Tritium E-12-11-112

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December 09th, 2014

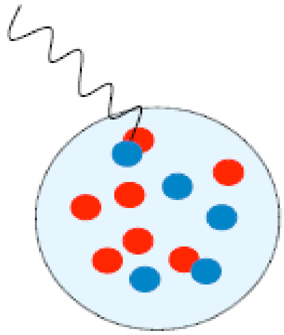
E12-11-112

Precision measurement of Isospin dependence in the 2N and 3N short range correlation region

Main physics goals

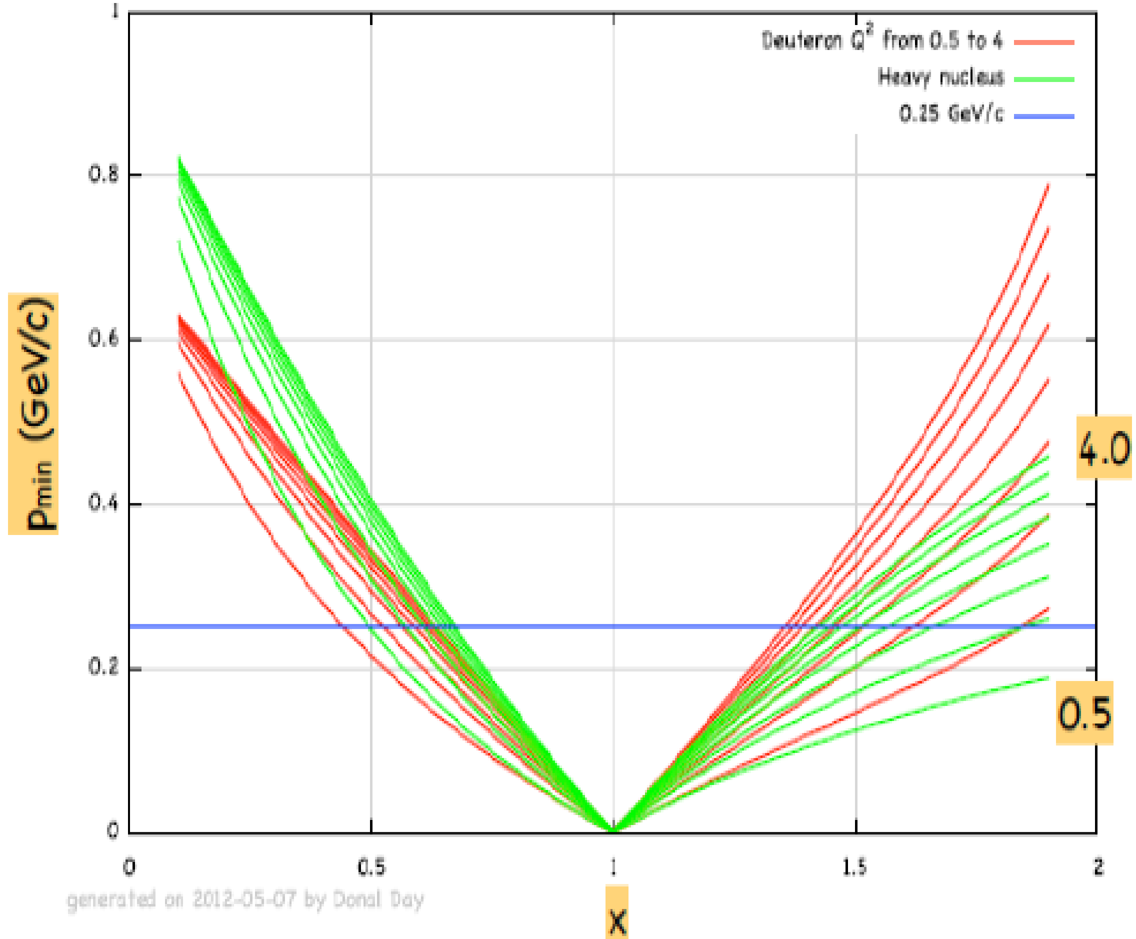
- Isospin-dependence of SRCs.
- 3N –structure (Momentum-sharing and Isospin).
- Cross section and ratio for the test of few-body calculation and final-state interactions.

