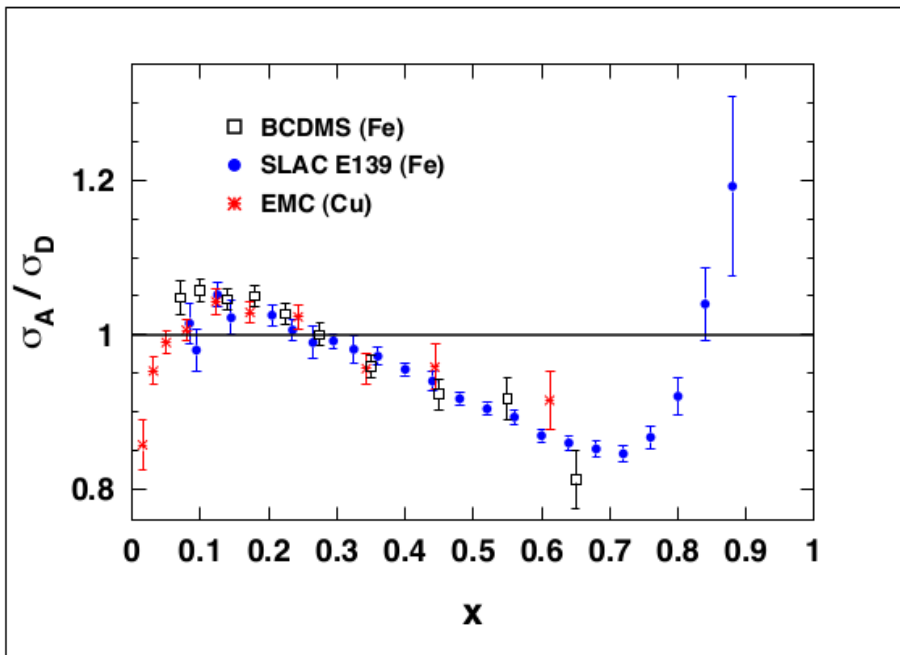# Nuclear Dependence in lighter nuclei
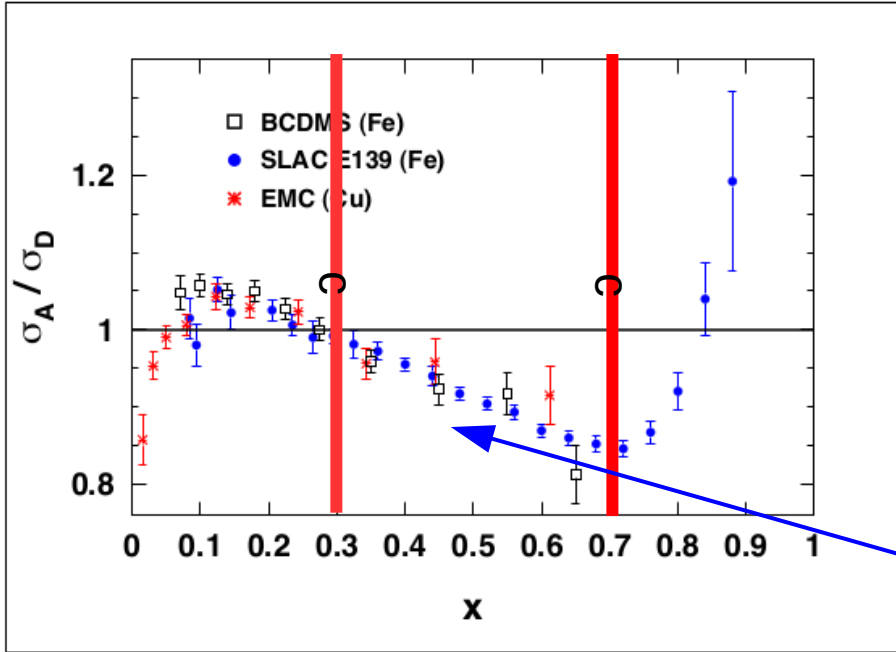
Abishek karki
MSU

Motivation

Representative plot showing cross-section ratios as function of x measured at different facilities with different beam types and energies

Significant differences in the inelastic structure function(per nucleon) of Fe over deuterium were observed over a large range in Bjorken x

First published measurement of nuclear dependence of F_2 by the European Collaboration in 1983.

More than 35 years still no consensus with its origin.

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Representative plot showing cross-section ratios as function of x measured at different facilities with different beam types and energies

Significant differences in the inelastic structure function(per nucleon) of Fe over deuterium were observed over a large range in Bjorken x

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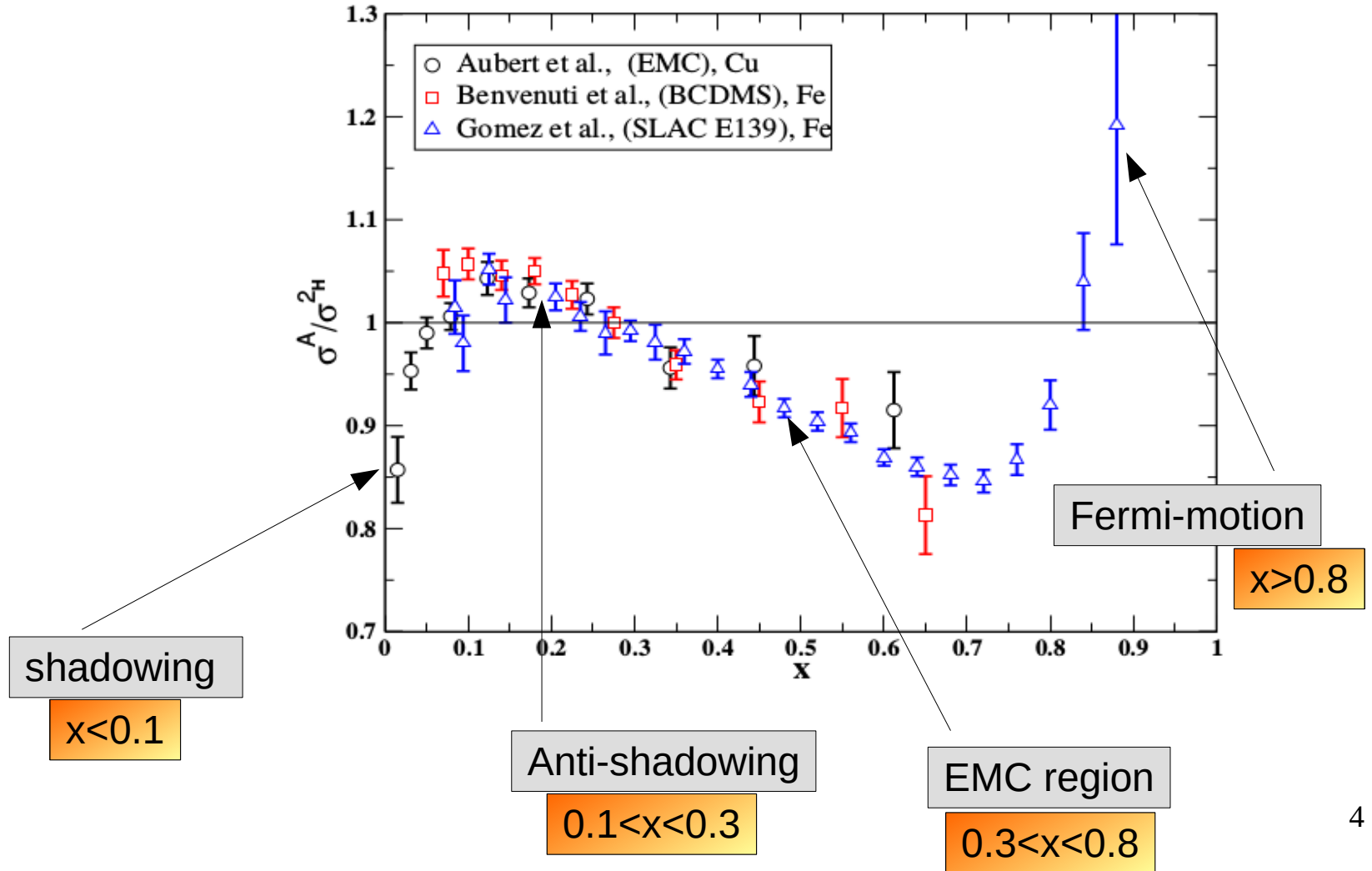
More than 35 years still no consensus with its origin.

