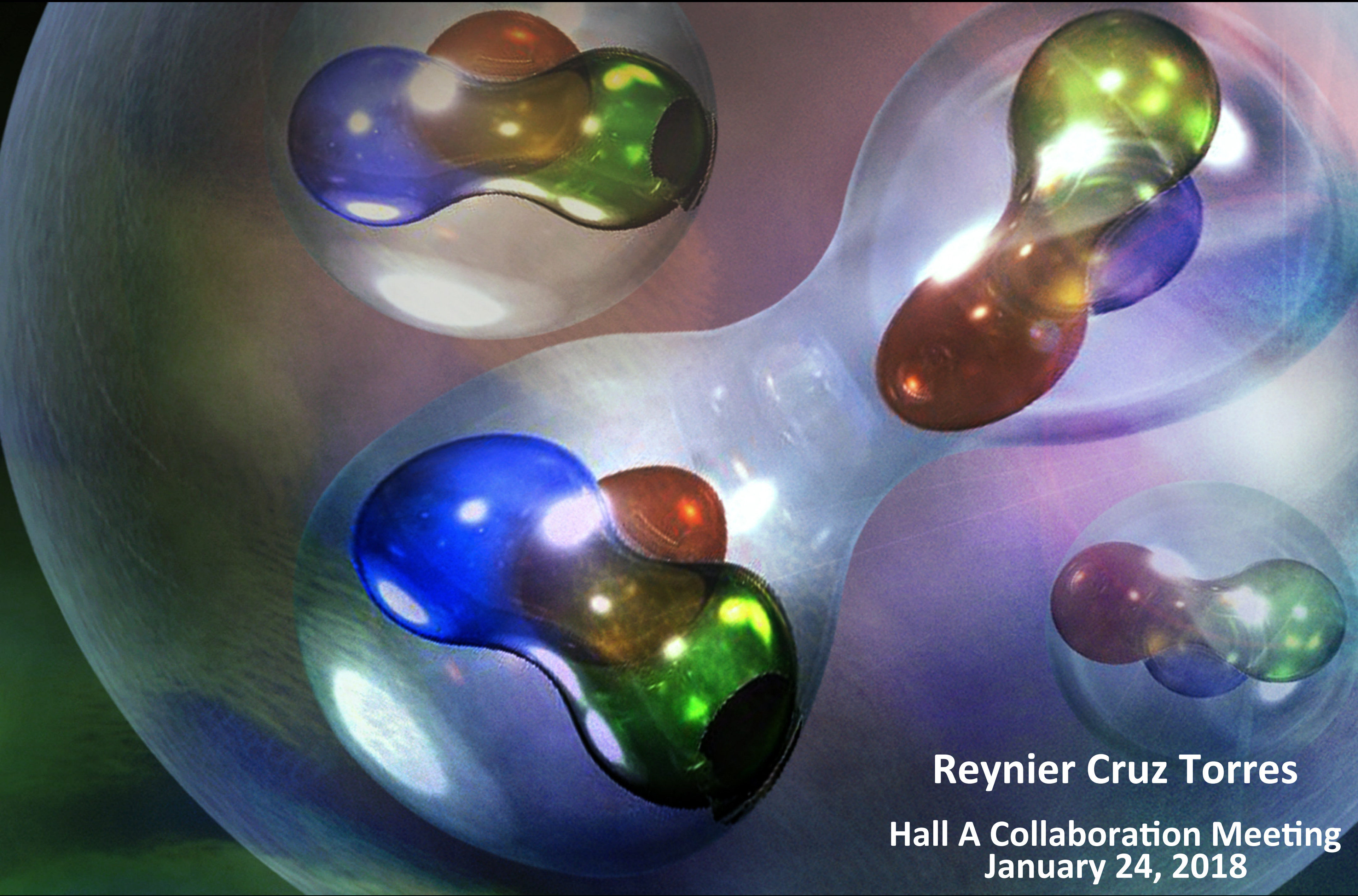
Jefferson Lab

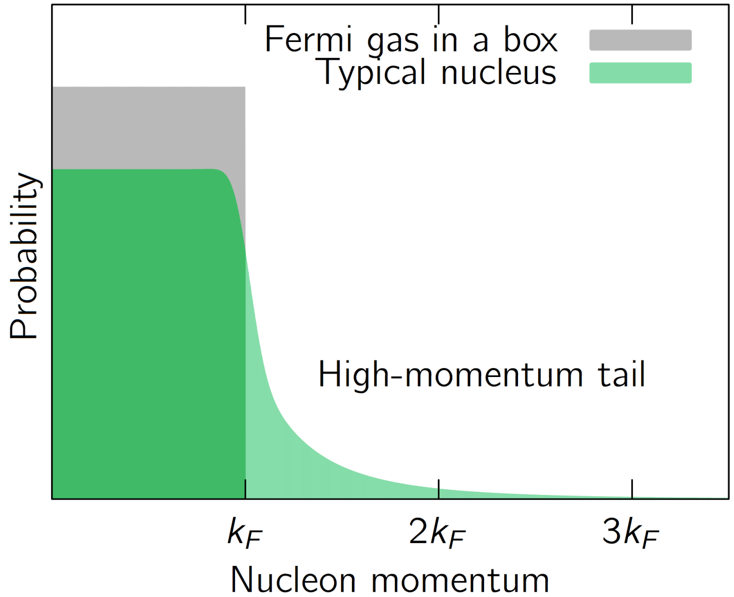
A = 3 Nuclei: A Lab for Energy Sharing in Asymmetric Systems

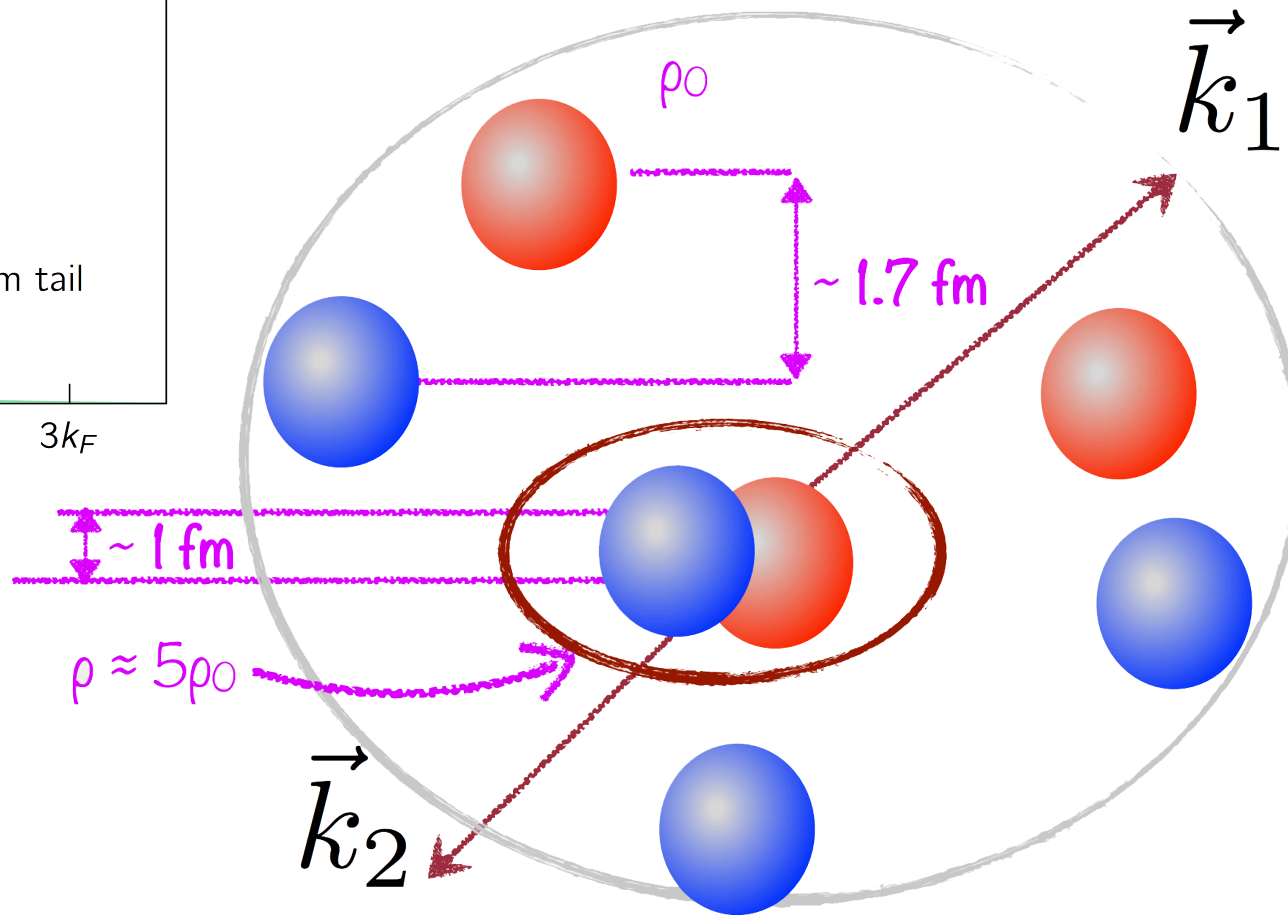


Reynier Cruz Torres

Hall A Collaboration Meeting
January 24, 2018

SRC 101

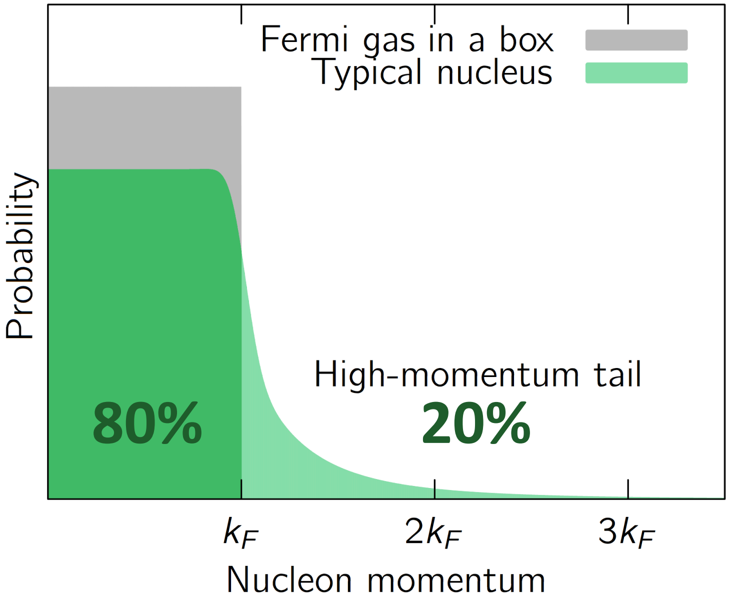




Majority = most abundant nucleon species in an asymmetric nucleus

Minority = least abundant nucleon species in an asymmetric nucleus

SRC 101



Account for ~20% of all nucleons in any nucleus.

