Diffractive structure functions from the analysis with higher twist

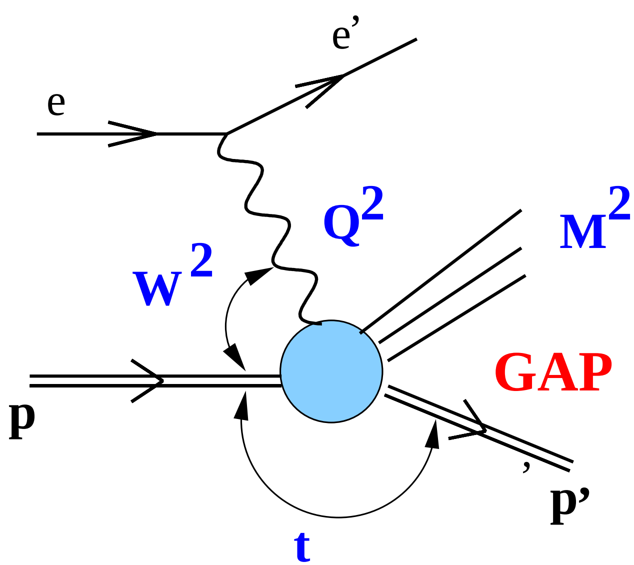
Krzysztof Golec-Biernat and Agnieszka Łuszczak

Institute of Nuclear Physics, Cracow, Poland

DIS2008, UCL, $7-11$ April 2008

Diffractive structure functions

- DIS with large rapididty gap



- lost proton momentum fraction

$$x_{I\!P} = \frac{M^2 + Q^2 - t}{W^2 + Q^2}$$

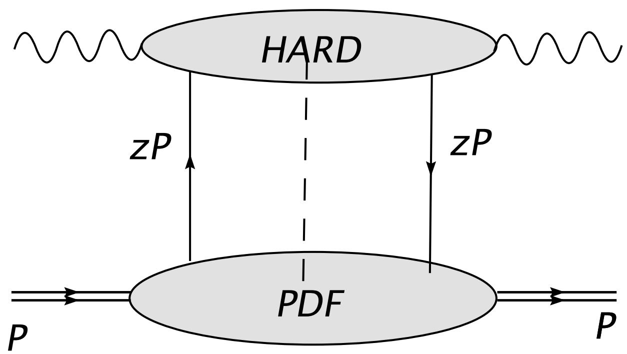
- analogue of Bjorken variable

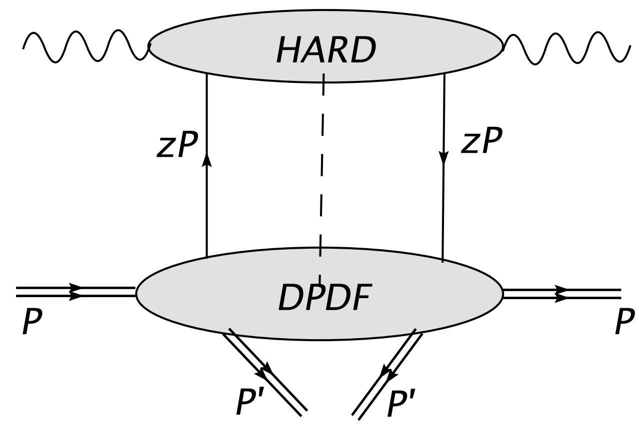
$$\beta = \frac{x}{x_{I\!P}} = \frac{Q^2}{M^2 + Q^2}$$

- After integration over proton azimuthal angle

$$\frac{d\sigma}{dx dQ^2 dx_{I\!P} dt} = \frac{2\pi\alpha^2(1+(1-y)^2)}{xQ^2} \left\{ F_2^D - \frac{y^2}{1+(1-y)^2} F_L^D \right\}$$

Collinear factorization





- Diffractive parton distributions (in $A^+ = 0$ gauge)

