EMC ratios in Lighter Nuclei

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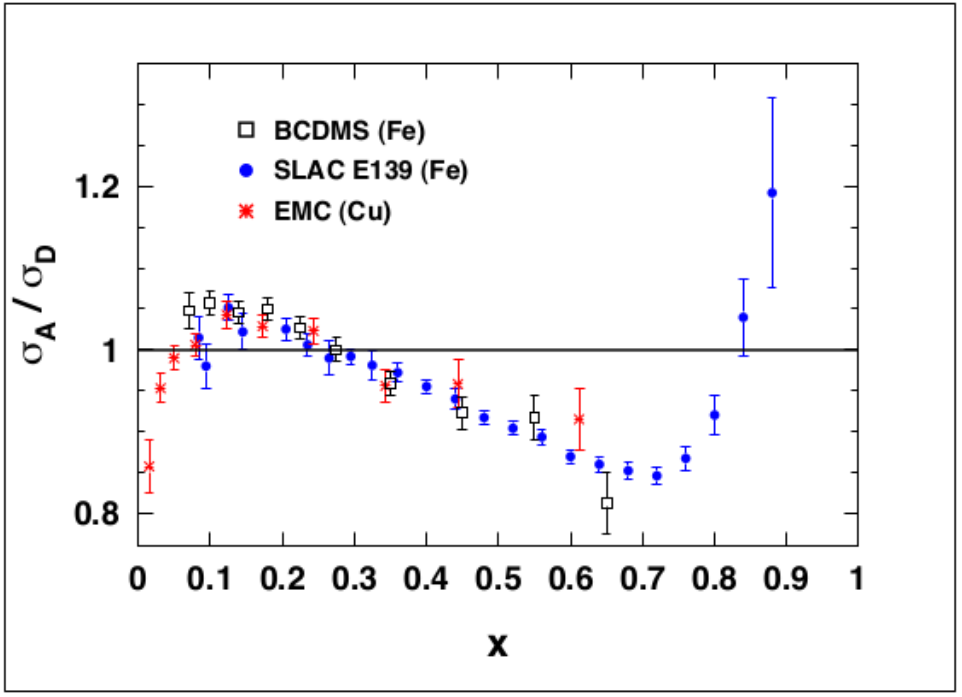
Introduction:

- European Muon Collaboration investigated Deep Inelastic Scattering (DIS) of muons on H, D, Fe

- Structure Function:
  - Naive Expected: $F^{A}_{2}(x) = ZF^{p}_{2}(x) + NF^{n}_{2}(x)$
  - Structure fns related to quark distribution

- Experiment concluded $\boldsymbol{\sigma}_A/\boldsymbol{\sigma}_D \neq 1$

- EMC is measure of medium modification of quark distribution



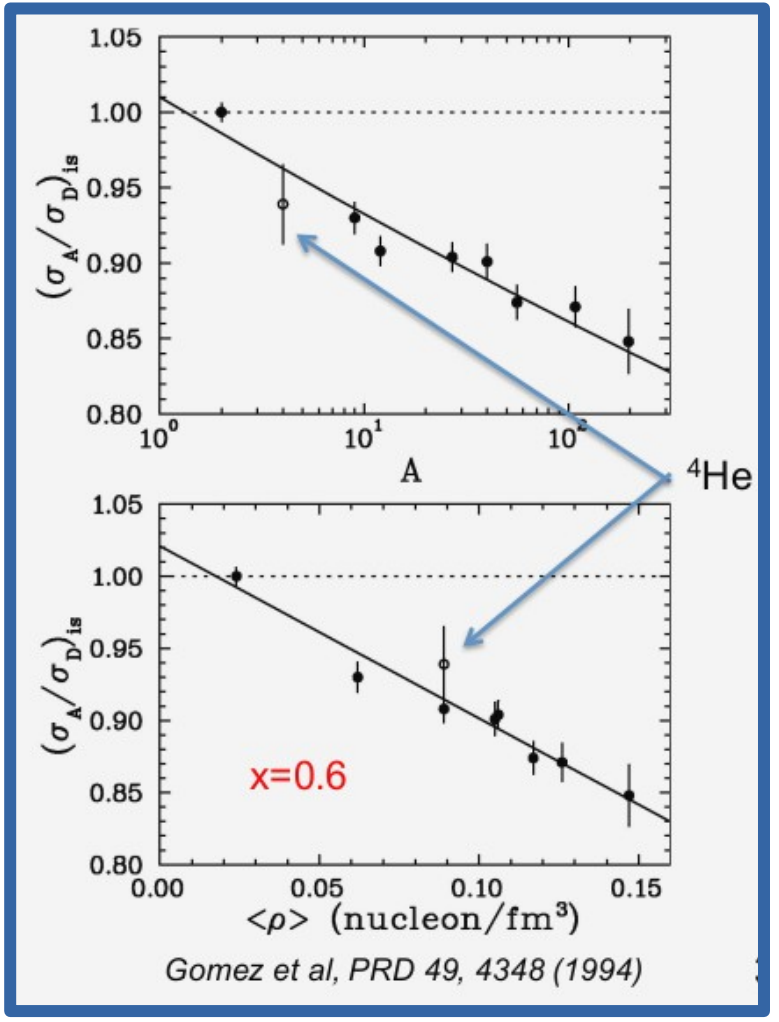
Intro.....

Nuclear dependence

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

Results:

- Simple logarithmic A dependence
- Average nuclear density



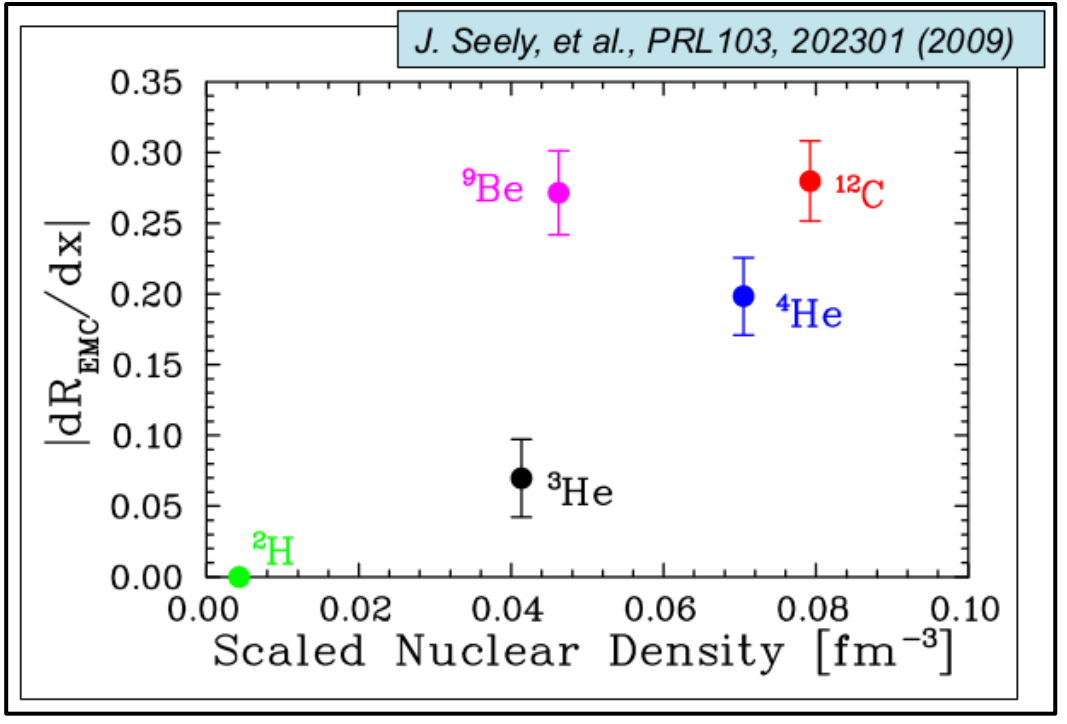
Motivation

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

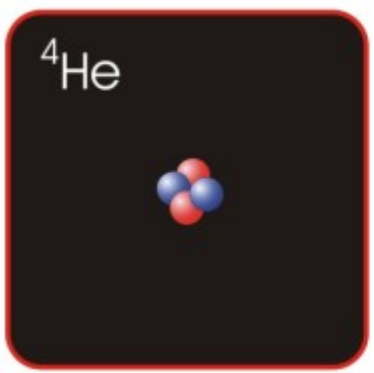


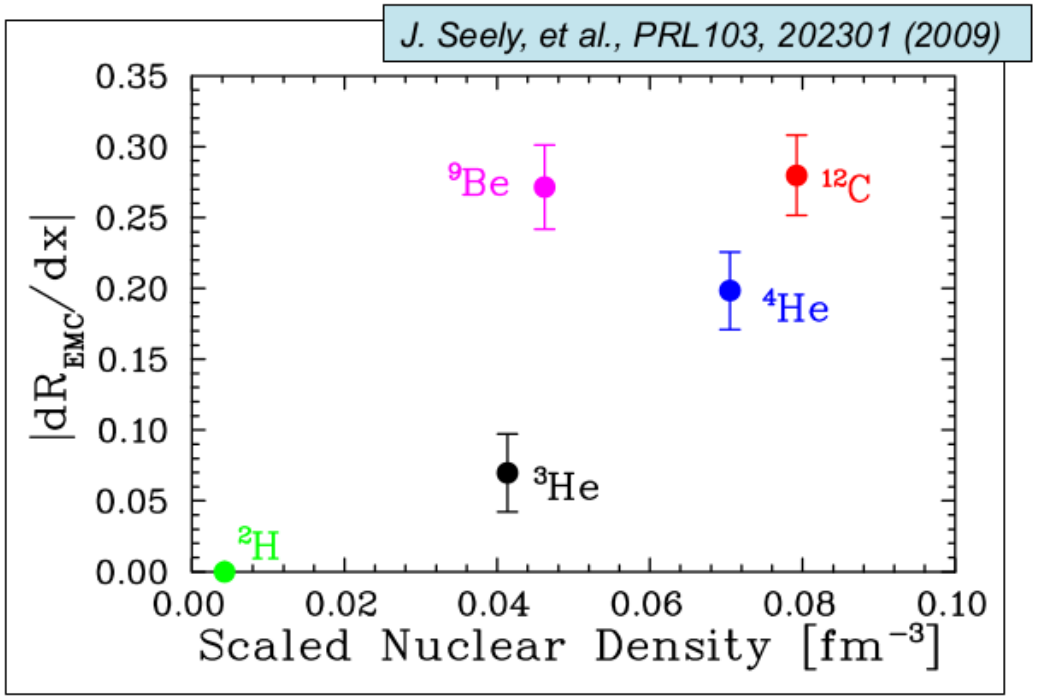
EMC effect and Local Nuclear density

^{9}Be has low average density

- Large component of structure is 2α+n
- Most nucleons in tight, α-like configuration

