THE UNIVERSITY of LIVERPOOL

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NEW RESULTS ON INCLUSIVE DIFFRACTION

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Overview:

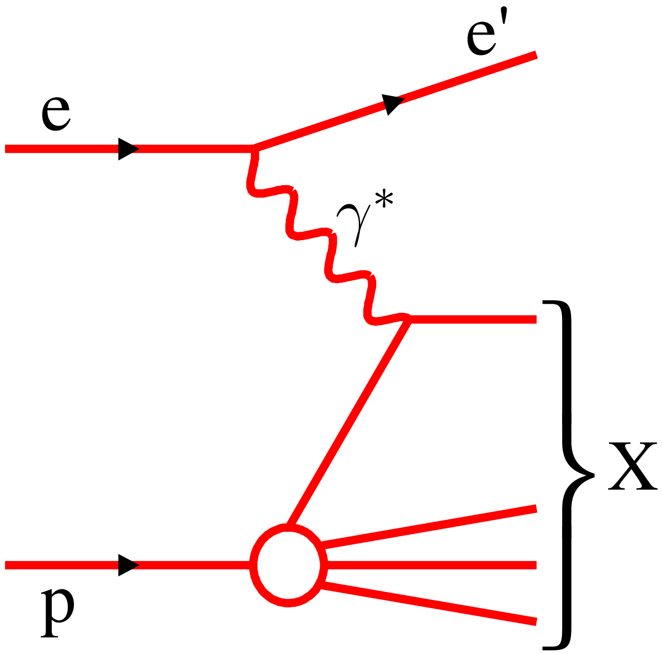
- **DIFFRACTION AT H1**
- **MEASUREMENT TECHNIQUES**
- **LATEST MEASUREMENTS**
- **QCD FITS - NEXT TALK !**
- **SUMMARY**

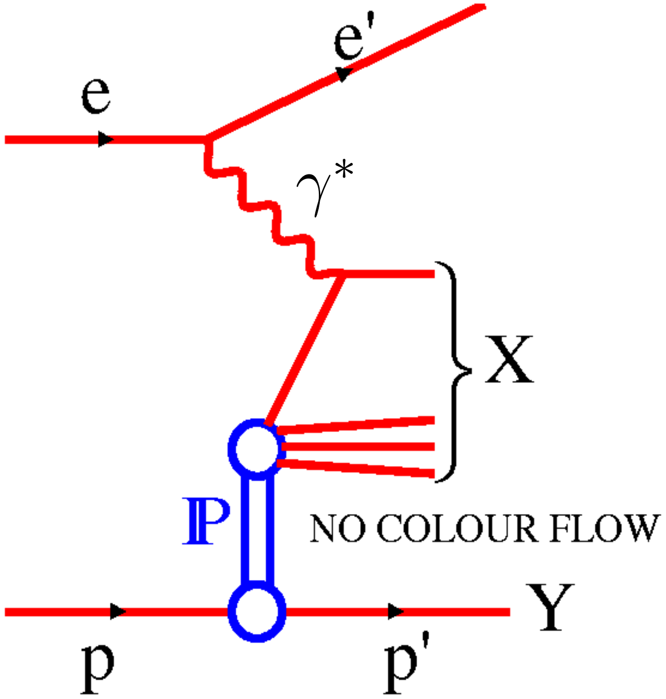
Inclusive Diffractive DIS at H1

The Bulk of hadronic interactions at high energy are diffractive

Study the QCD Structure of these interactions using :

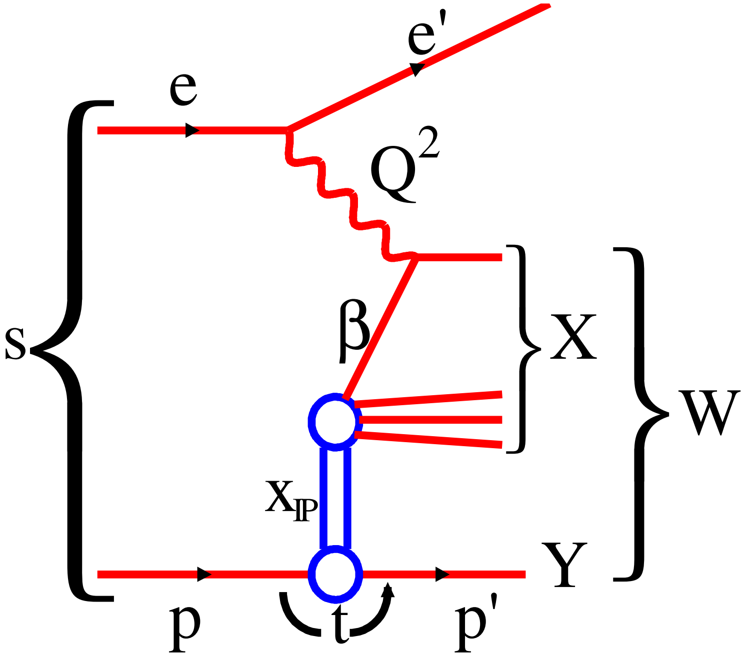
$$\gamma^* p \longrightarrow Xp$$





Probe the proton $\longrightarrow F_2^{Proton}$ Probe Diffractive dynamics $\longrightarrow F_2^D$

Inclusive Diffractive DIS $\gamma^* p \longrightarrow Xp$



$$Q^2 = -(e - e')^2 = -q^2$$

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

$$\beta = x_{quark/IP}$$

$$x_{IP} = x_{IP/proton}$$

$$x_{Bjoerken} = \beta \cdot x_{IP}$$

Cross Section :

$$\frac{d\sigma^{ep \longrightarrow eXY}}{d\beta dQ^2 dx_{IP} dt} = \frac{4\pi\alpha^2}{\beta Q^4}(1 - y + \frac{y^2}{2})\sigma_r^{D(4)}$$

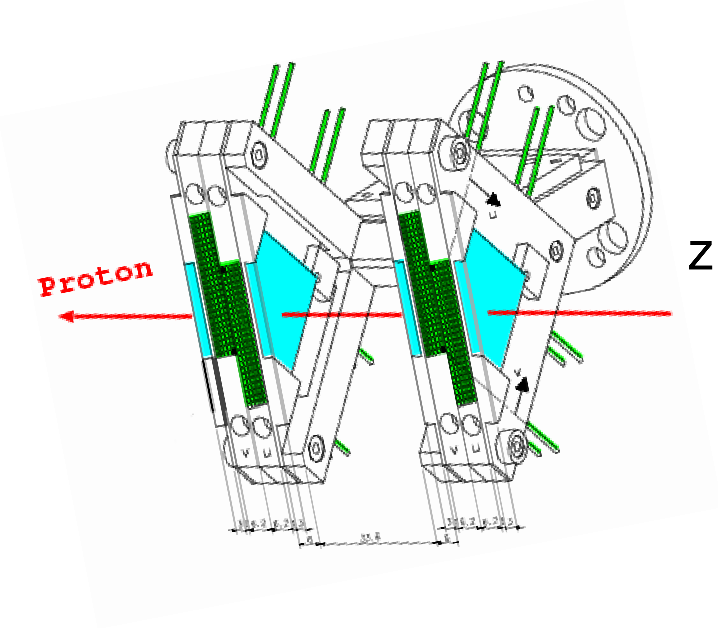
Reduced Cross Section :

$$\sigma_r^{D(4)} = F_2^{D(4)} - \frac{y^2}{1+(1-y)^2} F_L^{D(4)} \quad (\sigma_r^{D(4)} = F_2^{D(4)} \text{ if } F_L^{D(4)} = 0)$$