Dominate the momentum distribution above the Fermi momentum (k_F).

Nucleons in the pair have high relative momentum and low center of mass momentum relative to k_F.

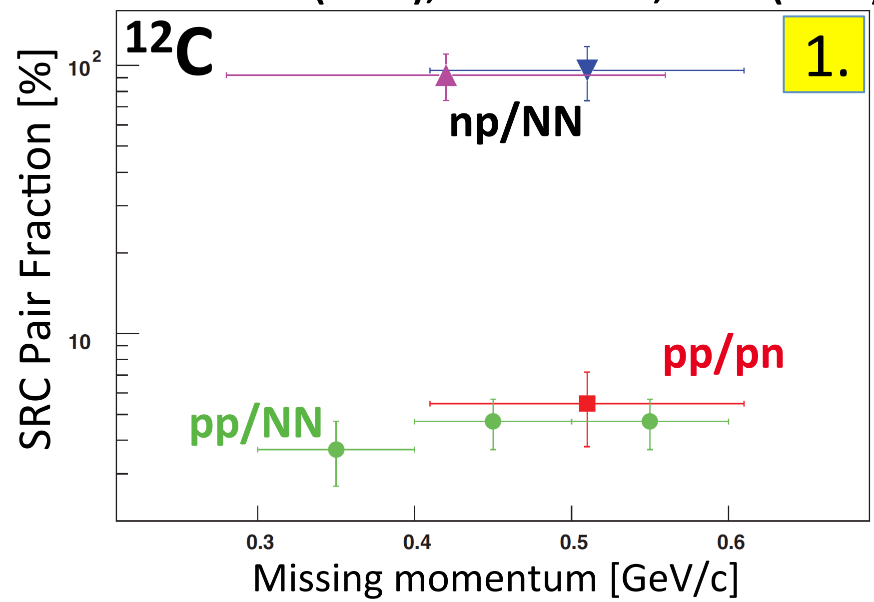
O. Hen et al., Science 364 (2014) 614.
Korover et al., PRL 113 (2014) 022501.
N. Fomin et al., PRL 108, 092502 (2012).
R. Subedi et al., Science 320 (2008) 1476.
K. Sh. Egiyan et al., PRC 68, 014313 (2003).
H. Baghdasaryan et al., PRL 105, 222501 (2010).
O. Hen, L. B. Weinstein, E. Piasetzky, *et al.*, PRC 92, no. 4, 045205 (2015).

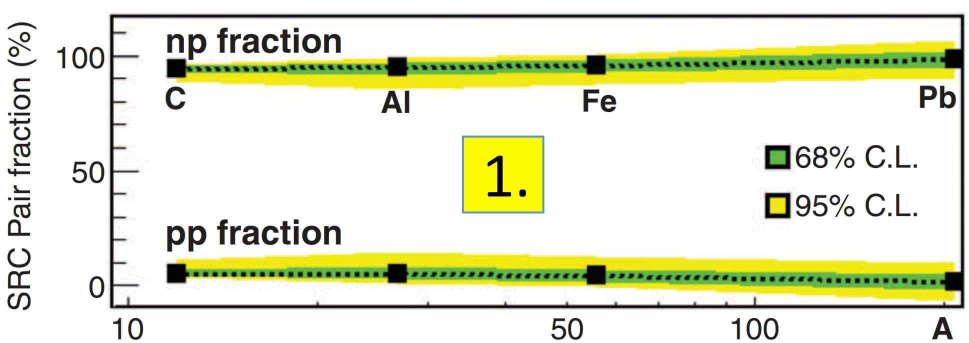
SRC 101

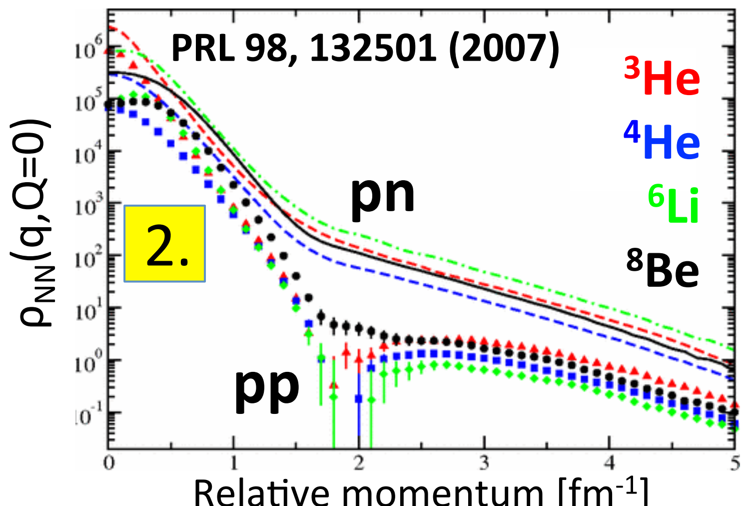
1. Probability for np-SRC is ~18 times larger than pp-SRC. Also true for heavy asymmetric nuclei.
2. Dominant NN force in 2N-SRC is tensor force.

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

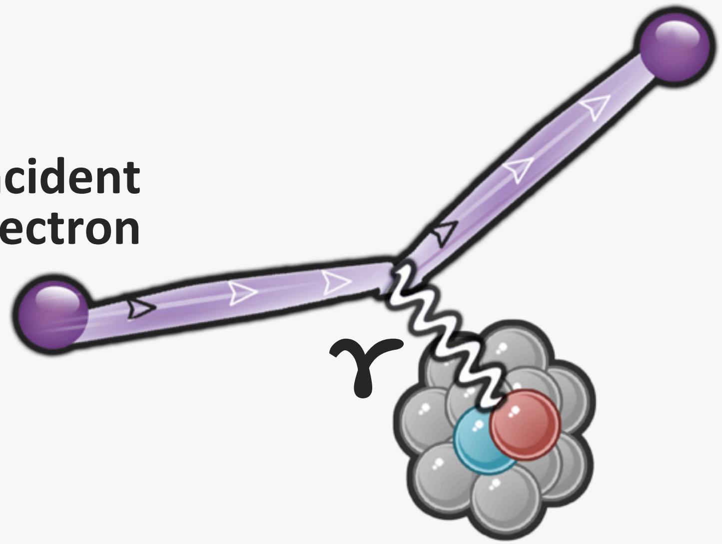
PRL 162504 (2006); Science 320, 1476 (2008)







electron-induced reactions



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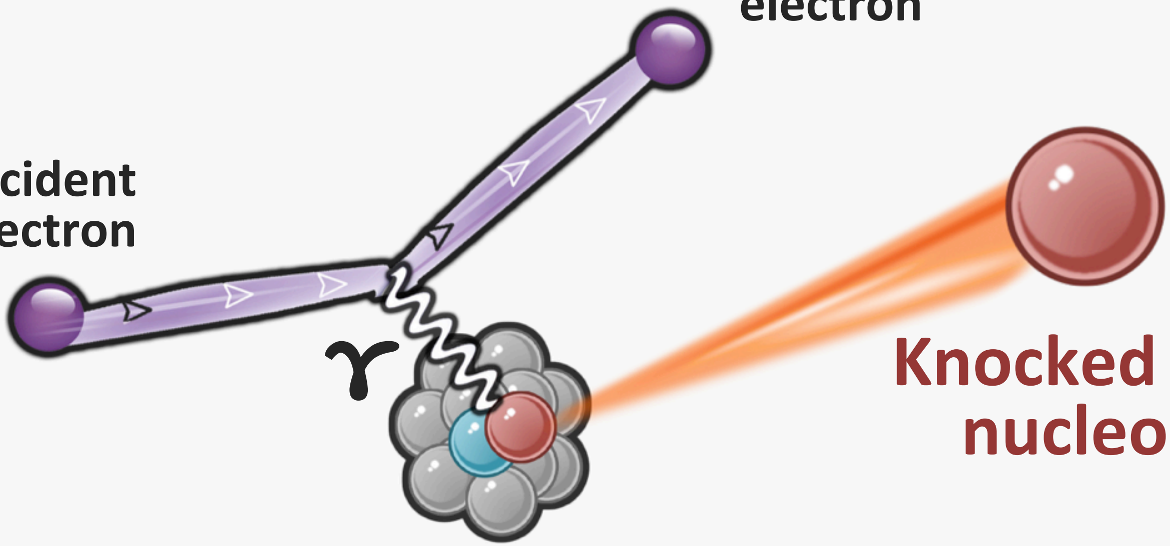

