Abstract

The standard model (SM) of particle physics successfully encapsulates the dynamics of elementary particles and their interactions. Despite its huge success, SM fails to resolve many key problems such as the inclusion of gravity, absence of dark matter candidate, unification of the gauge couplings at high energies, and the origin of mass. Several beyond the standard model scenarios have been proposed to explain some of these aspects. However, all these predictions need to be verified experimentally with ultra high precision. With this motivation, the world's most powerful hadron collider, the Large Hadron Collider (LHC) has been built at CERN. The physics programme at the LHC is driven by the need to provide a definitive answer about the existence of the SM Higgs boson and the new physics signatures.

The associated production of gauge bosons, termed as diboson processes, is a good potential candidate to test the predictions of SM. The production rate of diboson processes could be enhanced by a variety of new physics processes. Furthermore, diboson processes constitute an important background to the Higgs searches. Thus, a detailed understanding of the diboson processes at the LHC is necessary to realize its key goals. Several measurements involving diboson final states have been proposed and are being carried out at the LHC, such as the decay of Higgs boson into a pair of W/Z bosons or photons. The list of ongoing measurements also include a study of double-parton scattering (DPS) processes using WW production. DPS is the simplest realization of multi-parton interactions and is expected to have a high production rate in high luminosity proton-proton (pp) collisions at the LHC. An important outcome of the DPS studies is the effective cross section parameter, which holds the answer to fundamental questions about the partonic structure of the colliding protons. Experimental evidences for the existence of DPS processes have been found through various experiments at CERN and Tevatron. The modest approach to investigate DPS processes is to use a factorization approach which assumes negligible correlations among the constituents (partons) of

two colliding protons. This approximation holds when the partonic densities inside the colliding protons are significantly high. Some theoretical calculations predict deviation from this approximation, which need to be tested experimentally. Moreover, DPS processes can give rise to significant background contributions to certain rare single-parton scattering (SPS) signal processes. All these facts make it necessary to investigate DPS processes using different final states at highest possible collision energies.

This thesis presents the first study of DPS processes using same-sign WW events produced in pp collisions at a center-of-mass energy of 8 TeV. The analyzed data correspond to an integrated luminosity of $19.7\,\mathrm{fb}^{-1}$, collected using the Compact Muon Solenoid (CMS) detector at the LHC. The final state comprises of two W bosons decaying into an electron-muon or dimuon pair in association with their respective neutrinos. A set of DPS-sensitive observables are combined using a multivariate analysis based on boosted decision trees (BDT). The shape of BDT discriminant is used to conduct a statistical analysis based on the asymptotic approximation of the $\mathrm{CL_s}$ method. No significant excess of events is observed above the expected SPS yields. A 95% confidence (CL) level upper limit of 0.32 pb is set on the inclusive production cross section for same-sign WW via DPS process. Correspondingly, a 95% CL lower limit of 12.2 mb is set on the effective cross section parameter of the DPS processes. This limit on the effective cross section is consistent with the previous measurements and the predictions from simulations.

On the hardware front, this thesis covers the assembly, characterization, and testing of resistive plate chamber (RPC) detectors for the CMS muon detector system upgrade. Some of these RPCs are assembled, characterized, and tested in India at BARC, Mumbai and Panjab University Chandigarh. These RPCs are observed to have a detection efficiency $> 95\%$ and have been successfully installed at the CMS detector. These newly installed RPCs have resulted in an improved performance of the CMS muon detector system during the ongoing 13 TeV run of the LHC.