Rapidity gap survival and the unitarity limit

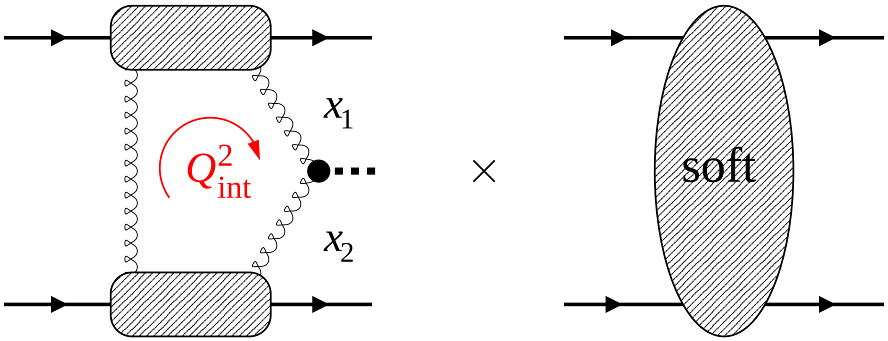
Ch. Weiss (JLab), DIS2007, Munich, Apr. 16–20, 2007
[with L. Frankfurt, Ch. Hyde, M. Strikman, PRD **75**, 054009 (2007)]

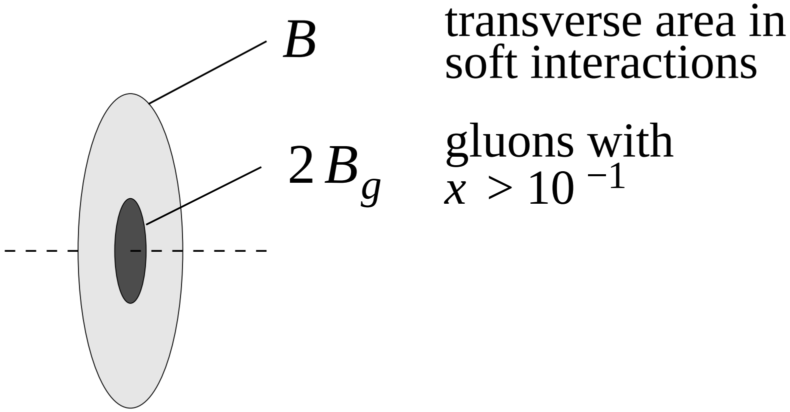
Parton–based approach to rapidity gap survival
in double–gap exclusive diffraction

$$pp \rightarrow p + H + p, \qquad H = \text{dijet}, \gamma\gamma, \bar{Q}Q, \text{Higgs}, \ldots$$

- Model–independent treatment $\leftrightarrow$ Pomeron exchange
- Unitarity limit in hard spectator interactions (black–disk regime)
- Correlations between partons

Hard and soft interactions in $pp \to p + H + p$





- H produced in hard process with two–gluon exchange

  $\mu^2_{\text{soft}} \ll Q^2_{\text{int}} \ll M^2$ [Khoze et al. 97]

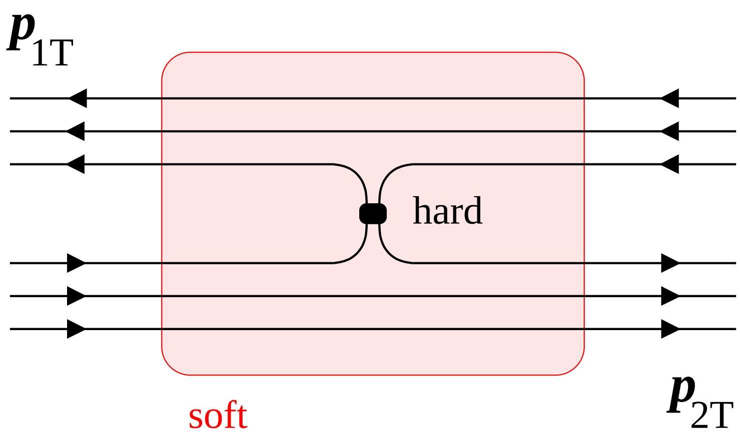
  $x_{1,2} \sim \frac{M}{\sqrt{s}} \sim 10^{-2}$ Higgs at LHC

- Soft interactions must not produce particles

  $$S^2 \equiv \frac{\sigma_{\text{diff}}(\text{full})}{\sigma_{\text{diff}}(\text{no soft})}$$ Gap survival probability

- Challenge: Describe interplay of hard and soft interactions!

