E07-006: SRC in Triple Coincidence ^{4}He(e,e'pN)

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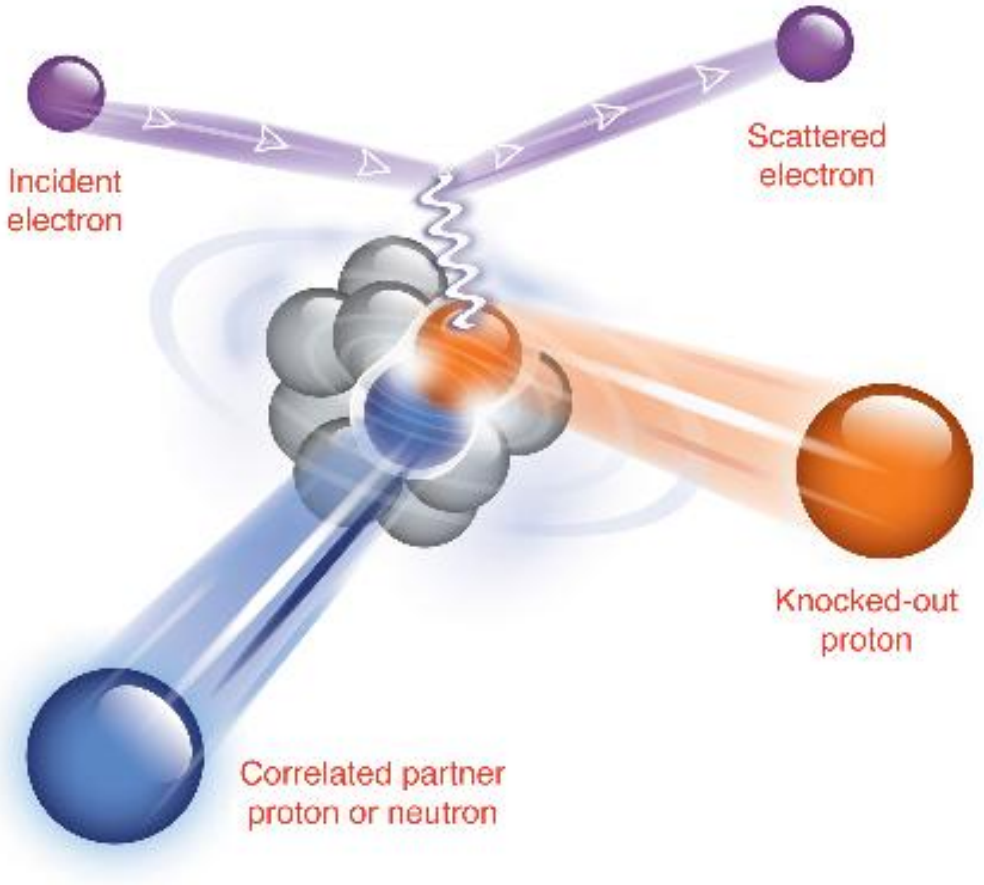
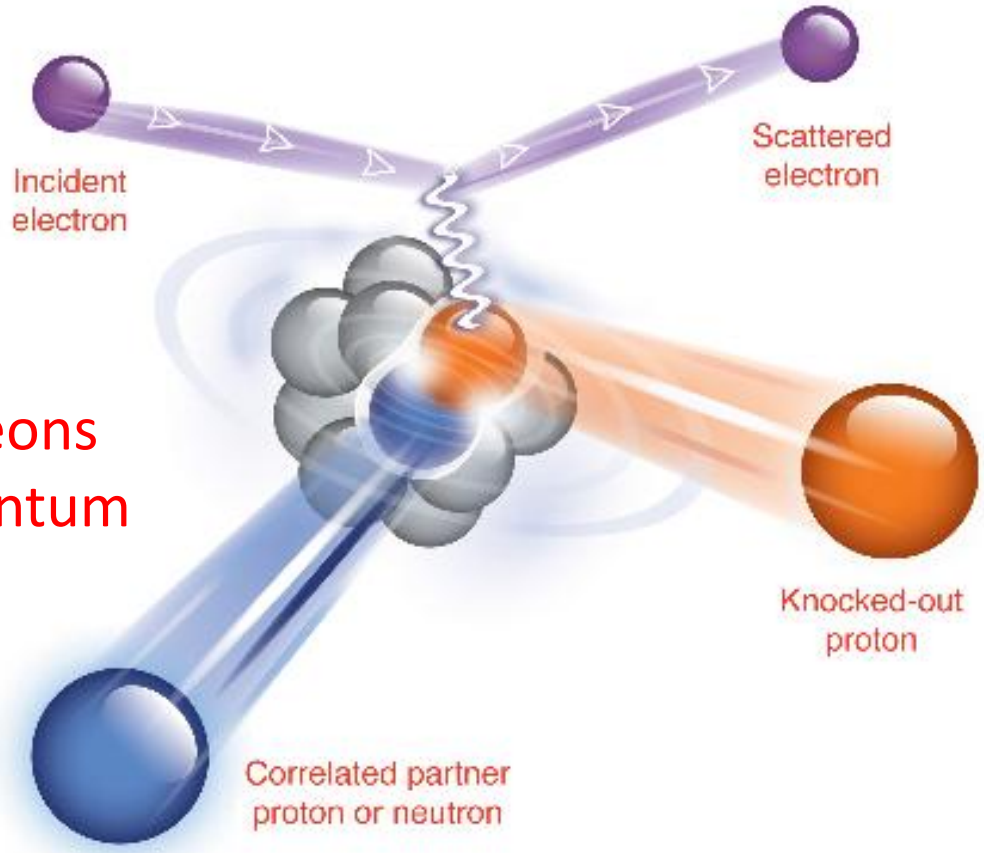
Massachusetts Institute of Technology



Customized (e,e'pN) Measurement

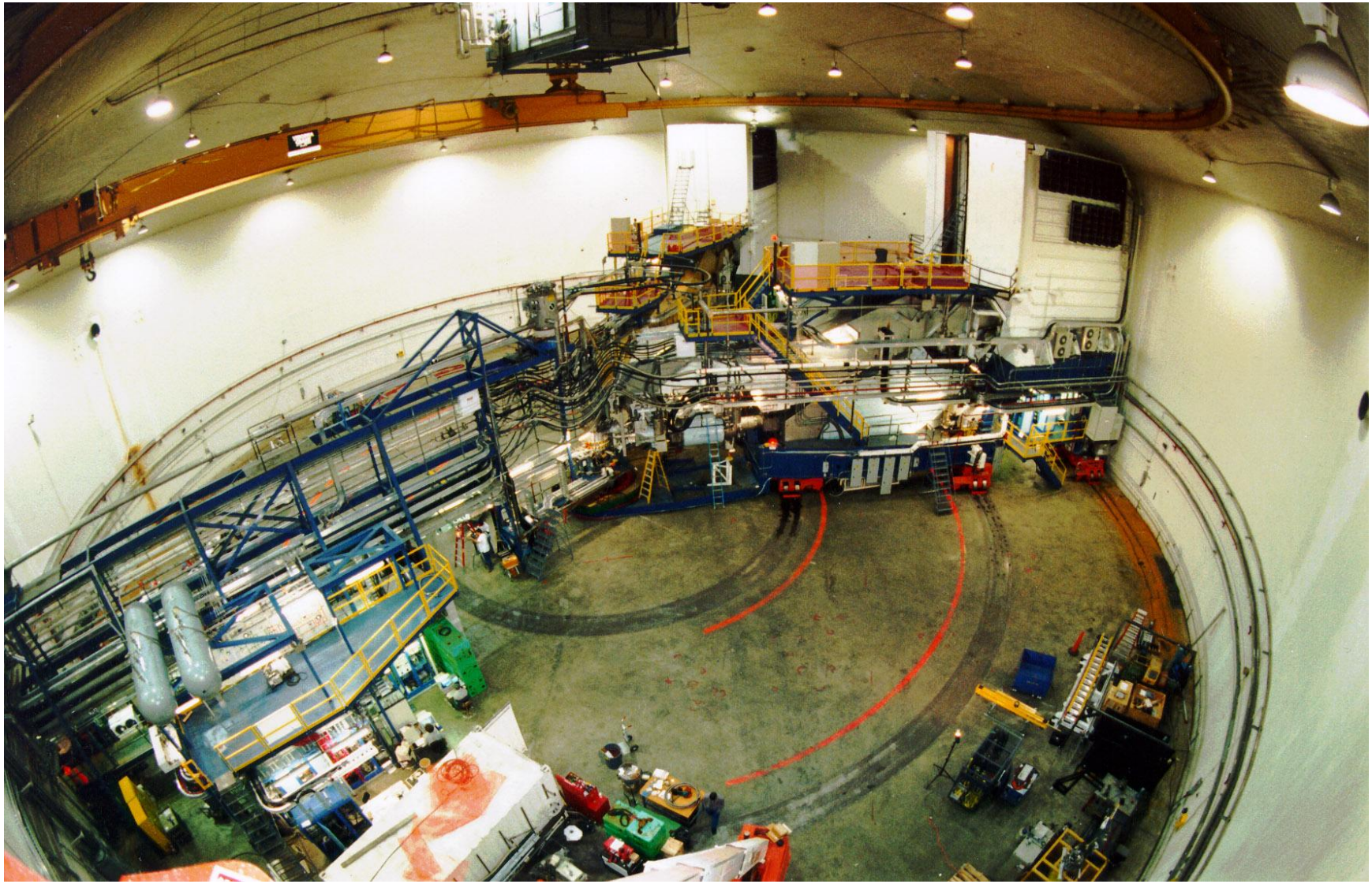
To study nucleon pairs at close proximity and their contributions to the large momentum tail of nucleons in nuclei.