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



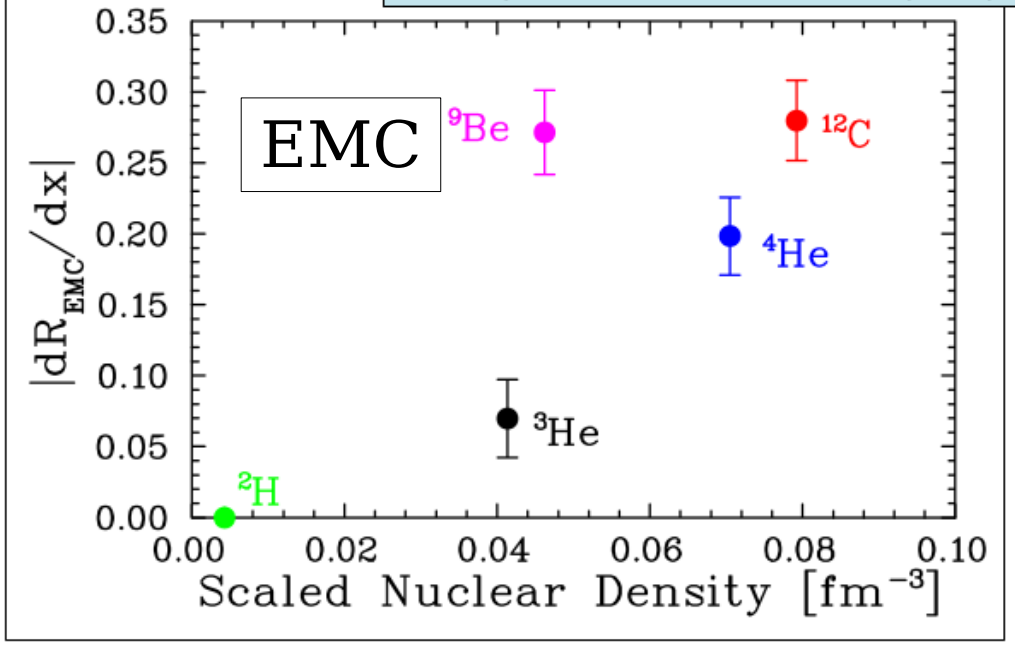


SRCs And Nuclear Density

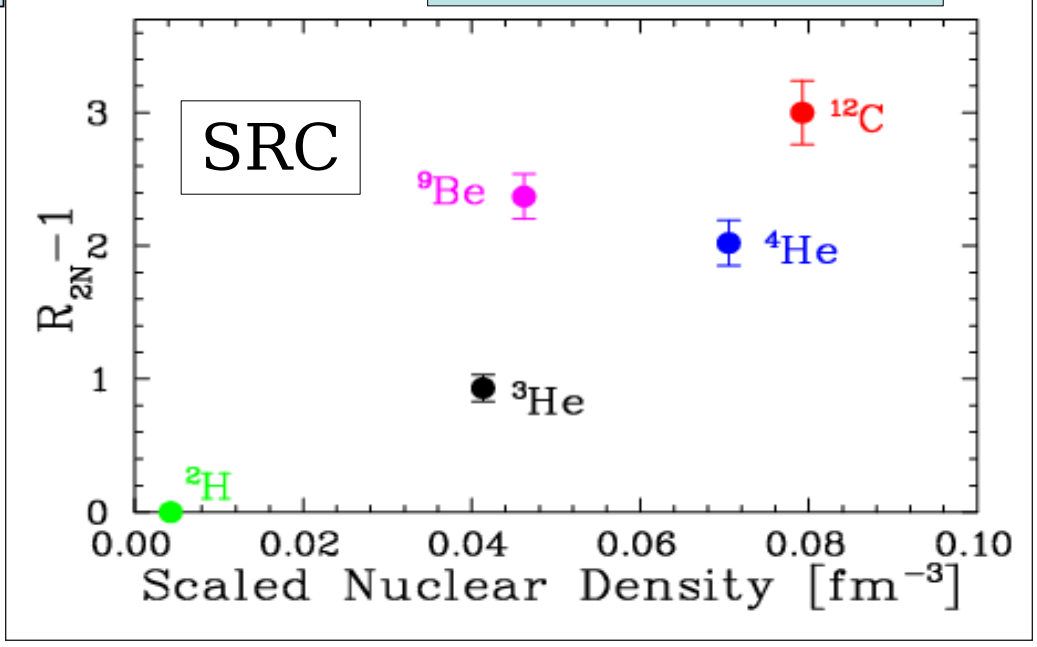
SRC (Short Range Correlation) is configuration when two nucleons come very close and act like a correlated pair such that they are heavily modified.

Common Nuclear Dependence

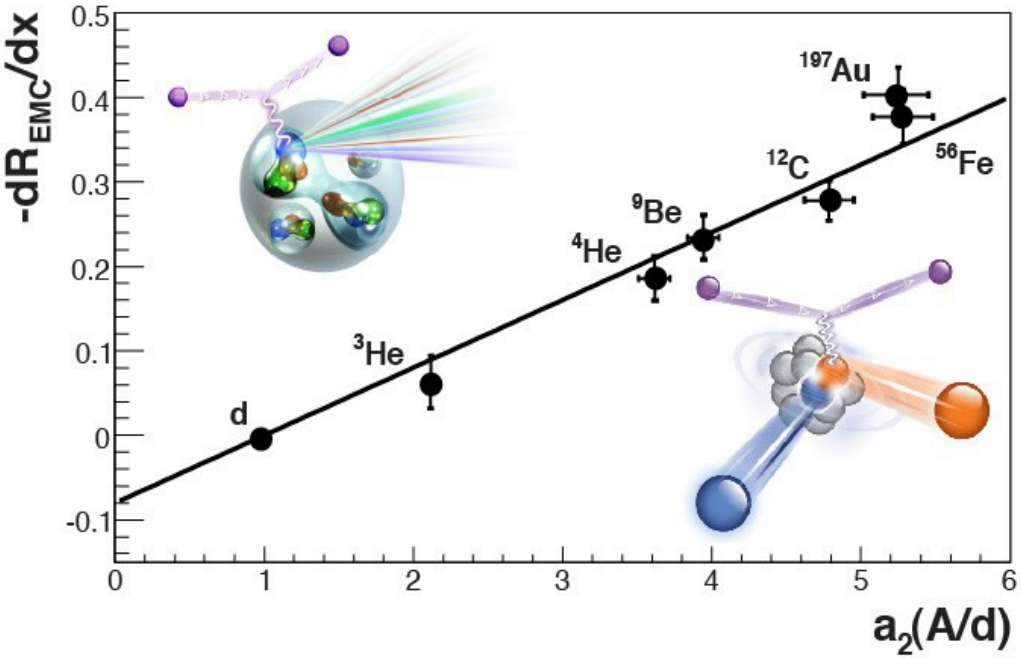
J. Seely, et al., PRL103, 202301 (2009)



N. Fomin et al, PRL 108 (2012)



SRCs And the EMC



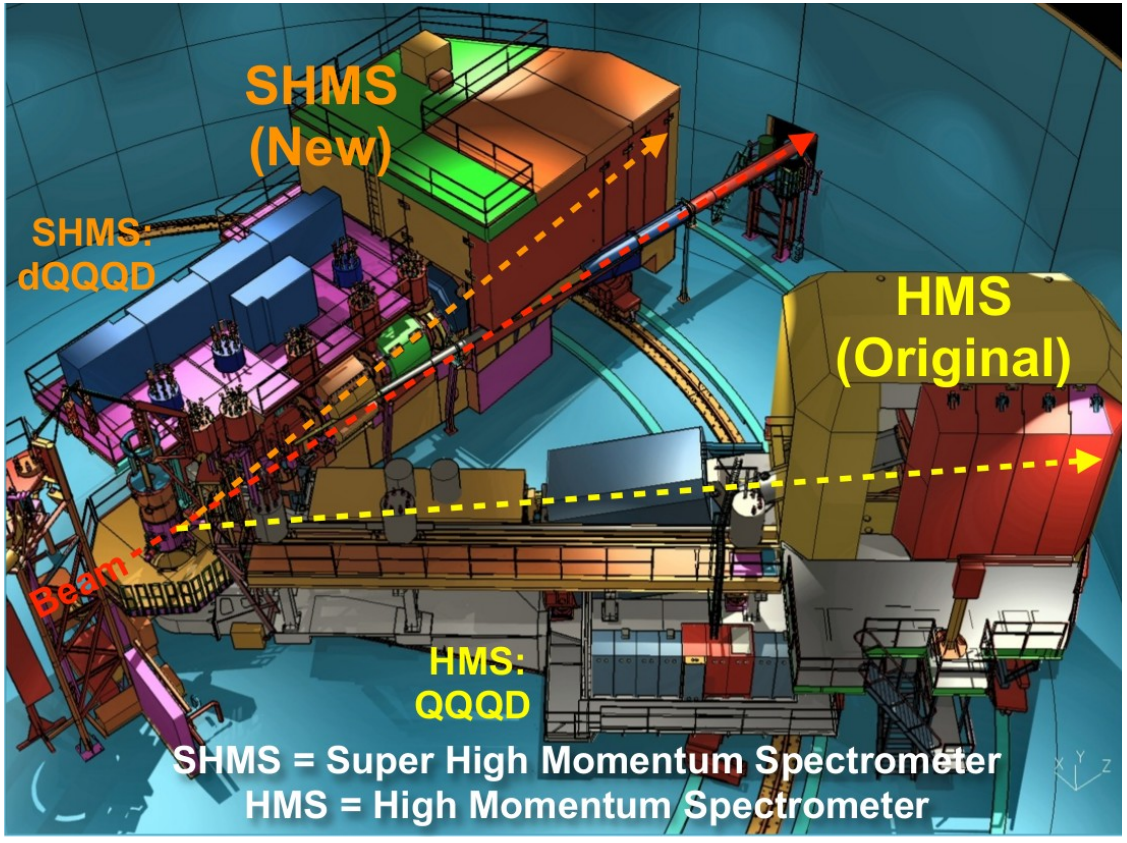
J. Seely, et al., PRL103, 202301 (2009)
N. Fomin, et al., PRL 108, 092052 (2012)
J. Arringon, A. Daniel, D. Day, N.Fomin, D. Gaskell, P. Solvignon, PRC 86, 065204 (2012)
O. Hen, et al, PRC 85, 047301 (2012)
L. Weinstein, et al., PRL 106, 052301 (2011)

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

Hall C: SHMS & HMS

SHMS
- HB,3Quads, Dipole
- P→ 2-11 GeV
- Resolution: δ < 0.2%
- Acceptance 30% ,4msr
- $5.5^0 < \theta < 40^0$

HMS
- 3 Quads, Dipole
- P→ 7.5 GeV
- Resolution: δ <0.1%
- Acceptance 18%,6.5msr
- $10.5^0 < \theta < 90^0$



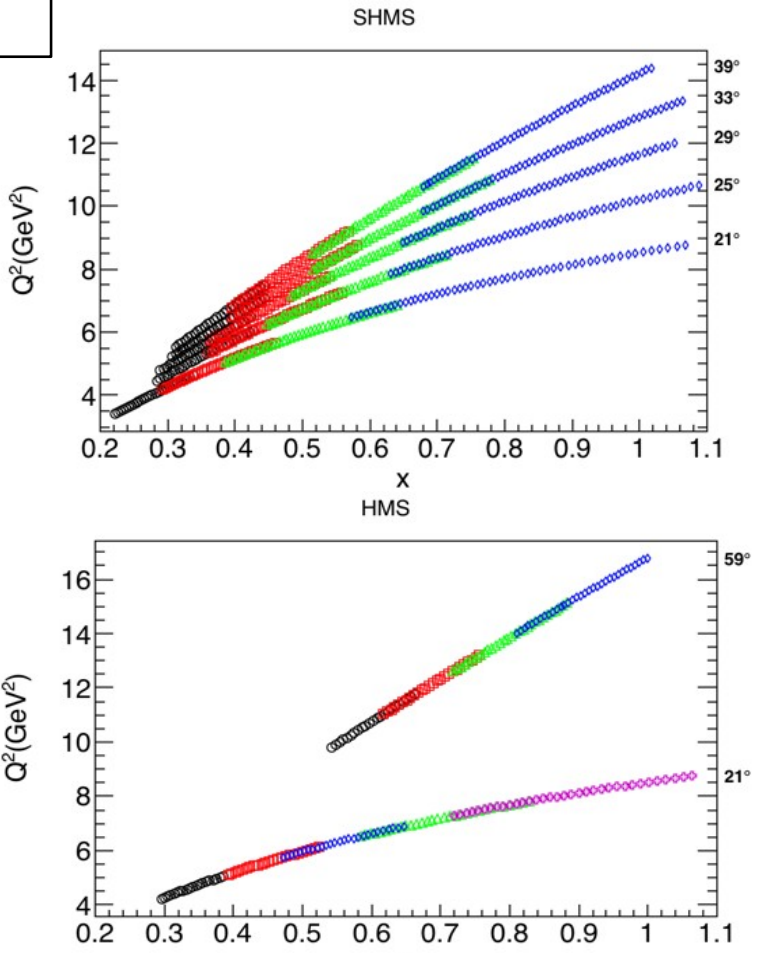
Detector Package:
- Drift Chamber
- Hodoscopes
- Cerenkovs
- Calorimeter

