E12-11-112: the x>1 ^{3}He/^{3}H experiment

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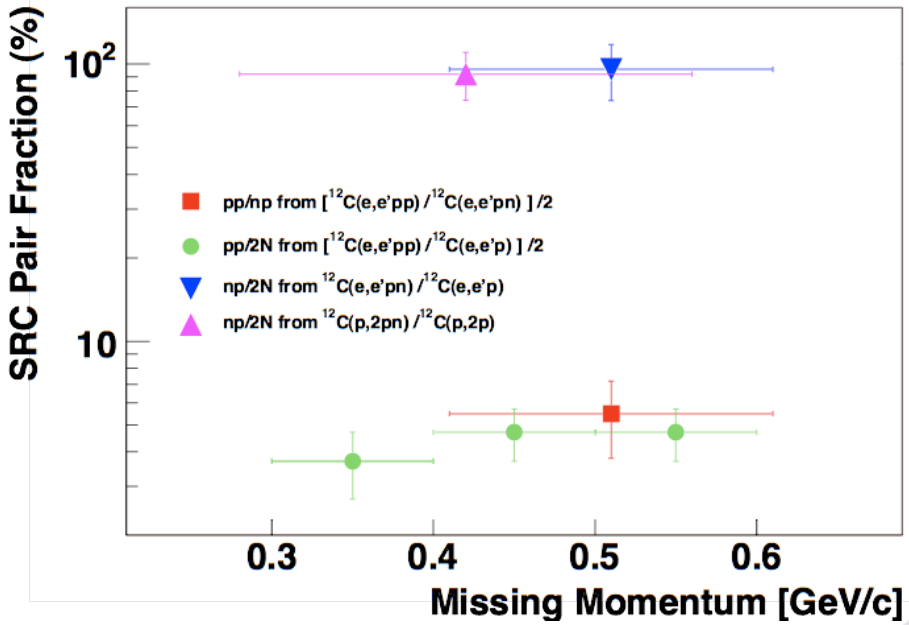
Tensor force dominance

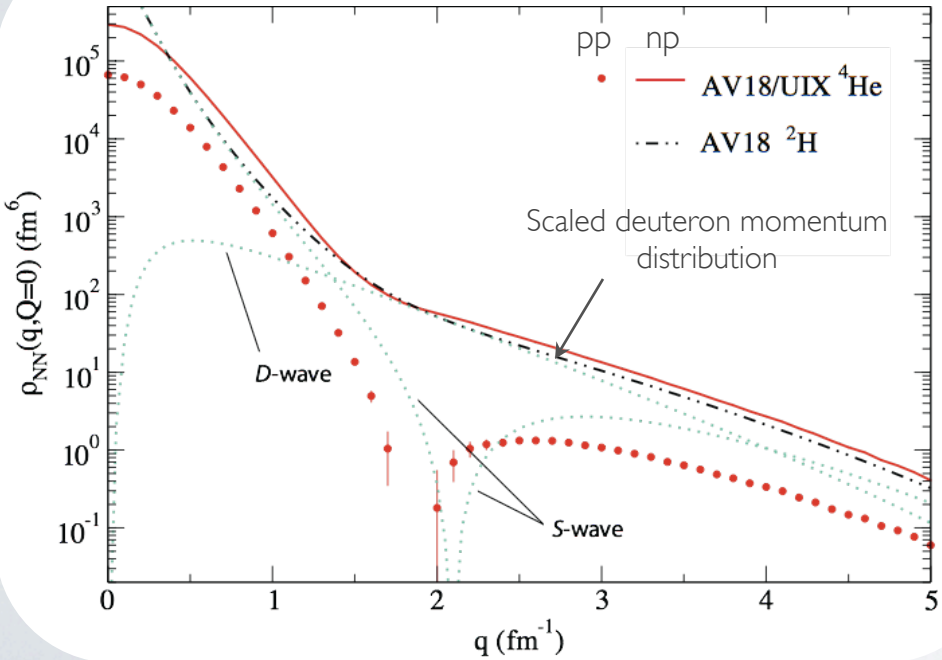
Simple SRC Model:

- 1N, 2N, 3N contributions dominate at x≤1,2,3
- 2N, 3N configurations "at rest" (total p_{pair} = 0)
- Isospin independent

