H1 diffractive structure functions measurement from new data

H1 Collaboration

DIS 2006 Tsukuba JAPAN

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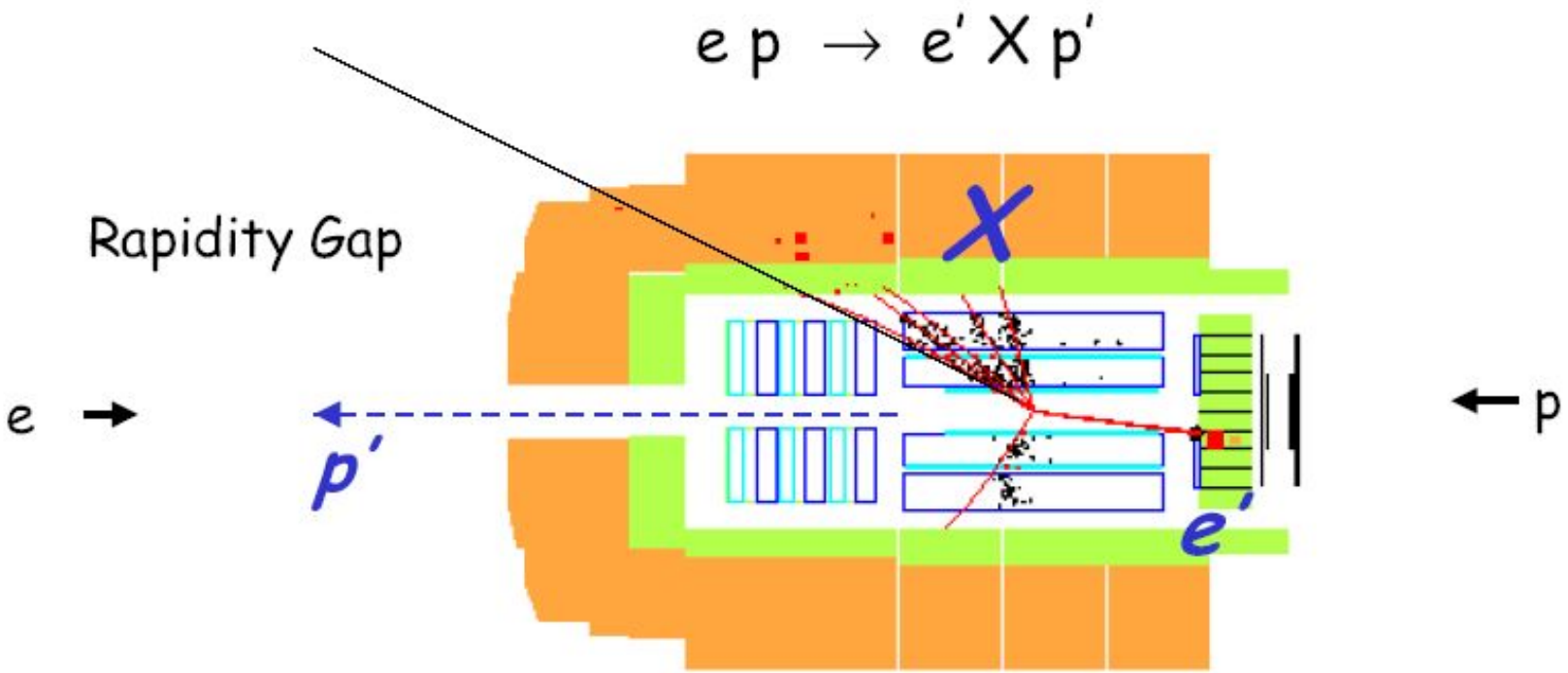
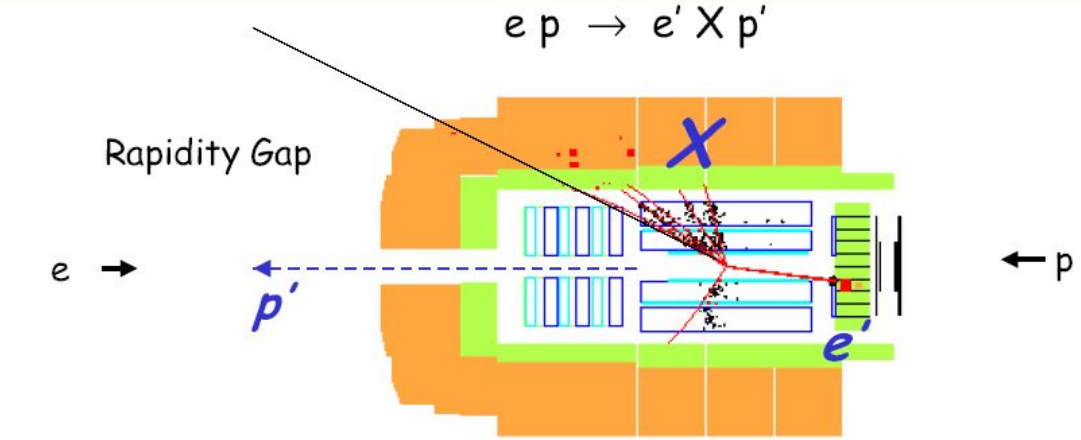
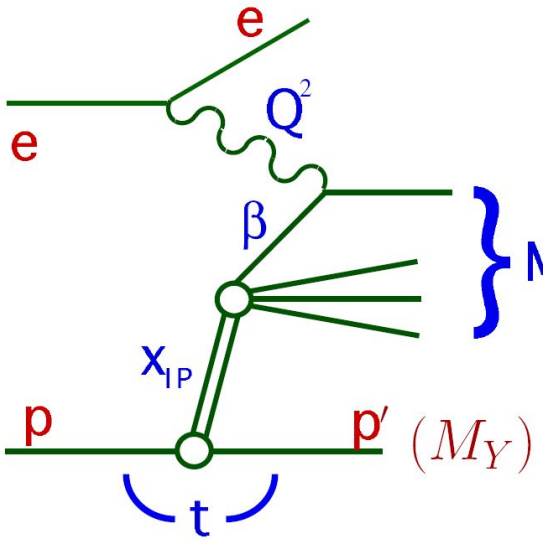


