Recent Electroweak Results from the Tevatron

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Abstract: We present new measurements of the W boson mass, W boson width and Drell-Yan pair production from data taken by the CDF and DØ collaborations during 1992-1996, in proton-antiproton collisions at $\sqrt{s} = 1.8$ TeV at the Fermilab Tevatron accelerator. Using refined techniques and new theoretical developments, the analyses utilize data from regions of the detectors previously excluded. The three analyses are described in the following sections.

1. W boson mass measurement

We present a new measurement [1] of the W boson mass based on 82 pb^{-1} of data collected by the DØ detector during 1994-1995. We utilize $e\nu$ events in which the electron shower is close to the phi edge of one of the 32 modules in the DØ central calorimeter. The electromagnetic calorimeter response and resolution in this region differs from that in the rest of the module. For this reason, edge electrons were not utilized in our previous measurements of the W mass [2].

Using the sample of $W \to e\nu$ events with edge electrons, we repeat the measurement described in our published results [2], and extract the W boson mass by fitting to the transverse mass (Fig. 1) and to the electron (Fig. 2) and neutrino (Fig. 3) transverse momentum distributions. In addition, we use $Z \to ee$ events that have one electron in the edge region, to additionally constrain the detector model for the non-edge electrons, and improve our previous measurement of the W boson mass. A summary of the results can be seen in Fig. 4. The updated result for the W boson mass from DØ is $M_W = 80.483 \pm 0.084$ GeV, which represents an improvement of 7 MeV with respect to our previous result.

2. W boson width measurement

We present a direct measurement of the W boson decay width (Γ_W) using 82 pb^{-1} of data collected by the DØ detector during 1994-1995. The width is determined from studies of

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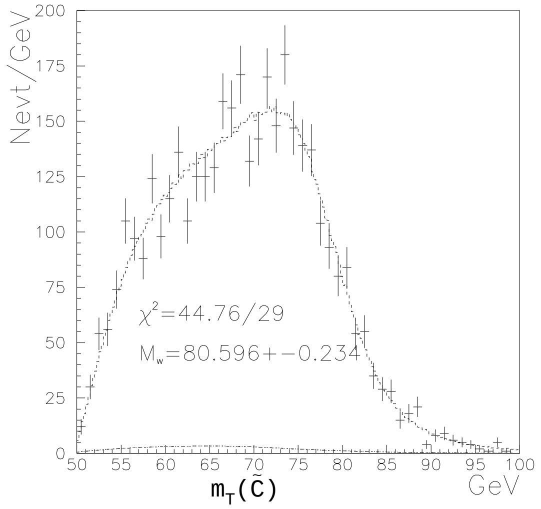

Figure 1: Distribution of M_T from edge electron data.

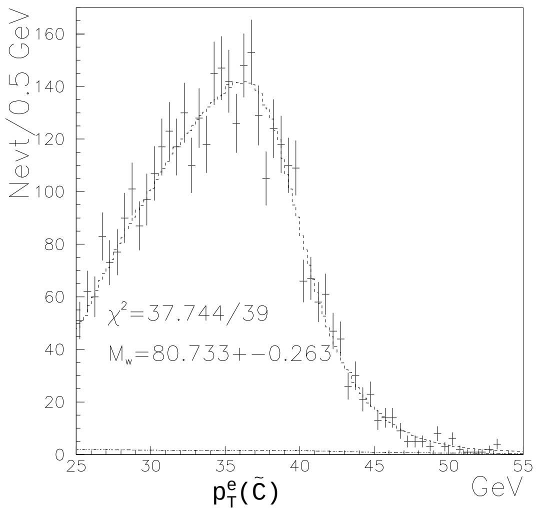

Figure 2: Distribution of P_T^e from edge electron data.

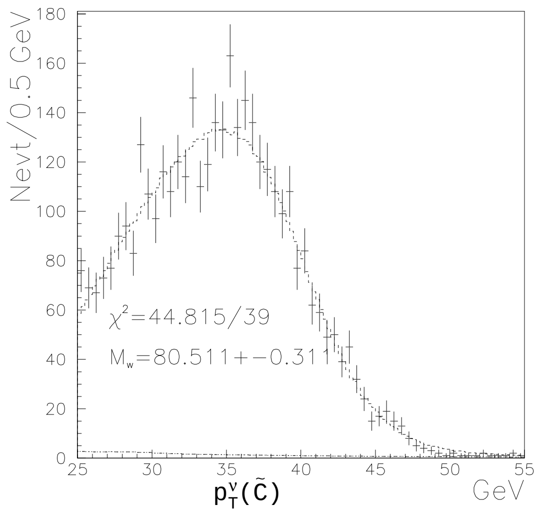

Figure 3: Distribution of P_T^ν from edge electron data.