R. Subedi et al, Science 320, 1476(2008)



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



From A(p,p' pn) and ^{12}C(e,e' pN):
90% of observed pN pairs are pn; tensor force → isosinglet dominance
R(pp/pn) = 0.056+/-0.018
R(T=1/T=0) = 20+/-8%

Main physics goals: E12-11-112

- Isospin-dependence
  - ✓ Improved precision: Extract R(T=1/T=0) to 3.8%
  - ✓ FSI much smaller (inclusive) and expected to cancel in ratio

- 3N SRCs structure (momentum-sharing and isospin)
  - ✓ Q^2 dependence can test models of the momentum sharing
  - ✓ $^3He/^3H$ ratio very sensitive to isospin-momentum correlations

- Improved A-dependence in light and heavy nuclei
  - ✓ Average of ^3H, ^3He → A=3 "isoscalar" nucleus
  - ✓ Determine isospin dependence → improved correction for N>Z nuclei, extrapolation to nuclear matter

- Absolute cross sections (and ratios) for ^2H, ^3H, ^3He: test calculations of FSI for simple, well-understood nuclei

Isospin structure of 2N-SRCs

^{3}He/^{3}H is simple/straightforward case:

Simple estimates for 2N-SRC

Isospin independent

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

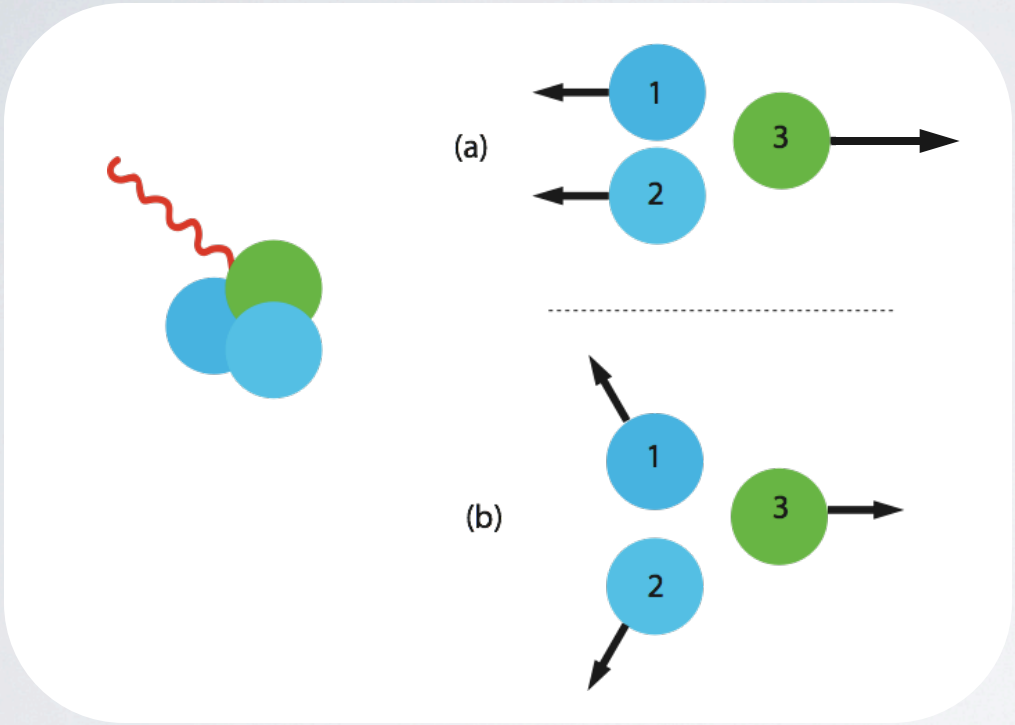
Full n-p dominance (no T=1)

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

- 40% difference between full isosinglet dominance and isospin independent
- Few body calculations [M. Sargsian, Wiringa/Pieper (GFMC)] predict n-p dominance, but with sizeable contribution from T=1 pairs
- Goal is to measure ^{3}He/^{3}H ratio in 2N-SRC region with 1.5% precision
  → Extract R(T=1/T=0) with uncertainty of 3.8%

3N-SRC configurations

Different configurations possible for 3N-SRCs, for example:



"Linear configuration"

$$p_3 = p_1 + p_2$$

extremely large momentum

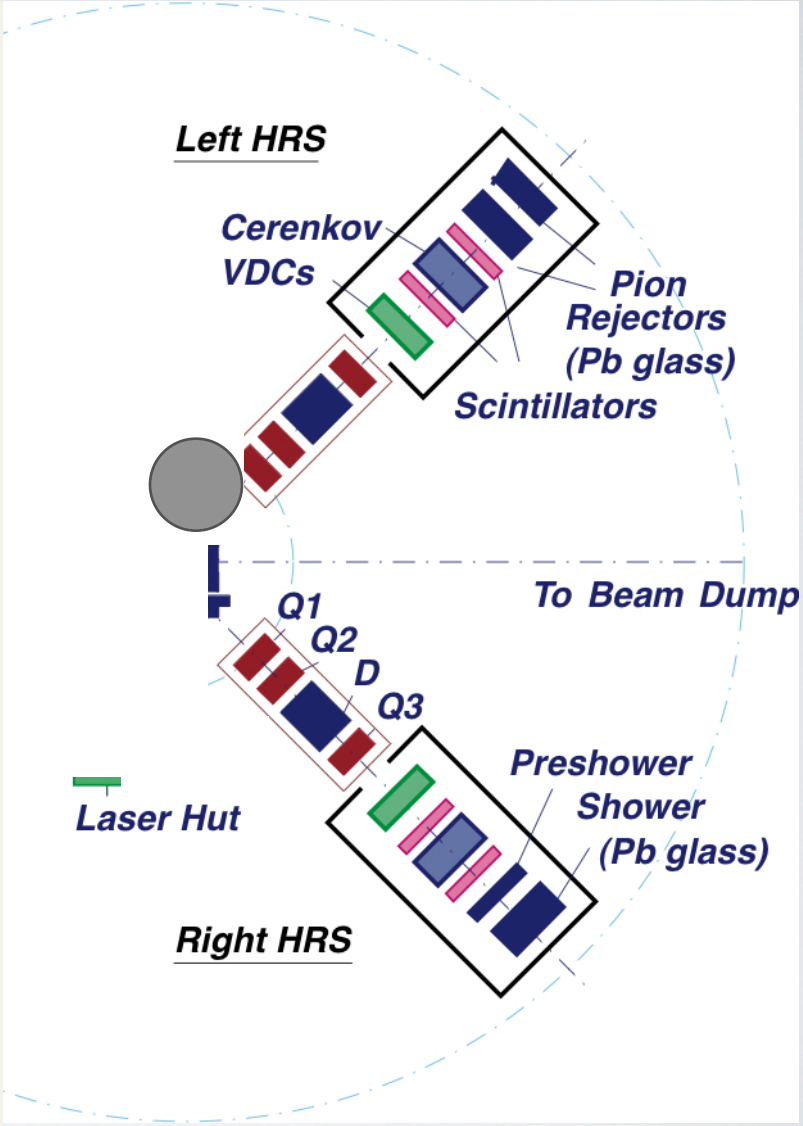
"Star configuration"

$$p_1 = p_2 = p_3$$

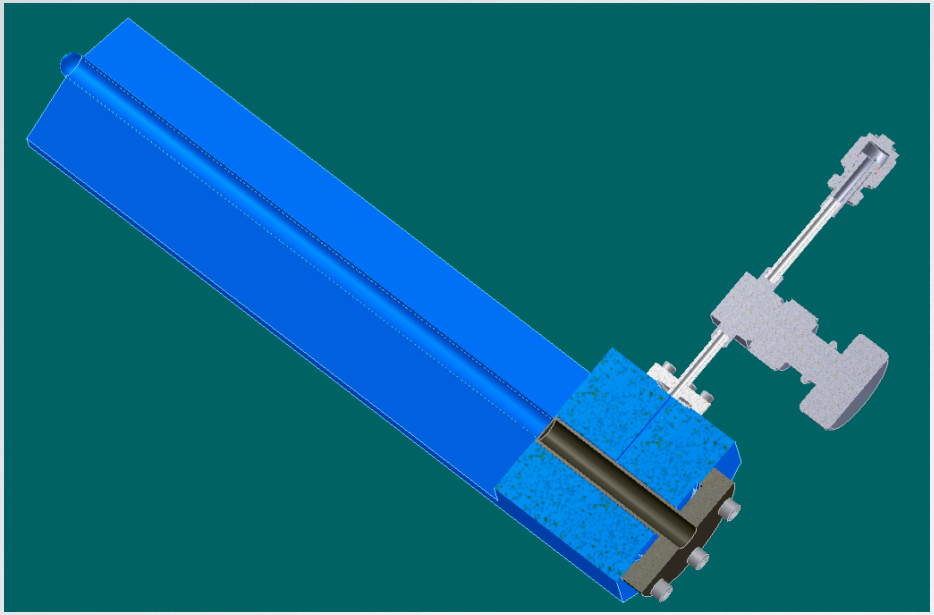
Inclusive measurement can help to differentiate between these configurations and test isospin structure

