E08-014:
3-NUCLEON CORRELATIONS

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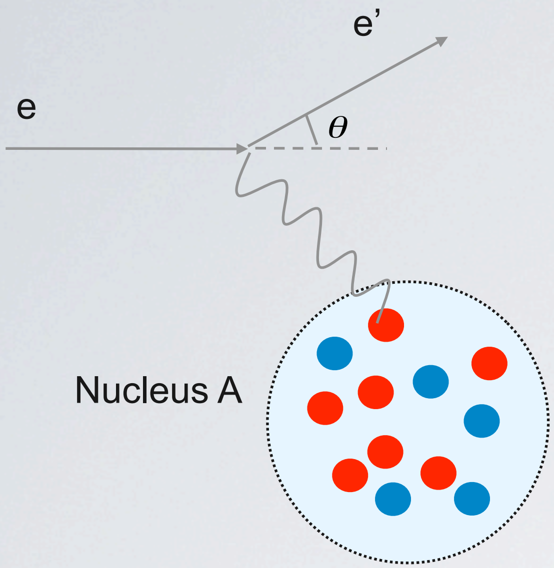
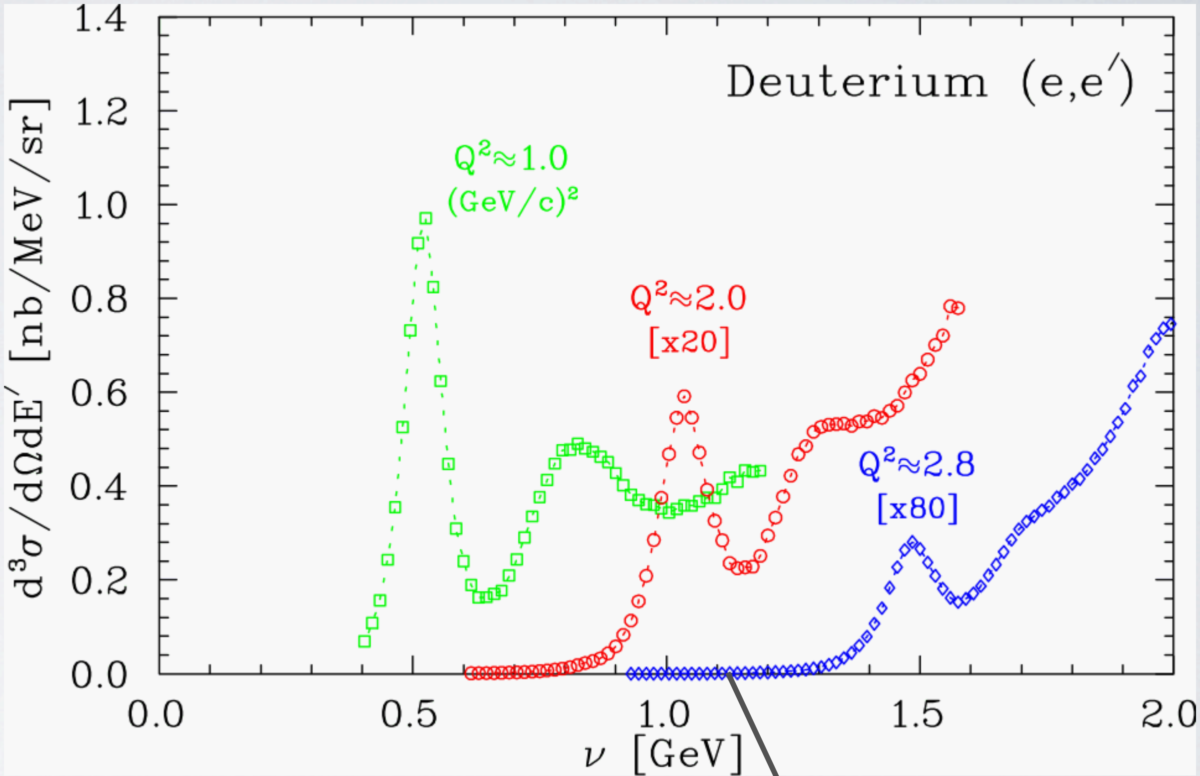
Hall A Collaboration Meeting
December 15-16 2009

INCLUSIVE SCATTERING AT LARGE X





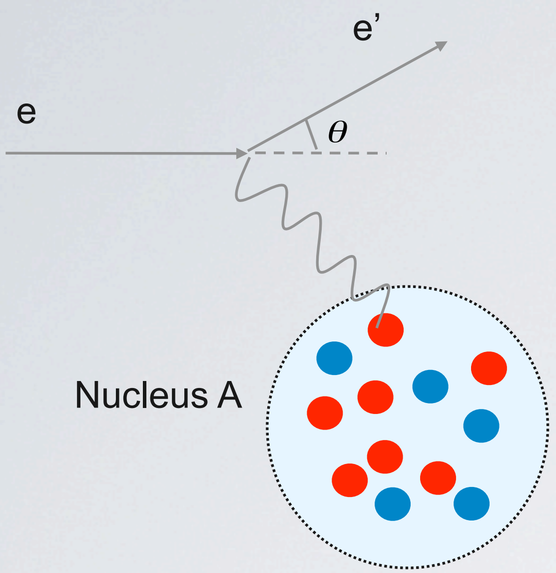
Quasi-Elastic Scattering

$x \approx 1$

Motion of nucleon in the nucleus broadens the peak

High momentum tail

INCLUSIVE SCATTERING AT LARGE X



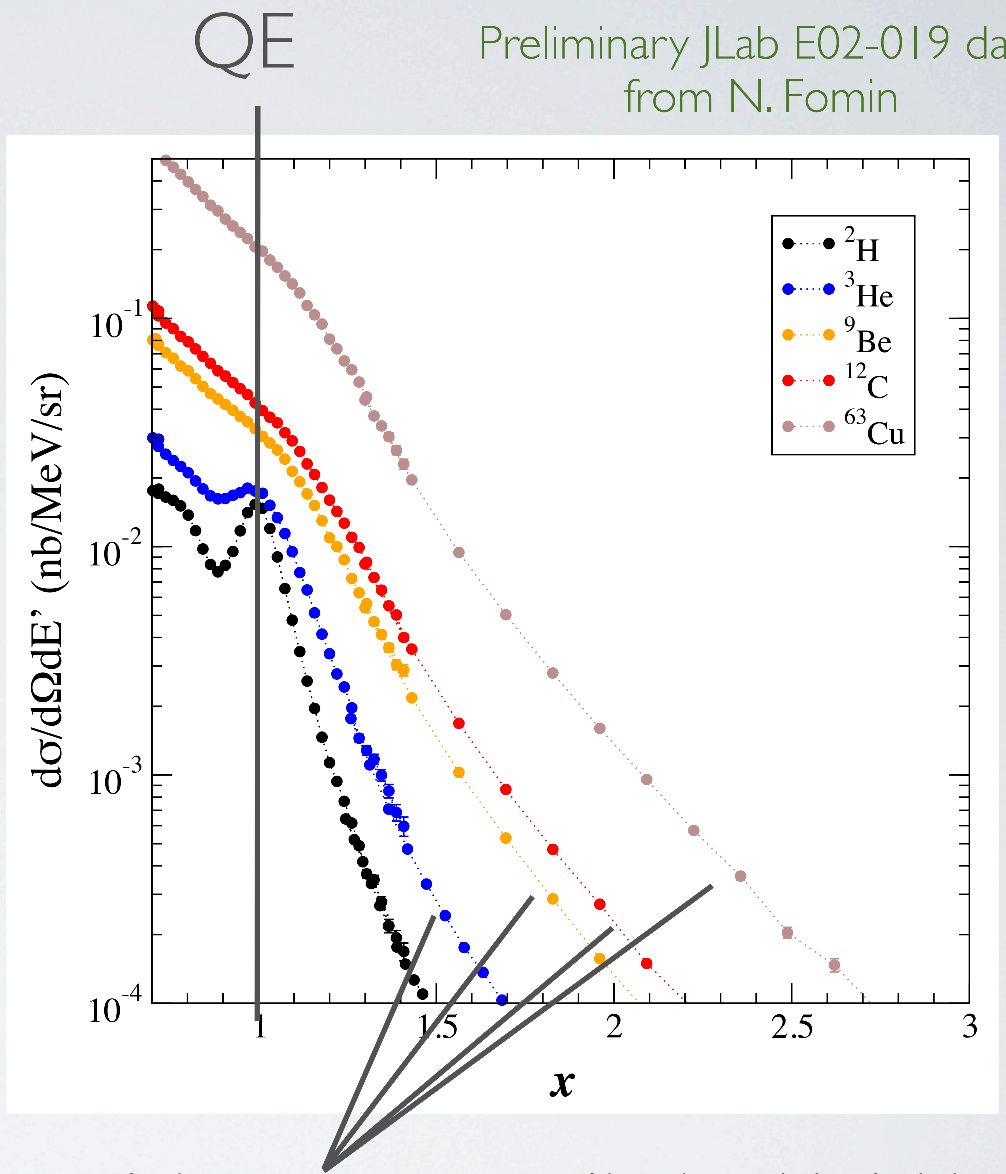
Quasi-Elastic Scattering

$x \approx 1$

Motion of nucleon in the nucleus broadens the peak

little strength from QE above $x \approx 1.3$

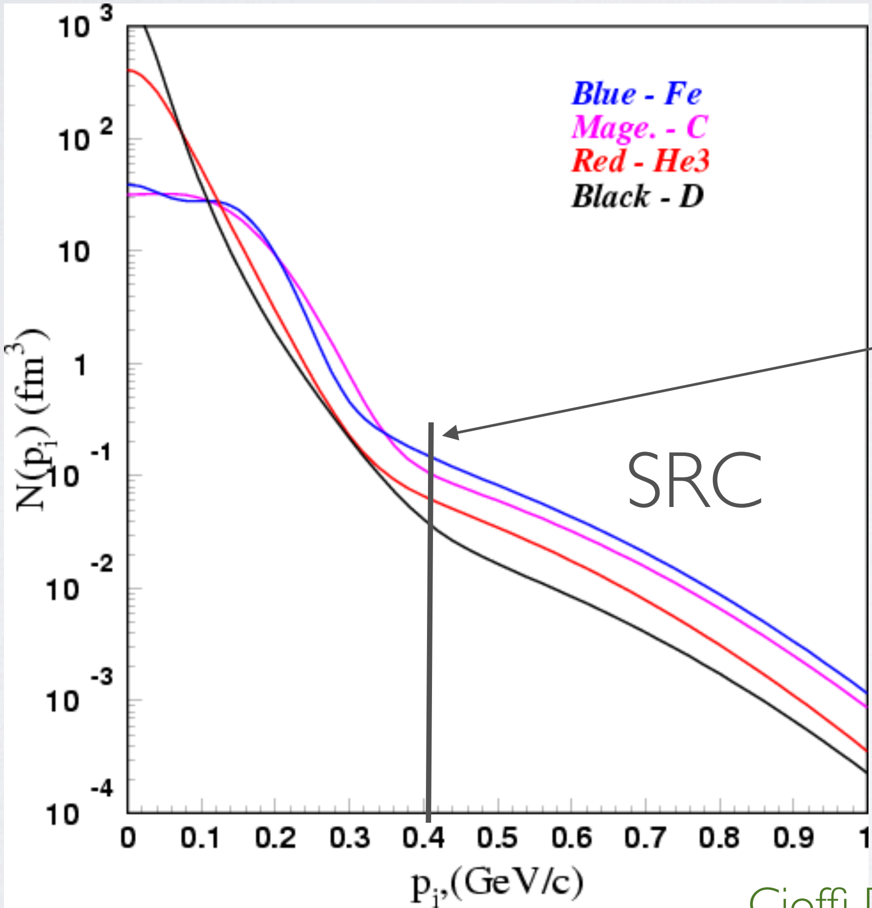
Preliminary JLab E02-019 data from N. Fomin