Diffraction at HERA





Invariant mass of the diffractive final state

- Momentum fraction of colour singlet exchange:

$$x_{\mathbb{P}} = \xi = \frac{Q^2 + M_X^2}{Q^2 + W^2}$$

- Fraction of exchange momentum of q coupling to γ^*:

$$\beta = \frac{Q^2}{Q^2 + M_X^2} = \frac{x}{x_{\mathbb{P}}}$$

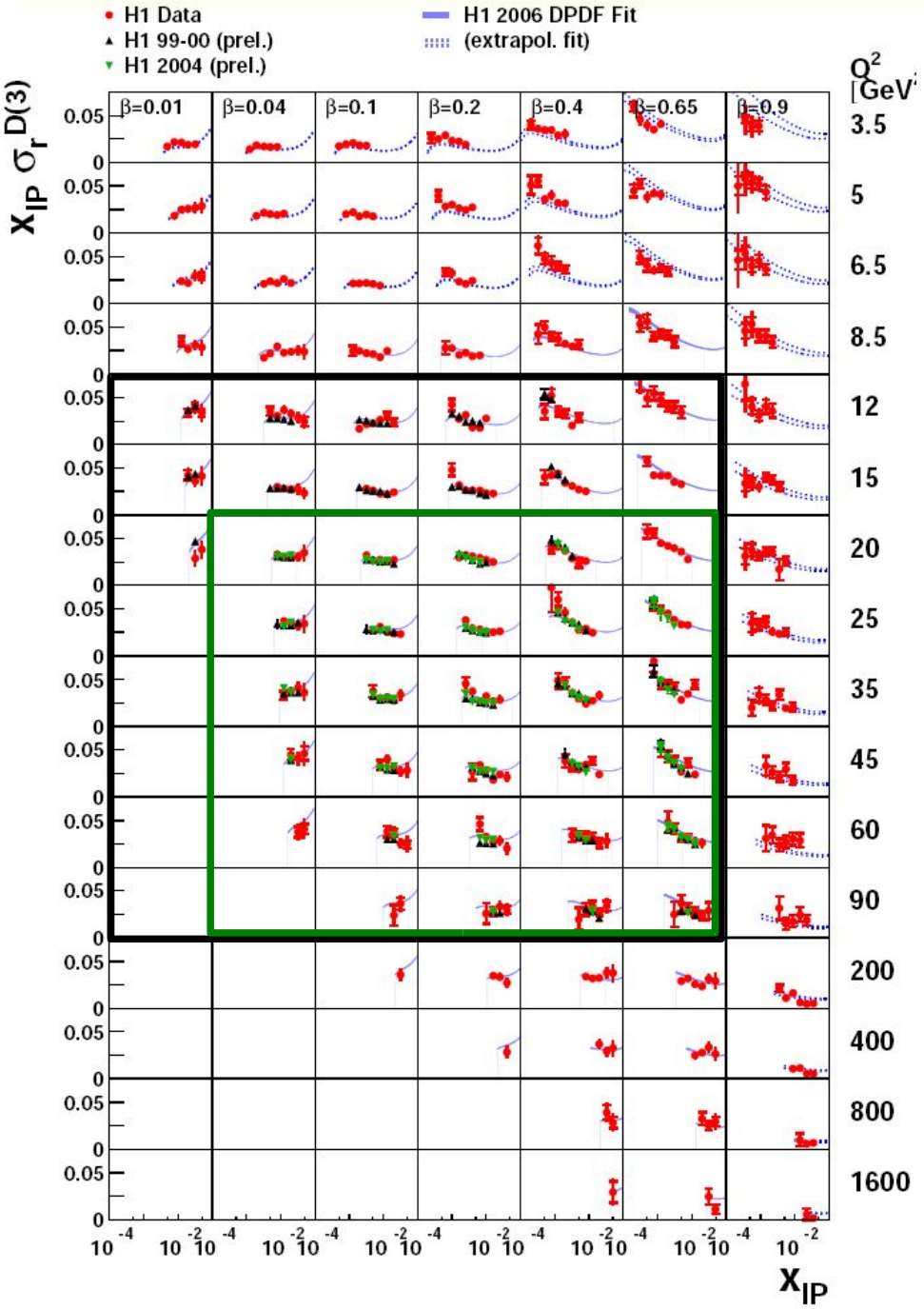
- 4-momentum transfer squared:

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

- Diffractive cross-section (integrated over t):

$$\frac{\mathrm{d}^3\sigma^D}{\mathrm{d}x_{\mathbb{P}}\,\mathrm{d}\beta\,\mathrm{d}Q^2} = \frac{2\pi\alpha_{em}^2}{\beta Q^4}\left(1 - y + \frac{y^2}{2}\right)\sigma_r^{D(3)}(x_{\mathbb{P}}, \beta, Q^2)$$

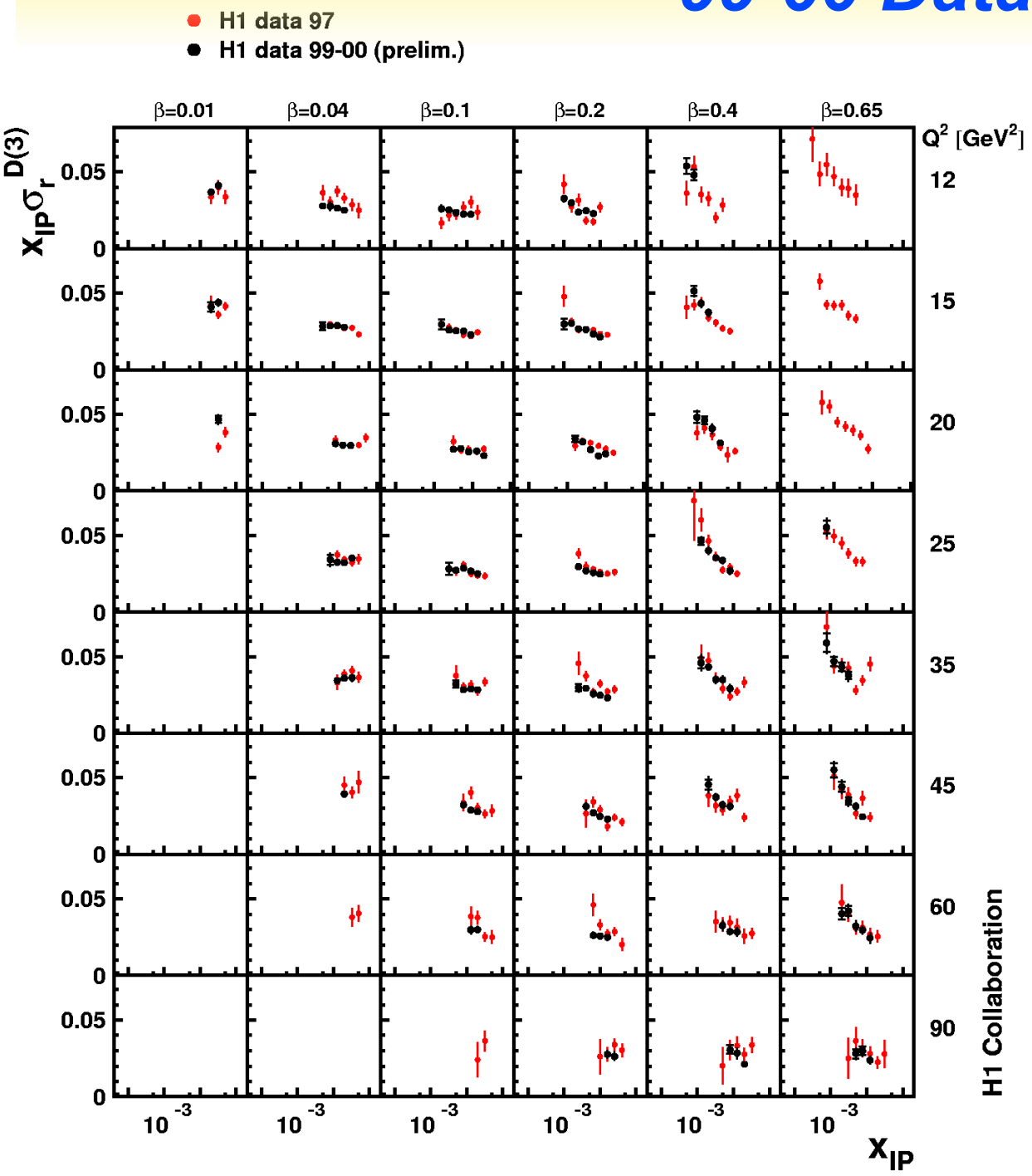
H1 data samples



- H1 measurements use the large rapidity gap method (LRG)
- Defined for $M_Y < 1.6$ GeV, $|t| < 1.0$ GeV^2
- In middle Q^2 region:
  - H1 data 97, 10.5 pb^{-1}
  - New H1 data 99-00, 34 pb^{-1}
  - New H1 data 2004, 34 pb^{-1}

