Saturation and the COLOUR DIPOLE MODEL

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Colour Dipole Model

Simple unified picture of many diffractive photoprocesses
Unified picture of hard & soft diffraction

- Deep inelastic scattering

  Fix parameters of model from F_2 data
  (Investigate saturation, predict F_L, F_2^c)

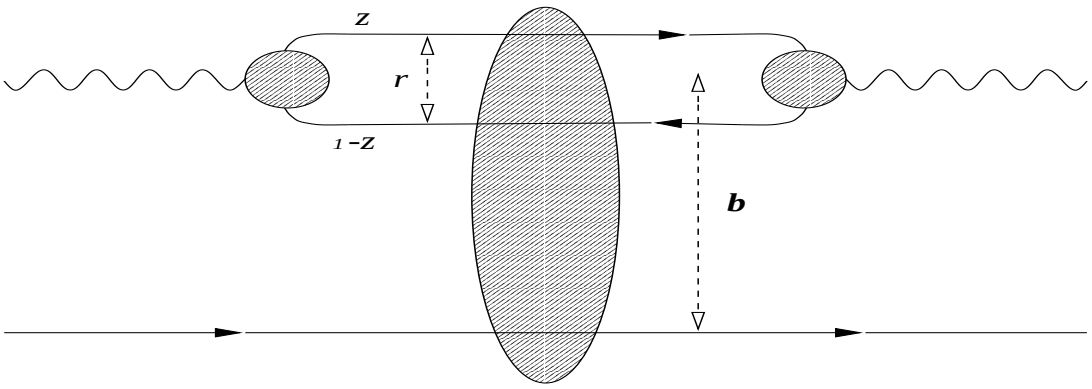
- Predictions for Exclusive Processes

  DVCS ,(ρ, ϕ) J/Ψ production

- Predictions for DDIS

J.Forshaw, R Sandapen and G.Shaw, JHEP 0611 (2006) 025; J.Forshaw and G.Shaw JHEP 0412 (2004) 025

DIS



$$\sigma^{T,L}_{\gamma^* p} = \int \mathrm{d}z \mathrm{d}^2 r \ |\psi^{T,L}_{\gamma}(z, r, Q^2)|^2 \sigma(x, r, z)$$

where

- $\psi(z, r, Q^2)$ is the *light cone wave function*
- $\sigma(x, r, z)$ is the *dipole cross section*

Fix parameters of chosen model from F_2 data.

Three models(apologies to rest)

- FS04 Regge model*

  Two pomeron Regge model,with hard pomeron for small dipoles, soft pomeron for large dipoles

- FS04 saturation model*

  Incorporates phenomenological saturation effects for small dipoles (no longer a Regge model)

- Colour Glass Condensate(CGC) model †

  Incorporates saturation dynamics via approx. solution to BK equation.

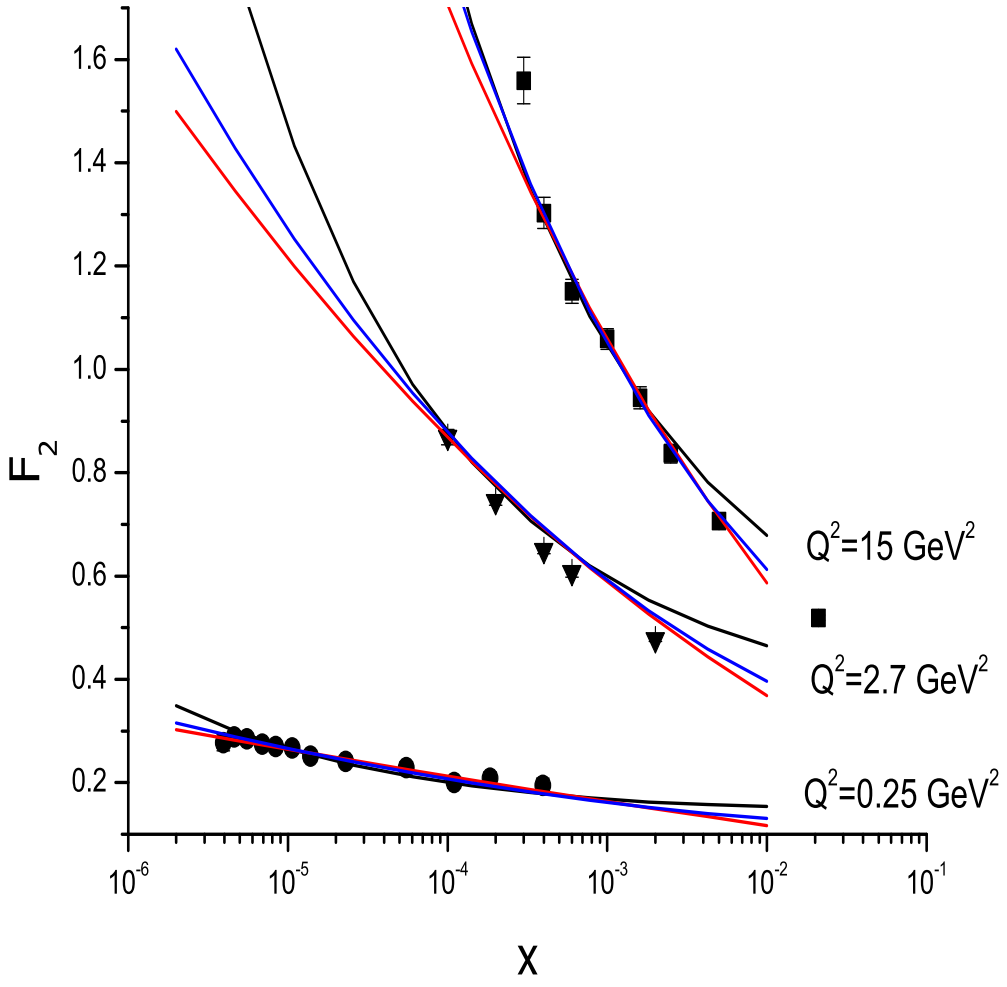
  Fits exrtended to include charm‡

*J. R Forshaw, and G. Shaw, JHEP 0412 (2004) 052

†E. Iancu, K Itakura, S. Munier, P.L. **B590** (2004)199

‡H.Kowalski, L.Motyka and G. Watt hep-ph/0606272

Saturation and Regge Fits: HERA F_2 Data



The unsaturated Regge fit(black line), the saturation fit(blue line) and the CGC model fit(red line). The last two both have $\chi^2/D.O.F \approx 1.0$; the unsaturated Regge fit has $\chi^2/D.O.F \approx 2.7$.