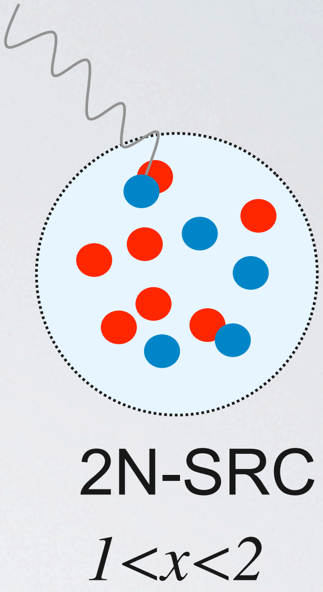


High momentum tails should yield constant ratio if seeing SRC

SHORT-RANGE CORRELATIONS (SRC)

- High-momentum tail dominated by 2N-SRCs
- NN interaction generates high momenta (k>kf)
- Similar shape for k>kf



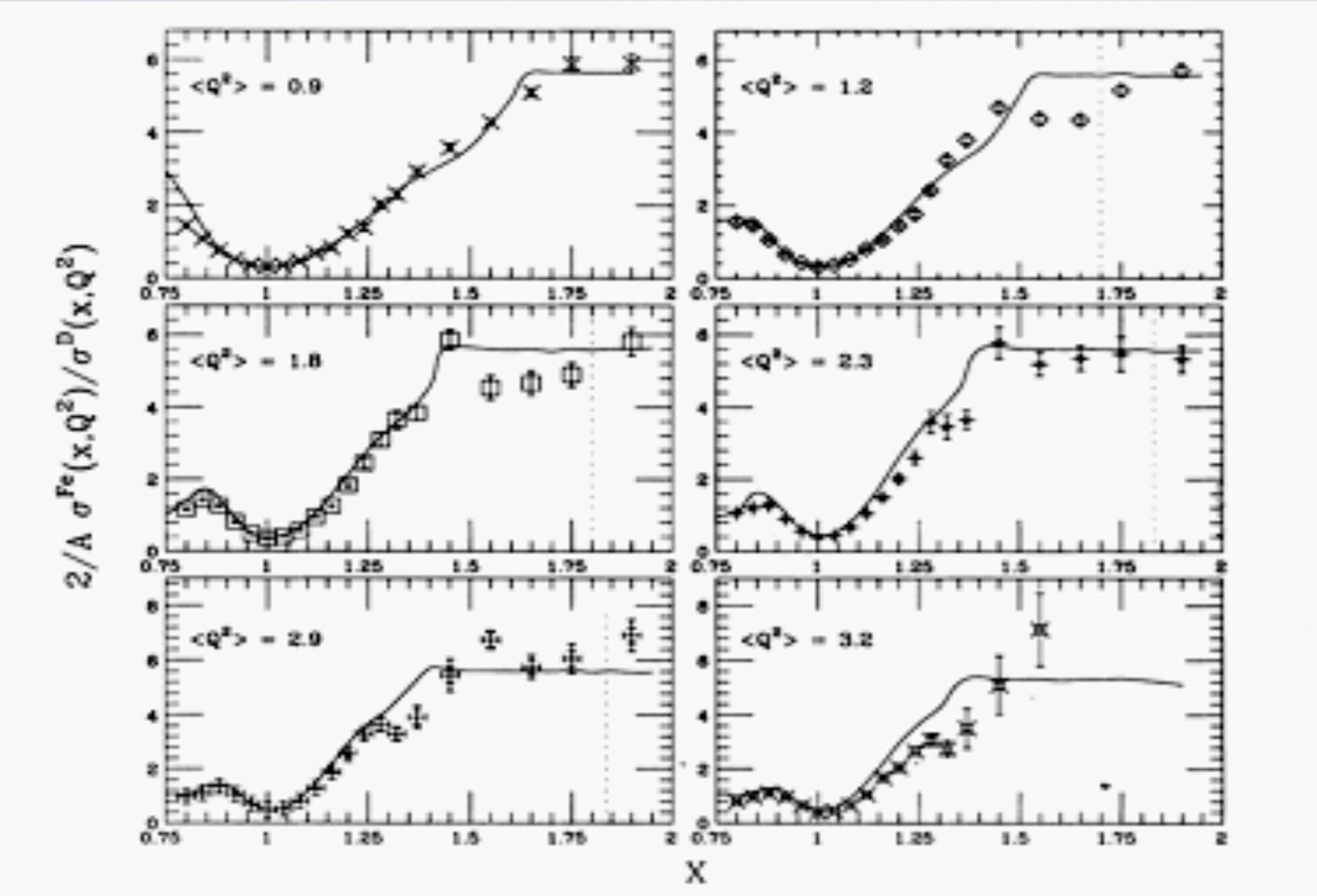


Above: ratio = constant

A(e',e) at x>1:
the simplest way to measure relative probability of SRC

Cioffi Degli Atti et Simula, PRC53, 1689 (1996)

SRC EVIDENCE AT SLAC



Frankfurt, Strikman, Day, Sargsian, PRC48, 2451 (1993)

Ratio in plateau, proportional to the number of 2N SRCs

$a_2(^3He)=1.7\pm0.3$

$a_2(^4He)=3.3\pm0.5$

$a_2(^{12}C)=5.0\pm0.5$

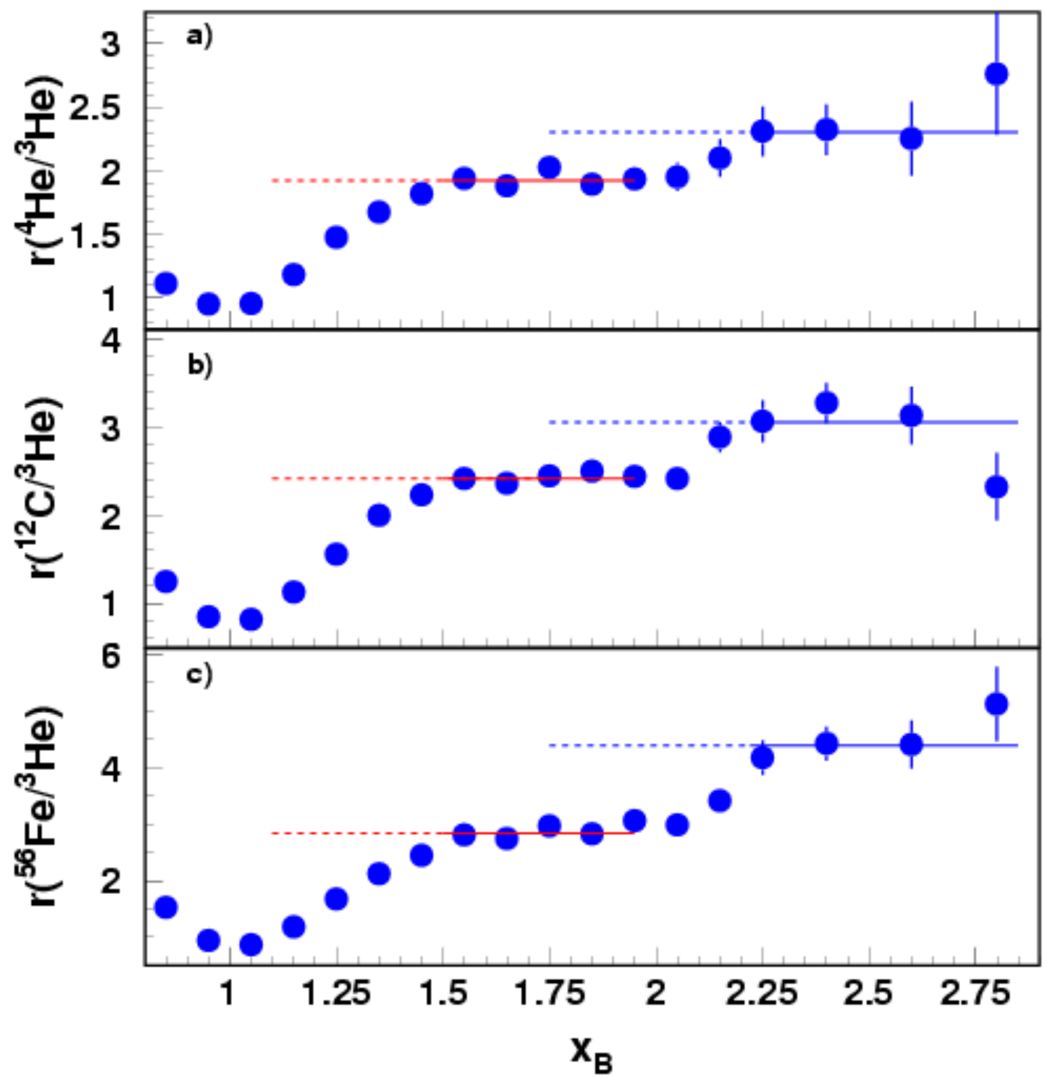
$a_2(^{27}Al)=5.3\pm0.6$

$a_2(^{56}Fe)=5.2\pm0.9$

$a_2(^{197}Au)=4.8\pm0.7$

Ratio of cross section (per nucleon) shows plateau above x ≈1.4, as expected if high-momentum tails dominated by 2N-SRCs

