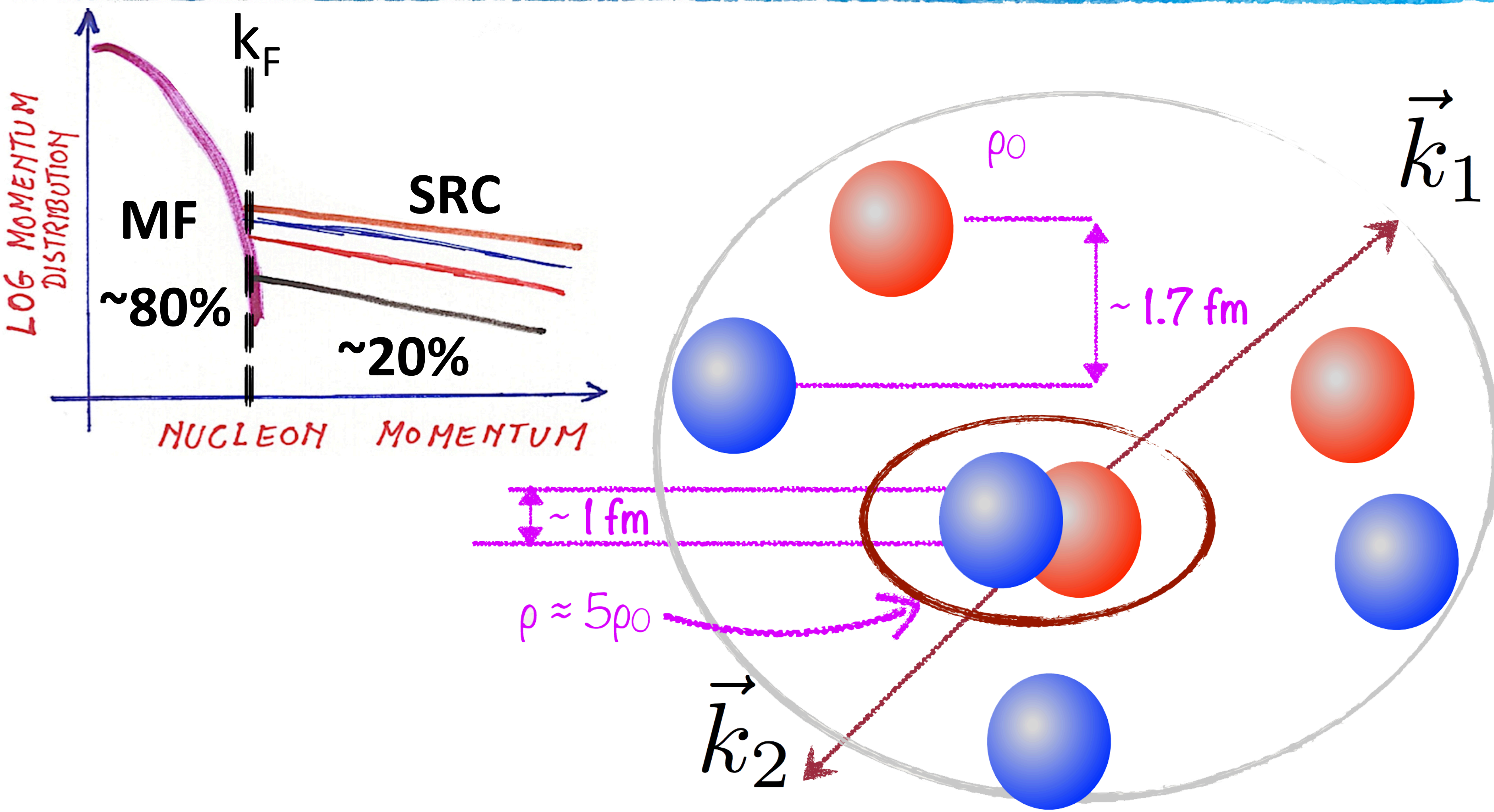
Momentum Distributions in A = 3 Asymmetric Nuclei

Reynier Cruz Torres

Hall A/C Collaboration Meeting, JLab

June 22, 2018

SRC 101



Majority = most abundant nucleon species in an asymmetric nucleus

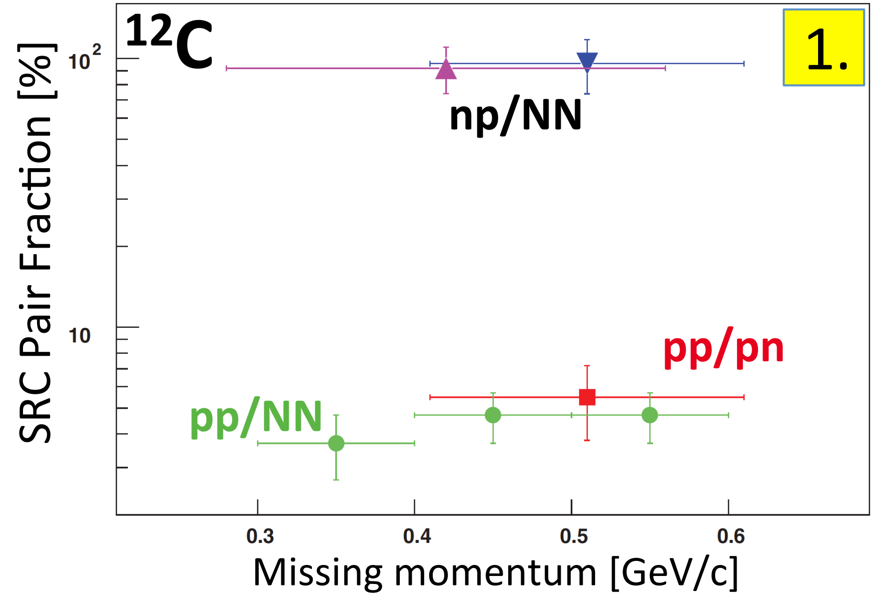
Minority = least abundant nucleon species in an asymmetric nucleus

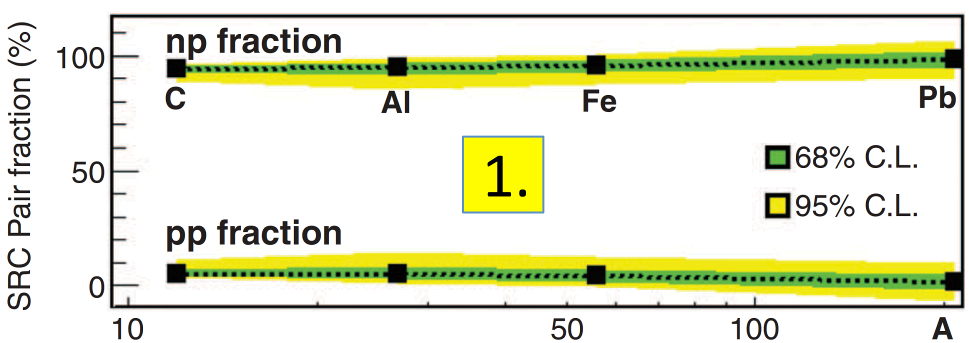
SRC 101

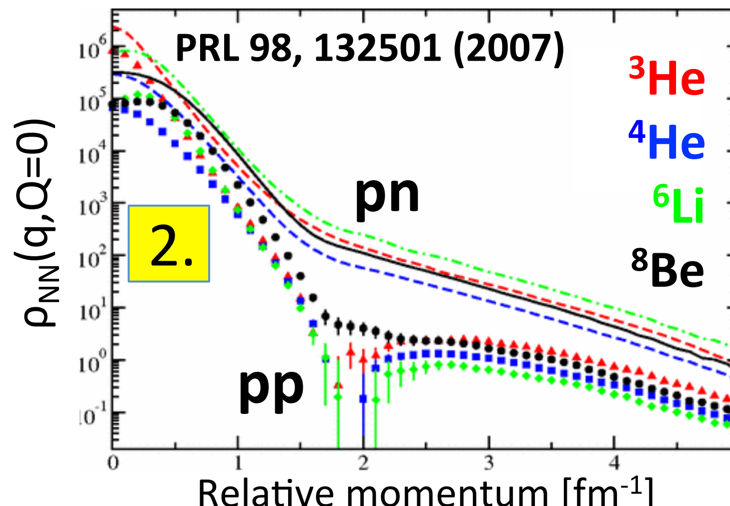
1. Probability for np-SRC is ~18 times larger than pp-SRC. Also true for heavy asymmetric nuclei.
2. Dominant NN force in 2N-SRC is tensor force.

High momentum tail (300-600 MeV/c) is dominated by L=0,2 S=1 pn-SRC pairs.

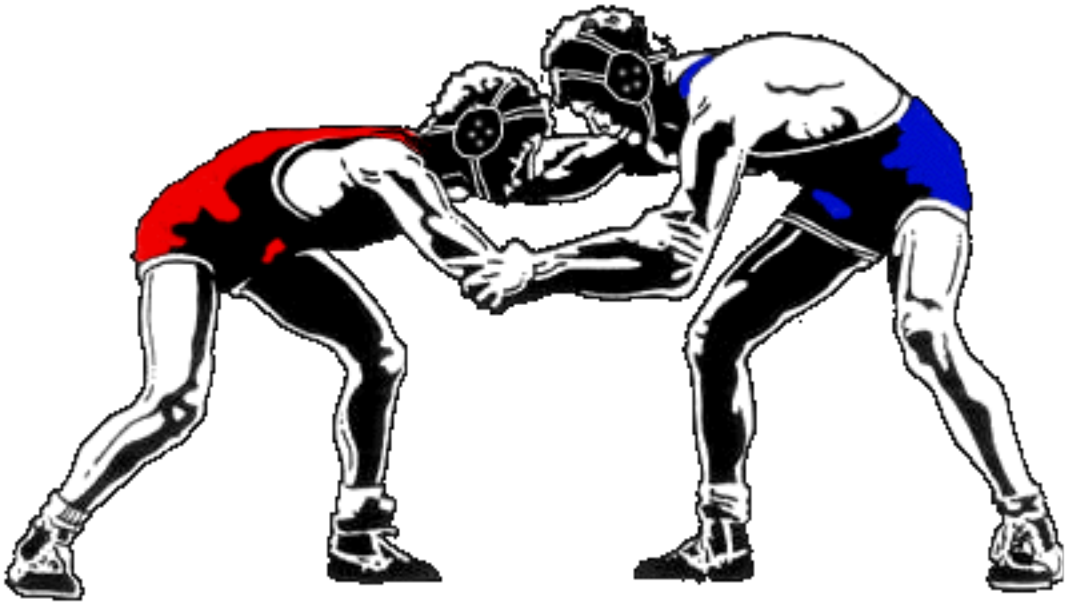
PRL 162504 (2006); Science 320, 1476 (2008)





