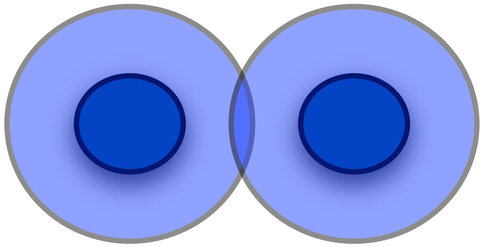
Superfast Quarks:
Theory Overview

Misak Sargsian

Florida International University

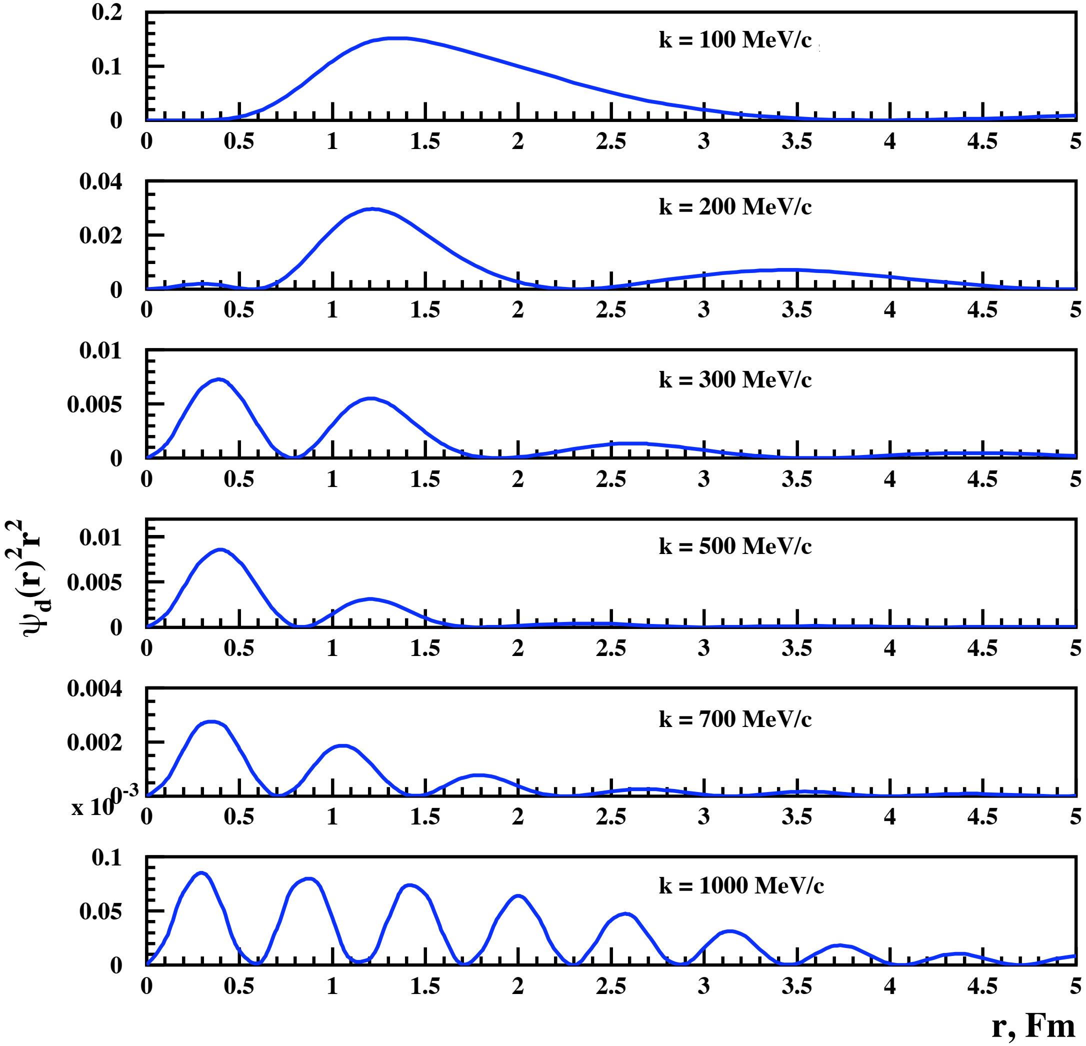
Argonne 7-9-April, 2006

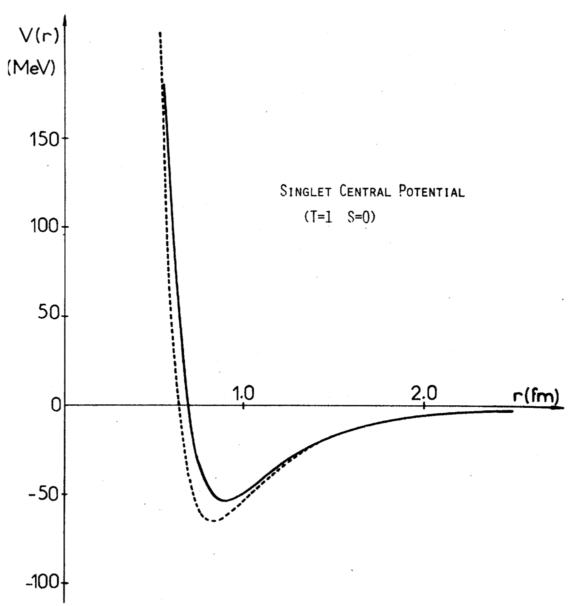
How to get nucleons close together



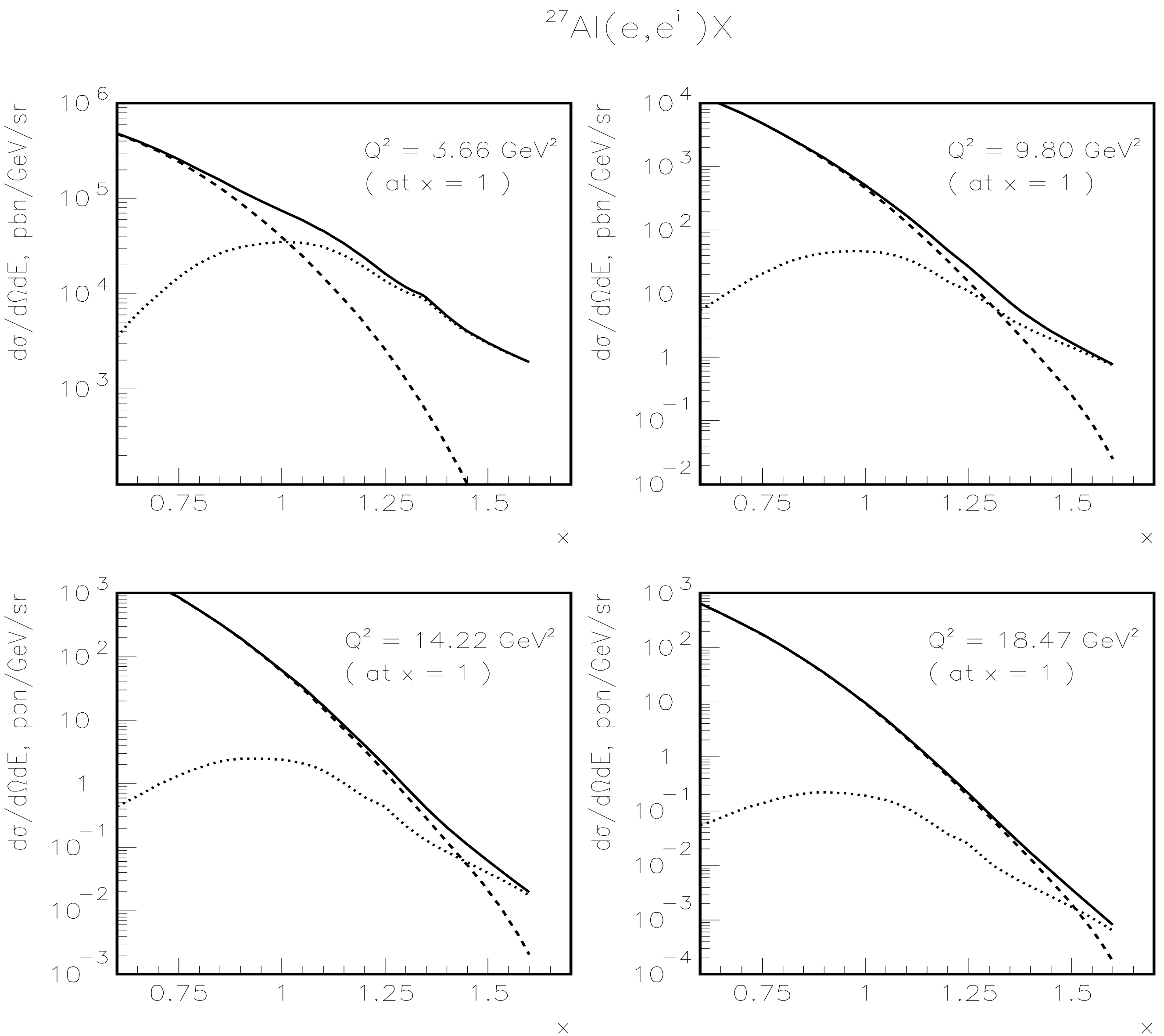
Probing at large relative momenta

$$r \sim \frac{1}{k}$$



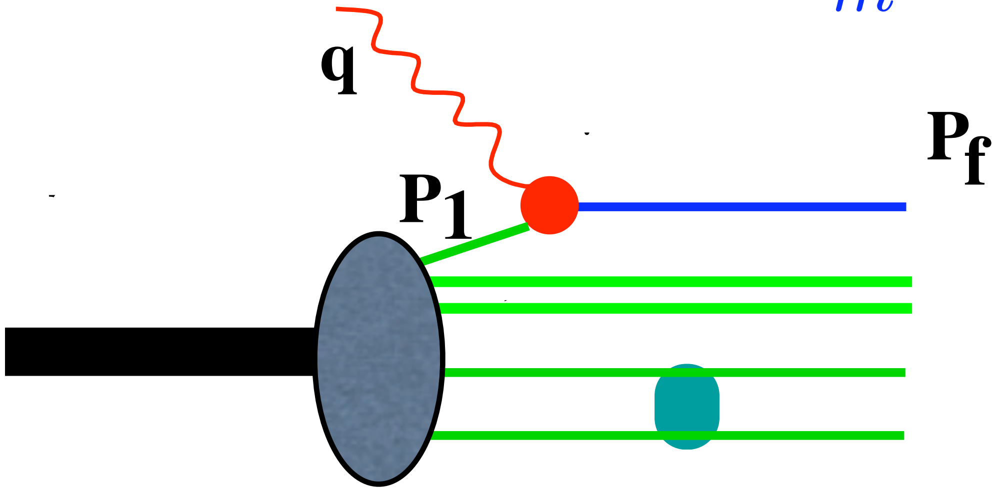


Inclusive (e,e') Scattering at large Q2 and x > 1

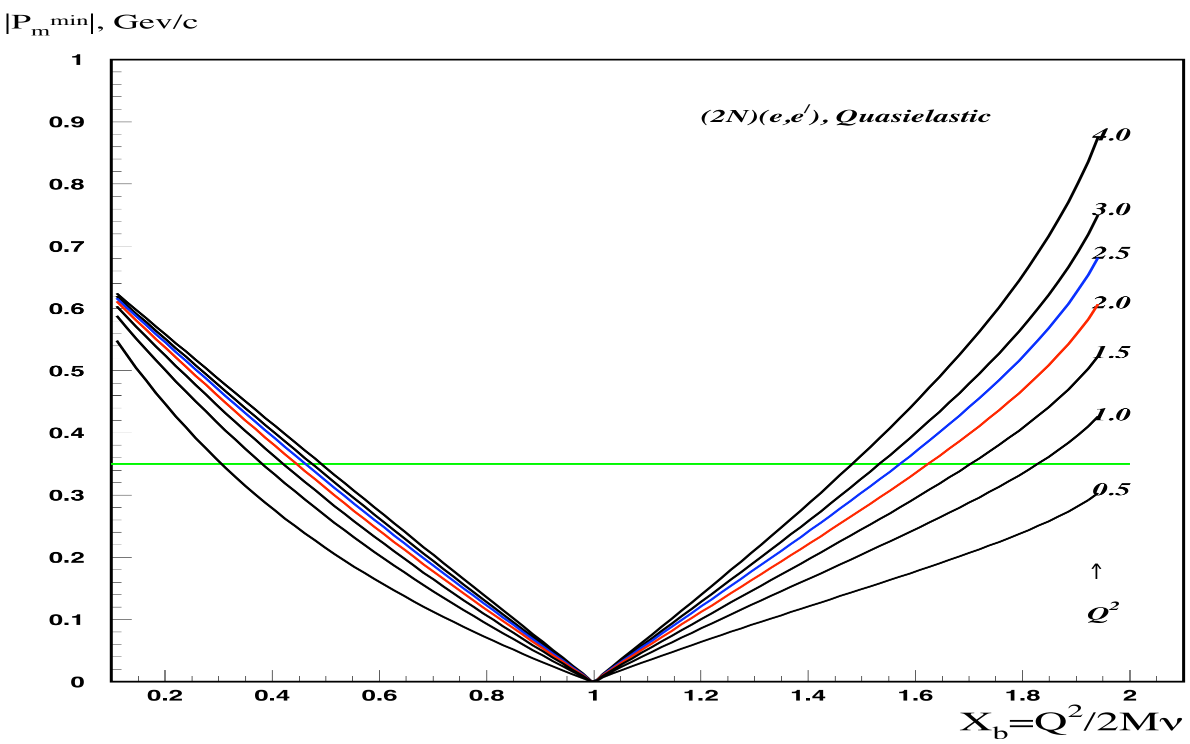


Quasi-Elastic Reaction

$$\vec{p}_1 = \vec{p}_f - \vec{q}$$
$$E_m = q_0 - T_f - T_{A-1}$$



$$\alpha \geq x$$
$$\alpha \approx 1 + \frac{p_1^z}{m}$$
$$p_1^z \approx m(1-x)$$



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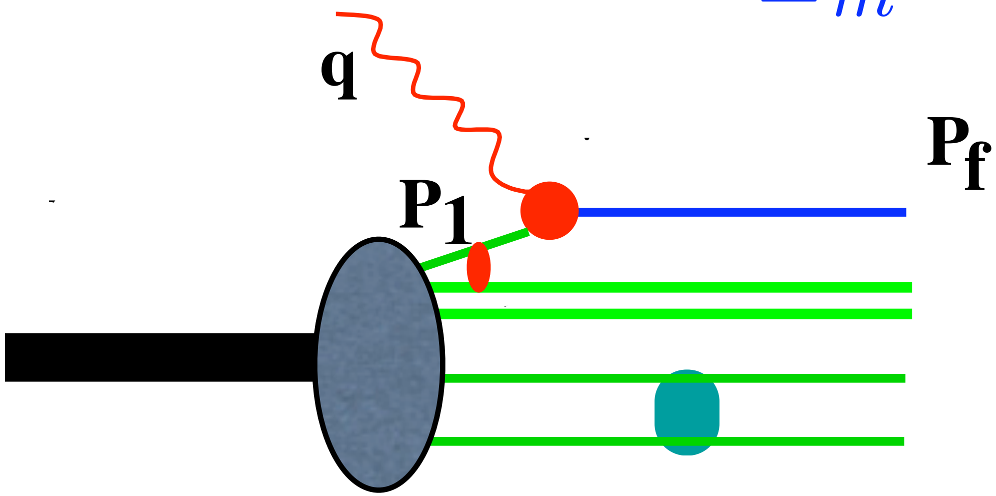

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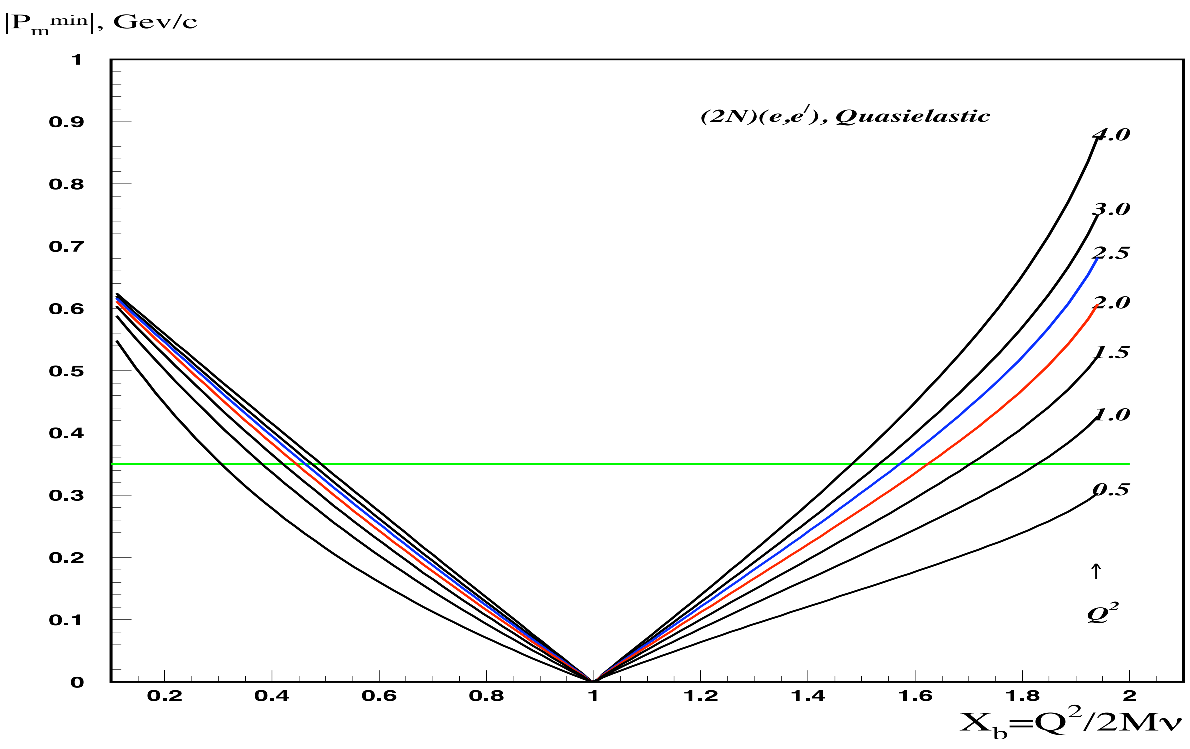