INDICATION OF 3N-SRC FROM CLAS



K. Egiyan et al, PRL96, 082501 (2006)

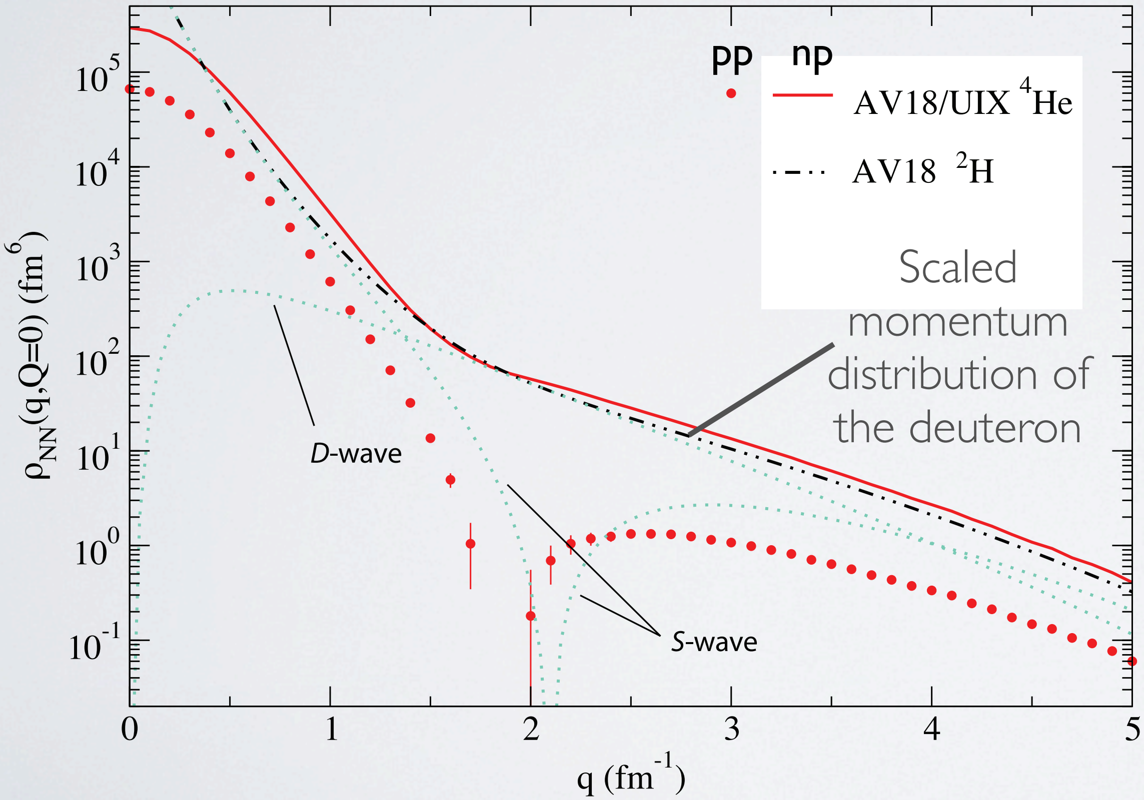
Experimental observations

- ✓ Confirmation of 2N-SRC at x>1.5
- ✓ Indication of 3N-SRC plateau
- ✓ Isospin dependence ?

DOMINANCE OF THE TENSOR FORCE

Simple SRC model assumes isospin independence

R. Schiavilla, R. Wiringa, S. Pieper and J. Carlson, PRL98, 132501 (2007)



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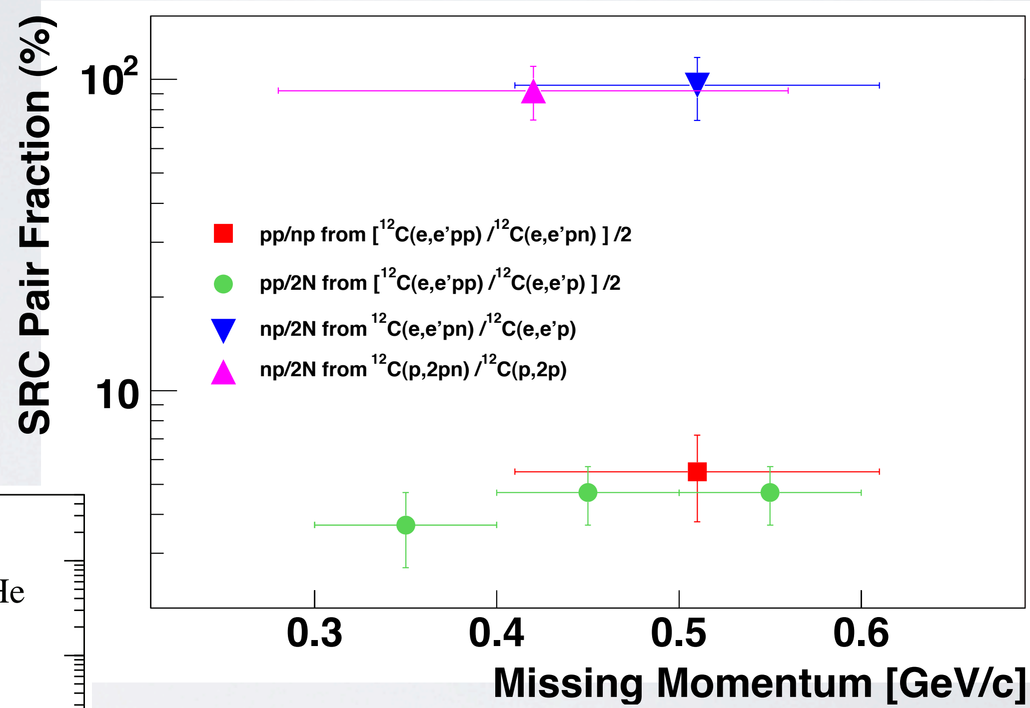
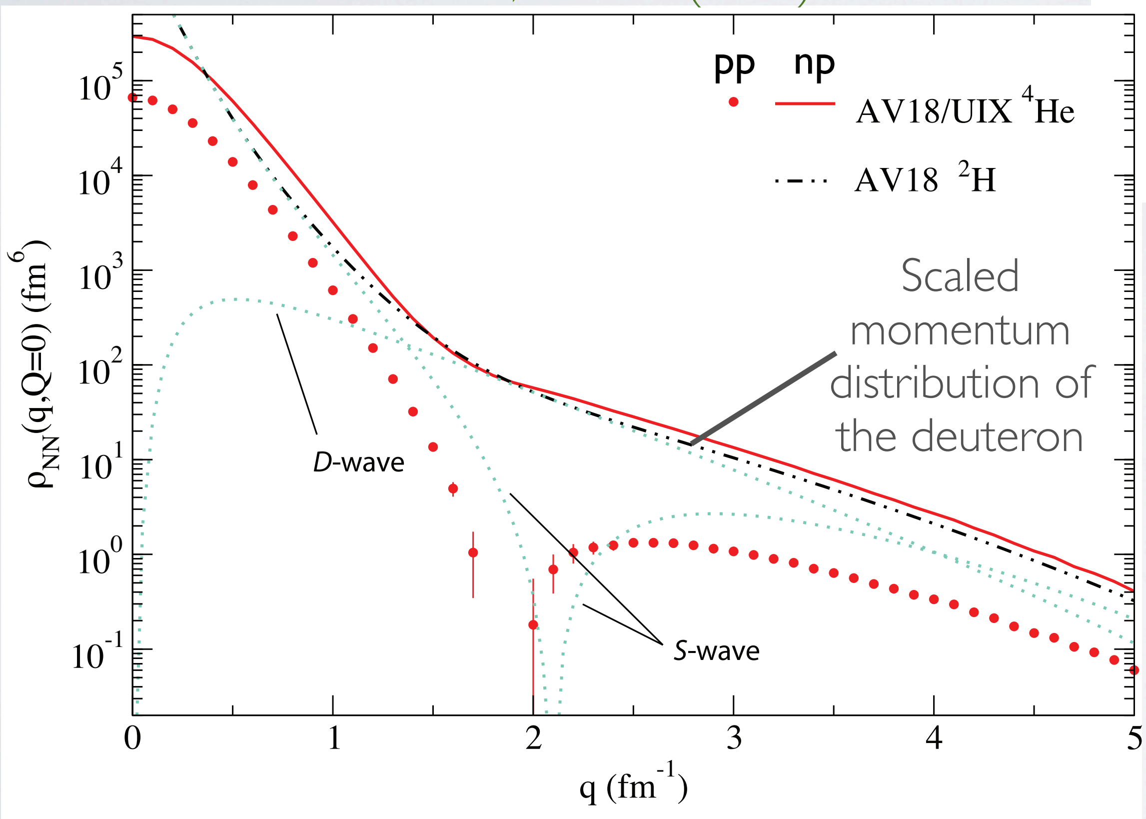




From A(p,ppn) and 12C(e,e'pN): 90% are pn 2-body tensor force leads to dominance of T=0 pairs

SRC ISOSPIN STUDY FROM INCLUSIVE SCATTERING

- Inclusive ratio is 'isospin-blind' (sum of n and p)
- ***Target*** can be isospin sensitive
    - ✓ *Compare ^{40}Ca to ^{48}Ca – approved JLab experiment*
    - ✓ *Compare ^{3}H to ^{3}He – proposed JLab experiment, 12 GeV upgrade*
- n-p pair dominance ➙ equal number of high momentum p, n
- Isospin-independent correlations ➙ Z protons, N neutrons at high p

ISOSPIN STUDY OF SRC

Simple mean field estimates for 2N-SRC

Isospin independent:

$$\frac{\sigma_{48}/48}{\sigma_{40}/40} = \frac{(20\sigma_p + 28\sigma_n)/48}{(20\sigma_p + 20\sigma_n)/40} \xrightarrow{\sigma_p \approx 3\sigma_n} 0.92$$

n-p (T=0) dominance:

$$\frac{\sigma_{48}/48}{\sigma_{40}/40} = \frac{(20*28)/48}{(20*20)/40} = 1.17$$

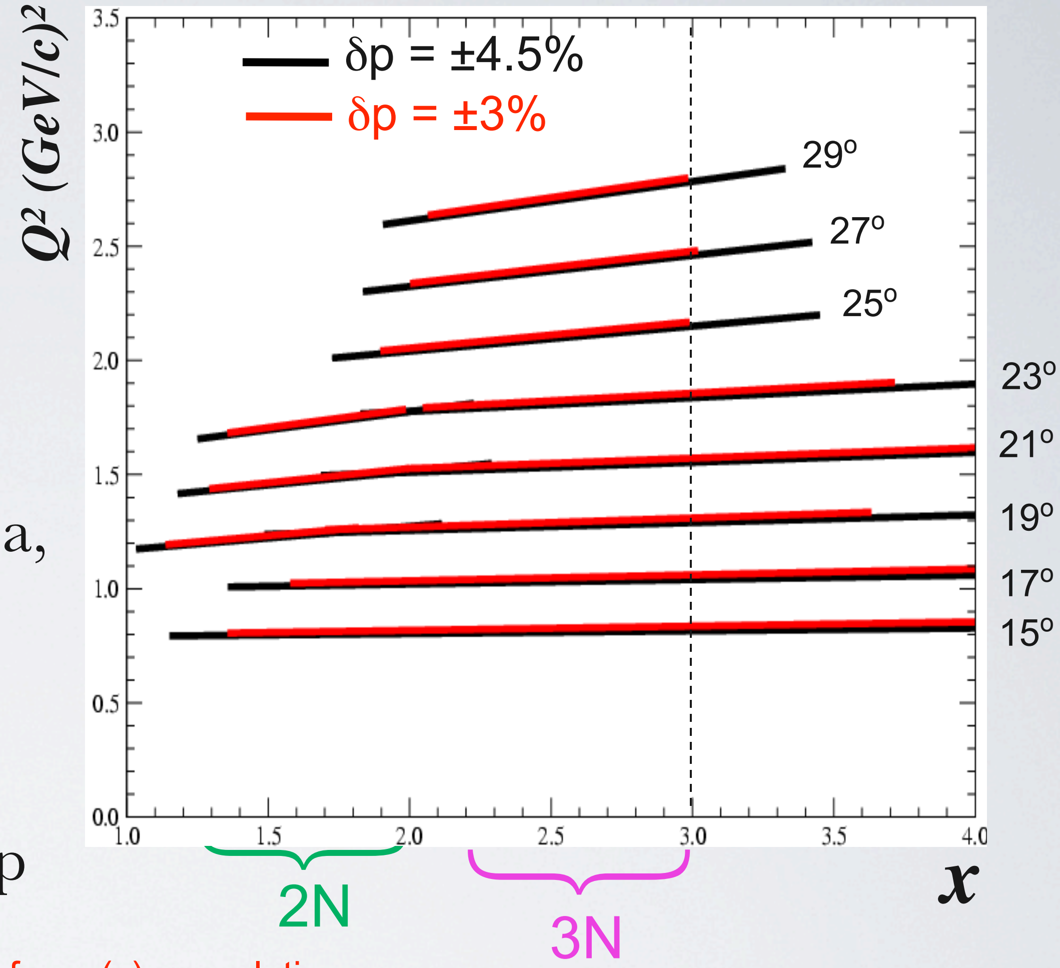
25% difference isospin indep. vs.pn-only (compare to 40% for $^3He/^3H$)