Study SRCs regime



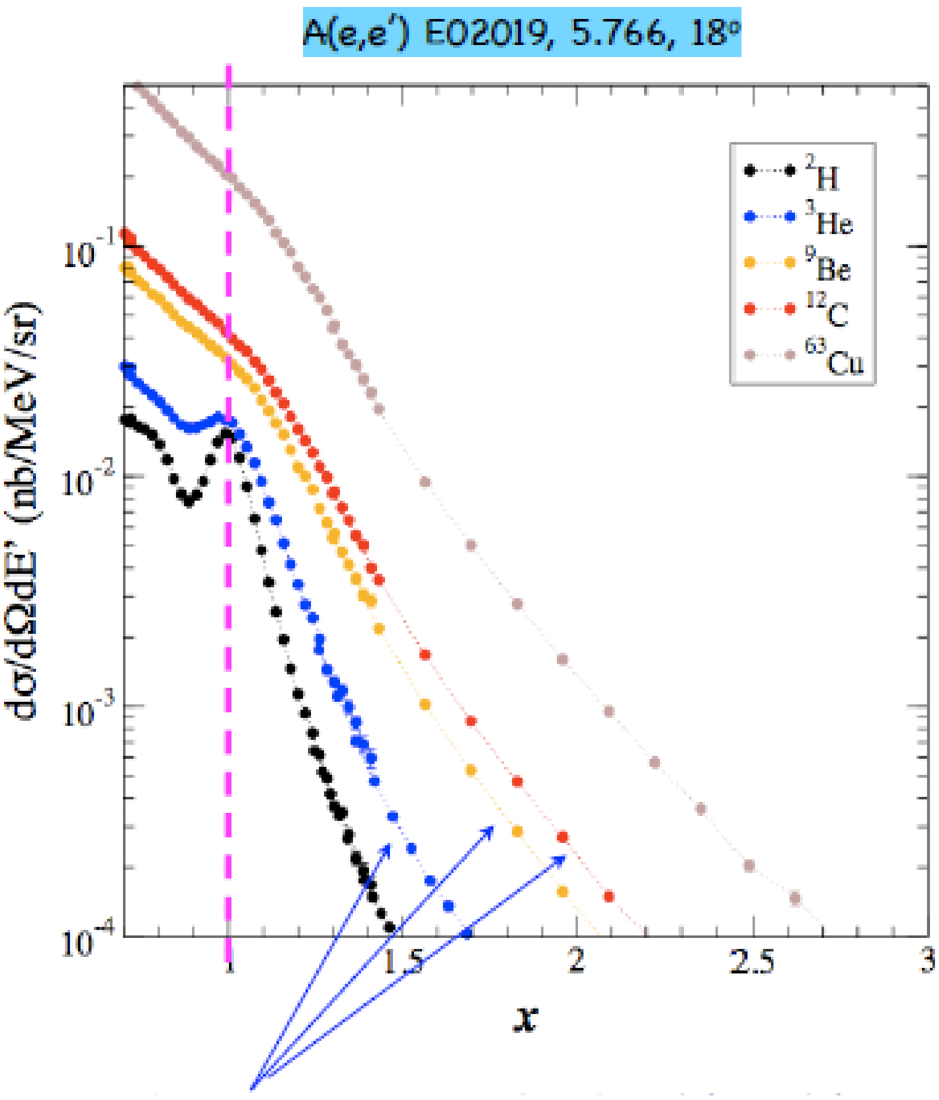
2N SRCs: 1<x<2

Minimum initial struck nucleon momentum

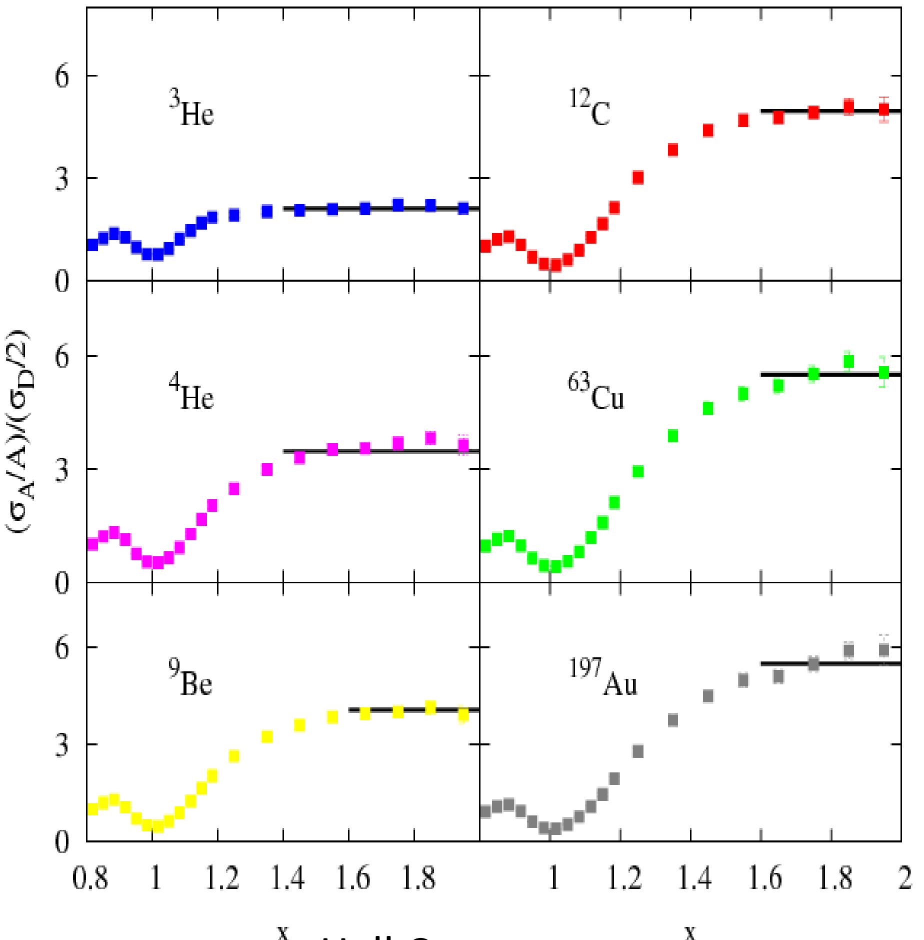


We need to go to high X and Q2 where distribution from mean field is very small

SRCs Evidence: Cross section ratios



N.Fomin, Phys.Rev. Lett. 108 (2012)



Hall C

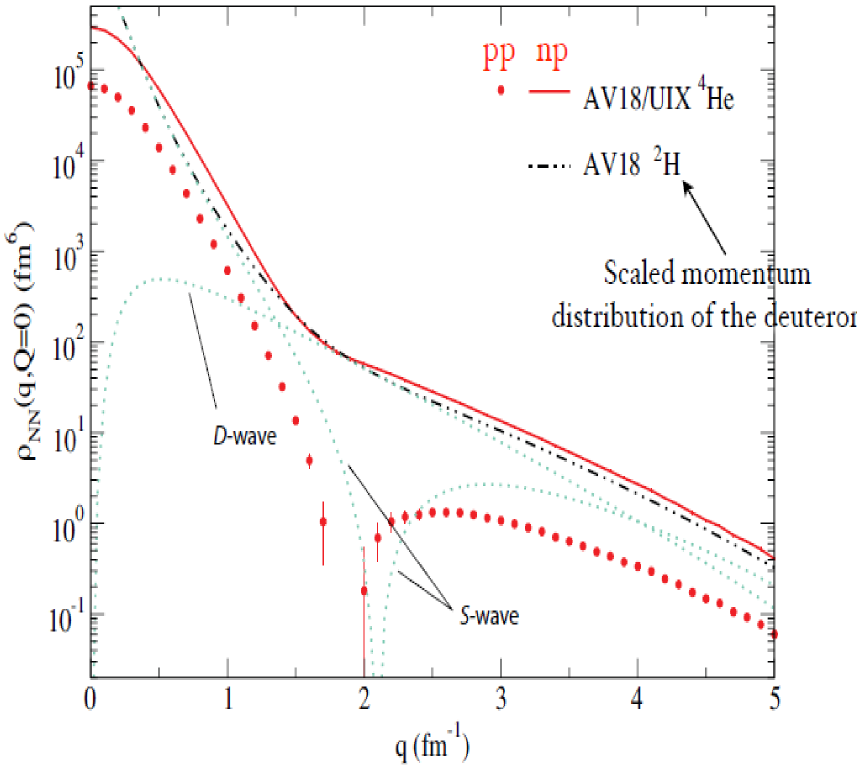
High momentum tails yield constant ratio if SRC exist

