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

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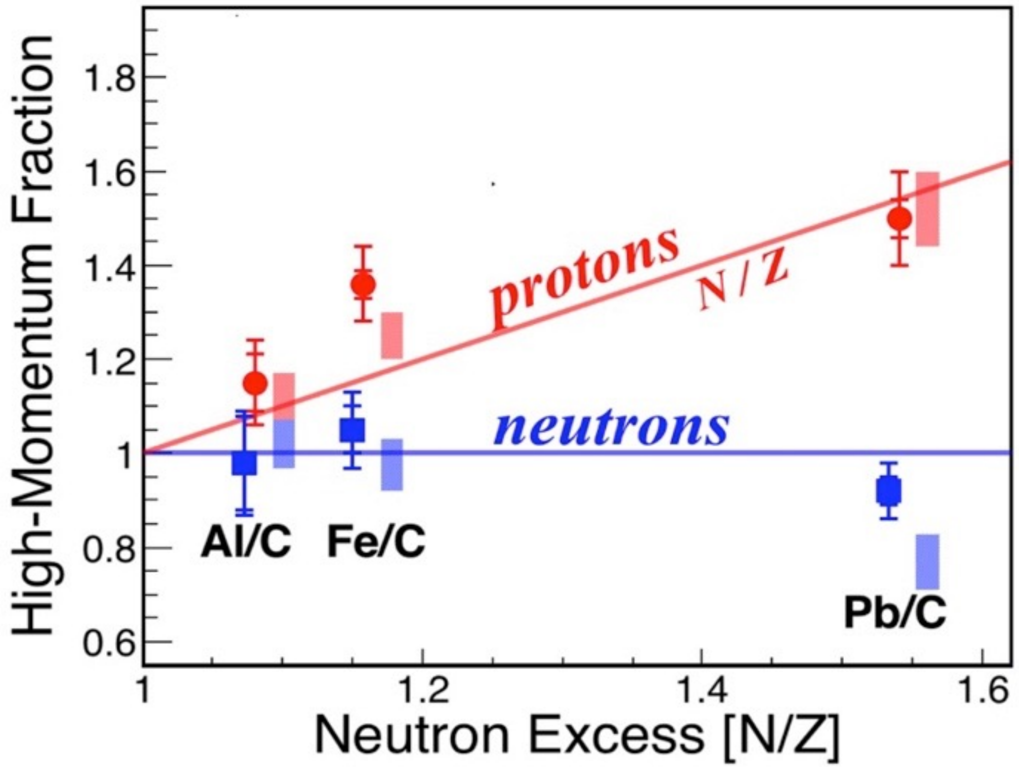
Protons “speed up” in neutron-rich nuclei

- Minority (p) moves faster than majority (n) in neutron-rich nuclei



Duer et al. (CLAS Collaboration), Nature 560, 617 (2018)

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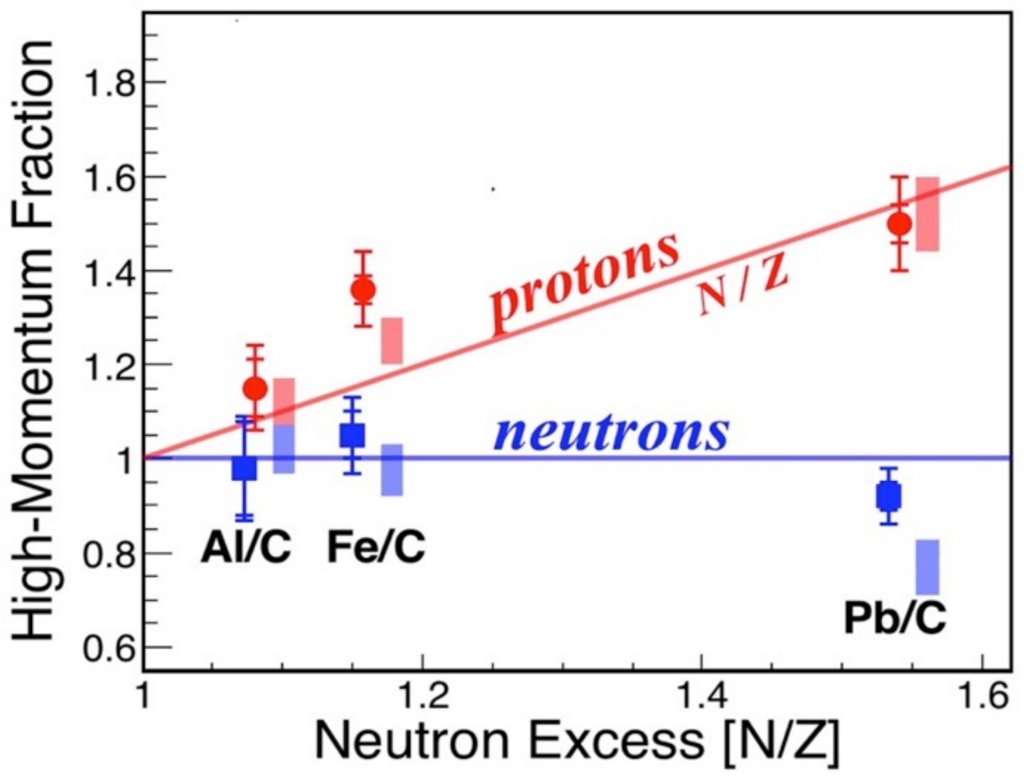

