

Non-Universal Anti-Shadowing

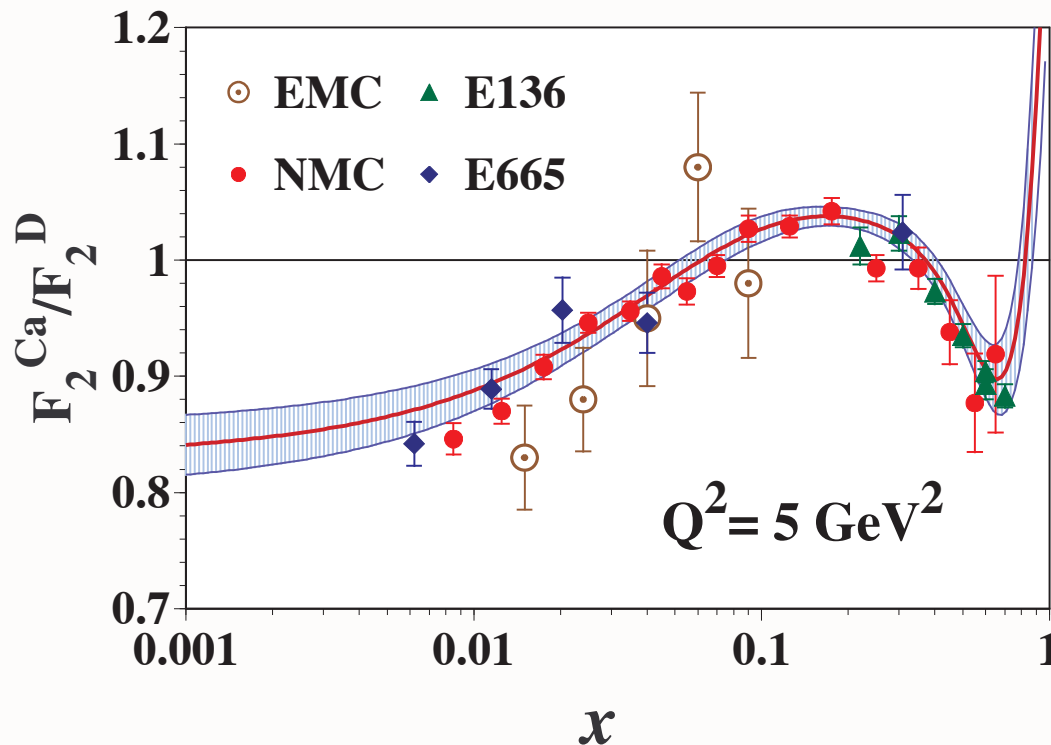
High Energy Nuclear Physics and QCD

Florida International University

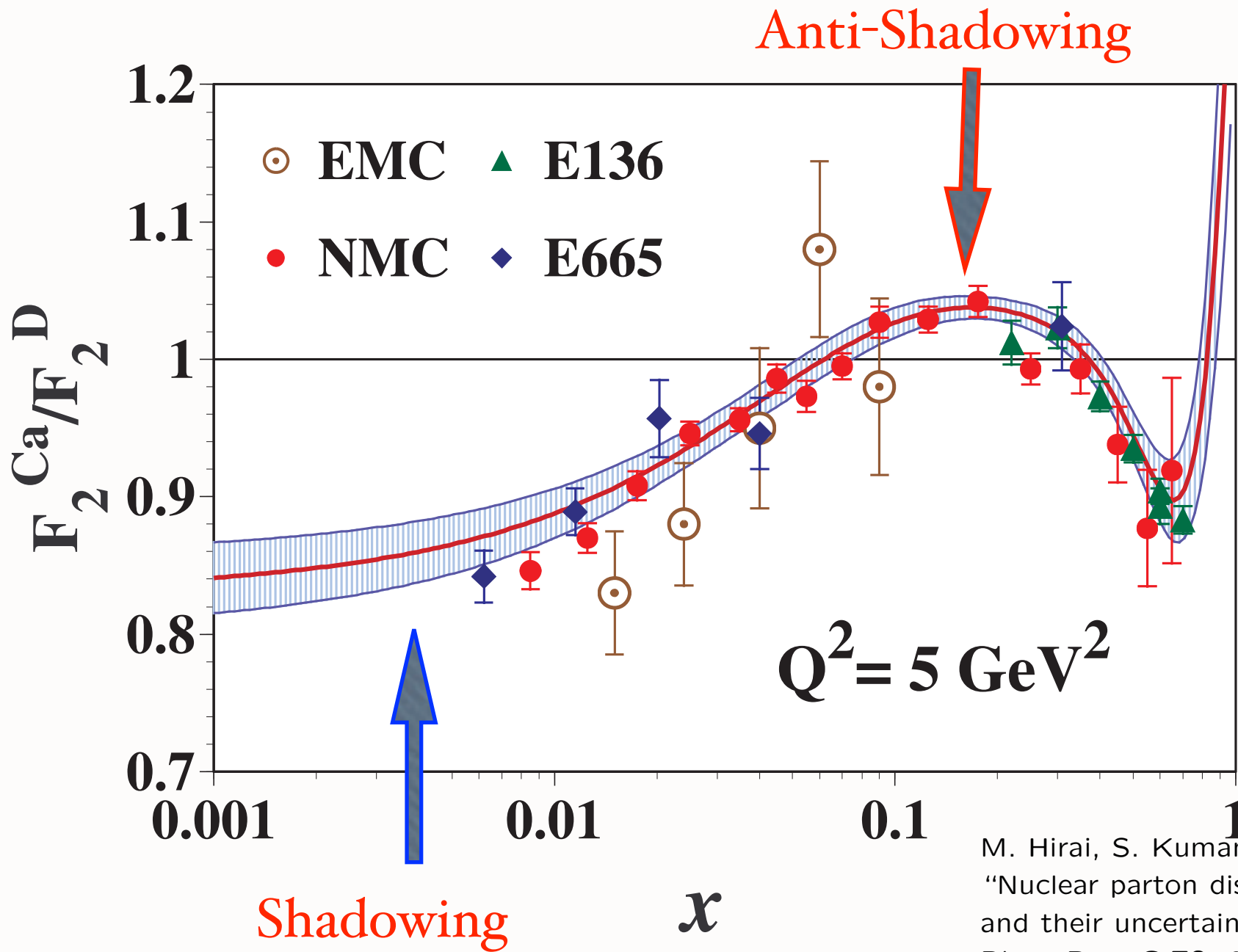
February 5, 2010

Mark Strikman: QCD Pioneer

Happy #60!



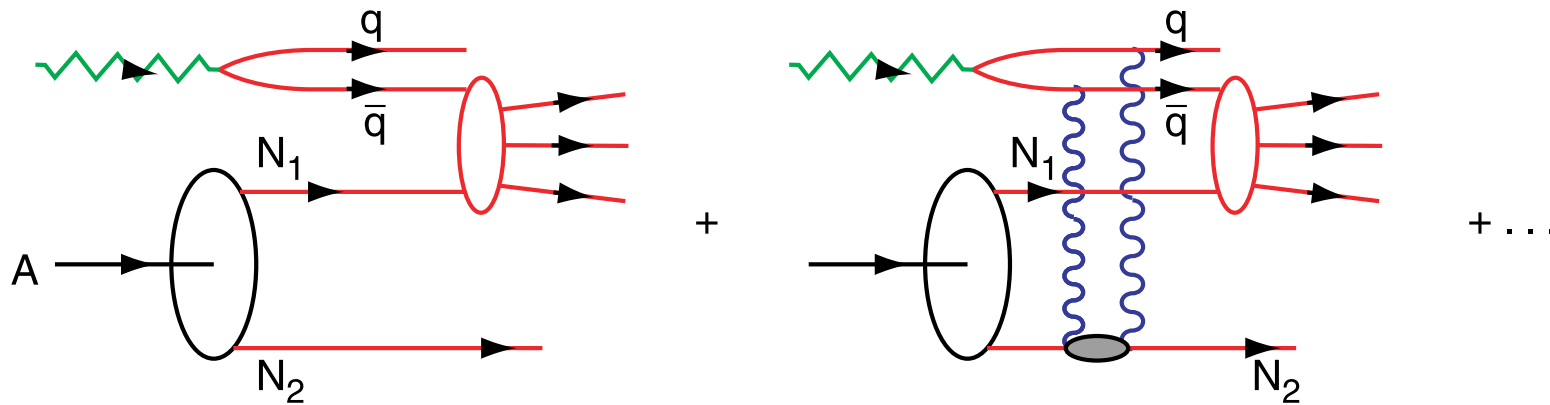
Stan Brodsky, SLAC National Accelerator Laboratory



M. Hirai, S. Kumano and T. H. Nagai,
