Kaons in flavour tagged $B$ decays

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Abstract. Using the ARGUS detector at the $e^+e^-$ storage ring DORIS II, flavour-dependent kaon production in $B$ meson decays has been studied. Using the leptons as flavour tags, it has been possible to separately measure the multiplicities of $K^+$, $K^-$ and $K^0$ in inclusive $B$ decays and in semileptonic $B$ decays. The kaon production in semileptonic $B$ decays was further used to estimate the ratio of charmed decays over all decays, and thus also the fraction of charmless $B$ decays.

Introduction

Kaons play an important role in the decay of $B$ mesons.* The most frequent production mechanism is via the quark decay chain $b \rightarrow c \rightarrow s$, and consequently there is a correlation between the flavour** of the kaon produced in this way, which we call the principal kaon, and the flavour of the $B$ meson. Additional kaons are produced through $s\bar{s}$ quark pairs from the vacuum or through the decay of virtual $W^\pm$ bosons (Fig. 1). Measurements of kaon production in $B$ meson decays can thus serve as a test of our understanding of the different mechanisms in these decays, and probe the ability of the spectator model to explain data. Charged kaons are expected to provide a means of tagging the flavour of $B$ mesons in future experiments. Since the quality of the tagging depends on both the tagging efficiency and the number of incorrectly tagged $B$ mesons, it is important to investigate accurately the multiplicities of both $K^+$ and $K^-$ in $B$ decays.

In this paper, we report on a measurement of kaon production in $B$ decays [1]. The $B$ mesons studied are produced through the reaction $e^+e^- \rightarrow Y(4S) \rightarrow B\bar{B}$, i.e. they are produced essentially at rest, so the final-state particles are spatially completely intermixed. Hence, a special procedure to deduce the flavour of the $B$ meson producing the kaon is necessary. For this purpose, one can use primary electrons and primary muons; i.e. leptons produced directly from the decay of the $b$ quark through the quark decay $b \rightarrow c\ell^+\nu$, so the charge of the lepton tags the flavour of the $B$ meson. Due to momentum conservation, the other decay products of this tagged $B$ meson will be emitted opposite to the tagging lepton. Decay products of the second $B$ meson, on the other hand, will be distributed isotropically with respect to the lepton direction. Thus the distribution of the angle between primary leptons and kaons will have a component due to particles from the same $B$ meson with a peak at 180° superimposed on an almost isotropic component from uncorrelated particles. By studying the shape of the angular distribution it is possible to estimate the sizes of the two components and thereby also obtain the kaon multiplicities. In this paper we refer to the two components as correlated yield and uncorrelated yield, respectively. The correlated yields of $\ell^+K^+$, $\ell^-K^-$ and $\ell^+K^0$ are thus proportional to the multiplicities in semileptonic $B$ decays of $K^+$, $K^-$ and $K^0$, respectively. Analogously, the uncorrelated yields are proportional to the kaon multiplicities in general $B$ decays.

The data sample used for this study was collected with the ARGUS detector at the DORIS II $e^+e^-$ storage ring. The integrated luminosity was 225 pb$^{-1}$ on the $Y(4S)$ resonance, corresponding to 191 000 ± 10 000 $B$ meson pairs, and 92 pb$^{-1}$ in the nearby continuum, needed for the estimation and subtraction of the continuum contribution under the $Y(4S)$ peak. A detailed description of the ARGUS detector, its trigger and particle identification capabilities can be found in [2].

Inclusive kaon multiplicities

Multihadron events were selected requiring five or more charged tracks originating from the interaction region. To suppress continuum we further demanded that the events contain no track with a momentum greater than 3.0 GeV/c and that the second Fox-Wolfram moment [3] of the event be less than 0.4.

Charged particle identification was made on the basis of specific energy loss in the main drift chamber and time-of-flight measurements, combined into a likelihood for each of the allowed particle hypotheses, $e^+, \mu^+, \pi^+, K^+$, and $p$ [2]. For the $e^+$ and $\mu^+$ hypotheses, information from the shower counters and the muon chambers also contributed to the particle likelihood. The likelihoods for the particle selection were required to be greater than 0.7 for $e^+$ and $\mu^-$, and 0.4 for $K^+$, respectively.

Charged kaons were selected in the momentum interval 0.2–1.0 GeV/c, the cuts being motivated by particle identification considerations: Below 0.2 GeV/c many kaons decay without leaving detectable tracks and above 1.0 GeV/c the separation between kaons and pions is no longer significant. The probability that an electron, a pion or a proton will be misidentified as a kaon was determined by studying clean samples of electrons from converted photons, pions from $K^0$ decays and protons from decaying $\Lambda$. These numbers range between 0% and 8%, depending on particle type and momentum range (see