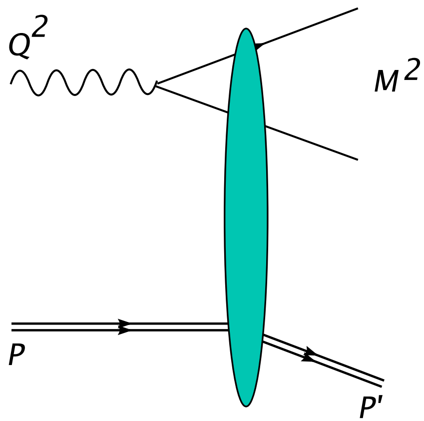
$$f_a^D(z,\mu^2,x_{I\!P},t) = \sum_X \int dy_-\, \mathrm{e}^{-i\,zP^+y^-} \langle P\,|\overline{\psi_a}(y_-)\gamma^+ \underbrace{|P'X\rangle\langle P'X|}\psi_a(0)|\,P\rangle$$

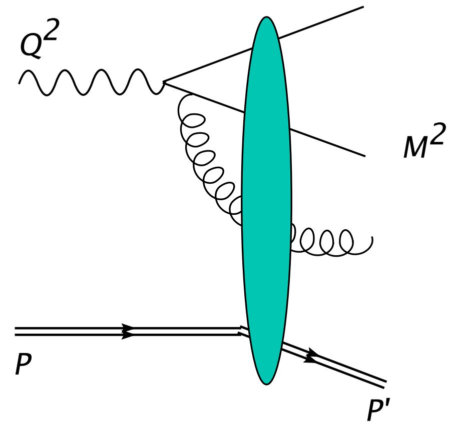
- Diffractive structure functions: $x \to \beta = x/x_{I\!P}$

$$F_{2,L}^D(\beta,Q^2;x_{I\!P},t) \;=\; \underbrace{C_{L,D}^a \otimes f_a^D}_{leading\ twist} + \mathcal{O}\left(\frac{1}{Q^2}\right)$$

Pomeron

- Dominant mechanism of vacuum quantum number exchange





- Dipole approach (Good–Walker) – dipole cross section

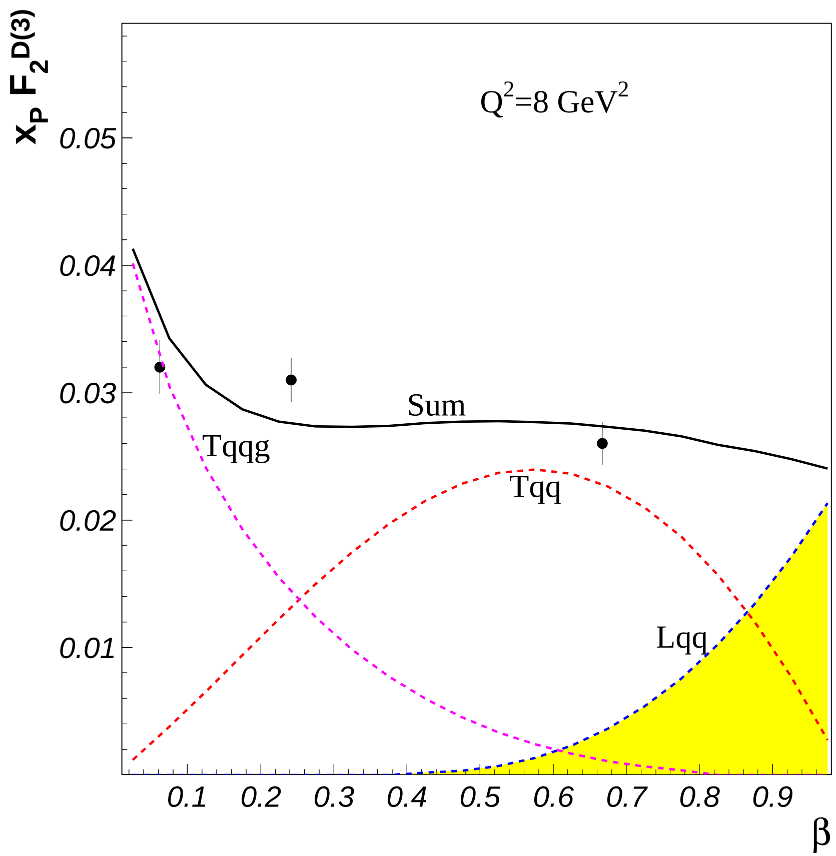
$$\hat{\sigma}(r, x_{I\!P}) = \sigma_0 \left\{1 - \exp(-r^2 Q_s^2(x_{I\!P}))\right\} \qquad Q_s = Q_0\, x_{I\!P}^{-\lambda}$$

