W AND Z CROSS SECTION MEASUREMENT AT CDF*

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We report on the new measurement of W and Z cross section times leptonic branching ratios in $p\bar{p}$ collisions at the Tevatron at $\sqrt{s}$ =1.96 TeV. The measurements are based on the decays $W \to e\nu$, $Z \to \mu^+\mu^-$ and $Z \to \tau\tau$.

1. Introduction

The study of electroweak processes plays a key role in the broad physics program of CDF Run II. Precise measurements from the Tevatron detectors are complementary to those performed at LEP (e^+e^-) and are important tests of the Standard Model(SM). Any observed discrepancy with the SM prediction would be evidence of new physics.

We will review the new measurements based on data collected during the years 2002-2004. The integrated luminosity of the data ranges from 223 to 349 pb^{-1}, depending on the measurements.

2. Cross section measurements

W and Z bosons are produced at the Tevatron by $q\bar{q}$ annihilation. Due to the large hadronic jet background, it is difficult to detect decays involving only quarks. Thus, leptonic channels are preferred for cleaner boson identification.

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The main ingredients of the cross section measurements are listed in the following equation 1.

$$\sigma(p\overline{p} \rightarrow X) \times BF(X \rightarrow l\nu(\bar{l})) = \frac{N_{events} - N_{bkg}}{\epsilon \times Acceptance \times \int \mathcal{L}dt}, \quad (1)$$

where N_{events} (N_{bkg}) is number of signal (background) events. The efficiency ϵ includes trigger, lepton reconstruction, and lepton identification efficiencies. Geometrical and kinematical *Acceptance* is usually evaluated from Monte Carlo and detector simulation. For the reviewed cross section measuremnts the integrated luminosity $\int \mathcal{L}dt$ is the dominant source of systematic uncertainty at $\pm$ 6%. An important source of systematic uncertainty to the *Acceptance* calculation is limited accuracy of the Parton Distribution Functions.

Previous cross section measurements[1] were based on 72 pb^{-1}. The measured values were $\sigma(p\overline{p} \rightarrow W) \times BF(W \rightarrow e\nu)$= 2780 $\pm$ 14$(stat)$ $^{+63}_{-57}(syst)$ $\pm$ 166 (lum) pb and $\sigma(p\overline{p} \rightarrow Z/\gamma^*) \times BF(Z/\gamma^* \rightarrow \mu^+\mu^-)$= 248 $\pm$ 5.9$(stat)$ $^{+8.0}_{-7.2}(syst)$ $\pm$ 15.1 (lum) pb. Taking the ratio of W to Z cross sections, an indirect measurement of Γ_W was performed with an accuracy comparable to the current world average.

3. $\sigma(p\overline{p} \rightarrow W) \times BF(W \rightarrow e\nu)$ in 1.2< $|\eta_e|$ <2.8

A new measurement of the W cross section has been performed by CDF using forward electrons. $W \rightarrow e\nu$ candidates are selected by a trigger which required a high E_T (> 20 GeV) electron detected in the forward region 1.2< $|\eta|$ <2.8[a] and high $\not{E}_T$ (> 25 GeV) as a signature of an undetected neutrino. The electron is required to be isolated and associated with a high p_T track. The tracks are measured by a combination of COT and silicon detectors, with the intermediate silicon layers[2] (ISL) playing an important role in the forward region. Using 223 pb^{-1} of data we detect 48144 candidates with 4.5% of background contamination. The measured and expected distributions for W transverse mass of our candidates is reported in Fig. 1. With an overall efficiency of 7.37% we measure the cross section to be 2815 $\pm$ 13$(stat)$ $^{+94}_{-89}(syst)$ $\pm$ 169 (lum) pb. The measured value is in good agreement with the previous measurement in the central region of the CDF detector, and with theoretical prediction $\sigma = 2687 \pm 54$ pb at NNLO [3].

The CDF capability to provide cross section measurements up to $|\eta|$ <2.8 is attractive to perform comparisons with theoretical predictions

[a] $\eta = -ln(tan(\theta/2))$

where good understanding of boson rapidity and visible lepton pseudo-rapidty distributions are key to using process of W production as a luminosity monitor for LHC experiments ([4] and references therein).

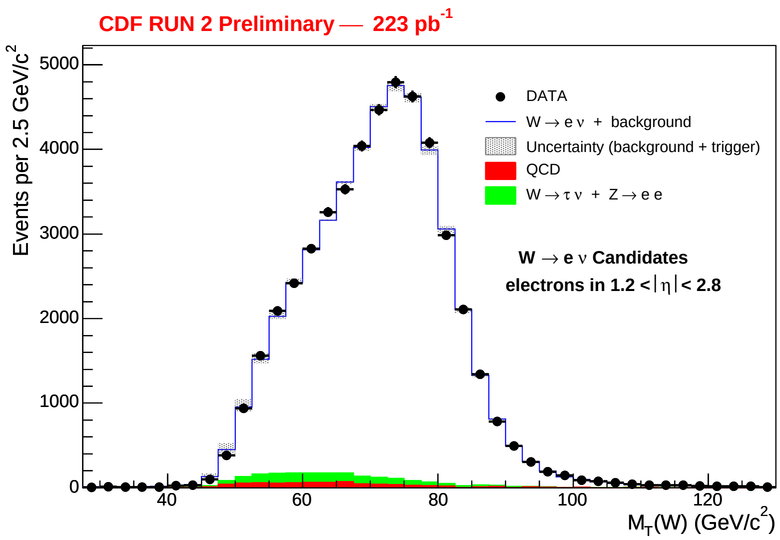

Figure 1. Transverse mass distribution of $W \to e\nu$ candidates with electron detected in forward region of CDF detector.

