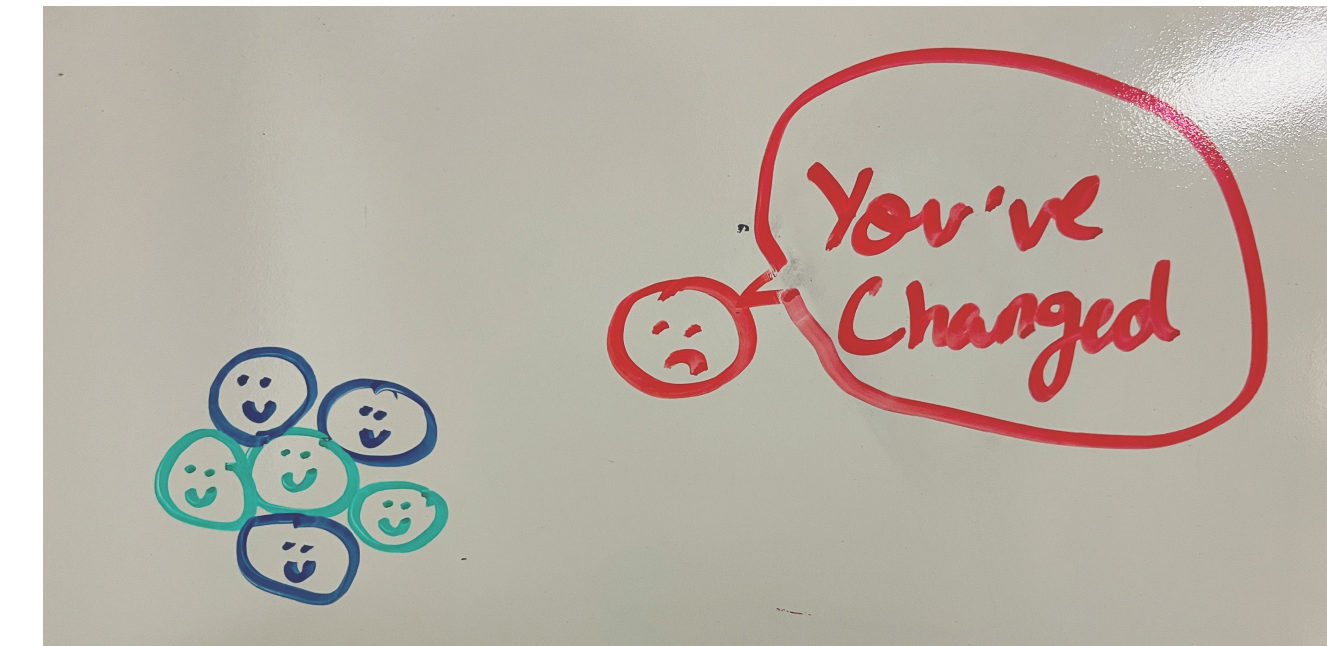


# EMC Effect at 11 GeV



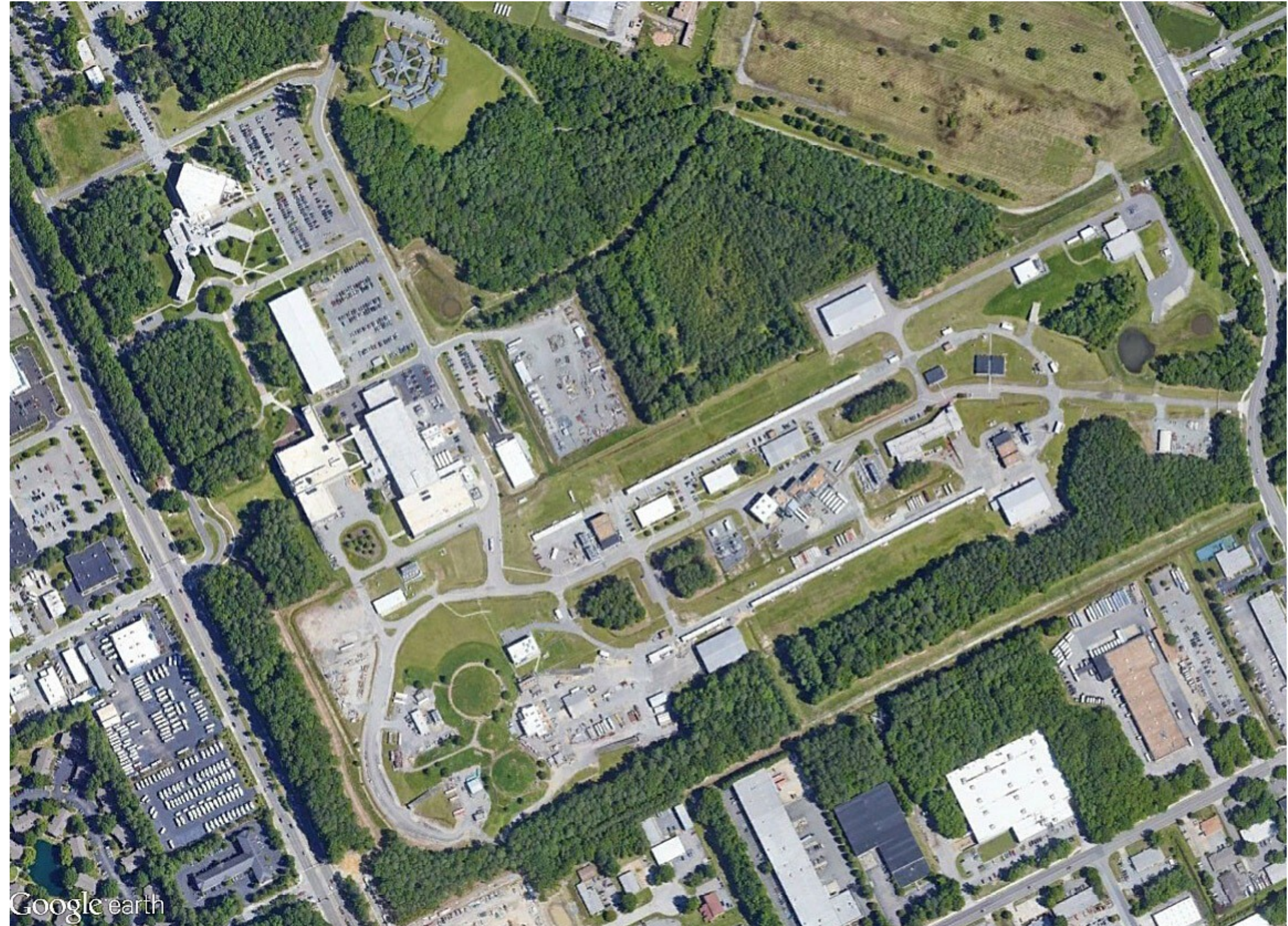
Abhyuday Sharda  
HUGS '23  
June 16th 2023





# Overview

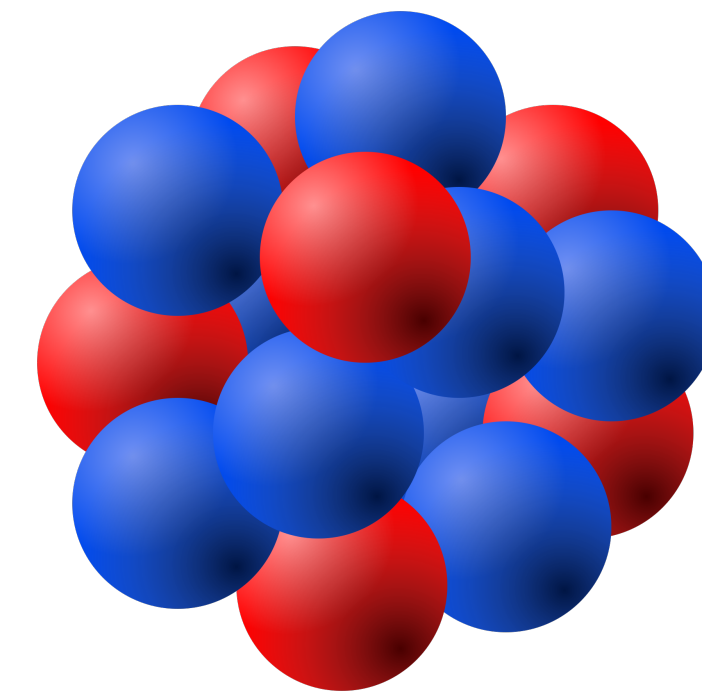
- *Physics Background*
- Overview of E12-10-008





# What is the EMC Effect?

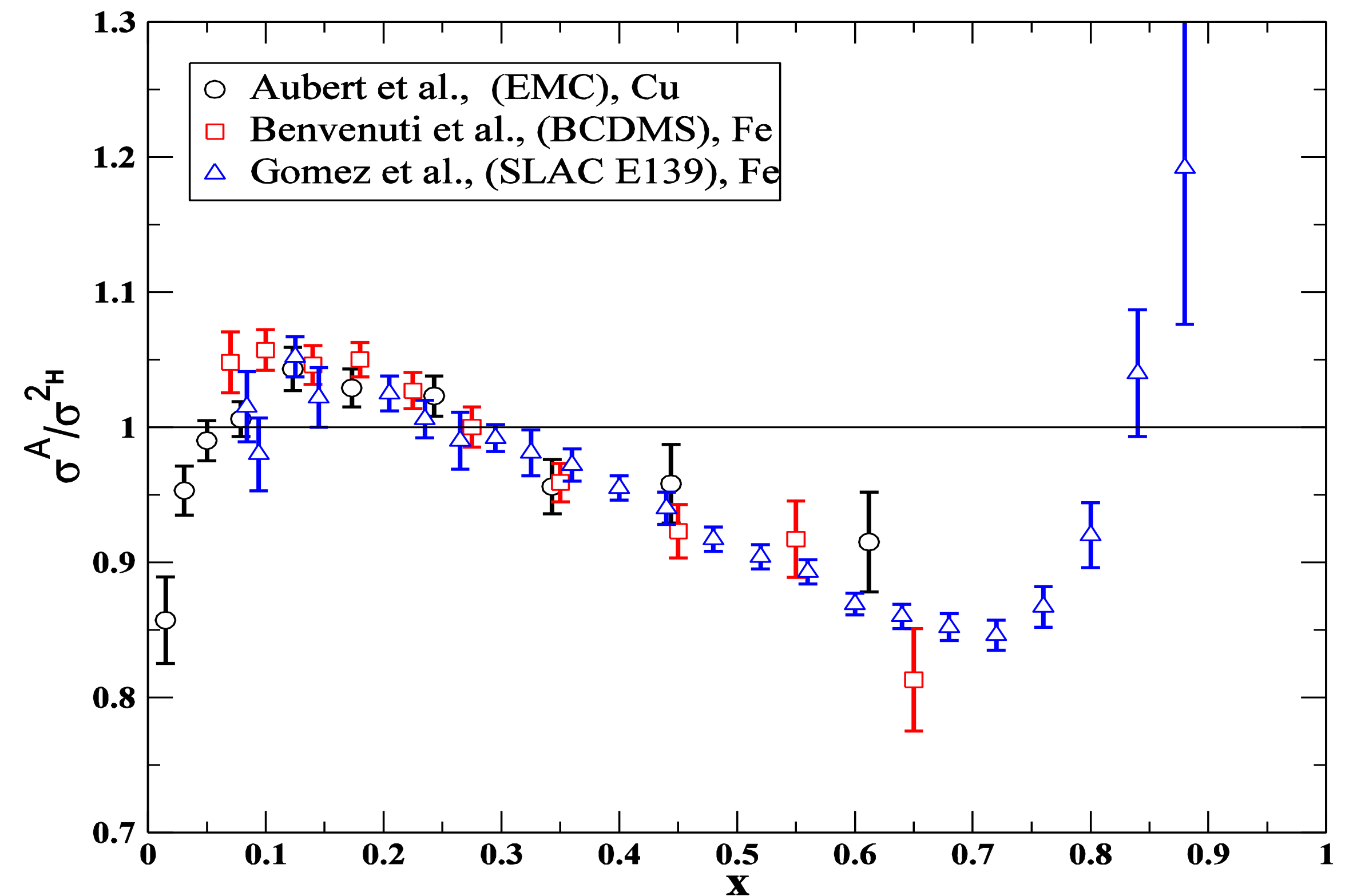
- Discovered by the European Muon Collaboration in 1983
- $F_2^A(x) = ZF_2^p(x) + NF_2^n(x)$



