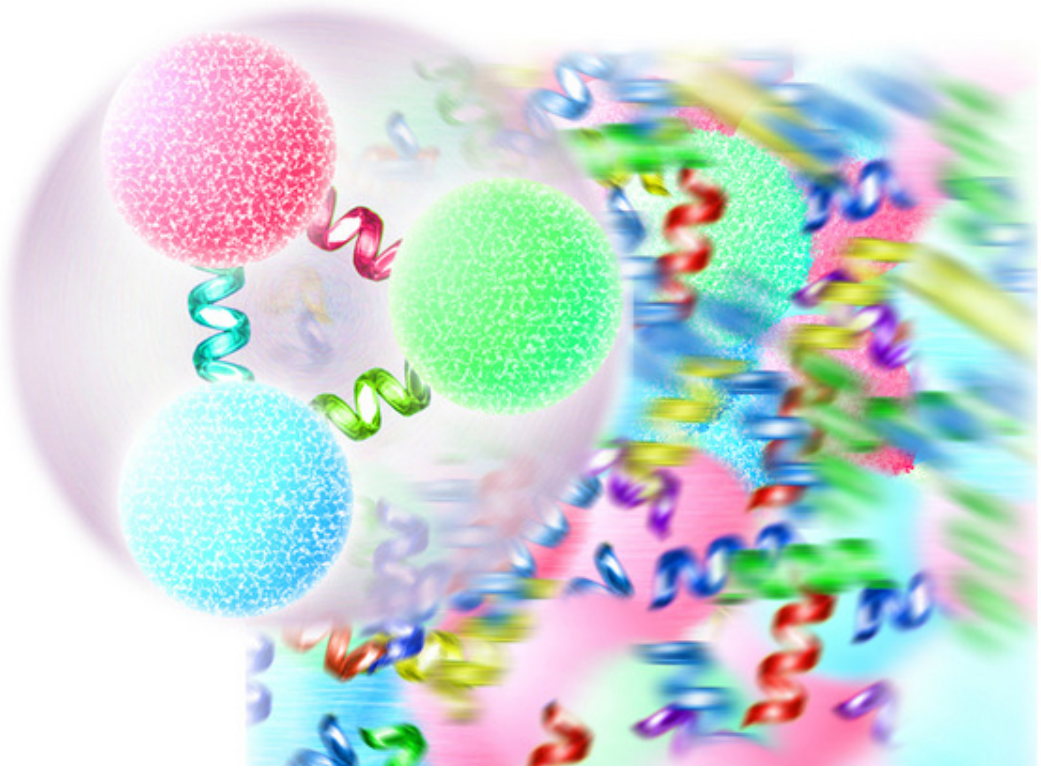
GLUEX workshop

JLab April 2016

Study the CONTENT of a bound nucleon



Eli Piasetzky

Tel Aviv University, ISRAEL

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A proton is a complex object

$$\left|proton\right\rangle = \alpha_{PLC}\left|PLC\right\rangle + \alpha_{3qg}\left|3q+g\right\rangle ... + \alpha_{3q\pi}\left|3q+\pi\right\rangle + \alpha\left|\ \right\rangle$$

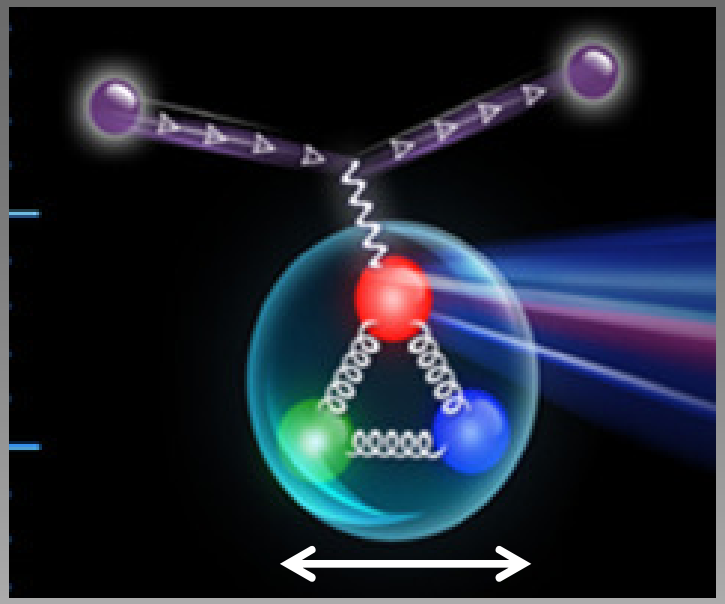
A bound proton in nuclei

$$\left|proton^{*}\right\rangle = \alpha^{*}_{PLC}\left|PLC\right\rangle + \alpha^{*}_{3qg}\left|3q+g\right\rangle ... + \alpha^{*}_{3q\pi}\left|3q+\pi\right\rangle + \alpha^{*}\left|\ \right\rangle$$

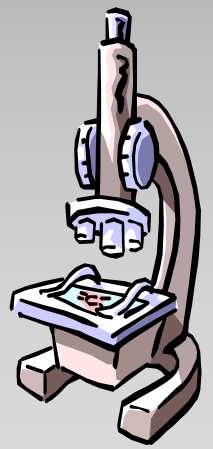
of a free and bound proton

Deep Inelastic scattering

With the resolving power required to probe the internal (partonic) structure of a proton



