Fermi National Accelerator Laboratory

FERMILAB-Conf-98/118-E
CDF

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April 1998

Presented at the *Diffractive Physics, LAFEX International School on High Energy Physics (LISHEP-98)*, Rio de Janeiro, Brazil, February 10-20, 1998

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy

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CDF/PUB/CDF/PUBLIC/4538
RU 98/E-05 | March 25, 1998

Dijets with a Central Rapidity Gap at $\sqrt{s} = 630$ and 1800 GeV[1]

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Abstract. Preliminary results on dijet production with a rapidity gap between jets in $\bar{p}p$ collisions at $\sqrt{s}$=630 GeV are presented and compared with published results at $\sqrt{s}$=1800 GeV.

INTRODUCTION

Results on dijet events with a rapidity gap between jets (Jet-Gap-Jet), attributed to strongly interacting color-singlet exchange (CSE), have been reported by CDF [1,2] and DØ [3] for $\bar{p}p$ collisions at $\sqrt{s}$=1800 GeV at the Tevatron, and by ZEUS [4] for $\gamma - p$ collisions at HERA. In this paper, we report preliminary results of Jet-Gap-Jet production at $\sqrt{s}$=630 GeV and compare them with those at 1800 GeV. After a brief review of the 1800 GeV results, we present the the new 630 GeV results, make comparisons and draw conclusions.

JET-GAP-JET EVENTS AT $\sqrt{S}$=1800 GEV

In a sample of 10200 single-vertex events with two jets of transverse energy $E_T^{jet} > 20$ GeV, pseudorapidity $1.8 < |\eta| < 3.5$ and $\eta_1 \cdot \eta_2 < 0$, a search was made for events with a rapidity gap in the region of $|\eta| < 1.0$ between the jets. The background of normal color-octet exchange events that happen to have a rapidity gap in this region due to mupliplicity fluctuations was evaluated by using as a template the track/tower multiplicity distribution of a sample of dijet events with the two jets in the same hemisphere [5]. The multiplicity of the same-side (SS) dijet events was evaluated within a larger η-region, $|\eta| < 1.2$, to ensure the same mean multiplicity as that of the opposite-side (OS) event sample. Figure 1 shows the track and tower multiplicity distributions for OS and (normalized) SS dijet events and their asymmetries. The asymmetry is defined as the bin-by-bin difference over sum of the corresponding multiplicities. The ratio of Jet-Gap-Jet to all events was

[1] Presented at "Diffractive Physics, LAFEX International School on High Energy Physics (LISHEP-98), Rio de Janeiro, Brazil, 10-20 February 1998."

evaluated from the excess OS over SS events in the low multiplicity bins (0 tracks and 0-2 towers), after correcting for the single-vertex cut acceptance:

$$R_{JGJ}(1800) = 1.13 \pm 0.12(stat) \pm 0.11(syst)\% = (1.13 \pm 0.16)\%$$
$$(E_T^{jet} > 20 \text{ GeV}, |\eta^{jet}| > 1.8, \eta_1\eta_2 < 0)$$

This value of R is consistent with the previously published results of

$$R_{\text{CDF}} = [0.85 \pm 0.12(stat)^{+0.24}_{-0.12}(syst)]\% \text{ [1]}$$
$$R_{\text{DØ}} = [1.07 \pm 0.10(stat)^{+0.25}_{-0.13}(syst)]\% \text{ [3].}$$

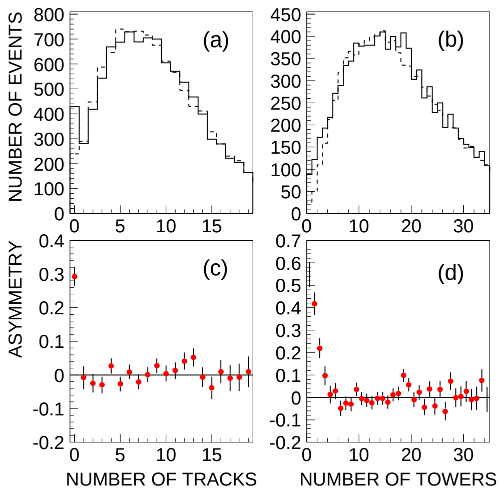

FIGURE 1. (a,b) Multiplicity distributions for OS (solid, $|\eta| < 1.0$) and SS (dashed, $|\eta| < 1.2$) dijet events; (c,d) the asymmetry (bin-by-bin difference over sum) of the distributions in (a) and (b). The low multiplicity excess is attributed to colorless exchange.