↘ 6 times more statistics

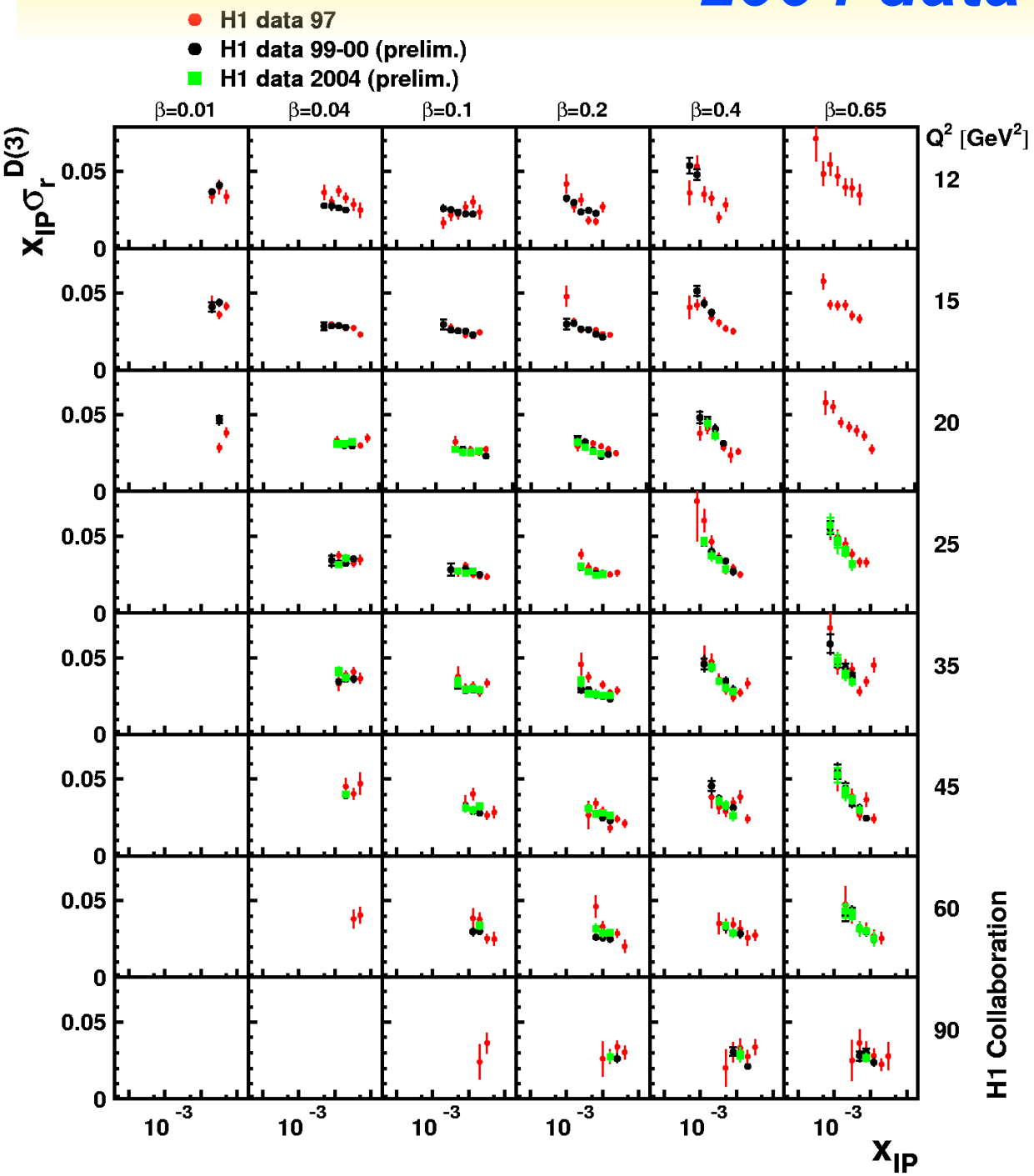
99-00 Data



- In middle Q^2 region: Q^2 = 10-105 GeV^2
- Mx >4 GeV
- LRG: η_{max} <3.2
- No activity above noise in forward detectors
- Correction to M_Y < 1.6 GeV, $|t|$ < 1.0 GeV^2 : 1.09 ± 0.06
  - ➔ Normalisation uncertainty of ~5%

➘ Good agreement between 97 and 99-00 data sets

2004 data



- Analysis of this sample more focused to larger Q^2 (17.5 – 105 GeV^2)
- Correction to M_Y < 1.6 GeV, $|t|$ < 1.0 GeV^2 : 1.18 ± 0.10

