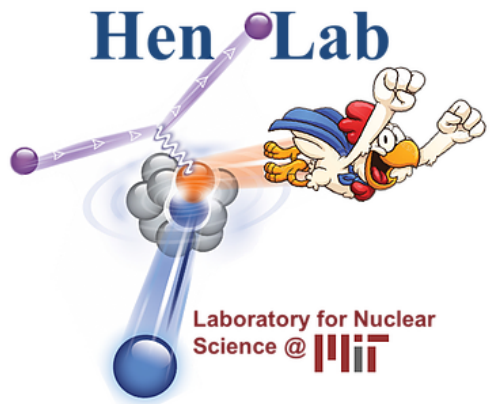
Generalized Contact Formalism Event Generator

Axel Schmidt

MIT

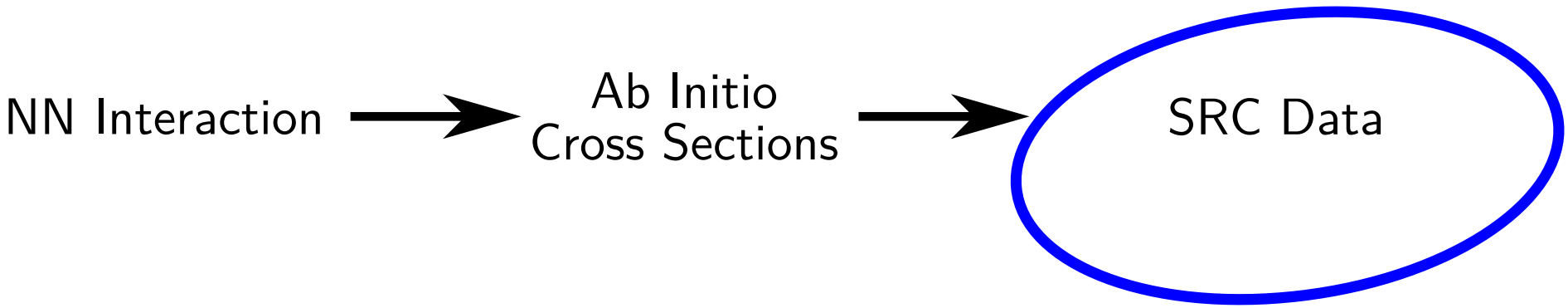
March 22, 2019



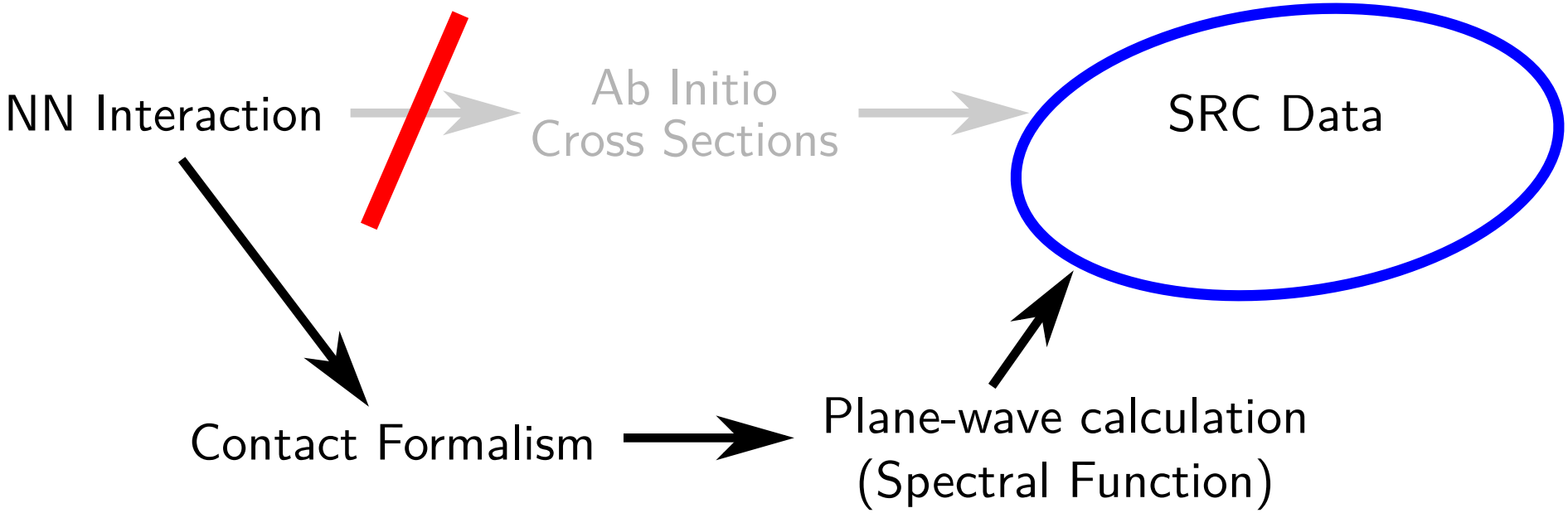
My controversial claim:

Our new analysis shows that SRC data can constrain the NN interaction *up to relative momenta of 1 GeV/c.*

Constraining the *NN* interaction with SRC data



Constraining the *NN* interaction with SRC data



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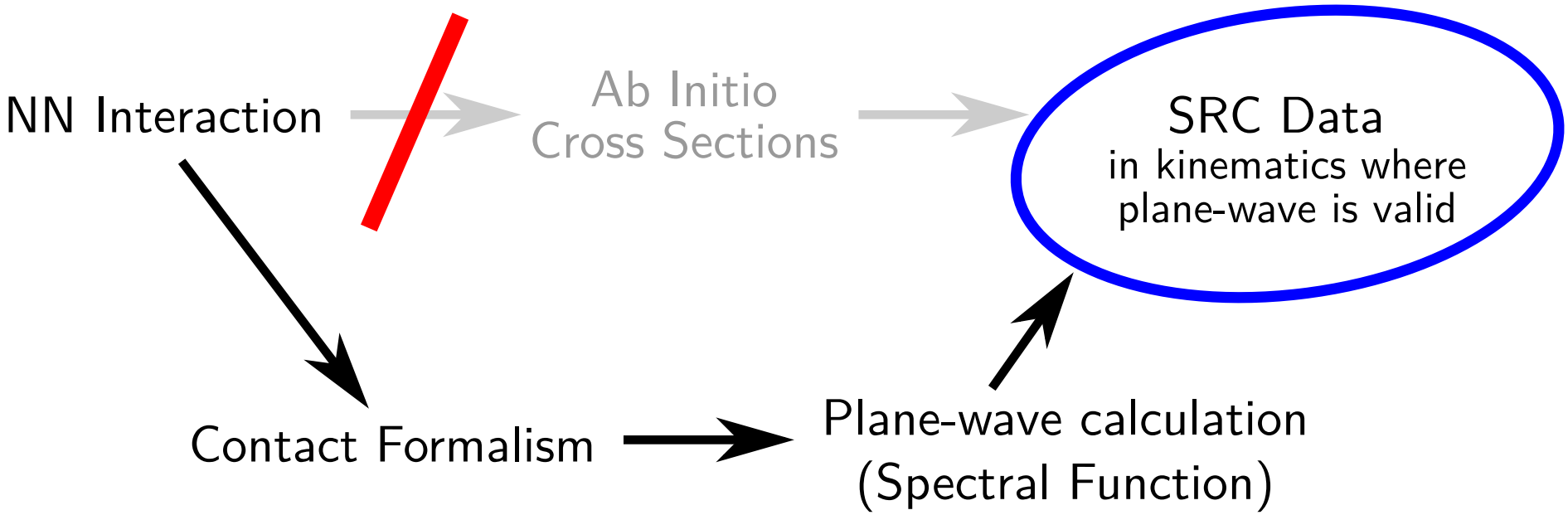

Generalized Contact Formalism

When $r_{ij} \to 0$ or $k_{ij} \to \infty$:

$$\psi(r_1, r_2 \ldots r_A) \quad \longrightarrow \quad \varphi(r_{ij}) \quad \times \quad A(r_1, \ldots r_A)$$

$$\text{Universal} \qquad \approx \text{constant}$$

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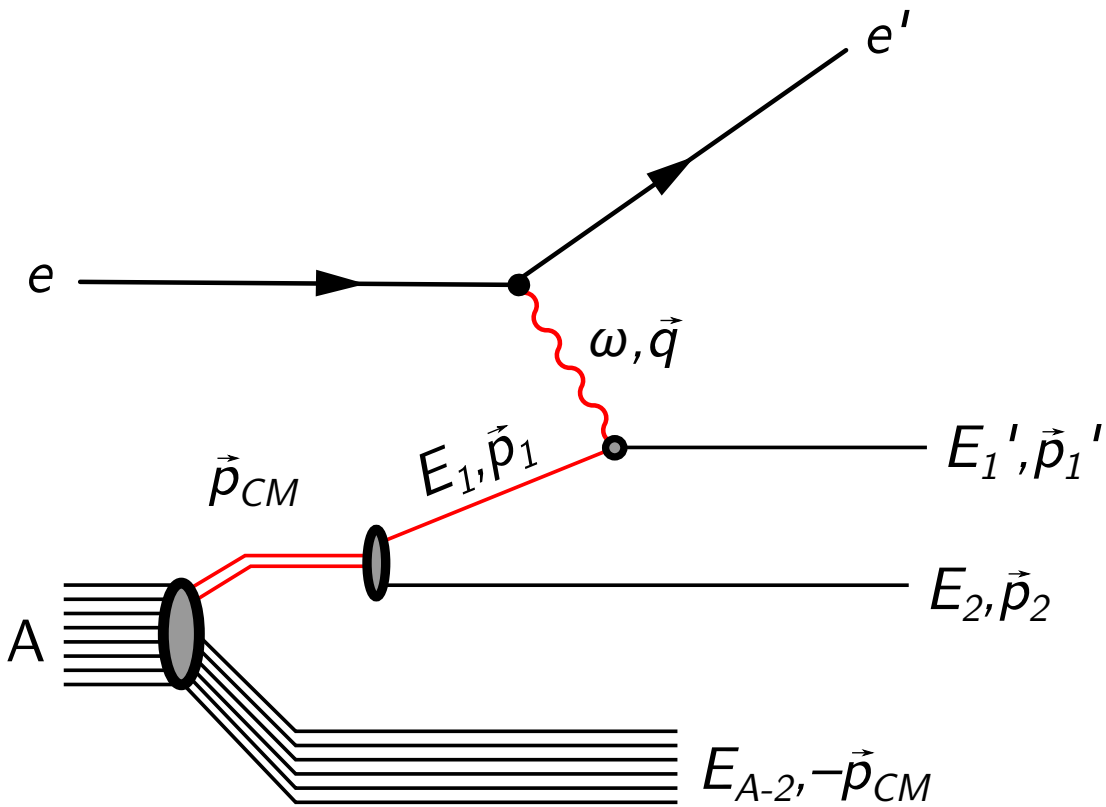
- φ: determined from NN interaction model
- A: abundance of pairs in this nucleus
  - $\int A \longrightarrow C$, nuclear contact

We assume a fully plane-wave reaction.



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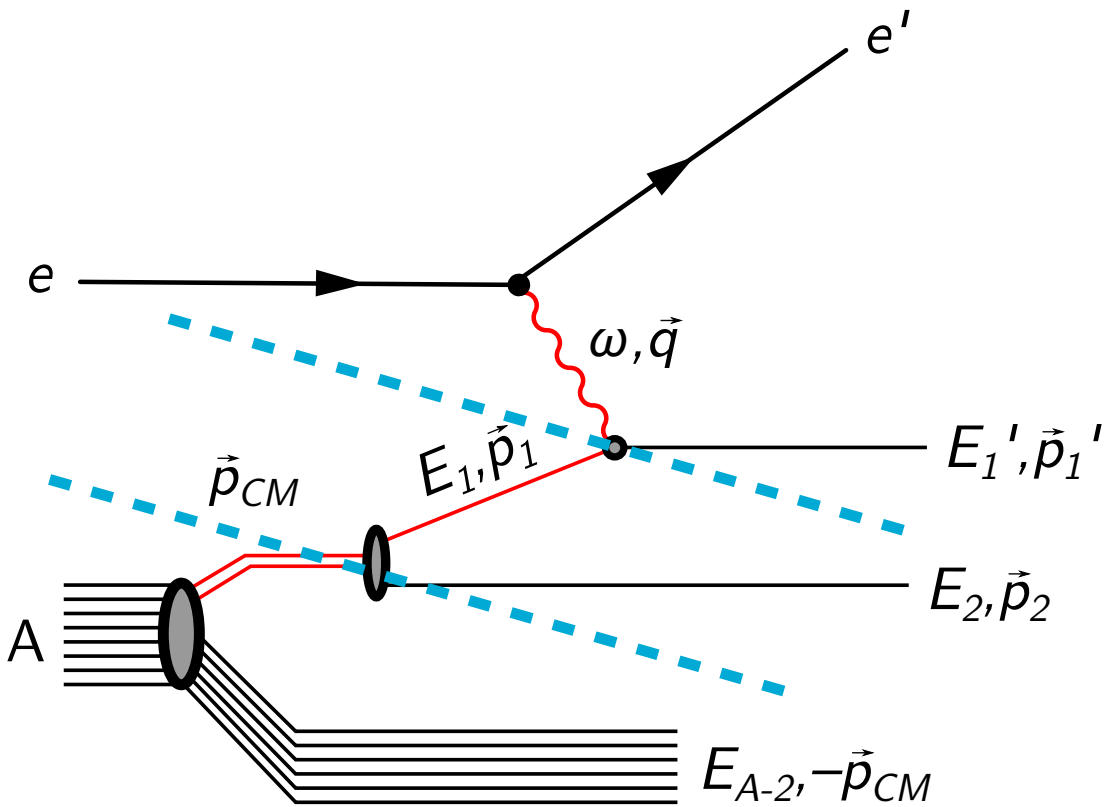

$$p_{CM} \ll p_{rel} \ll q$$

Integrating over $\vec{p}_2$ produces a spectral function for SRC break-up.