Evidence of 2N-SRCs at x>1.5

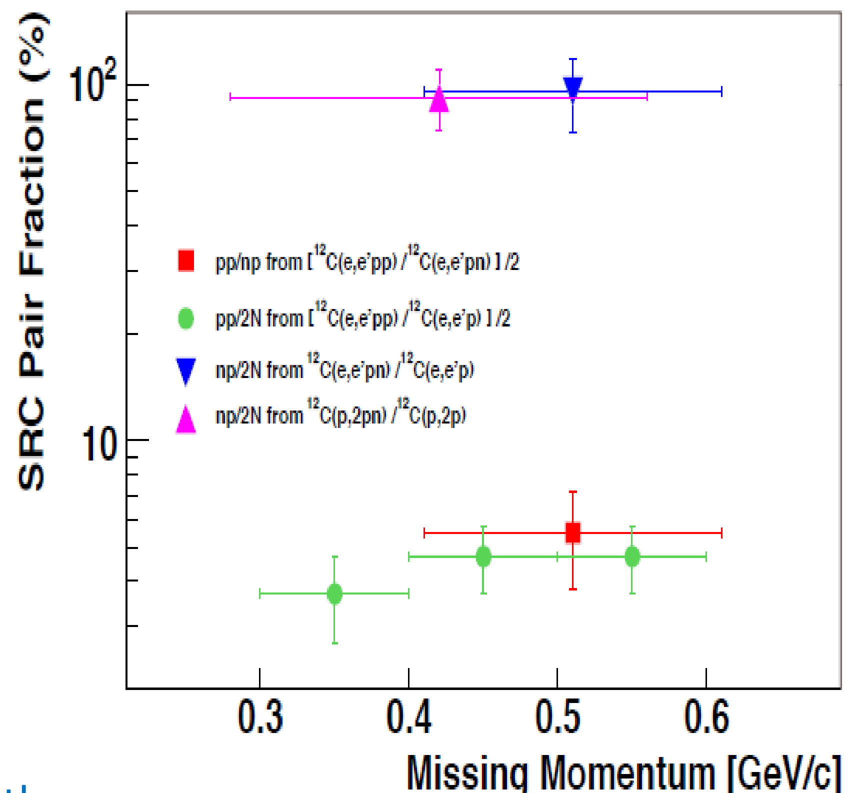
Isospin dependence SRCs

Simple SRCs model assumes isospin independence

Phy. Rev Letters. PRL 98,13501 (2007)



Experiment E01-015
R. Subedi et al, Sc 320, 1476(2008)



SRCs measurement: pp & nn combine is ~10%
Momentum distribution: np pair ~20 times bigger than pp

Solid evidence of Isospin dependence of SRCs

E12-11-112: kinematics

Beam current : 20 muA, unpolarized.

Beam Energy : 2.2 GeV and 4.4 GeV

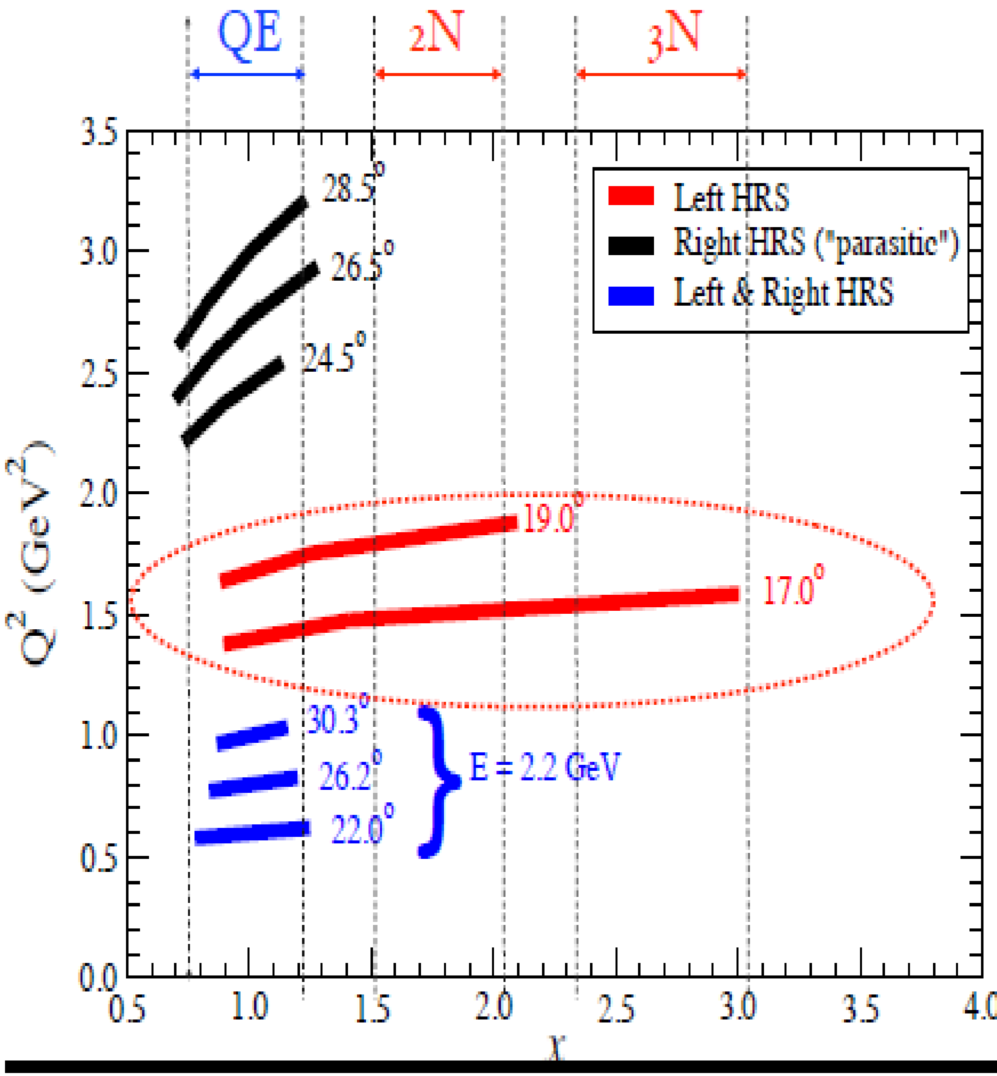
Scattering angle: 17 and 19 degree

Beam time :
17.5 days 4.4 GeV (main production)
1.5 days 2.2 GeV (checkout + QE)

Right HRS running ("parasitic")

Left HRS running (380 hours)

Left+Right HRS running (about 1 day)