  ➔ Normalisation uncertainty of ~8%

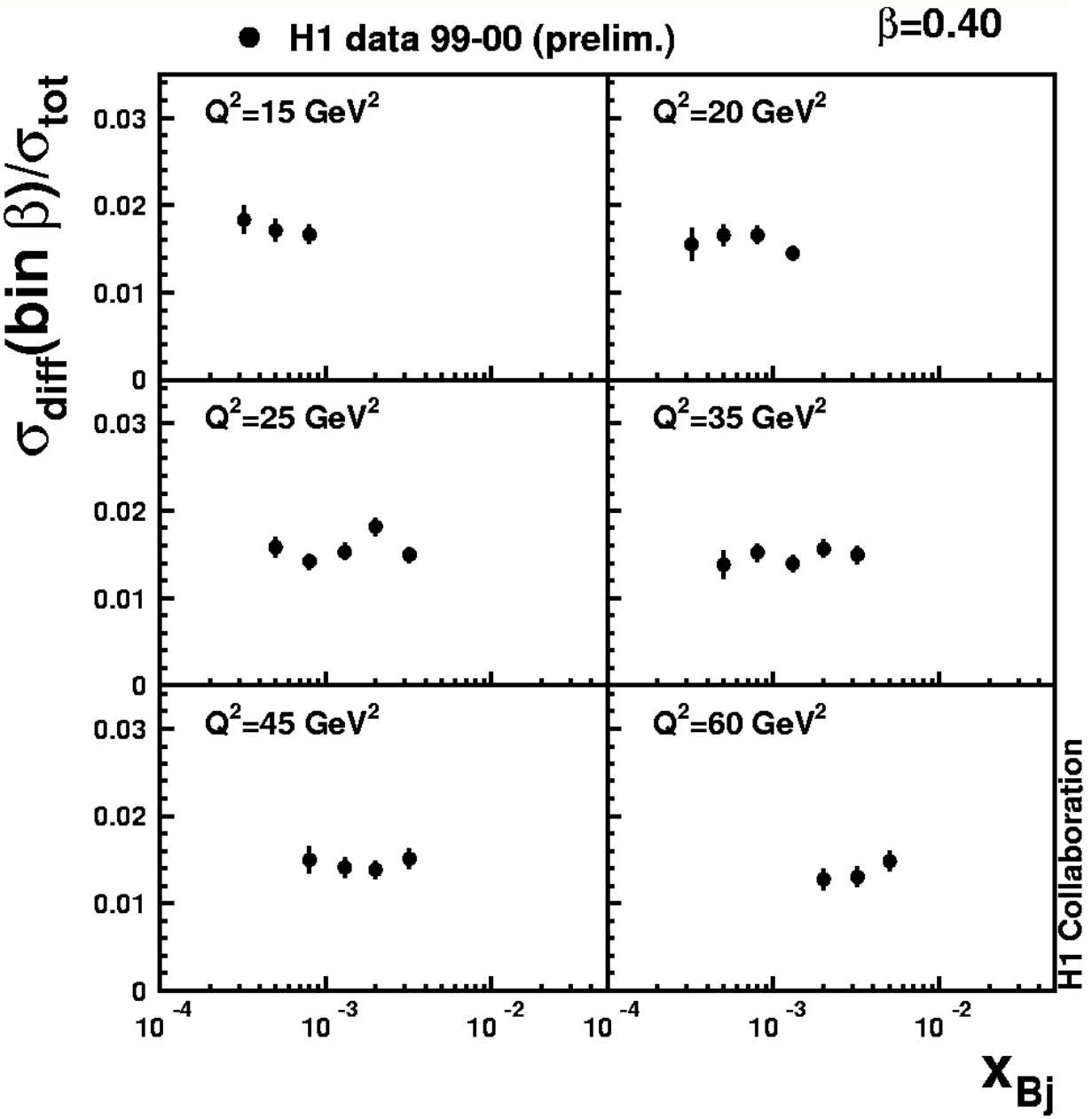
➘ Confirms 97 and 99-00 measurements

Diffractive contribution of the total cross-section

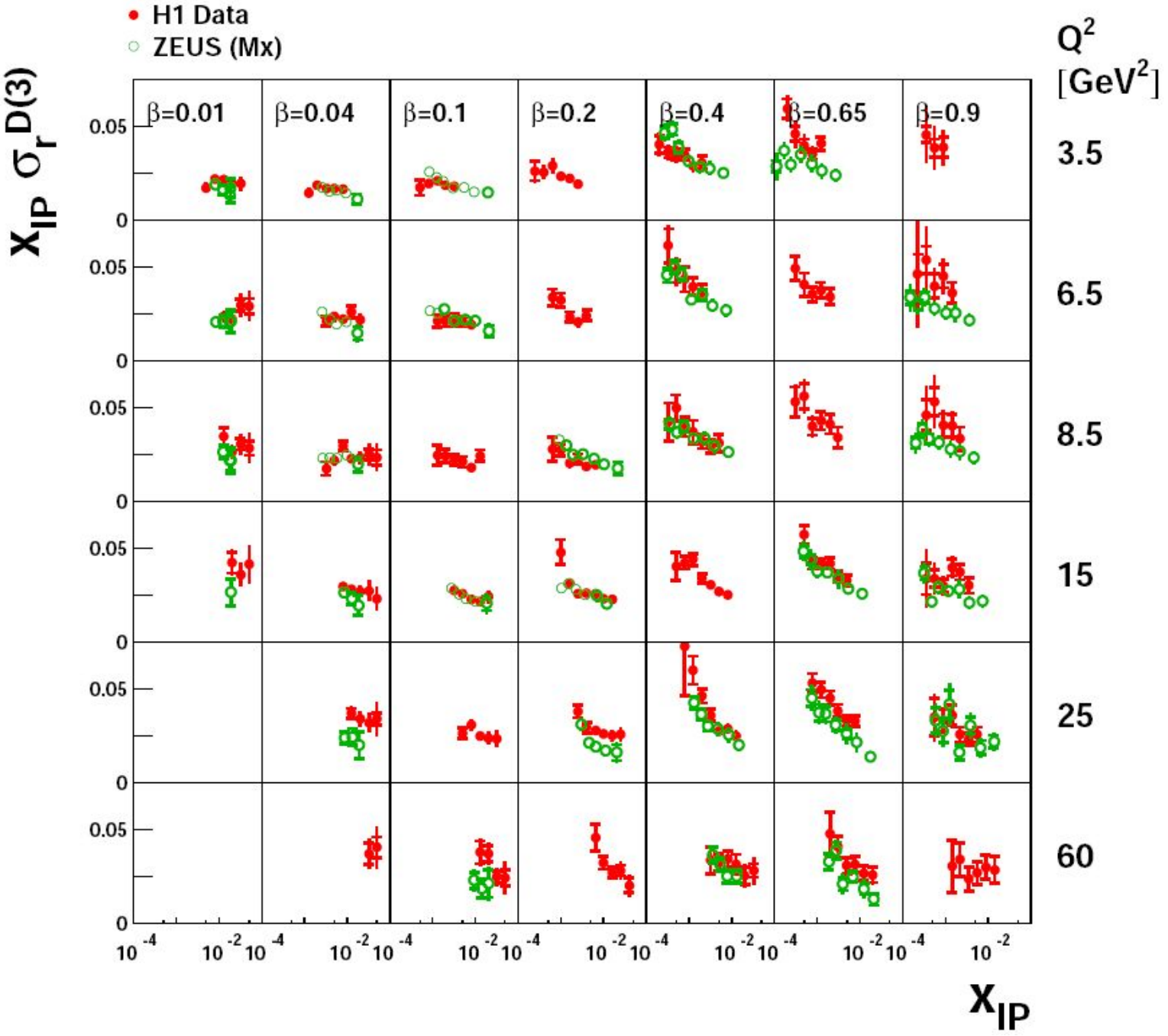
$$\frac{d\sigma^{diff}}{d\beta} = \frac{1}{\beta}\,\frac{4\pi^2\alpha_{em}}{Q^2}\,x_{\mathbb{P}}F_2^D$$

$$\sigma_{tot} = \frac{4\pi^2\alpha_{em}}{Q^2}\,F_2$$

- F_2^D / F_2 ~1-2% in each bin
  - ➔ Integrated over β : F_2^D ~ 10% F_2
  - ➔ Diffraction is a non-negligible fraction of F2
- Similar x dependencies for F_2^D and F_2
  - ➔ A unique factor between F_2^D and F_2 ?



