Measurements and Simulations of $(e,e'n)/(e,e'p)$ in the Proton-Rich Nucleus ^{3}He

Erin Marshall Seroka, Holly Szumila-Vance, Axel Schmidt

The George Washington University

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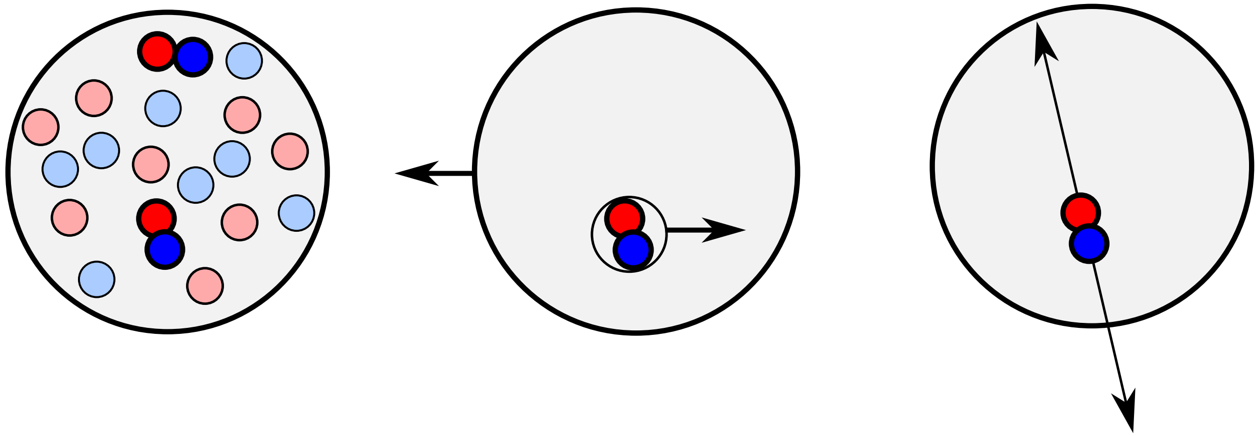
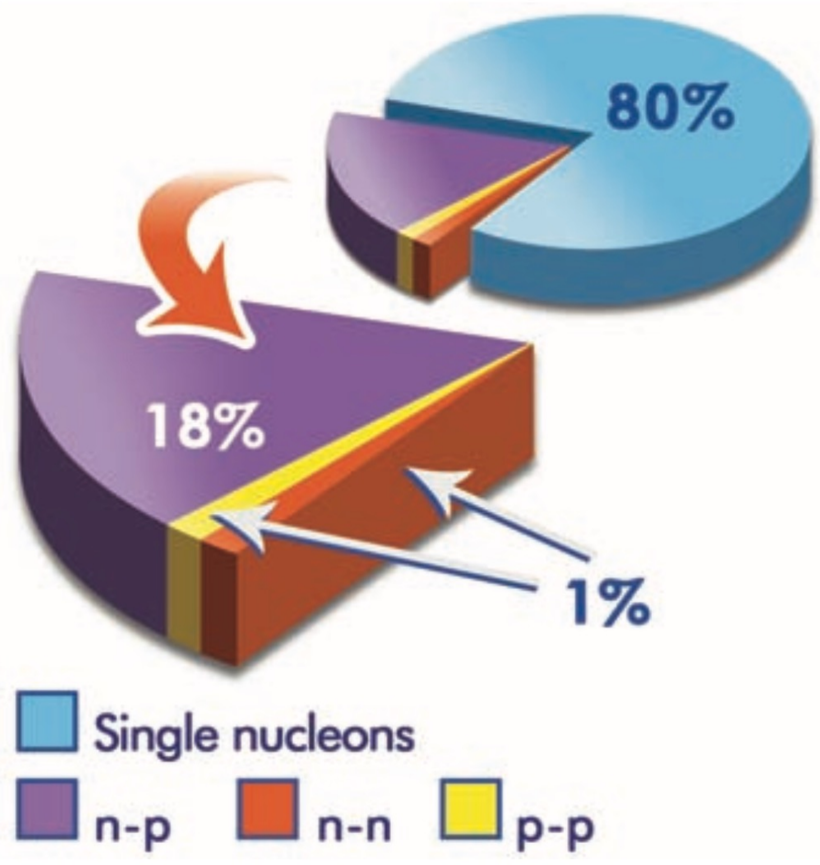
What are Short Range Correlations (SRCs)?

- Most nucleons move in mean field (MF)
- 20% of nucleons in short-range pairs
- Low center of mass momentum
- High relative momentum
- Predominantly *n-p* pairs