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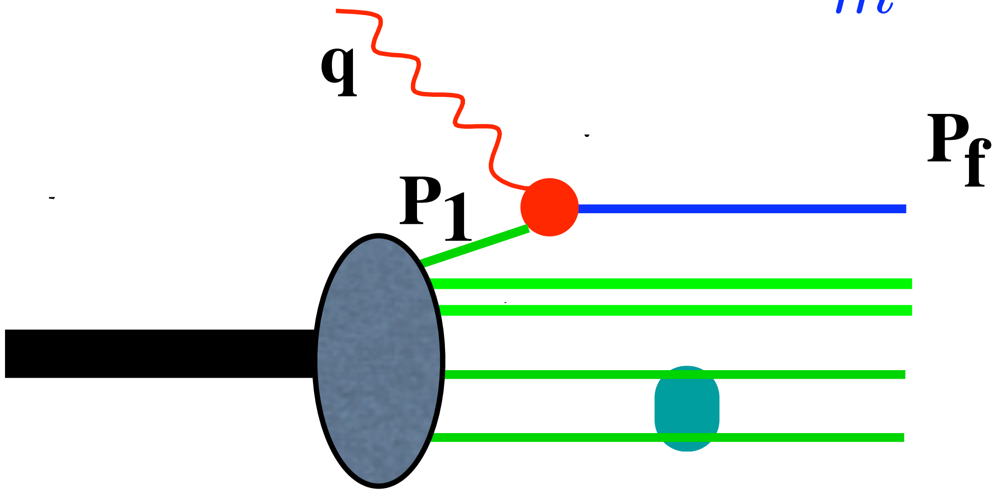

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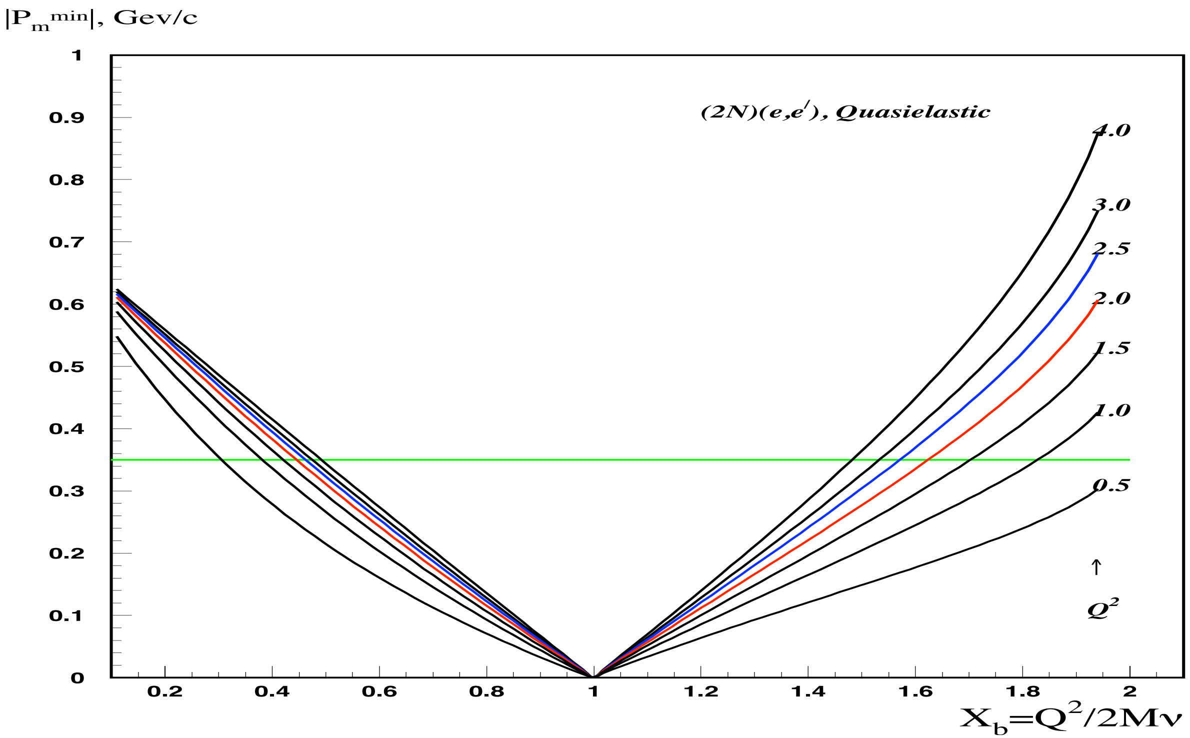

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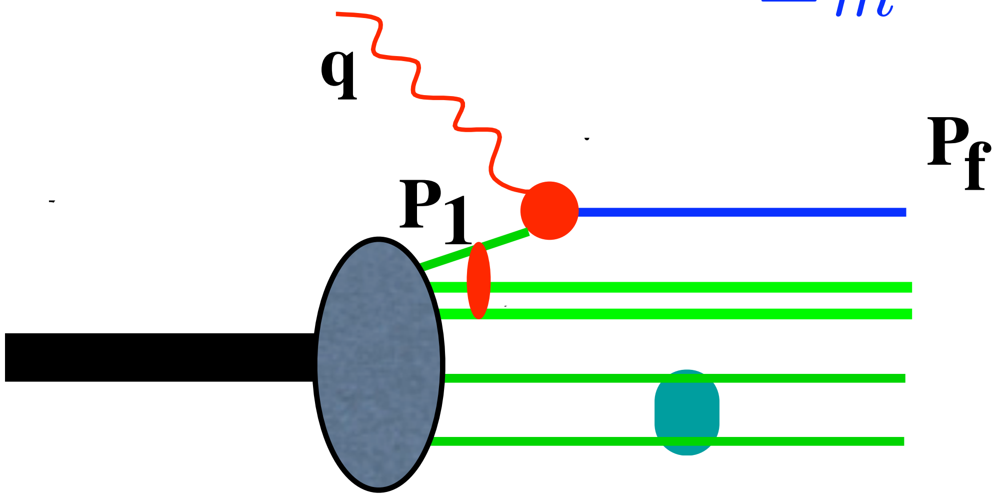

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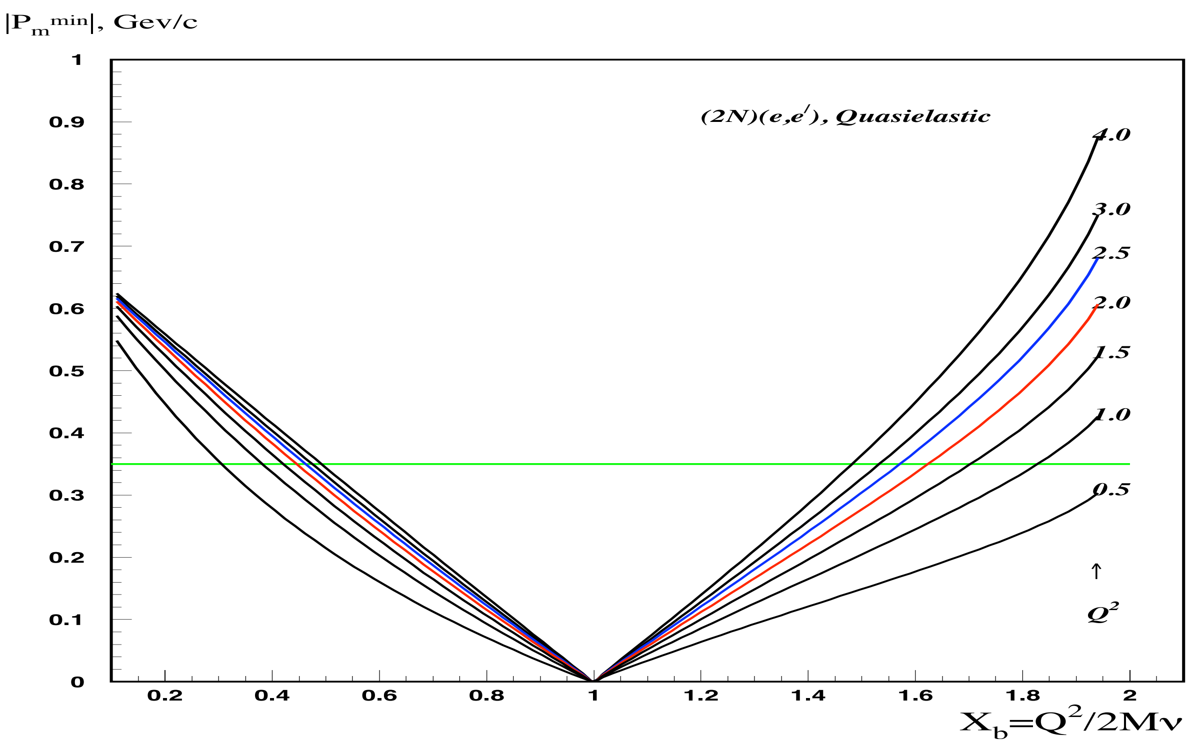
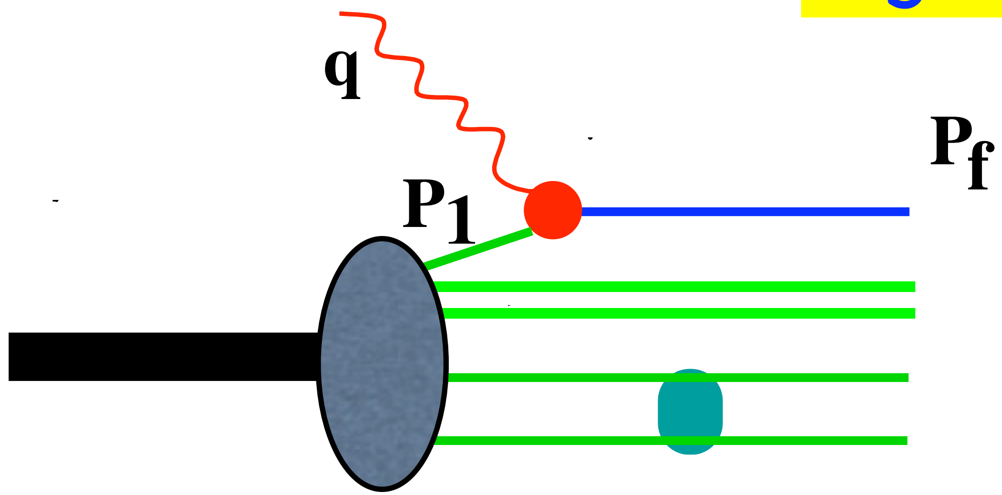


Signatures

Frankfurt, Strikman, Phys.Rep 1988



$$R = \frac{A_2 \sigma[A_1(e,e')X]}{A_1 \sigma[A_2(e,e')X]}$$

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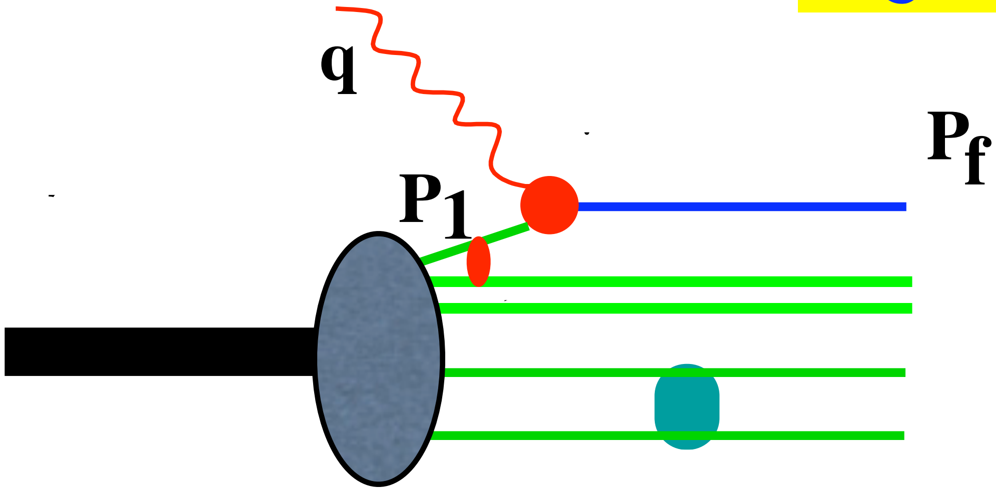
Frankfurt, Strikman, Phys.Rep 1988



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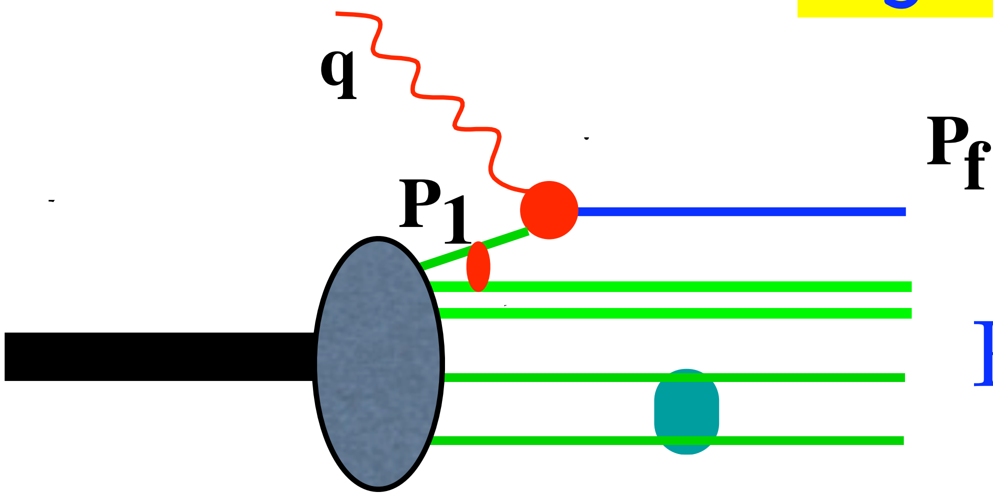

$$\boxed{R = \frac{A_2 \sigma[A_1(e,e')X]}{A_1 \sigma[A_2(e,e')X]}}$$

For $1 < x < 2$ $R \approx \dfrac{a_2(A_1)}{a_2(A_2)}$

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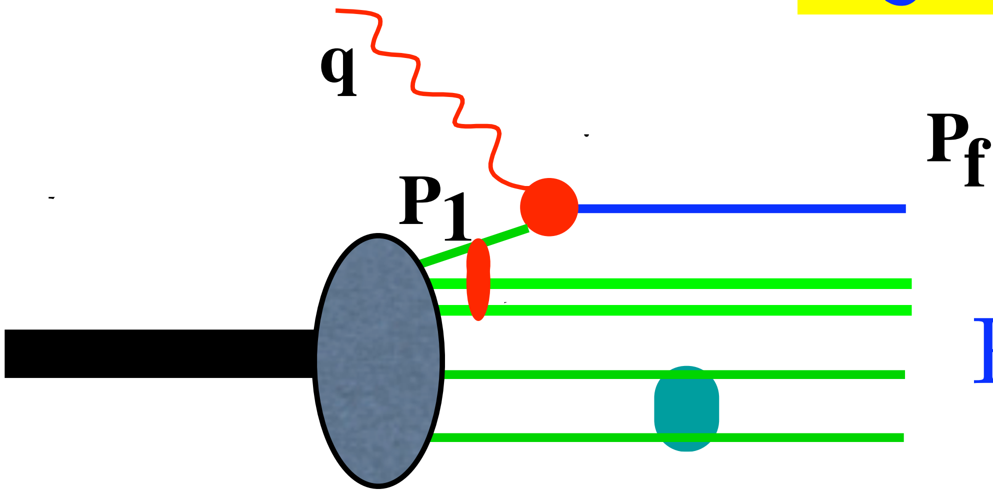

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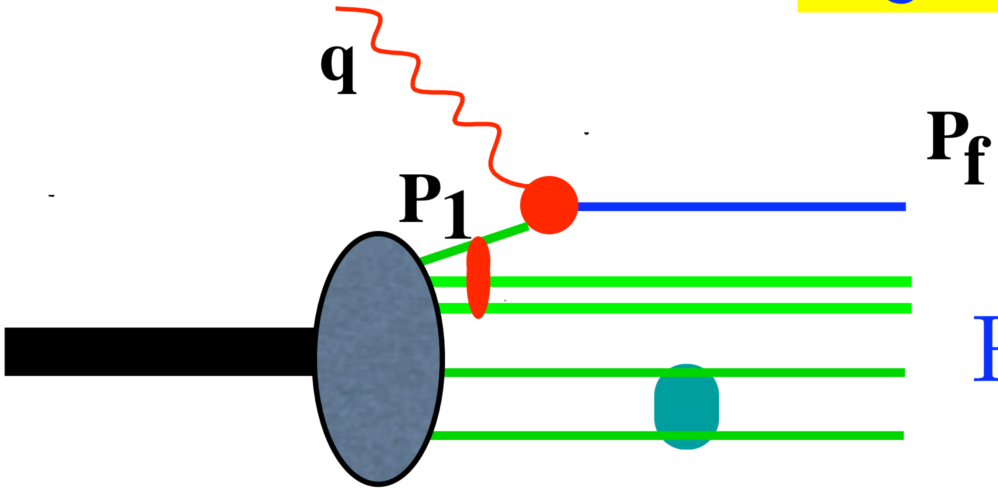

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For $2 < x < 3$ $R \approx \frac{a_3(A_1)}{a_3(A_2)}$

