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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 fast leptons as flavour tags it has been possible to separately measure the multiplicities of K^+, K^- and K^0_S 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.

Kaons play an important role in the decay of B[1] mesons. The most frequent production mechanism is via the quark decay chain $\bar{b}\to\bar{c}\to\bar{s}$, and consequently there is a correlation between the flavour[2] 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 $e^+e^-\to\Upsilon(4S)\to B\overline{B}$, 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 $\bar{b}$ quark through the quark decay $\bar{b}\to\bar{c}\ell^+\nu$, so the charge of the lepton tags the flavour of the B meson. Because of 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 ℓ^+K^+, ℓ^+K^- and $\ell^+K^0_S$ are thus proportional to the multiplicities in semileptonic B decays of K^+, K^- and K^0_S, respectively. Analogously, the uncorrelated yields are proportional to the kaon multiplicities in general B decays.

[1] Throughout this publication, references to a specific charge state are to be interpreted as implying the charge conjugate state also. The expression "B meson" is used as a notation for the mixture of B^+ and B^0 produced in $\Upsilon(4S)$ decays.

[2] *Flavour* of a hadron is understood to refer to the flavour of the heaviest quark in the hadron. Hence B^+ and B^0 have the same flavour, whereas B^+ and B^- have opposite flavours.

The data sample used for this study was collected with the ARGUS detector at the DORIS II e^+e^- storage ring. The integrated luminosity is 225 pb^{-1} on the $\Upsilon(4S)$ resonance, corresponding to $191\,000 \pm 10\,000$ B meson pairs, and 92 pb^{-1} in the nearby continuum, needed for the estimation and subtraction of the continuum contribution under the $\Upsilon(4S)$. 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^+, μ^+, π^+, K^+, and p [2]. For the e^+ and μ^+ 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 μ^+, 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 reasons: 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_S decays and protons from decaying Λ. These numbers range between 0% and 8%, depending on particle type and momentum range (see [1] p.65). The estimated contamination was subtracted from the obtained numbers.

The multiplicity of charged kaons in B decays was calculated by correcting for the efficiency and extrapolating to the unmeasured momentum regions. The number obtained was $(0.82 \pm 0.01 \pm 0.05)$, which compares well with a previous measurement by ARGUS, where a different method was used which gave a value of $(0.78 \pm 0.015 \pm 0.025)$ [4].

Neutral kaons were detected through resolved secondary vertices from the decay $K^0_S \to \pi^+\pi^-$. The K^0_S candidates were required to have an invariant mass within 20 MeV/c^2 of the nominal K^0_S mass [5], and a momentum in the range 0.2-3.0 GeV/c. The cosine of the angle between the measured momentum vector of the K^0_S candidate and its flight direction, defined as the vector between the main and the secondary vertices, was further required to be greater than 0.9. We also demanded the K^0_S candidate not to simultaneously be a Λ candidate within 75 MeV/c^2 of the nominal Λ mass. A sideband subtraction was made to compensate for the combinatorical background of pion candidate pairs passing the selection criteria.

The resulting K^0_S multiplicities in different momentum intervals, corrected for detector efficiency and for the branching ratio to $\pi^+\pi^-$ [5], can be found in table 1. The momentum distribution (fig. 2) agrees well in shape with results from Monte Carlo simulations.

An extrapolation of the momentum spectrum to the unmeasured region below 0.2 GeV/c

was made using the information on the kaon yields in the range 0.2-0.5 GeV/c and the shape of the momentum distribution as obtained from Monte Carlo simulations. The extrapolation is not very sensitive to modelling imperfections of the Monte Carlo generator. The total K^0_S multiplicity per B meson obtained is $(0.321 \pm 0.005 \pm 0.021)$, which compares well with a previous measurement [6]: $\mathrm{n}(B \to K^0/\overline{K}^0 X) = 0.63 \pm 0.08$.

The efficiency for detecting charged and neutral kaons was estimated through Monte Carlo studies. For charged kaons, the obtained efficiency was checked against data by comparing the reconstruction efficiency of the decay $\phi \to K^+K^-$ in Monte Carlo with that of data. The average efficiency for identifying $K^\pm$ in the momentum range 0.2-1.0 GeV/c was found to be 61%. For neutral kaons the efficiency was checked against data by comparing the K^0_S decay lenght distribution. The average efficiency for reconstructing the decay $K^0_S \to \pi^+\pi^-$ in the momentum range 0.2-3.0 GeV/c was found to be 36%. The results include systematic uncertainties in the size of the continuum scaling factor, in the estimation of the reconstruction efficiency and in the number of B mesons.

Lepton-Kaon Correlations

For the flavour tagged study, primary leptons from semileptonic B decays were needed. These are more energetic than leptons from secondary decays, so they were required to have momenta greater than 1.4 GeV/c [7]. This cut results in a suppression of secondary leptons down to a contamination level of a few percent, as specified below. Only muons hitting both the inner and outer chambers in the barrel part of the muon detector were selected. We also demanded the lepton candidate not to be consistent with being a decay product of a J/ψ or a converted photon. The applied cuts in the invariant mass were ± 75 MeV/c^2 and ± 40 MeV/c^2, respectively.

The number of hadrons accepted as electrons or muons was measured using $\Upsilon(1S)$ decays where no leptons are expected above 1.4 GeV/c [8]. The probability that a hadron track will be misidentified as an electron was found to be 0.005 ± 0.002 and as a muon 0.015 ± 0.005. These contaminations was subtracted from the obtained numbers.

