H1 – RECENT RESULTS

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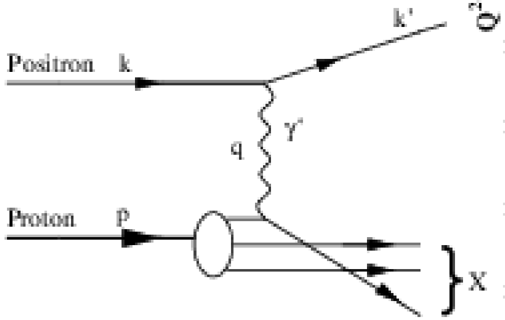
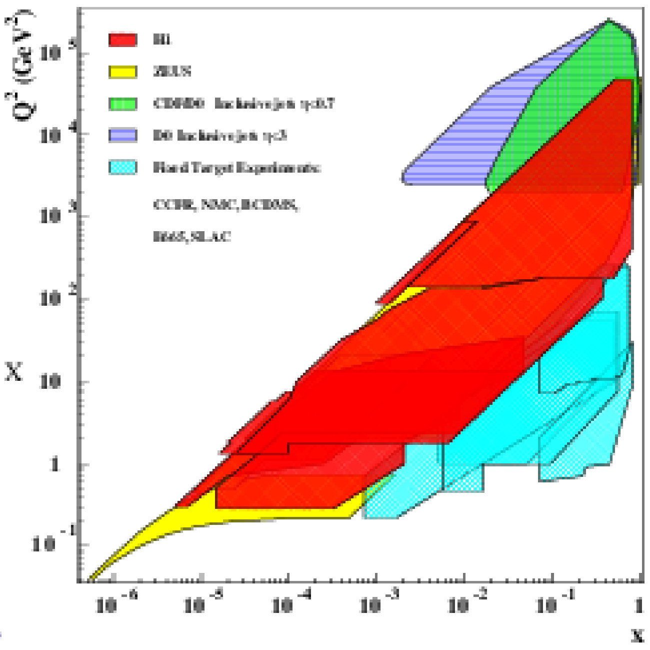
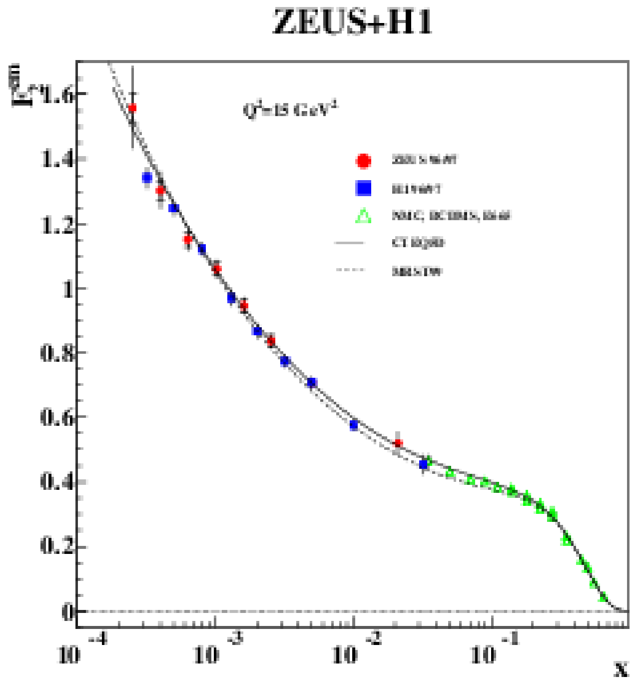
Recent Results Include:

- **Jet Physics, Photon Structure**
- **Heavy Flavour Physics**
- **Low-x Physics** $\Rightarrow$
  - Rise of F_2 at low-x
  - Diffractive Structure Function
  - Diffractive Final State – D^*, DVCS
- **High Q^2**
- **Exotic Searches**

Inclusive Deep-Inelastic Scattering at low-x







- $Q^2 = sxy$
- $W^2 = Q^2 \frac{1-x}{x}$
- $\sigma \approx F_2 - c(y) \cdot F_L$

At low x and low Q^2

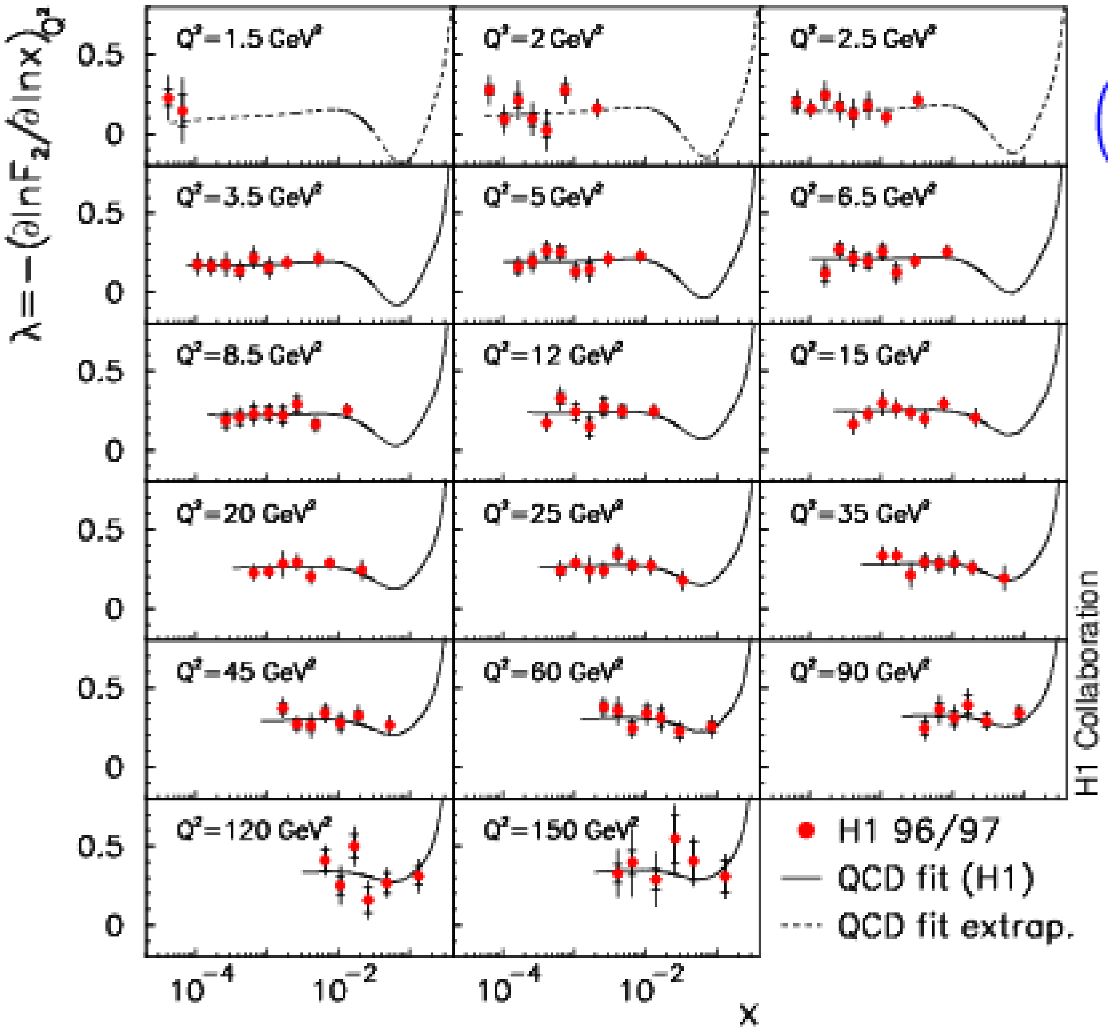
Rise of F_2 $\quad F_2 \propto x^{-\lambda}$ $\quad$ driven by gluon field

DGLAP is a perturbative QCD approximation (resums large log Q^2)

High Parton densities at low x – expect breakdown (resum $\frac{1}{x}$?, Saturation?)

