Investigation of the Anomalous $H \rightarrow \mu^+\mu^-$ Decay Channel at the ATLAS Experiment

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Introduction

The Higgs boson particle was discovered by the ATLAS and CMS experiments with a mass of 125.09±0.21 (stat.)±0.11(syst.) GeV. since then the LHC experiments have been investigating the properties of the Higgs by looking at how it is produced and how it decays. The relatively unknown channel, shown in figure 1, is being investigated in this project by comparing simulated Higgs processes to actual data from the ATLAS experiment.

The decay of Higgs to $\mu^+\mu^-$ is relatively rare because the probability of a Higgs decay occurring is proportional to the square of the mass of the produced particles, therefore the Higgs is much more likely to decay to higher mass particles, such as a ZZ boson pair which is a decay channel confirmed by the ATLAS experiment.

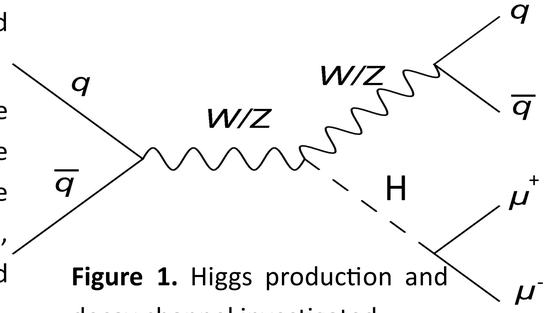

Figure 1. Higgs production and decay channel investigated.

Muon and electron resolution studies

Using the ROOT framework simulated data for the ATLAS experiment has been analysed. This analysis has focused on how the detector responds to electron and muon signals. Figure 5 and 6 show how this analysis calculates the standard deviation on the Z boson mass using a Gaussian fit within different muon P_t (momentum transverse to the beam line) boundaries.

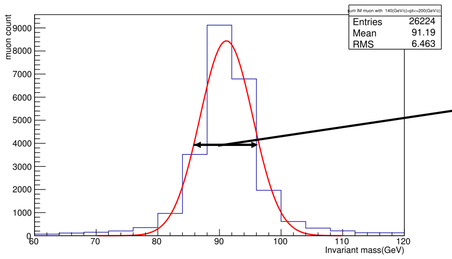

Figure 5. Gaussian fit on Z boson mass (sum of invariant mass of muons produced by a Z boson) with specific transverse momentum between 160GeV/c and 200GeV/c.

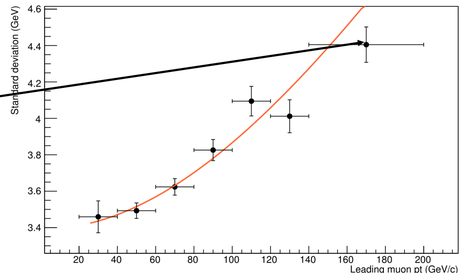

Figure 6. ATLAS detector resolution for muons with various transverse momentum and fitted tracker resolution.

By measuring the standard deviation on the Z boson mass for each range of transverse momentum, pseudorapidity and particle polar angle relative to the transverse plane the detector response is observed depending on the properties of the particles and their location.

ATLAS experiment

The ATLAS experiment has been running as one of the LHC detectors looking at, among other projects, the properties of the Higgs boson. It is important to understand the detector setup and its response to different particle detections in order to investigate different decay channels.

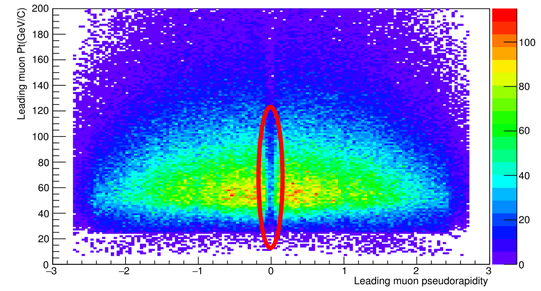

Figure 3. Muon momentum against pseudorapidity (particle angle relative to beam axis) showing a hole in the detector.

Using simulated data any 'holes' (areas where significantly less particles are detected) can be seen and corrected for. Figure 3 shows a hole originating from when the detector was assembled from two parts.

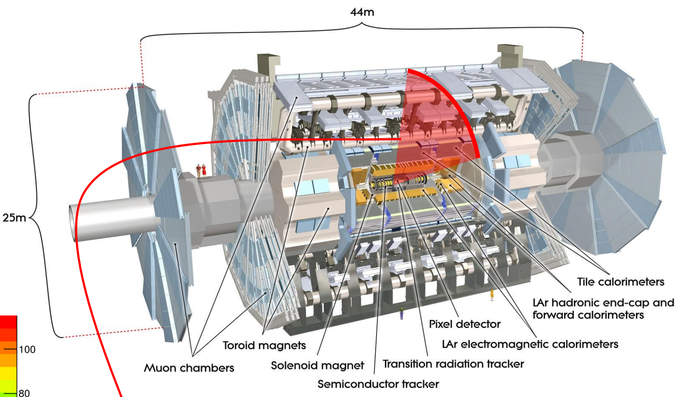

Figure 2. Labelled ATLAS detector.

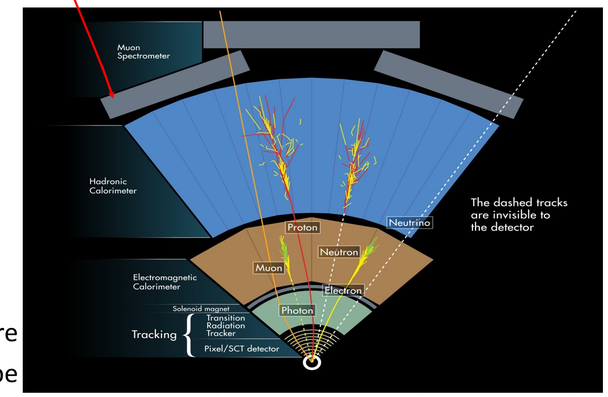

Figure 4. ATLAS cross section showing the four major components where different particle types are detected.

Project timeline

Electron and muon resolution studies → Determining cuts to optimise signal to background ratio. → Apply cuts to simulated data. → Determine the branching ratio for the proposed process and compare to ATLAS data.

Literature used

Combined Measurement of the Higgs Boson Mass in *pp* Collisions at *sV=7* and 8 TeV with the ATLAS and CMS Experiments arXiv:1503.07589 [hep-ex].