 "Nuclear parton distribution functions
 and their uncertainties,"
 Phys. Rev. C **70**, 044905 (2004)
 [arXiv:hep-ph/0404093].

Nuclear Shadowing in QCD

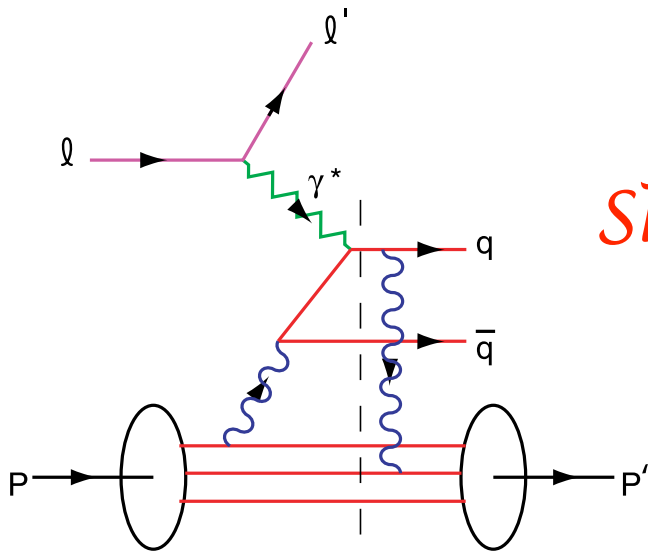
Destructive Interference



Shadowing depends on understanding leading twist-diffraction in DIS

Nuclear Shadowing not included in nuclear LFWF !

