

# Hall A & C Summer Collaboration Meeting

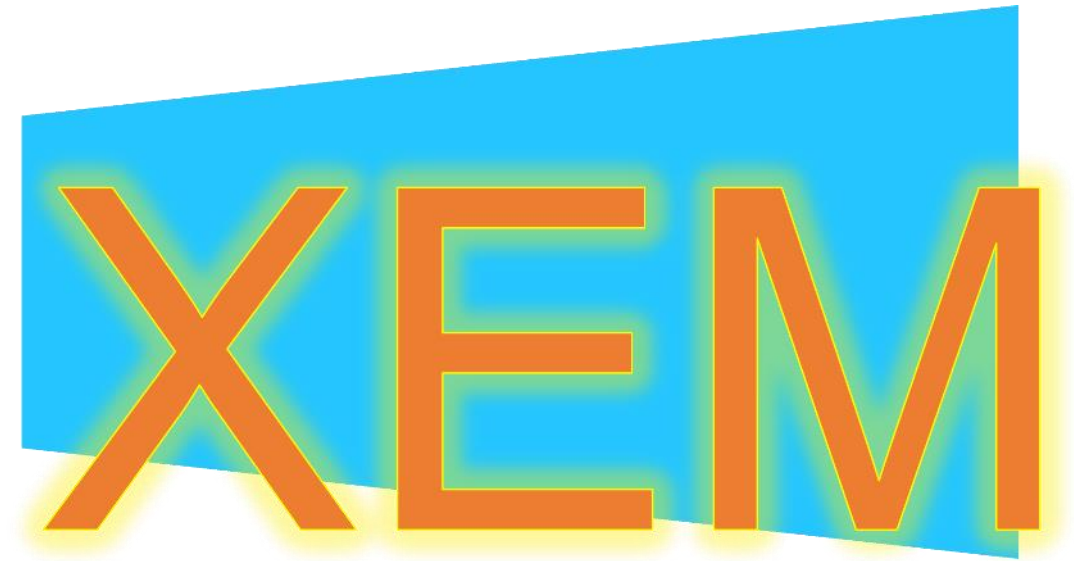
Next In Hall A & C

$x > 1$

EMC

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XEM

\*This work was supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under contract DE-SC0013615.

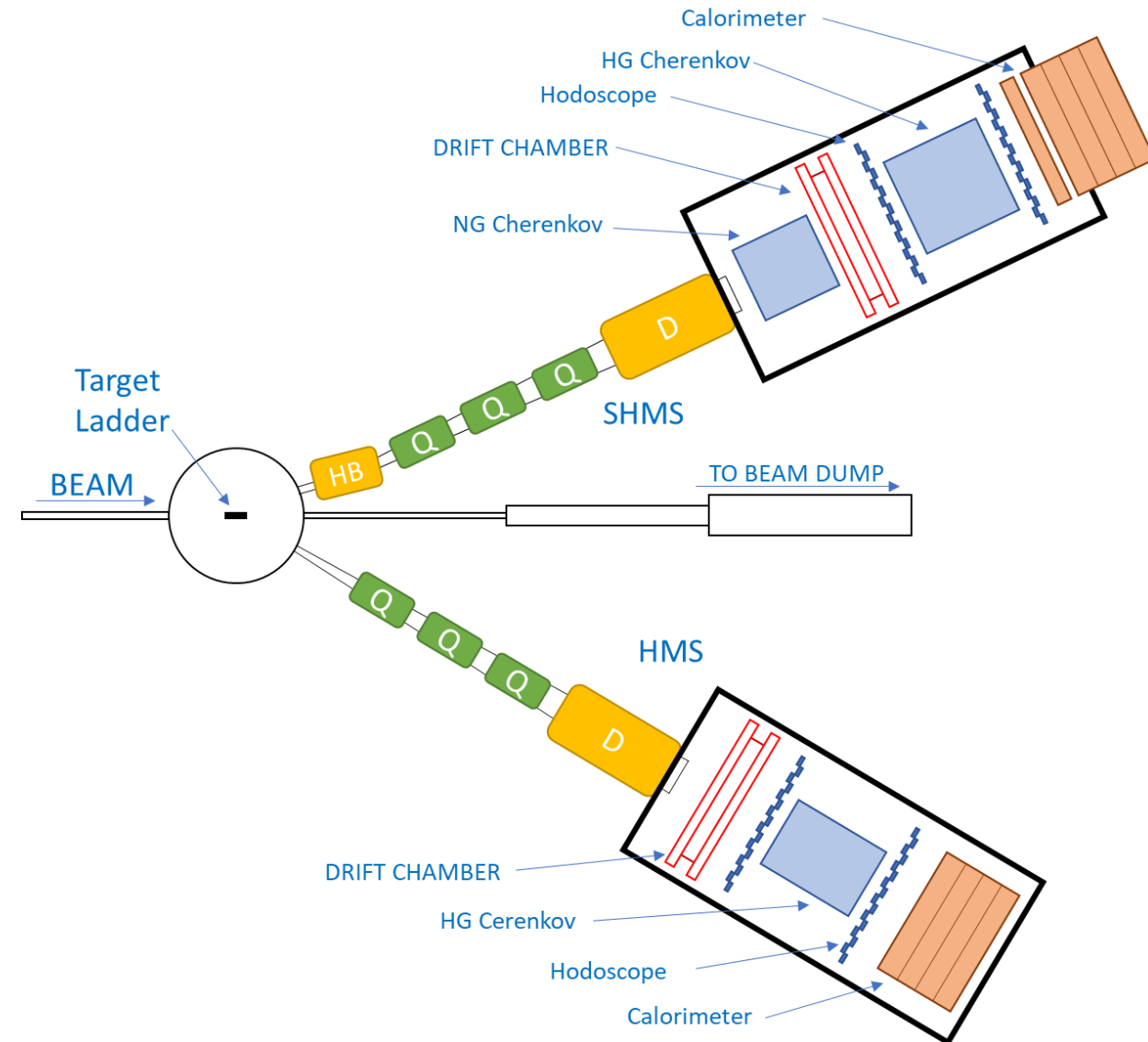
# Inclusive Scattering Experiments in Hall C

## E12-10-008 (EMC experiment)

- Detailed studies of the nuclear dependence of  $F_2$  in light nuclei
  - Precision measurement of EMC effect
  - Role of local nuclear environment on the modification of quark distributions
  - New  $H$ ,  ${}^2H$ ,  ${}^3He$  structure function measurements at high- $x$ , n/p ratio, iso-scalar corrections

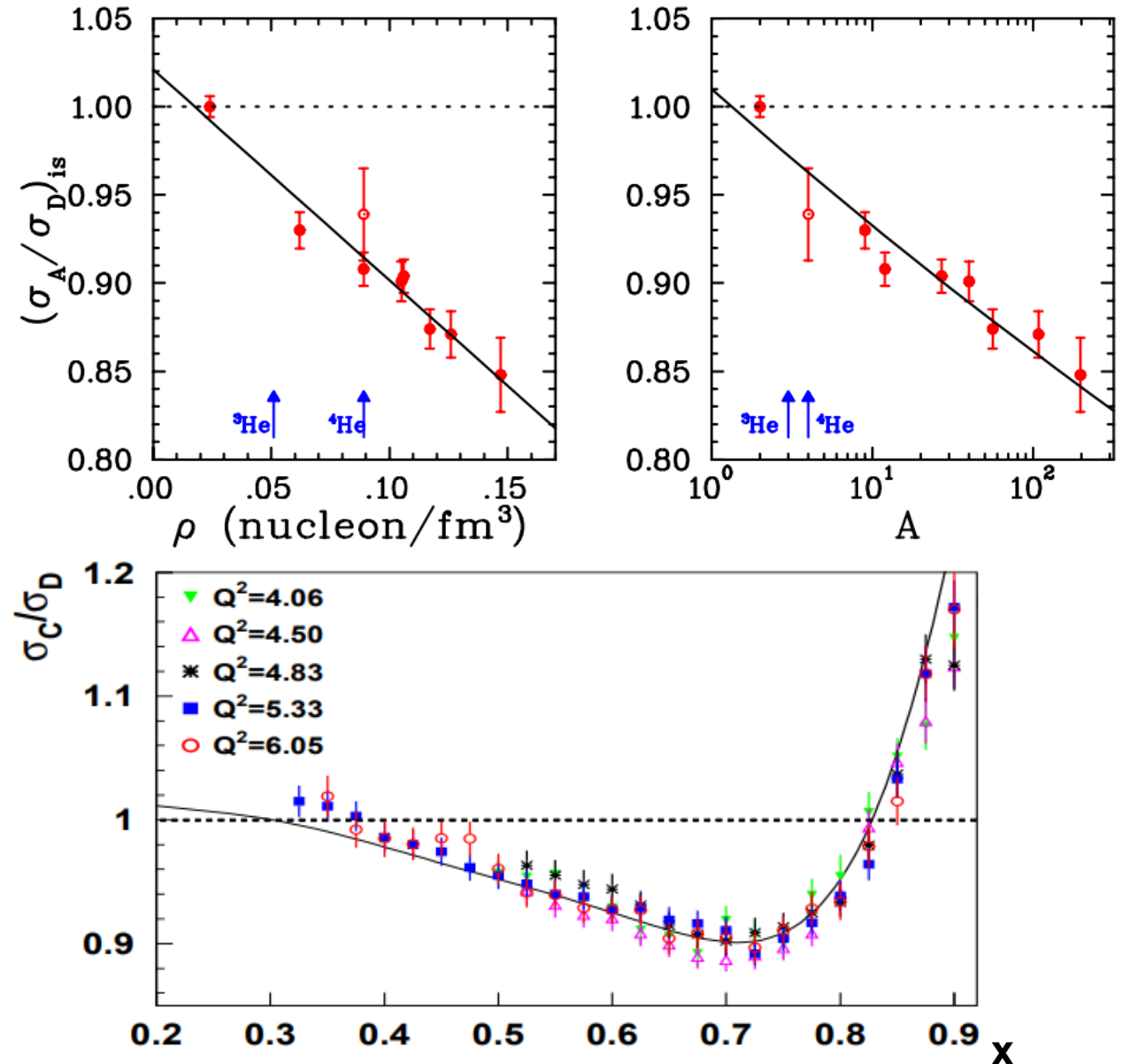
## E12-06-105 ( $x > 1$ experiment)

- Inclusive Scattering from Nuclei at  $x > 1$  in the quasielastic and deeply inelastic regimes
  - Precision 2N SRC measurements
  - First observation of 3N SRCs?
  - Super-fast quarks