Rigid support Structure

E12-10-008: Setup & Kinematics

Phase I Spring 2018

- Ran with E12-10-002 (f_2) as a part of commissioning experiment.
- 2 PAC Days were used
- Both spectrometers were used for measurement
- Beam 10.6 GeV, unpolarized
- Targets : ^{1}**H**,^{2}**H**,^{9}**Be**,^{10,11}**B**,^{12}**C** were taken at 21^{0}
  - Only ^{12}**C** was taken at larger angle to look at Q^2 dependence of EMC Effect



First measurement of the EMC effect in ^{10,11}B

Analysis Workflow

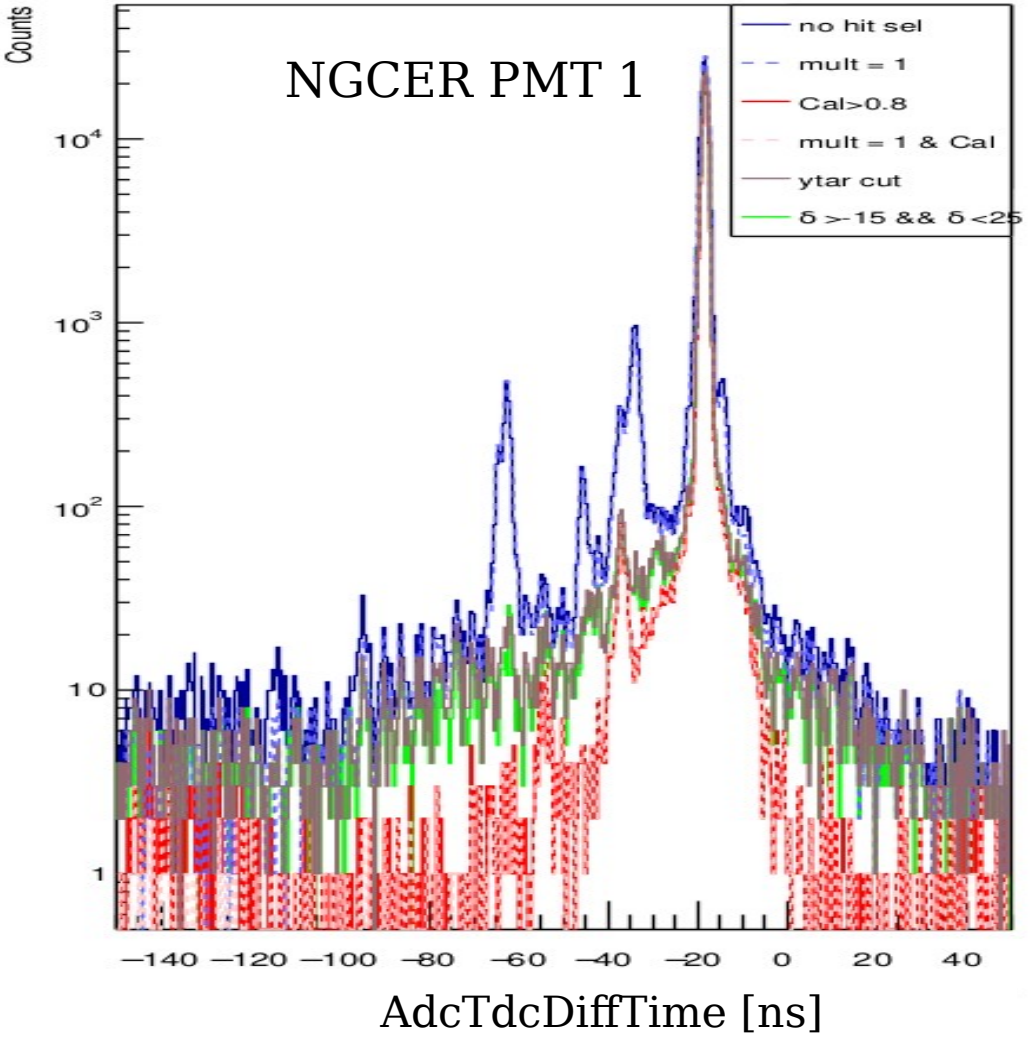
- **Timing cuts**
- **Detector calibration**
  - BCM (Deb's Talk)
  - Hodoscope
  - Drift Chamber
  - Calorimeter (Abel's Talk)
  - Cherenkov (Abel's Talk)
- **Efficiency Studies**
  - Tacking Efficiency
  - Trigger Efficiency
  - Computer Dead Time
  - Calorimeter & Cherenkov Cut Efficiency
- **Charge Symmetric Background** (Abel's Talk)
- **Acceptance Study** (Abel and Aruni Talk)
- **Radiative Correction**
- **Ratios Calculation**

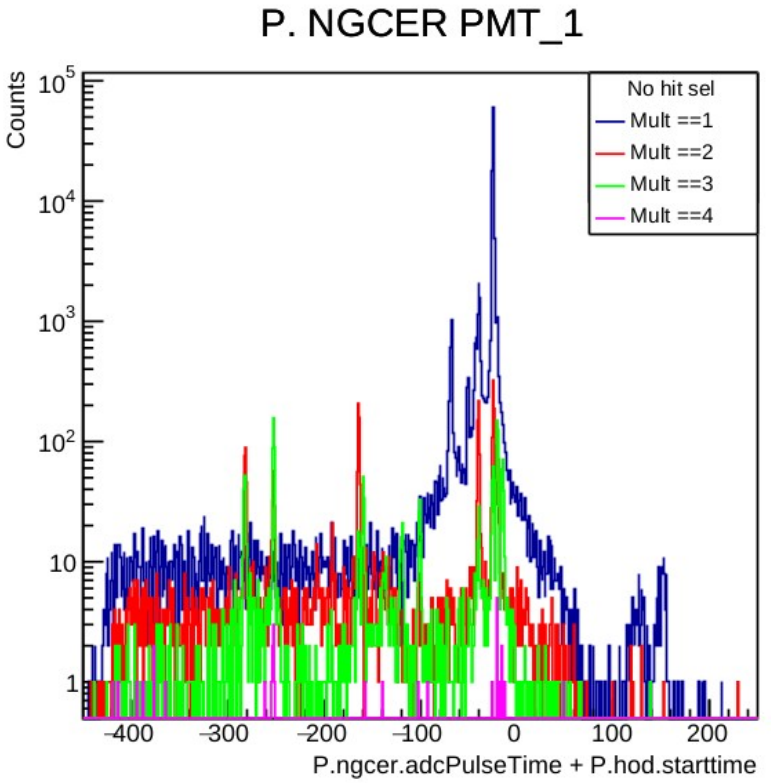
Analysis Status

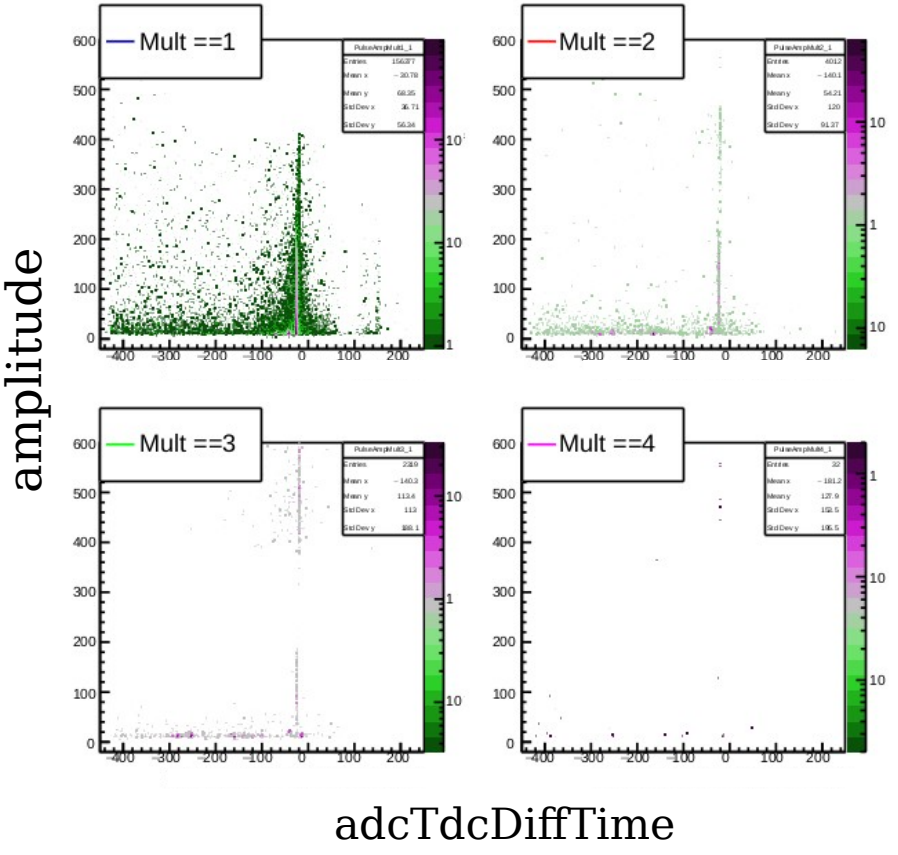
- Detector calibrations complete.
- Working on extracting the experimental efficiencies and understanding the SHMS acceptance.
- Extraction of raw EMC ratios is currently ongoing.
- Detailed Data/Monte-Carlo comparisons is in progress.
- Carbon ratio looks roughly as expected.
- Need to work on subtraction/modeling of charge symmetric background and radiative corrections.

Timing Cuts

First step in the analysis, is to set proper reference time cuts and TDC & ADC timing cuts for “good” hit selection. (Detectors have capability to accept multi-hits.)





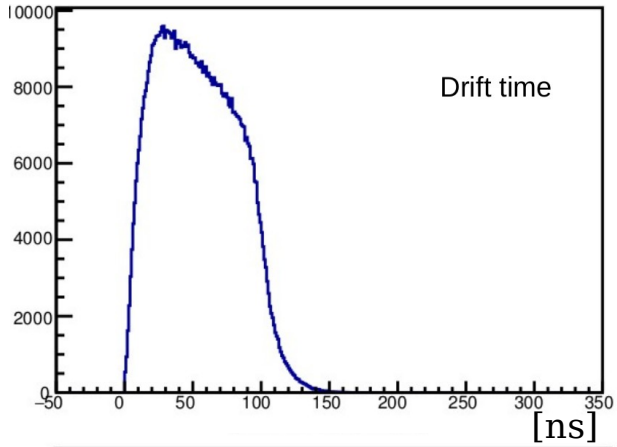


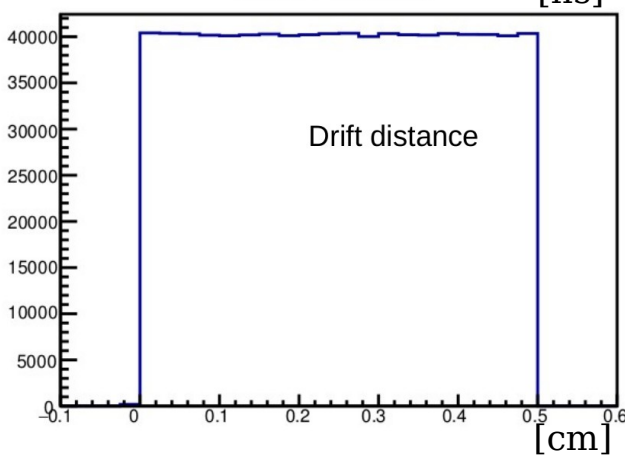
- We look for patterns when we have more than one hit: how often it comes with low-low, low-high and high-high amplitude. Most events with multiplicity greater than one have low-high pattern.
- We select hits based on timing but also based amplitude.