H1 η_{max} method vs ZEUS Mx method

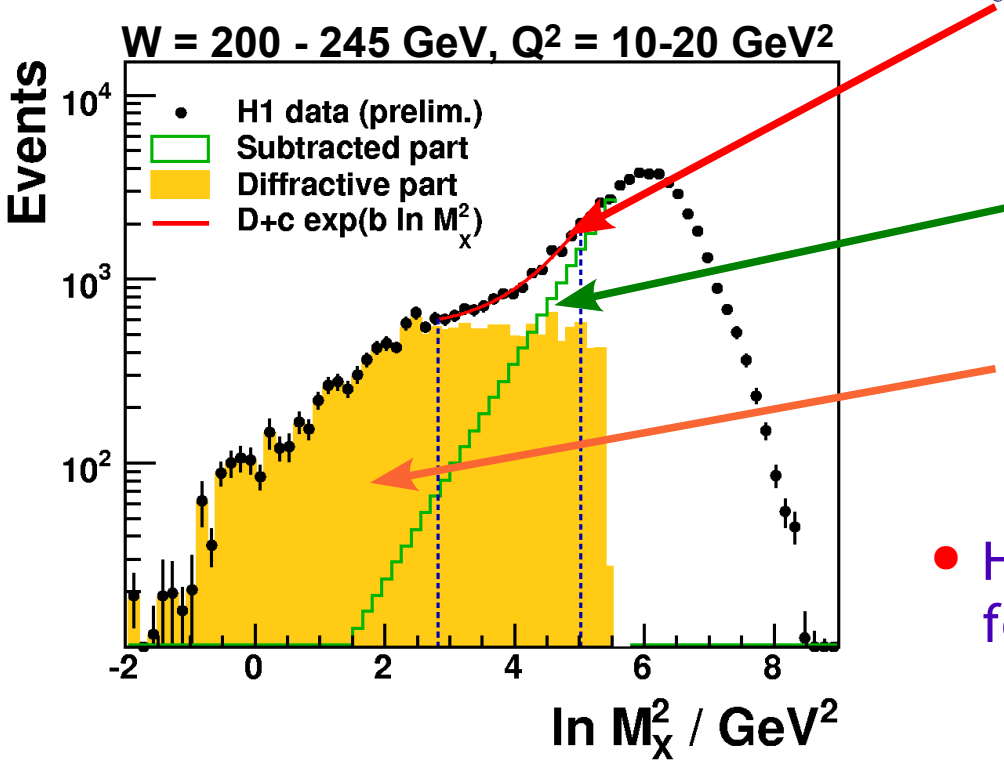


H1 Mx method

- Traditionaly used by ZEUS
  - ➔ Is there systematic differences between Mx and LRG methods ?
  - ➔ Apply Mx method to H1 data in the phase-space of this analysis

- In the Regge approach: different behaviour of ln M_X^2 for DIS and diffractive events

$$\frac{d\sigma^{diff}_{\gamma^* p}}{d\ln M_X^2} \simeq \left(\frac{s}{M_X^2}\right)^{\alpha-1} \simeq constant \ \ (\text{if} \ \ \alpha = 1)$$



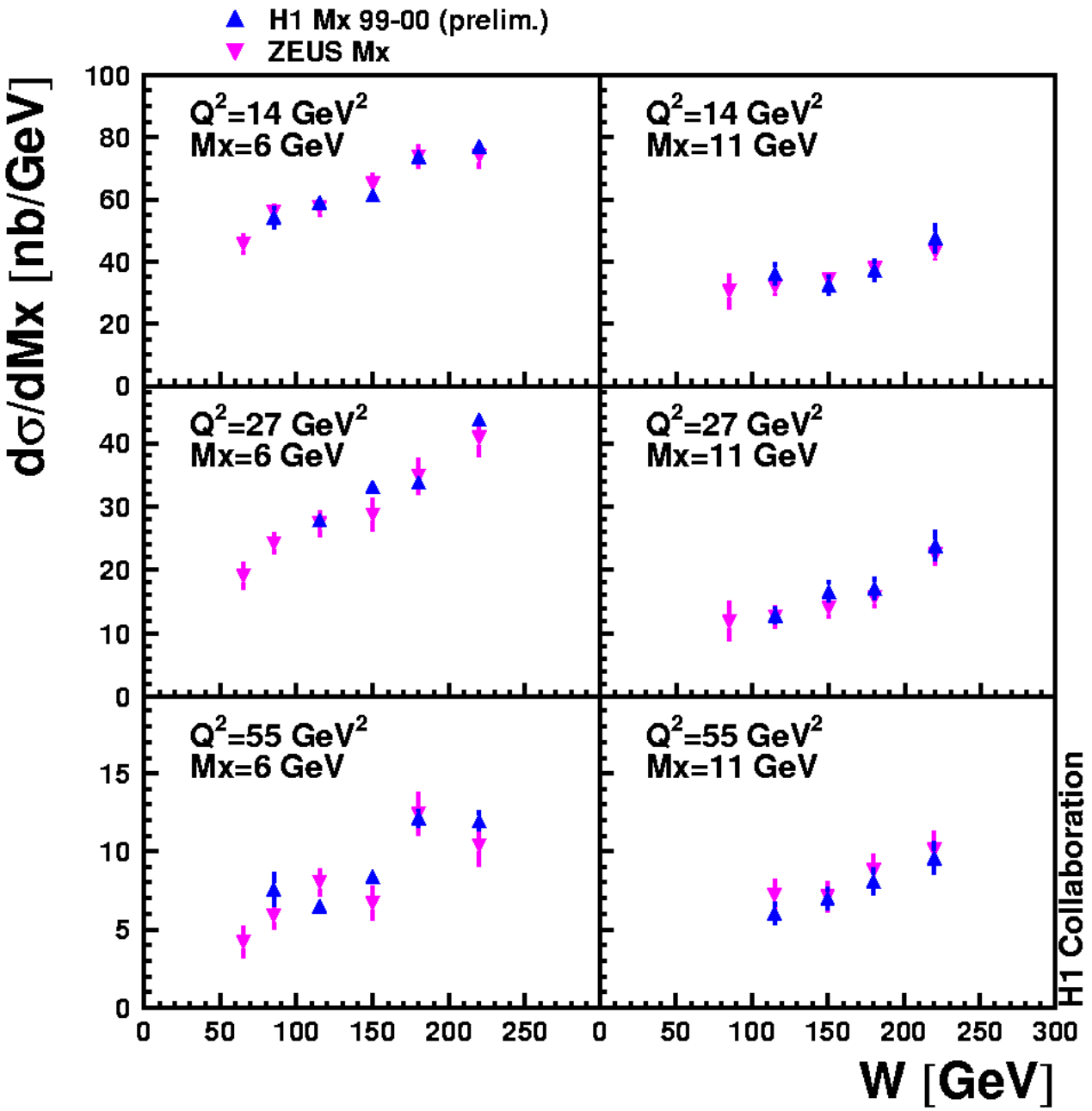
$$dN/d\ln(M_X^2) = D + c\ \exp(b\ln(M_X^2))$$
$$\textbf{for}\ \ln(M_X^2) \leq \ln(W^2) - \eta_0$$

$$N^{non\,diff.} = \int_{\ln(M_a^2)}^{\ln(M_b^2)} c\ \exp(b\ln(M_X^2))\ \ d\ln(M_X^2))$$

$$N^{diff.} = N^{obs.} - N^{non\,diff.}$$

- H1 detector: less acceptance in forward region
  - ➔ Large systematic on b (±15%)