Just as in the previously described study, we demanded that the events contain five or more charged tracks originating from the interaction region, and no track with a momentum greater than 3.0 GeV/c. In order to suppress continuum and other jet-like events, we also demanded a large fraction of the total momentum of the event to be perpendicular to the lepton according to the following expression:

$$\frac{\sum_{i,i\neq lep} |\vec{p}_i| \sin(\vec{p}_{lep}, \vec{p}_i)}{\sum_{j,j\neq lep} |\vec{p}_j|} > 0.6$$

Taking advantage of the hermiticity of the ARGUS detector, semileptonic B decays were further enhanced through a cut on the total missing momentum, which is correlated with the the momentum of the undetected neutrino. The missing momentum vector was required to make an angle of at least 60° with the lepton and have a magnitude greater than 0.8 GeV/c.

These cuts reduce the useful data sample by only 28% while rejecting events from background processes containing tracks passing the lepton selection criteria by 92%. This is essential in order to minimize the uncertainties introduced by background subtraction.

We found 9334 ± 117 electrons and 9546 ± 185 muons from B decays in our data sample after these cuts and after subtraction of the contributions from continuum and misidentifications (table 2).

The angular distributions and number of kaons per lepton were measured separately for the combinations e^+K^+, μ^+K^+, e^+K^-, μ^+K^-, $e^+K^0_S$ and $\mu^+K^0_S$. Since the shapes of the angular distributions are momentum-dependent, the data were further separated into two lepton momentum intervals 1.4-1.9 GeV/c and 1.9-2.8 GeV/c and three kaon momentum intervals 0.2-0.5 GeV/c, 0.5-0.8 GeV/c and 0.8-1.0 GeV/c. For neutral kaons, the third momentum interval was extended to 3.0 GeV/c, since the variation of the shape of the angular distribution was found to be inside the statistical errors at high kaon momenta. The resulting distributions, after subtraction of the estimated contributions from continuum and fakes, are shown in figures 3-8, along with the results of the fit of the modelled correlated and uncorrelated angular distributions to data as described below.

Data were well reproduced by distributions generated through the model by Wirbel, Bauer and Stech [9]. The shapes of the correlated components needed for the fit described below, were determined from Monte Carlo simulations using this model.

To determine the shape of the uncorrelated component, we used event mixing and studied the influence of detector acceptance on an isotropic angular distribution. Leptons were exchanged with those of other events to obtain new synthetic events with completely uncorrelated lepton-kaon pairs. The distributions were then transformed to account for the slight boost ($\beta = 0.06$) of the B mesons from $\Upsilon(4S)$ decays. The results were in good agreement with those predicted by Monte Carlo simulations.

Parametrizations of the modelled angular distributions were made separately for the different lepton and kaon momentum intervals.

The sizes of the correlated and uncorrelated components in each angular distribution were extracted through a two-parameter fit to the data of the modelled correlated and uncorrelated angular distributions (fig. 3-8). The distributions show the expected behaviour with a peak at 180°. The reason why many of the ℓ^+K^- distributions show no correlated signal, is that this contribution is small and to a large extent counterbalanced by a background of pairs with small opening angles involving non-primary leptons.

The resulting numbers of kaons were normalized to the number of primary leptons to give the numbers of kaons per lepton or, equivalently, per B meson. The fraction of non-primary leptons, coming mostly from decaying J/ψ and D mesons, was estimated through Monte Carlo to be 5% and 2% for the momentum ranges 1.4-1.9 GeV/c and 1.9-2.8 GeV/c, respectively. These numbers of lepton-kaon pairs with non-primary leptons were subtracted from the measured numbers.

The inclusive charged kaon multiplicities, n, were found using the uncorrelated yields, corrected for detection efficiency and extrapolating to excluded kaon momentum ranges.

Since the obtained mean multiplicities of the e^+ and μ^+ measurements were the same within the uncertainties, we assumed lepton universality, and averaged over the e^+ and μ^+ measurements, in addition to averaging over lepton and kaon momentum regions.

The sum of the obtained charged kaon multiplicities, $\mathrm{n}(B \to K^+X) + \mathrm{n}(B \to K^-X)$, was then compared to the total charged kaon multiplicity, $\mathrm{n}(B \to K^\pm X)$, previously measured [4] (table 3). The latter measurement has smaller uncertainties, and does not depend on the shape of the modelled angular distribution. The difference between the two measurements is less than two standard deviations of the estimated total uncertainty. Since we have three measurements and only two unknowns, a least-square fit was made to find the most probable values of the two multiplicities, $\mathrm{n}(B \to K^+X)$ and $\mathrm{n}(B \to K^-X)$.

The charged kaon multiplicities of semileptonic B decays are proportional to the correlated yields. They were thus extracted by subtracting the estimated uncorrelated yields before efficiency correction from the total yields, the uncorrelated yields being independent of the lepton momentum. The estimations of the uncorrelated yields were made from the average constrained multiplicities obtained in the fit described above. In this way we get a value of the correlated yield less sensitive to model imperfections than the value from the fit to the angular distributions itself. The obtained yields were thereafter corrected for efficiency as described above, and also for biases introduced when requiring a fast lepton from the same B meson.

The neutral kaon multiplicities were calculated in an analogous way, but since these are independent of the flavour of the B meson, the inclusive multiplicity found in the previously made non flavour tagged inclusive measurement was used instead of the value extracted from the uncorrelated yield, giving a larger sample and thus smaller uncertainties.

