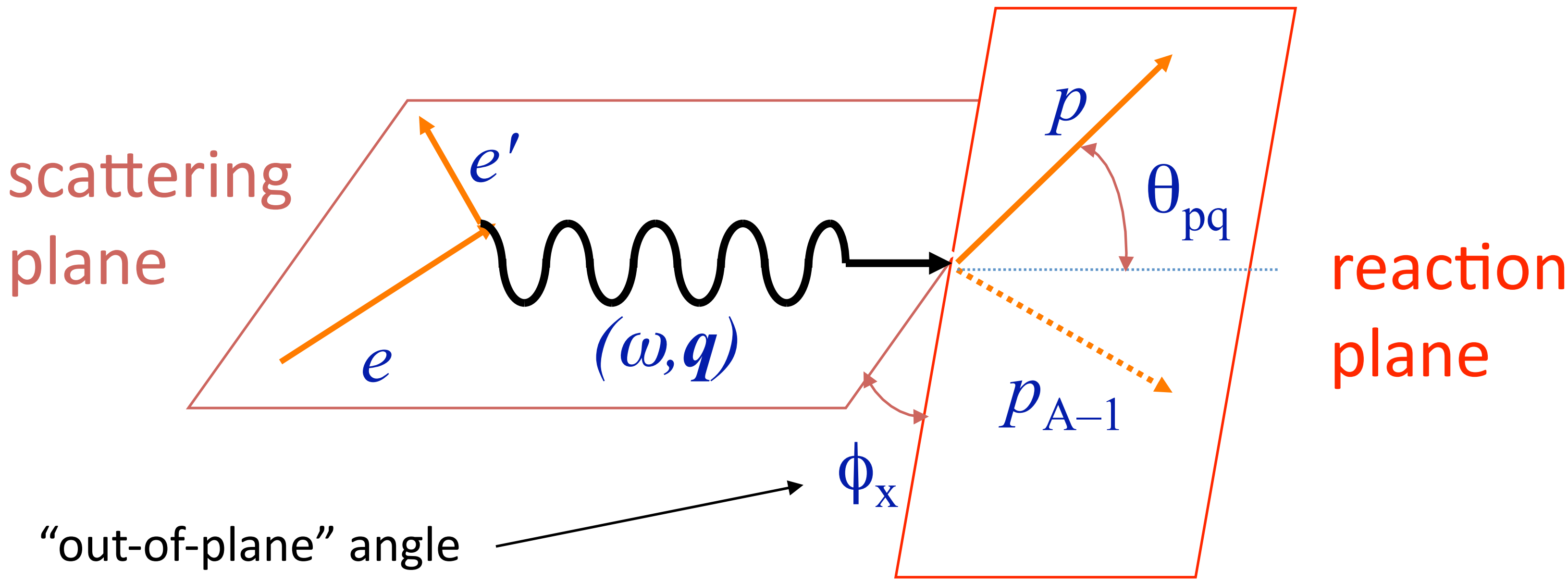
Jefferson Lab

Kinematics



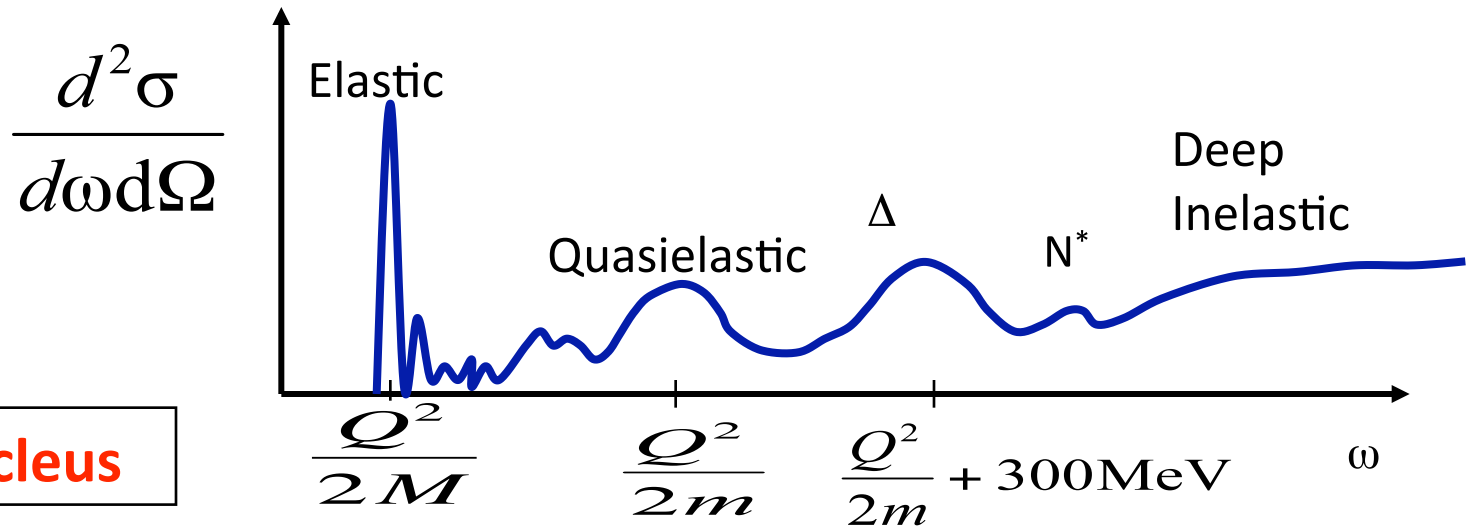
Four-momentum transfer: $Q^2 \equiv -q_\mu q^\mu = \boldsymbol{q}^2 - \omega^2 = 4ee' \sin^2\theta/2$

Missing momentum: $\boldsymbol{p}_\mathrm{m} = \boldsymbol{q} - \boldsymbol{p} = \boldsymbol{p}_{\mathrm{A}-1} = -\boldsymbol{p}_0$