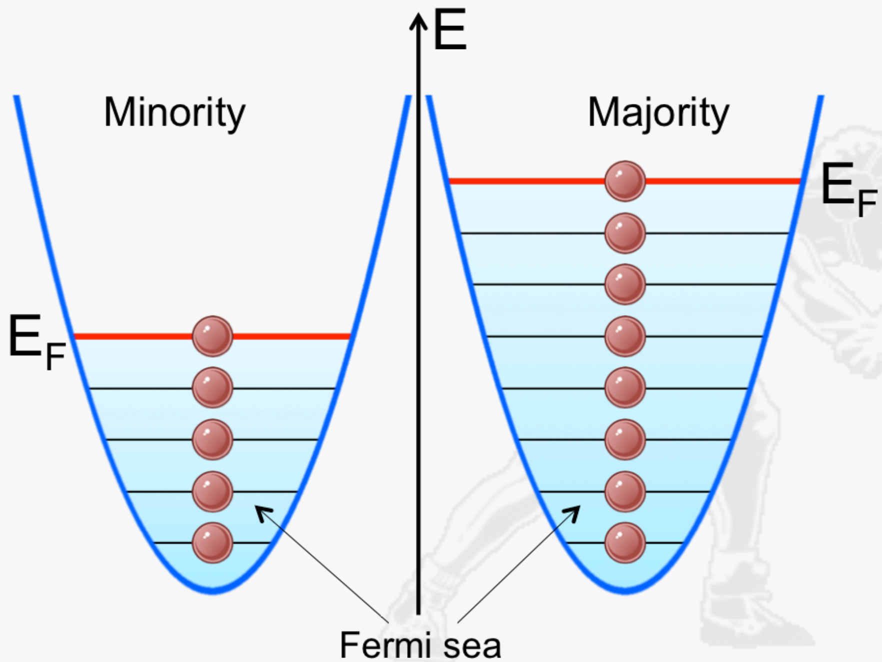


Competing effects



Competing effects

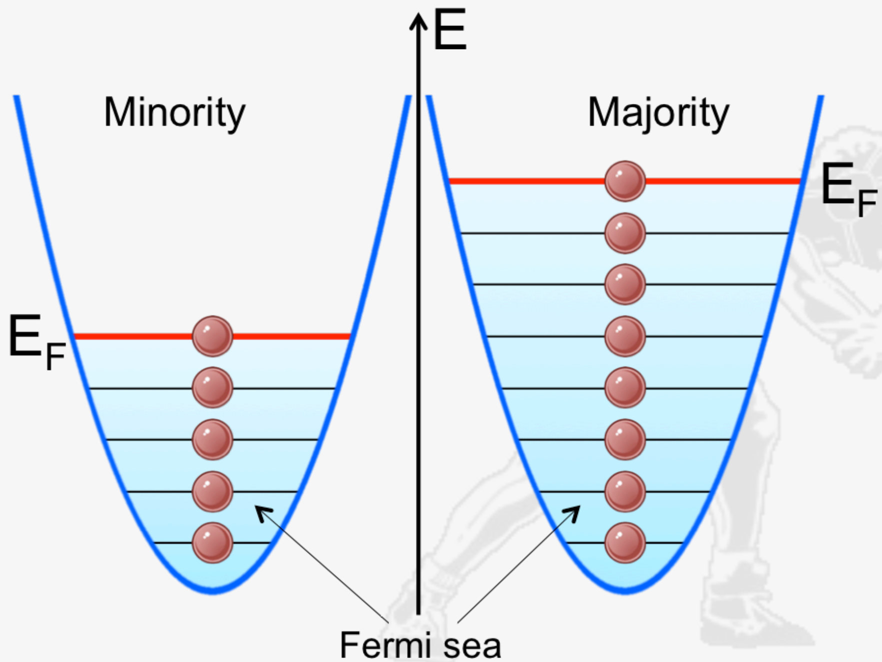
Pauli Principle



$$\langle T \rangle_{\text{Minority}} < \langle T \rangle_{\text{Majority}}$$

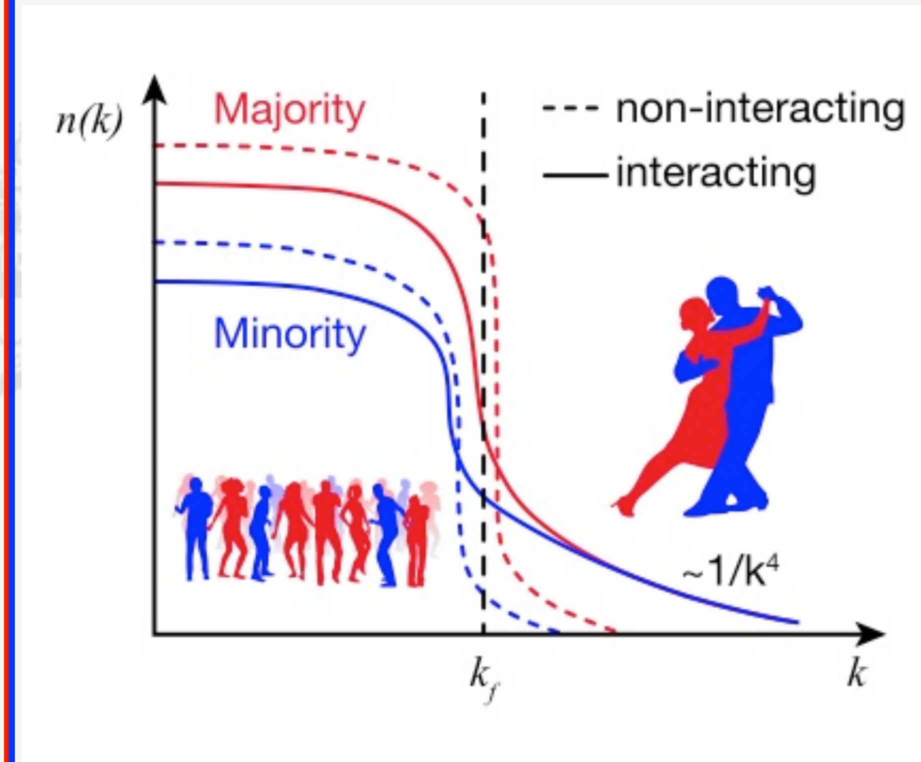
Competing effects

Pauli Principle



$\langle T \rangle_{Minority}$ < $\langle T \rangle_{Majority}$

np correlations



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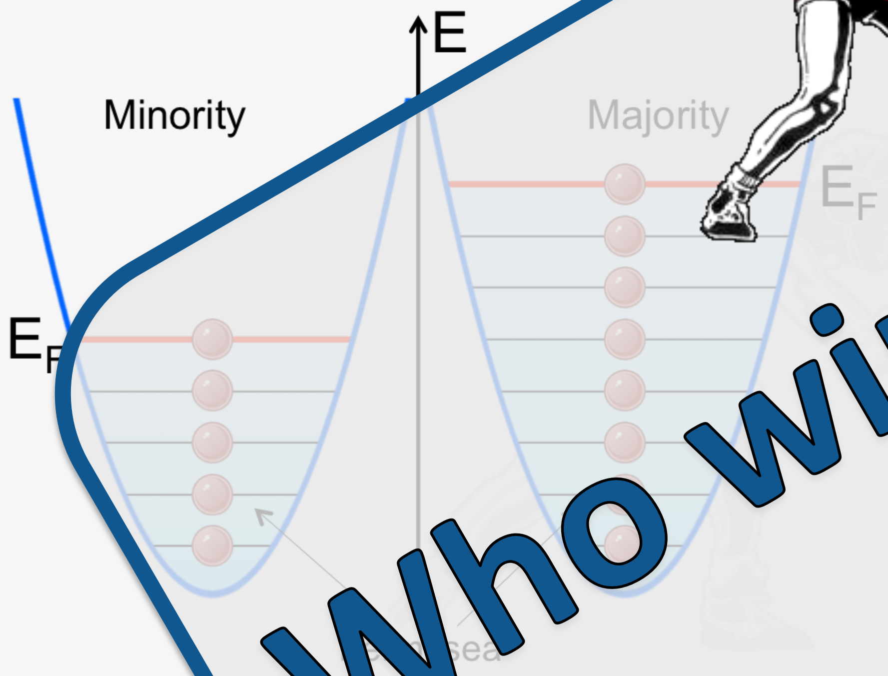

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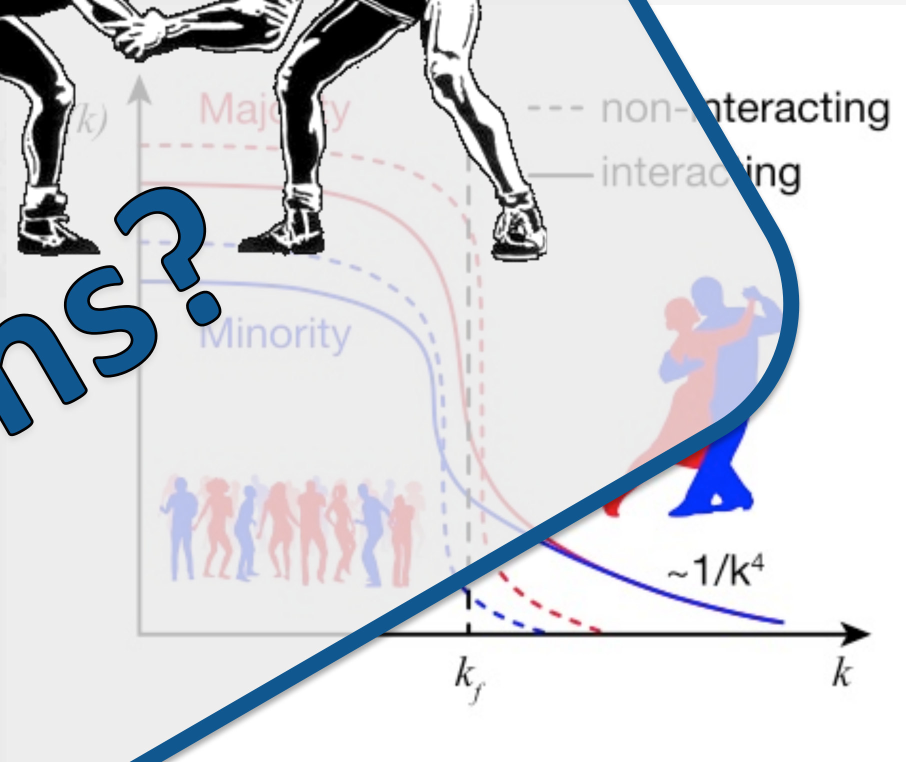
...elations



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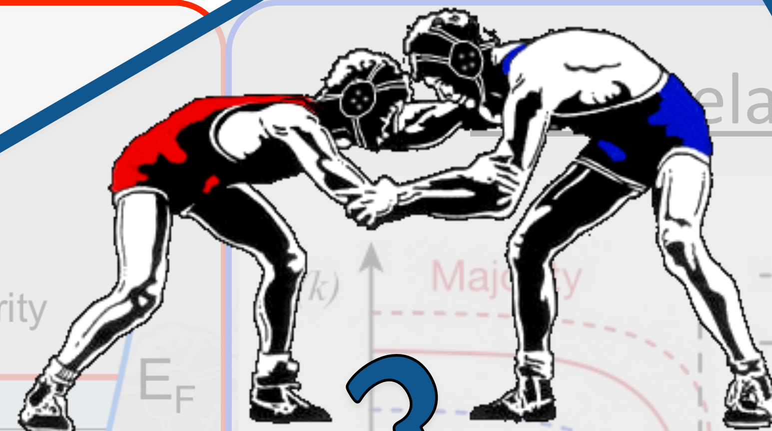
Who wins?