4. $\sigma(p\bar{p} \to Z/\gamma^*) \times BF(Z/\gamma^* \to \mu^+\mu^-)$

Identification of the Z boson is based on the reconstruction and identification of two leptons. In our case the candidates are selected by a high-p_T muon trigger, which utilizes muon detectors surrounding the calorimeter. A muon candidate must be associated with an isolated high-p_T (>18 GeV) track extrapolated to the muon detectors. Selection criteria were developed for the measurement of the p_T distribution of Z boson. In 337 pb^{-1} we reconstructed 9620 candidates with only 8 events of background coming from the decay of the Z boson to two taus. The invariant mass distribution is reported in Fig. 2. With overall efficiency 10.91% we measure the cross section to be 261.2± 2.7$(stat)$ $^{+5.8}_{-6.9}(syst)$ ± 15.1(lum) pb. The measured value is in good agreement with previous measurement in central part of CDF detector and with theoretical prediction $\sigma = 251.3 \pm 5.0$ pb based on an NNLO calculation [3].

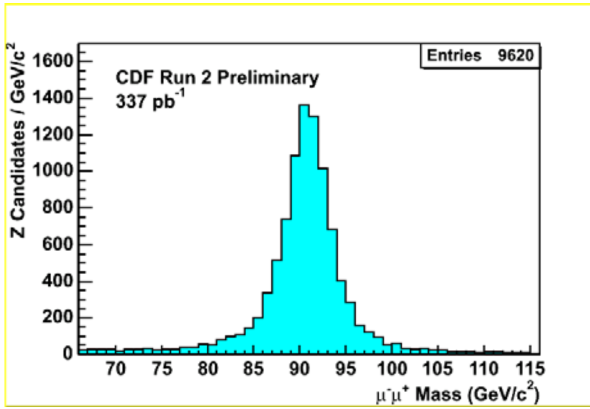

Figure 2. Invariant mass distribution of $Z \to \mu^+\mu^-$ candidates

5. $\sigma(p\overline{p} \to Z) \times BF(Z \to \tau^e\tau^h)$

Higgs and Supersymetry phenomenology predict τ-enriched signatures and τ physics plays an important role at CDF. The process $Z \to \tau\tau$ is the main irreducible background to many signatures of new physics[5].

The $Z \to \tau\tau$ cross section is measured by selecting a hadronic tau candidate and an electronic decay of the tau. The hadronic tau candidates are reconstructed by matching narrow calorimeter clusters with tracks. Around the highest p_T track an isolation cone is constructed and for signal candidates no tracks in the isolation cone are allowed. An isolated π_0 must also be reconstructed using the fine strip chamber at the decay photon's shower maximum.

To select Z candidates the *electron+track* trigger is used. Several cuts to remove conversion electrons and Drell-Yan background are applied. To increase the signal purity, selection criteria based on event topology were applied, $M_T(e, \not{E}_T) \leq 25$ GeV and $p_T(e, \not{E}_T) \geq$25GeV. The mass spectrum, defined as the invariant mass of the sum of electron, tau and $\not{E}_T$ four-momenta, is reported in Fig. 3. Using 349 pb^{-1} of data we measure the cross section to be 265 $\pm$ 20(*stat*) $\pm$ 21(*syst*) $\pm$ 15(*lum*) pb.

6. Conclusions

The CDF has produced new measurements of W and Z cross sections. The extended capability for electron identification up to $|\eta| <$2.8 was used. The low uncertainty of τ reconstruction at the level of 3% was reached. With

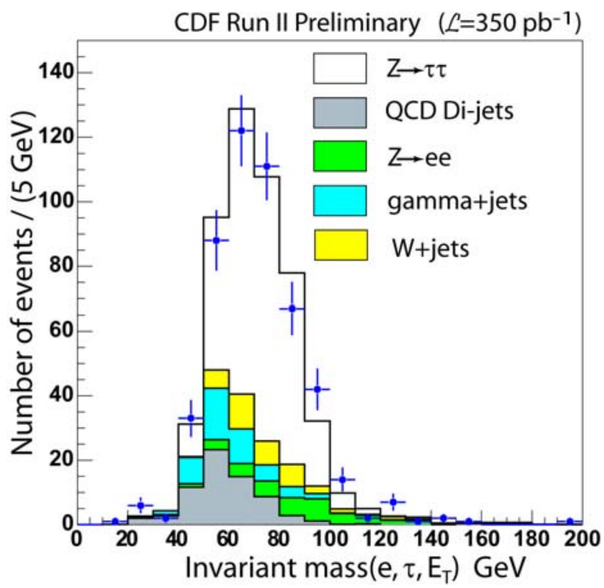

Figure 3. Invariant mass of the four-momenta of electron, hadronic tau candidate, and $\not{E}_T$ in the selected $Z \to \tau_e \tau_h$ candidate events.

the new results no deviation from the SM was observed.

7. Acknowledgments

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