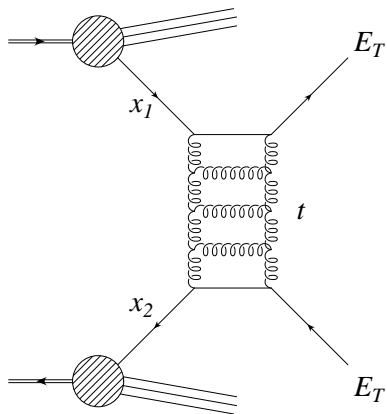


UNDERSTANDING RAPIDITY GAPS AND LEADING PROTONS

Soft/hard gap \Leftrightarrow small/large momentum transfer across gap
 non-perturbative/perturbative QCD description

Hard gap between jets:

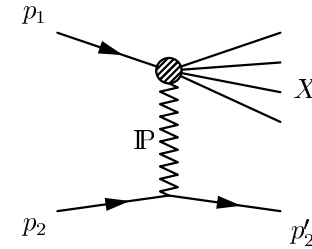
- observed at Tevatron
- understood/described by exchange of colour singlet BFKL gluon ladder with non-leading corrections



Enberg, GI, Motyka, PL B524 (2002) 273

Soft gap \leftrightarrow leading proton:

- 'soft-soft' \Rightarrow hadron basis \rightarrow Regge



- 'hard-soft' \leftrightarrow hard int'n – gap – proton
 DIS/jets/W + gap
 \rightarrow pQCD partons + hadronisation
 \Rightarrow mixed basis: parton & hadron

Models:

- Regge \rightarrow pomeron structure works, but problematic
- Soft Colour Interactions . . .

Soft Colour Interactions

Starting points:

- hard pQCD left unchanged – soft interactions does not affect hard ones
- soft non-pQCD interactions occur below cut-off $Q_0^2 \sim 1 \text{ GeV}^2$
- α_s large \Rightarrow large interaction probability (*e.g.* unity for hadronisation!)
- no proper theory for interaction probability or dynamics \rightarrow **models**
- soft colour exchange modifies colour/string topology \rightarrow different final state
- single model describing all final states — diffractive \leftrightarrow nondiffractive

Two 'pictures':

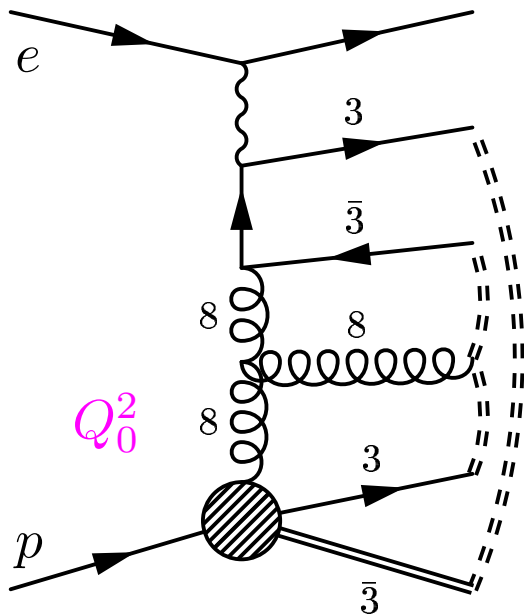
- parton basis (SCI): semi-soft/hard interactions between partons
- string basis (GAL): soft interactions between strings (partons not resolved)

PL B366 (1996) 371, ZP C75 (1997) 57, PR D56 (1997) 7317, PL B452 (1999) 364,
PR D64 (2001) 114015, PRL 89 (2002) 081801, EPJ C23 (2002) 527

Explicit model for Soft Colour Interactions

Add-on to Lund Monte Carlo's LEPTO (ep) and PYTHIA ($p\bar{p}$)