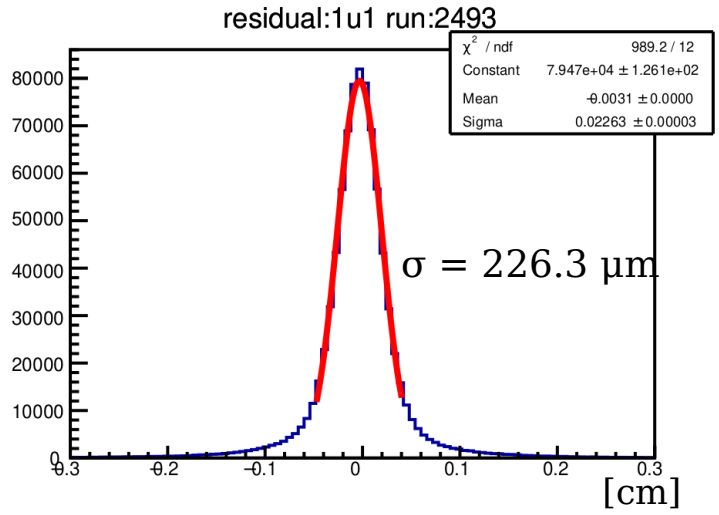
SHMS Drift Chambers : Calibration and resolution

It is a detector used to determine the position of the particle and hence the trajectory.

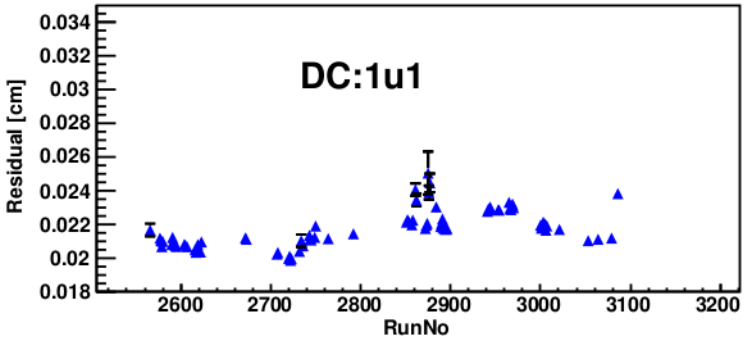
- TDC values from all of the wire in a given plane for a large no of events is taken to obtain a drift time distribution which is then averaged over all the wire of a plane to form a drift time distribution per plane.
- "t_0" offset is calculated for each plane.
- Makes a look up table to convert drift time to drift distance.

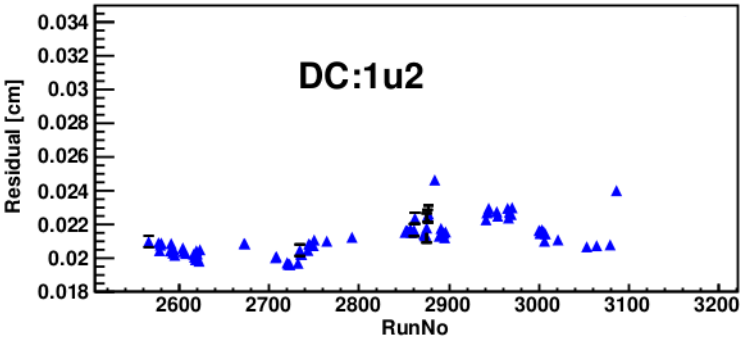




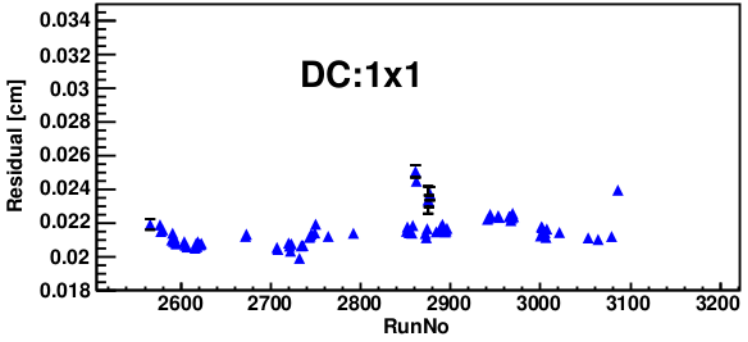


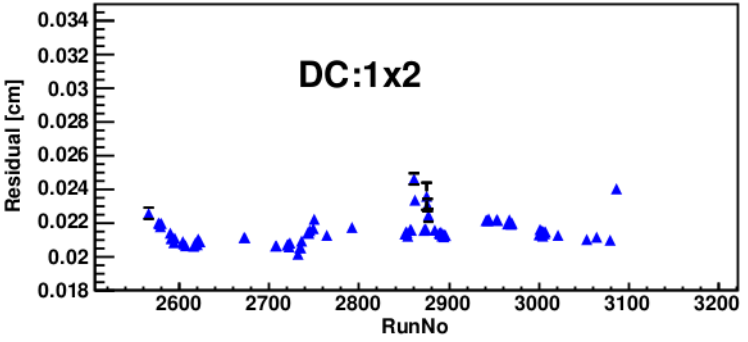
- Residual is the difference between the final track position and the hit location obtained from individual drift chamber planes.



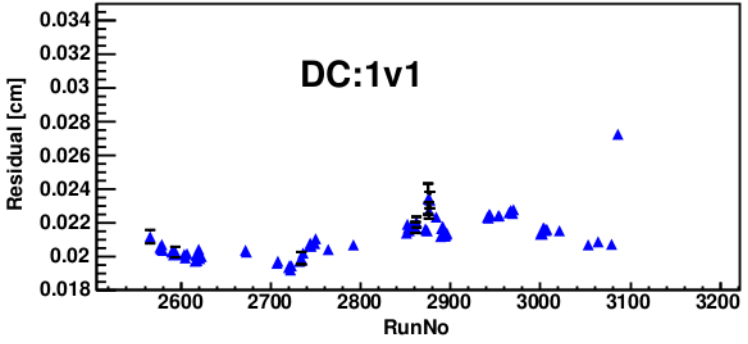


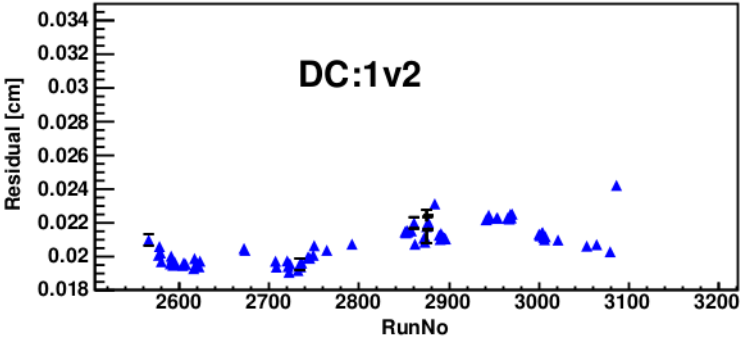
Residual is sigma value of fit.





Residual < 250 μm





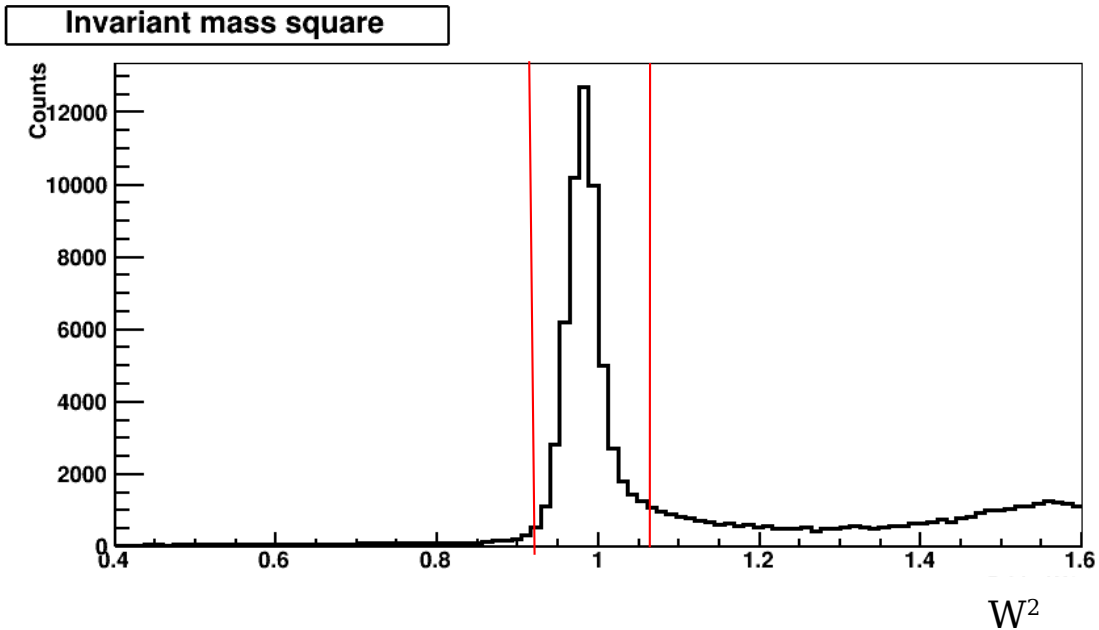
SHMS Calorimeter Cut Efficiency

- Difficult to extract efficiency from Inelastic data set.
  - (Hard to make pure electron sample just using Cherenkov)
- Obtaining efficiency from Elastic run

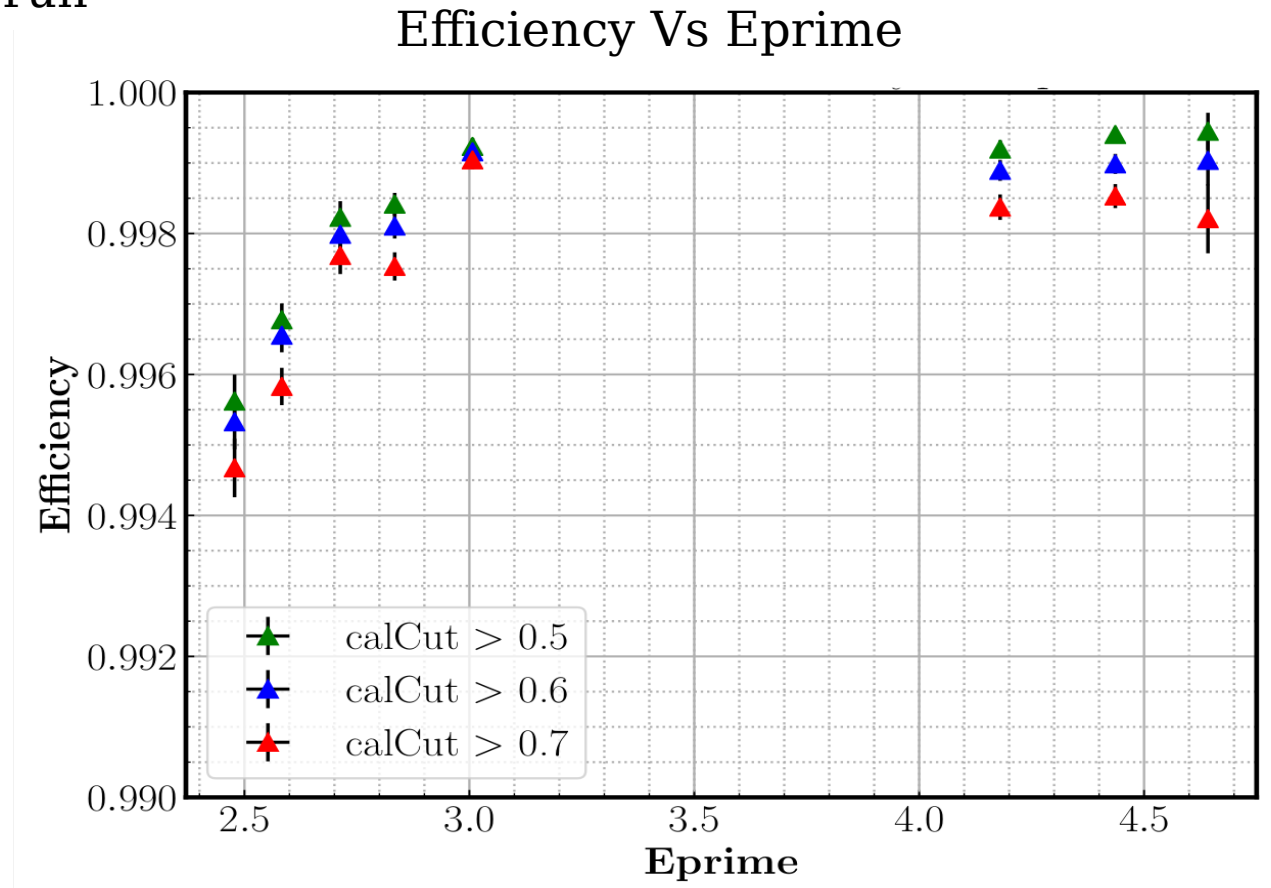
Efficiency = did/should

Should cut = -10< delta < 22 &&
ngc > 10 &&
0.9 < W2 < 1.1 &&
0.8 < beta< 1.2 &&
ntrack ==1 &&
oktrack ==1 &&
dipoleExit==1 &&
¾ and stof

