New Measurements of the EMC Effect at 12 GeV

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Frontiers and Careers Workshop
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Outline

- Physics Background
- E12-10-008 Physics Goals
- E12-10-008 Targets & Kinematics
- Phase I Results

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Background: Discovery of the EMC Effect

PREDICTION (PRE-1983)

$$F_2^A = ZF_2^p + NF_2^n$$

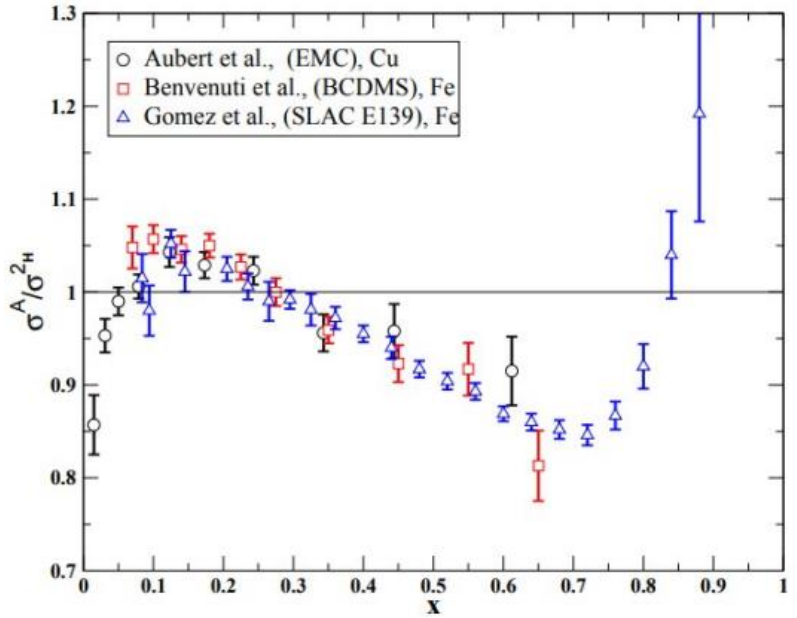
EXPERIMENT

J. Aubert et al., Phys. Lett. B123, 275 (1983)

Background: Discovery of the EMC Effect

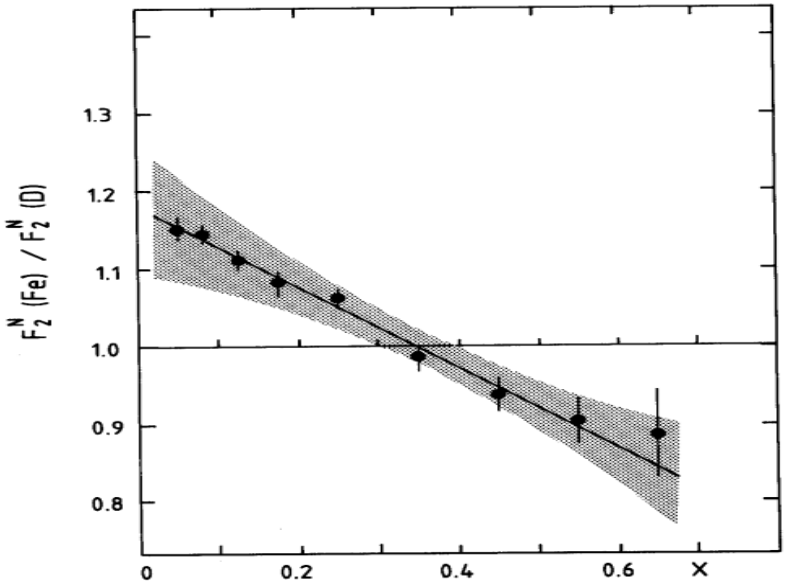
PREDICTION (PRE-1983)

$$\frac{F_2^A}{ZF_2^p + NF_2^n} = 1 \quad \xrightarrow{Assume\ R \equiv \frac{\sigma_L}{\sigma_T}\ is\ A\ Independent} \quad \frac{\sigma_A}{Z\sigma_p + N\sigma_n} = 1$$



EXPERIMENT

Quark distributions are modified in nuclei?!



J. Aubert et al., Phys. Lett. B123, 275 (1983)

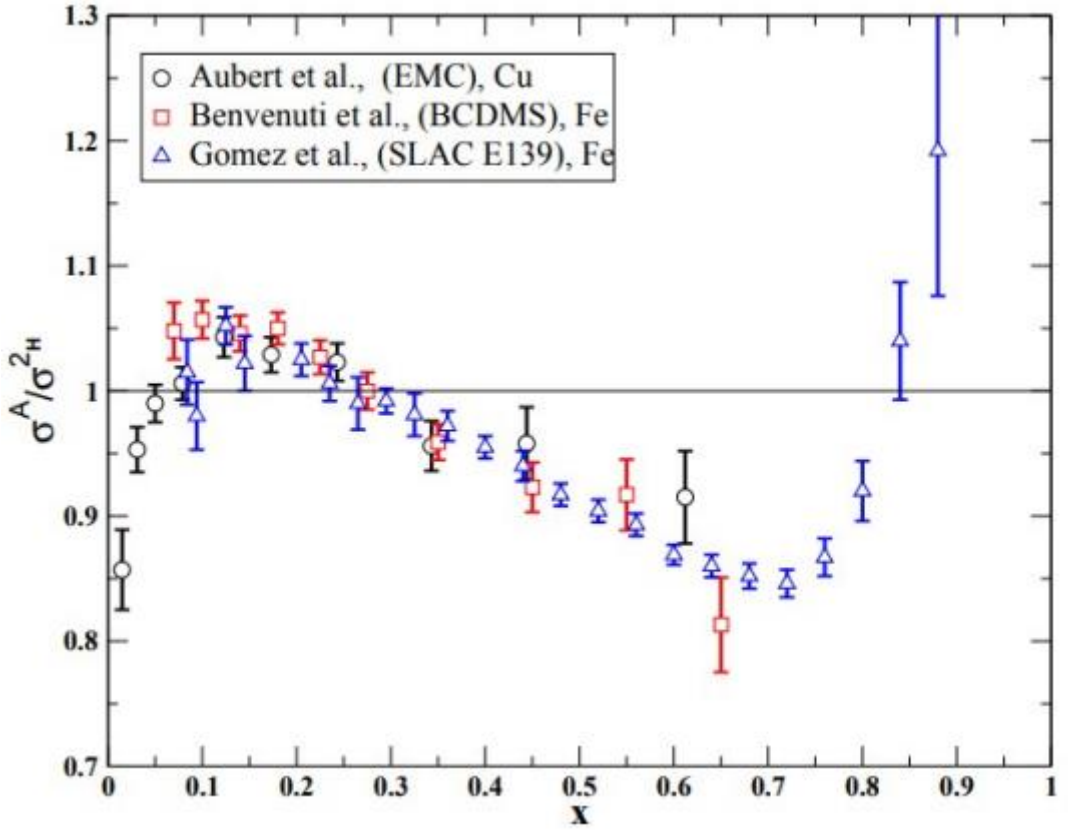
Background: The EMC Effect

The EMC Effect remains one of the biggest unsolved mysteries in nuclear physics.