$\lambda < R$



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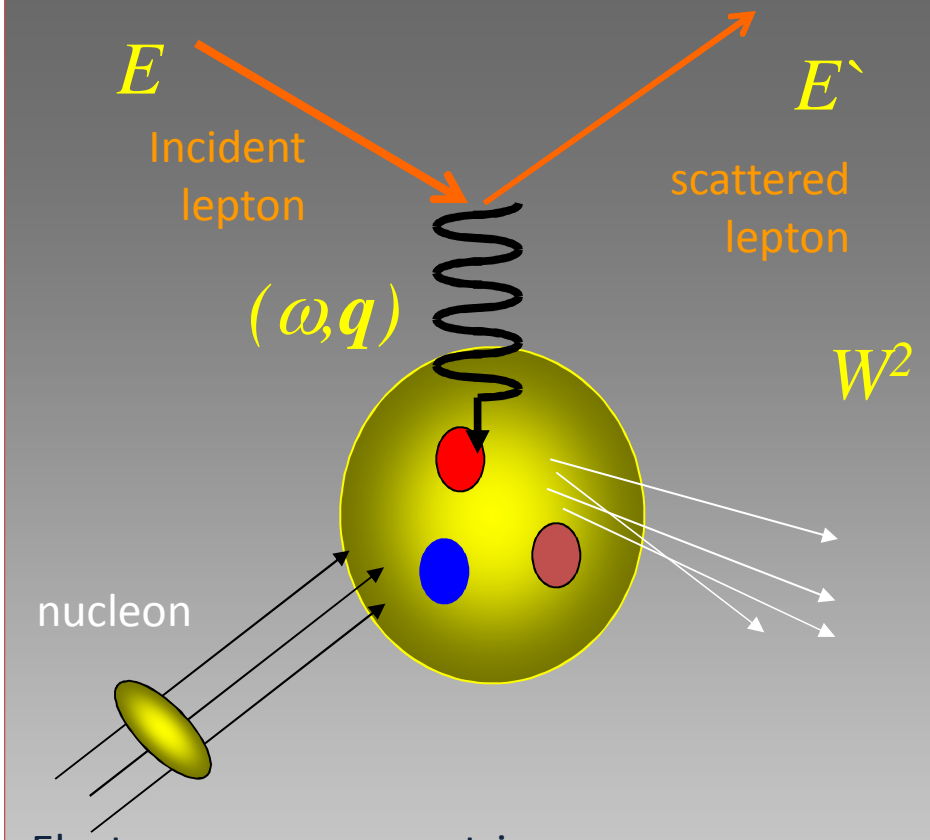
Deep Inelastic Scattering (DIS)