- For DIS data in the range

$$0.045\text{GeV}^2 < Q^2 < 45\text{GeV}^2 \quad x < 0.01$$

the CGC and FS2004 saturation fits are are satisfactory and much better than the unsaturated Regge fits

- Unable to find a better Regge fit - tried many variations

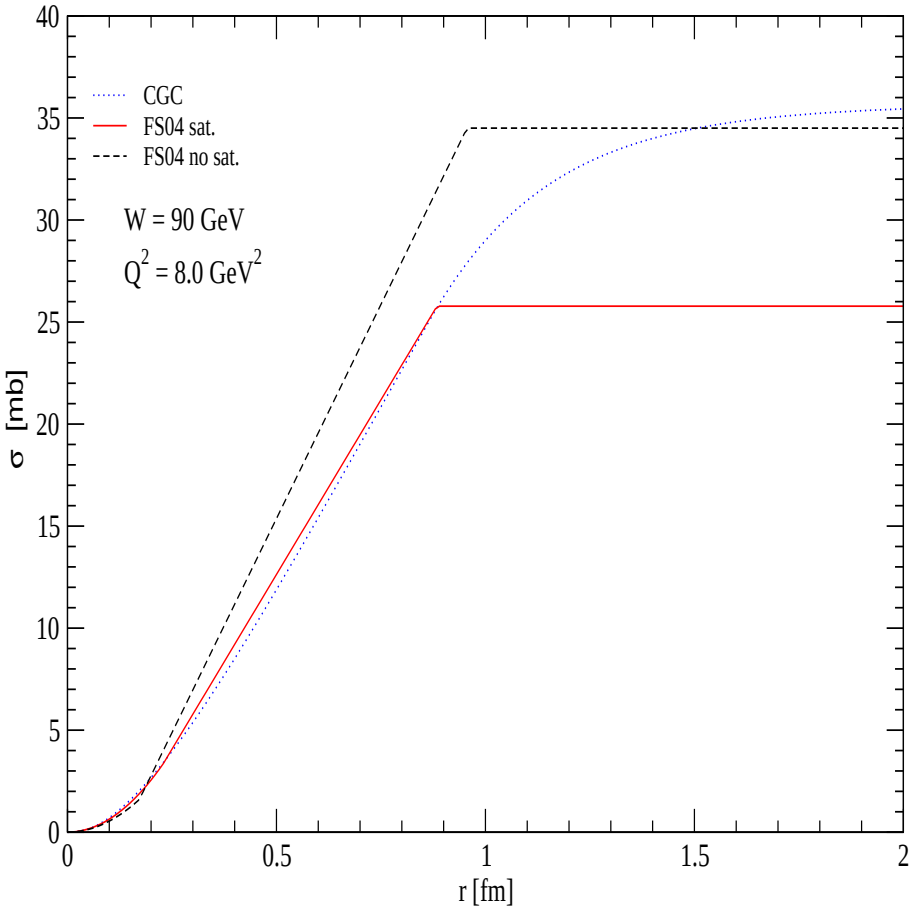
- BUT for DIS data in the range

$$1\text{GeV}^2 < Q^2 < 45\text{GeV}^2 \quad x < 0.01$$

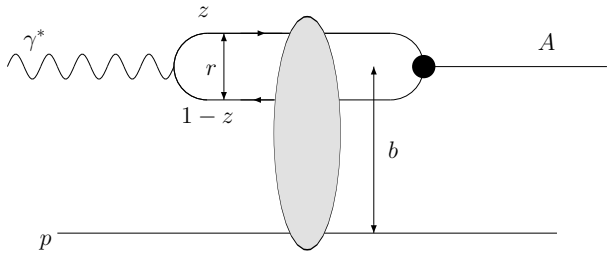
all three fits are satisfactory.

- The conclusion rests on the model correctly separating large and small dipole contributions in the low Q^2 region.

Comparison of the dipole cross sections



Exclusive Processes



$$\left.\frac{d\sigma}{dt}\right|_{t=0} = \frac{1}{16\pi s^2}|\mathrm{Im}A_\lambda(s,t=0)|^2(1+\beta^2)\ , \quad (1)$$

$$\sigma_{L,T}(\gamma^* p \to Ap) = \frac{1}{B}\left.\frac{d\sigma^{T,L}}{dt}\right|_{t=0}\ , \qquad (2)$$

β is calculated from Regge signature factor, dispersion relations.

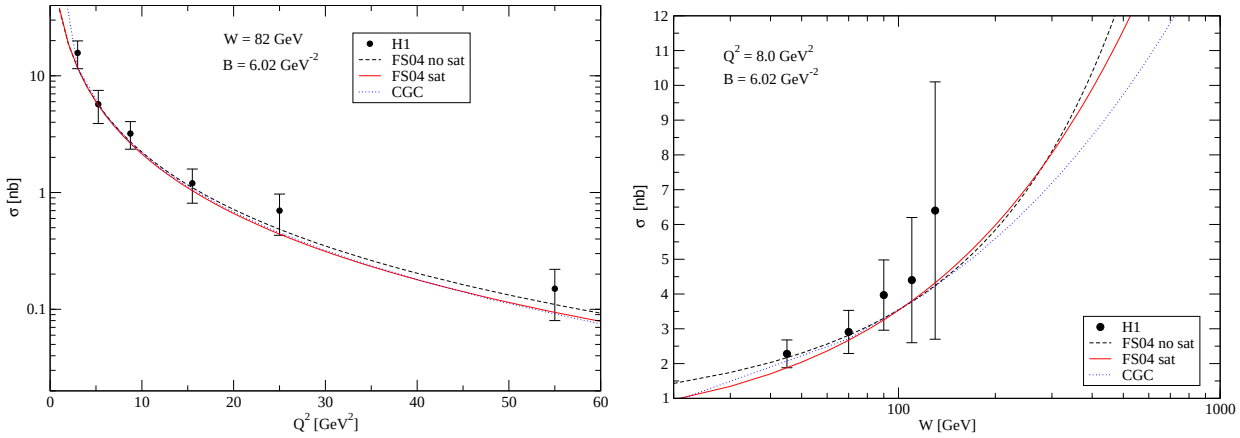
Slope parameter is taken from experiment

