

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

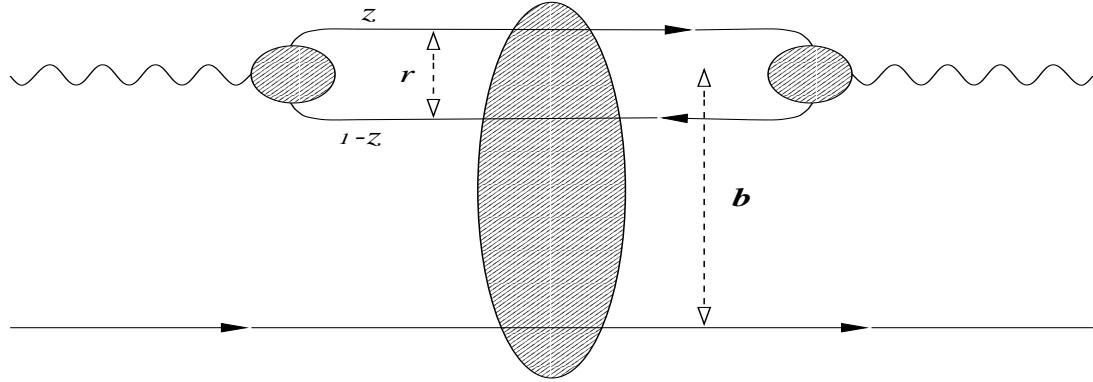
- Predictions for Exclusive Processes

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



$$\sigma_{\gamma^* p}^{T,L} = \int dz d^2r |\psi_{\gamma}^{T,L}(z, r, Q^2)|^2 \sigma(x, r, z)$$

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.