From Weiss et al., PLB 791 (2019) pp 242–248:

$$S_\alpha = \frac{1}{4\pi} \int \frac{d\vec{p}_2}{(2\pi)^3} \delta(f(\vec{p}_2)) \left| \varphi_\alpha \left(\frac{\vec{p}_1 - \vec{p}_2}{2} \right) \right|^2 n_\alpha(\vec{p}_1 + \vec{p}_2)$$

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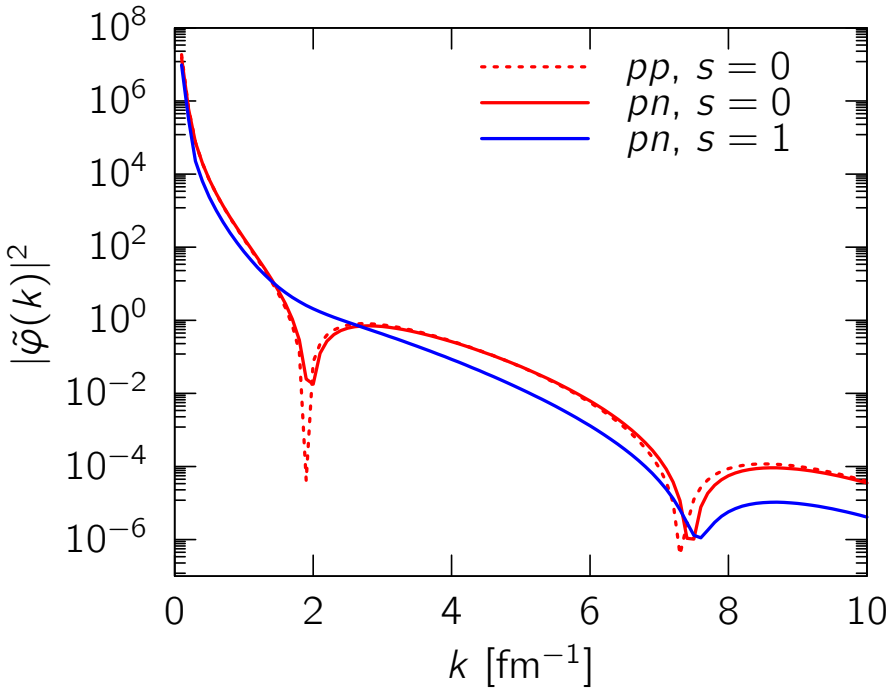
By sampling instead of integrating, we get a generator:

$$d\sigma \sim \sigma_{eN} \cdot n(\vec{p}_{CM}) \cdot \sum_\alpha C_\alpha |\tilde{\varphi}_\alpha(k)|^2$$

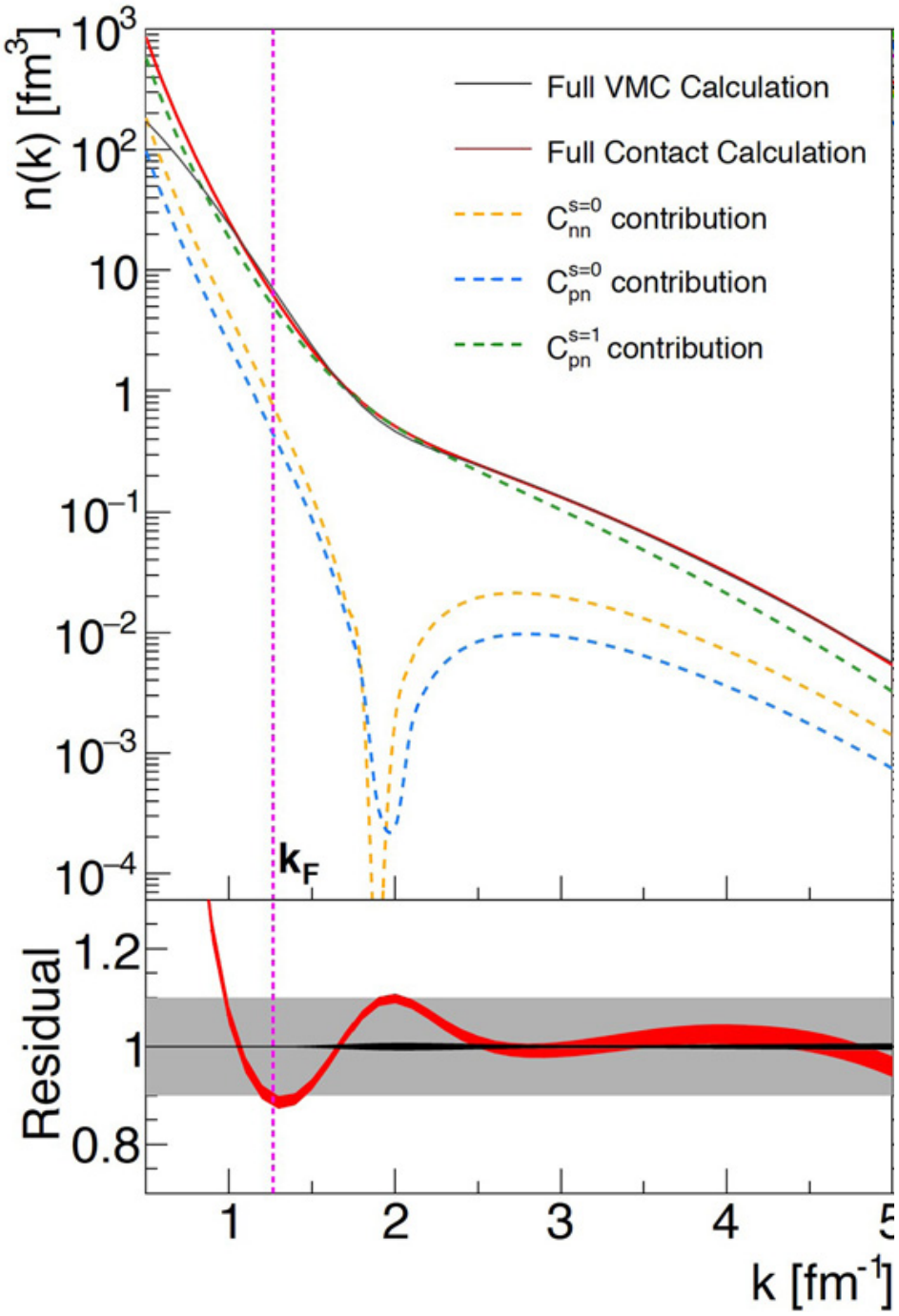
Model Input

- $\varphi_\alpha(\vec{p}_{\text{rel.}})$



Model Input

- $\varphi_\alpha(\vec{p}_{\text{rel.}})$
- C_α



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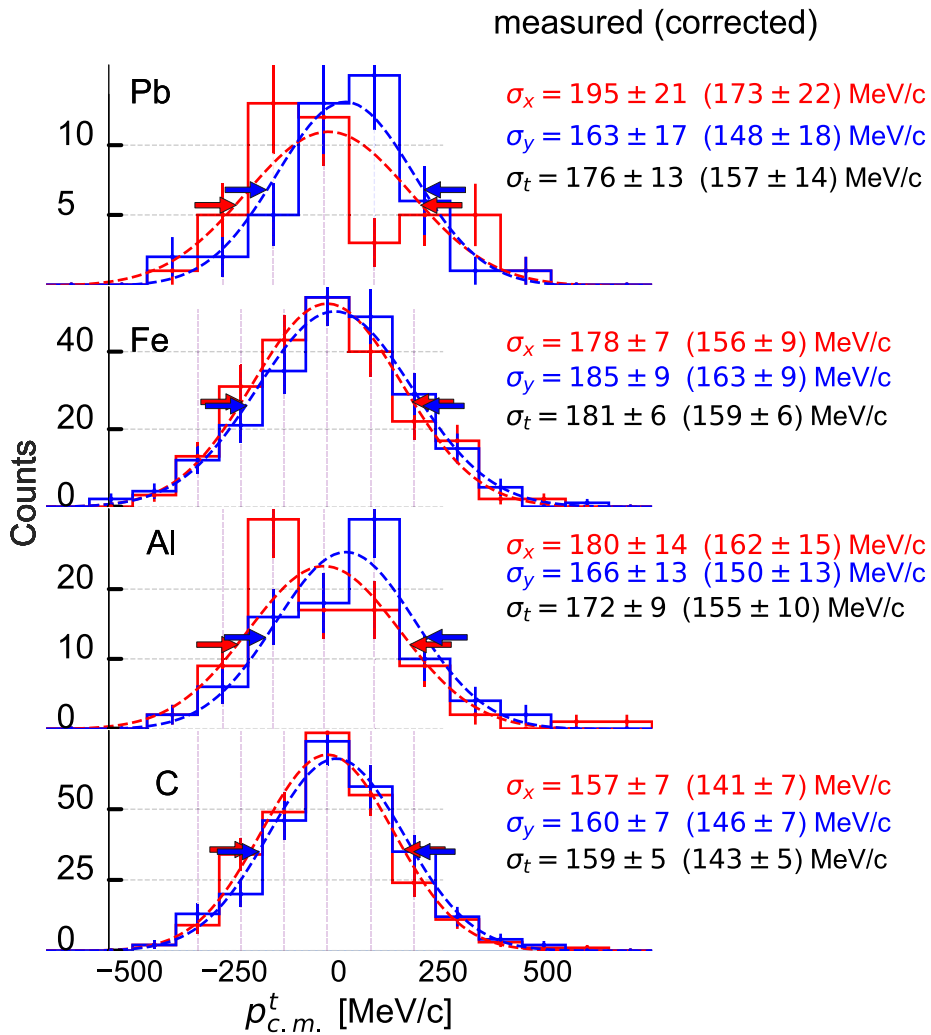
- C_α
- $n(\vec{P}_{cm})$: 3D Gaussian with σ_{cm}