EMC effect:

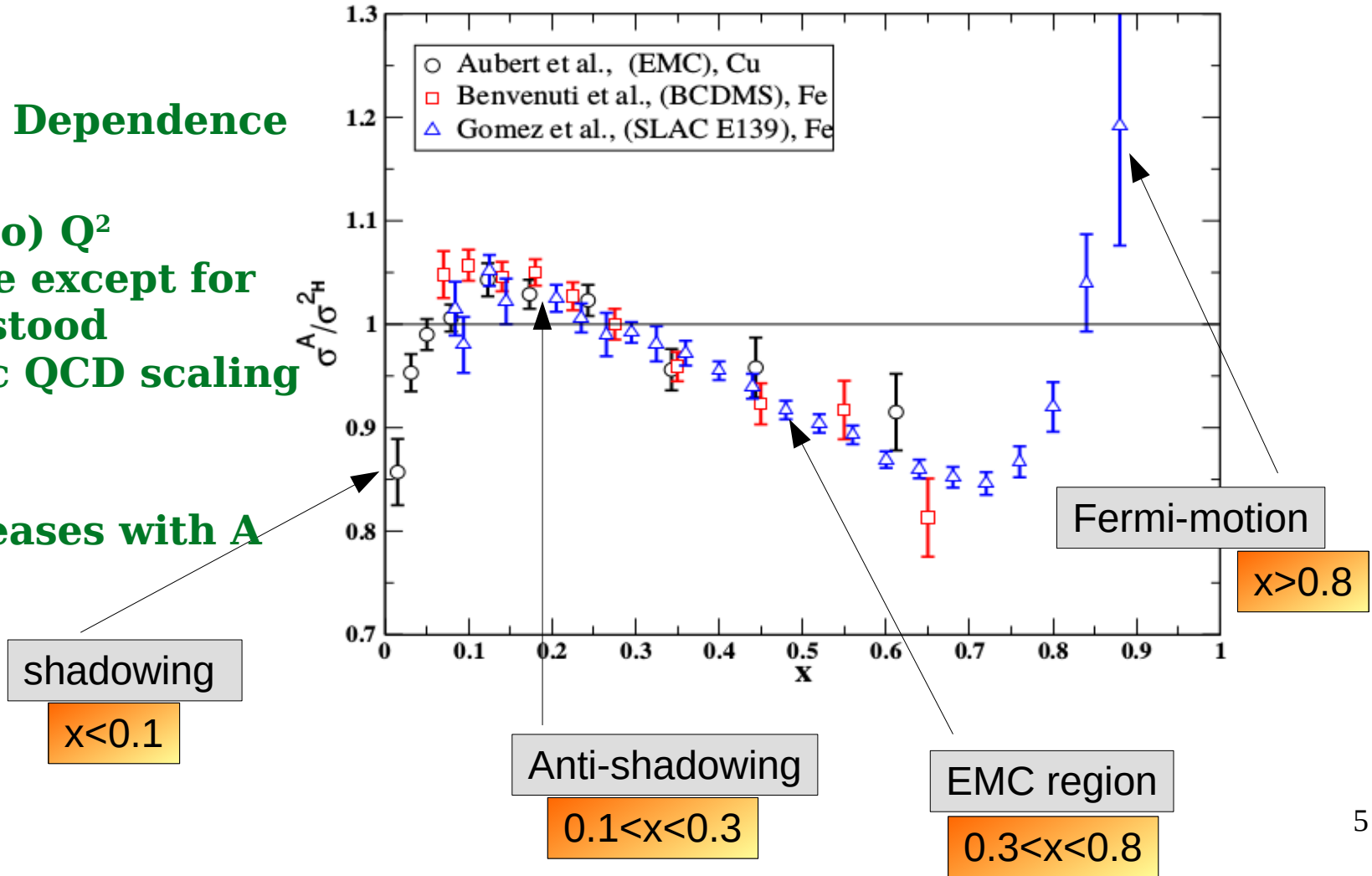ratio of DIS cross-section is not one

The resulting data is remarkably consistent over a large range of beam energies and measurement techniques.

3

Region of EMC Effect

Legend (in figure):
- ○ Aubert et al., (EMC), Cu
- □ Benvenuti et al., (BCDMS), Fe
- △ Gomez et al., (SLAC E139), Fe

Y-axis: σ^A/σ^{2H}
X-axis: x

shadowing
$x<0.1$

Anti-shadowing
$0.1<x<0.3$

EMC region
$0.3<x<0.8$

Fermi-motion
$x>0.8$

4

Global Properties of EMC Effect

- **Universal x Dependence**

- **Little (or No) Q^2 dependence except for well understood logarithmic QCD scaling violations**

- **Effect increases with A**

Plot legend:
- ○ Aubert et al., (EMC), Cu
- □ Benvenuti et al., (BCDMS), Fe
- △ Gomez et al., (SLAC E139), Fe

Y-axis: σ^A/σ^{2_H}
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0.3<x<0.8

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x>0.8

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Nuclear dependence

SLAC E139 studied the nuclear dependence of the EMC effect at fixed x

Results:

➜ Simple logarithmic A dependence

➜ Average nuclear density

Gomez et al, PRD 49, 4348 (1994)
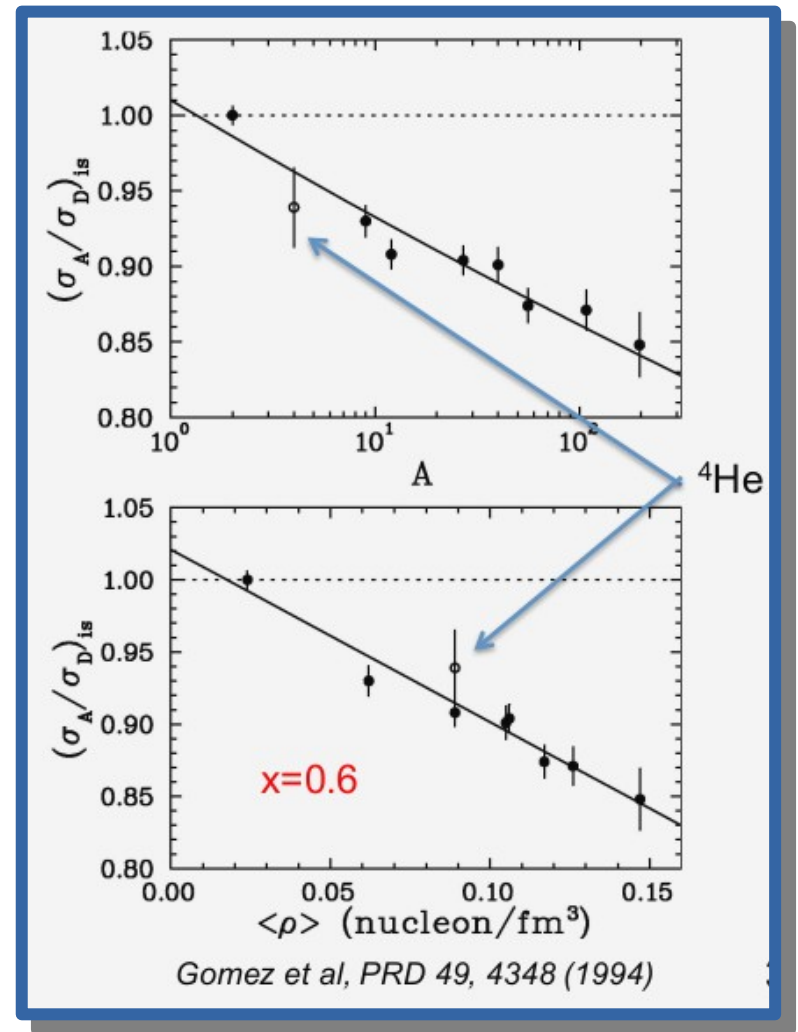
Jlab E03-103 was conducted in Hall C, at 6GeV

