Brief update from LHCb: photoproduction & gluon PDF

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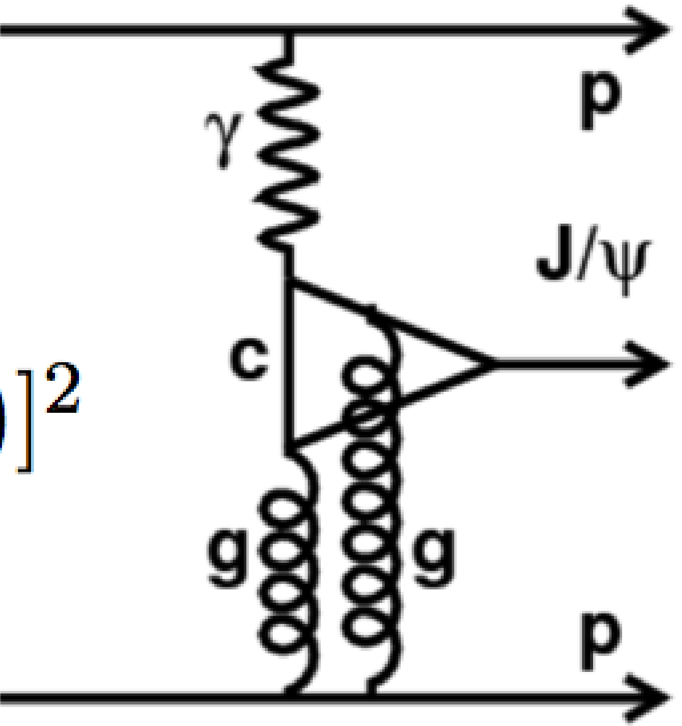
Photoproduction and the gluon PDF

- Exclusive production of J/ψ in pp collisions is sensitive to the gluon PDF
- At LO, σ is proportional to

$$[\alpha_S(M_V^2/4)xg(x, M_V^2/4)]^2$$

- Observed power-law dependence (compatible with pomeron trajectory or gluon PDF) from HERA: $\sigma(W) = aW^\delta$



Relationship between σ_{pp} and$\sigma_{\gamma p}$

$$\frac{d\sigma}{dy}_{pp\to pVp} = r(y)\left[k_{+}\frac{dn}{dk_{+}}\sigma_{\gamma p\to Vp}(W^{+}) + k_{-}\frac{dn}{dk_{-}}\sigma_{\gamma p\to Vp}(W^{-})\right]$$

absorptive correction

k » $\frac{M_{J/y}}{2}e^{y}$

photon flux

c.o.m. of γp: W^{2} » $x_{g}s$ $x = \frac{M_{J/y}}{\sqrt{s}}e^{\pm y}$

Note: Observation at rapidity y has two contributions coming from:

hard photon, (W^{+}) and thus low-x gluon

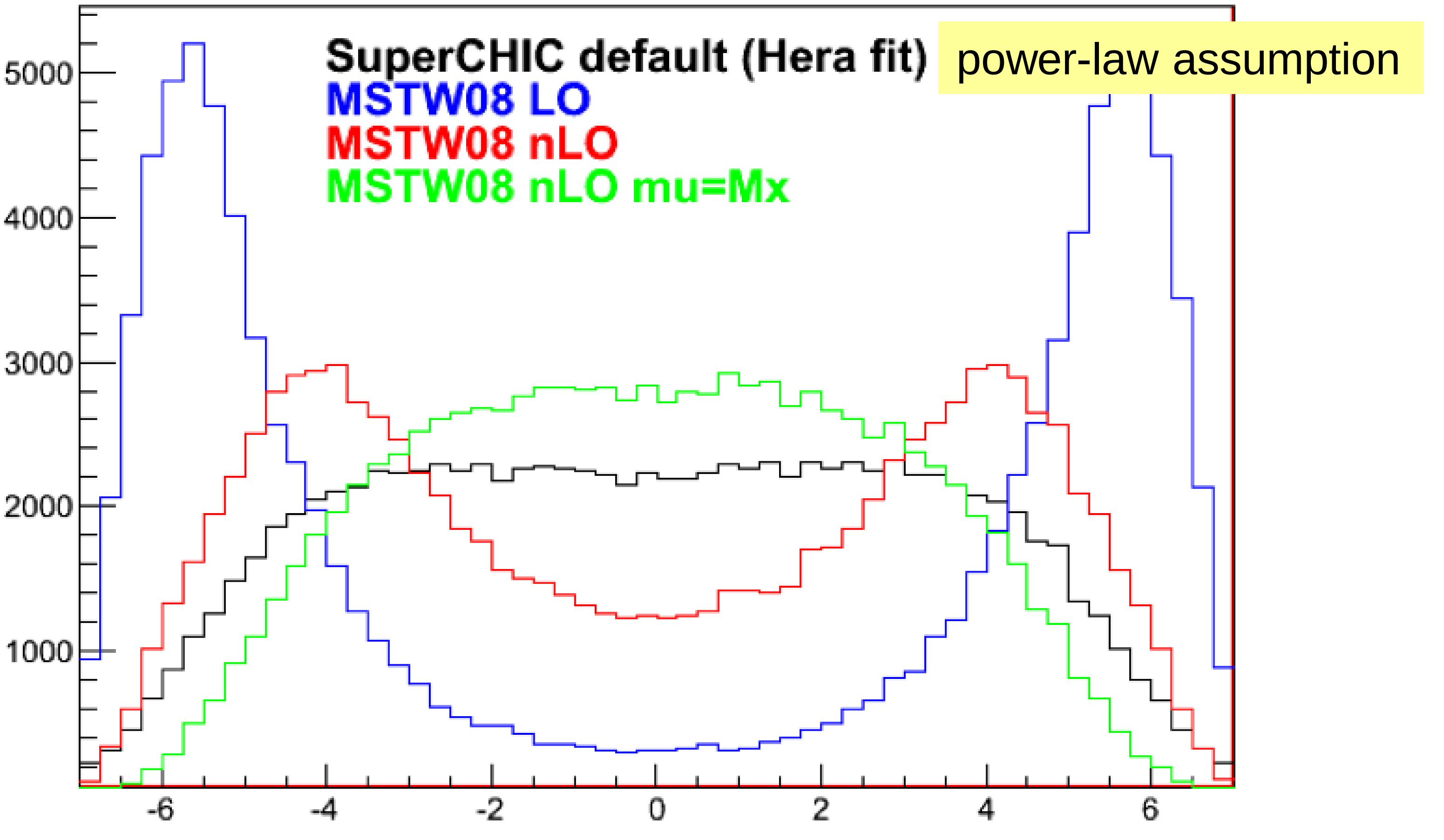
soft photon, (W^{-}) and high-x gluon.

Both absolute normalisation and shape depend on $\sigma_{\gamma p}$

Problems

1. Difficult to predict at LO/NLO
2. Absorptive corrections
3. Saturation effects

Dependence on order of calculation



This only shows shape dependence. Large normalisation difference as well.

Absorptive corrections
(Schaefer & Szczurk PRD 76 (2007) 094014)

