Inclusive Scattering from Nuclei at x>1 in the quasielastic and deeply inelastic regimes: E12-06-105 Jeopardy Update

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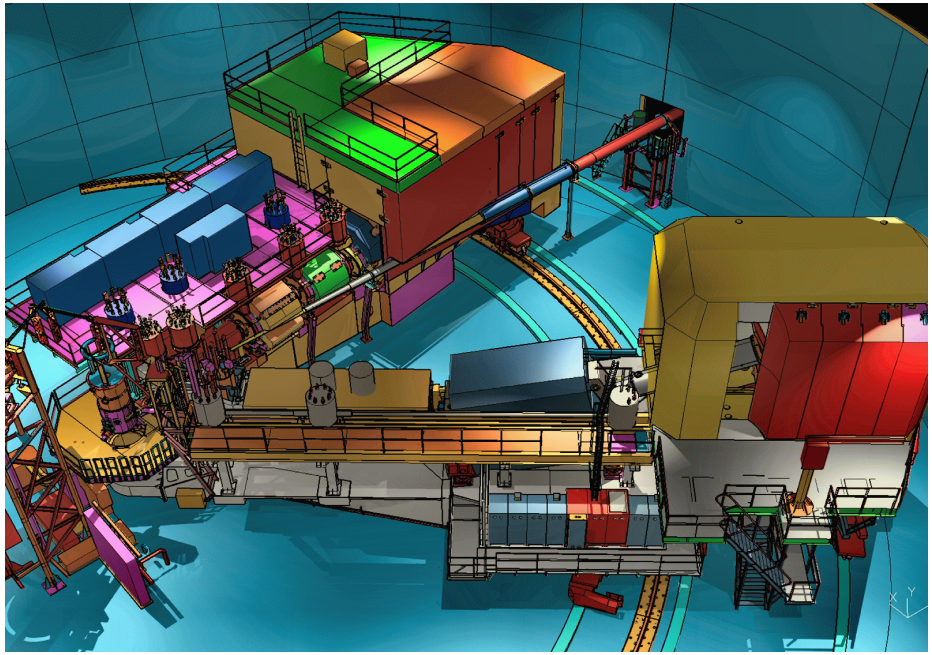
E12-06-105 Overview

Experiment Goals

- Inclusive SRC ratios at moderate Q^2, x>1
  - Measure (e,e') A/D cross section ratios to study nuclear and isospin dependence of SRCs
  - Provide additional data for EMC-SRC correlation studies
  - Large number of targets to study N/A, A dependence
  - Search for 3-nucleon correlation plateau
- DIS at x>1
  - Study nuclear parton distributions at x>1 by going to larger Q^2



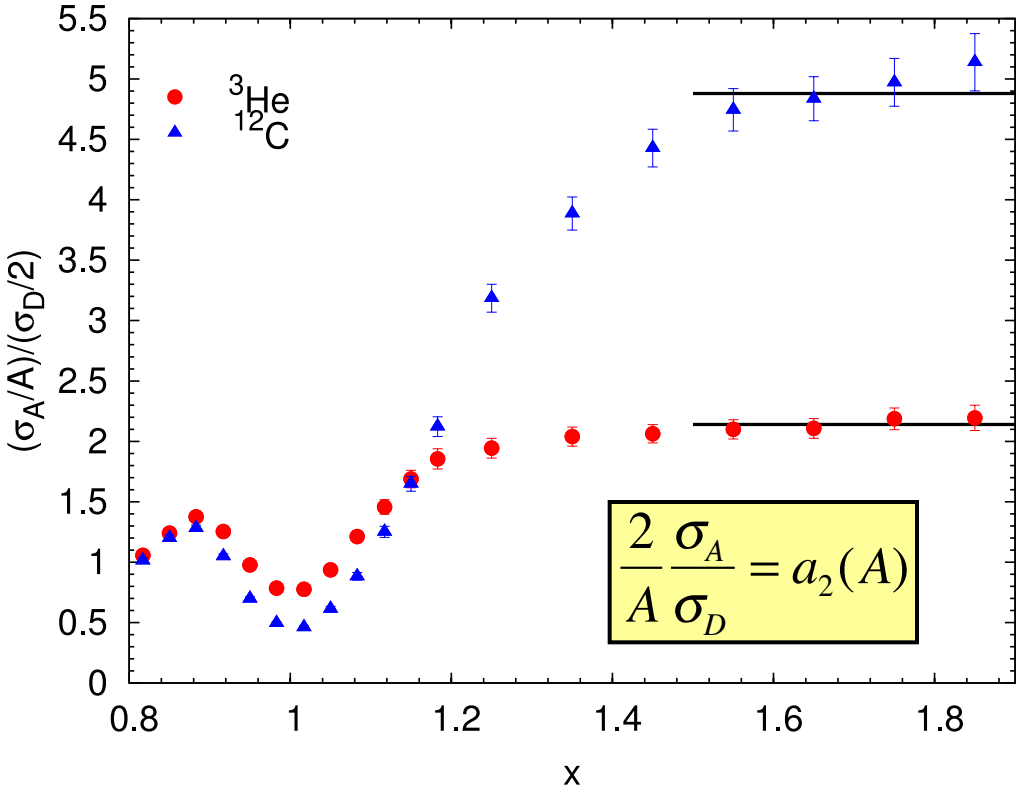
→ Uses both HMS and SHMS
→ SHMS will run at highest momentum to access large x physics
→ Noble gas Cerenkov also required for pion rejection at large momentum