# What is the EMC Effect?

- Discovered by the European Muon Collaboration in 1983

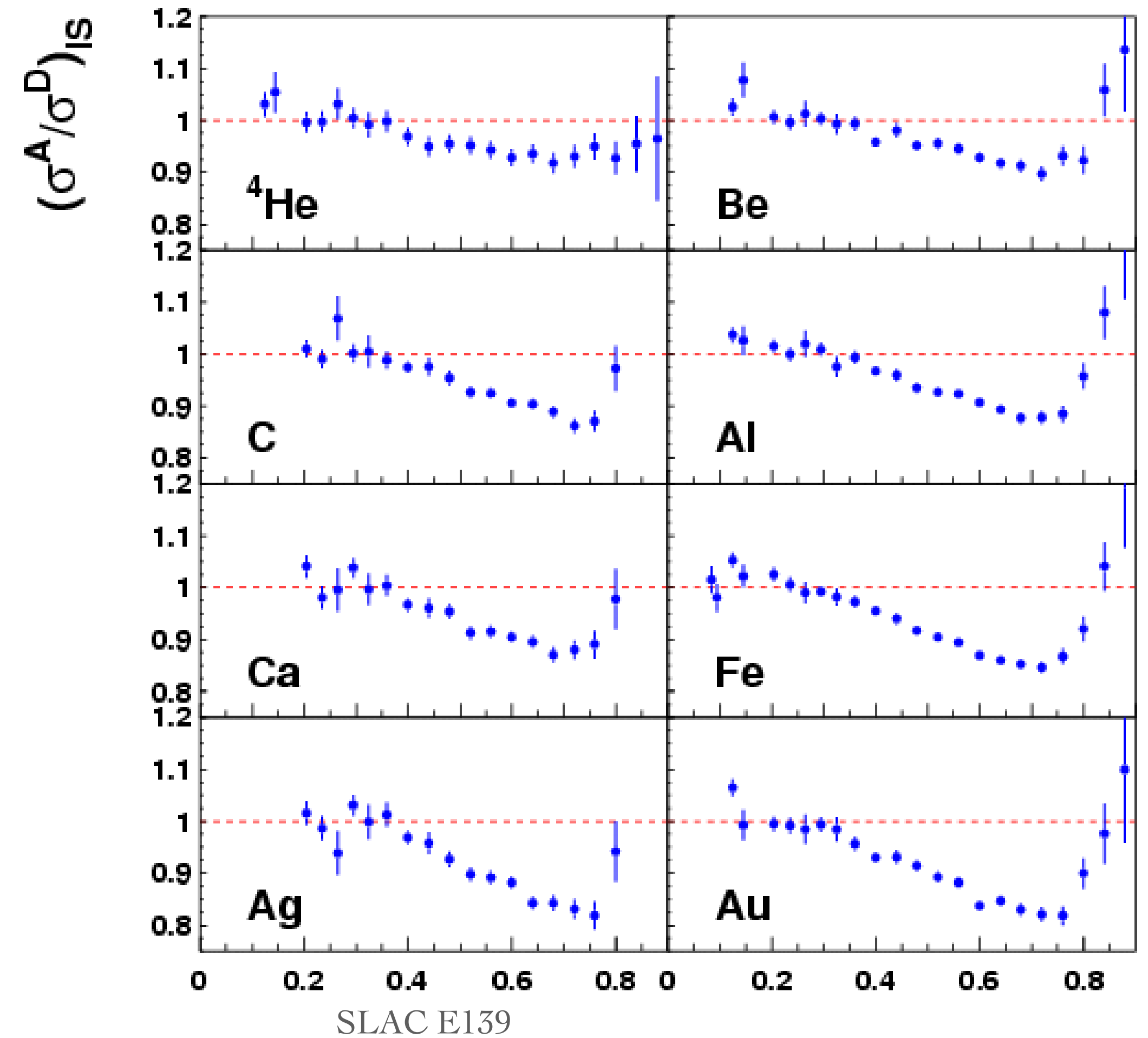
- $F_2^A(x) \neq ZF_2^p(x) + NF_2^n(x)$





# What is the EMC Effect?

$$\left| \frac{dR_{EMC}}{dx} \right| \sim \text{from } 0.35 < x < 0.7$$





# What is the EMC Effect?

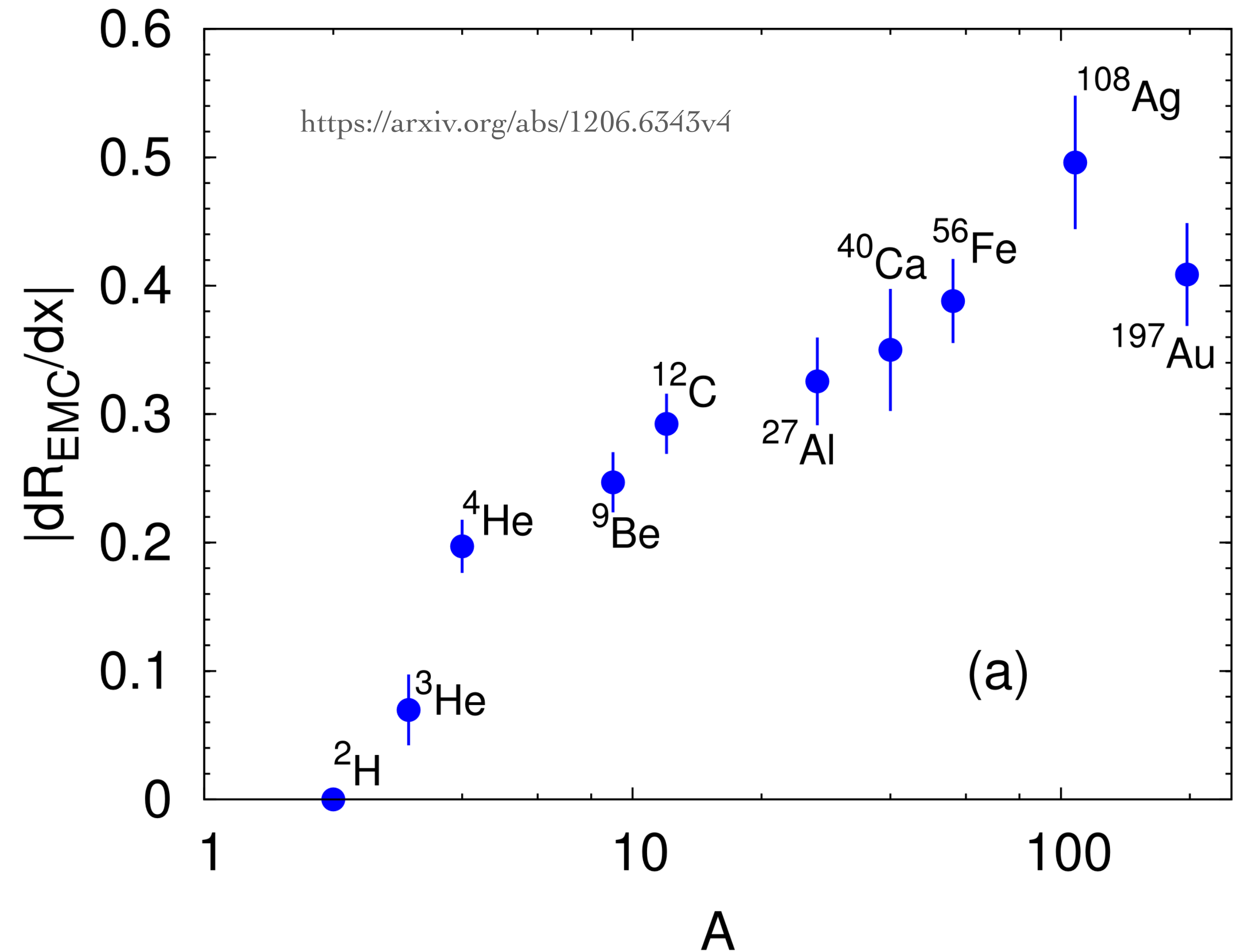
---

- >1000s of theory papers written
- No consensus after >40 years
- Typical nuclear binding energies are insignificant compared to energies in DIS experiments (MeV vs. GeV)
- Guided by experiments, we have hints



# Finding Correlating Properties

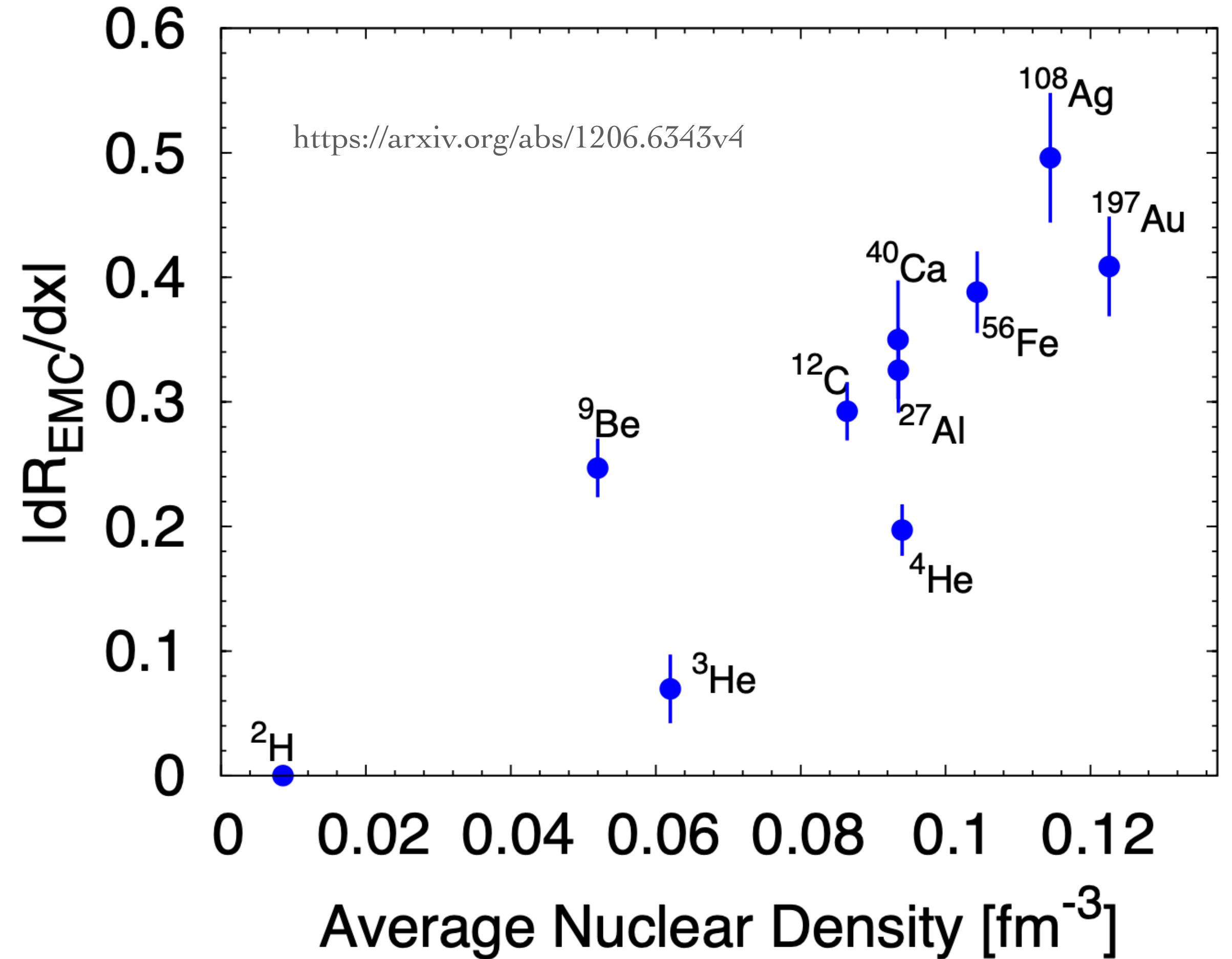
- No direct relation with  $A$





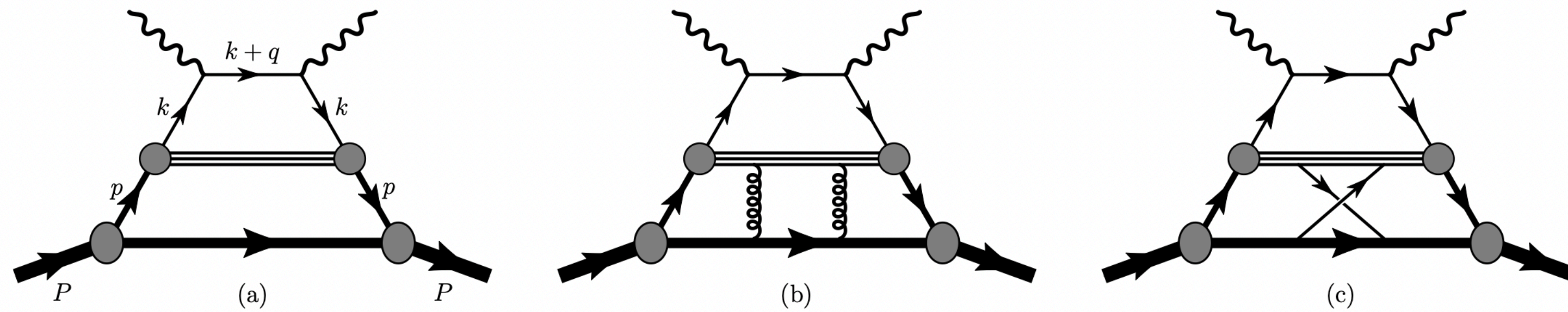
# Finding Correlating Properties

- Scaling with average nuclear density is not completely satisfactory for light nuclei