Diffraction in H1 $ep \longrightarrow e'Xp'$

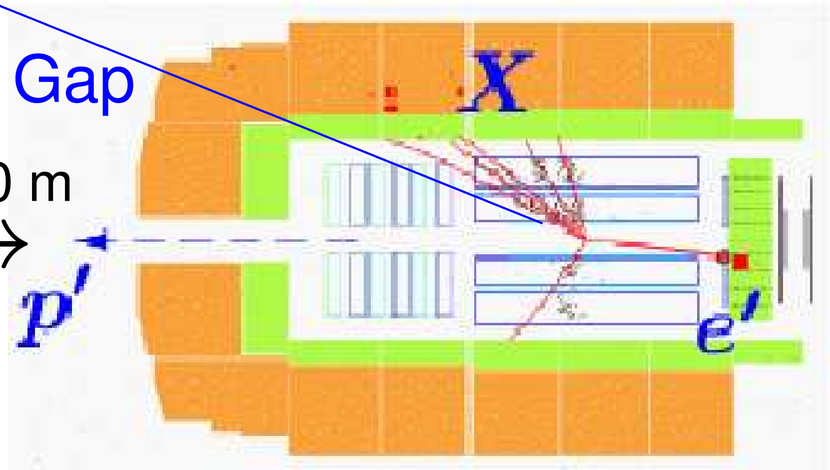
FPS Stations

Main Detector



Rapidity Gap

z = 64 and z = 80 m



Measure Leading Proton

Free of p dissociation background

Measure t distribution

Lower statistics due to acceptance

Require Large Rapidity Gap

Kinematics measured from X system

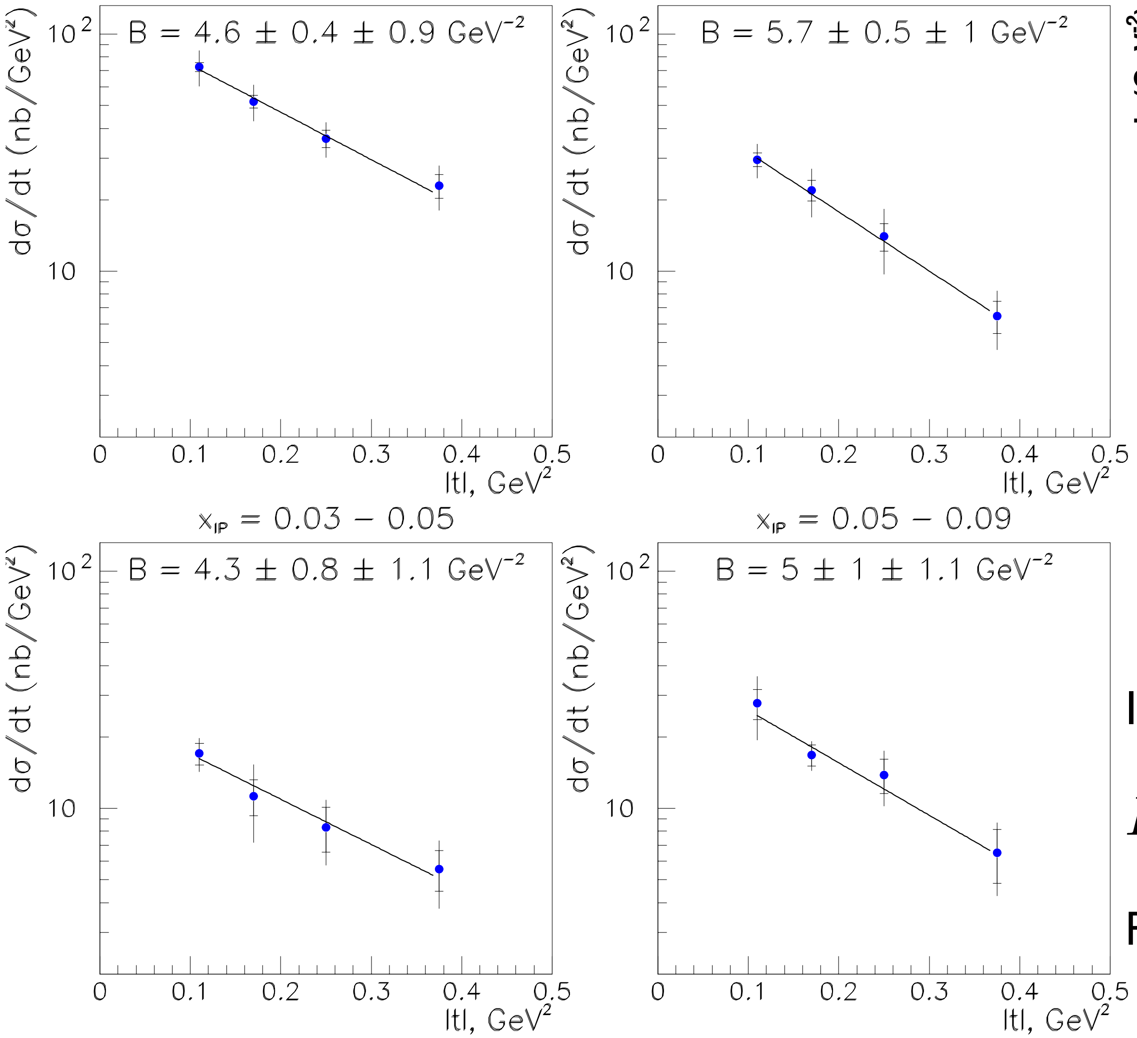
Integrate over t and M_Y

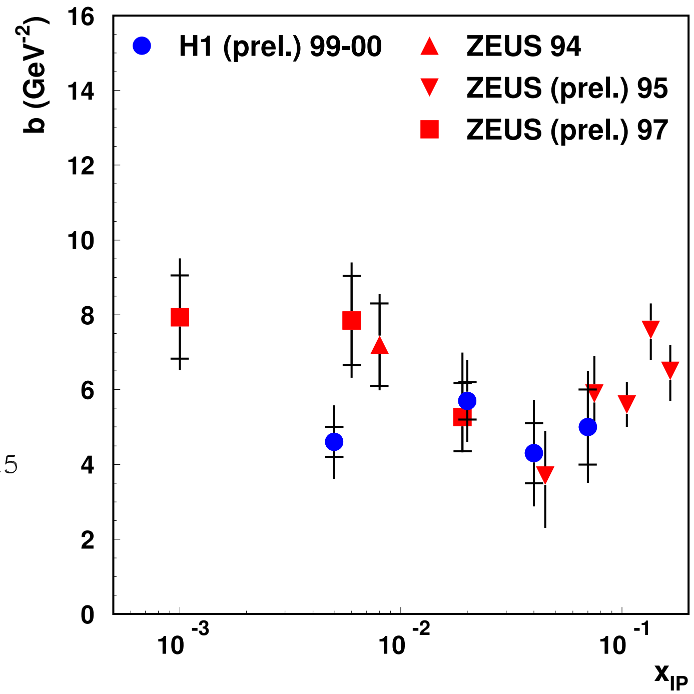
Higher statistics

The New Data Sets

	FPS	Rapidity Gap Selection
Kinematics :	$2 < Q^2 < 50\ GeV^2$	$6.5 < Q^2 < 120\ GeV^2$
	$5.10^{-3} < \beta < 1$	$0.01 < \beta < 0.9$
	$x_{IP} < 0.09$	$10^{-4} < x_{IP} < 0.05$
	$-0.45 < t < -0.08\ GeV^2$	
Years :	1999 - 2000	1997
Luminosity :	$28.8\ \ pb^{-1}$	$10.6\ \ pb^{-1}$
	New Measurement in diffractive region	5 $\times$ Lumi of previous publication