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



- high Q^2 to minimize MEC
- x>1 to suppress isobar contributions
- parallel kinematics to suppress FSI

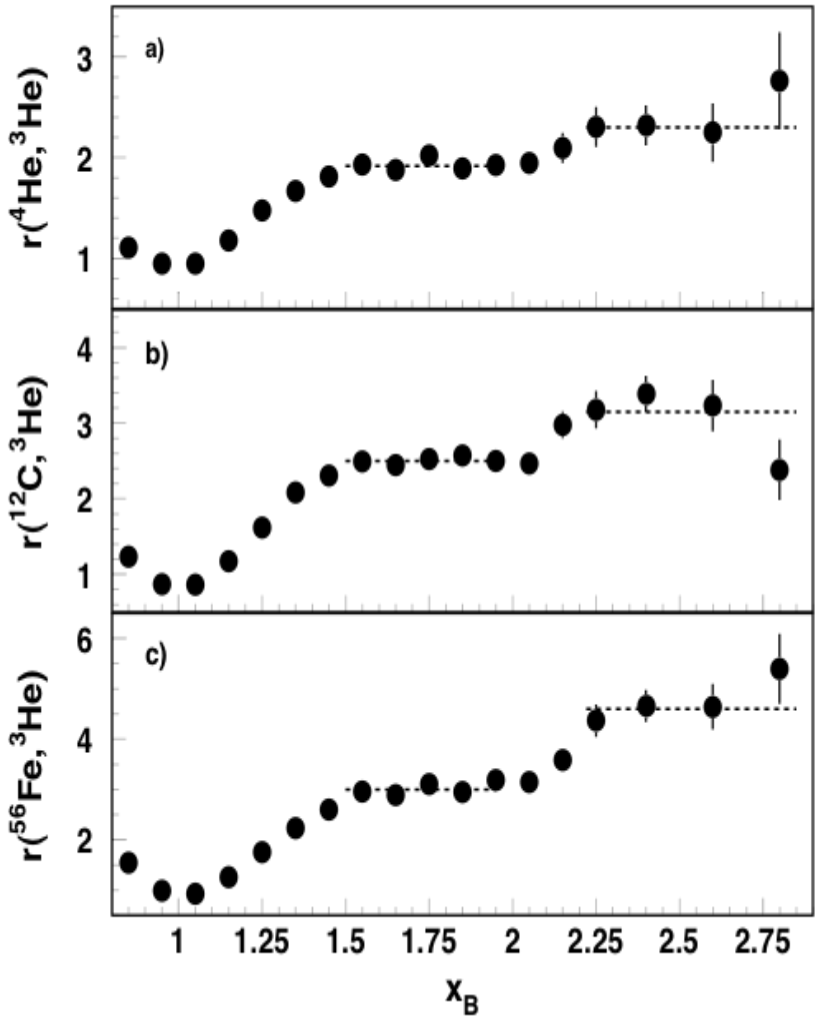
Jefferson Lab's Hall A



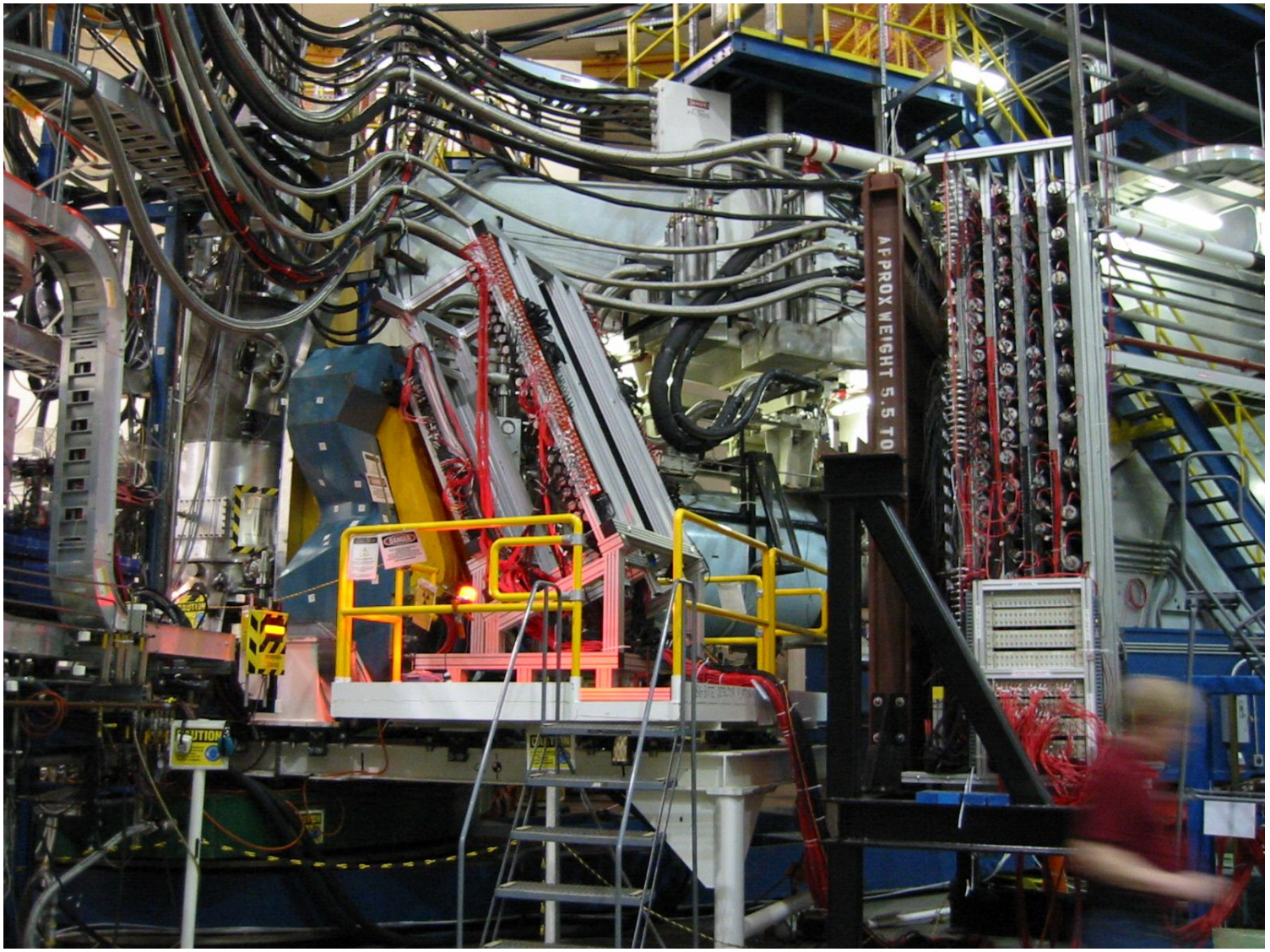
Estimate of ^{12}C Two and Three Nucleon SRC