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

$$\omega = E' - E$$

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

$$0 \le x_B \le 1$$

SLAC, CERN, HERA, FNAL, JLAB

E, E' 5-500 GeV

Q^2 5-50 GeV^2

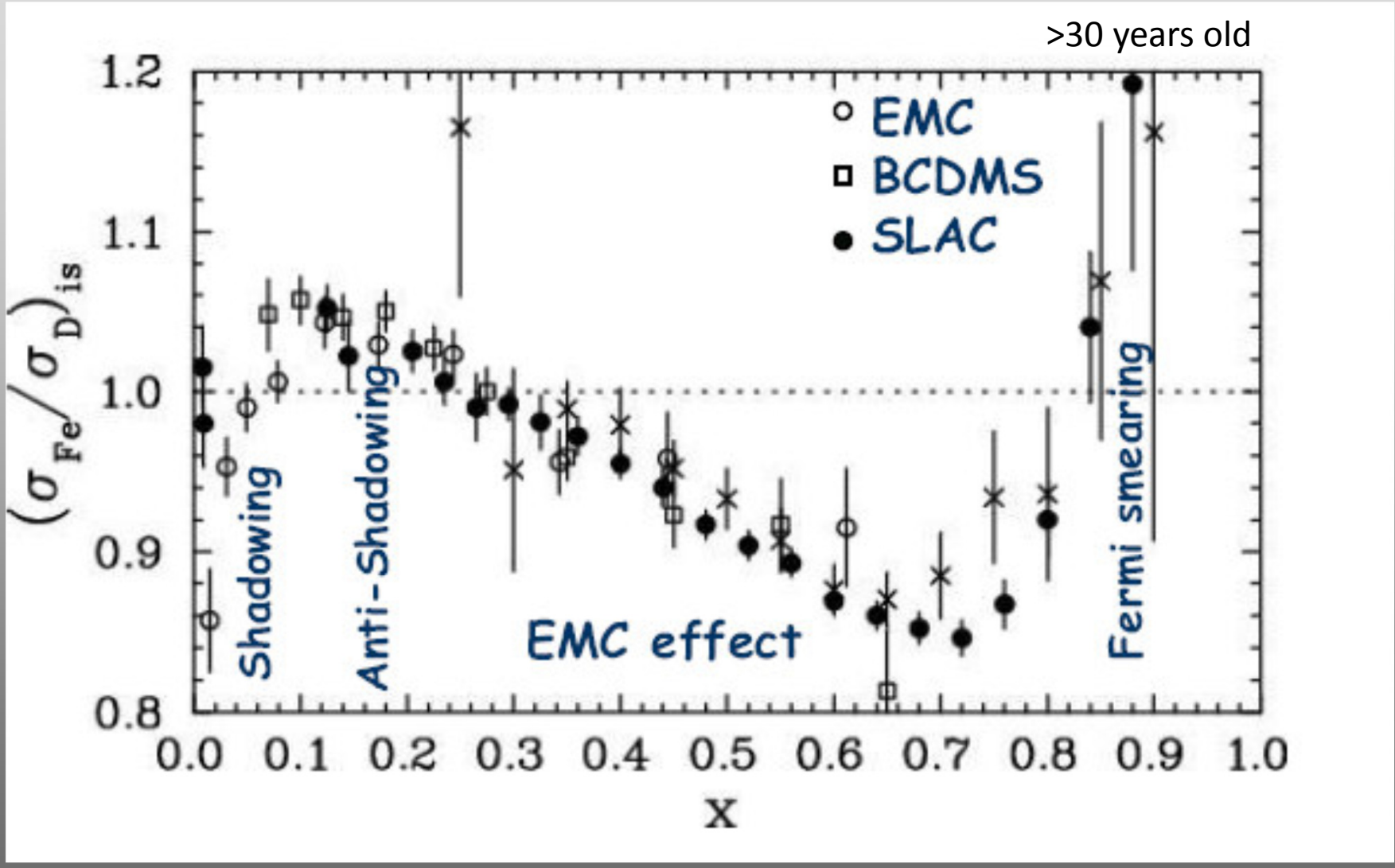
w^2 >4 GeV^2

$0 \le X_B \le 1$

X_B gives the fraction of nucleon momentur carried by the struck parto

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

The European Muon Collaboration (EMC) effect



σ^{DIS} per nucleon in nuclei ≠ σ^{DIS} per nucleon in deuteron

SLAC E139

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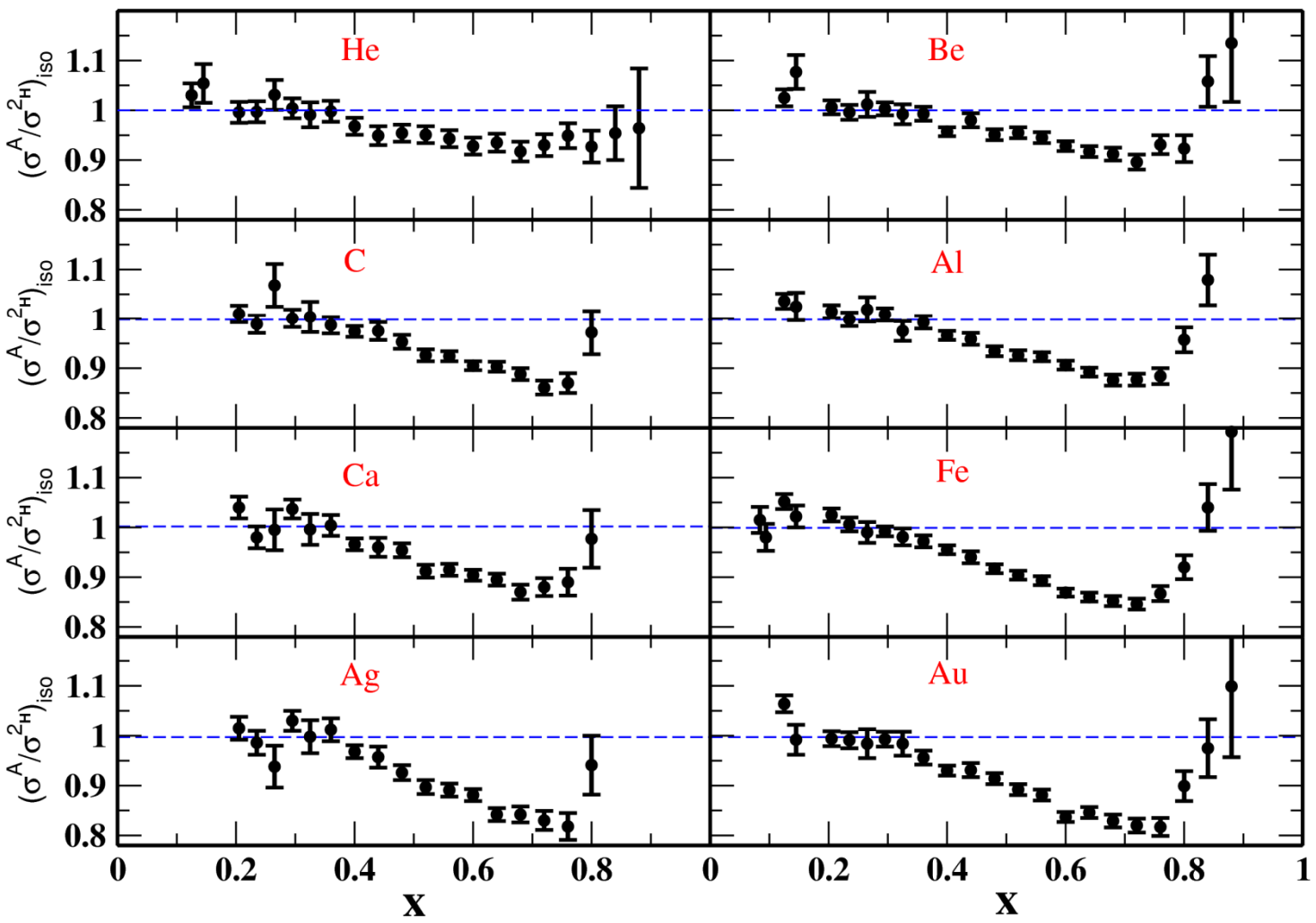

Data from CERN SLAC JLab
1983- 2009

EMC collaboration, Aubert et al. PL B 123,275 (1983)

SLAC Gomez et al., Phys Rev. D49,4348 (1994)

A review of data collected during first decade, Arneodo, Phys. Rep. 240,301(1994)