# Theoretical Approaches

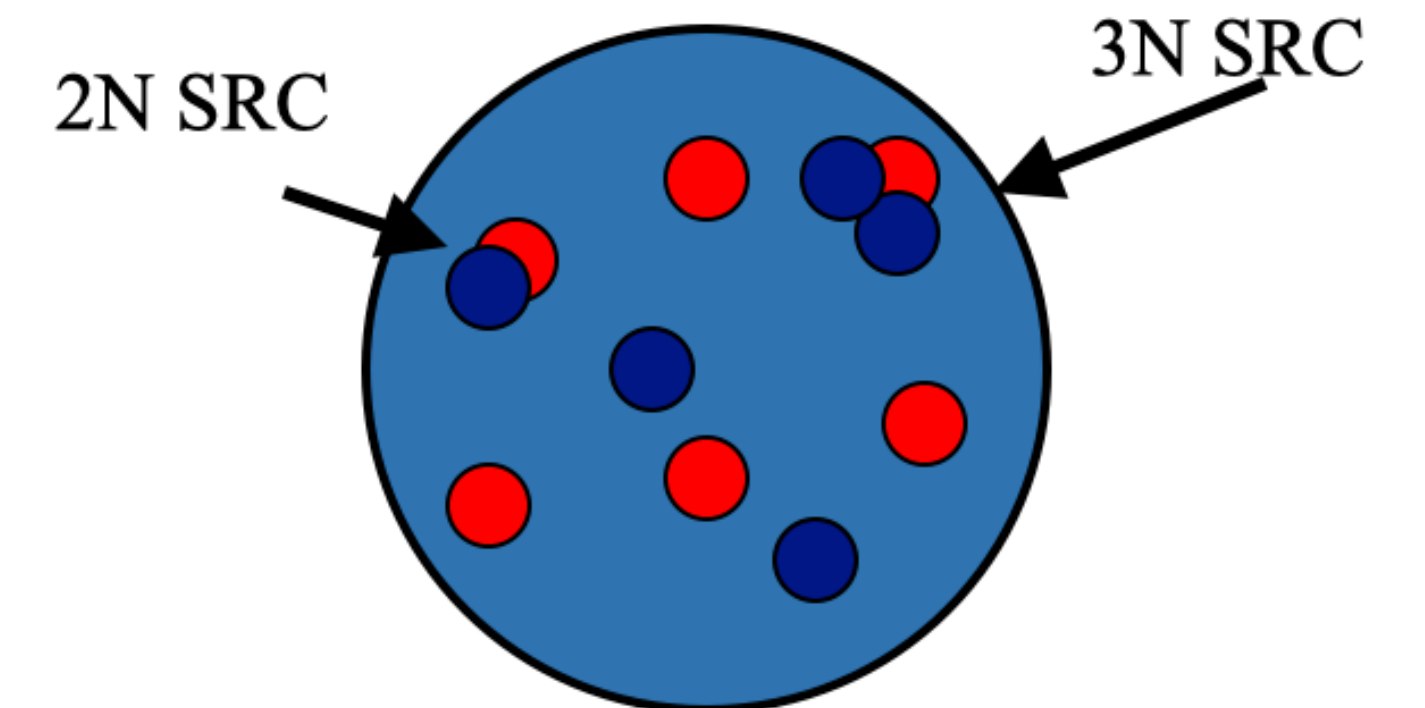
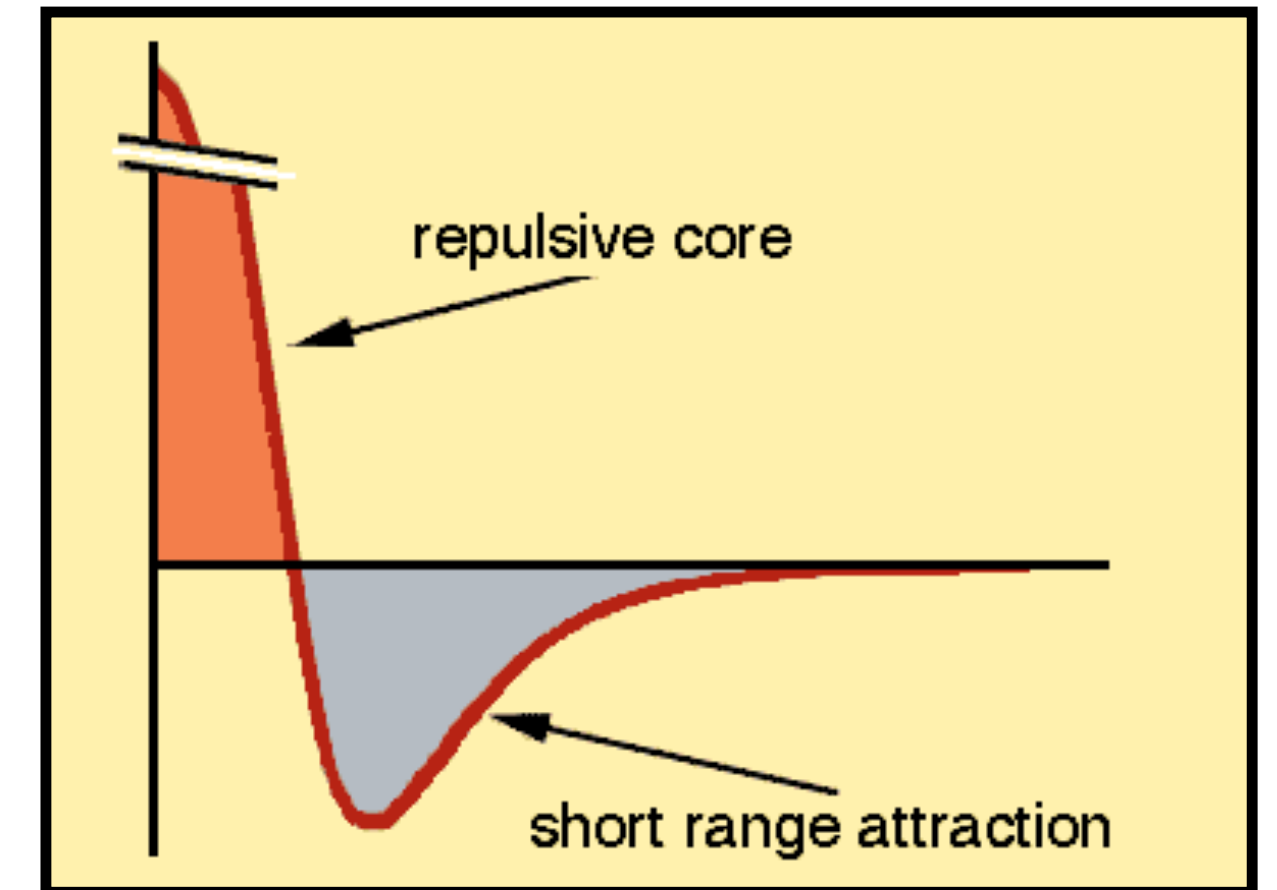


- Medium modification
- Multiquark clusters- 6 quark bag?



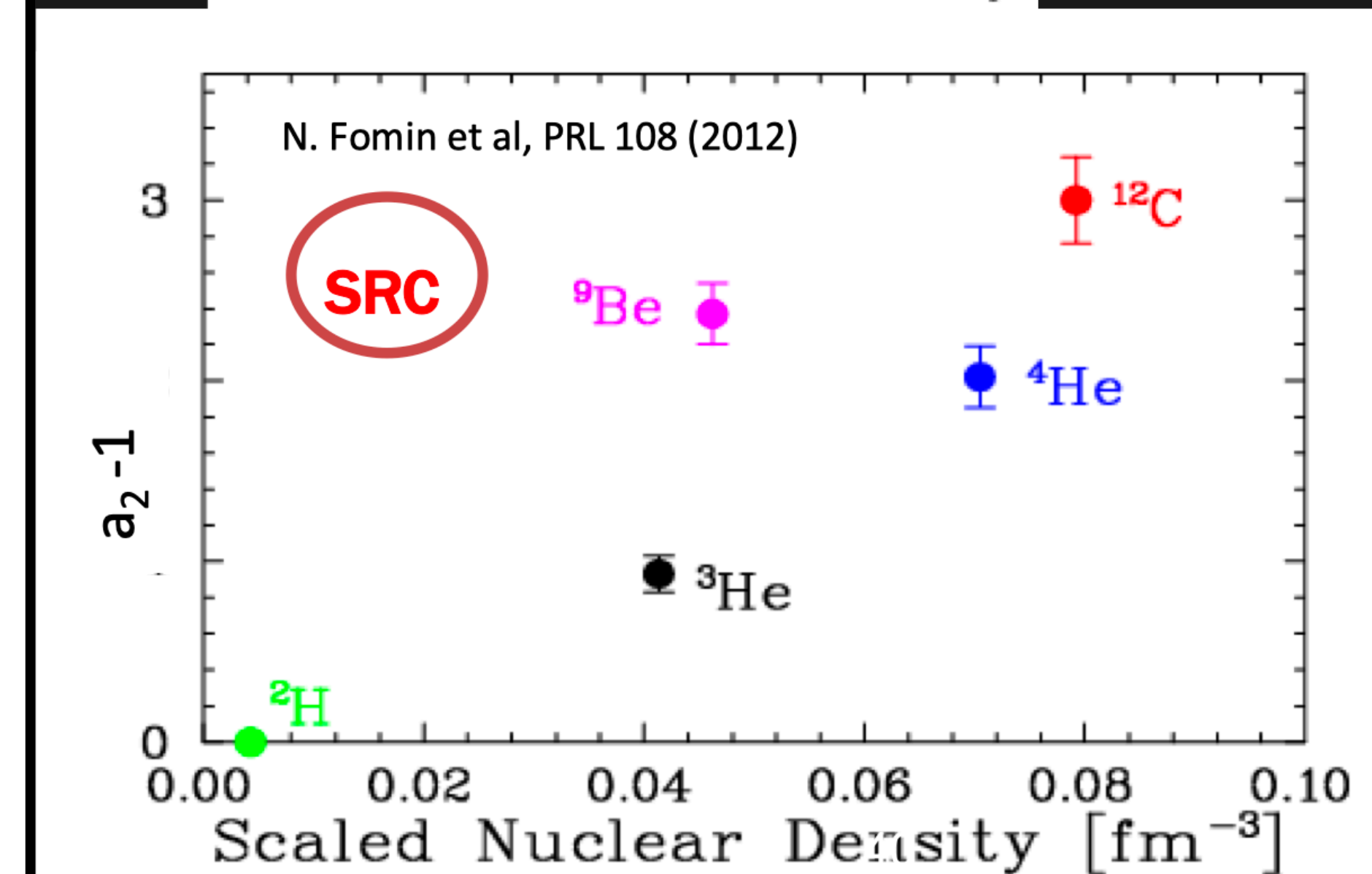
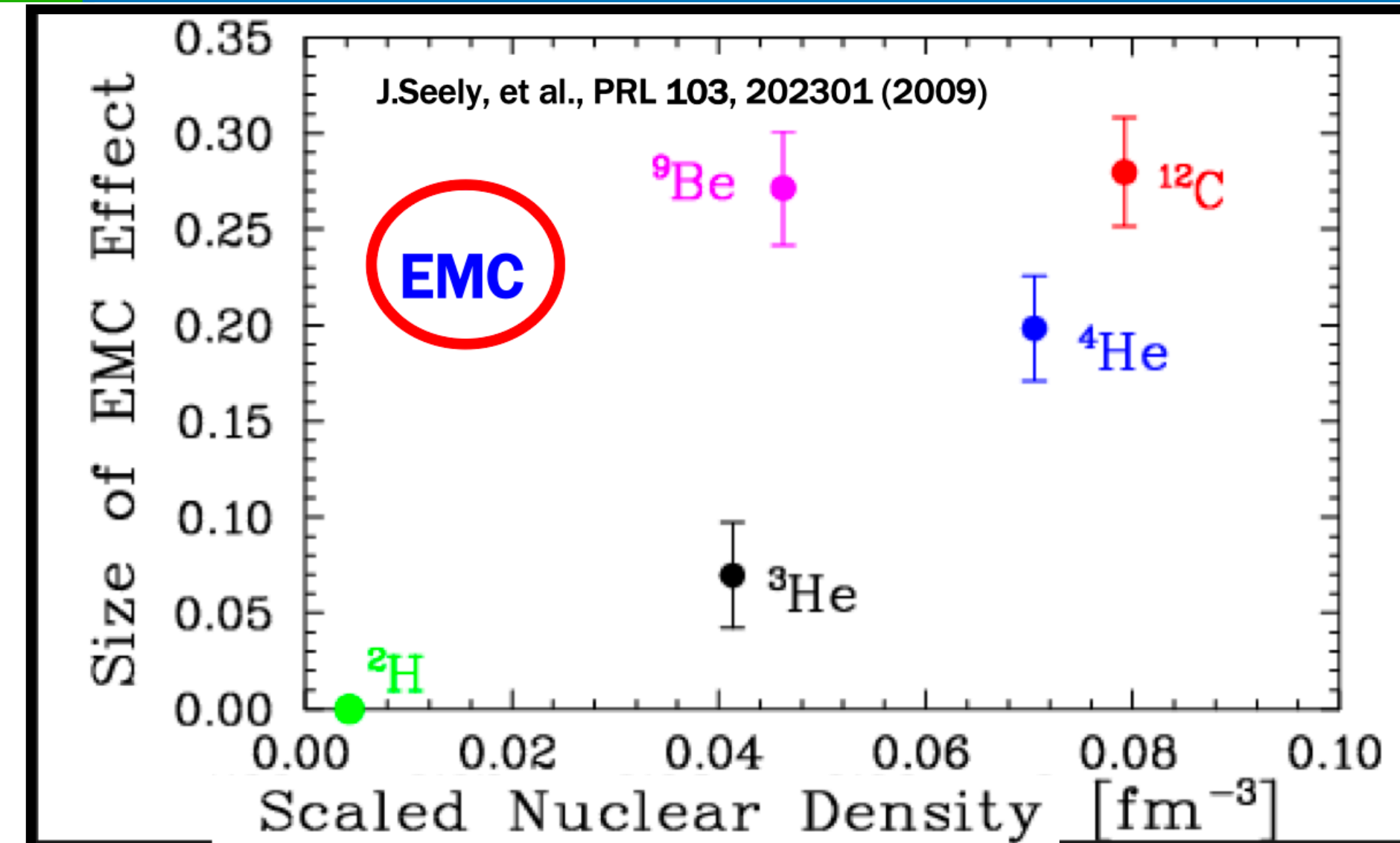
# The SRC Connection