# The Case for a 12GeV EMC effect Inclusive Measurement

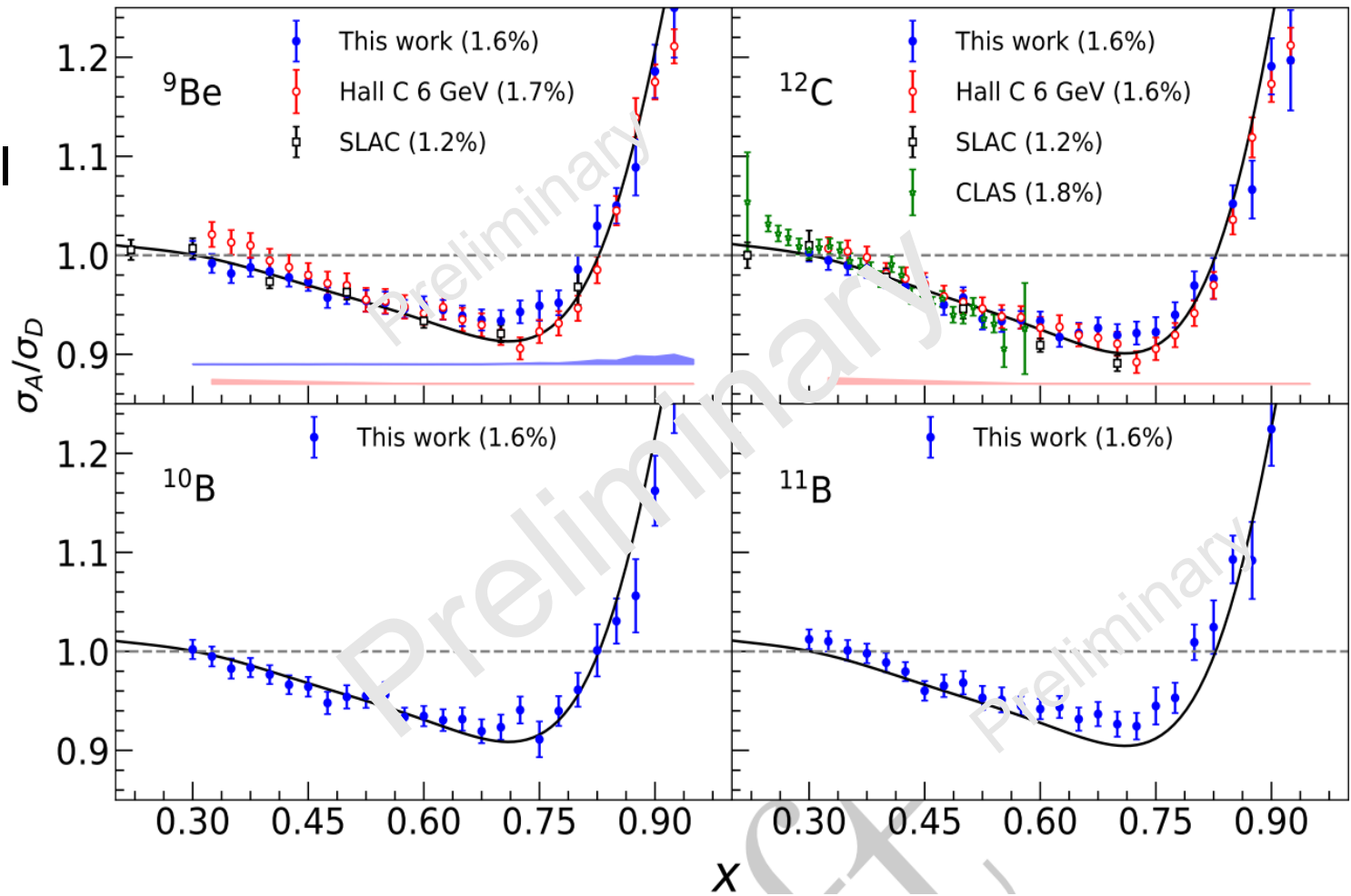
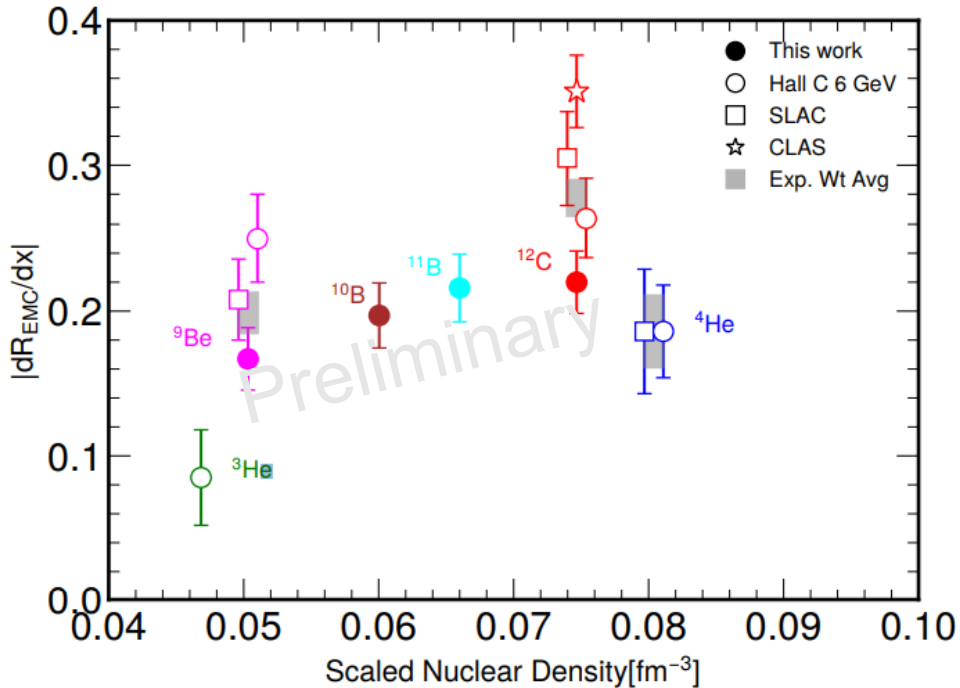
- Multiple approaches to obtain in-medium modification of quark distributions (EMC effect)
  - In-medium form factors measurements, polarized EMC effect, new theory predictions, Drell-Yan
- DIS measurements are clean in comparison to other techniques with a deep history of experiments
- Potentially multiple causes of nuclear dependence appear –Difficult to isolate
  - Conventional nuclear physics, quark-meson coupling, SRCs, (++)
- EMC effect at high- $x$  not well understood
  - $W^2 > 4 \text{ GeV}^2 (2 \text{ GeV}^2) \rightarrow \text{high} - Q^2$ 
    - PDFs drop rapidly!
    - Conventional NP effect all  $x$



# EMC Effect in Light Nuclei and MORE Nuclei

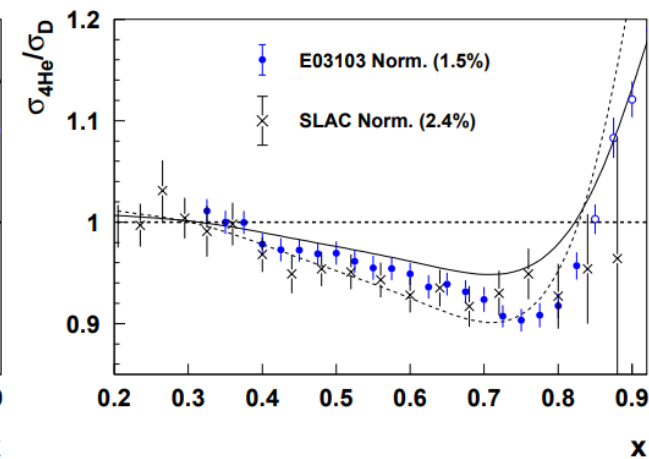
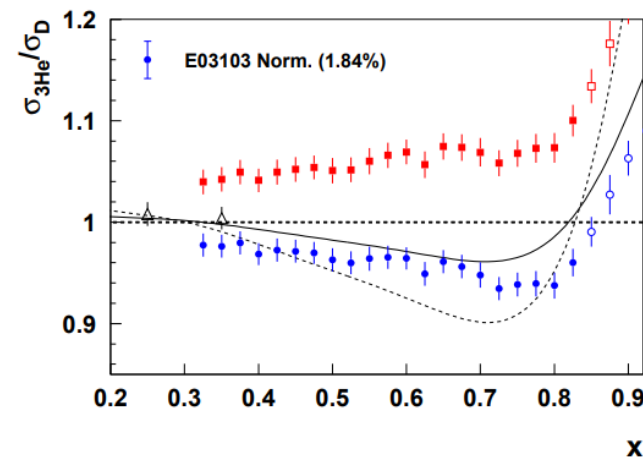
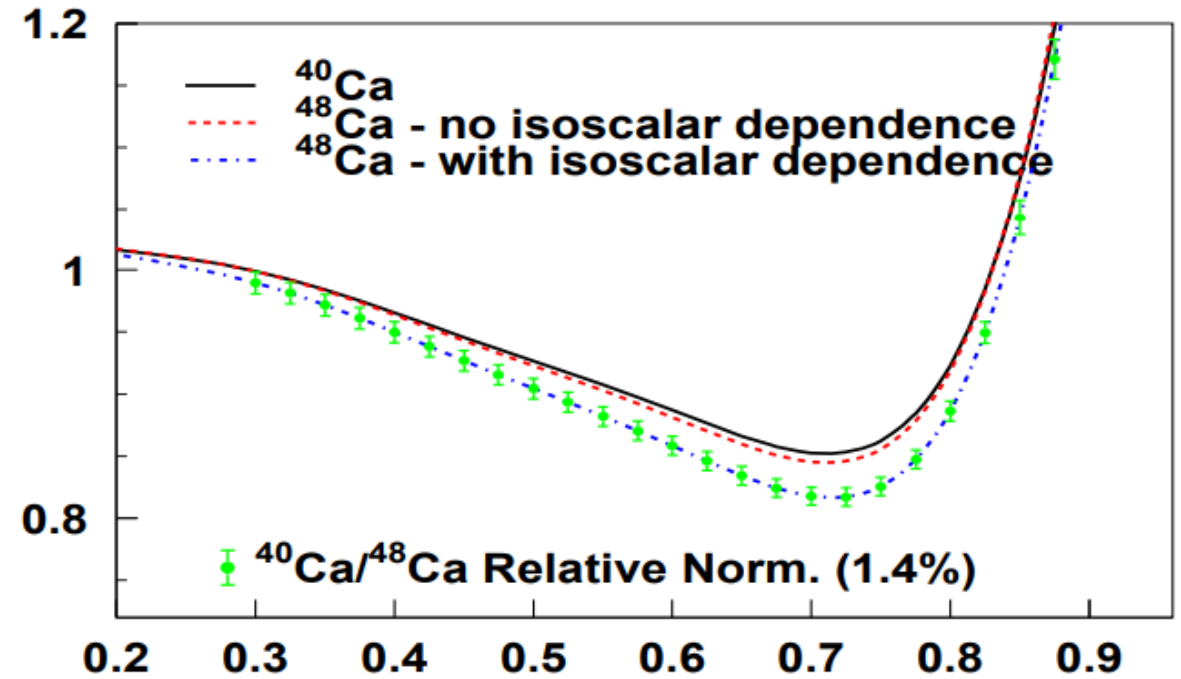
- A-dependence does not explain behavior of light nuclei
  - Nearby nucleons are most important (local density)
- Need more measurements on well understood nuclei (light nuclei)

See Abishek Karki's results from yesterday!