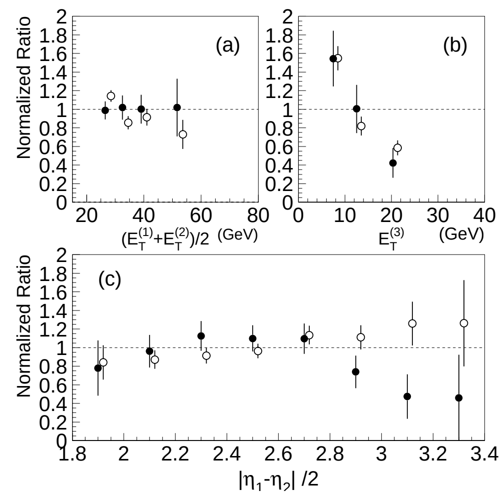

FIGURE 2. Normalized (to be unity on average) ratios of gap (solid points) and control samples (open circles) over all events versus: (a) the average E_T of the two leading jets, (b) the E_T of the third jet, and (c) half the η separation between the two leading jets.

In addition to measuring the overall ratio R, CDF studied the properties of a sample of 221 “gap” events with zero tracks and 0, 1 or 2 towers within $|\eta| < 1$. This sample contains an estimated 15% normal color-octet exchange events, in which the gap is due to multiplicity fluctuations. For this reason, the properties of the gap events were compared with those of a “control” sample consisting of events with 1, 2 or 3 tracks and up to 6 towers. Figure 2 shows normalized ratios of gap and control sample events to all events as a function of the average E_T of the two leading jets, the E_T of the third jet, and the η-separation of the two leading jets. The gap and control samples behave similarly. Within the (statistical) errors, the colorless exchange fraction is independent of jet E_T and $\Delta\eta$, decreasing somewhat at large $\Delta\eta$ (the systematic error of 10% in R does not affect the shapes of the distributions).

JET-GAP-JET EVENTS AT $\sqrt{S}$=630 GEV

The measurement of Jet-Gap-Jet production at $\sqrt{s}$=630 GeV is based on 860 OS and 934 SS dijet events with $|\eta|^{1,2} > 1.8$ and $E_T^{1,2} > 8$ GeV. A lower E_T^{jet} threshold was chosen at 630 than at 1800 GeV so that jets at the same η-values at the two energies correspond approximately to the same x-values of the scattered partons.

The data analysis was modeled after the analysis of the 1800 GeV data. The CSE signal is seen in Fig. 3, which is the counterpart of Fig. 1. Figure 4 shows two views of TOWERS-vs-TRACKS lego plots in the region $|\eta| < 0.9$ for OS and $|\eta_{tracks}| < 1.05$ ($|\eta_{towers}| < 1.2$) for SS events. The SS η-regions were chosen larger so that their mean multiplicity is the same as that for OS events within $|\eta| < 0.9$. The data analysis yielded a CSE fraction of

$$R_{JGJ}(630) = 2.3 \pm 0.9(stat) \pm 0.3(syst)\% = (2.3 \pm 1.0)\%$$
$$(E_T^{jet} > 8 \text{ GeV}, |\eta^{jet}| > 1.8, \eta_1\eta_2 < 0)$$