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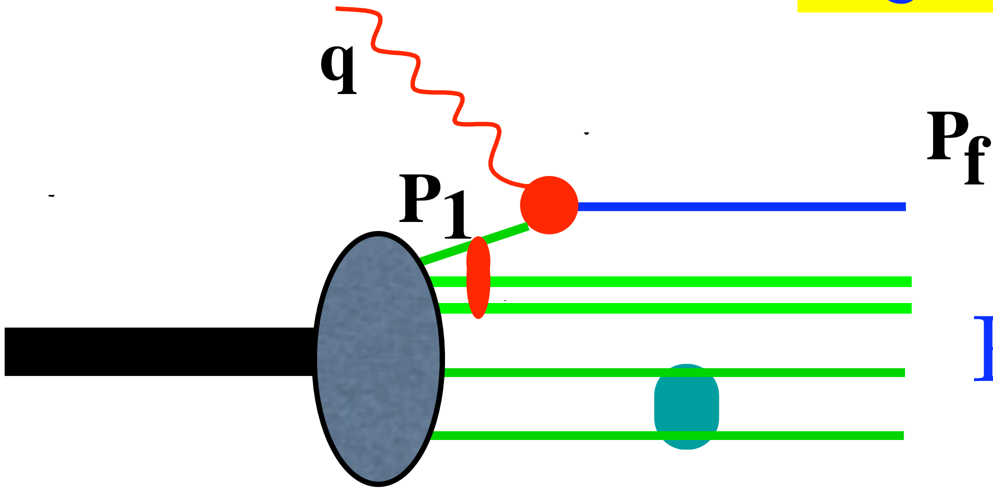

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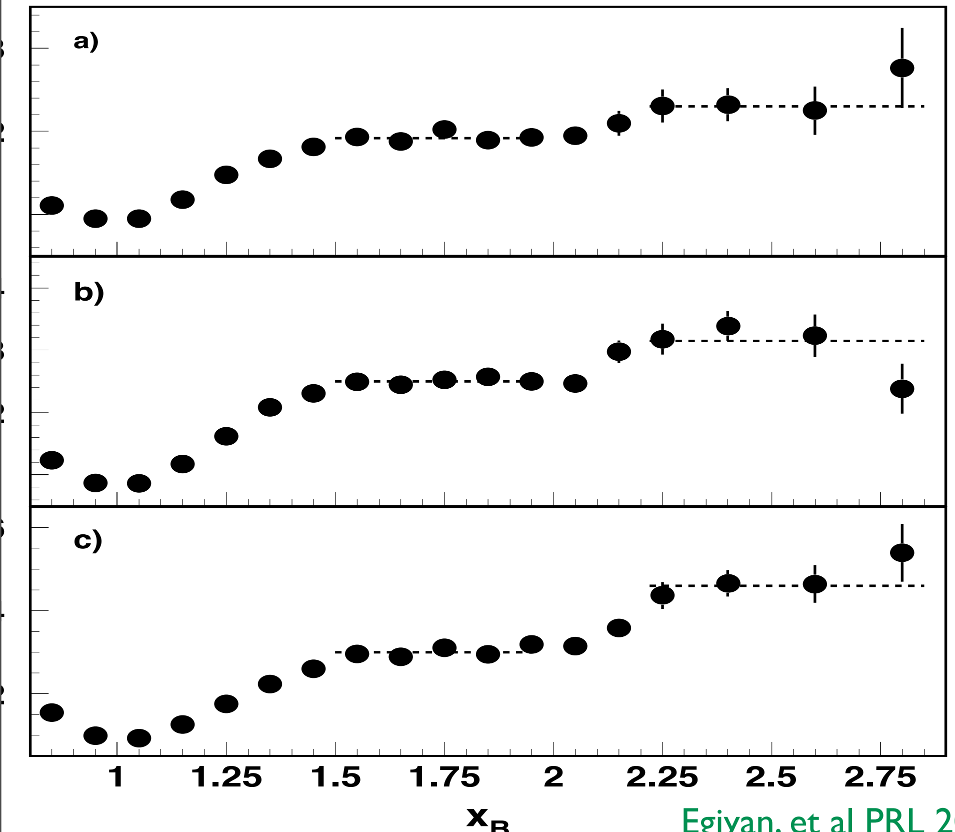

Egiyan, et al PRL 2006

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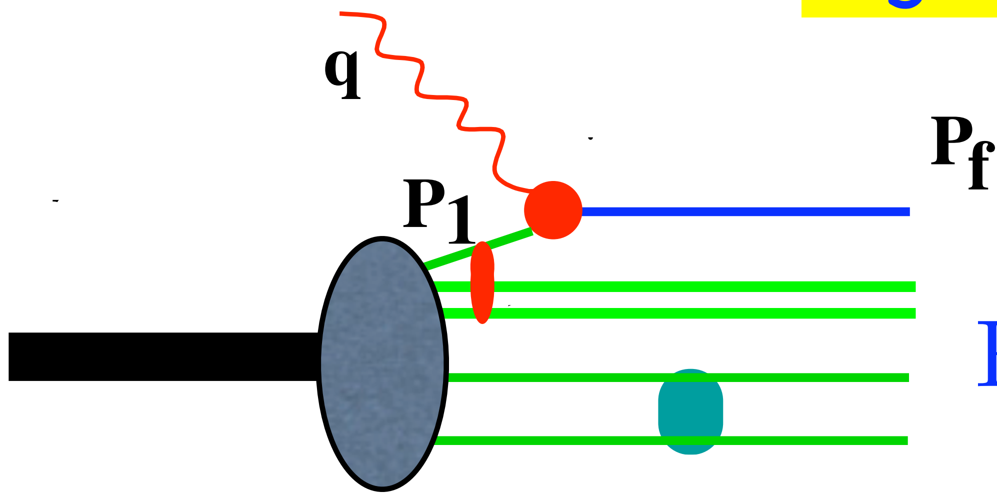

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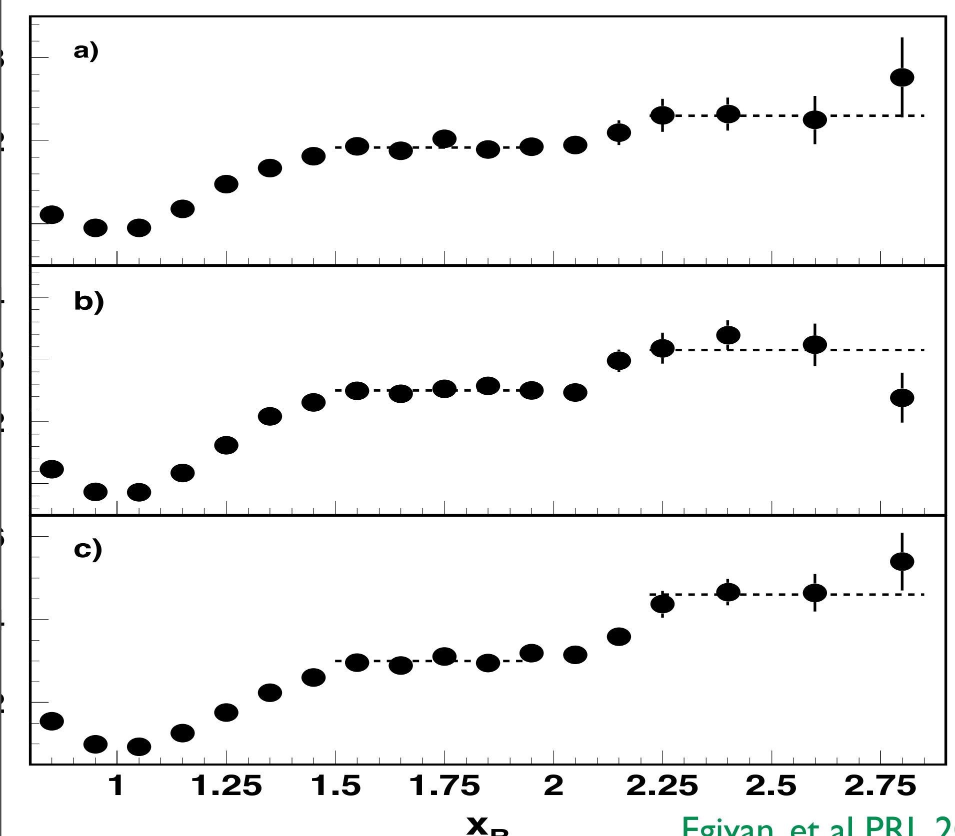
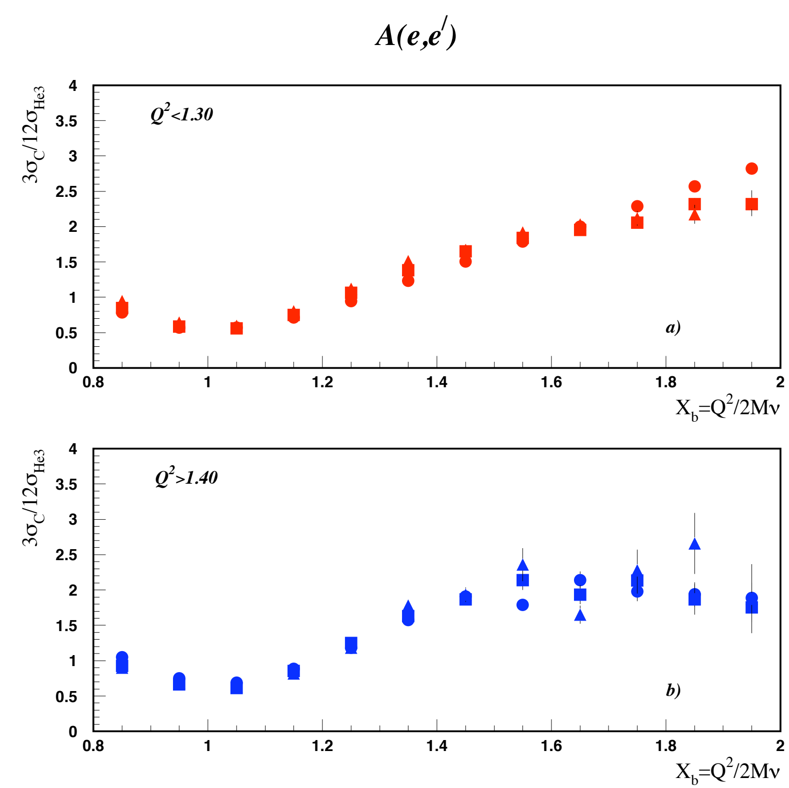