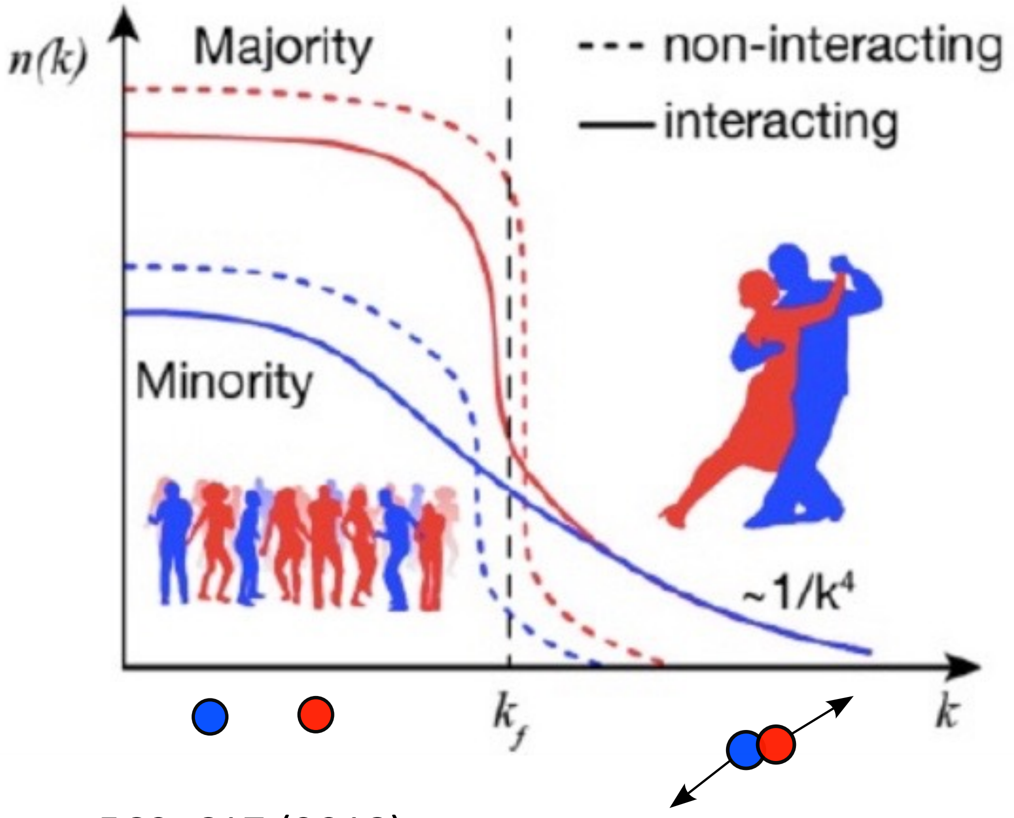

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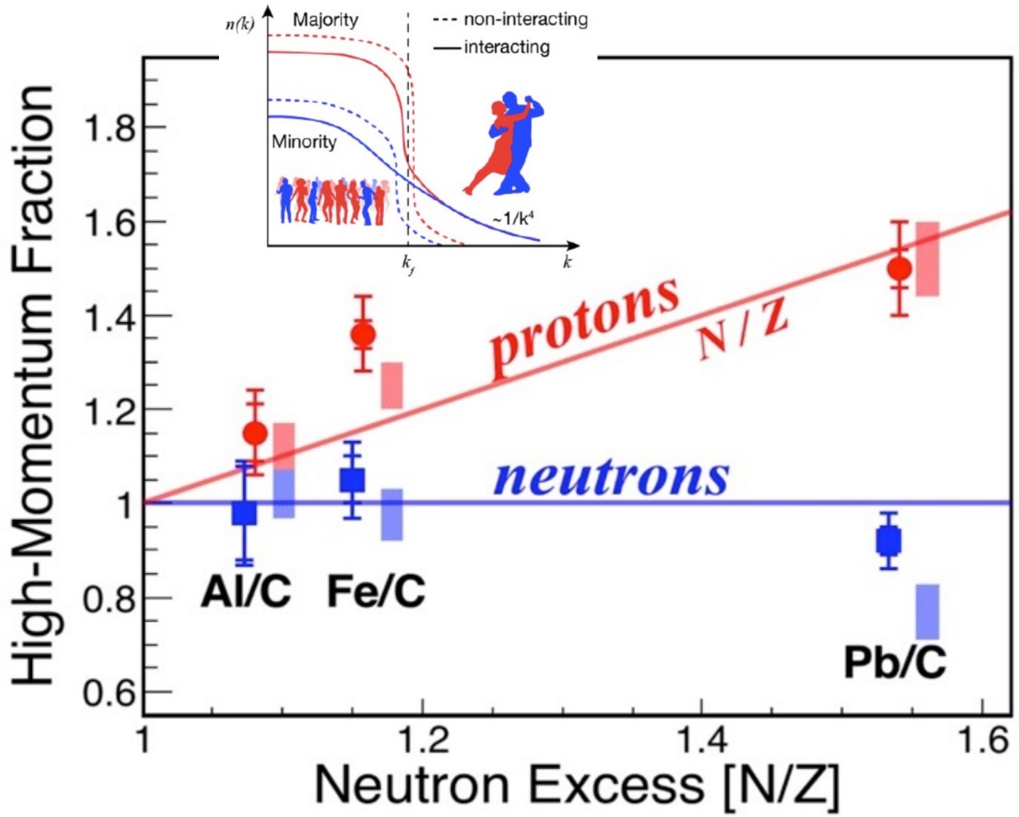

