

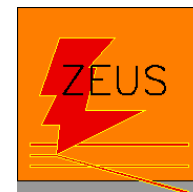
Inclusive diffraction and a measurement of the diffractive longitudinal structure function F_L^D at HERA

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On behalf of the H1 and ZEUS
Collaborations

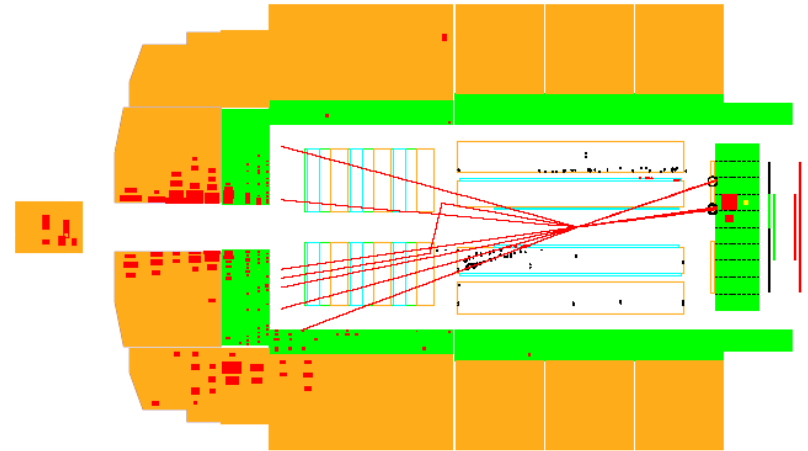
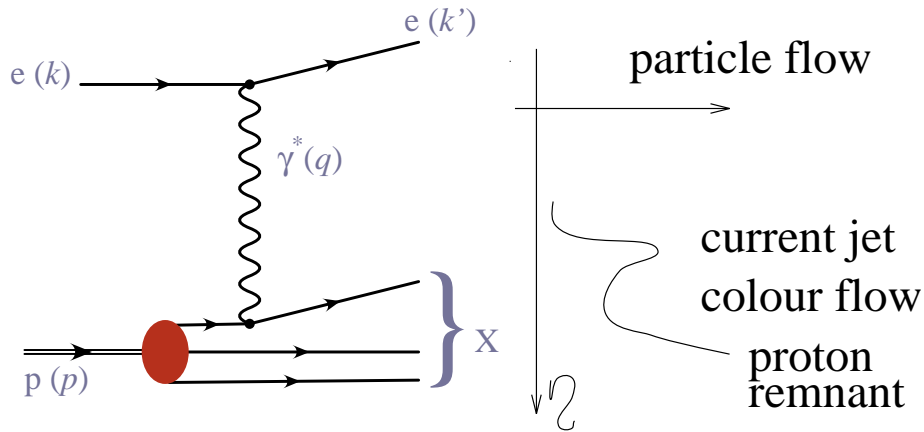


The 2009 Europhysics Conference on High Energy Physics Search

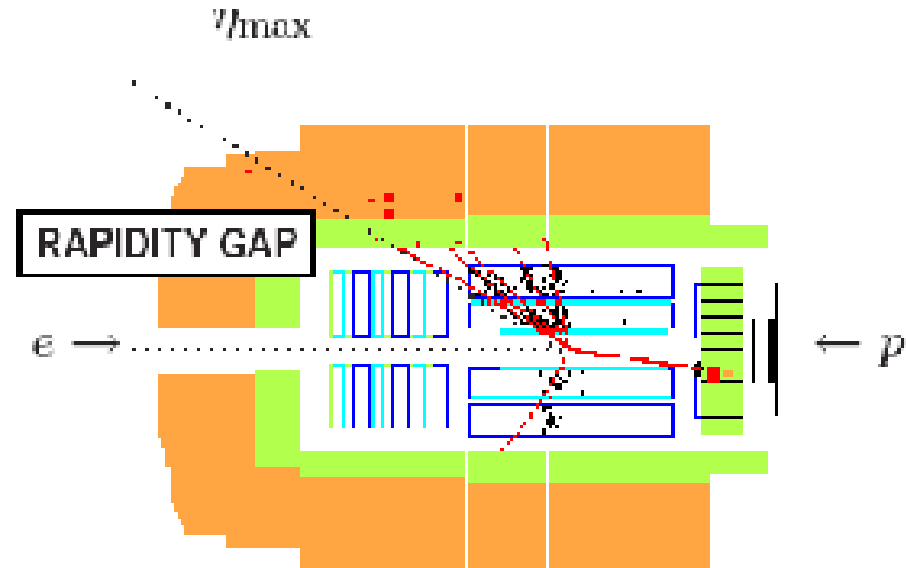
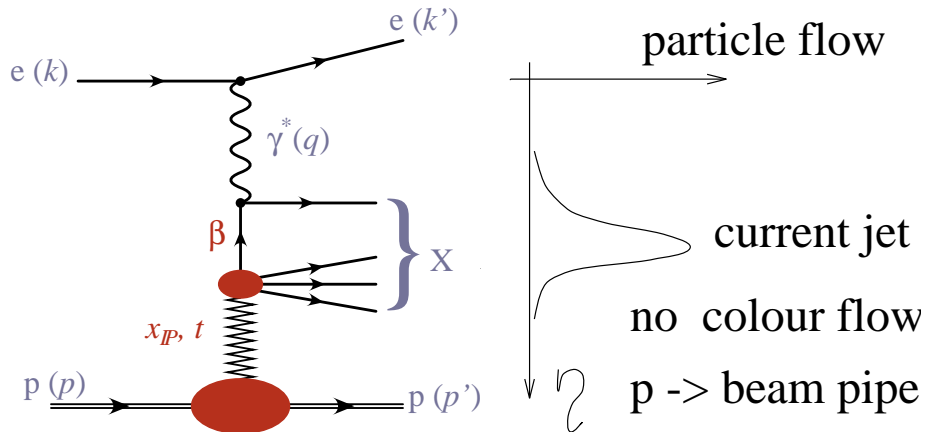
EPS09 - Kraków - 16-22th of July 2009

Diffractive Scattering

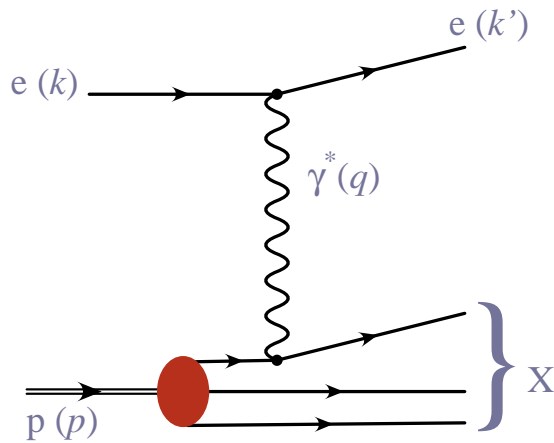
Deep Inelastic Scattering (DIS)