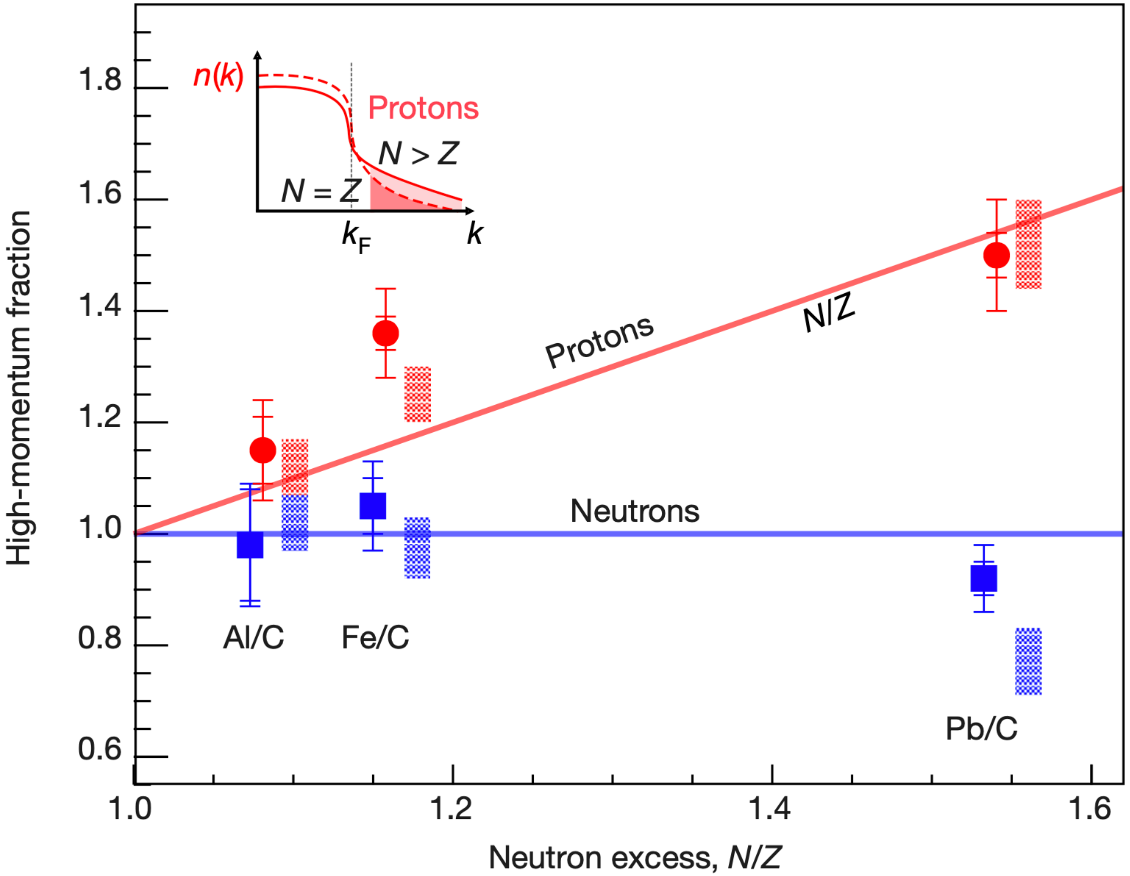


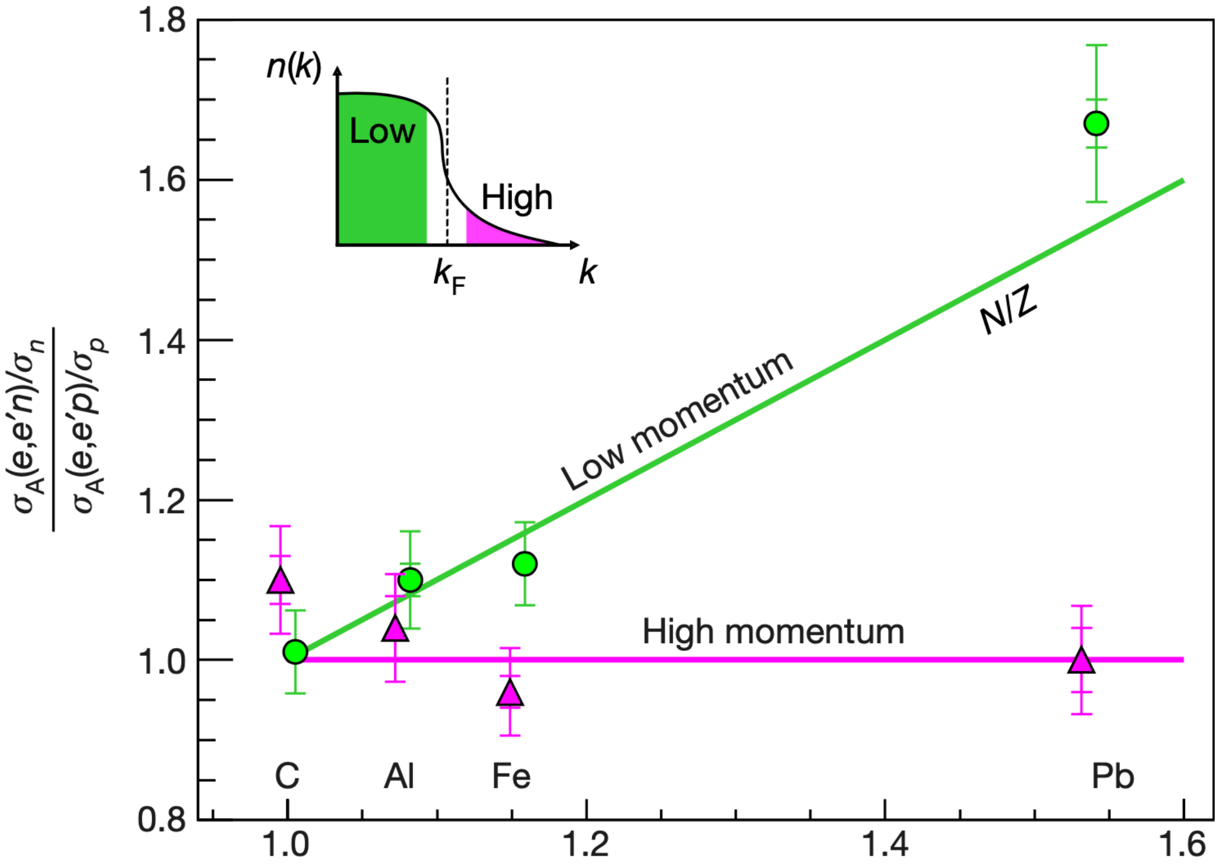


Source: Subedi et al. Science 320 (2008)

