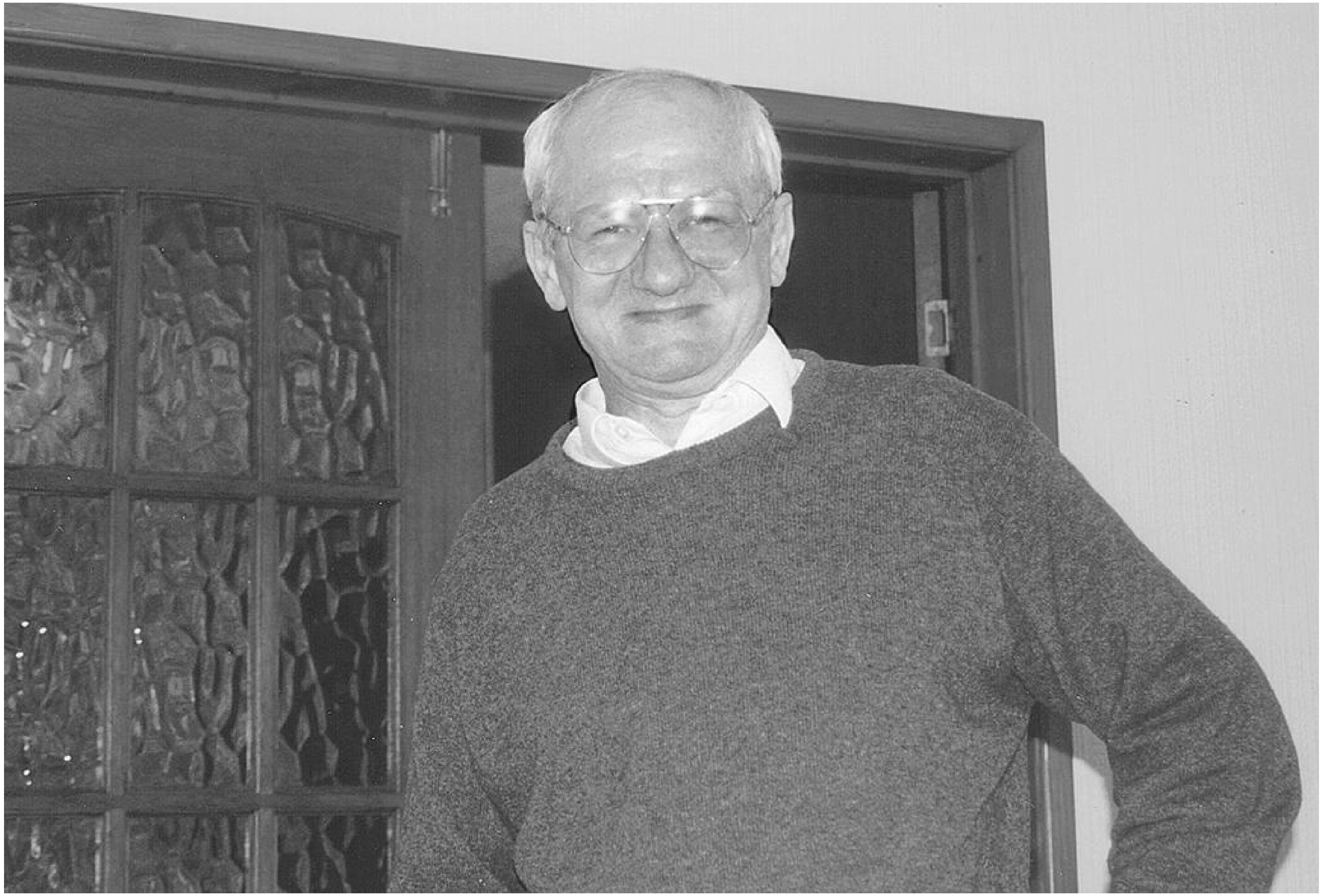


Jan Kwiecinski 1938 - 2003

…absolutely the kindest man I have ever met in my whole life. ….

CERN Courier, Jan-Feb 2004

Some of Jan's proteges:

Krzysztof Golec-Biernat
Leszek Motyka
Anna Stasto

⇒ excellent joint paper on saturation in BFKL

Michal Praszalowicz

BKP eq. for the odderon

QCD	Electroweak
$SU(3)$	$\times\ SU(2) \times U(1)$
expt. led	theory led (~30 yrs)
g, q confined, never observed	ℓ, γ, W, Z seen in detectors

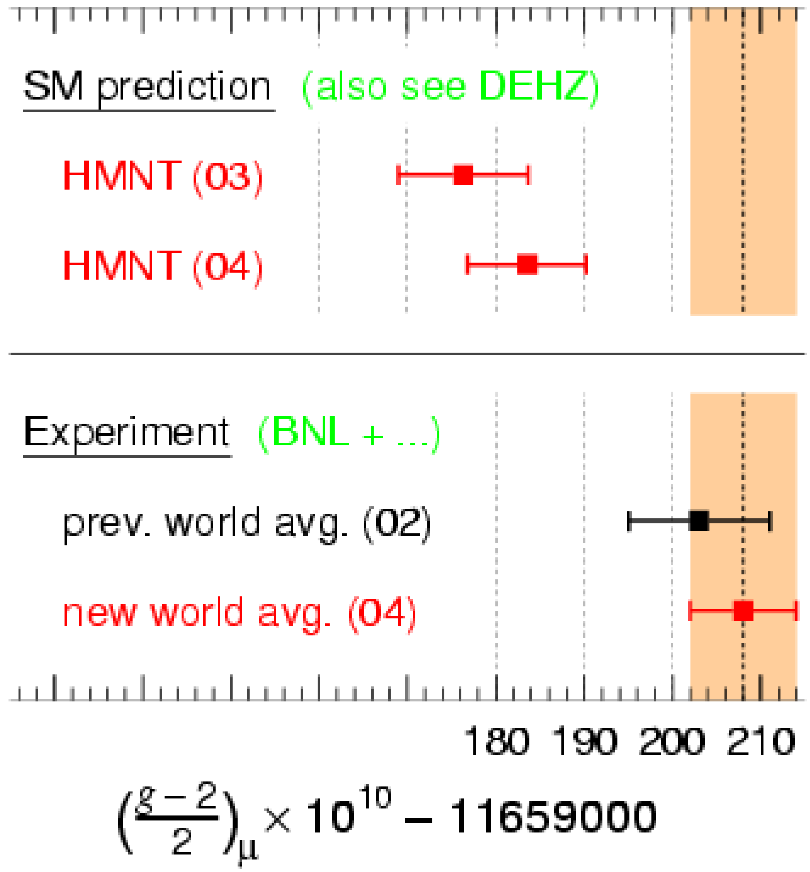
$$SU(3) \times SU(2) \times U(1)$$

Problem is low energy QCD

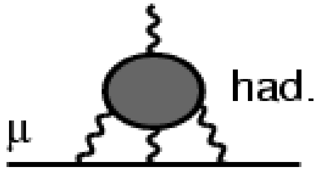
3 examples from W/S

Muon g-2

Teubner



Need accurate low energy $e^+e^- \to \pi^+\pi^-, \ldots$ data



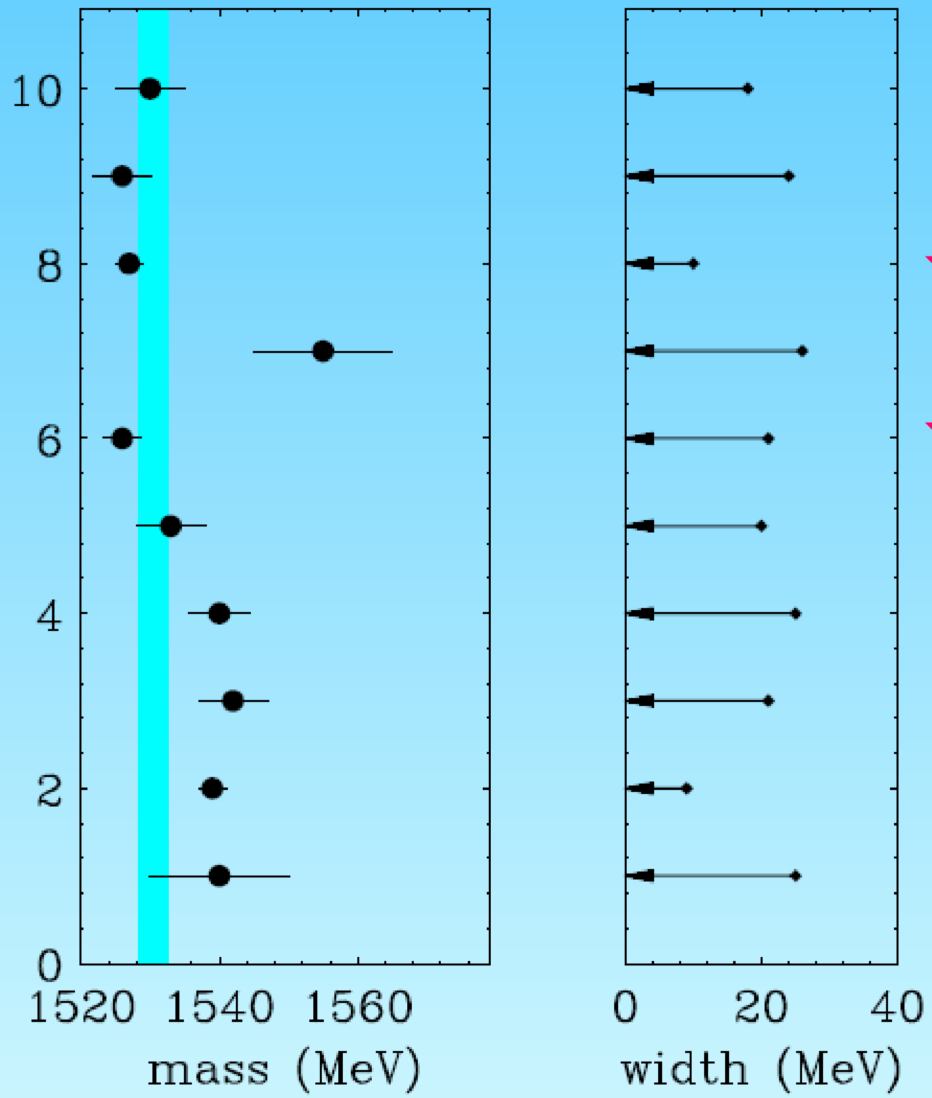
Need off shell $\pi, \eta, \ldots$ form factors
$+$ matching (latest: Melnikov & Vainshtein)

Pentaquarks

Several expts see an exotic B=1, S=1 baryon resonance in K^+n or K^0p channel

$\Theta_s(1530)$ with narrow width $\Gamma<10$ MeV

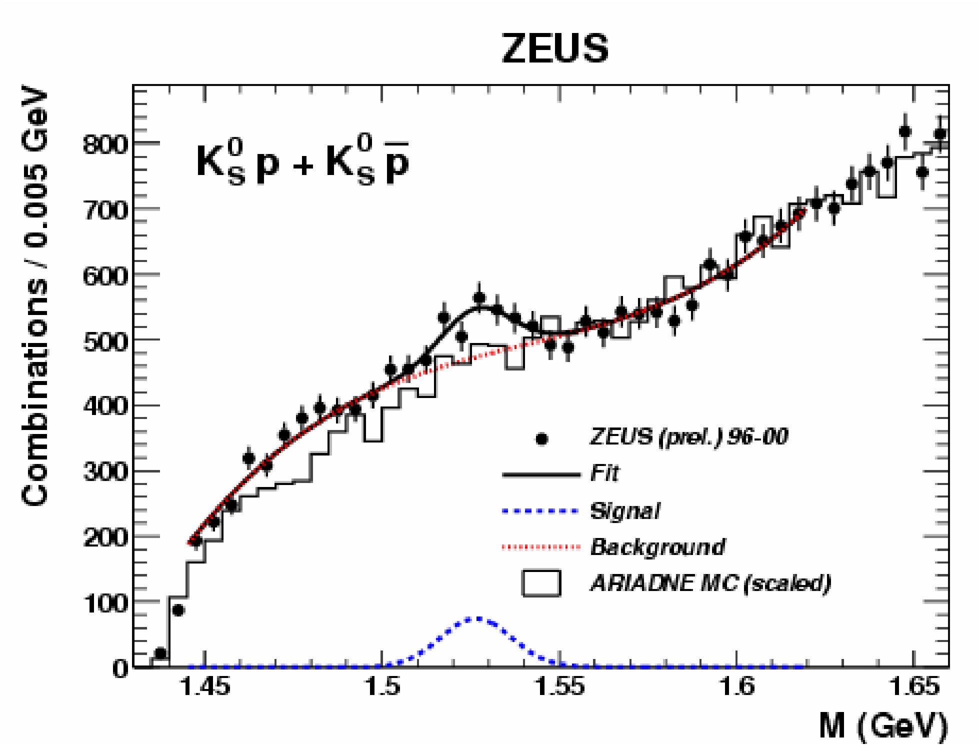
mass and width measurements of Θ^+

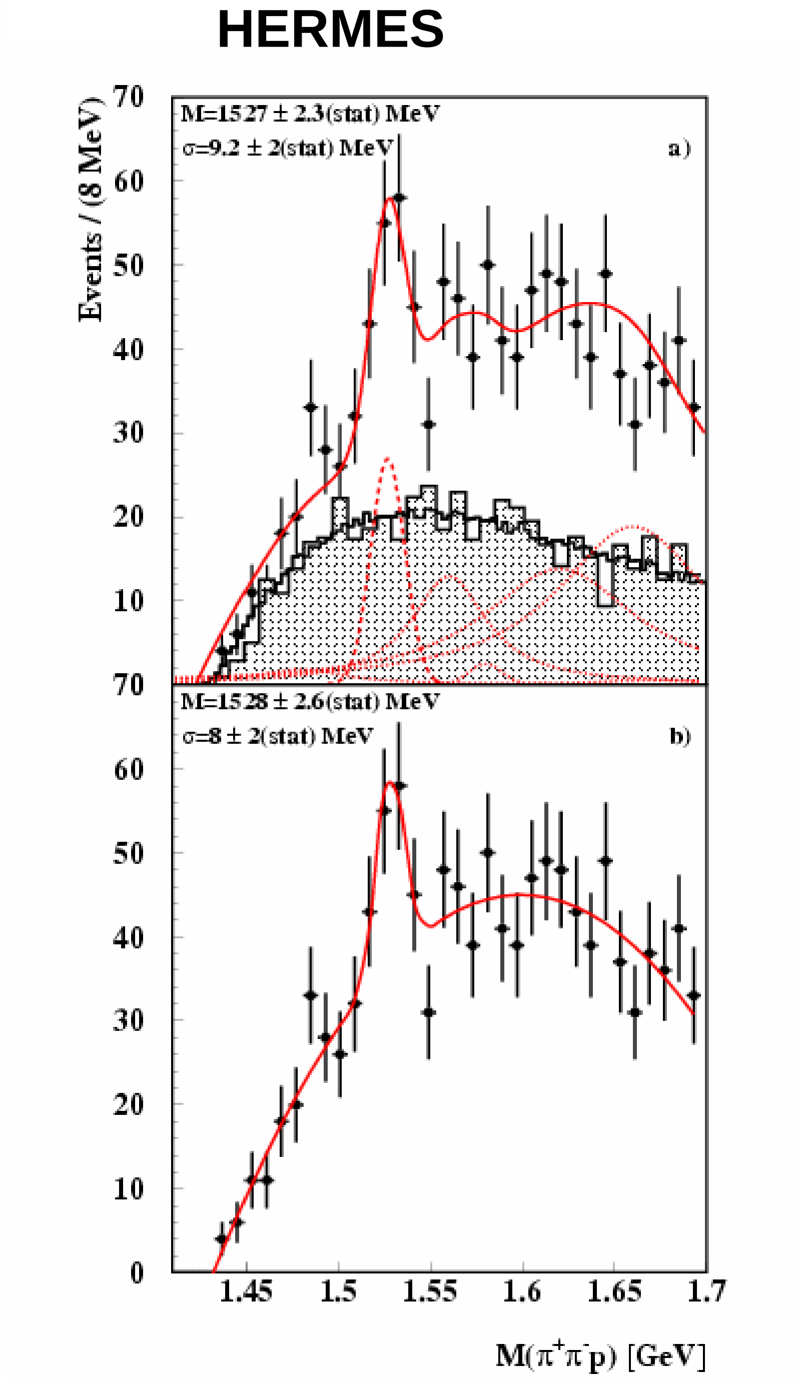


COSY: $pp \to \Sigma^+ K_s p$	$5 \pm 1\sigma$
SVD−2: pA	5.6σ
★ ZEUS: $\gamma^* p$	5.0σ
CLAS 2: γp	$7.8 \pm 1.0\sigma$
★ HERMES: $\gamma^* D$	$7.5 \pm 2.4\sigma$
ITEP: νA, $\bar{\nu} A$	6.7σ
SAPHIR: γp	4.8σ
CLAS: γD	$5.3 \pm 0.5\sigma$
DIANA: $K^+ Xe$	4.4σ
LEPS: $\gamma\, ^{12}C$	4.6σ

Karliner

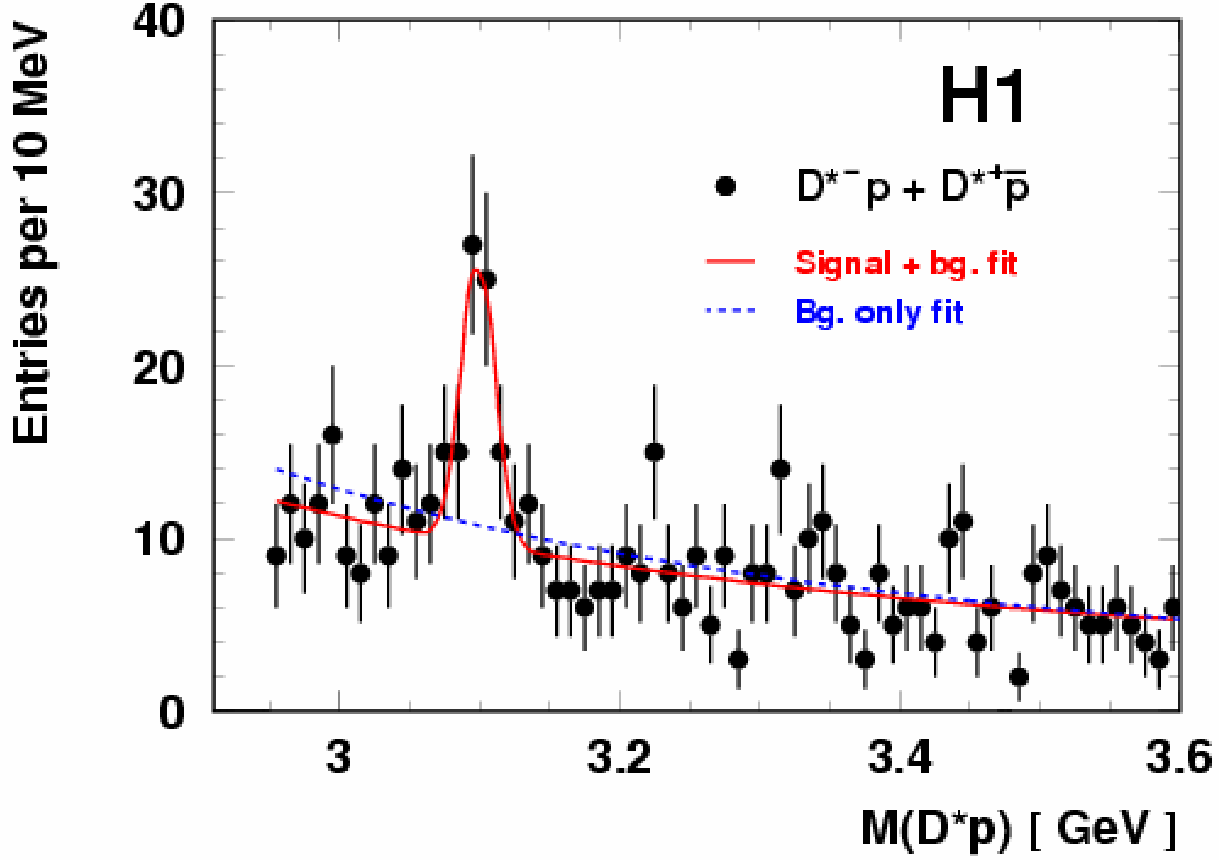
World average: $m = 1530.5 \pm 2.0$ MeV





but is $\Theta_s(1530)$ seen by H1 ??

