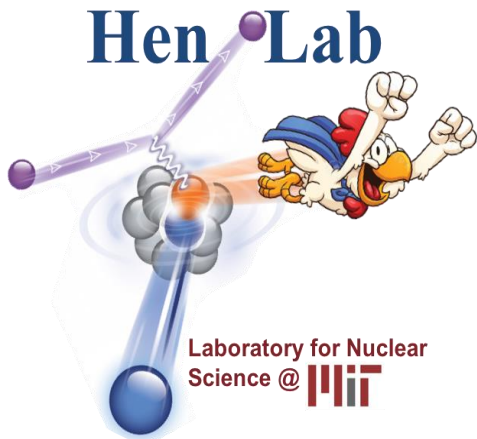


Probing the Core of the Strong Nuclear Interaction

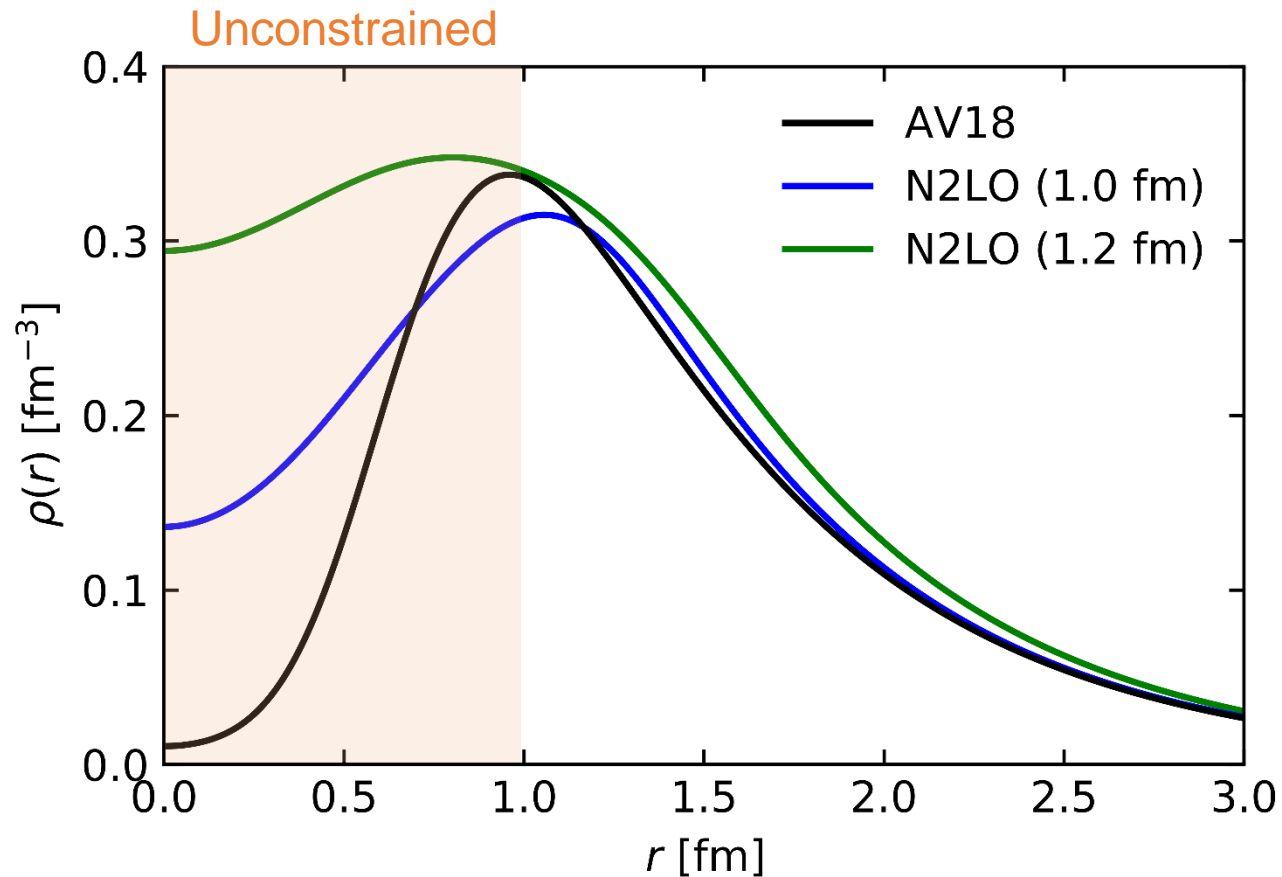
Jackson Pybus

Exploring QCD with Light Nuclei at EIC

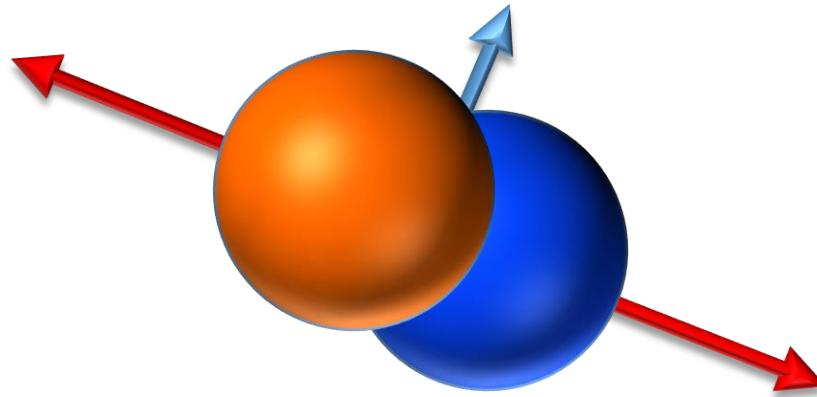
Jan 22, 2020



NN Interaction Model-Dependent at Short Distance or High Momentum

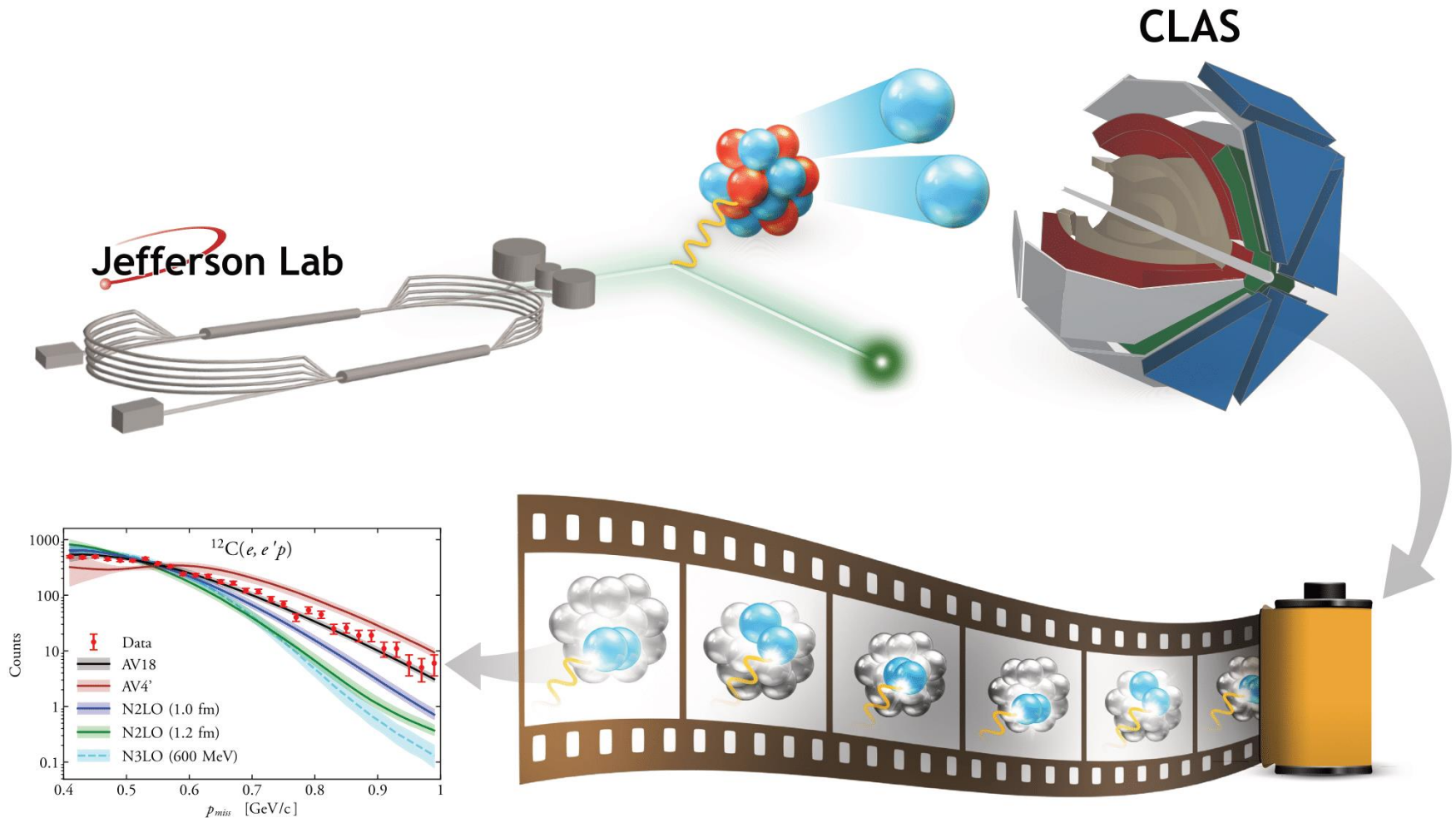


How to measure this behavior?

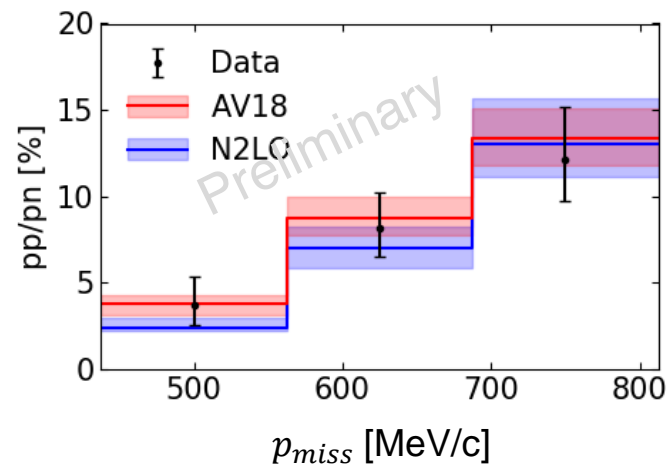
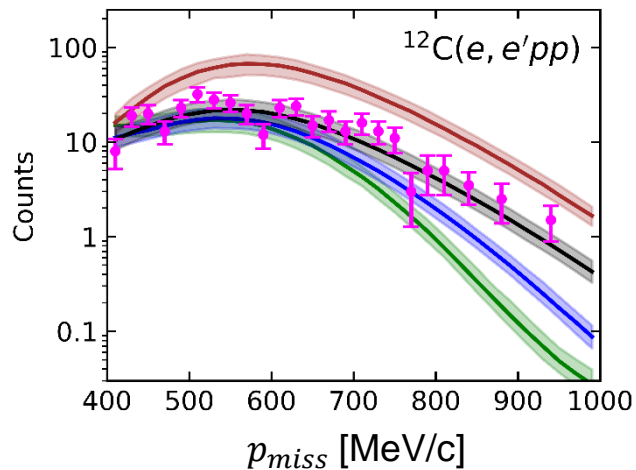
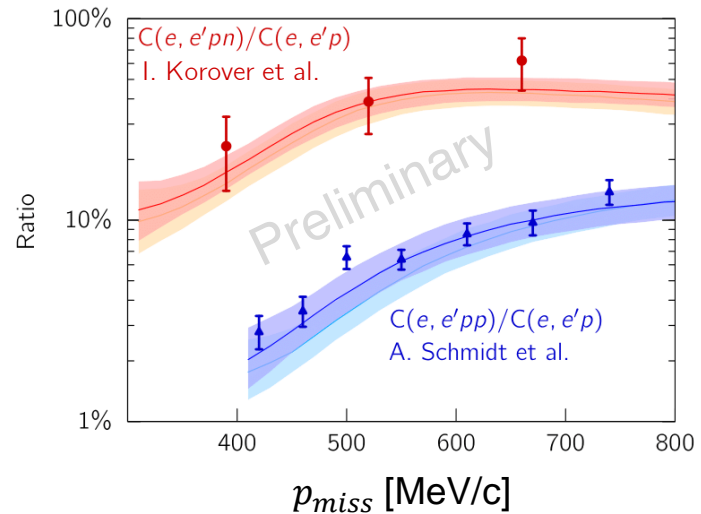
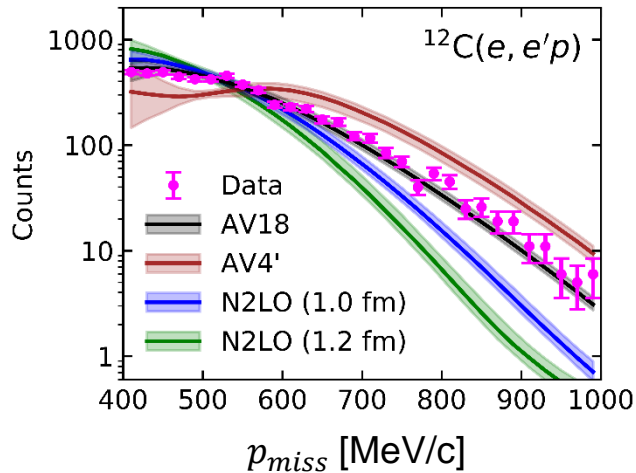


Short Range Correlations

GCF as a Data Analysis Tool



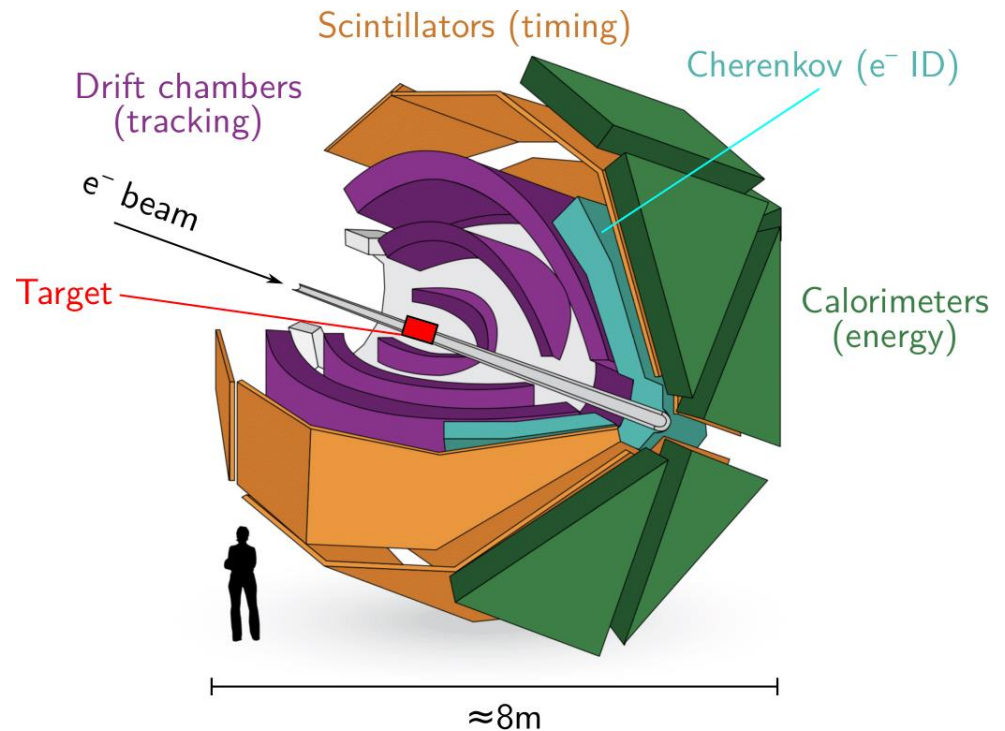
GCF as a Data Analysis Tool



CEBAF Large Acceptance Spectrometer (CLAS)

