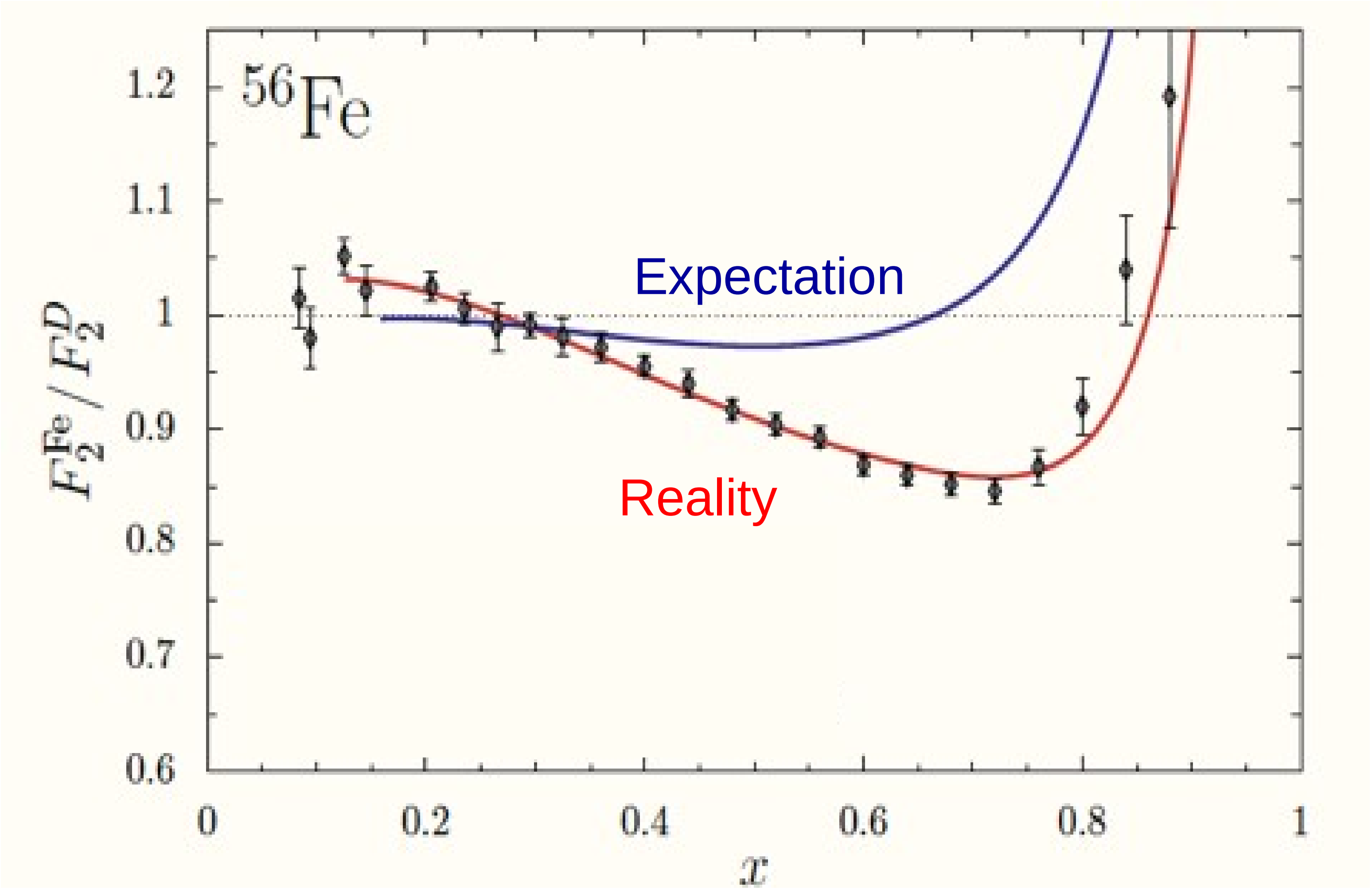
Isospin Dependence of the EMC Effect and Short-Range Correlations (SRC)

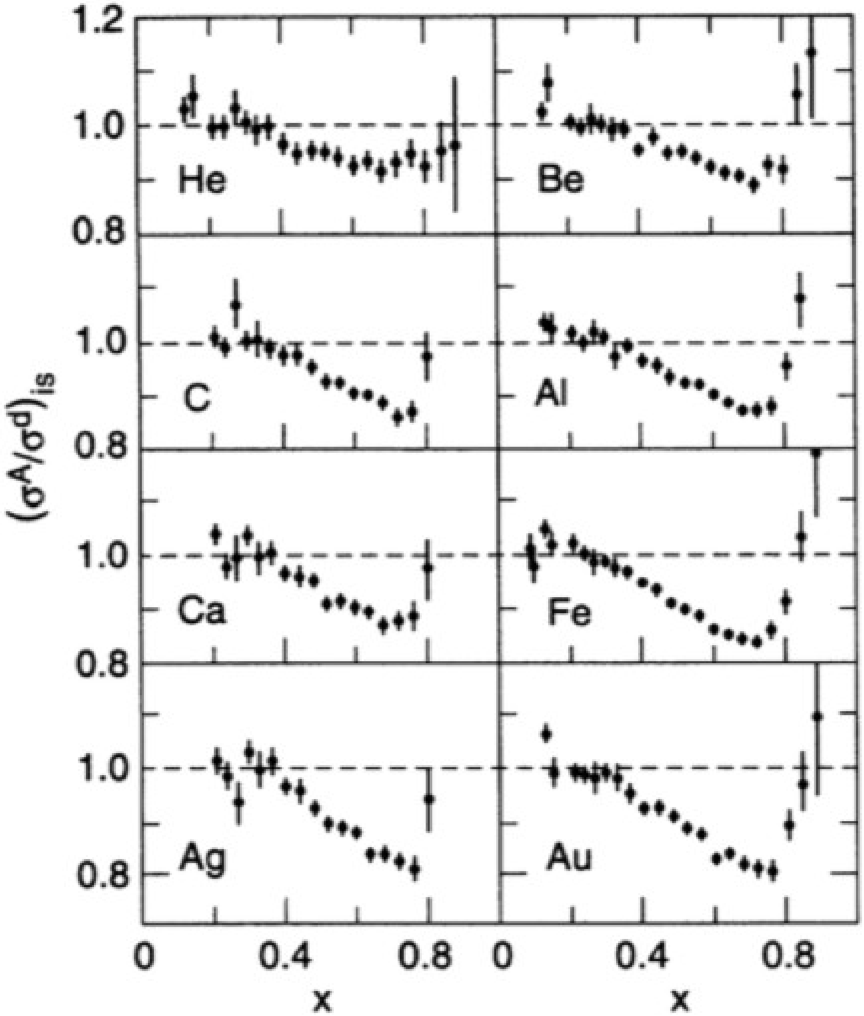
Barak Schmookler

MIT

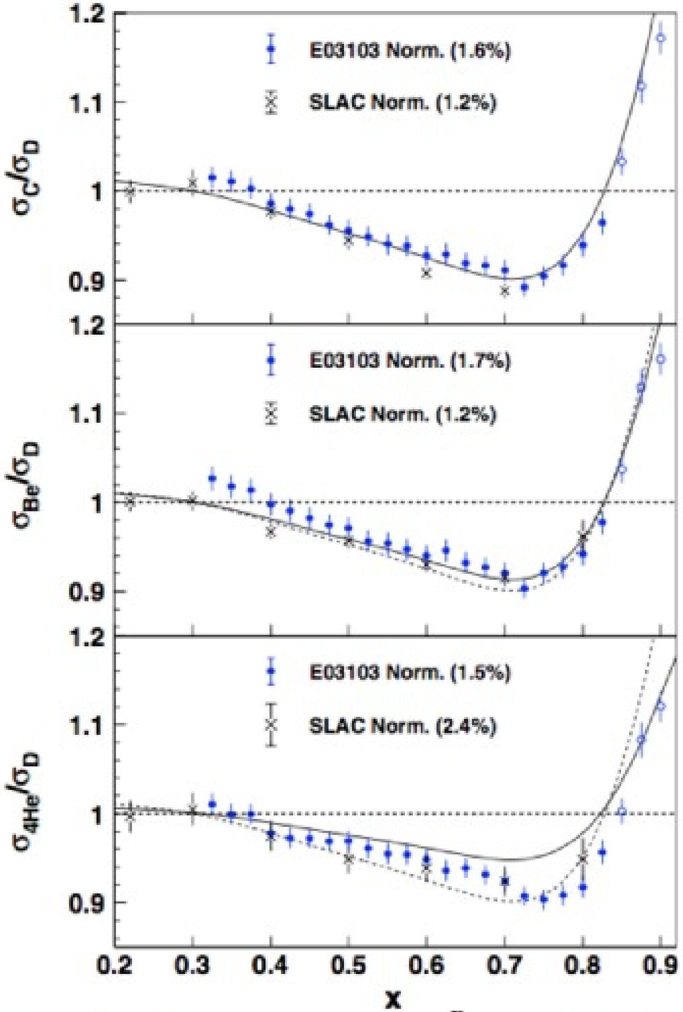
Deep Inelastic Scattering and the EMC Effect



The EMC Effect: Universal Nuclear Effect



J. Gomez et al., Phys. Rev. D **49**, 4348 (1994).



J. Seely et al., Phys. Rev. Lett. **103**, 202301 (2009).

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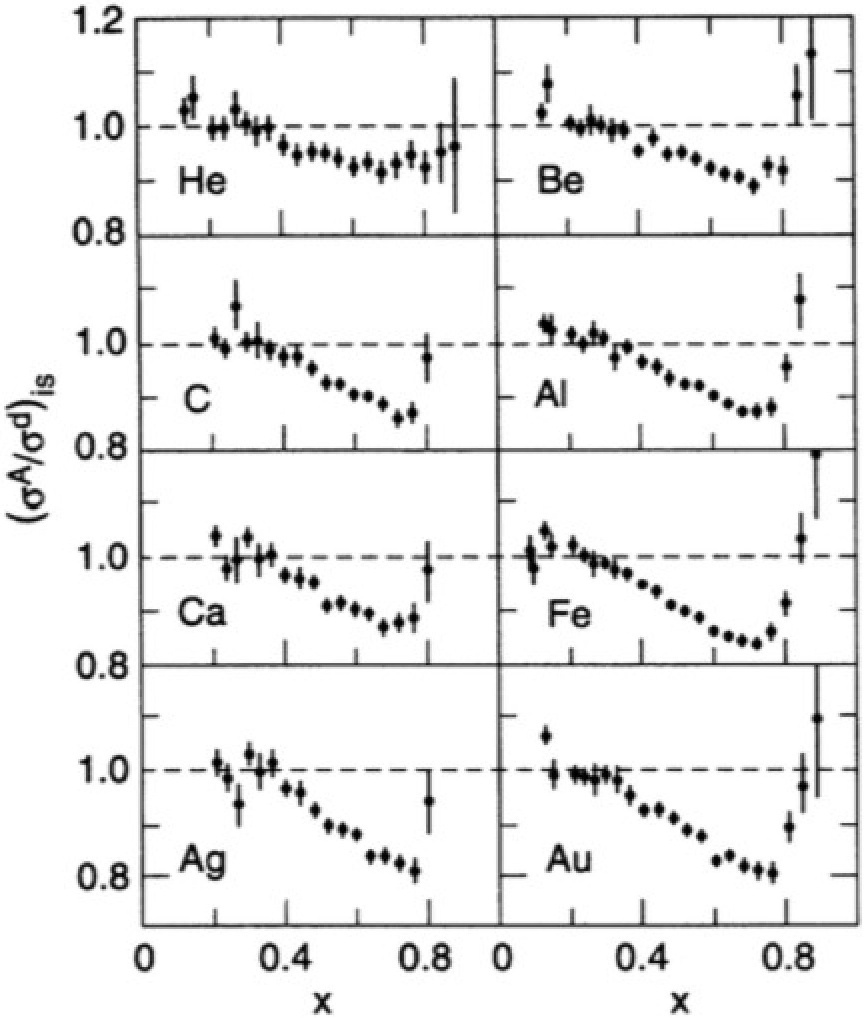