E12-11-112: Experimental setup

- Standard Hall A HRS configuration
- Gas Cerenkov + Calorimeter PID
- ^{1}H, ^{2}H, ^{3}H, ^{3}He room temperature cells, 20 atmospheres (10 for ^{3}H)
- Empty cell for window subtraction (check software cut on windows, subtract residual contribution)
- Carbon foils for optics

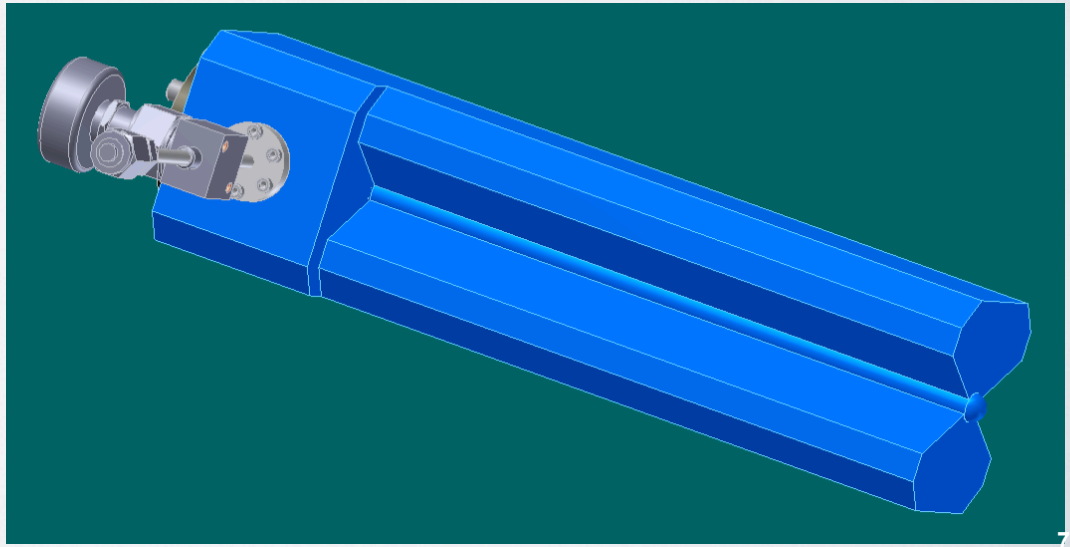


Tritium target: updated design



- Four identical cells: ^{1}H, ^{2}H, ^{3}He at 20 atm, ^{3}H at 10 atm.
- Operate at room temperature
- Length: 25cm, Diameter: 1.25cm
- 18 mil windows and walls

- Technical review in 2010
- Prototype requested and funded
- Goal is to be ready by 2015