Measured σ_A/σ_D for ^{3}He, ^{4}He, Be, C

- ^{3}He, ^{4}He, C EMC effect scales well with density

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

Jlab E03-103
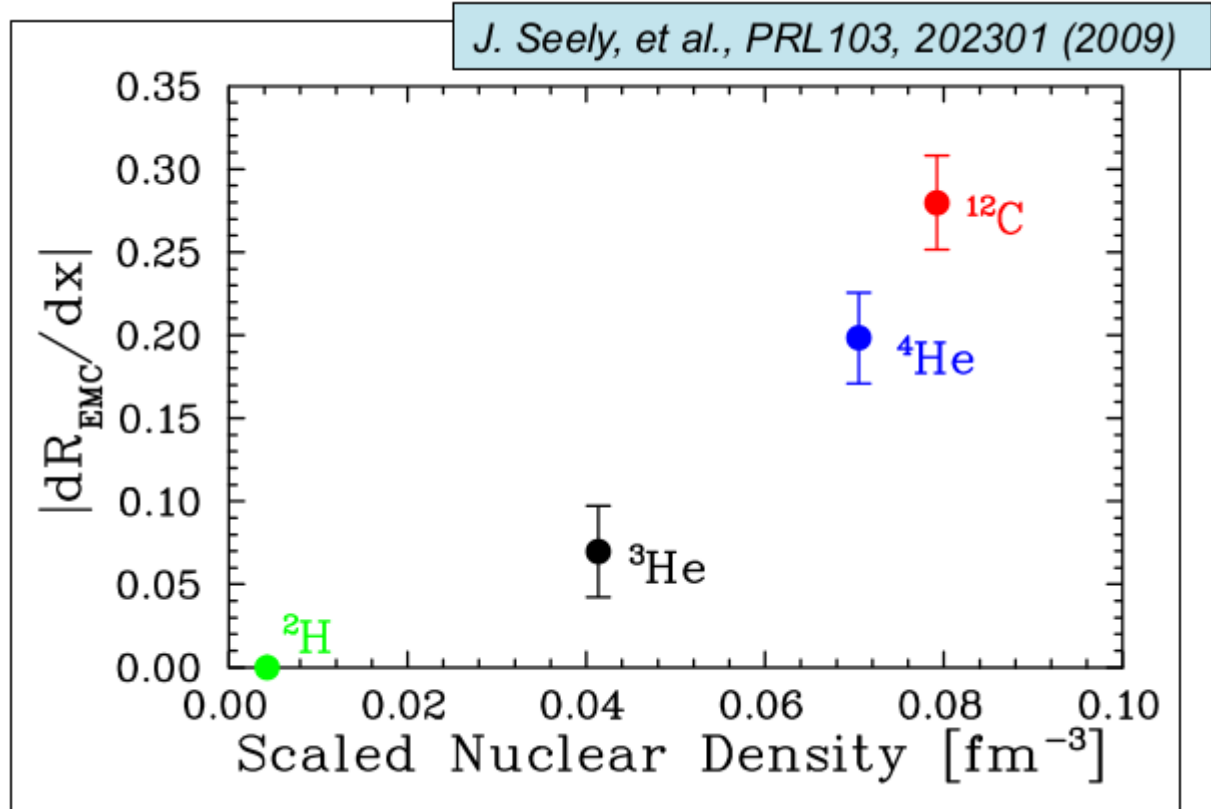
Results from JLab suggest that EMC Effect does not scale with average nuclear density

Measured σ_A/σ_D for ^{3}He, ^{4}He, Be, C

- ^{3}He, ^{4}He, C EMC effect scales well with density

- **Be** does not fit the trend

J. Seely, et al., PRL 103, 202301 (2009)

^{9}Be

^{12}C

^{4}He

^{3}He
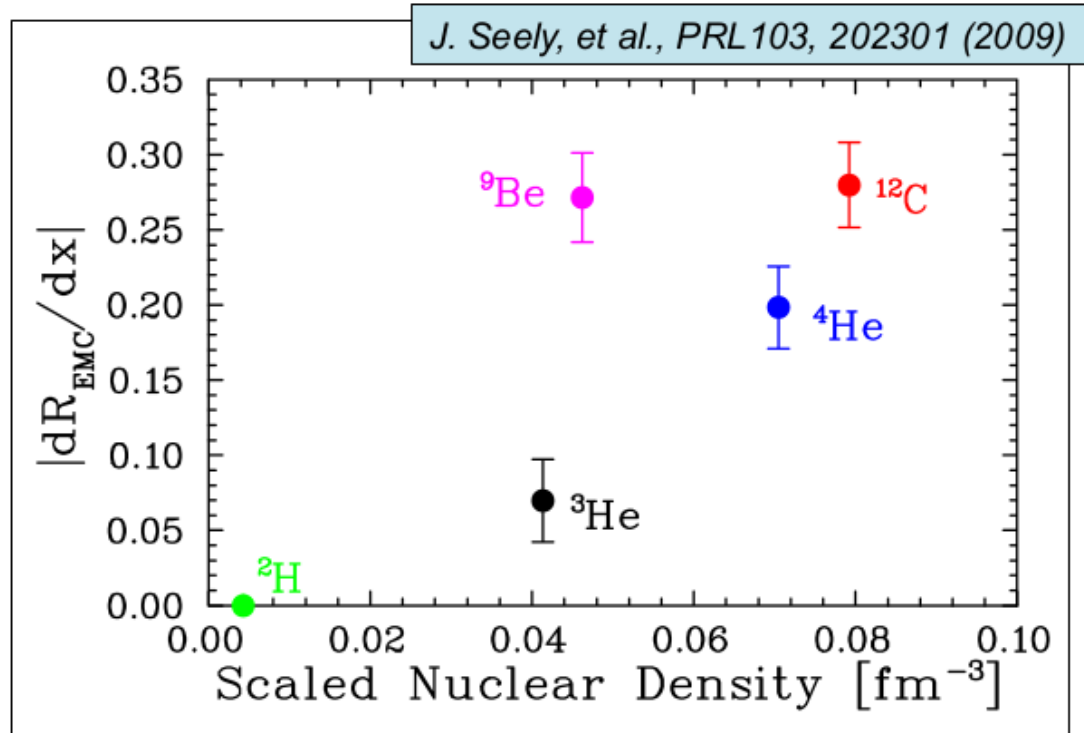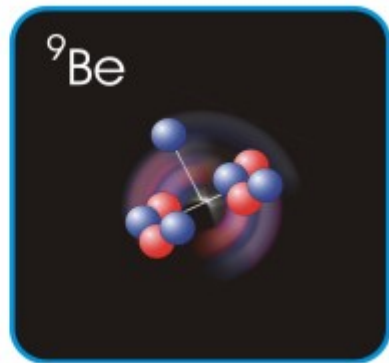
^{2}H