t-dependence of the Diffractive Cross section





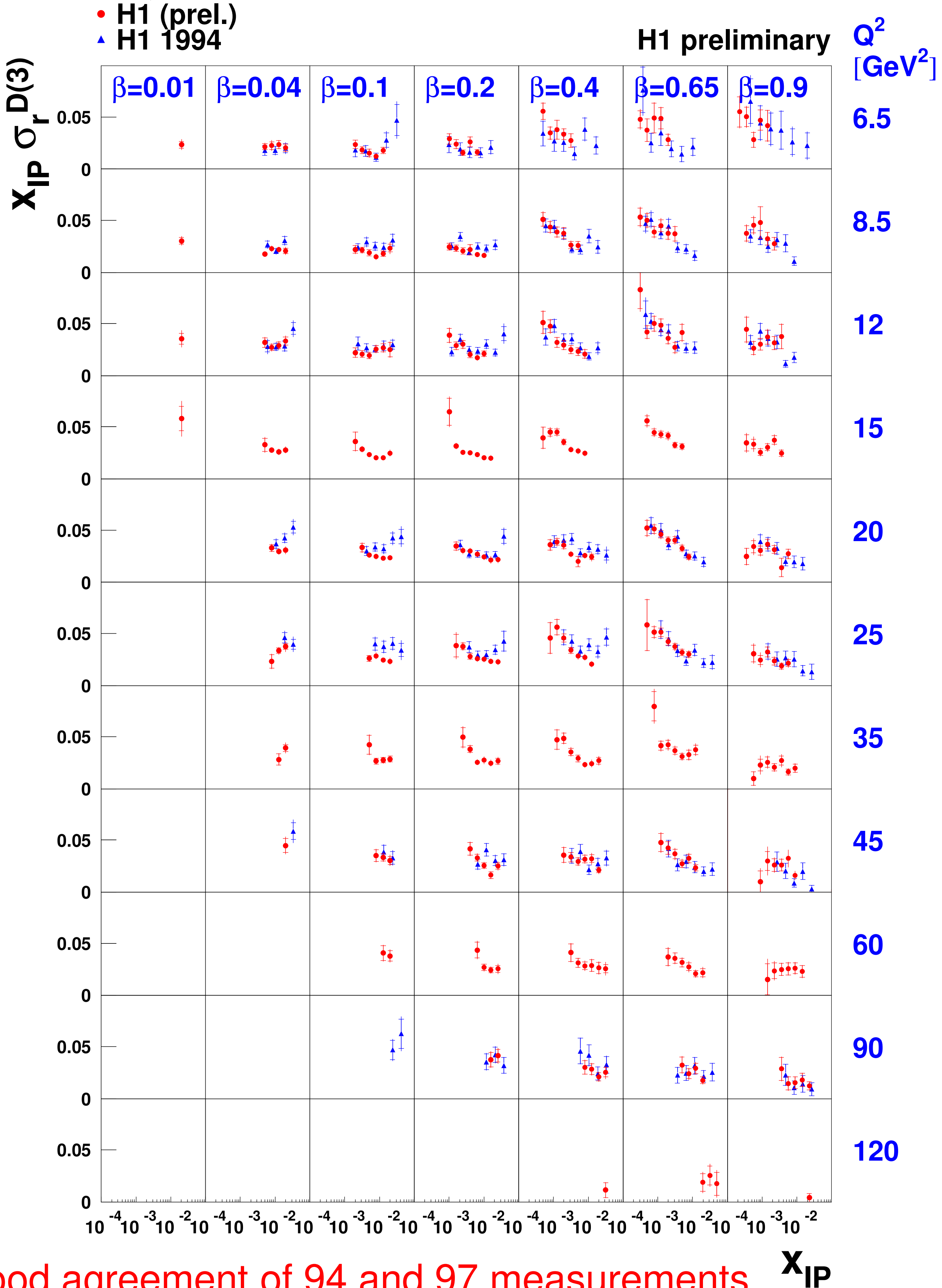
In Regge theory expect shrinkage :

$$B = B_0 + 2\alpha' \ln \frac{1}{x_{IP}}$$

For $x_{IP} < 10^{-2}$ data inconclusive

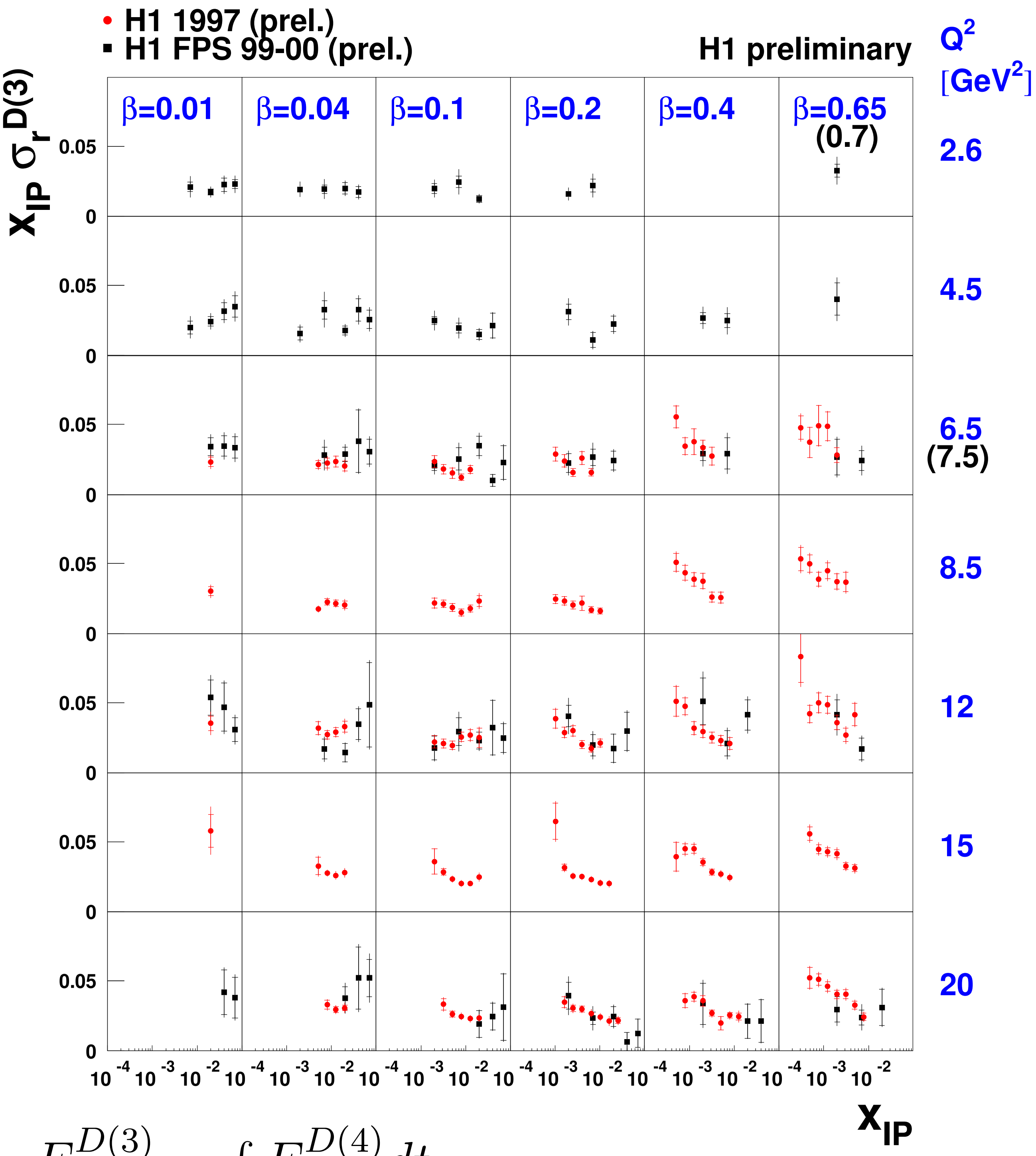
$$\frac{d\sigma}{dt} \propto e^{Bt} \rightarrow B = 5.0\ GeV^{-2} \pm 0.3(stat) \pm 0.8(syst)$$