Independence of hard and soft interactions



$$T_{\text{diff}}(\boldsymbol{p}_{1T}, \boldsymbol{p}_{2T}) \;=\; N \int d^2\Delta_T$$
$$\times\, G(x_1, \boldsymbol{p}_{1T} - \boldsymbol{\Delta}_T)$$
$$\times\, G(x_2, \boldsymbol{p}_{2T} + \boldsymbol{\Delta}_T)$$
$$\times\, S_{\text{elast}}(\boldsymbol{\Delta}_T)$$

- Hard process local on distance/time scale of soft interactions

  hard $\overset{\text{independent}}{\longleftrightarrow}$ soft

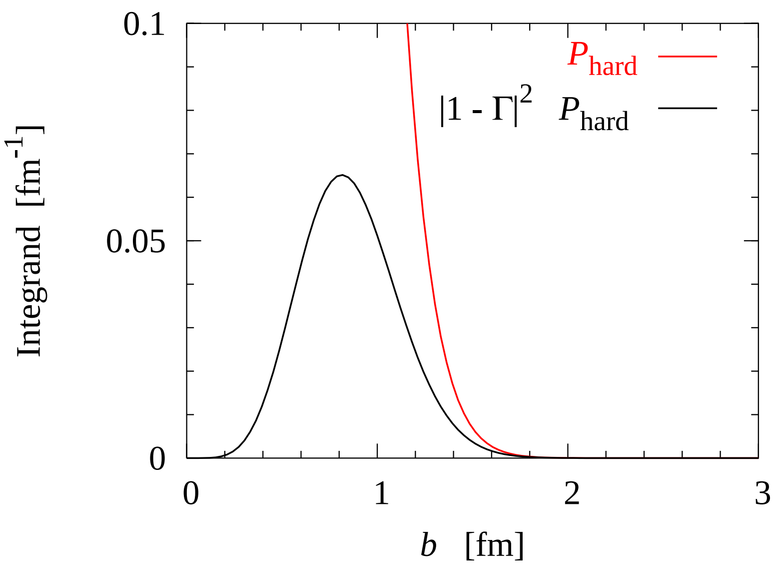
- Amplitude calculable through

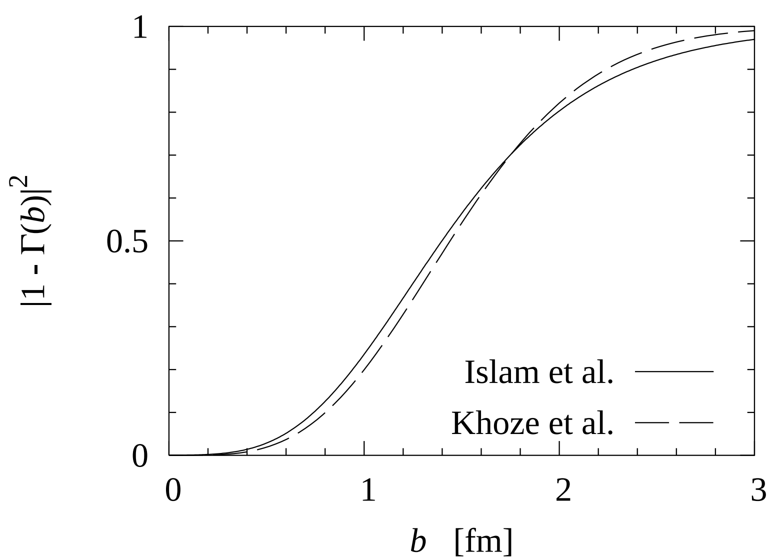
gluon GPD	exclusive J/ψ
pp elastic S–matrix	elastic scattering total cross section

- Model–independent treatment
  $\leftrightarrow$ eikonalized Pomeron exchange

[Details: FHSW, PRD **75**, 054009 (2007)]