The European Muon Collaboration (EMC) effect

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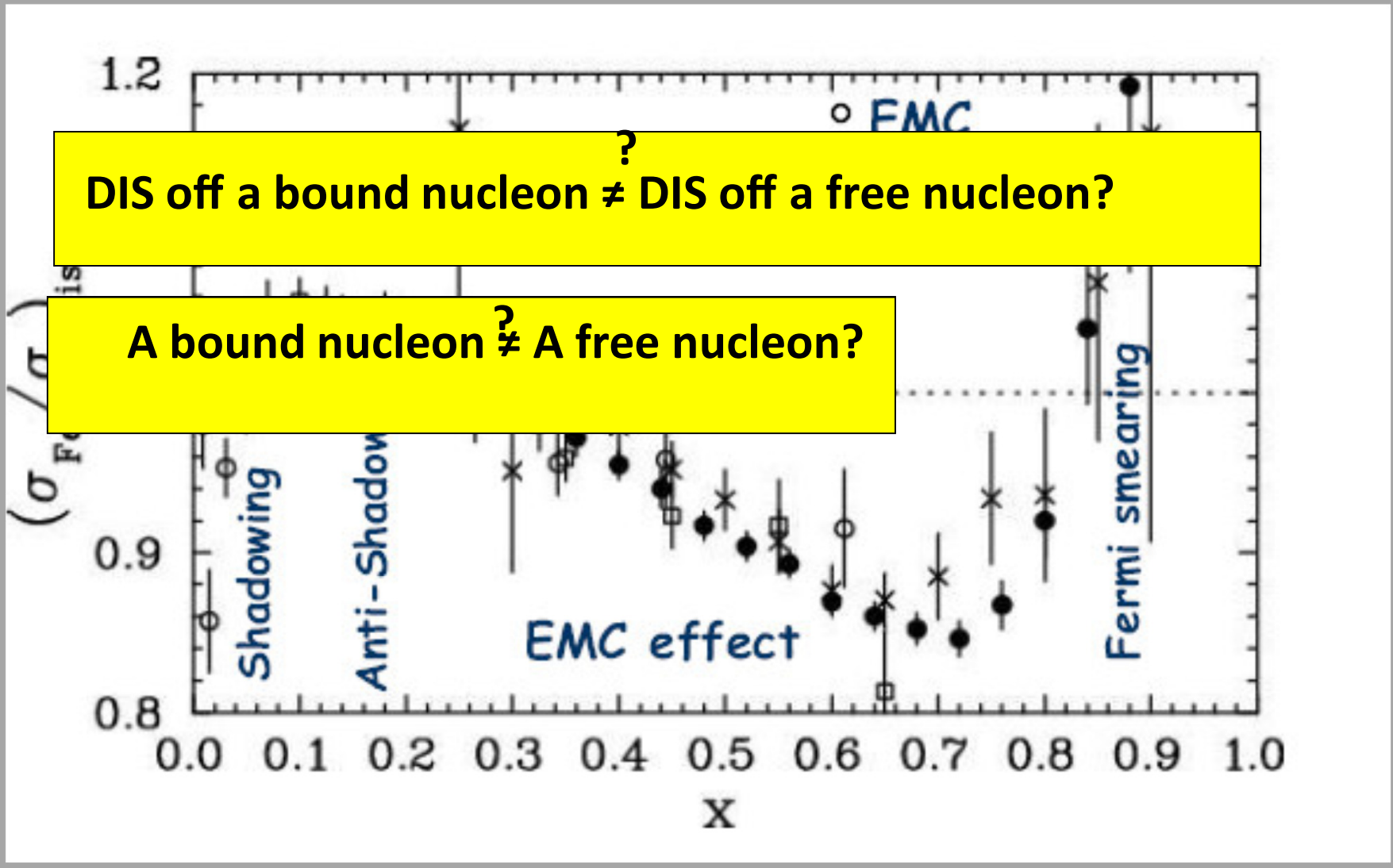

DIS off a bound nucleon ≠ DIS off a free nucleon?

A bound nucleon ≠ A free nucleon?

σ^{DIS} per nucleon in nuclei ≠ σ^{DIS} per nucleon in deuteron

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free

$$|proton\rangle = \alpha_{PLC}|PLC\rangle + \alpha_{3qg}|3q+g\rangle \ldots + \alpha_{3q\pi}|3q+\pi\rangle + \alpha|\ \ \rangle$$

A bound nucleon $\stackrel{?}{\neq}$ A free nucleon?

$$|proton^{*}\rangle = \alpha^{*}_{PLC}|PLC\rangle + \alpha^{*}_{3qg}|3q+g\rangle \ldots + \alpha^{*}_{3q\pi}|3q+\pi\rangle + \alpha^{*}|\ \ \rangle$$