- Diffractive structure function

$$F_2^D = F_T^{q\bar{q}} + F_L^{q\bar{q}} + F_T^{q\bar{q}g}$$

Higher twist

(Bartels, Ellis, Kowalski, Wüsthoff, G-BW)



- $F_L^{q\bar{q}}$ dominates for $\beta \to 1$ despite it is higher twist: $\sim 1/Q^2$

Strategy of our analysis

(K. Golec-Biernat, A. Luszczak, Phys. Rev. D76,114014,2007)

- Leading twist from collinear approach with DPDF

$$F_{2,L}^{(tw2)} = C_{2,L}^{a} \otimes f_a^D$$

Regge factorization, DGLAP evolution for $f_{a/\mathbb{P}}(\beta, Q^2)$.

$$f_a^D = \phi_{\mathbb{P}}(x_{\mathbb{P}}, t)\, f_{a/\mathbb{P}}(\beta, Q^2)$$

- Higher twist with energy dependence from saturation scale

$$F_L^{q\bar{q}} \sim \frac{Q_s^4(x_{\mathbb{P}})}{Q^2}\,(2\beta - 1)$$

- Reggeon exchange to improve high $x_{\mathbb{P}}$–dependence

$$F_2^{(R)} = \phi_R(x_{\mathbb{P}}, t)\,\underbrace{\left\{A_R\, \beta^{-0.08}(1-\beta)^2\right\}}_{F_R(\beta)}$$

Fit details

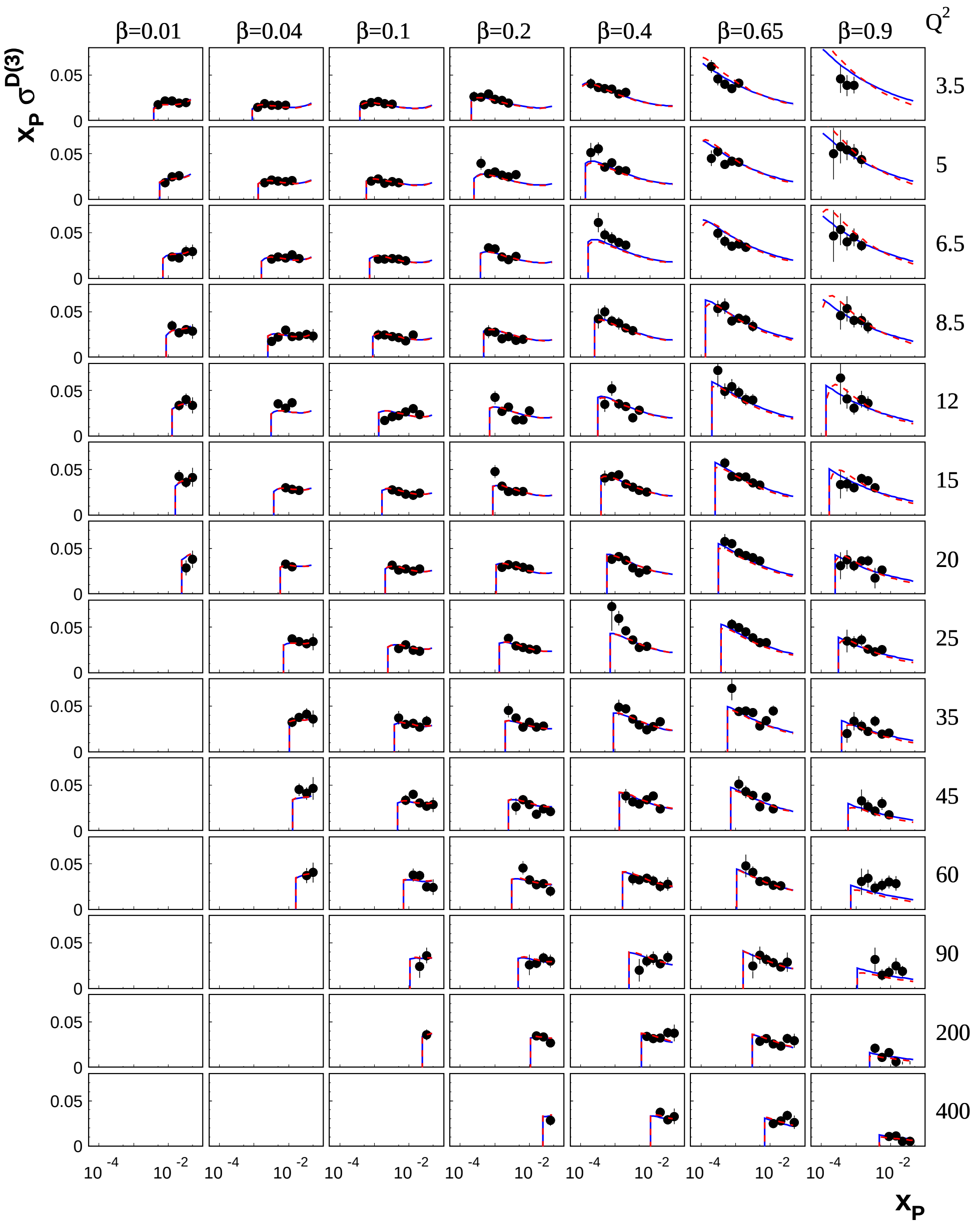
- Initial DPDF for H1 and ZEUS data separately