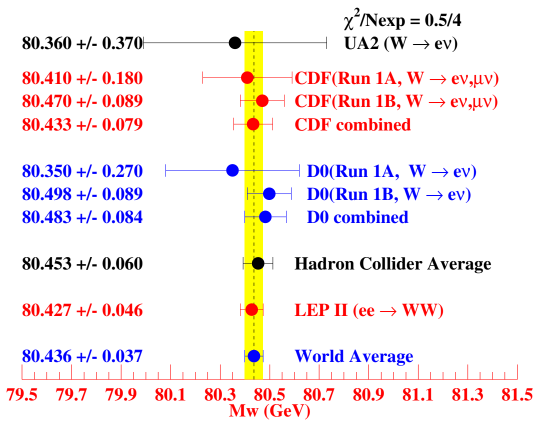

Figure 4: Summary of W boson mass measurements.

the transverse-mass spectra of $W \to e\nu$ events. The transverse mass is defined as $M_T = \sqrt{2p_T^e p_T^\nu[1 - cos(\Delta\Phi)]}$, where p_T^e and p_T^ν are the transverse momenta of the electron and the neutrino, respectively, and $\Delta\Phi$ is the azimuthal angle between them. The transverse mass spectrum exhibits a Jacobian edge at the W mass; events with $M_T > M_W$ arise from a combination of the nonzero W width and the detector resolution. In this paper we present a measurement of Γ_W from the high mass tail of the M_T distribution. Previous measurements of Γ_W using this method were presented by the CDF collaboration [3].

Candidate $W \to e\nu$ events are selected as described in reference [2]. The main contribution to the background arises from QCD multi-jet events, where a jet passes the electron identification requirements and the energy in the event is mismeasured, faking the presence of the neutrino. The fraction of QCD events in the sample, as well as the shape of the

M_T distribution for QCD events, are obtained directly from collider data. Another source of background are $Z \to ee$ events, where one electron is not reconstructed and fakes the presence of a neutrino. Other physics backgrounds are negligible, except for $W \to \tau\nu$, where the τ subsequently decays to e, which is included in the signal Monte Carlo model.

The W boson transverse mass spectrum is modeled by the parametric Monte Carlo initially developed for the W mass analysis [2]. We determine the W width by performing a binned log-likelihood fit of the M_T distribution in the data to a combination of backgrounds and signal Monte Carlo templates generated with different values of Γ_W. We choose the fitting range in M_T (from 90 to 200 GeV) that minimizes the systematic uncertainty in the measurement. Figure 5 shows the transverse mass distribution for DØ $W \to e\nu$ candidates, with best fit superimposed as a solid curve. The result obtained from the fit is $\Gamma_W = 2.231^{+0.145}_{-0.138}(\text{stat}) \pm 0.0986(\text{syst})\text{GeV}$, in good agreement with Standard Model predictions and previous measurements.