- Short-Range Correlations: Pairs of nucleons with high back-to-back momenta



# Results from the 6 GeV era

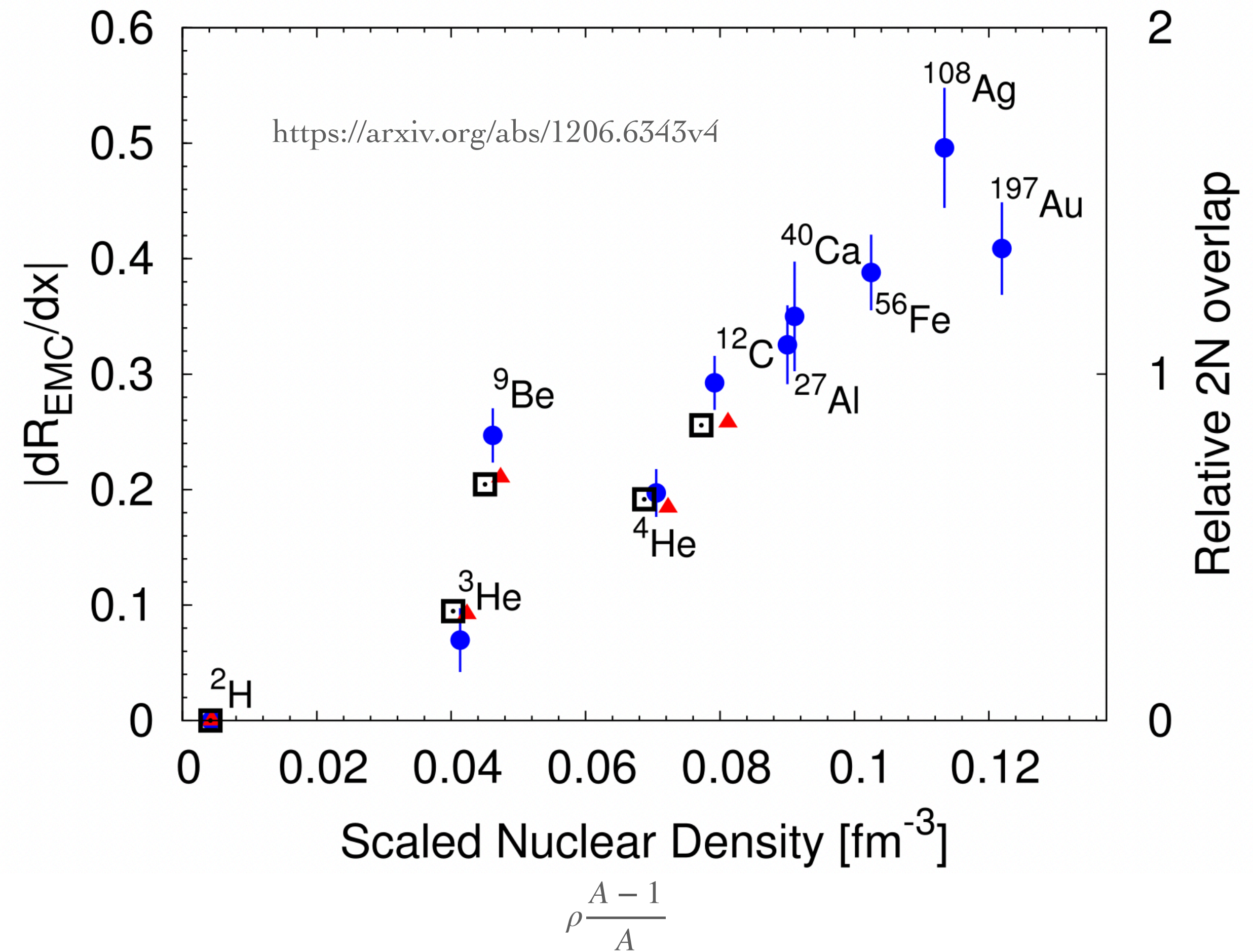
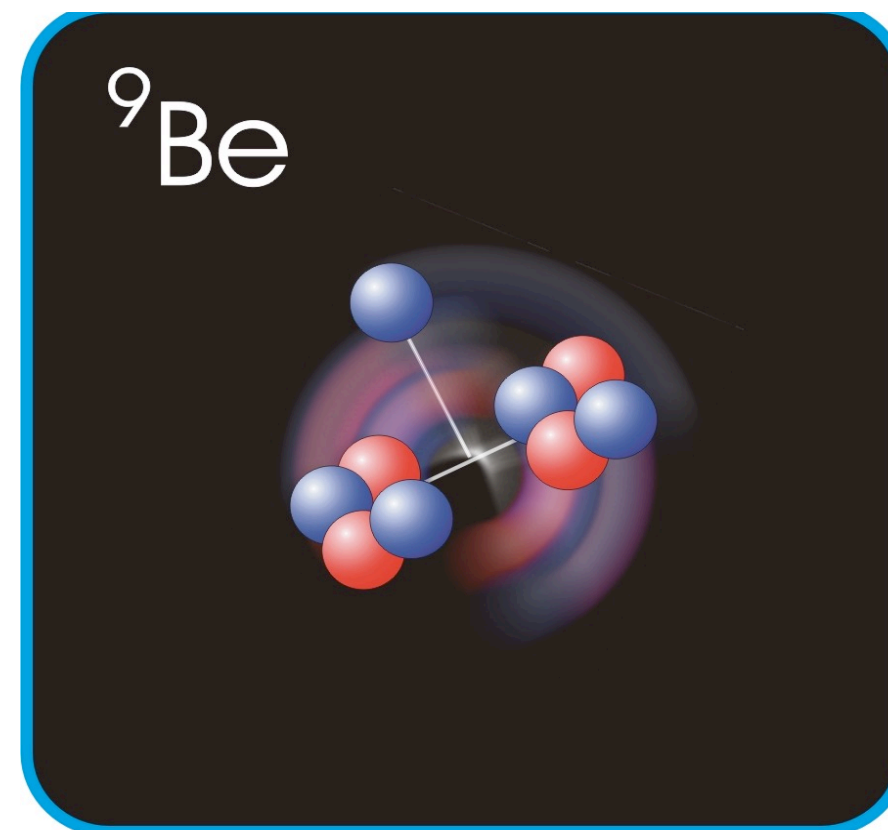
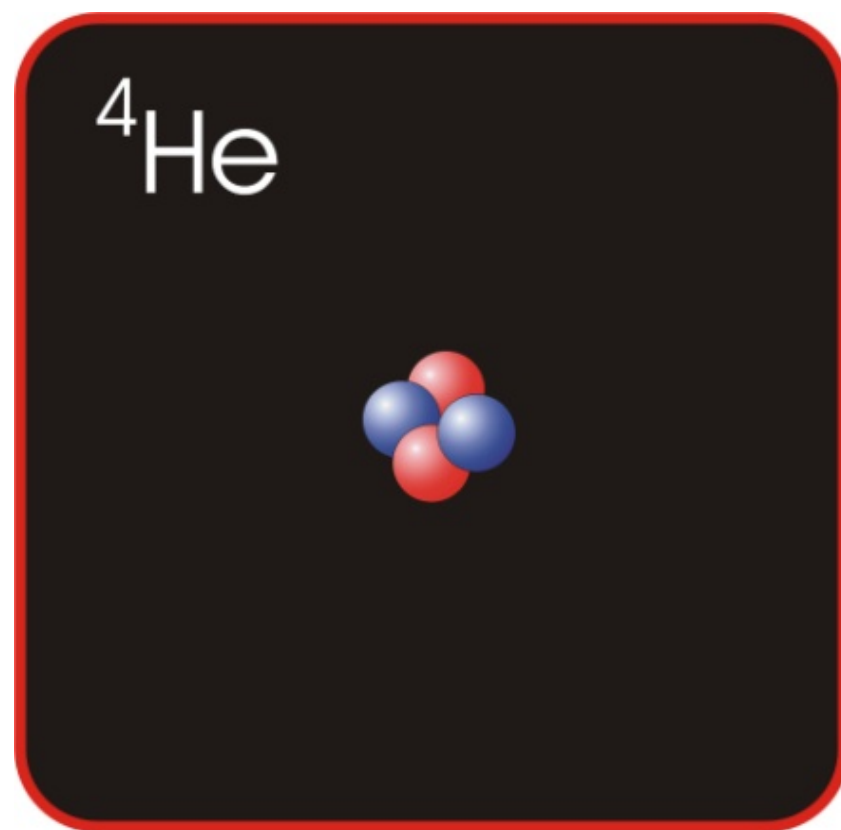
- Ran in Hall C@JLab in 2004
- EMC Effect and SRCs closely correlated
- Could they modify the nucleon structure?
- This experiment will address that