Diffractive Scattering (DDIS)



Cross sections and kinematics



Deep Inelastic Scattering $ep \rightarrow eX$

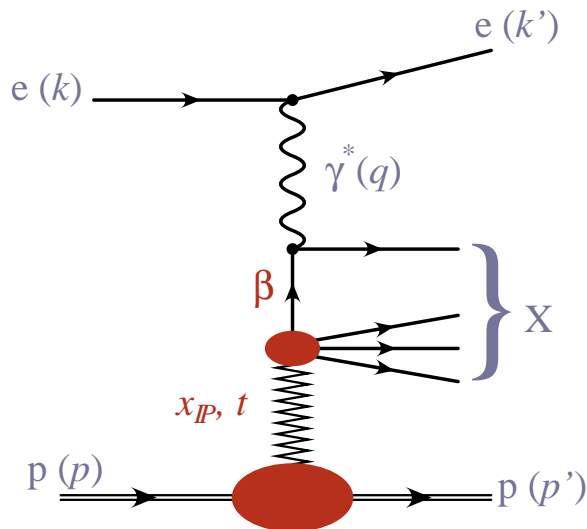
$Q^2 = -q^2$ - virtuality of the exchanged photon

W $\gamma^* - p$ system energy

x Bjorken- x : fraction of proton's momentum carried by the struck quark

y γ^* inelasticity : $y = Q^2 / s x$

$$\frac{d^2\sigma}{dx dQ^2} = \frac{2\pi\alpha^2}{x Q^4} Y_+ F_2(x, Q^2) - \frac{y^2}{Y_+} F_L(x, Q^2) \quad Y_+ = 1 + (1-y)^2$$



Diffractive Scattering $ep \rightarrow eXp$

$x_{\mathbb{P}}$ fraction of proton's momentum of the colour singlet exchange

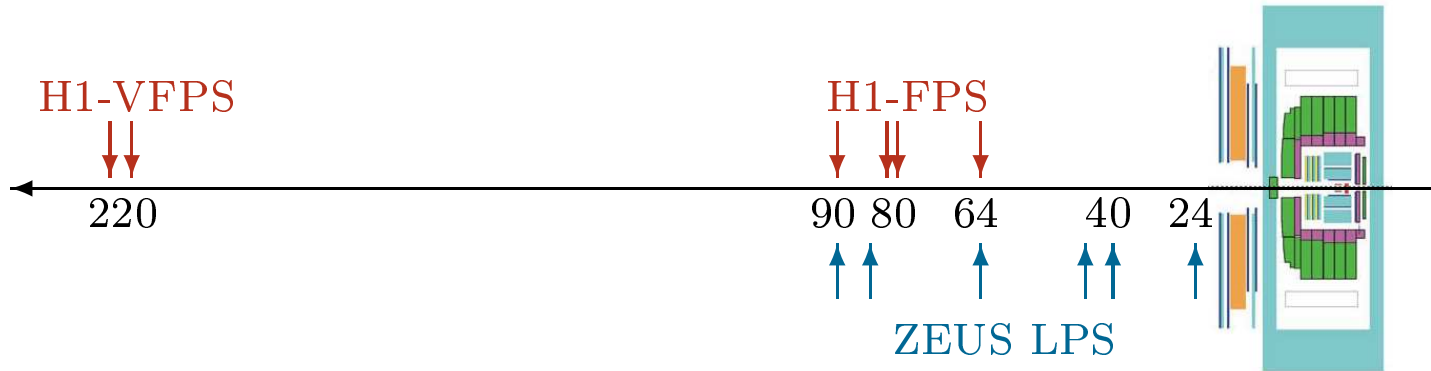
$$x_{\mathbb{P}} \simeq \frac{Q^2 + M_X^2}{Q^2 + W^2}$$

β fraction of \mathbb{P} carried by the quark "seen" by the γ^* $\beta = x/x_{\mathbb{P}}$

$t = (p - p')^2$, 4-momentum squared at the p vertex

$$\frac{d^4\sigma^D}{d\beta dQ^2 dx_{\mathbb{P}} dt} = \frac{2\pi\alpha^2}{\beta Q^4} Y_+ F_2^{D(4)}(\beta, Q^2, x_{\mathbb{P}}, t) - \frac{y^2}{Y_+} F_L^{D(4)}$$

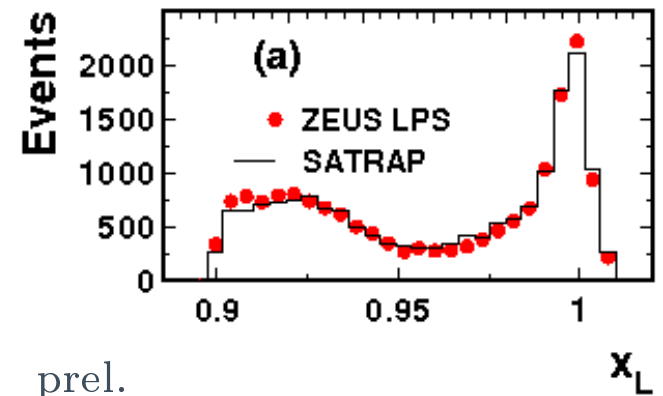
Roman Pot Method



- Purpose: direct measurement of the scattered proton: giving t and $x_{\mathcal{P}}$ measurements
- Roman Pot technology
- no p-diss. background
- low statistics due to Roman Pot detector acceptance