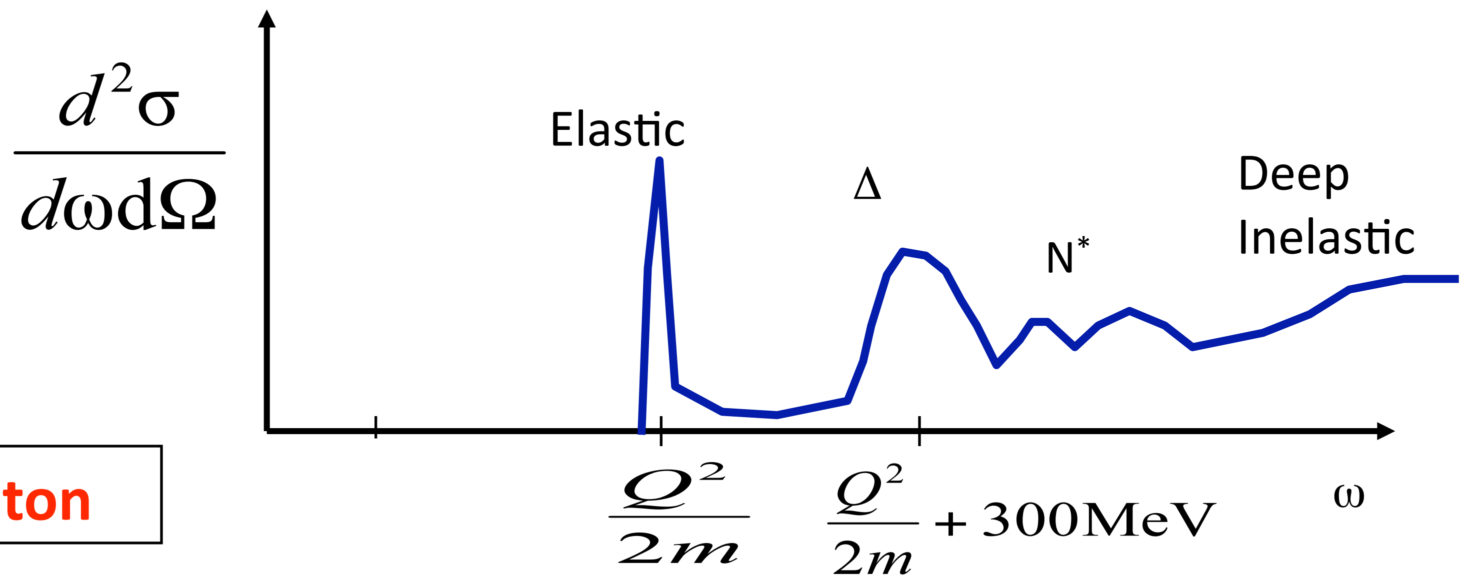
PWIA

Missing energy: $\varepsilon_\mathrm{m} = \omega - T_p - T_{\mathrm{A}-1}$

Electron Scattering at Fixed Q^2



Nucleus

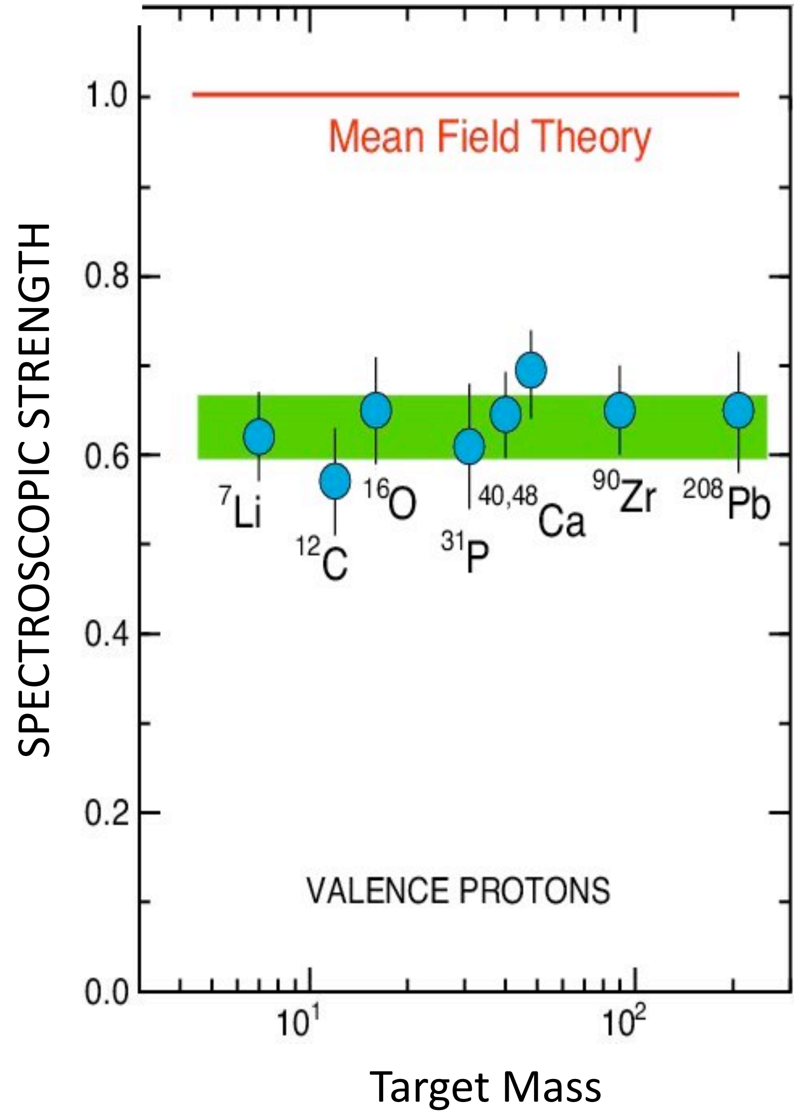


Proton

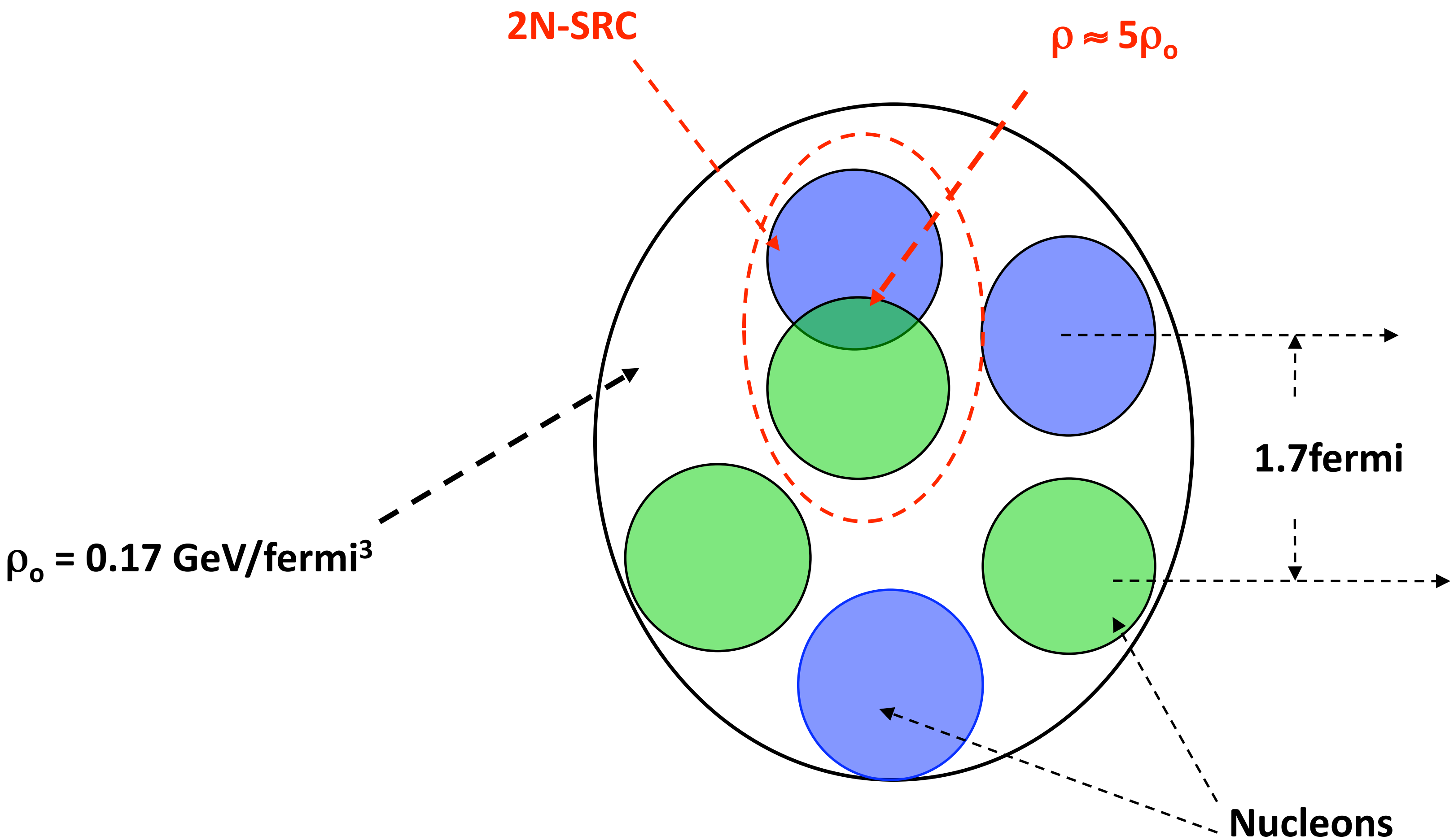
Results from (e,e'p) Measurements

Independent-Particle Shell-Model
is based upon the assumption that each nucleon moves independently in an average potential (mean field) induced by the surrounding nucleons