H1 Mx results



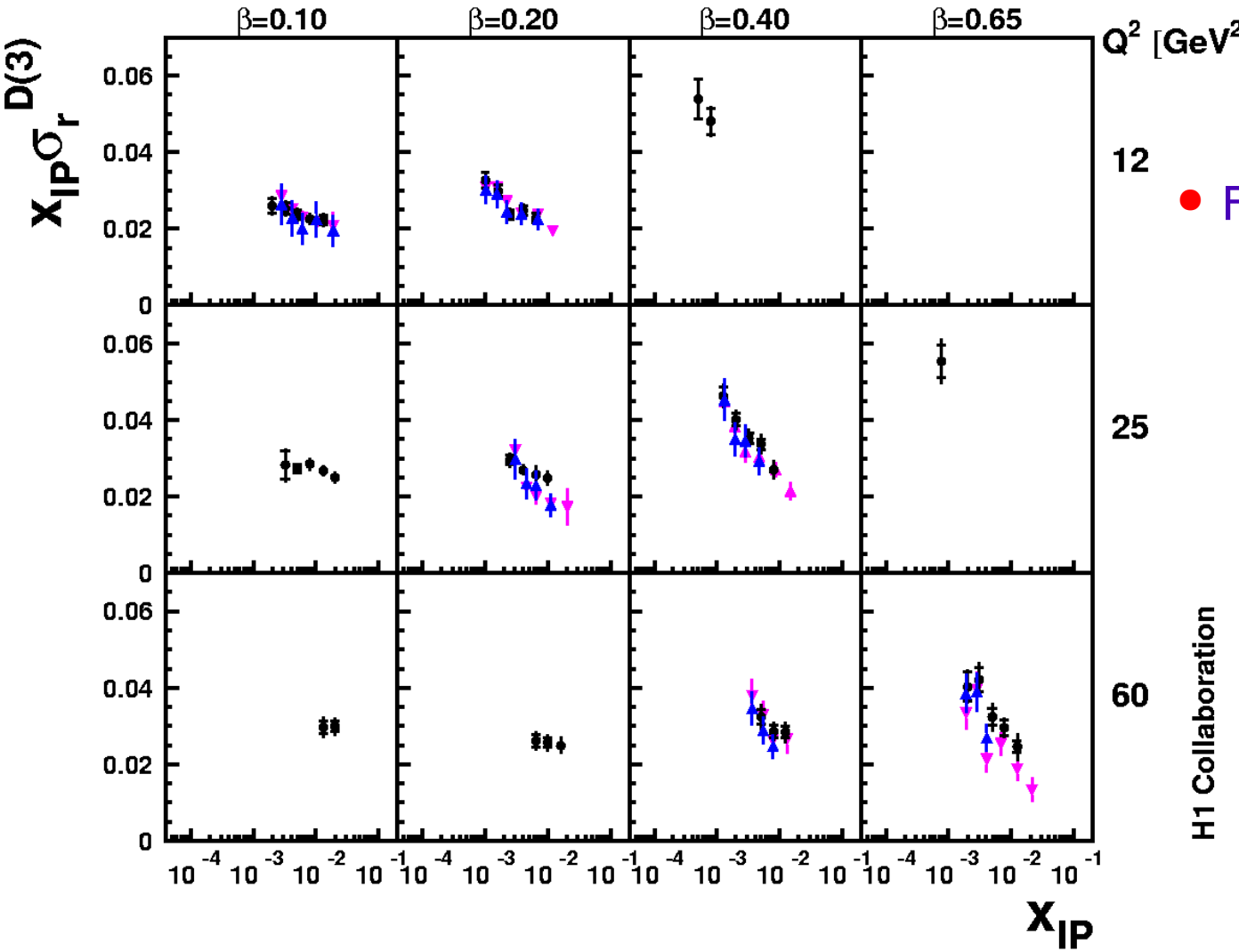
- Differential cross-sections in γ^*p
- Determined in W, Mx and Q^2 bins (similar to ZEUS binning scheme) and for the same M_Y range (< 2.3 GeV)

➔ Relatively good agreement between H1 and ZEUS points

H1 Mx results -II-

- Mx points moved to Q^2, β, x_{IP} bins and normalised to the same M_Y range (M_Y < 1.6 GeV)

