DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

Jefferson Lab PAC36
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Longitudinal structure of hadrons

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Outline

- Spin-*averaged* nucleon structure

E12-06-104
E12-10-002
PR12-06-113
PR12-06-118

→ d/u ratio at large x, with *minimal* nuclear corrections

→ new global QCD analysis ("CTEQ6X") with large-x focus
– importance of $1/Q^2$ corrections

→ resonance region structure / quark-hadron duality
– recent first confirmation for *neutron*

- Spin-*dependent* nucleon structure

E12-06-109
E12-06-121
E12-06-122
PR12-06-110

→ A_1 (or $\Delta u/u$, $\Delta d/d$) at large x

→ nuclear corrections for neutron extraction from ^{3}He or d

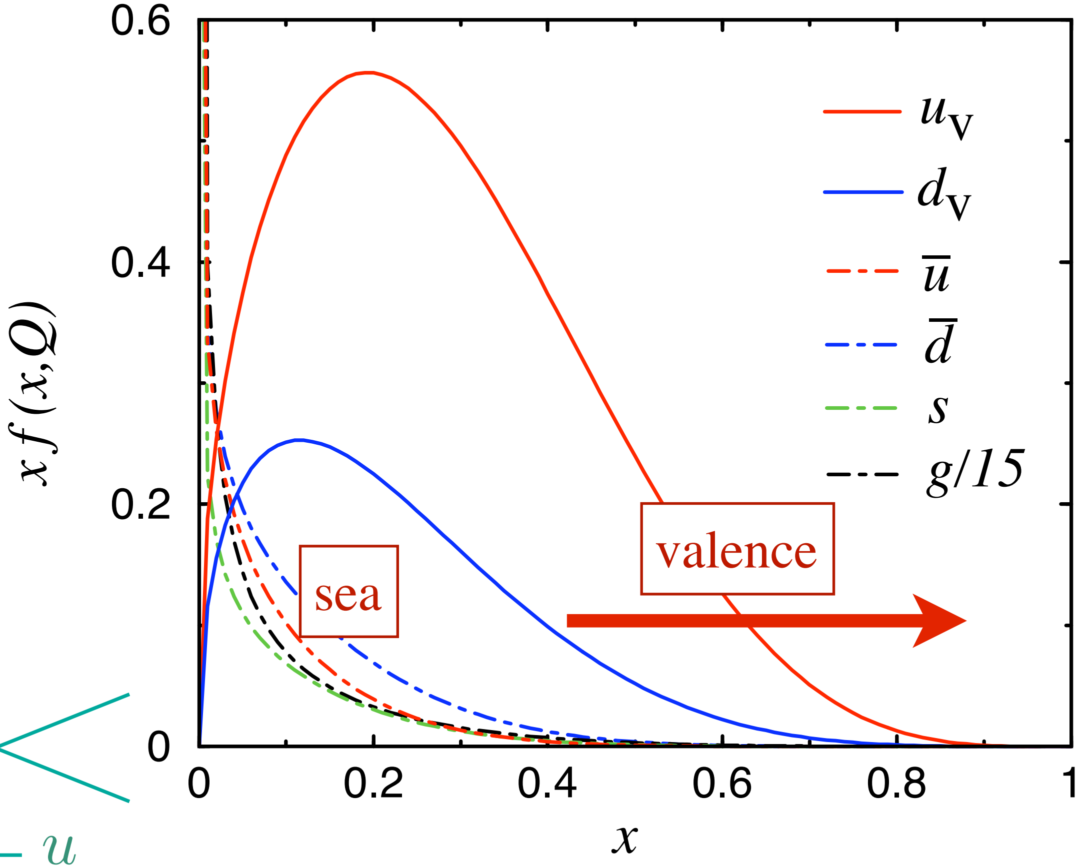
→ finite Q^2 corrections / higher twist extraction

Nucleon structure at large x:
spin-averaged

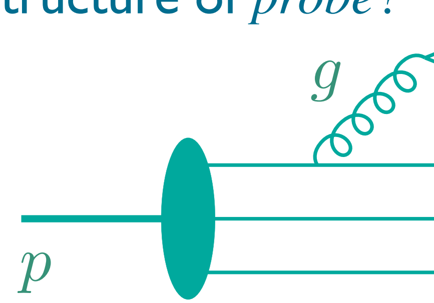
Why is nucleon structure at large x interesting?

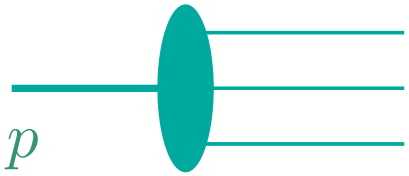
- Most direct connection between quark distributions and nonperturbative structure of nucleon is via *valence* quarks

  → most cleanly revealed at $x > 0.4$



structure of *hadron*
or structure of *probe*?





Why is nucleon structure at large x interesting?

- Most direct connection between quark distributions and nonperturbative structure of nucleon is via *valence* quarks

- Predictions for $x \to 1$ behavior of *e.g.* d/u ratio
  - → scalar diquark dominance: $d/u = 0$ *Feynman (1972)*
  - → hard gluon exchange: $d/u = 1/5$ *Farrar, Jackson (1975)*
  - → SU(6) symmetry: $d/u = 1/2$ *1960s*

- Needed to understand backgrounds in searches for *new physics* beyond the Standard Model at LHC or in ν oscillation experiments
  - → DGLAP evolution feeds low-x, high-Q^2 from high-x, low-Q^2

- At large x, valence u and d distributions determined from p and n structure functions, $e.g.$ at LO

$$\frac{1}{x}F_2^p \approx \frac{4}{9}u_v + \frac{1}{9}d_v$$

$$\frac{1}{x}F_2^n \approx \frac{4}{9}d_v + \frac{1}{9}u_v$$

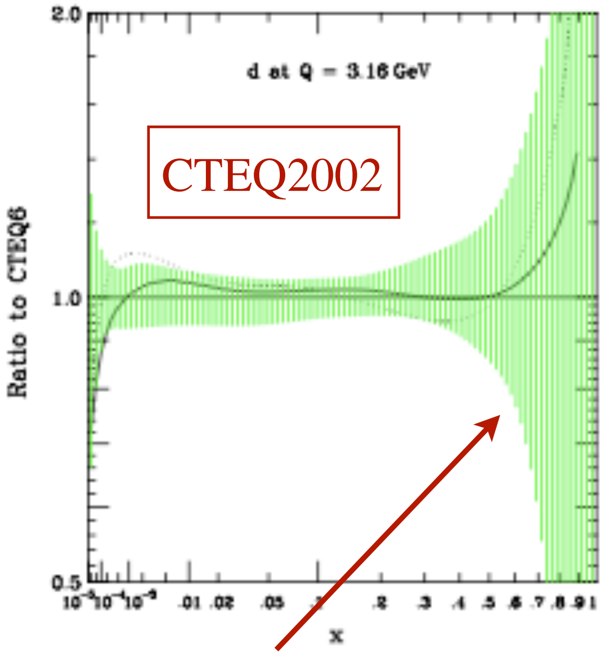
- u quark distribution well determined from *proton*
- d quark distribution requires *neutron* structure function

$$\Longrightarrow \qquad \frac{d}{u} \approx \frac{4 - F_2^n/F_2^p}{4F_2^n/F_2^p - 1}$$

- No **FREE** neutron targets

  (neutron half-life ~ 12 mins)

  ⟹ use deuteron as "effective" neutron target



large uncertainty beyond $x \sim 0.5$

- **BUT** deuteron is a nucleus

  ⟹ $F_2^d \neq F_2^p + F_2^n$

  ⟹ nuclear effects (nuclear binding, Fermi motion, shadowing) *obscure neutron structure* information

  ⟹ need to correct for "nuclear EMC effect"

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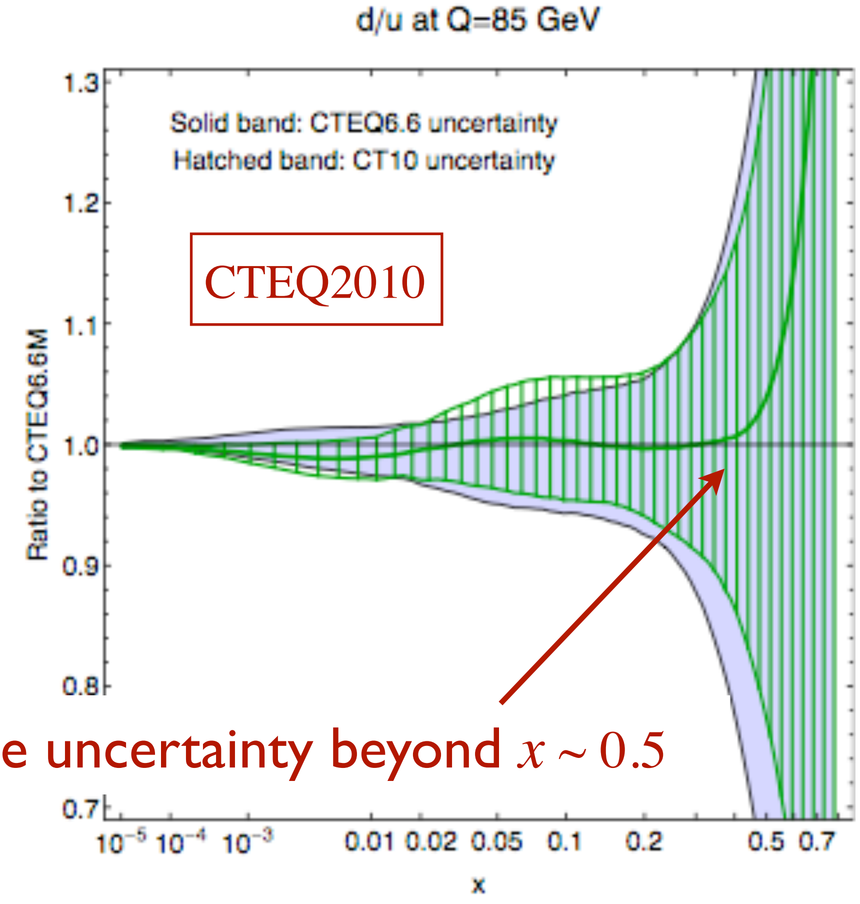

CTEQ2010

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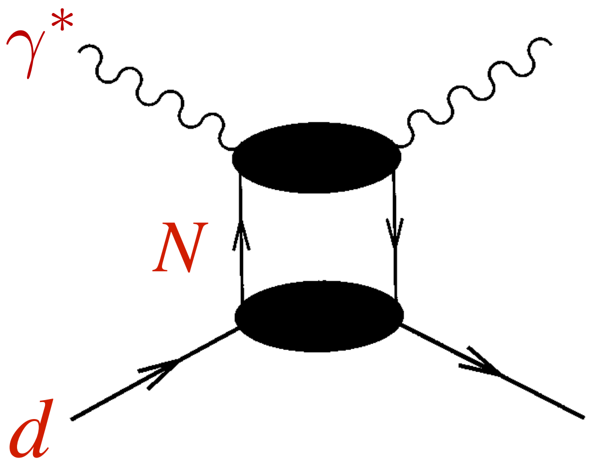
  ⟹ need to correct for "nuclear EMC effect"

EMC effect in deuteron

- Incoherent scattering from individual nucleons in d

  (good approx. at $x >> 0$)



N=p+n

$$F_2^d(x,Q^2) = \int_x dy\ f(y,\gamma)\ F_2^N(x/y,Q^2)$$

$$+\ \delta^{(\mathrm{off})} F_2^d$$

nucleon momentum distribution in d ("smearing function")

off-shell correction

→ $y = p\cdot q/P\cdot q$ light-cone momentum fraction of d carried by N

→ at finite Q^2, smearing function depends also on parameter

$$\gamma = |\mathbf{q}|/q_0 = \sqrt{1 + 4M^2x^2/Q^2}$$

EMC effect in deuteron

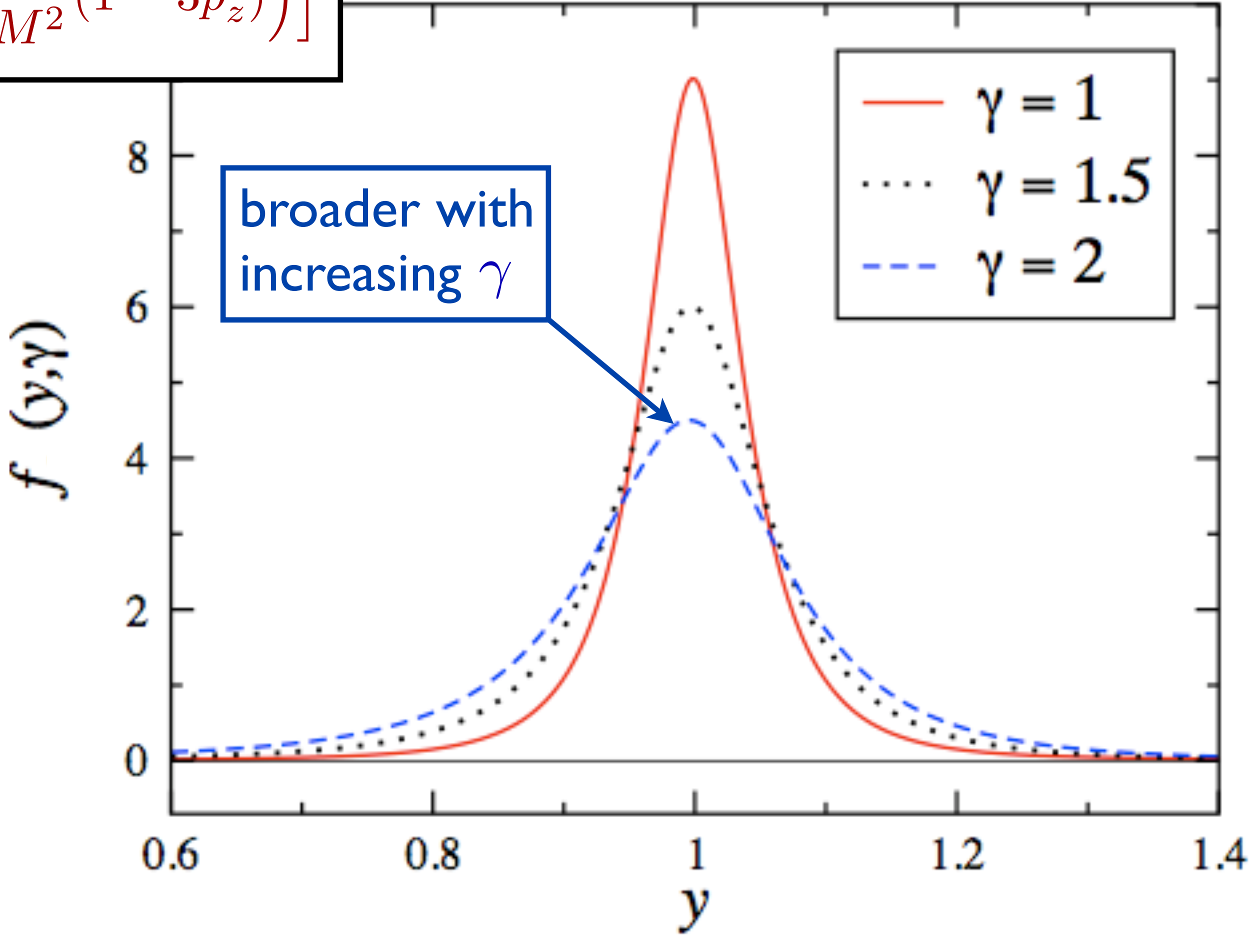
$$f(y,\gamma) = \int \frac{d^3p}{(2\pi)^3}\, |\psi_d(p)|^2\, \delta\Big(y - 1 - \frac{\varepsilon + \gamma p_z}{M}\Big)$$
$$\times \frac{1}{\gamma^2}\Big[1 + \frac{\gamma^2 - 1}{y^2}\Big(1 + \frac{2\varepsilon}{M} + \frac{\vec{p}^{\,2}}{2M^2}(1 - 3\hat{p}_z^2)\Big)\Big]$$

