Measurement of Two- and Three-Nucleon Short-Range Correlations in Nuclei

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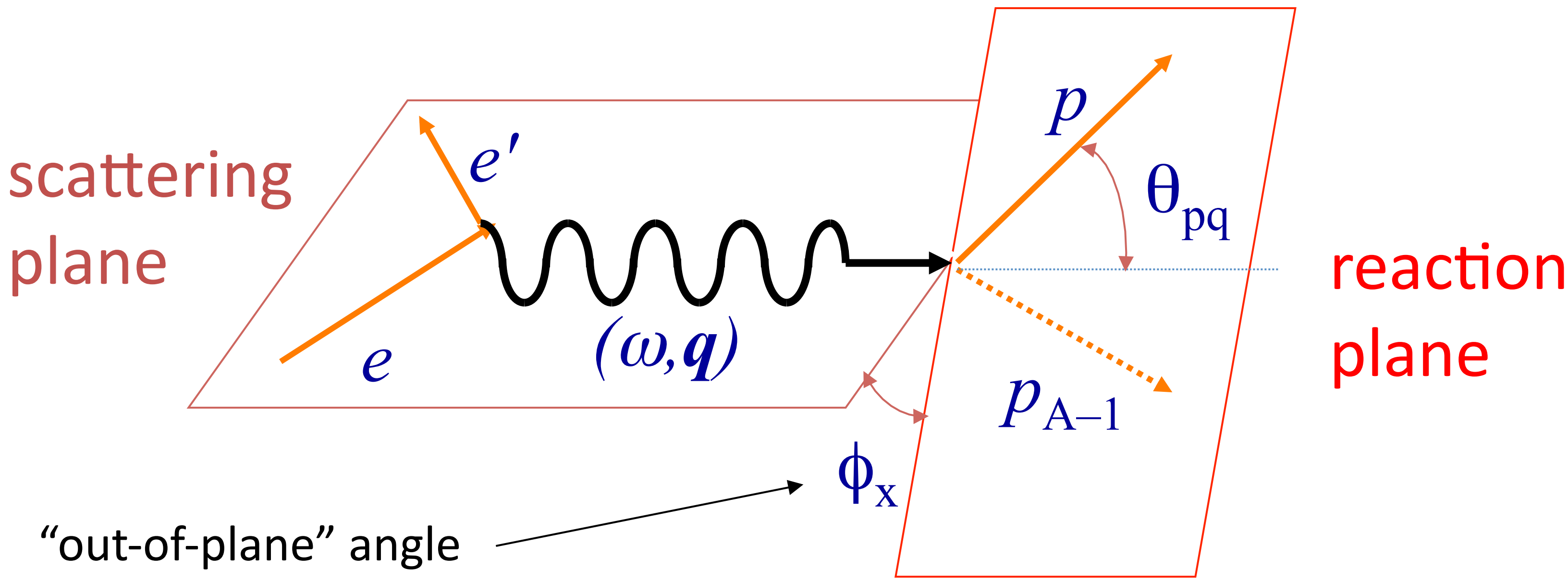
Quasi-Elastic Scattering Kinematics



Energy transfer: $\omega = e - e'$

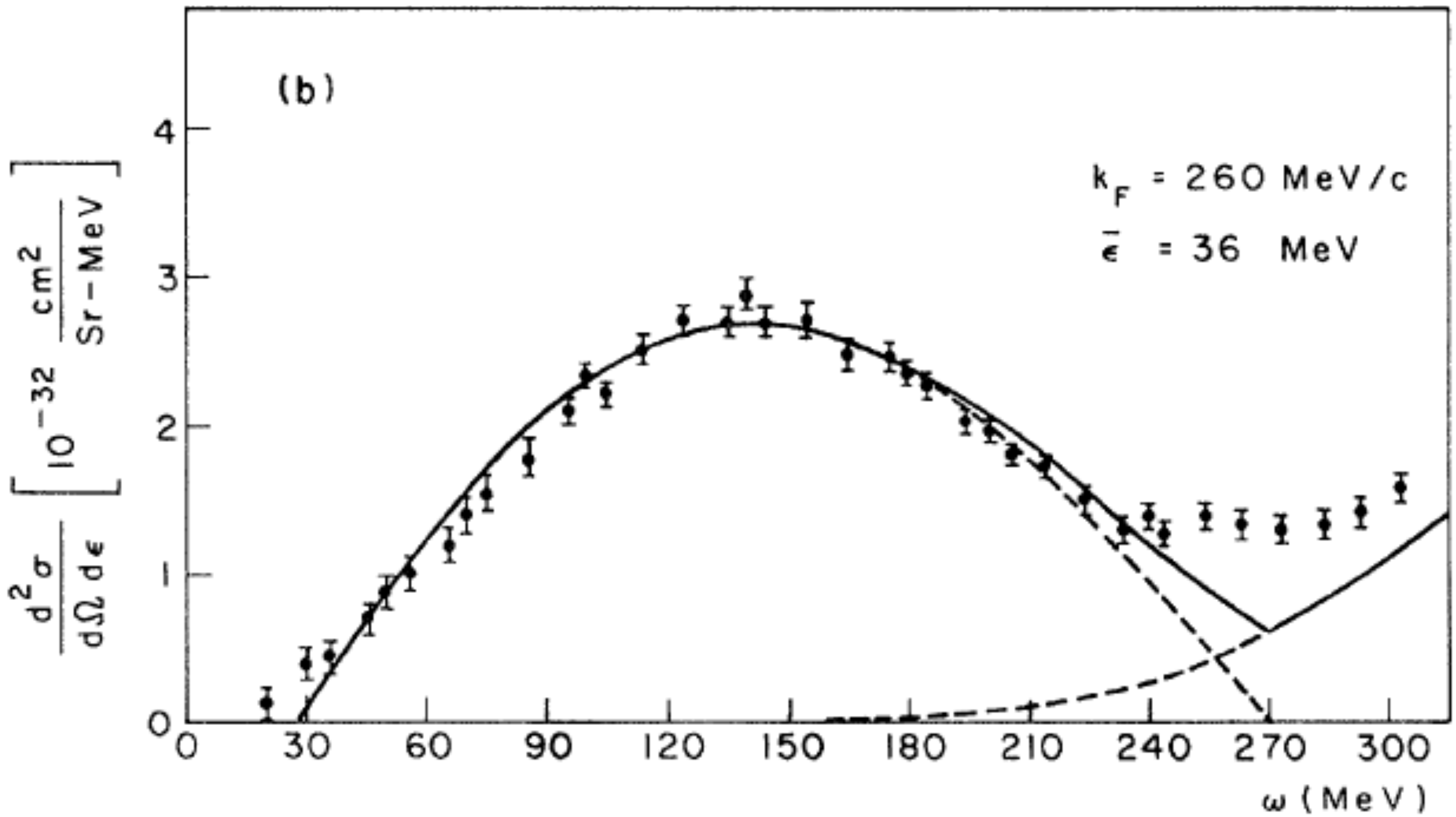
Four-momentum transfer: $Q^2 \equiv -q_\mu q^\mu = \boldsymbol{q}^2 - \omega^2$

