XEM2 Update

Zoe Wolters
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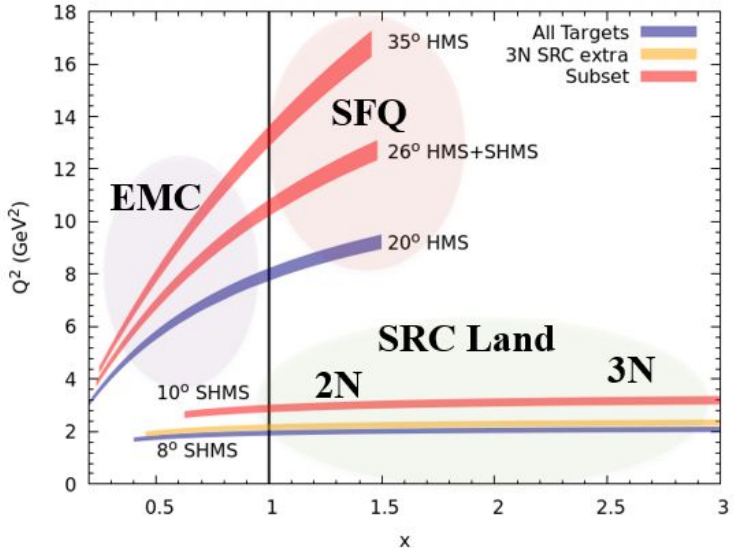
On behalf of the XEM2 Collaboration

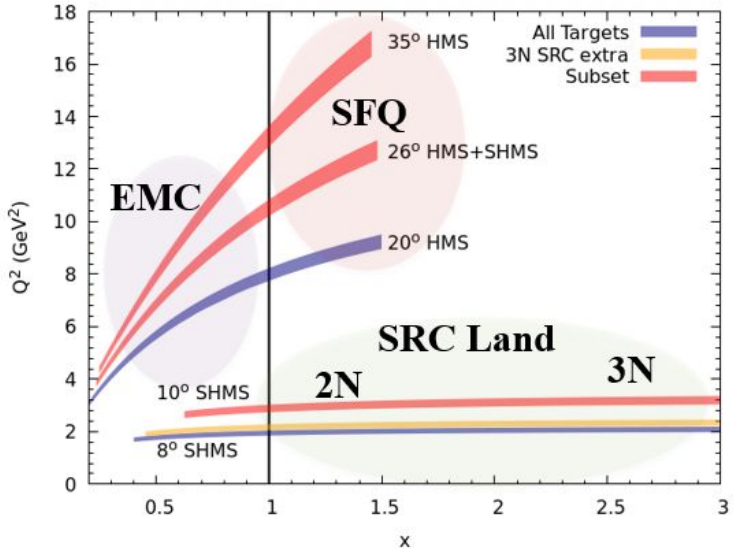
XEM2 Experiments

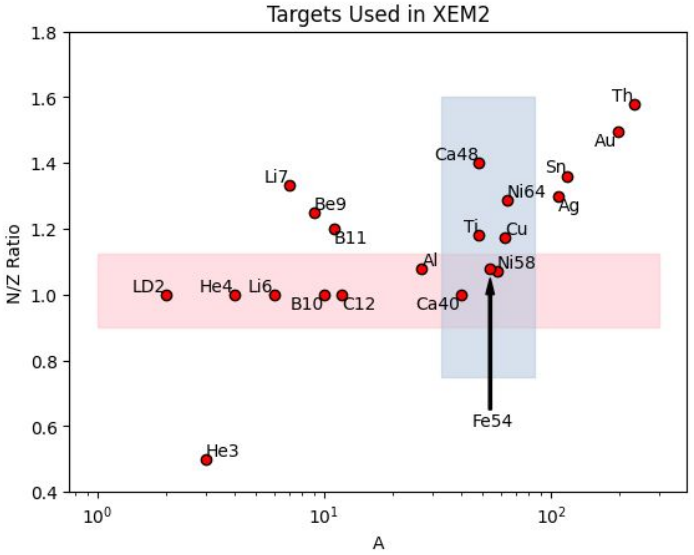
- E12-10-008: Studies of the EMC Effect (*See Abhyuday Sharda's talk for more information*)
  - Spokespersons: J. Arrington, A. Daniel, N. Fomin, and D. Gaskell

- E12-06-105: Inclusive Scattering from Nuclei x >1 in the Quasielastic Regime
  - Spokepersons: J. Arrington, D. Day, N. Fomin, and P. Solvignon



Experiment Kinematics and Targets



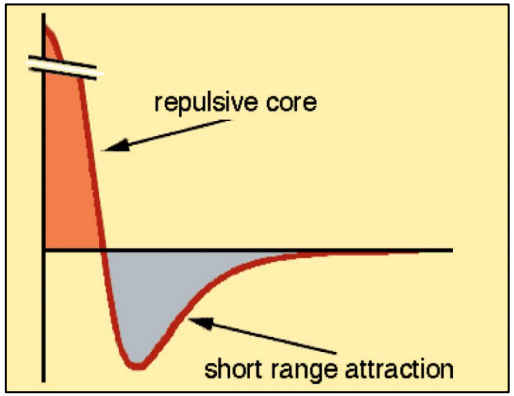


- This 2N SRCs region focuses on x range of 1.5 - 2.0
- The x > 2 region is for the first observation of 3N SRCS
- The new kinematics allow for more data on light nuclei and heavier nuclei
- Super fast quark (SFQ) region is 1 < x < 1.7
- Larger angles to explore Q^2 dependence

- Investigate cross sections with an A dependence at fixed N/Z or a N/Z dependence at fixed A
- Target nuclei were split between two target ladders

Short Range Correlations (SRCs)

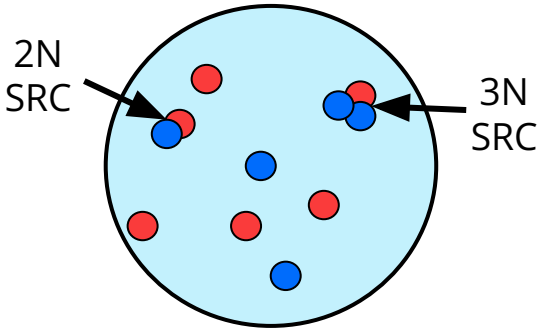
- Short Range Correlations (SRCs): A combination of a strong repulsion at short ranges and tensor attraction
- The resulting interaction creates part of the high momentum that is seen in the total nucleon momentum distribution
  - The nucleons that have these interactions are SRCs
- Cross section ratios of heavy to light nuclei are need to measure the relative probability of finding SRCs



$$\frac{2}{A}\frac{\sigma_A}{\sigma_D} = a_2(A)$$

Multiple Nuclei in a Correlation

- $1.5 < x < 2$ → 2 Nucleon (2N) Correlation
- $2.4 < x < 3$ → 3 Nucleon (3N) Correlation

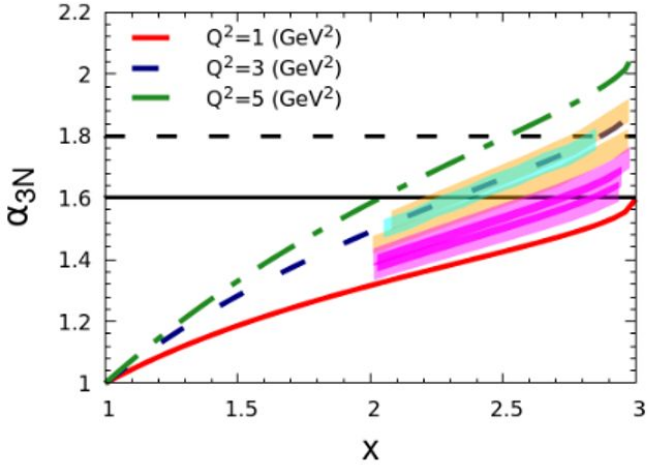


$$\sigma(x, Q^2) = \sum_{j=1}^{A} A \frac{1}{j} a_j(A)\sigma_j(x, Q^2)$$

$$= \frac{A}{2} a_2(A)\sigma_2(x, Q^2) +$$

$$\frac{A}{3} a_3(A)\sigma_3(x, Q^2) + \ldots.$$

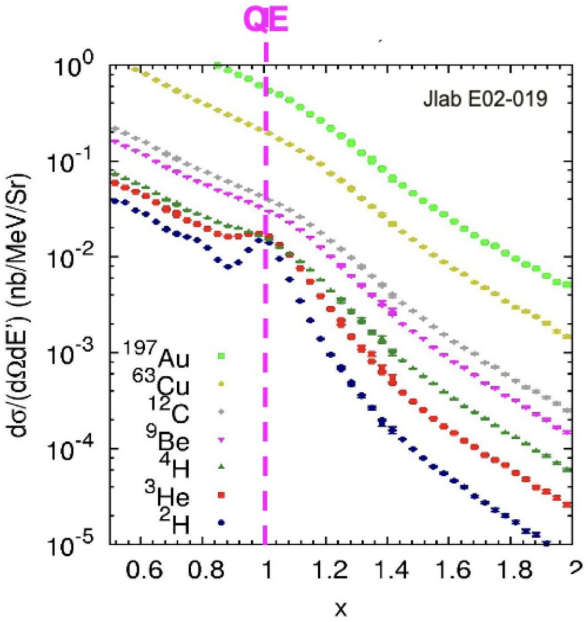
$$\frac{2}{A}\frac{\sigma_A}{\sigma_D} = a_2(A)$$