The resulting multiplicities after efficiency corrections are found in table 4. The numbers agree well with a similar measurement made by CLEO [6].

The main systematic uncertainties lie in the estimations of the kaon efficiency and of the number of non-primary leptons. Correlated pairs of oppositely charged tracks from semileptonic D meson decays have an angular distribution peaked at 0° and thus also add to the uncertainty of the fit. The size of this effect was estimated through Monte Carlo studies. The smaller uncertainties from the subtraction of misidentifications and of continuum have also been investigated and included in the presented numbers.

The results are however model dependent, since the measured numbers depend on the shape of the modelled angular distribution of correlated lepton-kaon pairs. The LUND model [10] was used as a second independent event generator to study the model dependence. The difference in result from the two models were of the same size as the quoted systematic uncertainties.

Discussion

Studying the results, we can see that the total charged kaon multiplicities are slightly larger than the total neutral kaon multiplicities (twice the K^0_S multiplicities). This is reasonable considering that the production rate of $\overline{D}^0$ in B decays, with a high probability of a subsequent decay into K^+, is larger than that of D^-, which has a lower probability of producing a K^+ [12,13].

The number of kaons produced via D mesons can be calculated using branching fractions previously measured [5,12,13,14,15]. If these numbers are compared to the number of kaons in inclusive B decays from this analysis, we can see that a significant amount of kaons originate from other sources than the decays of D mesons (table 5). Considering the equal production of K^0_L and K^0_S and summing over the four different pseudoscalar kaon types, we find an excess of 0.42 ± 0.12 kaons per B meson. However, this does not lead to a contradiction with the spectator model, since additional kaons are expected from other sources such as the decay $W^+ \to c\bar{s}$, $s\bar{s}$ production in the decay of the W^+, baryon decays, or colour-suppressed internal W^+-emission decays responsible for final states like $J/\psi\, K^0_S$.

Essentially all kaons from semileptonic B-decays are expected to be produced via D-mesons [15,16], and thus the kaon multiplicities can be estimated from the branching ratios involved. A comparison of these numbers with our measured multiplicities should show little difference. In fact, the difference is found not to be significant (see table 6). A small additional $s\bar{s}$ production from the vacuum is still possible, however.

The kaon multiplicities in inclusive B decays can also be compared with the multiplicities in semileptonic B decays. The difference between the two should approximately equal the kaon production from the decaying W^+, though the number also is affected by kaons from baryons and from internal W^+-emission decays. We find a difference of 0.30 ± 0.12 additional s- and $\bar{s}$- quarks per W^+, in agreement with what we expect from the spectator model.

The numbers given in table 4 are weighted averages of the kaon multiplicities of B^+, B^0 and $\overline{B}^0$ decays, where the weights are determined by the production ratio between charged and neutral B mesons and by the mixing parameter. From the obtained numbers we made an estimate of the kaon multiplicities of B^+, B^0_{mixed} and B^0_{unmixed} separately, where B^0_{mixed} is the notation for a B^0 that might oscillate before decaying, and B^0_{unmixed} is a B^0 that decays with the quark content $\bar{b}d$. In order to calculate separate kaon multplicities we assumed a production ratio between charged and neutral B mesons of 50/50, a mixing parameter r of $(18.1 \pm 4.3)\%$ [11] and took the ratios between $\mathrm{n}(B^0_{\text{unmixed}} \to K_x X)$ and $\mathrm{n}(B^+ \to K_x X)$ from our Monte Carlo generator since they are not measured. The obtained numbers for the kaon multiplicities are found in table 7. The systematical errors include a 20% contribution due to the unknown ratios $\mathrm{n}(B^0_{\text{unmixed}} \to K_x X)/\mathrm{n}(B^+ \to K_x X)$.

Since B mesons have a high probability of producing charged kaons, these can provide a useful tag for the flavour of B mesons. An observed K^+ is thus more likely a decay product of a B^0 rather than of a $\overline{B}^0$. Using the multiplicities of table 7 we find that $(82 \pm 5)\%$ of the charged kaons correctly tag the flavour of neutral B mesons at the time of their production. On the $\Upsilon(4S)$ with the B^0 meson always being accompanied by its antiparticle, and with equal phases of the two wavefunctions, $(72 \pm 4)\%$ of the charged kaons correctly tag the flavour of the other neutral B meson in the event at the time of its decay. The difference in tagging efficiency is due to mixing [11]. Obviously, the fairly large rate of incorrect tags is a drawback, but this might well be compensated by the advantage of a large branching ratio into charged kaons. As a comparison, the effective yield of another possible tag, primary

leptons (e^+ and μ^+), is only approximately a fifth of that of charged kaons. Thus, kaon tagging will be an indispensable tool for future measurements, e.g. of CP violation in the B system, at e^+e^- B factories and at high energy hadron machines.

