ATLAS muon reconstruction from a C++ perspective: a road to the Higgs
Hendriks, P.J.

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Introduction

Where do you want to go today?

*Microsoft advertising slogan*

For the past two decades Fortran 77 has been the dominant programming language in the high-energy physics community. At the time it was first introduced the typical experiments were small, both in terms of the physical size of the detectors and in the number of people working on them. But with every new generation of experiments both grew in size, placing ever more stringent demands not only on the detectors' hardware, but also on the software needed to simulate, reconstruct and analyse their physics events.

As a consequence, advancements in detector technology have been continuous and have led, among other things, to better resolutions and faster response times. Surprisingly however, any upgrades to the software development process have been few and far between. Despite major changes in the "real" world, the language of choice has remained to be Fortran. It wasn't until very recently that this anachronism was acknowledged and efforts were undertaken to bring the latest software techniques to the high-energy physics community.

The one technique that has had the largest impact has been the change from procedural to object-oriented programming, with the complementary adaptation of C++ as the implementation language. The first steps along this line were taken about 5 years ago, but a truly widespread acceptance has happened only much more recently.

The work described in this thesis is aimed at designing, implementing and testing a full-size object-oriented program. After some consideration, the choice was made to work on the reconstruction of events in the muon spectrometer of the *ATLAS* detector. The standard steps to take in the creation of such a program are [1]:

- **Analysis.** Chapter 1 describes the Standard Model and the theoretical foundation of the Higgs mechanism. Finding and studying the Higgs boson(s) is one of the major goals of the *ATLAS* detector. The experimental setup is described in chapter 2, in which special emphasis is placed on the muon spectrometer and the software infrastructure available within *ATLAS*.

1. The various acronyms used in this thesis are explained in the glossary (appendix C).
• **Design.** A detailed description of the design of the muon reconstruction software is given in chapter 3. First the various ATLAS-specific subdomains like the detector description and the event representation are explored. They are followed by an account of two general-purpose packages that are used to implement the reconstruction algorithm. The first is the Detector Reconstruction Toolkit, which defines general reconstruction classes like tracks and error cones, and performs tasks like track fitting and track propagation through a magnetic field. The second package is the Generic Dataview Library, which provides a framework in which data-driven algorithms can be implemented in a straightforward and intuitive way.

The reconstruction algorithm itself is described in chapter 4. It starts with the reconstruction of regions of activity from the hits in the trigger chambers. Within these so-called roads, the pattern recognition in the precision chambers is performed, followed by a global matching of the individual track segments. It is then concluded by a global fit through all precision and trigger hits.

• **Implementation and testing.** The first test of the algorithm, viz. the evaluation of its segment-reconstruction performance in a single precision chamber is described in chapter 5. Various levels of detector inefficiency and background are used to analyse the robustness of the algorithm.

This is followed in chapter 6 by a study of a complete tower of the muon spectrometer in the form of the DATCHA cosmic ray test setup. DATCHA is primarily a testbed for the muon alignment system, but is also well suited for testing the performance of the particle reconstruction.

And ultimately the performance of the whole spectrometer for single-muon, dimuon and 4-muon event topologies is explored in chapter 7.

In the last chapter of this thesis we return to the Higgs; to study its decay into a final state of four leptons and to ascertain its discovery potential of the ATLAS detector. In contrast to all other chapters, these final results are not obtained using my own software, but with the standard ATLAS production tools instead.