Need wavefunctions for vector mesons

DVCS

$$\gamma^* + p \to \gamma + P$$

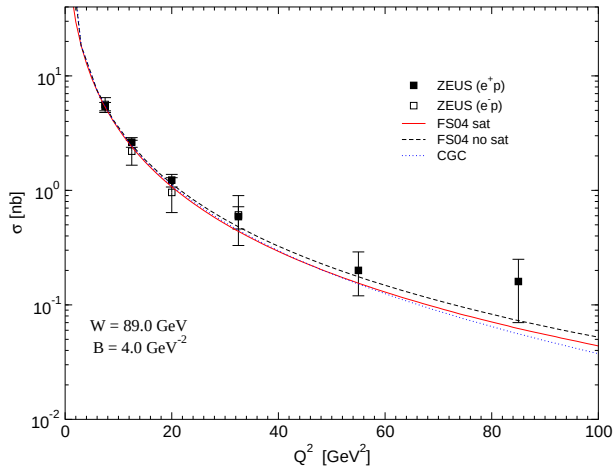
Comparison with HERA H1 data

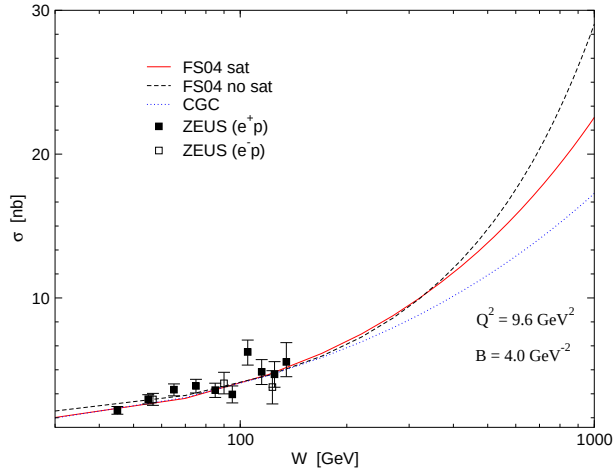


No unknown wave function, no free parameters

DVCS

Comparison with HERA ZEUS data





No unknown wave function, no free parameters

J/Ψ Production

$$\gamma^* + p \to J/\Psi + p$$

Predictions sensitive to charmed quark mass

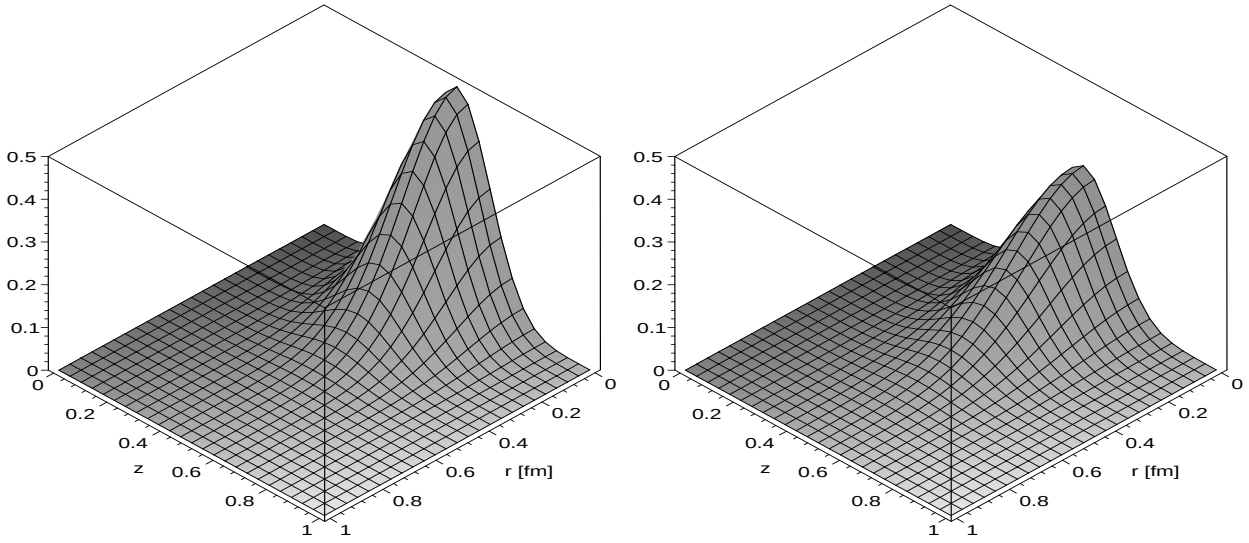
Need to fix scalar part of J/Ψ wavefunction

- DGKP : product of gaussians in r, z
- Boosted Gaussian : boost from rest frame using Brodsky-Lepage procedure