Charmless decays

From the measured kaon yields in semileptonic B decays an attempt has been made to estimate the amount of charmless B meson decays. Neglecting the possibility of $b \to s$ transitions, this can be obtained by comparing the number of principal kaons per B meson from data with the number found from Monte Carlo simulations in which 100% $b \to c$ is assumed. Since $b \to u$ decays do not produce principal kaons, any contribution from this transition would result in a smaller value from data than those predicted by Monte Carlo. The number of principal kaons per B meson was estimated through the excess of K^+ over K^-:

$$\mathrm{n}_{K_{princ}} = \mathrm{n}_{K^+} - \mathrm{n}_{K^-} + 2\mathrm{n}_{K^0_S} \frac{\mathrm{n}_{K^+} - \mathrm{n}_{K^-}}{\mathrm{n}_{K^+} + \mathrm{n}_{K^-}}$$

where the third term estimates the excess of K^0 over $\overline{K}^0$ per B^+/B^0-meson. The ratio between this number and the prediction from our $b \to c$ Monte Carlo was used as a measure of the $b \to c$ fraction in our selected B meson sample. Due to the fact that leptons from $b \to c$ decays are softer than those from $b \to u$ decays, a bias was introduced by the requirement of a fast lepton. This was taken onto account when calculating the $b \to c$ fraction in the total B meson sample.

For this calculation only correlated pairs including a lepton with momentum greater than 1.9 GeV/c were used, since the sensitivity for $b \to u$ transitions is highest for such combinations. We find $\Gamma_{b \to c}/\Gamma_{b \to all} = 0.99 \pm 0.02 \pm 0.04$, which agrees with previous measurements of $|V_{bu}/V_{bc}|$ [17].

Conclusions

We have measured mean multiplicities of K^+, K^- and K^0_S in inclusive B meson decays, and in semileptonic B meson decays. We have estimated the charmed fraction in semileptonic B decays, and found that $\Gamma_{b\to c}/\Gamma_{b\to all}$ is close to unity. All numbers measured are consistent with an overwhelming majority of the B mesons decaying according to the spectator model through the quark transition $b\to c$. Using charged kaons as a means of tagging the flavour of the B meson is possible, but since approximately one out of five kaons tag the B flavour incorrectly, a fairly large dilution must be taken into account.

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p [GeV/c]	$n(B \to K^0_S X)$
0.2 − 0.3	(26.1 ± 1.6 ± 1.8) · 10^{-3}
0.3 − 0.4	(37.2 ± 1.8 ± 2.5) · 10^{-3}
0.4 − 0.5	(41.7 ± 1.7 ± 2.8) · 10^{-3}
0.5 − 0.6	(39.0 ± 1.6 ± 2.6) · 10^{-3}
0.6 − 0.7	(33.3 ± 1.4 ± 2.2) · 10^{-3}
0.7 − 0.8	(28.8 ± 1.3 ± 1.9) · 10^{-3}
0.8 − 0.9	(23.4 ± 1.2 ± 1.6) · 10^{-3}
0.9 − 1.0	(17.9 ± 1.1 ± 1.2) · 10^{-3}
1.0 − 1.1	(13.3 ± 0.9 ± 0.9) · 10^{-3}
1.1 − 1.2	(10.4 ± 0.9 ± 0.7) · 10^{-3}
1.2 − 1.3	(9.4 ± 0.7 ± 0.7) · 10^{-3}
1.3 − 1.4	(6.9 ± 0.7 ± 0.5) · 10^{-3}
1.4 − 1.5	(4.6 ± 0.6 ± 0.4) · 10^{-3}
1.5 − 1.6	(2.9 ± 0.6 ± 0.3) · 10^{-3}
1.6 − 1.7	(3.2 ± 0.5 ± 0.3) · 10^{-3}
1.7 − 1.8	(1.6 ± 0.5 ± 0.2) · 10^{-3}
1.8 − 1.9	(1.4 ± 0.5 ± 0.2) · 10^{-3}
1.9 − 2.0	(1.0 ± 0.4 ± 0.1) · 10^{-3}
2.0 − 2.2	(2.0 ± 0.6 ± 0.3) · 10^{-3}
2.2 − 2.7	(0.7 ± 1.0 ± 0.6) · 10^{-3}
0.0 − 2.7	0.321 ± 0.005 ± 0.021

Table 1: Number of K^0_S per B meson in different momentum intervals after efficiency correction.

	$e^{\pm}$	$\mu^{\pm}$
On $\Upsilon(4S)$ resonance	12240	13205
Continuum contribution	−2740 ± 87 ± 41	−3202 ± 94 ± 48
Misidentifications	−166 ± 1 ± 66	−457 ± 3 ± 152
$\Upsilon(4S)$	9334 ± 87 ± 78	9546 ± 94 ± 159

Table 2: Number of leptons in data sample. The numbers for continuum contribution and misidentifications are estimates based on the number of lepton candidates found in data collected in continuum below the $\Upsilon(4S)$ resonance, and the number of hadron tracks found in $\Upsilon(4S)$ events, respectively.

	[4]	This measurement	
		raw numbers	constrained
$n(B \to K^+ X)$		0.708 ± 0.019 ± 0.058	0.620 ± 0.013 ± 0.038
$n(B \to K^- X)$		0.215 ± 0.013 ± 0.044	0.165 ± 0.011 ± 0.036
$n(B \to K^{\pm} X)$	0.78 ± 0.015 ± 0.025	0.923 ± 0.022 ± 0.073	0.785 ± 0.018 ± 0.053

Table 3: Comparison between the total charged kaon multiplicity from [4], and the charged kaon multiplicities in this measurement, before and after constraint. The constraint is described in the text.