→ deuteron wave function $\psi_d(p)$

→ deuteron separation energy

$$\varepsilon = \varepsilon_d - \frac{\vec{p}^{\,2}}{2M}$$

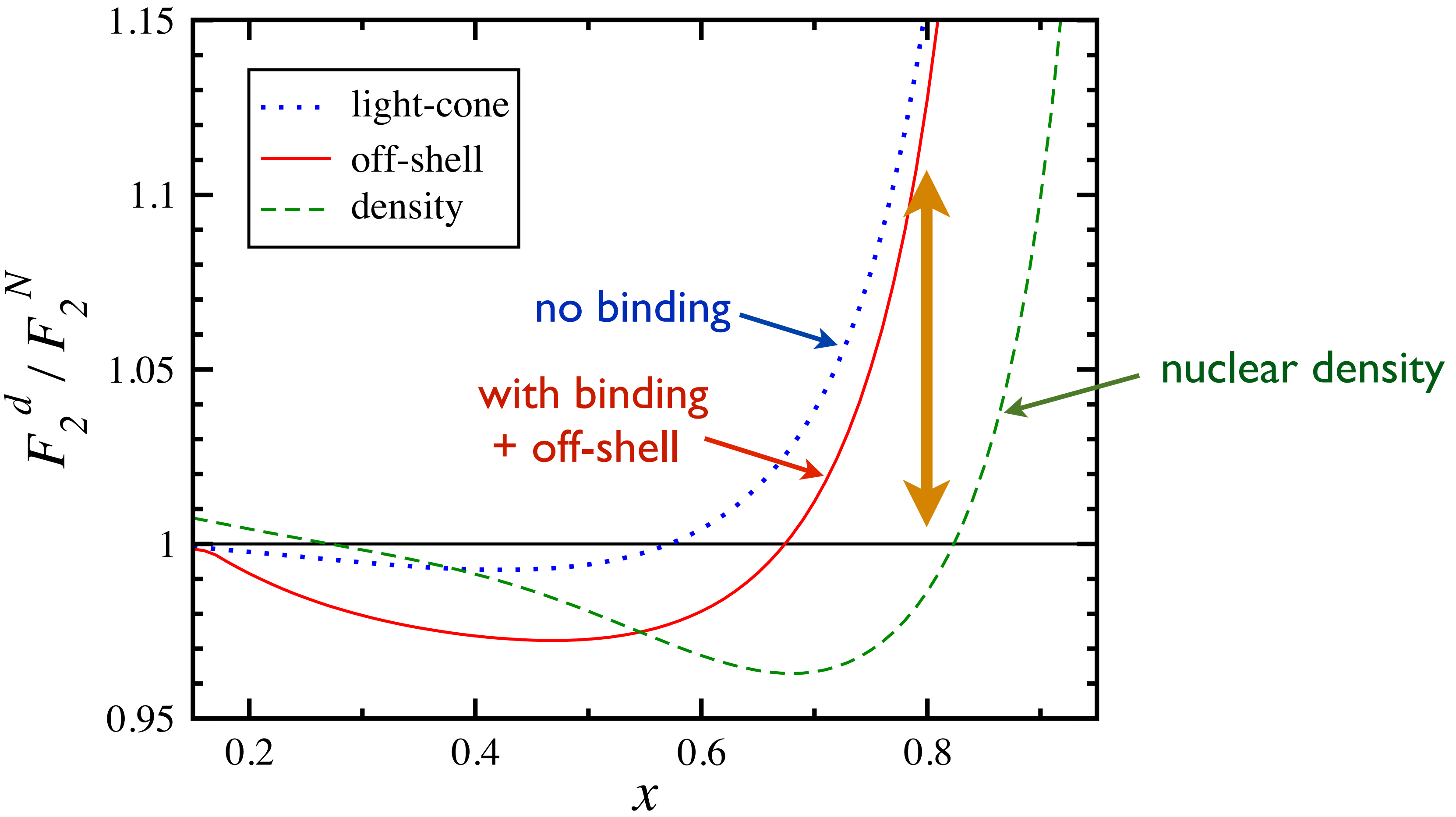
→ effectively more smearing for larger x or lower Q^2



broader with increasing γ

*Kulagin, Petti, NPA **765**, 126 (2006)*
*Kahn et al., PRC **79**, 035205 (2009)*

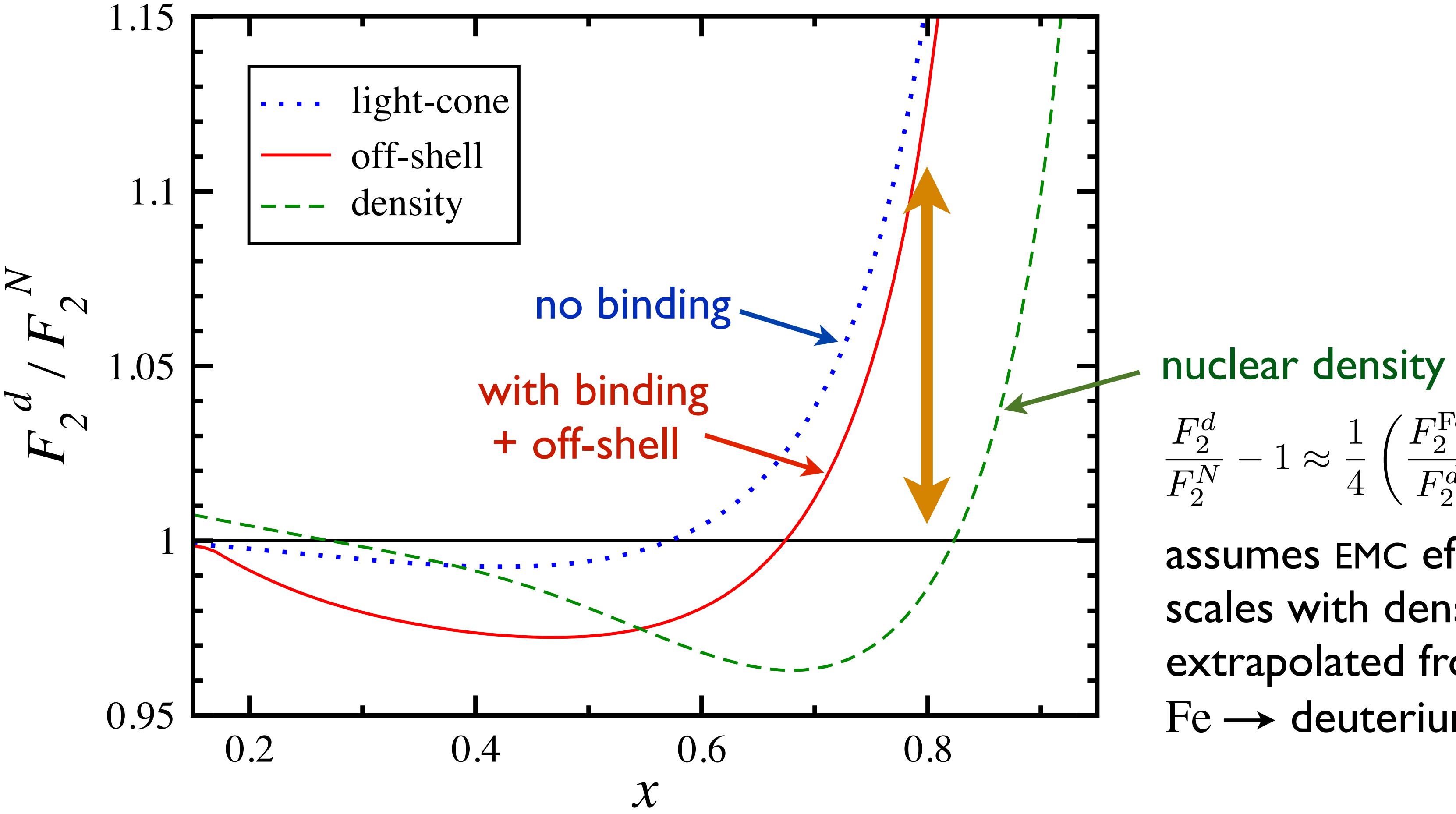
EMC effect in deuteron



→ using off-shell model, will get *larger* neutron *cf. light-cone* model

→ but will get *smaller* neutron *cf. no nuclear effects* or *density* model

EMC effect in deuteron



no binding

with binding + off-shell

nuclear density

$$\frac{F_2^d}{F_2^N} - 1 \approx \frac{1}{4}\left(\frac{F_2^{\rm Fe}}{F_2^d} - 1\right)$$

assumes EMC effect scales with density; extrapolated from Fe ⟶ deuterium

→ ~ 2–3% reduction of F_2^d/F_2^N at $x \sim 0.5$–0.6 with steep rise for $x > 0.6$–0.7

→ larger EMC effect at $x \sim 0.5$–0.6 with binding + off-shell corrections *cf.* light-cone

Finite-Q^2 corrections

- In OPE insertion of covariant derivatives in quark bilinears leads to terms ~ $Q^2/\nu^2 \sim M^2x^2/Q^2$

  → kinematical *target mass corrections* (formally leading twist)

  → gives rise to new *“Nachtmann”* scaling variable

$$\xi = \frac{2x}{1+\gamma}, \quad \gamma^2 = 1 + Q^2/\nu^2$$

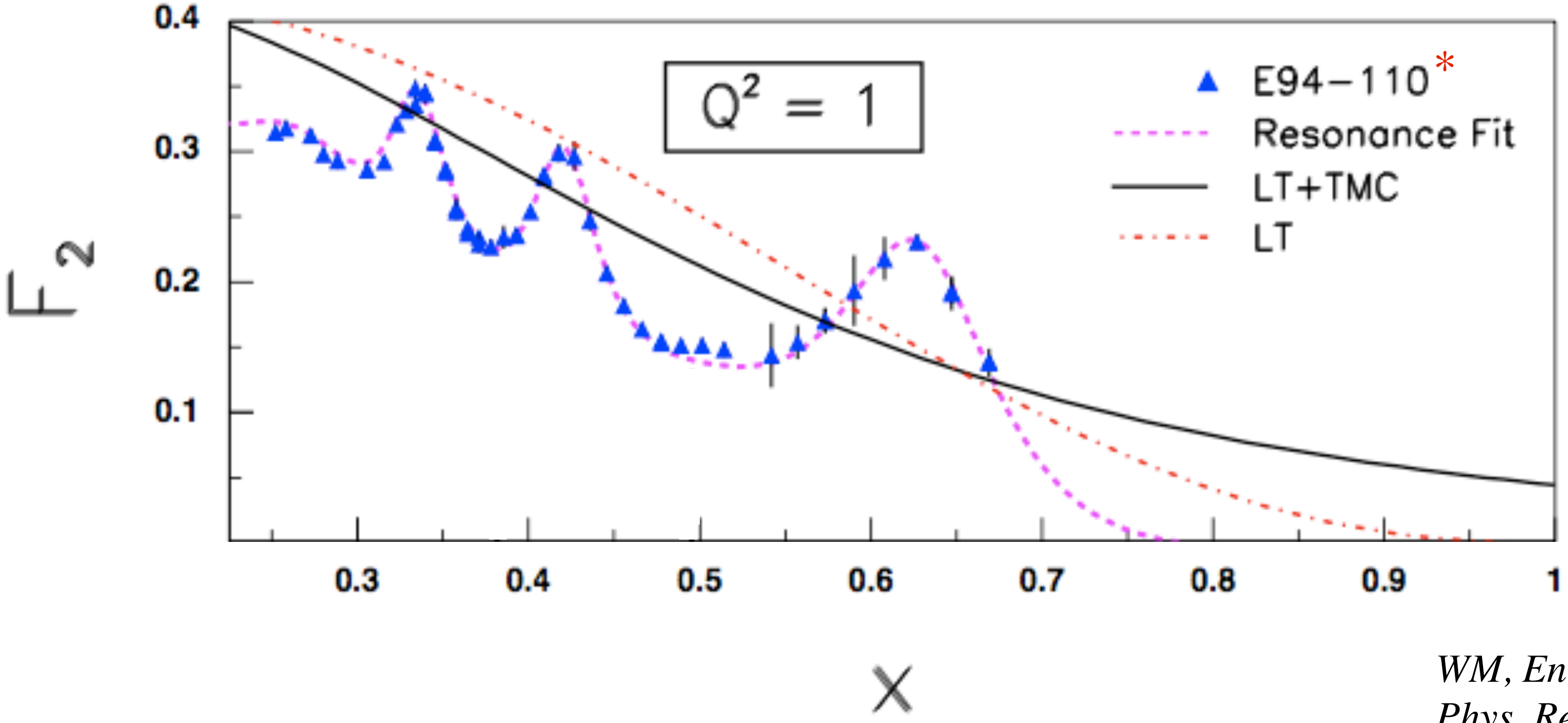
- Target mass corrected structure function (in OPE approach)

$$F_2(x,Q^2) = \frac{x^2}{\xi^2\gamma^3}\underset{\uparrow}{F_2^{(0)}}(\xi,Q^2) + \frac{6M^2x^3}{Q^2\gamma^4}\int_\xi^1 du \frac{F_2^{(0)}(u,Q^2)}{u^2}$$
$$+ \frac{12M^4x^4}{Q^4\gamma^5}\int_\xi^1 dv(v-\xi)\frac{F_2^{(0)}(v,Q^2)}{v^2}$$

massless limit function

Georgi, Politzer (1976)

Finite-Q^2 corrections



* JLab Hall C

WM, Ent, Keppel
Phys. Rept. (2005)

→ TMC important for verification of quark-hadron duality

Finite-Q^2 corrections

- ***But*** TMCs not unique: $e.g.$ in collinear factorization

→ work directly in *momentum* space at partonic level
(avoids Mellin transform; applicable also to non-DIS processes)

→ expand parton momentum k around its *on-shell* and *collinear* component $(k_\perp^2 \to 0)$

Ellis, Furmanski, Petronzio (1983)

$$F_{T,L}(x,Q^2) = \sum_q \int_\xi^{\xi/x} \frac{dy}{y}\, C^q_{T,L}\left(\frac{\xi}{y}, Q^2\right) q(y,Q^2)$$

Accardi, Qiu (2008)

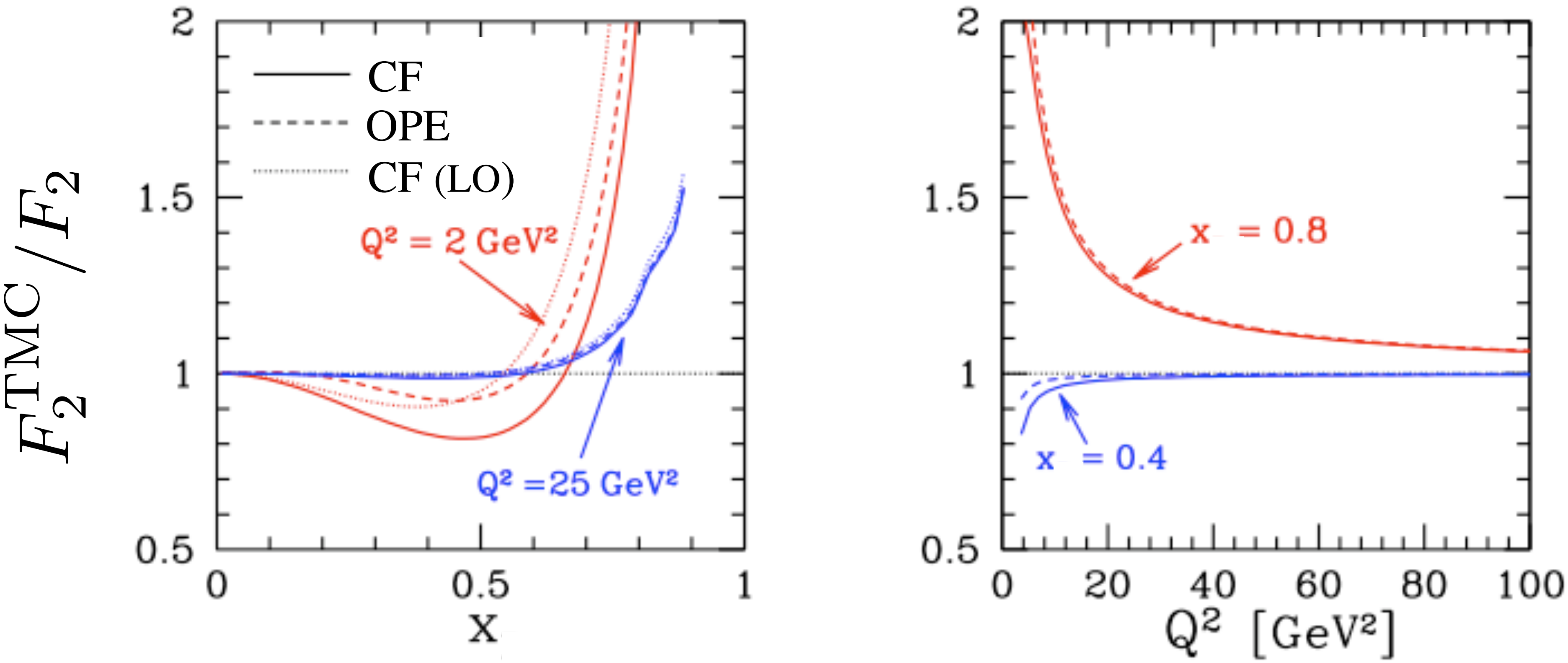
→ at leading order

$$F_2^{\rm CF}(x,Q^2) = \frac{x}{\xi\gamma^2}\, F_2^{(0)}(\xi,Q^2)$$
$$\approx \frac{\xi\gamma}{x}\, F_2^{\rm OPE}(x,Q^2)$$

Kretzer, Reno (2004)

Finite-Q^2 corrections

- *But* TMCs not unique: $e.g.$ in collinear factorization



Accardi, Qiu (2008)

→ TMC important at large x *even for large* Q^2

CTEQ6X global PDF fit

- New global QCD (next-to-leading order) analysis of expanded set of p and d data, including large-x, low-Q^2 region

  ⟶ joint JLab-CTEQ theory/experiment collaboration (with Hampton, FSU, FNAL, Duke)