Dynamical effect due to virtual photon interacting in nucleus



Shadowing depends on leading-twist DDIS

Integration over on-shell domain produces phase i

Need Imaginary Phase to Generate Pomeron

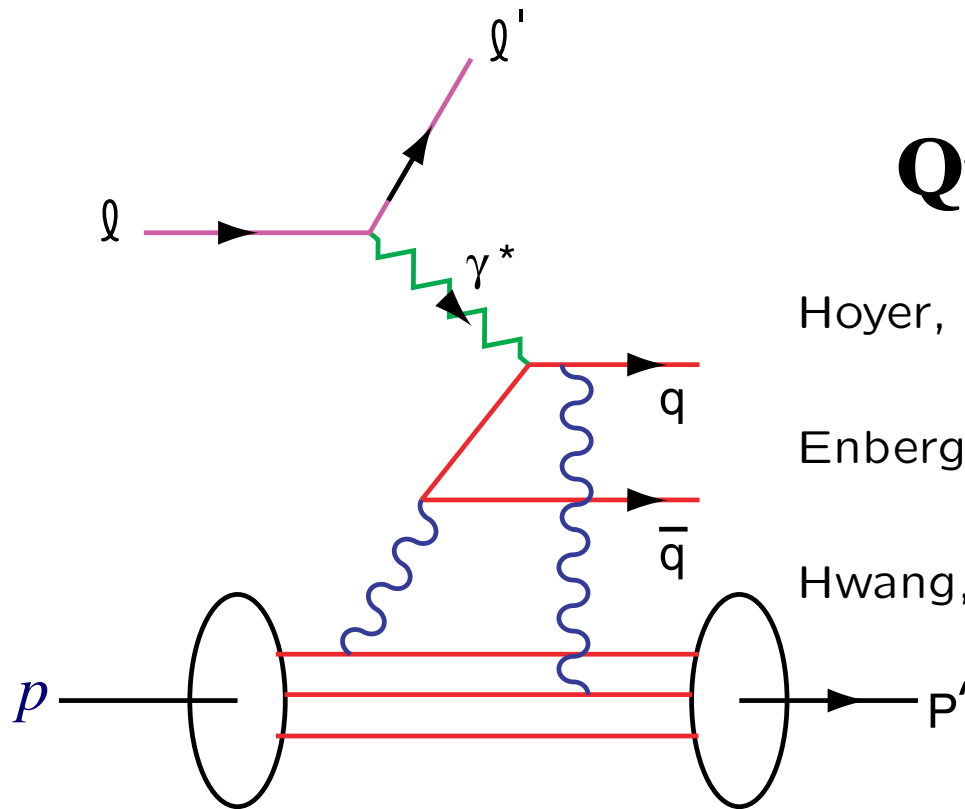
***Need Imaginary Phase to Generate T-Odd
Single-Spin Asymmetry***

Physics of FSI not in Wavefunction of Target

Antishadowing (Reggeon exchange) is not universal!

Schmidt, Yang, sjb

Final-State QCD Interaction Produces Diffractive DIS



Quark Rescattering

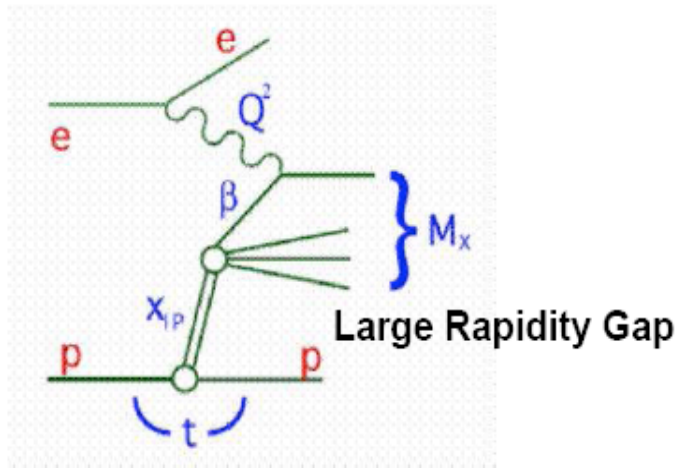
Hoyer, Marchal, Peigne, Sannino, SJB (BHMPS)

