

# Results on diffraction at CDF

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**Abstract.** In run I CDF made an extensive range of measurements studying diffractive processes. In run II these measurements can be extended using improved triggering, new detectors and larger data samples. In these proceedings run II measurements of single diffractive dijet production and double pomeron exchange production of dijets are presented.

## 1 Introduction

Diffractive events are characterised by a leading (anti-) proton and/or a rapidity gap. These events are associated with the exchange of a strongly interacting colour-singlet object known as the pomeron. Studying diffractive events in the presence of a hard scale, such as that in dijet production, may give an insight into the nature of the exchange.

CDF made an extensive number of diffractive measurements during run I in  $p\bar{p}$  collisions ( $\sqrt{s} = 1.8$  GeV). In run II ( $\sqrt{s} = 1.96$  GeV) these measurements can be extended with larger data-sets, new triggers and improved forward detectors. CDF has built new beam shower counters (BSC) covering  $5.5 < |\eta| < 7.5$  and MiniPlug calorimeters covering  $3.5 < |\eta| < 5.1$ . The roman pots on the out-going anti-proton side are retained from run I.

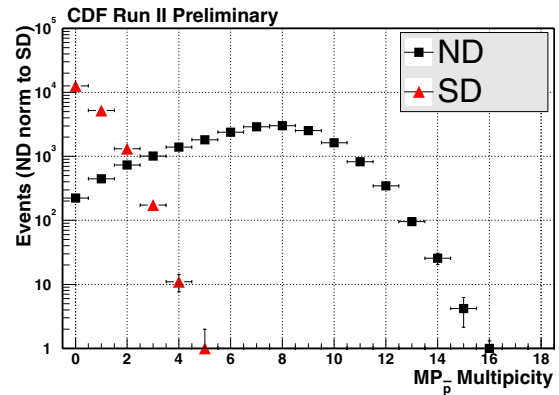
Figure 1 shows the hit multiplicity in the MiniPlug for diffractive events, selected with the roman pots, and non-diffractive events. There is a good discrimination between the two samples in the zero multiplicity bin where the diffractive signal is concentrated.

In run II CDF have, so far, studied single diffractive dijet production and double pomeron exchange dijet production. Diagrams of these processes are shown in Fig. 2 and these measurements are now described.

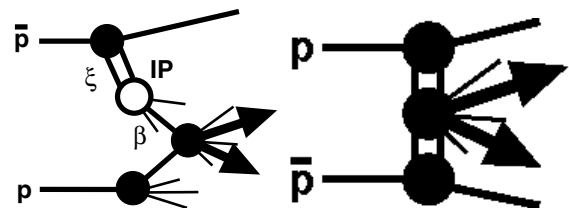
## 2 Diffractive dijet production

Diffractive dijet production, shown in Fig. 2(a), was measured in run I [1]. The events can be described in terms of a pomeron emitted from the anti-proton, carrying a momentum fraction  $\xi_{\bar{p}}$ , and a hard scatter between a parton from the pomeron, carrying momentum fraction  $\beta$ , and a parton from the proton. In leading order QCD the ratio of the single diffractive to non-diffractive cross sections is equal to the ratio of the diffractive to anti-proton structure functions.

The initial data sample (RP+J5) was collected with a trigger that requires the detection of the leading anti-

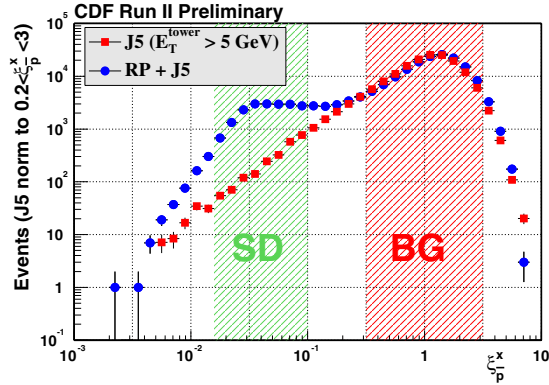


**Fig. 1.** The MiniPlug hit multiplicity for diffractive events, tagged by the out-going anti-proton in the roman pots, compared to the multiplicity of non-diffractive events