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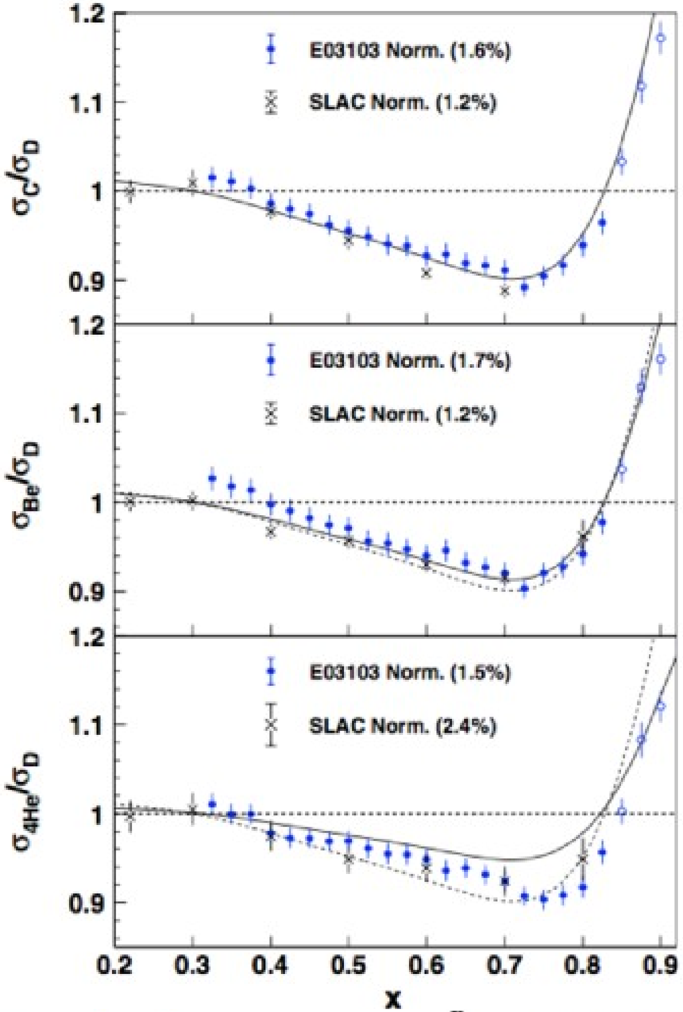

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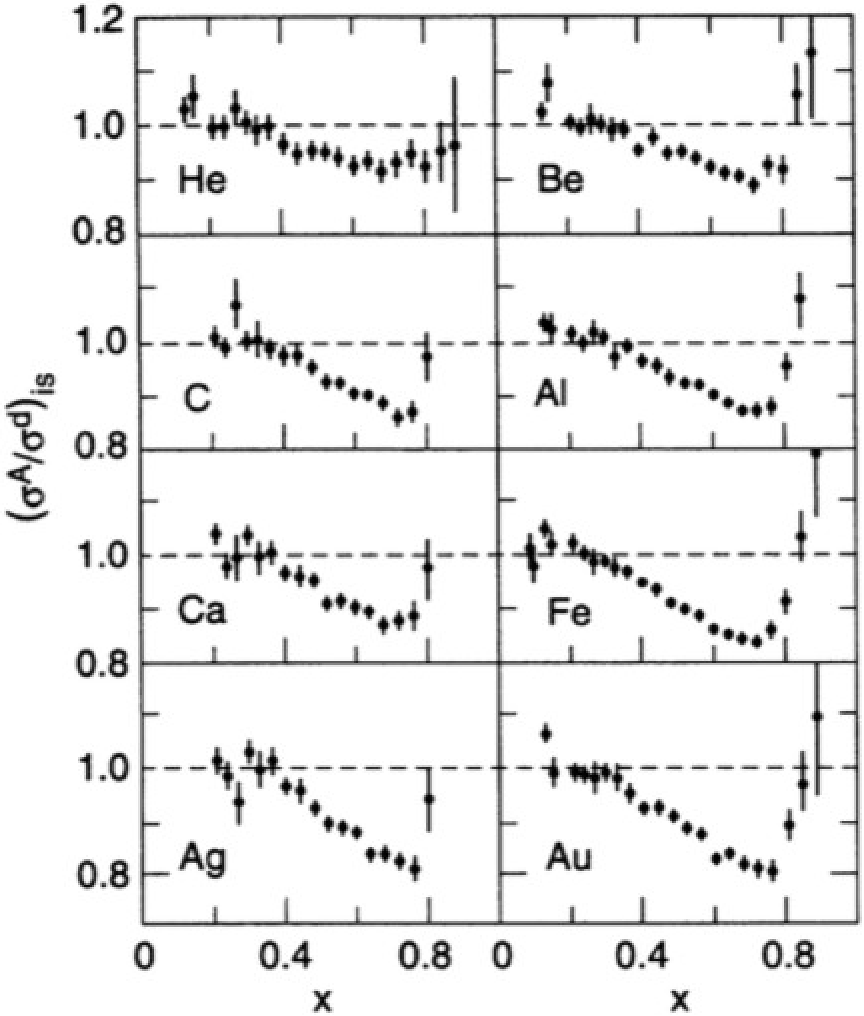

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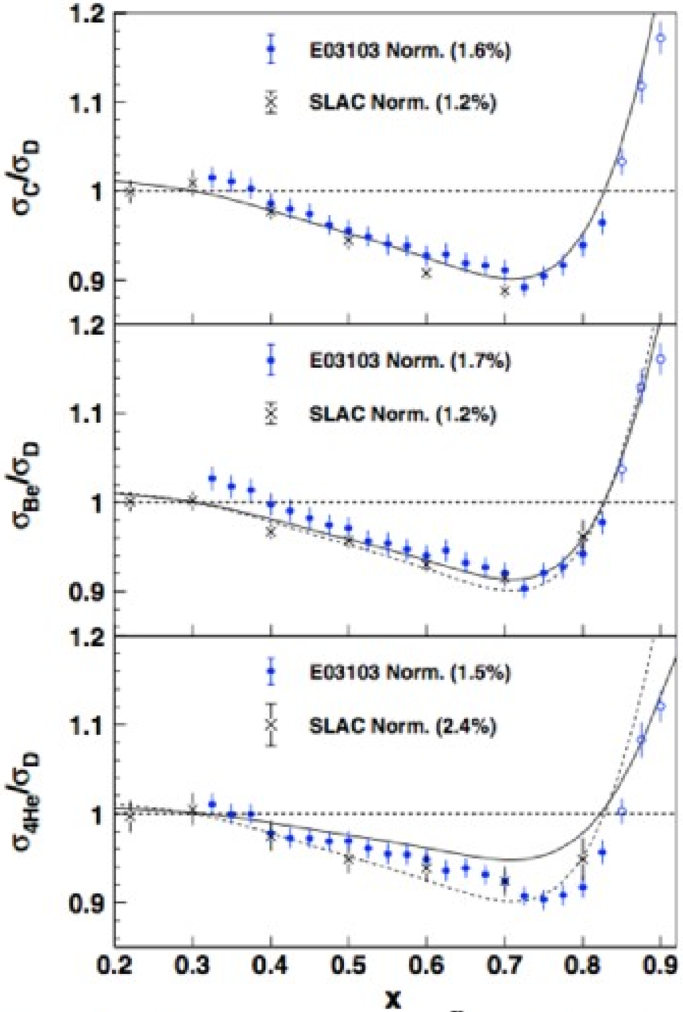

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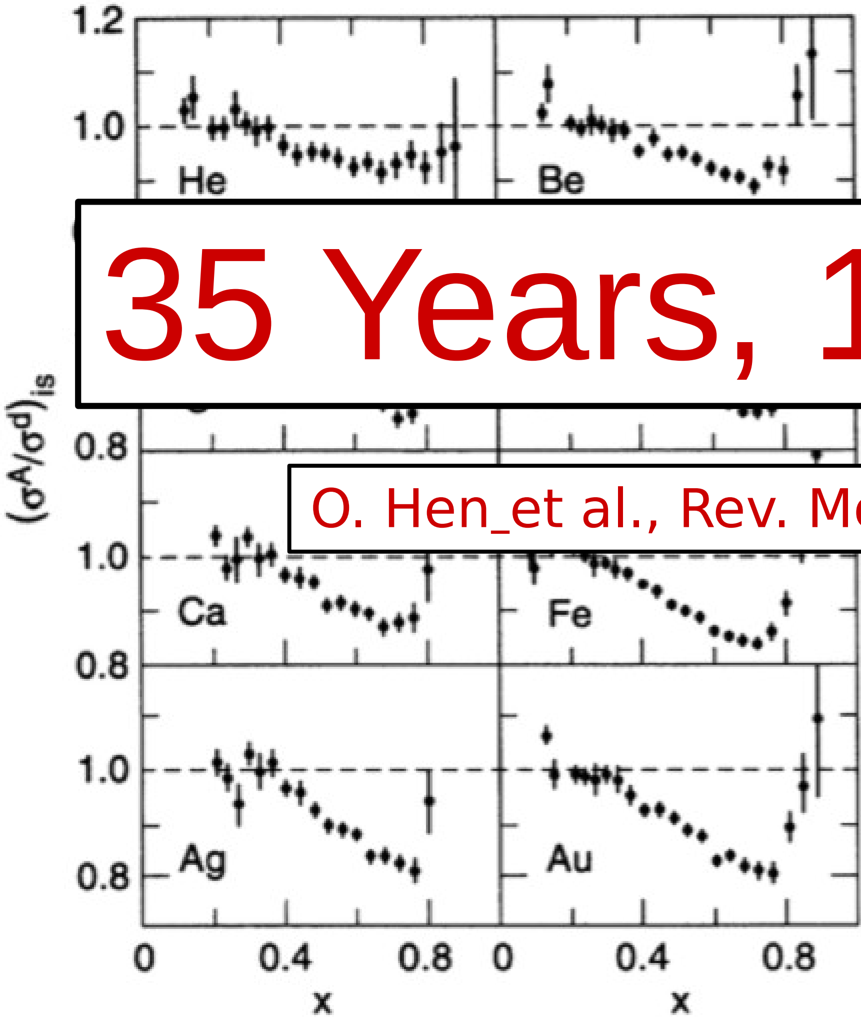

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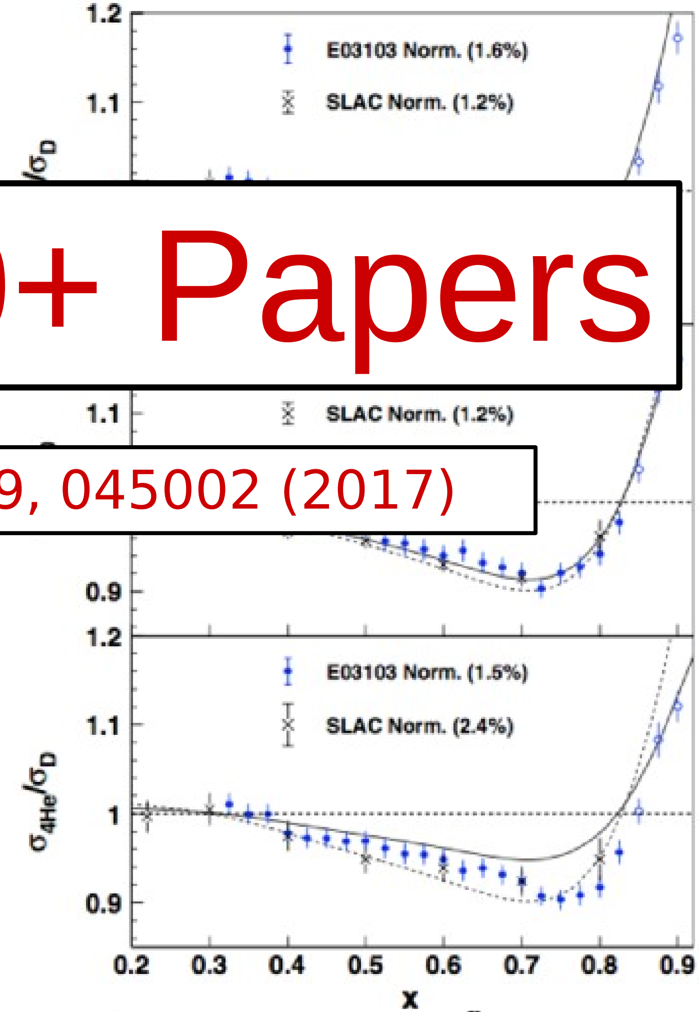
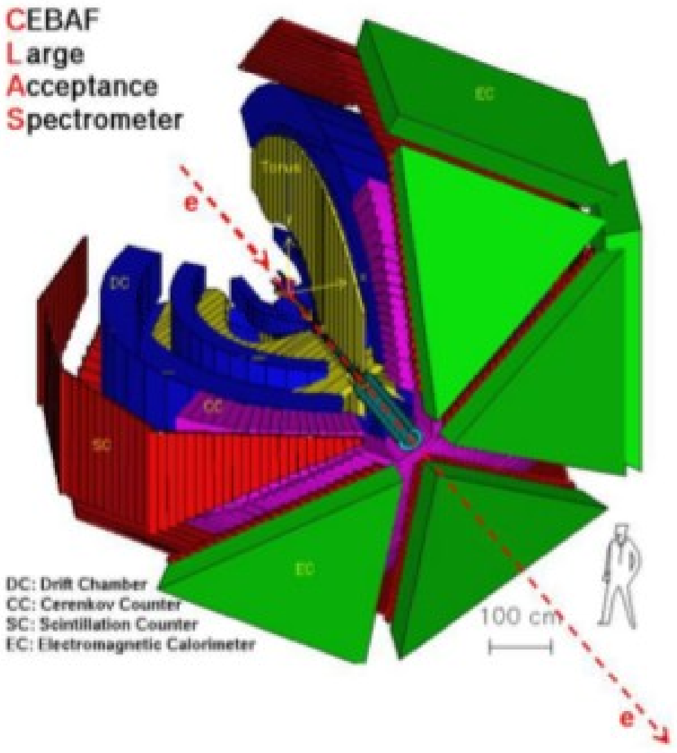


