PHOTOPRODUCTION OF EVENTS WITH RAPIDITY GAPS BETWEEN JETS AT ZEUS

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Cross sections for the photoproduction of dijet events, where the two jets with the highest transverse energy are separated by a large gap in pseudorapidity, have been studied with the ZEUS detector using an integrated luminosity of 38.6 pb^{-1}. Rapidity-gap events are defined in terms of the energy flow between the jets, such that the total summed transverse energy in this region is less than the value $E_{\mathrm{T}}^{\mathrm{CUT}}$. The data show a clear excess above the predictions of standard photoproduction models. Models which include color-singlet exchange are able to describe the data.

1. Introduction

The dominant mechanism for the production of jets with high transverse energy in *ep* collisions is a hard interaction via a quark or gluon propagator. The exchange of color quantum numbers gives rise to jets that are color connected to each other, which leads to energy flow which populates the pseudorapidity region between the jets. Events with a large rapidity interval and little or no hadronic activity between the jets would then be a signature of the exchange of a color singlet object.

2. Results

The inclusive dijet cross section as a function of $E_{\mathrm{T}}^{\mathrm{GAP}}$, where $E_{\mathrm{T}}^{\mathrm{GAP}}$ is the sum of the transverse energy of all jets lying in the pseudorapidity region between the two highest E_{T}-jets satisfying the event selection criteria, is presented in Fig. 1. At low $E_{\mathrm{T}}^{\mathrm{GAP}}$ values, where the color-singlet contribution should be most pronounced, the data demonstrates a rise at the lowest

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$E_T^{\rm GAP}$ values. In order to estimate the amount of the color singlet, the direct and resolved components of photoproduction MC were mixed according to their cross sections, as predicted by the MC, to give the color-non-singlet MC sample. The color-non-singlet and color-singlet MC samples were then fitted to the data according to

$$F = P_1 \frac{d\sigma^{CS}}{dE_T^{\rm GAP}} + P_2 \frac{d\sigma^{NCS}}{dE_T^{\rm GAP}},$$

where P_1 and P_2 are the free parameters of the fit. The best fit to the data resulted in $P_1 = 1.25$ and $P_2 = 426$ for PYTHIA 6.1[1] and $P_1 = 1.01$ and $P_2 = 1.45$ for HERWIG 6.1[2]. The large color-singlet scale factor, P_2, for PYTHIA is due to the use of the high-t γ exchange model to simulate the rapidity gap topology. These scaling parameters were used in this analysis when comparing data to the MC predictions.

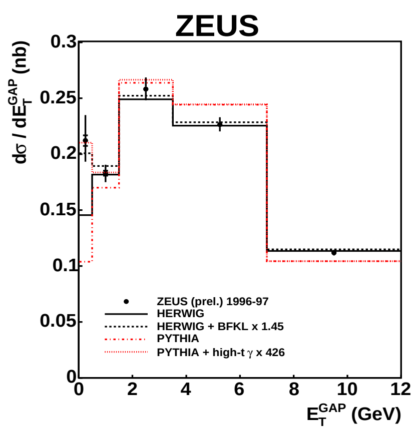

Figure 1. The inclusive dijet cross section differential in $E_T^{\rm GAP}$. The black circles represent the ZEUS data, with the inner error bars representing the statistical errors and the outer error bars representing the statistical and systematic uncertainties added in quadrature. The solid black line shows the prediction of HERWIG and the black dashed line shows the prediction of HERWIG plus BFKL Pomeron exchange. The dot-dashed line shows the prediction of PYTHIA and the dotted line shows the prediction of PYTHIA plus high-t photon exchange.

The inclusive dijet cross section, the gap cross section, and the gap fraction, as a function of the separation, $\Delta\eta$, of the two leading jets, are presented on the left side of Fig. 2 for $E_T^{\rm CUT} = 1$ GeV. Both cross sections and the gap fractions decrease as a function of $\Delta\eta$. In the inclusive cross section, both MC models with and without color-singlet exchange describe the data equally well, but for the gap cross section, the MC models without color-singlet exchange fall below the data while the MC models with color-singlet exchange describe the data. The contribution of color-singlet exchange to the total gap fraction increases as the dijet separation increases from 2.5 to 4 units in pseudorapidity.

The right side of Fig. 2 shows the gap fraction as a function of the dijet separation, $\Delta\eta$, for the four different values of $E_T^{\mathrm{CUT}} = 0.5, 1.0, 1.5$ and $2\,\mathrm{GeV}$. The data first fall and then level out as $\Delta\eta$ increases for all values of E_T^{CUT} except $E_T^{\mathrm{CUT}} = 0.5$, where the data is almost constant with $\Delta\eta$. The predictions of Pythia and Herwig without color-singlet exchange lie below the data over the entire $\Delta\eta$ range. With the addition of the color-singlet contribution both MCs describe the data well.