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

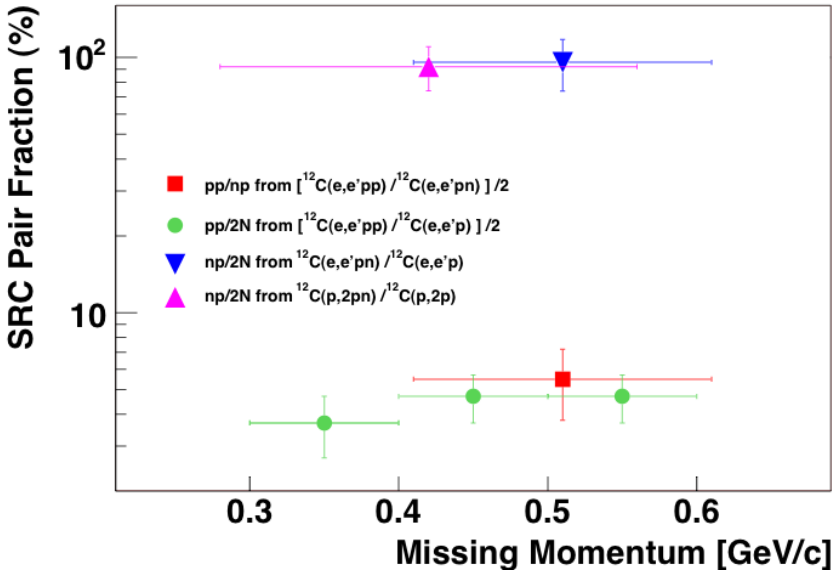


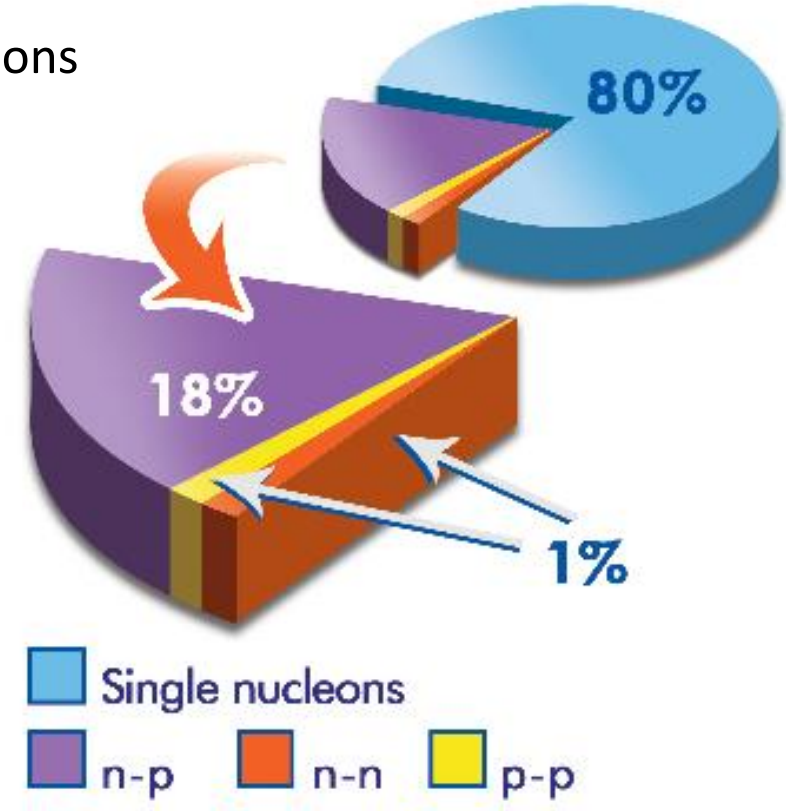
BigBite and Neutron Detector



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

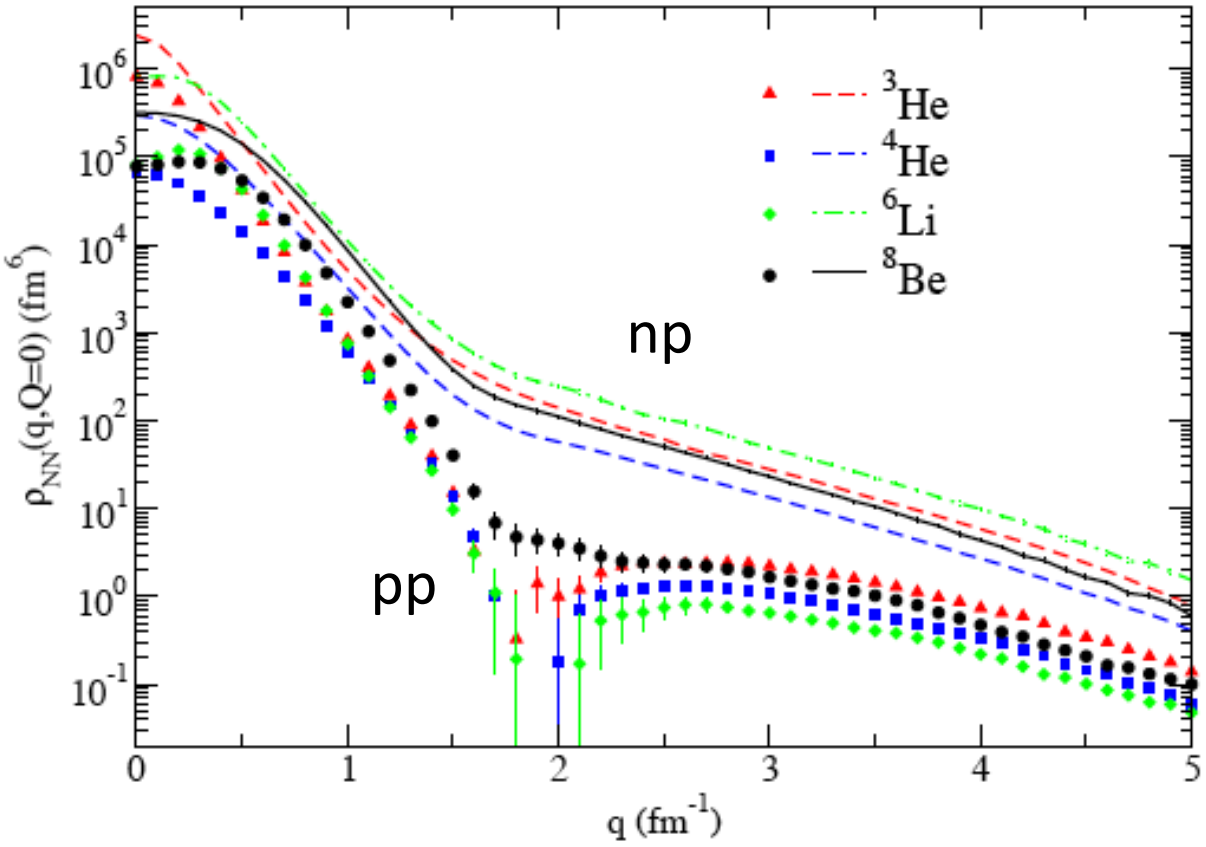
- 80 +/- 5% single particles moving in an average potential
  - 60 – 70% independent single particle in a shell model potential
  - 10 – 20% shell model long range correlations
- 20 +/- 5% two-nucleon short-range correlations
  - 18% np pairs
  - 1% np pairs
  - 1% nn pairs (from isospin symmetry)
- Less than 1% multi-nucleon correlations





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

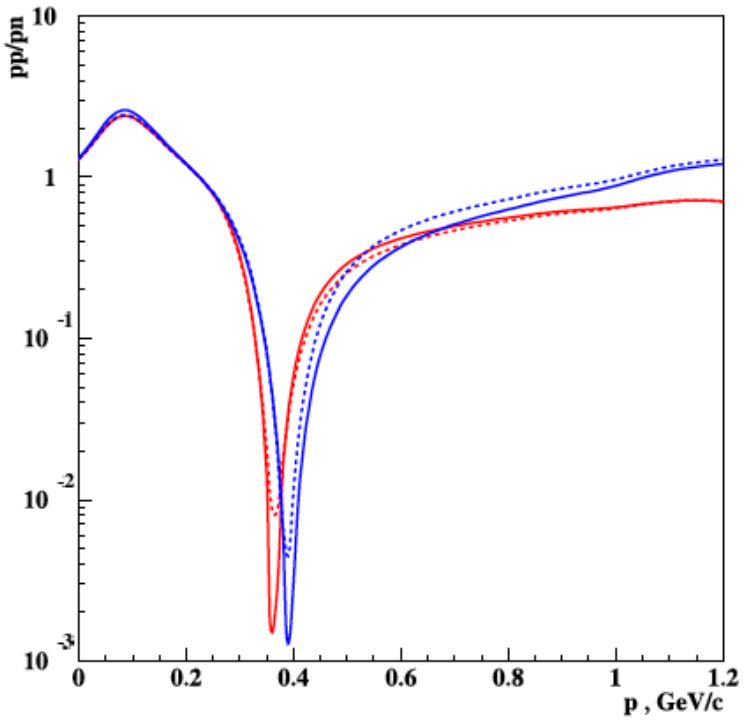
Importance of Tensor Correlations

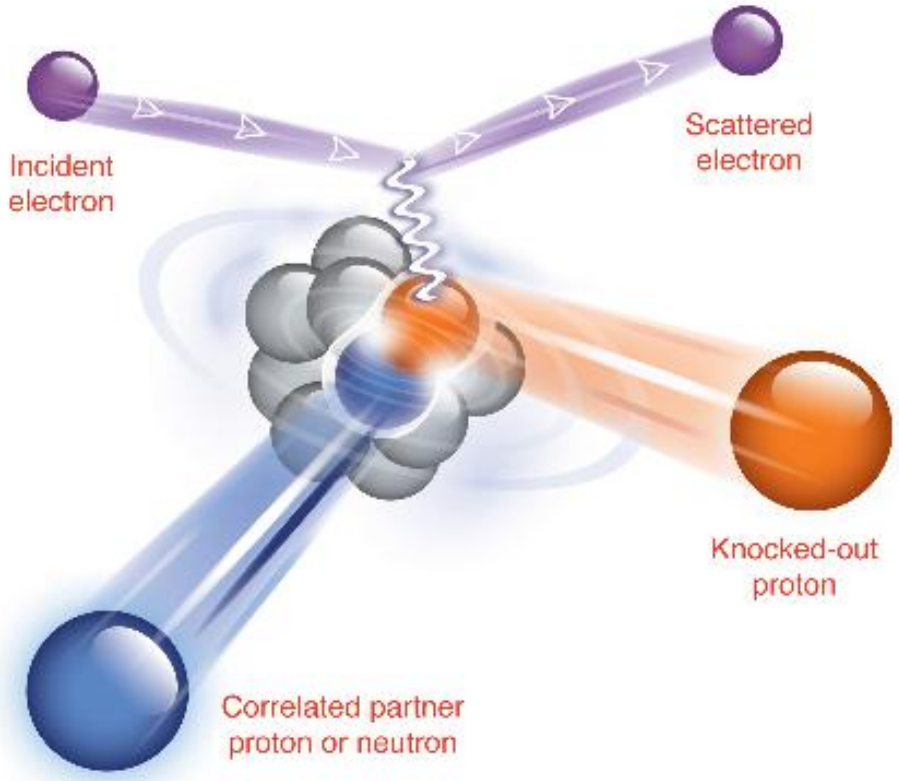


- R. Schiavilla et al., Phys. Rev. Lett. 98 (2007) 132501. [shown above]
- M. Sargsian et al., Phys. Rev. C (2005) 044615.
- M. Alvioli, C. Ciofi degli Atti, and H. Morita, Phys. Rev. Lett. 100 (2008) 162503.

E07-006: ^{4}He(e,e'pN)pn SRC

- ^{4}He Target
  - Dense Nuclear Matter
  - *MF & Exact* Calculations
- P_m from 400 – 800 MeV
- 25 PAC Days



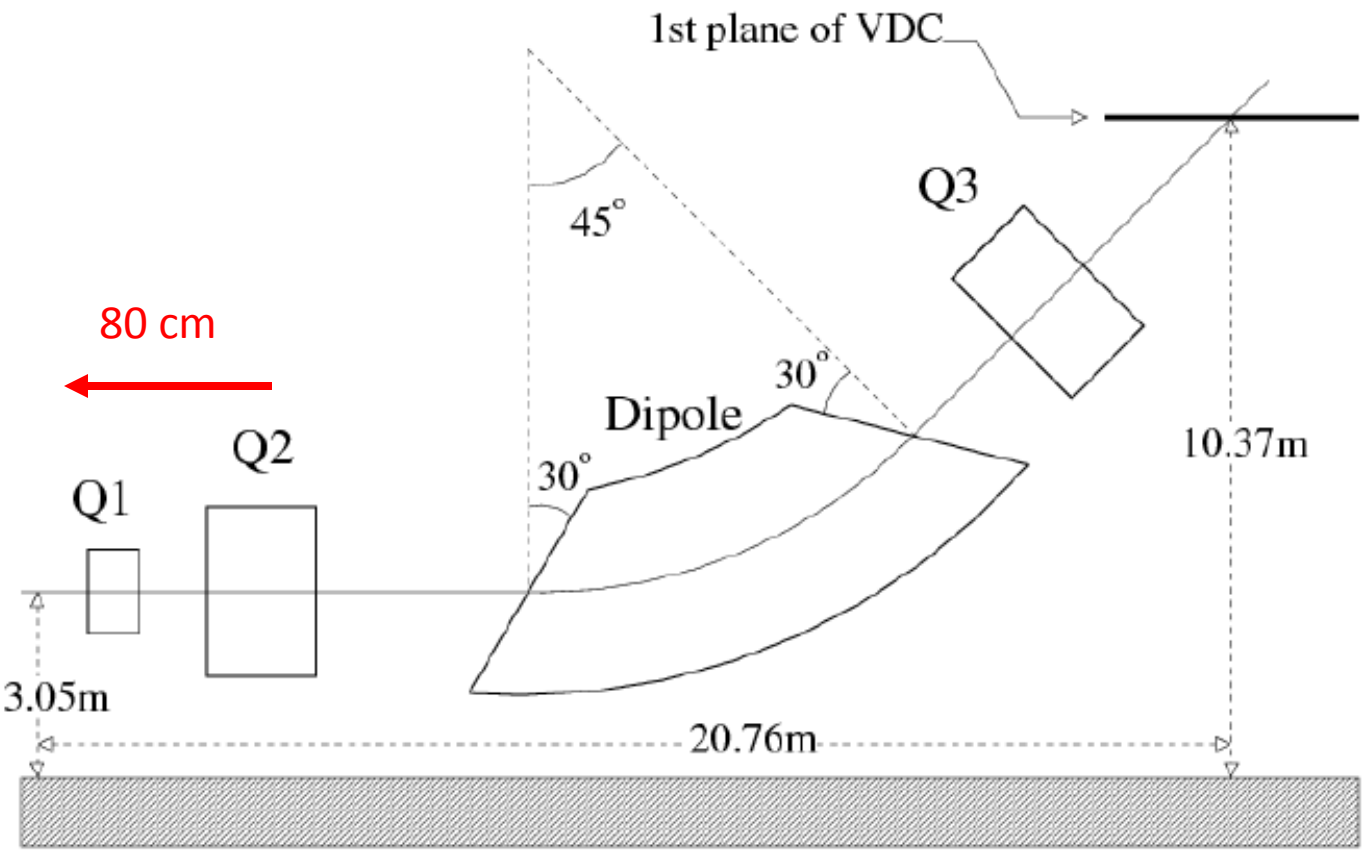


- Pushing Limits of NN Potential
  - Long range attraction
  - Short range repulsion

