Fermi National Accelerator Laboratory

FERMILAB-Conf-90/112-E
[E-741/CDF]

Properties of Inclusive W, Z Events in $\bar{p}p$ Collisions at 1.8 TeV *

The CDF Collaborations

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May 24, 1990

* To be published in the proceedings of the 15th APS Division of Particles and Fields General Meeting (DPF '90), Houston, Texas, January 3-6, 1990.

Operated by Universities Research Association Inc. under contract with the United States Department of Energy

CDF/ELECTROWEAK/PUB/PUBLIC/1205
DPF90 Meeting, Rice University, Houston, TX, Jan 1990
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Properties of Inclusive W,Z Events in $\bar{p}p$ Collisions at 1.8 TeV

CDF Collaboration*
Presented by T.Watts, Rutgers University.

Abstract

A preliminary measurement of the properties of W and Z production along with accompanying jets has been made in $\bar{p}p$ collisions at 1.8 TeV using the CDF detector at Fermilab. Distributions of jet multiplicity, and boson E_T, with and without selection on jet multiplicity, were obtained. Agreement was found with perturbative QCD predictions.

Introduction

The production of W and Z bosons, along with hard jets, in $\bar{p}p$ collisions provides a quantitative test of perturbative QCD. In addition, such events can show contributions from new physics such as heavy quark or Higgs particle decays. The recent CDF run, at Tevatron energy and with integrated luminosity of 4.4 pb^{-1}, provided a sample of W,Z events with larger statistics than has been available before. Results are shown for the boson decays $W \to e\,\nu$ and $Z \to e^+e^-$.

The data was taken in the CDF detector [1]. Important parts of the detector for this analysis were: scintillation counter planes (BBC) upstream and downstream of the interaction region which were used to record interactions in the trigger and as a monitor of $\bar{p}p$ luminosity; vertex time projection chambers (VTPC) around the interaction region which were used to determine the z coordinate of the collision; central tracking drift chamber (CTC) and axial magnetic field; electromagnetic and hadron calorimeters which covered polar angles to within 2° of the beam pipe; proportional chambers with wire and strip readout embedded in the EM calorimetry to give accurate EM shower positions.

Readout of data was triggered by a particle in one side of the BBC counters, by EM clusters in the calorimetry with E_T above 12 GeV, an associated track momentum above 6 GeV/c, and a ratio of transverse energy in hadron and EM parts of the cluster less than 0.125. The events were also filtered by an online farm of microprocessors which tested shower shape *inter alia*. About 4500 W candidates were collected and 350 Z candidates.

Energy scales of the detector components were calibrated with test beam data and with the mass peaks from $K^0_s \to \pi^+\pi^-$, $J/\psi \to \mu^+\mu^-$, and $\Upsilon \to \mu^+\mu^-$ [2]. Calorimeter energies were compared to track data, and dijet E_T balancing was used to compare calorimeters at different polar angles.

*The CDF Collaboration consists of the following institutions: Argonne National Laboratory, Brandeis University, University of Chicago, Fermi National Accelerator Laboratory, Laboratori Nazionale di Frascati (INFN), Harvard University, University of Illinois, National Laboratory for High Energy Physics (KEK), Lawrence Berkeley Laboratory, University of Pennsylvania, INFN University and Scuola Normale Superiore of Pisa, Purdue University, Rockefeller University, Rutgers University, Texas A&M University, University of Tsukuba, Tufts University, and University of Wisconsin.

