Mapping the Mean-Field to SRC Transition

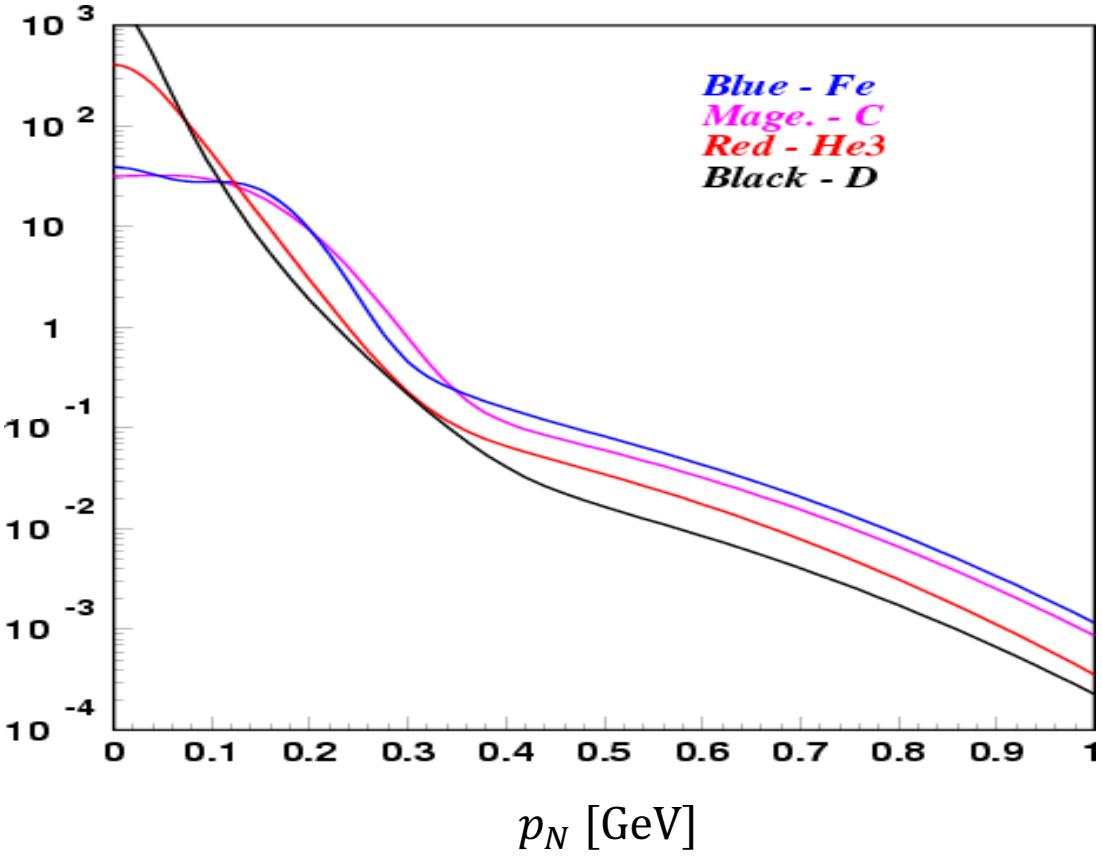
Andrew Denniston

MIT

August 6th , 2022

Mean-field + SRC

Nuclear Spectral Function



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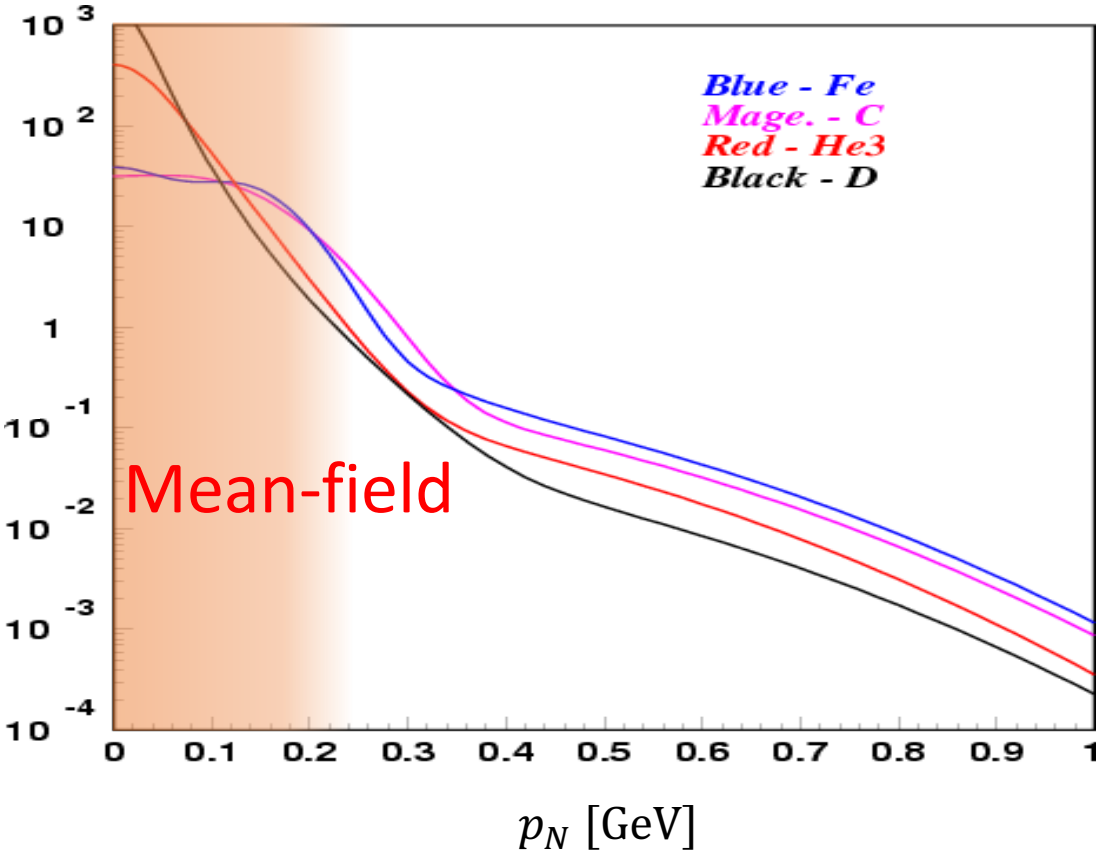

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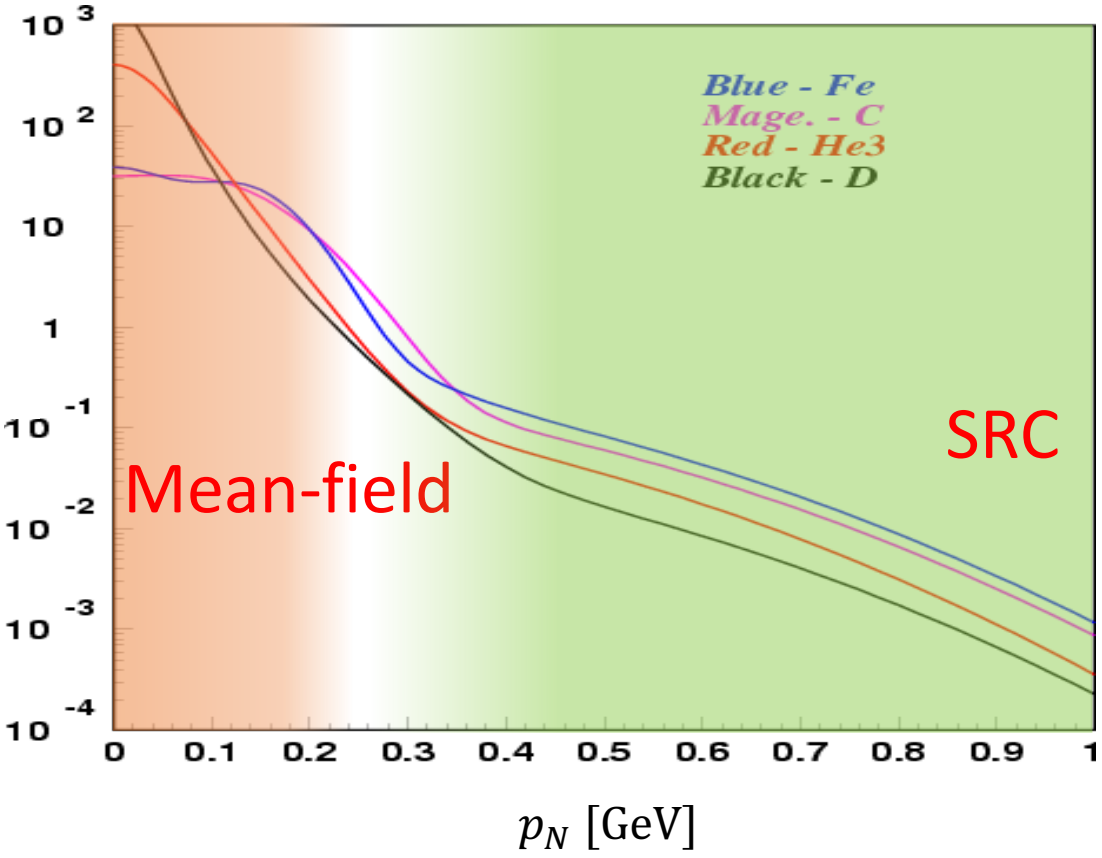

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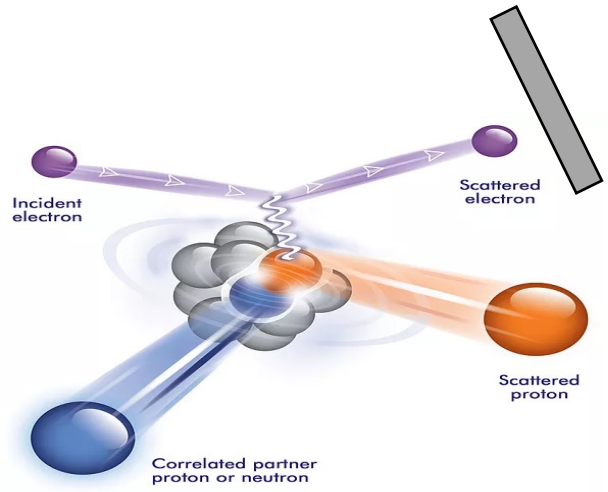

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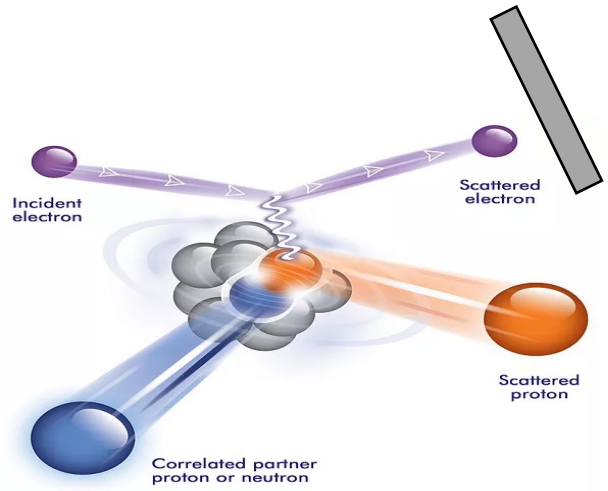

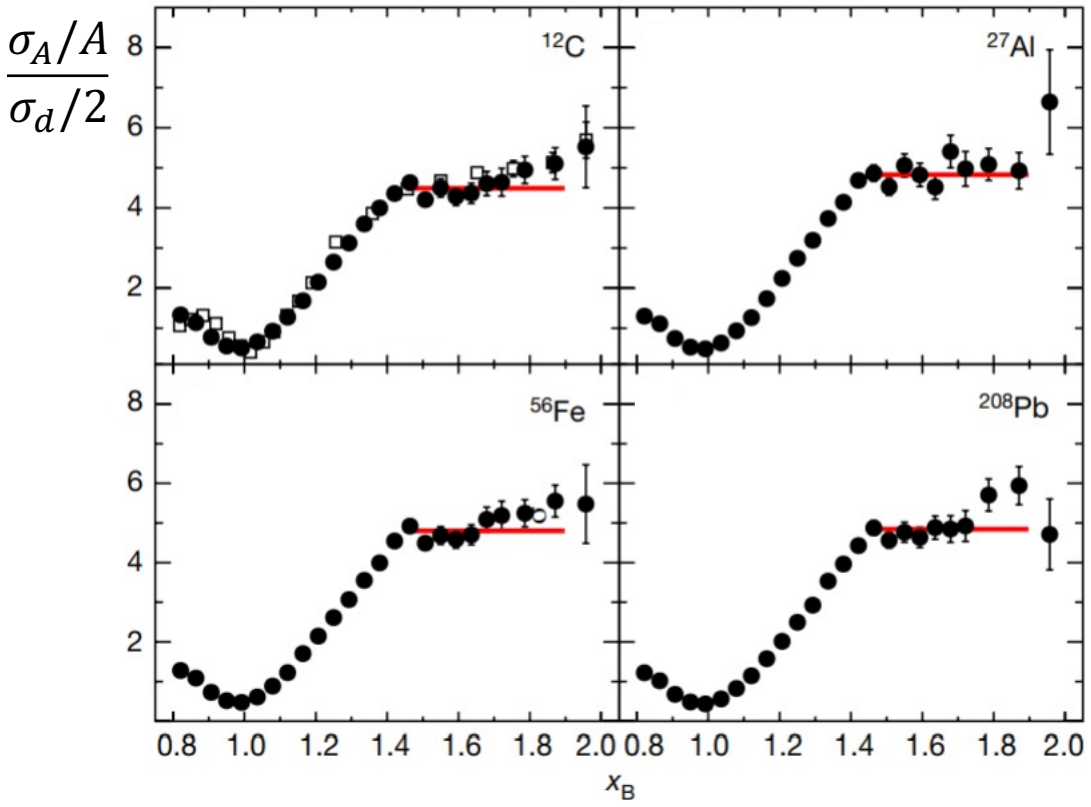

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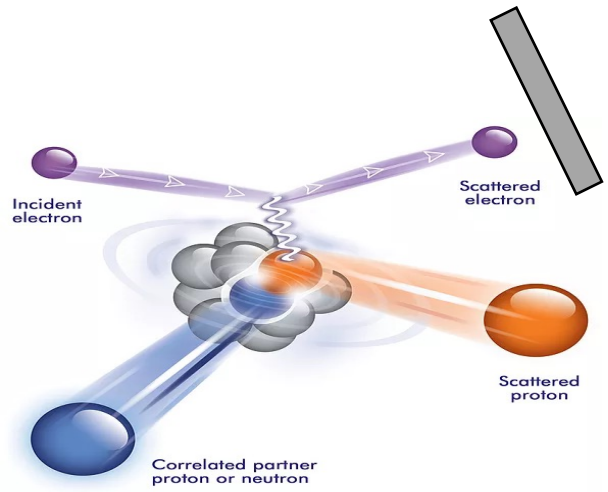

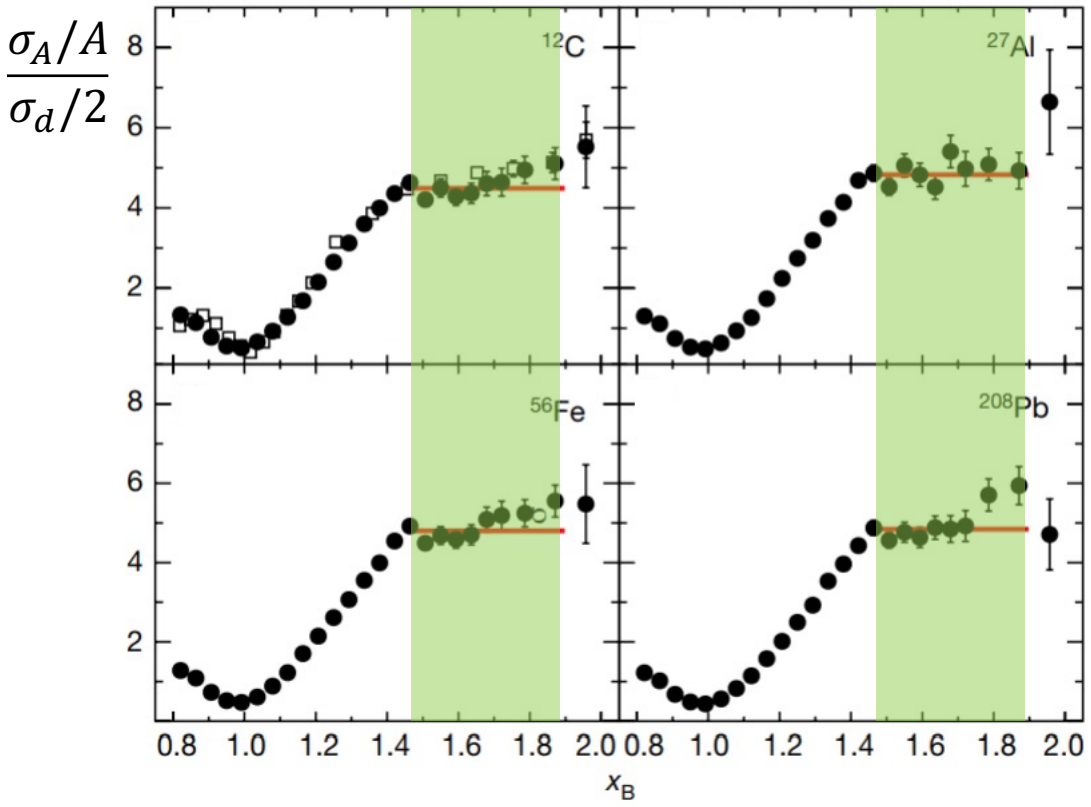

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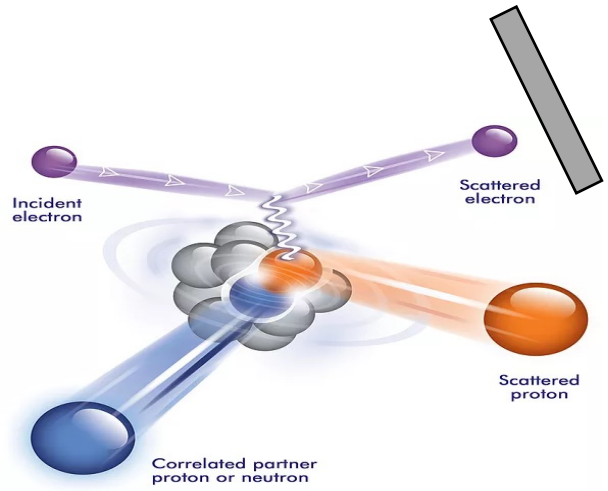
Looking for SRCs at low x_B



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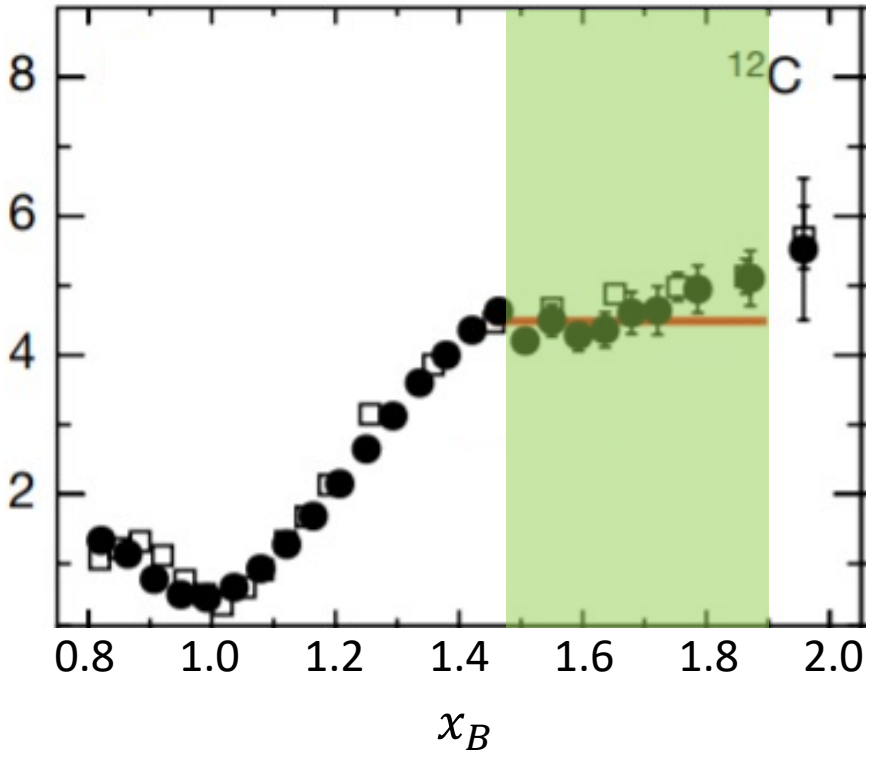

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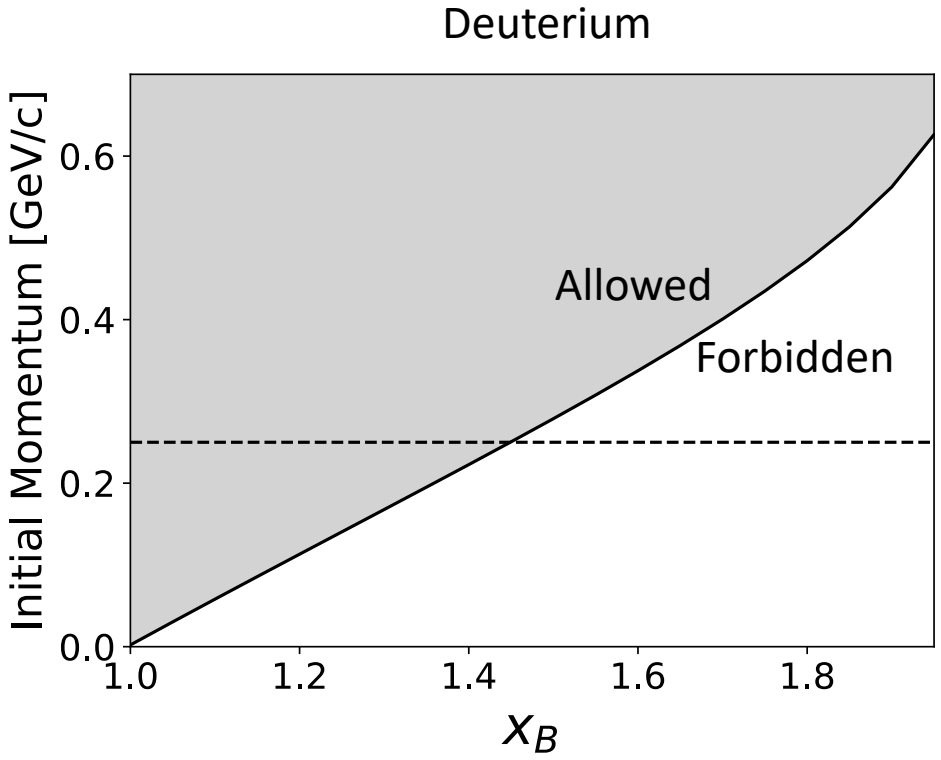

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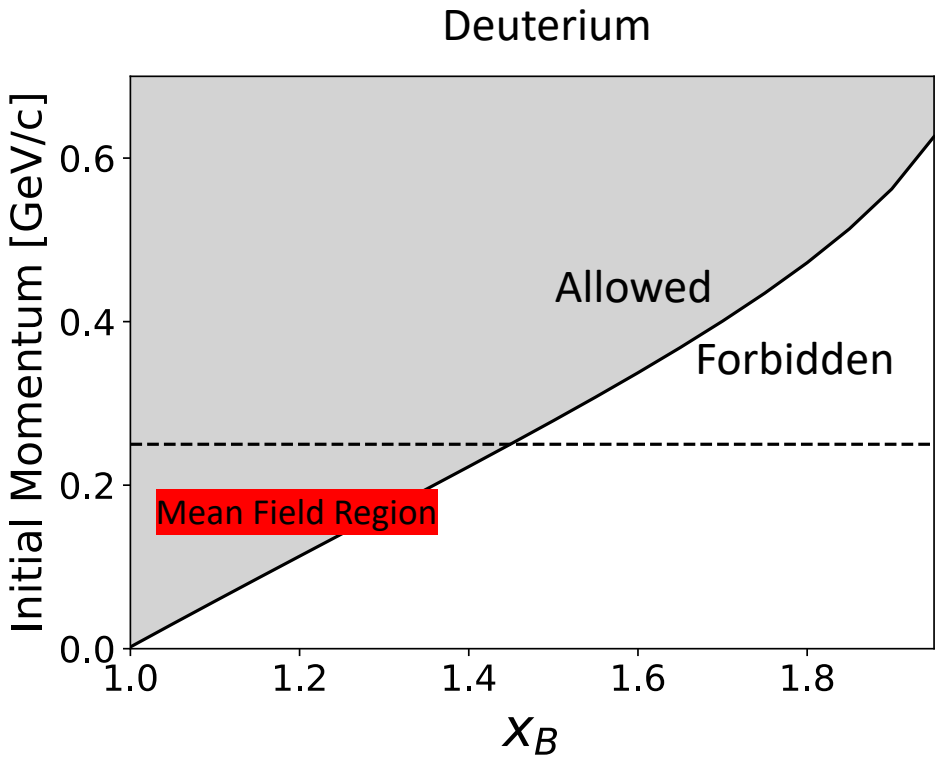

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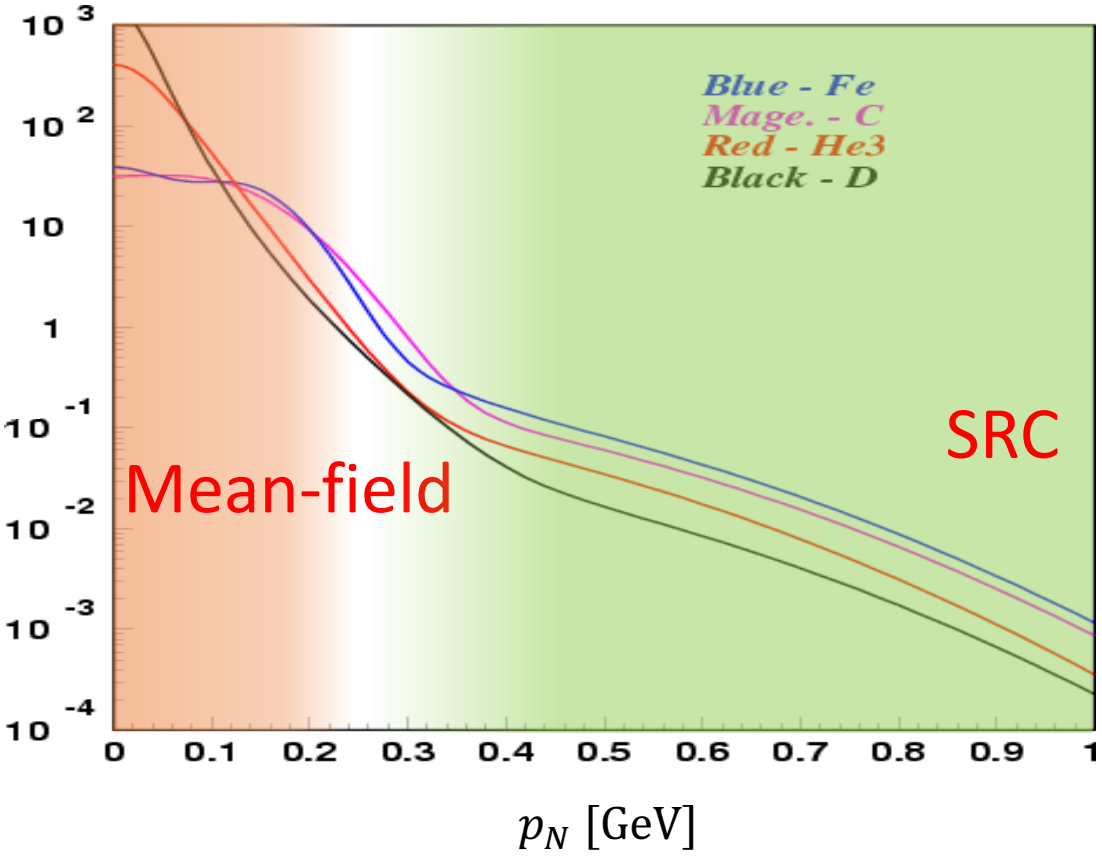

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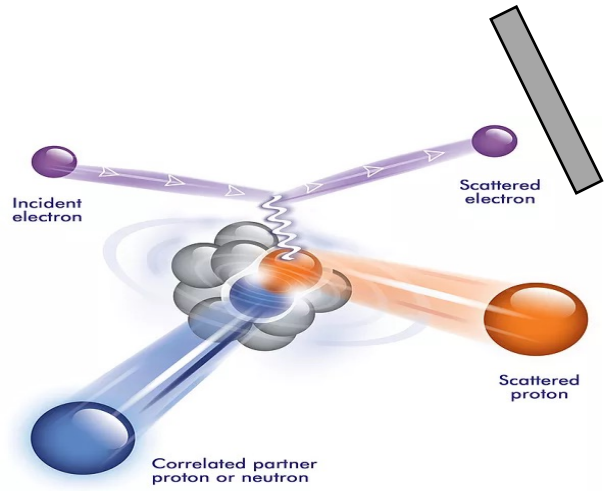

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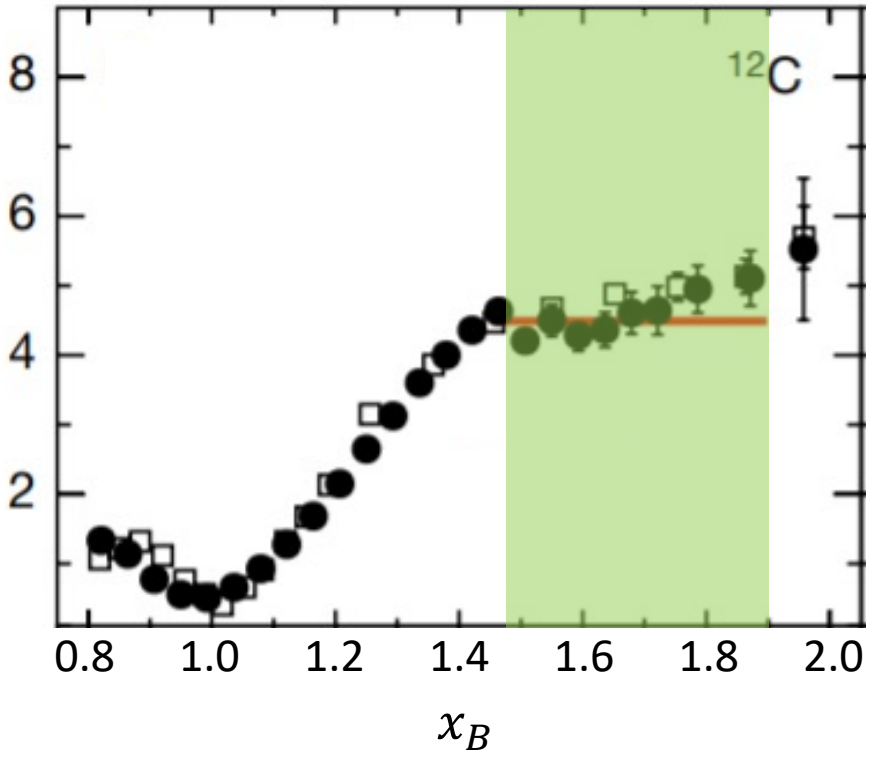

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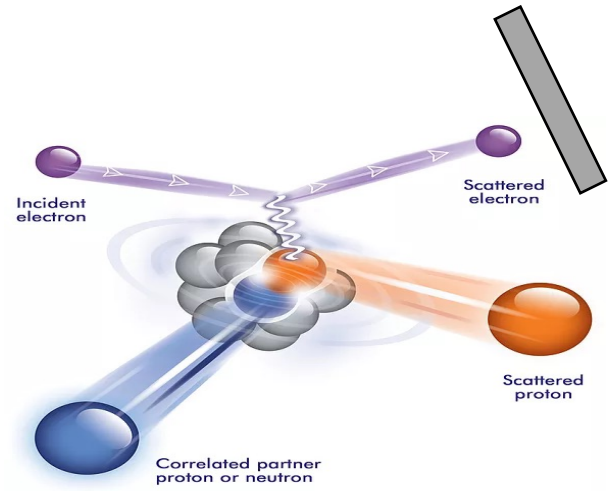

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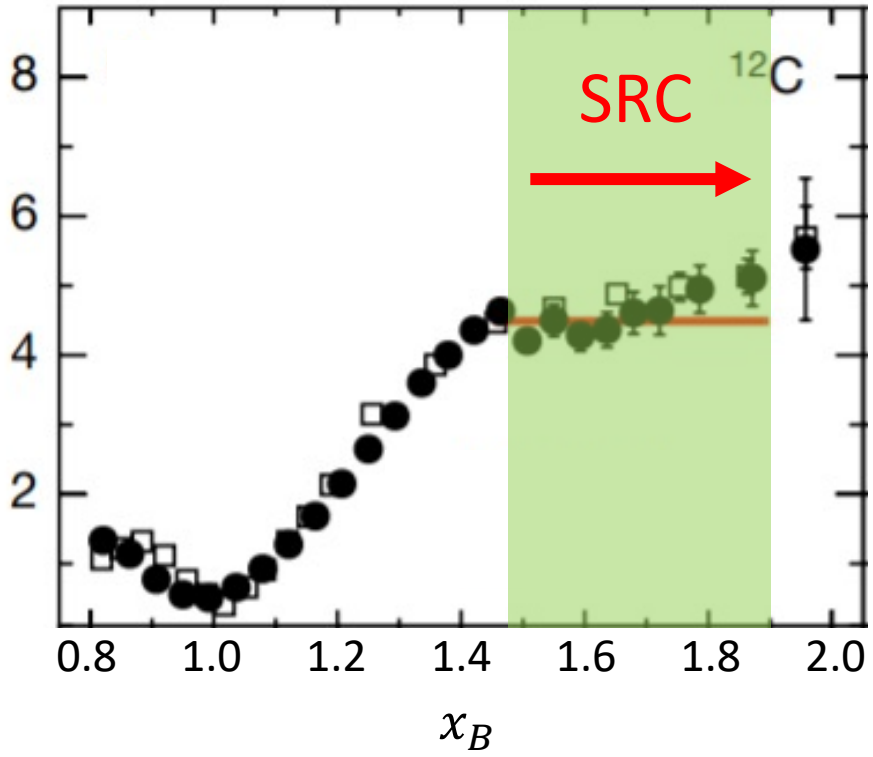

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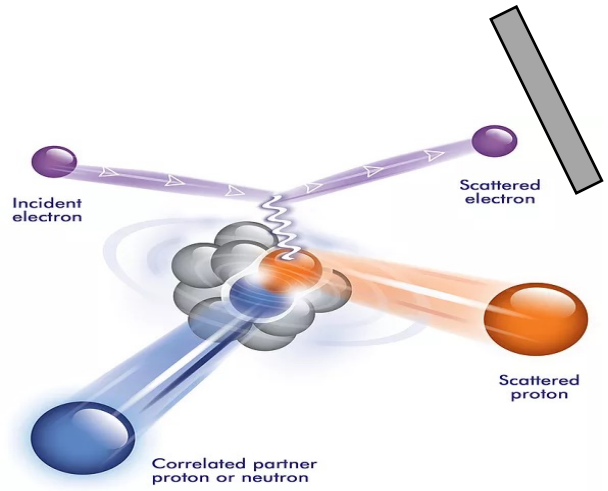

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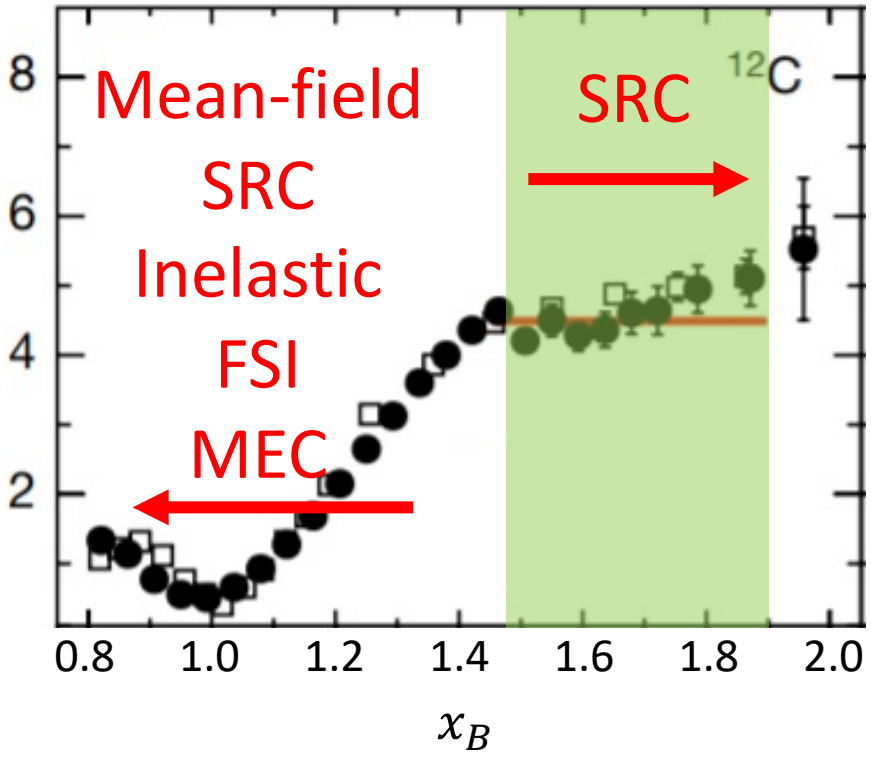

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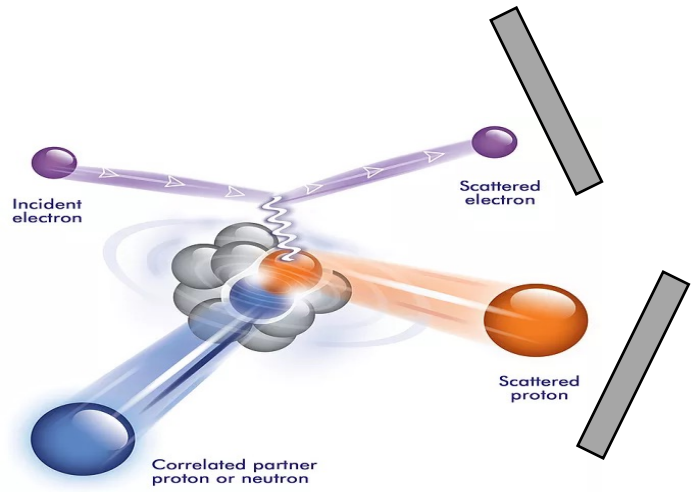
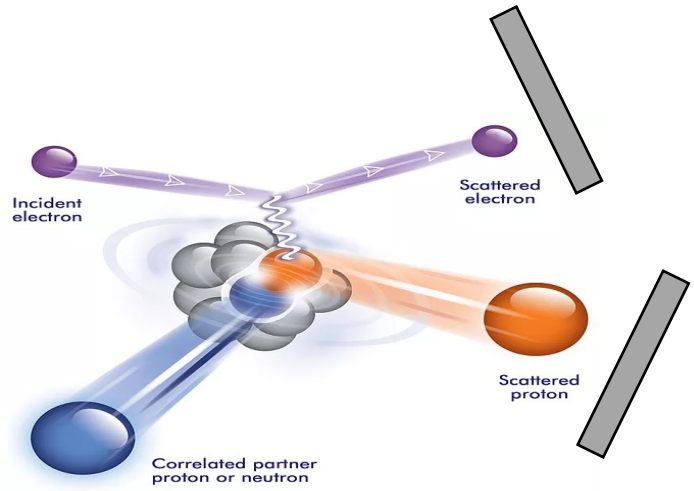
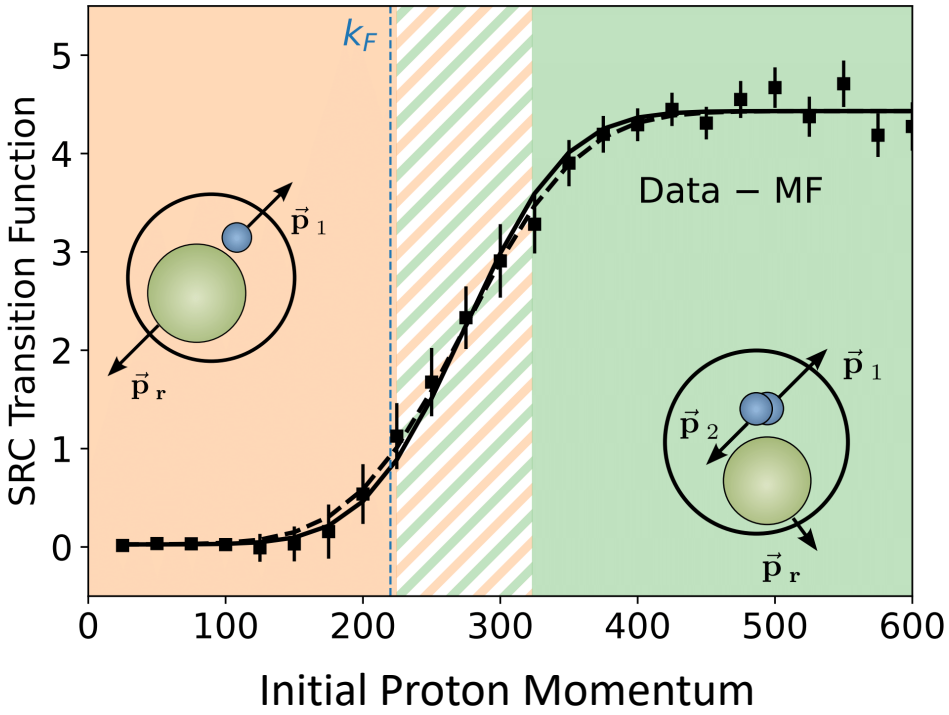
(e,e’) to (e,e’p)


Incident electron
Scattered electron
Scattered proton
Correlated partner proton or neutron

Mean-field to SRC Transition (e,e'p)

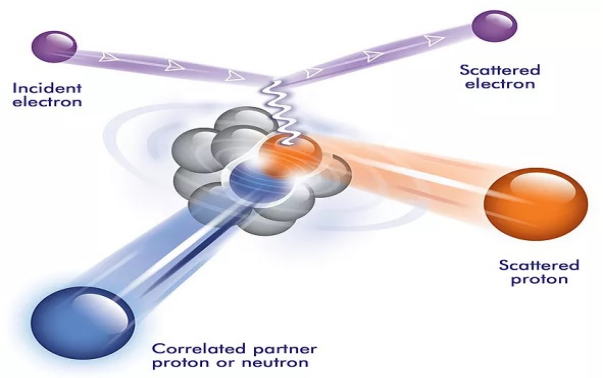




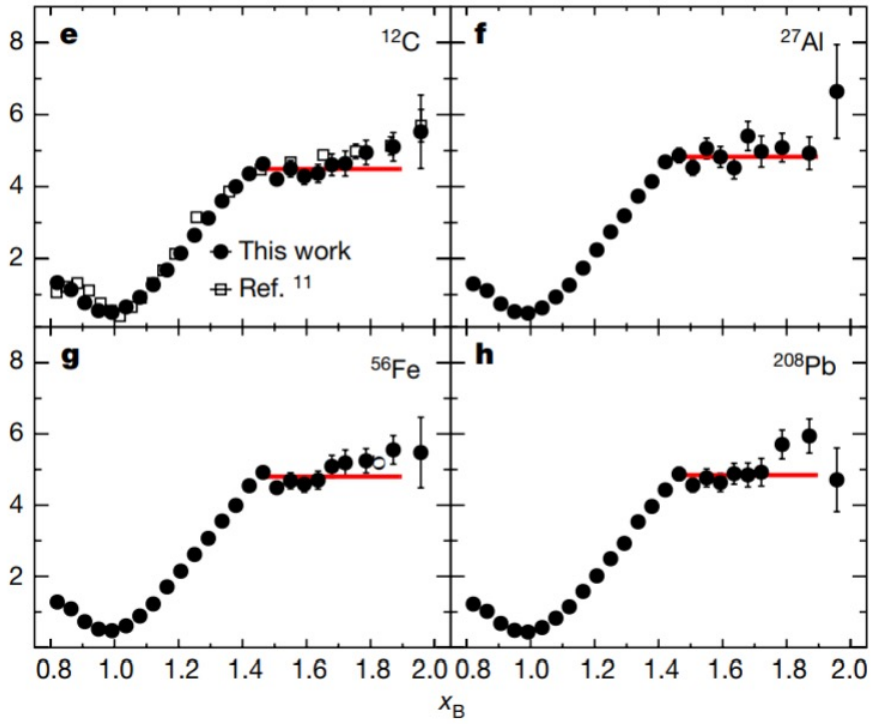
This Analysis

<u>CLAS eg2</u>

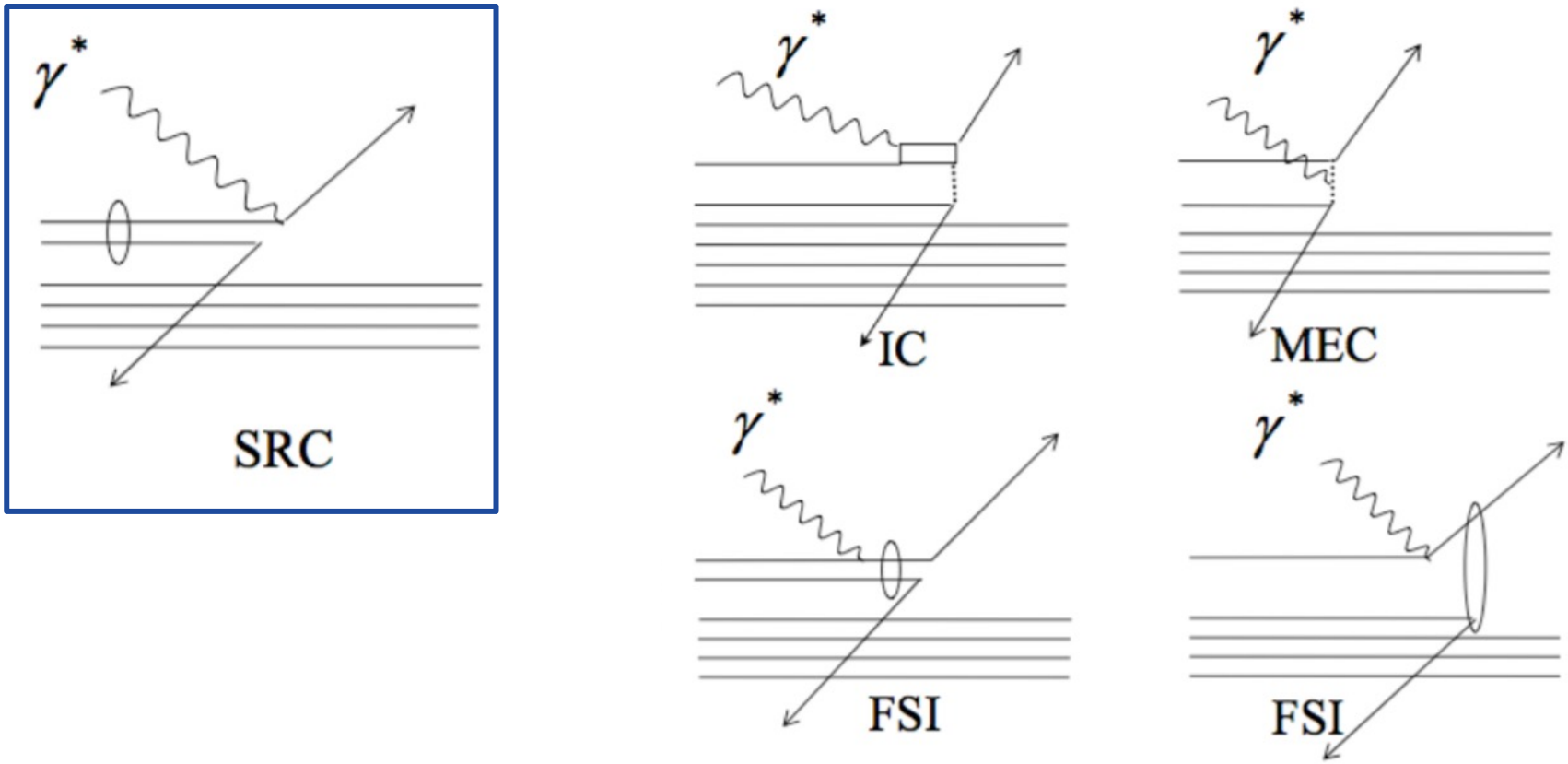
- 5 GeV
- (e,e'p)
- $d, {}^{12}C, {}^{27}Al, {}^{56}Fe, {}^{208}Pb$



$\frac{\sigma_A/A}{\sigma_d/2}$



Contributions to the Cross Section



- Frankfurt, Sargsian, and Strikman PRC (1997)
- Colle, Cosyn, and Ryckebusch, PRC (2016)

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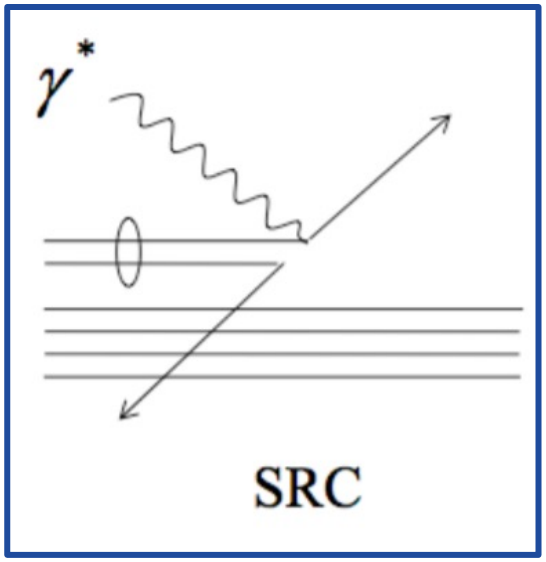

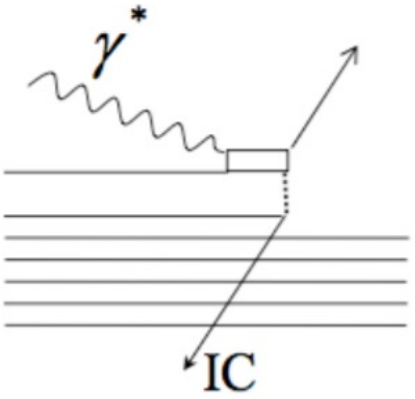

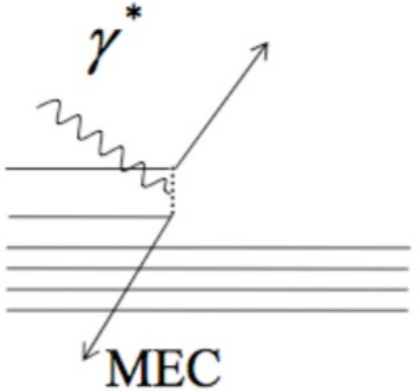

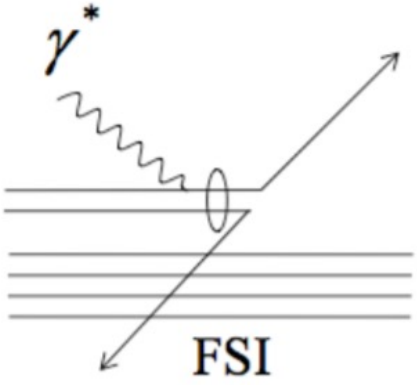

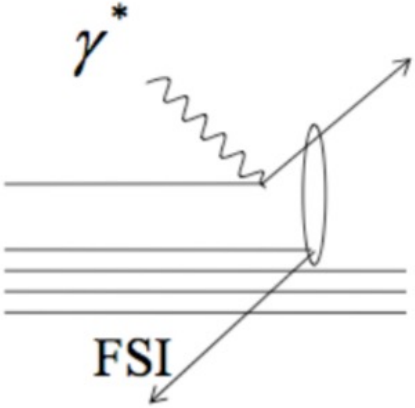

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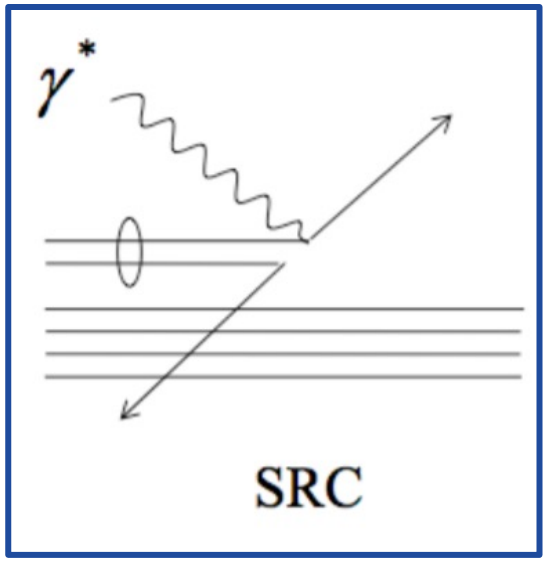

- Physics Letters B 722 (2013) 63–68
- Science 346, 614 (2014)
- Nature 560, 617–621 (2018)
- Physics Letters B 797 (2019) 134792
- Cohen et al. Phys. Rev. Lett. 121, 092501 2018
- Duer et al. Phys. Rev. Lett. 122, 172502 2019

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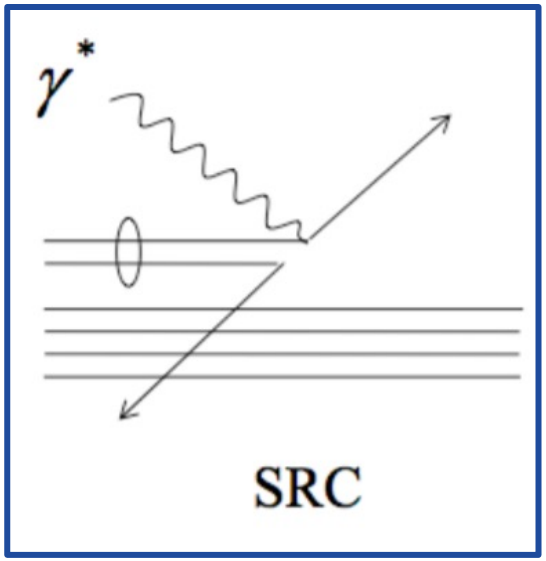

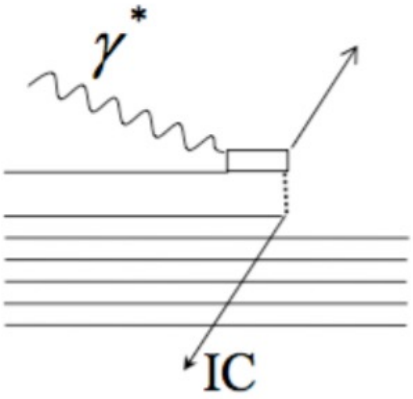

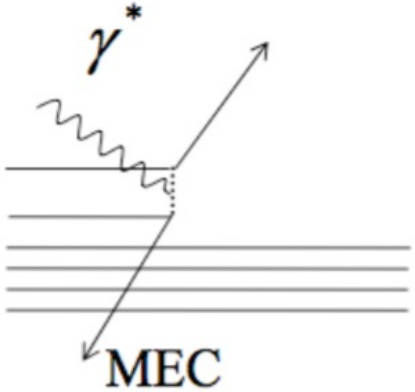

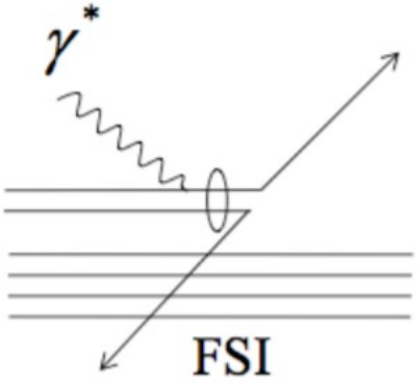

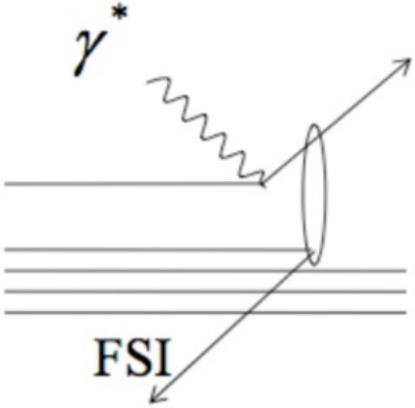

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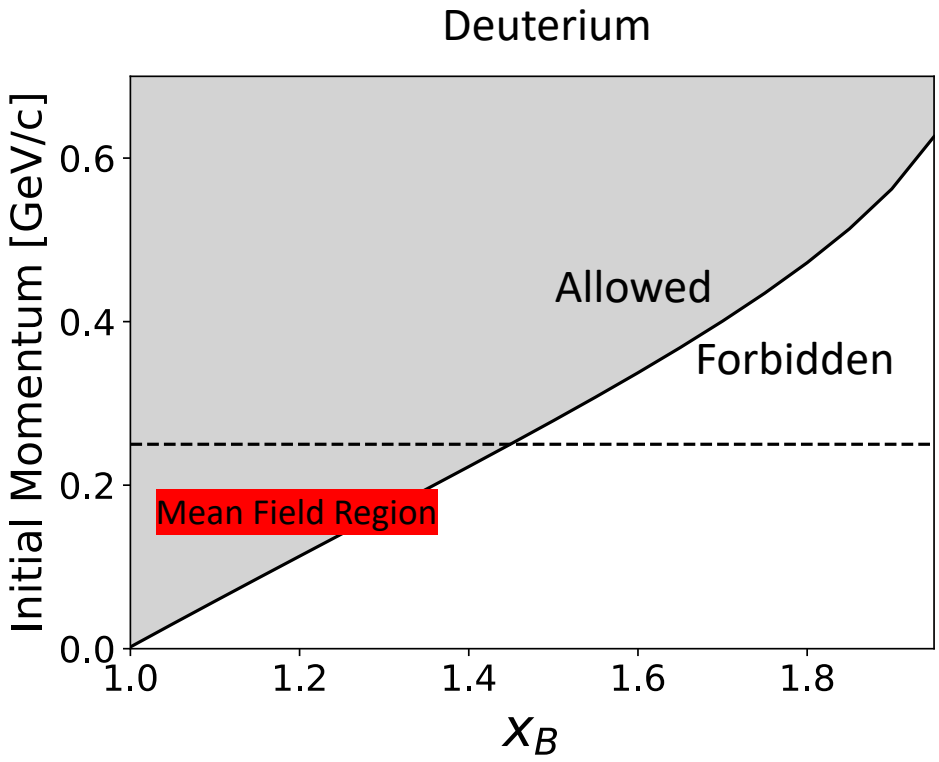

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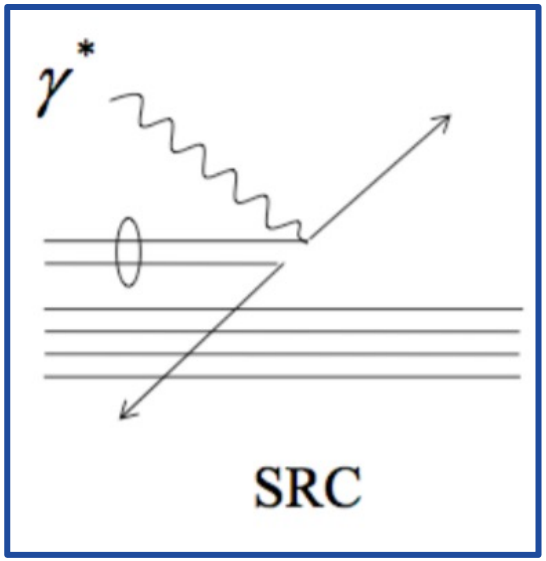

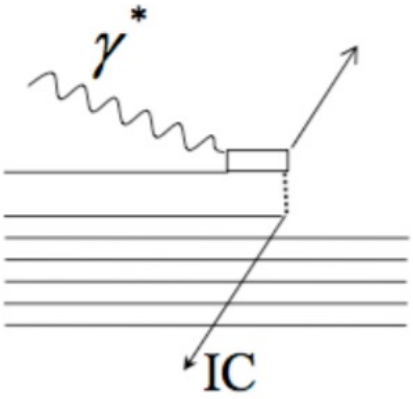

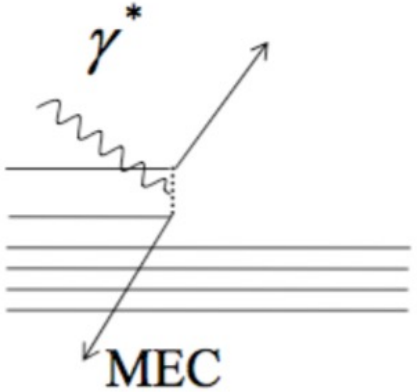

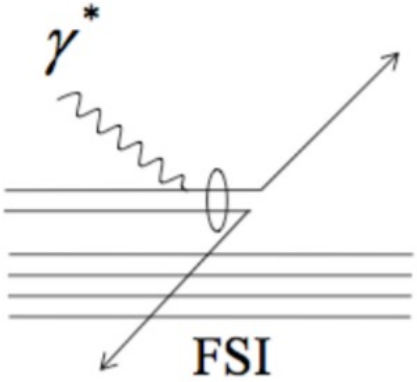

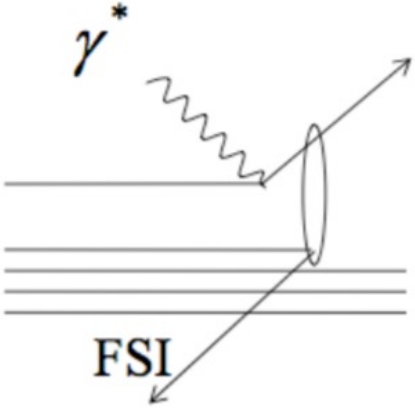

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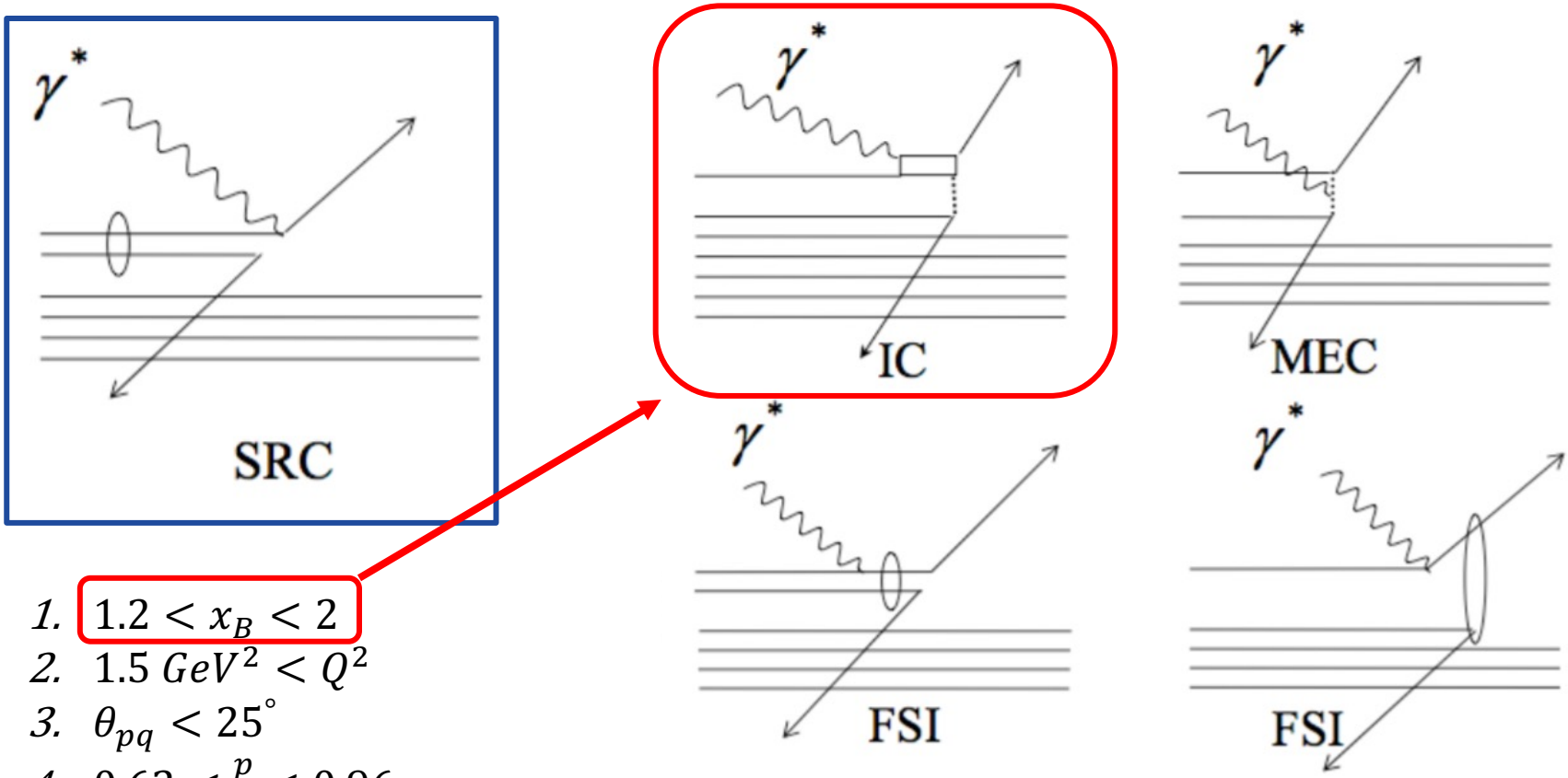

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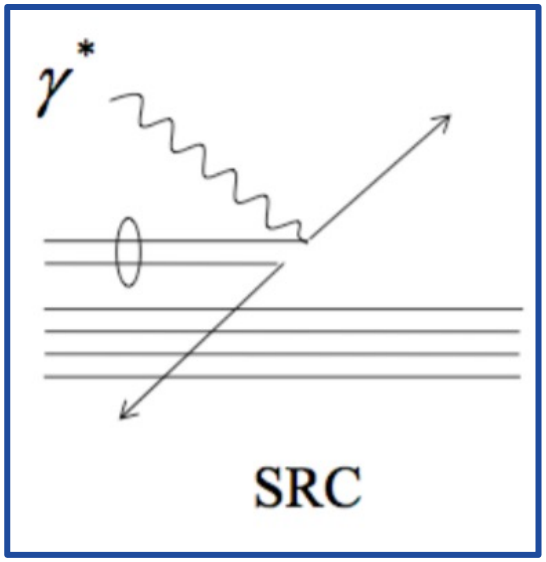

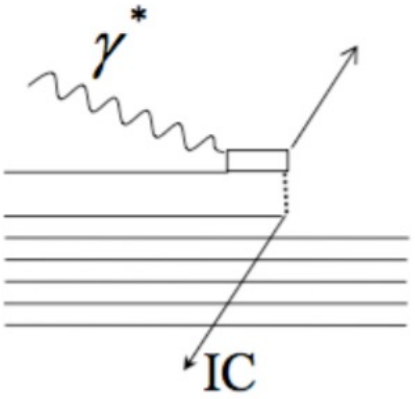

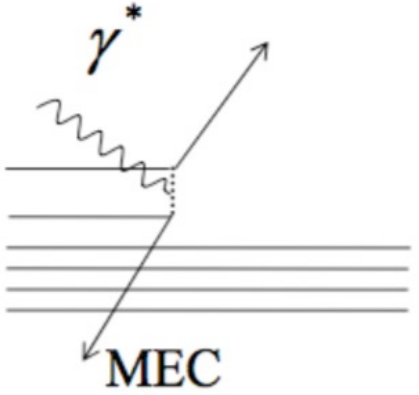

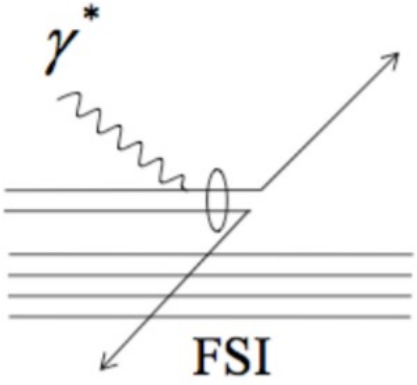

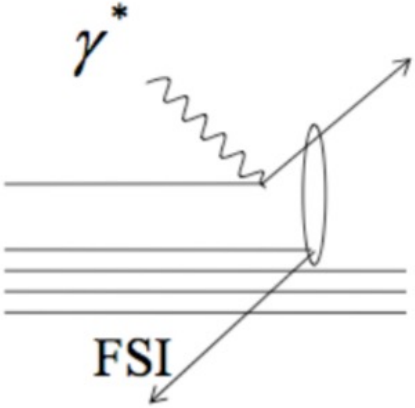

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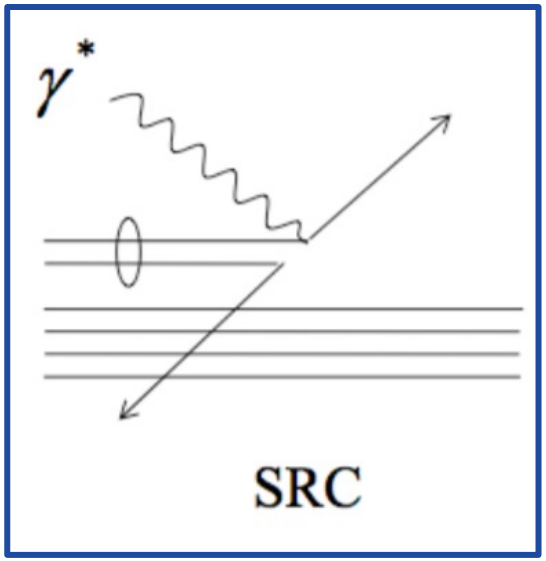
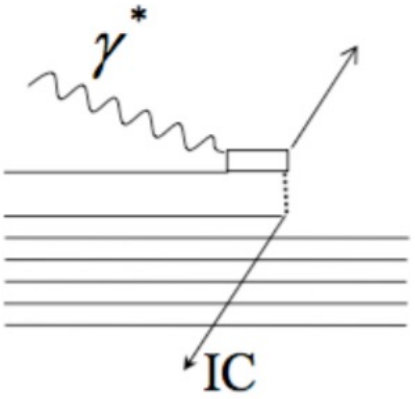
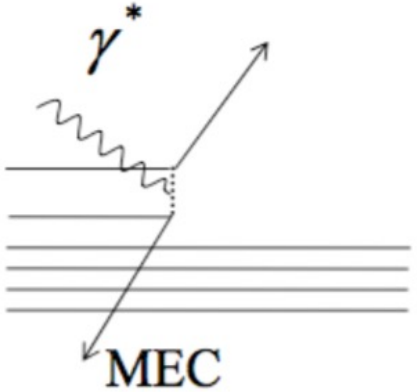
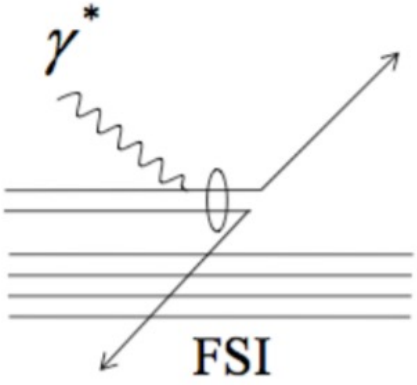
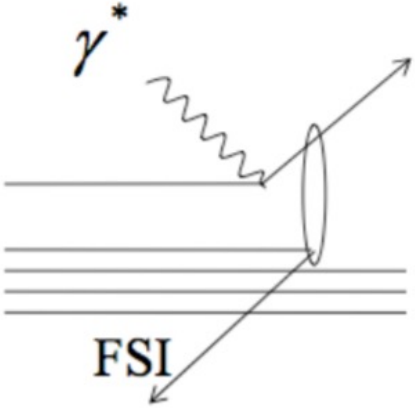




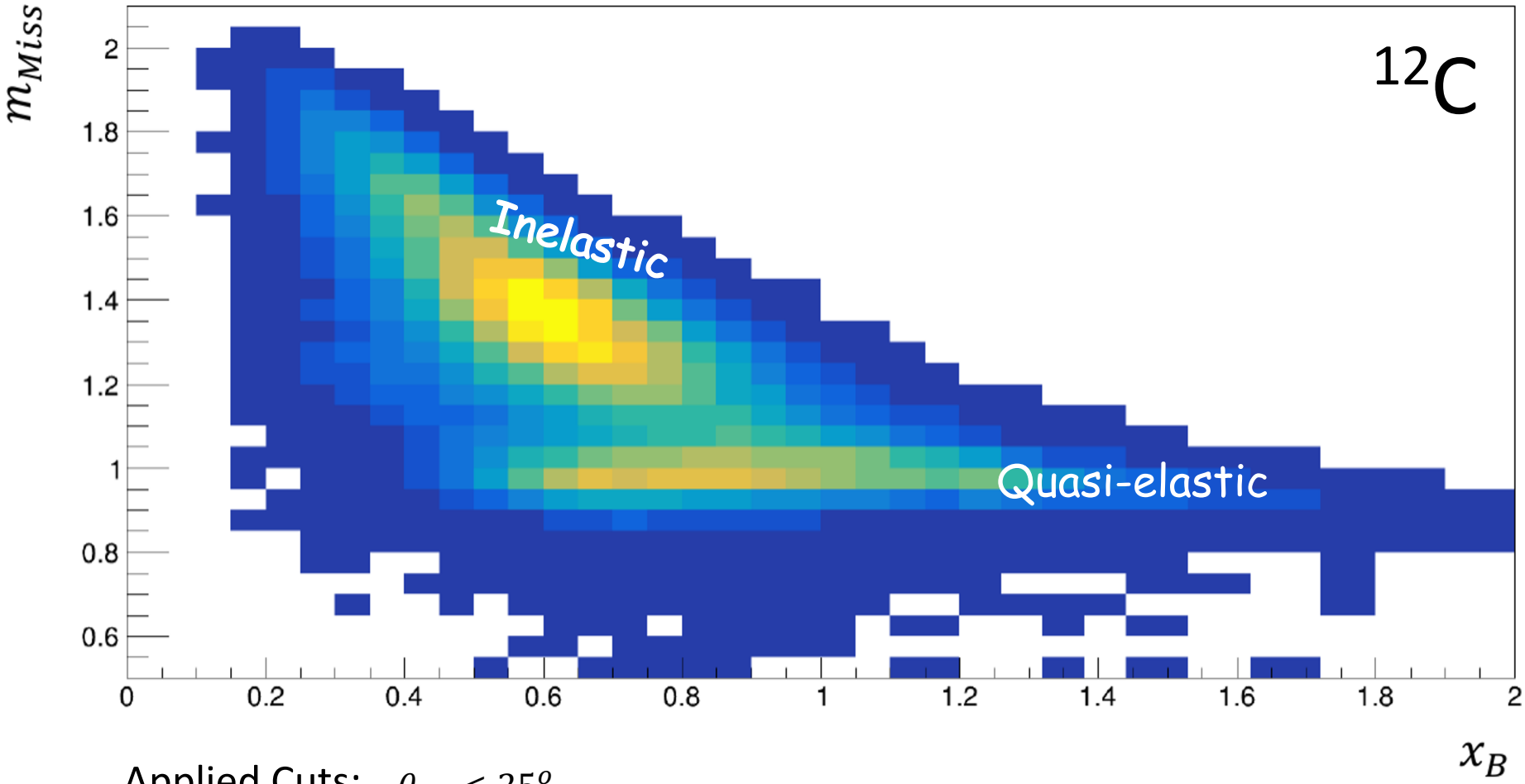






1. $1.2 < x_B < 2$
2. $1.5\ GeV^2 < Q^2$
3. $\theta_{pq} < 25^\circ$
4. $0.62 < \frac{p}{q} < 0.96$
5. $0.8\ GeV < m_{Miss} < 1.08\ GeV$
6. $0.3\ GeV < p_{Miss} < 0.6\ GeV$
7. $\theta_{miss,q}(x_B)$ Cut

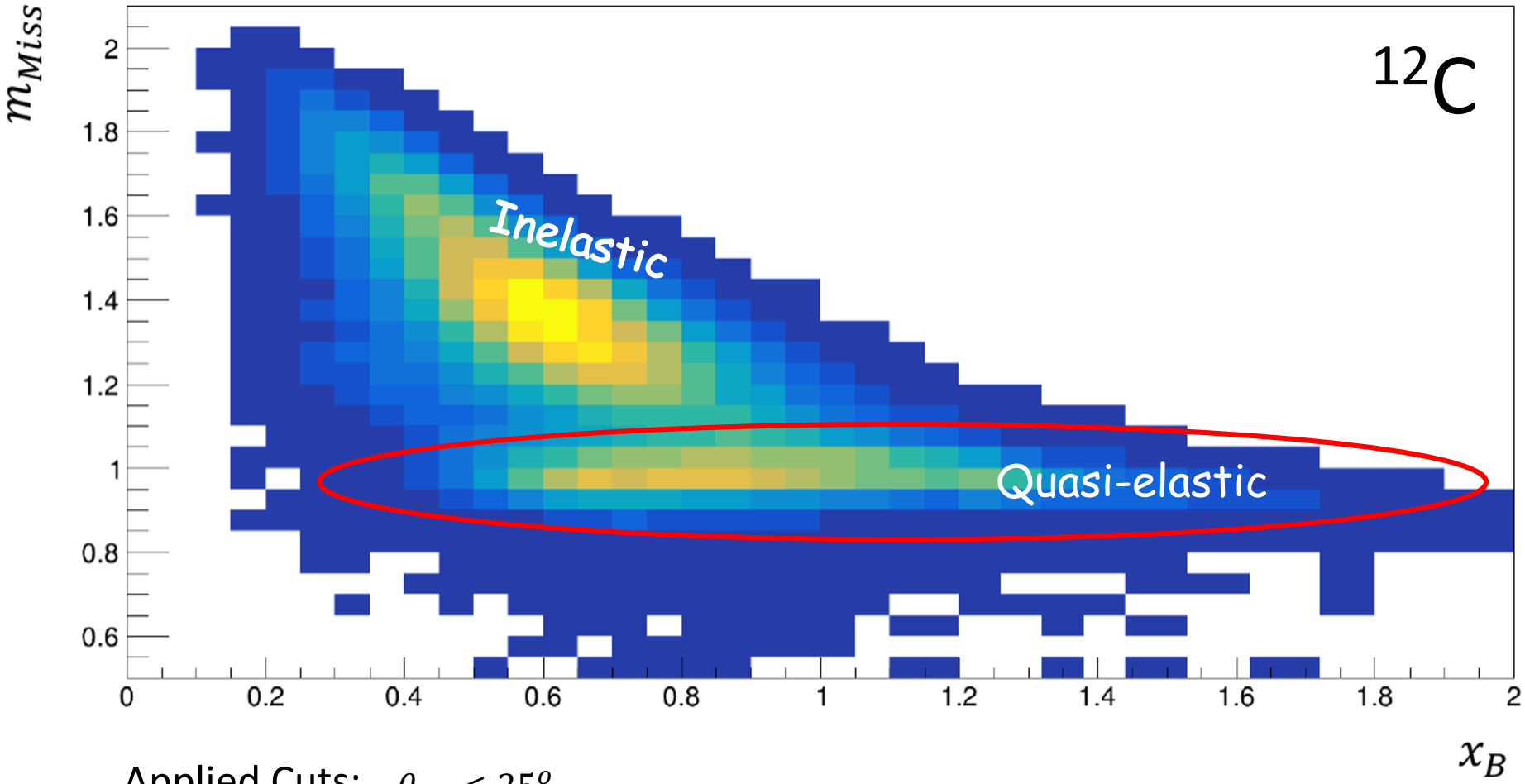
Inelastic Contribution



Applied Cuts: $\theta_{pq} < 25^o$

$0.3 < p_{miss} < 0.6[GeV/c]$

Inelastic Contribution



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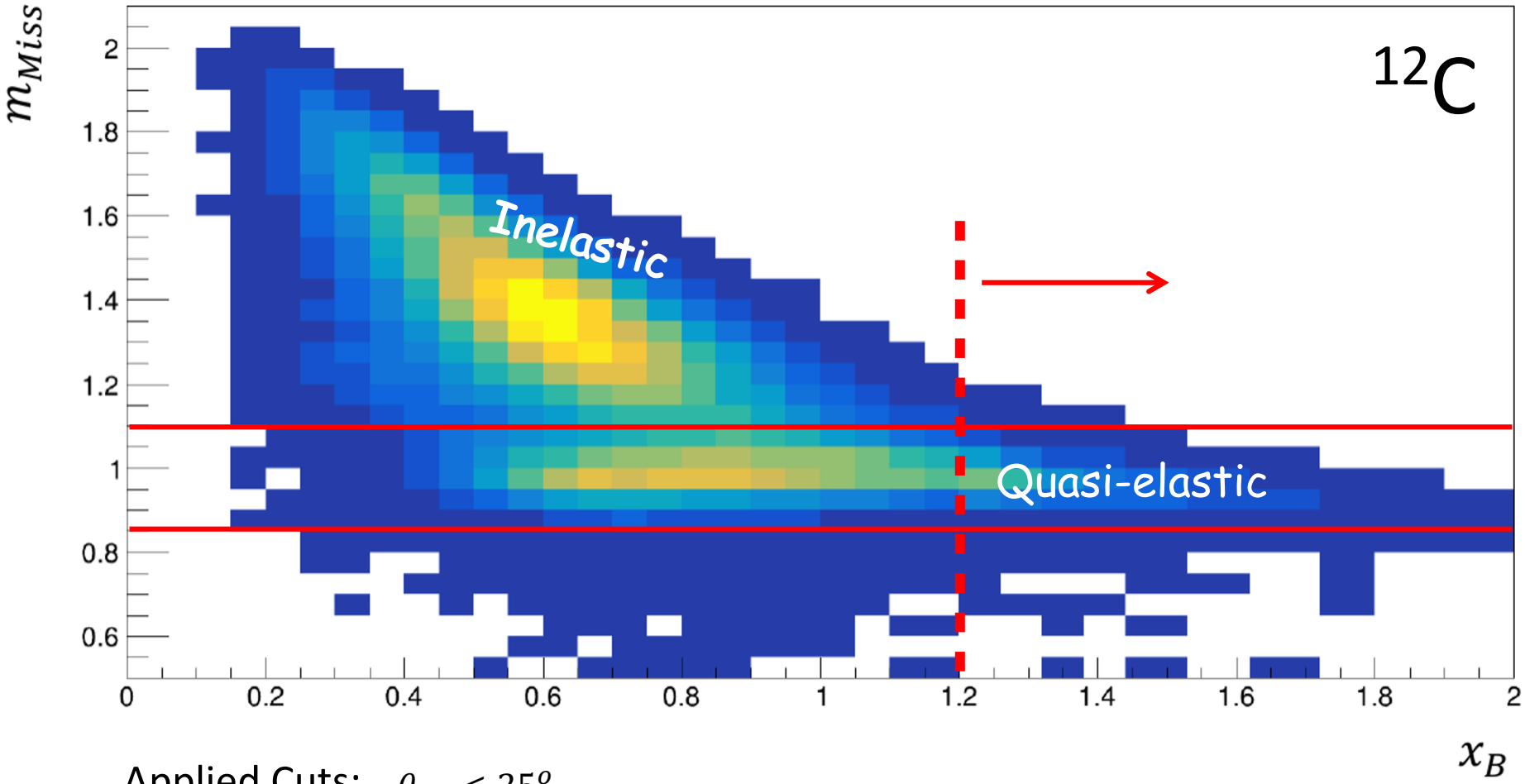

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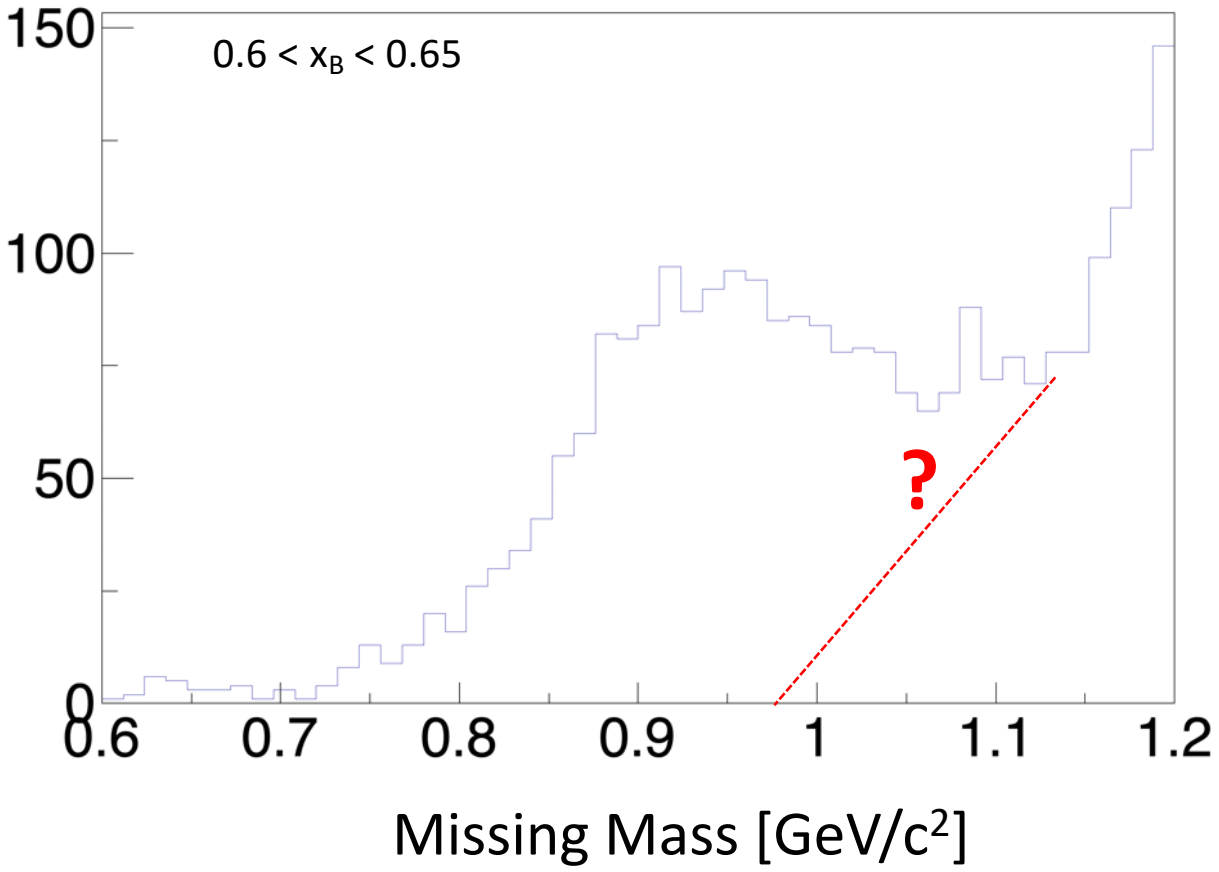
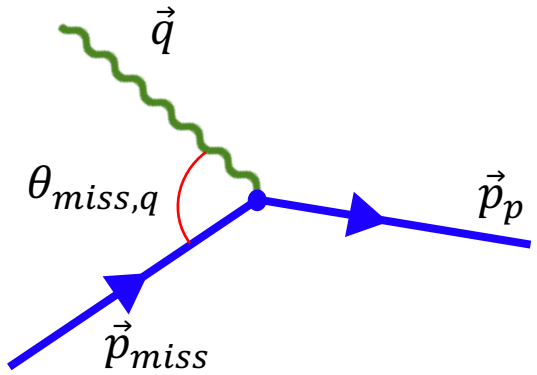
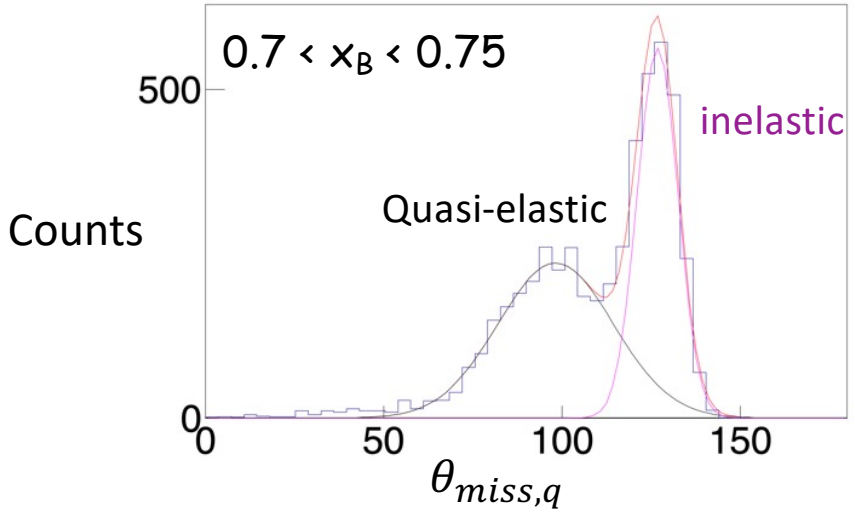
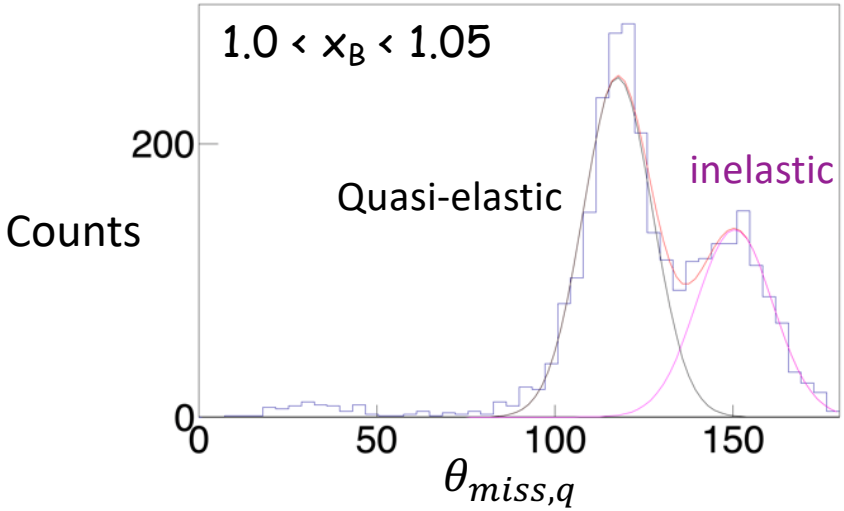
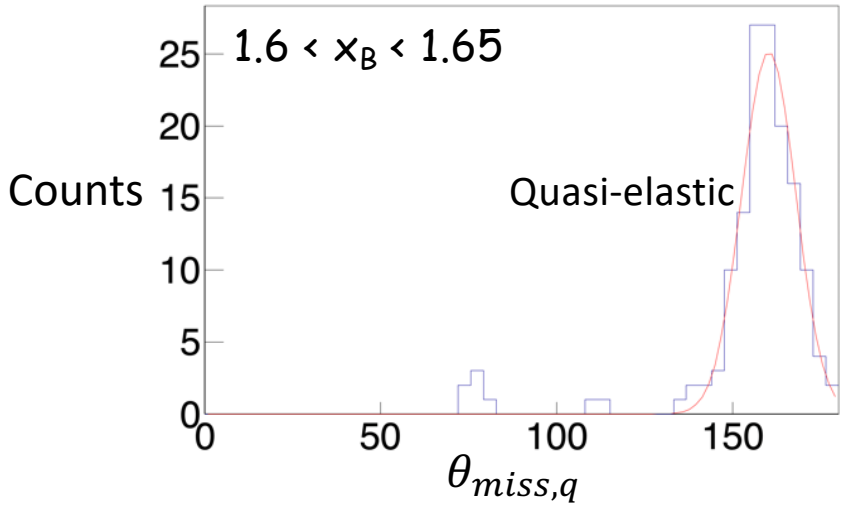


Angle Between $\vec{q}$ and $\vec{p}_{miss}$

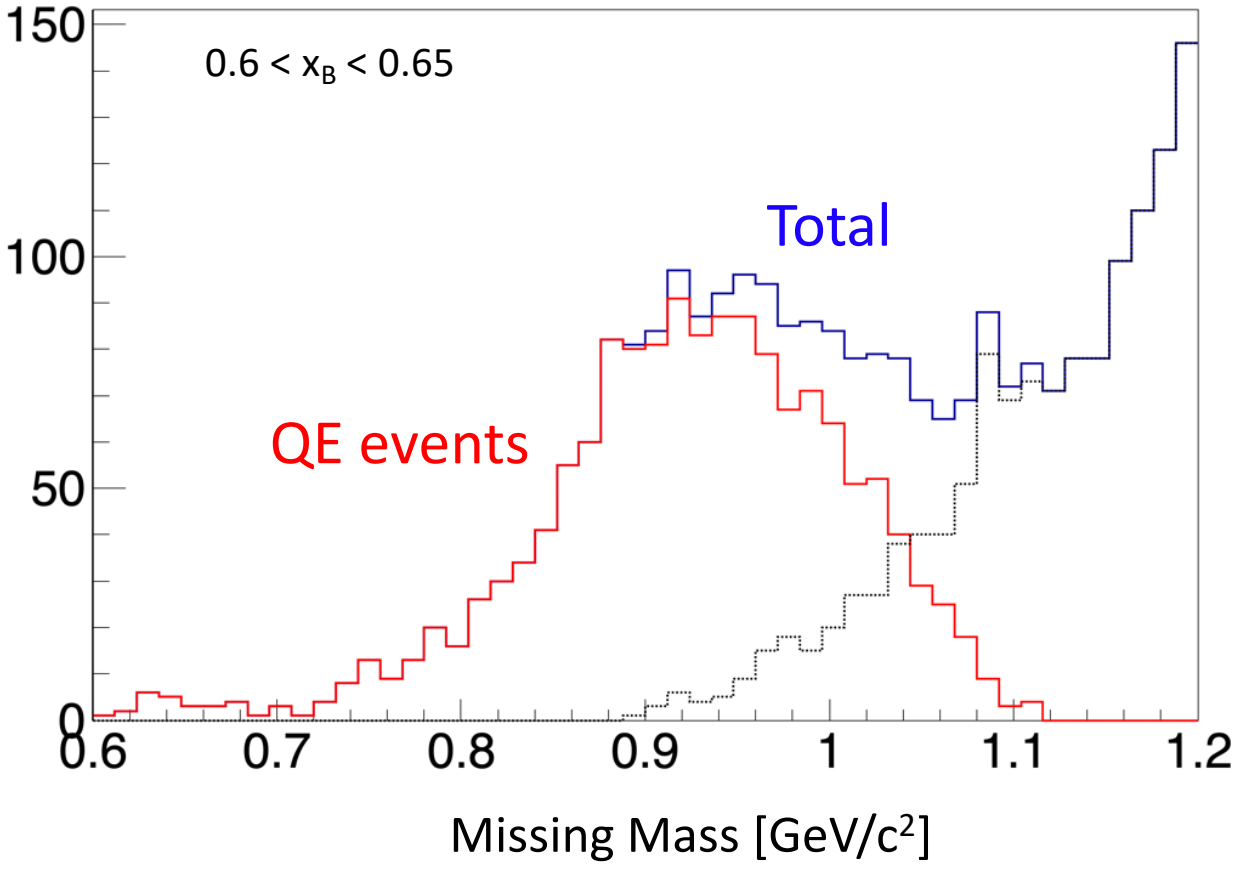




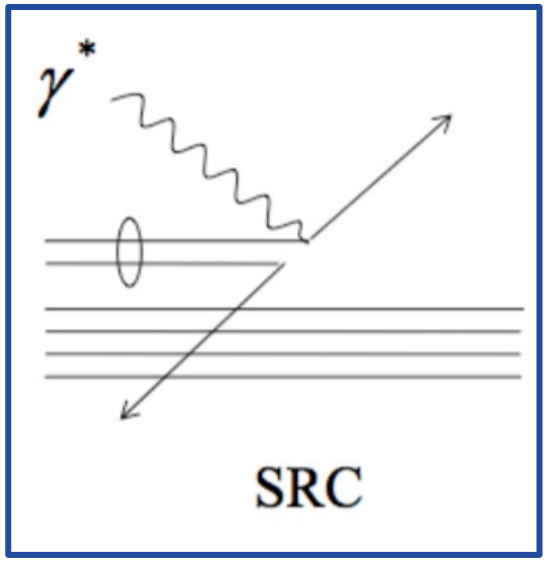




Inelastic Contribution



SRC Measurements



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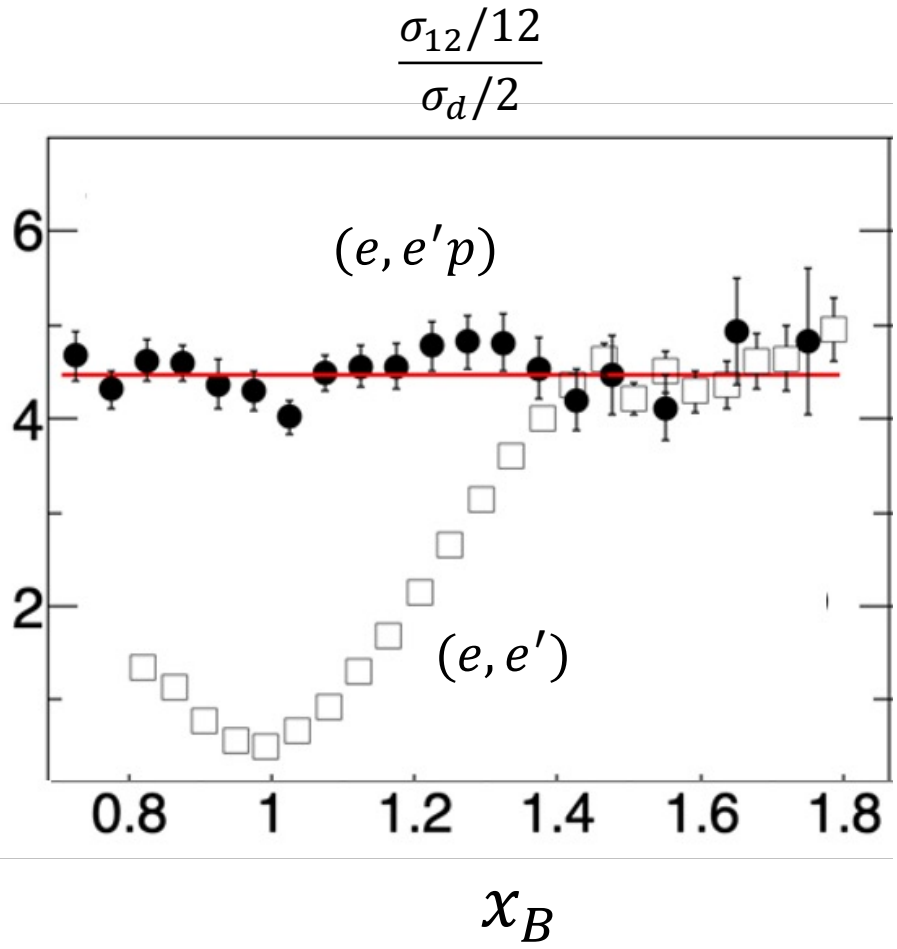
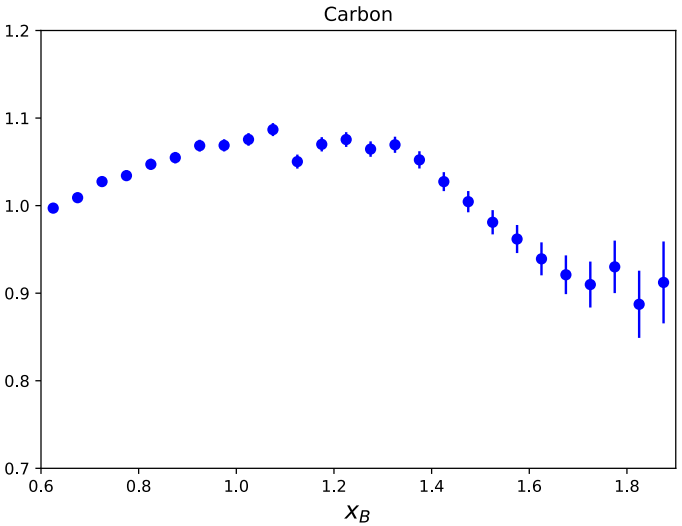


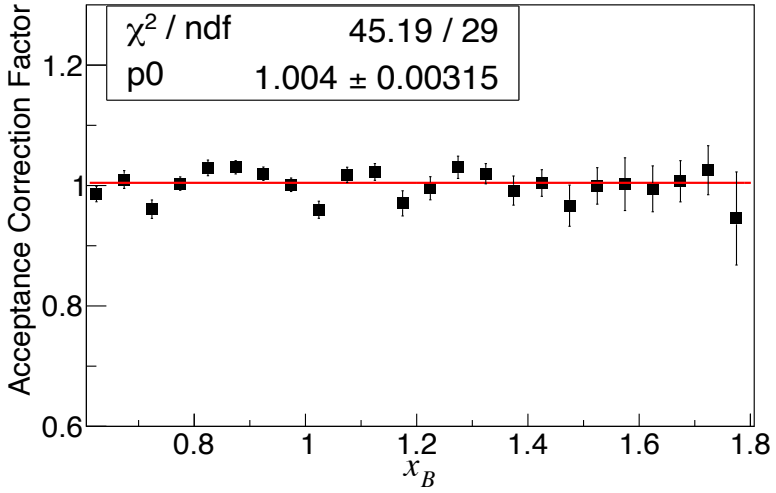
Correction Factors

- Transparency
- Coulomb
- Radiative
- Acceptance

Nucleus	Transparency	Uncertainty $[1\sigma]$
Deuteron	1	0
Carbon	0.53	0.052
Al	0.43	0.05
Fe	0.34	0.04
Pb	0.22	0.03

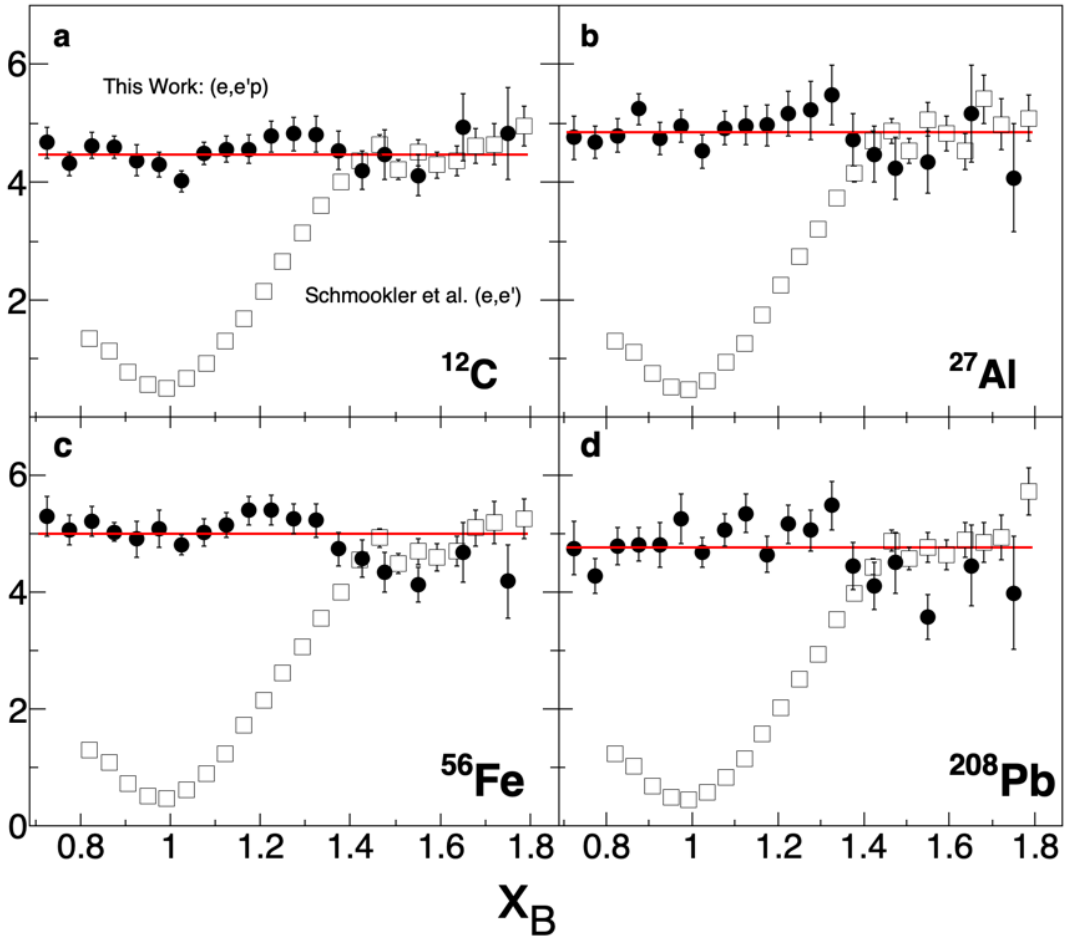
$$\frac{[\sigma_{12}/\sigma_2]_{Full}}{[\sigma_{12}/\sigma_2]_{Born}}$$



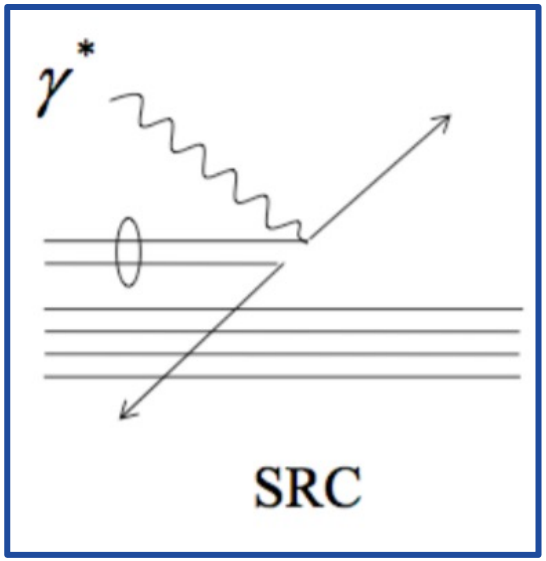


All Nuclei Scale for (e,e'p)

$$\frac{\sigma_A/A}{\sigma_d/2}$$



Mean Field Contribution



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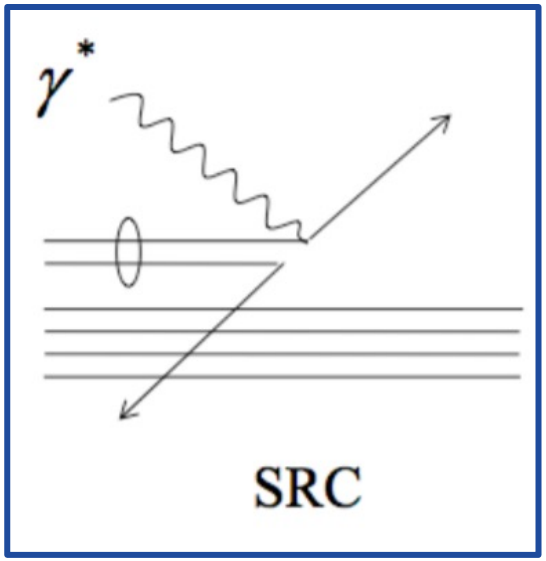
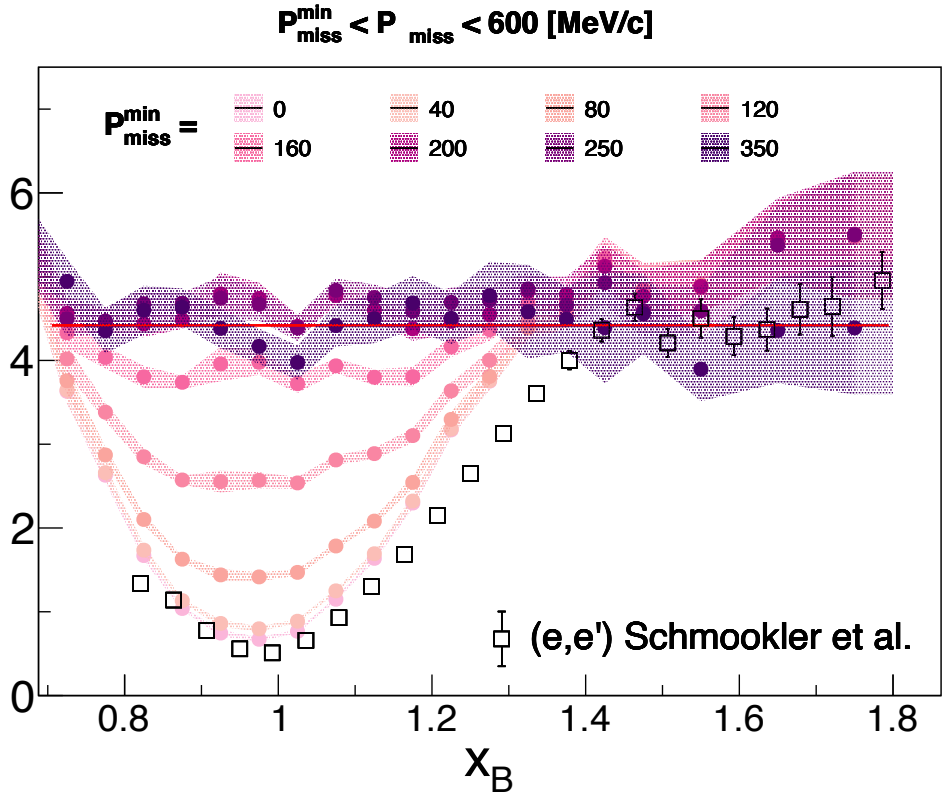
Mean Field Contribution



$\frac{\sigma_C/12}{d/2}$



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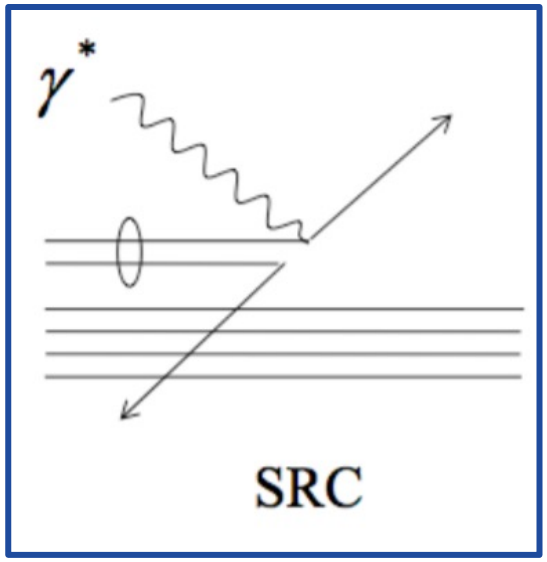
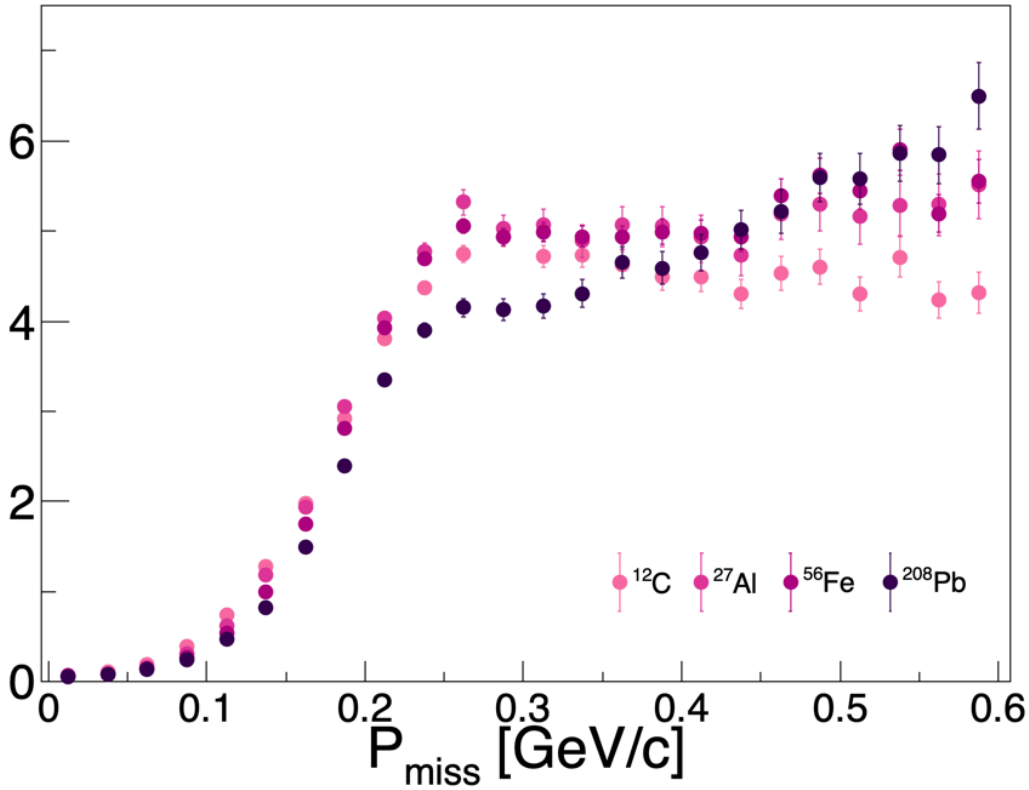
5. $\theta_{miss,q}(x_B)$ Cut

$p_{Miss} = p_{Lead} - q$

Mean-field to SRC Transition



$$\frac{\sigma_A/A}{d/2}$$



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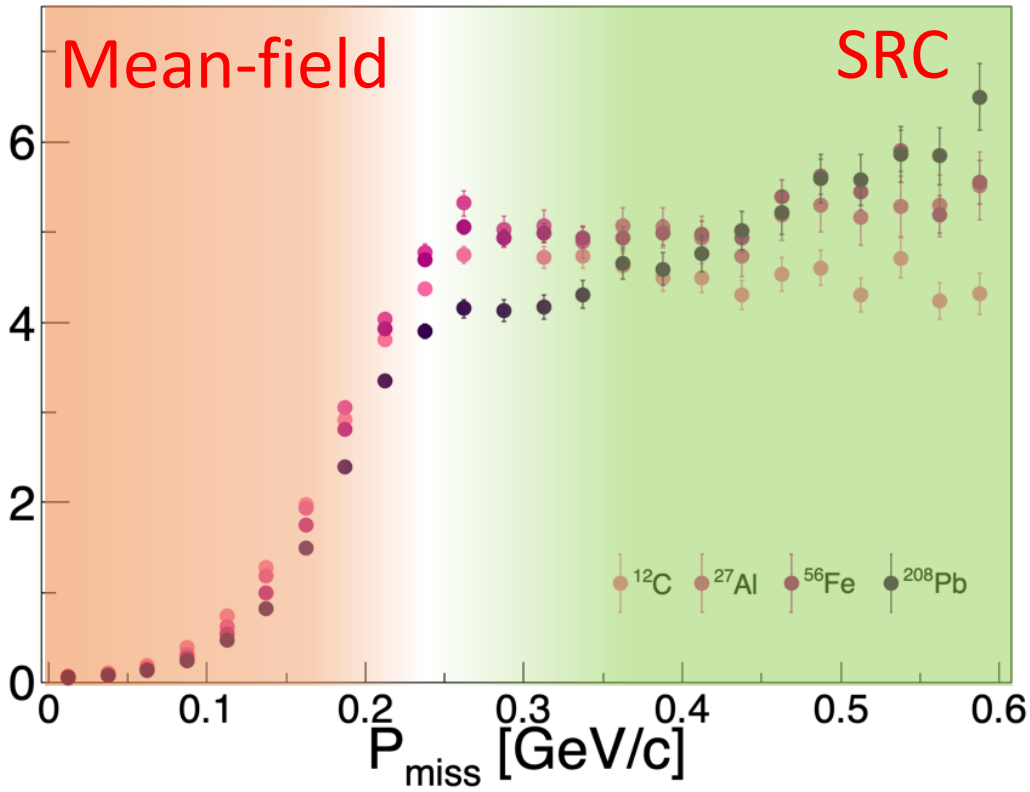
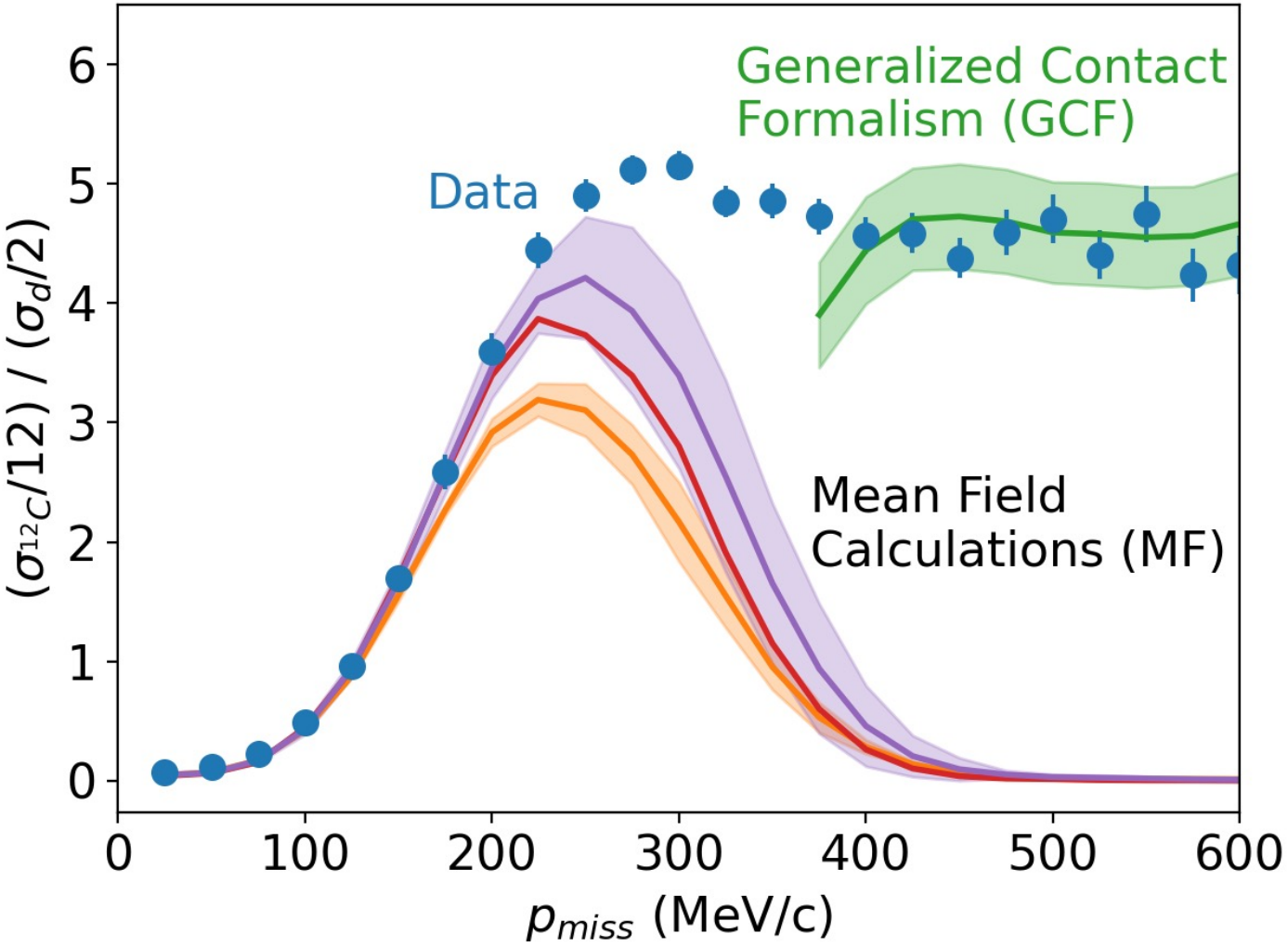
2. $\theta_{pq} < 25^\circ$
3. $0.8\ GeV < m_{Miss} < 1.05\ GeV$
4. $\theta_{miss,q}(x_B)$ Cut
5. $0.7 < x_B < 1.8$

Mean-field to SRC Transition

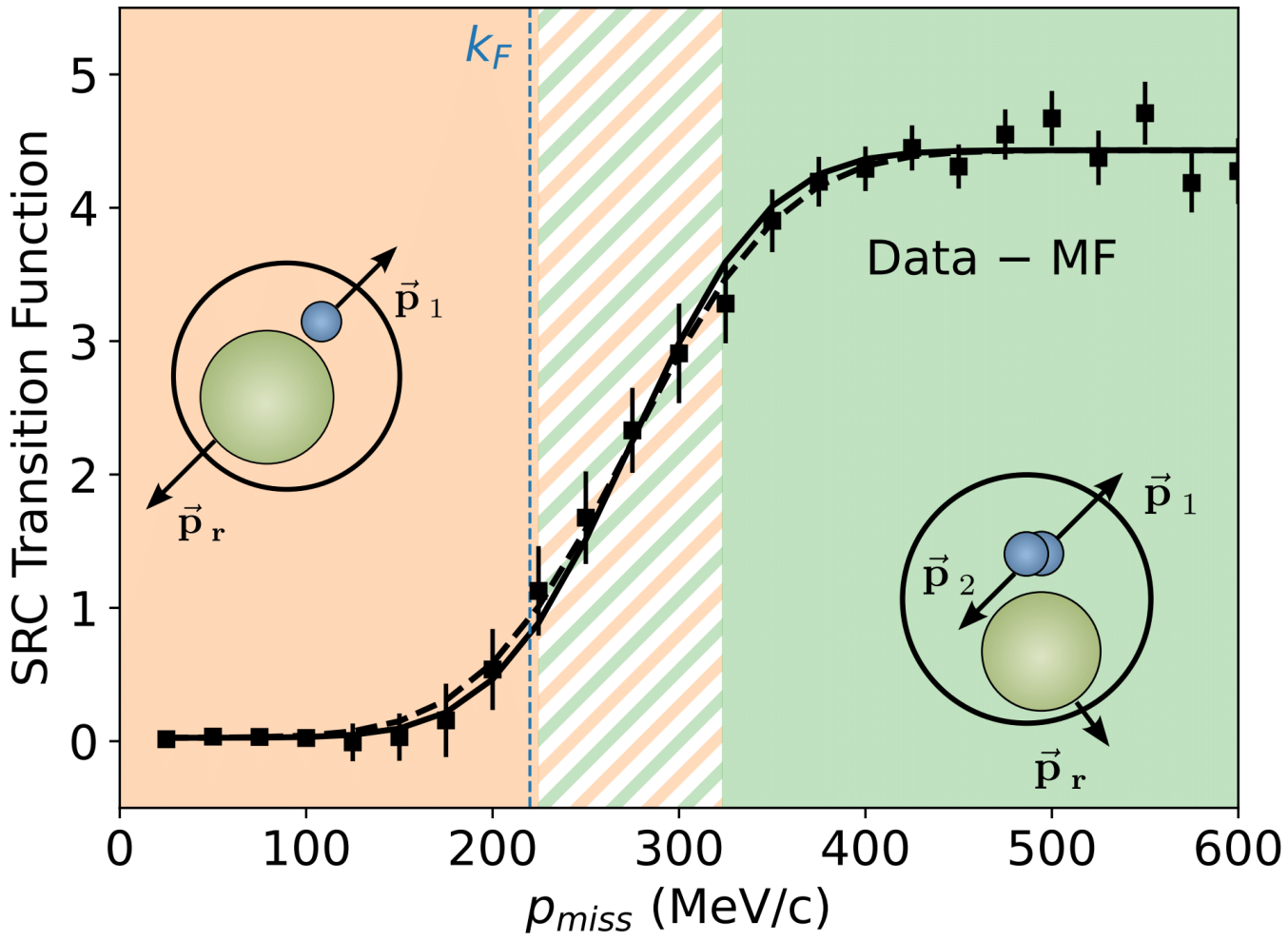
$\frac{\sigma_A/A}{d/2}$



Mean-field Contribution

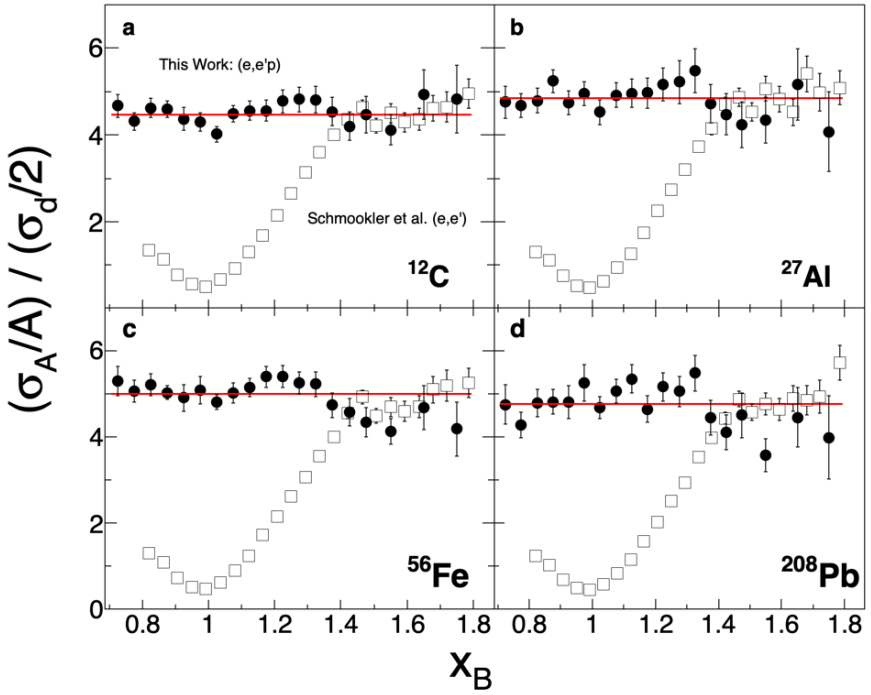


Three Domains of the Nucleus



Conclusion

- We have observed SRC scaling below the inclusive limit.



Conclusion

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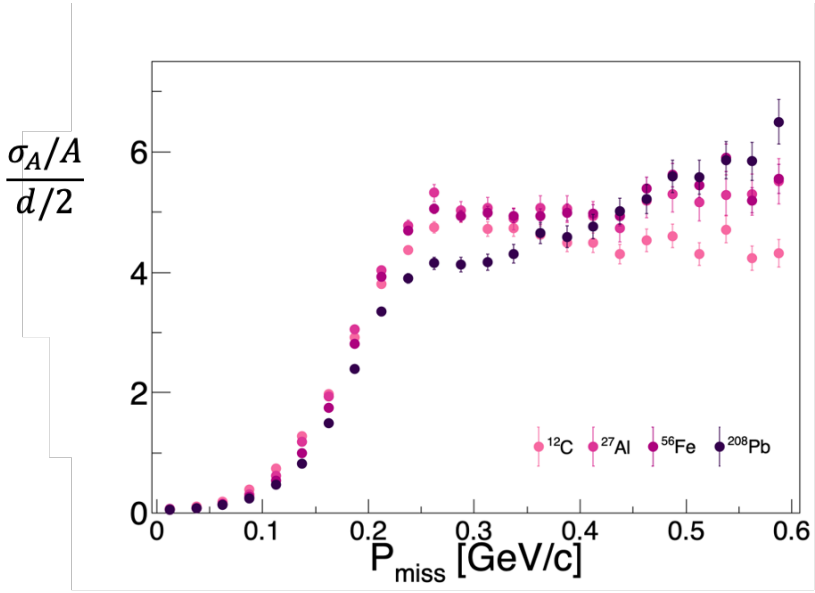
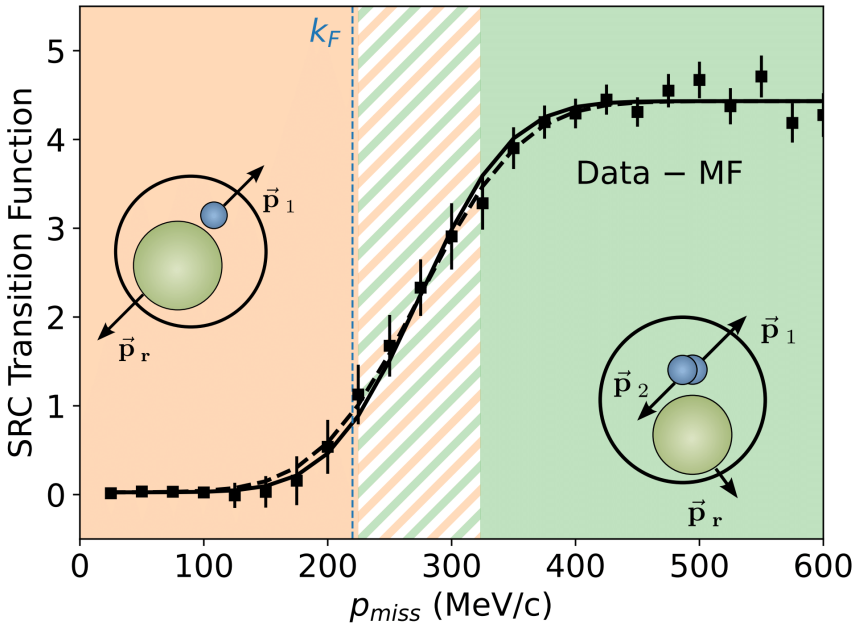


Conclusion

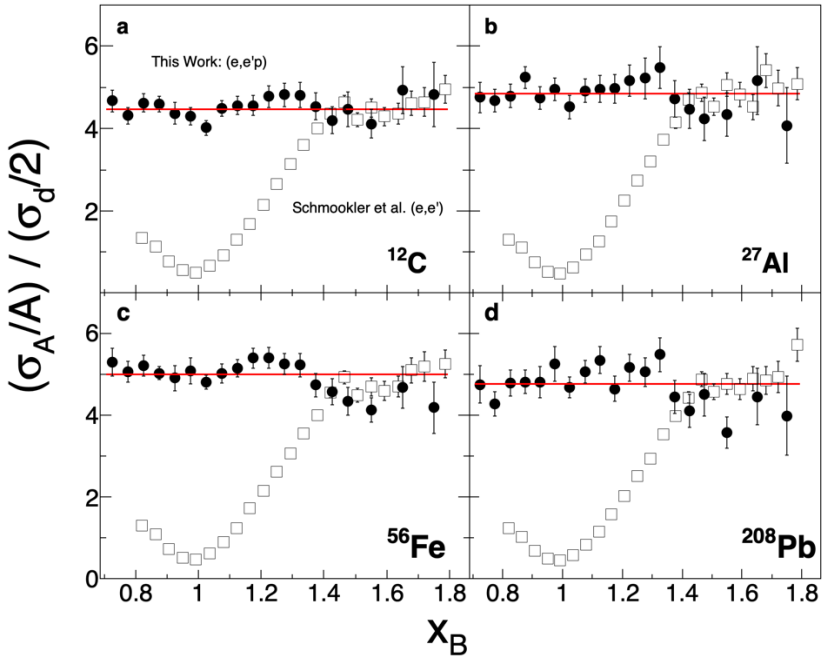
- We have observed SRC scaling below the inclusive limit.
- The extended kinematic range allows us to probe the SRC transition.
- We can now look at the onset of SRCs and separate the momentum distribution in to 3 domains.



Thank you

Backup Slides

Results Table



Target	Inclusive (a_2)	Semi-inclusive Ratio	Semi-inclusive Systematic Uncertainty
^{12}C	4.49 ± 0.17	4.5 ± 0.06	±10%
^{27}Al	4.86 ± 0.18	4.89 ± 0.08	±12%
^{56}Fe	4.81 ± 0.22	4.99 ± 0.06	±12%
^{208}Pb	4.89 ± 0.2	4.75 ± 0.08	±14%

Results Table

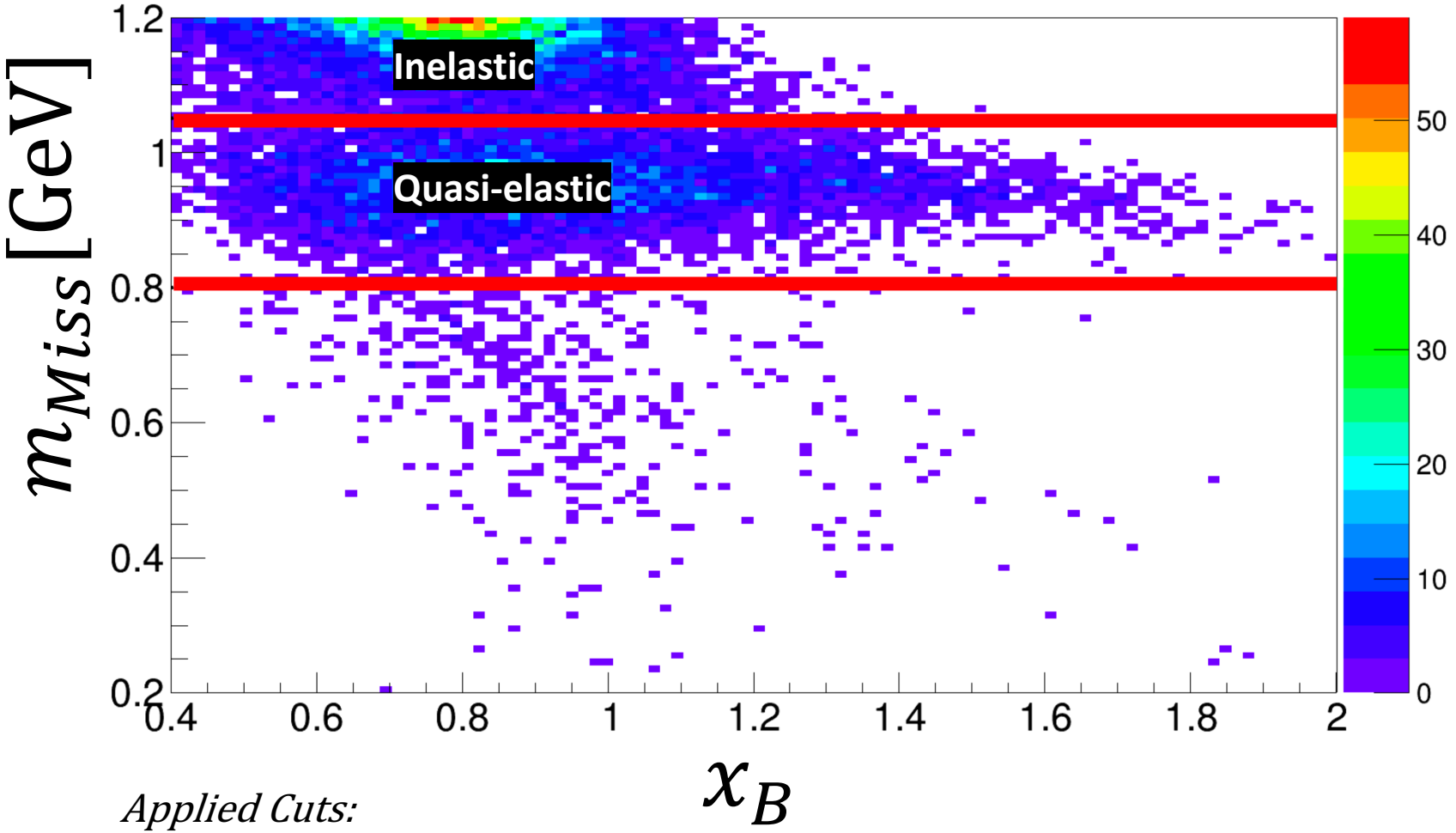
Target	Measured	Overall Systematic Uncertainty	a_2
Carbon	4.39 ± 0.07	$\pm 10\%$	4.49 ± 0.17
Aluminum	4.68 ± 0.09	$\pm 12\%$	4.86 ± 0.18
Iron	5.06 ± 0.10	$\pm 12\%$	4.81 ± 0.22
Lead	4.85 ± 0.12	$\pm 14\%$	4.89 ± 0.20

Systematic Uncertainties

Cut Type	Nominal Value	1σ
p_{miss} minimum	0.3 [GeV/c]	0.015
p_{miss} maximum	0.6 [GeV/c]	0.015
M_{miss} minimum	0.8 [GeV/c^2]	0.05
M_{miss} maximum	1.05 [GeV/c^2]	0.05
Θ_{PQ}	25°	0.5°
Q^2	1.5 [(GeV/c)^2]	0.01

Source	Per-Bin	Overall
Beam Charge	-	1%
Target Thickness	-	$\sim 1.5\%$
Acceptance Correction	$\sim 2.5\% - 10\%$	-
Radiative Correction	$< 1\%$	5%
Coulomb Correction	$< 3\%$	-
Nuclear Transparency	-	$10 - 15\%$
Deuteron Merging	-	$\leq 1.5\%$
Event Selection	$5\% - 12\%$	-
Total	$7\% - 16\%$	$\sim 11 - 16\%$

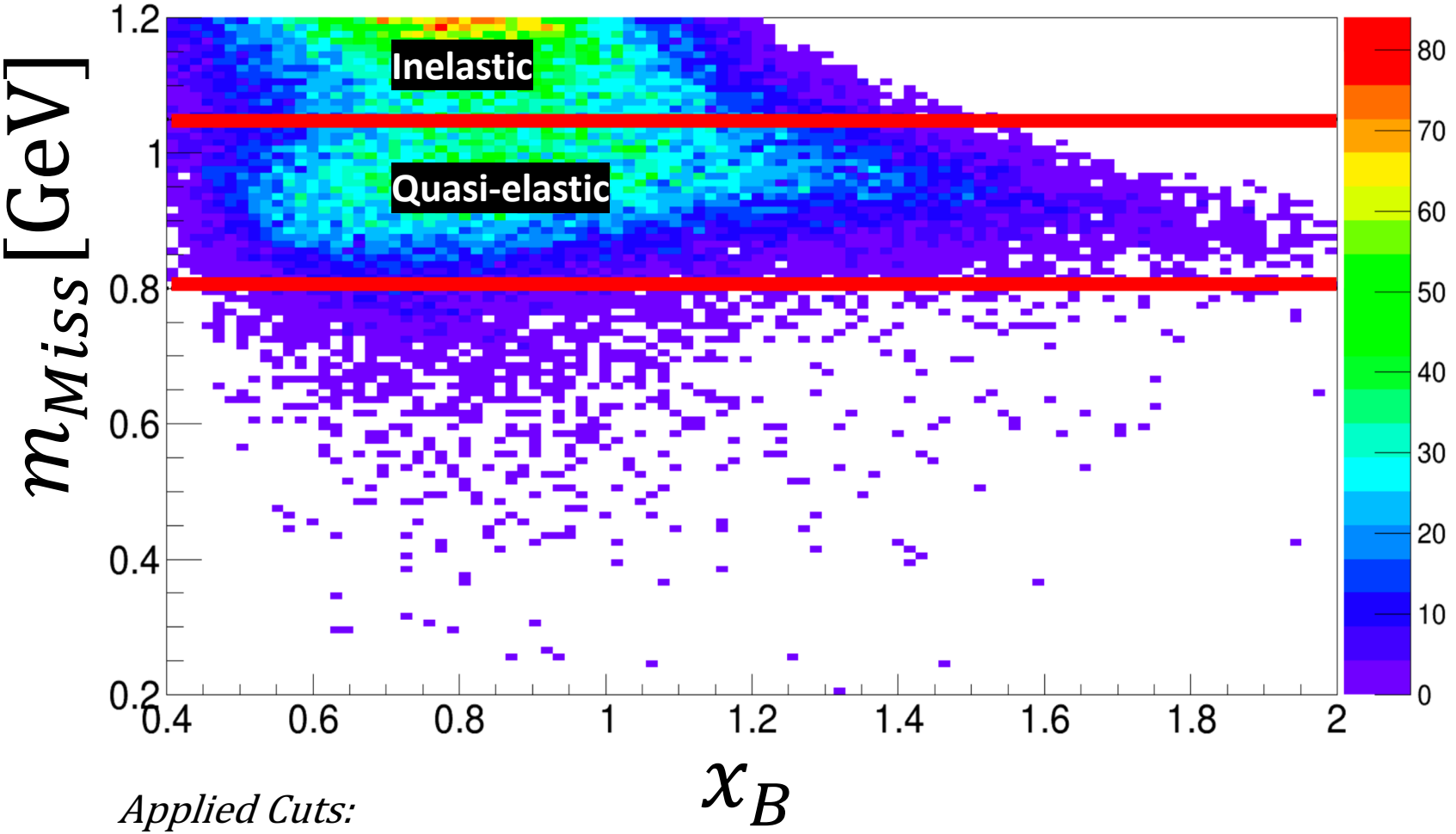
Deuterium



Applied Cuts:

- $1.5\ GeV^2 < Q^2$
- $\theta_{pq} < 25^{\circ}$
- $0.3\ GeV < p_{Miss} < 0.6\ GeV$

^{12}C

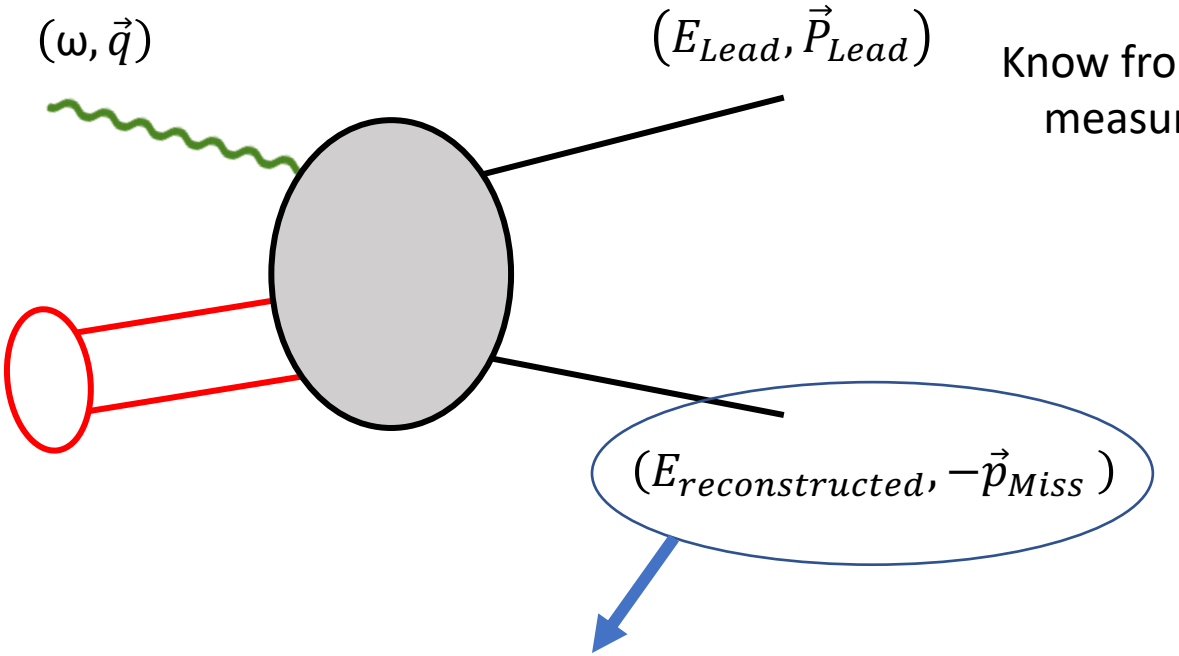


Applied Cuts:

- $1.5\ GeV^2 < Q^2$
- $\theta_{pq} < 25^{\circ}$
- $0.3\ GeV < p_{Miss} < 0.6\ GeV$

Missing Mass

Know from electron measurement



Know from proton measurement

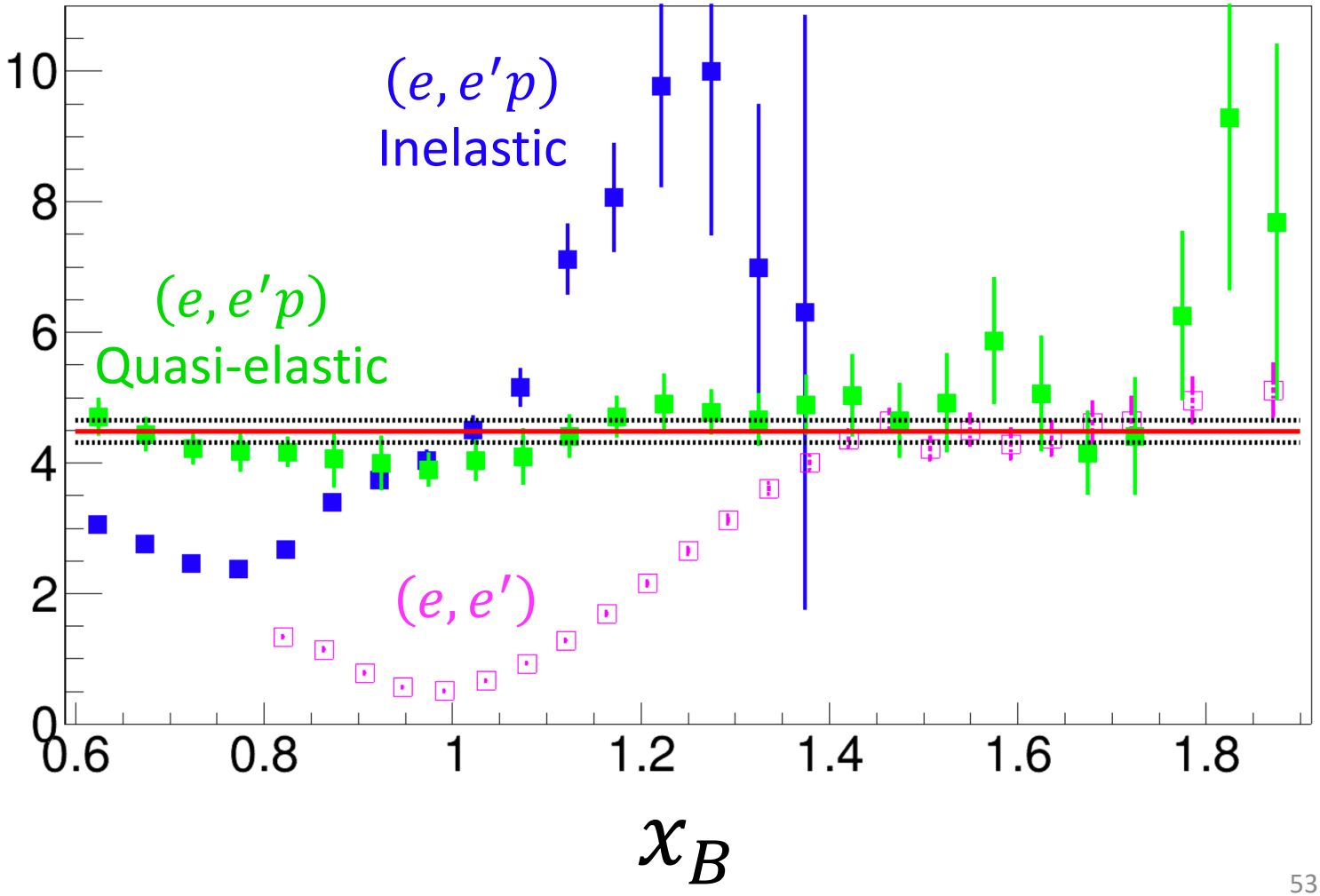
Approximation

$$M^2_{miss} = \left((\omega, \vec{q}) + (2M_N, 0) - \left(E_{Lead}, \vec{P}_{Lead}\right)\right)^2$$

$$M^2_{miss} = E^2_{reconstructed} - p^2_{Miss}$$

The Elastic Contribution

$$\frac{\sigma_C/12}{\sigma_d/2}$$



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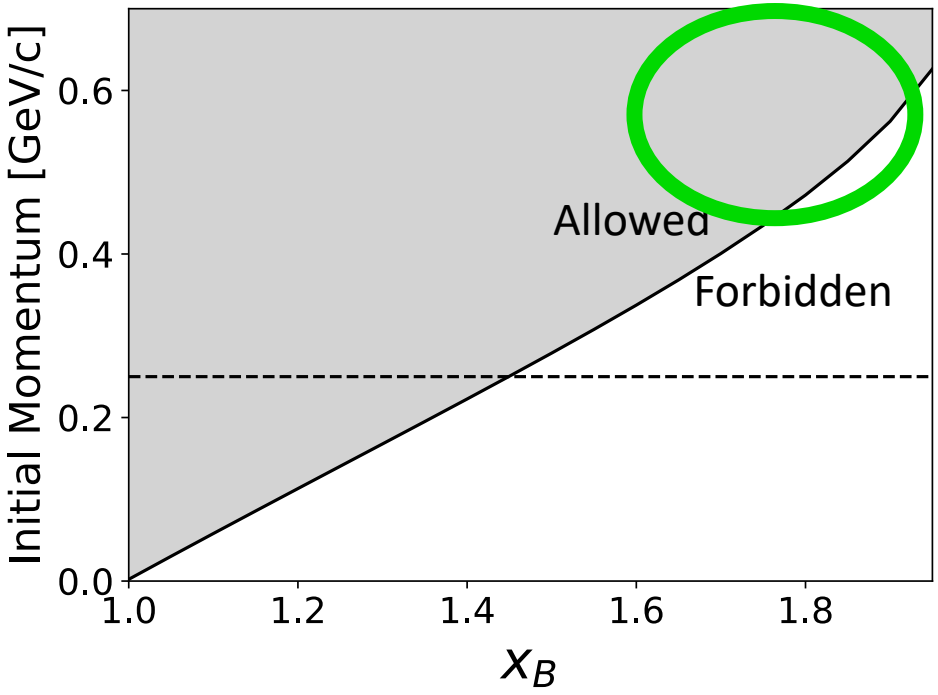
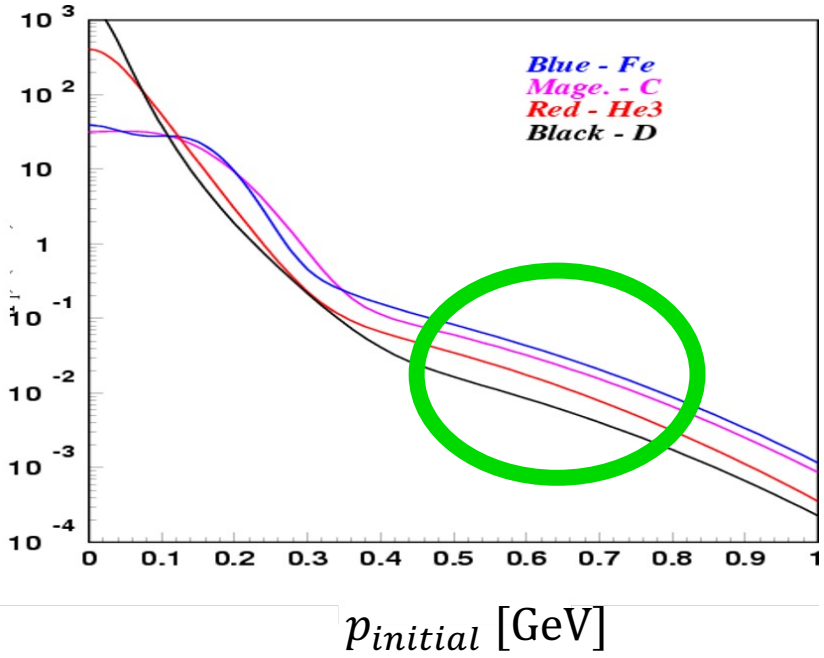
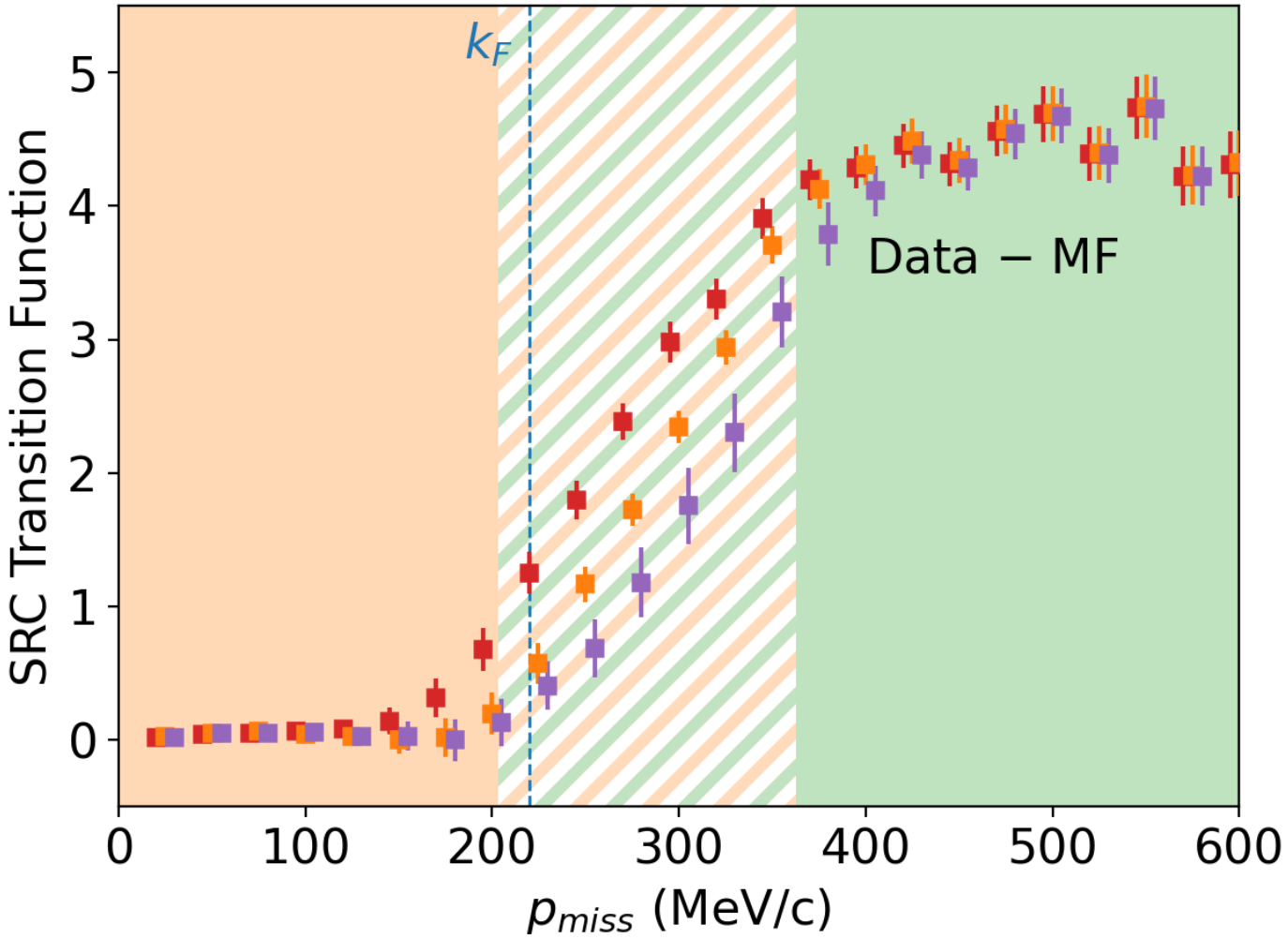


Nuclear Spectral Function



- Ciofi & Simula, PRC (1996)
- Weiss, PRC Lett. (2021)

$$x_B \equiv \frac{Q^2}{2m_N\omega} = \frac{q^2 - \omega^2}{2m_N\omega}$$


k_F
Data − MF
SRC Transition Function
0
1
2
3
4
5
0
100
200
300
400
500
600
p_{miss} (MeV/c)