SRCs Isospin study from $^3He/^3H$

- Isospin-independent

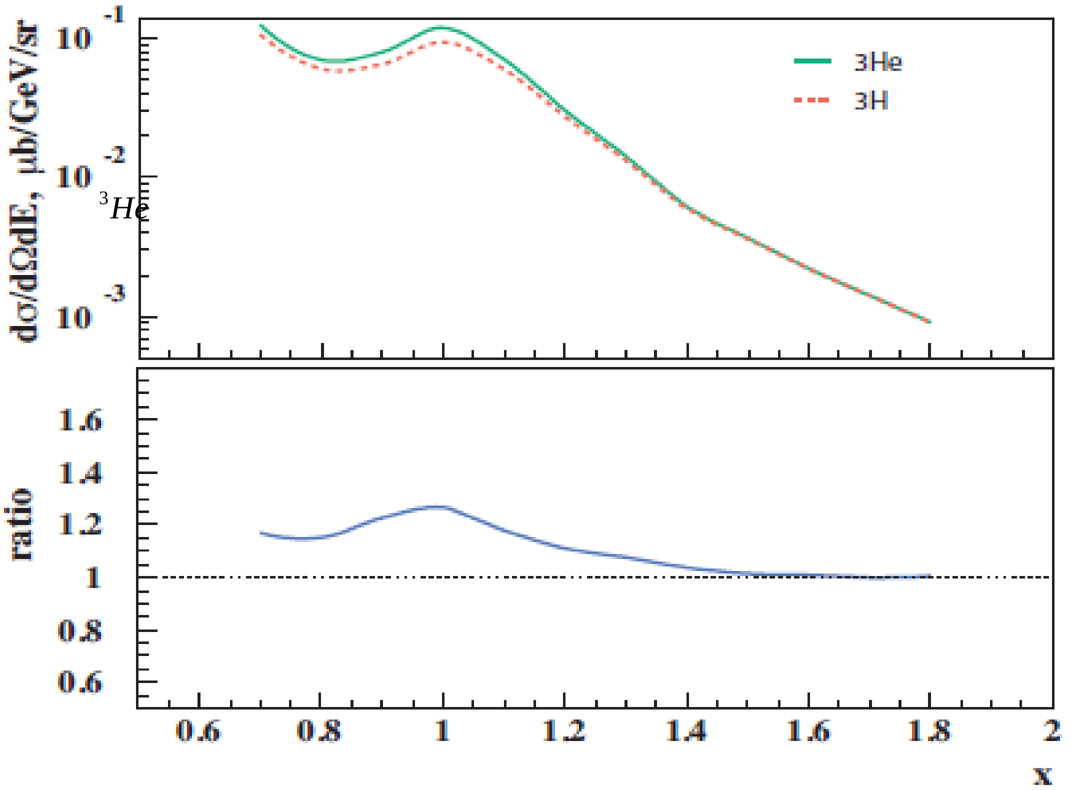
$$\frac{\sigma_{^3He}/3}{\sigma_{^3H}/3}=\frac{(2\sigma_p+1\sigma_n)/3}{(1\sigma_p+2\sigma_n)/3}\xrightarrow{\sigma_p=3\sigma_n}1.4$$

- n-p (T=0) dominance

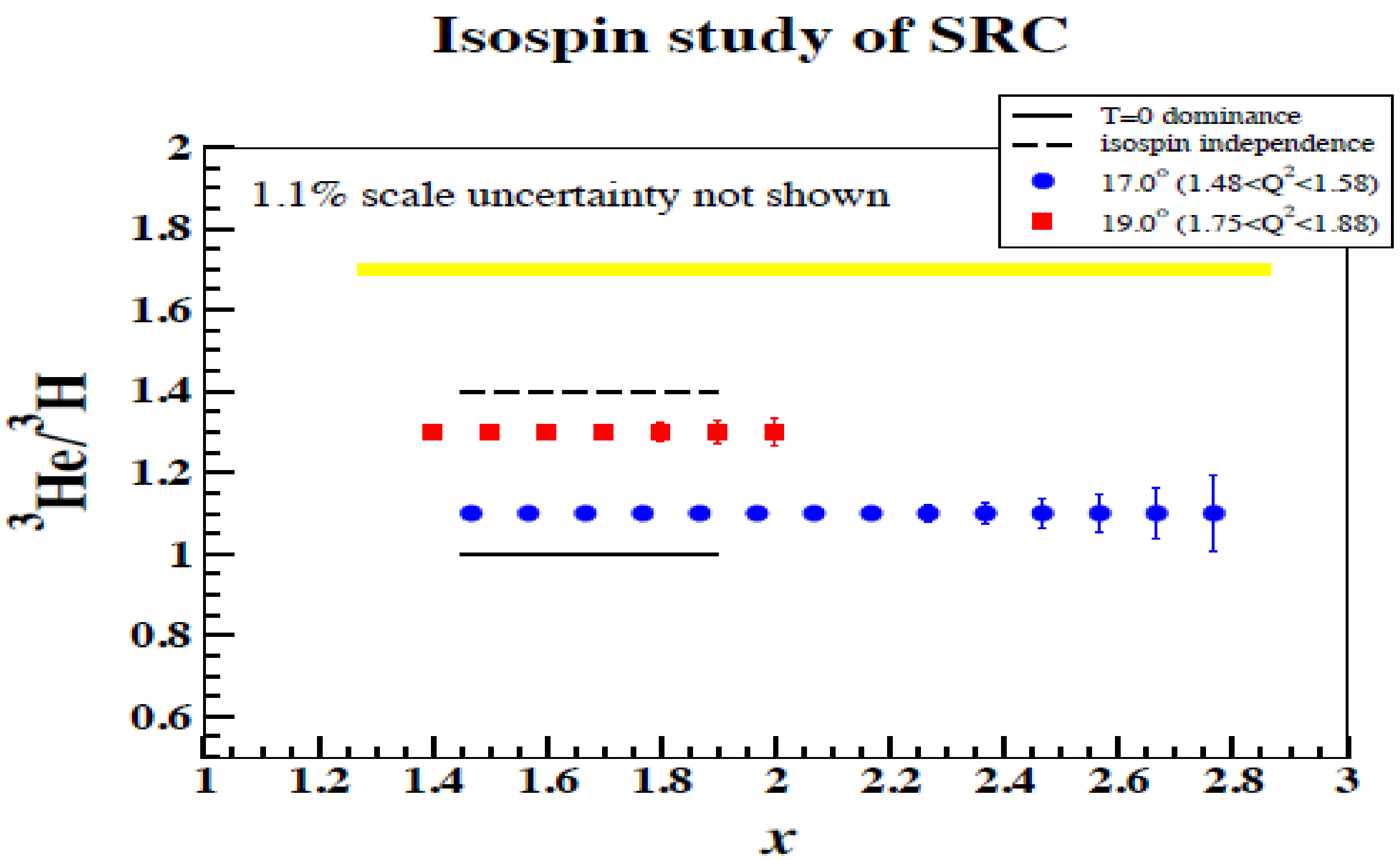
$$\frac{\sigma_{^3H}/3}{\sigma_{^3He}/3}=\frac{(2pn+1nn)/3}{(2pn+1pp)}=1.0$$

Inclusive cross section calculation from M. Sargsian

Reference:



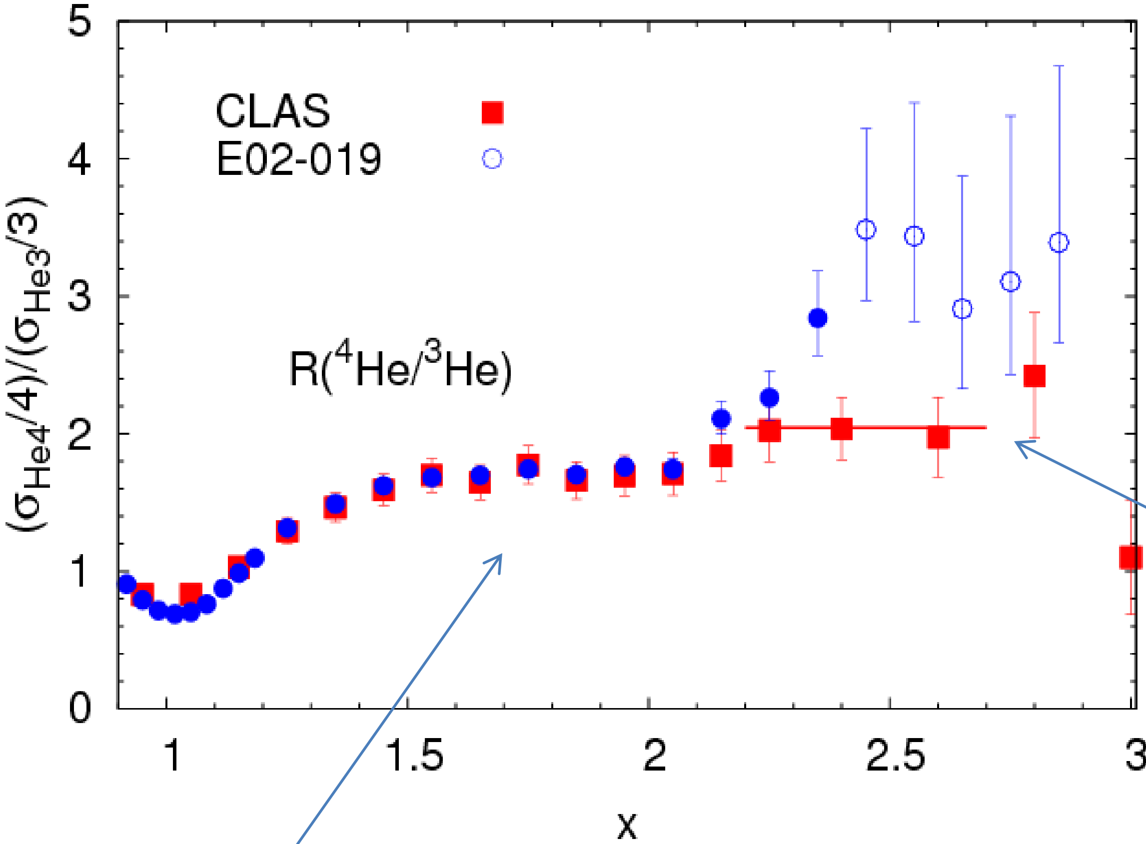
E12-11-112: projected results

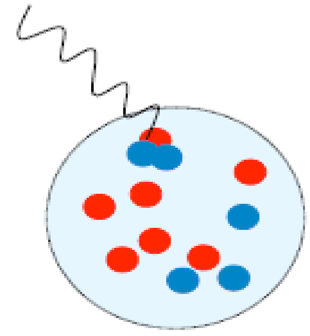


At x>2, $^3He/^3H \neq 1.4$ implies isospin dependence AND non-symmetric momentum sharing

Expected uncertainty in 2N-SRCs region approximately 2%
Which will improve a factor of 3-4 improvement of isospin-dependence measurement compare to result of Jlab experiment E01-015.

How about 3N- SRCs ?





3N SRCs: 2<x<3

Disagreement in 3N-SRC region

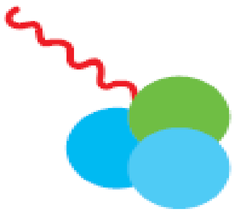
CLAS: Q2~1.6 GeV2

E02-019: Q2 ~ 2.9GeV2

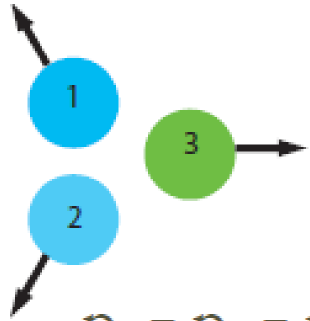
New data (x>2) from Jlab experiment E08014 is coming

Good agreement in 2N-SRC region

what is structure of 3N-SRCs?

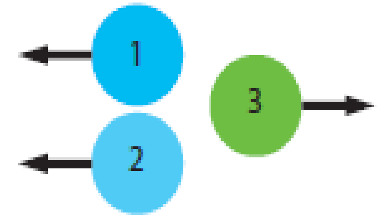


Symmetric



$p_1 = p_2 = p_3$

Non-Symmetric:



$p_3 = p_1 + p_2$

Symmetric:

$$\frac{^3He}{^3H} = \frac{2\sigma_p + \sigma_n}{\sigma_p + 2\sigma_n} \approx 1.4$$

Non-symmetric:

- **Case1:** nucleon 3 is single nucleon in 3N

$$\frac{^3He}{^3H} = \frac{\sigma_n}{\sigma_p} \approx 0.3$$

- **Case2**: nucleon 3 is in pair of 3N

$$\frac{^3He}{^3H} = \frac{\sigma_p}{\sigma_n} \approx 3$$

Calculation the absolute thickness of Target for Triton experiment

Question: How can we check the target thickness g/cm2?

