Abstract

Following the discovery of the Higgs boson by the ATLAS and CMS Collaborations at the Large Hadron Collider (LHC) in 2012, the attention has been focussed on studying the properties of the newly discovered particle to test the predictions of the Standard Model (SM). An object of particular interest is the top quark Yukawa coupling - the coupling of the Higgs boson to the top quark, which is predicted to be close to unity in the SM and at the same time very sensitive to the possible effects of new physics beyond the SM. The production of the Higgs boson in association with a pair of top quarks, $t\bar{t}H$, is the mode which gives direct access to the top quark Yukawa coupling. The decay of the Higgs boson into a pair of b-quarks, $H \to b\bar{b}$, is dominant in the SM (its branching ratio is approximately 58%). This decay channel also allows measuring the b-quark Yukawa coupling - the second largest coupling of the Higgs boson to a fermion in the SM.

In this dissertation the search for $t\bar{t}H$ ($H \to b\bar{b}$) in the single-lepton channel, resulting from the semileptonic decay of the $t\bar{t}$ system, is presented. The analysis is based on 36.1 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV recorded with the ATLAS detector in 2015 and 2016. The study is performed using a likelihood-based method that exploits kinematic properties of the selected events to separate the signal from the background, which is dominated by $t\bar{t}$ produced in association with additional jets. This search relies on the high multiplicity of jets originating from b-quarks (b-jets), so identification of these jets (b-tagging) is crucial. A study on the optimisation of b-jet identification algorithms in ATLAS is also presented in this dissertation. The ratio of the measured $t\bar{t}H$ cross-section to the SM expectation is found to be $\mu = 0.88^{+0.64}_{-0.61}$, assuming a Higgs boson mass of 125 GeV. This result is consistent with both the background-only hypothesis and the $t\bar{t}H$ SM prediction.