Study of the (e,e'n) reaction using JLAB - CLAS EG2 data

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Layout

* Motivation

* Calculating $\frac{(e,e'p)_A}{(e,e'n)_A}$ ratio

* Missing momentum $(e,e'n)$ vs. $(e,e'p)$

* Extracting $\frac{^{12}C(e,e'n/p)_{P_{miss-low}}}{^{12}C(e,e'n/p)_{P_{miss-high}}}$

np- dominance in asymmetric neutron rich nuclei

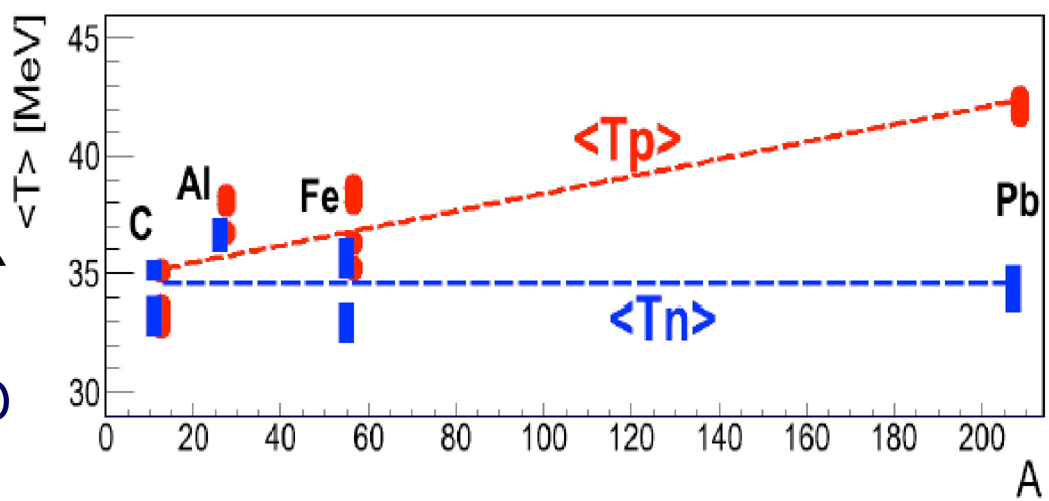
Pauli principle $\Rightarrow$ $\langle K_n \rangle > \langle K_p \rangle$

SRC $\Rightarrow$ $\langle K_p \rangle \overset{?}{>} \langle K_n \rangle$

Universal nature of SRC:

A proton have greater probability than a neutron to be above the Fermi sea. $(k > K_F)$

Prediction:



O. Hen et al., Science 346, 614 (2014)

How to check this hypothesis experimentally?

Problem: One body momentum distributions are not observables.

Solution: Define proxy which -

1. Reflects well the difference between proton and neutron momentum distributions.
2. Can be well determined experimentally.

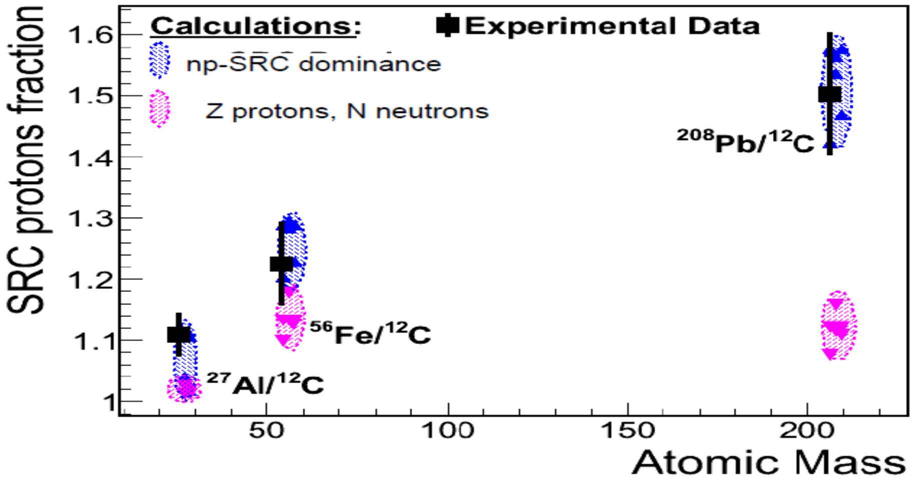
$$^{208}Pb: \quad N = 126 \quad Z = 82$$