→ Measurements at M_Y < 2.3 Gev are normalised by a factor 0.85

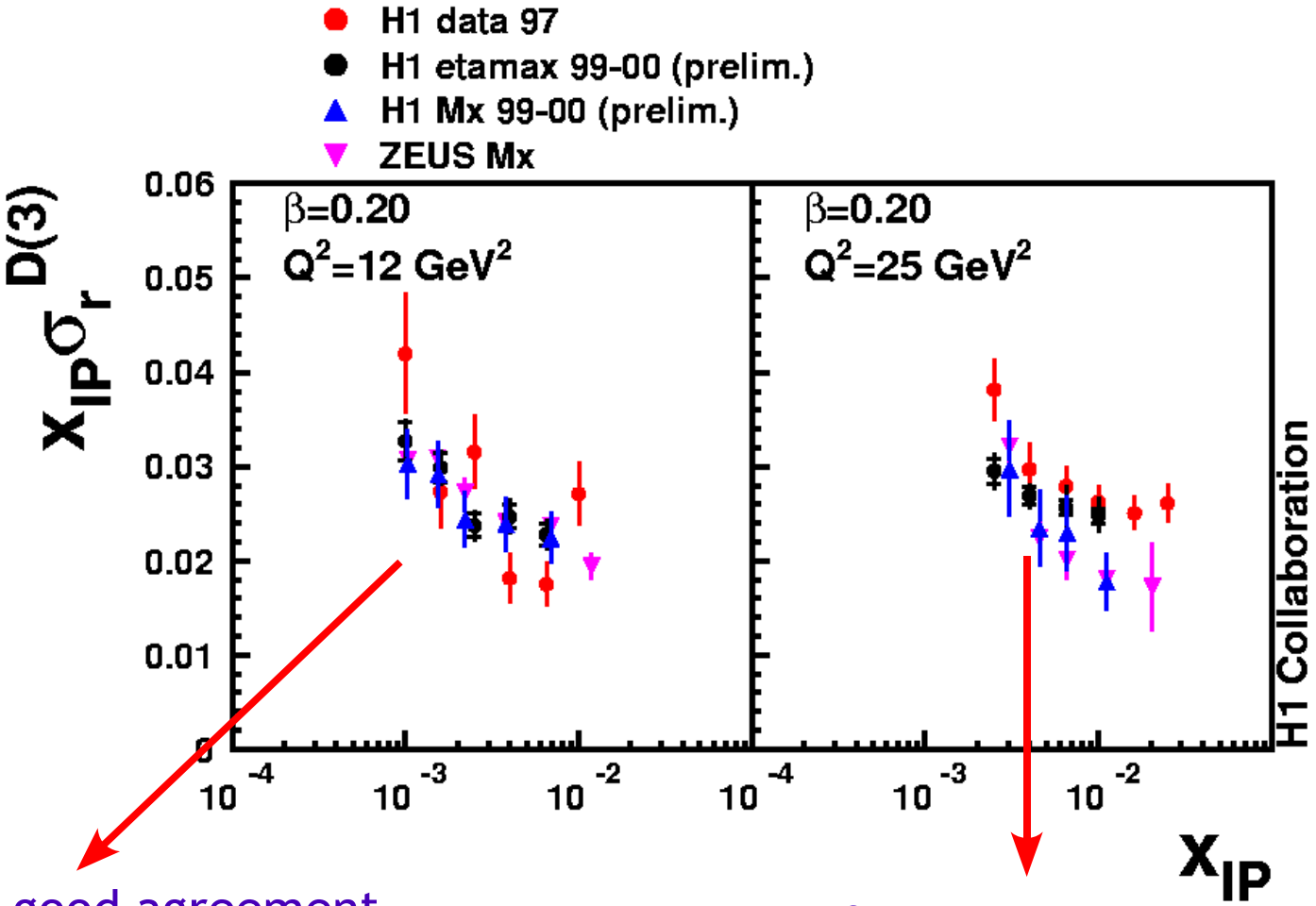


- For H1 data:
  - → η_{max} and Mx points agree well

- In the phase-space of this analysis:
  Mx method equivalent to LRG with η_{max} < 2.5

H1 Mx results (zoomed)

- Compare all data set in two specific bins:



- Bin of good agreement between data sets and methods

- Bin of worst agreement
  - ➔ Large systematics for Mx method
  - ➔ Presence of systematic difference Mx/η_{max} not clear

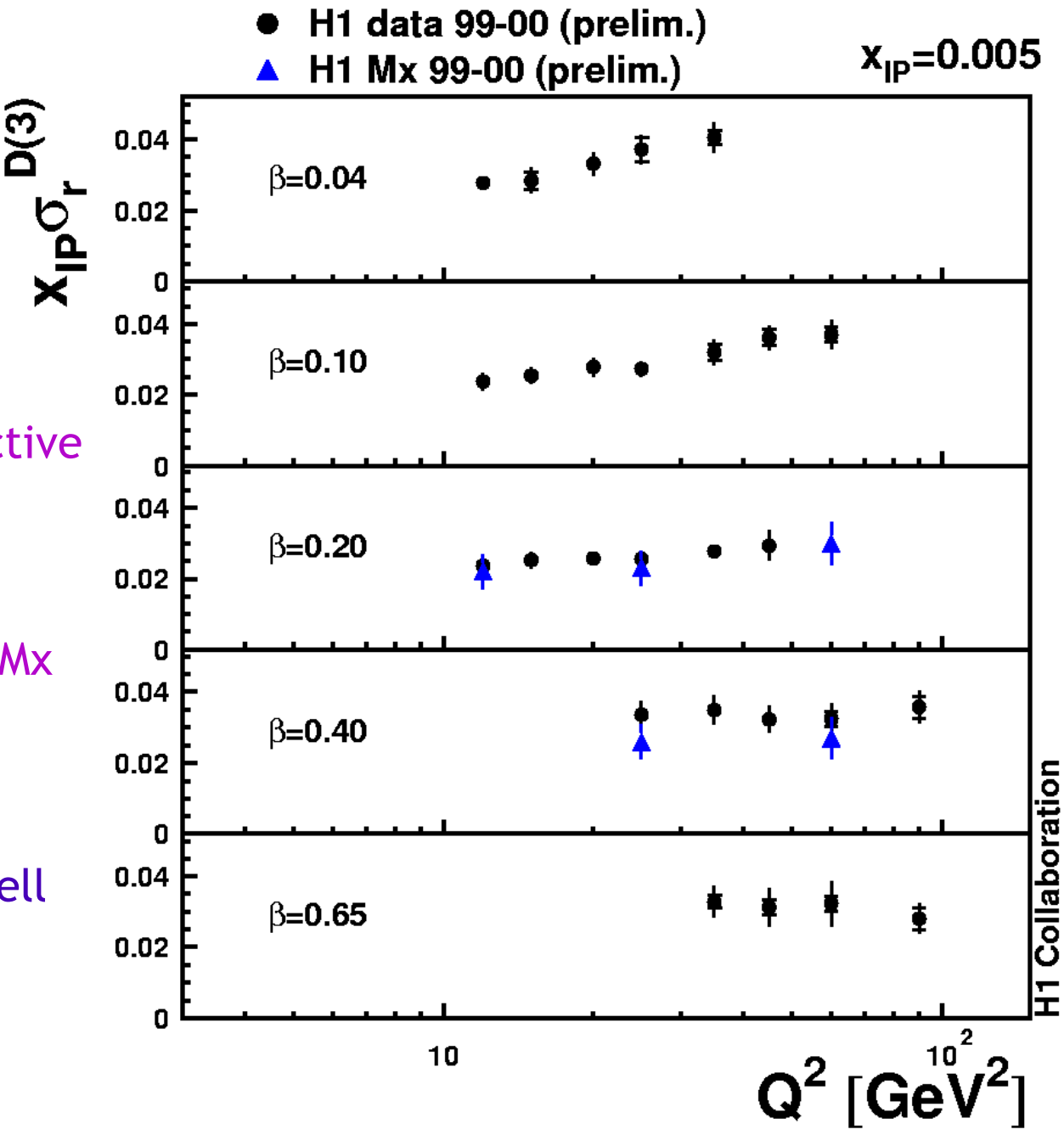
Q^2 dependence and the Mx method

- At x_{IP}=0.005, previous measurements expressed as a function of Q^2 for fixed beta values

➔ Standard behaviour for diffractive scattering

➔ No systematic Q^2-dependent difference observed between Mx and η_{max} methods

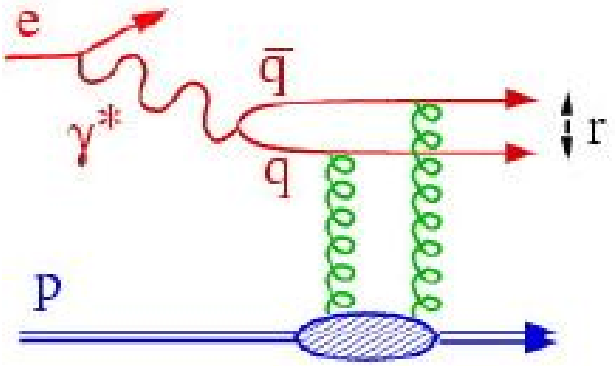
- Few Mx points: method not well adapted to H1 detector ...