1000s of papers have been written about the EMC Effect in the last 40 years - **still no consensus.**

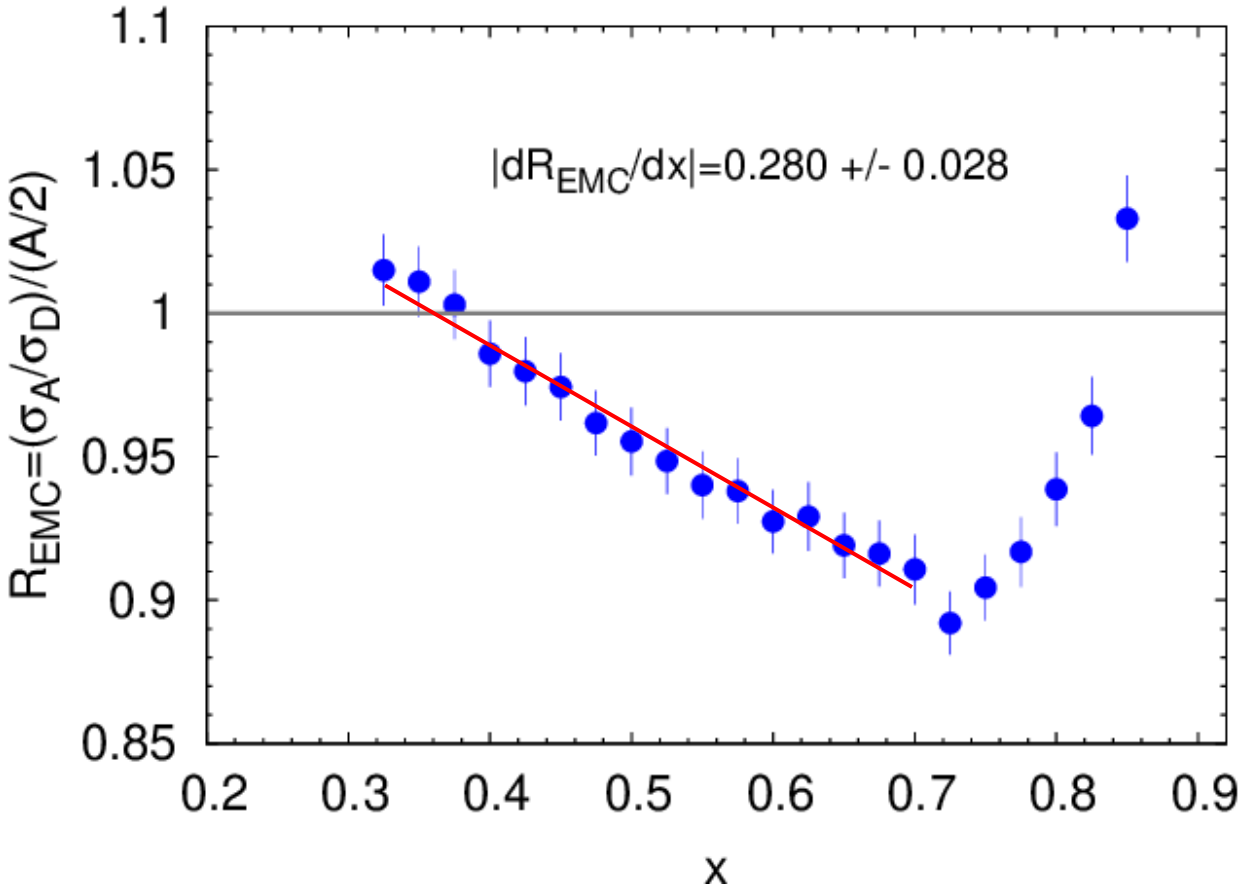
Some Open Questions:

- Is the nucleon structure modified in nuclei?
  - **Proton in Hydrogen ≠ Proton in Iron?**
- Is there a **connection to SRCs?**



Background: Quantifying the EMC Effect

The “size” of the EMC Effect in a given nucleus is determined from the slope in the range: $0.35 < x < 0.7$



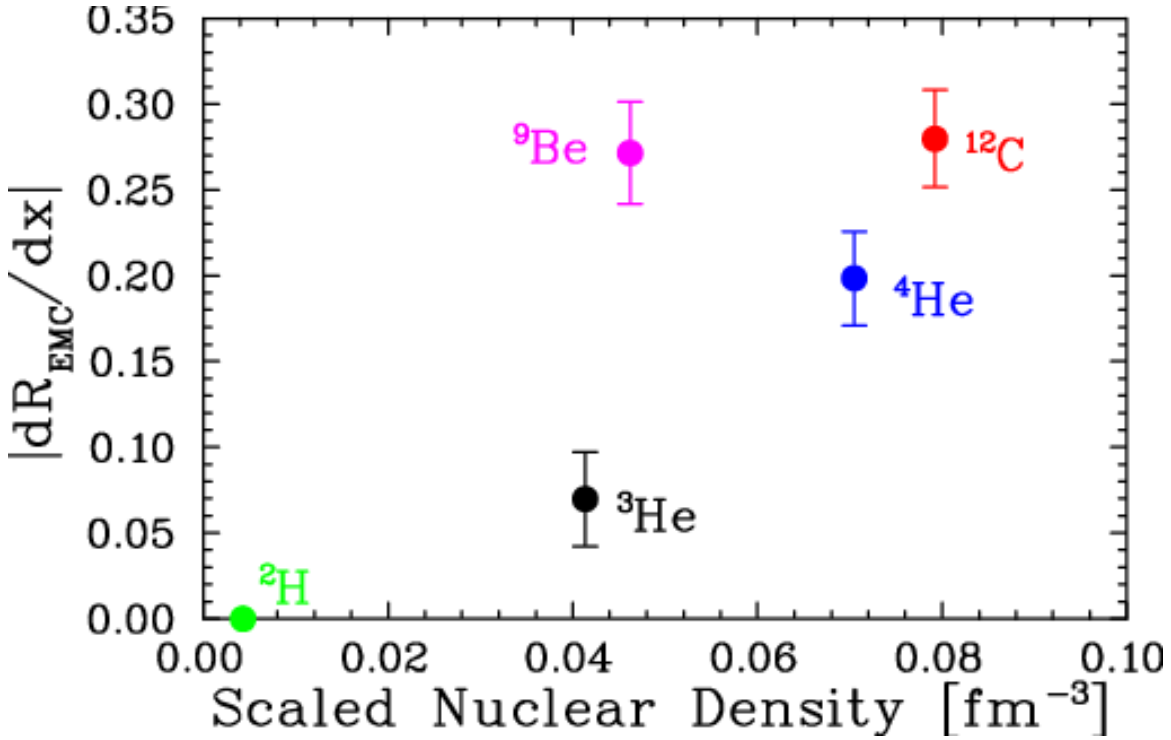
J. Arrington *et al.*, arXiv:1206.6343 [nucl-ex], (2022)

Background: Quantifying the EMC Effect

The “size” of the EMC Effect in a given nucleus is determined from the slope in the range: $0.35 < x < 0.7$

A density-dependent fit does an alright job for larger nuclei, but **totally fails for light (A<12) nuclei.**

What is driving the EMC Effect?



