PA 05-063

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

A Measurement of

$$\frac{BR(D_s^+ \to K^0 K^+)}{BR(D_s^+ \to \phi\pi^+)} \textbf{ and } \frac{BR(D_s^+ \to K^0 K^{*+})}{BR(D_s^+ \to \phi\pi^+)}$$

The ALEPH Collaboration

Abstract

The relative branching ratios for the decays $D_s \to K^0 K$ and $D_s \to K^* K^0$ have been determined. The analysis is based on about $4.6 \cdot 10^6$ hadronic Z^0 decays recorded by the ALEPH detector during the years 1991 to 1995. The preliminary results are
$\frac{BR(D_s \to K^0 K)}{BR(D_s \to \phi\pi)} = 0.80 \pm 0.15(\text{stat}) \pm 0.13(\text{syst})$, $\frac{BR(D_s \to K^* K^0)}{BR(D_s \to \phi\pi)} = 1.33 \pm 0.24(\text{stat}) \pm 0.18(\text{syst})$.

Paper contributed to 28th International conference on High Energy Physics, Warsaw/Poland, 25th – 31st July 1996

1 Introduction

The complete data sample recorded by the Aleph detector at LEP at center-of-mass energies around 91.2 GeV during the years from 1991 to 1995 contains about $4.6 \cdot 10^6$ hadronic Z^0 decays. These were used for the determination of the branching ratios for the decays $D_s \to K^0 K$ and $D_s \to K^* K^0$. The dominant origin of D_s mesons is either from direct production in $Z^0 \to c\bar{c}$ or from decays of B mesons produced in $Z^0 \to b\bar{b}$. This analysis of D_s branching ratios includes more data than previous ones [1, 2, 3] and therefore the values are determined more accurately.

1.1 Reconstruction of D_s from K K^0

D_s mesons decaying to K K^0_S are reconstructed only if the K^0_S mesons decay into two charged pions. The tracks of the two pions must originate from a common vertex and fulfill certain selection criteria imposed on their total momenta (> 1 GeV/c), their invariant mass ($|m(K^0) - m_{\pi\pi}| < 22$ MeV/c^2)and on the lifetime, which is calculated with respect to the primary vertex ($c \cdot \tau > 0.5$ cm). Charged kaons are identified by their specific ionisation loss, dE/dx, in the TPC, and are combined with the neutral kaon to form a D_s candidate. Again, cuts on momentum (> 2 GeV/ c) and the quality of the common vertex formed by the K_S meson ($\chi^2 < 12$) as well as cuts on the D_s momentum (> 7 GeV/c) are imposed.

In addition to purely combinatorial background, a very important background contribution arises from D^+ meson decays into $K^0\pi^+$, where charged pions are misidentified as charged kaons and therefore the reconstructed invariant mass is close to that of D_s mesons. To correct for this kind of reflection background, the same method was applied as described in [6].
The number of reconstructed D_s mesons and parameters of their reconstructed mass distribution are given in the following table. Figure 1 shows the resulting mass distribution.

Parameter	Value
$N_{rec}(D_s)$	684 ± 126
$m(D_s)$	(1.965 ± 0.0014) GeV/c^2
$\sigma(m_{D_s})$	(8.5 $\pm$0.2)MeV/c^2

Table 1: *Fit results for $D_s \to KK^0$ corrected for reflections*

A simulation of D_s production, based on JETSET 7.4, including all detector effects was used to determine the efficiency of the reconstruction algorithm, $\varepsilon = (16.3 \pm 0.4)\%$.

