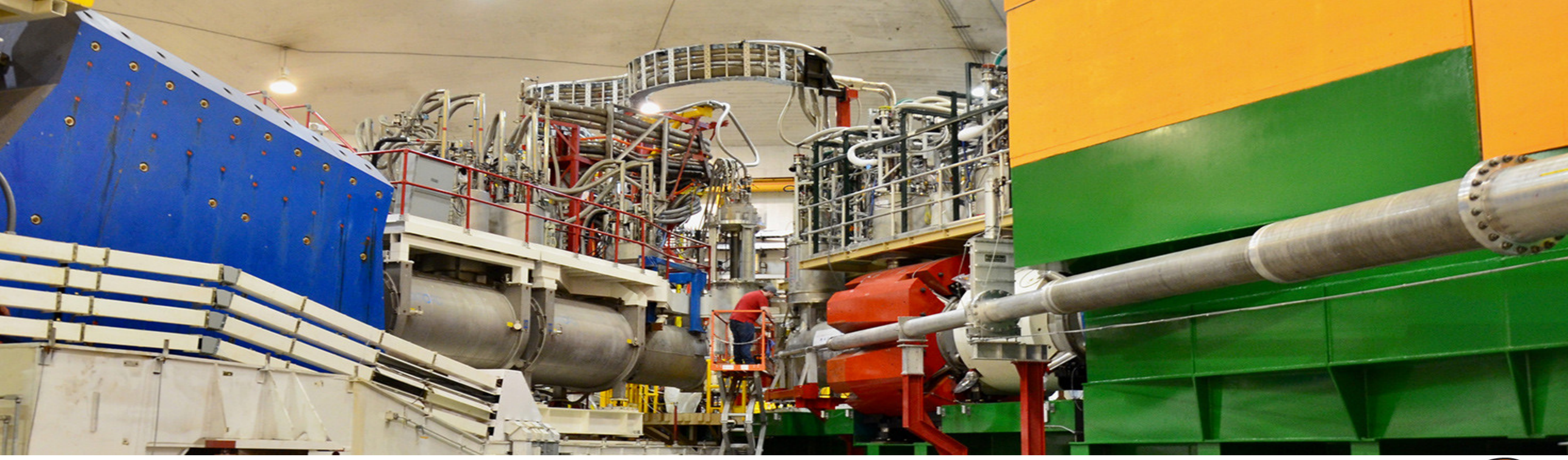


XEM2 (x>1 and EMC EFFECT) EXPERIMENTS IN Hall C

Burcu Duran

On behalf of the XEM2 Collaboration

Winter Hall C Collaboration Meeting

January 12, 2023

XEM

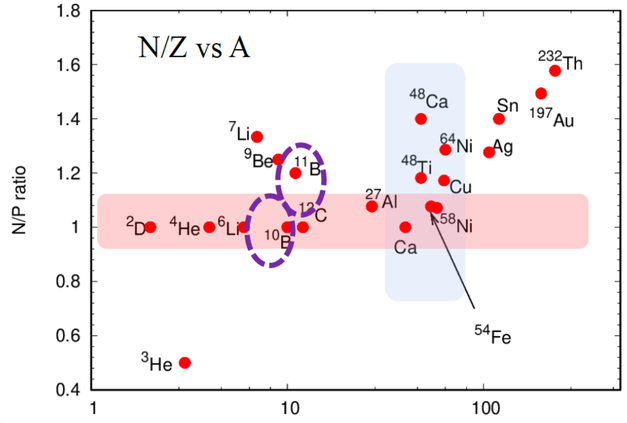
Jefferson Lab
Exploring the Nature of Matter

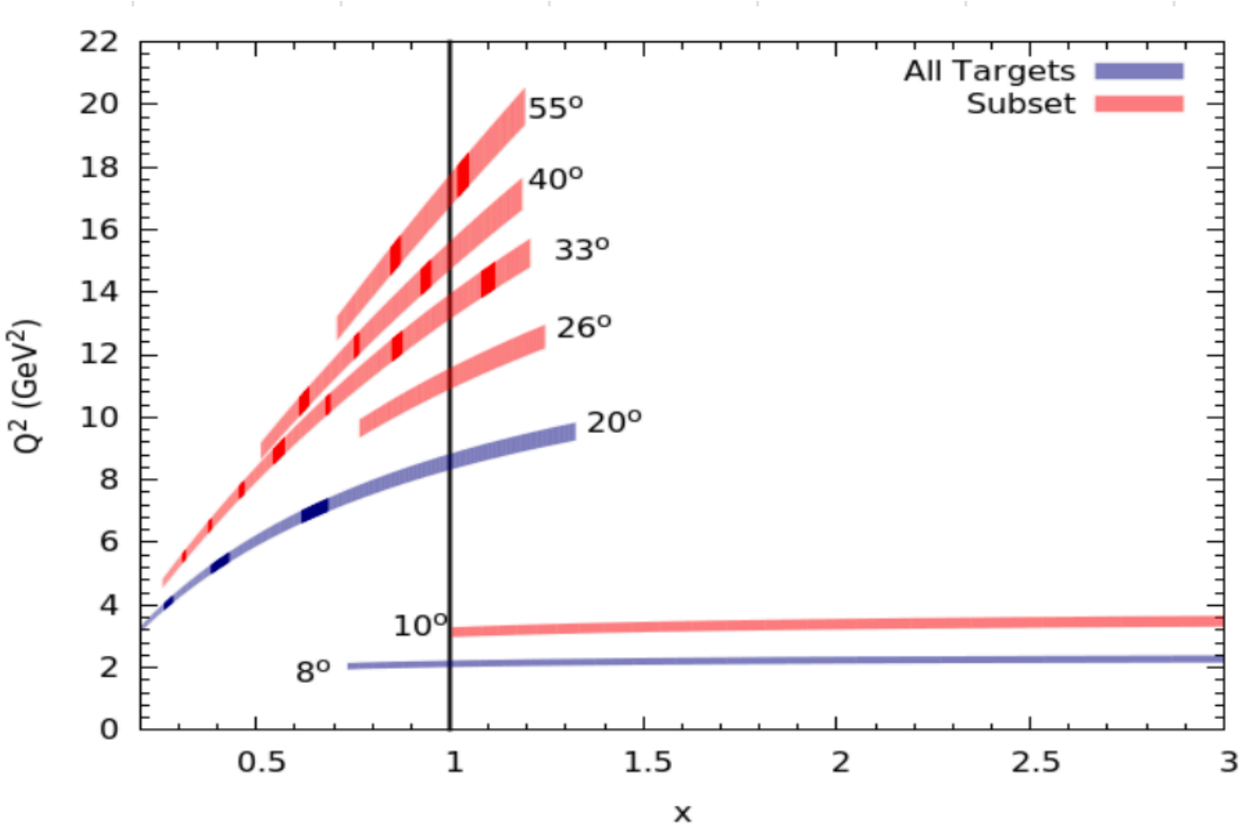
CURRENTLY IN HALL C

XEM2 (x>1 and EMC EFFECT) EXPERIMENTS

E12-06-105: J. Arrington, D. Day, N. Fomin, P. Solvignon
Inclusive Scattering from Nuclei at x>1 in the quasielastic and deeply inelastic regimes

E12-10-008: J. Arrington, A. Daniel, N. Fomin, D. Gaskell
Detailed Studies of the nuclear dependence of F_2 in light nuclei