Egiyan, et al PRL 2006

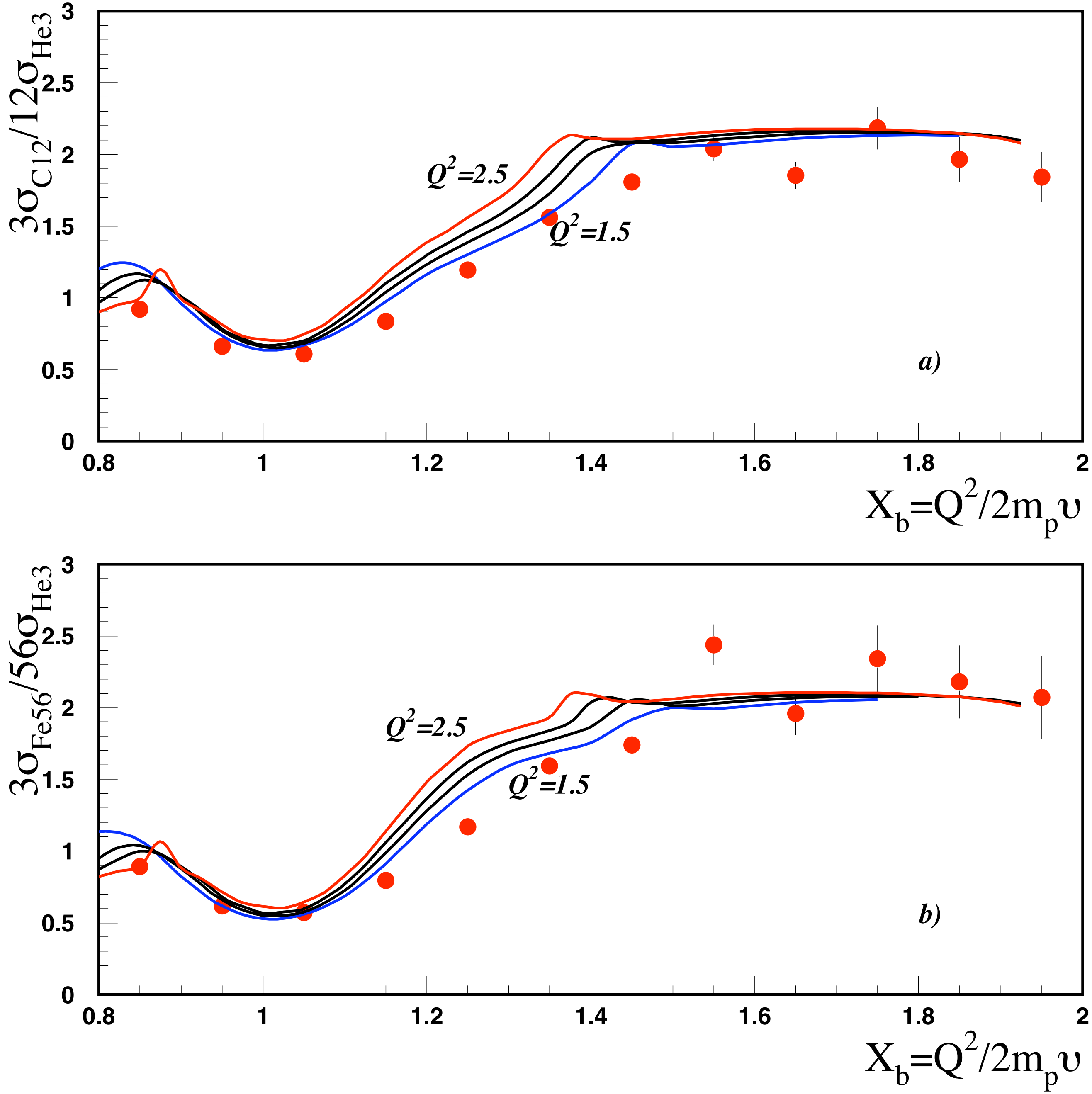


Egiyan, et al PRC 2004

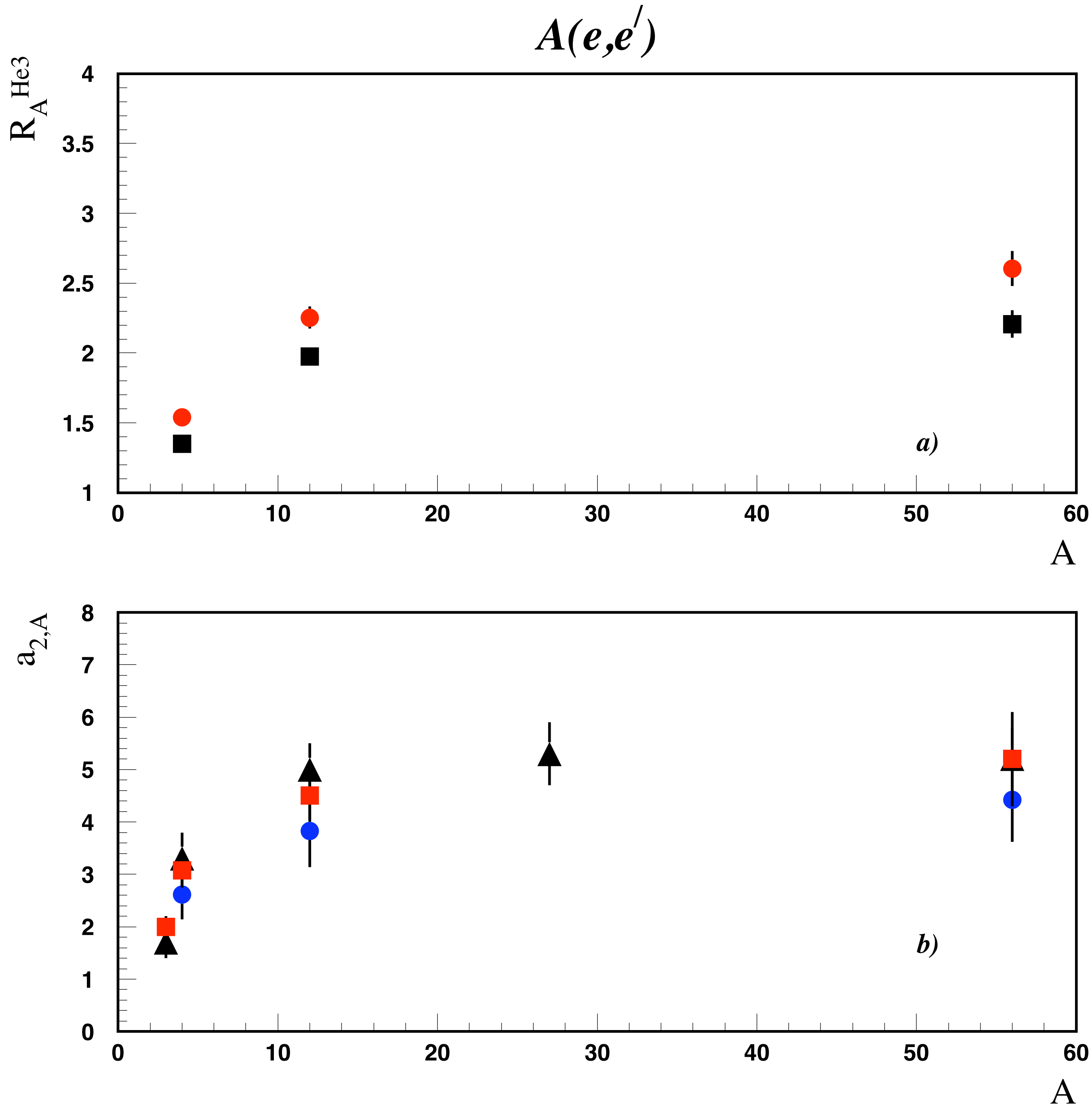
$A(e,e')$

Calculations

Day, Frankfurt, MS, Strikman, PRC 1993



Data Egiyan, et al PRC 2004

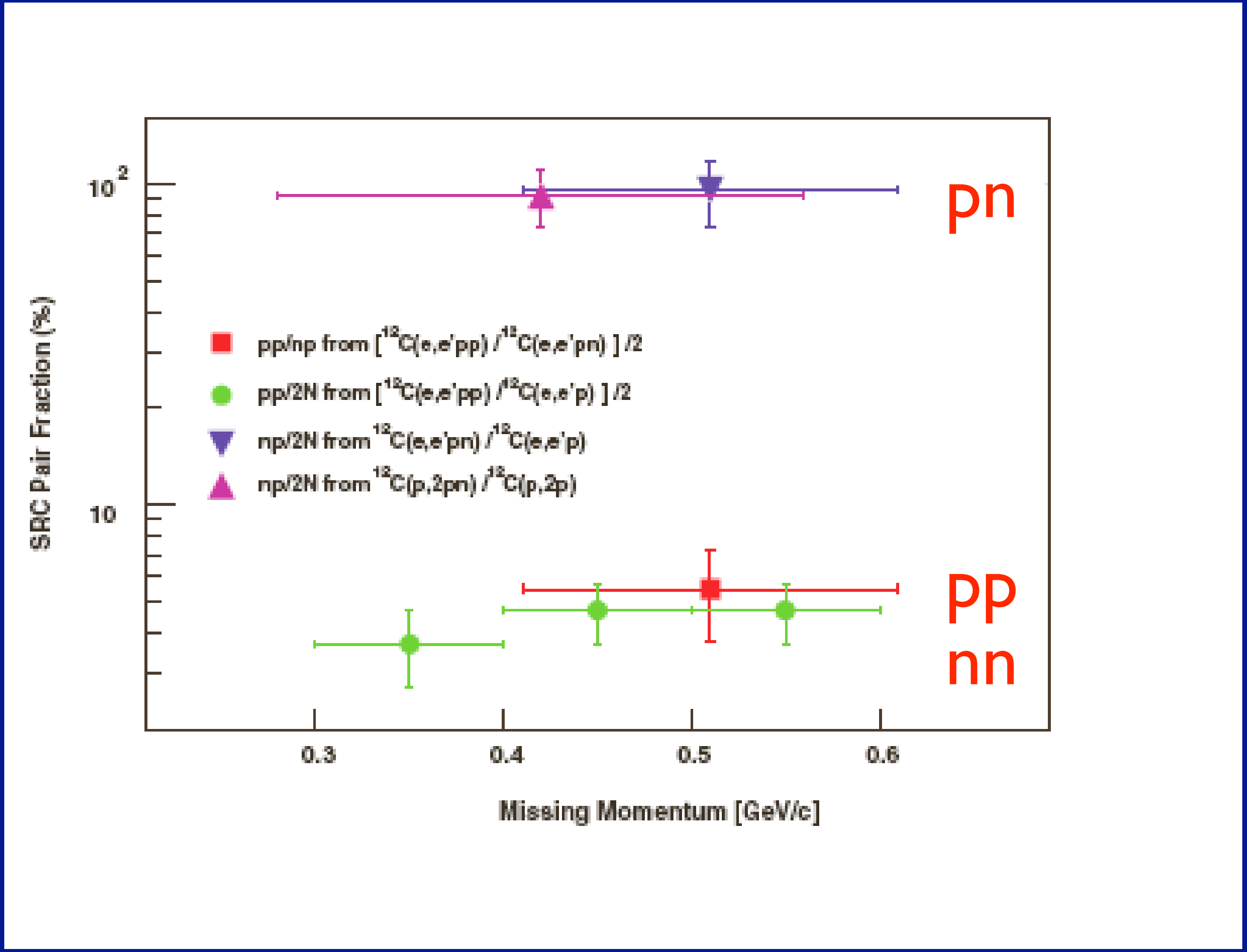


A(e,e')
R_A^{He3}
a)
A
$a_{2,A}$
b)
A

	$a_{2N}(A)$
^{3}He	0.080±0.000± 0.004
^{4}He	0.154±0.002± 0.033
^{12}C	0.193±0.002± 0.041
^{56}Fe	0.227±0.002± 0.047

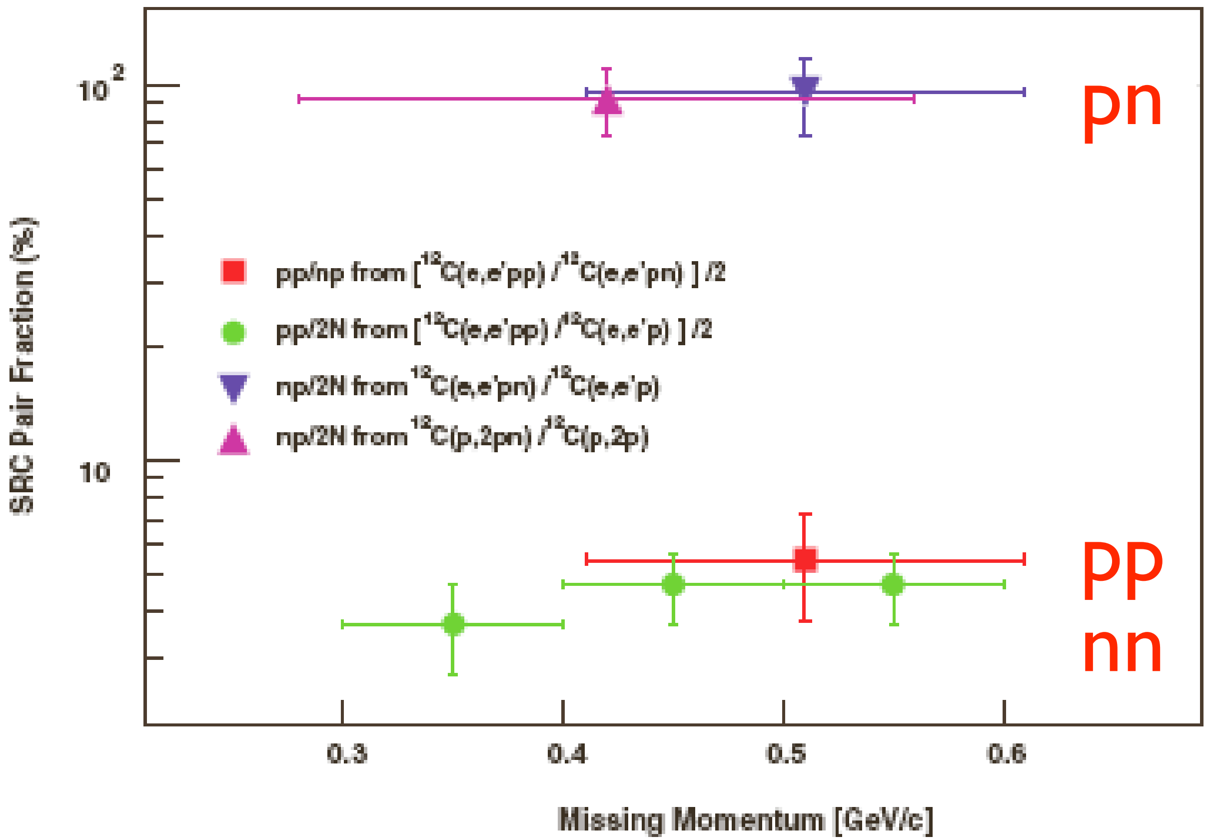
$a_{3N}(A)$
0.0018±0.0000±0.0006
0.0042±0.0002±0.0014
0.0055±0.0003±0.0017
0.0079±0.0003±0.0025

Combined Analysis



Combined Analysis

R.Subdei, et al Science , 2008



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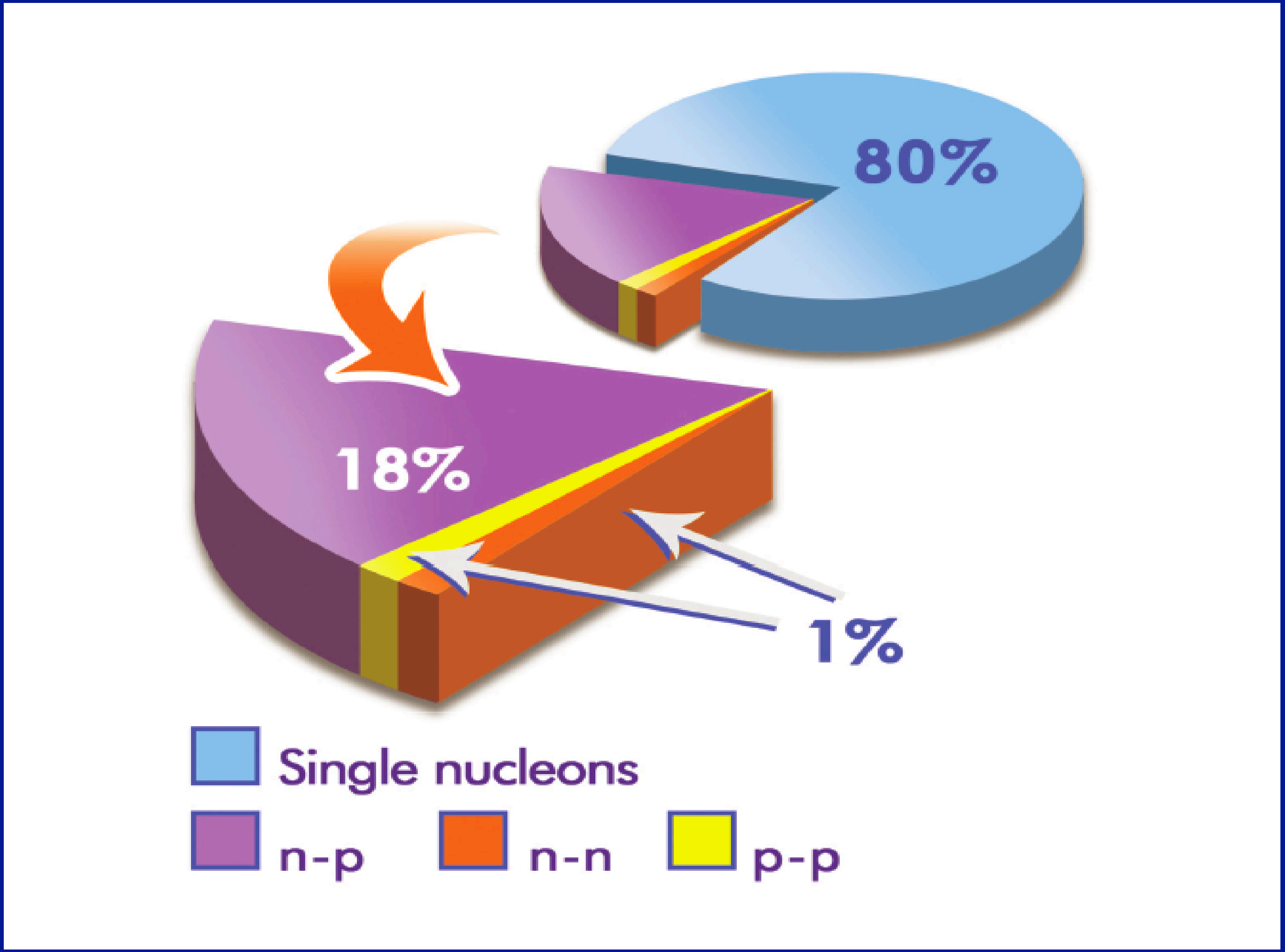

Nucleai probed up to 500 MeV/c

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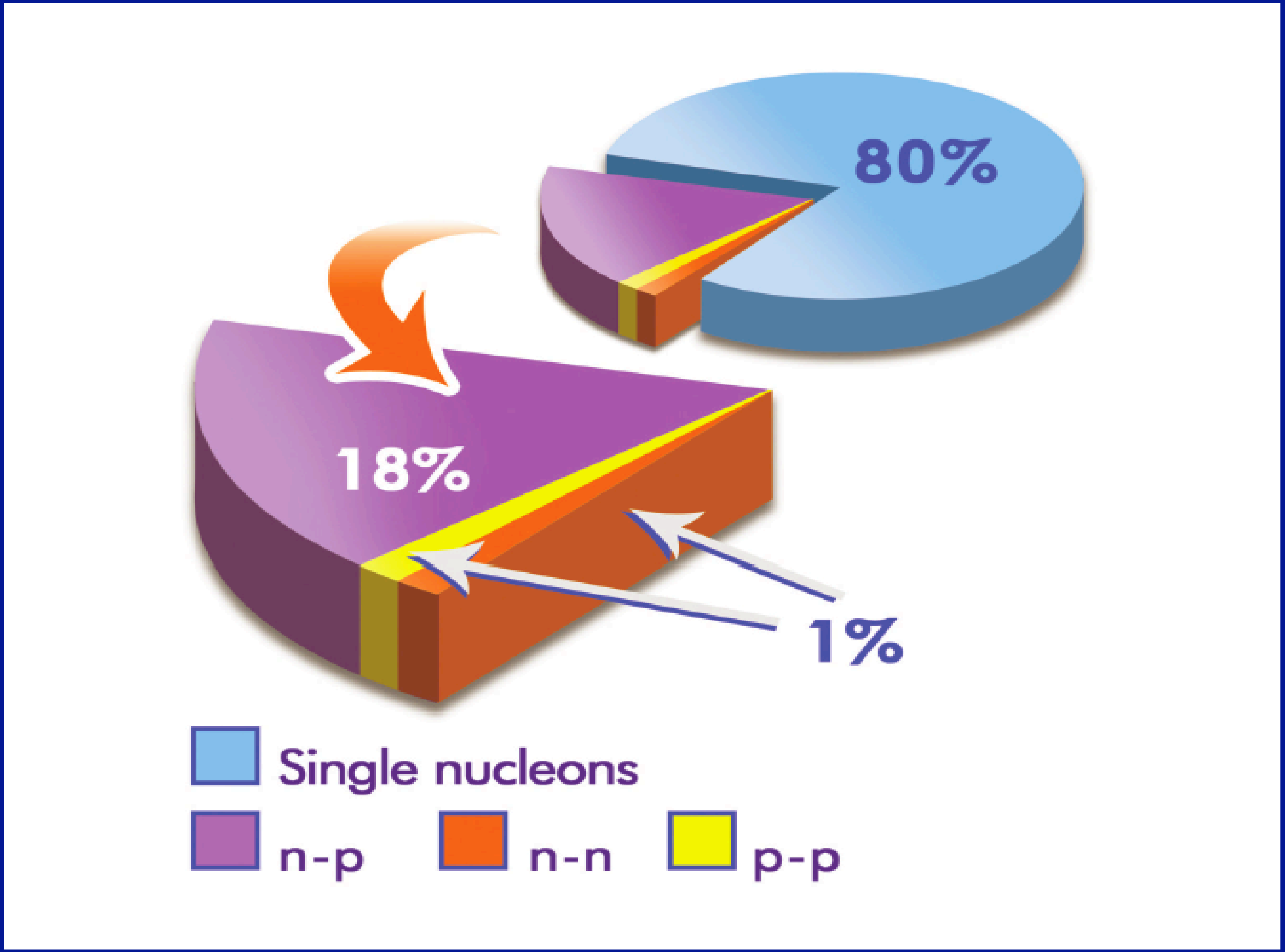
R.Subdei, et al Science , 2008



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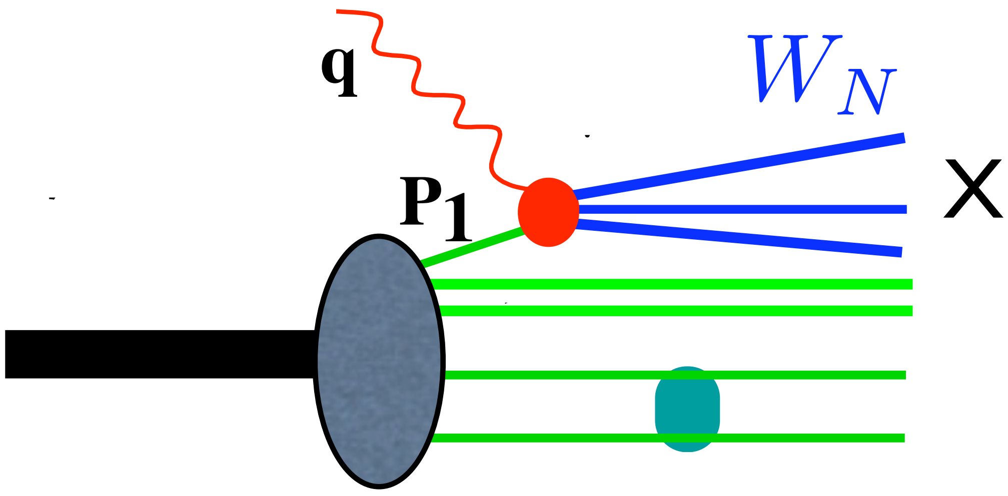
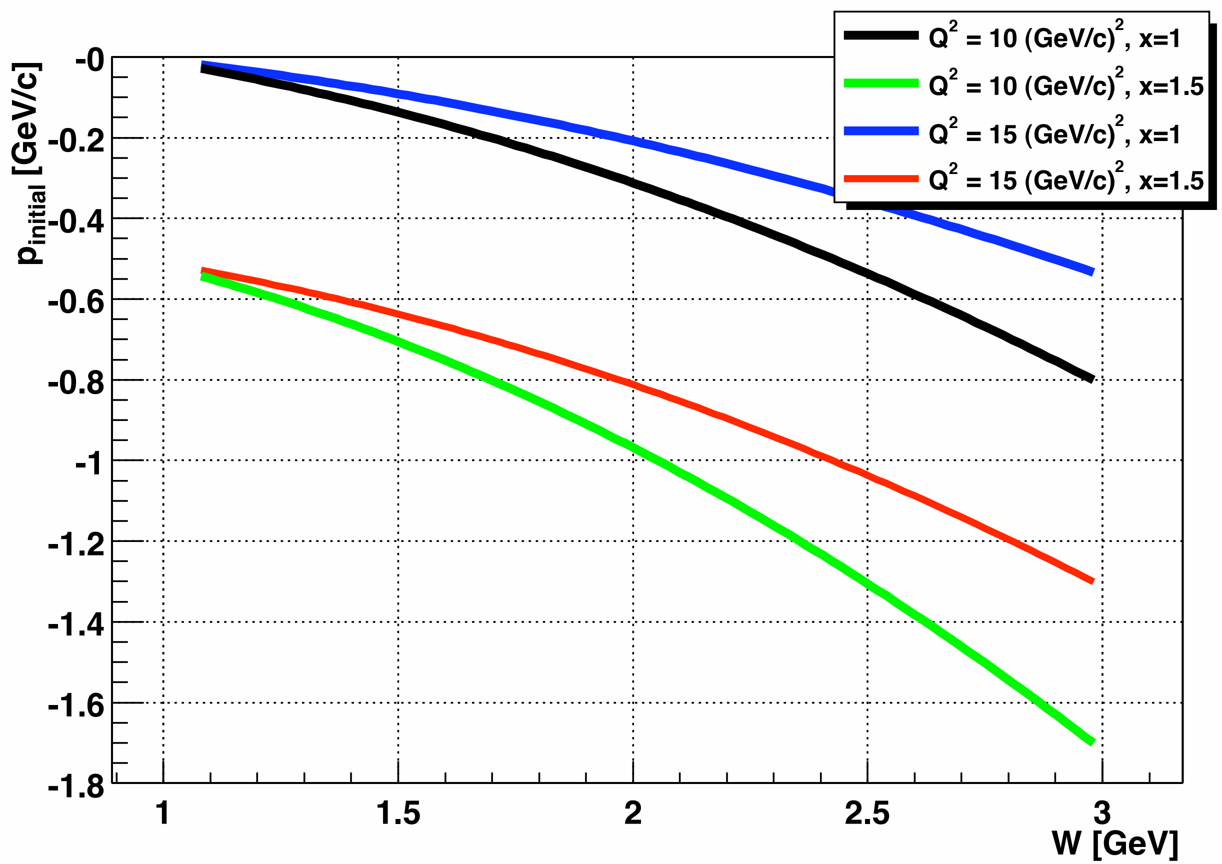
Deep Inelastic Scattering at x>1