but H1 see Θ_c

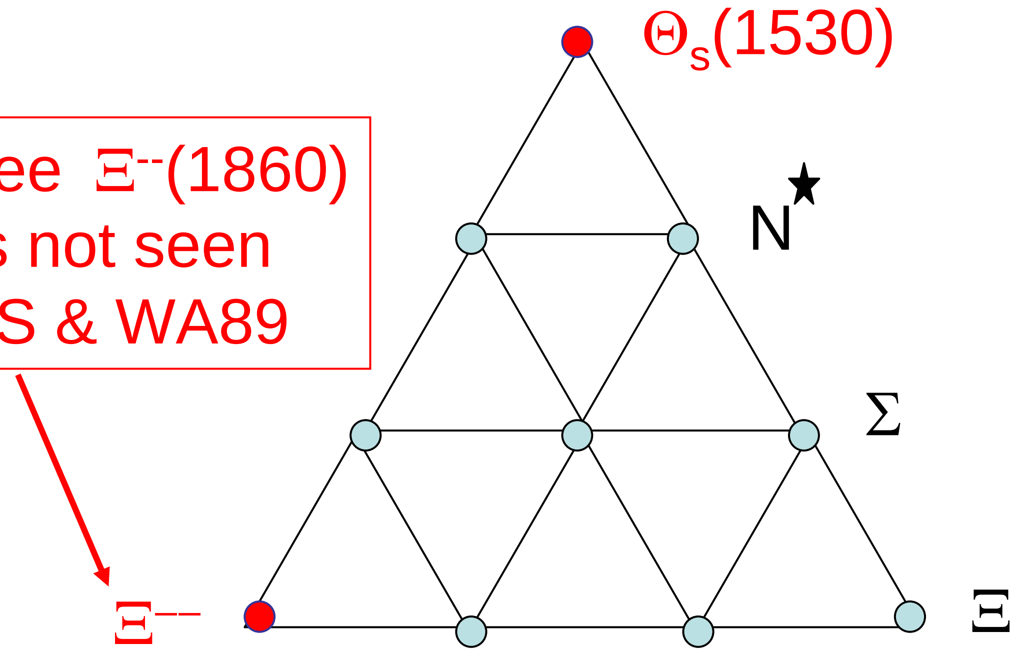


which is not seen by ZEUS ?

The chiral soliton (Skyrme) model (χSM) predicted $\Theta_s(1530)$ with Γ<15 MeV, $J^P=(1/2)^+$ in a $\overline{10}$ of $SU(3)_f$

Praszalowicz(1987), Diakonov,Petrov,Polyakov(1997)

NA49 see $\Xi^{--}(1860)$ which is not seen by ZEUS & WA89



χSM & CQM are complementary:
~shell & droplet nuclear models

Postdictive interpretation in terms of constit.quark model (CQM)

$\Theta_s = uudd\bar{s}$ in P-wave $(1/2)^+$ in $\overline{10}$

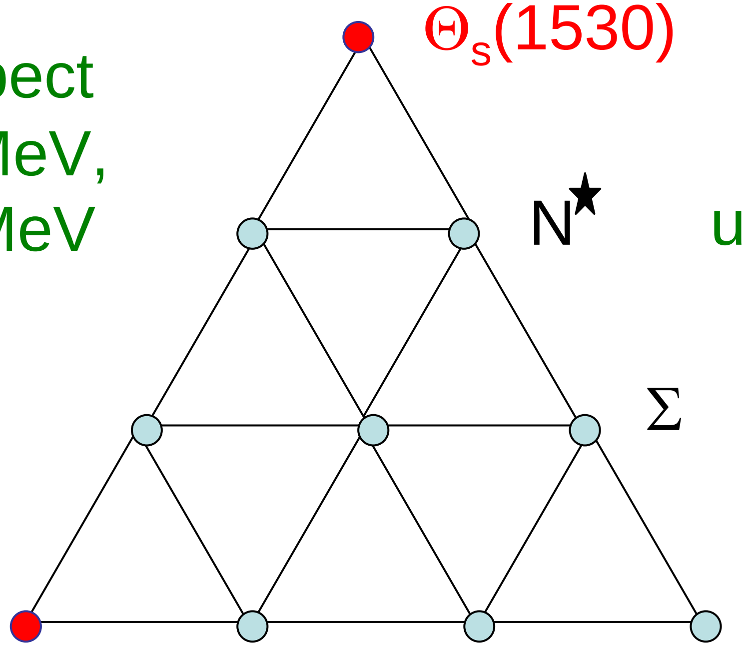
Karliner & Lipkin (ud) (u$d\bar{s}$) predict Θ_c(2985 +/- 50 MeV))

Jaffe & Wilczek (ud) (ud) $\bar{s}$ predict Θ_c(2710 MeV)

H1 see Θ_c(3099 MeV)

Anticipate $\Gamma(\Theta_c)\sim 10\Gamma(\Theta_s)$ from KN to DN phase space

Karliner & Lipkin expect $M(\Xi) - M(\Theta_s) < 300$MeV, whereas expt ~330MeV



Third example of expt. led QCD:

Wu-Ki Tung’s “trip down memory lane”

He showed us some the twists & turns of the PDF input needed to keep pace with the new experimental measurements

DIS → Bjorken scaling → quarks (of spectroscopy) really exist

→ Gross & Wilczek, Politzer →

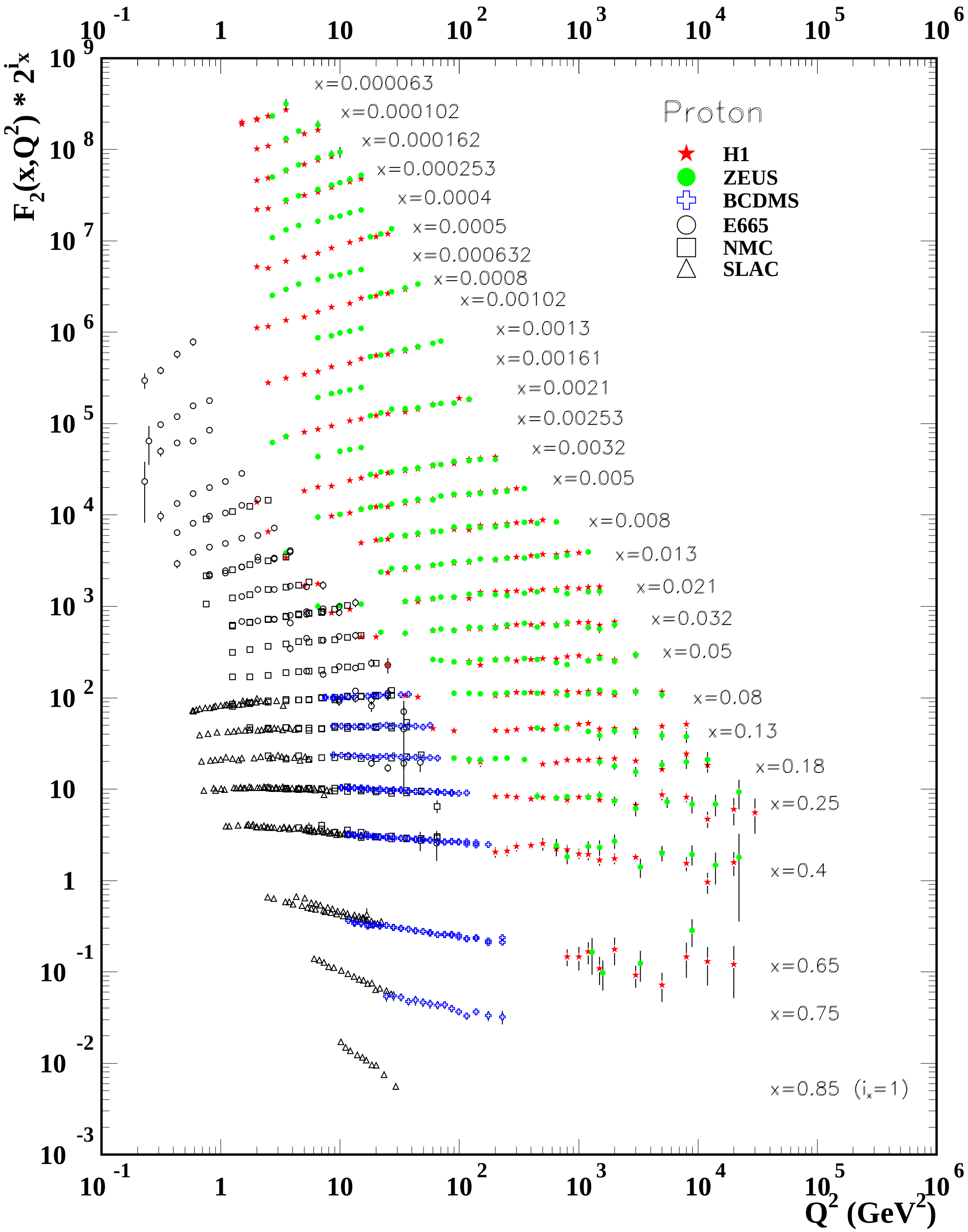
colour SU(3) gauge theory (QCD)

→ logarithmic scaling violations

A famous experimentalist to Wilczek:

You expect us to measure logarithms !

Not in your lifetime young man !



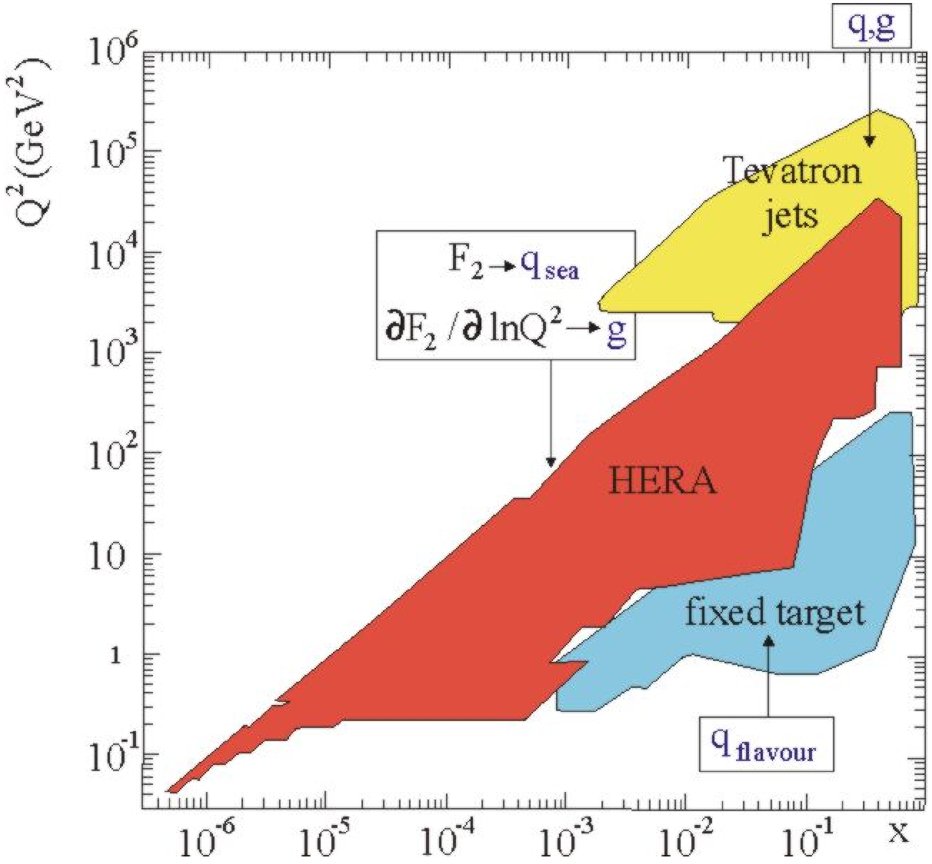
$F_2(x,Q^2) * 2^{i_x}$
Q^2 (GeV^2)
Proton
H1
ZEUS
BCDMS
E665
NMC
SLAC
x=0.000063
x=0.000102
x=0.000162
x=0.000253
x=0.0004
x=0.0005
x=0.000632
x=0.0008
x=0.00102
x=0.0013
x=0.00161
x=0.0021
x=0.00253
x=0.0032
x=0.005
x=0.008
x=0.013
x=0.021
x=0.032
x=0.05
x=0.08
x=0.13
x=0.18
x=0.25
x=0.4
x=0.65
x=0.75
x=0.85 (i_x=1)

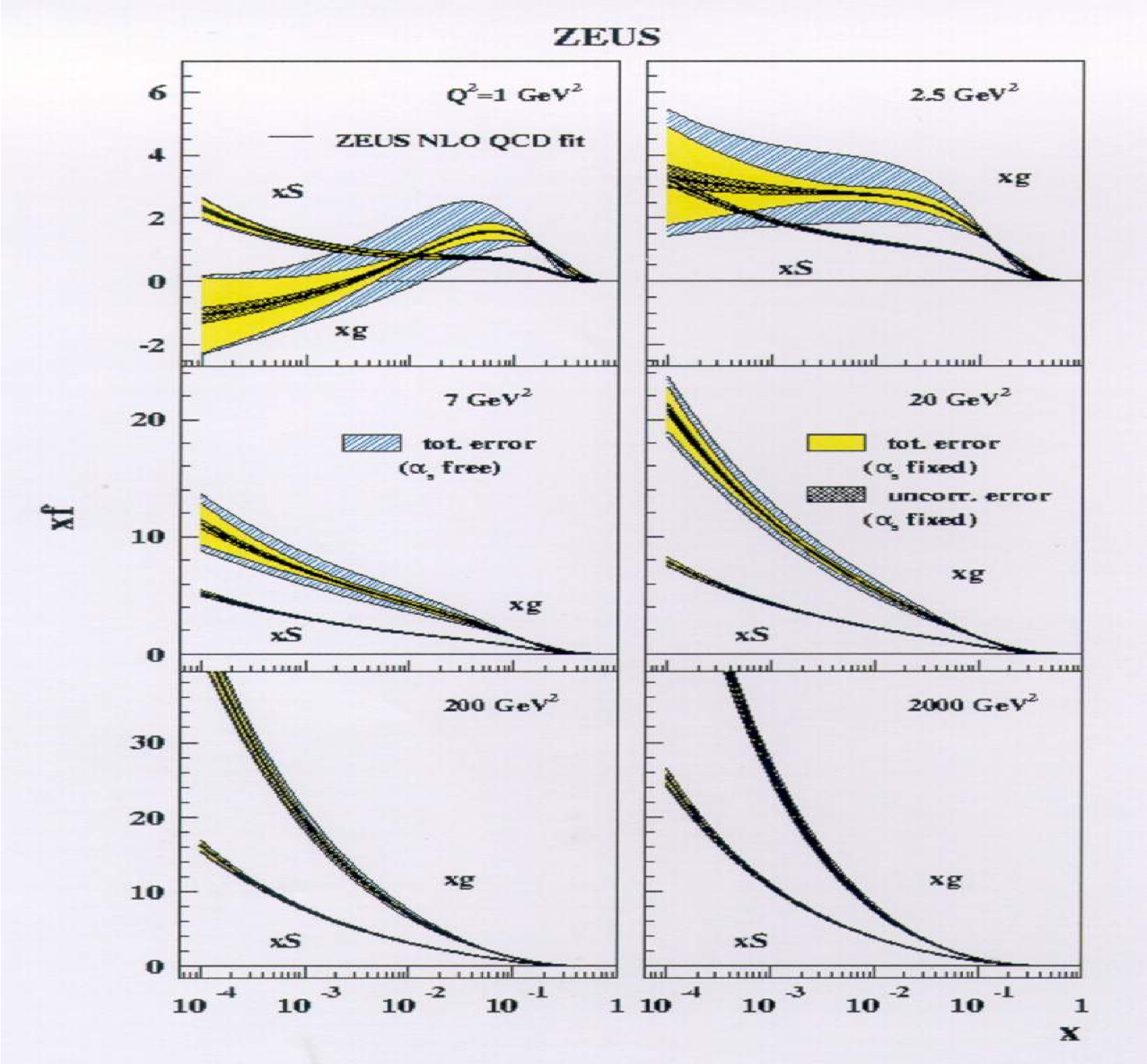
Fixed target DIS ep, ed, νN; D-Yan, W asym, Tevatron jets
HERA ep
→global DGLAP parton analyses CTEQ, MRST
→analyses to selected data sets Botje, Alekhin, ZEUS, H1…

Expect small x processes to be driven by the gluon.

Surprise → at v.low scales appear to be dominated by by singlet sea quarks → valence-like or -ve gluon !

Sea quarks & gluons not (perturbatively) connected.