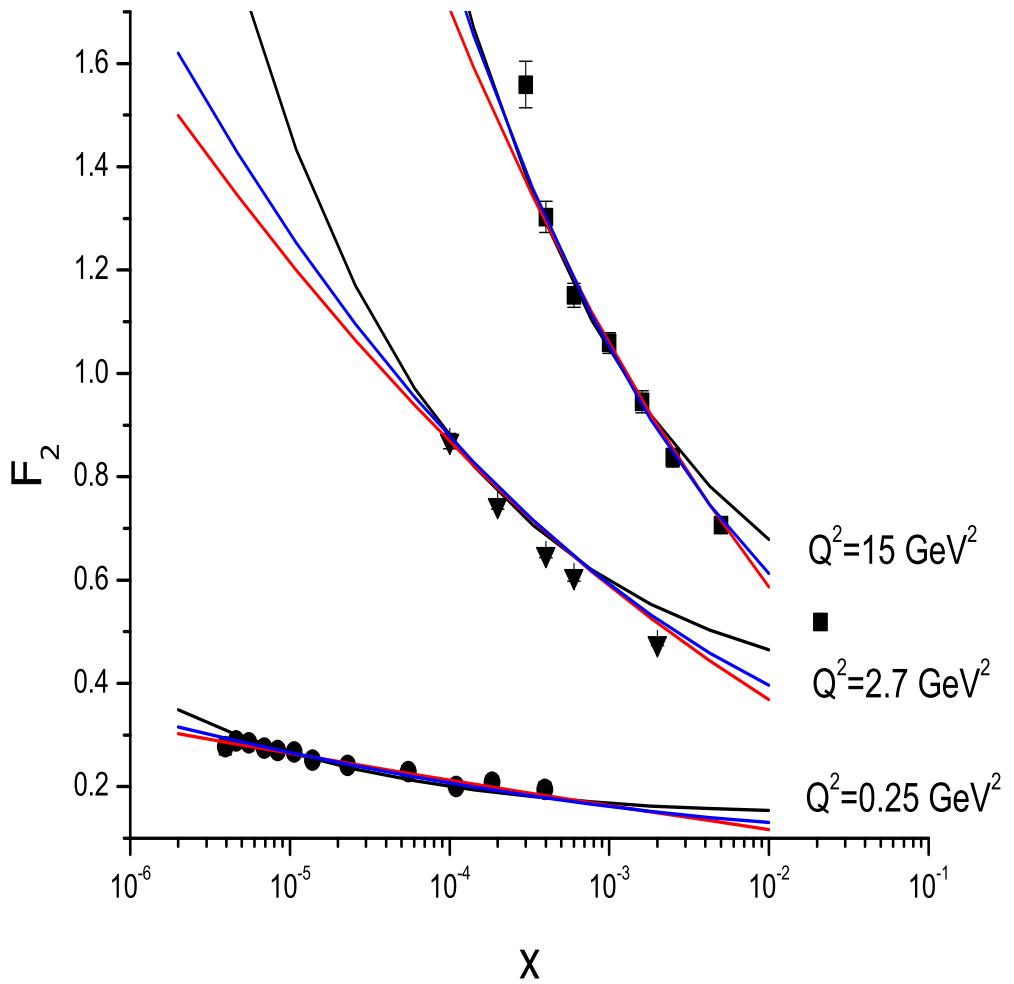
Fits exrtended to include charm‡

*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

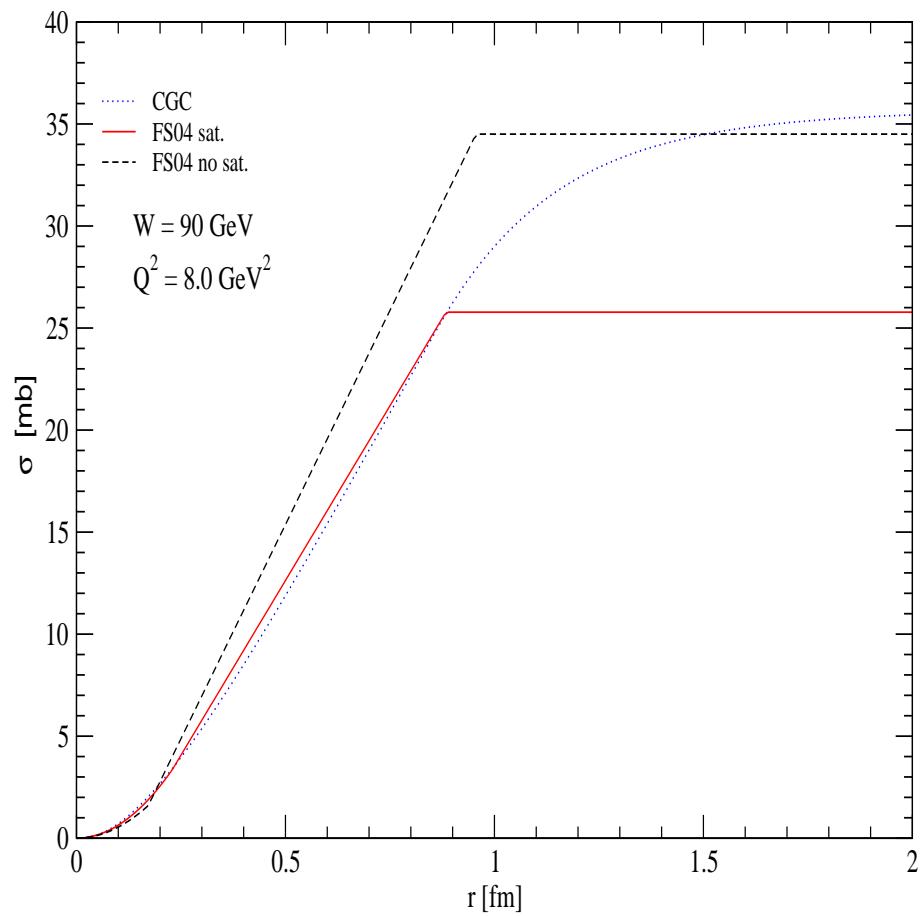
- BUT for DIS data in the range

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

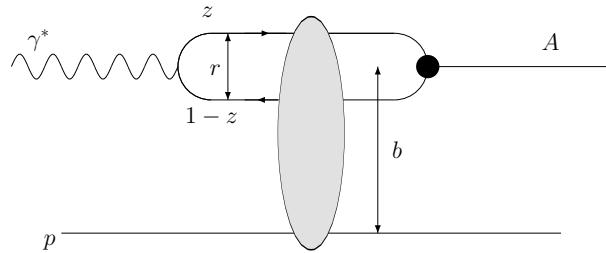
all three fits are satisfactory.