The (e,e'p) data for knockout of valence and deeply bound orbits in nuclei gives spectroscopic factors that are 60 – 70% of the mean field prediction.



Short-Range Correlations

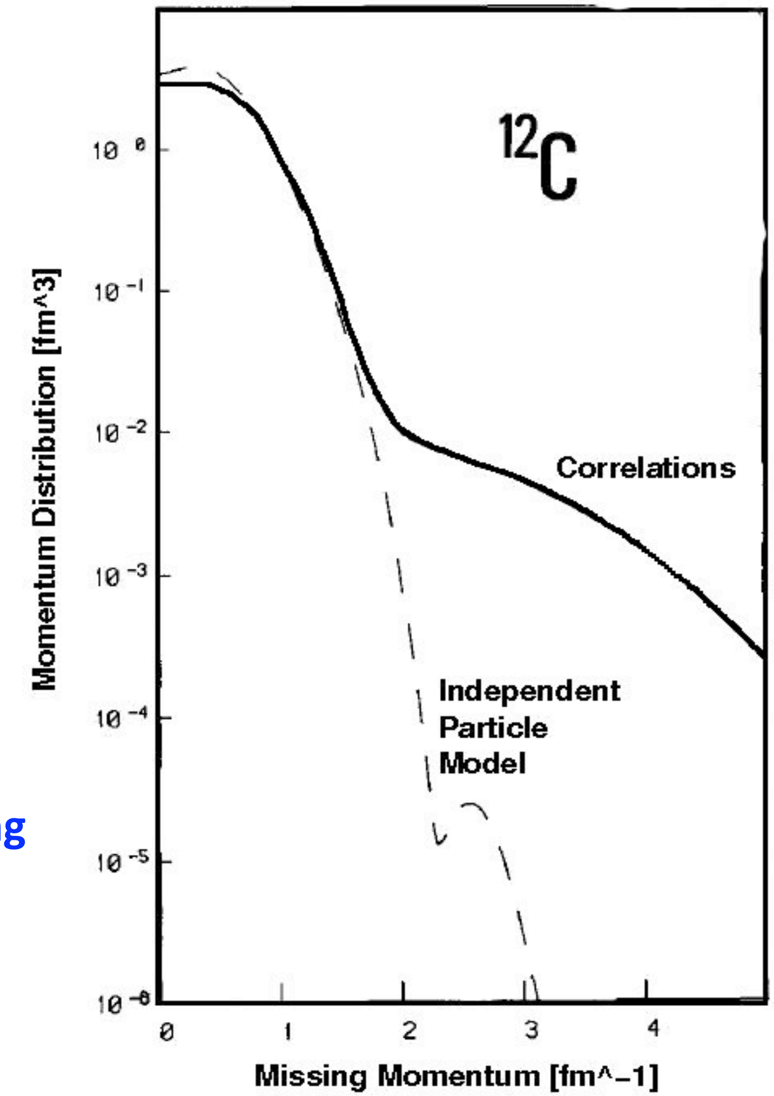


Many Questions

- What fraction of the momentum distribution is due to 2N-SRC?
- What is the relative momentum between the nucleons in the pair?
- What is the ratio of pp to pn pairs?
- Are these nucleons different from free nucleons (e.g. size)?

BUT Other Effects Such As A Final State Rescattering Can Mask The Signal…

Benhar et al., Phys. Lett. **B** 177 (1986) 135.