Rapidity gap survival probability



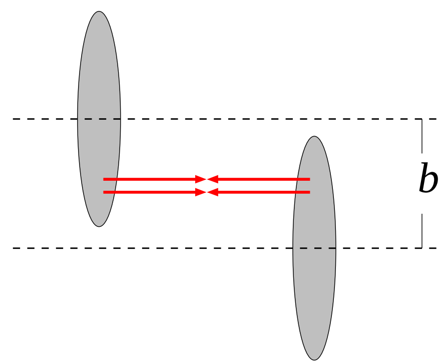


- Gap survival probability

$$S^2 = \int d^2b \quad P_{\text{hard}}(b) \quad |1 - \Gamma(b)|^2$$

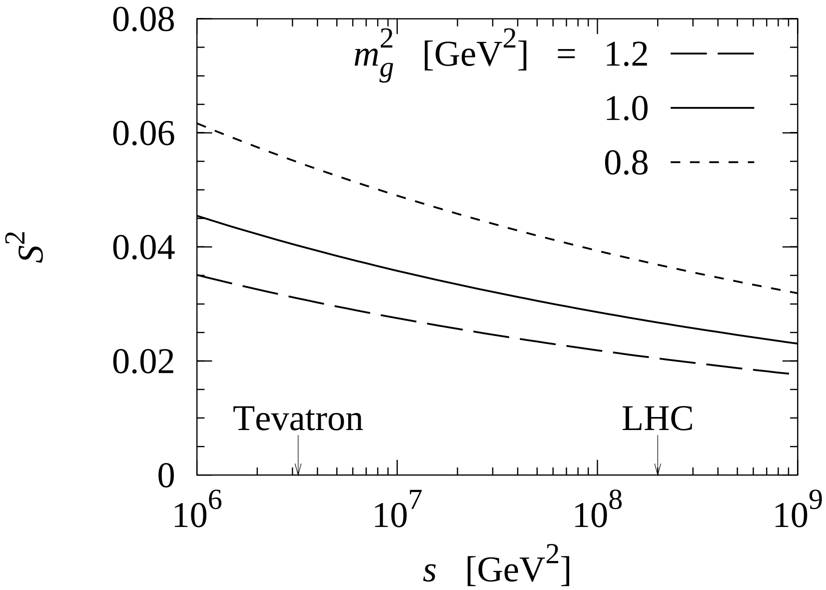
Probability for two gluons to collide

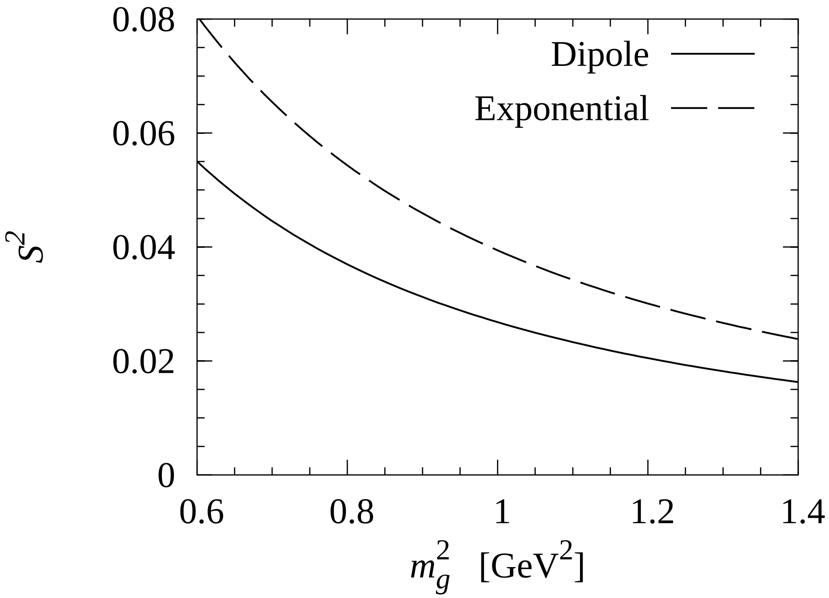
Probability for "no inelastic interaction"



"Geometric" picture of RGS

RGS probability: Numerical results





- Dominant effect: "Blackness" of pp amplitude suppresses small b

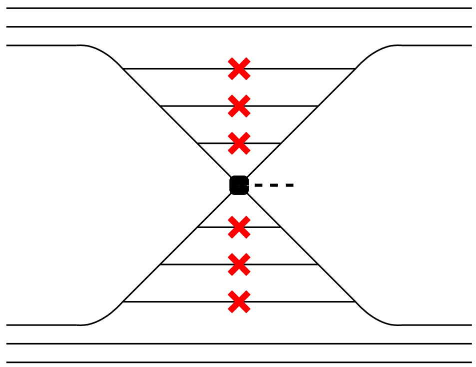
  . . . model–independent!

