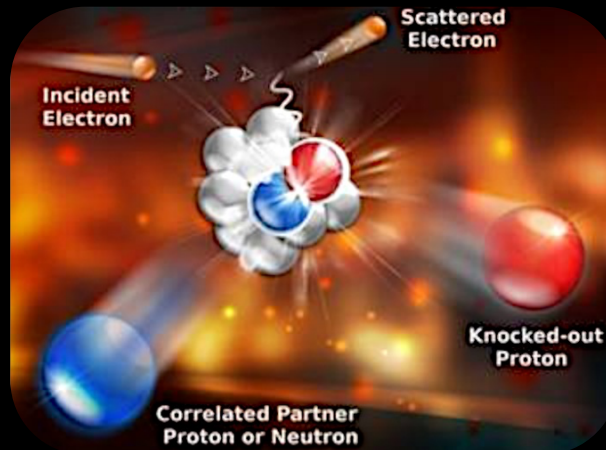
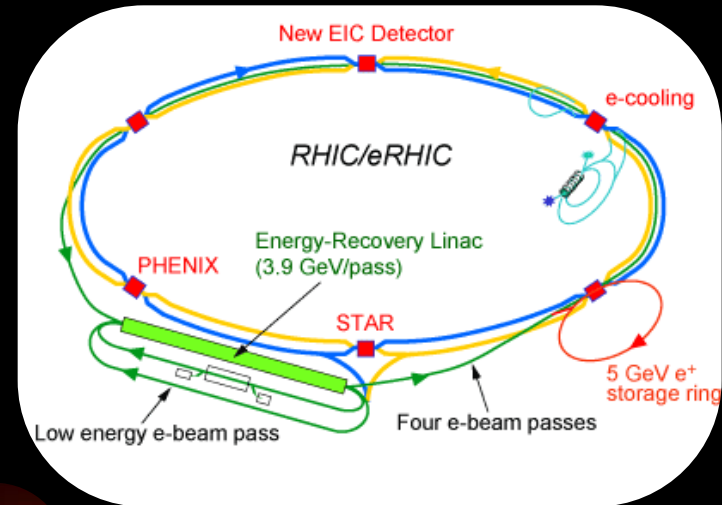
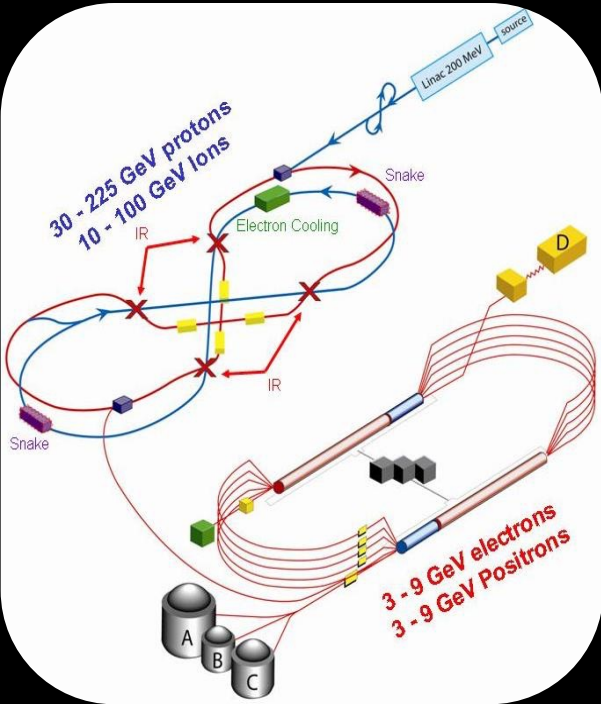


Electron Ion Collider

Tagging Correlations at an EIC

Or Hen
MIT



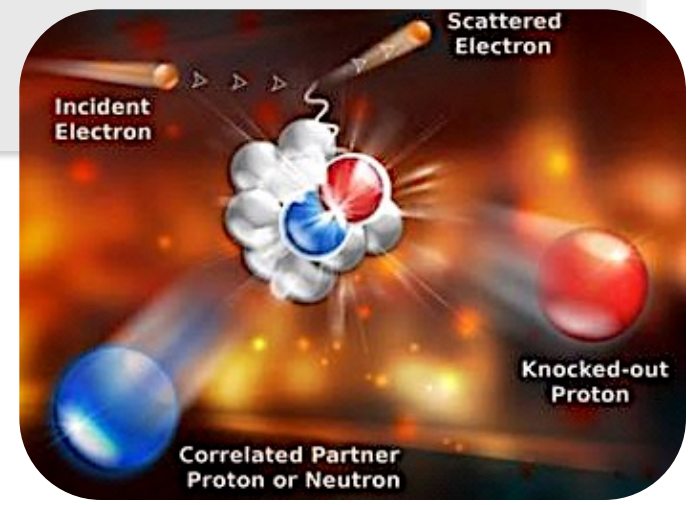
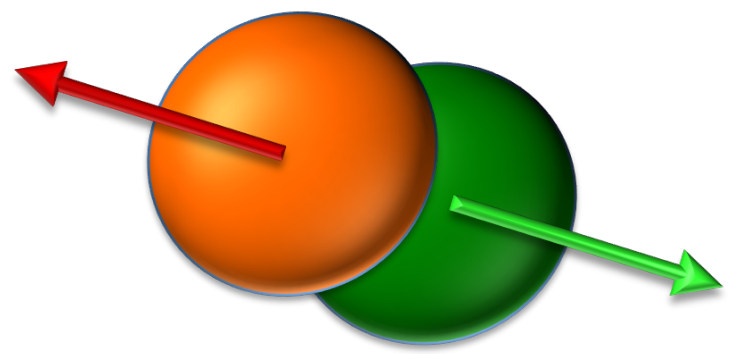
** Your Design Here? **



What are Short-Range Correlation (SRC)

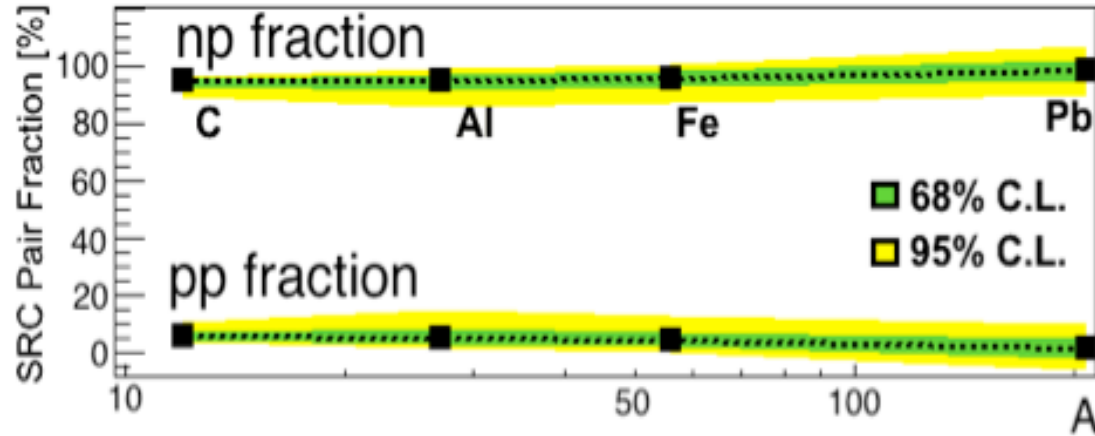


- Are close together (wave function overlap)
- Have high relative momentum and low c.m. momentum compared to the Fermi momentum (k_F)



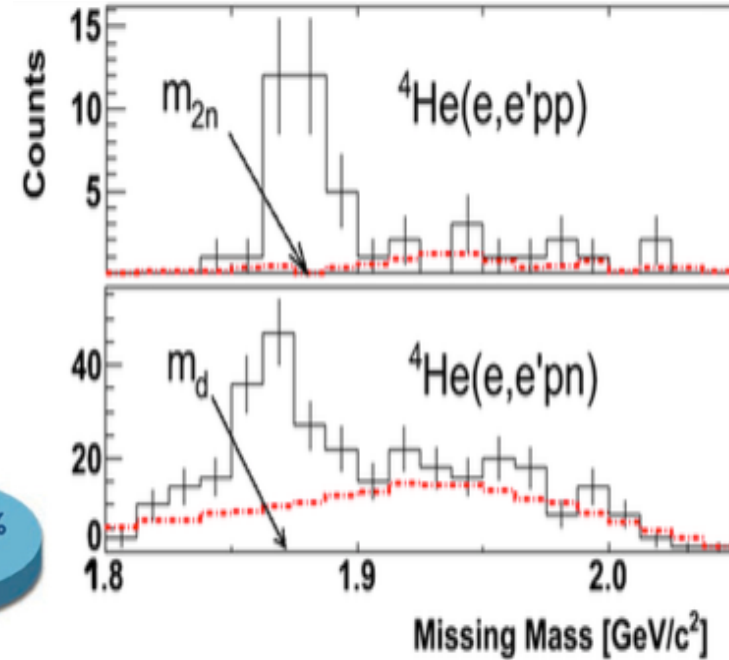
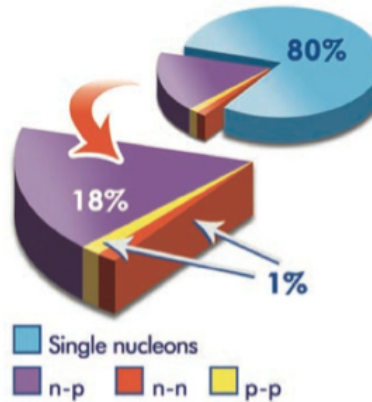
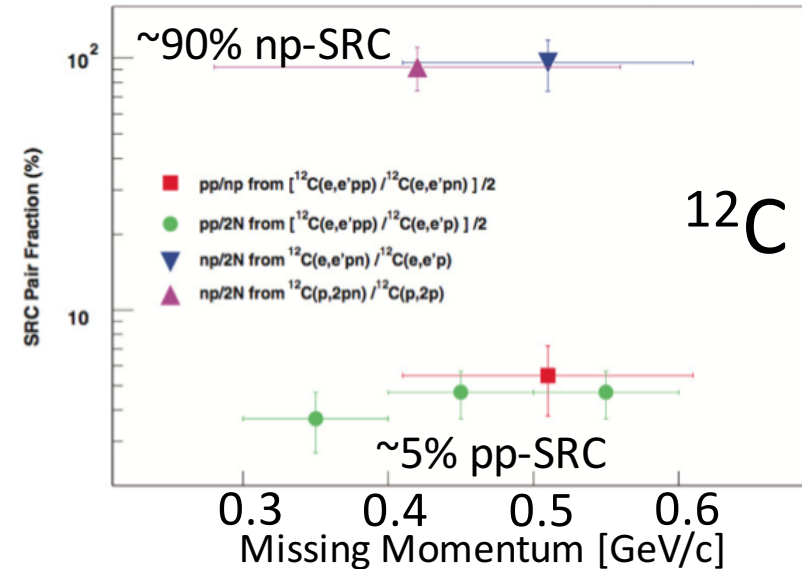


Isospin Structure



O. Hen et al., Science 364 (2014) 614

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



I. Korover et al., PRL 113, 022501 (2014)

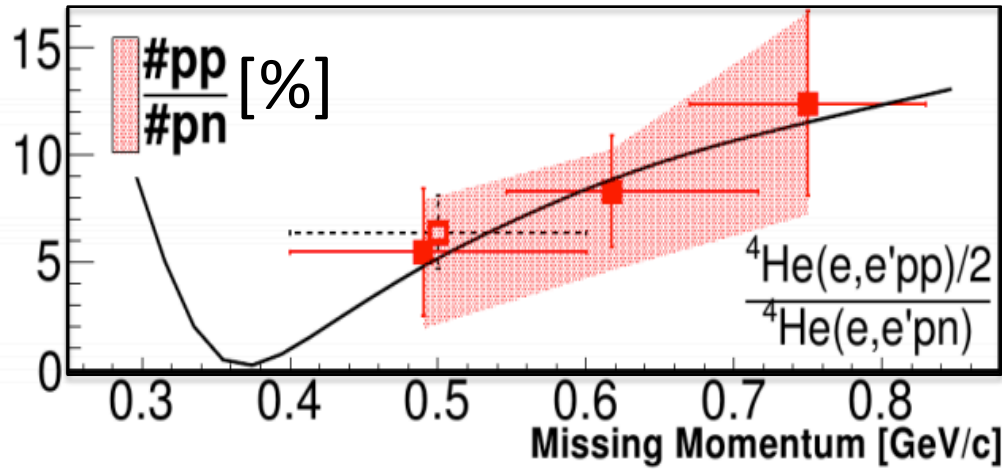
A. Tang et al., PRL (2003);

