Diffractive dijets at CDF

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We report results obtained from a study of Roman Pot triggered events with a leading antiproton of beam momentum fraction $0.905 < x_F < 0.975$ and 4-momentum transfer squared $|t| < 3$ GeV^2, produced in $\bar{p}p$ collisions at $\sqrt{s} = 1800$ GeV. Using events which contain two jets with transverse energy $E_T^{jet} > 7$ GeV, the diffractive structure function of the antiproton is evaluated and compared with expectations based on results obtained at HERA.

We have studied diffractive dijet events produced in $\bar{p}p$ collisions, which are characterized by two jets with high transverse energy and a leading (anti)proton accompanied by a rapidity gap. The rapidity gap, defined as a region of pseudorapidity devoid of particles, is associated with the exchange of a Pomeron ($I\!P$), which is a color-singlet state with vacuum quantum numbers. In this framework, diffractive dijet events produced in $\bar{p}p$ collisions can be expressed as, $\bar{p} + p \to [\bar{p}' + I\!P] + p \to \bar{p}' + \mathrm{Jet}_1 + \mathrm{Jet}_2 + X$.

Previously, the CDF collaboration studied diffractive W-boson, dijet and $\bar{b}b$ productions [1,2]. In these analyses, diffractive production is tagged by the requirement of a forward rapidity gap. The observed rates of diffractive W-boson, dijet and $b\bar{b}$ productions were found to be significantly lower than predictions based on factorization, while such models describe well the diffractive DIS and photoproduction data obtained at HERA [3,4]. The breakdown of factorization observed in the rate comparisons raises the question of whether the β-distribution is also process dependent, where β is the momentum fraction of the struck parton in the Pomeron. In this analysis, we measure the diffractive structure function of the antiproton, and compare it with expectations based on the diffractive parton densities obtained in diffractive DIS experiments at HERA [4].

The diffractive data used in this analysis were collected by triggering an antiproton detected in three Roman Pot (RP) spectrometers. The beam momentum fraction $x_F = 1 - \xi$ and the four momentum squared t of the detected antiproton were reconstructed from the X-Y RP track position, the position of the event vertex, and the machine transport matrix. The non-diffractive (ND) data were collected with a minimum bias (MB) trigger which required a coincidence of hits on two beam-beam counters (BBC). From these two data samples, we select diffractive and ND dijet events with two jets of $E_T > 7$ GeV.

Figs. 1(a) and 1(b) show the RP acceptance and a lego plot of the inclusive diffractive event sample as a function of ξ and t, respectively. The fraction of dijet events in the inclusive diffractive events is shown as a function of ξ in Fig. 1(c) and t in Fig. 1(d). The fraction is found to increase linearly with increasing ξ, but no significant t dependence is observed, in agreement with the UA8 result [5] which showed a flat t dependence in the region $0.9 < |t| < 2.3$. The jet E_T distributions fall faster with E_T in the diffractive events than in the ND. The diffractive dijets are boosted away from the leading antiproton in η, and are more back-to-back in ϕ than the ND.

In leading order QCD, the cross section ratio, $R(x)$, of the diffractive to ND dijet productions represents the ratio of the diffractive to ND effective structure functions defined as $F_{JJ}^{(D)}(x) = x\{g^{(D)}(x) + \frac{4}{9}\sum_i [q_i^{(D)}(x) + \bar{q}_i^{(D)}(x)]\}$. Thus, the diffractive structure may be obtained by multiplying the "known" ND structure by $R(x)$. The x, the momentum fraction of struck parton in the antiproton, is evaluated from the jets (including a third jet if $E_T^{jet3} > 5$ GeV) as, $x = \sum_{i=1,2(3)} E_T^{(i)} e^{-\eta^{(i)}}/(2p_0^{\bar{p}})$. Fig. 2 shows the ratio $R(x)$ of the diffractive dijet events to the ND dijet events for six ξ bins of width $\Delta\xi = 0.01$, where the two data samples are normalized to the same luminosity. The distributions are fitted well by the form $R(x) = R_0(x/0.0065)^{-r}$, with similar slopes for all ξ bins in the region $10^{-3} < x < 0.5\xi_{min}$.

The diffractive structure function can be determined by multiplying the measured $R(x)$ by the known ND structure function. By changing the variable from x to β $(= x/\xi)$, we obtain the diffractive structure function $F_{JJ}^D(\beta)$, shown in Fig. 3. This structure function is compared to that extracted by the H1 collaboration from diffractive DIS measurements using a QCD analysis [4]. The dashed (dotted) line in Fig. 3 is obtained from H1 diffractive parton densities derived with fit 2 (fit 3), scaled down by a factor of 20. The measured diffractive structure function does not agree with expectations from the H1 results both in normalization and shape. Summed over all β, the discrepancy in normalization is about a factor of 10, in general agreement with predictions based on the renormalized Pomeron flux model [6].