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

Bjorken x: $x_B = Q^2/2m\omega$ ***(just kinematics!)***

Nuclear Fermi Momenta

E. Moniz, I. Sick, R. Whitney, *et al.,* Phys. Rev. Lett. **26** (1971) 445.



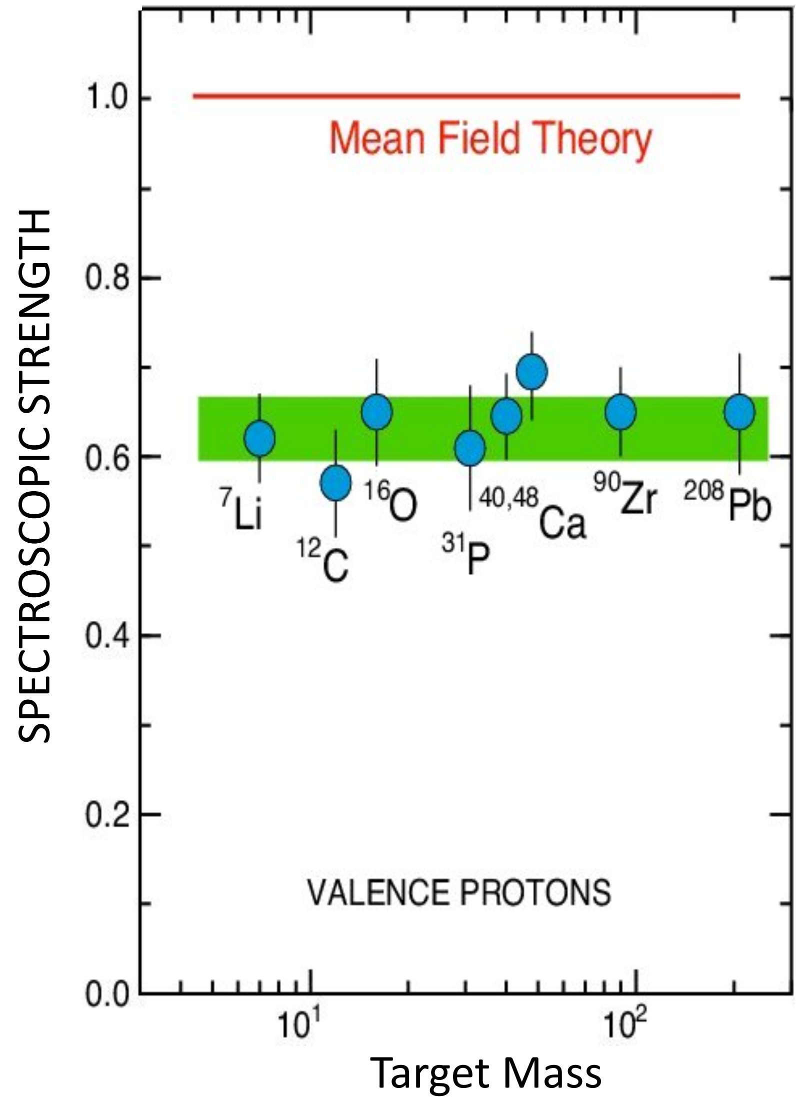
Fitted with Fermi Gas Model and nice got the **shape** of Quasi-Elastic peak.
NOTE: Missing low omega, high omega, and needs a normalization factor.

Classic (e,e'p) Results

L. Lapikas, Nucl. Phys. **A553** (1993) 297. (Review Article)

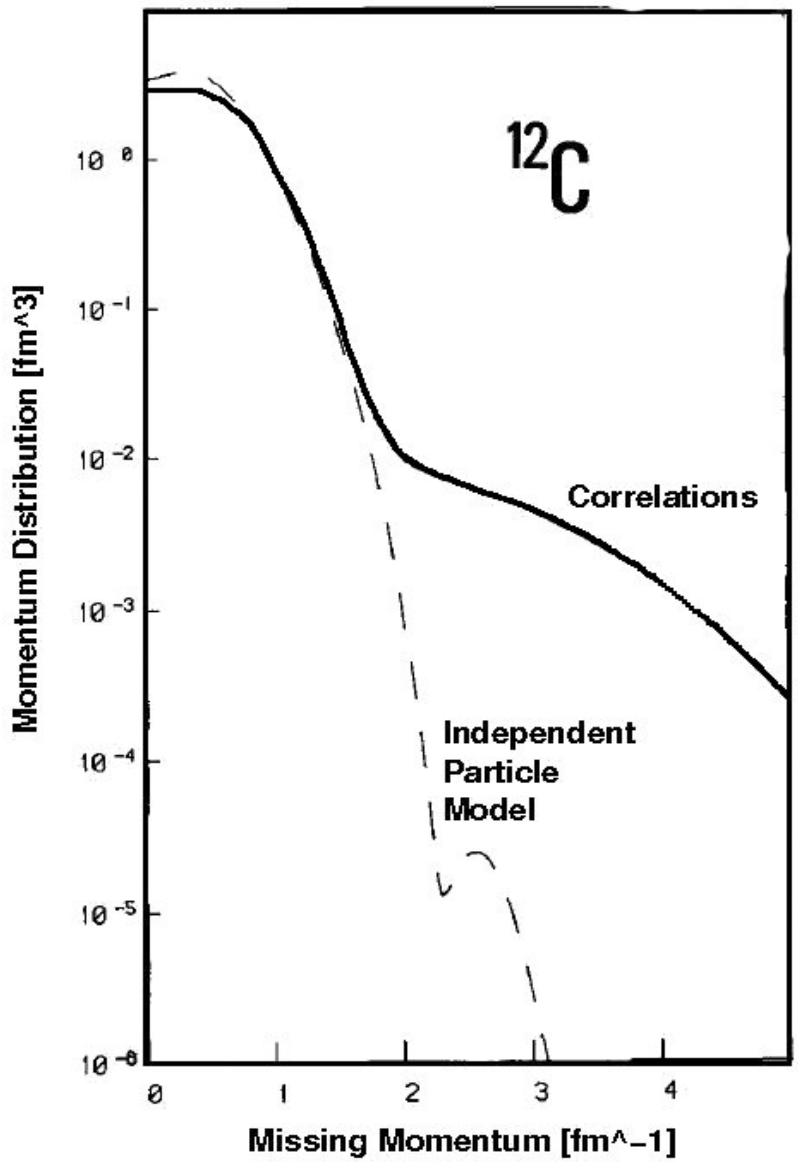
Independent-Particle Shell-Model is based upon the assumption that each nucleon moves independently in an average potential (mean field) induced by the surrounding nucleons

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.