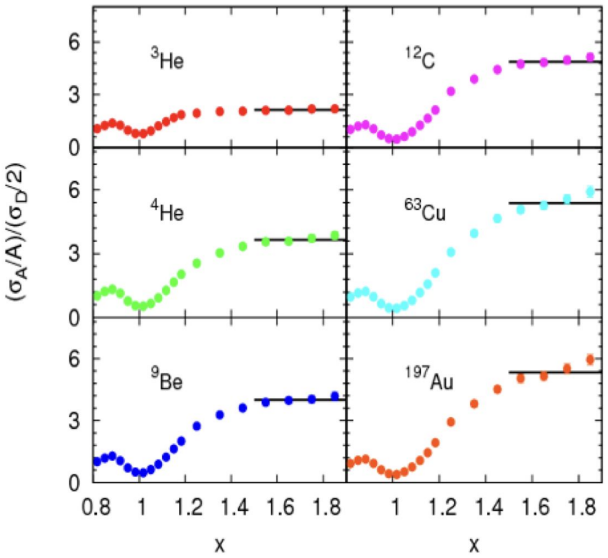


a_i refers to the light-cone momentum fraction of 3N SRCs carried by the correlated nucleon *i*

Experimentally Measuring 2N SRC Data

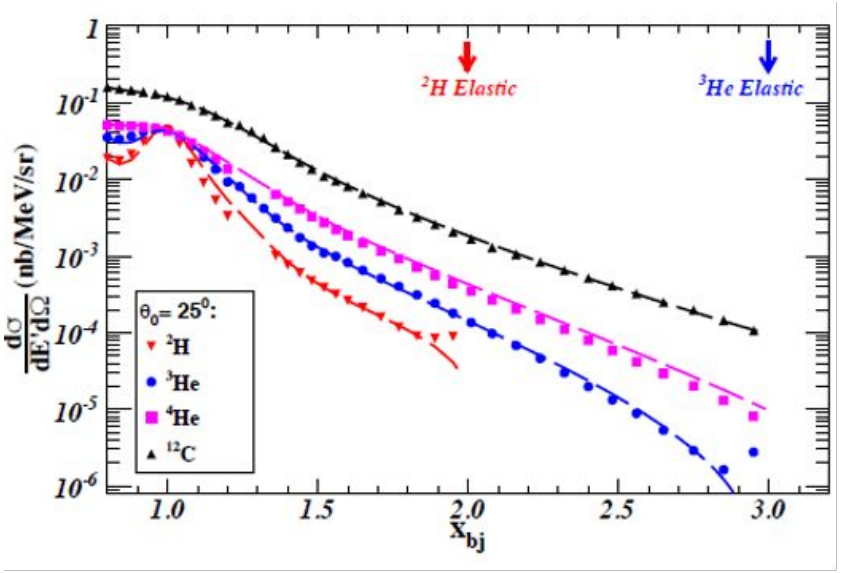
- Experimentally, SRCs are found through scattering of the Quasielastic regime (x > 1)
- Inclusive scattering is used because of its sensitivity to large x values
  - If a nucleon is detected that is a SRC pair, the cross section ratio of A/D will be a plateau





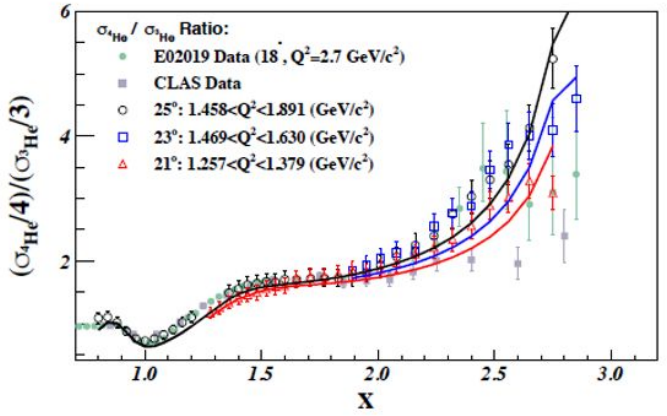
Fomin, N, *et. al. Phys.Rev.Lett.* 108 (2012)

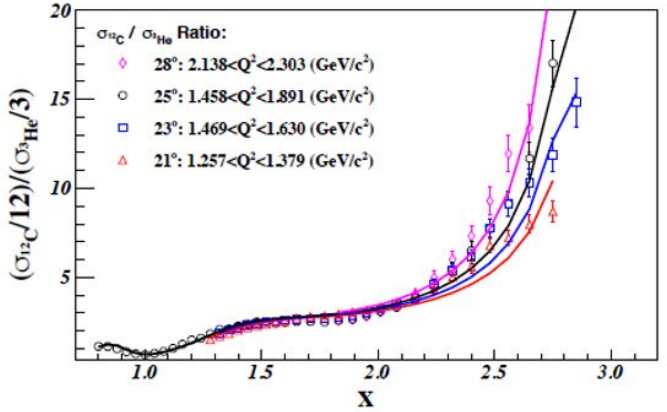
The Hunt for 3N SRCs



- Deuteron: SRC smearing similar until about x > 1.8 (begins to plateau)

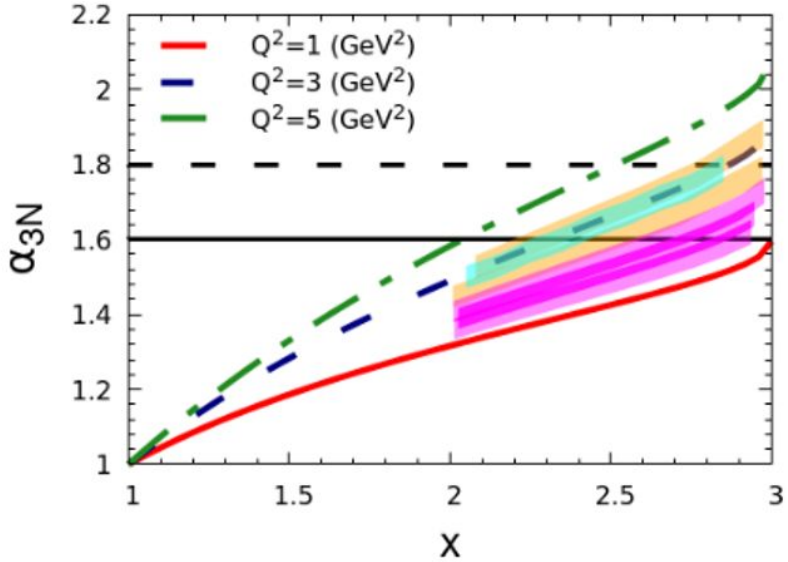
- ^{3}He: Cross section begins to fall off closer to about x = 2.6
  - Suggest a possible second plateau (3N SRC)





