

**Fermi National Accelerator Laboratory**

**FERMILAB-Conf-94/169-E**

**CDF**

# **Measurements of the Mass and Width of the W Boson from CDF**

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June 1994

Presented at the *Electroweak Session of the XXIXth Rencontres de Moriond*, Meribel, France, March 12-19, 1994

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# Measurements of the Mass and Width of the $W$ Boson from CDF

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## Abstract

We have made a preliminary determination of the  $W$  boson mass,  $M_W = 80.38 \pm 0.23 \text{ GeV}/c^2$  from a combined analysis of  $W \rightarrow e\nu$  and  $W \rightarrow \mu\nu$  in  $\bar{p}p$  collisions at  $\sqrt{s} = 1.8 \text{ TeV}$ . The electron data alone yields  $M_W = 80.47 \pm 0.15(\text{stat.}) \pm 0.25(\text{syst.}) \text{ GeV}/c^2$ , while the muon data gives  $M_W = 80.29 \pm 0.20(\text{stat.}) \pm 0.24(\text{syst.}) \text{ GeV}/c^2$ . Measuring the ratio  $\sigma_W \cdot B(W \rightarrow e\nu) / \sigma_Z \cdot B(Z \rightarrow e^+e^-)$ , we have extracted a value for the  $W$  width,  $\Gamma(W) = 2.063 \pm 0.061(\text{stat.}) \pm 0.060(\text{syst.}) \text{ GeV}$  and the branching ratio,  $\Gamma(W \rightarrow e\nu) / \Gamma(W) = 0.1094 \pm 0.0033(\text{stat.}) \pm 0.0031(\text{syst.})$ . This allows us to set a decay mode independent limit on the top quark mass,  $m_{top} > 62 \text{ GeV}/c^2$  at the 95% C.L.

Presented at the Electroweak Session of the XXIXth Rencontres de Moriond, Meribel, France, March 12-19, 1994.

## 1. Introduction

Recent results from LEP experiments have substantially improved our knowledge of the  $Z$  boson. However, hadron colliders remain our only source of direct measurements of the  $W$  boson. There have been measurements of the  $W$  boson mass from CDF [3] and UA2 [4] and measurements of the  $W$  boson width from CDF [5], UA1 [6], and UA2 [7]. These measurements continue to be subjects of great interest in testing the Standard Model.

We present a preliminary measurement of the  $W$  boson mass using our recent Run 1a data sample, which corresponds to a total integrated luminosity of  $19.7 \text{ pb}^{-1}$ , taken between Aug. 1992 and May 1993 at the Fermilab Tevatron. The present analysis has benefitted from the factor of five increase in  $W$  statistics, and in addition the larger sample of  $Z \rightarrow e^+e^-$  and  $Z \rightarrow \mu^+\mu^-$  events allows us to reduce the systematic errors in the  $W \rightarrow e\nu$  and  $W \rightarrow \mu\nu$  event reconstruction. We also present a measurement of the ratio  $\sigma_W \cdot B(W \rightarrow e\nu) / \sigma_Z \cdot B(Z \rightarrow e^+e^-)$ , from which the  $W$  width  $\Gamma(W)$  and the branching ratio  $\Gamma(W \rightarrow e\nu)/\Gamma(W)$  are extracted.

## 2. The Measurement of the $W$ Boson Mass

The  $W$  mass is measured from fits to the transverse mass spectra  $M_T^W$  in both  $W \rightarrow e\nu$  and  $W \rightarrow \mu\nu$  decays, where  $M_T^W$  is constructed from the transverse momenta,  $\vec{P}_T^{\text{lepton}}$  and  $\vec{P}_T^\nu$ , of the electron (or muon) and neutrino:

$$M_T^W = \sqrt{2P_T^{\text{lepton}} P_T^\nu (1 - \cos\phi_{\text{lepton},\nu})}$$

with  $\phi_{\text{lepton},\nu}$  being the azimuthal angle between the lepton and the neutrino direction.

### 2.1 Lepton Momentum Measurement

The muon momentum is measured from the central tracking chamber (CTC) [1] as it traverses a 14 kG magnetic field, while the electron energy is measured from the central electromagnetic calorimeter (CEM) [2]. The CTC momentum scale is determined by rescaling the invariant mass of the fitted  $J/\psi \rightarrow \mu^+\mu^-$  signal to the Particle Data Group (PDG) value. We have measured the  $J/\psi$  mass to be  $3094.28 \pm 0.08(\text{stat.}) \text{ MeV}$  as shown in Fig. 1. Corrections due to radiation ( $+0.3 \pm 0.3 \text{ MeV}$ ), energy loss in the detector material ( $+1.0 \pm 1.0 \text{ MeV}$ ), and alignment effects ( $-1.0 \pm 1.0 \text{ MeV}$ ) are applied to the  $J/\psi$  mass. Including uncertainties due to beam constraint ( $\pm 0.5 \text{ MeV}$ ), residual B-field non-uniformity ( $\pm 1.1 \text{ MeV}$ ), time variations ( $\pm 1.0 \text{ MeV}$ ), momentum non-linearities ( $\pm 0.5 \text{ MeV}$ ) and background ( $\pm 0.1 \text{ MeV}$ ), the  $J/\psi$  mass is  $3094.58 \pm 2.2 \text{ MeV}$ . The total systematic uncertainty of 2.2 MeV in the  $J/\psi$  mass translates to a 60 MeV uncertainty in the  $W$  mass. Normalizing this  $J/\psi$  mass to the PDG value, a scale factor of  $1.00076 \pm 0.00071$  is extracted which is applied to all the CTC tracks.

