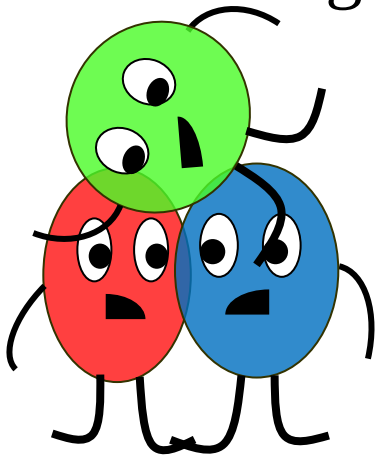
Continuing the search for 3N SRCS (maybe)



Science at the Luminosity Frontier:
Jefferson Lab at 22 GeV

Nadia Fomin

This work was supported by U.S. Department of Energy under award number: DE-SC0013615

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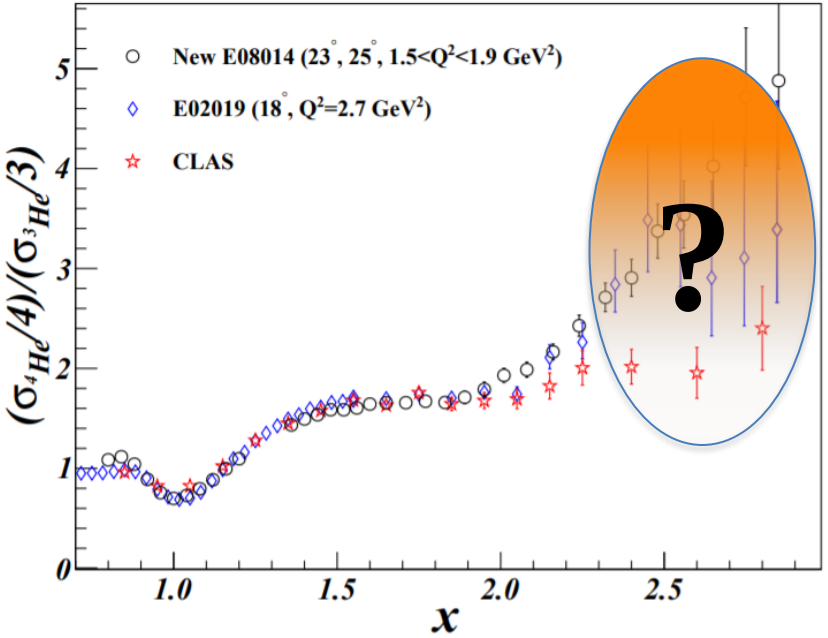
Status of 3N SRC searches

No observation of a 3N SRC plateau

- 2N Plateaus observed in many measurements – well understood and well studied
- Several previous measurements provided inconclusive results



Z. Ye et al, PRC 97 (2018) 6

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Background: 2N SRCs studies via inclusive scattering

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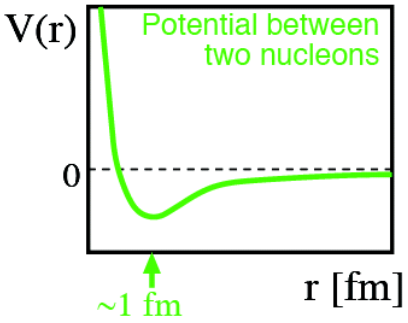
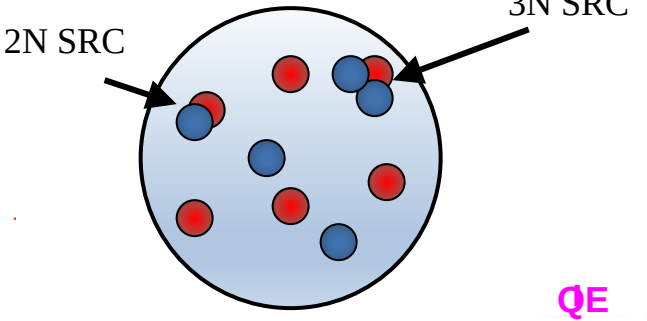
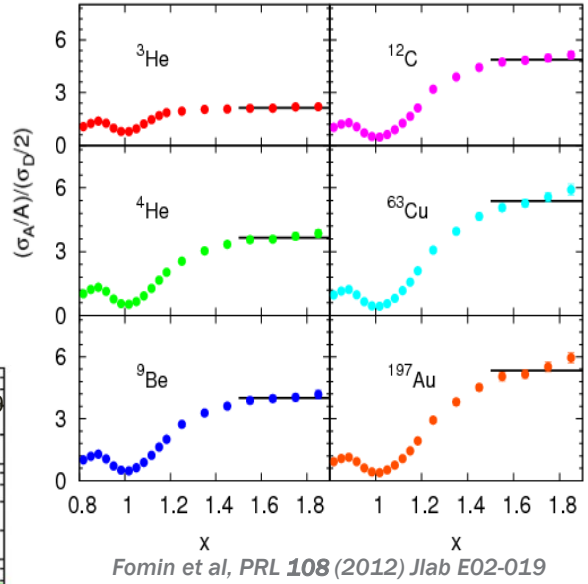
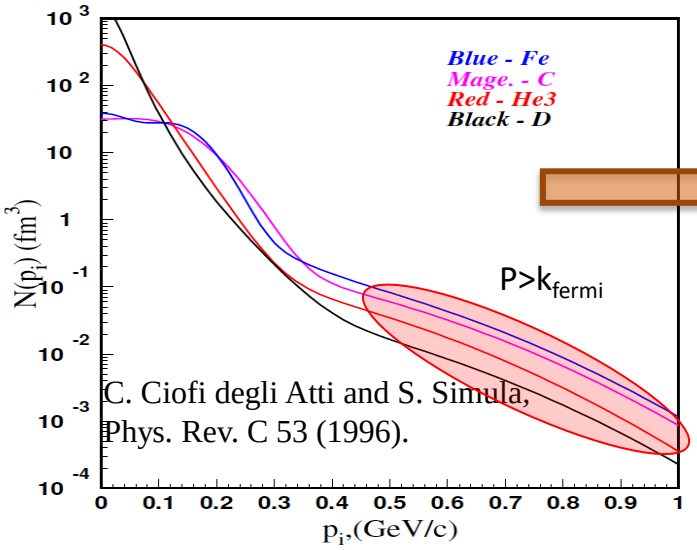


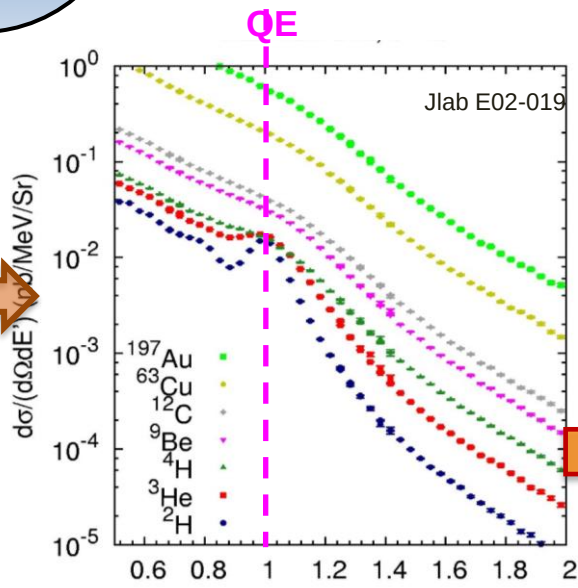




Fomin et al, PRL **108** (2012) Jlab E02-019



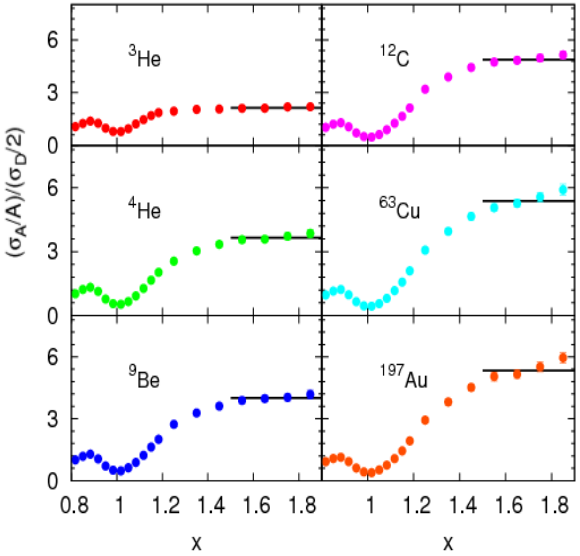
C. Ciofi degli Atti and S. Simula, Phys. Rev. C 53 (1996).