For light nuclei correlations are predicted to win

$\langle T \rangle_{\text{Minority}}$

vs

$\langle T \rangle_{\text{Majority}}$

	$\frac{\lvert N-Z \rvert}{A}$	$\langle T_p \rangle$	$\langle T_n \rangle$	$\langle T_p \rangle - \langle T_n \rangle$
^{8}He	0.50	30.13	18.60	11.53
^{6}He	0.33	27.66	19.06	8.60
^{9}Li	0.33	31.39	24.91	6.48
^{3}He	0.33	14.71	19.35	-4.64
^{3}H	0.33	19.61	14.96	4.65
^{8}Li	0.25	28.95	23.98	4.97
^{10}Be	0.2	30.20	25.95	4.25
^{7}Li	0.14	26.88	24.54	2.34
^{9}Be	0.11	29.82	27.09	2.73
^{11}B	0.09	33.40	31.75	1.65

VMC calculations by R. Wiringa *et al.* (PRC 89, 024305 (2013))

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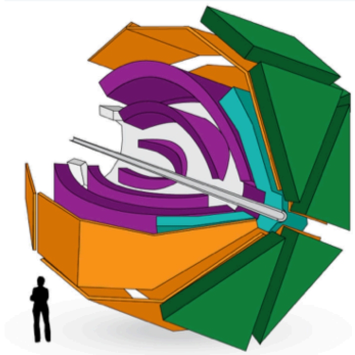
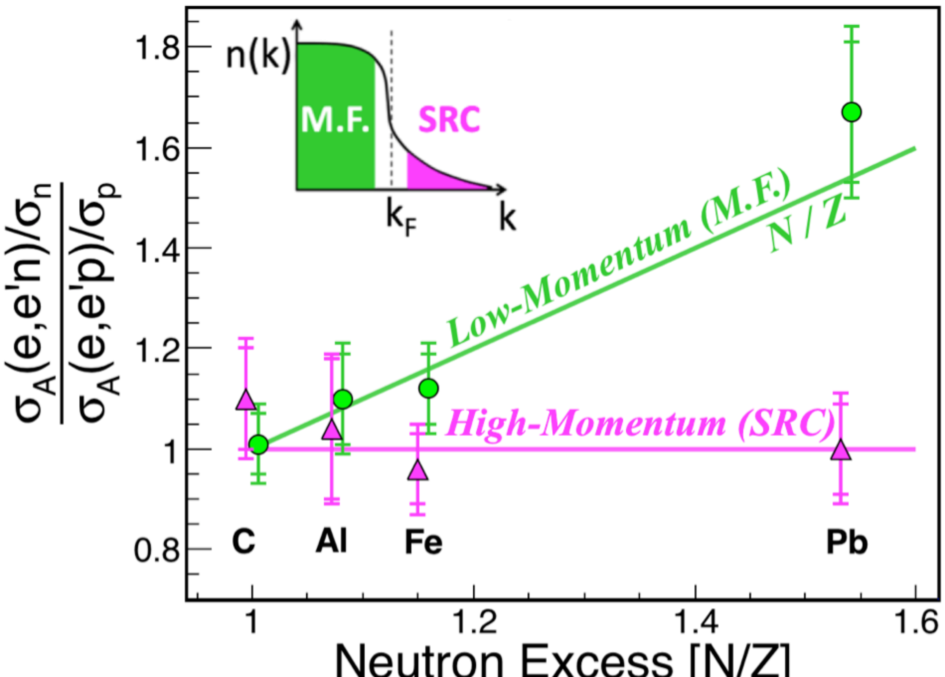
Can we test these predictions experimentally?

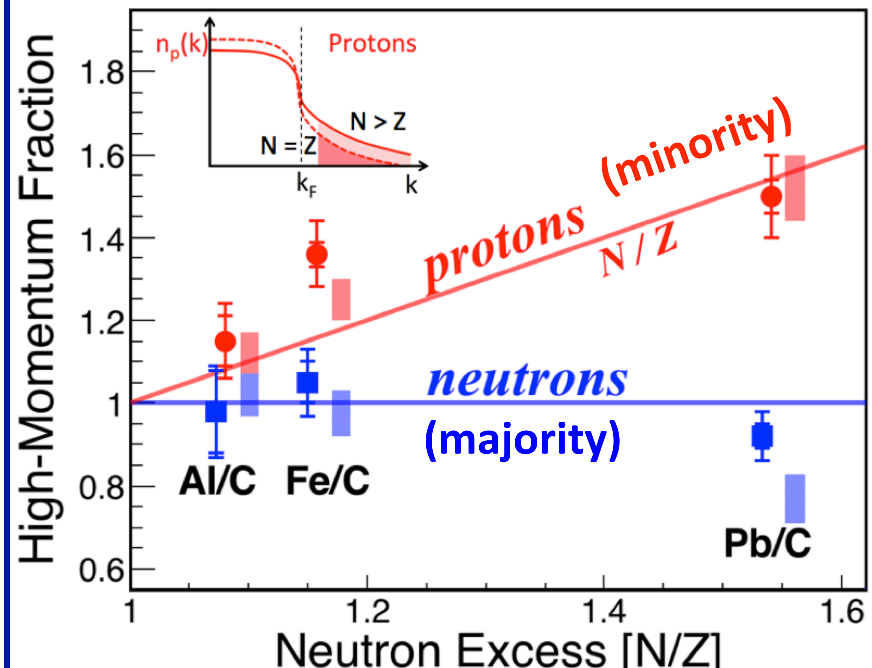
Heavy Nuclei

Meytal Duer's analysis (Hall B)





$$\frac{A(e,e'N)_{high}/A(e,e'N)_{low}}{{}^{12}C(e,e'N)_{high}/{}^{12}C(e,e'N)_{low}}$$



neutron's correlation probability saturates while proton's doesn't

Heavy Nuclei

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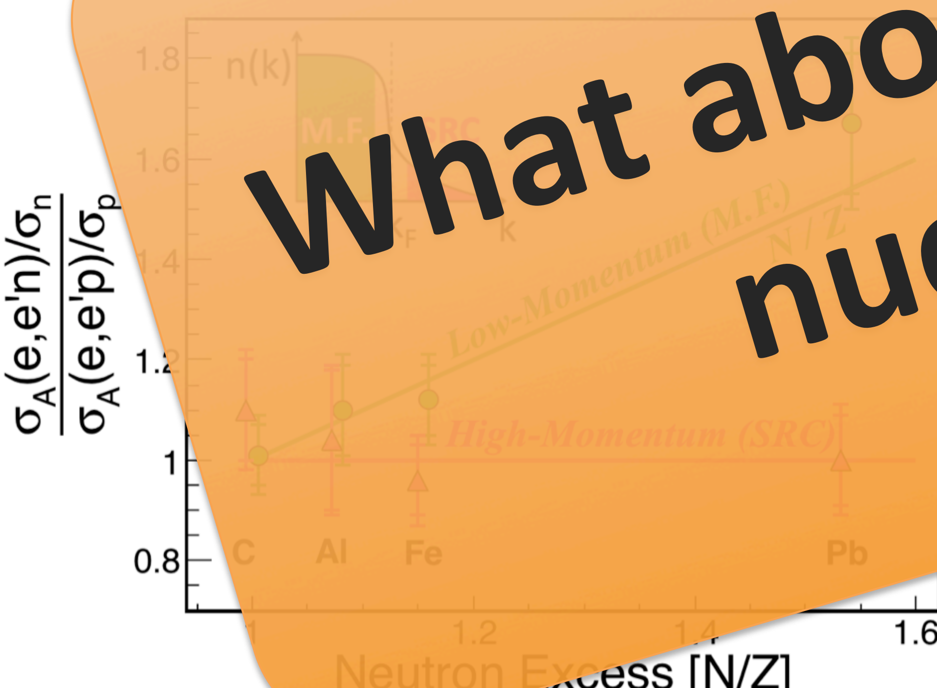
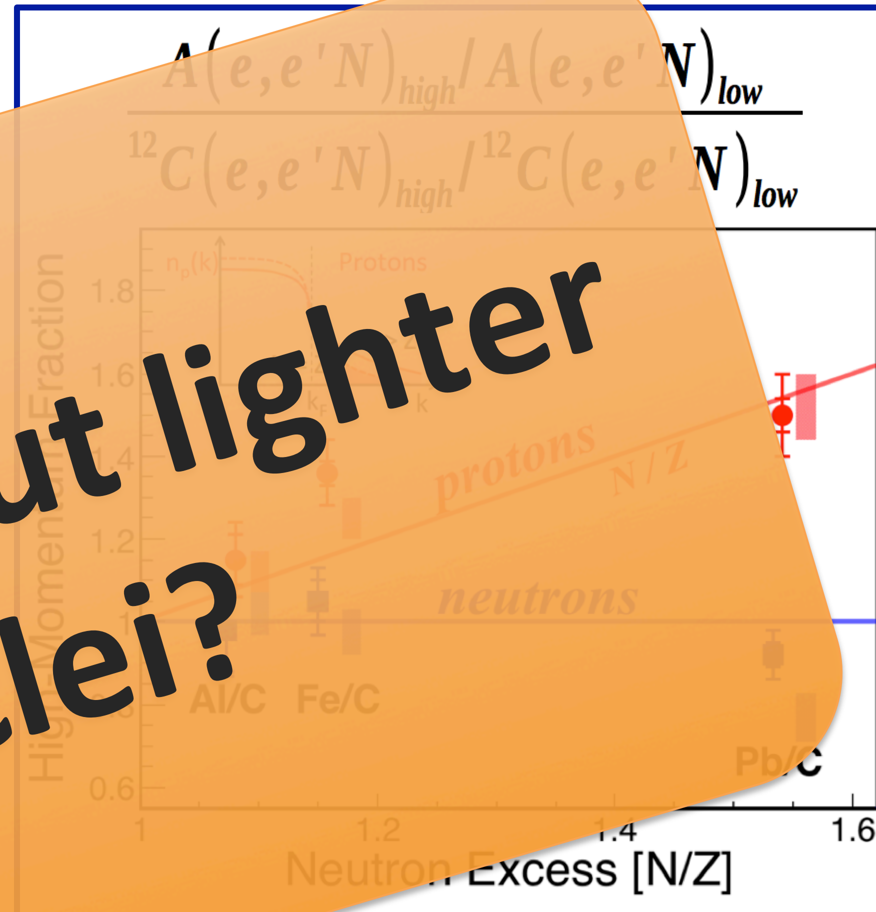




What about lighter nuclei?

