Rapidity Gaps Between Jets

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Rapidity Gaps Between Jets

- Large rapidity gap $\Delta\eta$

  $\longrightarrow$ colour singlet exchange

- High P_T jets

  $\longrightarrow$ hard scale at both ends of exchange

  $\longrightarrow$ pQCD

- Gap Fraction:

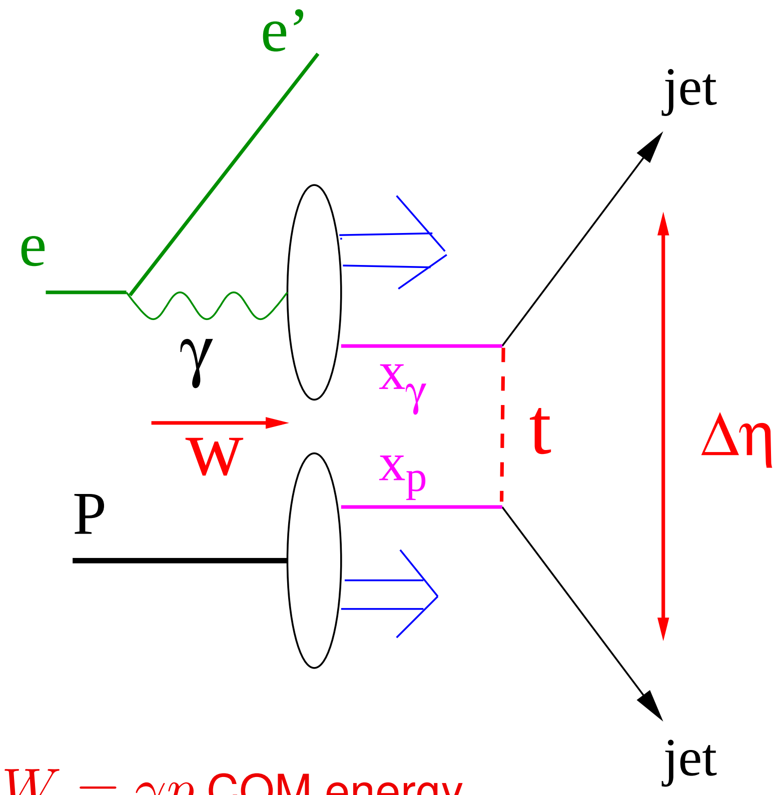
  f = $\frac{N_{gap}}{N_{inc}}$

- Longitudinal momentum fraction

  of p and γ in production of two jets:

$$x_p^{jets} = \frac{\sum_{jets1,2}(E^{jet}+p_z^{jet})}{2E_p}$$

$$x_\gamma^{jets} = \frac{\sum_{jets1,2}(E^{jet}-p_z^{jet})}{\sum_{objects}(E^{obj}-p_z^{obj})}$$



$W = \gamma p$ COM energy

Q^2 = virtuality of γ

(low $Q^2 \longrightarrow$ photoproduction)

What is Responsible for the Gap?

- The 'soft' pomeron ?

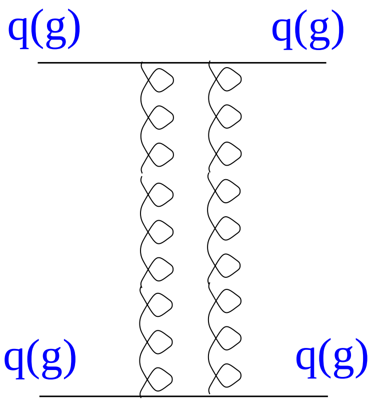
  Pomeron trajectory : $\alpha(t) = \alpha(0) + \alpha^{'} t \longrightarrow \frac{\mathrm{d}\sigma}{\mathrm{d}t} \simeq s^{2(\alpha(0)+\alpha^{'} t)}$

  $\alpha^{'} \sim 0.25$ leads to vanishing cross section at high $|t|$

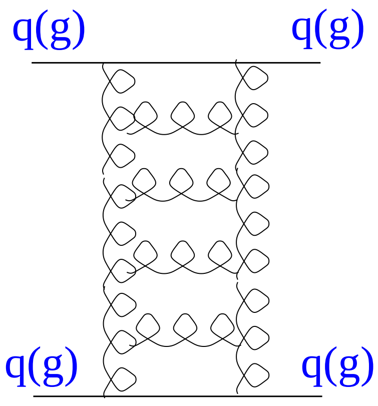
- QCD ?