Protons "speed up" in neutron-rich nuclei

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

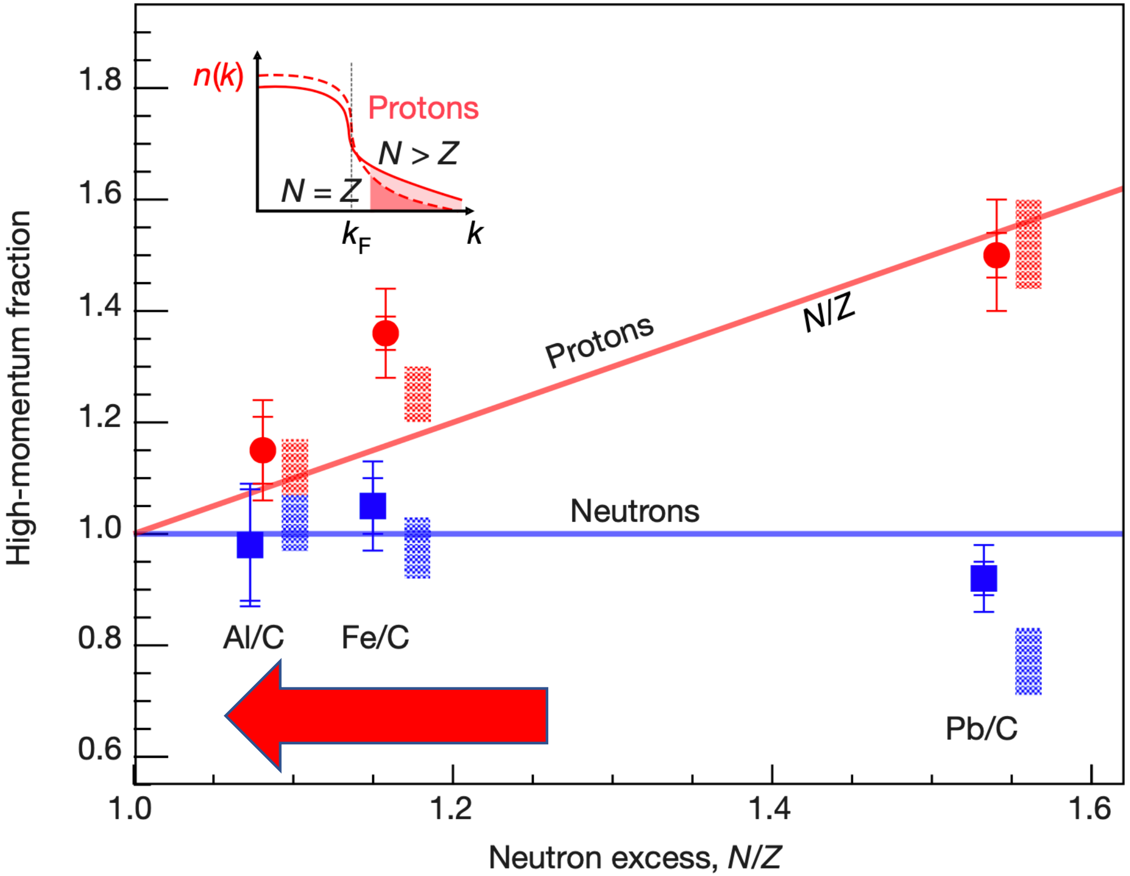


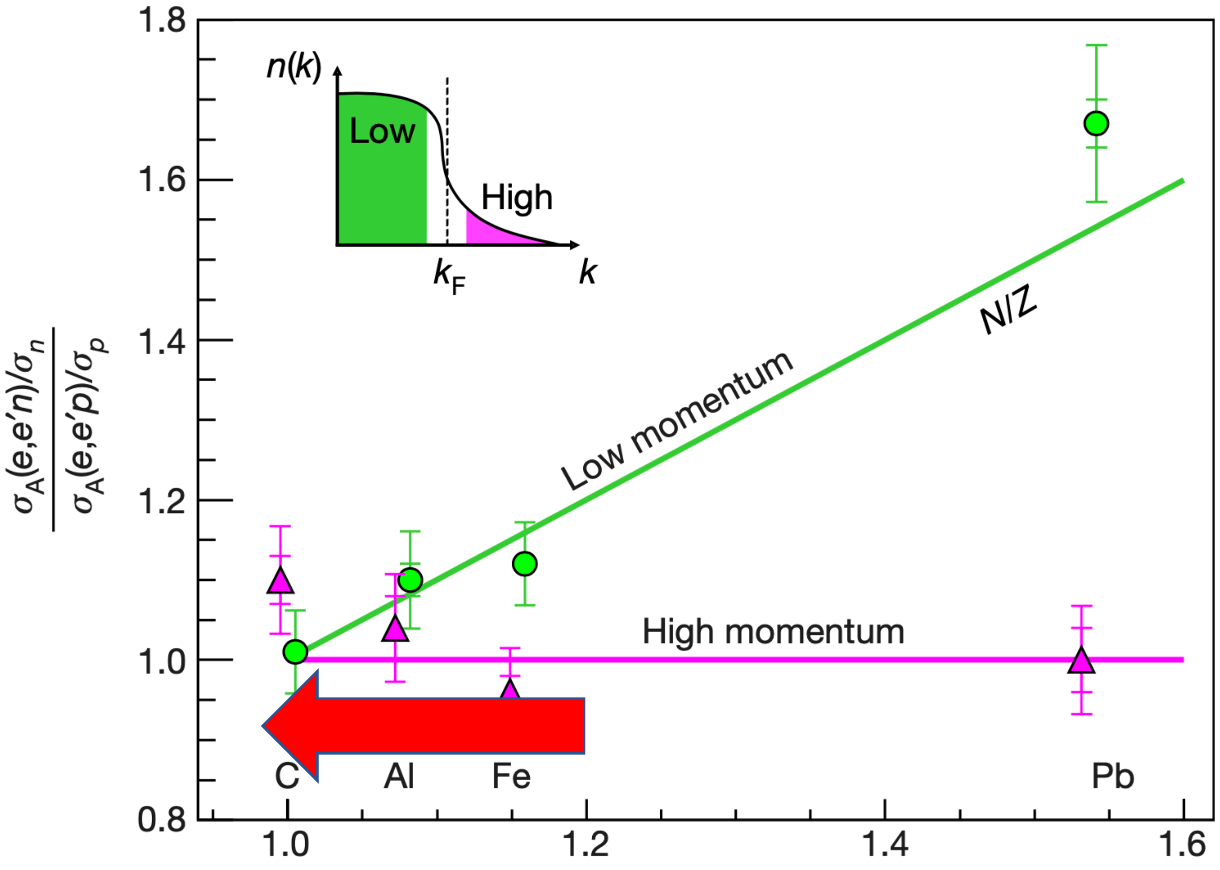


Duer et al. (CLAS Collaboration), Nature 560, 617 (2018)

Protons “speed up” in neutron-rich nuclei

What about proton-rich nuclei?





