Diffractive parton distributions from the analysis with higher twist

Agnieszka Łuszczak

Institute of Nuclear Physics PAN, Cracow

in collaboration with Krzysztof Golec-Biernat

DESY, October 25, 2006

Outline

- Diffractive structure functions.
- Twist-2 and twist-4 contributions.
- Reggeon contribution.
- Fit results.
- Summary and outlook

Main idea of the analysis

- Comprehensive analysis of diffractive structure function data from HERA.
- No global fit – we fit H1 and ZEUS data sets separately.
- Elements of the analysis:
  - diffractive parton distributions
  - twist-4 contribution
  - reggeon contribution
- Predictions on longitudinal structure function.

Diffractive structure functions

- In the QCD approach DSF decomposed into leading twist-2 and higher twist contributions:

$$F_{2,L}^{D}(x_{I\!P}, t, \beta, Q^2) \;=\; F_{2,L}^{D(tw2)} \;+\; F_{2,L}^{D(tw4)} \;+\; \ldots$$

- Twist-2 part given in terms of diffractive parton distributions (DPD):

$$F_{2}^{D(tw2)} \;=\; \sum_f e_f^2\, \beta\, \{ q_f^D \;+\; \overline{q}_f^D \} \;+\; \alpha_s \cdot NLL(q_f^D, g^D)$$

$$F_{L}^{D(tw2)} \;=\; 0 \;+\; \alpha_s \cdot NLL(q_f^D, g^D)$$

- Regge factorized form with pomeron flux $f_{I\!P}$ and pomeron sf $F_{2,L}^{I\!P}$

$$F_{2,L}^{D(tw2)}(\beta, Q^2, x_{I\!P}, t) \;=\; f_{I\!P}(x_{I\!P}, t)\, F_{2,L}^{I\!P}(\beta, Q^2)\,.$$

DGLAP based fits

- DPD evolve with Q^2 through DGLAP evolution equations in the NLL approximation.

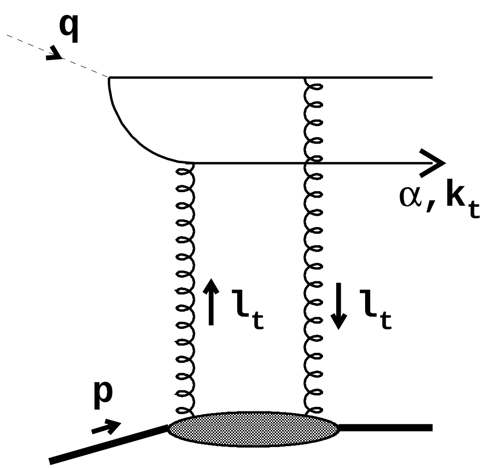
- Initial DPD contain 6 fitted parameters

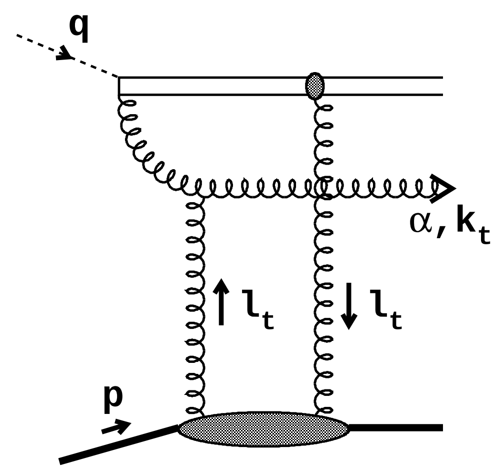
$$
\begin{aligned}
\Sigma^{I\!P}(\beta, Q_0^2) &= A_S\, \beta^{B_S}\, (1-\beta)^{C_S} \\
G^{I\!P}(\beta, Q_0^2) &= A_G\, \beta^{B_G}\, (1-\beta)^{C_G}
\end{aligned}
$$

