

The Nuclear EMC Effect

Wanli Xing
The University of Adelaide



Supervised by:
Professor Anthony Thomas

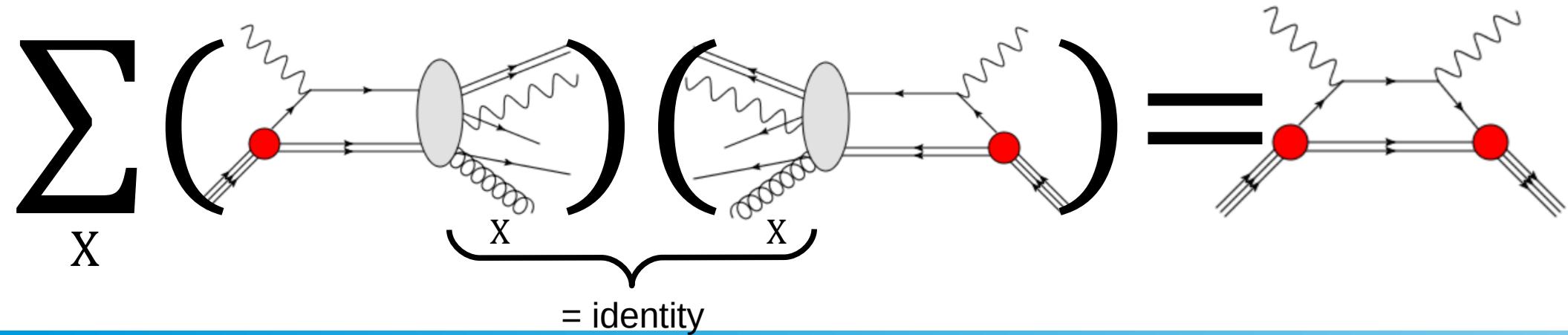
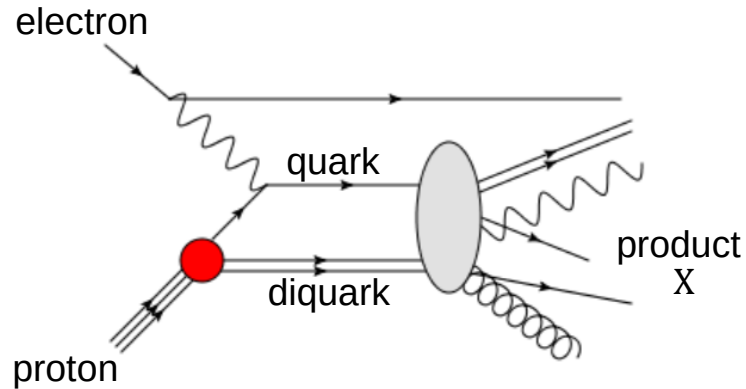