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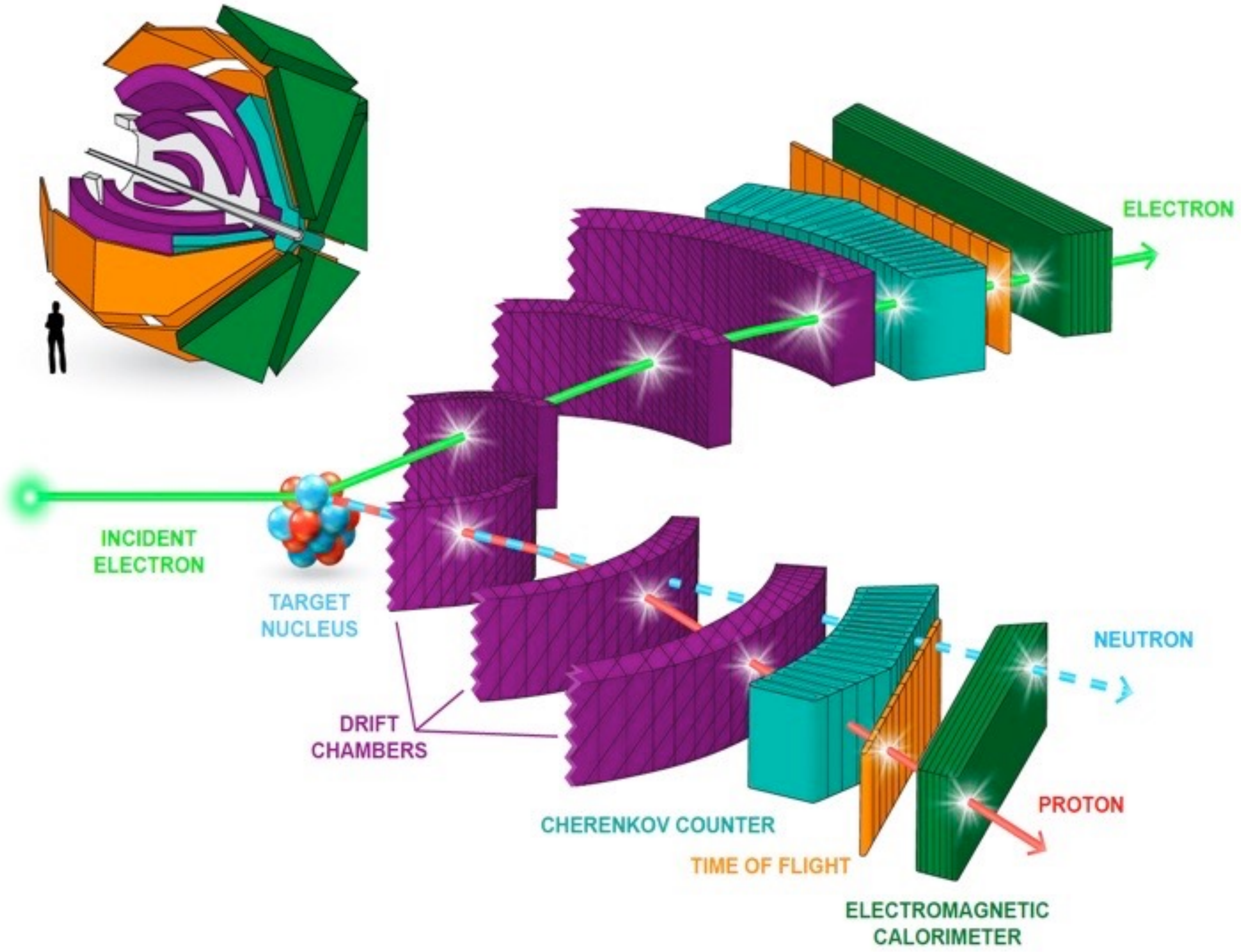
Neutron Detection in CLAS6

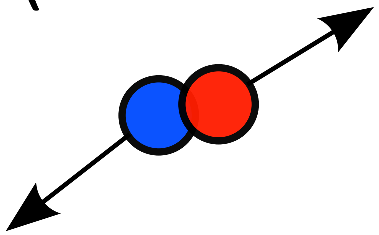
- Experiment e2a (April-May 1999)
- 4.4 GeV e^- beam
- ^{3}He, ^{4}He, ^{12}C targets
- Neutrons have worse momentum resolution than protons



Source: Meytal Duer thesis (2018)

Tried and True Event Selection (for Protons)

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



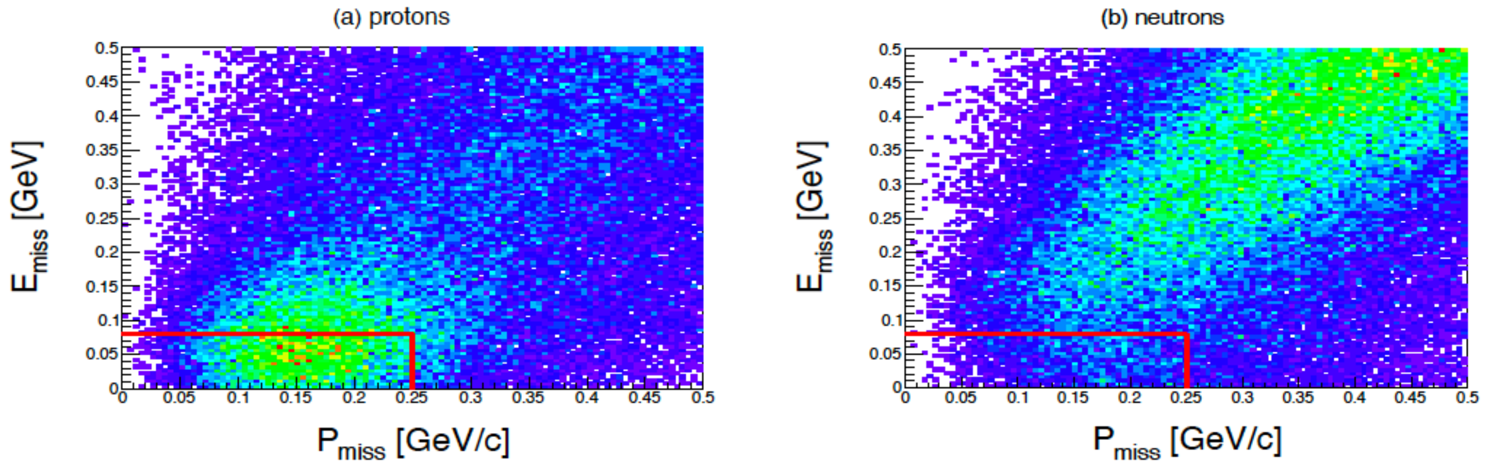
High Momentum (SRC)
$x_B > 1.2$
$0.62 < \frac{\|p\|}{\|q\|} < 1.1$
$\theta_{pq} < 25°$
$M_{miss} < 1.1$ GeV/c^2
$0.3 < p_{miss} < 1$ GeV/c

Hen et al., PRL (2013)
Duet et al., Phys Lett B (2019)
Schmidt et al.m Nature (2020)
Korover et al., Phys Lett B (2021)

