Diffractive Electromagnetic Processes from a Regge Point of View

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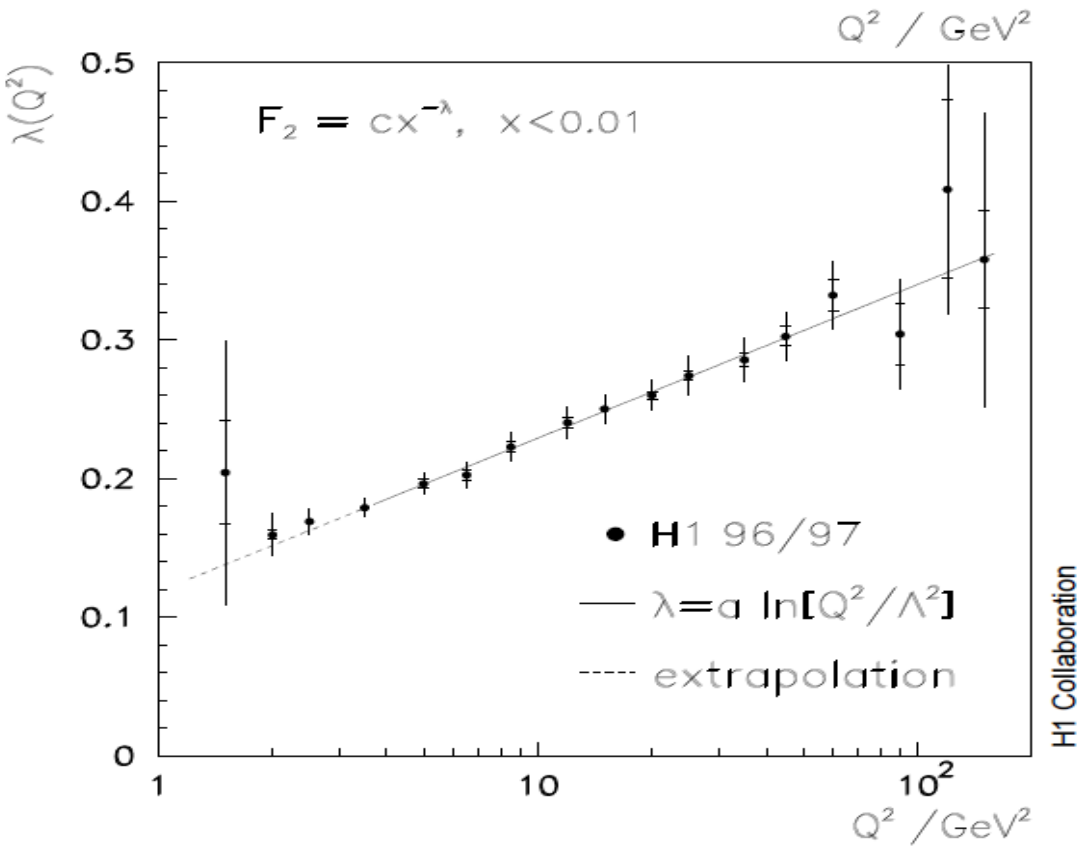
Phys. Rev. D, in print, arXiv:1507.03442

Motivation: Energy dependence of diffractive e m processes in Hera range: $\mathcal{T} = W^{2\lambda}$



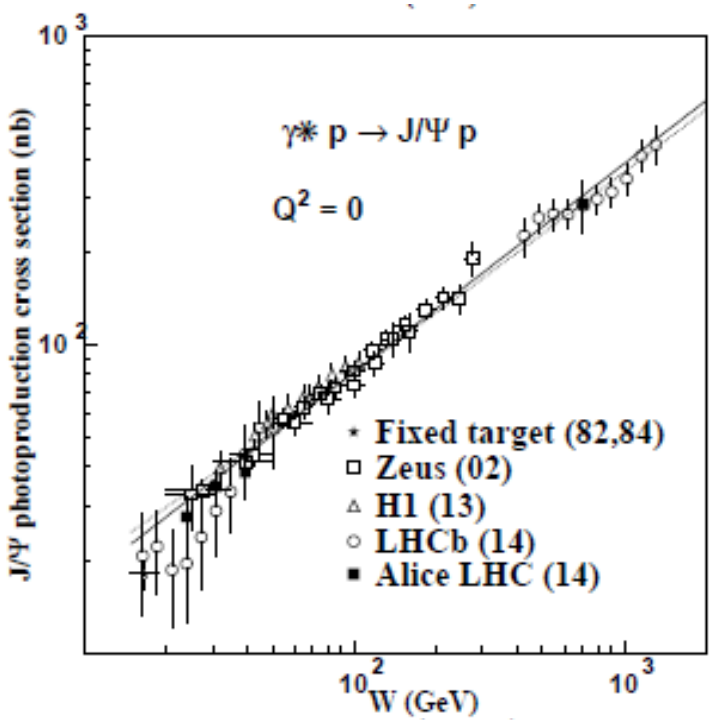
V. Radescu [H1 and ZEUS Coll.], arXiv:1308.0374

