DIFFRACTIVE DIJET PRODUCTION AT THE TEVATRON: CDF RESULTS

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We report a measurement of the diffractive structure function of the antiproton for dijet events produced in association with a leading antiproton in $\bar{p}p$ collisions at $\sqrt{s}$ =1800 GeV. Comparing our results with expectations based on parton densities extracted by the H1 Collaboration from diffractive deep inelastic scattering at the DESY ep collider HERA, we find a severe breakdown of QCD factorization.

The CDF Collaboration has performed measurements on hard single diffraction (SD) using two different techniques to identify diffractive events: a large forward rapidity gap or a leading antiproton. The analysis of the rapidity gap data (W [1], dijet [2], and b-quark [3] production) yielded a diffractive gluon fraction of [3] $f_g^D = 0.54^{+0.16}_{-0.14}$. The measured SD to non-diffractive (ND) ratios for all three processes were found to be ~ 5 times smaller than expectations based on diffractive deep inelastic scattering (DDIS) results obtained at the HERA ep collider, challenging the validity of QCD factorization (existence of universal parton densities) for diffraction. To further characterize the observed breakdown of factorization, CDF measured [4] the shape of the diffractive parton distribution function for dijet events produced in association with a leading antiproton detected in a Roman Pot Spectrometer (RPS). In this paper, we present the RPS results and compare them with expectations based on diffractive parton densities extracted by the H1 Collaboration at HERA.

The $\bar{p}$ diffractive structure function relevant to dijet production at the Tevatron can be written as a color weighted combination of gluon and quark parton densities,

$$F_{jj}^D(x,Q^2,\xi) = x\left[g^D(x,Q^2,\xi) + \frac{4}{9}\sum_i \left(q_i^D(x,Q^2,\xi) + \bar{q}_i^D(x,Q^2,\xi)\right)\right] \quad (1)$$

where x is the x-Bjorken of the parton in the $\bar{p}$, $Q^2 = \langle E_T^{jet}\rangle^2$, and $\xi = x_{I\!P}$ the fractional momentum loss of the $\bar{p}$. Assuming that QCD factorization holds for diffraction, $F_{jj}^D(x,Q^2,\xi)$ may be evaluated by multiplying the measured ratio of SD to ND rates, $R_{SD/ND}(x,Q^2,\xi)$, by the (known) ND structure function

$F_{jj}^{ND}(x, Q^2)$. The value of x is obtained from the jet variables E_T^{jet} and η^{jet},

$$x = \frac{1}{\sqrt{s}} \sum_{i=1,2(3)} E_T^i \cdot e^{-\eta^i} \tag{2}$$

where the sum is carried out over the two leading jets of $E_T > 7$ GeV plus a third jet of $E_T > 5$ GeV, if there is one. By a change of variables, $x \to \beta\xi$, $F_{jj}^D(x, Q^2, \xi)$ is transformed to $F_{jj}^D(\beta, Q^2, \xi)$, which is compared with values calculated from the H1 diffractive parton densities [5] evolved to our Q^2 range.

Figure 1 shows the ratio of SD to ND dijet rates, $\tilde{R}(x_{\bar{p}})$, as a function of $x_{\bar{p}}$ in the range of $E_T^{jet1,2} > 7$ GeV, 4-momentum transfer to the $\bar{p}$ of $|t| < 1$ GeV^2, and $0.035 < \xi < 0.095$; the tilde over the R indicates integration over E_T^{jet}, t, and ξ within each ξ-bin. The cut-off at $x = 10^{-3}$ is imposed to guarantee full detector acceptance and thus avoid the use of Monte Carlo and detector simulations. For $\beta < 0.5$ good fits to the data can be obtained by the form $\tilde{R}(x) = R_0(x/0.0065)^{-r}$. A fit to all the data $(0.035 < \xi < 0.095)$ yields $R_0 = (6.1 \pm 0.1) \times 10^{-3}$ and $r = 0.45 \pm 0.02$.