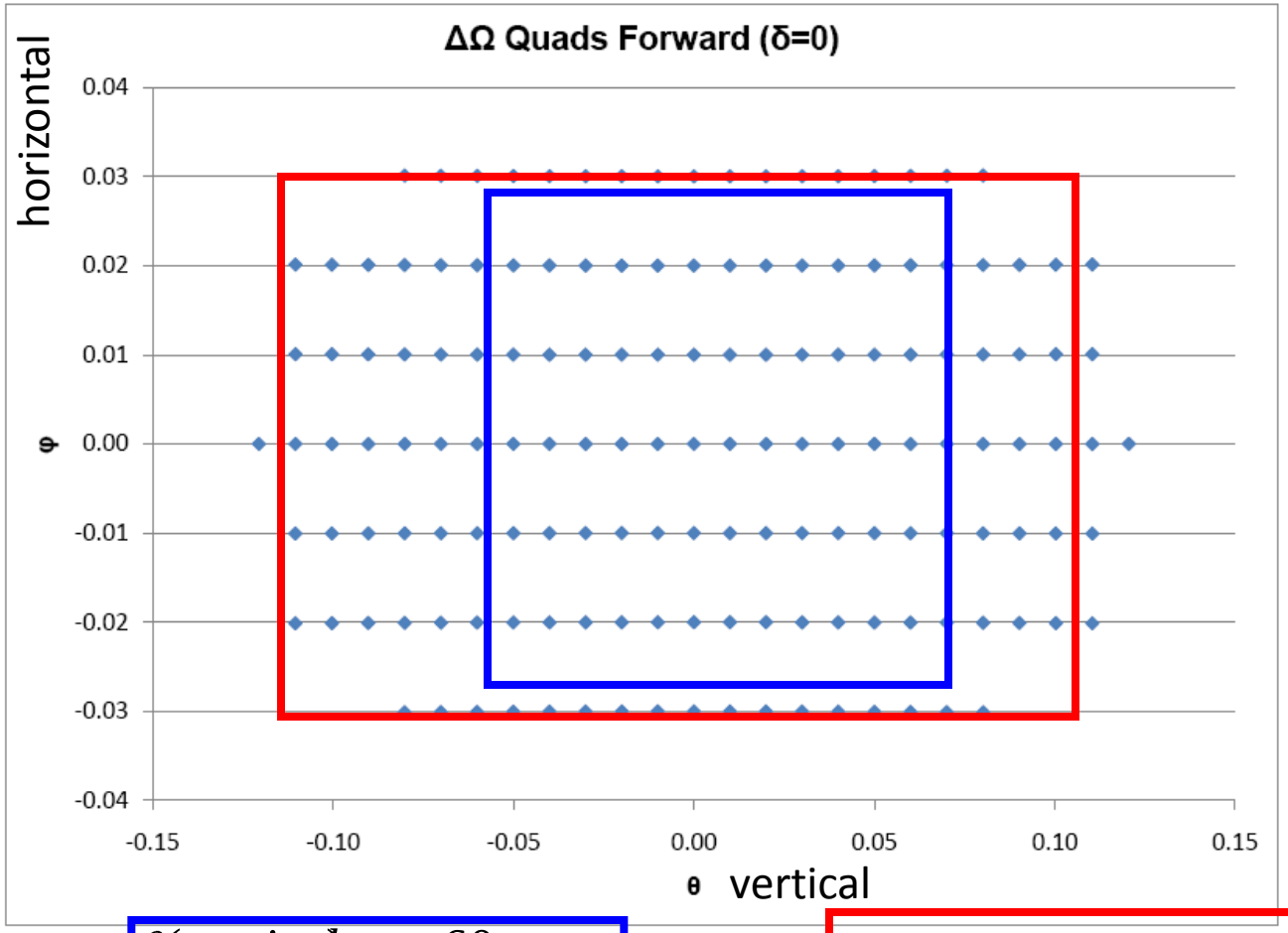
Moving Right Q1 and Q2

Impact study on E07-006 (SRC)

(and other experiments starving for larger solid angle)



Idea submitted as an MRI-R2 proposal



"Normal"

$\theta(vertical) \quad \pm 60mr$

$\varphi(horizontal) \quad \pm 28\text{mr}$

$\frac{\Delta p}{p} = 4.5\%$

$\theta(vertical) \quad \pm 120mr$

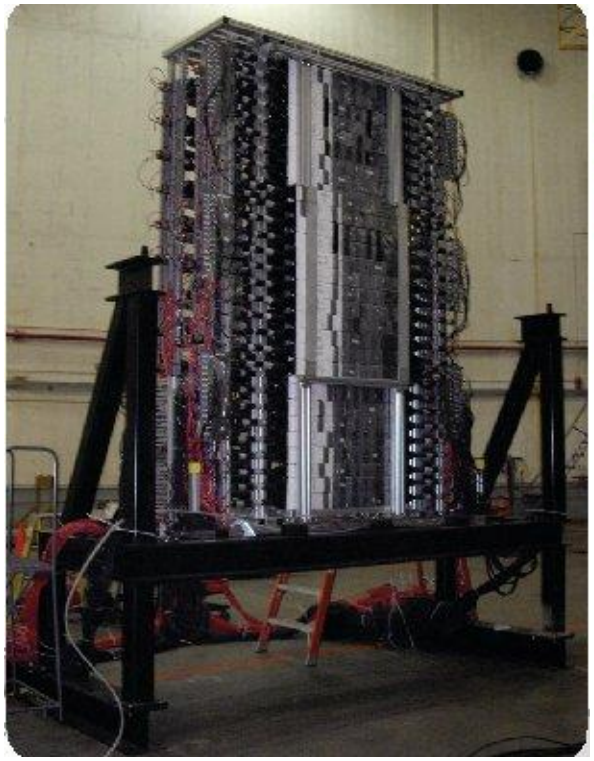
$\varphi(horizontal) \quad \pm 28\text{mr}$

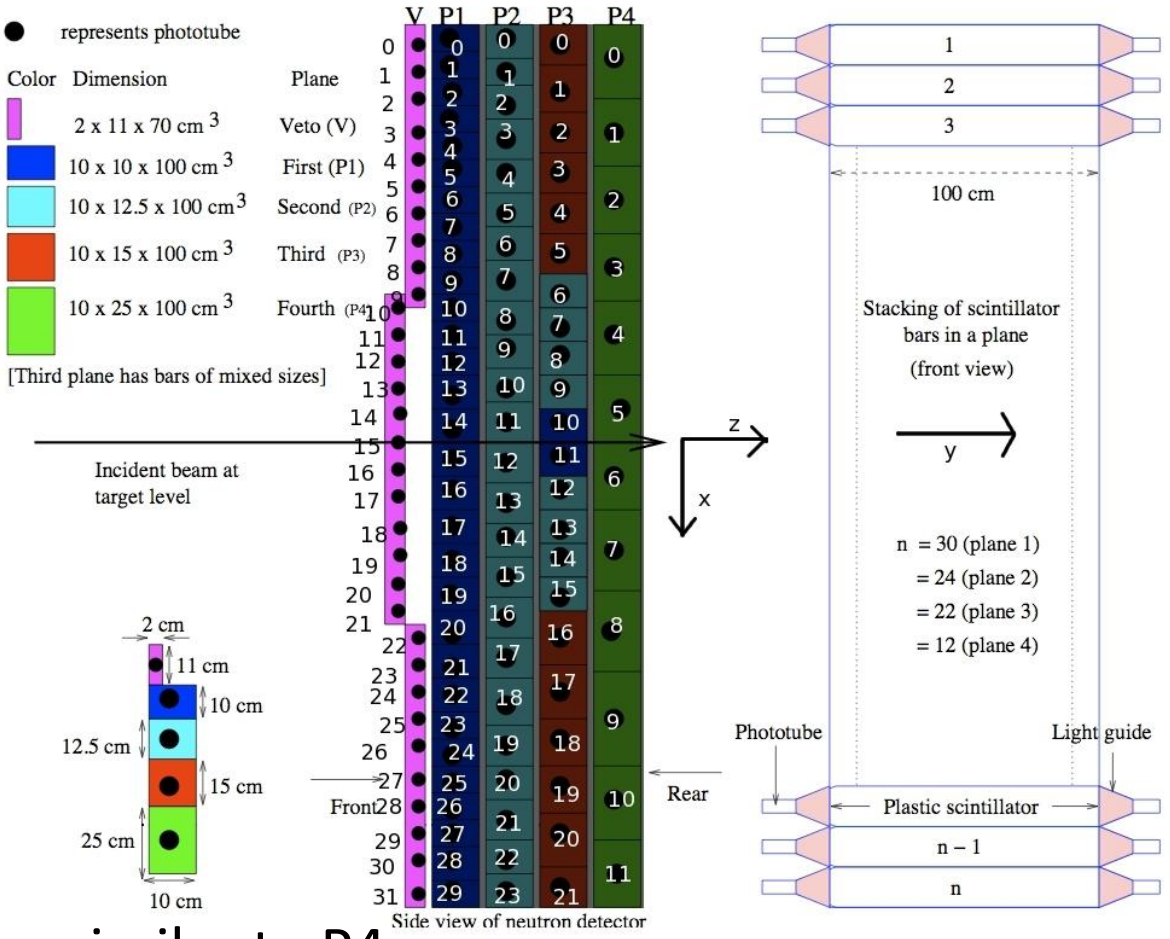
$\frac{\Delta p}{p} = 4\%$

Manpower

- Ran Shneor as Tel Aviv Postdoc
- Graduate Students:
  - Or Chen (Tel Aviv)
  - Igor Korover (Tel Aviv)
  - Tai (Navaphon) Muangma (MIT)