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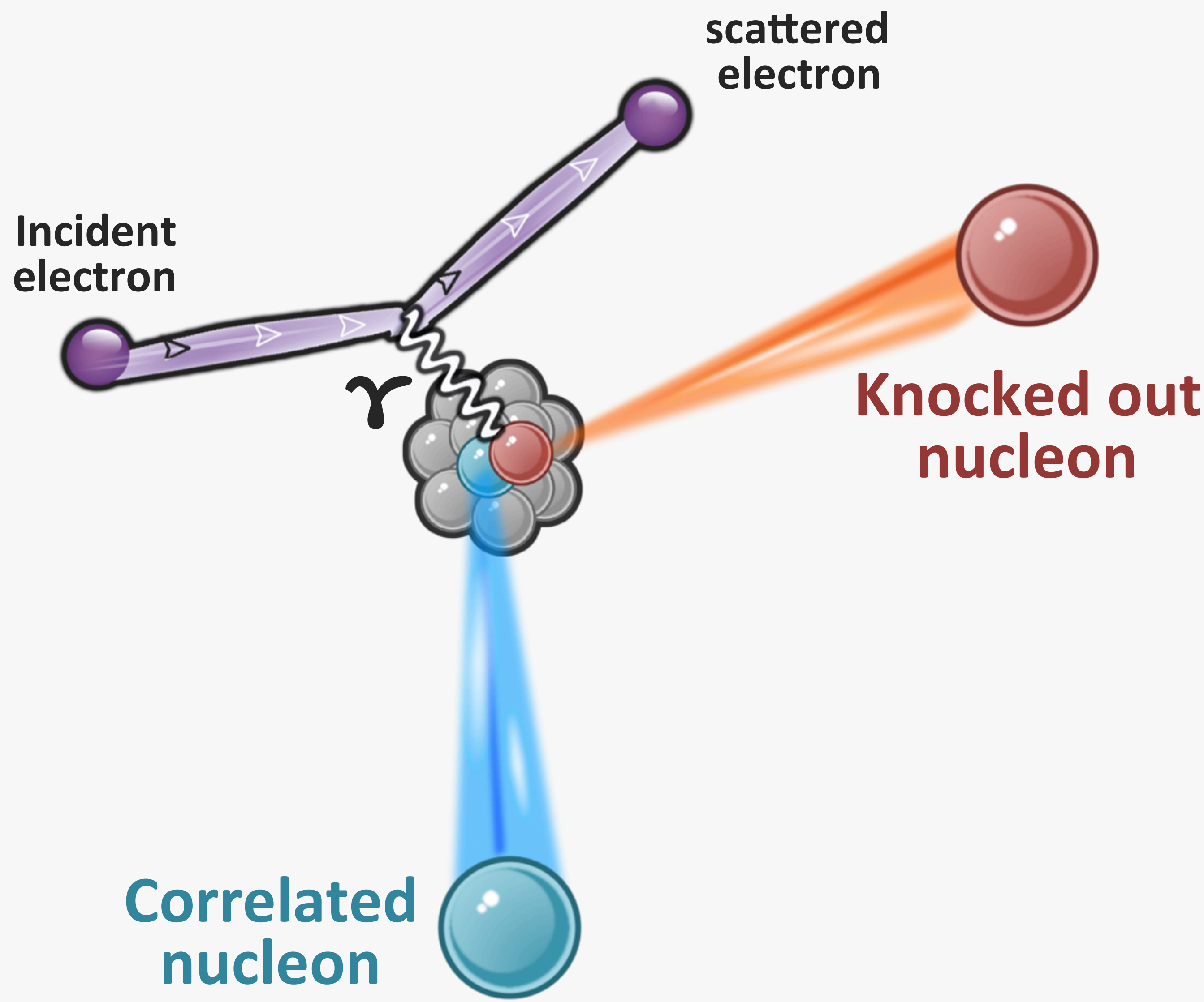

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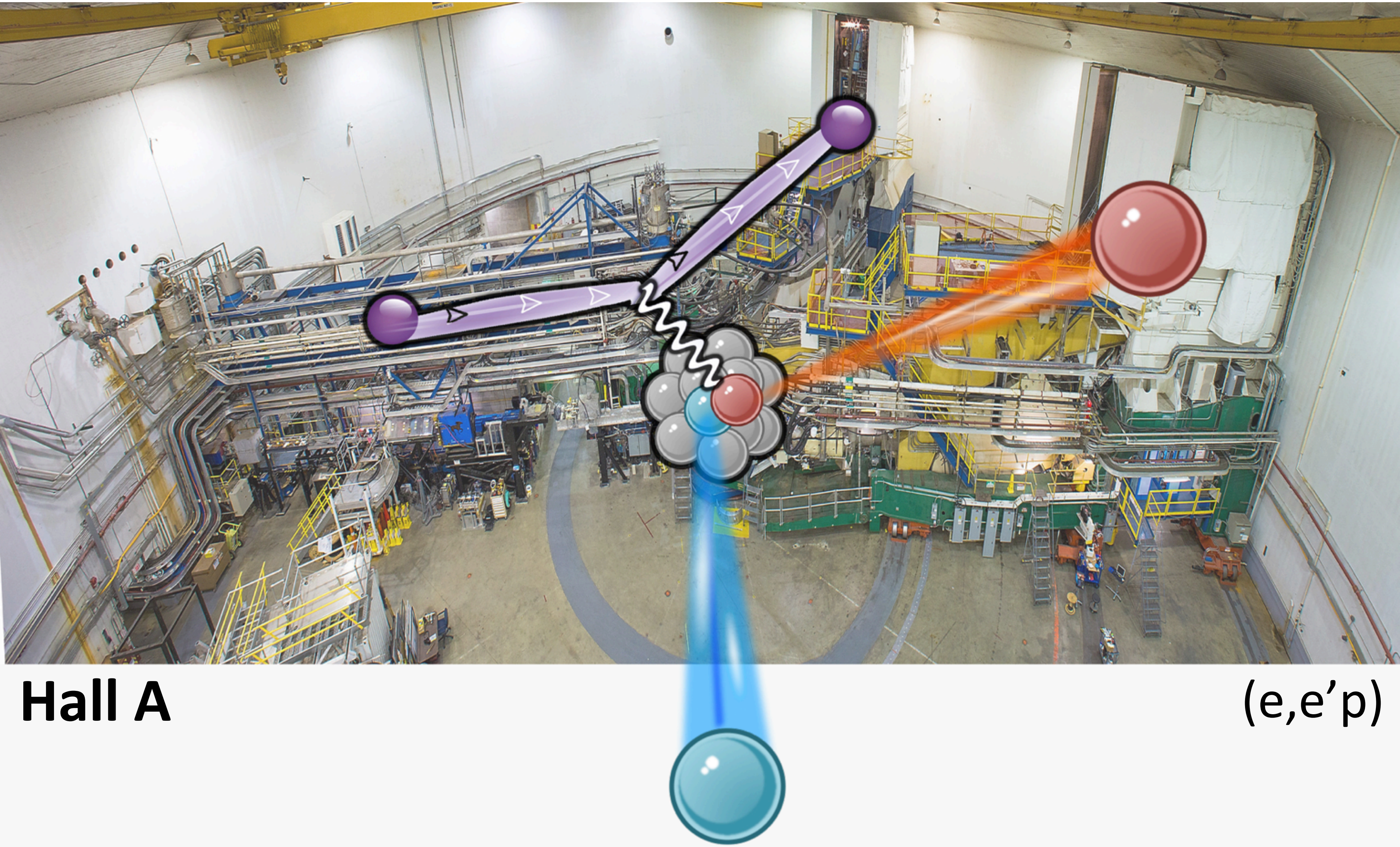
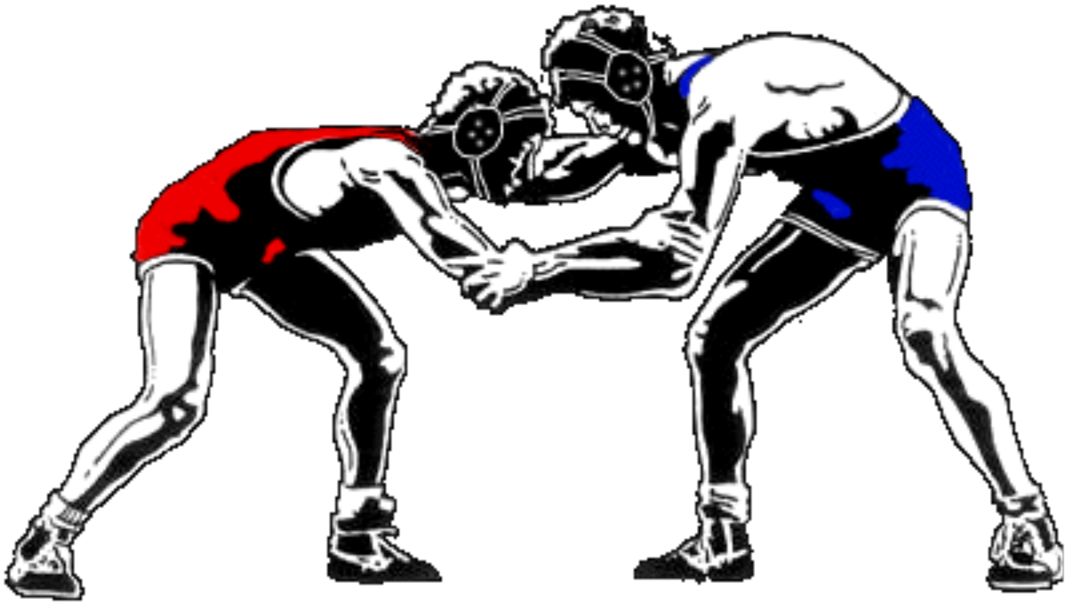


Hall A

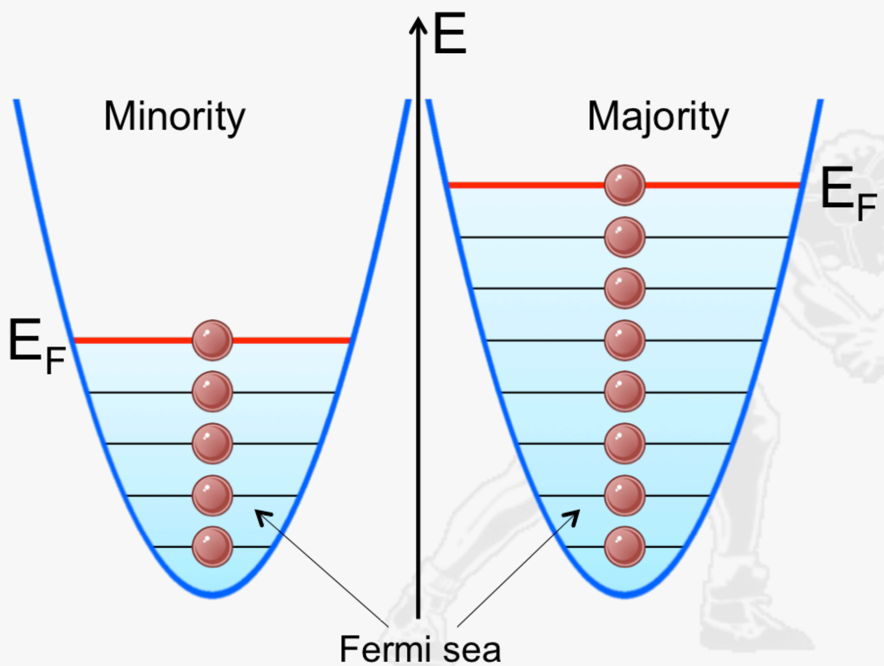
(e,e'p)

