Topical Session (SRC-EMC)
- Introduction

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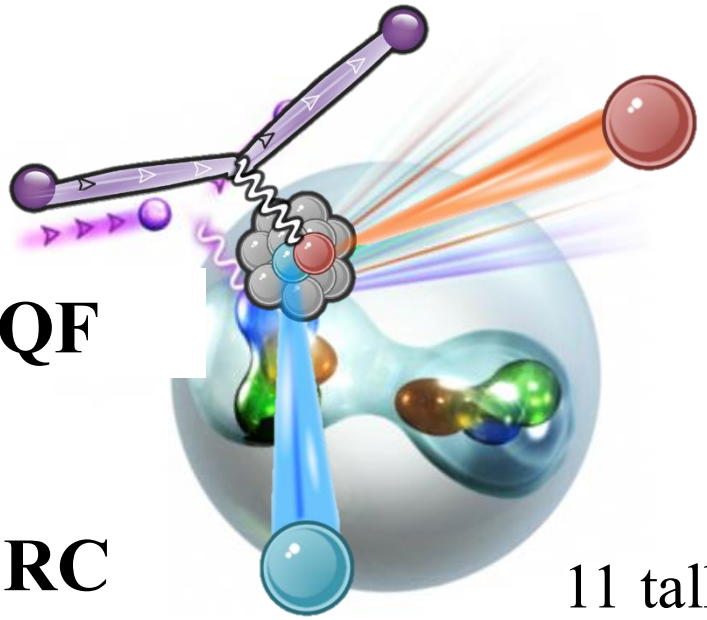
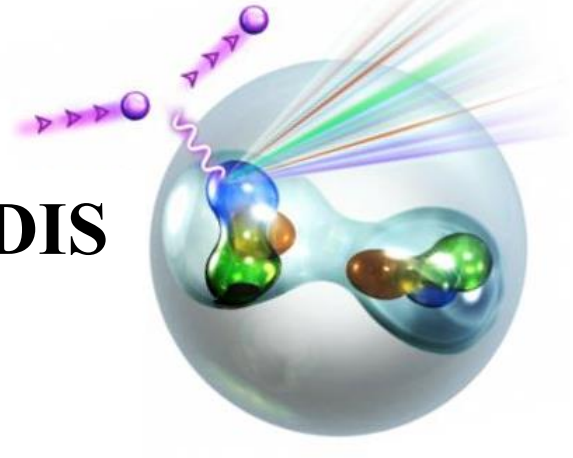


QF

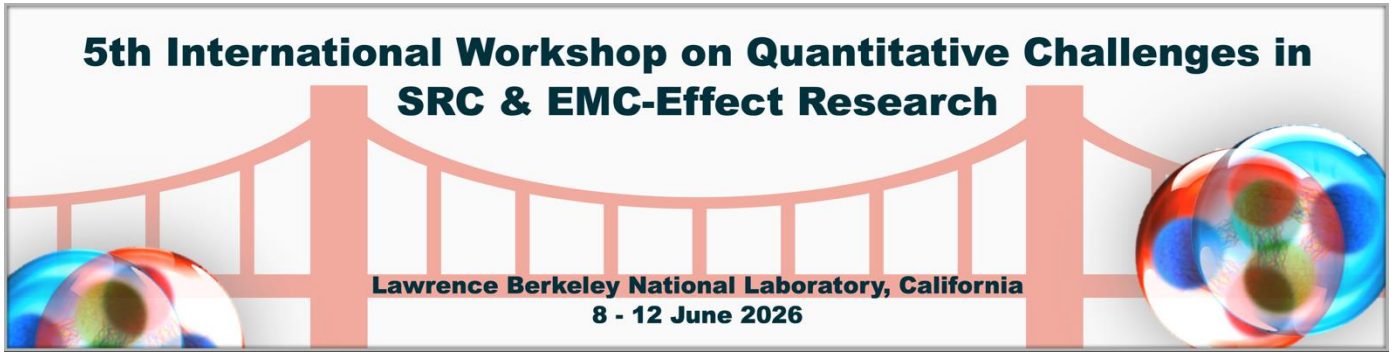
SRC



DIS

EMC effect

11 talks Thur / Fri



Eli Piasetzky

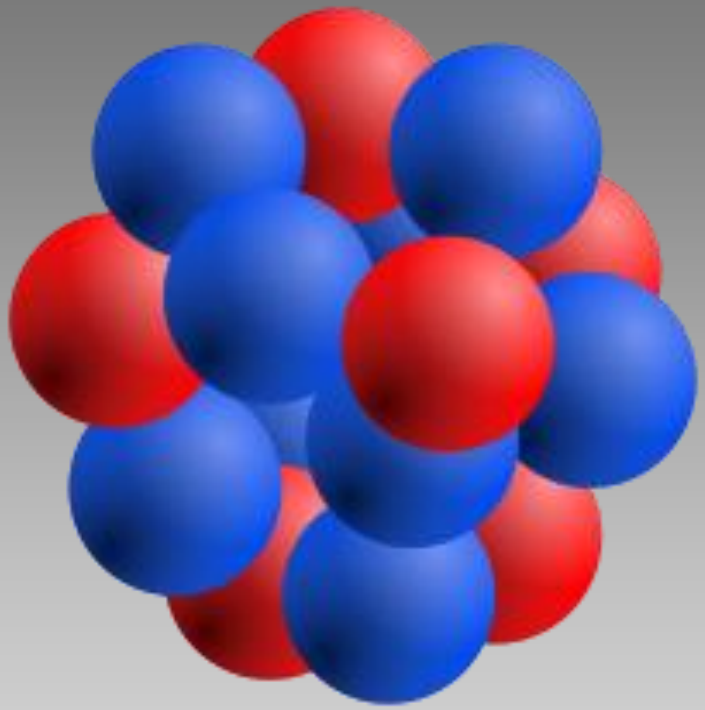
Tel Aviv University

It's All About Resolution

It's All About Resolution

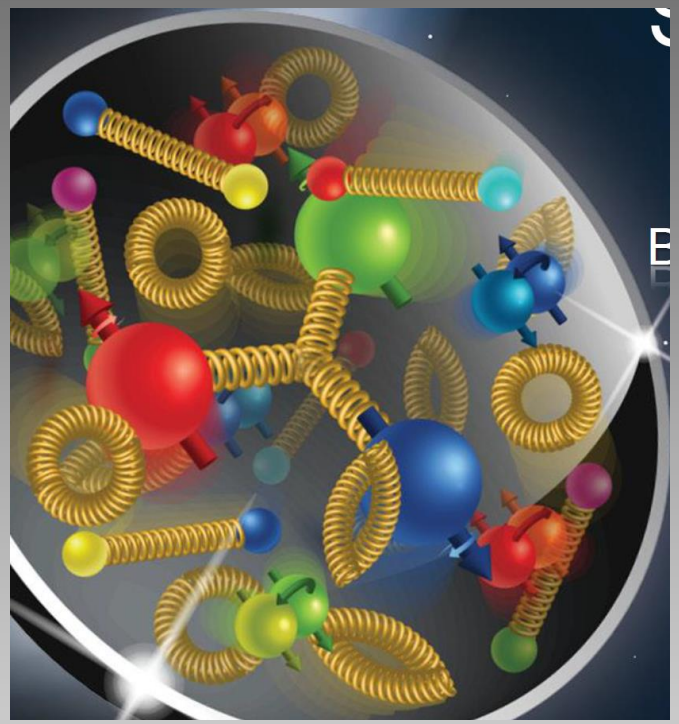
A drop of seawater X25

It's All About Resolution



B.E ~1% M_N

Low energy nuclear physics



Confinement ~1 Gev/c

high energy particle physics

It's All About Resolution

Low Q^2 → Medium Q^2 → High Q^2

resolution increases

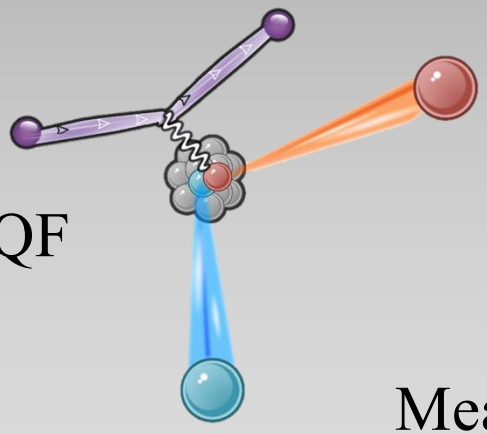
● Nucleus

○ ● ○ ● ○ Nucleons

[quarks] quarks + gluons

Galube

Same nucleus. Different resolution. Different physics.