Neutron Detector Additions

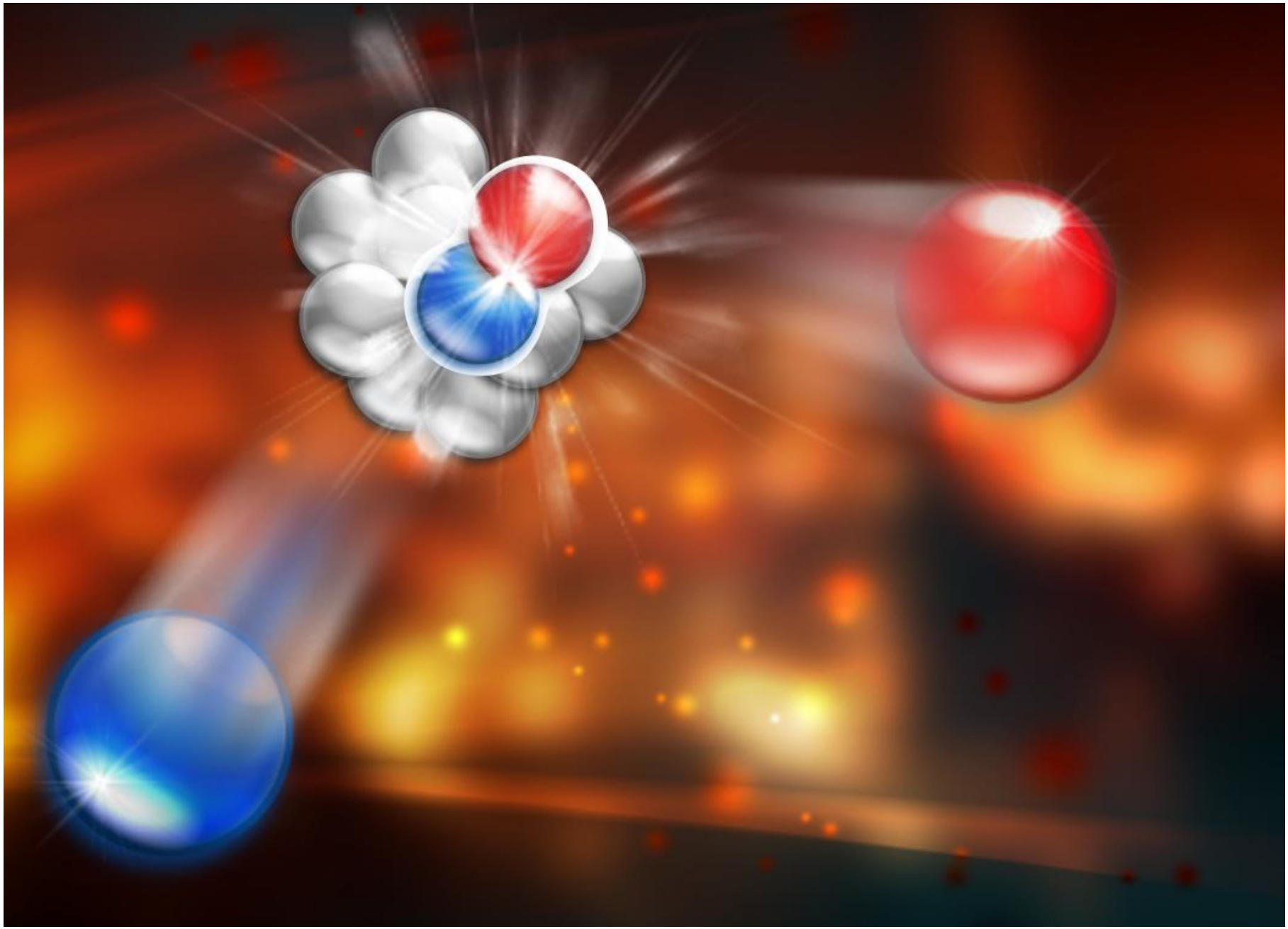




- Add two more layers, similar to P4
- Scintillator bars were prepared and tested Summer 2009
- Design a new lead wall and stand

Test Lab Work Jan/Feb 2010

- Set up the DAQ and Network
- Plan the layout of the Test Lab
  - Decide where to run the cables
  - Arrange the area to allow construction of HAND2
- Inventory of electronics and cables
- Build HAND2 (requires a frame)
- Need a new TOSP for the Test Lab
- Connect BigBite MWDC to electronics
- Set up cosmic trigger for BigBite and HAND



SNAKE model for HRS-R with Q1 and Q2 moved 80 cm closer to the target. 1st order observations.

From : John J. LeRose

some trade-offs

Dispersion goes from ~12 cm/% to 17 cm/%. So the maximum momentum will be lower

In this experiment we detect protons
With momentum below 2 GeV / c –not relevnat

Momentum resolution is degraded by a factor of 2.

	'normal'	With moved Q1,Q2
Vertical angle resolution	1 mrad	3.6 mrad
Horizontal angle resolution	0.1 mrad	0.9 mrad
y0	0.3 mm	0.5 mm

Impact

4.8 GeV which will increase the rates, compared to E01-015, by 10%. Therefore, the basic rate for ^{12}C and missing momentum of 500 MeV/c is expected for this proposal to be:

$$22\ (e,e'pp) \text{ and } 40\ (e,e'pn) \text{ events/day.}$$

With the quads moving forward

32 (e,e'pp) and 60 (e,e'pn) events per day

Based on the argument above, the proposed measurement plan, the total number of triple coincidence events and the beam time is summarized in the Table 2.

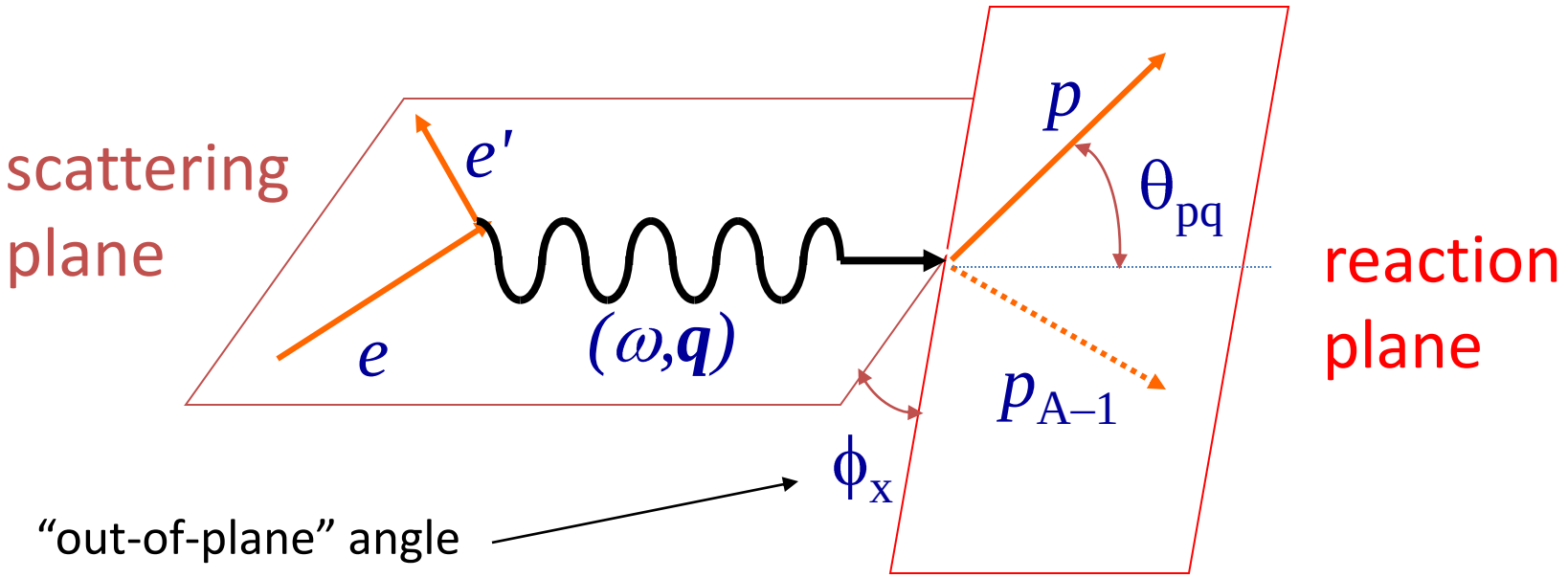
target	p_{miss} [MeV/c]	days	$(e,e'pp)$ events	$(e,e'pn)$ events
^{4}He	400	5	110	200
^{4}He	500	5	110	200
^{4}He	625	5	235	160
^{4}He	750	5	280	150
^{4}He	875	5	320	140

Table 2
Beam time request and expected triple coincidence rate.

160 300

Increases triple Coincidence rate by 40-45%!

Kinematics



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

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

PWIA

Missing energy: $\varepsilon_m = \omega - T_p - T_{A-1}$

Inclusive scattering at large x

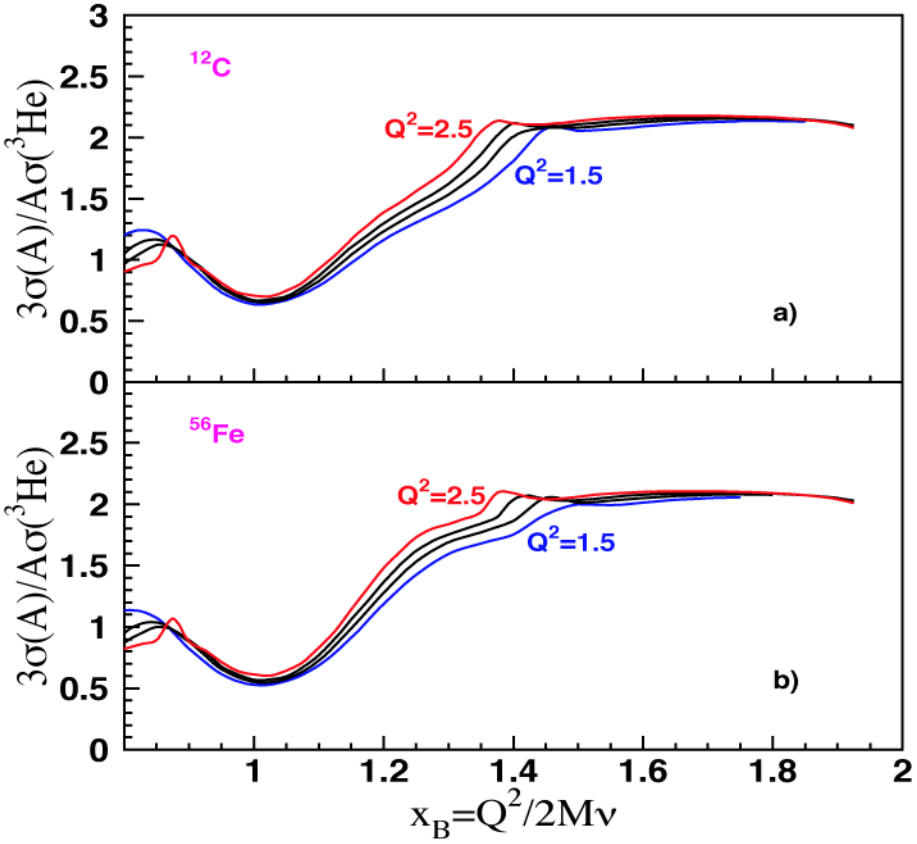
Define y as the x_B-value at which the minimum p_{miss} exceeds p_{Fermi}