Enberg, Hoyer, Ingelman, SJB

Hwang, Schmidt, SJB

Low-Nussinov model of Pomeron

Diffractive Structure Function F_2^D



Diffractive inclusive cross section

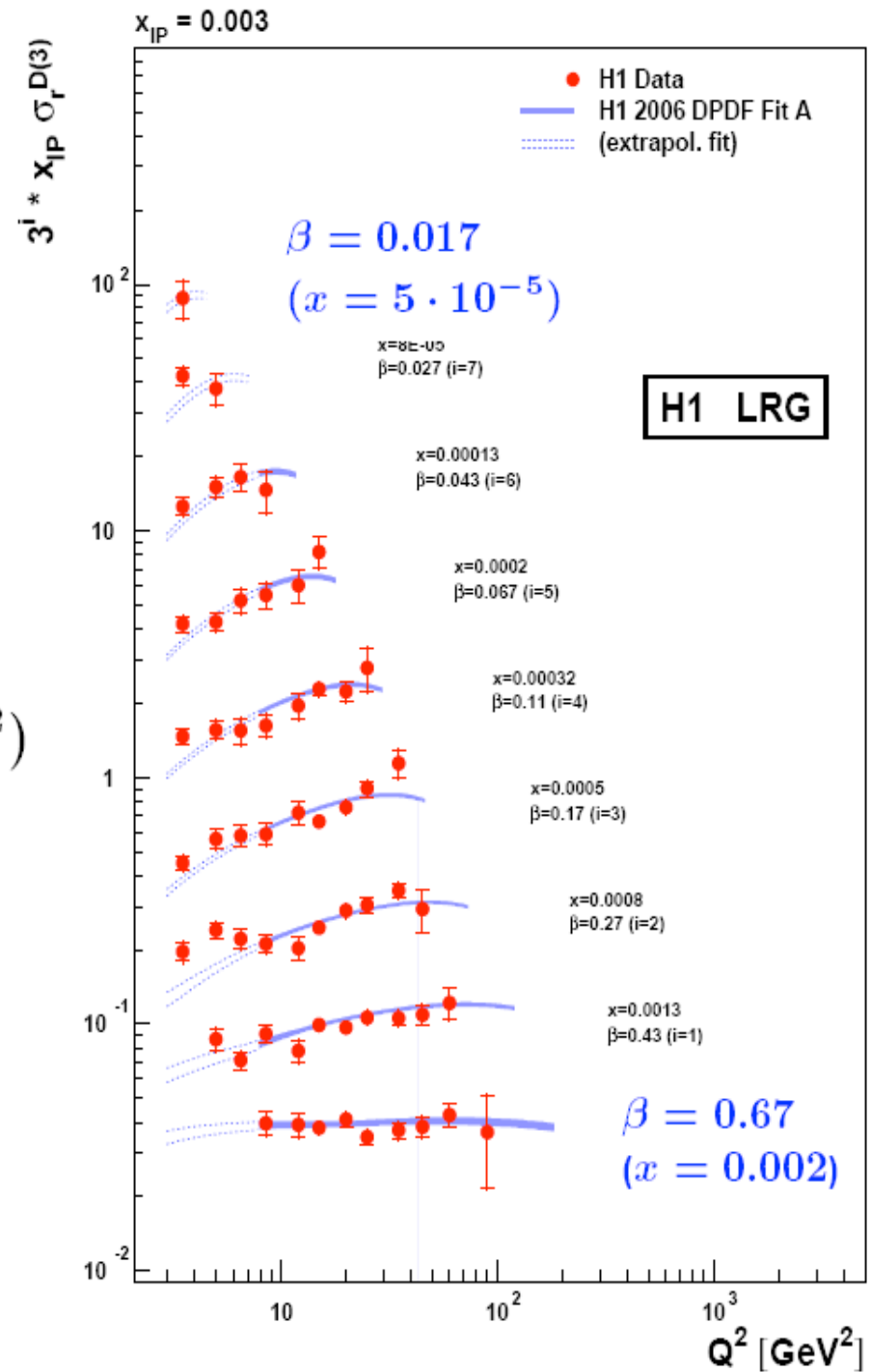
$$\frac{d^3 \sigma_{NC}^{diff}}{dx_{IP} d\beta dQ^2} \propto \frac{2\pi\alpha^2}{xQ^4} F_2^{D(3)}(x_{IP}, \beta, Q^2)$$

$$F_2^D(x_{IP}, \beta, Q^2) = f(x_{IP}) \cdot F_2^{IP}(\beta, Q^2)$$

extract DPDF and $xg(x)$ from scaling violation

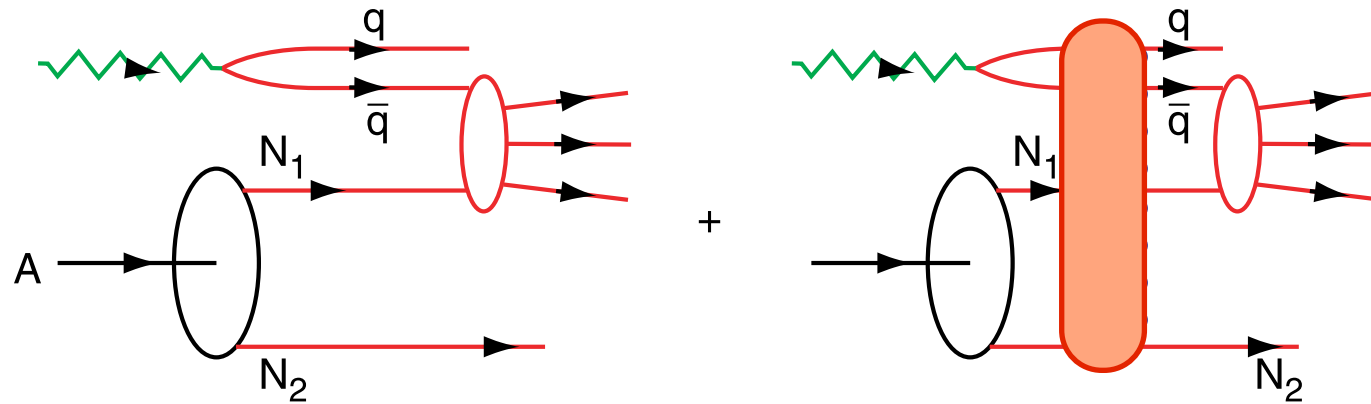
Large kinematic domain $3 < Q^2 < 1600 \text{ GeV}^2$

Precise measurements sys 5%, stat 5–20%



Nuclear Anti-shadowing in QCD

Constructive Interference Flavor-Specific!



**Diffractive
Reggeon
Exchange**

Antishadowing (Reggeon exchange) is not universal!

