Measurements and Simulations of $(e,e'n)/(e,e'p)$ in ^{3}He for High and Low Momentum Nucleons in CLAS6

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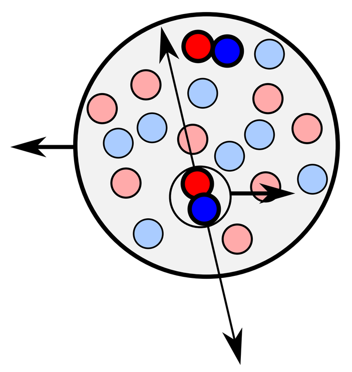
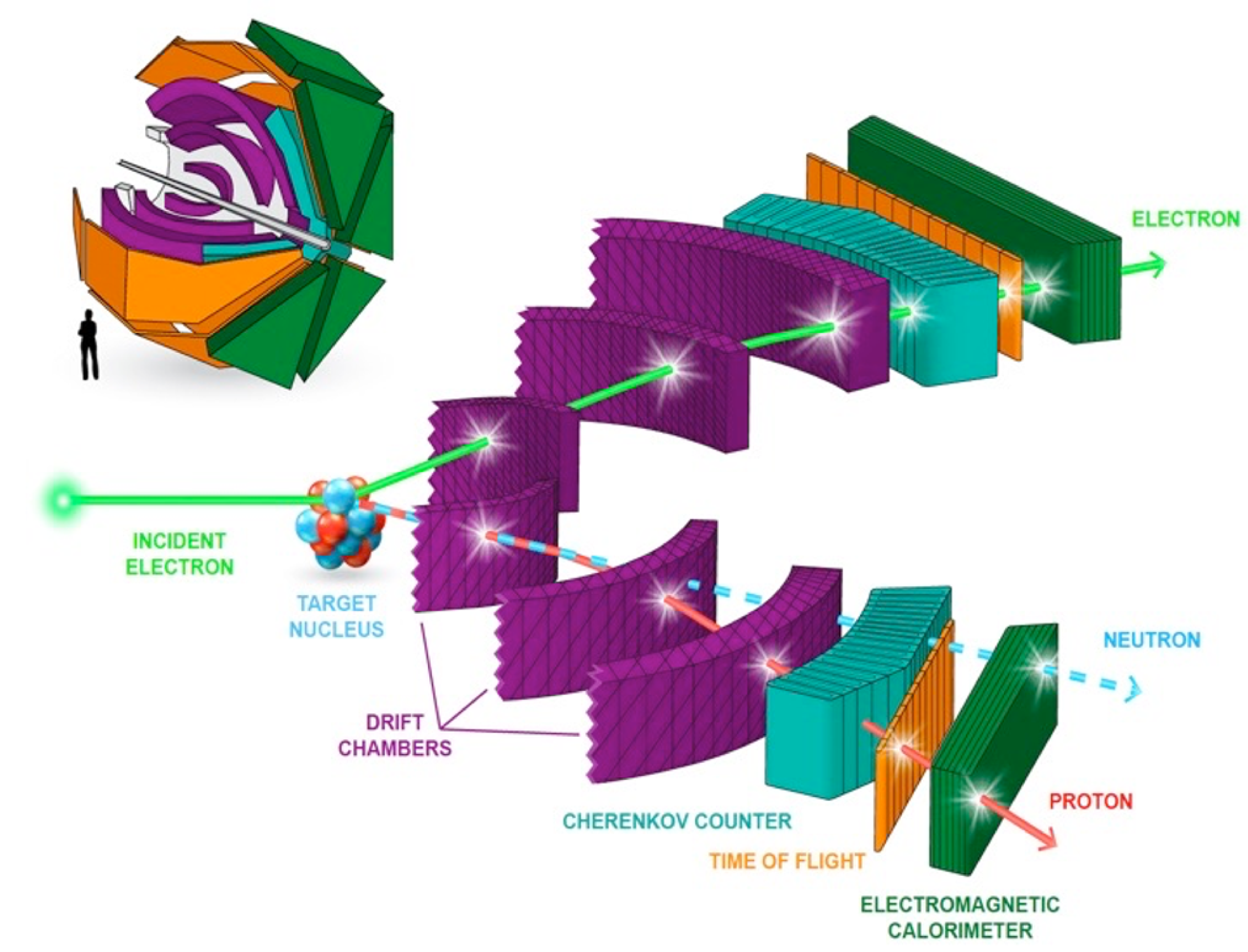
Introduction