- 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



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

$$\sigma_{L,T}(\gamma^* p \rightarrow Ap) = \frac{1}{B} \frac{d\sigma^{T,L}}{dt} \Big|_{t=0} , \quad (2)$$

β is calculated from Regge signature factor, dispersion relations.

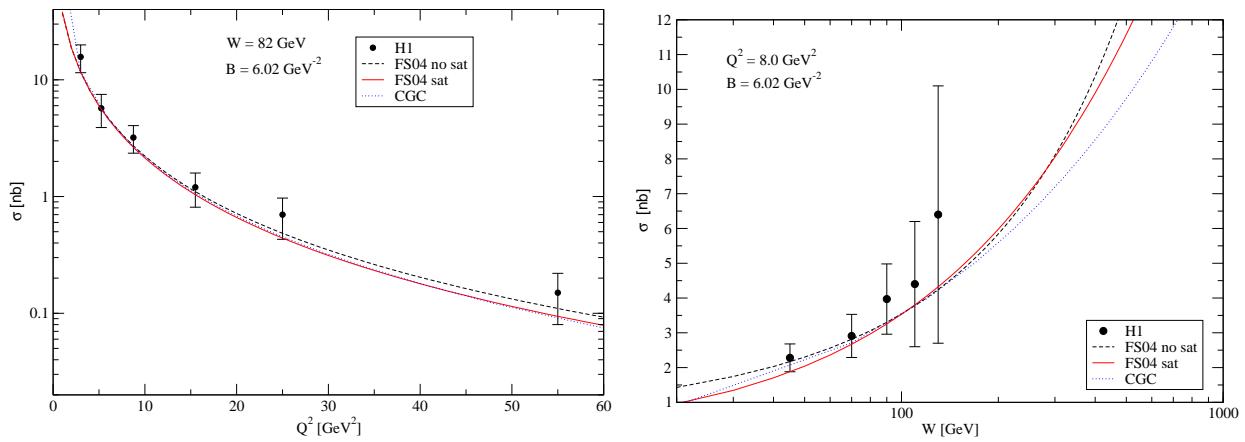
Slope parameter is taken from experiment