ZEUS
Q²=1 GeV²
ZEUS NLO QCD fit
xS
xg
2.5 GeV²
7 GeV²
tot. error
(αs free)
20 GeV²
tot. error
(αs fixed)
uncorr. error
(αs fixed)
200 GeV²
2000 GeV²
xf
x

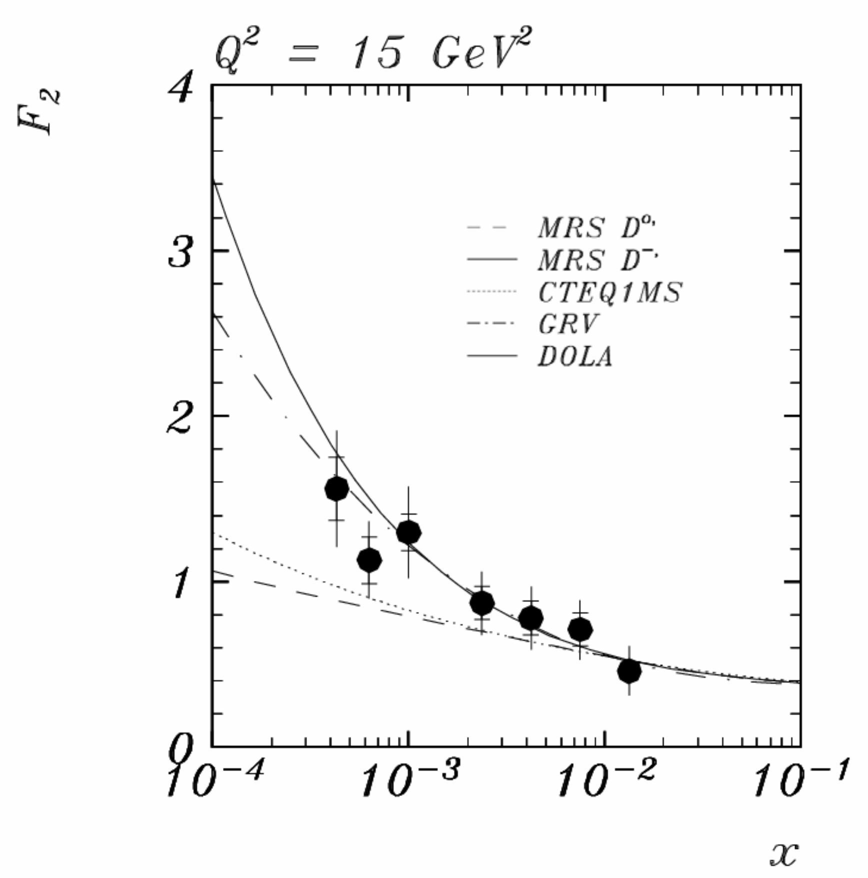
x

α_s from DIS

	$\Delta\chi^2$	$\alpha_S(M_Z^2)$	$\pm$ expt	$\pm$ theory	$\pm$ model
NLO					
CTEQ6	100	0.1165	$\pm$ 0.0065		
ZEUS	50	0.1166	$\pm$ 0.0049		$\pm$ 0.0018
MRST03	5	0.1165	$\pm$ 0.002	$\pm$ 0.003	
H1	1	0.115	$\pm$ 0.0017	$\pm$ 0.005	$^{+0.0009}_{-0.0005}$
Alekhin	1	0.1171	$\pm$ 0.0015	$\pm$ 0.0033	
NNLO					
MRST03	5	0.1153	$\pm$ 0.002	$\pm$ 0.003	
Alekhin	1	0.1143	$\pm$ 0.0014	$\pm$ 0.0009	

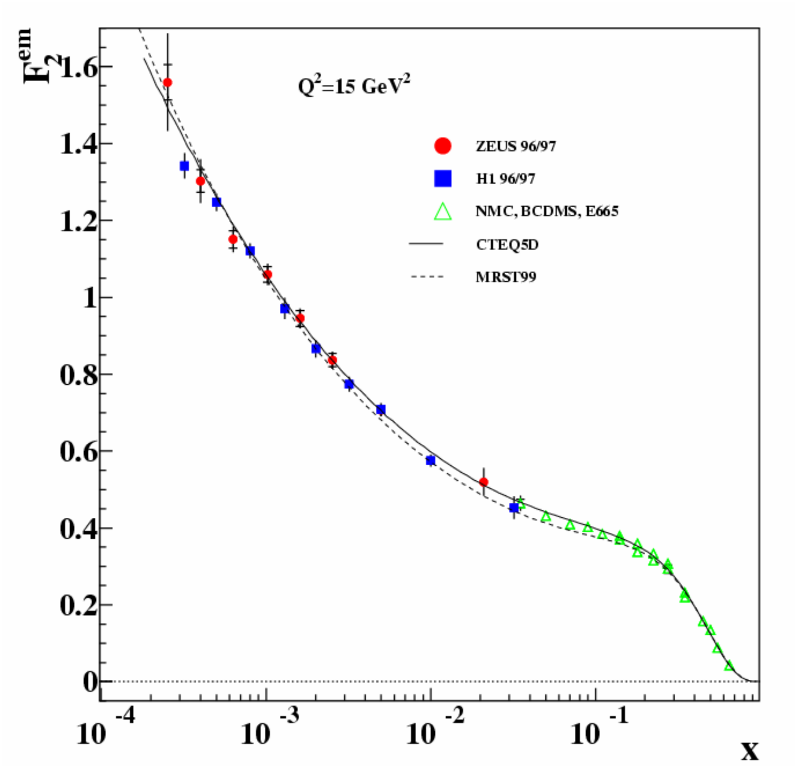
Remarkably consistent, considering v.different selection of data fitted –
but then all include the crucial BCDMS data

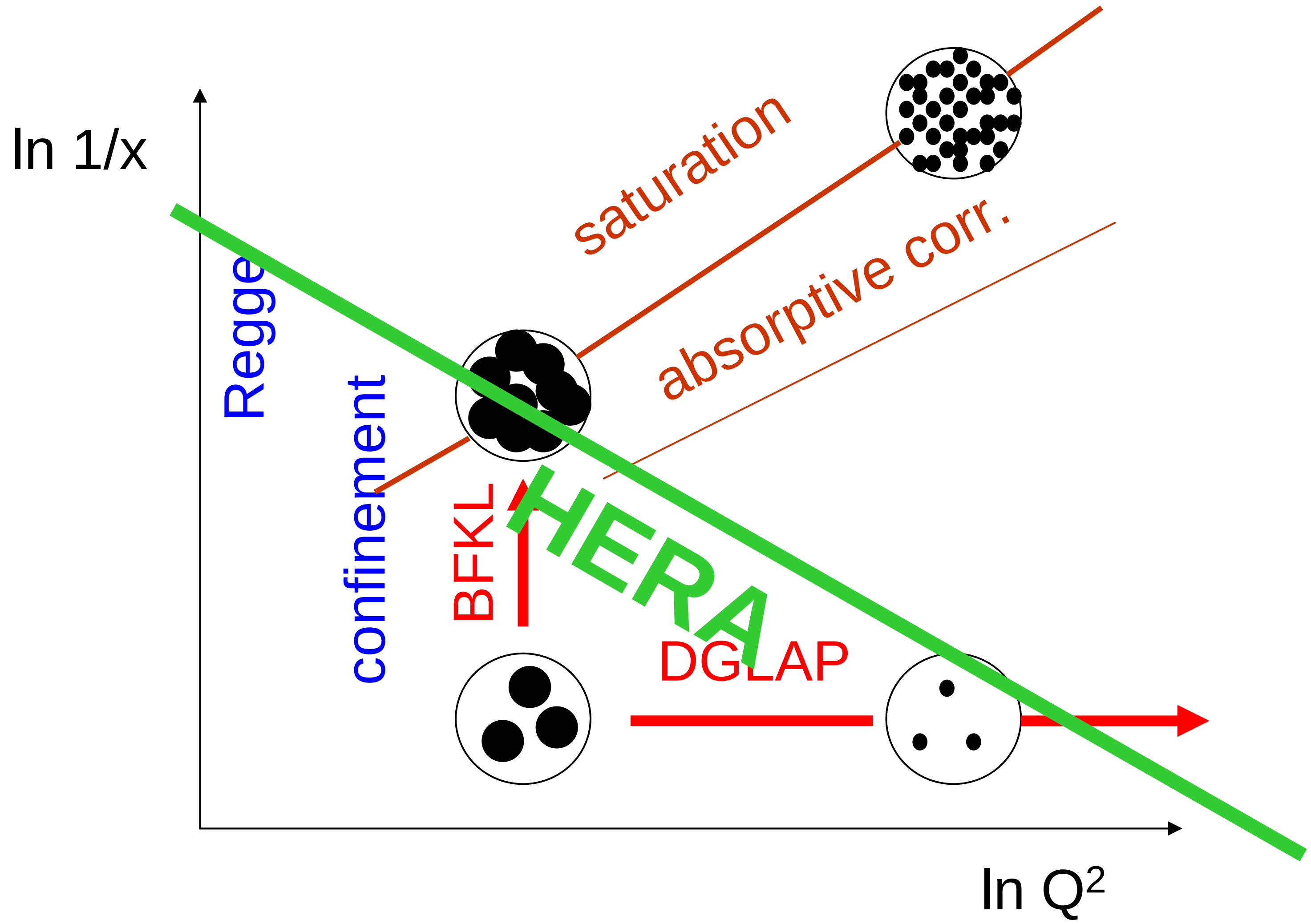
DIS 1993



(Lum=20 nb^{-1})

Now




ln 1/x
saturation
absorptive corr.
Regge
confinement
BFKL
HERA
DGLAP
ln Q^2

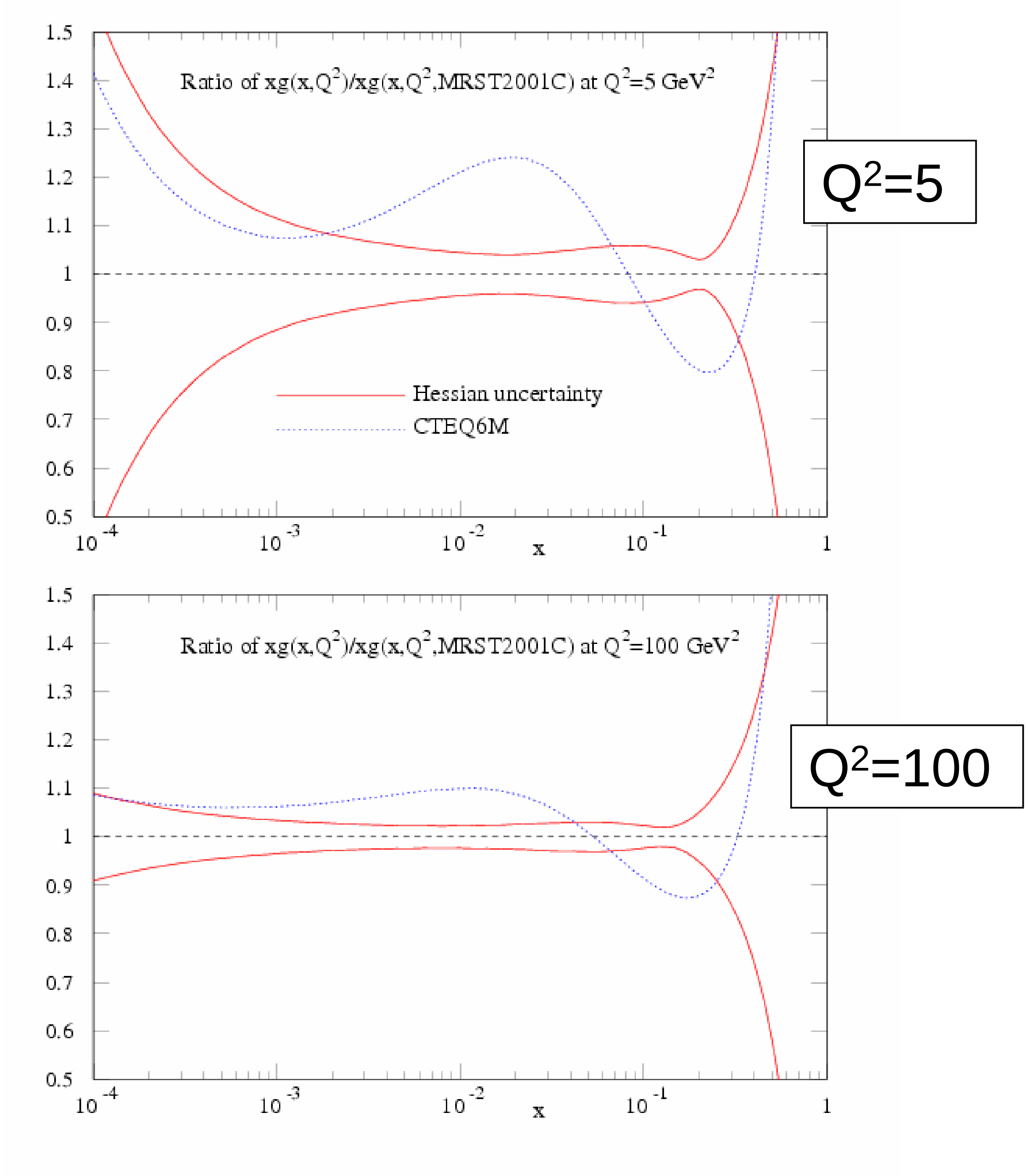
HERA has opened up the small x domain

- how large is the DGLAP domain ?
- are BFKL (log 1/x) effects evident ?
- is there any evidence of absorptive corrections, or even parton saturation ?
- HERA observes diffractive DIS (at ~10% of DIS). What role does it play ?
- what would we like HERA to measure now ?

CTEQ gluon

compared to

MRST error band



Parton uncertainties due to stat/sym errors of data fitted

Other uncertainties include

selection of data fitted; choice of x, Q^2, W^2 cuts

Theoretical uncertainties

higher-order DGLAP NLO, **NNLO…Moch,Vermaseren,Vogt**

$\alpha_s \ln(1/x)$ and $\alpha_s \ln(1-x)$ effects ★★★

absorptive corrections from parton recombination

residual higher-twist effects

QED effects

Uncertainties due to input assumptions

isospin-violating effects MRST

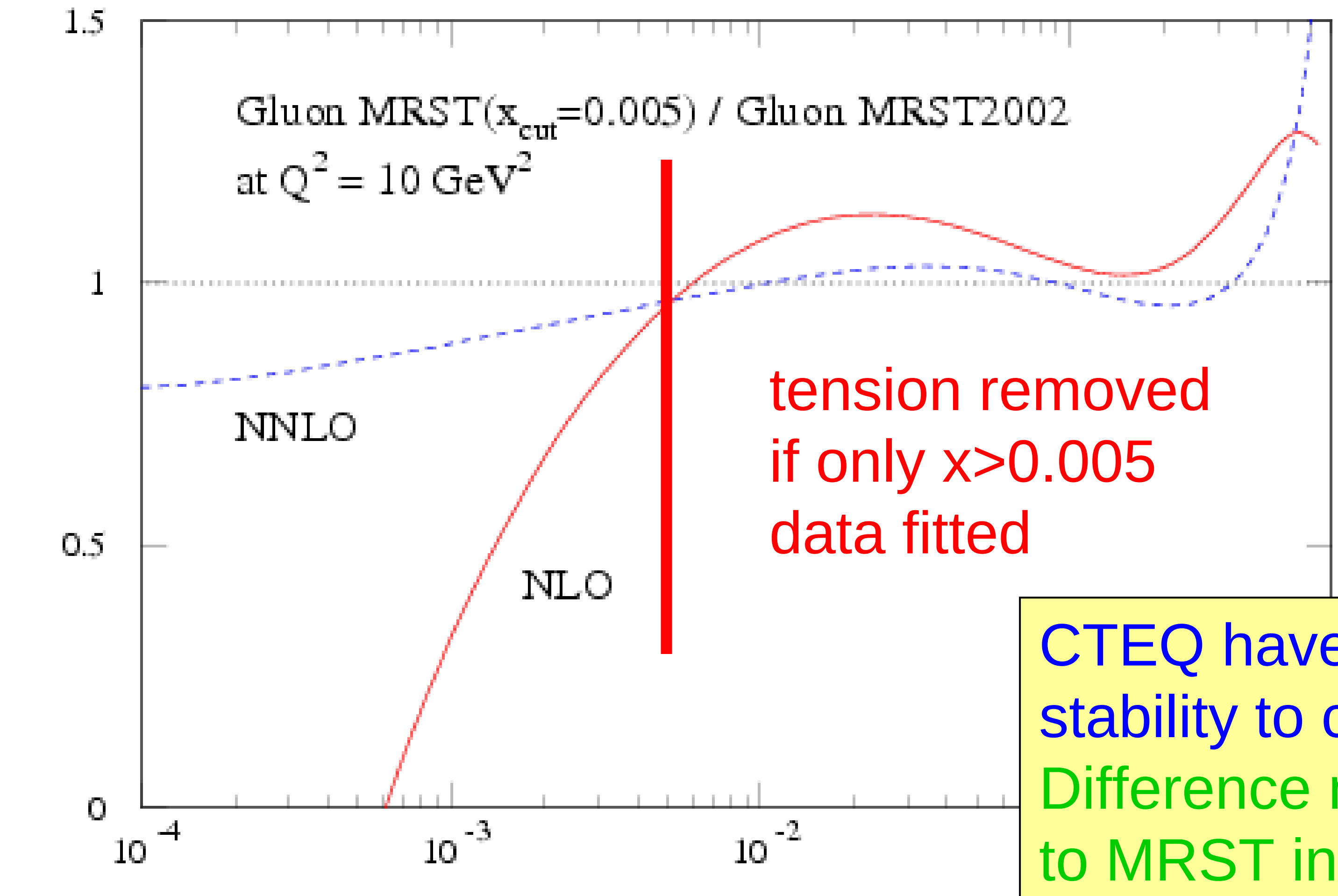
s not equal to $\bar{s}$ CTEQ

⇒ no NuTeV $\sin^2\theta$ anomaly

heavy-target corrections

choice of input parametrization Thorne, Tung

MRST find tension between data sets --- F_2 data (x~0.01) and Tevatron jets (x~0.07-0.5) both prefer more gluon



NNLO more stable to the x=0.005 cut.

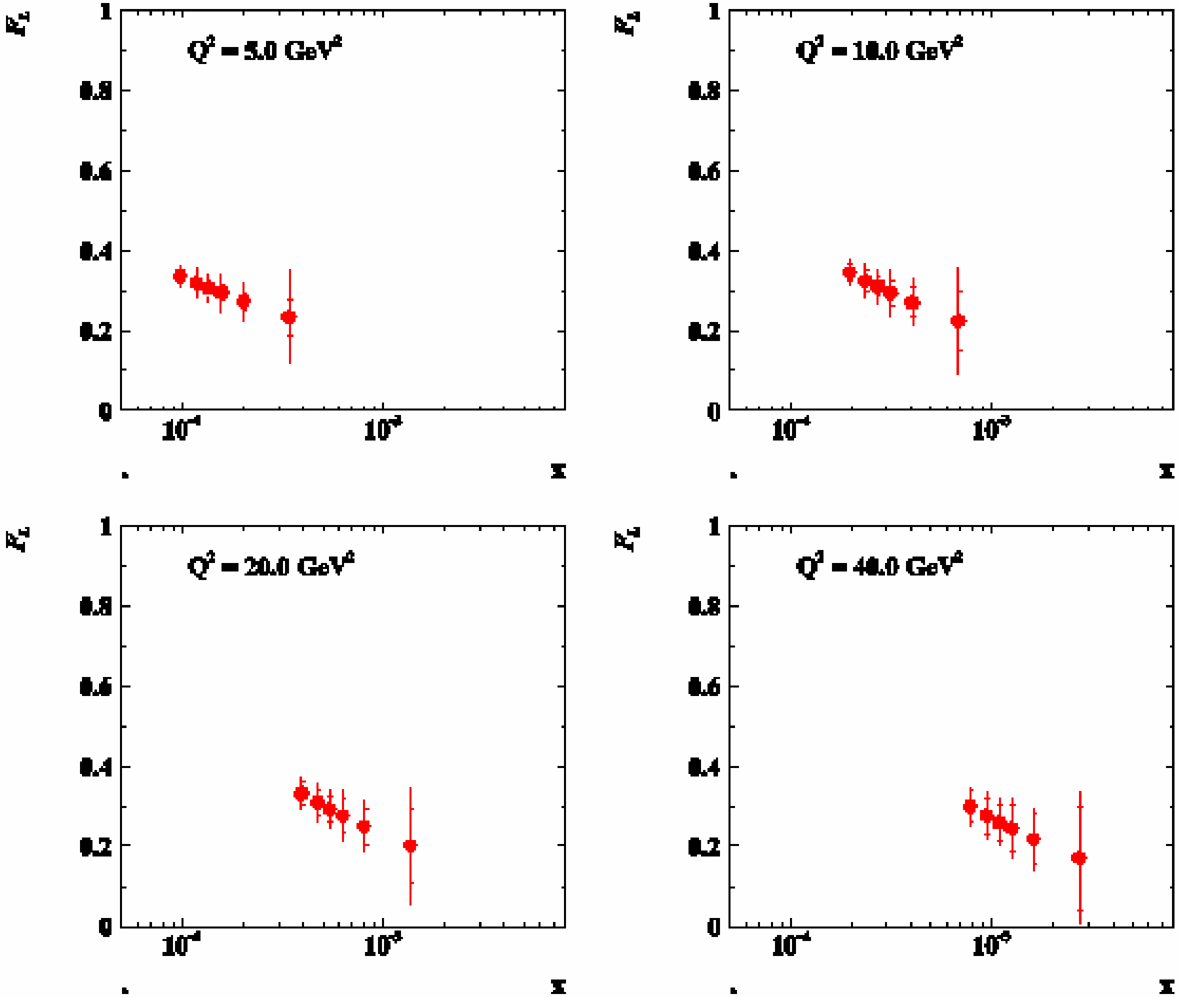
CTEQ have stability to cuts.
Difference may be due to MRST input form with explicit negative gluon term ??