As a consistency check for the CTC scale, especially for high  $P_T$  tracks, the masses of the  $\Upsilon(1s)$ ,  $\Upsilon(2s)$ ,  $\Upsilon(3s)$  states and the mass of the  $Z$  (see Fig. 1) are measured. As listed in the following table, the masses after the scale correction agree with the PDF values very well.

Sample	CDF	PDG	SCALED	Unit
$\Upsilon(1s)$	$9449.8 \pm 1.8$	$9460.3 \pm 0.2$	$9457.0 \pm 1.8 \pm 7$	MeV
$\Upsilon(2s)$	$10018 \pm 5$	$10023.3 \pm 0.3$	$10026 \pm 5 \pm 7$	MeV
$\Upsilon(3s)$	$10323 \pm 8$	$10355.5 \pm 0.5$	$10331 \pm 8 \pm 7$	MeV
$Z$	$91.22 \pm 0.21$	$91.173 \pm 0.020$	$91.29 \pm 0.21 \pm 0.065$	GeV

The CEM scale is determined by fitting the  $E/P$  lineshape of electrons from  $W$  decays to a simulated lineshape which includes the effects of radiative  $W$  decays and external bremsstrahlung in the detector material. Before the scale is determined, the CEM response as a function of

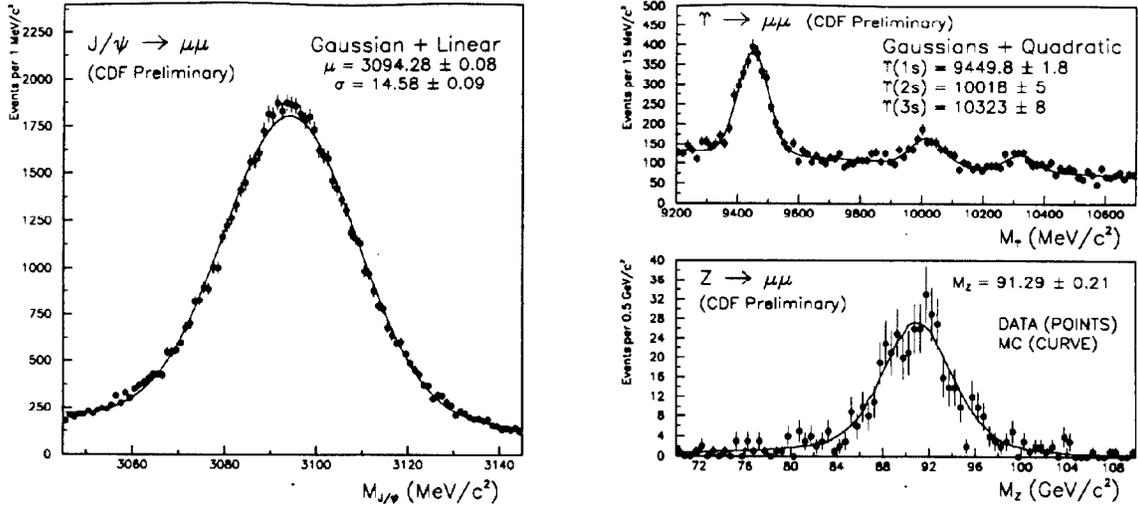


Figure 1: The mass spectra for the  $\mu^+\mu^-$  final state in the region of the  $J/\psi$  mass (left) and in the region of the  $\Upsilon$  and  $Z$  masses (right).