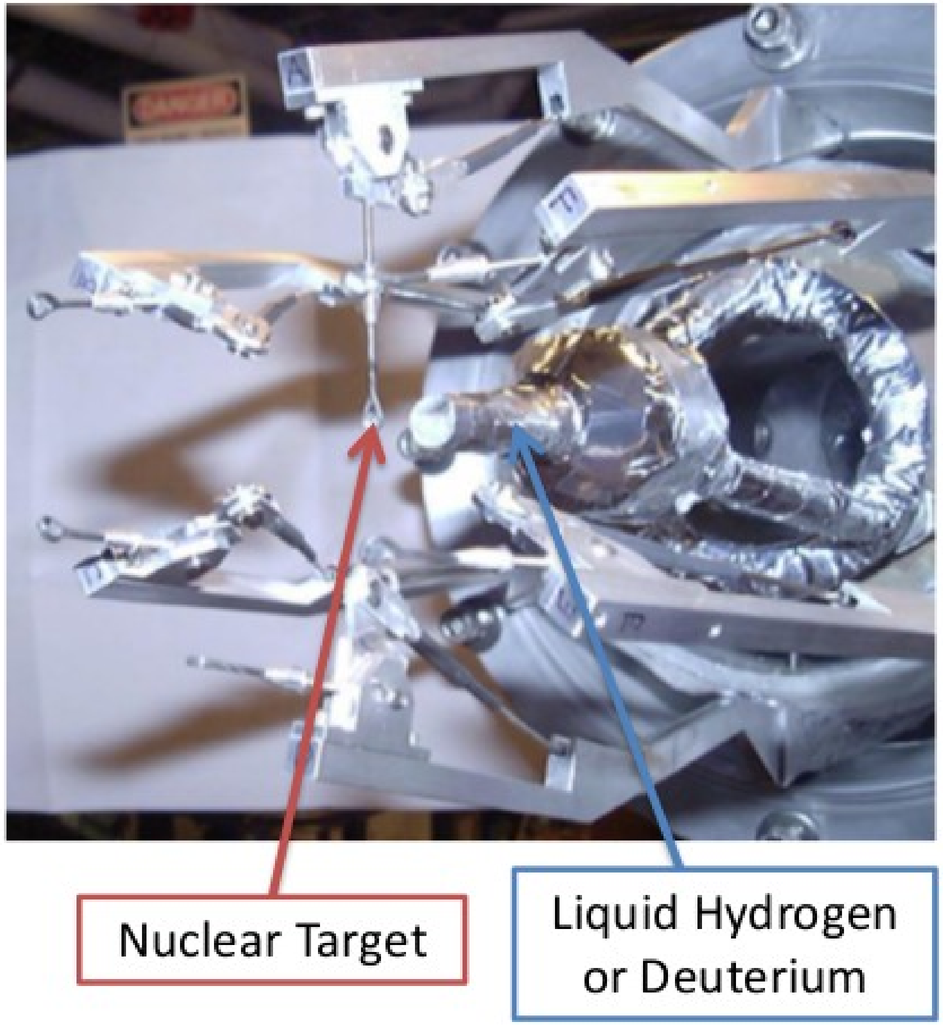
J. Seely et al., Phys. Rev. Lett. **103**, 202301 (2009).

35 Years, 1000+ Papers

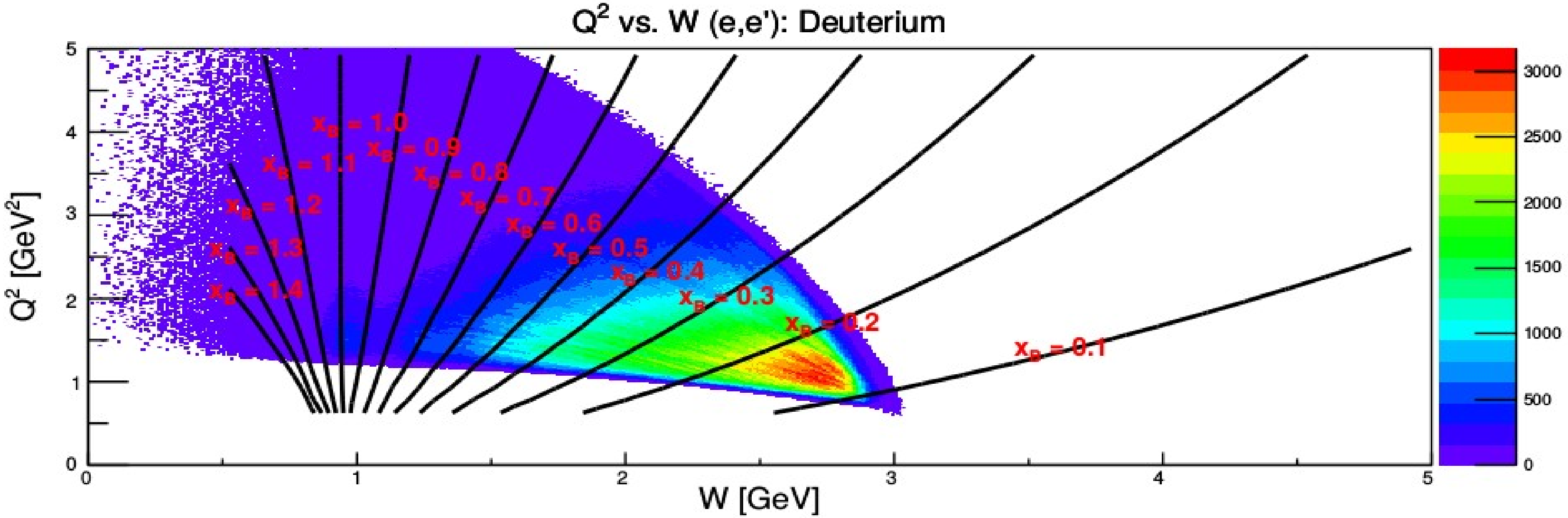
O. Hen_et al., Rev. Mod. Phys. 89, 045002 (2017)

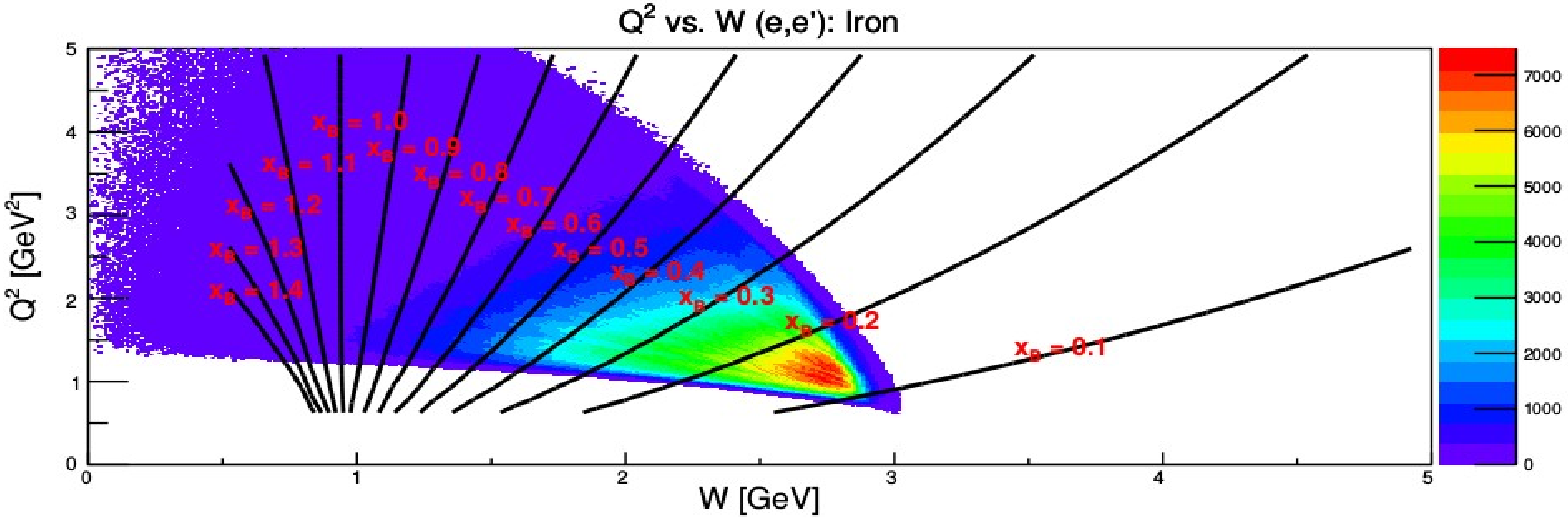
Study (e,e') Data from the CLAS6 Detector at JLab