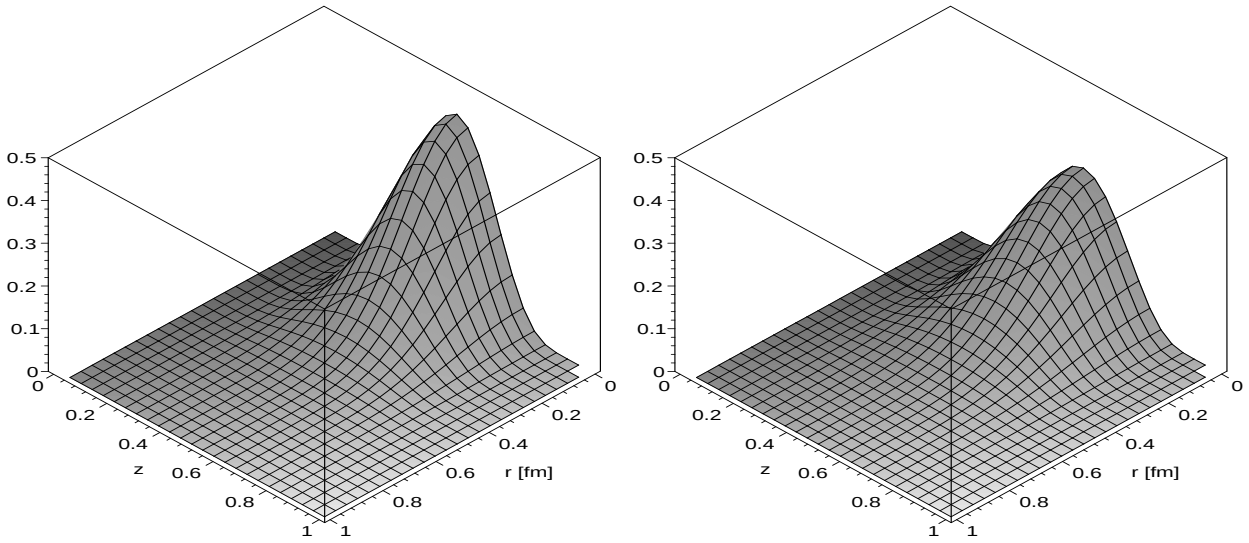
In both cases, parameters fixed by normalization, decay width for given quark mass.

The J/Ψ-wavefunctions

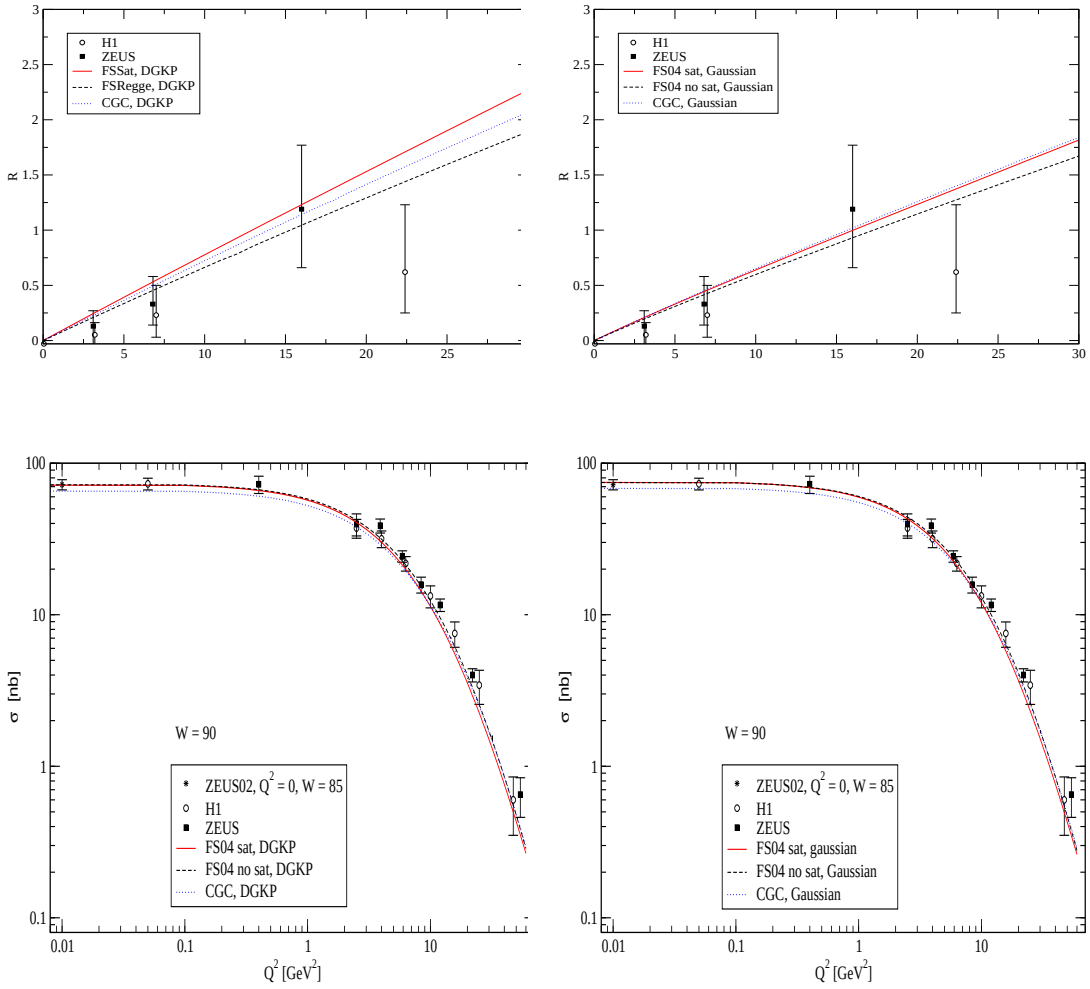
$|\Psi^L|^2$ (left) and $|\Psi^T|^2$ (right) in the DGKP model.



in the Boosted Gaussian model.