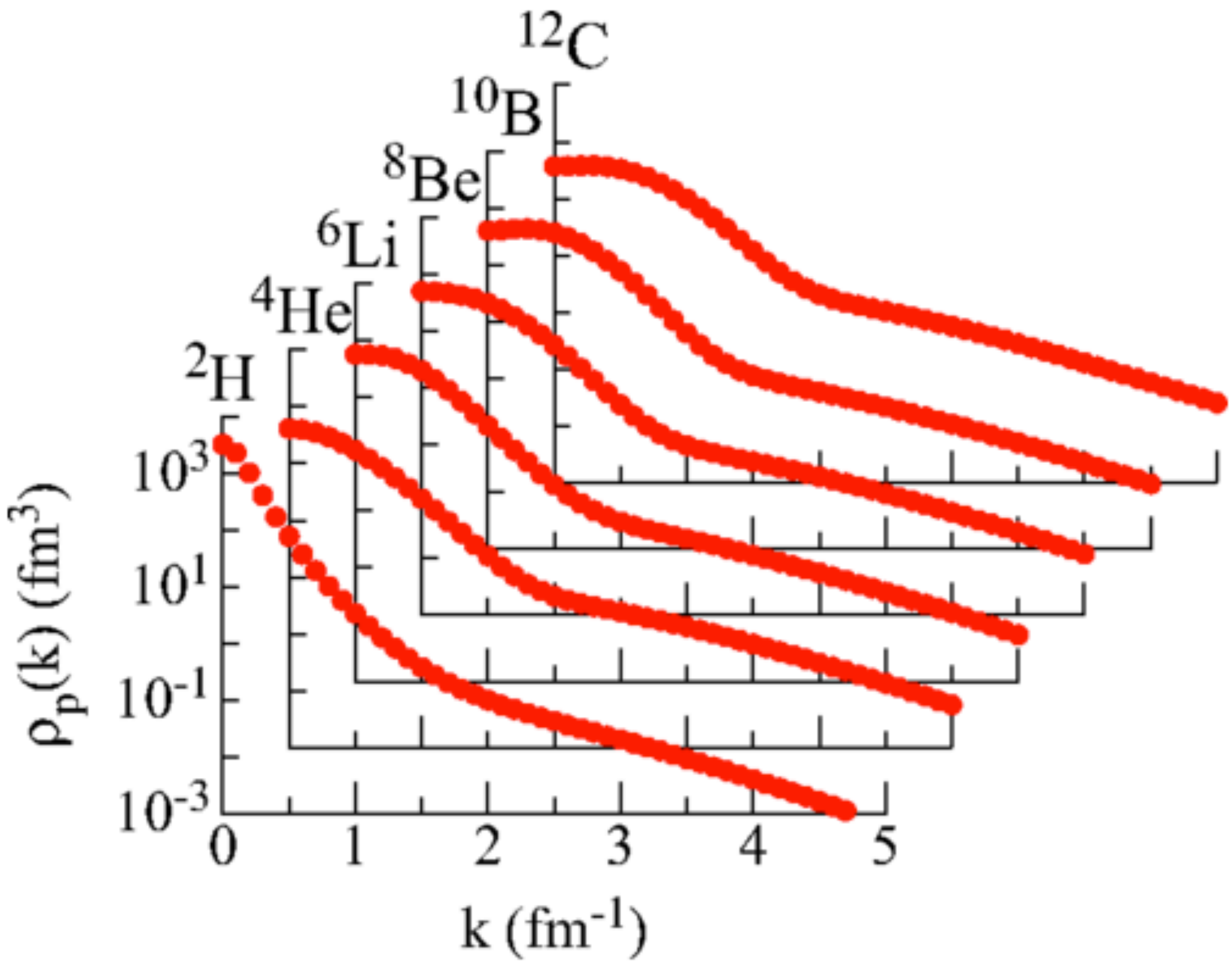
Classic Momentum Distribution

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

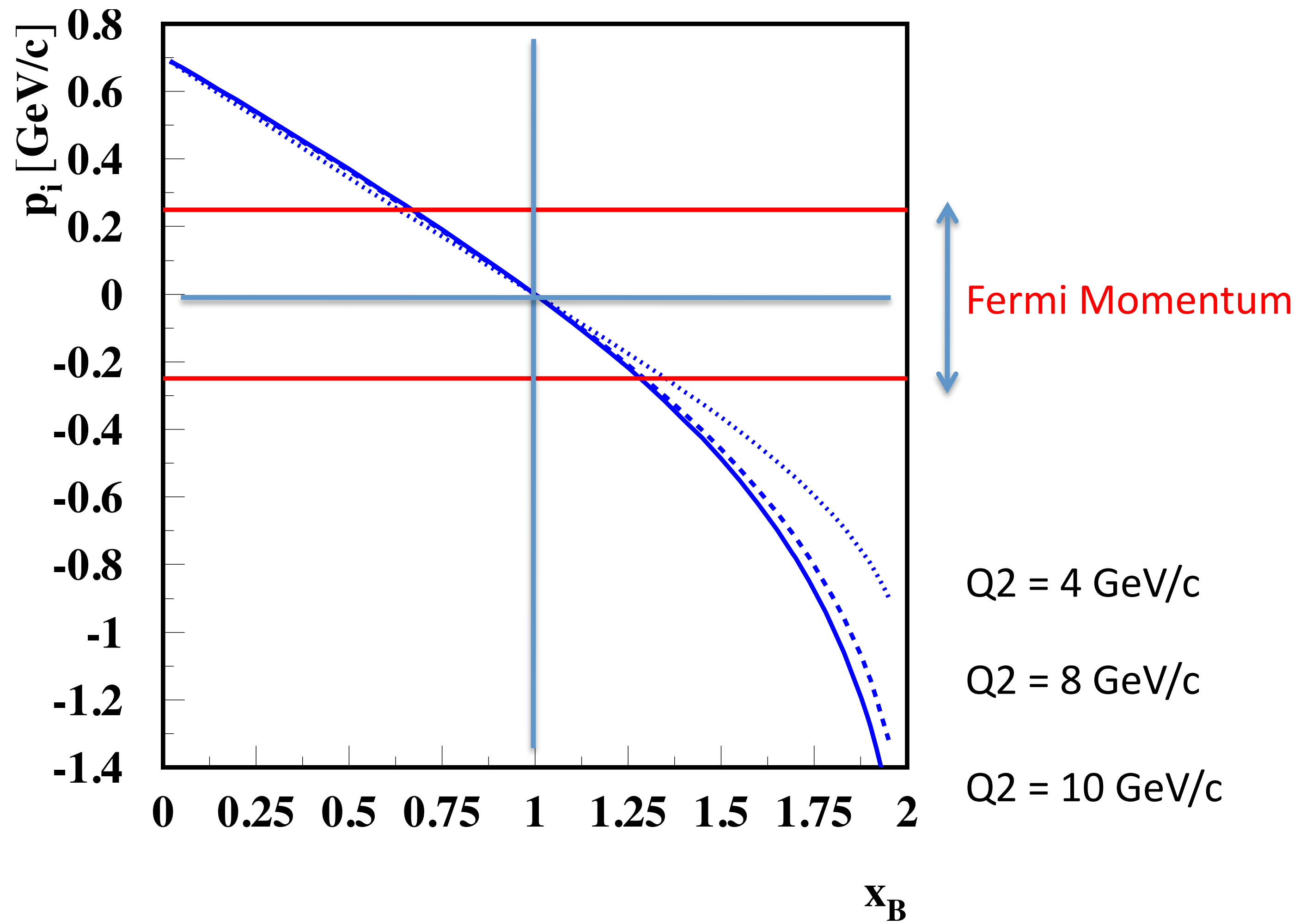


Modern AV18 and Urbana-X Results

R. Wiringa, R. Schiavilla, S. Pieper, and J. Carlson, Phys. Rev. C89 (2014) 024305.



D(e,e')pn Minimum Missing Momentum

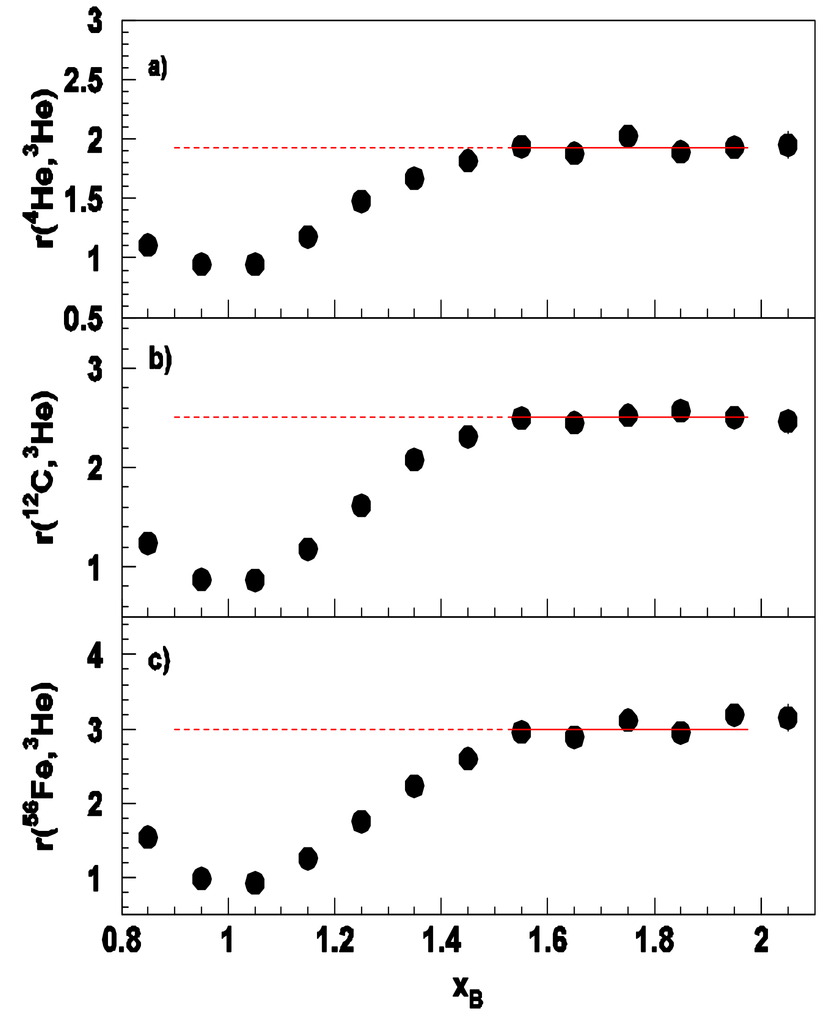


Shows the minimum initial nucleon momentum that can cause the final state electron to be in x>1 kinematics. (x>1 is forbidden for scattering from a stationary nucleon)