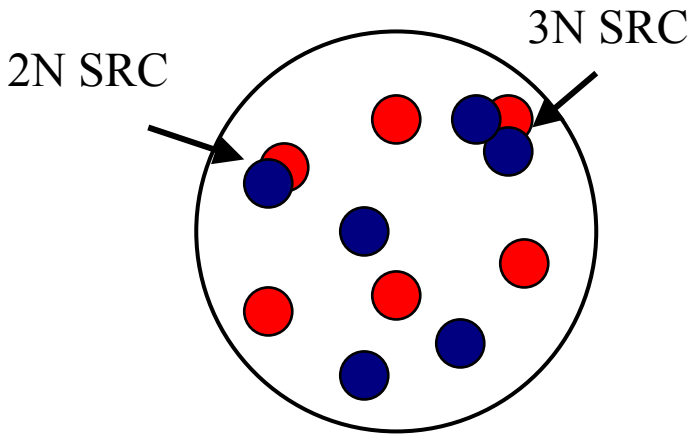
Selected as high impact experiment at PAC 41

Measuring Short Range Correlations

To measure the (relative) probability of finding a correlated pair, ratios of heavy to light nuclei are taken at ***x>1*** → QE scattering

If high momentum nucleons in nuclei come from correlated pairs, ratio of A/D should show a plateau (assumes FSIs cancel, etc.)

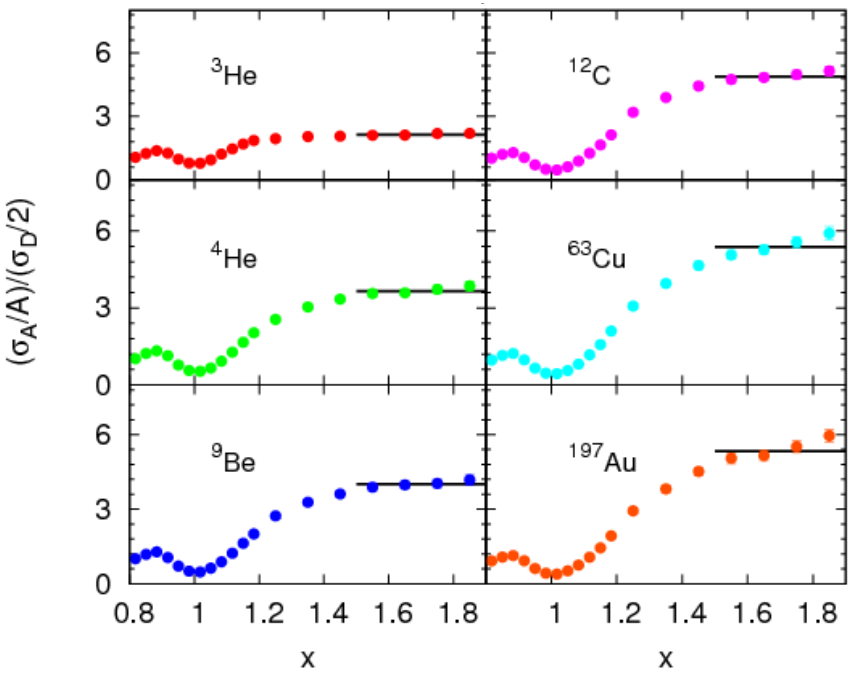




1.4<x<2 => 2 nucleon correlation

2.4<x<3 => 3 nucleon correlation

SRCs and Nuclear Density



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

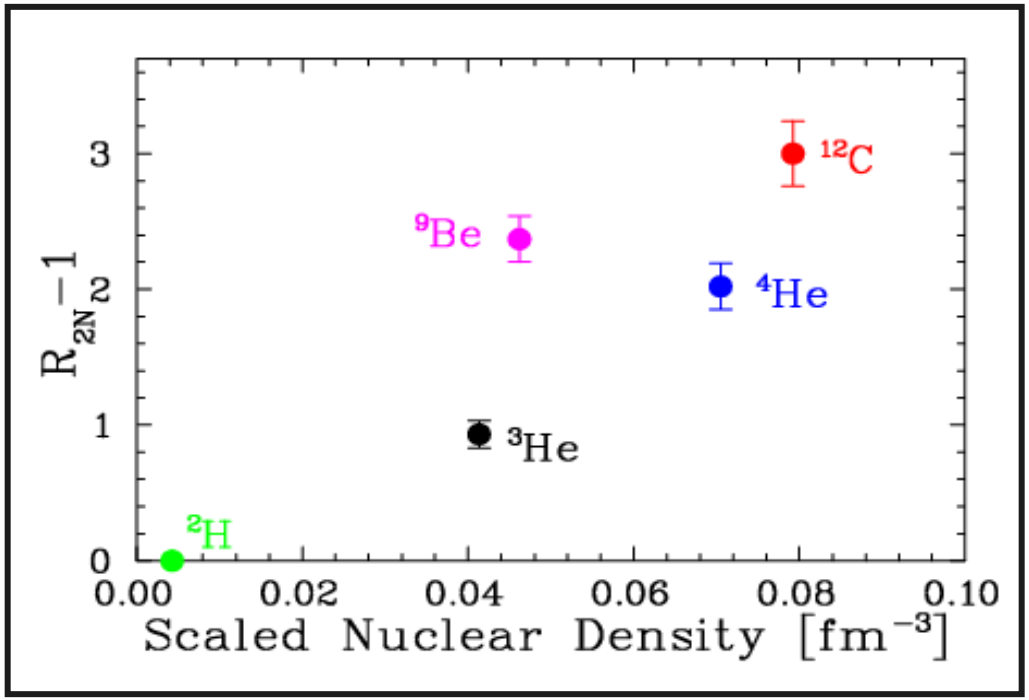
Hall C data on ratios at *x>1*

a_2 ratios for:

→Additional nuclei (Cu, Be, Au)

→Higher precision for targets with already existing ratios

→ Relative probability to find SRC shows similar dependence on nuclear density as EMC effect



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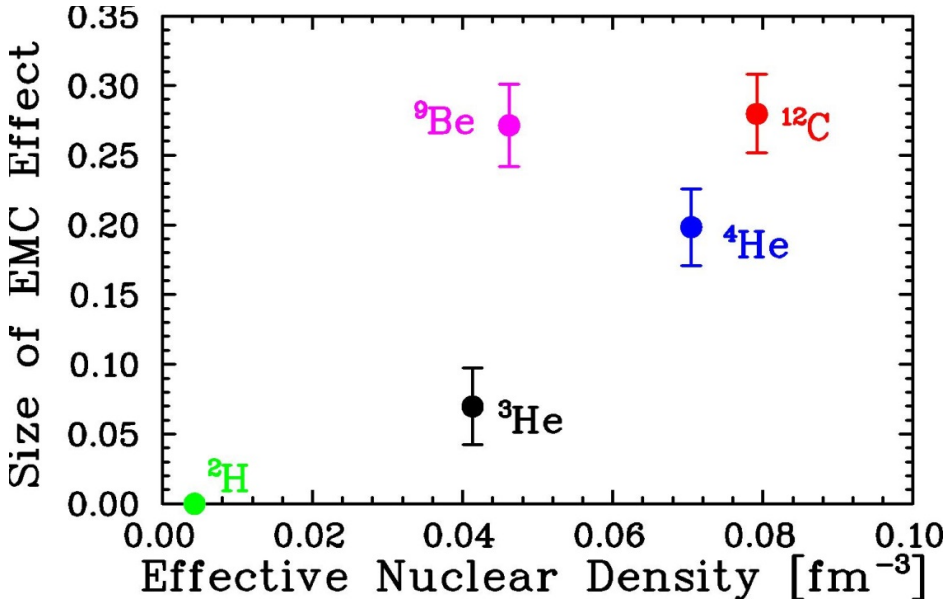
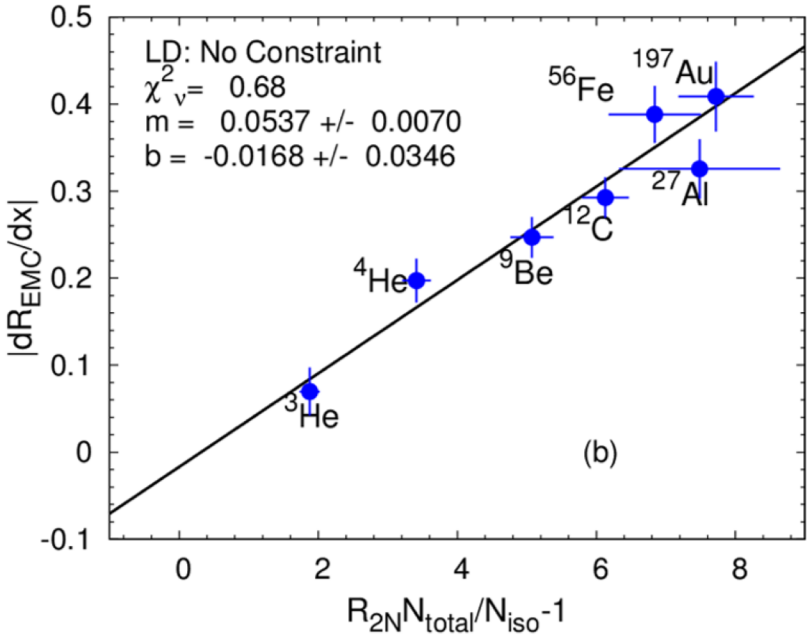
SRCs and the EMC Effect





SRCs show similar nuclear dependence as the EMC effect

→ Linear correlation between the 2 suggests some connection

→ The connection is particularly striking given the unexpected behavior with respect to Beryllium

Additional nuclei will provide information about the nuclear dependence of SRCs (and EMC effect) and relation to isospin (N/P)