Short Range Correlated pairs (SRC) of nucleons have high relative momentum and low center-of-mass momentum. Most SRC pairs contain a neutron and a proton, but few studies use direct neutron detection. In neutron-rich nuclei, the minority protons move faster than neutrons [1]. Low momentum nucleons have the same isospin distribution as the target nucleus. High momentum nucleons are nearly evenly split between neutrons and protons, indicating np dominance of SRC pairs. So far, np dominance in proton-rich nuclei is unexamined. Here we extend the measurement of $(e,e'n)/(e,e'p)$ to ^{3}He and compare with Monte Carlo simulations.

Neutron Detection in CLAS

Experiment: e2a in Hall B in 1999, with a 4.4 GeV electron beam on ^{3}He, ^{4}He, and C targets



A neutron interacts with a proton in the calorimeter, causing the proton to scatter and leave an energy deposition. Unlike a proton, the neutron does not leave a charged particle track [1].

Fast Monte Carlo Simulations

We use a fast Monte Carlo simulation of ^{3}He based on 3-body spectral functions [2]. We model the CLAS acceptance using acceptance maps. The generator produces quasielastic scattering events according to a plane-wave impulse approximation (PWIA) cross section

$$\frac{d^6\sigma}{d\Omega_e dE_e d\Omega_N dE_N} = |\vec{p}_N| E_N \sigma_{eN} S_N(E_m, \vec{p}_m), \quad (1)$$

where Ω_e and E_e are the solid angle and energy of the scattered electron, respectively; Ω_N, $\vec{p}_N$, and E_N are the solid angle, momentum, and energy of the knocked out nucleon, respectively; σ_{eN} is the electron-nucleon scattering cross section [3]; and S_N is the spectral function.