Nuclear Scaling Plateaus from CLAS

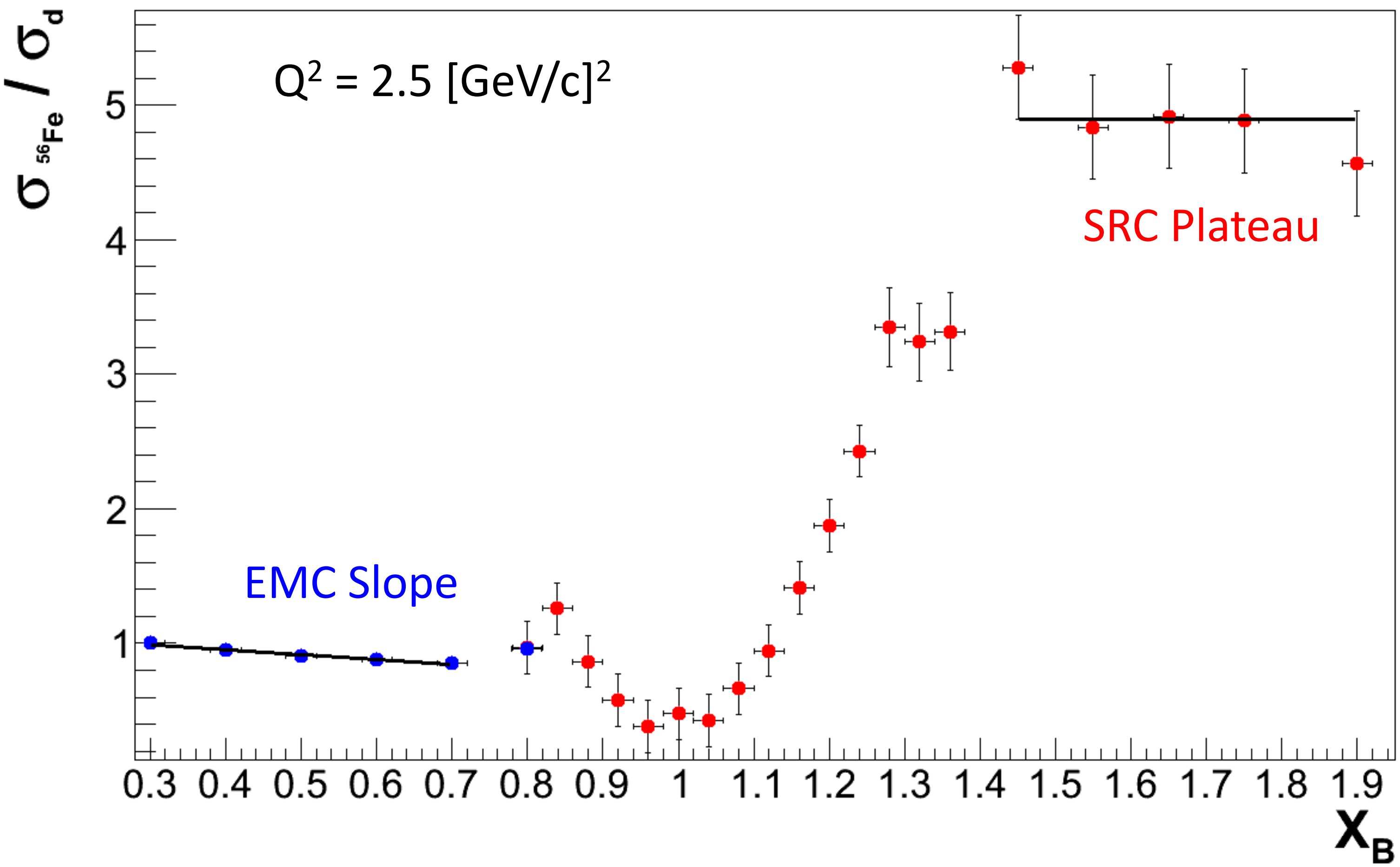
K. Sh. Egiyan *et al.,* Phys. Rev. C **68** (2003) 014313.

Originally done with SLAC data by Frankfurt et al., Phys. Rev. C **48** (1993) 2451.



Connections To Other Physics

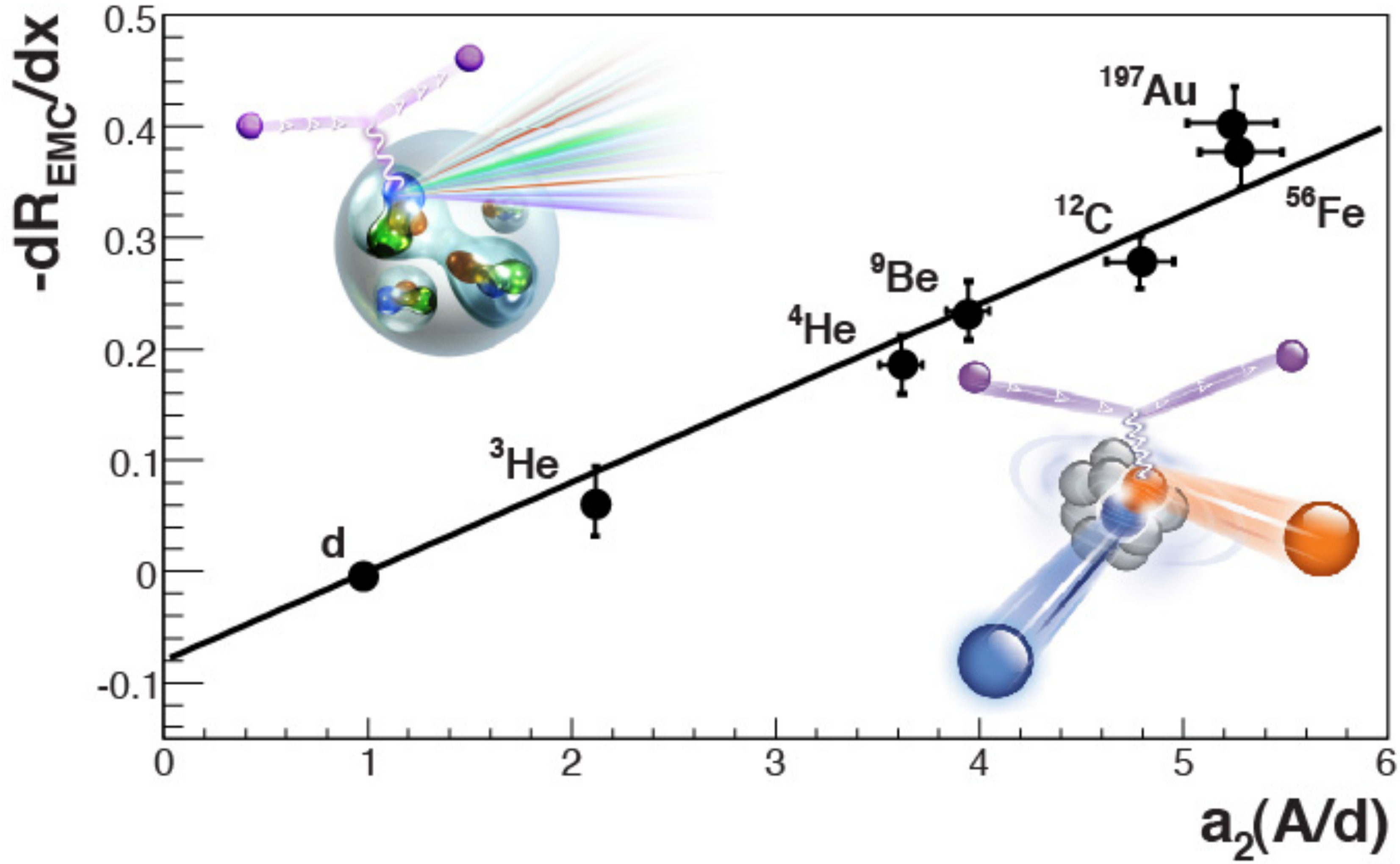
D. Higinbotham *et al.*, arXiv:1003.4497



- Scaling plateaus are likely due to proton-nucleon **local density** correlations
- EMC could also be due to local effects in the nuclear medium.