  No fundamental colour singlet object

  but at high $|t| \longrightarrow$ can construct one using pQCD (e.g. BFKL calculation)



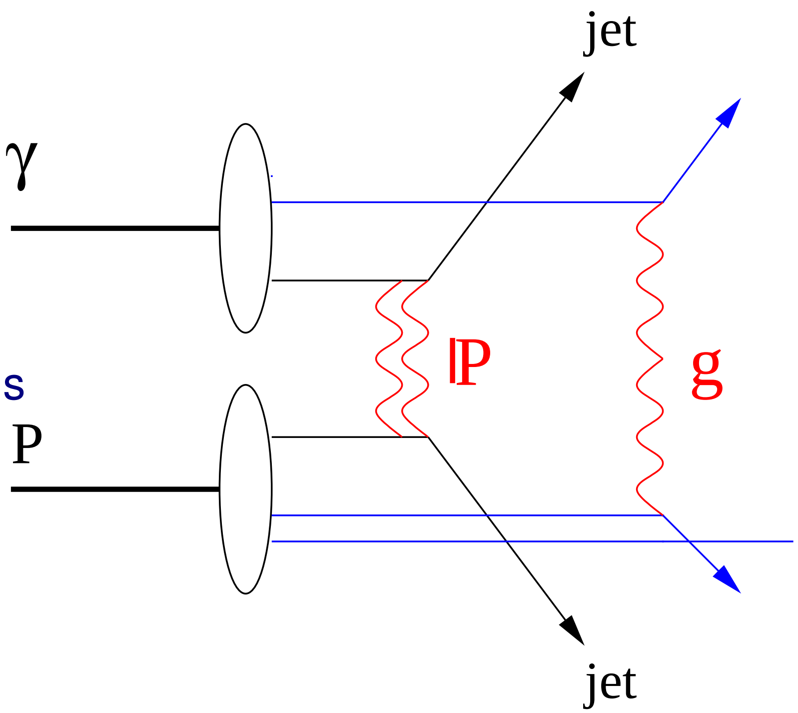
Two gluon



BFKL

Complications

- Multiplicity definitions not infra-red safe
- Multiple parton-parton interactions
  - Gap survival probability
  - $\longrightarrow$ potentially large non-perturbative corrections
  - Interesting place to study interplay between long and short distance physics. Gap formation:
  - Non-perturbative: soft colour models
  - Perturbative exchange (e.g BFKL) + gap survival probability
  - Purely perturbative (up to pdfs) if E_T^{cut} large (Oderda + Sterman Phys Rev Lett 81,3591 (1998))



Energy Flow Between Jets

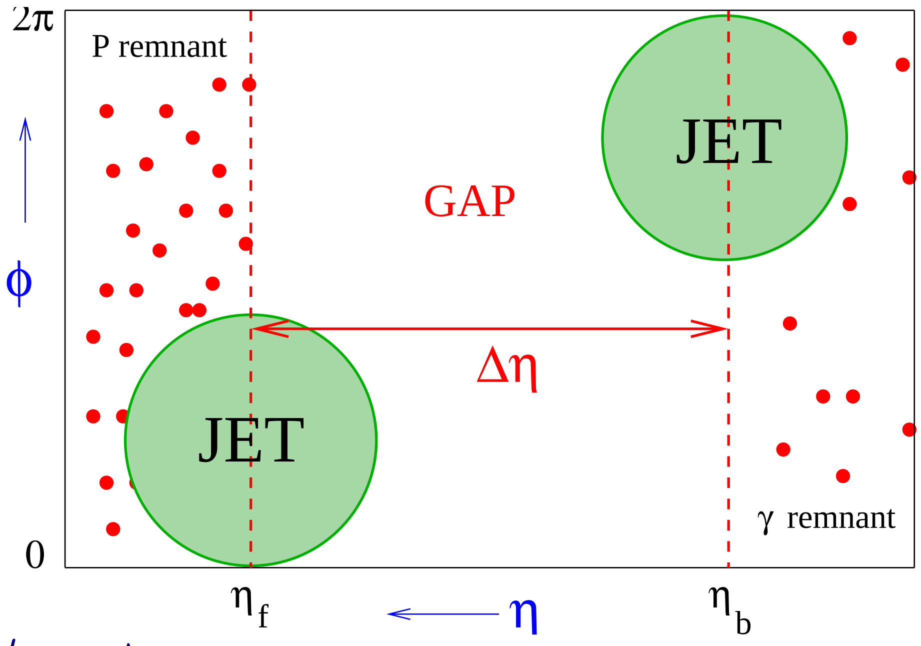
Oderda + Sterman Phys Rev Lett 81,3591 (1998)

- Identify rapidity gaps by the energy flow in the region between jets, Q_C rather than a multiplicity
- If $Q_C \gg \Lambda_{QCD} \longrightarrow$ perturbatively calculate cross-section

$\Rightarrow$ Perturbative part of gap survival probability is calculable

$\Rightarrow$ the low Q_C cross-section is dominated by colour-singlet exchange

Gap Definition



- Inclusive k_T algorithm
  $\longrightarrow$ every object associated with a jet
- Define $E_T^{gap} = \sum E_T^{jet,i}$,
  where $\eta_f^{jet} > \eta^{jet,i} > \eta_b^{jet}$
- Gap event : $E_T^{gap} < E_T^{cut}$
- Perturbative calculation possible for $E_T^{cut} \gg \Lambda_{QCD}$
- Infra-red safe definition of gap
- Large η region used to define E_T^{gap}