Did cut = Should && cal> 0.7



From elastic run

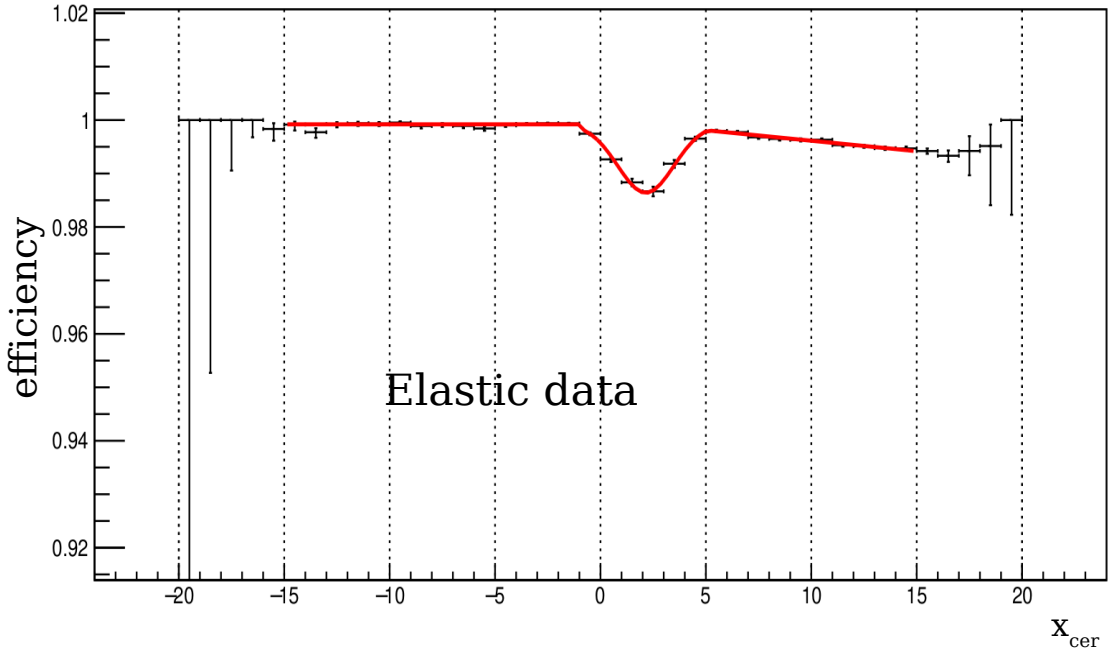


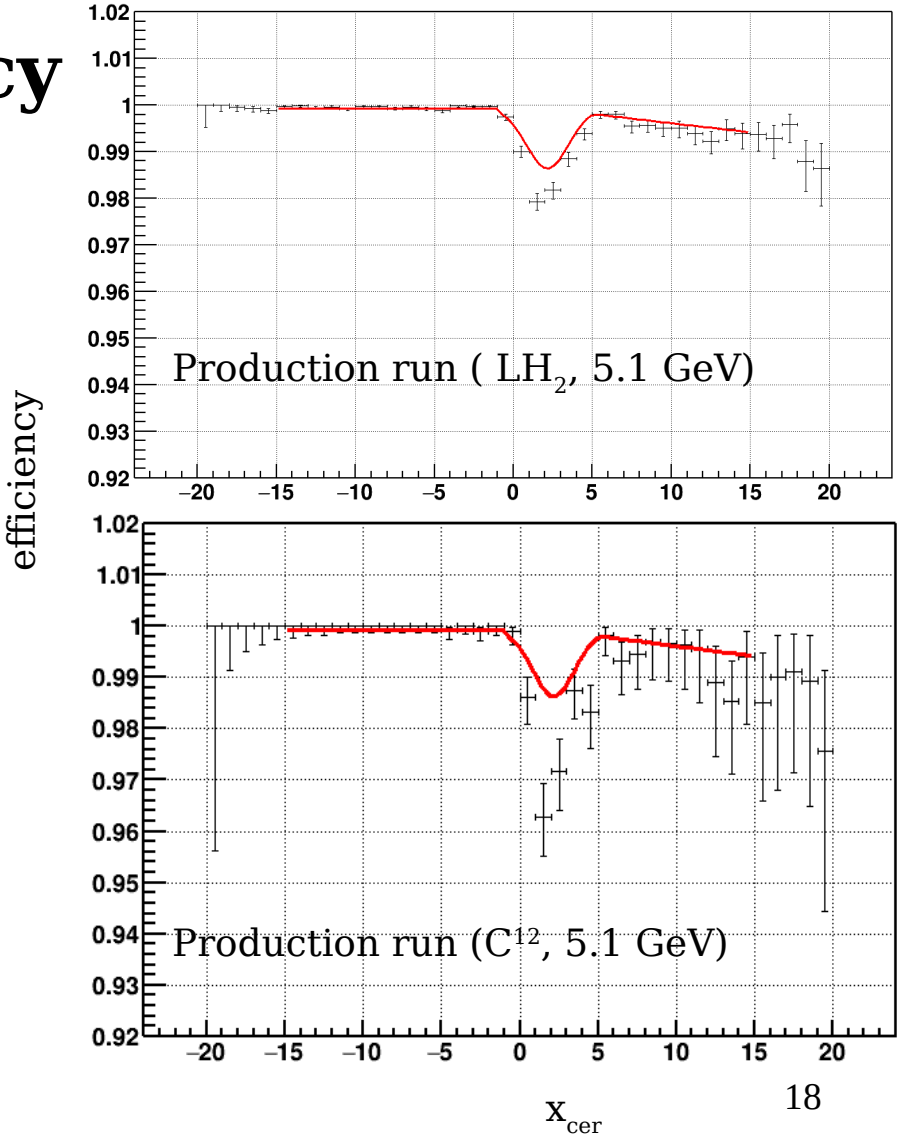
SHMS NGCER Cut Efficiency

1. Definition:

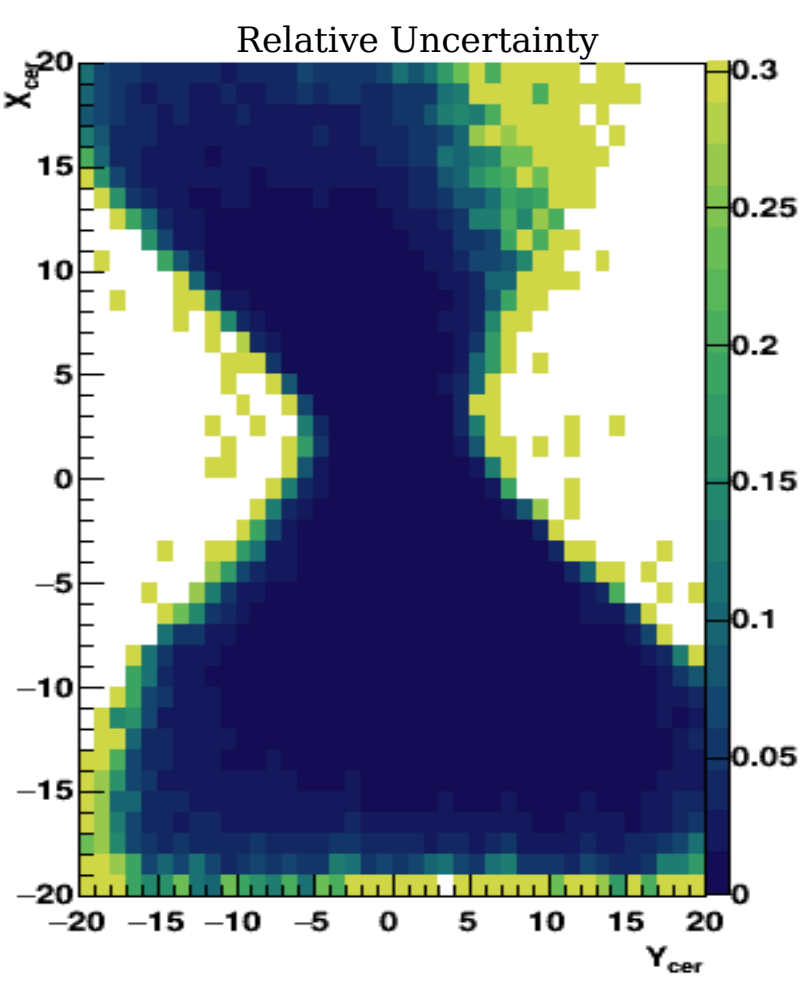
$$\text{eff} = \frac{\text{npe>2 \&\& clean sample of electron}}{\text{clean sample of electron}}$$

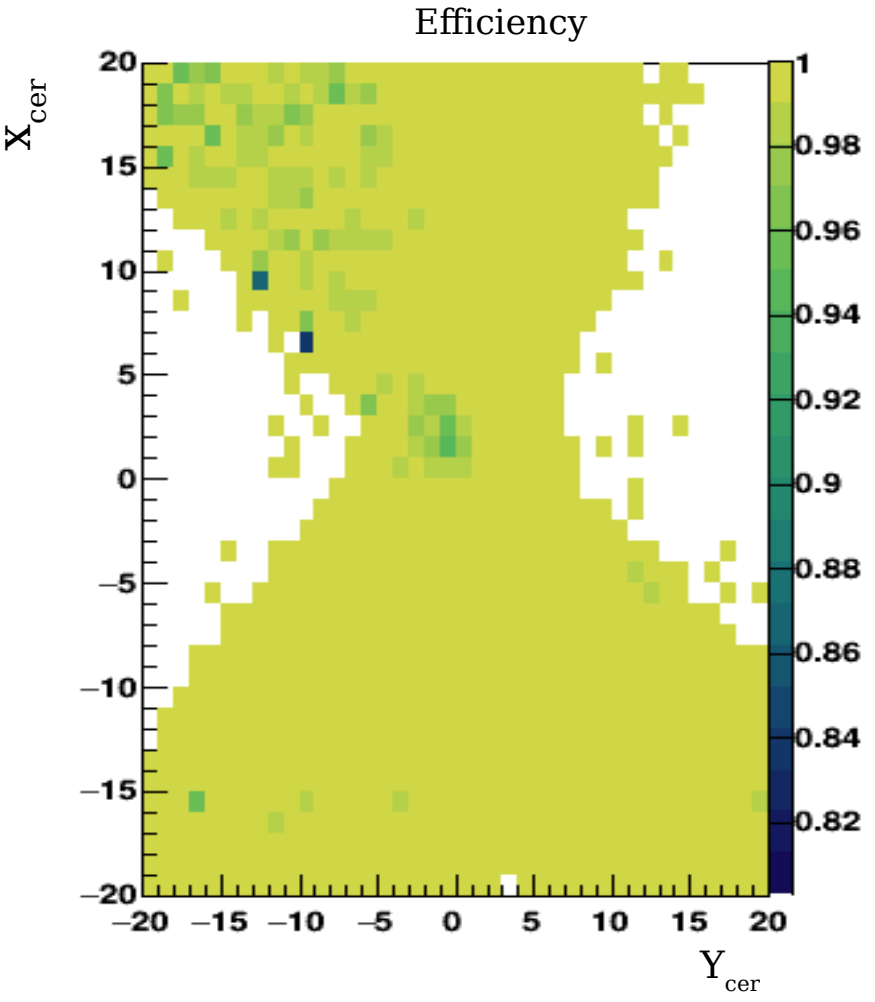
2. Using hydrogen elastic run (8.34 GeV).