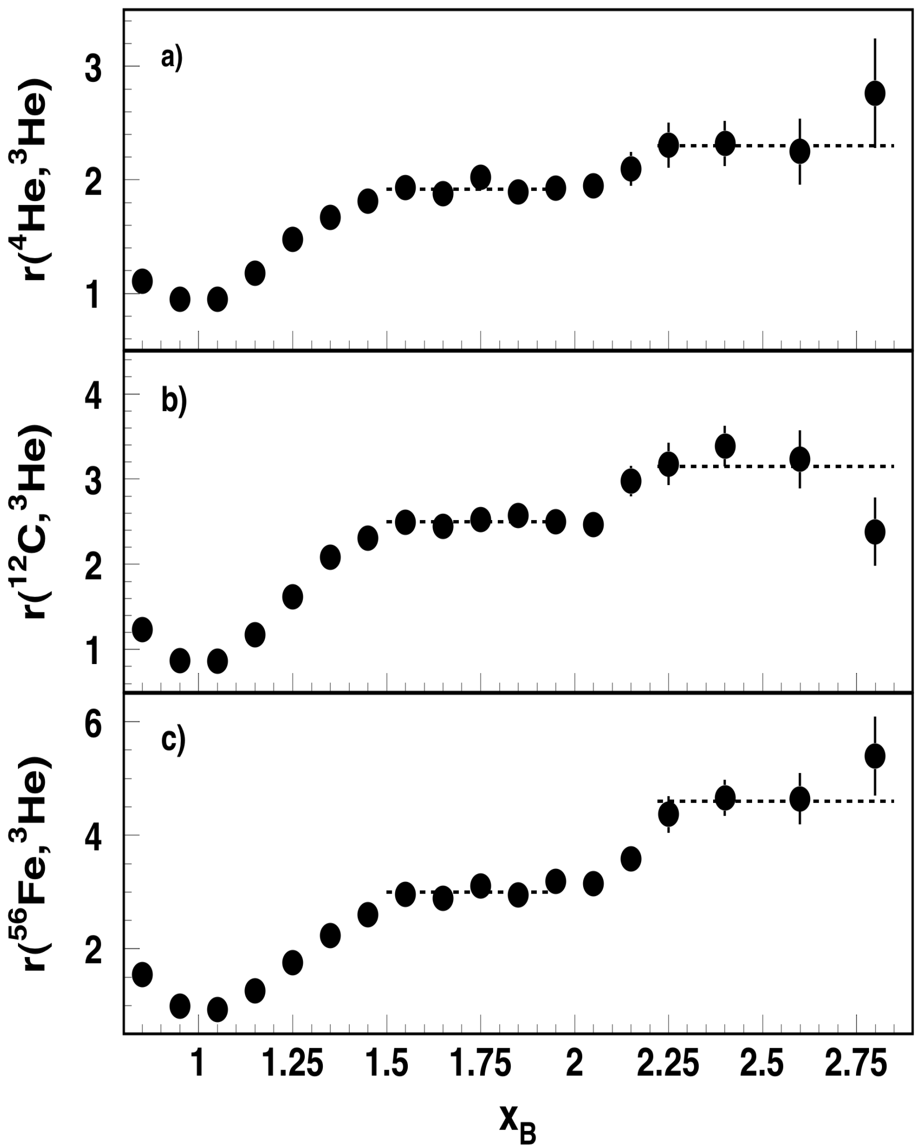
SRC and EMC Correlation

L. Weinstein *et al.*, Phys. Rev. Lett. **106** (2011) 052301.



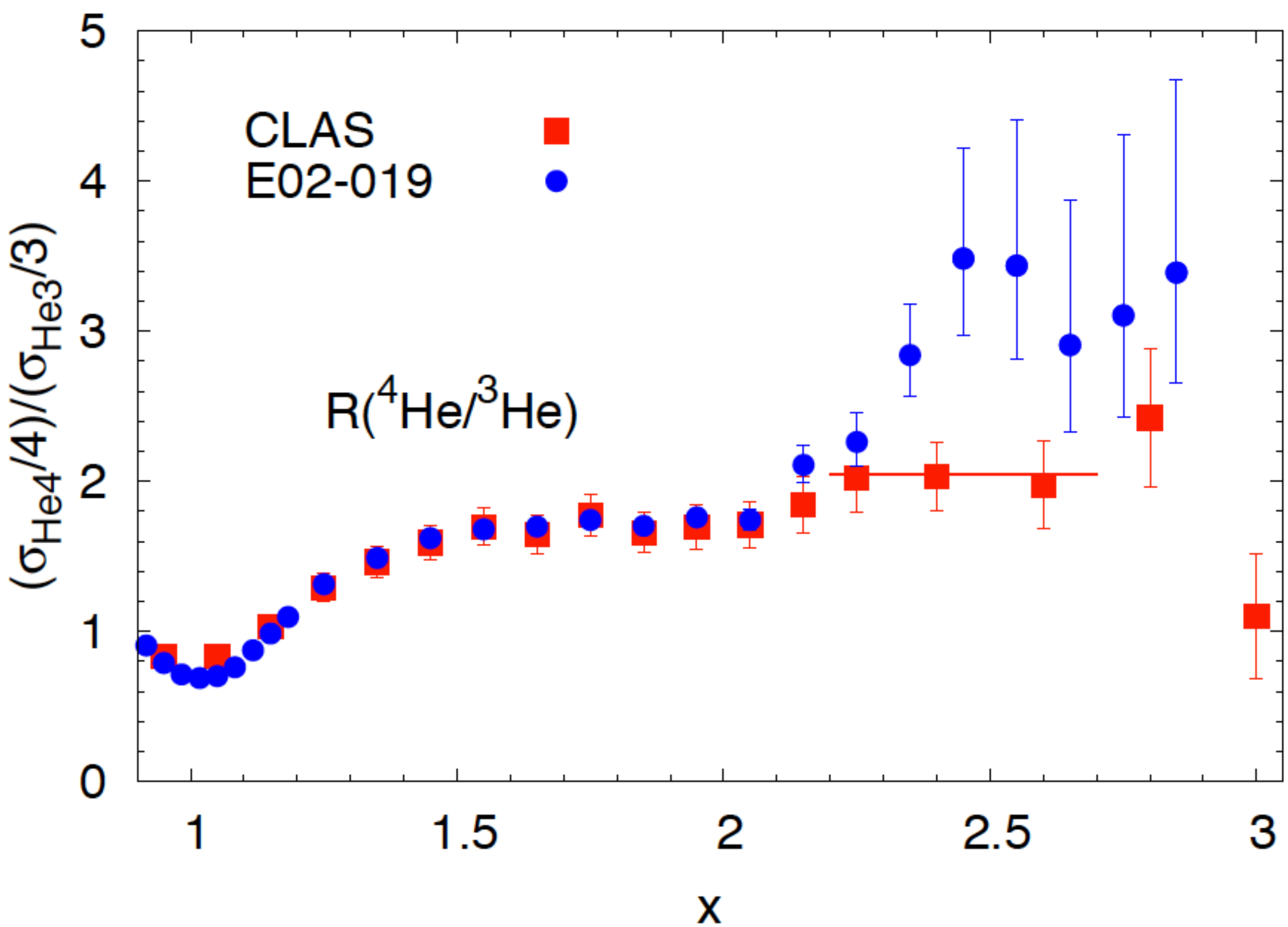
Three Nucleon Correlations

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



Hall C x>2 Data Gives Different Result

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

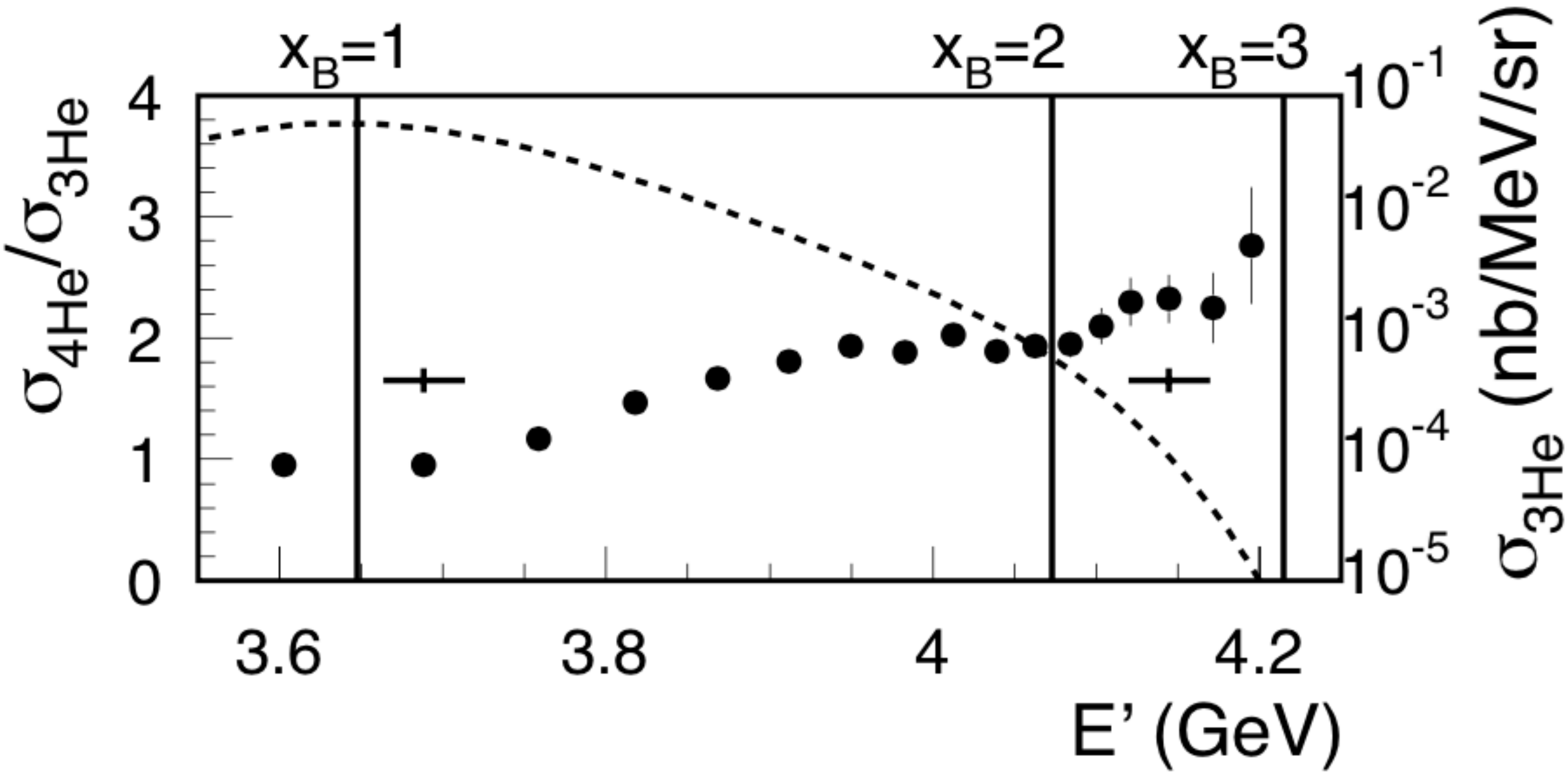


CLAS: mean 1.6 $[\mathrm{GeV/c}]^2$
Hall C: 2.9 $[\mathrm{GeV/c}]^2$

- Up to x_B=2.2 nice agreement in both the QE region and SRC regions.