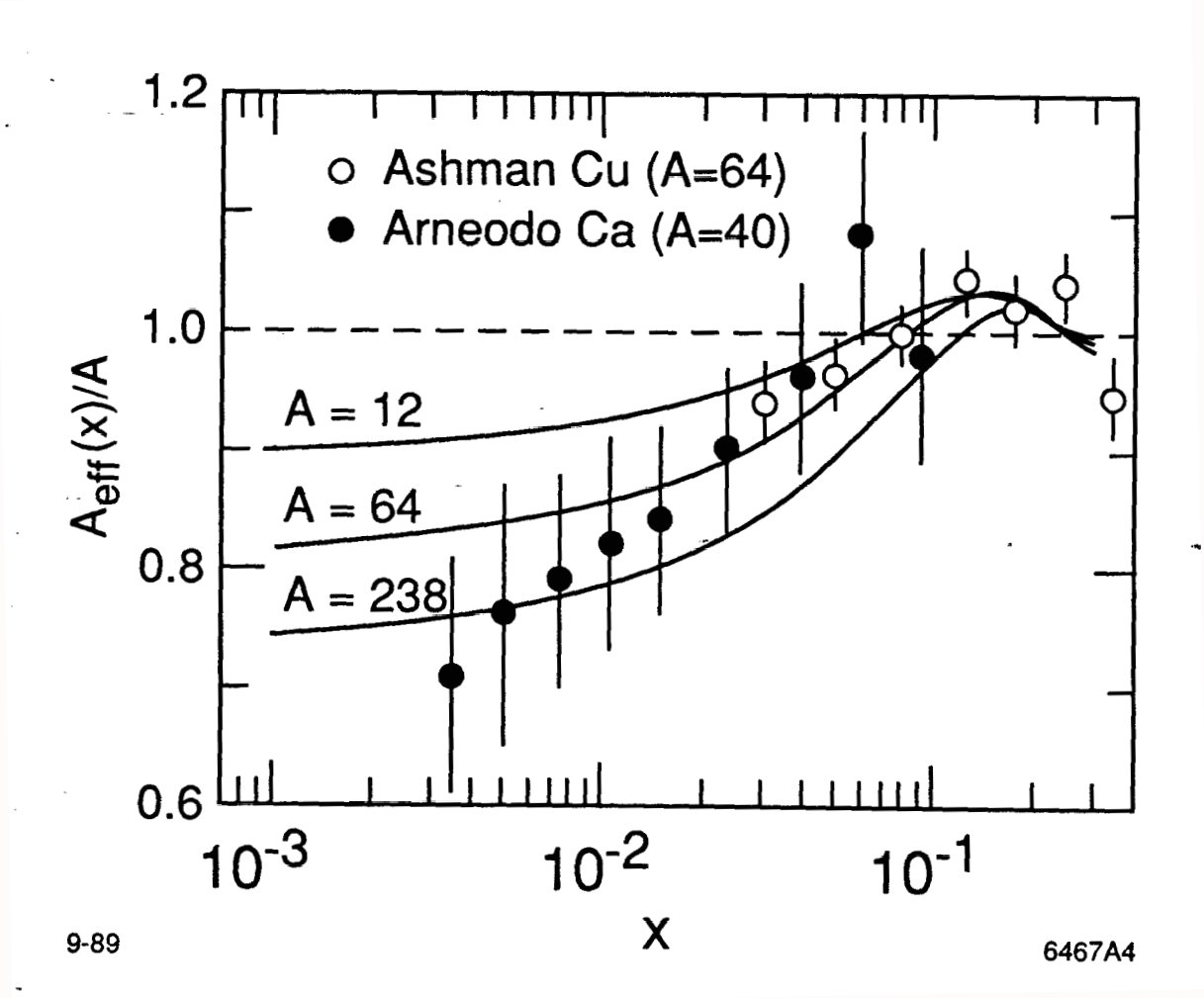
Reggeon coupling fixed from Kuti-Weisskopf: $F_{2p}(x) - F_{2n}(x) \simeq Cx^{1/2}$