- Systematically study effects of Q^2 & W cuts

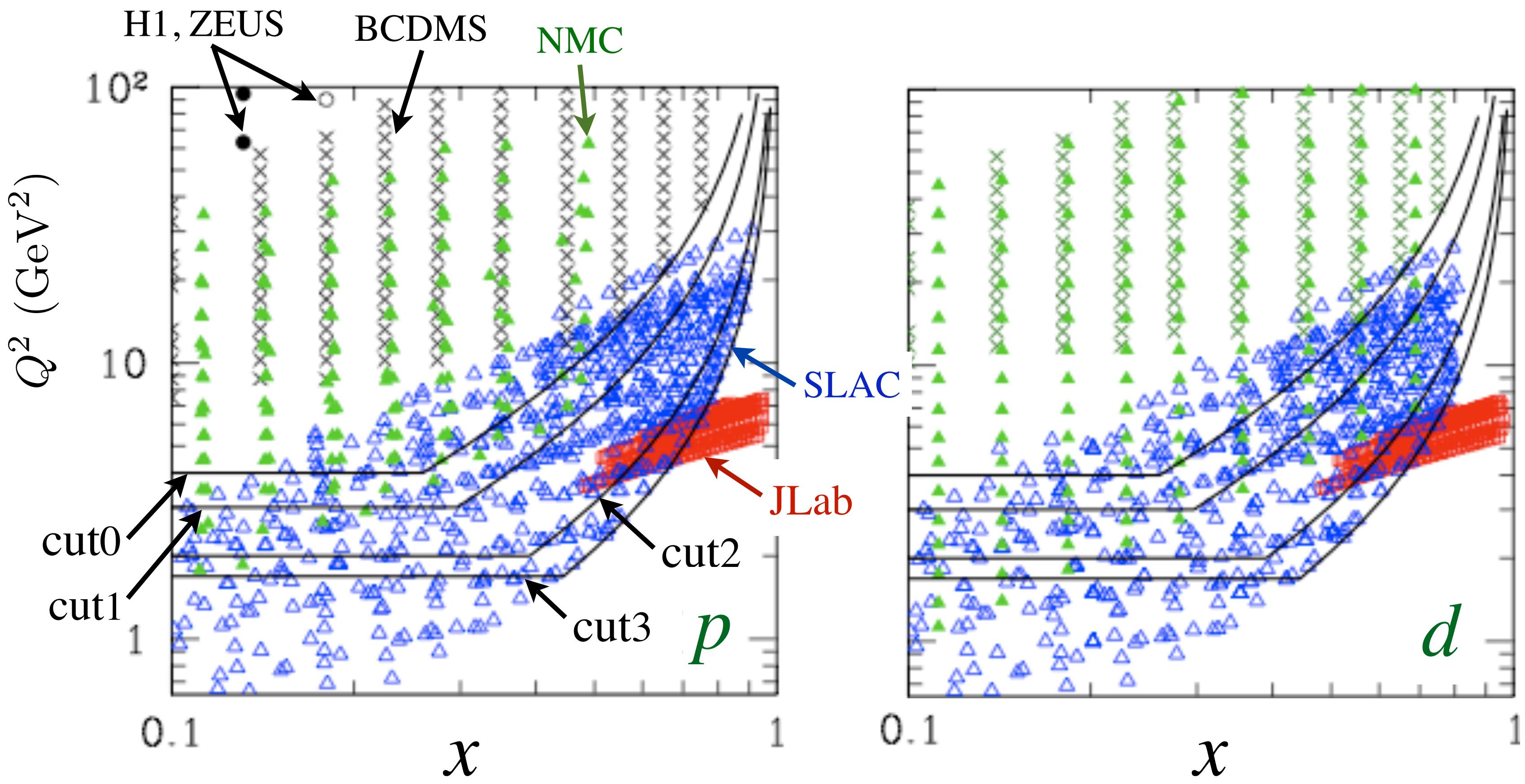
  ⟶ as low as $Q \sim m_c$ and $W \sim 1.7\ \mathrm{GeV}$

- Include large-x corrections

  ⟶ TMCs & higher twists $F_2(x,Q^2) = F_2^{\mathrm{LT}}(x,Q^2)(1 + C(x)/Q^2)$

  ⟶ realistic nuclear effects in deuteron (binding + off-shell) (most analyses use either no correction, or density model)

CTEQ6X – kinematic cuts



cut0: $Q^2 > 4\ \mathrm{GeV}^2, \quad W^2 > 12.25\ \mathrm{GeV}^2$

cut1: $Q^2 > 3\ \mathrm{GeV}^2, \quad W^2 > 8\ \mathrm{GeV}^2$

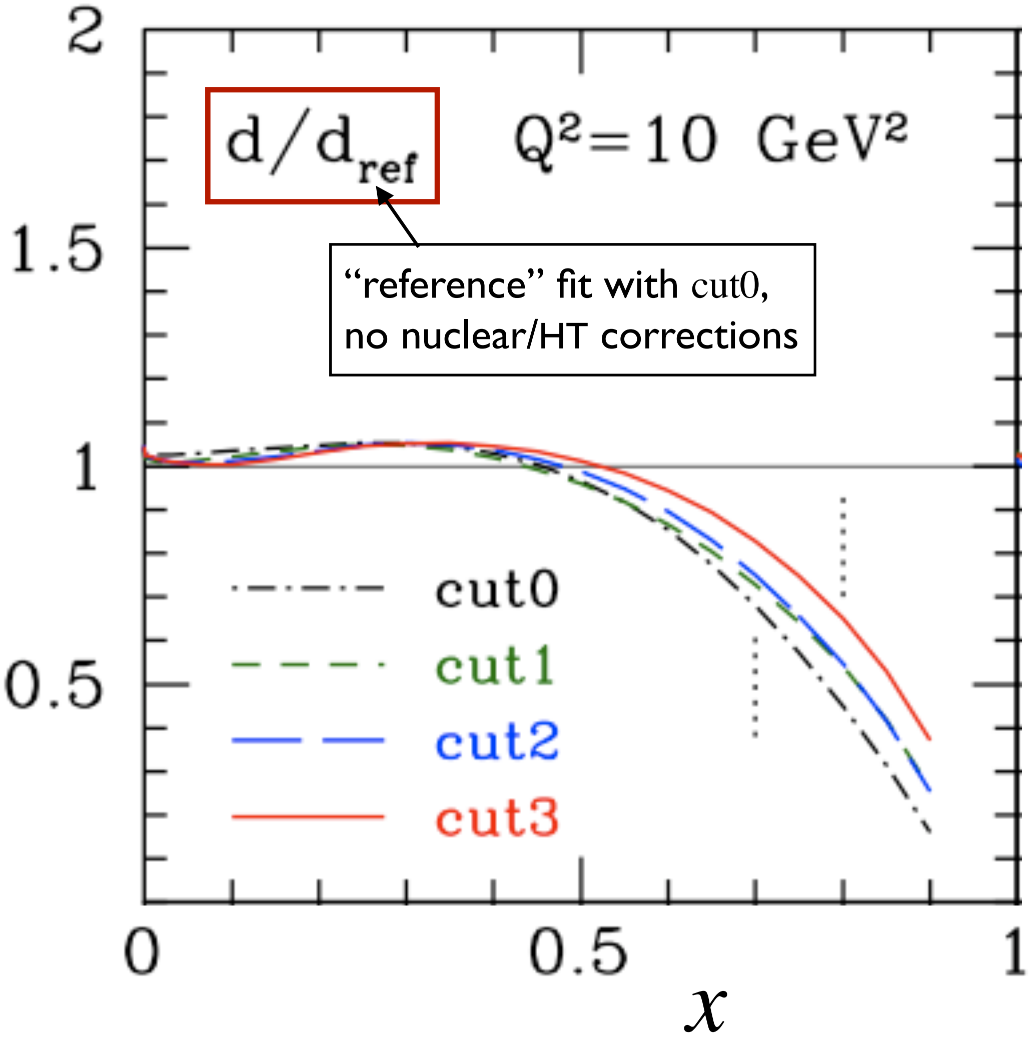
cut2: $Q^2 > 2\ \mathrm{GeV}^2, \quad W^2 > 4\ \mathrm{GeV}^2$

cut3: $Q^2 > m_c^2\ , \quad W^2 > 3\ \mathrm{GeV}^2$

<u>factor 2 increase</u> in DIS data from cut0 → cut3

CTEQ6X – kinematic cuts

- Systematically reduce Q^2 and W cuts, including TMC, HT & nuclear corrections



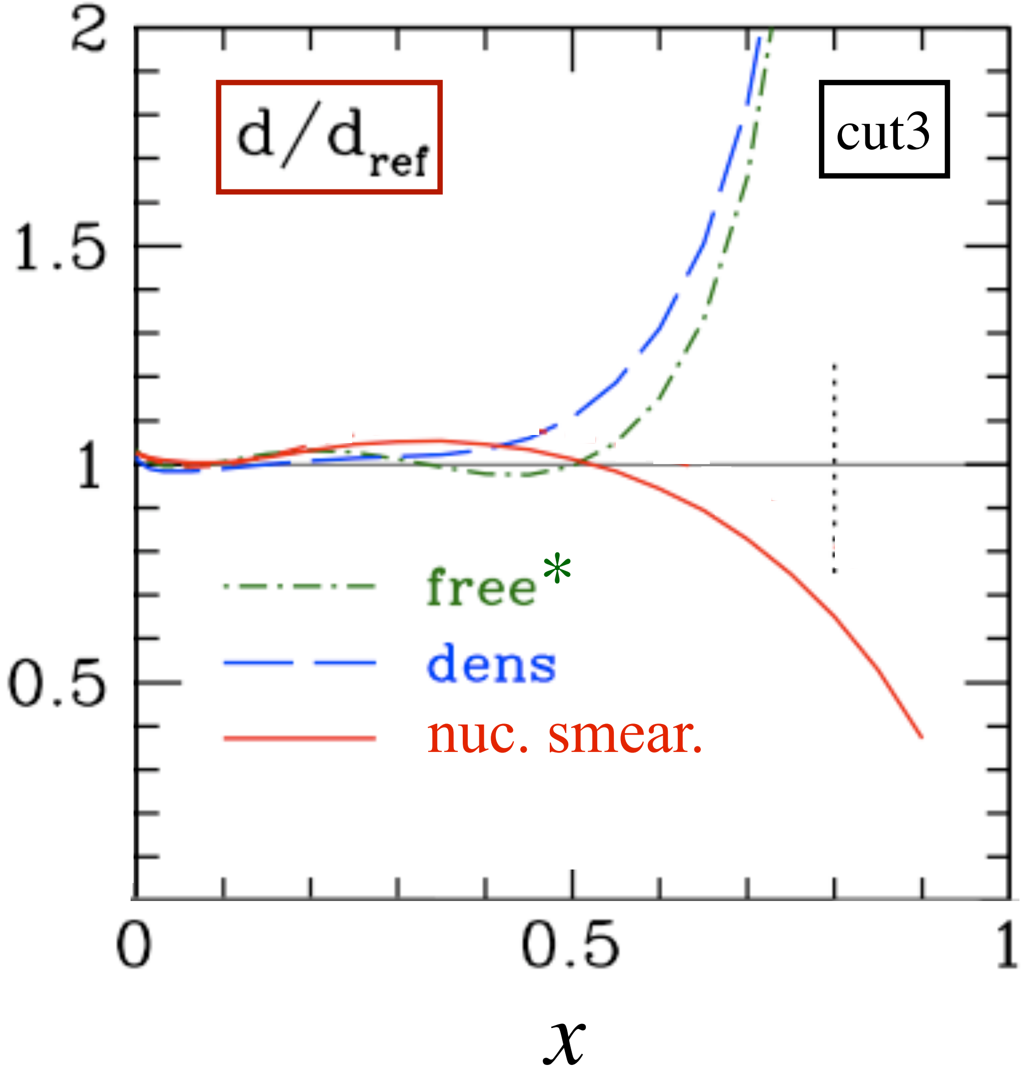
"reference" fit with cut0, no nuclear/HT corrections

→ *stable* with respect to cut reduction

→ d quark <u>suppressed</u> by $\sim 50\%$ for $x > 0.5$ (driven by nuclear corrections)

Accardi et al., Phys. Rev. D ***81****, 034016 (2010)*

CTEQ6X – nuclear effects



→ *increased* d quark for no nuclear effects

(compensates for nuclear smearing in deuteron → increased F_2^d)

→ *decreased* d quark for nuclear smearing models

↓

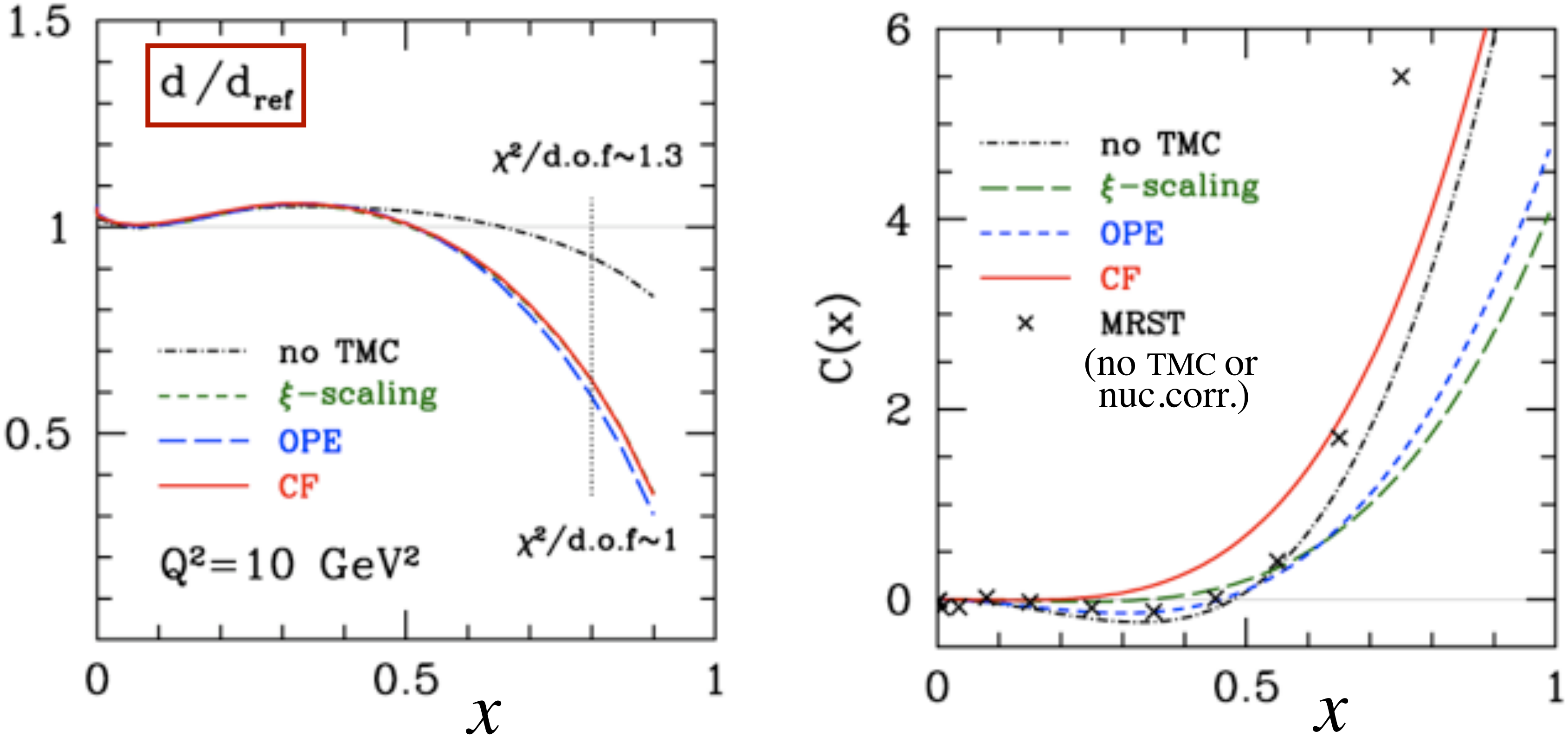
$F_2^d/F_2^N > 1$ for $x \sim 0.6$–0.8 while $F_2^d/F_2^N < 1$ for “free” and “density” models

$$F_2^d/F_2^N \uparrow \;\leftrightarrow\; F_2^n/F_2^p \downarrow$$

$$\leftrightarrow\; d/u \downarrow$$

* assumes $F_2^d = F_2^p + F_2^n$ as in CTEQ6.1 and most other global fits

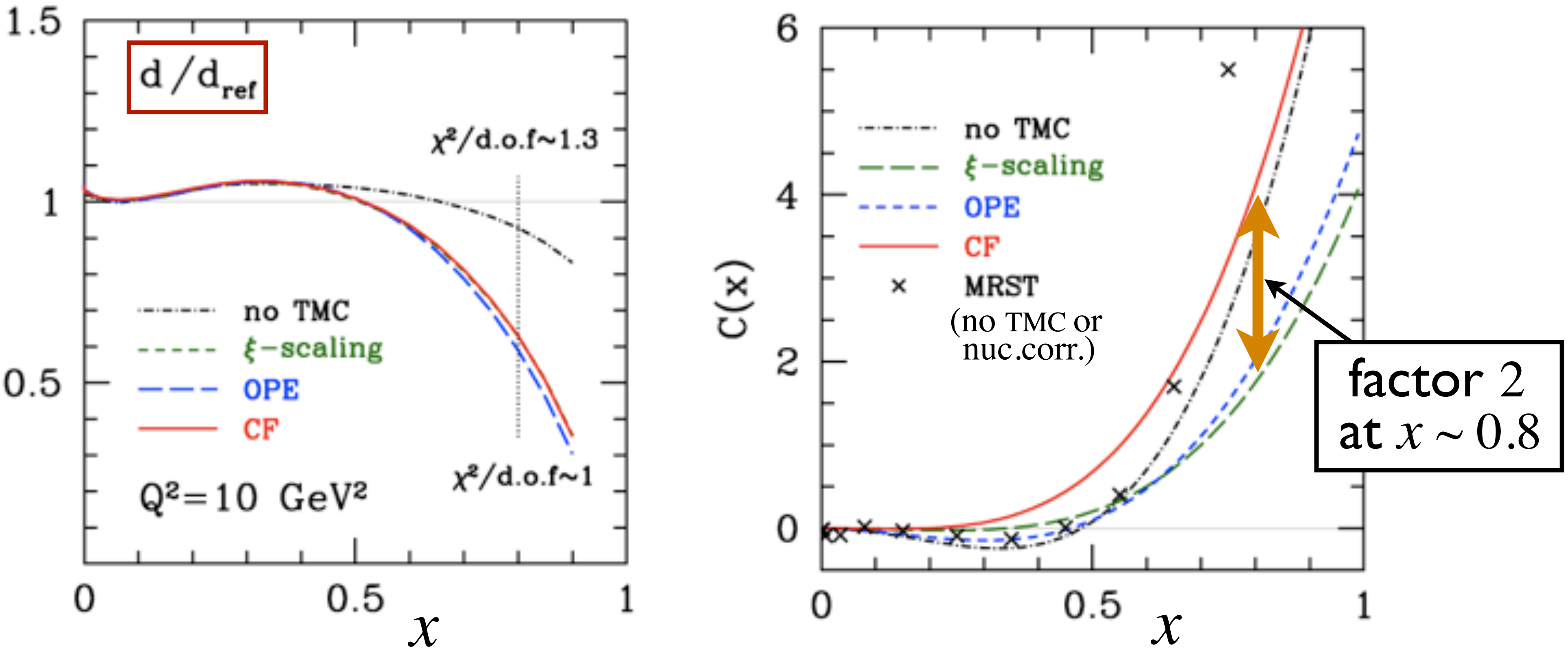
CTEQ6X – $1/Q^2$ corrections



→ important interplay between TMCs and higher twist:
HT alone *cannot* accommodate full Q^2 dependence