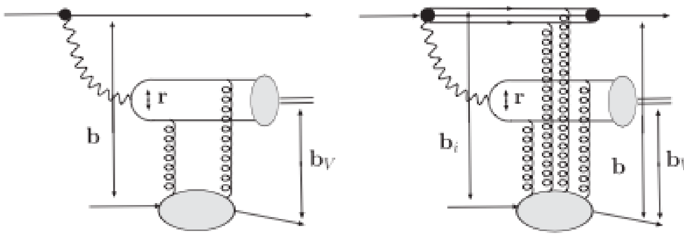
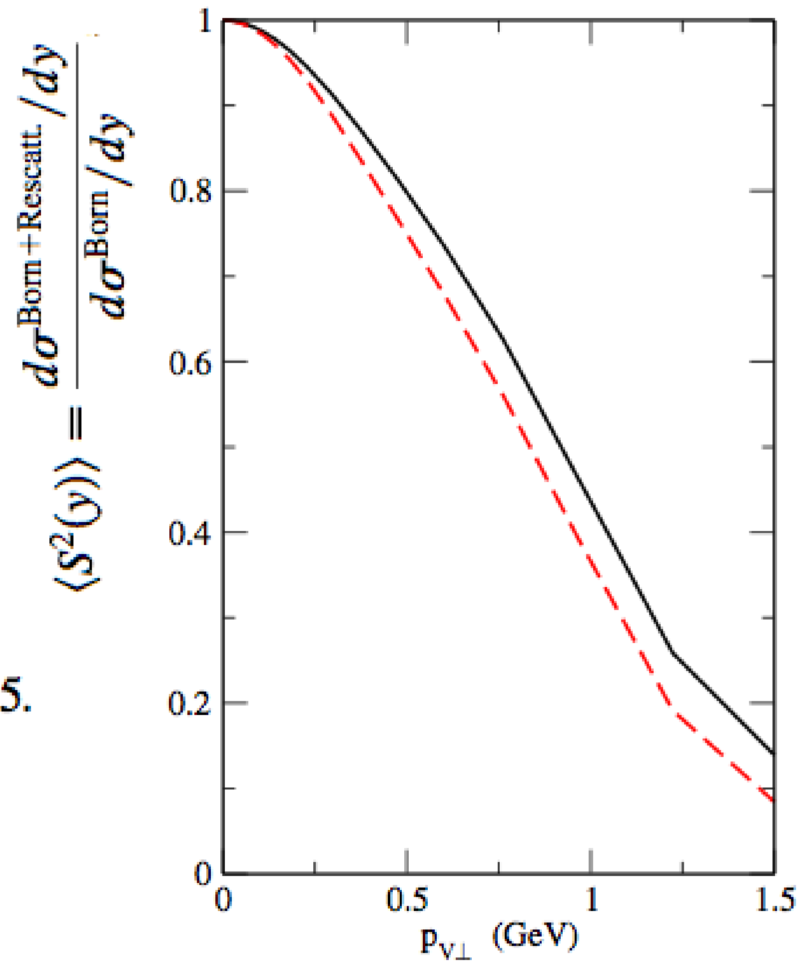


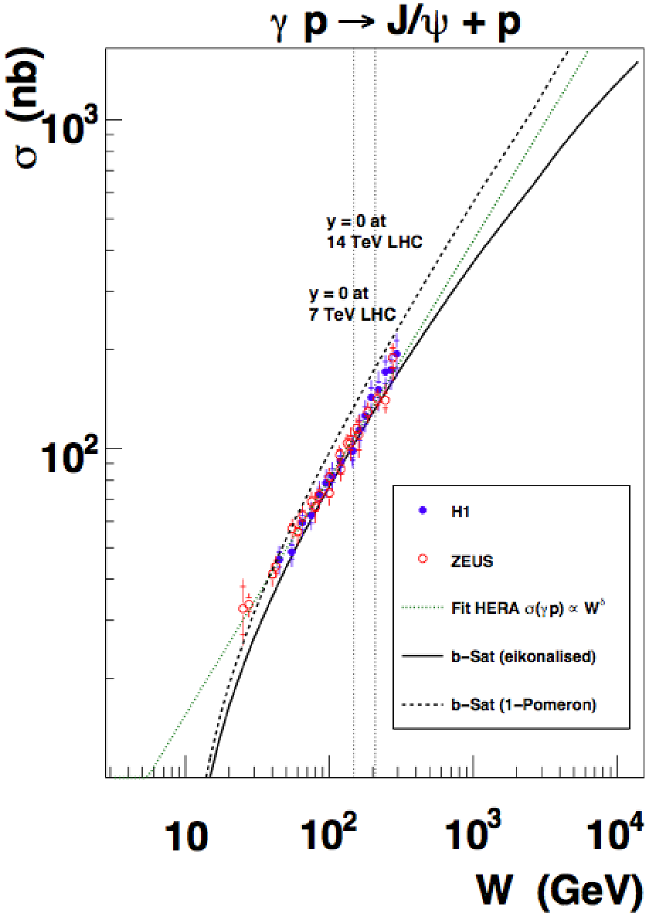
FIG. 2. Left panel: the QCD two-gluon exchange mechanism for the Born-level amplitude. Right panel: a possible multigluon-exchange contribution that involves uncanceled spectator interactions. The impact parameters relevant for the discussion are indicated.

