CDF results on double diffraction

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The double-diffractive cross section is measured for $\bar{p}p$ interactions which produce a central rapidity gap with width $\Delta\eta > 3$ at $\sqrt{s} = 1800$ and 630 GeV. Comparisons are made to predictions from Regge theory based on the triple Pomeron amplitude and factorization and to previous measurements.

Double-diffractive (DD) events are characterized by the exchange of a color singlet with the quantum numbers of the vacuum, the Pomeron, causing both incident hadrons to dissociate. The dissociated hadrons produce diffractive mass clusters along their initial direction, while, since the exchanged object does not radiate as, for example, a colored object would, the region in between the clusters is empty of particles.

Hard double diffraction (Fig. 1a) has previously been studied in events with rapidity gaps between jets. The fraction of dijet events with $1.8 < |\eta^{jet1,jet2}| < 3.5$, $\eta^{jet1}\eta^{jet2} < 0$, and $E_T^{jet1,jet2} > 20$ GeV at $\sqrt{s} = 1800$ GeV due to color singlet exchange (CSE) was found to be [1]

$$R_{JGJ}(1800) = [1.13 \pm 0.12(stat) \pm 0.11(syst)]\%,$$

and for jets with $E_T^{jet1,jet2} > 8$ GeV at $\sqrt{s} = 630$ GeV [2]

$$R_{JGJ}(630) = [2.7 \pm 0.7(stat) \pm 0.6(syst)]\%,$$

so that the CSE fraction at 630 GeV is greater than that at 1800 GeV by a factor of

$$R(630)/R(1800) = 2.4 \pm 0.7(stat) \pm 0.6(syst).$$

The distribution of the CSE fraction as a function of the rapidity separation between the jets was seen to drop as the jets reached the edges of the acceptance. No dependence was observed of the CSE fraction on mean dijet E_T or on jet x, determined from the E_T and η of the jets as $x_i = e^{|\eta_i|}E_T^i/\sqrt{s}$.

We have studied soft double diffraction (Fig. 1b) by looking for central rapidity gaps in minimum-bias events which have hits in the Beam-Beam Counters (BBC's). We looked for gaps which overlap $\eta = 0$ rather than the largest gap anywhere in the detector because the latter method is more likely to be biased by inefficiencies in the calorimeters. The η of the track or calorimeter tower above a given threshold with the smallest $|\eta|$ for $\eta > 0$ ($\eta < 0$) is defined to be $\eta_{max(min)}$. Events with the lowest-$|\eta|$ particle in the BBC, $3.2 < |\eta| < 5.9$, are assigned $|\eta_{max(min)}| \equiv 3.3$.

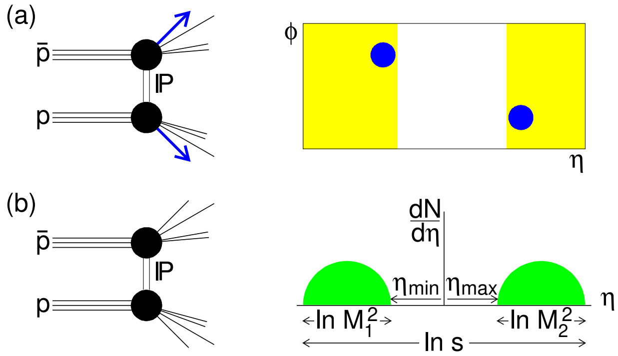

Figure 1. A double-diffractive interaction in which a Pomeron ($I\!P$) is exchanged in a $\bar{p}p$ collision at center-of-mass energy $\sqrt{s}$, (a) with a hard scattering producing jets on opposite sides of a rapidity gap, and (b) producing diffractive masses M_1 and M_2 separated by a rapidity gap of width $\eta_{max} - \eta_{min}$.

The data are compared to non-diffractive (ND), single-diffractive (SD), and DD Monte Carlo (MC) simulated events as a function of η_{max} and $-\eta_{min}$ (not shown). Structure due to different thresholds and efficiencies in the calorimeter is visible, e.g., at the interface between the plug and forward calorimeters at $\eta \sim 2.4$.

Figure 2 shows histograms of the data and MC as a function of $\Delta\eta^0 = \eta_{max} - \eta_{min}$. The SD contribution is fixed by known cross sections and the fraction of events passing the BBC trigger in the MC. The ND and DD contributions are determined as follows. The DD and non-DD MC distributions are normalized to give the number of events observed in the data in the region $\Delta\eta^0 < 0.8$ (dominantly ND) and $\Delta\eta^0 > 3$ (dominantly DD). The DD MC uses the differential cross sections from Regge theory based on the triple Pomeron amplitude and factorization. The agreement between data and MC seen in Fig. 2 shows that Regge theory appears to correctly predict the mass dependence, as was also observed by the H1 collaboration [3]. Note that the fluctuations in the $\Delta\eta^0$ distribution are due to structure in the calorimeter and are followed closely by the MC because of careful calibrations derived to match MC particle p_T's to observed calorimeter E_T's.