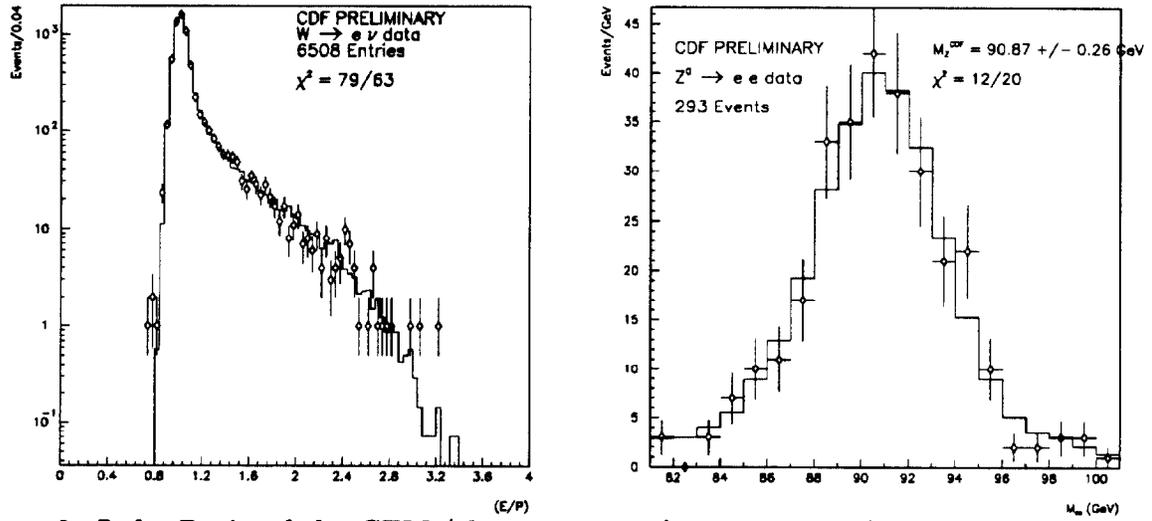


Figure 2: Left: Ratio of the CEM (electron energy) to the CTC (electron momentum) measurement for the  $W \rightarrow e\nu$  sample. The points (histogram) are the data (simulation). Right: The mass spectrum of the  $Z \rightarrow e^+e^-$  sample. The histogram shows the best fit to the data.

the electron impact point is corrected to be as uniform as possible by using a large sample of low transverse momentum electrons, resulting in better resolution for the electron energy. The  $E/P$  distribution for the  $W$  electrons after this correction is shown in Fig. 2, where  $E$  and  $P$  are the CEM and CTC measurements of the electron energy and momentum respectively. The long tail on the right-hand side is due to internal and external bremsstrahlung emitted by the electron before entering the tracking volume. Since the photon is nearly collinear with the electron, the CEM  $E$  measurement is largely unaffected but the CTC  $P$  measurement is lowered, resulting in the long tail. The solid histogram is from a radiative Monte Carlo which includes the contributions from both internal and external radiation. The CEM scale determined with this method provides a statistical precision of 0.08% and a systematic uncertainty of 0.13%.

As a cross check for the CEM scale, the invariant mass of  $Z \rightarrow e^+e^-$  events with both electrons in the central calorimeter is reconstructed. A simulation including contributions from the Drell-Yan continuum and radiative  $Z$  decays is used to fit the invariant mass distribution. The best fit is  $90.87 \pm 0.20(\text{stat.}) \pm 0.16(\text{syst.})$  GeV.

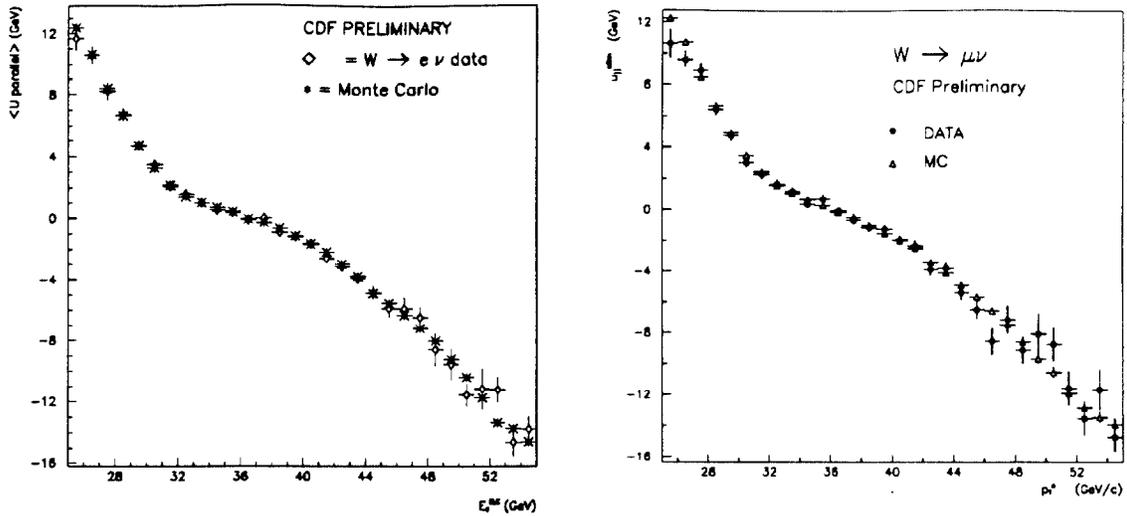


Figure 3:  $\langle u_{\parallel} \rangle$  as a function of the lepton  $P_T$ . The left (right) figure is from the  $W \rightarrow e\nu$  ( $W \rightarrow \mu\nu$ ) decays for the data and the simulation.