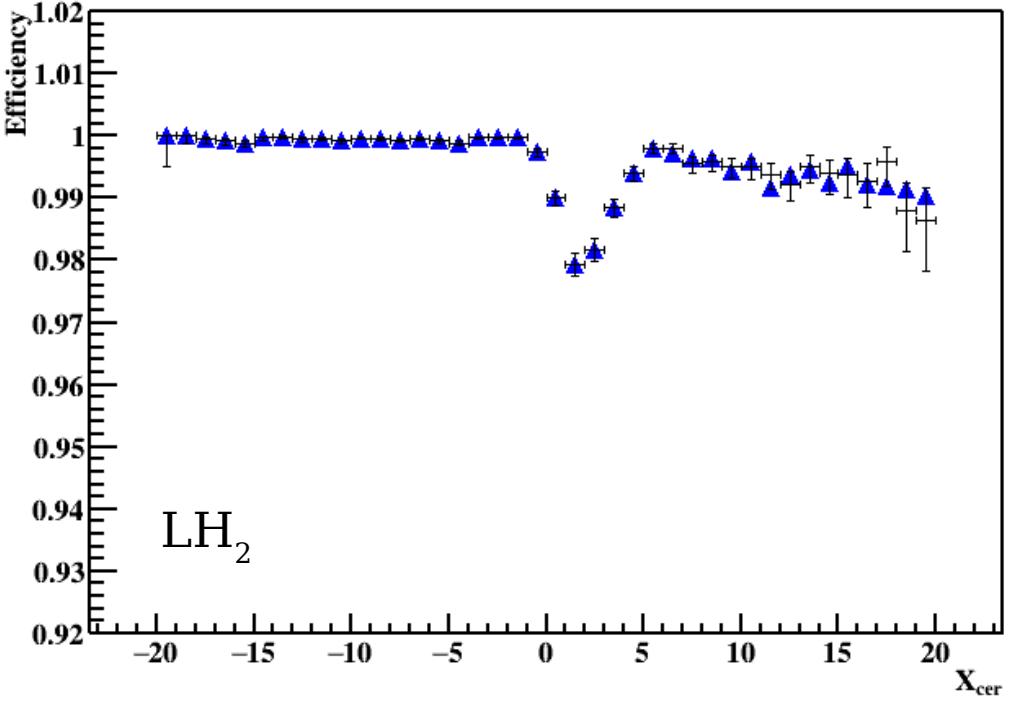


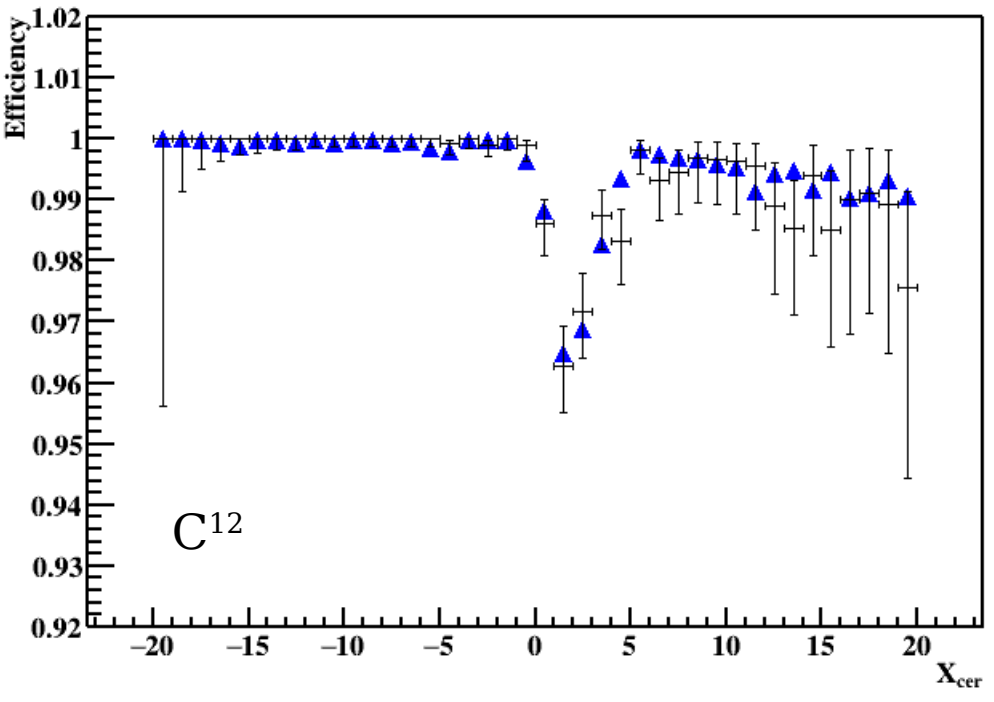
- Look up table generate from our production run (LH_2, 5.1 GeV at 21^0) binned in x and y.





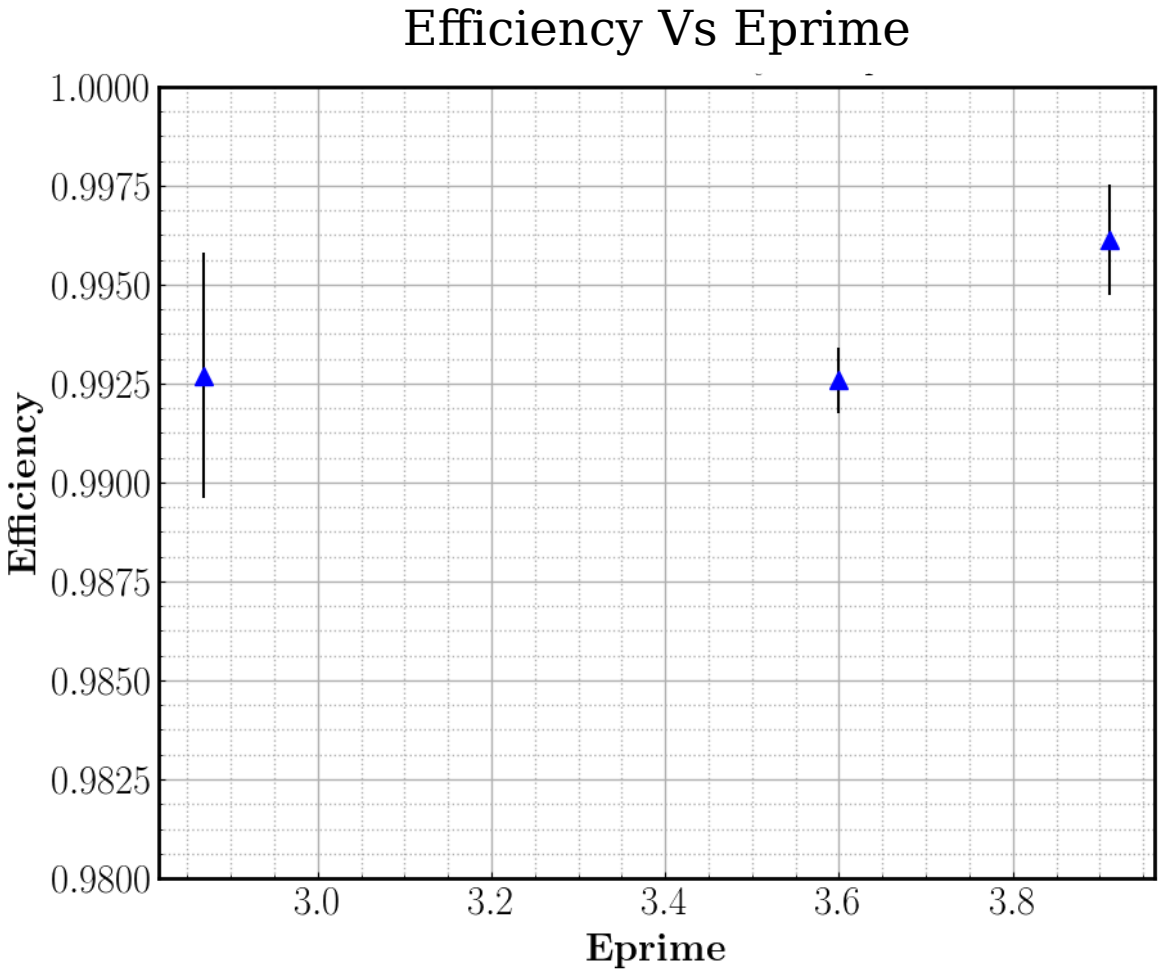
- Use this look up table for efficiency for our data set.





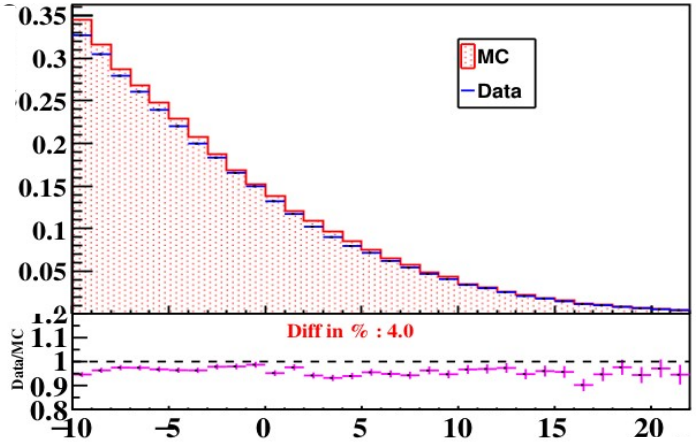
Note: Blue points are from look up table and black are data points.

- Plotted average efficiency across the momentum from elastic run
- Too small to claim momentum dependence

