ENERGY FLOW BETWEEN JETS AT LARGE RAPIDITY SEPARATIONS IN PHOTOPRODUCTION AT HERA

Angela Wyatt
for the H1 Collaboration
Dept. of Physics and Astronomy, University of Manchester, Manchester M13 9PL, England

Dijet events in photon-proton collisions in which there is a rapidity separation between the two highest E_t jets $\Delta\eta > 2.5$ are studied with the H1 detector at HERA. Jets are defined using the inclusive k_t algorithm. Rapidity gap events are defined as events in which the sum of the transverse energy of all jets between the two highest E_t jet axes is less than E_t^{cut}, for $0.5 < E_t^{cut} < 5.0$ GeV. The gap fraction, defined as the fraction of dijet events with a rapidity gap, is plotted for different E_t^{cut} values for the inclusive dijet sample, and differentially in the dijet separation, $\Delta\eta$, and in x_p^{jets} and x_γ^{jets} the fraction of the proton's and photon's momentum entering the hard scatter. A large excess of events with rapidity gaps at low values of E_t^{cut} is observed above the expectation from standard photoproduction processes.

1 Introduction

Events with large rapidity gaps in the hadronic final state and a perturbatively hard scale at both ends of the colourless exchange have been observed at both the Tevatron[1,2] and HERA[3]. Such events are characterised by two hard jets separated by a large rapidity interval and an unusually small energy flow between the jets. We tag such events by measuring the energy flow.

2 Event Selection

The data for this analysis were collected with the H1 detector [4] during the 1996 running period, when HERA collided 27.6 GeV positrons with 820 GeV protons, with an integrated luminosity of 6.2 pb^{-1}. Photoproduction events were selected with the photon virtuality $Q^2 < 0.01$ GeV^2. The photon-proton centre of mass energy is in the range $165 < W < 233$ GeV.

The inclusive k_t clustering algorithm[5] was applied, assigning every particle to a jet. Events with 2 or more jets were kept if the two highest E_t jets in the event fulfilled $E_t^{jet1} > 6.0$ GeV; $\mathrm{E_t^{jet2}} > 5.0$ GeV; $\eta^{\mathrm{jet1}}, \eta^{\mathrm{jet2}} < 2.8; \Delta\eta > 2.5$. Any other jets are now called mini-jets. This is the inclusive event sample.

In standard QCD processes the colour connection between the outgoing jet centres results in an energy flow in the entire space between them; this is suppressed in colour-singlet exchange. The transverse energy between the jets, $\not{E}_t^{jets}$, is calculated by summing the transverse energy of all mini-jets

whose jet-centre is between the axes of the two highest E_t jets in rapidity. This method is relatively insensitive to hadronisation effects and is infra-red safe[6]. A rapidity gap event is then defined as an event in which $\not{E}_t^{jets} < E_t^{cut}$, where E_t^{cut} is varied between 0.5 GeV and 5.0 GeV.

3 Results and Model Comparisons

The PYTHIA 5.7[7] and HERWIG 5.9[8] Monte Carlo event generators were used to correct the data for detector acceptance and bin migration effects. The gap fraction, defined as the fraction of dijet events with a rapidity gap, is plotted for different E_t^{cut} values for the inclusive dijet sample in figure 1. The fraction, differential in the dijet separation, $\Delta\eta$, and in x_p^{jets} and x_γ^{jets}, the fractions of the proton's and photon's momentum entering the hard scatter, is also shown in figure 1, for $E_t^{cut} = 0.5, 1.0, 1.5$ and 2.0 GeV. For the $\Delta\eta$ plot only, the $\Delta\eta$ cut is relaxed to $\Delta\eta > 2.0$. Figure 1 also shows the predictions of PYTHIA ($P_t^{min} = 2.2$ GeV, $P_t^{mi} = 1.5$ GeV) and HERWIG with JIMMY[9] ($P_t^{min} = 1.8$ GeV, $P_t^{mi} = 1.8$ GeV). P_t^{mi} is the P_t^{min} of the multiple scatters. These both underestimate the observed gap fraction in all bins, although the HERWIG with JIMMY gap fraction is significantly higher. In addition, the shape of the HERWIG + JIMMY prediction was found to depend strongly on P_t^{mi}.

The addition of a colour-singlet exchange provides a better description of the data. High-t photon exchange, with the cross section multiplied by a factor of 1200, was added to PYTHIA . HERWIG incorporates the BFKL[10] leading logarithmic approximation calculation of Mueller and Tang[11]. The normalisation of this cross-section is set by the choice of $\alpha_s = 0.17$. The agreement with the data is a significant observation; such a choice was also found to fit the Tevatron gaps between jets data[12]. It should be noted, however, that this does not take into account rapidity gap survival and that there is an uncertainty in the gap fraction in standard photoproduction.