Two processes driving nucleons close together

First: Kinematics

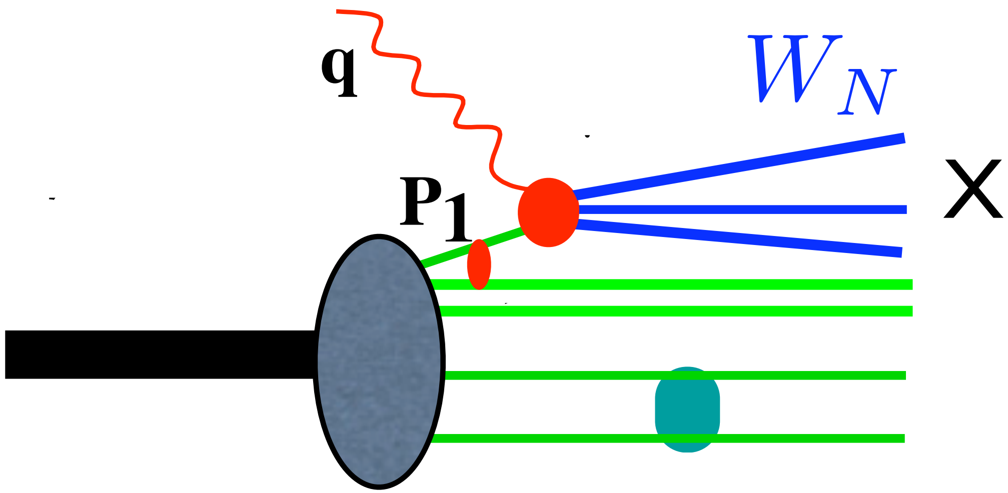
$$p_1^z = m(1 - x - x\left[\frac{W_N^2 - m^2}{Q^2}\right])$$



$$p_1^z \approx m(1-x)$$

For Quasi Elastic

Deep Inelastic Scattering at x>1



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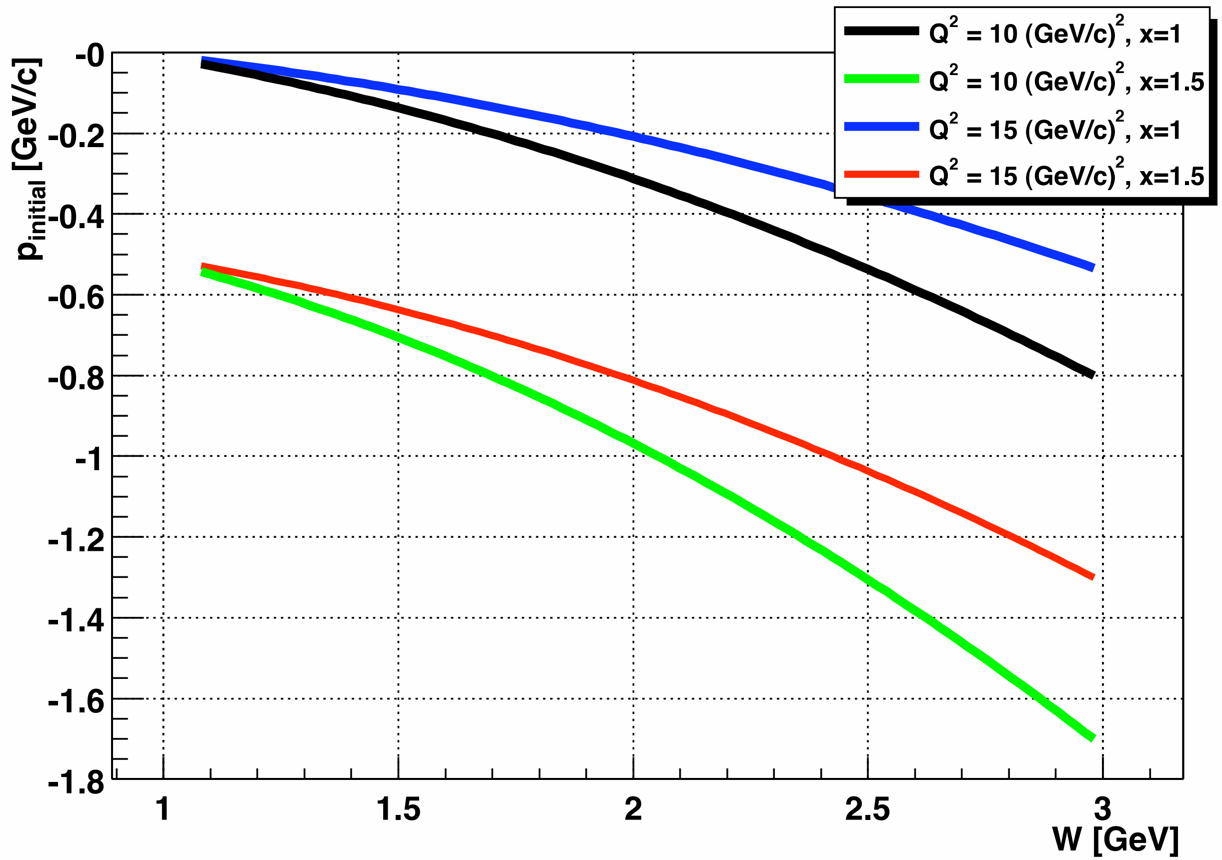

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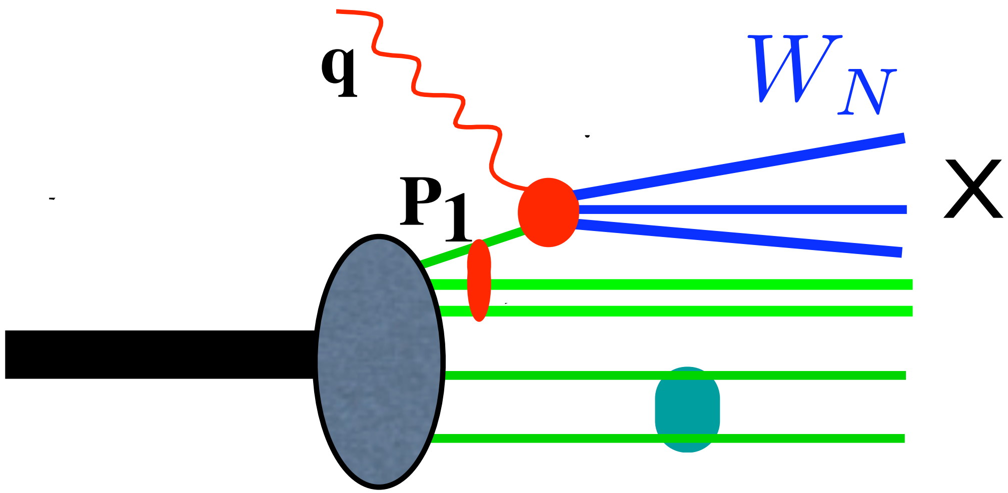

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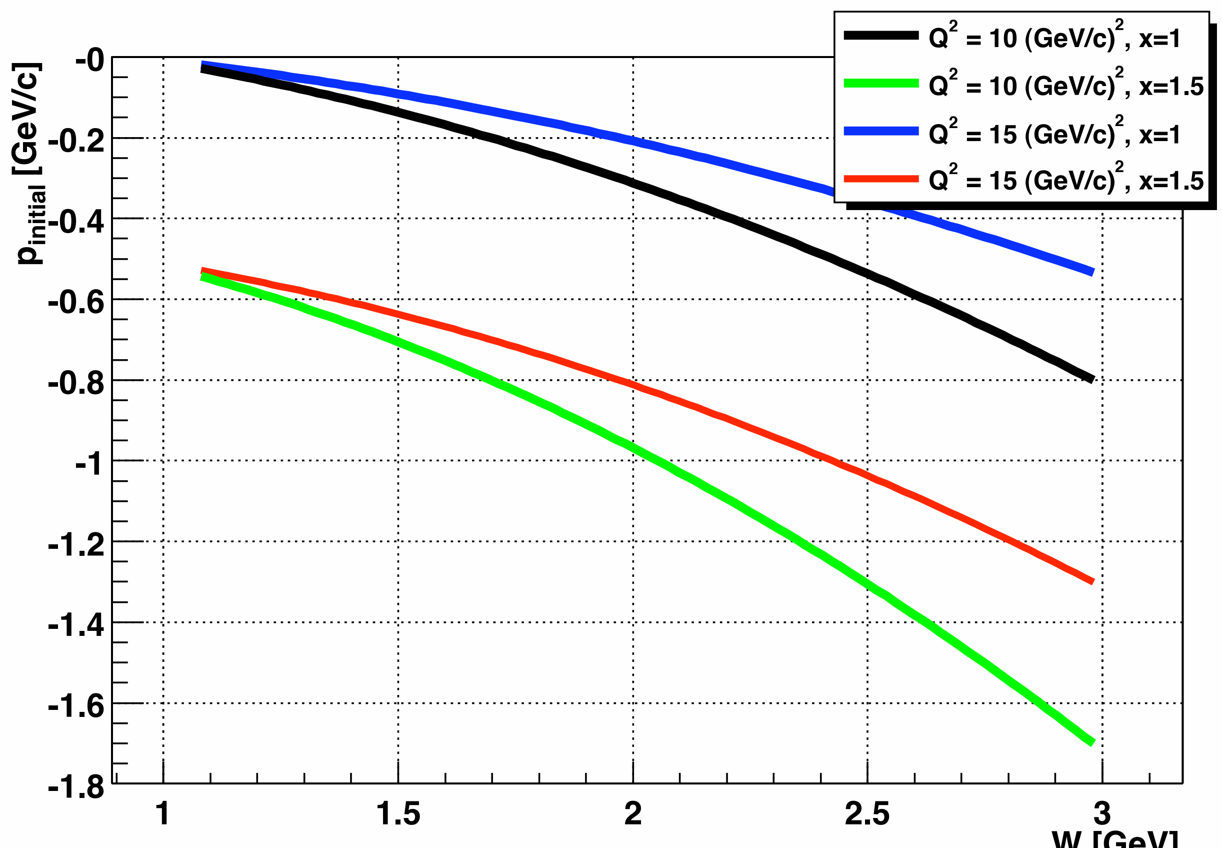

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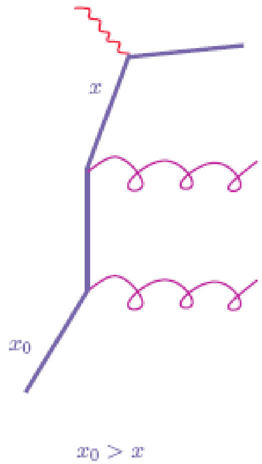
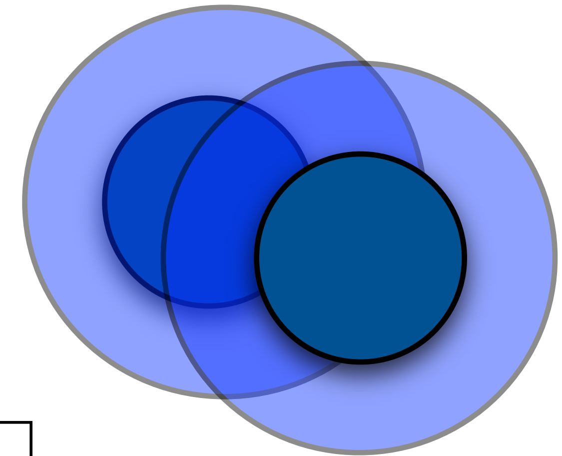
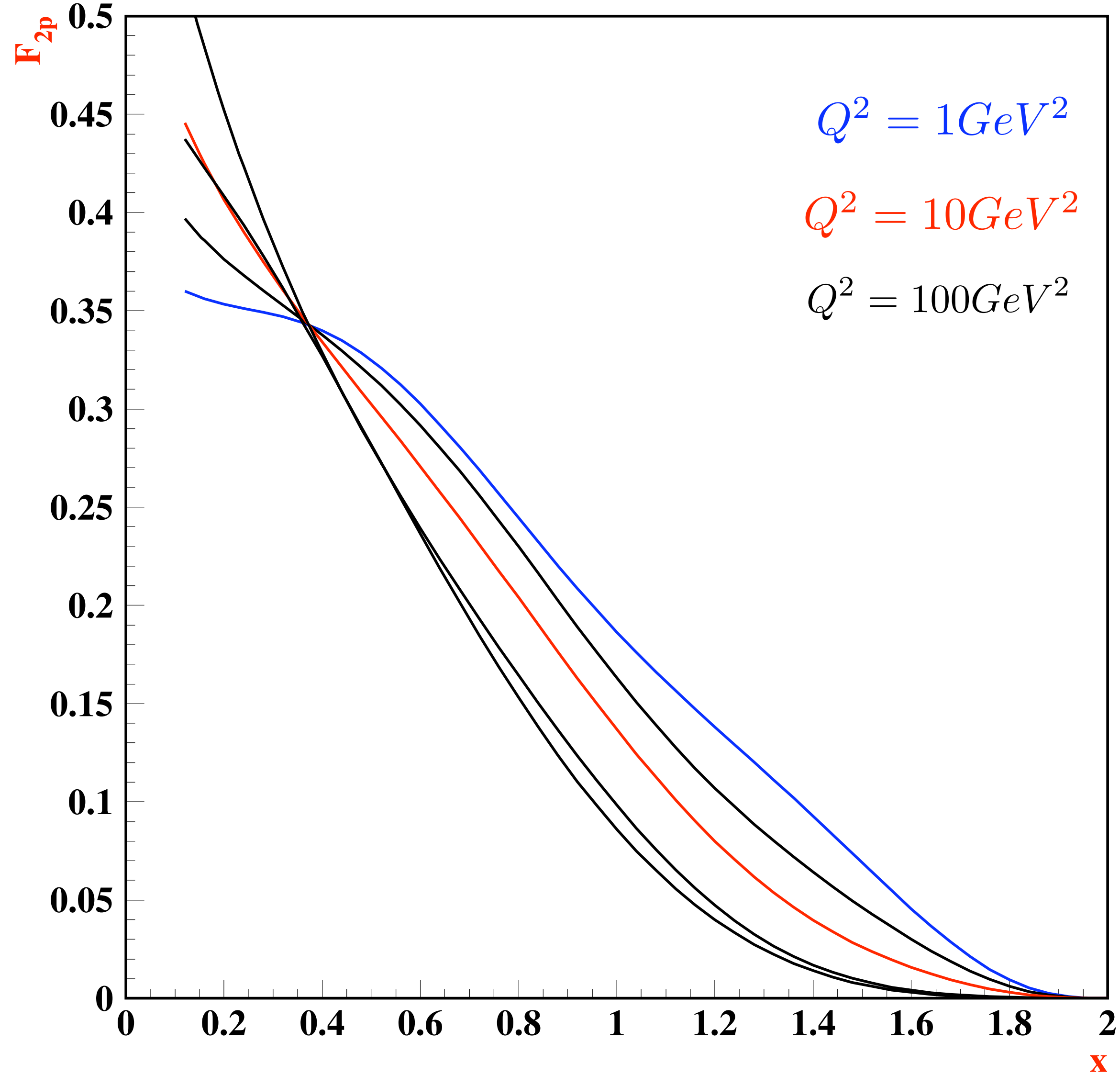
For Quasi Elastic