Wally Melnitchouk

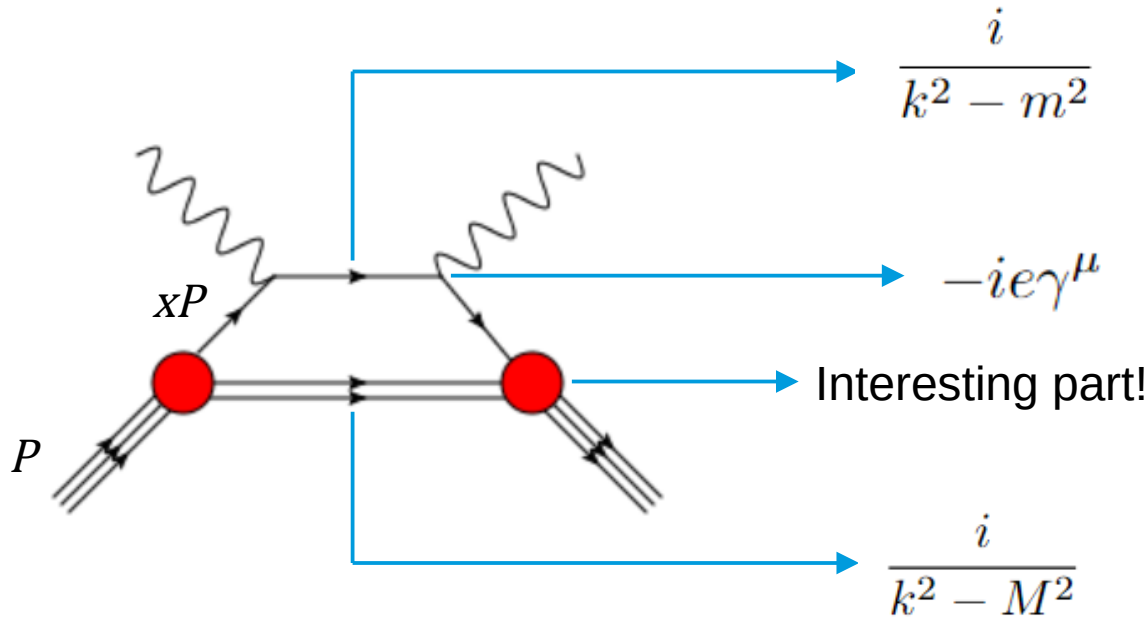


Xuan-Gong Wang

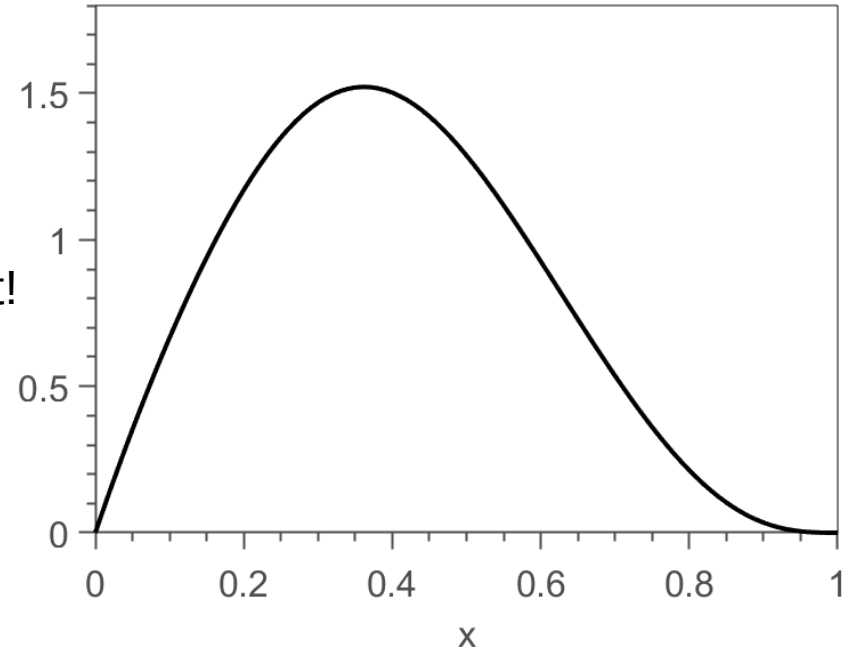
Deep Inelastic Scattering (DIS)



Deep Inelastic Scattering (DIS)