## 2.2 Neutrino Momentum Measurement

The neutrino momentum is determined by measuring the energy of all of the hadrons in the event which recoil against the  $W$ . We remove the calorimeter towers associated with the electron or muon, and replace them with the average transverse energy, 30 MeV per tower, from the underlying event in our  $W$  sample. Then, the momentum of the recoiling hadrons is the vector sum  $\vec{P}_T^{\text{hadrons}} = (\sum E_{\text{tower}} \vec{v}_{\text{tower}})_T$ , with  $E_{\text{tower}}$  being the energy in a given calorimeter tower in the pseudorapidity region  $|\eta| < 3.6$ , and  $\vec{v}_{\text{tower}}$  being a unit vector from the event vertex to the center of the given tower. The neutrino momentum is reconstructed from the transverse energy balance  $\vec{P}_T^{\nu} = -\vec{P}_T^{\text{lepton}} - \vec{P}_T^{\text{hadrons}}$ .

## 2.3 Event Selection

Events are removed if any detector elements used in this analysis were not functioning properly, or the running conditions were not stable. This removes  $\sim 10\%$  of the events. Events are required to satisfy  $P_T^e$  or  $P_T^{\mu} > 25$  GeV,  $P_T^{\nu} > 25$  GeV,  $P_T^{\text{hadrons}} < 20$  GeV, and  $60 < M_T^W < 100$  GeV. Events having jets with  $E_T^{\text{jet}} > 20$  GeV or other tracks with  $P_T > 10$  GeV are removed. The lepton track must be isolated, and satisfy tight fiducial requirements. The total number of  $W \rightarrow e\nu$  events is 6421 and the number of  $W \rightarrow \mu\nu$  events is 4090.

## 2.4 Detector Model and Fitting Procedure

$W$  events are generated with a leading-order calculation using the MRS  $D'_-$  parton distribution function. The bosons are given transverse momentum with a subsequent boost. To model  $M_T^W$ , one must calibrate the detector response to the hadrons recoiling against the  $W$ , which is poorly known. Since the production properties of  $Z$  and  $W$  bosons are very similar, and both leptons from  $Z$  decays are measured with better resolution than the recoiling hadrons, we make use of the  $Z \rightarrow e^+e^-$ ,  $\mu^+\mu^-$  events to model this response. When a  $W$  is generated with a given  $P_T$ , the  $\vec{P}_T^{\text{hadrons}}$  against the  $W$  is simulated by using the  $\vec{P}_T^{\text{hadrons}}$  against a  $Z$  event with the same  $P_T$  measured from  $e^+e^-$  or  $\mu^+\mu^-$ . The advantage of this method is that there are no detector resolutions to be tuned to the data. Only the input  $P_T^W$  distribution is tuned.

$\vec{P}_T^{\text{hadrons}}$  can be decomposed into  $u_{\parallel}$  and  $u_{\perp}$ , the components parallel and perpendicular to the lepton direction.  $u_{\parallel}$  contains most of the  $M_T^W$  information and it is the quantity sensitive to the lepton selection cuts (efficiency of leptons close to the recoiling hadron direction decreases), the residual leakage from the lepton energy into surrounding calorimeter towers, or errors in

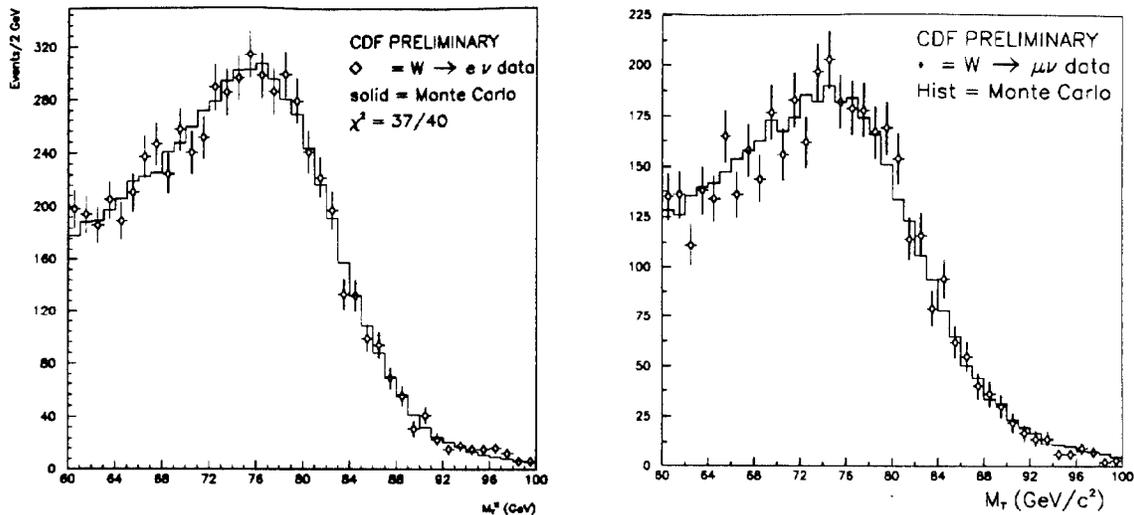


Figure 4: The transverse mass spectra of the data (points) and the best-fit (histograms) for the  $W \rightarrow e\nu$  (left) and  $W \rightarrow \mu\nu$  (right) samples.  $\Gamma(W)$  is fixed at 2.1 GeV in this fit.

accounting for the energy deposited under the lepton by the underlying event. Fig. 3 shows that the bias in  $u_{\parallel}$  is well modelled by the simulation over the full range of  $P_T^{\text{lepton}}$ . Similar agreement is seen over the full range of  $P_T^W$  and  $M_T^W$ . The measured offsets in  $u_{\parallel}$  from the data and simulation are  $-405 \pm 65$  MeV and  $-330$  MeV for the  $W \rightarrow e\nu$  decays and  $-496 \pm 83$  MeV and  $-442$  MeV for the  $W \rightarrow \mu\nu$  decays. The differences between the data and the simulation are not statistically significant and thus the statistical errors are taken as systematic uncertainties.