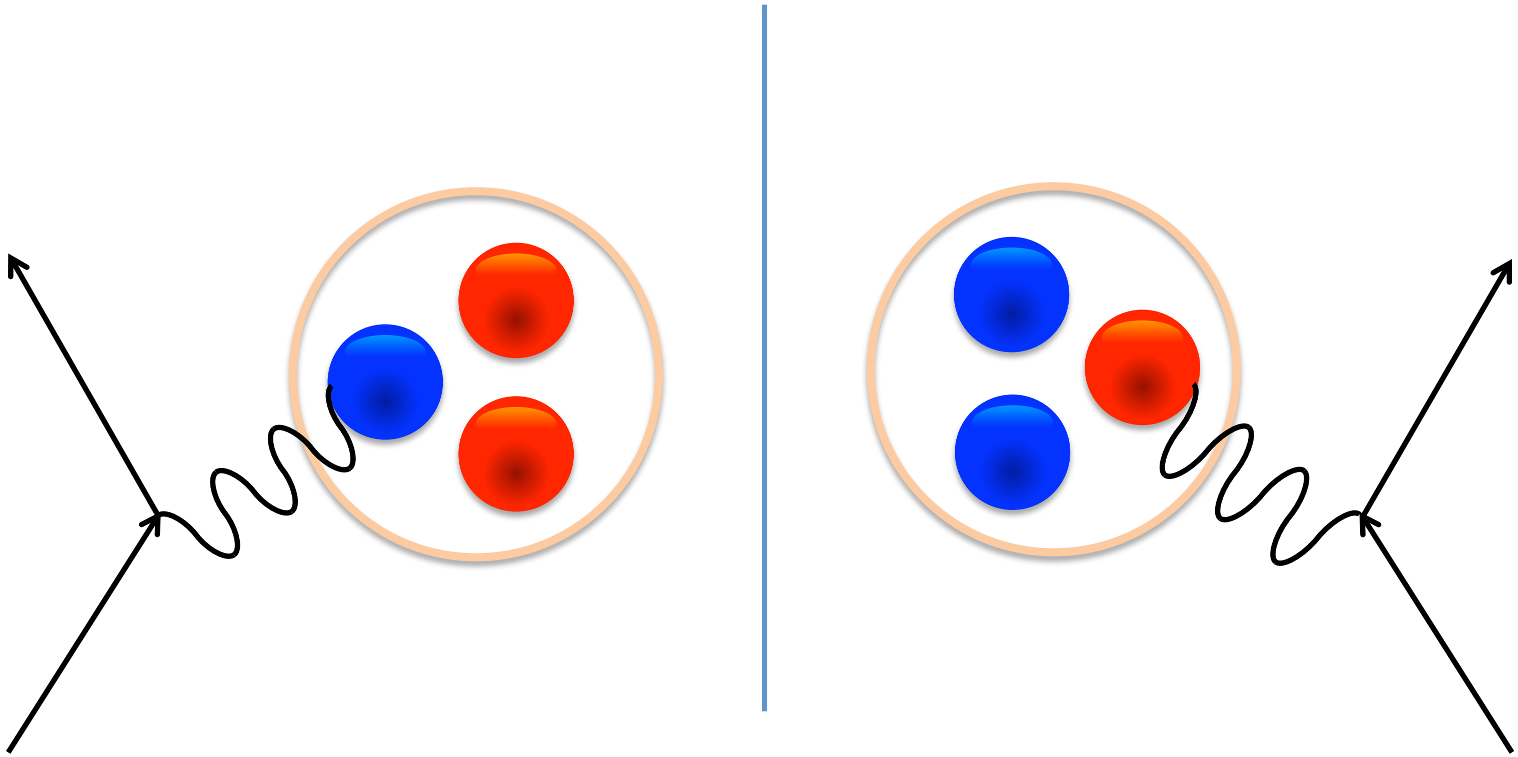
neutron's correlation probability saturates while proton's doesn't

Why tritium?

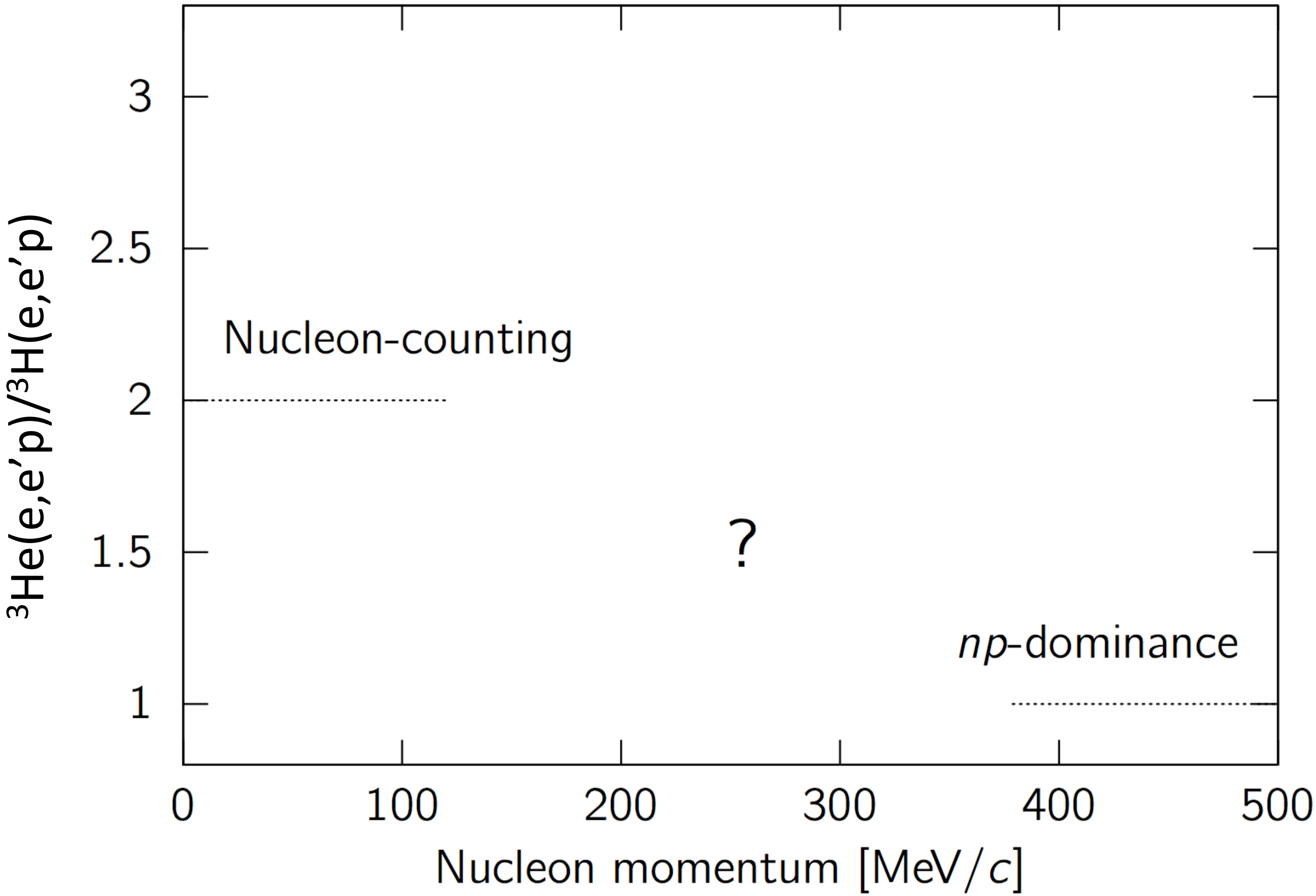
- Small
  - It's well in range of *ab initio* approaches.
- Wicked asymmetric
  - $A/2Z = 1.5$, compare to Pb, ≈ 1.27
- Isospin doublet
  - ^{3}He is stable mirror nucleus.

A=3 nuclear systems

$$\frac{^{3}\mathrm{He}(e,e'p)}{^{3}\mathrm{He}(e,e'n)} \cong \frac{^{3}\mathrm{He}(e,e'p)}{^{3}\mathrm{H}(e,e'p)}$$