the answer is using elastic scattering

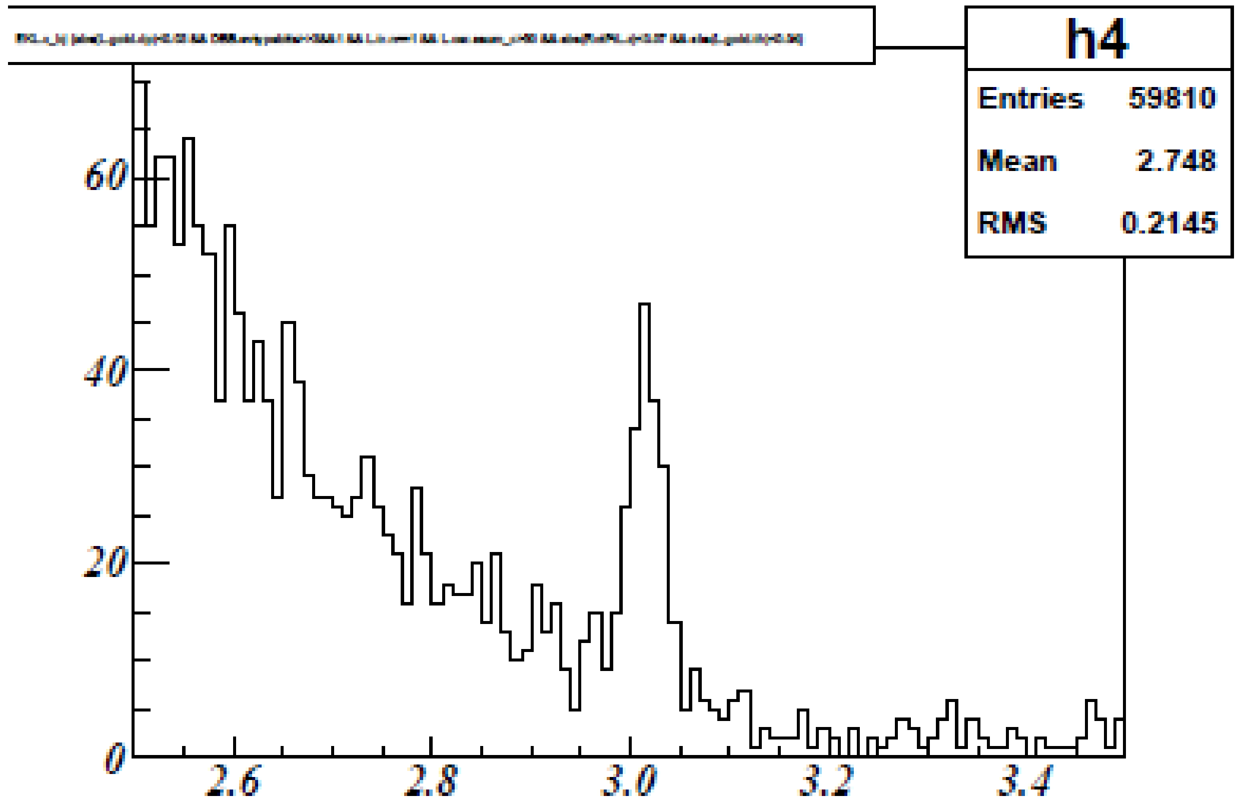
Experiment E08014

E0=3.356 GeV

Theta= 21,

1 hour run time

Q2=1.35 GeV2



The cut:

DBB.evtypebits >> 3&1

L.tr.n=1& L.cer.asum_c>50 &abs(RctPtL.z)<0.07&L.gold.th<0.03 & L.gold.ph<0.02&L.gold.dp<0.03

Tritium Target will be filled at Savannah River site(SRS) located in South Carolina.

$$yield = \frac{d\sigma}{d\Omega} * L * \Delta\Omega$$

First checking result:

E0= 2.2 GeV, Theta= 12.5 degree

Run time ~ 1 Hour 3He Yield ~ 1e7 events Statistic ~ 0.03%

3H Yield ~ 6e5 events Statistic ~ 0.13%

How about 15 degree ?

1 hour 3He yield ~5e5 events Statistic ~ 0.14%

3H yield ~5e4 events Statistic ~ 0.45%

Conclusion:

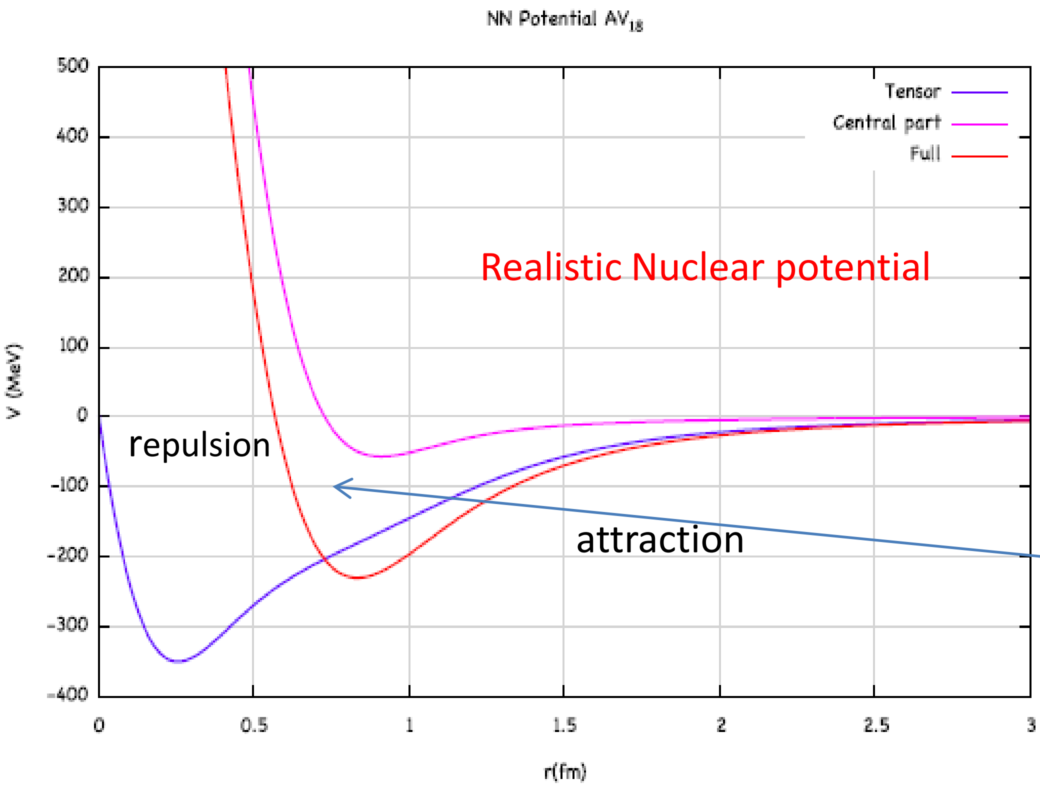
- Precision measurement of Isospin dependence in 2N-SRCs
-Will get absolute cross section to study about 3N-SRCs structure. Compare to theoritical
-Will get the absolute value for thickness of target 3He and Tritium 3H.

We are getting ready for excited tritium experiment in Spring 2016.

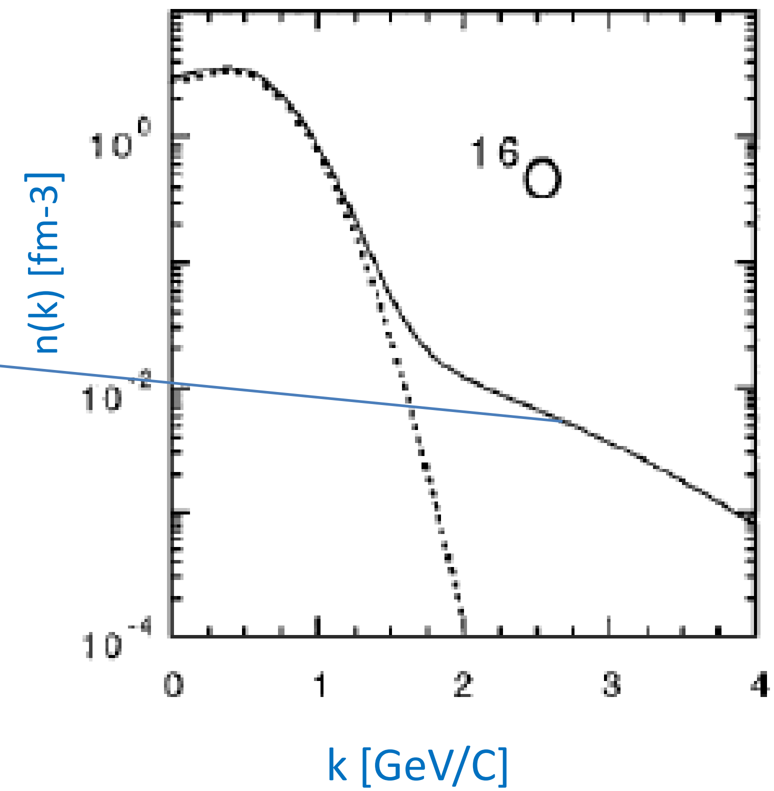
Thank you very much for your attention

Back up

Nuclear potential, n(k)