Transverse mass spectra are generated in the region of  $60 < M_T^W < 100$  GeV with various  $W$  masses and  $W$  widths. The data are compared to the simulation at each  $W$  mass and  $W$  width, and a log-likelihood is calculated. The log-likelihood points are fit to a parabola whose maximum value occurs at the most probable mass and width combination. The transverse mass spectra for the data used to fit the  $W$  mass and the best-fit lineshapes are shown in Fig. 4.

## 2.5 Systematic Uncertainties and Corrections

The individual uncertainties and corrections in the  $W$  mass measurement are briefly described.

**Lepton Momentum Scale:** The uncertainty in the muon momentum scale, coming from the CTC scale, is 60 MeV (see section 2.2). For the electrons there is another 120 MeV uncertainty from the  $E/P$  lineshape fitting procedure, and the total uncertainty is then 130 MeV.

**Lepton Momentum Resolution:** The electron and muon momentum resolutions were extracted from the  $Z \rightarrow e^+e^-$  and  $Z \rightarrow \mu^+\mu^-$  widths and they are  $(\delta E/E)^2 = (13.5\%/\sqrt{E_T})^2 + (2.1 \pm 1.0\%)^2$  and  $\delta P_T/P_T = (0.09 \pm 0.02)\% \cdot P_T$ , respectively. These uncertainties lead to uncertainties of 140 MeV and 120 MeV in the  $W$  mass, respectively.

**Neutrino Scale:** Biases from the lepton selection cuts, the residual leakage from the lepton energy, or errors in accounting for the underlying event energy deposited in the calorimeter towers associated with the lepton, are checked by comparing  $\langle u_{\parallel} \rangle$  between the data and the modeling. The uncertainties are 70 and 90 MeV for the  $W \rightarrow e\nu$  and  $W \rightarrow \mu\nu$  decays respectively (see section 2.4).

**$P_T^W$  Distributions:** The systematic effects due to  $P_T^W$  were investigated by scaling the input  $P_T^W$  distribution up and down. This gives 40 and 70 MeV for the  $W \rightarrow e\nu$  and  $W \rightarrow \mu\nu$  decays. The modelling of the detector response to  $P_T^W$  is derived from the  $Z \rightarrow e^+e^-$ ,  $\mu^+\mu^-$  events and thus effects from  $Z$  statistics and lepton resolution need to be taken into account. The

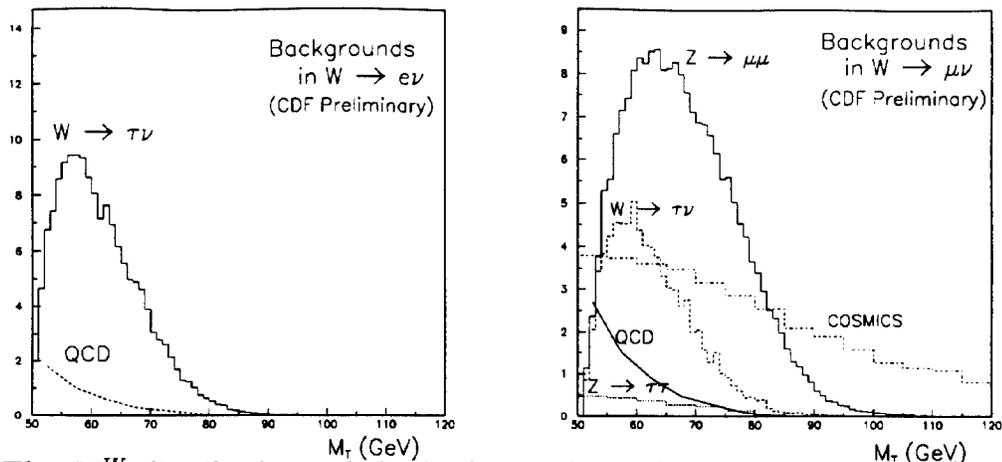


Figure 5: The  $M_T^W$  distributions of the backgrounds in the  $W \rightarrow e\nu$  sample (left) and the  $W \rightarrow \mu\nu$  sample (right).

uncertainties are 20 MeV from the  $Z$  statistics and 80 MeV from the lepton resolutions. All of these might be correlated, but in this preliminary analysis we take all of them in quadrature. The total uncertainties are 90 and 110 MeV for the  $W \rightarrow e\nu$  and  $W \rightarrow \mu\nu$  decays.