Data from the CLAS6
EG2 experiment tell us
about the NN interaction

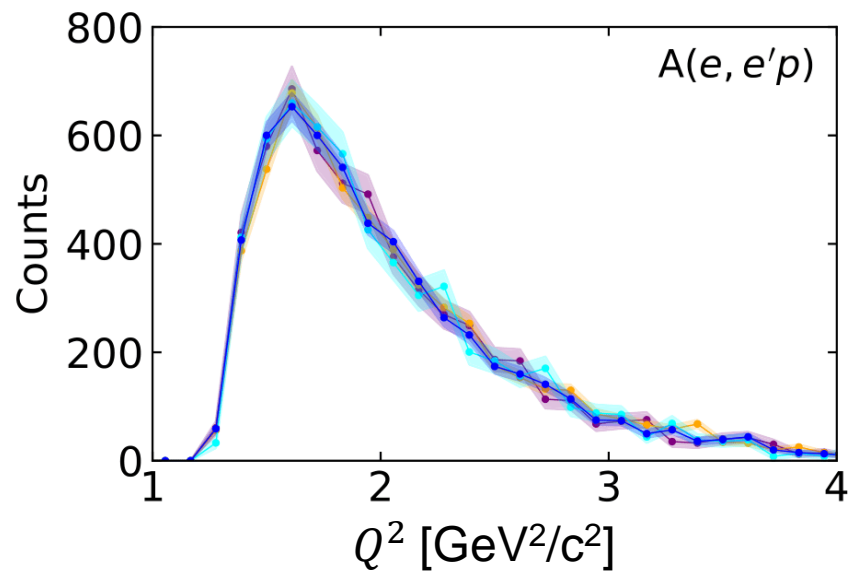
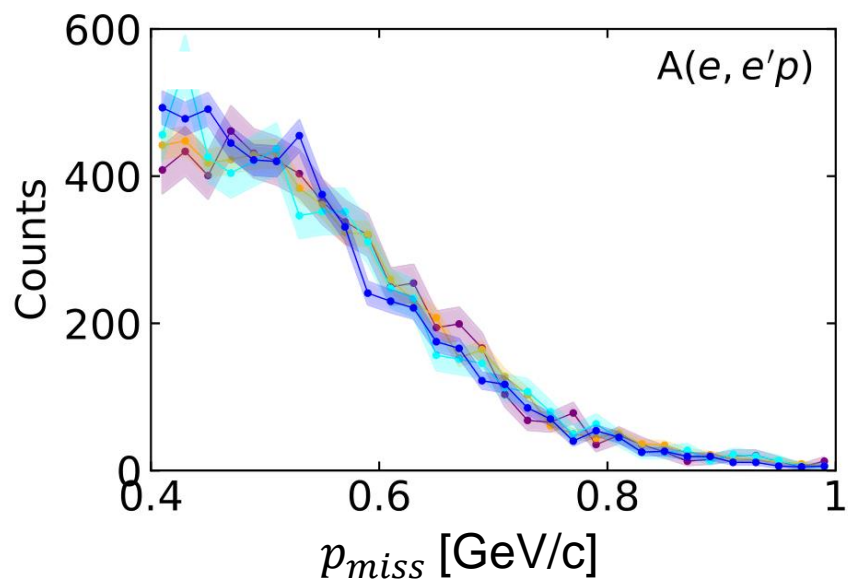
- JLab Hall B
- 5 GeV e^- Beam
- $\sim 10^{34} \text{ cm}^{-2}\text{s}^{-1}$
- C, Al, Fe, Pb Targets
- Open (e, e') Trigger



EG2 Data

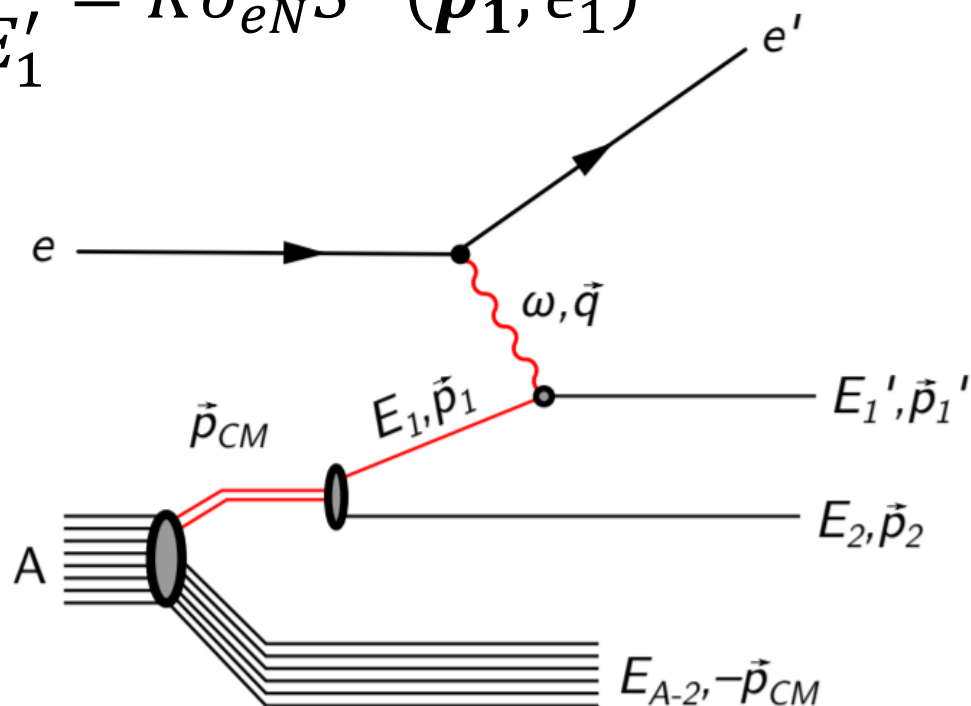
- $^{12}\text{C}(e, e'p)$ and $^{12}\text{C}(e, e'pp)$
- Kinematical cuts select SRC breakup:
 - $x_B > 1.2$
 - $\theta_{ppq} < 25^\circ$
 - $0.62 < \frac{|p_p|}{|q|} < 0.96$
 - $M_{miss} < 1.1 \text{ GeV}$
 - $0.4 < |\mathbf{p}_{miss}| < 1.0 \text{ GeV}/c$

EG2 Kinematics



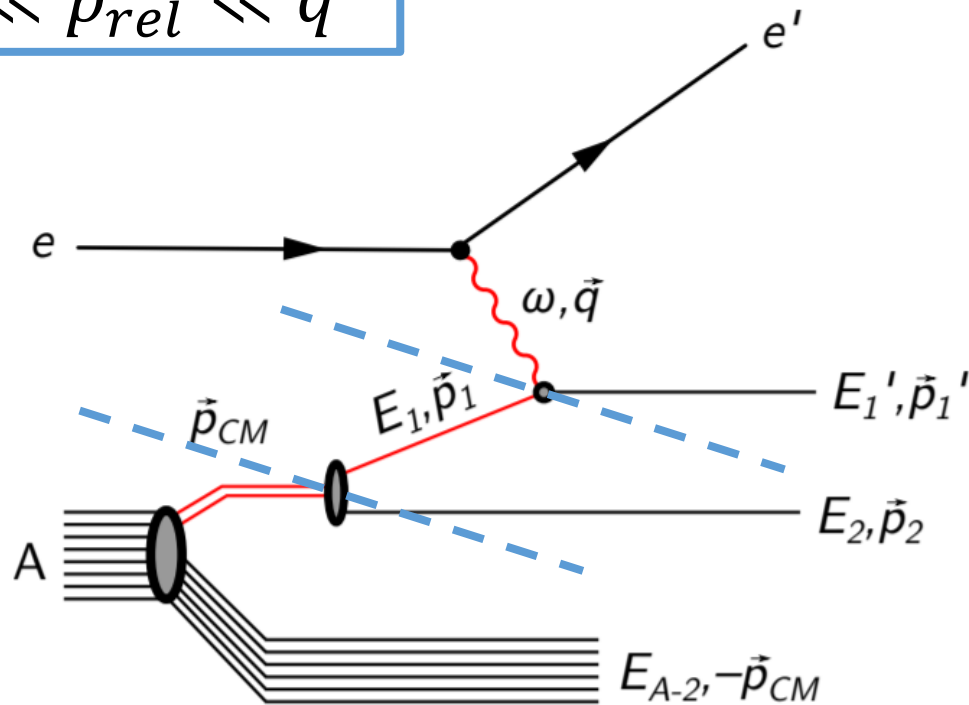
PWIA SRC Breakup

$$\frac{d^6\sigma}{d\Omega_k dE_k d\Omega_{p'_1} dE'_1} = K\sigma_{eN}S^N(\mathbf{p}_1, \epsilon_1)$$



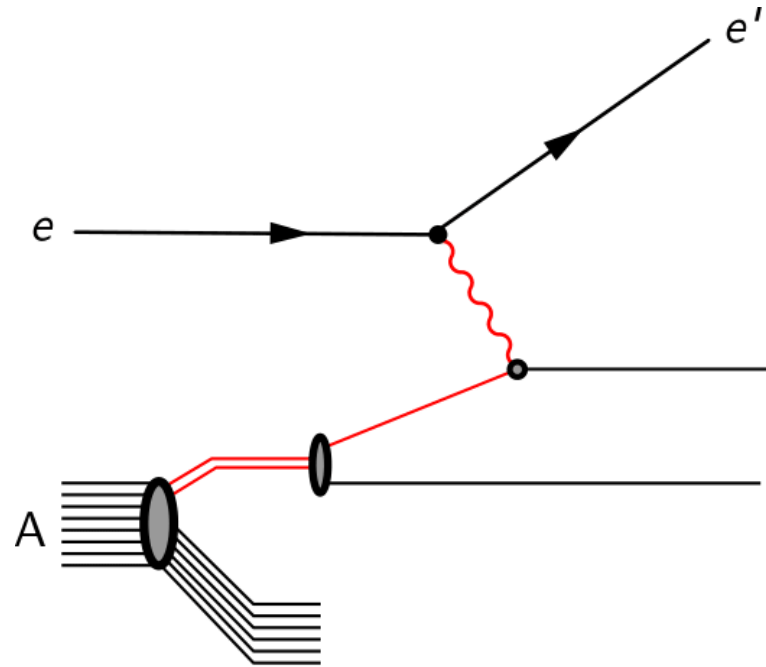
PWIA SRC Breakup: Generalized Contact Formalism

$$p_{CM} \ll p_{rel} \ll q$$



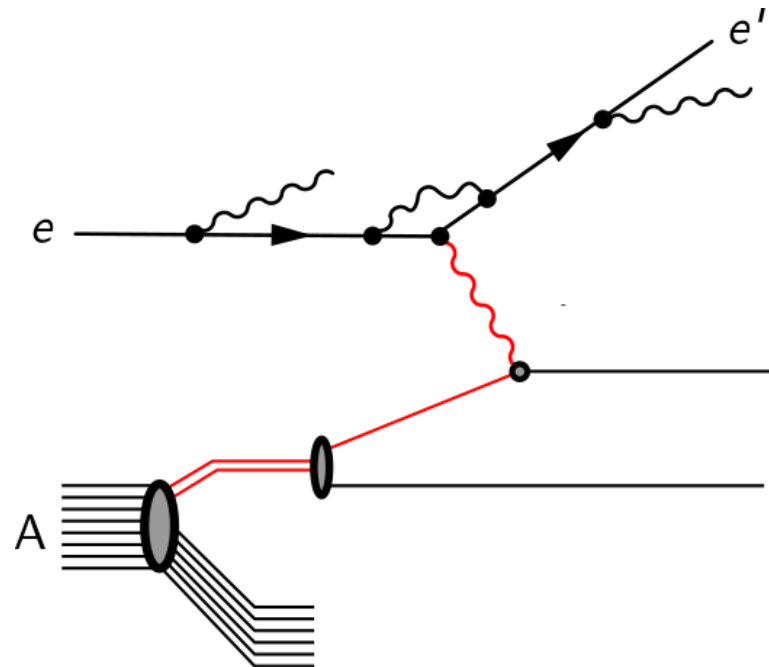
Data-Model Comparisons

1. Generate plane-wave events



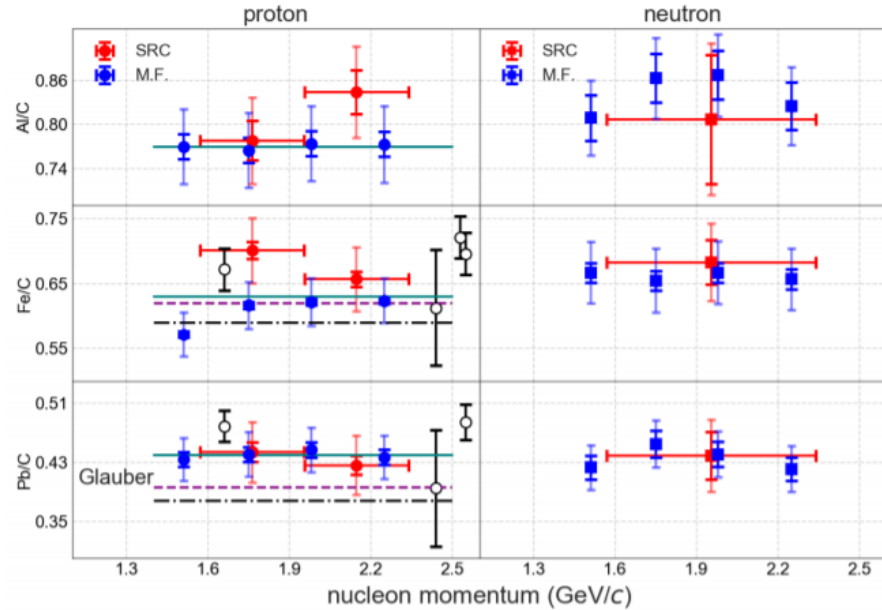
Data-Model Comparisons

1. Generate plane-wave events
2. Radiation



Data-Model Comparisons

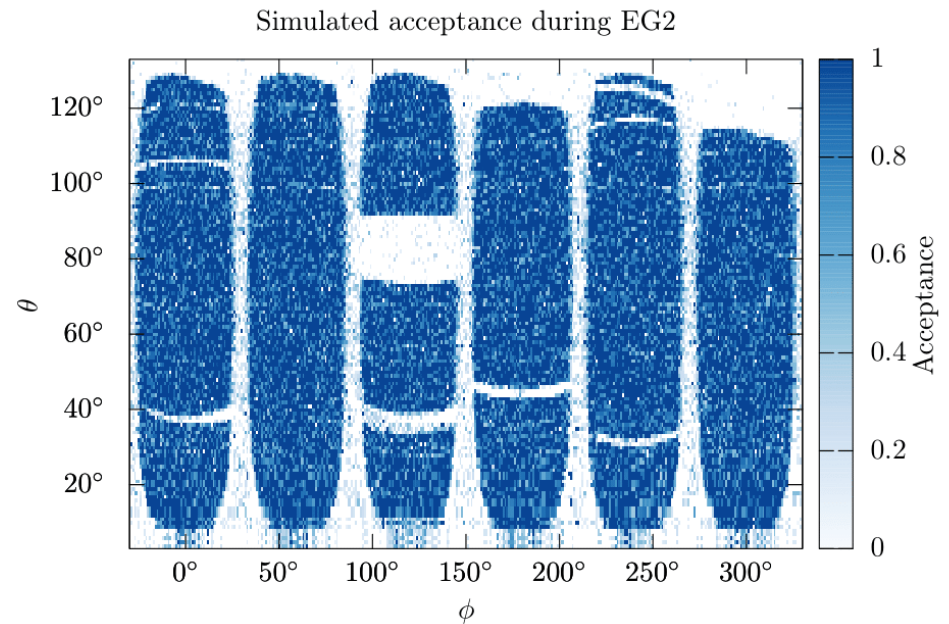
1. Generate plane-wave events
2. Radiation
3. Transparency + SCX (Glauber)



$$\begin{aligned} \sigma_{A(e,e'pp)}^{Exp} = & \sigma_{A(e,e'pp)}^{GCF} \cdot P_A^{pp} \cdot T_A^{NN} \\ & + \sigma_{A(e,e'np)}^{GCF} \cdot P_A^{[n]p} \cdot T_A^{NN} \\ & + \sigma_{A(e,e'pn)}^{GCF} \cdot P_A^{p[n]} \cdot T_A^{NN} \end{aligned}$$