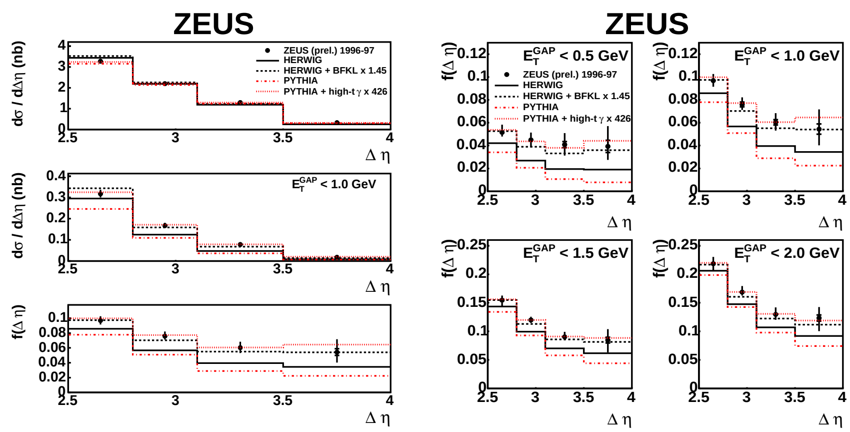

Figure 2. In the figure on the left, the top plot is the inclusive dijet cross section differential in $\Delta\eta$, the middle plot is the gap cross section differential in $\Delta\eta$ requiring that $E_{\mathrm{T}}^{\mathrm{GAP}} < 1\,\mathrm{GeV}$, and the bottom plot is the gap fraction, f, in $\Delta\eta$. The figure on the right shows the gap fraction, f, in $\Delta\eta$ for for four different values of $E_{\mathrm{T}}^{\mathrm{CUT}}$. The points and lines are as defined in Fig. 1.

For comparison with other experiments and pp measurements, the cross sections and gap fraction were also measured as function of x_γ^{OBS}. These results are presented on the left side of Fig. 3 for four different values of $E_{\mathrm{T}}^{\mathrm{CUT}}$. The gap fraction decreases as a function of x_γ^{OBS} and the data are reasonably well described by both MC models. In the x_γ^{OBS} region below 0.75, Herwig predicts larger cross sections than Pythia. Although the data have sufficiently small errors, the difference in the model predictions preclude an accurate determination of the color-singlet contribution to the gap fraction and its behavior as a function of $x_\gamma^{\rm OBS}$.

In order to compare with pp measurements the $\Delta\eta$ behavior was investigated in the resolved enhanced region ($x_\gamma^{\rm OBS} < 0.75$). The right side of Fig. 3 shows the gap fractions as a function of $\Delta\eta$ in resolved enhanced region for four different values of $E_{\rm T}^{\rm CUT}$. For $E_{\rm T}^{\rm GAP} < 0.5\,$GeV and $E_{\rm T}^{\rm GAP} < 1.0\,$GeV, both MC models predict almost no contribution to the gap fractions from the non-color-singlet component at high values of $\Delta\eta$. The measured amount of the color singlet is a few percent with large uncertainties mainly due to unfolding using different MC models. These values, within errors, agree well with the measurement for the total $x_\gamma^{\rm OBS}$ region.

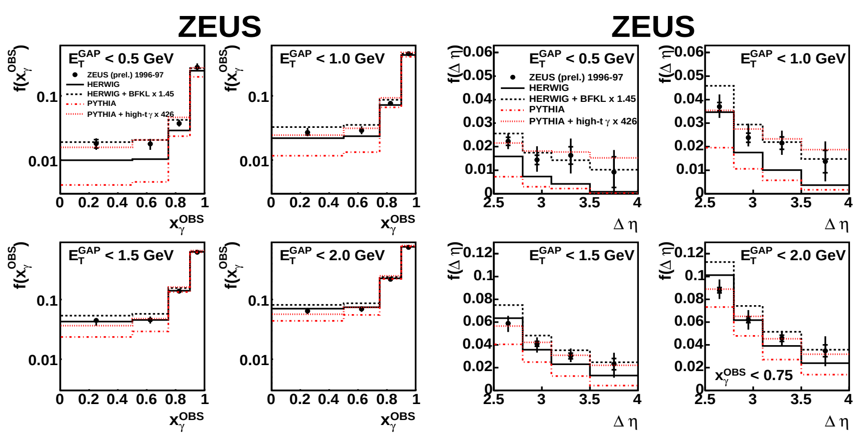

Figure 3. The plot on the left shows the gap fraction, f, in $x_\gamma^{\rm OBS}$ for four different values of $E_{\rm T}^{\rm CUT}$. The plot on the right shows the gap fraction, f, in $\Delta\eta$ in the resolved enhanced region ($x_\gamma^{\rm OBS} > 0.75$) for four different values of $E_{\rm T}^{\rm CUT}$. The points and lines are as defined in Fig. 1.

References

1. T. Sjostrand, Comput. Phys. Commun. **82**, 74 (1994)
2. G. Marchesini, B. R. Webber, G. Abbiendi, I. G. Knowles, M. H. Seymour and L. Stanco, Comput. Phys. Commun. **67**, 465 (1992).