Transition in the $^3He/^3H$ ratio



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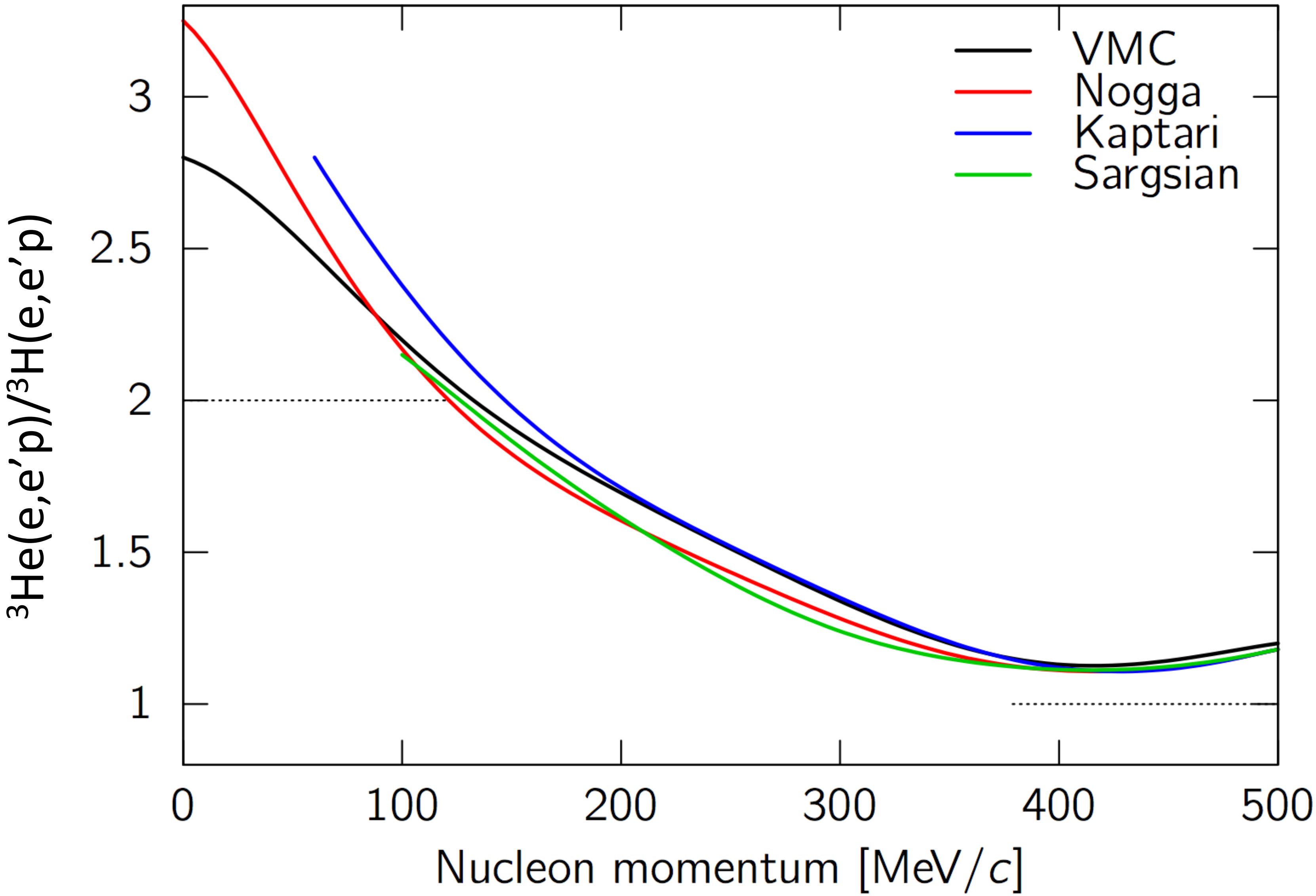
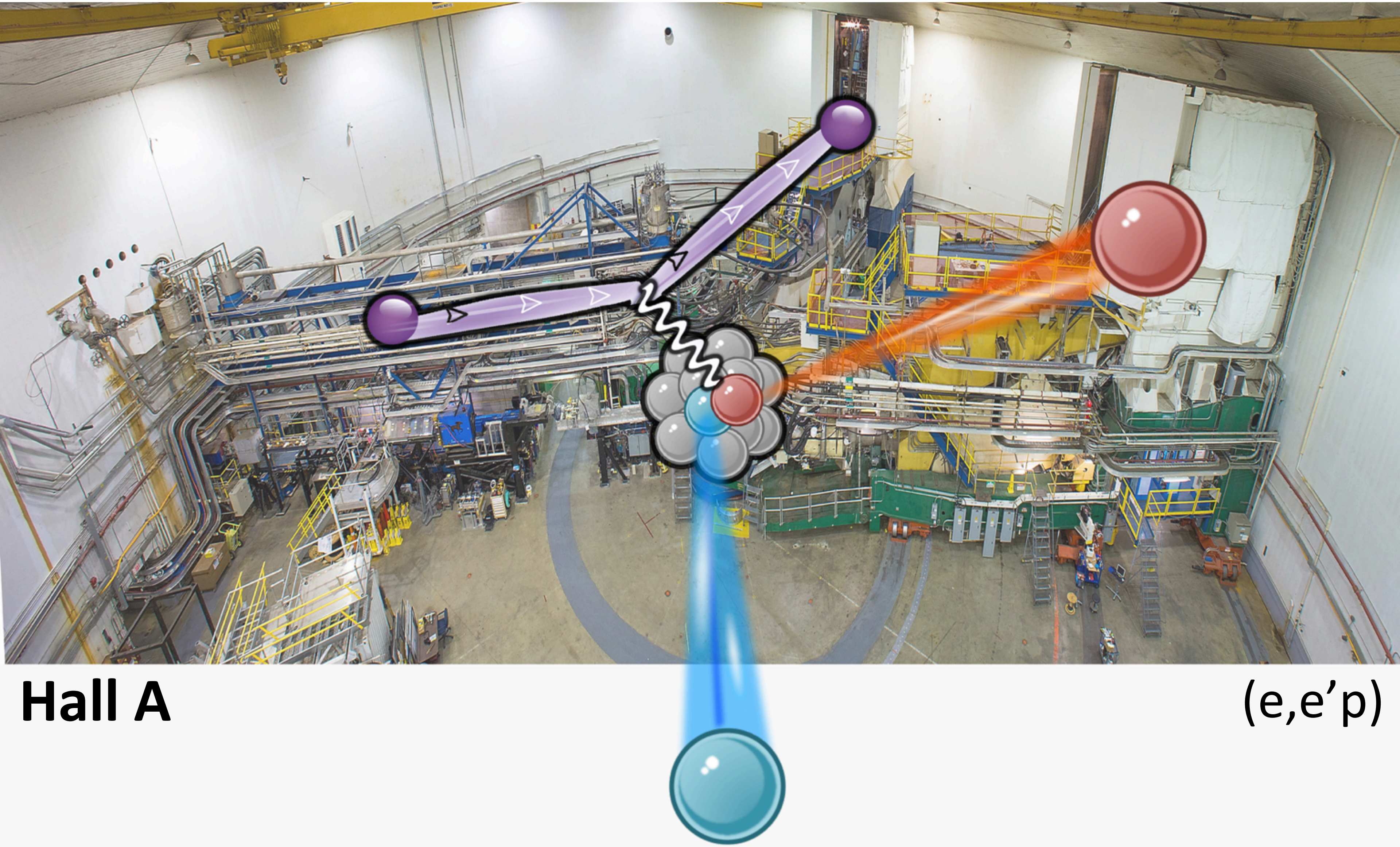


electron-induced reactions



Hall A

(e,e’p)

Data taking, Spring 2018

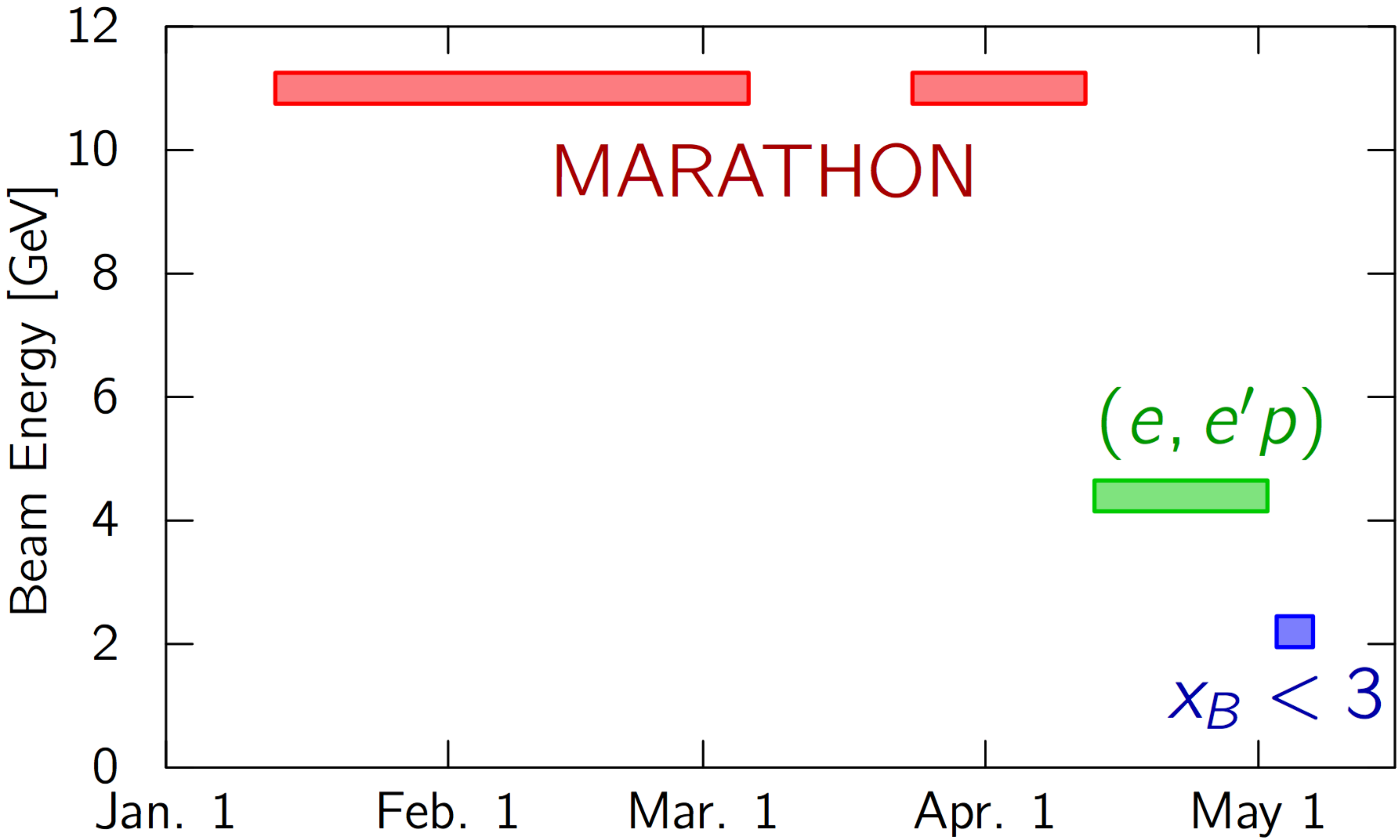
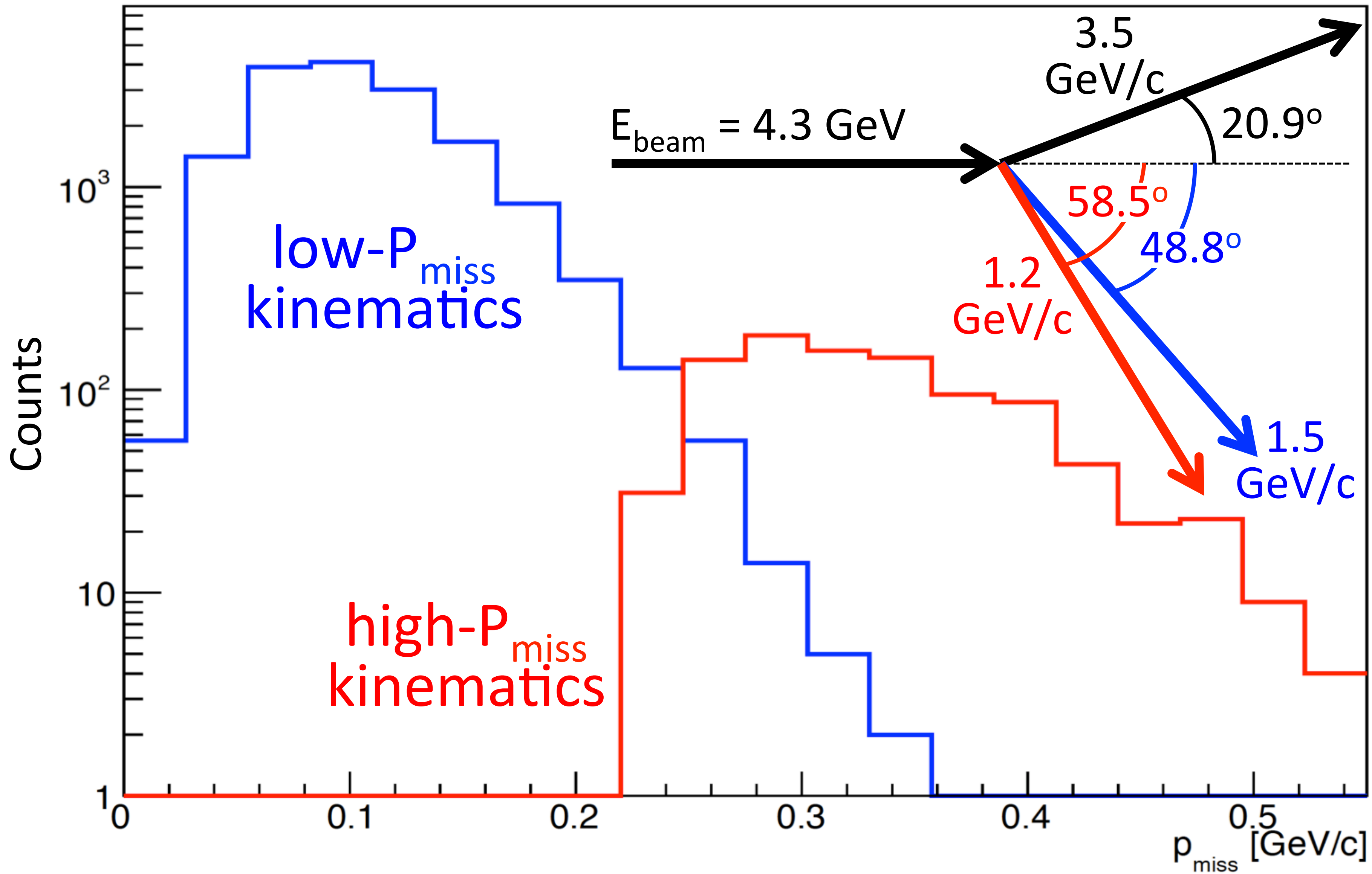