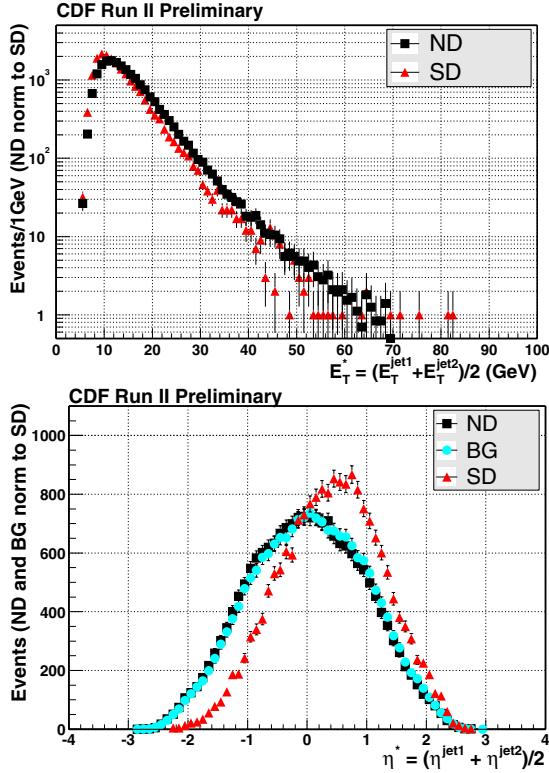


**Fig. 2.** Diagrams of a single diffractive dijet production labeled with the pomeron exchange, IP, and the kinematic variables, and of b double pomeron exchange dijet production

proton in the roman pots and a calorimeter tower with transverse energy,  $E_T$ , of at least 5 GeV. A non-diffractive control sample (J5) requires just the calorimeter tower. Offline, two jets (cone algorithm,  $R=0.7$ ) are required with  $E_T^{corr} > 5$  GeV and  $|\eta^{jet}| < 2.5$  where the jets are corrected for detector effects and underlying energy. The  $\xi_{\bar{p}}$  distributions of the RP+J5 and J5 data samples are compared in Fig. 3. The two distributions are normalized in the region  $0.2 < \xi_{\bar{p}} < 3$ , which is away from the diffractive signal with  $\xi_{\bar{p}} < 0.1$ .



**Fig. 3.** The  $\xi_{\bar{p}}$  distribution of data taken with the RP+J5 trigger compared to data taken with the J5 trigger

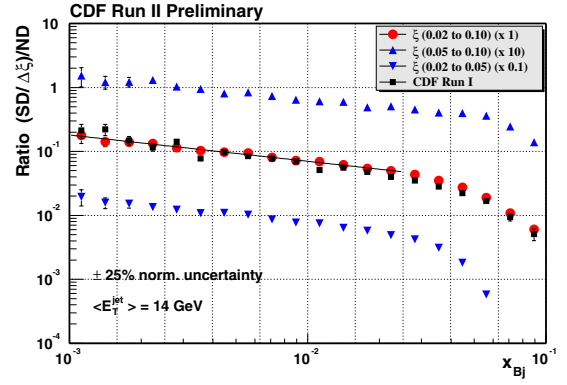


**Fig. 4.** The average  $E_T$  and  $\eta$  of the two highest  $E_T$  jets in the SD event sample compared to the ND event sample

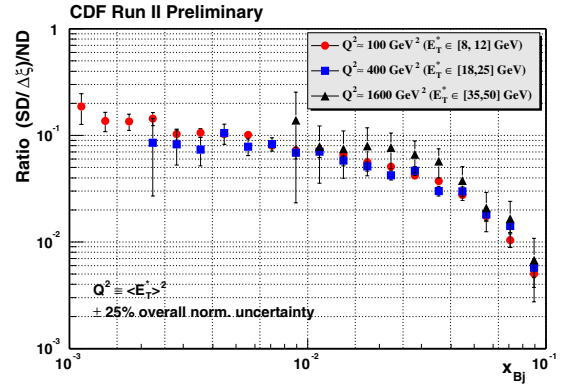
$\xi_{\bar{p}}$  is calculated from summing over all the towers,  $i$ , that have  $E_T > 100$  MeV and  $|\eta| < 5.1$ , and  $x_{Bj} = \beta\xi$  from summing over the jets,  $j$ :