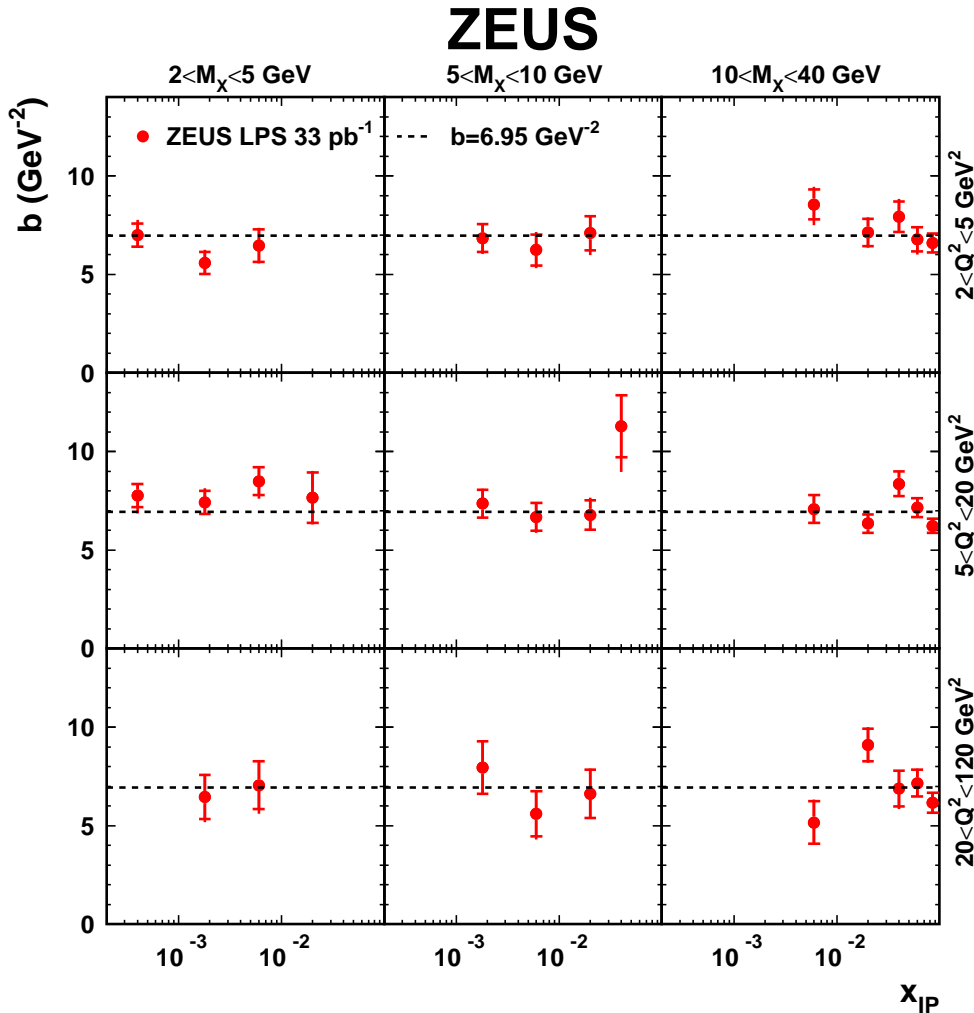
Data shown in this talk:

- New: H1 FPS	$x_{\mathcal{P}} < 0.1$	156 pb^{-1}	HERA II	prel.
- New: ZEUS LPS	$x_{\mathcal{P}} < 0.1$	33 pb^{-1}	HERA I	NPB 816 (2009)



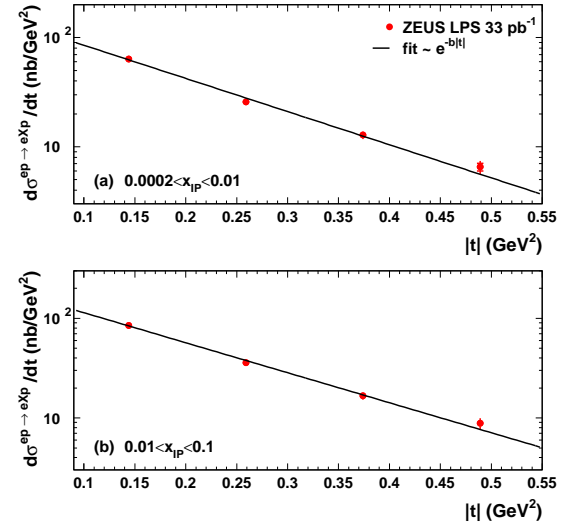
t dependence

ZEUS-LPS data



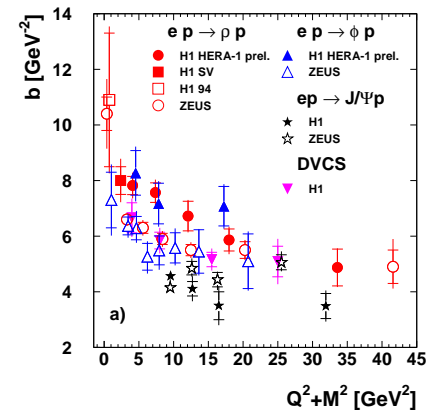
$$\Rightarrow \frac{d^4 \sigma^D}{d\beta dQ^2 dx_{IP} dt} = \frac{d^3 \sigma^D}{d\beta dQ^2 dx_{IP}} e^{-b|t|}$$

ZEUS



- Fit $\frac{d\sigma}{dt} \sim e^{-b|t|} \Rightarrow b = 7.0 \pm 0.4 \text{ GeV}^{-2}$

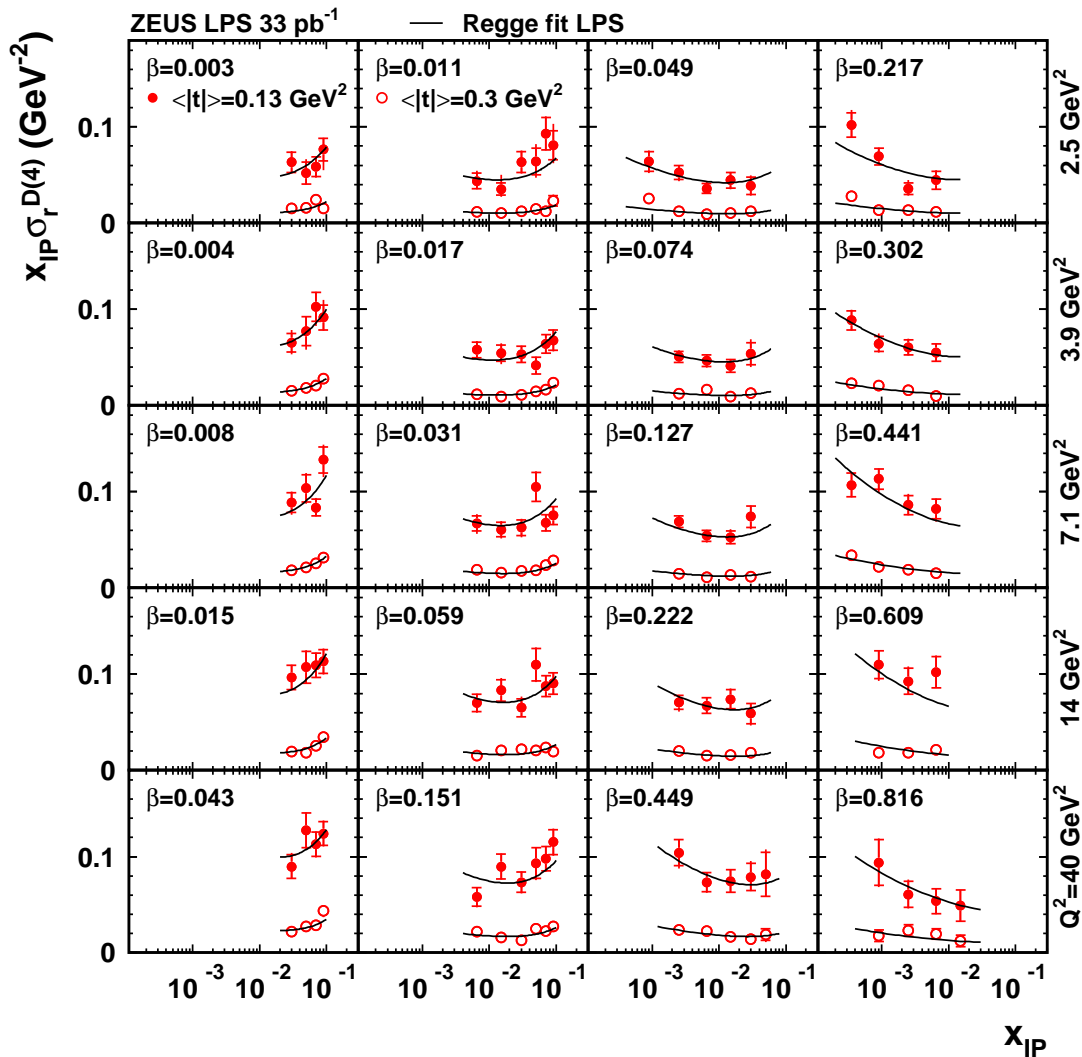
- No dependence observed in: Q^2, x_{IP}, M_X