Need wavefunctions for vector mesons

DVCS

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

Comparison with HERA H1 data



No unknown wave function, no free parameters

J/ Ψ Production

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

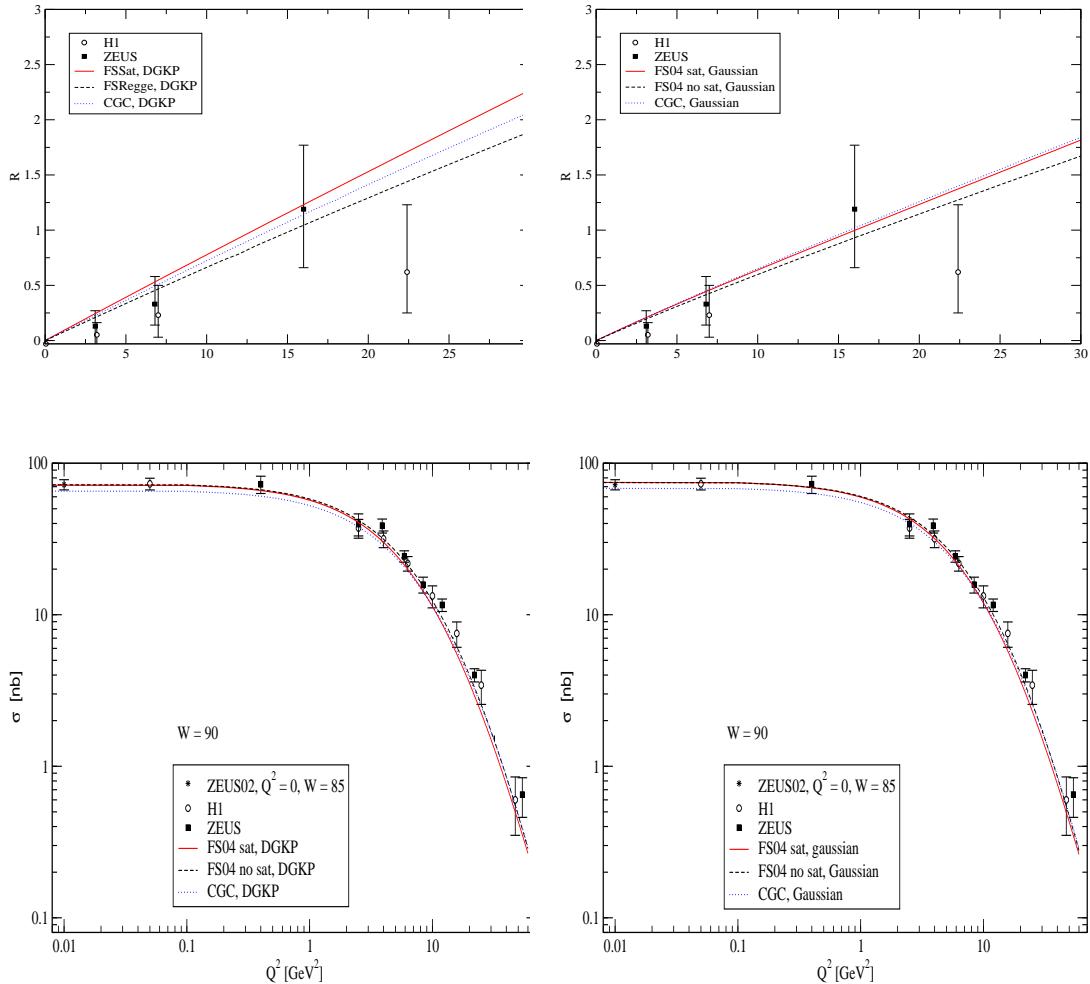
Predictions sensitive to charmed quark mass

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.