Model Input

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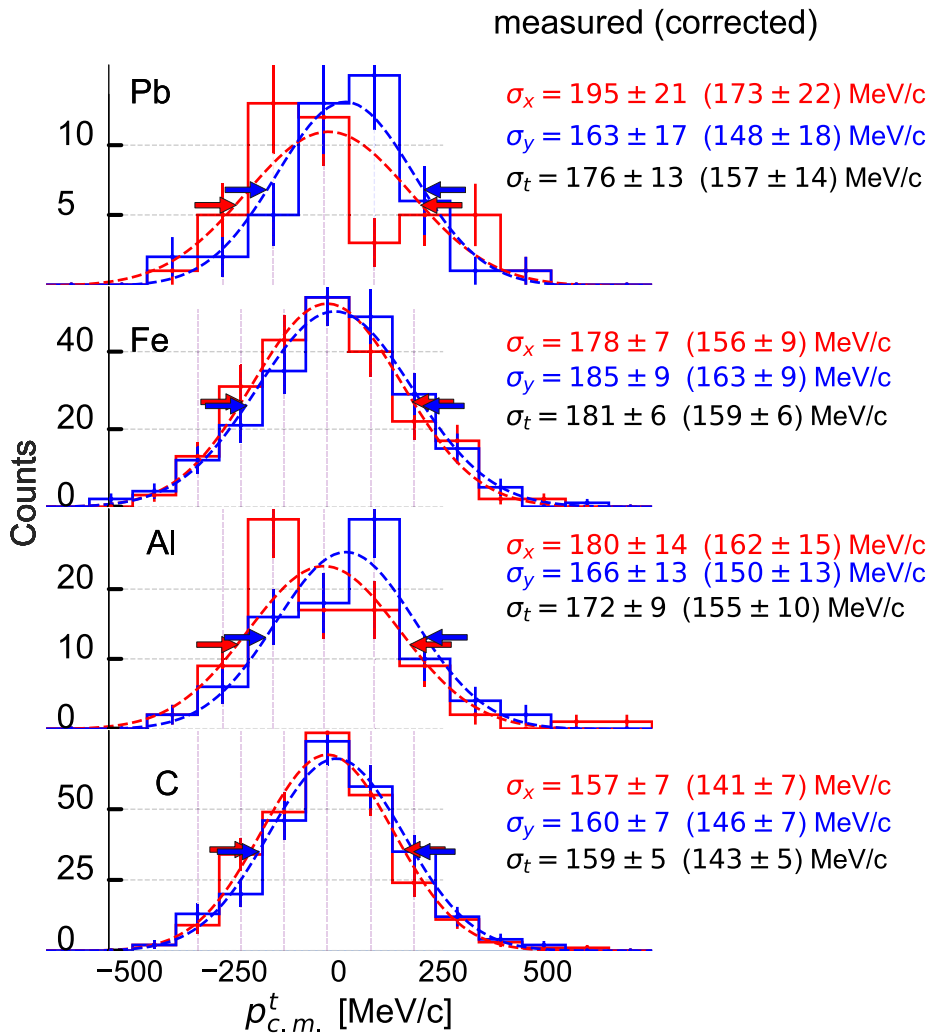
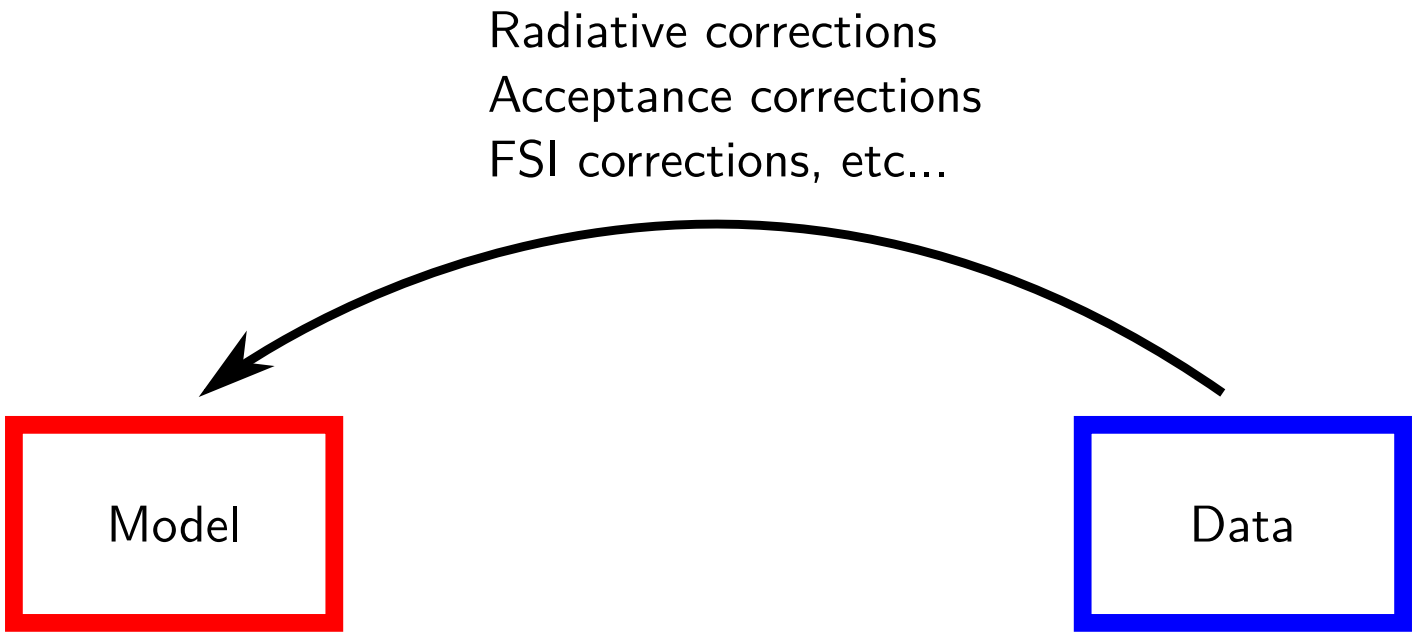
- C_α
- $n(\vec{P}_{cm})$: 3D Gaussian with σ_{cm}
- Residual excitation energy: E^*



Connecting the model to data



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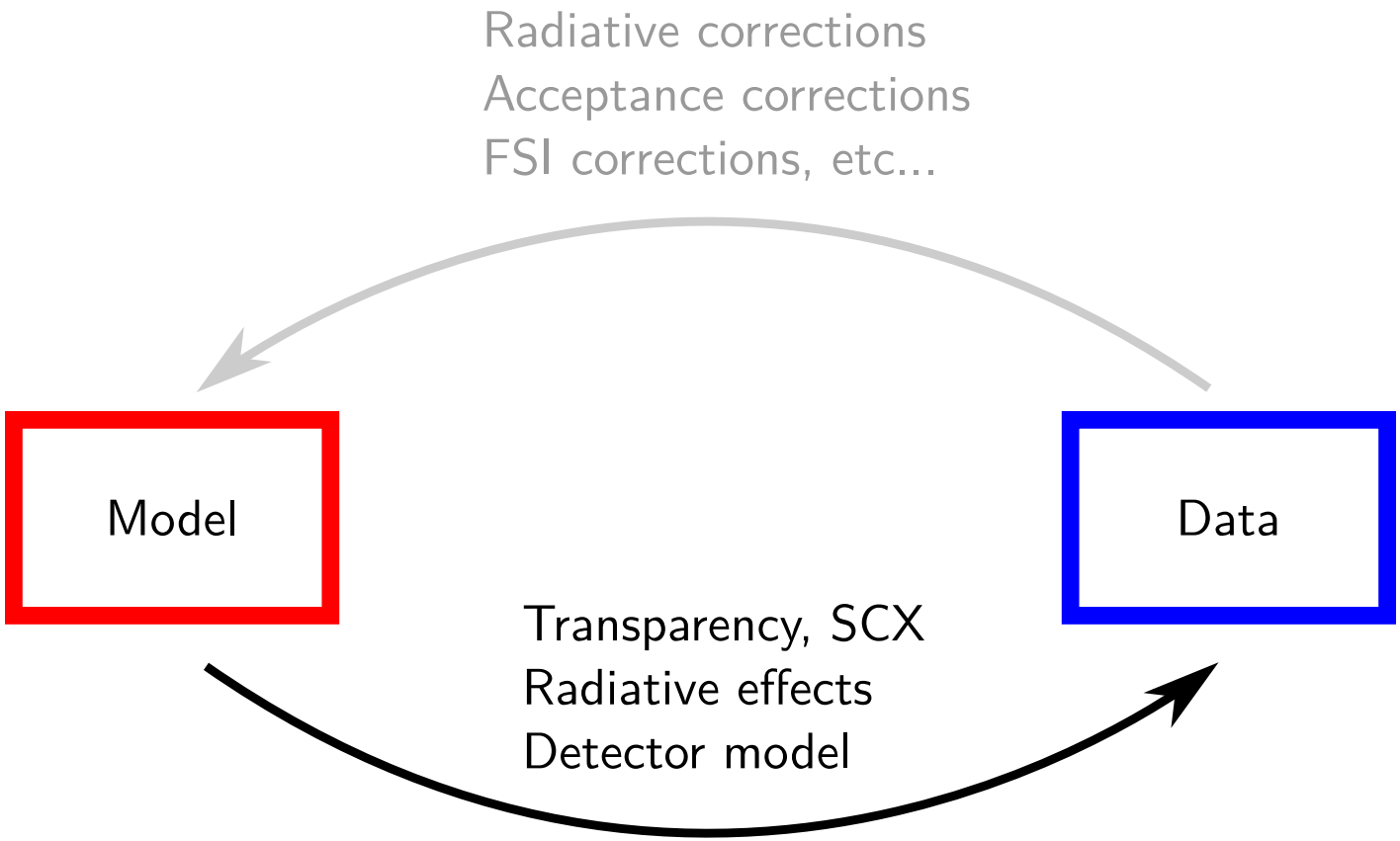
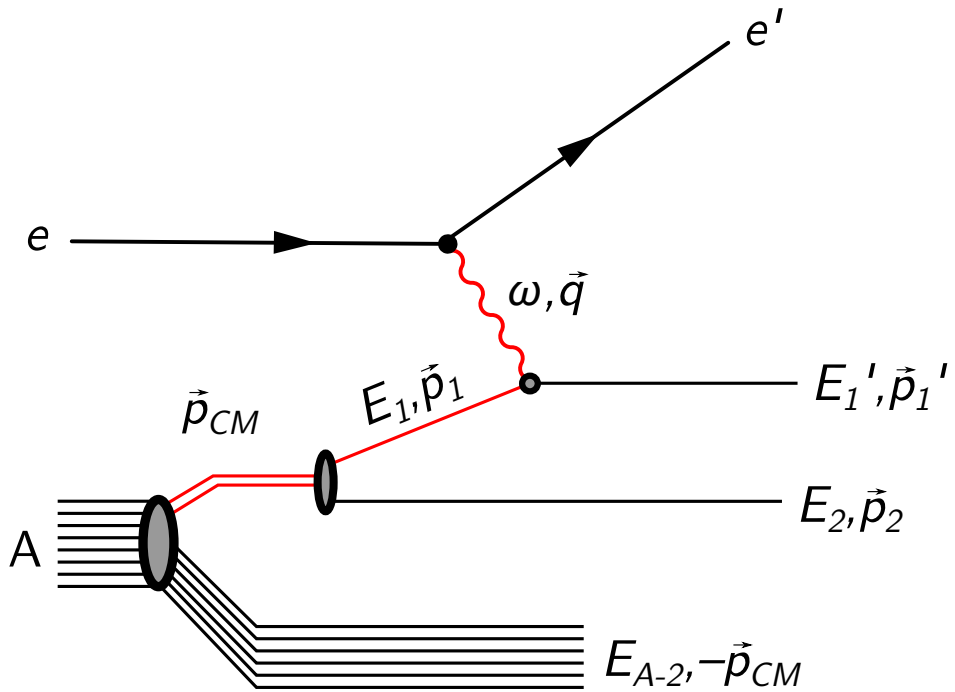


We forward propagate the model to the data.

1. Generate events according to model



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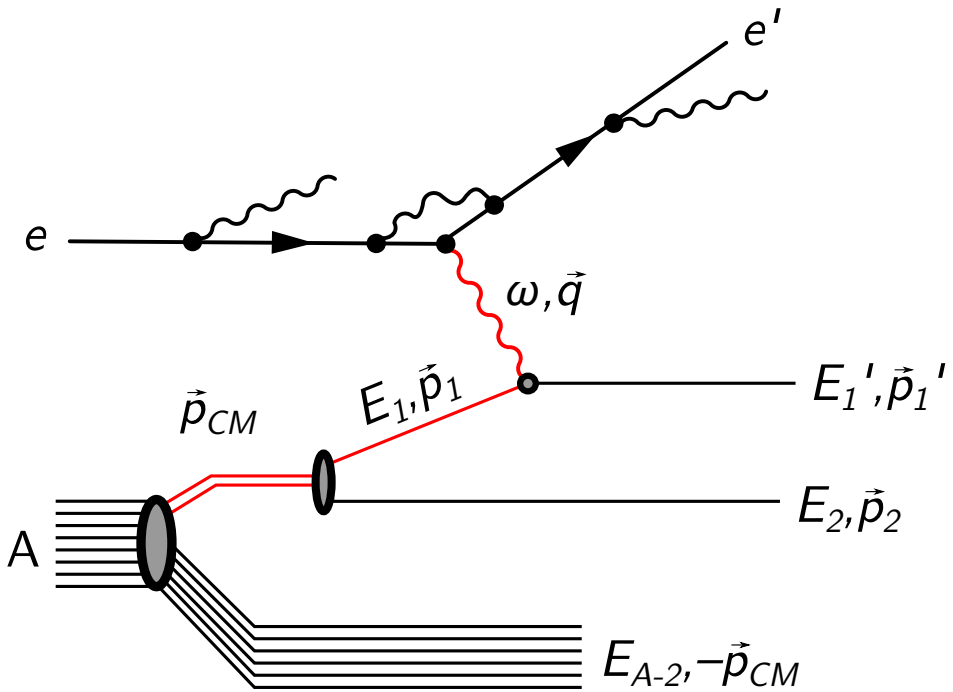
2. Radiative effects