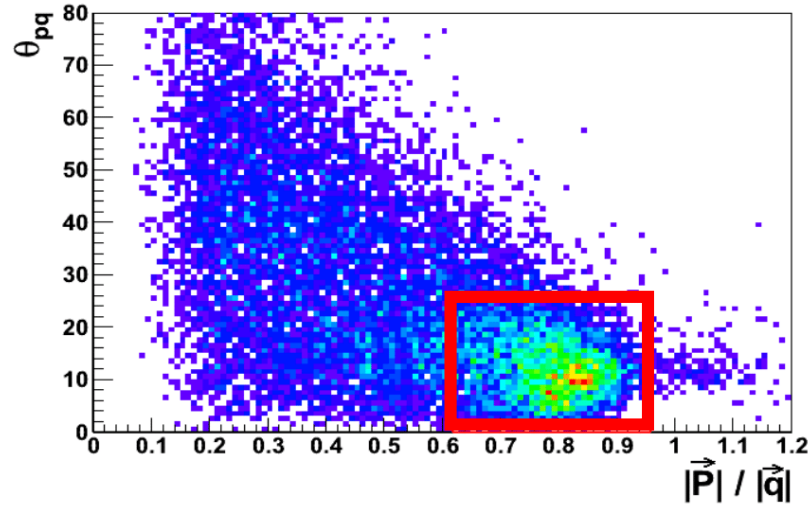
Data-Model Comparisons

1. Generate plane-wave events
2. Radiation
3. Transparency + SCX (Glauber)
4. Detector Effects



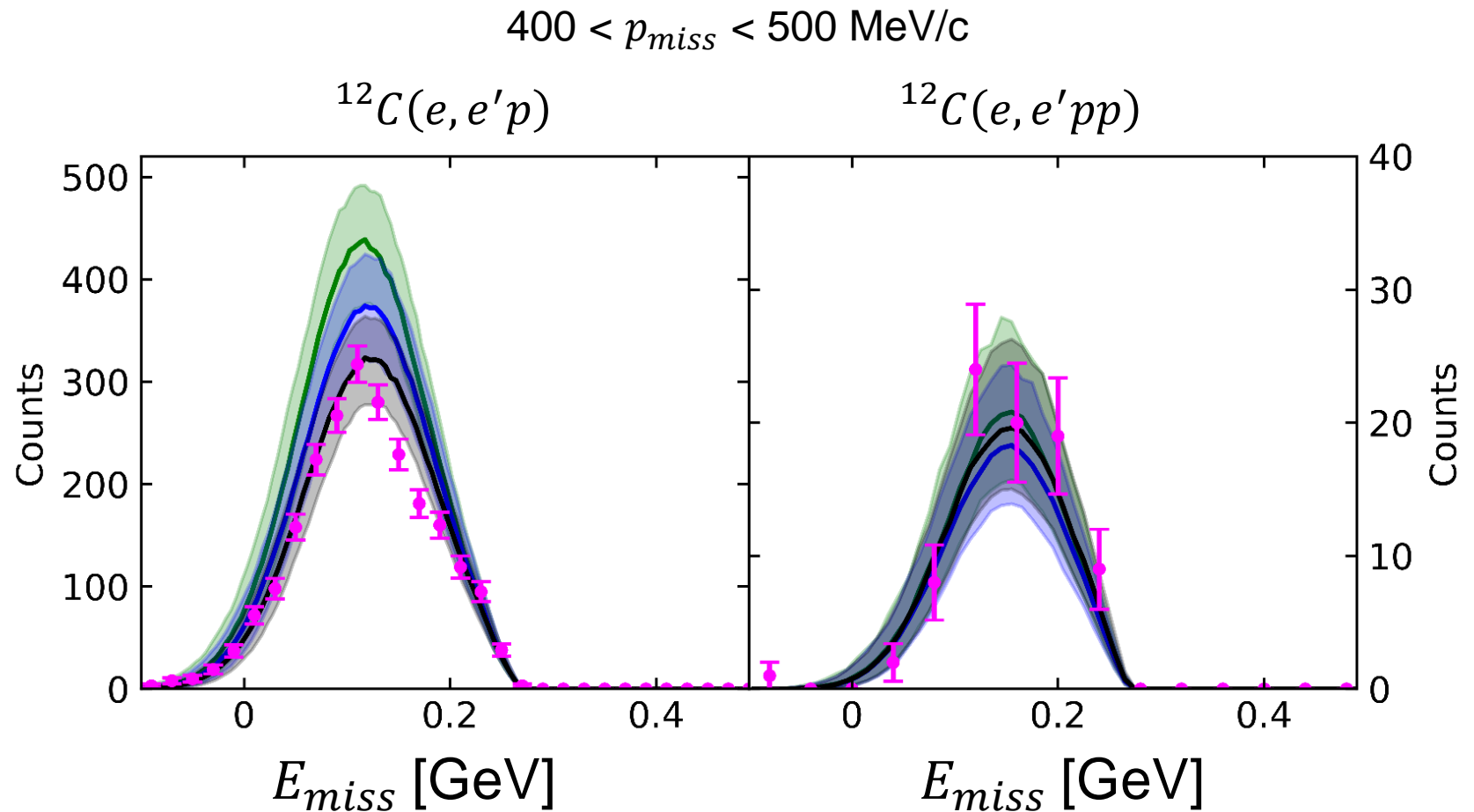
Data-Model Comparisons

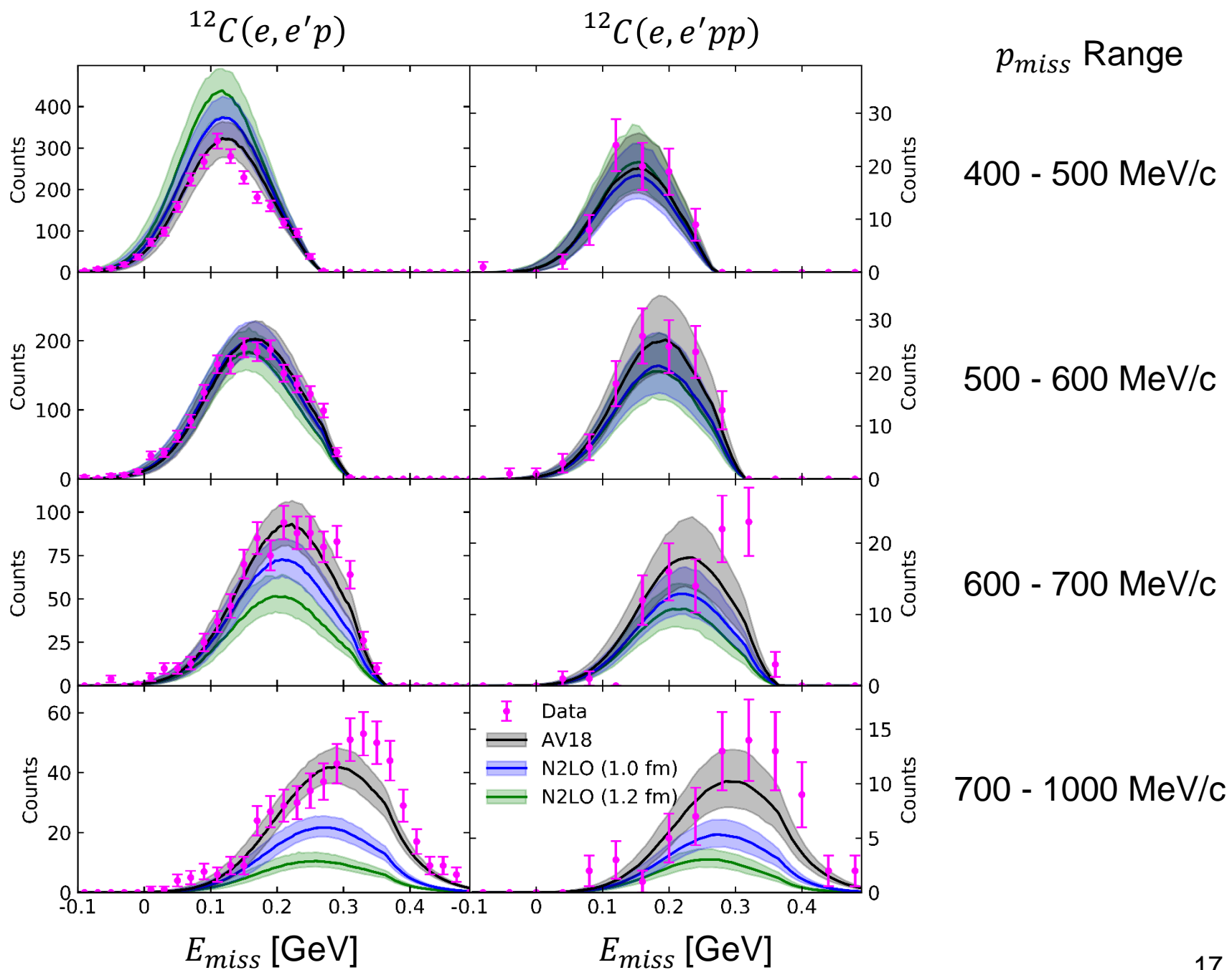
1. Generate plane-wave events
2. Radiation
3. Transparency + SCX (Glauber)
4. Detector Effects
5. Event Selection Cuts



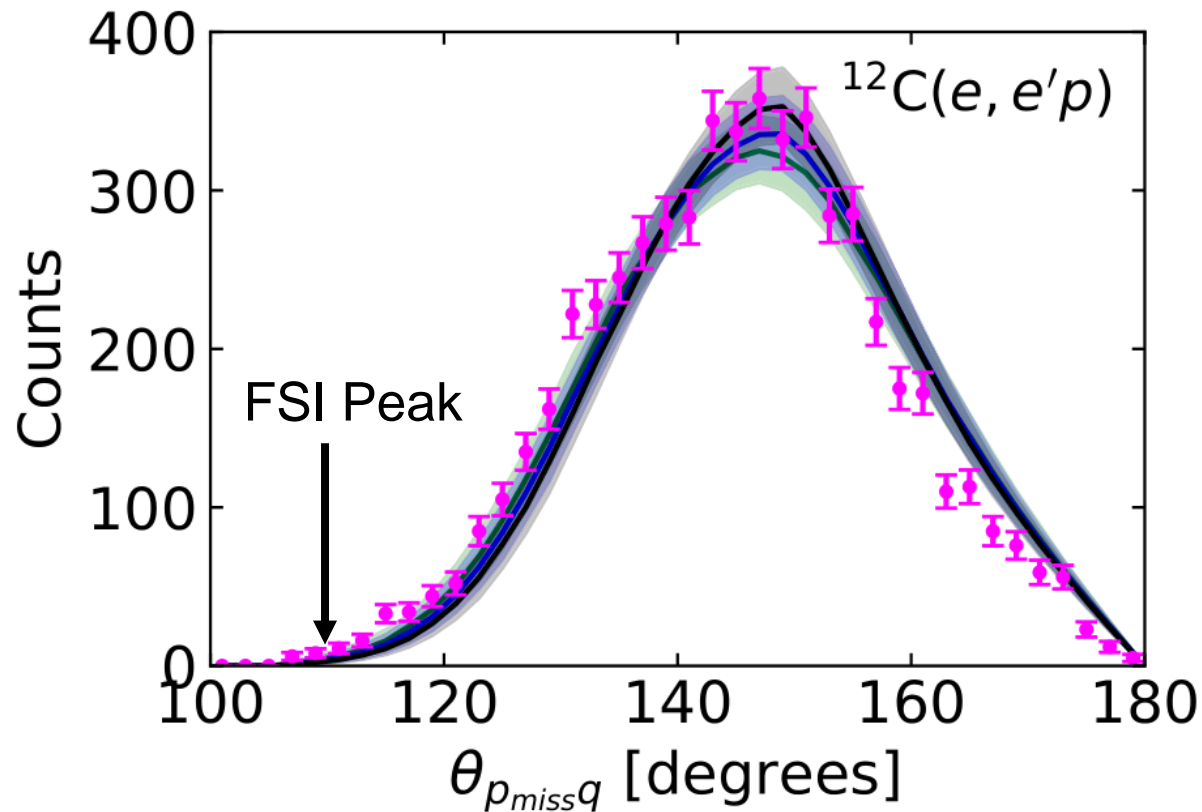
$$\begin{aligned}x_B &> 1.2 \\ \theta_{pq} &< 25^\circ \\ 0.62 &< \frac{|p_p|}{|q|} < 0.96 \\ M_{miss} &< 1.1 \text{ GeV} \\ 0.4 &< |\mathbf{p}_{miss}| < 1.0 \text{ GeV}/c\end{aligned}$$