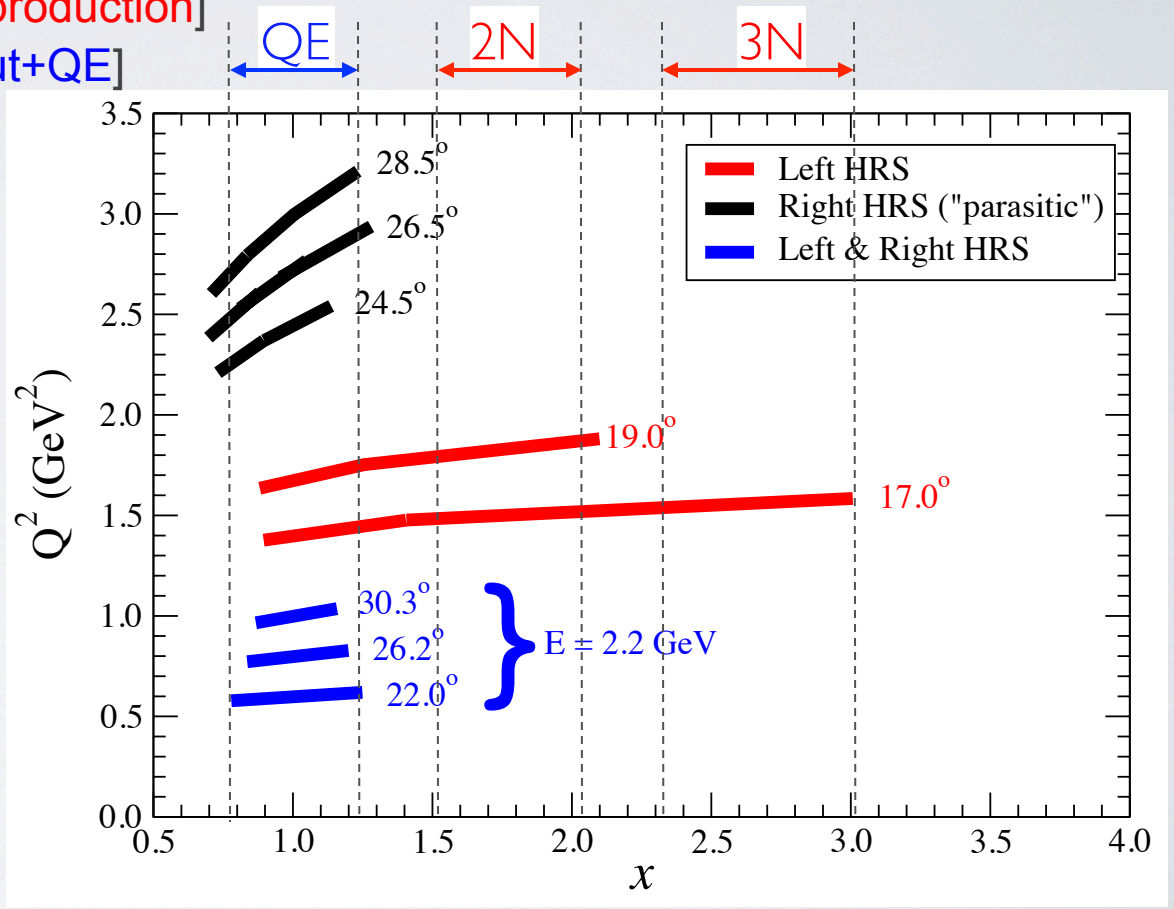
Kinematic coverage

Beam current: 25 μA, unpolarized

- Raster interlock

Beam energy: 4.4, (2.2) GeV

- 17.5 Days 4.4 GeV [main production]
- 1.5 days 2.2 GeV [checkout+QE]