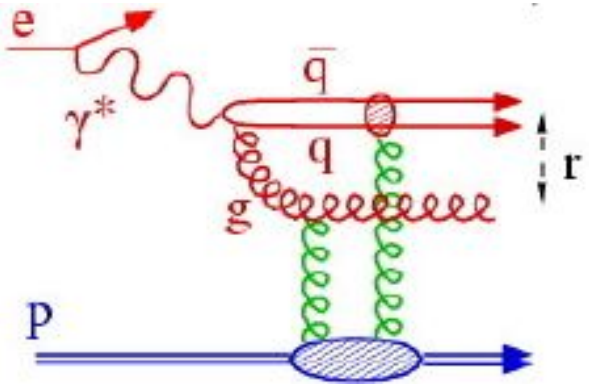


2 gluons exchange model

- LO realisation of the Singlet Exchange
- BEKW parametrisation: **[J. Bartels at al., Eur.Phys.J. C7, 443 (1999)]**
  - ➔ Modified form used **[ZEUS coll., Nucl. Phys. B713 (2005)]**

$$x_{\mathbb{P}} F_2^{D(3)} = c_T \cdot F_{q\bar{q}}^T + c_L \cdot F_{q\bar{q}}^L + c_g \cdot F_{q\bar{q}g}^T$$





- Dominant terms:

$$F_{q\bar{q}}^T \;\alpha\; \beta(1-\beta)$$

↘ At medium β

$$F_{q\bar{q}g}^T \;\alpha\; \log(1+\frac{Q^2}{Q_0^2})\,(1-\beta)^\gamma$$

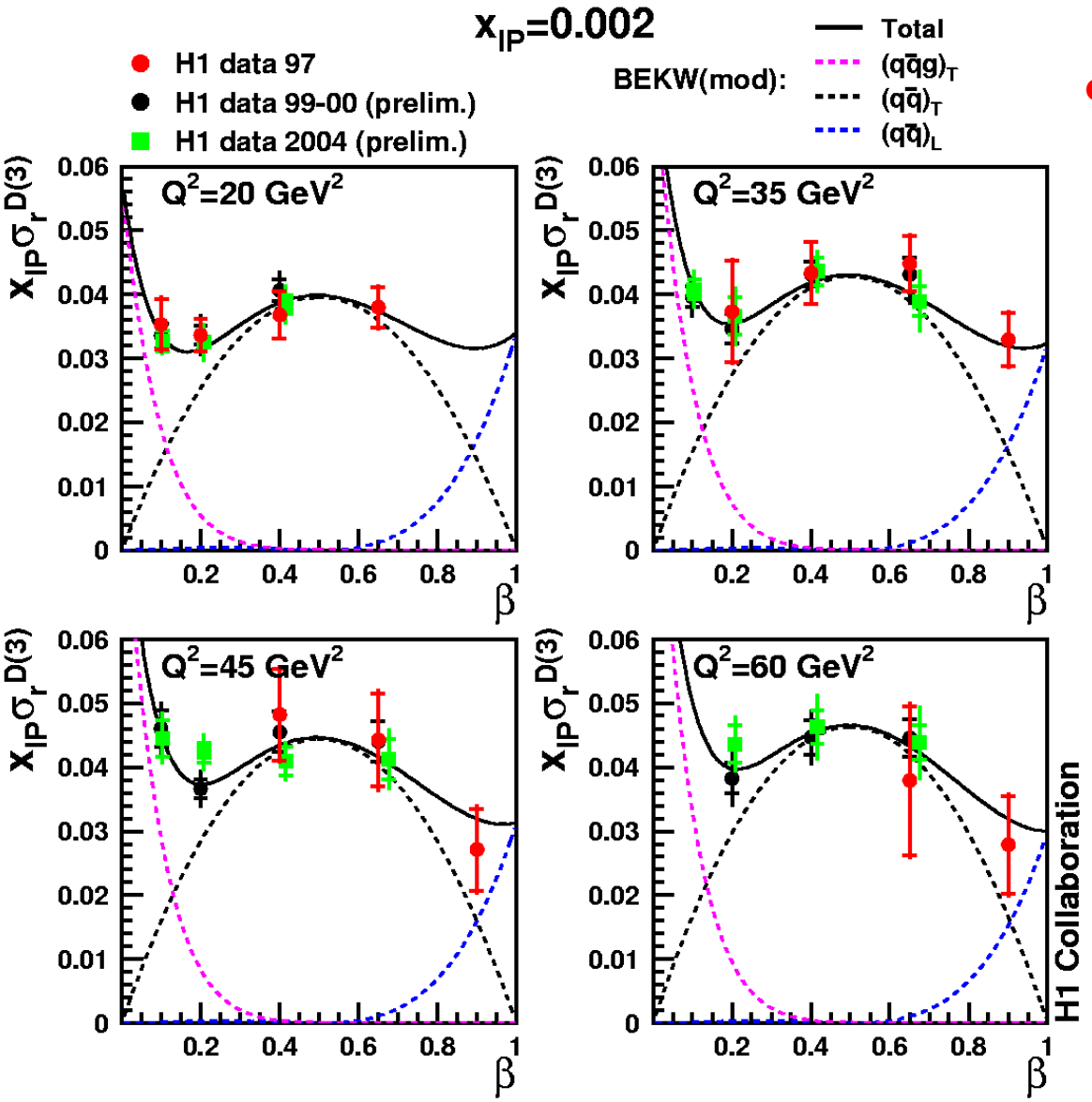
↘ At low β

$$F_{q\bar{q}}^L \;\alpha\; \frac{Q_0^2}{(Q^2+Q_0^2)} \log^2\left(\frac{7}{4}+\frac{Q^2}{4\beta Q_0^2}\right)\beta^3(1-2\beta)^2$$

↘ At large β

↘ Compare to data

BEKW fit result



- Fit all H1 data together: 97, 99-00, 2004
  - ➔ 672 points
  - ➔ χ^2/points = 1.26

↘ Good overall description of data

↘ β decomposition consistent over the full data set

Summary

- Two new data sets provided
  - ➔ 99-00: 34 pb^{-1}, $10 < Q^2 < 105$ GeV^2
  - ➔ 2004: 34 pb^{-1}, $17.5 < Q^2 < 105$ GeV^2
- In agreement with previous 1997 measurements
- Cross-section determined using both LRG and Mx methods
  - ➔ No systematic difference due to the method observed in the phase-space covered by this analysis
- Data compared to the 2-gluon exchange model via a modified BEKW fit
  - ➔ Good description of all data sets obtained

↘ Perspectives: > 100 pb^{-1} at larger Q^2 waiting for analysis …

Additional slides ....

Acceptance correction

- Need to correct the measurement in the range M_Y <1.6 GeV and $|t|$ < 1 GeV^2
- C(MY) correction = 1/A

$$A = [N_{gen}^{el}(\text{Range}) + N_{Rec}^{pdis}(\text{Fwd cuts OK})] / [N_{Gen}^{el+pdis}(M_Y<1.6\ \text{GeV}, |t|<1\ \text{GeV}^2)]$$

- Calculations done requireing a good M_X/M_Y separation

1999-2000 : A=1.09 +/- 0.06 => dA/A ~ 5% normalisation uncertainty on the xs

2004 : A=1.18 +/- 0.10 => 8% normalisation uncertainty on xs