The Rise of F_2 at Low x

Phys.Lett. B520 (2001), 183



$$\left(\frac{\partial \ln F_2(x,Q^2)}{\partial \ln x}\right)_{Q^2} \equiv -\lambda(x,Q^2)$$

For $5 \cdot 10^{-5} < x < 0.01$

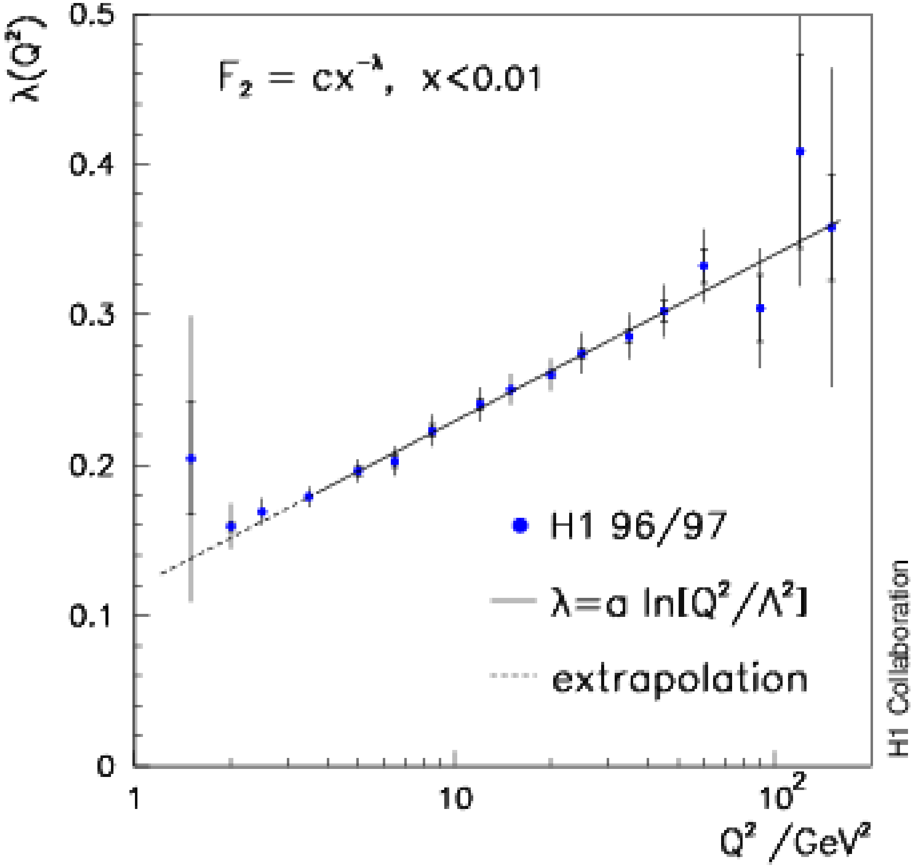
λ is independent of x

i.e. $F_2(x,Q^2) = c(Q^2)x^{-\lambda(Q^2)}$

No sign of breakdown!

DGLAP QCD fit works well

Rise of F_2 at Low x



$\lambda(Q^2)$ rises approx. linearly with $\ln Q^2$

Simplest Regge phenomenology:

$$F_2(x, Q^2) \propto x^{-\lambda} \propto x^{-(\alpha_{\mathbb{P}}(0)-1)}$$

For the 'soft' Pomeron

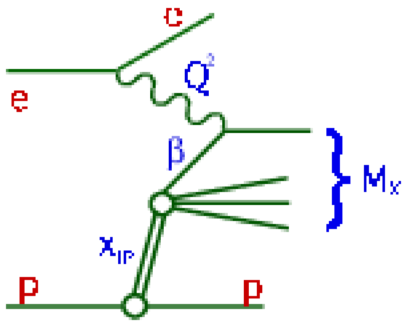
$$\alpha_{\mathbb{P}}(0) = 1.08$$

Reaches 'soft' Pomeron value for

$$Q^2 < 1\,\mathrm{GeV}^2$$

Diffraction at H1

Partonic Picture



$$x_{I\!P} = \frac{q.(p-p')}{q.p} \simeq \frac{Q^2+M_X^2}{Q^2+W^2}$$

$$\beta = \frac{Q^2}{q.(p-p')} \simeq \frac{Q^2}{Q^2+M_X^2}$$

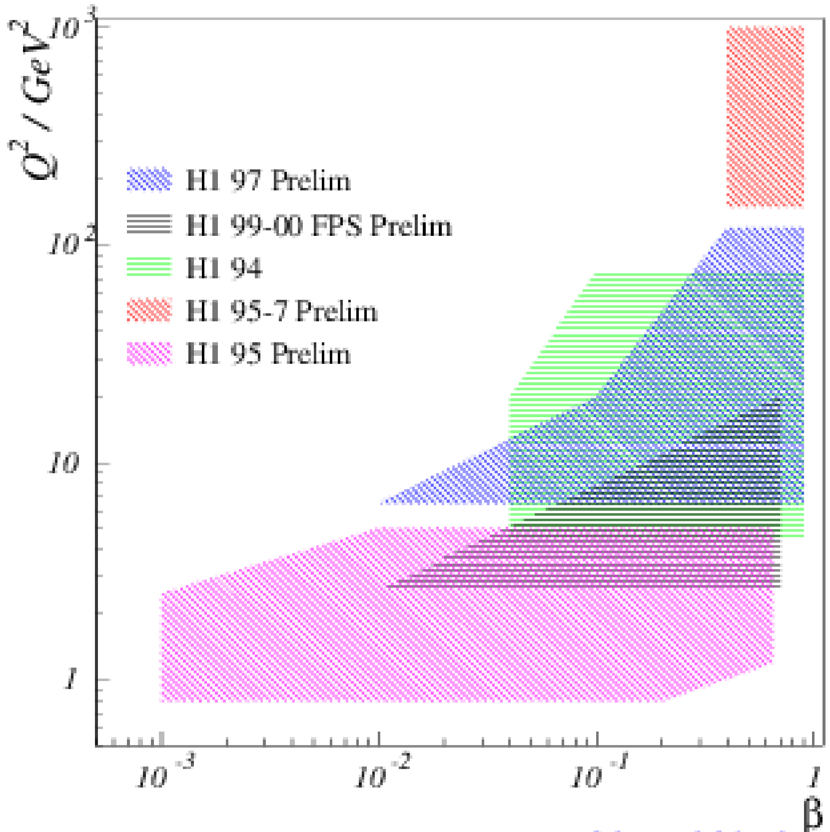
$$t = (p-p')^2$$

$(x = x_{I\!P}\beta)$

Diffractive Structure Function ...