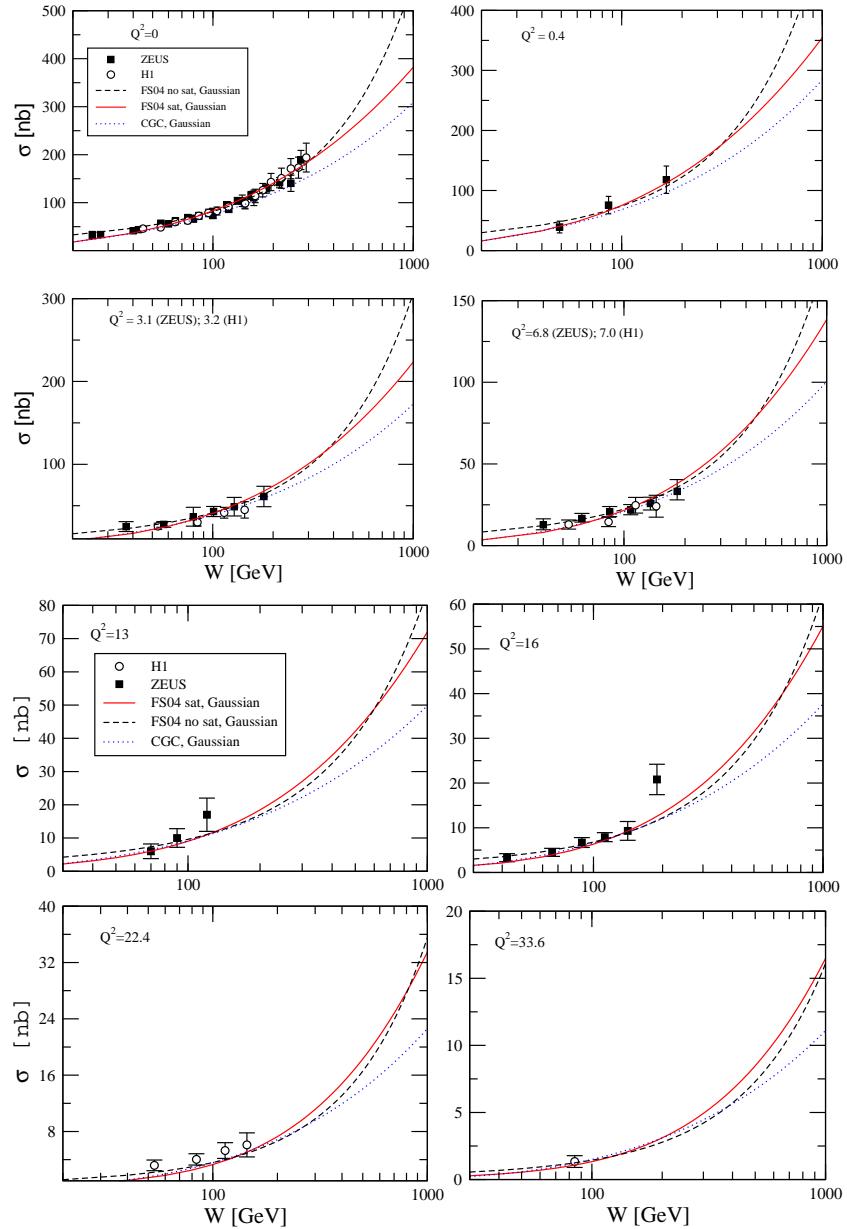
HERA data : Q^2 dependence



No strong dependence on choice of wavefunction.

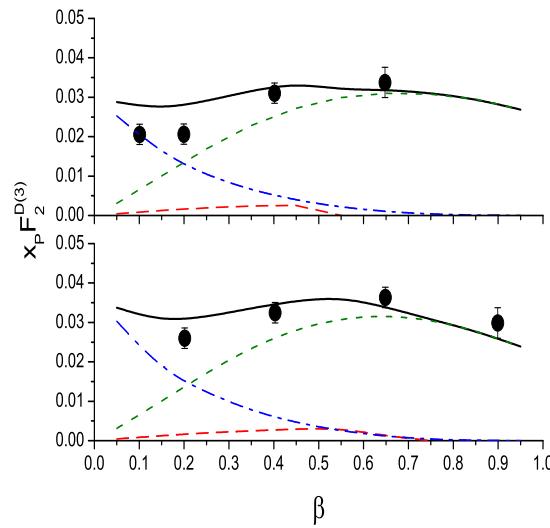
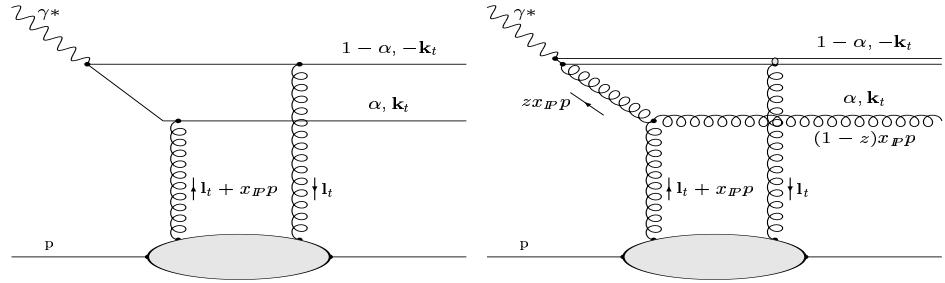
Depends on quark mass : chosen values
1.35(saturation models) 1.4 Regge model

