ABSTRACT

The Large Hadron Collider (LHC) operates at the highest energy scales ever artificially created in particle collision experiments with a center-of-mass energy $\sqrt{s} = 13\,\text{TeV}$. In addition, the high luminosity allows the unique opportunity to probe the Standard Model at the electroweak scale and explore for rare signs of new physics beyond the Standard Model. The coupling of the third-generation top quark to the Higgs boson introduces large, quadratic, radiative corrections to the Higgs mass, requiring a significant amount of fine-tuning that results in a nearly perfect correction of the Higgs mass from the Planck scale to the observable electroweak scale. A possible solution to the naturalness problem proposes a collection of supersymmetric partners to the Standard Model particles with the mass of lightest particles at the electroweak scale: the gluino, the stop squarks, and the lightest supersymmetric particle. This thesis presents the results of a search for gluino pair production decaying via stop squarks to the lightest neutralino in hadronic final states using a total integrated luminosity $36.1\,\text{fb}^{-1}$ of data collected with the ATLAS detector in 2015 and 2016. This analysis considers a simplified supersymmetry model targeting extreme regions of the phase space with large missing transverse momentum, multiple b-tagged jets, and several energetic jets. No excess is observed and limits on the gluino mass are set at the 95% CL, greatly extending the previous results in 2012 from $1.4\,\text{TeV}$ to $1.9\,\text{TeV}$. The increase of the LHC luminosity also poses challenges to the current trigger system in the ATLAS detector necessitating planned upgrades. One of the upgrades for the trigger system is the Global Feature Extractor (gFEX) which aims to recover lost efficiency in boosted hadronic final states by identifying large radius jets produced by top quarks, Higgs, Z and W bosons which are critical for future ATLAS physics programs. This module is a unique board with 3 processor FPGAs for data processing and an embedded multi-processor system-on-chip for slow-control and monitoring. This thesis will also describe the work on developing this hardware and several physics upgrade studies on the trigger performance.