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

Modify event selection for *n* and smeared *p*

- Smear proton momentum to match neutron momentum resolution



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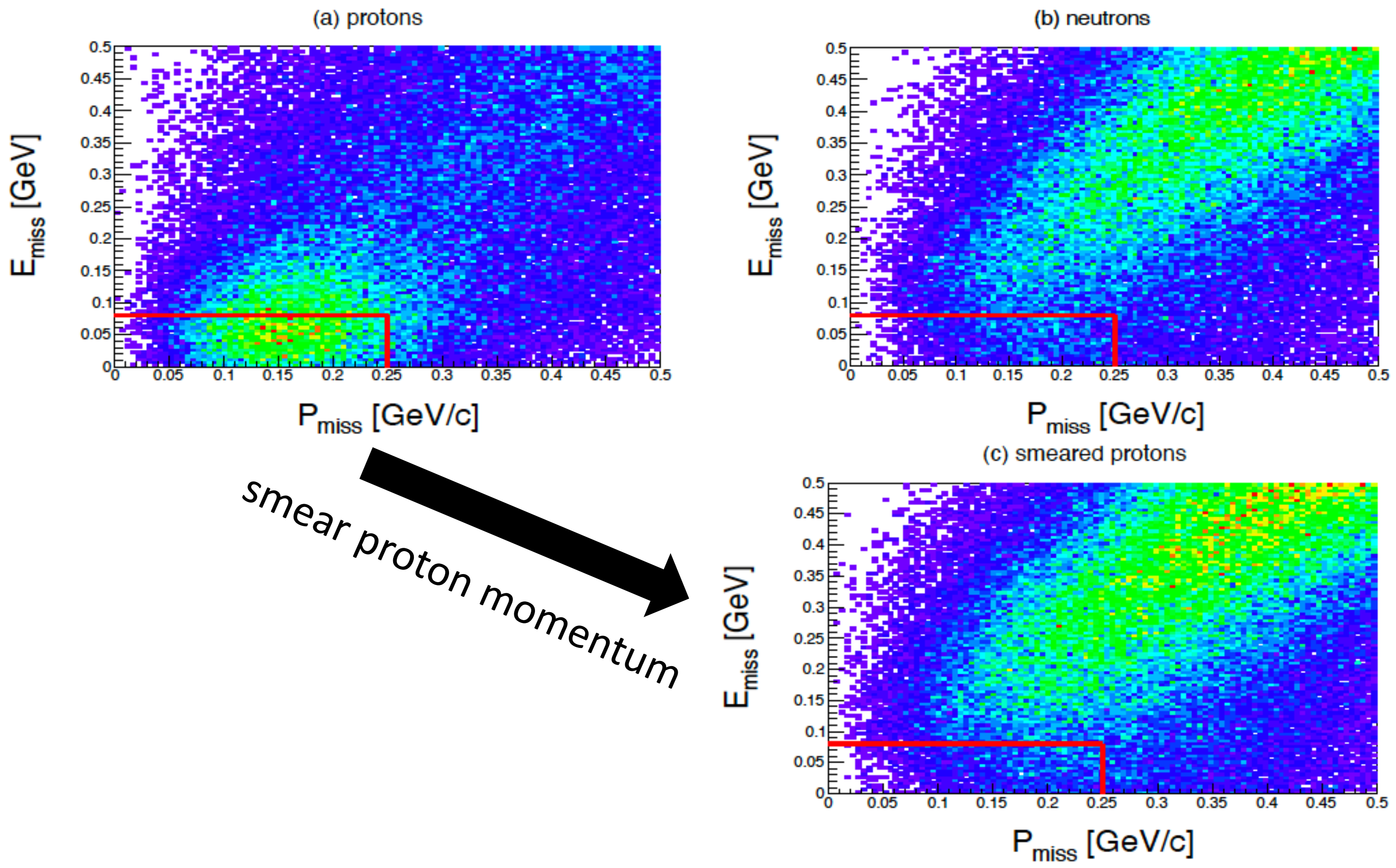

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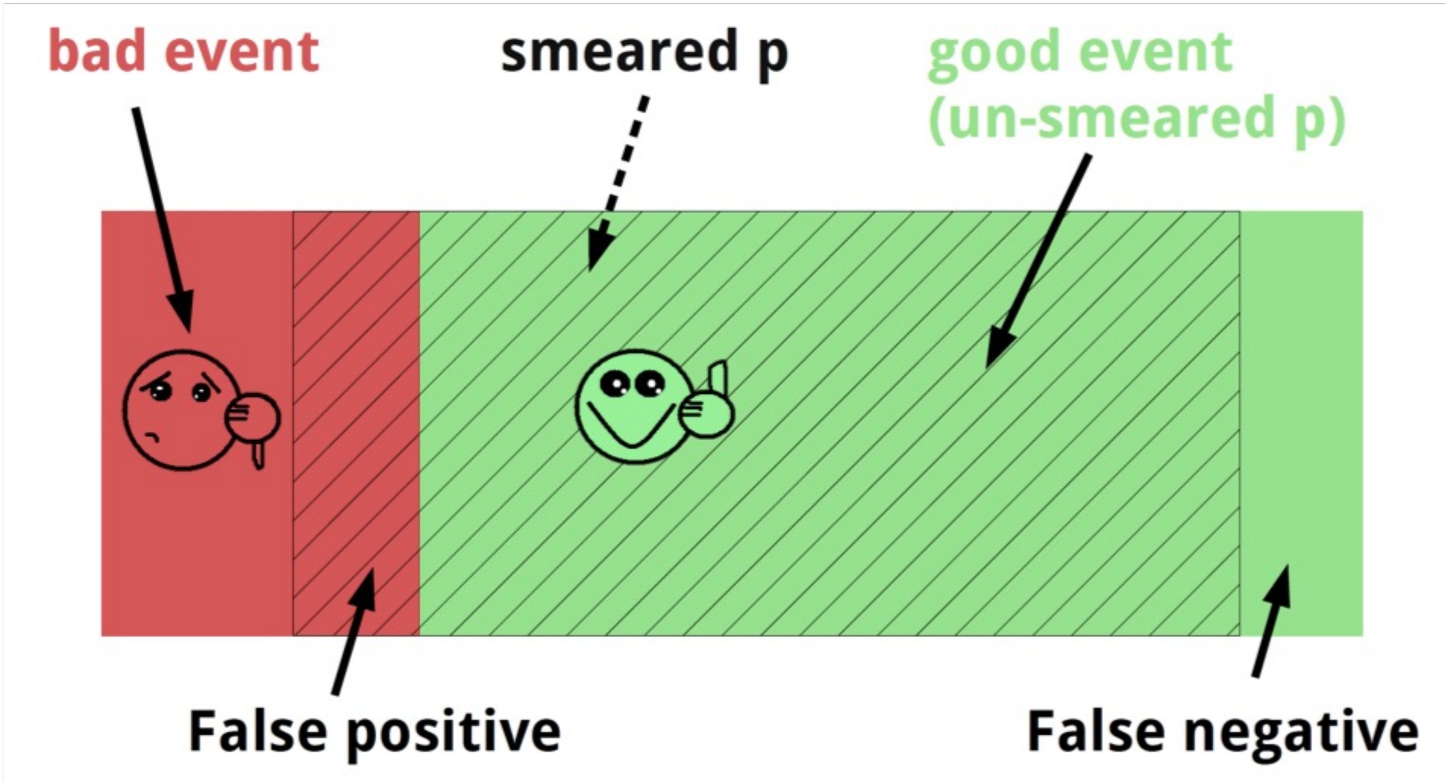
- Criterion: # of smeared p passing modified cuts = # of unsmeared p passing original cuts