Experimental ways to determine the gluon

- F_L most direct $x \sim 10^{-4} - 10^{-3}$ ★★★
- Prompt photon data (WA70,E706) and theory problems
- Tevatron jets $x \sim 0.07 – 0.5$
- HERA jets $x \sim 0.01 - 0.1$ Cooper-Sarkar, Butterworth (ZEUS)
- Diffractive J/ψ at HERA g^2 $x \sim 10^{-3}$ need to improve theory first attempt by Szymanowski

(+ momentum sum rule)

Simulation of low x FL measurement at HERA based on low Ep Runs



$$\sigma_r = F_2(x,Q^2) - f(y)\cdot F_L(x,Q^2)$$

$$y = Q^2/(4E_eE_p\cdot x) \cong 1 - E_e'/E_e$$

eID at low E' → high y
y=0.9 for E'=3GeV (H1)

keep Ee fixed, lower Ep
fix x,Q2 → vary E

Ep =	400,	465,	575,	920 GeV
Lum=	3	5	10	30 pb-1

case study

inner error bar: stat
full error: stat & syst

MK WGA 14.4.2004

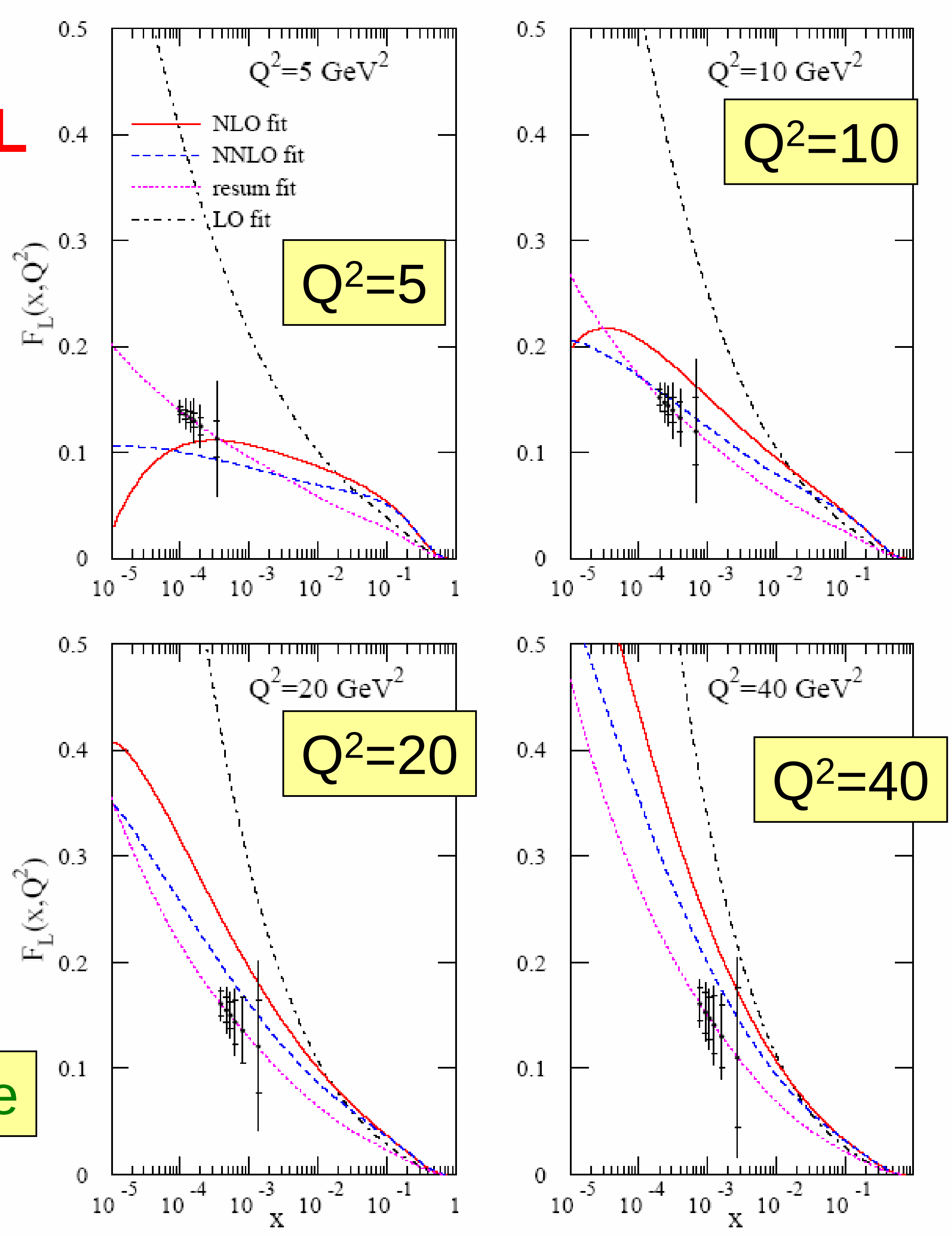
Simulation of F_L by Klein

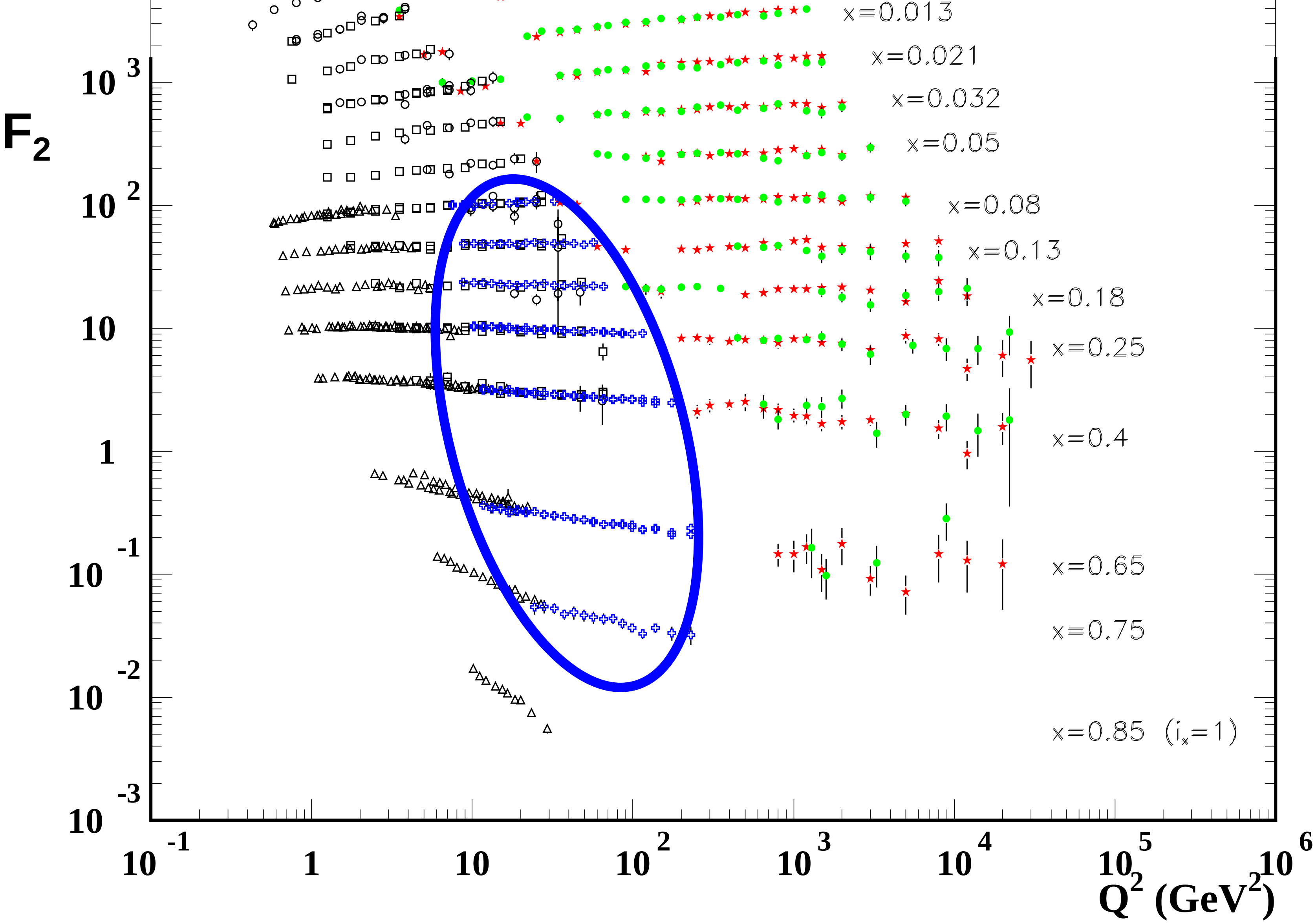
F_L

Extremely valuable if HERA could measure F_L with sufficient precision --- to pin down the low x gluon

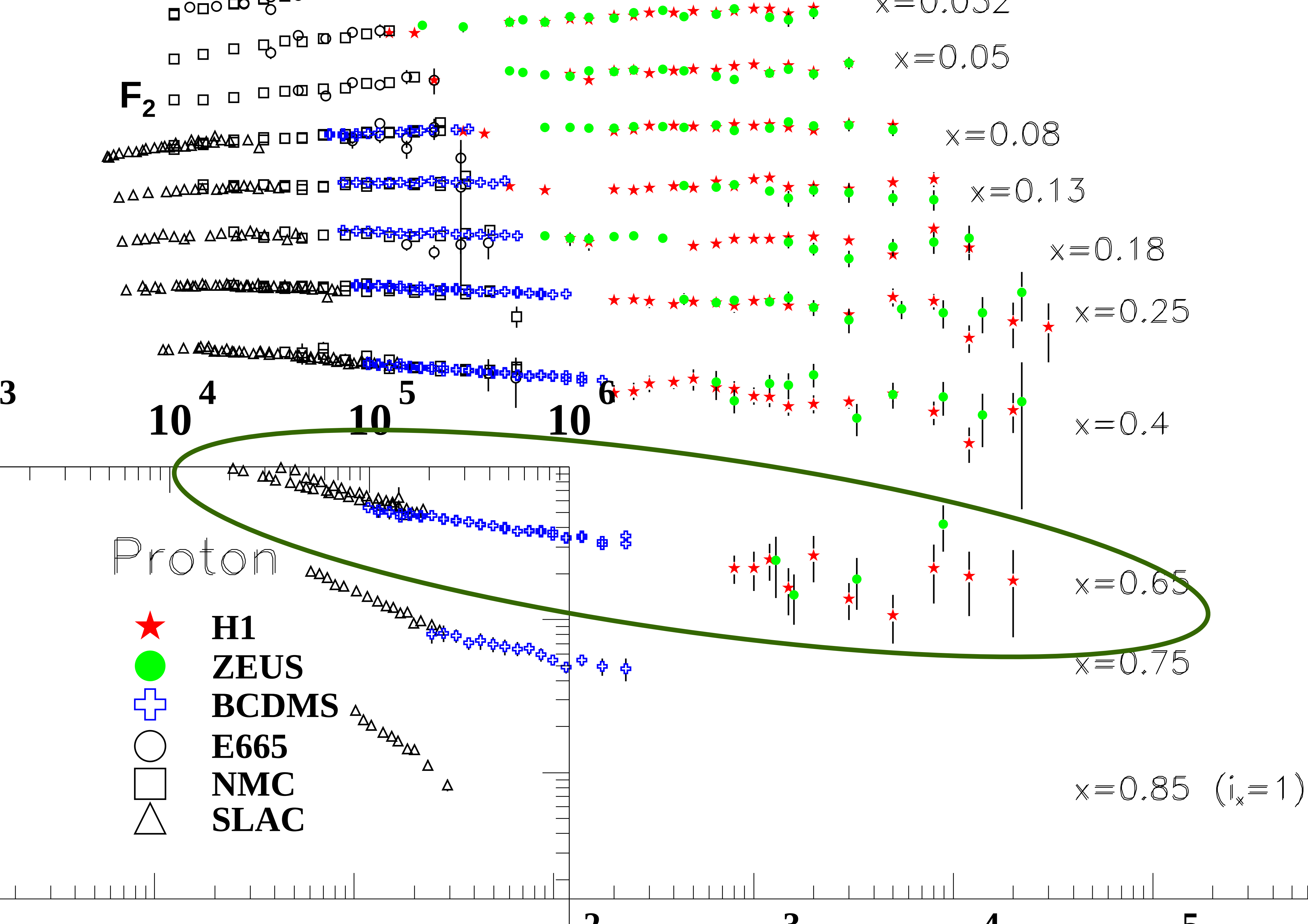
Data are Klein's simulation

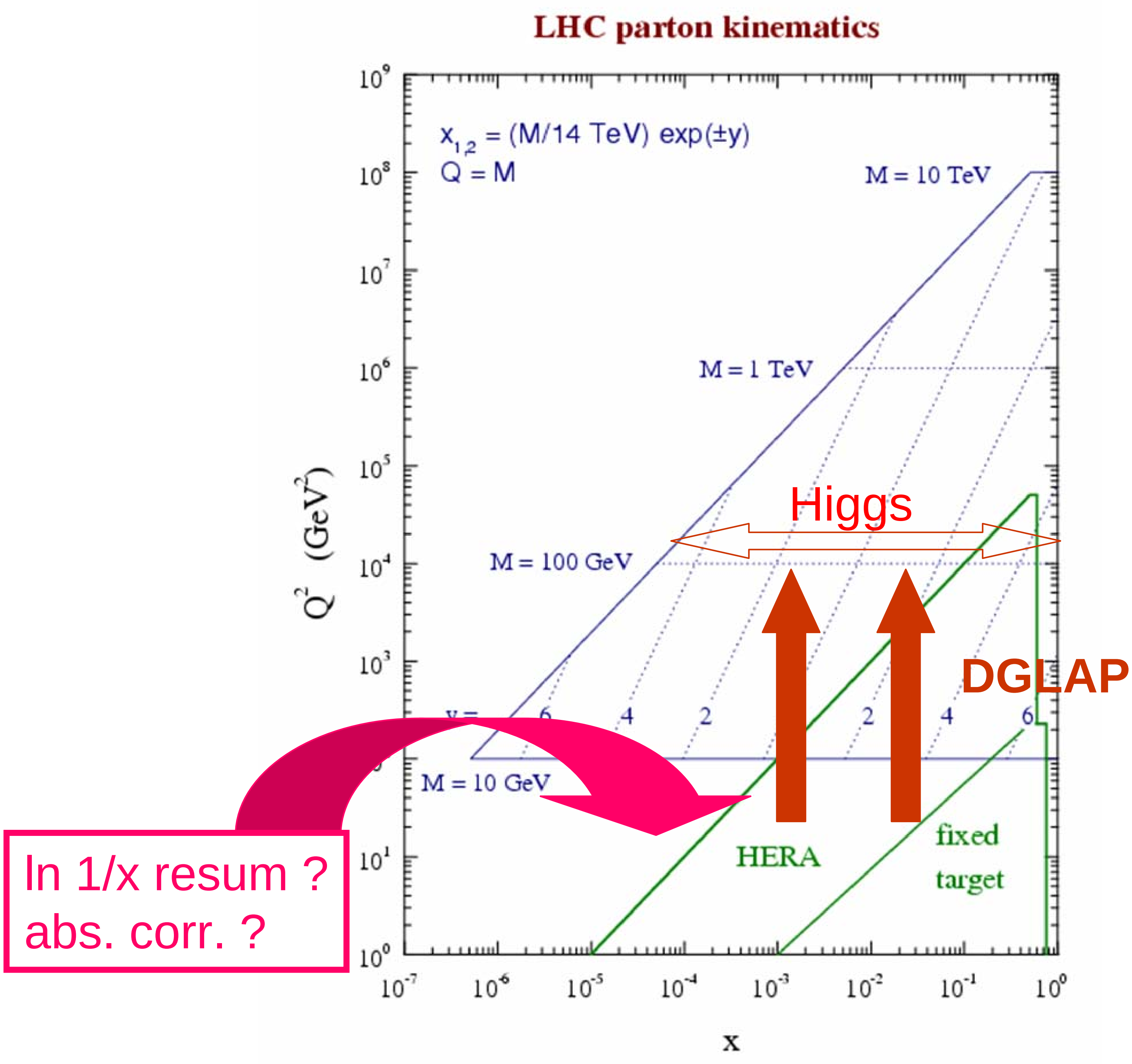
Thorne





Lower HERA beam energies could also provide a valuable check on the large x data, which rely on BCDMS. Also ed?

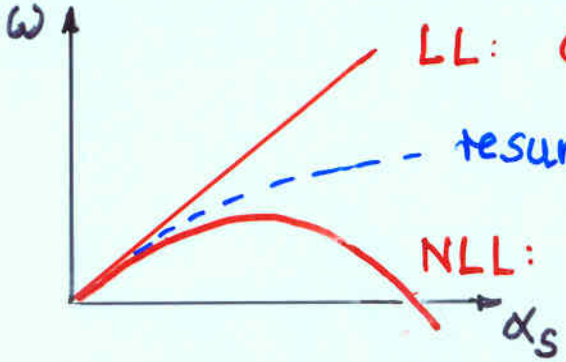

F2
x=0.032
x=0.05
x=0.08
x=0.13
x=0.18
x=0.25
x=0.4
x=0.65
x=0.75
x=0.85 (ix=1)
Proton
H1
ZEUS
BCDMS
E665
NMC
SLAC
10 3
10 4
10 5
10 6
2
3
4
5


LHC parton kinematics
x1,2 = (M/14 TeV) exp(±y)
Q = M
M = 10 TeV
M = 1 TeV
M = 100 GeV
M = 10 GeV
Higgs
DGLAP
HERA
fixed
target
Q² (GeV²)
x
In 1/x resum ?
abs. corr. ?