For no extra T=0 pairs with f7/2 neutron:

$$\frac{\sigma_{48}/48}{\sigma_{40}/40} = \frac{\sigma_{40}/48}{\sigma_{40}/40} = 0.83$$

EXPERIMENT E08-014

- Study onset of scaling, ratios as a function of α_{2n} for $1<x<2$



- Verify and define scaling regime for 3N-SRC:
  - 3N-SRC over a range of density: ^{40}Ca, ^{12}C, ^{4}He ratios
  - Test α_{3n} for $x> 2$

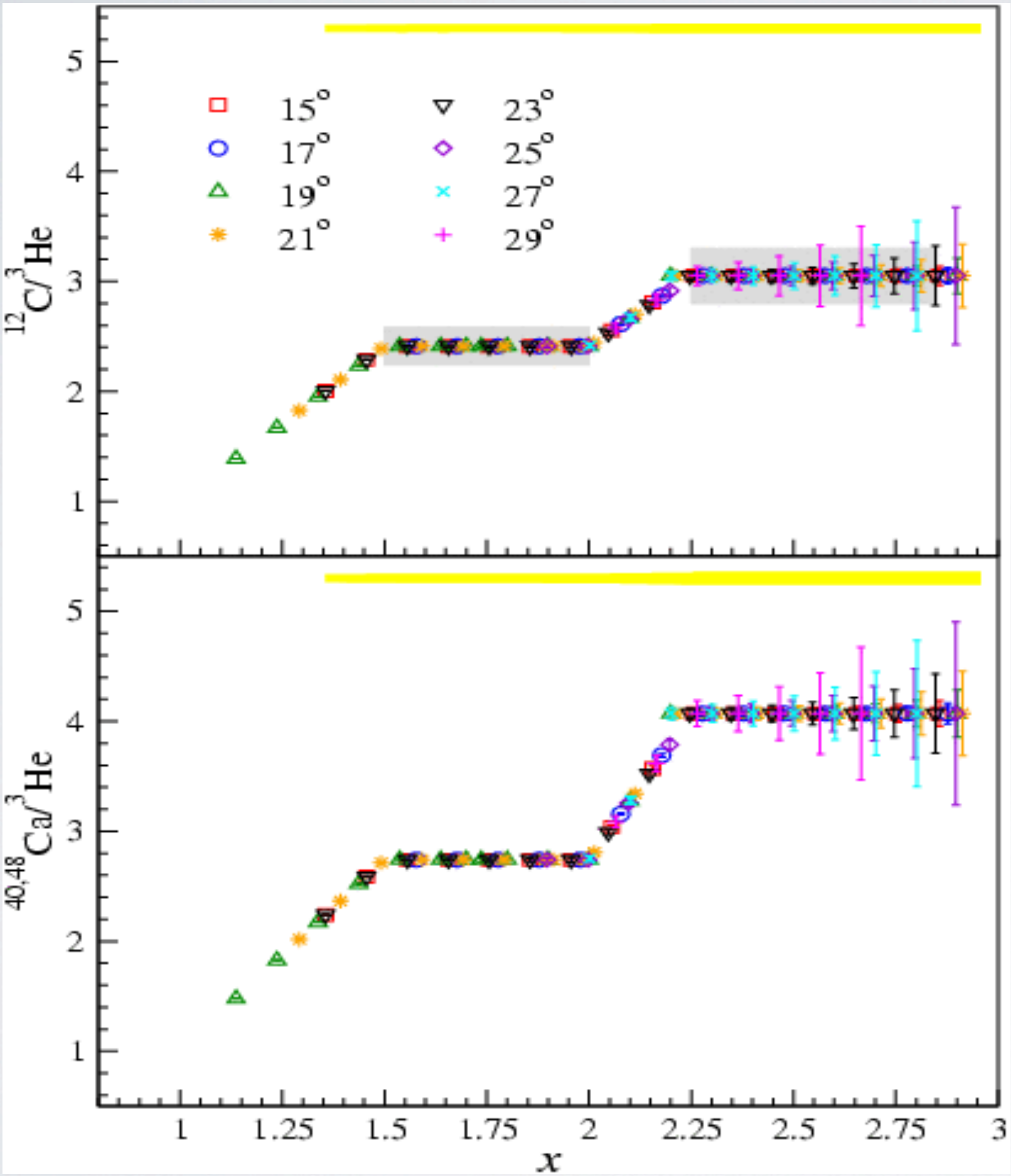
- Absolute cross sections: test FSI, map out IMF distribution $\rho_A(\alpha)$

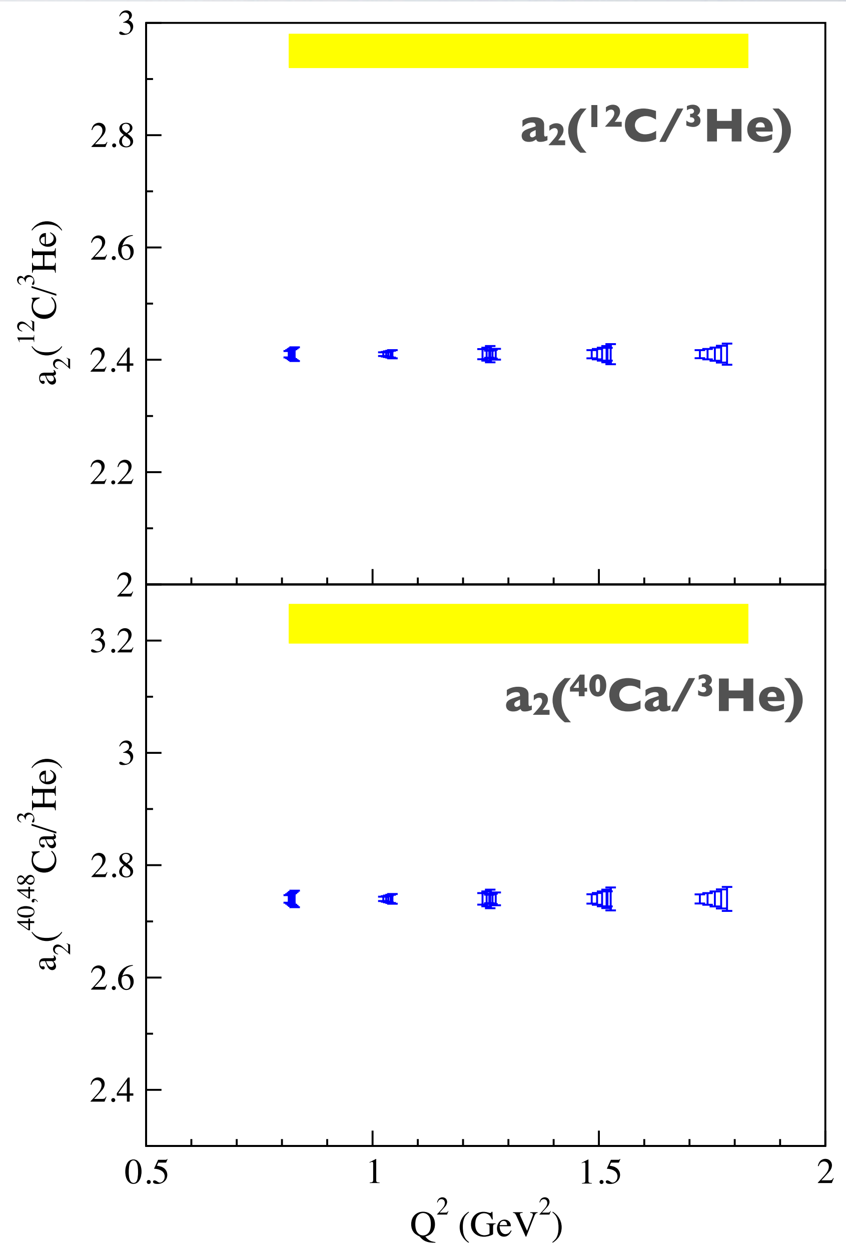
needed for $q_A(x)$ convolution
(EMC, hard processes in A-A collisions, …)