Z. Ye, et al, *Phys.Rev.C* 97 (2018) 6, 065204

The Hunt for 3N SRCs



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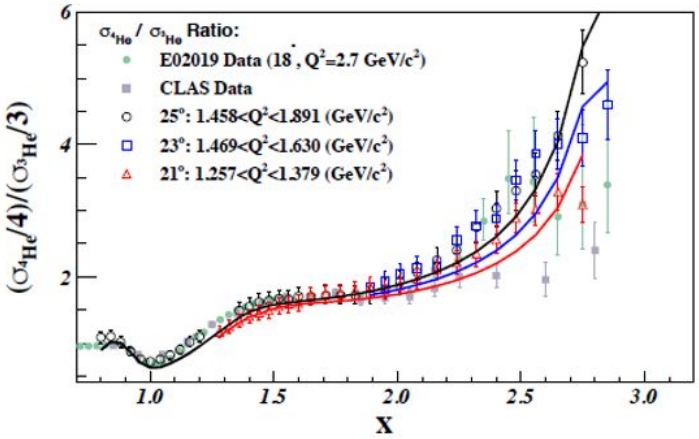
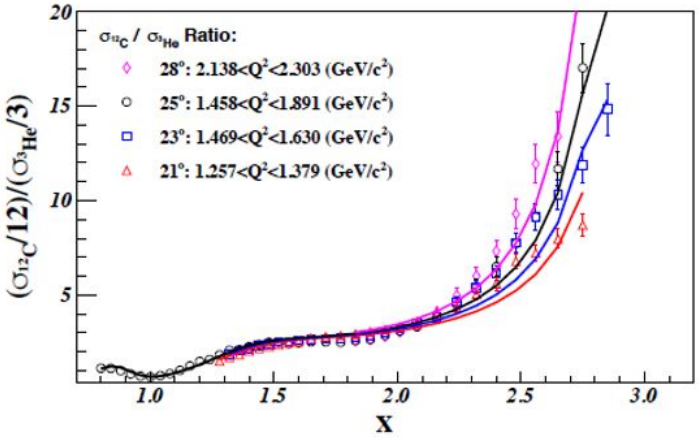


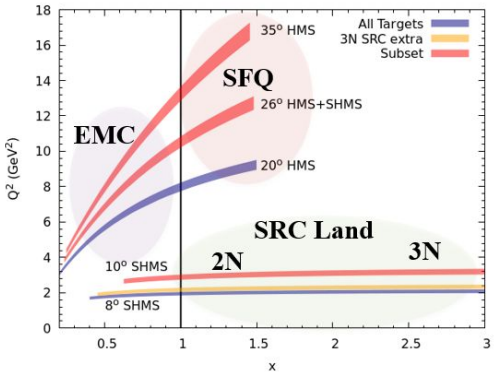


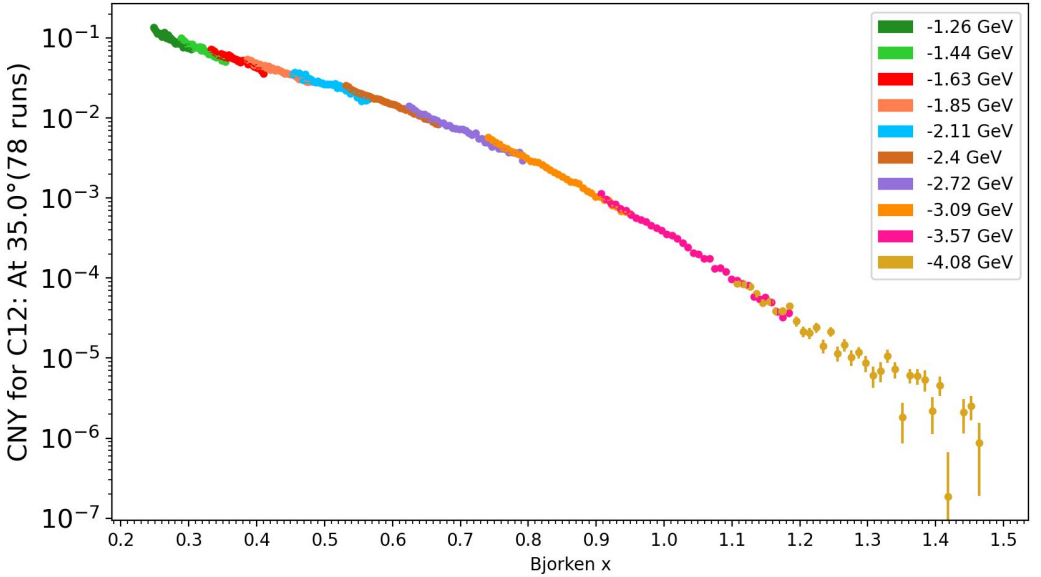
Z. Ye, et al, *Phys.Rev.C* 97 (2018) 6, 065204

Superfast Quarks (SFQ)

- Superfast Quarks (SFQs): Quarks moving rapidly at large x
  - Quark distributions at large x are not well understood
- Larger Q^2 ranges are needed to isolate PDFs
- A supplemental method to look at the impact of SRCs
- A small contribution of quasielastic scattering to the total cross section

- Analysis will be done by Sebastian Vasquez

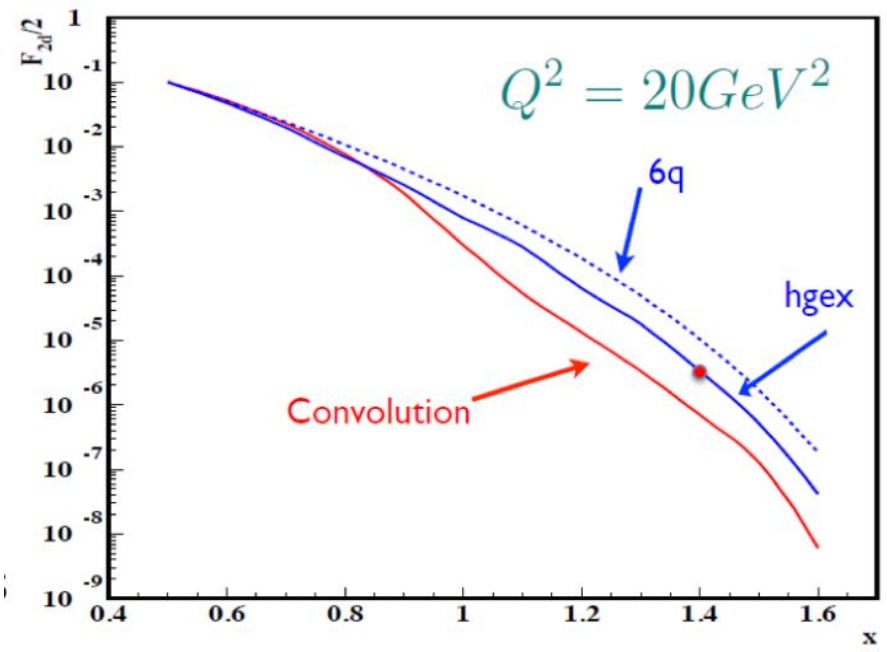




Courtesy of Abhyuday Sharda - UTK:

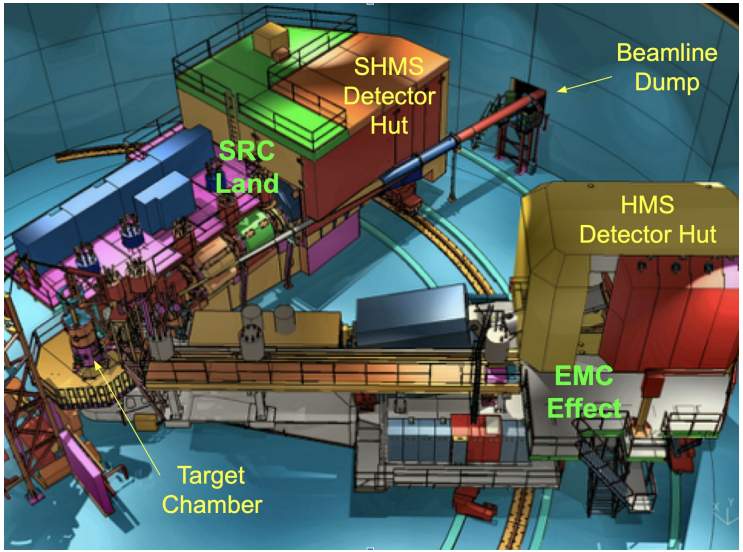
Superfast Quarks (SFQ)