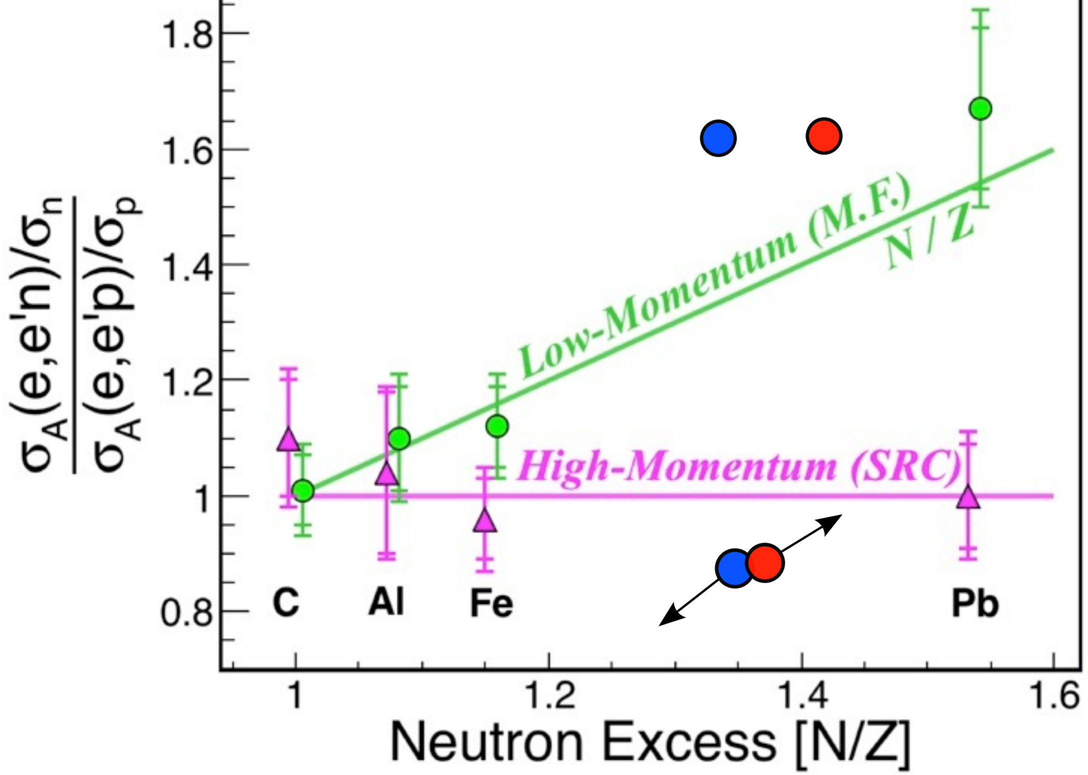

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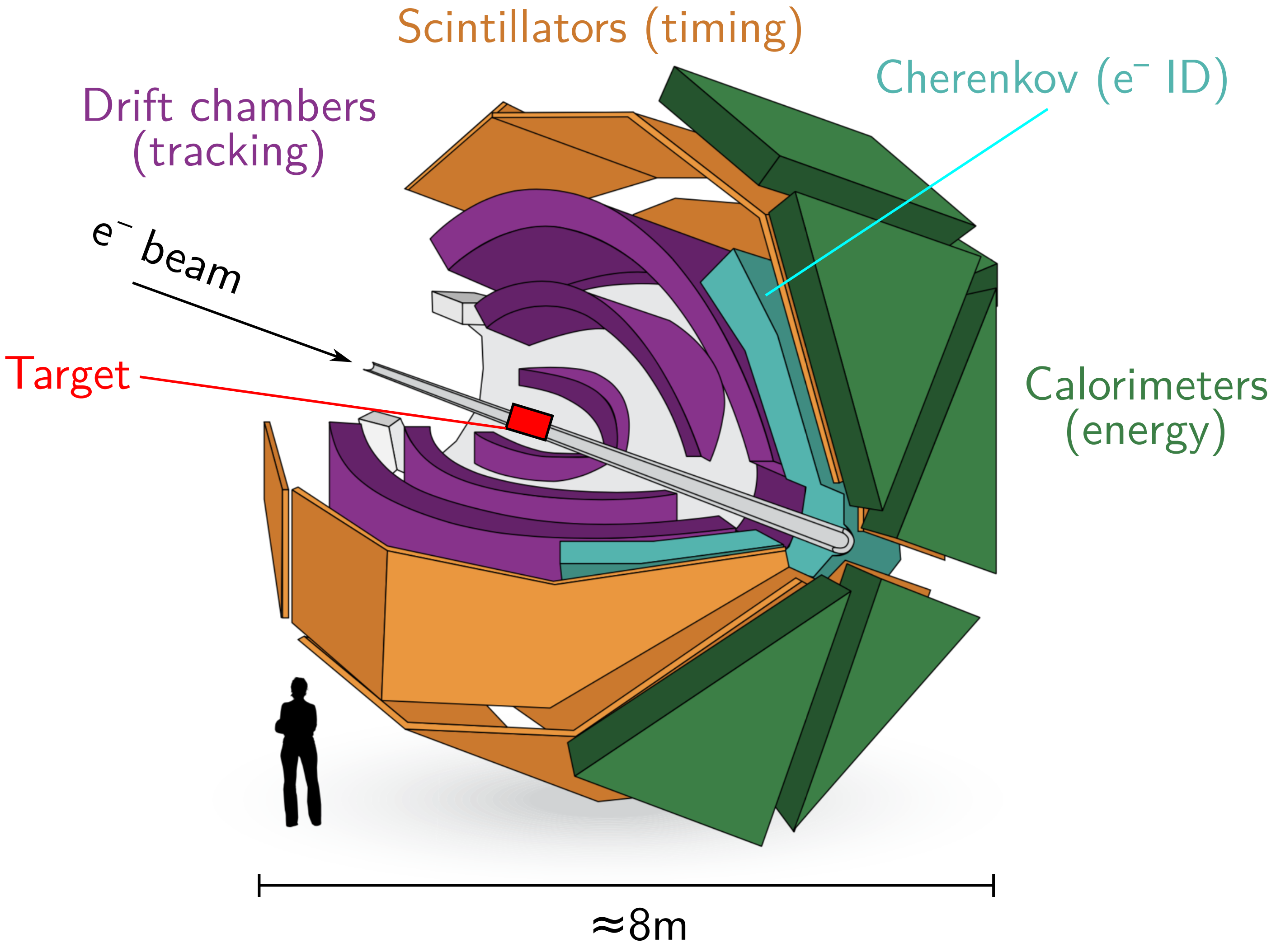
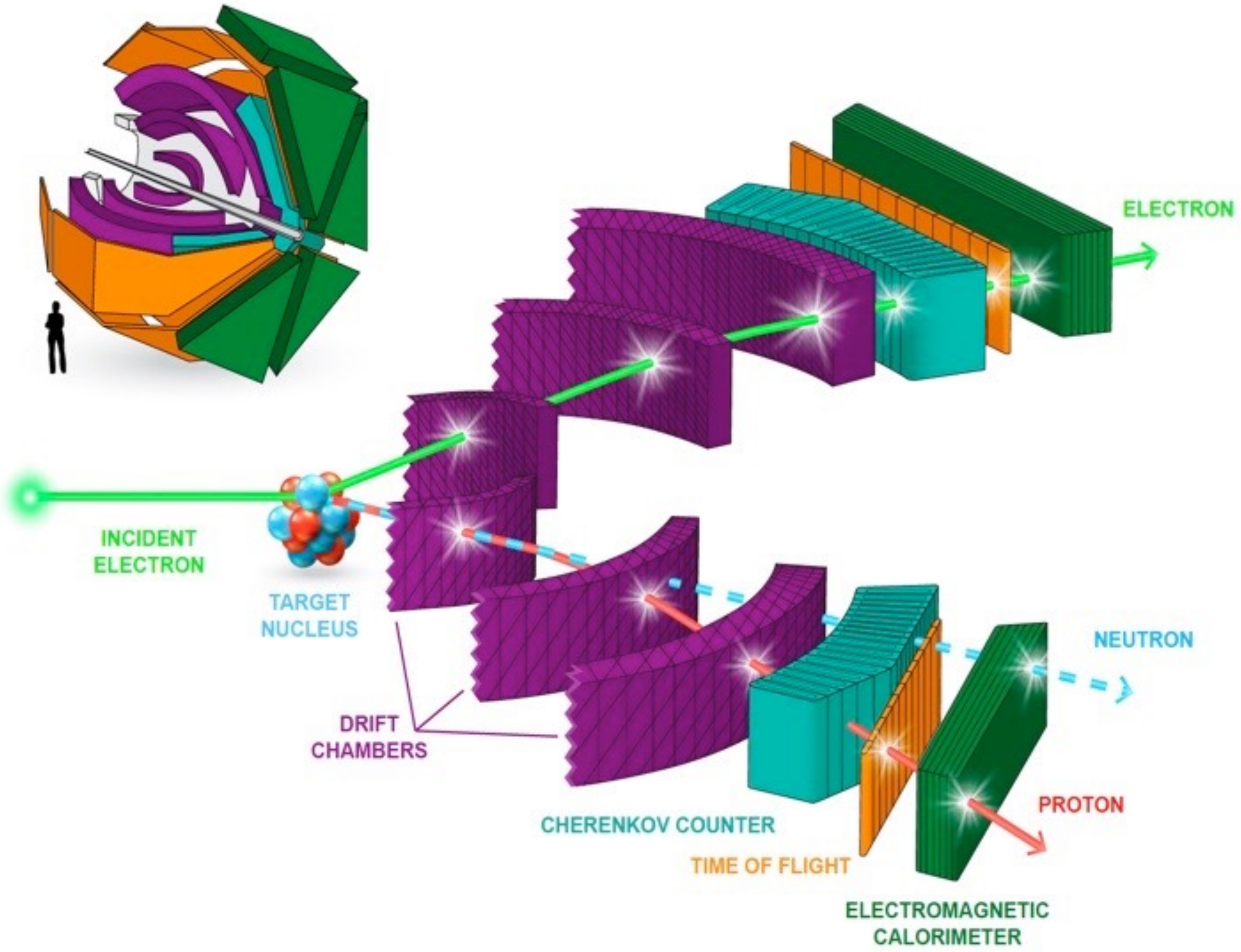
Data Mining