Missing momentum and energy well-described



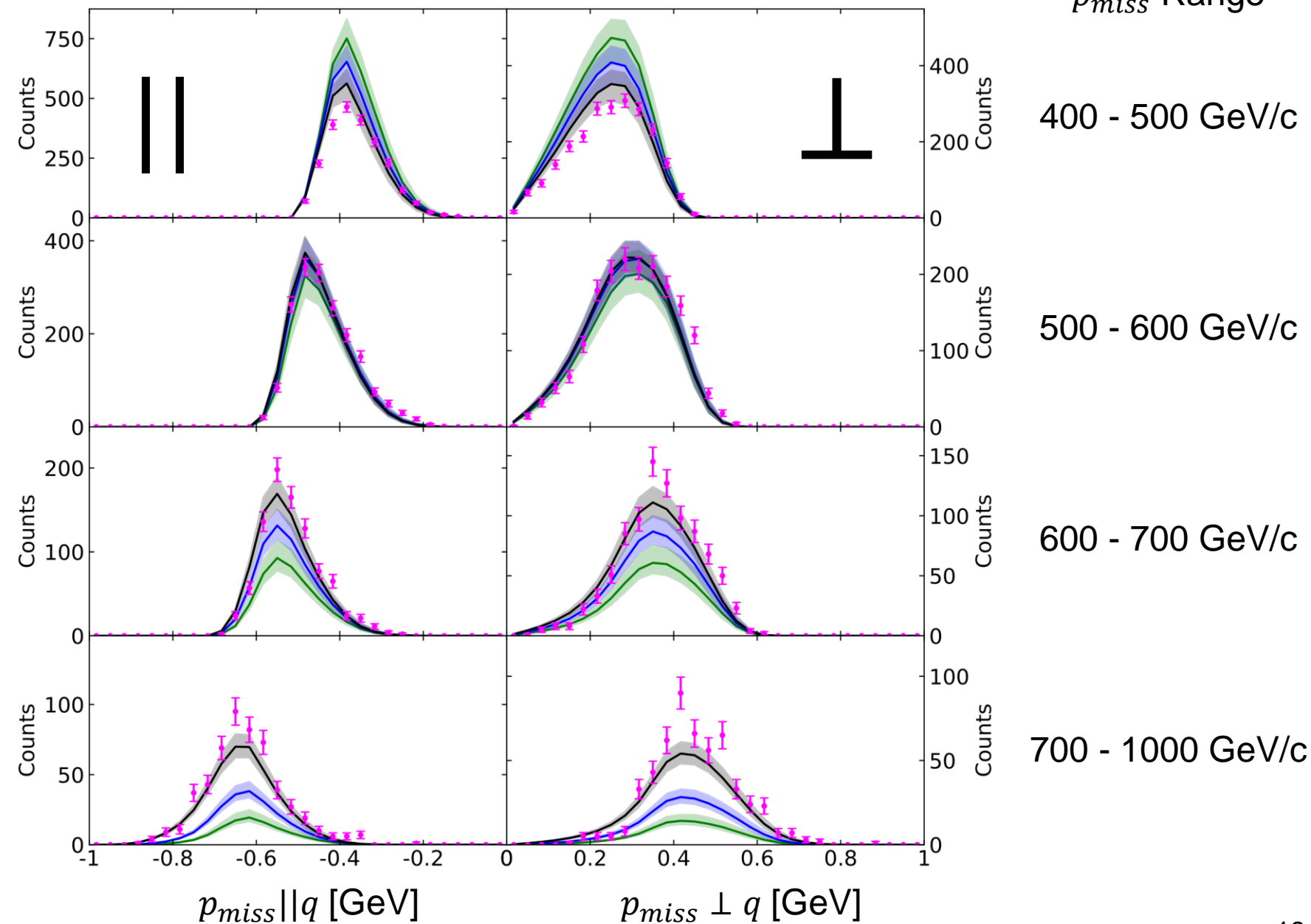


No Evidence of FSI Distortion

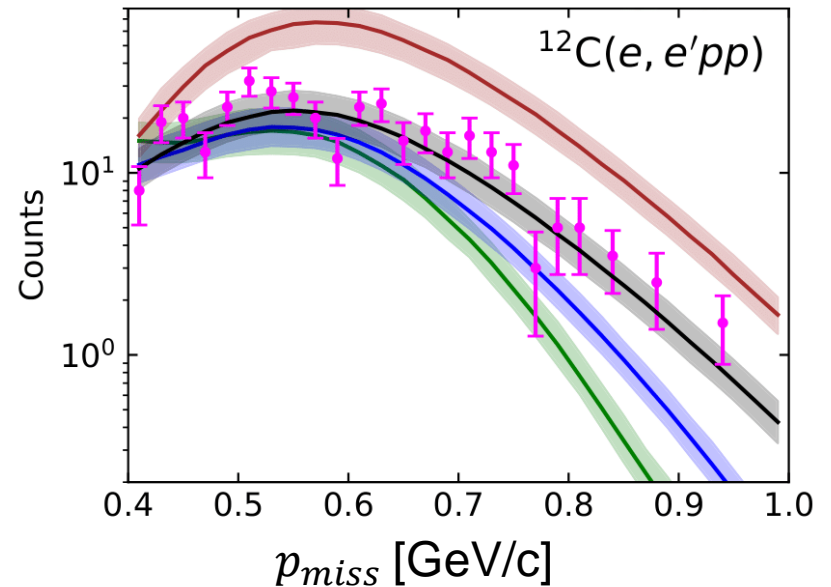
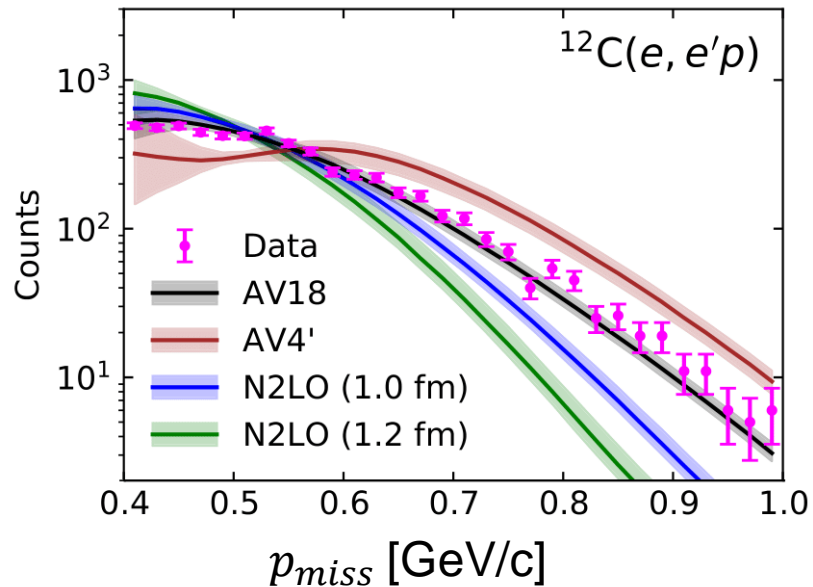


p_{miss} components with respect to q

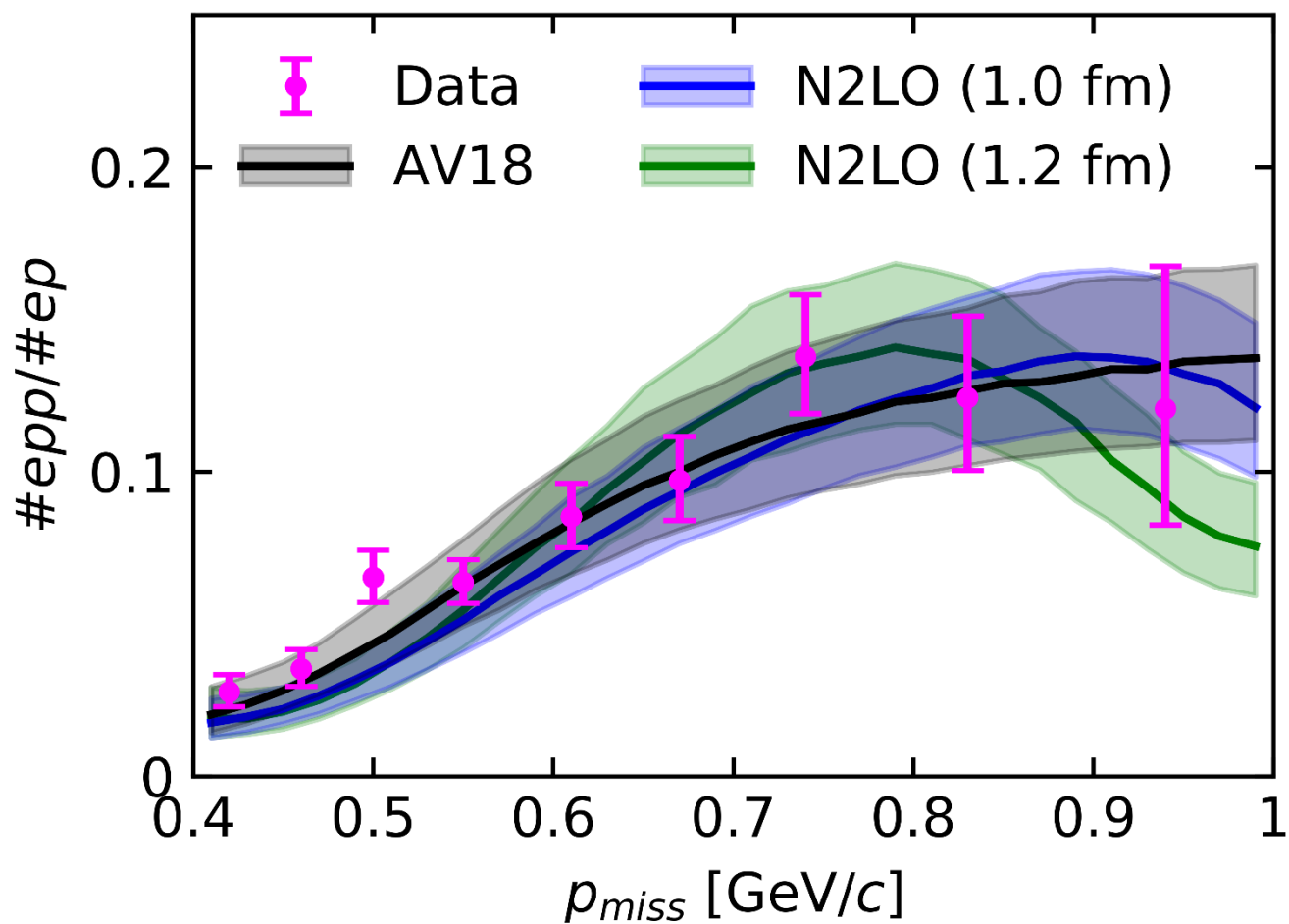
p_{miss} Range



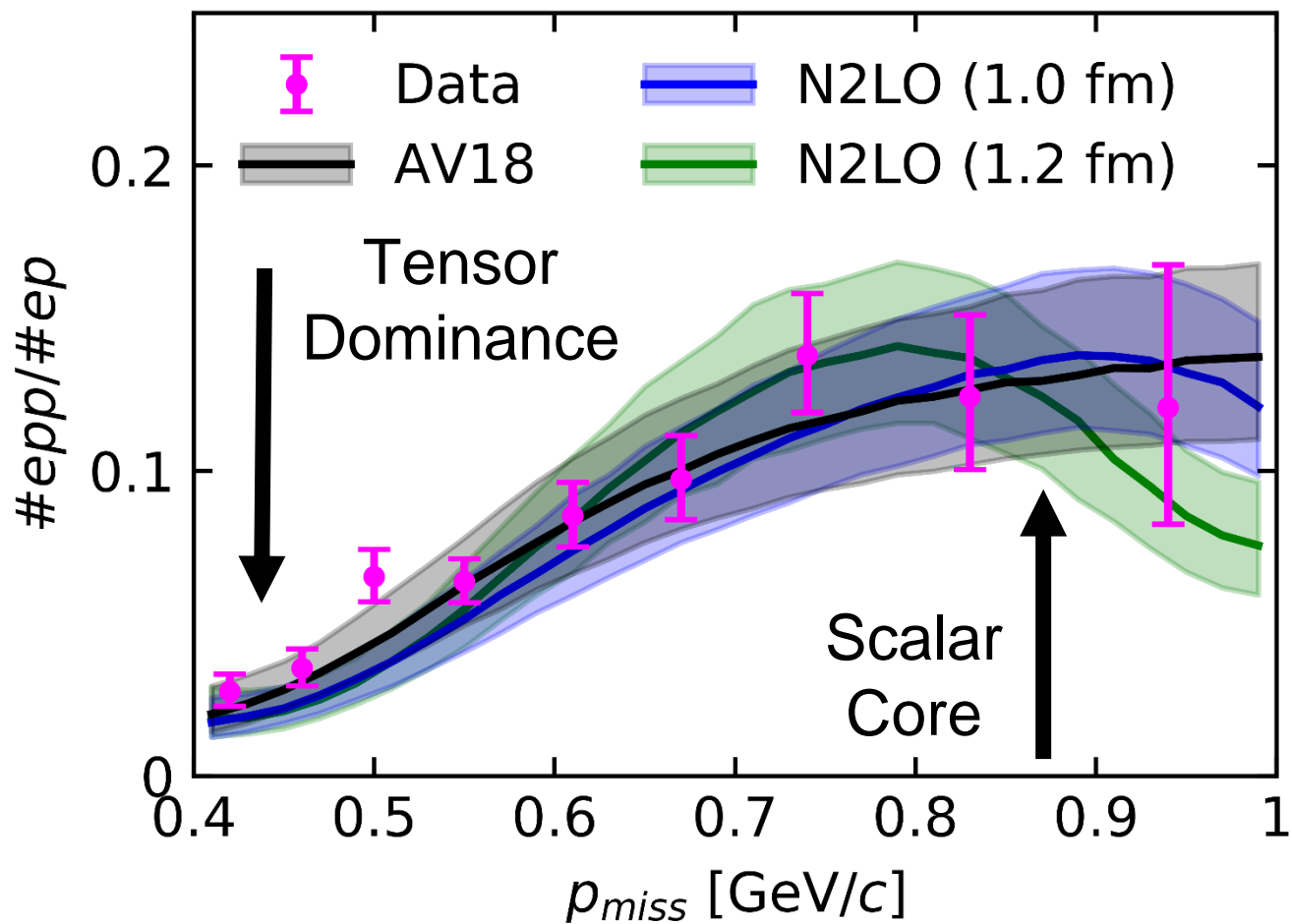
Missing Momentum Sensitive to NN Interaction



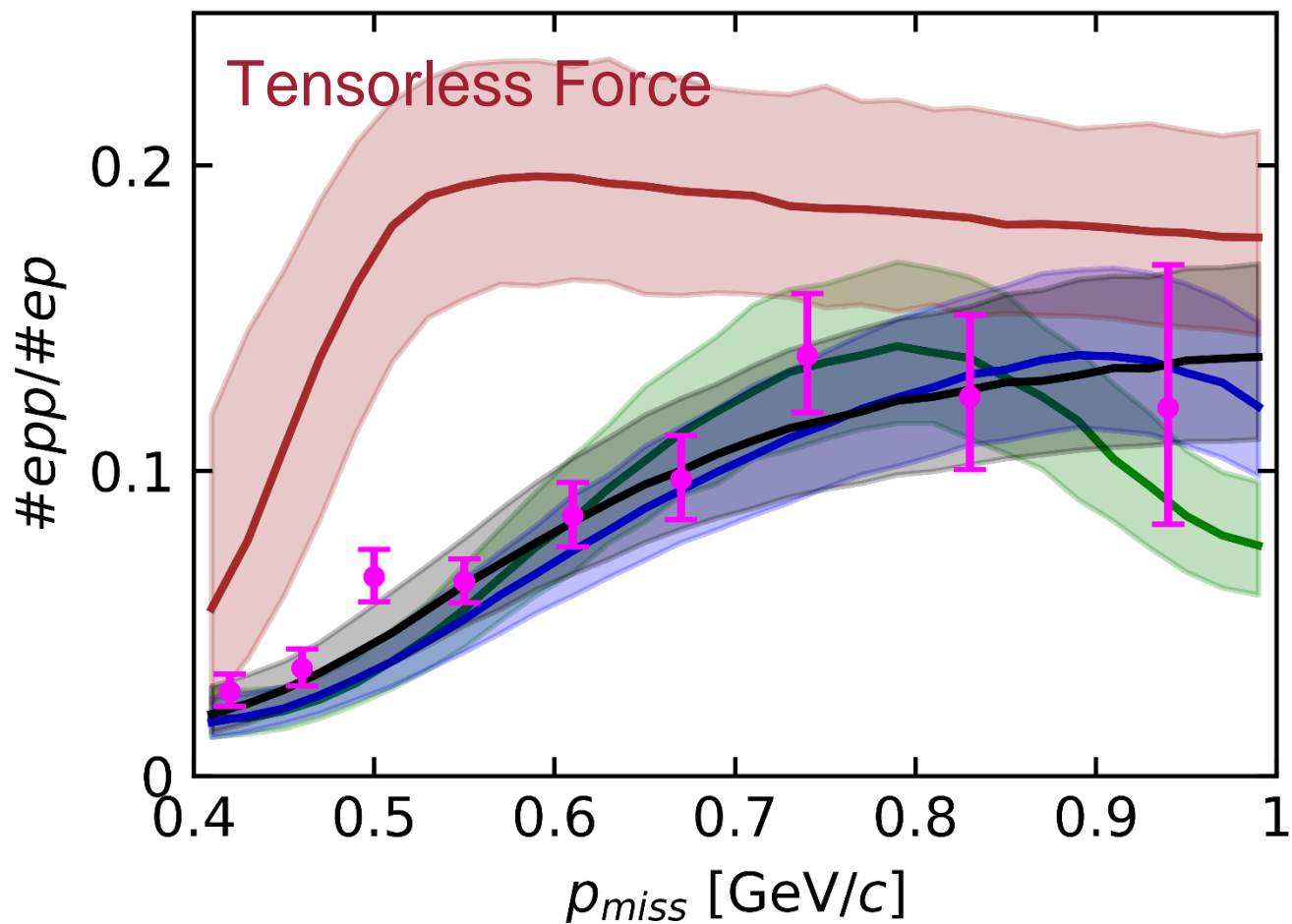
Tensor to Scalar Transition



Tensor to Scalar Transition



Tensor to Scalar Transition



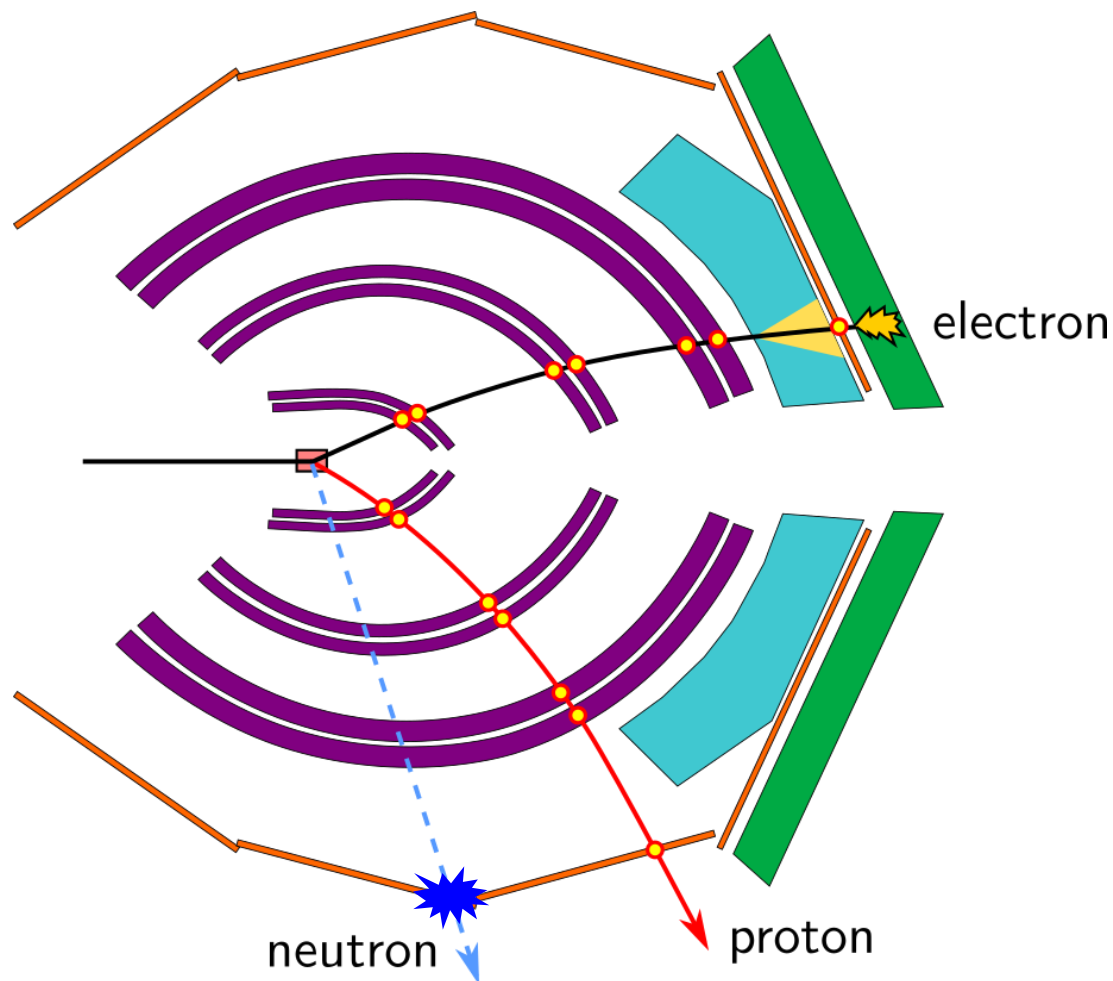
This isn't the complete picture

Proton-only analysis has limitations:

- Many $(e, e'pp)$ result from np -SCX
- GCF assumes SRC dominance

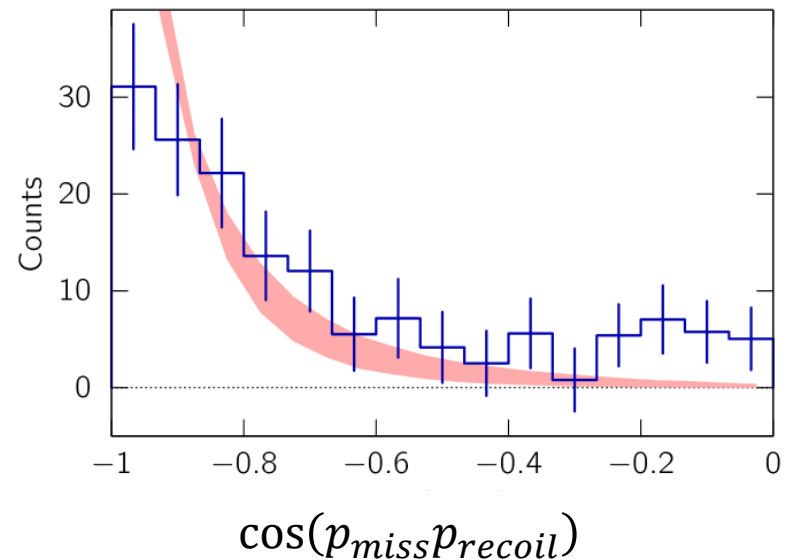
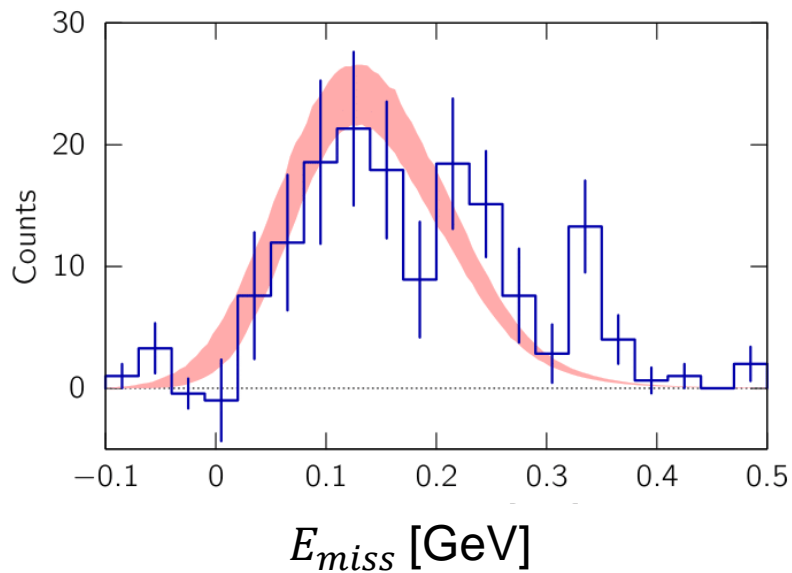
Need to look at neutrons!

Recoil Neutron Detection

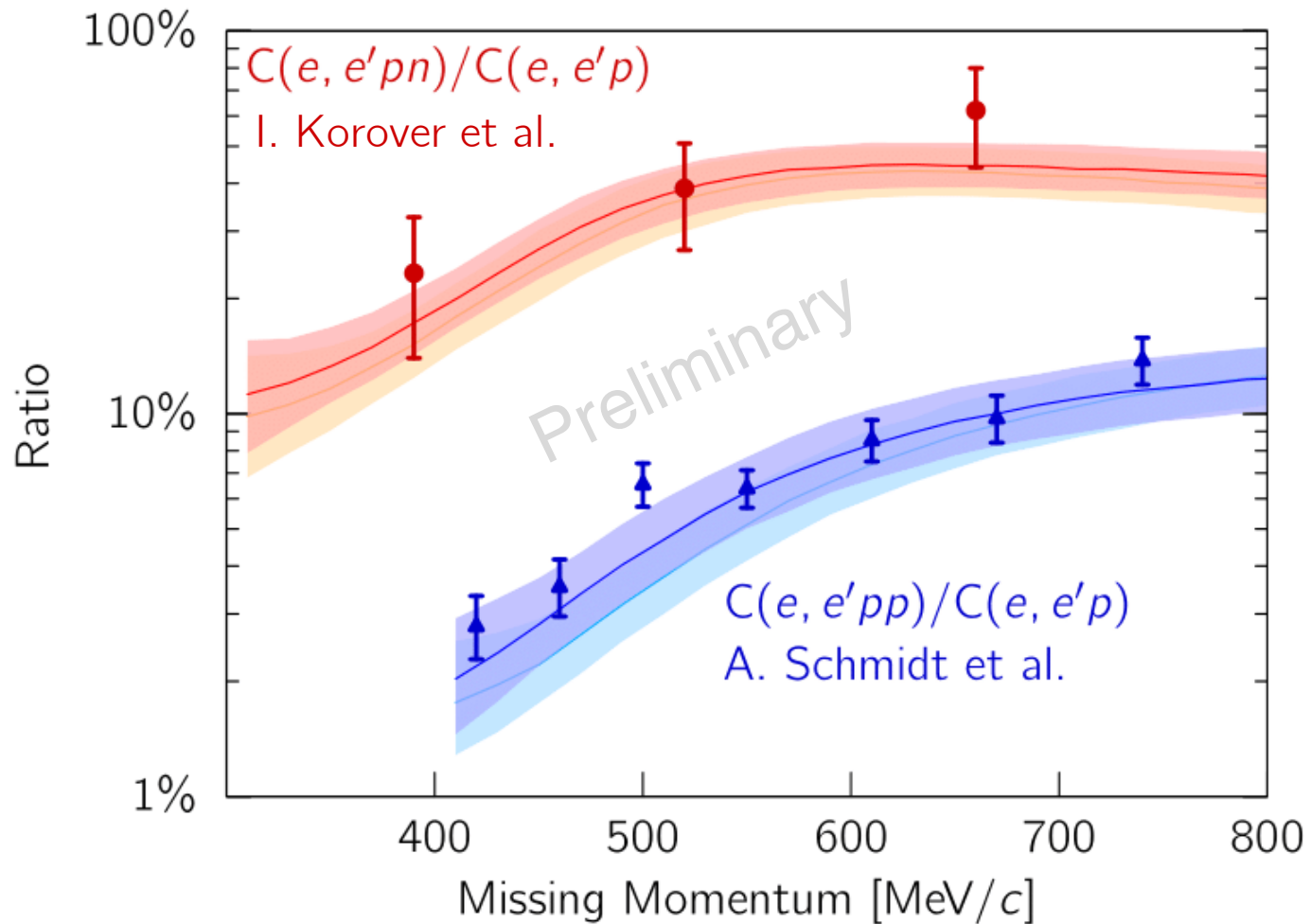


What about neutrons?

$$^{12}\text{C}(e, e'pn)$$

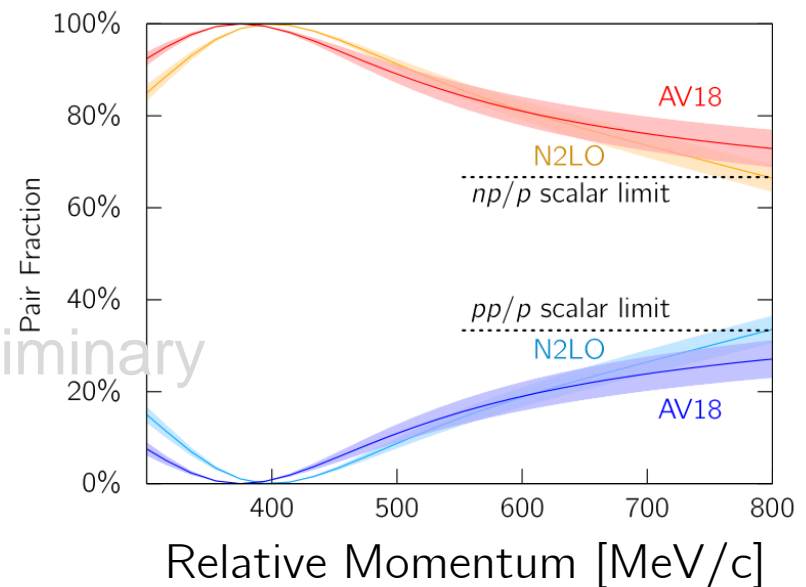
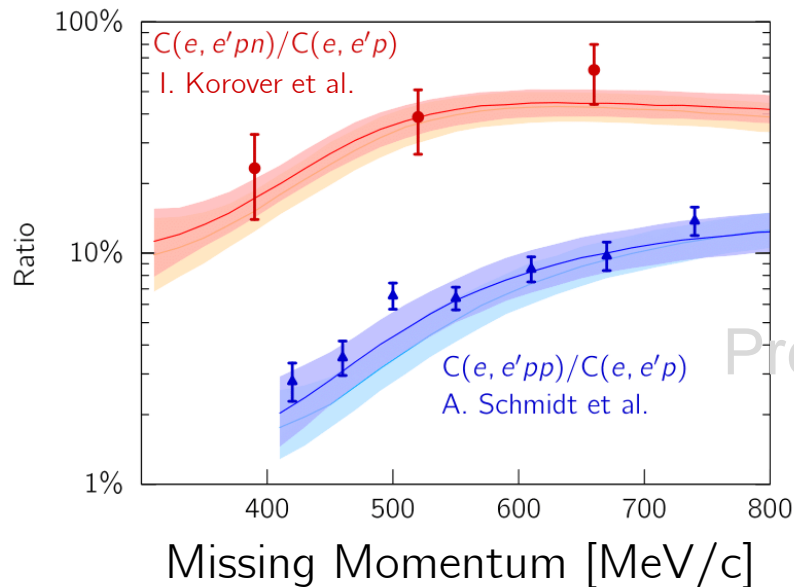


What about **neutrons**?



All high-momentum nucleons are paired!

Data \longleftrightarrow Theory



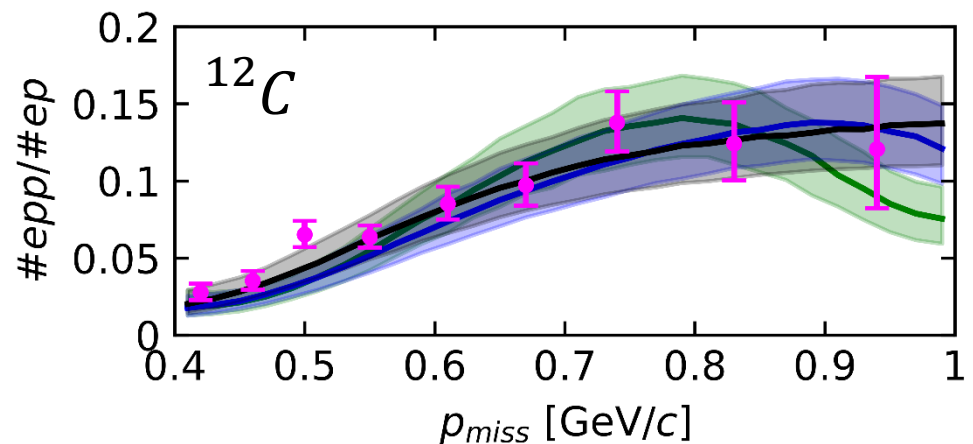
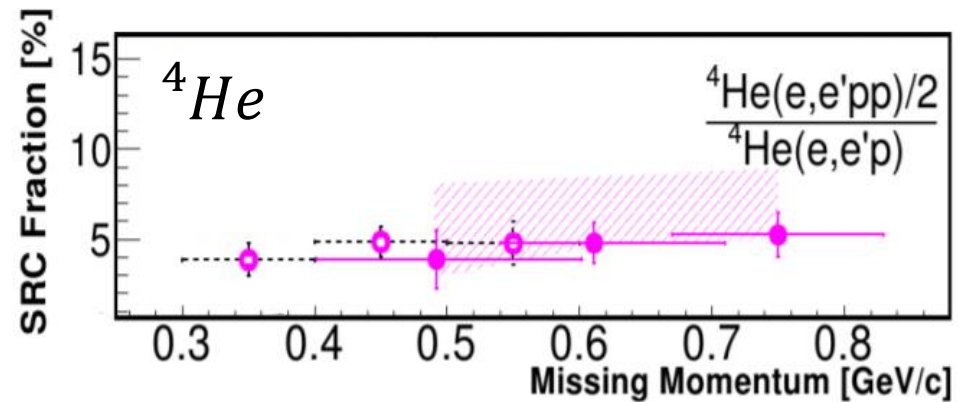
... in our kinematics, within uncertainties

Revisiting Previous Work

Hall A pp/p fraction flat

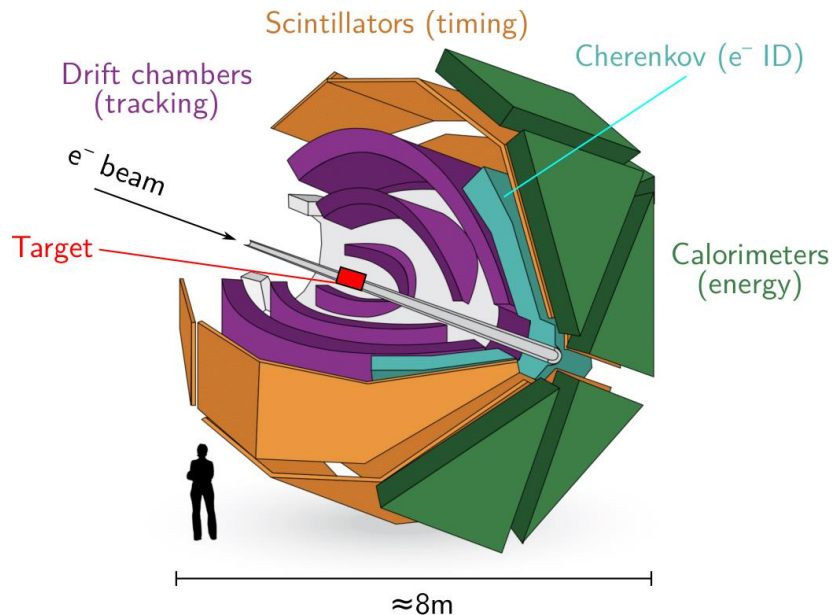
Hall B pp/p fraction rises

Is this a difference in phase space, physics, or statistics?