BFKL high s (small x) region, where $\alpha_s \ll 1$, but $\alpha_s \ln s \sim 1$

$\sigma \sim s^{\omega}$

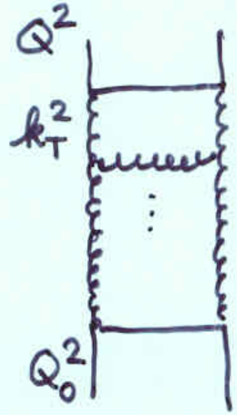
$\bar{\alpha}_s \equiv \frac{3\alpha_s}{\pi}$



LL: $\omega = \omega_0 = 4\bar{\alpha}_s \ln 2$

-- resum higher-order terms

NLL: $\omega = \omega_0(1 - 6.47\,\bar{\alpha}_s)$



<u>Characteristic fn</u>: $\chi(\gamma) = 2\psi(1) - \psi(\gamma) - \psi(1-\gamma)$

$\frac{1}{\gamma} + \ldots$ $\qquad$ $\frac{1}{1-\gamma} + \ldots$

Mellin trans: $s \leftrightarrow \omega$, $k_T \leftrightarrow \gamma$

DGLAP $Q^2 \gg k_T^2$ $\qquad$ Anti-DGLAP $k_T^2 \gg Q^2$

coll. limit $(s_0 = Q^2)$ $\qquad$ anti-coll. limit $(s_0 = Q_0^2)$

Ciafaloni, Colferai + Salam →

<u>Collinearly enhanced contribns</u> (~ major part of higher-order corrns)

- running α_s + splitting fn
- symmetrize energy scales of coll. + anti-coll. behaviours, $s_0 = QQ_0$

(see also Altarelli, Ball, Forte: γ for small x evoln)

Dominant phenomenological structure is dip

- Rapid rise in P_{gg} is not for today's energies!
- Main feature is a *dip at* $x \sim 10^{-3}$

Questions:

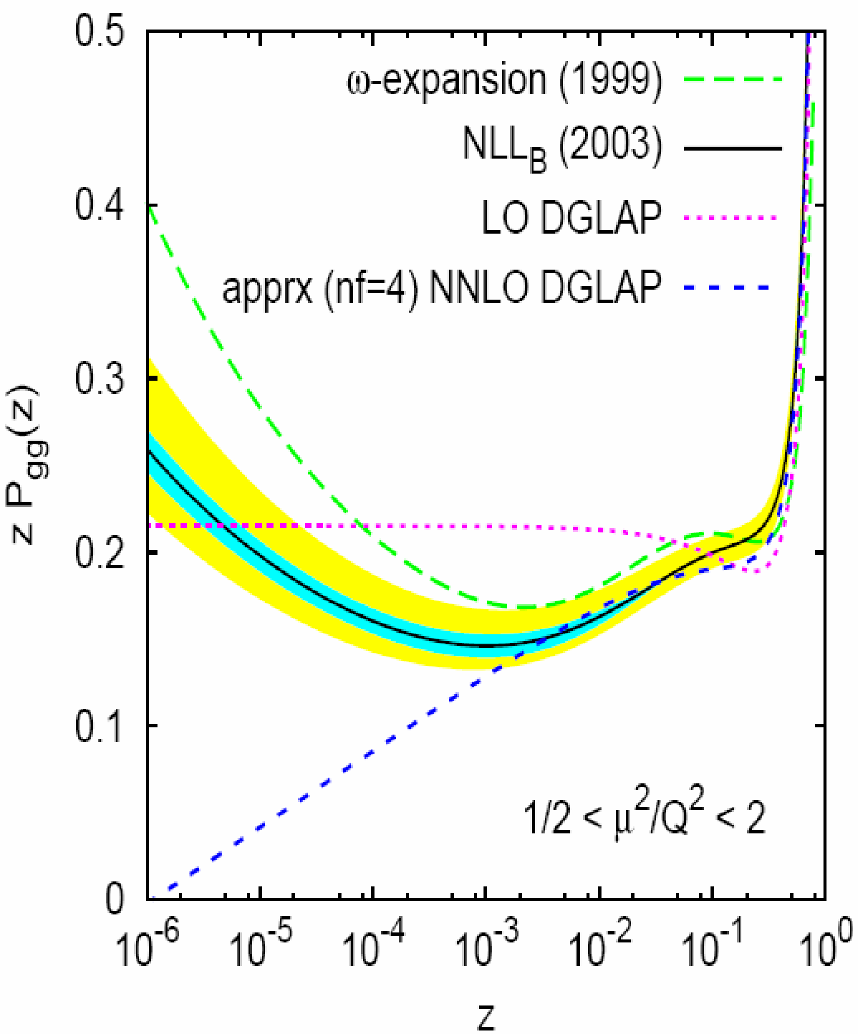
- Various 'dips' have been seen
  - Thorne '99, '01 (running α_s, NLLx)
  - ABF '99–'03 (fits, running α_s)
  - CCSS '01,'03 (running α_s, NLL$_B$)

  Is it always the same dip?
- Is the dip a rigorous prediction?
- What is its origin?

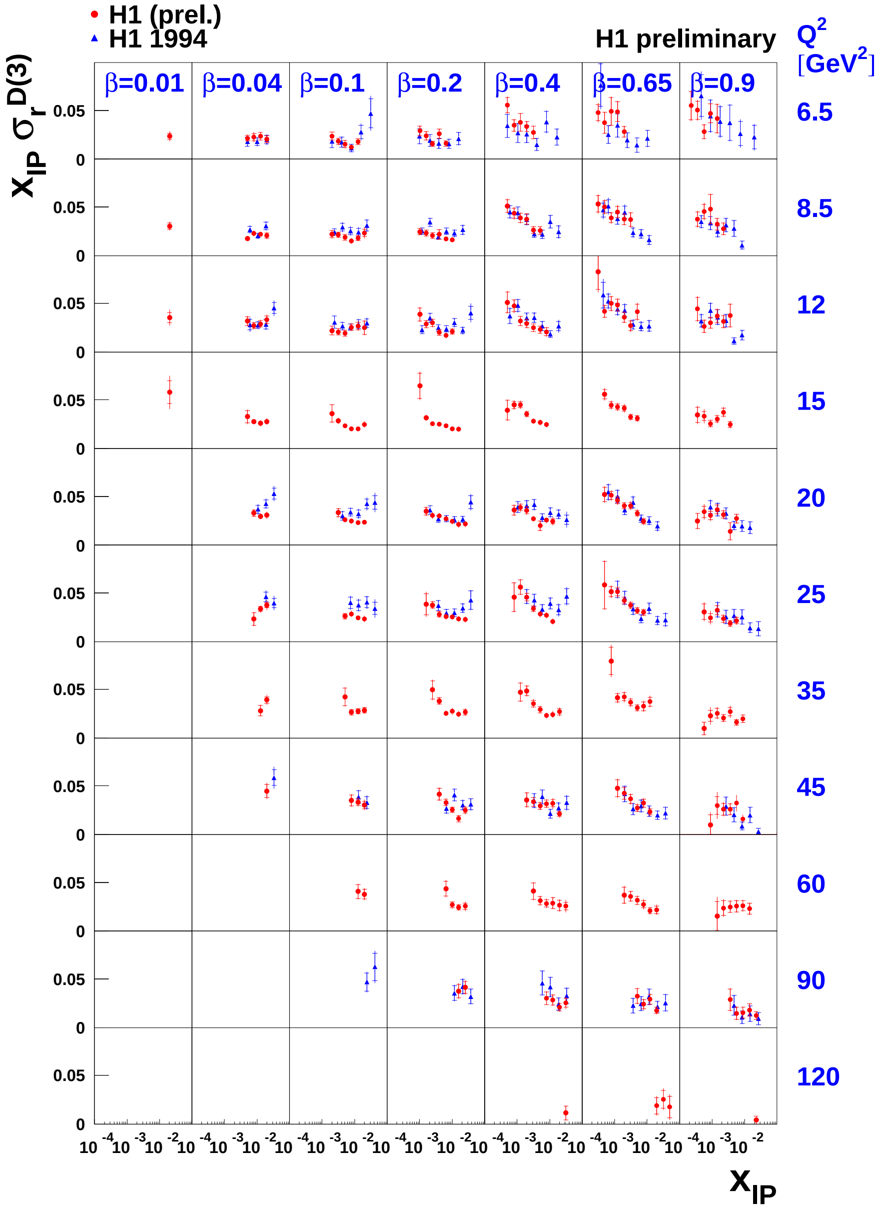
  Running α_s, momentum sum rule. . . ?

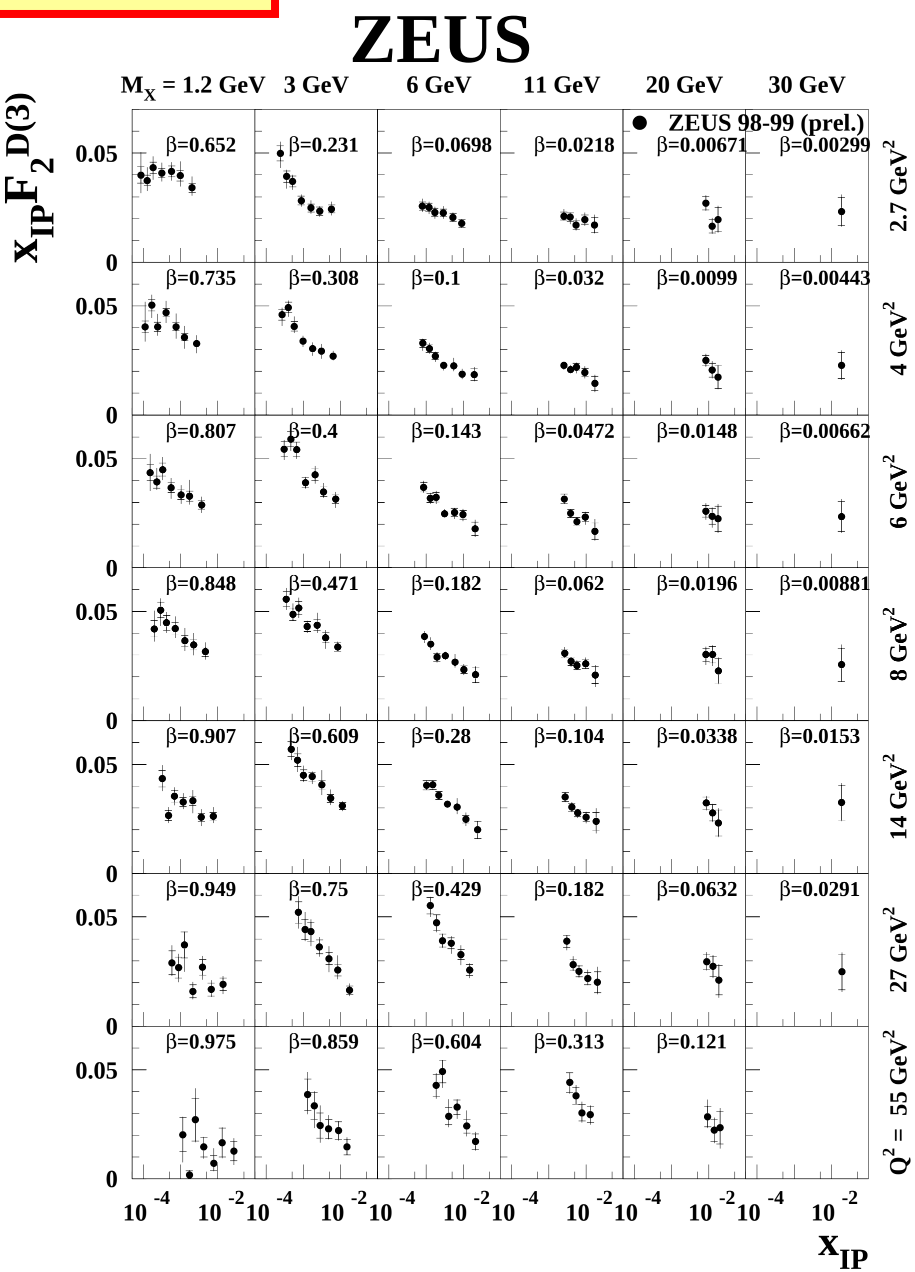
NNLO DGLAP gives a clue. . .

$$-1.54\,\bar{\alpha}_s^3 \ln\frac{1}{x}$$



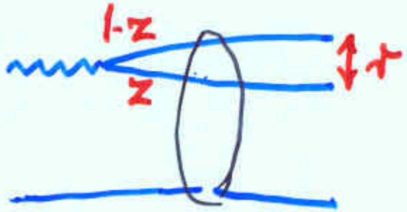
Diffractive DIS data





Dipole formulation

Nikolaev + Zakharov
Mueller

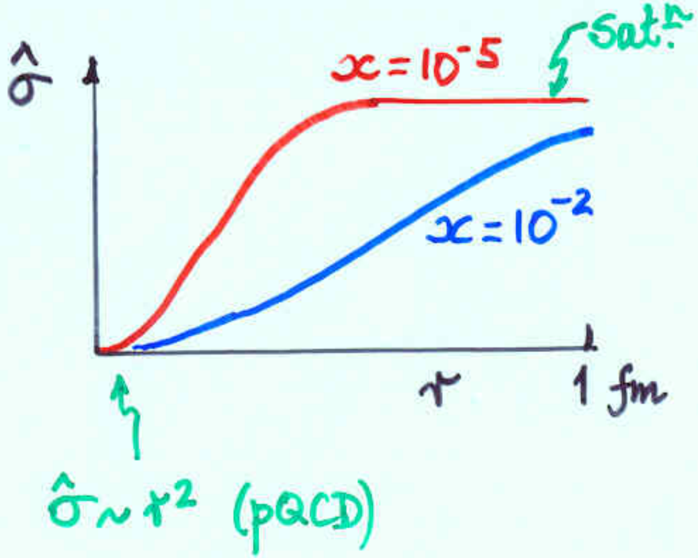


$\gamma^* p \to X(q\bar{q})p \qquad \gamma^* \to q\bar{q} \qquad \sigma(q\bar{q}-p)$

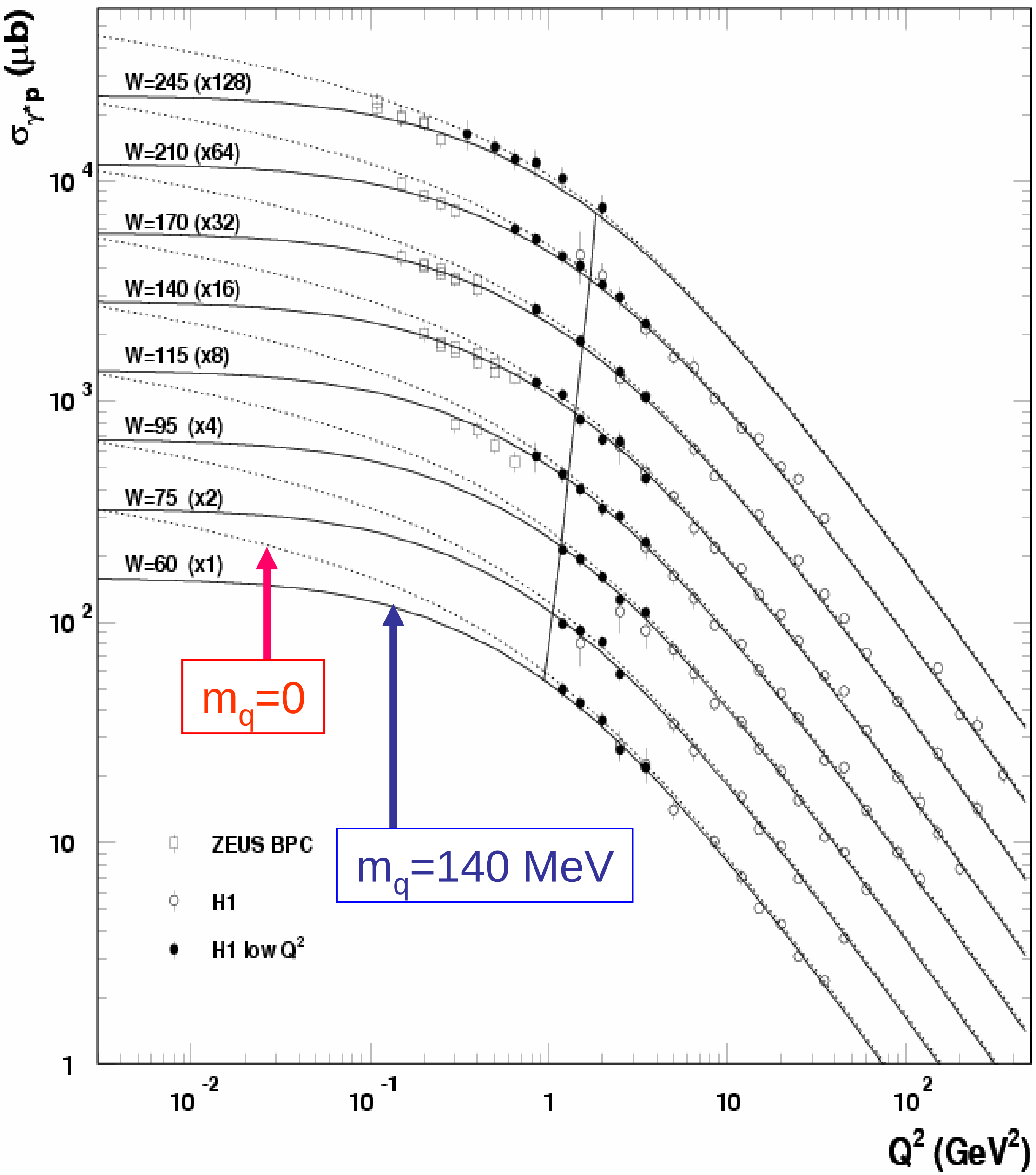
DIS : $\sigma_{T,L}(x,Q^2) = \int d^2r \int_0^1 dz \left|\psi_{T,L}(\vec{r},z,Q^2)\right|^2 \hat{\sigma}(x,\vec{r})$

DDIS $\sigma_{T,L}^{\text{diffractive}} = \frac{1}{16\pi B} \int d^2r \int_0^1 dz \left|\psi_{T,L}(\vec{r},z,Q^2)\right|^2 \hat{\sigma}^2(x,\vec{r})$

Golec-Biernat + Wüsthoff saturation model



Original Golec-Biernat, Wusthoff fit



Include charm.

Relate to xg & evolve in Q^2

+Bartels,Kowalski

Is it saturation or confinement ?

There are other dipole fits without saturation

e.g. Forshaw, Kerley & Shaw.

Saturation

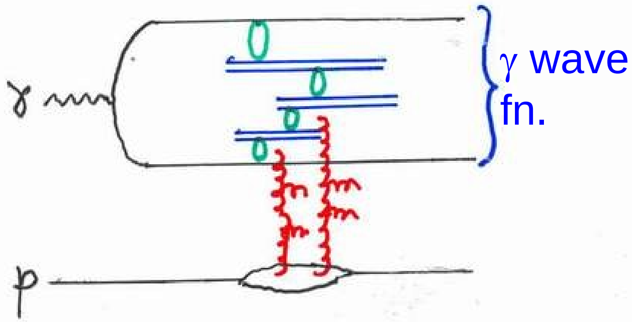
No definitive experimental evidence

Much theoretical activity and progress-----
BK, JIMWLK, KPP…equations

A glimpse for pedestrians
(with help from Icanu, Golec-Biernat)

Complementary approaches

p rest frame / fast dipole

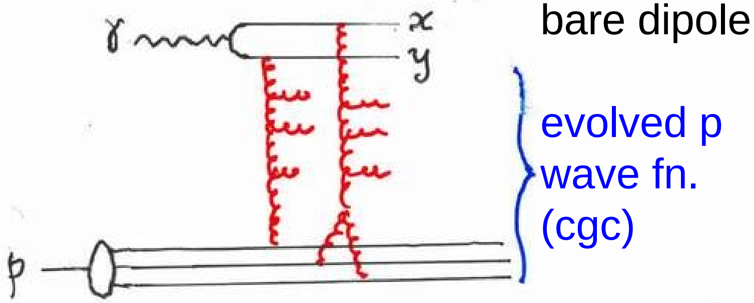


Balitsky Kovchegov eq.