We find cross sections at $\sqrt{s}$ = 1800 (630) GeV by measuring $\sigma_{DD}\mathcal{A}$, where $\mathcal{A}$ is the detector acceptance for triggering on diffractive mass clusters. Preliminary calculations from MC yield $\mathcal{A} = (48.7 \pm 8.4)\%$ [$(61.4 \pm 6.8)\%$], and

$$\sigma_{DD}(\sqrt{s} = 1800 \text{ GeV}, \Delta\eta^0 \geq 3) = 4.71 \pm 0.02(\text{stat})^{+0.92}_{-0.90}(\text{syst}) \text{ mb},$$

$$\sigma_{DD}(\sqrt{s} = 630 \text{ GeV}, \Delta\eta^0 \geq 3) = 4.32 \pm 0.01(\text{stat})^{+0.54}_{-0.76}(\text{syst}) \text{ mb}.$$

The cross sections for all gaps of width $\Delta y > 2.3$, corresponding to the SD coherence limit of $\xi < 0.1$, can be obtained by extrapolation using the differential cross section shape from Regge theory, and are greater by a factor of 1.72 (1.67) at $\sqrt{s}$ = 1800 (630) GeV. The resulting cross sections are shown in Fig. 3 along with results from UA5 [4] and other cross sections at lower energies [5,6], most of which were derived from exclusive measurements using factorization relations. The DD cross sections measured by CDF are an order of magnitude smaller than what is predicted using Regge theory, but are in general agreement with the renormalized gap model [7],

The improved plug calorimeters and proposed miniplug detectors for CDF in Run II will allow a better measurement of the DD cross section and hard DD dijet production, including better resolution of gaps and jets out to $\eta \approx 5.5$.

REFERENCES

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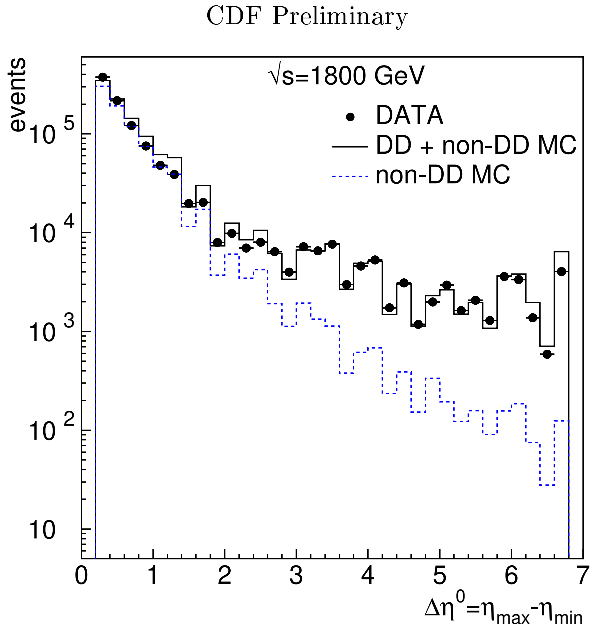

Figure 2. The number of events as a function of $\Delta\eta^0 = \eta_{max} - \eta_{min}$ for 1800 GeV data, and for DD + non-DD and only non-DD MC-generated events.

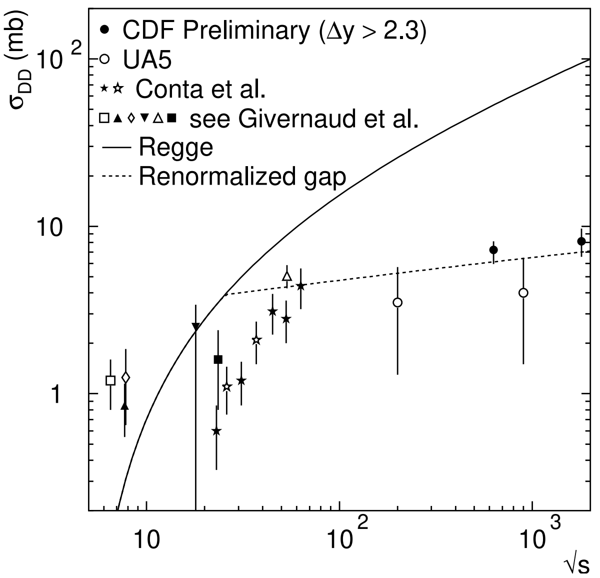

Figure 3. The total DD cross section versus $\sqrt{s}$ compared with predictions from standard Regge theory based on the triple-Pomeron amplitude and factorization (dashed curve) and from the renormalized gap model (solid curve).