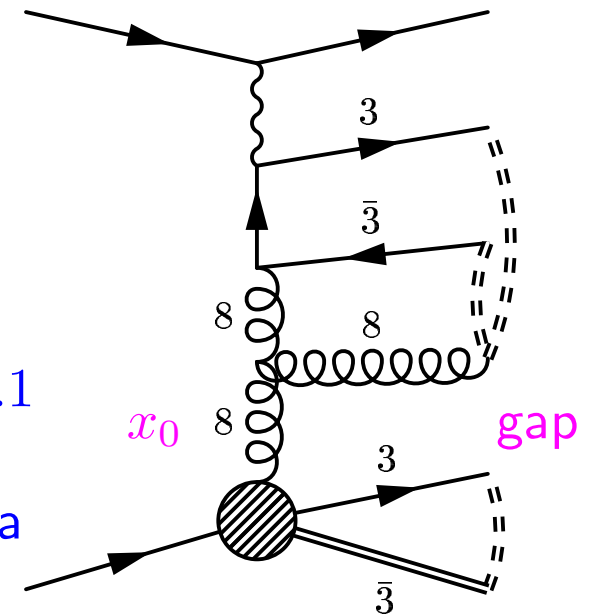
ME + DGLAP PS $> Q_0^2$ → SCI/GAL interactions → String hadronisation $\sim \Lambda$
 colour ordered parton state rearranged colour order modified final state



Probability P for soft ($p \simeq 0$)
 gluon (colour-anticolour) exchange

SCI between parton pairs
 $P = \text{const} \approx 0.5$

GAL between strings
 $P = P_0(1 - e^{-b\Delta A})$, $P_0 \approx 0.1$
 ΔA is change in string 'area'
 determined from HERA rap-gap data