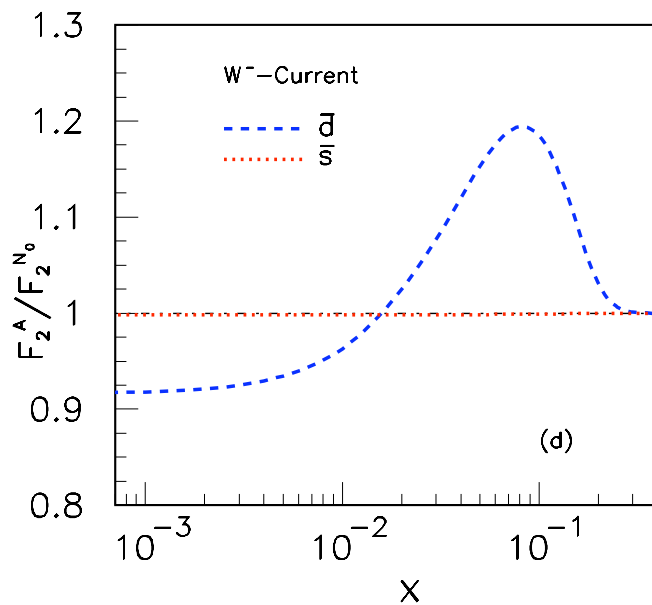
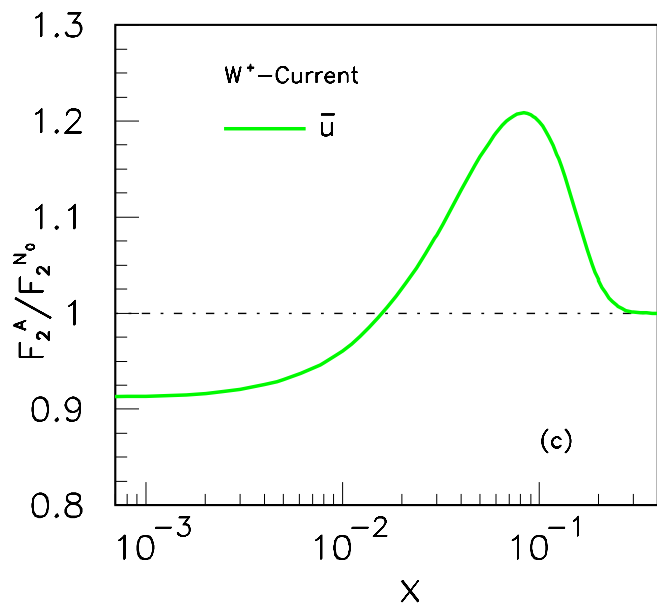
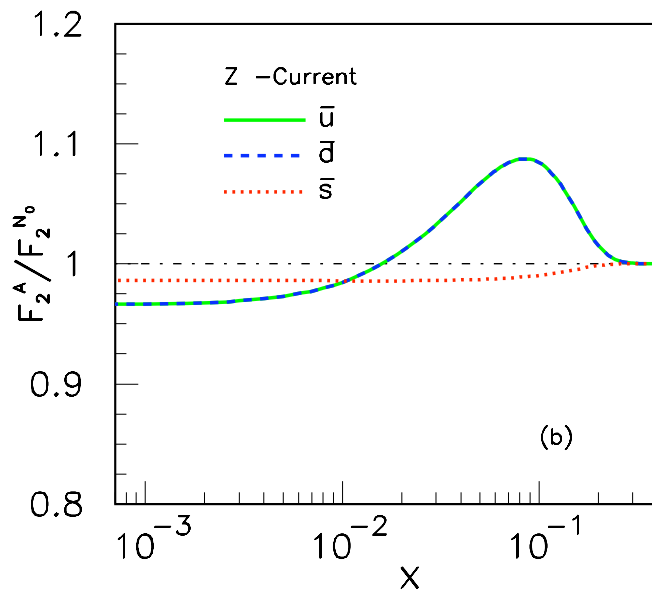
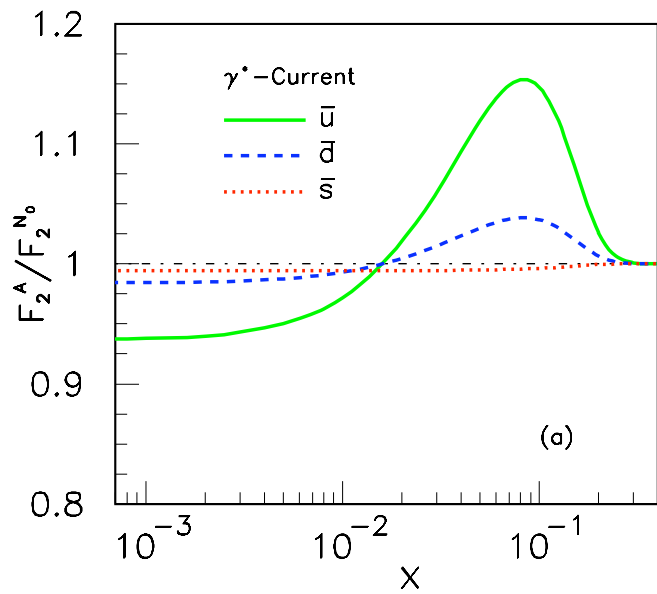
Nuclear Anti-shadowing not included in nuclear LFWF !

Dynamical effect due to virtual photon interacting in nucleus

$$T_{\bar{q}N}^{sea}(s, \nu^2) = \sigma[is\beta_1(\nu^2) + 1.2(1-i)s^{1/2}\beta_{1/2}(\nu^2)]$$

$$T_{\bar{q}N}^{valence}(s, \nu^2) = \sigma[-0.2(1-i)s^{1/2}\beta_{1/2}(\nu^2) + is^{-1}\beta_{-1}(\nu^2)]$$