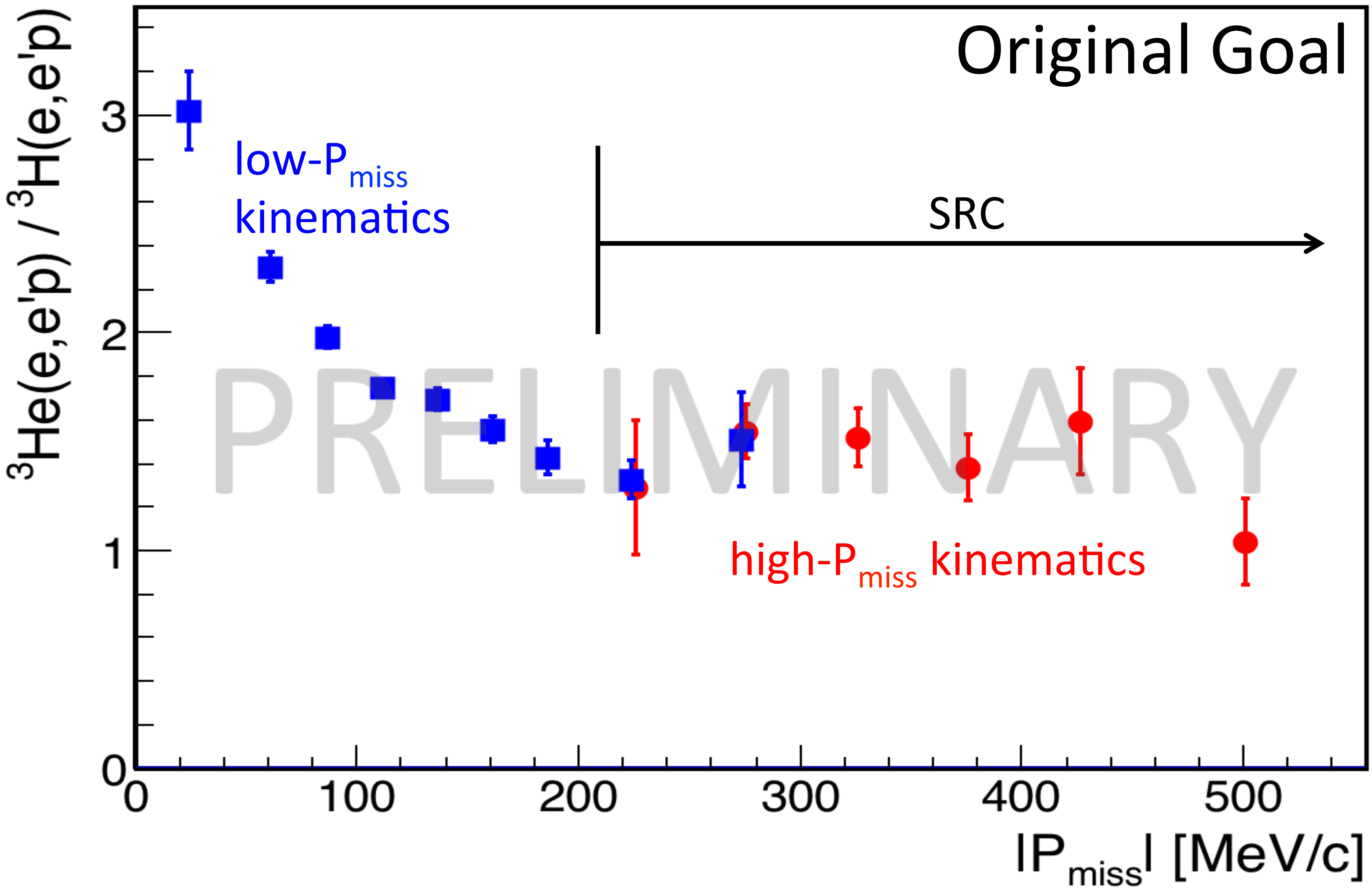
Figure by A.Schmidt

Kinematics

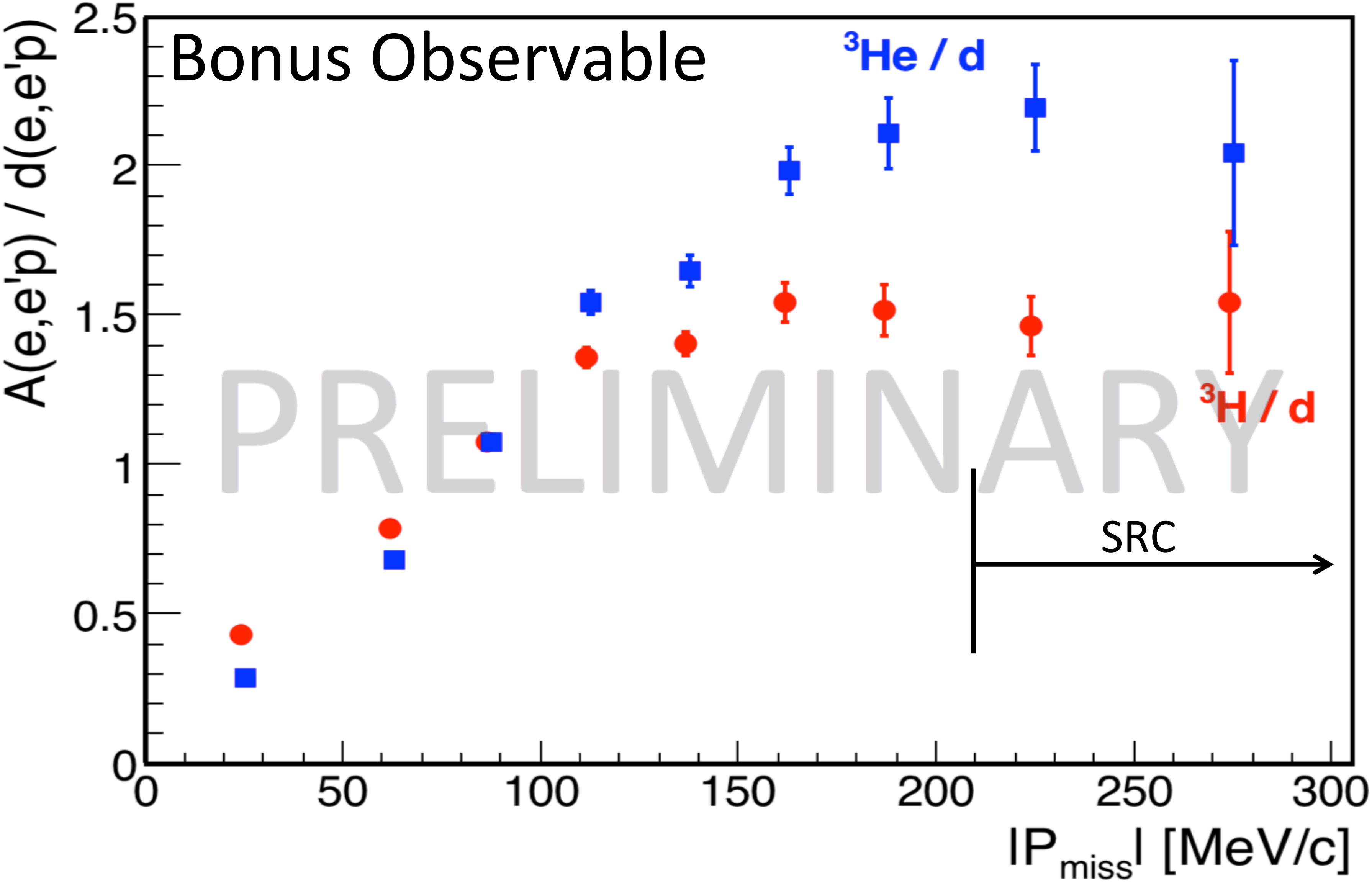


3.5
GeV/c
20.9°
E beam = 4.3 GeV
58.5°
48.8°
1.2
GeV/c
1.5
GeV/c
low-P miss
kinematics
high-P miss
kinematics
Counts
10³
10²
10
1
0
0.1
0.2
0.3
0.4
0.5
p miss [GeV/c]