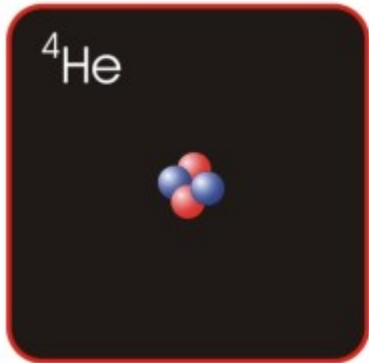$|dR_{EMC}/dx|$

Scaled Nuclear Density $[\text{fm}^{-3}]$
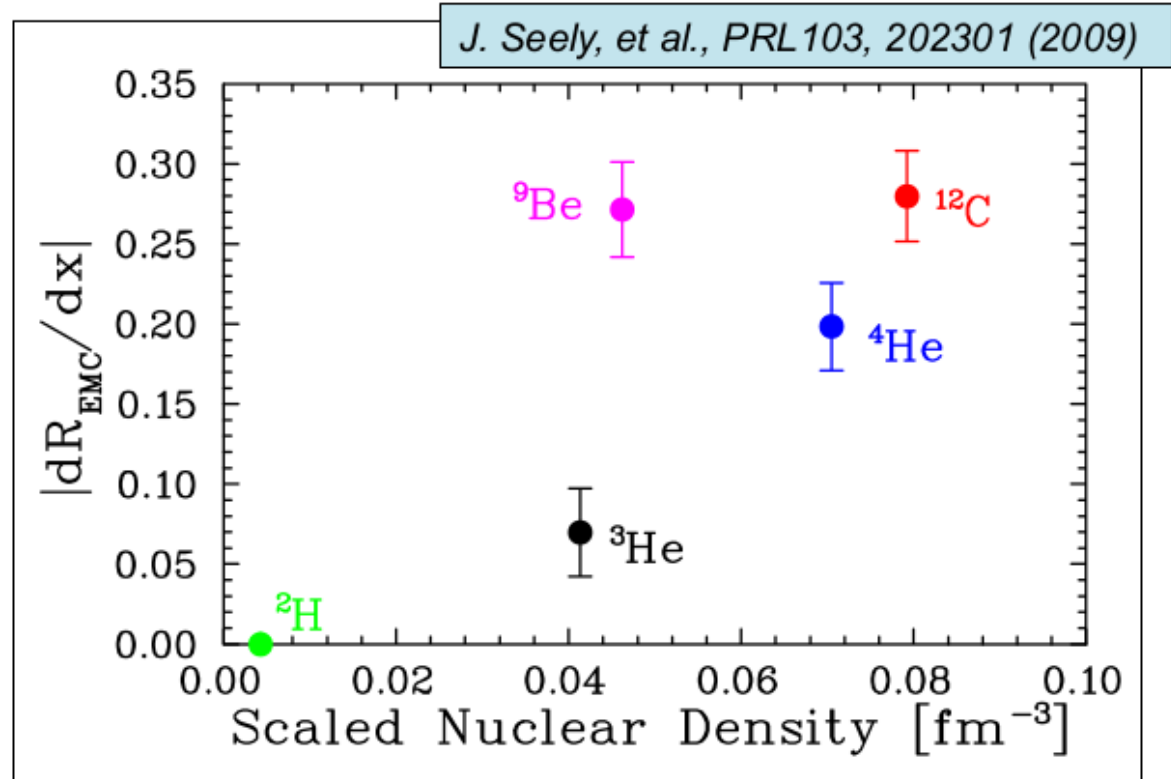
EMC effect and Local Nuclear density
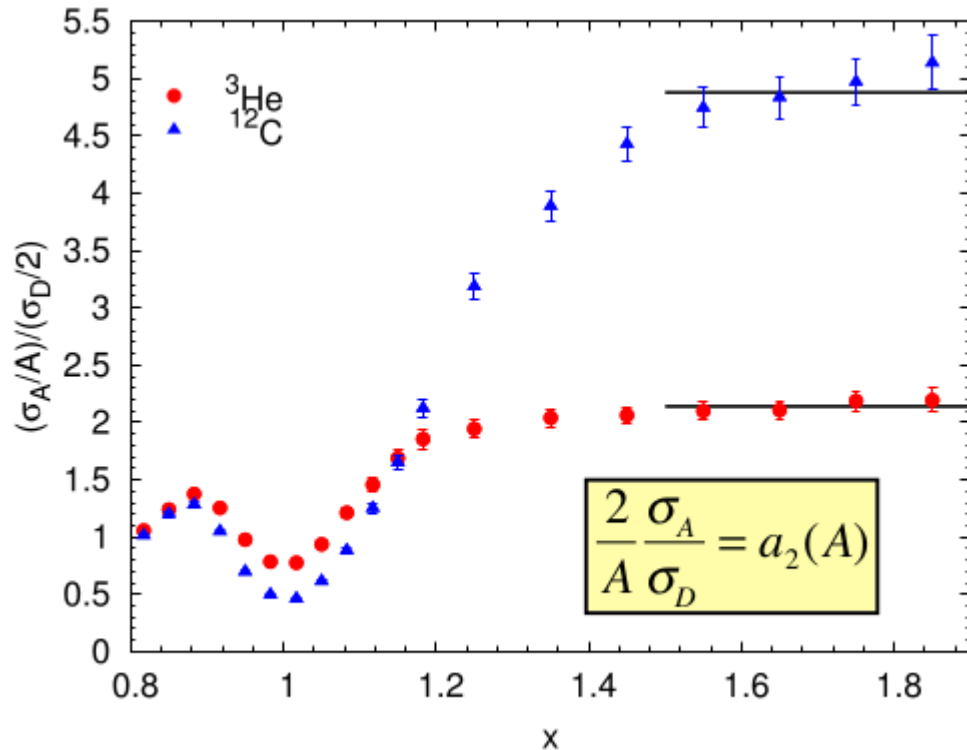
^{9}Be has low average density

- Large components of structure is 2α+n

- Most nucleons in tight, α-like configuration

EMC effect is driven by **local** rather than *average density*

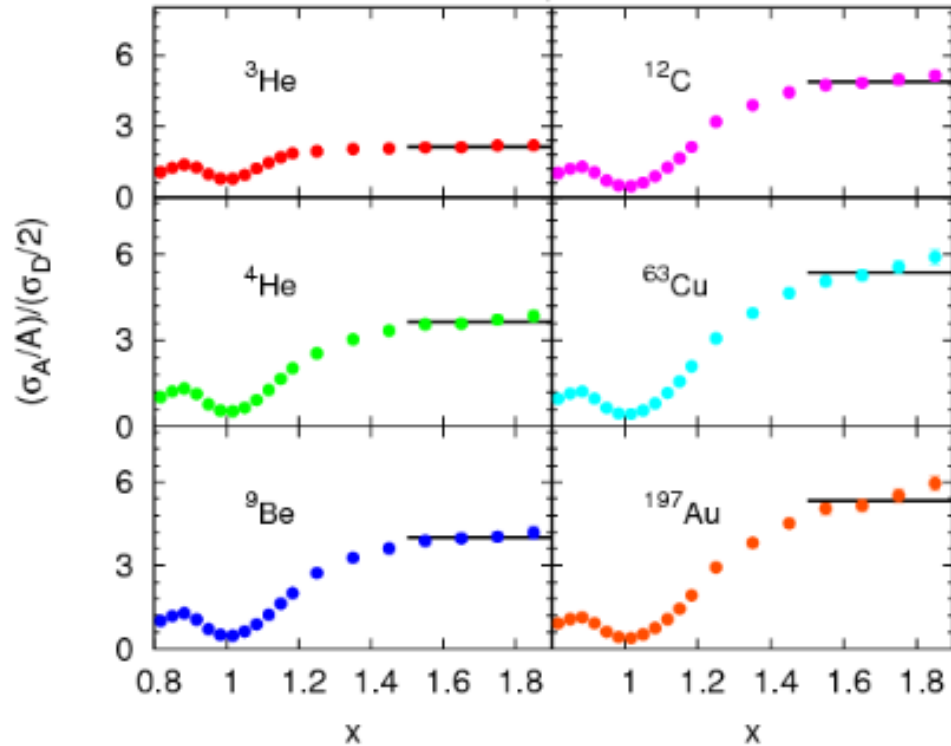J. Seely, et al., PRL 103, 202301 (2009)