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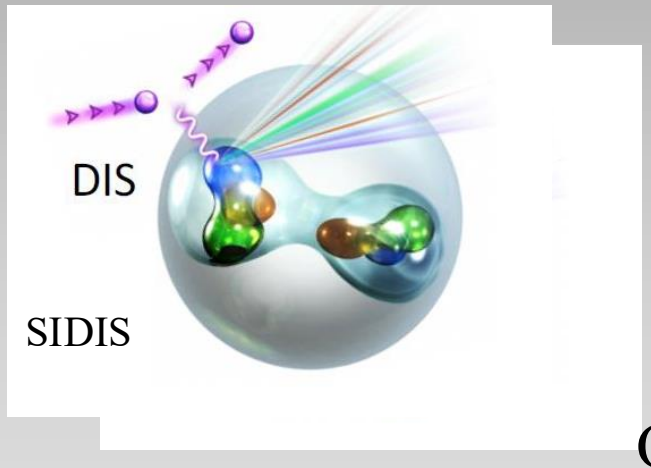


Mean Field
Shell models
Effective field …

DWIA

QCD

Glauber

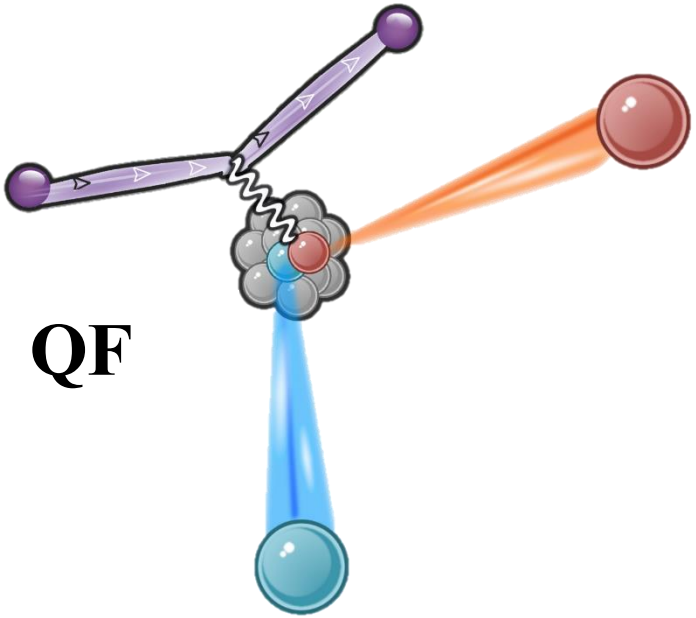
SRC-EMC

Session | **Location:** Bldg. 66 Auditorium

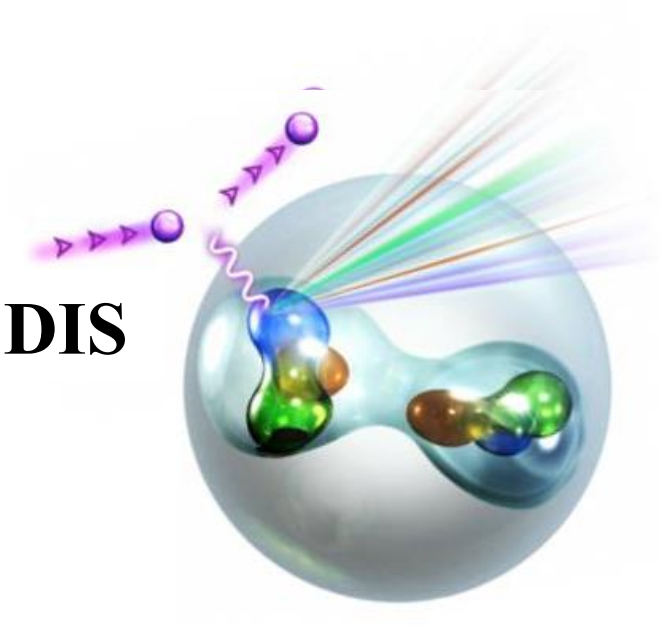
3:30 – 4:00 PM **QCD Properties of Nucleons and Nuclei (20+10min)**