$$\frac{d\sigma_{ep\to eXY}}{d\beta\, dQ^2\, dx_{I\!P}\, dt} \approx F_2^{D(4)}(\beta, Q^2, x_{I\!P}, t)$$

(Assumes $F_L^{D(4)} = 0$)



New H1 data for

$6.5 \leq Q^2 \leq 120$ GeV^2

$0.04 \leq \beta \leq 0.9$, $x_{I\!P} < 0.05$

'Bulk' data for precision QCD tests

Factorisation Properties of F_2^D

1. QCD Hard Scattering Factorisation for Diffractive DIS

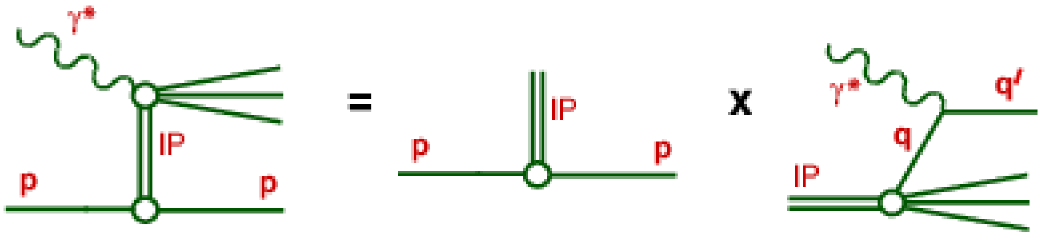
(Trentadue, Veneziano, Berera, Soper, Collins...)

$$\sigma(\gamma^* p \rightarrow Xp) \sim f_{q/p}(x_{I\!P}, t, x, Q^2) \otimes \hat{\sigma}_{\gamma^* q}(x, Q^2)$$

At fixed $x_{I\!P}$, t, Diffractive Parton Densities $f(x, Q^2)$ evolve with x, Q^2 according to DGLAP equations.

2. 'Regge' Factorisation

Regge motivated *pomeron* flux



$$\sigma(\gamma^* p \rightarrow Xp) \sim f_{I\!P/p}(x_{I\!P}, t) \otimes f_{q/I\!P}(\beta, Q^2) \otimes \hat{\sigma}_{\gamma^* q}(\beta, Q^2)$$