$x_{\mathbb{P}}$ dependence

$$\sigma^D = \frac{2\pi\alpha^2}{\beta Q^4} Y_+ \sigma_r^D$$

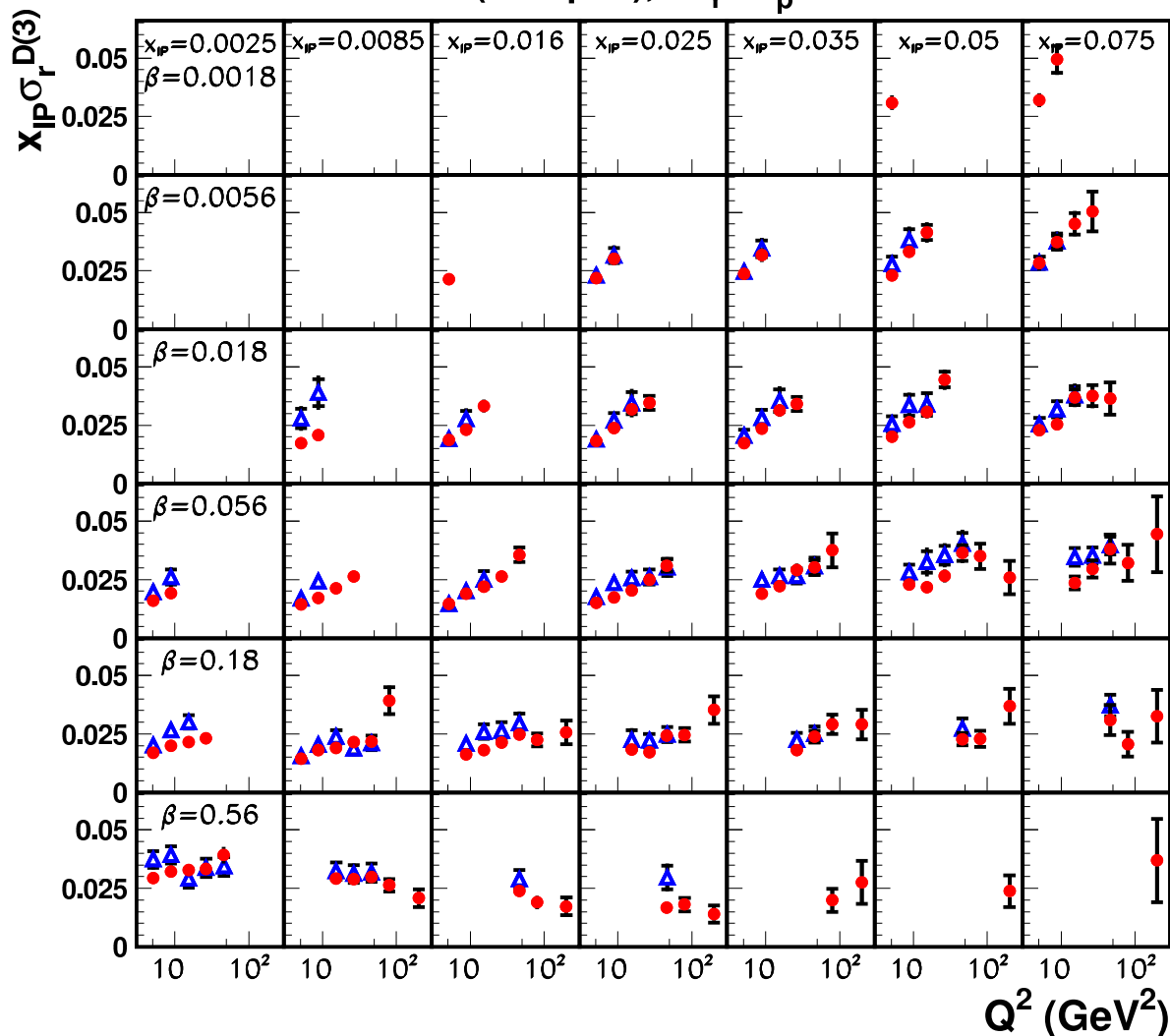
$$\sigma_r^D = F_2^D - \frac{y^2}{Y_+} F_L^D$$



- first measurement in two t bins
- Low $x_{\mathbb{P}}$: σ_r^D falls with $x_{\mathbb{P}}$ faster than $1/x_{\mathbb{P}}$
- High $x_{\mathbb{P}}$: σ_r^D flattens or increases with $x_{\mathbb{P}}$ (Reggeon exchange)
- Same $x_{\mathbb{P}}$ dependence in the two t bins

Q^2 dependence

- H1 FPS HERA-2 (prel.), $M_\gamma=M_p$
- ▲ ZEUS LPS (interpol.), $M_\gamma=M_p$



- after correcting for the photon propagator, the cross section **increases** with Q^2 for $\beta \lesssim 0.2$

- Reasonable agreement between H1-FPS and ZEUS-LPS - cleanest possible comparison in principle...