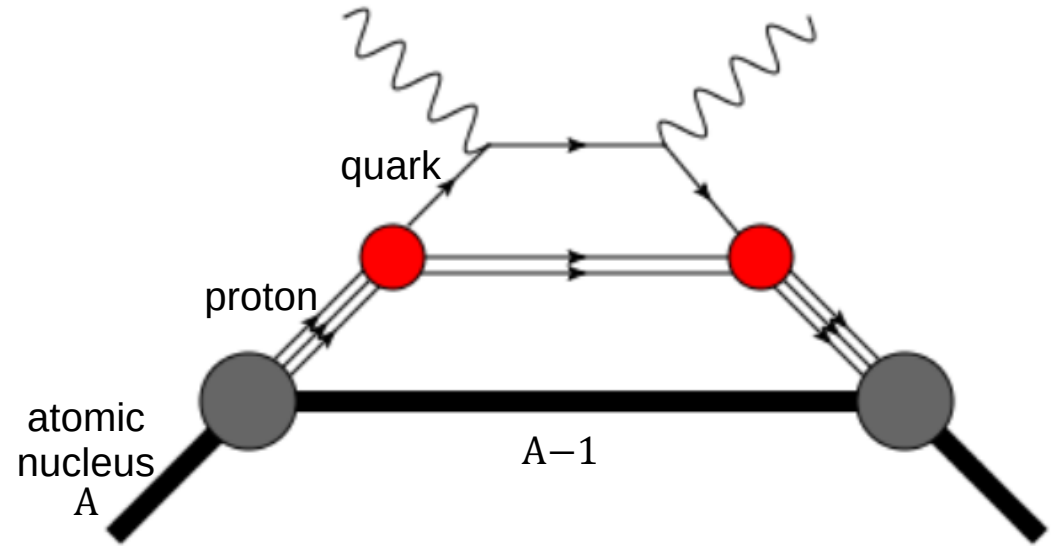
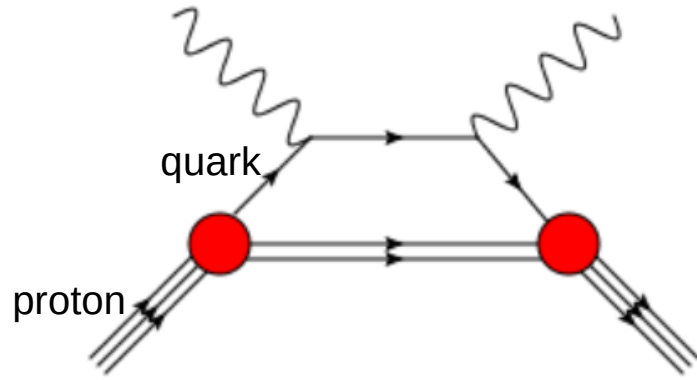


valence quark structure function $x(u+d)$



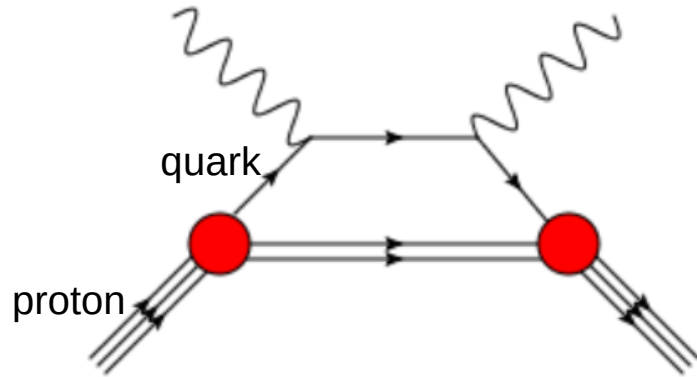
- “DIS cross section”
- “structure function”
- “parton distribution function (PDF)”