SRC model predicts:

- Scaling for $x_B > y$ and $Q^2 > 1.5$ GeV^2
- No scaling for $Q^2 < 1$ GeV^2
- In scaling regime ratio Q^2-independent and only weakly A-dependent

Glauber Approximation predicts:

- No scaling for $x_B < 2$ and $Q^2 > 1$ GeV^2
- Nuclear ratios should vary with A and Q^2



CLAS A(e,e’) Data

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

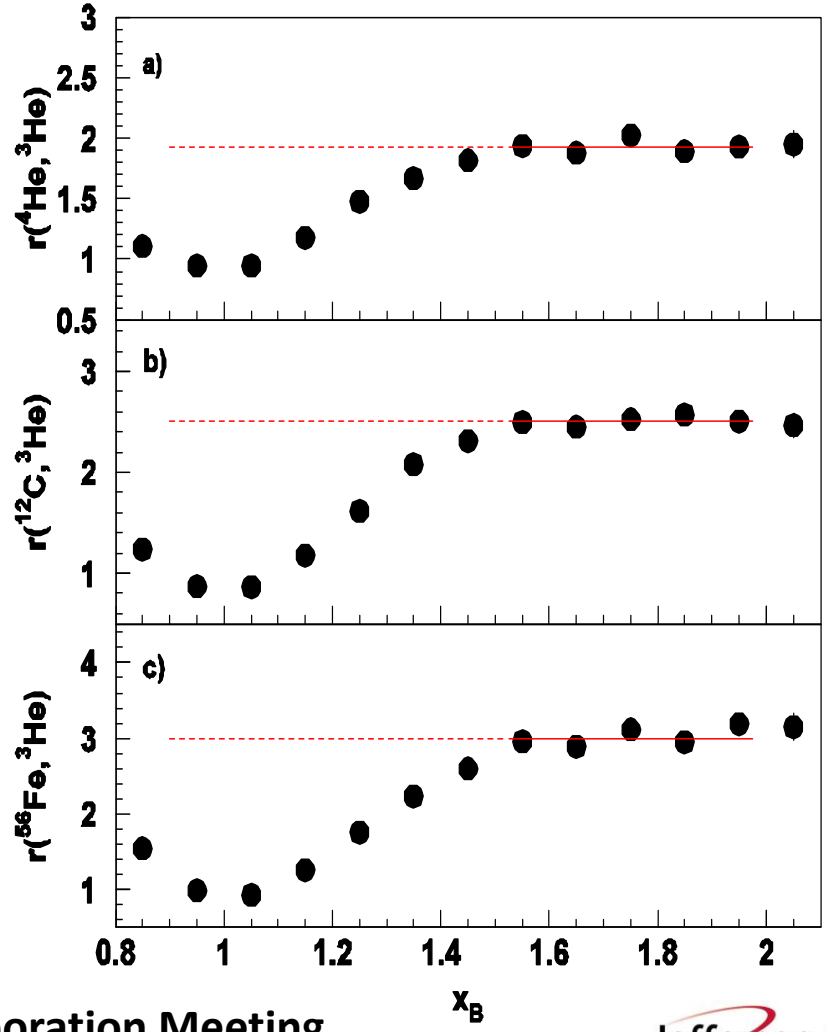
Originally done with SLAC data by D.B. Day *et al.*, Phys. Rev. Lett. 59 (1987) 427.