- Isospin effects on SRCs: ^{48}Ca vs. ^{40}Ca

12 days of beam time in Hall A in standard configuration

A/³He RATIO: MAP OUT 2N-SCALING REGION





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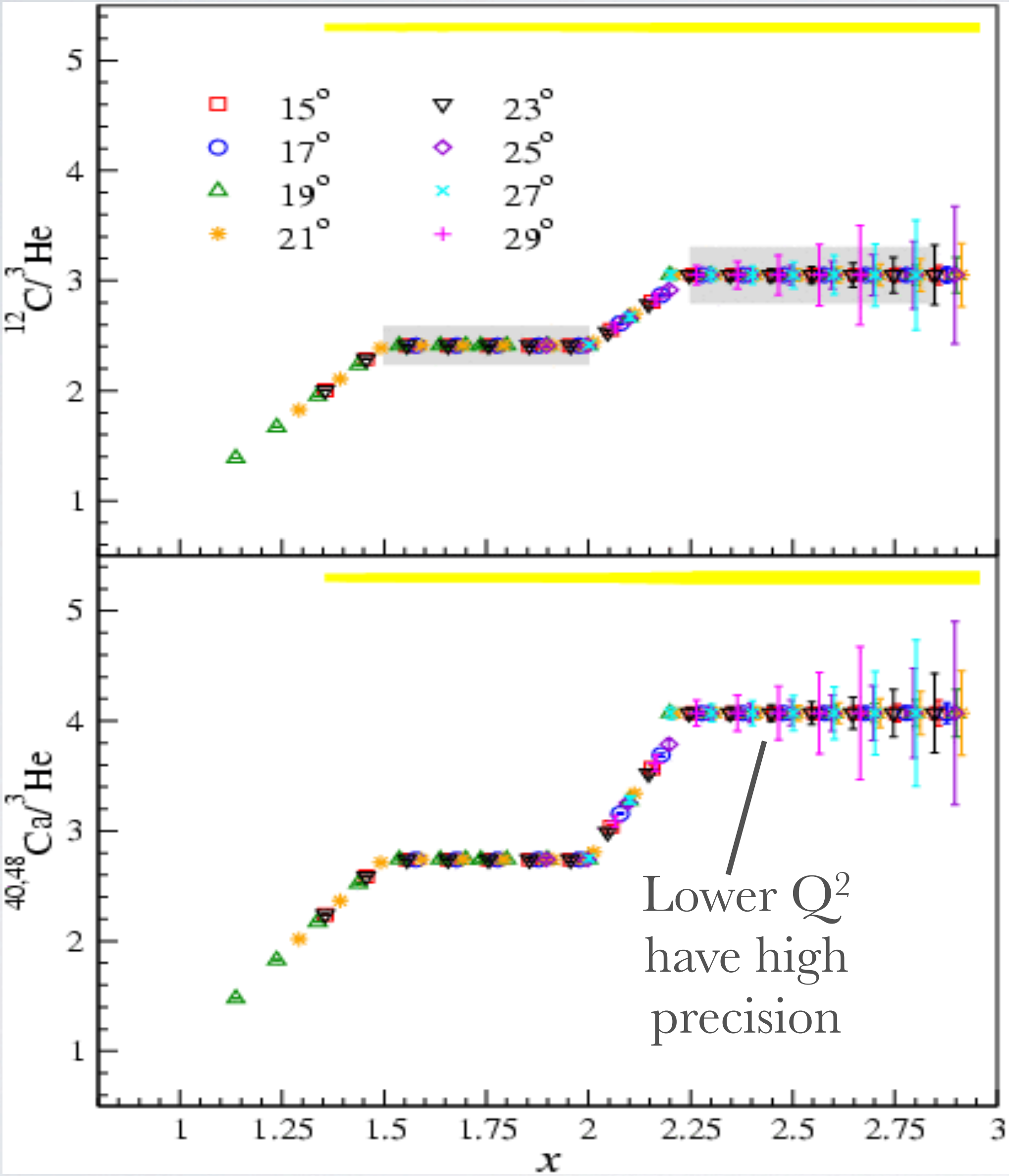
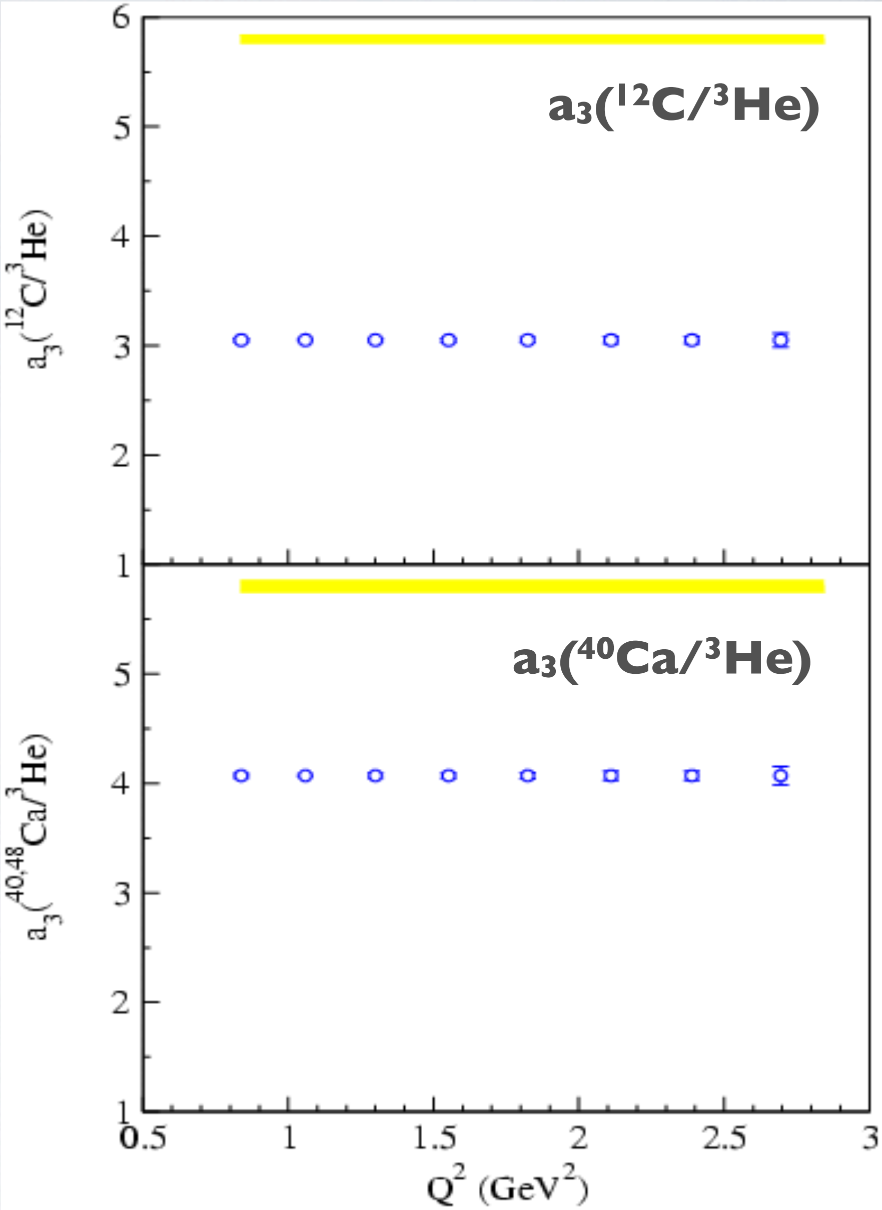