# Local Density

- Seems to be a better indicator of the size of the EMC Effect
- Example:  ${}^9\text{Be}$  vs  ${}^4\text{He}$





# Takeaway Message

Universe: **Exists**

Physicists:

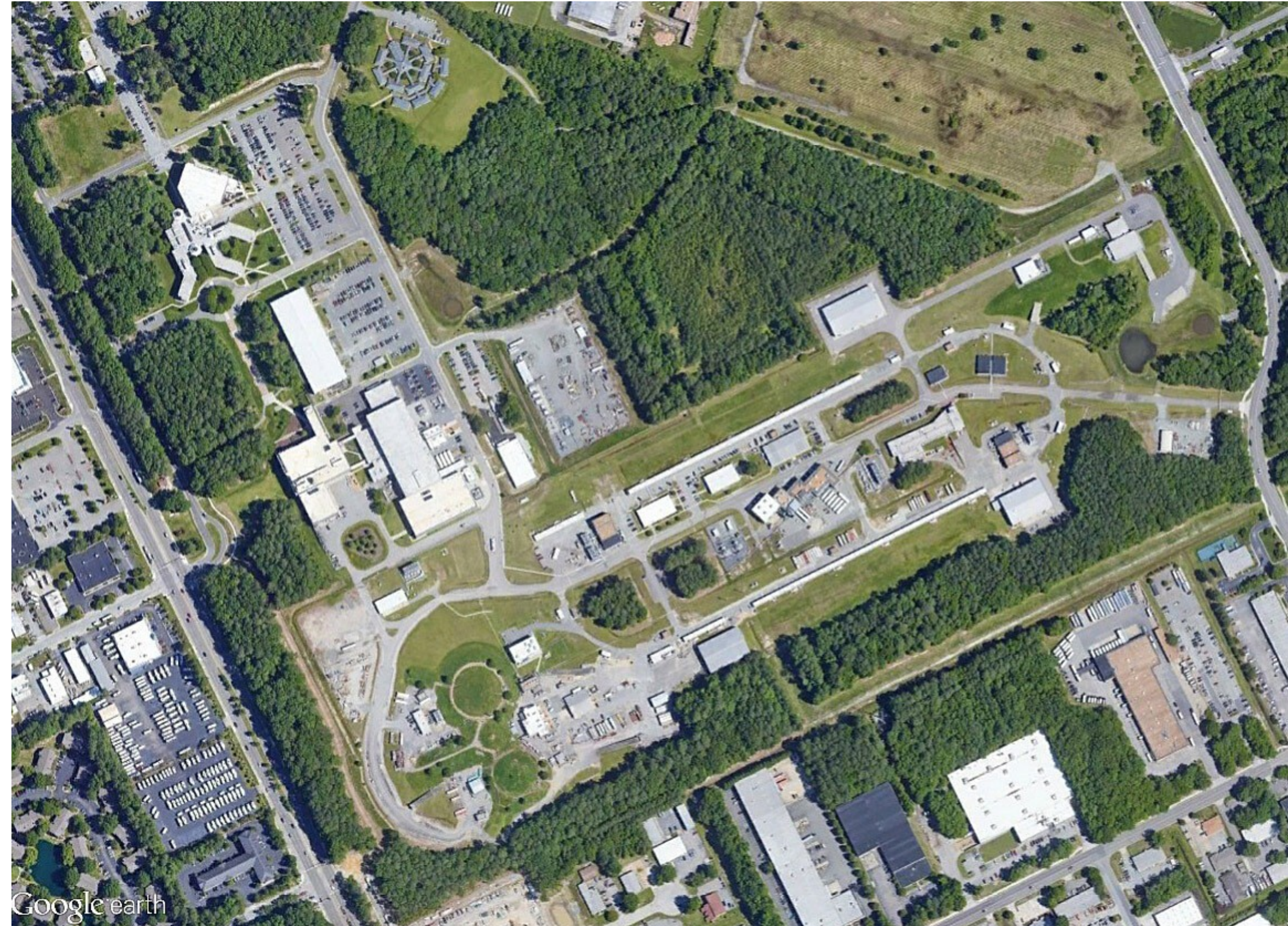


**“In the history of physics, every time we've looked beyond the scales and energies we were familiar with, we've found things that we wouldn't have thought were there. You look inside the atom and eventually you discover quarks. Who would have thought that? It's hubris to think that the way we see things is everything there is.”**

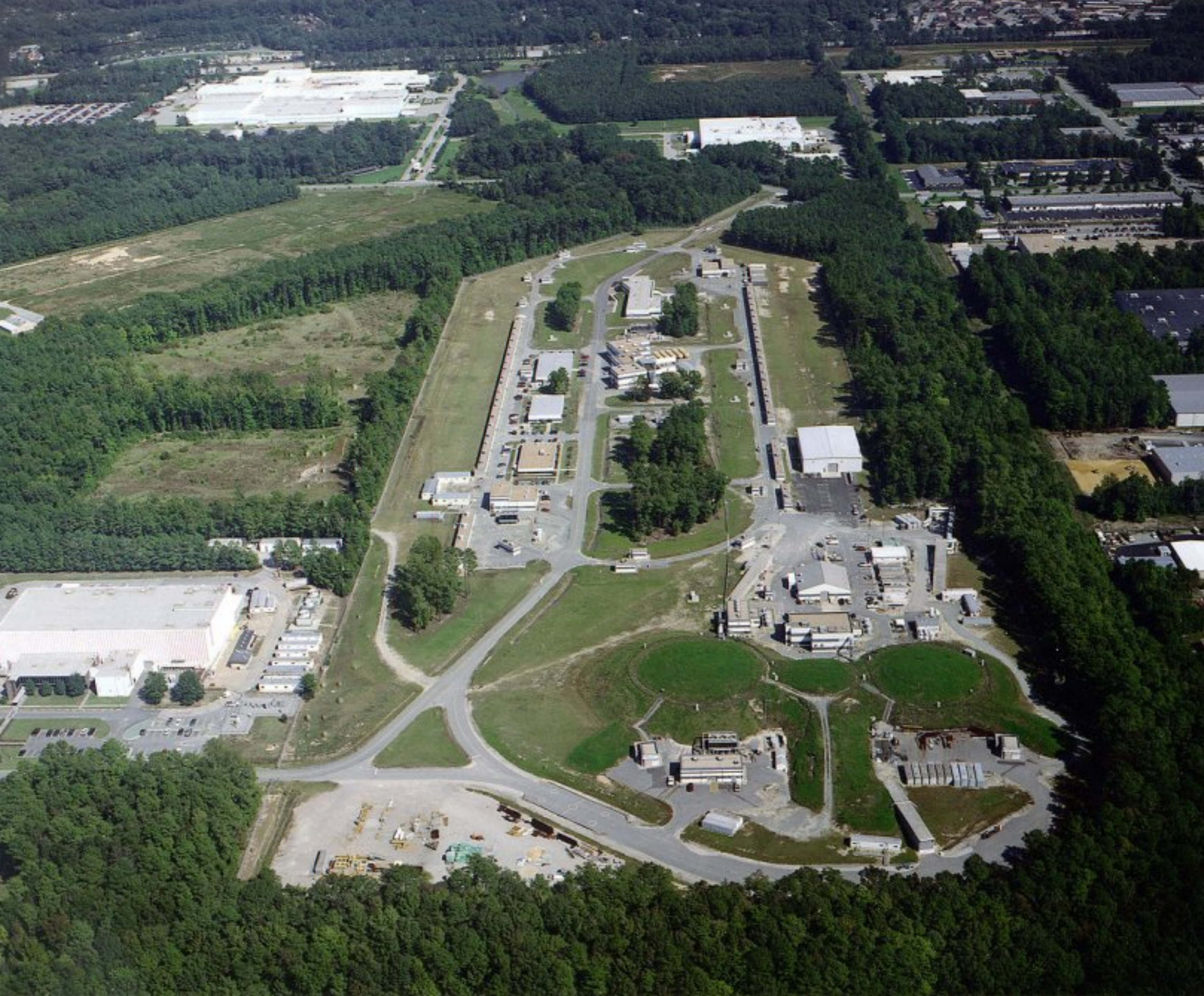


# Overview

- Physics Background
- *Overview of E12-10-008*







- Inclusive scattering using 10.5 GeV electron beam from CEBAF at JLab
- Performed in Hall C