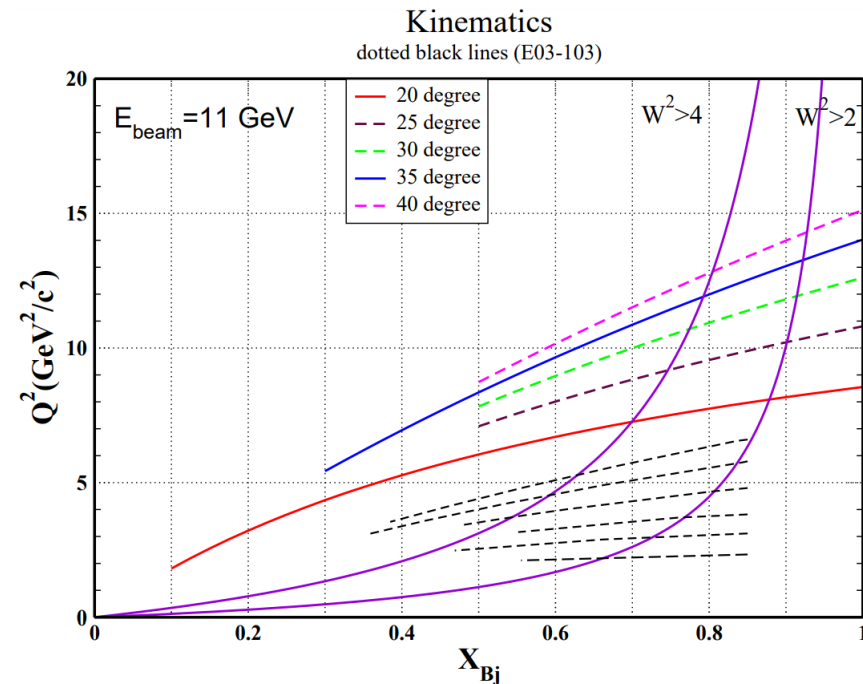
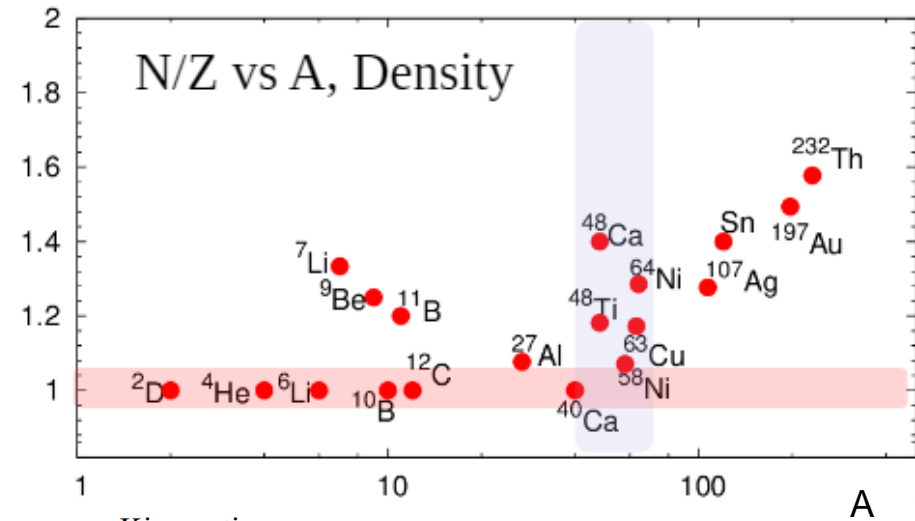
# E12-10-008 cont. Iso-Scalar Corrections, n/p Ratio, Neutron structure functions

- Iso-scalar corrections –  ${}^{56}_{26}\text{Fe}$  and  ${}^{56}_{28}\text{Ni}$ 
  - Use proton & neutron structure functions at those kinematics
  - $F_{2p}$  and  $F_{2n}$  contributions to nuclear structure functions instead of p and n structure functions
- Better iso-scalar corrections will reduce uncertainty e.g.  ${}^9\text{Be}$  and  ${}^3\text{He}$
- Minimize neutron structure function impact on  ${}^3\text{He}$  take ratio to  ${}^2\text{H} + \text{H}$ 
  - Resonance contributions lower @ 11GeV
- Calcium 40 and 48 to be used to measure n/p ratio in the nucleus (similar mass and density)
  - Flavor dependence (isospin-dependence)



# E12-10-008 Targets and Kinematics

- Iso-scalar corrections –  ${}^{56}_{26}\text{Fe}$  and  ${}^{56}_{28}\text{Ni}$ 
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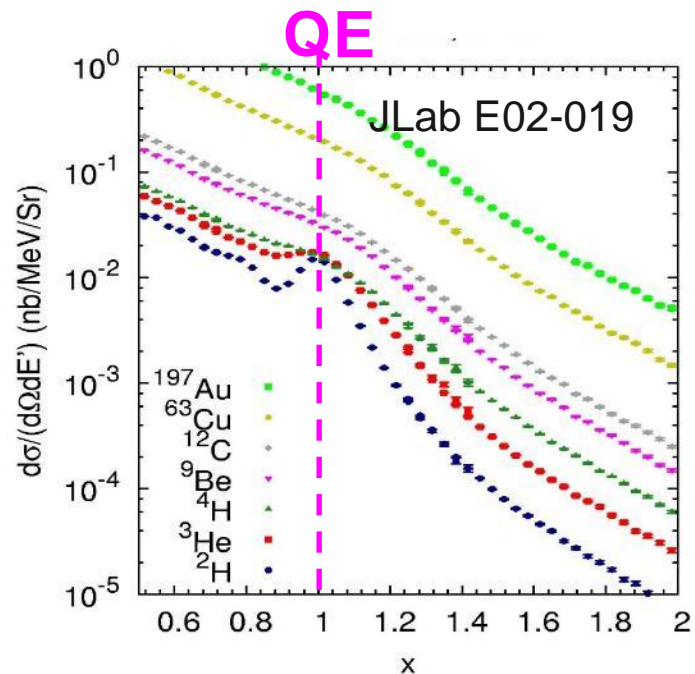
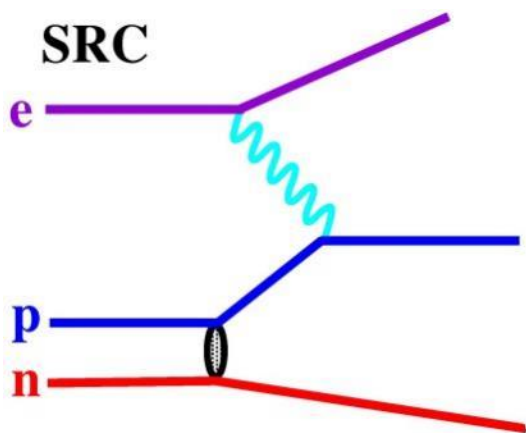


# E12-06-105 Physics Goals

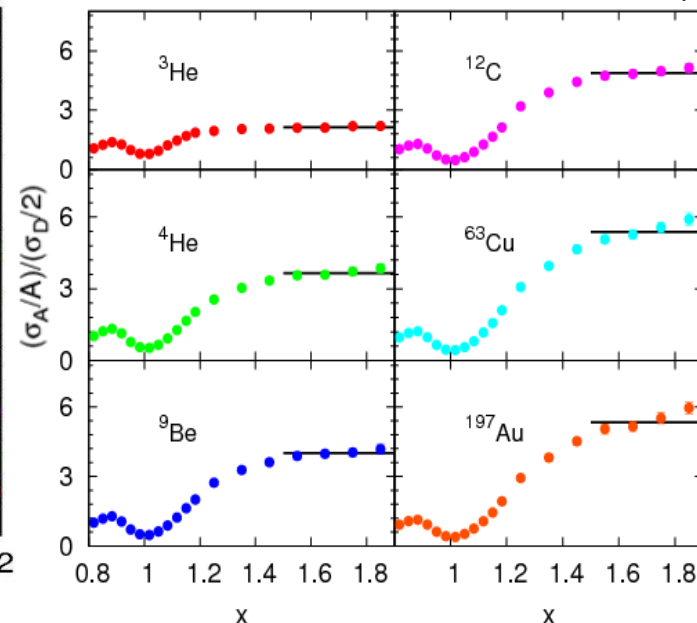
- Make precision measurements of 2N SRCs

- Nuclear dependence of  $a_2$
- Variation with neutron excess
- Connect the EMC effect and SRCs

- Aim to make first observations of 3N SRCs
- Look for superfast quarks  
Nuclear PDFs at  $x > 1$