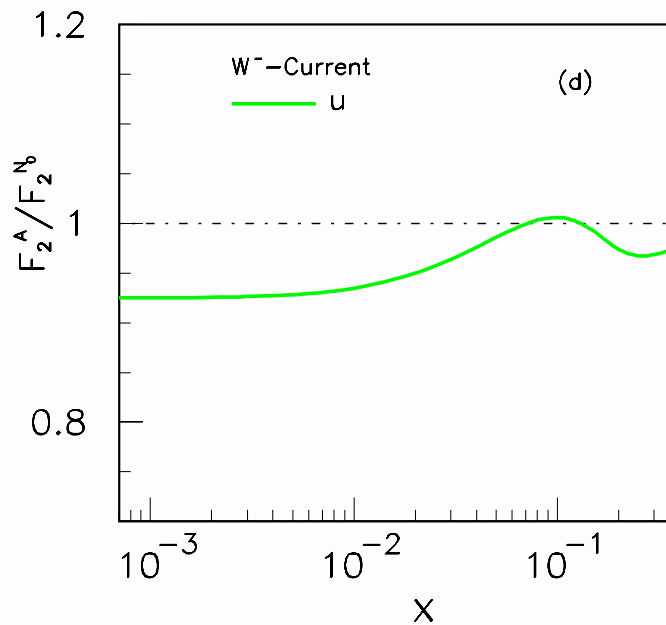
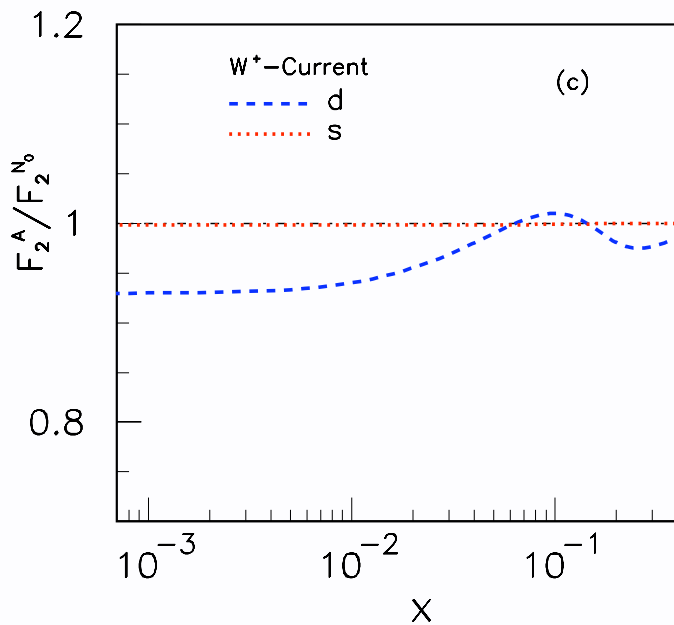
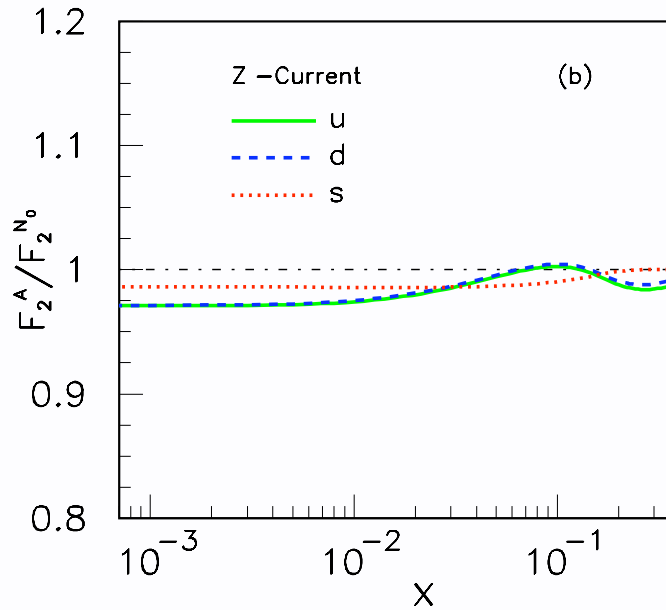
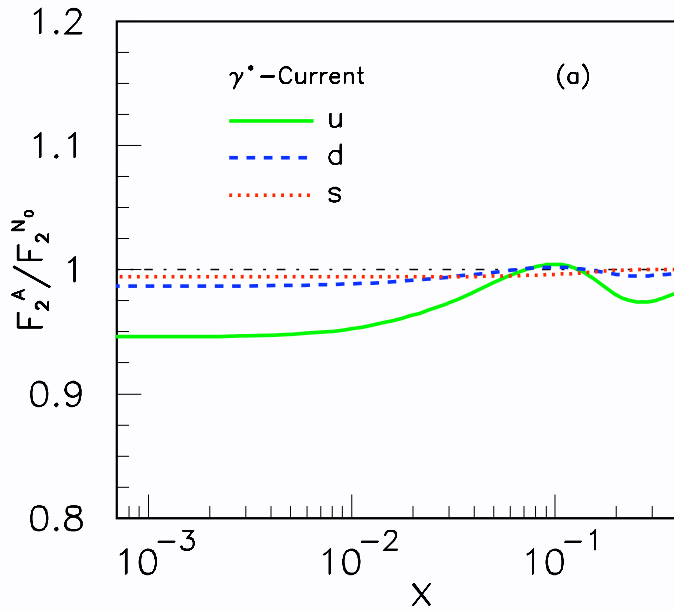
Schmidt, Yang; sjb

**Reggeon
Contribution to
DDIS
Constructive
Interference!**

**Phase from
signature factor**

Nuclear Antishadowing not universal!