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

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



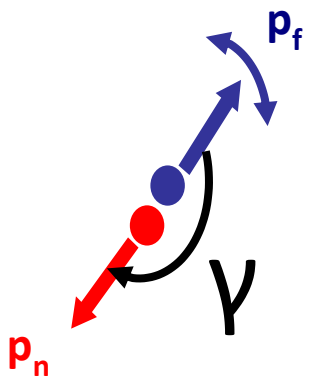
From the (e,e') and (e,e'p) Results

- 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

Brookhaven EVA Collaboration Result

A. Tang *et al*., Phys. Rev. Lett. **90** (2003) 042301.

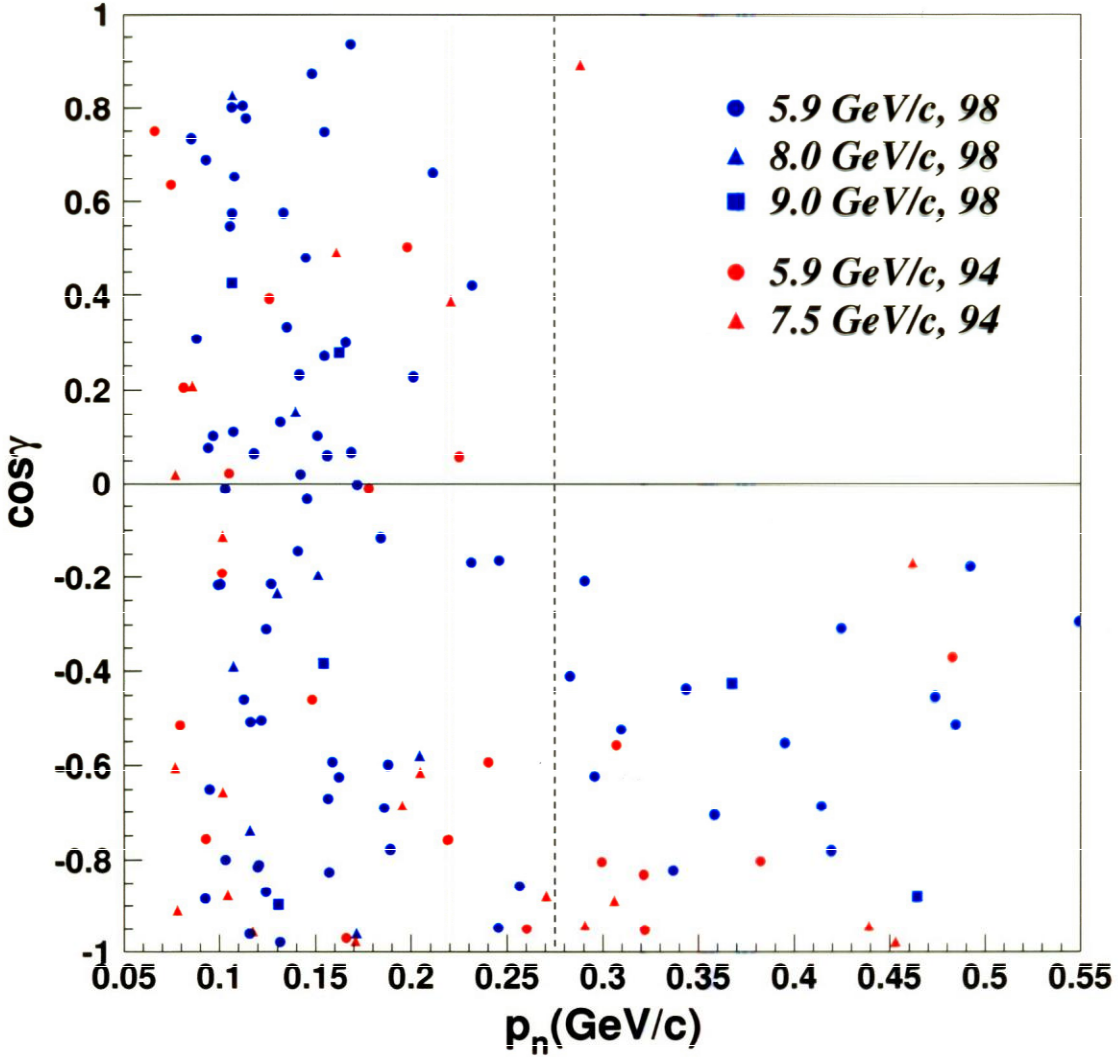
^{12}C(p,2p+n) Reaction



$p_f = p_1 + p_2 - p_0$

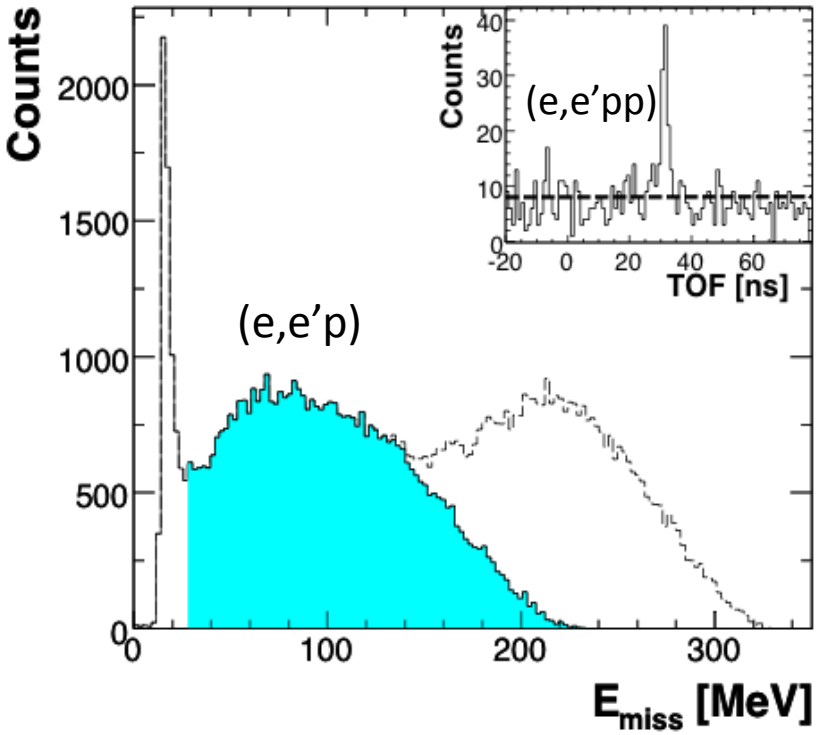
p_0 = incident proton

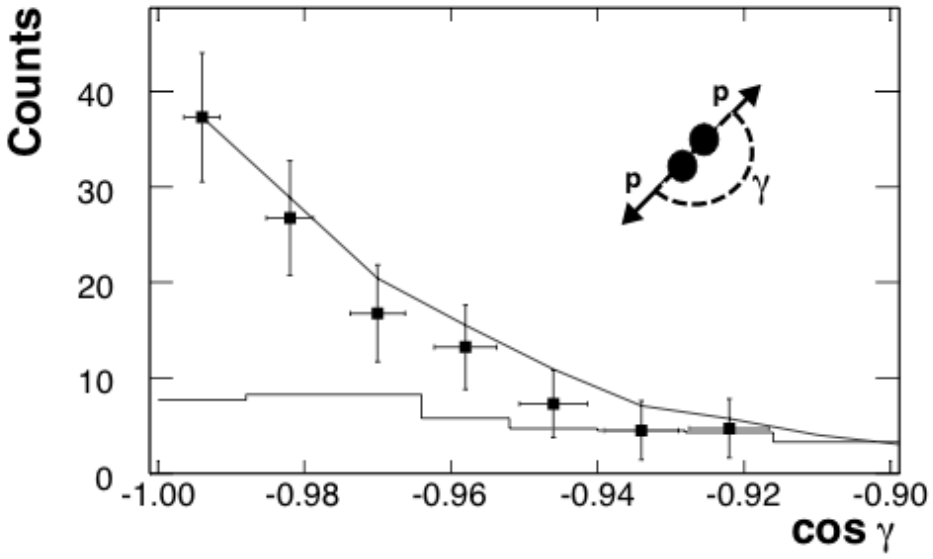
p1 and p2 are detected



(e,e'p) & (e,e'pp) Data

R. Shneor *et al.*, Phys. Rev. Lett. **99** (2007) 072501.





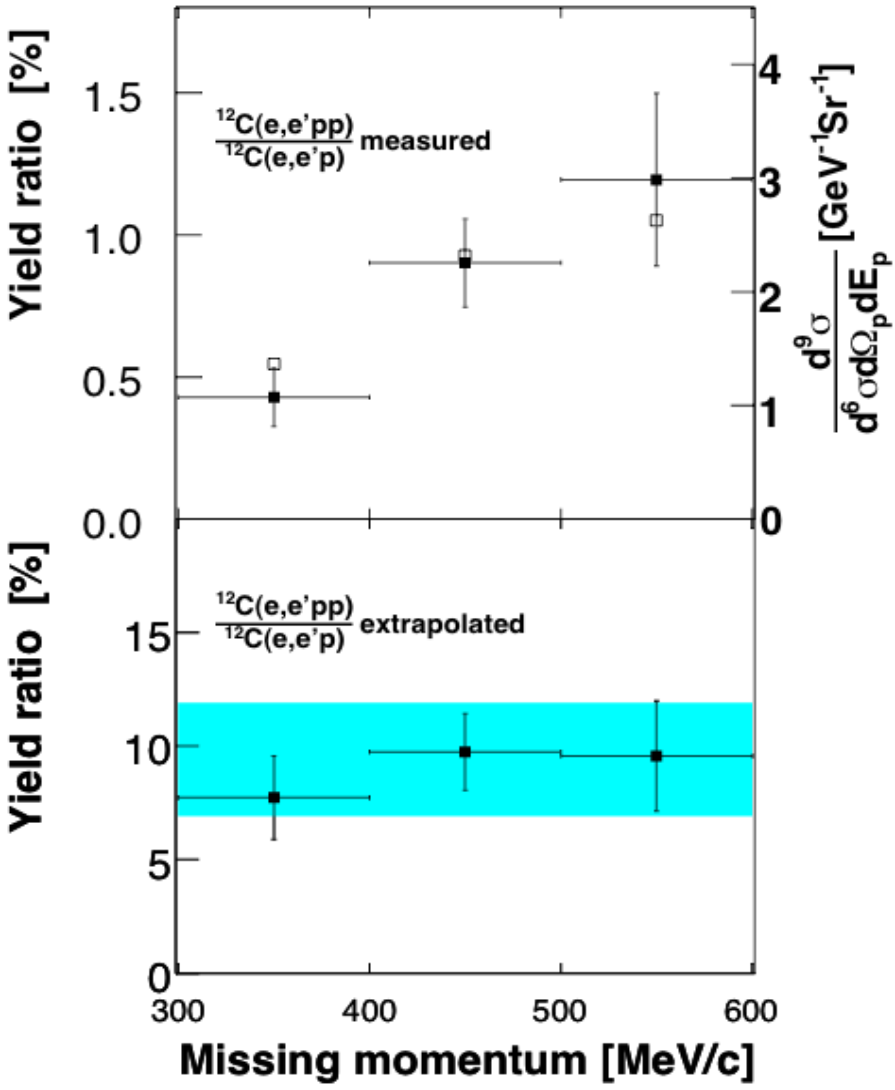
Strong back-to-back correlation!

- ^{12}C(e,e'p)
- Quasi-Elastic Shaded In Blue
- Resonance Even at x_B>1

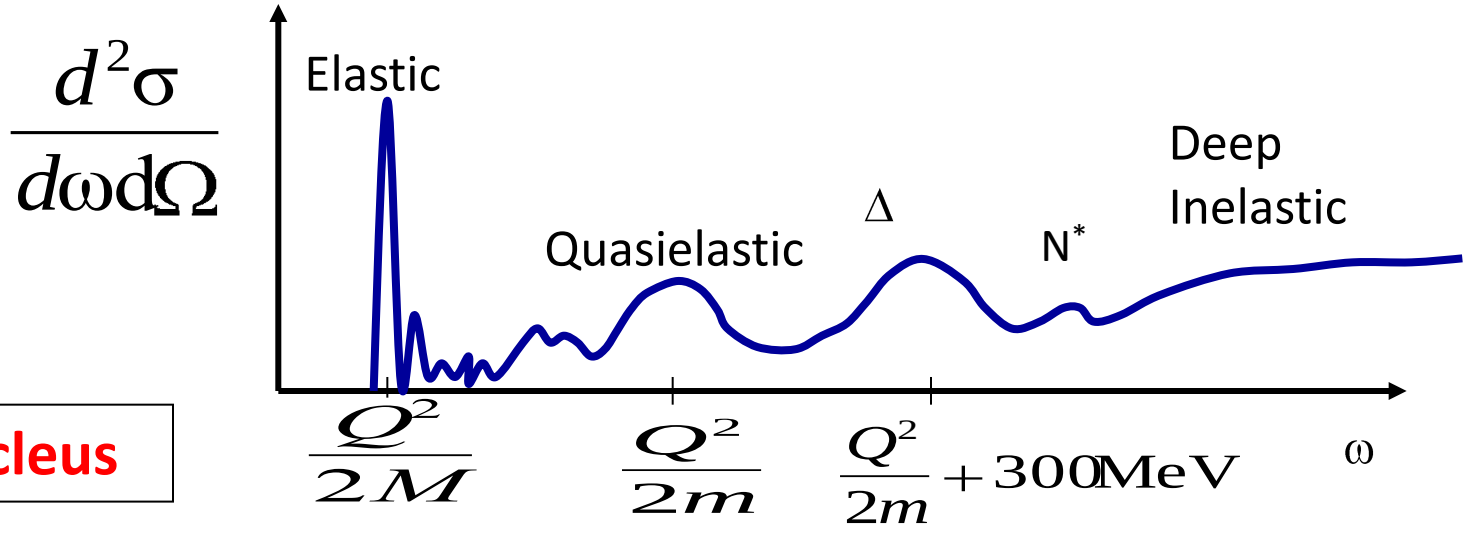
Ratio of ^{12}C(e,e'pp) to ^{12}C(e,e'p)

R. Shneor *et al.*, Phys. Rev. Lett. **99** (2007) 072501.

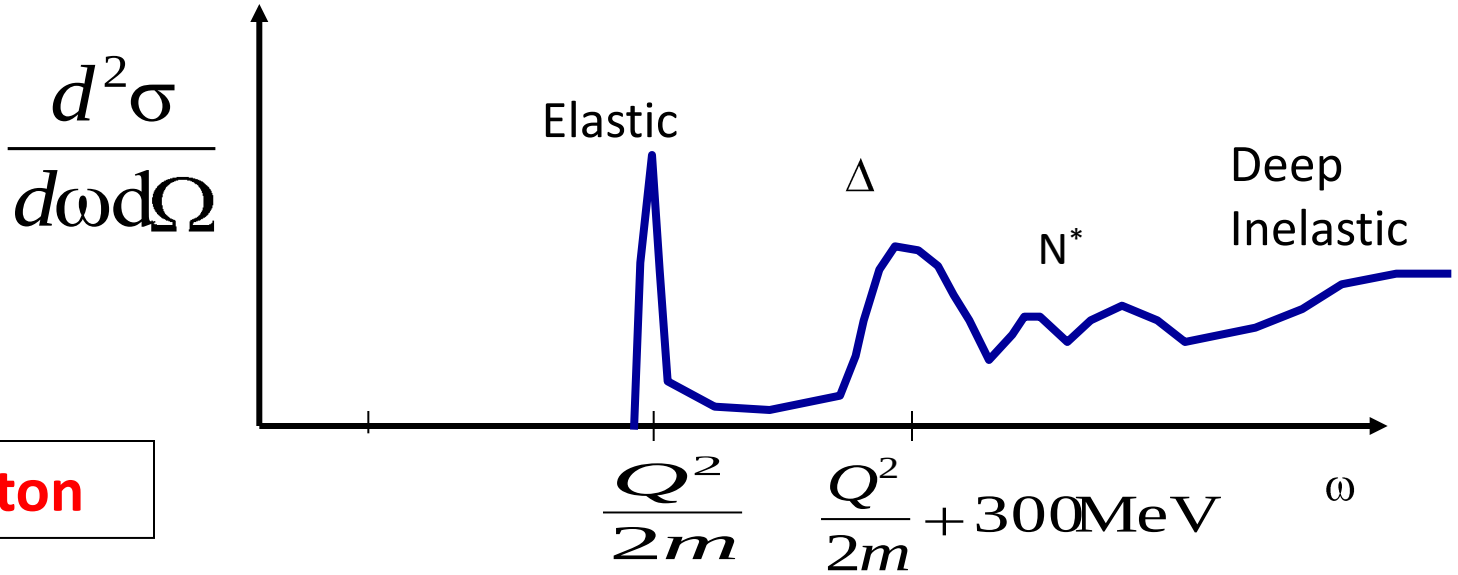
- Top plot shows the raw measured ratio
- Bottom plot shows the extrapolated where the finite acceptance of BigBite and pair center of mass motion has been taken into account.
- Determined pair cm motion to be 136+/-20 MeV/c and blue band indication two-sigma around this value.
- Note Brookhaven found 143+/-17 MeV/c