$$\Sigma_{I\!P}(\beta) \;=\; A_q\,\beta^{B_q}\,(1-\beta)^{C_q}$$
$$G_{I\!P}(\beta) \;=\; A_g\,\beta^{B_g}\,(1-\beta)^{C_g}$$

- Pomeron intercept $\alpha^0_{I\!P}$ and reggeon normalization A_R are fitted.
- Two fits: with and without higher twist term.

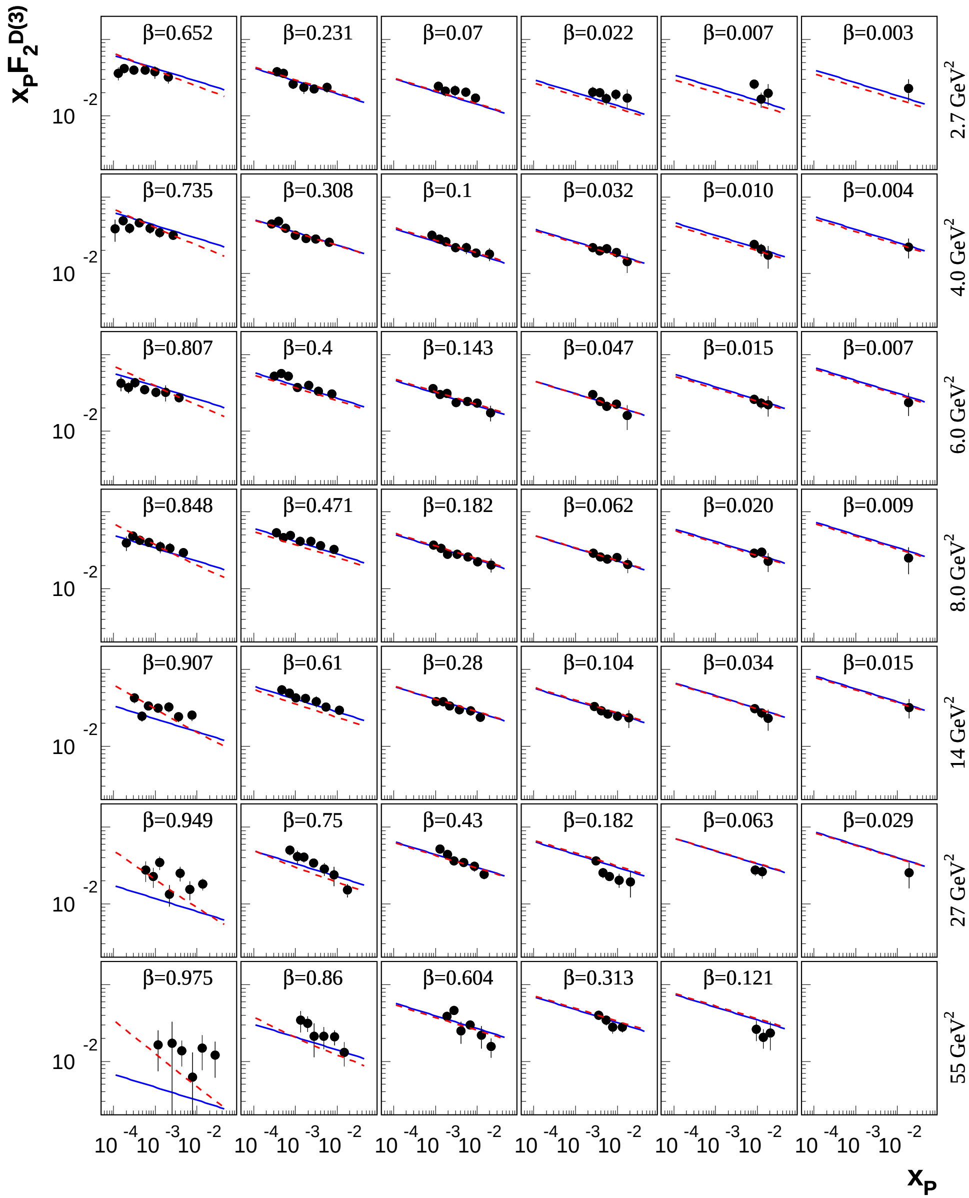
Data	Fit	$\alpha^0_{I\!P}$	C_g	χ^2/N
H1	tw2	1.117	-1.10	1.04
	tw(2+4)	1.119	-1.68	1.17
ZEUS	tw2	1.093	- 0.40	1.35
	tw(2+4)	1.092	-1.48	1.82