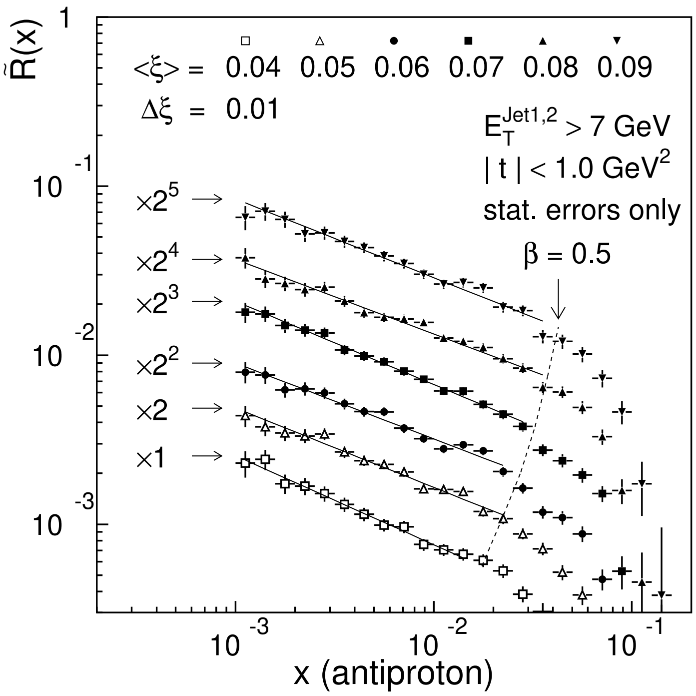

Figure 1: Ratio of diffractive to non-diffractive dijet event rates as a function of x (momentum fraction of parton in $\bar{p}$). The solid lines are fits to the form $\tilde{R}(x) = R_\circ(x/0.0065)^{-r}$.

The $\bar{p}$ diffractive structure function is obtained from the equation $\tilde{F}^{D}_{jj}(\beta) = \tilde{R}(x = \beta\xi) \times \tilde{F}^{ND}_{jj}(x \to \beta\xi)$ using GRV98LO parton densities to evaluate $\tilde{F}^{ND}_{jj}(x \to \beta\xi)$. The result is shown in Fig. 2. A fit to the data of the form $\tilde{F}^{D}_{jj}(\beta) = B(\beta/0.1)^{-n}$ for $\beta < 0.5$ yields $B = 1.12 \pm 0.01$ and $n = 1.08 \pm 0.01$. The dashed (dotted) curve is the expectation for $\tilde{F}^{D}_{jj}(\beta)$ calculated from fit 2 (fit 3) of the H1 diffractive structure function [5] evaluated at $Q^2 = 75$ GeV^2, the $\langle E_T^{jet}\rangle^2$ of our data. The disagreement between the CDF data and the expectation from DDIS represents a breakdown of factorization.

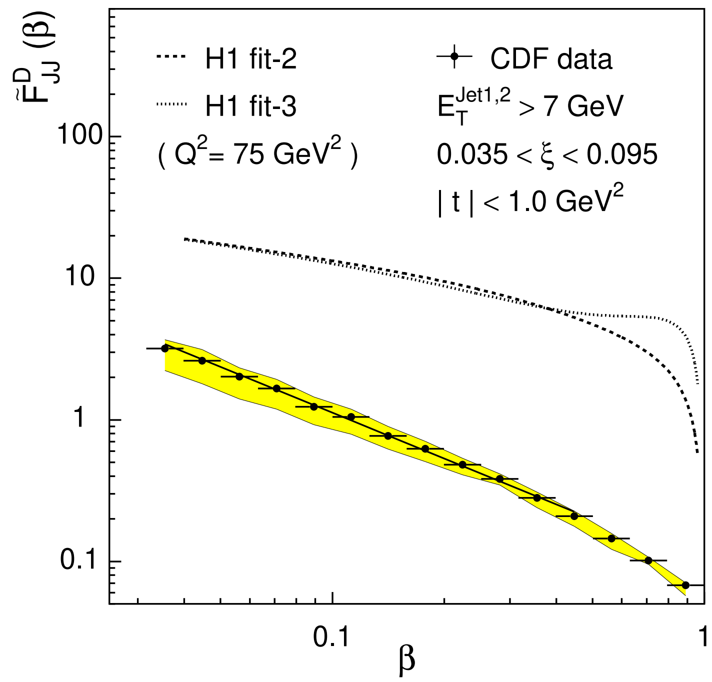

Figure 2: Data β distribution (points) compared with expectations from the parton densities of the proton extracted from diffractive deep inelastic scattering by the H1 Collaboration.

References

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