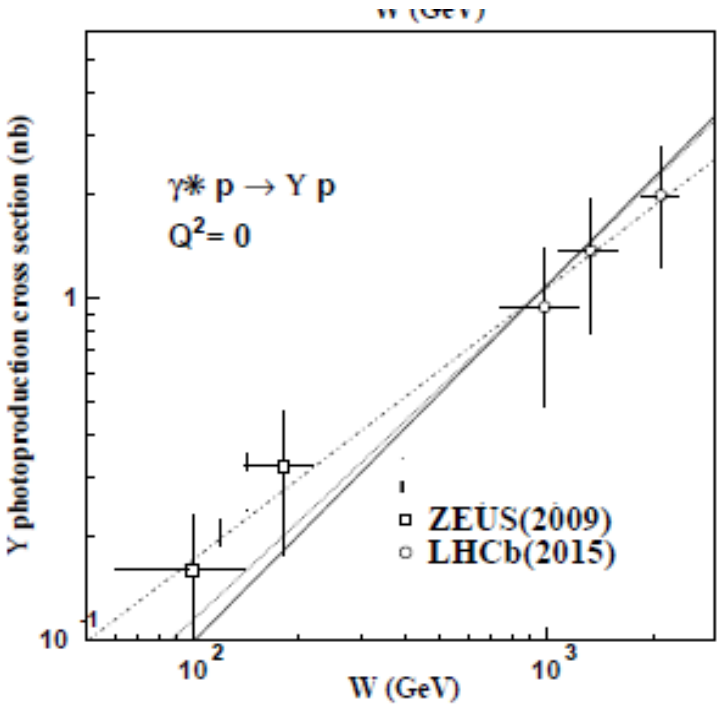
For VM production: $\lambda_\Upsilon > \lambda_{J/\psi} > \lambda_\rho$

Can in Hera Range be very well fitted by two pomerons.

Donnachie Landshoff ...

LHCb, Alice: J/ψ production in TeV region obtain the same single λ as obtained from HERA data.





[23] R. Aaij et al. [LHCb Coll.], J. Phys. G **41** , 055002 (2014)

[24] B. Abelev et al. [Alice Coll.], Phys. Rev. Lett. **113**, 232504 (2014)

[25] R. Aaij et al. [LHCb Coll.], arXiv: 1505.08139 [hep-ex]

Policy: Believe experimentalists

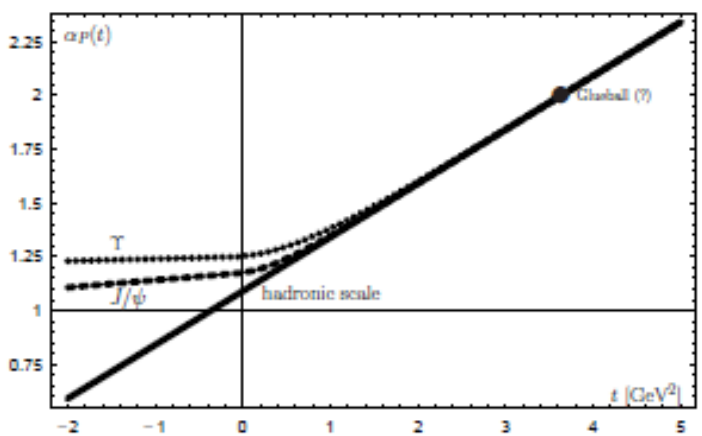
Consequence:
1) Dominance by a single Regge pole

2) Position on pole depends on scale

No contradiction to general principles.

Loss of predictivity. But:
Assume: Position depends only on scale of process.