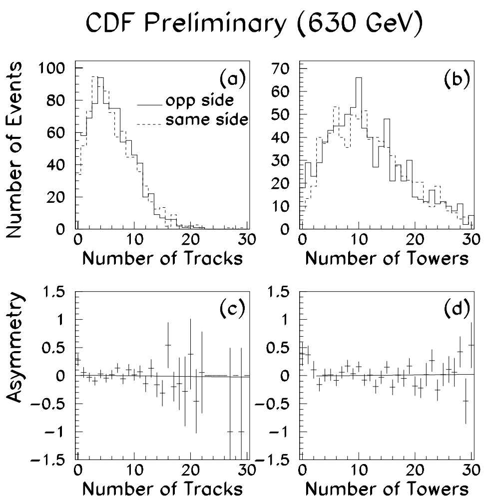

FIGURE 3. Multiplicity distributions (a) for tracks and (b) for calorimeter towers in the regions $|\eta| < 0.9$ for OS (solid lines) and $|\eta| < 1.05$ (1.2) for tracks (towers) of SS dijet events (dashed lines); (c,d) the asymmetry (bin-by-bin difference over sum) of the distributions shown in (a) and (b). The low multiplicity excess is attributed to colorless exchange.

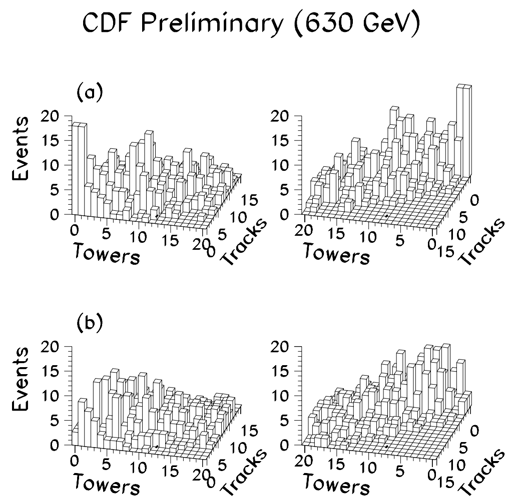

FIGURE 4. TOWERS vs TRACKS: (a) in the region $|\eta| < 0.9$ for OS and (b) in the regions $|\eta| < 1.05$ (1.2) for tracks (towers) of SS dijet events. The SS distribution is normalized so that the number of events with $N_{track} > 0$ and $N_{tower} > 2$ is equal to that for OS events. Two views of the same distribution are shown in (a) and (b).

The distributions for $\bar{E}_T \equiv (E_T^1 + E_T^2)/2$ of the two leading jets and for $\bar{\eta} \equiv |\eta_1 - \eta_2|/2$ are shown in Fig. 5 for gap and control sample events. The definition of the data samples and of the normalization are the same as those in the 1800 GeV case (Fig. 2). The "gap sample" consists of 42 (0 or one vertex) events in the bins with zero tracks and 0, 1 or 2 towers in Fig. 4(a). These events contain a background of 19 events (45%), as estimated from an extrapolation from larger multiplicity bins guided by the distribution of the SS lego plot of Fig. 4(b). The "control sample" consists of (low multiplicity) OS events with 1-3 tracks and 0-6 towers. Both gap and control sample distributions in Fig. 5 are normalized to be unity on average to facilitate comparison of their shapes. As in the 1800 GeV case, the gap and control sample distributions are similar. Assuming that the background in the gap sample has the same $\bar{E}_T$ and $\bar{\eta}$ dependence as the control sample, we have scaled the number of events in the control sample to 45% of the events in the gap sample and subtracted the resulting control sample $\bar{E}_T$ and $\bar{\eta}$ distributions from the corresponding gap sample distributions; the same was done for the 1800 GeV data samples, where the background was 15%. Distributions for 630 and 1800 GeV data after background subtraction are compared below.

COMPARISON OF 630 WITH 1800 GEV RESULTS

A meaningful comparison of dijet production characteristics at two energies can be made using the x and x_T variables of the scattered partons, which are given in terms of E_T^{jet} and η^{jet} by $x_T^i = E_T^i/2\sqrt{s}$ and, for our OS kinematics, $x^i \approx (E_T^i/\sqrt{s})\, e^{|\eta^i|}$.

