Zero Momentum Gluons and total cross-section at LHC

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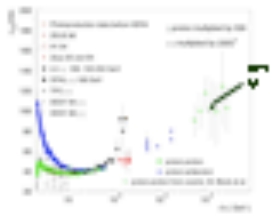
All total cross-sections rise with energy



- All hadronic cross-sections rise
- Do they stay in a curve clique?
- Do they obey the Froissart bound?

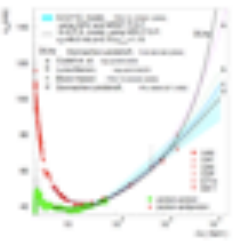
$$\sigma_{tot} \leq \log^2 s \quad as \quad s \to \infty$$

Hadronic total cross-section

Regge-eikonal analysis

Dual multiperipheral cascade gluon

$$\sigma_{tot} \sim \log^2 s$$



Our prediction

$$\sigma_{tot}^{LHC} = 102^{+10}_{-13} \text{ mb}$$

1. The dual multiperipheral model - dual gluon exchange - dipole model

Dipole model (Kuti-Weisskopf)

Dipole model (Nikolaev-Zakharov)

Saturation

The Multiperipheral model for elastic and total cross-section

Multiperipheral

Multiperipheral

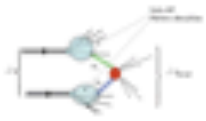
Multiperipheral

Multiperipheral

Multiperipheral

Multiperipheral

The elastic cross-section

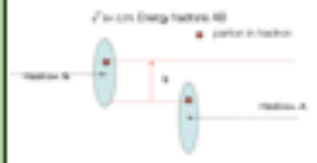


Chaos in QCD and other models: GRAPTOO, MGF, ...

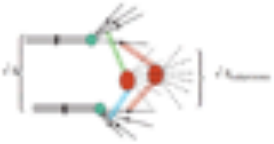
Fail to describe Froissart, MI

Difficulty in the elastic cross-section in the dual approximation for impact parameter, and possible fix with gluons

The diffractive cross-section - elastic in the impact parameter space



The diffractive cross-section implies multiple-scattering



Takes the impact parameter distribution and total cross-section

The gluon momentum distribution

$$d^2P(K_\perp) = \frac{d^2K_\perp}{(2\pi)^2} \int d^2b e^{iK_\perp \cdot b} e^{-h(b,s)}$$

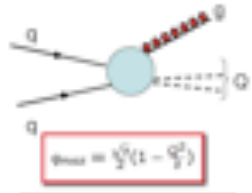
$$h(b,s) = \alpha_s(s) + \frac{16}{3}\int_{k_0}^{s} \frac{\alpha_s(k_\perp)}{k_\perp} dk_\perp \approx \frac{16}{3}\frac{\alpha_s}{k_0}$$

$$\approx \frac{16}{33-2N_f}\left[\ln\frac{16}{3} + \left[\ln\ln\frac{s}{\Lambda^2} - \ln\ln\frac{k_0^2}{\Lambda^2}\right] - \ln\frac{k_0^2}{\mu^2}\right]$$

Multiperipheral Feynman diagrams

$$h(b,s) = \alpha_s \int d^2k_\perp e^{-ik_\perp \cdot b} \frac{d^2P(k_\perp)}{dk_\perp^2} = \int d^2k_\perp \frac{\alpha_s(k_\perp)}{k_\perp^2}$$

$$h(b,s) = \frac{16}{3}\int_{k_0}^{s} \frac{\alpha_s(k_\perp)}{k_\perp} dk_\perp \ln\frac{s}{k_\perp^2} - h(b,s)$$

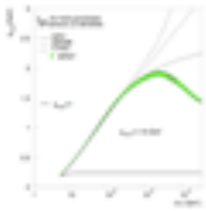


$$\phi_{max} = \frac{\sqrt{s}}{2}\left(1 - \frac{Q^2}{s}\right)$$

Analytic - in the eikonal

$$\alpha_s(k_\perp^2) = \frac{\int_0^1 dz \int_0^{2\pi} d\phi_k \int_0^{2\pi} d\phi_{k'} \alpha_s(k_\perp^2)\alpha_s(k'^2_\perp) - \alpha}{\int_0^1 dz \int_0^{2\pi} d\phi_k \int_0^{2\pi} d\phi_{k'} \alpha_s(k_\perp^2)}$$

$$\alpha_{max} = \alpha_s(\sqrt{s}/2)$$



Our model has momentum gluon

$$\alpha_s(k_\perp^2) = \frac{12\pi}{(33-2N_f)\ln(s/\Lambda^2)} \frac{p}{p(\ln^2 k_\perp^2/\Lambda^2)} \approx \frac{1}{k_\perp^{2p}} \quad k_\perp \to 0$$

Dually - analytically the dual

Dually the momentum gluon $\Pi_\perp$

2. Dual gluon in the dipole law - eikonal - in terms of the Froissart bound

Analytically simple :

$$\sigma_{tot} \approx 2\pi \int_0^\infty (dP^2)[1 - e^{-\alpha_{dual}(h(s))}]$$

$$\alpha_{dual}(b,s) = \sigma_{pp}(s) A_{dual}(b,s)$$

$$\sigma_{pp}(s) \approx \left(\frac{s}{s_0}\right)^p \sigma_1$$

$$A_{dual}(b,s) \approx e^{-h(b,s)}$$

$$h(b,s) = \int d^2 n_g(k)[1 - e^{-ikb}]$$

$$d^2 n_g(k) \propto \alpha_s(k_\perp^2)$$

$$\alpha_s(k_\perp^2) \approx \frac{1}{(k_\perp)^{2p}} \quad as \quad k_\perp \to 0$$

Eikonal - analytically

$$A_{dual}(b,s) \propto e^{-(bq)^{2p}}$$

$$\alpha_{dual} = 2C(s/s_0)^p e^{-(bq)^{2p}}$$

$$\frac{1}{2} < p < 1$$

$$\sigma_{tot}(s) \approx 2\pi \int_0^\infty dP^2[1 - e^{-C(s)e^{-(bq)^{2p}}}]$$

More Gluons - momentum - eikonal

$$\sigma_{tot}(s) \to [s\ln(s)]^{C(s)}$$

$$\frac{1}{p} \leq 2$$

Phenomenology - Regge - eikonal