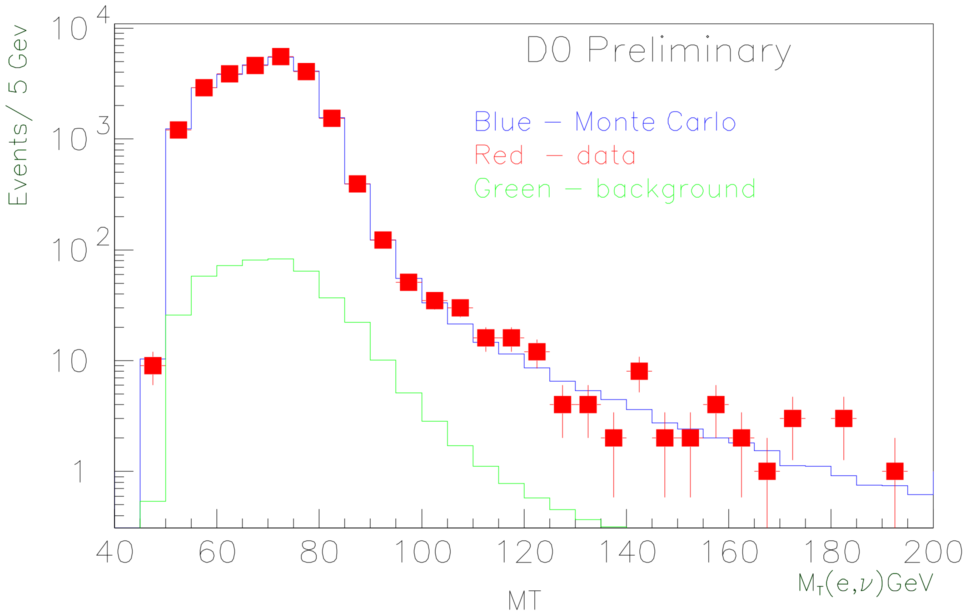

Figure 5: Transverse mass spectrum for data (red squares), with best fits superimposed as a blue curve. The green curve shows the sum of estimated backgrounds.

3. Studies of high mass Drell-Yan pairs

We present a new measurement [4] of the mass dependence of the forward-backward asymmetry (A_{FB}), and production cross section ($d\sigma/dM$) for e^+e^- pairs with mass $M_{ee} > 40$ GeV from 108 pb^{-1} of data taken by the CDF Collaboration during 1992-1995. The measurements are compared to predictions from the Standard Model and from a model with an additional Z' gauge boson. Previous measurements by CDF [5] restricted the data to central rapidity leptons (electrons or muons) and measured the $d^2\sigma/dMdy$ averaged over central rapidities. This new result includes electrons in the forward calorimeters, new techniques to reduce the backgrounds from QCD processes, and reports on measurements of A_{FB} in small bins over a large range in mass (from 40 to 500 GeV).

Figure 6 compares the measured $d\sigma/dM$ and A_{FB} to theoretical predictions. The upper plot shows $d\sigma/dM$ for e^+e^- pairs for both the CDF and DØ collaborations, and $\mu^+\mu^-$ pairs from CDF. The lower plot shows the A_{FB} measurement in the e^+e^- channel from CDF. The Standard Model NNLO prediction is shown as a solid line. The data is in good agreement with the Standard Model predictions. However, the measured A_{FB} is 2.2σ below the Standard Model prediction in the highest mass bin, from 300 to 600 GeV. From the four events in the sample, three are in the negative hemisphere. A negative asymmetry in this region could result from a new interaction not included in the Standard Model. As one possible example of additional interactions that could be compatible with the measured A_{FB}, we show in Fig. 6 predictions that include an additional E_6 Z' boson, with a width of 10% its mass, for two masses of 350 GeV and 500 GeV respectively. Although both CDF and DØ have set limits on the mass of additional Z' bosons of the order of 600 GeV [5, 6] those were based on assuming a narrower Z' ($\Gamma_{Z'} \approx 0.01 M_{Z'}$) with the same couplings to the three generations than the Standard Model Z boson. Allowing for additional decay modes with larger couplings to third generation reduces the direct limits by 100 to 150 GeV [7]. The high mass Drell-Yan data will be included in global fits to electroweak data to search for physics beyond the Standard Model.

4. Conclusions

The DØ and CDF Collaborations continue to produce interesting physics results from data taken during 1992-1996. At the same time, Run 2 started in March 2001, and we expect to accumulate 20 times more data in the following months. New interesting results await us in the near future from the Run 2 data at the Tevatron.

References

[1] V. M. Abazov *et al., DØ Collaboration,* `hep-ex/0106018`

[2] *S. Abachi et al., DØ Collaboration, Phys. Rev. Lett.* **77** *(1996) 3309; Phys. Rev. Lett.* **80** *(1998) 3008; Phys. Rev. Lett.* **84** *(2000) 222; Phys. Rev.* **D 58** *(1998) 12002; Phys. Rev.* **D 58** *(1998) 92003; Phys. Rev.* **D 62** *(2000) 92006.*

[3] *T. Affolder et al., CDF Collaboration, Phys. Rev. Lett.* **85** *(2000) 3347*

[4] *T. Affolder et al., CDF Collaboration, Submitted to Physics Review Letters.*

[5] *F. Abe et al., CDF Collaboration, Phys. Rev. Lett.* **79** *(1997) 2198; Phys. Rev.* **D 59** *(1999) 52002.*