Local Density $\longrightarrow$ Short Range Correlation

To measure the (relative) probability of finding a correlated pair, ratio of heavy to light nuclei are taken at x>1

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

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

SRCs and Nuclear Density

$(\sigma_A/A)/(\sigma_D/2)$

^{3}He ^{12}C ^{4}He ^{63}Cu ^{9}Be ^{197}Au

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

Jlab data on ratios at x>1
a_2 ratios for:
- Additional nuclei (Cu, Be, Au)
- Higher precision for targets with already existing ratios
- These ratios were taken at the same time as the E03-103

**Weinstein et al** first published the correlation.

This was followed up by the **O. Hen et al** when the Jlab **Be** results became available

This result provides a **quantitative** test of level of **correlation** between the **two effects.**

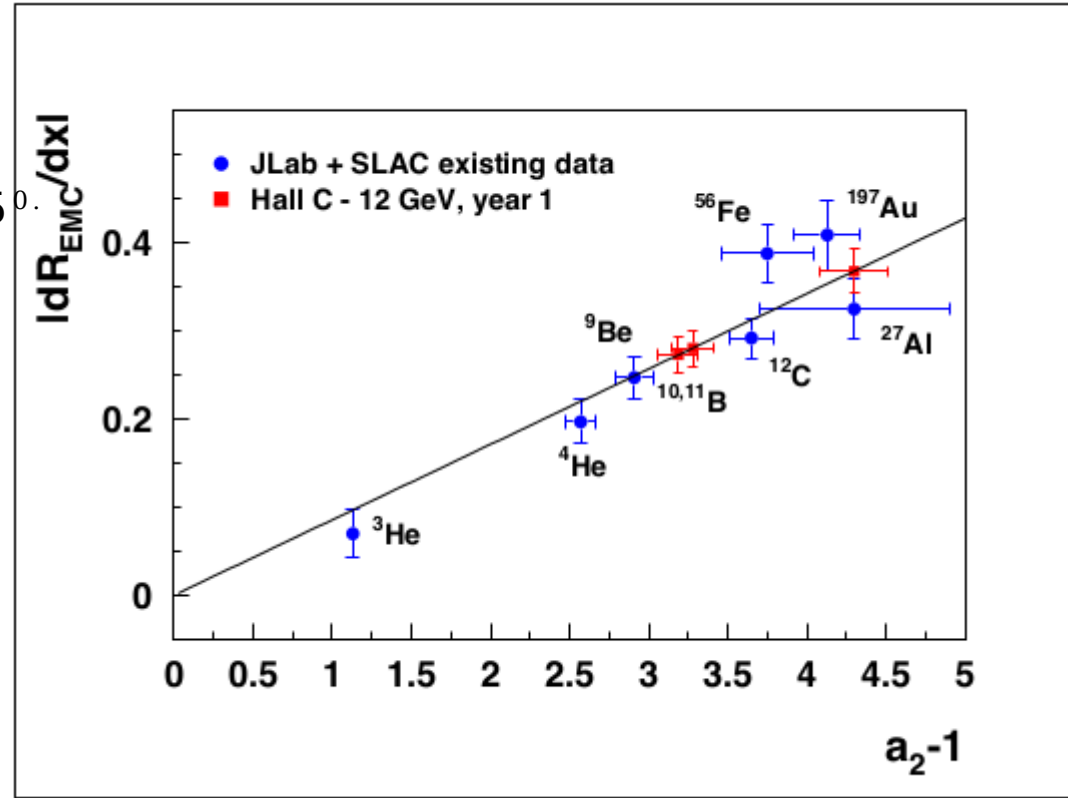χ^2 / ndf   4.895 / 5

p0   -0.08426 ± 0.003869

O. Hen et al, Phys.Rev. C85 (2012) 047301
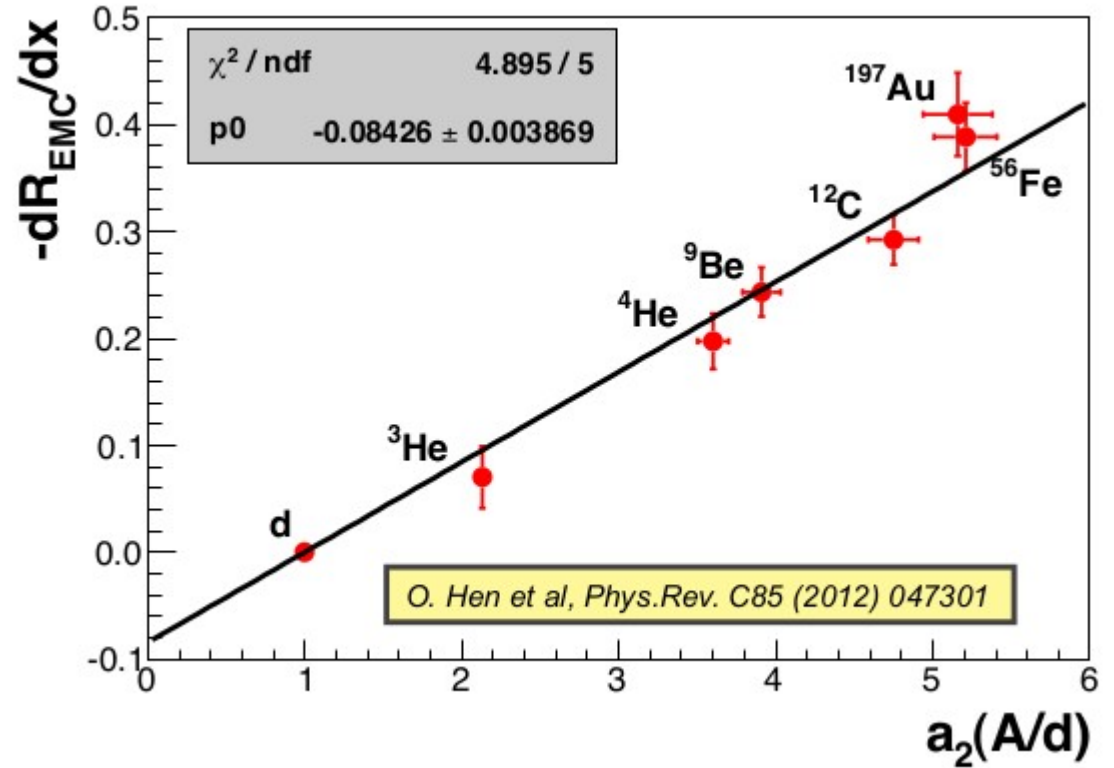
Jlab E12-10-008

- Detailed studies of the nuclear dependence of F_2 in light nuclei

- $0.2 < x < 0.9$

- Up to $Q^2 \approx 15$ GeV^2

- Light nuclei: ^{1}**H, ^{2}H, ^{3}He, ^{4}He, ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12}C**

- Medium/Heavy nuclei: Al, ^{40,48}Ca, Ti, ^{54}Fe, ^{58,64}Ni, Cu, Ag, Sn, Au, Th

- Data x $\longrightarrow$ 0.1 will facilitate the comparison of the shape of the EMC Effect on light nuclei