Diffractive Measurement Techniques

1. Direct Measurement of Leading Protons

Free of p dissociation background

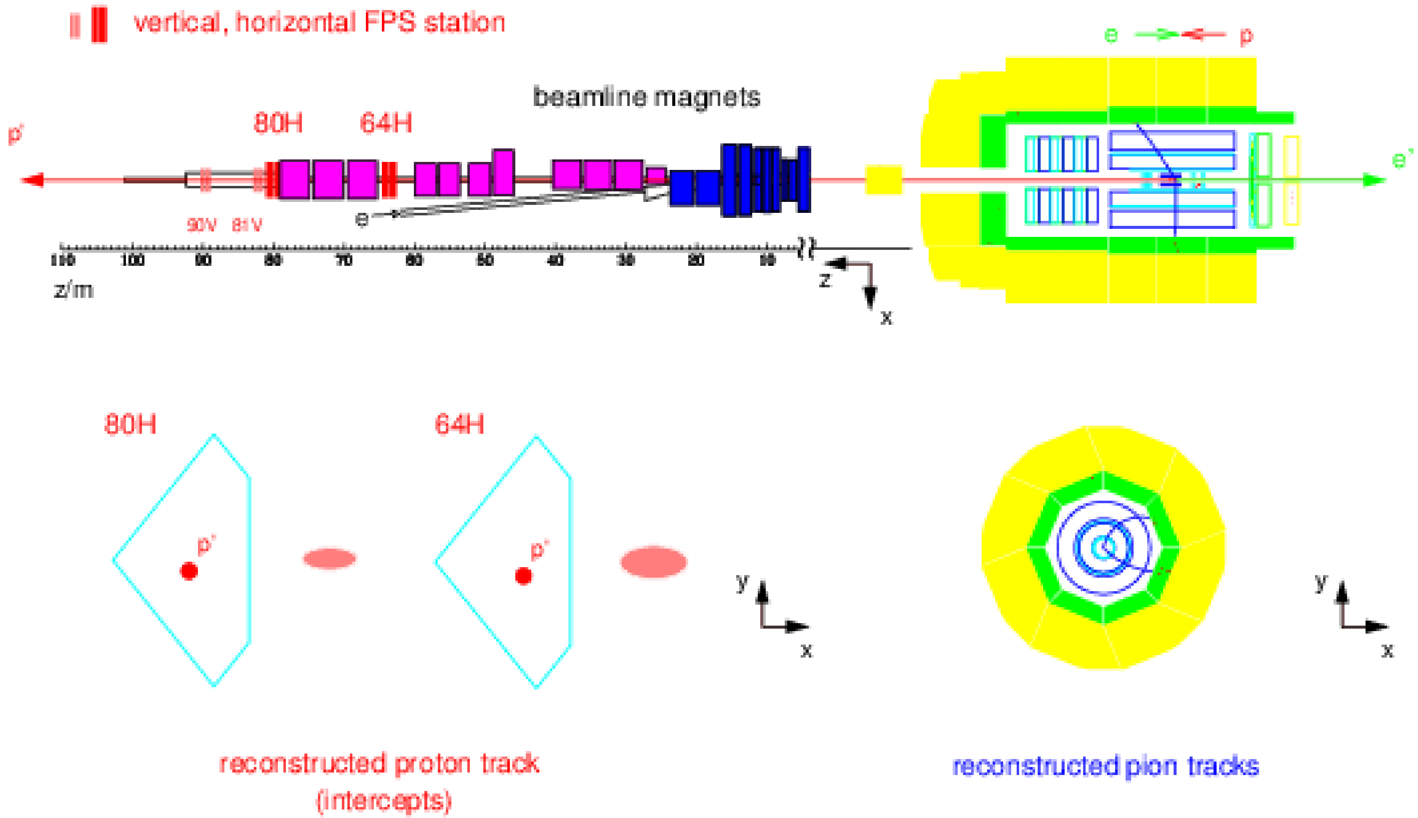
Measure t distribution

But low statistics due to acceptance

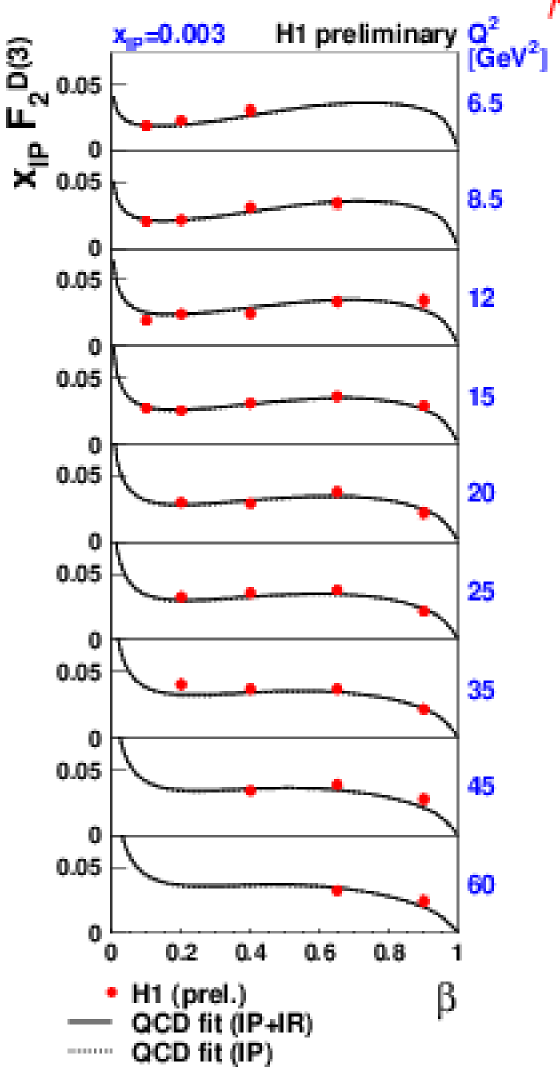
2. Large Rapidity Gap

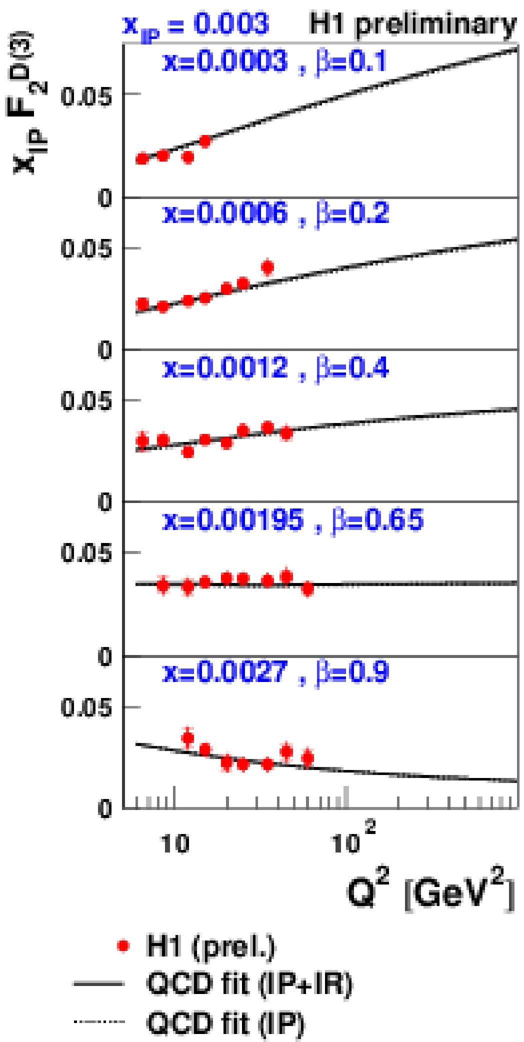
Reconstruct kinematics from X

Integrate over t



β, Q^2 dependence of $F_2^{D(3)}$





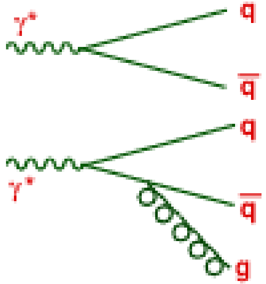
- β dependence relatively flat.
- Rising scaling violations with $\ln Q^2$ up to large β

$\Rightarrow$ Gluon contribution dominates diffractive pdf's and extends to large fractional momenta

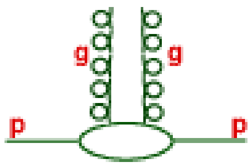
Data well described by H1 QCD fit

Comparison with a Colour Dipole Model (Golec-Biernat, Wüsthoff)