HERA data : W-dependence



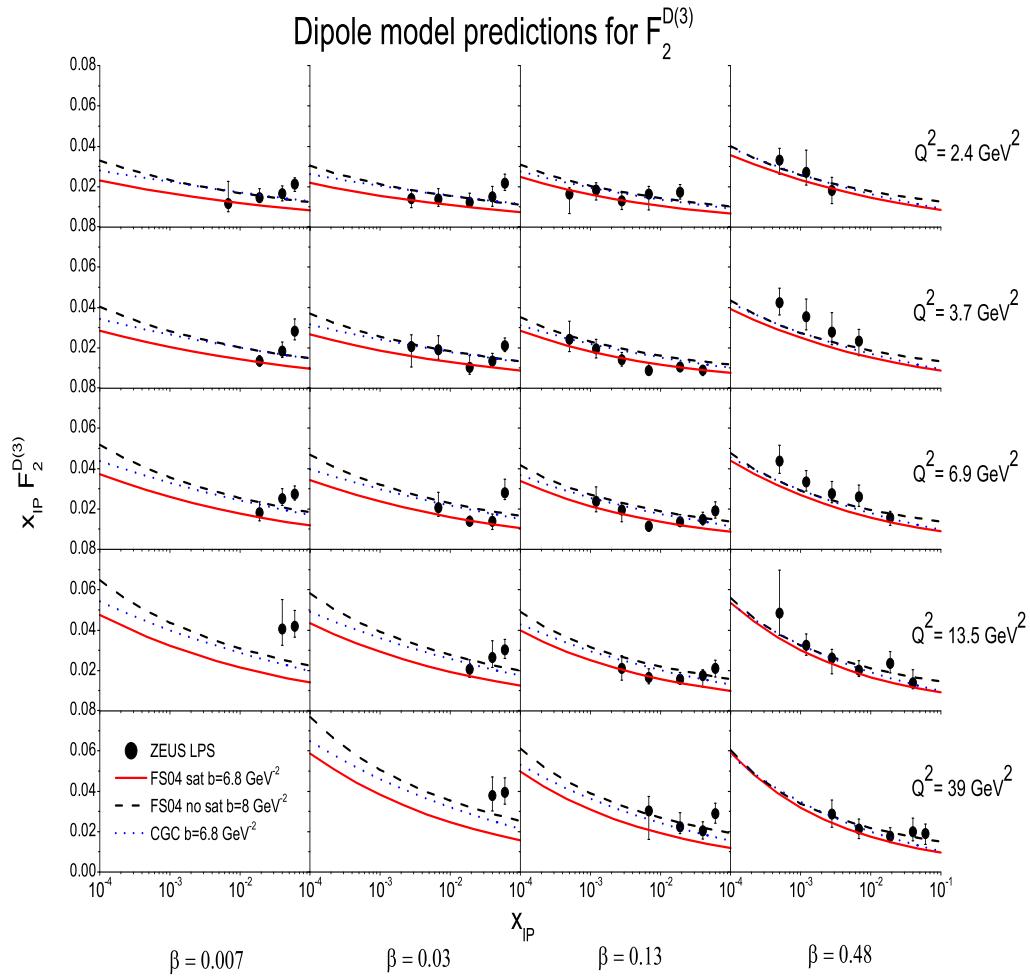
Just shown Gaussian : DGKP similar.