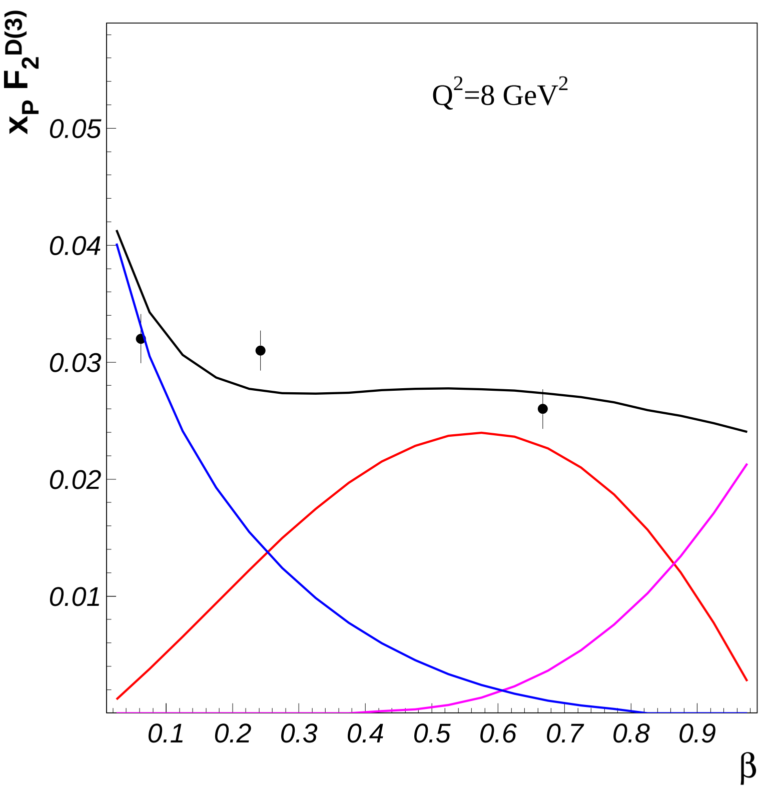
- Pomeron intercept is the 7^{th} parameter

$$
f(x_{I\!P}) \sim x_{I\!P}^{1-2\alpha_{I\!P}}
$$

Twist-4 contribution







- $\beta = Q^2/(Q^2 + M^2)$
- $F_2^D(\beta, x_{I\!P}, Q^2) = F_{q\bar{q}}^L + F_{q\bar{q}}^T + F_{q\bar{q}g}^T$
- $F_{q\bar{q}}^L \sim 1/Q^2$ is higher twist

Summary of the contributions

- In our analysis diffractive structure functions are of the form:

$$F_2^D = F_2^{D(tw2)} + F_{Lq\bar{q}}^{D(tw4)} + F_2^{D(R)}$$

$$F_L^D = F_L^{D(tw2)} + F_{Lq\bar{q}}^{D(tw4)}$$

- Twist-4 sf describes diffractive $q\bar{q}$ production from longitudinally polarized virtual photons – important for $\beta \to 1$.
- Saturation model formula for twist-4.
- f_2 and ω reggeon exchange contributions – important for $x_{I\!P} > 0.01$:

$$F_2^{D(R)} = f_R(x_{I\!P}, t)\,(A_R\,\beta^{-0.08})$$

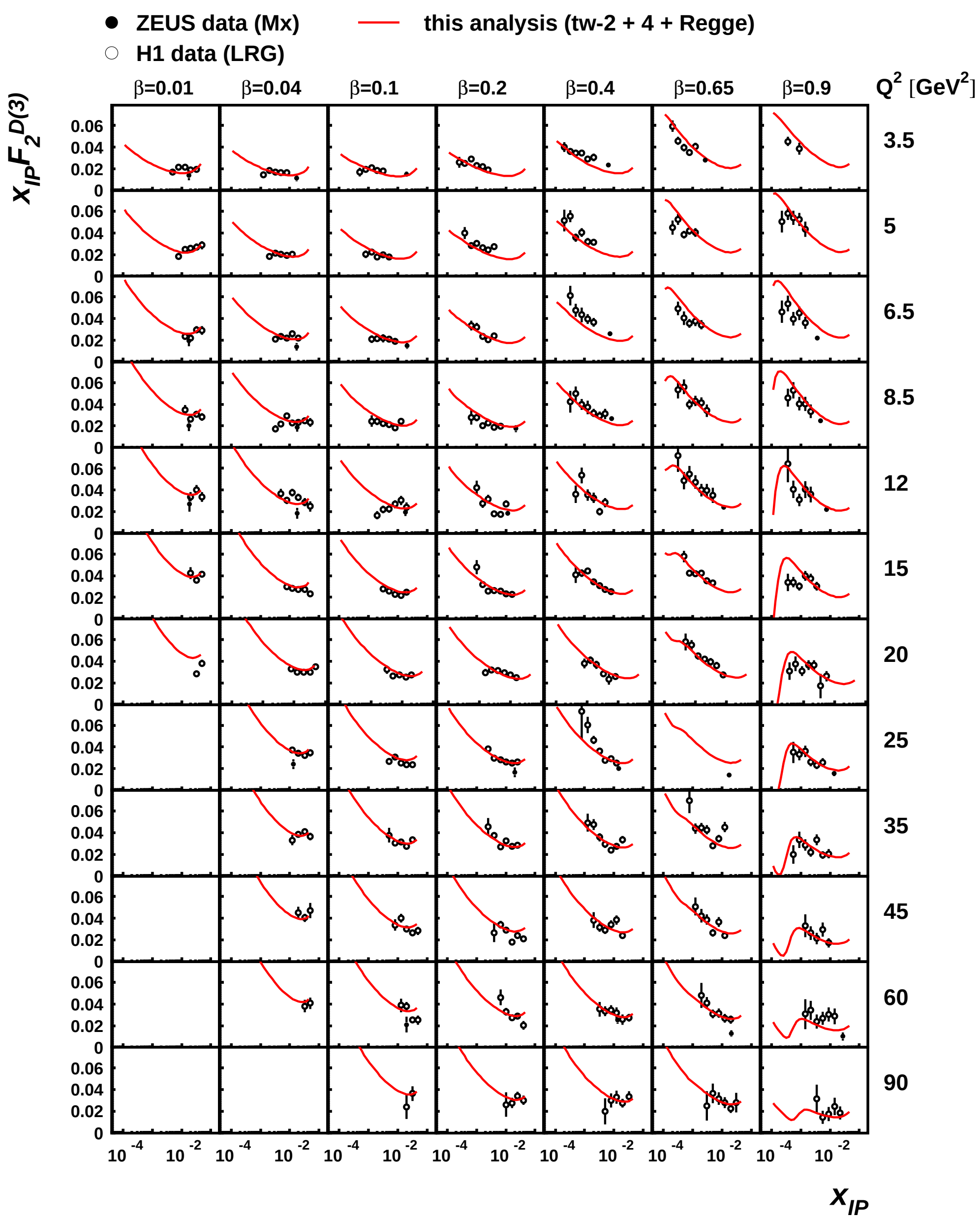
Fits to data

Collaboration	Data	t-range $[\mathrm{GeV}^2]$	Q^2-range	β-range
H1 (72)	leading proton	$0.08 < \lvert t\rvert < 0.5$	$[2.0, 50]$	$[0.02, 0.7]$
H1 (276)	$M_Y < 1.6$ GeV	$\lvert t_{min}\rvert < \lvert t\rvert < 1$	$[3.5, 1600]$	$[0.0017, 0.8]$
ZEUS (80)	leading proton	$0.075 < \lvert t\rvert < 0.35$	$[2.0, 100]$	$[0.007, 0.48]$
ZEUS (198)	$M_Y < 2.3$ GeV	$\lvert t_{min}\rvert < \lvert t\rvert < \infty$	$[2.2, 80]$	$[0.003, 0.975$

