6

Summary

In this thesis, we presented the results of the search for the SM Higgs boson in di-electron and missing transverse energy final state, performed at the DØ experiment with 8.6 fb^{-1} of data. No significant excess above the expectation from the SM processes is observed in the analysis presented. Considering various sources of systematic uncertainties upper limits on the Higgs boson production cross section at 95% confidence level are set. To achieve maximal sensitivity the analysis in the di-electron final state is combined with the orthogonal di-muon and electron-muon final states. The integrated luminosity of all the di-lepton final state corresponds to 8.6 fb^{-1}.

The cross section limit of the $gg \rightarrow H \rightarrow VV$ $(V = Z, W)$ process is also interpreted under the assumption of a fourth generation of fermions. No signicant excess is observed in the data, and the theory predicts a measurable excess over the background. In this scenario, we exclude the SM-like Higgs boson with a mass in the range $140 - 210$ GeV/c^2.

This work also resulted in a measurement of SM WW diboson production cross section. The measurement of the SM WW process which agrees with the theoretical value gives us confidence in our techniques for search of the elusive Higgs boson.

The search for the Higgs boson proves to be a challenge in this channel because the final state cannot be fully re-constructed. Nevertheless this channel has the highest sensitivity in the High mass Higgs regime. With rapid development of new and innovative techniques the sensitivity of this analysis has improved since the last publication result [71]. This is due to many improvements introduced in the analysis; addition of more data, splitting the final state into jet multiplicity bins, using Boosted Decision trees over Neural Network method used previously, are some of them. Fig. 6.1 shows the comparison of the expected sensitivity in each jet multiplicity bin and their combination for the di-electron channel. One can clearly see the improvement in the sensitivity with splitting in jet multiplicity bins.

For the first time at DØ , we were able to probe the high-mass range, i.e. at 95% C.L the existence of the Higgs boson with a mass value of about 165 GeV/c^2. These results are also combined with the corresponding search channels from the CDF experiment.

The combination of these results, yield the exclusion of a SM Higgs boson in a mass range from $m_H = 156 - 177$ GeV/c^2 and $m_H = 100 - 108$ GeV/c^2, approaching the LEP exclusion limit $m_H < 114.4$ GeV/c^2 as shown in Fig. 6.2. First, we reach the sensitivity required to test the hypothesis of a SM Higgs boson by combining the searches at CDF and at DØ experiments. we then reached the SM sensitivity with the DØ search alone.

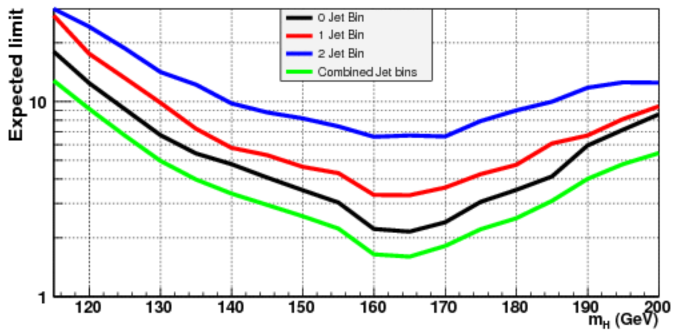

Figure 6.1: Comparison of the expected limits for the three di-electron subsets with zero jets, with one jet, with two or more jets, and of their combination.

The results of the fourth generation searches when combined with CDF experiment excludes the SM Higgs boson hypothesis over a wider mass range from $130-280\ GeV/c^2$. This is presented in Fig. 6.3.

6.1 Future Prospects for Higgs Searches at the Tevatron

Looking towards the future, the Tevatron's ability to observe the Higgs boson is an interesting question. Tevatron ended it's data taking on September 2011. Both experiments, CDF and DØ, have collected data sets with a luminosity of 10 fb^{-1} . Over the time, the expected sensitivity to the Higgs boson has improved faster than luminosity. This is due to addition of more channels, improved lepton and jet identification algorithms, smarter analysis techniques.