Decay	ARGUS	CLEO
	$\frac{n(B \to \ell^+ \nu K_x X)}{BR(B \to \ell^+ \nu X)}$	
$B^+/B^0 \to \ell^+ \nu K^+ X$	0.594 ± 0.021 ± 0.056	0.54 ± 0.07 ± 0.06
$B^+/B^0 \to \ell^+ \nu K^- X$	0.086 ± 0.011 ± 0.044	0.10 ± 0.05 ± 0.02
$B^+/B^0 \to \ell^+ \nu K^0_S X$	0.226 ± 0.019 ± 0.028	0.195 ± 0.03 ± 0.02
Decay	$n(B \to K_x X)$	
$B^+/B^0 \to K^+ X$	0.620 ± 0.013 ± 0.038	0.66 ± 0.05 ± 0.07
$B^+/B^0 \to K^- X$	0.165 ± 0.011 ± 0.036	0.19 ± 0.05 ± 0.02
$B^+/B^0 \to K^0_S X$	0.321 ± 0.005 ± 0.021	0.315 ± 0.03 ± 0.03

Table 4: Mean kaon multiplicities in B meson decays. The multiplicities of the inclusive non semileptonic B decays include production through mixing of the neutral B^0 meson.

$BR(B \to D^0, \overline{D}^0 X)$	0.60 ± 0.07 [12]	
$BR(B \to D^\pm X)$	0.29 ± 0.06 [12]	
$BR(B \to D_s^\pm X)$	0.11 ± 0.03 [14]	
	Estimated, through D mesons (excl. B^0 mixing)	Our result assuming no B^0 mixing
$n(B \to K^+ X)$	0.46 ± 0.07	0.66 ± 0.05
$n(B \to K^- X)$	0.05 ± 0.02	0.13 ± 0.04
$n(B \to K_S^0 X)$	0.25 ± 0.04	0.32 ± 0.02

Table 5: Comparison between estimated numbers of kaons, produced through charmed mesons, per inclusive B meson decay, and our results. The kaon multiplicities in D meson decays used in the estimation were taken from a MARK III measurement [13].

$\frac{BR(B \to \ell^+ \nu \overline{D}^0 X)}{BR(B \to \ell^+ \nu X)}$	0.69 ± 0.10 [15]	
$\frac{BR(B \to \ell^+ \nu D^- X)}{BR(B \to \ell^+ \nu X)}$	0.27 ± 0.06 [15]	
	Estimated, through D mesons	Our result
$\frac{n(B \to \ell^+ \nu K^+ X)}{BR(B \to \ell^+ \nu X)}$	0.49 ± 0.07	0.59 ± 0.06
$\frac{n(B \to \ell^+ \nu K^- X)}{BR(B \to \ell^+ \nu X)}$	0.03 ± 0.01	0.09 ± 0.04
$\frac{n(B \to \ell^+ \nu K_S^0 X)}{BR(B \to \ell^+ \nu X)}$	0.24 ± 0.04	0.23 ± 0.03

Table 6: Comparison between estimated numbers of kaons, produced through charmed mesons, per semileptonic B meson decay, and our results.

Decay	$\frac{n(B_x \to \ell^+ \nu K_x X)}{BR(B \to \ell^+ \nu X)}$
$B^+ \to \ell^+ \nu K^+ X$	$0.68 \pm 0.02 \pm 0.09$
$B^+ \to \ell^+ \nu K^- X$	$0.07 \pm 0.01 \pm 0.04$
$B^+ \to \ell^+ \nu K_S^0 X$	$0.20 \pm 0.02 \pm 0.03$
$B^0_{unmixed} \to \ell^+ \nu K^+ X$	$0.51 \pm 0.02 \pm 0.08$
$B^0_{unmixed} \to \ell^+ \nu K^- X$	$0.10 \pm 0.01 \pm 0.05$
$B^0_{unmixed} \to \ell^+ \nu K_S^0 X$	$0.26 \pm 0.02 \pm 0.04$
Decay	$n(B_x \to K_x X)$
$B^+ \to K^+ X$	$0.73 \pm 0.02 \pm 0.08$
$B^+ \to K^- X$	$0.13 \pm 0.01 \pm 0.04$
$B^+ \to K_S^0 X$	$0.29 \pm 0.00 \pm 0.04$
$B^0_{mixed} \to K^+ X$	$0.51 \pm 0.01 \pm 0.07$
$B^0_{mixed} \to K^- X$	$0.20 \pm 0.01 \pm 0.04$
$B^0_{mixed} \to K_S^0 X$	$0.35 \pm 0.01 \pm 0.04$
$B^0_{unmixed} \to K^+ X$	$0.58 \pm 0.01 \pm 0.08$
$B^0_{unmixed} \to K^- X$	$0.13 \pm 0.01 \pm 0.05$
$B^0_{unmixed} \to K_S^0 X$	$0.35 \pm 0.01 \pm 0.04$

Table 7: Estimated kaon multiplicities in B^+, B^0_{mixed} and $B^0_{unmixed}$ decays.

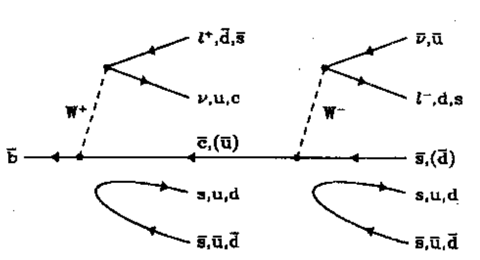

Figure 1: Possible sources of s and $\bar{s}$ quarks in B meson decays.