Preliminary Results

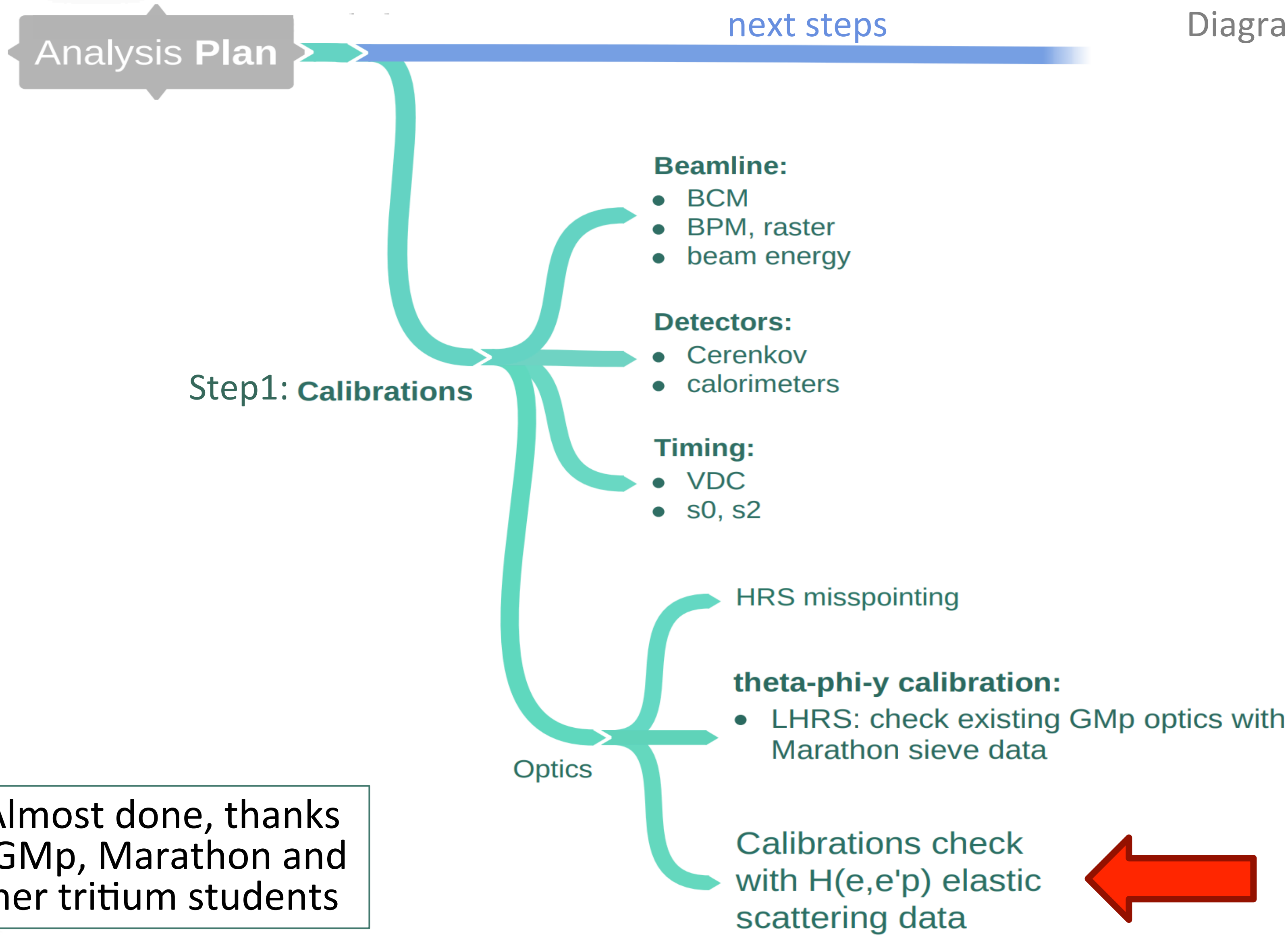


Preliminary Results



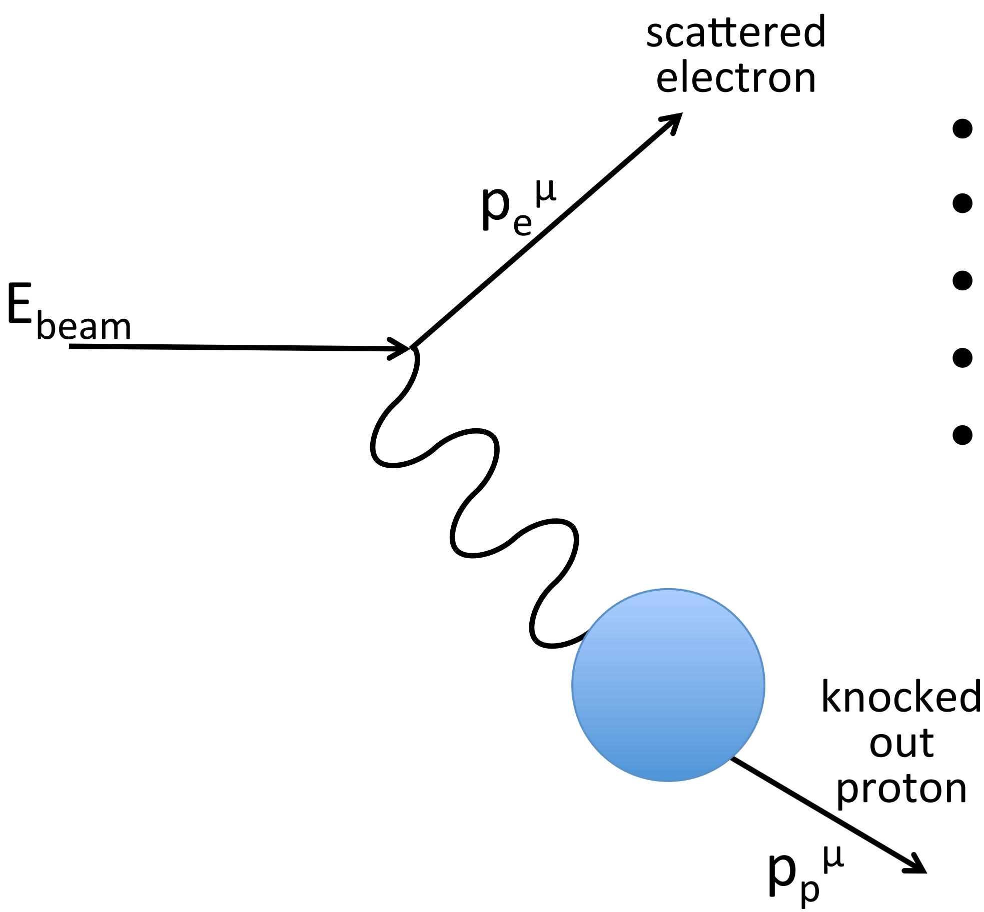
Analysis Plan

Diagram by S.Li



* Almost done, thanks to GMp, Marathon and other tritium students

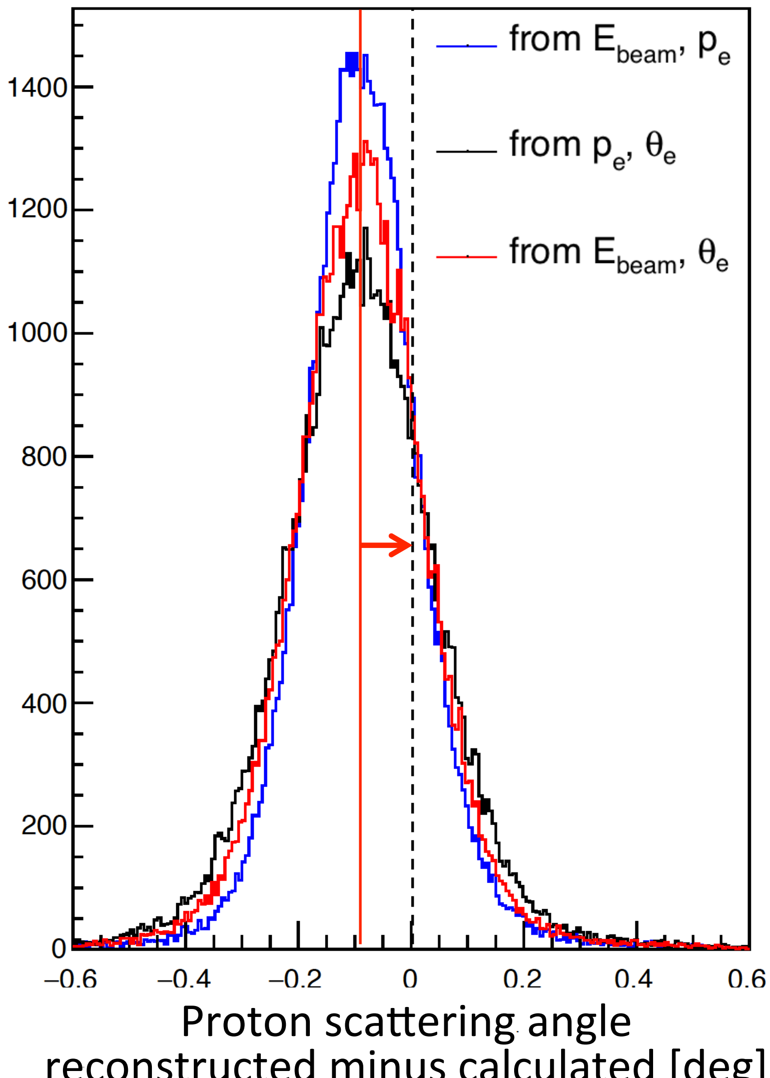
$^{1}H(e,e'p)$ elastic scattering can be used to check and fix calibrations



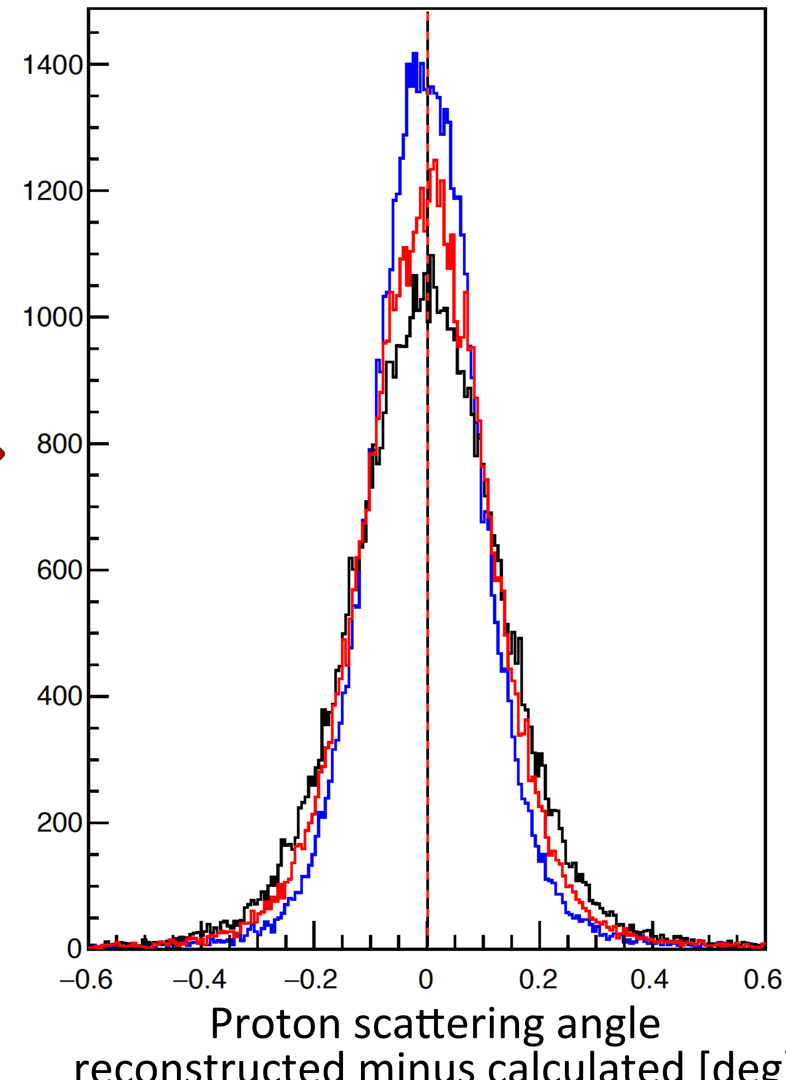
- 9 degrees of freedom:
- -1 (Energy Conservation)
- -3 (Momentum Conservation)
- -1 (Reaction on a Plane)
- -2 ($E^2 = m^2 + p^2$)

2 degrees-of-freedom i.e. Any two quantities are enough to fully characterize the kinematics