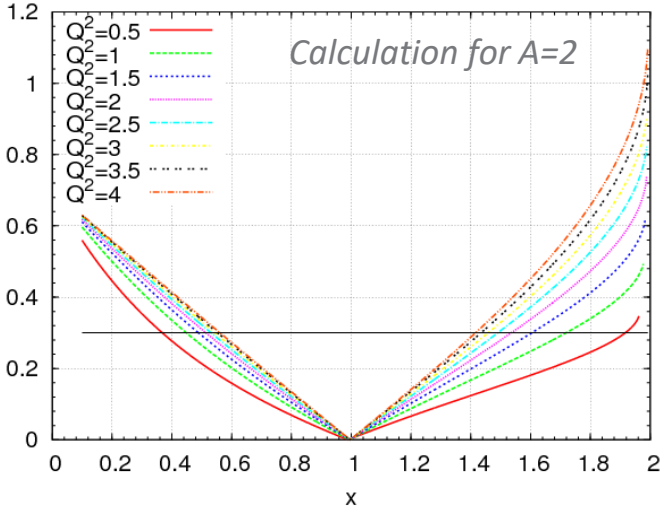
1.4<x<2 => 2 nucleon correlation

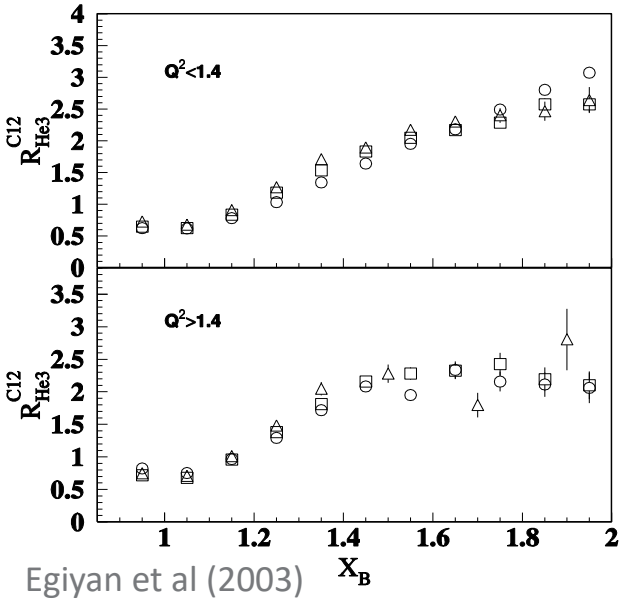
Q^2 threshold for 2N SRC Observation

$\langle Q^2 \rangle \sim 2.7\ GeV^2$



*Fomin et al, PRL **108** (2012) Jlab E02-019*





Egiyan et al (2003)

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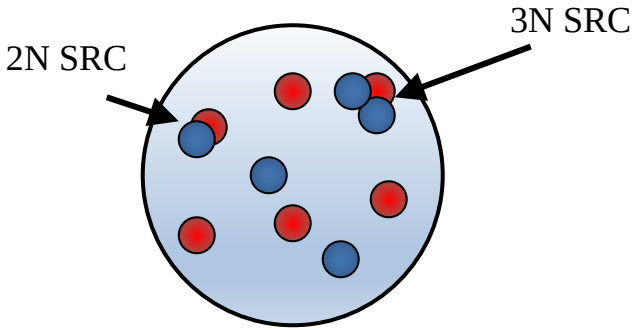
More nucleons in a correlation



$1.4 < x < 2$ => 2 nucleon correlation

$2.4 < x < 3$ => 3 nucleon correlation

$$\sigma(x, Q^2) = \sum_{j=1}^{A} A \frac{1}{j} a_j(A)\sigma_j(x, Q^2)$$

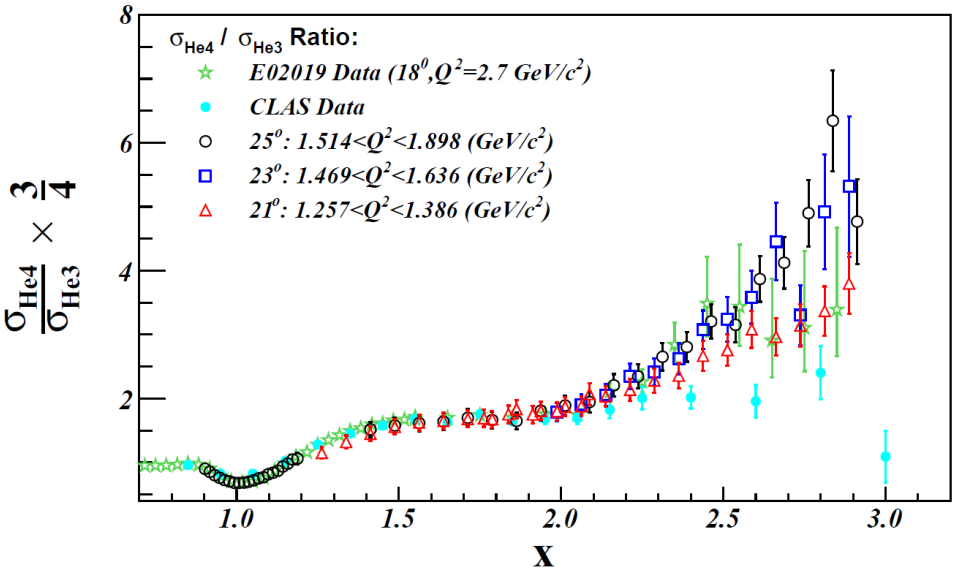
$$= \frac{A}{2} a_2(A)\sigma_2(x, Q^2) +$$

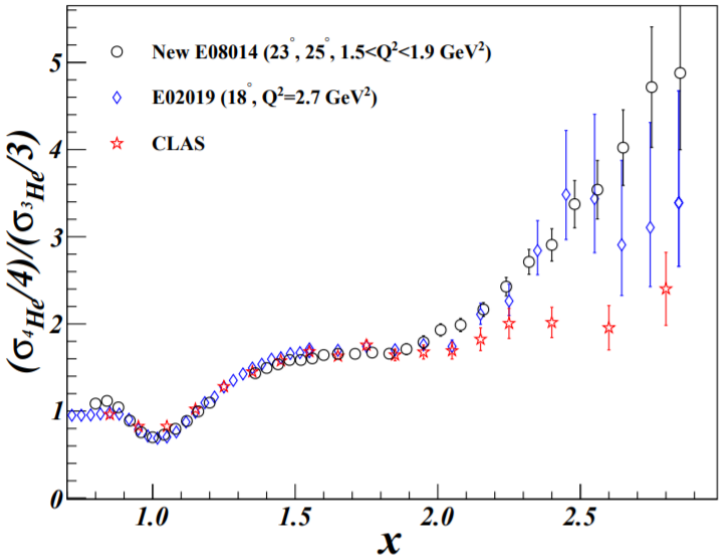
$$\frac{A}{3} a_3(A)\sigma_3(x, Q^2) + ...$$

Go to x>2 to see a second, 3N SRC plateau in $\frac{\sigma_A}{\sigma_{3He}}$

Inclusive 3N SRC data so far

Experiment	Q^2 range (GeV^2)	Note
E02019	~2.7	XEM (6 GeV)
E08014	1.3-1.9	Hall A 6 GeV
CLAS	1.6 (ave)	Resolution Limited

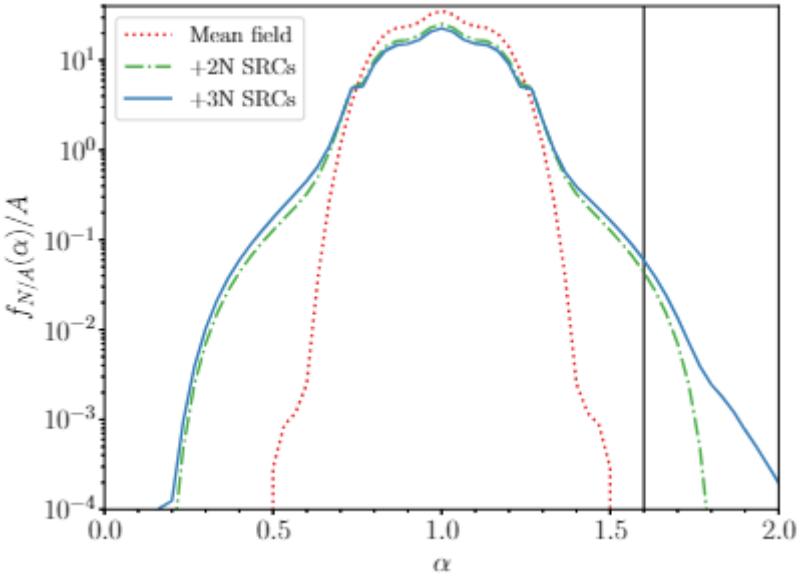


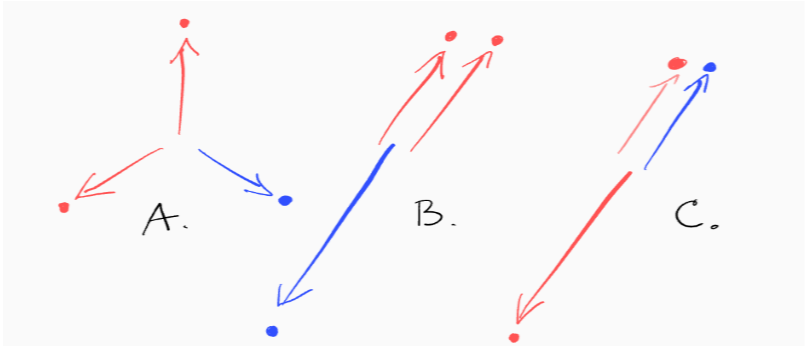


Onset of 3N Dominance

Light cone momentum fraction in a 3N system

$$\alpha_{3N} = 3 - \frac{q_- + 3m_N}{2m_N}\left[1 + \frac{m_S^2 - m_N^2}{W_{3N}^2} + \sqrt{\left(1 - \frac{(m_S^2 + m_N^2)^2}{W_{3N}^2}\right)\left(1 - \frac{(m_S^2 - m_N^2)^2}{W_{3N}^2}\right)}\right]$$