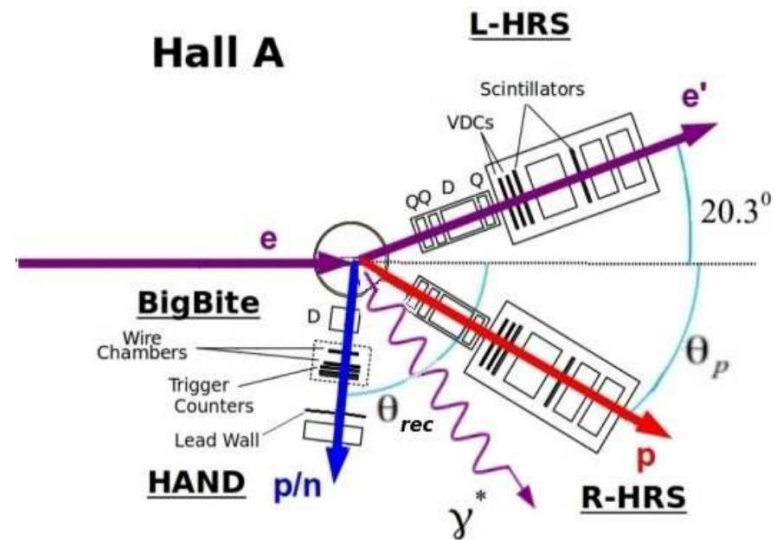


Different Experimental Setups

$$^{12}\text{C}(e, e'pN)$$

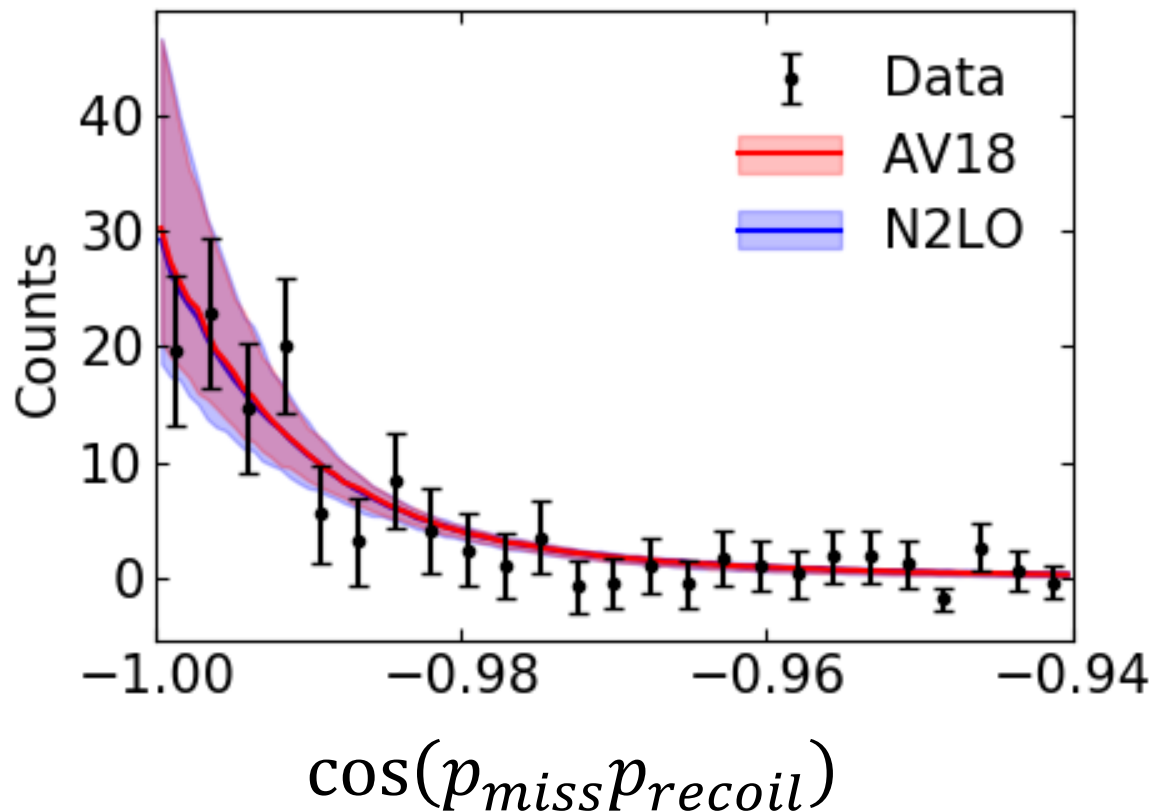


$$^4\text{He}(e, e'pN)$$



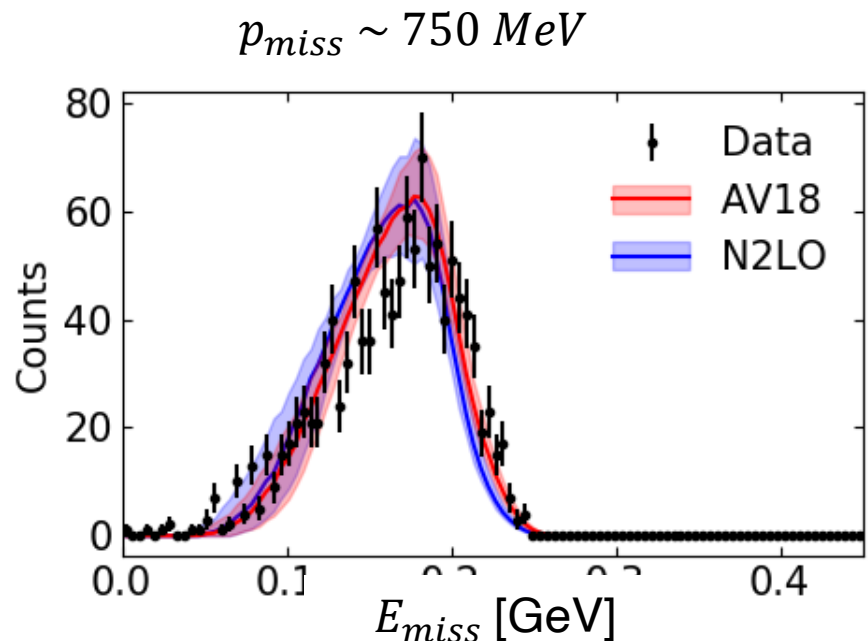
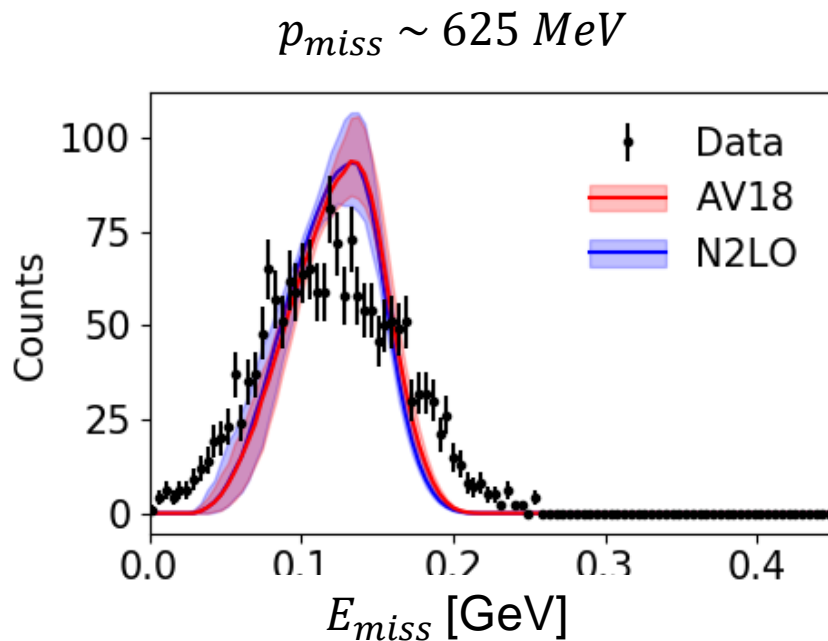
Good Kinematic Agreement with GCF Model

$${}^4\text{He}(e, e'pn)$$

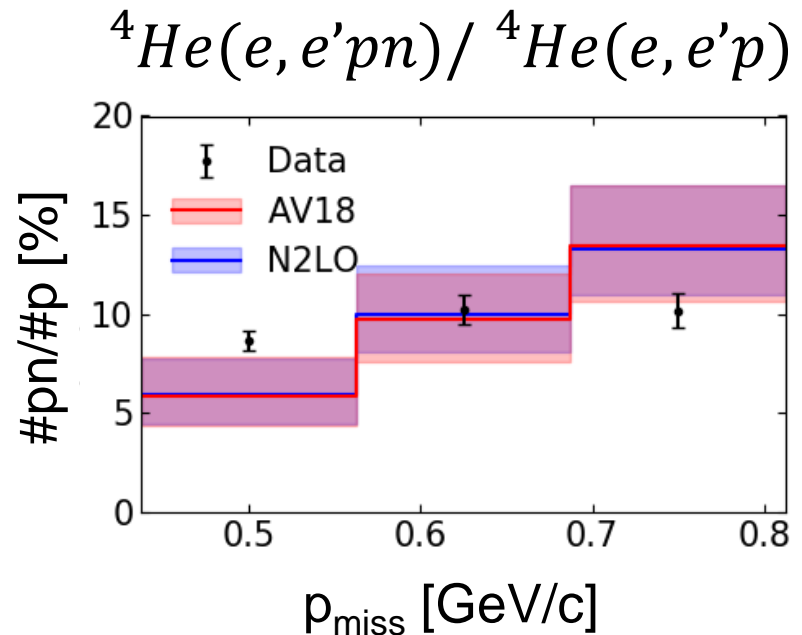
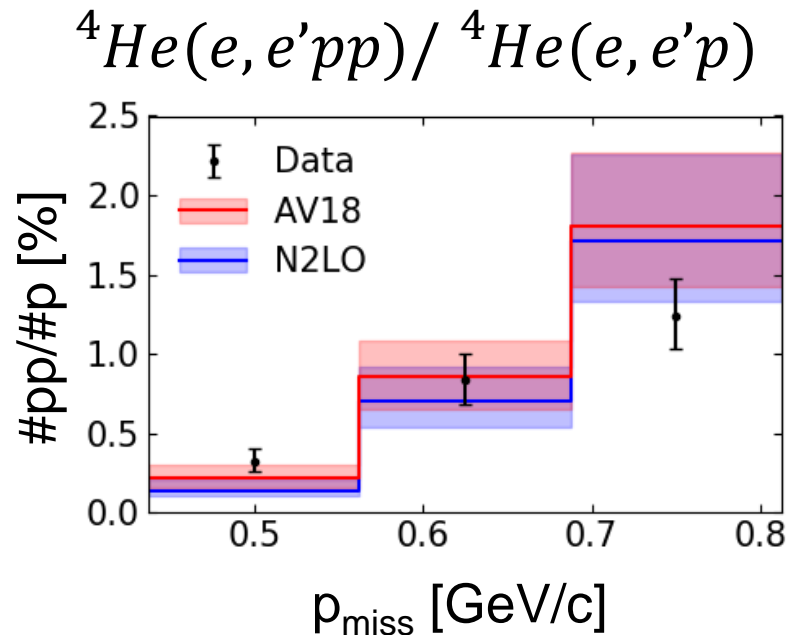


Good Kinematic Agreement with GCF Model

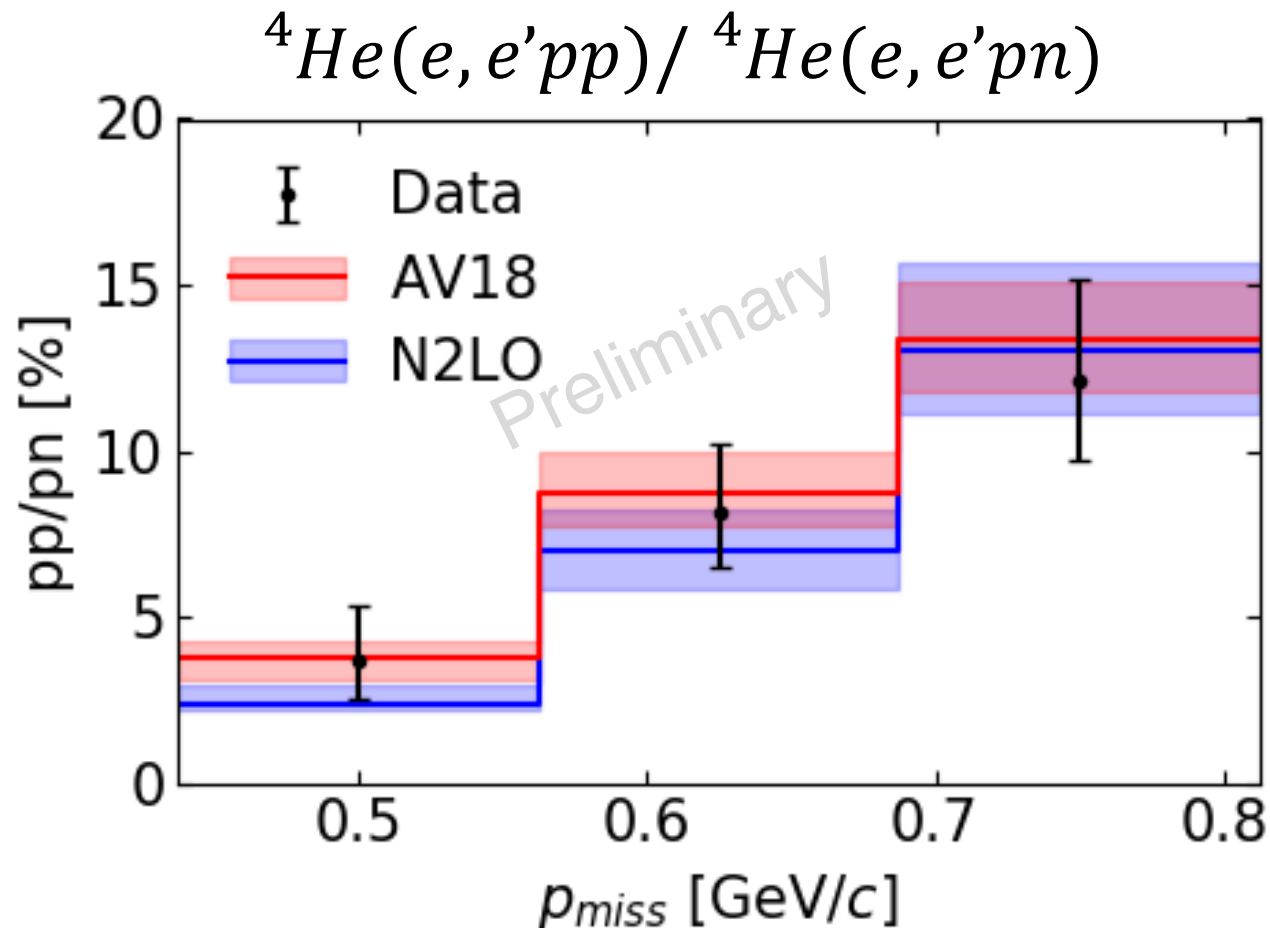
$${}^4\text{He}(e, e'p)$$



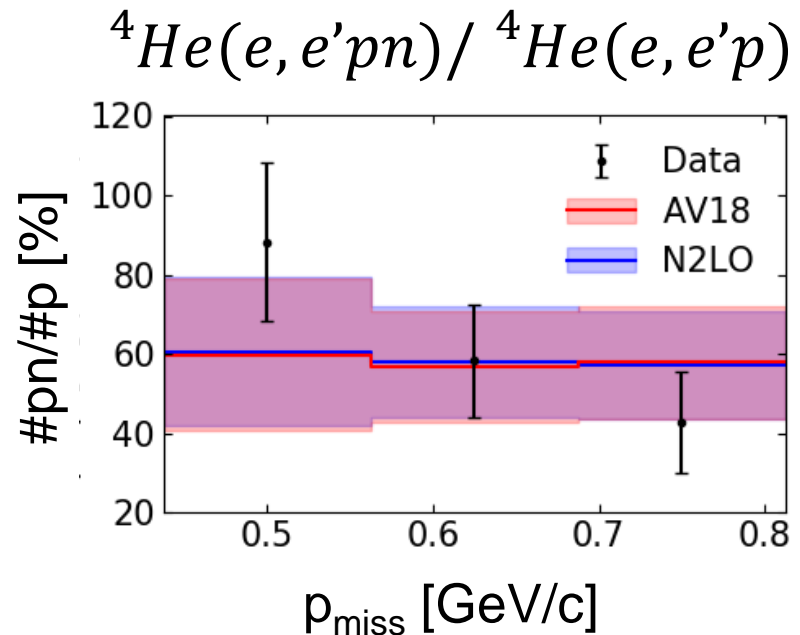
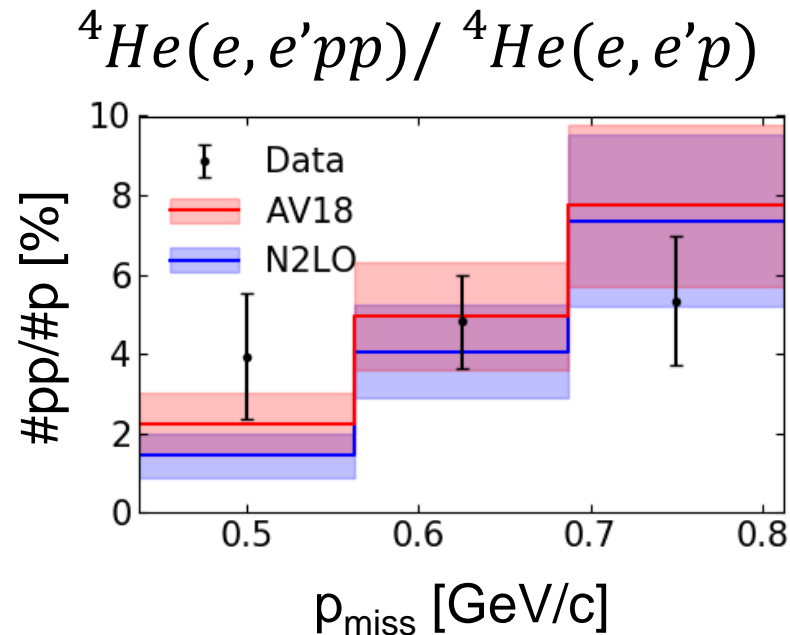
Yield ratios agree well with GCF model (uncorrected for acceptance)