1.2 Reconstruction of D_s from K^* K^0

D_s mesons in this channel are reconstructed from the decay of K^* into a neutral kaon, K_S, and a charged pion, $K^{*\pm} \to K^0_S \pi^{\pm}$. Neutral kaon decays are reconstructed only if they decay into two charged pions. To optimize the selection efficiency in this channel, the Fisher Discriminant Analysis (FDA) was used [5]. With this method one variable is determined which discriminates the signal from the various backgrounds using sets of Monte Carlo generated distributions of variables for the signal and background contributions; correlations between the variables are taken into account automatically. The variables entering into the procedure were the mass, momentum, impact parameter of the daughter particles and the lifetime of the two K^0_S mesons. Furthermore the momentum of the pion is taken into account as well as the mass and the momentum of the K^* which is refitted from one K^0_S and the pion. The variable used for the D_s mesons, created from the second K^0_S and the K^* is their momentum. Figure 2 shows the mass distribution of D_s candidates obtained in this way. The number of D_s mesons in the signal region was determined from an unbinned log likelihood fit by parameterizing the signal as a gaussian distribution and the background as a second-order polynomial. The results are given in Table 2.

Parameter	Value
$N_{rec}(D_s)$	225 ± 37
$m(D_s)$	(1.967 ± 0.003) GeV/c^2
$\sigma(m_{D_s})$	14.6MeV/c^2 (fixed, taken from MC)

Table 2: *Fit results for* $D_s \to K^*K^0$

The efficiency of the selection algorithm was determined from Monte Carlo to be $\varepsilon = (14.1 \pm 0.8)\%$.

2 The determination of relative branching ratios

Branching ratios are quoted relative to the channel $D_s \to \phi\pi$, which has a very good signal to background ratio and is well measured [4]. D$_s$ mesons decaying into $\phi\pi$ were reconstructed from the decay chain $D_s \to \phi\pi \to KK\pi$. Cuts are applied on the momenta of the pion ($>$ 2.5 GeV/c), the kaons ($>$ 1 GeV/c) and of the ϕ ($>$ 4 GeV/ c) and on the reconstructed ϕ mass ($|m(\phi) - m_{K^+K^-}| < 5$ MeV/c^2). Furthermore, there is a cut on the angle in the ϕ rest frame between the direction of flight of the kaons and the pion ($|cos\theta^*| > 0.4$). The reconstruced D$_s$ meson candidate must pass cuts on its total ($>$ 7.5 GeV/c) and transverse momentum ($>$ 0.5 GeV/c). Results are given in table 3. Figure 3 shows the mass distribution of the D$_s$ mesons decaying into $\phi\pi$.

Parameter	Value
$N_{rec}(D_s)$	1190 ± 53
$m(D_s)$	(1.968 ± 0.004) GeV/c^2
$\sigma(m_{D_s})$	(7.3 $\pm$0.4)MeV/c^2

Table 3: *Fit results for* $D_s \to \phi\pi$

The reconstruction efficiency for $D_s \to \phi\pi$ obtained from Monte Carlo is $\varepsilon = (15.8 \pm 0.4)\%$.

Taking the numbers of reconstructed events from Tables 1 to 3 and the relevant reconstruction efficiencies in the decay chains considered allows the determination of the following relative branching ratios:

$$\frac{BR(D_s \to K^0K)}{BR(D_s \to \phi\pi)} = 0.80 \pm 0.15(\text{stat.}) \pm 0.13(\text{syst.})$$
$$\frac{BR(D_s \to K^*K^0)}{BR(D_s \to \phi\pi)} = 1.33 \pm 0.24(\text{stat.}) \pm 0.18(\text{syst.})$$

The systematic errors quoted were determined by variation of cuts for $D_s \to K^0K$ and $D_s \to \phi\pi$ and by variation of the set of loose cuts used in $D_s \to K^*K^0$ to compute the coefficients for the FDA. The variation resulted in new values for the efficiency and the number of reconstructed events. With the new numbers, a new branching ratio was determined and the difference between the new ratio and the one resulting from the analysis was considered as systematic error.

3 Conclusion

D$_s$ meson decays in the channels $D_s \to KK^0$ and $D_s \to K^*K^0$ were reconstructed from a sample of about 4.6×10^6 hadronic Z^0 decays. The branching ratios relative to the channel $D_s \to \phi\pi$ were measured to be

$$\frac{BR(D_s \to K^0 K)}{BR(D_s \to \phi\pi)} = 0.80 \pm 0.15(\text{stat.}) \ \pm 0.13(\text{syst.})$$
$$\frac{BR(D_s \to K^* K^0)}{BR(D_s \to \phi\pi)} = 1.33 \pm 0.24(\text{stat.}) \ \pm 0.18(\text{syst.})$$

These results are preliminary.