Kinematics
dotted black lines (E03-103)
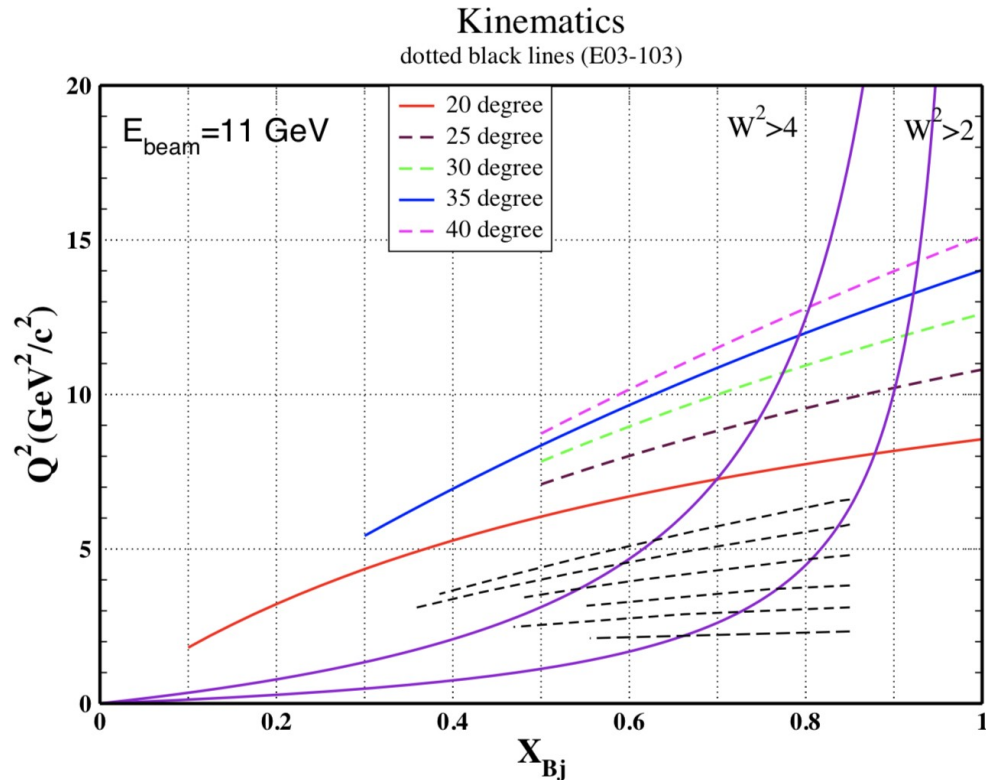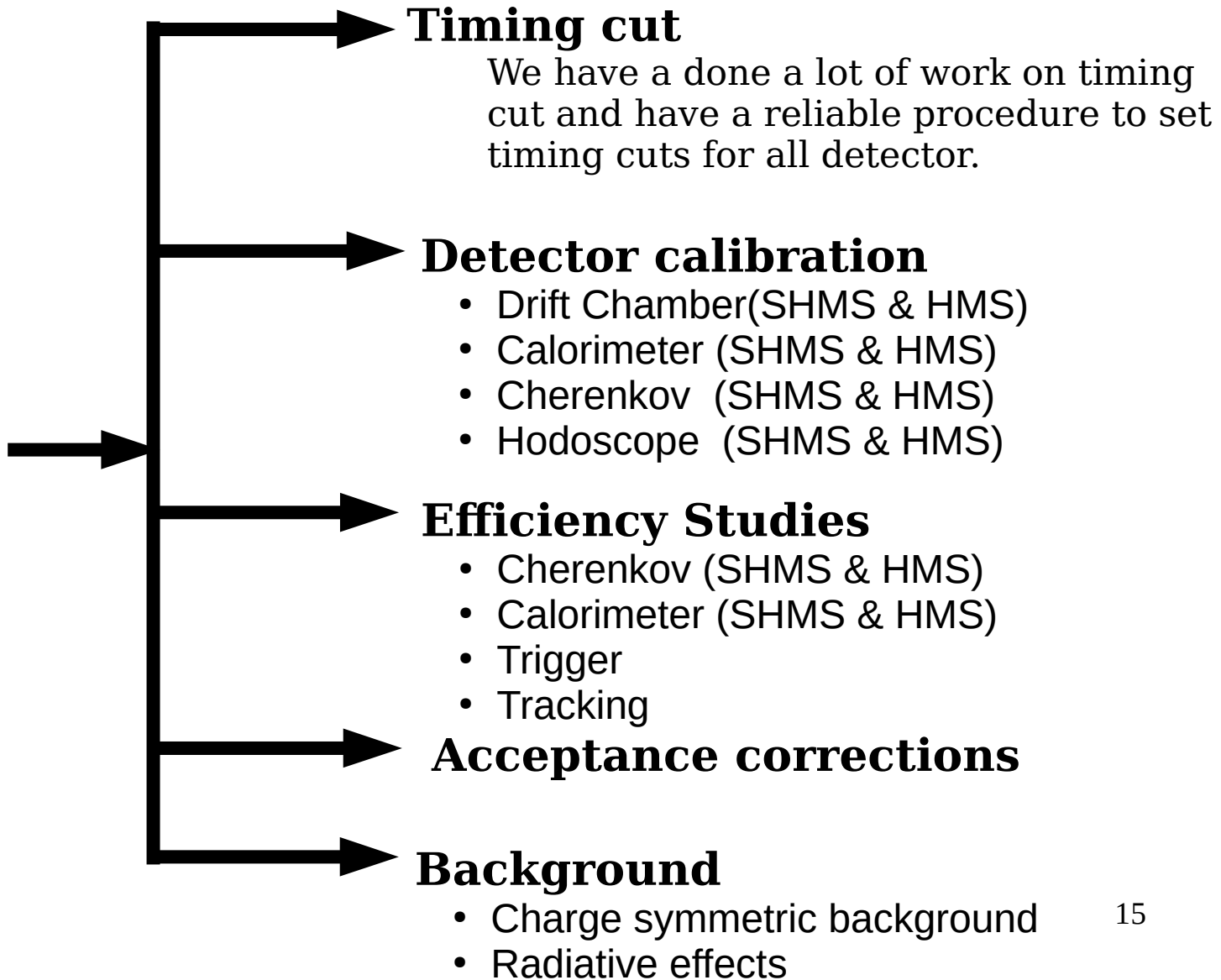
PAC 35 Proposal (2009)

My experiment is small subset of big EMC experiment schedule in Hall C

- Lighter nuclei: ^{1}**H, ^{2}H,^{10,11}B, ^{12}C**

- All targets were taken at θ = 21.035^0.

- Both spectrometer (SHMS & HMS) were used to collect data

- Also took data at x>1 on lighter nuclei

- New measurement of EMC in ^{10,11}**B** significant for clustering behavior

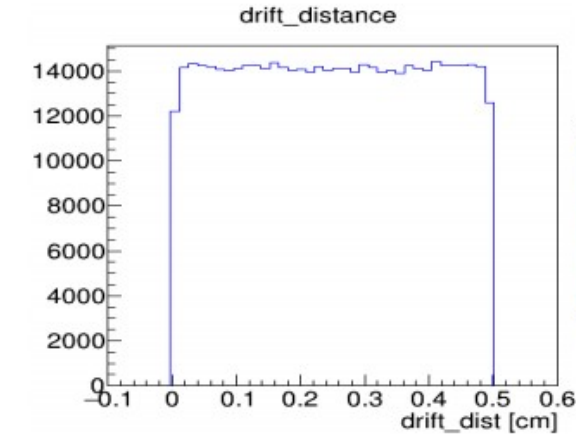- ^{12}**C** was taken only at larger angle to look at Q^2 dependence of EMC Effect


Courtesy plot from D. Gaskell

Analysis Workflow →

Timing cut

> We have a done a lot of work on timing cut and have a reliable procedure to set timing cuts for all detector.