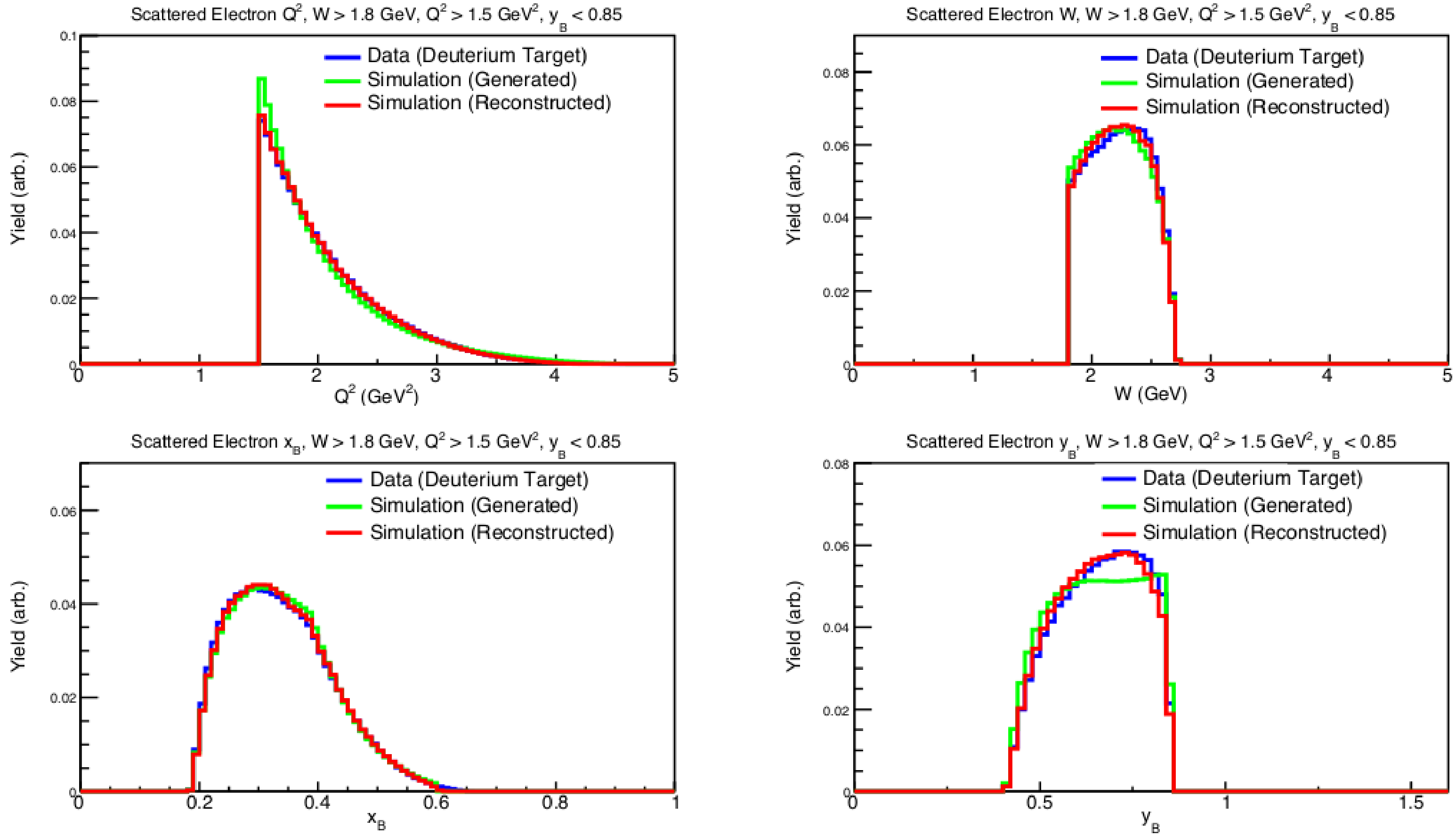


Kinematic Coverage and Event Selection

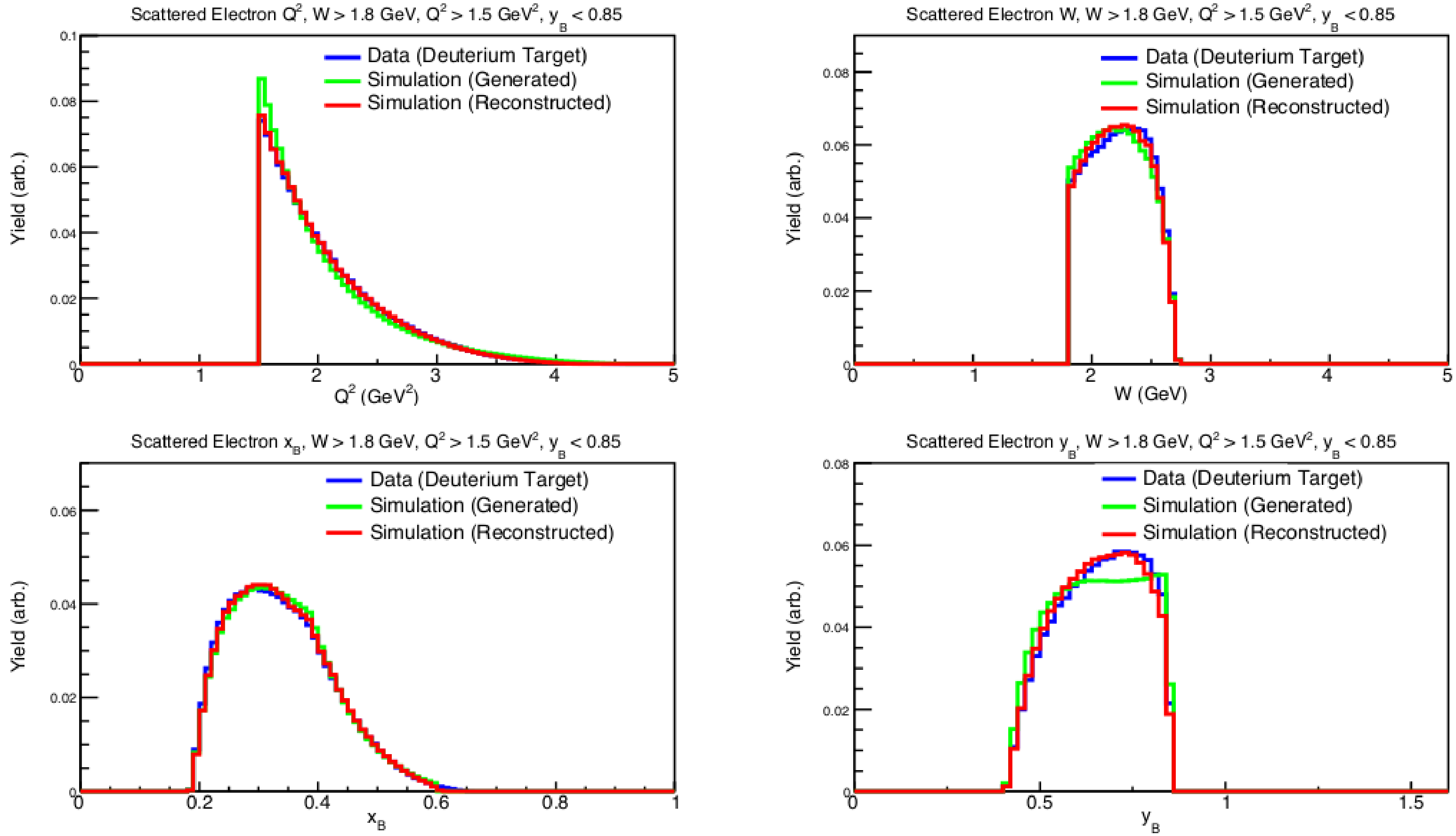




Cross-Section Ratio Extraction



Cross-Section Ratio Extraction

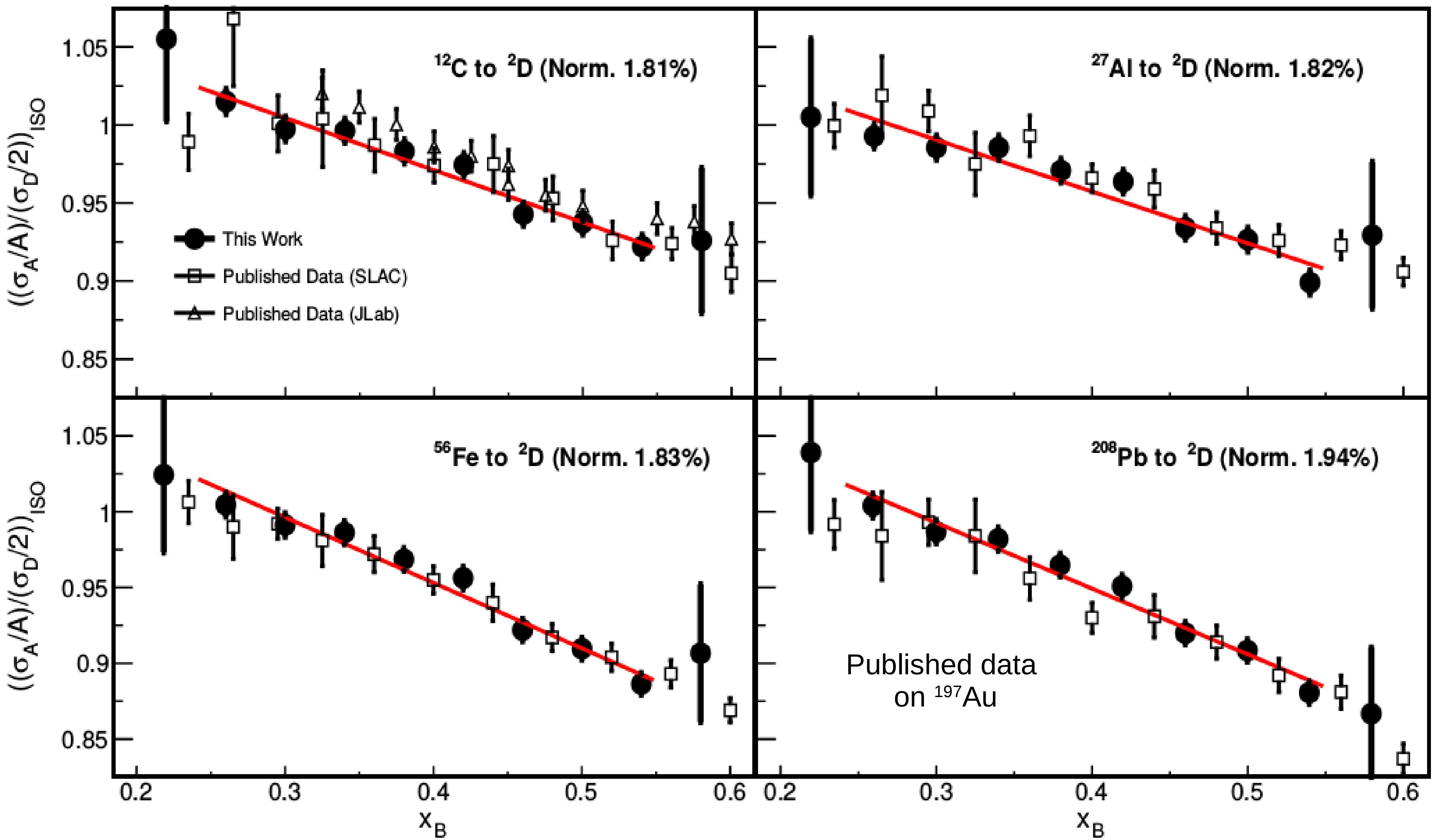


$$weight = \frac{RC \times CC \times ISO}{NORM \times ACC} \times BC$$

Uncertainties Cross-Section Ratios

Source	Point-to-point (%)	Normalization (%)
Beam Charge/ Time-Dependent Instabilities	—	1.0
Target Thickness and Cuts	—	1.42 – 1.58
Acceptance Corrections	0.6 (5)	—
Radiative Corrections	—	0.5
Coulomb Corrections	—	0.1
Bin-Centering Corrections	0.5	—
Total	**0.78**	**1.81 – 1.94**