Second: Dynamics

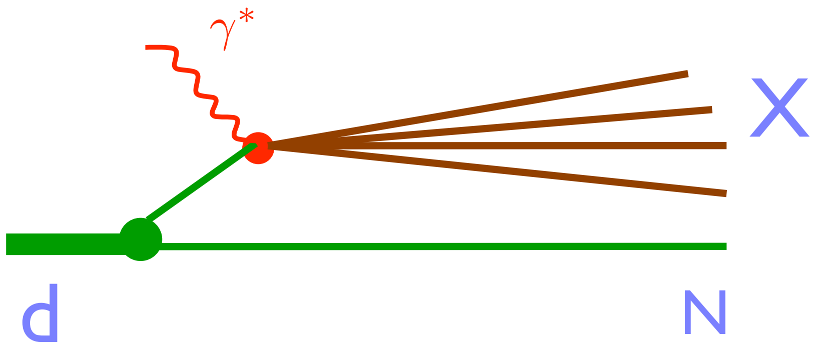


Consider: Deuteron



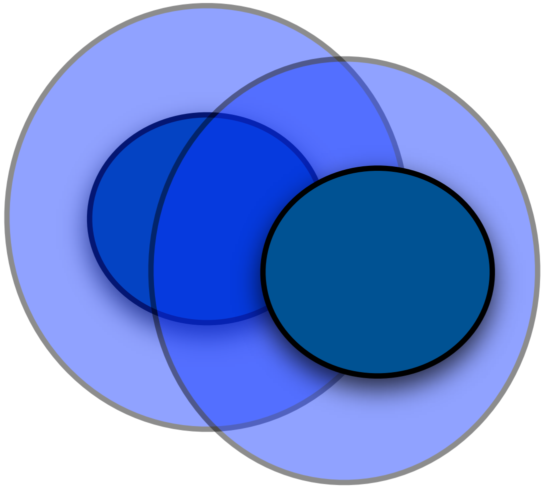


Convolution Model



$$F_{2d} = \int_x^2 \rho_d^N(\alpha, p_t) F_{2N}\left(\frac{x}{\alpha}, Q^2\right) \frac{d^2\alpha}{\alpha} d^2 p_t$$

$$F_{2N} \longrightarrow F_{2N}^{mod}$$



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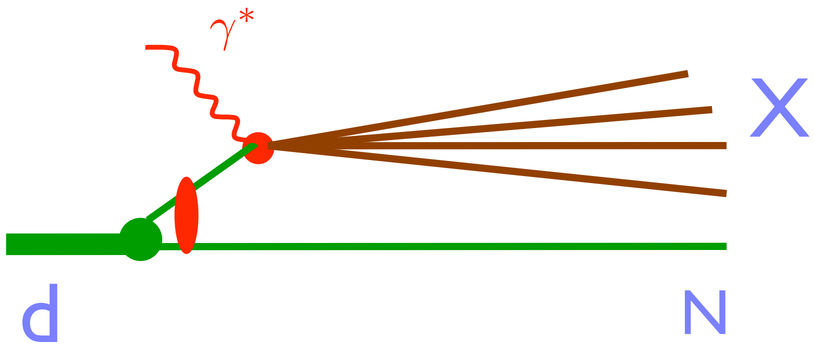

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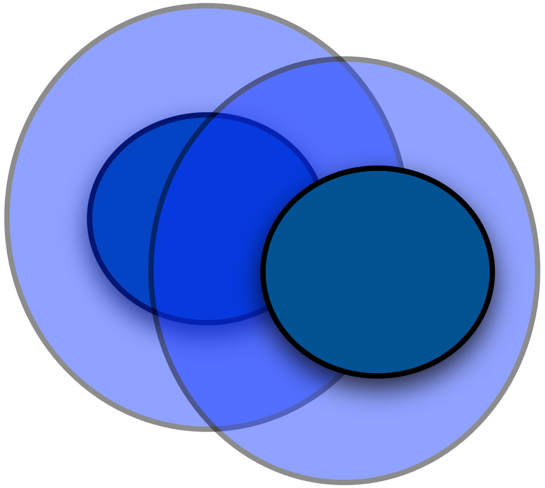

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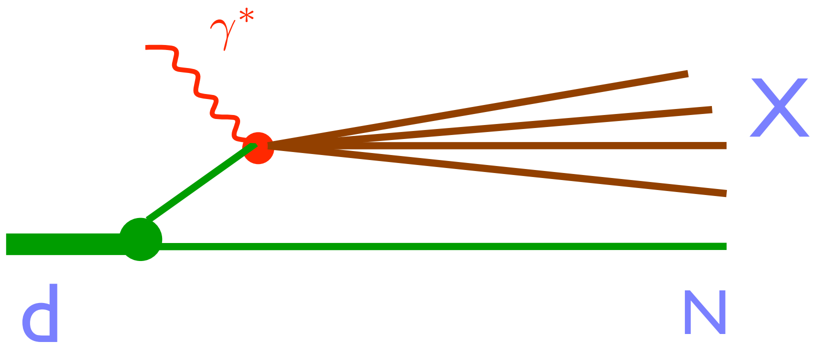

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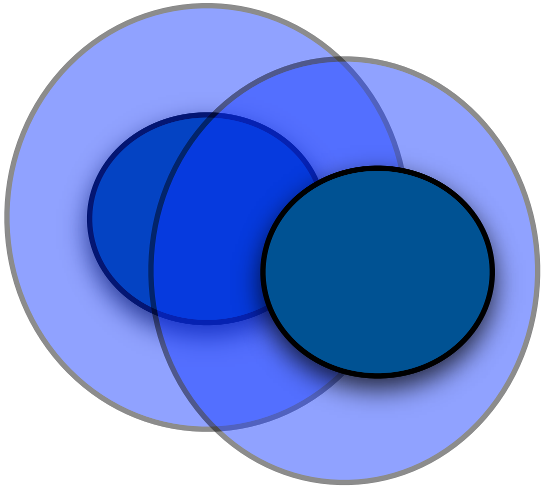
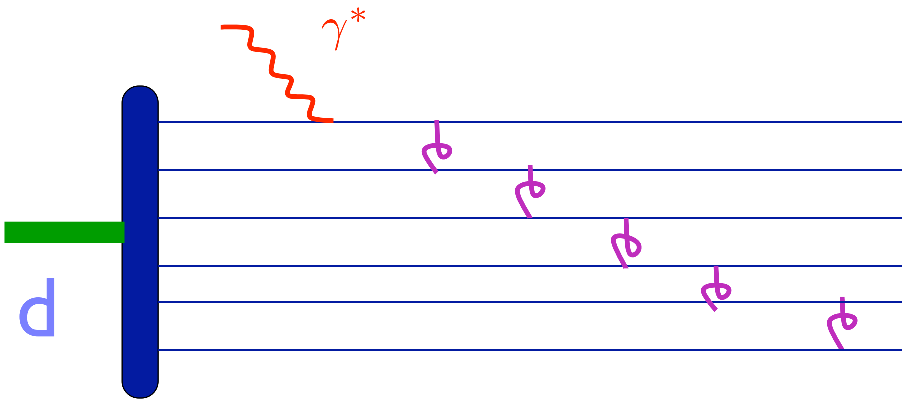
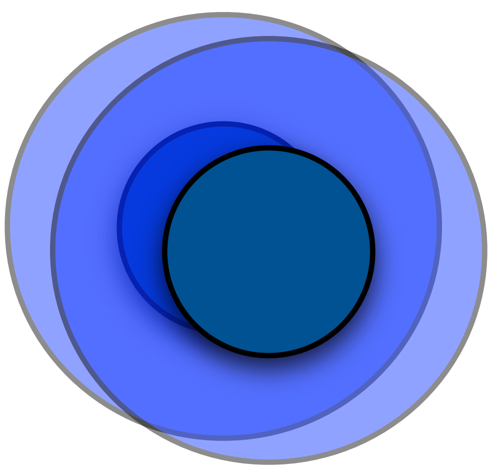


Quark-Cluster - 6q - Model



$$F_{2D} = F_{2,(6q)} \sim (1 - \frac{x}{2})^{10}$$



Lassila, Sukhatme, PLB 1988

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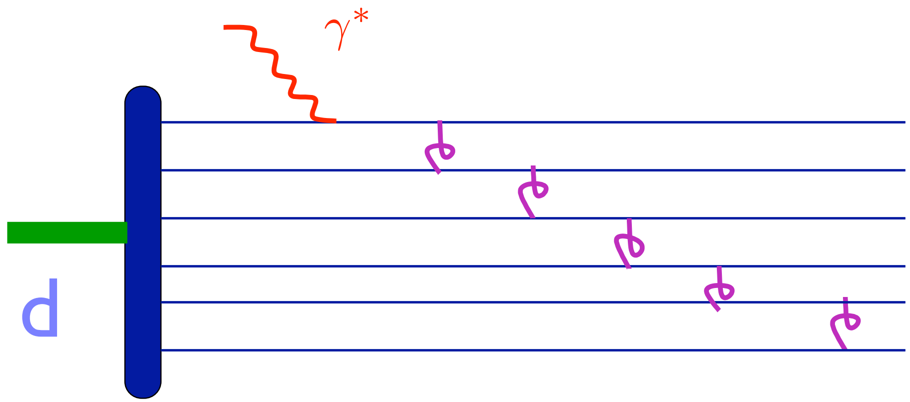

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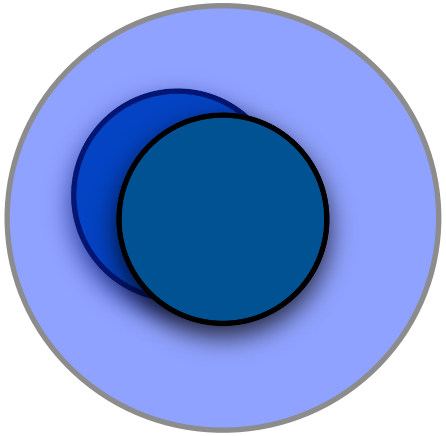

Lassila, Sukhatme, PLB 1988

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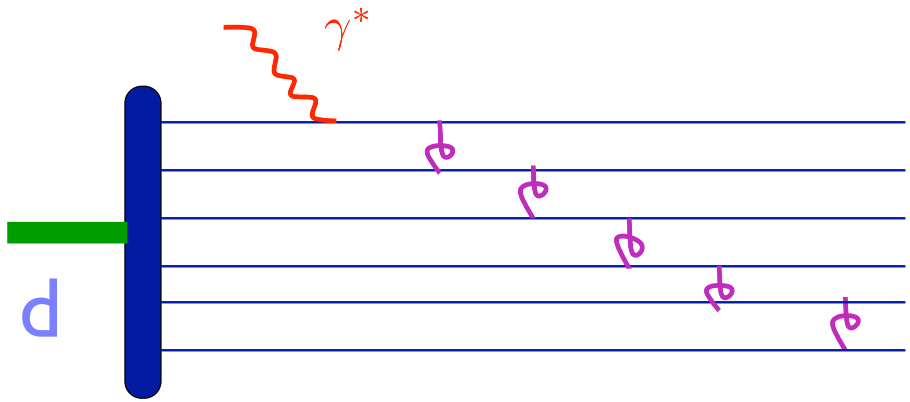

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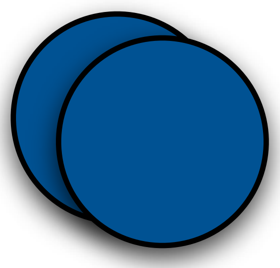
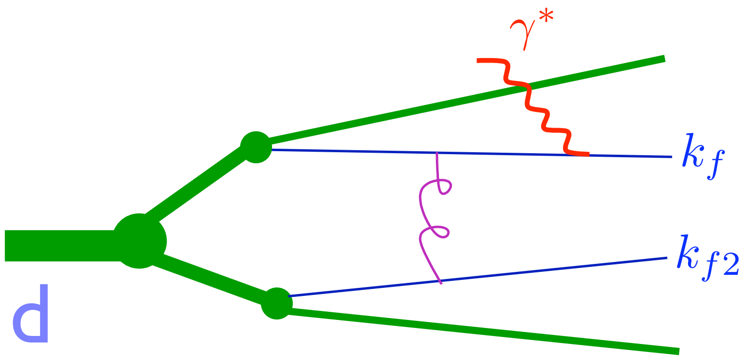
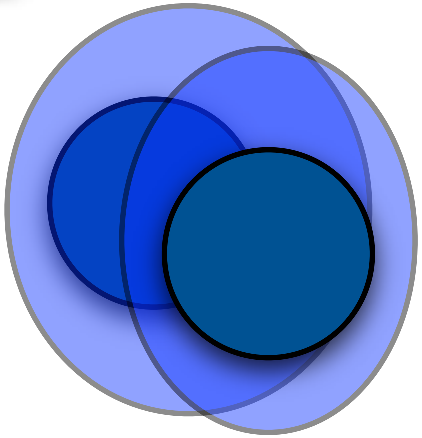


Lassila, Sukhatme, PLB 1988

Hard Gluon-Exchange Model



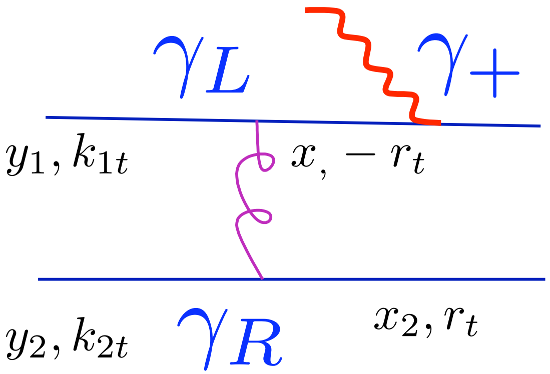


$$\mathcal{M}^\mu = \int \frac{\Psi_d(\alpha, p_t)}{(1-\alpha)} \frac{d\alpha}{\alpha} \frac{d^2 p_t}{2(2\pi)^3} \times$$

$$\bar{u}(k_f)[e_q \gamma^\mu] u_{\zeta'}(k_f - q) \frac{1}{(k_f - q)^2 - m_q^2} \bar{u}_{\zeta'}(k_f - q)[g T^a \gamma^{\nu_1}] u_\zeta(k_1) \frac{\psi_N(y_1, k_{1t})}{y_1}$$

$$\bar{u}_{\eta'}(k_{f2})[g T^b \gamma^{\nu_2}] u_\eta(k_2) \frac{\psi_N(y_2, k_{2t})}{y_2} \frac{d^{\nu_1,\nu_2} \delta_{ab}}{(k_2 - k_{f2})^2}$$

$$F_{2d} = W^{++} \cdot \nu \left(\frac{m_N}{p_{d+}}\right)^2 \qquad W^{++} = \frac{1}{4\pi m_d} \int |\mathcal{M}^+|^2 dQ$$



$$\gamma_{R,L} = \gamma_x \pm \gamma_y$$

$$\gamma_\pm = \gamma_0 \pm \gamma_z$$

Reference Frame

$$q_+ = 0$$

$$q = (0, \frac{2\nu m_d}{p_{d+}}, \sqrt{Q^2})$$

$$p_d = (p_{d+}, \frac{m_d^2}{p_{d+}}, 0)$$

$$kernel = \sqrt{x x_2}(1-\alpha)\alpha(1-\frac{x}{y_1+y_2})\frac{8p_{d+}}{((1-\alpha)y_1+\alpha y_2)r_t^2}$$

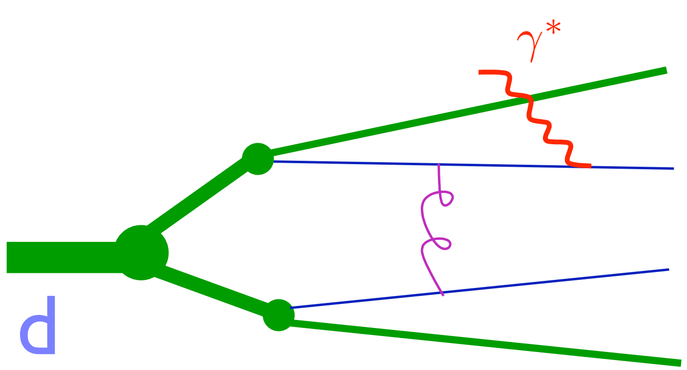
$$F_{2D} \approx N\left[\int \psi_d(\alpha, p_t)\cdot \frac{d\alpha}{\alpha}\frac{d^2p_t}{2(2\pi)^3}\right]^2 \times$$

$$\times \int_0^1\int_0^1 \left(1-\frac{x}{y_1+y_2}\right)^2 \theta(y_1+y_2-x) f_1(y_1) f_2(y_2) dy_2 dy_1$$

-This softening of x distribution

-This may be unique to DIS

-May not happen to QE scattering



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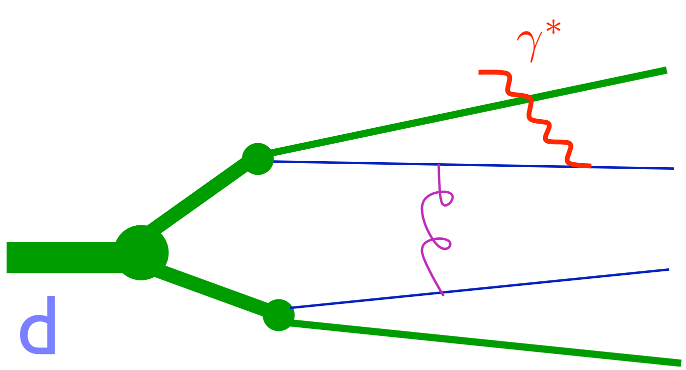

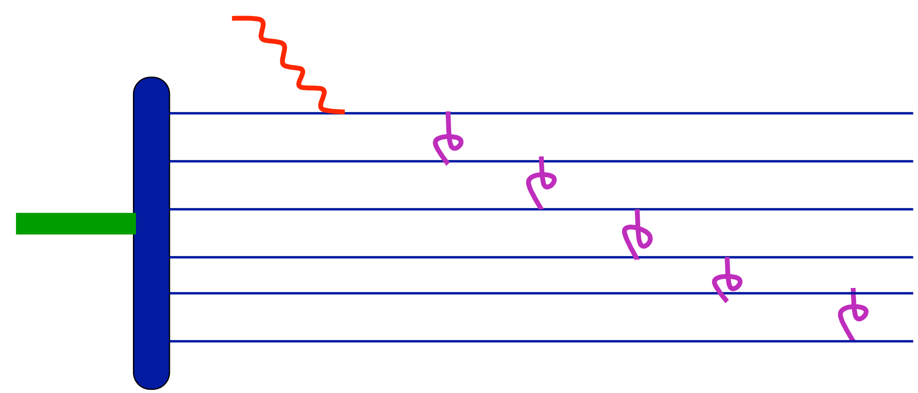

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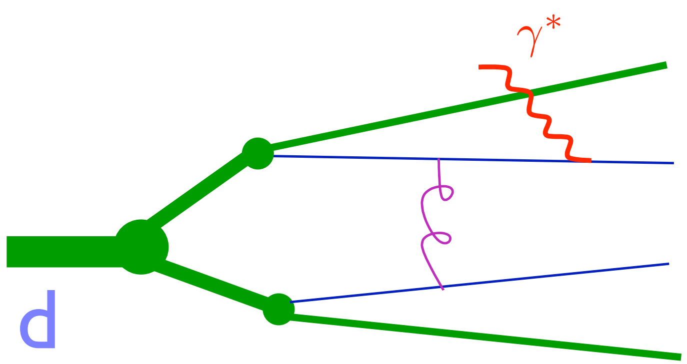