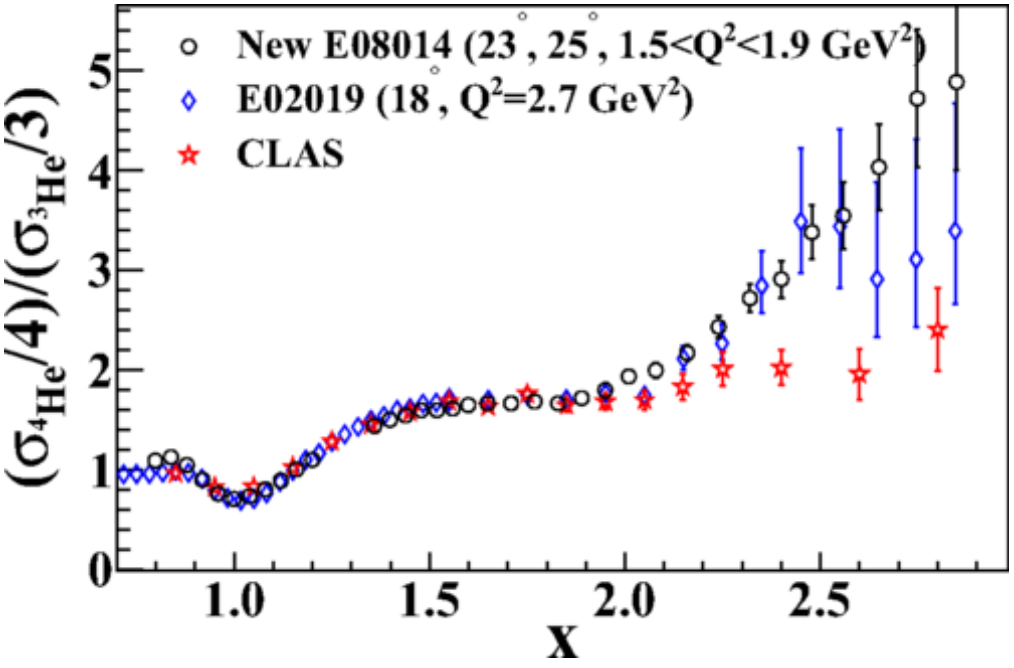
3-Nucleon Correlations

CLAS results from 6 GeV suggested presence of 3N SRC plateau

→ Plateau not observed in 2004 Hall C data, although errors were large

→ Later investigation suggested that CLAS observation could have been due to resolution effects (over-binning)

→ Subsequent Hall A experiment consistent with Hall C result, no 3N plateau



Z. Ye et al, PRC97 (2018) no.6, 065204

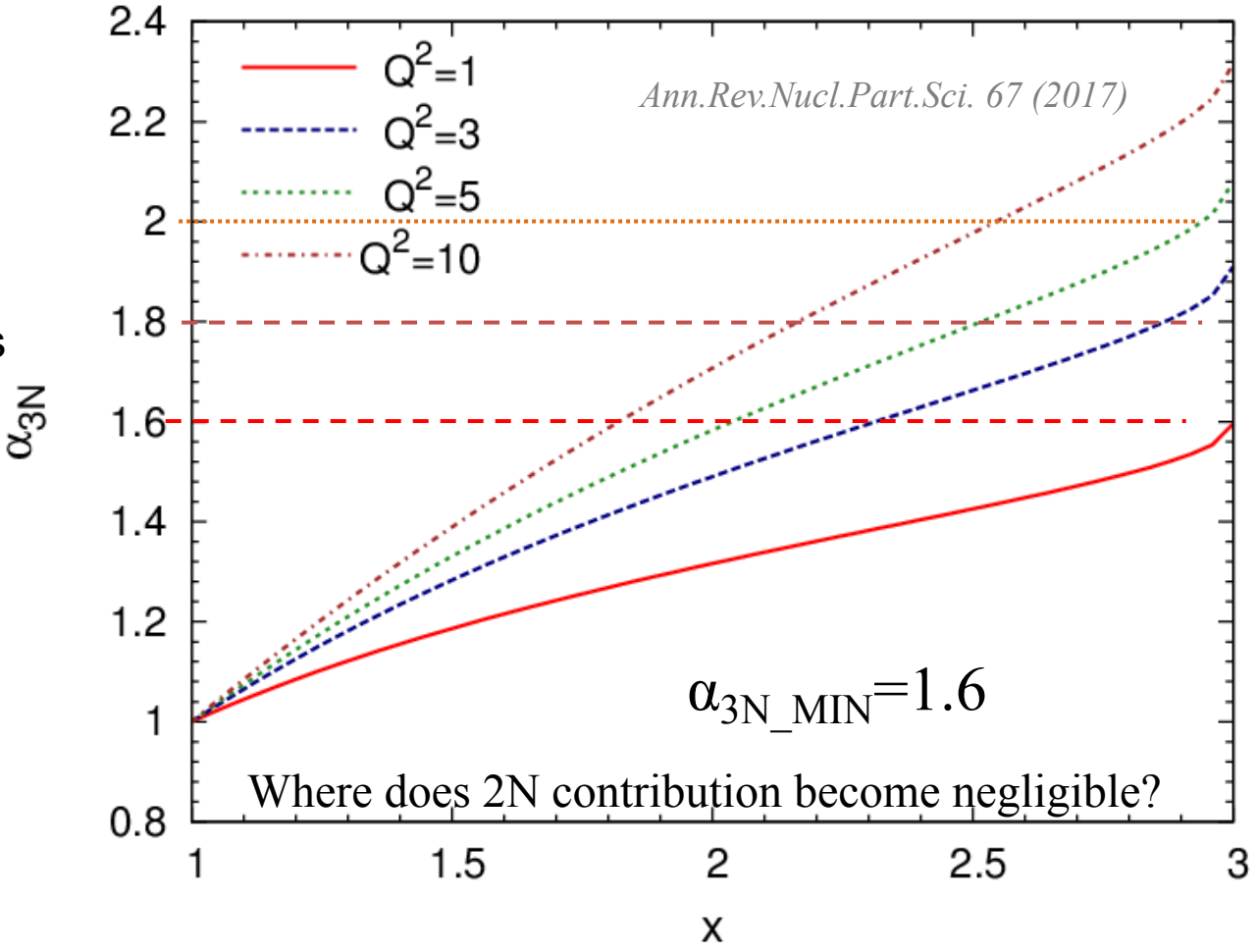
3N Correlations

Calculations suggest that minimum light-cone fraction for correlated nucleon ~ 1.6 to observe 3N correlations