- CLAS6: precursor to CLAS12
- Experiment e2a (April-May 1999)
- 4.4 GeV e^- beam
- ^{3}He, ^{4}He, ^{12}C targets
- Measure ^{3}He(*e,e'n*)/^{3}He(*e,e'p*)



Neutron Detection in CLAS6

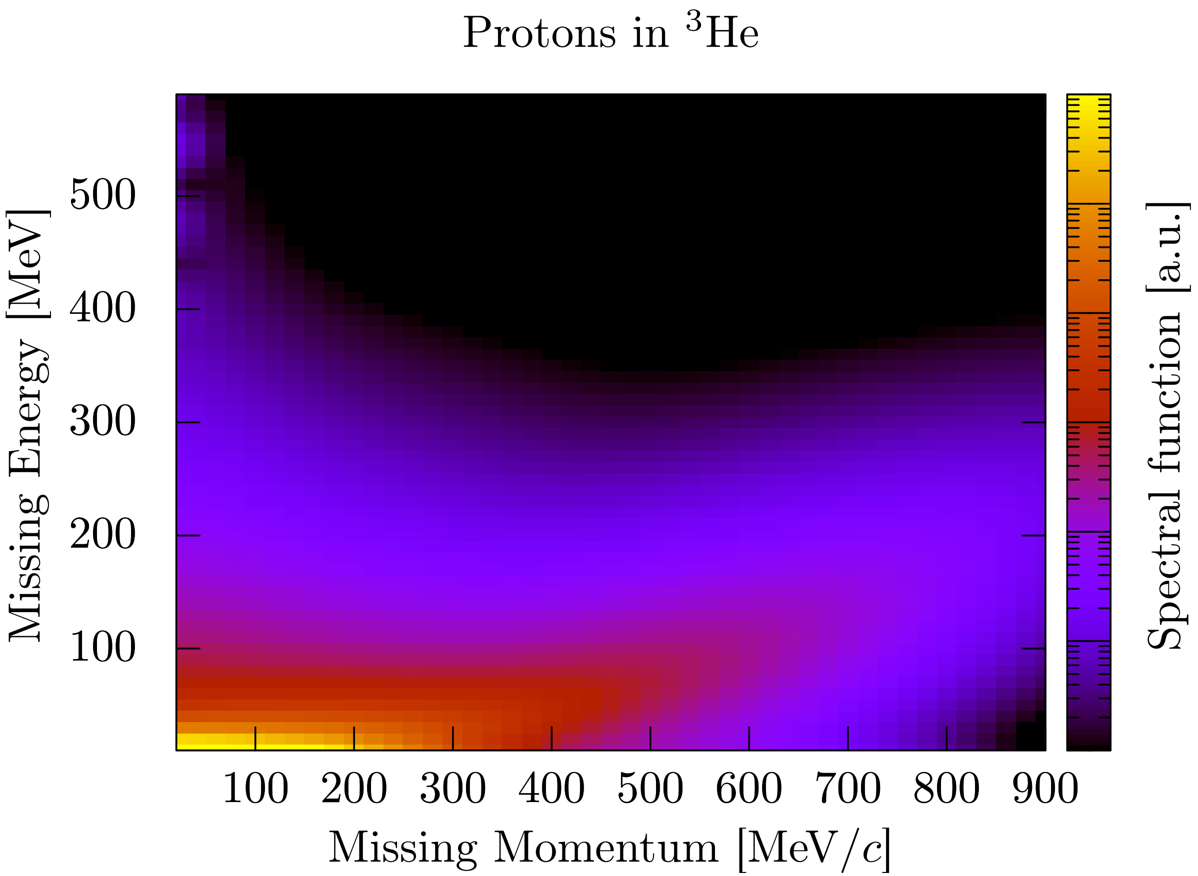
- Neutron knocks out proton in the EC
- Unlike proton, no DC track or TOF hit
- Neutrons have worse momentum resolution than protons



Source: Meytal Duer thesis (2018)

Fast Monte Carlo Simulations

- Used 3-body spectral functions based on Fadeev equations from Ciofi degli Atti and Kaptari
- Unweighted quasielastic generator under PWIA

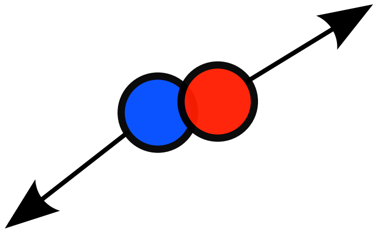


$$\frac{d^6\sigma}{d\Omega_e dE_e d\Omega_N dE_N} = |\vec{p}_N| E_N \sigma_{eN} S_N(E_m, \vec{p}_m)$$

Ciofi delgi Atti and Kaptari, Phys. Rev. C 71:024005, 2005.

Event Selection Criteria for Protons

Low Momentum (MF)
$-0.05 < y < 0.2$
$0.9 < \nu < 1.6\ GeV$
$\theta_{pq} < 7\ deg$
$\boldsymbol{E_{miss} < 0.08\ GeV}$
$\boldsymbol{p_{miss} < 0.22\ GeV/c}$