# High Momentum Spectrometer

## 1. Drift Chambers

- Provides tracking information

## 2. Cerenkov

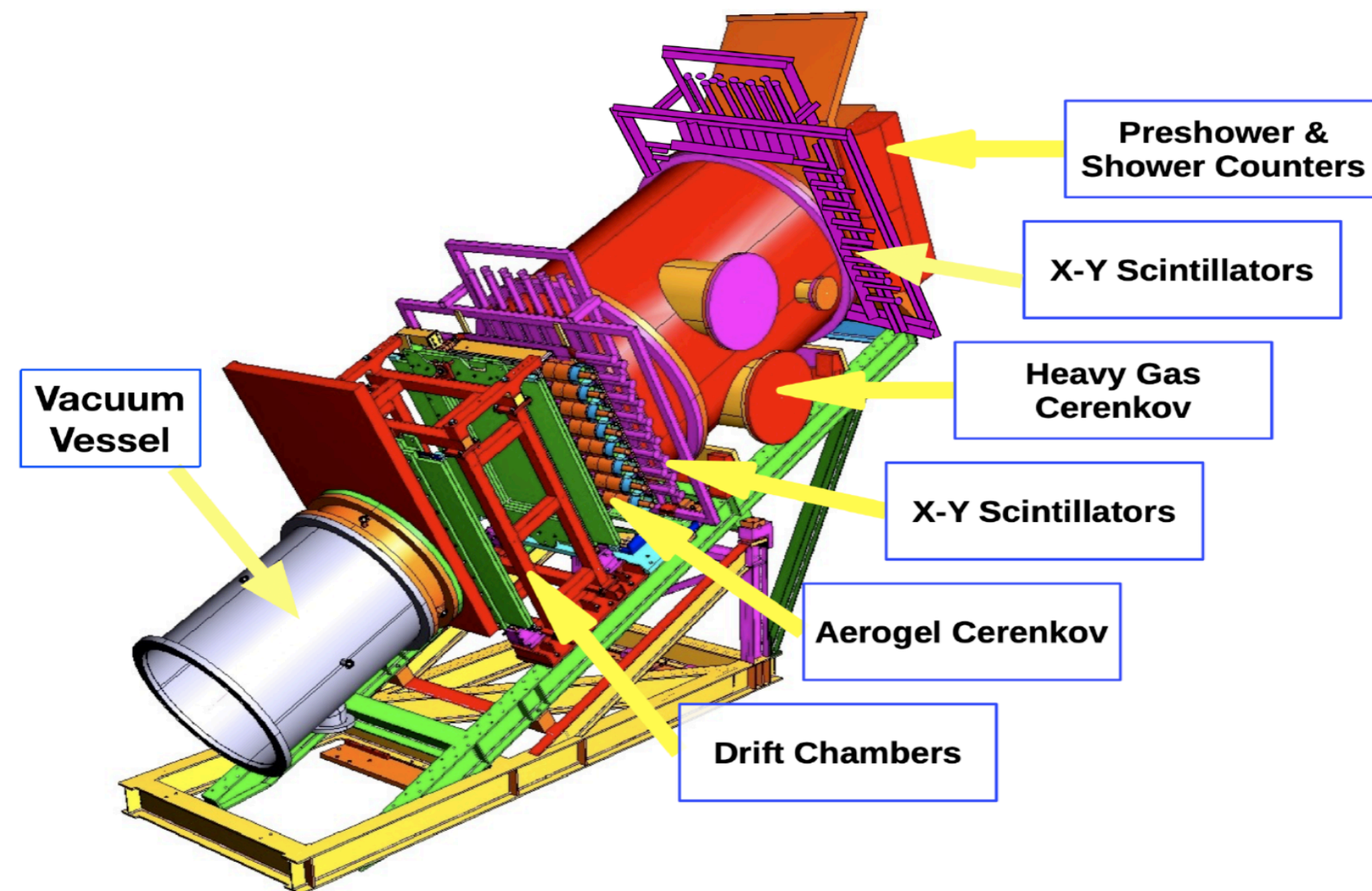
- Particle identification

## 3. Hodoscopes

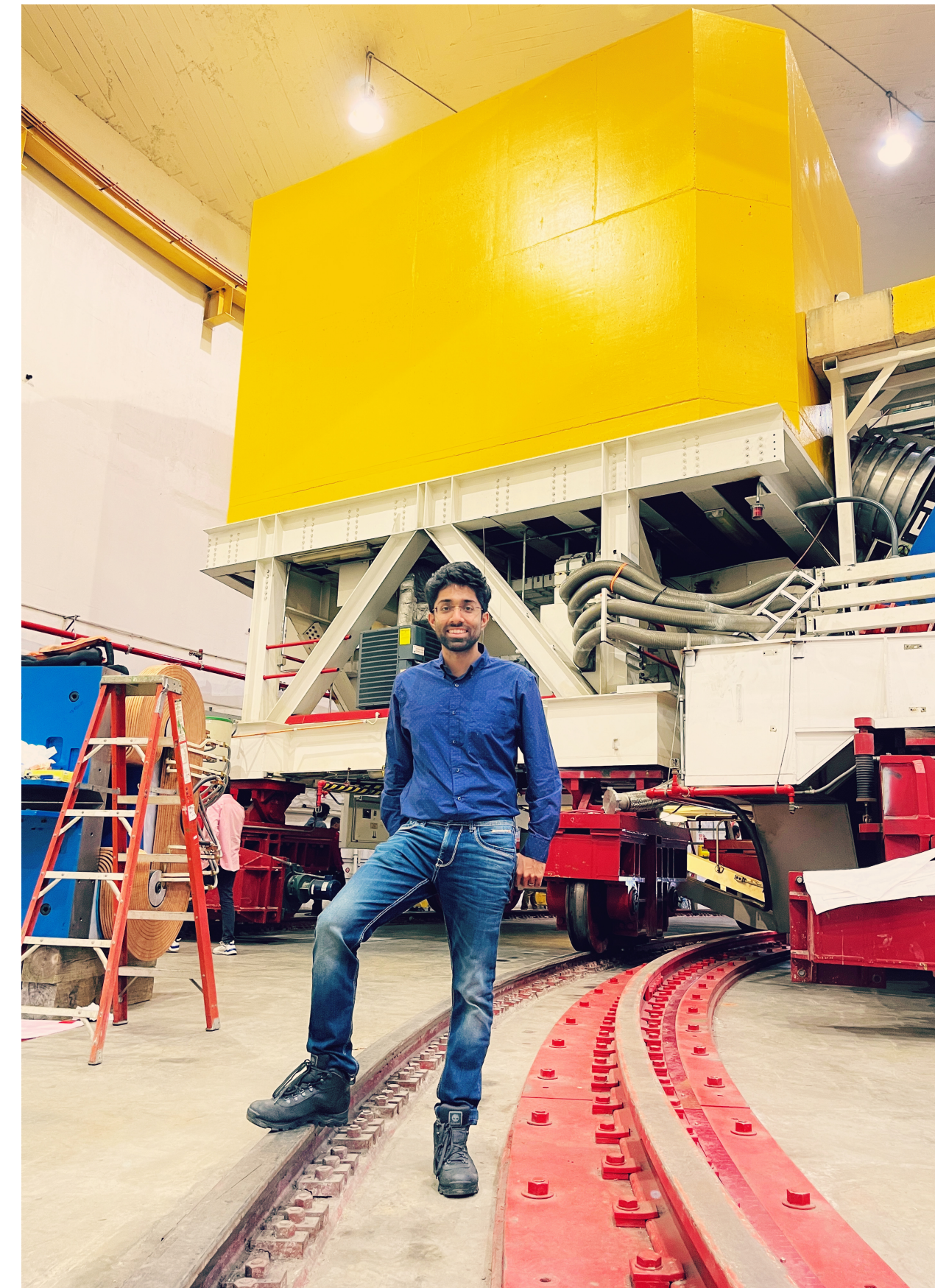
- Trigger
- Tracking Efficiency

## 4. Calorimeter

- Particle identification



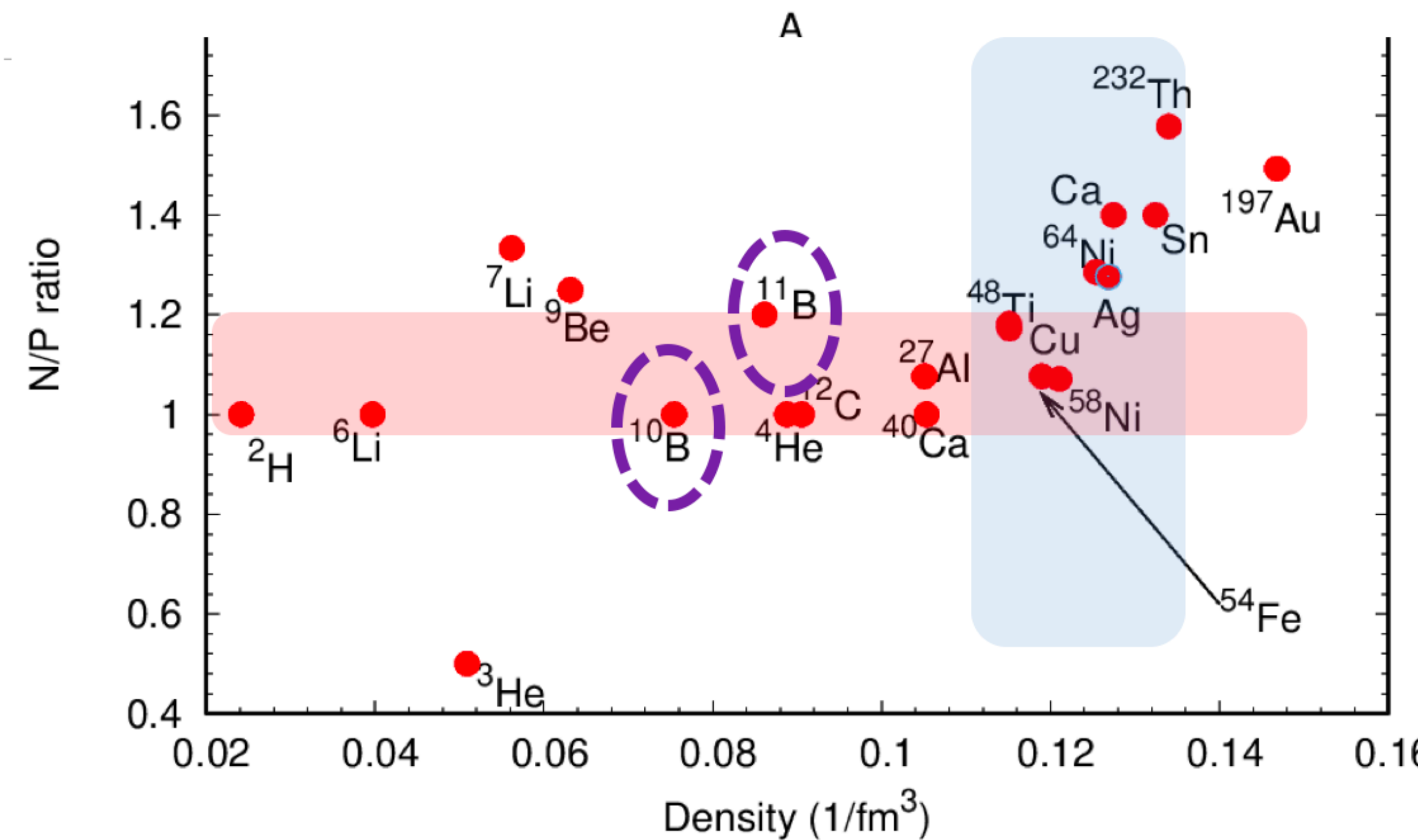
CAD Drawing of the HMS detector stack





# E12-10-008: Targets

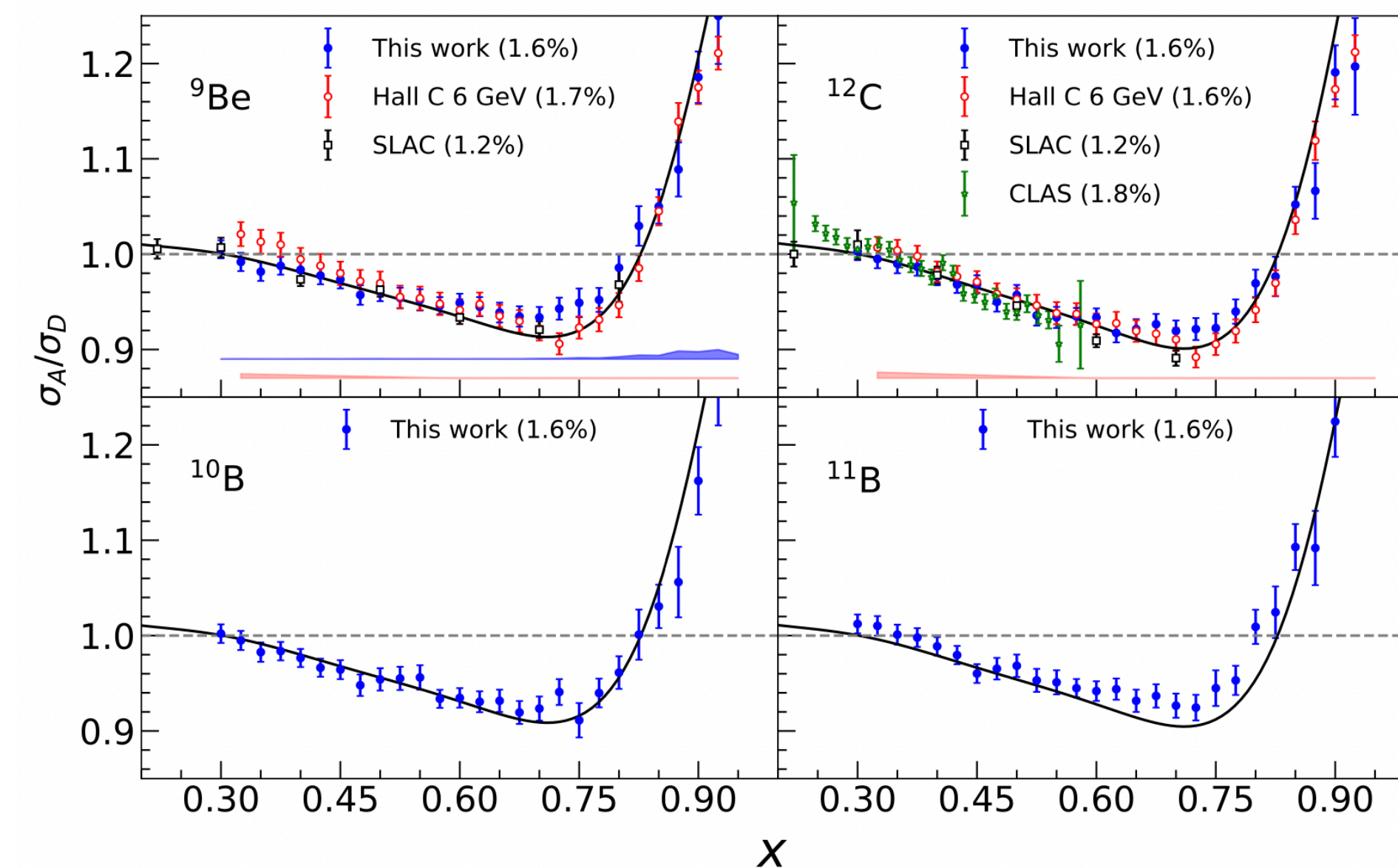
- Ran from Sep '22-Feb '23
- Investigates EMC effect in various light to medium nuclei
- Uses  $^{40}\text{Ca}$  and  $^{48}\text{Ca}$  which will provide insight into models predict a significant flavor dependence in the EMC effect.
- Comparisons of nuclei which differ by just one nucleon ( $^{11}\text{B}$ - $^{10}\text{B}$ ,  $^7\text{Li}$ - $^6\text{Li}$ ,  $^{12}\text{C}$ - $^{11}\text{B}$ ) will allow to study isospin dependence





# Summary

- The origin of the EMC effect is still a mystery
- E12-10-008 will provide several key results:
  - Isospin dependence
  - Measurement in several light nuclei
  - More data for comparison with SRCs
  - Can get  ${}^3\text{He}/({}^2\text{H}+{}^1\text{H})$  without relying heavily on large isoscalar corrections
  - Superfast Quarks
- We have some results and much more to come