Speaker
Leonid Frankfurt

Bound and Free Nucleon Structure



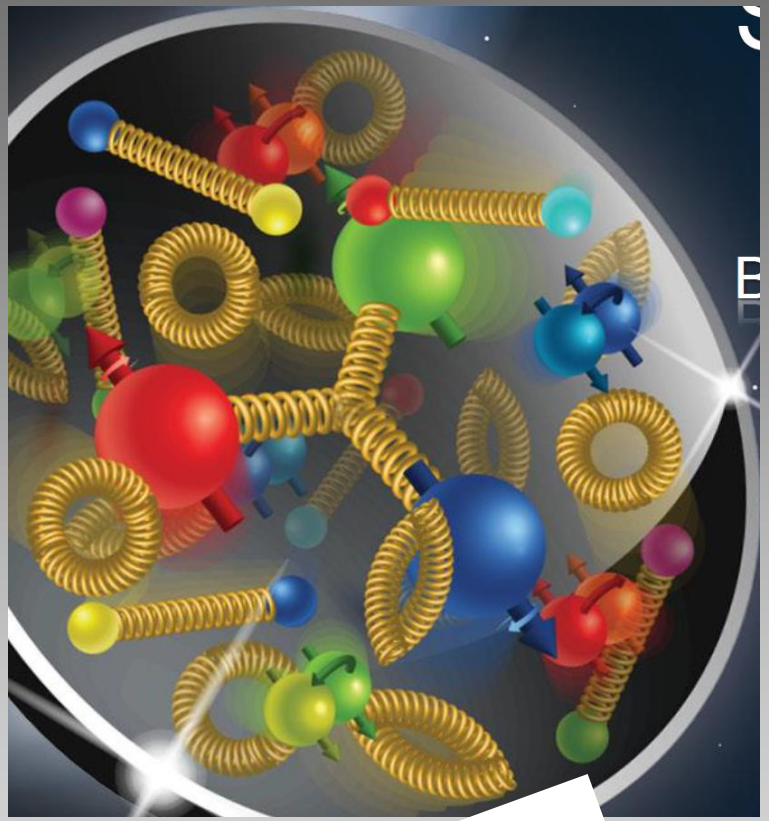
QF



DIS

SRC

DIS



Adapted from Rolf

Valance quarks

sea quarks

anti quarks

gluons

Structure functions

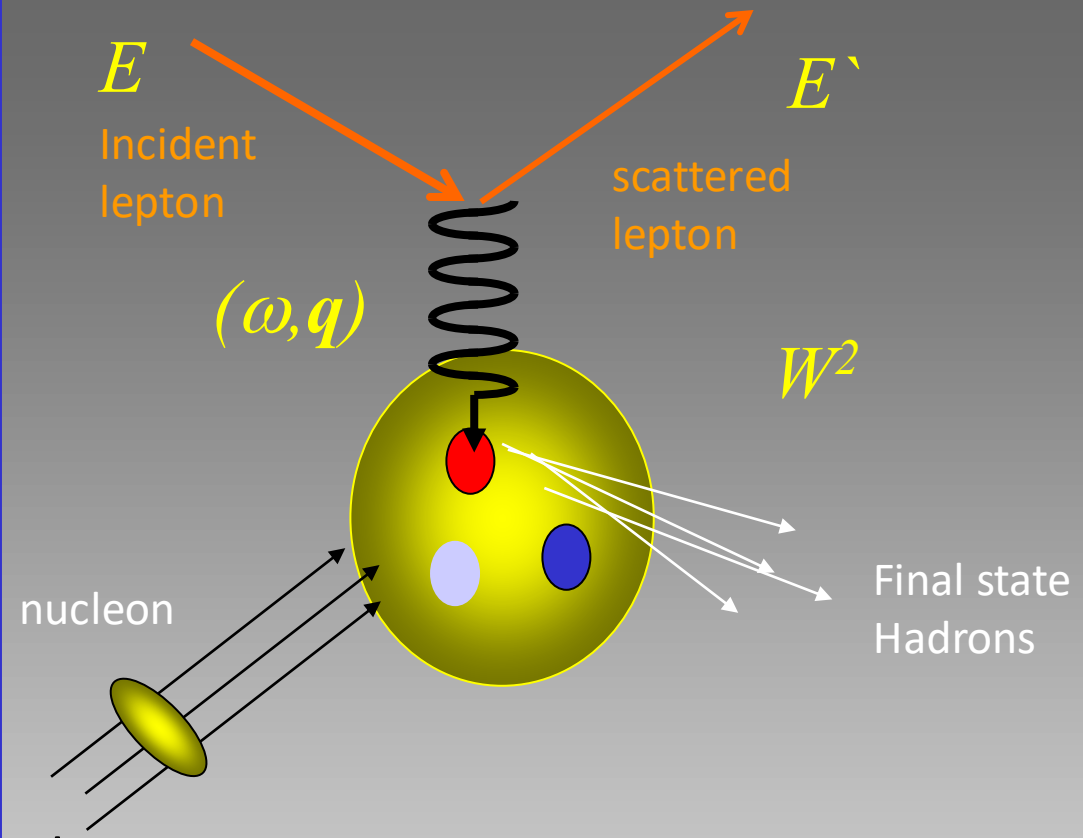
PDF

GPDF

TMD

All these particles you cannot see. That's what drove me to drink. But now I can see them.

Deep Inelastic Scattering (DIS)



$$Q^2 = -q_\mu q^\mu = q^2 - \omega^2$$

$$\omega = E' - E$$

$$x_B = \frac{Q^2}{2m\omega} \qquad (= \frac{Q^2}{2(q \cdot p_T)})$$

$$0 \le x_B \le 1$$

Electrons, muons, neutrinos

SLAC, CERN, HERA, FNAL, JLAB

E, E' 5-500 GeV

Q^2 5-50 GeV^2

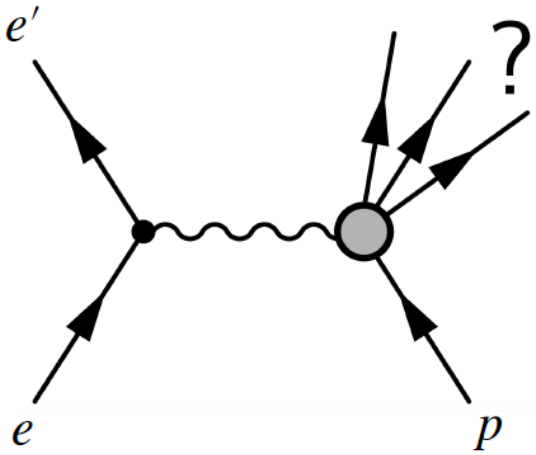
w^2 >4 GeV^2

$0 \le X_B \le 1$

X_B gives the fraction of nucleon momentum carried by the struck parton

Information about nucleon vertex is contained in $F_1(x,Q^2)$ and $F_2(x,Q^2)$, the unpolarized structure functions

Deep Inelastic Scattering (DIS)



$$\frac{d\sigma}{dxdQ^2} = \frac{4\pi\alpha^2}{Q^4}\left[\left(1 - y - \frac{m_p^2 y^2}{Q^2}\right)\frac{F_2(x,Q^2)}{x} + y^2 F_1(x,Q^2)\right]$$

$$Q^2 = -q_\mu q^\mu = q^2 - \omega^2$$

$$\omega = E' - E$$

$$x_B = \frac{Q^2}{2m\omega} \quad \left(= \frac{Q^2}{2(q \cdot p_T)}\right)$$

$$0 \le x_B \le 1$$

The fraction of nucleon momentum carried by the struck parton.

Information about the nucleon is contained in $F_1(x,Q^2)$ and $F_2(x,Q^2)$, the unpolarized structure functions.

$$\frac{d\sigma}{dxdQ^2} \Big\} \; F_2^p(x,Q^2)$$

$$\frac{d\sigma^A}{dxdQ^2} \Big\} \; F_2^A(x,Q^2)$$

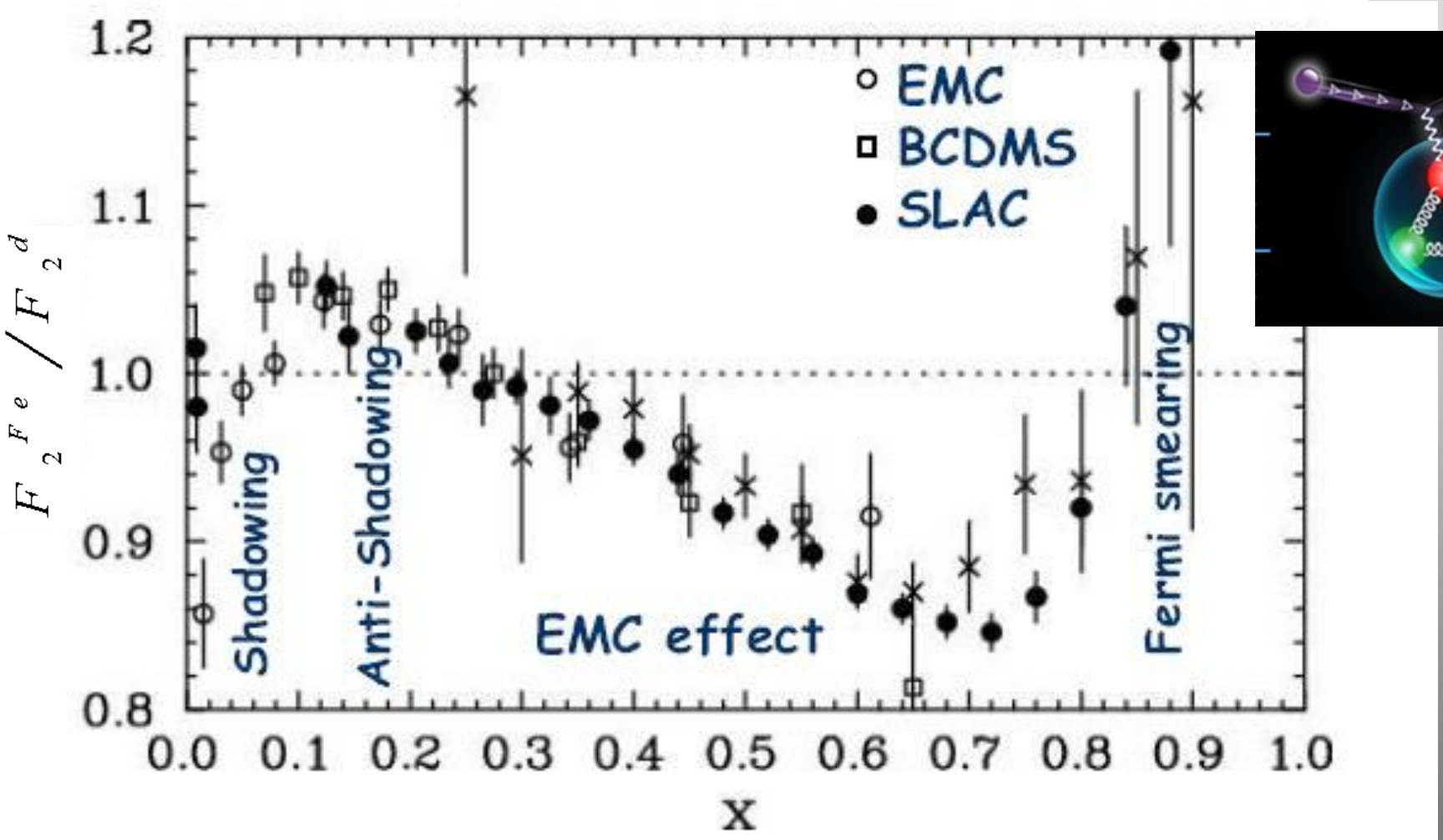
Is the distribution of partons in bound nucleons same as in free nucleons ?