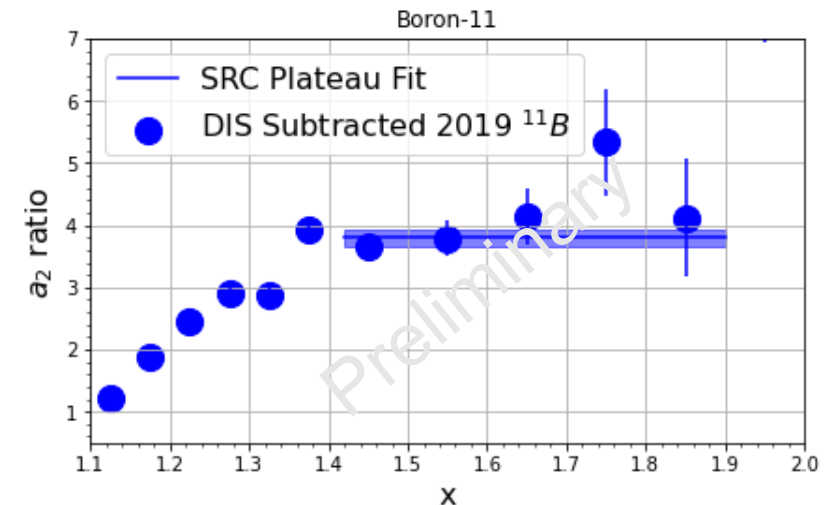
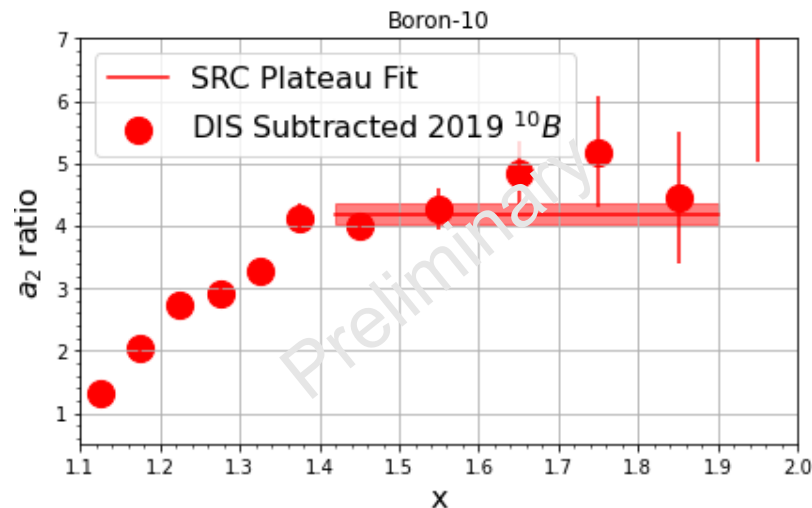
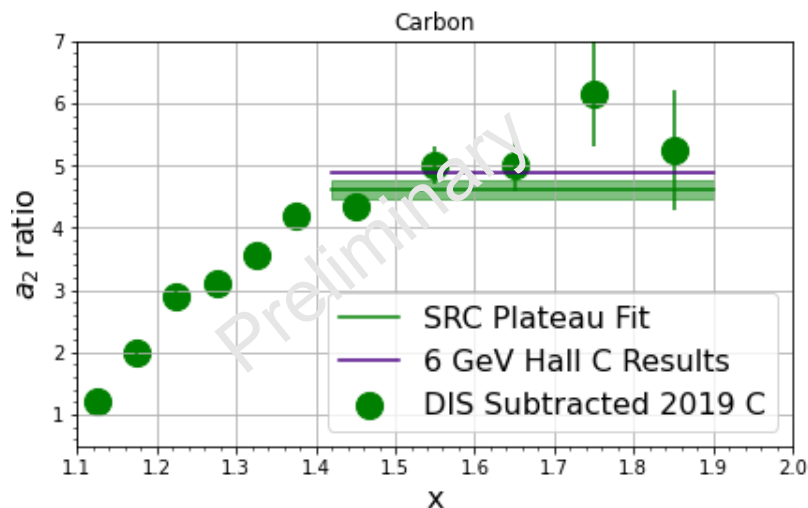
N Fomin et al. PRL **105**, 212502 (2010)



# E12-06-105: Preliminary Results (2019)

- Cross-section ratios extracted opportunistically during J/Psi running (HMS was down)
- 13 degrees because of larger beam pipe installed
- 2018 Commissioning results not shown due to challenges with optics and deadtime
  - In-depth optics check required for future 9.8GeV/c running
- Finalizing systematics and studies (where possible)

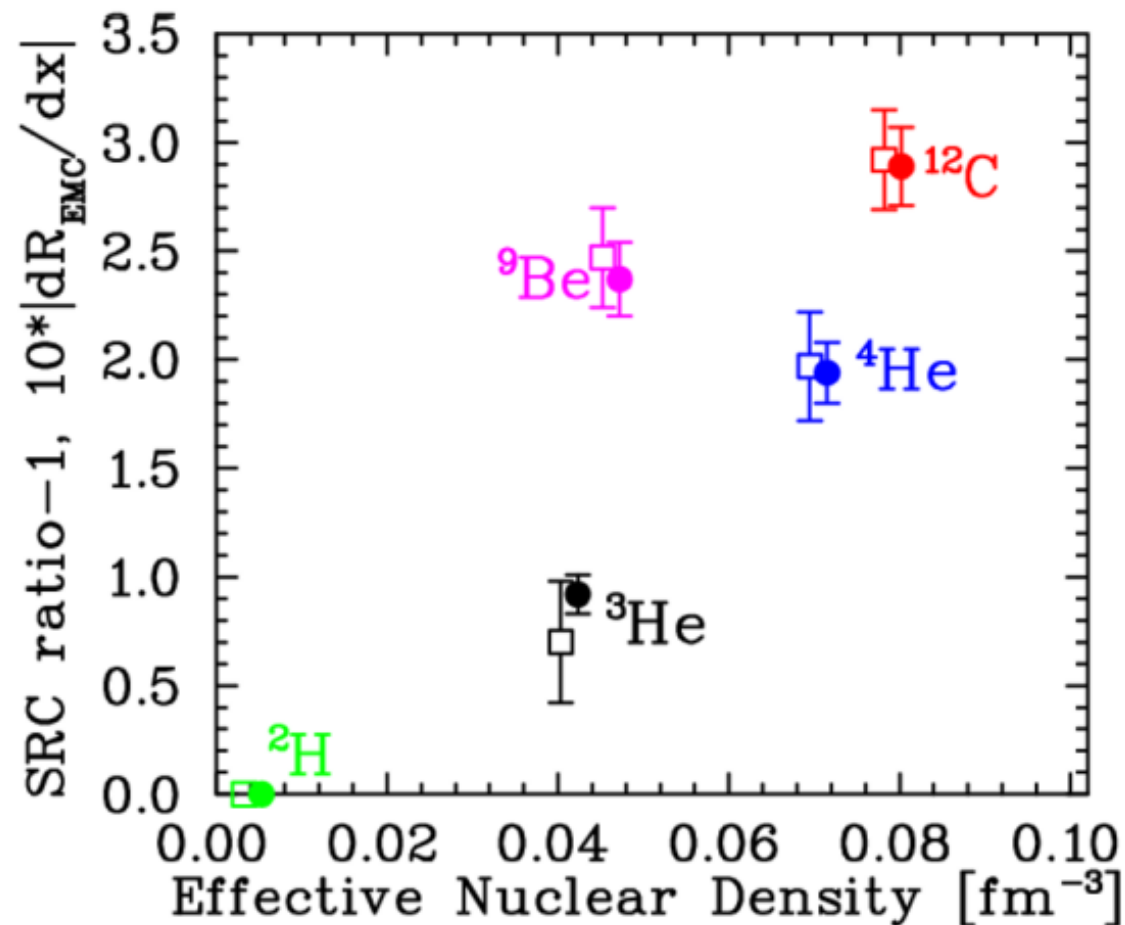
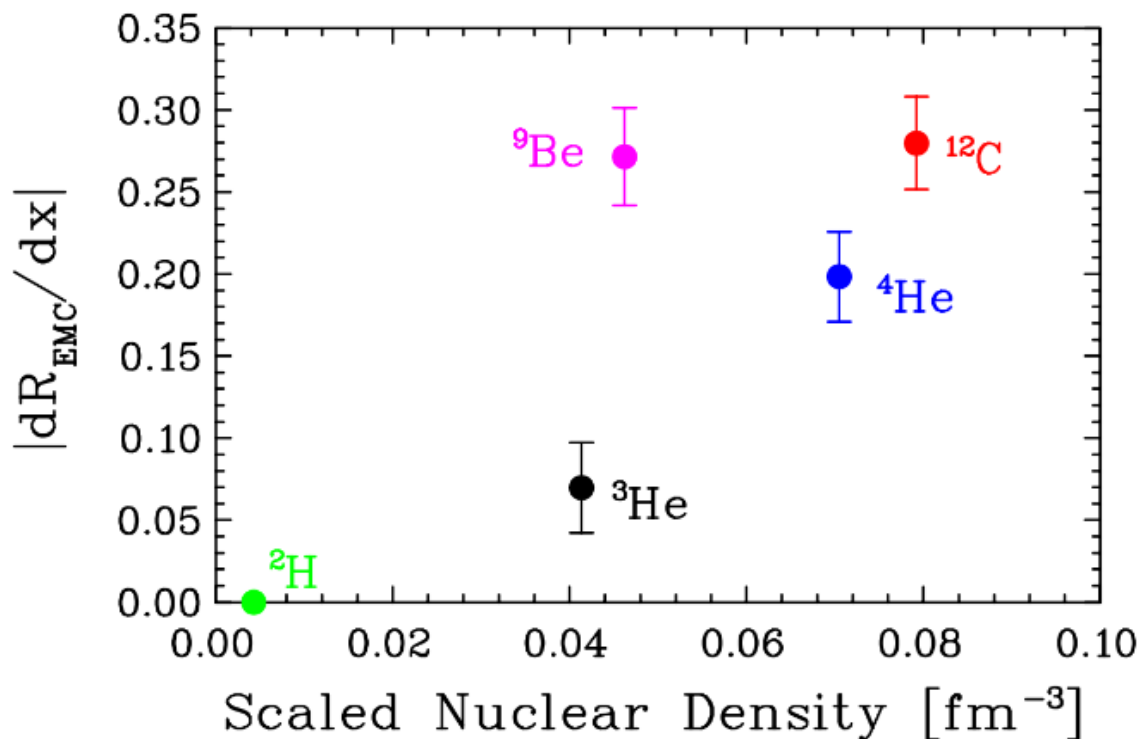
2019	
Central Momentum	9.8 GeV
Q <sup>2</sup>	4.46
Angle	13.10
Elements	H, D, C, Al, <sup>10</sup> B, <sup>11</sup> B