Free protons vs. protons in atomic nuclei



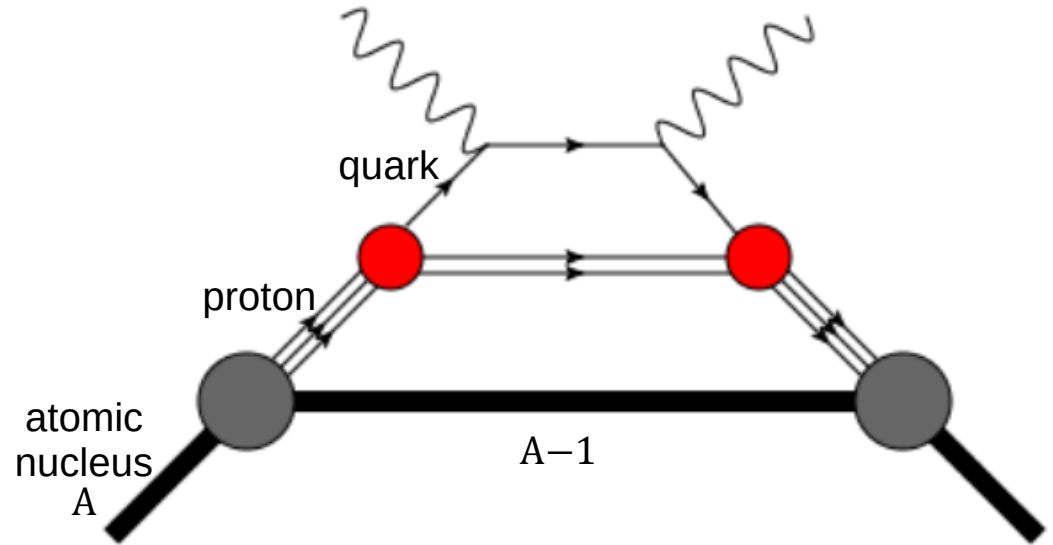
Significant difference?