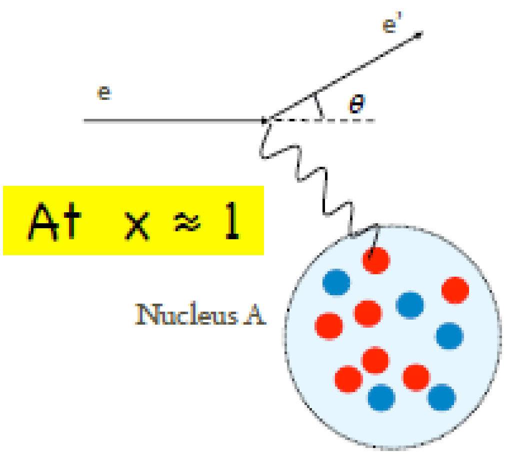


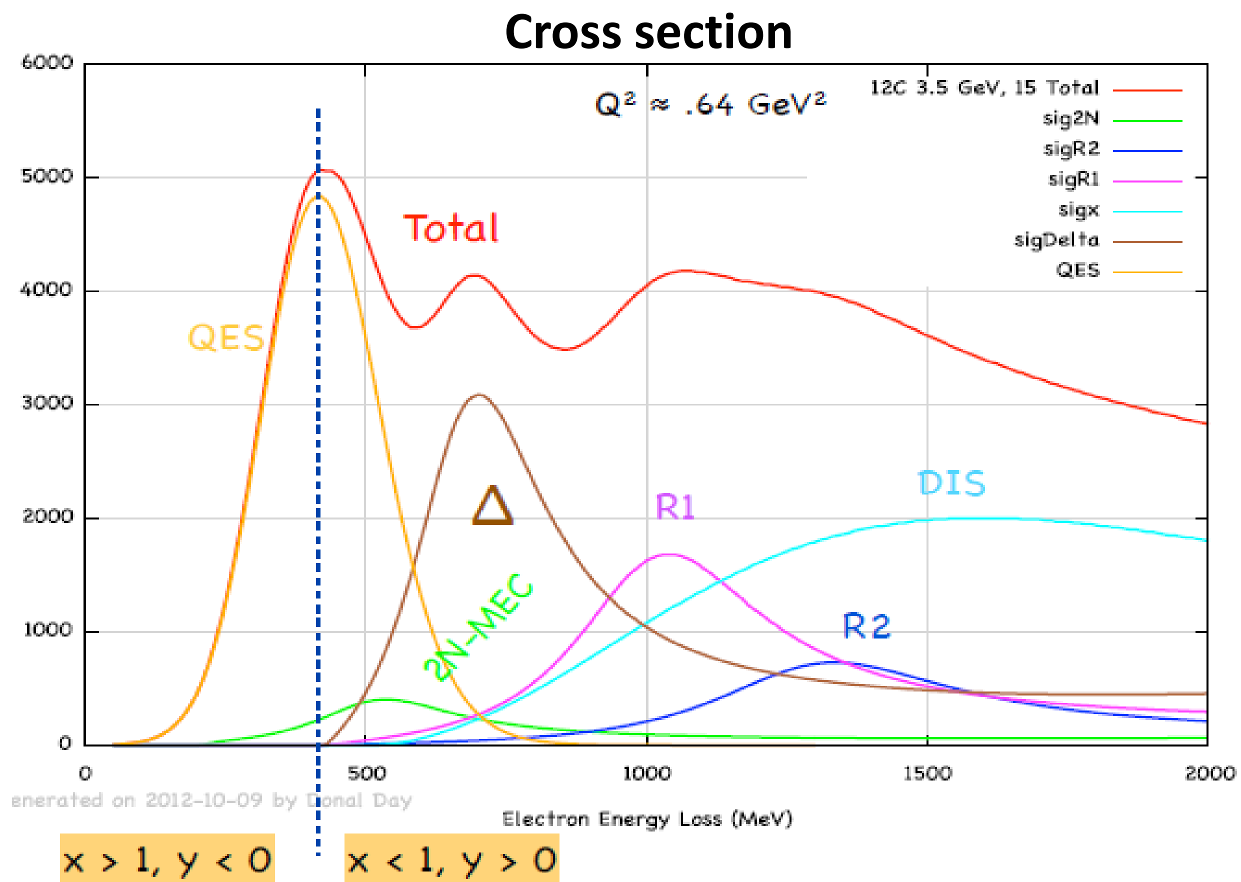
Nucleon momentum distribution in 16O



Short range N-N interaction is responsible for high momentum tail of the momentum distribution in nuclei (significant contribution with k>kf)

