Diffraction news from CDF

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Abstract. We report updated results by the CDF II collaboration on diffractive W and Z production and preliminary results from a study of rapidity gaps between very forward jets.

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1. INTRODUCTION

The central issue in diffraction is understanding the underlying QCD mechanism of factorization breaking in *hadron-hadron* and $\gamma/\gamma^* - hadron$ collisions. In *DIFFRACTION 2008* [1], we summarized the results on diffraction obtained by the Collider Detector of Fermilab (CDF) in Runs I&II of the Fermilab Tevatron $\bar{p}p$ collider, concentrating on two new Run II measurements, namely diffractive *dijet* production and diffractive W/Z production. While the $dijet$ analysis, which is aiming at obtaining the diffractive structure function, is still being finalized, the W/Z analysis has been completed [2]. In this paper, we present some analysis details and updated results for W/Z production, and report on an ongoing study of rapidity gaps between very forward jets.

2. DIFFRACTIVE W AND Z PRODUCTION

Diffractive interactions are presumed to be mediated by the exchange of a strongly-interacting color singlet quark/gluon exchange with the quantum numbers of the vacuum, historically referred to as *Pomeron*, $I\!P$ (see, e. g., [3]). Since no radiation is expected in vacuum exchange, a *rapidity gap* (pseudorapidity region devoid of particles) is present in the final state. Diffractive processes are classified as single diffraction (SD), double diffraction (DD) and double Pomeron exchange (DPE), depending on whether one, both or neither the proton or the antiproton dissociates.

In Run I, CDF measured the fraction of diffractively produced events in inclusive dijet, W boson, b quark and J/ψ event samples at $\sqrt{s} = 1800$ GeV, and found it to be in all cases $\sim 1\%$ (see [2]). Since diffractive dijets can be produced via quarks or gluons, whereas to leading order a diffractive W is produced via a quark in the Pomeron (see Fig. 1), combining cross section measurements of diffractive dijet production and diffractive W production was used by CDF to determine the quark/gluon content of the Pomeron [4]. This result, however, was brought into question by a measurement by the D0 collaboration [5], which reported a diffractive W fraction of up to 4 times larger than the CDF result depending on the theory model used to determine the *gap survival* probability, defined as the likelihood that the diffractive rapidity gap will not be filled by products of additional parton-parton interactions in the same $\bar{p}p$ collision. The results presented here on diffractive W and Z production were obtained by tagging diffractive events by the recoil $\bar{p}$ and measuring directly its momentum loss, ξ.

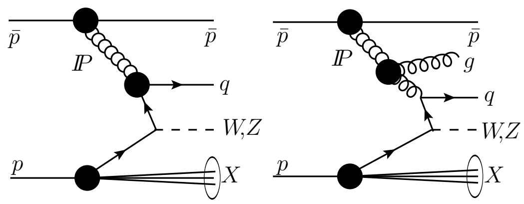

FIGURE 1. Diffractive W/Z production: (left) via quarks in $I\!P$, and (right) via gluons.

The CDF II diffractive program was made possible by the use of special forward detectors integrated into the CDF II main detector, presented in Fig.2 and described in more detail in Ref. [1].

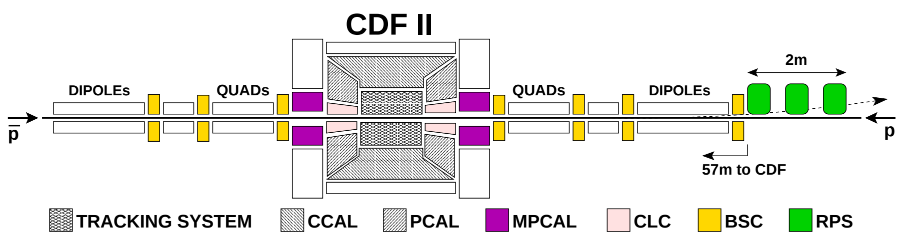

FIGURE 2. Plan view of the CDF II detector (not to scale) showing the MiniPlug calorimeters (MP-CAL, $3.5 < |\eta| < 5.1$), Beam Shower Counters (BSC, $5.4 < |\eta| < 7.4$), and Roman Pot Spectrometer (RPS, $0.03 < \xi <\sim 0.10$); the proton beam points to the $+\hat{z}$ (positive η) direction.