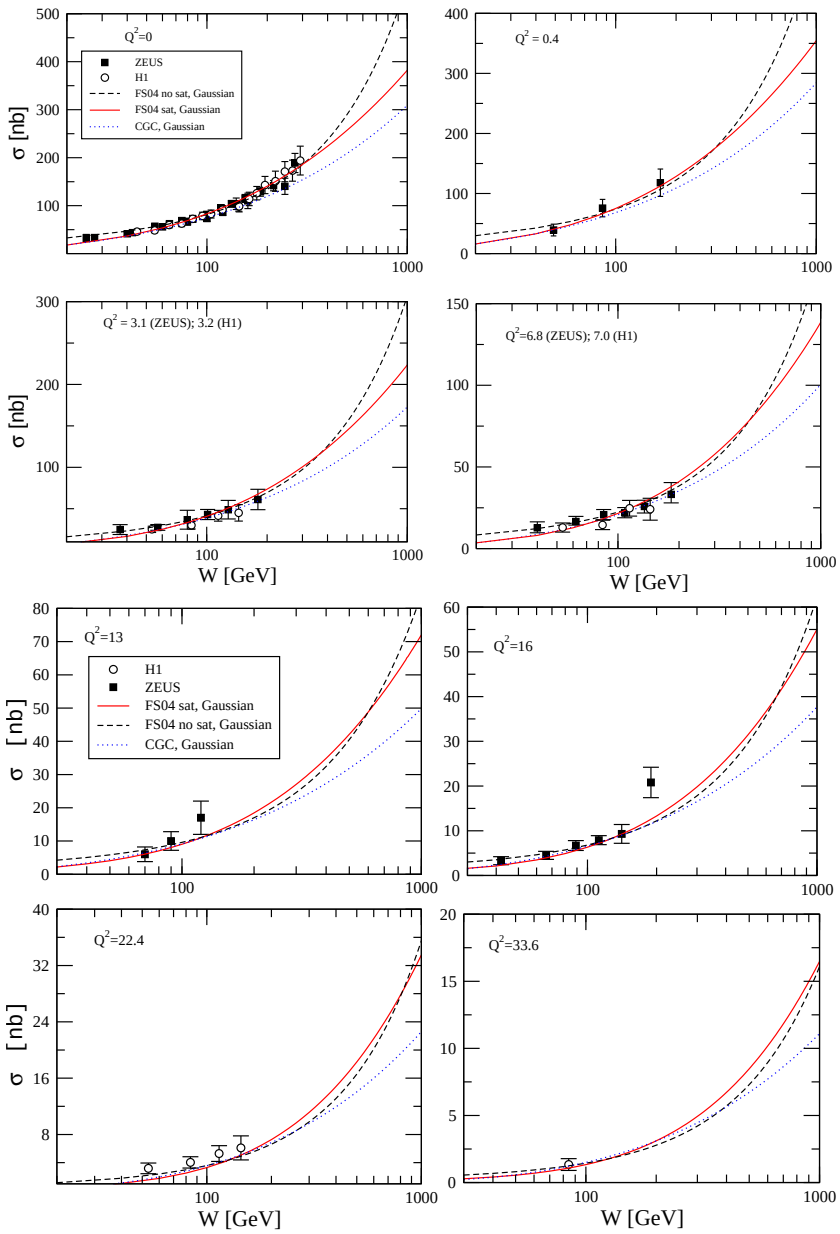
HERA data : Q^2 dependence



No strong dependence on choice of wavefunction.

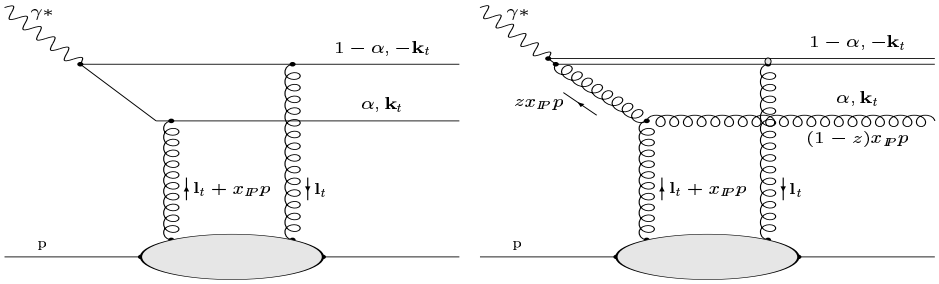
Depends on quark mass : chosen values 1.35(saturation models) 1.4 Regge model

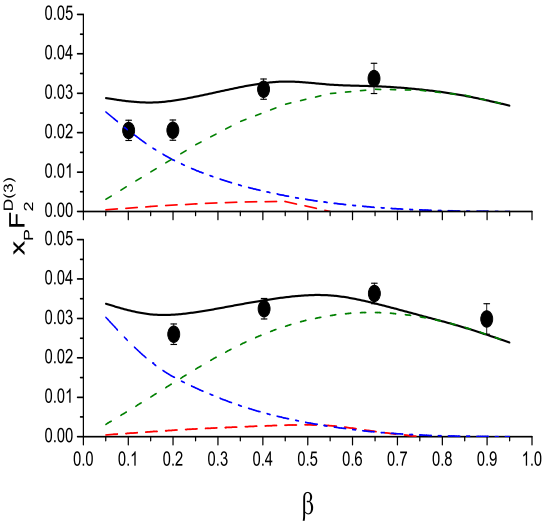
HERA data : W-dependence



Just shown Gauusian : DGKP similar.