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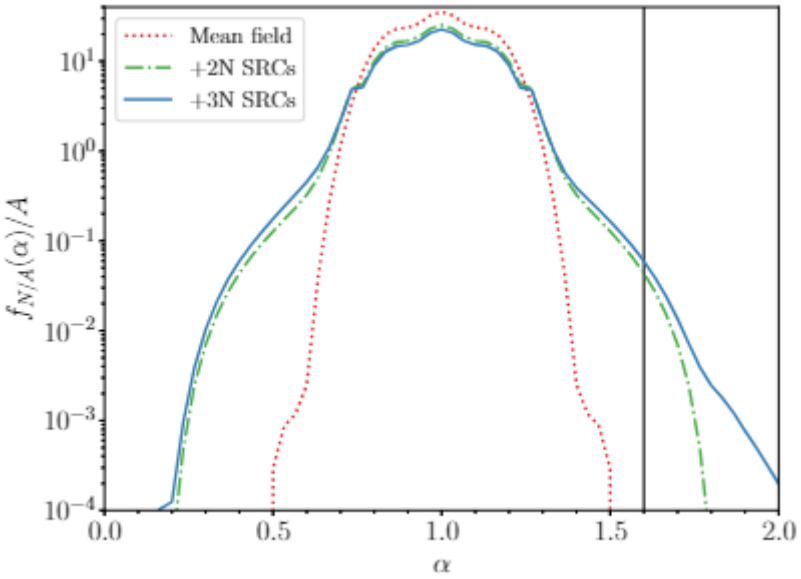

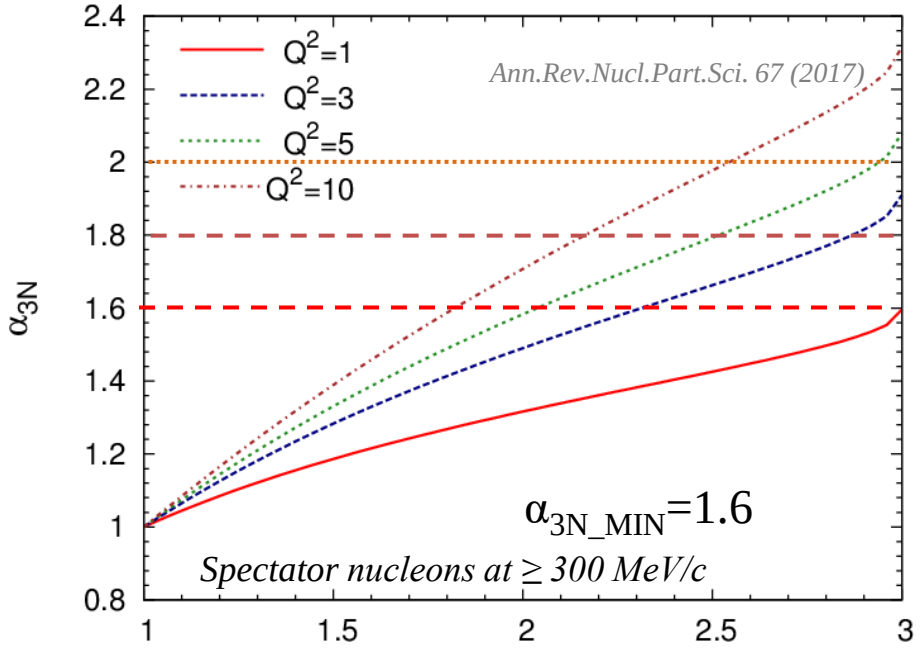

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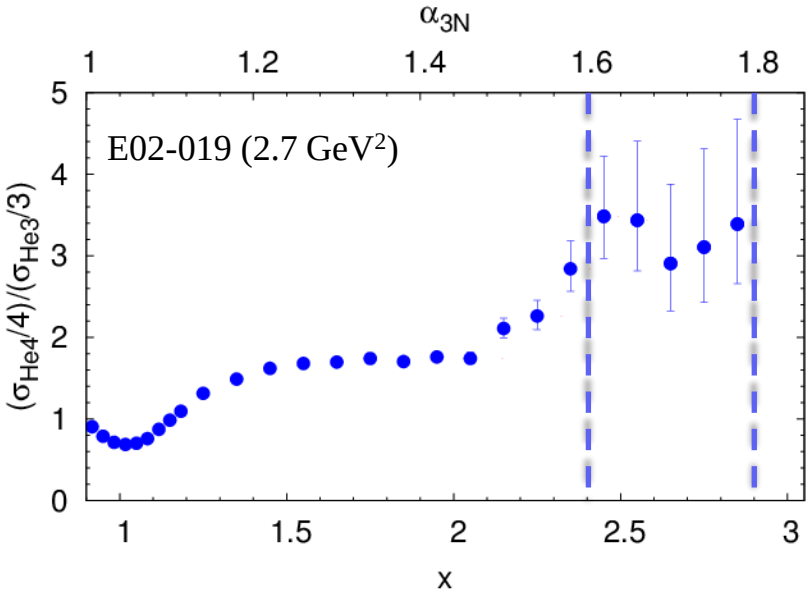
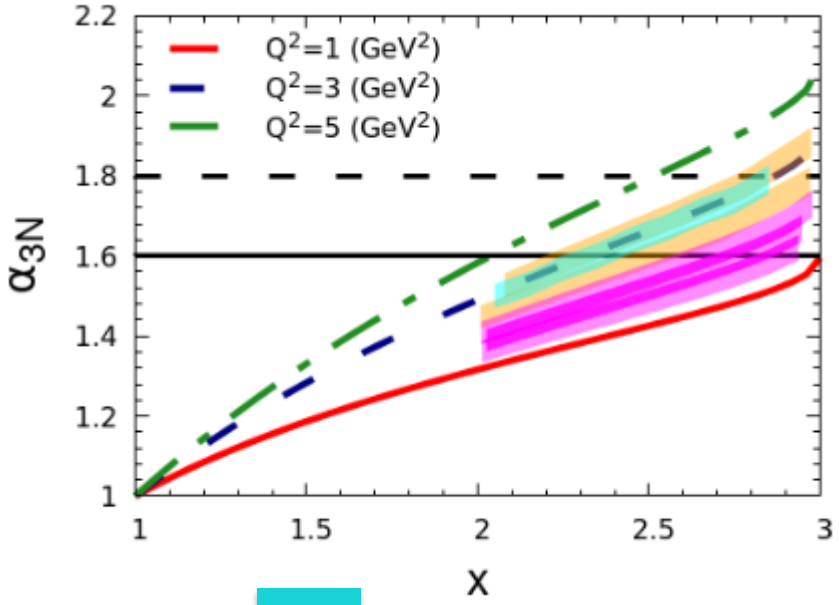
Hall C XEM data from 6 GeV