H1 DATA



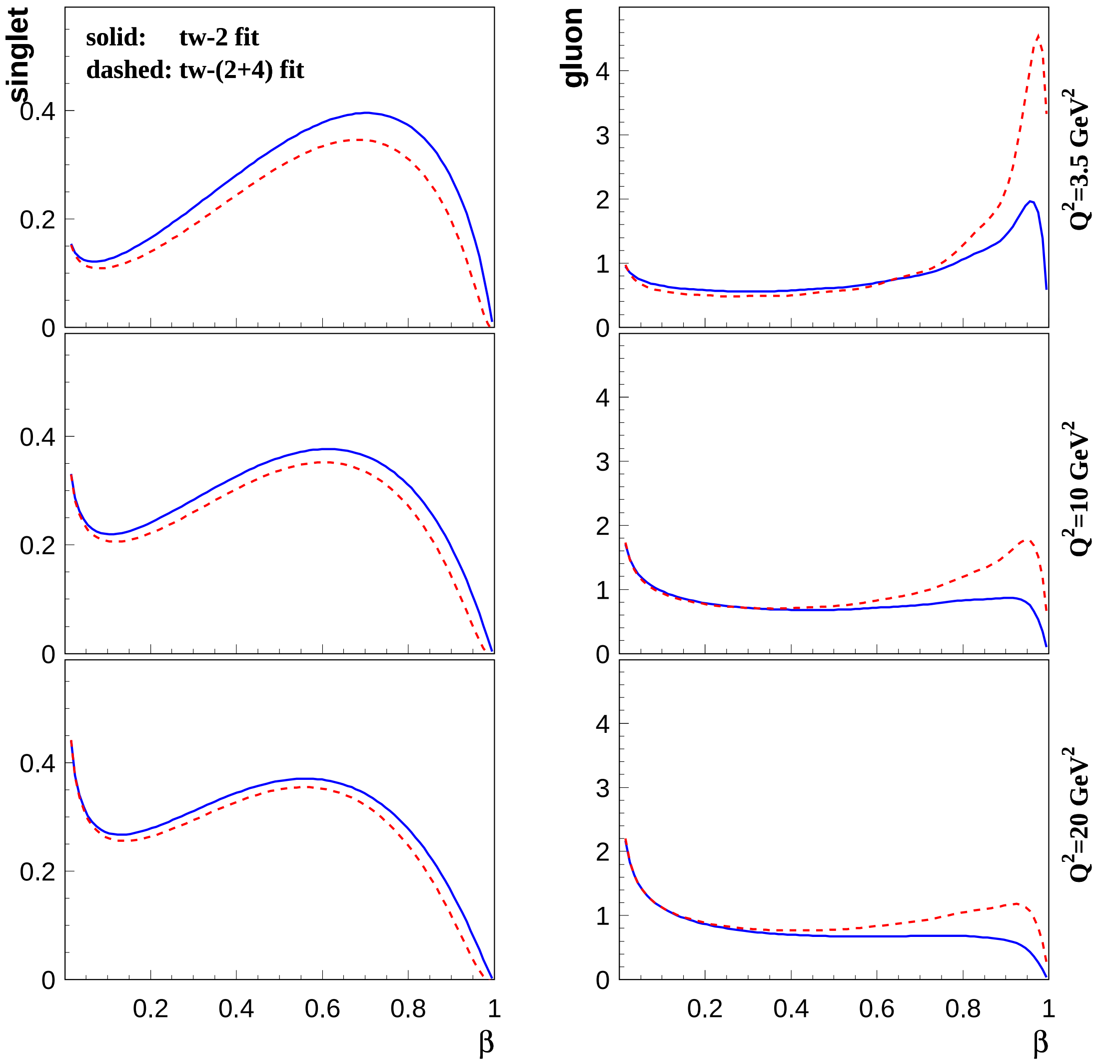
blue solid – twist-2 fit red dashed – twist-(2+4) fit