E. Piasezky et al., PRL (2006);

R. Shneor et al., PRL (2007)



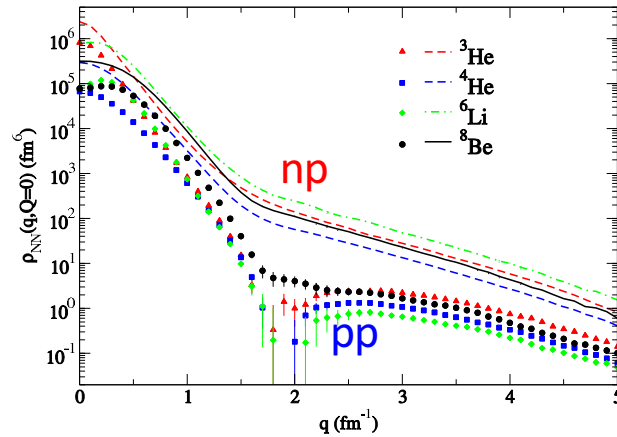
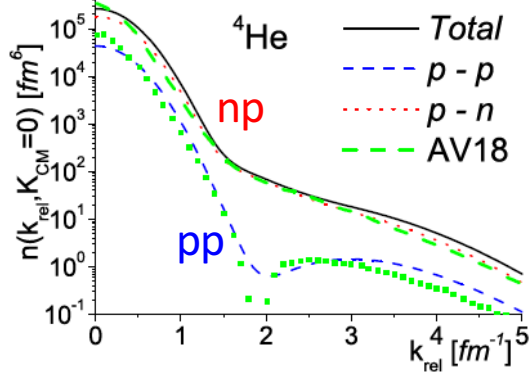
pp/np ratio increase with P_{miss}



I. Korover, N. Muangma, and O. Hen et al., Phys. Rev. Lett 113, 022501 (2014).

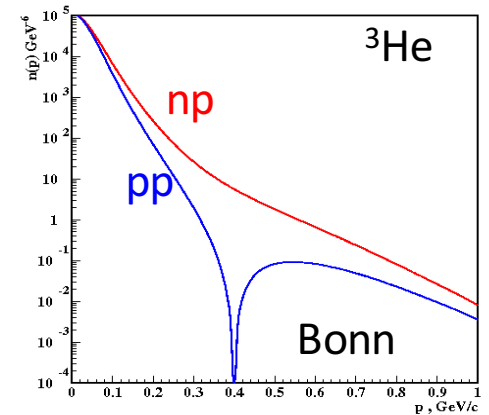
Pair density calculations:

Ciofi and Alvioli PRL 100, 162503 (2008)



Schiavilla et al., PRL 98,132501 (2007)

Sargsian et al., PRC 71 044615 (2005)



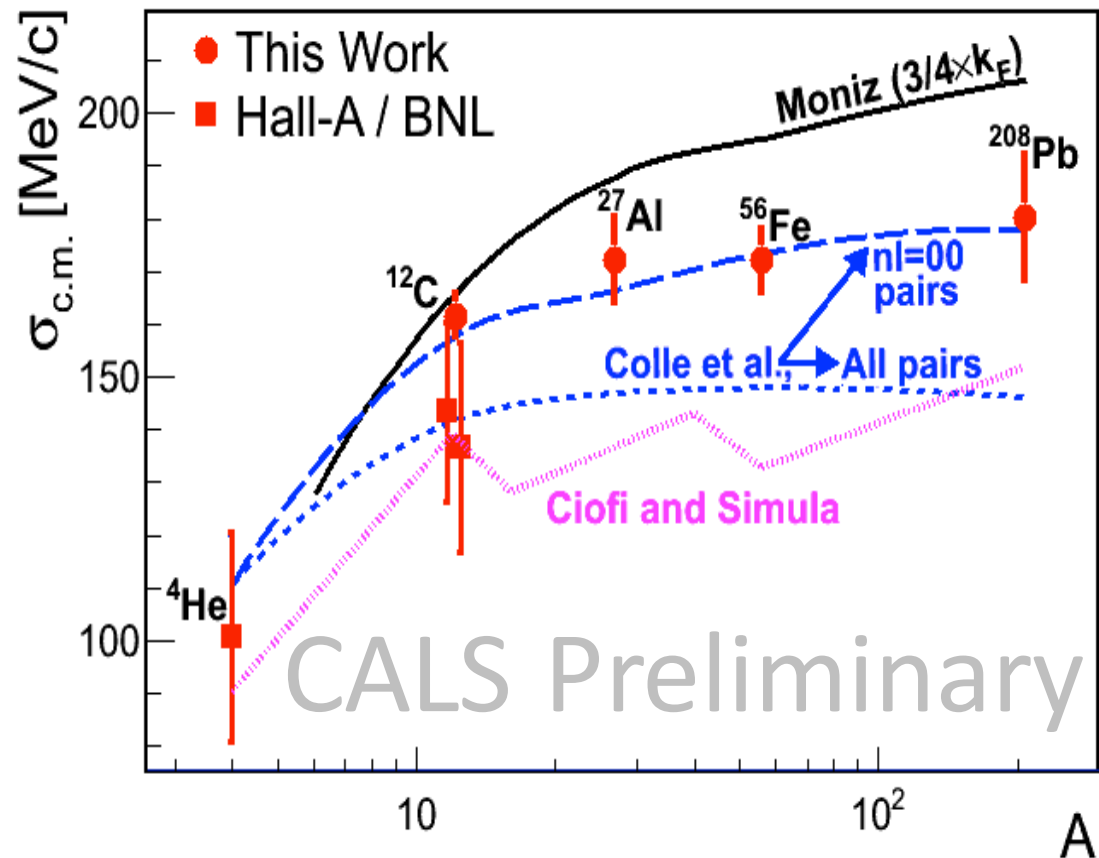


Pair c.m. motion



“... *high relative momentum* and low c.m. momentum compared to the Fermi momentum (k_F)”

- Reconstructed total (c.m) pair momentum insensitive to FSI in the pair.
- Observed to be Gaussian in each direction.
- Small width, consistent with calculations.

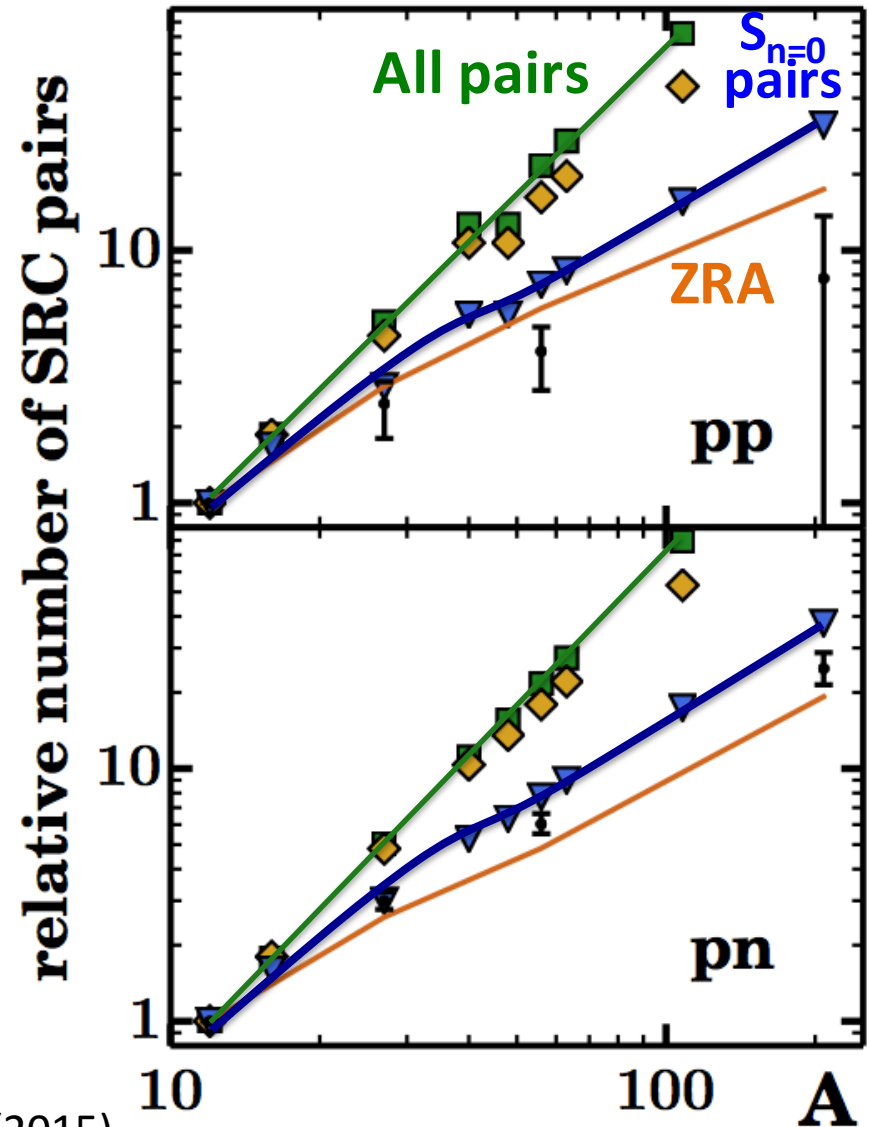




Selectivity of SRC Pairs



- Extract the number of pp (np) SRC pairs in nuclei relative to ^{12}C .
- Pair number increases very slowly with A
- consistent with 1S_0 (3S_0) pairs creating SRCs.