Even if there are particle poles on the pomeron trajectory for t>0, it can be accomodated:



For hadronic scale (determined by confinement) : Usual soft pomeron

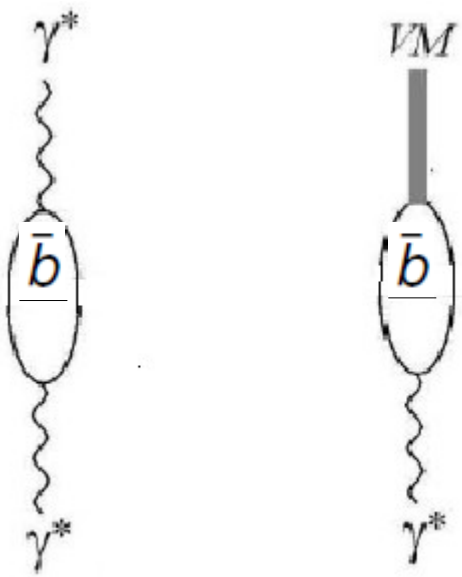
for smaller scales: deviations for negative t

Procedure:

From Hera data: $$\lambda(Q^2) = \alpha_{\mathbf{P}}(0) - 1 = 0.0481 \log\left[\frac{Q^2 + 0.554}{0.0853}\right] ,$$

adjusted for $\alpha_{\mathbf{P}}(0)$ =1.09

Relate Q^2 with hadronic size of photon $\rightarrow$ $\lambda\left(Q^2(\bar{b}^2)\right)$



$$\rho_{\gamma^*\gamma^*;\pm1}(Q^2, u, b_\perp) = \hat{e}_f^2 \frac{6\alpha}{4\pi^2} b_\perp \tag{8}$$
$$\left[(Q^2 u(1-u) + m_f^2)(u^2 + (1-u)^2)\, K_1^2(\epsilon b_\perp) + m_f^2\, K_0^2(\epsilon b_\perp)\right] ,$$

$$\rho_{\gamma^*\gamma^*;0}(Q^2, u, b_\perp)$$
$$= \hat{e}_f^2 \frac{12\alpha}{4\pi^2} b_\perp\, Q^2\, u^2(1-u)^2\, K_0^2(\epsilon b_\perp)$$

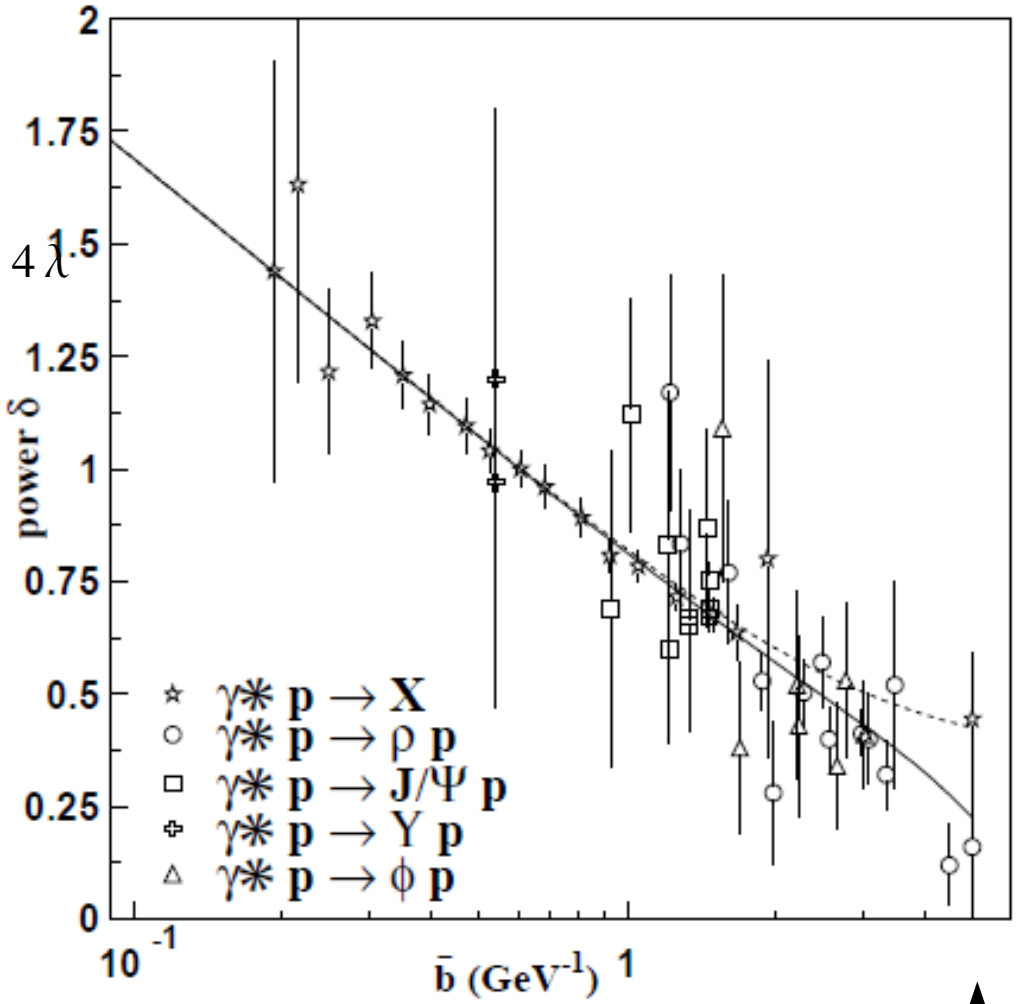
Determine hadronic size of overlap VM - γ^*

