Measurements of the W-pair production rate and the W mass using four-jet events at LEP
van Dierendonck, D.N.

Citation for published version (APA):
van Dierendonck, D. N. (2002). Measurements of the W-pair production rate and the W mass using four-jet events at LEP
Chapter 1

Introduction

Perhaps the most interesting challenge in physics is to describe as much of the world as possible with a model as simple and general as possible. Certainly the most successful model to date is the unimaginatively but perhaps appropriately called Standard Model. The essence of this theory, the Lagrangian, fits on a single page. However this compact theory successfully describes all electromagnetic, weak and strong interactions in a quantum mechanically correct way and is consistent with special relativity. It is hard to overestimate the magnitude of this accomplishment or the scope of its applications. The Standard Model ultimately describes processes ranging from chemical reactions throughout our body, through nuclear fusion in the sun, to electromagnetic processes in our television sets. Many tests of the theory have been performed, often with astonishing precision. Up to now, the theory has always been able to describe the observed phenomena - to the disappointment of some physicists. The main part of the model that still requires experimental verification is the confirmation of the existence of the Higgs boson. This crucial particle is predicted by the Standard Model, but has not yet been observed directly. Although a surprise would be most welcome, there are indications that the Higgs is just around the corner and will be found in the not so distant future.

The success of the Standard Model is especially intriguing as we know that it is not a complete theory: gravity is not included. At some scale the theory’s description of nature should therefore break down. To gain insight into the missing part of the theory, it is essential to continue to challenge it experimentally. Therefore, accurate measurement are needed to verify Standard Model predictions and its fundamental properties.

In 1983, the existence of the W boson was demonstrated by the UA1 collaboration. In the Standard Model, the W boson is the charged mediator of the electroweak force. In this thesis precision measurements involving W bosons are presented. The first measurement described is the W pair production rate in $e^+e^-$ collisions. This production rate is highly sensitive to possible anomalies in certain interactions, for example in the ZWW coupling.

Subsequently, the collected W pairs have been used to extract the mass of the W boson. This mass is a fundamental parameter of the Standard Model which is not fixed by theory.
Introduction

This alone justifies a measurement of the W mass. In addition, the Standard Model can be tested to a level of great precision by comparing the directly measured W mass with the indirect W mass prediction. This prediction is obtained by performing a Standard Model fit to several precisely measured observables.

The layout of this thesis is as follows. In Chapter 2, the theory is briefly discussed. In Chapter 3, the LEP accelerator and the L3 detector are described, followed in Chapter 4 by an overview of some specific analysis methods and tools used to perform the measurements. In the next Chapter the selection of W pair events and the determination of the W pair production rate are described. Also in Chapter 5, the W mass is determined from the production rate at the center-of-mass energy where this rate is sensitive to the W mass: i.e. at the W-pair production threshold. In Chapter 6, the previously selected events are used for a direct measurement of the W mass. Finally, in Chapter 7, the results are discussed in the framework of the Standard Model. Also, some implications of the measurements for possible physics beyond the Standard Model are given.