# Acknowledgement

## Spokespeople:

John Arrington(LBL), Nadia Fomin(UTK) & Dave Gaskell(JLab)

## Postdocs:

Burcu Duran(UTK), Tyler Hague(LBL), Shujie Li(LBL)

## Graduate Students:

Cameron Cotton (UVA), Ryan Goodman(UTK), Abishek Karki (MSU), Casey Morean (UTK), Ramon Ogaz (UTK), Abhyuday Sharda (UTK), Sebastian Vasquez(UCR), Zoe Wolters (UNH)





# Gracias!



- I am deeply grateful for financial support from DOE and Hampton University to attend this awesome summer school in person!!
- It was lovely to be in company with you all



**Thank you!**

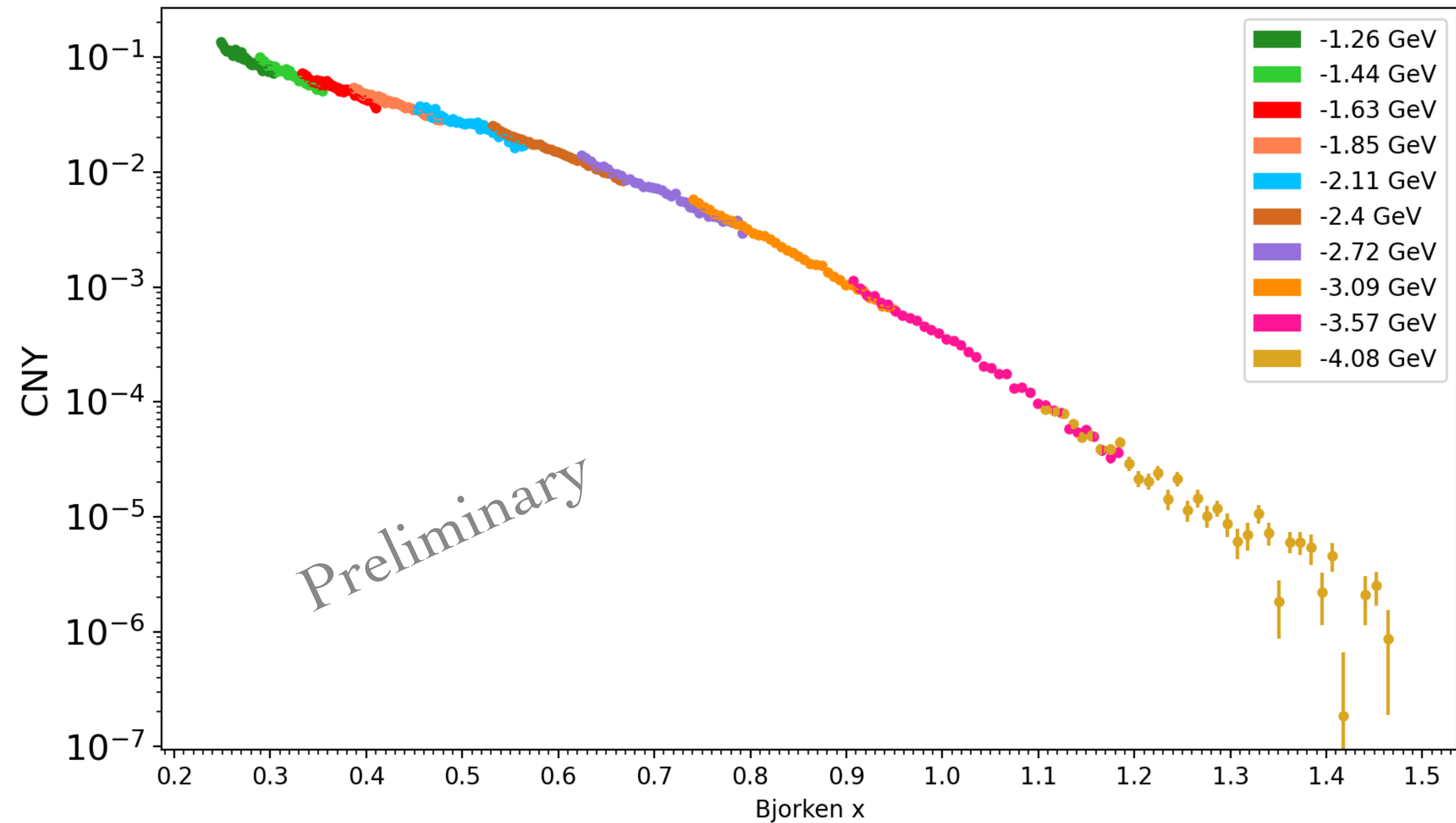


# Backup

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# Latest Data

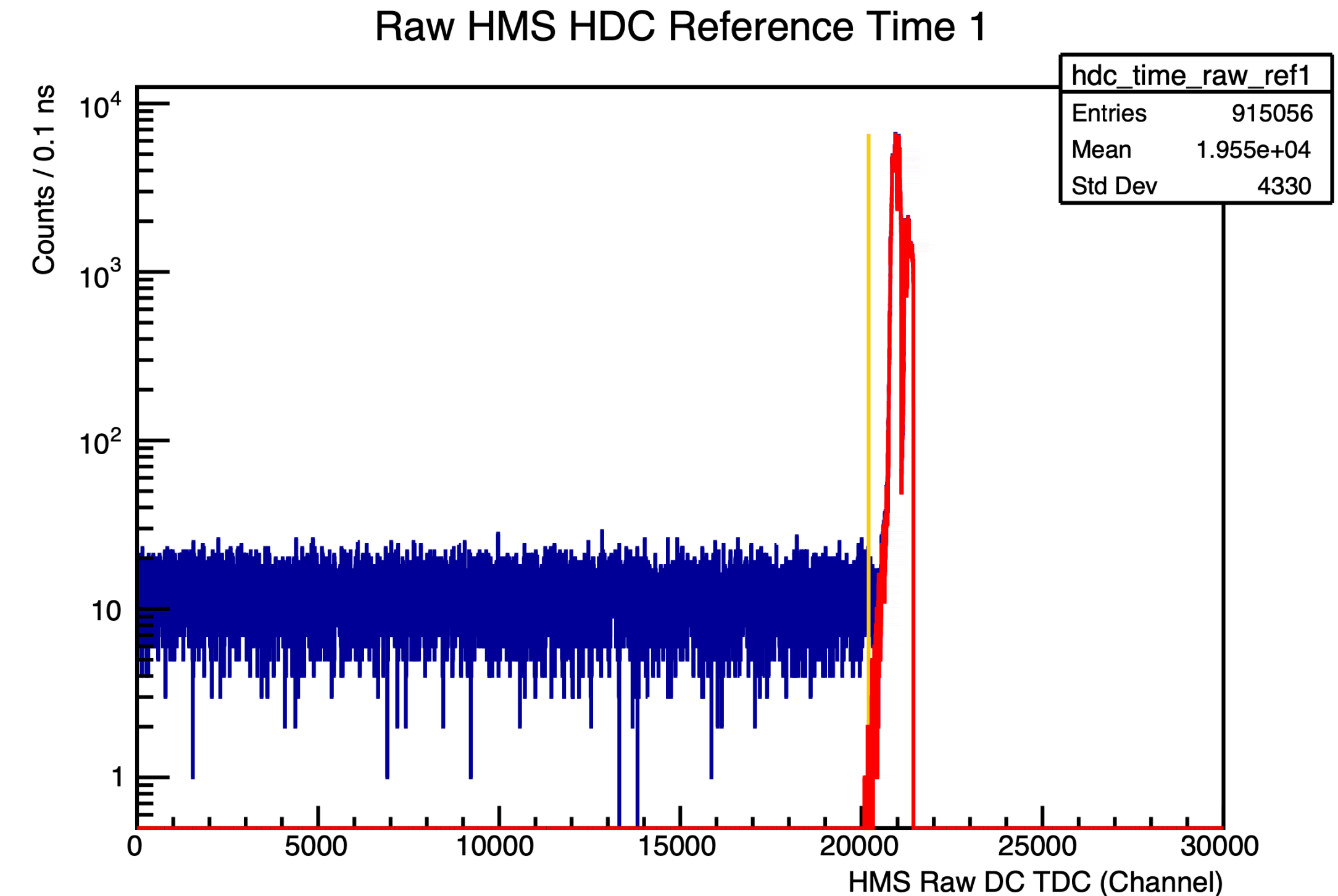
- Charge Normalized Yield vs  $x$
- C12 Target@ $35^\circ$
- Does not have any radiative corrections, acceptance corrections etc.





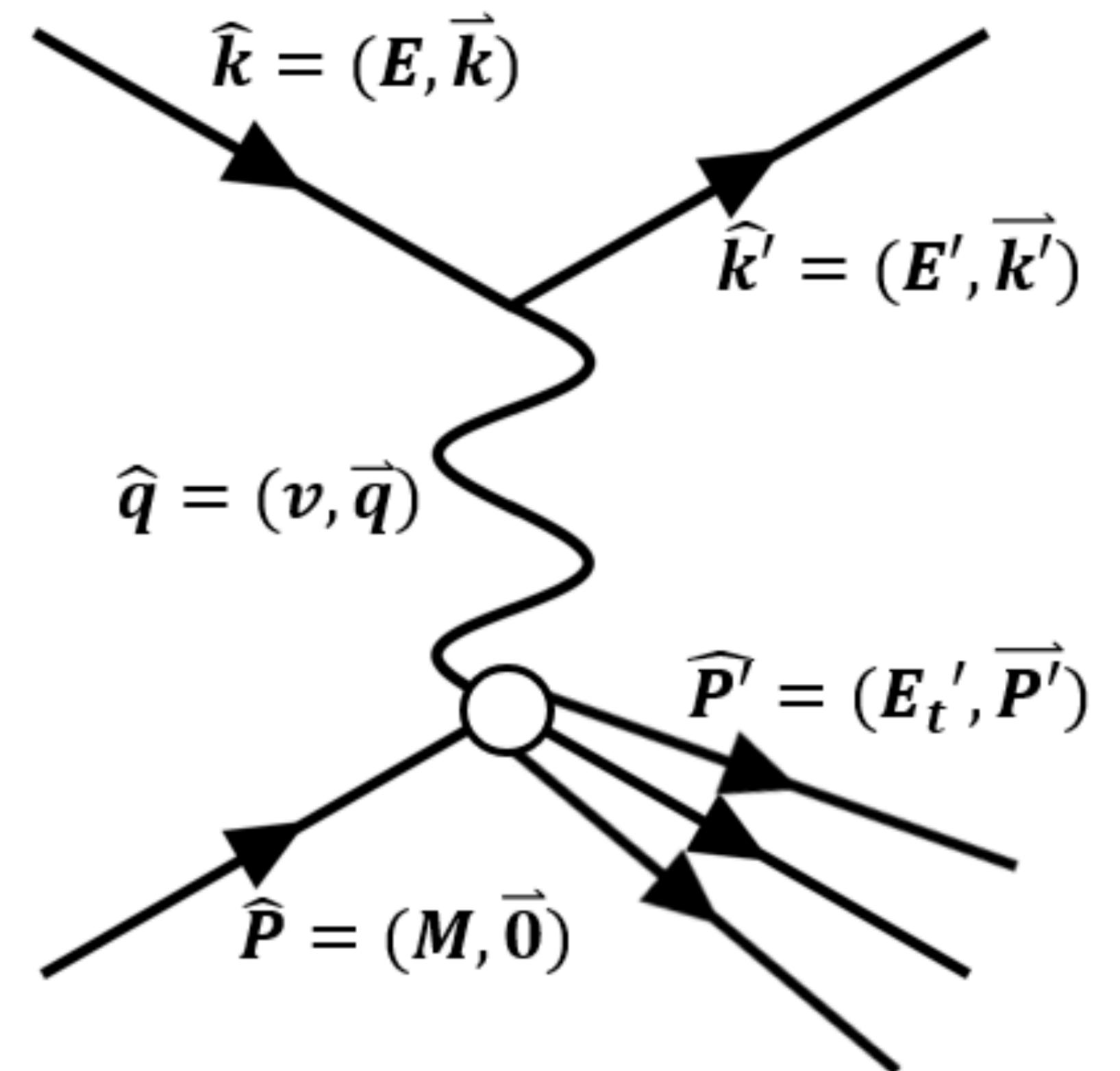
# Current Status

- Data taking completed just 3 months ago
- Detector Calibrations underway
- Data checks
- Hope to have preliminary results by later this year