$$\xi_{\bar{p}} = \frac{\sum_i E_T^i e^{-\eta_i}}{\sqrt{s}}, \quad x_{Bj} = \frac{\sum_{jets} E_T^j e^{-\eta_j}}{\sqrt{s}} \quad (1)$$

Roman pot tracking information will also be used to measure  $\xi_{\bar{p}}$  in the future. The RP+J5 events are peaked at  $\xi_{\bar{p}} = 1$ ; this is due to non-diffractive events overlapping the diffractive events. In the low  $\xi_{\bar{p}}$  region ( $0.02 < \xi_{\bar{p}} < 0.1$ ) the distribution is approximately flat as would be expected from diffractive events; the events in this region are selected as the single diffractive (SD) event sample.



**Fig. 5.** The ratio of run II SD to ND  $x_{Bj}$  distributions compared to run I data; the ratio is also shown for different  $\xi_{\bar{p}}$  regions



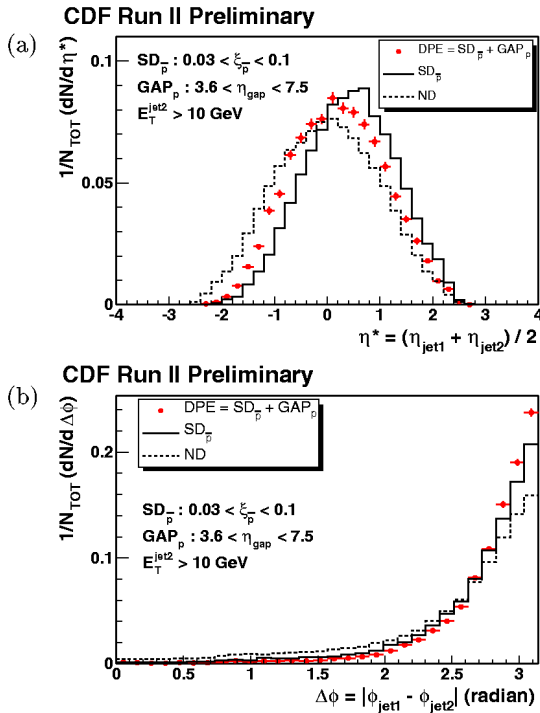
**Fig. 6.** The ratio of the SD to ND  $x_{Bj}$  distributions in different  $Q^2$  regions

The average  $E_T$  and  $\eta$  of the jets in the SD sample are compared to those in the non-diffractive (ND) sample in Fig. 4. The  $E_T$  distribution of the SD events is slightly steeper than in the ND event sample, but note that the jets are more forward. The distribution of the average jet rapidity shows that the SD jets are slightly boosted in the direction of the outgoing proton due to the low  $\xi_{\bar{p}}$ .

The ratio of SD to ND dijets as a function of  $x_{Bj}$  is shown in Fig. 5. The data are in good agreement with run I both in normalisation and shape. The ratio is measured in different  $\xi_{\bar{p}}$  ranges and no appreciable  $\xi_{\bar{p}}$  dependence is observed. The ratio has also been measured for different  $Q^2 = \langle E_T^* \rangle^2$  ranges, Fig. 6; no significant  $Q^2$  dependence has been observed over the range  $100 < Q^2 < 1600$  GeV<sup>2</sup>.