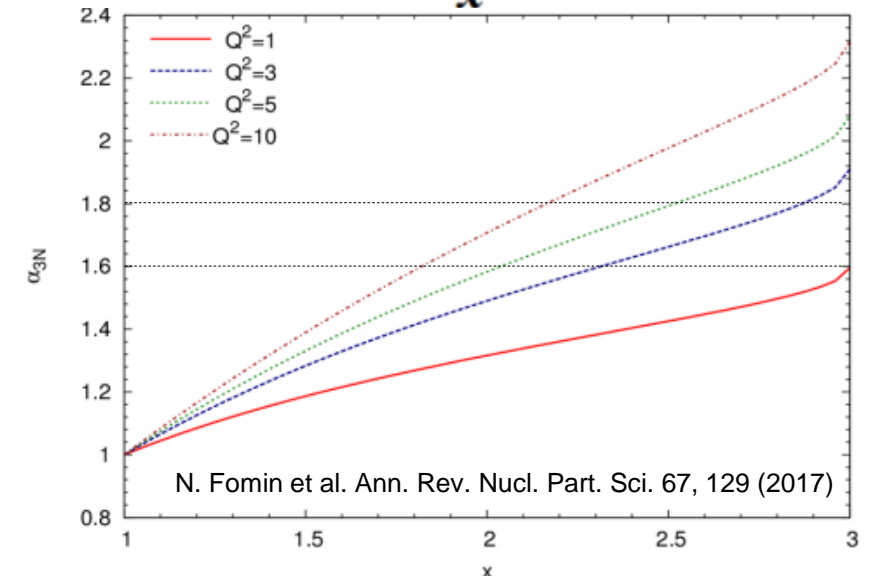
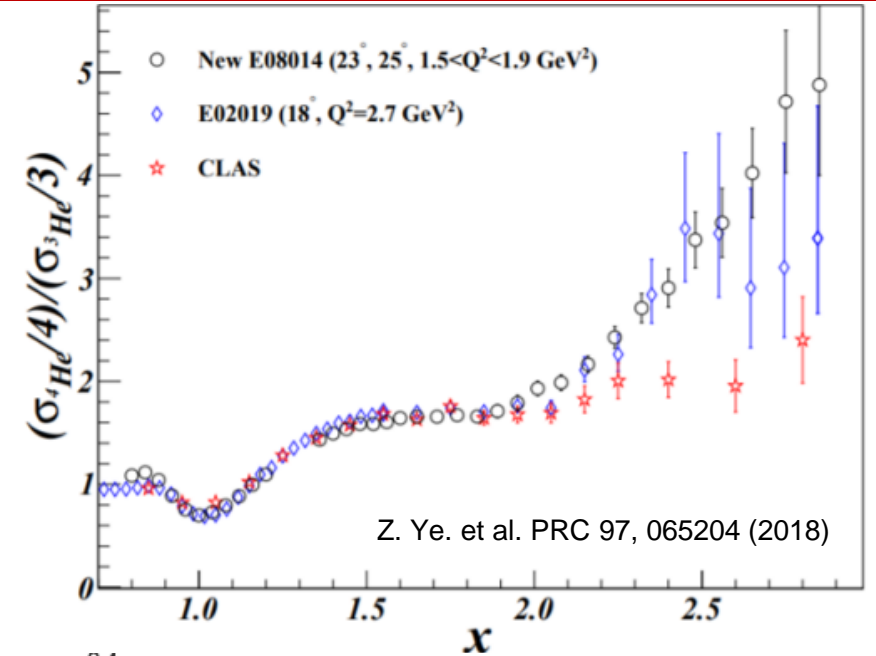
# Previous Hall C SRC Results

- 6 GeV experiment performed on:  
 $^2\text{H}$ ,  $^3\text{He}$ ,  $^4\text{He}$ ,  $^9\text{Be}$ ,  $^{12}\text{C}$ ,  $^{63}\text{Cu}$ ,  $^{197}\text{Au}$



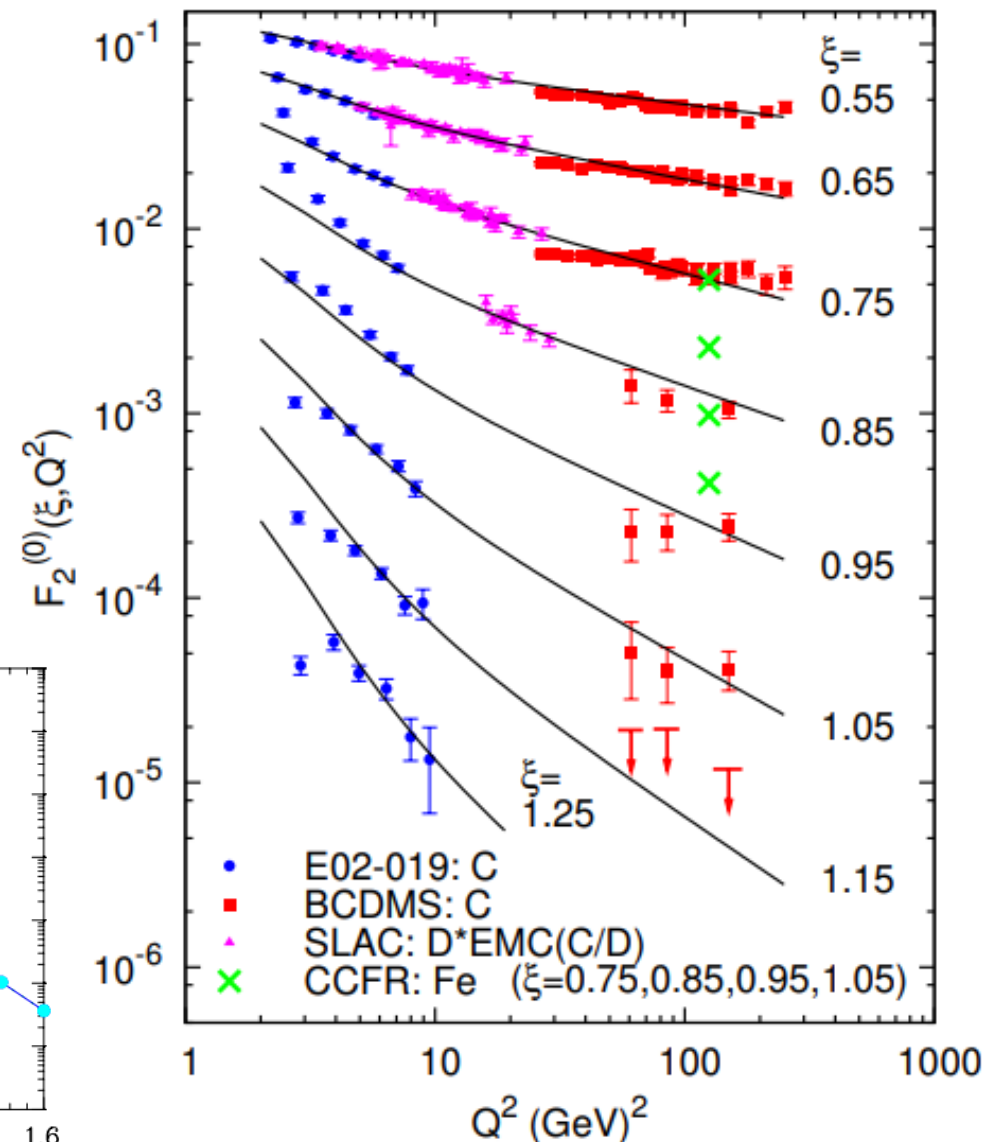
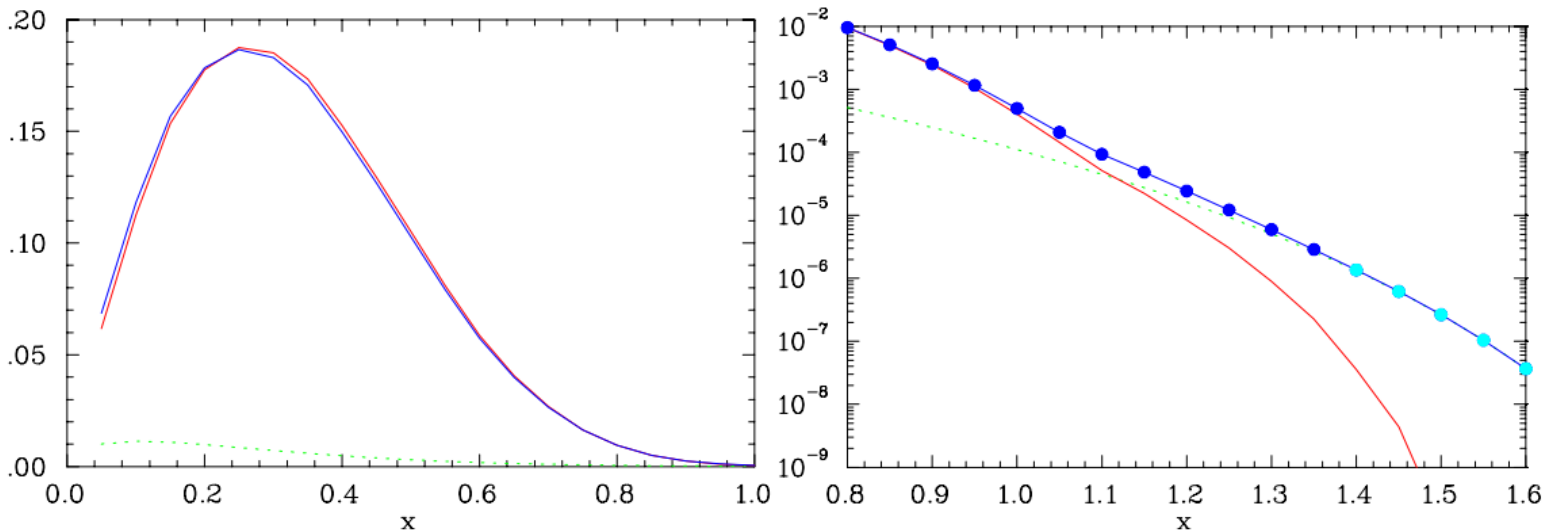
## E12-06-105: 3N SRCs at High $Q^2$

- $\alpha_{3N}$  allows for more precise determination of SRC onset
- Current work suggests 3N SRCs do not become dominant until higher  $Q^2$ 
  - $\alpha_{3N}$  of around 1.6-1.8;  $Q^2 > 3 \text{ GeV}^2$
- Proposed subset of nuclei reaches highest  $Q^2$  in the minimal amount of time