$$F_2^A(x,Q^2) = Z \cdot F_2^p(x,Q^2) + N \cdot F_2^n(x,Q^2)$$

$$F_2^d(x,Q^2) = F_2^p(x,Q^2) + F_2^n(x,Q^2)$$

free neutron?

The European Muon Collaboration (EMC) effect



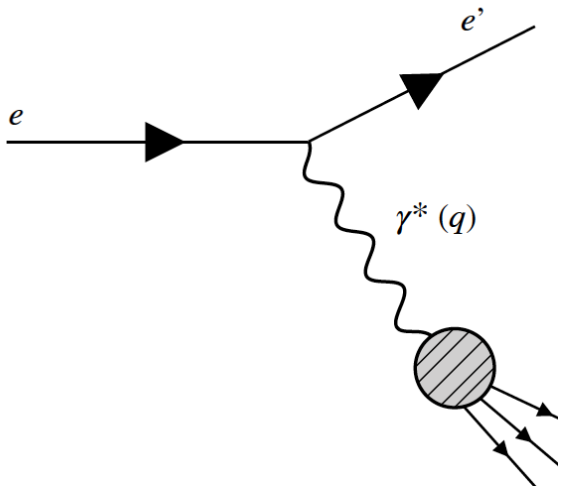
Aubert et al., PLB (1983); [illegible] et al., PLB (1988); Allasia et al., PLB (1990); Gomez et al. [illegible] 2009); Schmookler et al., Submitted (2018)

$$F_2^A \neq Z \cdot F_2^p + N \cdot F_2^n$$

After 40 years no consensus on cause [illegible]ct

Close nucleons

SIDIS Semi Inclusive DIS



Fragmentation Function:

$$\sigma_{SIDIS} \sim PDF \otimes D_q^h(z, p_T)$$

$$z = E_\pi/\omega$$

Parton model

$$\sigma_p^{\pi\pm} \propto 4u_p(x_B)D_u^{\pm}(z) + d_p(x_B)D_d^{\pm}(z) + \text{(sea contributions)}$$

$$\sigma_n^{\pi\pm} \propto 4u_n(x_B)D_u^{\pm}(z) + d_n(x_B)D_d^{\pm}(z) + \text{(sea contributions)}$$

Isospin symmetry (i.e. $D_u^{\pm} = D_d^{\mp} = D^{\pm}$)

$$r = \frac{D^-}{D^+} = \frac{4\frac{u}{d} - (\sigma_p^{\pi+}/\sigma_p^{\pi-})}{4\frac{u}{d}(\sigma_p^{\pi+}/\sigma_p^{\pi-}) - 1}$$

$$r = \frac{4 - (\sigma_d^{\pi+}/\sigma_d^{\pi-})}{4(\sigma_d^{\pi+}/\sigma_d^{\pi-}) - 1}$$ for the deuteron!

4:00 – 4:15 PM
Study of superfast quarks using Jefferson Lab 11 GeV data (10+5min)

Speaker
Sebastian Moran

4:15 – 4:30 PM **Extracting d/u at large x using SIDIS at CLAS12 (10+5min)**

Speaker
Jason Phelan

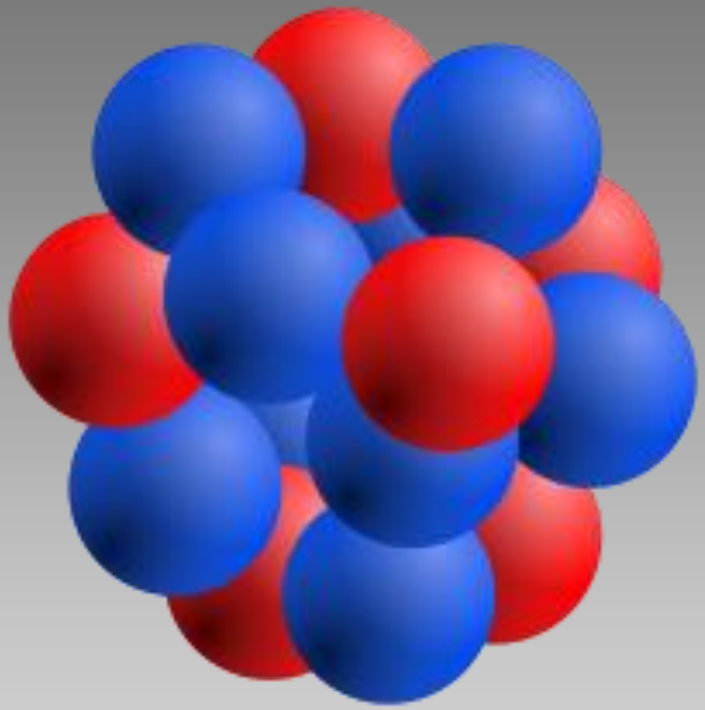
and more about the stucture and properties of bound nucleons (neutrons)

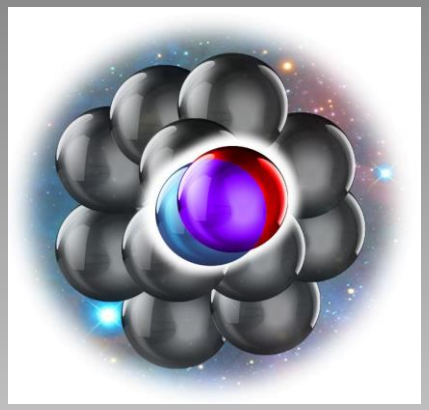
9:00 – 9:30 AM **Results from MARATHON Experiment (20+10min)**

Speaker
John Arrington

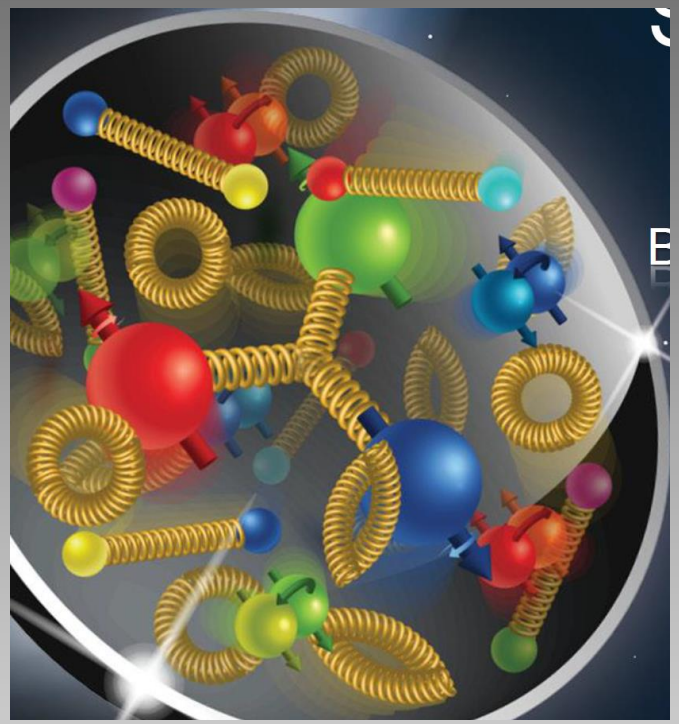
9:30 – 10:00 AM **Results from the BONuS12 Experiment with CLAS12 (20+10min)**