- Fit results for 7 parameters

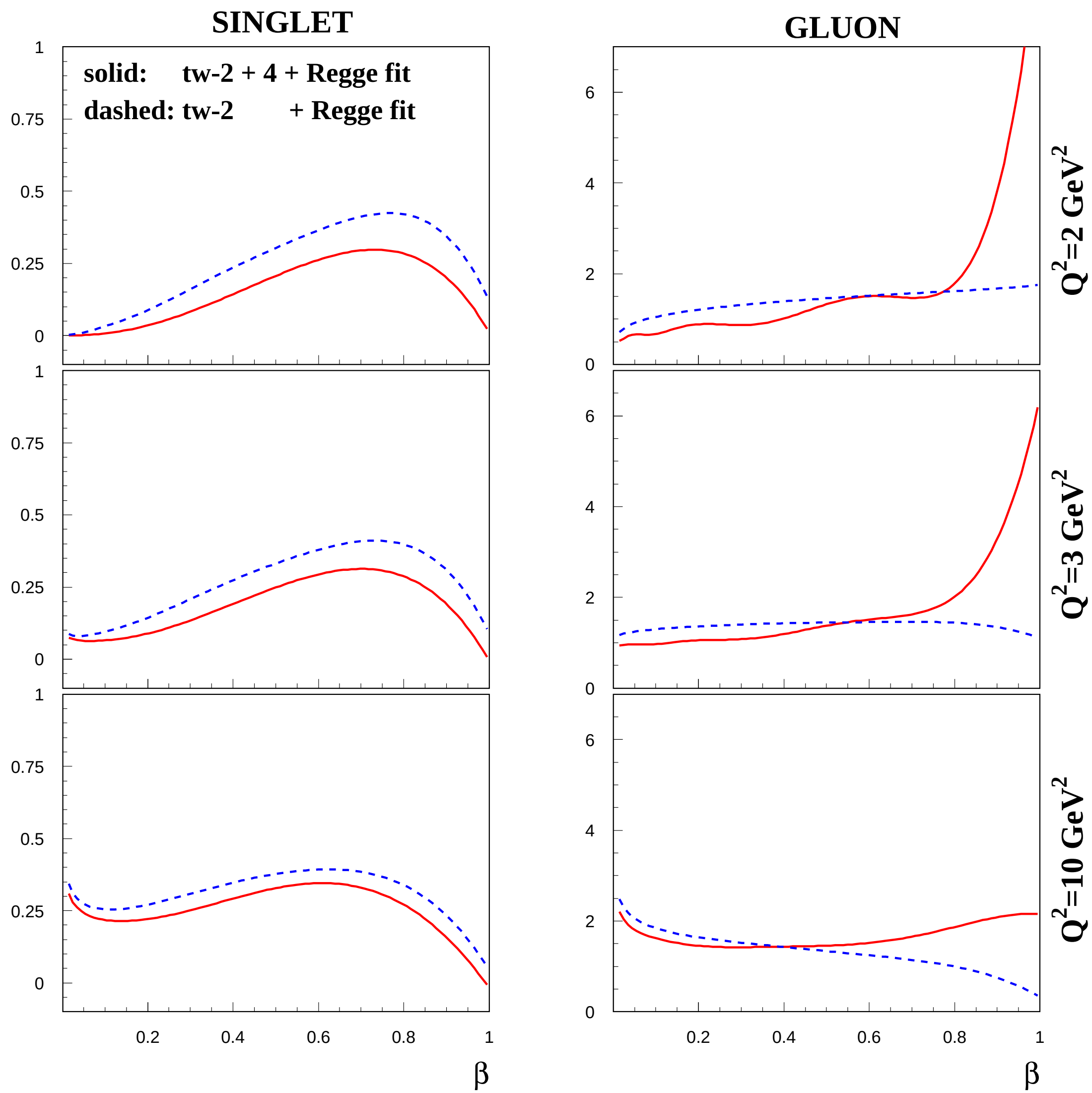
Data	Fit	$\alpha_{I\!P}$	A_S	B_S	C_S	A_G	B_G	C_G	χ^2/N
H1	tw-2	1.05	0.64	0.31	-0.43	34.6	0.62	9.23	0.60
(lp)	tw-2+4	1.04	0.64	0.23	-0.40	20.4	0.43	8.62	0.57
H1	tw-2	1.08	1.53	1.08	0.31	3.10	0.10	0.59	1.11
	tw-2+4	1.10	2.17	1.83	0.70	1.32	-0.04	-0.48	1.29
	tw-2+reg	1.13	1.31	1.60	0.49	1.66	0.20	-0.01	0.93
	2+4+reg	1.14	2.01	2.40	0.89	0.89	0.12	-0.55	1.01