Free protons vs. protons in atomic nuclei

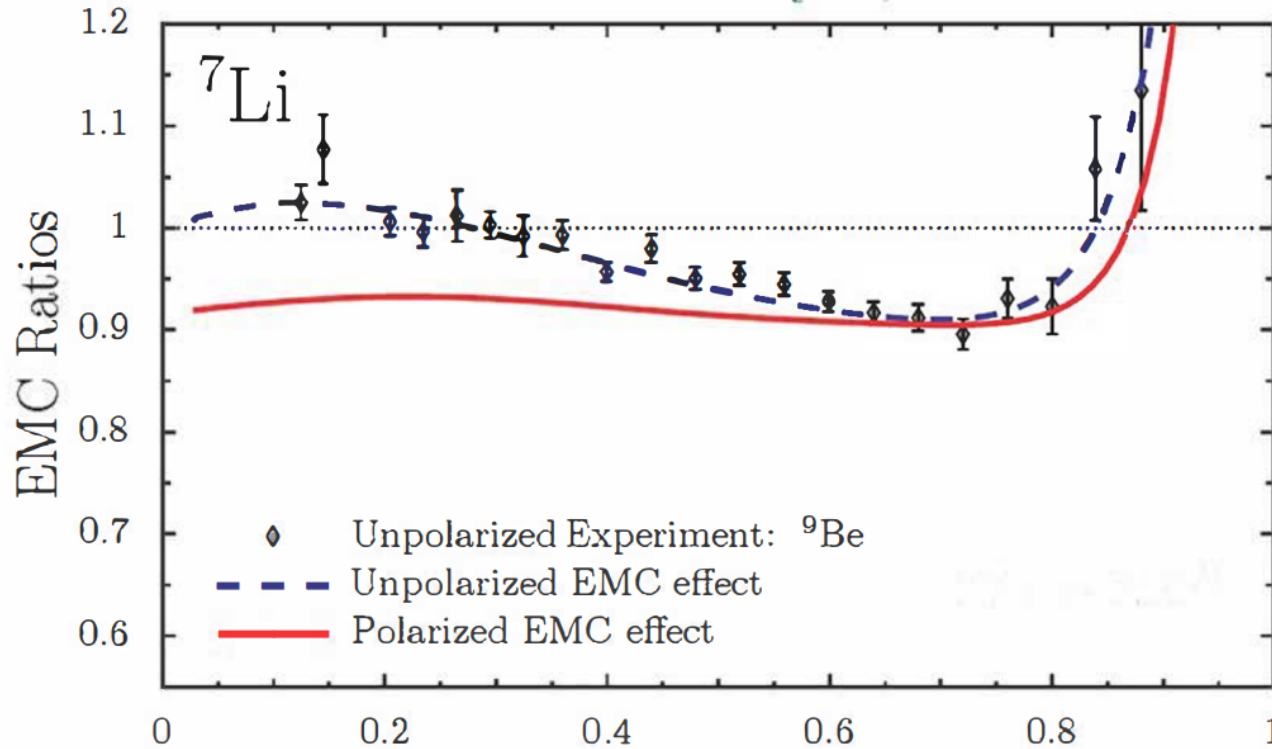


Nucleus binding energy: ~ 10 MeV
DIS energy scale: ~ 1 GeV
Difference $\sim 1\%$?

Reality: $\sim 10\%$!! \rightarrow **EMC effect.**
Quark structures modified by nuclear environment!
EMC effect \uparrow as nucleus size \uparrow



Explanation 1: Mean-field modification



- EMC effect: Ratios of cross sections of different nuclei $\neq 1$
- Mean-field modification: Constant modification of nuclear environment

Explanation 2: Short-range correlation (SRC)

Nucleon randomly pair up sometimes

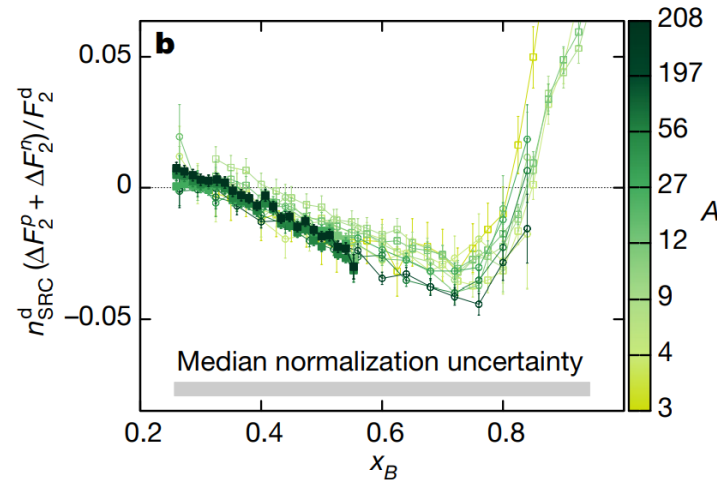
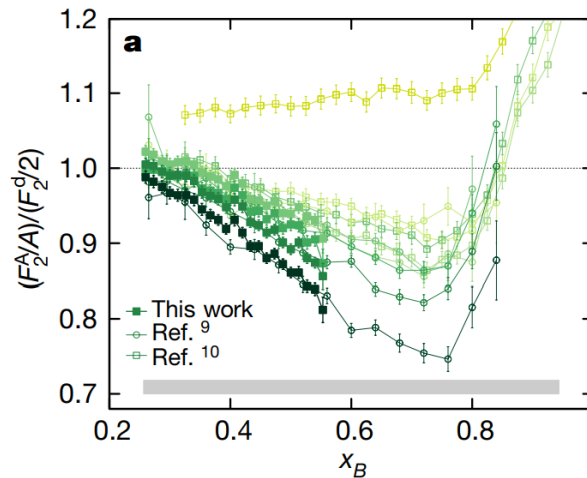
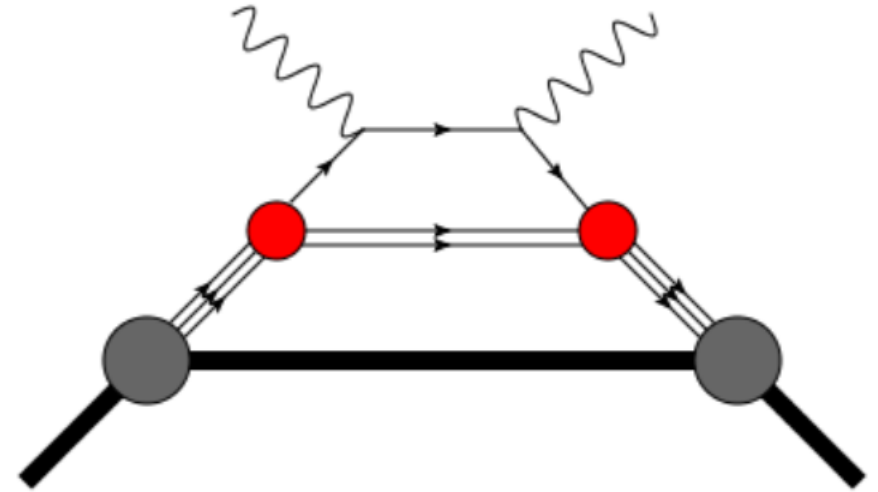
Letter | [Published: 20 February 2019](#)