Munier & Peschanski:

The BK eq. is approximated
by the Kozmogorov,Petrovski,
Pisconov eq., which is well studied
in condensed matter physics

fast p / slow dipole



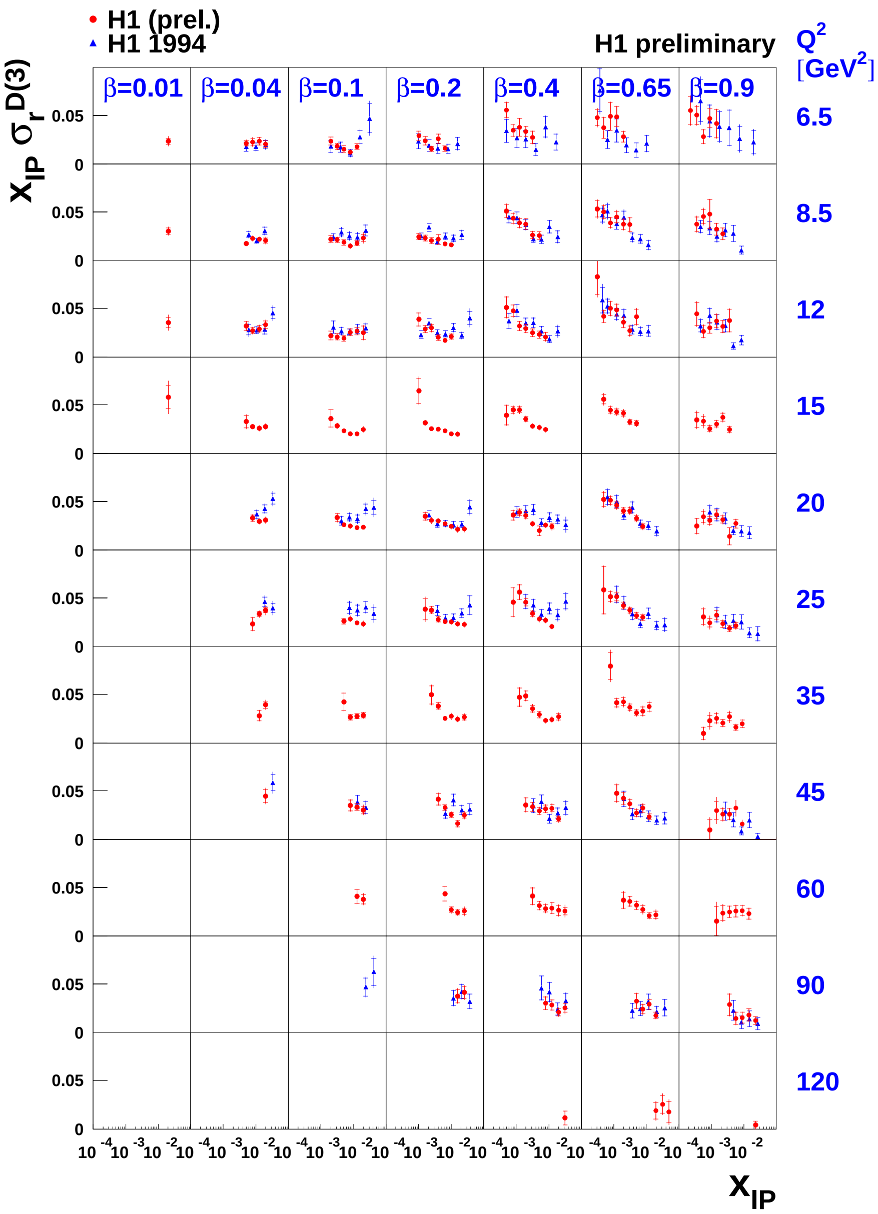
$$\frac{\partial \langle U_x^\dagger U_y \rangle}{\partial Y} = \alpha_s K_{BFKL} \left\{ \langle -U_x^\dagger U_y \rangle + \underbrace{\langle U_x^\dagger U_z \, U_z^\dagger U_y \rangle}_{\approx \langle U_x^\dagger U_z \rangle \langle U_z^\dagger U_y \rangle} \right\}$$

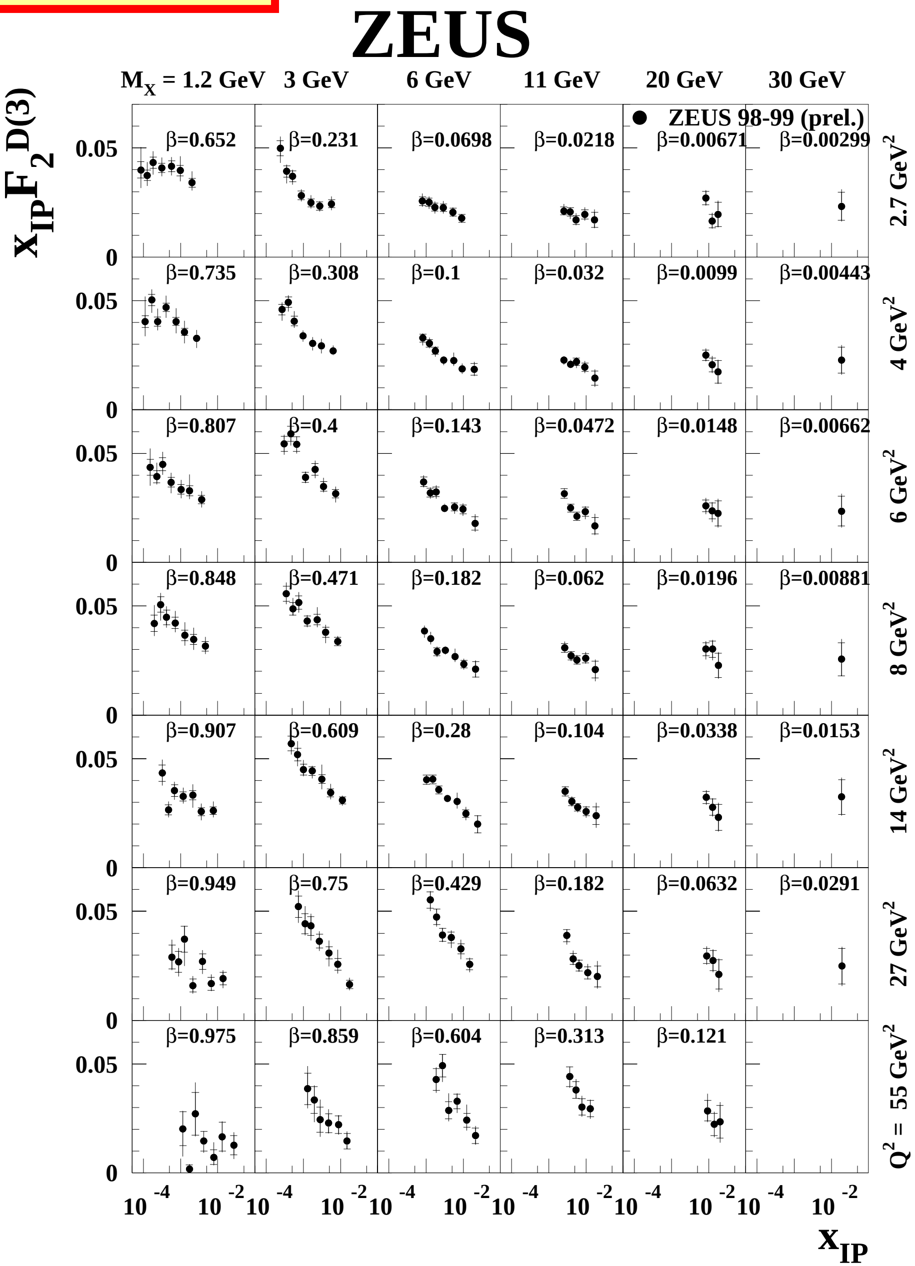
$$U_x \equiv e^{ig \int dx_\ell A^a(x_\ell, x_T) T^a}$$

leads to

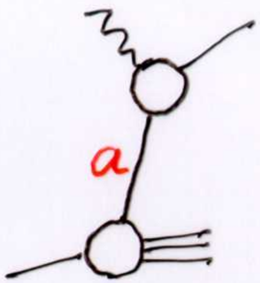
Jalilan Marian, Iancu, McLerran,
Weigert, Leonidov, Kovner eq.

Diffractive DIS data





DIS



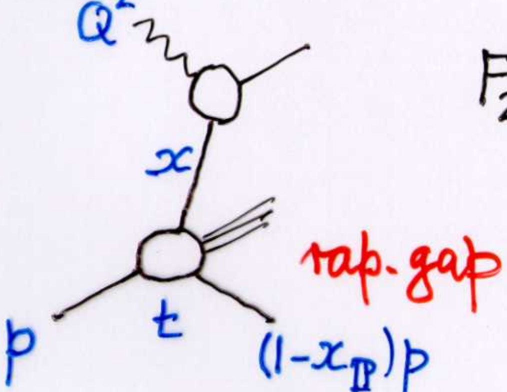
universal partons (DGLAP)

hard subprocess

$$F_2(x, Q^2) = \sum_a \int_0^1 d\xi \; f_a(\xi, Q^2) \; \hat{F}_2^{\,a}\left(\frac{x}{\xi}, Q^2\right)$$

same

Diffractive DIS



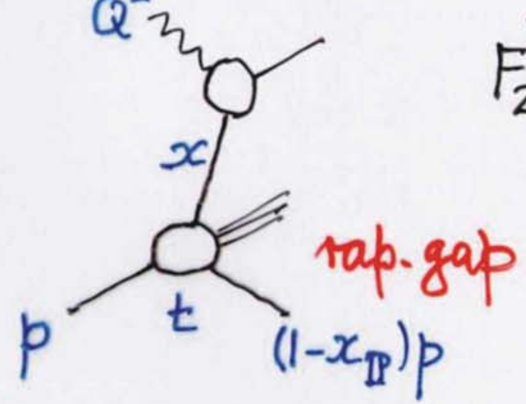
$$F_2^{D(4)} \equiv \frac{dF_2^D(x, Q^2; x_{I\!P}, t)}{dx_{I\!P}\, dt} = \sum_a \int_0^1 d\xi \; \frac{df_a^D(\xi, Q^2; x_{I\!P}, t)}{dx_{I\!P}\, dt} \; \hat{F}_2^{\,a}$$

diffractive parton density

Factorization proved for DDIS (Collins)

Not true for diff. hadron-hadron collisions

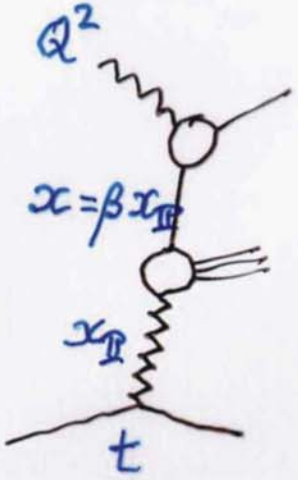
Diffractive DIS



$$F_2^{D(4)} \equiv \frac{dF_2^D(x,Q^2;x_{\mathbb{P}},t)}{dx_{\mathbb{P}}\,dt} = \sum_a \int_0^1 d\xi \, \underbrace{\frac{df_a^D(\xi,Q^2;x_{\mathbb{P}},t)}{dx_{\mathbb{P}}\,dt}}_{\text{diffractive parton density}} \hat{F}_2^a$$

Additional assumpt$^{\underline{n}}$: Regge fact$^{\underline{n}}$

Ingelman, Schlein
$\mathbb{P}$ ~ particle

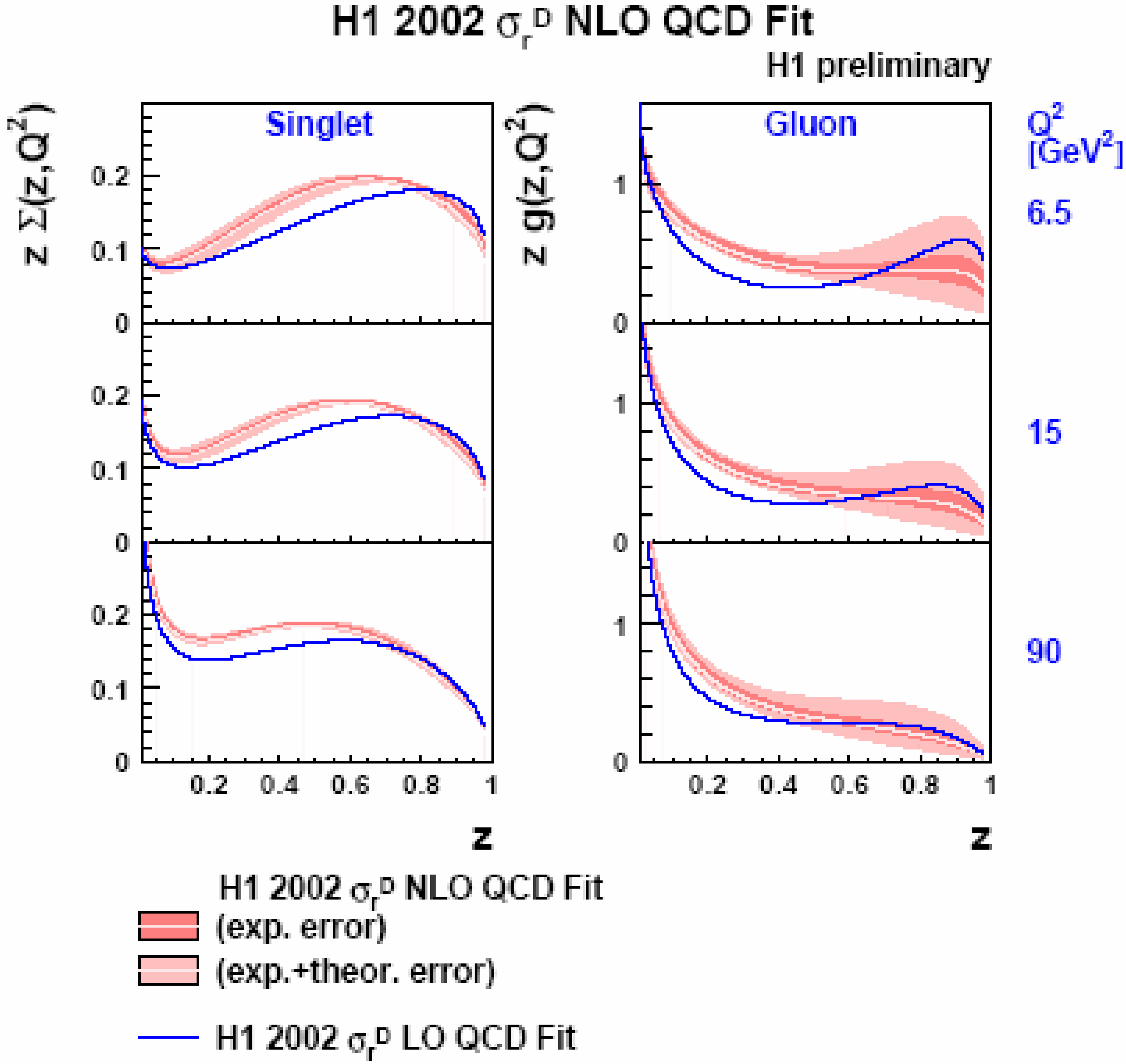


$$F_2^{D(4)} = \underbrace{f_{\mathbb{P}}(x_{\mathbb{P}},t)}_{\text{Pomeron flux}} F_2^{\mathbb{P}}(\beta, Q^2) + \text{sec}^{\underline{dy}} \text{ Reggeon}$$

β: $x/x_{\mathbb{P}}$

Pomeron flux: $x_{\mathbb{P}}^{1-2\alpha_{\mathbb{P}}(t)} |\beta_{\mathbb{P}}(t)|^2$

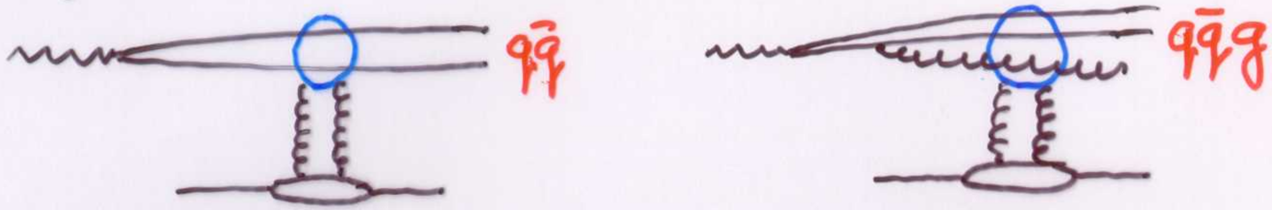
$F_2^{\mathbb{P}}(\beta, Q^2) \rightarrow \sum_q e_q^2 \, \beta \, q^D(\beta)$ + DGLAP evol$^{\underline{n}}$



H1 2002 σ_r^D NLO QCD Fit
H1 preliminary
Singlet
Gluon
$z\,\Sigma(z,Q^2)$
$z\,g(z,Q^2)$
Q^2 [GeV^2]
6.5
15
90
0
0.1
0.2
1
0.2
0.4
0.6
0.8
z
H1 2002 σ_r^D NLO QCD Fit
(exp. error)
(exp.+theor. error)
H1 2002 σ_r^D LO QCD Fit

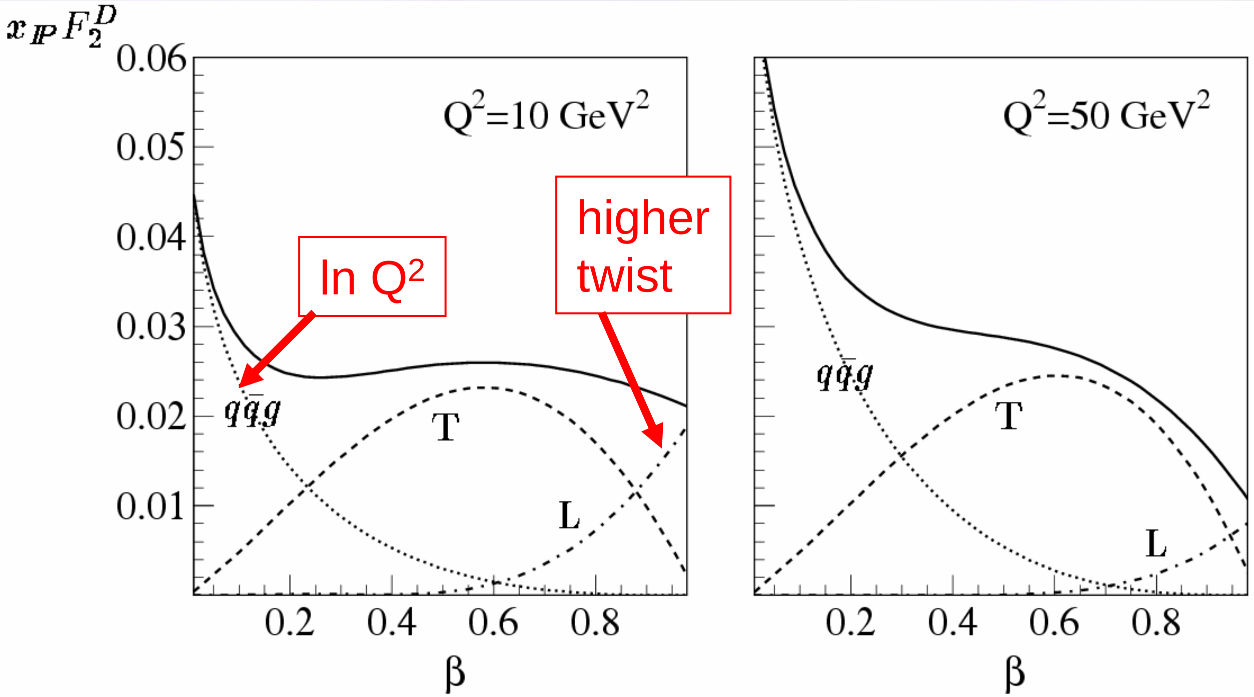
QCD description of diffractive DIS

proton rest frame



β spectrum determined by wave fns of $\gamma \to q\bar{q}$ and $\gamma \to q\bar{q}g$