Fit quality



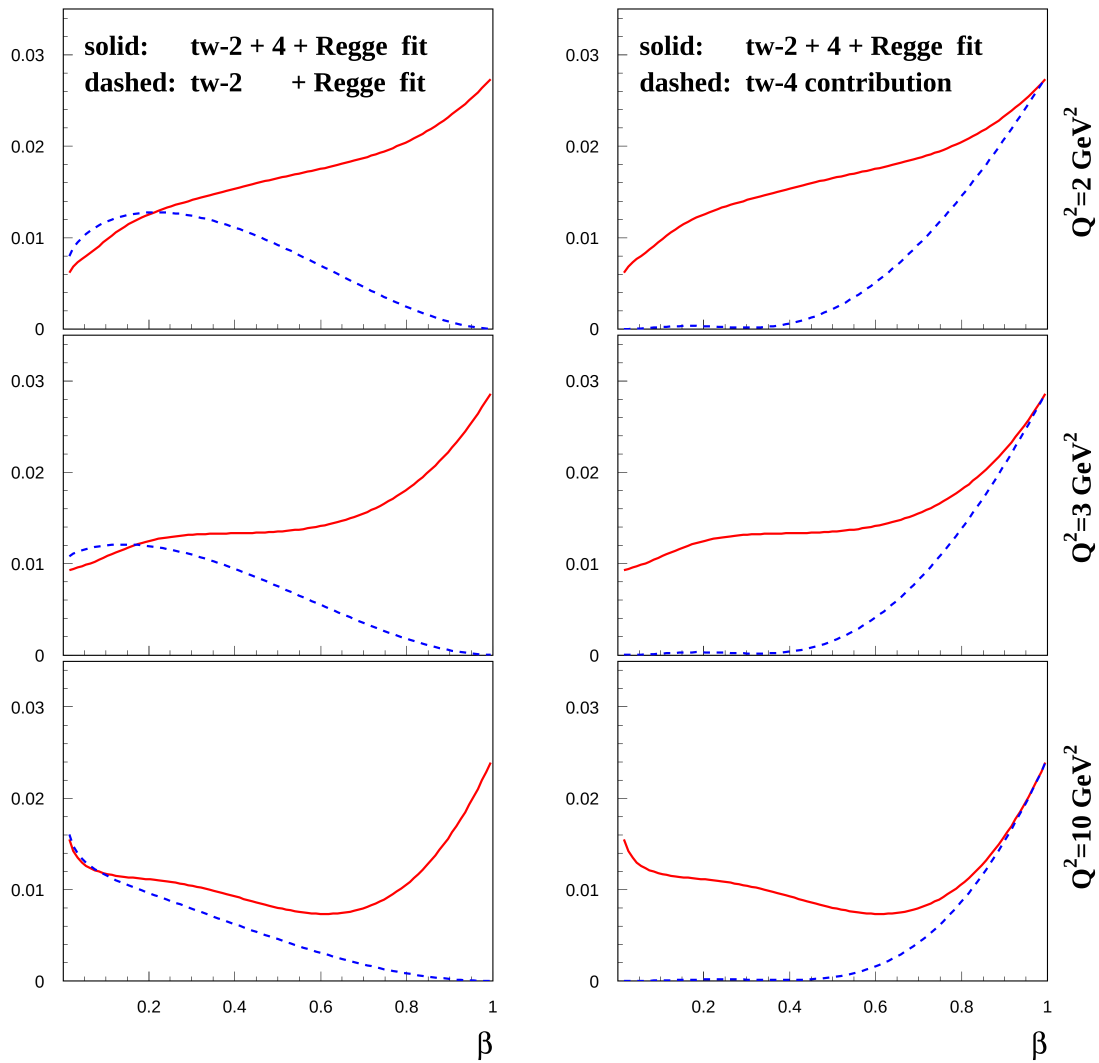
ZEUS data (Mx)
this analysis (tw-2 + 4 + Regge)
H1 data (LRG)
β=0.01
β=0.04
β=0.1
β=0.2
β=0.4
β=0.65
β=0.9
Q^2 [GeV^2]
3.5
5
6.5
8.5
12
15
20
25
35
45
60
90
$x_{IP}F_2^{D(3)}$
0.06
0.04
0.02
0
10^{-4}
10^{-2}
x_{IP}