C. Colle and O. Hen et al., Phys. Rev. C **92**, 024604 (2015)

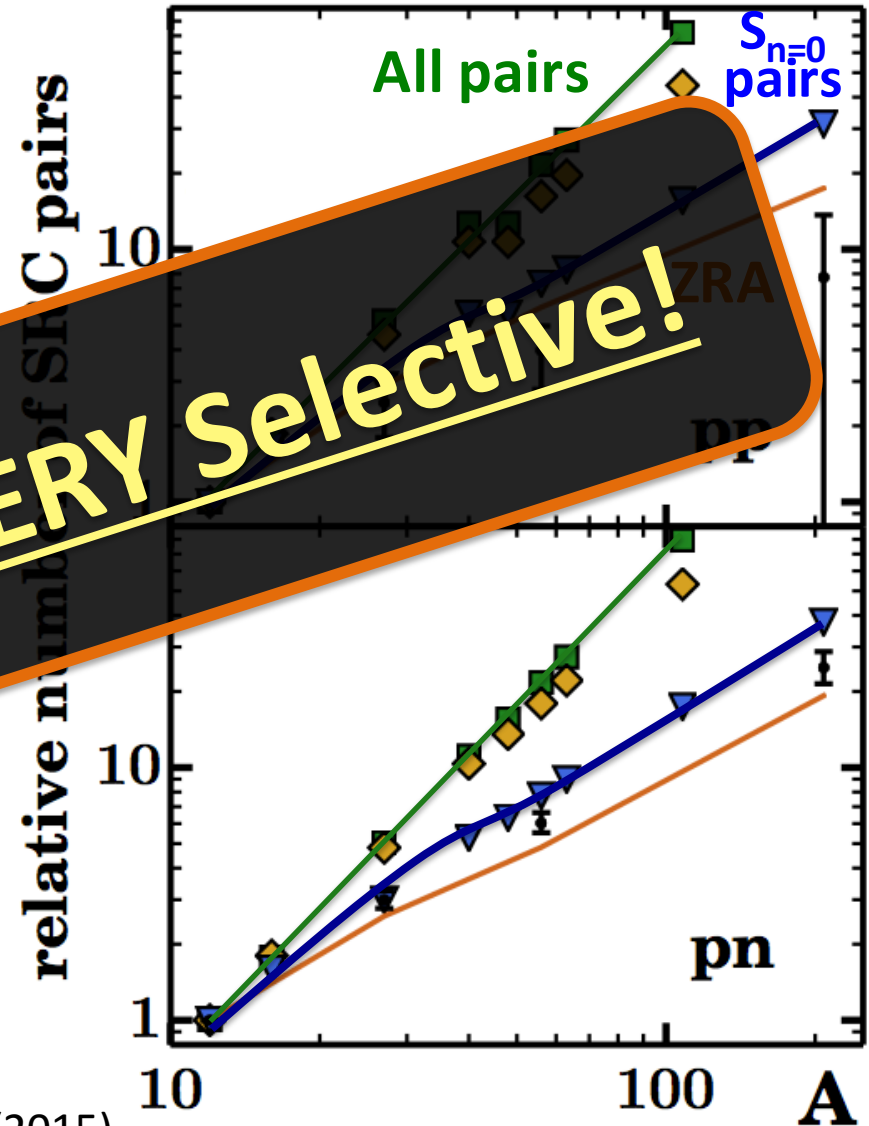


Selectivity of SRC Pairs



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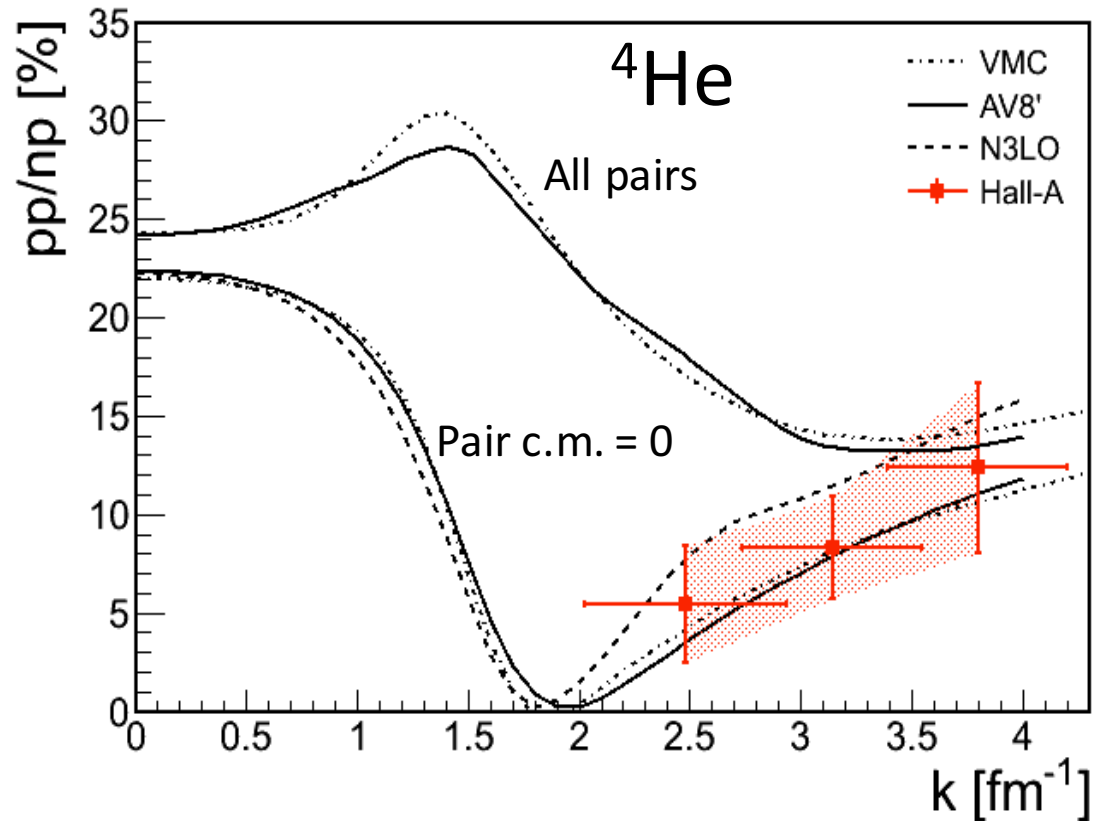
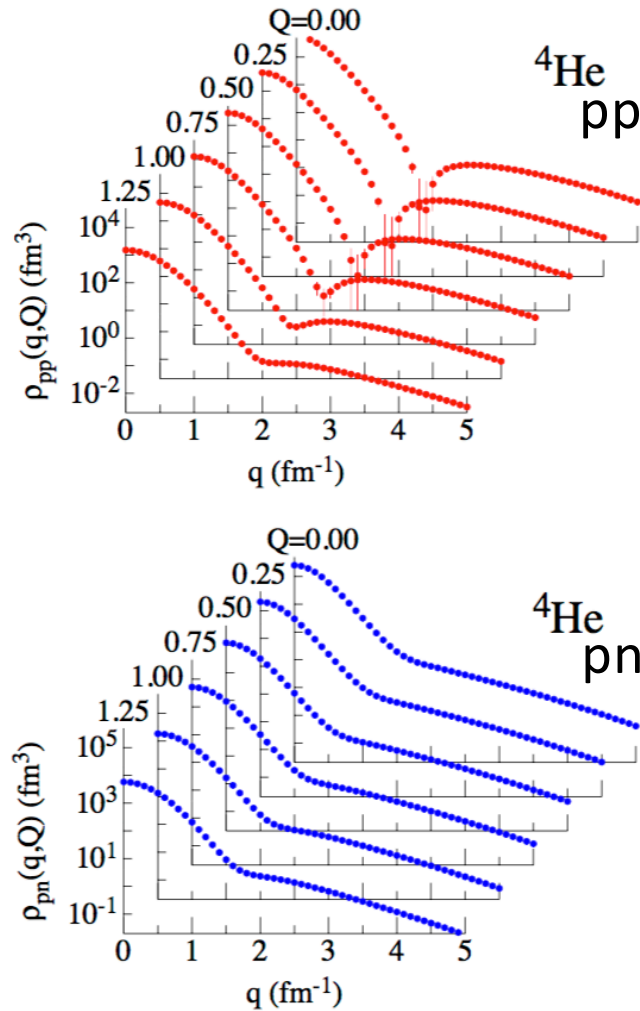
SRC Pairs are VERY Selective!



C. Colle and O. Hen et al., Phys. Rev. C **92**, 024604 (2015)



Selectivity in Light Nuclei



SRC pairs are consistent with $Q = 0$
back-to-back pairs

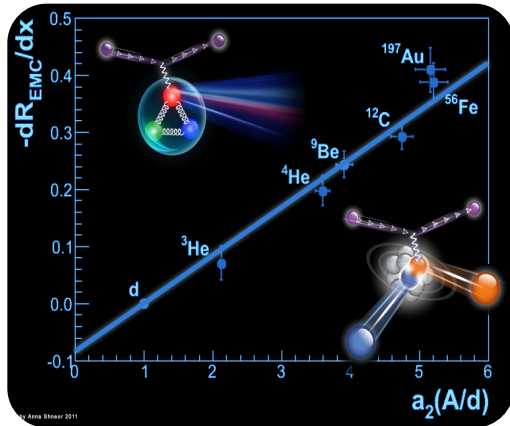
R. Wiringa et al., Phys. Rev. C 89, 024305 (2014).

T. Neff, H. Feldmeier and W. Horiuchi, Phys. Rev. C 92, 024003 (2015).

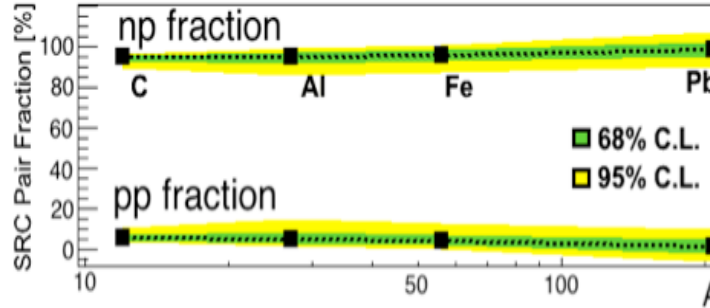
I. Korover, N. Muangma, and O. Hen et al., Phys. Rev. Lett 113, 022501 (2014).



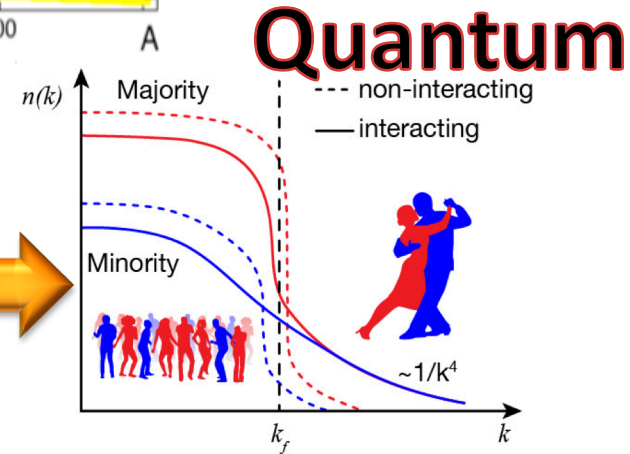
Importance of SRC Properties



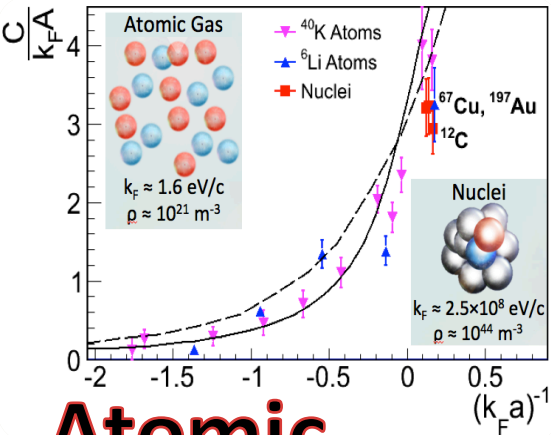
Particle



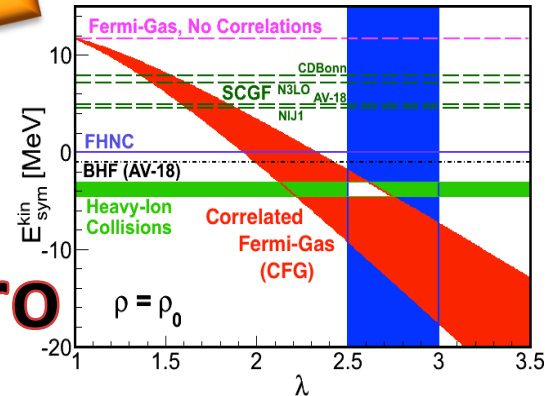
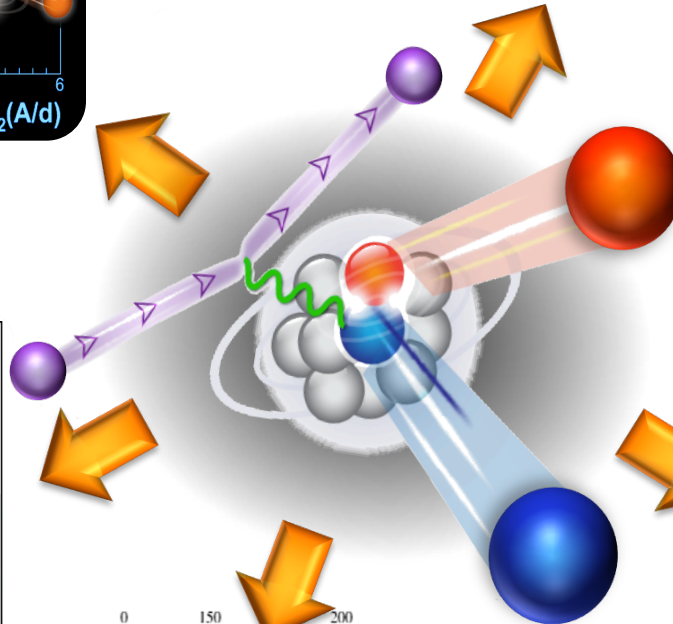
Nuclear