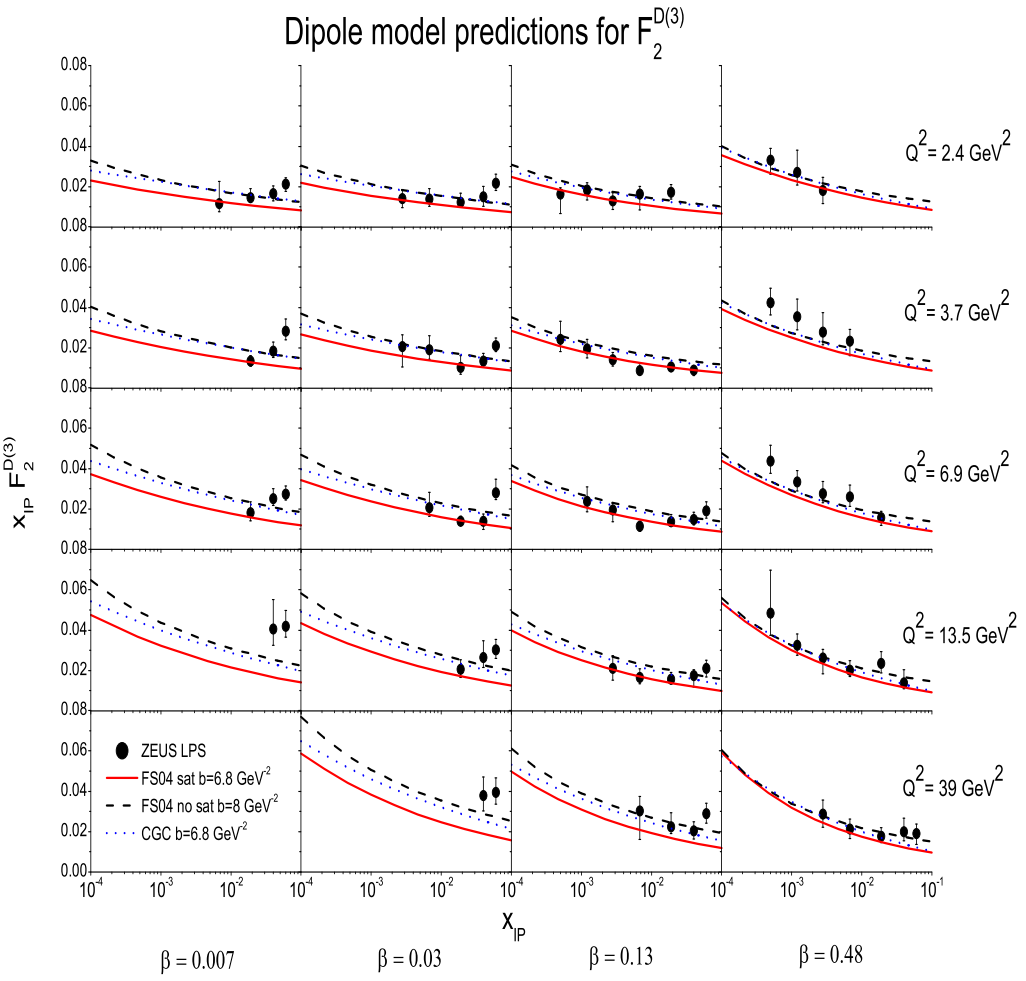
DDIS





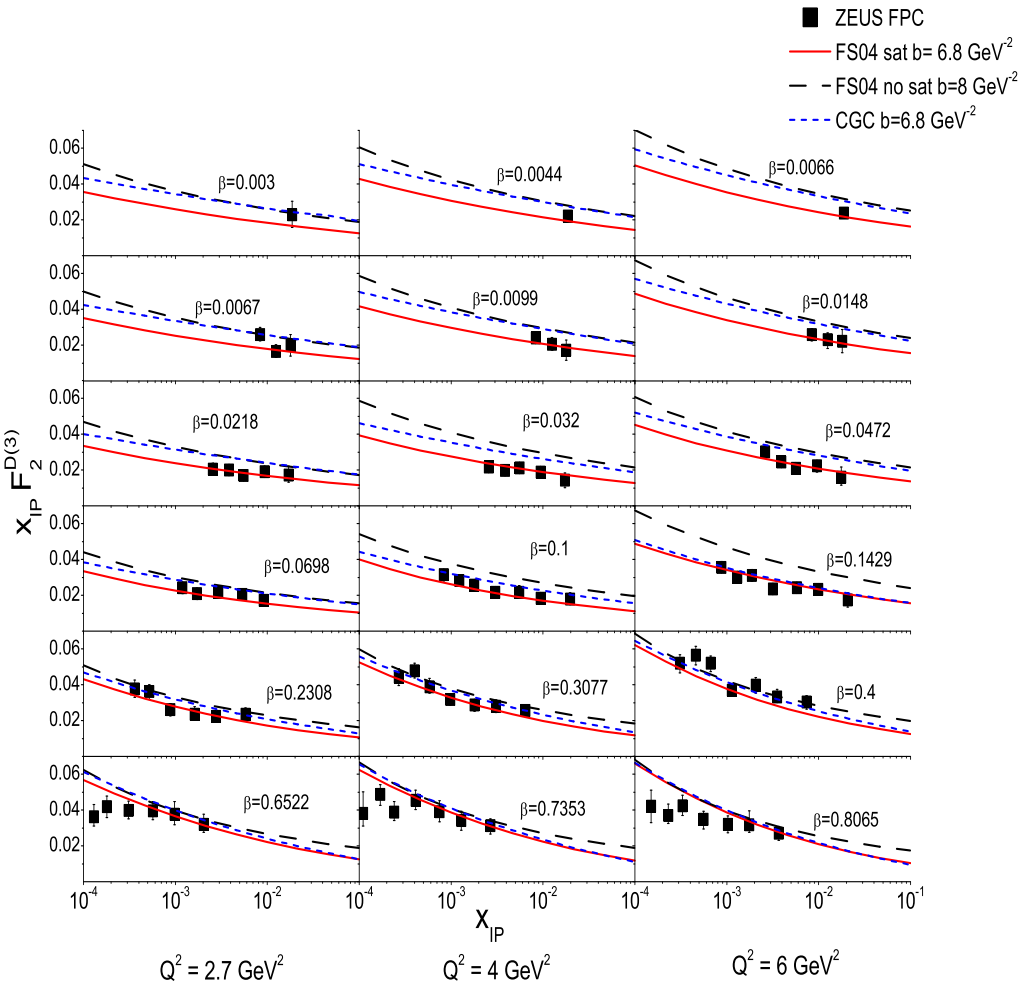
Contributions to $F_2^{D(3)}$ calculated using the CGC model: total (solid blackline); light $q\bar{q}$ (dashed red line); $q\bar{q}g$ (dash-dot blue line); $c\bar{c}$ (dashed red line). (Preliminary H1 data) $x_P = 0.003$, $Q^2 = 8.5, 15$

