(A whistle stop tour of) models of diffraction in DIS

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- High energy, small x, *diffractive*, hadron scattering
  $\rightarrow$ Large rapidity gaps.
- $t \approx 0$ or hadron disintegrates
- Regge Theory $\rightarrow$ at high enough energies
  elastic and diffractive total hadronic cross sections
  dominated by t-channel Pomeron exchange
- Small x limit of DIS is the Regge limit of the $\gamma^* P$ sub-process
  $(s \gg t, Q^2, m_p^2)$
- 1993 H1 and Zeus data reveal $\sim 10\%$ of DIS events
  at small x contain large rapidity gaps
  $\rightarrow$ leading twist contbn. consistent with Regge Factorization
  1994 data reveal factorization breaking at low β
- Diffractive events surprising from p.o.v. of perturbative QCD
  (exponentially suppressed)
- Ideal environment to investigate interplay of soft and hard physics
- Models of diffraction in DIS
  1. Pomeron structure function (PSF) models
  2. QCD models with two gluon exchange in t-channel
  3. "Aligned jet" type models (in PRF)
- For more discussion and refs see
  M.McDermott and G Briskin, p691, Vol 2,
  Desy Workshop 95/96, "Future Physics at Hera"
  Also discusses Charm in diffractive DIS

Pomeron Structure Function Models

Ingelman, Schlein; Gehrmann, Stirling; Golec-Biernat, Kwiecinski, H1: Kniehl, Kohrs, Kramer...

Diffractive structure functions defined in analogy to inclusive:

$$\frac{d\sigma^D}{dx_{\mathbb{P}}dxdQ^2dt} = \frac{4\pi\alpha^2_{\text{e.m}}}{xQ^4}\left[1 - y + \frac{y^2}{2[1 + R^D(x, Q^2, x_{\mathbb{P}}, t)]}\right] F_2^D(x, Q^2, x_{\mathbb{P}}, t)$$

- Ingelman and Schlein - probe parton densities inside pomeron
  Factorization into flux factor and Pomeron Structure Function

$$F_2^D(x, Q^2, x_{\mathbb{P}}, t) = f(x_{\mathbb{P}}, t)F_2^{\mathbb{P}}(\beta, Q^2, t)$$

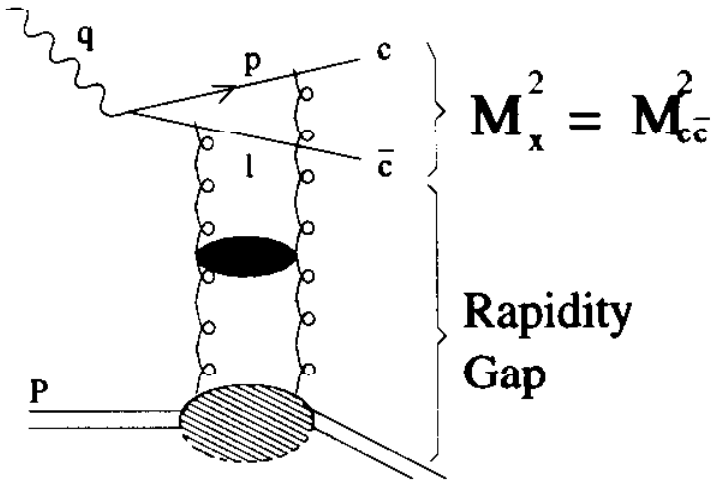
- e.g. Donnachie, Landshoff flux factor based on Regge theory

$$f(x_{\mathbb{P}}, t) \sim [F_1(t)]^2 x_{\mathbb{P}}^{1-2\alpha_{\mathbb{P}}(t)}$$

- $\beta = Q^2/(Q^2 + M_x^2 - t)$ momentum fraction of the Pomeron carried by the struck parton : $x_{\mathbb{P}}$ momentum fraction of proton carried by Pomeron: $\beta x_{\mathbb{P}} = x_{bj}$ for $t, m_p^2 = 0$
- e.g. GS(I) resolved, GS(II) - res. + direct
- Usual DGLAP fit of parton structure needs very strongly peaked gluon at high β to fit rising Q^2 dependence at intermediate β
- NLO QCD fit (GBK) to get to R^D
- 1994 data breaks factorization at low β
- Sub-leading trajectories (?), interference of f and Pomeron
- Warnings :
  1. QCD factorization NOT PROVEN for diffractive events
  2. fit demands high β gluons $\rightarrow$ higher twist effects (?)
  3. lots of free parameters

Two gluon exchange models

Low, Nusinov; Landshoff, Nachtmann, Diehl; Nikolaev, Zakharov, Genovese; Bartels, Ewertz, Levin, Lotter, Wüsthoff; Bialas, Peschanski; Levin, Martin, Ryskin and Teubner etc....