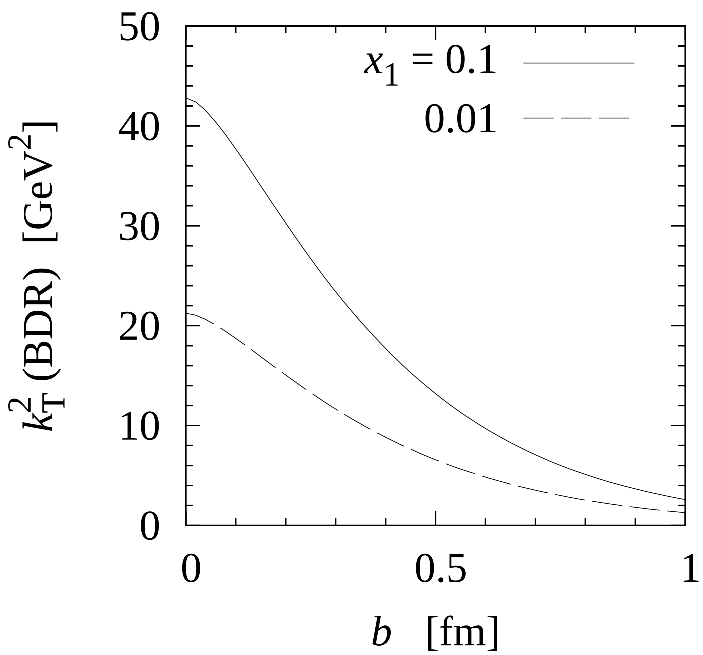
- Sensitive to functional form of t–dependence of gluon GPD

- Agreement with Khoze et al. partly accidental (different parameters)

[Details: FHSW, PRD **75**, 054009 (2007)]

Spectator interactions in saturation regime





- Parent partons ($k^2 \sim$ few GeV^2) experience absorptive interactions with small–x gluons in other proton

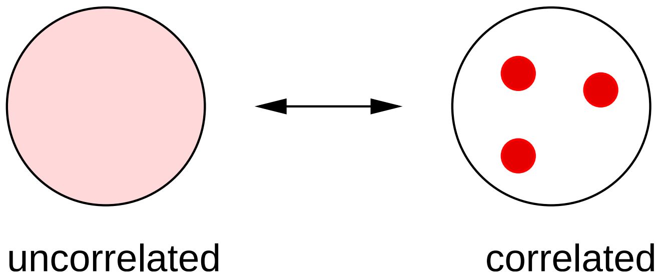
  "Black–Disk Regime"

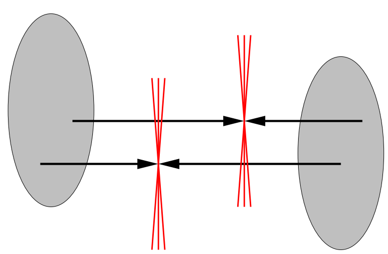
- Use estimate of "critical" k_T^2 from dipole model

- Effect reduces RGS probability at LHC by at least factor 2 . . . much weaker effect at Tevatron

- Larger impact parameters $\rightarrow$ steeper p_{1T}, p_{2T} dependence!

Correlations between partons





- Indications for significant transverse correlations between partons
  - CDF data $p\bar{p} \to$ dijet $+ \gamma + X$
  - "Constituent quarks" of size $r \sim 0.3\,$fm

    [cf. Instanton vacuum model: Diakonov, Petrov 86]

- General trend: Correlations reduce RGS probability . . . increase local opacity for soft interactions

  [Examples see FHSW, PRD **75**, 054009 (2007)]

Potentially large effect; requires detailed modeling

Summary

- RGS probability in independent interaction approximation

  . . . Model–independent calculation: Gluon GPD, pp elastic amplitude

  . . . Numerical results comparable to Pomeron model of Khoze et al.

- Hard spectator interactions in black–disk regime estimated to significantly lower the RGS probability at LHC energies

  . . . Marginal effect at Tevatron — careful with extrapolation!

- Correlations in partonic wavefunction expected to further lower the RGS probability

  . . . Requires detailed modeling!