Yield ratios agree well with GCF model

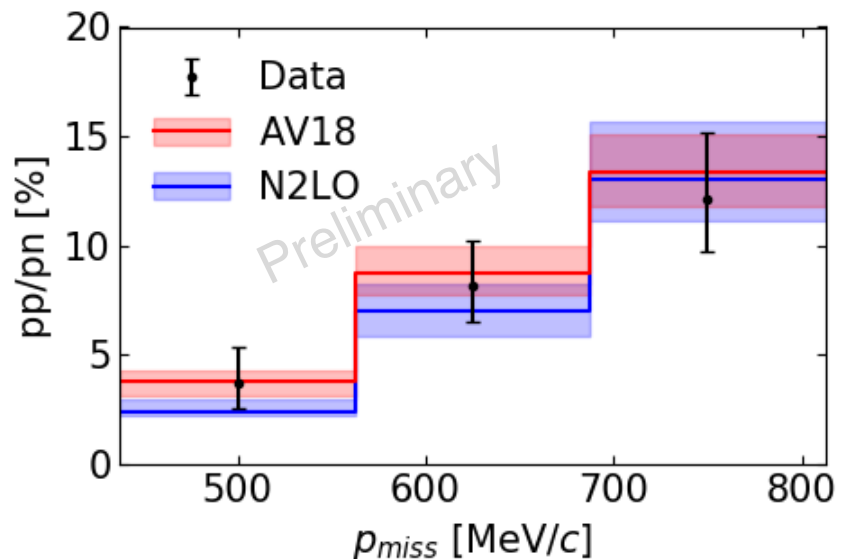
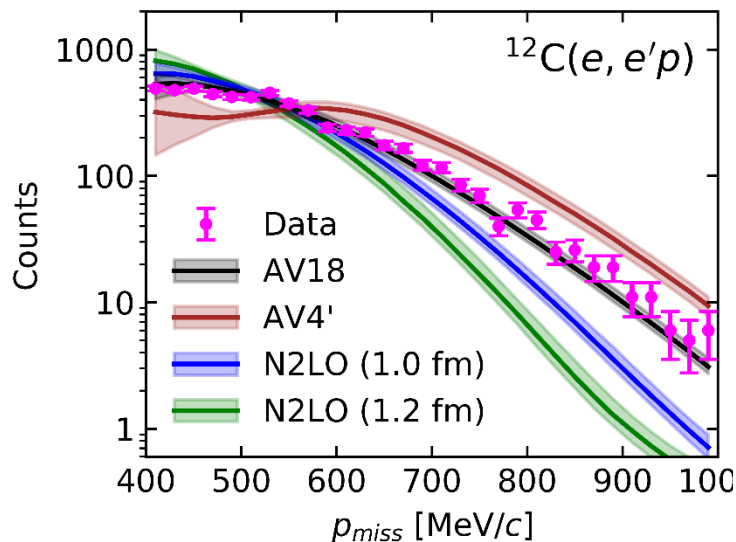


Data are consistent with GCF model up to statistical uncertainty



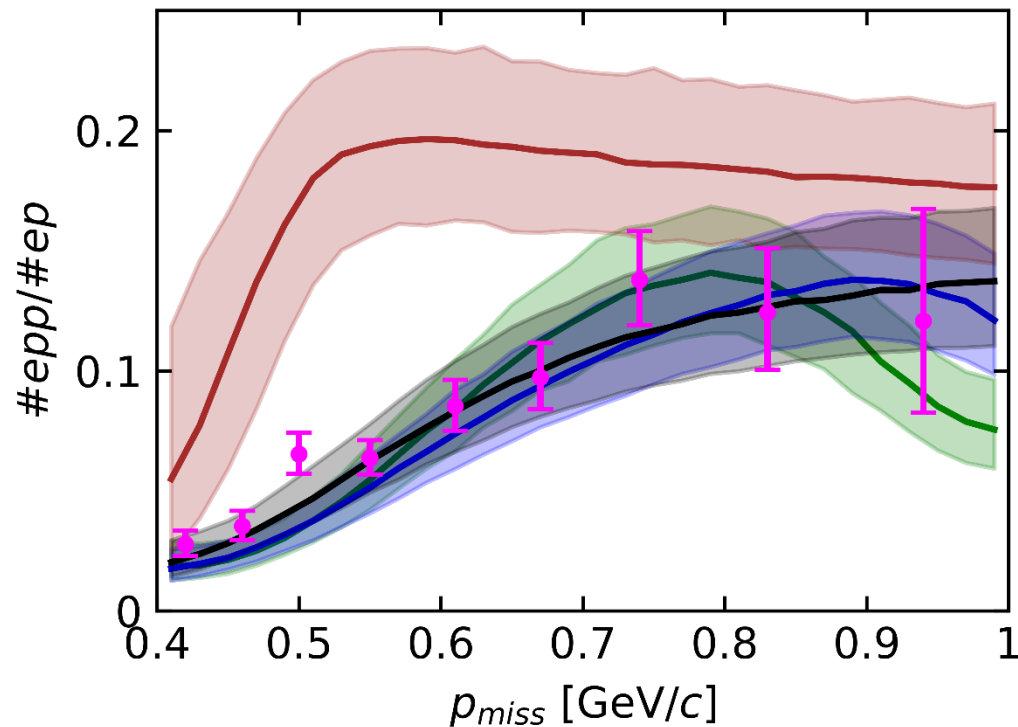
Conclusions

- GCF shows success in modelling SRC breakup in multiple experiments



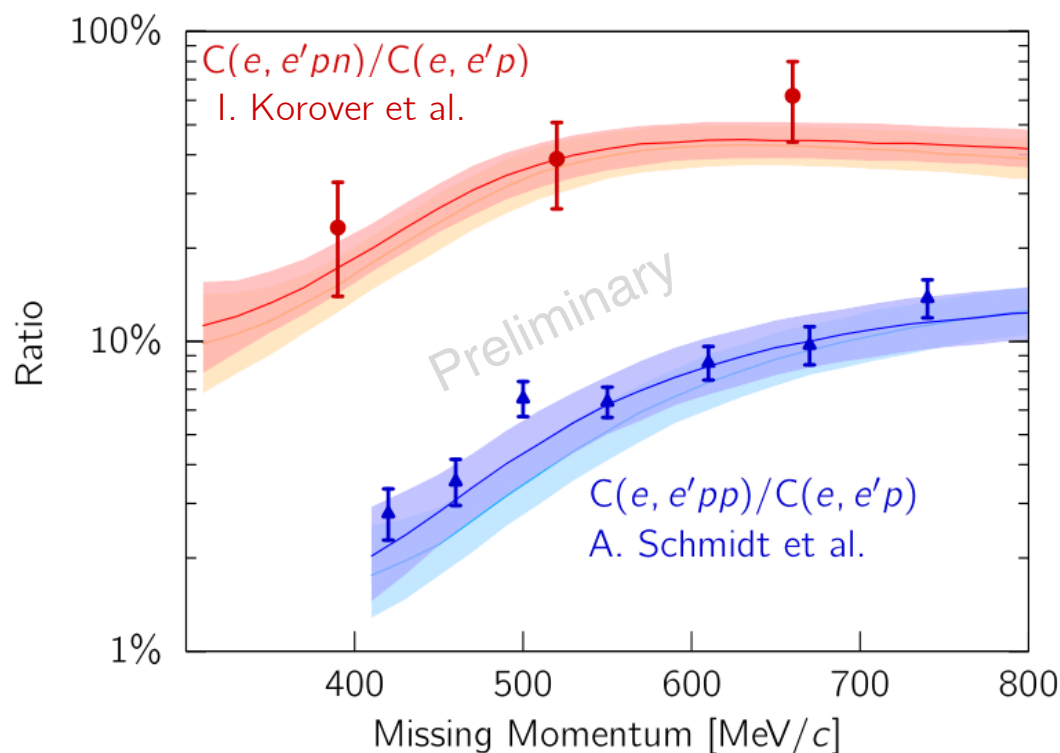
Conclusions

- Data show transition from tensor-dominated region to scalar core of NN interaction



Conclusions

- Neutron data support SRC-dominance in high-momentum region



SRC Breakup and GCF at EIC

High Q^2 will provide clean factorization for SRC quasielastic breakup, allowing us to examine:

- Cross-section scaling with Q^2
- Off-shell behavior of nucleons in quasielastic reactions
- Reaction dynamics in electron scattering

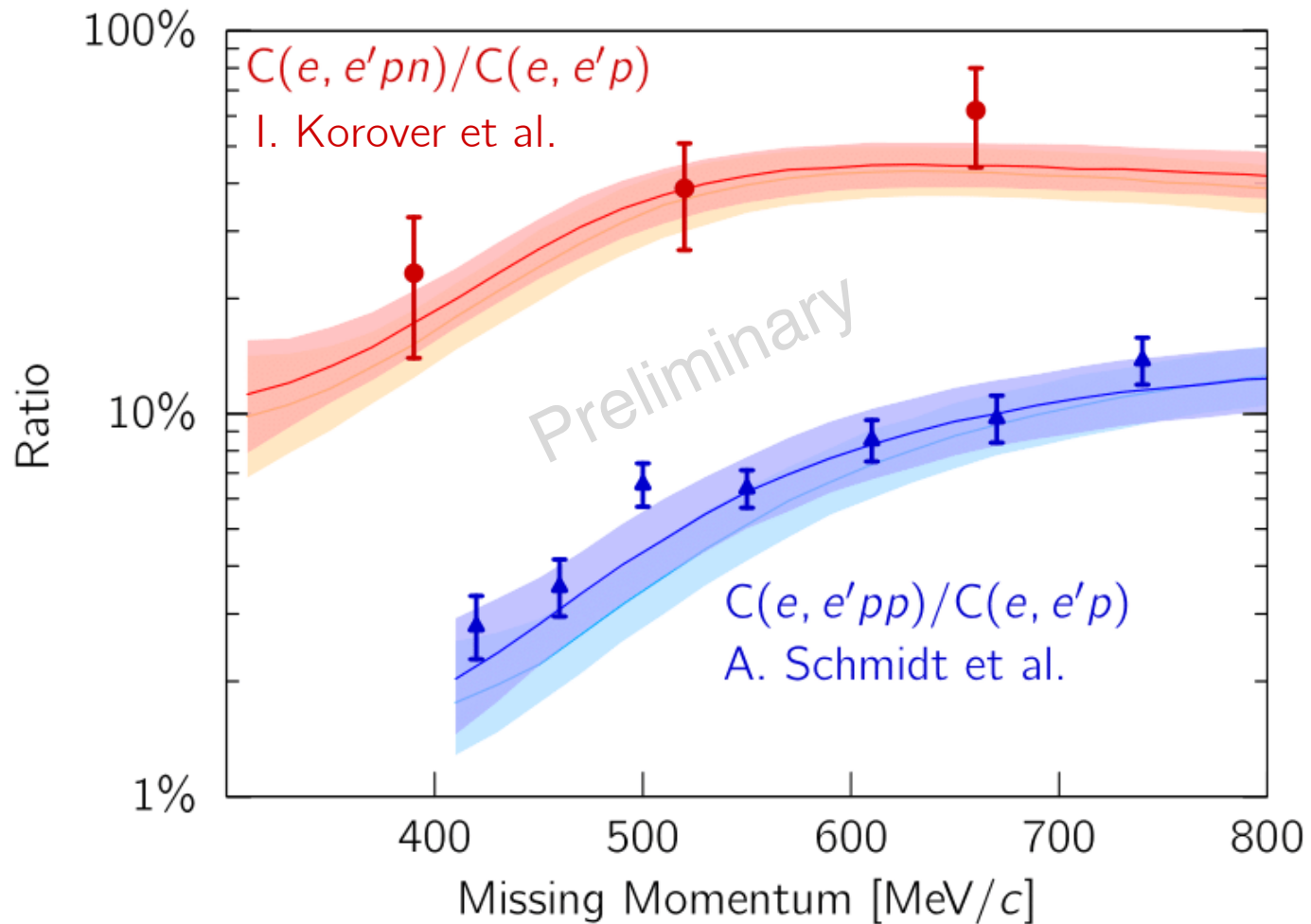
Modelling SRC breakup is crucial for this!

SRC Breakup and GCF at EIC

- GCF is being used to make predictions for EIC
- SRC Breakup being integrated into BeAGLE
- Modelling of residual system
- Other channels in development (DIS, etc...)

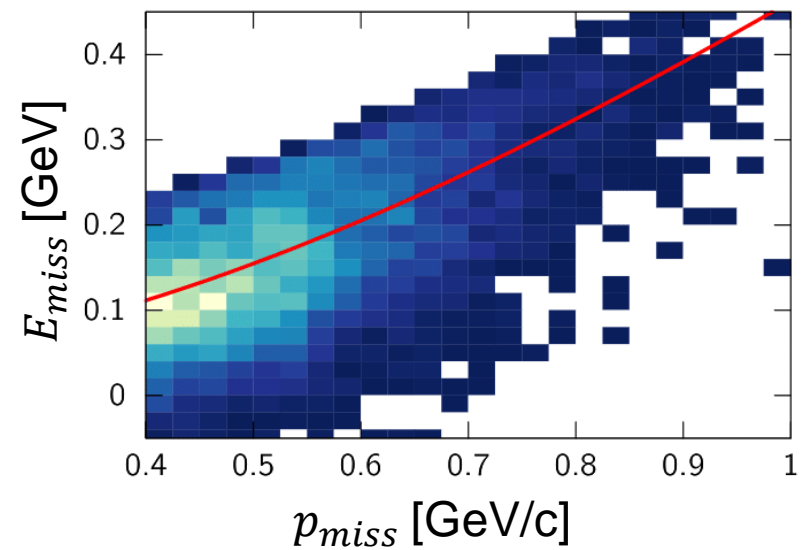
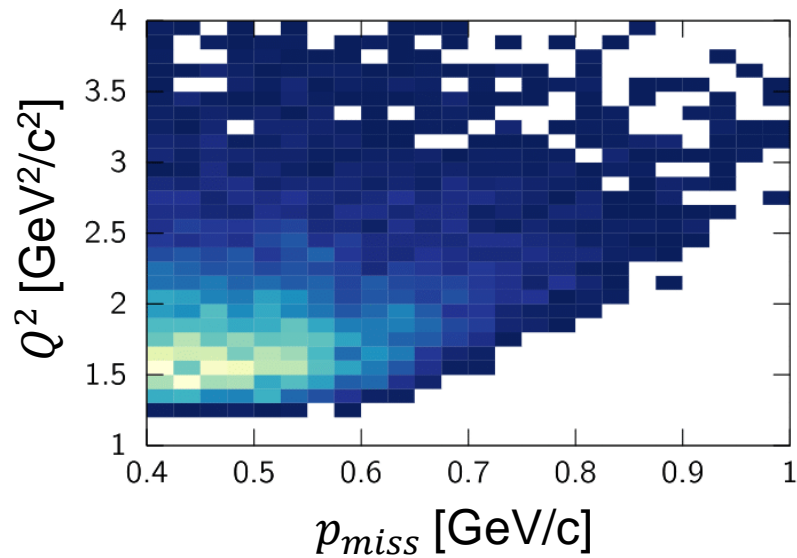
(See Florian's Talk for more details)

Thanks!