bound

The European Muon Collaboration (EMC) effect

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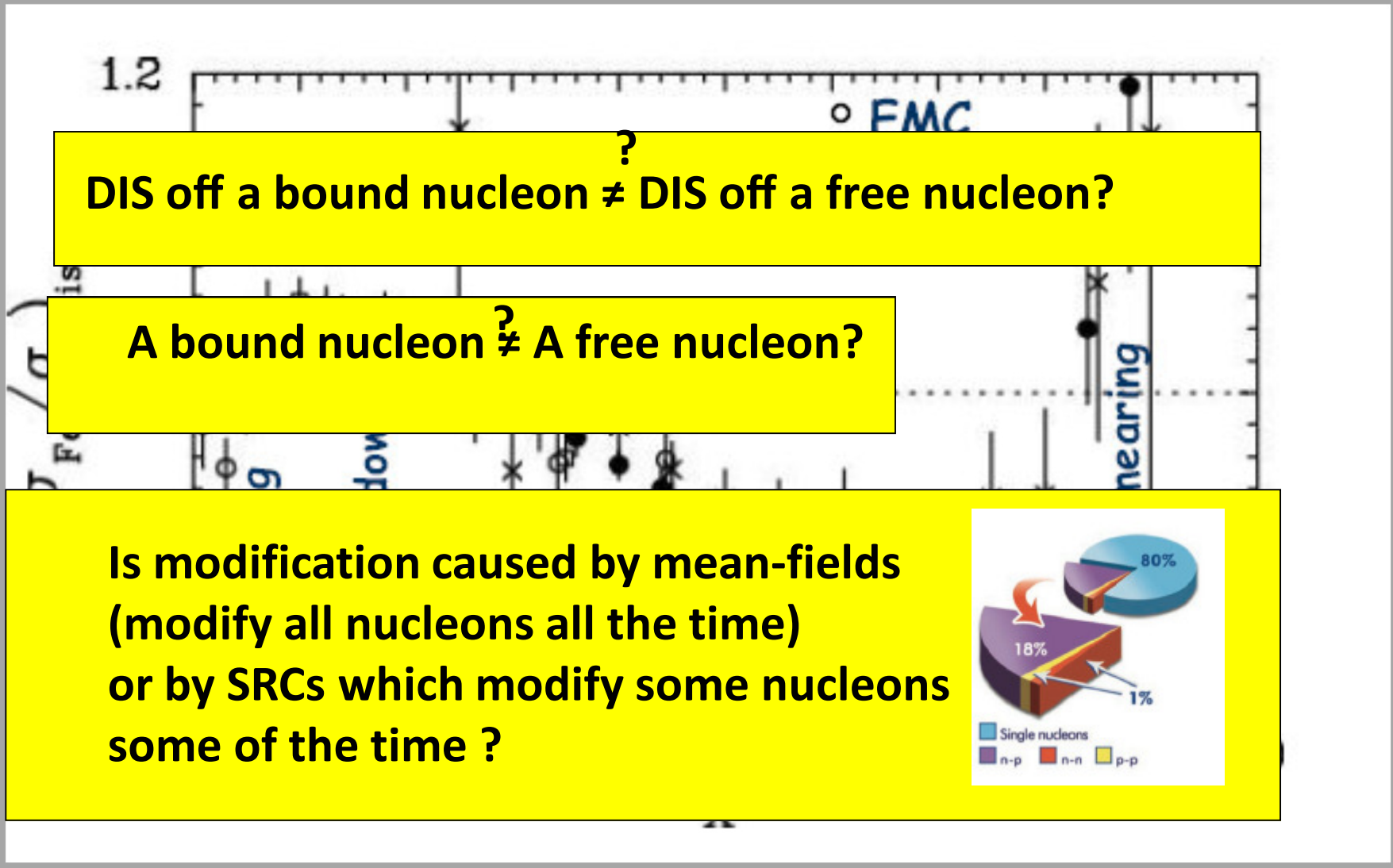
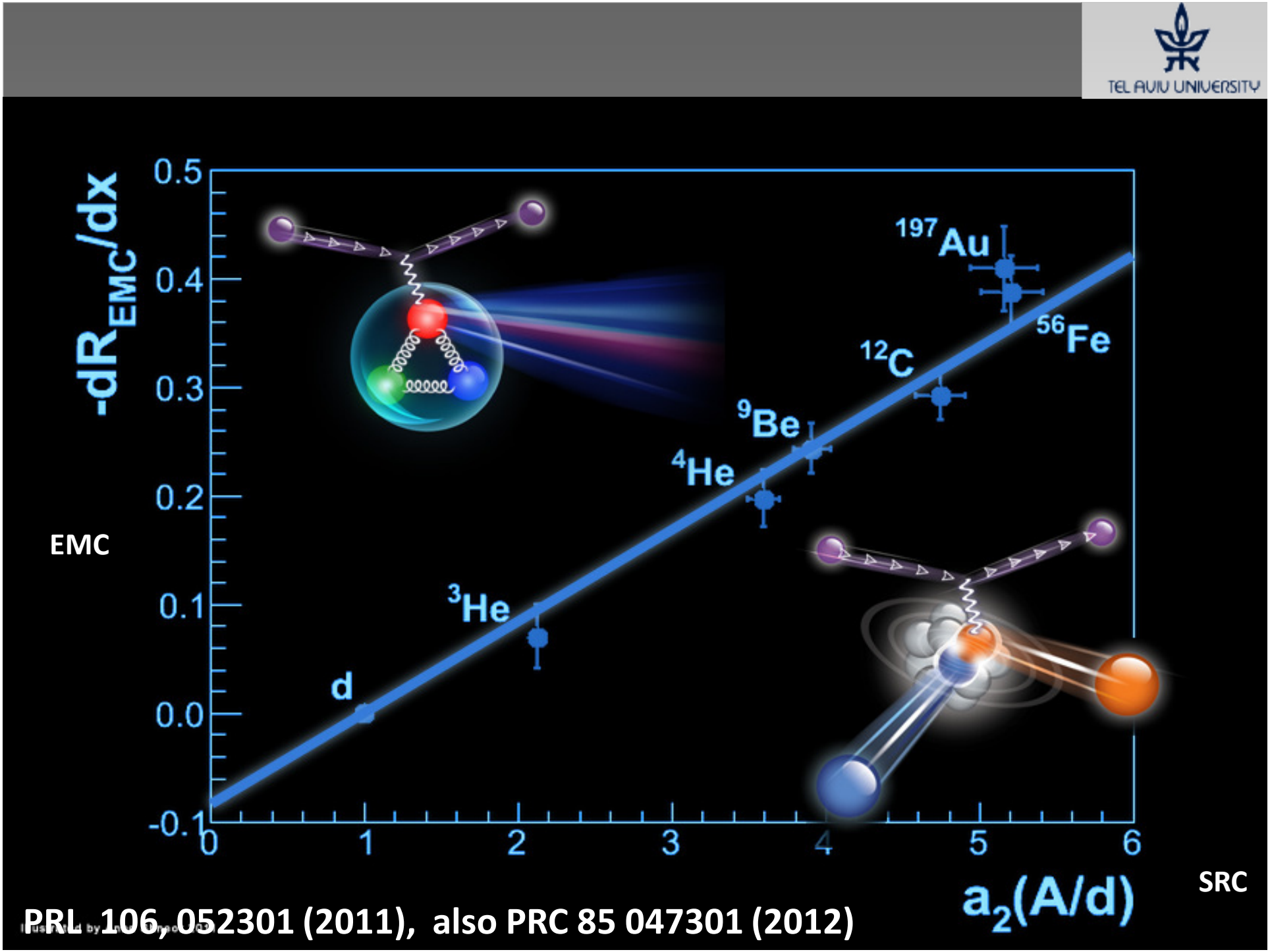