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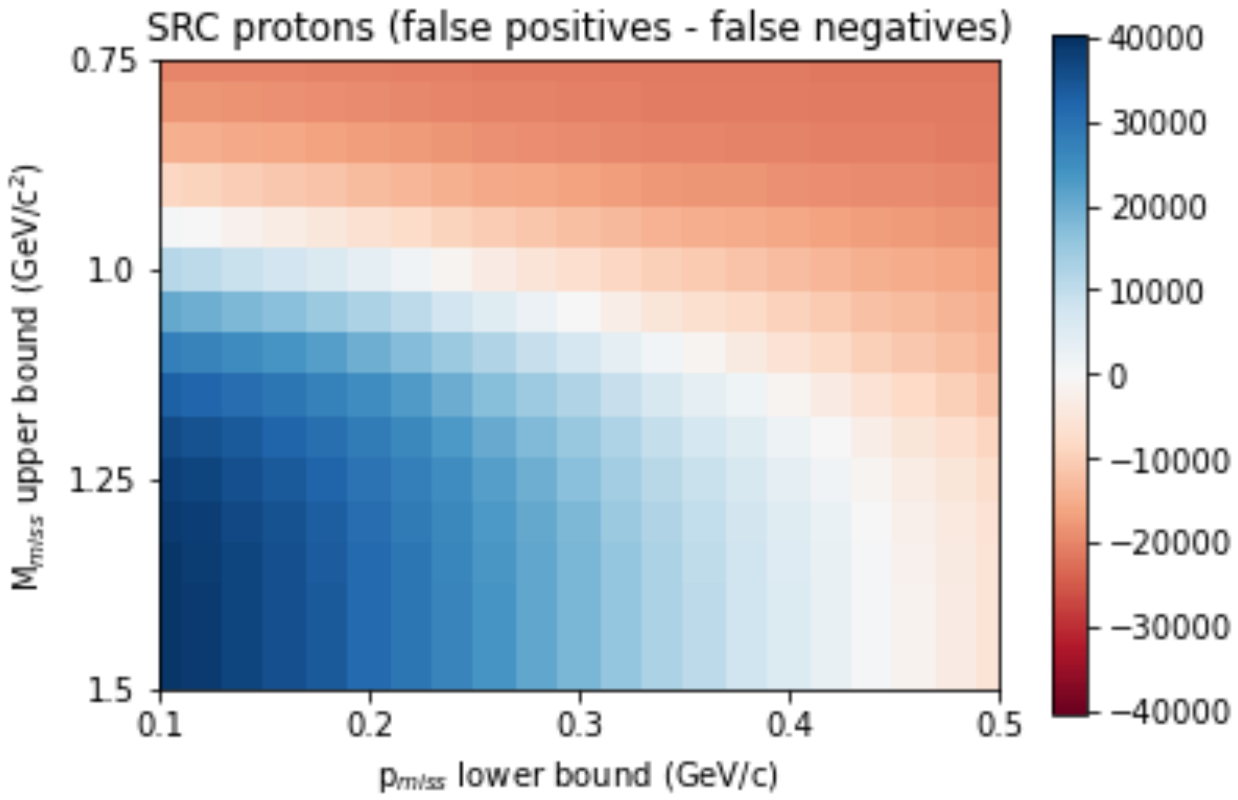
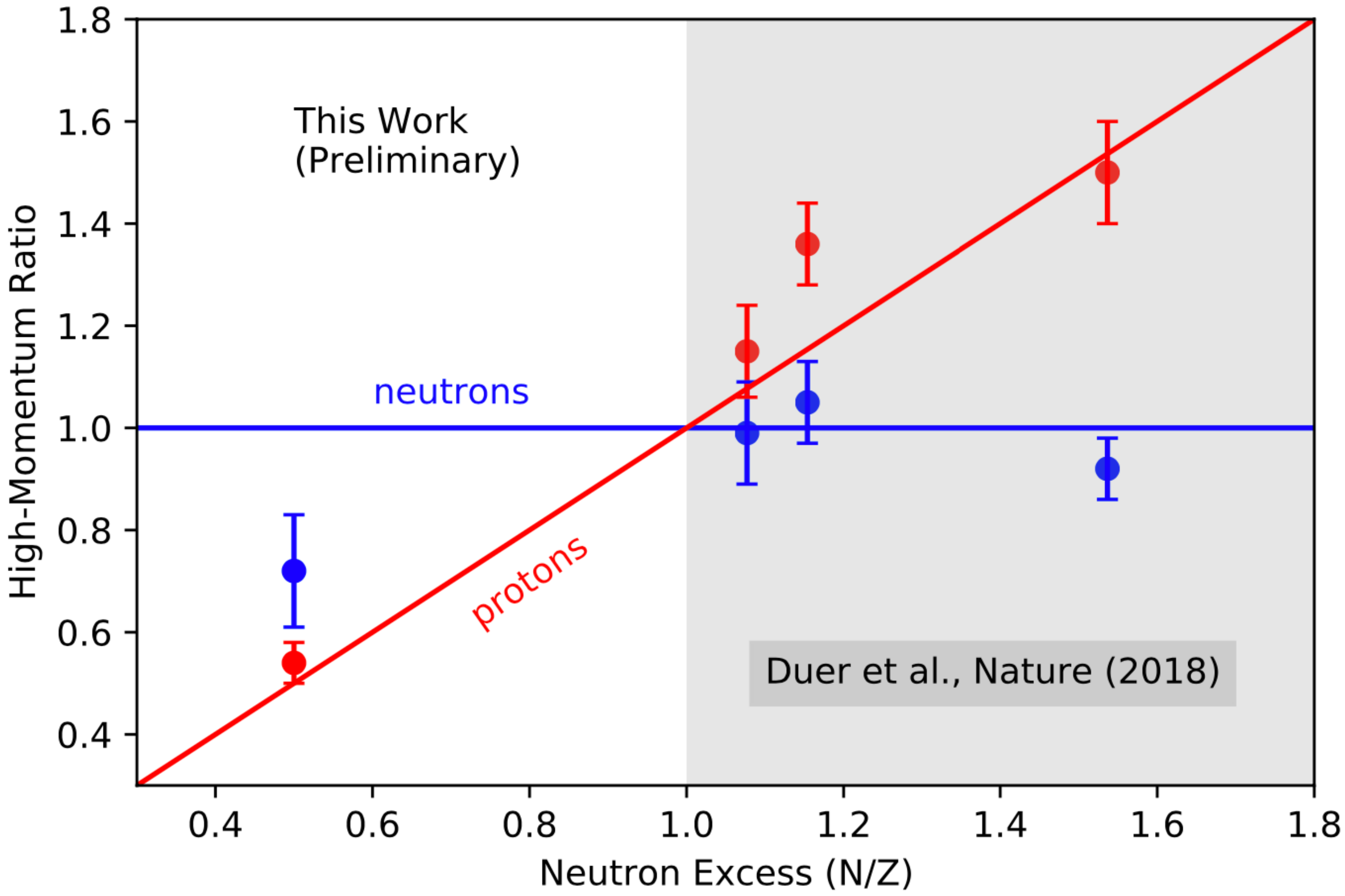