Quantum

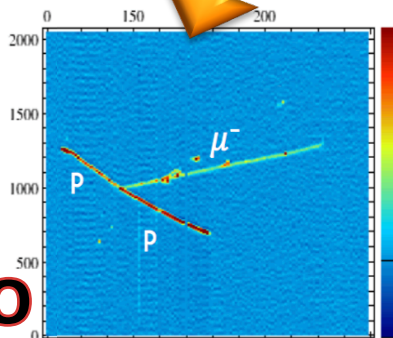


Atomic



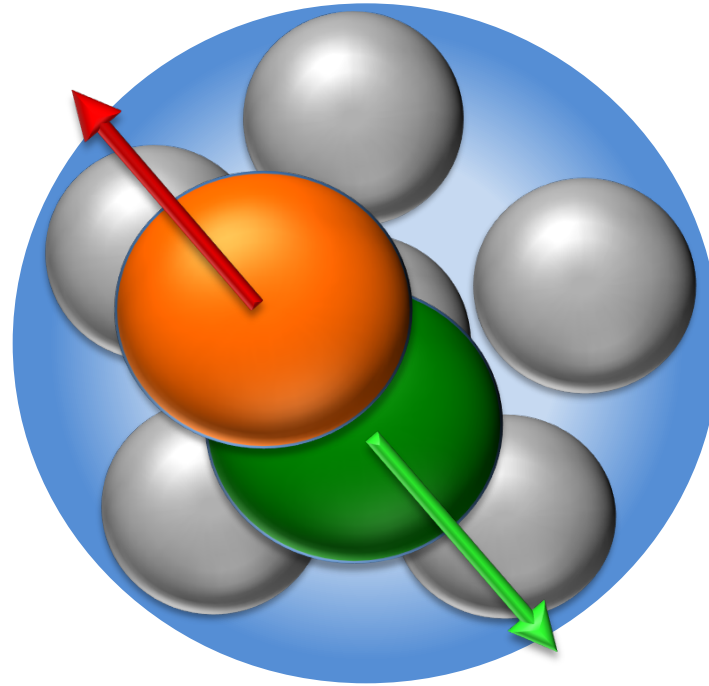
Astro

Neutrino



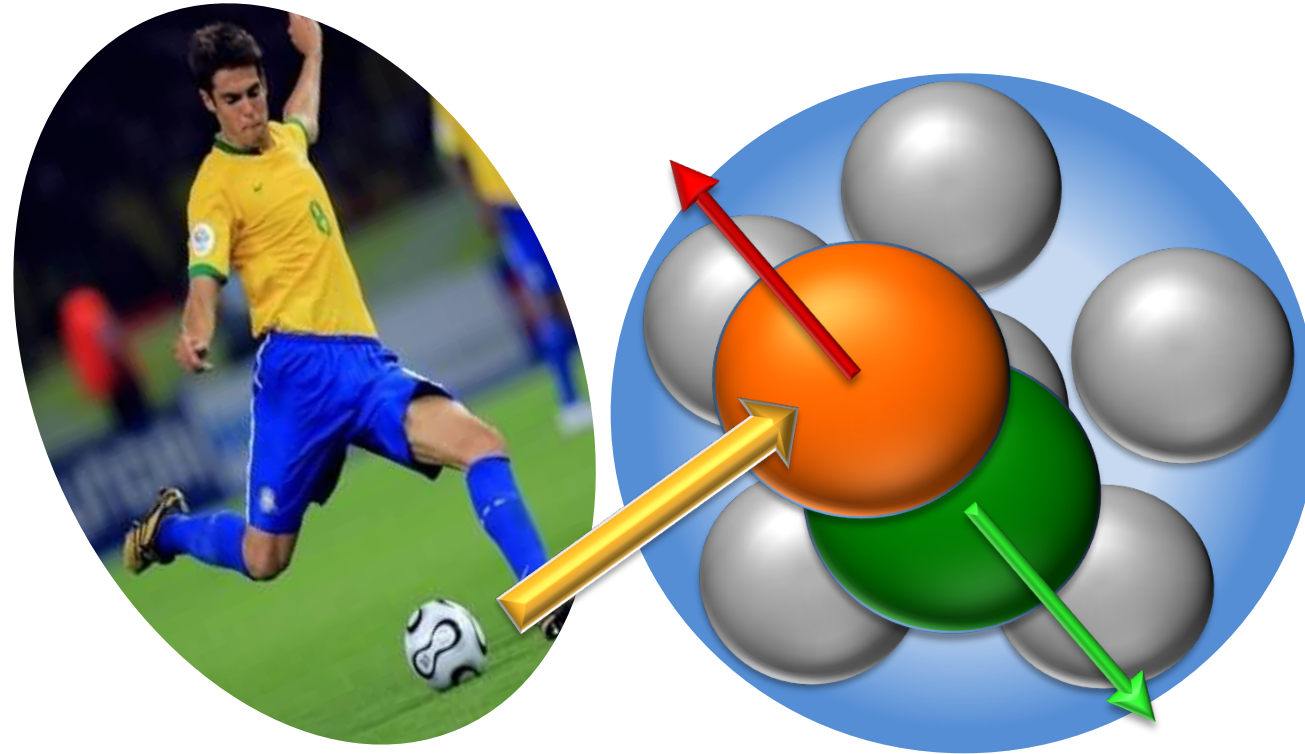


Exclusive 2N-SRC Studies



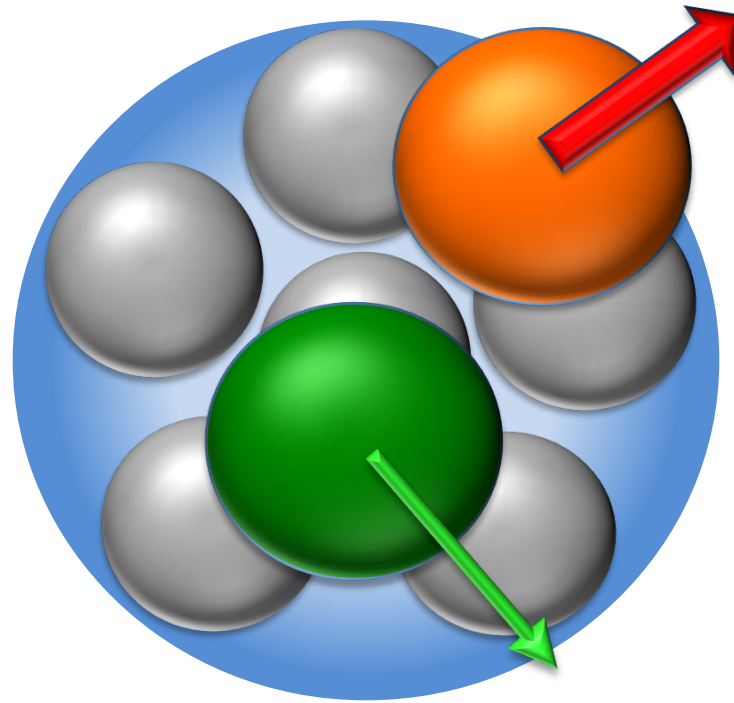


Exclusive 2N-SRC Studies

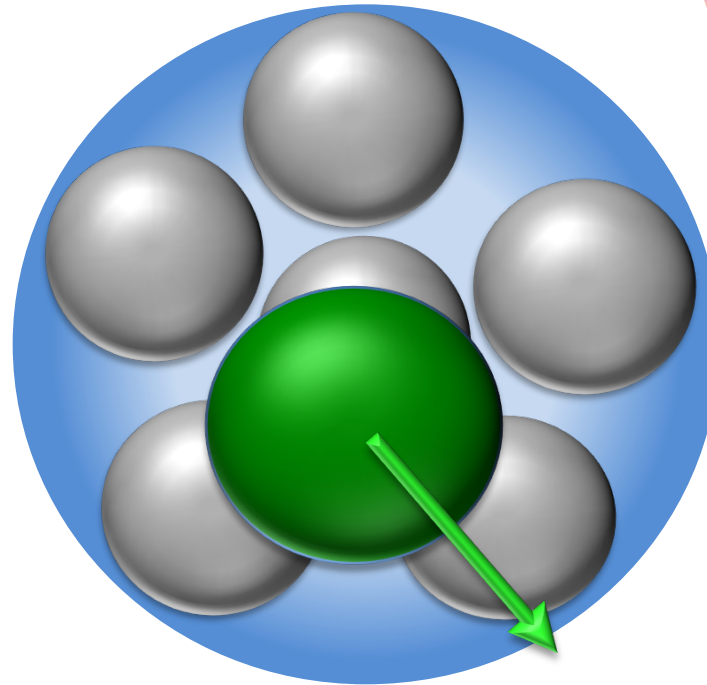




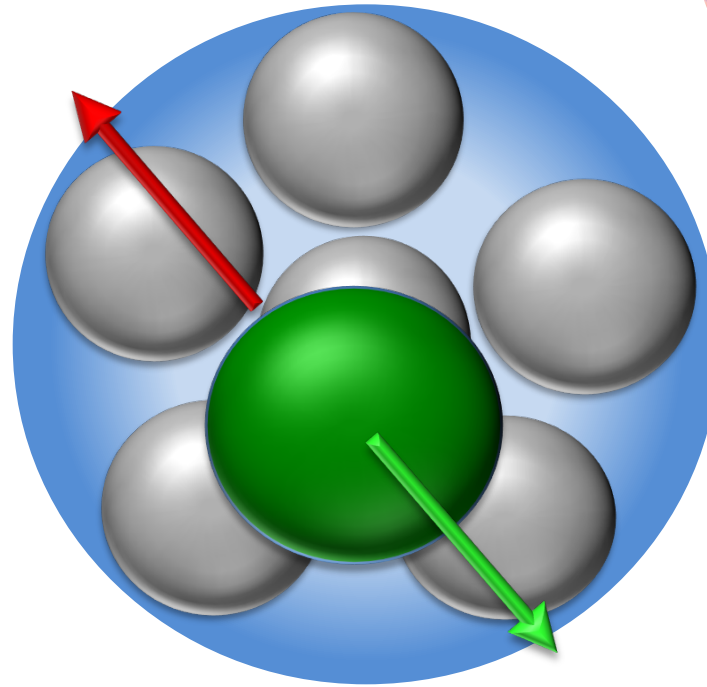
Exclusive 2N-SRC Studies



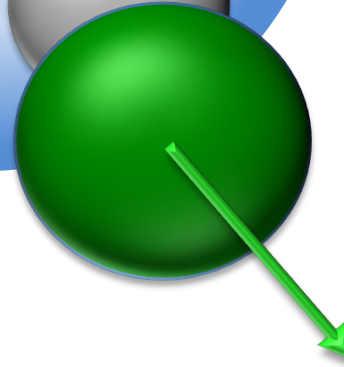
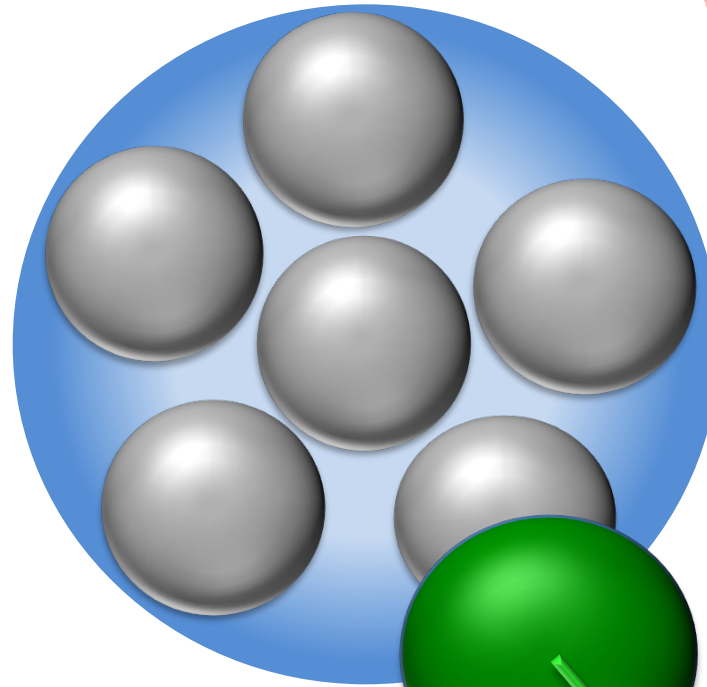
Exclusive 2N-SRC Studies