Speaker
Sebastian Kuhn





~100 MeV



B.E ~10 Mev

Confinement ~1 Gev/c

Low energy nuclear physics

high energy particle physics

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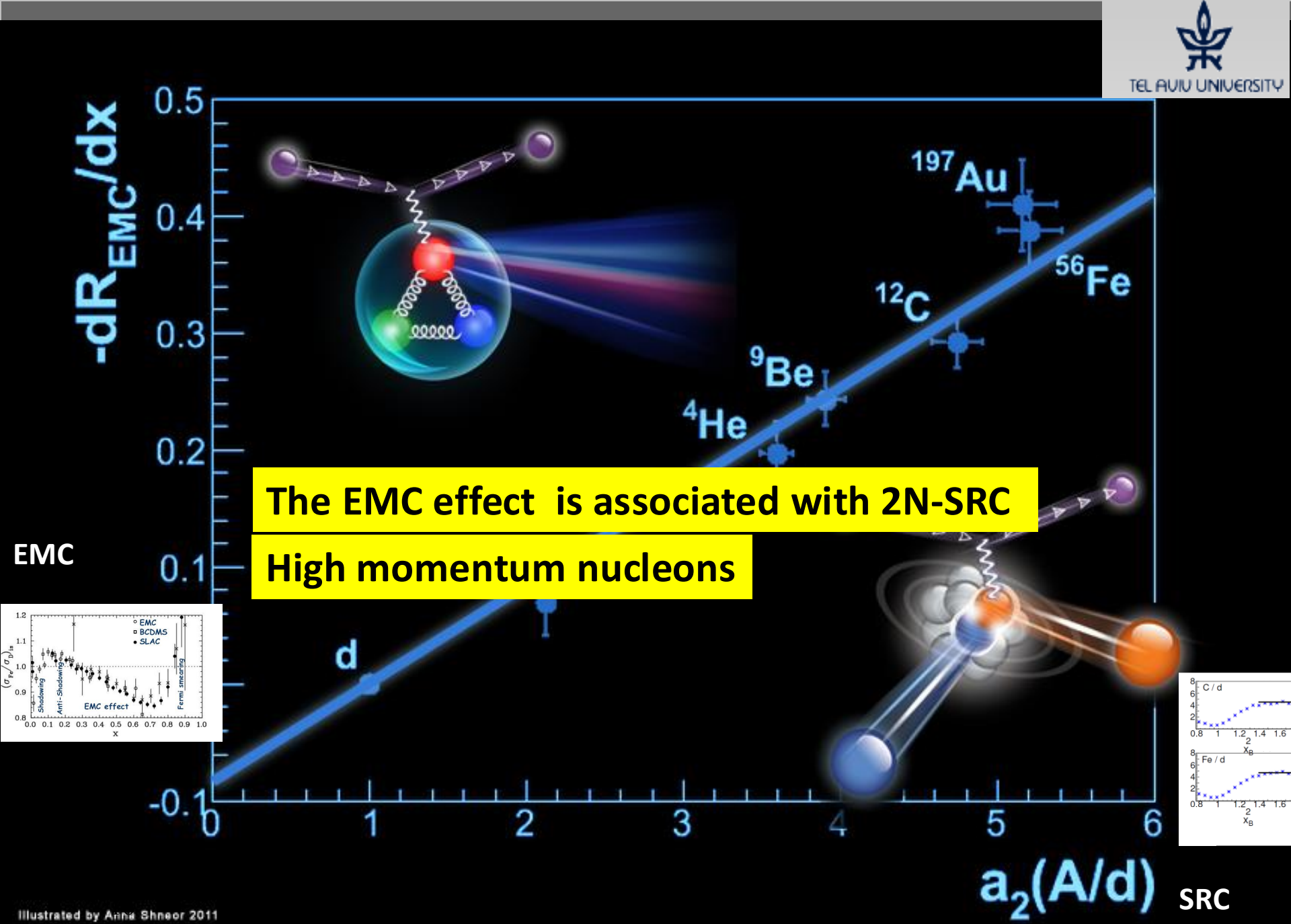
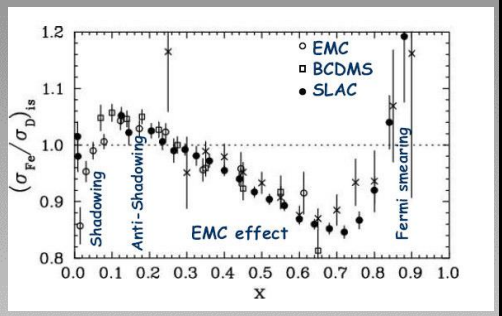
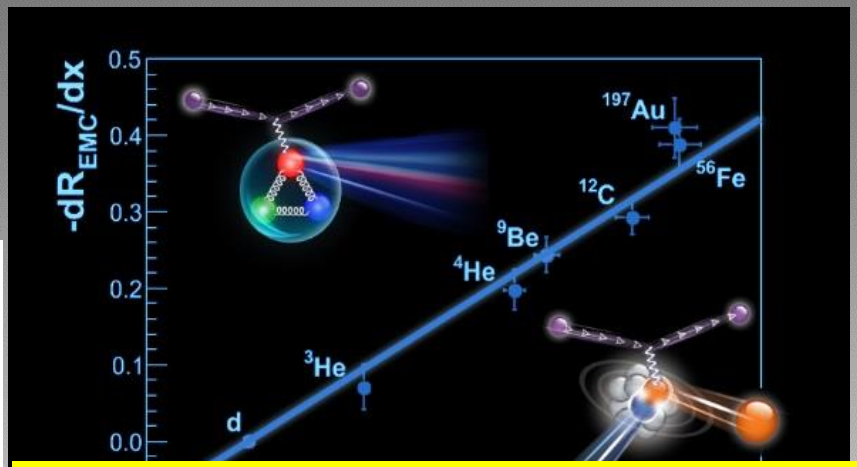


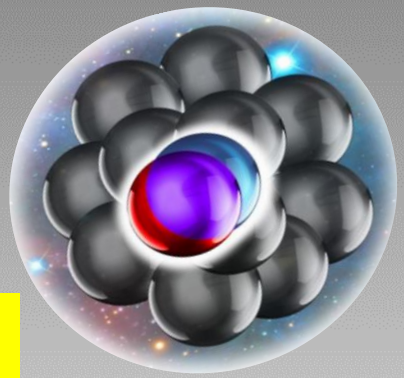
PRL 106, 052301 (2011), PRC 85 047301 (2012), RMP 89, 04500 (2017)

EMC





2N SRC



If both EMC and 2N-SRC are associated high-momentum nucleons

nucleon structure

SRC

Summary of SRC results

In nuclei the momentum distribution of nucleons can be divided into two distinct regions