$\sigma_r^{D(3)}$ from Rapidity Gap Selection



Good agreement of 94 and 97 measurements

Tagged proton Vs Rapidity Gap Selection



$$F_2^{D(3)} = \int F_2^{D(4)} dt$$

Use measured t slope to extrapolate to full t range

Good Agreement between the two techniques

Factorisation Properties of F_2^D

1. QCD Hard Scattering Factorisation for Diffractive DIS

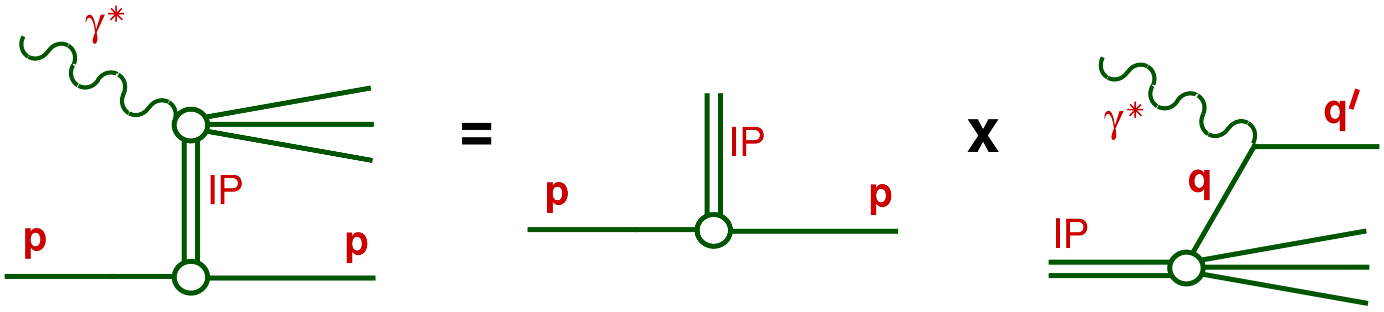
QCD Proof by Collins

$$\sigma(\gamma^* p \to Xp) \;\sim\; p_{q/p}(x_{IP}, t, x, Q^2) \;\otimes\; \hat{\sigma}_{\gamma^\star q}(x, Q^2)$$

At fixed x_{IP}, t, Diffractive Parton Densities evolve with x, Q^2 according to DGLAP equations.

2. 'Regge' Factorisation

Additional assumption - Shape of Diffractive pdfs are independent of x_{IP} and t



$$\sigma(\gamma^* p \to Xp) \;\sim\; f_{IP/p}(x_{IP}, t) \;\otimes\; p_{q/IP}(\beta, Q^2) \;\otimes\; \hat{\sigma}_{\gamma^\star q}(\beta, Q^2)$$

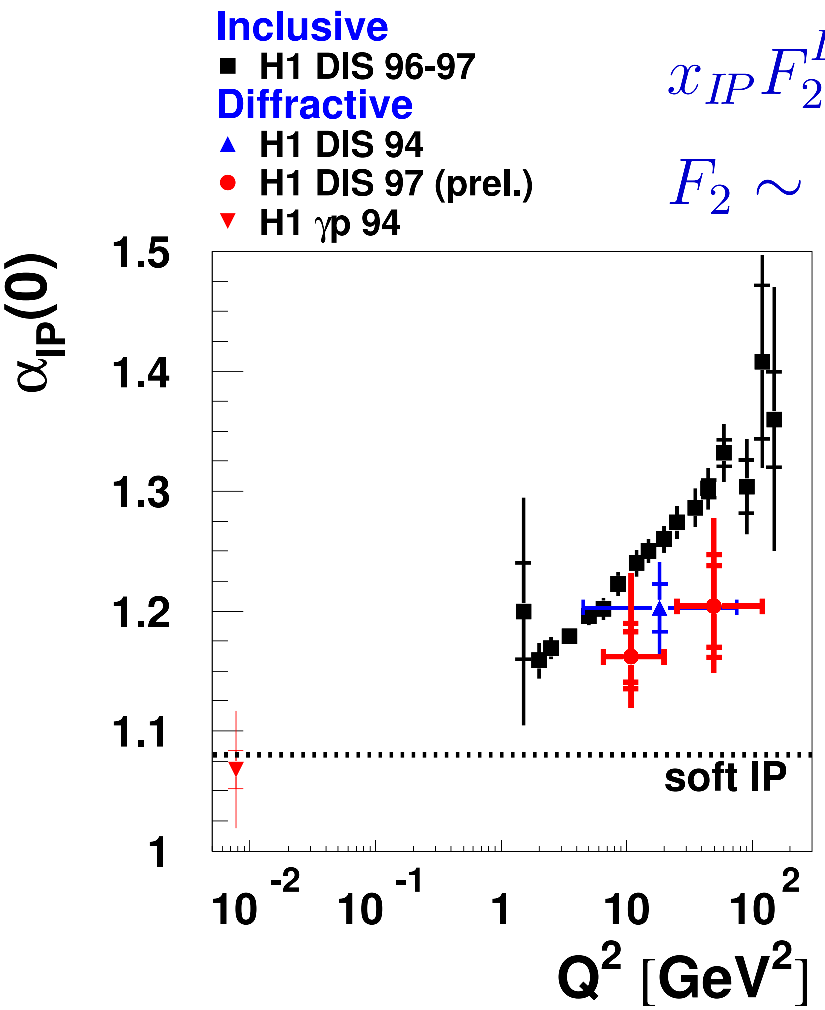
Diffractive flux | Pomeron pdfs | Hard Scatter

Effective $\alpha_{IP}(0)$ *for* F_2 *and* $F_2^{D(3)}$

Compare effective $\alpha_{IP}(0)$ from $F_2^{D(3)}$ and F_2

$$x_{IP} F_2^{D(3)} \sim A(\beta, Q^2) x_{IP}^{-2(\alpha_{IP}(\langle t \rangle)-1)}$$

$$F_2 \sim B(Q^2) x^{-(\alpha_{IP}(0)-1)}$$



$\alpha_{IP}(0)$ grows with Q^2

$\longrightarrow$ larger than soft pomeron at large Q^2

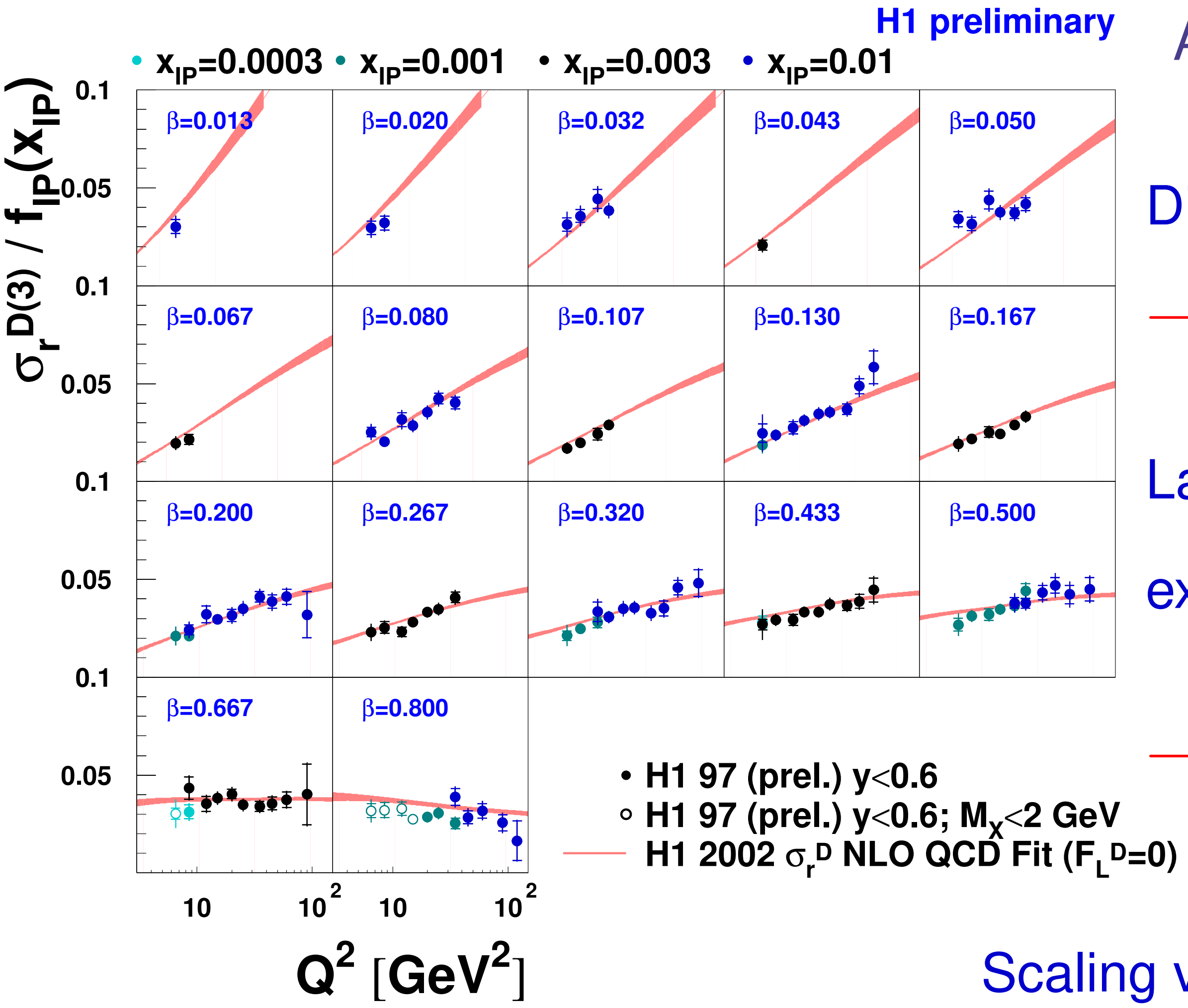
Growth of effective $\alpha_{IP}(0)$ slower for diffractive than for inclusive ?