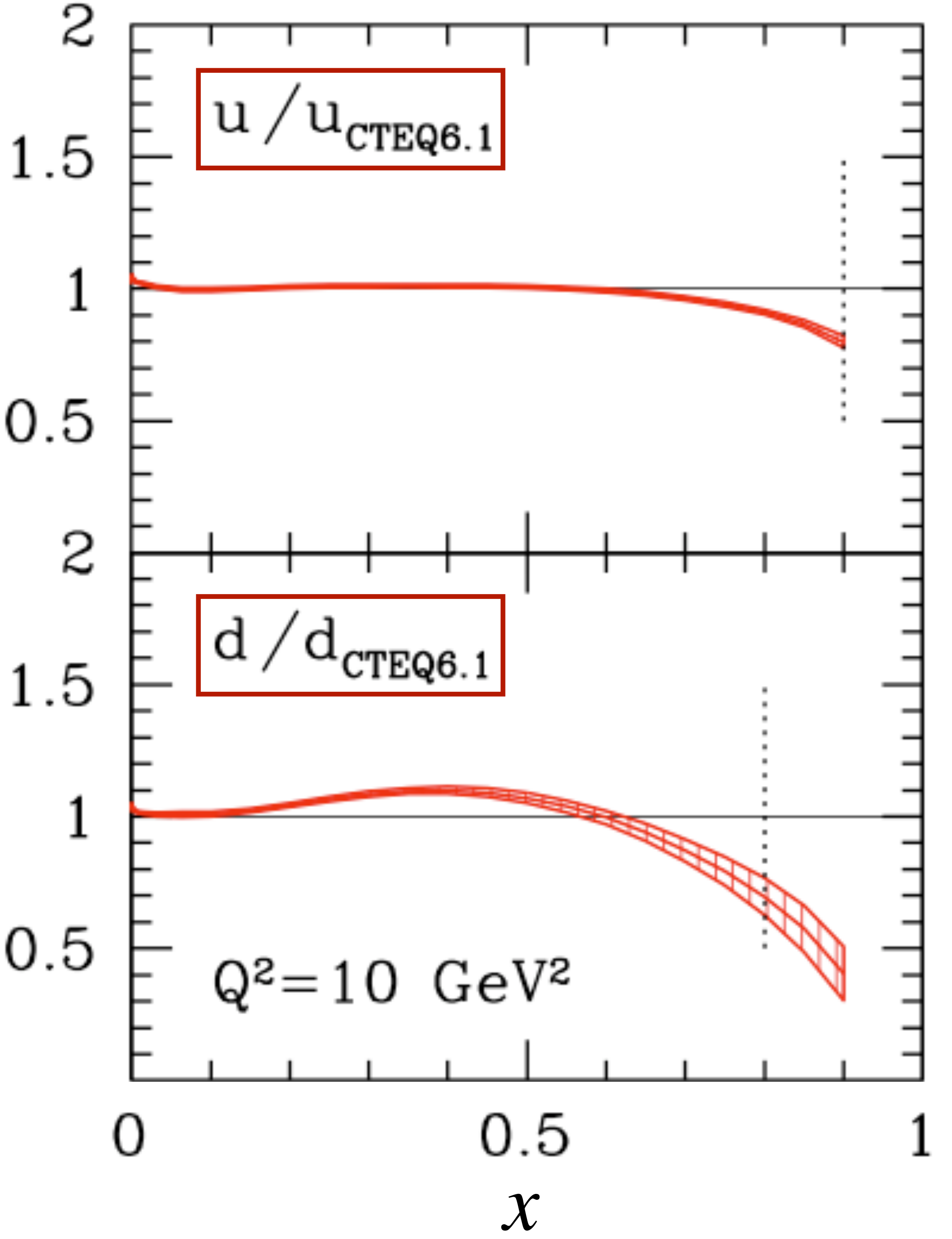
→ stable leading twist when *both* TMCs and HTs included

CTEQ6X – $1/Q^2$ corrections



- → important interplay between TMCs and higher twist: HT alone *cannot* accommodate full Q^2 dependence
- → stable leading twist when *both* TMCs and HTs included
- → prescription dependence of TMCs may limit extraction of higher twist contributions

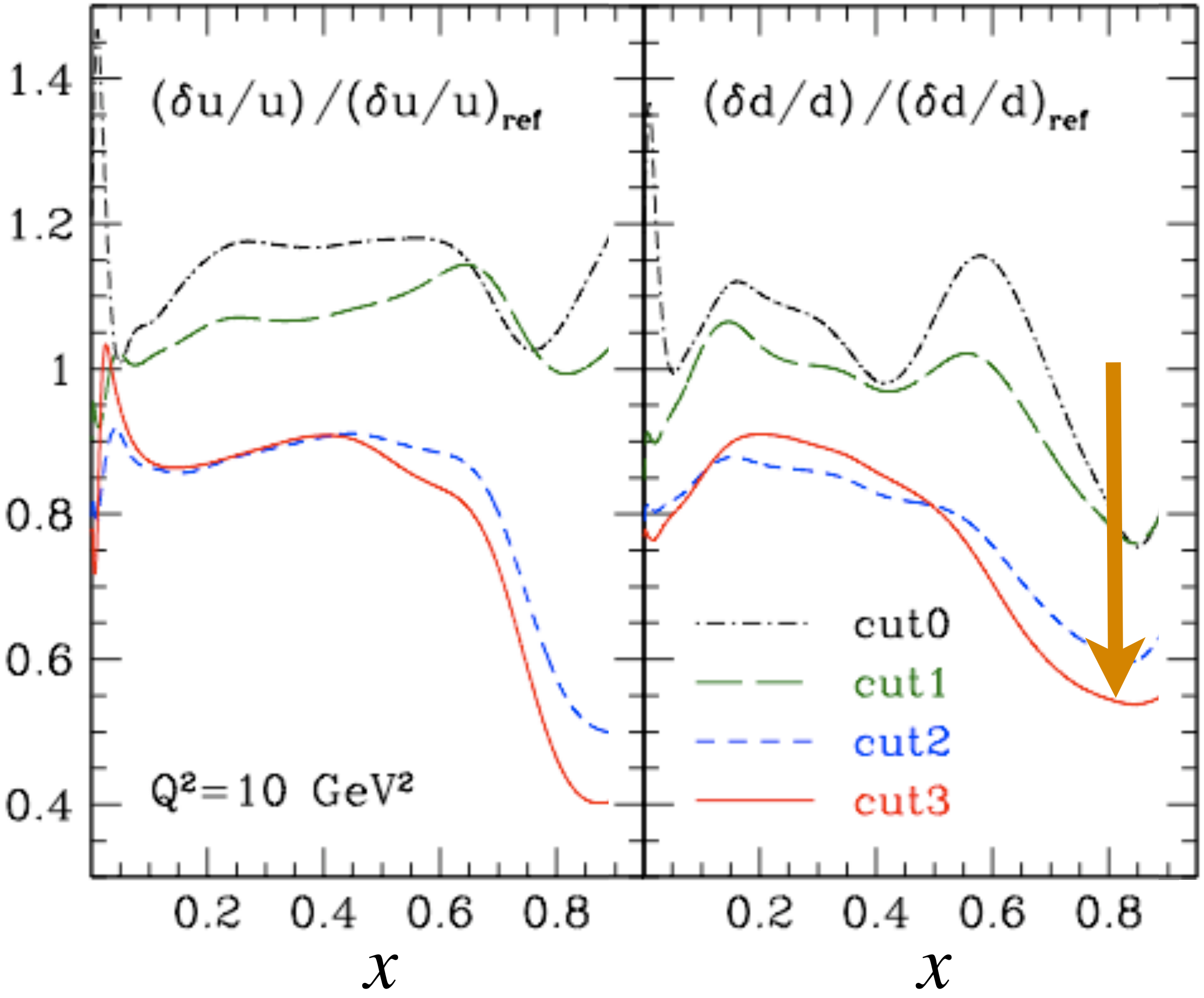
CTEQ6X – final PDF results



→ **full fits favors *smaller d/u* ratio**

(CTEQ6.1 had no nuclear or TMC/HT corrections)

CTEQ6X – final PDF results



Accardi et al., Phys. Rev. D ***81****, 034016 (2010)*

→ full fits favors *smaller d/u* ratio

(CTEQ6.1 had no nuclear or TMC/HT corrections)

→ up to 40-60% *reduced errors* with weaker cuts

CTEQ6X – implications

- *Stable* leading twist PDFs for $W \gtrsim 1.7$ GeV & $Q^2 \gtrsim 1.5$ GeV^2 – provided nuclear and subleading $1/Q^2$ corrections included

  → advocates using (high statistics) low-W data to constrain large-x PDFs

- Prescription dependence of TMCs limits extraction of higher twist matrix elements

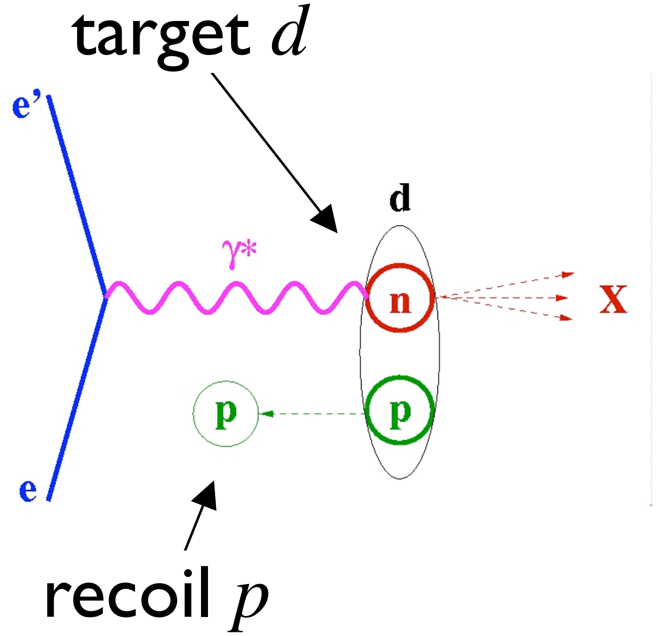
  → TMC / HT interplay needs to be better understood

- *Nuclear corrections* in deuteron significant at for $x \gtrsim 0.6$

  → completely obscure d quark extraction at large-x, require new methods free of nuclear uncertainties

New methods – spectator tagging (“BONUS”)

- $e\ d \to e\ p\ X$

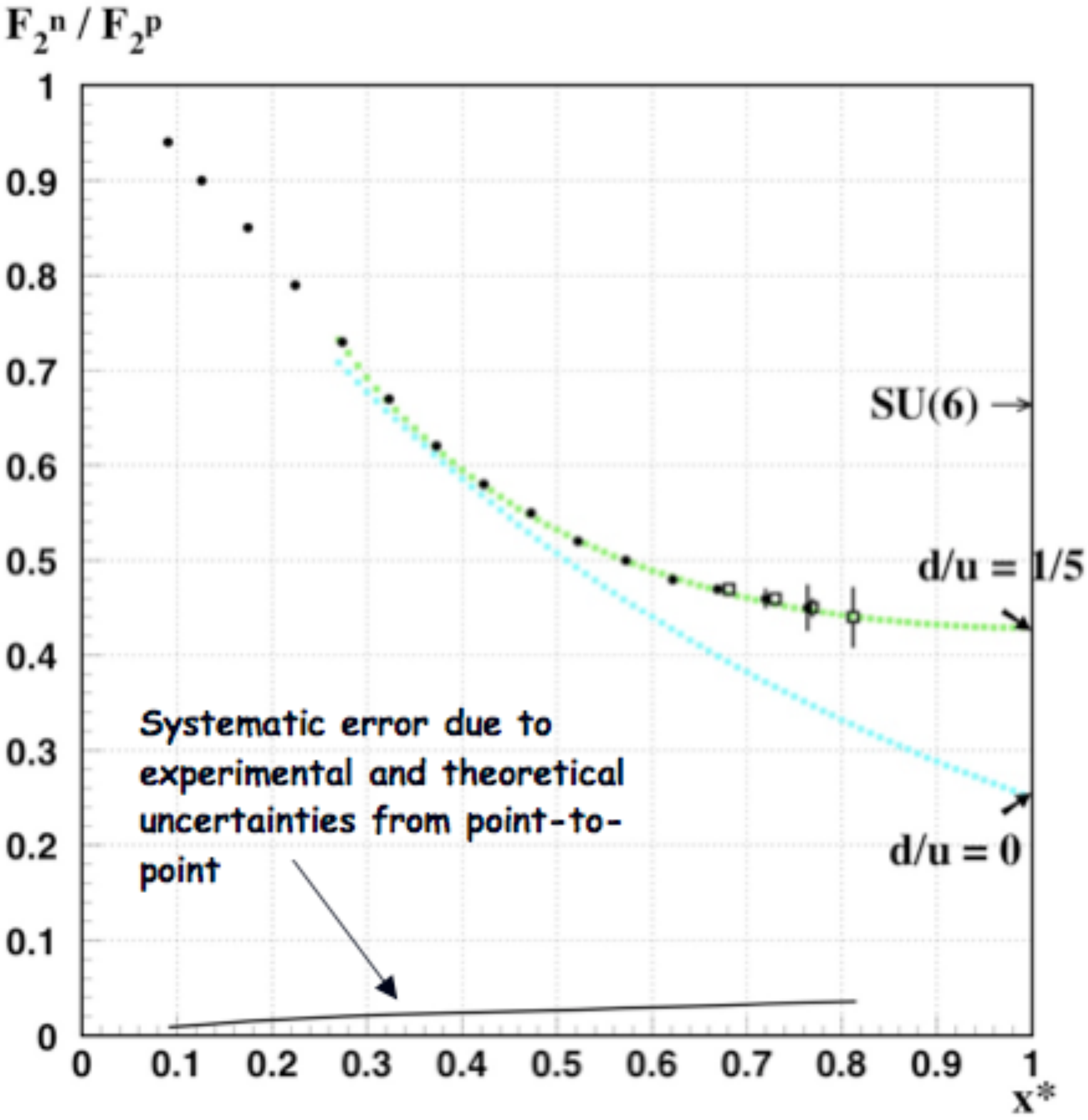


slow backward p

($\mathbf{p} < 100$ MeV)

→ neutron nearly on-shell

→ minimize rescattering



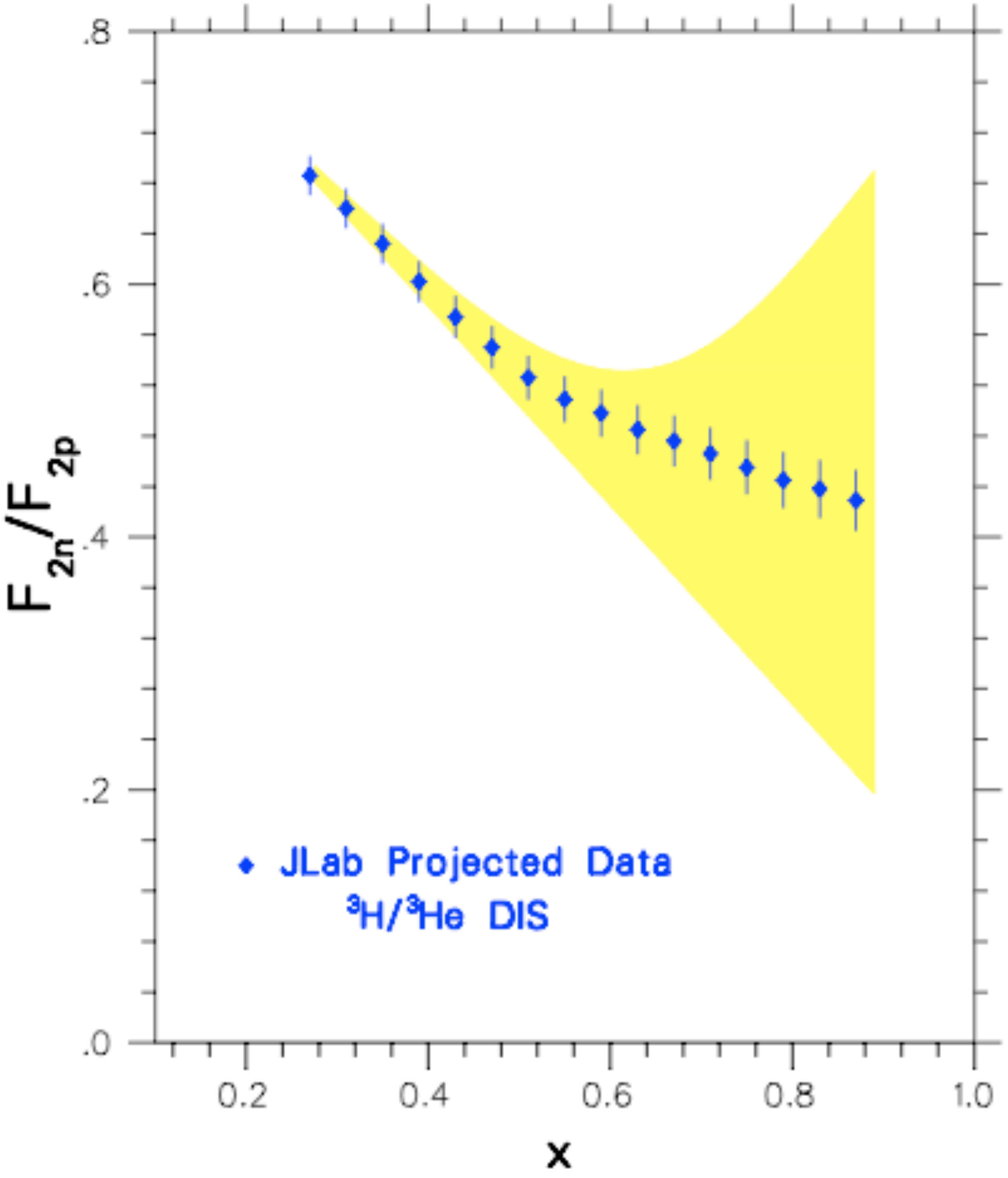
Systematic error due to experimental and theoretical uncertainties from point-to-point

New methods – DIS from A=3 (“MARATHON”)