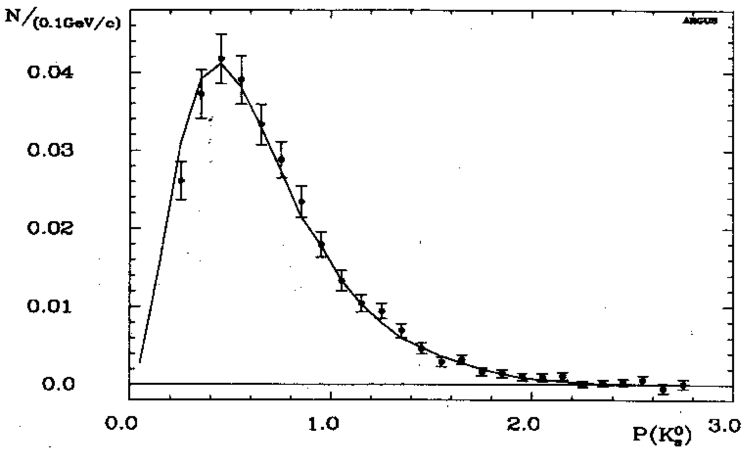

Figure 2: K_S^0 multiplicity in B meson decays as a function of momentum. The solid line is the Monte Carlo generated momentum distribution for $b \to c$ decays normalized to the measured total multiplicity.

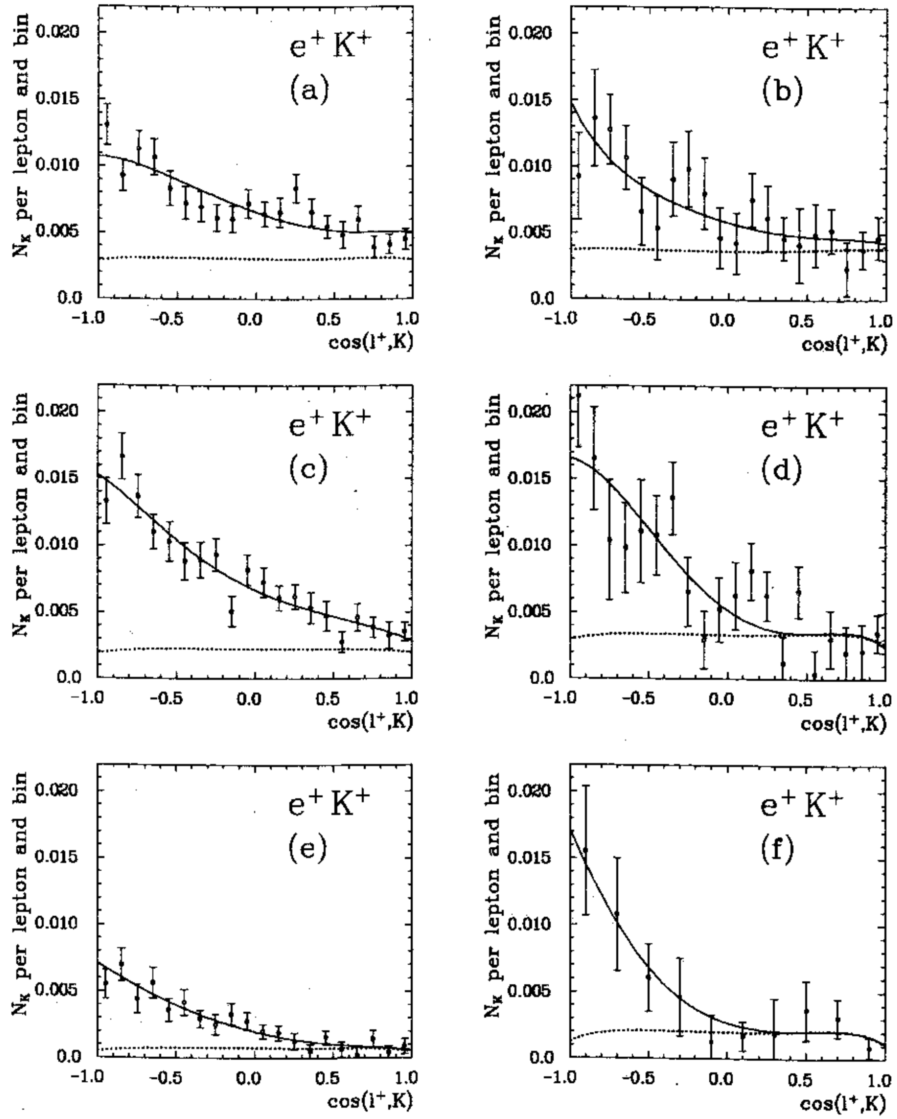

Figure 3: Angular distributions of e^+K^+ pairs after subtraction of continuum and fakes. The dotted line marks the size of the uncorrelated component, as obtained in the fit described in the text. Lepton momentum: 1.4-1.9 GeV/c in (a,c,e), and 1.9-2.8 GeV/c in (b,d,f). Kaon momentum: 0.2-0.5 GeV/c in (a,b), 0.5-0.8 GeV/c in (c,d) and 0.8-1.0 GeV/c in (e,f).