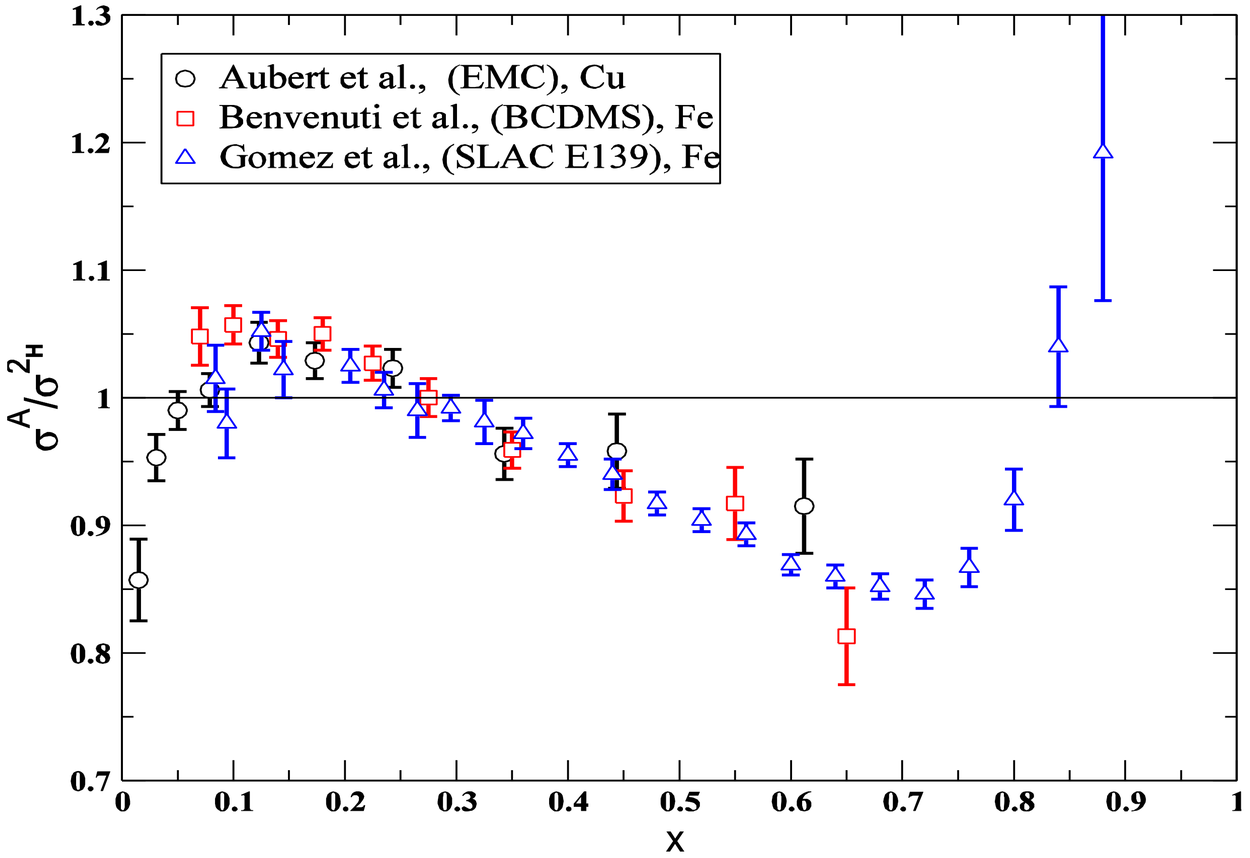




ERR Figure

NON-TRIVIAL STRUCTURE OF THE NUCLEUS

THE EMC EFFECT



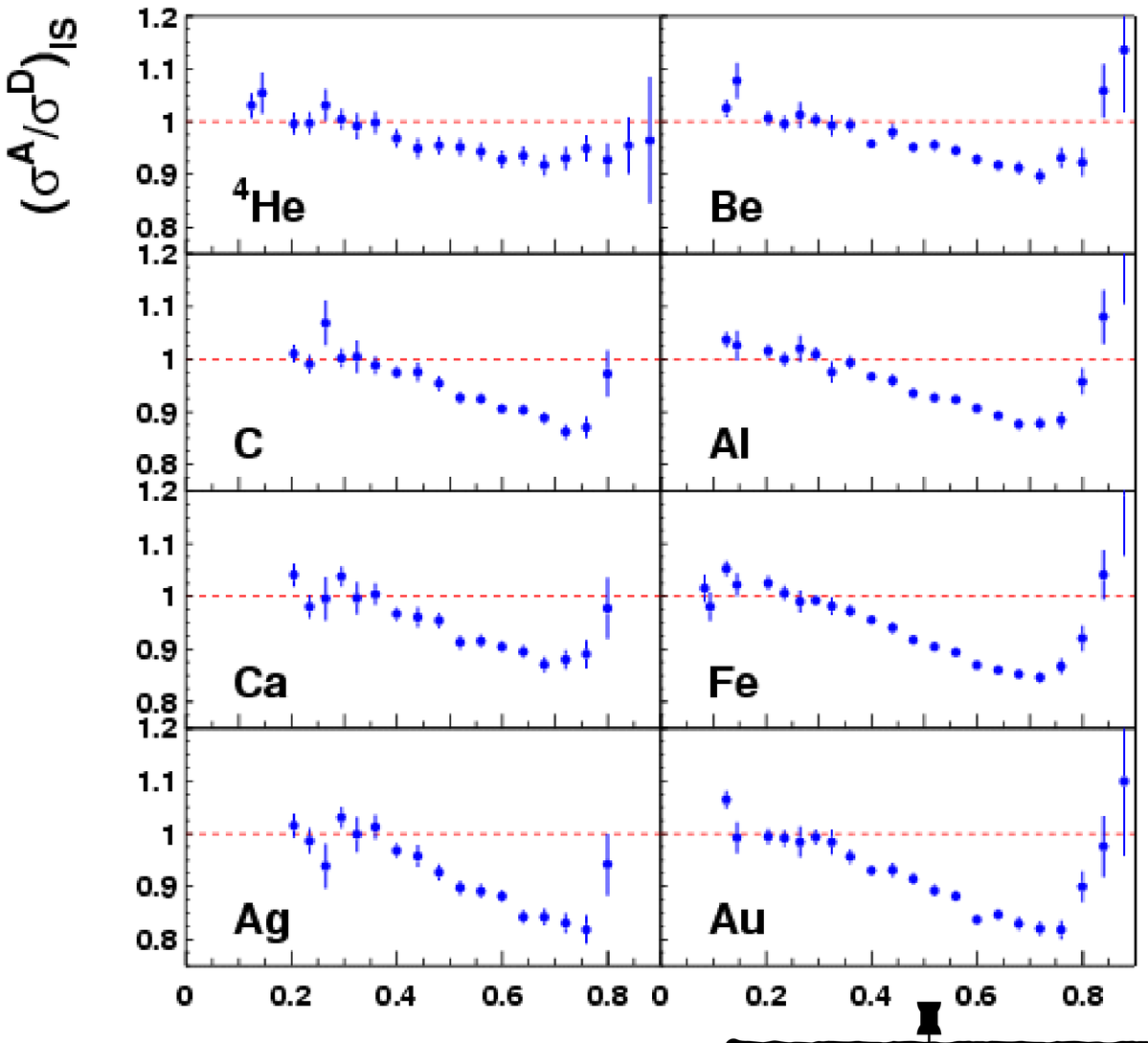
- Initial observation: per-nucleon DIS structure function for Iron significantly different than that of for deuterium. Confirmed for the several other nuclei.
- Suppression of the high momentum quarks for 0.3<x<0.7 in nuclei relative to the deuterium.
- After 40 years, no definitive explanation for the origin of the EMC effect.

THE EMC EFFECT: DATA STATUS

- SLAC E139:

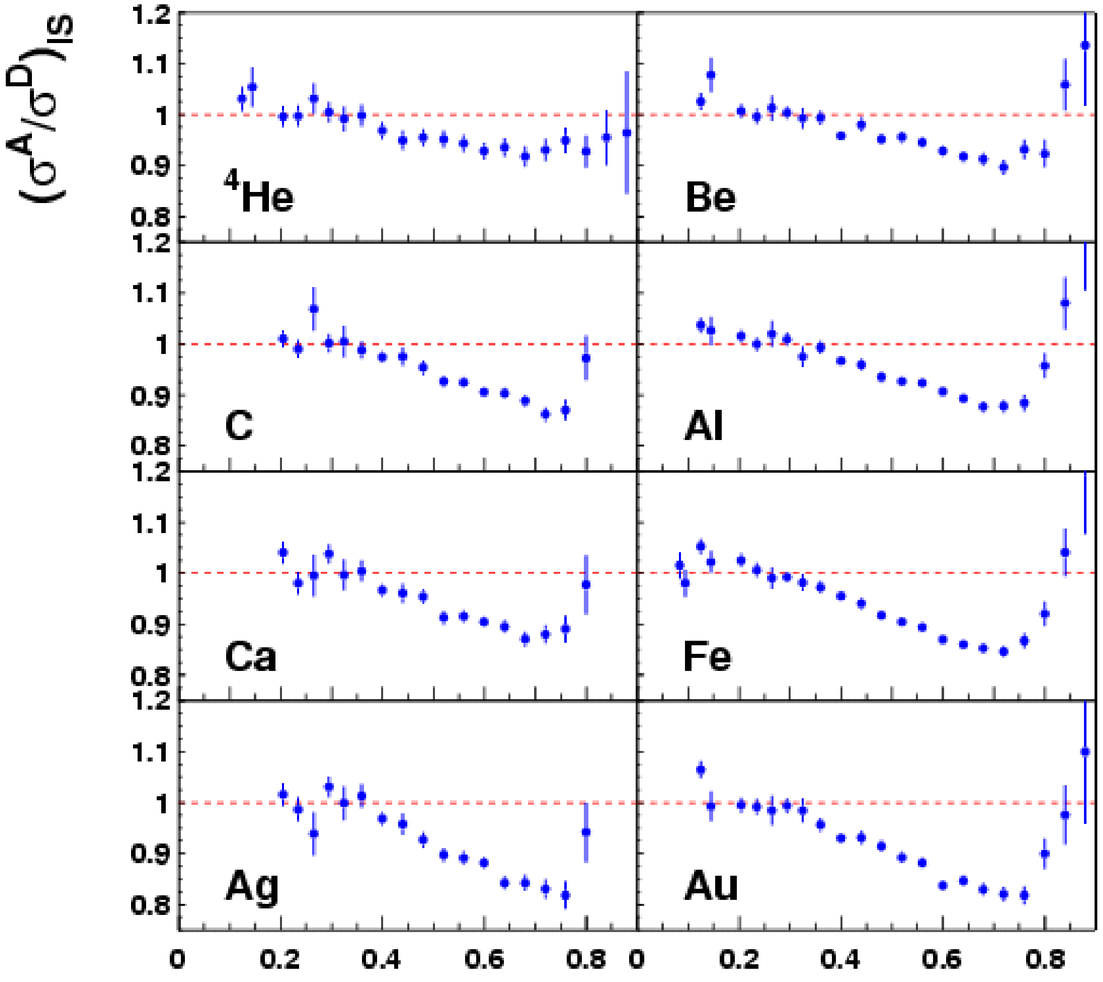
"Nuclear Dependence of the EMC Effect at Fixed x"

- Several nuclei ranging from ^{4}He to ^{197}Au.
- Universal x-dependence for all the nuclei measured
- No significant Q^2 dependence
- Largest data set at high x (back then)