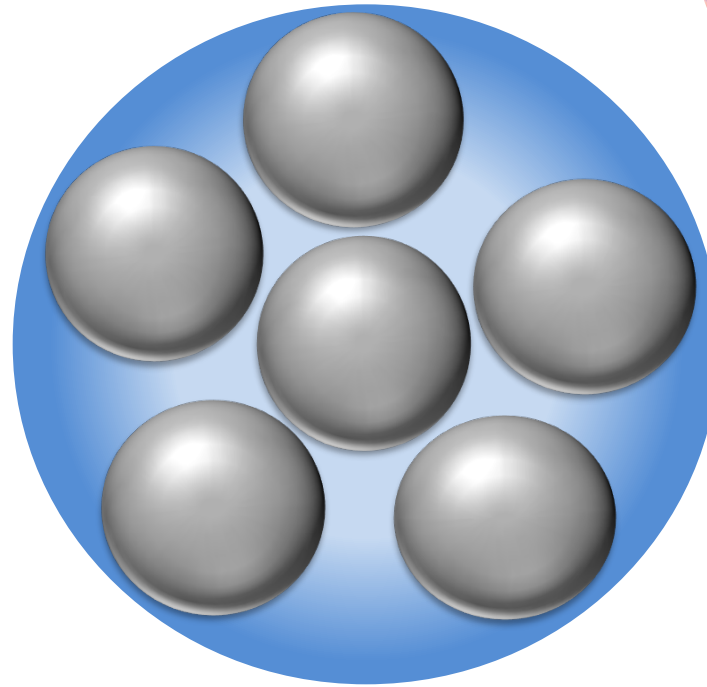
Exclusive 2N-SRC Studies



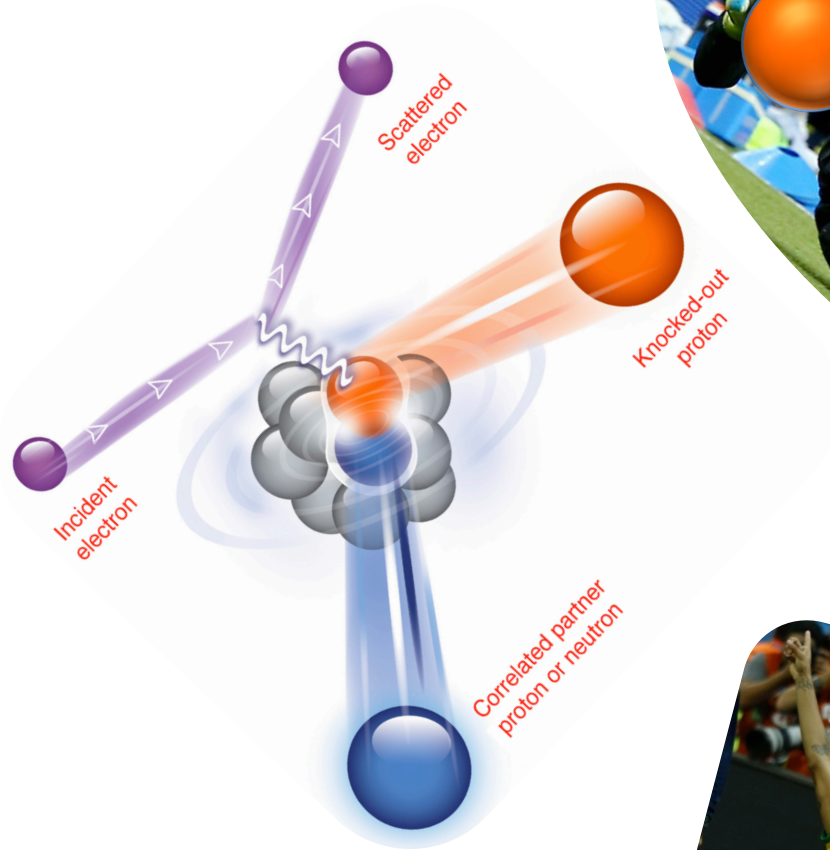
Exclusive 2N-SRC Studies



Exclusive 2N-SRC Studies

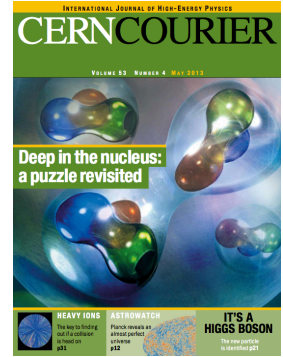
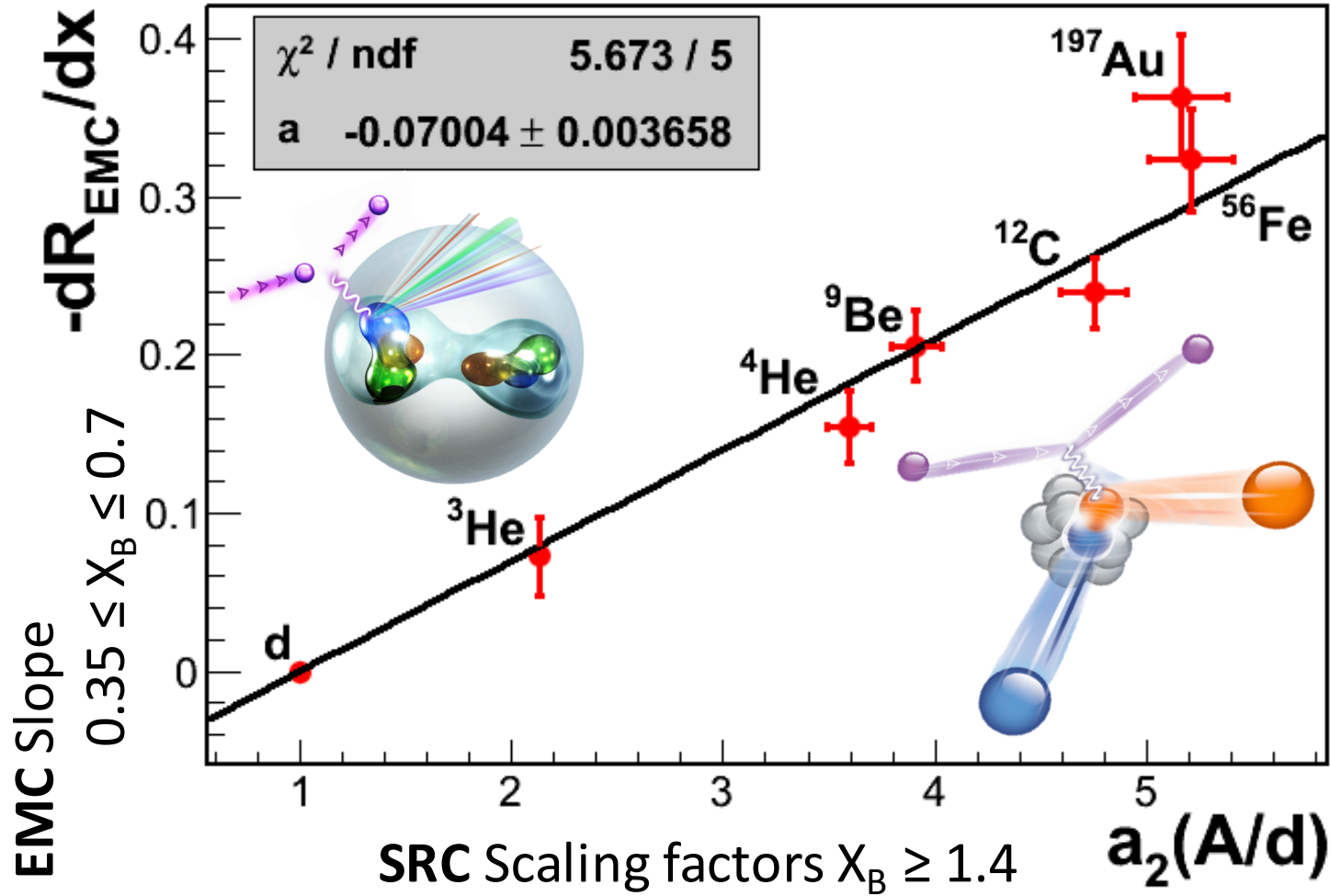


Exclusive 2N-SRC Studies





From QE to DIS



O. Hen et al., Int. J. Mod. Phys. E. **22**, 1330017 (2013).

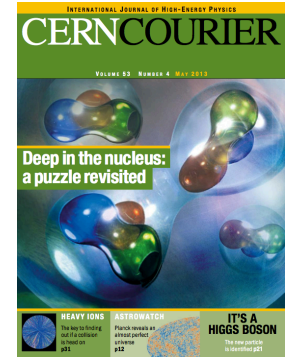
O. Hen et al., Phys. Rev. C **85** (2012) 047301.

L. B. Weinstein, E. Piasezky, D. W. Higinbotham, J. Gomez, O. Hen, R. Shneur, Phys. Rev. Lett. **106** (2011) 052301.



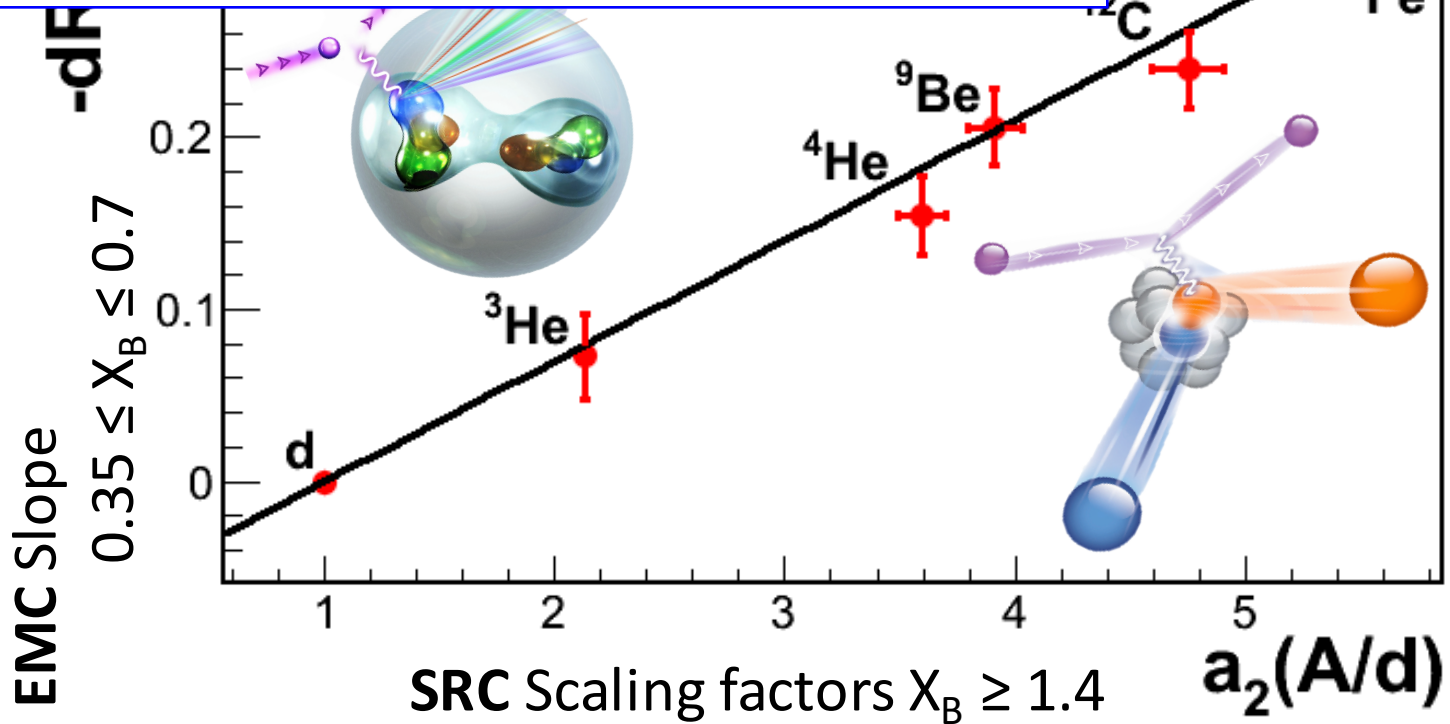


From QE to DIS



EMC and SRC are probably both dominated by high momentum (high virtuality) nucleons in nuclei

- Not due to Fermi Motion
- Probably due to nucleon medium modification



O. Hen et al., Int. J. Mod. Phys. E. **22**, 1330017 (2013).

O. Hen et al., Phys. Rev. C **85** (2012) 047301.

L. B. Weinstein, E. Piassetzky, D. W. Higinbotham, J. Gomez, O. Hen, R. Shneur, Phys. Rev. Lett. **106** (2011) 052301.





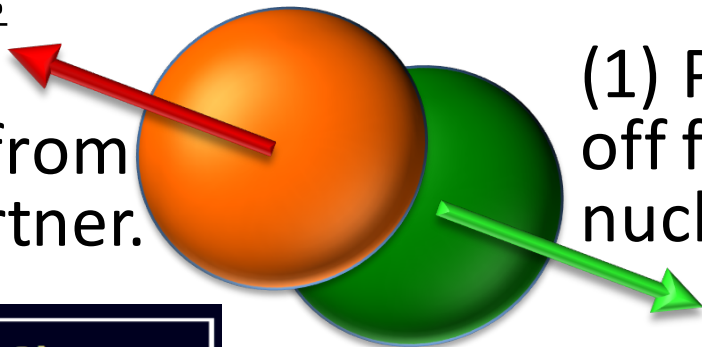
Tagged Structure Functions (JLab12)



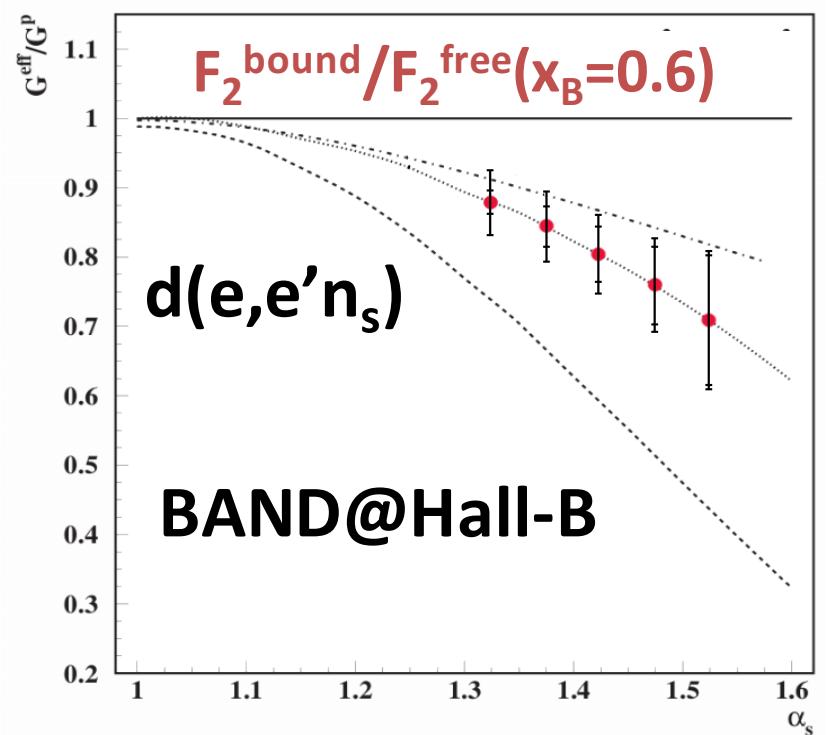
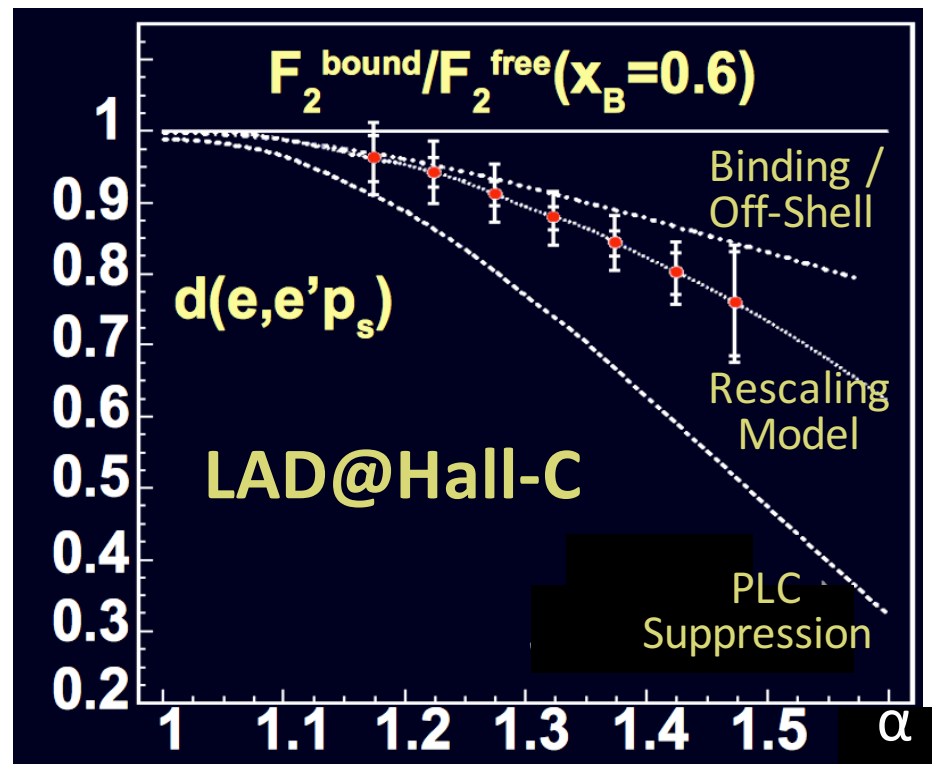
Internal structure of SRC nucleons?

Focus on the deuteron:

(2) Infer its momentum from the recoil partner.