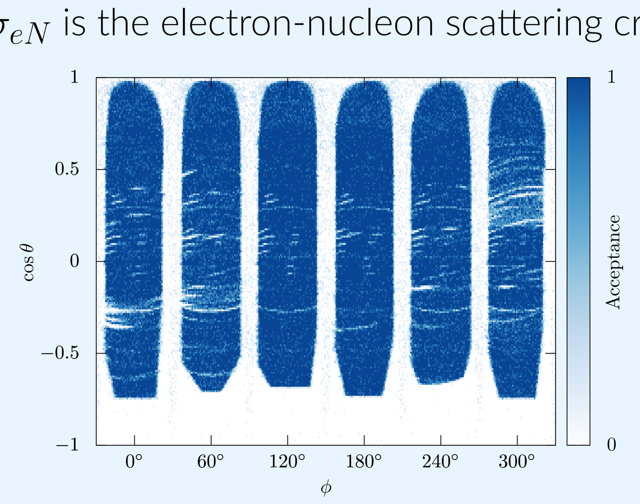


Figure 1. e2a acceptance map for 2 GeV/c protons

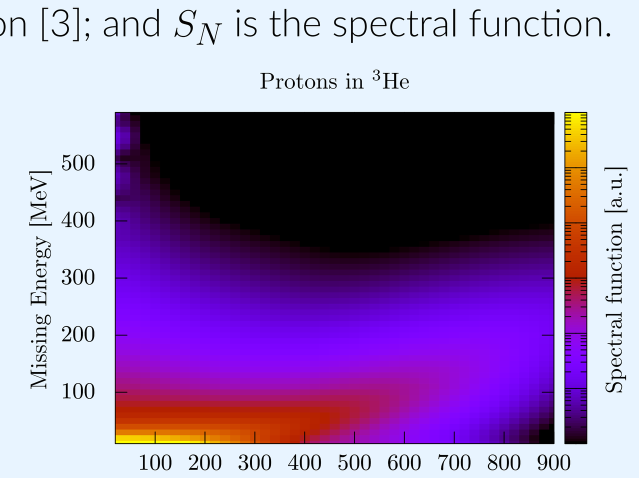
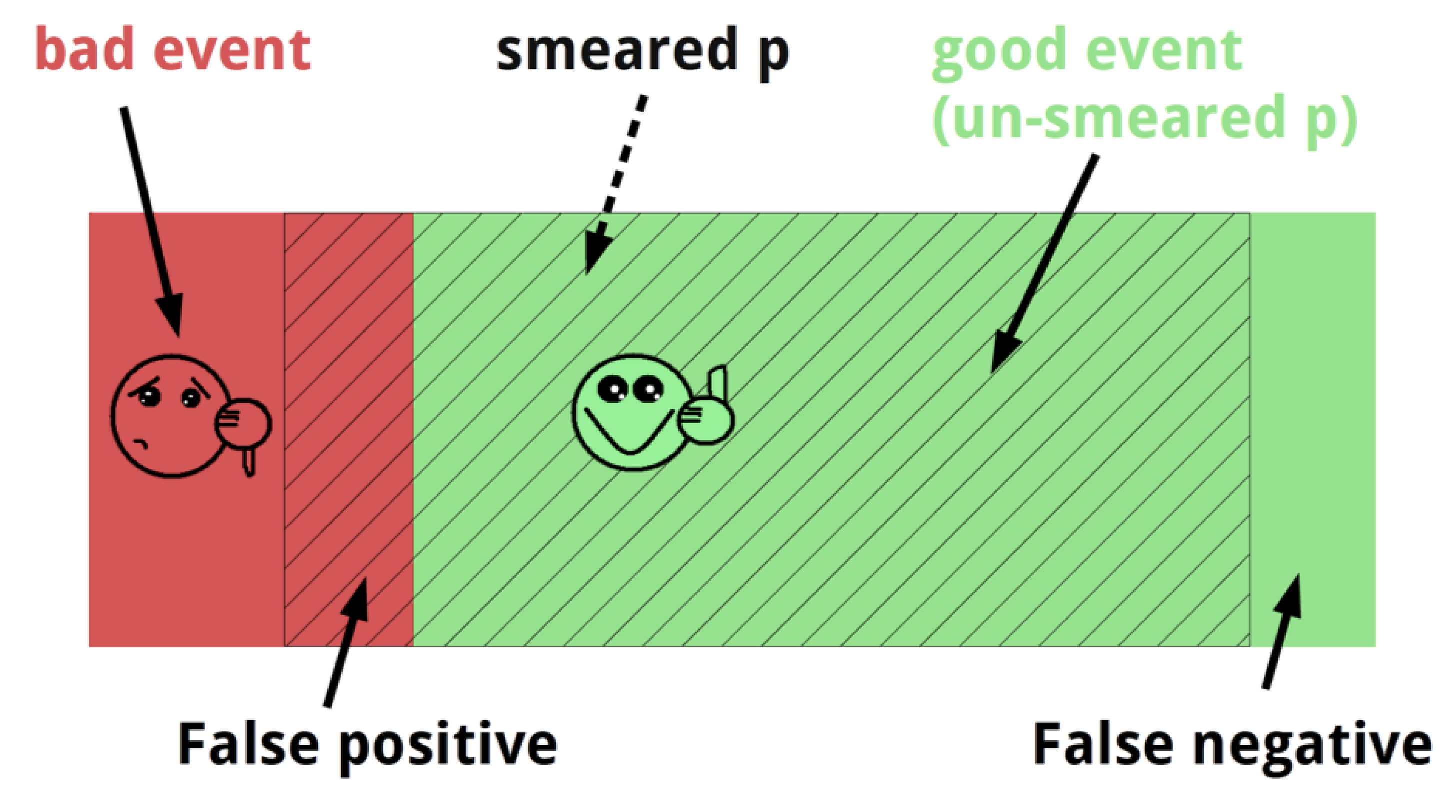


Figure 2. Proton spectral function

Comparing Neutrons and Protons

Neutrons have worse momentum resolution than protons. We find new optimal cuts for neutrons and artificially smear the proton momenta to match the neutron resolution, applying the same cuts to both species.