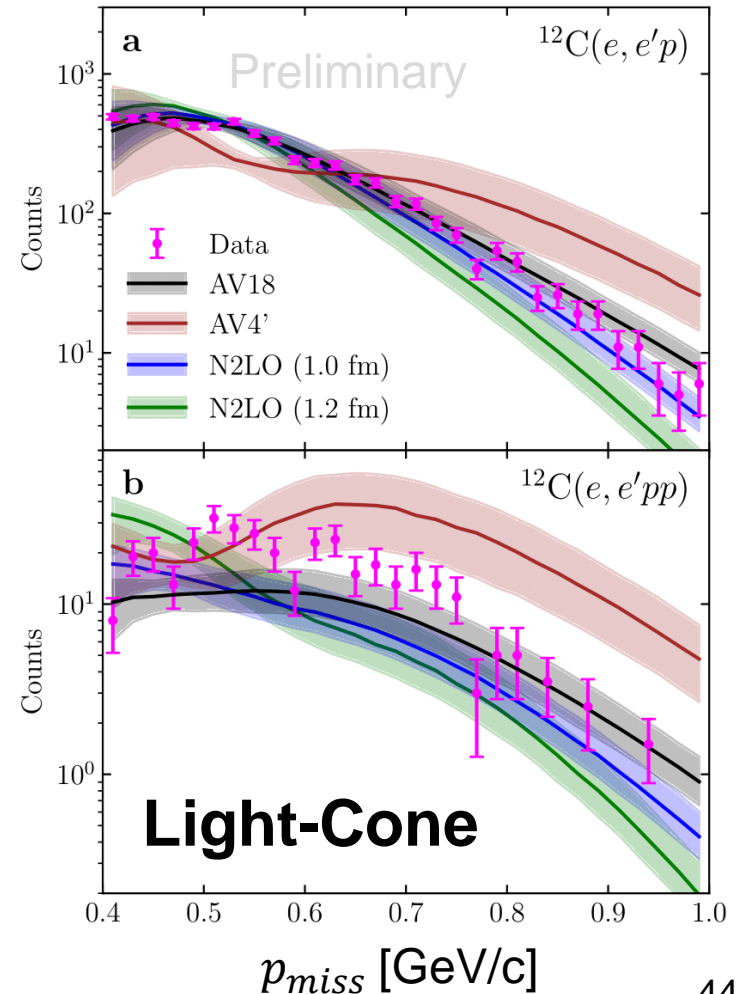
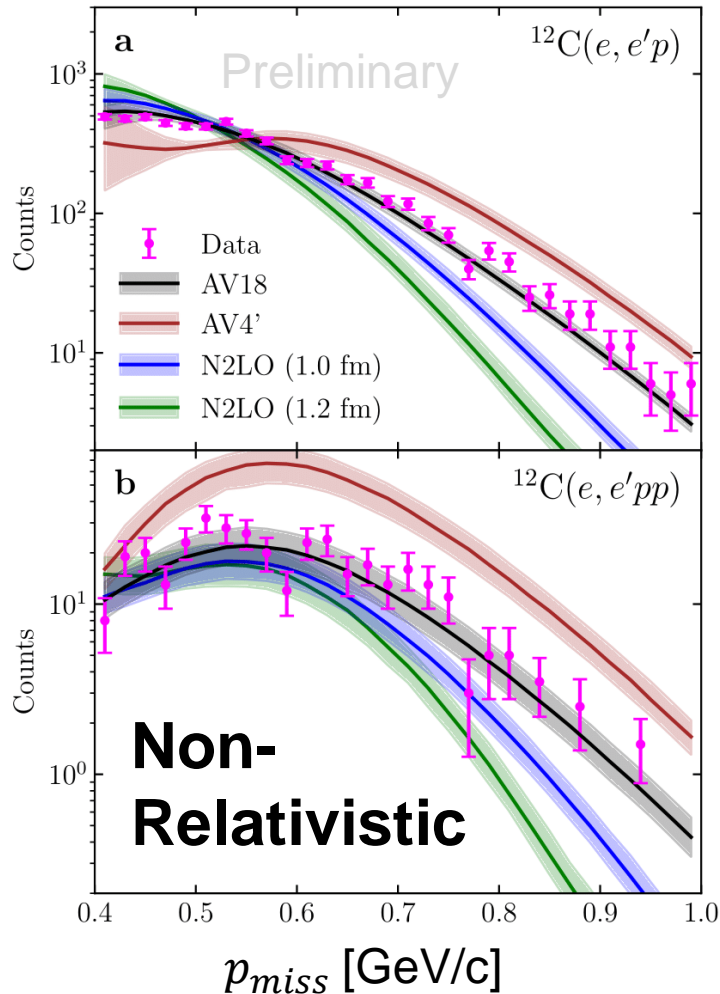


Backup

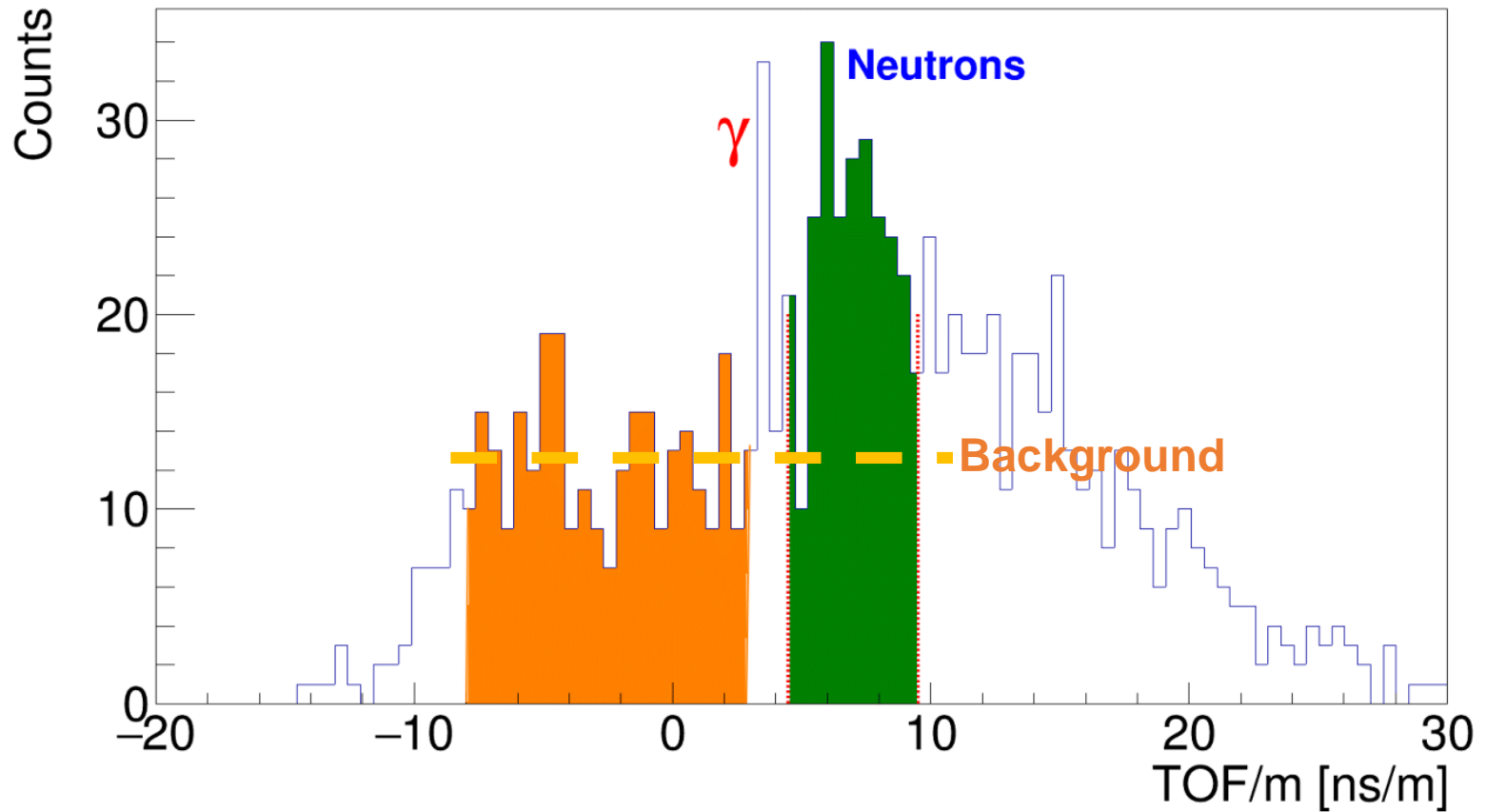
EG2 Kinematics



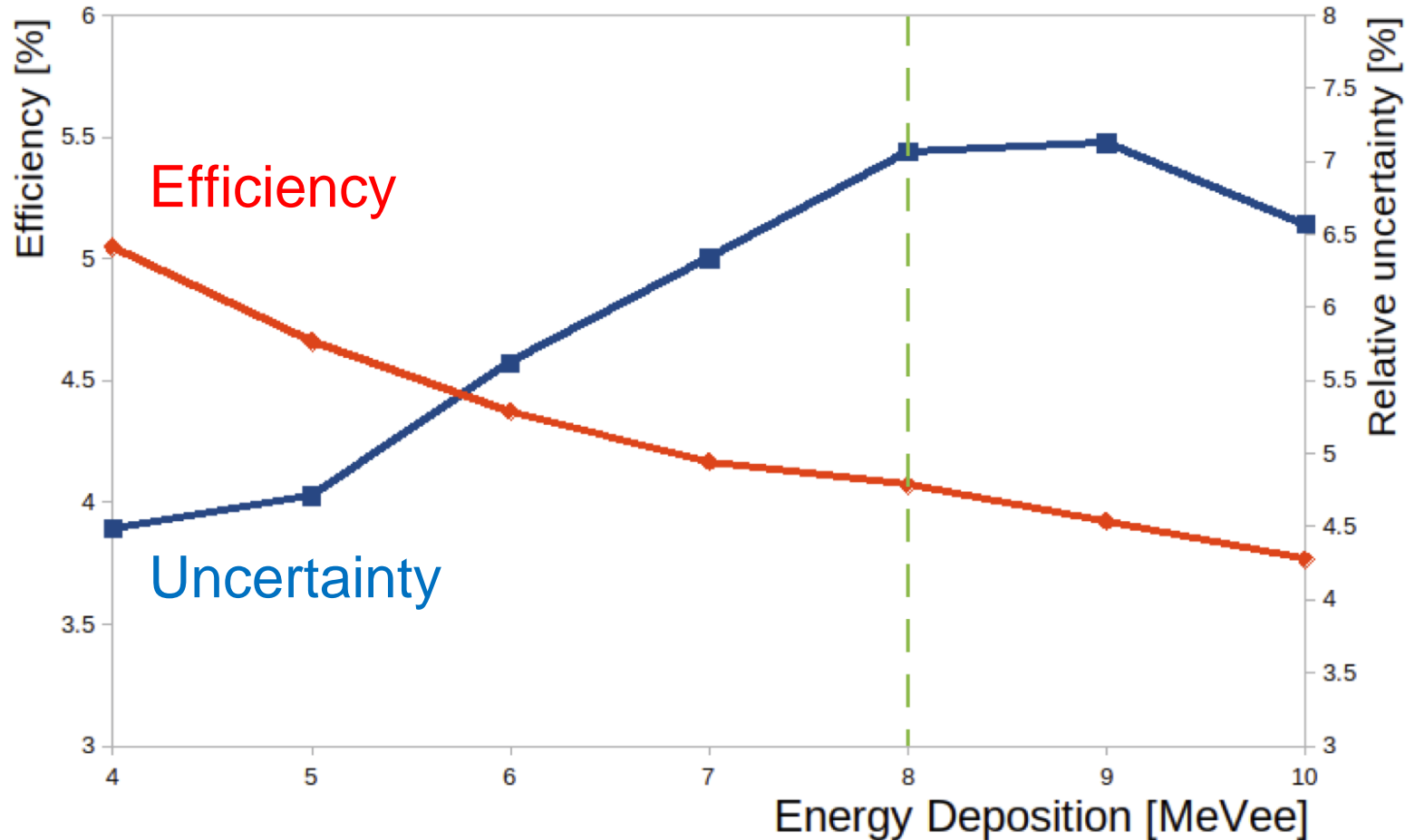
Relativistic Effects: Light-Cone Formalism



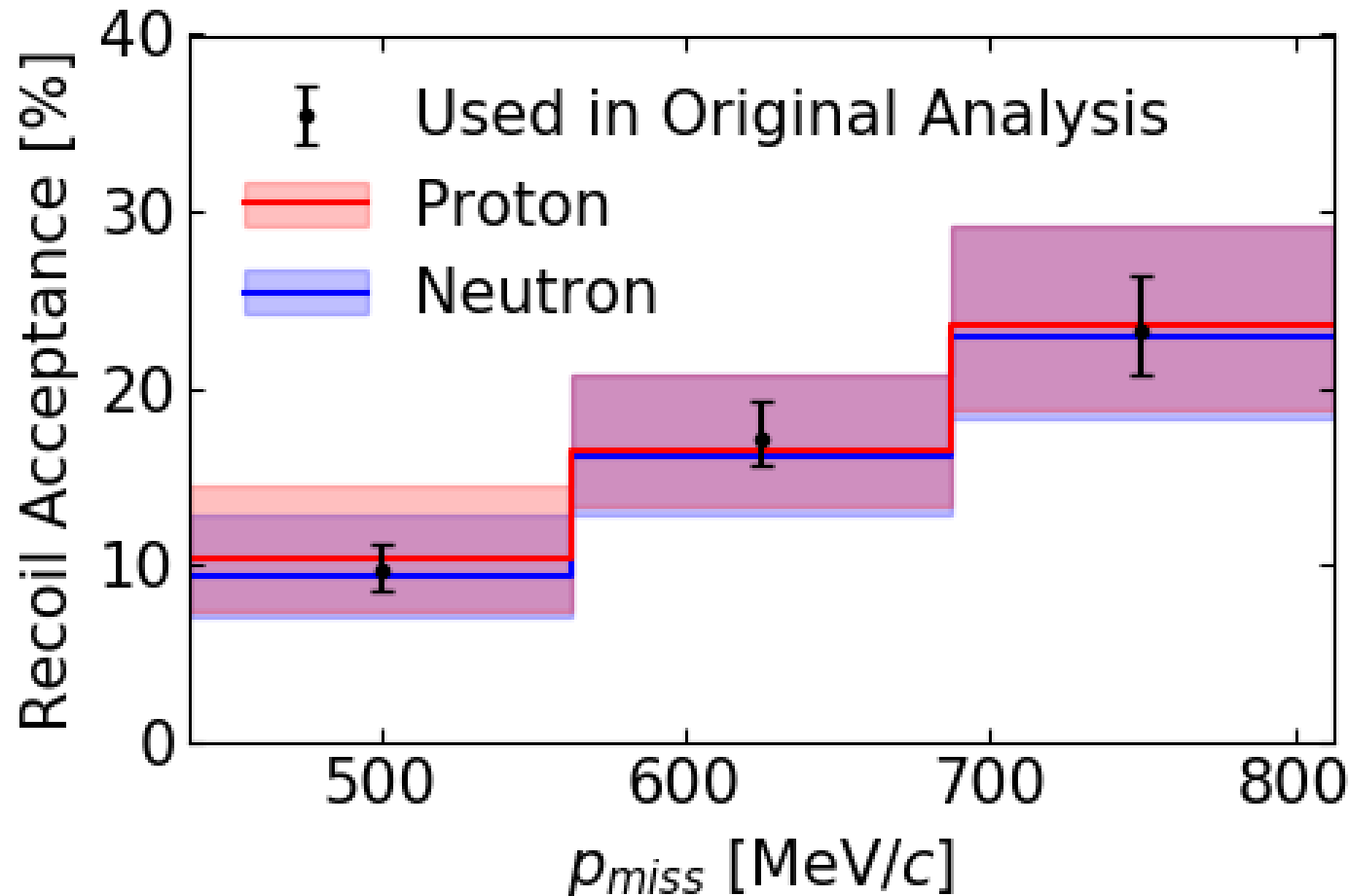
Recoil Neutron Detection



Neutron Detection



Validates acceptance corrections



Data are consistent with theory