**Structure Functions:** We have studied the variations in the fitted  $W$  mass for most of the available structure functions such as the GRV, MT, old MRS, recent MRS sets and the CTEQ sets. The extreme variations  $\pm 100$  MeV are taken as a conservative uncertainty.

**Radiative Correction:** In order to study the  $W$  mass shift due to radiative  $W$  decays, the decays  $W \rightarrow e\nu\gamma$  and  $W \rightarrow \mu\nu\gamma$  are simulated with an  $O(\alpha)$  Monte Carlo program [8]. The photon is lost when it lands in the calorimeter towers traversed by the muon, while it is included in the electron energy when it lands in the towers traversed by the electron. Otherwise, the photon energy is added to  $P_T^{hadrons}$ . The corrections due to radiation in the  $W$  mass are +80 MeV and +154 MeV for the  $W \rightarrow e\nu\gamma$  and  $W \rightarrow \mu\nu\gamma$  decays respectively.

**Backgrounds:** The largest background ( $4.35 \pm 0.64$  %) comes from the presence of  $Z \rightarrow \mu^+\mu^-$  events in the  $W \rightarrow \mu\nu$  sample. This background is large because neither the CTC nor the muon chambers cover the high  $\eta$  region. Another significant background ( $\sim 1.2$  %) comes from the  $W \rightarrow \tau\nu$  where  $\tau \rightarrow e\nu\nu$  in the  $W \rightarrow e\nu$  sample or  $\tau \rightarrow \mu\nu\nu$  in the  $W \rightarrow \mu\nu$  sample. There is also a relatively large cosmic ray background ( $\sim 0.8\%$ ) in the  $W \rightarrow \mu\nu$  sample. QCD and  $Z \rightarrow \tau^+\tau^-$  backgrounds are small. The  $M_T$  distributions of the backgrounds are shown in Fig. 5. The corrections due to the backgrounds in the  $W$  mass are  $+80 \pm 50$  MeV for the  $W \rightarrow e\nu$  sample and  $+232 \pm 50$  MeV for the  $W \rightarrow \mu\nu$  sample.

## 2.6 Results

We obtain the preliminary  $W$  mass of  $M_W = 80.47 \pm 0.15(\text{stat.}) \pm 0.21(\text{syst.}) \pm 0.13(\text{scale})$  GeV/ $c^2$  using the  $W \rightarrow e\nu$  decays [10], and  $M_W = 80.29 \pm 0.20(\text{stat.}) \pm 0.22(\text{syst.}) \pm 0.06(\text{scale})$  GeV/ $c^2$  using the  $W \rightarrow \mu\nu$  decays, where the  $W$  width has been fixed at 2.1 GeV. Fits in which the  $W$  width is allowed to vary, as well as fits to the  $P_T^{\text{lepton}}$  distributions and to the  $P_T^\nu$  distributions, give consistent results. The combined results from the  $W \rightarrow e\nu$  and  $W \rightarrow \mu\nu$  decays give

$$M_W = 80.38 \pm 0.23 \text{ GeV}/c^2.$$

In Fig. 6, we compare this measurement to our previous measurement [3] and other measurements by UA2 [4] and D0 [9] experiments. Combining these  $W$  mass measurements, assuming a common error of 100 MeV/ $c^2$  for the structure function uncertainty, gives

$$M_W = 80.23 \pm 0.18 \text{ GeV}/c^2,$$

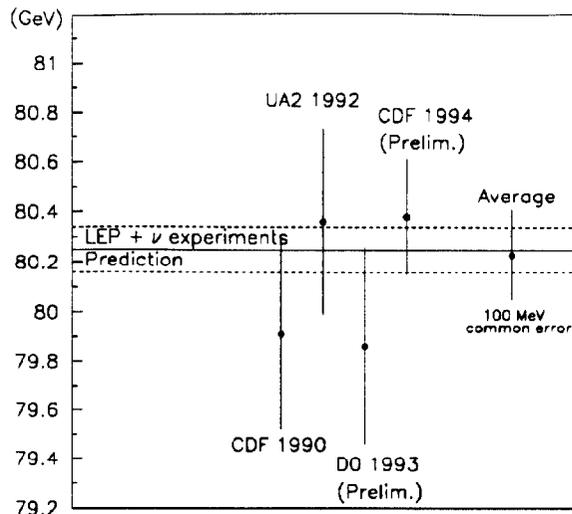


Figure 6: The current measurement of the  $W$  mass is compared to other measurements.