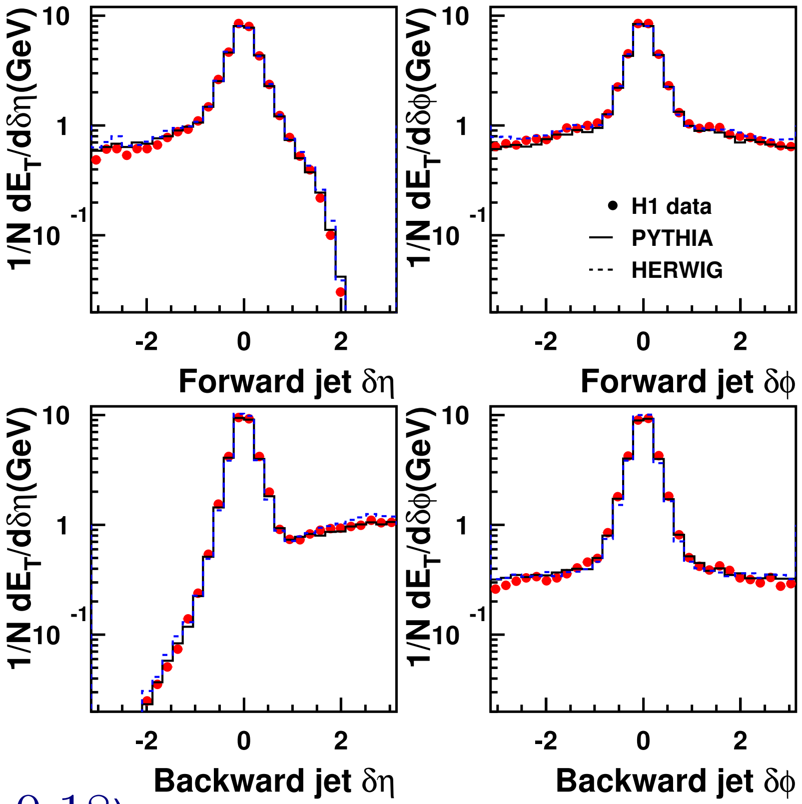
Event Selection

- $Q^2 < 0.01$ GeV^2 (quasi-real photon, scattered electron detected in 33m tagger)
- $165 < W < 243$ GeV (avoid low acceptance regions in 33m tagger)
- Jets found with inclusive k_T algorithm
- $E_T^{jet1} > 6.0$ GeV
- $E_T^{jet2} > 5.0$ GeV (asymmetric cuts to allow comparison to NLO QCD)
- $\eta^{jet1}, \eta^{jet2} < 2.65$ (most forward jet in calorimeter)
- $2.5 < \Delta\eta \equiv |\eta^{jet1} - \eta^{jet2}| < 4.0$

  (large jet-jet separation, but most backward jet still in calorimeter)

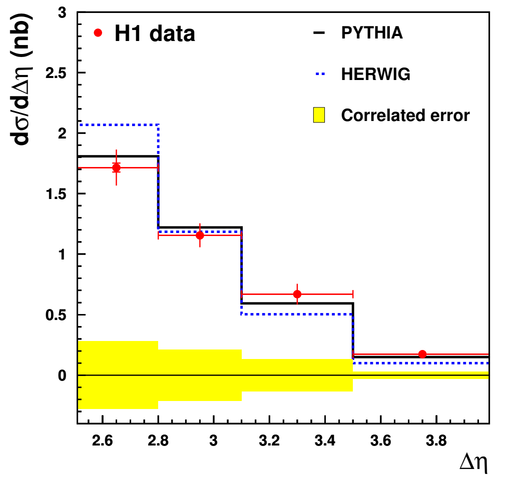
MC Models

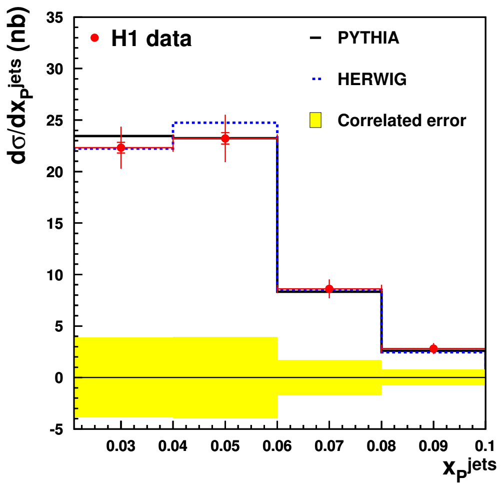
- Herwig 6.1 + JIMMY
- Pythia 5.7
- Multiple interactions tuned to data:

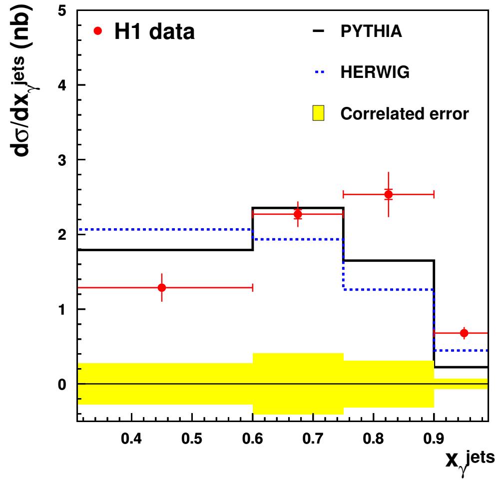


- Colour singlet models:
  - Herwig 6.1 + JIMMY + BFKL $\mathbb{P}$ $(\alpha_s = 0.18)$
  - Pythia 5.7 + high-t γ exchange $(\times 1200)$
    (colour singlet exchange, but very different dynamics)

Differential Dijet Cross Sections





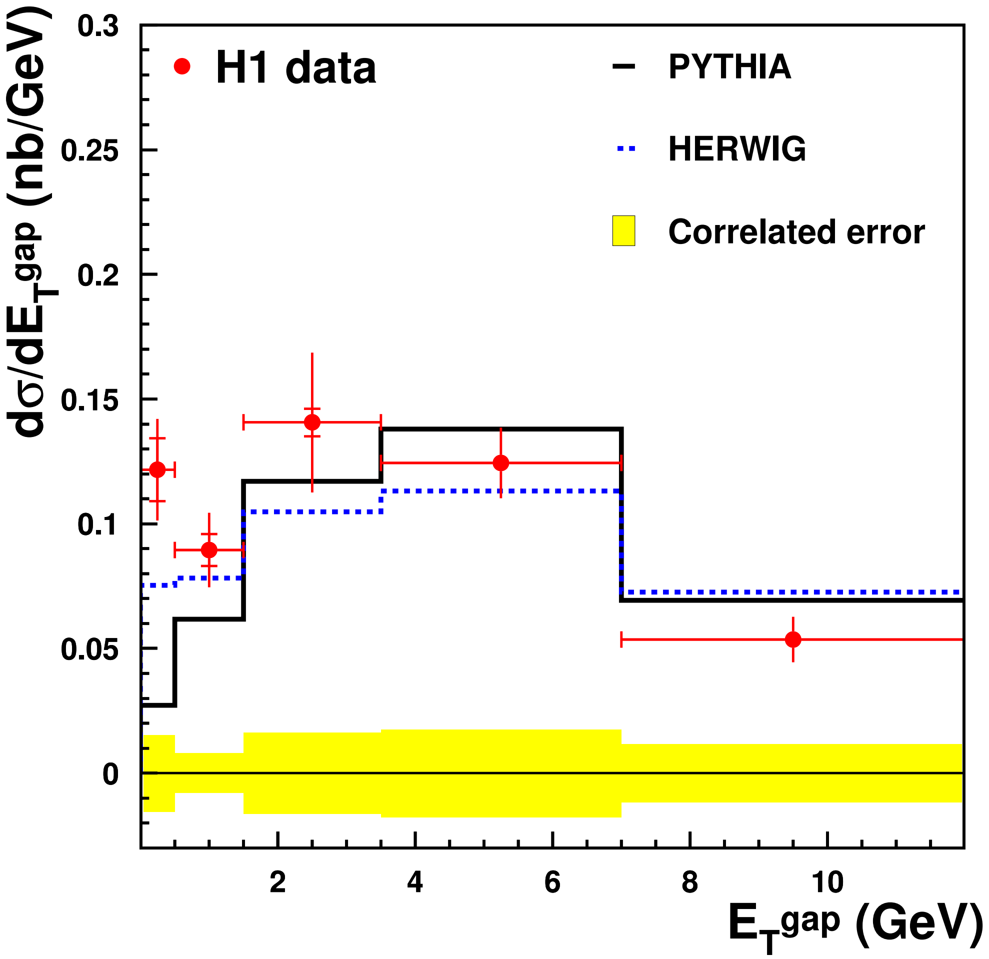


Pythia 5.7 and Herwig 6.1 + JIMMY