ZEUS DATA



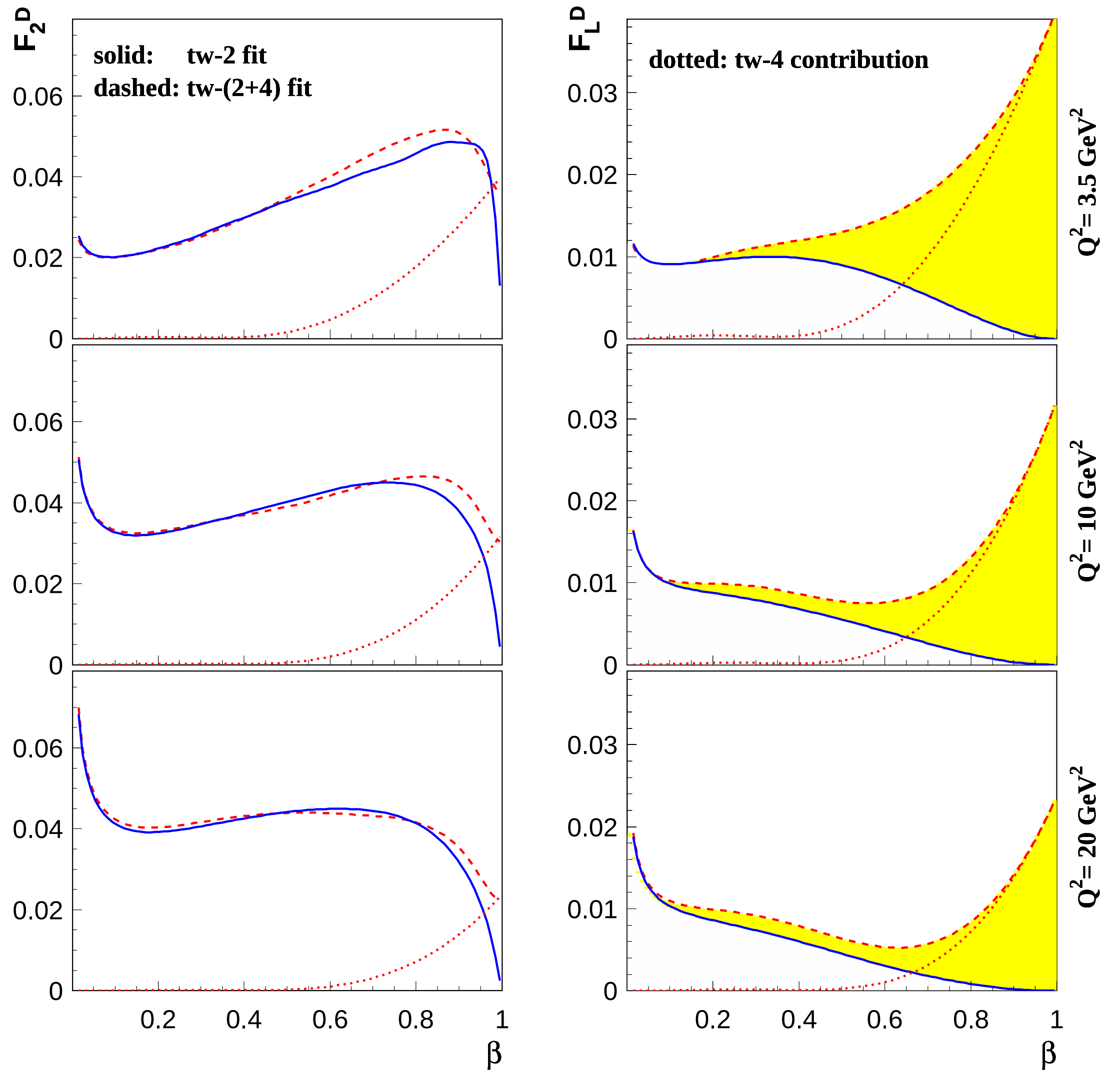
blue solid – twist-2 fit red dashed – twist-(2+4) fit