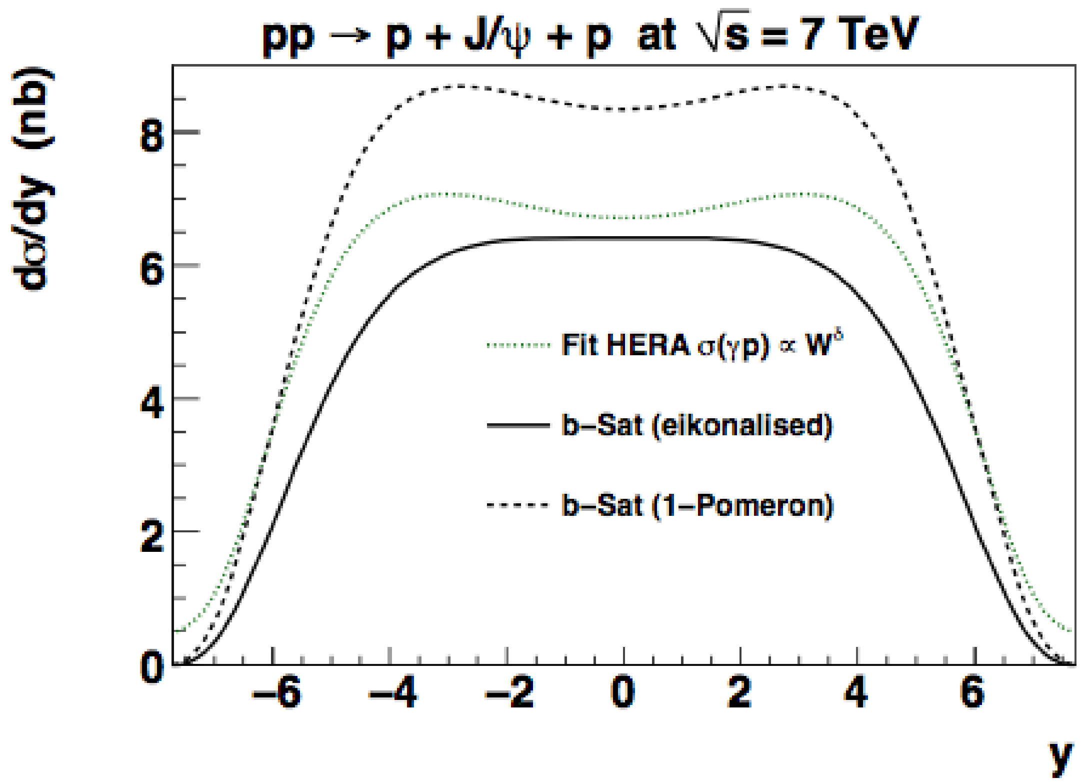


Rather flat dependence:

$$\langle S^2(y=0)\rangle|_{pp} \approx 0.85, \qquad \langle S^2(y=3)\rangle|_{pp} \approx 0.75.$$

Saturation effects (from Graeme Watt)





Fit to LHCb differential distribution

$$\frac{\mathrm{d}\sigma}{\mathrm{d}y}_{pp\to pVp} = r(y)\left[k_+\frac{\mathrm{d}n}{\mathrm{d}k_+}\sigma_{\gamma p\to Vp}(W^+) + k_-\frac{\mathrm{d}n}{\mathrm{d}k_-}\sigma_{\gamma p\to Vp}(W^-)\right]$$