Competing effects



Competing effects

Pauli Principle



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

Competing effects

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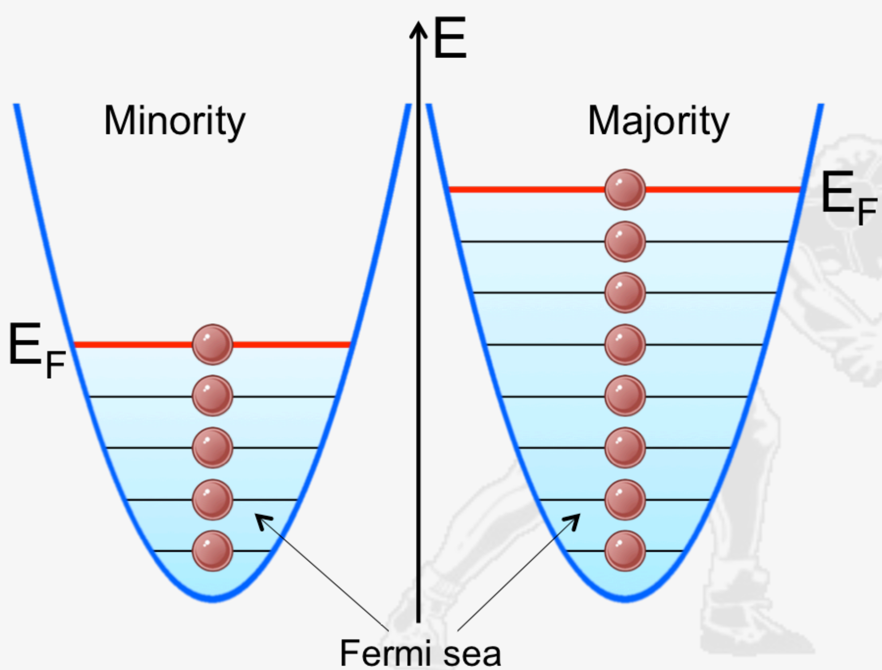

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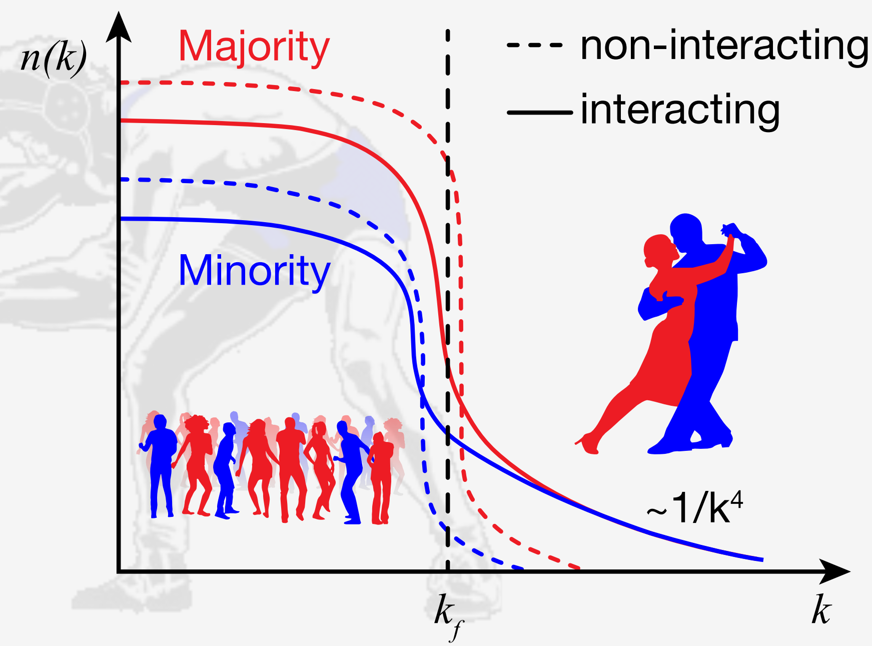
np correlations



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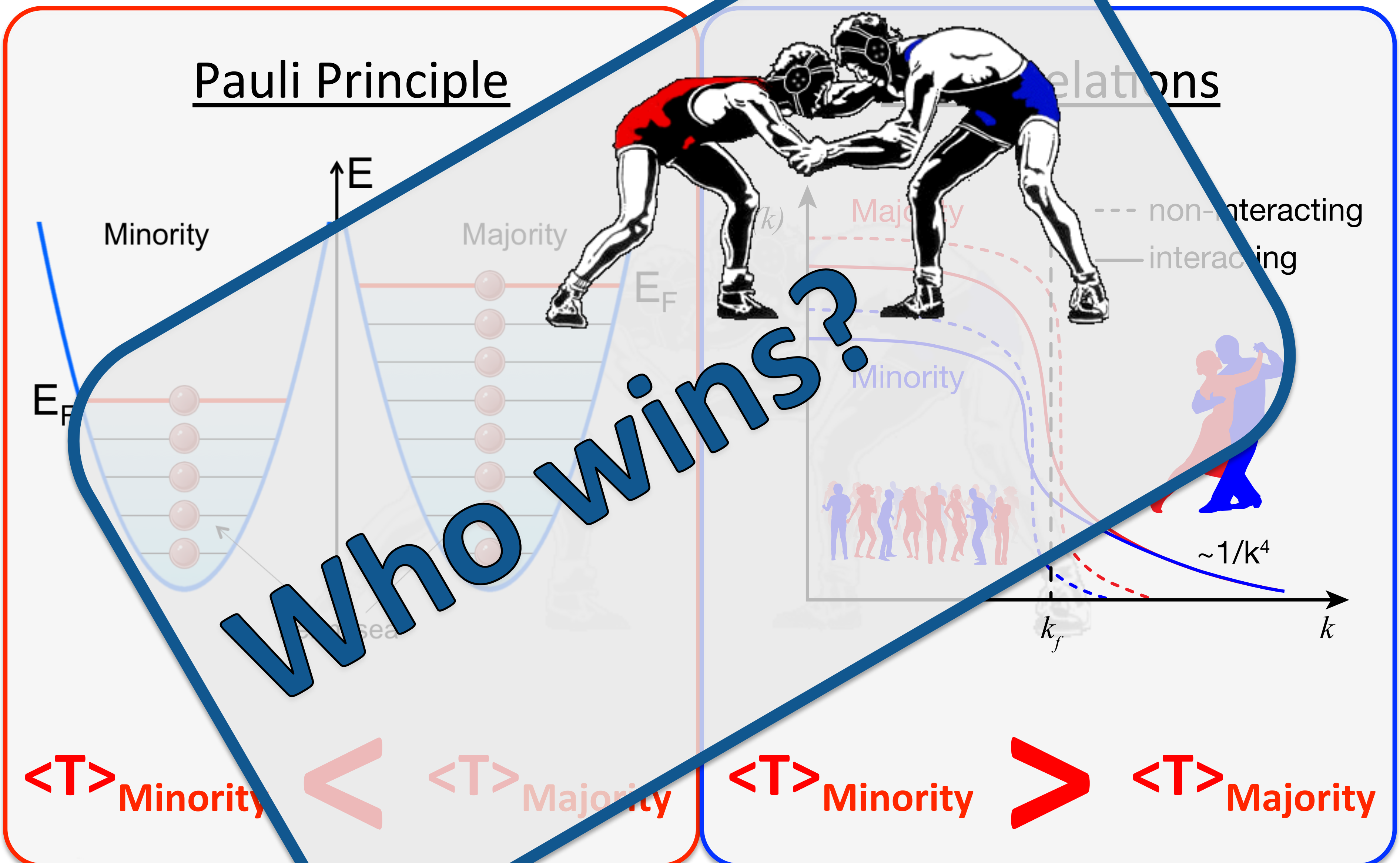

For light nuclei correlations are predicted to win

$\langle T \rangle_{Minority}$

vs

$\langle T \rangle_{Majority}$

	$\frac{\lvert N-Z \rvert}{A}$	$\langle T_p \rangle$	$\langle T_n \rangle$	$\langle T_p \rangle - \langle T_n \rangle$
^{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
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^{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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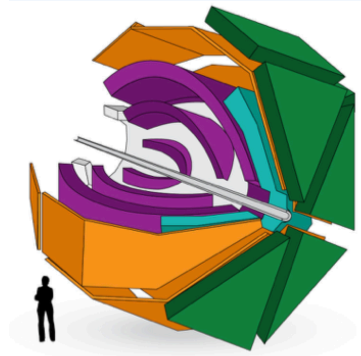
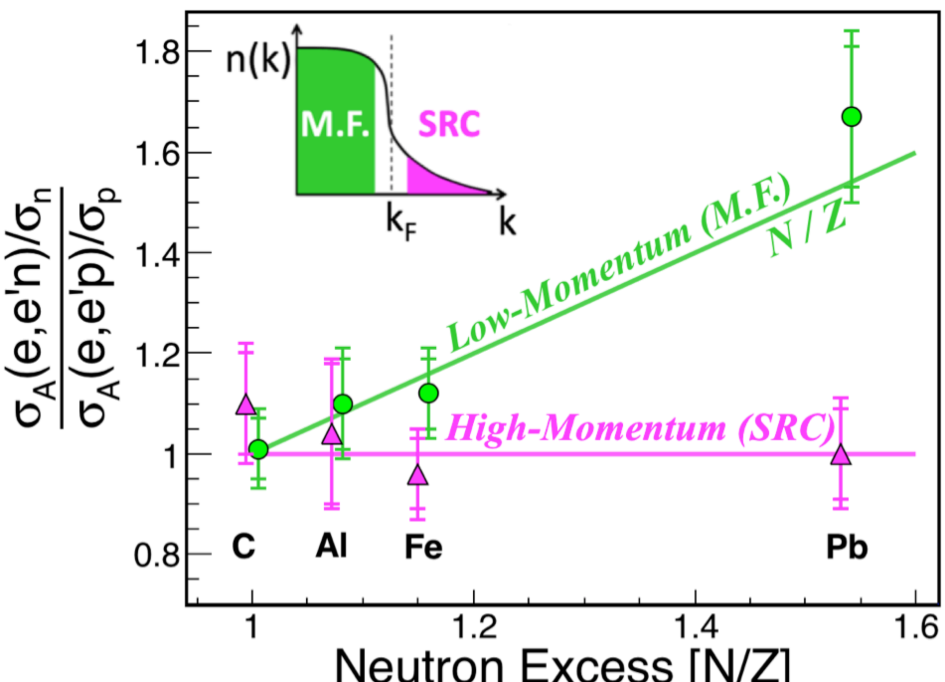
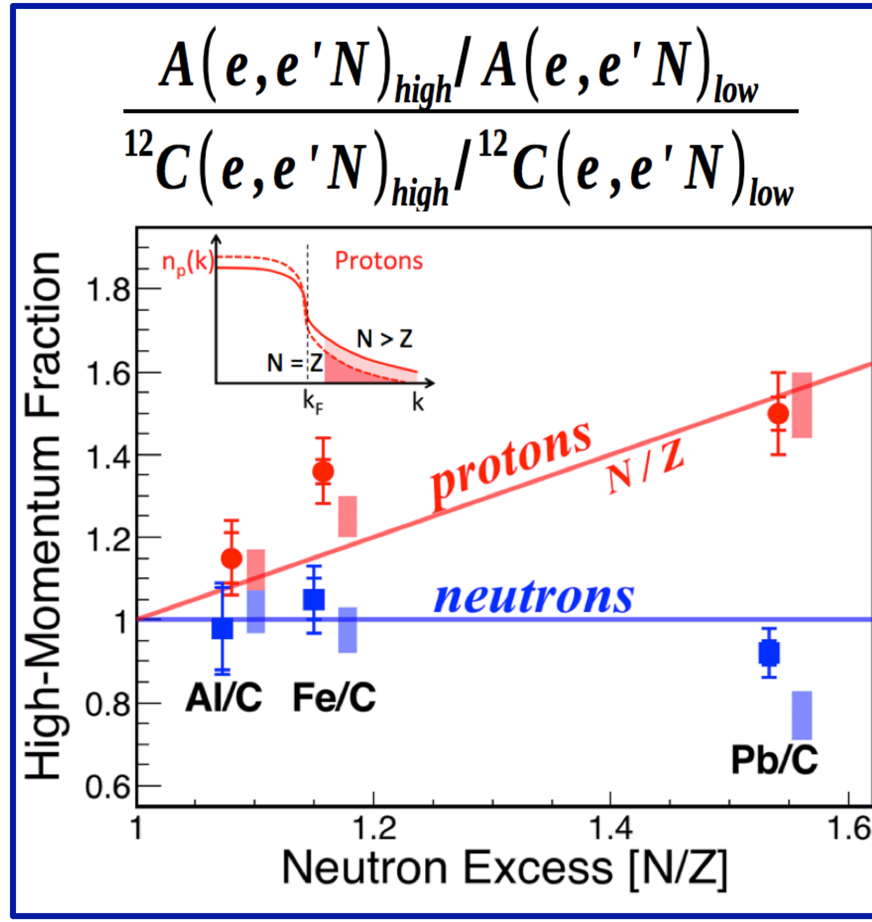
Can we test these predictions experimentally?