Energy dependences of diffractive and inclusive similar at high Q^2 ?

Dominant error from ignorance of $F_L^{D(3)}$

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

Q^2 *Dependence of* $\sigma_r^{D(3)}$



At fixed x_{IP} and β

Divide by $f_{IP}(x_{IP})$

$\longrightarrow$ compare different x_{IP} bins

Large +ve Scaling violations

except at highest β

$\longrightarrow$ gluon dominated

Scaling violations similar at

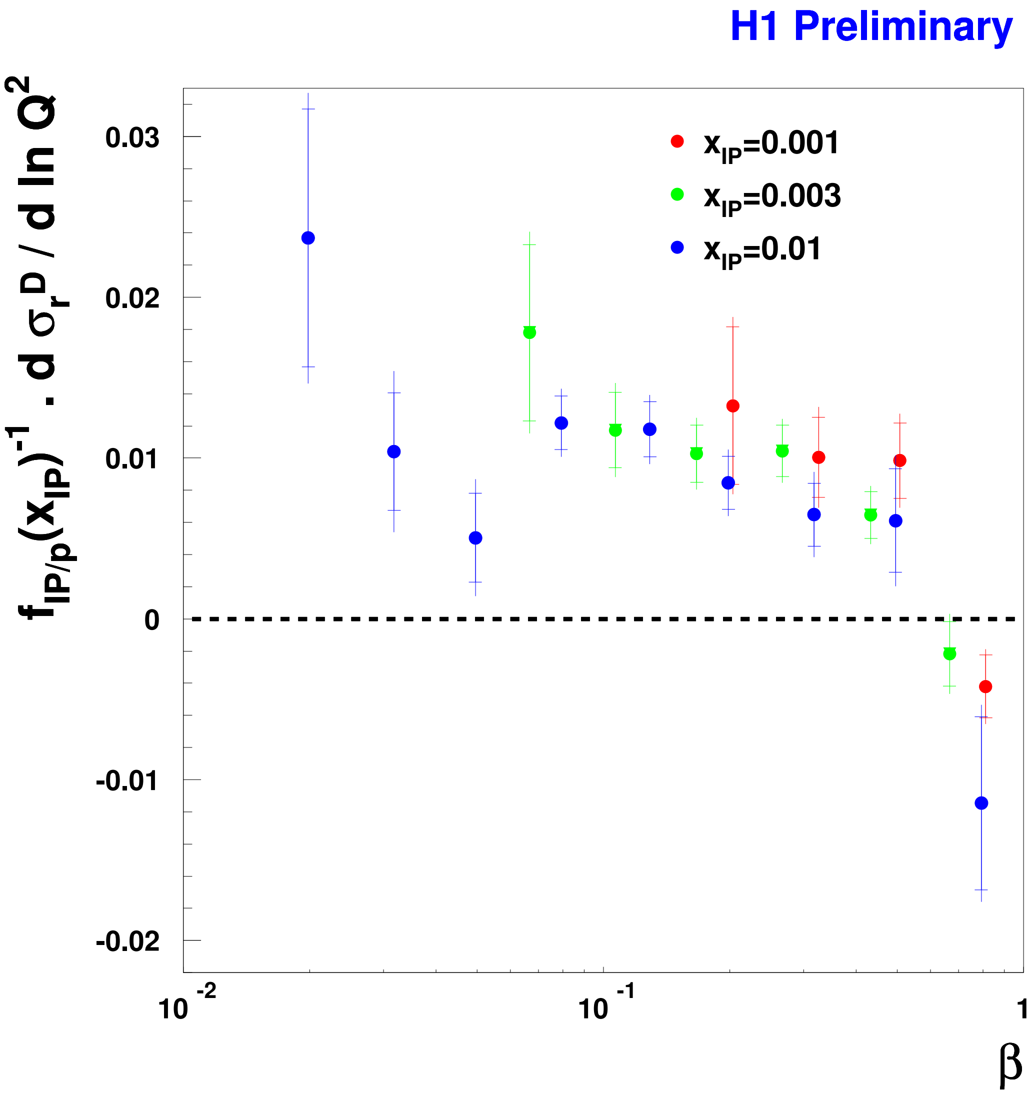
all values of x_{IP}

QCD fit describes the data

Details in the next talk

$\longrightarrow$ Support for Regge factorisation

Logarithmic Q^2 *derivative of* $\sigma_r^{D(3)}$



Quantify Scaling violations ...