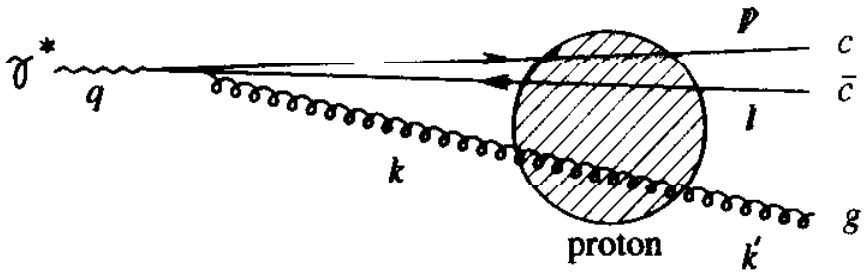
- simplest QCD model
  → two gluons, in singlet config. exchanged in t-channel
- e.g. BW et al., factorization-breaking ansatz
  for unintegrated gluon distbn. ω: fit to F_2

$$F_2^D \sim \left| \int d^2k_\perp \omega(k_\perp^2, x_{I\!P}, \ldots) \right|^2$$

- additional gluon important at low β
  but full calculation of $\mathcal{O}(\alpha_s)$ not available
- interacting gluons ?
  BFKL dipole picture (NZG, BP)
  stronger energy dependence
- Common features : Large R^D at high β, factorization breaking

Aligned Jet Type models

Bjorken...; Buchmüller, Hebecker, McDermott; Ingelman



- Proton rest frame calculation.
- Photon fluctuates into frozen system of partons large distance ($d \sim 1/x$) upstream of proton
- "Soft colour interaction" of partons with proton colour field
- Slow parton for diffraction. $\alpha = p_0/q_0 \ll 1$
  photon fluct. develops large transverse size
  $\rightarrow$ aligned jet type config.
- Calculated to $\mathcal{O}(\alpha_s)$. slow gluon config. dominates