- Note: the stat. error of the CLAS data seems to be almost the same x_B = 2.2 & 2.4 ?!

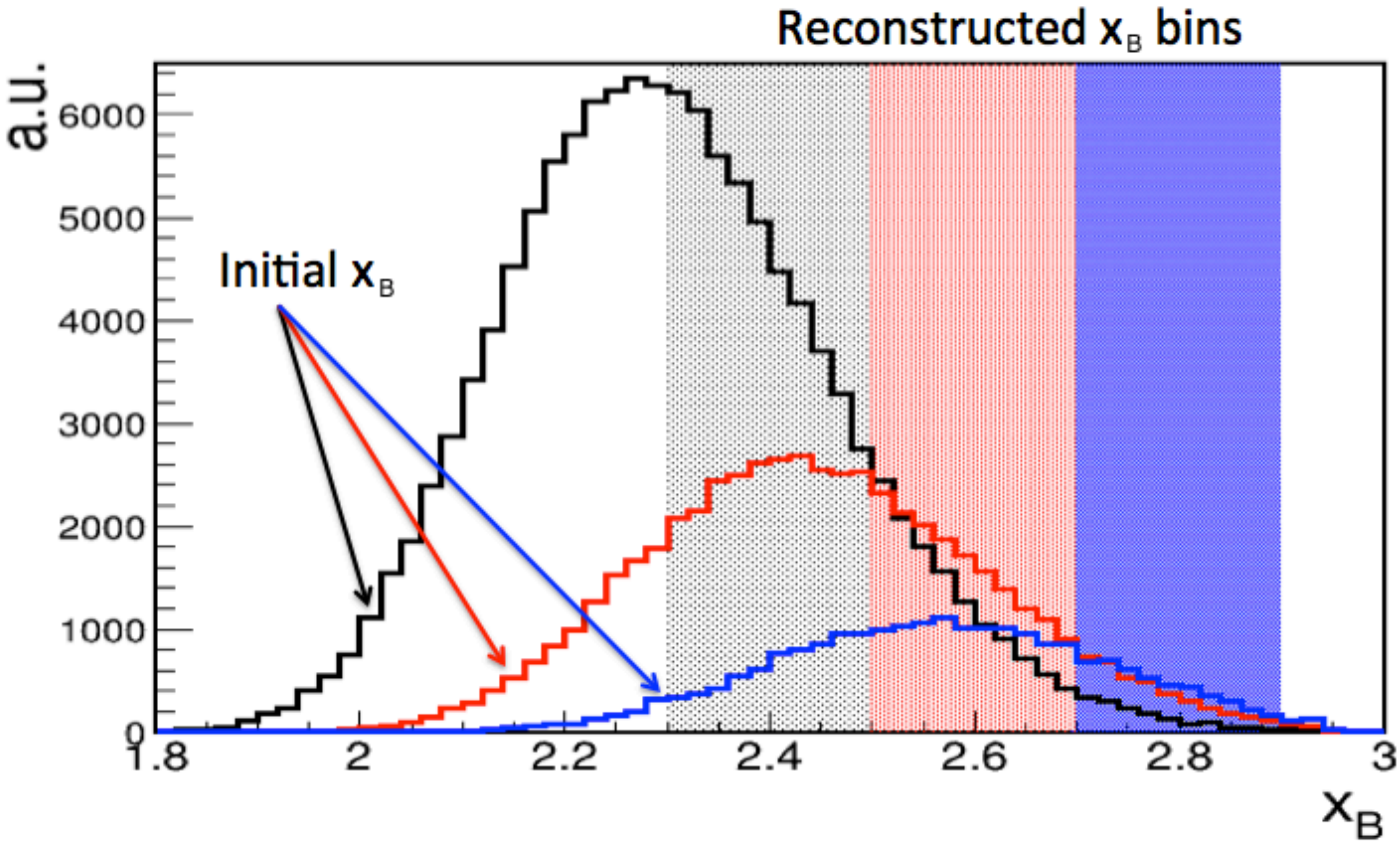
Plotting CLAS Results vs. E’

D. Higinbotham and O. Hen, Phys. Rev. Lett. **114** (2015) 169201.



Reverse Engineering Where Events Came From

D. Higinbotham and O. Hen, Phys. Rev. Lett. **114** (2015) 169201.



Shifts for ^{4}He are different, making it necessary go back to the original data as only ratios were published. Also note, that for these bins, Egiyan *et. al* only has ten's of events.