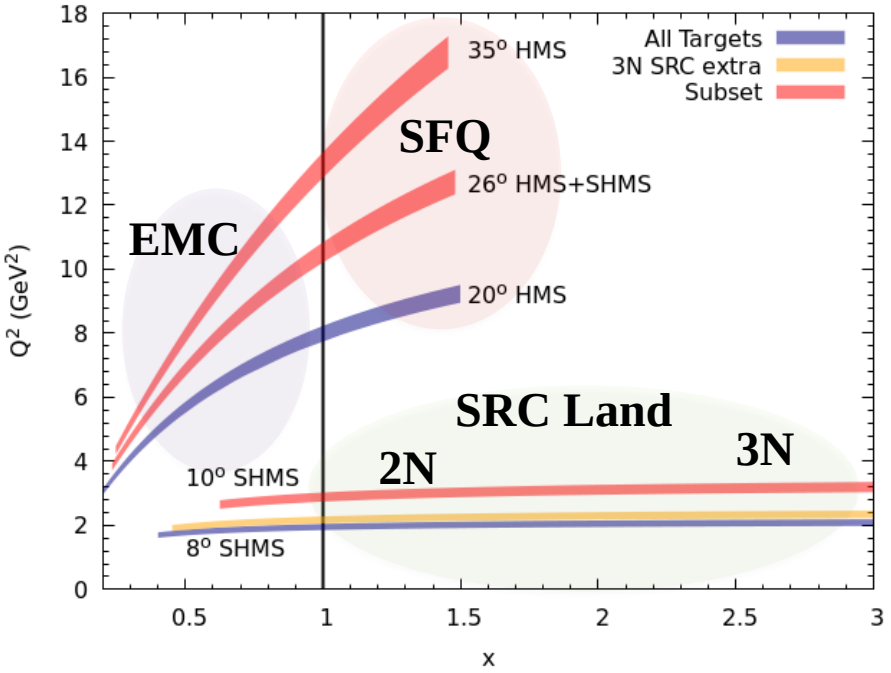


6 GeV XEM

12 GeV XEM2 (Under Analysis)

Hall A at 6 GeV

E12-06-105 (XEM2): 3N SRC Data Under Analysis



θ_{SHMS}	Q^2 at x=2.5 (GeV^2)
8.5	2.3
10	3.2
11, 12*	3.8, 4.4 *(test kinematics)*

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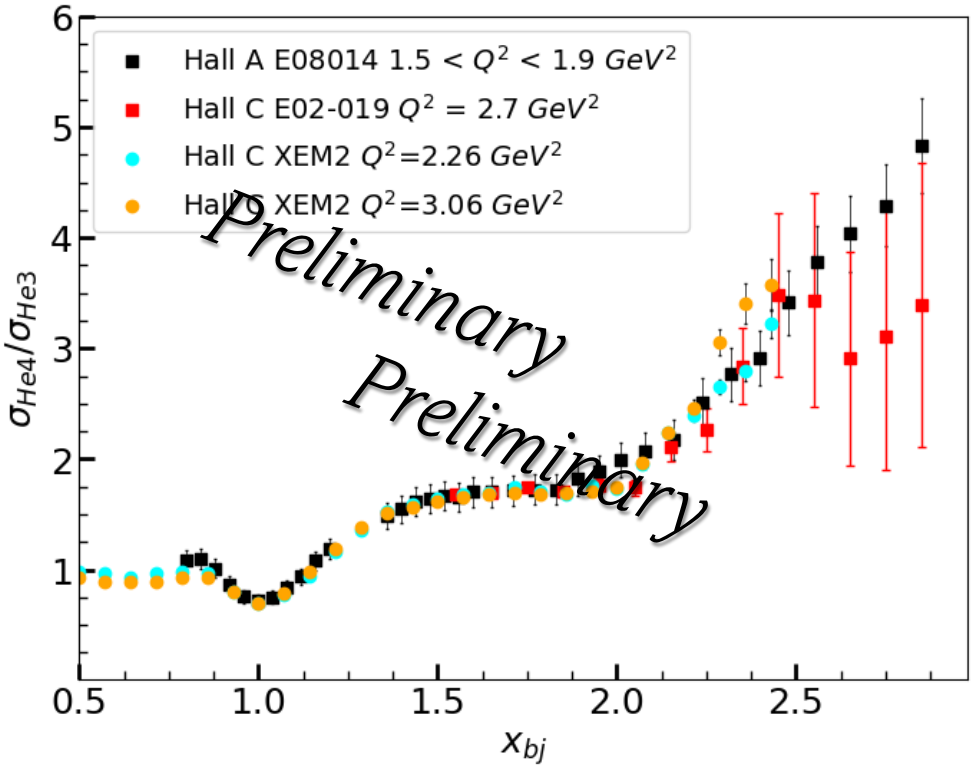
E12-06-105: 3N SRC Data Under Analysis



- Data in 1.6 < α < 1.8 region are not at necessary precision
- Possible Q^2 dependence in the ratio observed at x>2.2

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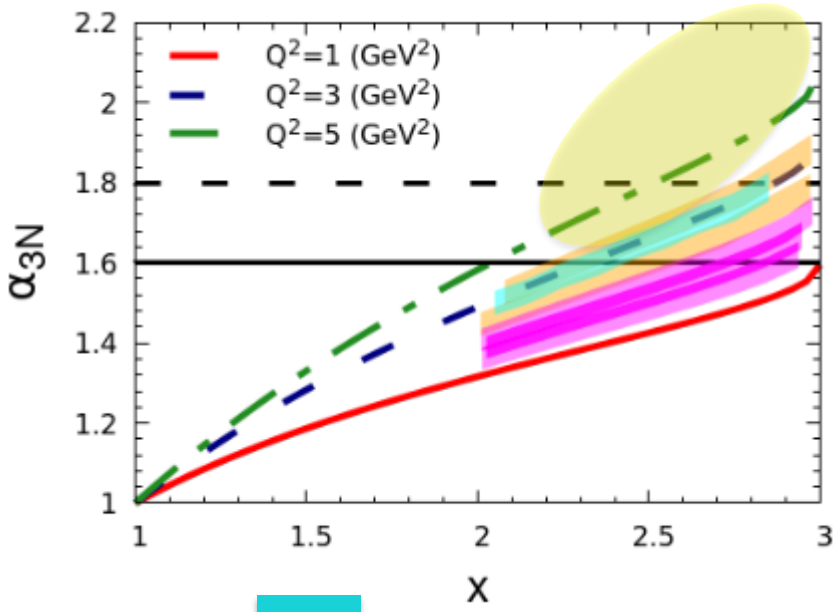
Why don’t you just go to higher Q^2?



6 GeV XEM

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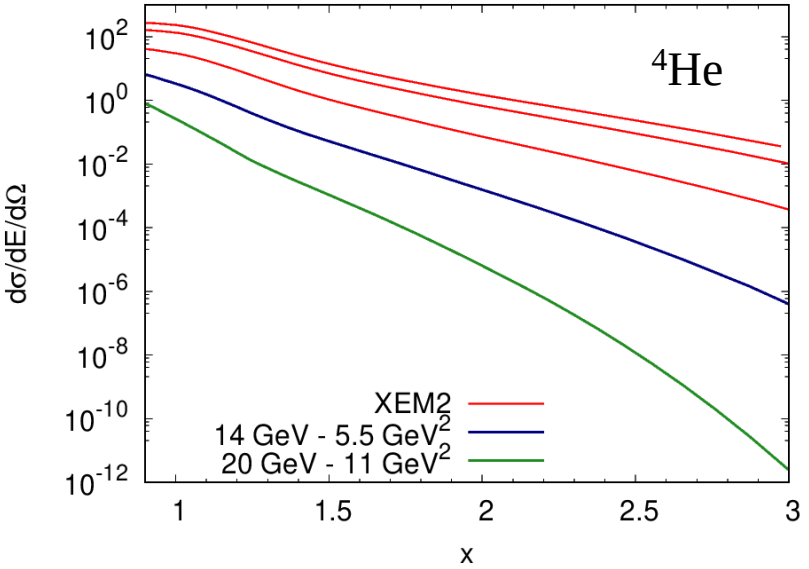
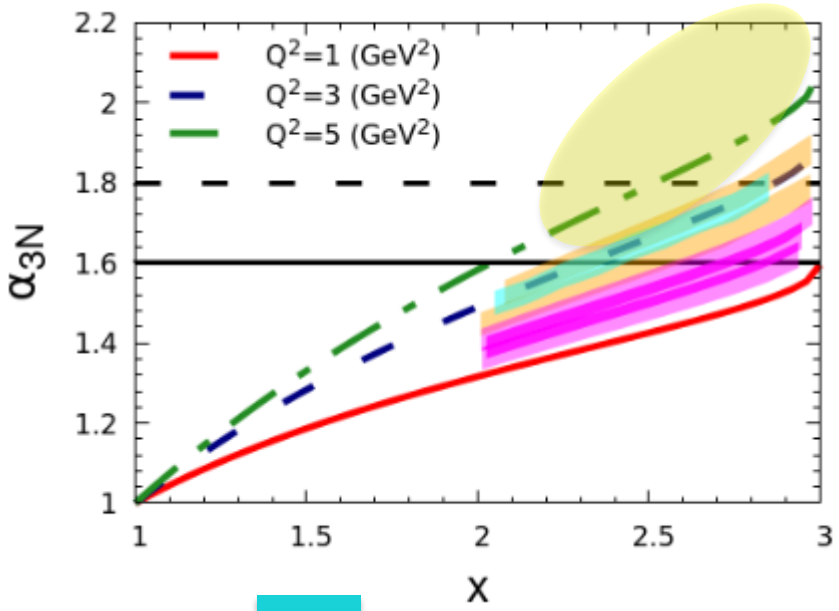
Why don’t you just go to higher Q^2?