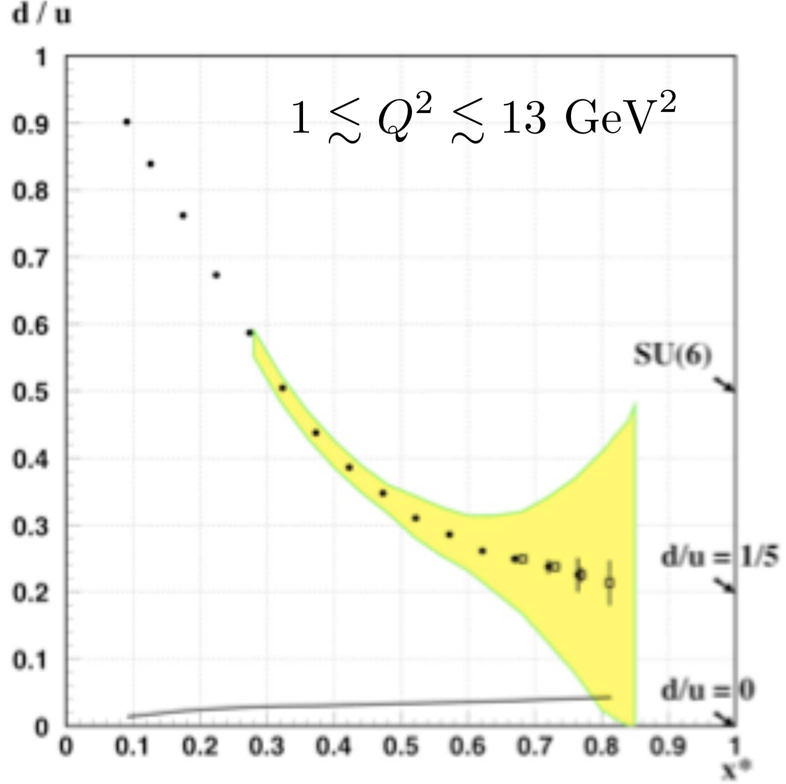
- extract n/p ratio from ratio of A=3 structure functions

$$\frac{F_2^n}{F_2^p} = \frac{2\mathcal{R} - F_2^{^3\mathrm{He}}/F_2^{^3\mathrm{H}}}{2F_2^{^3\mathrm{He}}/F_2^{^3\mathrm{H}} - \mathcal{R}}$$

→ ratio of ^{3}He to ^{3}H EMC ratios cancels to ~1% for $x < 0.85$

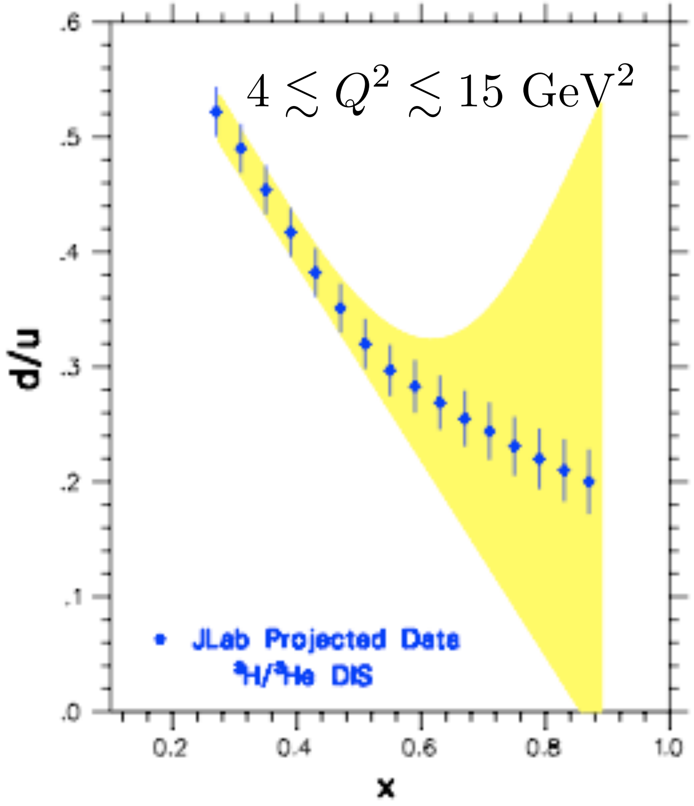


BONUS



$x \le 0.77$ (0.83) [$W \ge 2$ (1.8) GeV]

MARATHON



$x \le 0.83$ (0.87) [$W \ge 2$ (1.73) GeV]

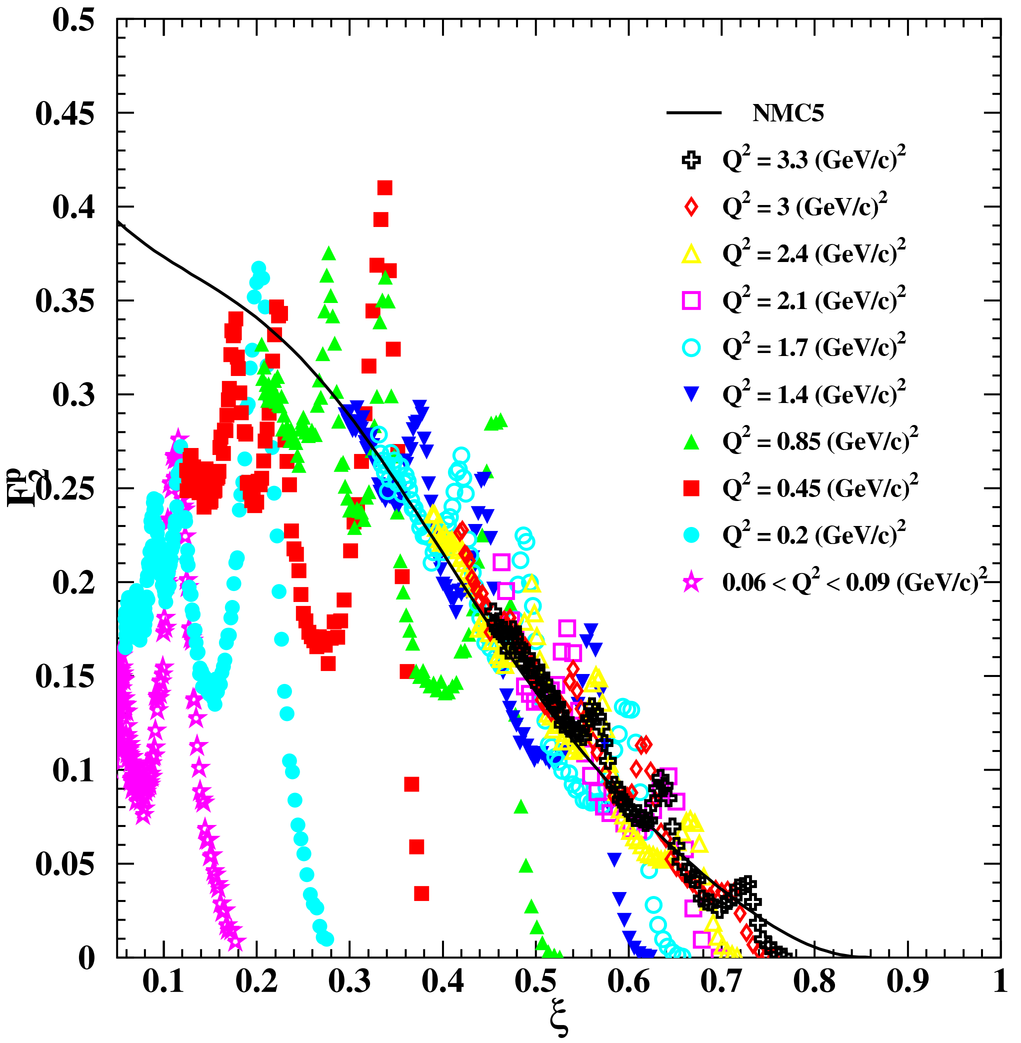
- theoretical uncertainties similar to $x \sim 0.85$
- other: π structure function; $^3A(e,e'd)X$; (ideally) *neutron* tagging for cross-check!

other: EMC effect in $A=3$; isospin-dependence of nuclear corrections; SIDIS

Quark-hadron duality

Quark-hadron duality

- average over resonances
  (strongly Q^2 dependent)
  $\approx$ leading twist str. fn.
  (~ Q^2 independent)

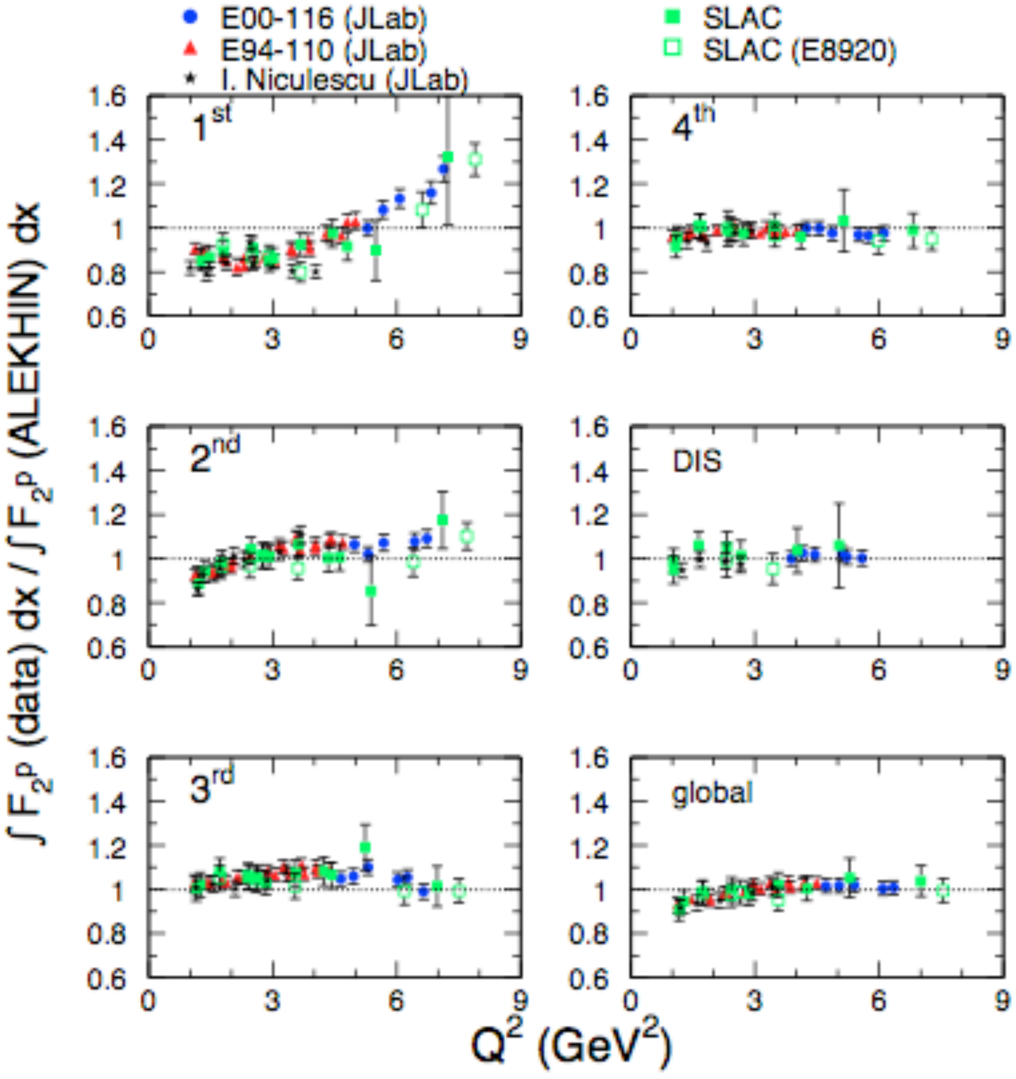


Niculescu et al., PRL ***85***, *1182 (2000)*

Quark-hadron duality

- average over resonances (strongly Q^2 dependent) $\approx$ leading twist str. fn. ($\sim Q^2$ independent)

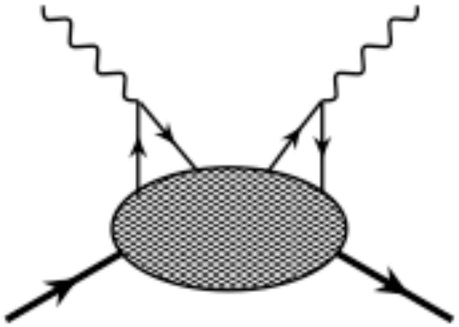
- duality violation for proton $\lesssim 10\%$, integrated over x



Malace et al., PRC ***80****, 035207 (2009)*

- Is duality in the proton a coincidence?

→ consider model with symmetric nucleon wave function



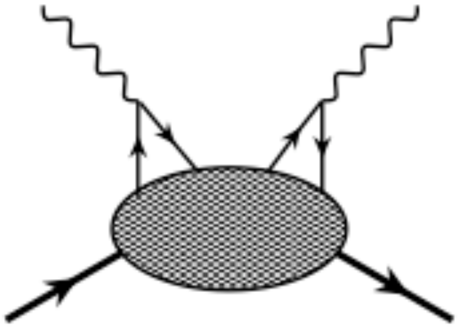
cat's ears diagram (4-fermion higher twist $\sim 1/Q^2$)

$$\propto \sum_{i \neq j} e_i \, e_j \sim \Big(\sum_i e_i\Big)^2 - \sum_i e_i^2$$

$\uparrow$ *coherent* $\uparrow$ *incoherent*

- Is duality in the proton a coincidence?

→ consider model with symmetric nucleon wave function



cat's ears diagram (4-fermion higher twist ~ $1/Q^2$)

$$\propto \sum_{i \neq j} e_i \, e_j \sim \Big(\sum_i e_i\Big)^2 - \sum_i e_i^2$$

↑ coherent ↑ incoherent

- *proton* $\mathrm{HT} \sim 1 - \left(2 \times \frac{4}{9} + \frac{1}{9}\right) = 0\,!$
- *neutron* $\mathrm{HT} \sim 0 - \left(\frac{4}{9} + 2 \times \frac{1}{9}\right) \neq 0$

Brodsky, hep-ph/0006310

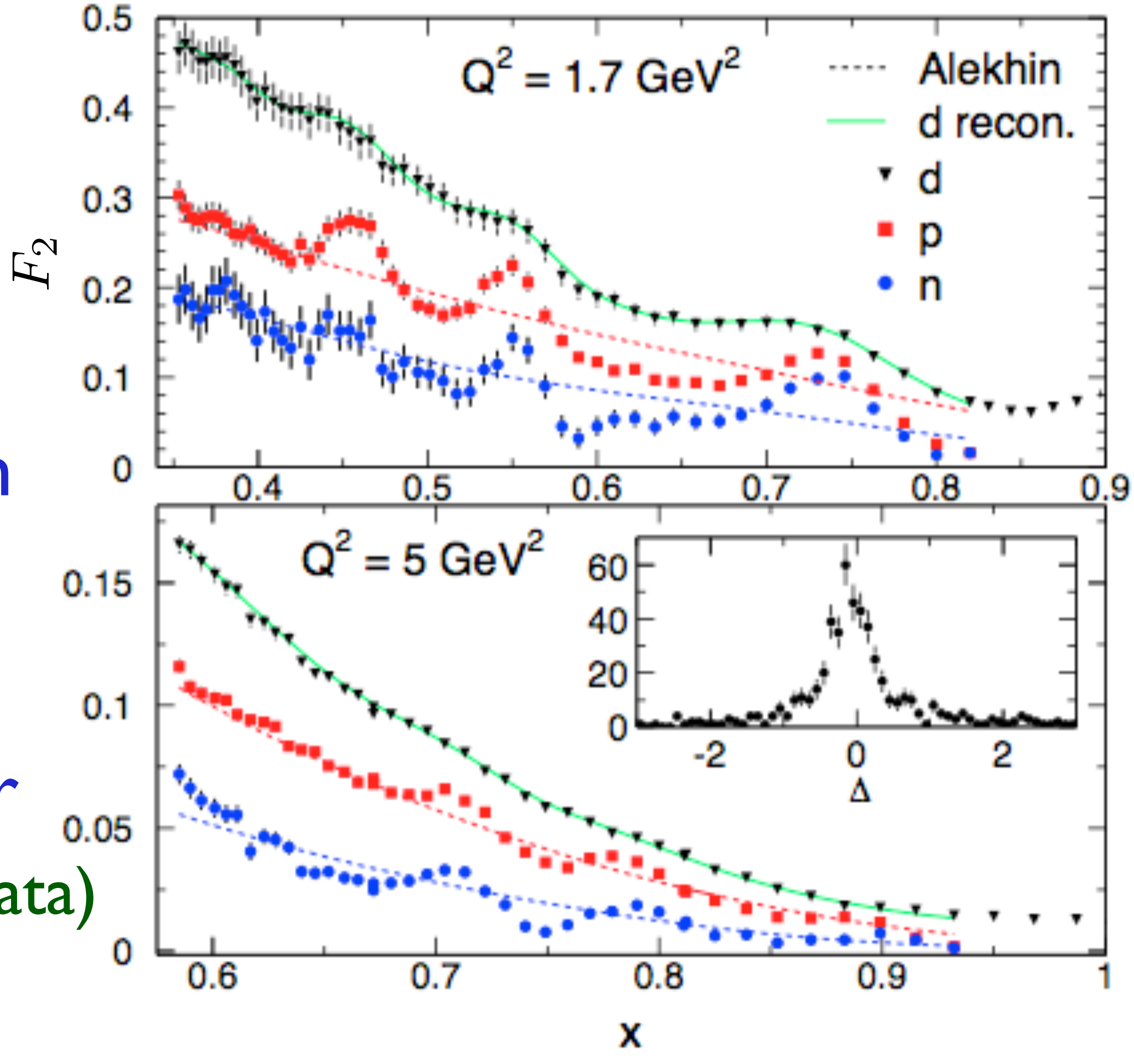
→ need to test duality in the neutron!

