Measurement of $\Gamma(Z^0 \rightarrow b\bar{b})/\Gamma(Z^0 \rightarrow \text{hadrons})$
using impact parameters and leptons

OPAL Collaboration

Abstract. A measurement of \( \frac{I_{bb}/I_{had}}{I_{had}} = \Gamma(Z^0 \rightarrow b \bar{b})/\Gamma(Z^0 \rightarrow \text{hadrons}) \) is presented using a "mixed tag" method involving the identification of \( Z^0 \rightarrow b \bar{b} \) events by two different techniques. The first uses the large impact parameter of tracks emerging from the decay of \( b \)-flavoured hadrons and the second their semi-leptonic decay. The identification efficiencies are measured from the data using all possible combinations of the two tags in opposite hemispheres. The method is therefore insensitive to Monte Carlo modelling of bottom quark production and of \( b \)-flavoured hadron production and decay properties, and depends only weakly on the simulation of the detector. The data sample collected by OPAL at LEP in 1990 and 1991 is considered. The result is:

\[
\frac{I_{bb}}{I_{had}} = 0.218 \pm 0.006 \text{(stat)} \pm 0.007 \text{(syst)} \pm 0.007 (\epsilon_c/\epsilon_{had}),
\]

where the systematic uncertainty due to the charm quark partial width has been separated from the other systematic uncertainties. Combination with previous OPAL measurements gives:

\[
\frac{I_{bb}}{I_{had}} = 0.220 \pm 0.004 \text{(stat)} \pm 0.006 \text{(syst)} \pm 0.006 (\epsilon_c/\epsilon_{had}).
\]

1 Introduction

A precise measurement of the partial width for the decay \( Z^0 \rightarrow b \bar{b} \) would provide a stringent test of the Standard Model [1] and some possible extensions [2]. Measurements that have been performed to date make use of semi-leptonic \( b \) quark decays [3-5] and impact parameter distributions of tracks from \( b \)-flavoured hadron decay [6, 7]. Differences in event shapes between \( Z^0 \rightarrow b \bar{b} \) and \( Z^0 \) decays into other quarks [8] can also be used, although the accuracy of this technique is limited by uncertainties in the modelling of hadronisation. The \( Z^0 \) partial decay width into \( b \) quarks, \( I_{bb} \), is measured by selecting hadronic \( Z^0 \) decays and determining the fraction of decays into \( b \bar{b} \) pairs in the selected sample, \( I_{bb}/I_{had} \). This paper describes a new method of measuring the fraction of \( Z^0 \) decays into \( b \bar{b} \) pairs in the hadronic event sample.

In the "mixed tag" method each event is divided into two hemispheres by the plane perpendicular to the thrust axis. The presence of a \( b \) quark in a hemisphere is tagged by either a high momentum lepton or several tracks with a large impact parameter. The fractions of hemispheres with a lepton or impact parameter tag are measured, as are the fractions of events with combinations of these tags in opposite hemispheres. The expected tagging fractions can be expressed in terms of the efficiencies of tagging individual quark flavours and the partial widths of the \( Z^0 \) decaying into these flavours. The resulting expressions are used to derive \( I_{bb}/I_{had} \), the efficiencies of correctly identifying \( b \) quark hemispheres for both tagging techniques, and the impact parameter tagging efficiency for background. This procedure renders the result for \( I_{bb}/I_{had} \) insensitive to branching fractions, fragmentation and decay modelling for \( b \) quarks and \( b \)-flavoured hadrons. It also allows the use of impact parameter tags that are relatively impure, but have high efficiency.

The following sections describe the OPAL detector, the selection of hadronic \( Z^0 \) decays, the two tagging techniques for hemispheres containing a \( b \) quark, and the application of the mixed tag method to measure \( I_{bb}/I_{had} \).