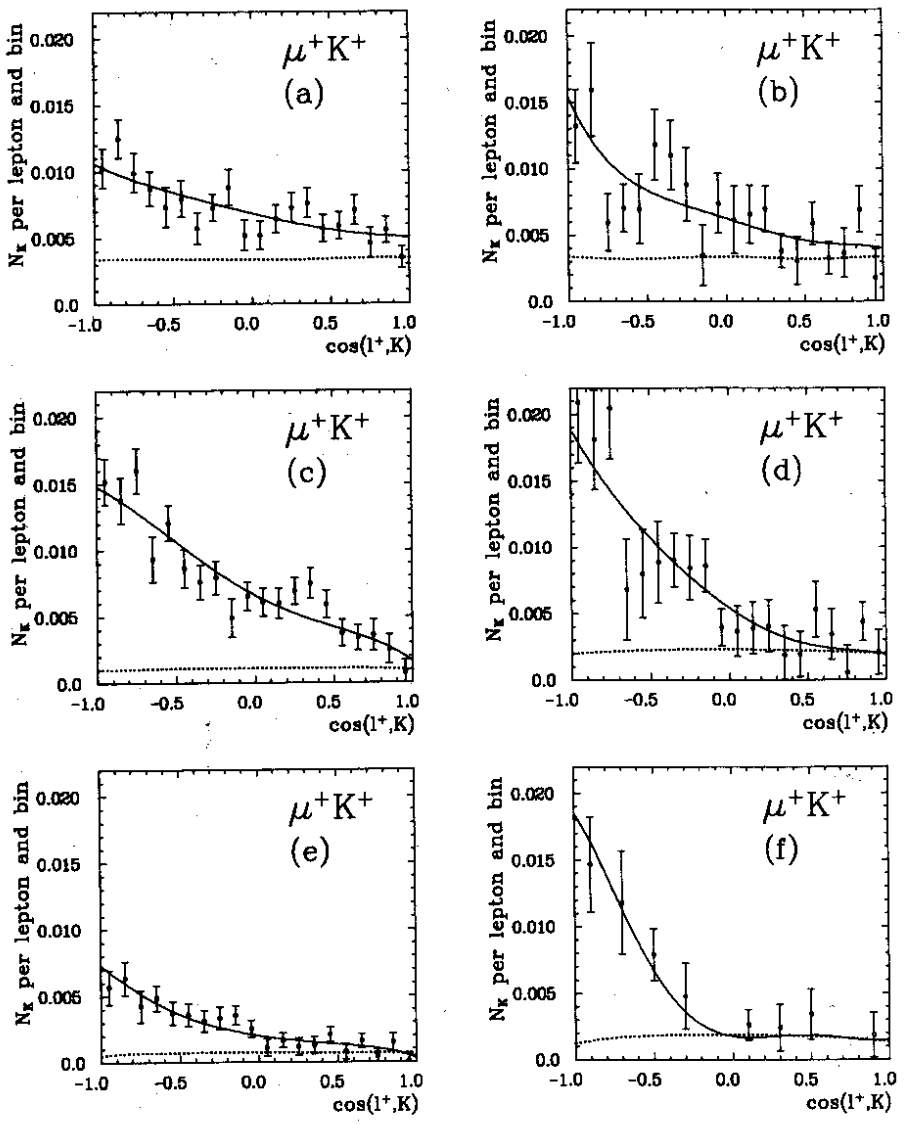

Figure 4: Angular distributions of μ^+K^+ pairs after subtraction of continuum and fakes. The dotted line marks the size of the uncorrelated component, as obtained in the fit described in the text. Lepton momentum: 1.4-1.9 GeV/c in (a,c,e), and 1.9-2.8 GeV/c in (b,d,f). Kaon momentum: 0.2-0.5 GeV/c in (a,b), 0.5-0.8 GeV/c in (c,d) and 0.8-1.0 GeV/c in (e,f).