Heavy Nuclei

Meytal Duer's analysis (Hall B)







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

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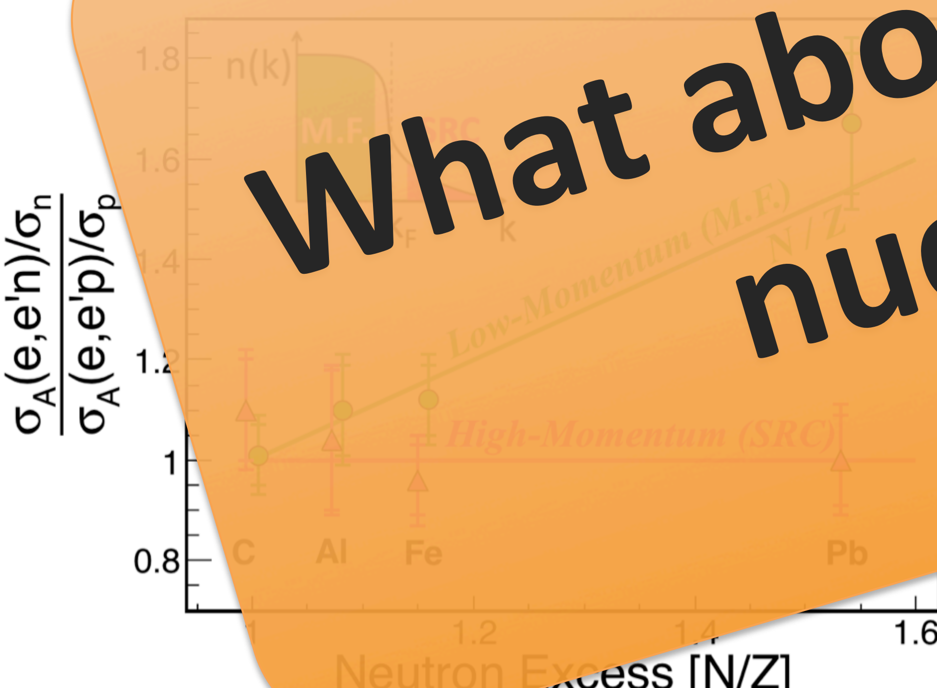
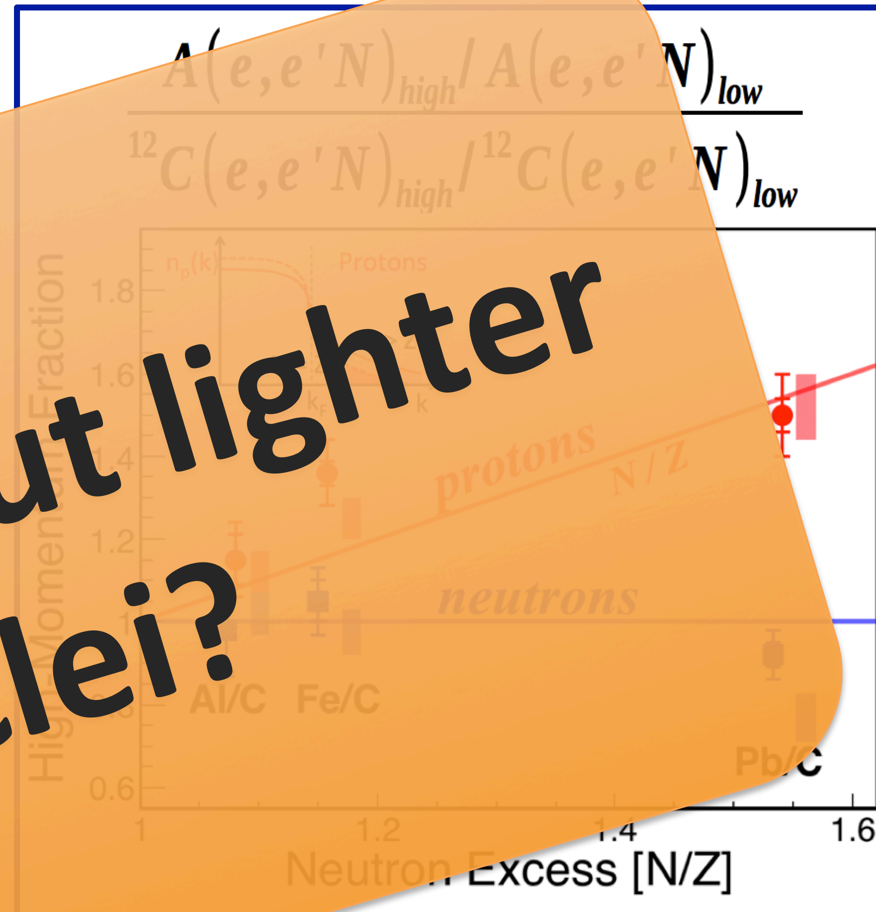


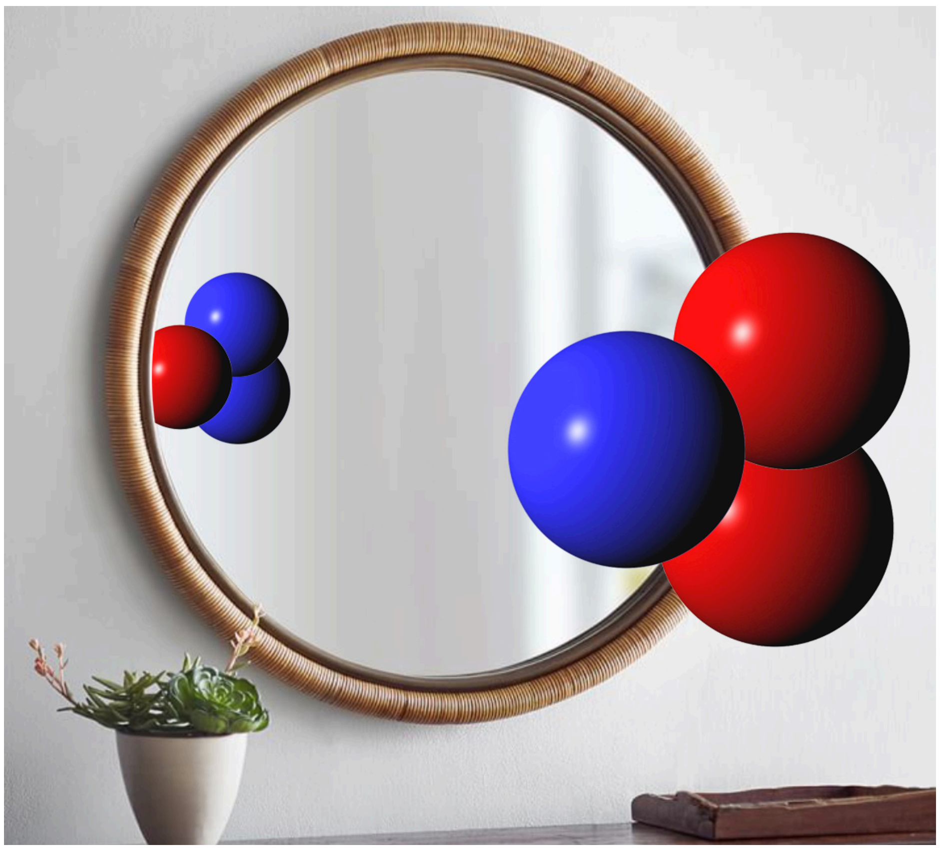


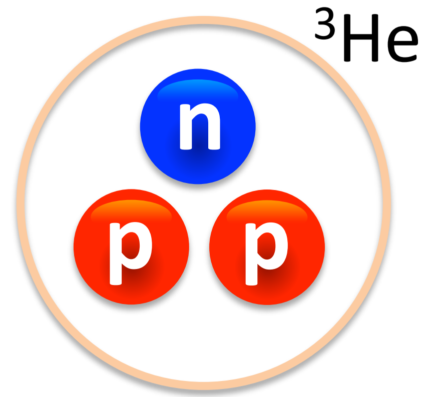
What about lighter nuclei?