Diffractive PD from fits



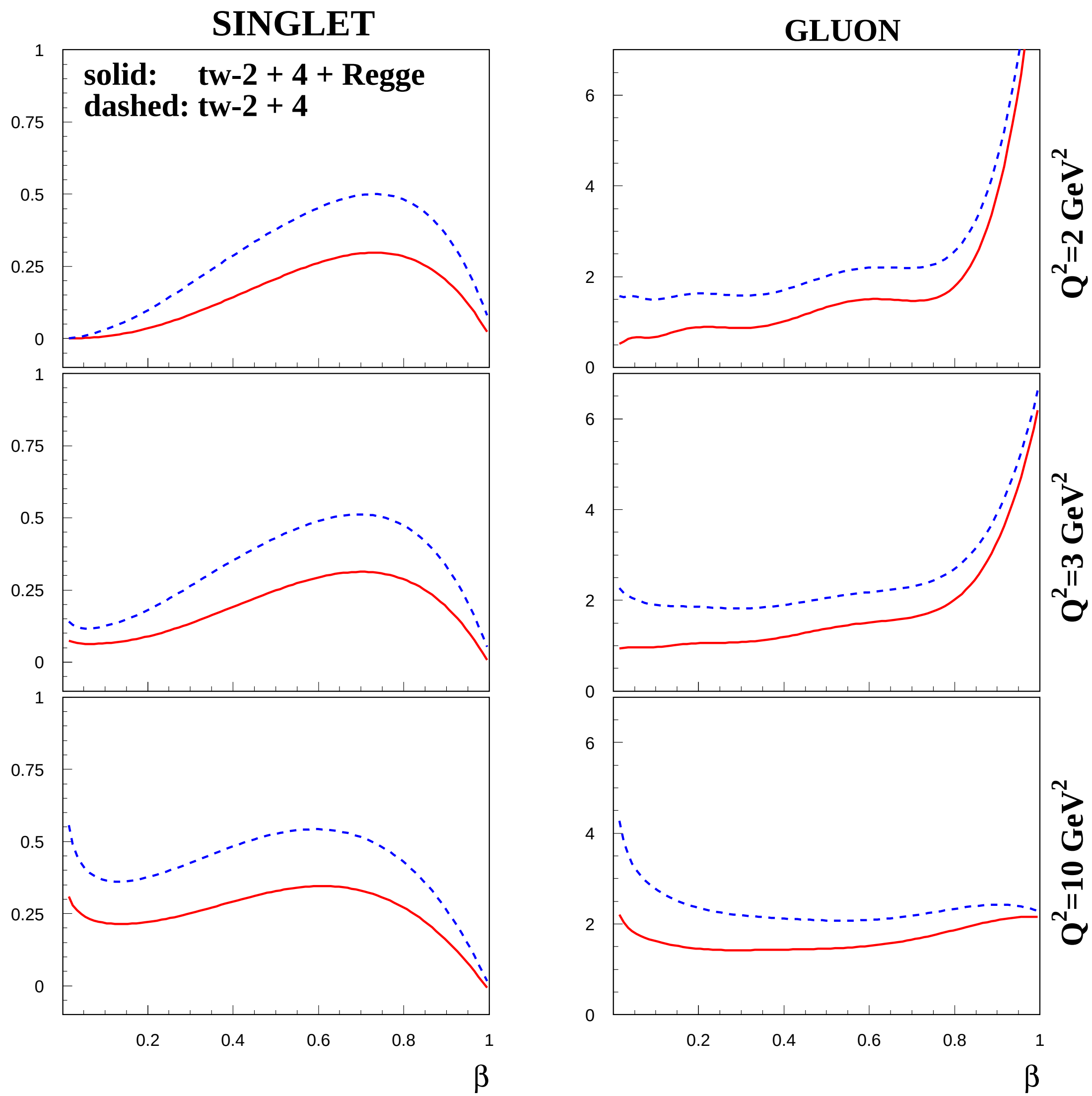
- Large impact of twist-4 fit on gluon distribution for $\beta \to 1$.

Predictions for diffractive F_L



- Large difference for F_L due to twist-4 contribution and different gluon distributions.

How important is Regge term ?



- Changes DPD up to 50%.

Summary and outlook

- Twist-4 is important for $\beta > 0.7$.
- Twist-4 changes dramatically gluon distribution at $\beta \to 1$
- F_L is significantly changed due to higher twist for $\beta > 0.4$.
- Regge contribution improves fit quality through better $x_{I\!P}$-shape and changes DPD up to 50%.
- Outlook: ZEUS data analysis.
- Comparison with analyses of other groups.