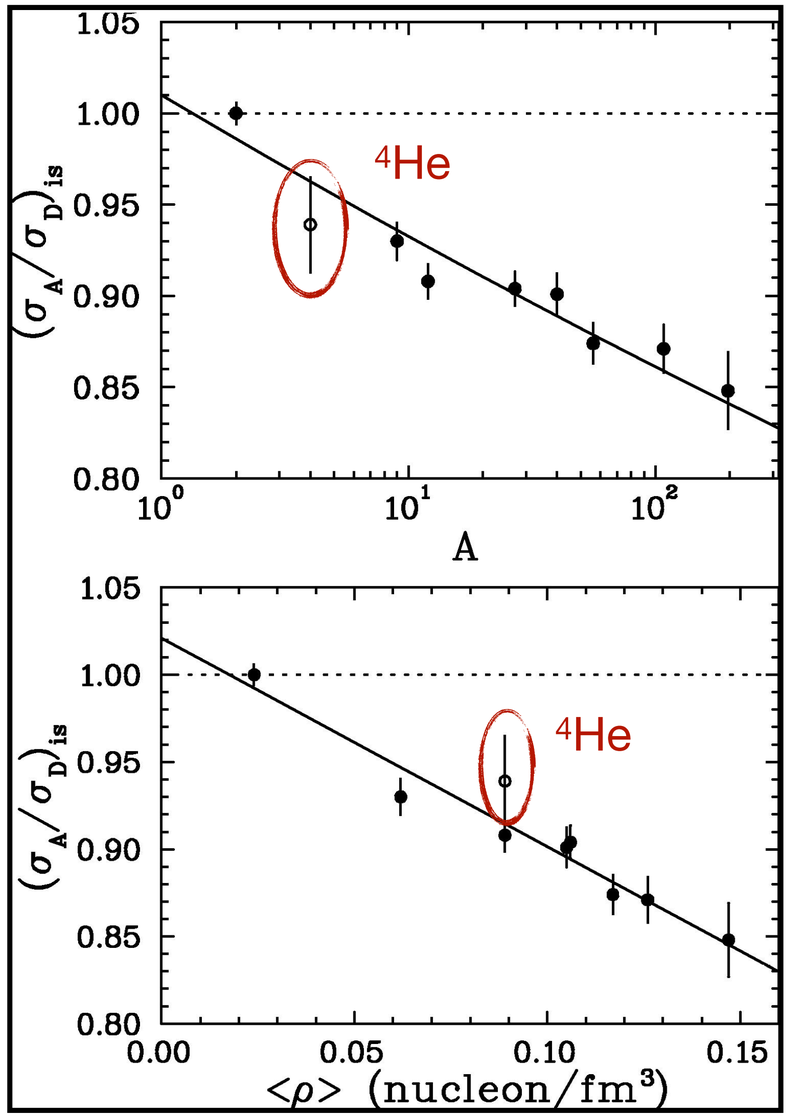


Gomez et al, PRD 49, 1994

THE EMC EFFECT: DATA STATUS CONT'D

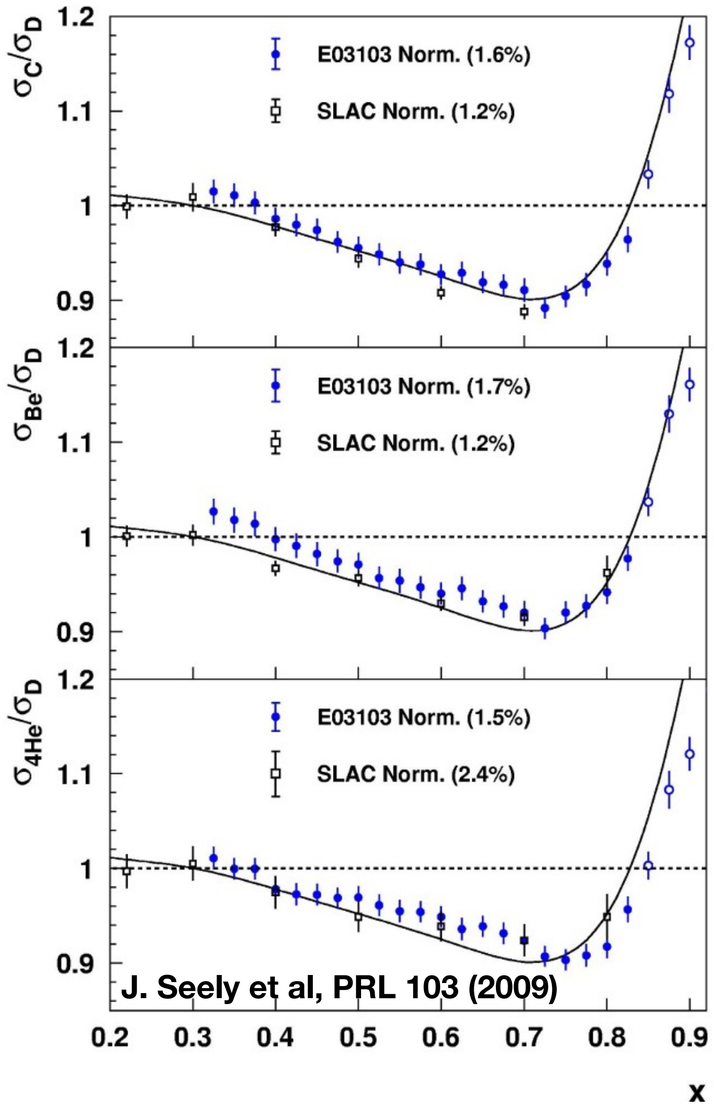


x=0.6



Modification scales with log(A) and average density.

THE EMC EFFECT: JLab E03-103 RESULTS



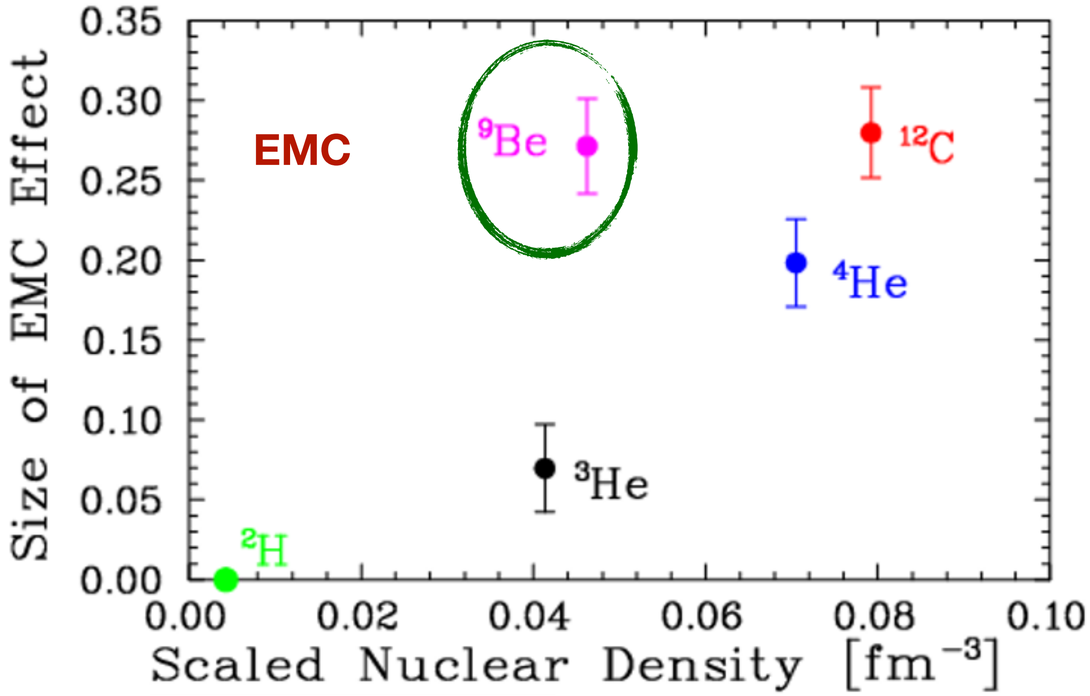
Hall C E03-103: Precision Results on Light Nuclei

- Emphasis on light nuclei (4He, 9Be, 12C)
- Confirms the SLAC results
- Much better precision at high x
- Improved ^{4}He statistics
- Additional light nuclei measurement with ^{3}He

THE EMC EFFECT: JLab E03-103 RESULTS

^{9}Be does not fit the trend!

J. Seely et al, PRL 103



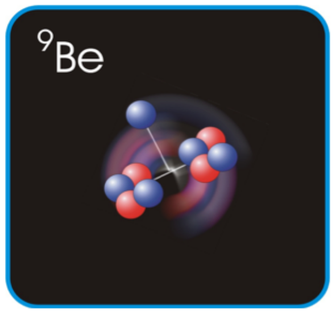
Density determined from *ab initio* few-body calculation
S.C. Pieper and R.B. Wiringa, Ann. Rev. Nucl. Part. Sci 51, 53 (2001)

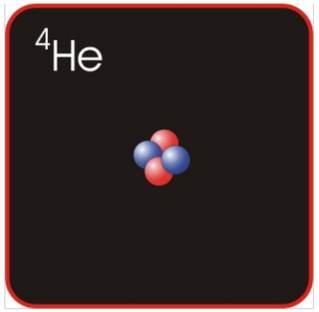
**average nuclear density was scaled by a factor of (A-1)/A to remove the struck nucleon's contribution to the average nuclear density*

Hall C E03-103: Precision Results on Light Nuclei

^{9}Be → **strong alpha clustering**

3 body system of **2 alpha clusters** and **a neutron**





EMC effect seems to follow local density rather than average density!

LOCAL DENSITY → SHORT RANGE CORRELATIONS

The short-distance part of the nucleon-nucleon interaction:

- **A hard short-range repulsive core + strong intermediate-range tensor attraction**
- These strong interactions between nucleons at short distance yield **high-momentum components in the nucleon momentum distributions in nuclei**
- **Pairs of nucleons with high back to back momenta: short range correlations**
- Inclusive electron scattering from nuclei at large momentum transfer and low energy transfer are sensitive to these high-momentum components (high x)

- Focusing on short distance structure of the nuclei to understand the origin of the EMC effect?

MEASURING THE SHORT RANGE CORRELATIONS

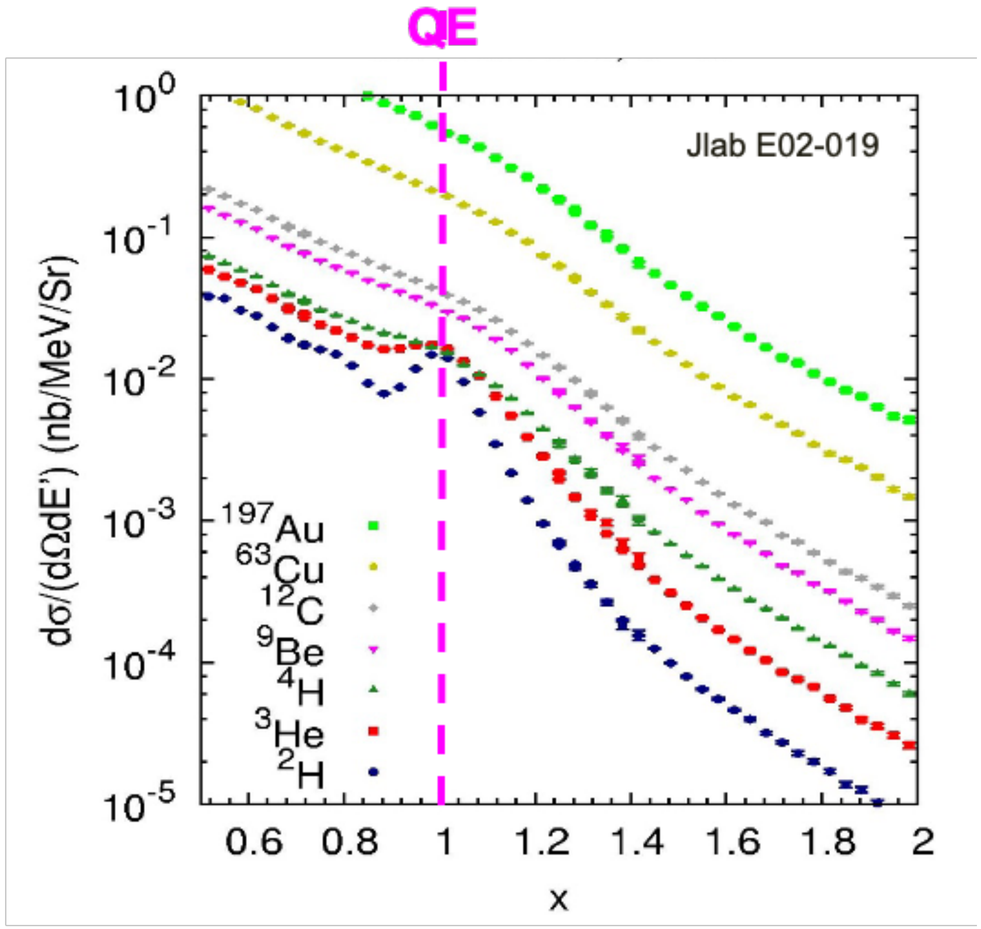
★ To measure the relative probability of finding a correlation, ratios of heavy to light nuclei are taken

★To experimentally probe SRCs, must be in the high-momentum region (x>1): QE scattering

★If the high momentum nucleons in nuclei come from correlated pairs, ratio of A/D should show a plateau.