CLAS A(e,e') Data

K. Sh. Egiyan *et al.,* Phys. Rev. C **68** (2003) 014313.

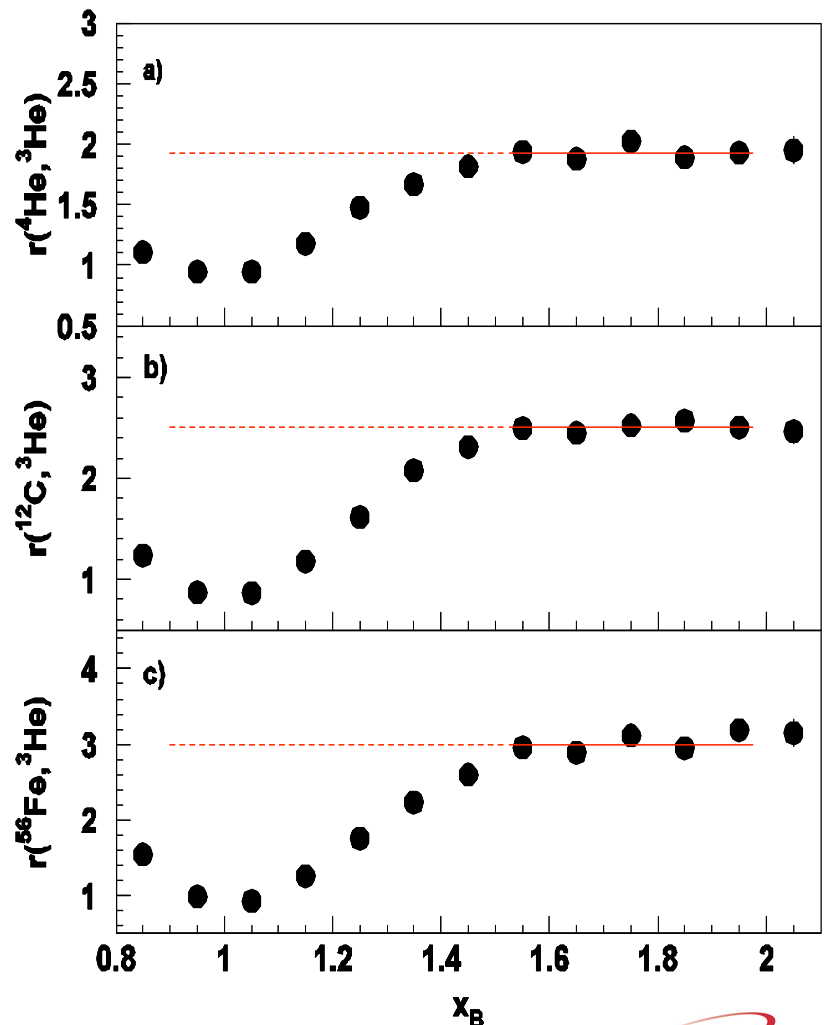
Originally done with SLAC data by D.B. Day *et al.*, Phys. Rev. Lett. 59 (1987) 427.

$$x = \frac{Q^2}{2M\omega} > 1.5 \quad \text{and} \quad Q^2 > 1.4\ [\mathrm{GeV/c}]^2$$

then

$$r(A, {}^3He) = a_{2n}(A)/a_{2n}({}^3He)$$

The observed *scaling* means that the electrons probe the high-momentum nucleons in the 2N-SRC phase, and the scaling factors determine the per-nucleon probability of the 2N-SRC phase in nuclei with A>3 relative to ^{3}He



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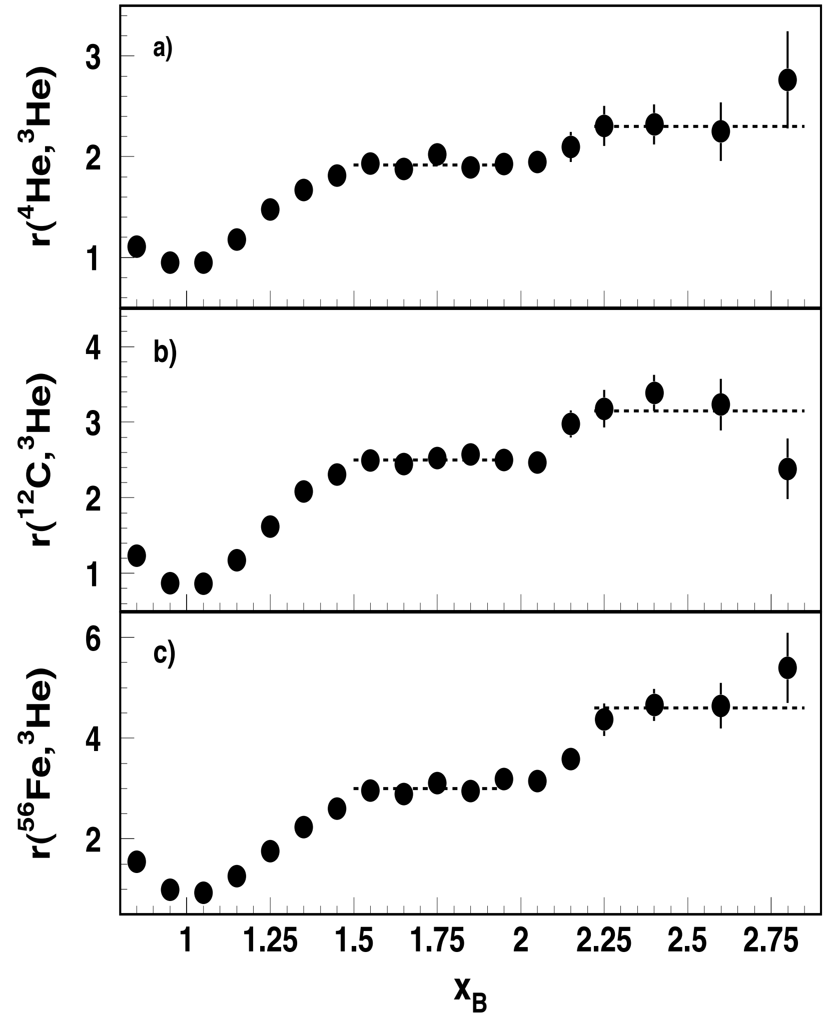
Estimate of ^{12}C Two and Three Nucleon SRC

K. Sh. Egiyan *et al.,* Phys. Rev. Lett. **96** (2006) 082501.

- K. Egiyan *et al*. related the known correlations in deuterium and previous r(^{3}He,D) results to find:
- ^{12}C 20% two nucleon SRC
- ^{12}C <1% three nucleon SRC