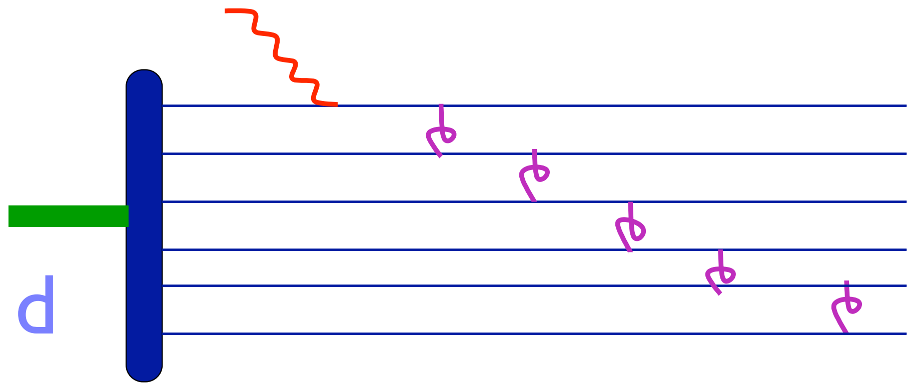

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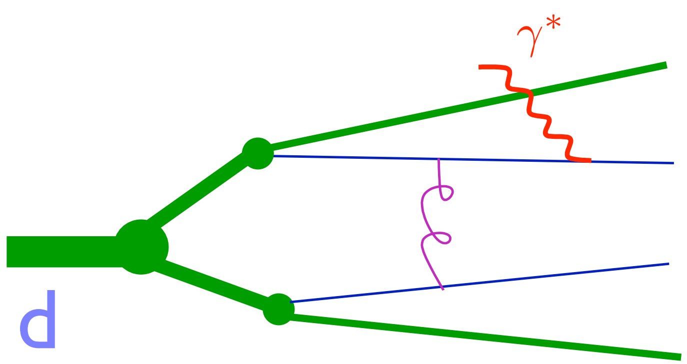

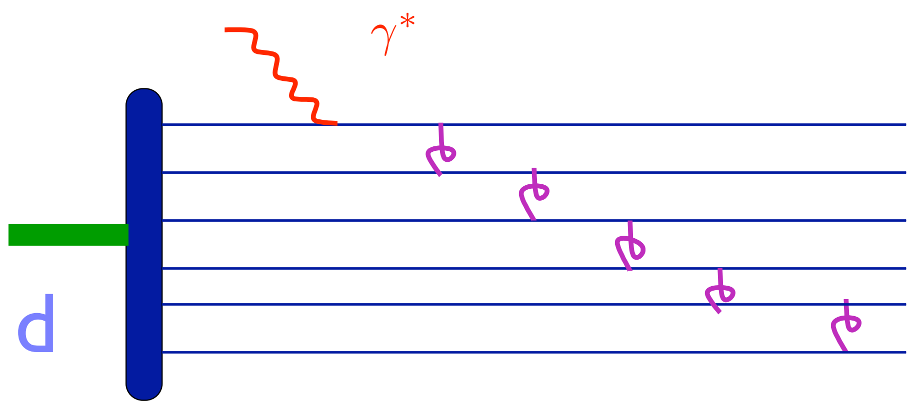

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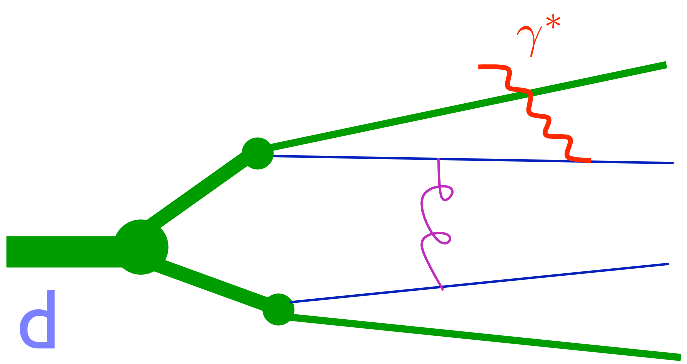

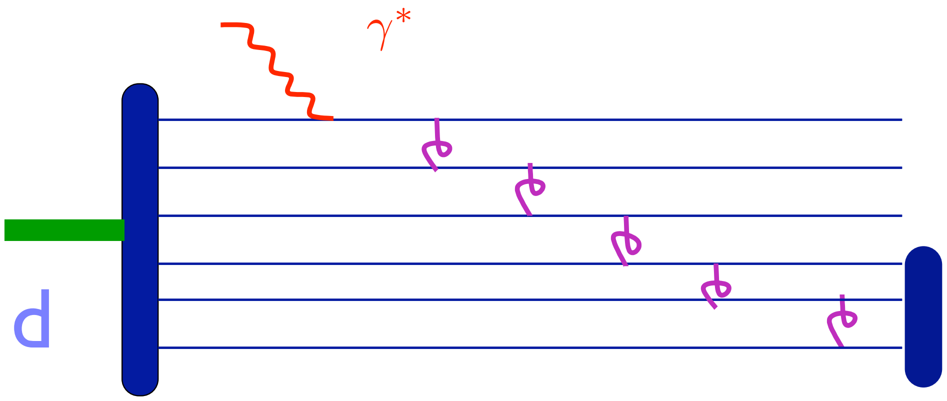

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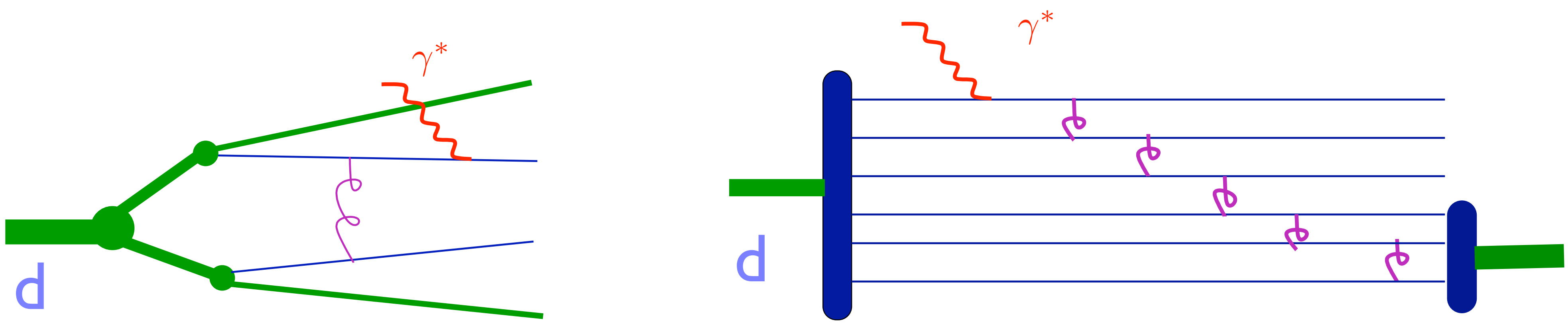

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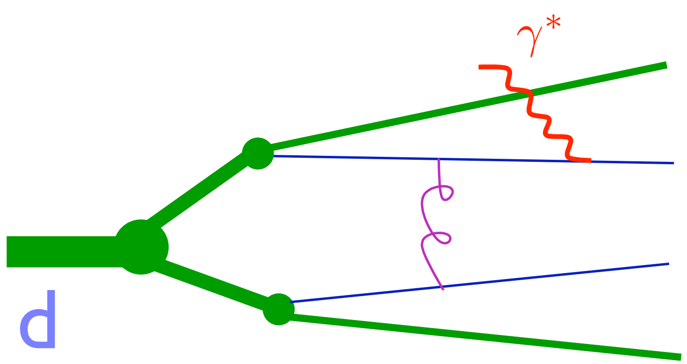

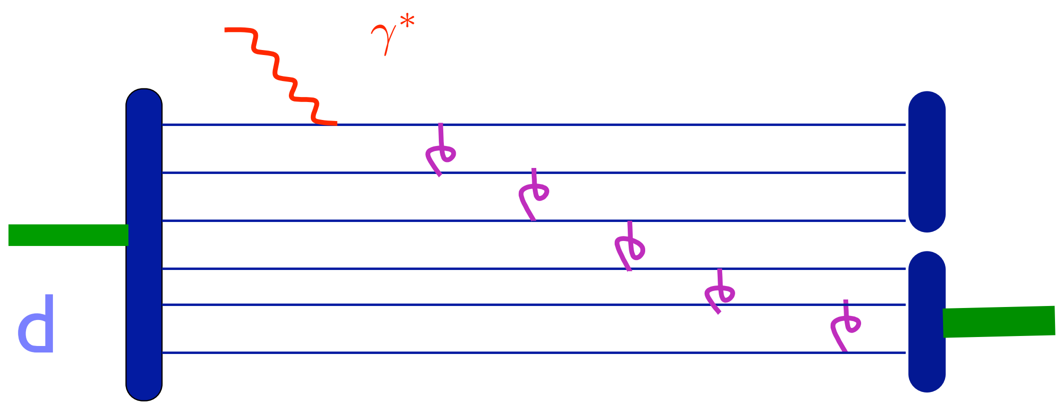

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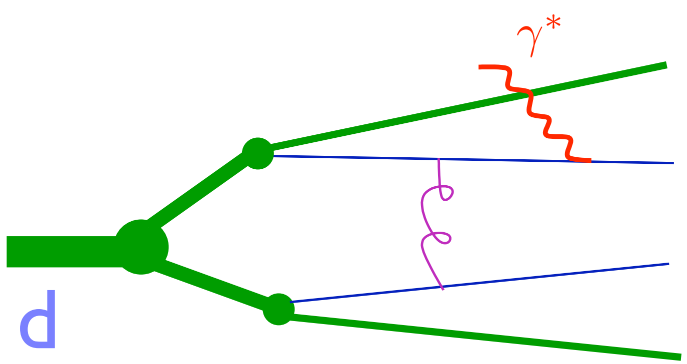
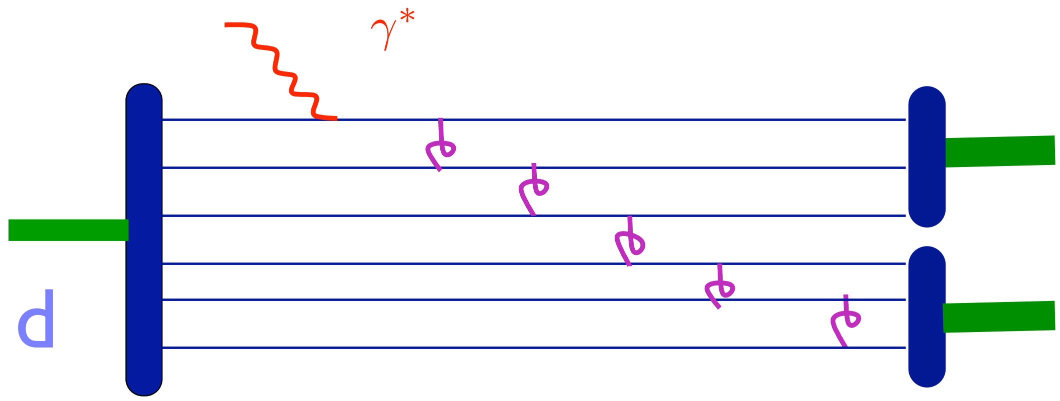
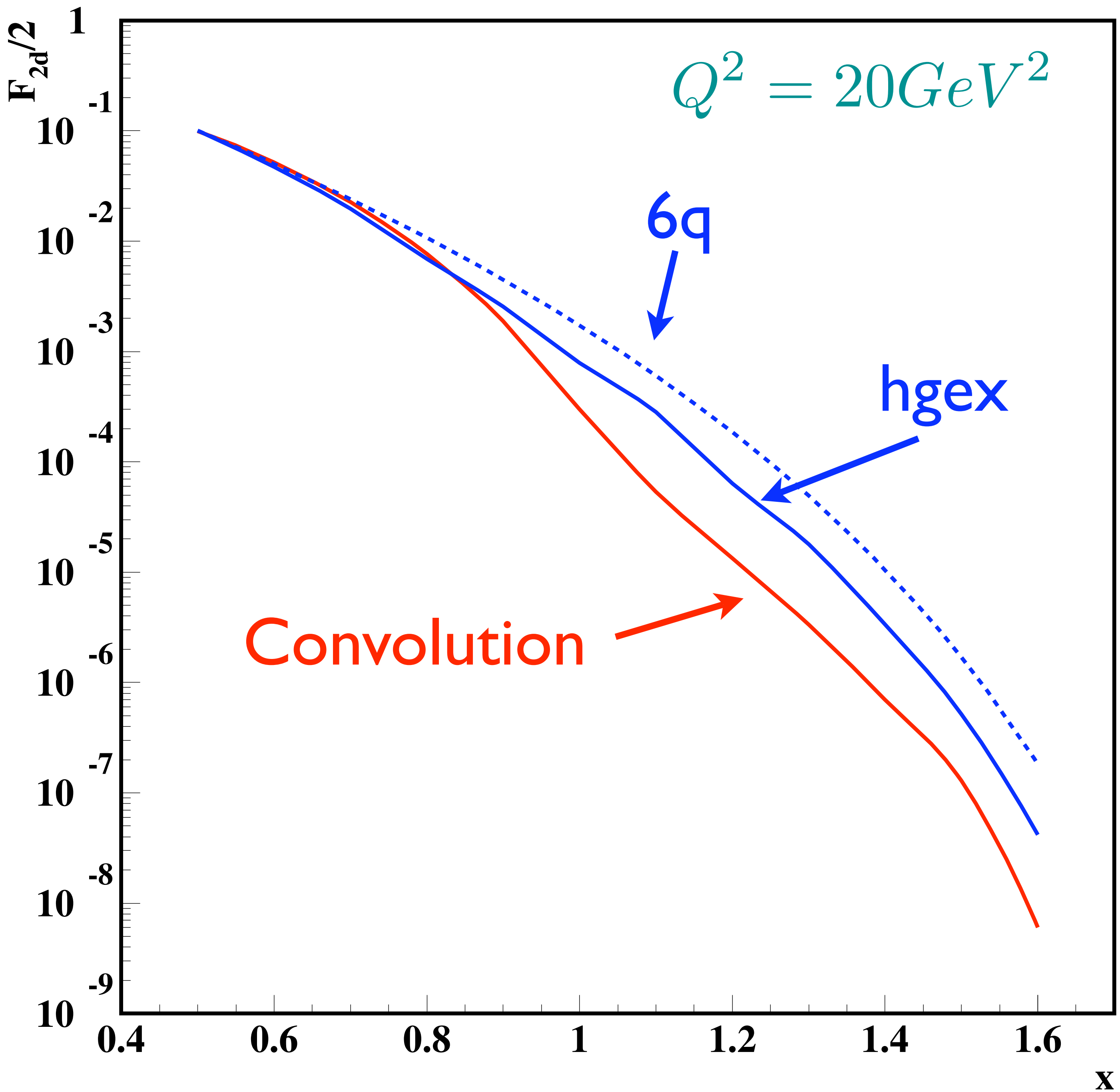
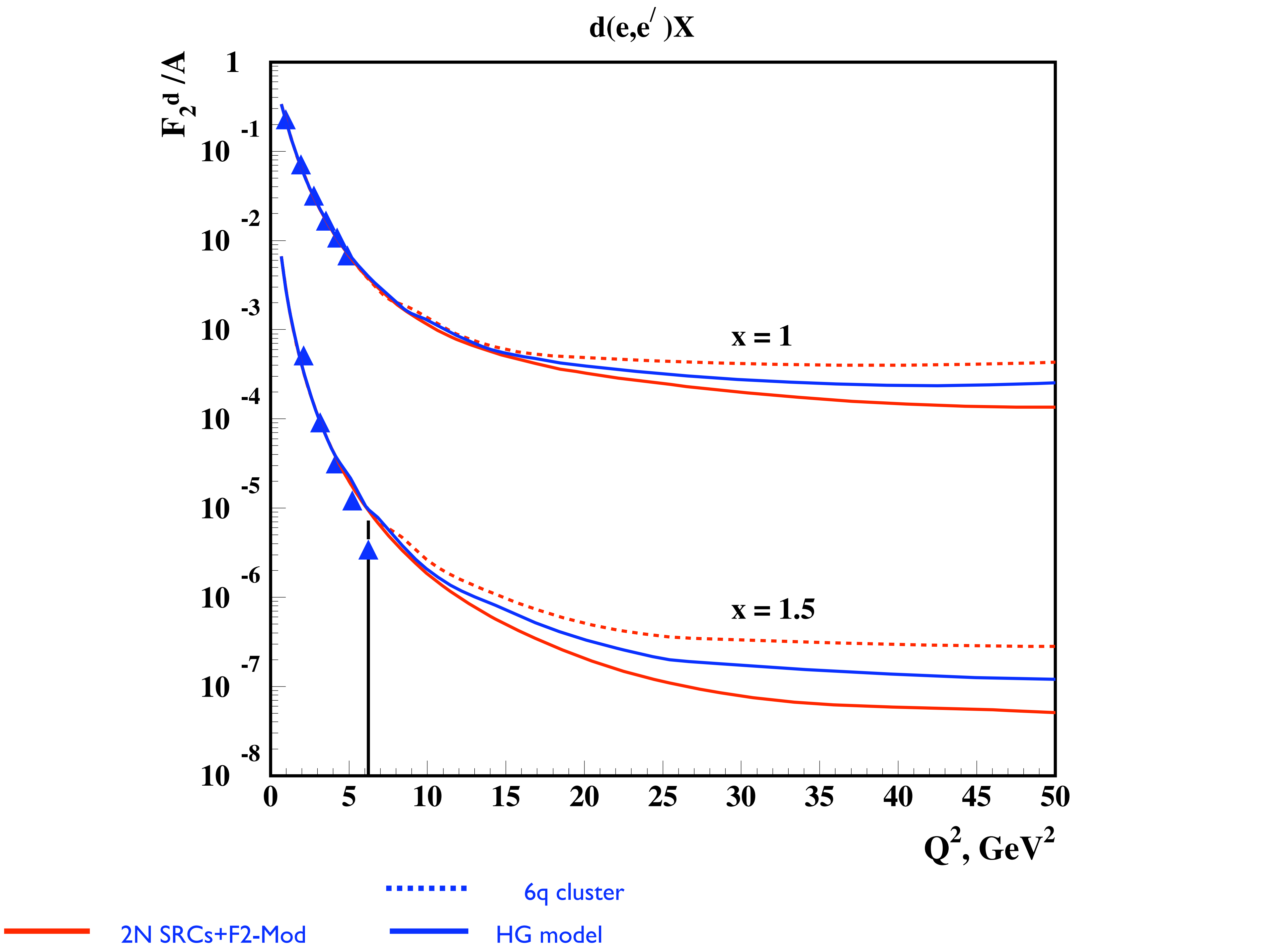