Detector calibration
- Drift Chamber(SHMS & HMS)
- Calorimeter (SHMS & HMS)
- Cherenkov (SHMS & HMS)
- Hodoscope (SHMS & HMS)

Efficiency Studies
- Cherenkov (SHMS & HMS)
- Calorimeter (SHMS & HMS)
- Trigger
- Tracking

Acceptance corrections

Background
- Charge symmetric background
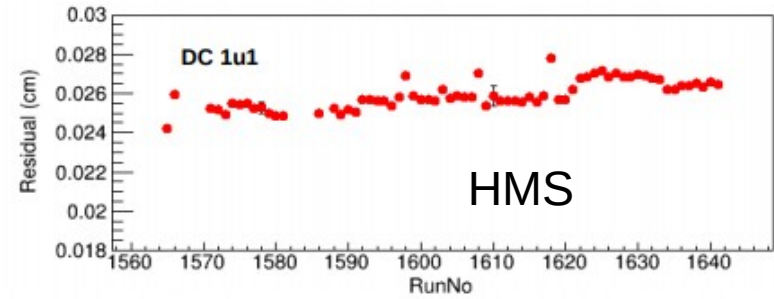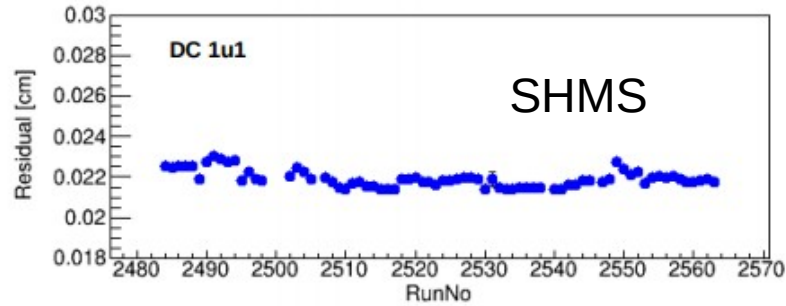- Radiative effects

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Calibration result

Drift Chamber

To check the flatness of drift distance histogram, we take the ratio of maximum bin content to minimum bin content
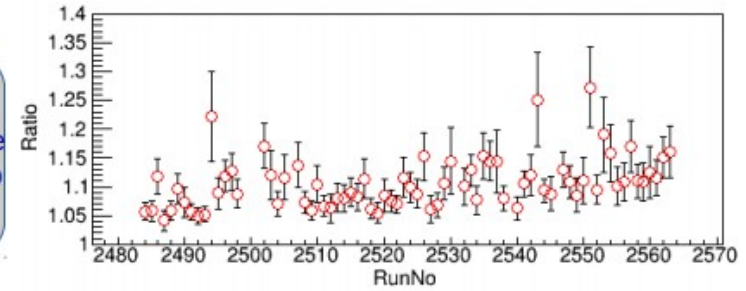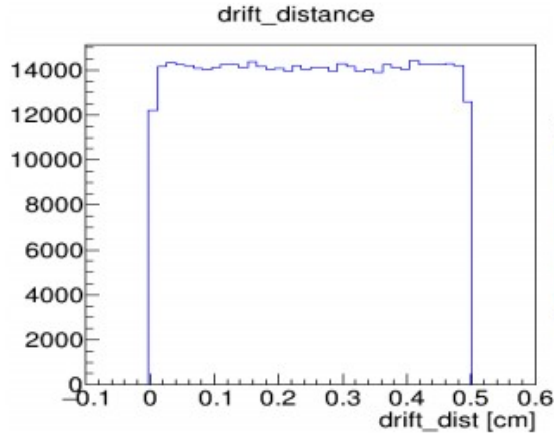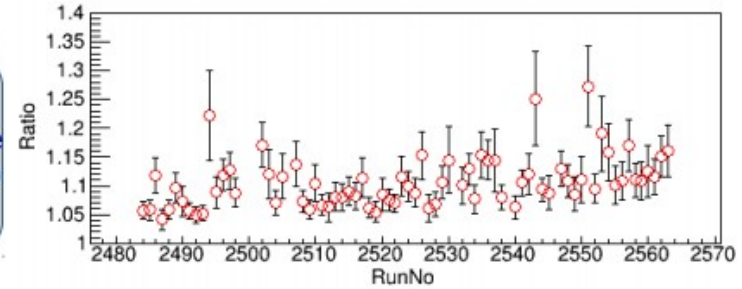
SHMS

HMS
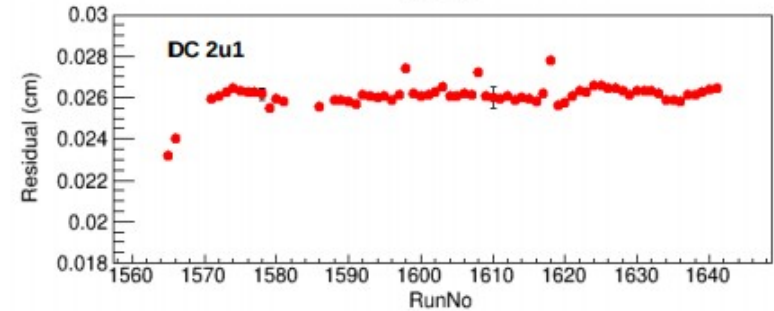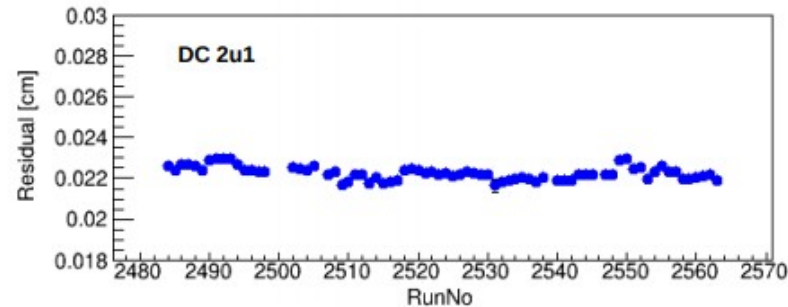
Calibration result

Drift Chamber

To check the flatness of drift distance histogram, we take the ratio of maximum bin content to minimum bin content

- Here I am only showing the residual from the best two planes which is around ~ 250 microns for SHMS and for HMS is ~270 microns.