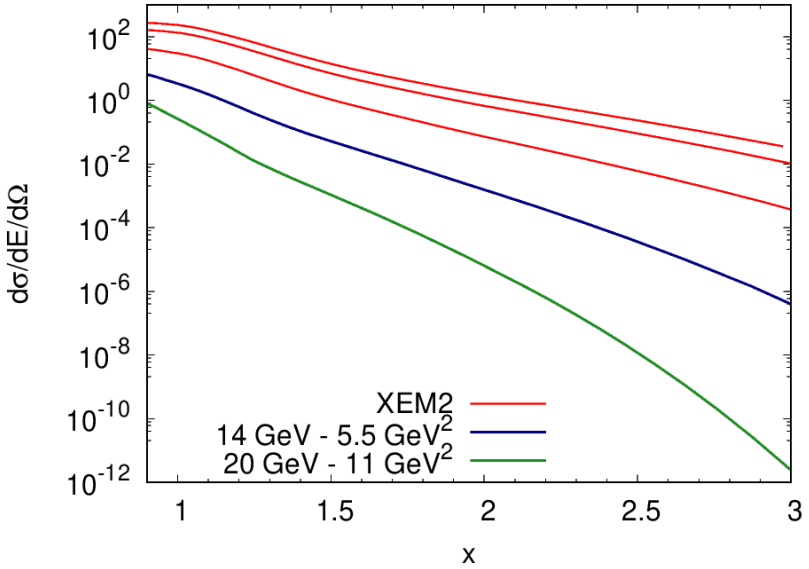


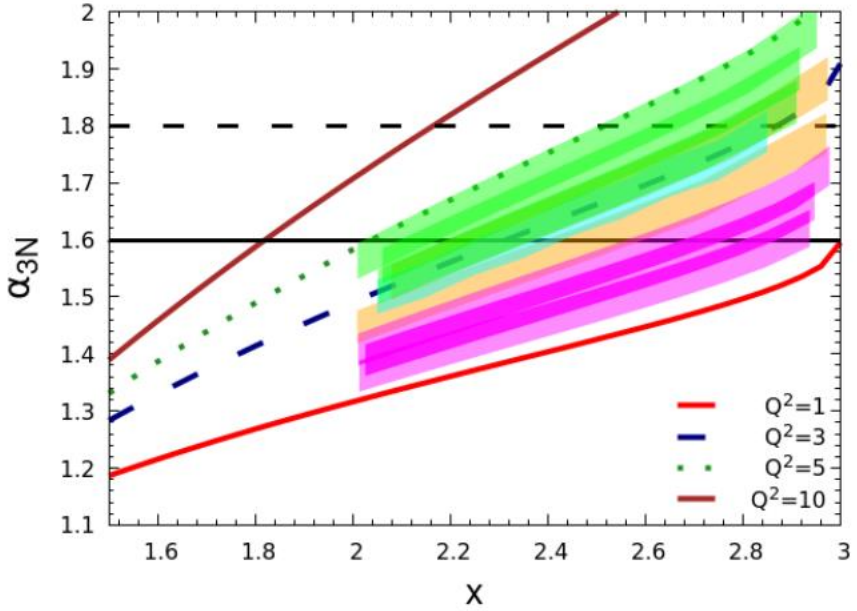
6 GeV XEM

12 GeV XEM2 (Under Analysis)

Hall A at 6 GeV

E12-06-105: 3N SRC Data Under Analysis





Proposed Kinematics (10,11,12)

XEM2 (Under analysis: 8.5, 10)

Hall A at 6 GeV

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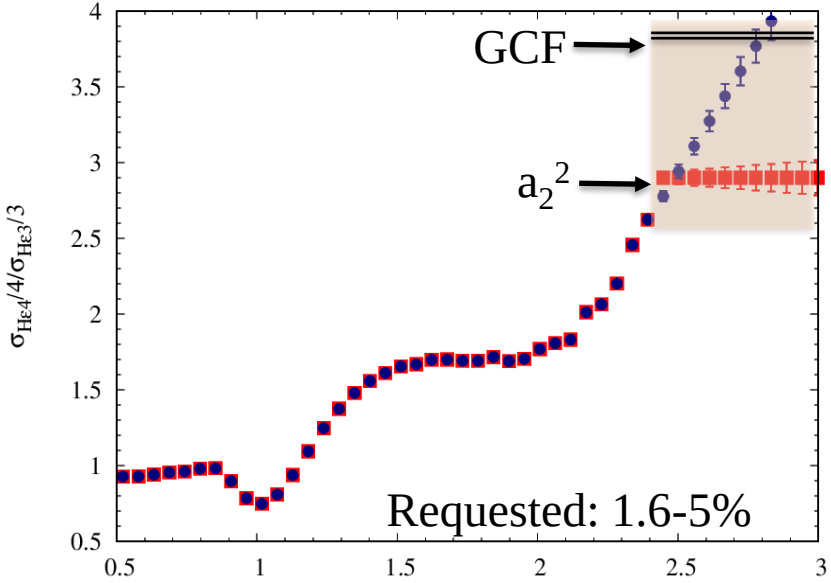
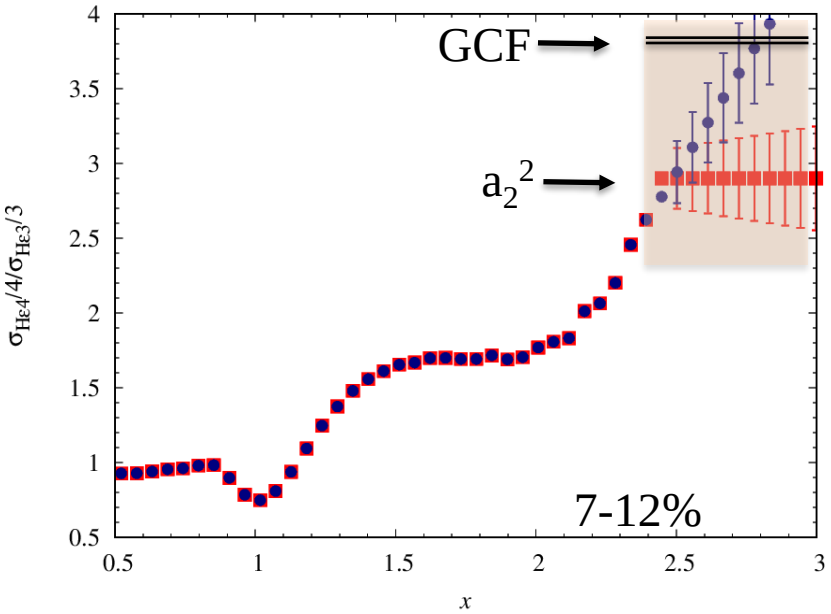
How much data do you really need?

$$\frac{\sigma_{4He}/4}{\sigma_{3He}/3}$$





- Statistics focused on $2.5 < x < 3.0$ kinematic range
  The high statistics goal is driven by the prediction from Misak Sargsian of $a_3 \sim (a_2)^2$
  - For 4He/3He ratio, $a_3 \sim 2.9$
- Projections don't show fluctuations in the data

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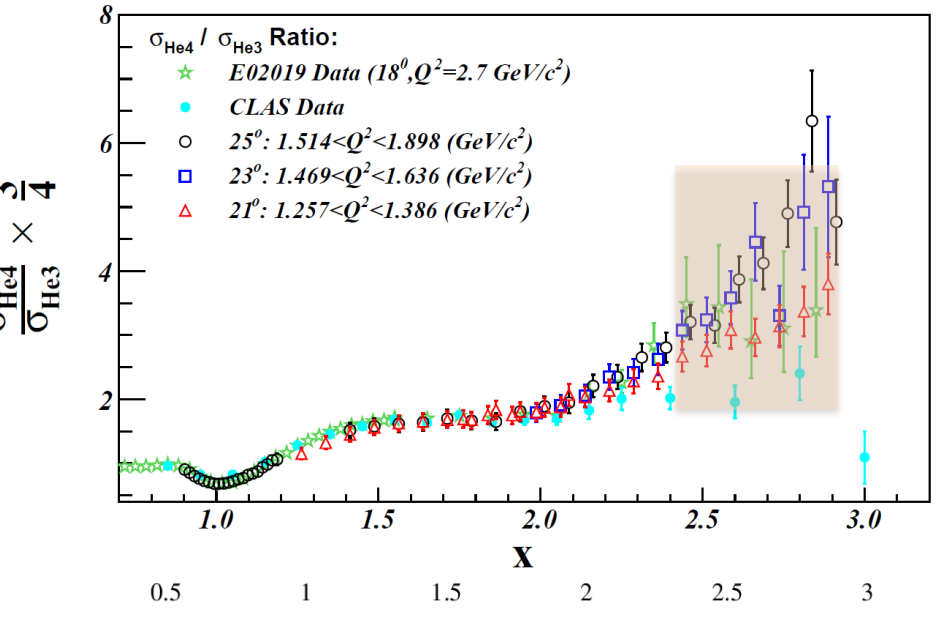
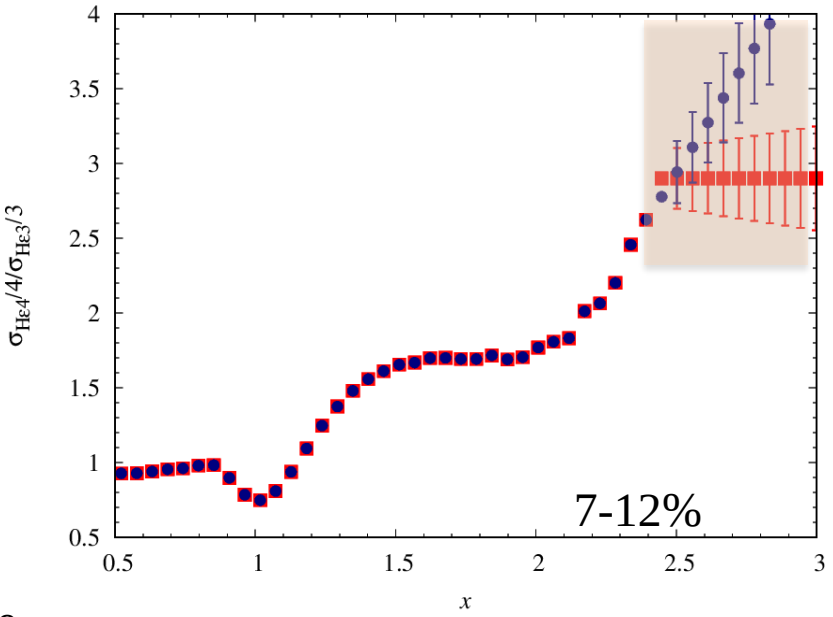
How much data do you really need?