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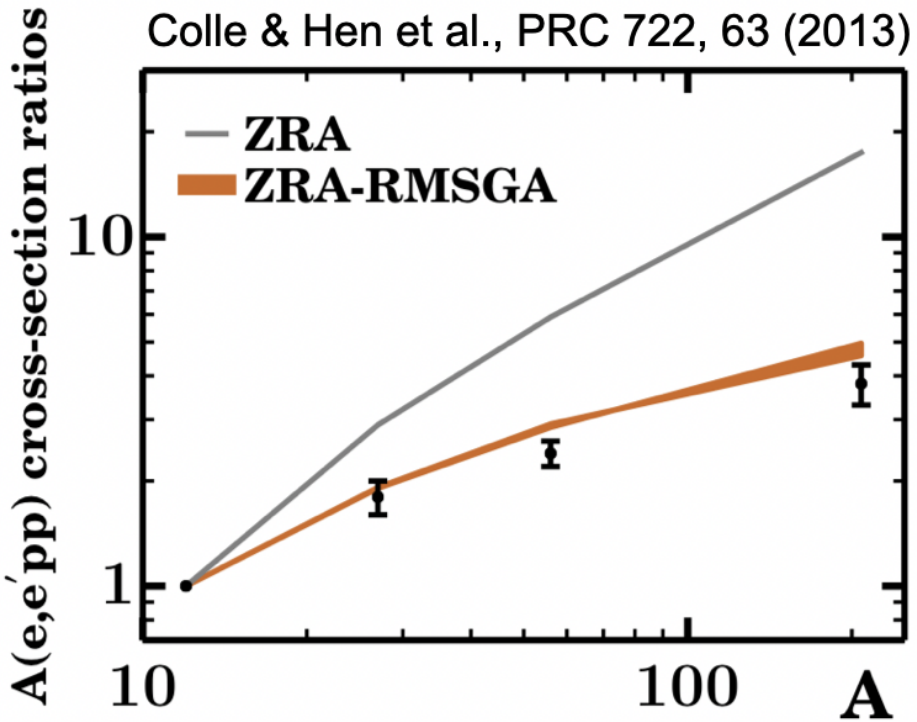
3. Transparency/SCX using Glauber



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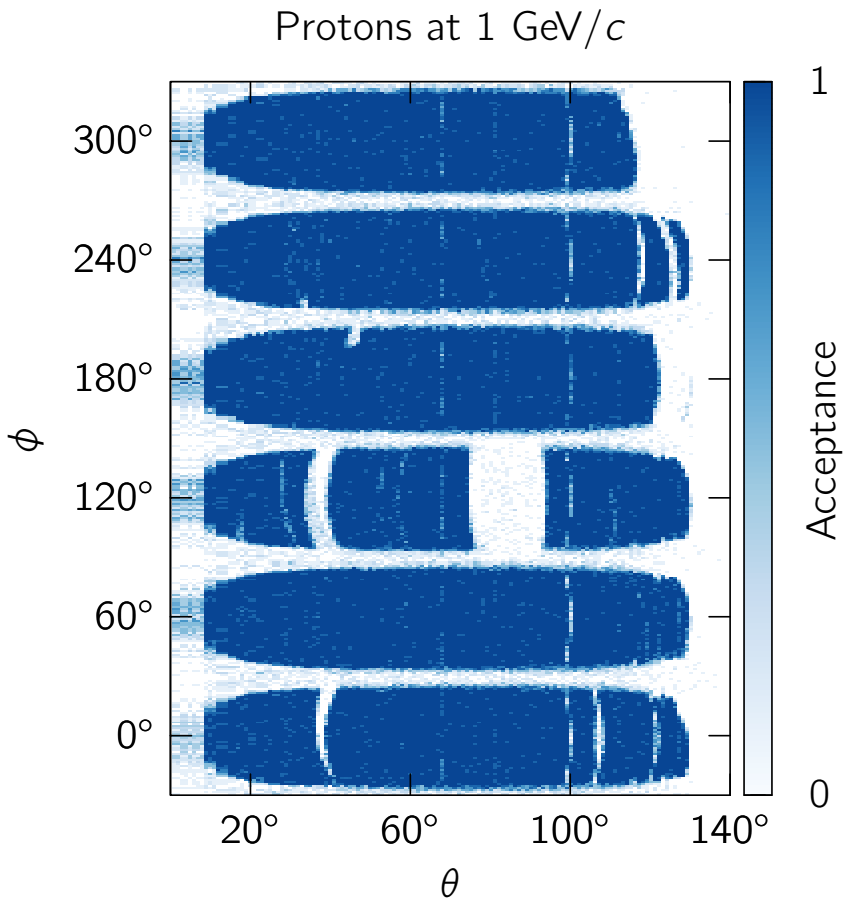
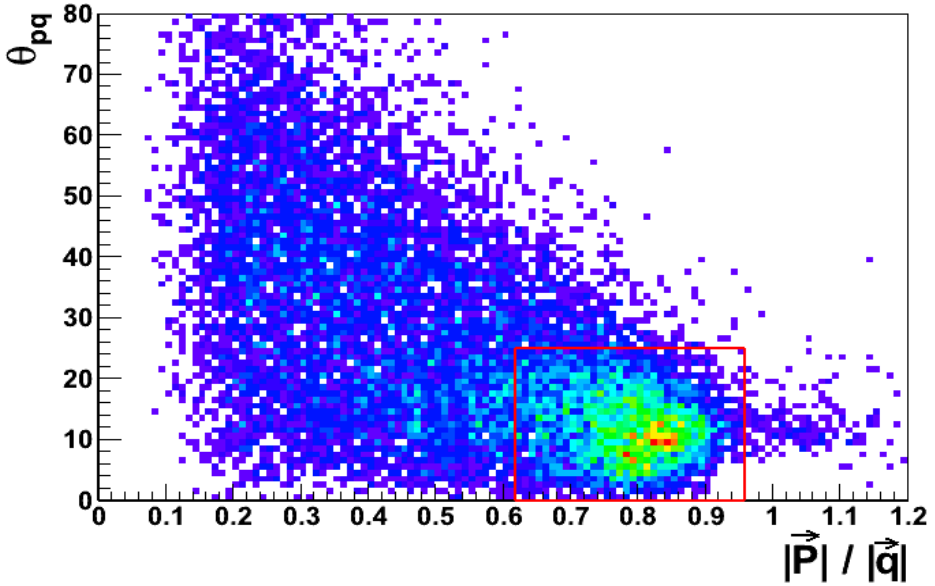


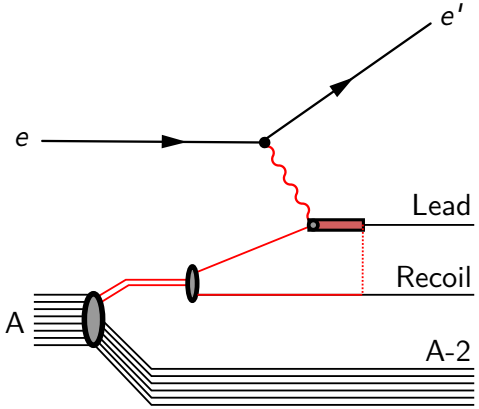
We forward propagate the model to the data.

1. Generate events according to model
2. Radiative effects
3. Transparency/SCX using Glauber
4. Detector acceptance
5. Same event selection as data

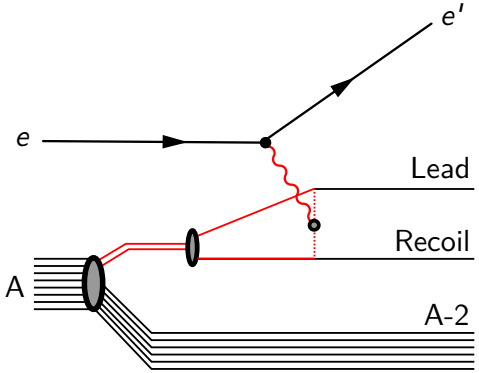


Choosing kinematics that minimize FSI

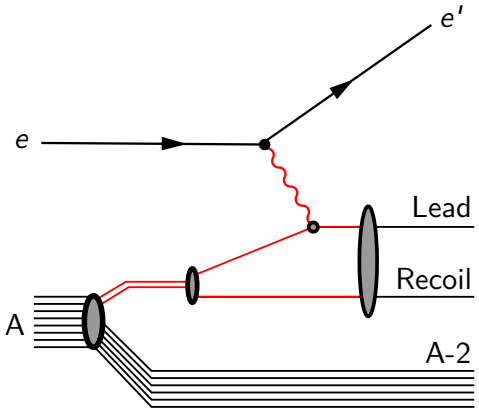
Isobar Config.



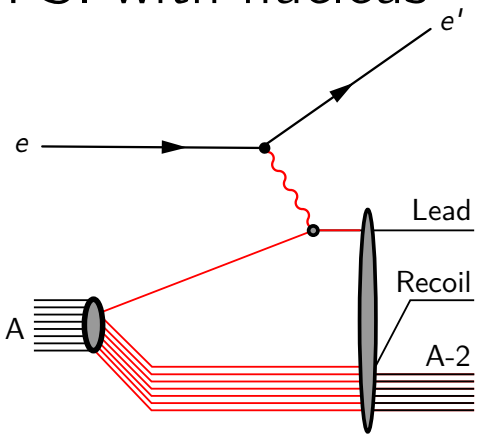
Meson-exchange curr.



FSI within pair



FSI with nucleus



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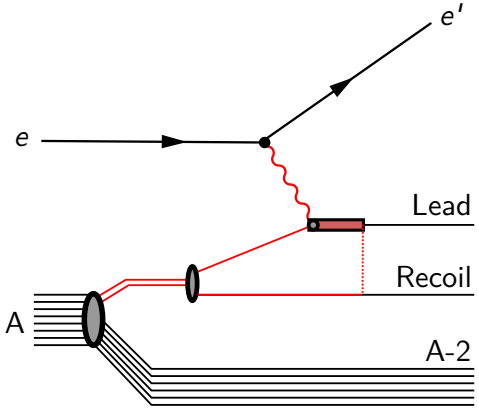

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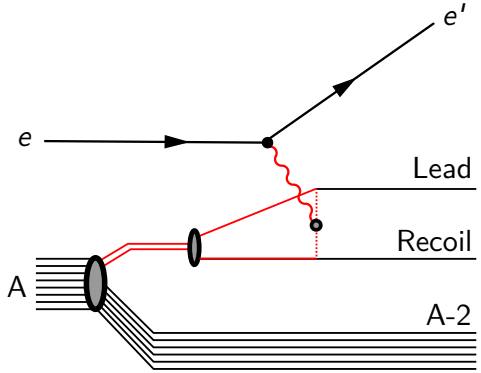

- $x_B > 1.2$
- High Q^2

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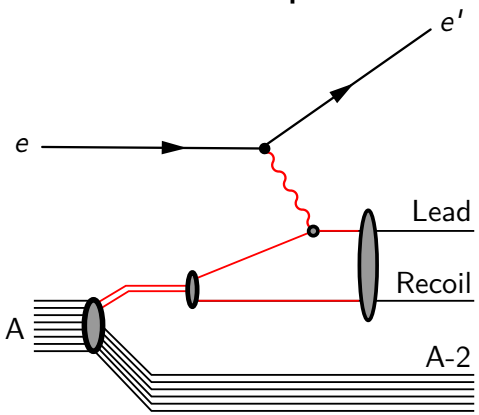

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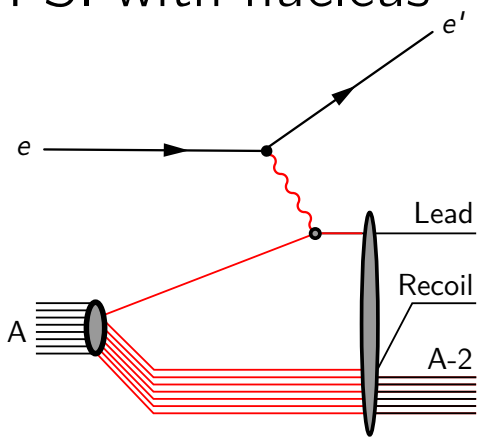

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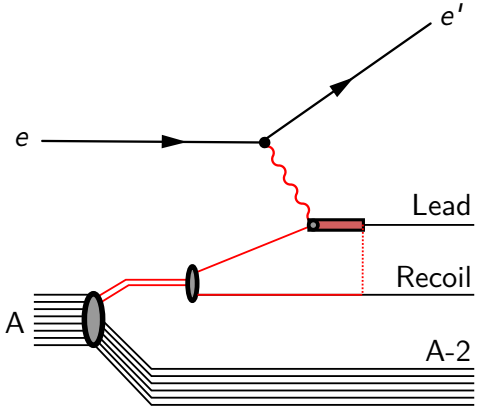

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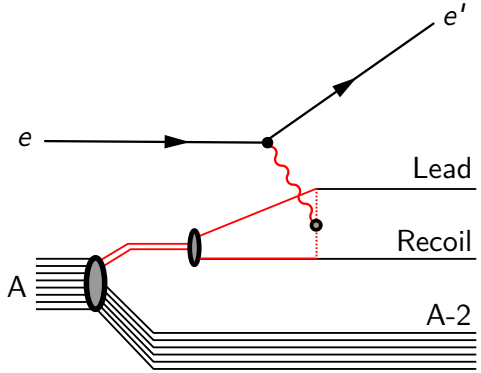