Analysis and Results

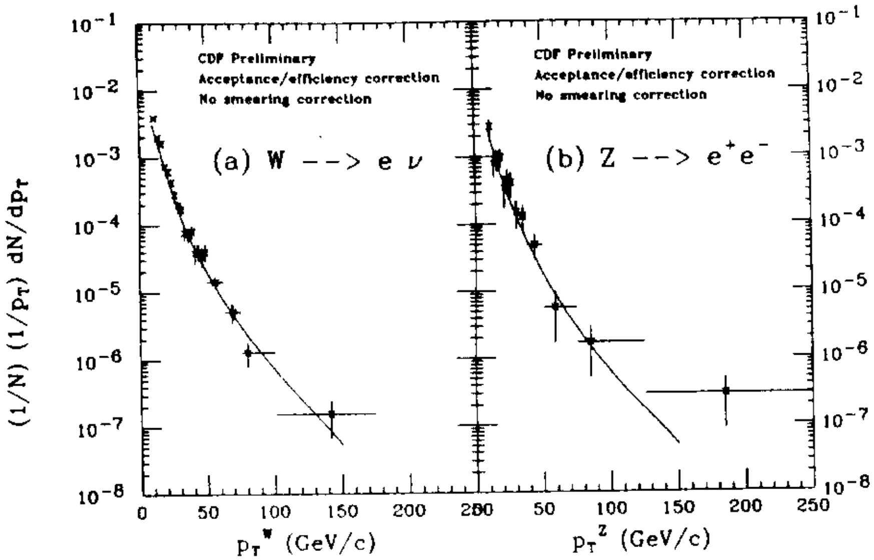

Figure 1: Inclusive p_T spectra for (a) W and (b) Z events. The solid line is the theoretical calculation of Bawa et al., and Martin et al.[8]

Stringent cuts were made for one central electron in all events[4]. These cuts included $E_T \geq 20$ GeV, isolation of the EM cluster, shower shape tests, match of cluster and track momenta and of positions to a few cm, and fiducial cuts to avoid cracks and bad towers in calorimetry.

Hadron clusters were found in the calorimetry with a fixed cone size of 0.7 in η-ϕ space [5]; these jets were required to have $E_T \geq 10$ GeV. From calorimeter responses to individual particles in test beam data, and from Monte Carlo simulation of jet fragmentation and detector responses, a correction was applied to jet energies [5]. At low jet energies this is strong correction, e.g. 10 GeV after correction becomes 15 GeV.

The missing E_T in the W events was required to be ≥ 20 GeV and large compared to its expected fluctuation. In order to apply calorimeter energy corrections, the E_T sum over all towers was separated into 3 components: electron cluster, jet clusters, and underlying event contribution from the rest of the calorimeter towers. Jets were corrected as above, and the underlying event multiplied by 1.2, a factor derived from analysis of the underlying event contribution in Z events.

The W was identified by calculating the transverse mass of electron and missing E_T, and requiring this mass ≥ 40 GeV/c^2 [3]. For the Z, the second electron passed less stringent cuts and was also allowed up to $|\eta| \leq 2.2$; the cut on the mass of two electrons was 75 through 105 GeV/c^2. After these cuts and those discussed above, 2685 W events remained and 220 Z events.

The inclusive distributions of p_T of both W and Z are shown in Figure 1. These plots show shape only and have a background in the mass cuts estimated to be 4% not yet subtracted. The W distribution is expected to have a background which could reach 20% at p_T above 80 GeV/c, and the effects of "smearing" caused by calorimeter resolution have not yet been unfolded; this smearing could change the W distribution by 15% at p_T above 80 GeV/c. The data points are corrected for acceptance and efficiency. The W and Z distributions are very similar and are compared to an $\mathcal{O}(\alpha_s^2)$ QCD calculation [8] which used the MRSB parton distribution. At this stage of the data, agreement is quite acceptable.

The fraction of W or Z events with n jets, where n=0,1,2,3,4, is shown in Figure 2. Again W and Z distributions are very similar and the relation $(\sigma_n/\sigma_0) \simeq (\sigma_1/\sigma_0)^n$ [10] is approximately satisfied. Comparison is made to a QCD calculation with up to 3 jets [9] with parton E_T above 15 GeV, and to a Monte Carlo event generator [7] which gives up to 2 jets. This latter comparison used ISAJET for fragmentation and underlying event simulation [6], and used the CDF detector simulation; generated events were passed through the data analysis chain and the plots normalized by luminosity. Both predictions agree with the data.

Figure 3 investigates the agreement between data and perturbative QCD in more detail by showing the p_T distribution for W bosons in events with 1 and 2 accompanying jets. The QCD model compared is again the PAPAGENO/ISAJET/CDFSIM chain and comparison and cuts are made in uncorrected p_T.

In summary, perturbative QCD predictions for the production of W and Z bosons accompanied by jets shows acceptable agreement at this stage of the data.