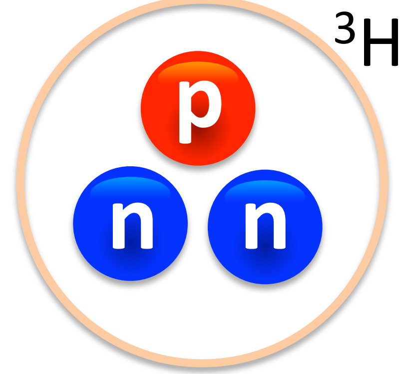
neutron's correlation probability saturates while proton's doesn't

A=3 nuclear systems

- ^3H and ^3He are mirror nuclei:
  - n in ^3H = p in ^3He
  - p in ^3H = n in ^3He







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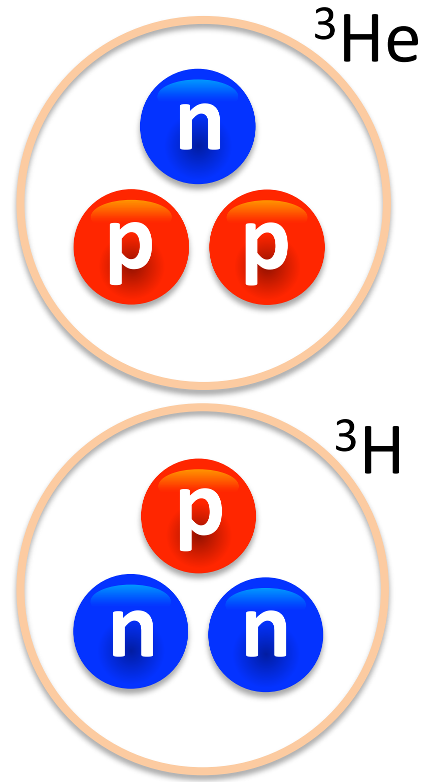

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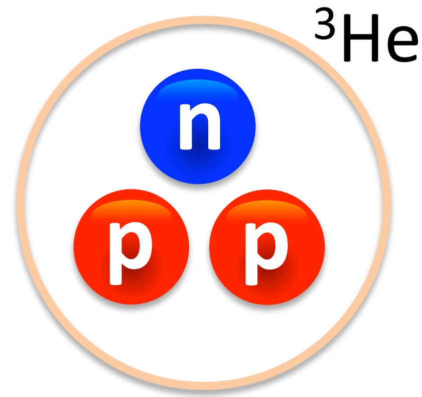
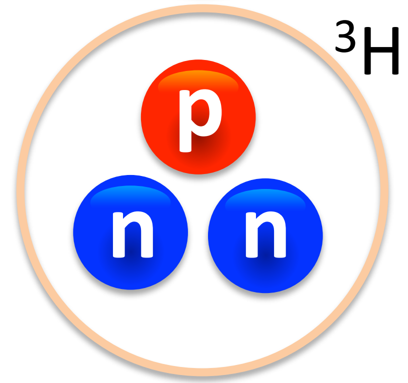
    [Low accuracy due to the neutron measurement]





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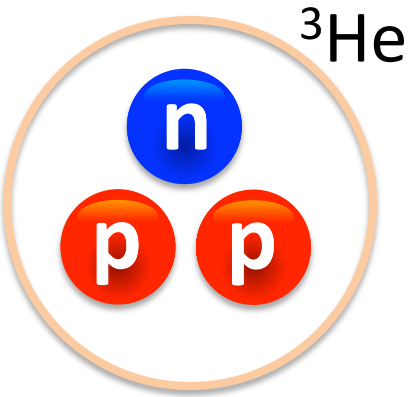

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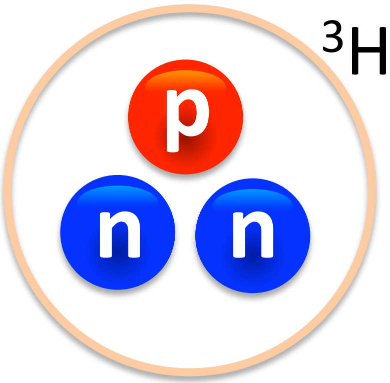

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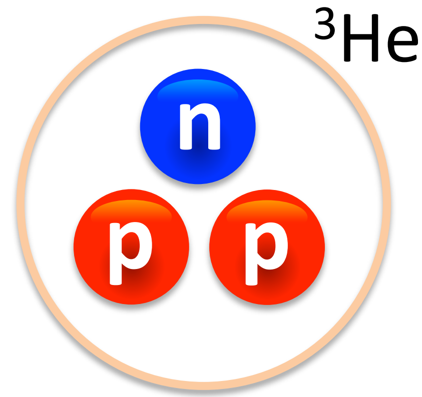

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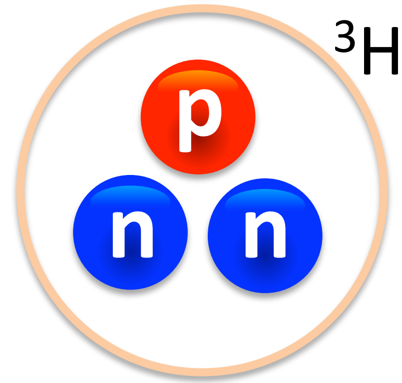
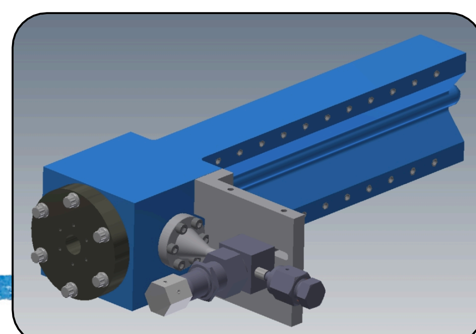
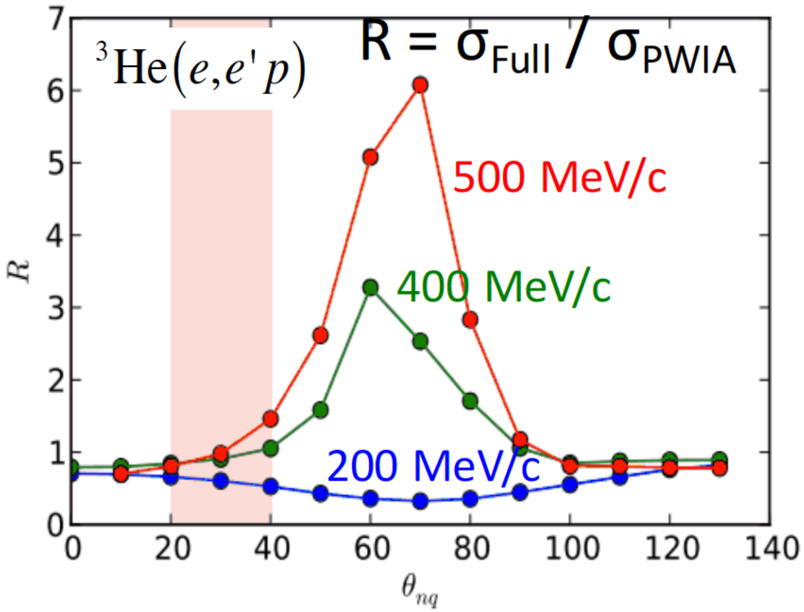


[Hall A has one]