$$\rho_{\gamma^*,V;\pm1}(Q^2, u, b_\perp) = \hat{e}_V \frac{\sqrt{6\alpha}}{2\pi} b_\perp\, \phi_\omega(u, b_\perp)$$
$$\left[4\epsilon\, b_\perp\, \omega^2(u^2 + (1-u)^2)\, K_1(\epsilon b_\perp) + m_f^2\, K_0(\epsilon b_\perp)\right] ,$$

$$\rho_{\gamma^*,V;0}(Q^2, u, b_\perp)$$
$$= 16\hat{e}_V \frac{\sqrt{3\alpha}}{2\pi} b_\perp \omega\, Q\, u^2(1-u)^2\, K_0(\epsilon b_\perp)\, \phi_\omega(u, b_\perp)$$

Compare $\lambda(\bar{b}_{\mathrm{VM}})$ with $\lambda(\bar{b}_{\gamma^*})$

$\delta = 4\lambda$



γ^* Forward scattering amplitude

VM production:
Integrated cross sections

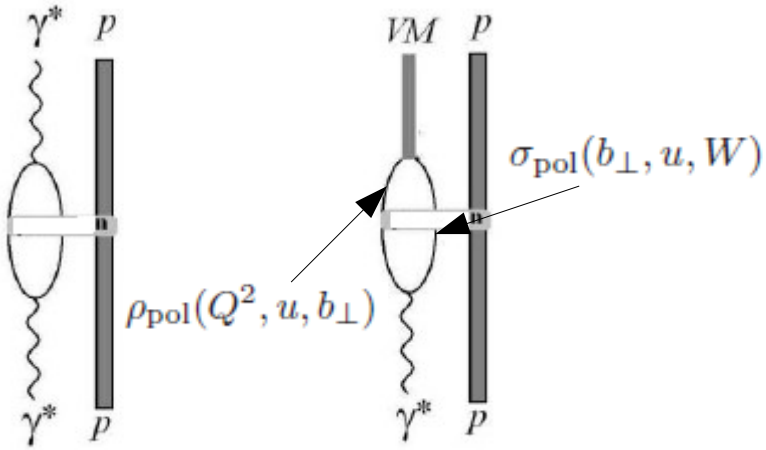
hadronic scale

Simple AdS model for Regge slope:

$$\alpha'_{\mathrm{p}} = \alpha' \frac{\bar{b}^2}{\bar{b}^2_{\mathrm{conf}}} ,$$

More detailed comparison later

Alternative model: **Energy dependent dipole cross section.**



$$\mathcal{T}_{0,\rm pol} = iW^2 \int_0^\infty db_\perp \int_0^1 du\, b_\perp\, \sigma_{\rm pol}(b_\perp, u, W)\; \rho_{\rm pol}(Q^2, u, b_\perp)\ .$$

$$\sigma_{\rm pol}(b_\perp, u, W) = \sigma_{\rm dip}(b_\perp, u)(W/W_0)^{2\,\beta_{\rm pol}(b_\perp, u)}\ .$$