→ Hall C 6 GeV data was above this threshold for part of x range, but uncertainties large

→ $Q^2 < 3$ GeV^2, plateau may appear at x>2.4

→ At 12 GeV, larger Q^2 accessible, so will sample larger part of relevant region



α_i represents the light-cone momentum fraction of 3N SRCs carried by the correlated nucleon i

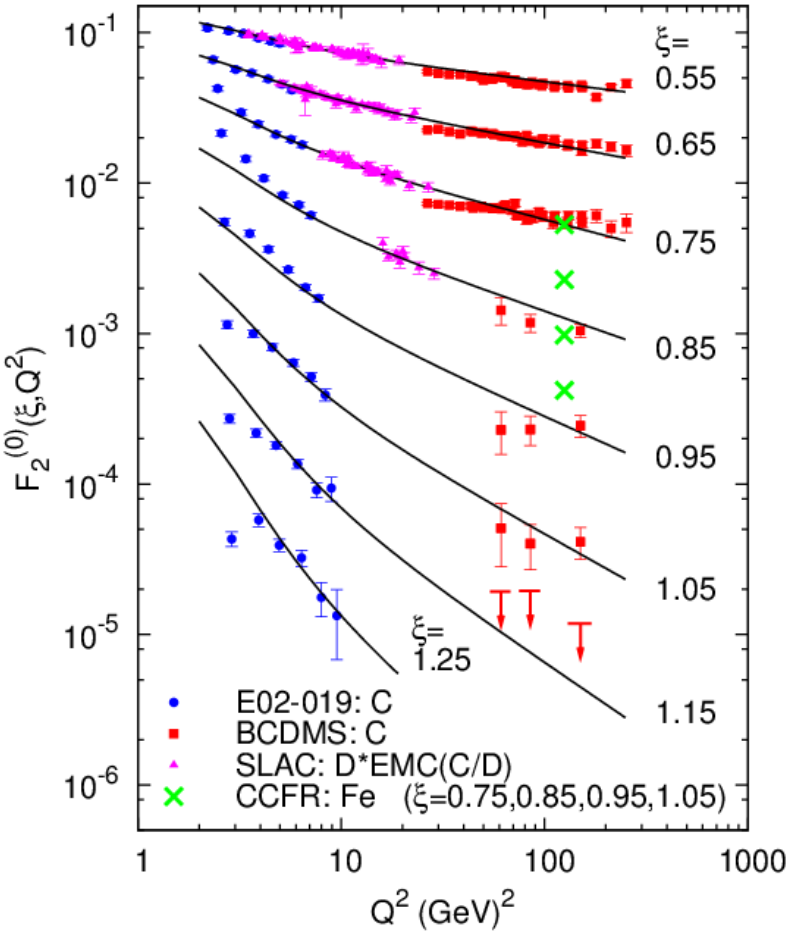
Nuclear Parton Distributions

At large enough Q^2, inclusive measurements at x>1 are potentially sensitive to quark distributions where quarks carry very high momenta

→ Possible to test this sensitivity by checking for logarithmic Q^2 dependence at fixed x in F_2

→ Results from Hall C experiment (2004) consistent with this expectation

→ Hall C fit to Q^2 dependence consistent with BCDMS result – do not require extremely large contributions from SRCs (in contrast to CCFR)

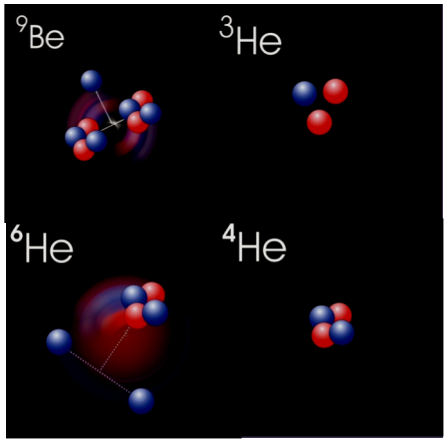


N. Fomin et al, PRL105 (2010) 212502

E12-06-105 and E12-10-008 ERR

In 2017, went through ERR due to large number of additional solid targets and first use the cryogenic helium targets in 12 GeV era in Hall C

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



Light nuclei

→ Availability of "exact" nuclear wave functions will allow for comparison with calculations incorporating detailed nuclear structure