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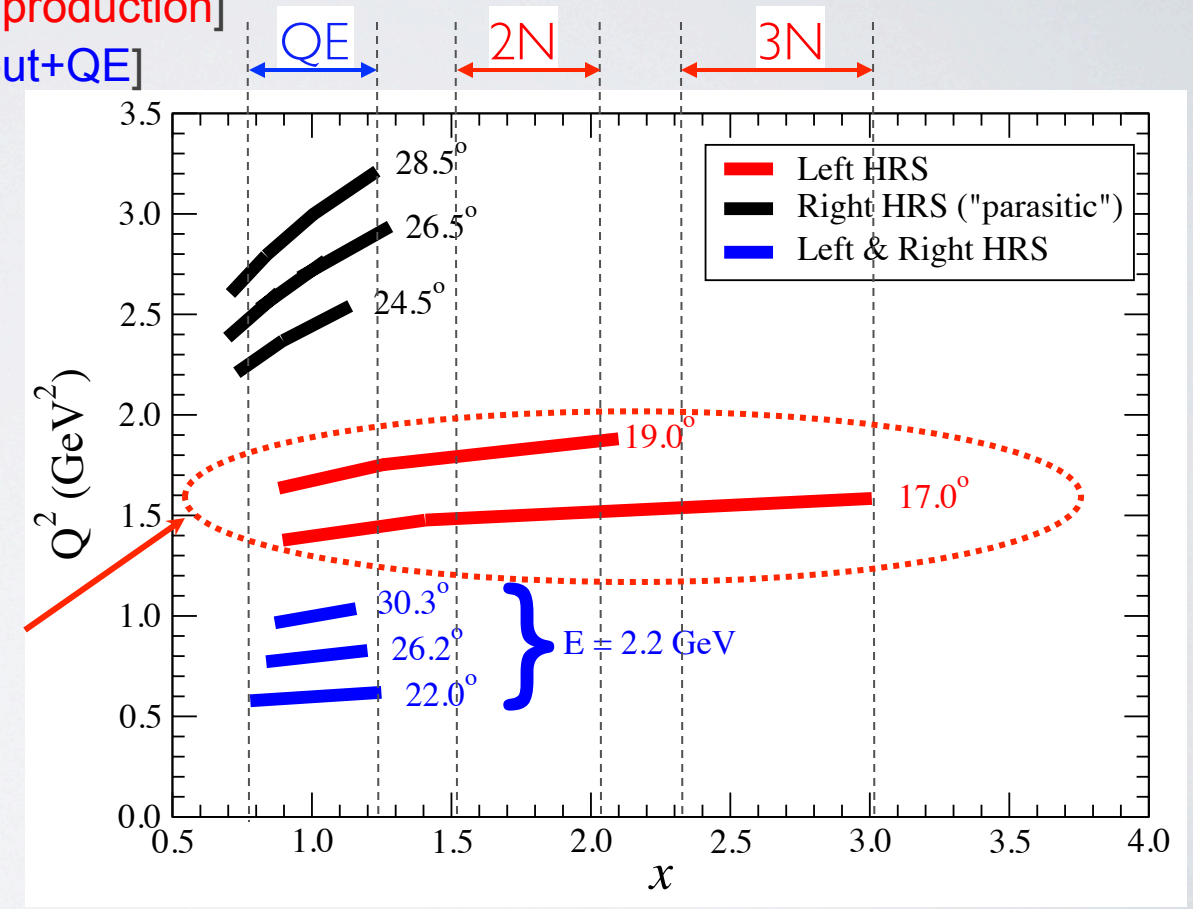

Left HRS running
(380 hours)

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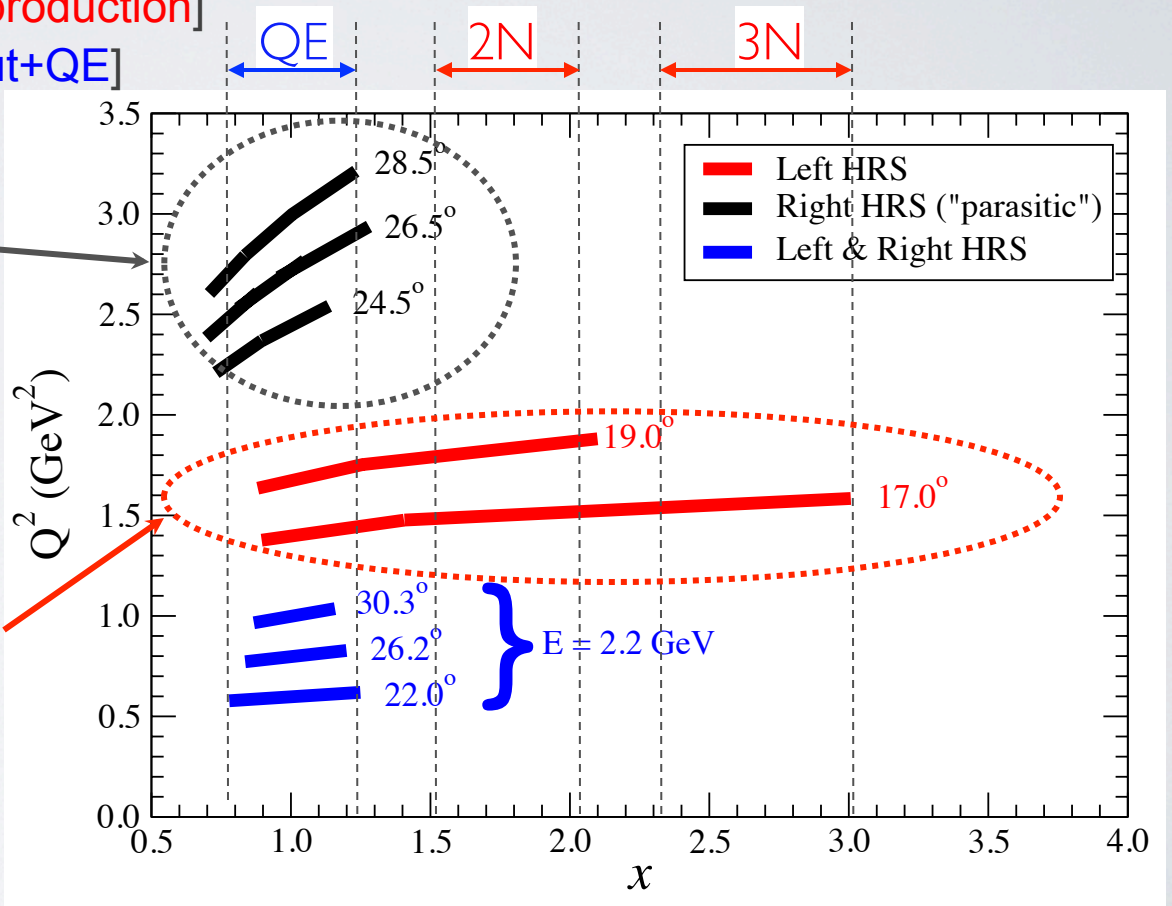
Right HRS running (parasitic)