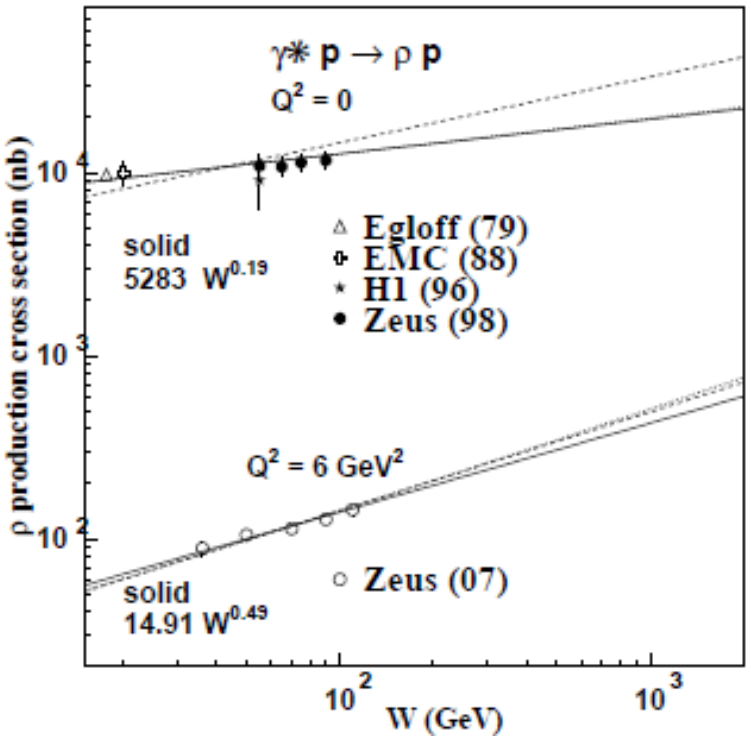
From data: $\beta_{\rm pol} = \beta_{\rm pol}(\zeta)$