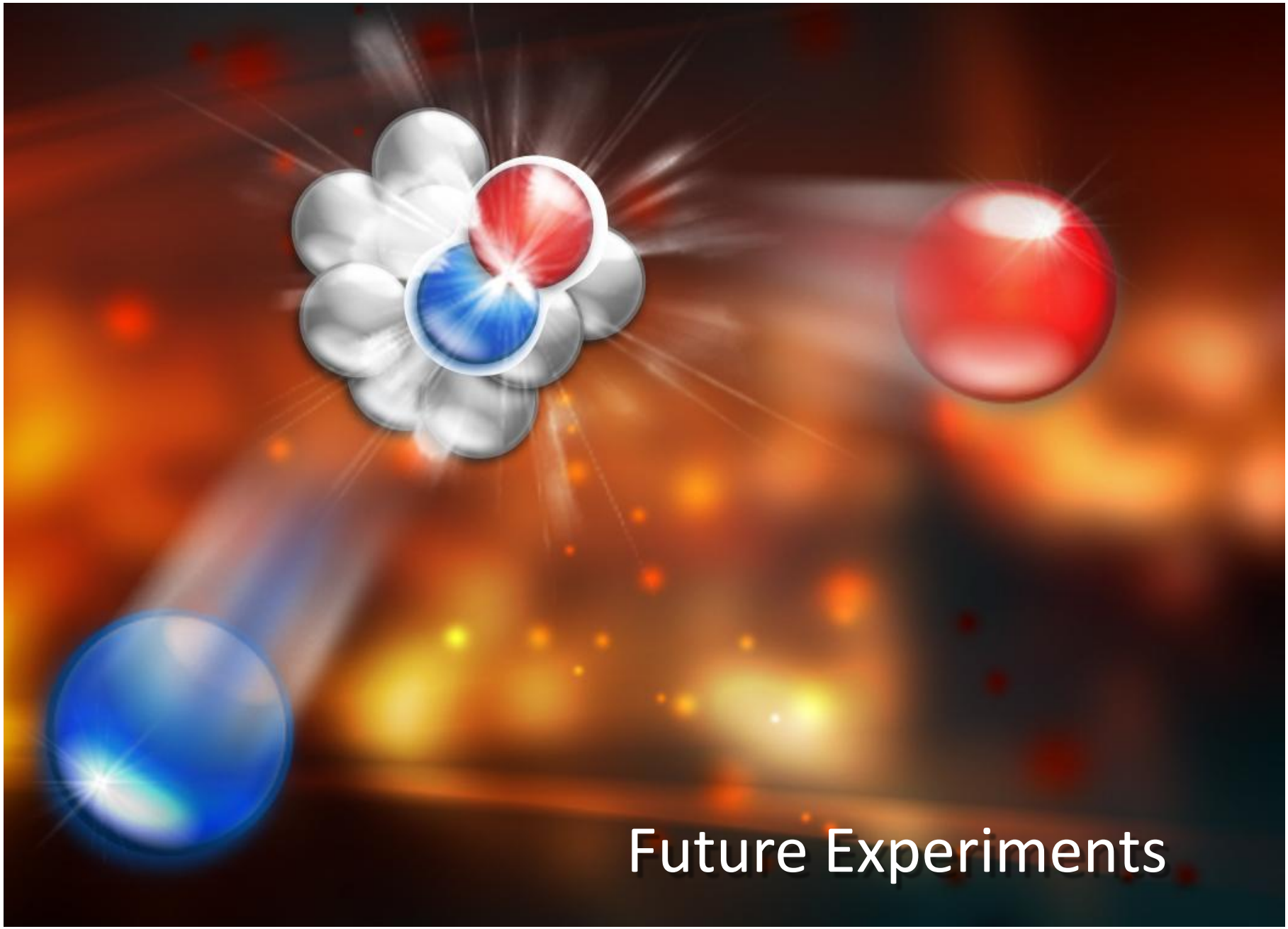
Electron Scattering at Fixed Q^2



Nucleus

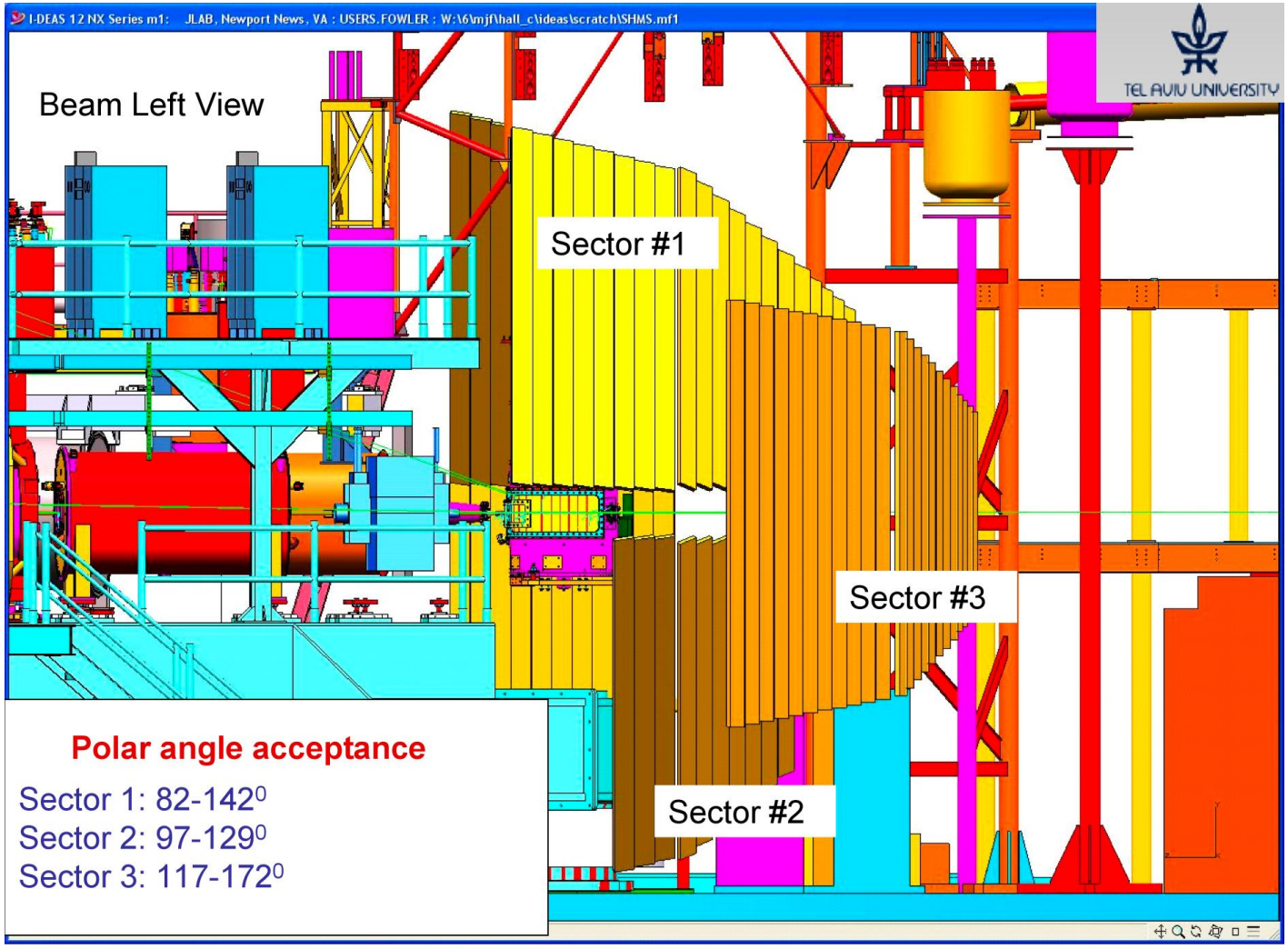


Proton


Future Experiments

New Idea: Large Acceptance Device

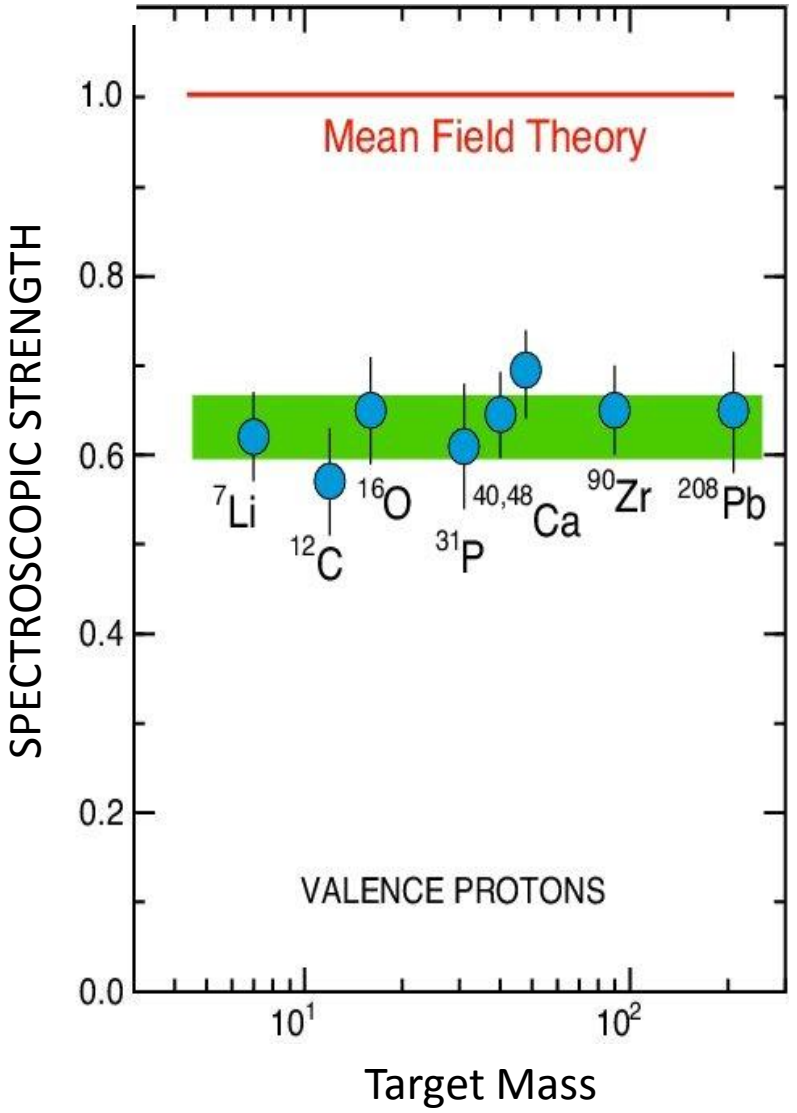
Letter of Intent at Most Recent Jefferson Lab Program Advisory Committee Meeting



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