Draft of New Hall A x>2 Data

Analysis by Zhihong Ye.

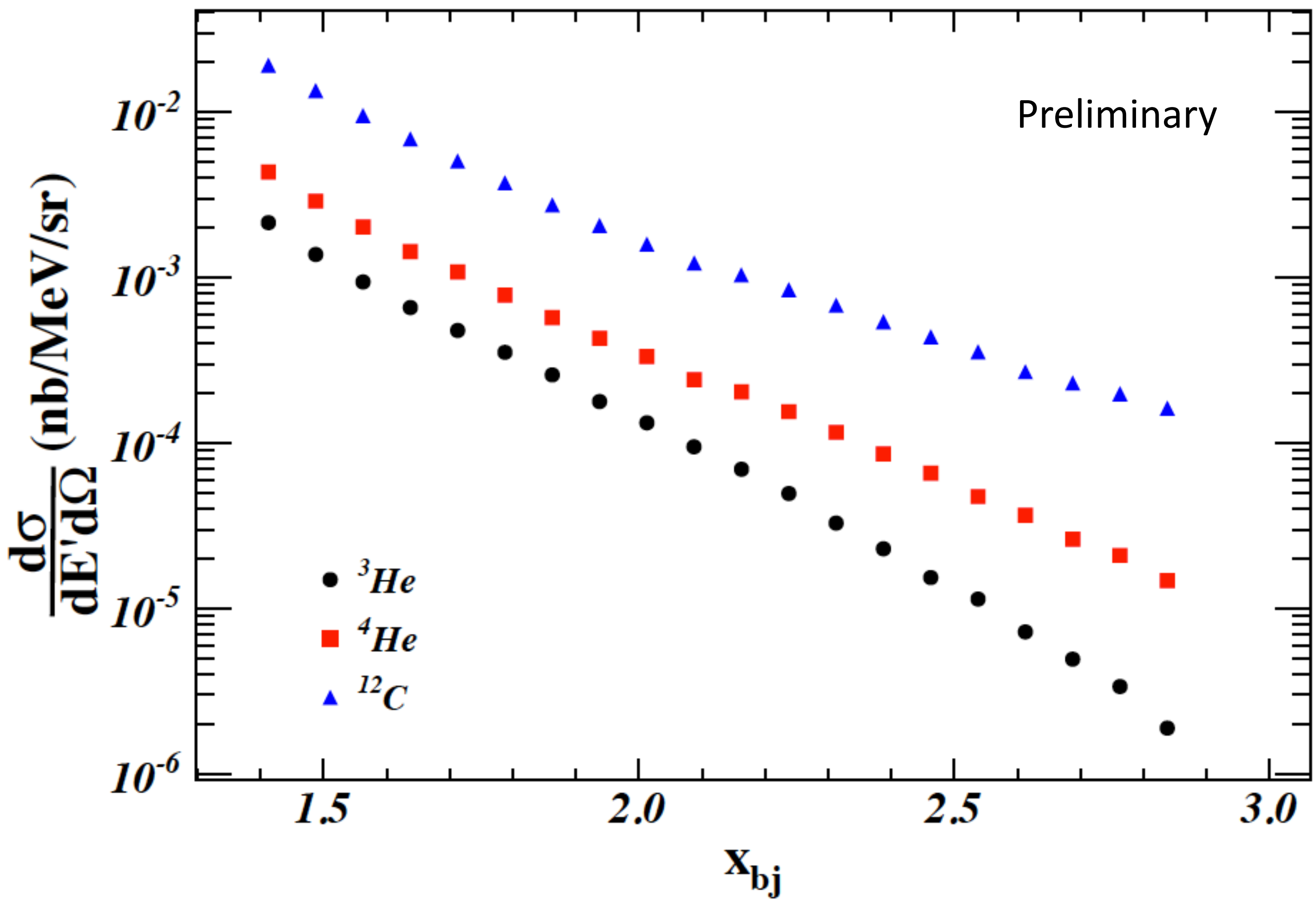
Search for three-nucleon short-range correlations in nuclei

Z. Ye,[1,2] P. Solvignon,[3,4] J. Arrington,[5] D. Day,[1] D. W. Higinbotham,[3] P. Aguilera,[6] Z. Ahmed,[7] H. Albataineh,[8] K. Allada,[9] B. Anderson,[10] D. Anez,[11] K. Aniol,[12] J. Annand,[13] W. Armstrong,[14] T. Averett,[15] T. Badman,[4] H. Baghdasaryan,[1] X. Bai,[16] A. Beck,[17] S. Beck,[17] V. Bellini,[18] F. Benmokhtar,[19] W. Bertozzi,[20] J. Bittner,[21] W. Boeglin,[22] A. Camsonne,[3] C. Chen,[23] J.-P. Chen,[3] K. Chirapatpimol,[1] E. Cisbani,[24] M. M. Dalton,[1] A. Daniel,[25] C. W. de Jager,[3,1] R. De Leo,[26] W. Deconinck,[20] M. Defurne,[27] D. Flay,[14] N. Fomin,[28] M. Friend,[19] S. Frullani,[24] E. Fuchey,[14] F. Garibaldi,[24] D. Gaskell,[3] S. Gilad,[20] R. Gilman,[29,3] O. Glamazdin,[30] C. Gu,[1] P. Gueye,[23] D. Hamilton,[13] C. Hanretty,[31] J.-O. Hansen,[3] M. Hashemi Shabestari,[1] O. Hen,[32] T. Holmstrom,[21] M. Huang,[2] S. Iqbal,[12] G. Jin,[1] N. Kalantarians,[33] H. Kang,[34] A. Kelleher,[20] M. Khandaker,[35] I. Korover,[32] J. LeRose,[3] J. Leckey,[36] R. Lindgren,[1] E. Long,[4] J. Mammei,[37] D. J. Margaziotis,[12] P. Markowitz,[22] A. Marti Jimenez-Arguello,[38] D. Meekins,[3] Z. Meziani,[14] R. Michaels,[3] M. Mihovilovic,[39] P. Monaghan,[20] N. Muangma,[20,23] C. Munoz Camacho,[38] B. Norum,[1] Nuruzzaman,[40] K. Pan,[20] S. Phillips,[4] E. Piasetzky,[32] I. Pomerantz,[32,41] M. Posik,[14] V. Punjabi,[35] X. Qian,[2] Y. Qiang,[2] X. Qiu,[42] P. E. Reimer,[5] A. Rakhman,[7] S. Riordan,[1,43] G. Ron,[44] O. Rondon-Aramayo,[1] A. Saha,[3,*] E. Schulte,[29] L. Selvy,[10] A. Shahinyan,[45] R. Shneor,[32] S. Sirca,[46] J. Sjoegren,[13] K. Slifer,[4] N. Sparveris,[14] R. Subedi,[1] V. Sulkosky,[20,21] W. Tireman,[47] D. Wang,[1] J. W. Watson,[10] L. B. Weinstein,[8] B. Wojtsekhowski,[3] S. A. Wood,[3] W. Yan,[48] I. Yaron,[32] X. Zhan,[5] J. Zhang,[3] Y. Zhang,[29] B. Zhao,[15] Z. Zhao,[1] X. Zheng,[1] P. Zhu,[48] and R. Zielinski[4]
(The Jefferson Lab Hall A Collaboration)

Goal to have a draft for the collaboration to review by the end of the summer!