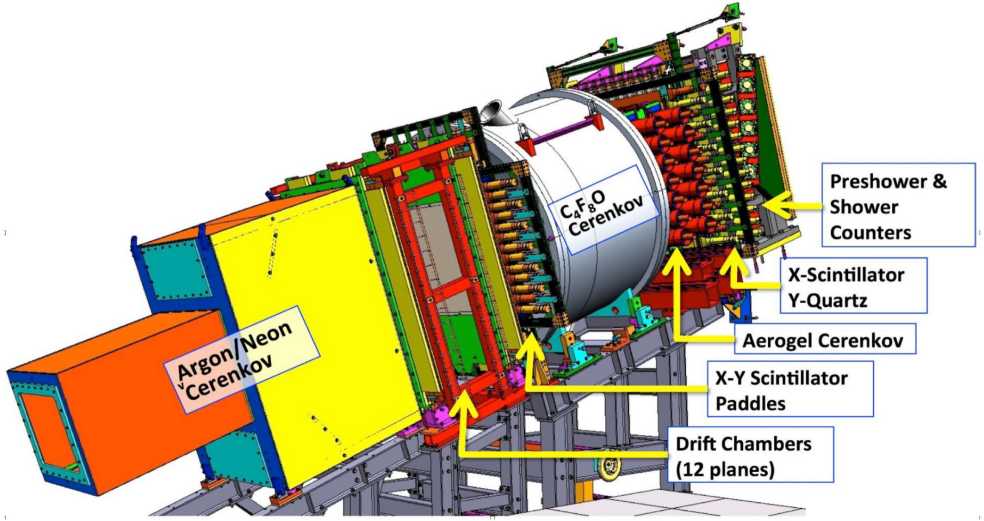
- SFQs offer possible explanation for the EMC effect
- Convultion on plot represents 2N SRC smearing
  - 6-quark bag
    - One 6-q bag, **NOT** two 3-q bags
    - Impact on the EMC effect is very minimal
  - Momentum sharing (hgex)
    - Important at large quark momenta
      - Over taking highest x quarks in highest-momentum nucleons



J. Arrington, APHA 21 (2004) 295, arXiv:hep-ph/0304213
Misak M. Sargsian, NPA 782 (2007) 199
D. Kim and G. Miller, arXiv:2304.14552

Experimental Hall C





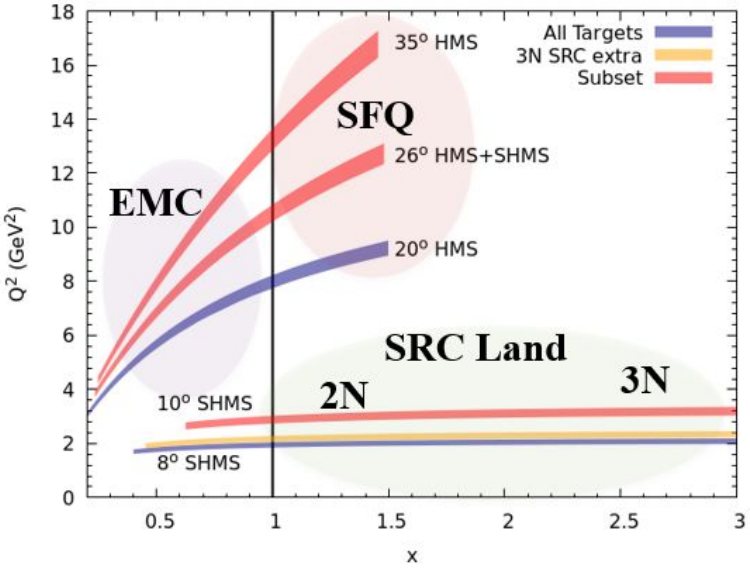
- Hall C Layout
- Beamline electron energy: 10.544 GeV

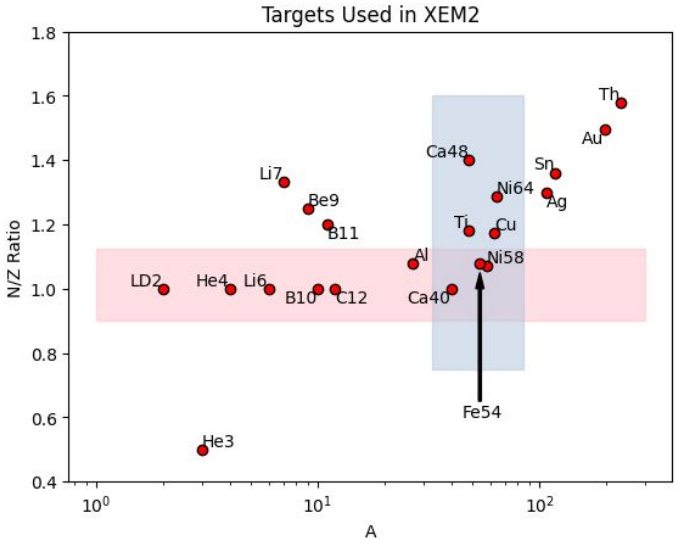
* See Abhyuday Sharda's talk for more information for more on the EMC Effect*

- Within the Super High Momentum Spectrometer (SHMS) Detector Hut
- Detectors within the stack

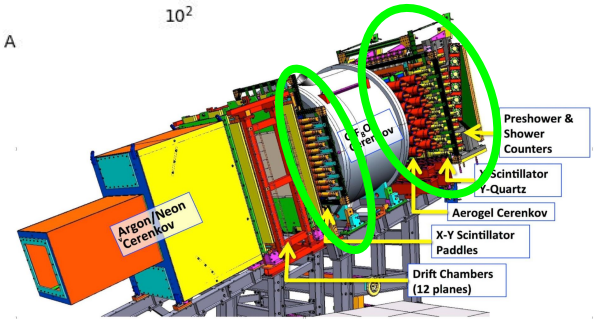
Duration of the Experiment

- Experiments E12-10-008 and E12-06-105 ran from Fall 2022 to Spring of 2023 in Hall C

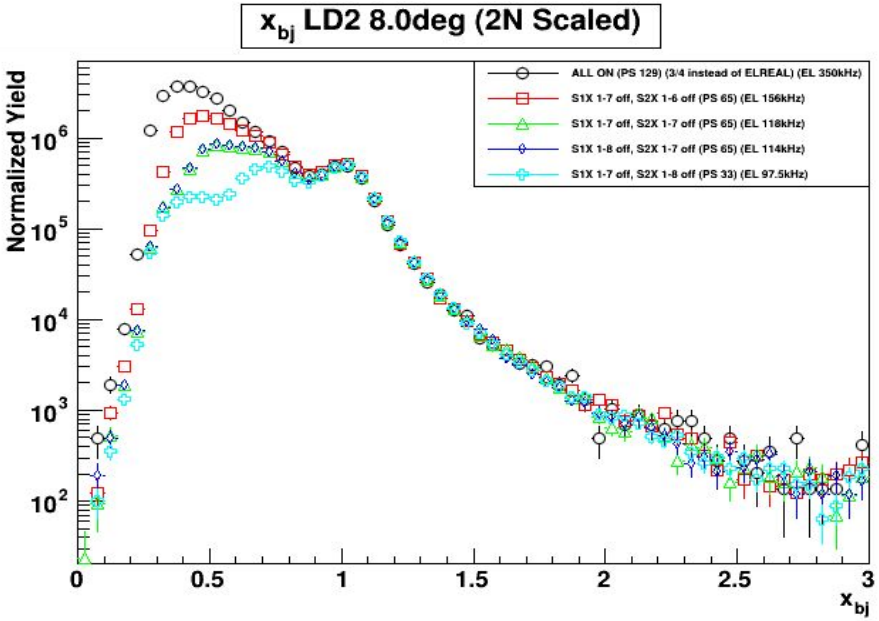




- During the experiment the Hodoscope Paddles and Calorimeter preshowers were turned on and off



Turning Off Detector Components



Courtesy of Tyler Hague - LBL:

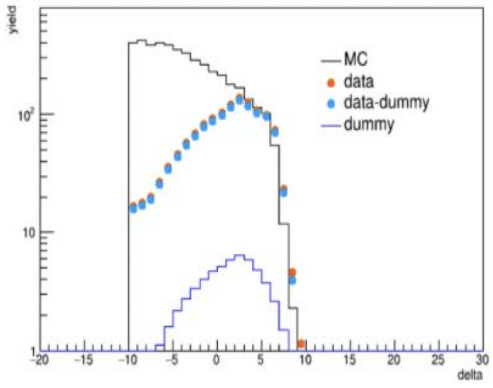
- To focus on the larger x values, Hodoscope paddles were turned on and off
  - Turning off certain Hodoscope paddles cause large bumps in low x to minmize
- Black circles (with all Hodoscope paddles turned on) on the diagram show large bumps at low x and appears scattered at large x
- Colored symbols show the same plot, but with different Hodoscope paddles turned off
  - Colored symbols illustrate the bumps at low x becoming smaller and the scattering at larger x becoming more focused