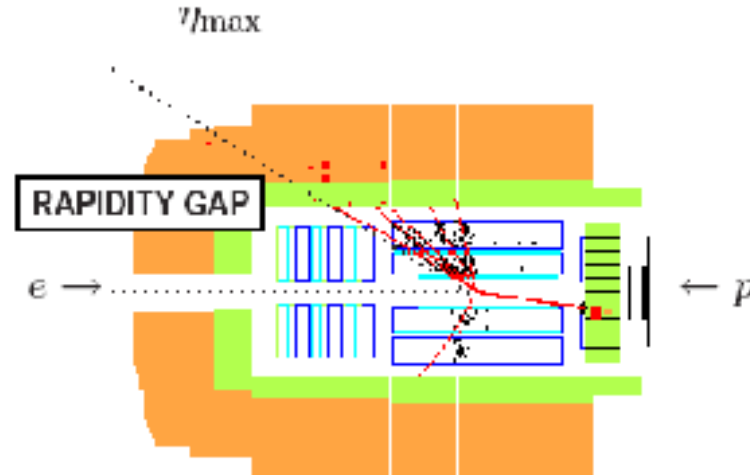
...but **large normalisation uncertainties**:

H1-FPS: $\pm 10\%$

ZEUS-LPS: $+11 - 7\%$

- new H1-FPS (HERA II): reaches higher Q^2

Large Rapidity Gap Method

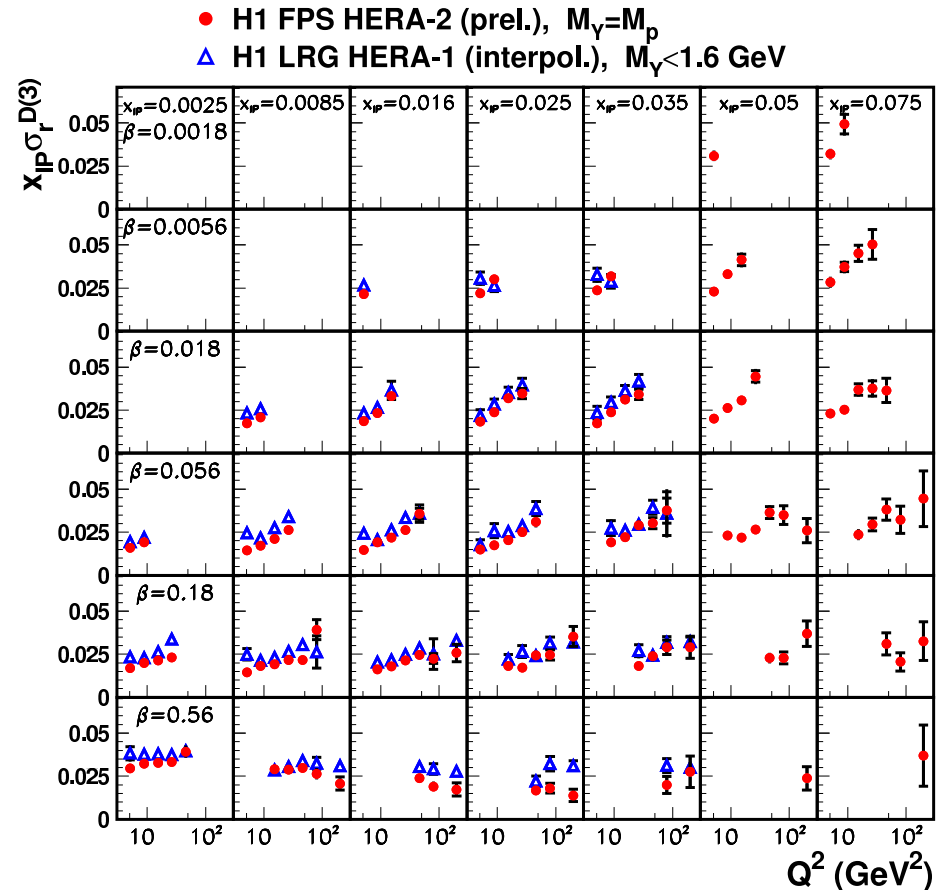
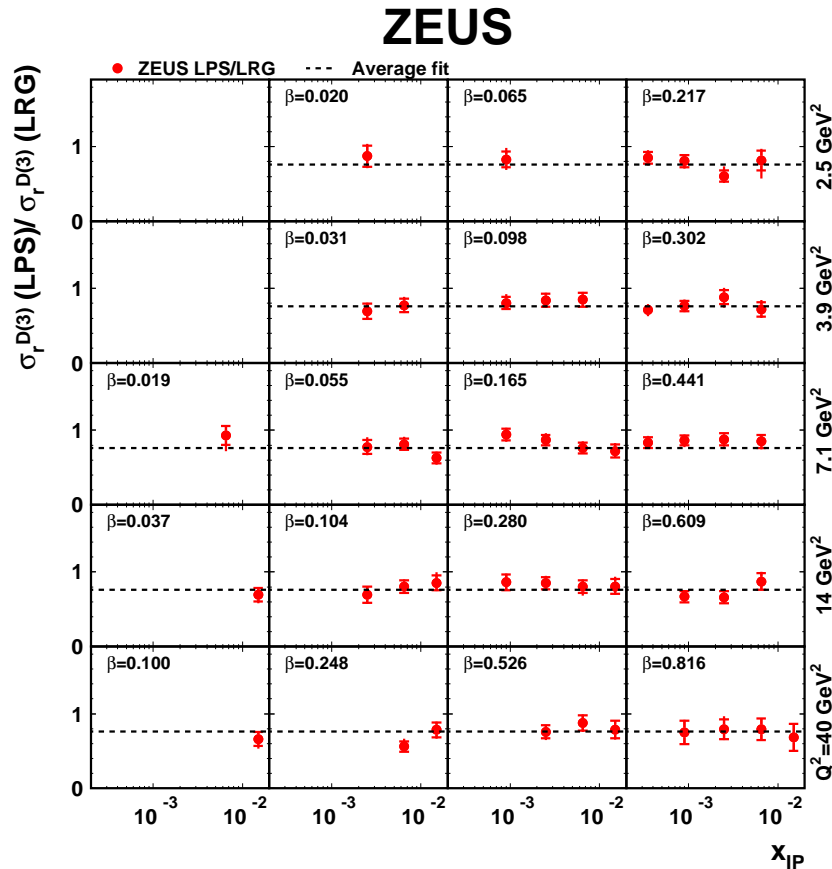