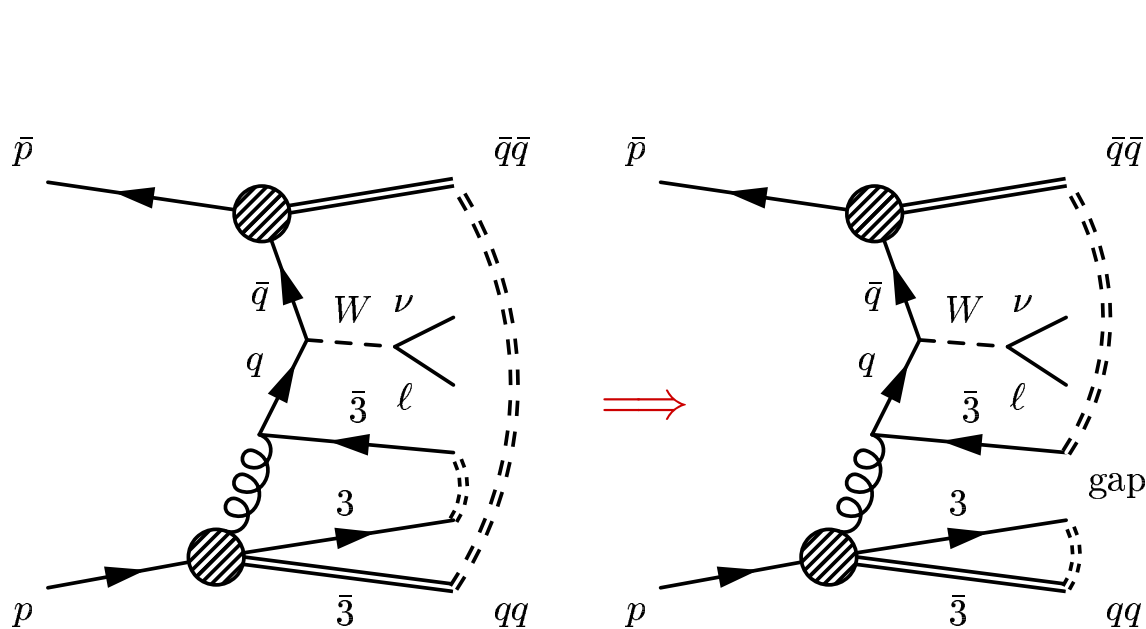


Proton remnant with $(1 - x_0)$ important for large gaps

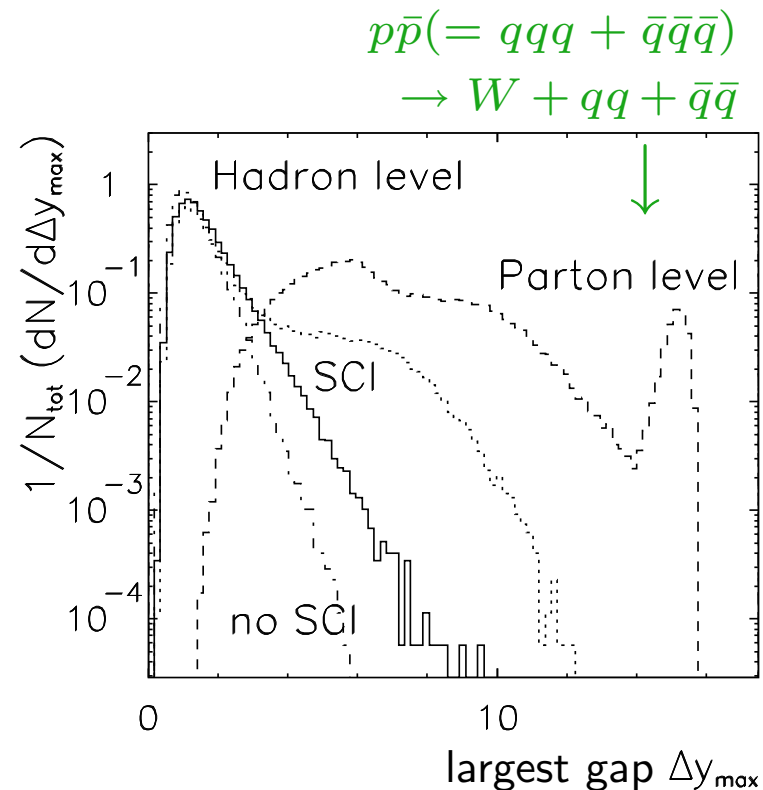
Model (with *one* parameter) reproduces HERA diffractive F_2 data

Also reasonable description of observed leading neutron spectrum

SCI on hard processes in $p\bar{p}$ via PYTHIA



→ Diffractive W at Tevatron



Large gaps at parton level — normally string across → hadrons fill up
SCI → new string topologies, some with gaps

Model (with 'HERA-parameter') reproduces *all* Tevatron data on hard diffraction:

- $W / Z / b\bar{b} / \psi /$ dijets + gap / leading proton (single diffractive)
- gap + dijets + gap / leading proton (DPE)

⇒ Basis for predictions of diffractive Higgs production at Tevatron & LHC

New theoretical understanding emerging

Rescattering interactions *à la* Brodsky-Hoyer *et al.*:

Leading twist gluon exchange between

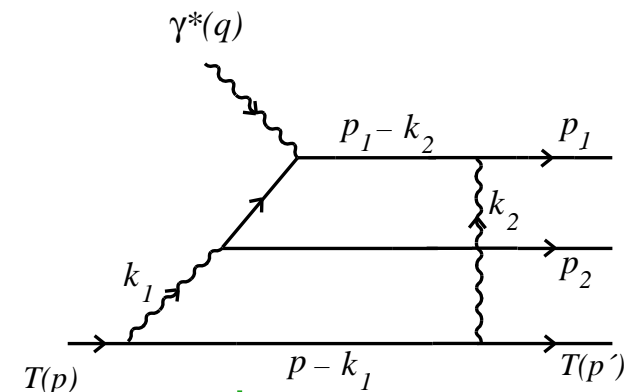
fast outgoing partons and target 'spectators'

Instantaneous 'Coulomb' gluons (light-front/Breit frame)

→ soft rescattering on 'frozen' target

Gluon attached *after* photon vertex ⇒ no pre-existing pomeron in proton

Shadowing and diffraction are rescattering effects



SCI effective model for this!

Brodsky, Enberg, Hoyer, GI, in preparation

Colour exchange → modified colour (string) field topology

→ modified hadronic final state → gaps may arise

- gluon k_2 quickly after k_1 ⇒ can screen colour giving singlet exchange
- even/odd # gluons → pomeron/odderon exchange
- path-ordered exponential of gluon field (Wilson line)
- on-shell intermediate state ⇒ imaginary amplitude ↔ diffraction
 k_2 is 'soft' → small kinematic effect
- $F_2^D \sim g_p(x_{\mathbb{P}}) q_g(\beta)$, *i.e.* gluon distr. ↔ \mathbb{P} and $g \rightarrow q\bar{q}$ gives $(\beta^2 + (1 - \beta)^2)$

... to be continued ...