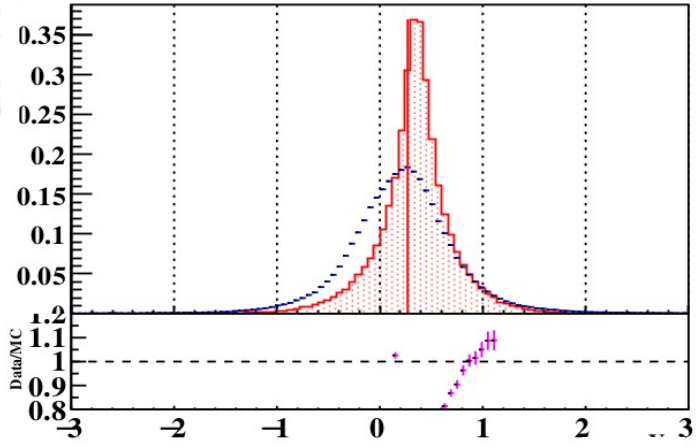


Data to Monte – Carlo Comparison

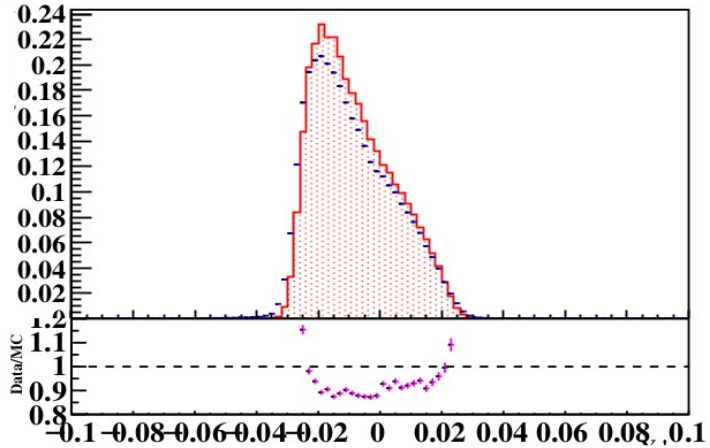
C^{12} at 5.1GeV, 21^0



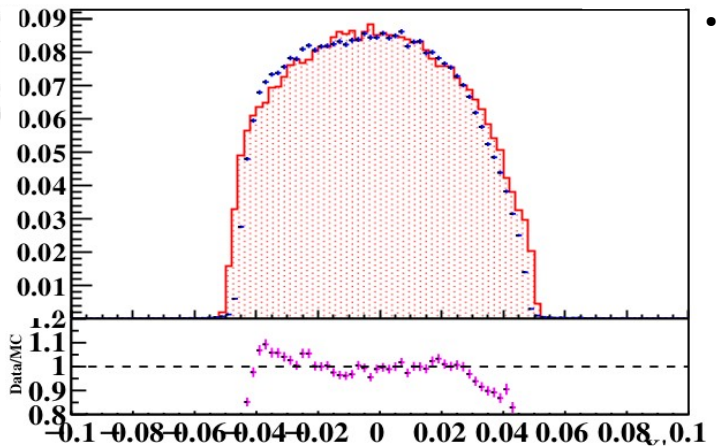
delta



Y_{tar}



Y'_{tar}

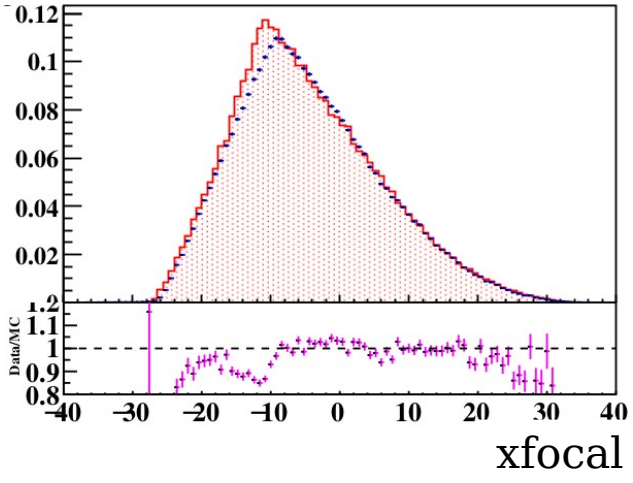


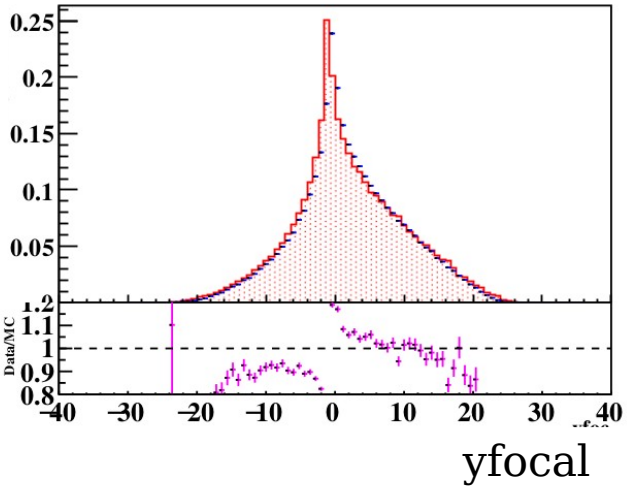
X'_{tar}

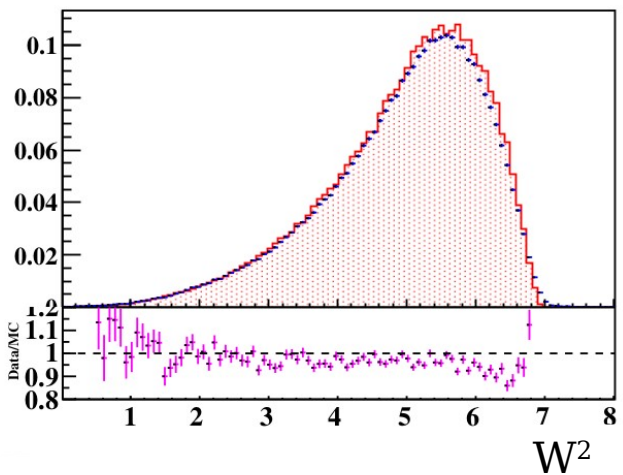
- Integral Difference between Data and Monte – Carlo ~ 5%
- Understanding on shape of Y_{tar} and Y^{p}_{tar}
- No Charge Symmetric background correction
- No Detector efficiency correction.

Data to Monte – Carlo Comparison

C^{12} at 5.1GeV, 21^0

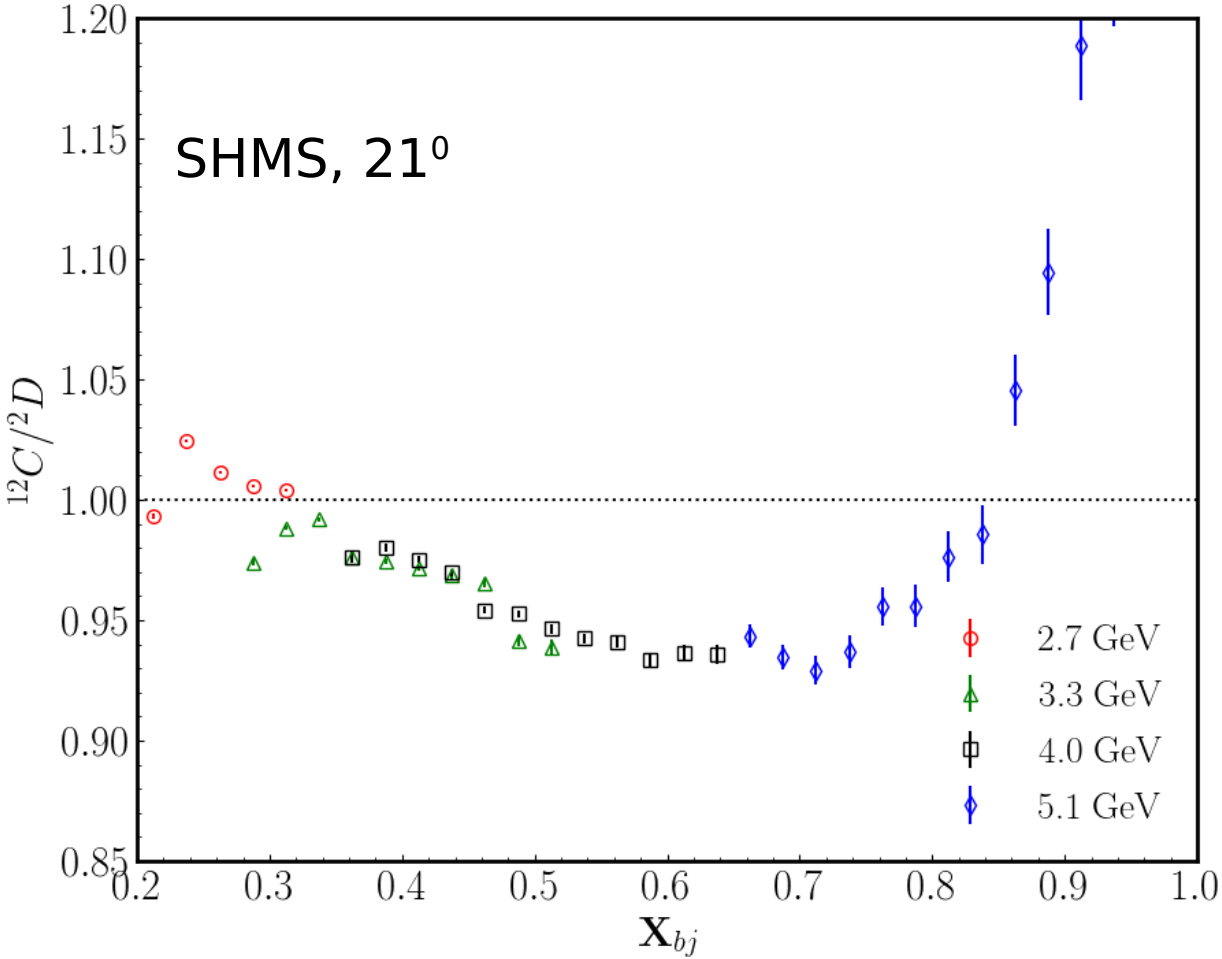






Preliminary Ratio of Charged Normalized Yield

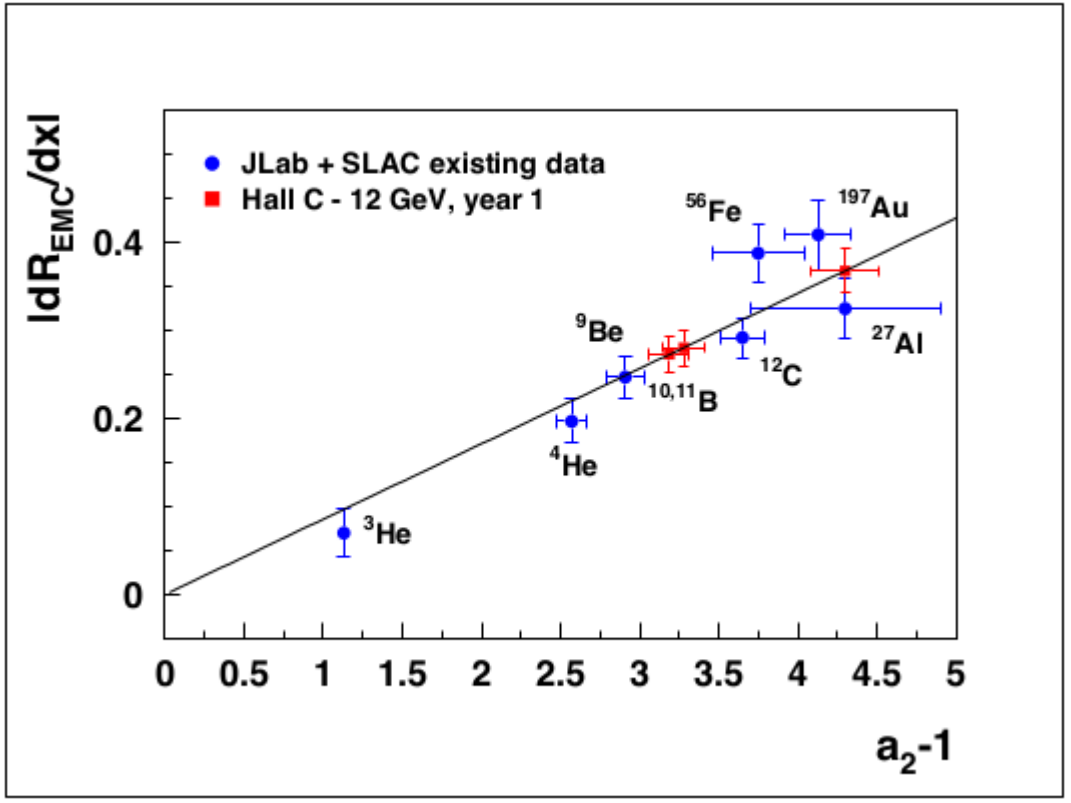
- Yields binned in x_{bj}
- Very raw ratio extraction
- Except for target thickness correction, no other corrections are applied
- Mis-match likely due to resolution, acceptance differences



E12-10-008: Projection

E12-10-008, in combination with X>1 will provide:

- EMC ratios for Be, ^{10}B, ^{11}B, C
- a2 ratios for same nuclei
- New information for EMC-SRC correlation