Wüsthoff (Mueller, Nikolaev & Zakharov)

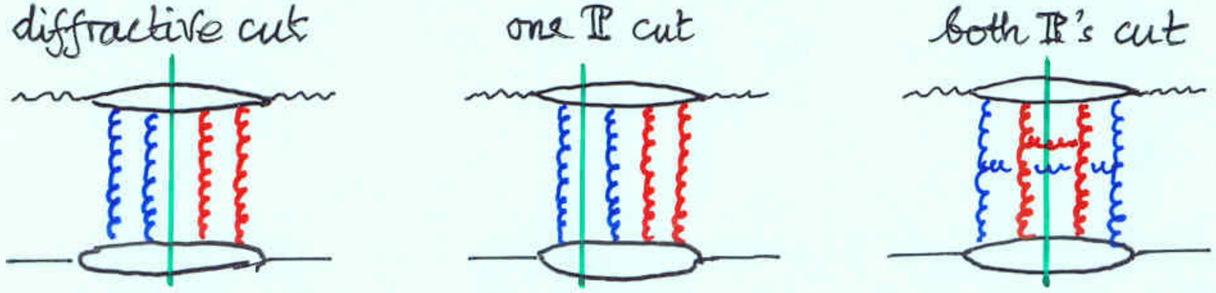


Bartels, Ellis, Kowalski & Wusthoff base parametrization on these forms

Contribution of diffractive F_2 to (inclusive) F_2

Apply AGK cutting rules to '$\mathbb{P} \otimes \mathbb{P}$' contribution to F_2

(AGK in QCD: Bartels + Ryskin)



$(\mathrm{Im}\, T_{el} \sim \sigma^{tot})$

+1   −4   +2   = total −1

$$\boxed{\Delta F_2^{\text{abs. corr}} \simeq -F_2^D}$$

negative (~ Glauber shadowing)

In pQCD $\mathbb{P}$ is a cut, not a pole   Lipatov

$\mathbb{P}$ has continuous no. of compts. of different size $r \sim 1/\mu$

For each compt. DGLAP evol.^{n} of $F_2^D(x, Q^2, \mu^2)$ starts from $\mu \to Q$

provided it is large enough

Simultaneous QCD analysis of DDIS and DIS data

(Pomeron size $r = 1/\mu$) Martin, Ryskin, Watt

1. Fit to F_2^D data:

$$F_2^D = \int_{Q_0^2}^{Q^2} d\mu^2 \, \text{DGLAP}\,(\mu \to Q) \quad (\mu > Q_0) \quad \leftarrow \text{need 'global' partons}$$

$$+ \text{ non-pert. contrib } (\mu < Q_0) + F_L^D + \text{secondary Reggeon}$$

2. Re-do 'global' fit to inclusive F_2

$$F_2 \text{ data} = F_2^{\text{DGLAP}} + \Delta F_2^{\text{abs. corr}}$$

$\uparrow$ $(-F_2^D)_{\text{pert}}$ — negative.

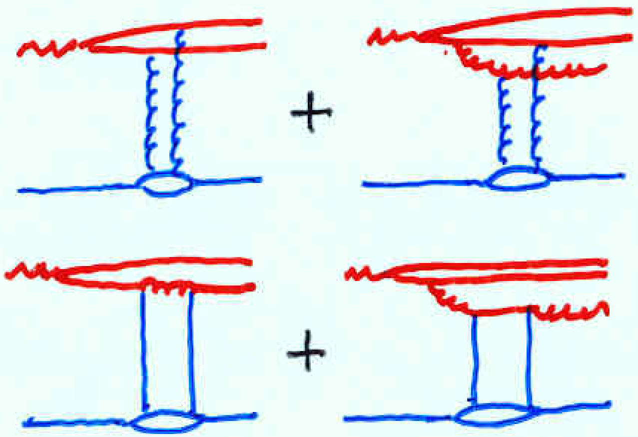
{ $\mu < Q_0$ part is already in input to DGLAP evol.

$\rightarrow$ more gluon?

3. Iterate

The perturbative contribution ($\mu > Q_0$):

$$F_2^{D(3)}(x_{\mathbb{P}}, \beta, Q^2) = \int_{Q_0^2}^{Q^2} \frac{d\mu^2}{\mu^2}\, f_{\mathbb{P}}(x_{\mathbb{P}}, \mu^2)\, F_2^{D(2)}(\beta, Q^2, \mu^2)$$



$f_{\mathbb{P}}(x_{\mathbb{P}}, \mu^2)$ given by

$$[x g(x, \mu^2)]^2$$

$$+$$

$$[x q_{sea}(x, \mu^2)]^2$$

at $x = x_{\mathbb{P}}$

$F_2^{D(2)}(\beta, Q^2, \mu^2)$: DGLAP evol$^{\underline{n}}$ with input based on $\gamma \to q\bar{q}, q\bar{q}g$ wave fns. & couplings to gg, $q\bar{q}$

Simultaneous QCD analysis of DDIS and DIS data

(Pomeron size $r = 1/\mu$) Martin, Ryskin, Watt

1. Fit to F_2^D data:

$$F_2^D = \int_{Q_0^2}^{Q^2} d\mu^2 \, \text{DGLAP}\overset{(\mu > Q_0)}{(\mu \to Q)} \quad \leftarrow \text{need 'global' partons}$$

$$+ \underset{(\mu < Q_0)}{\text{non-pert. contrib}} + F_L^D + \text{secondary Reggeon}$$

2. Re-do 'global' fit to inclusive F_2

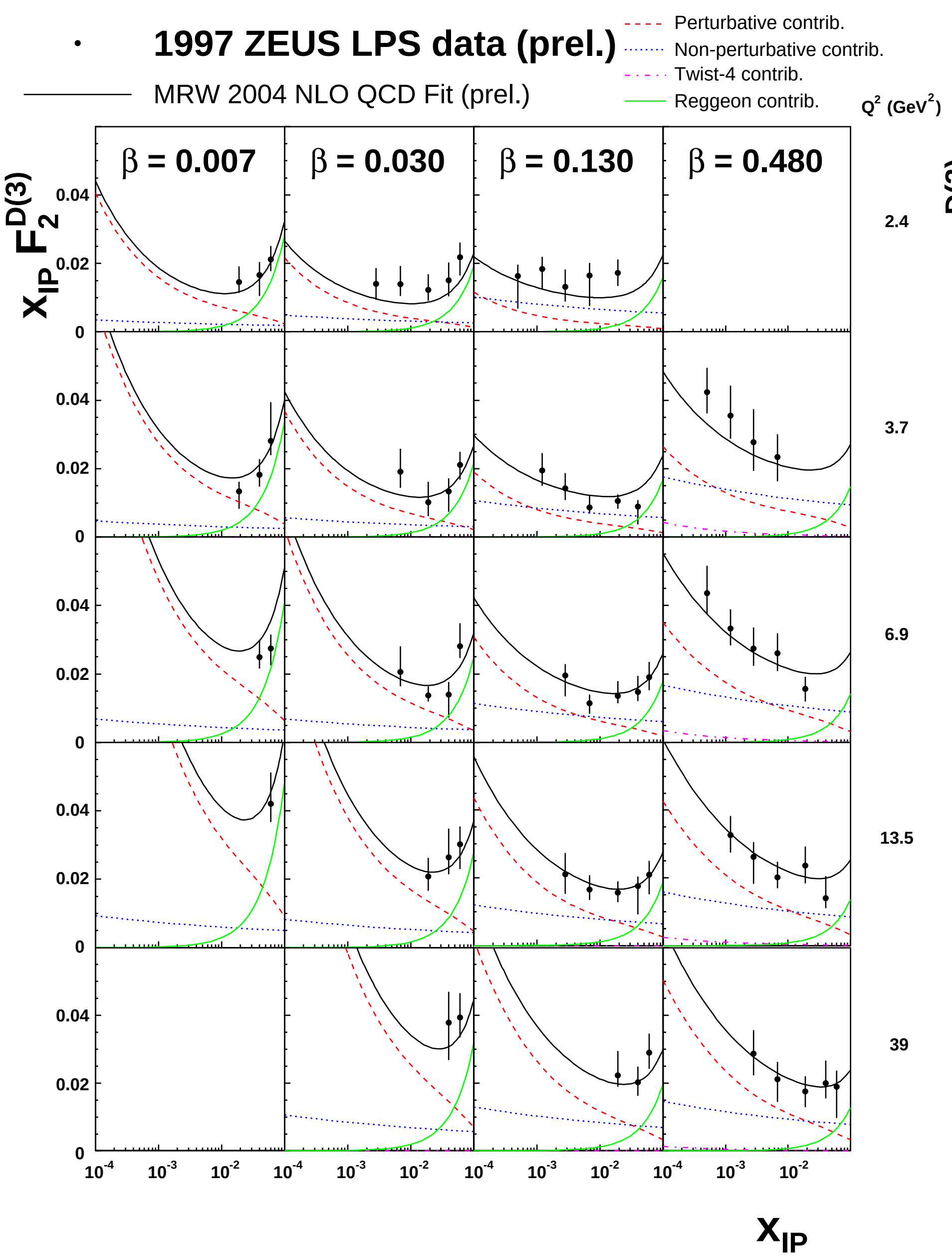
$$F_2 \text{ data} = F_2^{DGLAP} + \Delta F_2^{abs.\,corr}$$

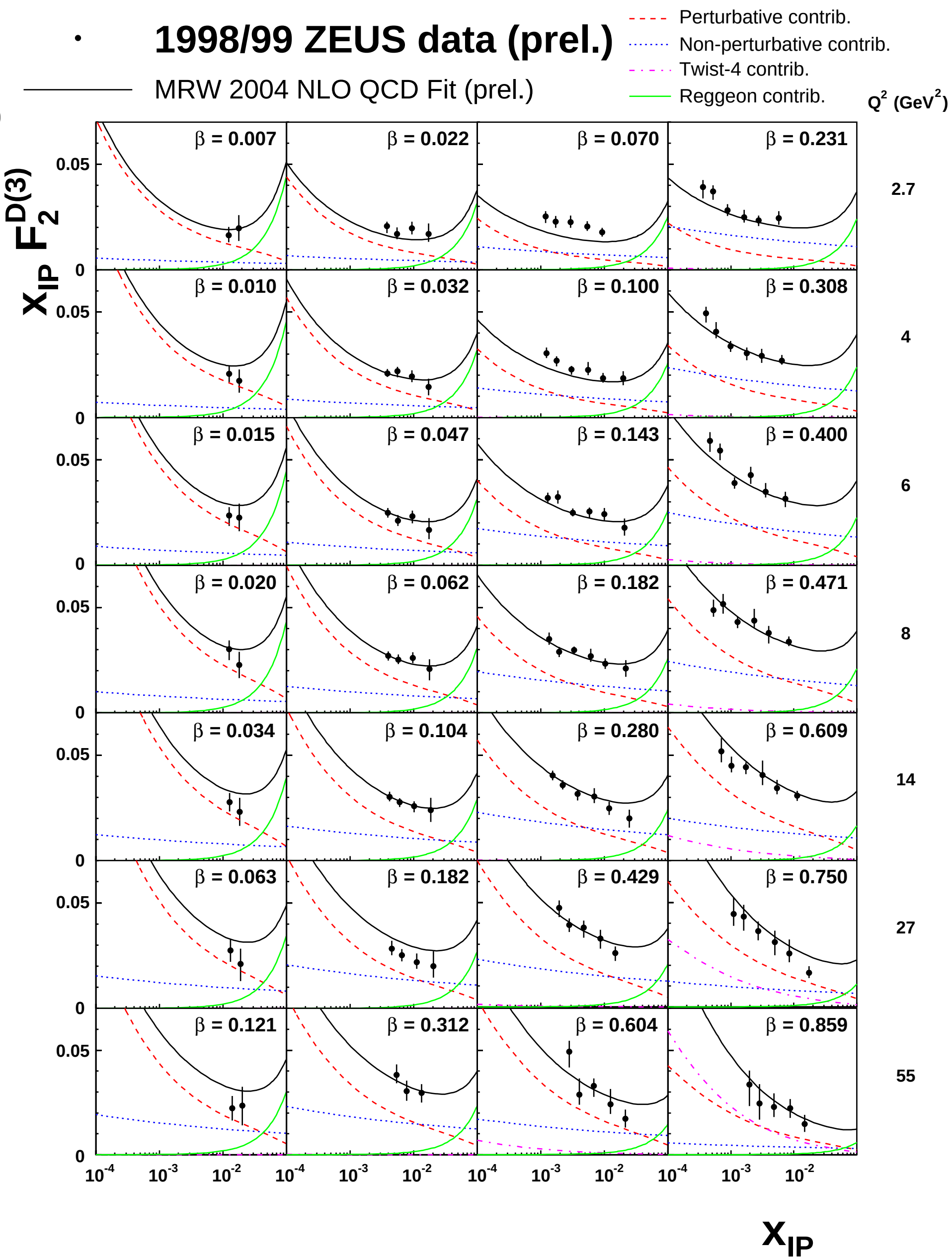
$\uparrow$ $(-F_2^D)_{pert}$ — negative.

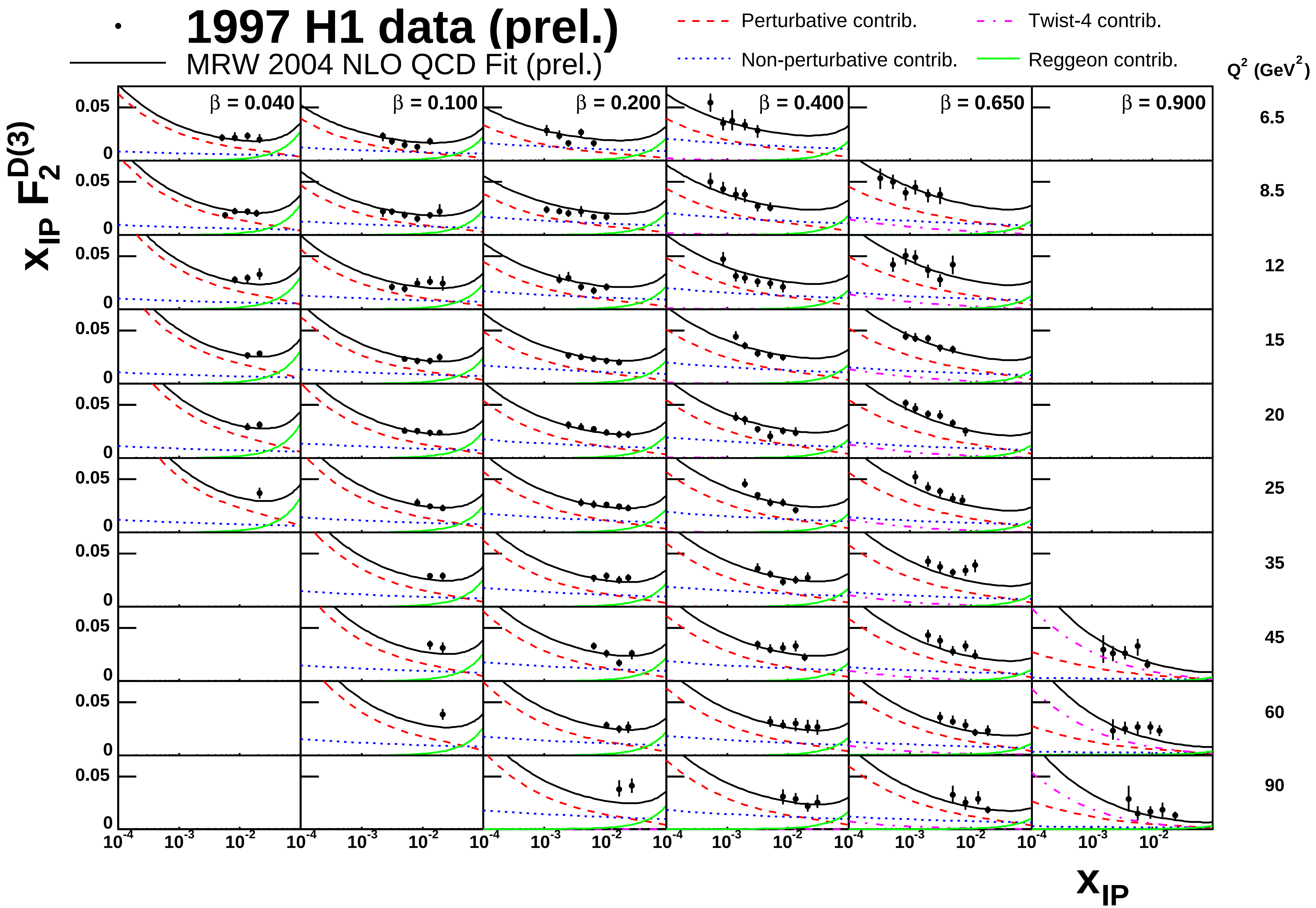
{ $\mu < Q_0$ part is already in input to DGLAP evol.

$\rightarrow$ more gluon?