- The worst plane has residuals about ~300 microns in SHMS & for HMS it was about ~ 320 microns.
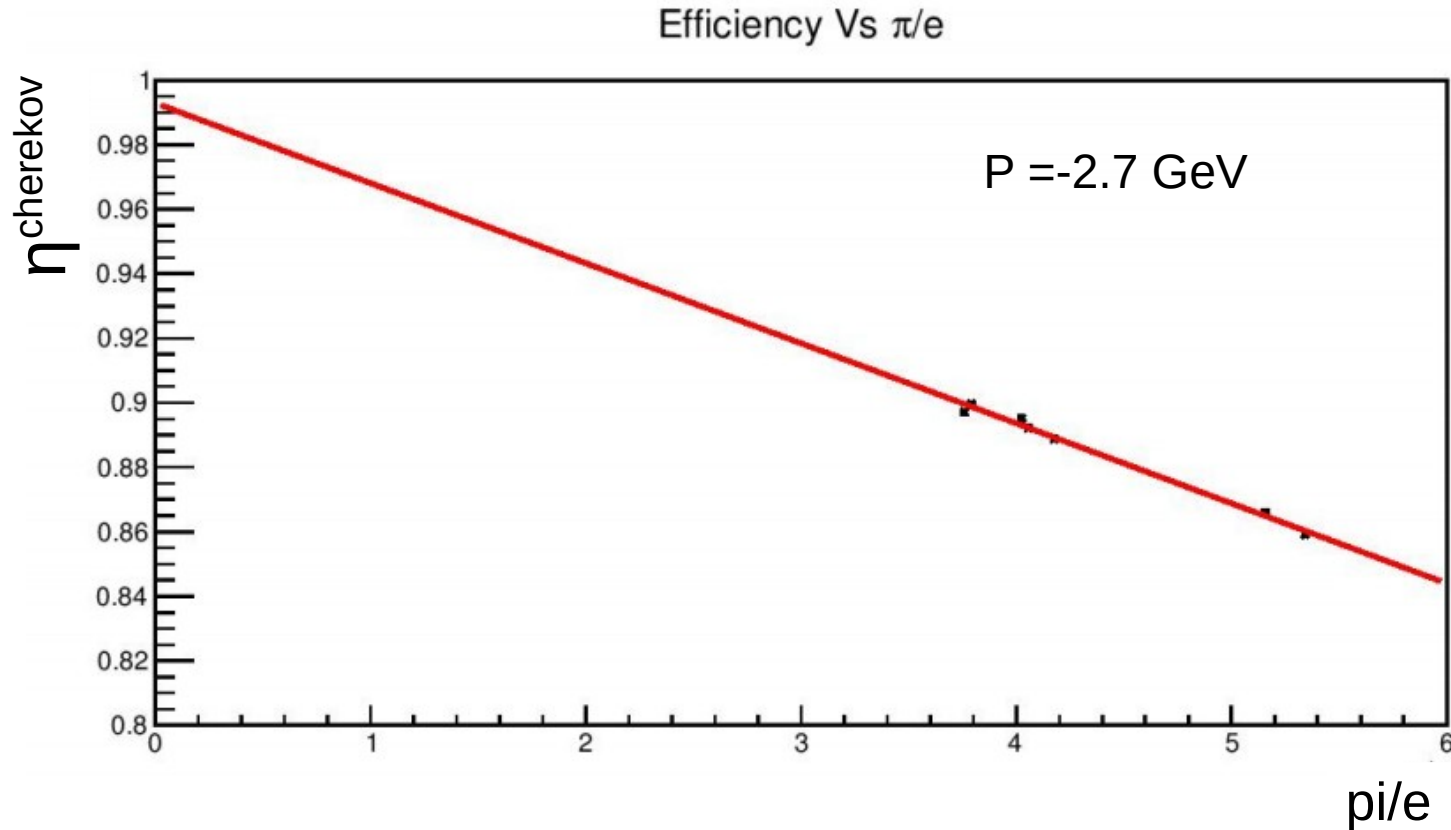
Efficiency Studies: Ngcer

- Clean sample of electron was created by putting cuts on calorimeter and trigger

- Pions can still contaminate out clean sample of electrons

- Efficiency can be calculated from different runs with different π rates

  (different target), then extrapolate ratio to zero.
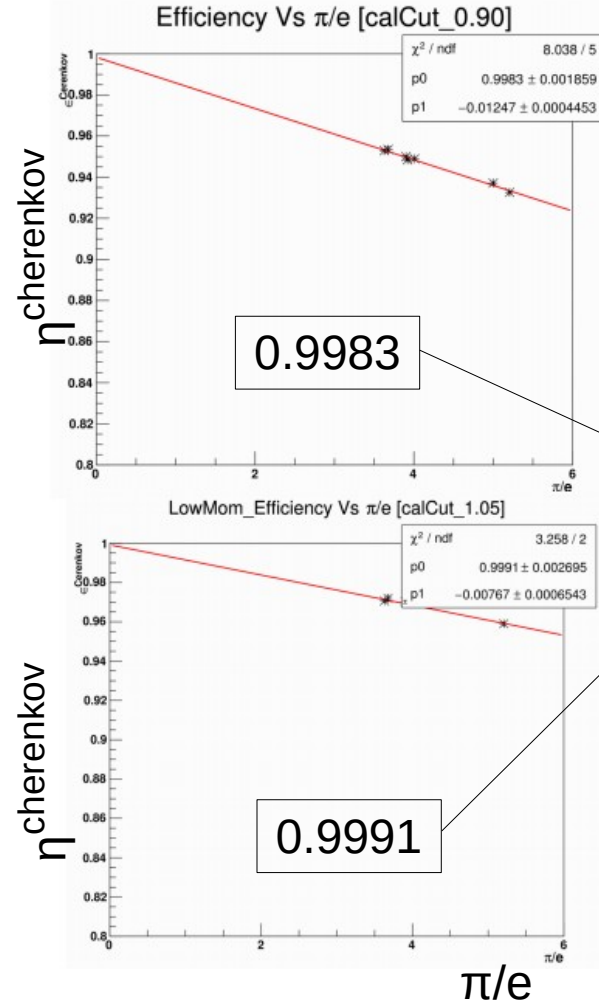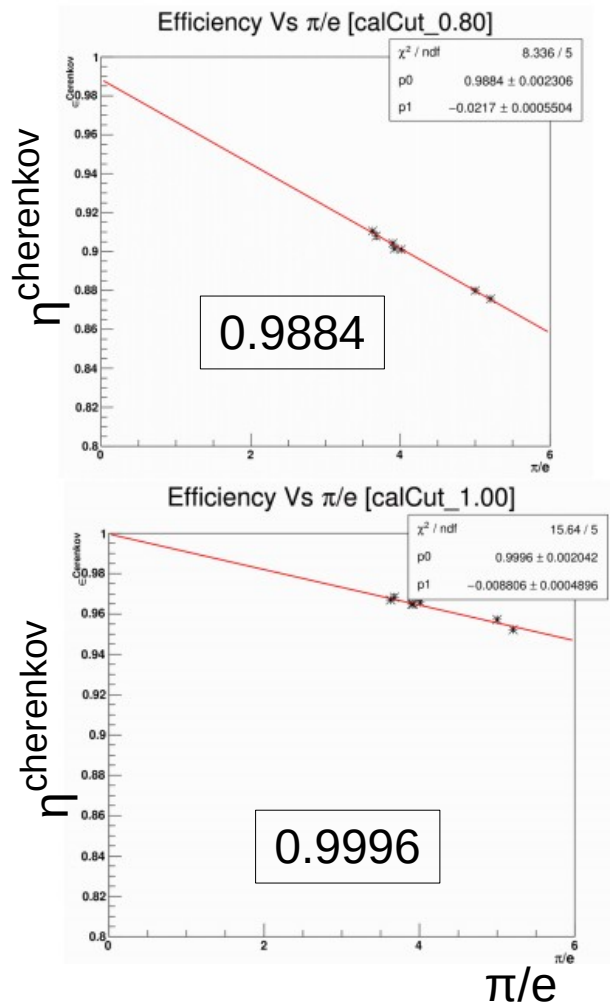
  π/e ratio was calculated,

  $$\pi/e \; = \; \frac{Nevents(Cherenkov=0)}{Nevents(Cherenkov=10)}$$

This is work under progress

Efficiency Vs π/e

P =-2.7 GeV

$\eta^{cherekov}$

pi/e

Here I am only showing one representative plot. More studies need to be done for all momentum setting. Also, look for delta dependence for efficiency.
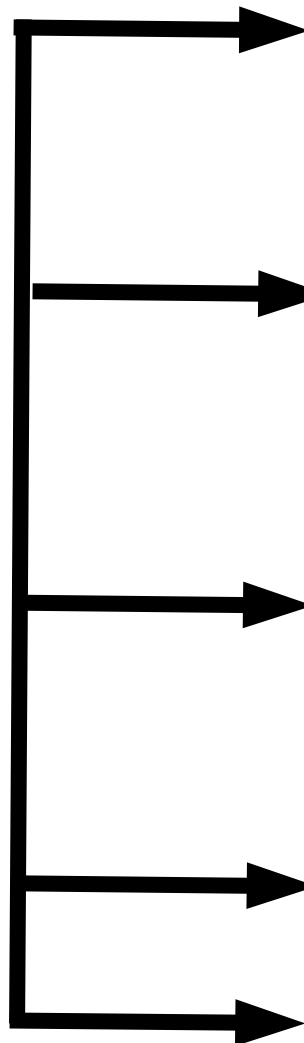
How consistent is efficiency if we change the calorimeter cut.

P = -2.7 GeV

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More updates on overall F2/EMC experiment on next talk
by Fernando

Thank you for your attention