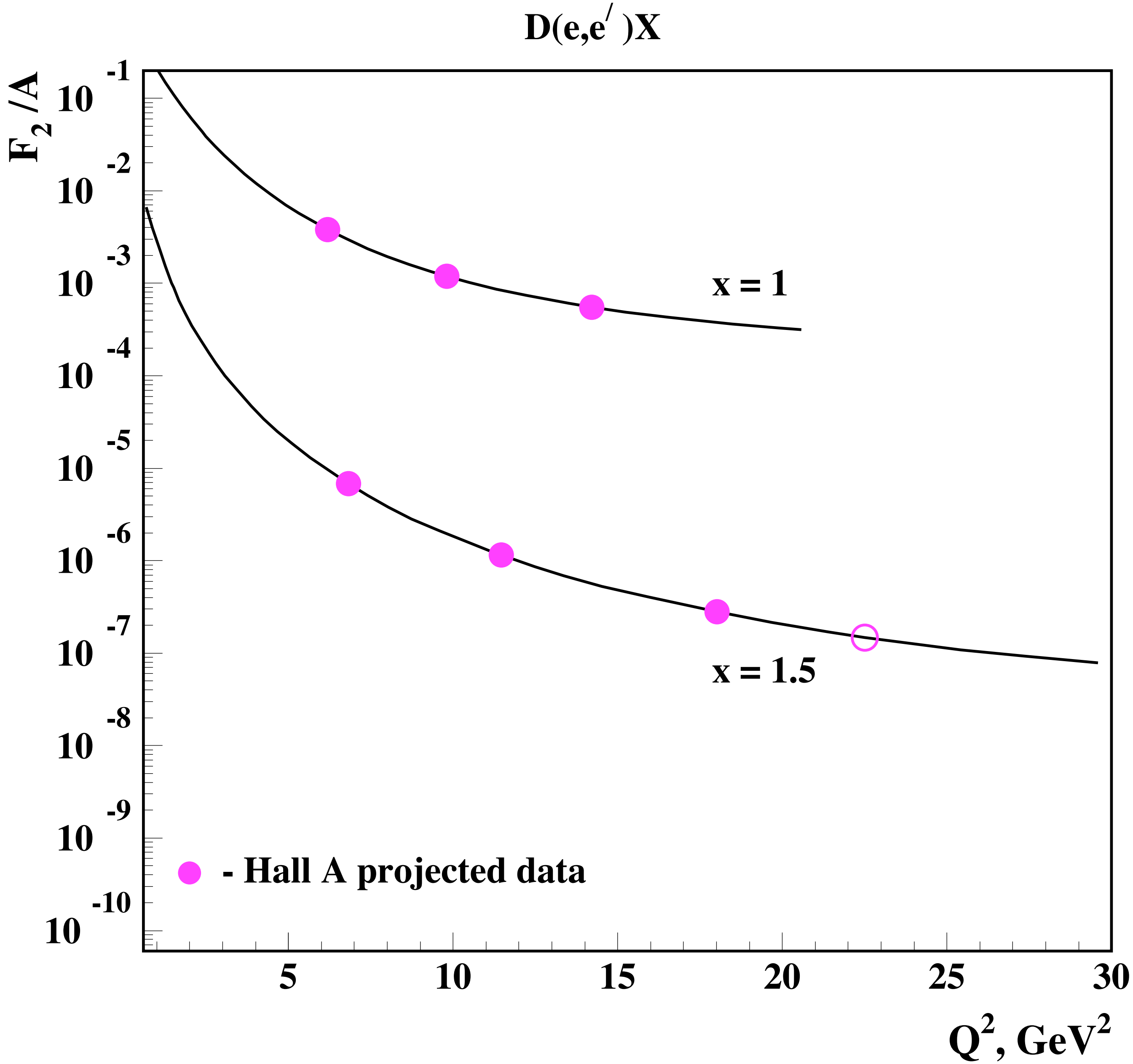




$F_{2d}/2$
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
0.4
0.6
0.8
1
1.2
1.4
1.6
x
$Q^2 = 20GeV^2$
6q
hgex
Convolution

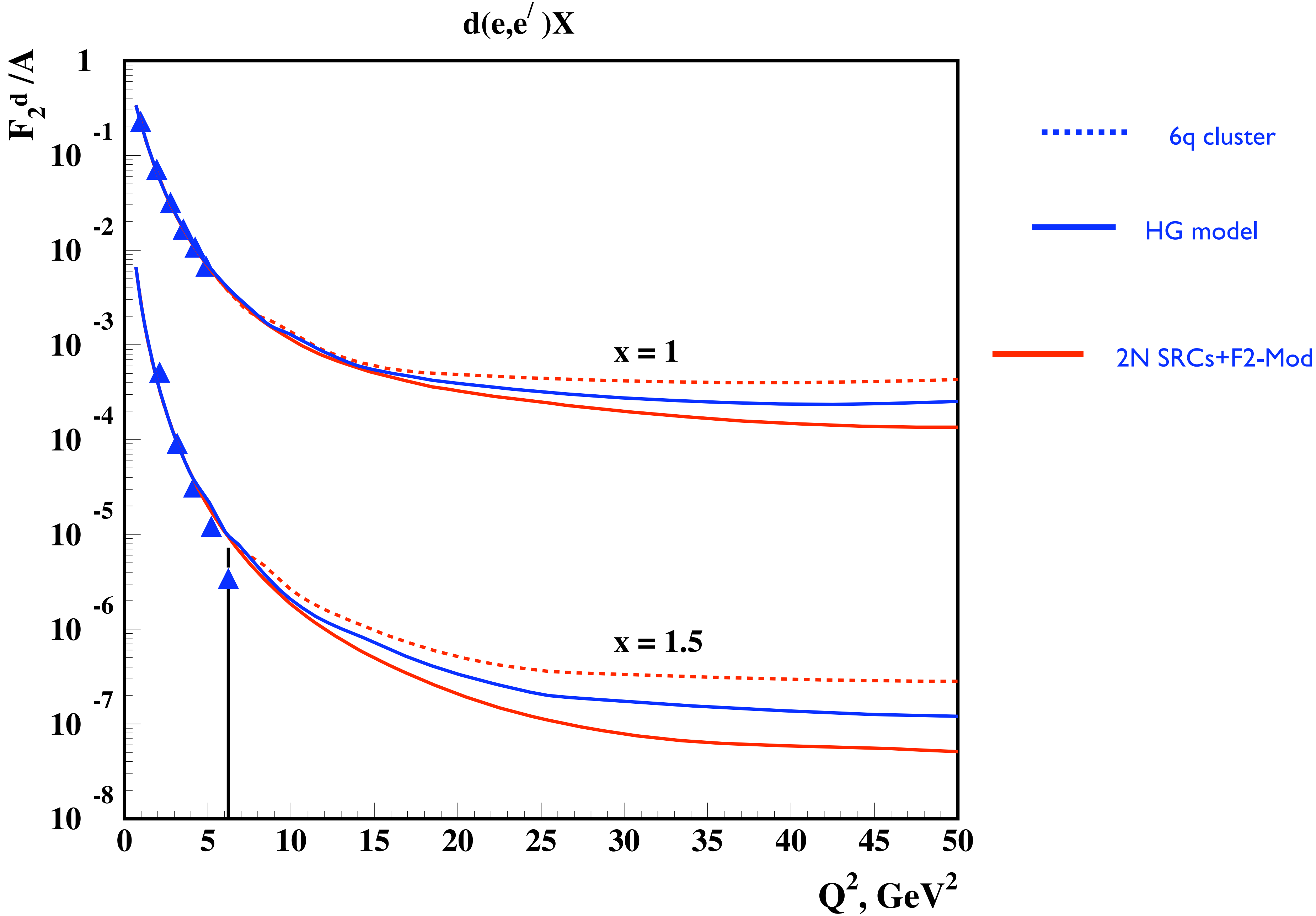


d(e,e′)X
F_2^d/A
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
0 5 10 15 20 25 30 35 40 45 50
Q^2, GeV^2
x = 1
x = 1.5
6q cluster
2N SRCs+F2-Mod
HG model



JLab12

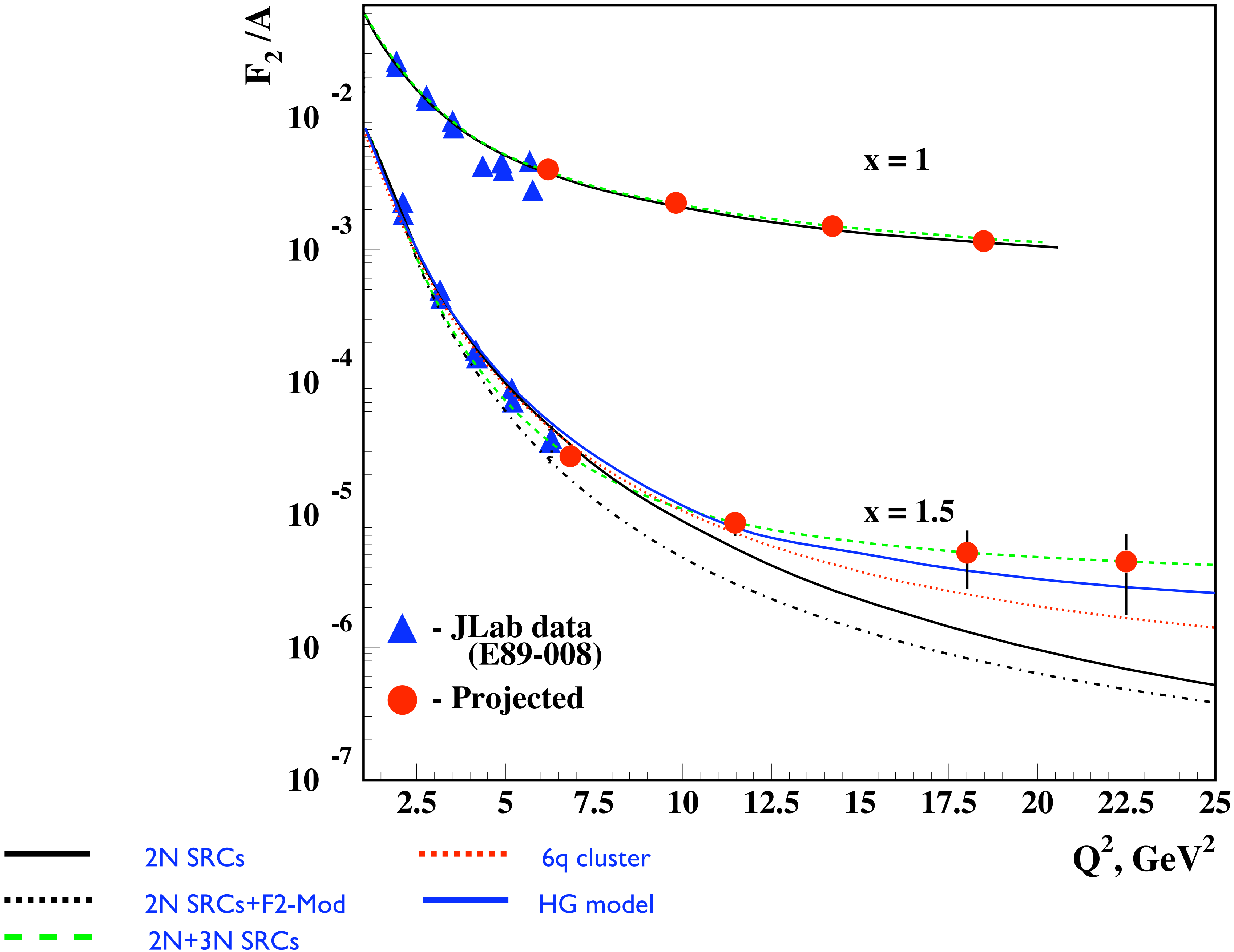
$$Q^2_{max} = 2E_e m_N x$$



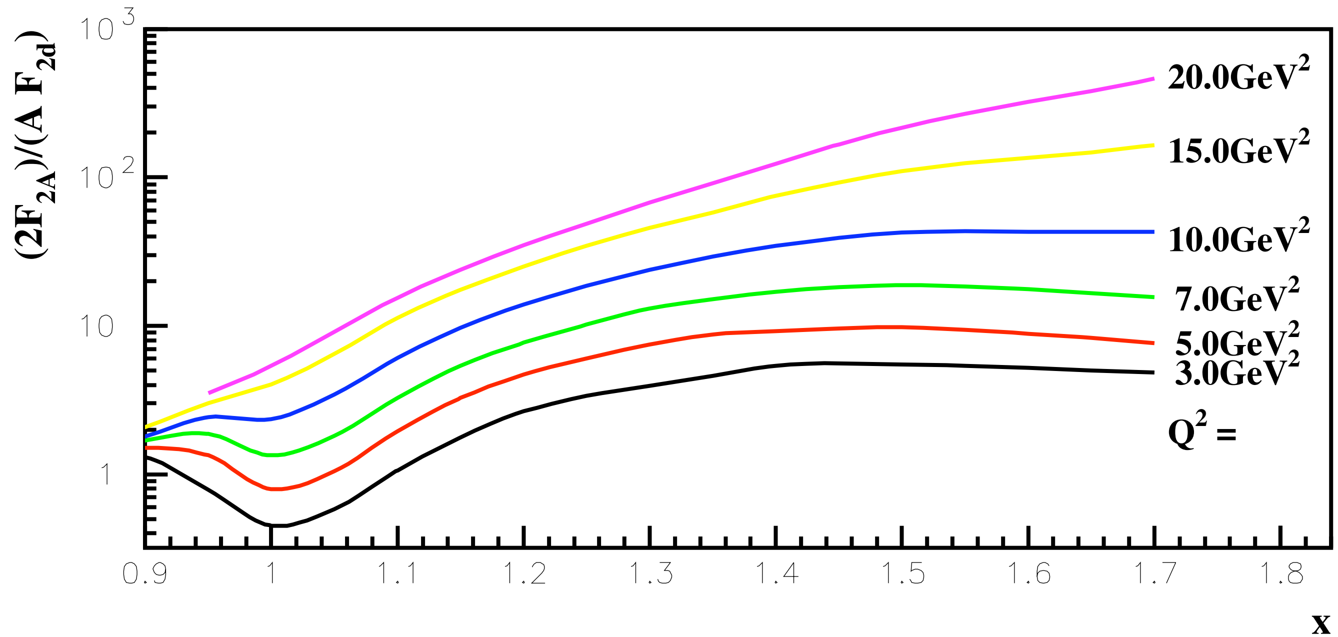
EIC

$$Q^2_{max} = min(4E_eE_px, 4E_e^2)$$

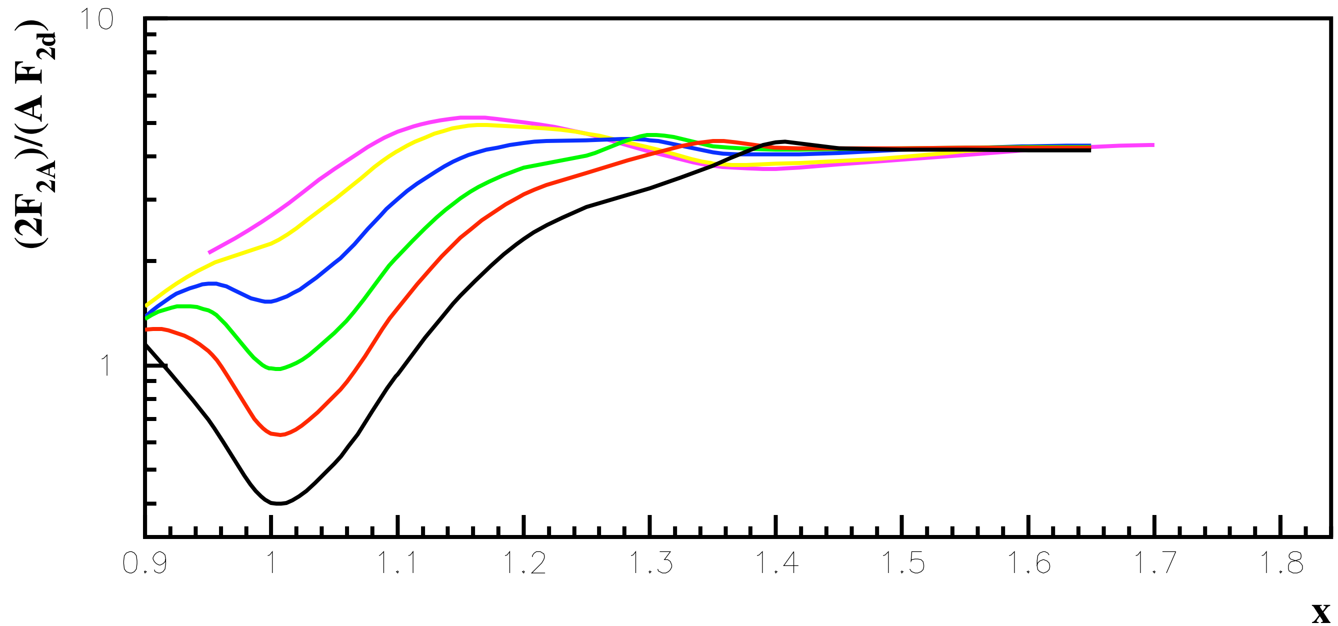
Superfast quarks in Heavy Nuclei



A/d Ratios with Parton Evalution



2N+3N models



2N models only

Summary

- DIS reactions at x>1 may allow to probe the content of the nuclear core

- It may allow to study the hadron-quark transition at short space time separation in nuclei

- EIC will allow to probe superfast qarks at larger Q2 and smaller x