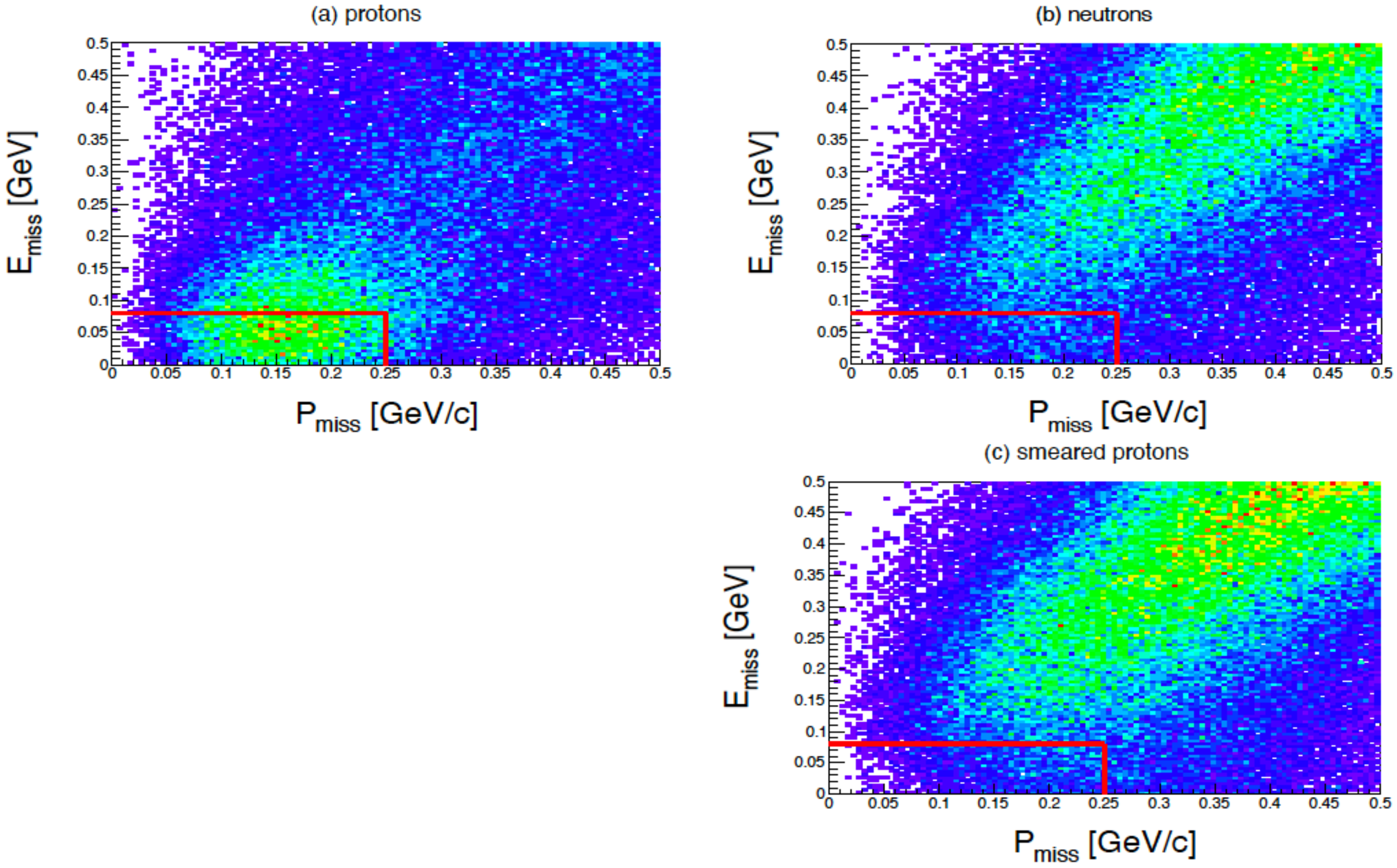


High Momentum (SRC)
$x_B > 1.2$
$0.62 < \frac{\lvert p \rvert}{\lvert q \rvert} < 1.1$
$\theta_{pq} < 25\ deg$
$\boldsymbol{M_{miss} < 1.1\ GeV/c^2}$
$\boldsymbol{0.3 < p_{miss} < 1\ GeV/c}$

The p-dependent cuts developed for protons don’t work for neutrons!

Smearing the Proton Momentum

- Neutron have worse momentum resolution than protons
- Need to apply same cuts to both p and n
- **Solution**: smear proton momentum and find modified cuts!



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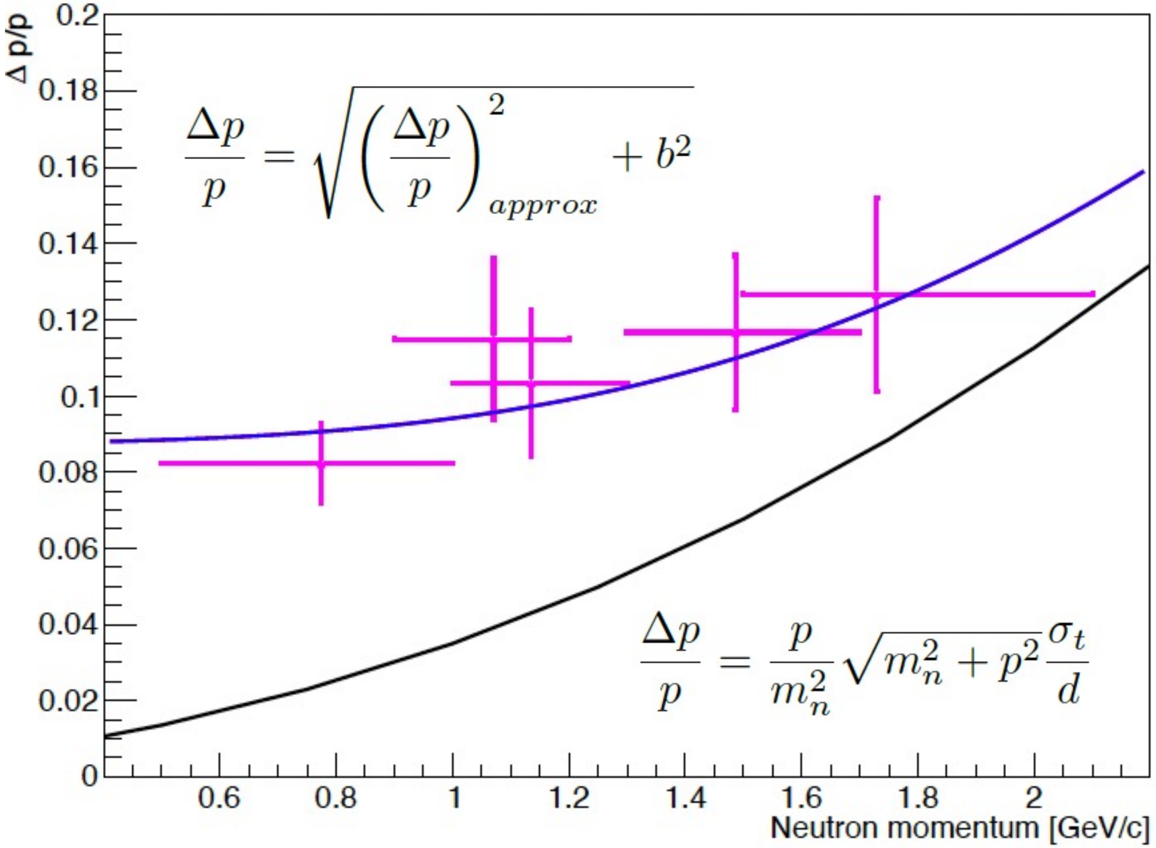
Momentum Smearing Methodology