$\frac{\sigma_{4He}/4}{\sigma_{3He}/3}$





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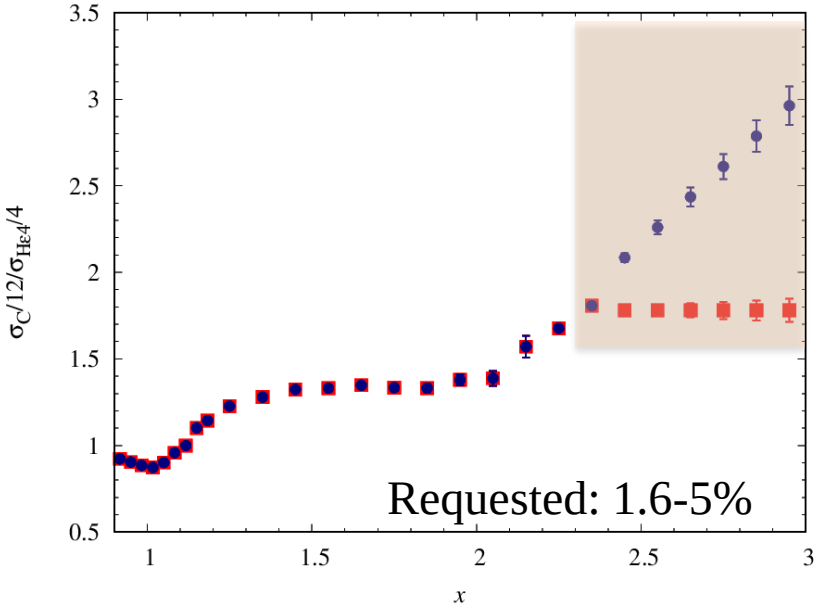
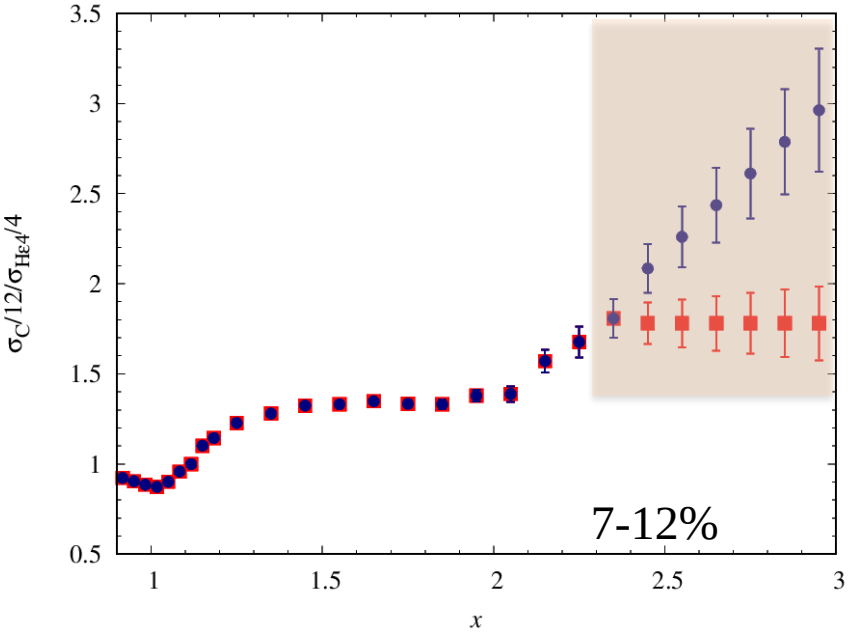
How much data do you really need?

$$\frac{\sigma_C/12}{\sigma_{4He}/4}$$





- Statistics focused on 2.5 < x < 3.0 kinematic range
  The high statistics goal is driven by the prediction from Misak Sargsian of $a_3 \sim (a_2)$
- Projections don't show fluctuations in the data

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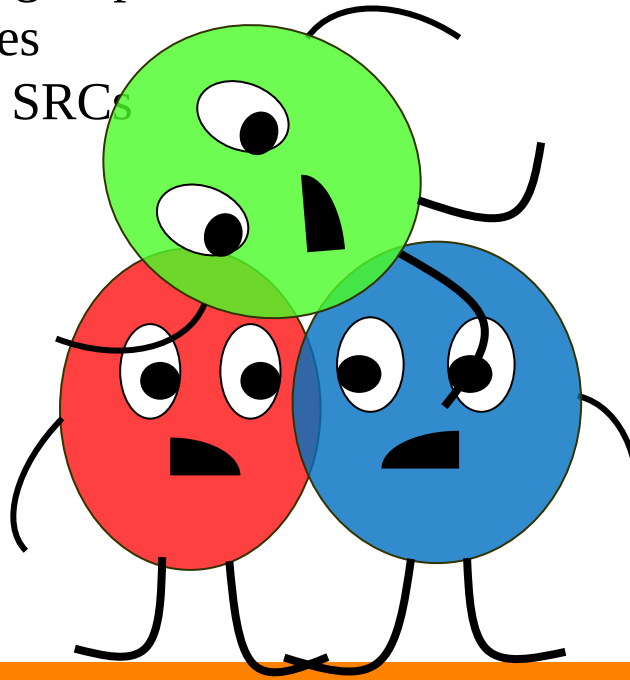
Summary

- No clear advantage to 22 GeV for Quasielastic Scattering Experiments
  - Vital to capitalize on the 11 GeV era for SRC studies
  - Next few years are the last chance to search for 3N SRCs
    - Need a dedicated experiment
      - ***CAN reach necessary kinematics!***
    - Need additional support from theory
      - Misak is our only champion



