Chapter 1

INTRODUCTION

All matter interacts via the four fundamental forces: gravitational, electromagnetic, weak, and strong; at least up to the scale of the weak interactions. Gravity is very well-described by Einstein's theory of General Relativity. The remaining three forces are described by a group of theories that describe fundamental particle physics and the interactions of all known elementary particles, the Standard Model. Formulated over the last century, this theory was kickstarted by Sheldon Glashow's [1] discovery of combining electromagnetic and weak interactions in 1961. The Standard Model has stood up to rigorous testing by many experiments and shown to be robust. However, this is not a complete model given the success so far, as certain assumptions are still made that need to be reconciled. **??** introduces the theories of the Standard Model and motivates the search for new physics. **??** introduces the Large Hadron Collider and the ATLAS detector, and its role in enabling searches for physics beyond the Standard Model. **??** discusses the current limitations in recording all of the data produced by the collider and the ATLAS detector's solution to managing this enormous influx of data. This chapter finishes off with an introduction of the necessary instrumentation upgrades for the ATLAS detector in parallel with the upgrades to the collider. At this point the reader will have a broad understanding of the fundamental interactions of particles, designing a massive and complex hardware system that enables us to probe for new physics, and being able to record all of the raw data of proton-proton collisions. But now, we must be like Sherlock Holmes, using the footprints of the collision data to look for patterns to reconstruct a picture of the original collision and what happened. **??** explores the many tried-and-proven techniques used by the ATLAS collaboration to reconstruct many of these fundamental particles. The energy scale of the proton-proton collisions at the ATLAS detector produces showers of Lorentz-boosted partons that form massive hadrons

with interesting substructure, a tell-tale signature of many beyond the Standard Model theories, necessitating specialized reconstruction techniques described in **??**. **??** applies these boosted reconstruction techniques to a particular search for gluinos, a new theoretical particle whose existence at the electroweak scale could help answer some questions about the Standard Model. The results of the search for gluinos is detailed in **??**. This search, and many others, can benefit from the future upgrades of the ATLAS detector whose physics impact is being studied in **??** to enhance the detector's sensitivity to these boosted objects that are copiously produced. Finally, **??** provides some concluding remarks about the search for new physics and the exciting outlook of the LHC physics program.

Bibliography

[1] Sheldon L. Glashow. "Partial-symmetries of weak interactions". In: *Nuclear Physics* 22.4 (1961), pp. 579–588. ISSN: 0029-5582. DOI: https://doi.org/10.1016/0029-5582(61)90469-2. URL: http://www.sciencedirect.com/science/article/pii/0029558261904692 (cit. on p. 1).