At fixed x_{IP} and β

Fit $\sigma_r^D = A + B \ln Q^2$

$\longrightarrow B = \frac{d}{d\ln Q^2}(\sigma_r^D)$

Large +ve Scaling violations

Flat at $\beta \simeq 0.6$

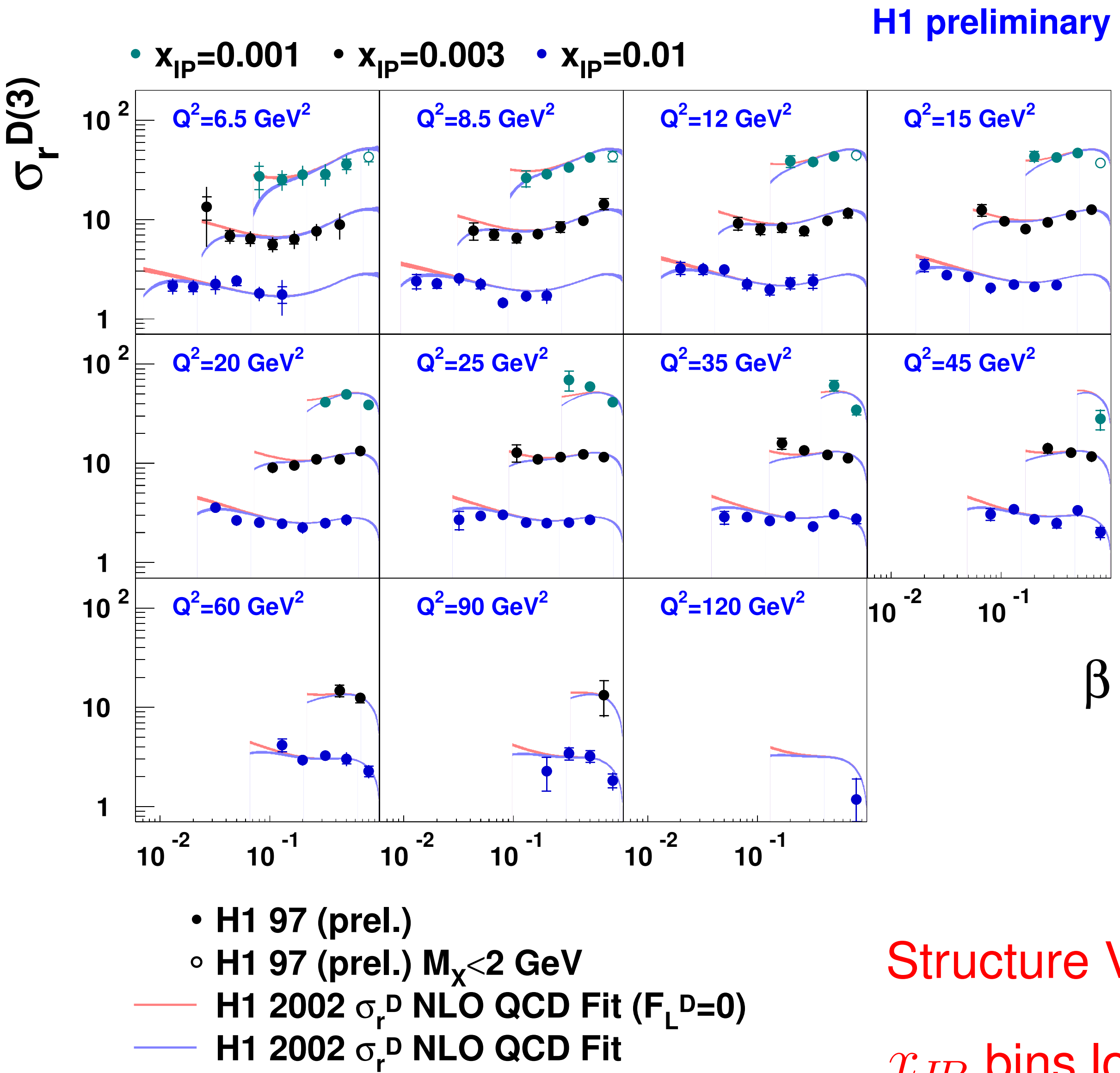
$\longrightarrow$ gluon dominated

Scaling violations similar at

all values of x_{IP}

$\longrightarrow$ Support for Regge factorisation

β *Dependence of* $\sigma_r^{D(3)}$



At fixed x_{IP} and Q^2

Not all Data shown

Looking at ∼ quark density

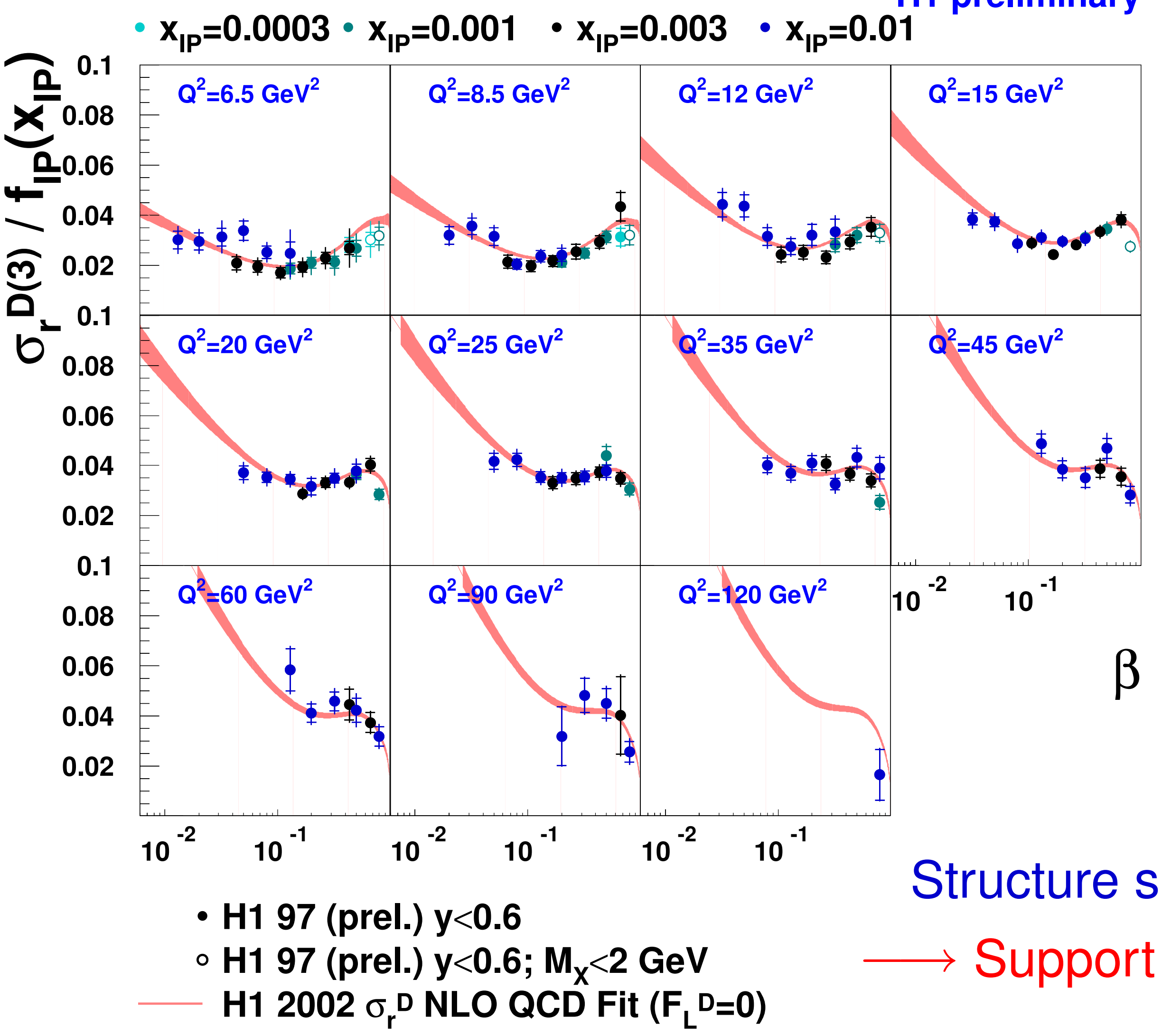
$$F_2 = x \sum e^2 q(x)$$

$\longrightarrow$ still large at high β

Structure VERY different to the proton !