- p_{miss} = expected neutron momentum based on $^3He(e,e'pp)n$ momentum conservation
- Find neutron momentum error $\Delta p/p$ vs momentum

$$\frac{\Delta p}{p} = \frac{p_{miss} - p_{measured}}{p_{measured}}$$

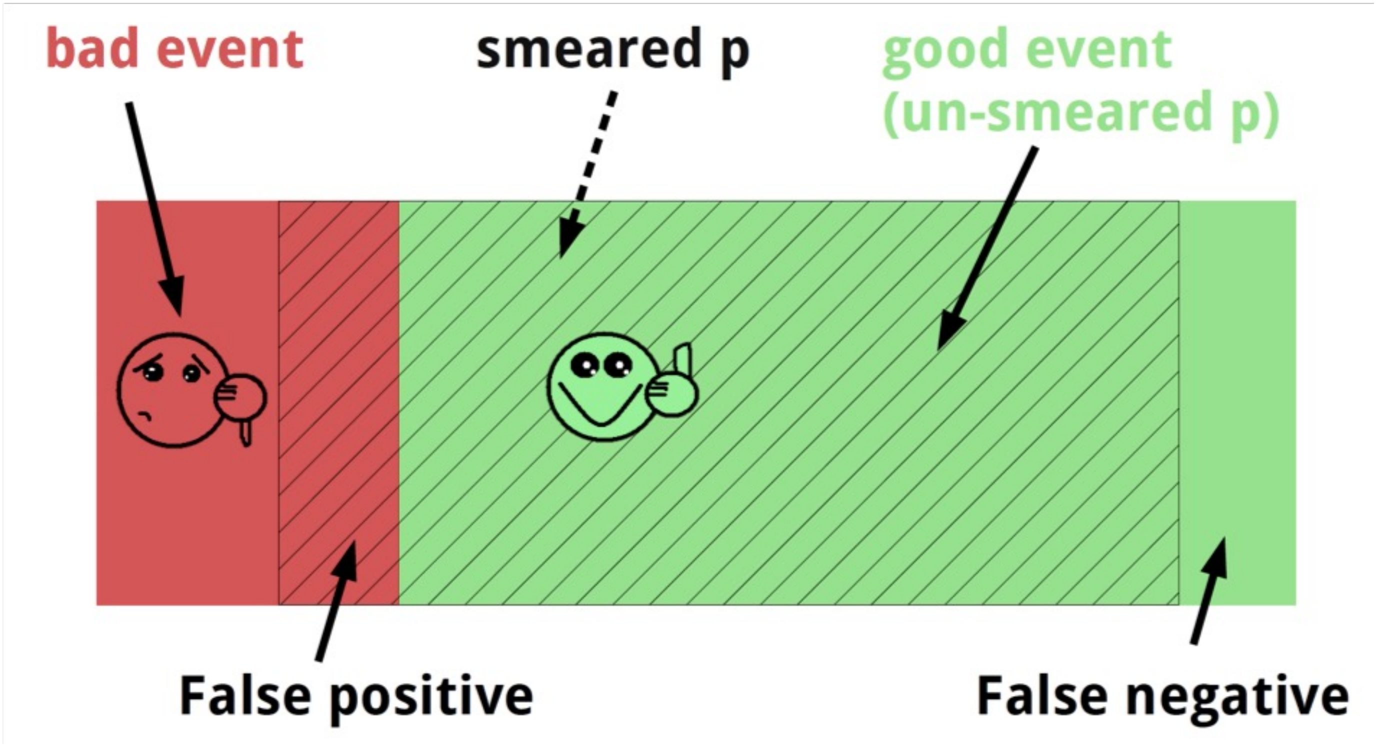
- Scale proton momentum by smearing factor drawn from Gaussian with $\sigma = \Delta p$



Finding Modified Cuts

Low Momentum (modified)
$E_{miss} < ?$
$p_{miss} < ?$

High Momentum (modified)
$M_{miss} < ?$
$p_{miss} > ?$



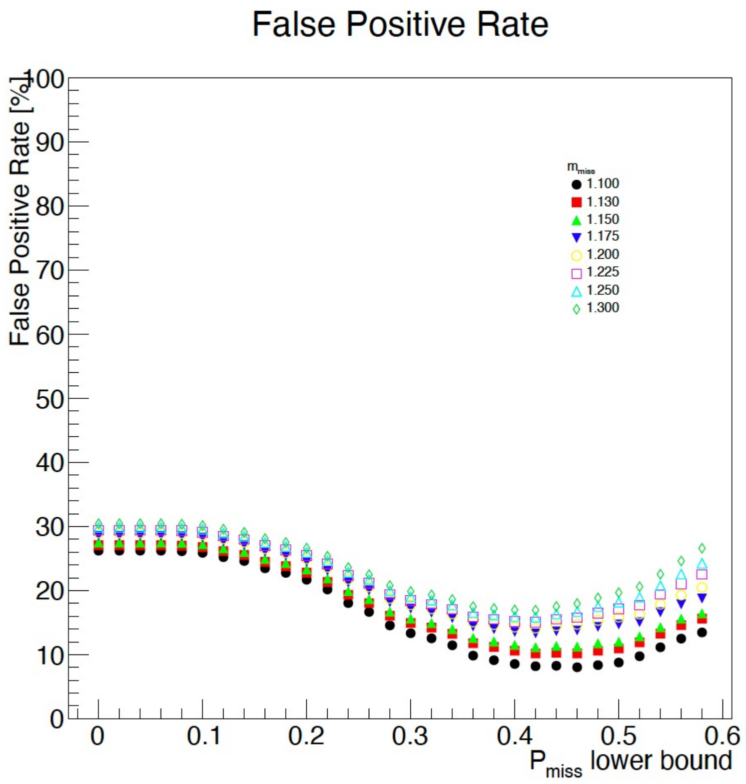
Goal: # of smeared protons passing modified cuts = # of unsmeared protons passing original cuts