multiple interaction models tuned to data

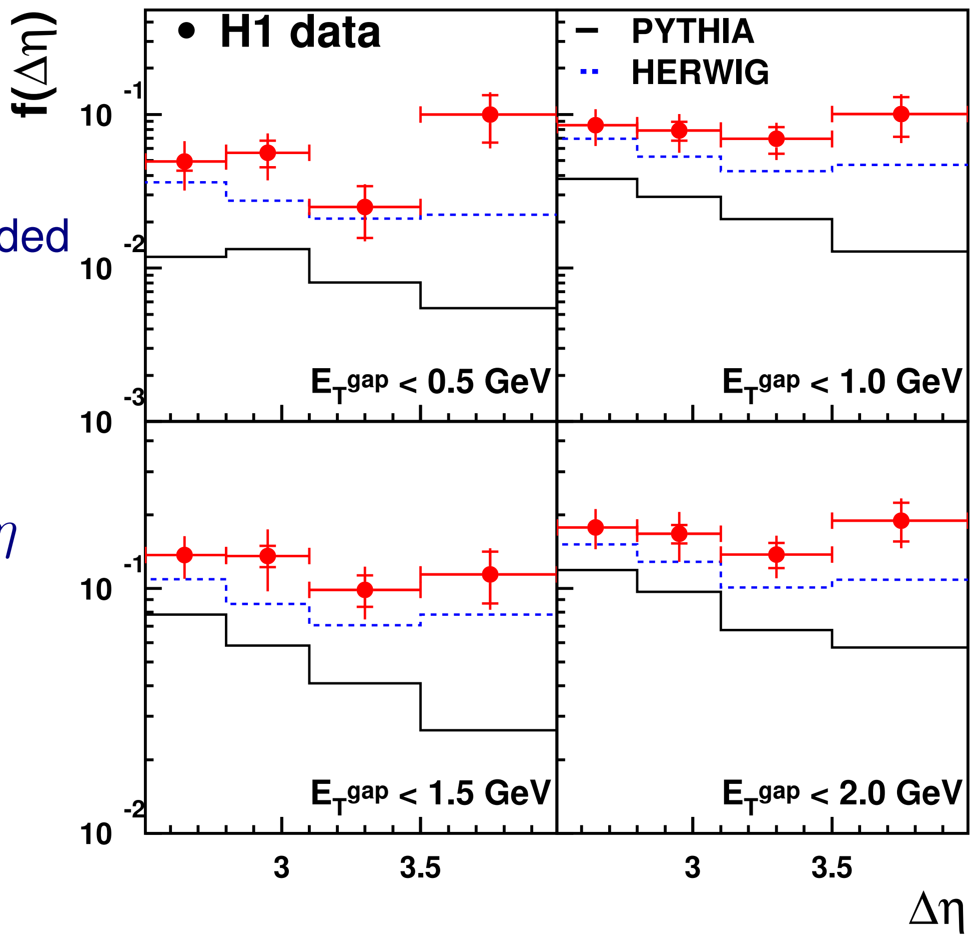
Dijet Cross Section Differential in E_T^{gap}

- No colour singlet exchange included
- Excess for $E_T^{gap} < 0.5$ GeV over both Herwig and Pythia
- Significant differences between two predictions



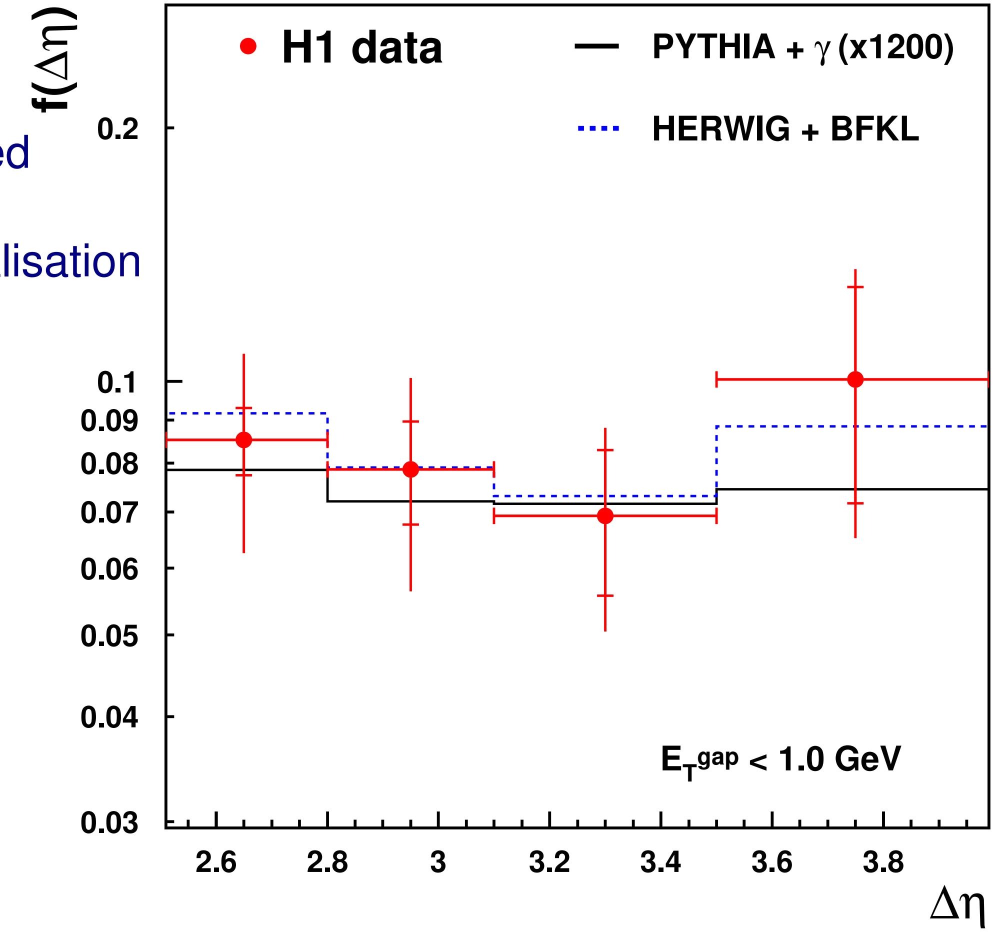
Gap Fraction Differential in $\Delta\eta$