x_{IP} bins look very similar

β Dependence of $\sigma_r^{D(3)}$



At fixed x_{IP} and Q^2

Divide by $f_{IP}(x_{IP}) to$

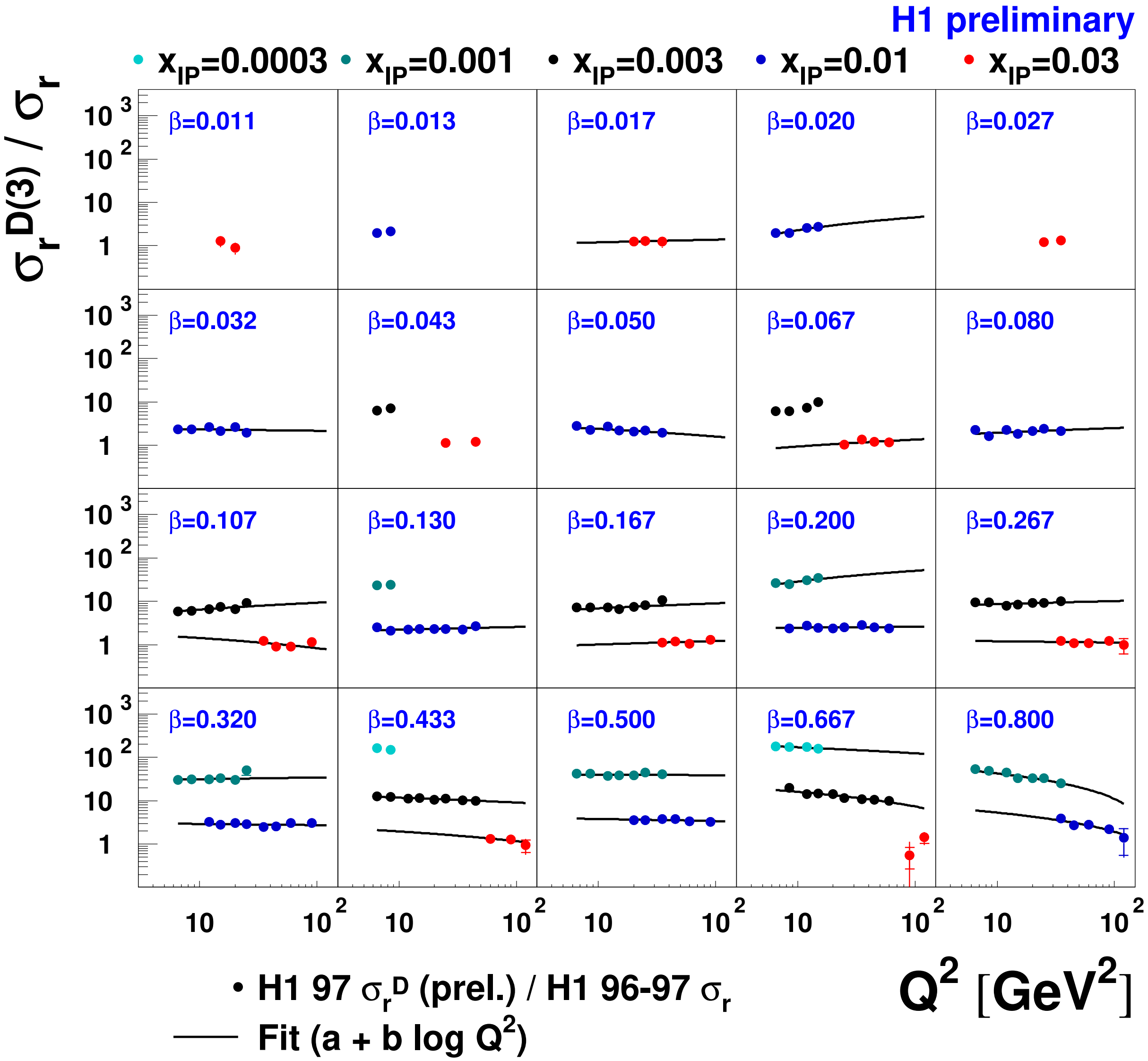
compare different x_{IP} bins

$\longrightarrow$ See full β structure

Structure similar at all values of x_{IP}

$\longrightarrow$ Support for Regge factorisation

Q^2 *Dependence of ratio* $\frac{\sigma_r^{D(3)}}{\sigma_r}$



σ_r taken from 96-97 Data

Look at ratio of diffractive to inclusive cross section

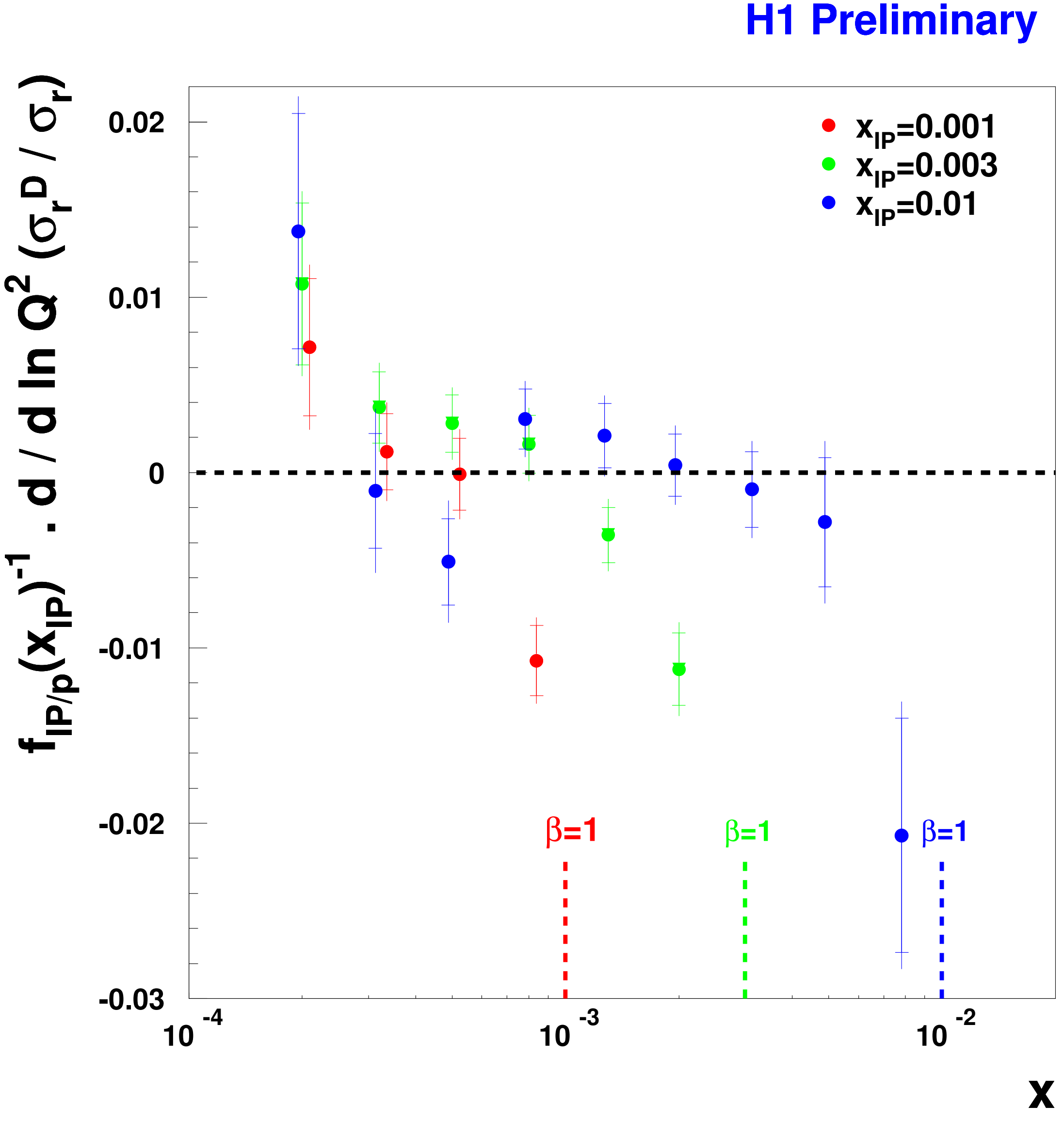
$$\rightarrow \mathcal{R} = \frac{\sigma_r^{D(3)}(x_{IP}, x, Q^2)}{\sigma_r(x, Q^2)}$$

Remarkably flat !

except at highest β

Fit $\mathcal{R} = A + B \ln Q^2$

Logarithmic Q^2 *derivative of ratio* $\frac{\sigma_r^{D(3)}}{\sigma_r}$

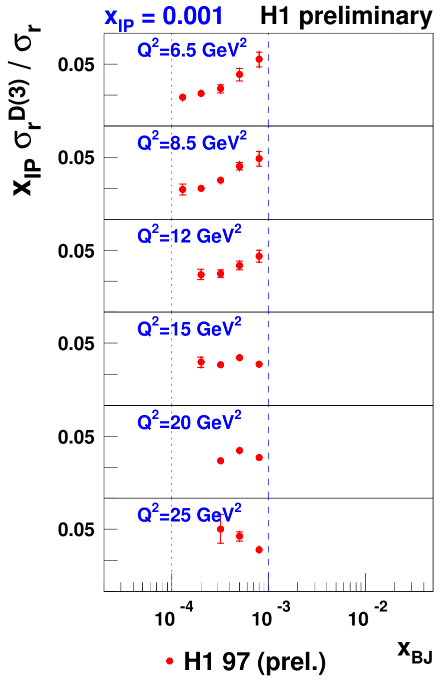


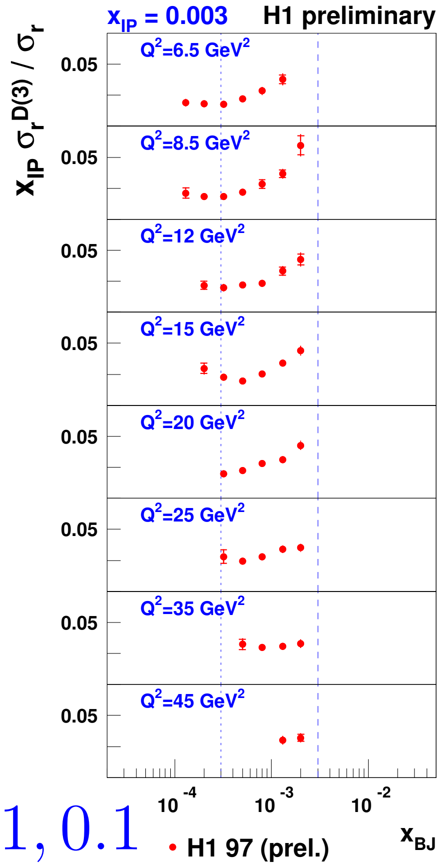
$\frac{\sigma_r^D}{\sigma r} \sim$ flat vs Q^2