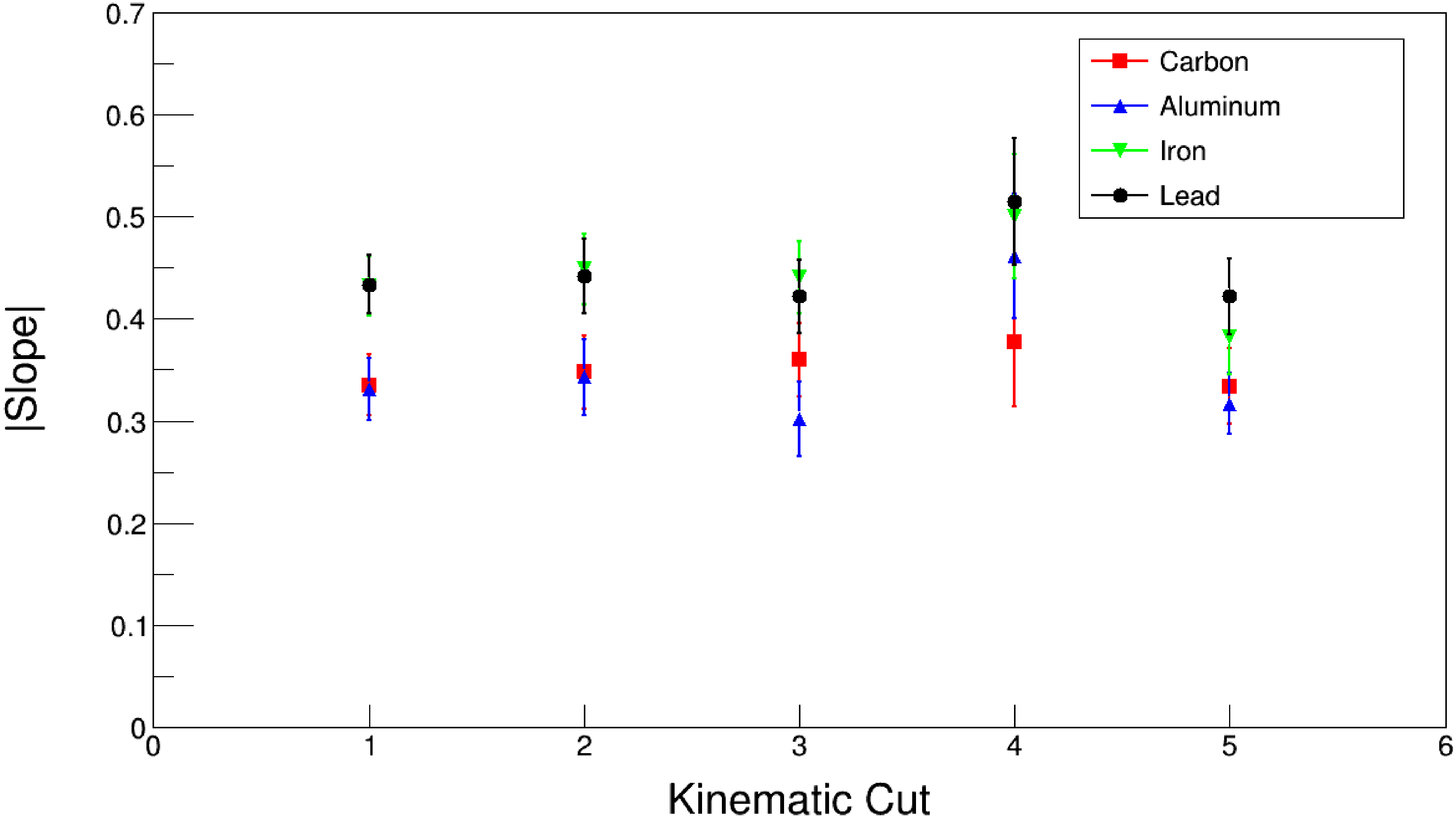
Our New EMC Effect Measurements



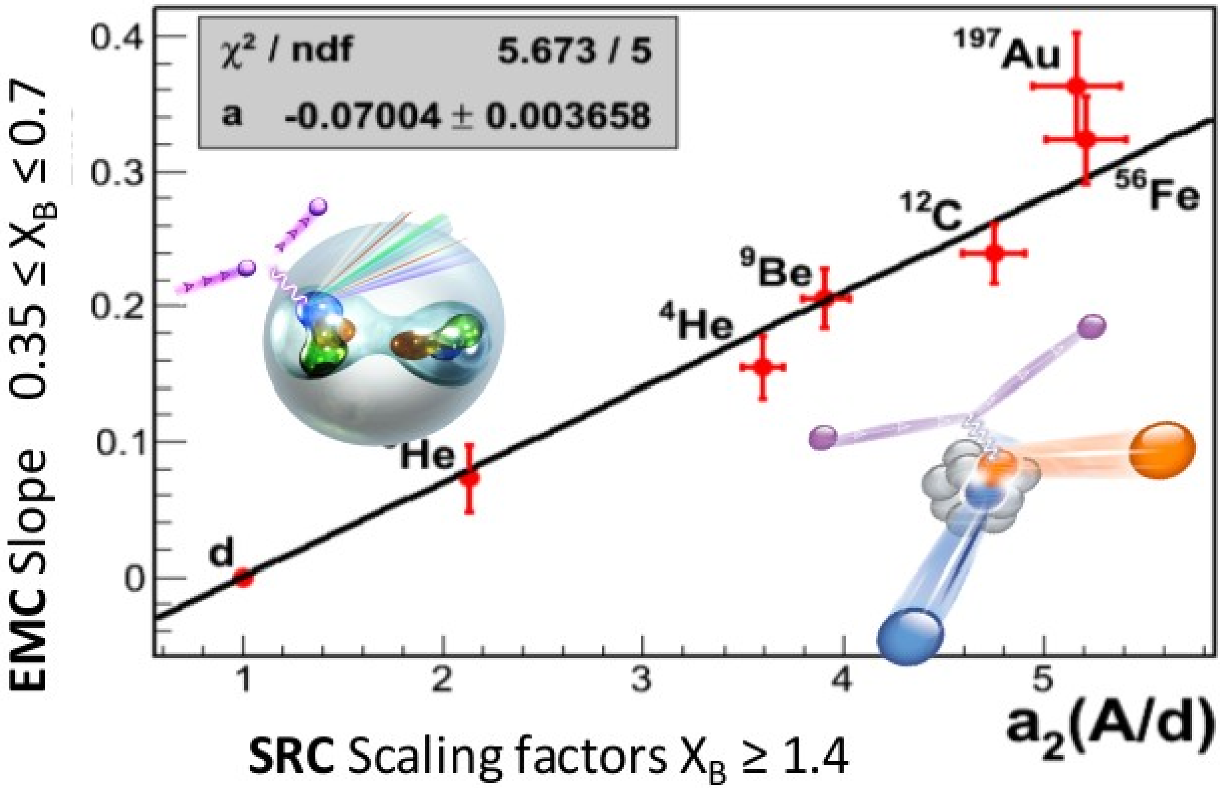
Slopes are Reasonably Independent of Kinematic Cut

Applied Q^2, W Cut	Fit Range	C/D $\|Slope\|$	Al/D $\|Slope\|$	Fe/D $\|Slope\|$	Pb/D $\|Slope\|$
$Q^2 > 1.5GeV^2$ $W > 1.8GeV$	0.26-0.54	0.335 ± 0.030	0.331 ± 0.030	0.432 ± 0.029	0.434 ± 0.029
$Q^2 > 1.5GeV^2$ $W > 2.0GeV$	0.26-0.50	0.334 ± 0.037	0.317 ± 0.038	0.382 ± 0.036	0.422 ± 0.037
$Q^2 > 1.75GeV^2$ $W > 1.8GeV$	0.30-0.54	0.348 ± 0.036	0.343 ± 0.037	0.449 ± 0.035	0.442 ± 0.036
$Q^2 > 2.0GeV^2$ $W > 1.8GeV$	0.30-0.54	0.360 ± 0.036	0.302 ± 0.037	0.441 ± 0.035	0.422 ± 0.036
$Q^2 > 2.5GeV^2$ $W > 1.8GeV$	0.38-0.54	0.377 ± 0.063	0.461 ± 0.061	0.501 ± 0.061	0.515 ± 0.062

Slopes are Reasonably Independent of

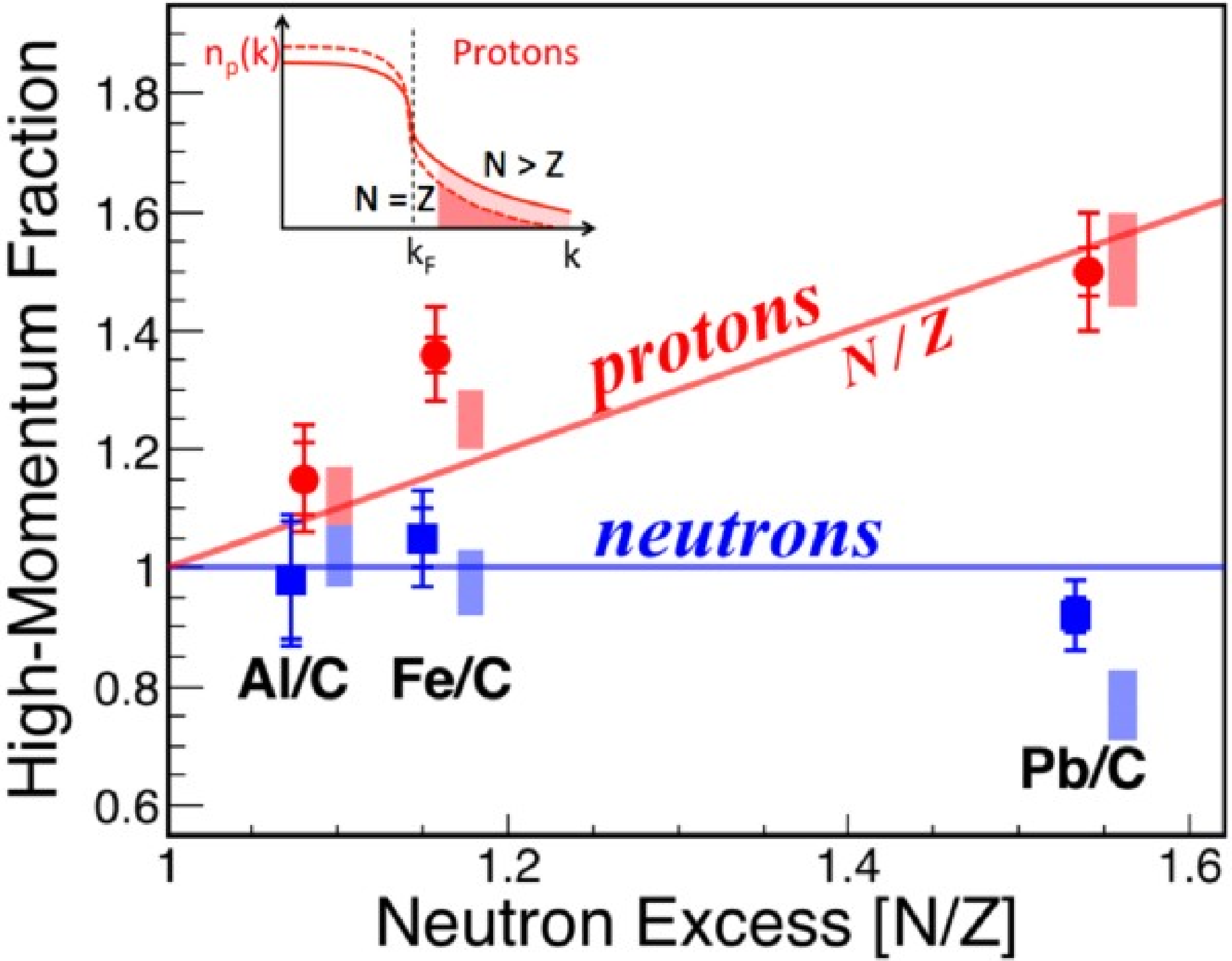


Observed EMC-SRC Correlation



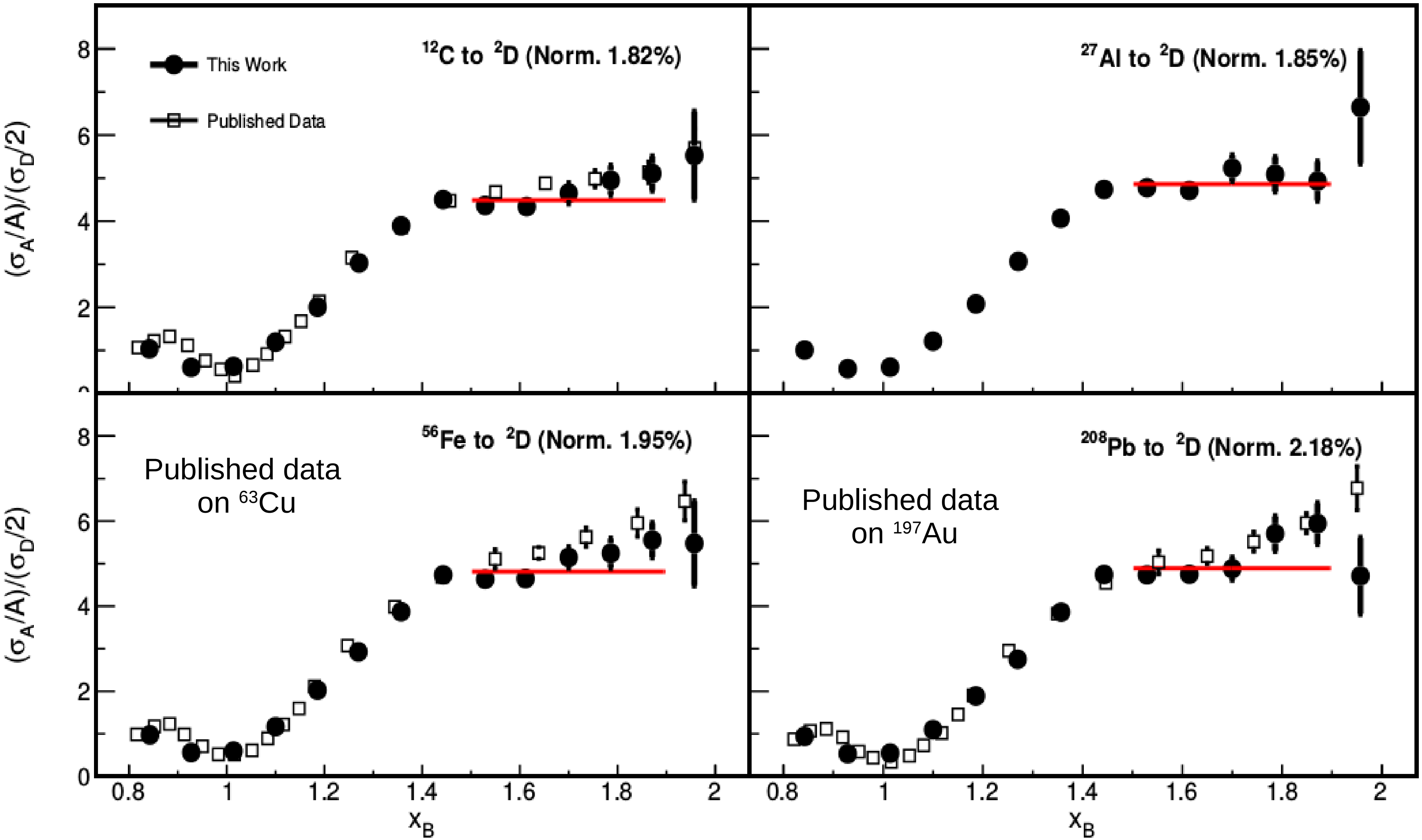
L. Weinstein et. al., Phys. Rev. Lett. 106, 052301 (2011)
O. Hen et al. Phys. Rev. C 85 047301 (2012).
O. Hen et al., Rev. Mod. Phys. 89, 045002 (2017)