$$R_p = \frac{\#\, protons|_{k>K_F}}{\#\, protons|_{k<K_F}} \approx \frac{16}{82-16} \approx 0.25$$

$$R_n = \frac{\#\, neutrons|_{k>K_F}}{\#\, neutrons|_{k<K_F}} \approx \frac{16}{126-16} \approx 0.15$$

$$\frac{R_p}{R_n} \approx 1.7$$

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



Neutrons

* Detecting neutrons in CLAS electromagnetic calorimeter (EC) – M. Braverman thesis (2014).

The goal:

Calculating $\frac{A(e,e'n)/^{12}C(e,e'n)|high}{A(e,e'n)/^{12}C(e,e'n)|low}$ ratio.

To do so:

* Identify $(e,e'n)$ mean field events.
* Identify $(e,e'n)$ SRC events.

Calculating $\frac{A(e,e'p)}{A(e,e'n)}$ ratio

EG2 data: ^{2}d , ^{12}C , ^{27}Al , ^{56}Fe , ^{208}Pb

- * Select (e,e'p) QE events
- * Identify (e,e'n) QE events
- * Check the event selection
- * Apply corrections
- * Calculate $\frac{A(e,e'p)}{A(e,e'n)}$ ratio

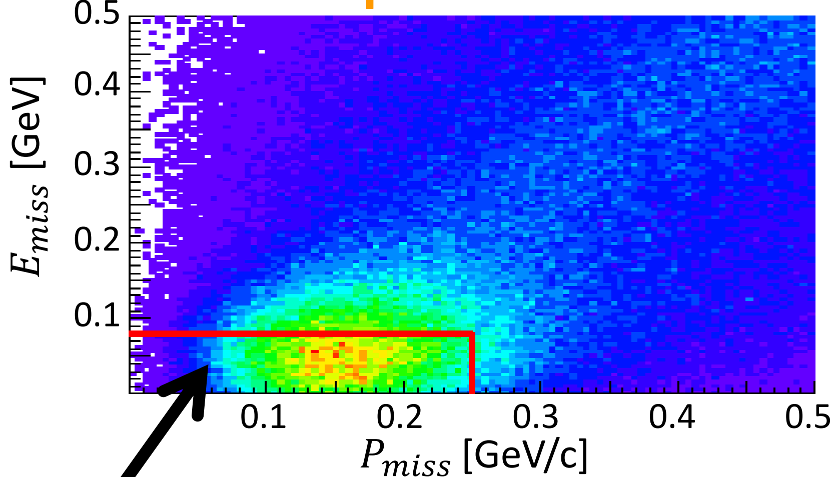
Selecting Quasi-Elastic events

Problem: Poor resolution in the EC - $\Delta P \sim 200 \frac{MeV}{c}$.

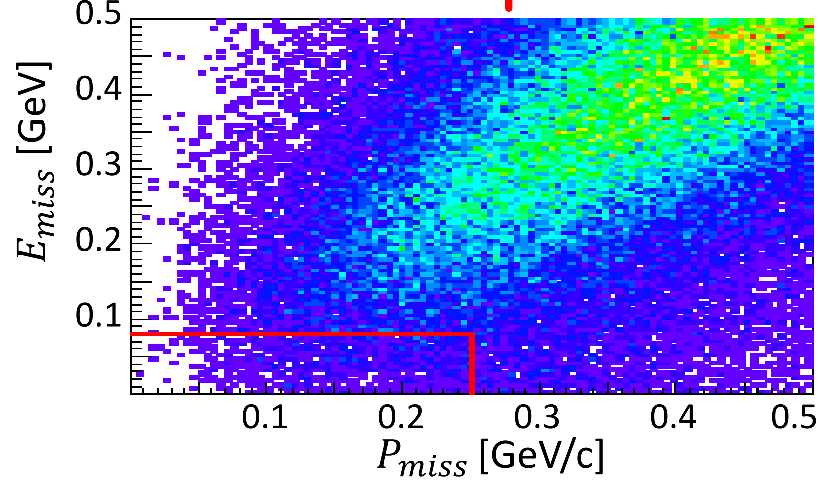
Solution 1: Using smeared protons.