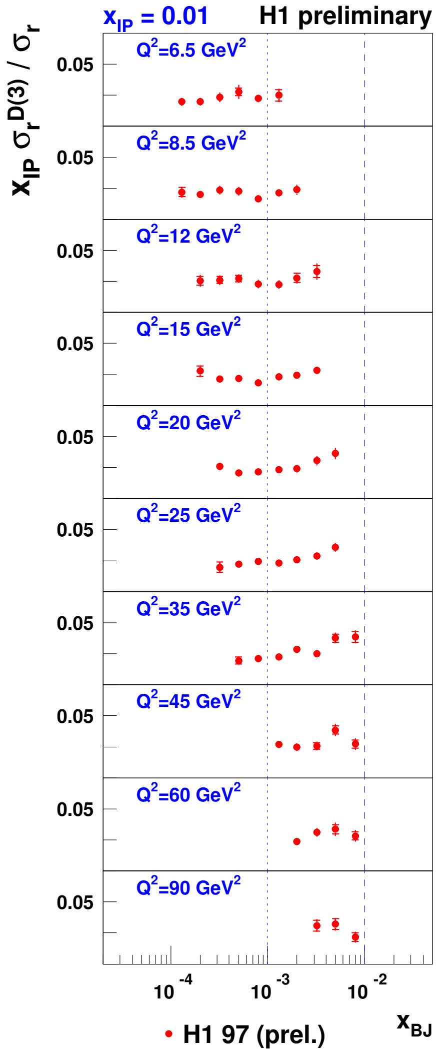
Except at highest β

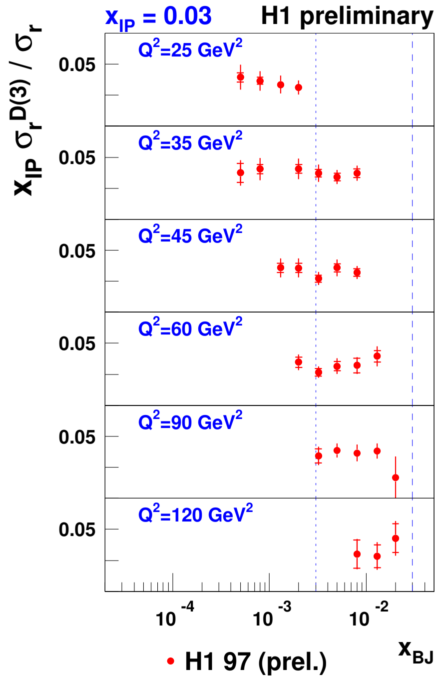
Similar Q^2 dynamics ?

$x_{Bjoerken}$ *Dependence of ratio* $\dfrac{\sigma_r^{D(3)}}{\sigma_r}$









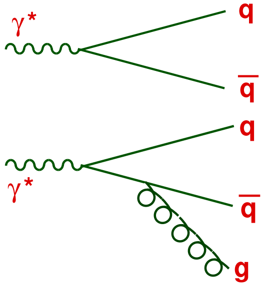
Vertical lines at $\beta = 1, 0.1$

$\beta \gtrsim 0.1 \longrightarrow$ Complicated structure

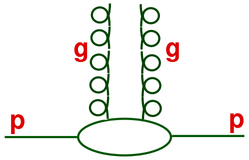
$\beta \lesssim 0.1 \longrightarrow \dfrac{\sigma_r^D}{\sigma_r} \sim$ flat vs x

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

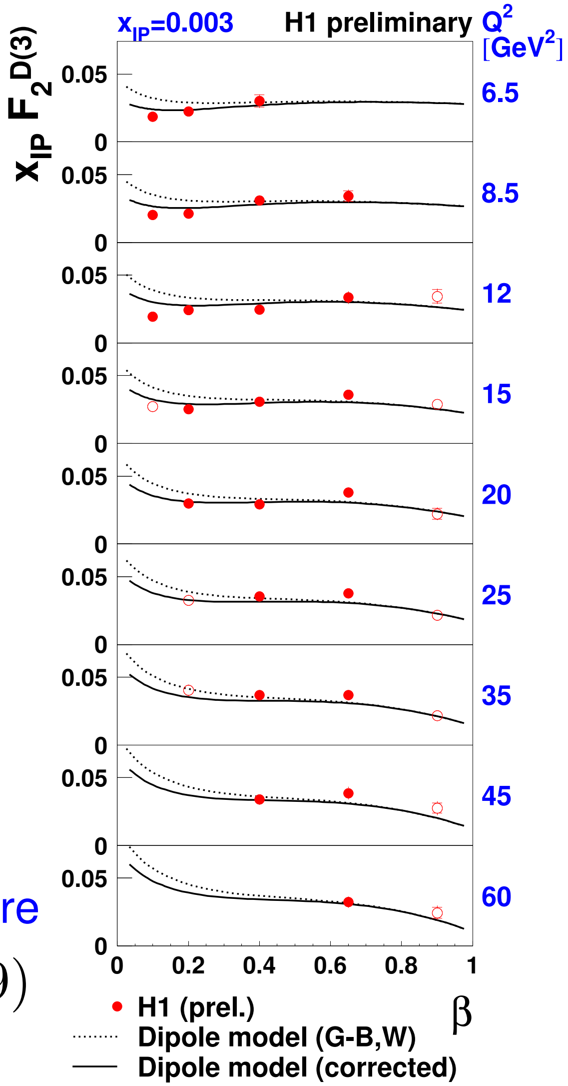
well reproduced

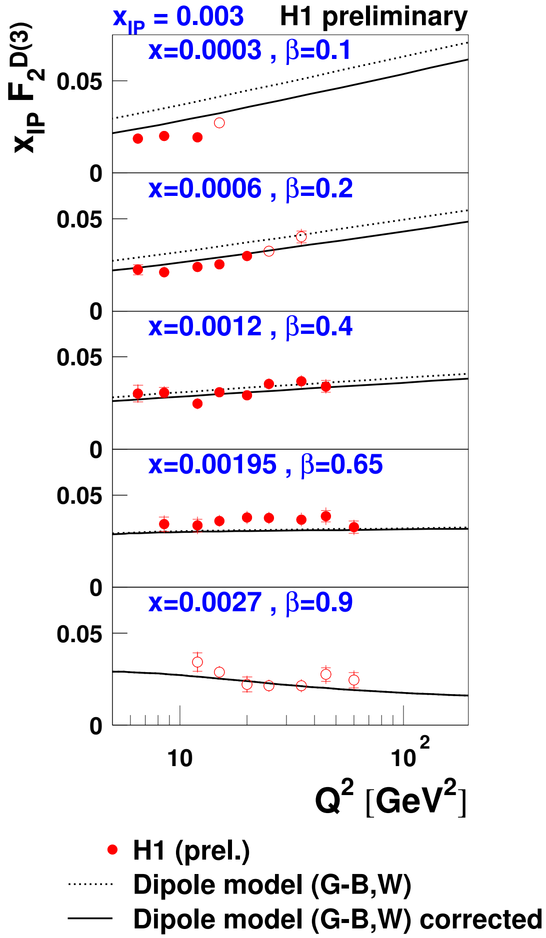
Higher twist at high β

No QCD Evolution included here

Correction - Colour factor $(4/9)$

added for qq̄g





Summary

The Data describing the QCD Structure of Diffractive Interactions has reached high precision

- **FPS and Rapidity Gap methods show good agreement**
- **Data show sensitivity to quark/gluon content of Diffraction**
- **Large gluon density persists out to very high β**
- **Very different QCD structure to the proton !**
- **Suggestion of similar (x, Q^2) dynamics to inclusive DIS at medium β**
- **Colour Dipole Model gives reasonable overall description of data**

More Precision yet to come !