Observed Isospin Dependence to SRC



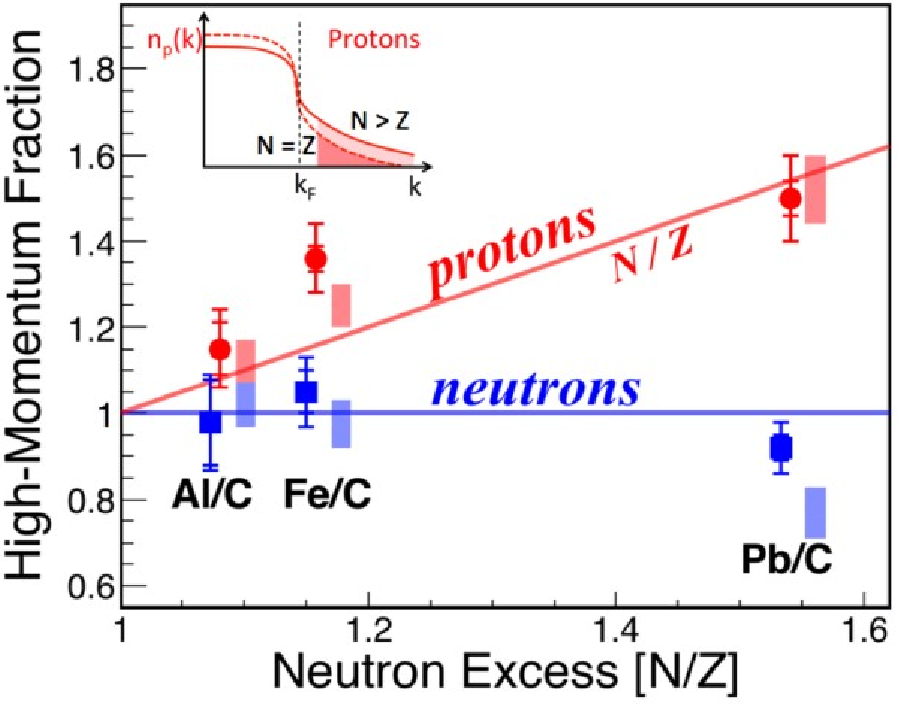
M. Duer et al., submitted for publication (2018).

Our New SRC a_2(A/d) Measurements

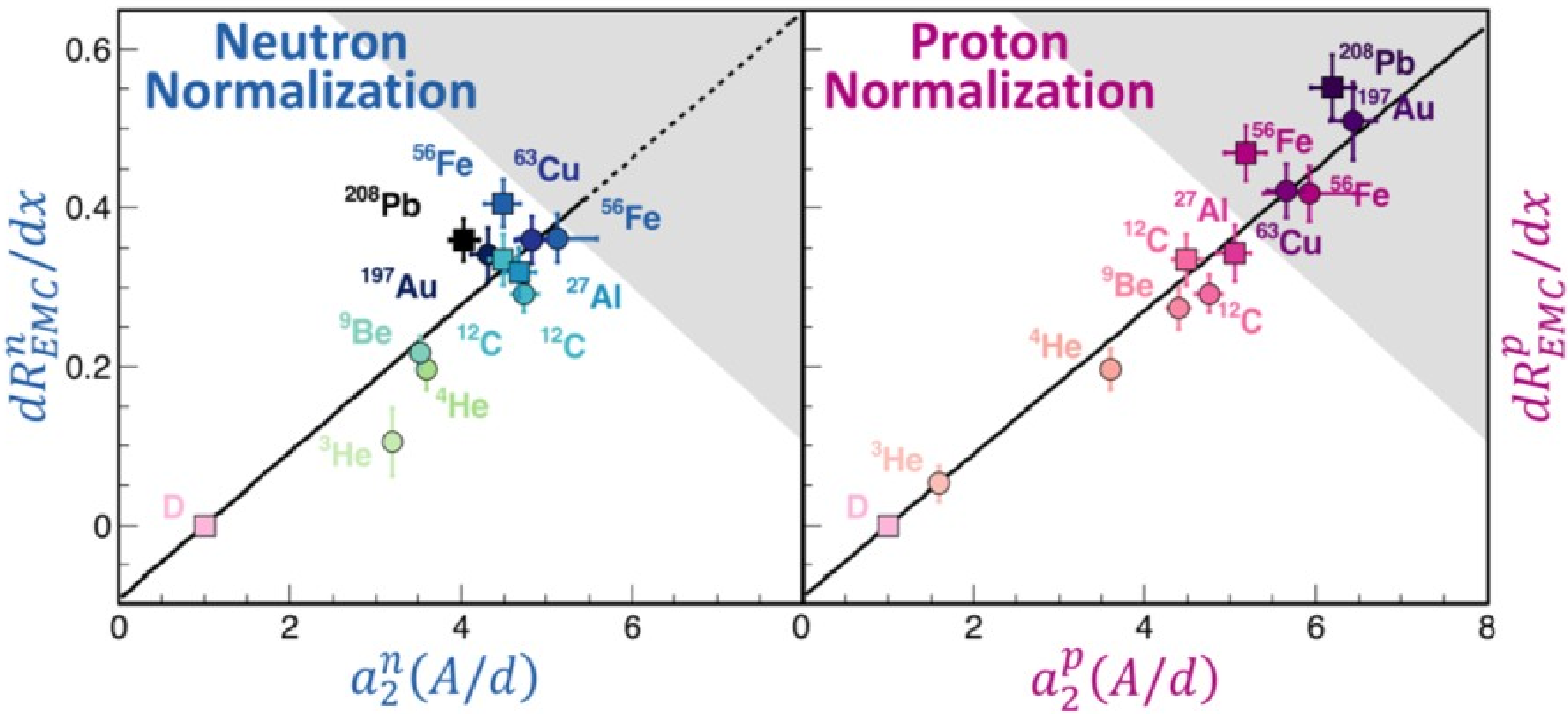


Focus on Neutron-Rich Nuclei

Prediction: EMC effect will show no growth for neutrons and grow for protons



Renormalized EMC/SRC Correlation Plots



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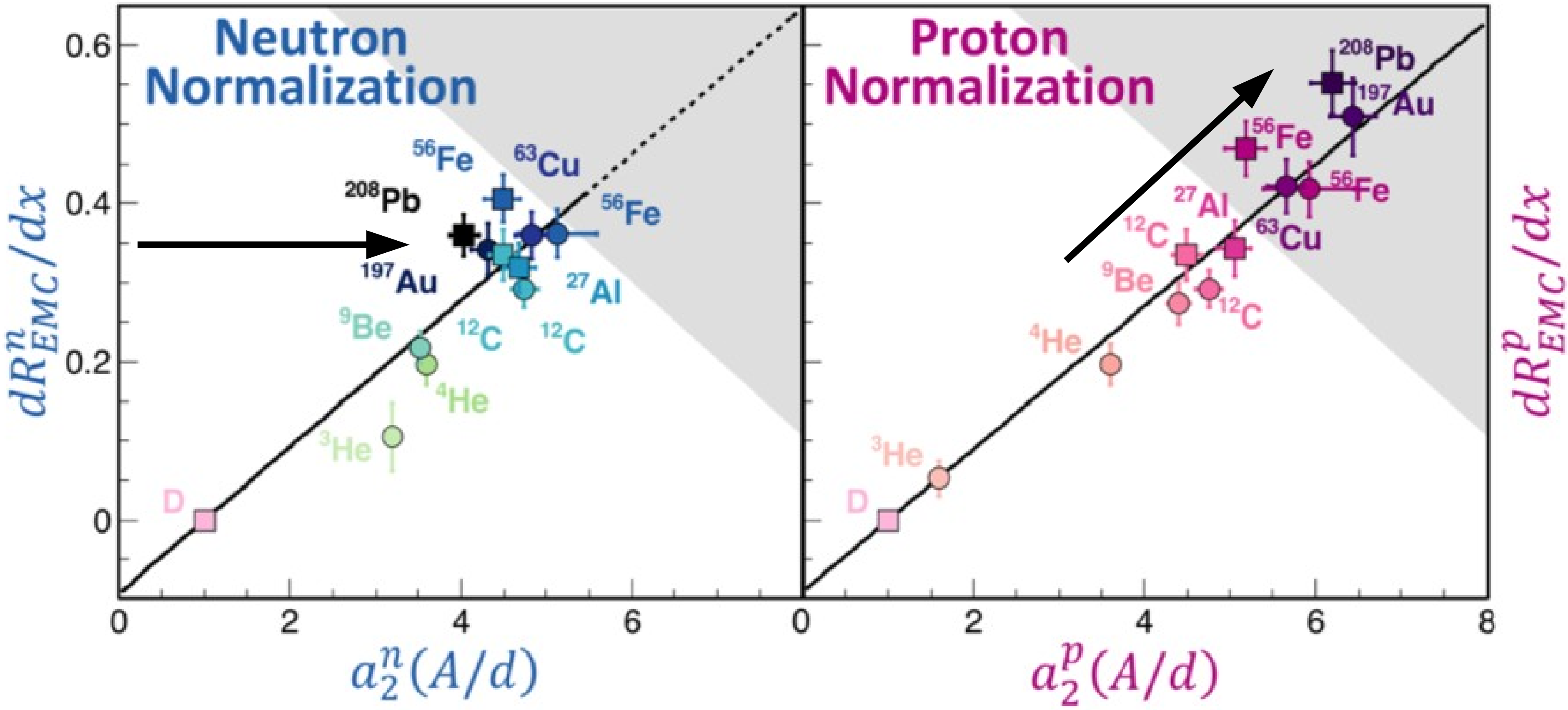
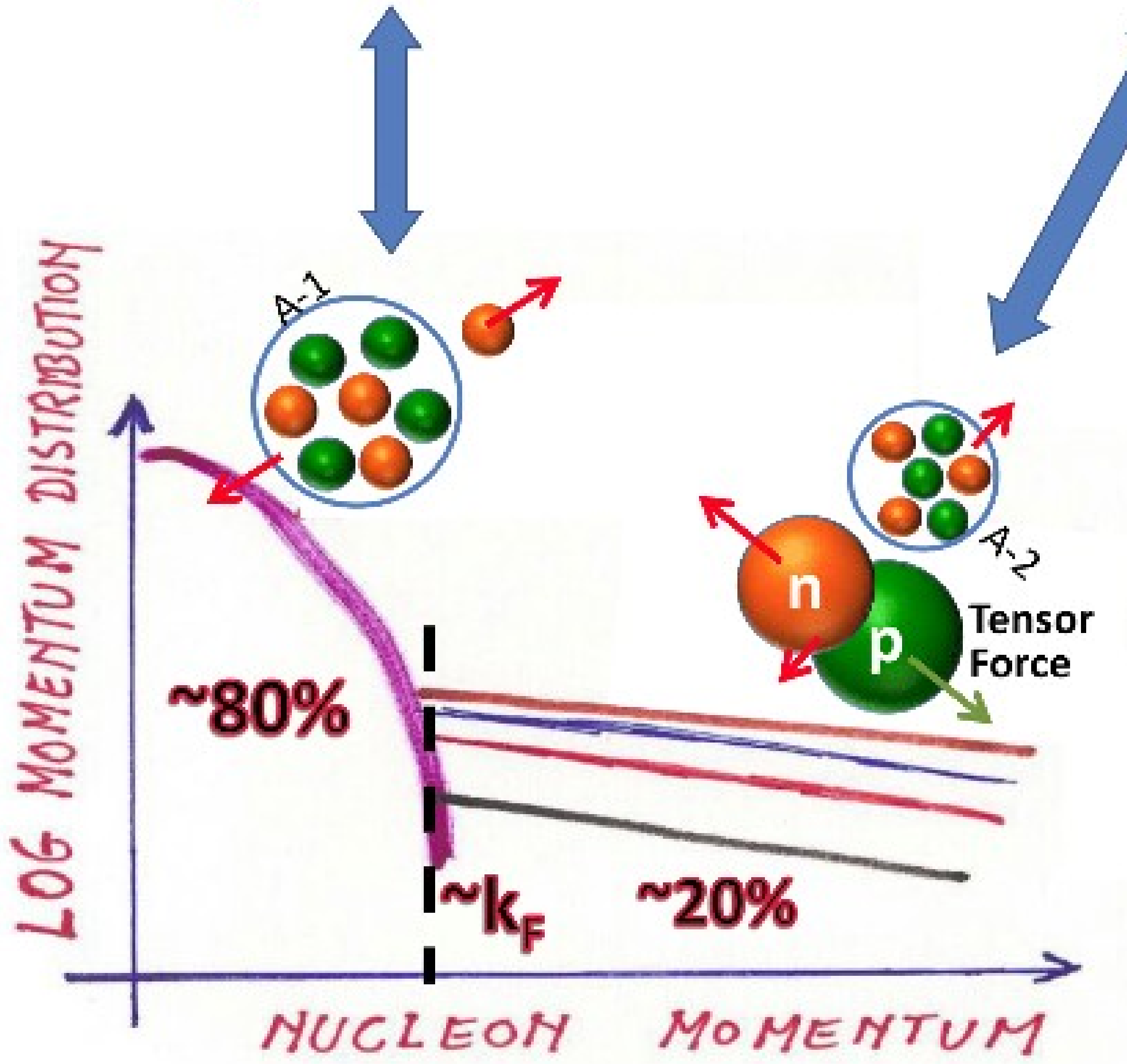
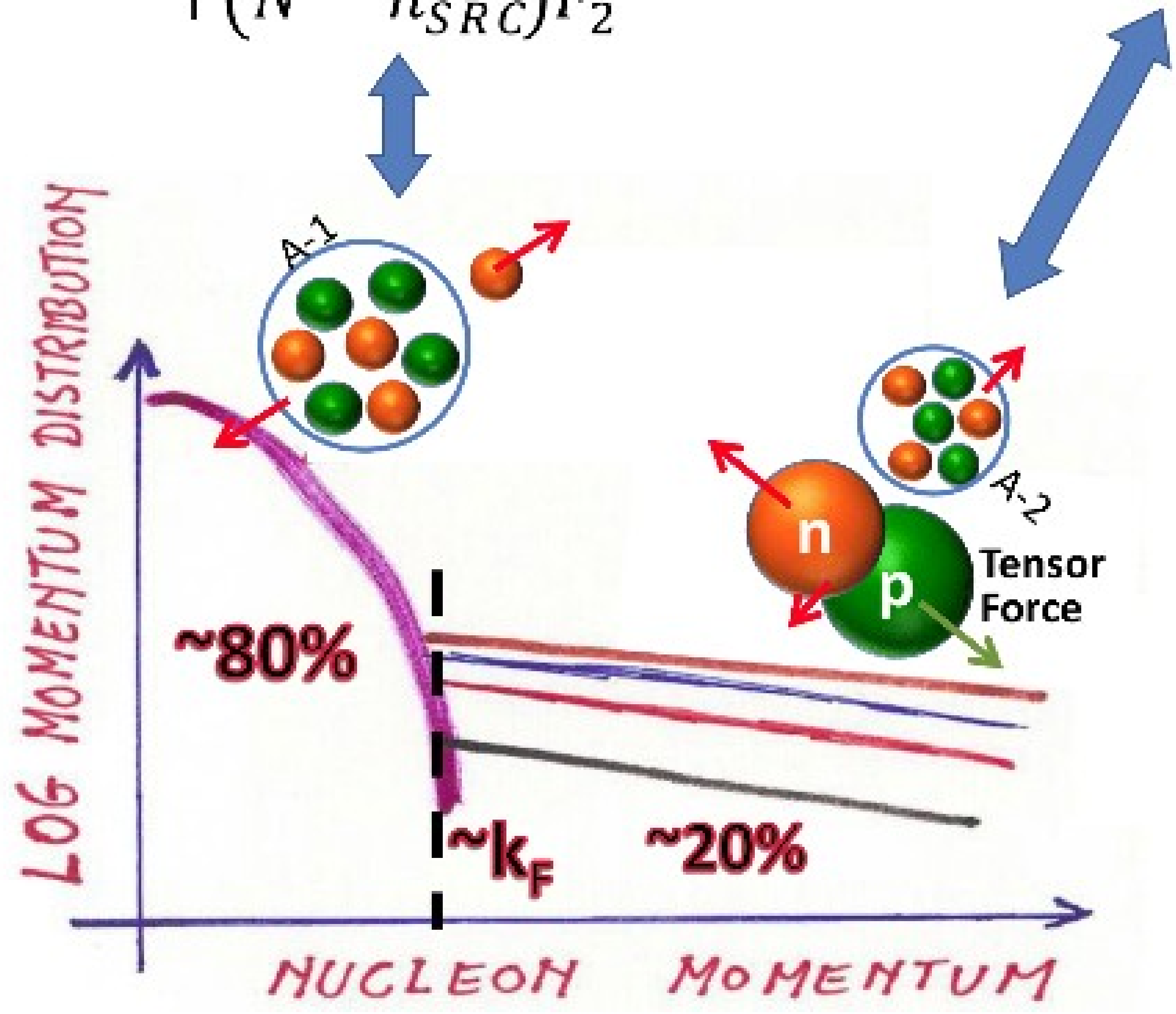


Bound = 'quasi Free' + Modified SRCs



Bound = 'quasi Free' + Modified SRCs

$$F_2^A = \begin{array}{c}(Z - n_{SRC}^A)F_2^p \\ +(N - n_{SRC}^A)F_2^n\end{array} + n_{SRC}^A(F_2^{p*} + F_2^{n*})$$



Bound = 'quasi Free' + Modified SRCs

$$F_2^A = ZF_2^p + NF_2^n + n_{SRC}^A\left(\Delta F_2^p + \Delta F_2^n\right)$$

$$\Delta F_2^N = F_2^{N*} - F_2^N$$

Bound = 'quasi Free' + Modified SRCs

$$F_2^A = ZF_2^p + NF_2^n + n_{SRC}^A\left(\Delta F_2^p + \Delta F_2^n\right)$$

$$\Delta F_2^N = F_2^{N*} - F_2^N$$

→ $$F_2^d = F_2^p + F_2^n + n_d^{SRC}\left(\Delta F_2^p + \Delta F_2^n\right)$$

→ $$a_2 \equiv \frac{2}{A} n_A^{SRC} / n_d^{SRC}$$

$$n_d^{SRC}\,\frac{\Delta F_2^p+\Delta F_2^n}{F_2^d}=\frac{\frac{F_2^A}{F_2^d}-(Z-N)\frac{F_2^p}{F_2^d}-N}{\frac{A}{2}a_2-N}$$

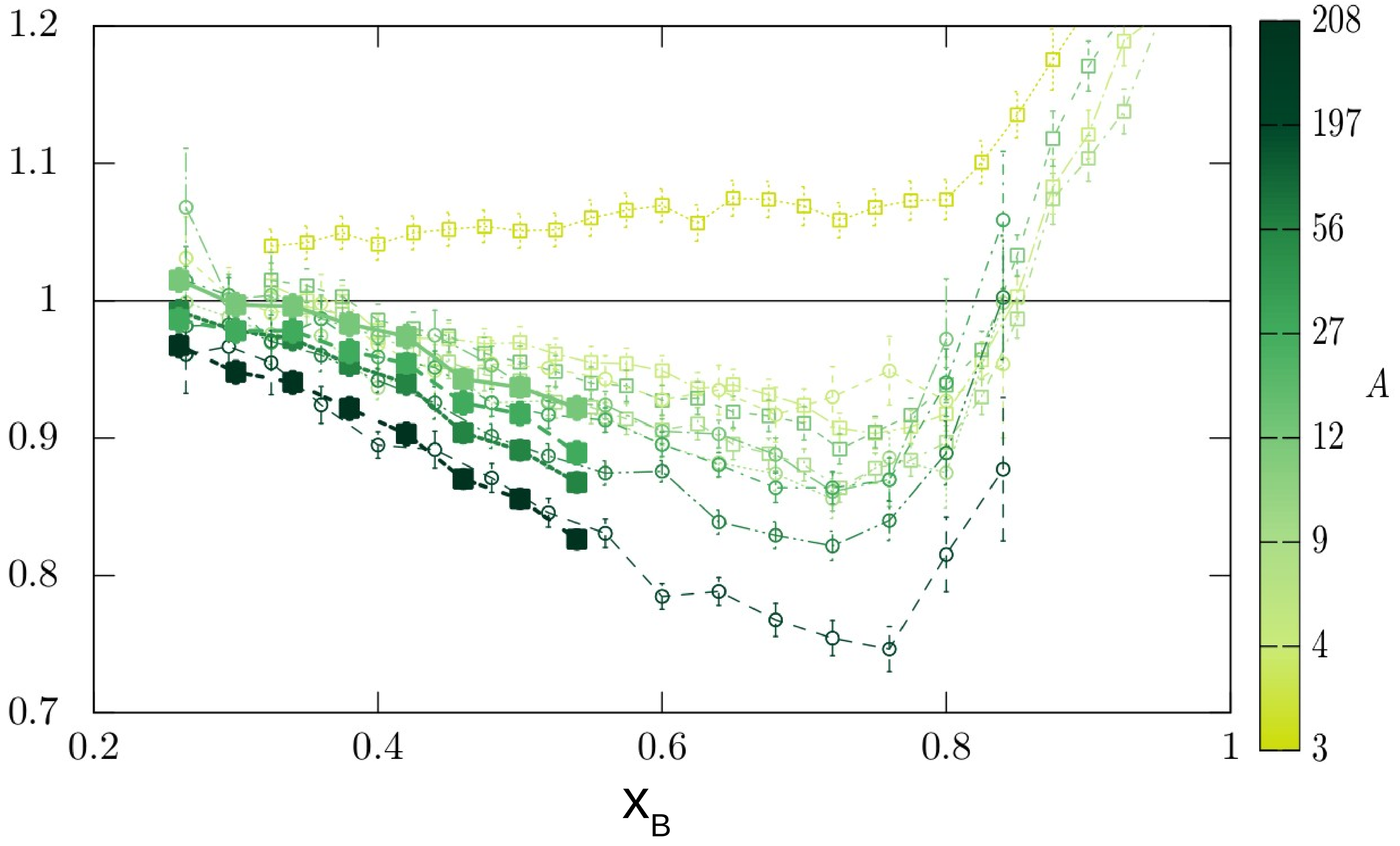
Universal???