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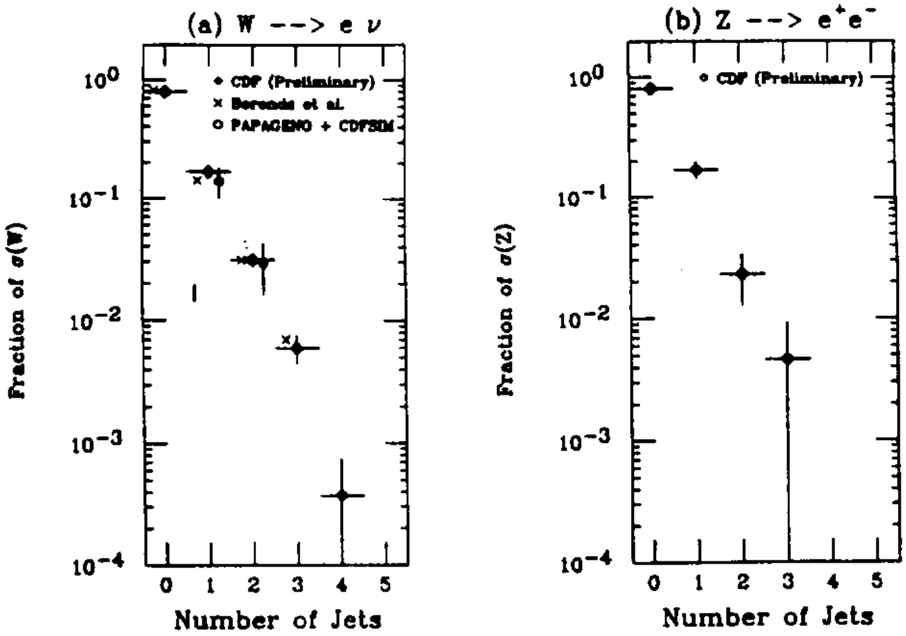

Figure 2: Jet multiplicity distributions for (a) W and (b) Z events. Comparison is made to theoretical predictions of Berends et al. [9], and PAPAGENO/ISAJET/CDFSIM [7].

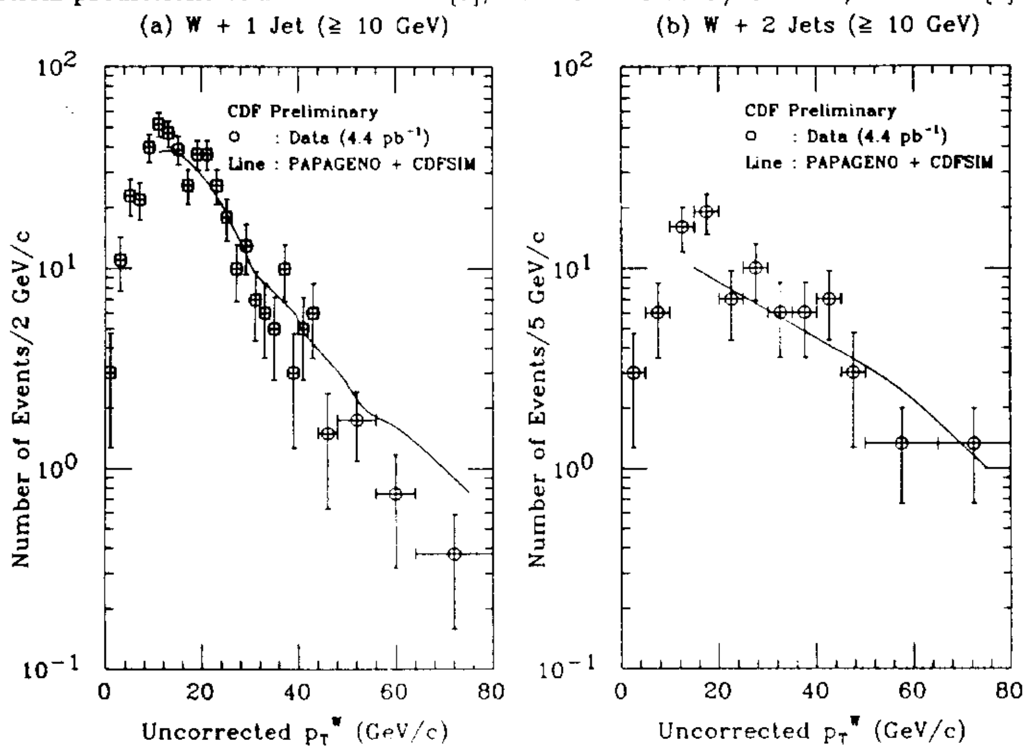

Figure 3: (a) W p_T spectrum for W + 1-jet events. (b) W p_T spectrum for W + 2-jet events. The solid curves are predictions from PAPAGENO/ISAJET/CDFSIM [7].