$\gamma^\star \longrightarrow q\bar{q}, q\bar{q}g$ in p rest frame



Partonic - two gluon exchange



$\sigma_{\rm dif}$ derived from $\sigma_{\rm tot}$

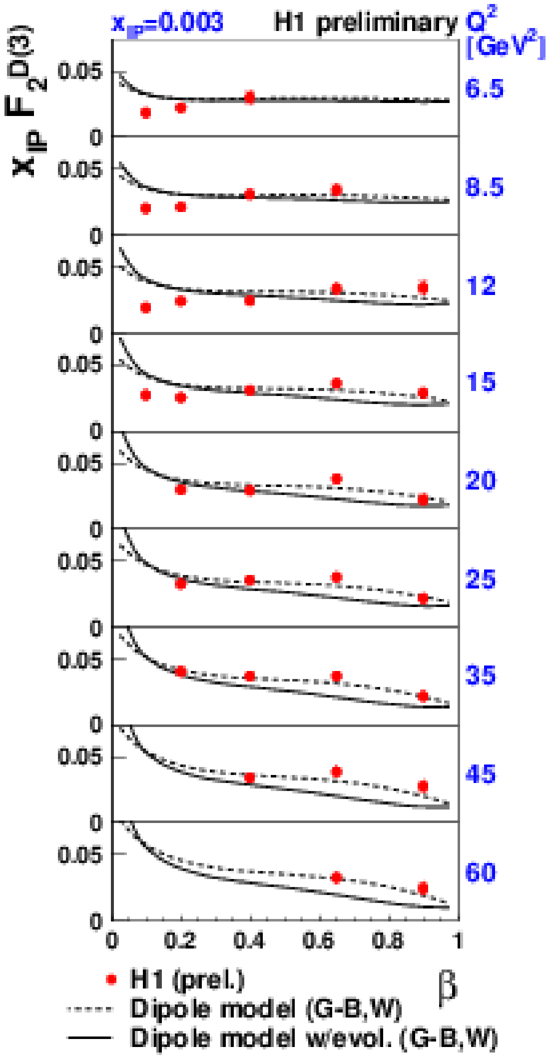
General features of data

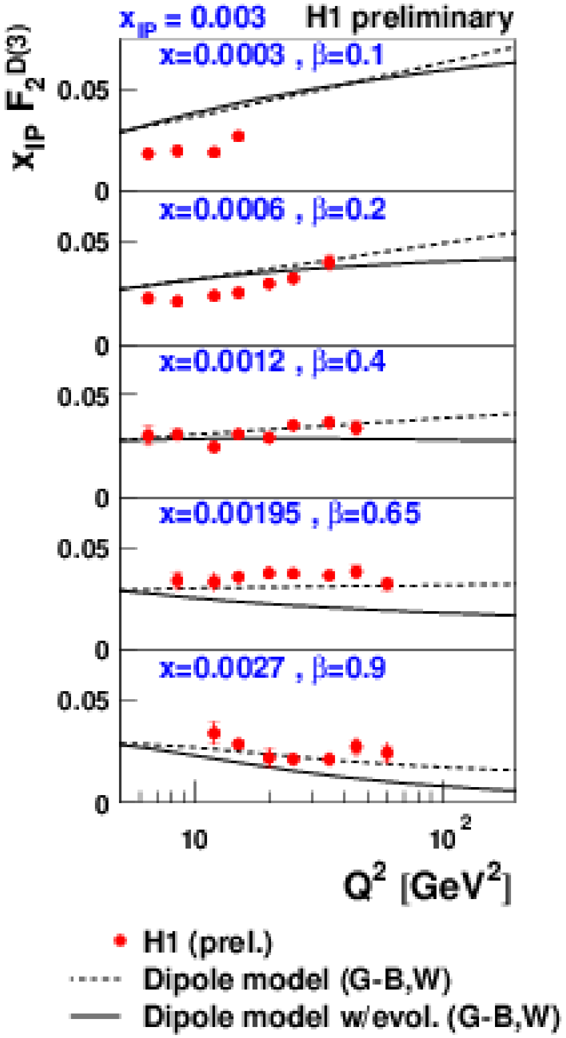
well reproduced

Higher twist at high β

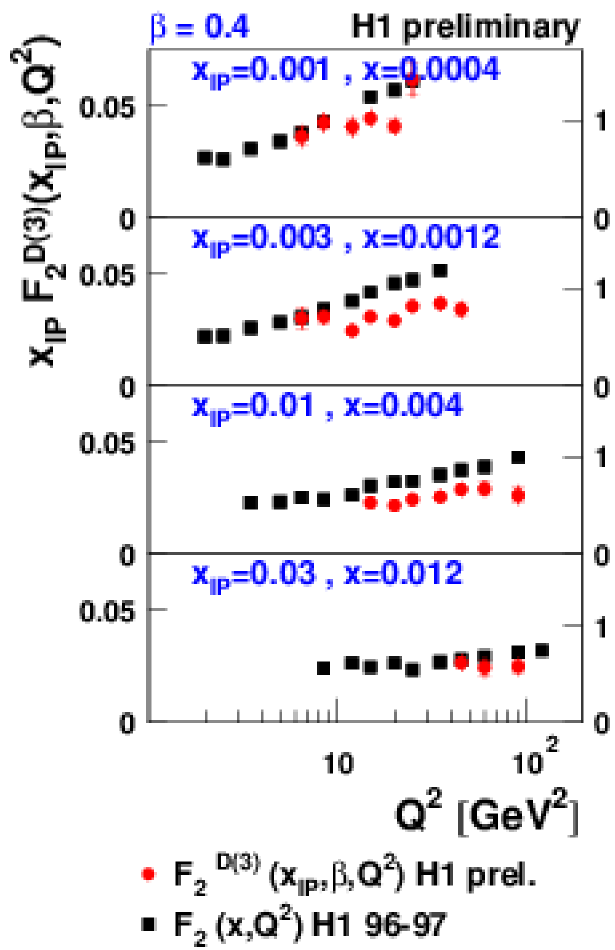
Inclusion of QCD evolution

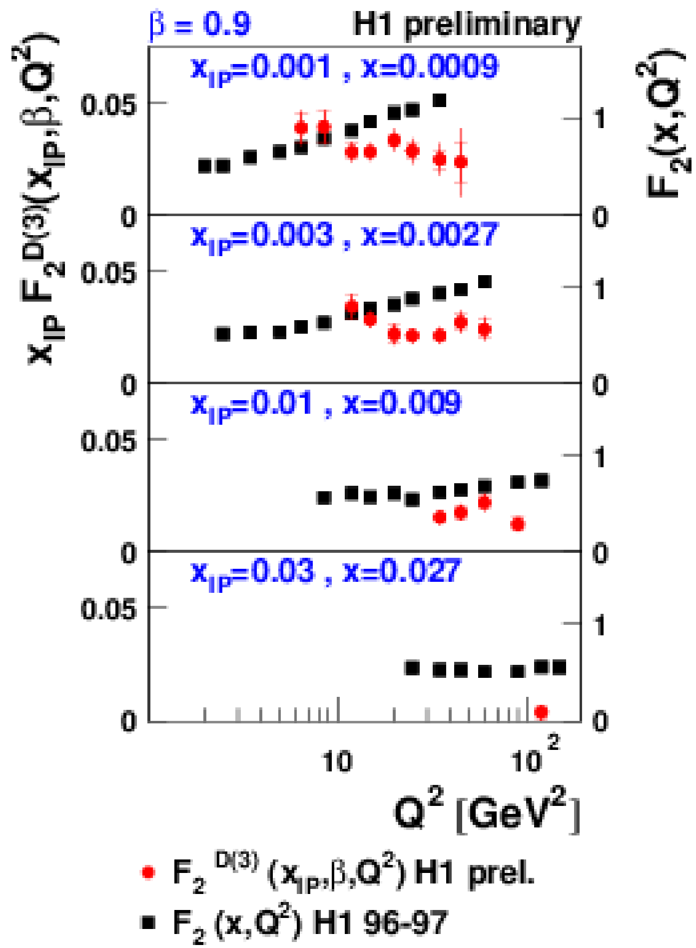
in model does not help





Compare Scaling Violations of F_2^D at $x = (x_{I\!P} \cdot \beta)$ with F_2 at x





At low β, F_2^D shows similar Q^2 dependence as F_2

At $\beta = 0.9$, F_2^D falls with Q^2 whereas F_2 continues to rise.

Different dynamics at work in diffractive processes!