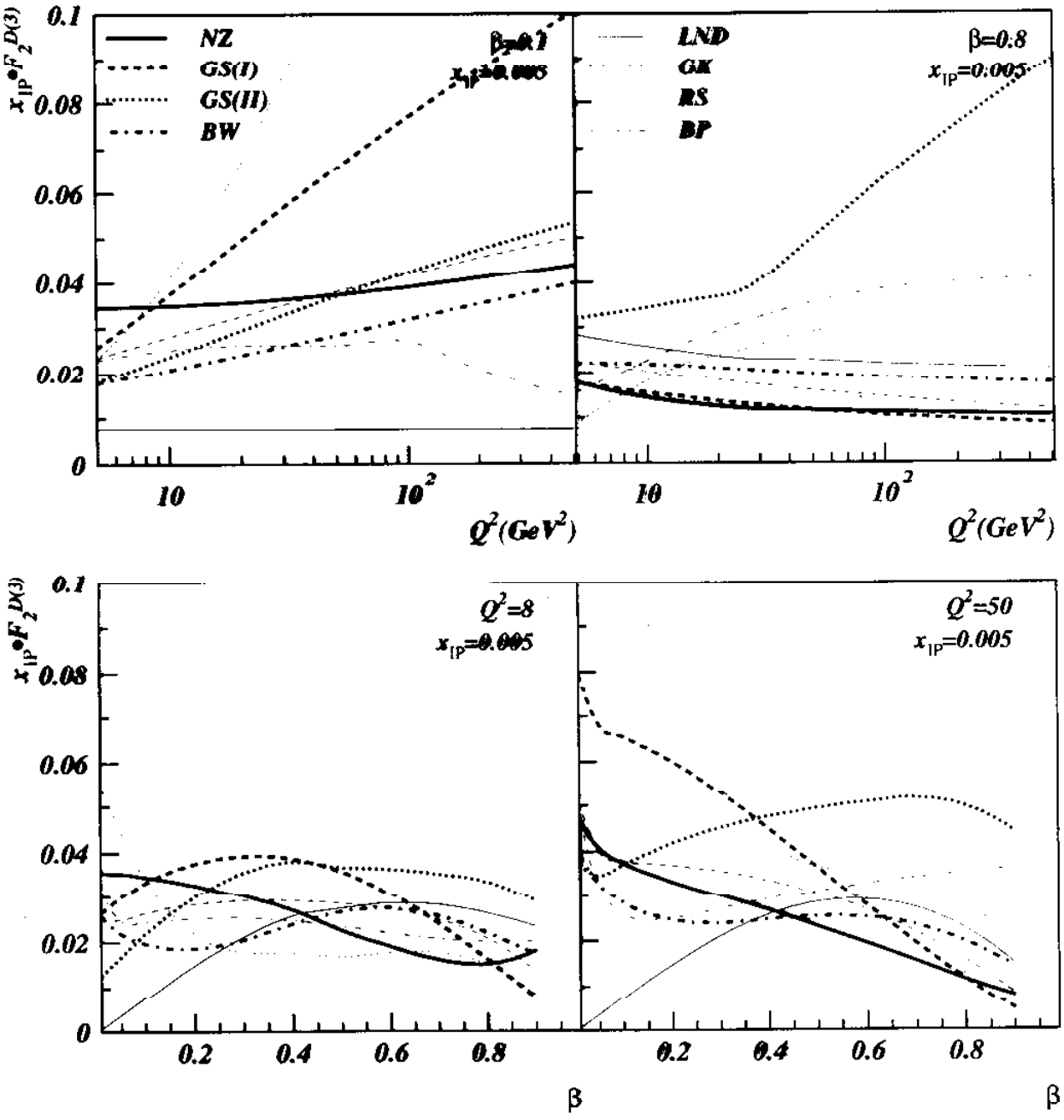


Fig 1: The diffraction structure function at fixed x_{IP} plotted as a function of β and Q^2. for various theoretical models.

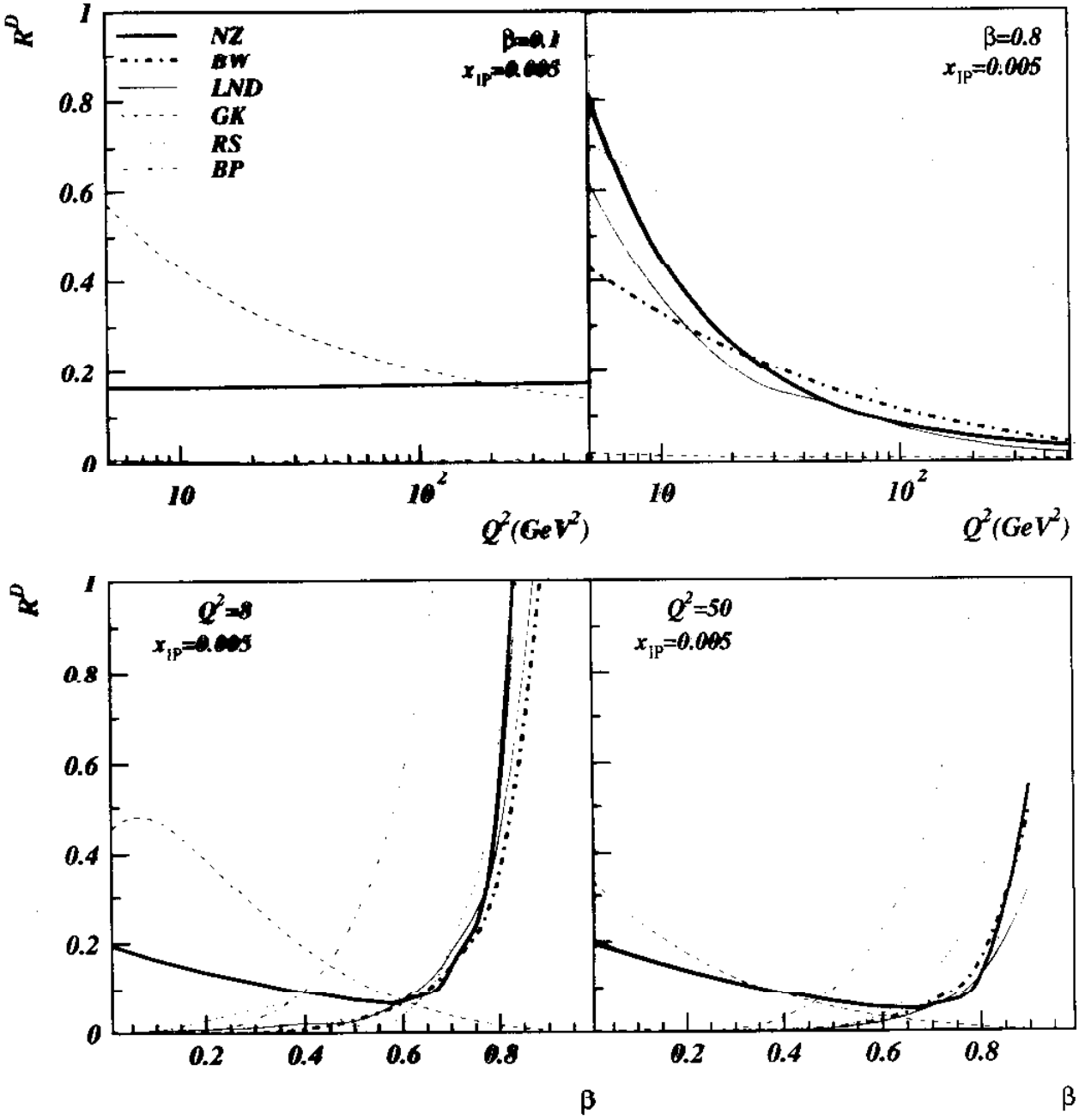


Fig 2 : The structure function $R^D(\beta, Q^2) = F_2^D / (F_2^D - F_L^D)$ at fix. $x_{IP} = 5 \times 10^{-3}$ as a function of β and Q^2 for various theoretical models.