Measurements on top quark pairs in proton collisions recorded with the ATLAS detector

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Preface

In this thesis I describe measurements on top quark pairs that are produced in collisions in the Large Hadron Collider (LHC). The measurements of the production rate of top quarks (Chapter 5) and the so-called charge asymmetry (Chapter 6) are direct tests of the contemporary theory of elementary particles and fundamental forces, the Standard Model. These measurements form a part of the LHC programme designed to verify the theory as precisely as possible, and potentially extend or even overthrow it. The ultimate goal is to increase understanding of physics at the smallest scales, and thus of the tiny building blocks of everything we see around us. Hence, research in the subfield of top quark physics forms a contribution to extending our knowledge of nature.

For this reason I joined the top quark subgroup in the collaboration of the ATLAS-experiment in 2008, before the LHC became operational. The top quark with its high production rate at LHC and its involved decay properties would form a significant marker of the possibilities of the experiment. In the beginning that meant that analyses were tested on simulated events. When the accelerator finally started running, a defect after just a few days caused a shutdown and a subsequent delay of more than a year. Only in November 2009, the first proton collisions were produced, as I have experienced from close by during the period when I was stationed at CERN.

The LHC finally produced the first high-energy collisions (7 TeV) in 2010. This allowed us to publish the observation of top quarks and measurements on their production rate in the most important decay channel, albeit with adjusted analyses; the calibration was improved to levels higher than anticipated, due to the longer preparation time. With the prosperous running of LHC and the resulting wealth of collision events, it was tempting to continue top quark research. Especially since Tevatron experiments reported intriguing results that could be verified with the LHC. This led to the measurement of the top quark charge asymmetry in the final chapter.

The thesis consists of six chapters. Chapter 1 describes the theoretical motivation for top quark research and addresses the role of the top quark in the Standard Model. Also presented are some hypotheses and alternative models that could influence top quark observables. The accelerator and all subcomponents of the ATLAS detector are described in Chapter 2. Chapter 3 discusses the process of simulating collision events and the detector response, and the reconstruction of the different types of particles in ATLAS.

In Chapters 4-6 we make use of the recorded data. Chapter 4 introduces the selection of collisions that is designed to effectively isolate top quark events, and compares the relevant

observables in the 2010 and 2011 data sets. These are the data sets on which the analyses in the later chapters are conducted. Chapter 5 is a description of the measurement of the production rate of top quark pairs in data from 2010 and Chapter 6 shows the measurement of the charge asymmetry making use of the data recorded in 2011.

For all analyses in this thesis we make use of work of hundreds or even thousands of other people. In addition to all engineers and physicists that are responsible for the design and construction of the experiment, also on the level of data analysis many stepping stones are required before reaching a final measurement. Because subgroups in the ATLAS collaboration studied the efficient reconstruction of electrons, jets, muons and various other objects, and others distributing the data from CERN to all around the world, we can make use of all this information to conduct research on top quarks.

Besides these people, I would like to thank the people that supervised me and contributed to my research. First Stan Bentvelsen, who gave me the opportunity to start doing research at Nikhef and kept being enthusiastic and interested during the entire period. Secondly, I want to thank Pamela Ferrari for the supervision, especially during the period at CERN when the first data arrived and when working from deadline to deadline. A great thanks to Menelaos Tsiakiris and Hegoi Garitaonandia for the teamwork during the top quark cross section measurement, the skills I gained during this period helped me greatly in the subsequent asymmetry analysis.

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