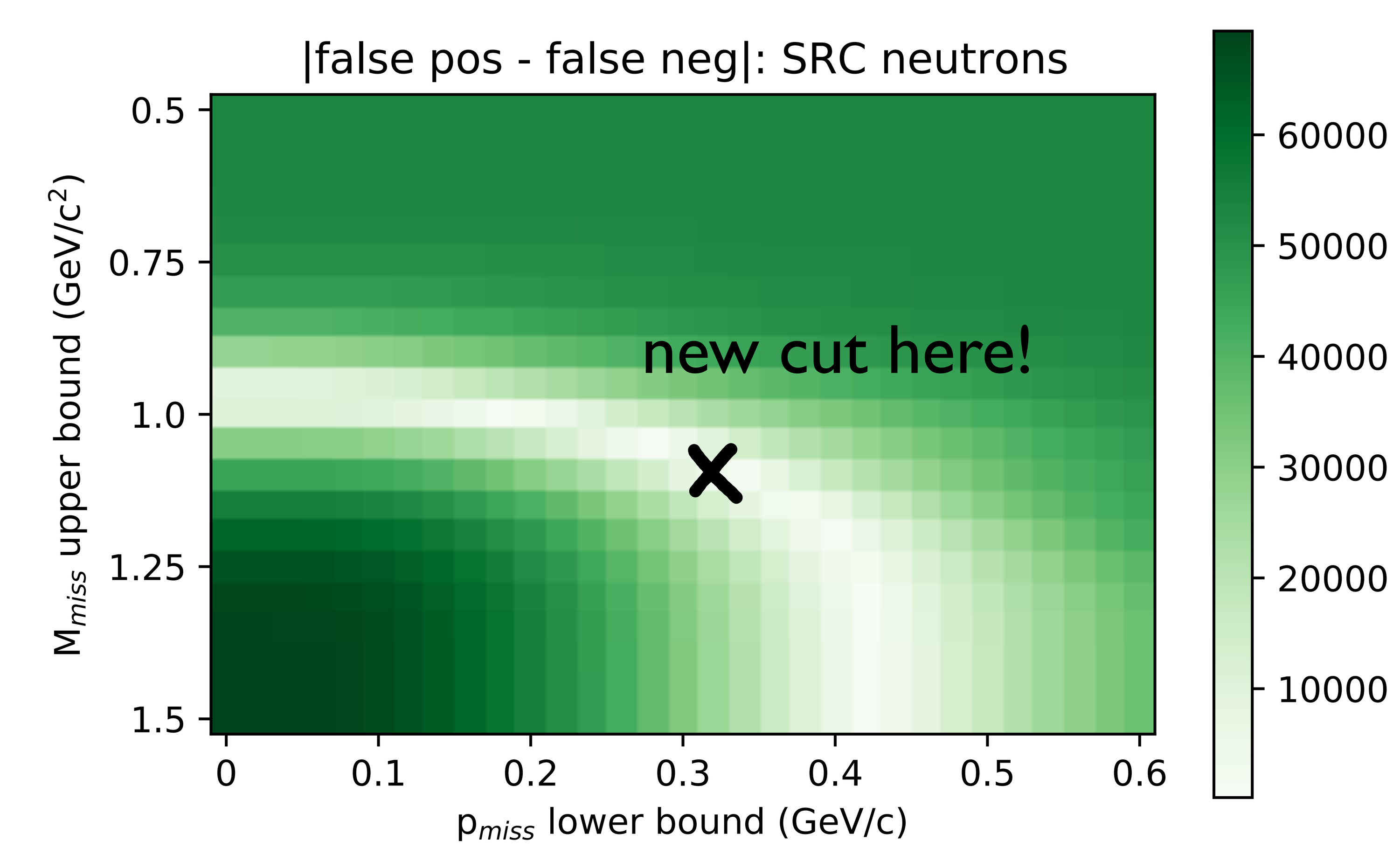
We determine the optimal cuts for neutrons by testing a range of new cuts for protons, minimizing the difference between the number of protons that pass the ideal proton cuts but fail the new cuts (false negatives) and those that fail the original cuts but pass the new cuts (false positives).