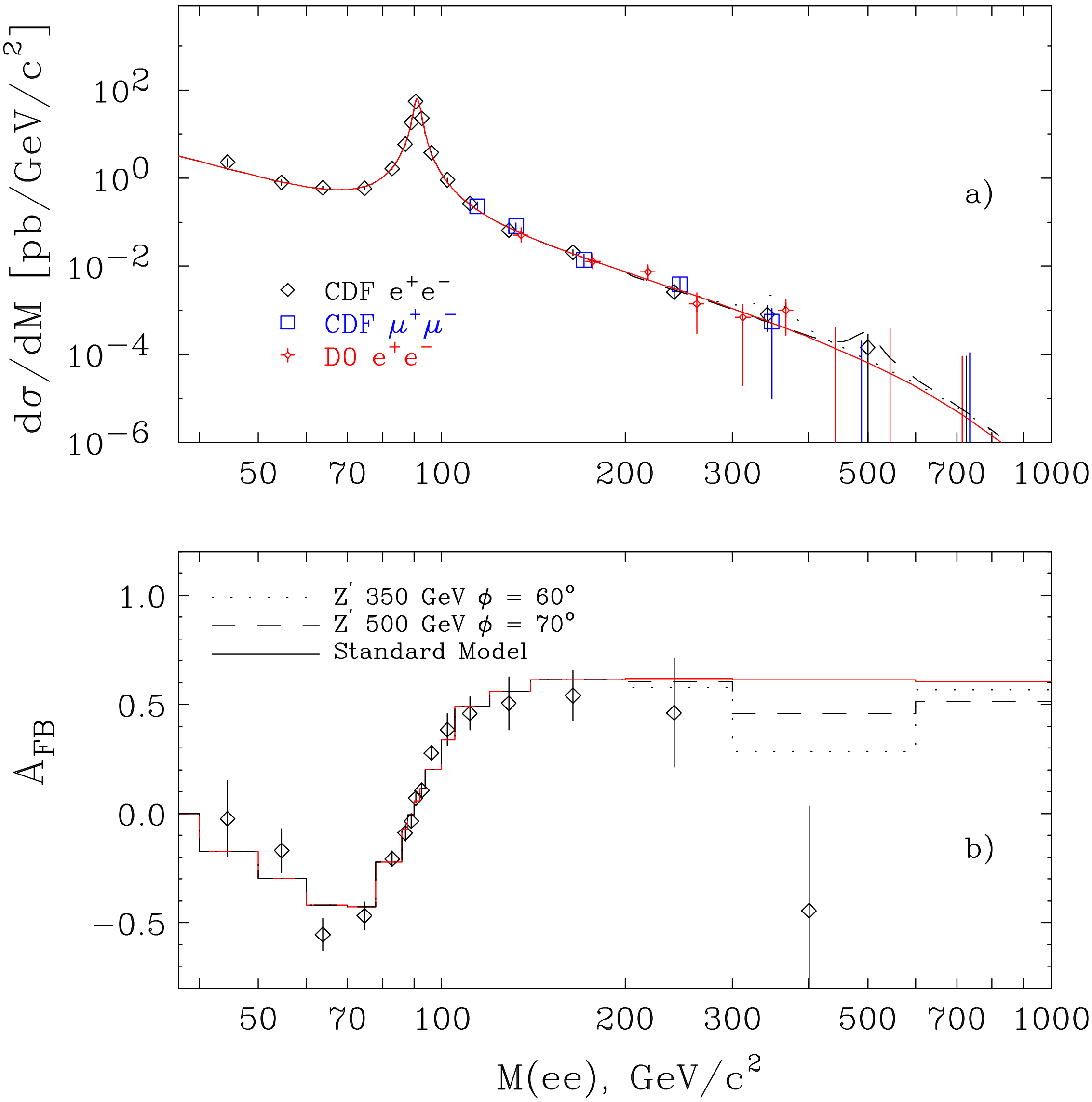

Figure 6: $d\sigma/dM$ (top) and A_{FB} (bottom) distributions from data compared to predictions from the Standard Model (solid line), and a model that includes an extra E_6 Z' boson with $M_{Z'}$ = 350(500) GeV shown as dotted (dashed) lines.

[6] *B. Abbott et al., DØ Collaboration, Phys. Rev. Lett.* **82** *(2000) 4769.*

[7] *A. Bodek and U. Baur,* `hep-ph/0102160`.