E_{miss} $vs.$ P_{miss}

protons

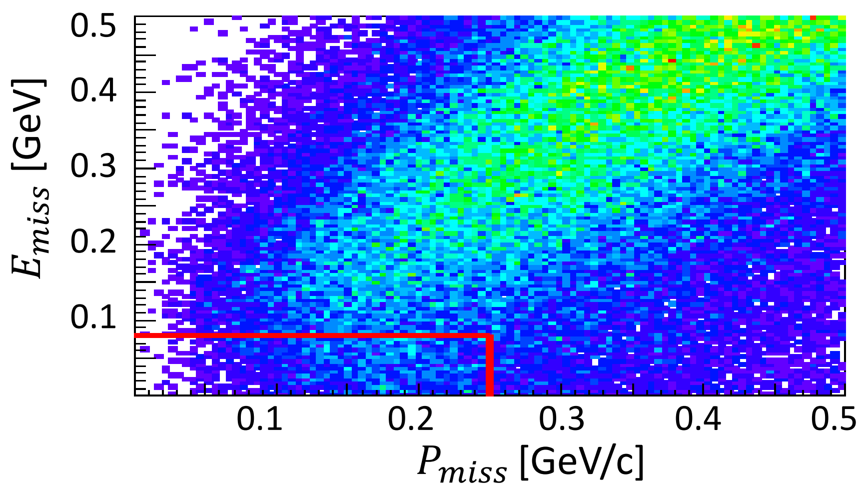


smeared protons



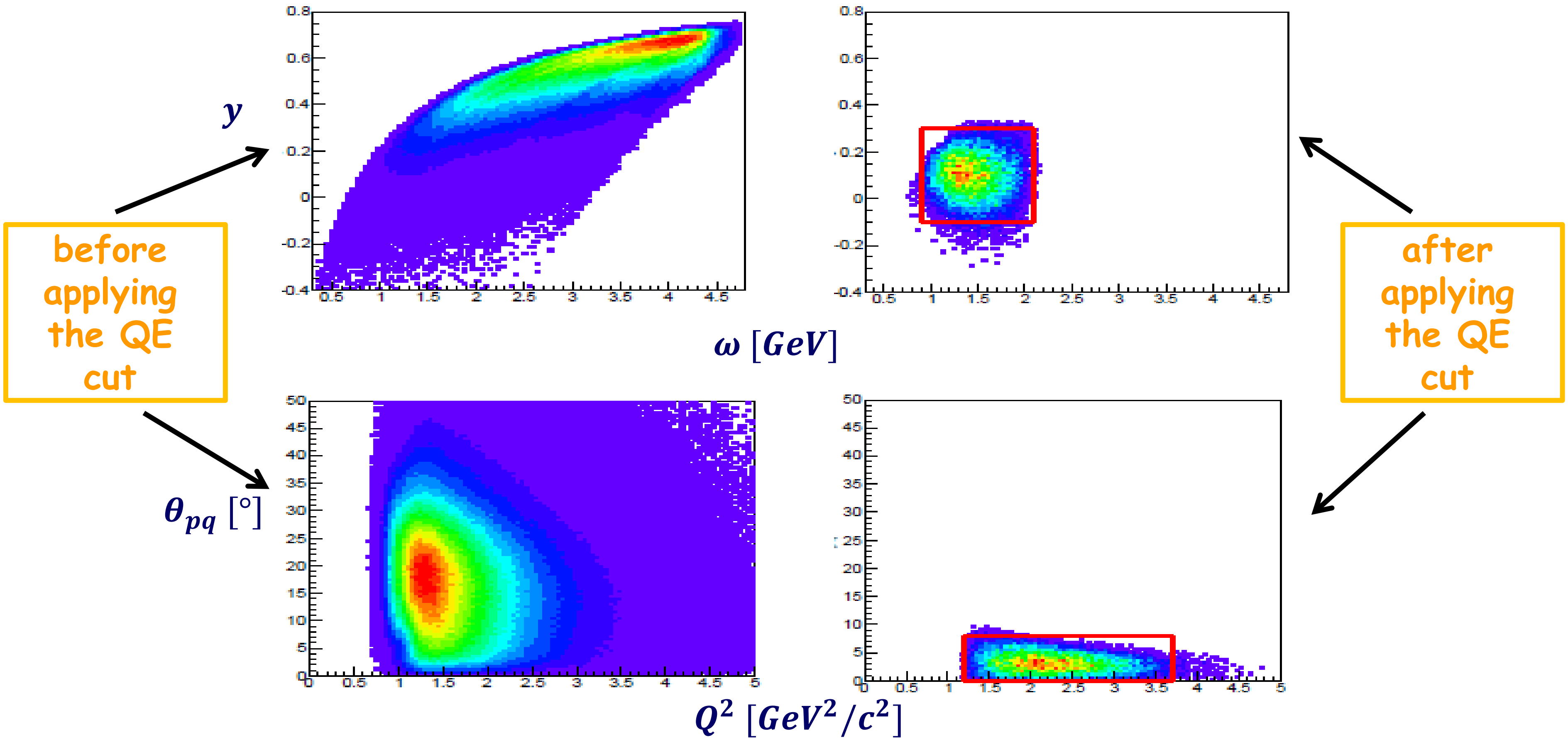
QE pick:

$P_{miss} < 0.25\ GeV/c$
$E_{miss} < 0.08\ GeV$



neutrons

Solution 2: Using electron quantities and scattering angle of the nucleon.



$$y \equiv \left((M_A + \omega)\sqrt{\Lambda^2 - {M^2}_{A-1} W^2} - q\Lambda \right) / W^2$$

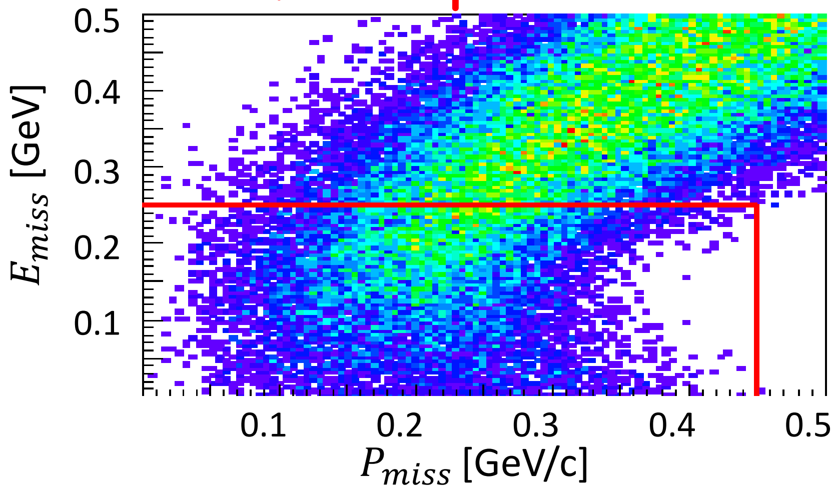
$$\Lambda = ({M^2}_{A-1} - {M^2}_N + W^2)/2 \qquad W = \sqrt{(M_A + \omega)^2 - q^2}$$

We applied the following cuts:

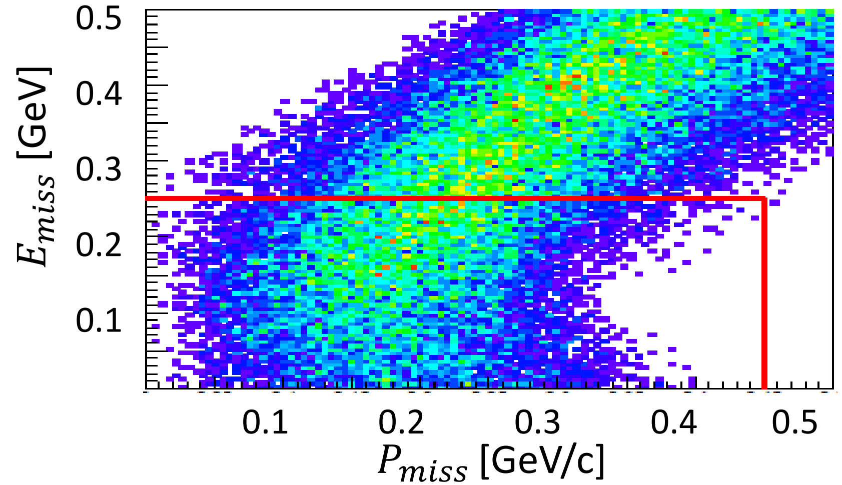
E_{miss} $vs.$ P_{miss}

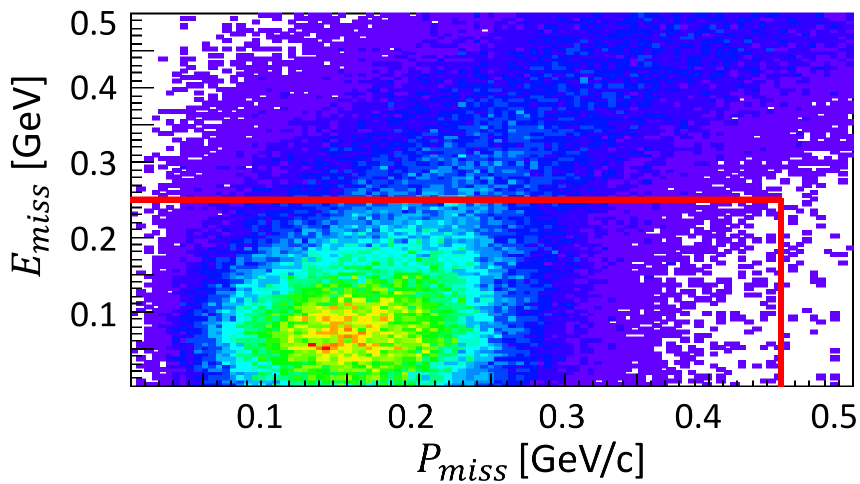
* $-0.1 < y < 0.3$
* $0.9 < \omega < 2.1\ GeV$
* $\theta_{pq} < 8^o$
* $1.2 < Q^2 < 3.7\ GeV^2/c^2$

smeared protons



neutrons





un - smeared protons

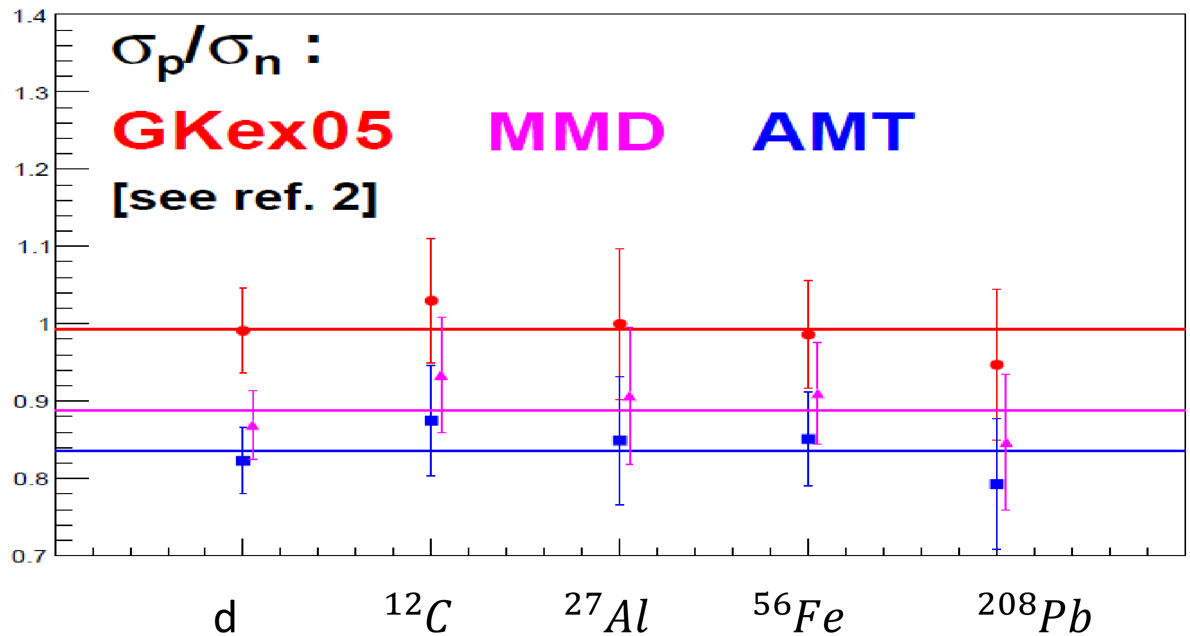
The selected cuts:

$P_{miss} < 0.45\ GeV/c$

$E_{miss} < 0.25\ GeV$

$\frac{A(e,e'p)}{A(e,e'n)}$ ratios

$$\frac{(e,e'p)/Z\cdot\sigma_p}{(e,e'n)/N\cdot\sigma_n}$$



Constant fits:

$\text{const} = 0.99 \pm 0.04 \;\; \chi^2 = 0.76$

$\text{const} = 0.88 \pm 0.03 \;\; \chi^2 = 0.95$

$\text{const} = 0.83 \pm 0.03 \;\; \chi^2 = 0.74$

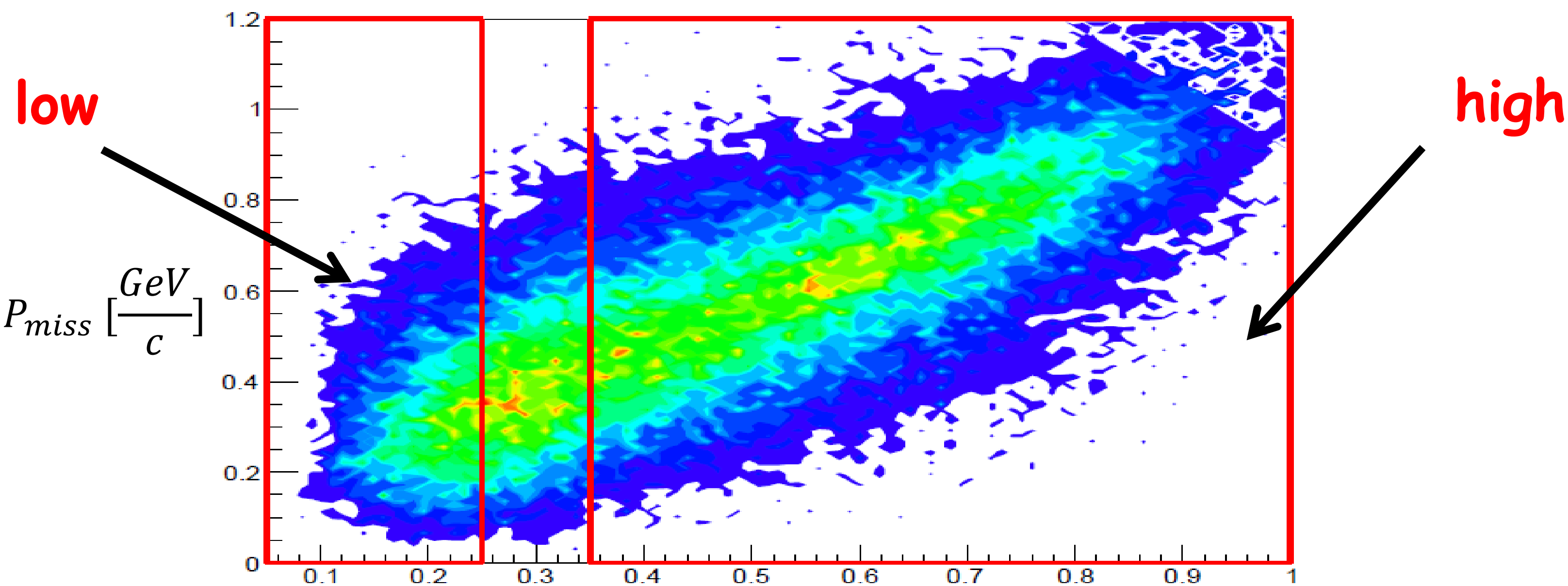
will be used later

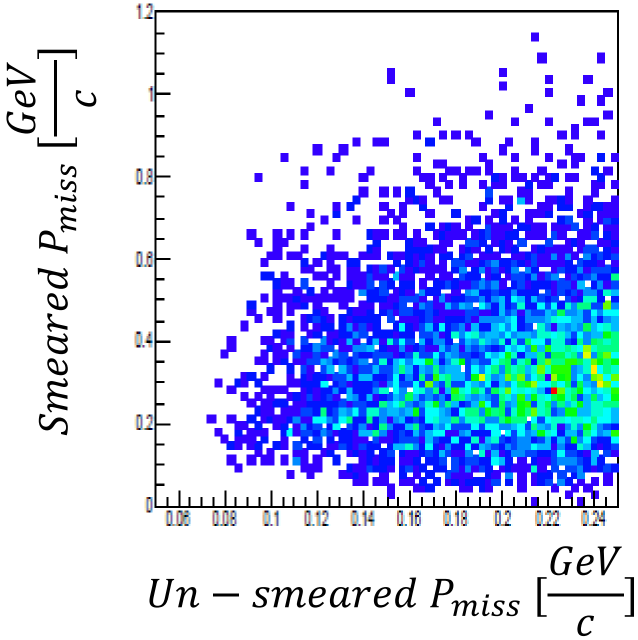
[2] W. P. Ford, S. Jeschonnek and J. W. Van Orden, arXiv:1411.3306v1 [nucl-th] (2014)