Quark-hadron duality

- average over resonances
  (strongly Q^2 dependent)
  $\approx$ leading twist str. fn.
  (~ Q^2 independent)

- duality violation for proton
  $\lesssim 10\%$, integrated over x

- recently confirmed also for *neutron* (from inclusive p, d data)
  → duality *not* accidental!

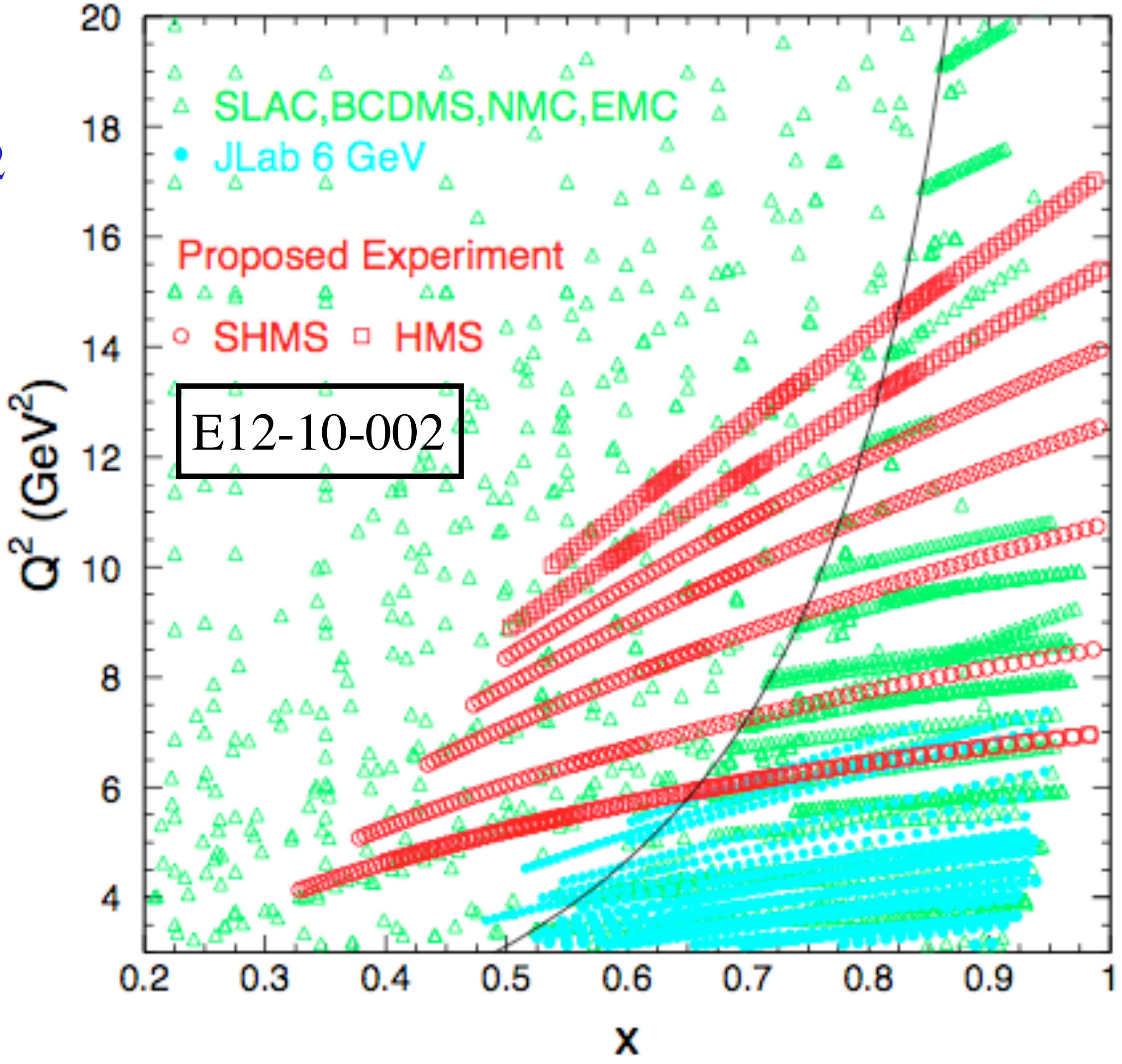


Malace et al., PRL ***104****, 102001 (2010)*

Quark-hadron duality

- currently duality studies limited to $Q^2 \lesssim 6\ \mathrm{GeV}^2$, beyond which no resonance data exist

- with $12\ \mathrm{GeV}$ will map out resonances to $Q^2 \sim 17\ \mathrm{GeV}^2$



- high-precision low-W data base will constrain PDFs at larger x values

→ input into CTEQ6X-like global QCD fits

Semi-inclusive DIS

- Semi-inclusive DIS at $12\ \mathrm{GeV}$ offers tremendous opportunity for determining

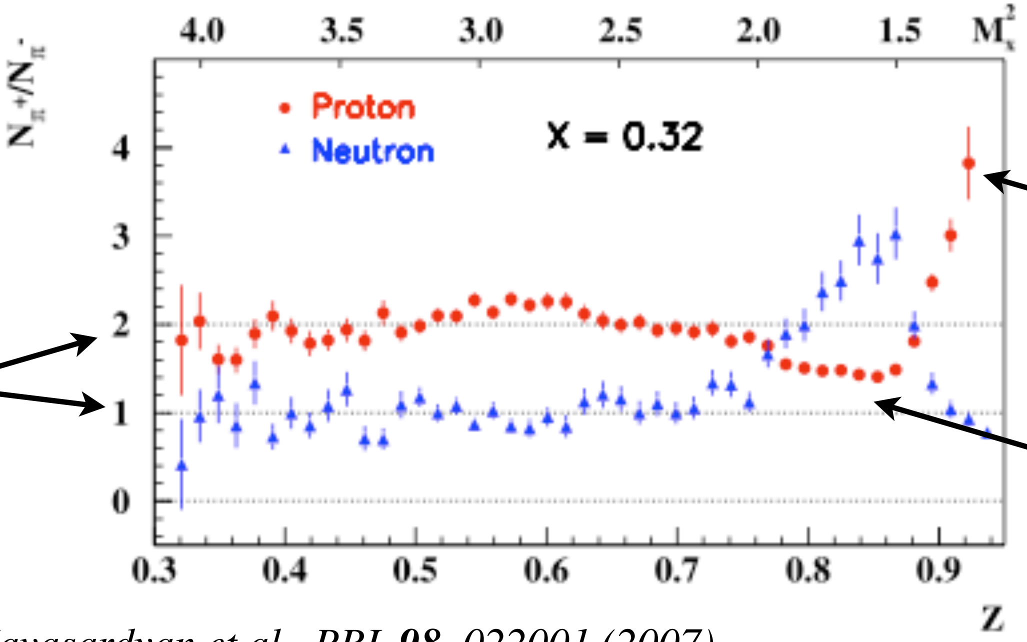
→ flavor-spin decomposition of nucleon PDFs
($e.g.\ d/u,\ \bar{d}/\bar{u},\ \Delta\bar{d}-\Delta\bar{u}$)

→ new distributions, not accessible in inclusive DIS
($e.g.$ transversity, Sivers function, *etc*)

→ vital issue: does factorization of scattering & fragmentation processes (needed for pQCD treatment) hold at these energies?

⇒ must establish *empirically* before method can be reliably utilized

■ 6 GeV data hint at intriguing quark-hadron duality in SIDIS



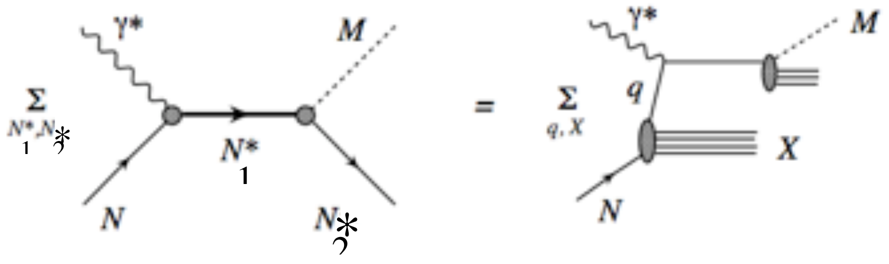
expect
p ratio
$\gg n$ ratio

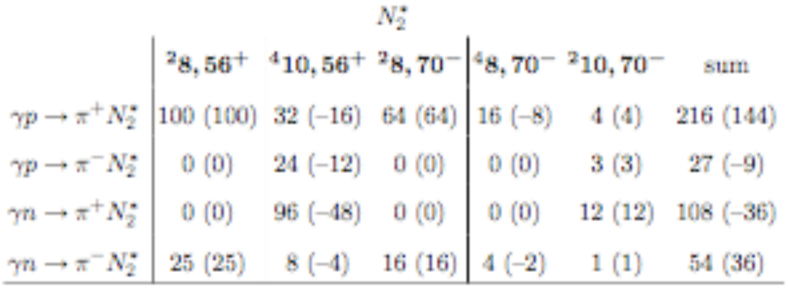
N elastic
p ratio $\gg n$ ratio

Δ region
n ratio $\gg p$ ratio

Navasardyan et al., PRL ***98****, 022001 (2007)*

→ trends consistent with resonance model predictions

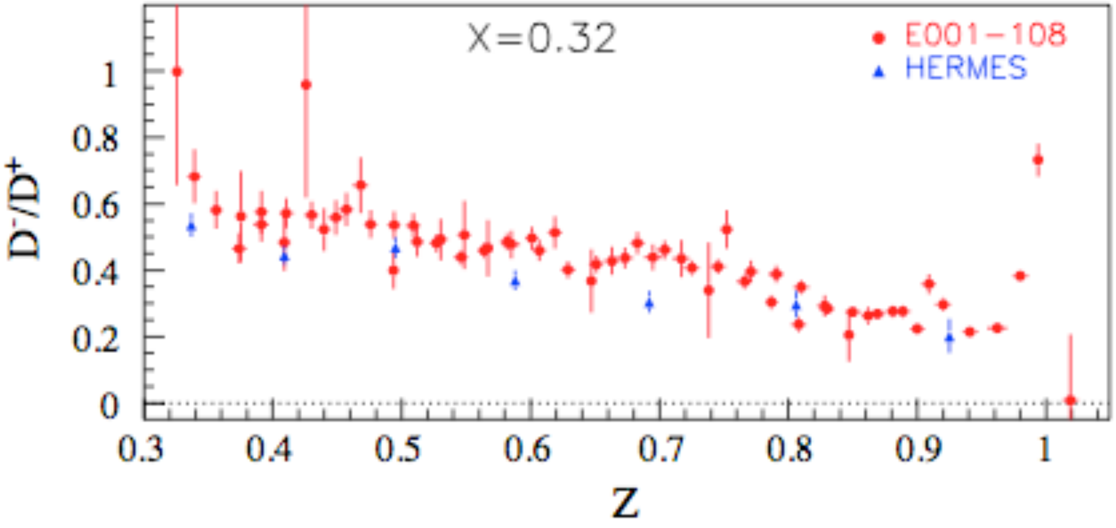




			N_2^*			
	$^28,56^+$	$^410,56^+$	$^28,70^-$	$^48,70^-$	$^210,70^-$	sum
$\gamma p \to \pi^+ N_2^*$	100 (100)	32 (−16)	64 (64)	16 (−8)	4 (4)	216 (144)
$\gamma p \to \pi^- N_2^*$	0 (0)	24 (−12)	0 (0)	0 (0)	3 (3)	27 (−9)
$\gamma n \to \pi^+ N_2^*$	0 (0)	96 (−48)	0 (0)	0 (0)	12 (12)	108 (−36)
$\gamma n \to \pi^- N_2^*$	25 (25)	8 (−4)	16 (16)	4 (−2)	1 (1)	54 (36)

Close, WM, PRC ***79****, 055202 (2009)*

6 GeV data hint at intriguing quark-hadron duality in SIDIS

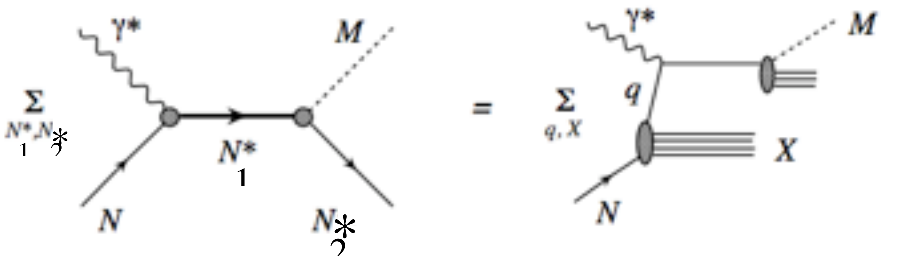


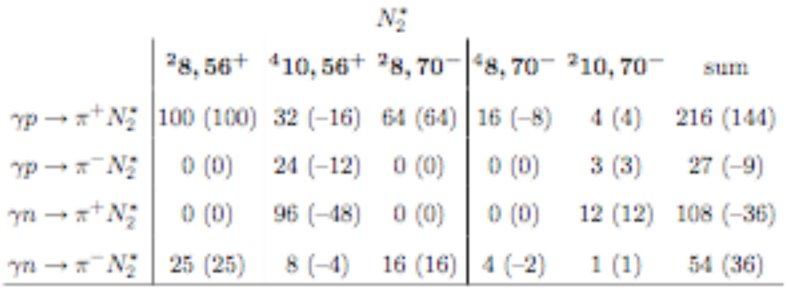
Navasardyan et al., PRL ***98****, 022001 (2007)*

$$\frac{D^-}{D^+} = \frac{4 - N_\pi^+/N_\pi^-}{4N_\pi^+/N_\pi^- - 1}$$

resonance contributions to ratio cancel in quark model!

→ trends consistent with resonance model predictions





	N_2^*					
	$^2\mathbf{8},\mathbf{56}^+$	$^4\mathbf{10},\mathbf{56}^+$	$^2\mathbf{8},\mathbf{70}^-$	$^4\mathbf{8},\mathbf{70}^-$	$^2\mathbf{10},\mathbf{70}^-$	sum
$\gamma p \to \pi^+ N_2^*$	100 (100)	32 (−16)	64 (64)	16 (−8)	4 (4)	216 (144)
$\gamma p \to \pi^- N_2^*$	0 (0)	24 (−12)	0 (0)	0 (0)	3 (3)	27 (−9)
$\gamma n \to \pi^+ N_2^*$	0 (0)	96 (−48)	0 (0)	0 (0)	12 (12)	108 (−36)
$\gamma n \to \pi^- N_2^*$	25 (25)	8 (−4)	16 (16)	4 (−2)	1 (1)	54 (36)

Close, WM, PRC ***79****, 055202 (2009)*

- In parton model cross section has simple factorization:

$$\frac{d\sigma}{dx\,dQ^2\,dz_h} \sim \sum_q e_q^2\, q(x,Q^2)\, D_q^h(z_h,Q^2)$$

$$z_h = \frac{p_h \cdot p}{q \cdot p} \longrightarrow \frac{E_h}{\nu}$$

- At finite Q^2 hadronic mass corrections (target & fragment):

$$\frac{d\sigma}{dx\,dQ^2\,dz_h} \sim \sum_q e_q^2\, q(\xi_h,Q^2)\, D_q^h(\zeta_h,Q^2)$$

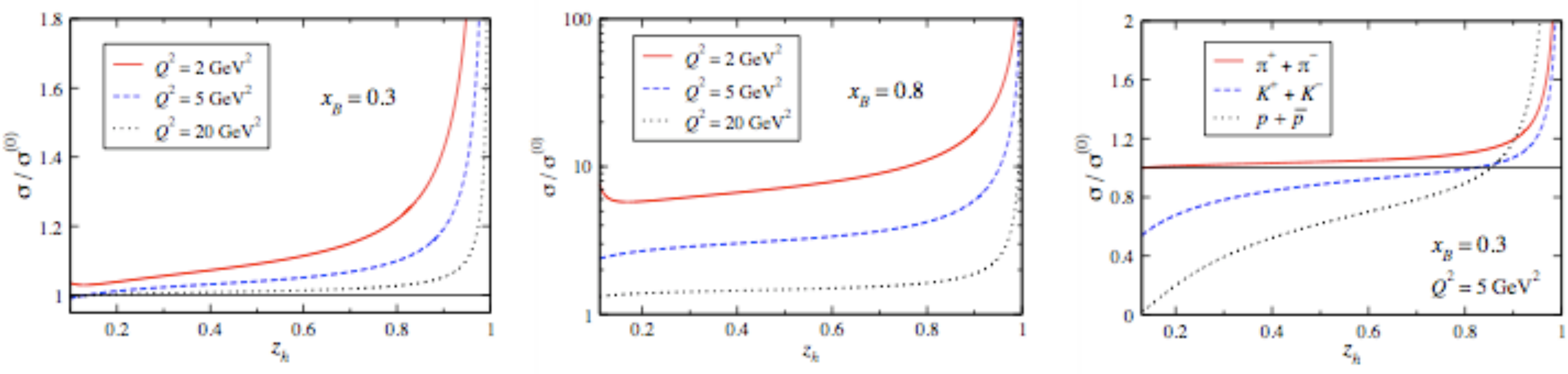
$$\xi_h = \xi\left(1+\frac{m_h^2}{\zeta_h Q^2}\right) \qquad \zeta_h = \frac{z_h}{2}\frac{\xi}{x}\left(1+\sqrt{1-\frac{4x^2M^2m_h^2}{z_h^2Q^4}}\right)$$

Mulders (2001), Albino et al. (2007), Hobbs et al. (2009)

$\longrightarrow$ *hadron* mass dependence in quark *distribution* function

$\longrightarrow$ factorization breakdown (quantifiable!)