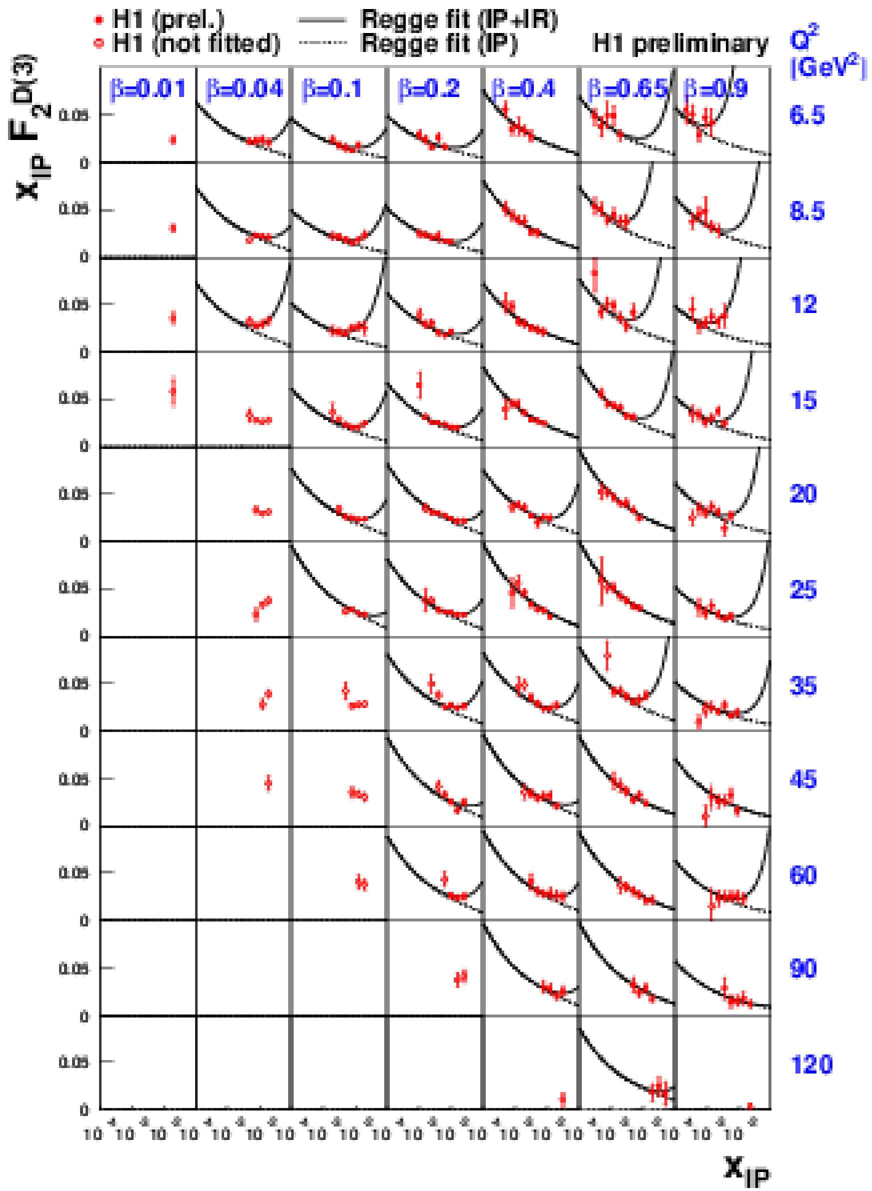
Test of ‘Regge’ Factorisation

$$x_{I\!P} F_2^D \sim A(\beta, Q^2)\ x_{I\!P}^{-2(\alpha_{I\!P}(t)-1)}$$

- Fit $x_{I\!P}$ dependence at fixed β and Q^2
- Data well described by exchange of two trajectories $I\!P$ and $I\!R$
- No evidence for variation of $\alpha_{I\!P}(0)$ with β or Q^2

$\alpha_{I\!P}(0) = 1.173 \pm 0.018(stat.)$
$\pm 0.017(syst.)^{+0.063}_{-0.035}(model)$

Error dominated by $0 < F_L^{D(3)} < F_2^{D(3)}$



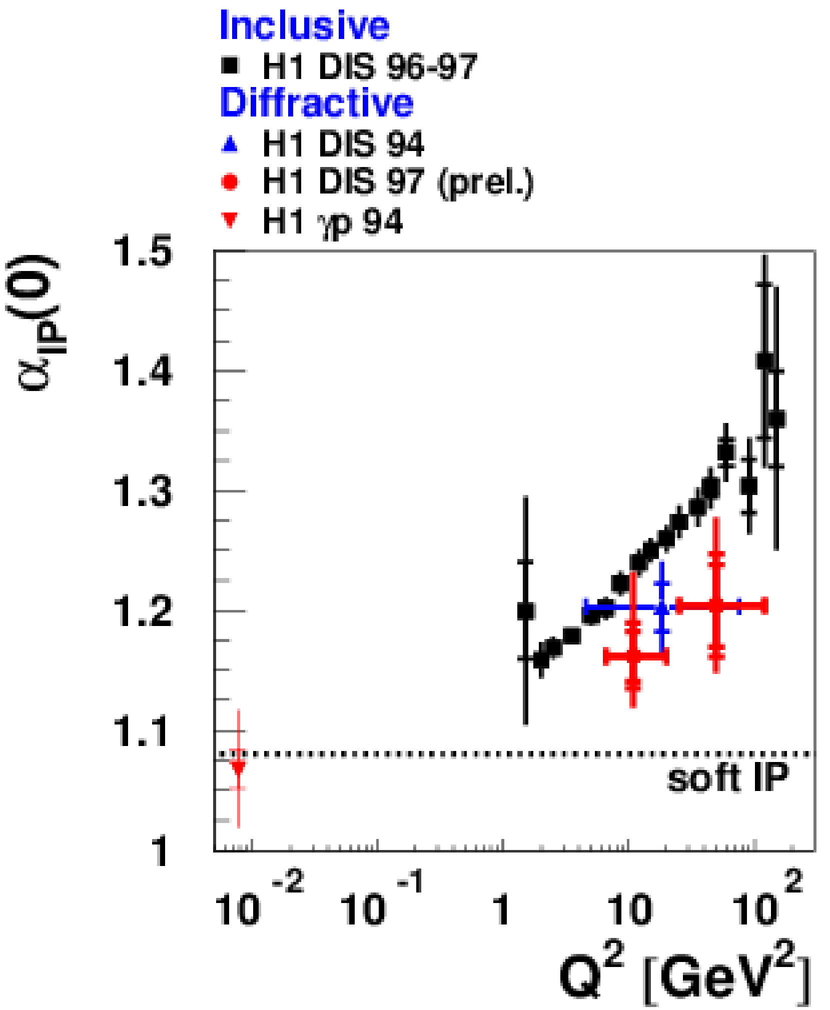
Overview of Energy Dependence for F_2 and F_2^D

Compare effective $\alpha_{I\!P}(0)$ from F_2 and F_2^D ...

$F_2 \sim c(Q^2)\ x^{-(\alpha_{I\!P}(0)-1)}$

$x_{I\!P} F_2^D \sim A(\beta, Q^2)\ x^{-2(\alpha_{I\!P}(t)-1)}$

- $\alpha_{I\!P}(0)$ in diffraction larger than soft $I\!P$ at large Q^2
- Effective $\alpha_{I\!P}(0)$ at large Q^2 lower for diffractive than for inclusive cross section?