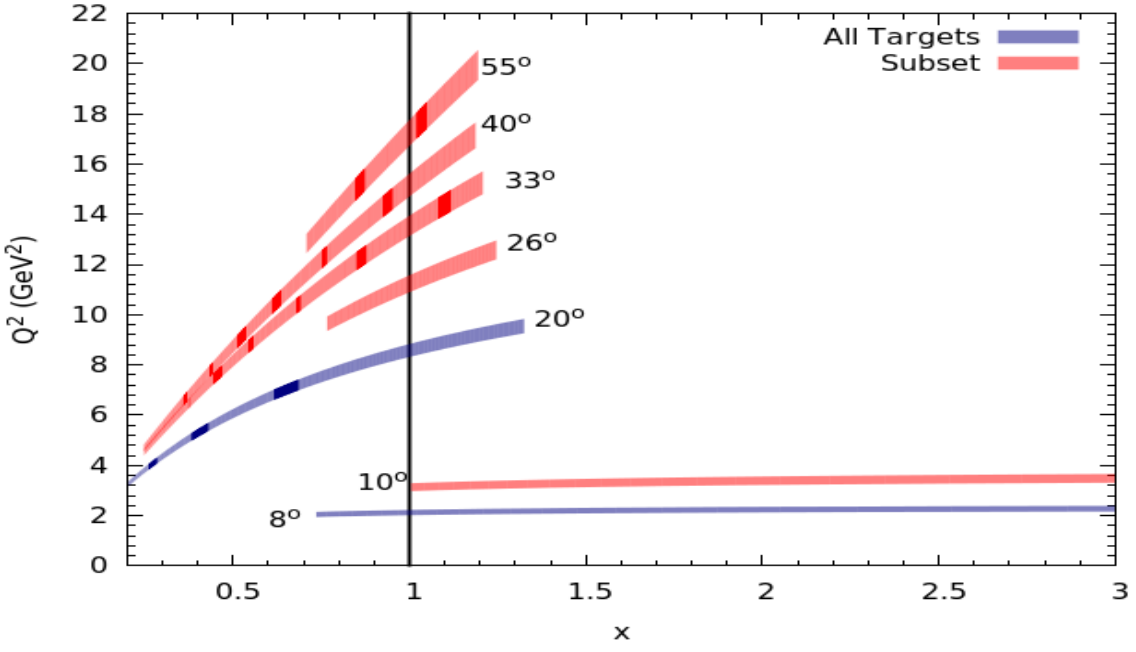


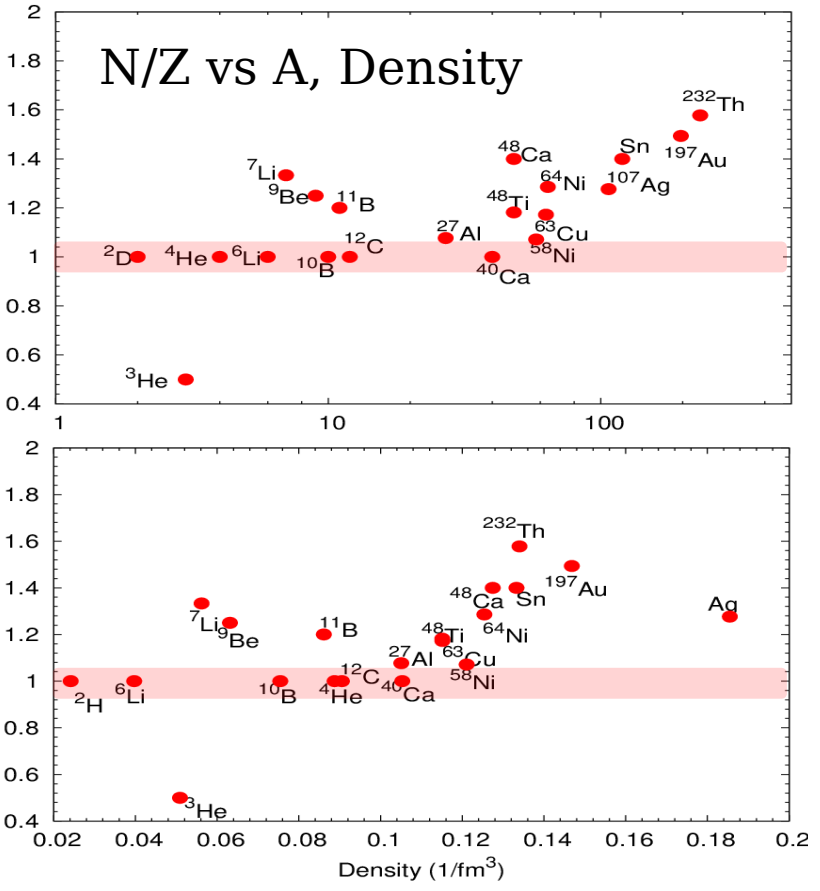
Courtesy plot from D. Gaskell

Detailed Studies of the nuclear dependence of F2 in light nuclei [E12-100-008: J. Arrington, A Daniel, N. Fomin, D. Gaskell]

Full Phase

Target Choice motivated by physics impact





Coming soon* in Hall C

Summary

- EMC effect demonstrates that quarks are modified in the nucleus
- E12-00-008 will provide a new data on several nuclei
- Provides first EMC measurements on ^{10}B and ^{11}B
- Only initial stages of ratio extraction

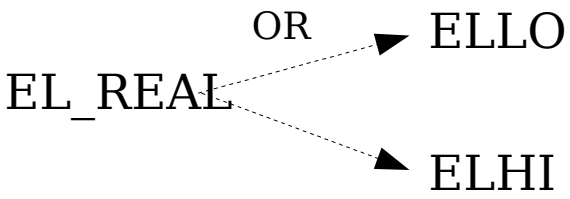
Thank you for your attention

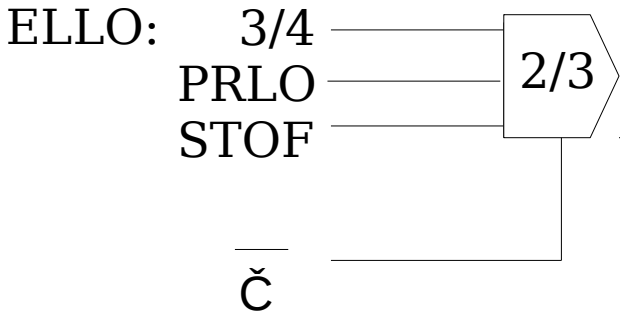
BACK UP SLIDE

Trigger Efficiency

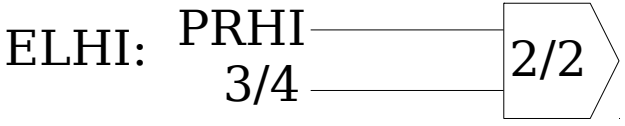
Here I am looking at relative trigger efficie

- All our data was taken with EL_REAL trigger





$$= \Sigma_c(\Sigma_{3/4}*\Sigma_{STOF}*\Sigma_{PRLO} + \Sigma_{3/4}*\Sigma_{STOF}*(1-\Sigma_{PRLO}) + \Sigma_{3/4}*(1-\Sigma_{STOF})*\Sigma_{PRLO} + (1-\Sigma_{3/4})*\Sigma_{STOF}*\Sigma_{PRLO})$$

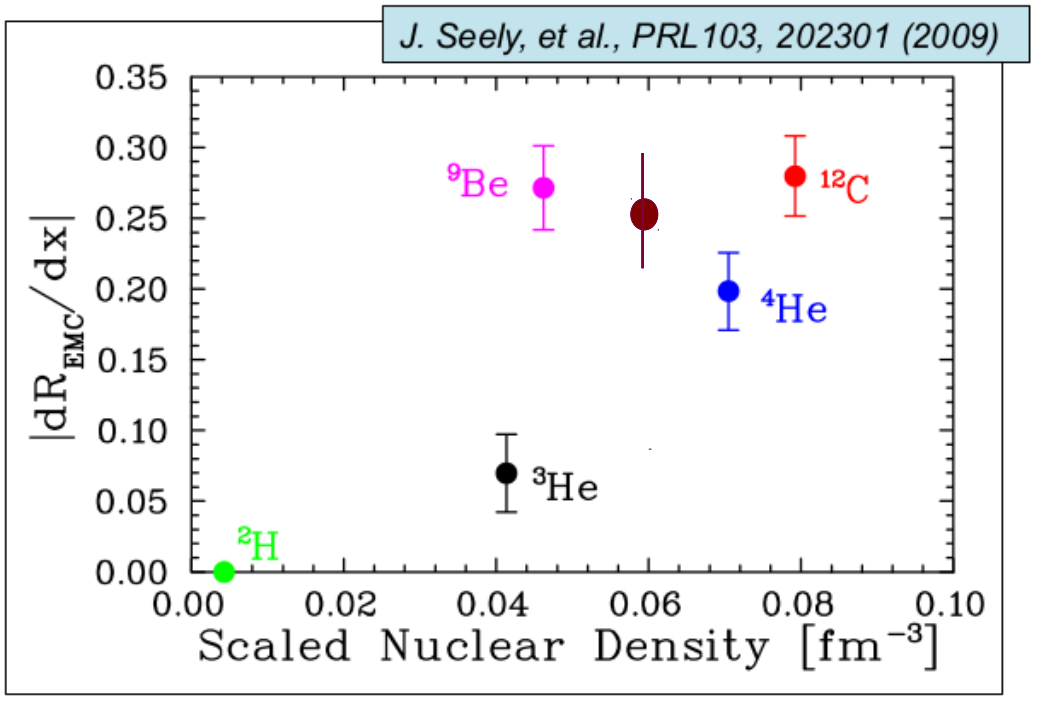


$$= \Sigma_{3/4} * \Sigma_{PRHI}$$

WHY EMC in new Nuclear Target ^{10,11}B ?

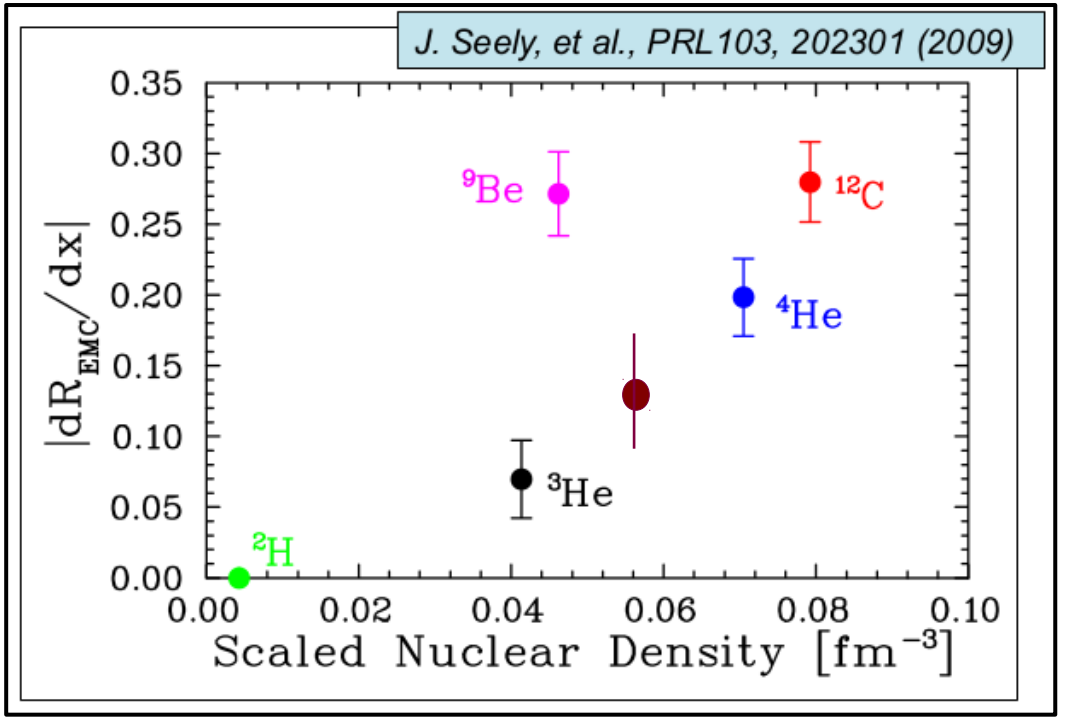
- **Strengthen the hypothesis that EMC Effect may be driven by local nuclear density**

Expected



WHY EMC in new Nuclear Target ^{10,11}B ?

Expected



- **Rule out the hypothesis that EMC effect is govern by Local density.**