Ratio $\sigma/\sigma^{(0)}$ of corrected to uncorrected (massless limit) $\pi^+ + \pi^-$ cross sections



Hobbs, Accardi, WM, JHEP ***11****, 084 (2009)*

- → dramatic rise as $z_h \to 1$, more pronounced at low Q^2
- → downward correction at small z_h for heavier hadrons driven by suppression of PDF from $(1 + m_h^2/\zeta_h Q^2)$ factor in $\xi_h \ (> \xi)$
- → need to account for HMC at large x or small Q^2 even at 12 GeV

Nucleon structure at large x:
spin-dependent

Spin structure at large x

- Spin-dependent PDFs are even less well understood at large x than spin-averaged PDFs

- Predictions for $x \rightarrow 1$ behavior:

  → scalar diquark dominance

$$\frac{\Delta u}{u} \rightarrow 1\,, \quad \frac{\Delta d}{d} \rightarrow -\frac{1}{3} \qquad A_1^{p,n} \rightarrow 1$$

  → hard gluon exchange

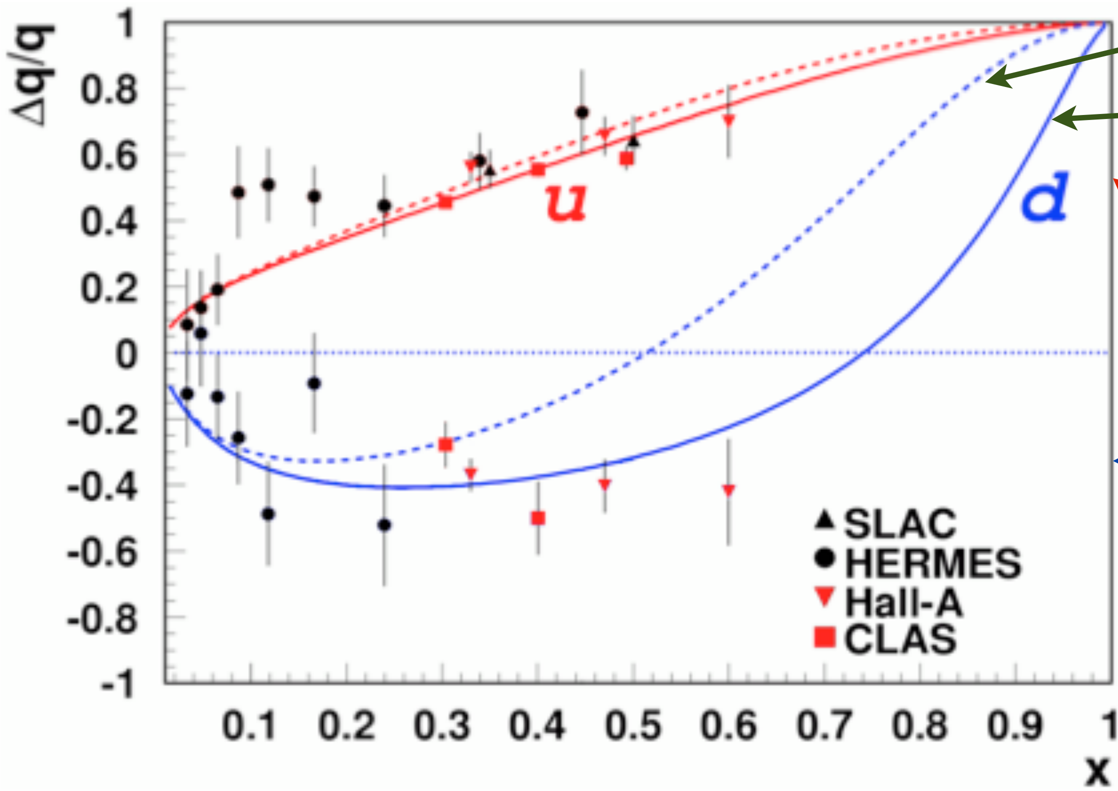
$$\frac{\Delta u}{u} \rightarrow 1\,, \quad \frac{\Delta d}{d} \rightarrow 1 \qquad A_1^{p,n} \rightarrow 1$$

  → spin-flavor symmetry

$$\frac{\Delta u}{u} = \frac{2}{3}\,, \quad \frac{\Delta d}{d} = -\frac{1}{3} \qquad A_1^p = \frac{5}{9}\,, \quad A_1^n = 0$$

- Spin PDFs almost completely unconstrained for $x \gtrsim 0.6$

Spin structure at large x



pQCD-inspired fit

including OAM

5/9

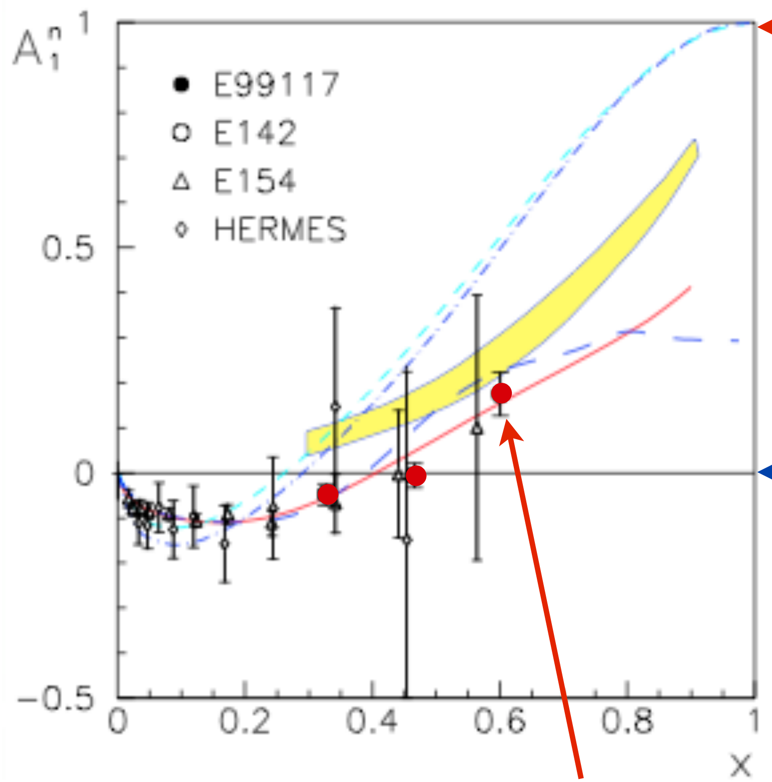
−1/3

→ data consistent with SU(6) predictions (*cf.* unpolarized)

→ dramatic behavior expected in $\Delta d/d$ for $x \gtrsim 0.6$

reflects upturn in neutron asymmetry A_1^n

Spin structure at large x



pQCD

SU(6)

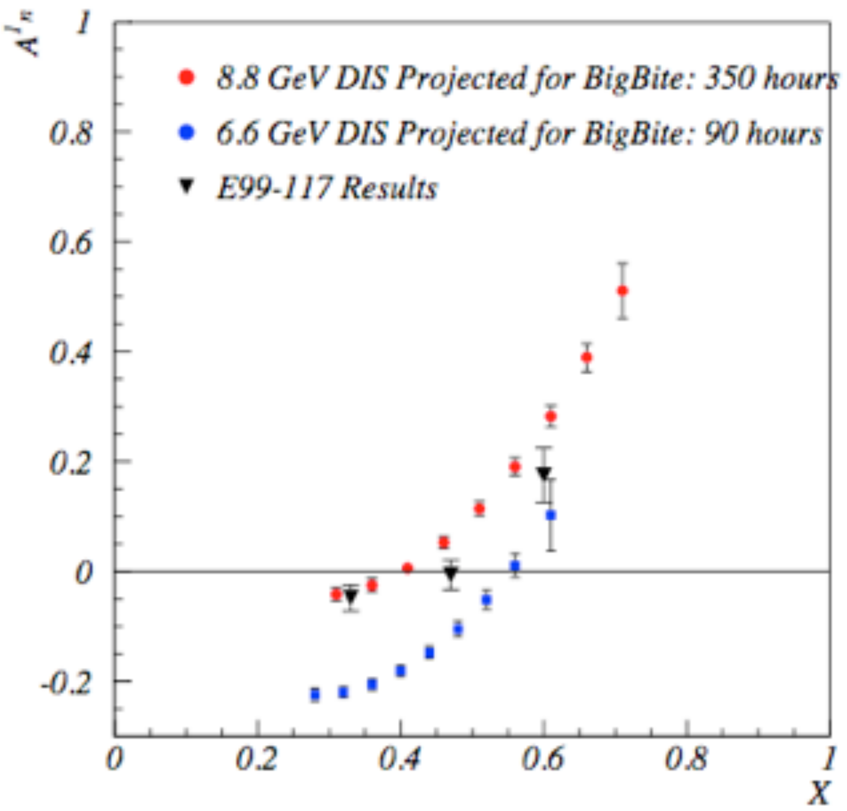
Zheng et al.,
PRL ***92****, 012004 (2004)*

first evidence of rise above unity!

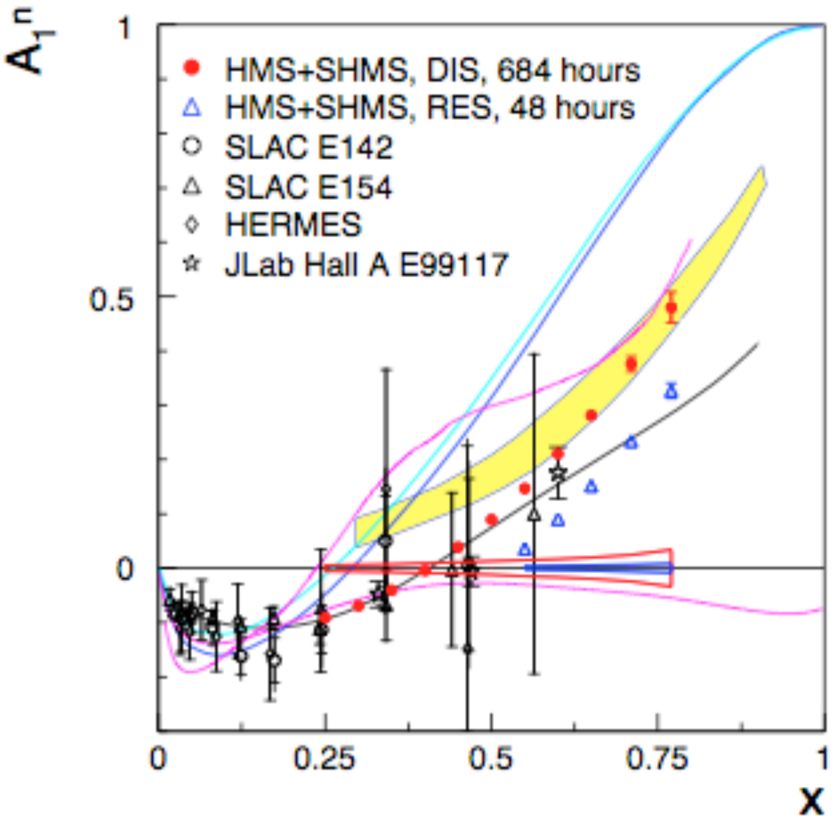
→ dramatic behavior expected in $\Delta d/d$ for $x \gtrsim 0.6$

reflects upturn in neutron asymmetry A_1^n

E12-06-122 (Hall A)



PR12-06-110 (Hall C)



$\boxed{x \leq 0.71}$

DIS kinematics

$\boxed{x \leq 0.77}$

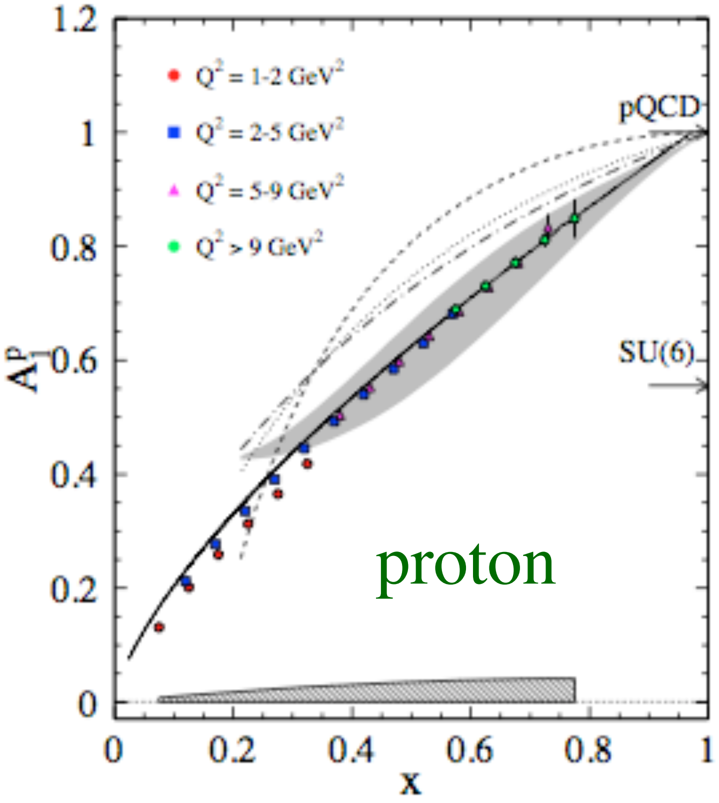
$3.0 \lesssim Q^2 \lesssim 7.8 \text{ GeV}^2$

$2.8 \lesssim Q^2 \lesssim 10.5 \text{ GeV}^2$

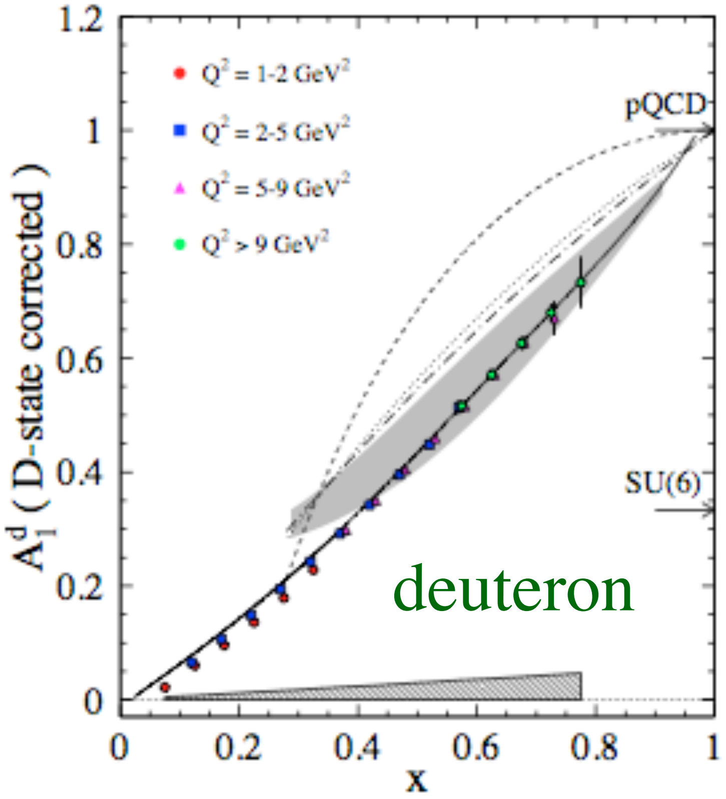
Flagship 12 GeV measurement!

E12-06-109 (Hall B)

- Comprehensive program of *inclusive* and *semi-inclusive* measurements with CLAS12



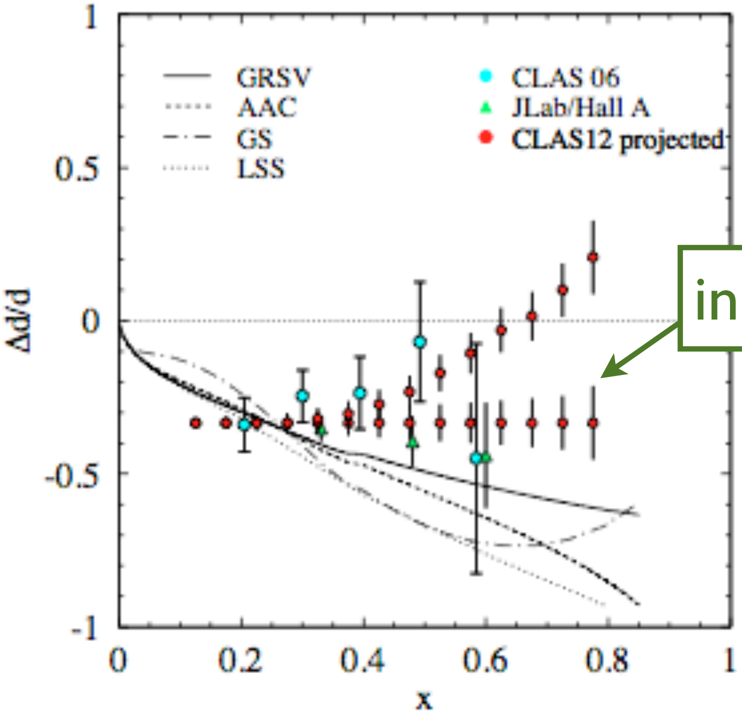
$x \leq 0.78$



- Reconstruct large-x $\Delta u/u$ & $\Delta d/d$ from any *two* of $A_1^p,\ A_1^d,\ A_1^{^3\mathrm{He}}$ (and d/u ratio!)