### 3 Double pomeron exchange

The production of dijets by double pomeron exchange was studied in run I [2]. In run II a data-set that is about a factor of 200 larger has already been collected using a dedicated trigger. The trigger requires the detection of the leading anti-proton in the roman pots, a rapidity gap in the BSC on the out-going proton side and a tower of at least 5 GeV in the main calorimeters. Offline, the rapidity gap selection is tightened by requiring a gap in the



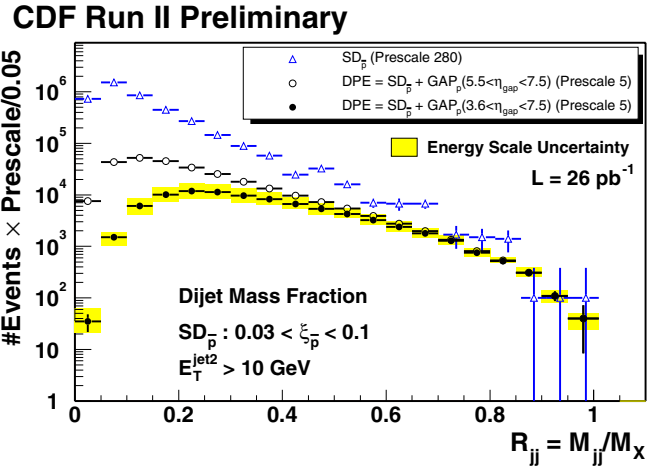
**Fig. 7.** The average  $\eta$  and the  $\Delta\phi$  of the two highest  $E_T$  jets in the DPE event sample compared to the SD and ND events

MiniPlug on the out-going proton side and by selecting  $0.03 < \xi_{\bar{p}} < 0.1$ . Overlapping events are rejected by cutting on the number of vertices,  $N_{vertex} \leq 1$ , and cosmics are rejected by demanding there to be no significant missing  $E_T$ . At least two jets are required with  $E_T^{corr} > 10$  GeV and  $|\eta| < 2.5$ . The jets are corrected for detector effects, underlying energy corrections and out-of-cone corrections (from particle-jet to parton energy). The final event sample (the DPE sample) contains around 17,000 events.

The  $E_T$  distribution of the jets in the DPE event sample is similar to that in the SD event sample. The average jet  $\eta$  distribution is shown in Fig. 7(a). The jets are more central than in the SD event sample, now that  $x_p$  is more similar to  $x_{\bar{p}}$ . The dijet  $\Delta\phi$  distribution is shown in Fig. 7(b). The jets are more back-to-back than in the SD event sample in which the jets are more back-to-back than in the ND event sample. This may be due to the suppression of initial state QCD radiation when you replace a coloured parton line with a pomeron.

There has recently been a lot of interest in the possibility that exclusive production may be an interesting search channel for the Higgs boson at the LHC [3]. In exclusive Higgs production no other particles are produced apart from the Higgs and the out-going protons remain intact. Measurements of exclusive dijet production at the Tevatron can be used to normalise predictions for exclusive Higgs production.

Exclusive dijet events will be characterised by large values of  $R_{jj}$ , the ratio of the raw dijet mass measured within the cones  $R=0.7$  to the total mass of the central system. Out-of-cone energy causes  $R_{jj}$  to be less than one



**Fig. 8.** The dijet mass fraction distribution of the SD event sample and of the DPE event sample, with two different rapidity gap selections

**Table 1.** The cross section for  $R_{jj} > 0.8$  for a minimum  $E_T^1$  for the DPE sample defined in the text (cone  $R=0.7$ )

Min $E_T^1$	Cross Section ( $R_{jj} > 0.8$ )
10 GeV	$970 \pm 65$ (stat) $\pm 272$ (syst) pb
25 GeV	$34 \pm 5$ (stat) $\pm 10$ (syst) pb

for exclusive events, but still large. The distribution of  $R_{jj}$  is shown in Fig. 8 and is seen to be smoothly falling. The events at large  $R_{jj}$  are used to put an upper limit on the cross-section for exclusive dijet production which is given in Table 1.

## 4 Summary

Run II will enable CDF to extend its studies of diffraction. Run II data are in good agreement with run I. The  $Q^2$  dependence of the ratio of the diffractive to non-diffractive structure function has been measured and studies of double pomeron exchange dijet production have been significantly extended. We look forward to a wide range of new and improved measurements from run II.

## References

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