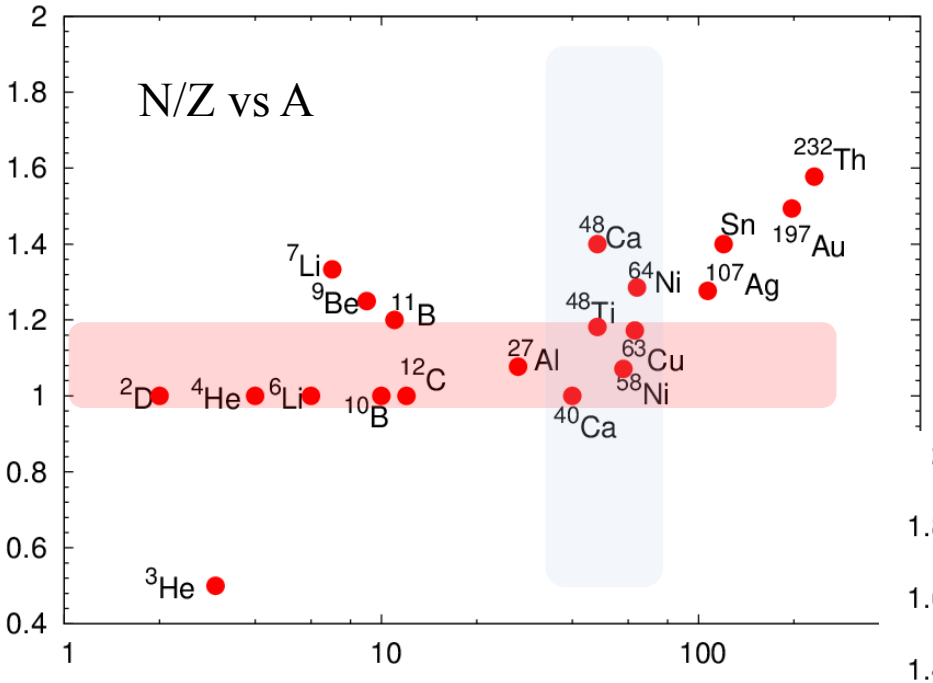
→ Study different clustering behavior

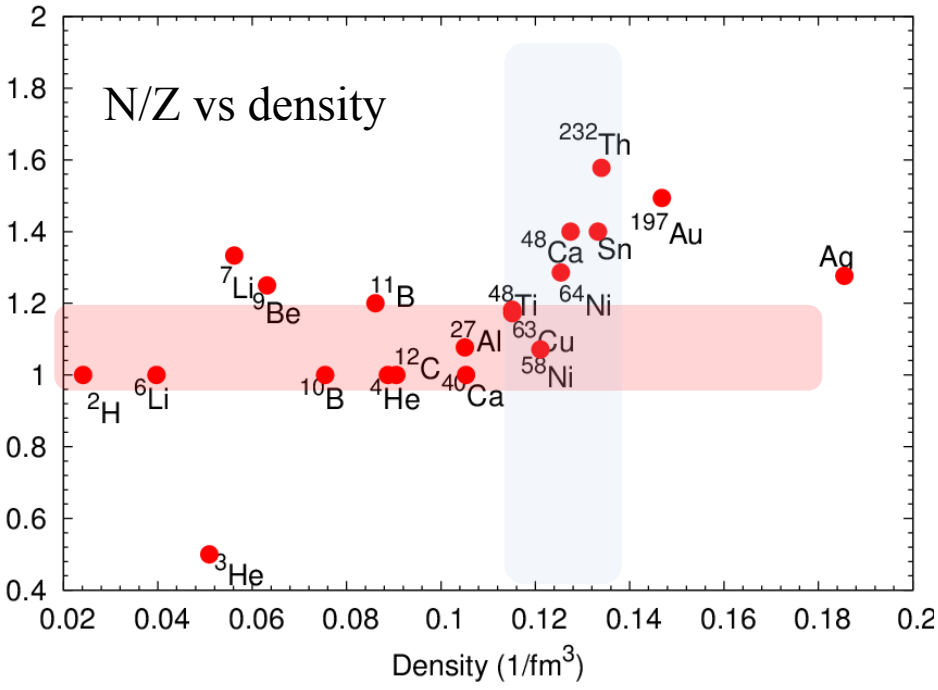
Medium/heavy nuclei

→Allow measurements for different N/Z at fixed A

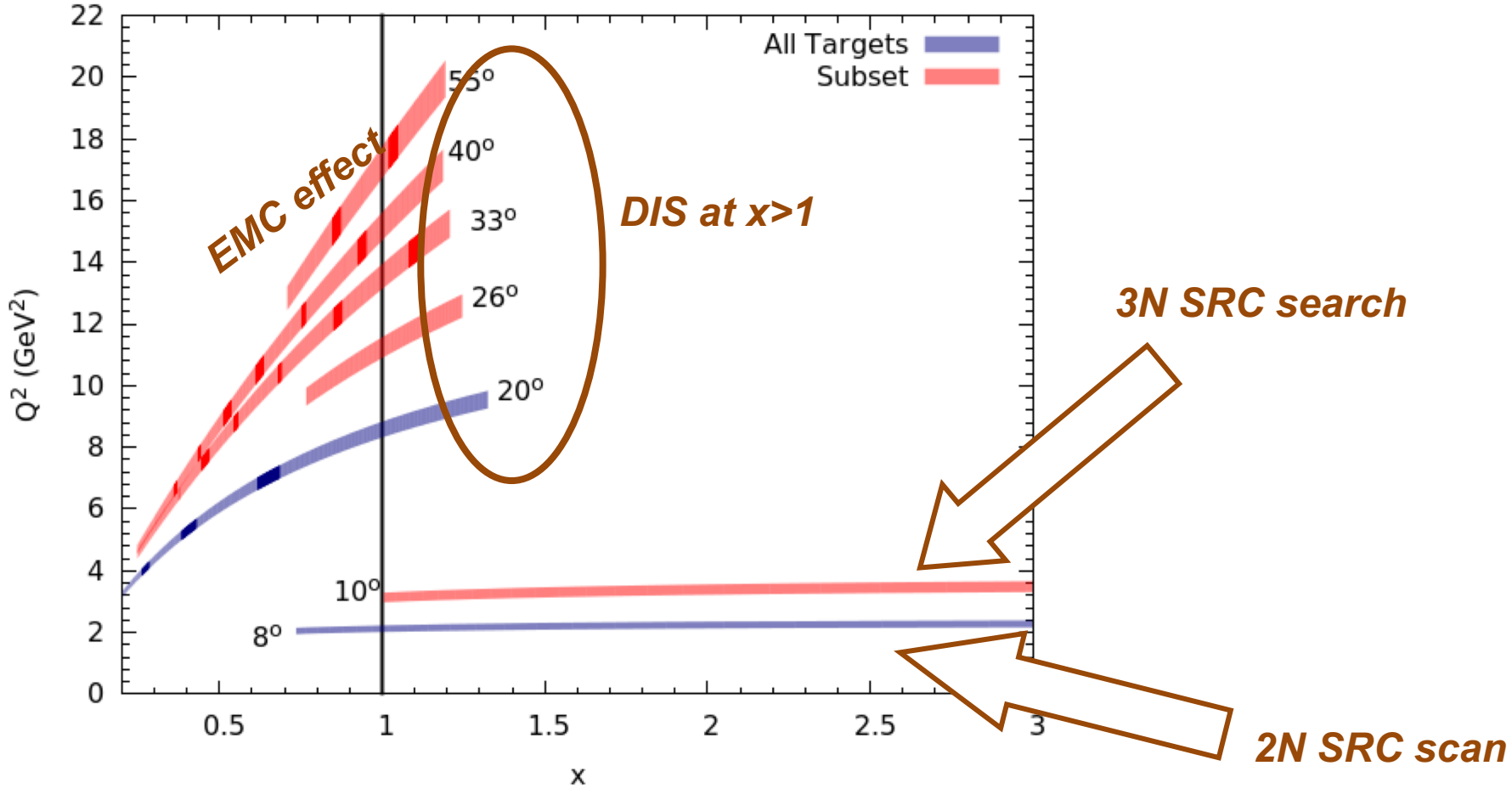
^{27}Al	^{64*}Cu
^{40*,48}Ca	^{108*}Ag
^{48}Ti	^{119*}Sn
^{54}Fe	^{197*}Au
^{58,64}Ni	^{232}Th

E12-06-105 and E12-10-008 Targets





E12-06-105 and E12-10-008 ERR



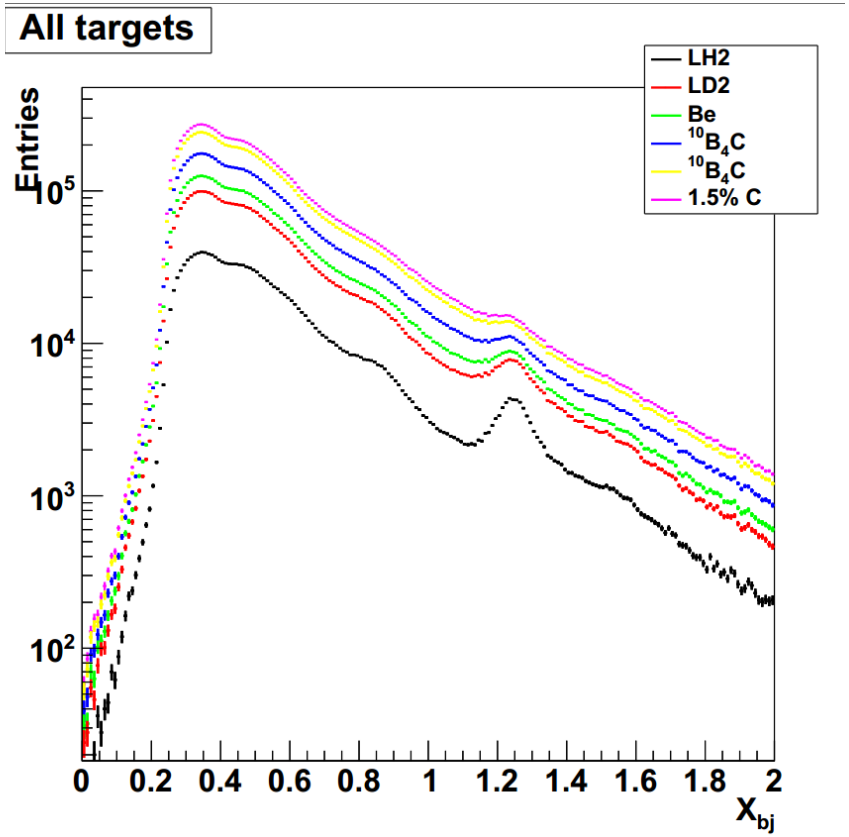
Initial data at high energies

As part of E12-10-002 (F2)/E12-10-008 (EMC) commissioning run, took some data (~1 shift) at large x (Spring 2018)

→ P_{SHMS}=9.8 GeV,
→ θ_{SHMS}=8 degrees

Used same nuclear targets as EMC measurements so can possibly compare EMC slopes to a_2 ratios

→ Unfortunately, at the time these data were taken, the SHMS magnet-settings at high momentum we not well constrained
→ Will take work to understand the optics