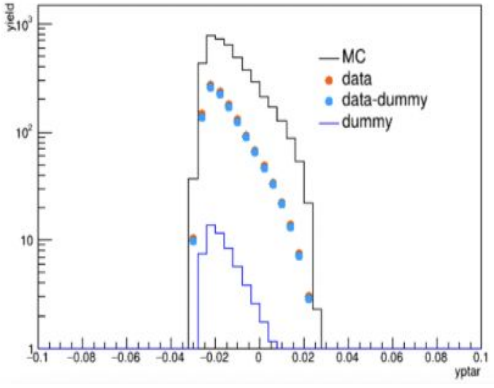
Simulation and Calibration Issues

Target variable: delta

Target variable: yptar

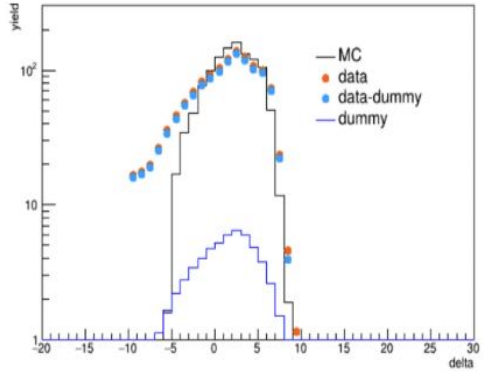
Monte Carlo - All Hodoscope Paddles On

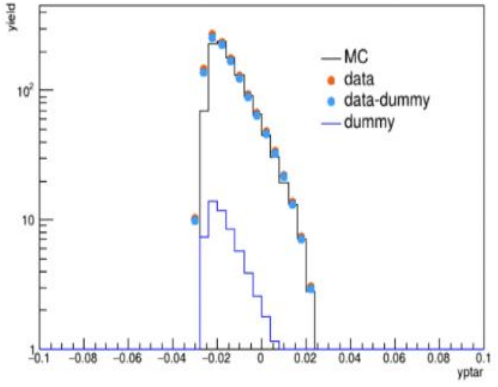




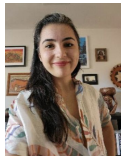
8 degrees LD2
Monte Carlo - Data
Comparison Plots

Monte Carlo - S1X 1-7 & S2X 1-7 OFF





Courtesy of Burcu Duran - UTK:



SHMS Calibration Status

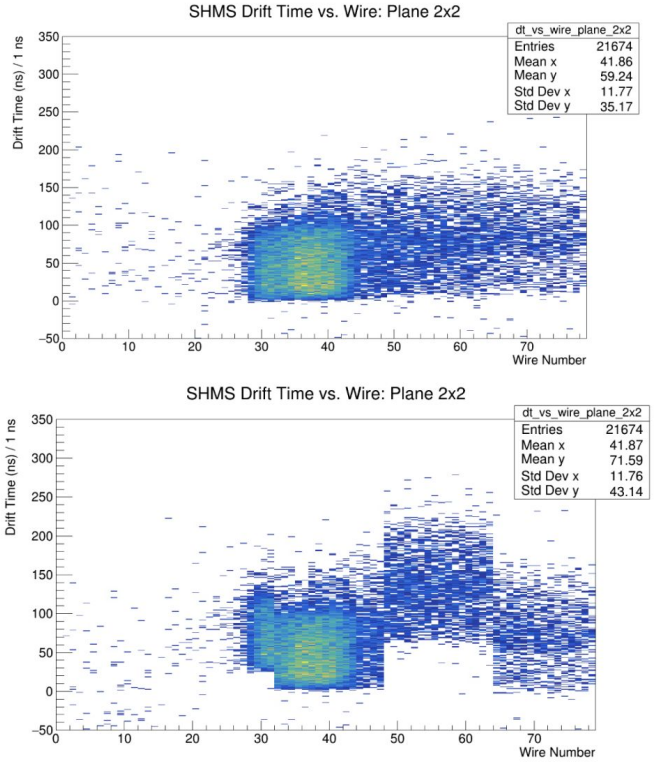
Current Calibrations:

Drift Chambers - Zoe Wolters

Calorimeter - Ramon Ogaz

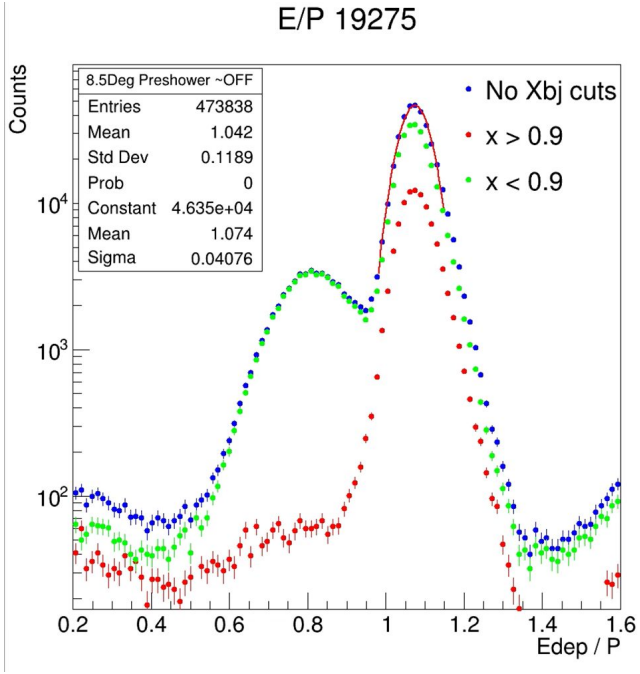
Noble Gas Cherenkov - Ryan Goodman

Drift Chambers Calibration Plots



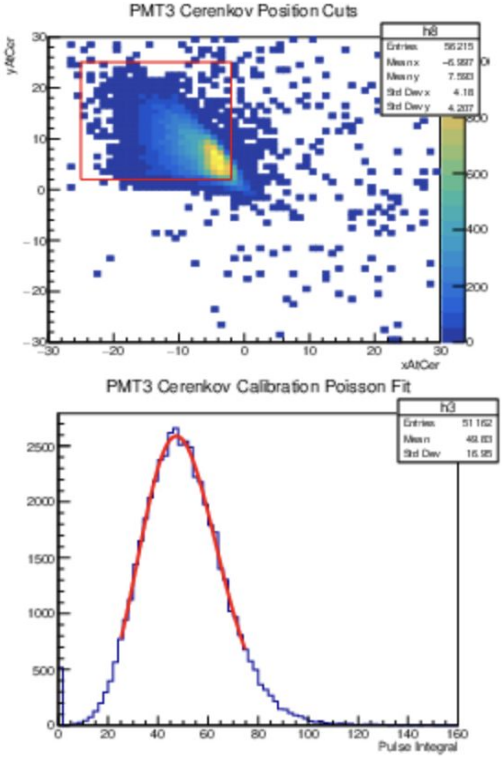
SHMS Calibration Status

Calorimeter Calibration



Courtesy of Ramon Ogaz - UTK:

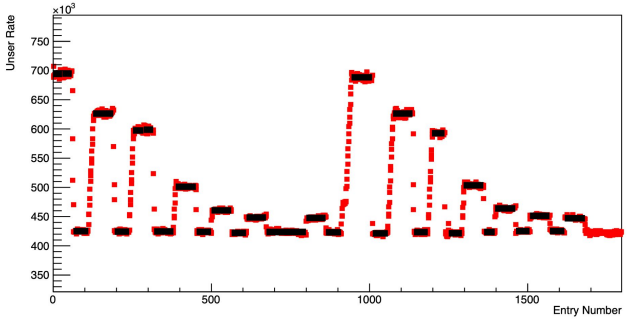
Noble Gas Cherenkov Calibration Plots

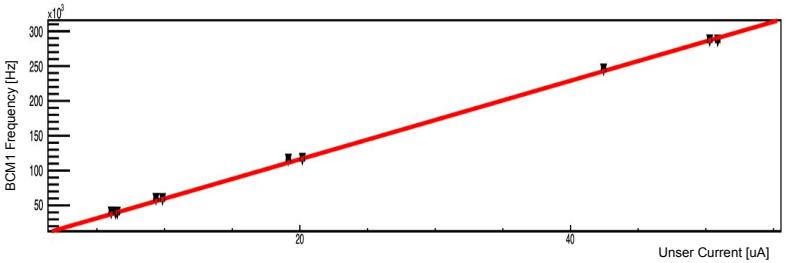


Courtesy of Ryan Goodman - UTK:

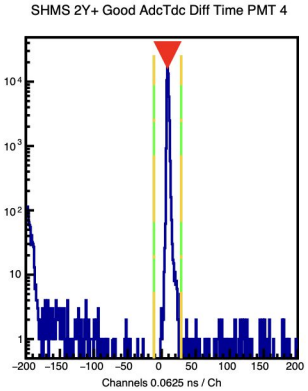
Previous Calibrations

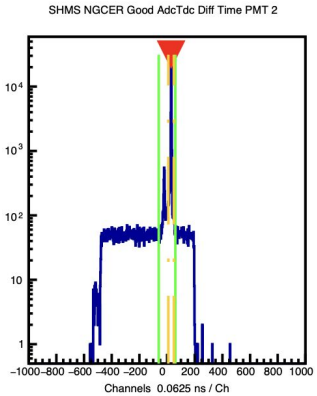
BCM Calibrations



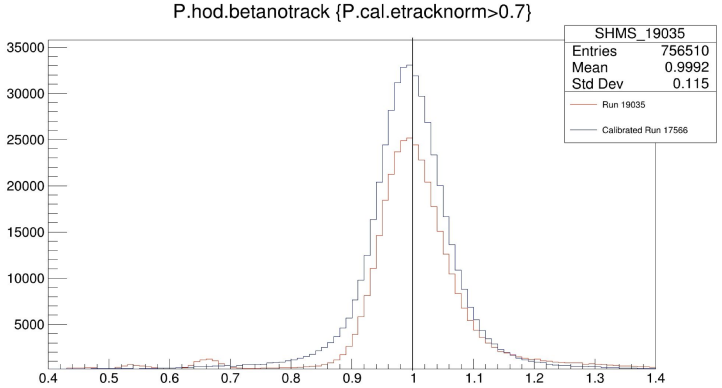


Timing Window Cuts

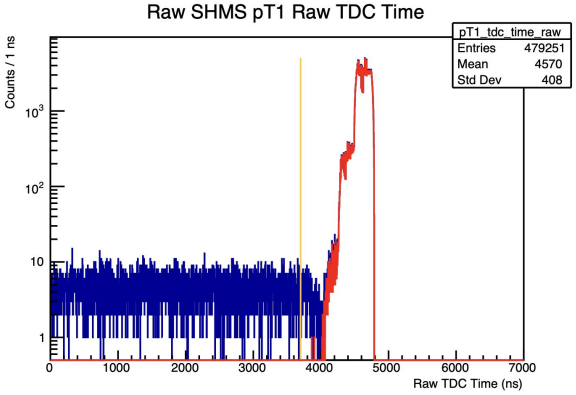




Hodoscope Calibration



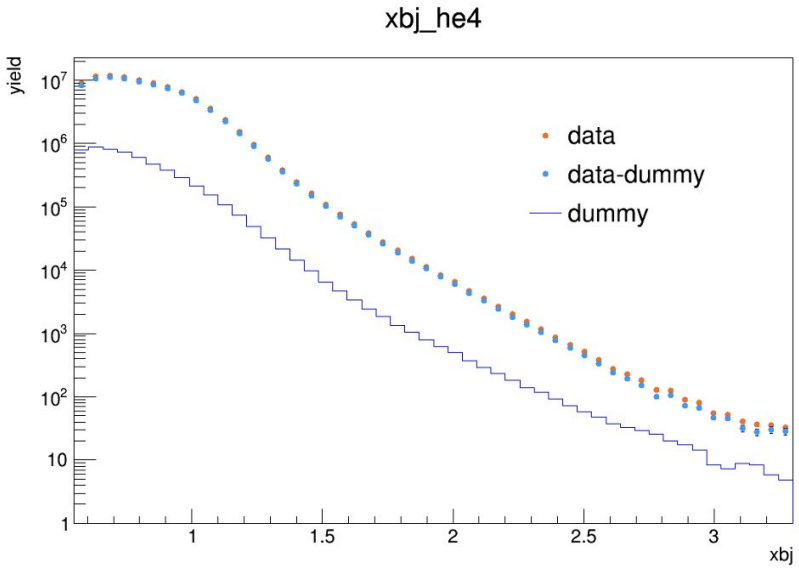
Reference Time Cuts



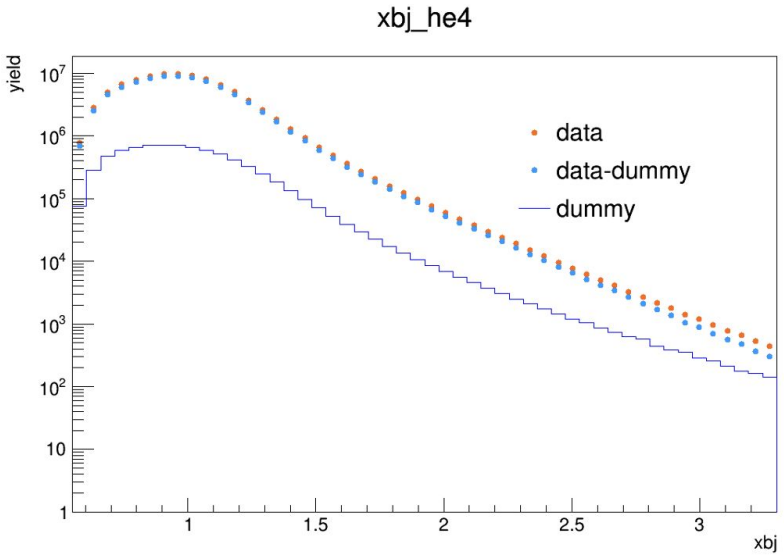
Courtesy of Ramon Ogaz - UTK:

Charge Normalized Yields for 3N SRC

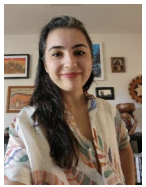
He4 At 10 degrees



He4 At 8.5 degrees

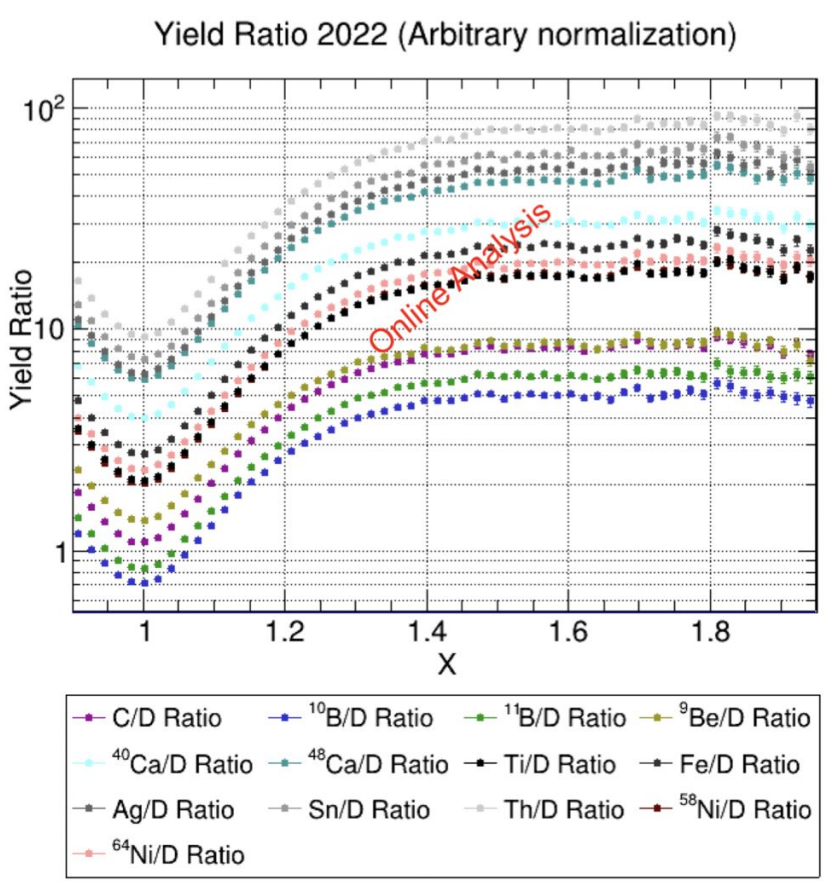


Courtesy of Burcu Duran - UTK:



Online Results

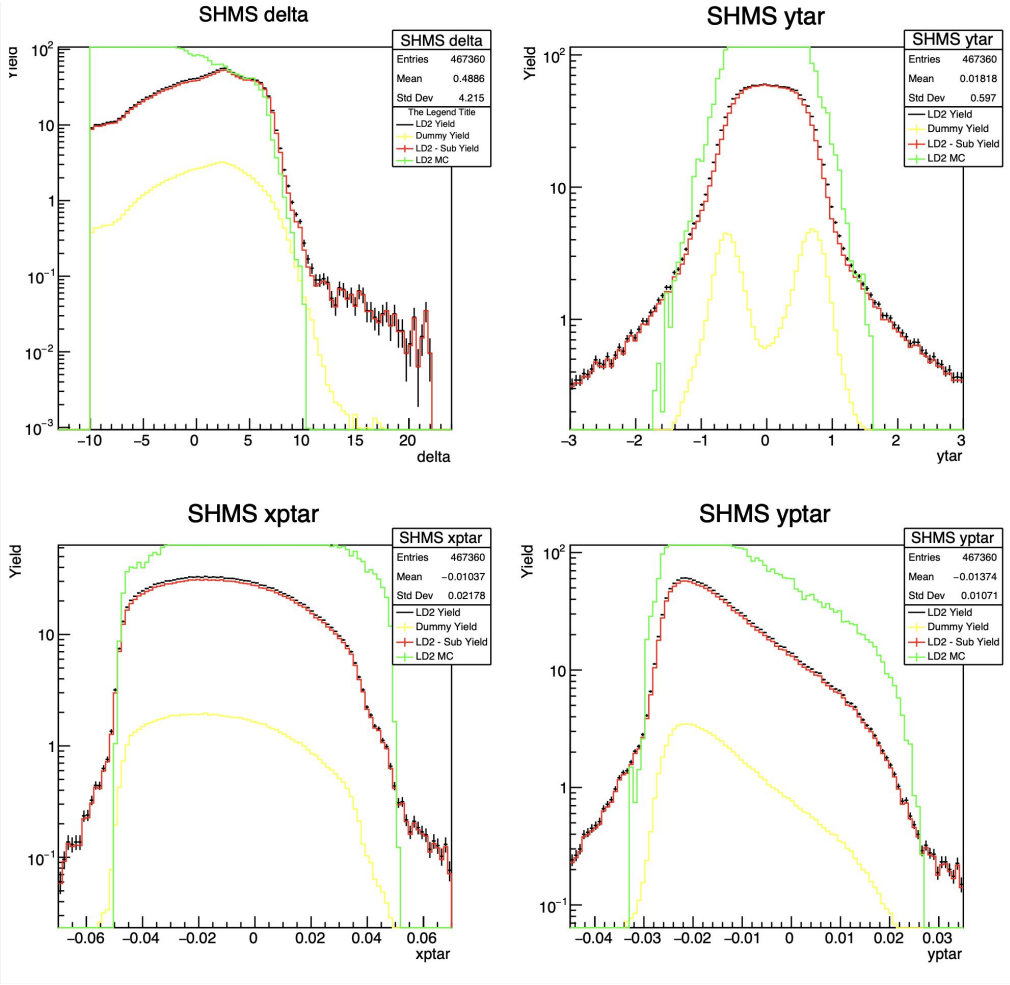
- Preliminary 2N SRC Charge Yield Ratios
  - Results shown are for all targets in the first ladder in 2022
- No radiative corrections applied



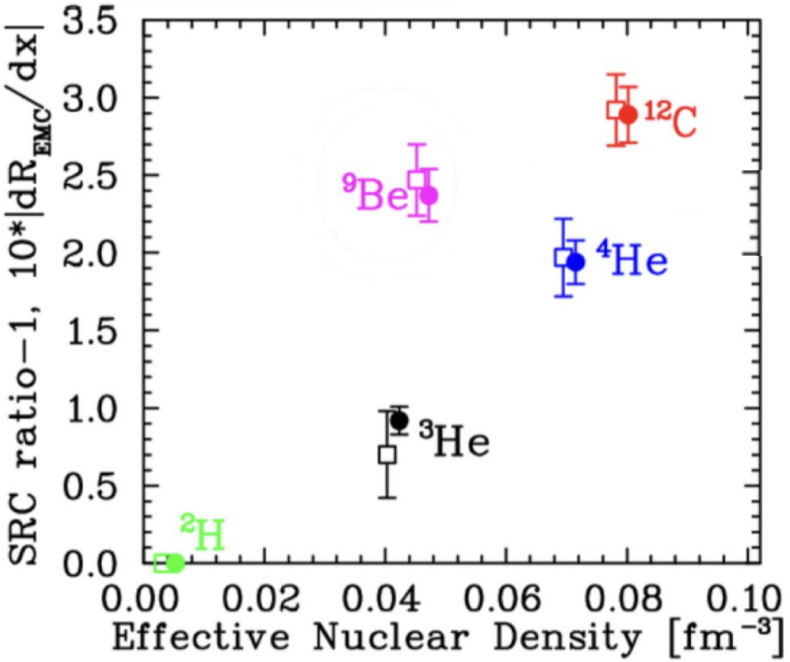
Courtesy of Casey Morean:

Future Work

- Finish Drift Chamber Calibration and other calibrations
- Generate preliminary results and yields
- Comparing Monte Carlo simulations of our detector data to actual data
    - Dummy subtraction
- Calculating SHMS Momentum Offsets
- Calculating cross sections
- Calculating cross section ratios



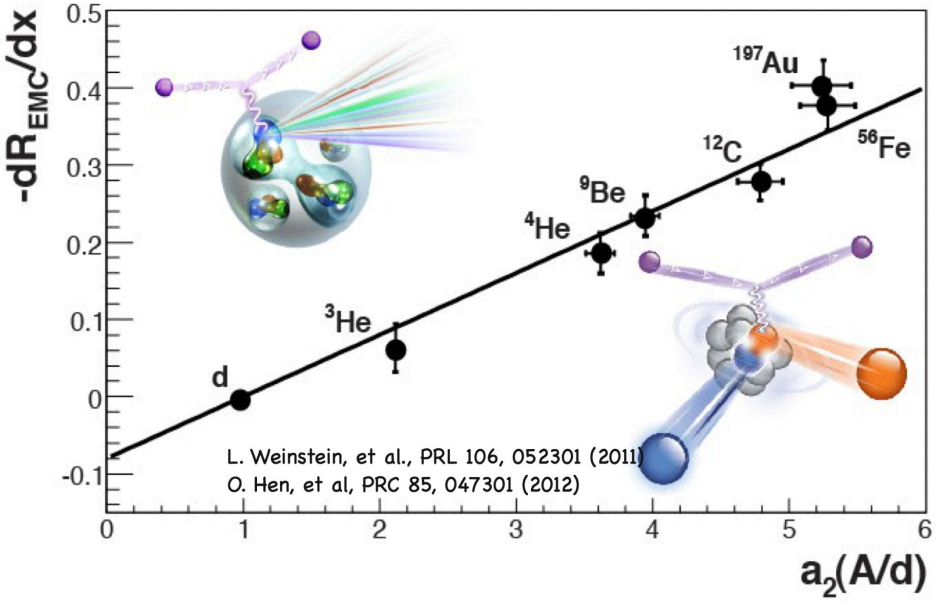
EMC - SRC Correlation



J. Seely, et al., PRL103, 202301 (2009)

N. Fomin, et al., PRL 108, 092052 (2012)

JA, A. Daniel, D. Day, N. Fomin, D. Gaskell, P. Solvignon, PRC 86, 065204 (2012)



O. Hen, et al, PRC 85, 047301 (2012)

L. Weinstein, et al., PRL 106, 052301 (2011)

Thank you!

Graduate Students & Post-Docs


Cameron Cotton
UVA


Ryan Goodman
UTK


Abhyuday Sharda
UTK


Zoe Wolters
UNH


Ramon Ogaz
UTK

To be photographed:
Sebastian Vasquez - UCR


Abishek Karki
MSU


Casey Morean
UTK


Burcu Duran
UTK


Tyler Hague
LBL

Spokespersons and Senior Collaborators:

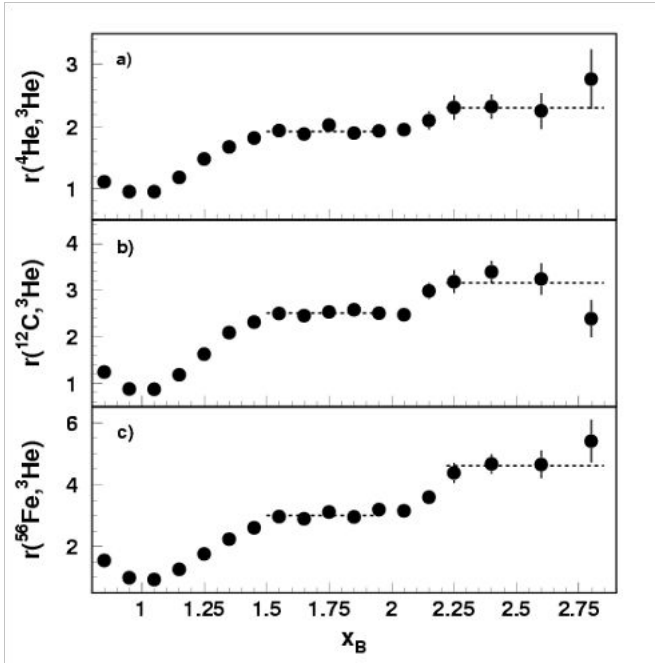
Nadia Fomin, Dave Gaskell, John Arrington, Donal Day, Aji Daniel