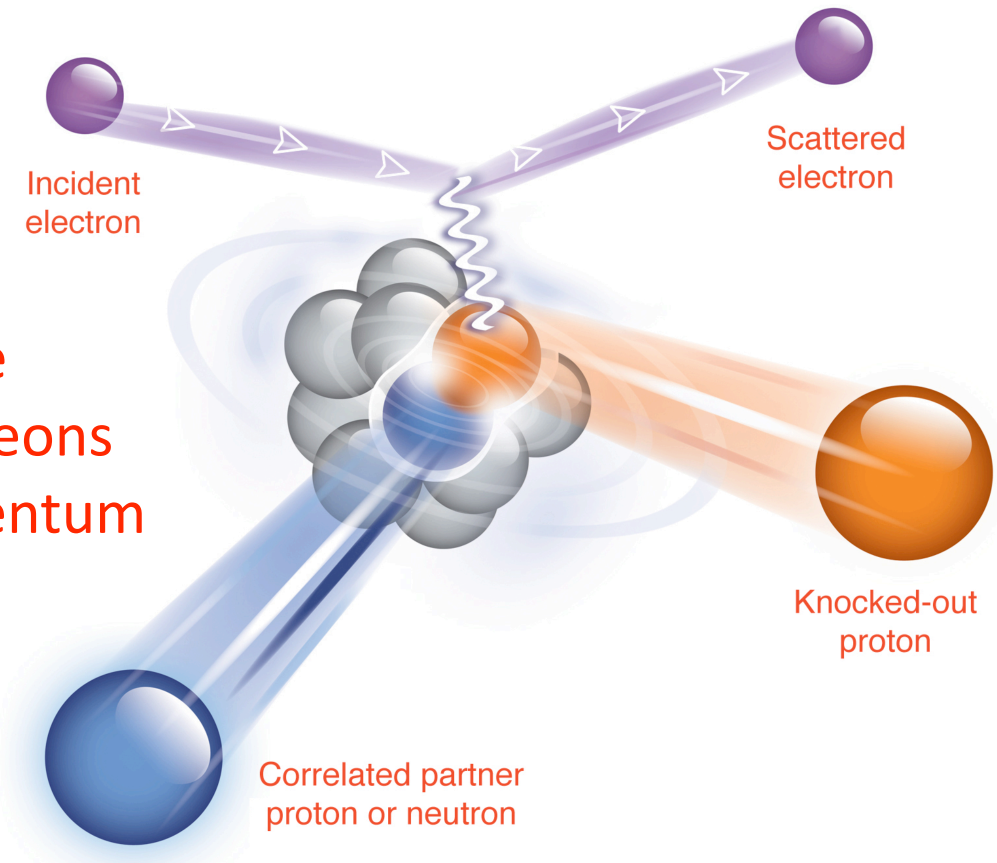


From the (e,e') and (e,e'p), and Results

- 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
- Less than 1% multi-nucleon correlations

Customized (e,e'pN) Measurement

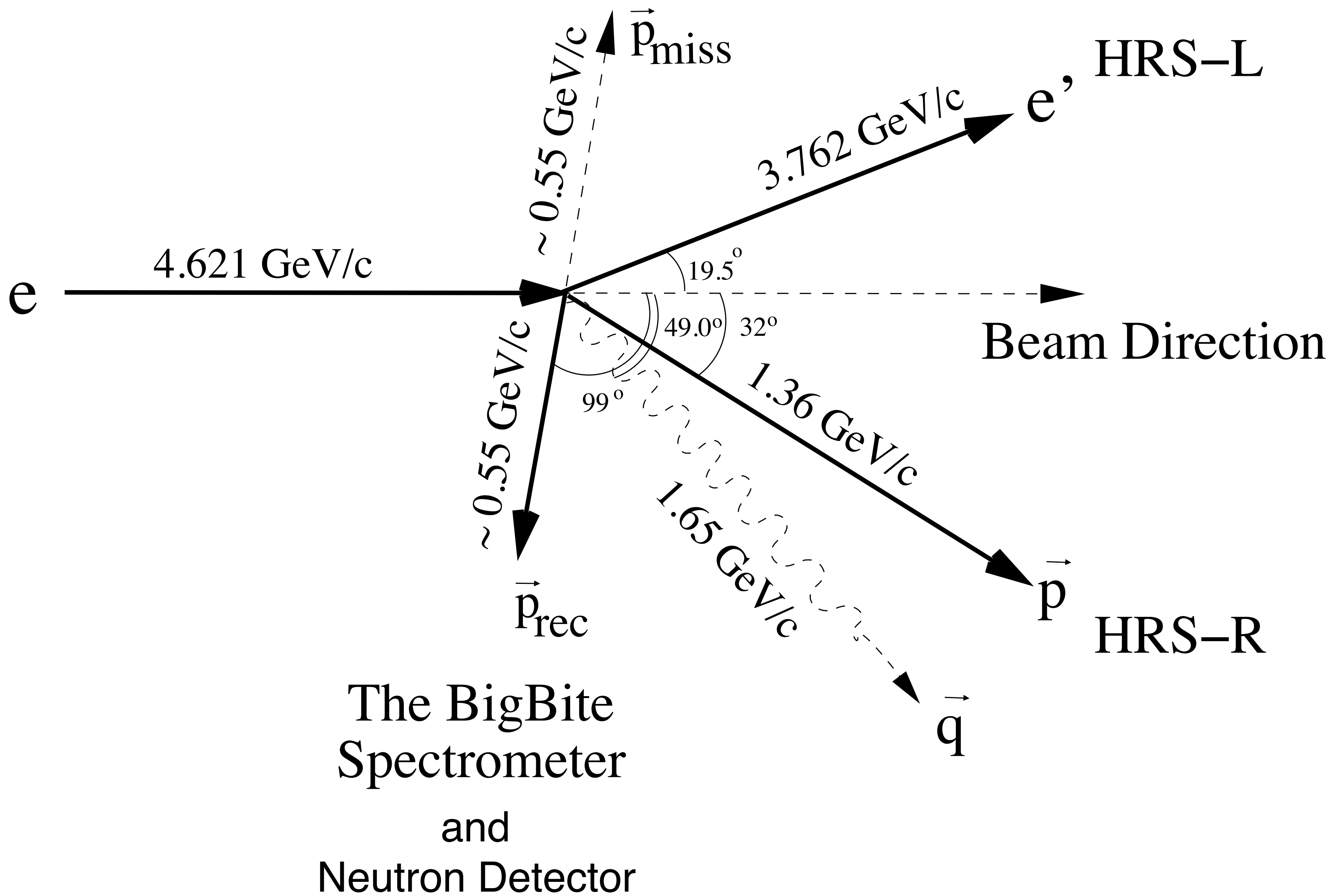
To study nucleon pairs at close proximity and their contributions to the large momentum tail of nucleons in nuclei.



A pair with "large" relative momentum between the nucleons and small center of mass momentum