$k<\sim 0.8k_F$

Mean field region

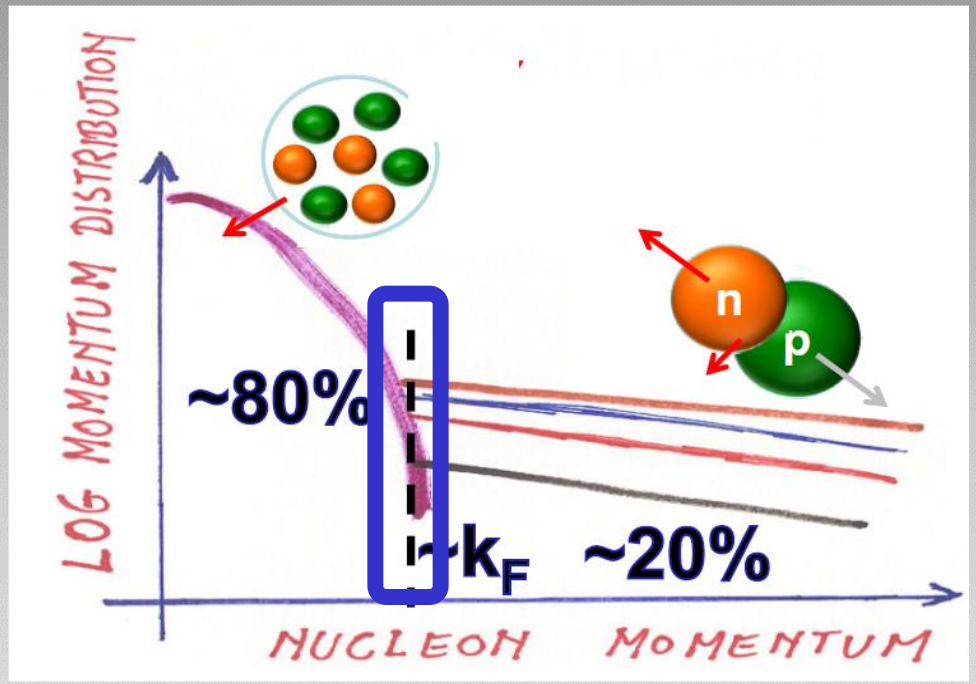
Single nucleons

$k>1.5\ k_F$

Correlated / high momentum region

SRC pairs

SRC domain



~20% of the nucleons

scaling

Universality

np-SRC dominance (tensor force)

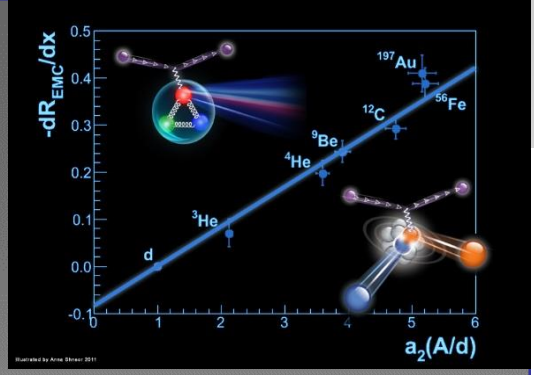
Protons have a greater probability than neutrons to be above the Fermi sea.

E. Piasetzky et al., PRL. 97 (2006) 162504.

R. Subedi et al., Science 320, 1476 (2008).

A. Schmidt et al., Nature ( )

If EMC is associate with 2N SRC:



* Nucleon is normally normal except when close to another nucleon.

* Small number of universal strongly modified nucleons.

Prediction for the EMC effect

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SRC universality →

Universal modification of the bound nucleon structure function (same for all nuclei).

Universal function (data from all nuclei) can be used to extract F_2^n

SRC np-dominance →

For nuclei with N>Z

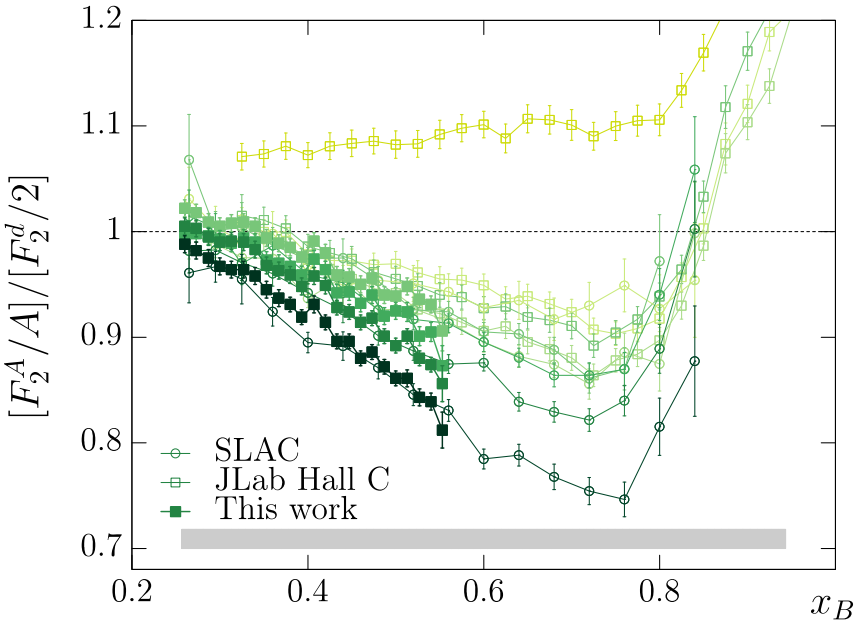
More protons larger EMC effect.

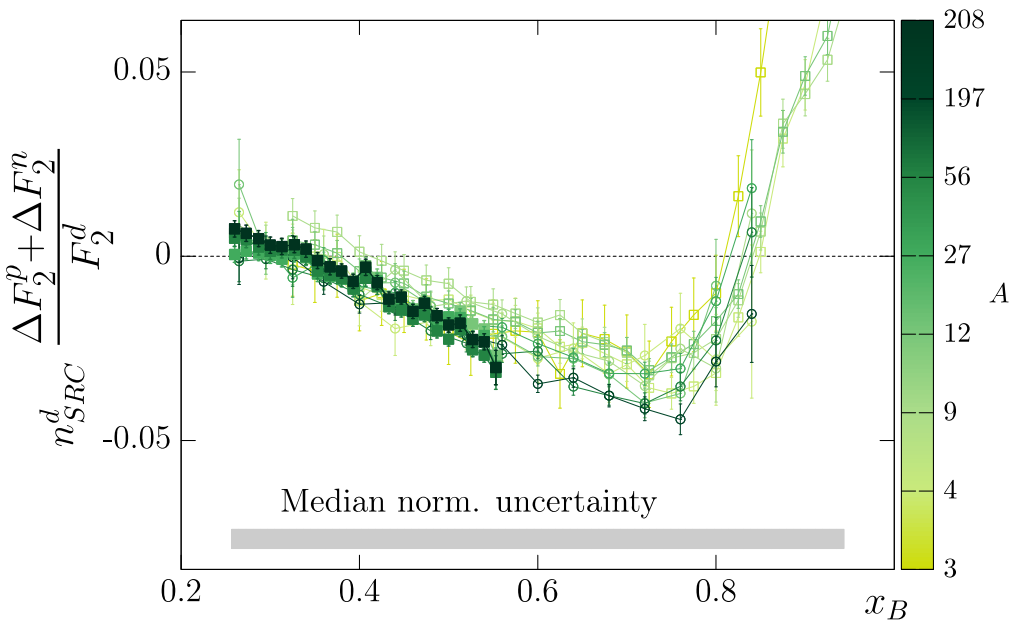
More Neutrons Saturation.

$$\frac{F_2^A}{F_2^d} = \left(n_{SRC}^A - N n_{SRC}^d\right)\frac{\Delta F_2^p + \Delta F_2^n}{F_2^d} + (Z-N)\frac{F_2^p}{F_2^d} + N$$

A Dependent — **Universal!** — **A Dependent**

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





Schmookler, Duer, and Schmidt et al., Nature 566 (2018) 354-358

SRC Universality!