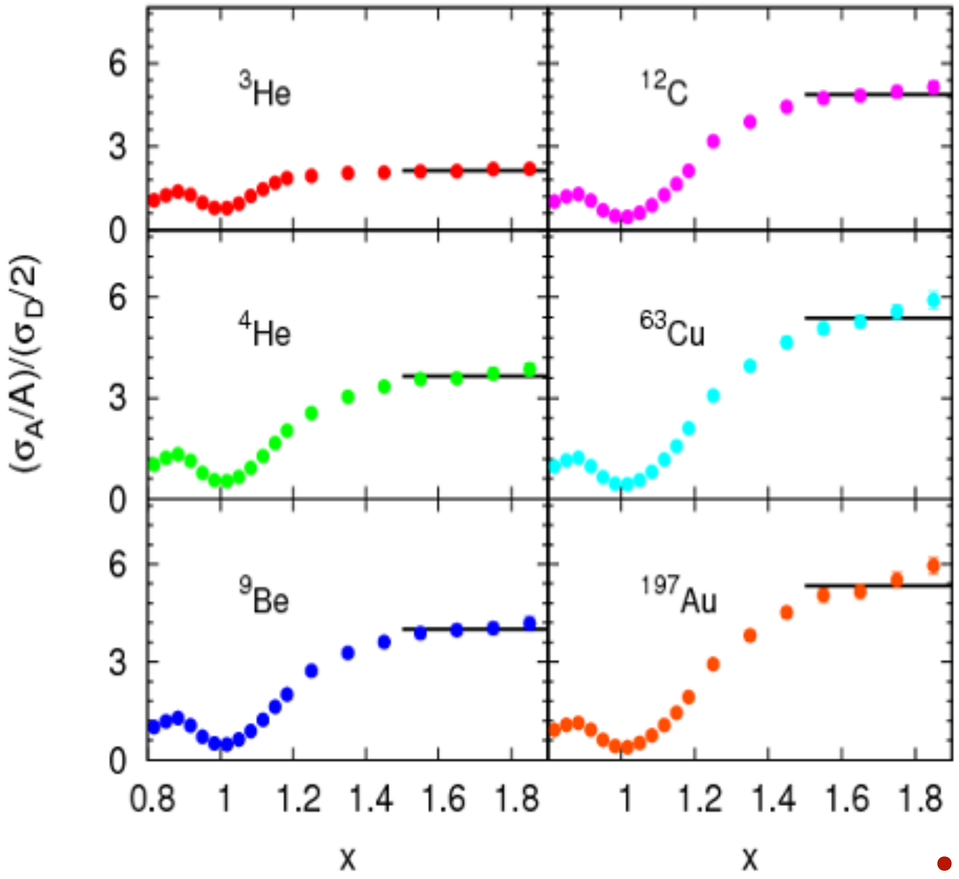
★FSIs are thought to be confined to the SRCs so cancel in the cross section ratios

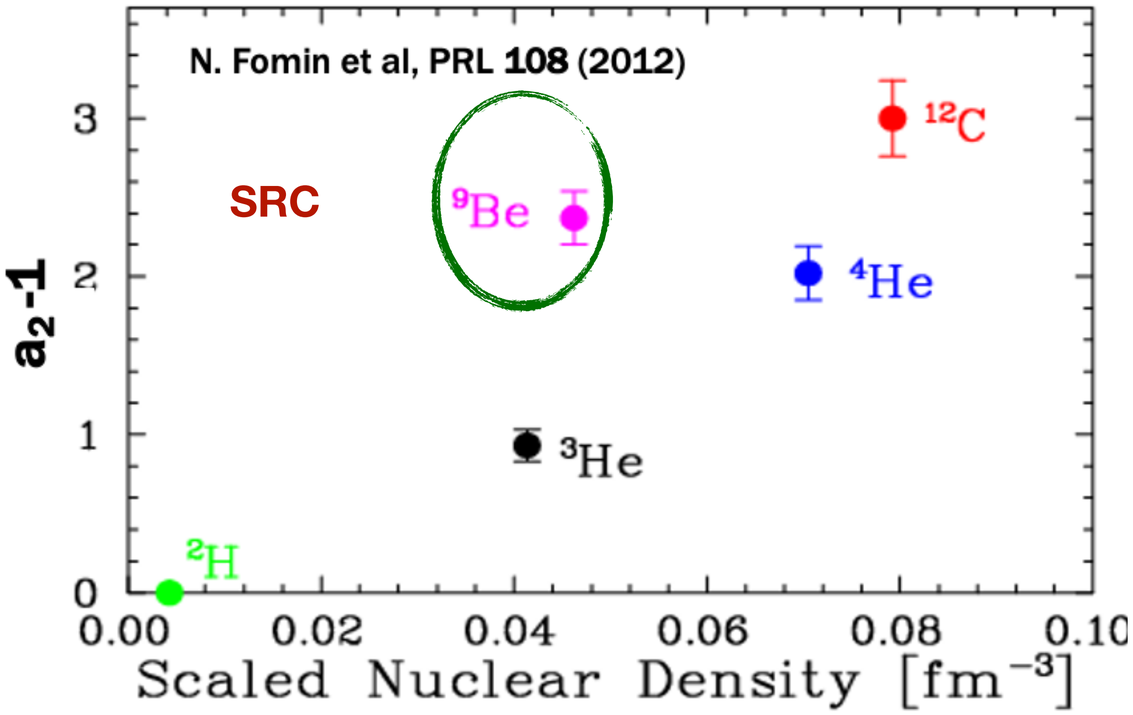
$$\frac{2}{A}\frac{\sigma_A}{\sigma_D} = a_2(A)$$



JLab Hall C 6 GeV 2N SRC RESULTS

Hall C E02-019: Precision Results on Light Nuclei

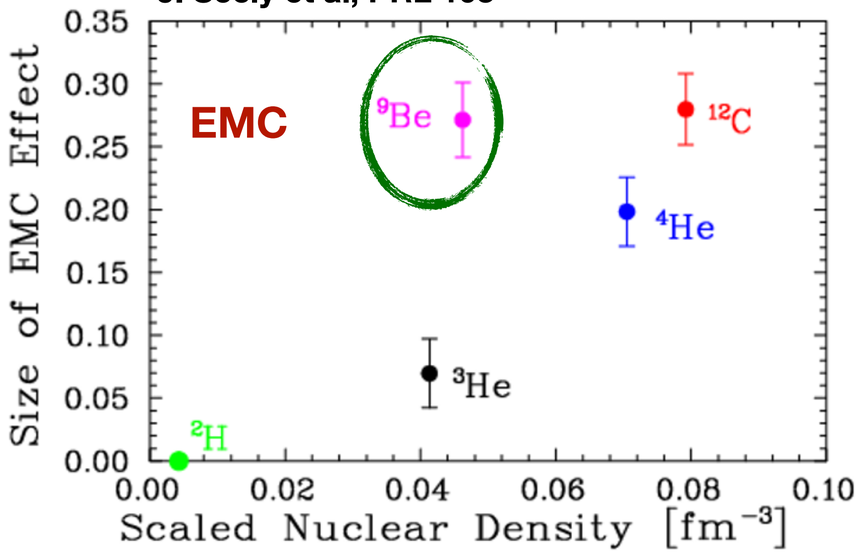


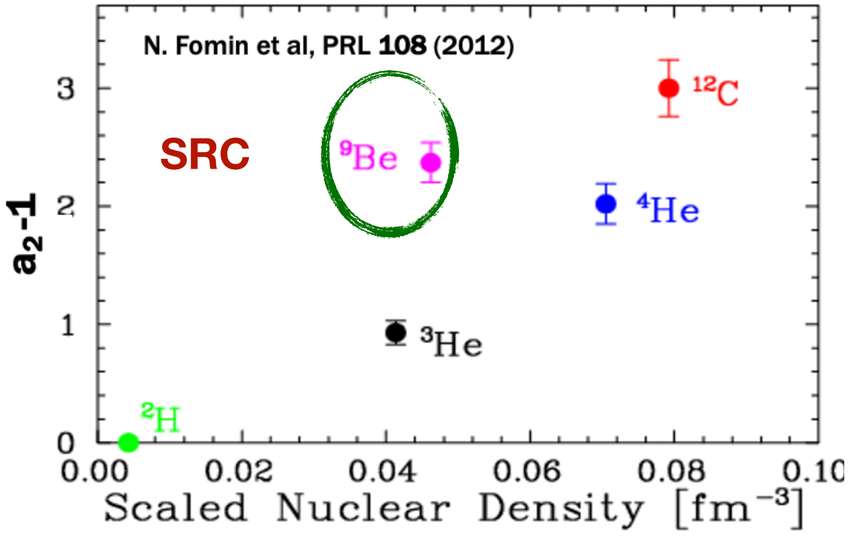


- Similar pattern with the SRC measurements in light nuclei
- Suggesting a possible connection between the EMC and SRC?

EMC-SRC CORRELATION

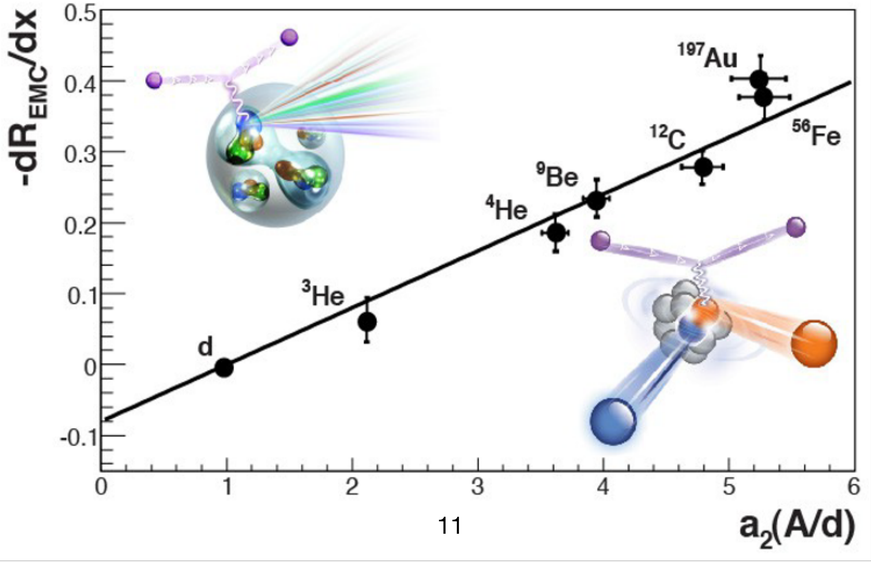
J. Seely et al, PRL 103





Linear correlation between the size of the EMC effect and SRC plateau

9Be strengthens the case!