Worlds ^{3}H QE data: $Q^2 \leq 0.9$ GeV^2

Left HRS running (380 hours)



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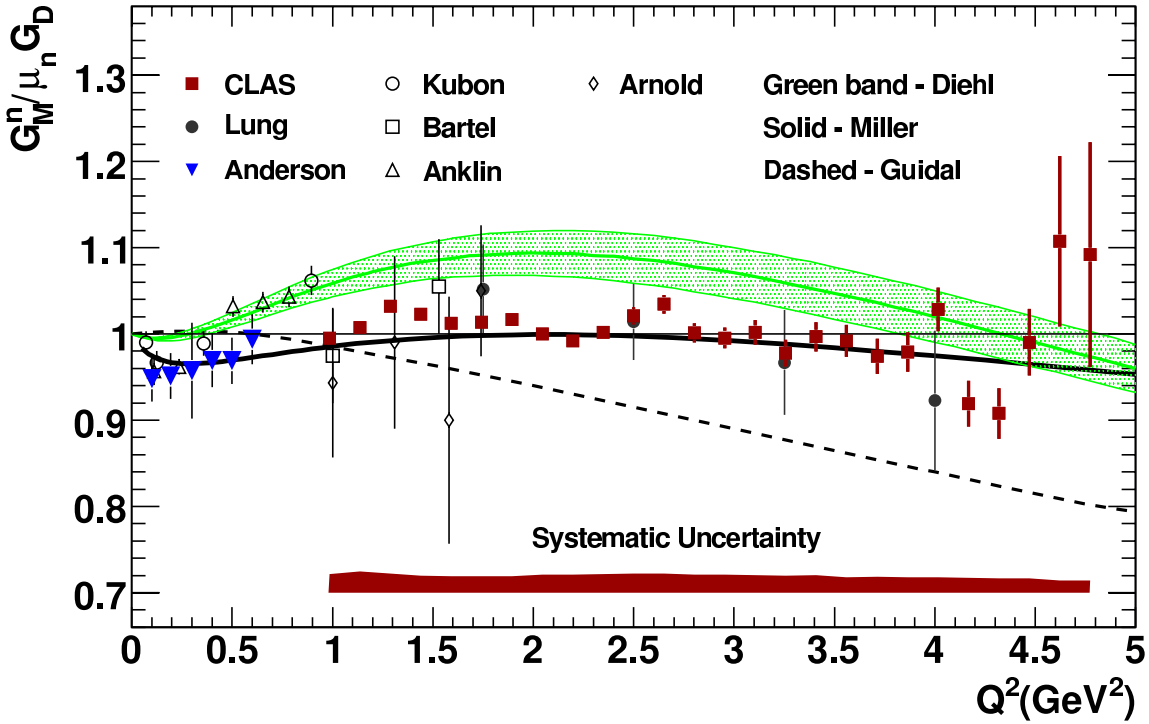
Summary

- Study of isospin dependence of 2N-SRC from ^{3}H/^{3}He from inclusive scattering: will complement the results of 2N knockout experiments
  - Greater precision
  - Smaller final-state interactions
- First look at isospin-momentum structure in 3N-SRC region
- Quasi-elastic data on ^{3}H and ^{3}He for Q^2 of 0.6-3.0 $(GeV/c)^2$
- *Beam time approved*: 19 days including data taking, calibrations, background studies and configuration changes
- Hall A spectrometers in standard configuration, same ^{3}H target system needed for the approved MARATHON experiment (E12-10-103)