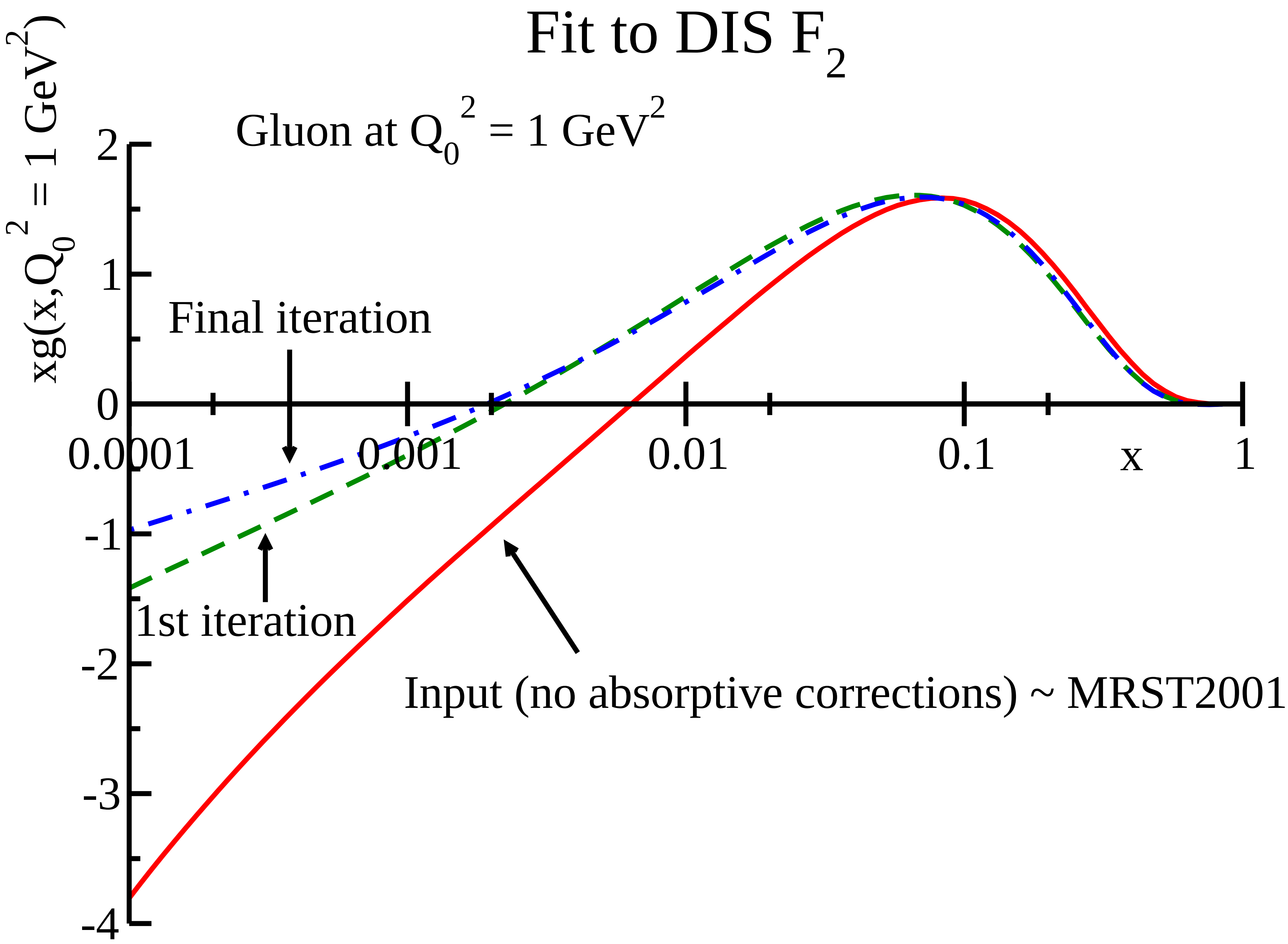
3. Iterate


1997 ZEUS LPS data (prel.)
MRW 2004 NLO QCD Fit (prel.)
Perturbative contrib.
Non-perturbative contrib.
Twist-4 contrib.
Reggeon contrib.
Q² (GeV²)
β = 0.007
β = 0.030
β = 0.130
β = 0.480
2.4
3.7
6.9
13.5
39
$x_{IP} F_2^{D(3)}$
x_{IP}


1998/99 ZEUS data (prel.)
MRW 2004 NLO QCD Fit (prel.)
Perturbative contrib.
Non-perturbative contrib.
Twist-4 contrib.
Reggeon contrib.
Q² (GeV²)
2.7
4
6
8
14
27
55
$x_{IP} F_2^{D(3)}$
x_{IP}

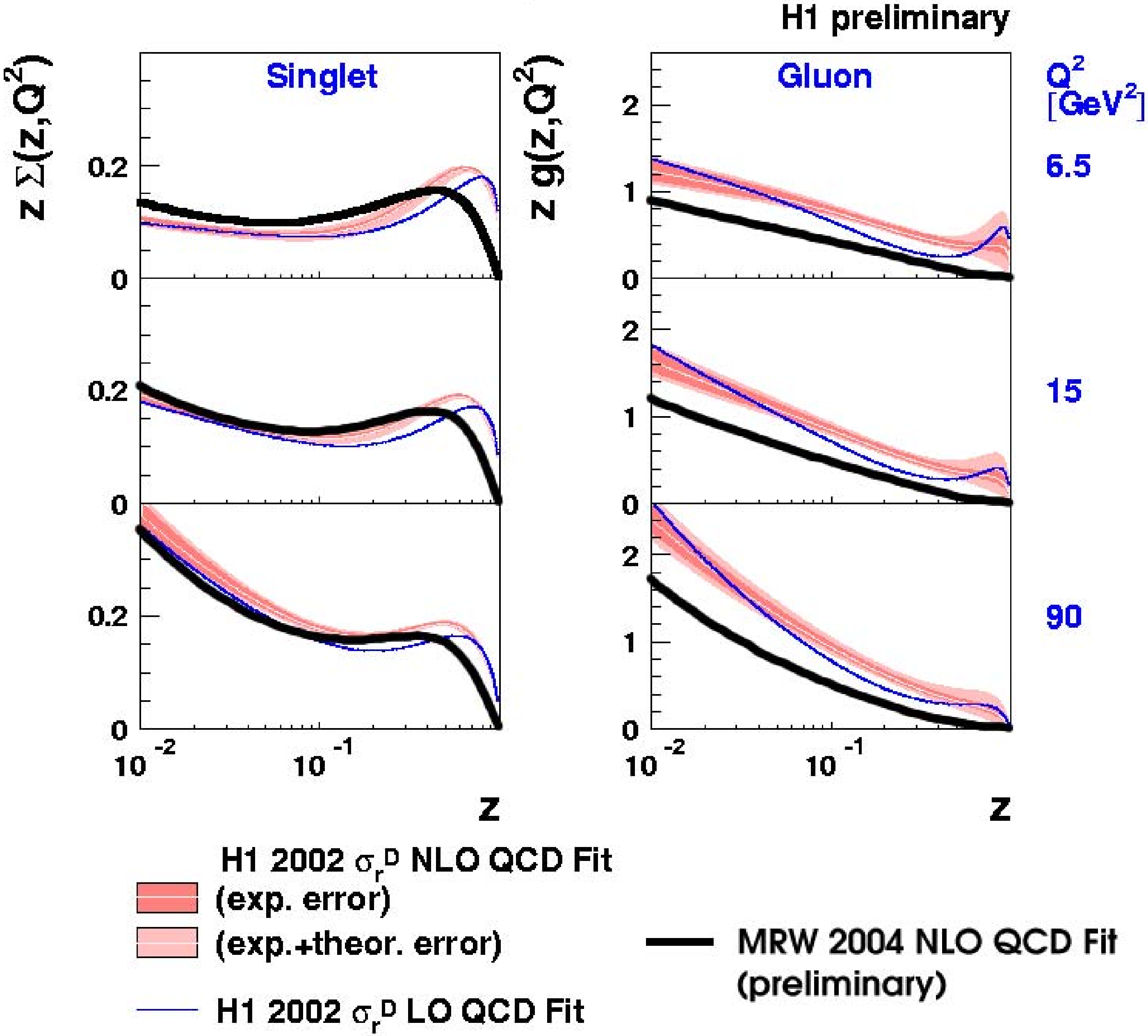


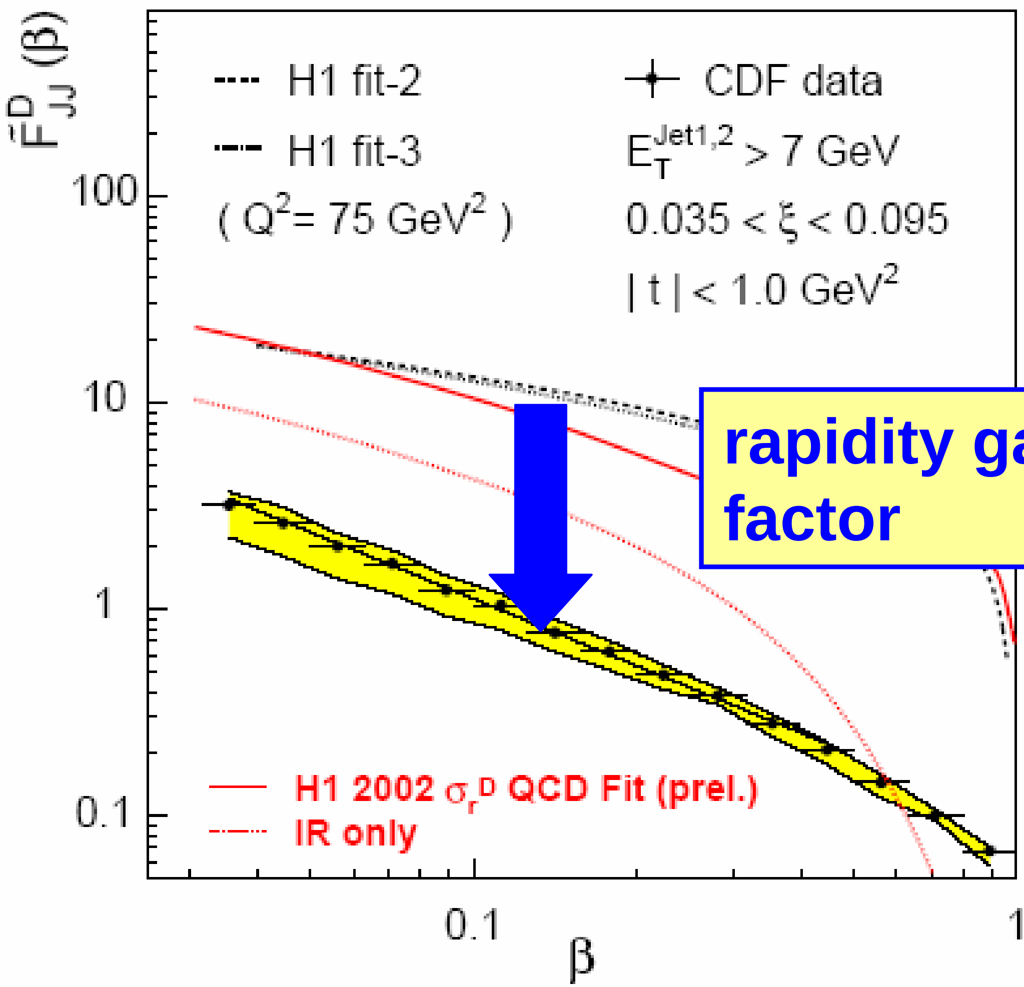
1997 H1 data (prel.)
MRW 2004 NLO QCD Fit (prel.)
Perturbative contrib.
Non-perturbative contrib.
Twist-4 contrib.
Reggeon contrib.
Q² (GeV²)
β = 0.040
β = 0.100
β = 0.200
β = 0.400
β = 0.650
β = 0.900
6.5
8.5
12
15
20
25
35
45
60
90
$x_{IP} F_2^{D(3)}$
0.05
0
10^{-4}
10^{-3}
10^{-2}
x_{IP}



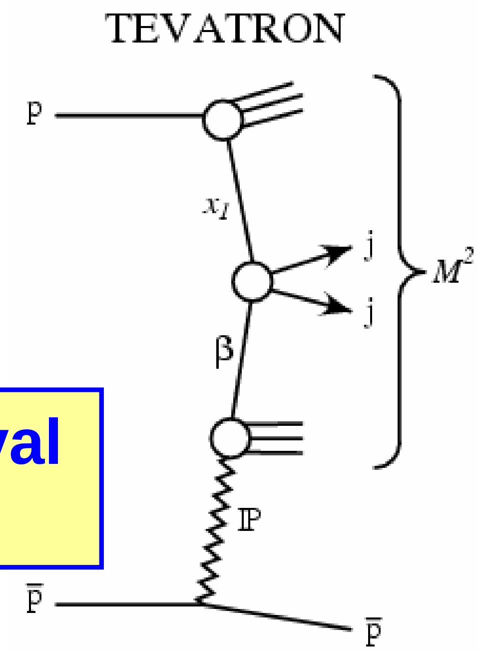
Fit to DIS F_2
Gluon at $Q_0^2 = 1\ \mathrm{GeV}^2$
$xg(x, Q_0^2 = 1\ \mathrm{GeV}^2)$
2
1
0
-1
-2
-3
-4
0.0001
0.001
0.01
0.1
x
1
Final iteration
1st iteration
Input (no absorptive corrections) ~ MRST2001

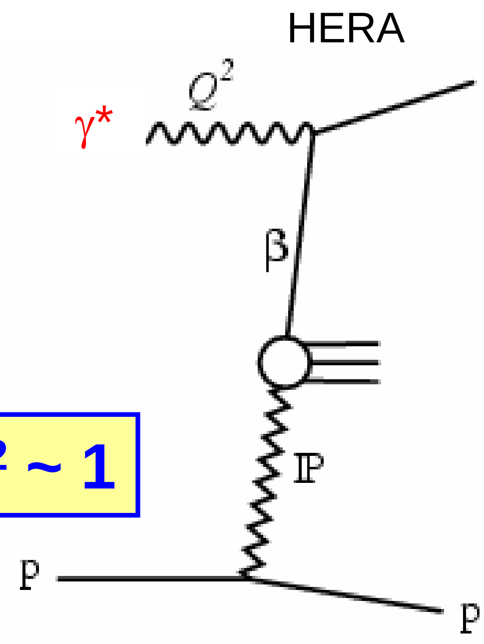
H1 2002 σ_r^D NLO QCD Fit





rapidity gap survival factor $S^2 \sim 0.1$

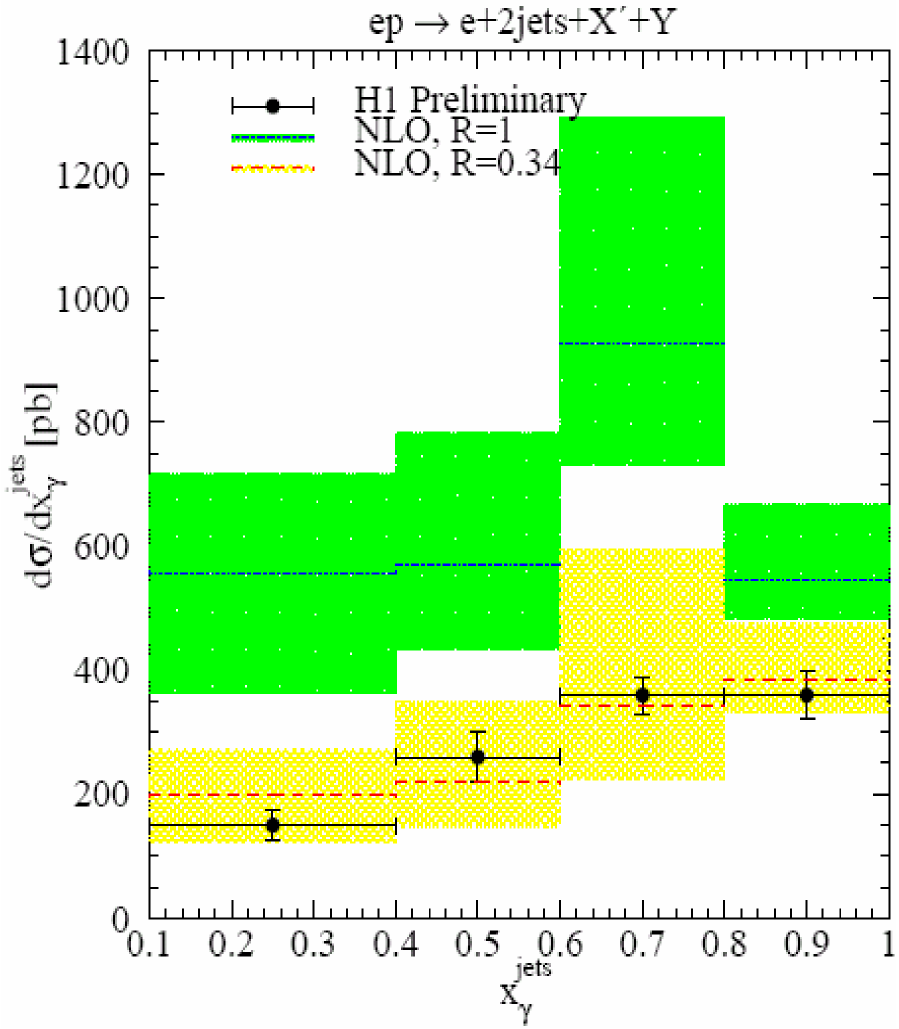




$S^2 \sim 1$

Survival factors calc. from 2-ch eikonal model based on multi-Pom. exchange & s channel unitarity KKMR

Diffractive photoproduction of dijets:
direct compt. $S^2 \sim 1$
resolved compt. (hadron-like) $S^2 \sim 0.34$

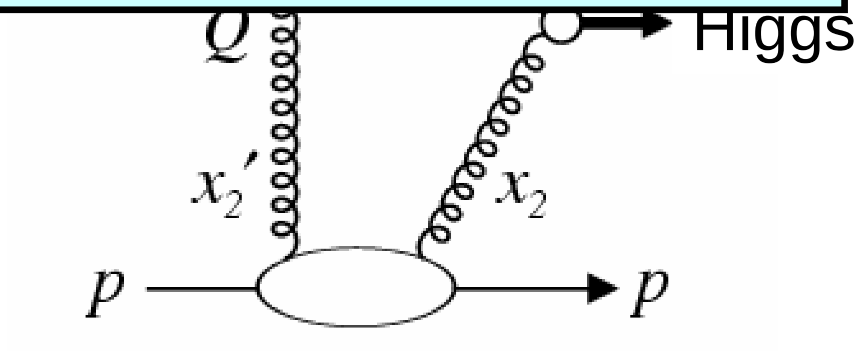


NLO analysis by Klasen & Kramer,-- good agreement with prelim. H1 data

Note in LO analysis, data would prefer $S^2 \sim 1$ for resolved

Exclusive diffractive Higgs signal pp → p+H+p

Health warning:
Royon confirms KMR prediction for cross section, but notes present technology will yield smaller S/B



$S^2 = 0.026$

Khoze,Martin,Ryskin

Advantages: 2 indep. M_H det.
1. missing mass to proton taggers ($\Delta M \sim 1$ GeV)
2. $b\bar{b}$ decay ($\Delta M \sim 10$ GeV)

$b\bar{b}$ backgd v.suppressed by $J_z=0$ selection rule

For a 120 GeV (SM) Higgs at the LHC ($L=30\ fb^{-1}$)
11 events / 4 background
For MSSM
with $\tan\beta \sim 50$, $m_A \sim 130$ GeV
70 events / 3 background

DIS continues to flourish – the W/S contains more results & research activity than those on any other topic

Much remains to be learnt – we are just getting to grips with many basic problems – data are not sufficient / absent !

It is inconceivable that HERA will not measure F_L with sufficient precision to determine the gluon – low energy runs must be done – they will also determine large x PDFs ESSENTIAL FOR THE LHC

bb in DIS & photoproduction, electron runs for CC & xF_3, precision on F_2(diffractive),…

exotica

There are so many crucial measurements still to be done, and unless the correct action is set into motion soon, time will run out for HERA (& DIS) while the physics potential of the machine is still coming to its prime.

A global analysis is required – can the eRHIC enthusiasts be persuaded to join in the push for a future HERA programme – scientifically it would seem to be a far better solution all round.