CHAPTER 12

CONCLUSIONS

The lifetime is an underexplored region of phase space for many natural BSM theories and this thesis describes a search that covers a large gap in signature space at the LHC. In 139 fb^{-1} of $\sqrt{s} = 13$ TeV LHC data collected by the ATLAS detector, no signs of BSM physics are seen. Three orthogonal signal regions are defined and less than 1 background event is predicted in each. 0 events are seen and limits are set on the possible mass and lifetime of $\tilde{\ell}$ in GMSB SUSY models. For a lifetime of 0.1 ns, selectron NLSP, smuon NSLP, stau NSLP, and co-NLSP scenarios are excluded for slepton masses up to 720 GeV, 720 GeV, 370 GeV, and 830 GeV, respectively, exceeding the OPAL co-NLSP limit [1] by almost an order of magnitude. Co-NSLP events are also excluded up to 10 ns for masses below 330 GeV.

A minimal, though substantial, set of optimizations were done to enable this result, but future analyses could improve upon this result in several ways. First, further optimization could be done of the electron reconstruction algorithm in order to boost efficiency at high $|d_0|$ as well as reduce the systematic uncertainty due to the variation in the lepton displacement selection efficiency. An additional signal region could be added using a MET trigger could increase sensitivity. This signal model has real MET due to the gravitinos, but also muons are not included in the High Level Trigger (HLT) MET calculation, so an MET trigger is an effective displaced muon trigger. This is particularly potentially effective for low mass staus, which really suffer from high single lepton trigger p_{T} thresholds. A bolder improvement would be to reconstruct all recorded events with LRT, instead of the filtered 10% that is currently used. This would enable more creativity in signal region design.

This result should also be interpreted in conjunction with other searches, including prompt searches and those for stable massive particles, to probe the full possible lifetime space of sleptons and make a more lifetime-inclusive statement about GMSB SUSY at the LHC. Furthermore, the minimal event-level requirements make this result model-

independent and applicable to any BSM decay resulting in displaced leptons.