Abstract

Many proposals for physics beyond the Standard Model suggest new massive bosons at the TeV energy scale. By observing phenomena at the most powerful particle accelerator – the Large Hadron Collider, the ATLAS detector probes the nature at such high energy scale. Since 2016, the accelerator has established a new record of luminosity. To benefit from the increase in luminosity, the DAQ system of the ATLAS Transition Radiation Tracker has to be upgraded to cope with higher trigger rate and higher luminosity, that are beyond the original design of the tracking detector. The improvement developed in the hardware and firmware of the DAQ system is documented in this dissertation, with a study to evaluate the performance of the system.

This dissertation also presents two searches for new physics at the TeV scale, that have broadened the ATLAS program with first-time searches. One analysis seeks for heavy resonances decaying into a hadronic Z/W/Higgs boson and a photon. The boosted Z/W/Higgs boson is identified using large-radius jet mass and substructure informations. The analysis is based on 36 fb^{-1} of $\sqrt{s} = 13$ TeV proton–proton collision data, collected with the ATLAS detector in Run II of the Large Hadron Collider. No significant deviations from the Standard Model prediction is observed. Upper limits are set on the signal cross section times the branching fraction of resonance for the three different diboson final states at 95% confidence level, excluding those productions at 10–0.2 fb in the resonance mass range of 1–6.8 TeV.

The second analysis searches for scalar leptoquark pair productions, where each leptoquark decays into a top quark and an electron or muon. The search sensitivity is optimized for high leptoquark masses, at which the hadronic decay products of each top quark are contained within a large-radius jet. The analysis exploits the full Run II dataset that corresponds to an integrated luminosity of 139 fb^{-1}. No significant excess of events is found. Lower mass limits on leptoquarks decaying into electron–top-quark or muon–top-quark pair are set to 1.48 TeV and 1.47 TeV at 95% confidence level.