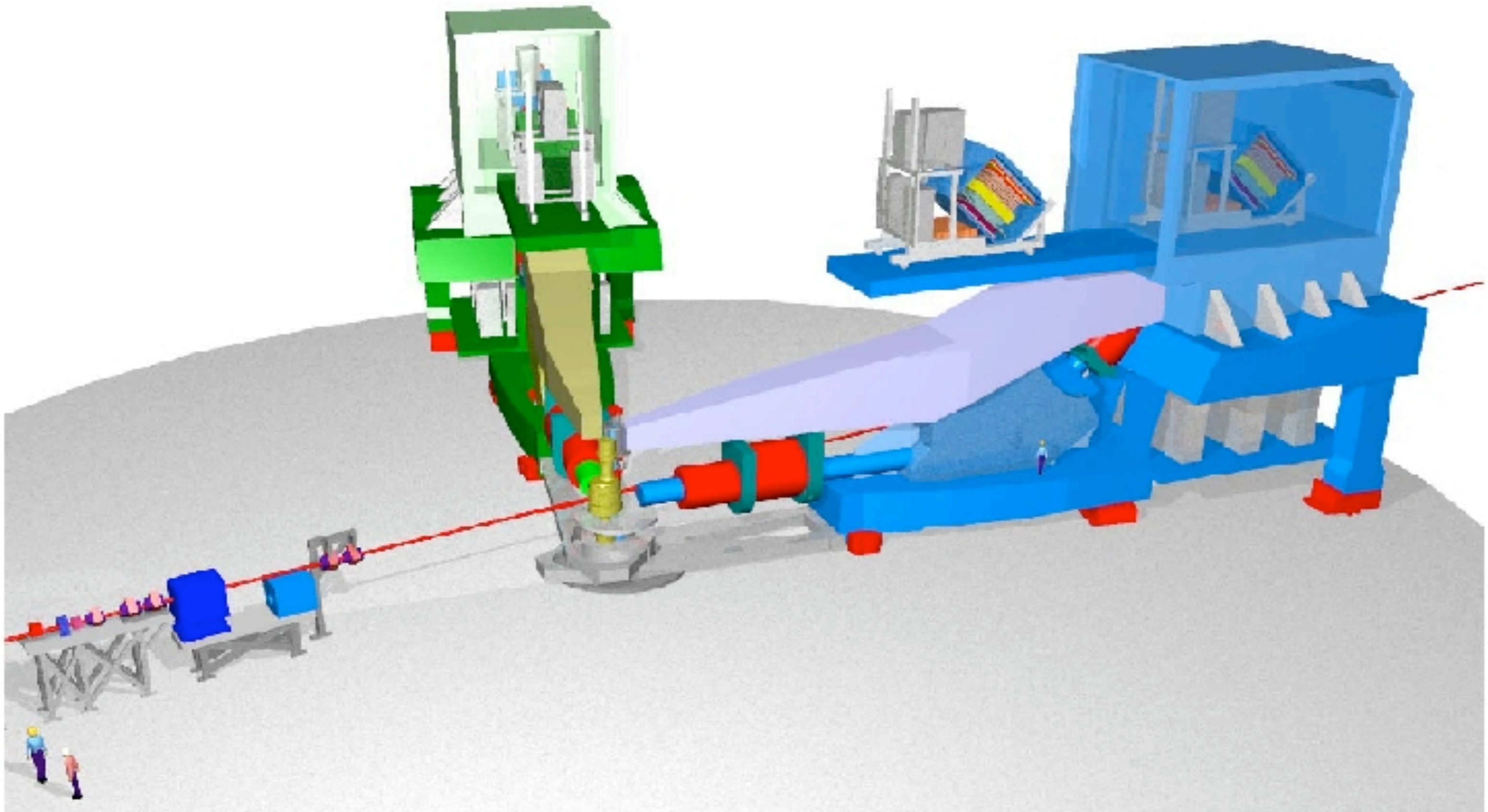
- high Q2 to minimize MEC
- x>1 to suppress isobar contributions
- anti-parallel kinematics to suppress FSI

Kinematics

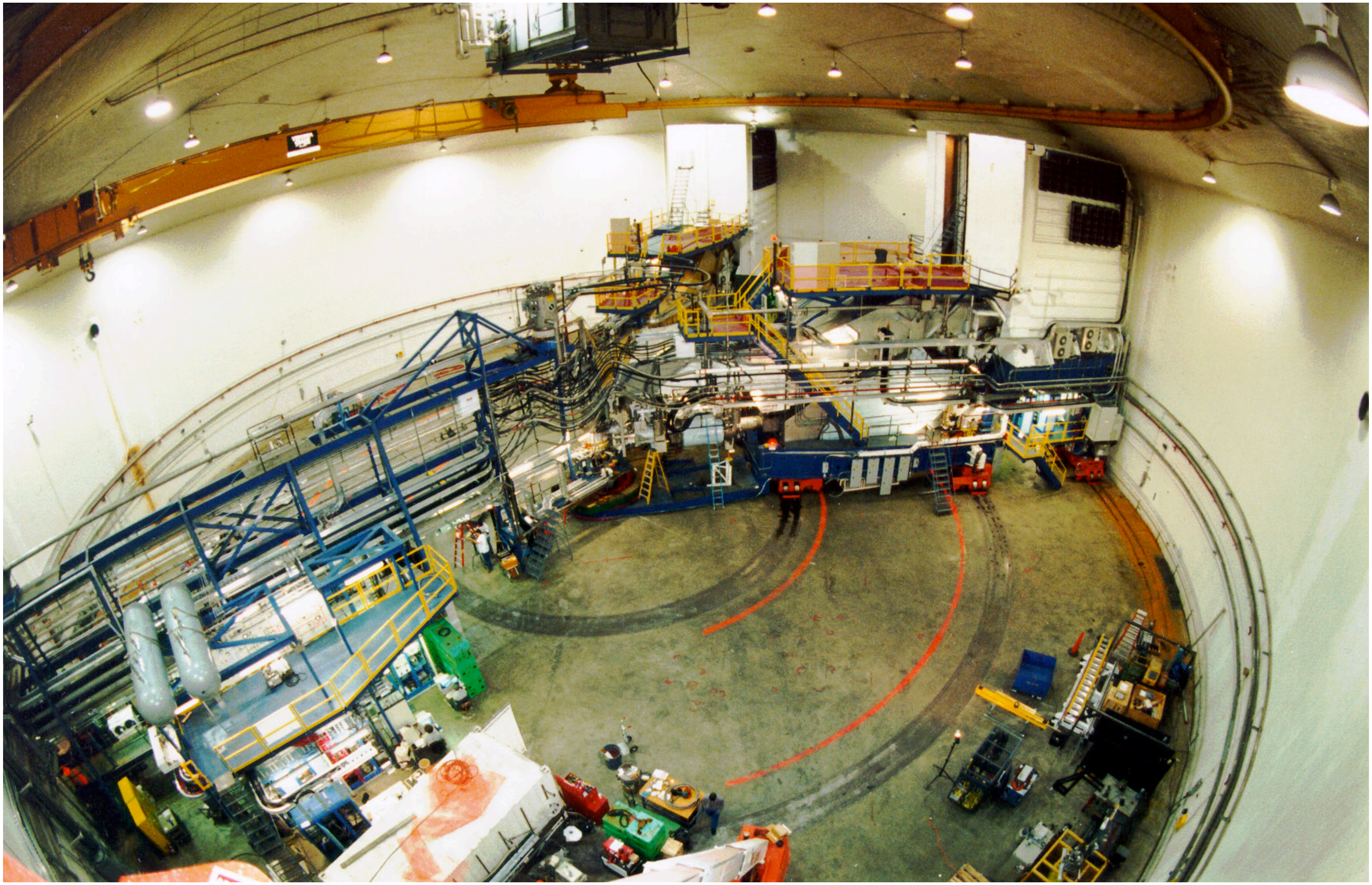


$\vec{p}_{miss}$
~ 0.55 GeV/c
HRS–L
e'
3.762 GeV/c
e
4.621 GeV/c
19.5°
Beam Direction
49.0°
32°
~ 0.55 GeV/c
99°
1.36 GeV/c
1.65 GeV/c
$\vec{p}$
HRS–R
$\vec{p}_{rec}$
$\vec{q}$
The BigBite
Spectrometer
and
Neutron Detector