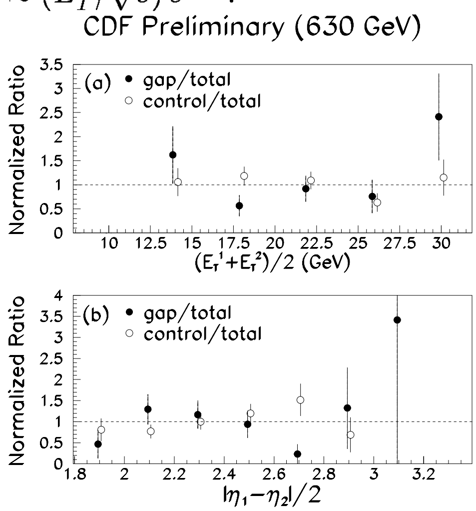

FIGURE 5. Normalized (to be unity on average) ratios of gap (solid points) and control sample events (open circles) over all events versus: (a) the average E_T of the two leading jets; (b) half the η separation between the two leading jets. The gap sample contains an estimated 45% background.

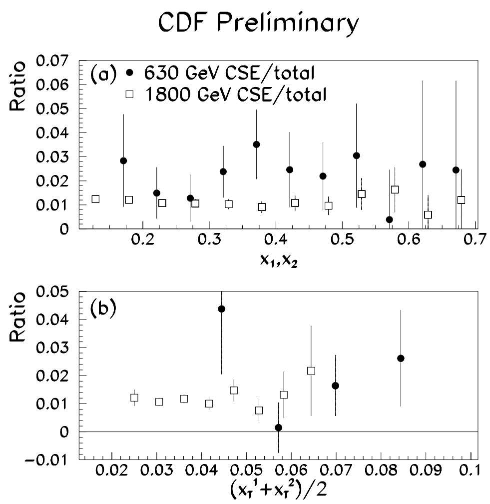

FIGURE 6. Comparison of distributions of the ratio of CSE events to all events for $\sqrt{s}$=630 and 1800 GeV: (a) x of the two leading jets (two entries per event); (b) x_T of the two leading jets. The overall normalization has been scaled to correspond to the value of the average ratio R measured using the track multiplicities.

Figure 6 shows (a) x distributions (two entries per event) and (b) x_T distributions for the (background-subtracted) gap samples of 630 and 1800 GeV. Both distributions are consistent with being flat over the range of the measurement.

CONCLUSION

New results were presented on dijet events with a rapidity gap between jets produced in $\bar{p}p$ collisions at $\sqrt{s}$=630 GeV at the Tevatron and compared with published results at $\sqrt{s}$=1800 GeV. The Jet-Gap-Jet event topology is presumed to be due to strongly interacting color-singlet exchange. A candidate for such an exchange is the pomeron, which is exchanged in soft [6] and hard [7] diffraction dissociation. For jets of $\eta_1\eta_2 < 0$, $|\eta| > 1.8$ and $E_T^{jet} > 8$ (20) GeV at $\sqrt{s}$ =630 (1800) GeV, the fraction of Jet-Gap-Jet to all dijet events was found to be $R_{JGJ} = 2.3 \pm 1.0\%$ ($1.13 \pm 0.16\%$). The ratio of the fractions at the two energies is $R\left(\frac{630}{1800}\right) = 2.0 \pm 0.9$. Not withstanding its statistical significance, the observed increase of the Jet-Gap-Jet fraction with decreasing energy is consistent with theoretical expectations [8].

The x and x_T values of the scattered partons were extracted from the E_T^{jet} and η^{jet} measured values at 630 and 1800 GeV and their distributions were presented and compared. Within errors, the distributions at both energies are flat, indicating that the color-singlet (pomeron?) and color-octet couplings to quarks and gluons are of the same magnitude.

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