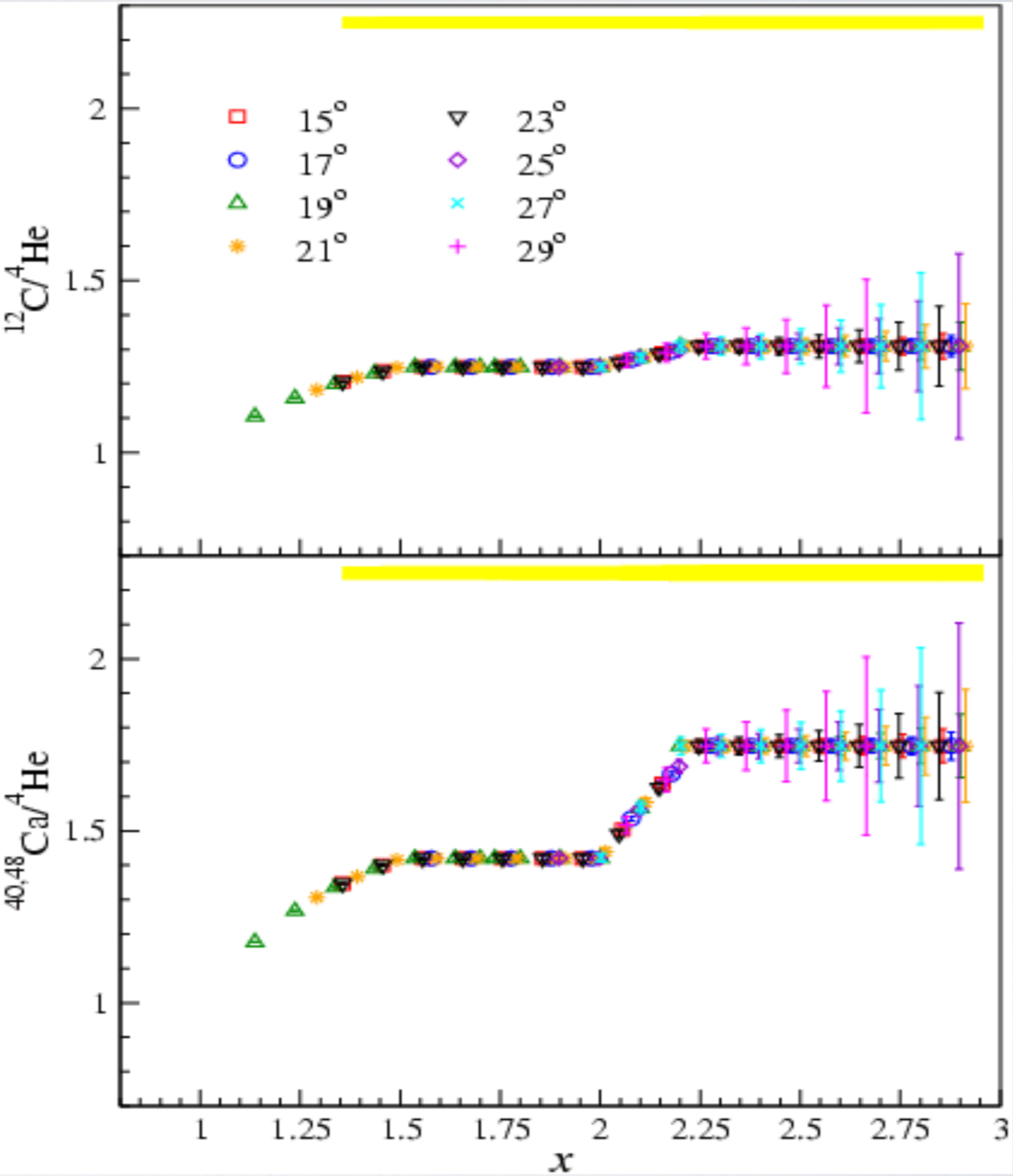


A/⁴He RATIO: MAP OUT 3N-SCALING REGION

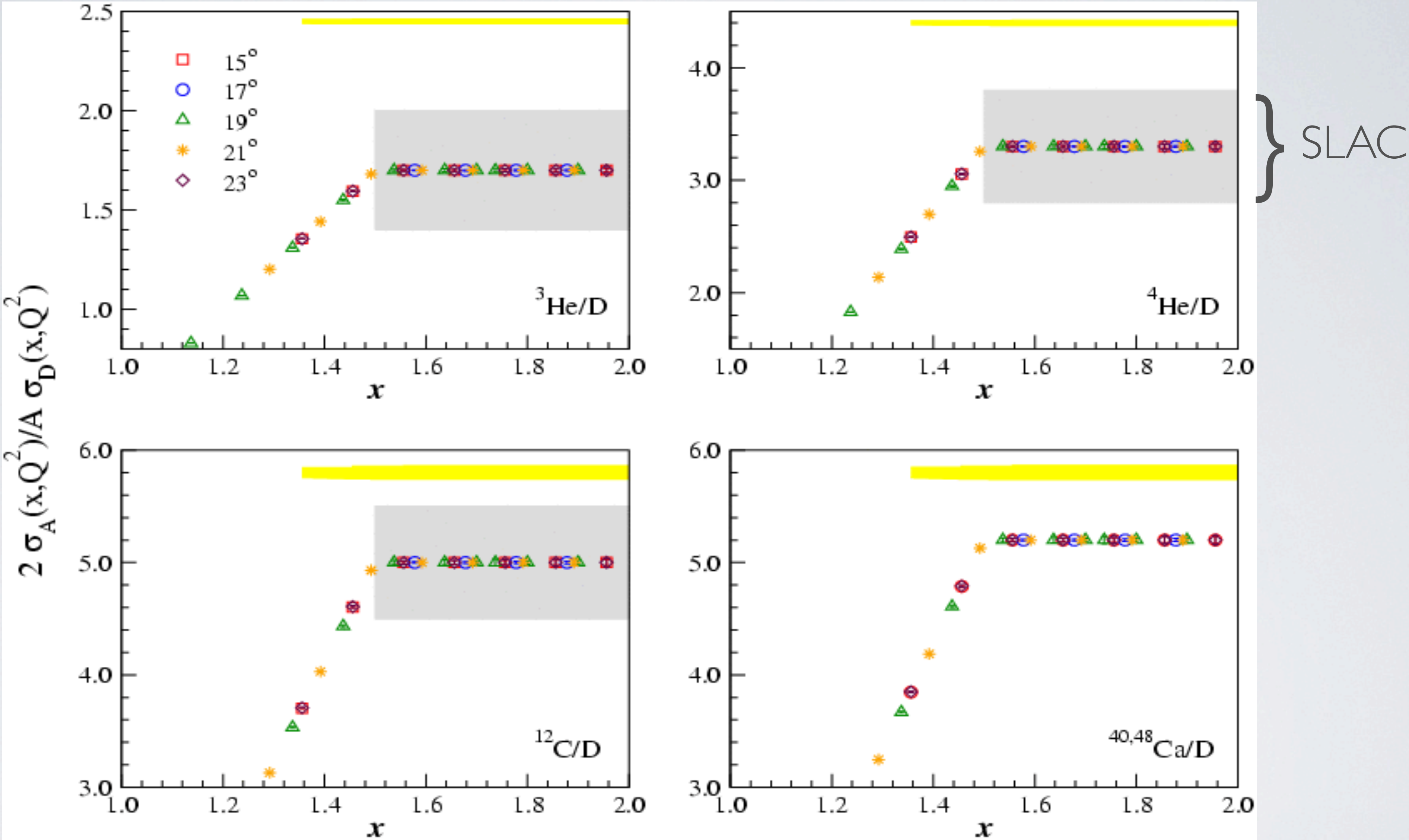
A/ ⁴He ratios

↓

Suppression of the c.m. motion of 3N-SRC



A/D RATIO: MAP OUT SCALING ONSET VS. X, Q^2

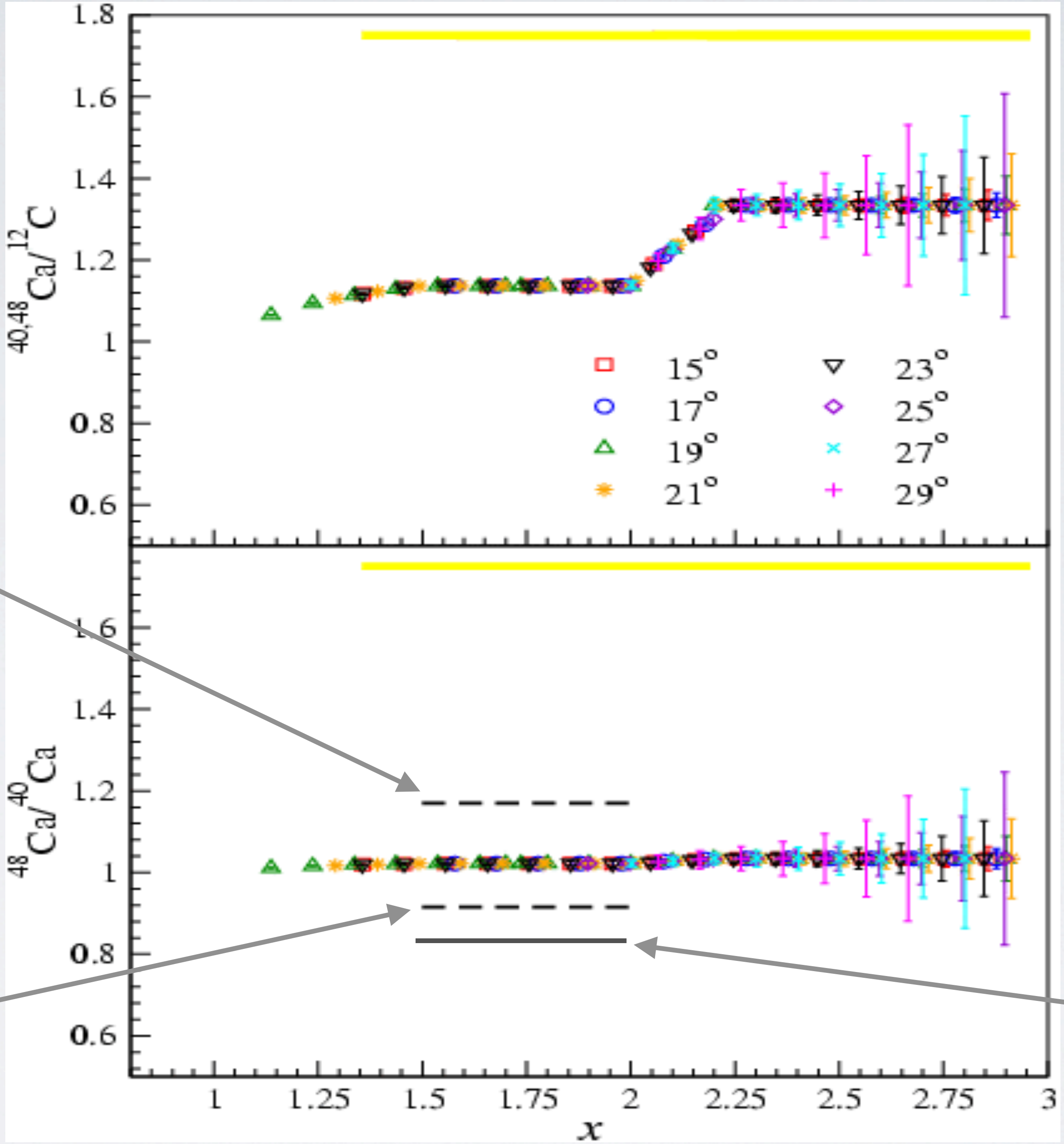


Improved test of scaling and a_2 extraction

Add heavy isoscalar study

1.2-2.8% scale uncertainty not shown

ISOSPIN STUDY FROM $^{48}Ca/^{40}Ca$ RATIO



Mean field prediction for pn-dominance in 2N-SRC

Mean field prediction for isospin independence in 2N-SRC

No extra n-p pair

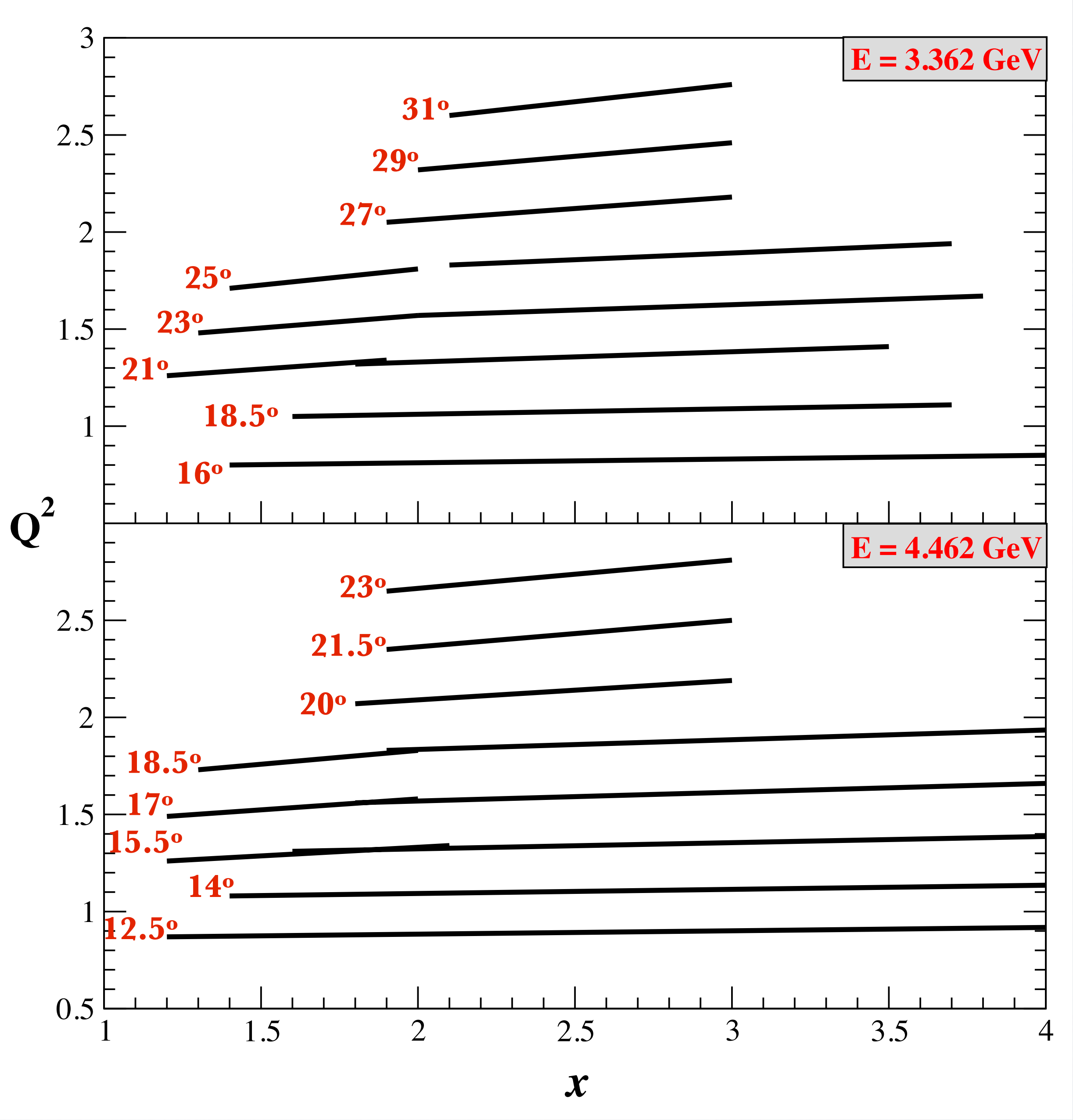
TARGET SPECS

Target	T(K), P(psia), L(cm)	Thickness(g/cm^2)
^{2}H	22.0, 22.0, 20.0	3.35
^{3}He	8.0, 200.0, 20.0	1.38
^{4}He	8.0, 200.0, 20.0	2.28
Al Entrance	N/A, N/A, 0.035	0.09
Al Exit	N/A, N/A, 0.035	0.09
Al Wall	N/A, N/A, 0.035	0.09

Target	T (K)	P (psia)	length (cm)	RL (g/cm^2)	I^{limit} (μA)
^{2}H	22.0	22.0	20.0	3.35	60.0
^{3}He	8.0	200.0	20.0	1.38	60.0
^{4}He	8.0	200.0	20.0	2.28	60.0
	thickness (cm)				
^{12}C	0.50			0.95	80.0
^{40}Ca	0.43			0.66	40.0
^{48}Ca	0.43			0.66	40.0