DPD (H1)



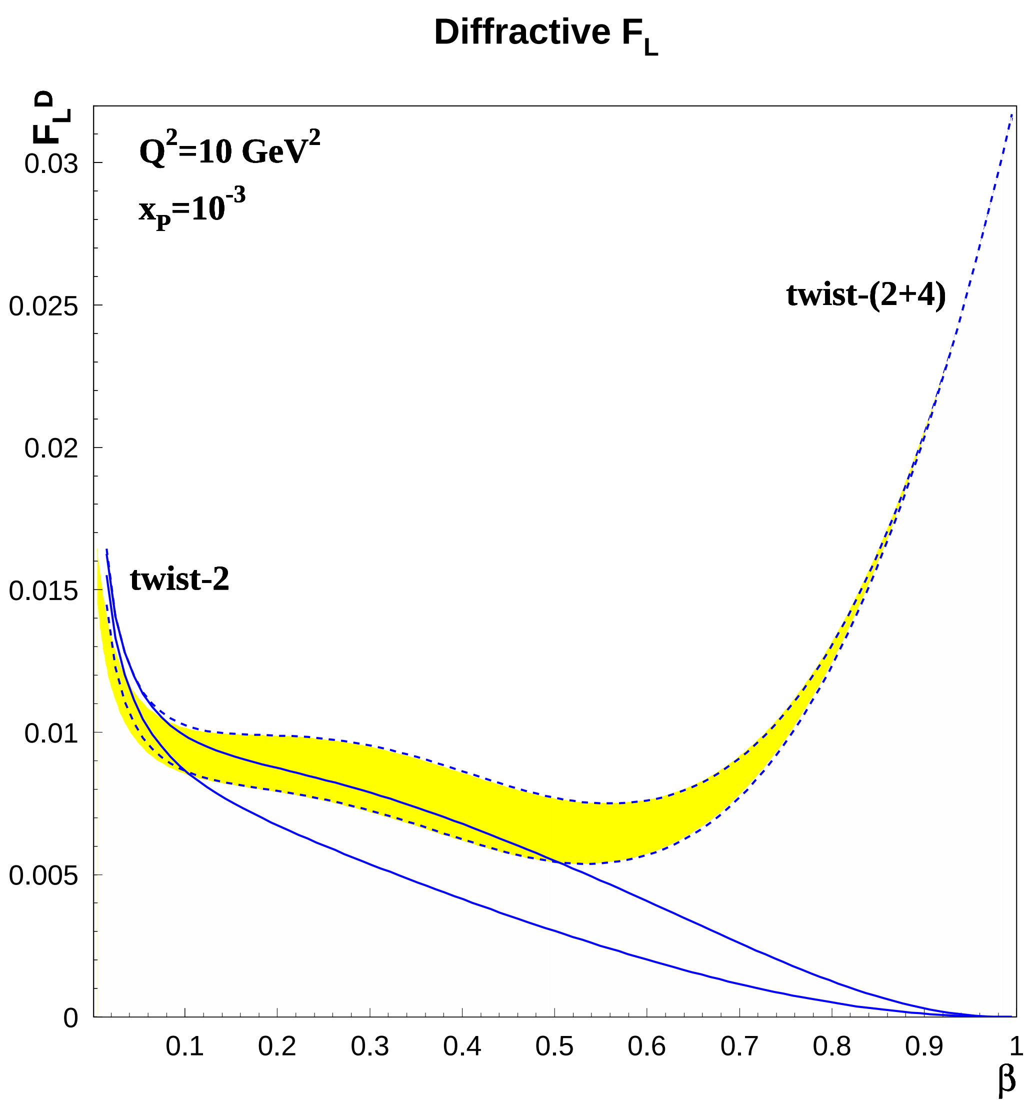
gluon distribution stronger peaked at $\beta \approx 1$ in the fit with higher twist

DSF (H1)