Low Momentum (modified)
$E_{miss} < 0.265\ GeV$
$p_{miss} < 0.265\ GeV/c$

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

Results

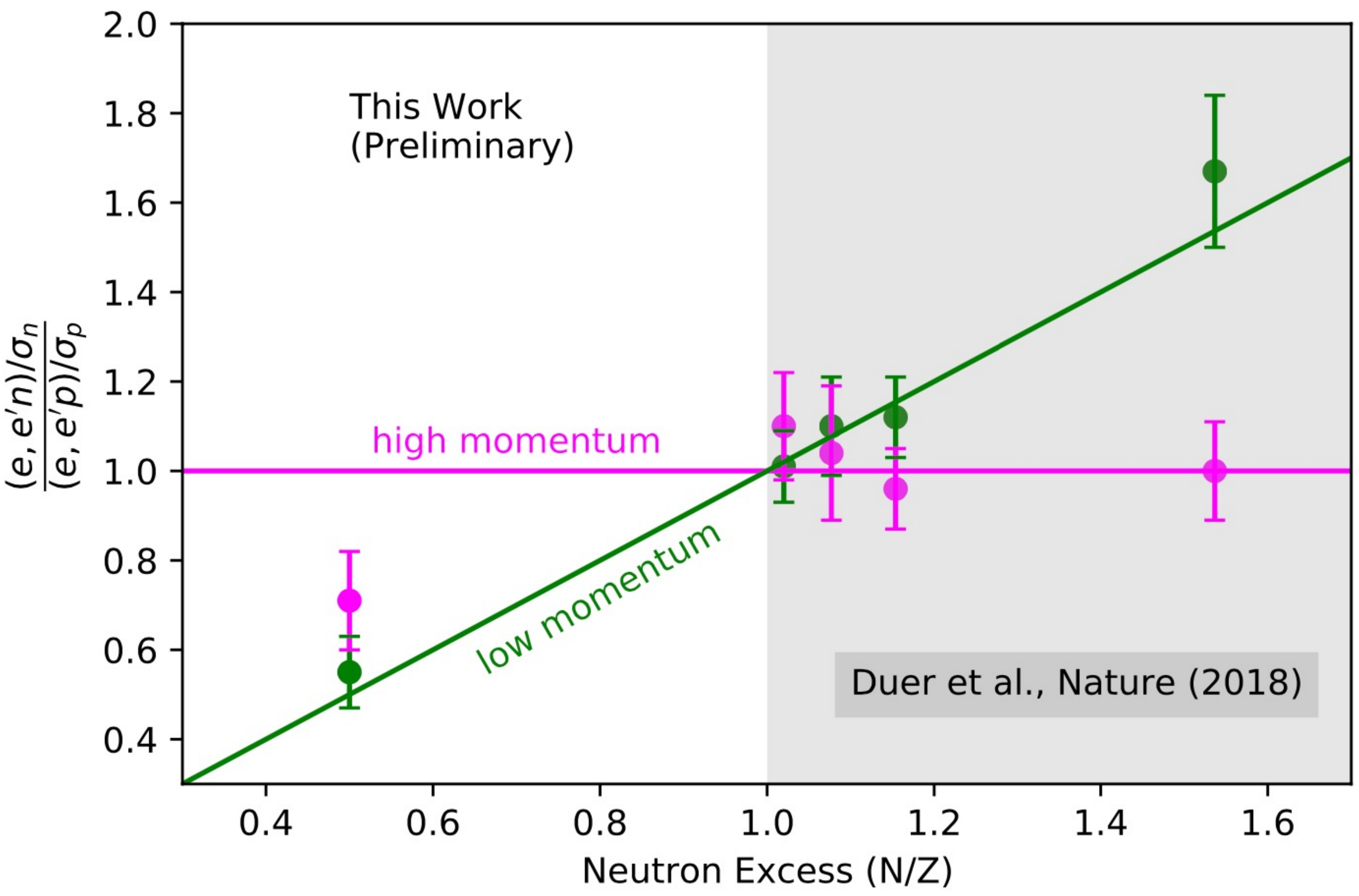
- Protons slow down, as expected
- Neutrons are faster than protons
- Neutrons not as fast as expected



$$R^{A/^4\mathrm{He}}_{\mathrm{high/low}} = \frac{A(e,e'N)_{\mathrm{high}}/A(e,e'N)_{\mathrm{low}}}{^4\mathrm{He}(e,e'N)_{\mathrm{high}}/^4\mathrm{He}(e,e'N)_{\mathrm{low}}}$$