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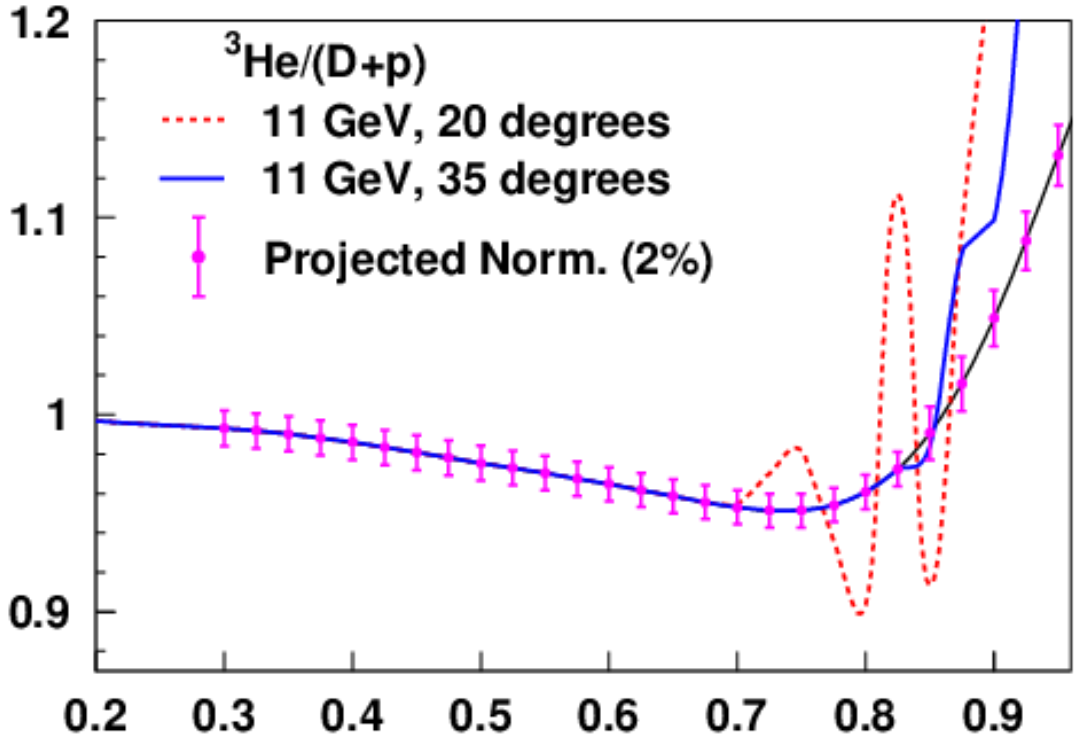
Physics Goals: EMC Effect in 3He

3He/D ratio requires a **large isoscalar correction** to extract the EMC Effect.

Strong model dependency of the isoscalar correction is **avoided by measuring 3He/(D+p) instead.**

The proton introduces a **problem at low Q^2** -it has no Fermi Motion to smooth resonances – **can't get clean 3He/(D+p) slope at low Q^2.**

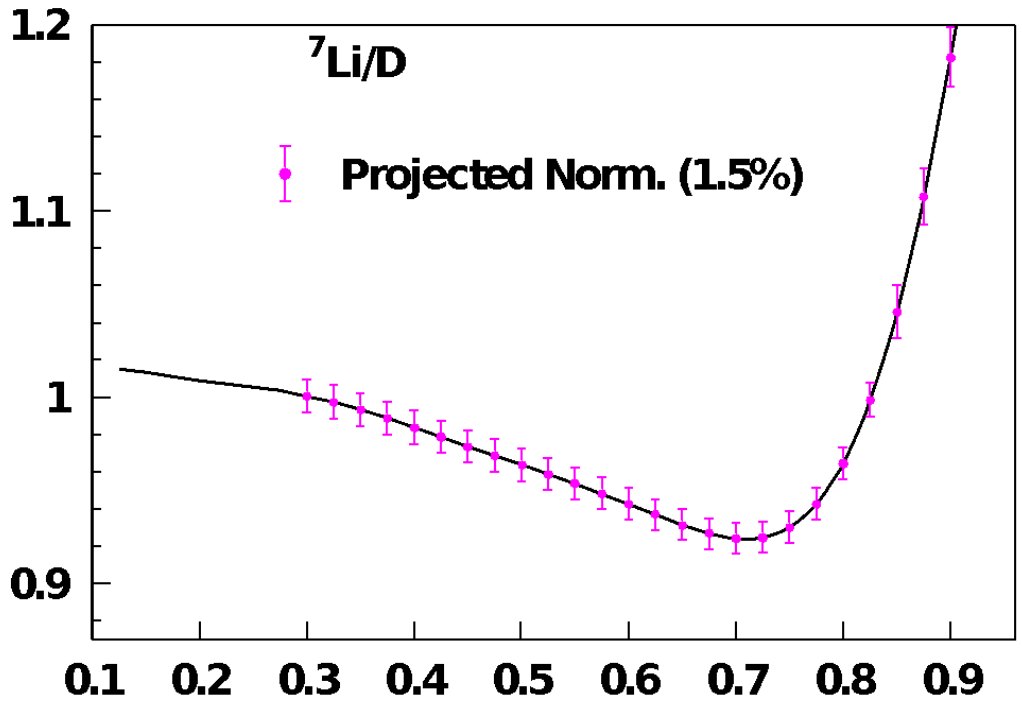
Using higher energy beam, we reach higher Q^2 and resonance structure pushed out to x>0.8, allowing for comparison with 3He/D data out to larger x to validate isoscalar correction model.



Physics Goals: EMC Effect in Light Nuclei

E12-10-008 will be the **first experiment to measure the EMC Effect in several light nuclei** including 6Li and 7Li.

Light nuclei are **amenable to comparison with theorists' calculations** that can exact nuclear wave functions.



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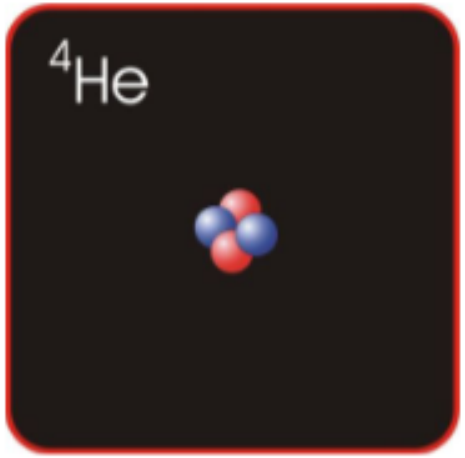
Light nuclei provide a great environment to study **nuclear structure and clustering** within the nucleus.