σ^{DIS} per nucleon in nuclei ≠ σ^{DIS} per nucleon in deuteron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-dR_EMC/dx
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0
1
2
3
4
5
6
a_2(A/d)
197Au
56Fe
12C
9Be
4He
3He
d
EMC
SRC
PRL 106, 052301 (2011), also PRC 85 047301 (2012)

Is the EMC effect associated with large virtuality ?

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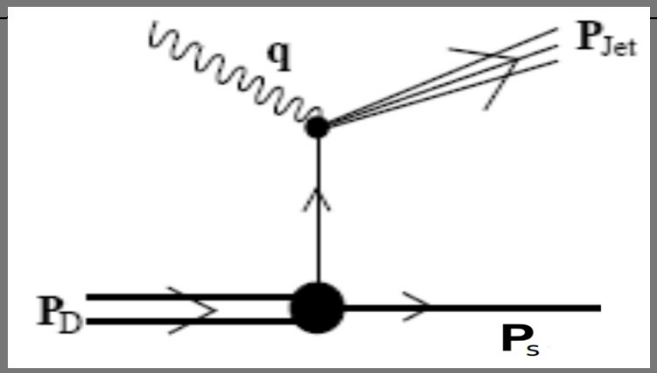
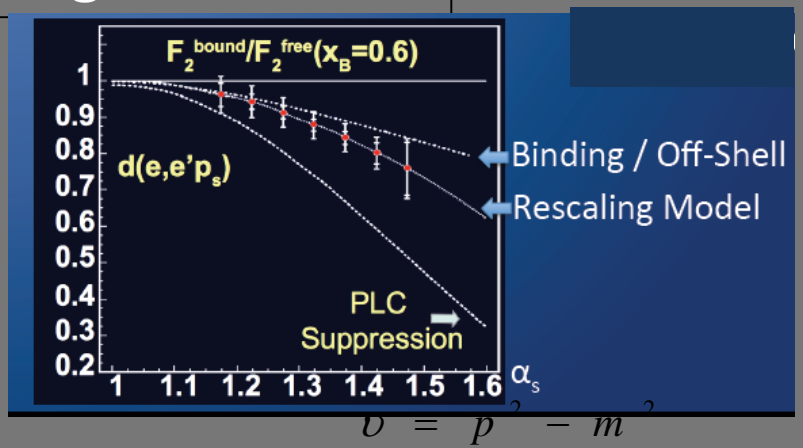
Hypothesis can be verified by measuring DIS off Deuteron tagged with high momentum recoil nucleon



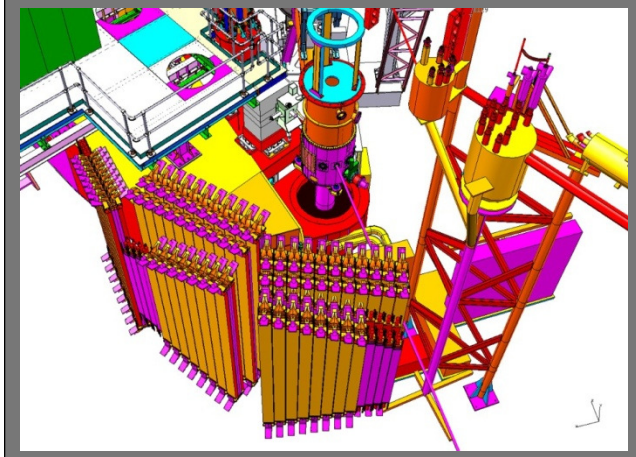


$$v = p^2 - m^2$$

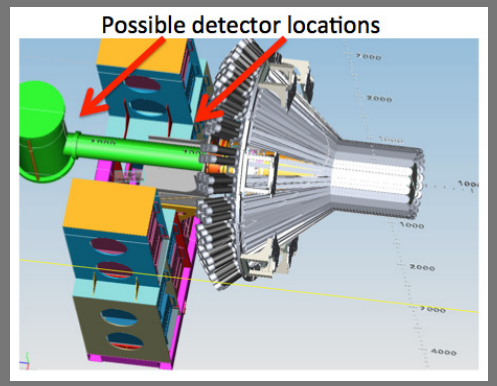
12 GeV JLab/ Hall C approved experiment E 12-11-107