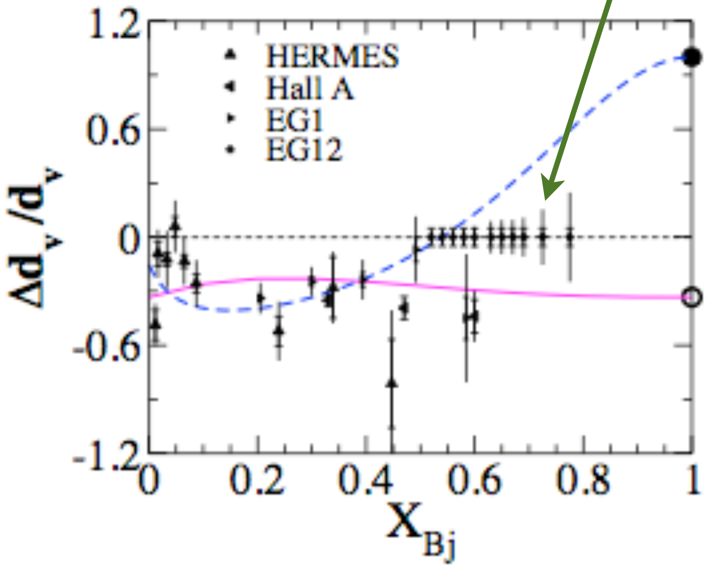
E12-06-109 (Hall B)

- Comprehensive program of *inclusive* and *semi-inclusive* measurements with CLAS12



inclusive

semi-inclusive



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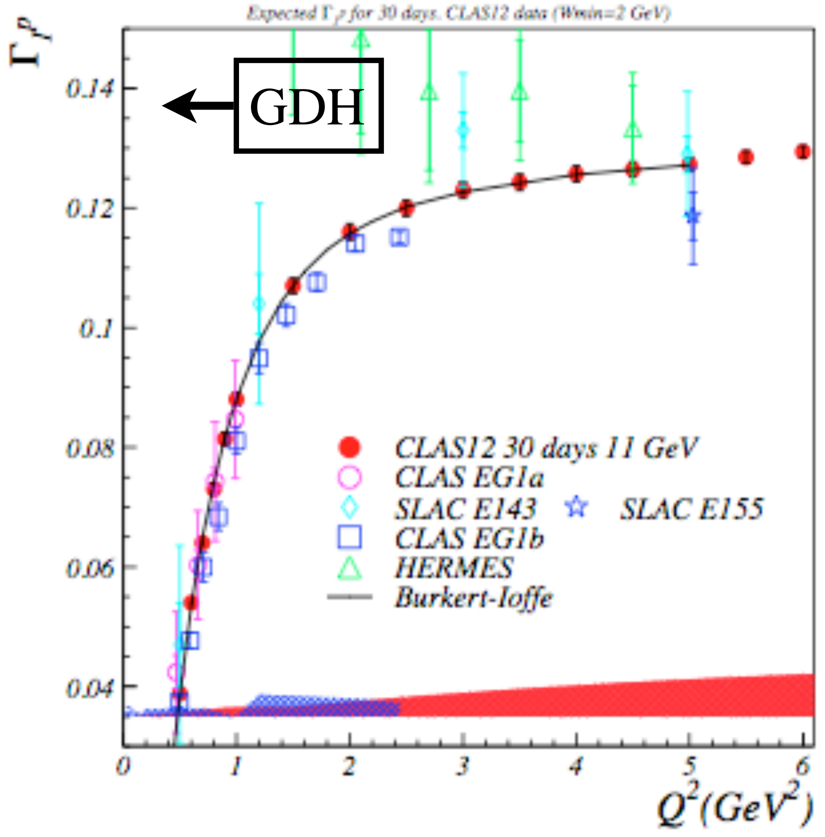
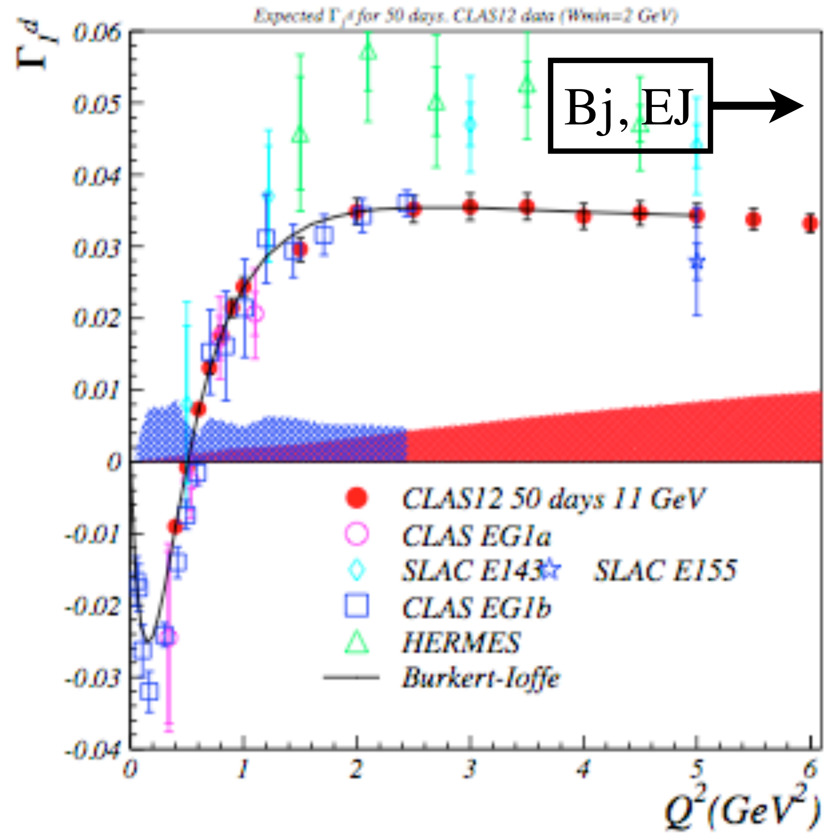
E12-06-109 (Hall B)

- Comprehensive program of *inclusive* and *semi-inclusive* measurements with CLAS12
  - → integrals over x allow direct comparison with *lattice* QCD
  - → Q^2 dependence allows extraction of (leading & higher twist) *matrix elements*





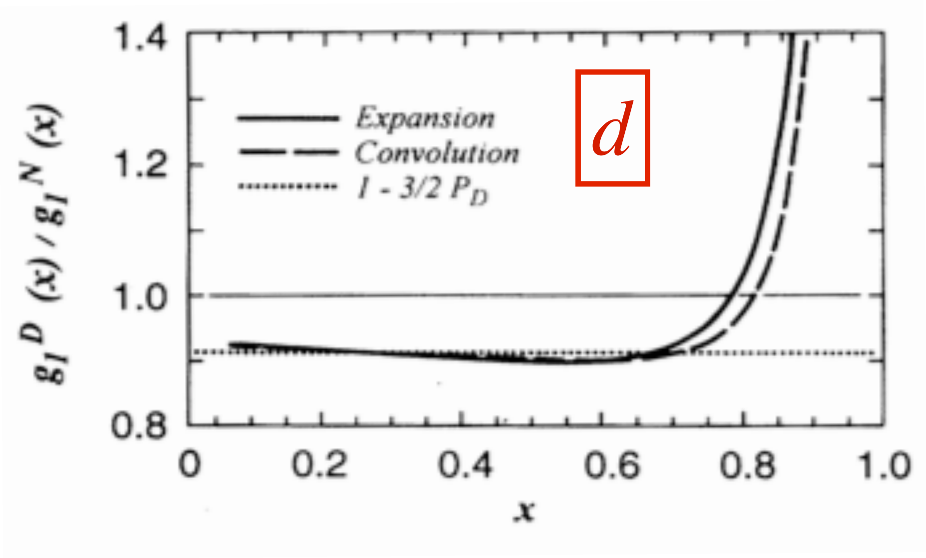
Spin structure at large x – nuclear effects

- Extracting neutron information from ^{3}He or d data requires subtraction of nuclear corrections
- Usual prescription accounts for *effective polarizations* of bound nucleons, assuming x & Q^2 independent effects

$$g_1^A = \langle \sigma_z \rangle^p \; g_1^p + \langle \sigma_z \rangle^n \; g_1^n$$

→ reasonable approximation for $x \lesssim 0.65$

→ breaks down for $x \gtrsim 0.7$



WM, Piller, Kulagin, Thomas, Weise (1995)

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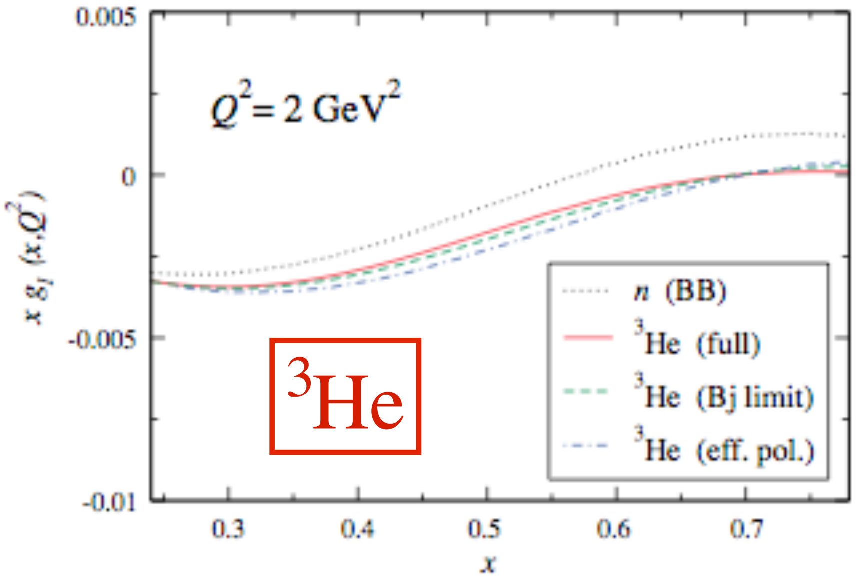

Kulagin, WM, PRC ***78****, 065203 (2008)*

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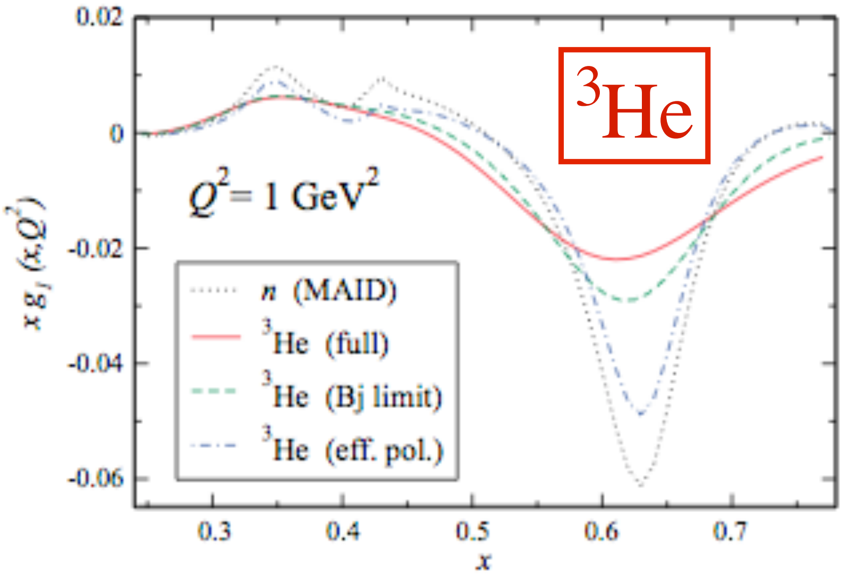
→ *finite-*Q^2 corrections recently computed

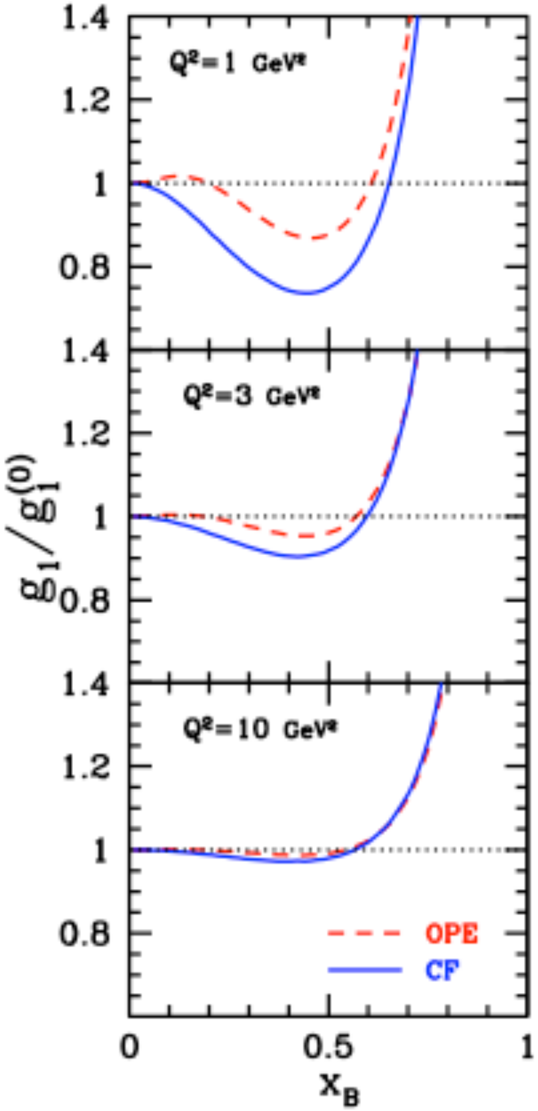
→ especially egregious in *resonance* region



Kulagin, WM, PRC **78**, 065203 (2008)

Spin structure at large x – finite Q^2

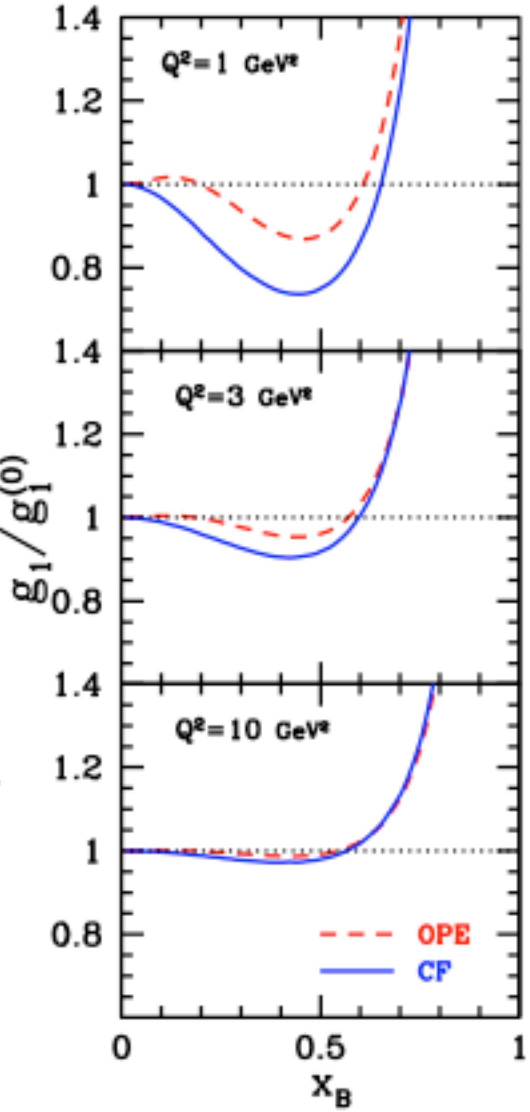
- Limited Q^2 requires careful treatment of $1/Q^2$ corrections
  - → prescription dependence of TMCs
  - → expect cancellation with dynamical HTs for stable LTs (*cf.* CTEQX)



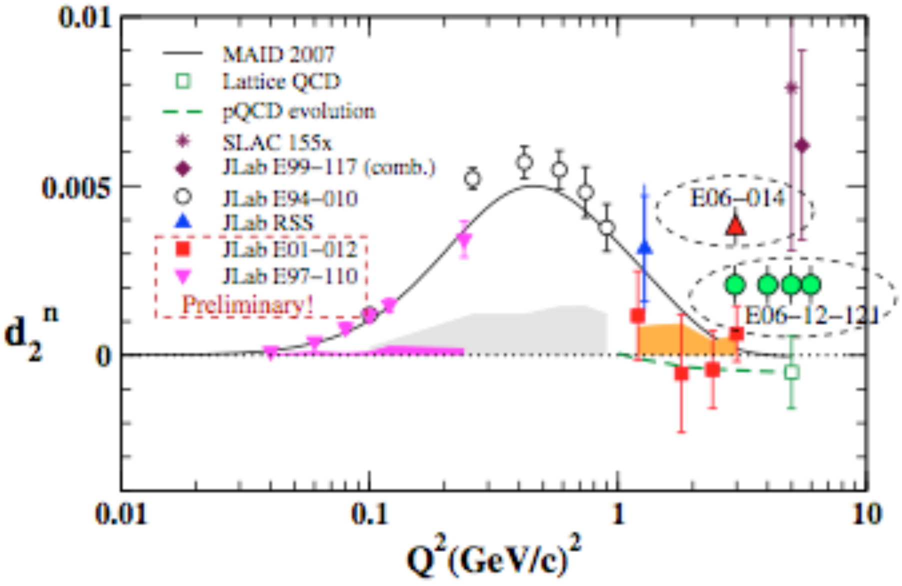
Accardi, WM,
*PLB **670**, 114 (2008)*

Spin structure at large x – finite Q^2

- Limited Q^2 requires careful treatment of $1/Q^2$ corrections
  - → prescription dependence of TMCs
  - → expect cancellation with dynamical HTs for stable LTs (*cf.* CTEQX)
- Impact on extraction of higher twist matrix elements (*e.g.* color polarizabilities, E12-06-121) needs to be assessed



Accardi, WM,
*PLB **670**, 114 (2008)*



$$\frac{\Gamma_1^{\rm HT}}{Q^2} \propto \frac{a_2^{\rm TMC} + d_2 + \overset{\text{twist-4}}{\boxed{f_2}}}{Q^2}$$

$$\chi_E = \frac{2}{3}(2d_2 + f_2)$$

$$\chi_B = \frac{1}{3}(4d_2 - f_2)$$

Summary

- Measurement of structure functions at large x at $12\ \mathrm{GeV}$ will resolve long-standing questions about $x \rightarrow 1$ behavior of PDFs

  → dramatic behavior for $x \gtrsim 0.6$ best revealed with *highest possible x*

- Need largest Q^2 range possible to constrain subleading $1/Q^2$ corrections

  → prescription dependence of TMCs needs to be better understood for unambiguous HT matrix element extraction

- Era of using effective polarization *ansatz* for nuclear corrections should end with end of $6\ \mathrm{GeV}$ program

  → both in the *resonance & DIS* regions

Summary

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- Era of using effective polarization *ansatz* for nuclear corrections should end with end of $6\ \mathrm{GeV}$ program
  - → both in the *resonance & DIS* regions
- Ongoing interest in & support for high x physics

HiX2010

October 13-15, 2010 JEFFERSON LAB

Newport News, Virginia

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The End