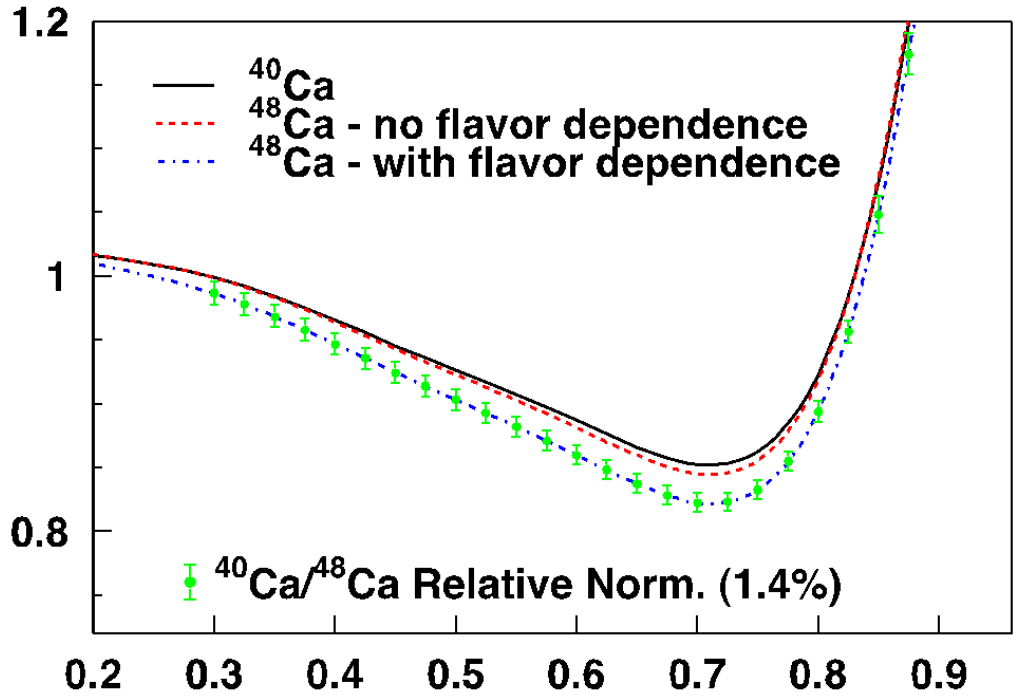


Physics Goals: Flavor Dependence of EMC Effect

We will study possible **flavor dependence of the EMC Effect** through measurements of 40Ca and 48Ca**.**

The flavor-dependent CBT Model predicts a **~3% difference** between 40Ca and 48Ca at x=0.6.

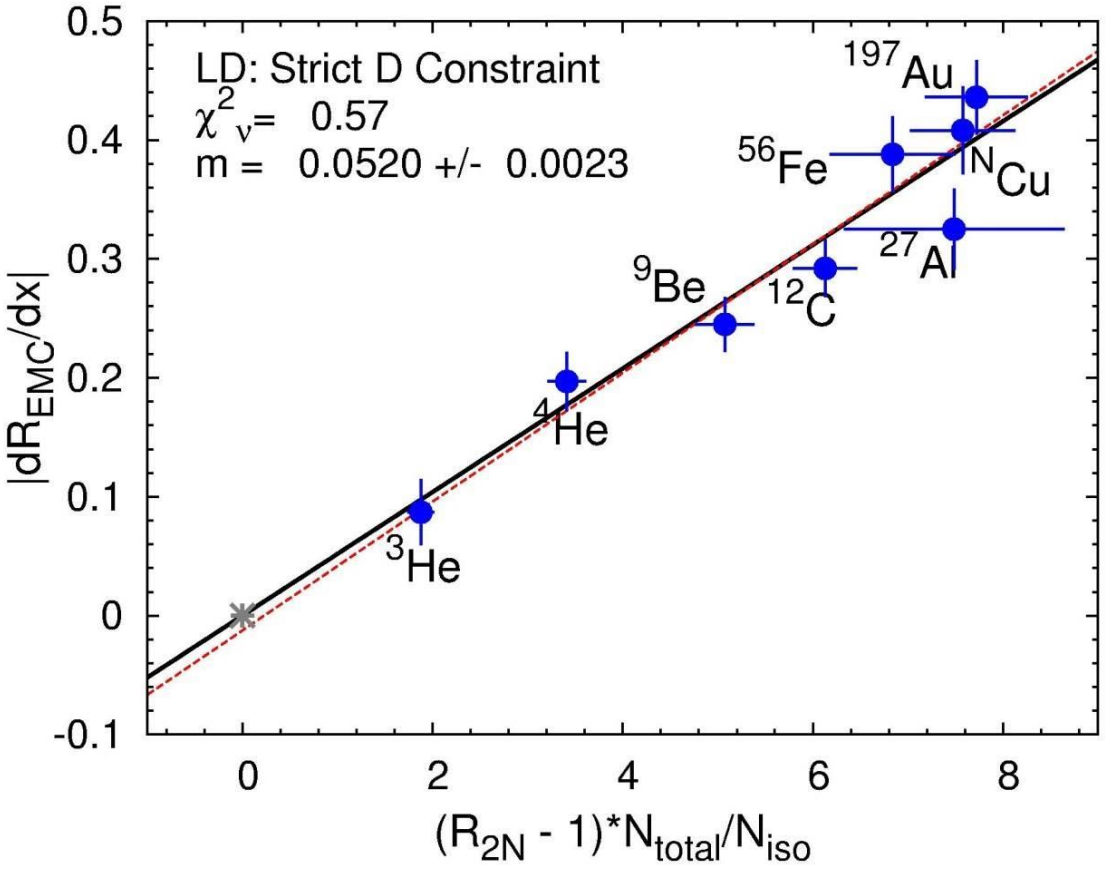
On the other hand, we would expect a **difference of <1%** if there is no flavor dependence.



Physics Goals: EMC-SRC Correlation

There is a **strong correlation between the size of the EMC Effect and SRCs.**

With data from our experiment and the x>1 experiment that will run in parallel, we will **add many new nuclei** to investigate this connection.



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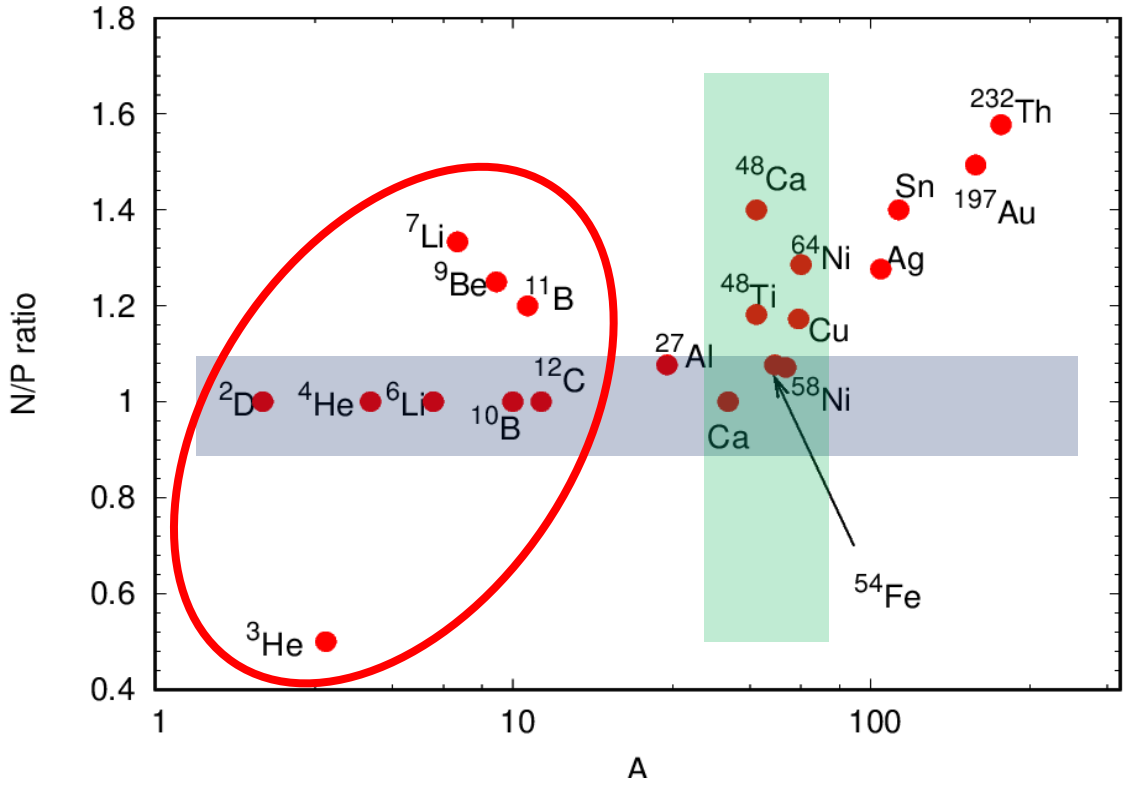
Upcoming Run: Targets