- No colour singlet exchange included
- Plot gap fraction f for different gap definitions
- Pythia falls exponentially with $\Delta\eta$
- Data flat or rising $\longrightarrow$ diffractive



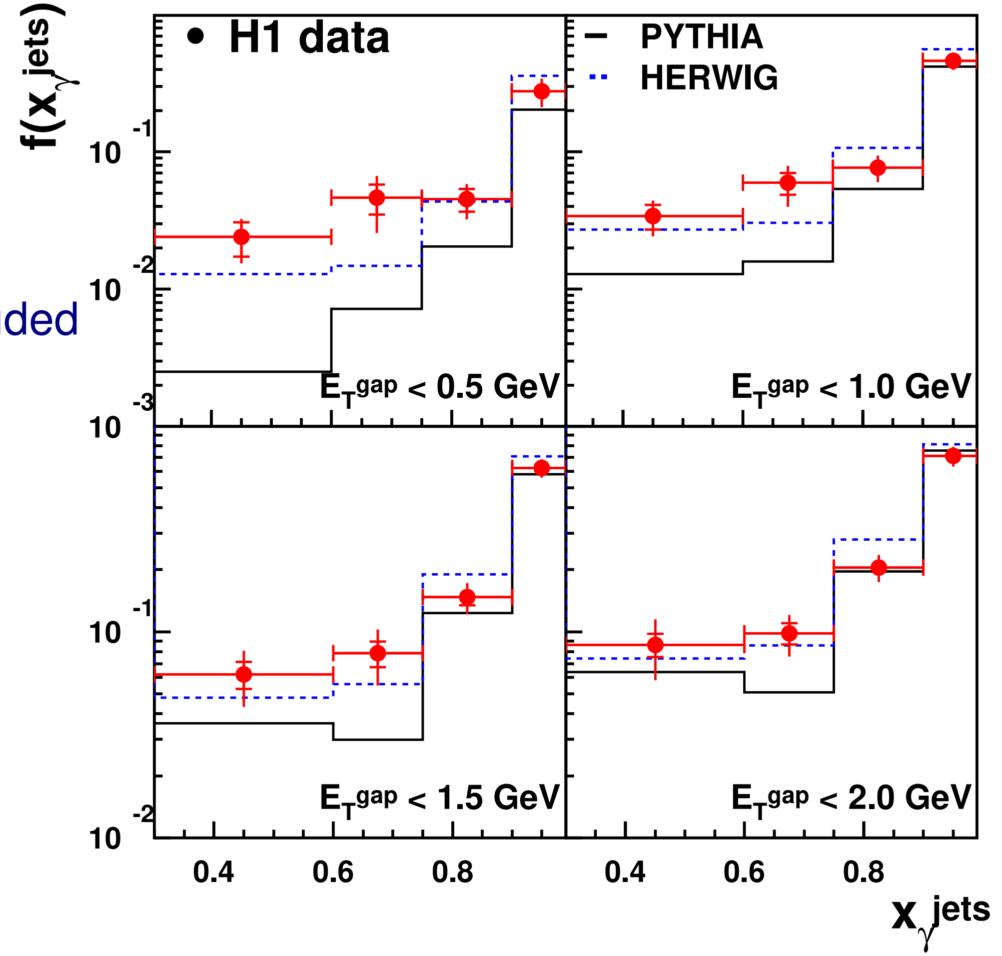
Gap Fraction Differential in $\Delta\eta$

- Colour singlet exchange included
- LO BFKL describes data normalisation and shape for $\alpha_s = 0.18$
- Large $\Delta\eta$ similar to ZEUS: 11% at $\Delta\eta = 3.7$