- J. Seely et al, PRL 103 (2009)
- N. Fomin et al, PRL 108 (2012)
- J. Arrington, A. Daniel, D. Day, N. Fomin, D. Gaskell, P. Solvignon, PRC 86 (2012)
- O. Hen et al, PRC 85, 2012
- L. Weinstein et al, PRL 106, 2011

XEM2 (x>1 and EMC EFFECT) EXPERIMENTS at 12 GeV

XEM2 (x>1 and EMC EFFECT) EXPERIMENTS at 12 GeV

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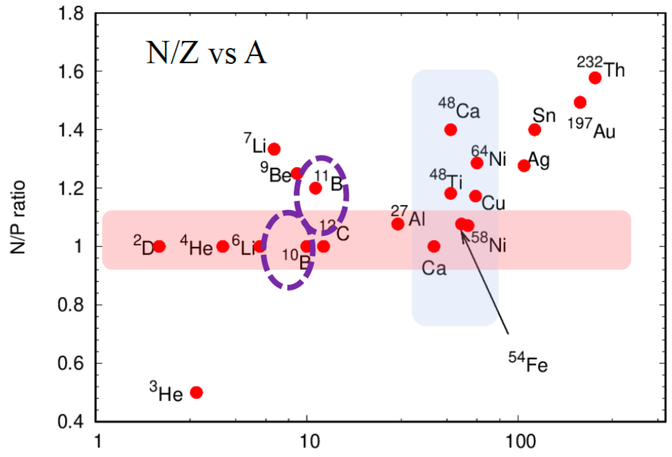
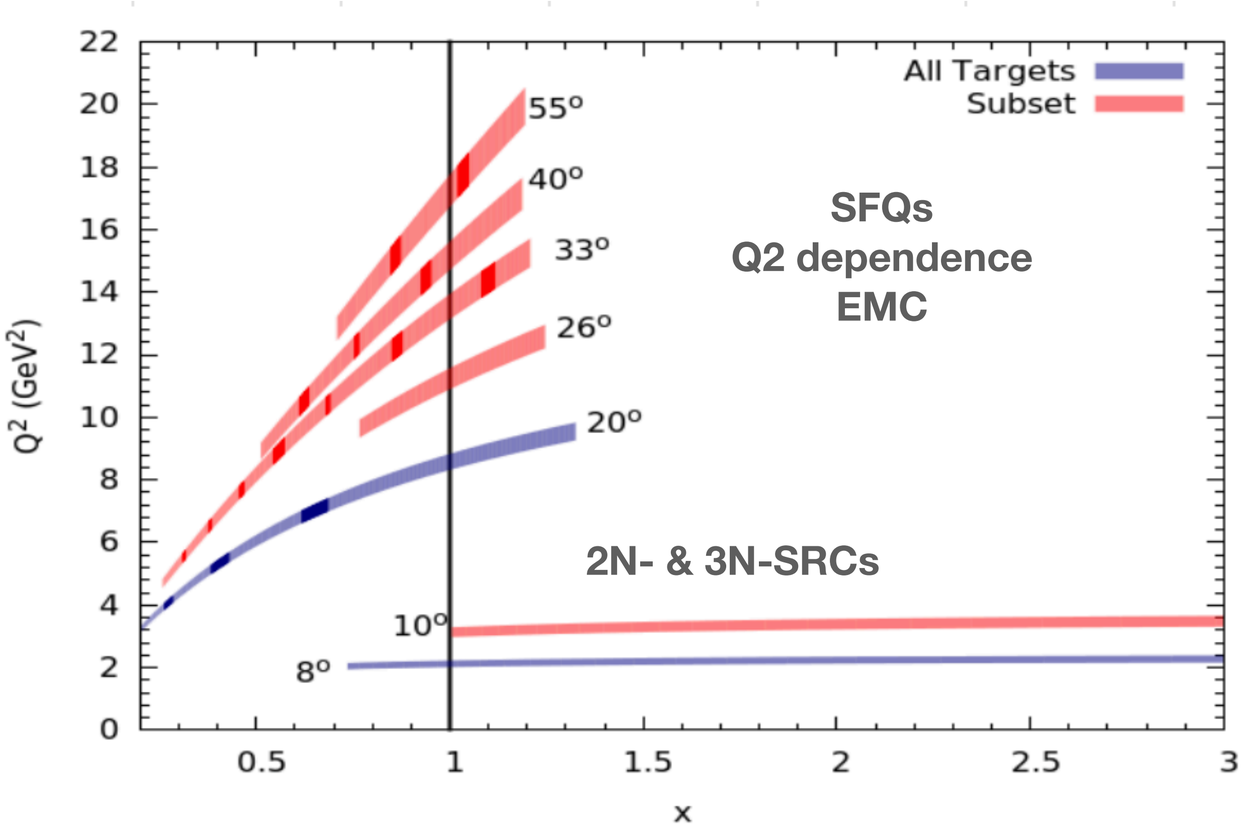




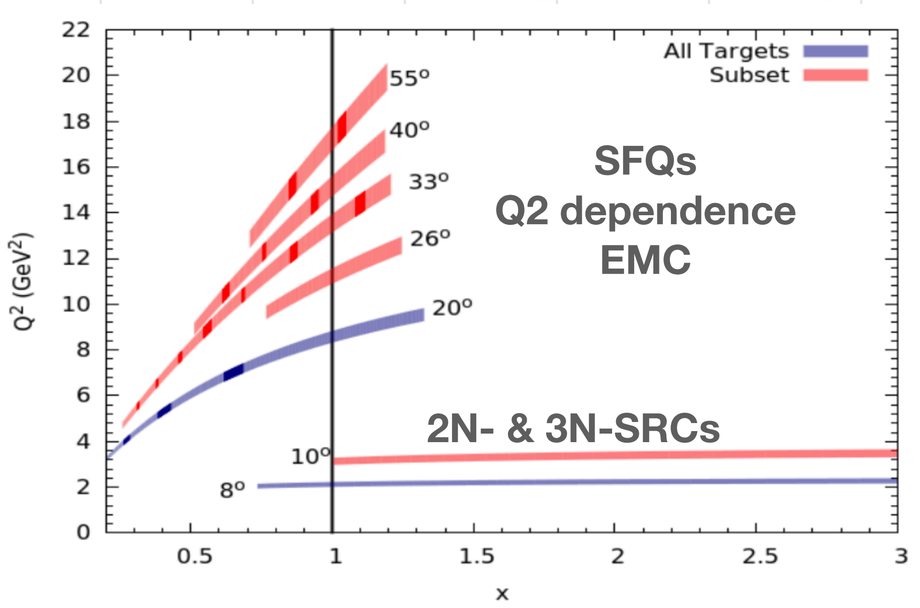
ERR Figure

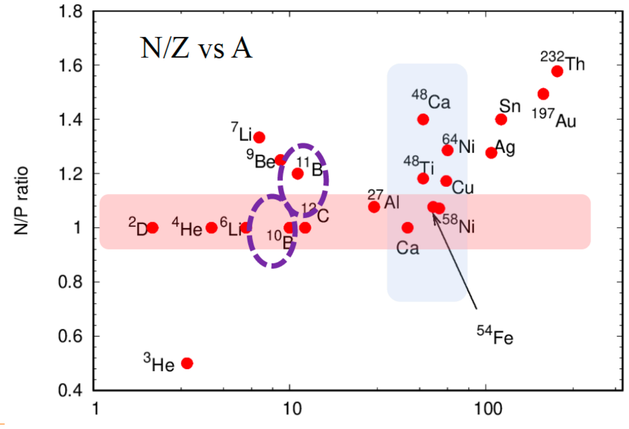
XEM2 (x>1 and EMC EFFECT) EXPERIMENTS in 12 GeV Hall C

XEM2 (x>1 and EMC EFFECT) EXPERIMENTS at 12 GeV

- **Higher Q2**, **expanded range in x** (both low and high x) at 12 GeV
- **More** measurements on **well understood light nuclei** but **also heavy nuclei**
- **First** measurement on the **Boron isotopes** - crucial for the clustering effects
- **Heavy nuclei include 40Ca, 48Ca and Cu** and additional heavy nuclei of particular interest for **EMC-SRC correlation studies**
- **2N- and 3N-SRC** measurements
  - 3N-SRC would be its **first experimental observation ever!**
- **Super Fast Quarks** at high x and Q2
  - Sensitive to the short range structure in nuclei especially non-hadronic components such as 6 quark bags
- Explore **N/Z dependence at fixed A** and **A dependence at fixed N/Z**
- Q2 dependence studies at larger angles

ERR Figure





SMALL SUBSET OF THE DATA TAKEN IN 2018/19

Overview of the experiment(E12-10-008) Phase - I

- Ran during spring 2018 concurrently with E12-10-002 (F_2) as a part of commissioning experiment in HallC
- Measurement of inclusive electron scattering cross section from lighter Nuclei
  - Cryo tragets: H, ^{2}H
  - Solid targets: Be, C, Al, $^{10,11}B$ (Al for cell wall subtraction)
- Single-arm measurement
- Unpolarized electron beam energy 10.6 GeV
- Data were taken at a single (Q^2) /angle (21^0)
  - Additional data on C were taken at larger angle to investigate detailed Q2-dependence of the EMC ratios