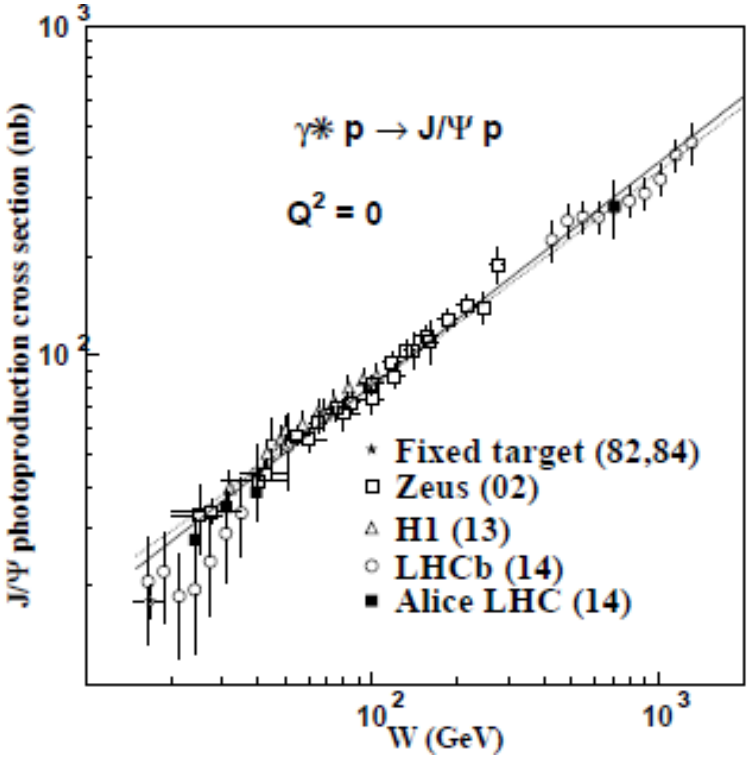
$$\zeta = \sqrt{u(1-u)}\, b_\perp$$

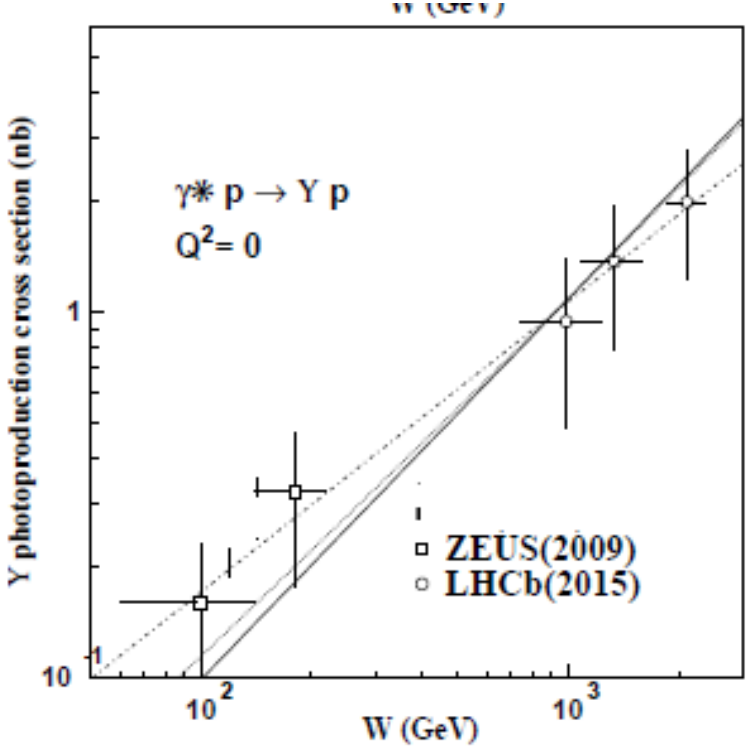
$$\tilde{\beta}_T(\zeta) = 0.0481 \log\left[\frac{10.47}{\zeta^2} + 6.541\right]$$

$$\tilde{\beta}_L(\zeta) = 0.0481 \log\left[\frac{17.68}{\zeta^2} + 6.530\right]$$

Q^2 GeV^2	λ(theory) HERA	LHC	λ(experiment) HERA
2	0.183	0.205	0.159±0.016
5	0.213	0.237	0.196 ± 0.01
15	0.258	0.288	0.250 ±0.01
25	0.280	0.310	0.274 ± 0.015
45	0.306	0.335	0.302 ± 0.02
60	0.319	0.348	0.332 ± 0.026
90	0.337	0.365	0.304 ± 0.05

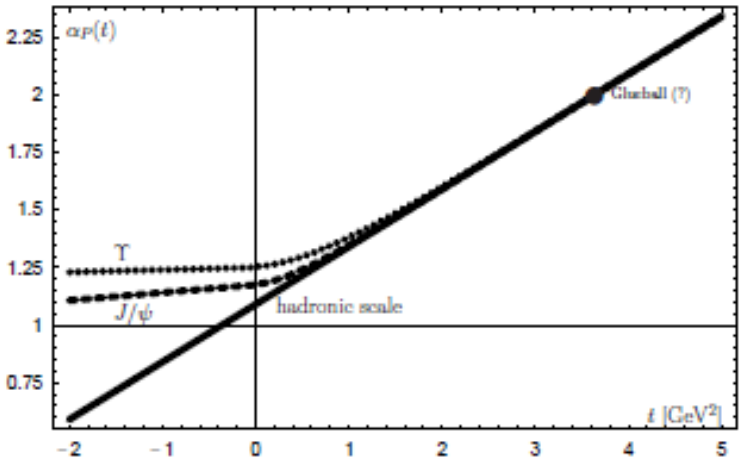






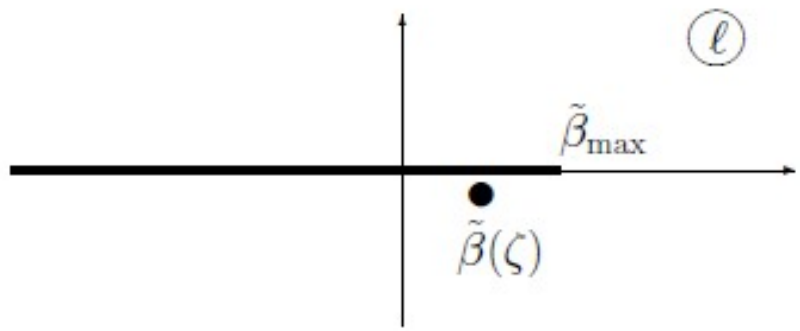
The two models give very similar results.

But different singularities in angular momentum plane:



scale dependent Regge pole

$$\mathcal{T}_a = W^{2\lambda(\bar{b})}$$



Regge cut with nearby pole

Energy dependent dipole cross section

$$\sigma_{\rm dip}(b_\perp, u)(W/W_0)^{2\,\beta_{\rm pol}(\zeta)}$$

asymptotic behaviour

$$\mathcal{T}_a \sim \left(\frac{W}{W_0}\right)^{\beta_0} L^{-(4-\epsilon)/n} \,. \qquad L = \log\frac{W}{W_0}$$

β_0 is maximum of $\beta(\zeta)$

Behaviour for finitel W depends crucially on form of $\beta(\zeta)$