DDIS



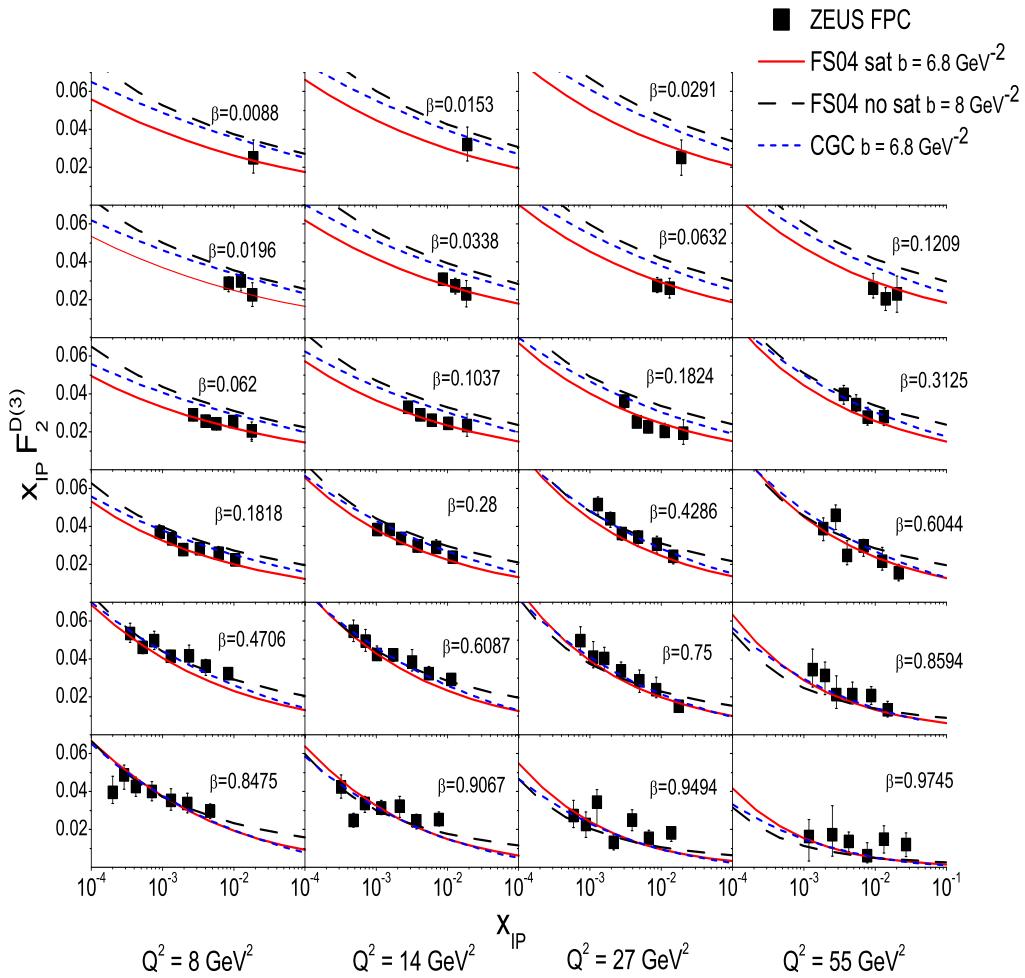
Contributions to $F_2^{D(3)}$ calculated using the CGC model: total (solid blackline); light $q\bar{q}$ (dashed red line); $q\bar{q}g$ (dash-dot blue line); $c\bar{c}$ (dashed red line).
 (Preliminary H1 data) $x_P = 0.003$, $Q^2 = 8.5, 15$

ZEUS LPS data - x_P dependence



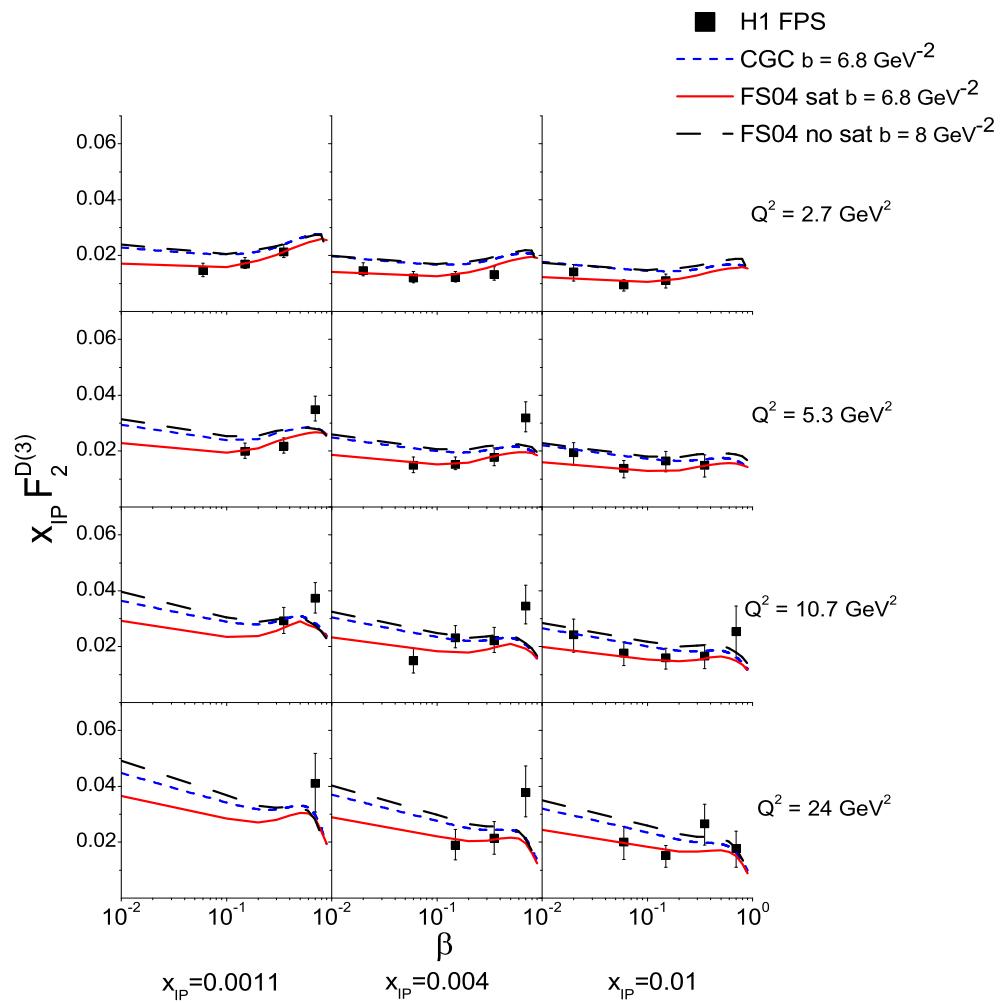
Data includes non-diffractive contribution.