Extracting nPDFs

$$F_2^A \neq Z \cdot F_2^p + N \cdot F_2^n$$

Data

DIS

DY

W Z production

SRC inspire nCTEQ

Only pairs are universally modified

Fit well non DIS data

Fit well large and low XB beyond the EMC range

PRD 103, 114015 (2021)

12:30 – 12:45 PM

Modification of Quark-Gluon Distributions in Nuclei by Correlated Nucleon Pairs (10+5min)

Speaker

Andrew Denniston→Eli→Andrew Denniston

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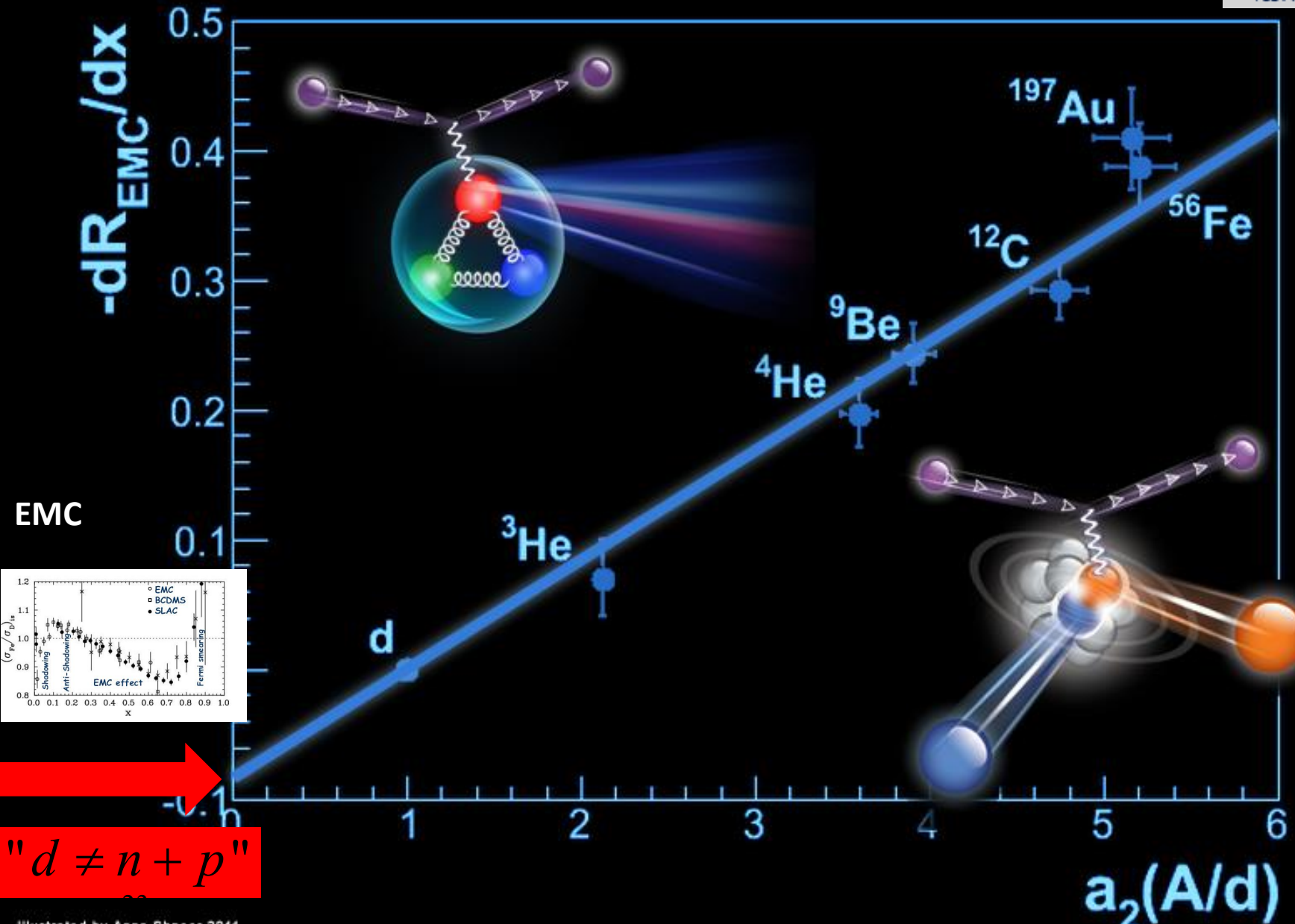


EMC

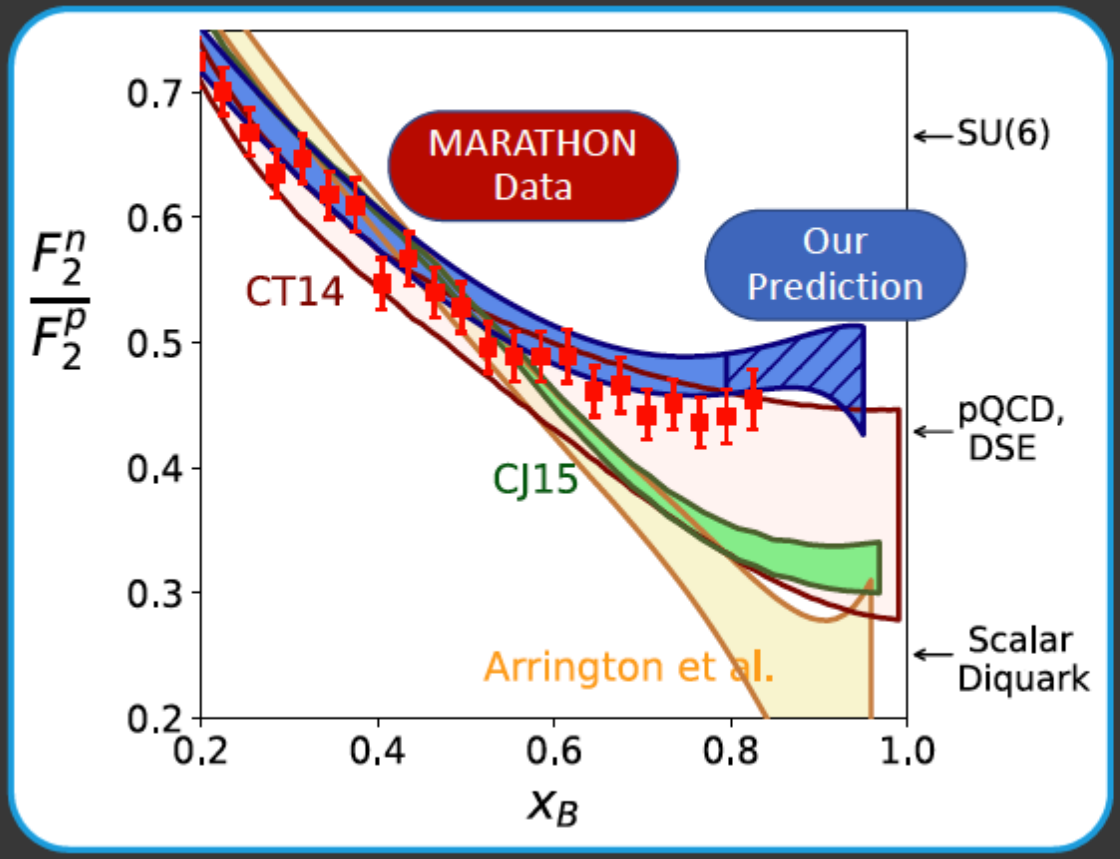
SRC

$"d \neq n + p"$

Illustrated by Anna Shneor 2011

PRL 106, 052301 (2011), PRC 85 047301 (2012), RMP 89, 04500 (2017)

Verified Predictions!



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

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

SRC Universality!