Modified structure of protons and neutrons in correlated pairs

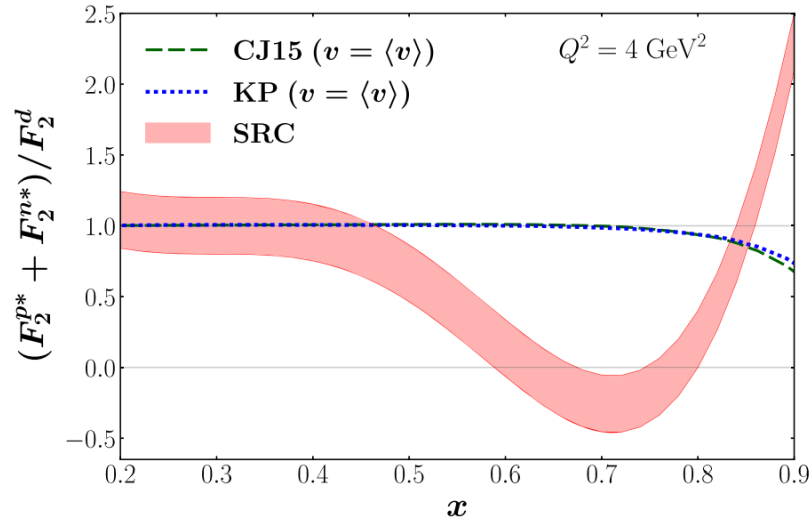
[The CLAS Collaboration](#)

Nature **566**, 354–358 (2019) | [Cite this article](#)

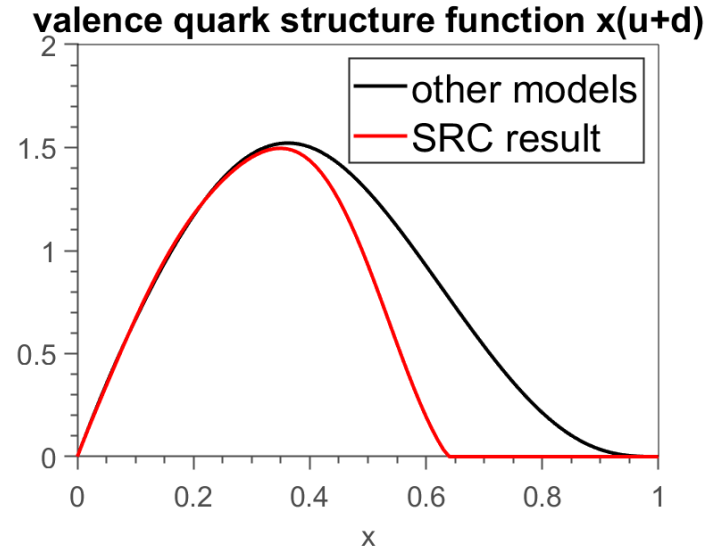
9670 Accesses | 75 Citations | 168 Altmetric | [Metrics](#)



Explanation 2: Short-range correlation (SRC)



PHYSICAL REVIEW LETTERS **125**, 262002 (2020)



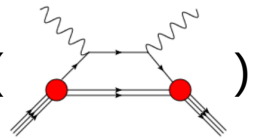
Do Short-Range Correlations Cause the Nuclear EMC Effect in the Deuteron?