# E12-06-105: Superfast Quarks

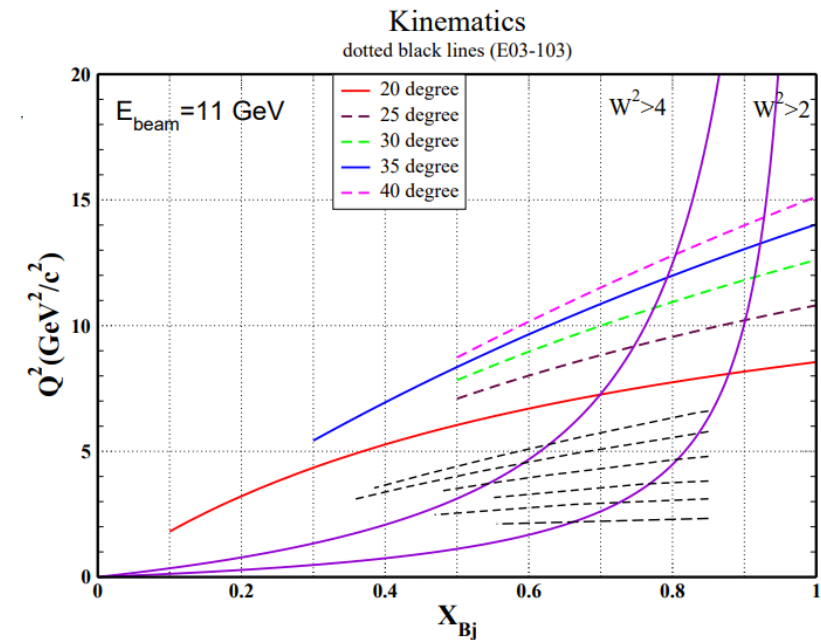
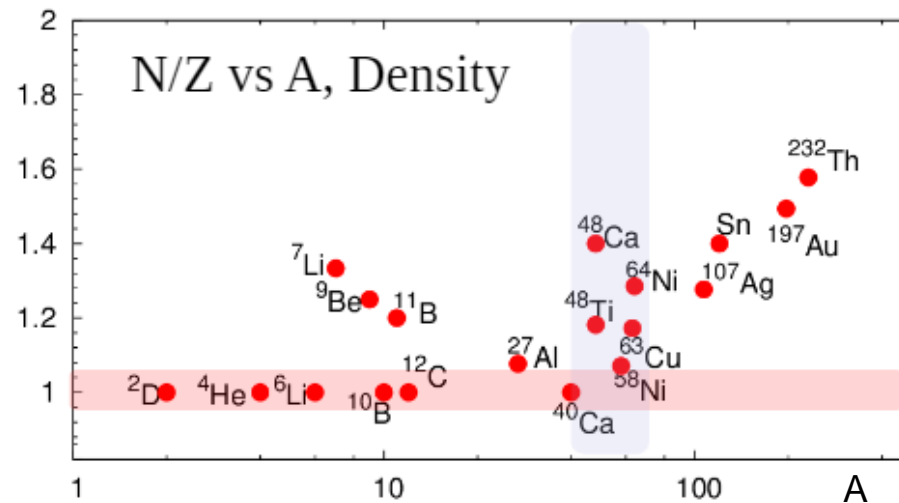
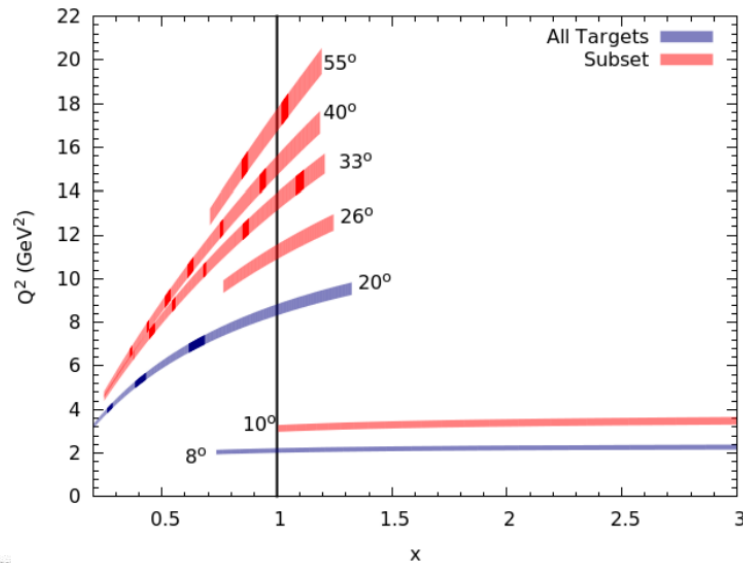
- Higher beam energy allows us to use deep inelastic scattering to probe PDFs at  $x > 1$ 
  - $Q^2$  in the 7-9  $\text{GeV}^2$  range
- Phenomenological fit to world data (black lines)
- First order target mass corrected structure function,  $F_2^{(0)}$
- JLab data E02-019 has a 'relatively high' DIS contribution event at 6 GeV



L. W. Whitlow et al. Phys. Lett. B282, 475 (1992)

# E12-10-008 & E12-06-105: Experiment Kinematics and Times

- Finalizing runtimes in the combined experiment using input from commissioning running (EMC / SRC)
  - Production Running
  - Positron Runs
  - Checkout / Calibration
  - Kinematic Changes
  - Target Chang-over
  - Boiling Studies
  - Hydrogen Elastics
  - BCM Calibrations
  - Radiative Corrections Check
  - Spectrometer Check

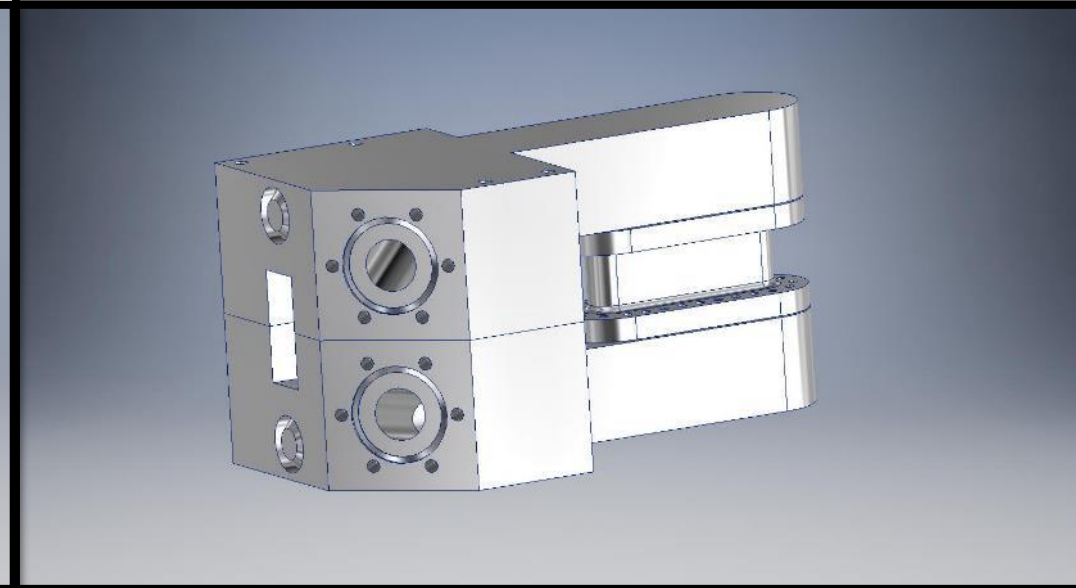
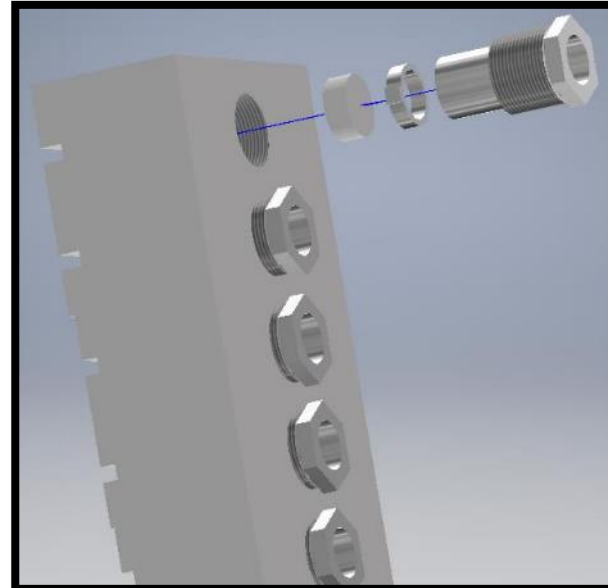
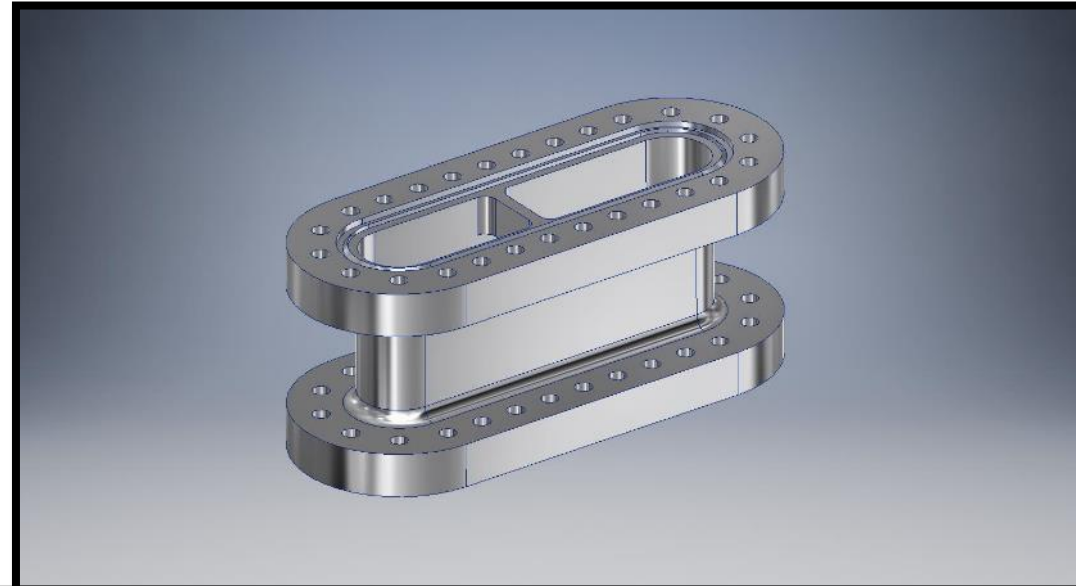


# New High-Pressure Target

- The target group is fabricating a never-before used target cell made to handle high pressure and cryogenic temperatures
- Engineering DWGs:  
-Dave Meekins

## First Solid Target Ladder

Target	Z	A	Req Thick	Thick (g/cm <sup>2</sup> )
Beryllium	4	9	978 mg/cm <sup>2</sup> (1.5% RL)	0.978
Calcium-40	20	40	800 mg/cm <sup>2</sup>	0.8
Calcium-48	20	48	800 mg/cm <sup>2</sup>	0.8
Carbon-12	6	12	524.4 mg.cm <sup>2</sup>	0.524
Boron-11	5	11	634.4 mg/cm <sup>2</sup> (B4C )	0.634
Boron-10	5	10	572.2 mg/cm <sup>2</sup> (B4C )	0.572
Tin-Nat	50	120	6% RL	0.529
Iron-54	26	54	415.2 mg/cm <sup>2</sup> (3% RL)	0.4152
Silver-Nat	47	108	6% RL	0.538
Thorium-232	90	232	6% RL	0.3642
Nickel-58	28	58	253.6 mg/cm <sup>2</sup> (2% RL)	0.2536
Nickel-64	28	64	253.6 mg/cm <sup>2</sup> (2% RL)	0.2536