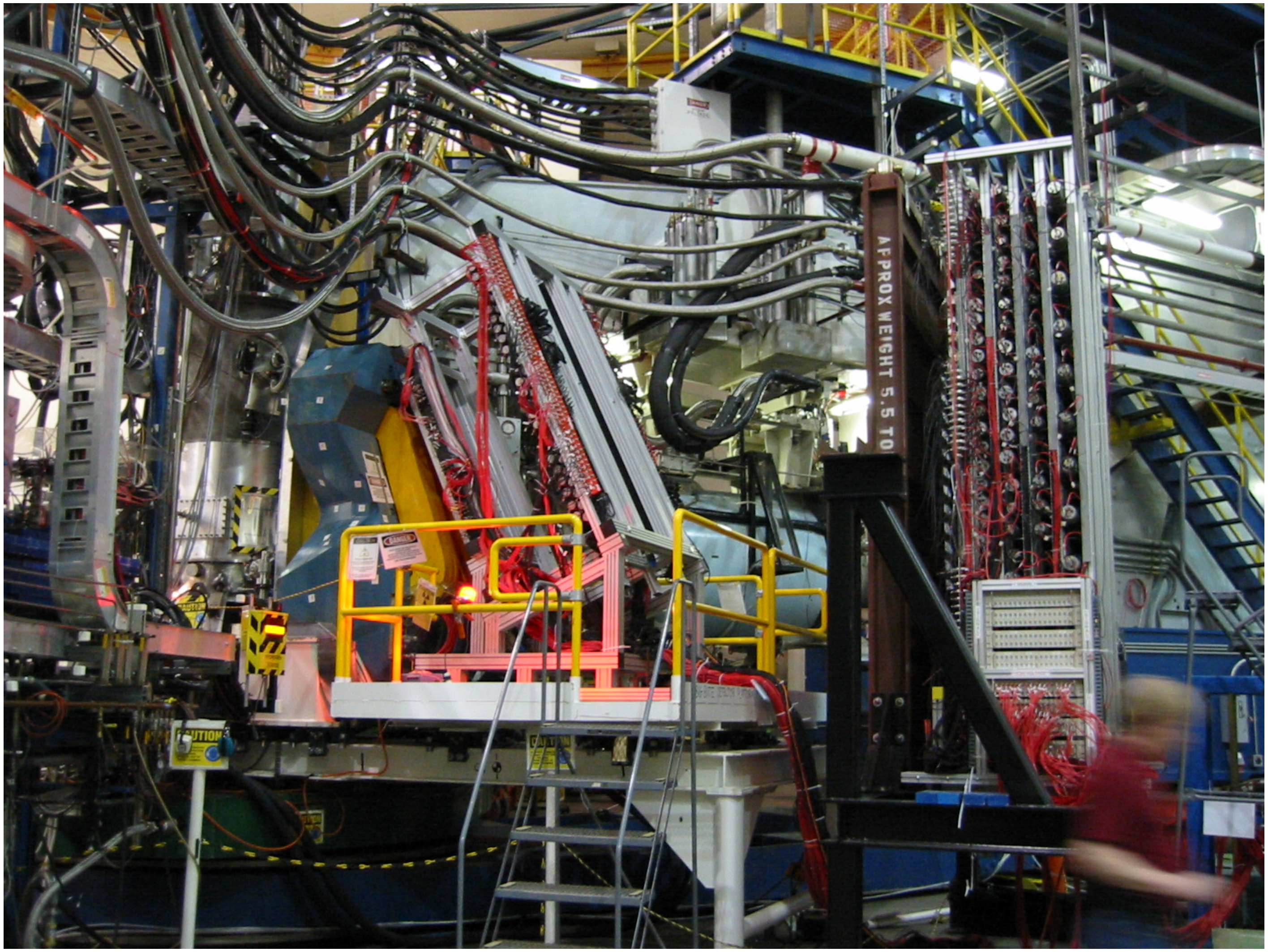
Jefferson Lab's Hall A



Jefferson Lab's Hall A

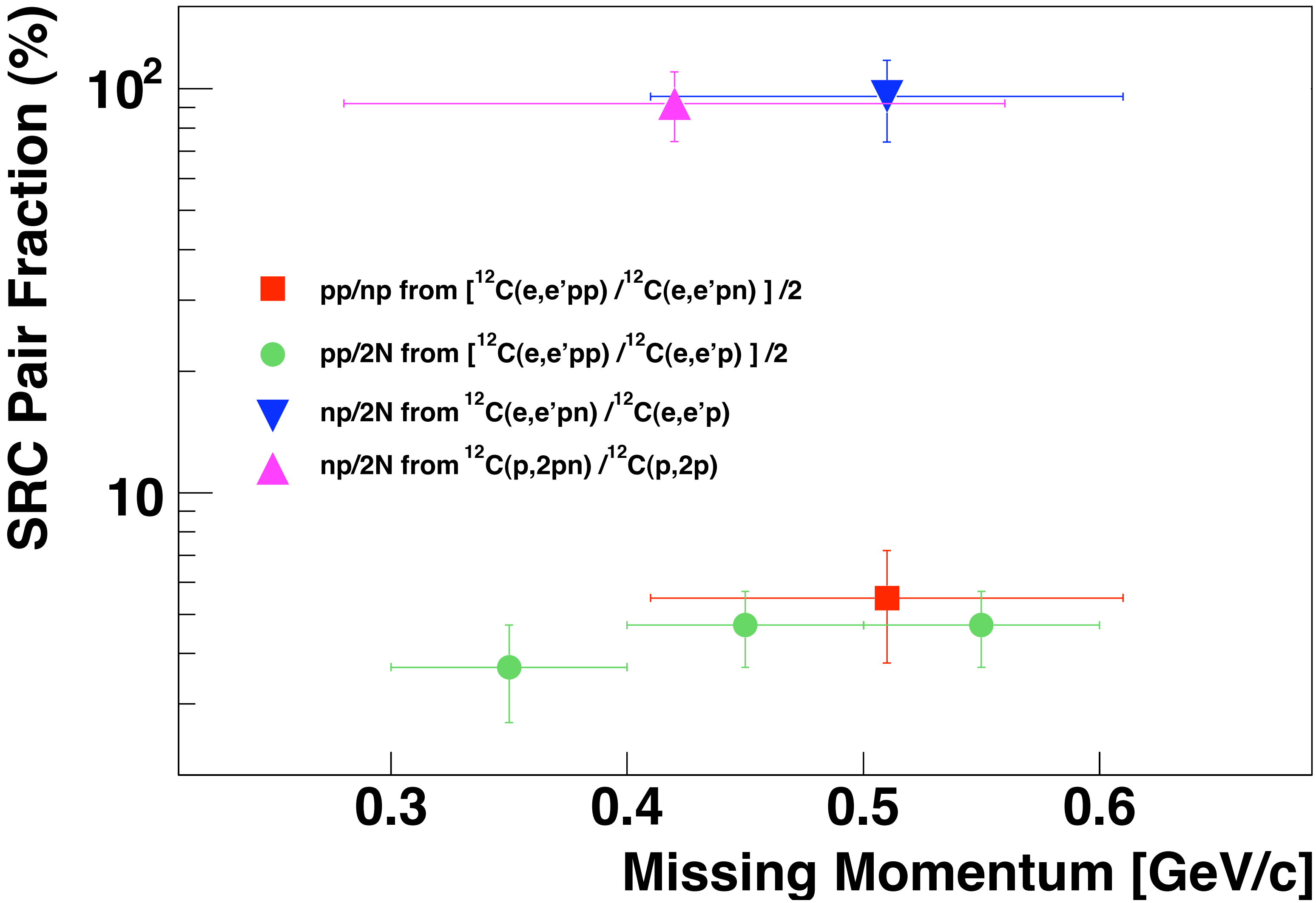


BigBite and Neutron Detector



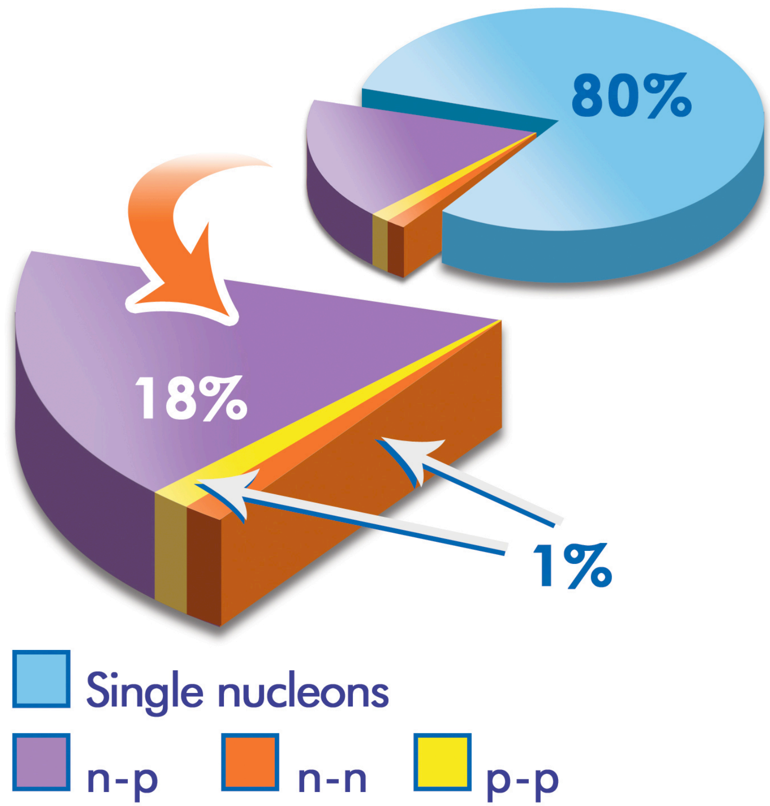
SRC Pair Factions

R. Subedi *et al.*, Science **320**, 1476 (2008), published online 29 May 2008 (0.1126/science.1156675).

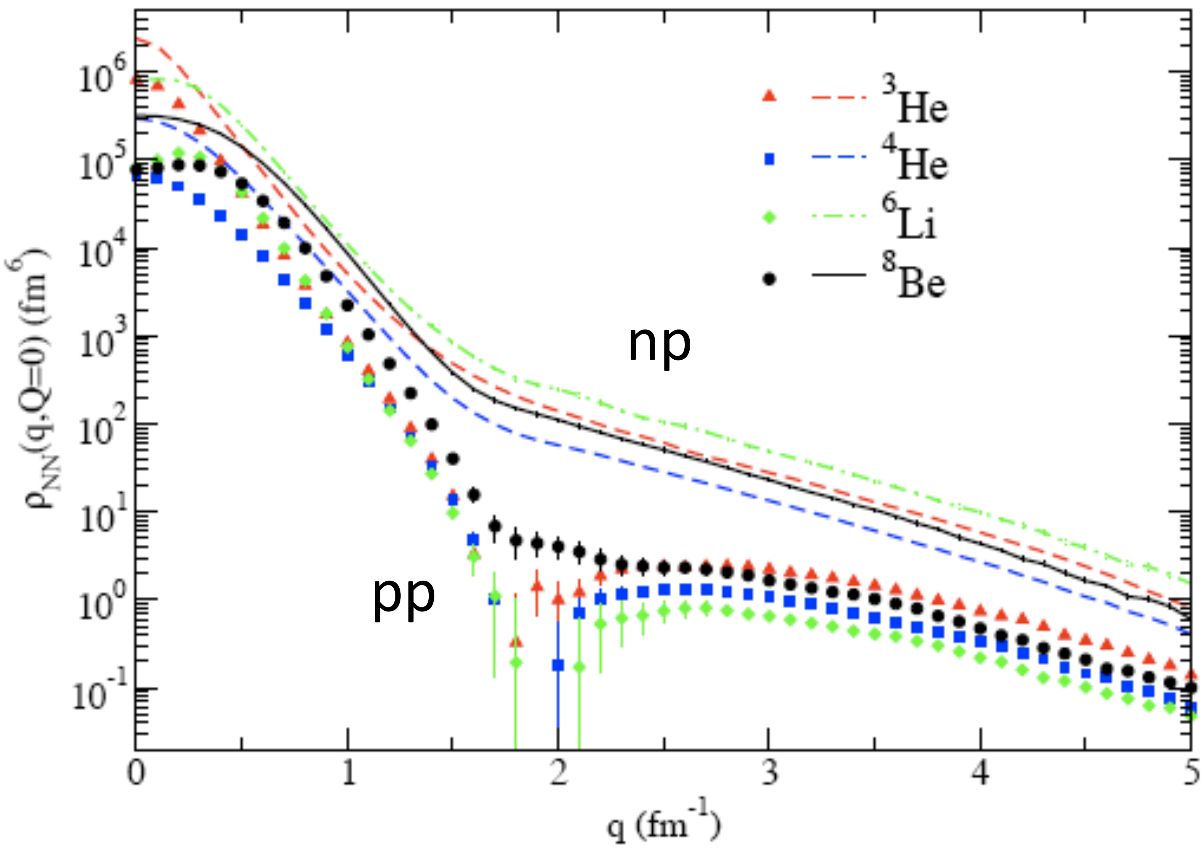


From the (e,e'), (e,e'p), and (e,e'pN) Results

- 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
  - 18% np pairs
  - 1% np pairs
  - 1% nn pairs (from isospin symmetry)
- Less than 1% multi-nucleon correlations



Importance of Tensor Correlations



- R. Schiavilla et al., Phys. Rev. Lett. 98 (2007) 132501. [shown above]
- M. Sargsian et al., Phys. Rev. C (2005) 044615.
- M. Alvioli, C. Ciofi degli Atti, and H. Morita, Phys. Rev. Lett. 100 (2008) 162503.

Implications for Neutron Stars