- Coverage of large range of target masses, densities, and n/p values
- Many new light targets (cluster structure)

Upcoming Run: Kinematics

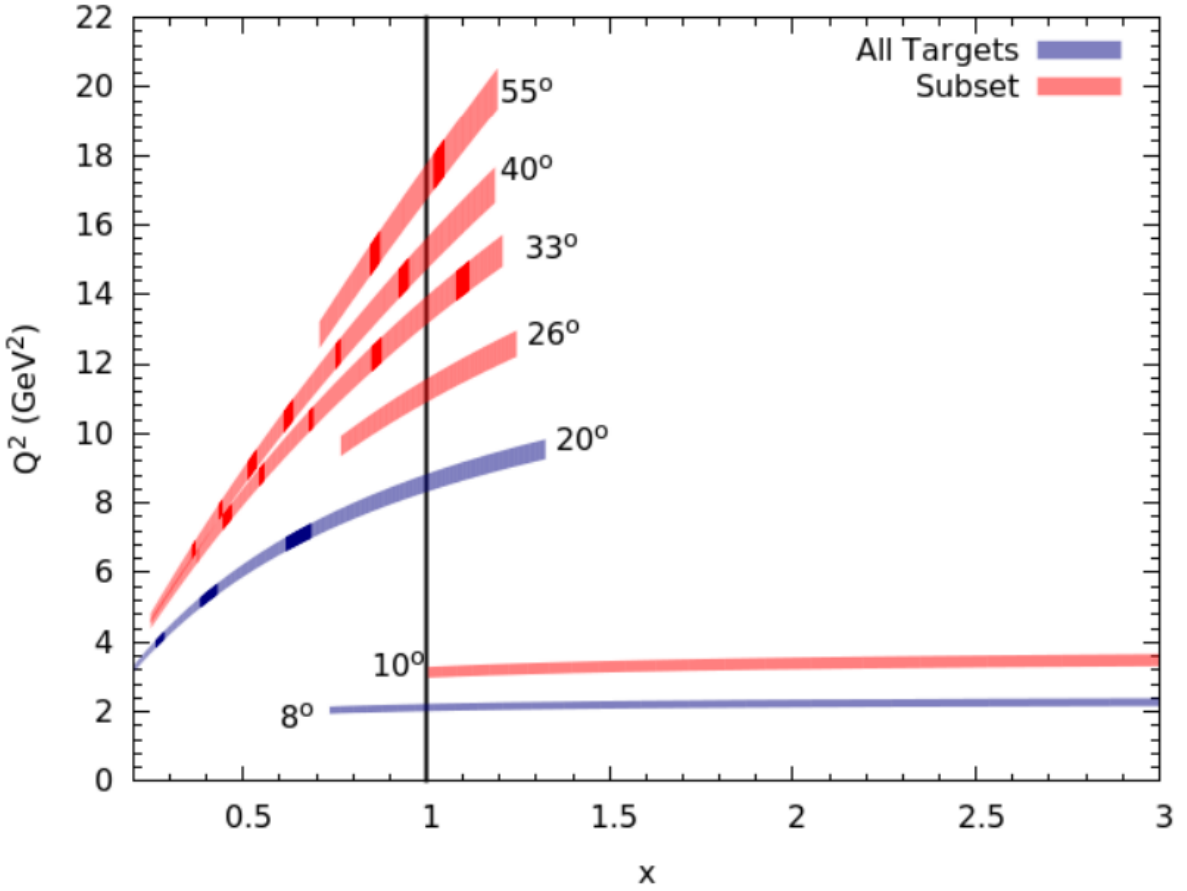
Kinematic coverage for both EMC and x>1 (SRC) experiments.

EMC and x>1 will run in parallel in the hall, utilizing both the SHMS and HMS detectors.

Coverage of a large range of Q2 to verify we are in scaling regime

Total 23 PAC days for Phase I and II

- Phase I completed in 2018 (2 days)