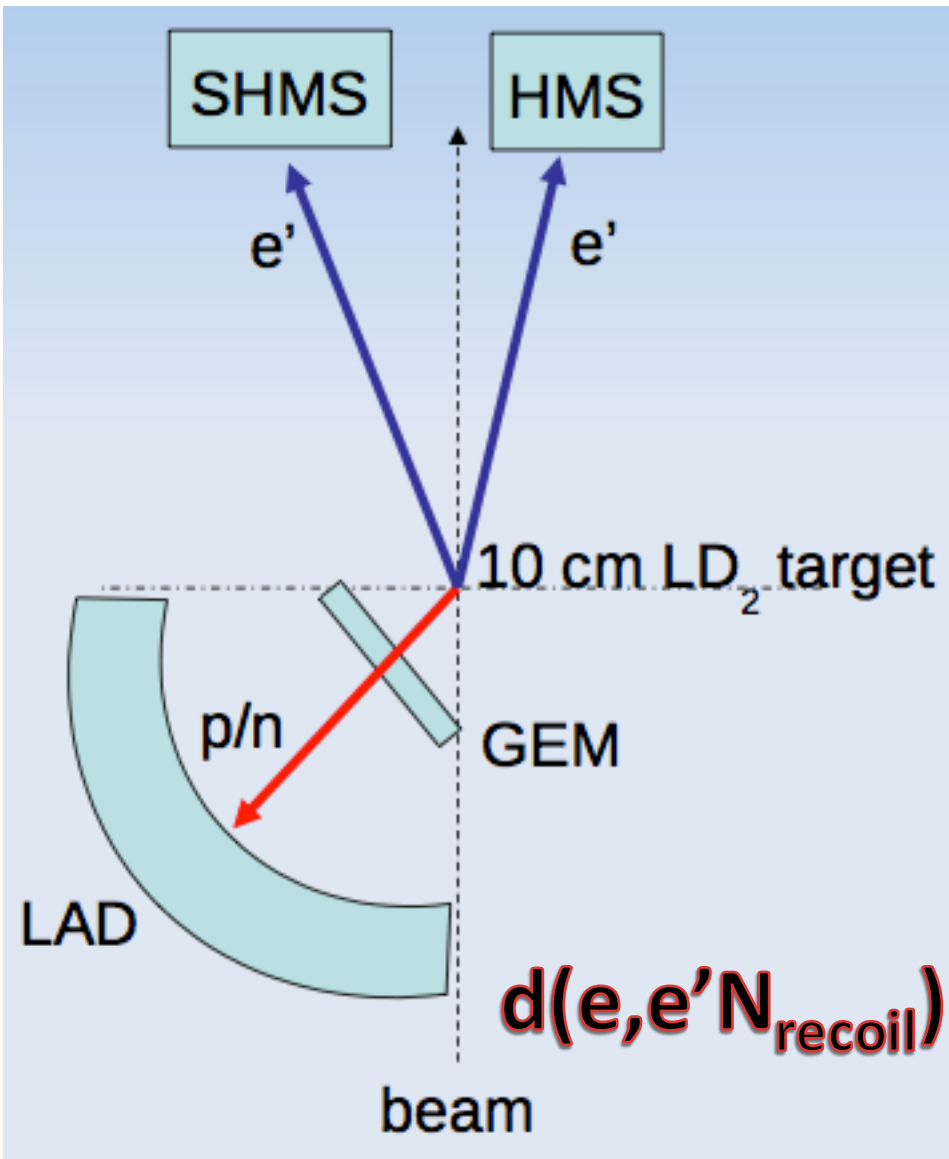


(1) Perform DIS off forward going nucleon.





Fixed Target Concept...



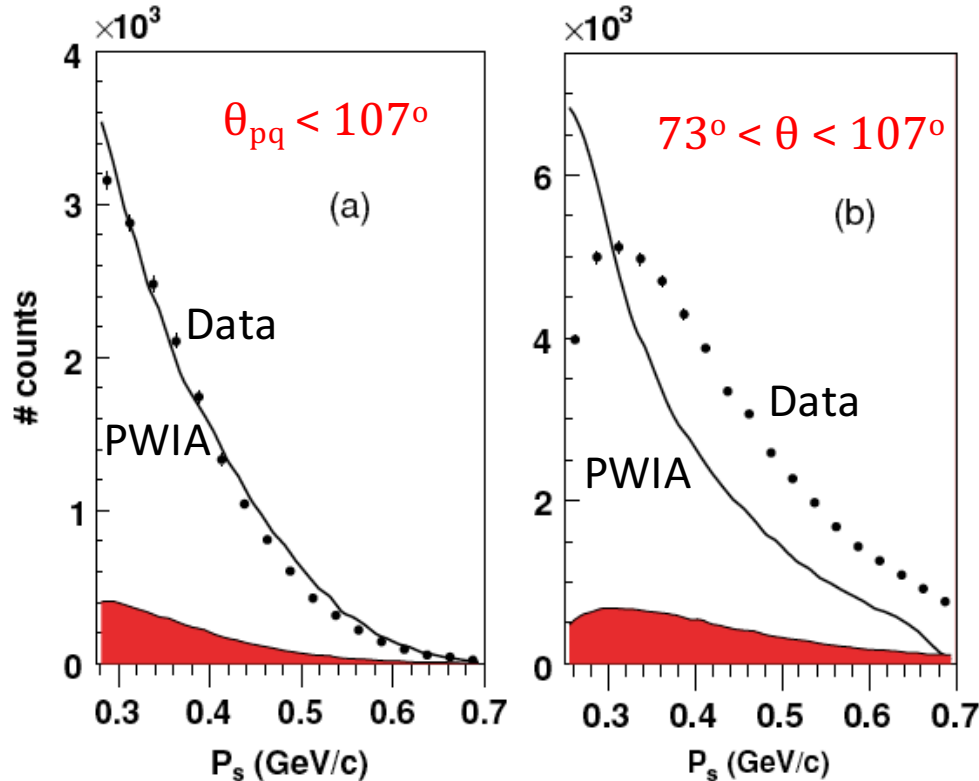
- High resolution spectrometers for $d(e, e')$ measurement in DIS kinematics
- Large acceptance recoil proton \ neutron detector
- Long target + GEM detector – reduce random coincidence



Backward Kinematics:

Minimize Re-Scattering

$D(e, e' p_s)$



FSI:

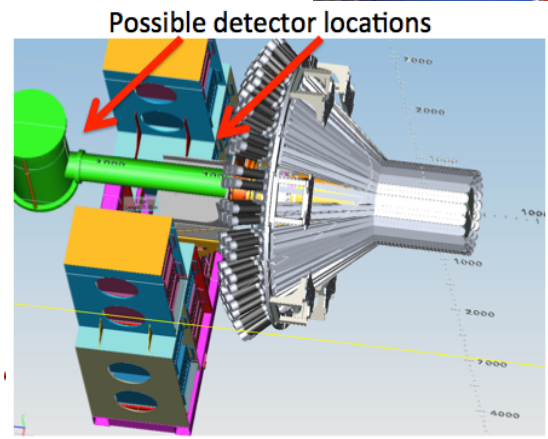
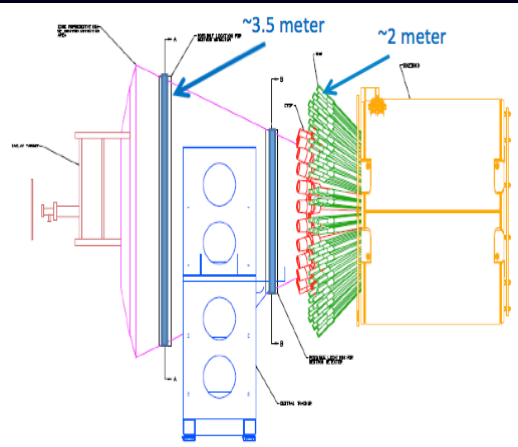
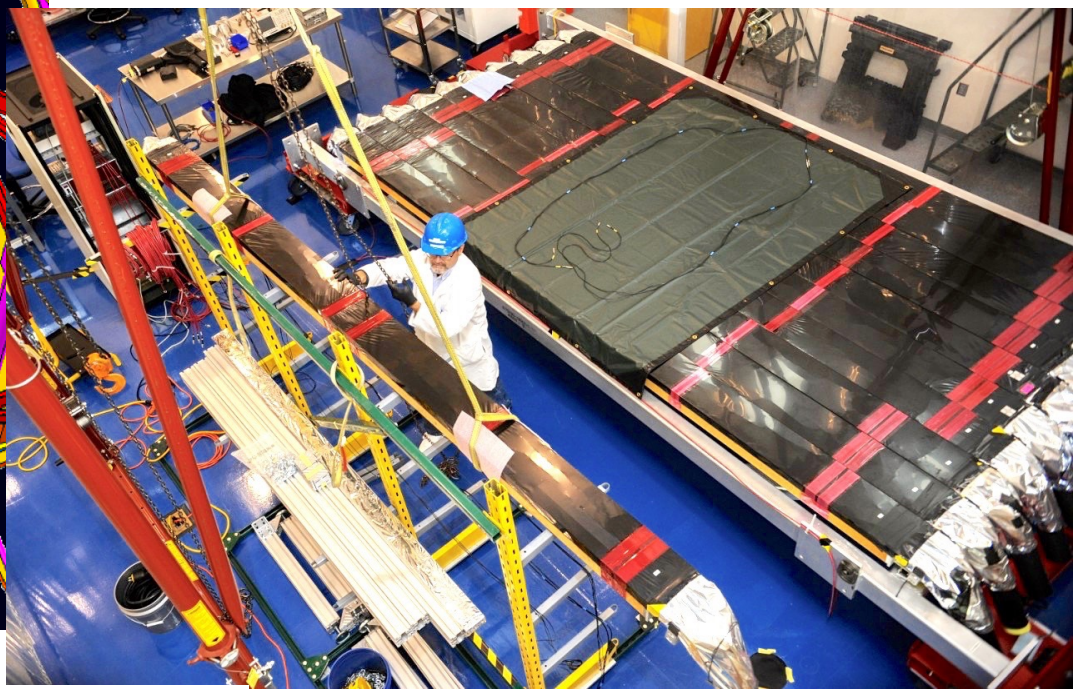
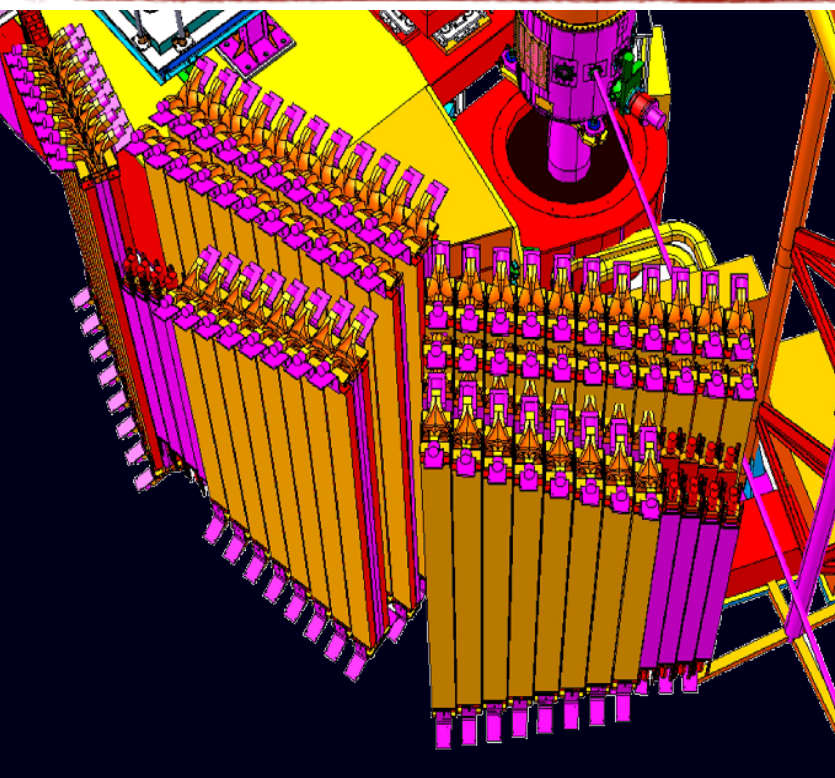
- Decrease with Q^2
- Increase with W'
- Not sensitive to x'
- Small for $\theta_{pq} > 107^\circ$

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



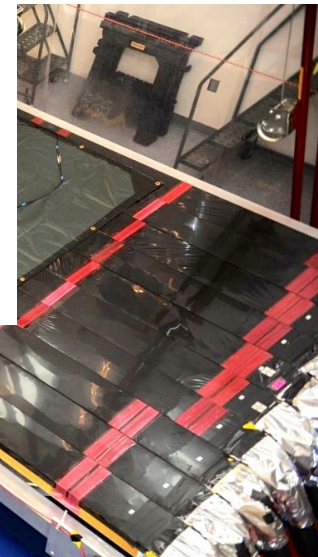
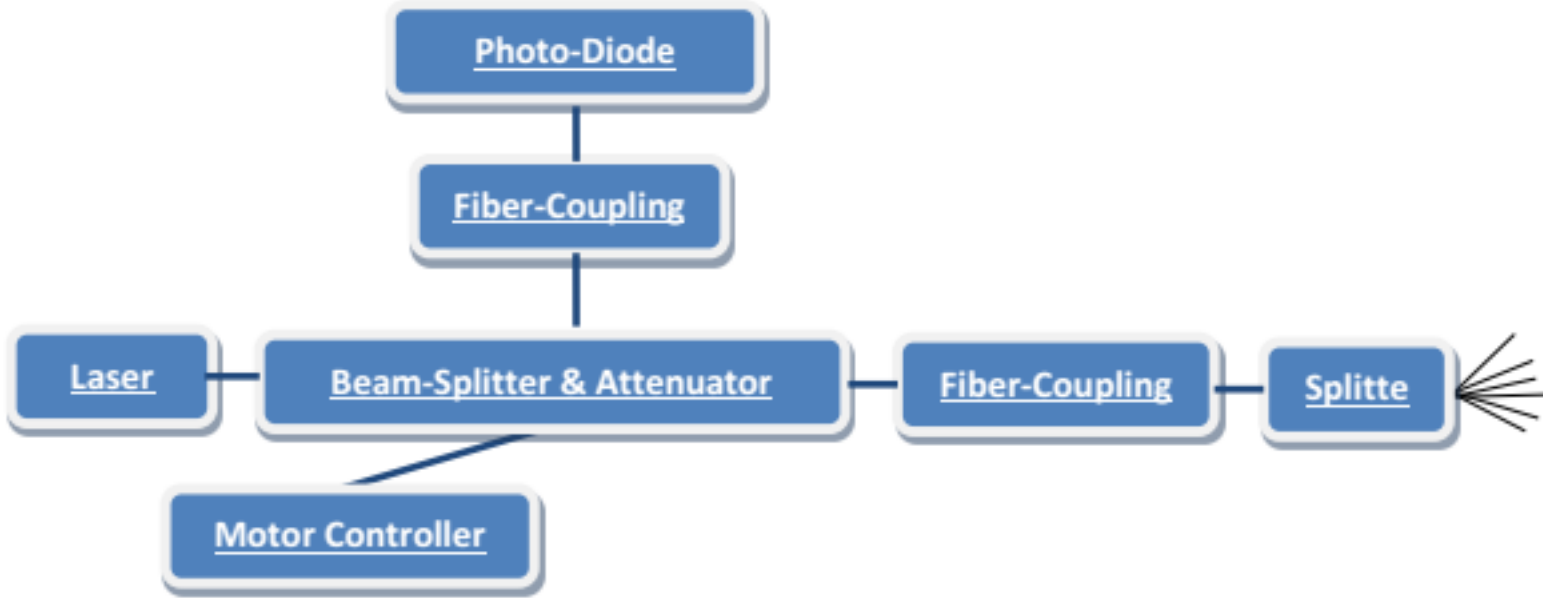
Building Large-Acceptance Detectors