Smeared P_{miss} vs. un-smeared

$^{12}C(e,e'p)$ & $^{12}C(e,e'p_{smeared})$

- $-0.1 < y < 0.3$
- $\theta_{pq} < 8^o$
- $0.9 < \omega < 2.1\ GeV$
- $1.2 < Q^2 < 3.7\ GeV^2/c^2$
- $\beta < 0.95$
- EC fiducial cut
- $|\vec{p}| < 2.34\ GeV/c$

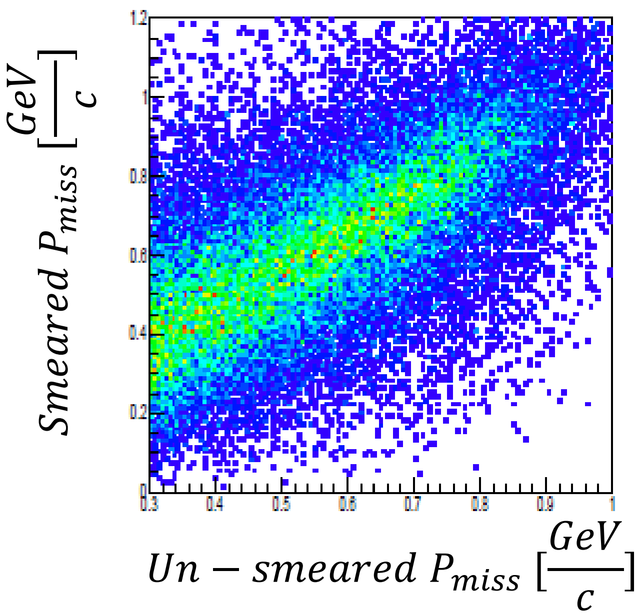




Low (lost events)

$0 < P_{miss} < 0.25\ GeV/c$

$$\eta_{low} = \frac{\#(e,e'p)_{smeared}}{\#(e,e'p)}\Bigg|_{P_{miss}<0.25} = 0.63 \pm 0.01$$



High (gain events)

$0.35 < P_{miss} < 1\ GeV/c$

$$\eta_{high} = \frac{\#(e,e'p)_{smeared}}{\#(e,e'p)}\Bigg|_{0.35<P_{miss}<1} = 1.17 \pm 0.02$$

Back to neutrons

Calculating different ratios for ^{12}C:

low

$$\left.\frac{^{12}C(e,e'p)/\sigma_p}{^{12}C(e,e'n)/\sigma_n \cdot \eta_{low}}\right|_{P_{miss}<0.25} = 1.09 \pm 0.12$$

high

$$\left.\frac{^{12}C(e,e'p)/\sigma_p}{^{12}C(e,e'n)/\sigma_n \cdot \eta_{high}}\right|_{0.35<P_{miss}<1} = 1.06 \pm 0.14$$

neutrons - low/high

$$R_n = \frac{^{12}C(e,e'n)_{p_{miss}<0.25}/\eta_{low}}{^{12}C(e,e'n)_{0.35<p_{miss}<1}/\eta_{high}} = 9.8 \pm 0.9$$