Preliminary Hall A Cross Sections

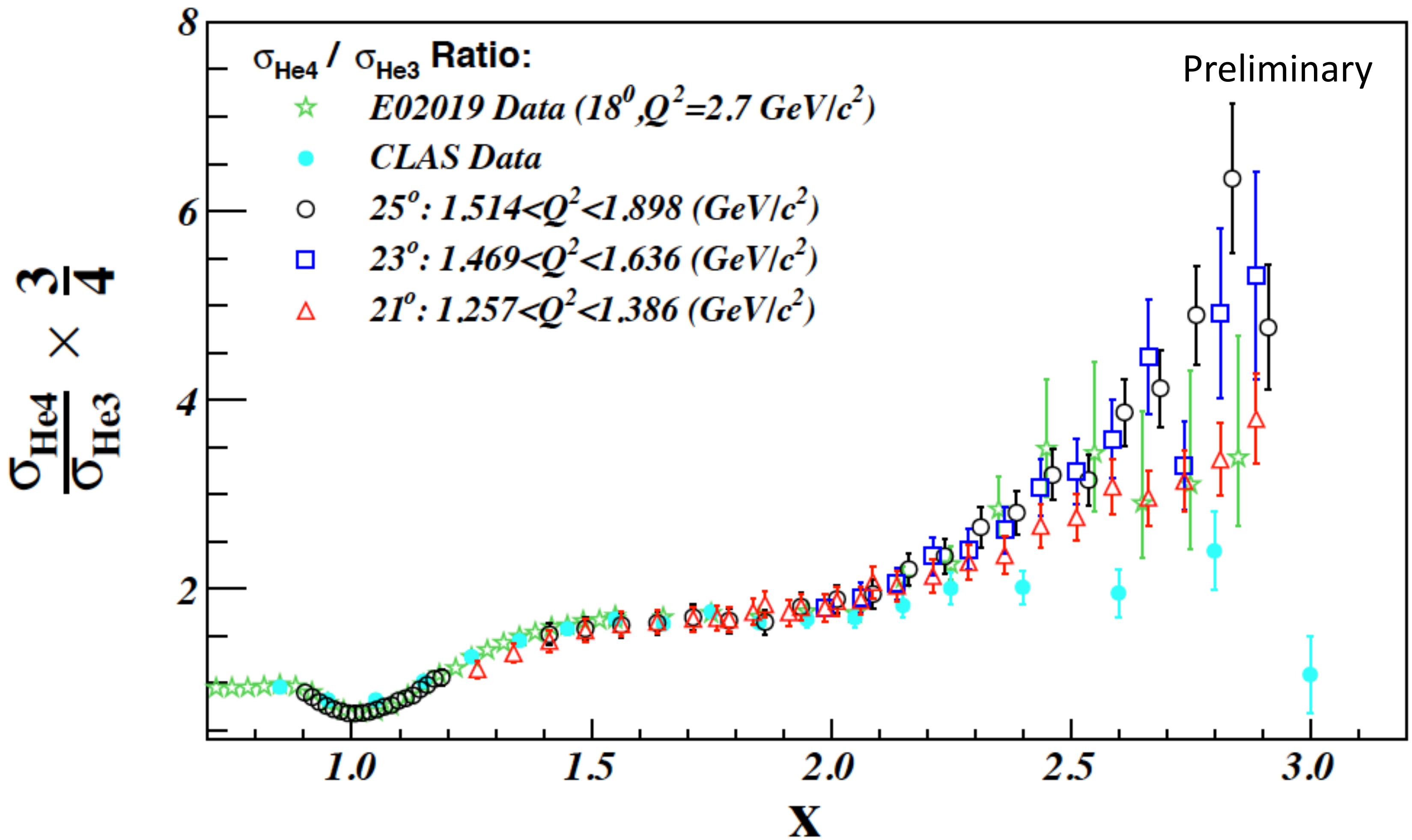
Analysis by Zhihong Ye.



Highest two x_B points not yet shown.

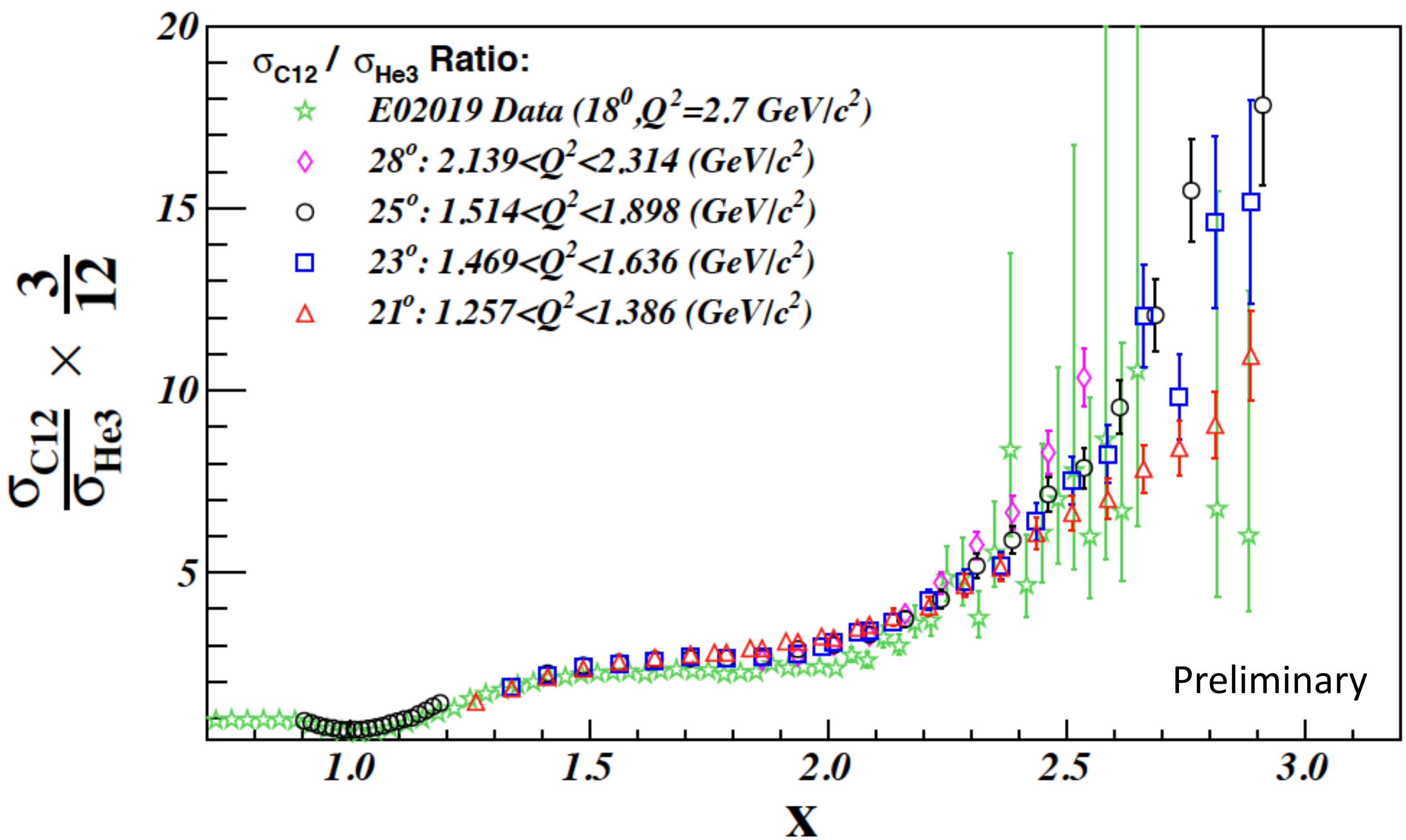
Preliminary Results

Analysis by Zhihong Ye.



Preliminary Results

Analysis by Zhihong Ye.



Summary

- Classic A(e,e'p)A-1 cross section results pointed to the need for correlations to be included in the initial-state.
- The experimental problem for many years was how to find direct evidence of these states.
- Now many x_B>1 experiments, (e,e') ratios as well as (e,e'pN), have shown evidence for the two-nucleon, high-momentum states.
- And these high-momentum states seem to nicely link to the magnitude of the deep inelastic EMC effect.
- **BUT the signature of three nucleon-correlations is proving elusive.**
- Saving the half-*million dollar* Calcium results for next time.