First Measurement of EMC effect in $^{10,11}B$

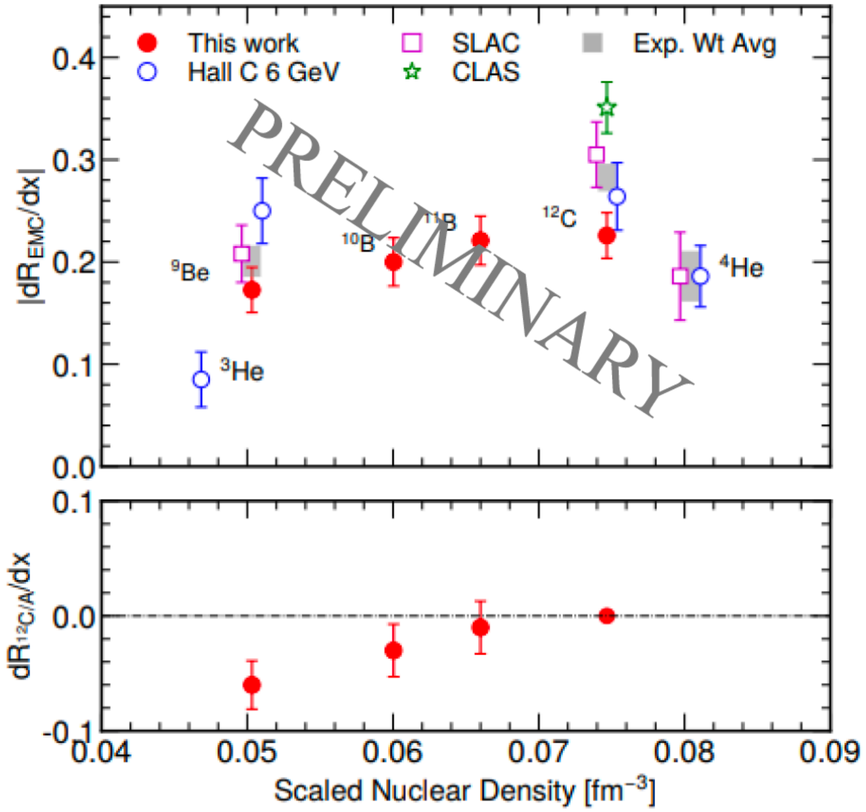
Slide Credit: Abishek Karki

FIRST PUBLICATION FROM COMMISSIONING DATA SUBMITTED TO PRL

First Measurement of the EMC Effect in ^{10}B and ^{11}B

A. Karki,[1] D. Biswas,[2,*] F. A. Gonzalez,[3] W. Henry,[4] C. Morean,[5] A. Nadeeshani,[2] A. Sun,[6] D. Abrams,[7] Z. Ahmed,[8] B. Aljawrneh,[9,†] S. Alsalmi,[10] R. Ambrose,[8] D. Androic,[11] W. Armstrong,[12] J. Arrington,[13] A. Asaturyan,[14] K. Assumin-Gyimah,[1] C. Ayerbe Gayoso,[15,1] A. Bandari,[15] J. Bane,[5] J. Barrow,[5] S. Basnet,[8] V. Berdnikov,[16] H. Bhatt,[1] D. Bhetuwal,[1] W. U. Boeglin,[17] P. Bosted,[15] E. Brash,[18] M. H. S. Bukhari,[19] H. Chen,[7] J. P. Chen,[4] M. Chen,[7] M. E. Christy,[2] S. Covrig,[4] K. Craycraft,[5] S. Danagoulian,[9] D. Day,[7] M. Diefenthaler,[4] M. Dlamini,[20] J. Dunne,[1] B. Duran,[21] D. Dutta,[1] C. Elliott,[5] R. Ent,[4] H. Fenker,[4] N. Fomin,[5] E. Fuchey,[22] D. Gaskell,[4] T. N. Gautam,[2] J. O. Hansen,[4] F. Hauenstein,[23] A. V. Hernandez,[16] T. Horn,[16] G. M. Huber,[8] M. K. Jones,[4] S. Joosten,[12] M. L. Kabir,[1] N. Kalantarians,[24] C. Keppel,[4] A. Khanal,[17] P. M. King,[20] E. Kinney,[25] H. S. Ko,[26] M. Kohl,[2] N. Lashley-Colthirst,[2] S. Li,[27] W. B. Li,[15] A. H. Liyanage,[2] D. Mack,[4] S. Malace,[4] P. Markowitz,[17] J. Matter,[7] D. Meekins,[4] R. Michaels,[4] A. Mkrtchyan,[14] H. Mkrtchyan,[14] S. Nanda,[1] D. Nguyen,[7] G. Niculescu,[28] I. Niculescu,[28] Nuruzzaman,[29] B. Pandey,[2] S. Park,[3] E. Pooser,[4] A. J. R. Puckett,[22] M. Rehfuss,[21] J. Reinhold,[17] N. Santiesteban,[27] B. Sawatzky,[4] G. R. Smith,[4] H. Szumila-Vance,[4] A. S. Tadepalli,[29] V. Tadevosyan,[14] R. Trotta,[16] S. A. Wood,[4] C. Yero,[17] and J. Zhang[3,‡]

(for the Hall C Collaboration)



Analysis by Abishek Karki (MSU)

SMALL SUBSET OF THE DATA TAKEN IN 2018/19

E12-06-105 PHASE I

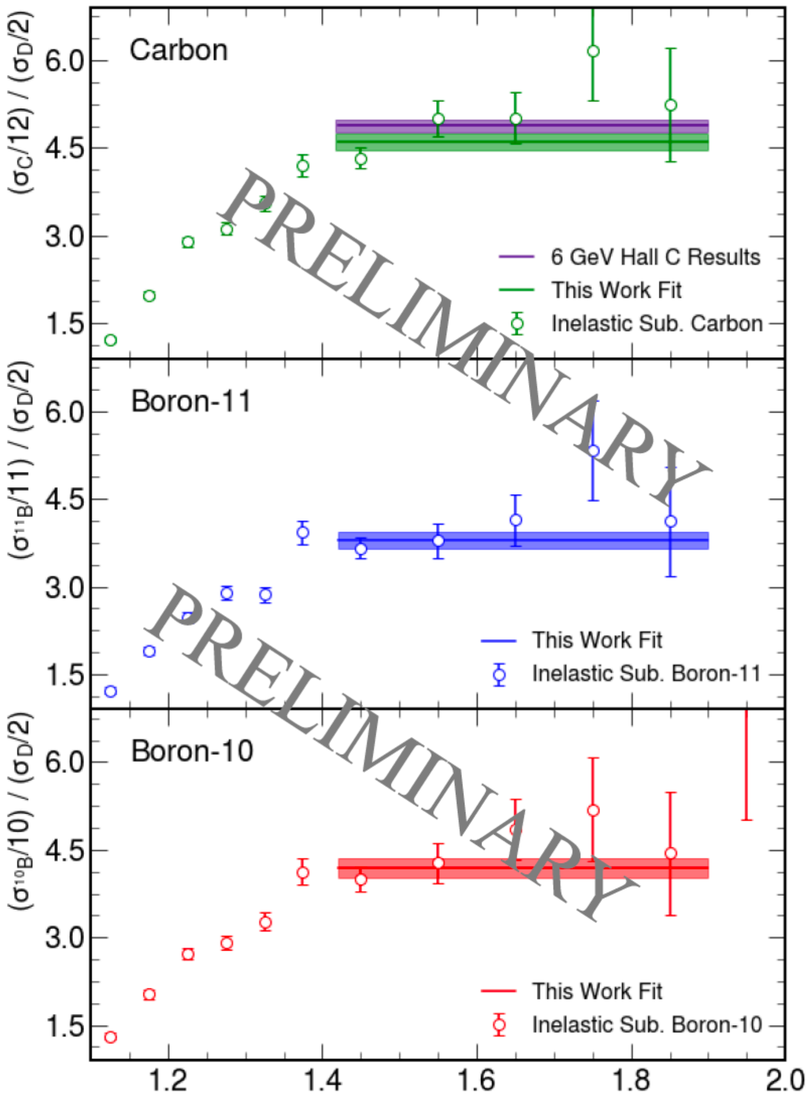
2018	
Central Momentum	9.8 GeV
Q^2	2.08
Angles	8.02
Elements	H, D, C, Al, ^{9}Be,^{10}**B**,^{11}**B**

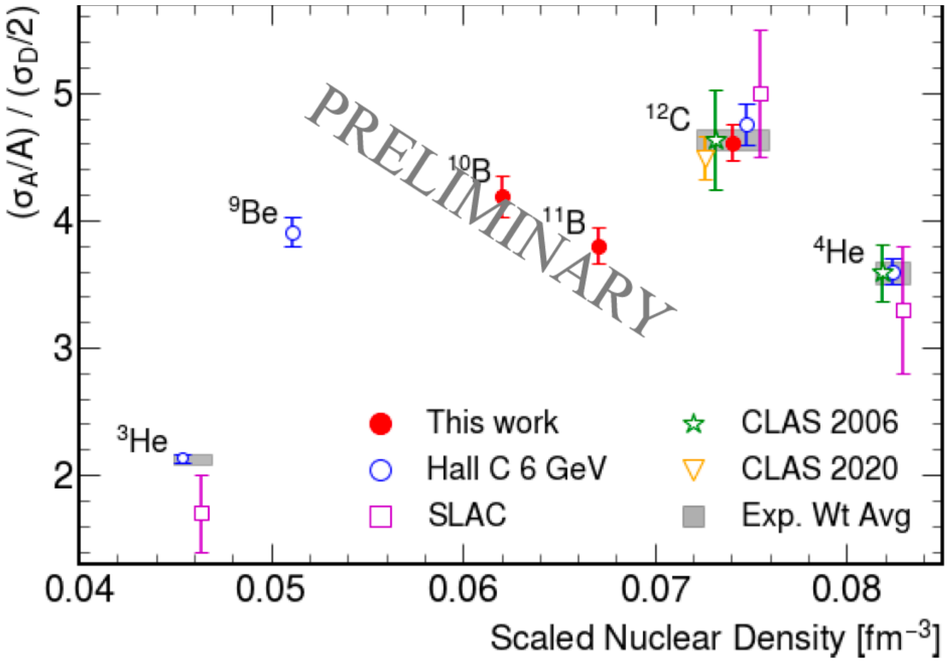
2019	
Central Momentum	9.8 GeV
Q^2	4.46
Angle	13.10
Elements	H, D, C, Al, ^{10}**B**,^{11}**B**

*Boron targets are boron carbide B_4C

Slide Credit: Casey Morean

2N SRC PUBLICATION UNDER PREPARATION





Analysis by Casey Morean
Next Talk!