RUNNING DURING QWEAK

2 possible incident energies:
~3.362 and 4.462 GeV



RUNNING DURING QWEAK

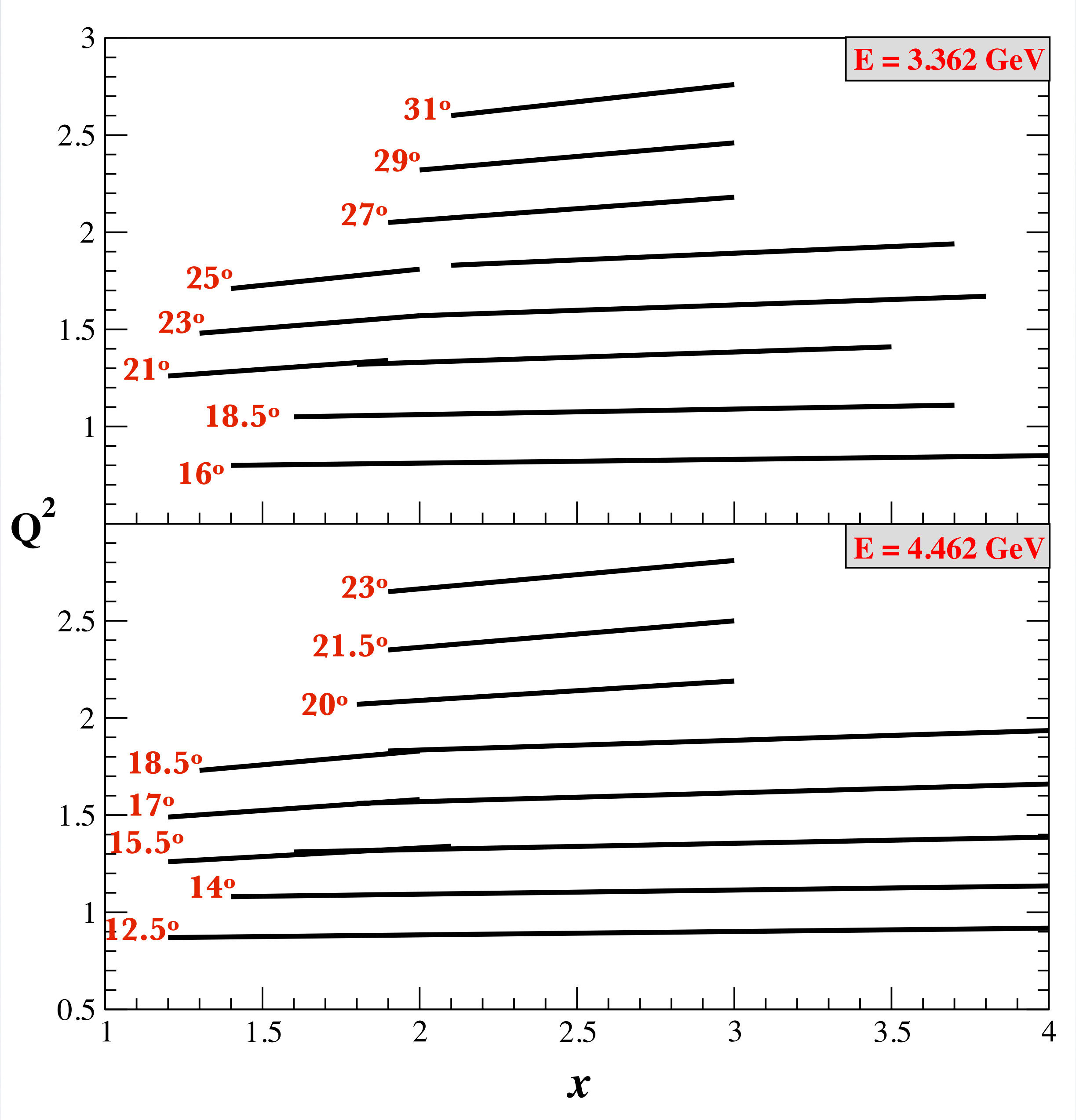
2 possible incident energies: ~3.362 and 4.462 GeV

For the same physics goal and uncertainties:

- at 3.362GeV → 2 HRSs:
  14 (prod.) + 4 (over.) days

- at 4.462GeV → left HRS:
  19 (prod.) + 3.5 (over.) days

At the optimized energy of the proposal (3.6GeV):
10 (prod.) + 3 (over.) days



OVERHEAD ESTIMATE (QWEAK ENERGIES)

Increased overhead due to coolant constraints: one cryo-target cooled at a time.

	Estimate	3.362 GeV time(hrs)	4.462 GeV time(hrs)
HRS angle change	0.5hr/change	2.5 (5 changes) $\times$ 3(or 4)	3.5 (7 changes) $\times$ 3(or 4)
Target motion	10min/motion	6.7	7.3
Cryo-target change	8hr/change	16	16
Optics	0.5hr/angle	3.5	4
Dummy run	15% of ^{3}He time	32.5	22
BCM calibration		2 $\times$ 1	
Energy measurement		1 $\times$ 2	
Boiling study		8	
Rate-dependence tests		4	
Intial checkout		8	
TOTAL		90	84

Unofficial estimates are that we'll likely be running at 20% of proposed luminosity or lower for ^{3}He

SUMMARY

Inclusive scattering measurements from E08-014 (and PR09-010) will produce a detailed study of:

➡ **Q^2 dependence of 2N, 3N-SRC from A/^{2}H, A/^{3}He and A/^{4}He ratios**

➡ **Study of isospin dependence of 2N-SRC**

➡ **Look at isospin dependence in 3N-SRC region**

➥ Nice complement to the results of 2N knock-out experiments

E08-014 is scheduled to run in Spring 2011

ISOSPIN STUDY FROM ^{3}He/^{3}H RATIO

Simple mean field estimates for 2N-SRC

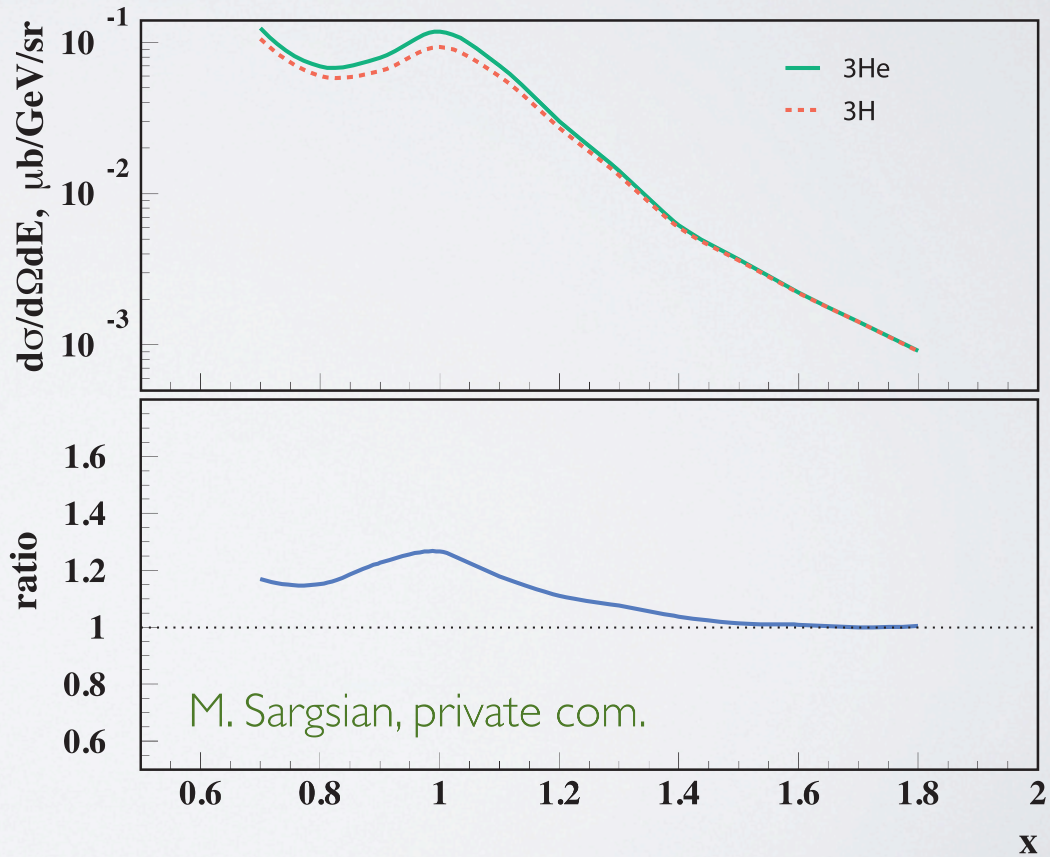
Isospin independent:

$$\frac{\sigma_{^3He}/3}{\sigma_{^3H}/3} = \frac{(2\sigma_p + 1\sigma_n)/3}{(1\sigma_p + 2\sigma_n)/3} \xrightarrow{\sigma_p \approx 3\sigma_n} 1.40$$

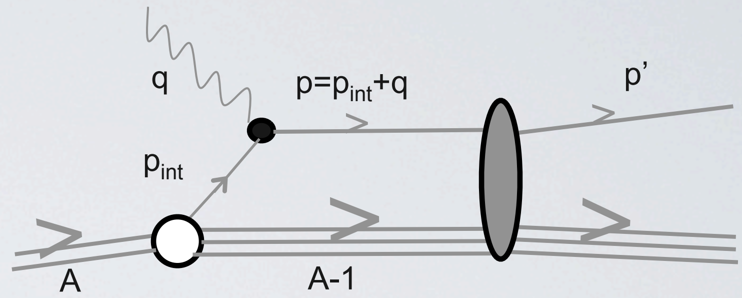
n-p (T=0) dominance:

$$\frac{\sigma_{^3H}/3}{\sigma_{^3He}/3} = \frac{(2pn + \not{1nn})/3}{(2pn + \not{1pp})/3} = 1.0$$

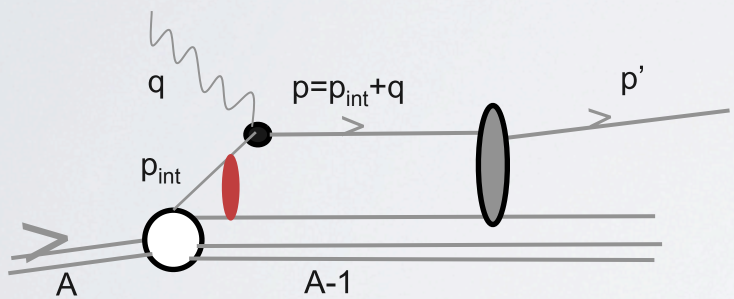
Inclusive cross section calculation from M. Sargsian using AV18/UIX