References

[1] Anjos et. al. Phys. Rev. D41 2705 (1990)

[2] Adler et. al. Phys. Rev. Lett. 63 1211 (1989)

[3] Chen et.al. Phys. Lett. B226 192 (1989)

[4] Particle Data Group, Phys. Rev. D50 3-I (1994)

[5] R.A. Fisher, Ann. Eugen., 7 (1936) 179.
P.A. Lachenbruch, Discriminant Analysis, Hafner Press, New York

[6] ALEPH coll., *Measurement of the B_s^0 lifetime and D_s^+ meson production in Z^0 decays*, Z. Phys. C69 (1996) 585

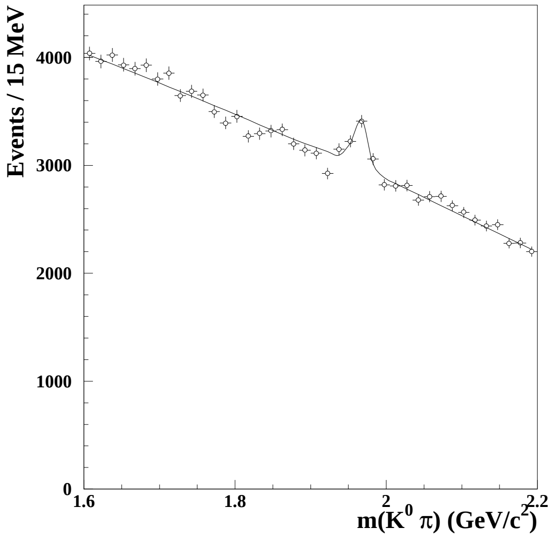

Figure 1: *Mass distribution for* $D_s \to K^0 K$

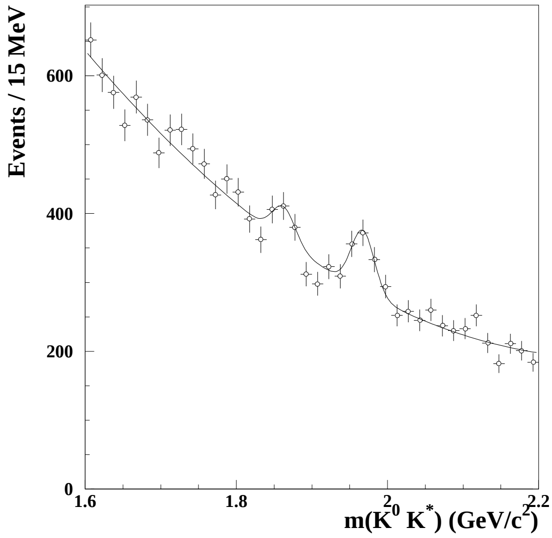

Figure 2: *Mass distribution for* $D_s \to K^0 K^*$

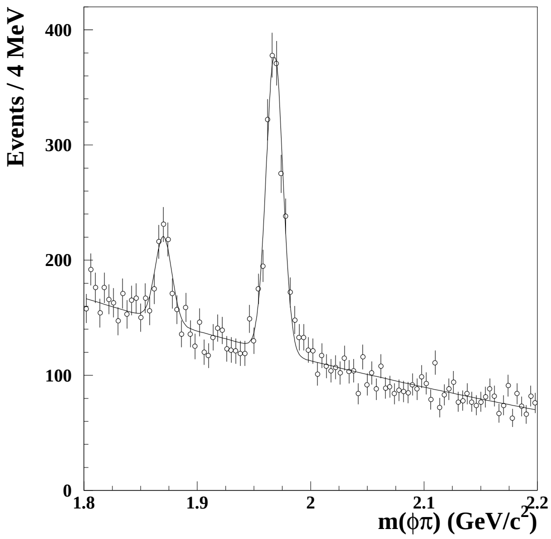

Figure 3: *Mass distribution for* $D_s \to \phi\pi$