CURRENTLY IN HALL C

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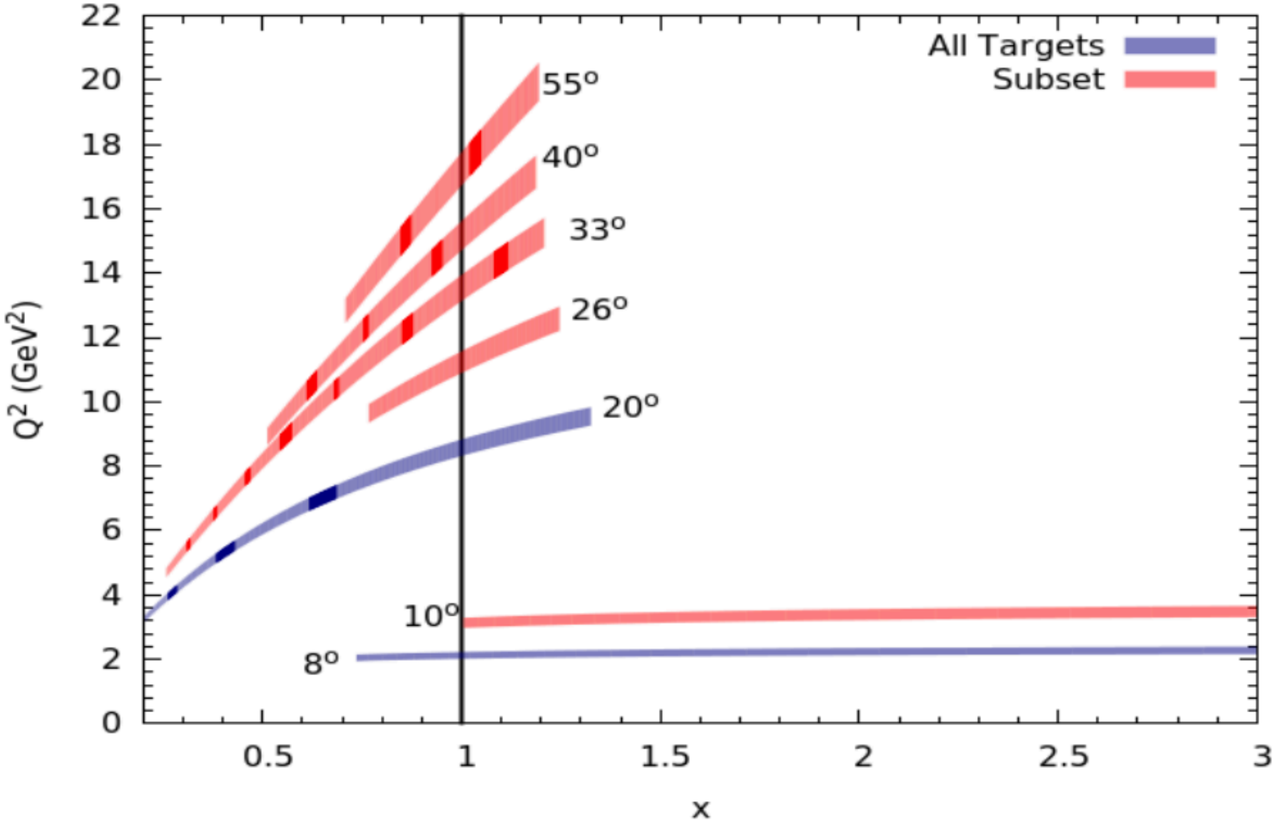
Detailed Studies of the nuclear dependence of F_2 in light nuclei

ERR Figure



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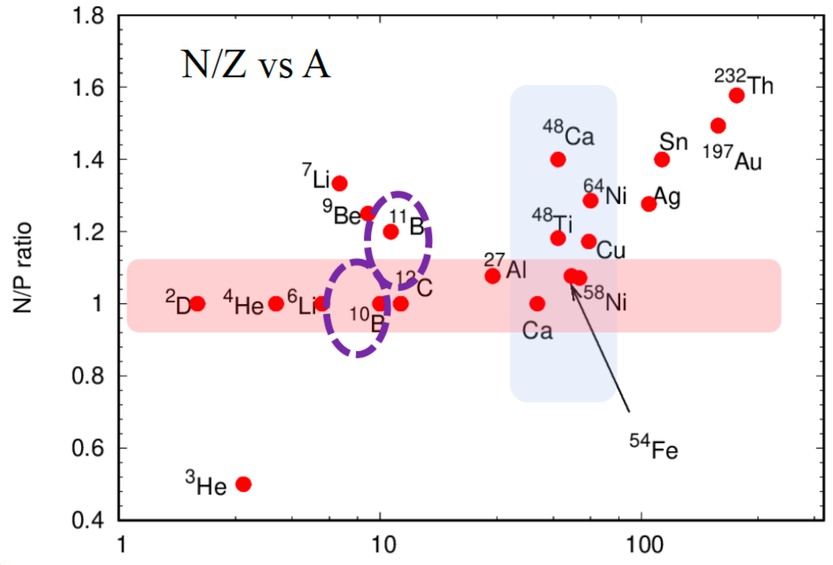
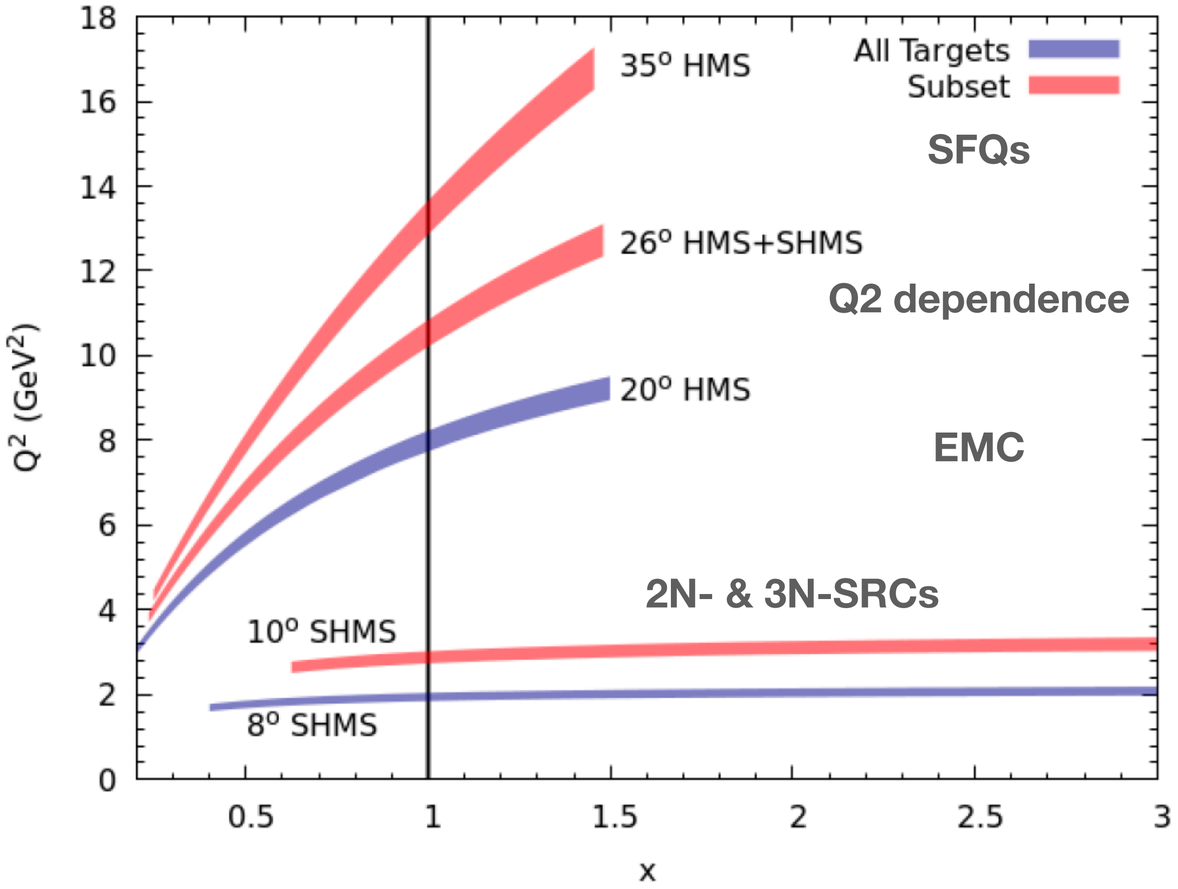


CURRENTLY IN HALL C



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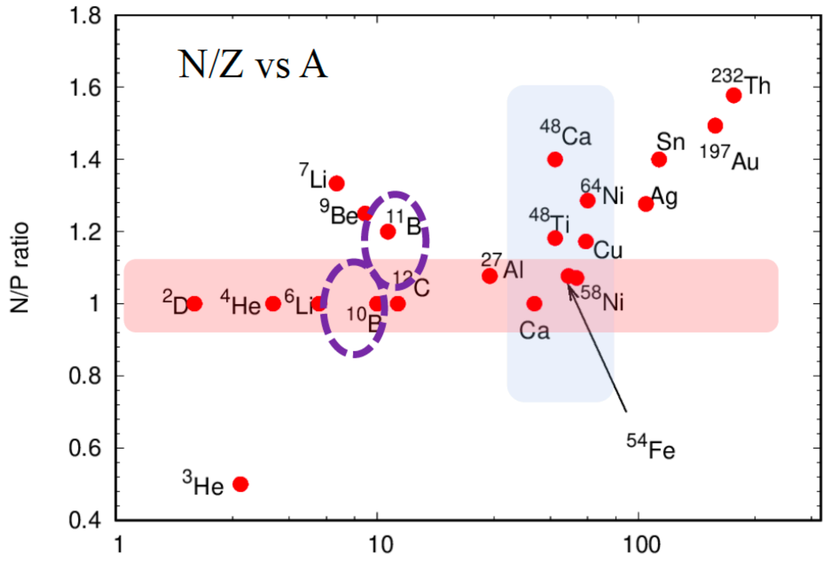