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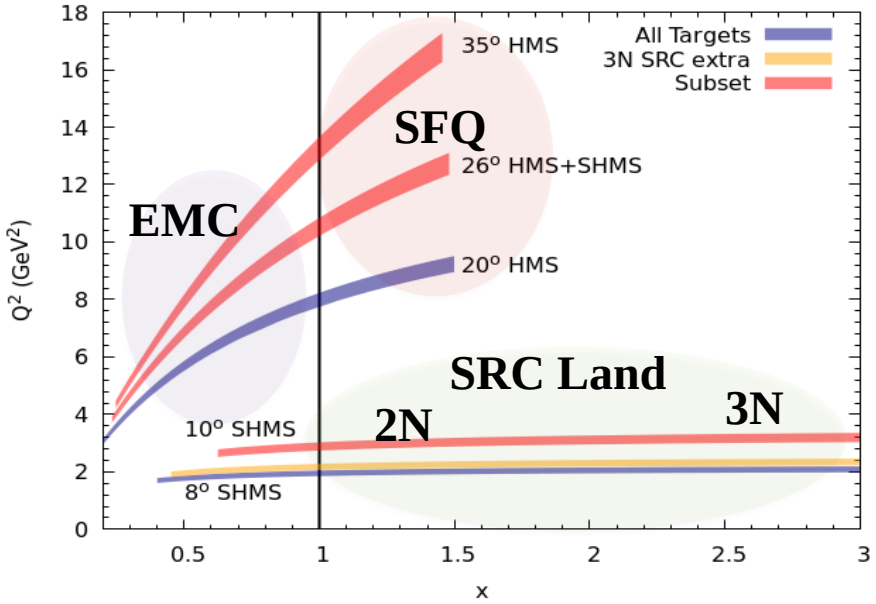
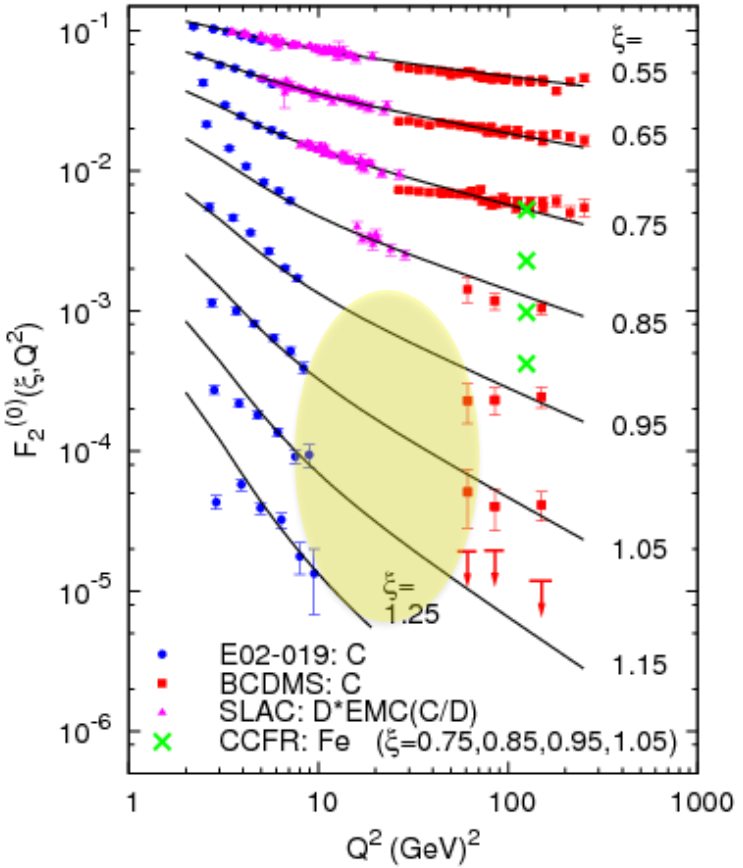
Other fun things at x>1 at high Q^2

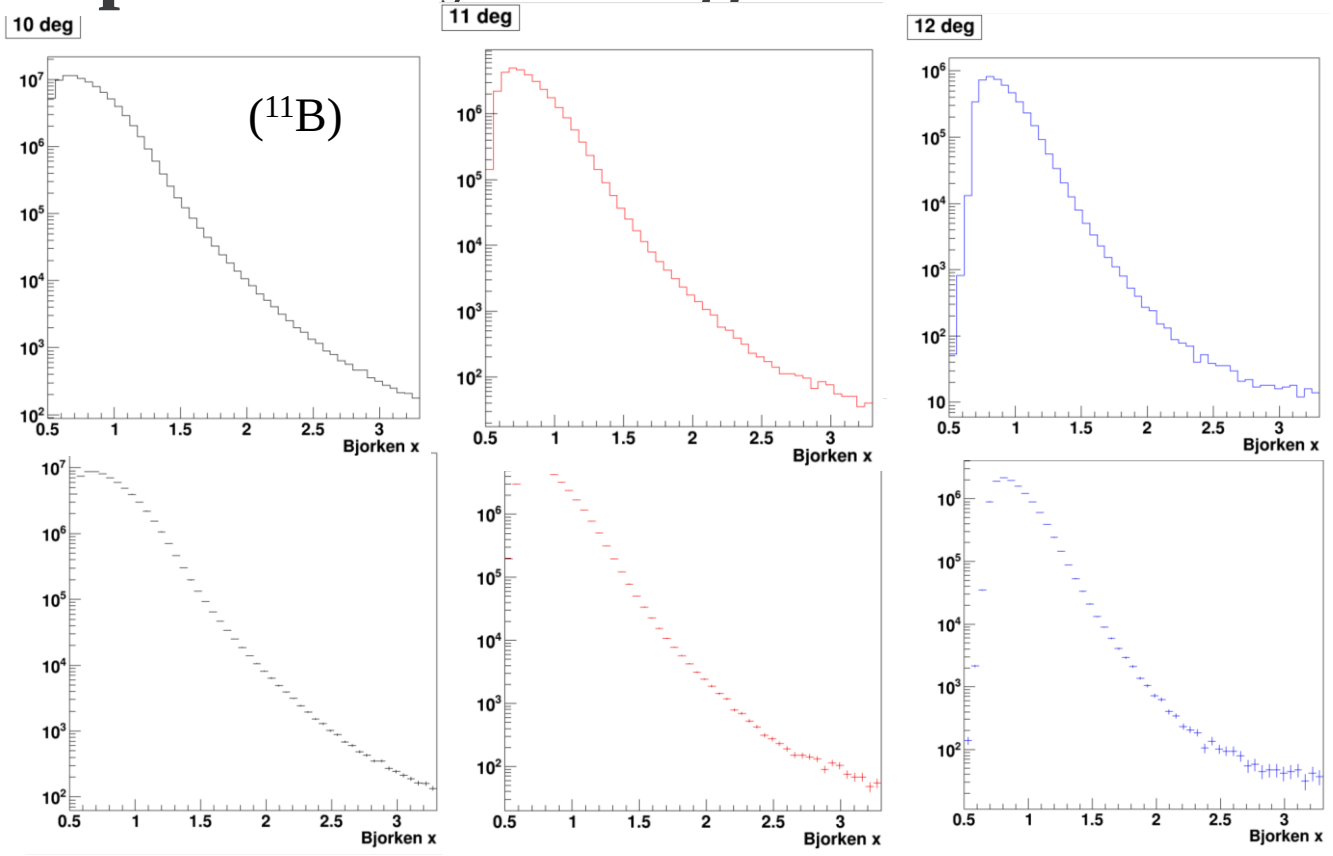
See J. Arrington's talk later





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

Exponentially Falling Cross Section



- Rates in the 2.5<x<3.0 region known from XEM2 for 10 degrees
- Relative scaling based on ^{11}B data for higher angles

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BACKUPS

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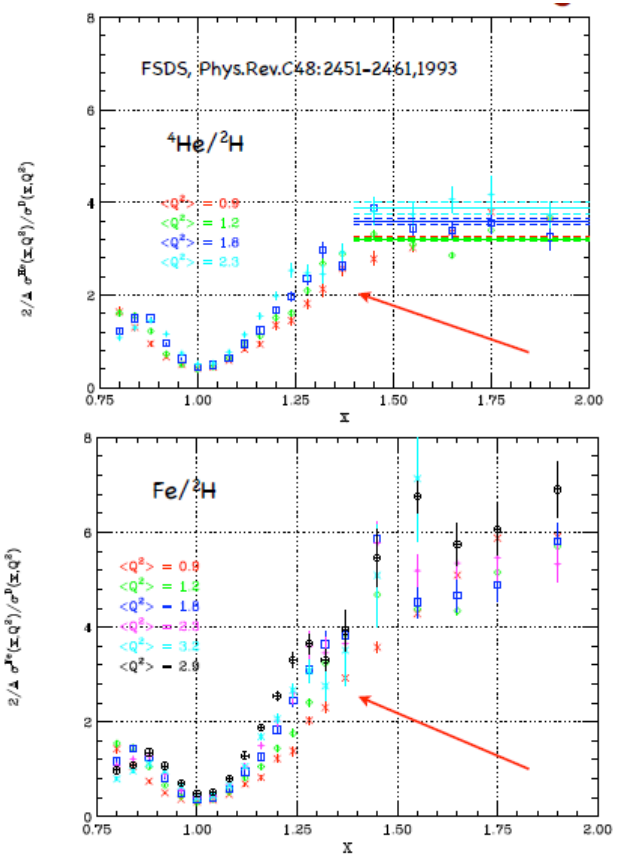
20th Century Data



- Moderate Q^2 data from SLAC
- Originally analyzed in the *y*-scaling picture

$$\sigma(x, Q^2) = \sum_{j=1}^{A} A \frac{1}{j} a_j(A)\sigma_j(x, Q^2)$$

$$= \frac{A}{2} a_2(A)\sigma_2(x, Q^2) +$$

$$\frac{A}{3} a_3(A)\sigma_3(x, Q^2) + ...$$

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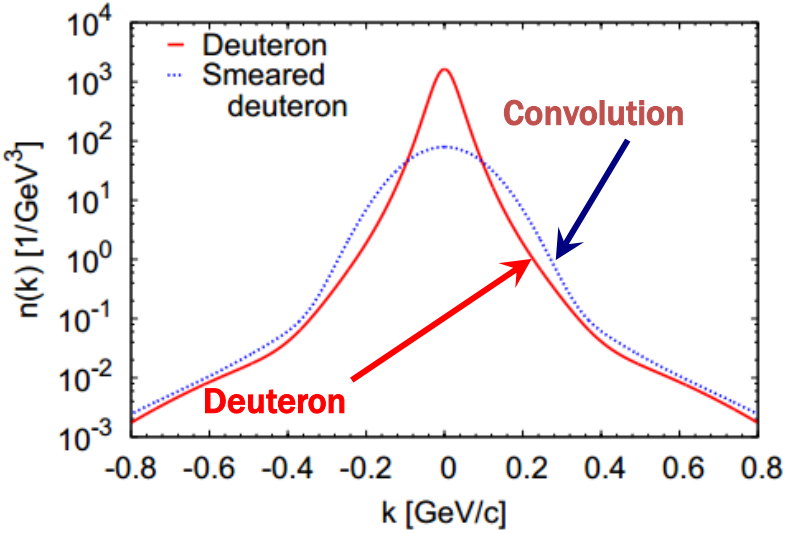
NOTE: $a_2 = \frac{\sigma_A}{\sigma_D}$! =RELATIVE #OF SRCS