Quasielastic data

Worlds ^{3}H QE data:
$Q^2 \leq 0.9$ GeV^2

This experiment:
0.6-1.0 GeV^2
1.4,1.7 GeV^2
2.2-3.0 GeV^2



In PWIA, ^{3}He/^{3}H with 1.5% uncertainty corresponds to 3% on G_M^n

* Limited to $Q^2 \leq 1$ GeV^2, where QE peak has minimal inelastic contribution

* This is the region with ~8% discrepancy between the Anklin, Kubon data and the CLAS ratio and Hall A polarized ^{3}He extractions

Nuclear effects expected to be small, largely cancel in ratio

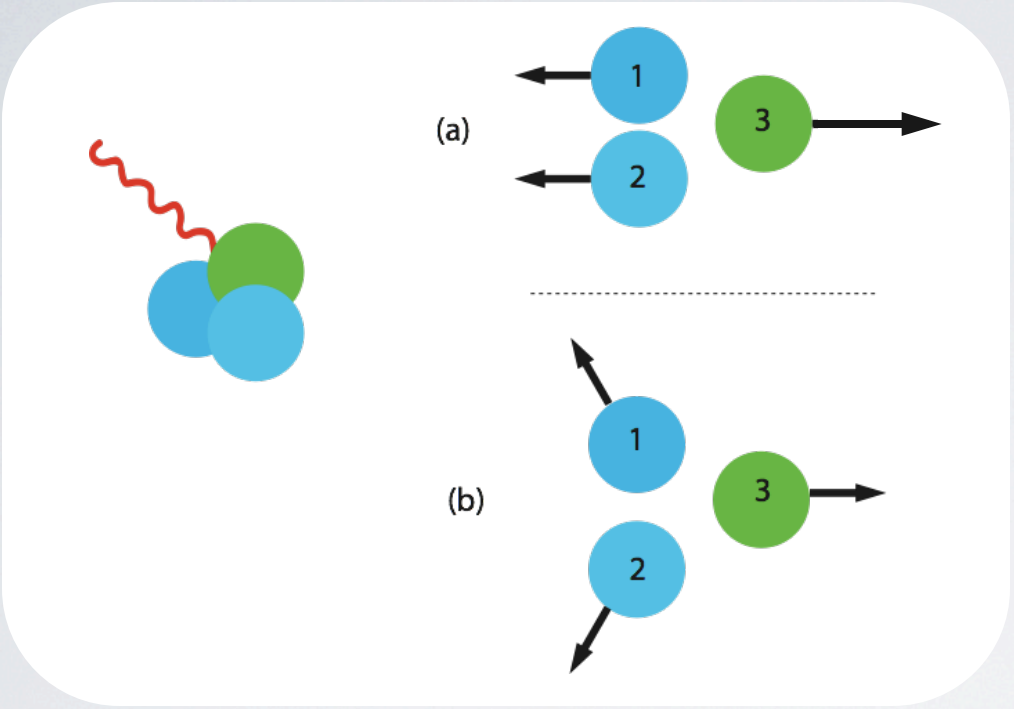
E08-014

E08-014: Finished data taking in April/May 2011

- **Extract Q^2 dependence for $^3He/^2H$, $^4He/^3He$ ratios**
  - Precisely determine scaling regions for 2N, 3N-SRCs in light nuclei
  - Initial Q^2 dependence of ratios vs. different 3N scaling variables (α_{3N})

- **Isospin ($^{40}Ca/^{48}Ca$)**
  - Intrinsic sensitivity is roughly half of $^3H/^3He$
  - Total uncertainty in R(T=1/T=0) about 12% (^{40}Ca target problems)

Momentum-isospin correlations



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(a) yields $R(^3He/^3H) \approx 3.0$ if nucleon #3 is always the doubly-occurring nucleon

(a) yields $R(^3He/^3H) \approx 0.3$ if nucleon #3 is always the singly-occurring nucleon

(a) yields $R(^3He/^3H) \approx 1.4$ if configuration is isospin-independent, as does (b)

$R \neq 1.4$ implies isospin dependence AND non-symmetric momentum sharing