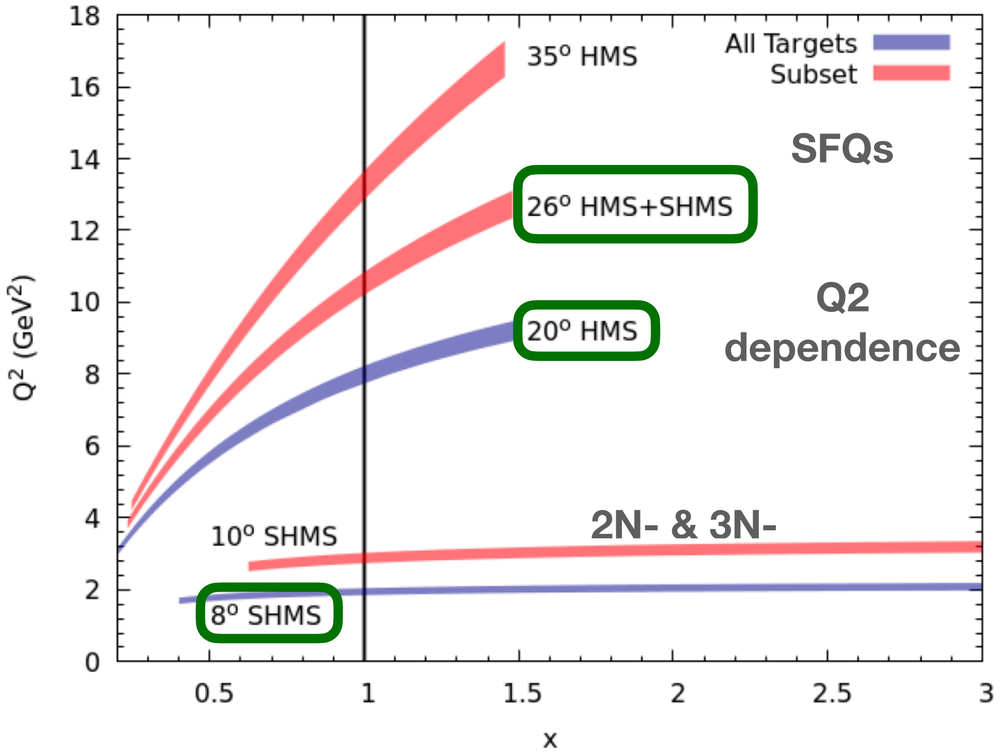
XEM2 EXPERIMENTS: DATA STATUS

Completed

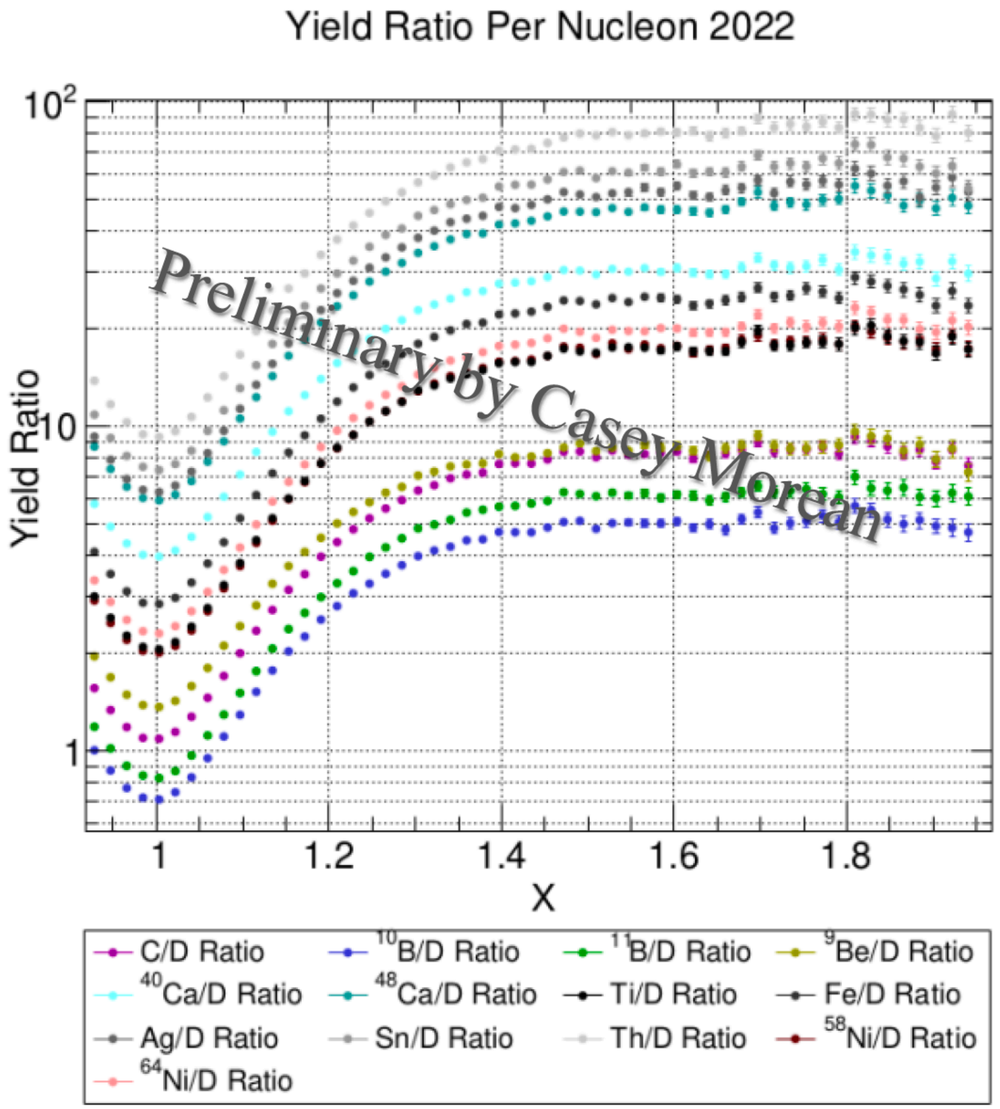
- Coincidence and single arm elastic data, and delta scan with the SHMS including some runs with sieve
- Special set of data for detector calibrations and PID threshold checks
- BCM calibrations and boiling studies
- Charge symmetric background measurements at selected kinematics and targets (20/26/35 deg) except for 35 deg on ladder II
- 26 deg SHMS/HMS Q2 dependence studies
- 20 deg HMS (EMC) & 8 deg SHMS (2N-SRC) both target ladders
- 35 deg in HMS (SFQ/EMC) and 10 deg (3N-SRC) on target ladder I

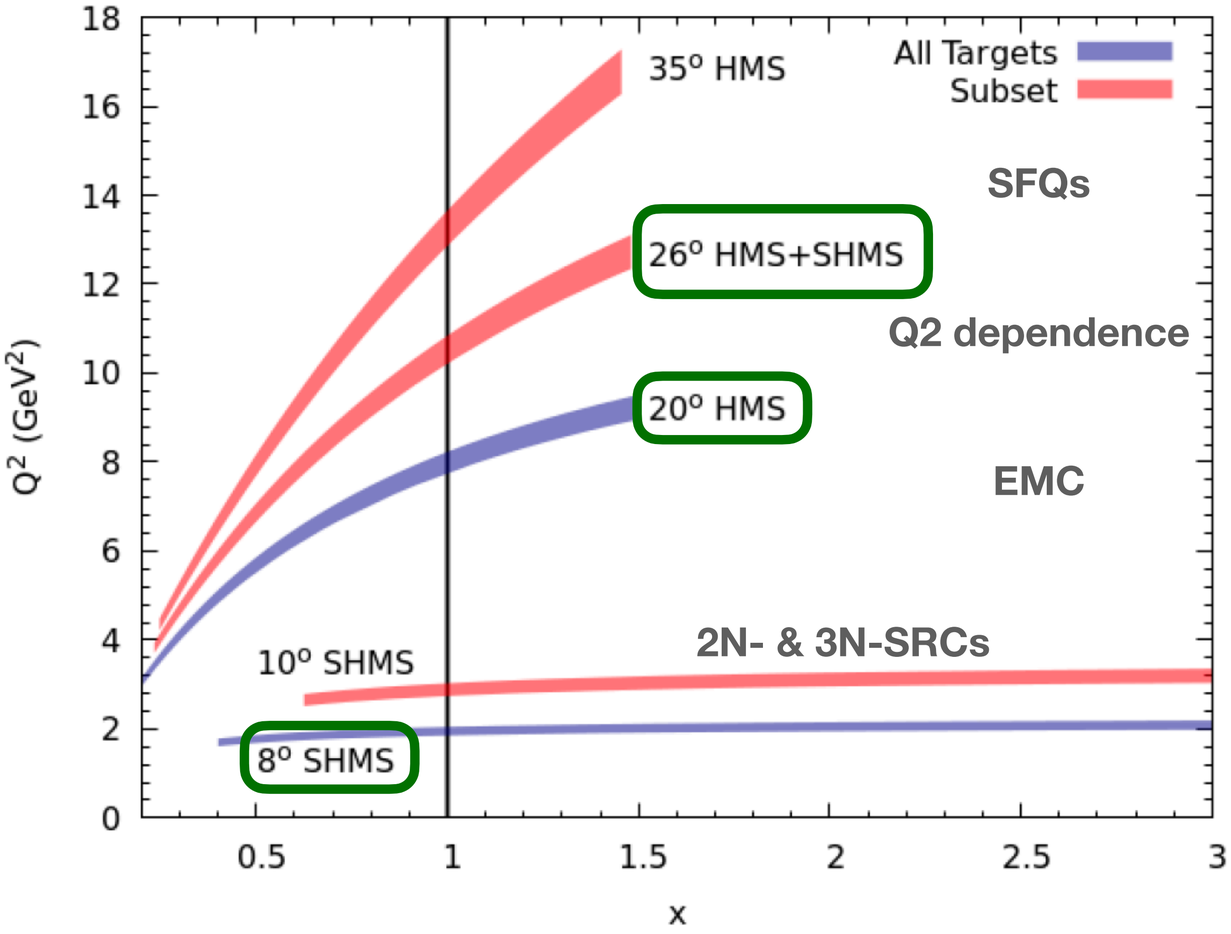
Ongoing

- Charge symmetric background measurements for 35 deg on ladder II
- 35 deg in HMS (SFQ/EMC) and 10 deg (3N-SRC) on target ladder II



SUMMARY





See next talk by Casey Morean for the details of x>1 analysis!

THE MOST IMPORTANT SLIDE

Fall 2022-Winter 2023 Hall C Shift Schedule Shift Schedule

Notes:
SL - Shift Leader TO - Target Operator
Read-only shift schedule: Fall 2022-Winter 2023

Your permissions in this application:

- You can sign up for shifts
- You can sign up as a shift leader
- You can sign up as a target operator
- **You are signed up for target operator shifts. This requires both lecture and practical training.**

Daily run coordinator summary:

Shift Instructions:
Shift schedule for XEM2 (EMC, E12-10-008 and x>1, E12-06-105), and Deuteron Electro-Disintegration (E12-10-003)

Note that at this time, Deuteron Electro-disintegration is expected to run for the last month of the run-period.

Please subscribe to the hallc_running mailing list to receive updates about the running of the experiment(s) and possible updates to the shift schedule.
hallc_running signup

Shift requirements:

15 shifts are required for authorship on papers for both experiments XEM2 and Deuteron Electro-Disintegration
12 shifts required for XEM2 ONLY
5 shifts required for Deuteron Electro-Disintegration ONLY

OWL shifts receive extra weight (1.5).

PLEASE

SIGN UP

FOR

SHIFTS!!!

Shift sign up link: https://misportal.jlab.org/mis/apps/physics/shiftSchedule/index.cfm?experimentRunId=HALLC-XEM2