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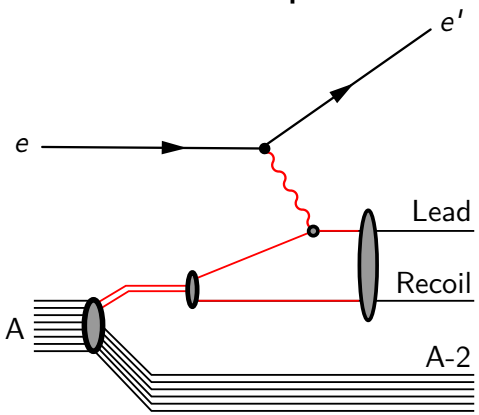

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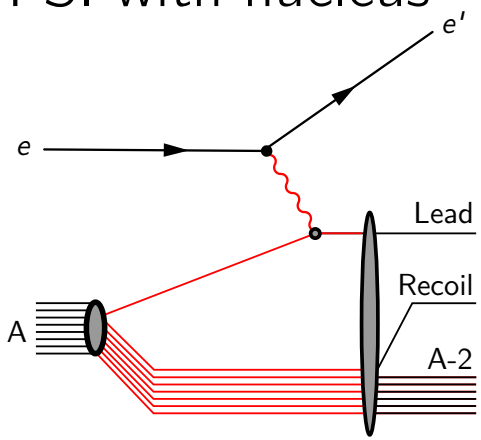
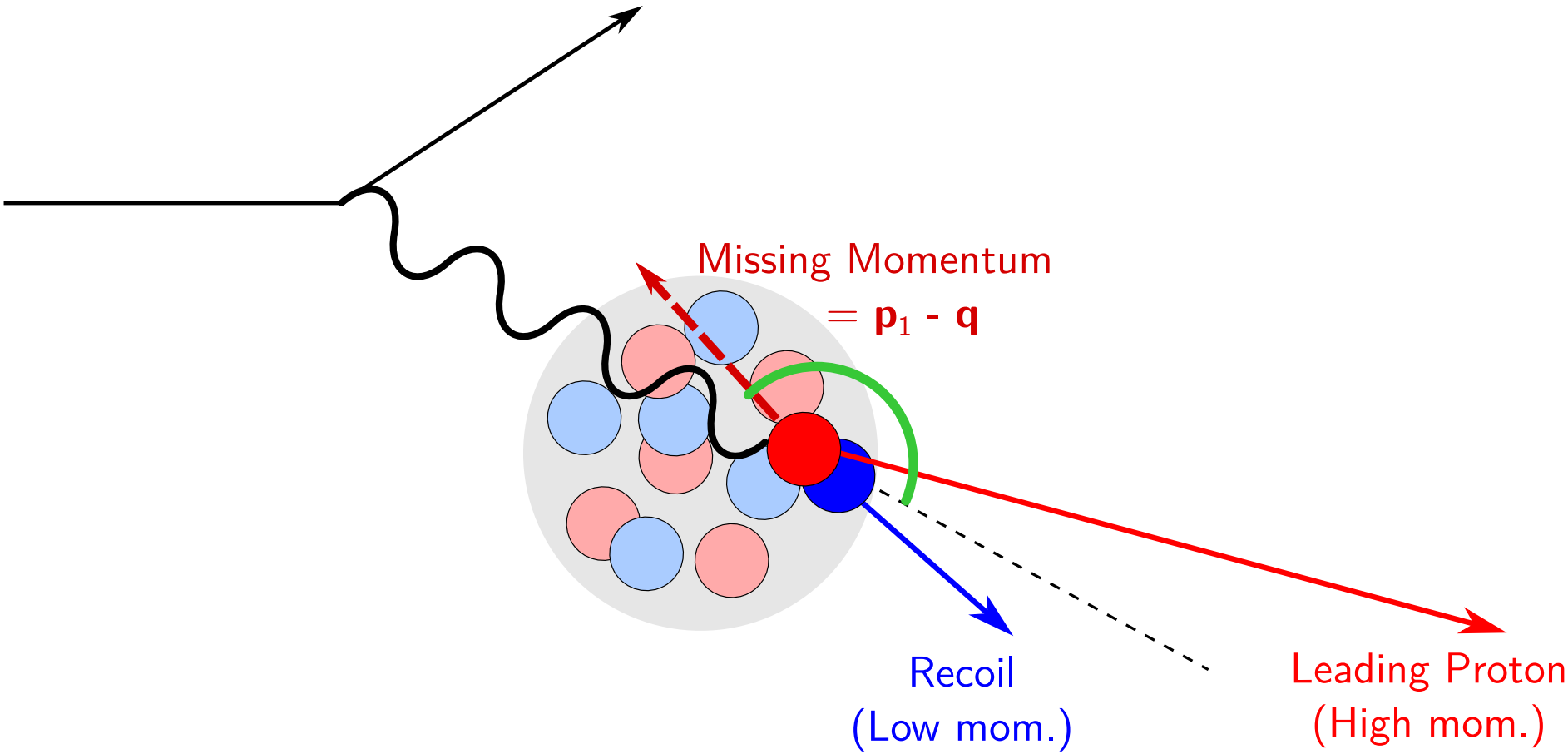
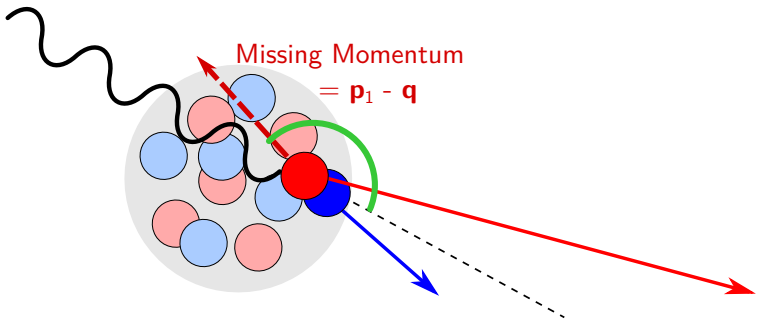


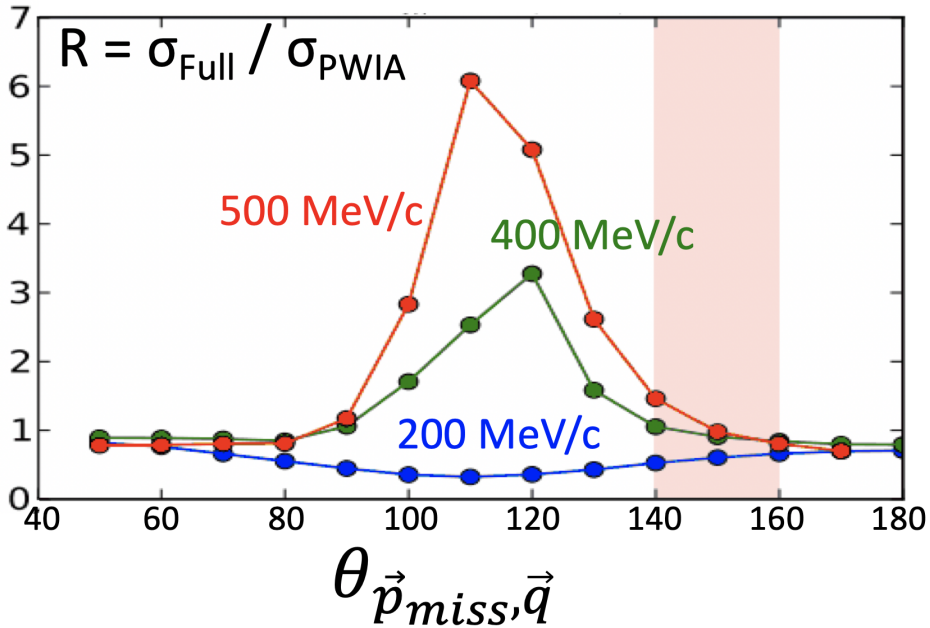
- Anti-parallel kinematics

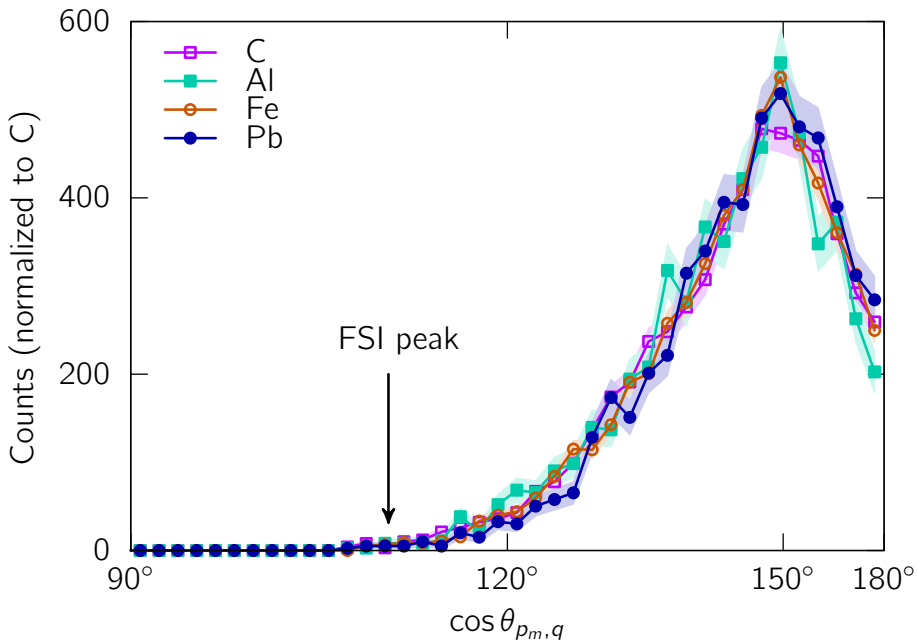
SRC events are selected in kinematics that minimize final-state interactions.



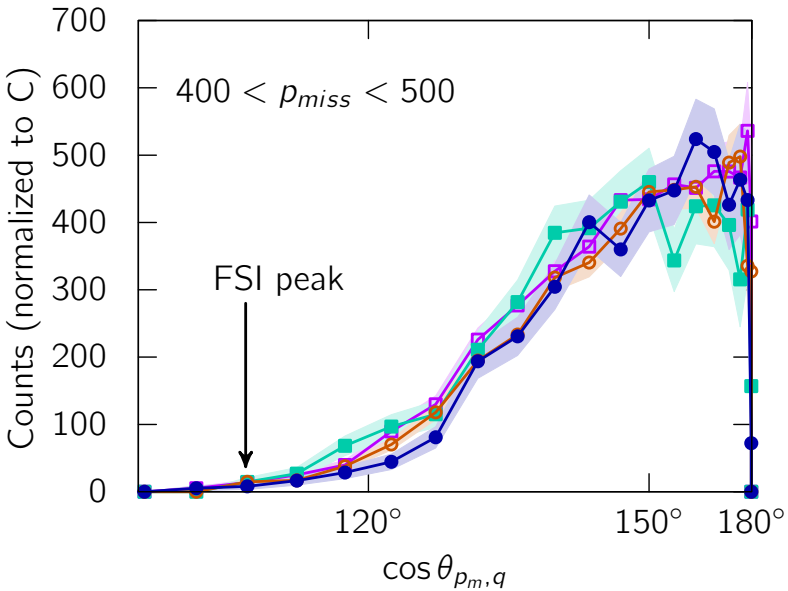
$\vec{p}_{\text{miss}}$ is anti-parallel to $\vec{q}$ for C, Al, Fe, Pb.

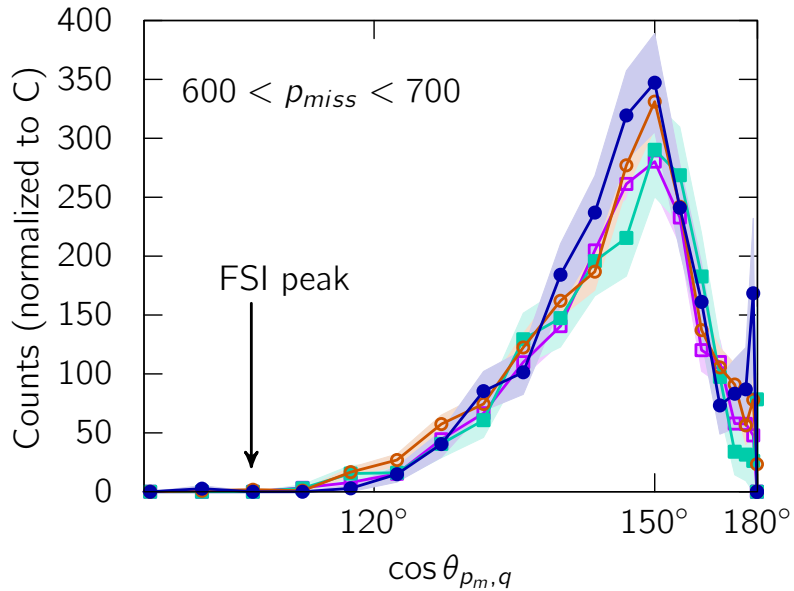


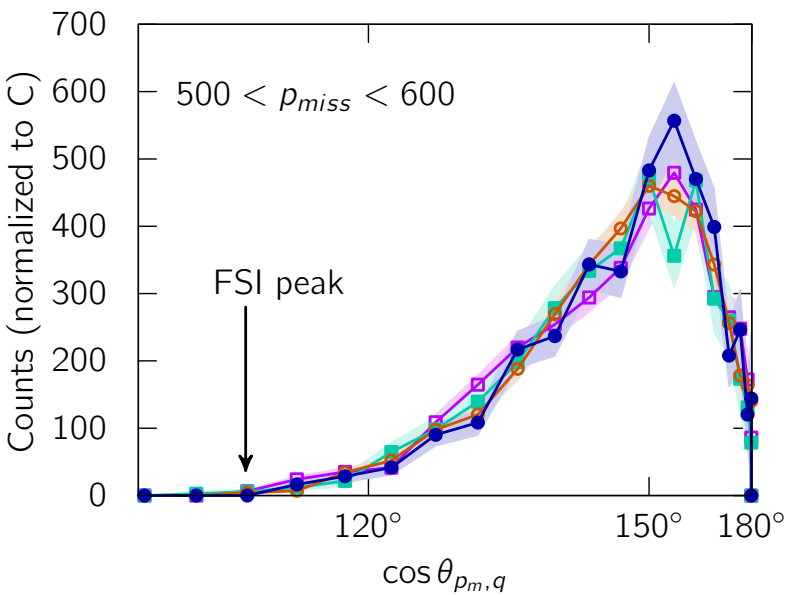


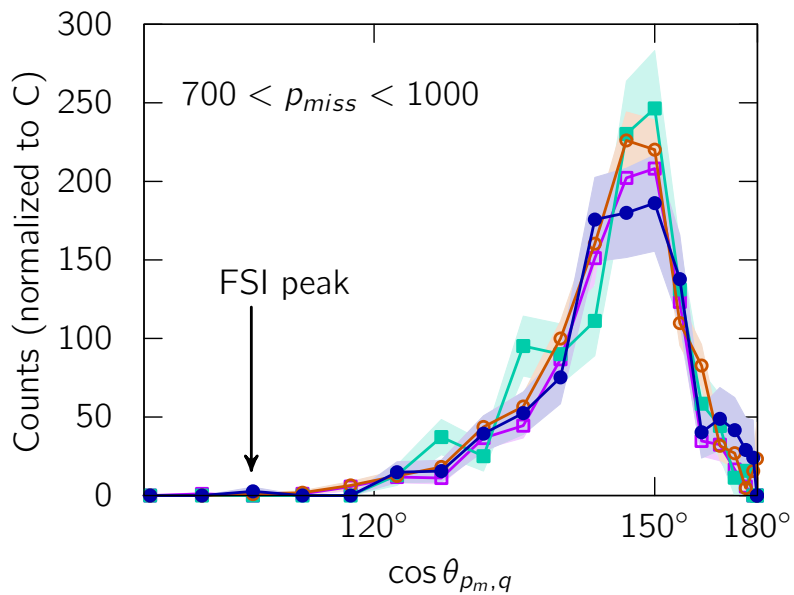


We remain anti-parallel over our p_{miss} range.









Event selection criteria

- $A(e, e'p)$
  - $x_B > 1.2$
  - $\theta_{pq} < 25^\circ$
  - $0.62 < |\vec{p}_p|/|\vec{q}| < 0.96$
  - $M_{miss} < 1.1$ GeV
  - $0.3 < |\vec{p}_{miss}| < 1.0$ GeV$/c$
  - Fiducial cuts on e', p

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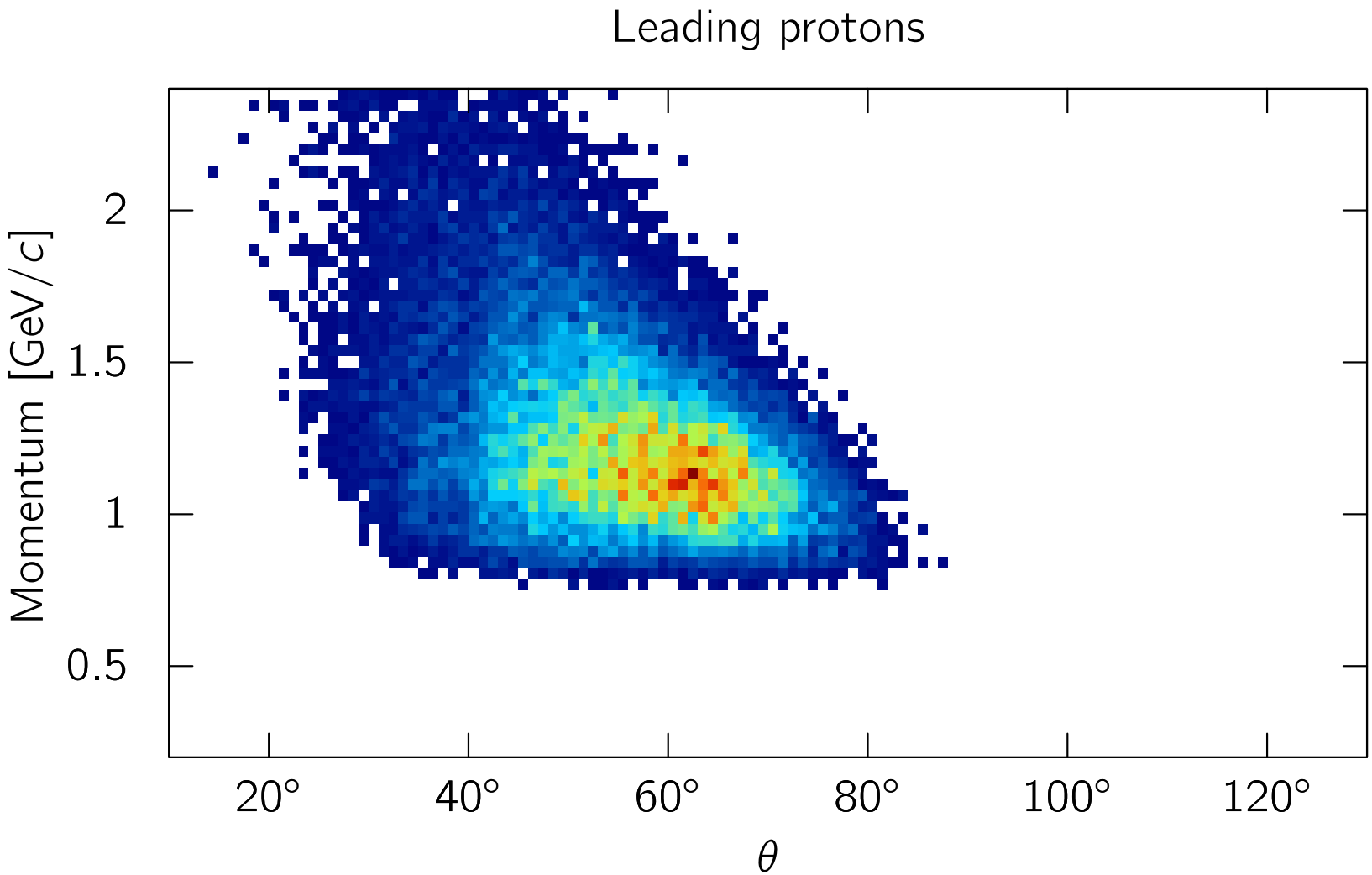
- $A(e, e'pp)$
  - Event passes $A(e, e'p)$ criteria
  - Additional recoil proton with $|\vec{p}| > 0.35$ GeV$/c$
    - . . . passing fiducial cuts

Leading and recoil protons are distinct.



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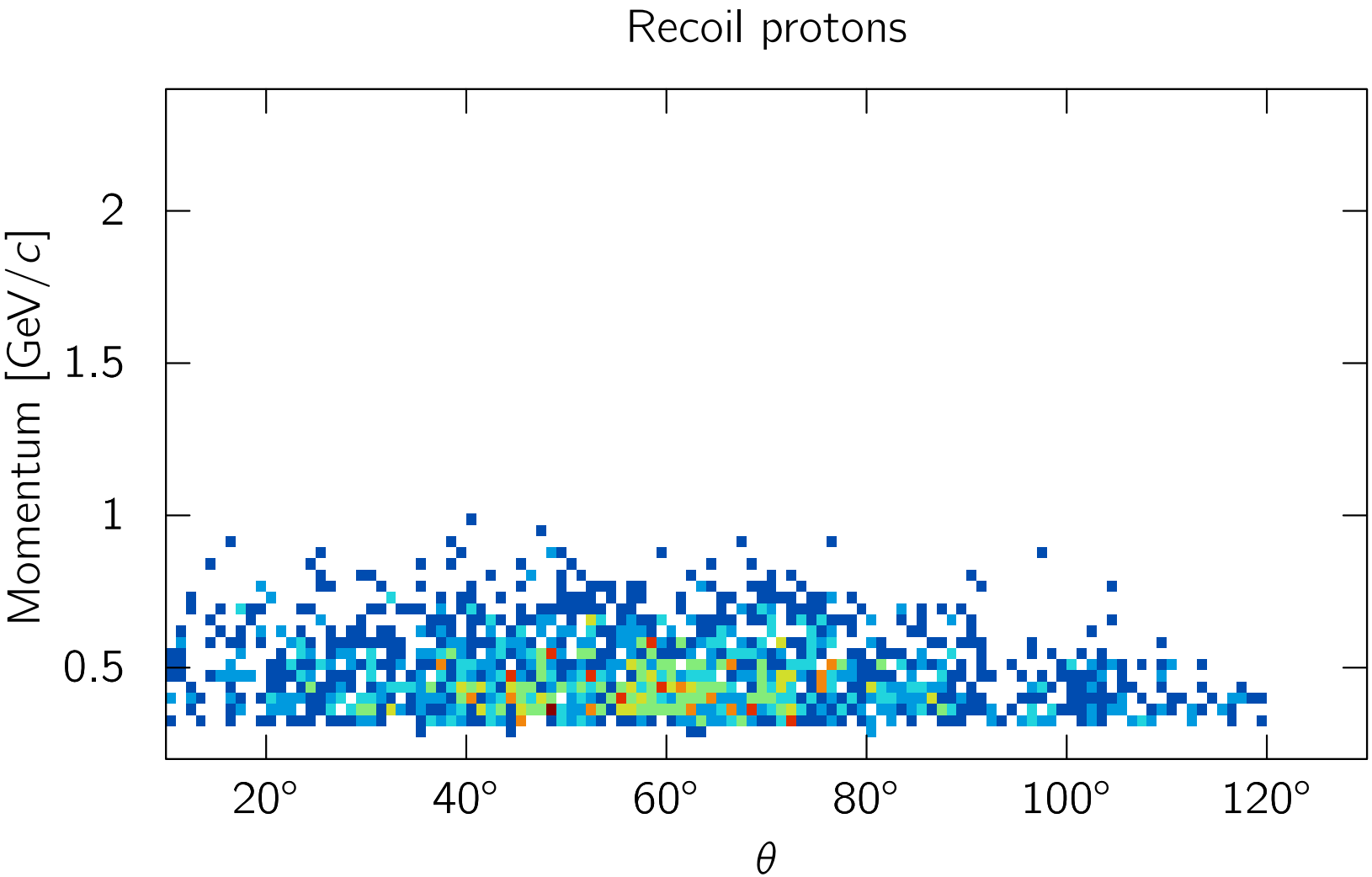

Data-Model comparisons

- Carbon data only
  - Contacts determined from fits to VMC

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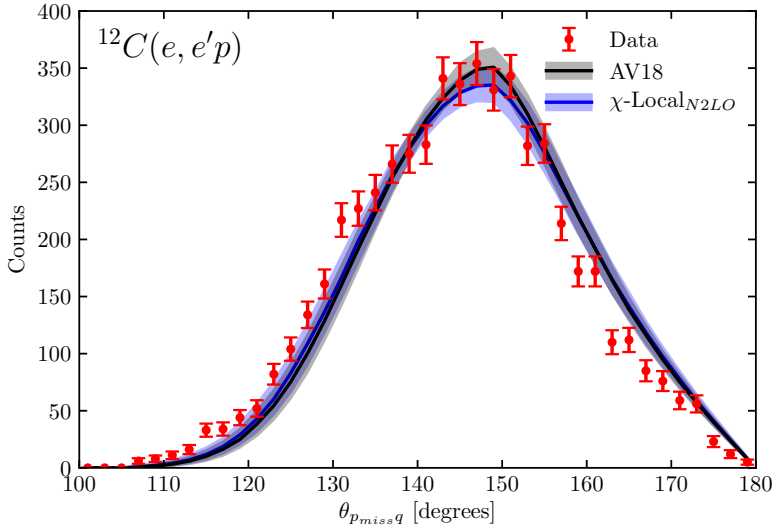
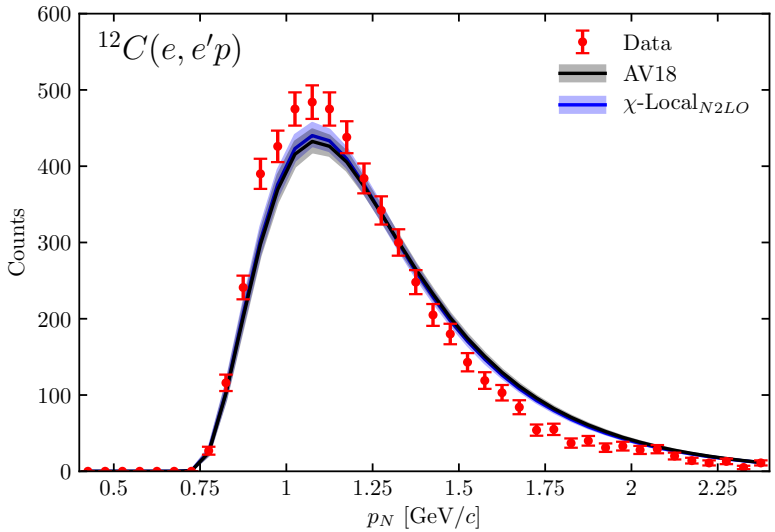
- Model uncertainty from:

- Contacts
- σ_{CM}
- SCX prob.
- Transparency
- $A-2$ excitation E^*
- $p_{\text{rel.}}$ cut-off
- e^- res.
- p res.

The model accurately predicts kinematics.

C$(e, e'p)$





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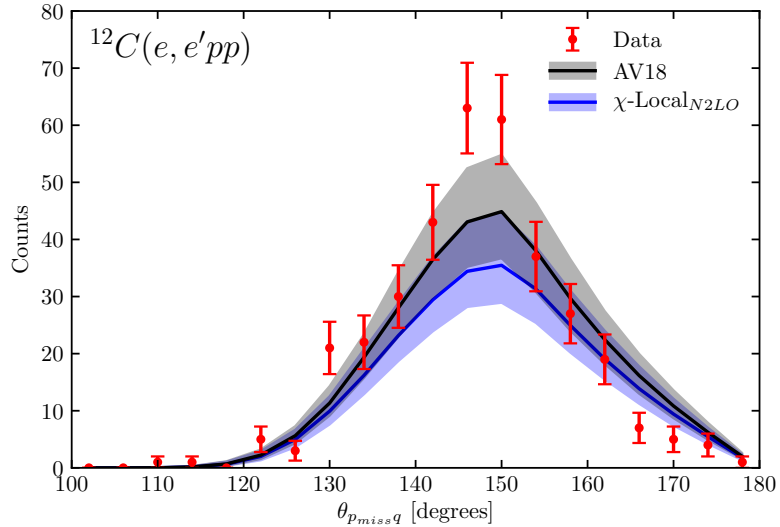
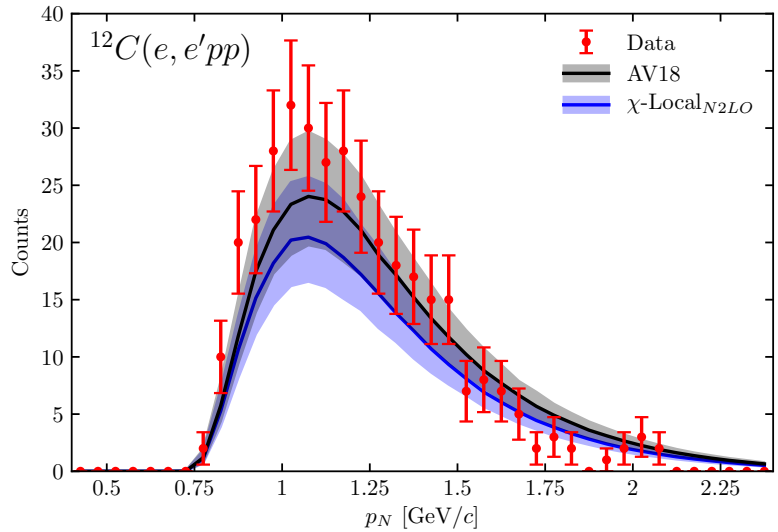
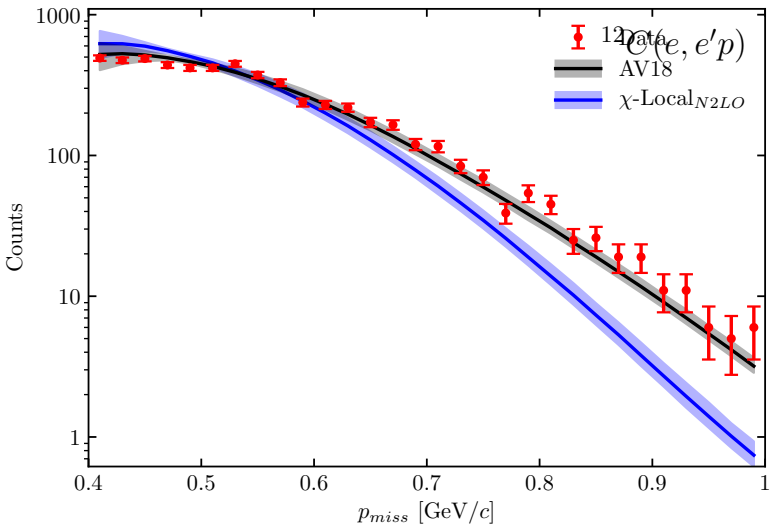




Missing-momentum distributions

C$(e, e'p)$



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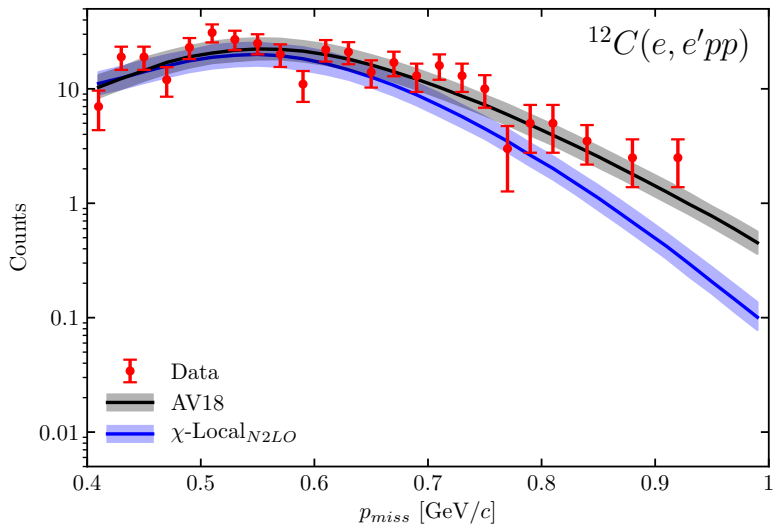
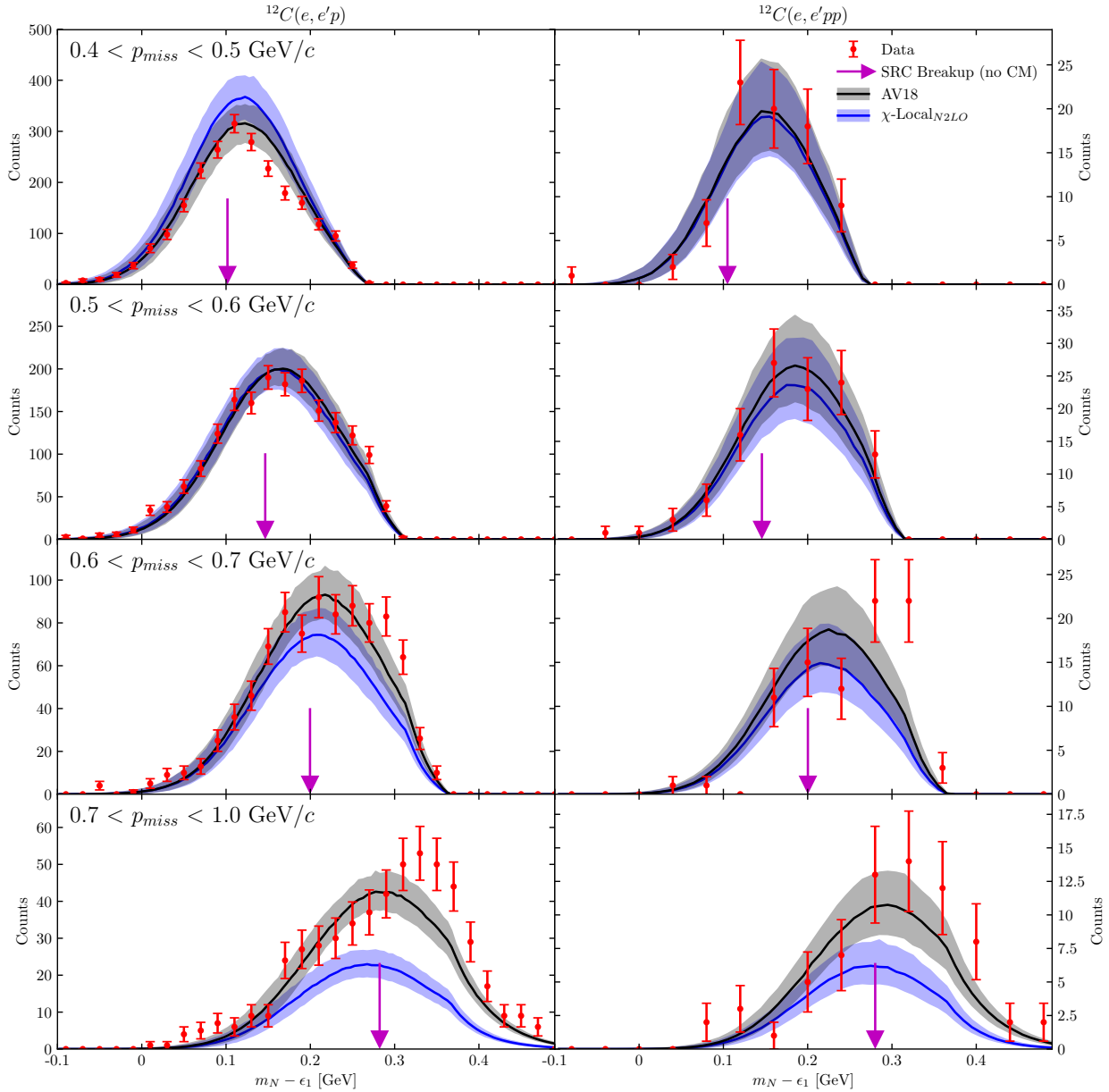
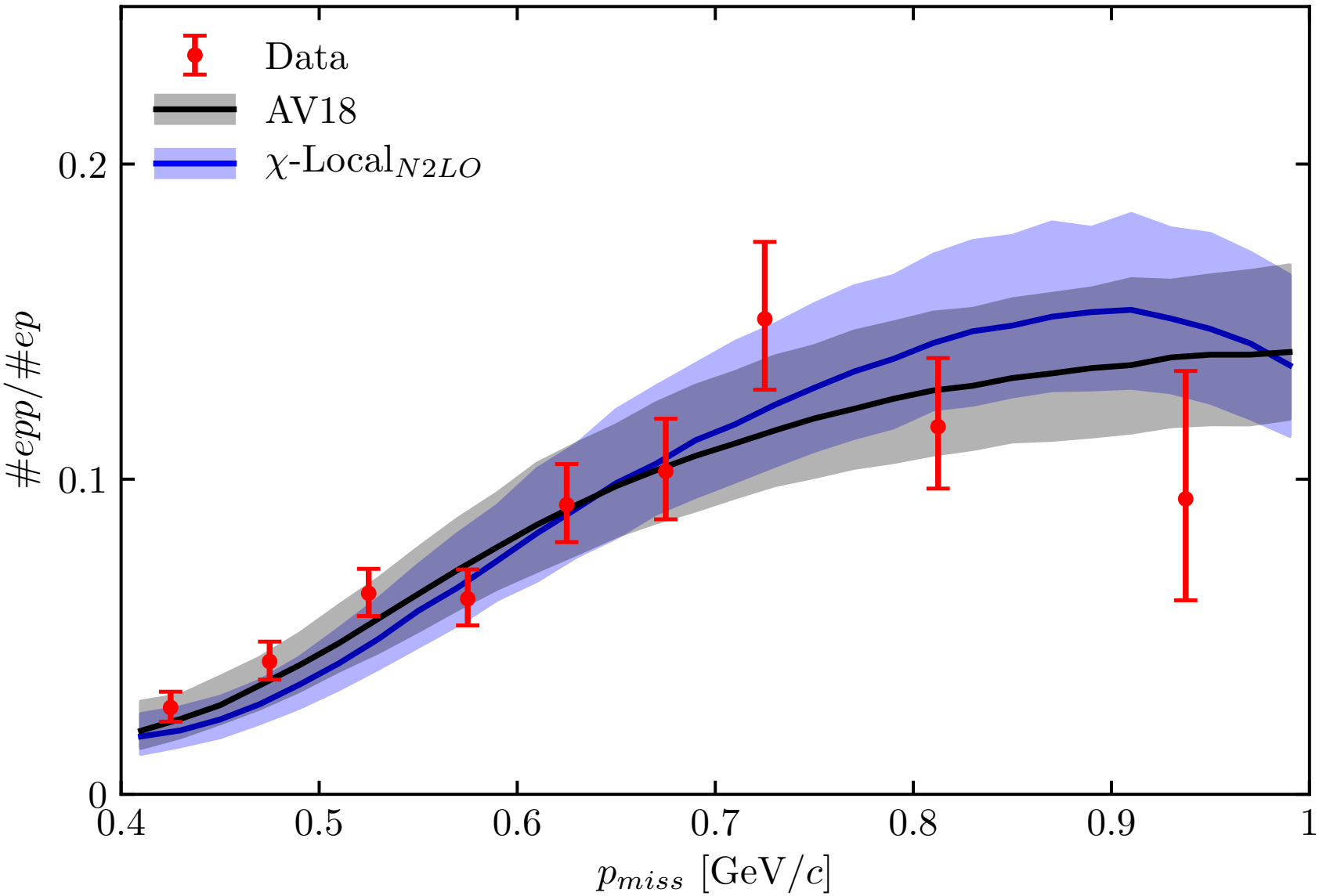