Online spectra – kinematic corrections missing

SHMS High Momentum Optics

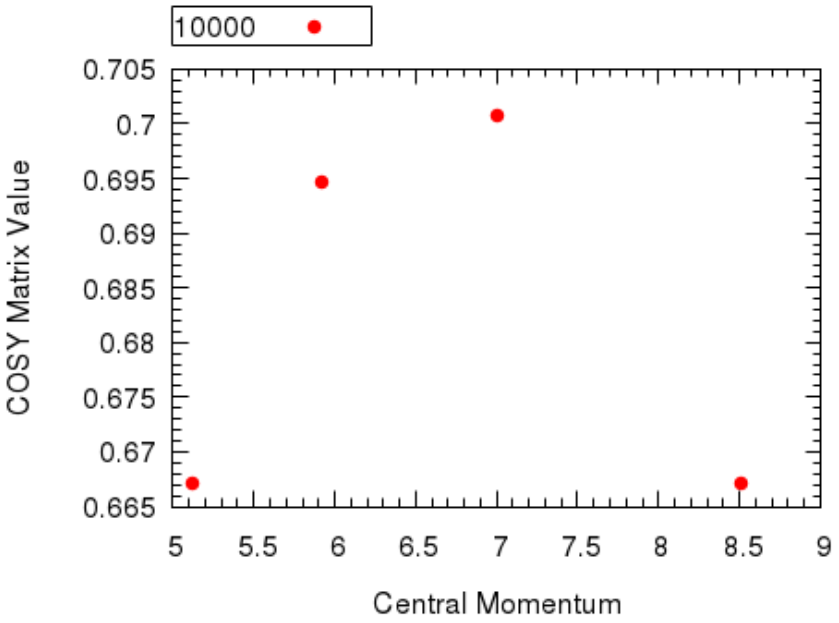
Early SHMS running incorporated saturation corrections for Q1/Q3

→ Discovered later these were not necessary

→ Not an issue at lower momenta, but impacted Color Transparency running and high momentum inclusive setting

CT: Corrections were fit to 1st order matrix elements by studying correlations from H(e,e'p) data

x>1 data set only has inclusive elastic peak



δ-xfp matrix element – from CT data

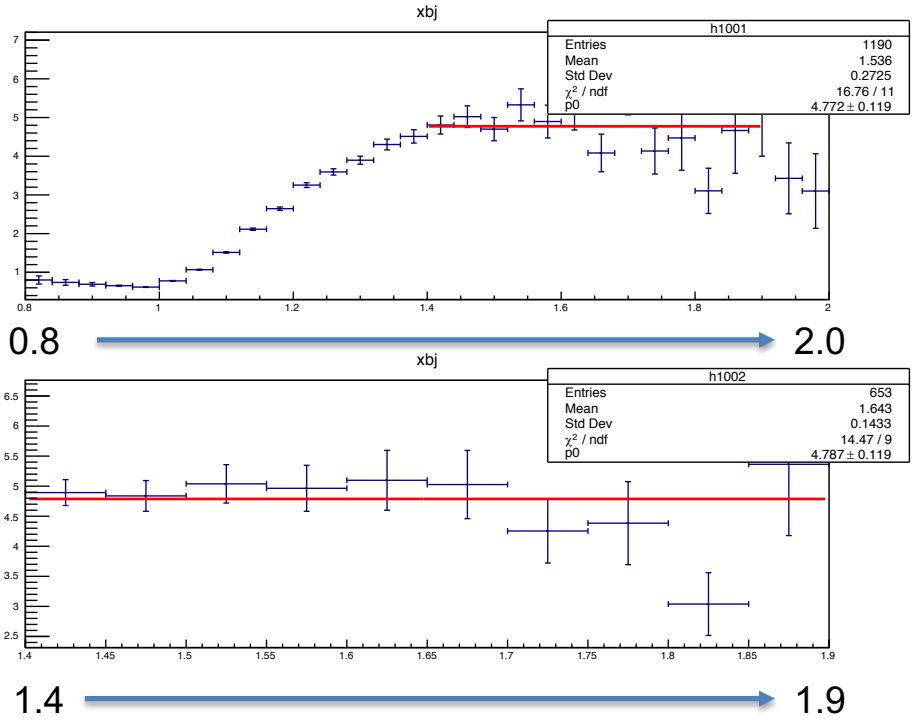
Extrapolation of ME's from CT results might not be straightforward

Additional Data at Large x

HMS issues during J/Psi experiment allowed some opportunistic running with SHMS

→ Took some more large x data
→ No saturation effects due to correction to SHMS magnet-setting algorithm
→ Minimum SHMS angle was 13.1 degrees due to large angle beam pipe
→ Q^2=4.9 GeV^2 at x=1
→ Statistical precision on a_2 ratio ~2.4%

Carbon/LD2



Online ratio, no RC, bin centering, etc.

If smaller angle data proves too difficult to analyze, this could serve as a (lower-precision) backup for comparison to EMC ratios

Summary

- E12-06-105 will provide a large body of data for studies of 2N/3N SRCs and DIS in nuclei at x>1
  - Smaller angle data at x>1.4 will be used for 2N/3N studies
  - Large angle/Q^2 (at slightly smaller x) will be used DIS studies
- In combination with E12-10-008 (EMC Effect), will study EMC-SRC correlation
  - Study N/Z dependence at fixed A
  - A dependence at ~fixed N/Z
- Some initial test data from 2018/2019 runs under analysis – should be able to extract reasonably precise a_2 ratios