Measurement of $\Gamma(Z^0 \rightarrow bb)/\Gamma(Z^0 \rightarrow \text{hadrons})$
using a double tagging method

OPAL Collaboration


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to obtain an event sample enriched in $Z \rightarrow b \bar{b}$ decays.

The presence of electrons or muons from semileptonic decays of bottom hadrons and the detection of bottom hadron decay vertices were used together to obtain an event sample enriched in $Z \rightarrow b \bar{b}$ decays. To reduce the systematic error on the measurement of the $Z \rightarrow b \bar{b}$ fraction, the efficiency of the $b \bar{b}$ event tagging was obtained from the data by comparing the numbers of events having a bottom signature in either one or both thrust hemispheres. A value of

$$\frac{\Gamma(Z^0 \rightarrow b \bar{b})}{\Gamma(Z^0 \rightarrow \text{hadrons})} = 0.2171 \pm 0.0021 \pm 0.0021$$

was obtained, where the first error is statistical and the second systematic. The uncertainty on the decay width $\Gamma(Z^0 \rightarrow c \bar{c})$ is not included in these errors. A fractional variation of this width by $\pm 8\%$ about its Standard Model prediction would result in a variation of the measured $Z^0 \rightarrow b \bar{b}$ fraction of $\pm 0.0015$.

1 Introduction

The partial width for the decay $Z^0 \rightarrow b \bar{b}$ is of special interest in the Standard Model. Electroweak corrections involving the top quark affect the $Z^0 \rightarrow b \bar{b}$ width, $\Gamma_{b\bar{b}}$, differently from the widths for lighter quarks. This results in a reduced dependence of $\Gamma_{b\bar{b}}$ on the top quark mass, $m_{t\bar{t}}$, providing the possibility of a stringent and $m_{t\bar{t}}$-independent test of the Standard Model [1]. On the other hand, the fraction

$$\frac{\Gamma(Z^0 \rightarrow b \bar{b})}{\Gamma(Z^0 \rightarrow \text{hadrons})} \equiv \frac{I_{b\bar{b}}}{I_{\text{had}}}$$

depends on $m_{t\bar{t}}$, but has negligible uncertainty from the unknown Higgs boson mass and the strong coupling constant $\alpha_s$. A precise measurement of $I_{b\bar{b}}/I_{\text{had}}$ therefore provides a good constraint on the Standard Model parameters. Note that the small number of $b\bar{b}$ pairs produced in the hadronisation process, rather than directly from $Z^0$ decay, are not included in the definition of $I_{b\bar{b}}$.

The fraction $I_{b\bar{b}}/I_{\text{had}}$ is measured by selecting $b\bar{b}$ events in hadronic decays of the $Z^0$ using various tagging methods. For the measurement presented here, two different tagging methods are employed: one is to detect electrons or muons coming from semileptonic decays of bottom hadrons, and the other is to find decay vertices of bottom hadrons separated significantly from the primary interaction point. In order to achieve an improved systematic error, the efficiency of the tagging methods is obtained from the data using the double tagging technique. This technique makes use of the fact that each $b\bar{b}$ event contains two bottom hadrons produced mostly back-to-back and decaying independently. By applying the tagging methods separately to the two thrust hemispheres in each event, the efficiency can be calculated from the number of tagged hemispheres and the number of events with both hemispheres tagged.

The principle of the double tagging technique is described in the next section. The most important features of the OPAL detector relevant to the analysis are described in Sect. 3. Section 4 reviews the event samples used, both from real collisions and from simulation. The identification of electrons and muons and the estimation of lepton background are discussed in Sect. 5. The detection of secondary vertices and a technique to reduce the systematic error due to the detector resolution are described in Sect. 6. The effect of the tagging efficiency correlation, particularly important for measurements using the double tagging technique, is discussed in Sect. 7. Section 8 presents the result of the $I_{b\bar{b}}/I_{\text{had}}$ measurement.