Leading Proton Measurement

Horizontal Stations give acceptance to lower $x_{I\!P}$ region

Preliminary 1999-2000 data

$\mathcal{L} = 29\ \mathrm{pb}^{-1}$

$2 < Q^2 < 50\ \mathrm{GeV}^2$

$\beta > 5 \cdot 10^{-3}$

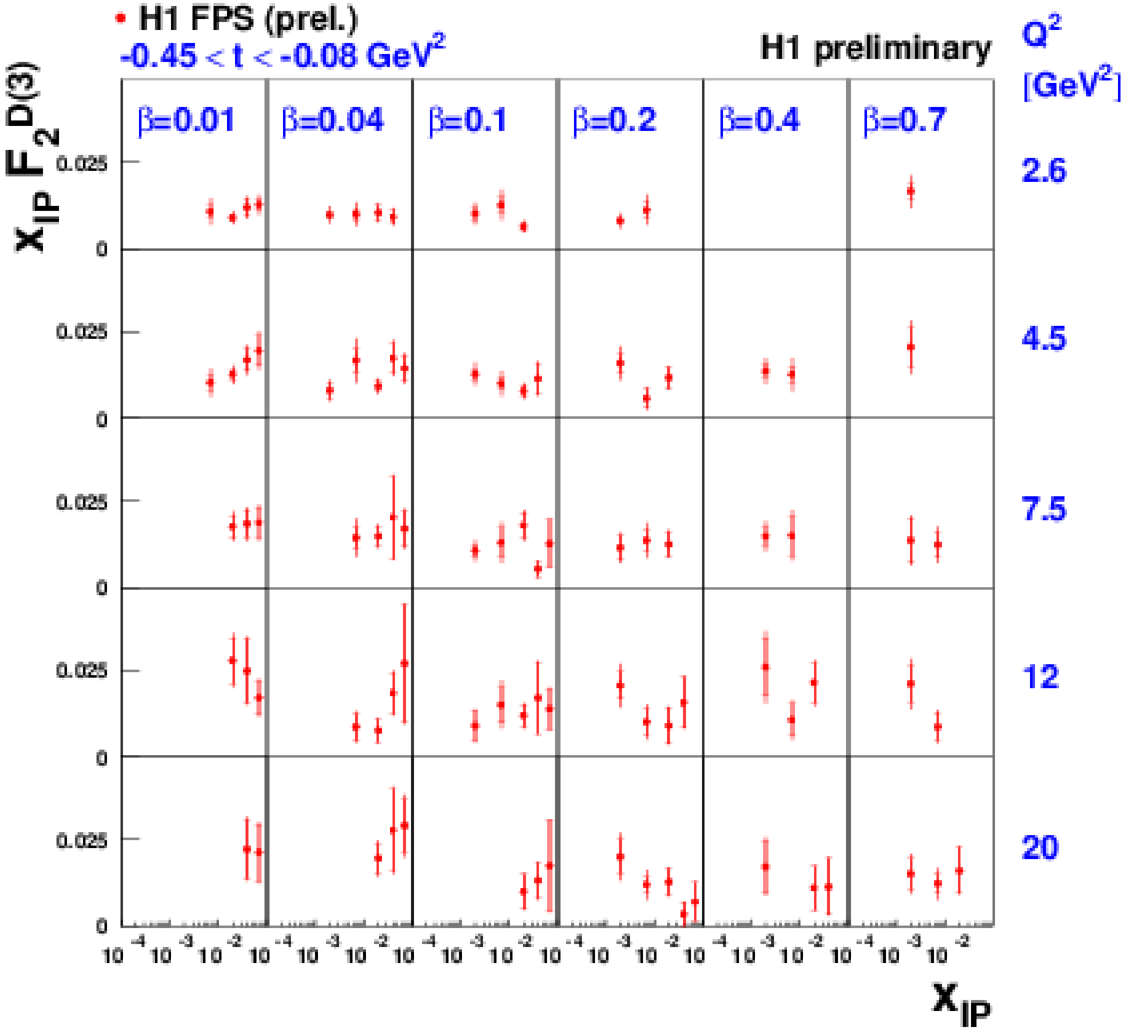
$x_{I\!P} < 0.09$

$-0.45 < t < -0.08 \mathrm{GeV}^2$

fit: $\frac{d\sigma}{dt} \propto e^{bt}$

$b = 5.0 \pm 0.3(stat.)$

$\pm 0.8(syst.)\ \mathrm{GeV}^{-2}$



Comparison with Rapidity Gap Analysis

$F_2^{D(3)} = \int F_2^{D(4)}\,\mathrm{d}t$

Use measured t-slope to extrapolate

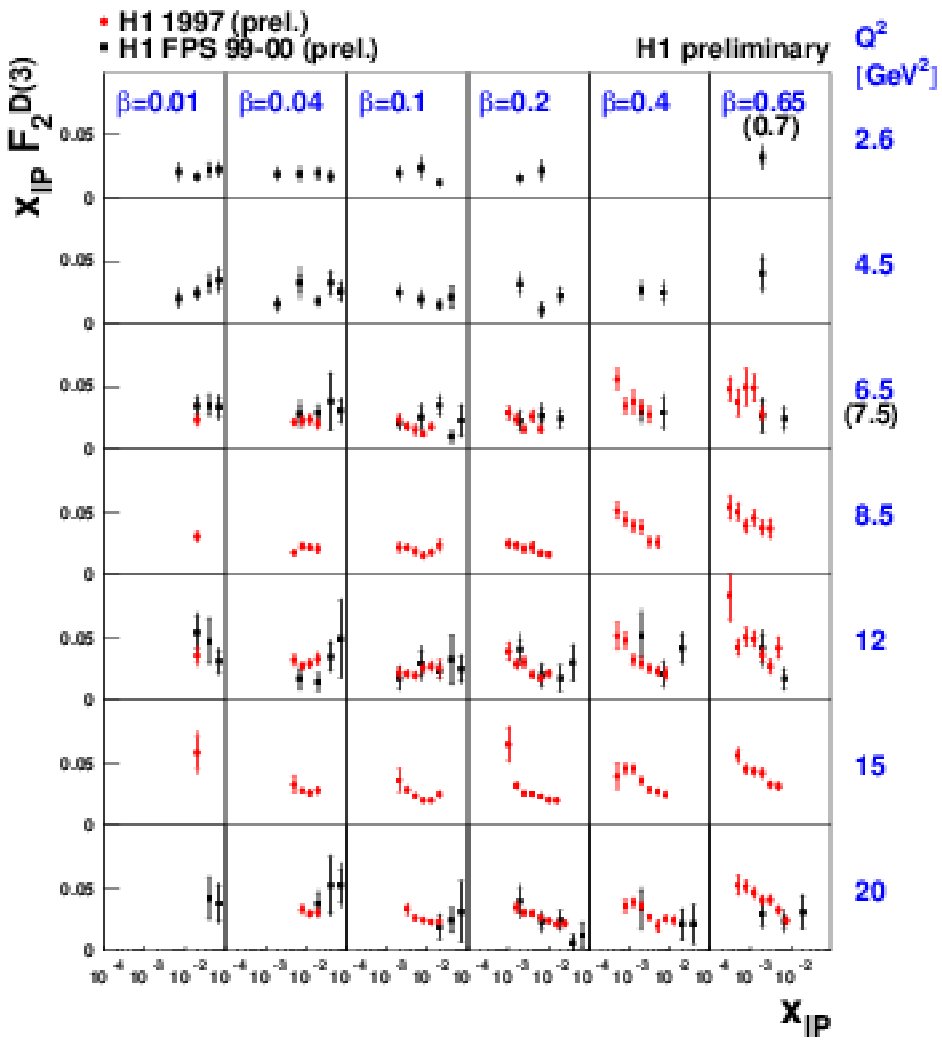
to full t range ($|t| < 1\ \mathrm{GeV}^2$)

Extracted results compatible with

results from rapidity gap analysis.

For stronger statements

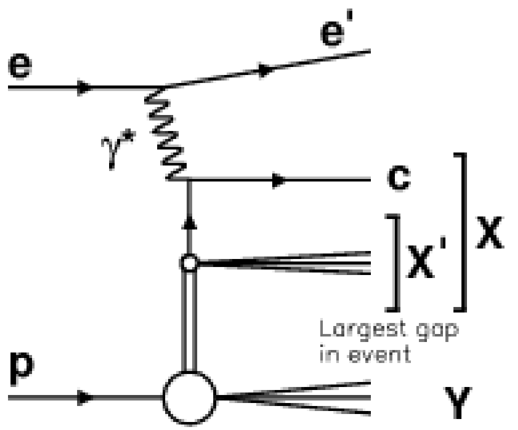
require higher acceptance (e.g. VFPS)