Low Momentum	High Momentum
$-0.05 < y < 0.2$	$x_B > 1.2$
$0.9 < \nu < 1.6$ GeV	$0.62 < p/q < 1.1$
$\theta_{pq} < 7°$	$\theta_{pq} < 25°$

The table above shows ideal low and high momentum proton cuts, which diminish the effect of final state interactions [4]. We normalize the n/p ratios to the electron-neutron & electron-proton cross sections σ_n and σ_p.

Optimization of Event Selection Criteria

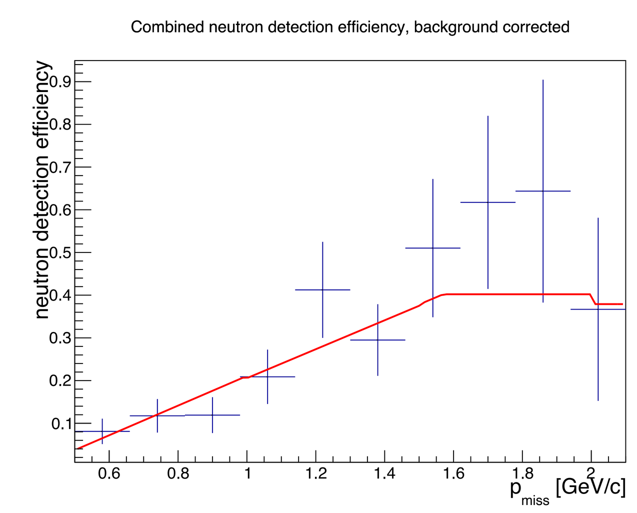
The momentum-dependent cuts which must be modified are the missing mass M_{miss} and missing momentum p_{miss} for SRCs, and the missing energy E_{miss} and p_{miss} for low momentum nucleons.



High Momentum			Low Momentum		
Cut Variable	p	n, smeared p	Cut Variable	p	n, smeared p
M_{miss} (GeV/c^2)	1.1	1.13	E_{miss} (GeV)	0.08	0.265
p_{miss} (GeV/c)	0.3	0.32	p_{miss} (GeV/c)	0.22	0.265