# Summary & Outlook

- Rich physics program between experiments E12-06-105 and E12-10-008
  - 2N SRCs, EMC Effect, investigation of SRC-EMC correlation
  - Superfast quark distributions, high-x QCD moments, high-x nuclear structure function
  - Improved iso-scaler corrections, n/p ratio, flavor dependence of EMC effect
- Data taking for full experiment begins this August!
- Well equipped for the upcoming experiment
- Finalizing the order of our running
  
- We need you! Please, take shifts. There is a lot of physics coming out of these two experiments
  - Exploring shared shift taking requirements

# Post-Docs and Graduate Students



Cameron Cotton  
UVA



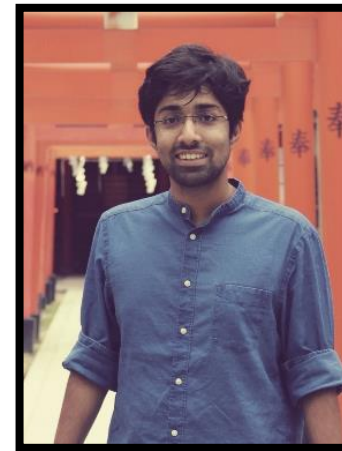
Ryan Goodman  
UTK



Abishek Karki  
MSU



Casey Morean  
UTK



Abhyuday Sharda  
UTK



Burcu Duran  
UTK



Tyler Hague  
LBL

## Spokespersons

Nadia Fomin, Dave Gaskell, John Arrington, Donal Day, Aji Daniel

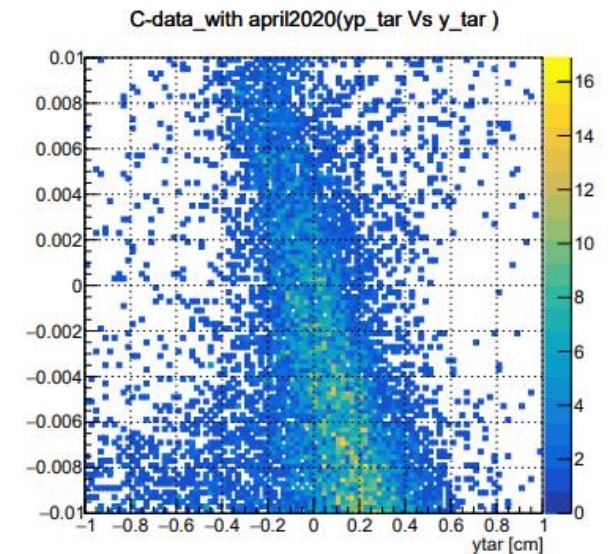
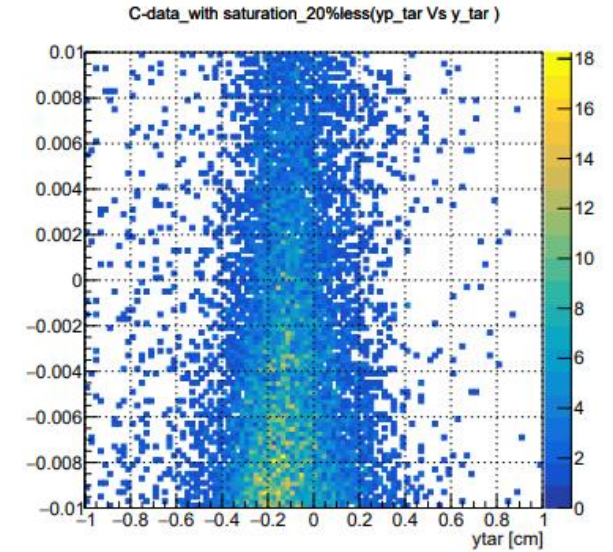
## Special Thanks

Bill Henry, Mark Jones, Dave Mack, Simona Malace, Eric Christy

# Questions?

# SHMS Optics

- Momentum saturation factor erroneously added to optics model based on field probe measurements
  - Early (e,e'p) experiment showed correlation between the spectrometer arms
- Mis-set optics model of Monte Carlo to replicate data
  - Use this information to correct the matrix elements in hcana
- Many small improvements over time
  - Not an issue for 2019 dataset



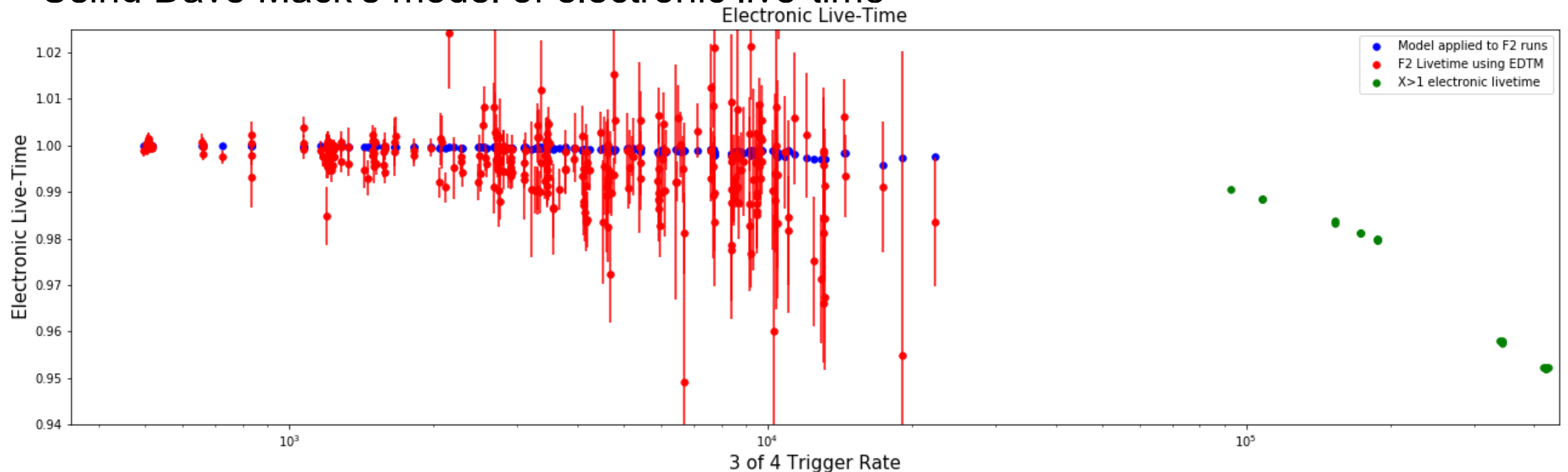
Plots courtesy of Aruni

Nadeeshani



# Electronic Dead-Time

- 100ns gates used during commissioning experiments
- STOF trigger leg removed in 2019
- Improper use of EDTM system for the higher rate running (Didn't account for ps)
  - Total live-times greater than 100%
- Using Dave Mack's model of electronic live-time



# Data Taken Spring 2018/2019

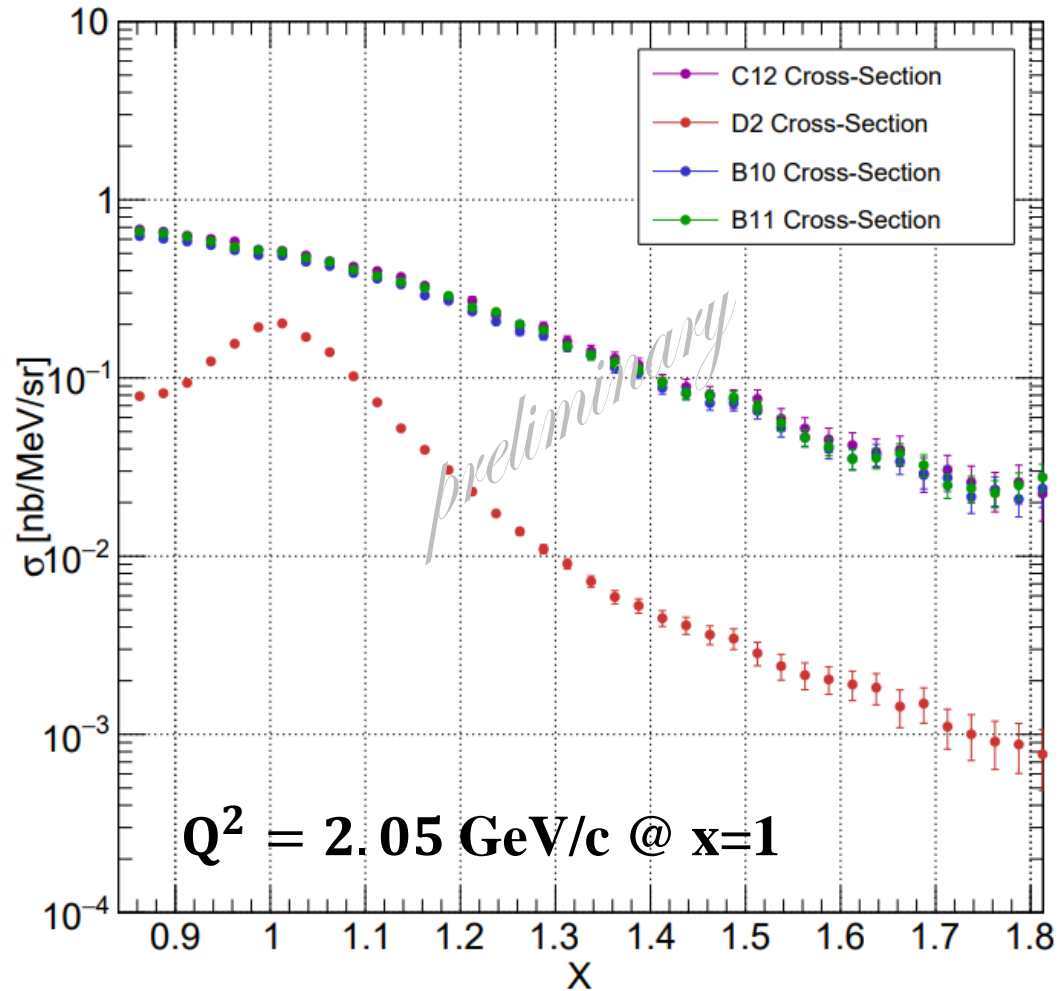
2018	
Central Momentum	9.8 GeV
$Q^2$	2.08
Angles	8.02
Elements	H, D, C, Al, $^9\text{Be}$ , $^{10}\text{B}$ , $^{11}\text{B}$