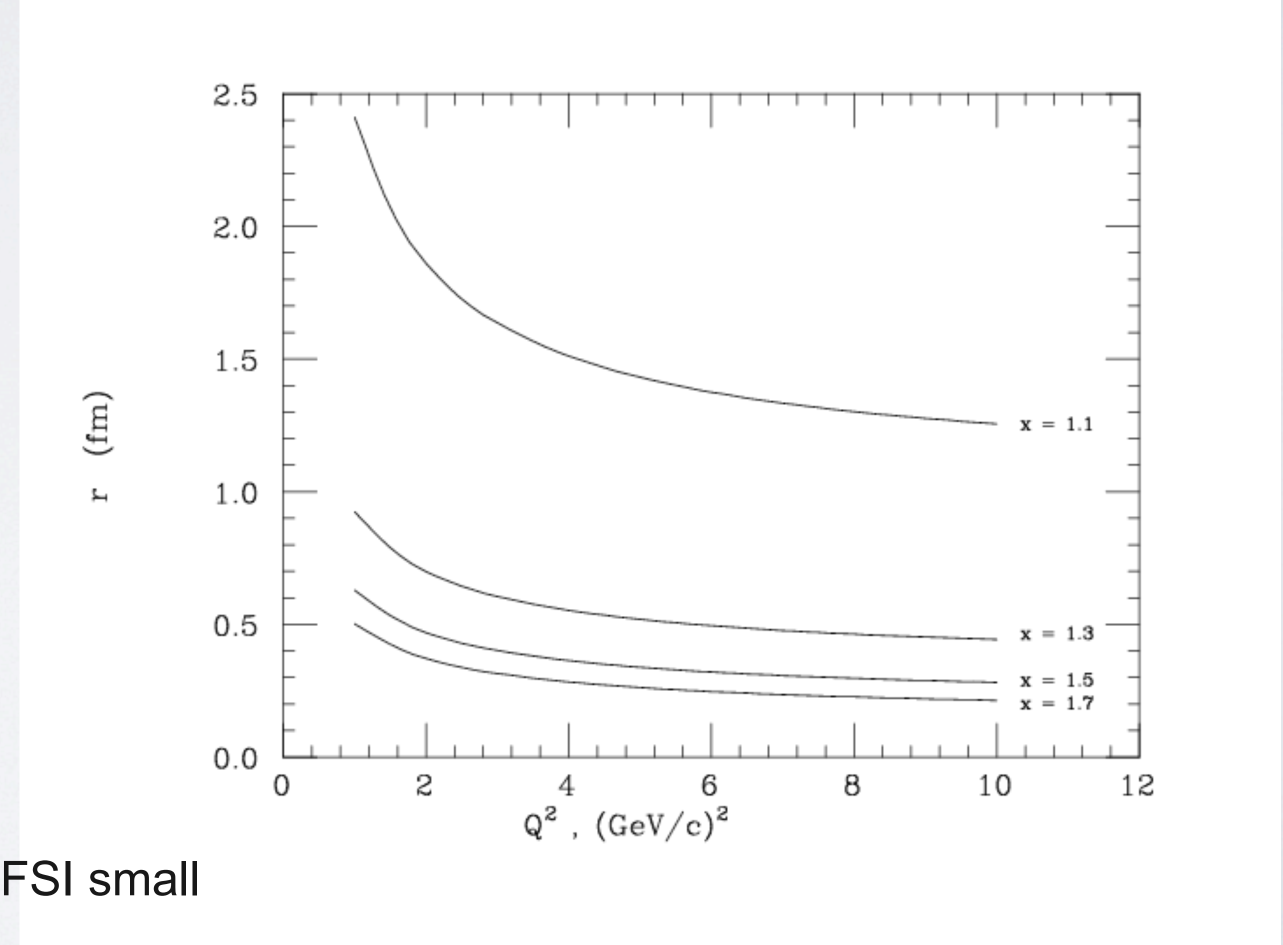


FINAL STATE INTERACTIONS



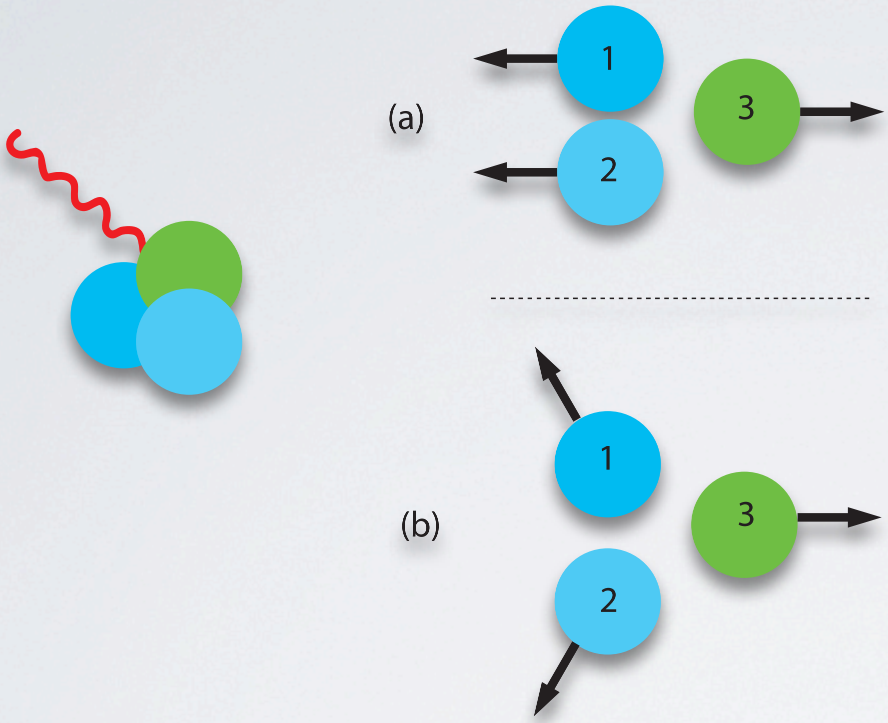
- GEA very successful in A(e,e'p)
- GEA predicts FSI:
  1. small
  2. A-independent
  3. conserve α





Inclusive data in deuterium support FSI small

3N-SRC CONFIGURATIONS



$p_3 = p_1 + p_2$

extremely large momentum

"Star-configuration"

$p_1 = p_2 = p_3$

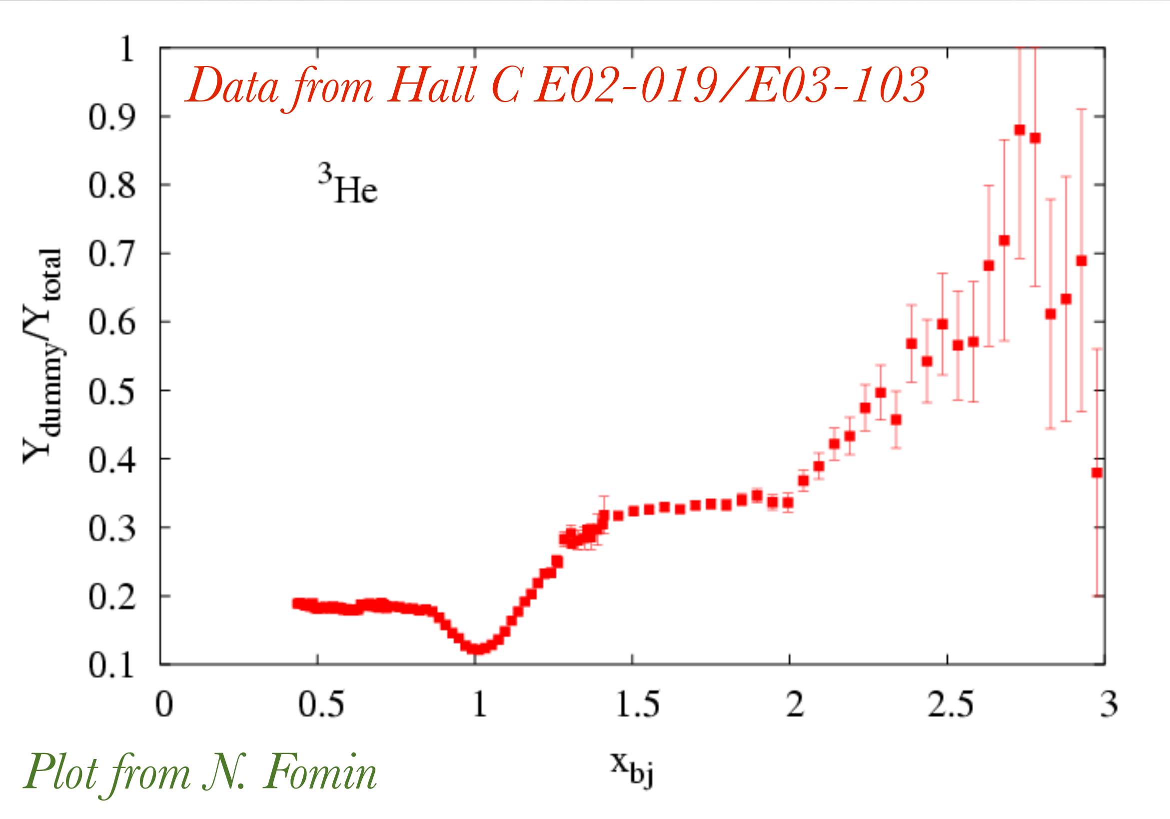
Inclusive measurement should be able to differentiate between these momentum ranges

E08-014 SYSTEMATICS

	δσ/σ	δR/R	δR/R
		(normalization)	(pt-to-pt)
Acceptance correction	2.0%*	0.5-2.0%	0.0-1.0%
Radiative correction	2.0%*	-	0.3%
Tracking efficiency	1.0%*	-	0.2%
Trigger efficiency	0.5%*	-	0.1%
PID efficiency	1.5%*	-	0.2%
Target thickness	0.5-2.0%	1.1-2.0%	-
Charge measurement	0.5%	-	0.5%
Energy measurement	0.05%	-	-
COMBINED	4.1-4.6%	1.2-2.8%	0.7-1.2%
Uncertainty on a2,a3		1.5-3.0%	
CLAS		6.3-8.1%	
SLAC		10-18%	

Most kinematics are systematics dominated

CRYO-WINDOW CONTAMINATION



Advantage of PR08-104:

Will use 20cm target

HRS resolution: cut away most of the window contribution

Empty can running: subtract the remaining contamination

KINEMATICS

	^{4}He	^{2}H	^{4}He	^{12}C	^{40}Ca	^{48}Ca	Total (per kin)
15°	2.0	2.8	1.2	0.8	0.7	0.7	8.2
17°	2.4	1.9	1.4	1.5	1.6	1.6	10.4
19° (2N)	2.4	3.8	1.3	0.9	1.2	1.2	10.8
19° (3N)	3.0	2.4	0.9	0.9	2.0	2.0	11.2
21° (2N)	3.0	2.4	1.1	1.2	2.9	3.1	13.7
21° (3N)	6.0	-	1.8	1.8	3.9	4.1	17.6
23° (2N)	6.0	4.8	2.1	2.3	5.8	6.2	27.2
23° (3N)	12.0	-	3.5	3.7	7.9	8.2	35.3
25°	24.0	-	7.1	7.3	15.7	16.4	70.5
27°	42.0	-	12.4	12.8	27.6	28.6	123.4
29° *	21.0*	-	6.2*	6.4*	13.8*	14.3*	61.7
Total (per tgt)	72.8	10.9	23.4	23.3	46.8	48.5	~226

9.4 days (data taking) + 2.6 days (calibration + overhead)
= 12 days of beam time