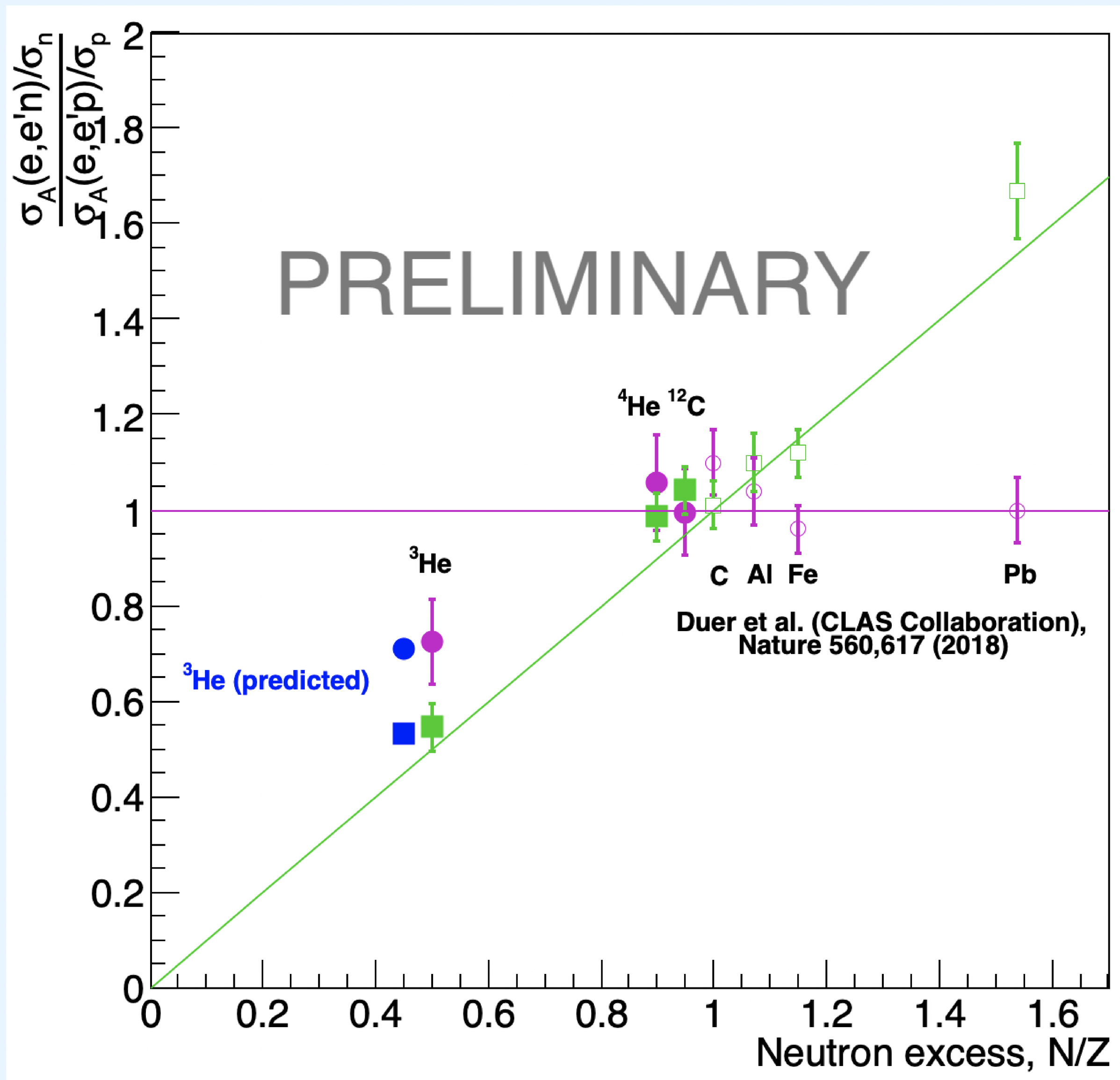
Neutron Detection Efficiency

We measure and correct for the neutron efficiency using $d(e,e'pn)$ and $d(e,e'\pi^+\pi^-pn)$.



Results

Our results (solid) are compared to Duer's study (empty) [1]. High momentum ratios are magenta circles, and low momentum ratios are green squares. The simulation results are in blue.



Low Momentum States

As expected, $(e,e'n)/(e,e'p)$ is approximately N/Z, indicating that knocked-out low momentum neutrons and protons appear with the same isospin distribution as the target nucleus.

High Momentum States

Neutrons do speed up in proton-rich nuclei, but not as much as expected, since $(e,e'n)/(e,e'p)$ is lower than unity. This suggests that np dominance breaks down for ^{3}He, possibly due to an inability to describe small nuclei in terms of many-body mean field and SRC descriptions.

Simulation Quality

The consistency between the calculations and data show a remarkable understanding of the three-body dynamics of ^{3}He as expressed in the spectral functions.

References

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[3] Taber De Forest. Off-shell electron-nucleon cross sections. The impulse approximation. *Nuclear Physics, Section A*, 392(2-3):232–248, 1983.

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