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

\*Boron targets are boron carbide  $B_4C$

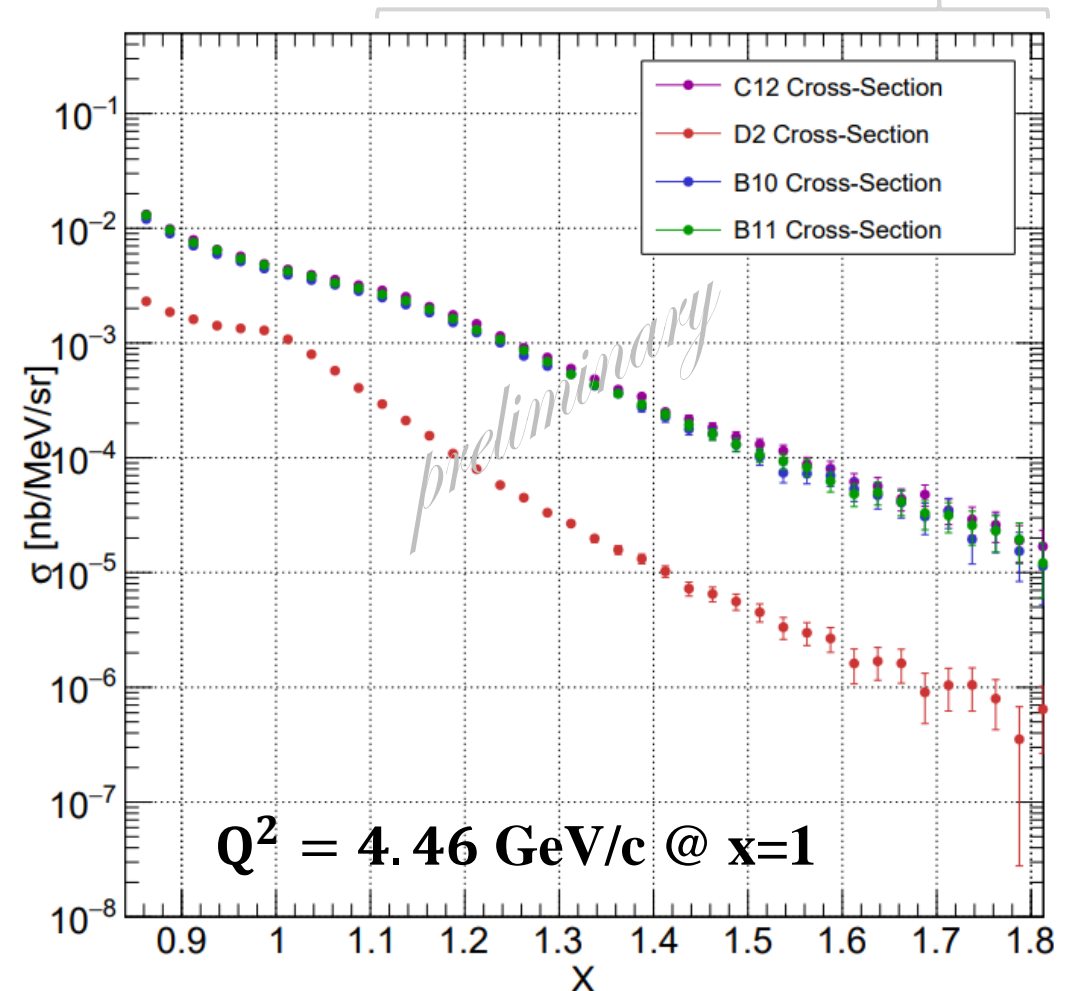
# Data Quality

## Spring 2018 Born Cross-Section



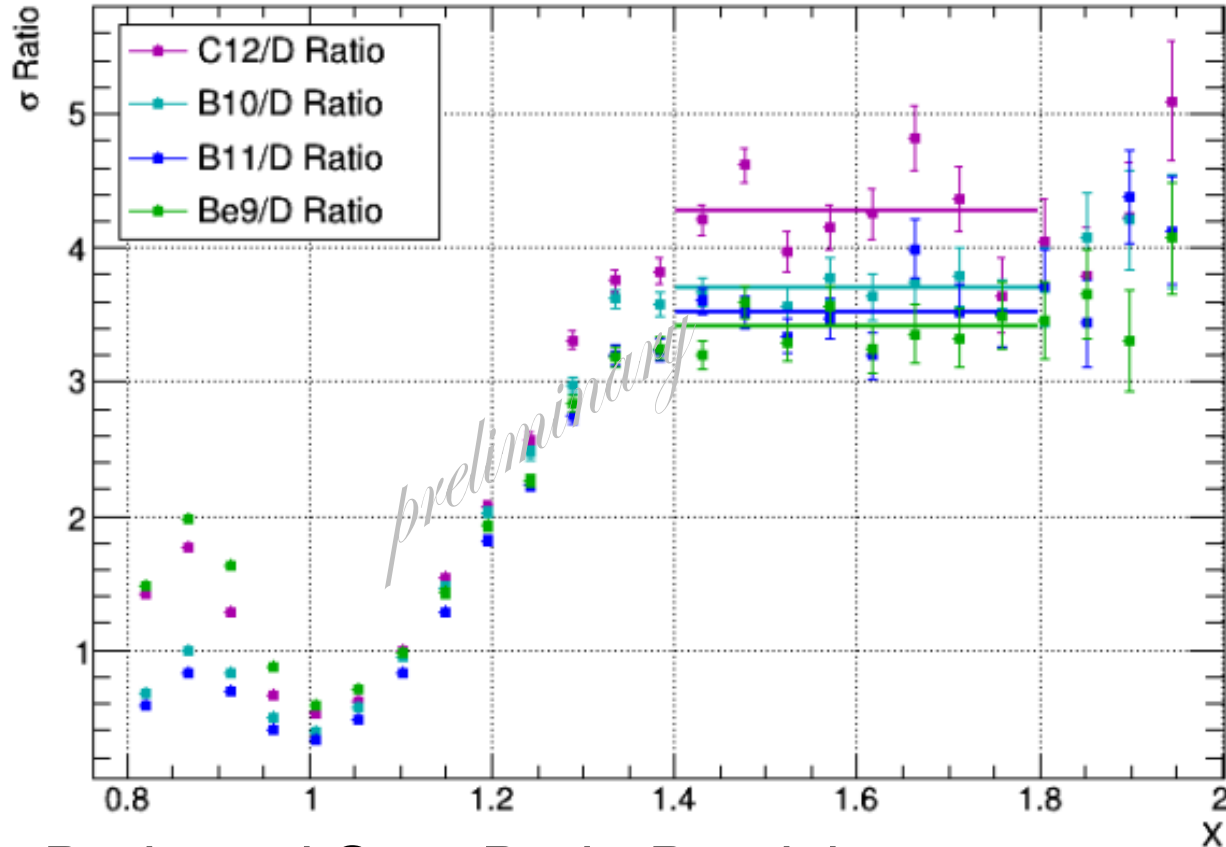
## Spring 2019 Born Cross-Section

Nominal Acceptance



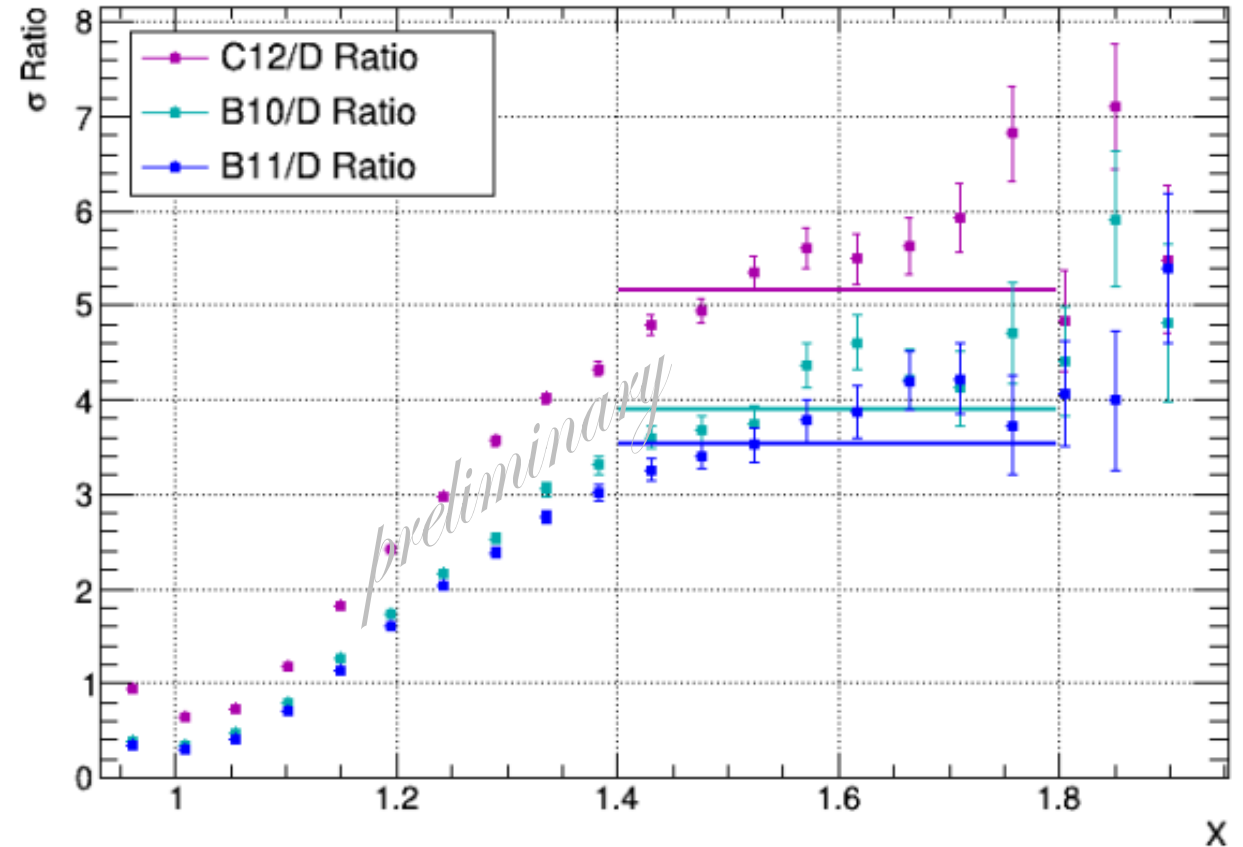
# Statistics Projection for Ratios

Spring 2018 Born Cross-Section Ratio



Spring 2019 Born Cross-Section Ratio

Nominal Acceptance



Projected Stat. Ratio Precision

2018: 3.5%



2019: 3%



6 GeV: 2%

