The search for the doubly charged version of the Higgs Boson

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Long has humanity questioned what the basic building blocks of the Universe are. The idea of the atom started with ancient Greek philosophers but it was not until the late 21st century that the field of particle physics fully emerged. Throughout the last 70 years progress has quickly been made through the discovering of fundamental particles and developing theories describing them which all have led to the creation of the Standard Model. The Standard Model explains what we know about the fundamental components of matter in the Universe and how they interact with each other. This model has been highly successful but still there are questions that it can not explain.

In 2012 the latest particle, the Higgs Boson, was discovered with the ATLAS detector at the Large Hadron Collider(LHC) located at CERN. This particle is the source of the mass of the particles within the Standard Model, expect for one type of particle: the neutrino. Several other models try to explain the origin of the mass for the neutrino and some of these model theorize a new particle called the doubly charged higgs which this thesis have studied. The doubly charged higgs is introduced similarly to the Higgs Boson to the Standard Model but the doubly charged higgs has two electrical charges. The decay of this particle is therefore special as it might potentially be the only doubly charged particle in the Standard Model.

The Large Hadron Collider accelerates and collide protons in a 27 km circumference tunnel to probe potential extensions of the Standard Model. When the protons collide they create a firework of different fundamental particles that is measured in detectors covering as much as possible around the collision. One of these detector is the ATLAS detector which together with CMS made the discovery of the Higgs Boson in 2012. In figure 1 one can see an event display showing the chaotic environment inside one event within the detector. This particular figure is from a potential $Z \to \mu\mu$ event which is similar to how doubly charged higgs events would look.

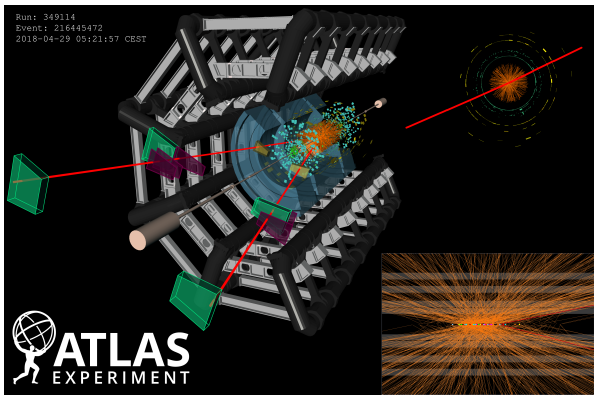

Figure 1: An event display of a potential $Z \to \mu\mu$ event which is similar to the $H^{\pm\pm}$ signal (ATLAS Experiment © 2022 CERN).

In this thesis the number of events of the doubly charged higgs that would be observable at the ATLAS detector have been investigated. In particular a new production mechanism of this particle involving leptons created within the proton have been studied. This production process could enable a cleaner signal to search for with the ATLAS detector. The results of the study have shown that events of this process could be detected at ATLAS but that it is highly dependent on parameters within the model and potential background processes that drown out the signal. For certain model values this process could compete with previously analyzed processes. This thesis has built a foundation for the potential of a future full analysis of this production process.