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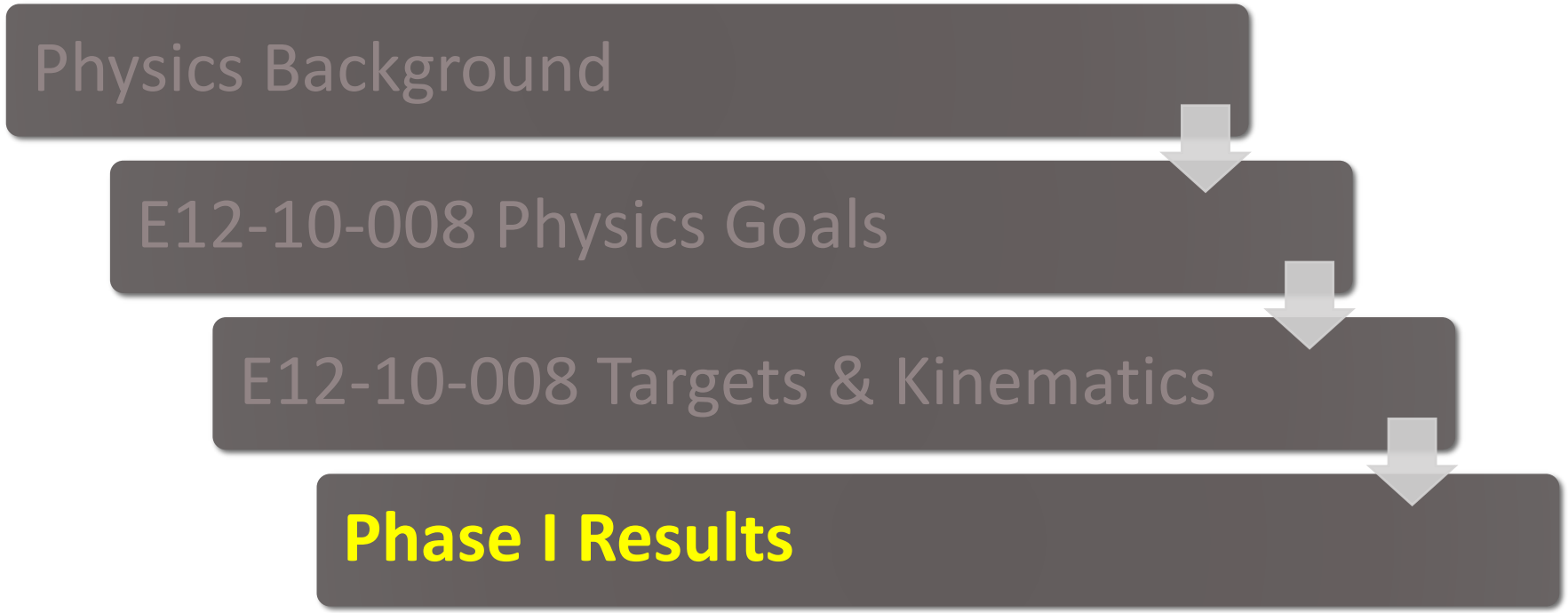
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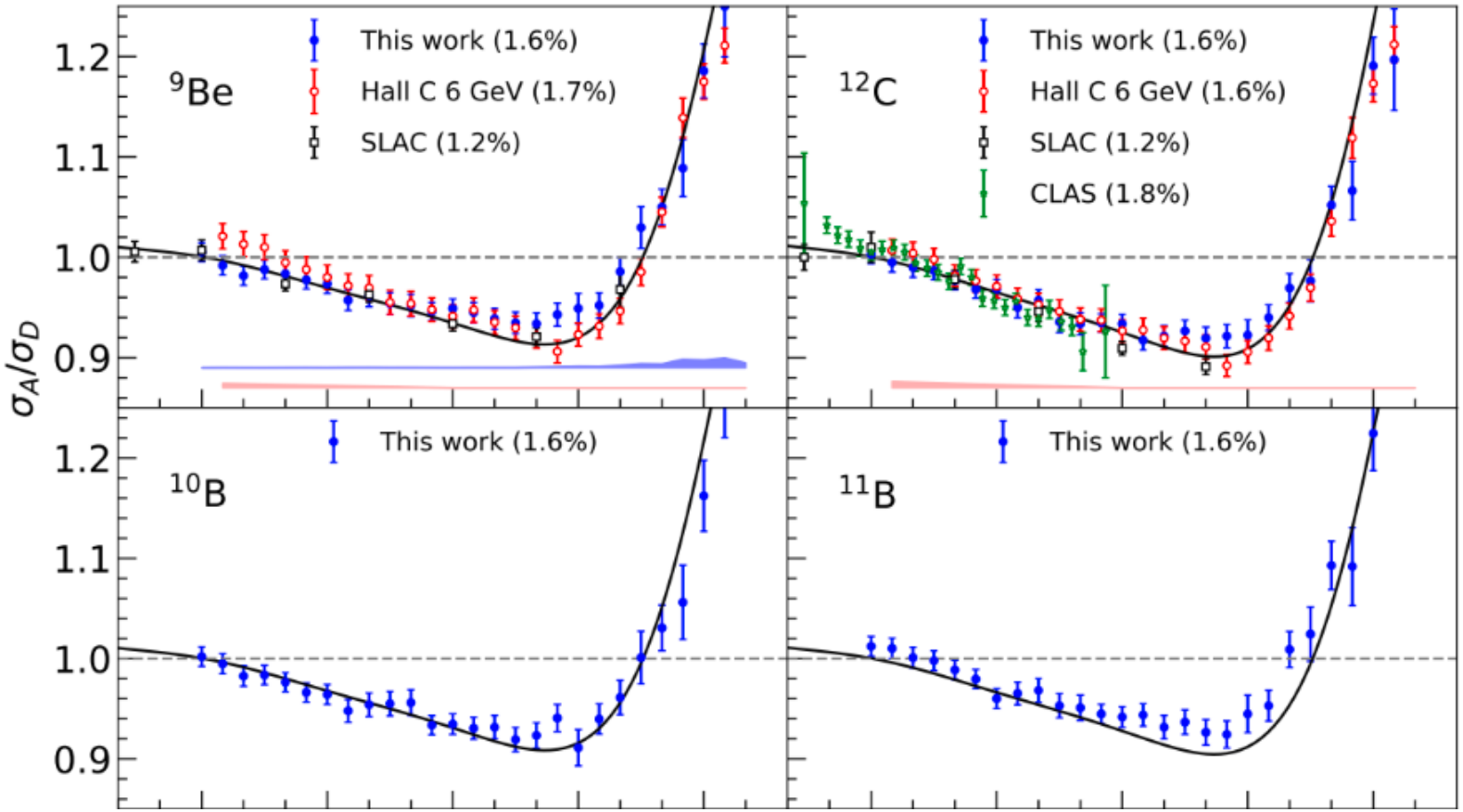
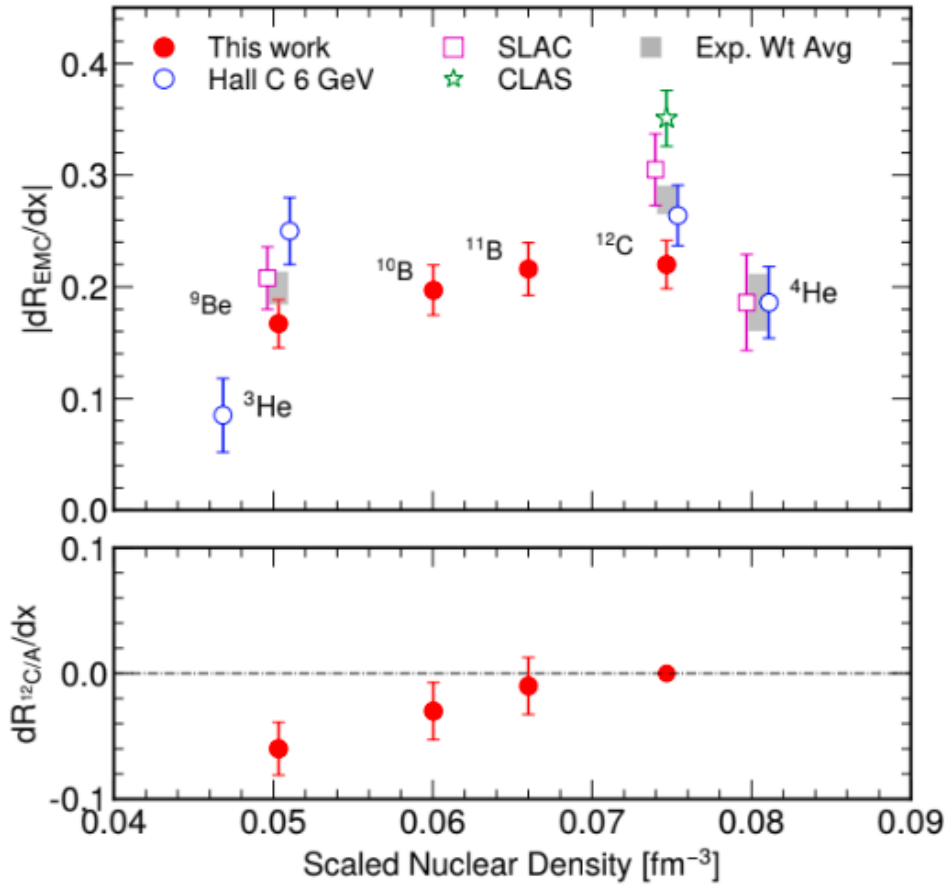
Results: Canonical EMC Plots

Phase I – Collected data for several light nuclei

Data showing characteristic EMC Effect shape!