ZEUS LPS data - x_P dependence



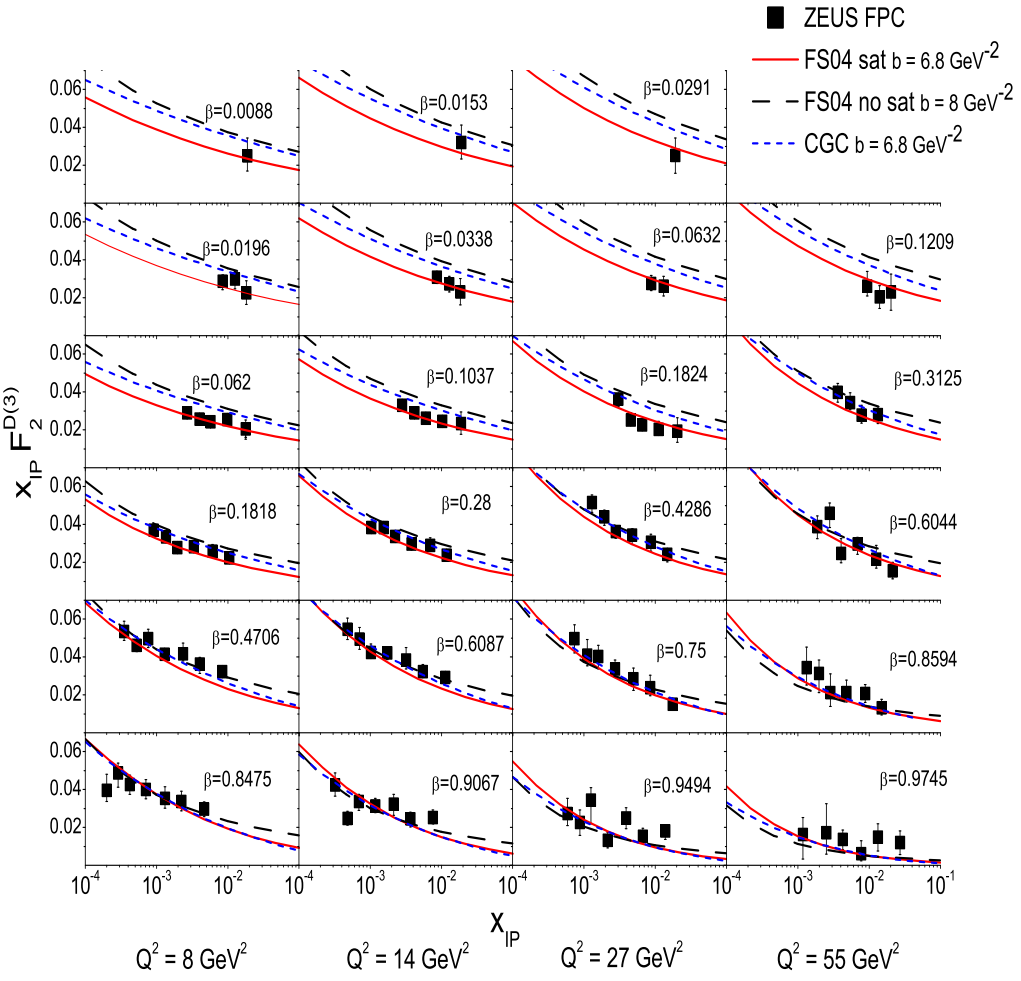
Data includes non-diffractive contribution.

ZEUS FPC data - x_P dependence at low Q^2



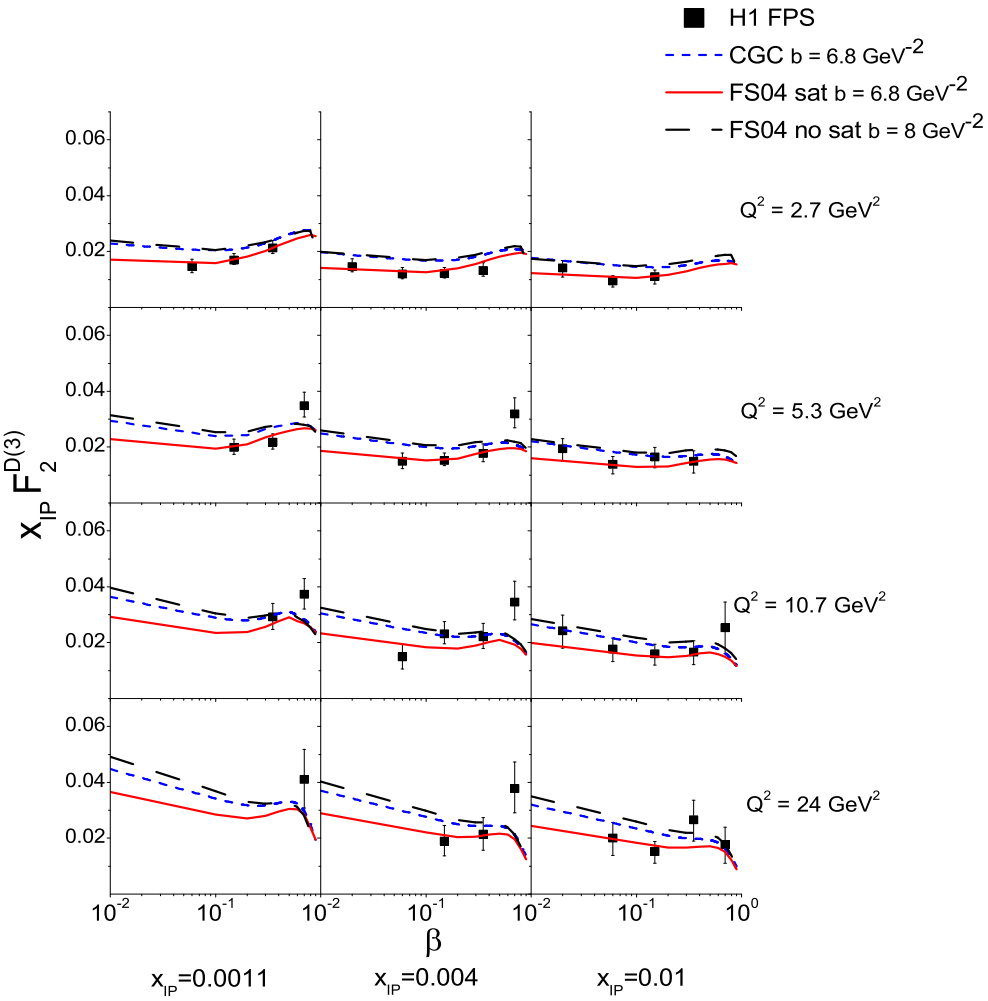
No non-diffractive. $M_Y < 2.3$ GeV - correction 0.7