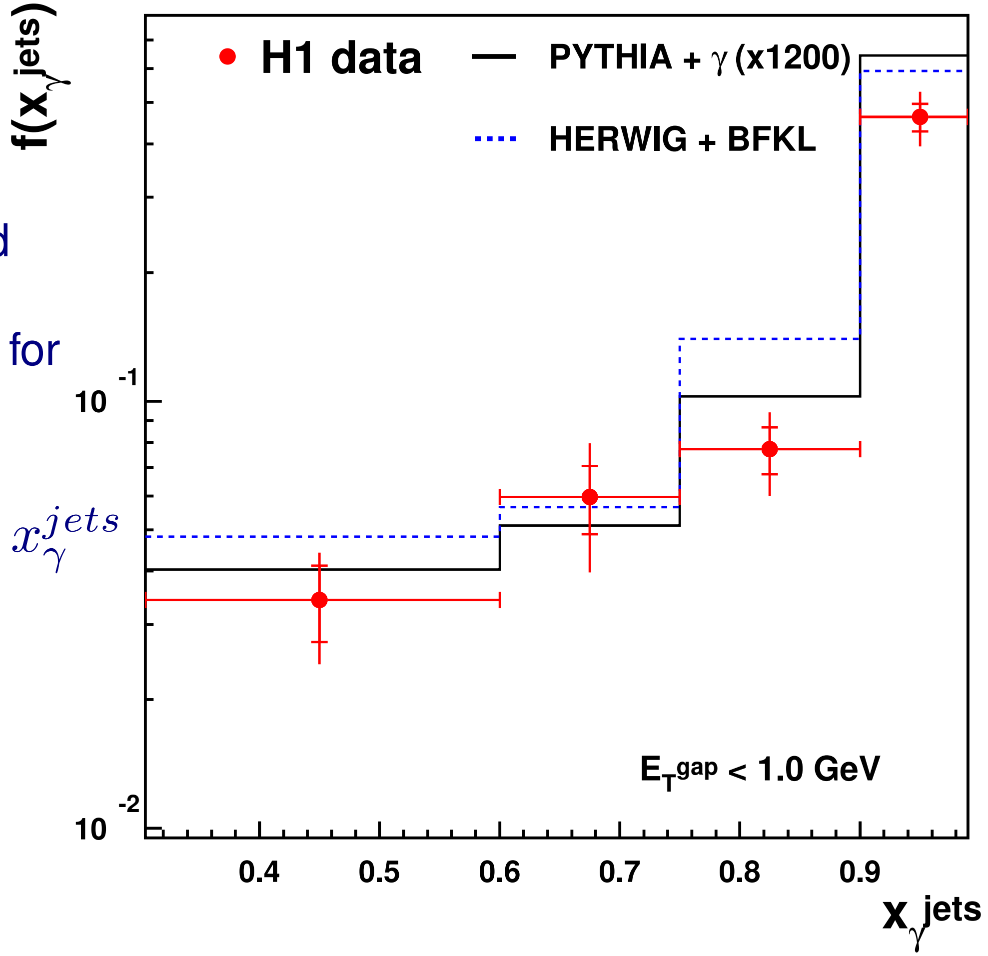
Gap Fraction Differential in x_γ^{jets}

- No colour singlet exchange included
- Standard photoproduction mainly at high x_γ
- High x_γ = direct events
  $\longrightarrow$ quark propagator
  $\longrightarrow$ more likely to produce gaps