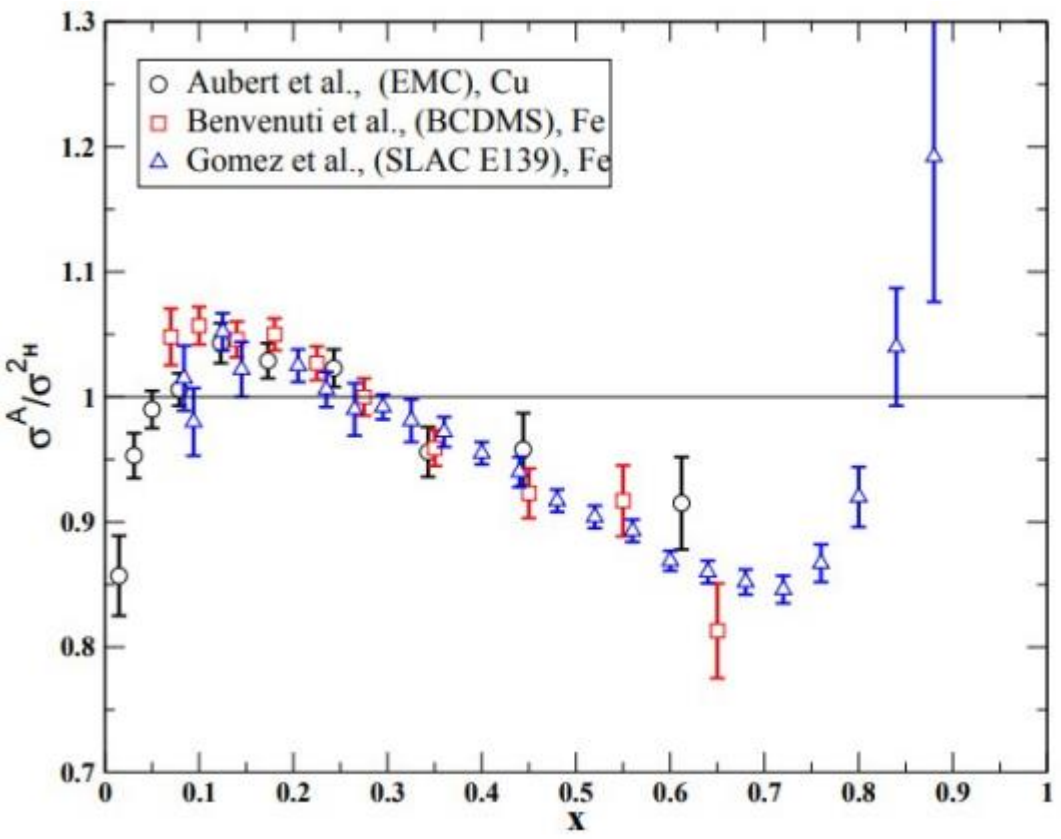
Results: EMC Slope v. Density



A. Karki *et al.*, arXiv:2207.03850 [nucl-ex], (2022)

Summary

After 39 years and 1000s of papers, we still don't know the cause of the EMC Effect.



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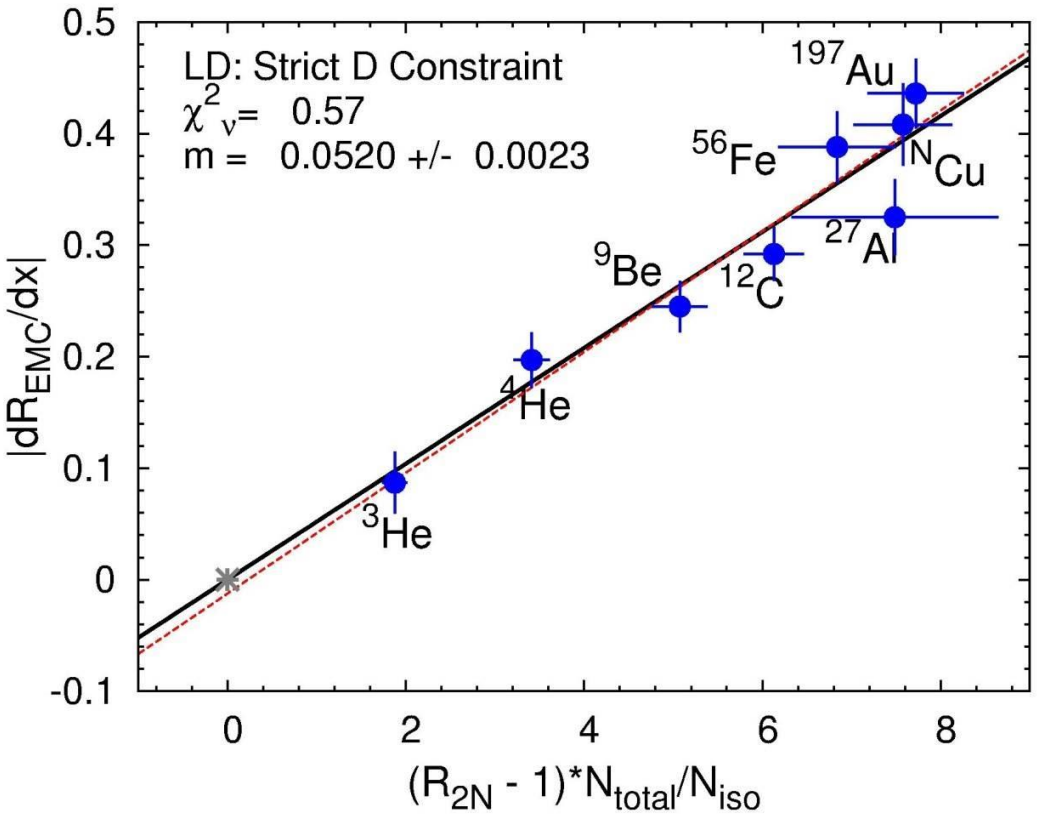
- 40Ca and 48Ca will allow us to study **possible flavor dependence of the EMC Effect**, as predicted in several models
- More nuclei for **EMC-SRC** comparison



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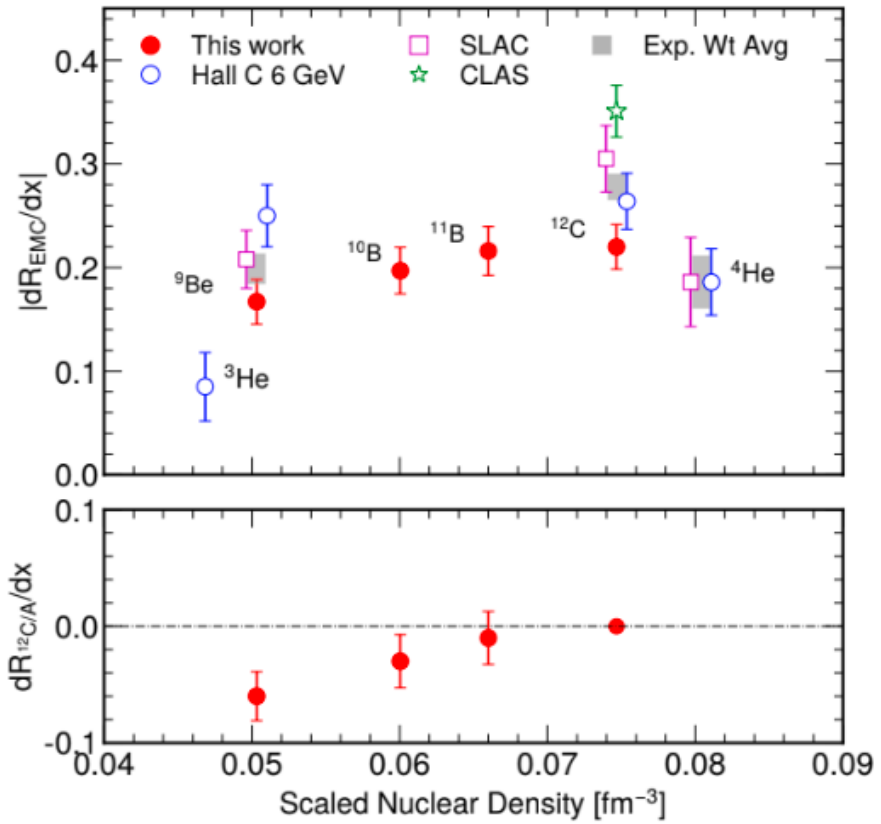