Events were selected by requiring a central e or μ consistent with being from $W/Z \rightarrow e(\mu) + \nu$ with a reconstructed $E_T^e(p_T^\mu) > 20$ GeV (GeV/c); for Z candidates, e's were also accepted if detected in the plug calorimeter within $1.2 < |\eta| < 2.8$. To select diffractive events, a RPS trigger was also required. Figure 3 (left) shows the RPS acceptance vs ξ and t for diffractive events, and Table 1 the number of events passing successive offline selection requirements. A total of 352 (36) W (Z) events were obtained.

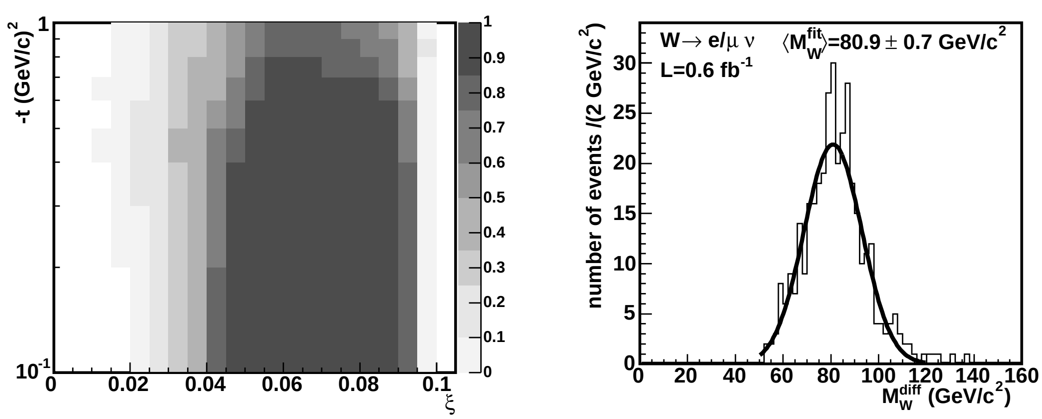

FIGURE 3. (left) RPS acceptance vs $\xi_{\bar{p}}$ and t; (right) reconstructed $M_{\rm W}^{\rm diff}$ with a Gaussian fit.

TABLE 1. W and Z events passing successive selection cuts.

	$W \to e\nu$	$W \to \mu\nu$	$W \to l(e/\mu)\nu$
RPS-trigger-counters	6663	5657	12 320
RPS-track	5124	4201	9325
$50 < M_W < 120$	192	160	352
	$Z \to ee$	$Z \to \mu\mu$	$Z \to ll$
RPS-trigger-counters	650	341	991
RPS-track	494	253	747
$\xi^{\rm cal} < 0.10$	24	12	36

The requirement on $\xi_{\bar{p}}^{\rm cal}$ is important for removing *overlap background*, consisting mainly of a nondiffractive dijet event overlapped by a soft diffractive event providing the RPS trigger (see Ref. [1]). The removal of overlap events is illustrated in Fig. 4. A cut rejecting events with $\log_{\xi^{\rm cal}} > -1$ is applied.

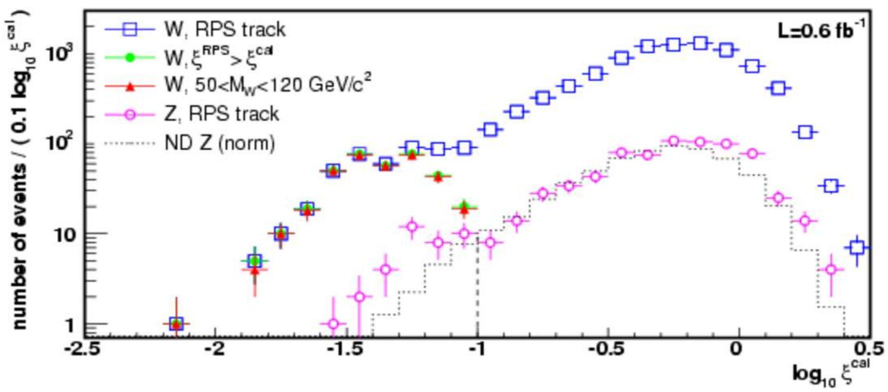

FIGURE 4. $\xi_{\bar{p}}^{\rm cal}$ for W/Z events with a RPS track. The histogram is from ND Z events rescaled.