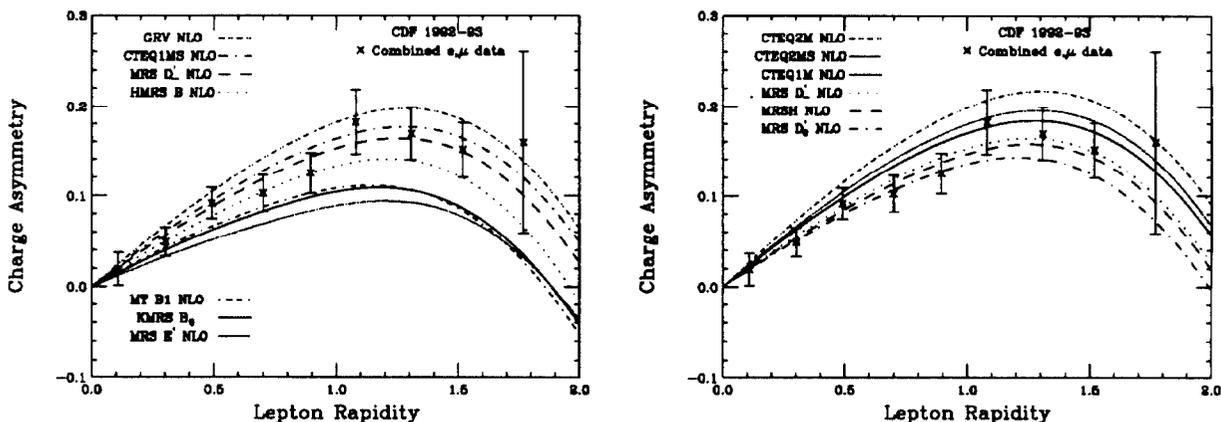


Figure 7: The  $W$  charge asymmetry measured by CDF, compared to predictions of various PDF's. The older MRS and MT B1 sets predict lower asymmetries, while the CTEQ 2 sets predict higher asymmetries. MRS H and MRS  $D'_-$  give a good agreement with the CDF data.

which is in a good agreement with the combined prediction for the  $W$  mass,  $M_W = 80.25 \pm 0.09$  GeV, from the LEP experiments ( $M_W = 80.25 \pm 0.10$  GeV) [11] and the neutrino experiments ( $M_W = 80.24 \pm 0.25$  GeV) [12]. This agreement is a stringent test of the Standard Model.

The present analysis is still preliminary. We anticipate further reductions in the systematic uncertainties before the analysis is complete. One source of this reduction is an improvement in our knowledge of the lepton momentum resolution. Another comes from the use of the measurement of our  $W$  lepton charge asymmetry [13] shown in Fig. 7. This measurement is able to distinguish between parton distributions and thus reduce the number of structure function candidates, resulting in a reduction in the structure function uncertainty.

### 3. Measurements of $\Gamma(W)$ and $\Gamma(W \rightarrow e\nu)/\Gamma(W)$

The ratio of the production cross sections ( $\sigma_W, \sigma_Z$ ) times the branching ratios into electrons for  $W$  and  $Z$  bosons is related [14] to the  $W$  decay width  $\Gamma(W)$  by

$$R = \frac{\sigma_W \cdot BR(W \rightarrow e\nu)}{\sigma_Z \cdot BR(Z \rightarrow e^+e^-)} = \frac{\sigma_W}{\sigma_Z} \cdot \frac{\Gamma(W \rightarrow e\nu)}{\Gamma(W)} \cdot \frac{\Gamma(Z)}{\Gamma(Z \rightarrow e^+e^-)},$$

where  $\Gamma(Z)$  is the  $Z$  decay width, and  $\Gamma(W \rightarrow e\nu)$  and  $\Gamma(Z \rightarrow e^+e^-)$  are the  $W$  and  $Z$  partial widths into  $e\nu$  and  $e^+e^-$ , respectively.  $\sigma_W/\sigma_Z$  can be calculated using the Standard Model couplings and parton distribution functions, as can  $\Gamma(W \rightarrow e\nu)/\Gamma(Z \rightarrow e^+e^-)$ . With the LEP [15] measurements of  $\Gamma(Z)$  and  $\Gamma(Z \rightarrow e^+e^-)$ , one can extract a value for the branching ratio  $\Gamma(W \rightarrow e\nu)/\Gamma(W)$  from a measurement of  $R$ . Alternatively, one may use a calculation of  $\Gamma(W \rightarrow e\nu)/\Gamma(Z \rightarrow e^+e^-)$  and the LEP value for  $\Gamma(Z)$  to extract  $\Gamma(W)$ .

In terms of experimentally measured quantities, the ratio  $R$  is

$$R = \frac{N_W A_Z \epsilon_Z}{N_Z A_W \epsilon_W},$$

where  $N_W$  ( $N_Z$ ) are the number of  $W$  ( $Z$ ) candidates after background subtraction,  $A_W$  ( $A_Z$ ) is the geometric and kinematic acceptance for  $W$  ( $Z$ ) decays, and  $\epsilon_W$  ( $\epsilon_Z$ ) is the lepton selection efficiency for the  $W$  ( $Z$ ). Many theoretical and experimental systematic uncertainties cancel in measuring the ratio  $R$ , making it a precise method for determining  $\Gamma(W)$  and  $\Gamma(W \rightarrow e\nu)/\Gamma(W)$ .