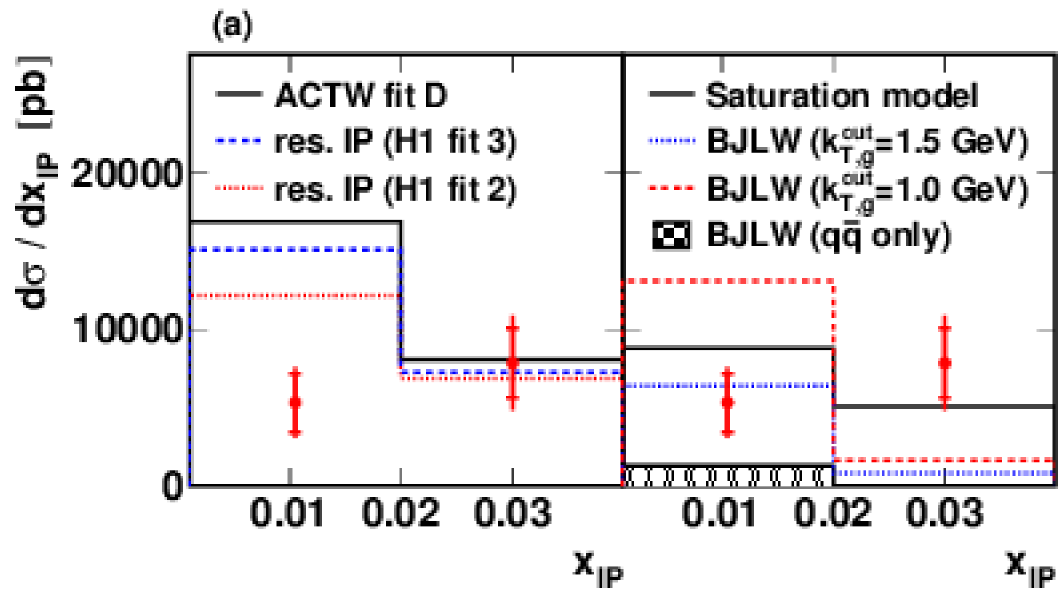


Diffractive D^* Production

- Directly sensitive to gluon content of pomeron
- Test of diffractive pdf's from F_2^D and pQCD

Phys. Lett. B520 (2001) 191



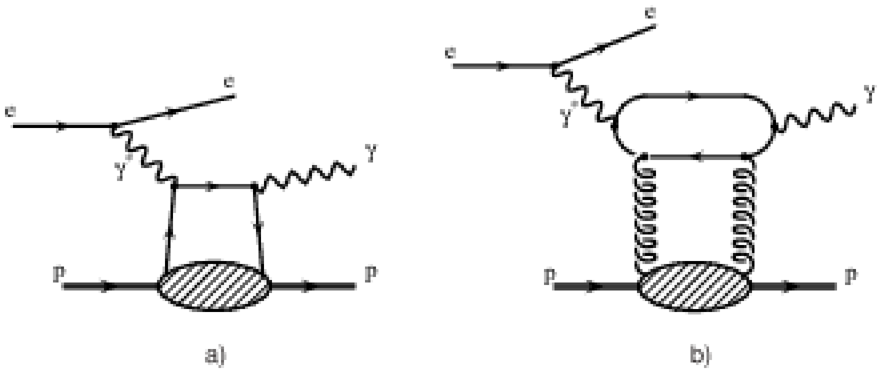


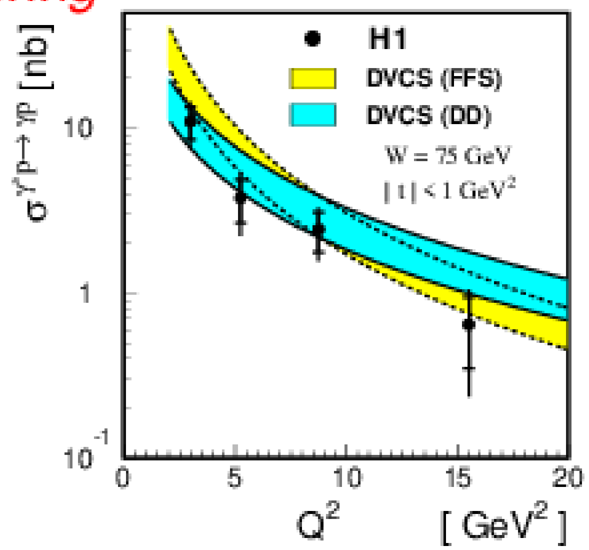
- None of models is perfect
- First discrepancy with resolved $\mathbb{P}$ model at low $x_{\mathbb{P}}$??
- Perturbative 2 Gluon Models describe data in region of applicability (low $x_{\mathbb{P}}$ domain)
- Require more statistics

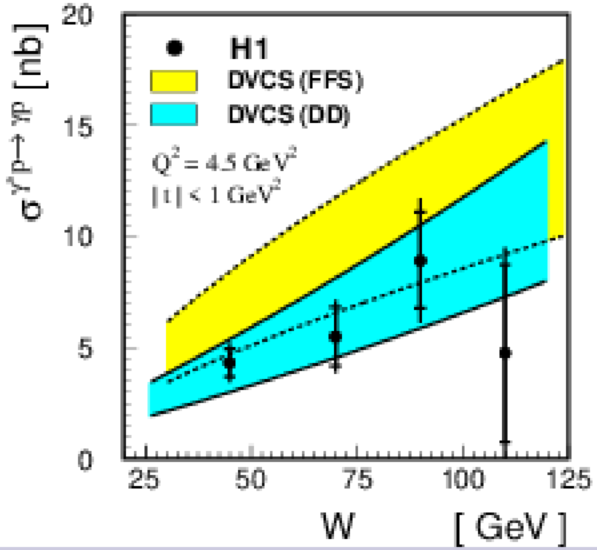
Deeply Virtual Compton Scattering

Phys.Lett. B517 (2001) 47

- Study of exclusive diffraction without VM wave function
- Sensitive to skewed parton distributions







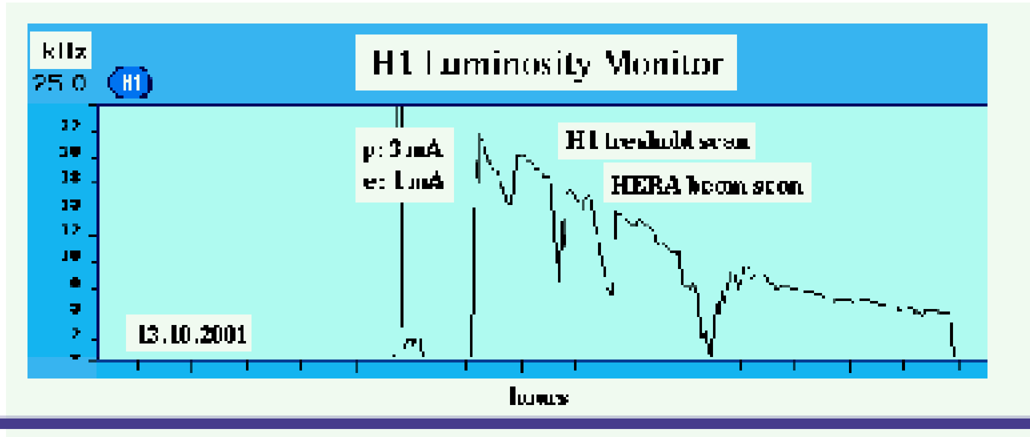
Agreement within errors with LO pQCD calculations

Summary

- Wealth of HERA I data analysed by H1 (more still to come)
- This talk focused only on recent low x results:
- No sign of breakdown of DGLAP in $\left(\frac{\partial \ln F_2(x,Q^2)}{\partial \ln x}\right)_{Q^2}$
- High Precsion measurement of $F_2^{D(3)}$ + QCD factorisation theorem

– tools for pQCD to provide description of diffractive final state?

- HERA II focus on searches/high Q^2 physics but increased statistics essential for diffractive final states (VFPS)
- H1 is ready to take data at increased luminosity!



HERA running in 2002

H1 requests to run through the entire year 2002 with positrons.

- clarify situation of events with isolated leptons, and large $P_{T,miss}$
- searches in competition with Tevatron
- technical reasons