$n_D^{CONV}(k)$ is the convolution of $n_D(k)$ with the CM motion of correlated pairs in iron

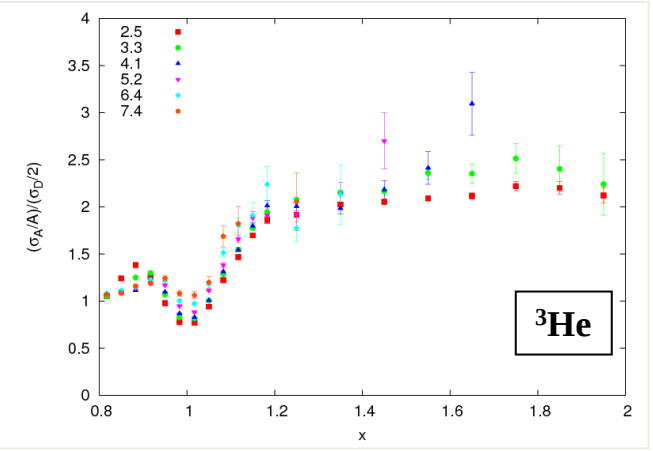
Following prescription from C. Ciofi degli Atti and S. Simula, Phys. Rev. C 53 (1996)

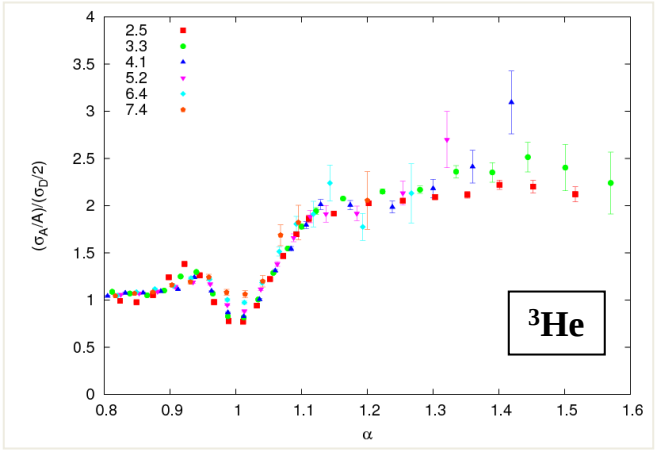
$a_2 = \sigma_A/\sigma_D$ → *relative measure of high momentum nucleons*

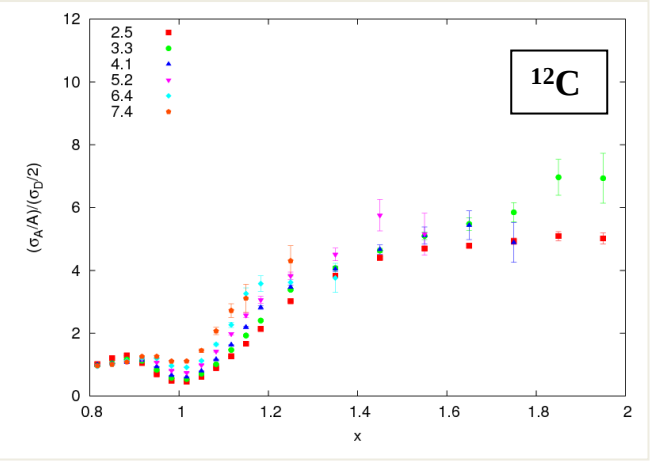
R_{2n} → *relative measure of correlated pairs*

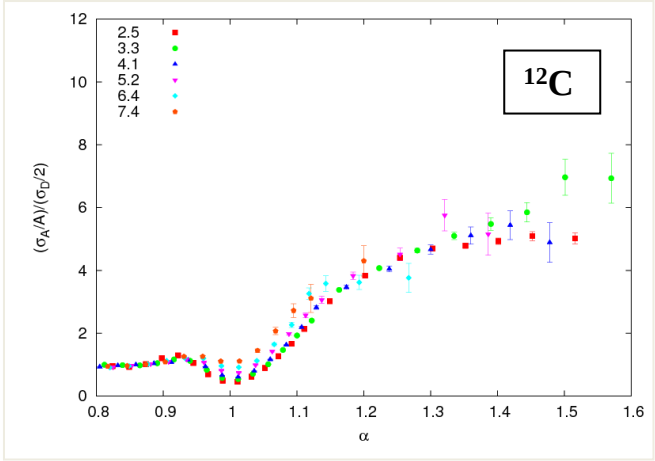
	E02-019	SLAC	CLAS	R_{2N}-ALL	a_2-ALL
^{3}He	1.93±0.10	1.8±0.3	–	1.92±0.09	2.13±0.04
^{4}He	3.02±0.17	2.8±0.4	2.80±0.28	2.94±0.14	3.57±0.09
Be	3.37±0.17	–	–	3.37±0.17	3.91±0.12
C	4.00±0.24	4.2±0.5	3.50±0.35	3.89±0.18	4.65±0.14
Al	–	4.4±0.6	–	4.40±0.60	5.30±0.60
Fe	–	4.3±0.8	3.90±0.37	3.97±0.34	4.75±0.29
Cu	4.33±0.28	–	–	4.33±0.28	5.21±0.20
Au	4.26±0.29	4.0±0.6	–	4.21±0.26	5.13±0.21

Test scaling in x and Q^2





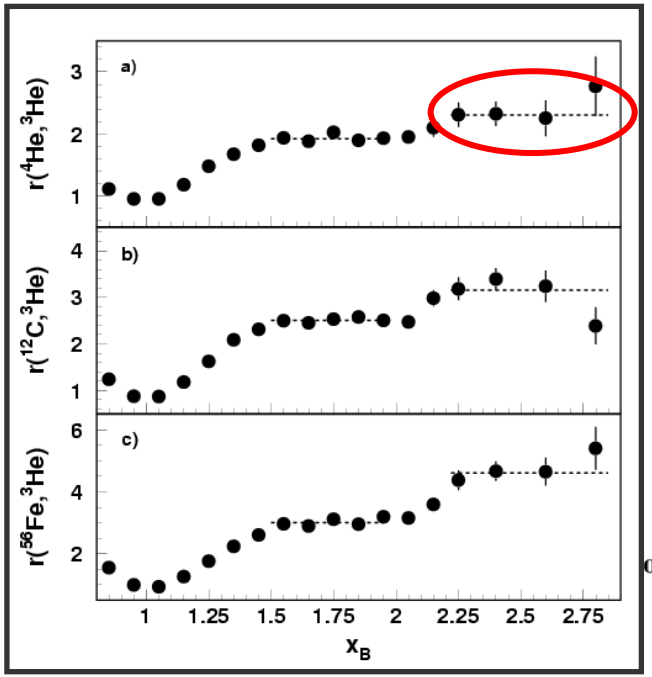


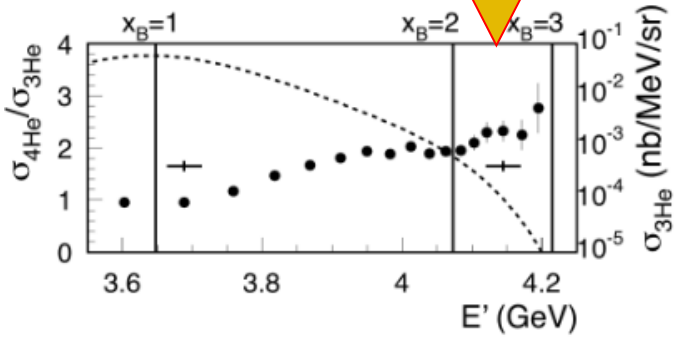


$$\alpha = 2 - \frac{q^- + 2M}{2M}\left(1 + \frac{\sqrt{W^2 - 4M^2}}{W}\right)$$

Phys. Rev. C **48**, 2451(1993)

Have we actually seen 3N SRC in ratios?





omment on "Measurement of 2- and 3-nucleon short range correlation probabilities in nuclei"

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