- Require a large rapidity gap adjacent to the outgoing (untagged) proton
- Escaping scattered proton \Rightarrow cross section **integrated over t**
- **Large statistics** (no Roman Pot det. acceptance limitation), **large range** in $Q^2, x_{\mathbb{P}}, \beta$
- Contamination of p-dissociation background: $ep \rightarrow eXY$ with $M_Y \ll W$

Data shown in this talk:

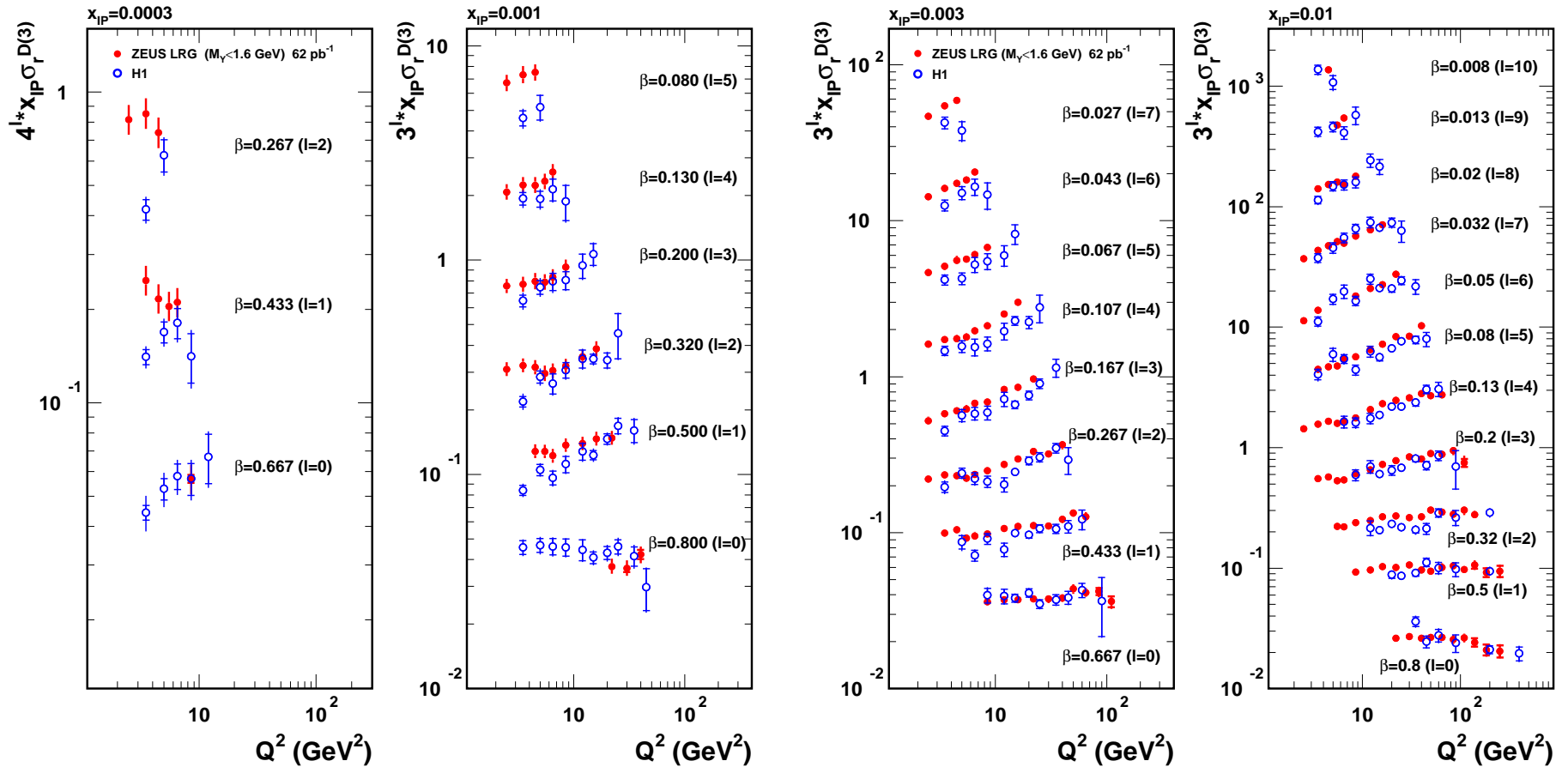
- | | | | | |
|------------------------|-------------------------|-----------------|------------------------------|----------------|
| - New: ZEUS LRG | $x_{\mathbb{P}} < 0.02$ | $M_Y = m_p$ | HERA I - 62 pb ⁻¹ | NPB 816 (2009) |
| - H1 LRG | $x_{\mathbb{P}} < 0.03$ | $M_Y < 1.6$ GeV | HERA I - 62 pb ⁻¹ | EPJ C48 (2006) |

LRG vs Roman Pots



- ZEUS LPS/LRG: independent of Q^2 , x_{IP} , β
 \Rightarrow p-diss. = 24 ± 1 (stat) + 2 – 3(syst) + 5 – 8(norm)%
- H1-FPS vs H1-LRG: Reasonable agreement in shape
 normalisation difference due to different M_Y cut (normalisation uncertainty of 8.5%).

LRG: H1 / ZEUS



- remaining normalisation difference of 13% (global fit) covered by uncertainty on p-diss. correction (8%) and relative normalisation uncertainty (7%)