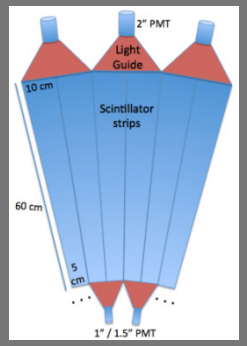
12 GeV JLab/ Hall B approved experiment

Tagged recoil proton measure neutron structure function



Tagged recoil neutron measure in the proton structure function

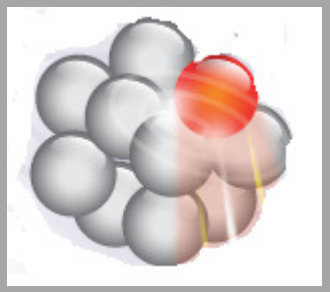




A free proton

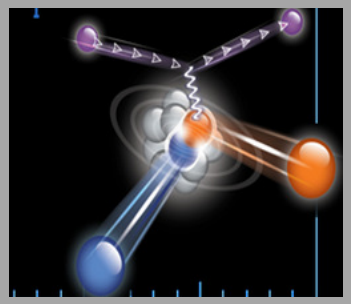
$$\left|proton\right\rangle = \alpha_{PLC}\left|PLC\right\rangle + \alpha_{3qg}\left|3q+g\right\rangle ... + \alpha_{3q\pi}\left|3q+\pi\right\rangle + \alpha\left|\ \right\rangle$$

A bound proton



$$\left|proton^{*}\right\rangle = \alpha^{*}_{PLC}\left|PLC\right\rangle + \alpha^{*}_{3qg}\left|3q+g\right\rangle ... + \alpha^{*}_{3q\pi}\left|3q+\pi\right\rangle + \alpha^{*}\left|\ \right\rangle$$

A nucleon in a SRC pair



$$\left|proton^{SRC}\right\rangle = \alpha^{SRC}_{PLC}\left|PLC\right\rangle + \alpha^{SRC}_{3qg}\left|3q+g\right\rangle ... + \alpha^{SRC}_{3q\pi}\left|3q+\pi\right\rangle + \alpha^{SRC}\left|\ \right\rangle$$

SNAPSHOT With GLUEX

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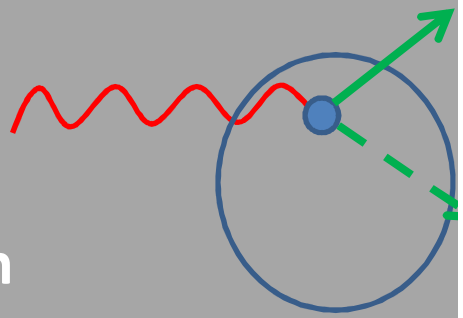
$$\left\langle \begin{array}{l|l} \gamma p_{free} & p\pi^- \\ \gamma p_{bound} & \pi^-\Delta^{++} \\ \gamma p_{SRC} & \rho^0 p \\ & K^+\Lambda \\ & K^+\Sigma^0 \end{array} \right\rangle^2$$



Compare the BRs for free, QE, and tagged proton

SNAPSHOT With GLUEX

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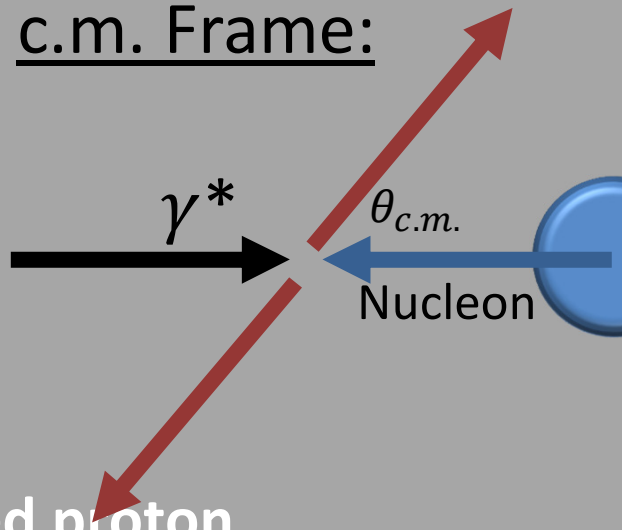
With hard scattering conditions (large S u t):

$$\left\langle \begin{array}{l|l} \gamma p^{PLC}{}_{free} & p\pi^- \\ & \pi^-\Delta^{++} \\ \gamma p^{PLC}{}_{bound} & \rho^0 p \\ \gamma p^{PLC}{}_{SRC} & K^+\Lambda \\ & K^+\Sigma^0 \end{array} \right\rangle^2$$

c.m. Frame:



Compare the BRs for free, QE, and tagged proton

SNAPSHOT With GLUEX

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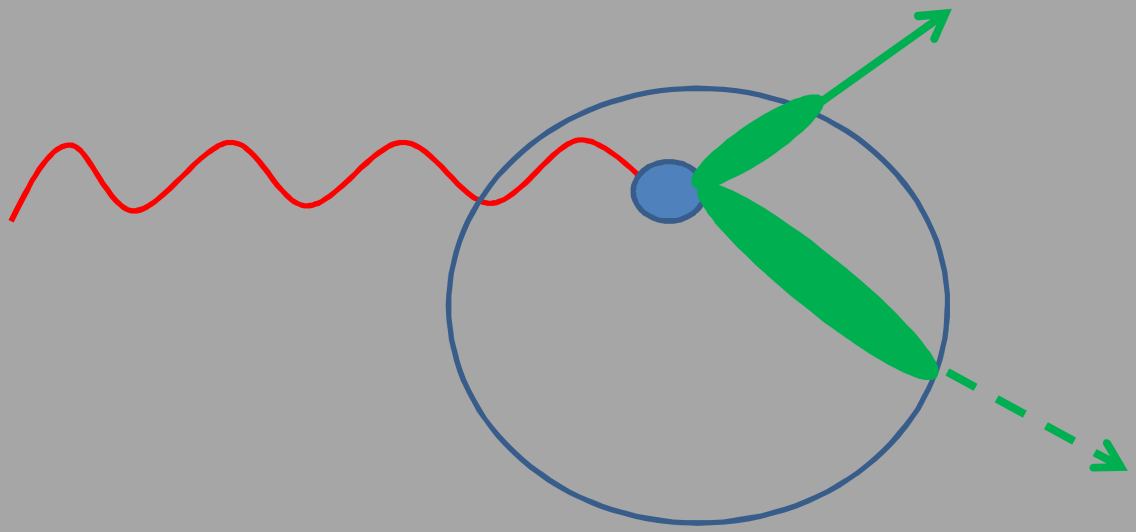
With hard scattering conditions (large S u t):



Different transition in the nucleus for each reaction measurement for different nuclei (C, Ca, Fe, Ag, Pb) → and extrapolation to A=1

'Physics' of one is the 'BG' for the other:

Hafidi, Kawtar	Color transparency experiments overview
Strikman, Mark	Color transparency in nuclear

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Beam time: 60 PAC days (can be with SRC and CT)

Luminosity: 5x10^7 γ/sec at the 8-9 GeV peak

Targets: 5-6 targets like C, Al, Ca, Fe , Ag, Pb (total 2gr/cm^2)

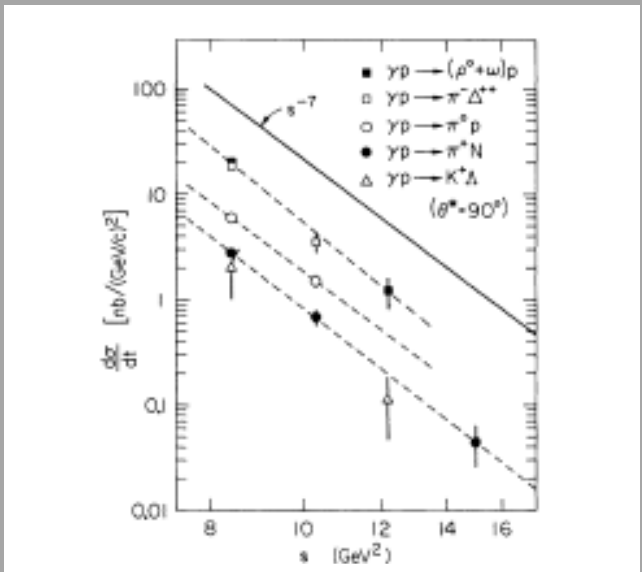
^{4}**He** + A= **4**, 12, 27, 40, 56, 100, 208

Transparency: 0.5 per particle

Detection efficiency: 0.75 per particle

[t], [u] >3 GeV

~8,000 events /reaction/target



PHYSICAL REVIEW D VOLUME 14, NUMBER 3 1 AUGUST 1976

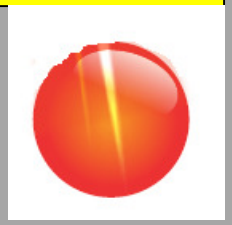
Measurements of exclusive photoproduction processes at large values of t and u from 4 to 7.5 GeV*

R. L. Anderson, D. B. Gustavson, D. M. Ritson, and G. A. Weitsch†
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

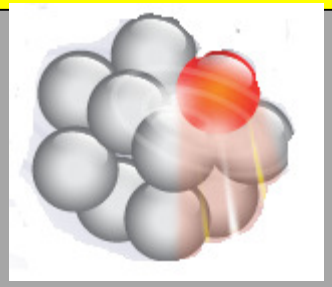
H. J. Halpern,‡ R. Prepost, D. H. Tompkins,§ and D. E. Wiser
University of Wisconsin, Madison, Wisconsin 53706

(Received 2 February 1976)

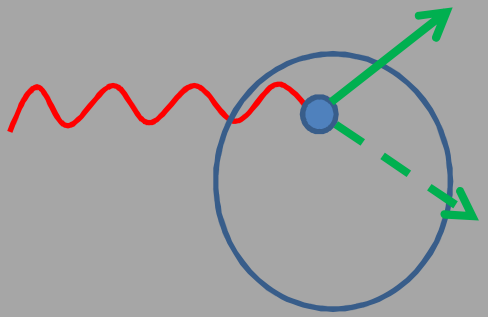
A free proton



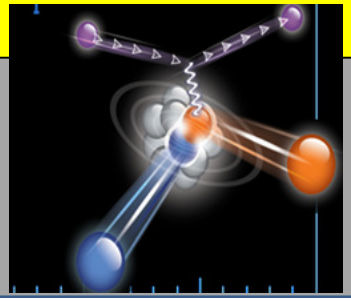
A bound proton



$$\gamma p \to \pi^0 p$$
$$\gamma p \to \pi^- \Delta^{++}$$
$$\gamma p \to \rho^0 p$$
$$\gamma p \to K^+ \Lambda$$
$$\gamma p \to K^+ \Sigma^0$$



A nucleon in a SRC pair



Compare the BR at the hard vertex as indication for a possible difference between a free and a bound nucleon