9:00 AM

SRC-EMC

Session | **Location:** Bldg. 66 Auditorium

9:00 – 9:30 AM **Results from MARATHON Experiment (20+10min)**

Speaker
John Arrington

9:30 – 10:00 AM **Results from the BONuS12 Experiment with CLAS12 (20+10min)**

Speaker
Sebastian Kuhn

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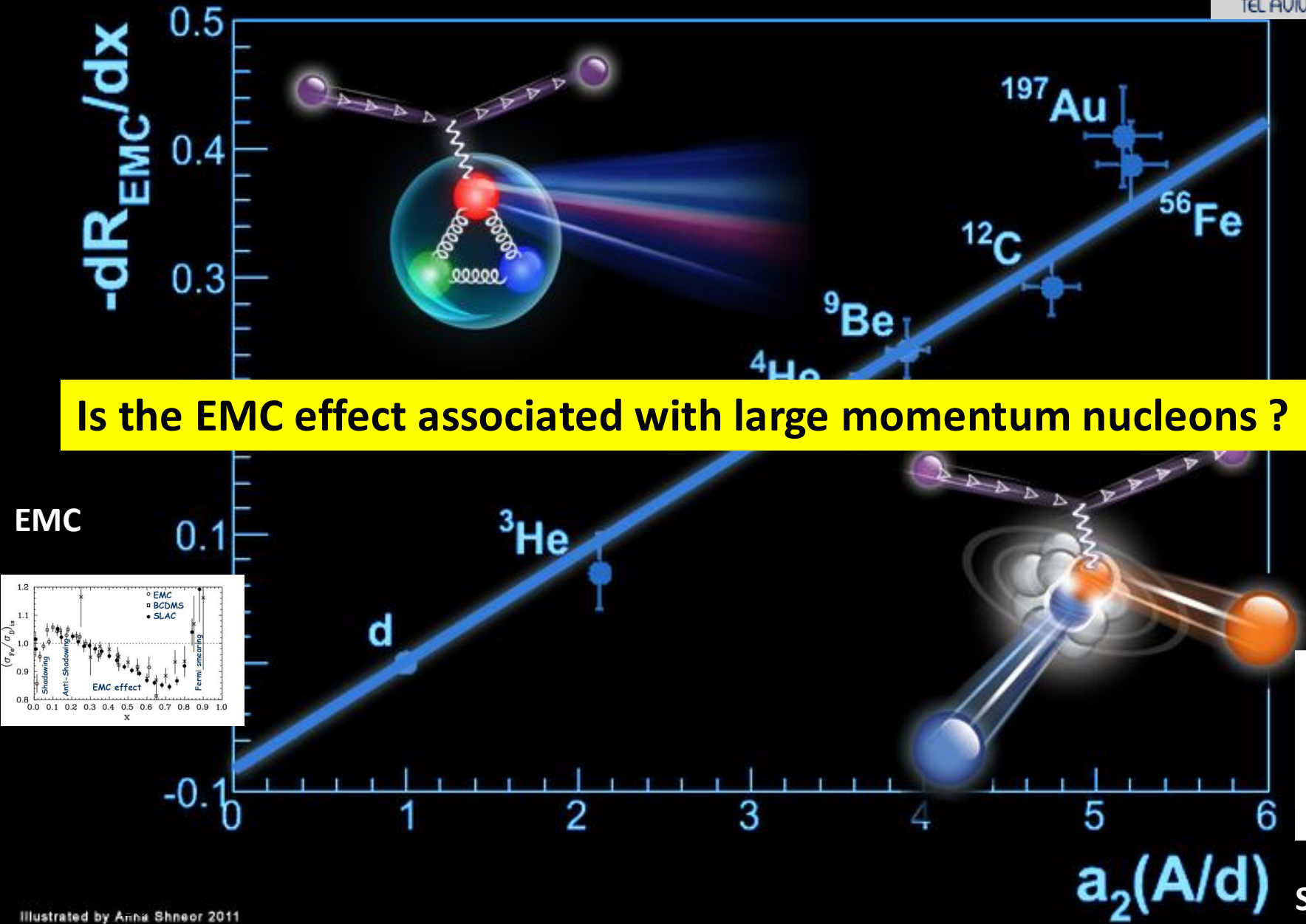
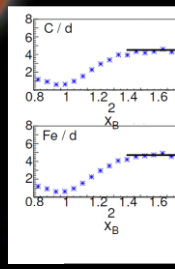


Is the EMC effect associated with large momentum nucleons ?

EMC



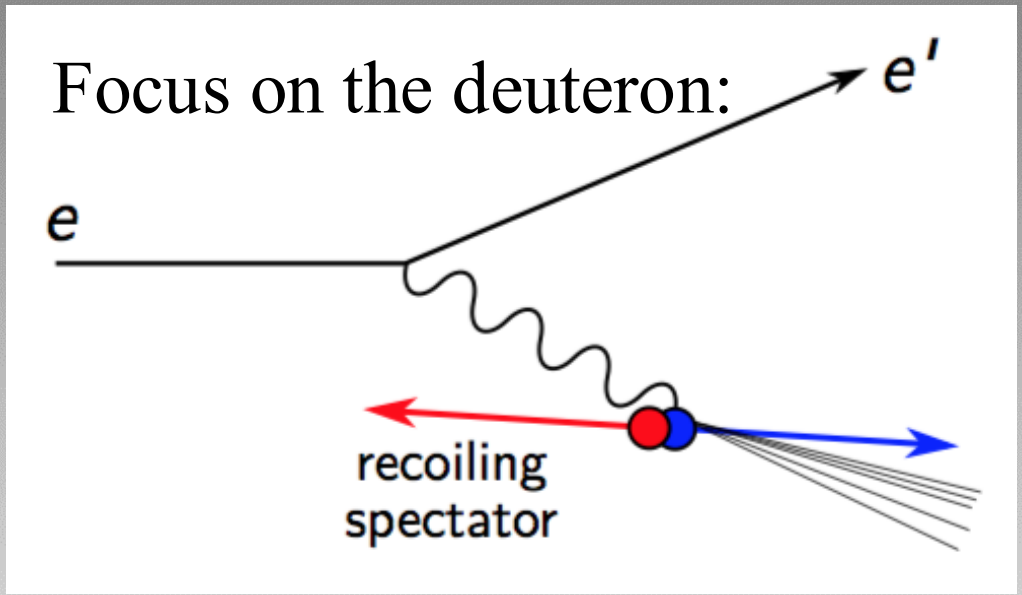
SRC

Illustrated by Anna Shneor 2011

PRL 106, 052301 (2011), PRC 85 047301 (2012), RMP 89, 04500 (2017)

Is the EMC effect associated with large momentum nucleons ?

Hypothesis can be verified by measuring DIS off Deuteron tagged with high momentum recoil nucleon



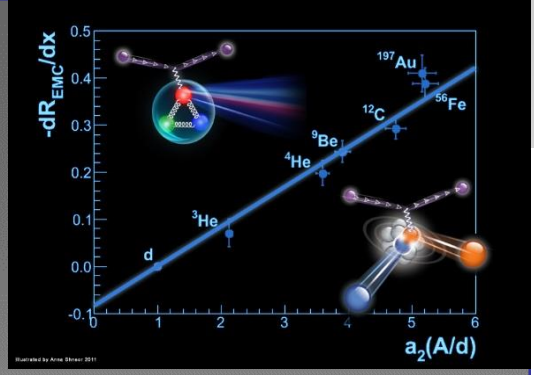
10:00 – 10:30 AM **Results from BAND Experiment (20+10min)**

Speaker
Natalie Wright

11:00 – 11:15 AM **The LAD Experiment (10+5min)**

Speaker

If EMC is associate with 2N SRC:



***Protons are more medium modified than neutron (N>Z nuclei).**

EMC effect is isospin dependent

11:15 – 11:30 AM **Flavor Dependence of the EMC Effect in 3He/ 3H (10+5min)**

Speaker
Michael Nycz

11:30 AM – 12:00 PM
Using polarization observables to study medium modifications (20+10min)

Speaker
Mark Dalton

12:00 – 12:30 PM **XEM2 Studies of EMC Isospin Dependence (20+10min)**

Speaker
Tyler Hague

A long and exciting session ahead!

Adapted from Hen Colq.