The high-t photon gap fraction rises with increasing x_p^{jets}, whilst the BFKL sample is flat or falling. This can be understood since a t channel photon can only couple to quarks in the colliding hadrons, whilst the BFKL pomeron couples more strongly to gluons than to quarks due to the enhanced colour factor. The background photoproduction sample is strongly peaked at high x_γ^{jets}. The colour singlet events are distributed across the whole x_γ^{jets} range.

1. B. Abbott et al (D0 collaboration), Phys. Lett. B440 (1998) 189.
2. F. Abe et al (CDF collaboration), Phys. Rev. Lett. 81 (1998) 5278.
3. M. Derrick et al (ZEUS collaboration), Phys. Lett. B369 (1996) 55.
4. H1 Collab.; I. Abt et al., Nucl. Instrum. Meth. **A386** (1997) 310; 348.
5. S. D. Ellis and D. E. Soper, Phys. Rev. **D48** (1993) 3160.

6. B. E. Cox, M. H. Seymour and A. C. Wyatt, in preparation.
7. T. Sjöstrand and M. van Zijl, *Phys. Rev.* D36 (1987) 2019.
8. G.Marchesini et al., Comp.Phys.Comm. 67 (1992) 465.
9. J. M. Butterworth, J. R. Forshaw and M. H. Seymour, Z. Phys. **C72** (1996) 637-646.
10. E.A.Kuraev, L.N.Lipatov and V.S.Fadin, Sov.Phys.JETP 45 (1977) 199. Ya.Ya.Balitsky and L.N.Lipatov, Sov.J.Nucl.Phys 28 (1978) 822. L.N.Lipatov, Sov.Phys.JETP 63 (1986) 904.
11. A.H.Mueller and W.-K.Tang, Phys. Lett. B284, (1992) 123.
12. B.E.Cox, J.R. Forshaw, L.Lönnblad, JHEP10 (1999) 023.

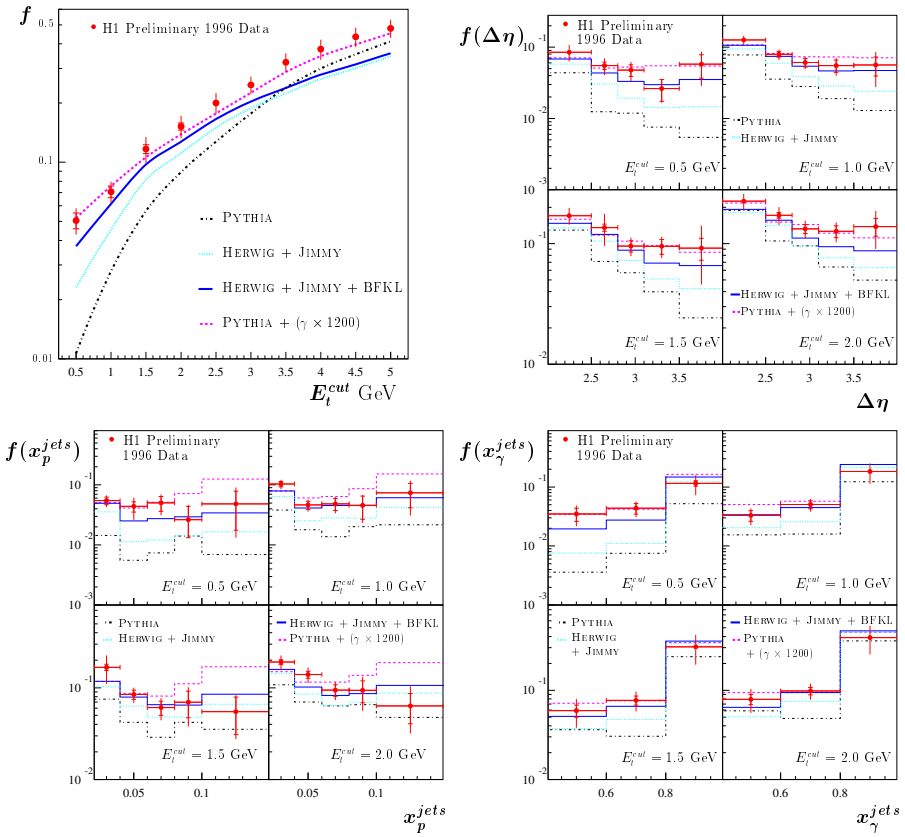

Figure 1: The gap fraction for the inclusive sample and differential in $\Delta\eta$, x_p^{jets} and x_γ^{jets} for $E_t^{cut} = 0.5, 1.0, 1.5, 2.0$ GeV , compared to different Monte Carlo models (see text).