ZEUS FPC data - x_P dependence at high Q^2

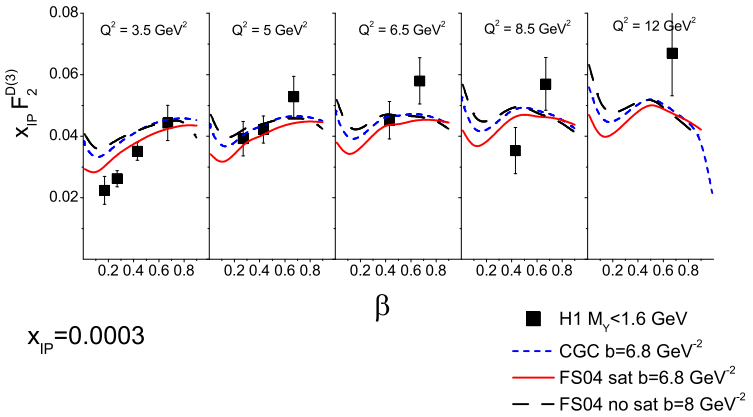


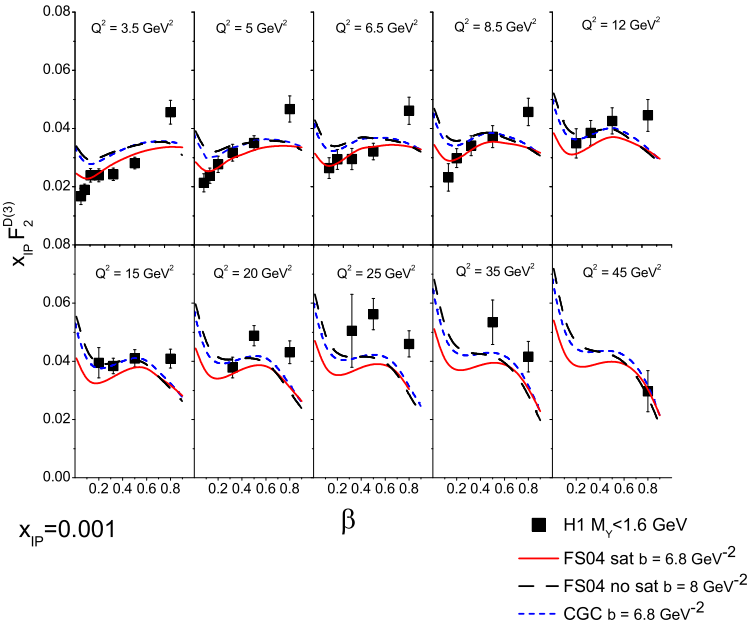
No non-diffractive. $M_Y < 2.3$ GeV - correction 0.7

H1 FPS data -β dependence



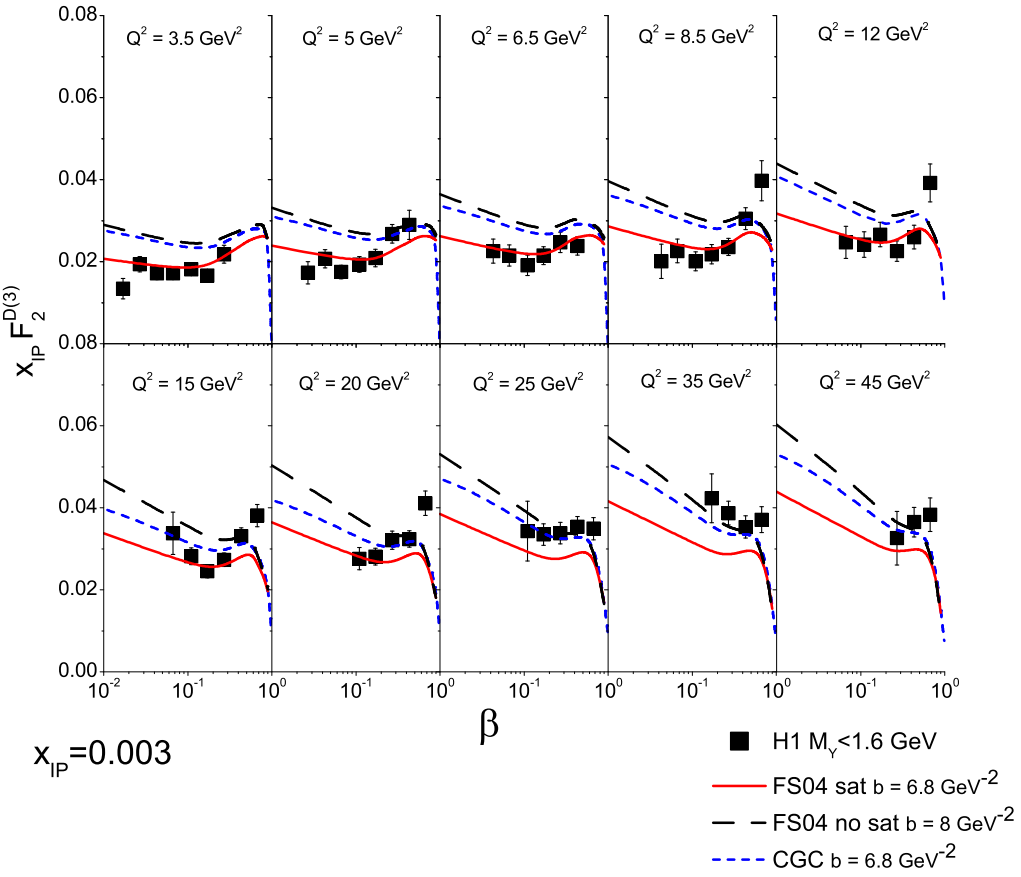
H1 M_Y cut data -β dependence





$M_Y < 1.6$ GeV. Correction factor 0.8.

H1 M_Y cut data -β dependence



$M_Y < 1.6$ GeV. Correction factor 0.8.

CONCLUSIONS

- Can only fit F_2 data set with "saturation."

- Excellent agreement for DDIS and DVCS data without adjustment of dipole parameters.

- Excellent agreement for J/Ψ with adjustment of charm mass, but not much dependence on the wavefunctions, at least for the simple cases considered.