Missing-momentum and missing-energy



$(e, e'pp)/(e, e'p)$ ratio

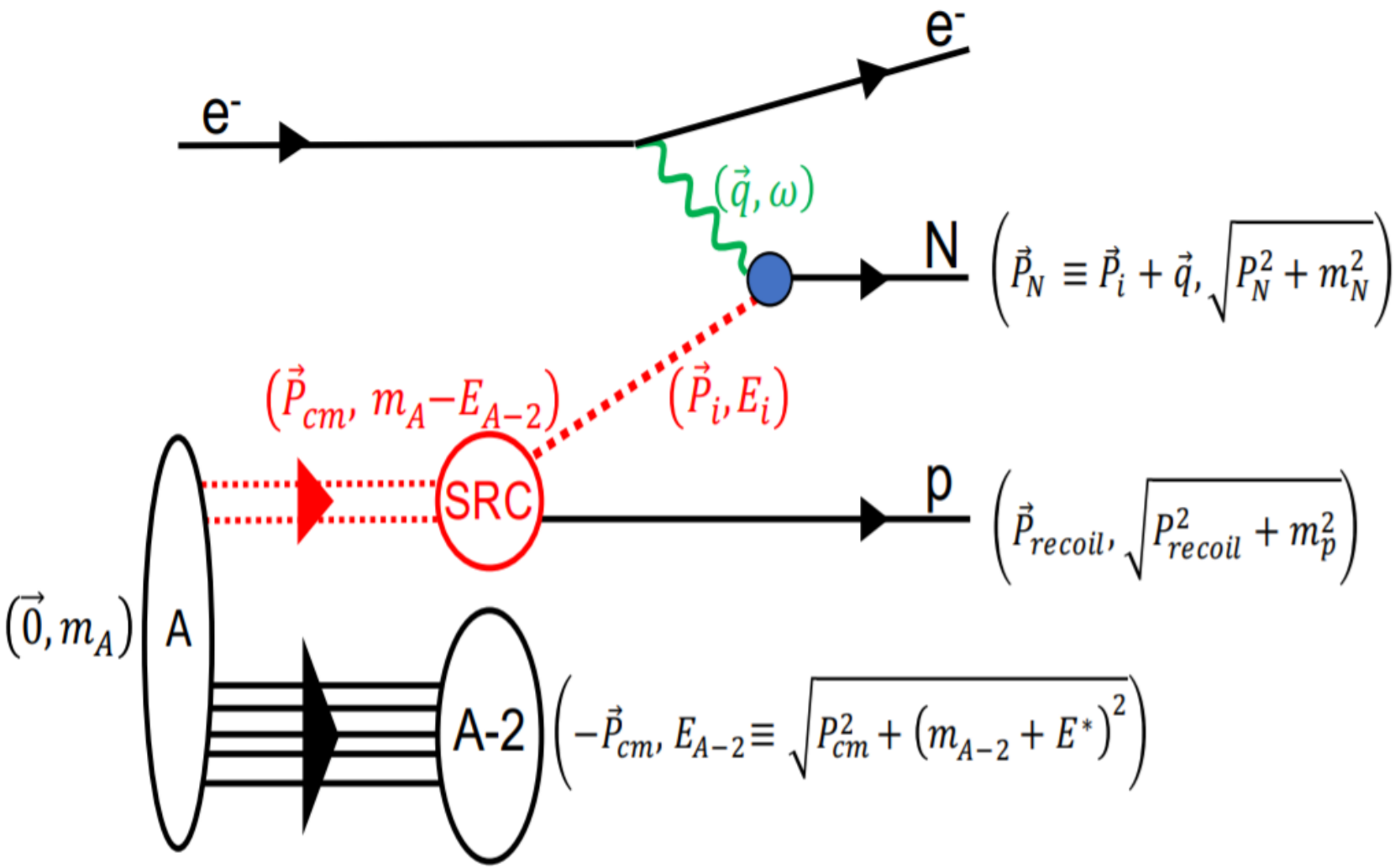


My controversial claim:

Our new analysis shows that SRC data can constrain the NN interaction *up to relative momenta of 1 GeV/c.*

BACK-UP

Reaction


e-
e-
$(\vec{q},\omega)$
N
$\left(\vec{P}_N \equiv \vec{P}_i + \vec{q}, \sqrt{P_N^2 + m_N^2}\right)$
$(\vec{P}_{cm},\ m_A - E_{A-2})$
$(\vec{P}_i, E_i)$
SRC
p
$\left(\vec{P}_{recoil}, \sqrt{P_{recoil}^2 + m_p^2}\right)$
$(\vec{0}, m_A)$
A
A-2
$\left(-\vec{P}_{cm}, E_{A-2} \equiv \sqrt{P_{cm}^2 + \left(m_{A-2} + E^*\right)^2}\right)$

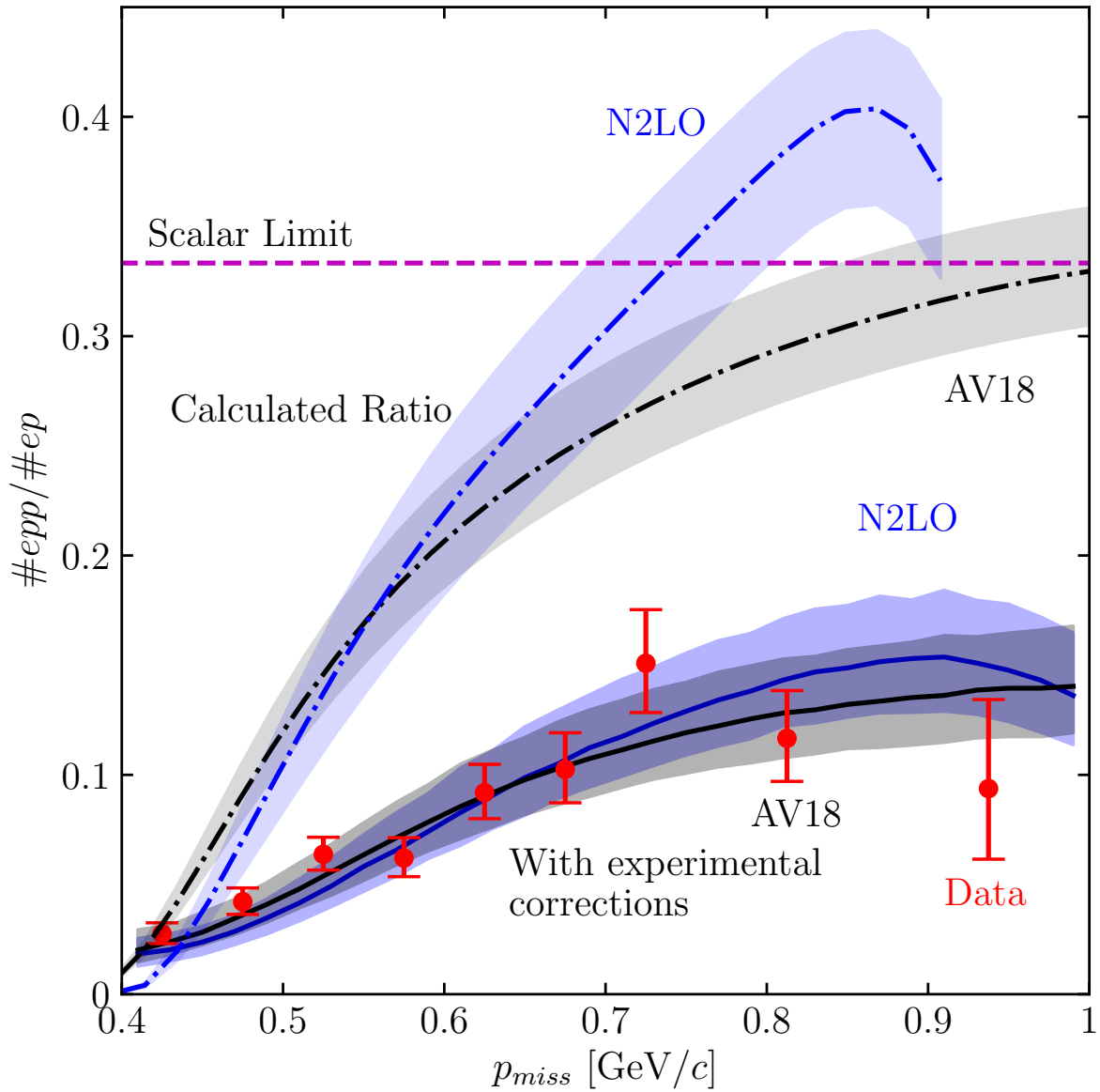
Model cross section

$$\frac{d^8\sigma}{dQ^2 dx_B d\phi_e d^3\vec{p}_{CM} d\Omega_2} = \frac{\sigma_{eN}}{32\pi^4} n(\vec{p}_{CM}) \mathcal{J} \sum_\alpha C_\alpha |\tilde{\varphi}^\alpha(|\vec{p}_{rel}|)|^2$$

$$\mathcal{J} = \frac{E_1' E_2 p_2^2}{|E_2(p_2 - Z\cos\theta_{Z,2}) + E_1' p_2|} \frac{\omega}{2E_{beam} E_e x_B}$$

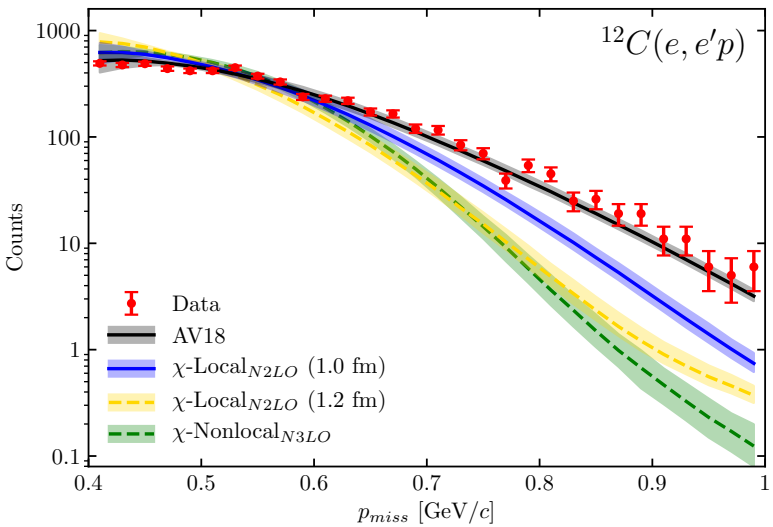
$$\vec{Z} \equiv \vec{q} + \vec{p}_{CM}$$

$(e, e'pp)/(e, e'p)$ ratio



Missing-momentum distributions

C$(e, e'p)$



C$(e, e'pp)$