Large Acceptance Detector (LAD@Hall-C)



Backward Angle Neutron Detector (BAND@Hall-B)

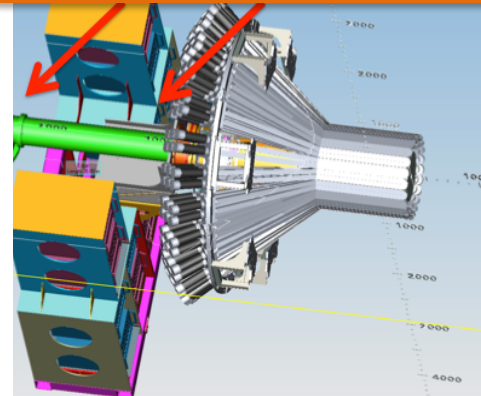
R&D @ MIT /
Construction @ BATES



+ Building a laser calibration system



Fig 2: Standa STA-01-TH Laser



Possible detector locations

Backwa
Detecto
R
Const



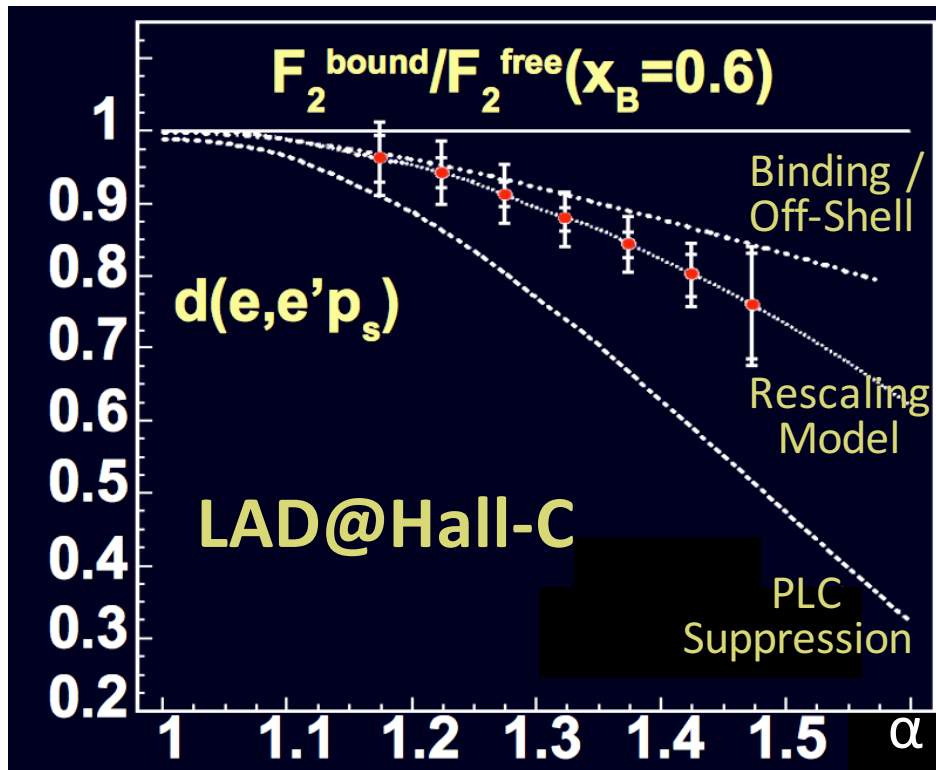


Kinematics and Uncertainties

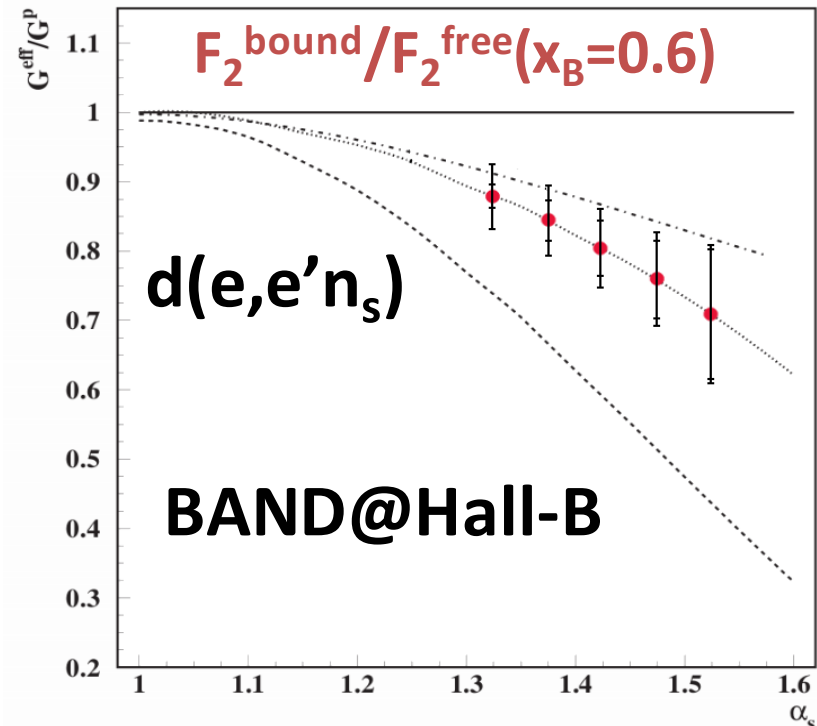


- Tagging allows to extract the structure function in the nucleon reference frame: $x' = \frac{Q^2}{2(\bar{q} \cdot \bar{p})}$
- Expected coverage: $x' \sim 0.3$ & $0.45(0.5) < x' < 0.55(0.7)$ @

$W^2 > 4$ [GeV/c]²

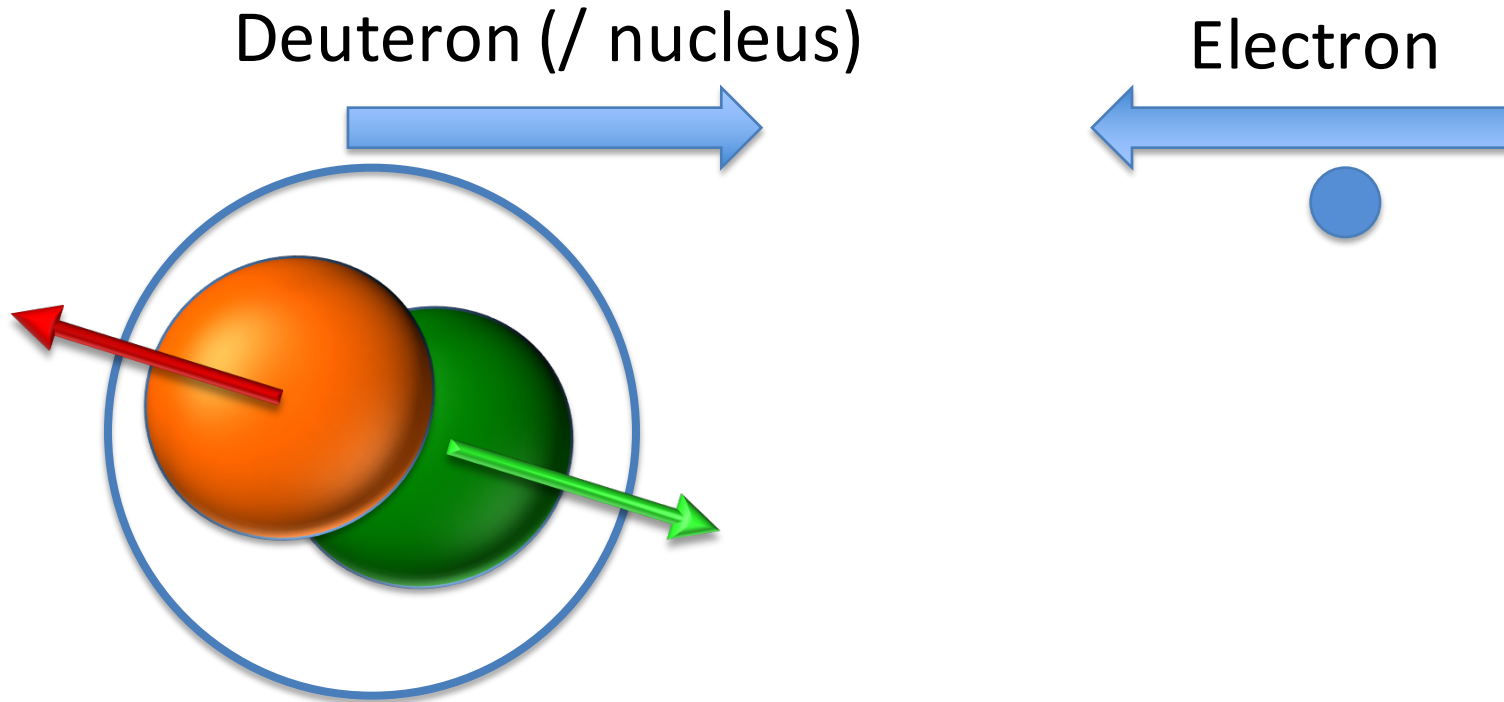


Melnitchouk et al., Z. Phys. A 359, 99-109 (1997)



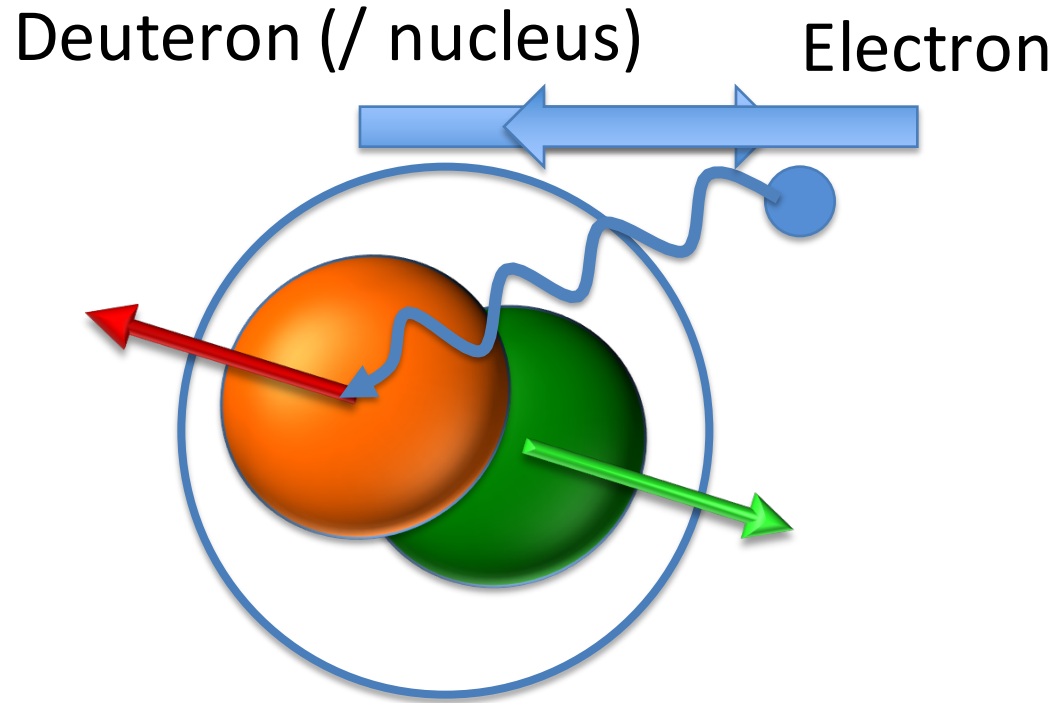


Collider Concept...