Shadowing and Antishadowing of DIS Structure Functions

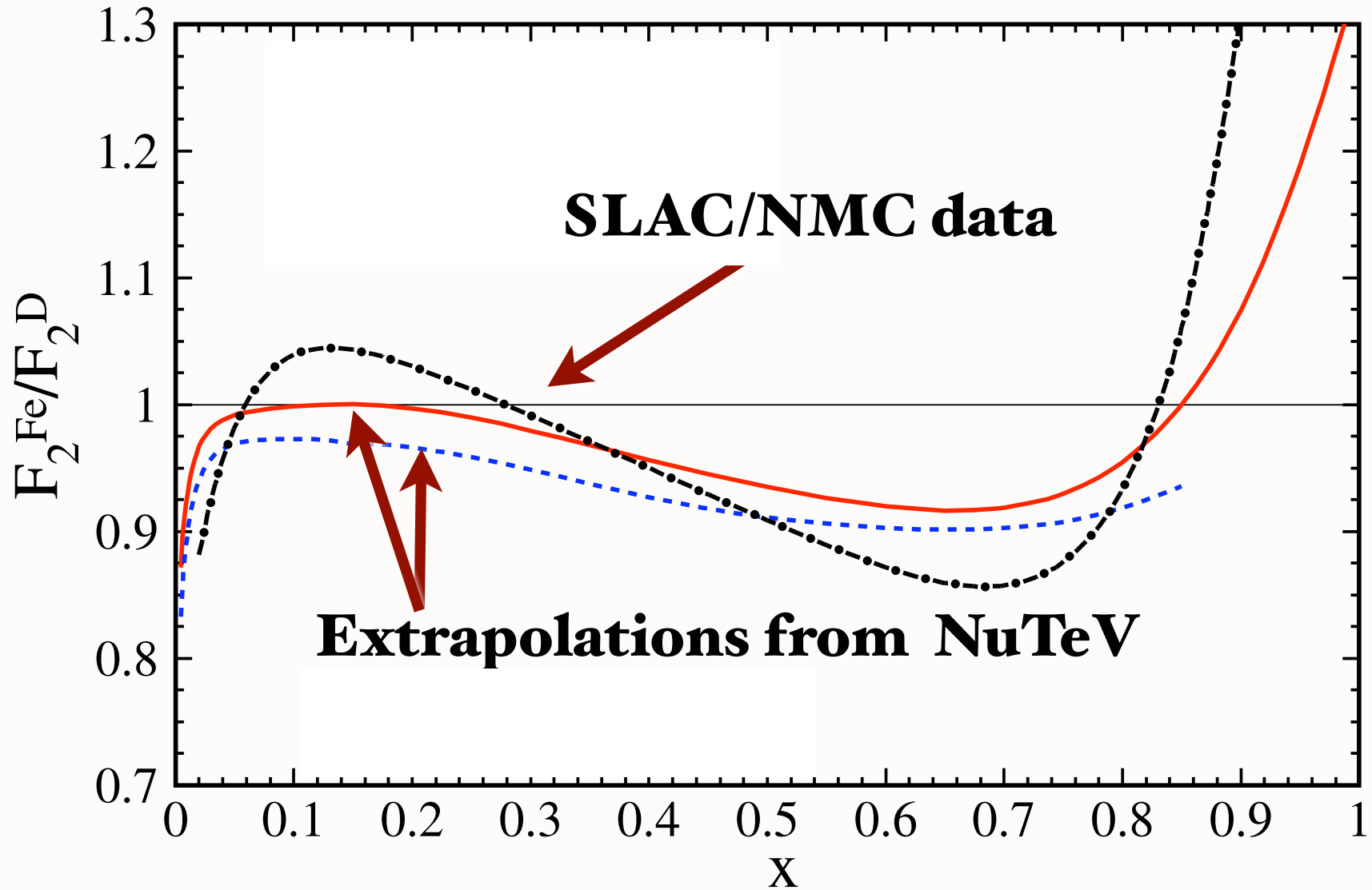


S. J. Brodsky, I. Schmidt and J. J. Yang
 “Nuclear Antishadowing in
 Neutrino Deep Inelastic Scattering,”
 Phys. Rev. D 70, 116003 (2004)
 [arXiv:hep-ph/0409279].

Modifies
NuTeV extraction of
 $\sin^2 \theta_W$

**Test in flavor-tagged
 lepton-nucleus collisions**

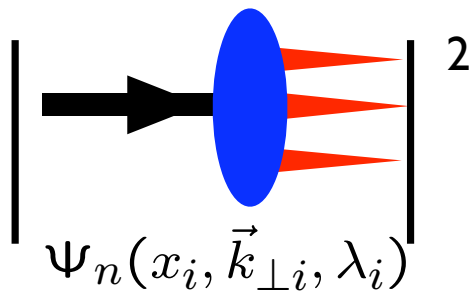
$$Q^2 = 5 \text{ GeV}^2$$



Scheinbein, Yu, Keppel, Morfin, Olness, Owens

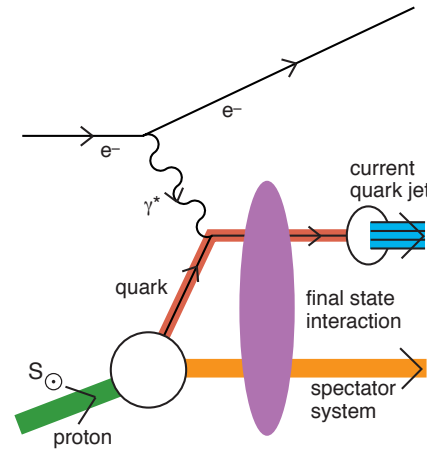
Static

- Square of Target LFWFs
- No Wilson Line
- Probability Distributions
- Process-Independent
- T-even Observables
- No Shadowing, Anti-Shadowing
- Sum Rules: Momentum and J^z
- DGLAP Evolution; mod. at large x
- No Diffractive DIS



Dynamic

- Modified by Rescattering: ISI & FSI
- Contains Wilson Line, Phases
- No Probabilistic Interpretation
- Process-Dependent - From Collision
- T-Odd (Sivers, Boer-Mulders, etc.)
- Shadowing, Anti-Shadowing, Saturation
- Sum Rules Not Proven
- DGLAP Evolution
- Hard Pomeron and Odderon Diffractive DIS



**Hwang,
Schmidt, sjb,
Mulders, Boer
Qiu, Sterman
Collins, Qiu**

**Pasquini, Xiao,
Yuan, sjb**
Augmented LFWF