- **Shape agreement ok** except at low Q^2

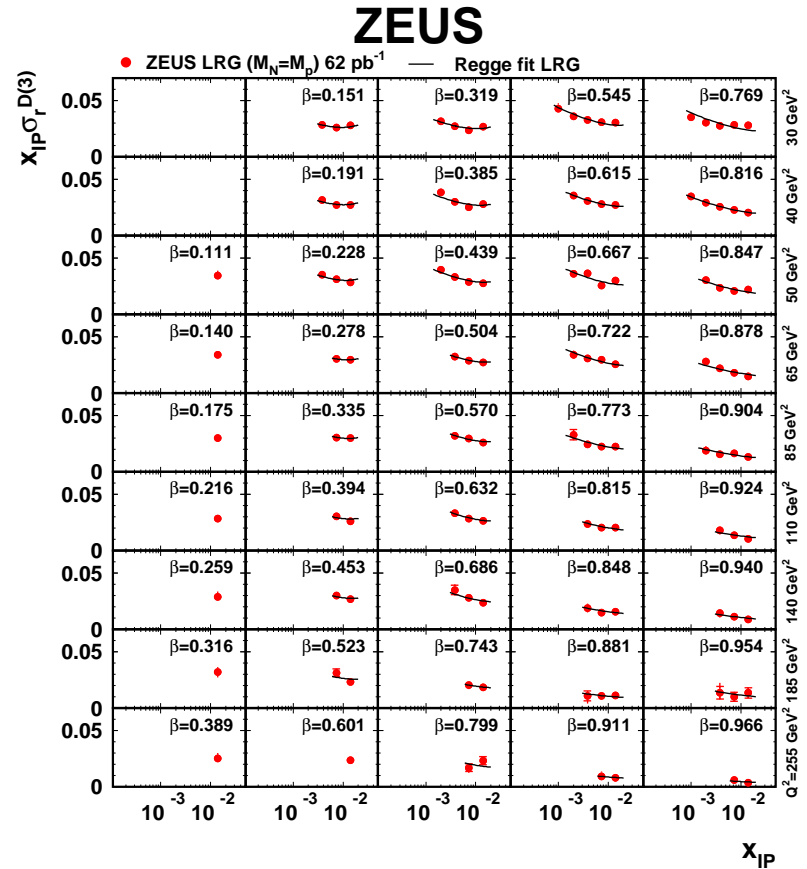
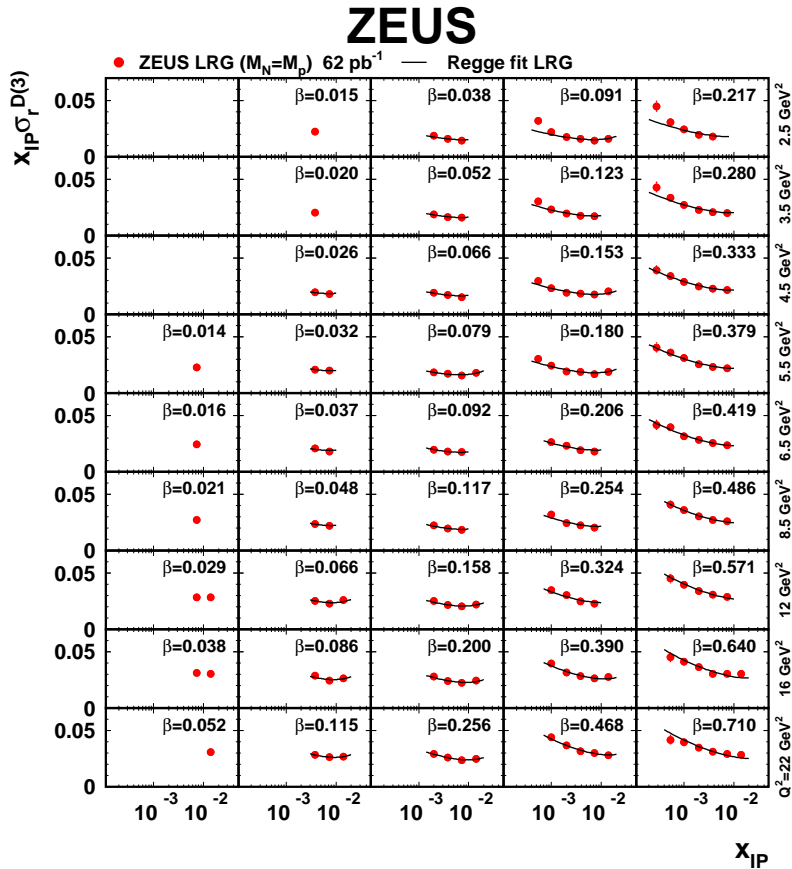
- note: here ZEUS points corrected to $M_Y < 1.6$ GeV.

- **QCD** fit on these data → see next talk (Alberto Garfagnini).

Regge Fit to LRG data

$$F_2^{D(4)}(\beta, Q^2, x_P, t) = f_{P/p}(x_P, t) F_2^P(\beta, Q^2) + n_R f_{R/p}(x_P, t) F_2^R(\beta, Q^2)$$

$$f_{P,R/p}(x_P, t) = e^{bt}/x_P^{2\alpha(t)-1} \quad \alpha(t) = \alpha(0) + \alpha' t$$

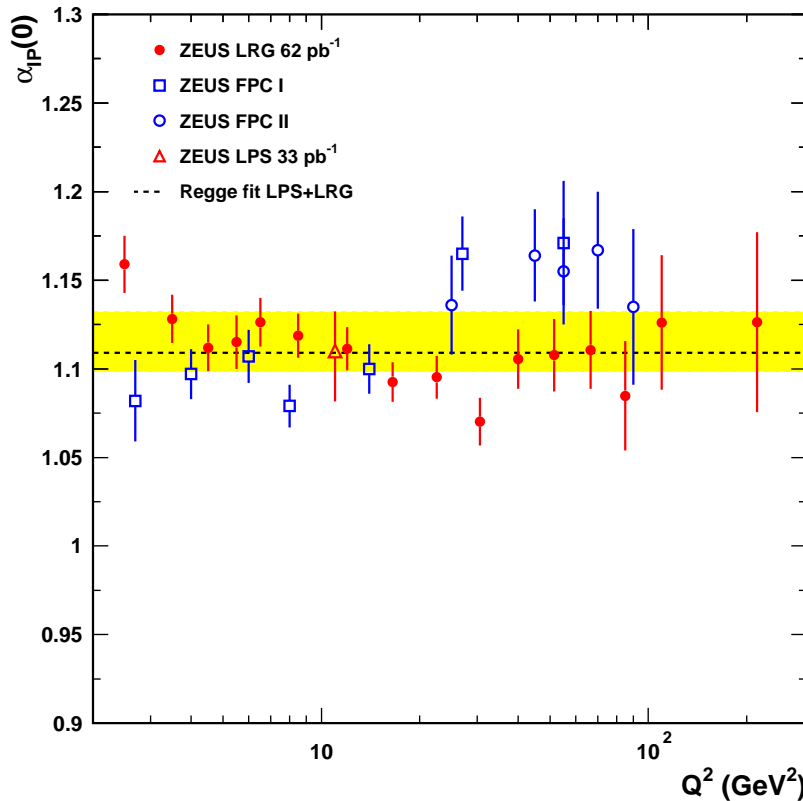


- Assuming that the Regge factorisation holds :
 $\alpha_P(0) = 1.108 \pm 0.008(\text{stat+syst}) + 0.022 - 0.007(\text{model})$