Inclusive scattering at large x

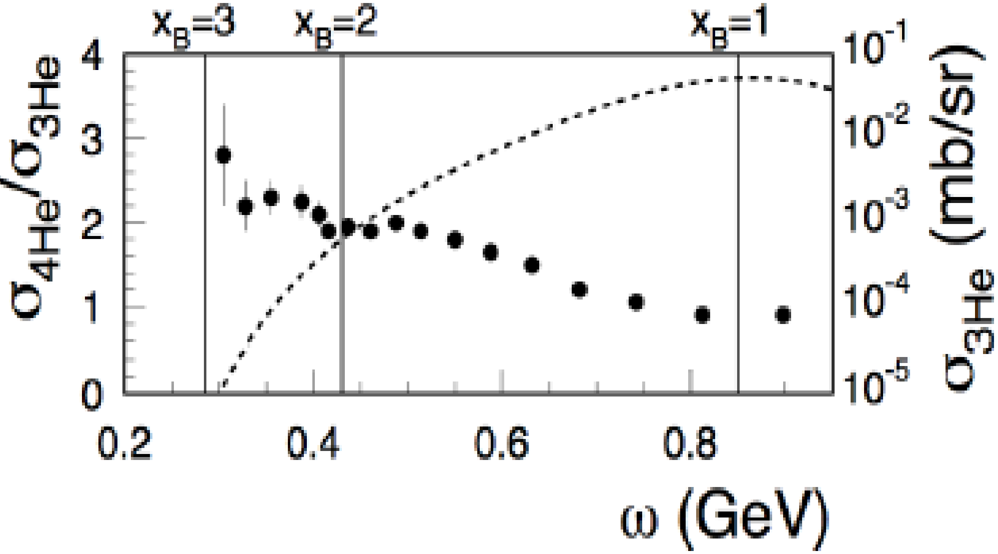




Nucleon's Fermi motion broadens QE peak

The strength of the single particle reaction extends to x~1.3

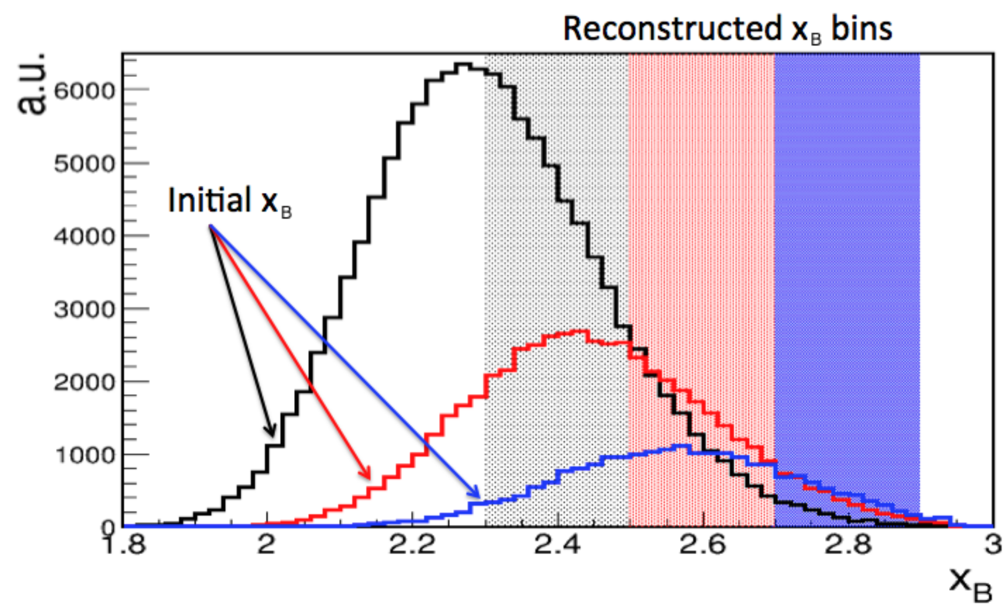
Binning correction in hall B Data



Clas : q ~1.6 GeV2
E02-019: Q2~2.9GeV2

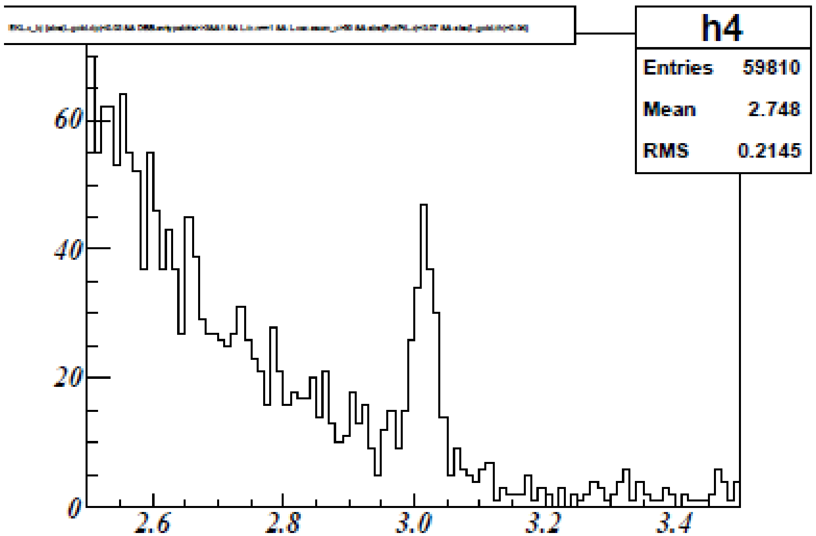
Reference : ArXiv: 1409.3069v1
10 Sep 2014

(Douglas's paper)



Calculation the absolute thickness of Target for Triton experiment

Question: How can we check the target thickness g/cm2?



Maybe the answer is elastic scattering?

E0=3.356 GeV and Theta= 21, ~1 hour run time

$$yield = \frac{d\sigma}{d\Omega} * L * \Delta\Omega$$

E0= 2.2 GeV, Theta= 12.5 degree

Run time ~ 1 Hour 3He Yield ~ 1e7 events Statistic ~
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Yield from theoretical calculation

Beam enery : 3.356 GeV, theta=21 degree
Runtime= 0.786 hour
Target He3: ideal density 0.029g/cm3, length=20cm
Total charge: 0.283 C.

$$N_e = 1.766e18(electrons)$$

$$N_n = 1.2e23(nucleons)$$

$$L = N_e * N_n$$

$$XS = 1.36e-6\mu b$$

$$\theta_{tg} = \pm 30mrad$$

$$\varphi_{tg} = \pm 20mrad$$

$$\Delta\Omega = 2.4msr$$

$$yield = \frac{d\sigma}{d\Omega} * L * \Delta\Omega$$

Yield = 692 events

About 3 times different from real data with the same condition.

Simulation: MCEEP

Setup simulation like theoretical calculation: with target is thin foil with the same thickness (g/cm2)

$$yield_{mc} = 694 events$$

? Question for experiment will be how can we check the target thickness g/cm2

Target 3He, current= 25 muA
Rho=0.029g/cm3, length=30 cm
=>thickness ~0.9g/cm2
Lu= 22.5 muA.g/cm2

Target 3H, current=25muA
Rho=2.5mg/cm3, length=30cm
=>thickness~0.075g/cm2
Lu=0.075*25=1.875 muA.g/cm2

E0=2.2 GeV, theta=12.5, Rate=0.8699e4
E0=2.2GeV, theta=21, Rate=5.409

E0=2.2 GeV, theta=12.5, Rate=0.5338e3
E0=2.2 Gev, theta=21, Rate =0.4508

Assume runtime = 1hour

3He theta=12.5 Yield(ideal)=3.131e7 events => experimental Yield ~1e7 events
3He theta=21 Yield(ideal)=1.94e4 events => experimental Yield~ 6500 events
3H theta=12.5 Yield(ideal)= 1.9e6 events => experimental Yield ~ 6e5 events
3H theta=21 Yield(ideal)=1623 events => experimental Yield ~ 541 events

Uncertainty for Tritium experiment

Systematic	$\delta\sigma/\sigma$	$\delta R/R$ (normalization)	$\delta R/R$ (pt-to-pt)
Acceptance correction	2.0%*	0.5%	1.0%
Radiative correction	3.0%*	0.4%	0.3%
Tracking efficiency	1.0%*	-	0.2%
Trigger efficiency	0.5%*	-	0.1%
PID efficiency	1.5%*	-	0.2%
Target thickness	2.0%	2.0%	-
Charge measurement	0.5%	-	0.5%
Energy measurement	0.05%	-	-
COMBINED UNCERTAINTY	4.6%	2.1%	1.2%