In Run 2, the Roman Pot spectrometers will be placed closer to the antiproton beam, which will enable us to extend our measurement to lower ξ values. In addition, the improved plug calorimeters, two proposed miniplug calorimeters and a set of beam shower counters (BSC) to tag forward rapidity gaps will provide the basis for improved studies in hard diffraction.

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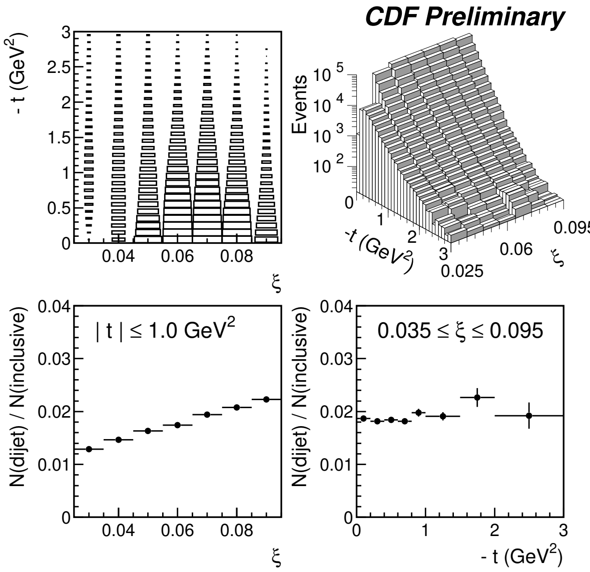

Figure 1. Distributions versus ξ and t: (a) Roman Pot acceptance; (b) inclusive diffractive event sample; (c) ratio of dijet to inclusive diffractive events versus ξ and (d) versus t.

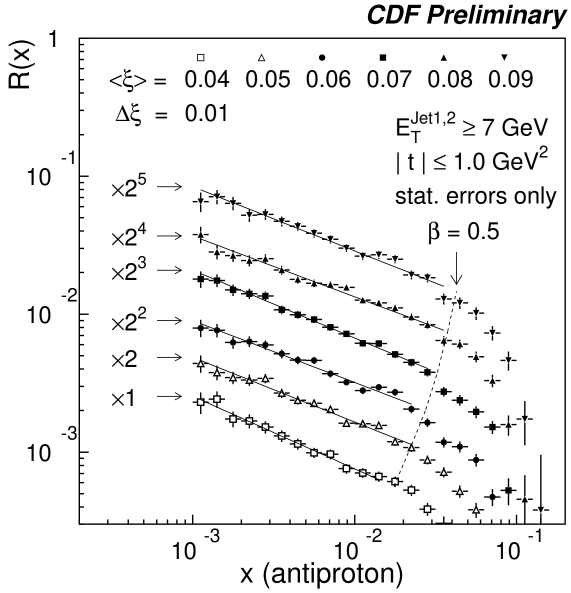

Figure 2. Ratio of diffractive to non-diffractive dijet event rates as a function of x (momentum fraction of struck parton in antiproton). The solid lines are fits to the form $R(x) = R_0(x/0.0065)^{-r}$ for $\beta < 0.5$, where $\beta = x/\xi_{min}$.

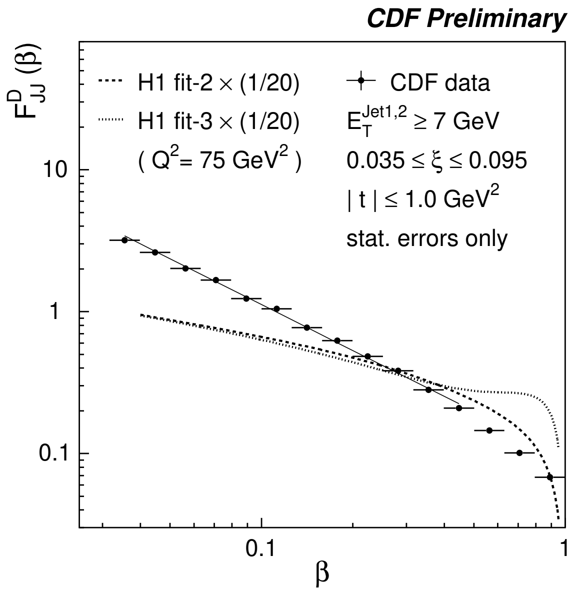

Figure 3. The β distribution from the data (points) and fit (solid line), compared with expectations from the diffractive parton densities of the proton from H1 fit 2 (dashed) and fit 3 (dotted) scaled down by a factor of 20.