X. G. Wang¹, A. W. Thomas¹ and W. Melnitchouk²

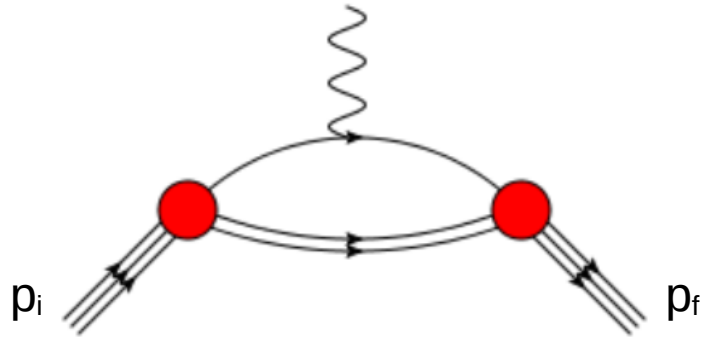
¹CSSM and ARC Centre of Excellence for Particle Physics at the Terascale, Department of Physics, University of Adelaide, Adelaide, South Australia 5005, Australia

²Jefferson Lab, Newport News, Virginia 23606, USA

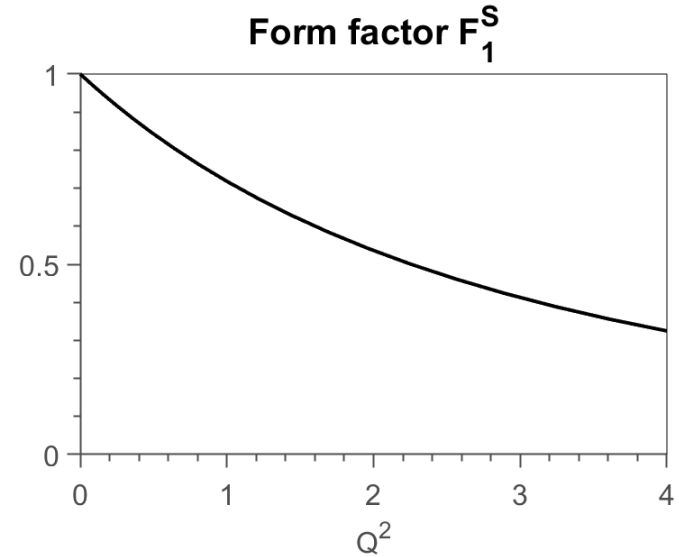
“Off-shell structure function” (of SRC model is strange!