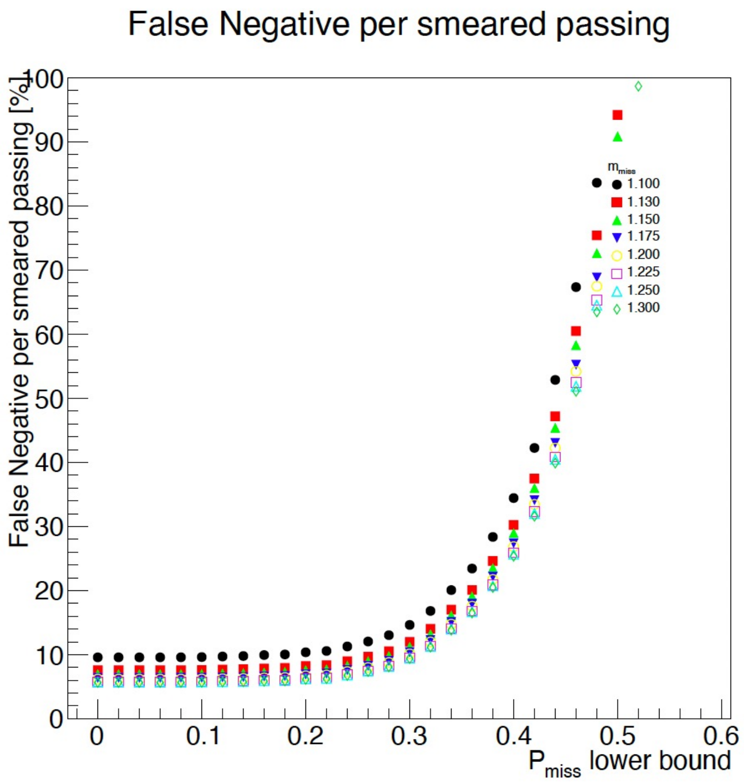
Cut Optimization

- Minimize difference between false negatives and false positives
- Same cuts for all targets

Low Momentum (modified)
$E_{miss} < 0.265\ GeV$
$p_{miss} < 0.265\ GeV/c$

High Momentum (modified)
$M_{miss} < 1.13\ GeV/c^2$
$0.32 < p_{miss} < 1\ GeV/c$





Cut Optimization

- Minimize difference between false negatives and false positives
- Same cuts in simulation as data

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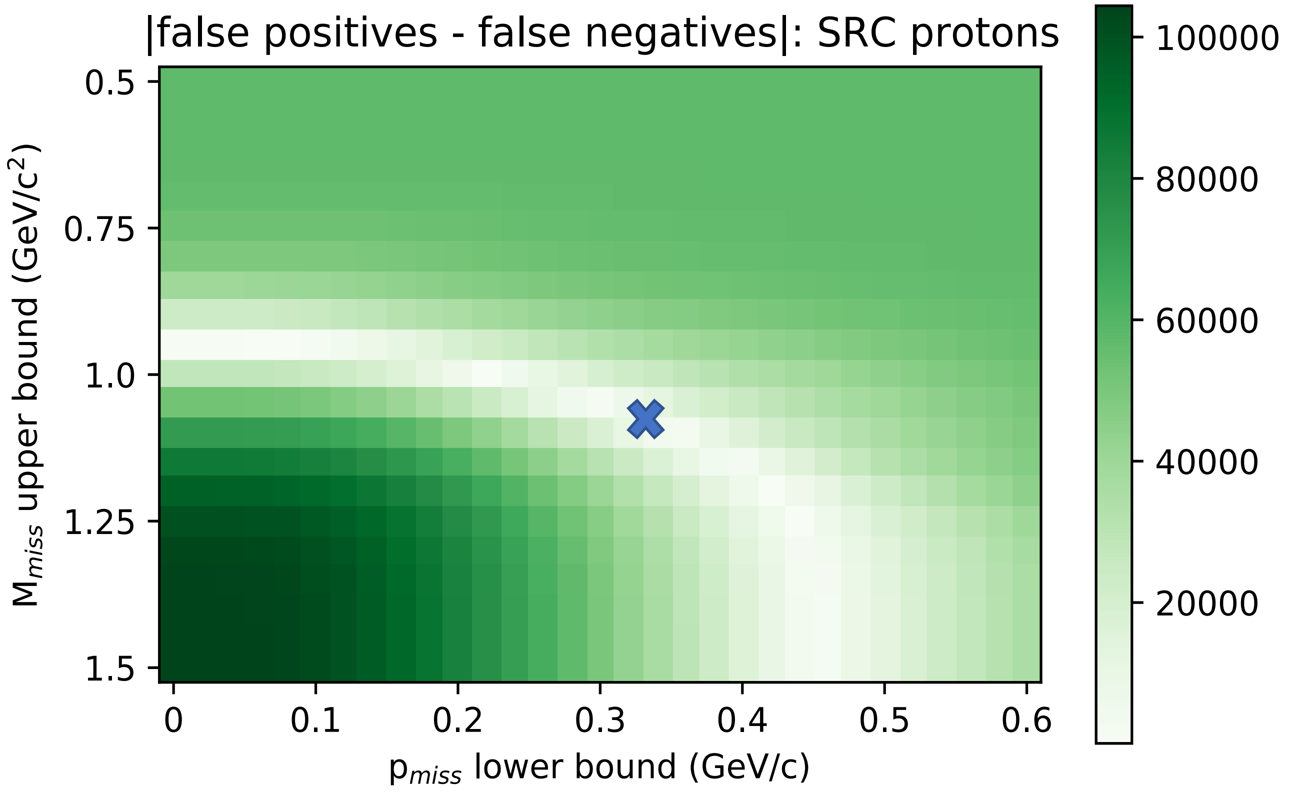
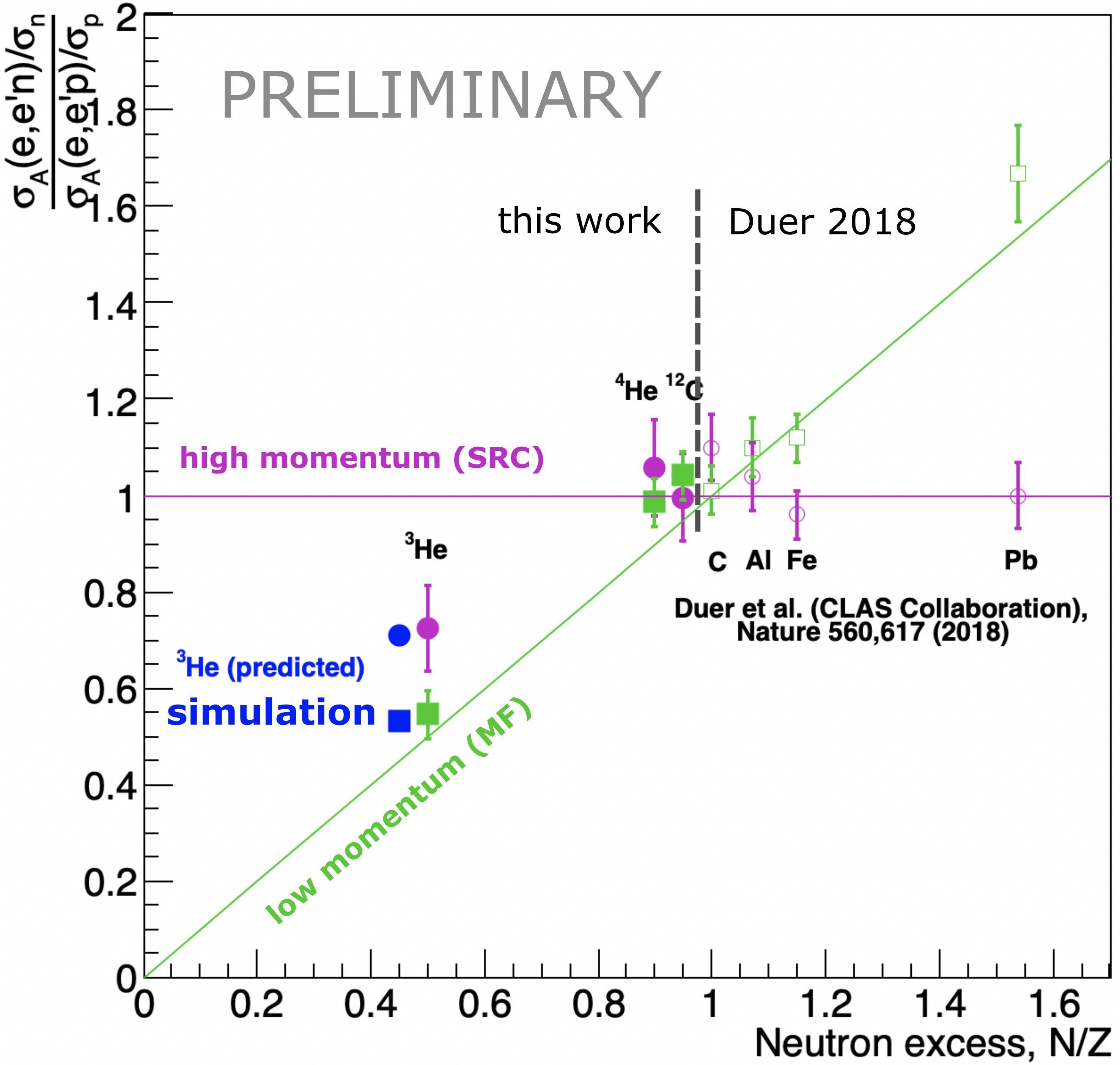