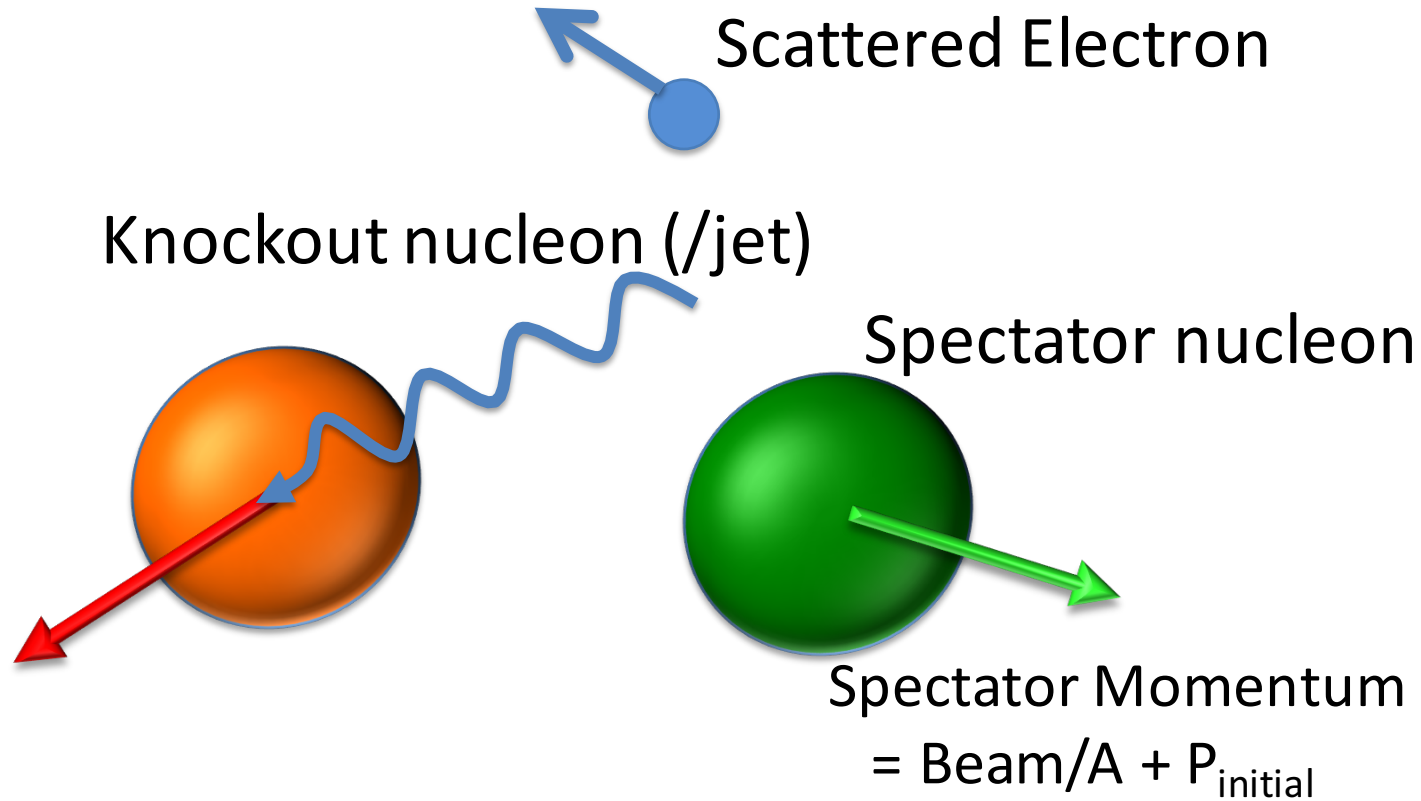


Collider Concept...





Collider Concept...

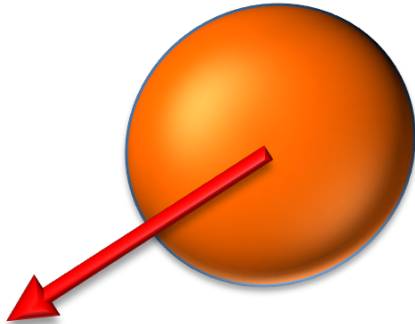




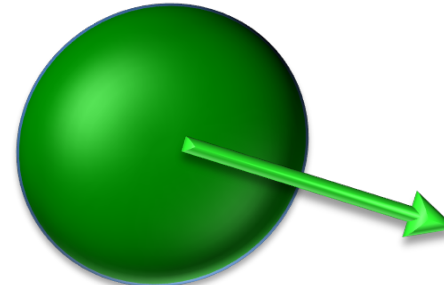
Collider Concept...



Knockout nucleon (/jet)



Spectator nucleon



$$\text{Spectator Momentum} = \text{Beam}/A + P_{\text{initial}}$$

Signature of Correlations:

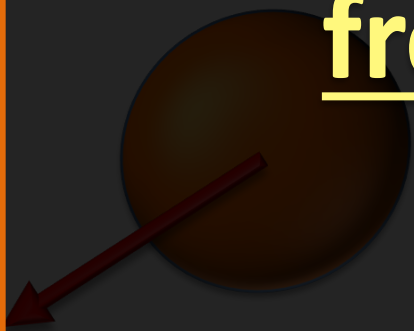
Spectator momentum > beam momentum



Collider Concept...



Note: Detection of recoils
from NUCLEI is more
complicated...



Spectator Momentum
 $= \text{Beam}/A + P_{\text{initial}}$

Signature of Correlations:

Spectator momentum > beam momentum

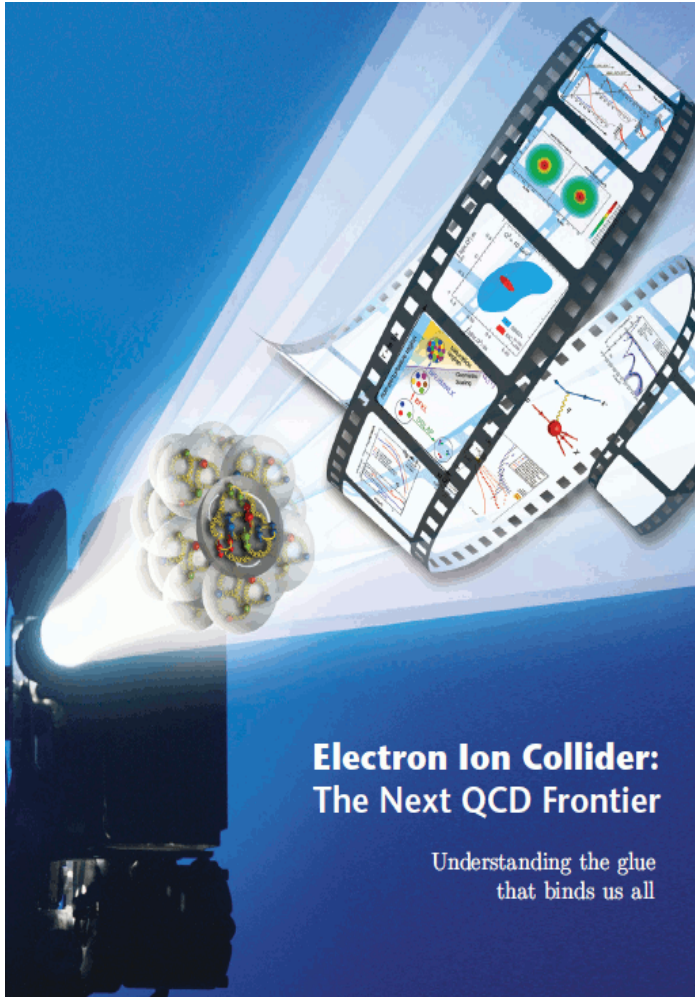


Collider Tagging Kinematics



Spectator Momentum

100 GeV d : $\gamma = 50$



Center of Mass

Lab

P_z (CM) GeV/c	P_{perp} (CM) GeV/c	P_z (Lab) GeV/c	θ_p (Lab)
0	0	50	0
0.2	0	41	0
0.4	0	34	0
0.6	0	28	0
0.6	0.2	29	0.007
0.6	0.6	36	0.02



EIC/SRC Physics Shopping List?



- Proton / Neutron structure functions – from low to high virtuality.
- NN Interactions at short distance (see Matt's talk).
- Polarization of SRC pairs.
- 2N-SRC IsoSpin structure at very high P_{miss}
- 2N-SRC dynamics in heavy, asymmetry, nuclei.
- 3N-SRC, #N-SRC ???
- Your ideas here!

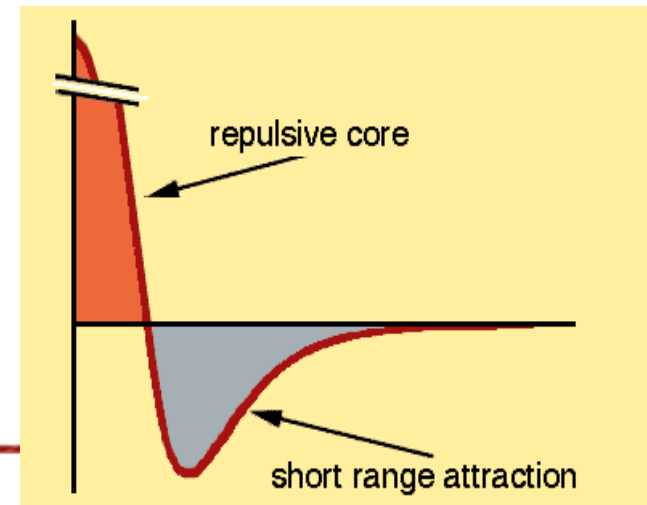
Need very versatile detectors!!



“What holds the nucleons of the atom together? In the past quarter century physicists have devoted a huge amount of experimentation and mental labor to this problem, probably more man hours than have been given to any other scientific question in the history of man kind” – Hans Bethe, Scientific American 1953

63 years later....

**Did we solve the nuclear problem??
How about the ‘partonic’ problem??**

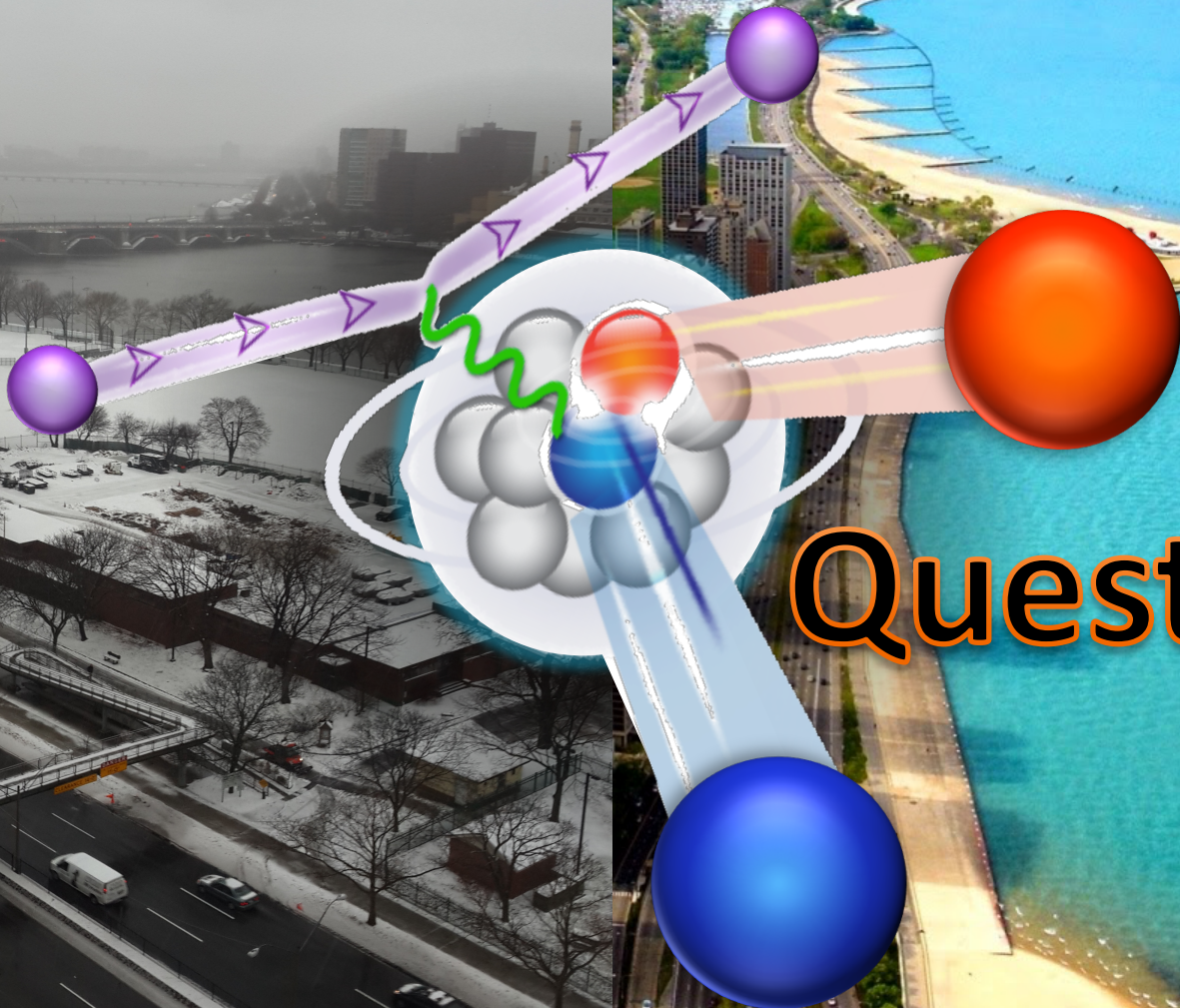


Thank You! (again...)



Questions?

Thank You! (again...)



Questions?

* Different views to wakeup to...