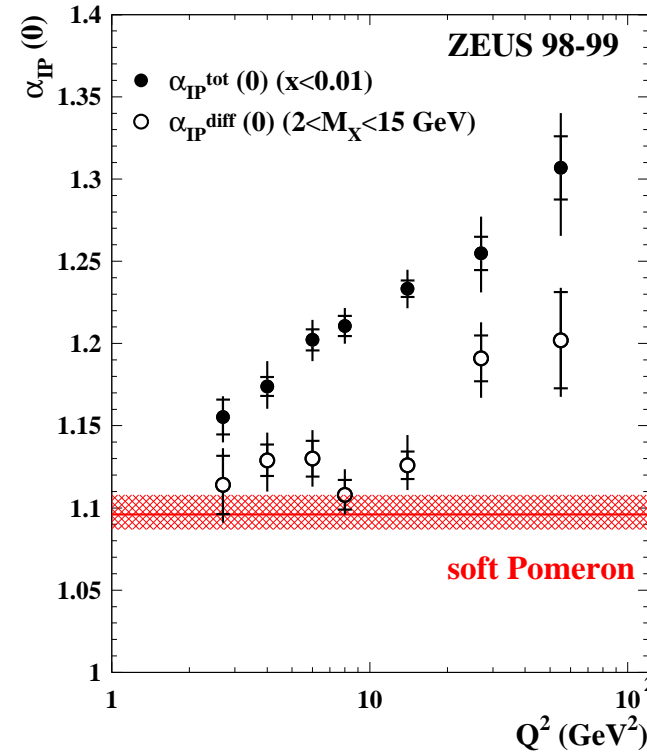
Pomeron intercept

Applying the Regge fit in different Q^2 bins:

ZEUS



ZEUS

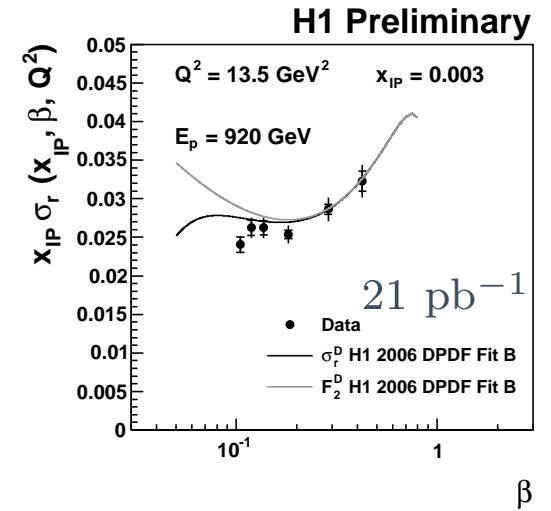
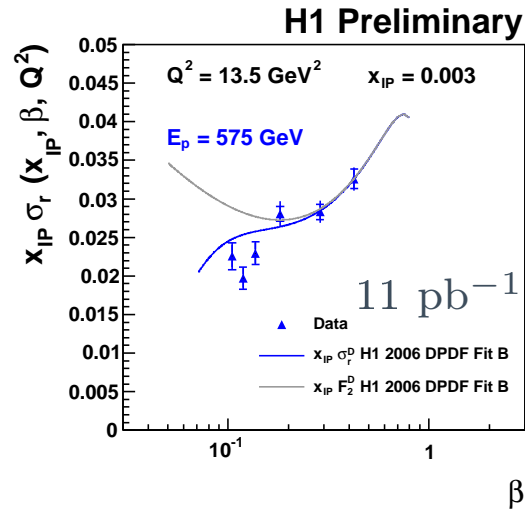
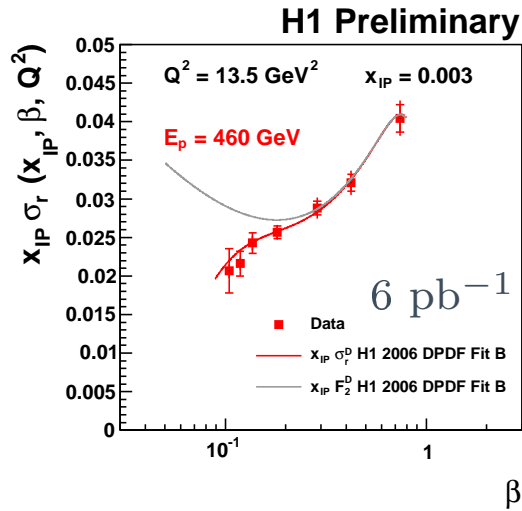


- confirms with higher precision the lack of strong Q^2 dependence in contrast to non-diffractive DIS.

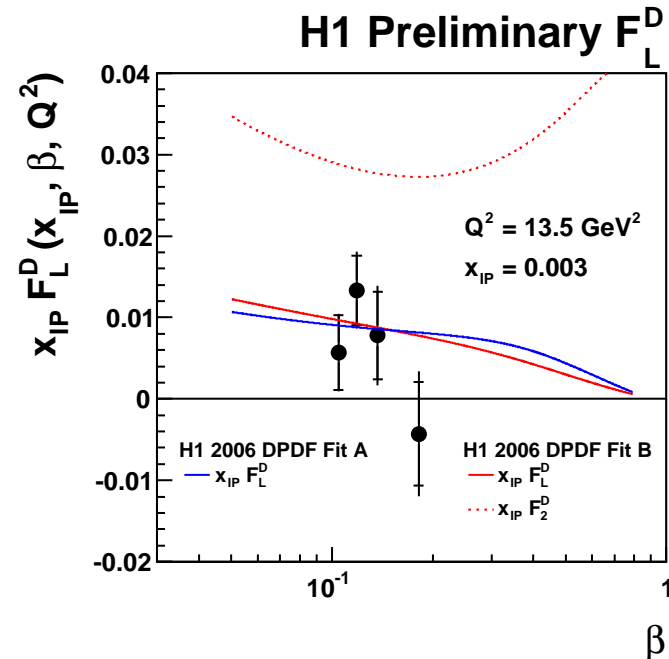
- confirms that Regge factorisation holds, i.e. **the dominance of non-perturbative** effects in the pomeron structure.

First F_L^D Measurement

$$\sigma_r^D = F_2^D - \frac{y^2}{Y_+} F_L^D \quad F_L^D \sim \alpha_S xg(x)$$



- sensitivity to F_L^D at the highest y
 (i.e. lowest $\beta = \frac{Q^2}{x_{IP}} \frac{1}{ys}$)
- to access it, need to vary s
 \Rightarrow HERA ran at reduced p beam energy
- compatible with pQCD prediction from DPDF.



Conclusion

- Still many new results from HERA data, more results to come
- Agreement between H1 and ZEUS and among different methods used to extract inclusive diffraction. Better understanding of proton dissociative background.
- Regge factorisation is a good approximation for inclusive diffraction at HERA
- First F_L^D measurement. In agreement with QCD expectations.
- QCD analyse of this data in the next talk...