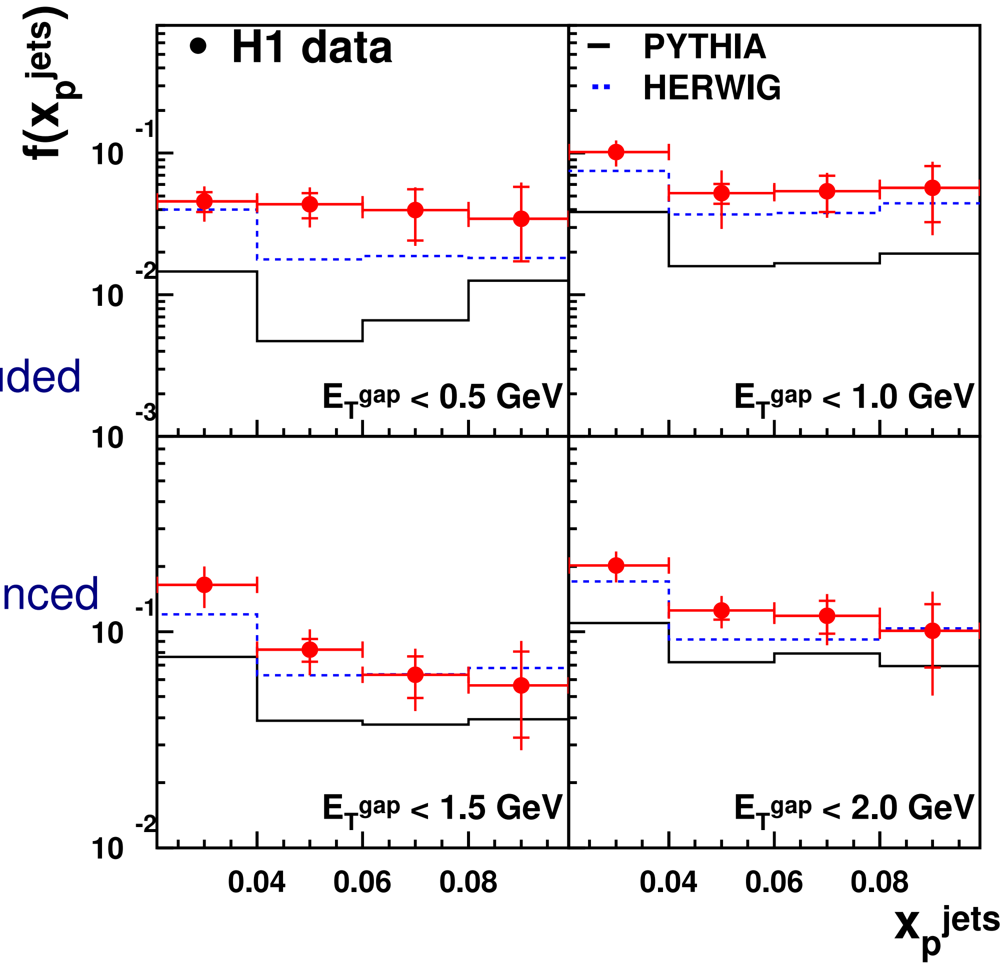
Gap Fraction Differential in x_γ^{jets}

- Colour singlet exchange included
- Better description of gap fraction for $x_\gamma^{jets} < 0.75$ from both models
- But gap fraction too high at large x_γ^{jets}



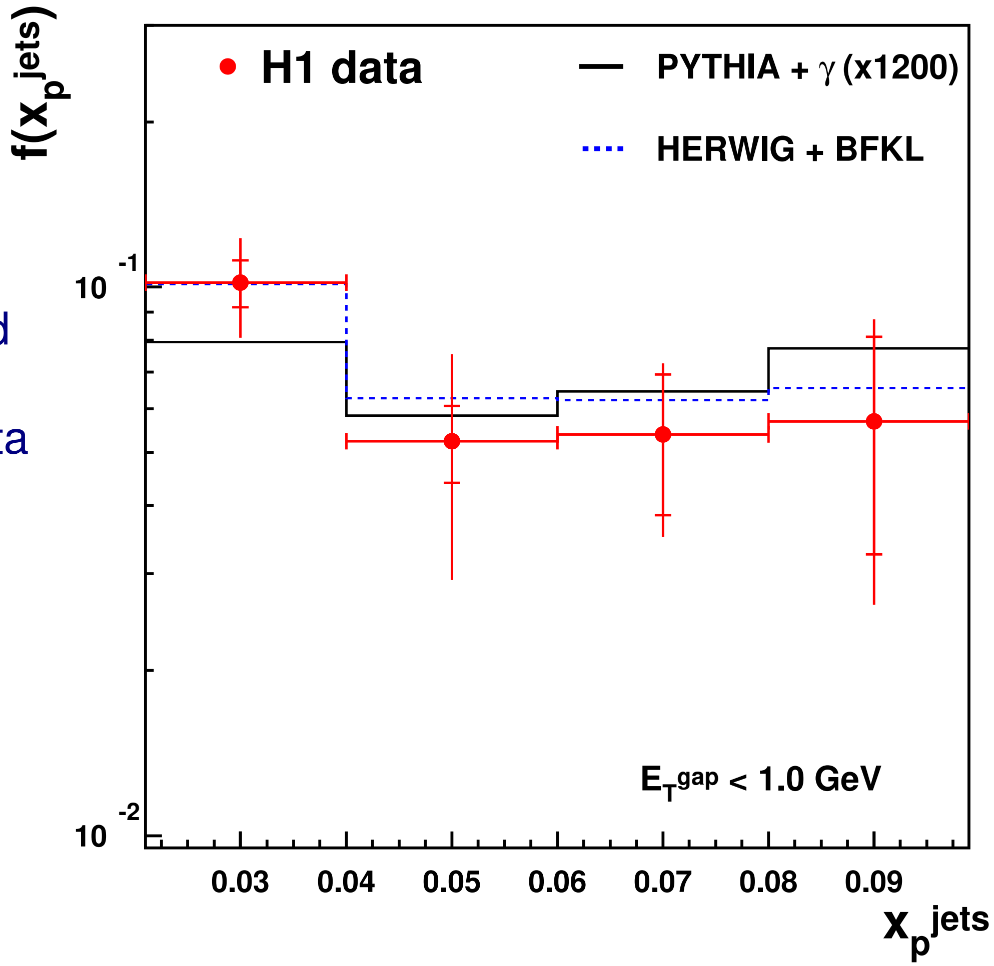
Gap Fraction Differential in x_p^{jets}

- No colour singlet exchange included
- Data has excess over Pythia
- Excess over Herwig less pronounced



Gap Fraction Differential in x_p^{jets}

- Colour singlet exchange included
- Both models able to describe data



Conclusions

- Dijet events in photoproduction with a large rapidity gap between the two highest E_T jets have been studied
- New definition of the rapidity gap is now infra-red safe and allows perturbative calculations
- An excess of events with small E_T^{gap} has been observed for $\Delta\eta > 2.5$
- LO BFKL with $\alpha_s = 0.18$ gives a good description of normalization and shape
- However, little sensitivity to the underlying dynamics of model