Massachusetts Institute of Technology

Hen Lab

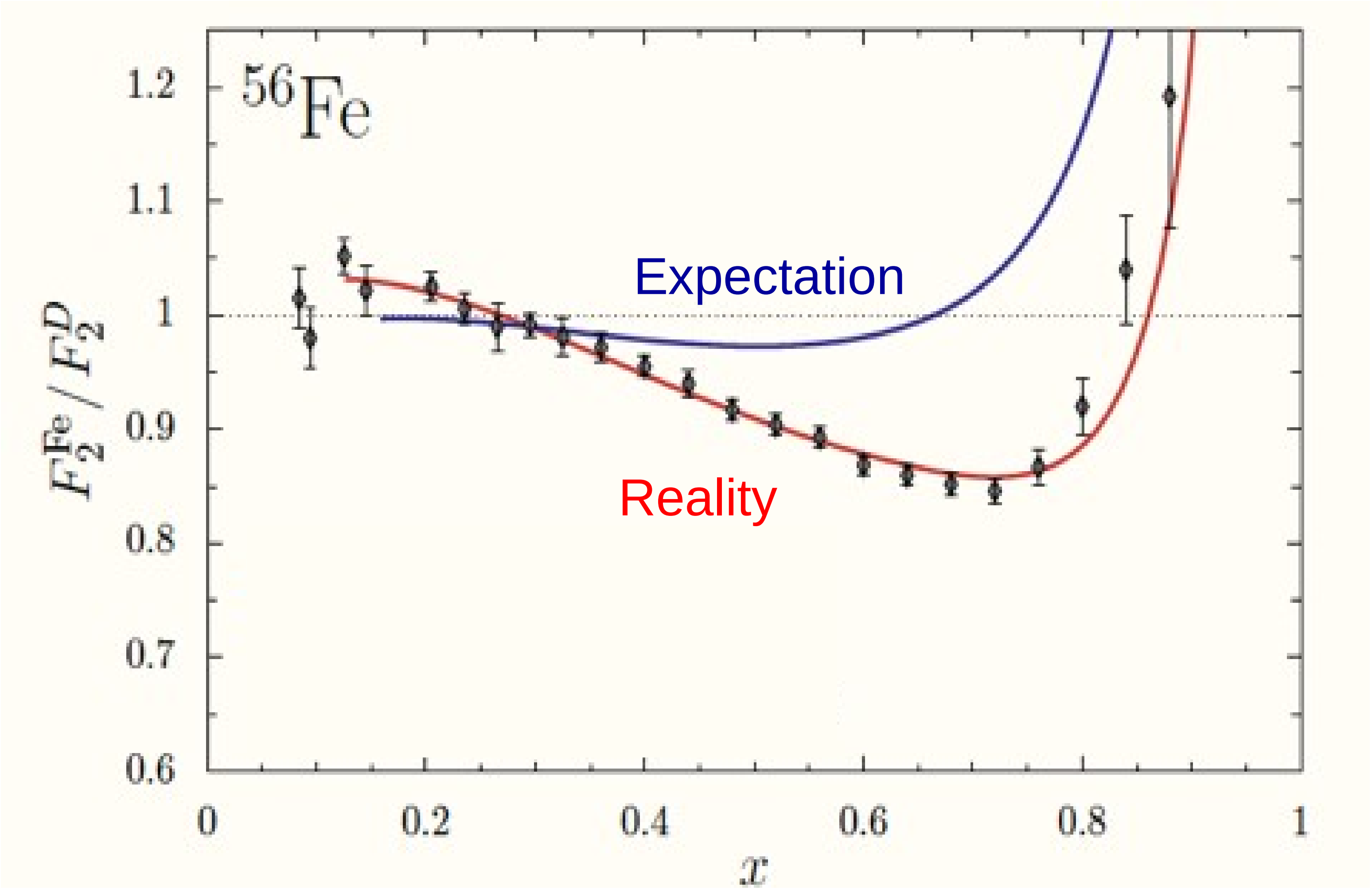
Laboratory for Nuclear Science @ MIT

Isospin Dependence of the EMC Effect and Short-Range Correlations

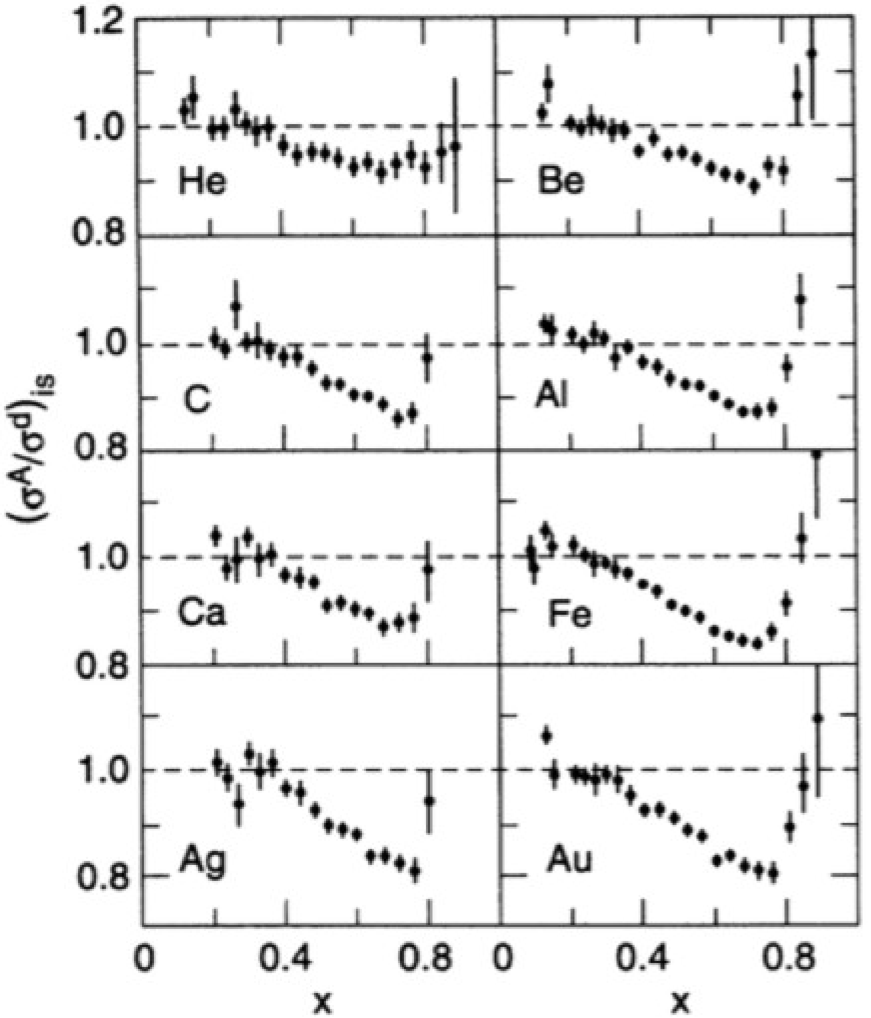
Barak Schmookler

MIT

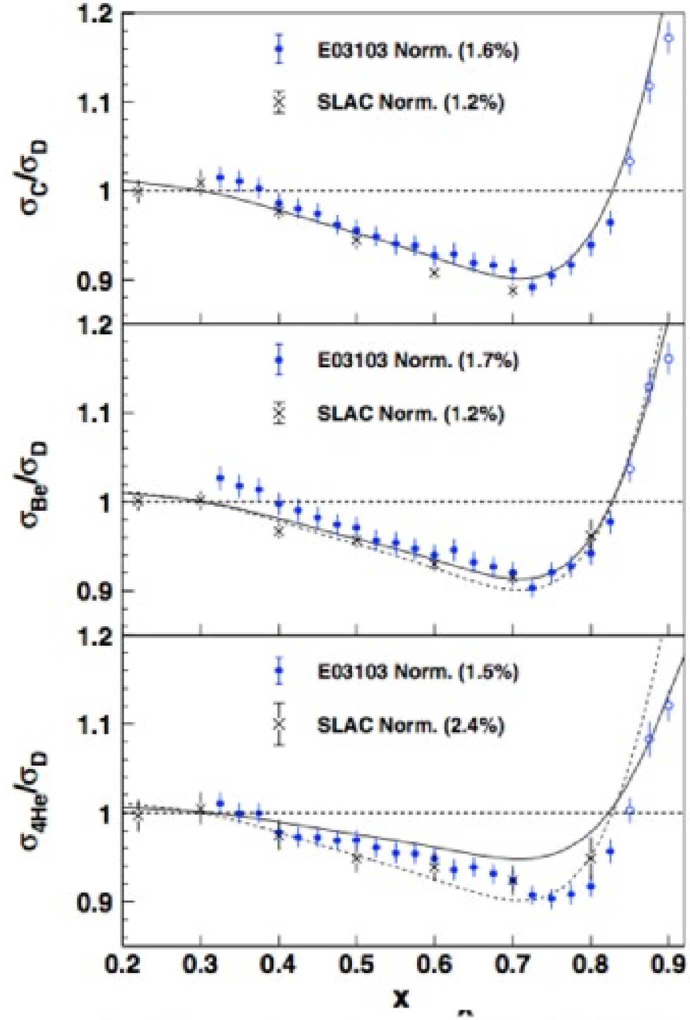
Deep Inelastic Scattering and the EMC Effect



The EMC Effect: Universal Nuclear Effect

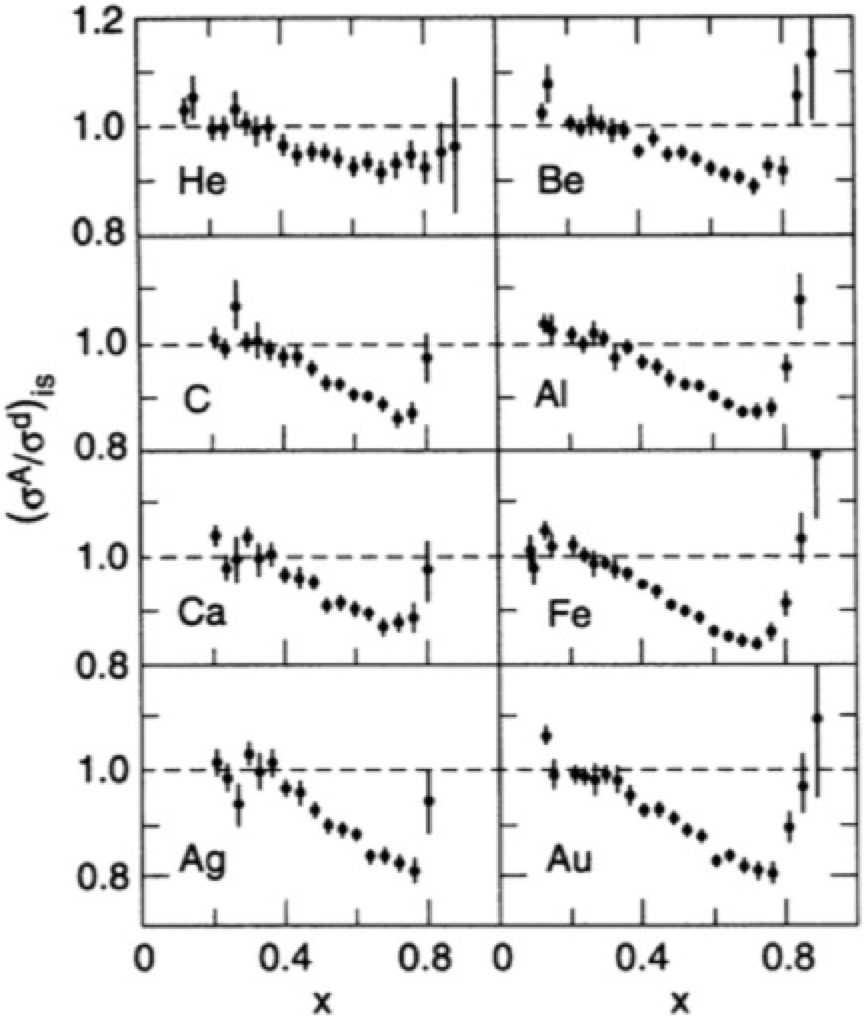


J. Gomez et al., Phys. Rev. D **49**, 4348 (1994).



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

The EMC Effect: Universal Nuclear Effect



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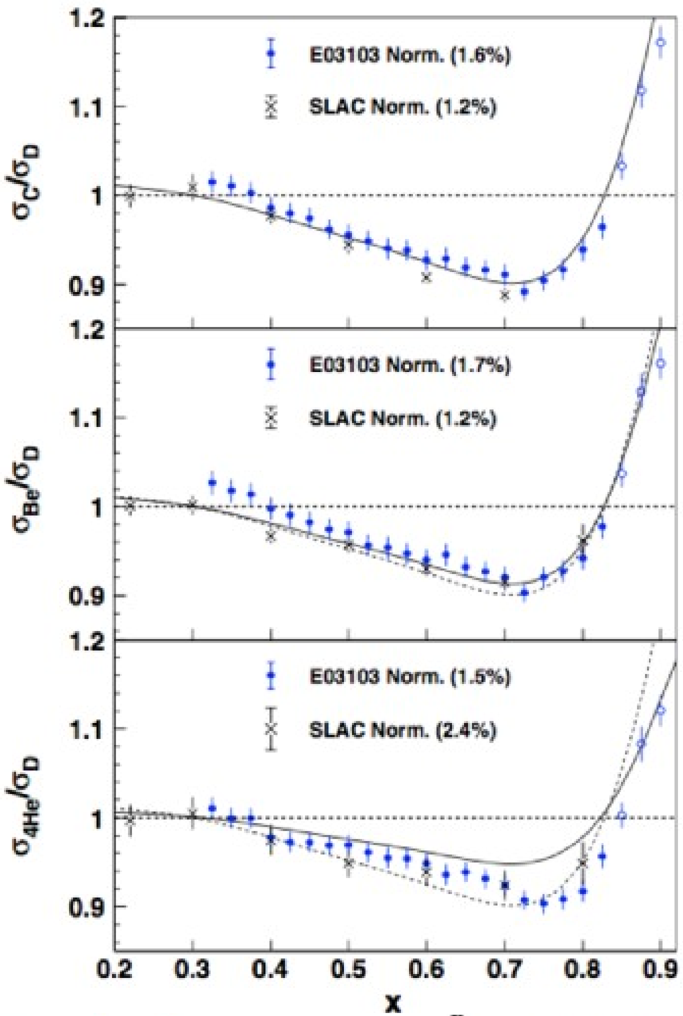

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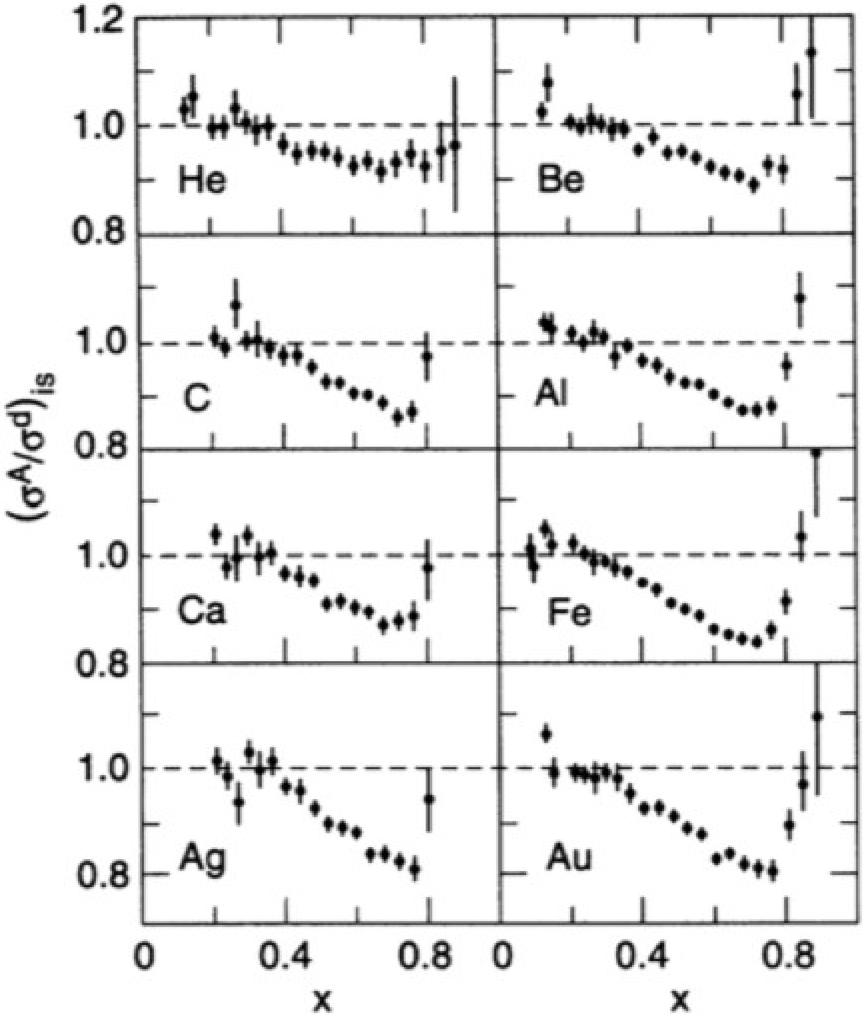
The EMC Effect: Universal Nuclear Effect



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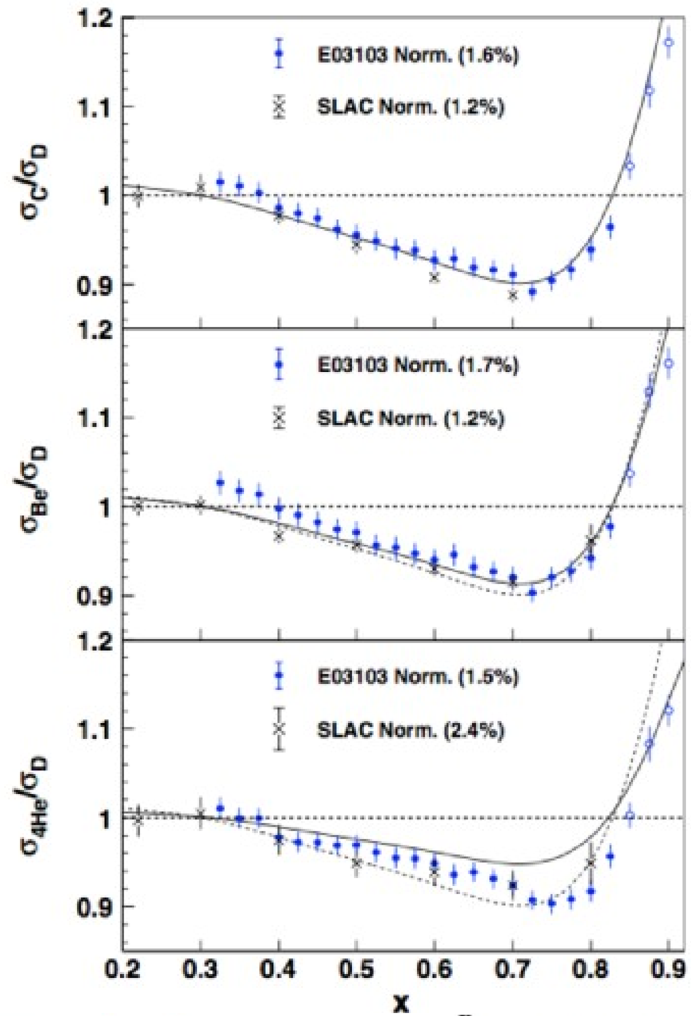

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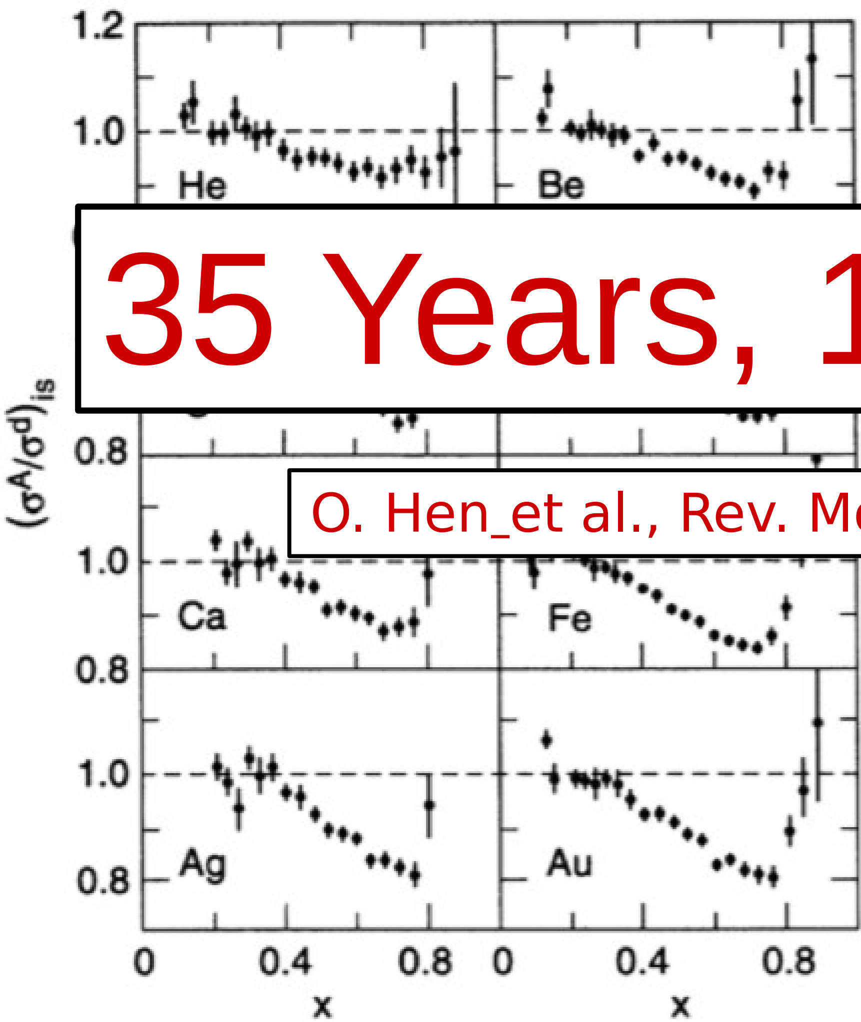
The EMC Effect: Universal Nuclear Effect



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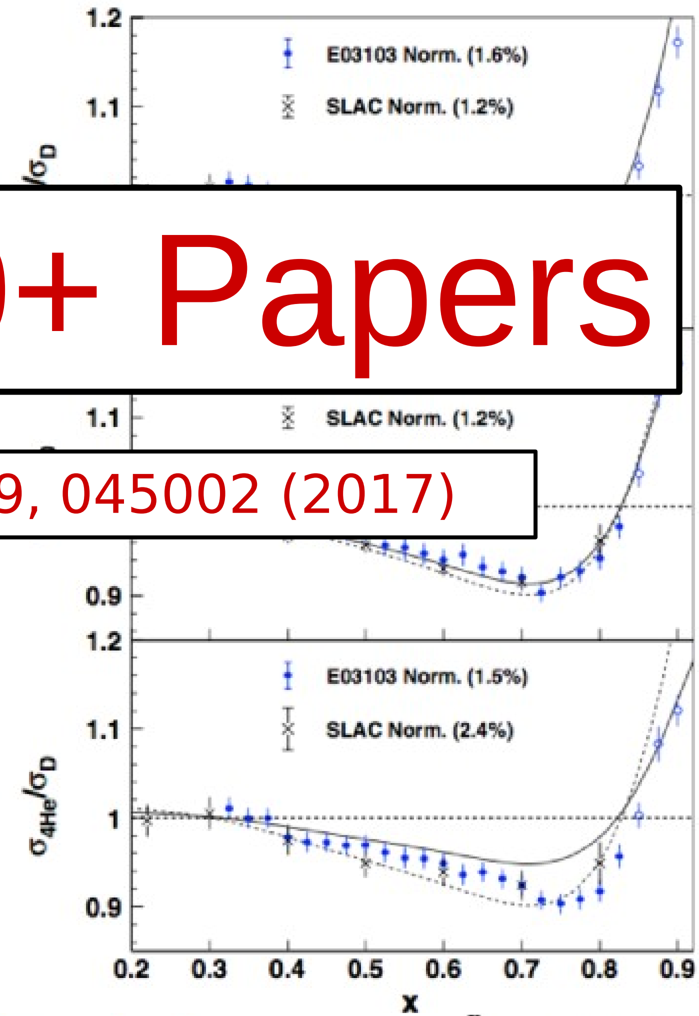
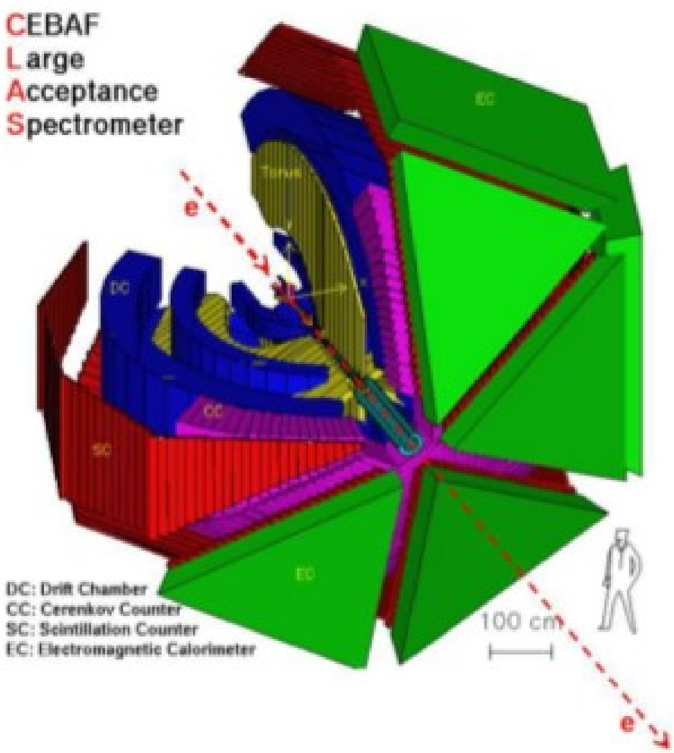


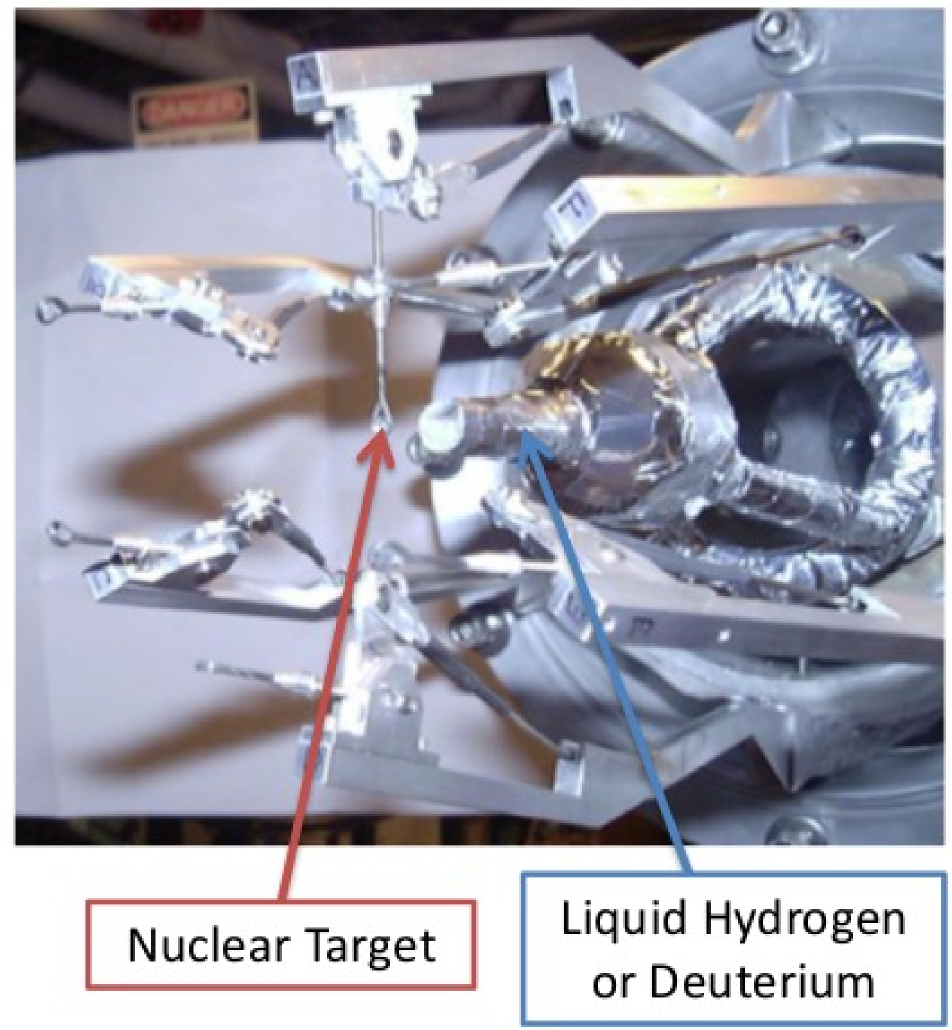
J. Seely et al., Phys. Rev. Lett. **103**, 202301 (2009).

35 Years, 1000+ Papers

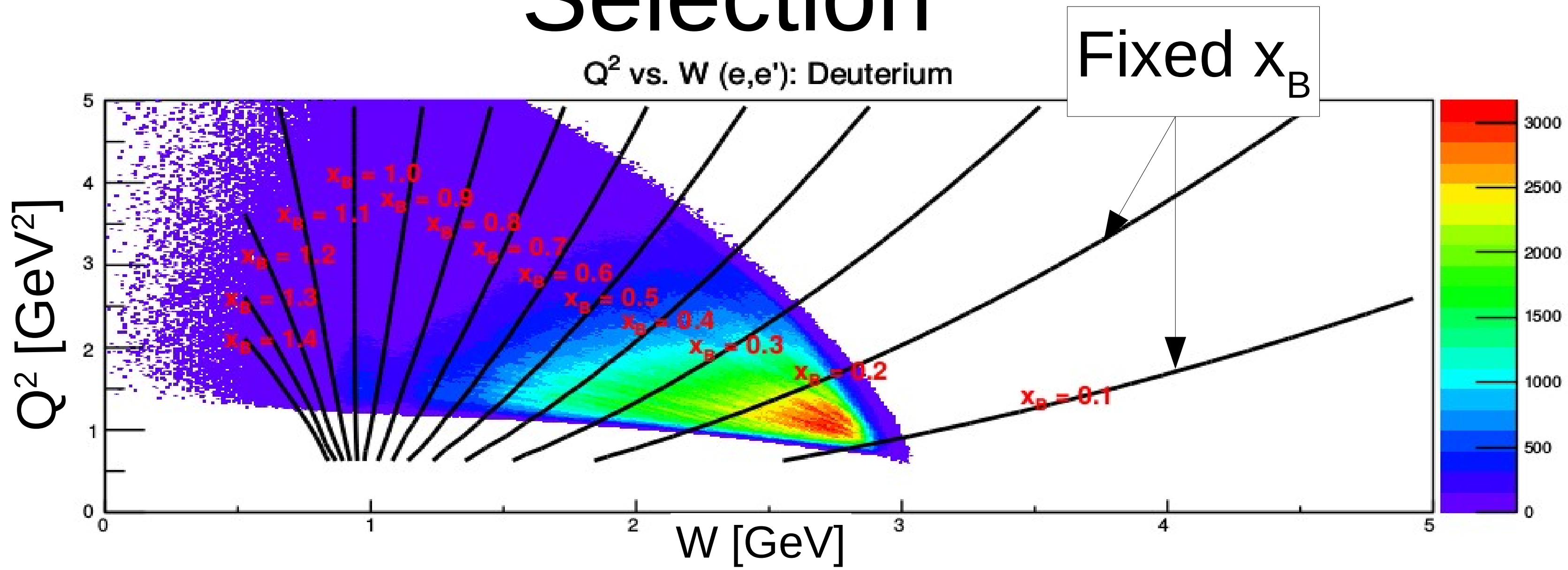
O. Hen_et al., Rev. Mod. Phys. 89, 045002 (2017)

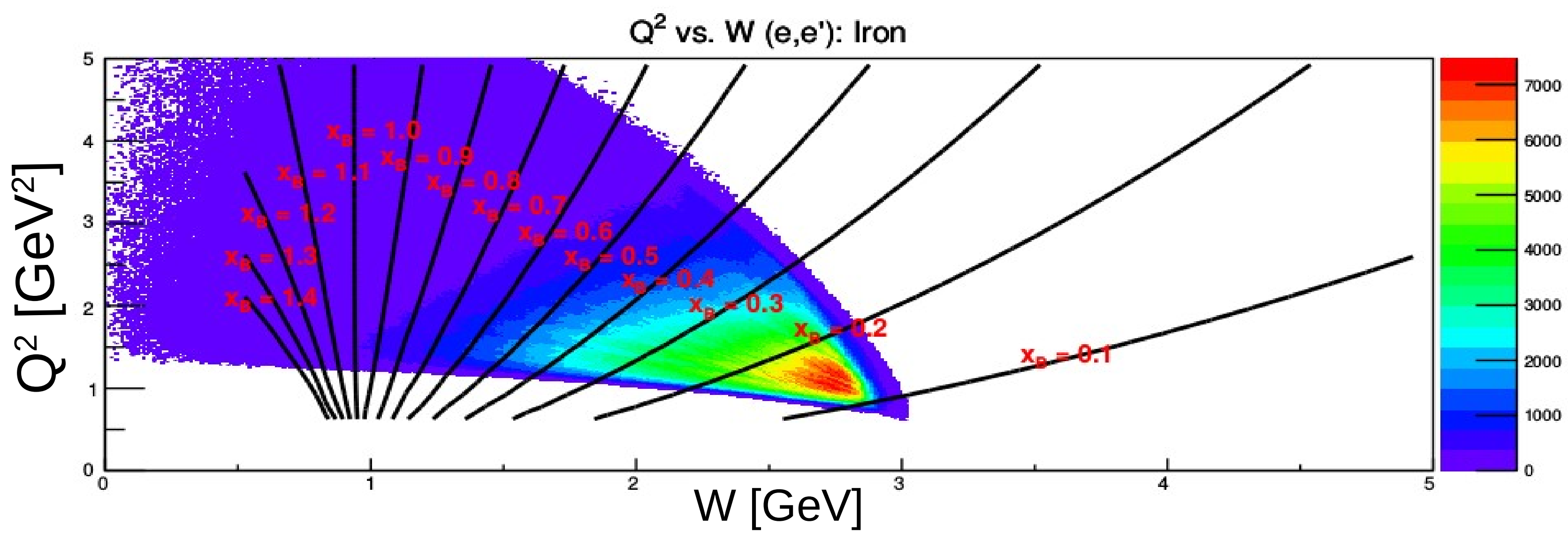
Study (e,e') Data from the CLAS6 Detector at JLab



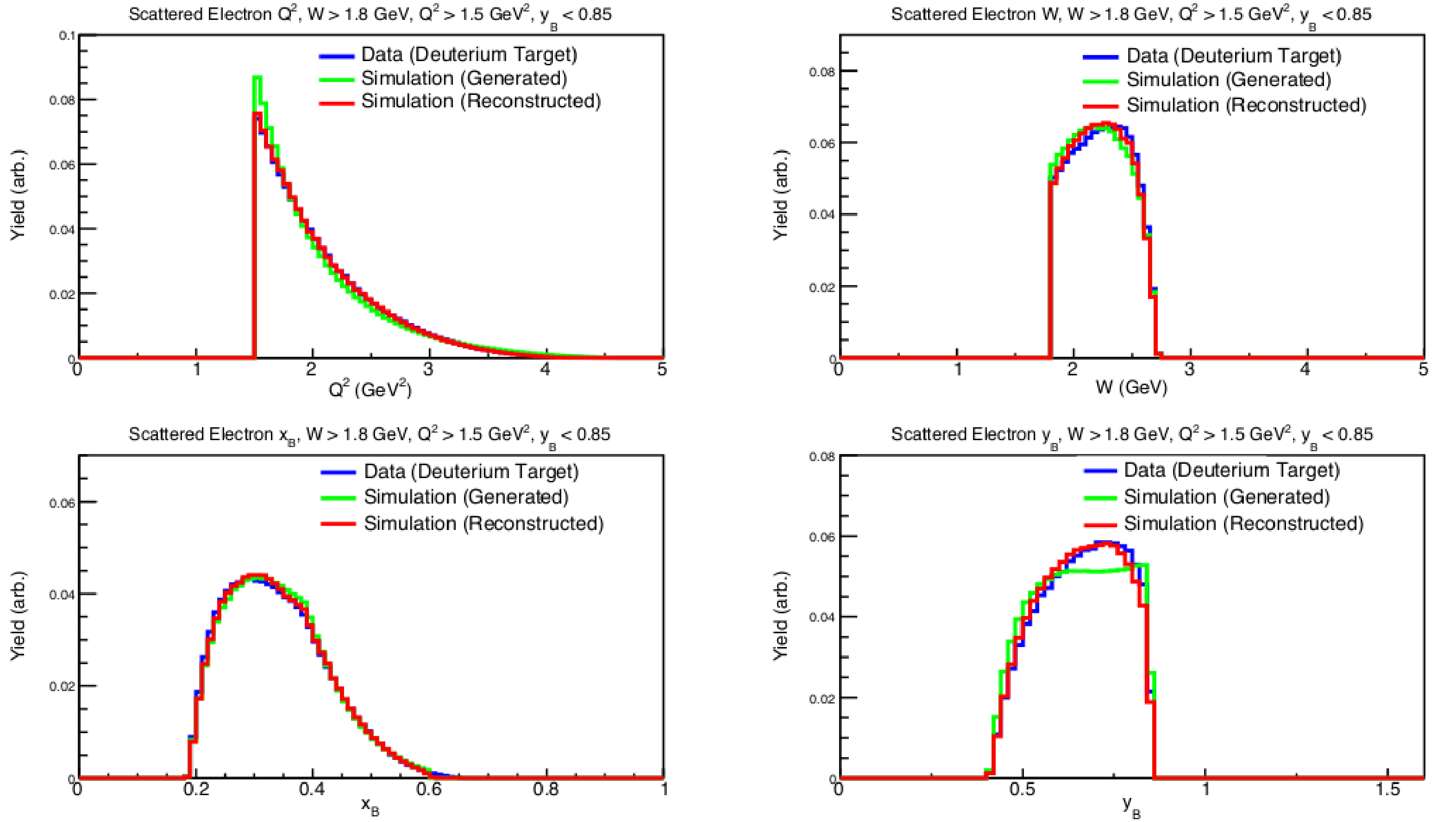


Kinematic Coverage and Event Selection

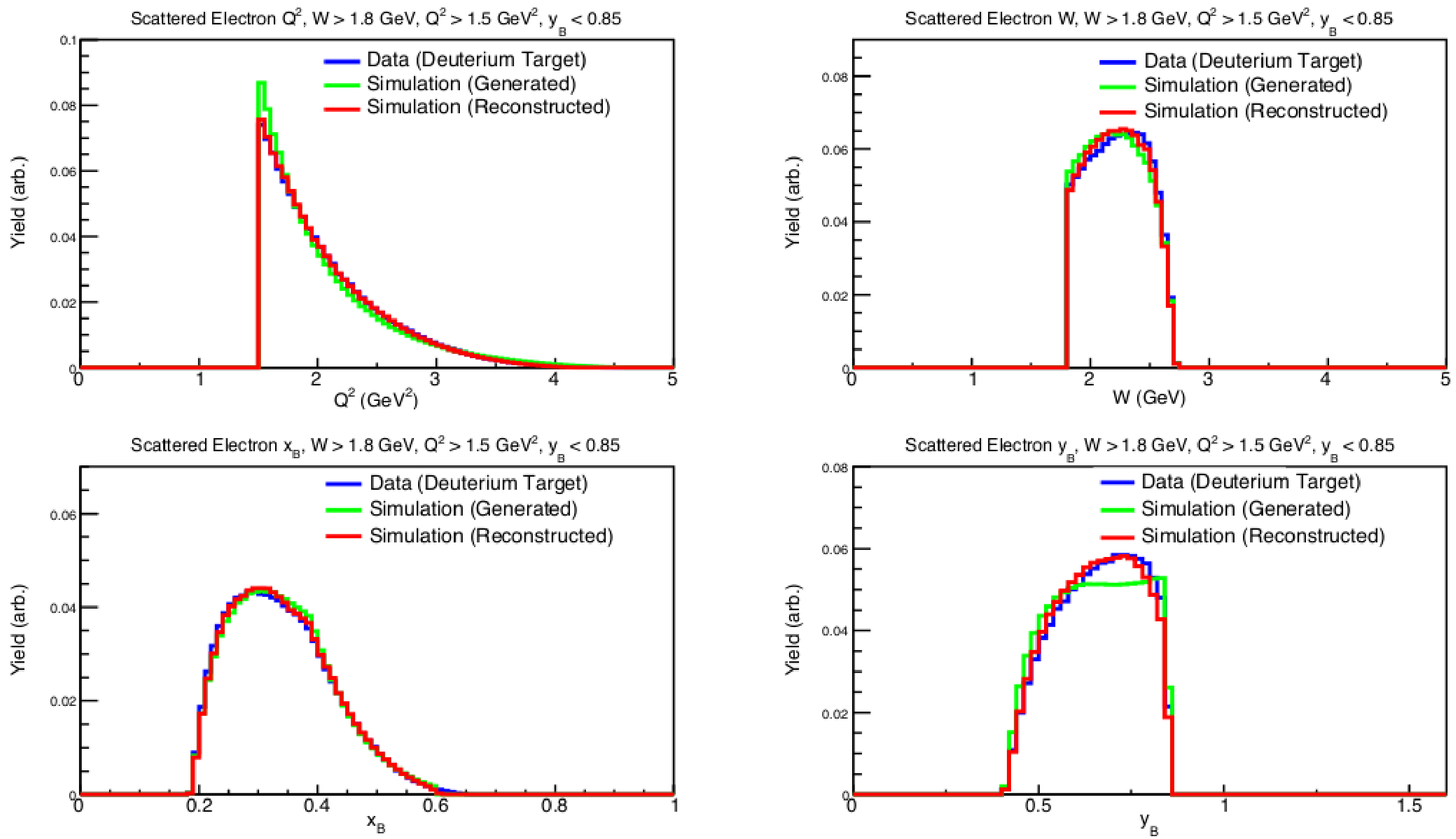




Cross-Section Ratio Extraction



Cross-Section Ratio Extraction

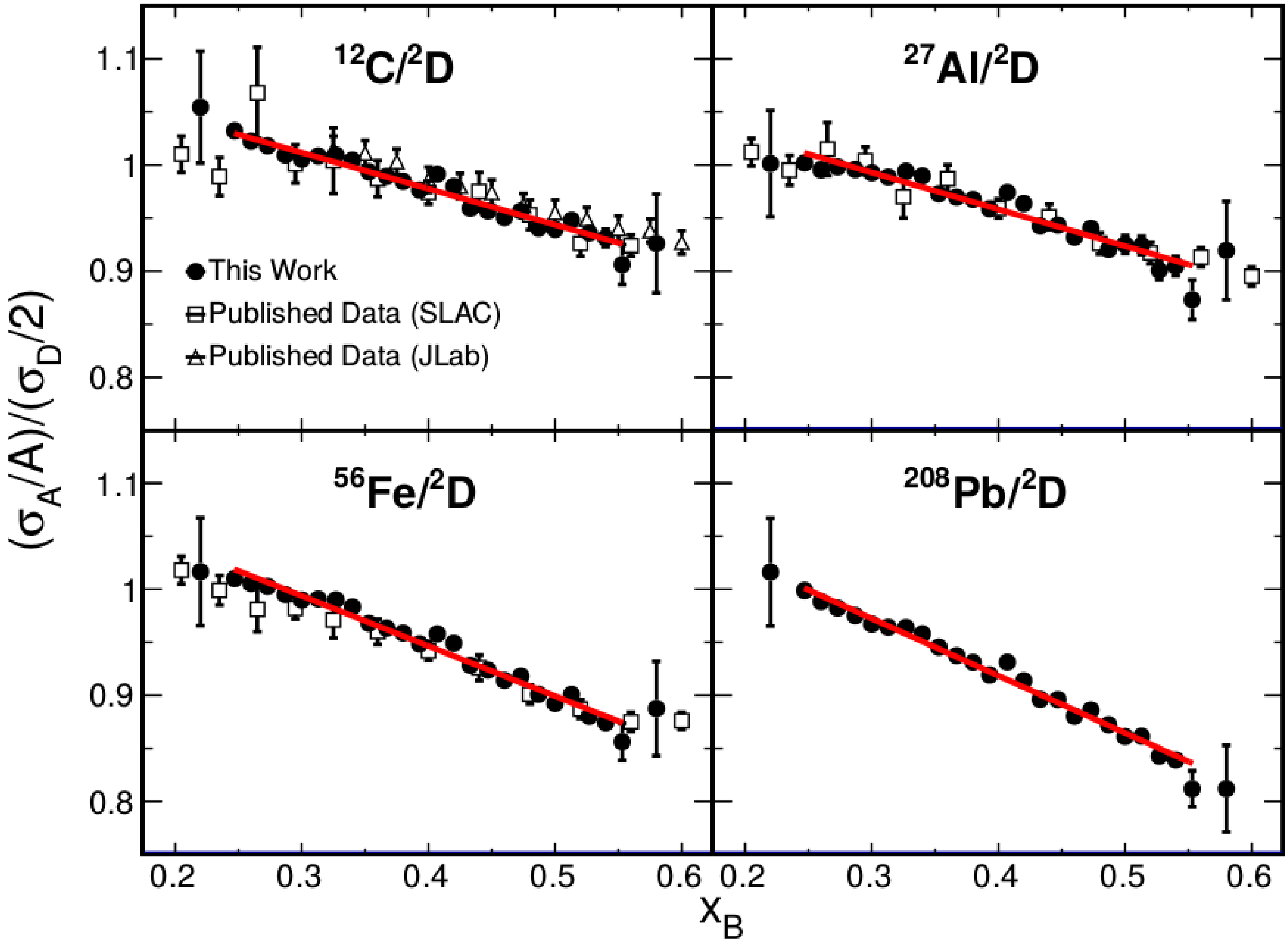


$$weight = \frac{RC \times CC}{NORM \times ACC} \times BC$$

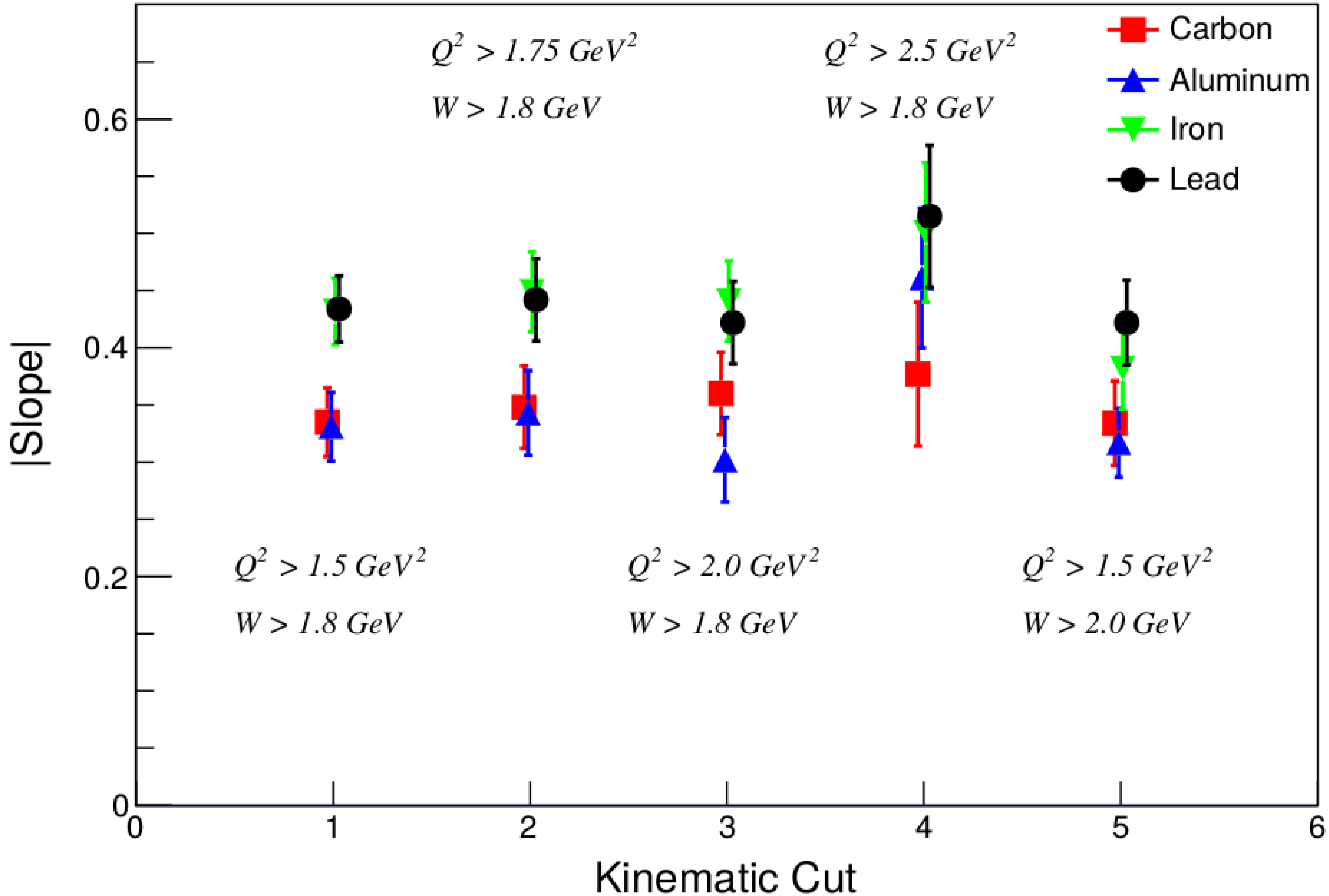
Uncertainties Cross-Section Ratios

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**

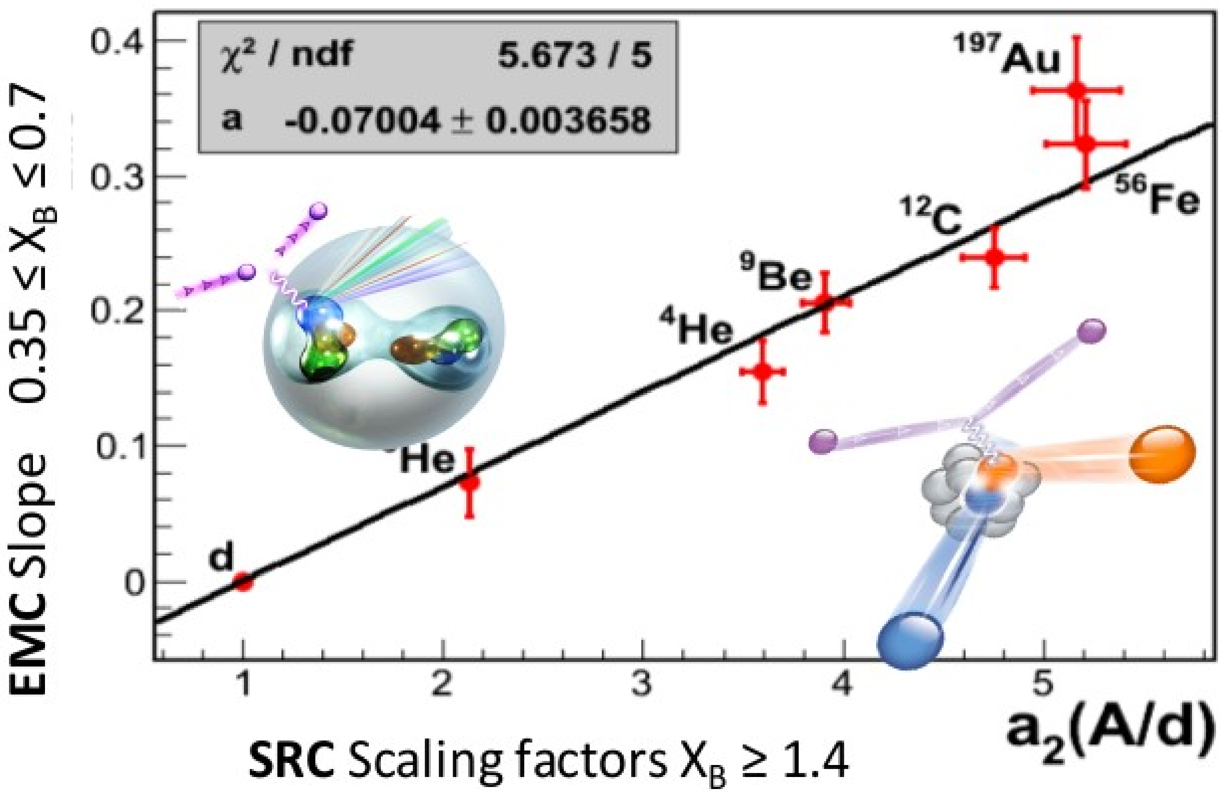
Our New EMC Effect Measurements



Slopes are Stable to Kinematic Cut

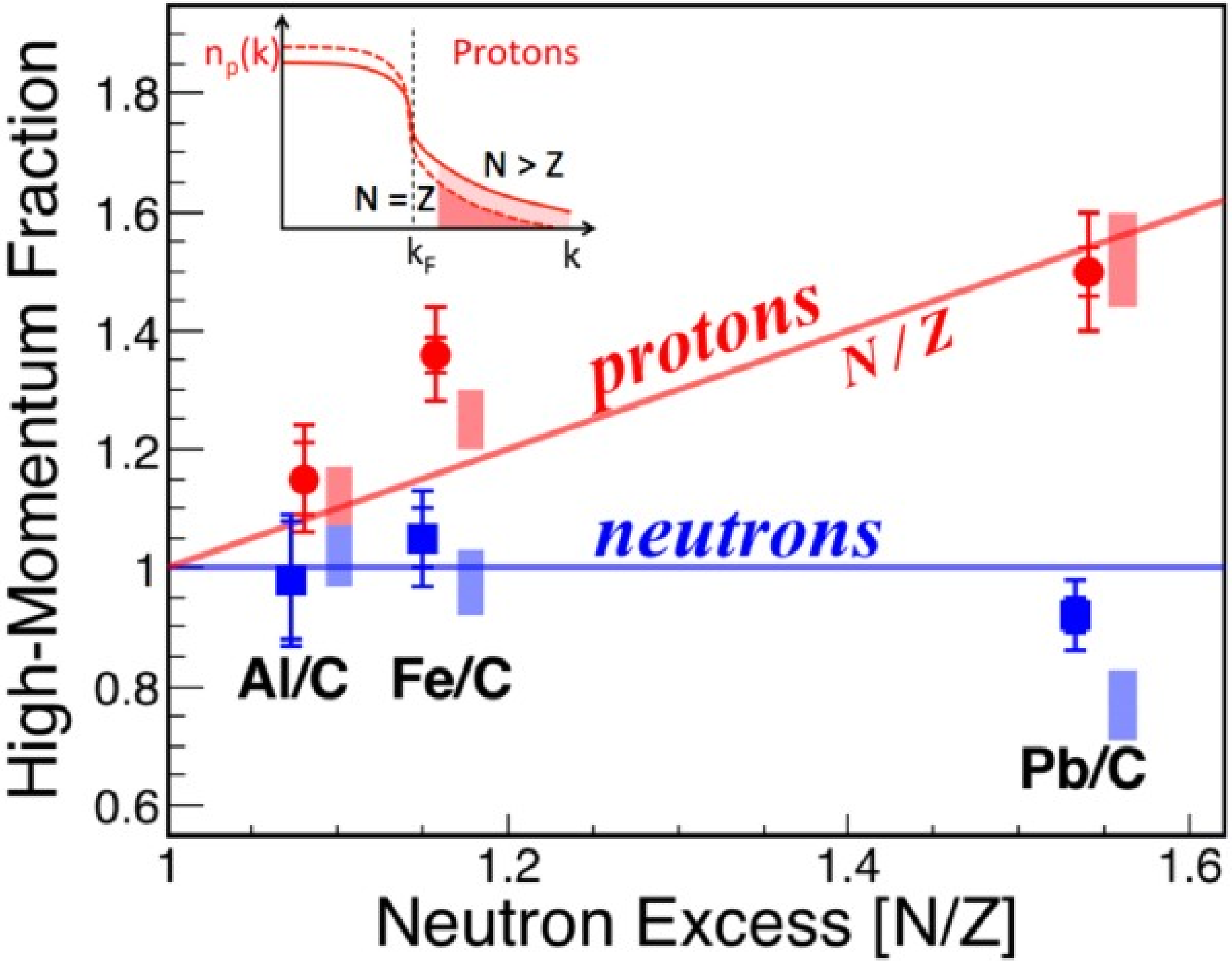


Observed EMC-SRC Correlation



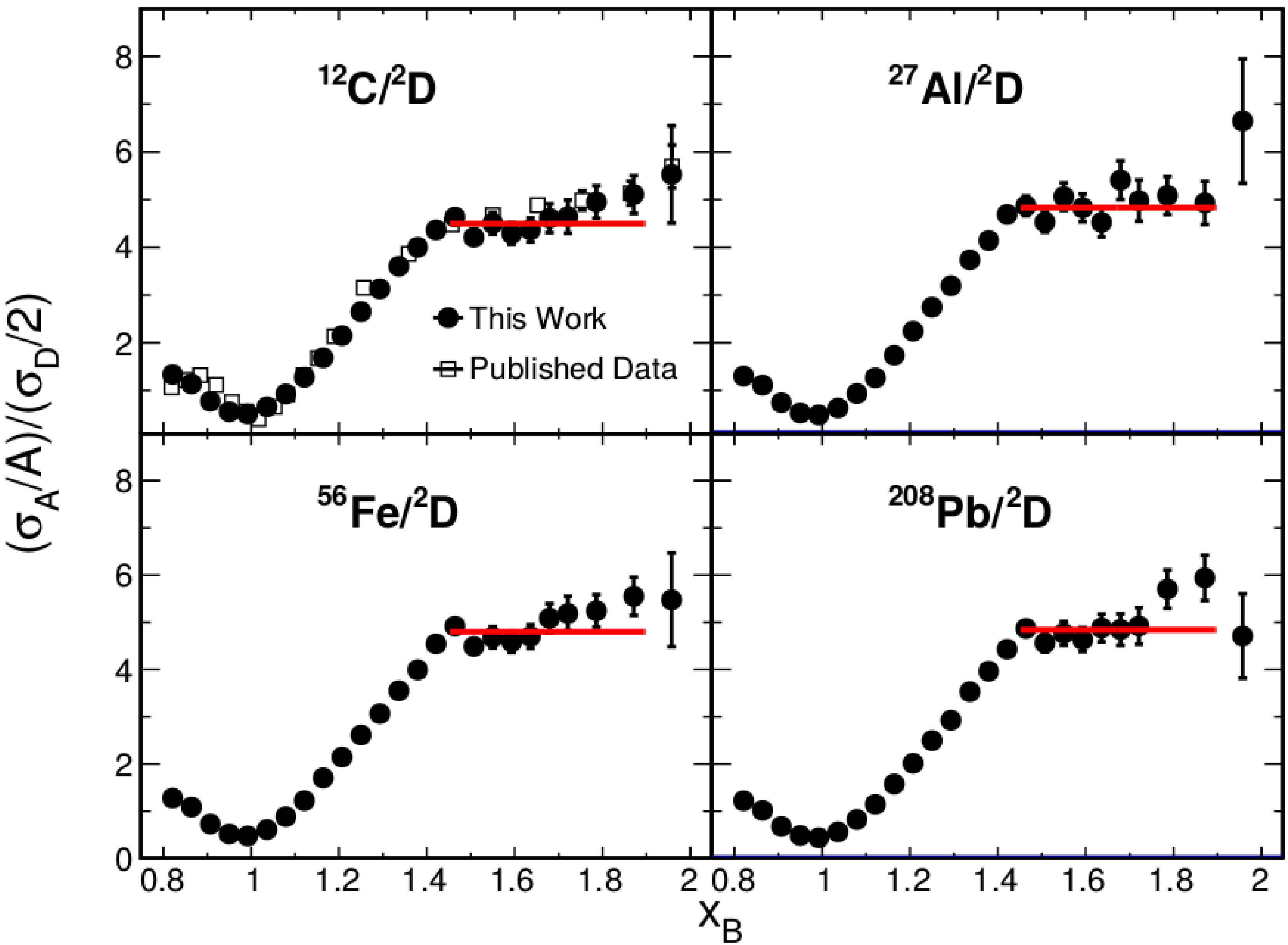
L. Weinstein et. al., Phys. Rev. Lett. 106, 052301 (2011)
O. Hen et al. Phys. Rev. C 85 047301 (2012).
O. Hen et al., Rev. Mod. Phys. 89, 045002 (2017)

Observed Isospin Dependence to SRC

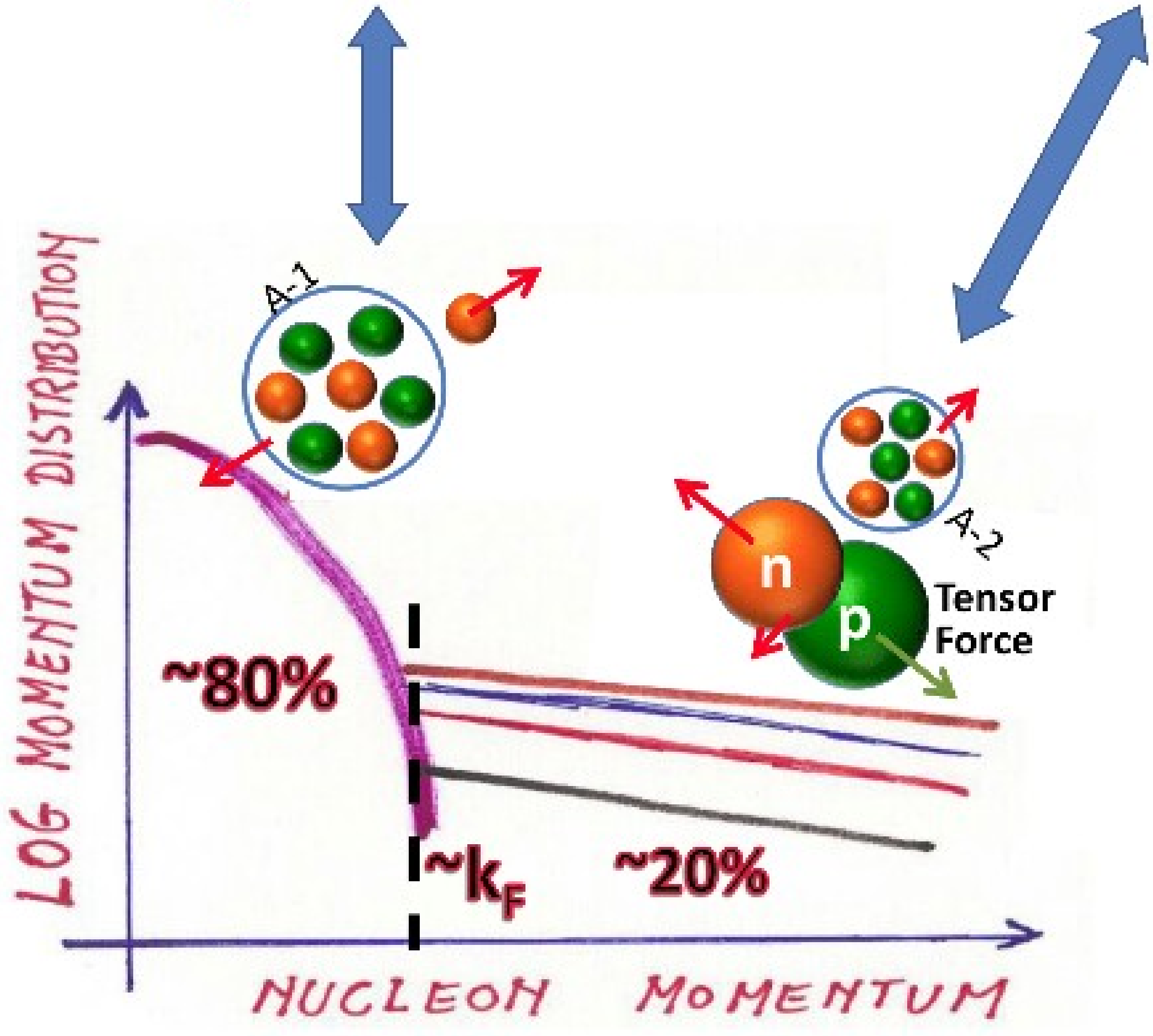


M. Duer et al., submitted for publication (2018).

Our New SRC a_2(A/d) Measurements

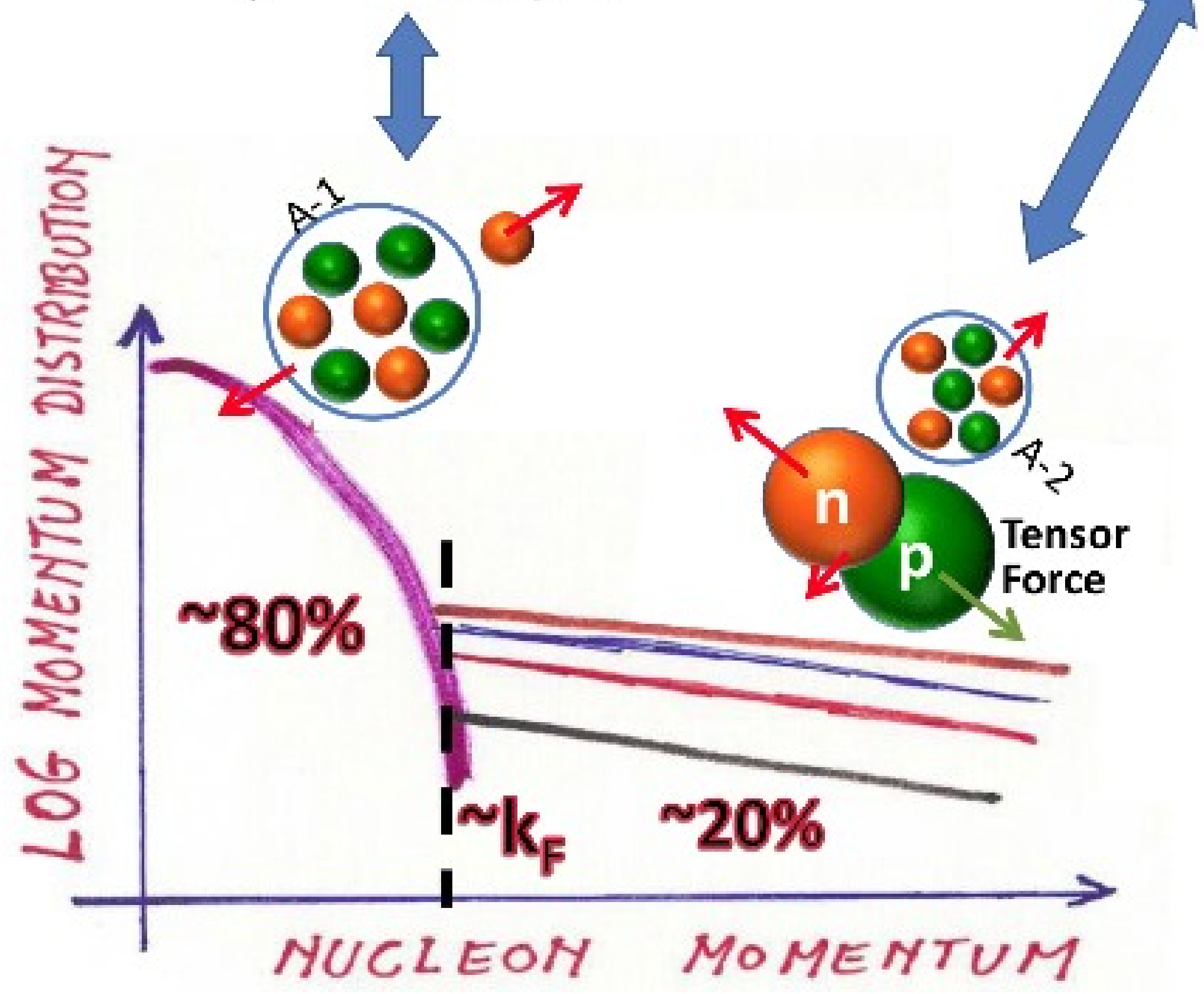


Bound = ‘quasi Free’ + Modified SRCs



Bound = 'quasi Free' + Modified SRCs

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



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

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

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

Not Well Constrained

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

Can Solve for F_2^n

Bound = 'quasi Free' + Modified SRCs

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

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

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

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

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

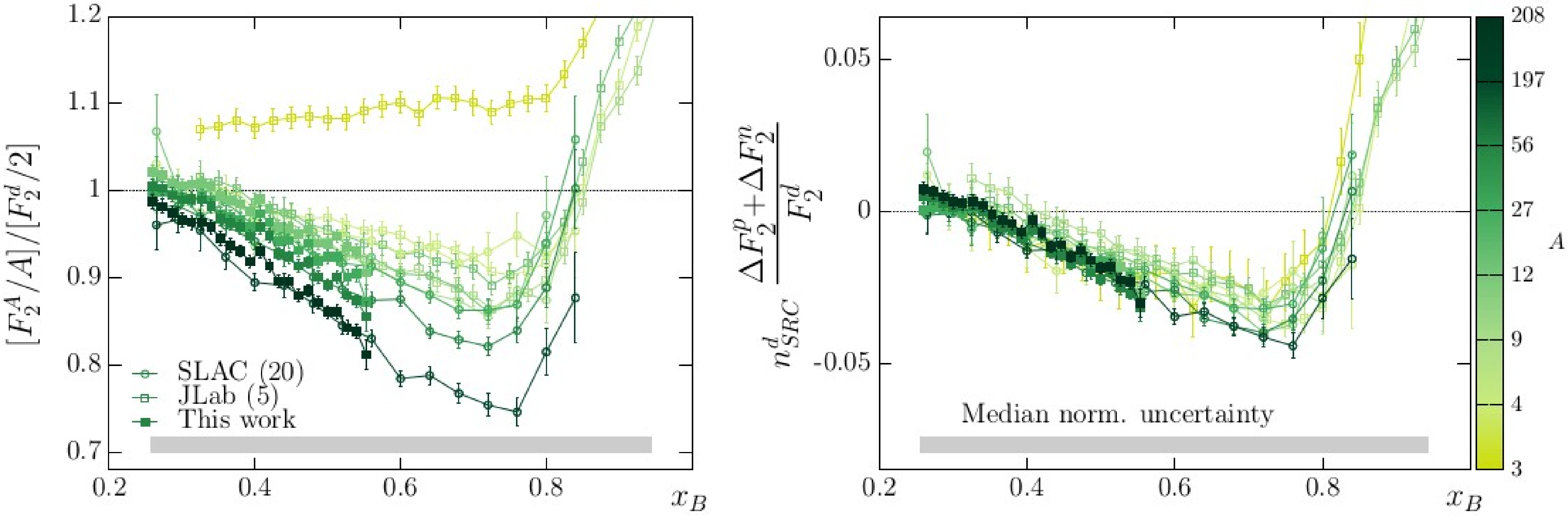
Universal???

Nucleus-Dependent

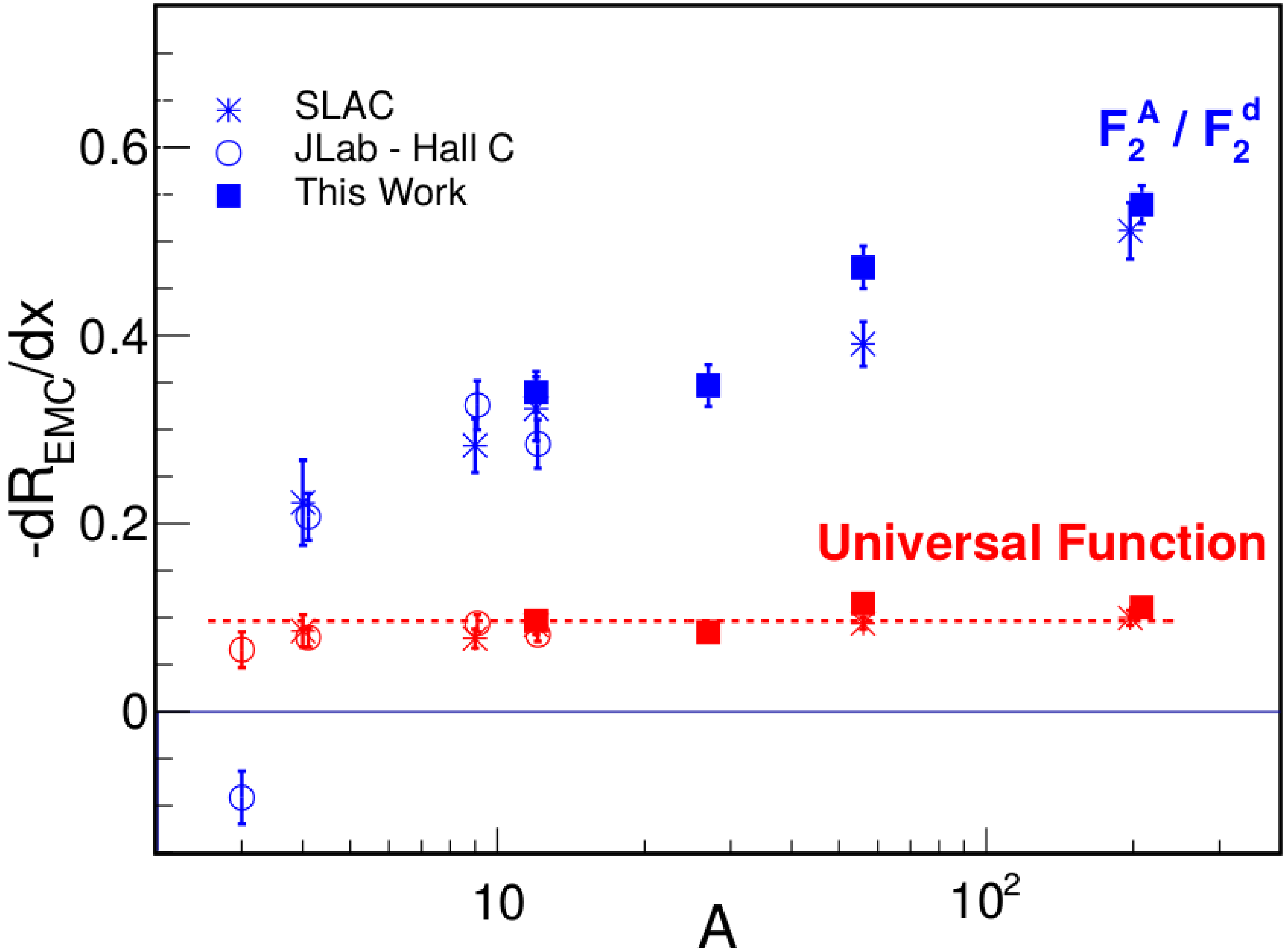
$$n_d^{SRC}\frac{\Delta F_2^p+\Delta F_2^n}{F_2^d}=\frac{\frac{F_2^A}{F_2^d}-(Z-N)\frac{F_2^p}{F_2^d}-N}{\frac{A}{2}a_2-N}$$

Everything is Known

Universal EMC Modification Function

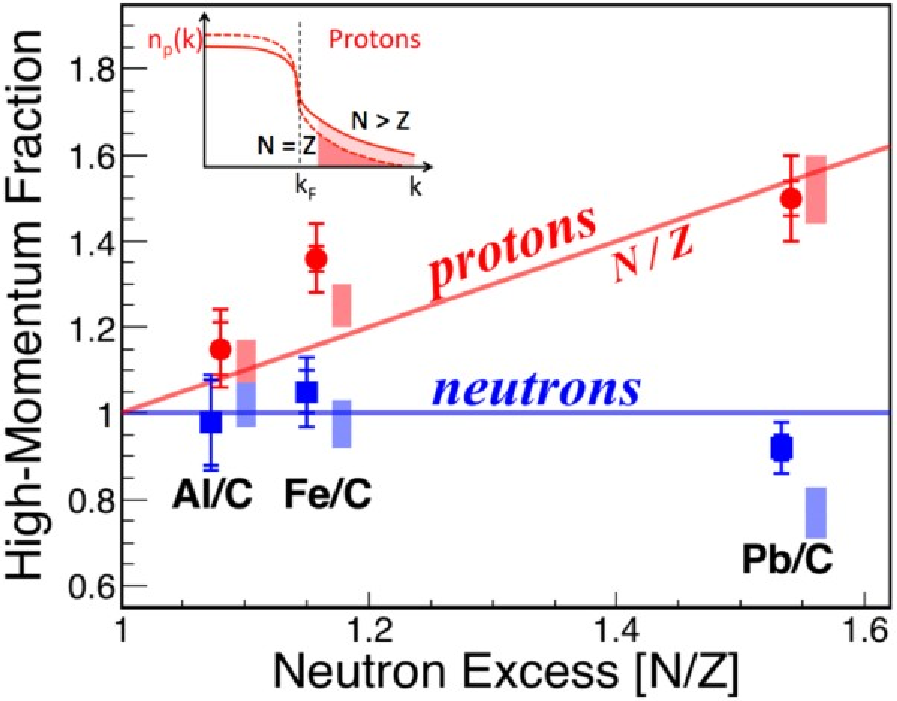


Universal EMC Modification Function



Focus on Neutron-Rich Nuclei

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



Form New Per-Neutron (Proton) Quantities

Per-Neutron Quantities:

$$dR^{n}_{EMC}/dx = \left(\frac{A}{2 \cdot N}\right) \times dR_{EMC}/dx \qquad a_2^n = \left(\frac{A}{2 \cdot N}\right) \times a_2$$

Per-Proton Quantities:

$$dR^{p}_{EMC}/dx = \left(\frac{A}{2 \cdot Z}\right) \times dR_{EMC}/dx \qquad a_2^p = \left(\frac{A}{2 \cdot Z}\right) \times a_2$$

Per-Neutron (Proton) Ratios: What Does Our Model Predict?

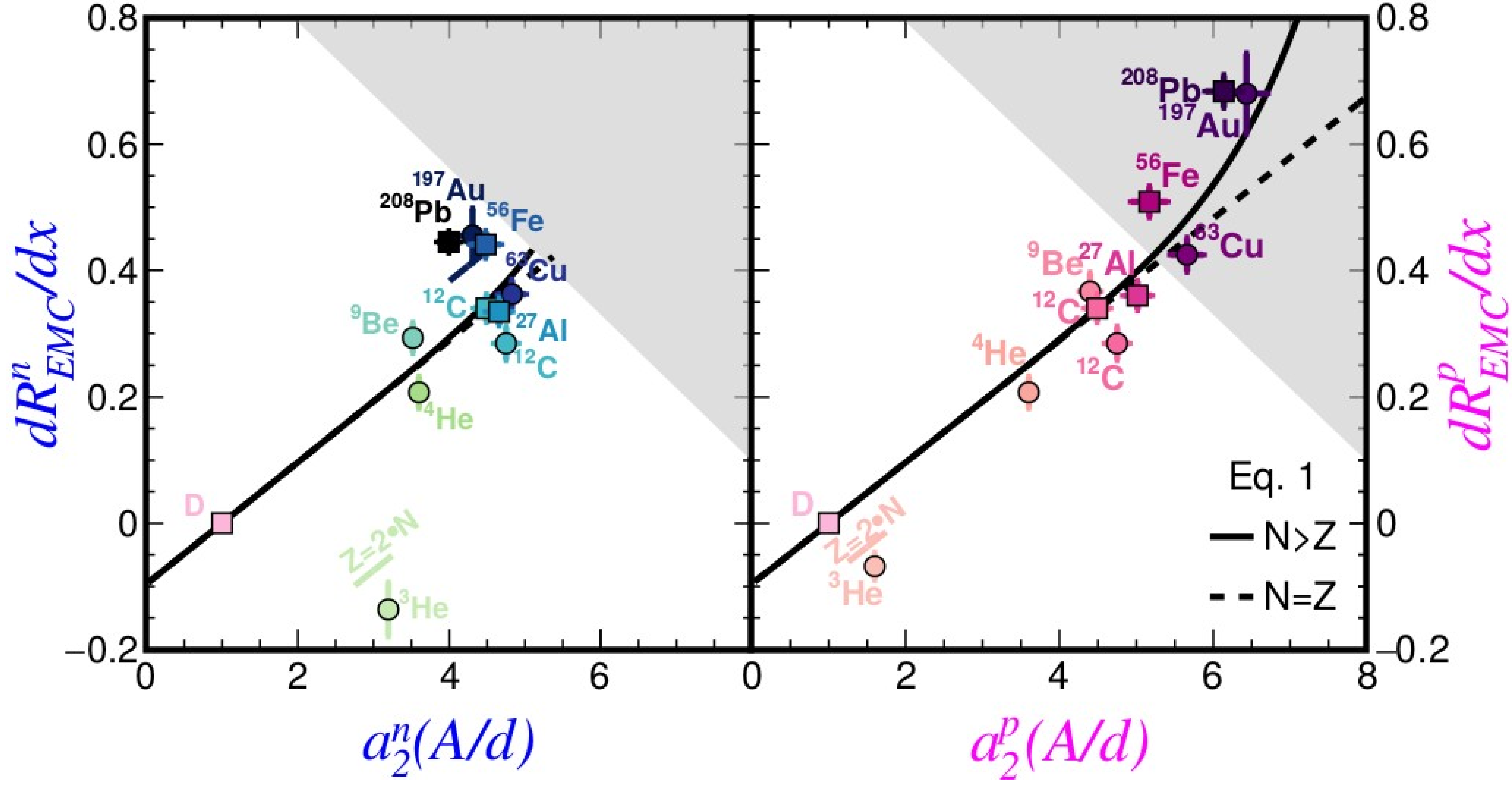
$$\frac{F_2^A/N}{F_2^d/1} = \left(a_2^n - 1\right) \cdot \left[n_{SRC}^d \frac{\Delta F_2^p + \Delta F_2^n}{F_2^d} \right] + \left(\frac{Z}{N} - 1\right) \frac{F_2^p}{F_2^d} + 1$$

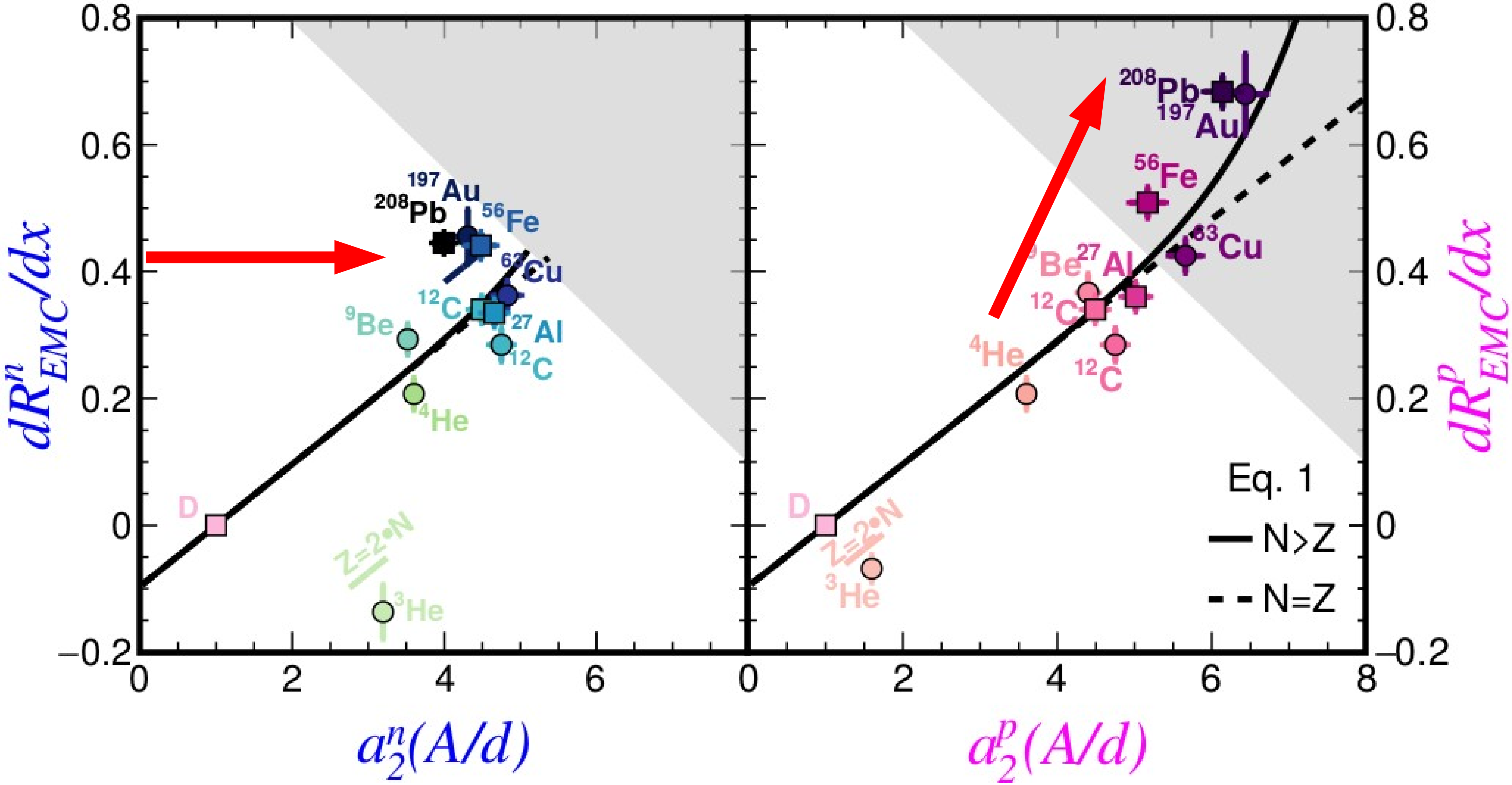
$$a_2^n = \frac{n_{SRC}^A/N}{n_{SRC}^d/1}$$

Per-Neutron (Proton) Ratios: What Does Our Model Predict?

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

Extract Per-Neutron (Proton) Slope


dR^n_{EMC}/dx
dR^p_{EMC}/dx
$a^n_2(A/d)$
$a^p_2(A/d)$
Eq. 1
N>Z
N=Z
D
^{3}He
^{4}He
^{9}Be
^{12}C
^{27}Al
^{56}Fe
^{63}Cu
^{197}Au
^{208}Pb
Z=2•N



0.8
0.6
0.4
0.2
0
−0.2
0
2
4
6
8
dR^n_{EMC}/dx
dR^p_{EMC}/dx
$a^n_2(A/d)$
$a^p_2(A/d)$
208Pb
197Au
56Fe
63Cu
12C
27Al
9Be
4He
3He
D
Z=2•N
Eq. 1
N>Z
N=Z

Thank You !!!