Results

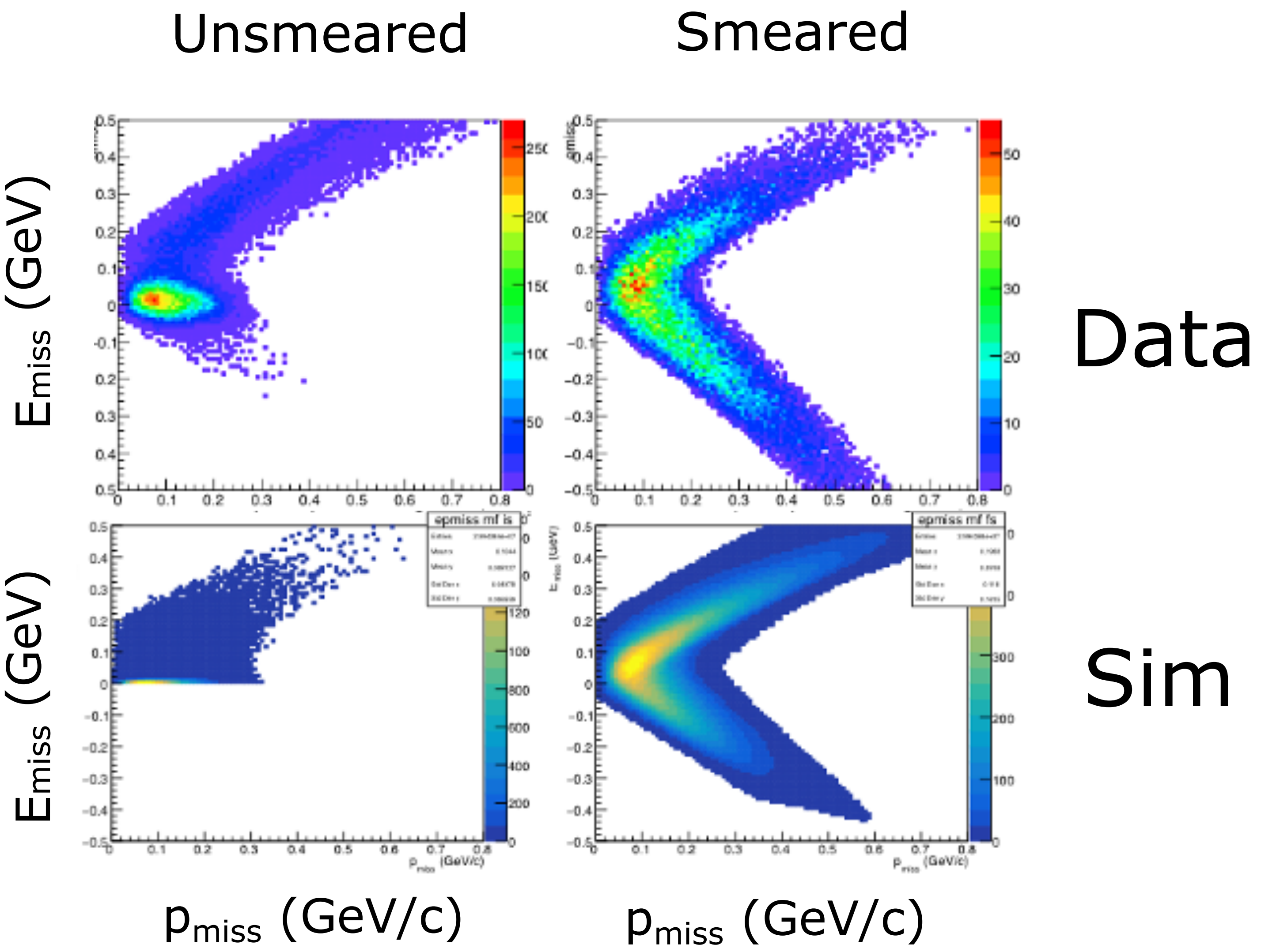
- Low momentum nucleons behave as expected
- Neutrons do speed up in proton-rich nuclei
- Reduced *np*-dominance in ^{3}He compared to larger nuclei
- Spectral functions good at replicating ^{3}He(e,e’n)/^{3}He(e,e’p) ratios



Thank You!

Questions?

Data and Simulation in Agreement



Definitions

$$P_\mu^{miss} = q_\mu + p_\mu^d - p_\mu^p$$

$$M_{miss} = \sqrt{P_\mu^{miss} P^{\mu,miss}}$$

$$\vec{p}_{miss} = \vec{p}_N - \vec{q}$$

$$E_{miss} = \omega - T_N - T_B$$

$$T_B = \omega + m_A - E_N - \sqrt{(\omega + m_A - E_N)^2 - |\vec{p}_{miss}|^2}$$