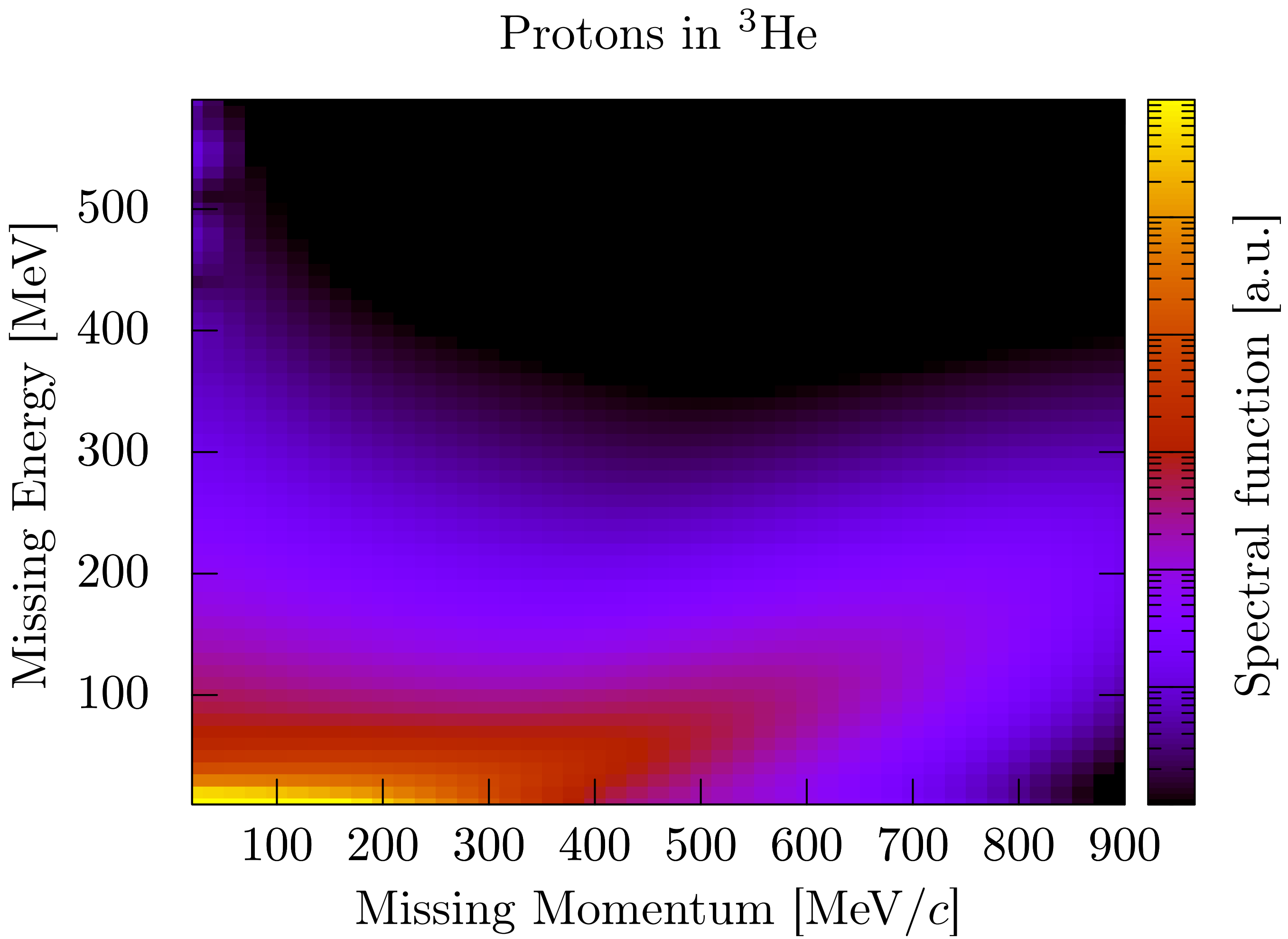
Results

- Low momentum nucleons follow N/Z trend
- Neutrons overrepresented in high-momentum states
- *np*-dominance decreased compared to large A



Simulating ^{3}He

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

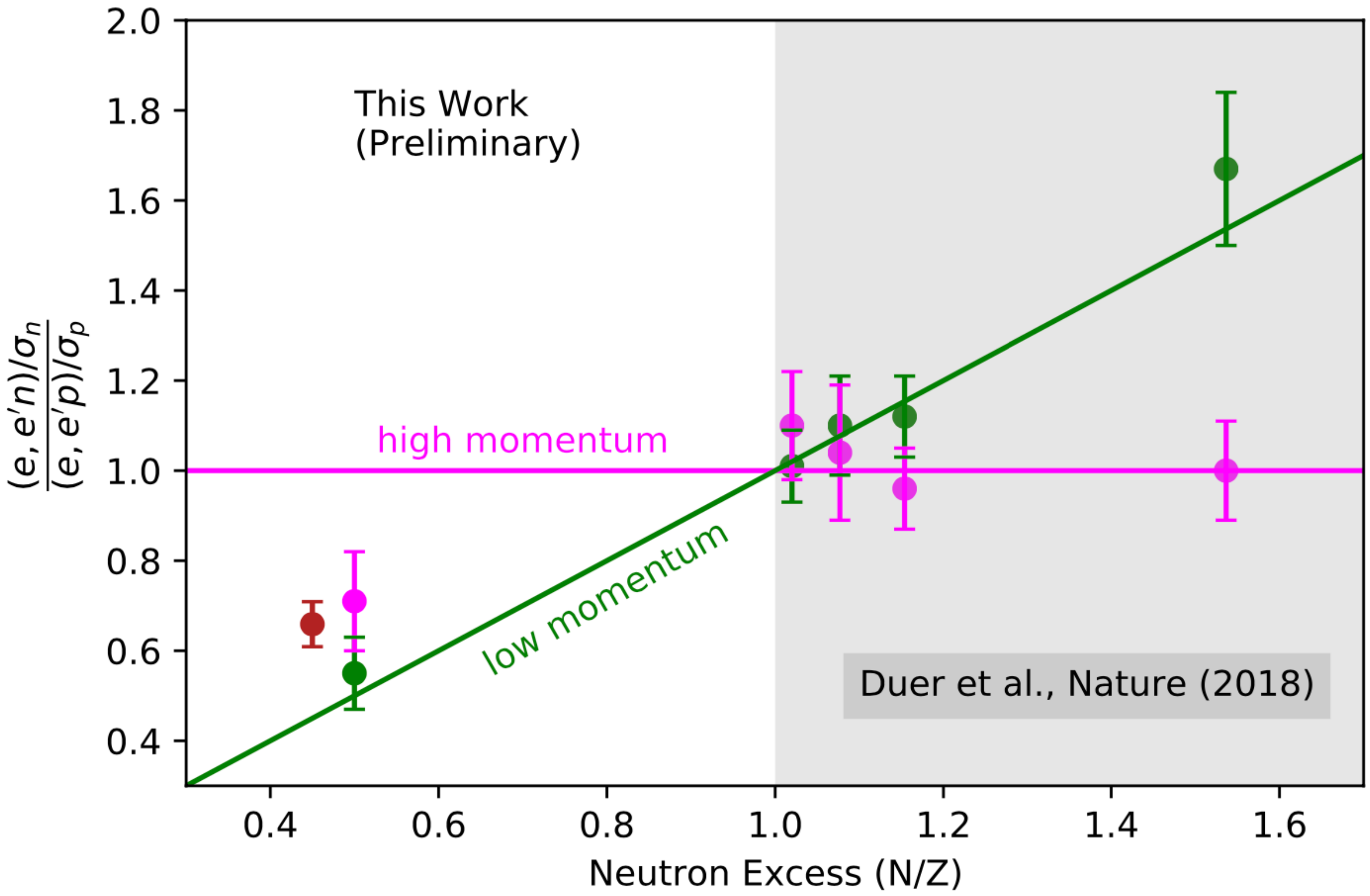


$$\frac{d^6\sigma}{d\Omega_e dE_e d\Omega_N dE_N} = |\vec{p}_N| E_N \sigma_{eN} S_N(E_m, \vec{p}_m)$$

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

Results

- Low momentum nucleons follow N/Z trend
- Neutrons overrepresented in high-momentum states
- *np*-dominance decreased compared to large A
- Spectral functions model dynamics well



Stay tuned!

- Currently in CLAS review
- Ongoing simulation work
- Paper soon to come

Thank you!