Shujie Li, Nathaly Santiesteban

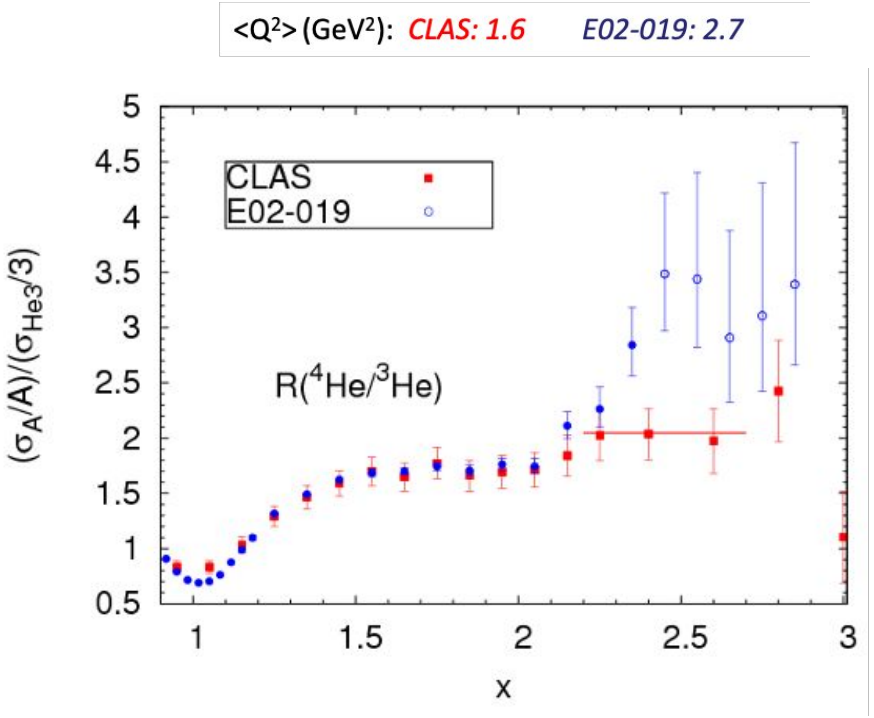
Questions?

Extra Slides

The Hunt for 3N SRCs

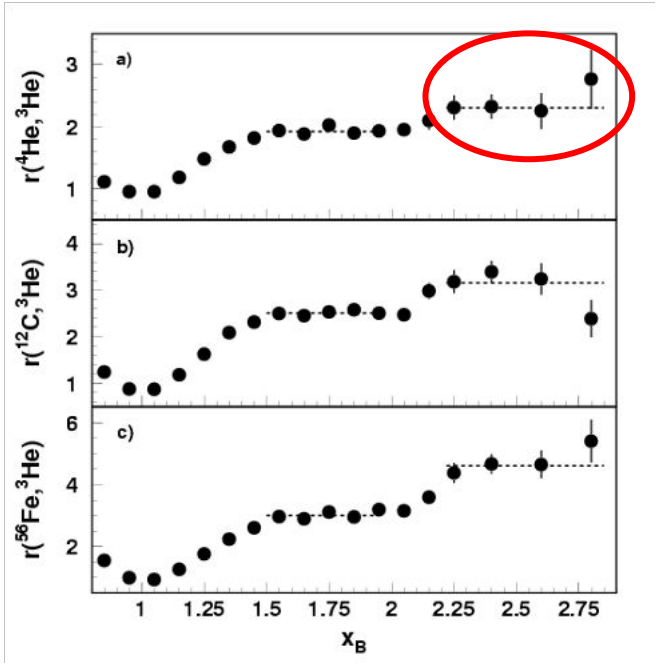


K. Egiyan et al, PRL96, 082501 (2006)

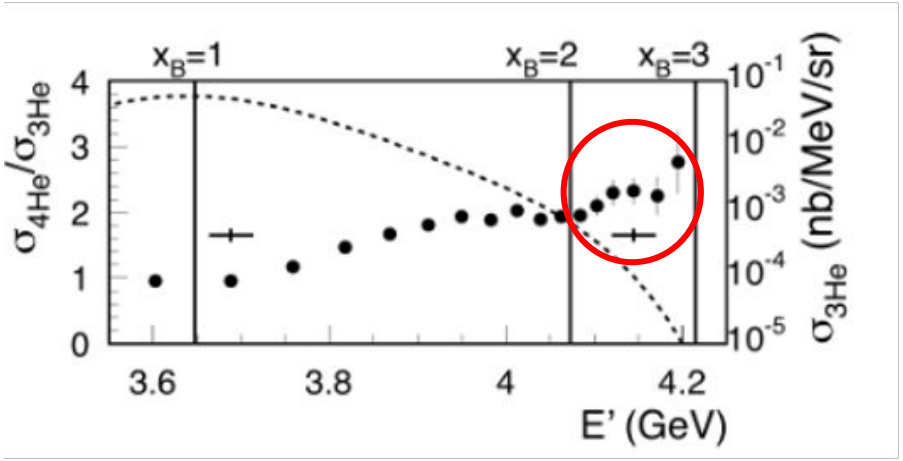


Hall A or C?

The Hunt for 3N SRCs



K. Egiyan et al, PRL96, 082501 (2006)



Comment on "Measurement of 2- and 3-nucleon short range correlation probabilities in nuclei"

Douglas W. Higinbotham[1] and Or Hen[2]

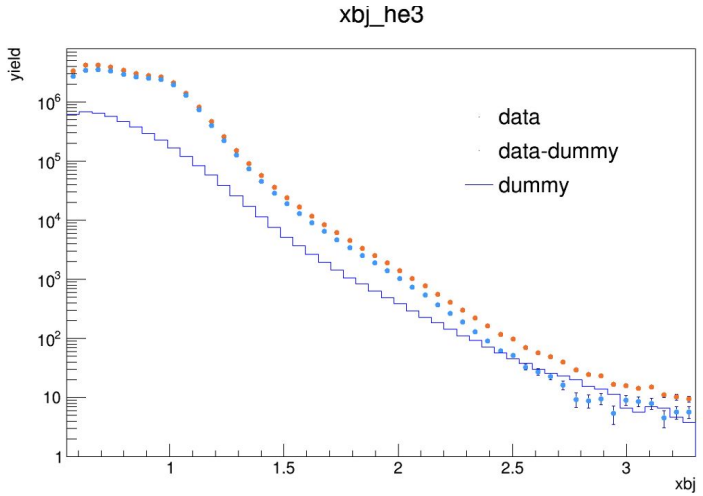
[1] *Jefferson Lab, Newport News, VA 23606, USA*

[2] *Tel Aviv University, Tel Aviv, Israel*

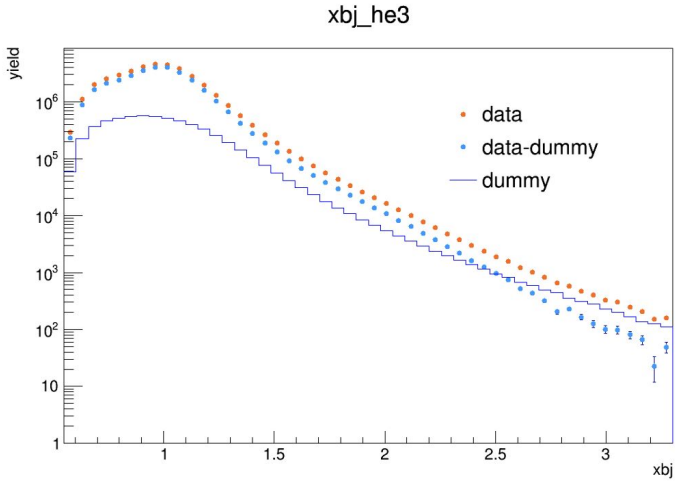
More Charge Normalized Yields for 3N SRC

- Good statistics at x<2

He3 At 10 degrees



He3 At 8.5 degrees



Courtesy of Burcu Duran - UTK: