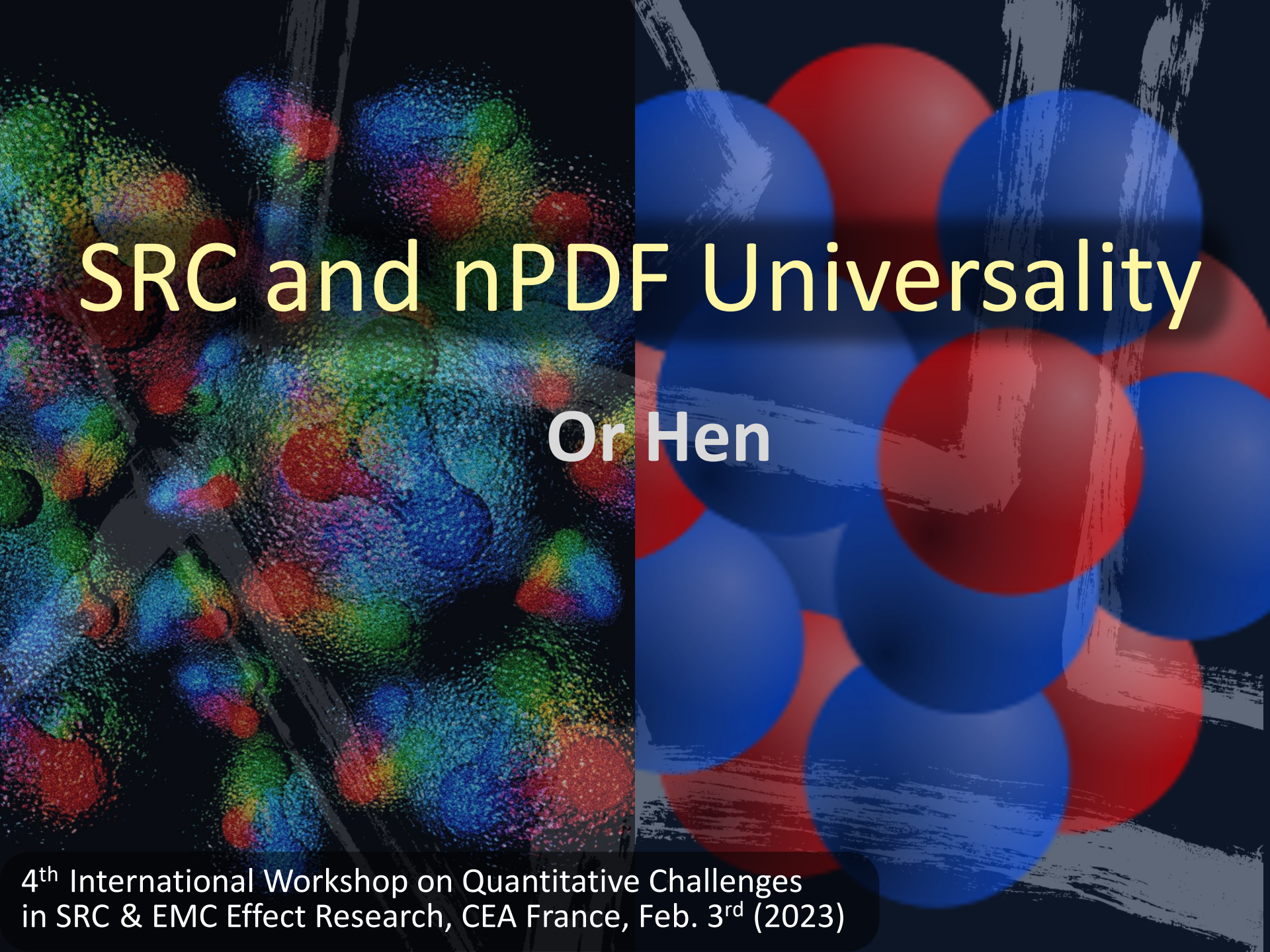
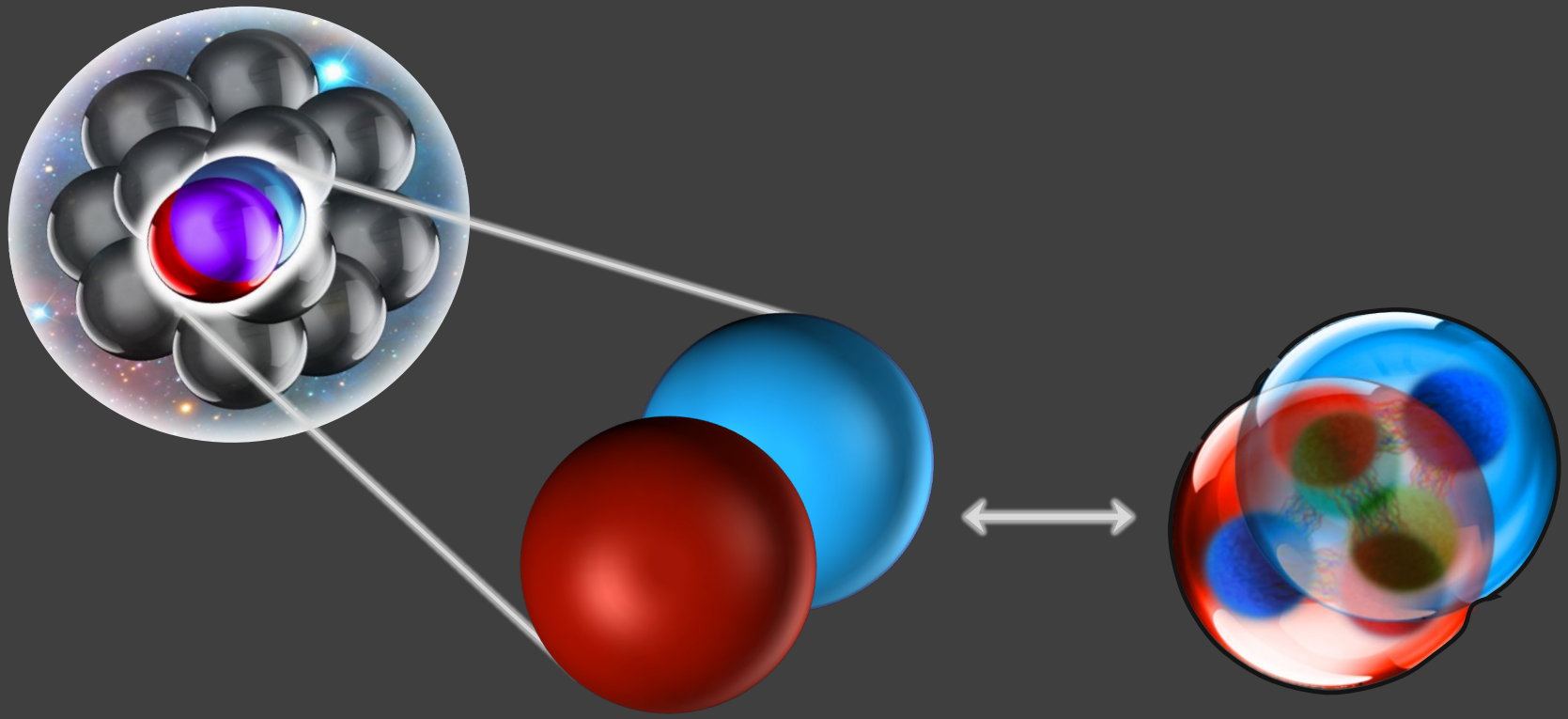


SRC and nPDF Universality

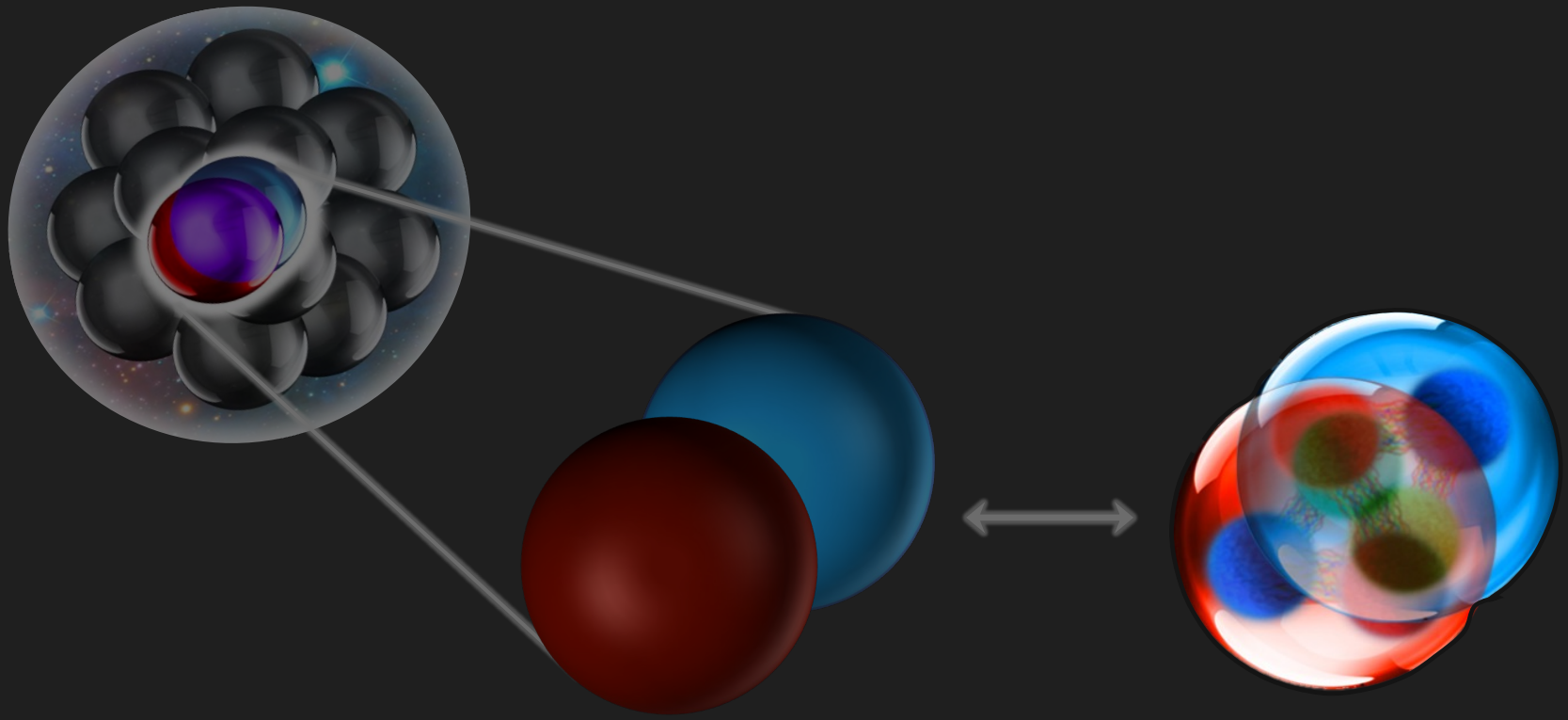
Or Hen

4th International Workshop on Quantitative Challenges
in SRC & EMC Effect Research, CEA France, Feb. 3rd (2023)

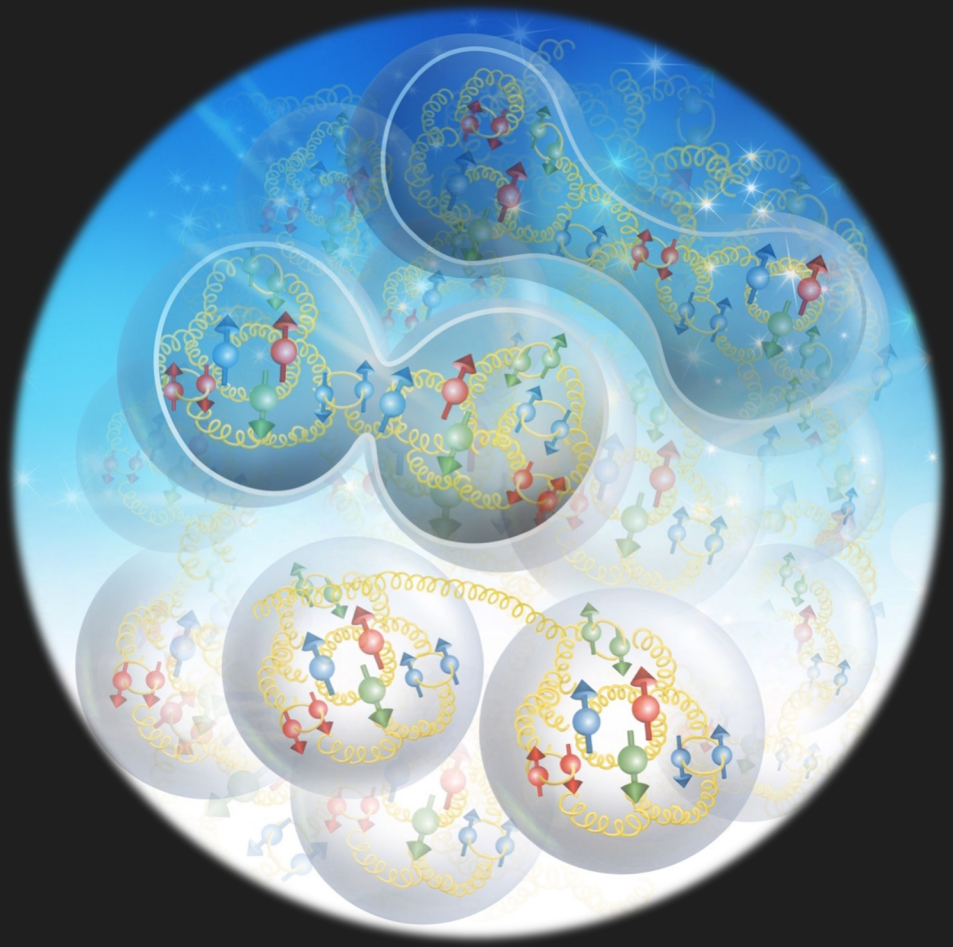
Short-Range Correlations Across Scales



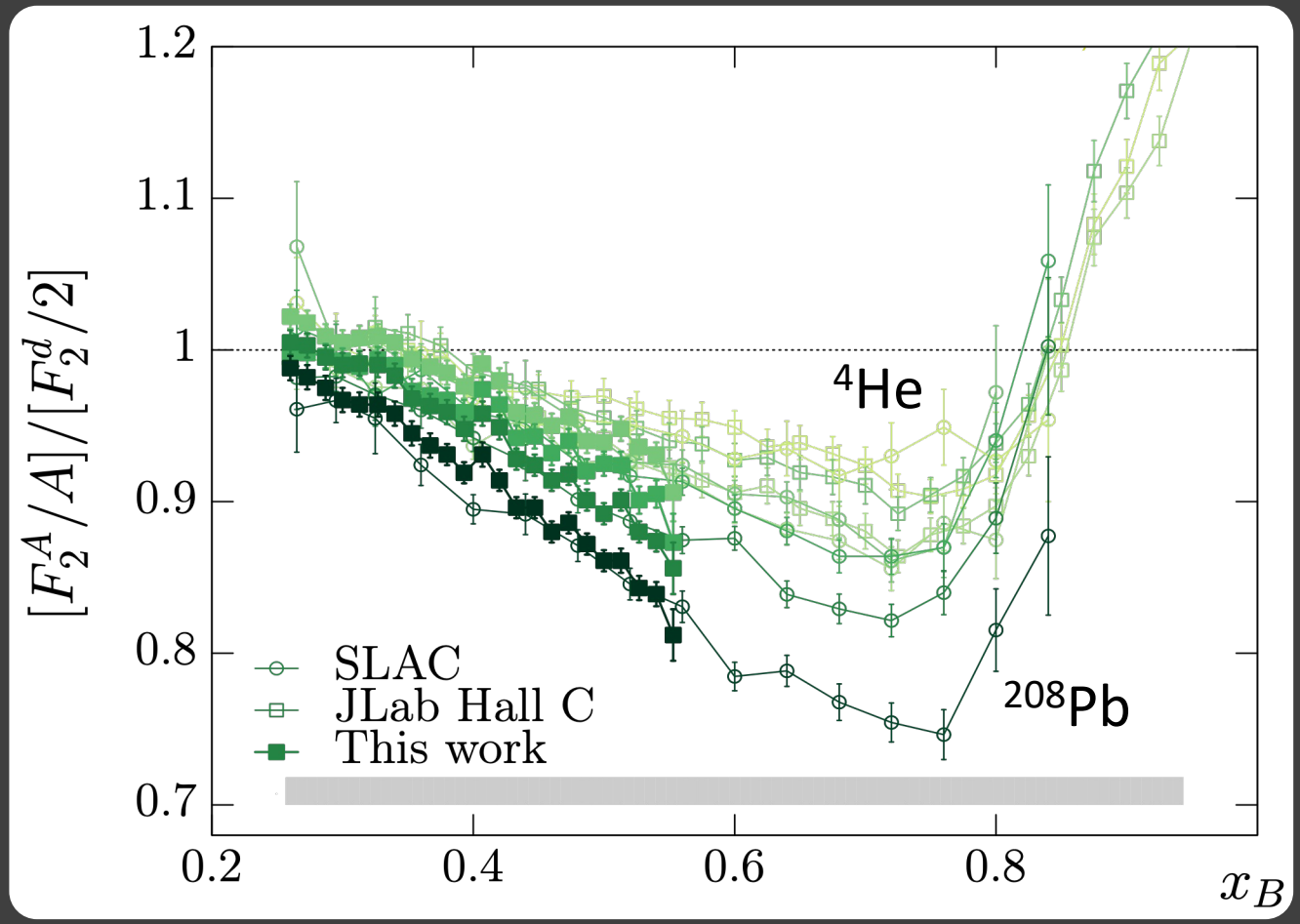
Quarks in SRCs and Nuclei



How does QCD dynamics affect the identity of nucleons in nuclei?



Quark Momentum Suppression in Nuclei (EMC Effect)



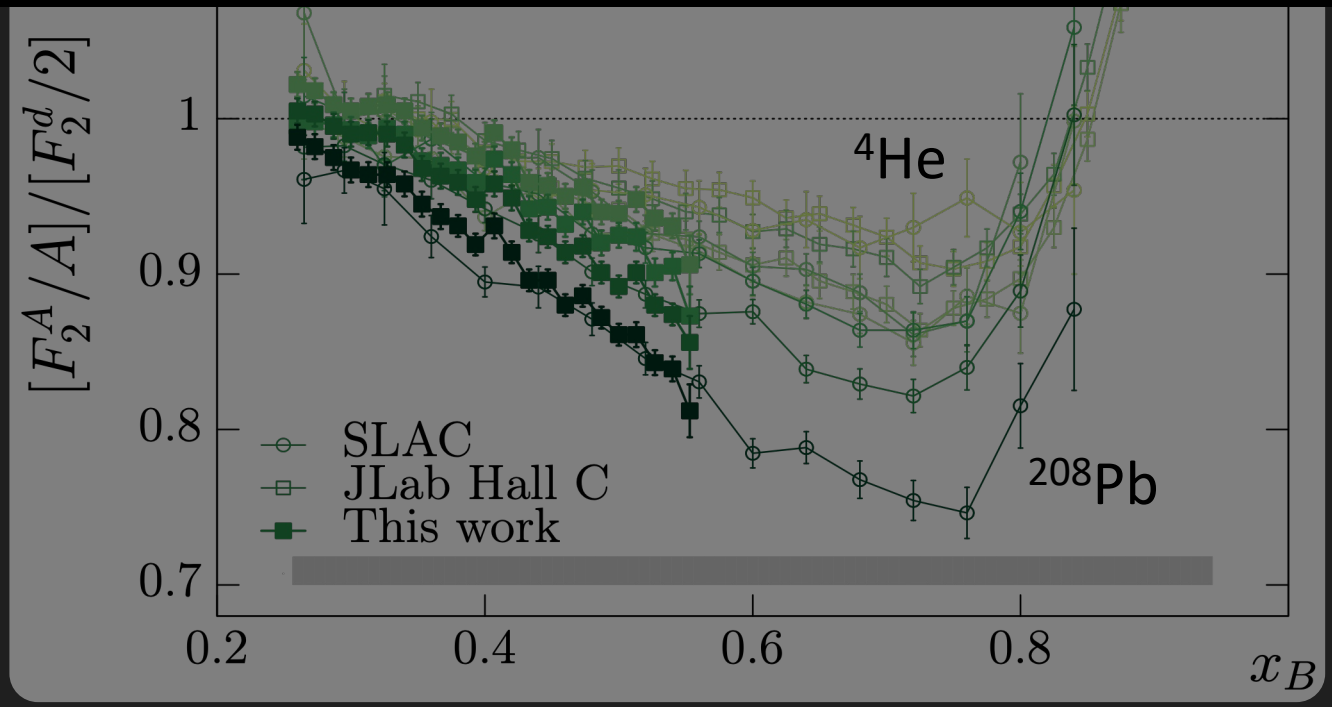
x_B = quark momentum fraction

Aubert et al., PLB (**1983**); Ashman et al., PLB (1988); Arneodo et al., PLB (1988); Allasia et al., PLB (1990); Gomez et al., PRD (1994); Seely et al., PRL (2009); Schmookler et al., Nature (**2019**)

Quark Momentum Suppression

38 years, > 1000 publications, no consensus.

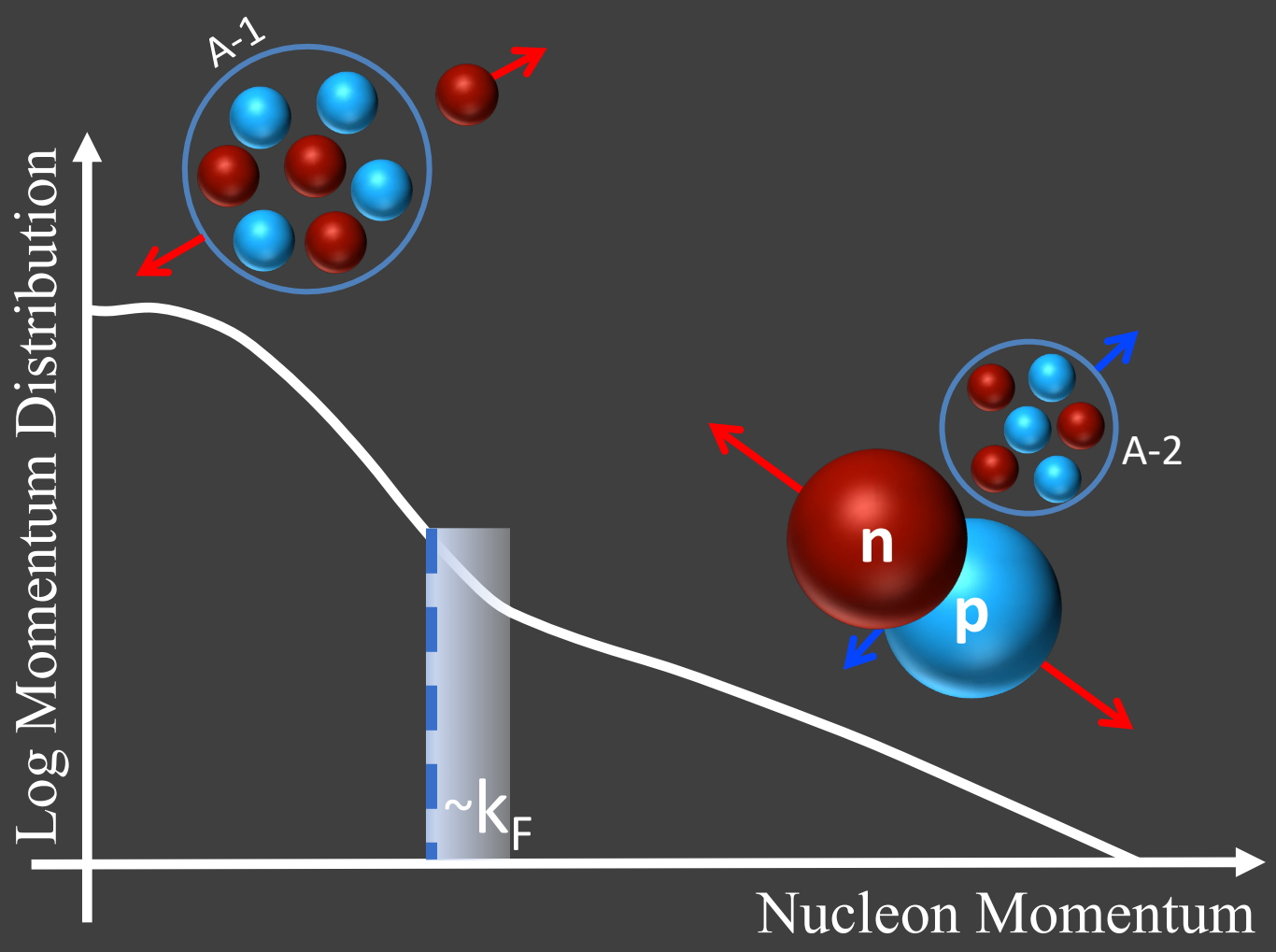
Effect driven by nuclear structure & dynamics



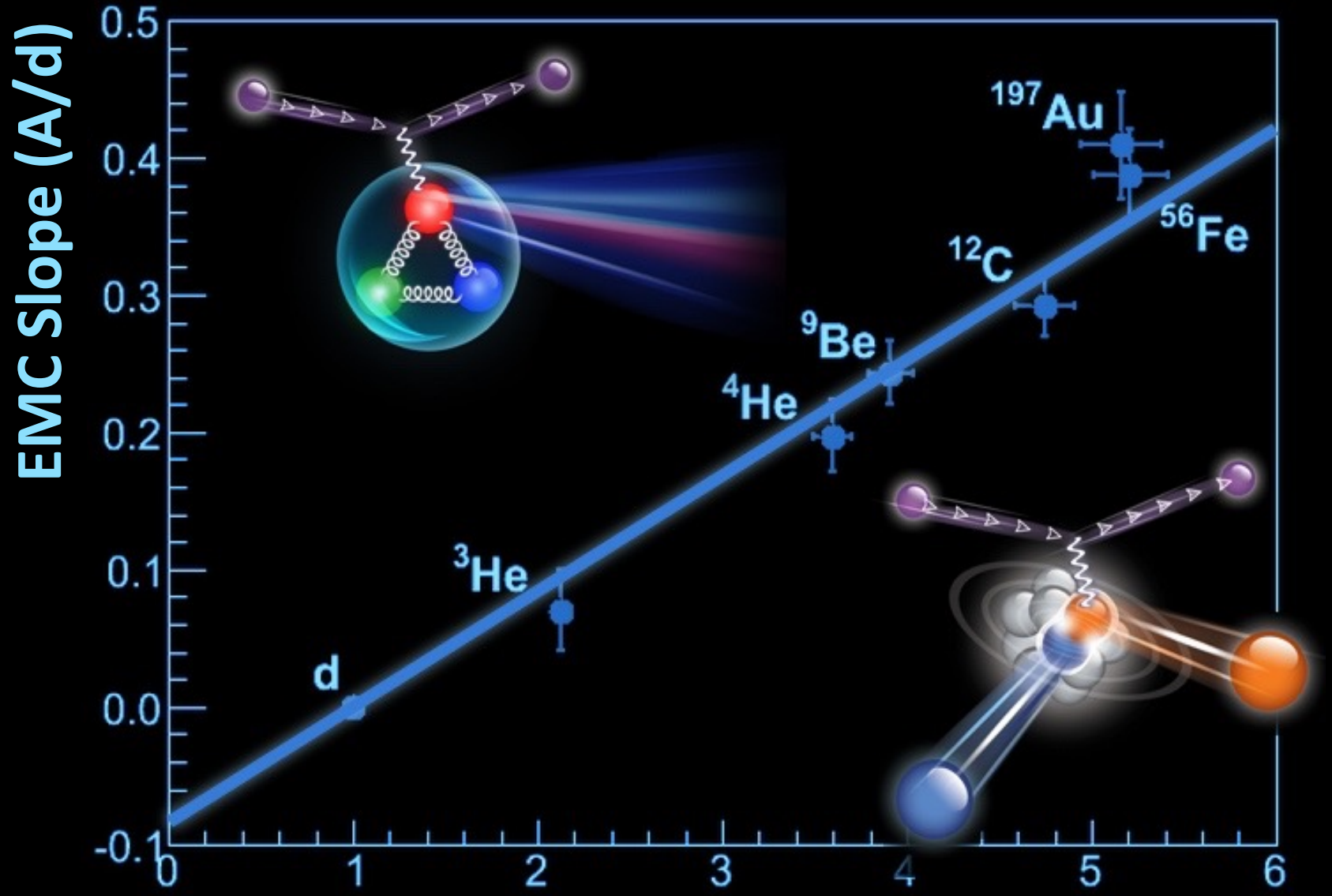
x_B = quark momentum fraction

Aubert et al., PLB (**1983**); Ashman et al., PLB (1988); Arneodo et al., PLB (1988); Allasia et al., PLB (1990); Gomez et al., PRD (1994); Seely et al., PRL (2009); Schmookler et al., Nature (**2019**)

SRC Picture of Nuclei

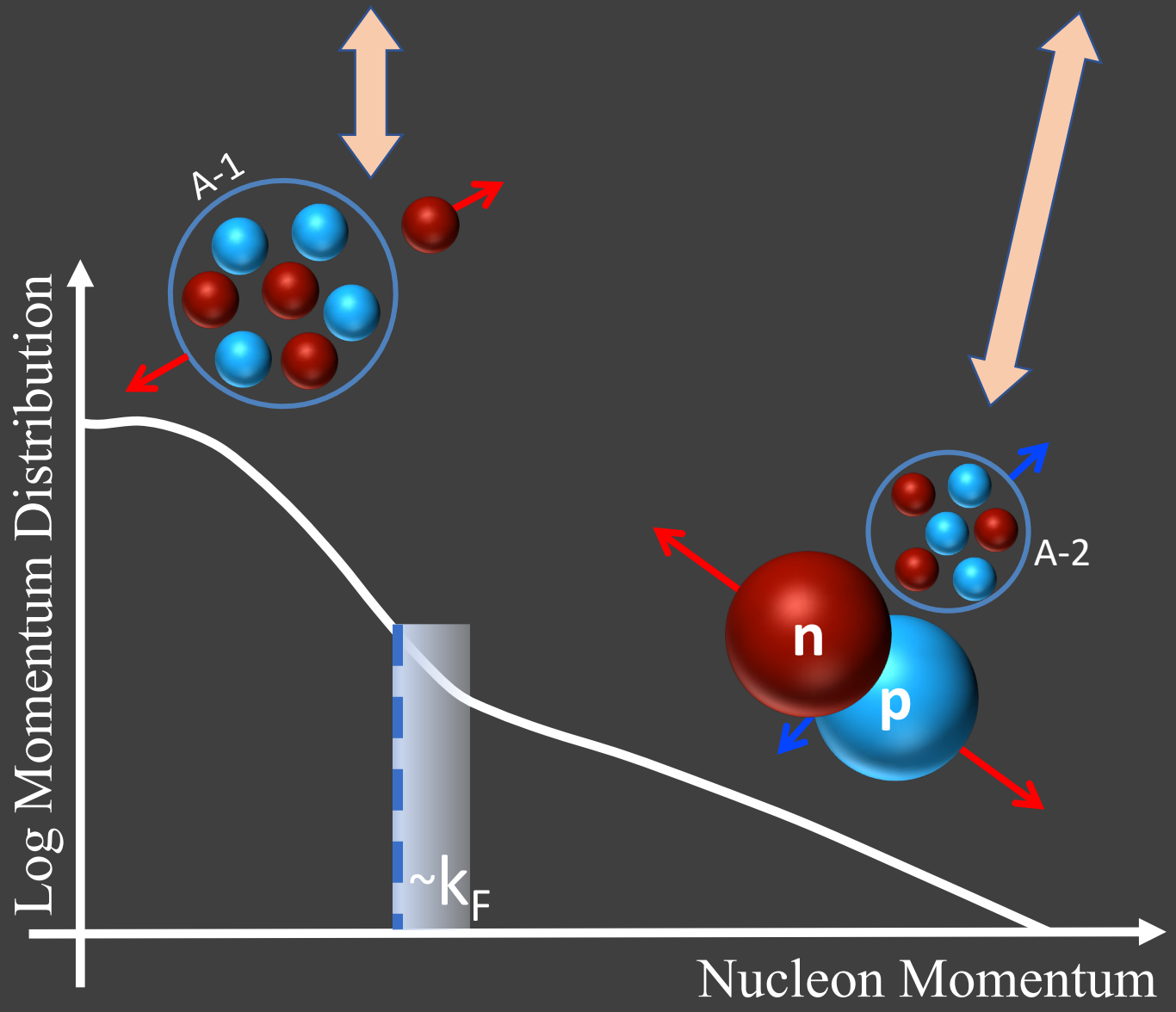


EMC – SRC Correlation



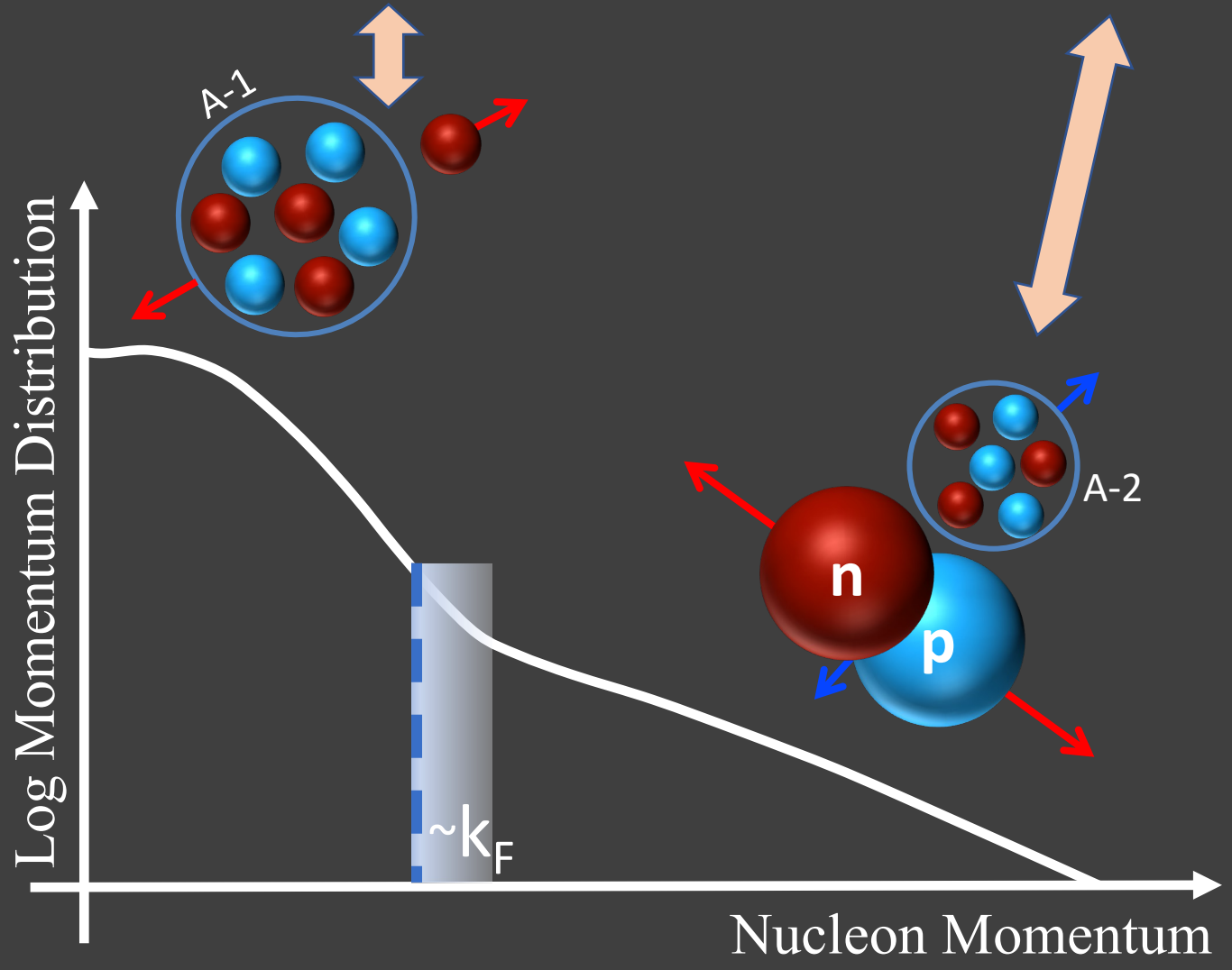
Nature (2019); RMP (2017); IJMPE (2013); PRC (2012); PRL (2011); …

Bound = ‘Quasi-Free’ + Modified SRCs



Bound = ‘Quasi-Free’ + Modified SRCs

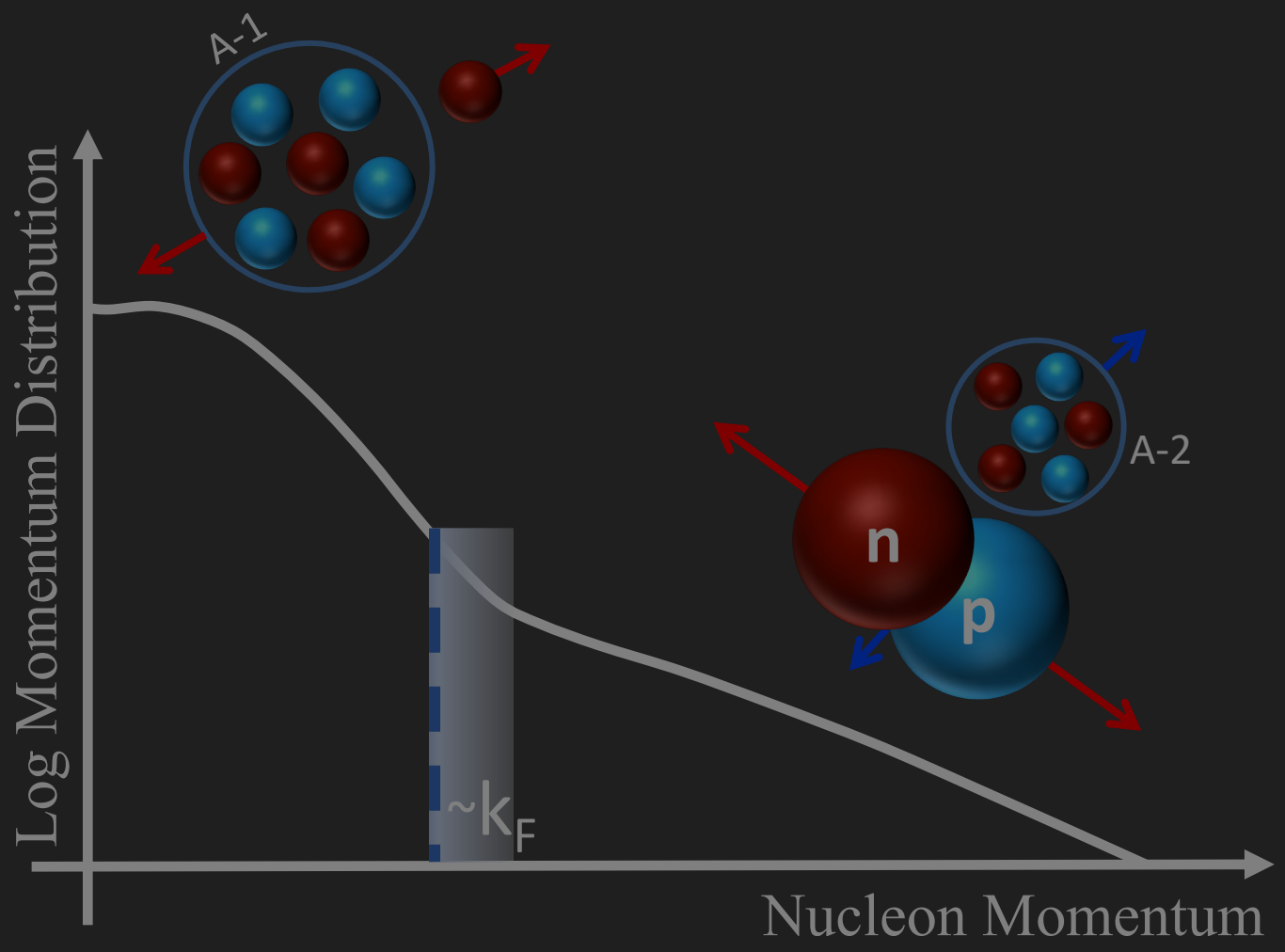
$$F_2^A = (A - \#SRC_A) \cdot F_2^N + \#SRC_A \cdot F_2^{SRC}$$



Bound = 'Quasi-Free' + Modified SRCs

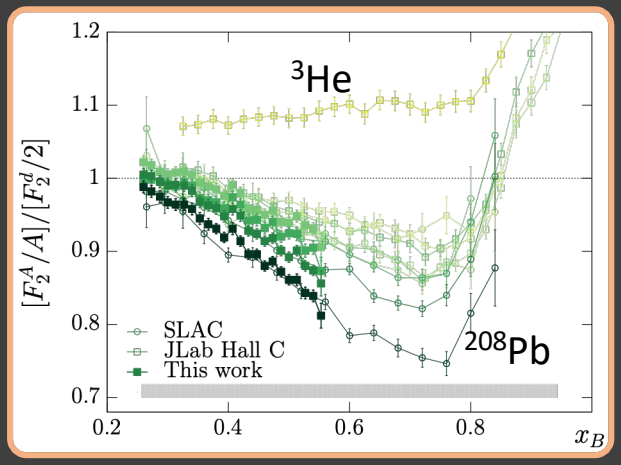
$$F_2^A = (A - \#SRC_A) \cdot F_2^N + \#SRC_A \cdot \boldsymbol{F_2^{SRC}}$$

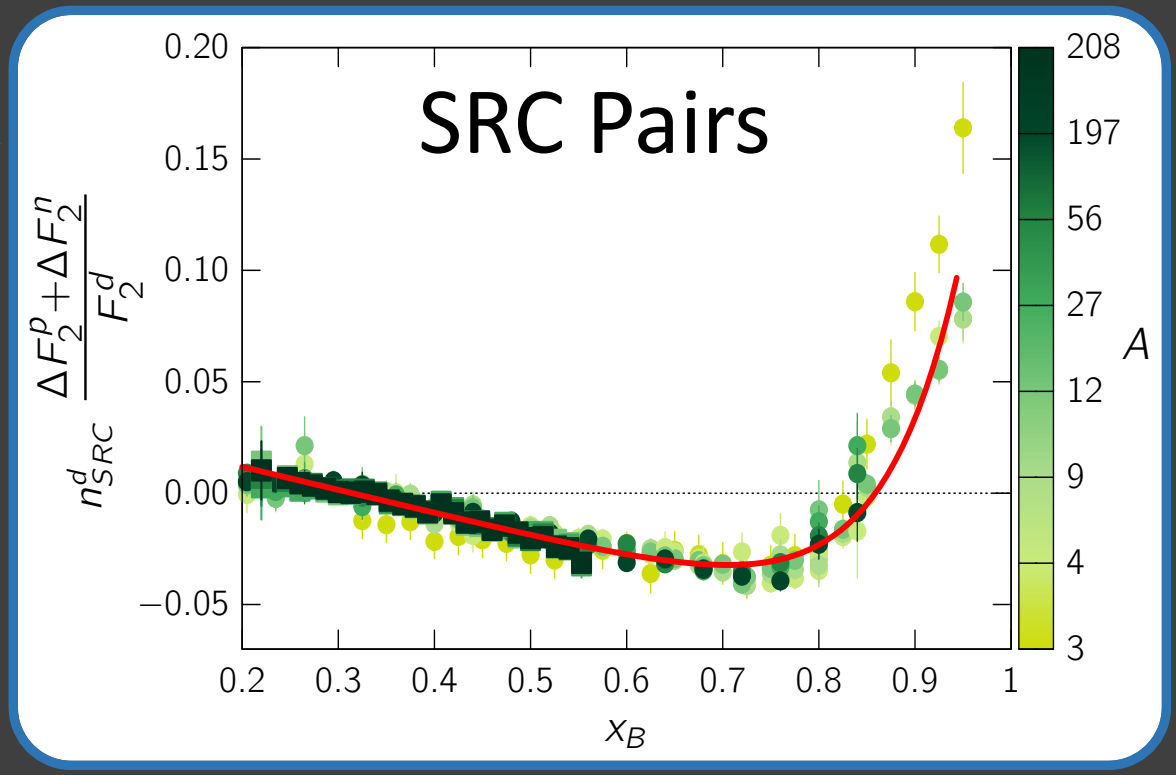
✓ Measured ✓ Measured ✓ Measured **Can extract!**



SRC Universality!

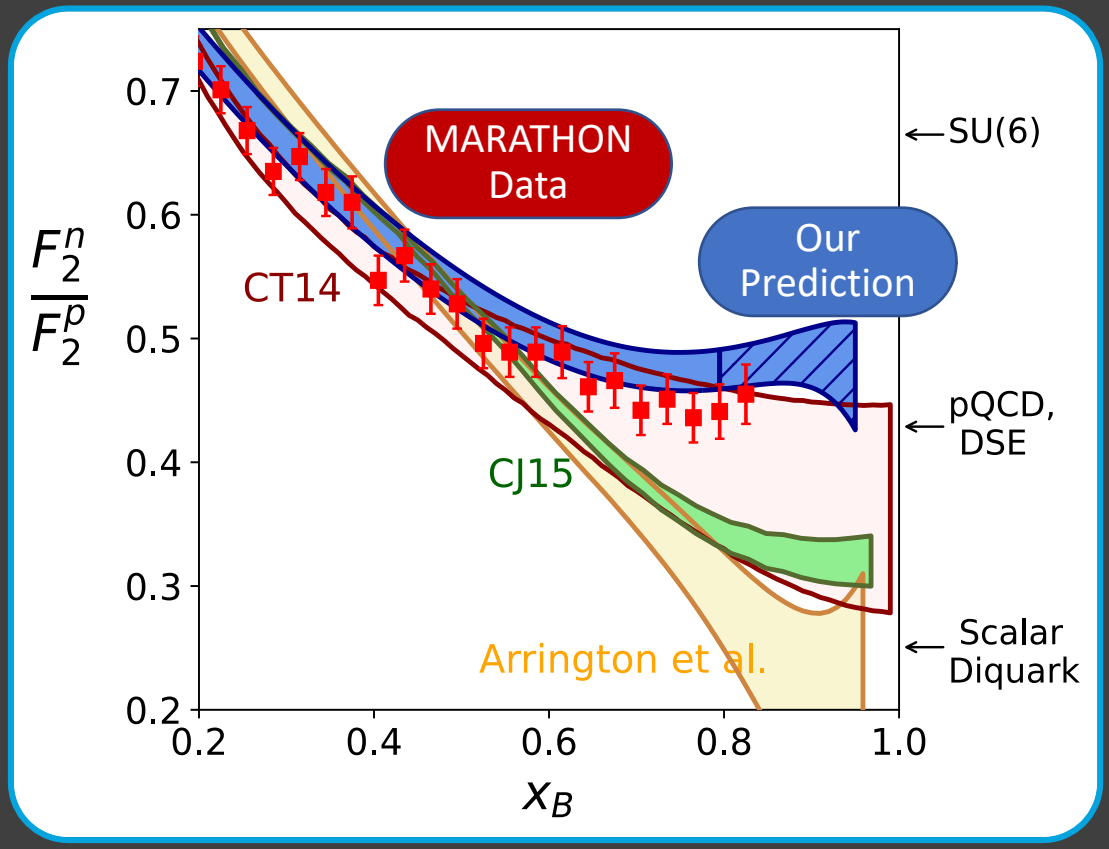
All Nucleons





Schmookler et al., Nature (2019);
Segarra et al., Phys. Rev. Lett. (2020);
Segarra and Pybus et al., Phys. Rev. Research (2021)

Verified Predictions!



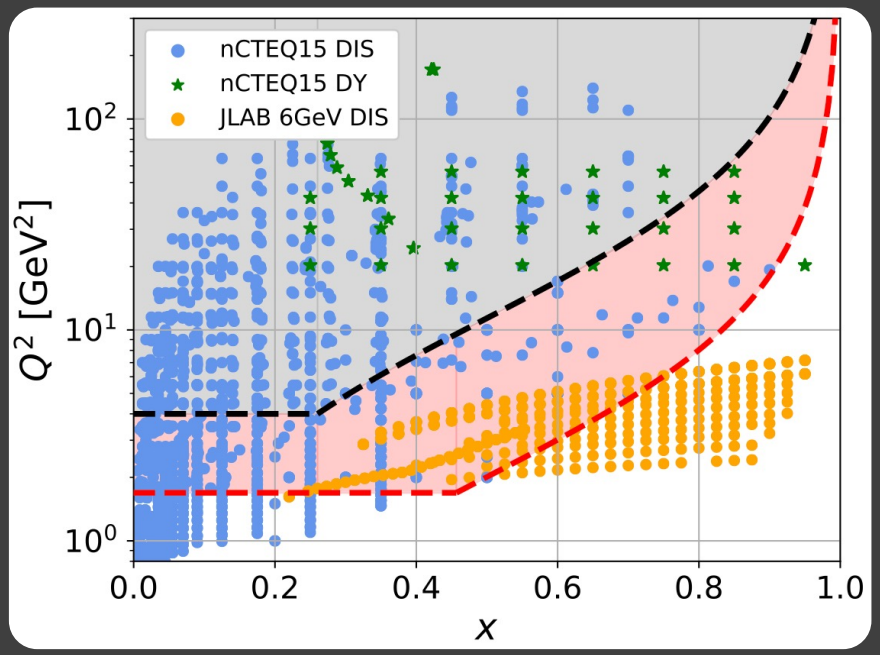
MARATHON Data: Abrams et al., Phys. Rev. Lett. (2022)

Our Prediction: Segarra et al., Phys. Rev. Lett. (2020)

Next Step: Nuclear Quark-Gluon Distributions From Global Analysis

Introduction to nPFDs

(1) Data



(2) Theory

$$xf_i^{p/A}(x,Q_0) = c_0 x^{c_1}(1-x)^{c_2} e^{c_3 x}(1+e^{c_4 x})^{c_5},$$

$$c_k \to c_k(A) \equiv p_k + a_k(1-A^{-b_k})$$

Corrections…

$$F_2^{\mathrm{TMC}}(x,Q) = \frac{x^2}{\xi^2 r^3} F_2^{(0)}(\xi,Q) + \ldots$$

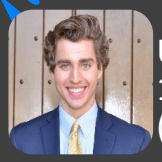
$$\frac{F_2^{A,\mathrm{TMC}}(x,Q)}{F_2^{D,\mathrm{TMC}}(x,Q)} \simeq \frac{F_2^{A,\,\mathrm{leading\ TMC}}(x,Q)}{F_2^{D,\,\mathrm{leading\ TMC}}(x,Q)} = \frac{F_2^{A,(0)}(\xi,Q)}{F_2^{D,(0)}(\xi,Q)}$$

$$F_2^A(x,Q) \to F_2^A(x,Q)\left[1 + \frac{C_{\mathrm{HT}}(x,A)}{Q^2}\right]$$

$$C_{\mathrm{HT}}(x,A) = h_0 x^{h_1}(1+h_2 x)A^{\tau},$$

$$\frac{F_2^A}{F_2^p} \equiv \frac{F_2^A}{F_2^D} \cdot \left(\frac{F_2^D}{F_2^p}\right)_{\mathrm{CJ}}$$

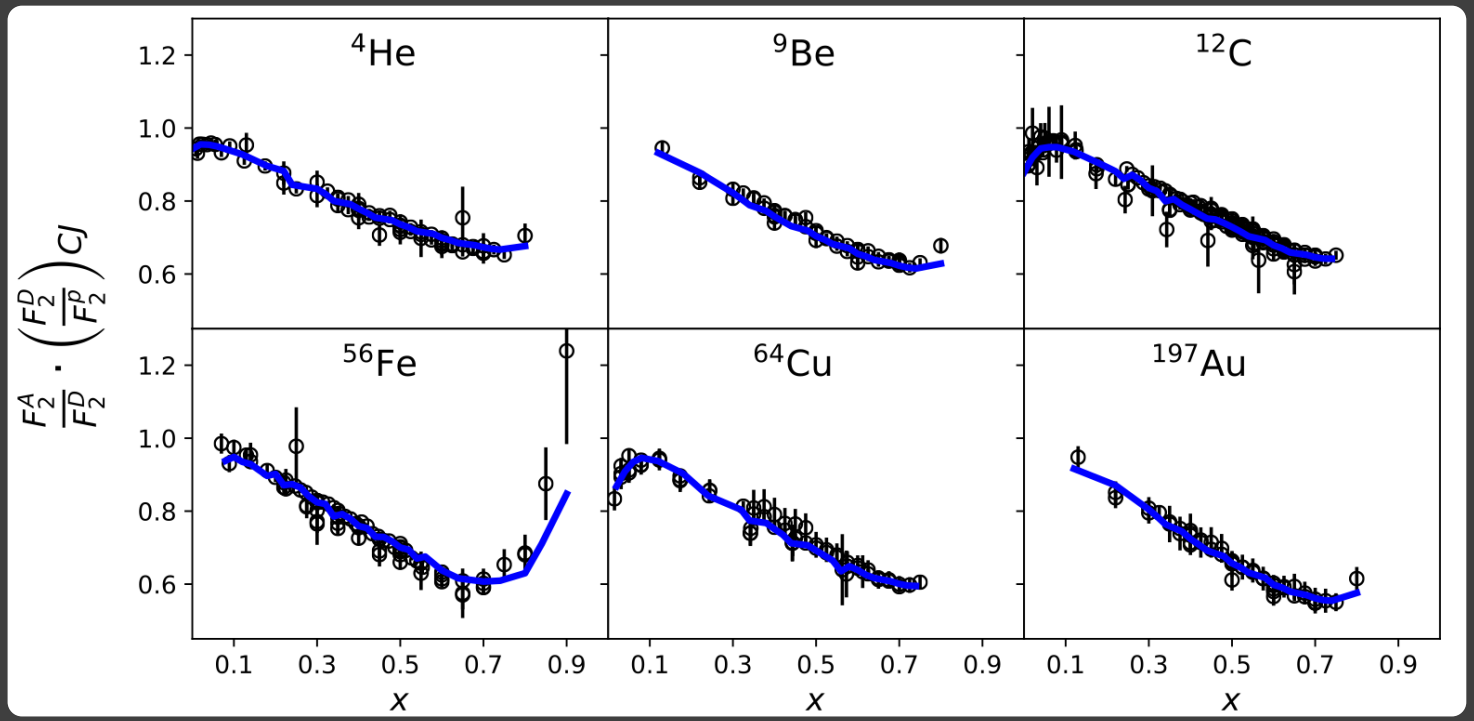
NEW!



Utilizing PRD 103, 114015 (2021)

Introduction to nPFDs

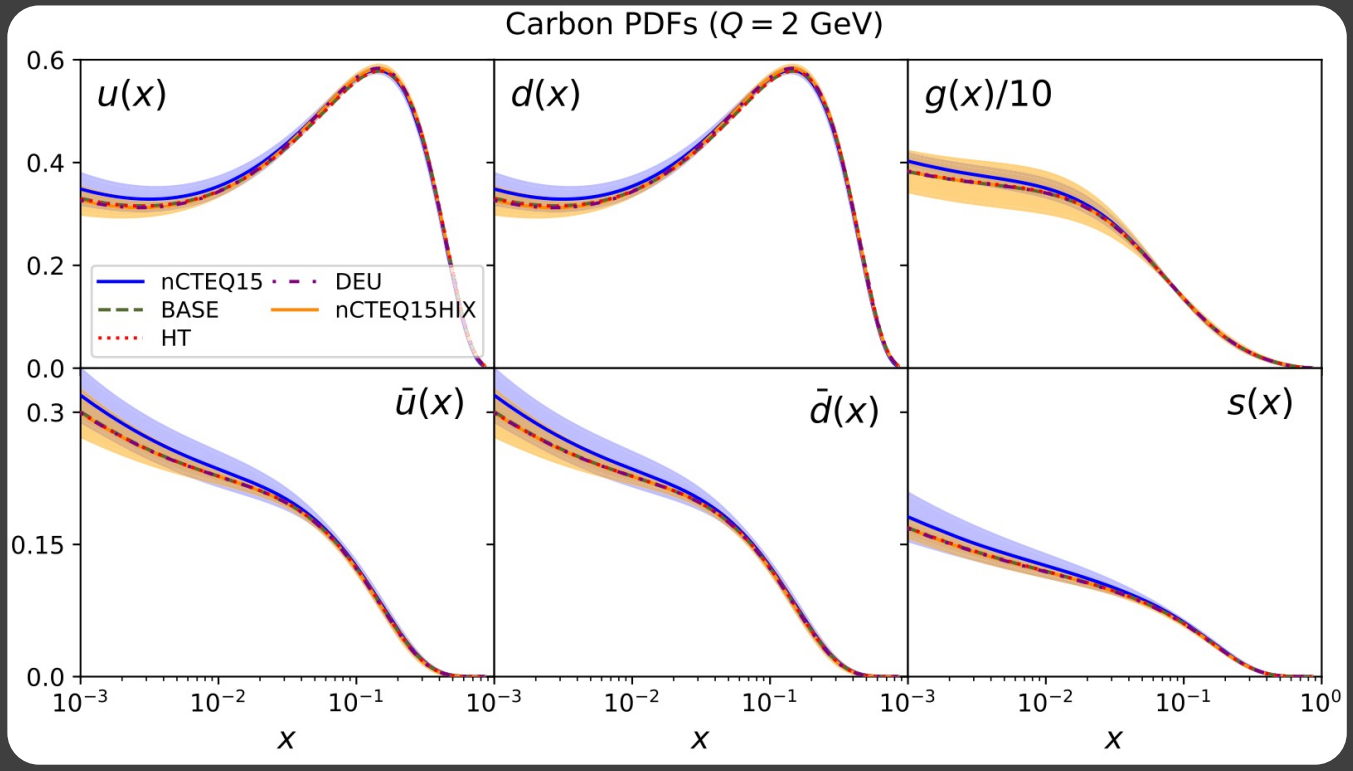
(3) Fit

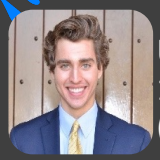


Utilizing PRD 103, 114015 (2021)

Introduction to nPFDs

(4) Extract Flavor-Dependent Distributions





Utilizing PRD 103, 114015 (2021)

Nuclear Quark-Gluon Distributions From Global Analysis

$$q_i^A(x,Q^2) = \left(1 - \%_{SRC}^A\right) \times f_i^{free}(x,Q^2) +$$
$$\%_{SRC}^A \times f_i^{SRC}(x,Q^2)$$

Utilizing PRD 103, 114015 (2021)

Nuclear Quark-Gluon Distributions From Global Analysis

$$q_i^A(x,Q^2) = \left(1 - \%_{SRC}^A\right) \times f_i^{free}(x,Q^2) + \%_{SRC}^A \times f_i^{SRC}(x,Q^2)$$

➔ Nuclear dependence comes in via a *single*, flavor independent, parameter: %SRC

Utilizing PRD 103, 114015 (2021)

Nuclear Quark-Gluon Distributions From Global Analysis

$$q_i^A(x,Q^2) = \left(1 - \%_{SRC}^A\right) \times f_i^{free}(x,Q^2) + \%_{SRC}^A \times f_i^{SRC}(x,Q^2)$$

➔ Nuclear dependence comes in via a *single*, flavor independent, parameter: %SRC

Utilizing PRD 103, 114015 (2021)

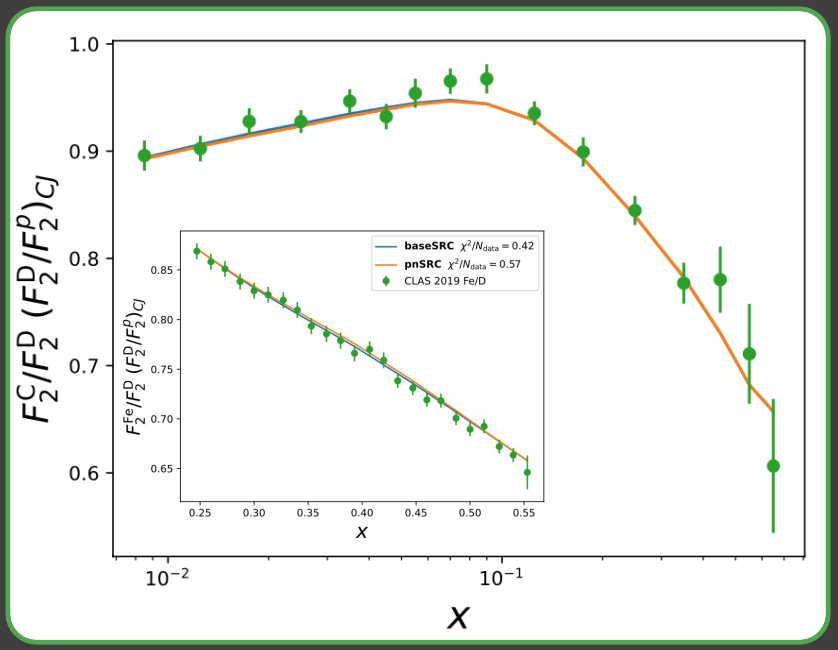
Reminder: traditionally nuclear dependence is a complex parametrization:

$$xf_i^{p/A}(x,Q_0) = c_0 x^{c_1}(1-x)^{c_2} e^{c_3 x}(1+e^{c_4 x})^{c_5},$$

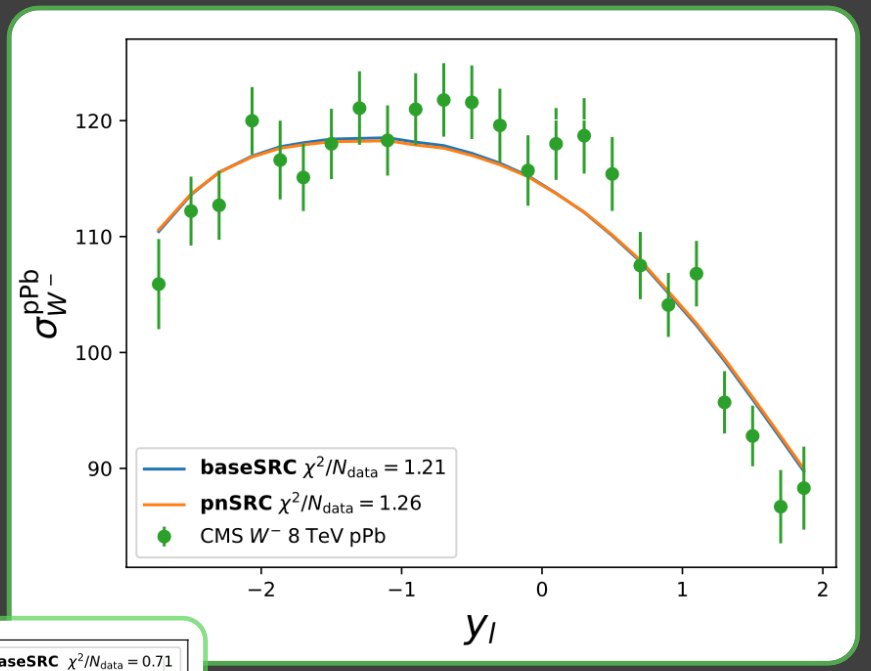
$$c_k \to c_k(A) \equiv p_k + a_k(1 - A^{-b_k})$$

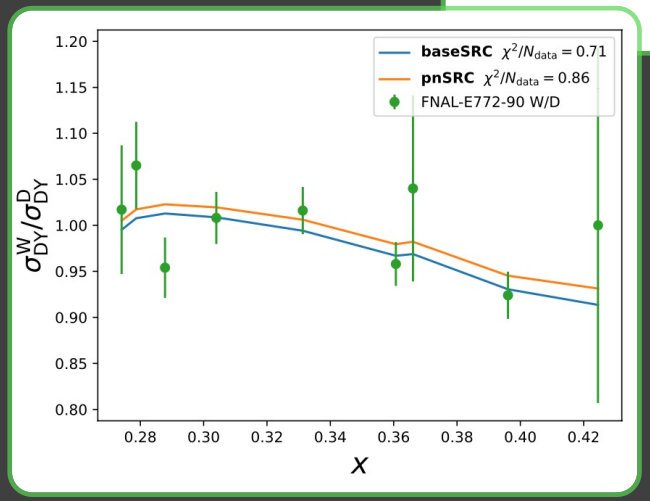
✓ Describes Data Well

Nuclear DIS (EMC + Shadowing)



LHC p+Pb W production



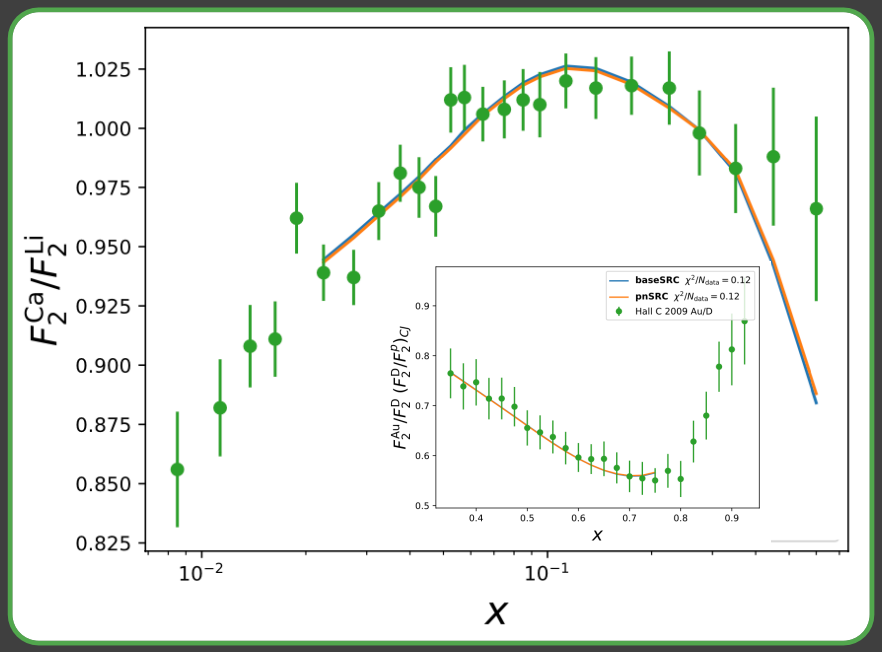


Nuclear Drell-Yan

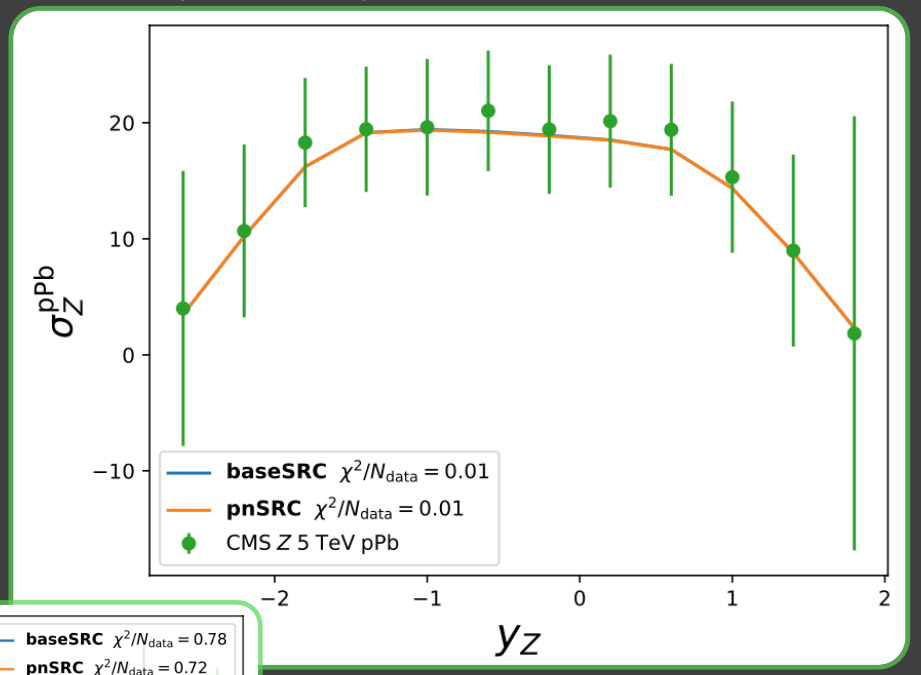
Utilizing PRD 103, 114015 (2021)

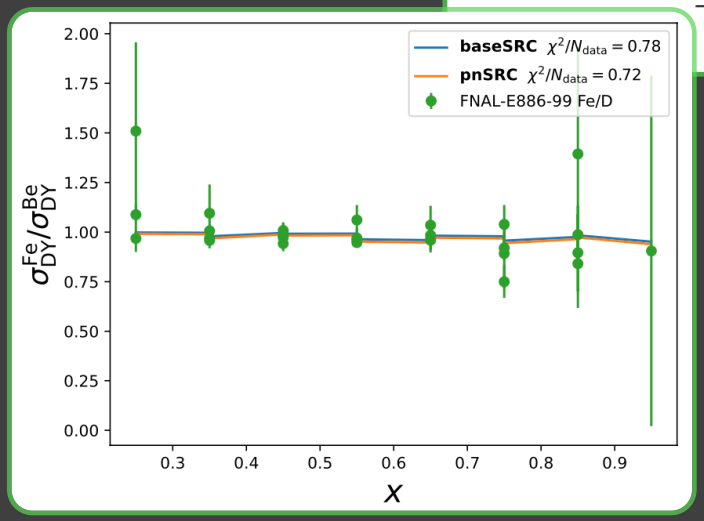
✓ Describes Data Well

Nuclear DIS (EMC + Shadowing)

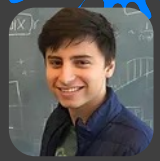


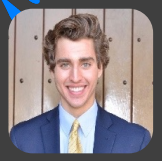
LHC p+Pb W production





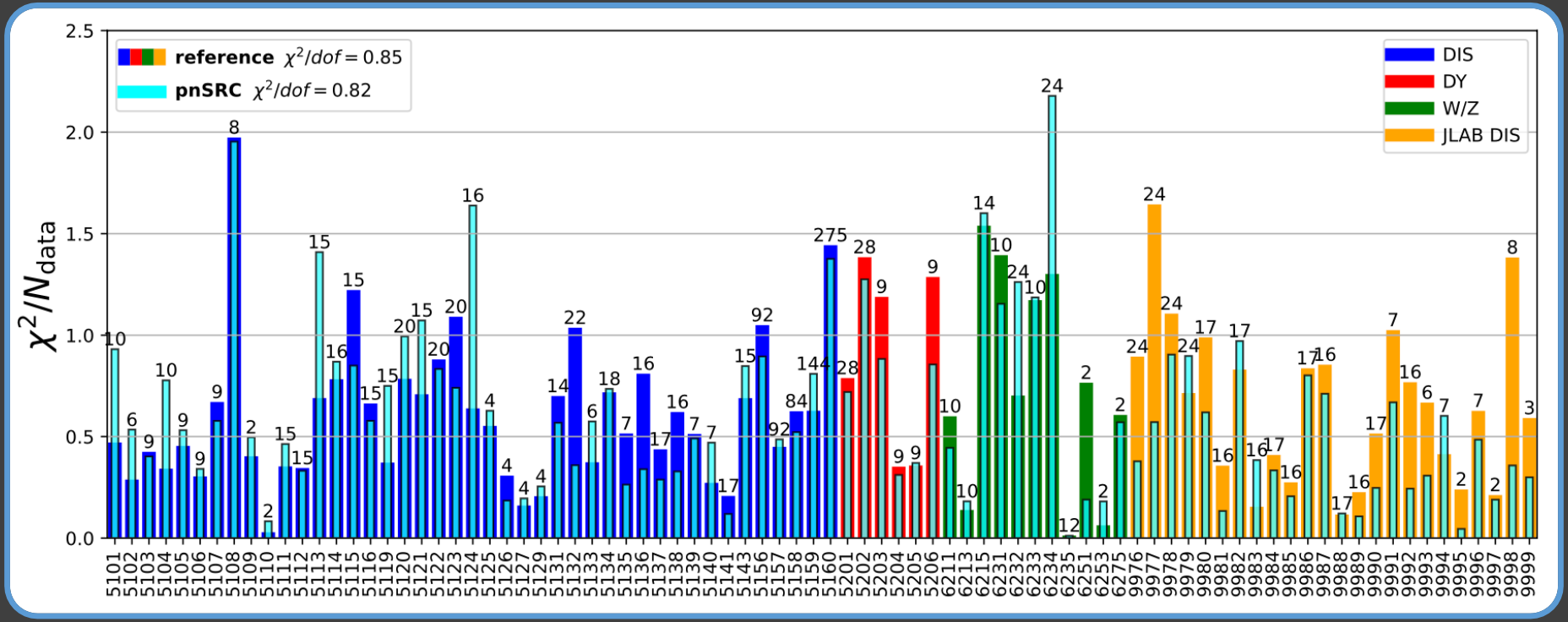
Nuclear Drell-Yan





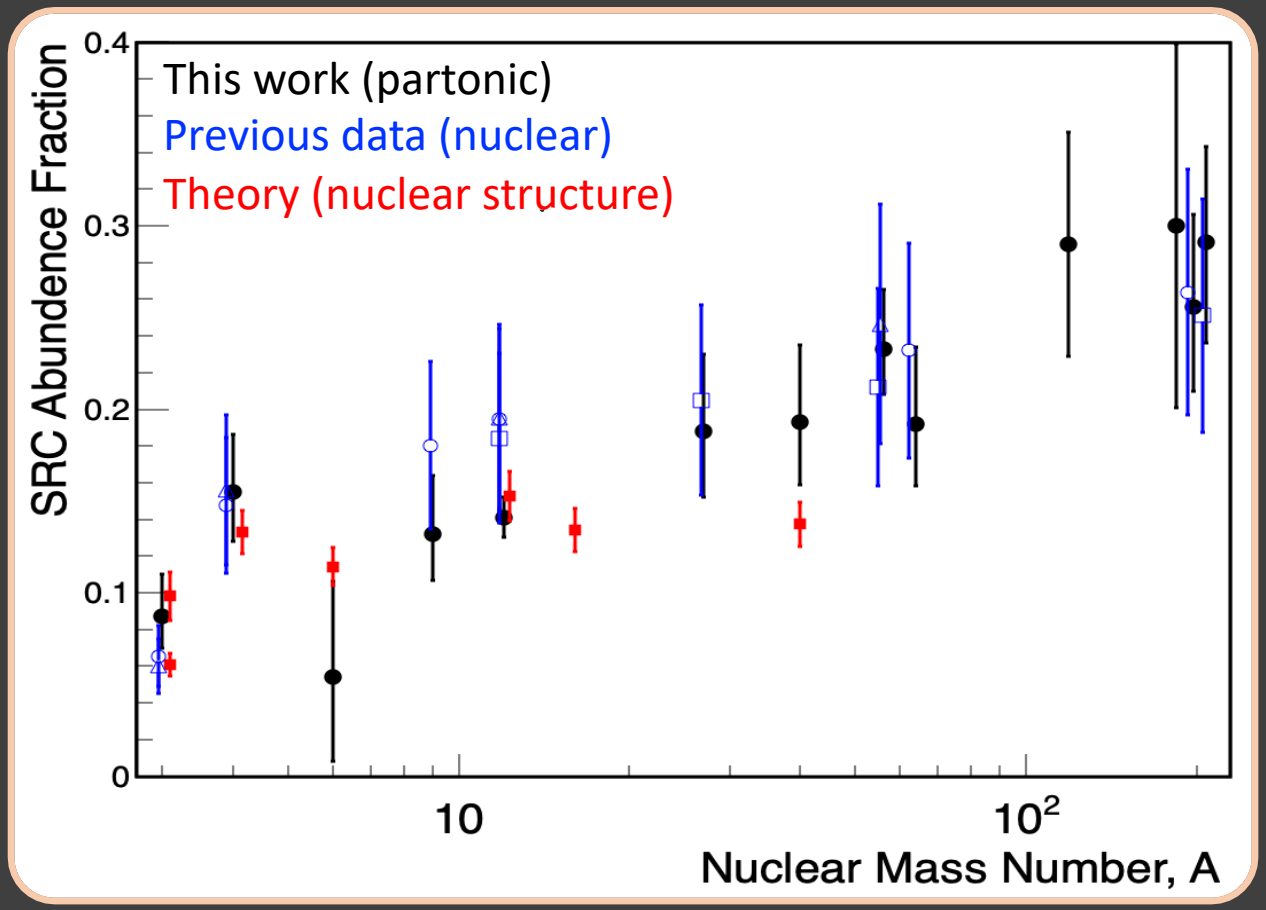
Utilizing PRD 103, 114015 (2021)

✓ Describes Data Well



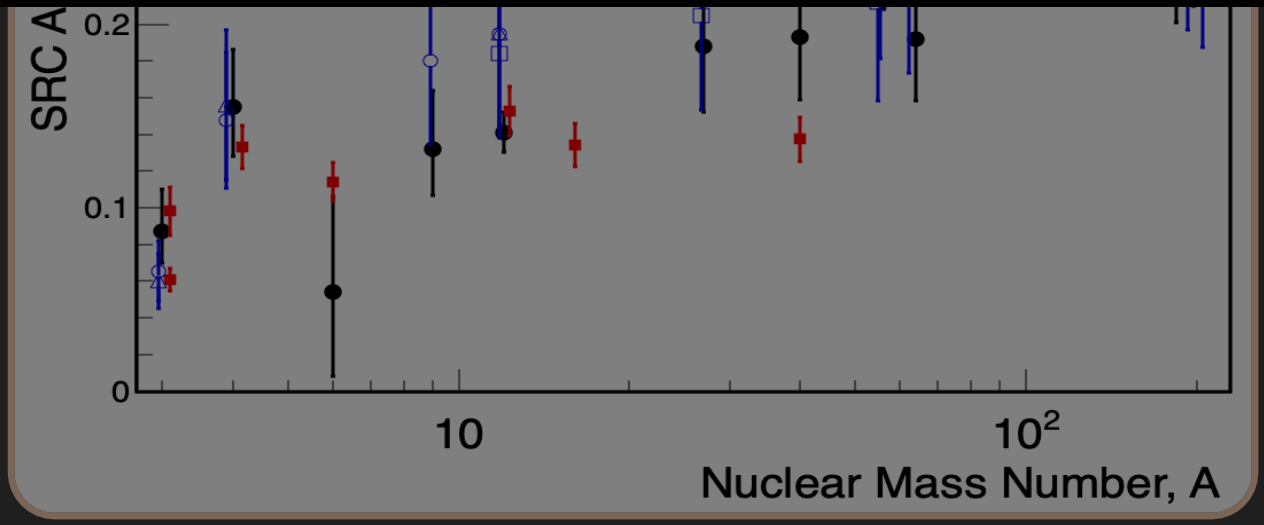
Utilizing PRD 103, 114015 (2021)

✓ Correctly Predict SRC Abundances

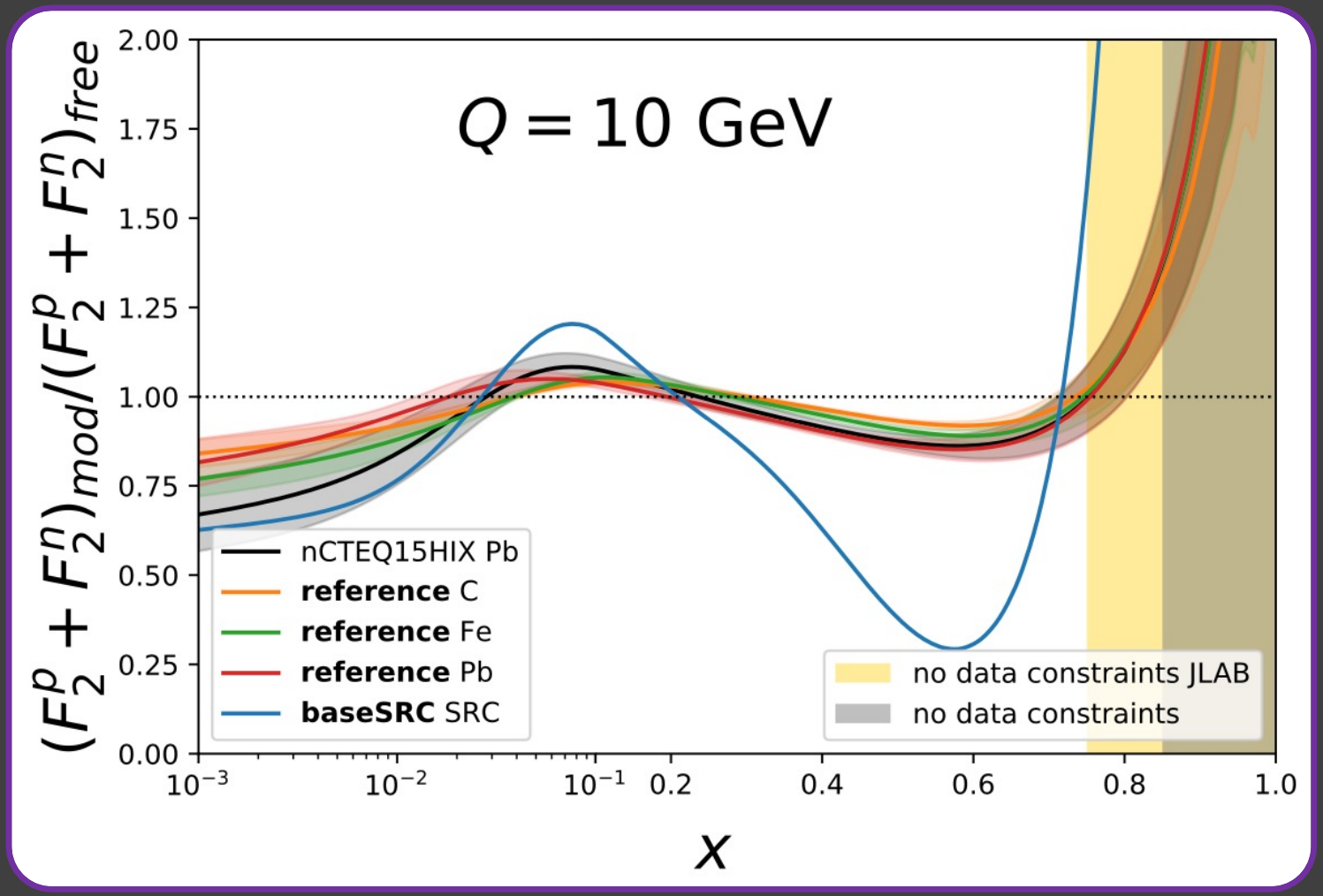


✓ Correctly Predict SRC Abundances

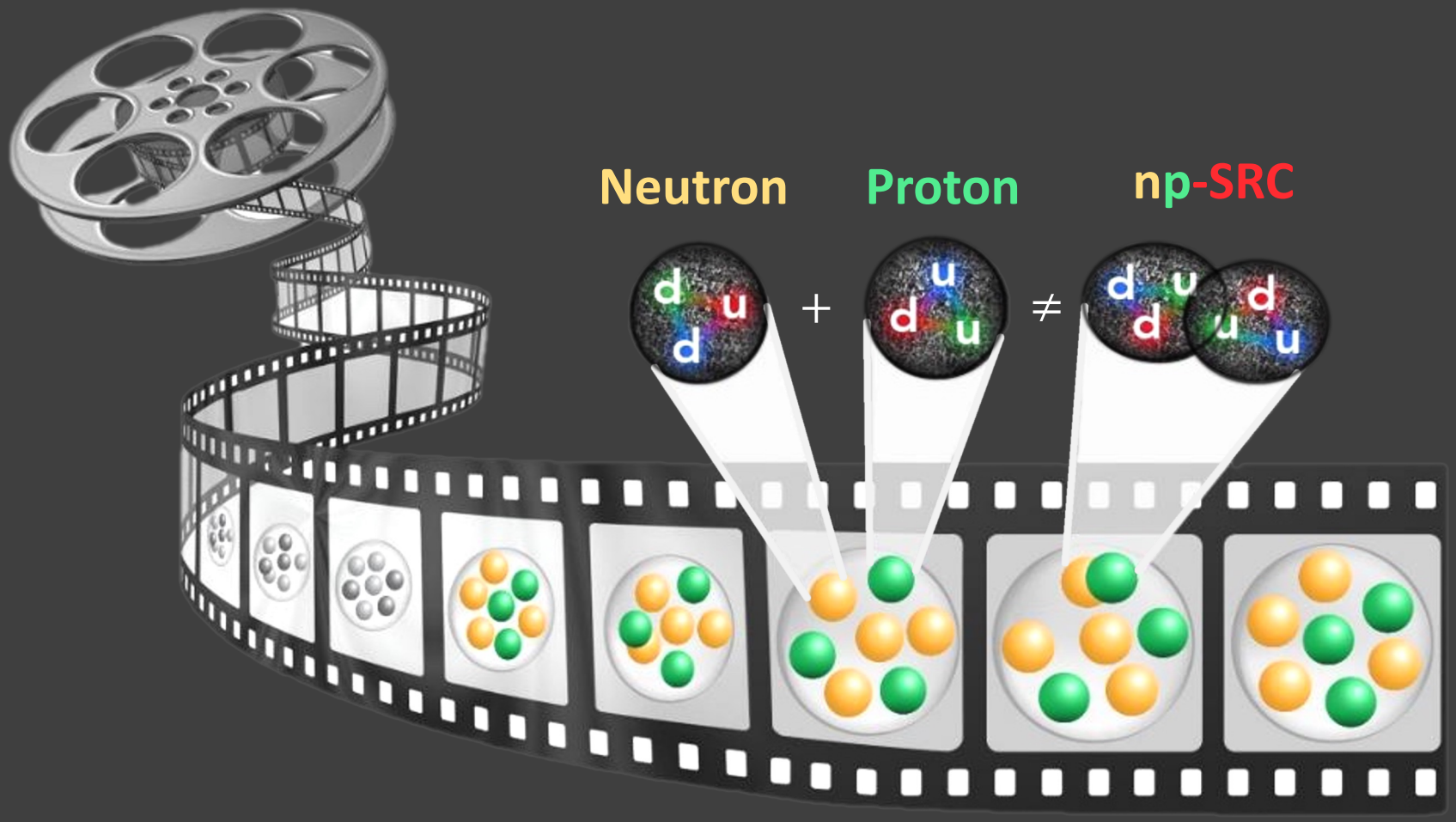
First (?) prediction of a nuclear structure property, i.e. SRC abundance, from purely partonic observables!



+ Enhanced *Valance* SRC Modification

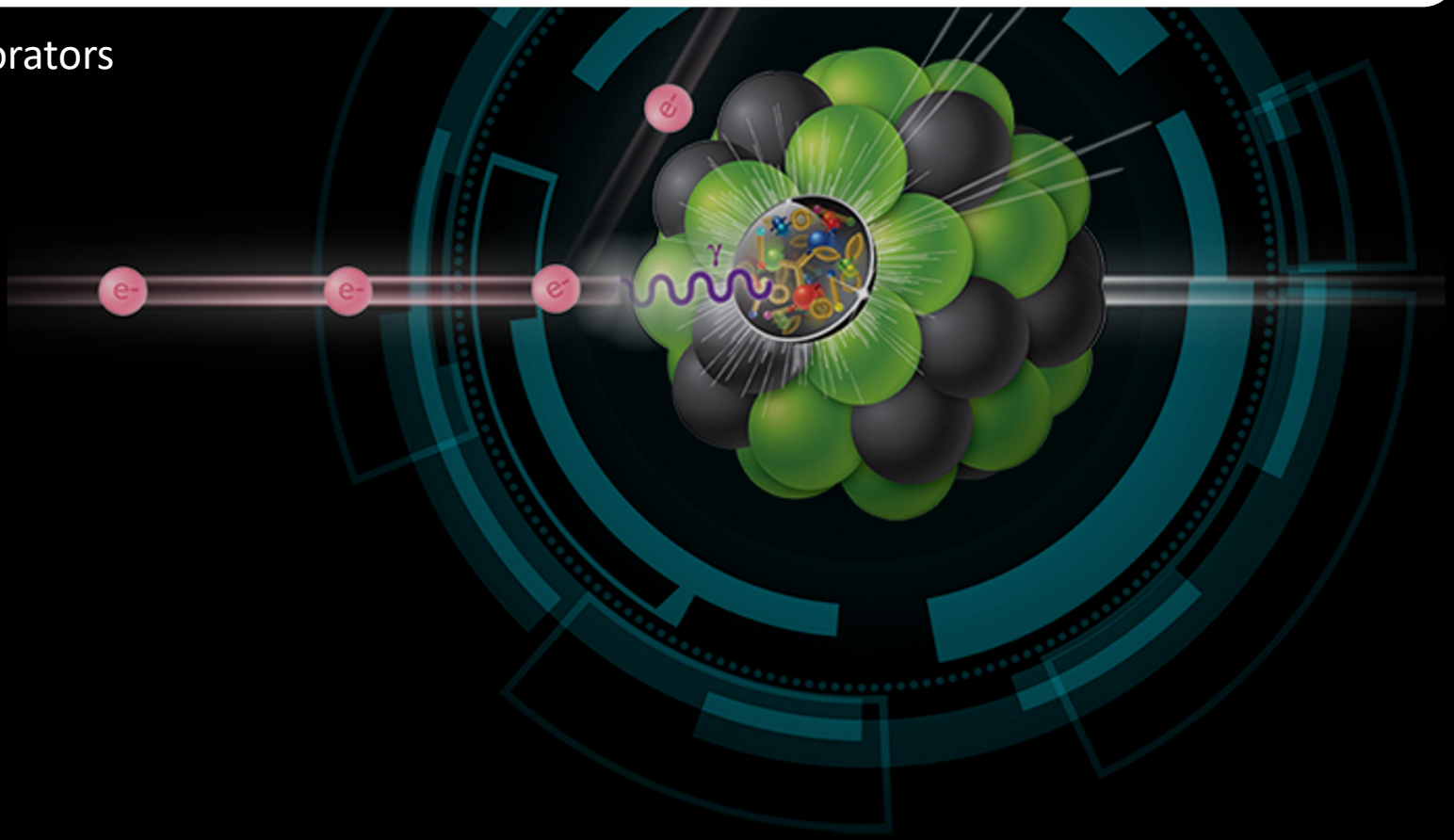


Nuclear Interaction *Universally* Impacts Quark-Gluon Distributions

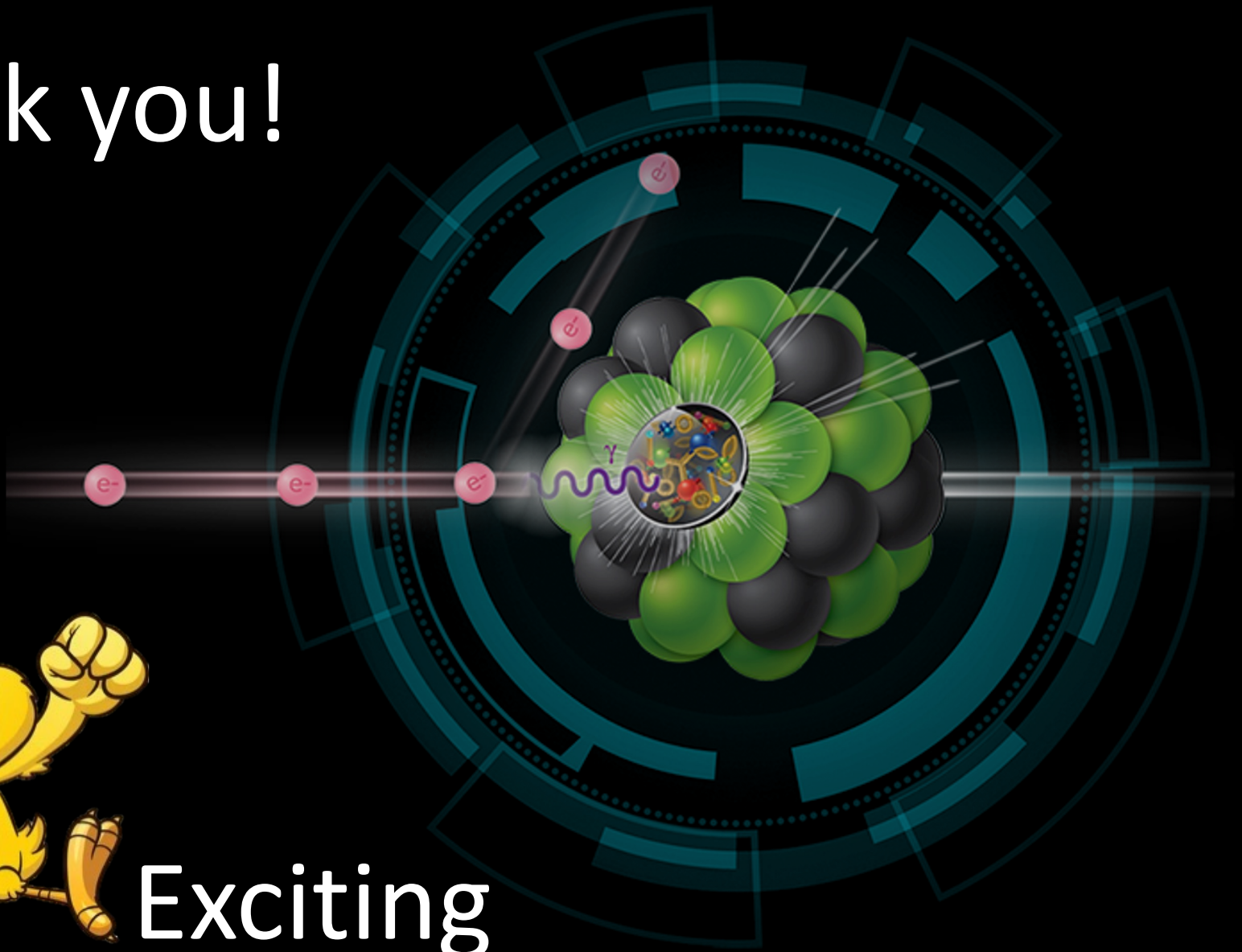


A.W. Denniston,[1,*] T. Ježo,[2,†] A. Kusina,[3] P. Duwentäster,[2,4,5] O. Hen,[1]
C. Keppel,[6] M. Klasen,[2,7] K. Kovařík,[2] J.G. Morfín,[8] K.F. Muzakka,[2,9]
F.I. Olness,[10,‡] P. Risse,[2] R. Ruiz,[3] I. Schienbein,[11] and J.Y. Yu.[11]

*nCTEQ Collaborators



Thank you!



Exciting
Times Ahead!