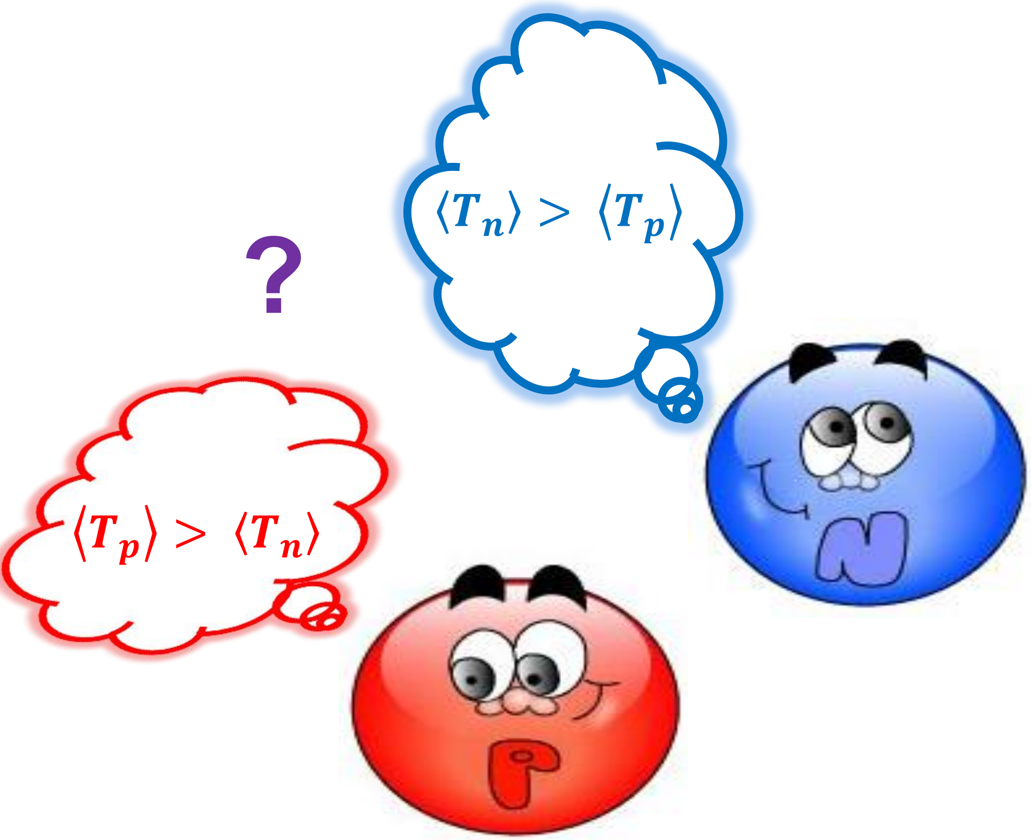
protons - low/high

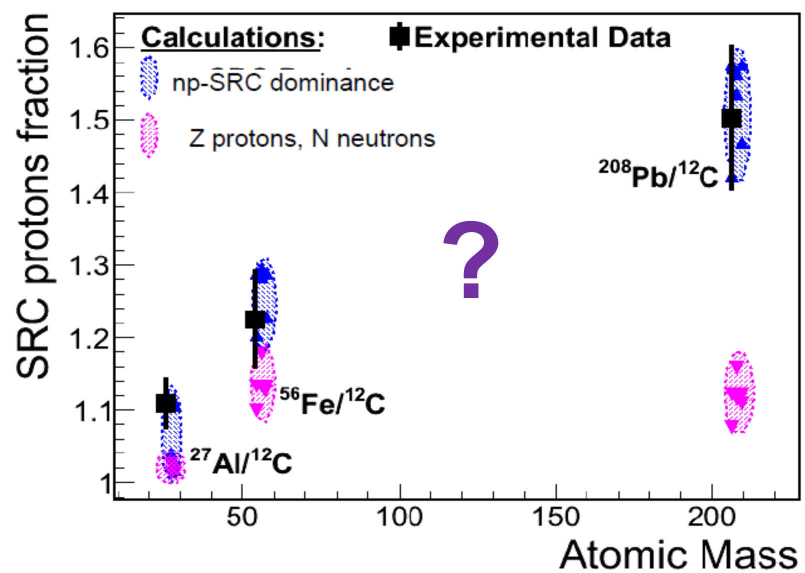
$$R_p = \frac{^{12}C(e,e'p)_{p_{miss}<0.25}}{^{12}C(e,e'p)_{0.35<p_{miss}<1}} = 10.2 \pm 0.4$$

Estimate relative number of high momentum nucleons:

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

and the same for protons.





Future Plans

np- dominance

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

2N – SRC

$(e,e'np_{back})$

3N- SRC

$(e,e'npp)$