$W$  and  $Z$  candidates are selected from a common set of inclusive electrons with  $P_T^e > 20$  GeV triggered by the central electron. Tight selection criteria are placed on this first central electron for both  $W$  and  $Z$  candidates. The  $Z$  candidates are selected by requiring a second electron with  $P_T^e > 20, 15, 10$  GeV if in the central, plug ( $1.1 < |\eta| < 2.4$ ), and forward ( $2.4 < |\eta| < 4.2$ ) regions respectively, and an  $e^+e^-$  invariant mass in the range of 66 – 116 GeV/ $c^2$ . The  $W$  candidates are selected by requiring  $P_T^e > 20$  GeV and not a  $Z$  candidate. The following table summarizes the number of  $W$  and  $Z$  candidates, backgrounds, the selection efficiencies, and the acceptances for the  $W$  and  $Z$  events.

	$W$ events	$Z$ events
Candidates	13796	1312
Backgrounds		
Hadron Jets	$898 \pm 155$	$20 \pm 9$
$W \rightarrow \tau\nu$	$473 \pm 29$	–
$Z \rightarrow \tau^+\tau^-$	$48 \pm 7$	$1 \pm 1$
$Z \rightarrow e^+e^-$	$281 \pm 42$	–
Top	$0 + 52 - 0$	–
Signal	$12096 \pm 117 + 163 - 171$	$1291 \pm 36 \pm 9$
Acceptance $A_W, A_Z$	$0.342 \pm 0.008$	$0.409 \pm 0.005$
Efficiency $\epsilon_W, \epsilon_Z$	$0.754 \pm 0.011$	$0.729 \pm 0.016$
Drell-Yan correction	–	$1.005 \pm 0.002$
$A_W/A_Z$	$0.835 \pm 0.013$	
$\epsilon_W/\epsilon_Z$	$1.035 \pm 0.016$	
$\sigma_W \cdot B(W \rightarrow e\nu)/\sigma_Z \cdot B(Z \rightarrow e^+e^-)$	$10.90 \pm 0.32(\text{stat.}) \pm 0.29(\text{syst.})$	

We find  $R = 10.90 \pm 0.32(\text{stat.}) \pm 0.29(\text{syst.})$ .

Using the theoretical calculations  $\sigma_W/\sigma_Z = 3.33 \pm 0.03$  and  $\Gamma(W \rightarrow e\nu)/\Gamma(Z \rightarrow e^+e^-) = 2.710 \pm 0.018$ , and the LEP measurement  $\Gamma(Z) = 2.492 \pm 0.007$  GeV, and assuming Standard Model couplings to the fermions, we extract a value for the  $W$  width of

$$\Gamma(W) = 2.063 \pm 0.061(\text{stat.}) \pm 0.060(\text{syst.}).$$

For comparison, the Standard Model prediction is  $2.067 \pm 0.021$  GeV. If we use the LEP value  $\Gamma(Z \rightarrow e^+e^-) = 83.33 \pm 0.30$  MeV instead of the calculation of  $\Gamma(W \rightarrow e\nu)/\Gamma(Z \rightarrow e^+e^-)$ , we can extract an absolute measurement of the  $W$  branching ratio into  $e\nu$ :

$$\Gamma(W \rightarrow e\nu)/\Gamma(W) = 0.1094 \pm 0.0033(\text{stat.}) \pm 0.0031(\text{syst.}).$$

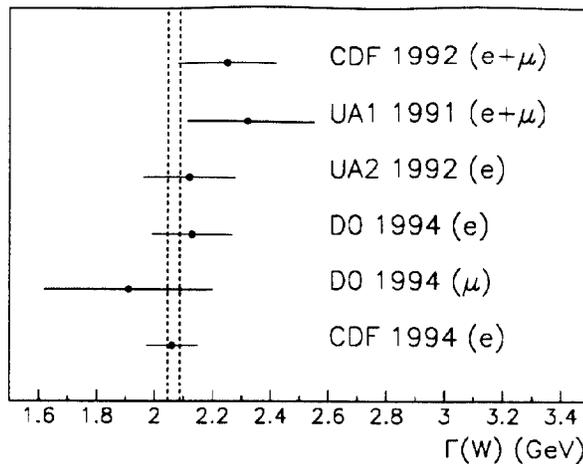


Figure 8:  $\Gamma(W)$  measurements from CDF and other experiments with the Standard Model prediction in the vertical band.

This measurement is sensitive to new decay modes of the  $W$ . One such decay mode would be  $W$  decaying to top, where the top can decay in a manner outside the Standard Model, for example via a charged Higgs ( $t \rightarrow H^+ b$ ). Using the Standard Model prediction and this measurement, we set a decay mode independent limit on the top quark mass of  $m_{top} > 62$  GeV (95% C.L.). In Figure 8, we compare our current measurement of  $\Gamma(W)$  [16] to other measurements by the CDF [5], UA2 [7] and D0 [17] experiments using their  $R$  values along with the same theoretical inputs used in this measurement except  $\sigma_W/\sigma_Z = 3.26 \pm 0.09$  at  $\sqrt{s} = 630$  GeV.

## References

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