6.2 Future Prospects for Higgs Searches at the LHC

The LHC collider at CERN, Geneva is providing data at the center of mass energy of $\sqrt{s}$ = 8 TeV, offering an unprecedented physics reach. One of the design goals for LHC was to achieve sensitivity for the SM Higgs boson across the entire Higgs boson mass range. On July 4^{th} CERN announced the observation of a new boson. Both ATLAS and CMS experiments have observed an excess in the decay channels $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4l$. Results from ATLAS experiment used the dataset corresponding to an integrated luminosity of 4.8 fb^{-1} at $\sqrt{s} = 7$ TeV and 5.8 fb^{-1} at $\sqrt{s} = 8$ TeV. An excess of events was observed above the expected background, with a local significance of 5.9 standard deviations, at m_H=126 ± 0.4 GeV/c^2 [94]. Similarly results from CMS experiment using a dataset corresponding to an integrated luminosity of 5.1 fb^{-1} at $\sqrt{s} = 7$ TeV and 5.3 fb^{-1} at $\sqrt{s} = 8$ TeV. The excess of events observed correspond to a local significance of 5.0 standard deviations, at m_H=125.3 GeV/c^2 [95].

At present, both the experiments are conducting tests to validate the compatibility of this boson with the SM Higgs boson. Once discovered, LHC experiments will work on measuring the properties and nature of this boson.

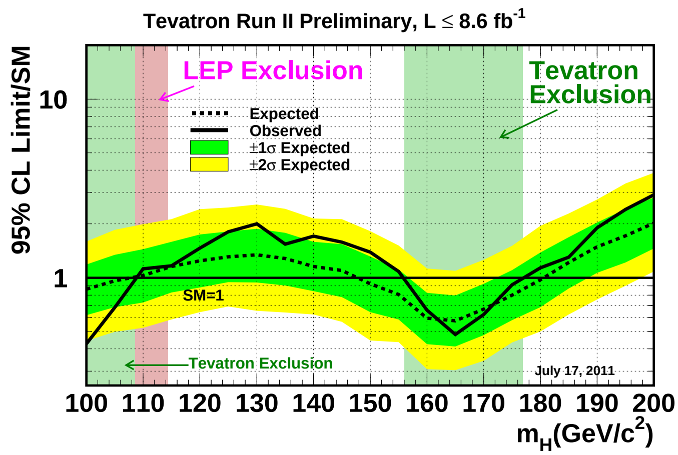

Figure 6.2: Observed and expected (median, for the background-only hypothesis) 95% C.L. upper limits on the ratios to the SM cross section, as functions of the Higgs boson mass for the combined CDF and D0 analyses. The limits are expressed as a multiple of the SM prediction for test masses (every 5 GeV/c^2) for which both experiments have performed dedicated searches in different channels. The bands indicate the 68% and 95% probability regions where the limits can uctuate, in the absence of signal. The limits displayed in this gure are obtained with the Bayesian calculation.

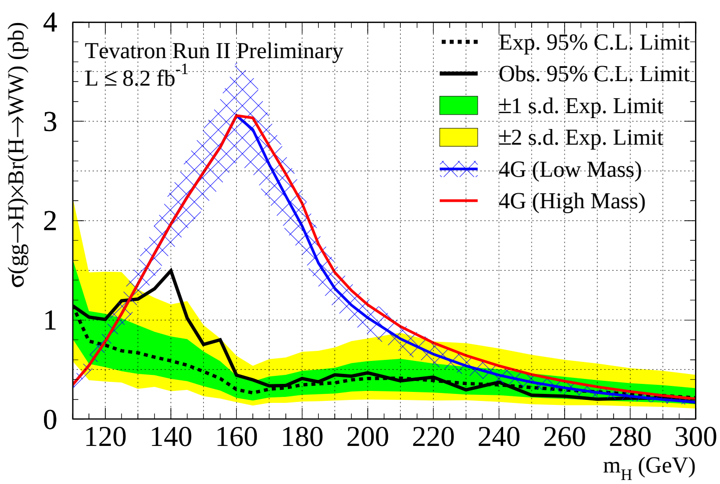

Figure 6.3: The Tevatron combined observed (solid black lines) and median expected (dashed black lines) 95 $\rightarrow W^+W^-$). The shaded bands indicate the ± 1 standard deviation (s.d.) and ± 2 s.d. intervals on the distribution of the limits that are expected if a Higgs boson signal is not present. Also shown the prediction for a fourth-generation model in the low-mass and high-mass scenarios, 4G (Low mass) and 4G (High mass) respectively. The hatched areas indicate the theoretical uncertainty from PDF and scale uncertainties. The lighter curves show the high-mass theoretical prediction.