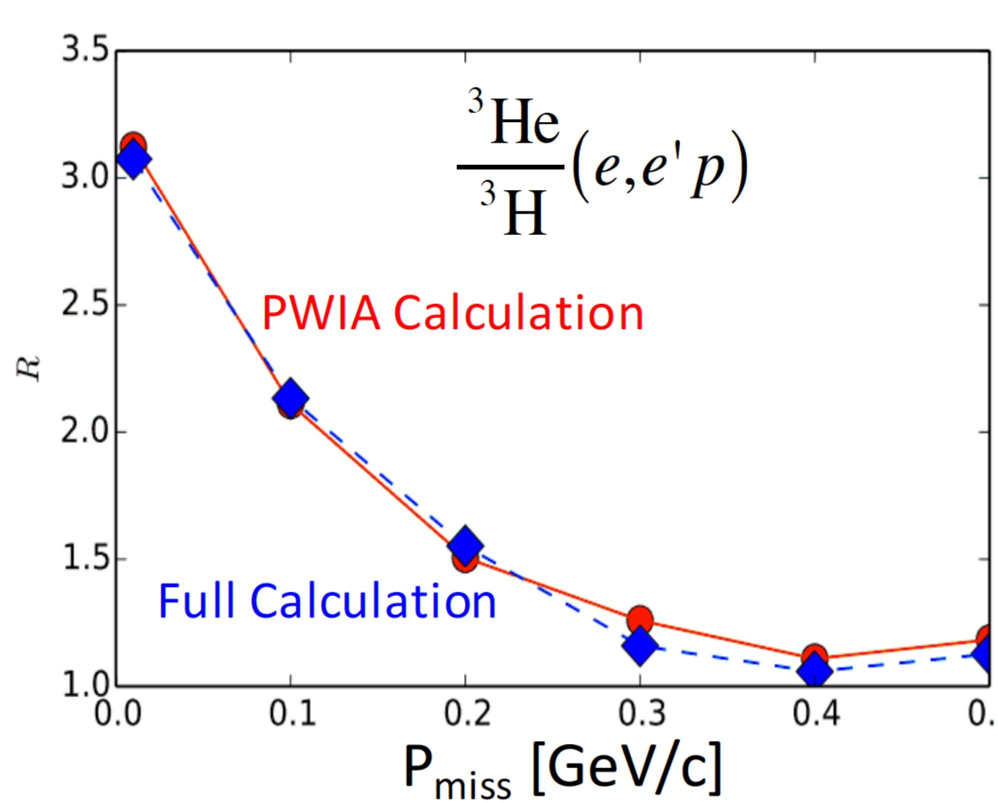


Accessing momentum distributions - FSI



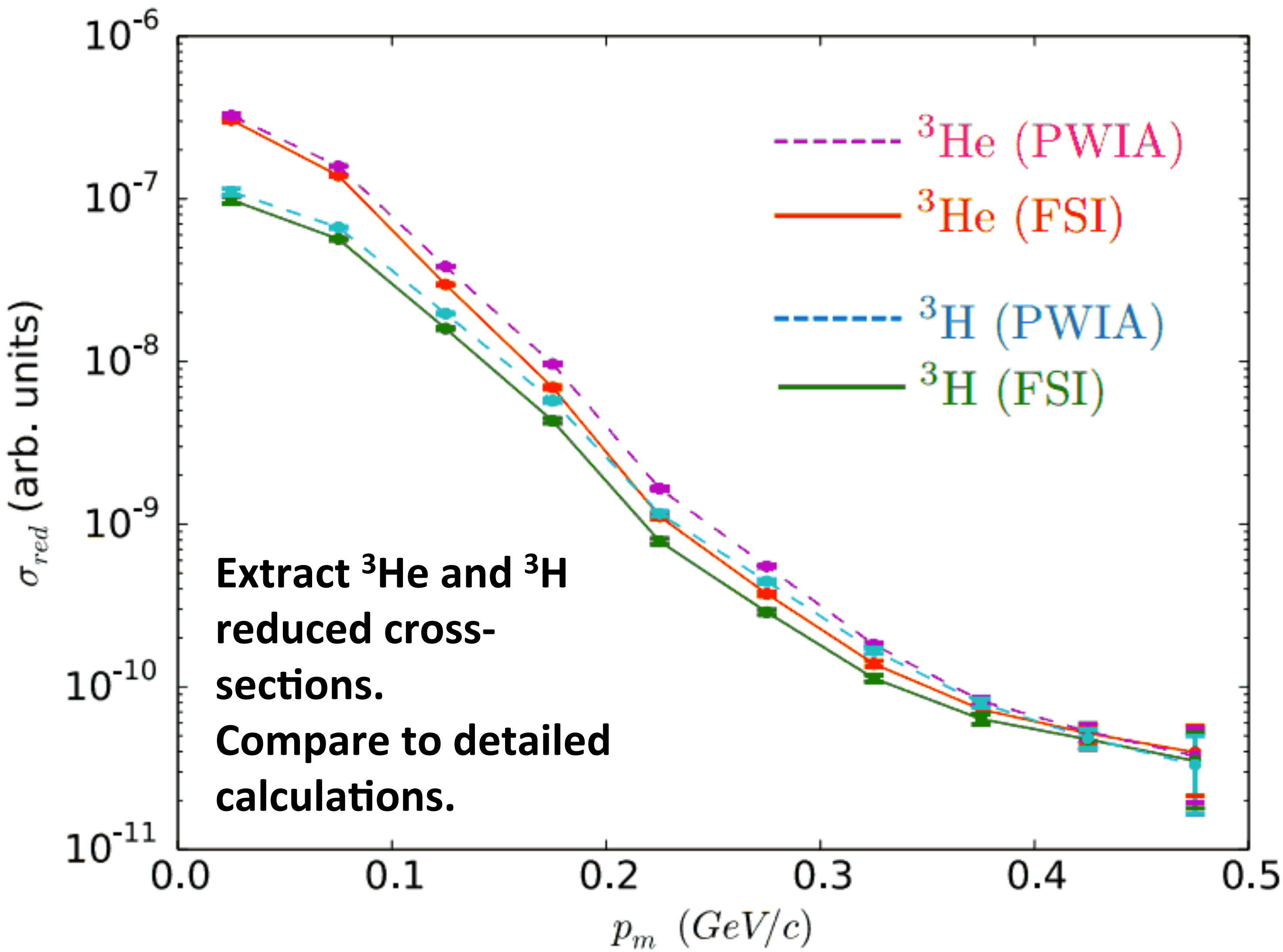
Rescattering effects as a function of the angle between P_{miss} and q.

- Rescattering minimized at small angles (verified for deuterium).
- Small angles => $x_B>1$ => suppress MEC and IC effects.



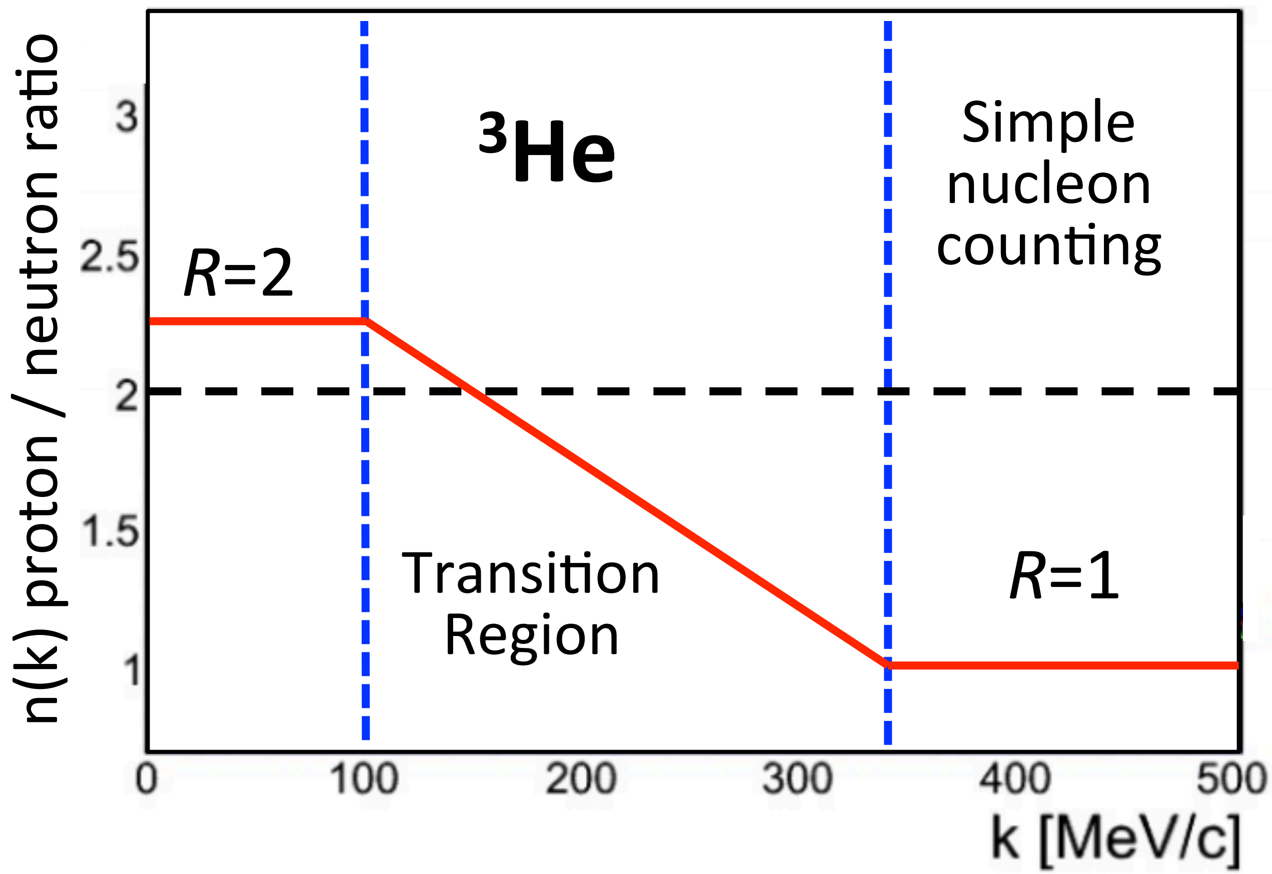
Rescattering effects cancel in the $^3He/^3H$ ratio

Reduced cross sections

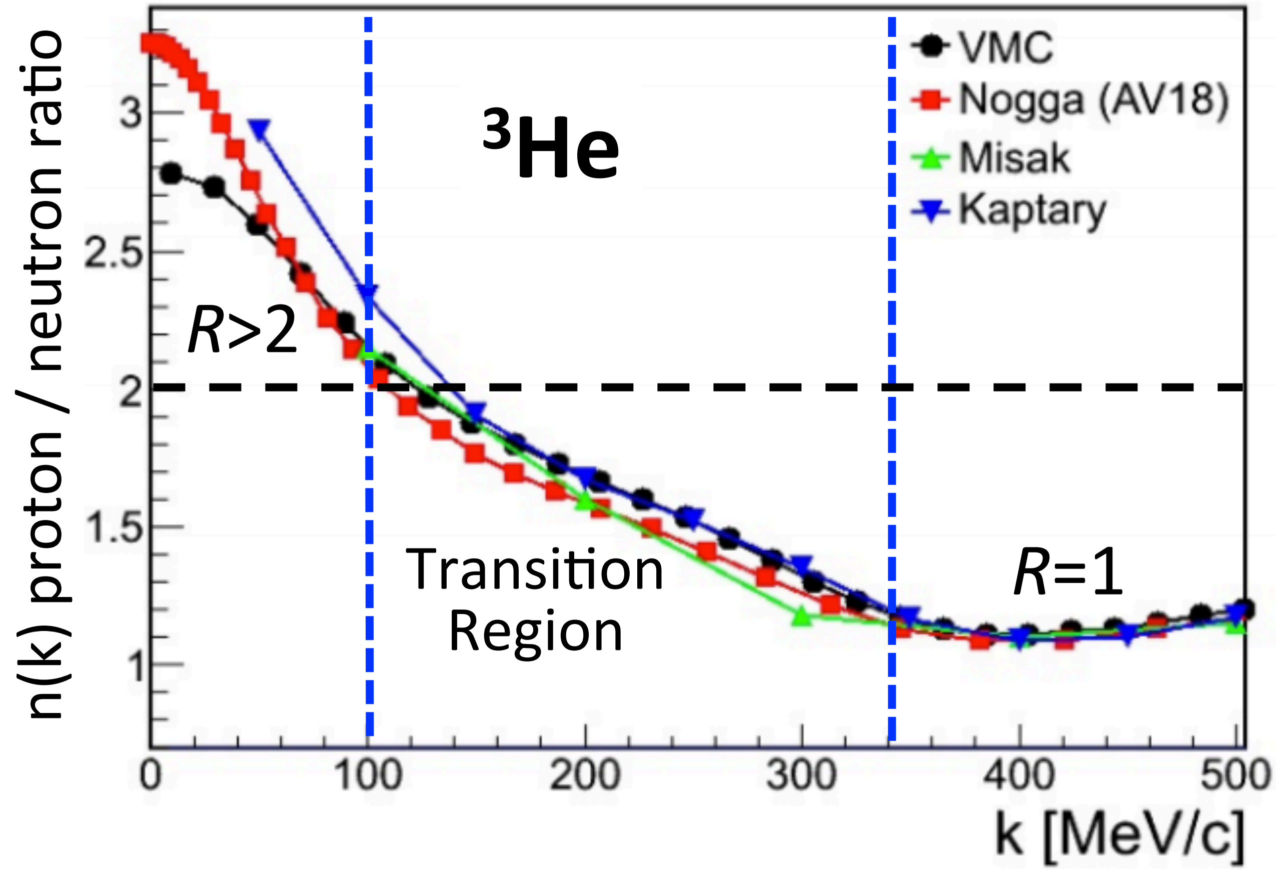


Extract ^{3}He and ^{3}H reduced cross-sections.
Compare to detailed calculations.