Combining $\xi_{\bar{p}}^{\rm cal}$ and $\xi^{\rm RPS}$ yields the missing longitudinal momentum due to ν's:

$$\xi_{\bar{p}}^{\rm cal} = \sum_{i=1}^{N_{\rm towers}} \frac{E_{\rm T}^{i}}{\sqrt{s}} e^{-\eta^{i}}, \; \xi^{\rm RPS} - \xi_{\bar{p}}^{\rm cal} = \sum_{i=1}^{N_{\rm towers}} \frac{\not{E}_T^{i}}{\sqrt{s}} e^{-\eta^{\nu}}, \; p_z^{\nu} = \not{E}_T / \tan\left[2\tan^{-1}\left(e^{-\eta^{\nu}}\right)\right]. \quad (1)$$

This enables full reconstruction of the W kinematics and yields the W mass shown in Fig. 3 (right), which agrees with the world value $M_W^{\rm PDG} = (80.398 \pm 0.025)$ GeV/c^2 [6].

The SD/ND ratios for SD events in $0.03 < \xi < 0.10$ and $-1 < t < 0$ (GeV/c)^2 are:

$$R_{\rm W} = [1.00 \pm 0.05\,({\rm stat.}) \pm 0.10({\rm syst.})], \quad R_{\rm Z} = [0.88 \pm 0.21({\rm stat.}) \pm 0.08({\rm syst.})]\%. \quad (2)$$

3. RAPIDITY GAPS BETWEEN JETS

Rapidity gaps between jets (Jet-Gap-Jet, JGJ) can be used to test perturbative models of gap formation, e.g., the BFKL hypothesis (see, e.g., [3]). Of particular interest is the suppression relative to expectations between JGJ and minimum bias DD events (MinBias). A CDF II analysis in progress is aimed at making such a comparison using MiniPlug MinBias and Jet triggers. Figure 5 shows the distribution of the gap fraction (ratio of gap to all events) for MinBias and two different $E_T^{\rm jet2}$ thresholds with a CCAL gap is required. The observed jet ratios are suppressed relative to the MinBias ratio, and the suppression is independent of the width of the gap. A BFKL type contribution to the JGJ distribution would be expected to be at the high $\Delta\eta$. No excess that could be attributed to a BFKL contribution is observed.

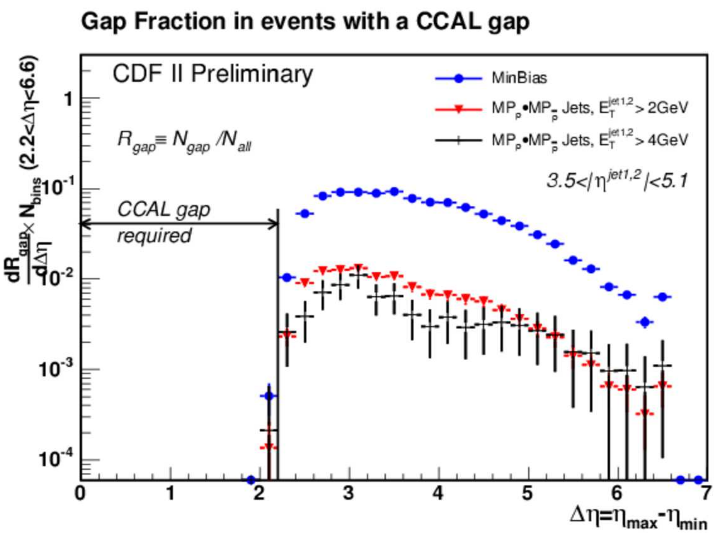

FIGURE 5. Gap fractions $R_{gap} = N_{gap}/N_{all}$ vs. $\Delta\eta = \eta_{max} - \eta_{min}$ for MinBias and MiniPlug jet events of $E_T^{jet1,2}$ >2 GeV and $E_T^{jet1,2}$ >4 GeV.

4. CONCLUSIONS

Updated results by the CDF II collaboration on diffractive W and Z production using a roman pot spectrometer, and preliminary results from an ongoing study of rapidity gaps between very forward jets are presented. The W result agrees with the CDF I rapidity gap result, the Z/W ratio is similar to that for inclusive Z and W events, and the "gap-fraction" in dijet events versus gap width is uniformly suppressed relative to that in minimum bias events with no discernible signal for a BFKL contribution at high $\Delta\eta$.

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