Nucleus-Dependent

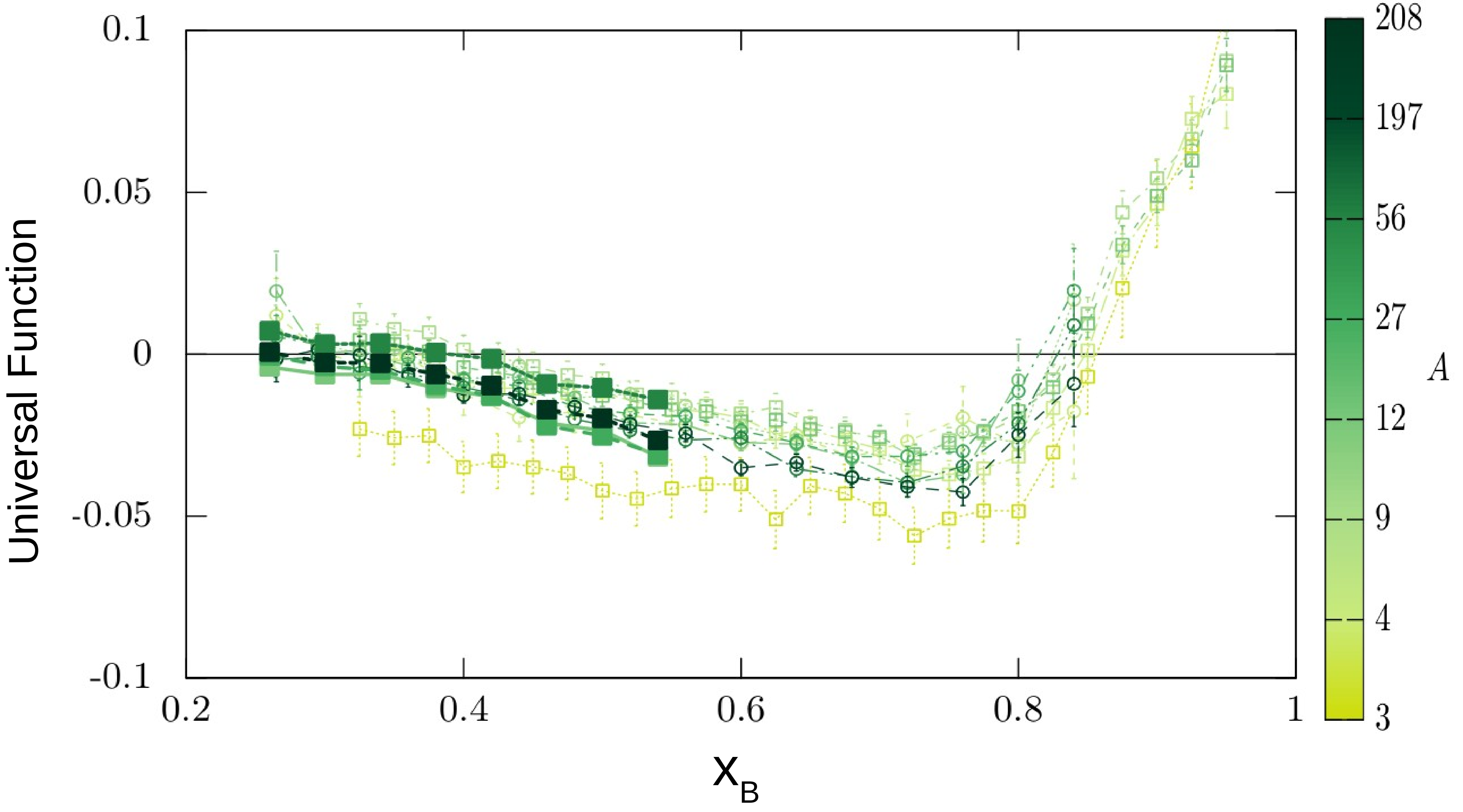
$$n_d^{SRC}\frac{\Delta F_2^p+\Delta F_2^n}{F_2^d}=\frac{\frac{F_2^A}{F_2^d}-(Z-N)\frac{F_2^p}{F_2^d}-N}{\frac{A}{2}a_2-N}$$

Everything is Known

Measured EMC Ratios



Universal EMC Modification Function



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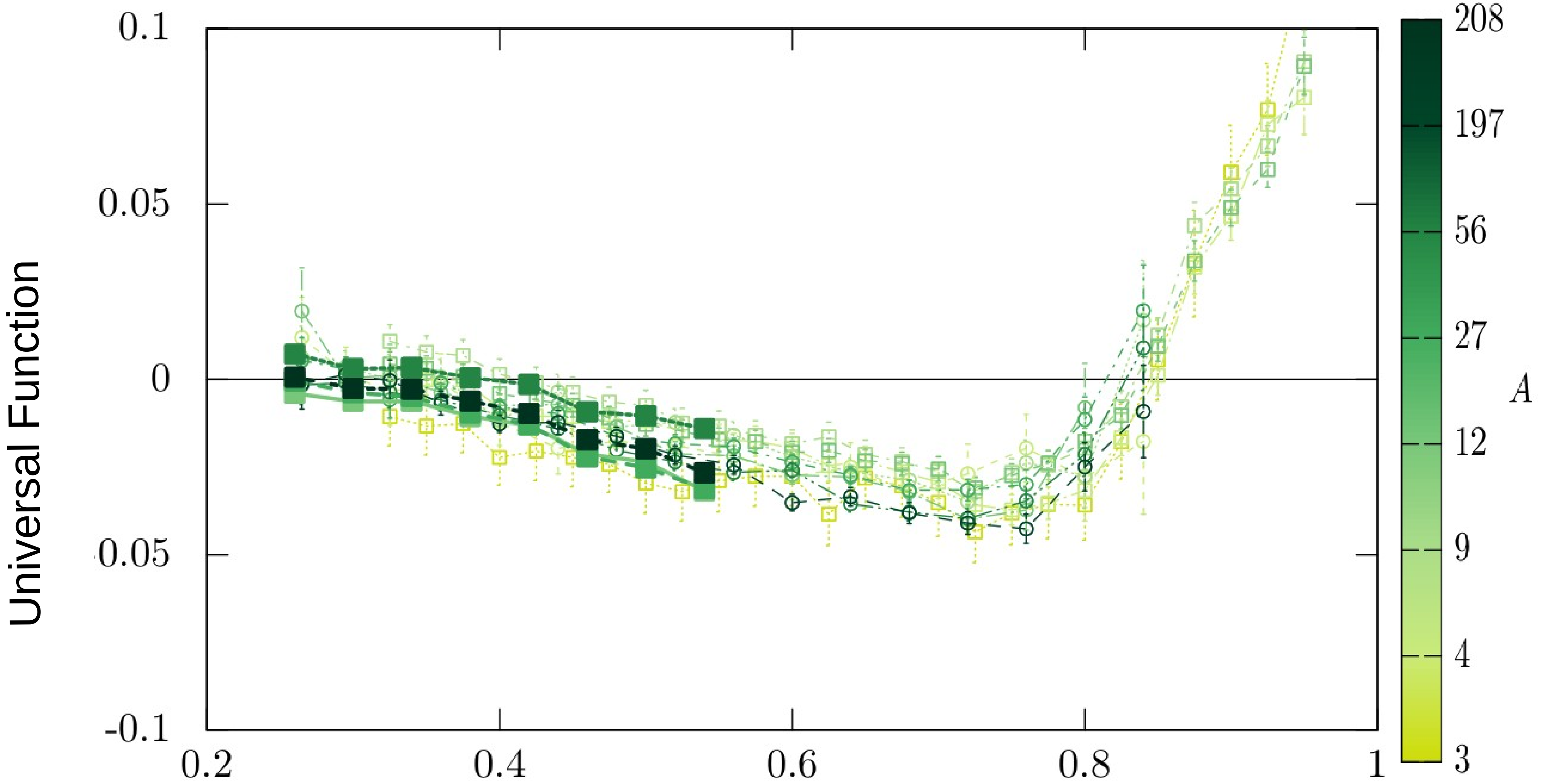
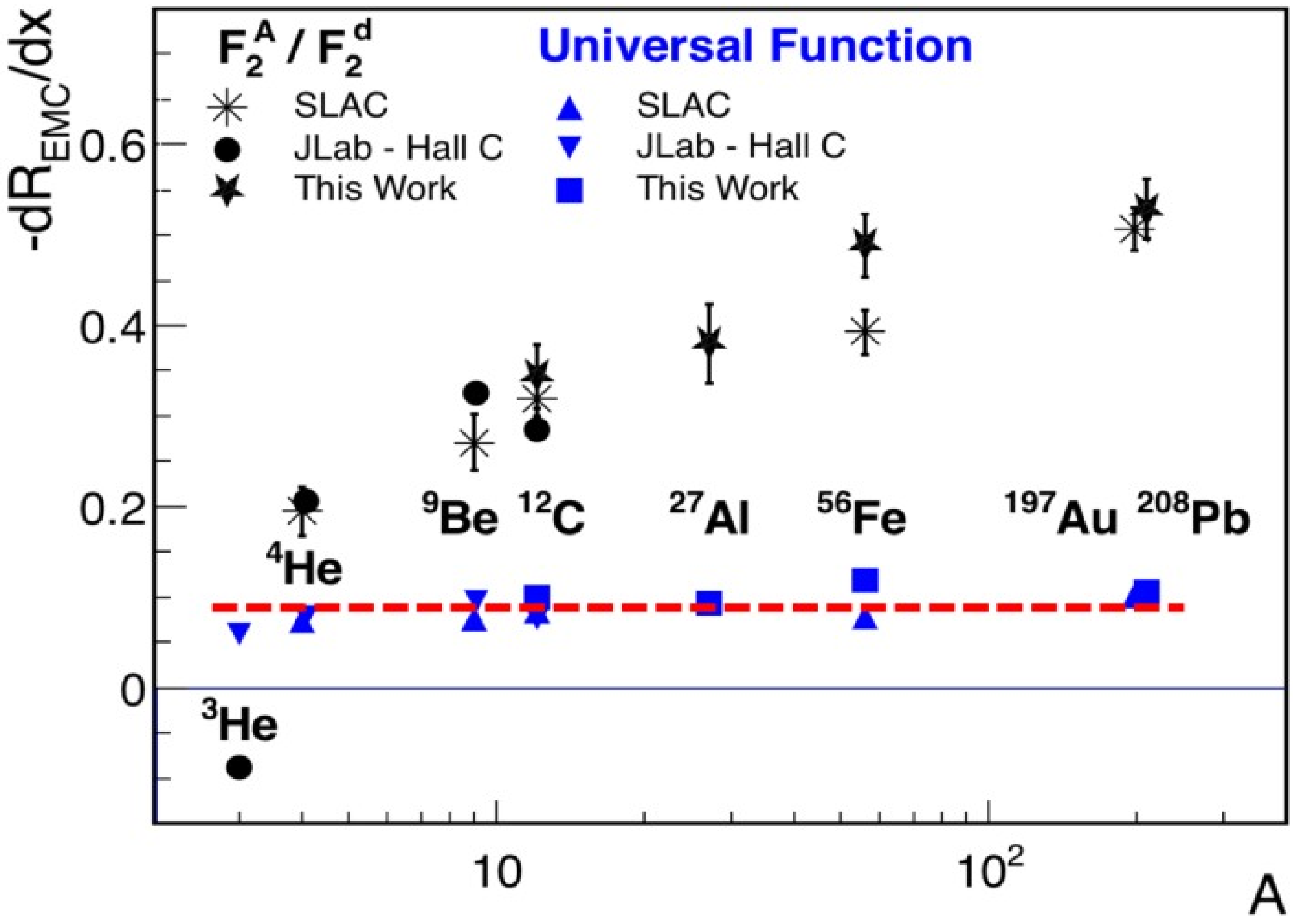


See Kulagin and Petti, PRC 82 054614 (2010)

x_B

Universal EMC Modification Function



Back to Per-Neutron (Per-Proton) Ratios: What Does Our Model Say?

$$\frac{F_2^A/N}{F_2^d/1} = \left(a_2^n - 1\right) \cdot \left[n_{SRC}^d \frac{\Delta F_2^p + \Delta F_2^n}{F_2^d} \right] + \left(\frac{Z}{N} - 1 \right) \frac{F_2^p}{F_2^d} + 1$$

$$a_2^n = \frac{n_{SRC}^A / N}{n_{SRC}^d / 1}$$

Back to Per-Neutron (Per-Proton) Ratios: What Does Our Model Say?

$$\frac{F_2^A/N}{F_2^d/1} = \left(a_2^n - 1\right)\cdot\left[n_{SRC}^d \frac{\Delta F_2^p + \Delta F_2^n}{F_2^d}\right] + \left(\frac{Z}{N} - 1\right)\frac{F_2^p}{F_2^d} + 1$$

Extract Per-Neutron (Proton) Slope

Back to Per-Neutron (Per-Proton) Ratios: What Does Our Model Say?