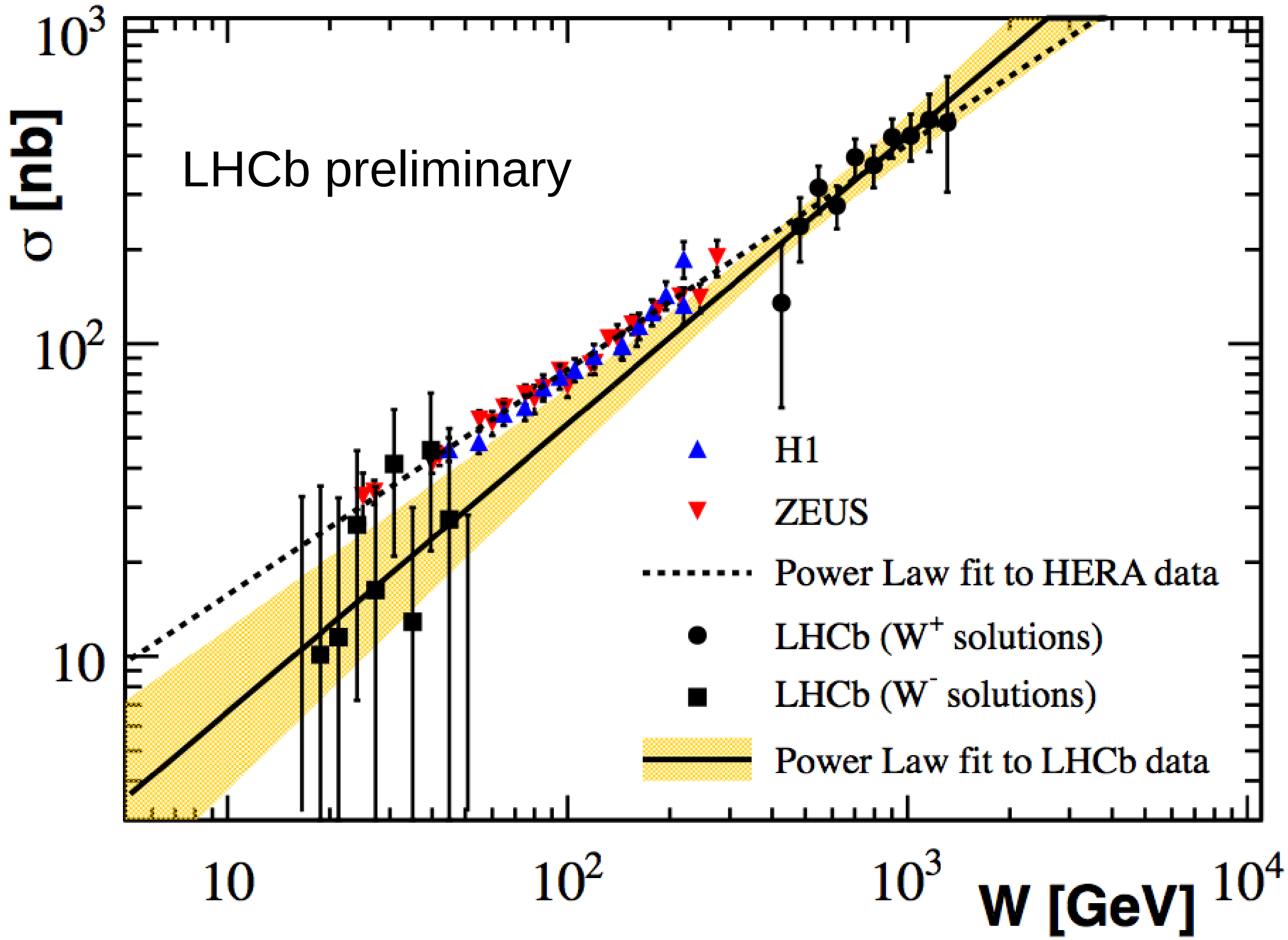
Assume power-law of form $W=aW^{\delta}$

$$\frac{d\sigma}{dy}_{pp\to pVp} = a(2\sqrt{s})^{\delta/2} r(y)\left[\frac{dn}{dk_+}{k_+}^{1+\delta/2} + \frac{dn}{dk_-}{k_-}^{1+\delta/2}\right]$$

$a = 0.8^{+1.2}_{-0.5}\,nb, d = 0.92 \pm 0.15$ in agreement with HERA fit a=3nb, δ=0.72

LHCb data consistent with power-law

LHCb data compared to HERA



Conclusions

- In principle, LHCb data can be used to constrain gluon PDF
- In practice, the large scale-uncertainties may mean that deviations from a power-law behaviour can be used to look for saturation effects.
- LHCb probes x values of 5×10^{-6}.