# Physics Background

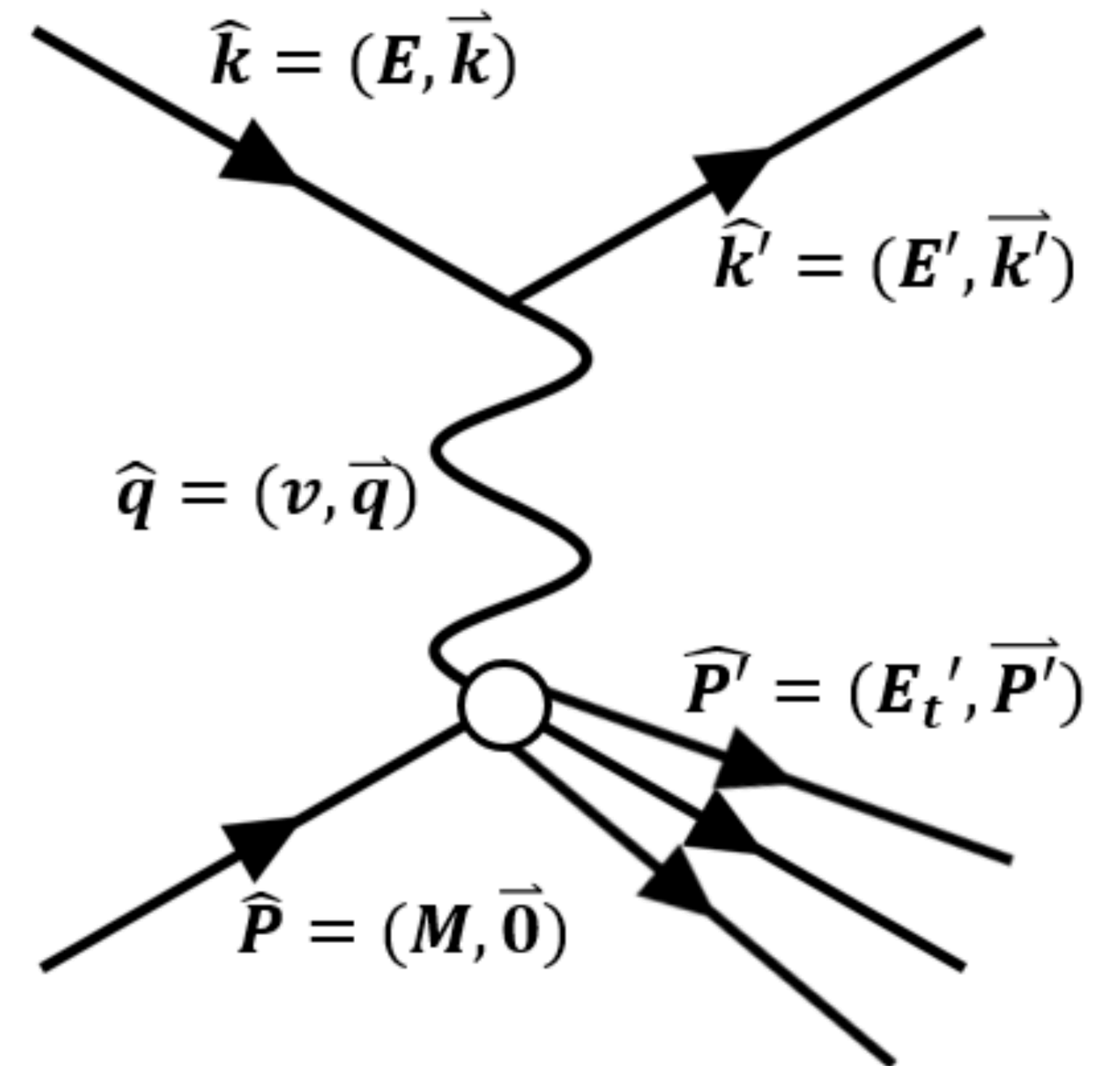
- In inclusive DIS, only the scattered electron's final state is measured in the spectrometer
- $\theta$
- $\nu = E - E'$
- $M$





# Physics Background

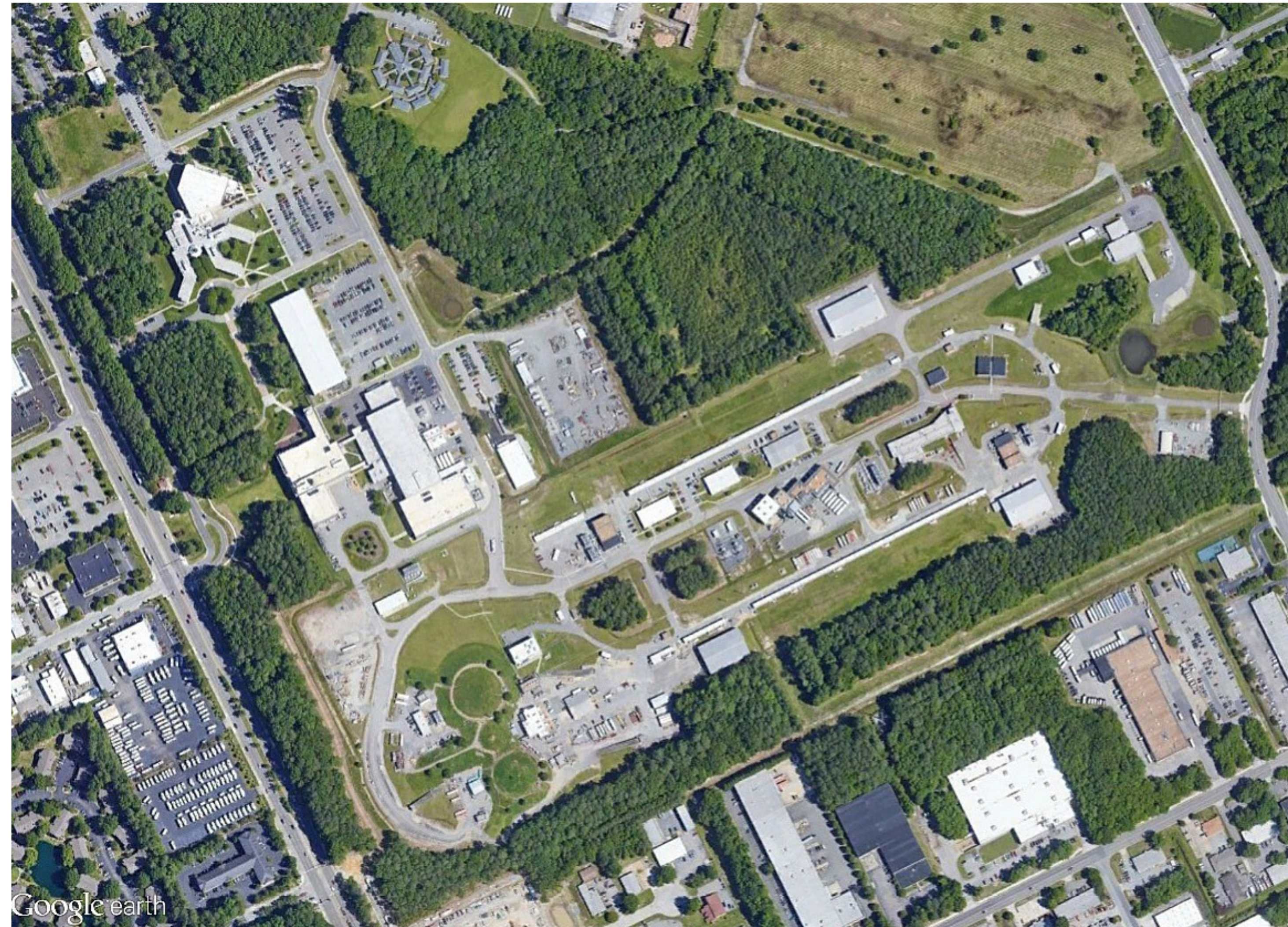
- $Q^2 \equiv -q^2 \simeq 4EE' \sin^2(\theta/2)$
- $W^2 = 2M\nu + M^2 - Q^2$
- $x = x_{Bj} \equiv \frac{Q^2}{2M\nu}$





# Overview

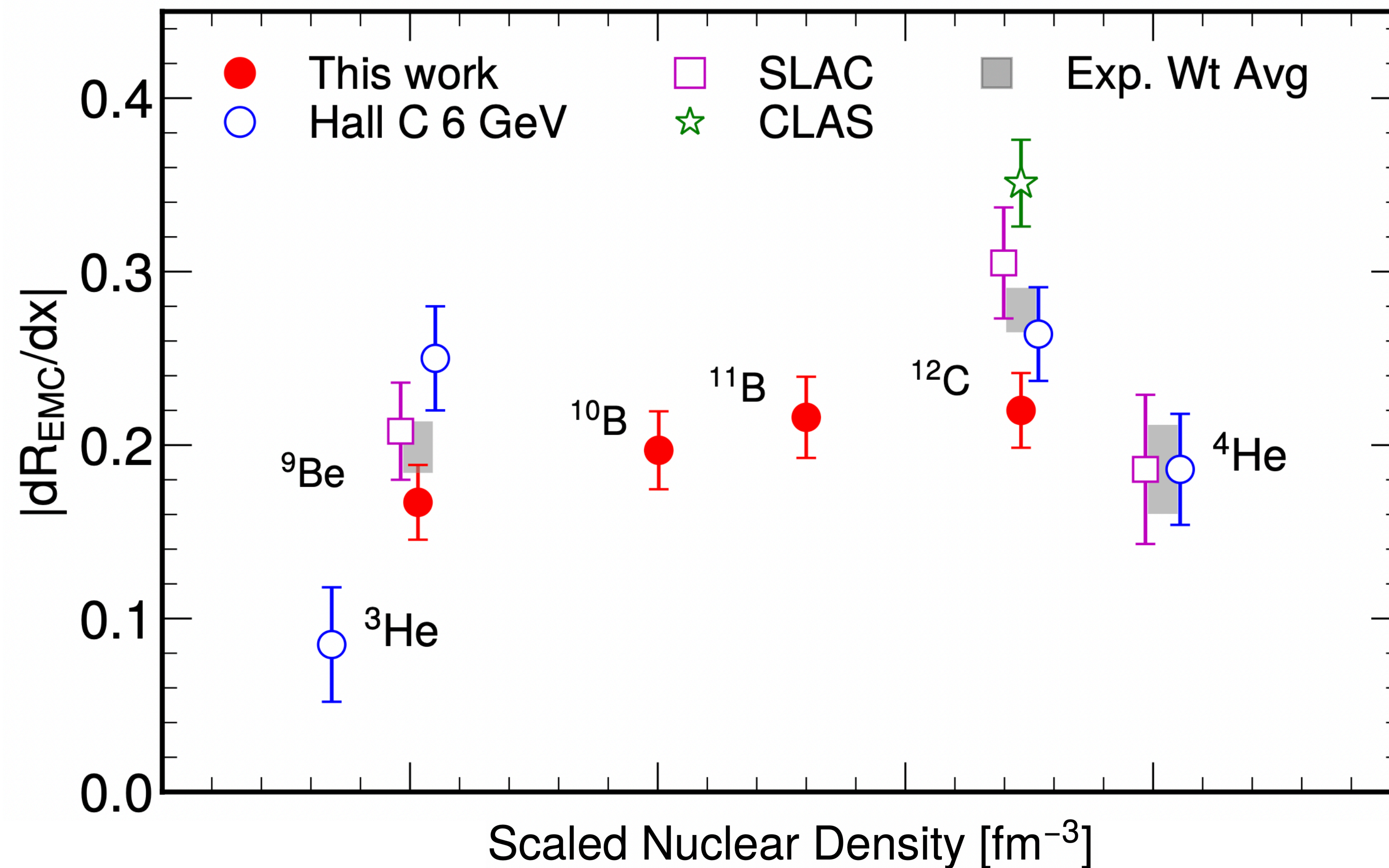
- Physics Background
- Overview of E12-10-008
- *Preliminary Results*





# E12-10-008: We have results

- Ran for ~2 days in February 2018
- $^{10}\text{B}$  &  $^{11}\text{B}$  also thought to have alpha clustering
- Little nuclear dependence





# SRC results

- Correlates with the EMC effect data!