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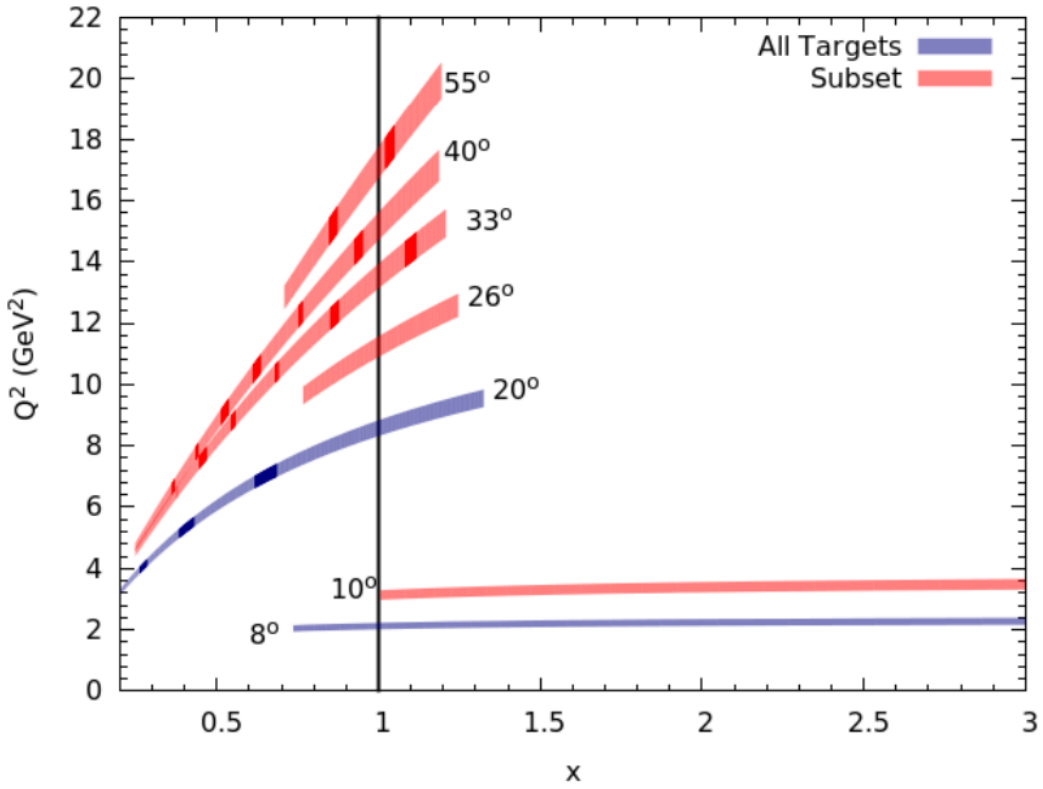
Phase II will run this Fall!



$|XEM\rangle$ Collaboration

Spokespeople:

John Arrington (LBL), Aji Daniel, Donal Day (UVa), Nadia Fomin (UTK), Dave Gaskell (JLab)

Postdocs:

Burcu Duran (UTK), Tyler Hauge (LBL)

Graduate Students:

Cameron Cotton (UVa), Abishek Karki (MSU), Casey Morean (UTK)

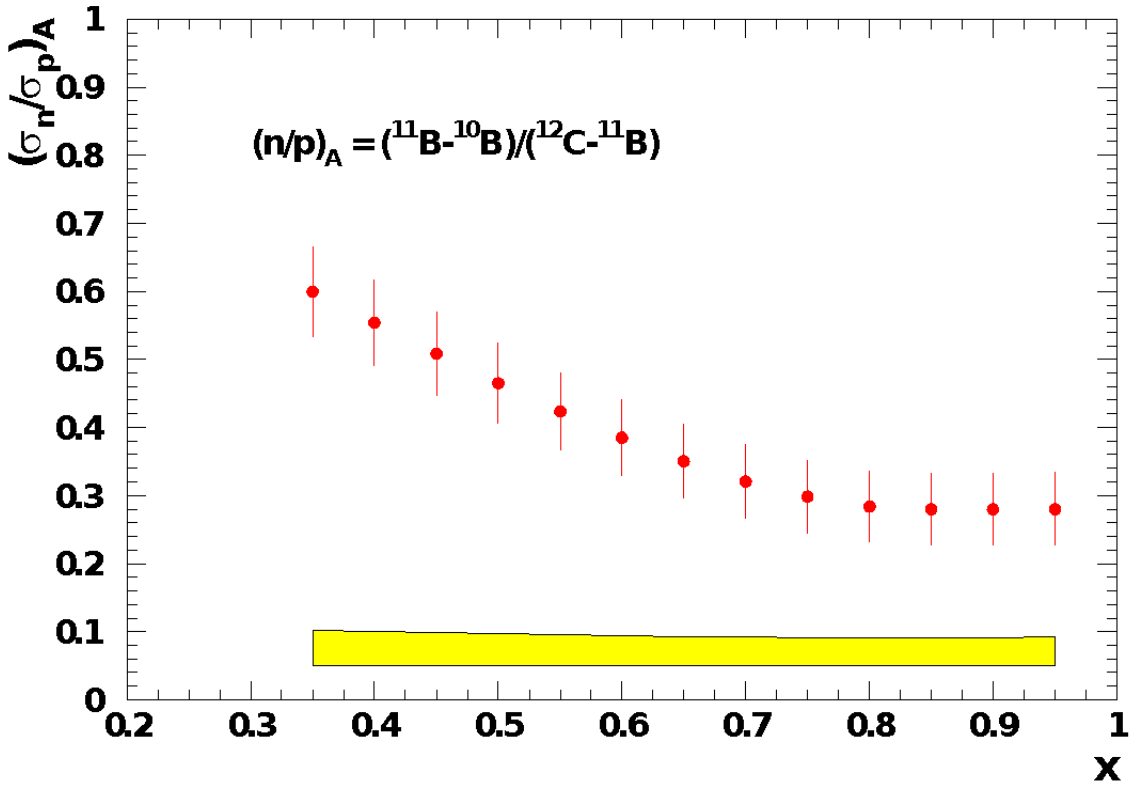
Questions?

Backup Slides

Physics Goals: n/p ratio

We will be able to **extract the n/p ratio in nuclei** by comparing cross sections of adjacent nuclei.

This may provide insight into nuclear modeling that is required to **extract n/p cross sections from D/p.**



Fermi Smearing