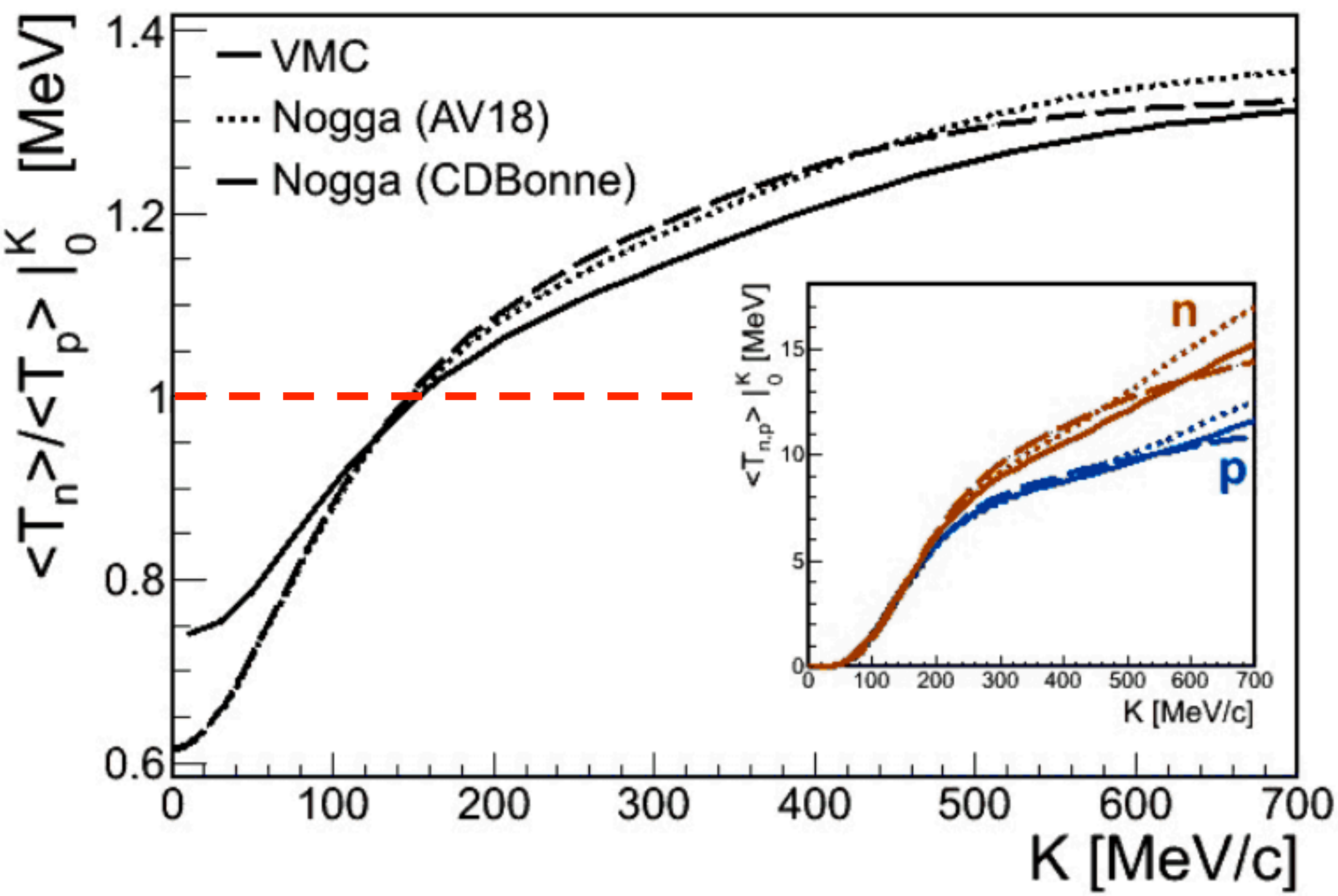
Extracting the proton/neutron ratio



Extracting the proton/neutron ratio



Inversion in the kinetic energy sharing

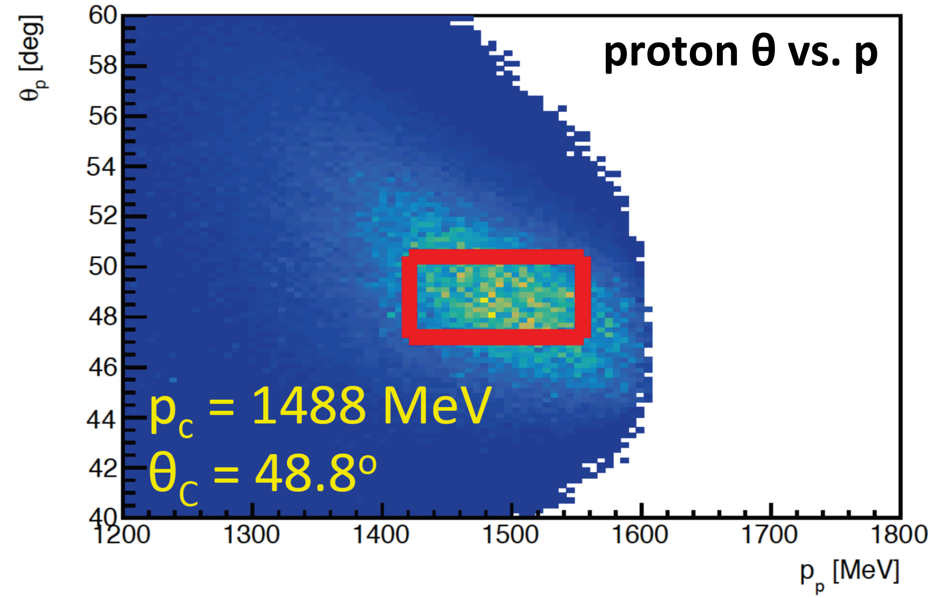


$$\langle T_p\rangle|_0^k = \int_0^k n_p(k')(\sqrt{m_p^2 + k'^2} - m_p)d^3k'$$

Experiment preparation

Kinematics optimization:

1) Start with back-of-the-envelope calculation to determine "interesting" kinematics.
2) Fix electron arm kinematics and look where protons go.
3) Scan proton θ vs. p phase-space with a "box" the size of the HRS acceptance looking for maximum yield.



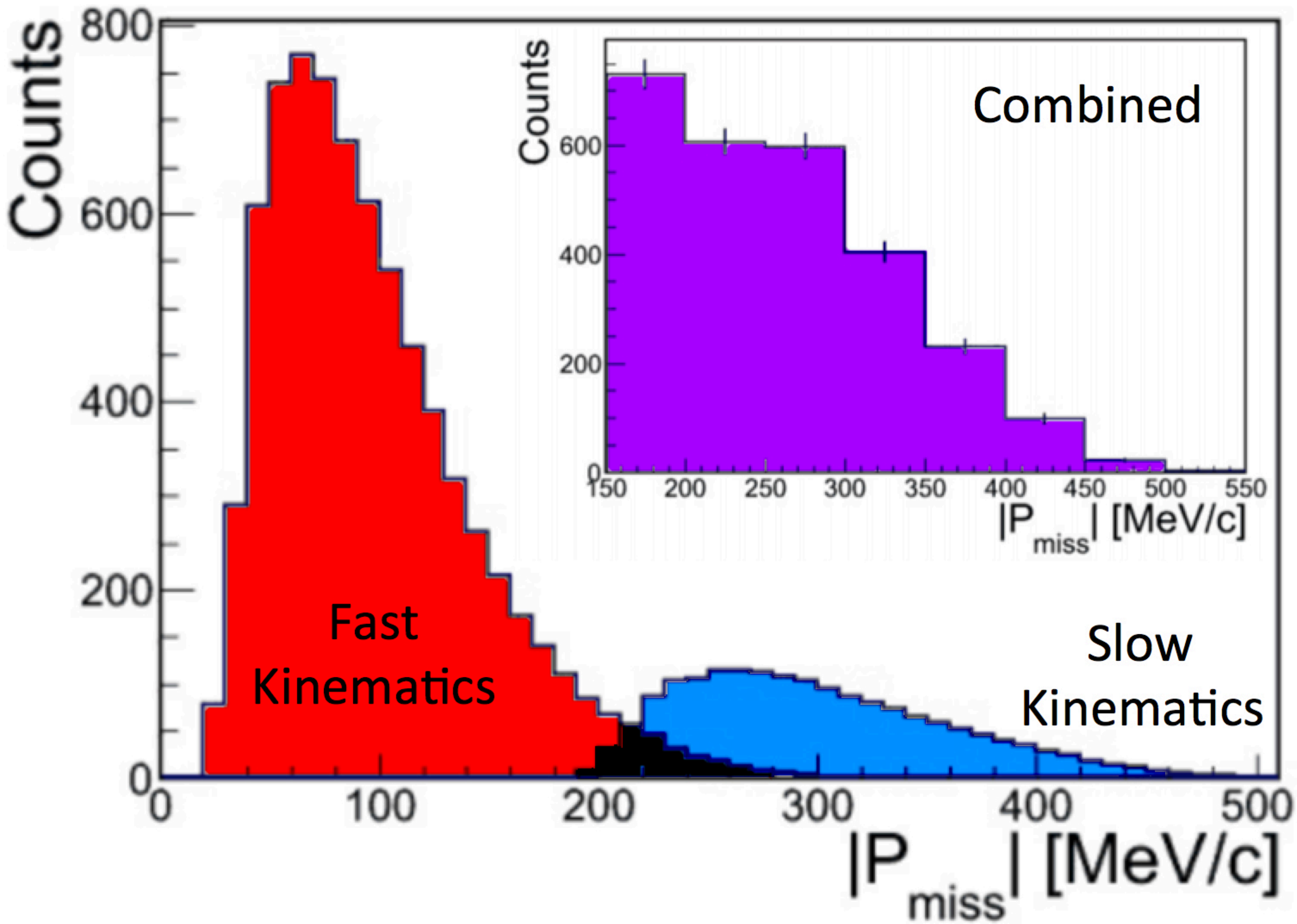
Fast kinematics

E_{beam}	p_e (MeV/c)	θ_e (deg)	p_p (MeV/c)	θ_p (deg)
4.3 GeV	3543.28	20.88	1480.5	48.8

Slow kinematics

E_{beam}	p_e (MeV/c)	θ_e (deg)	p_p (MeV/c)	θ_p (deg)
4.3 GeV	3543.28	20.88	1246	58.5

Expected events



Summary

- First extraction of momentum distribution ratio via mirror-nuclei measurements to study relative kinetic energies of protons and neutrons in asymmetric nuclei
- First direct test of calculated distributions in ^{3}H/^{3}He
- Coincidence trigger is already setup
- Kinematics have been studied and optimized

Thank you!