F_L^D strongly enhanced at $\beta \approx 1$ due to twist-4

Summary



Measure diffractive longitudinal structure function F_L^D

BACKUP SLIDES

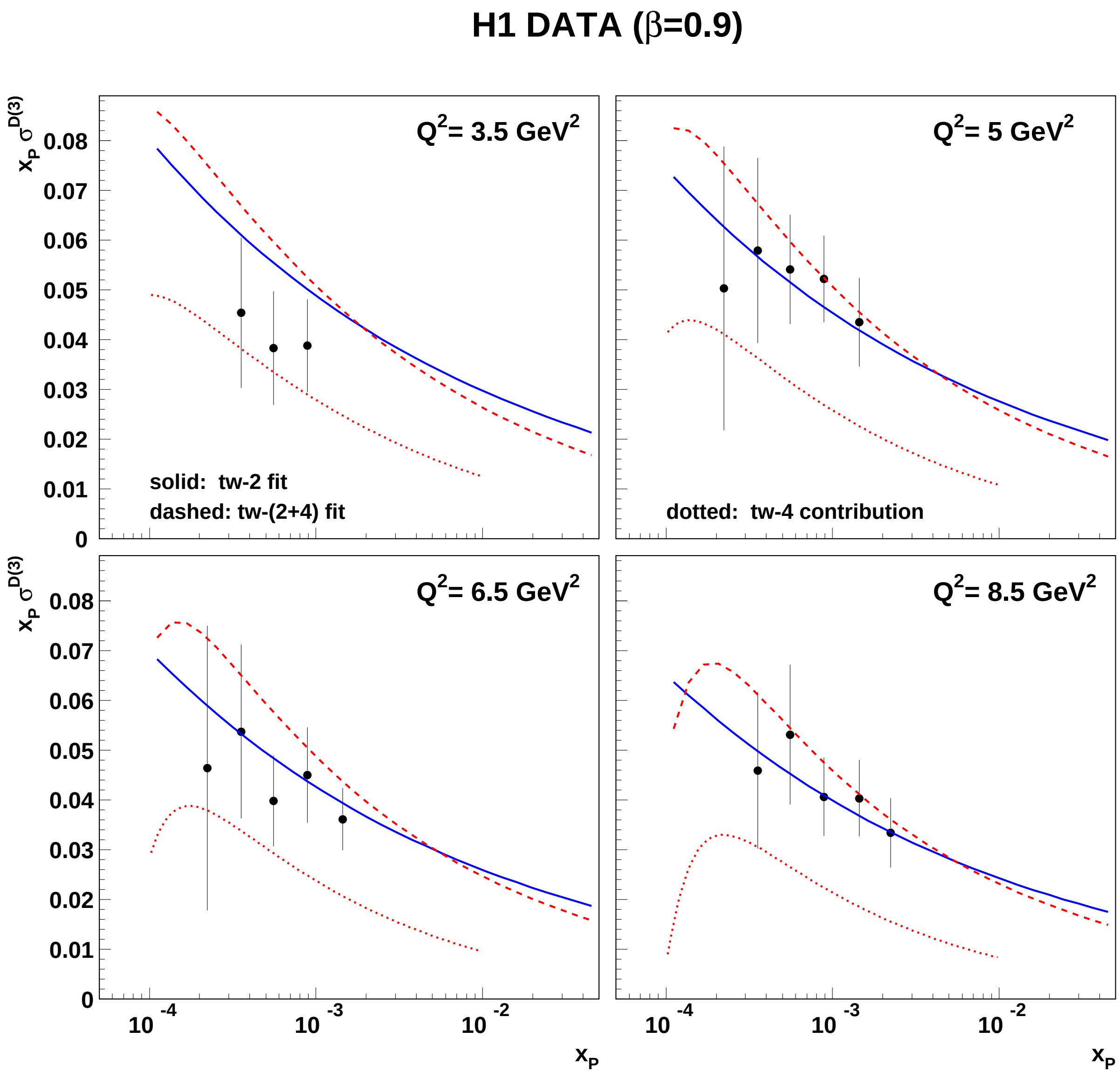
Why stronger peak ?

- Higher twist contributes negative term to the slope

$$\frac{\partial F_2^D}{\partial \ln Q^2} = P_{qq} \otimes q_f + P_{qg} \otimes G - \mathcal{O}\left(\frac{1}{Q^2}\right)$$

- Bigger gluon compensates higher twist

Large β region



Large β region