$^{1}H(e,e'p)$ elastic scattering can be used to check and fix calibrations



Correcting proton angle



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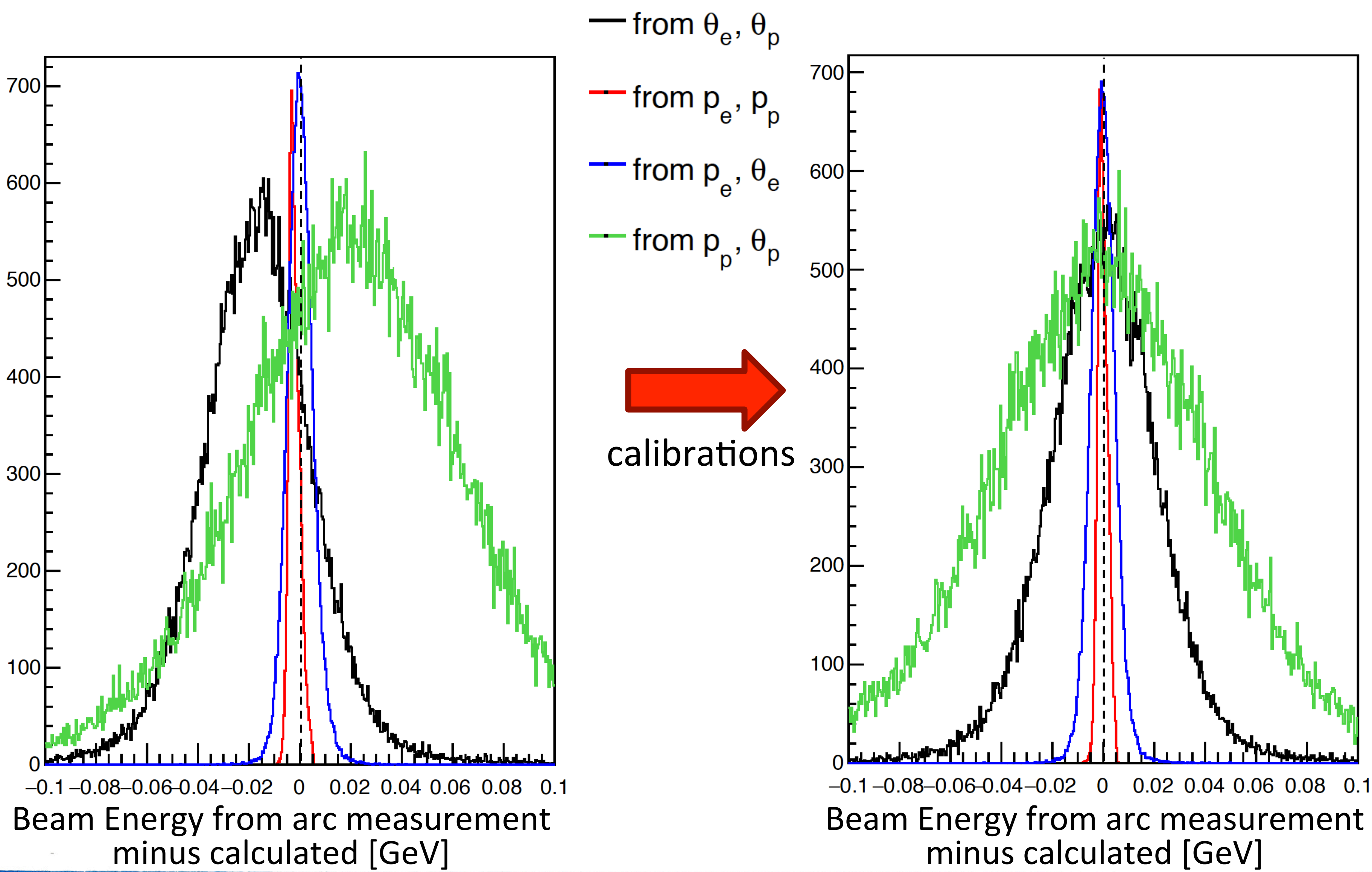

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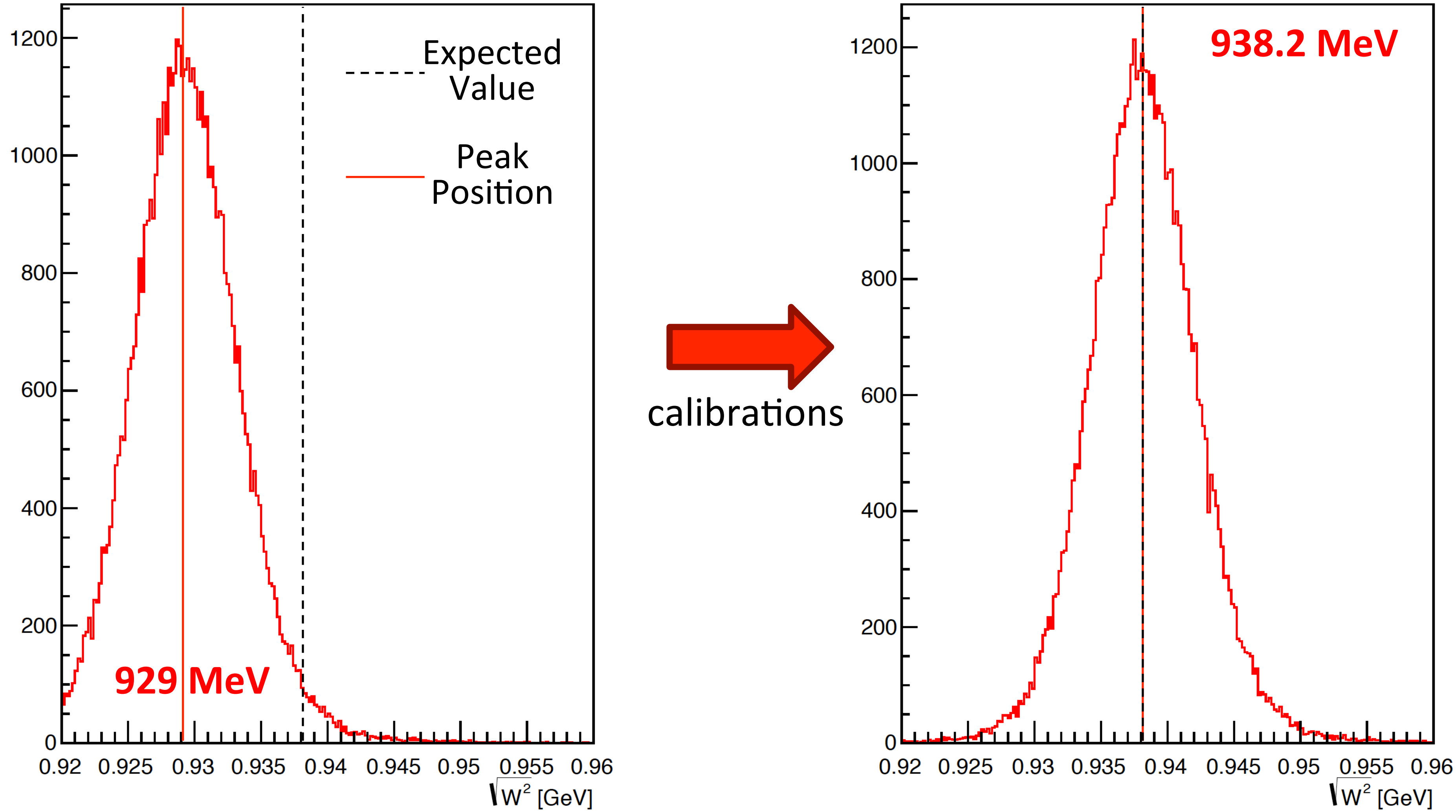
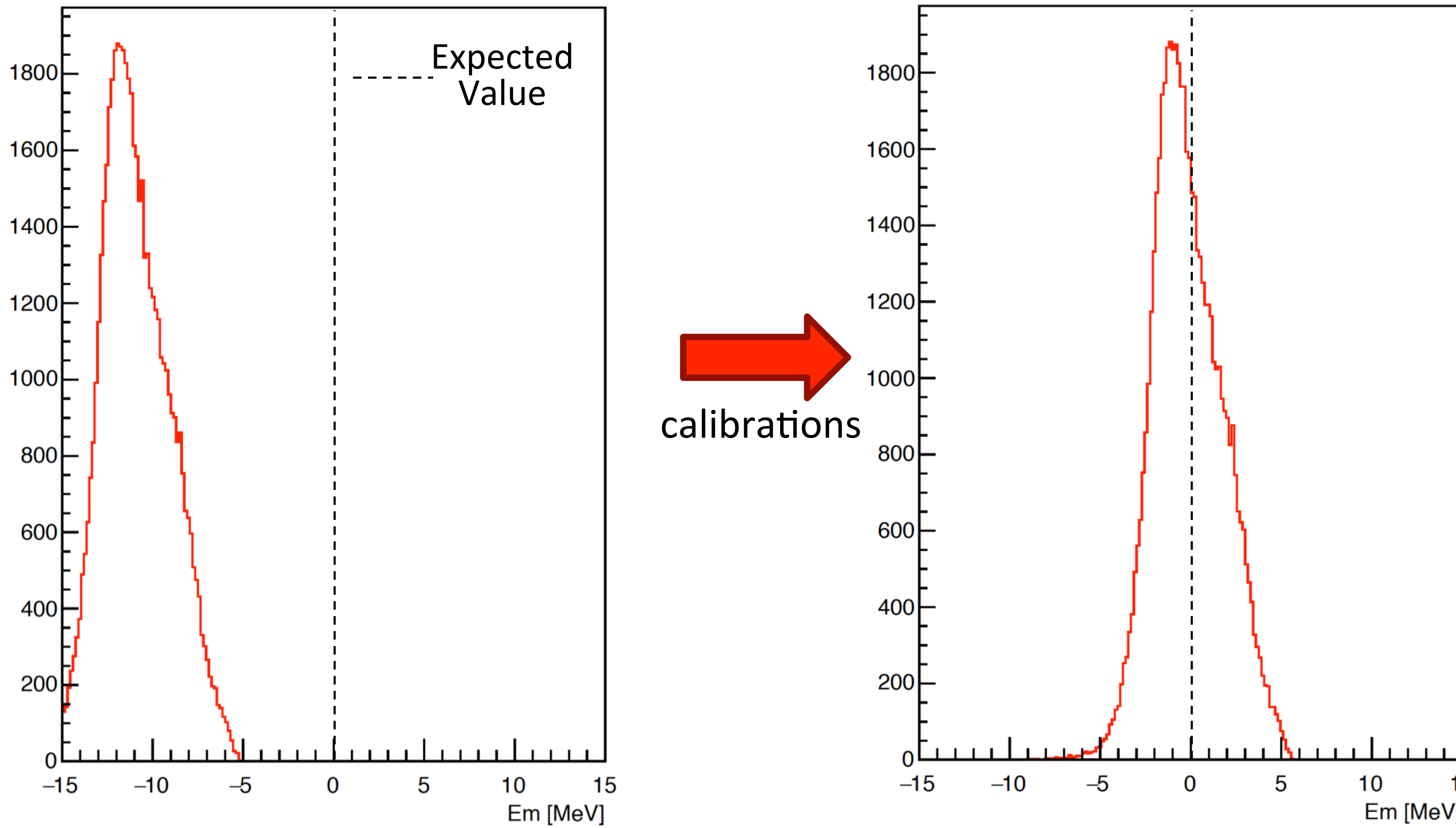
Invariant Mass Distribution



^{1}H(e,e'p) elastic scattering can be used to check and fix calibrations

Missing Energy Distribution



Summary and conclusions

- The experimental study of short-range correlations in light nuclei provides a very stringent test of theoretical calculations.
- Experiments on Tritium are a once-in-a-generation opportunity.
- We conducted a successful experiment in Hall-A in April.
- Expect results in the near future. Stay tuned!

Thank you!

"The <u>precious tritium</u> is the fuel that makes this project go"

Otto Octavius