ZEUS FPC data - x_P dependence

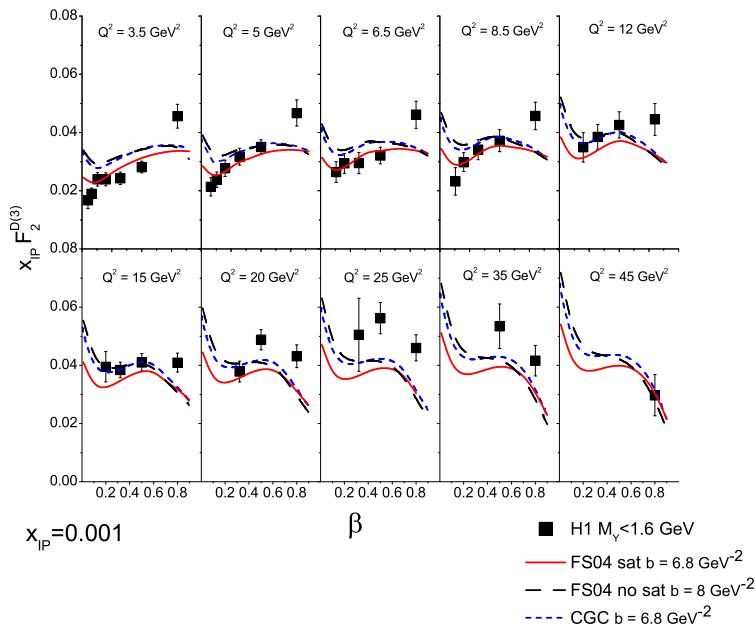
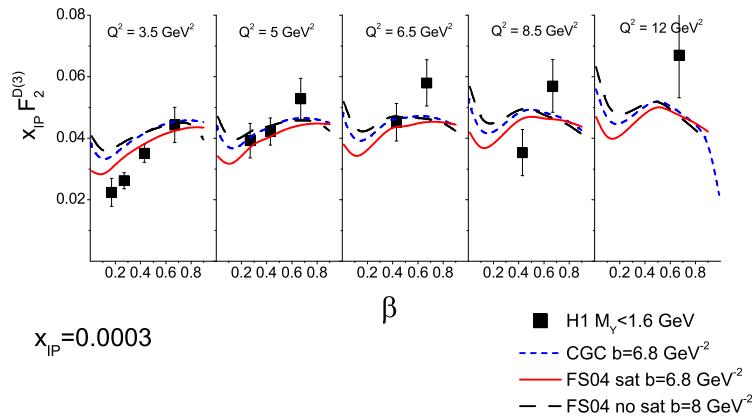


No non-diffractive. $M_Y < 2.3 \text{ GeV}$ - correction 0.7

H1 FPS data - β dependence



H1 M_Y cut data - β dependence



$M_Y < 1.6 \text{ GeV}$. 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.