Form factors in elastic scattering



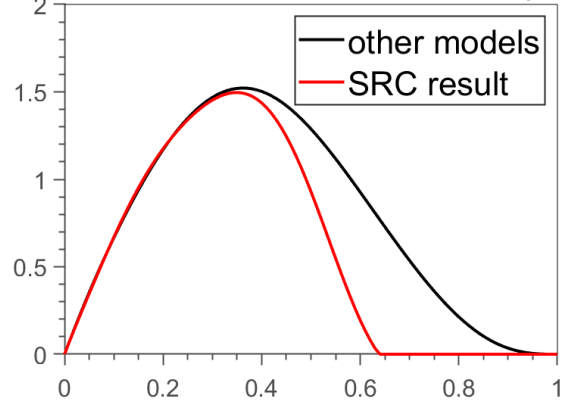
Amplitude for *elastic scattering*



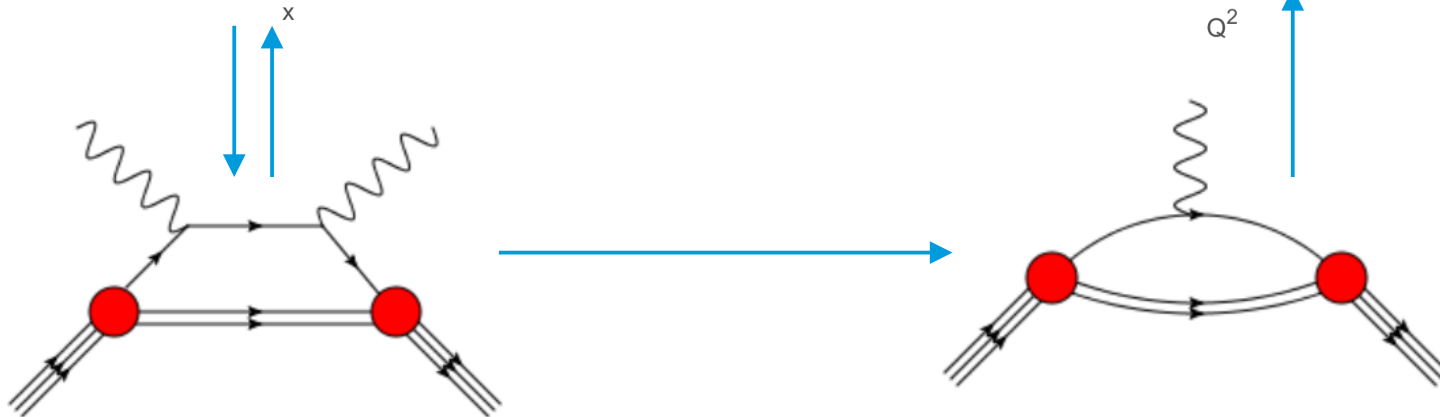
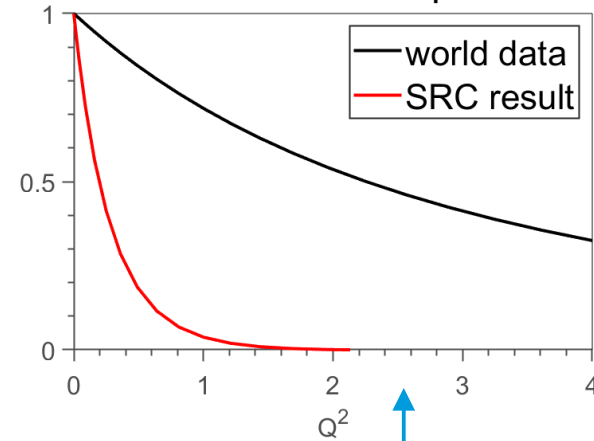
form factors

Testing the SRC hypothesis

valence quark structure function $x(u+d)$



Form factor F_1^S



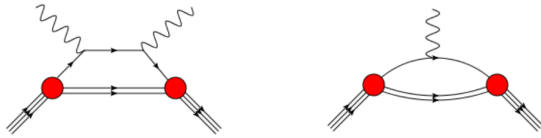
Testing the SRC hypothesis

PHYSICAL REVIEW D

VOLUME 49, NUMBER 3

1 FEBRUARY 1994

1) MST model



2) Light cone wavefunctions

e.g. form factors \sim amplitude $(p_i \rightarrow p_f) \sim \sum_{\text{quarks}} \Psi^*(p_f) \Psi(p_i)$

3) Quark-hadron duality – intuitive and qualitative

All three methods: Same conclusion!

SRC model predicts unrealistically suppressed form factors!

Deep-inelastic scattering from off-shell nucleons

W. Melnitchouk*

Department of Physics and Mathematical Physics, University of Adelaide, Adelaide, South Australia 5005

A. W. Schreiber

Paul Scherrer Institut, Würenlingen und Villigen, CH-5232 Villigen PSI, Switzerland

A. W. Thomas

Department of Physics and Mathematical Physics, University of Adelaide, Adelaide, South Australia 5005

(Received 24 June 1993)

Moral

SRC is probably NOT the leading cause of the EMC effect!