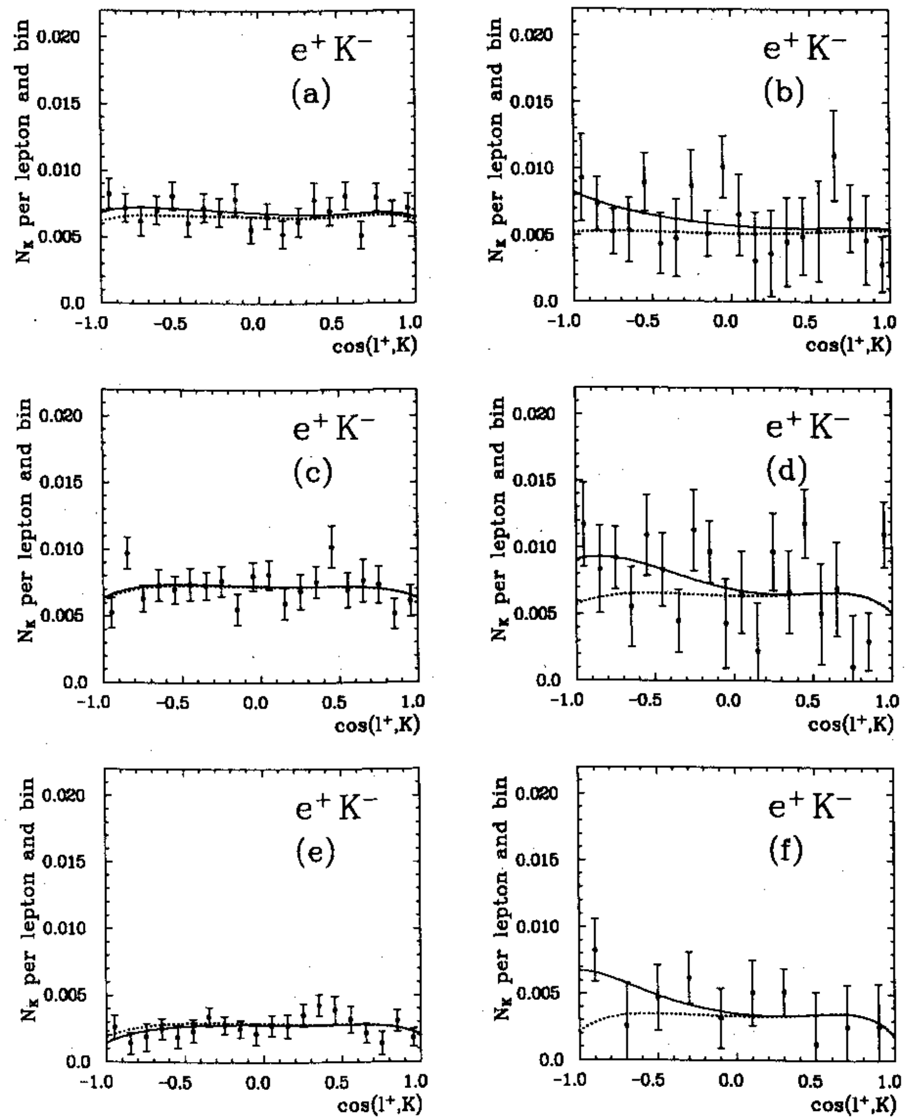

Figure 5: Angular distributions of e^+K^- pairs after subtraction of continuum and fakes. The dotted line marks the size of the uncorrelated component, as obtained in the fit described in the text. Lepton momentum: 1.4-1.9 GeV/c in (a,c,e), and 1.9-2.8 GeV/c in (b,d,f). Kaon momentum: 0.2-0.5 GeV/c in (a,b), 0.5-0.8 GeV/c in (c,d) and 0.8-1.0 GeV/c in (e,f).

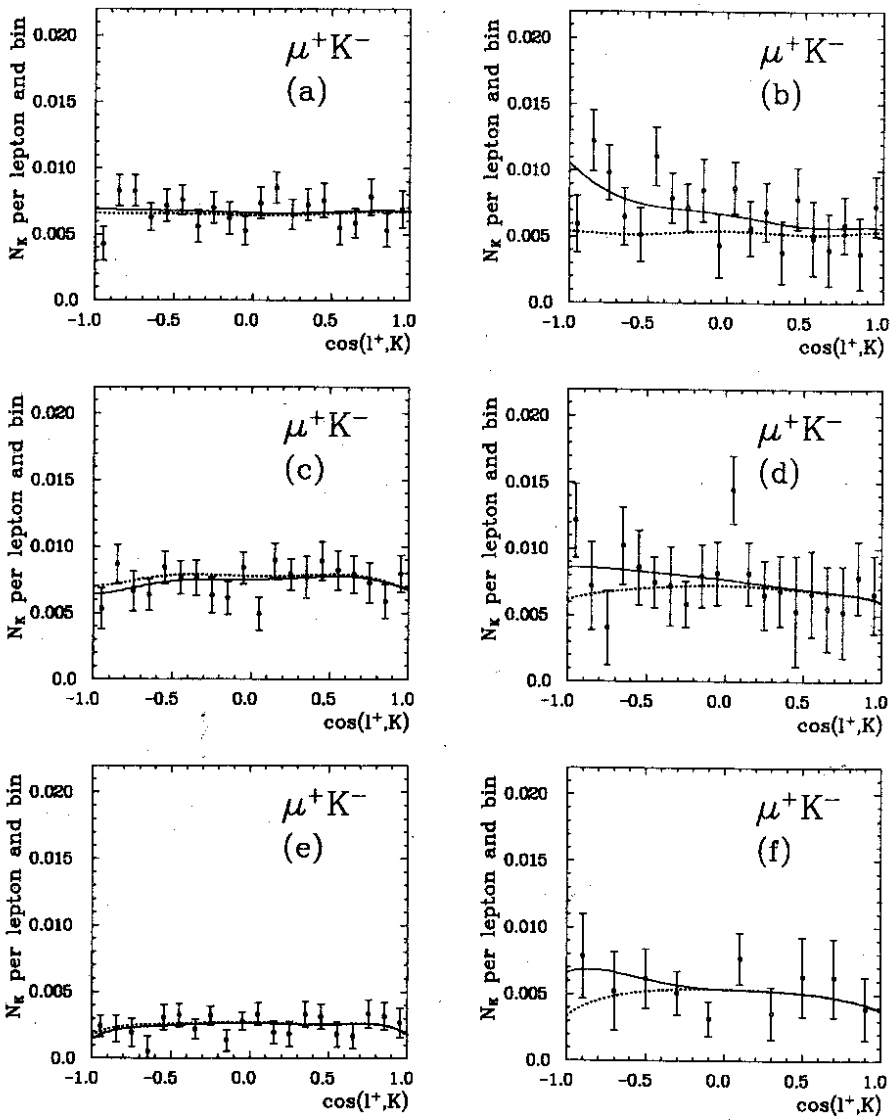

Figure 6: Angular distributions of μ^+K^- pairs after subtraction of continuum and fakes. The dotted line marks the size of the uncorrelated component, as obtained in the fit described in the text. Lepton momentum: 1.4-1.9 GeV/c in (a,c,e), and 1.9-2.8 GeV/c in (b,d,f). Kaon momentum: 0.2-0.5 GeV/c in (a,b), 0.5-0.8 GeV/c in (c,d) and 0.8-1.0 GeV/c in (e,f).

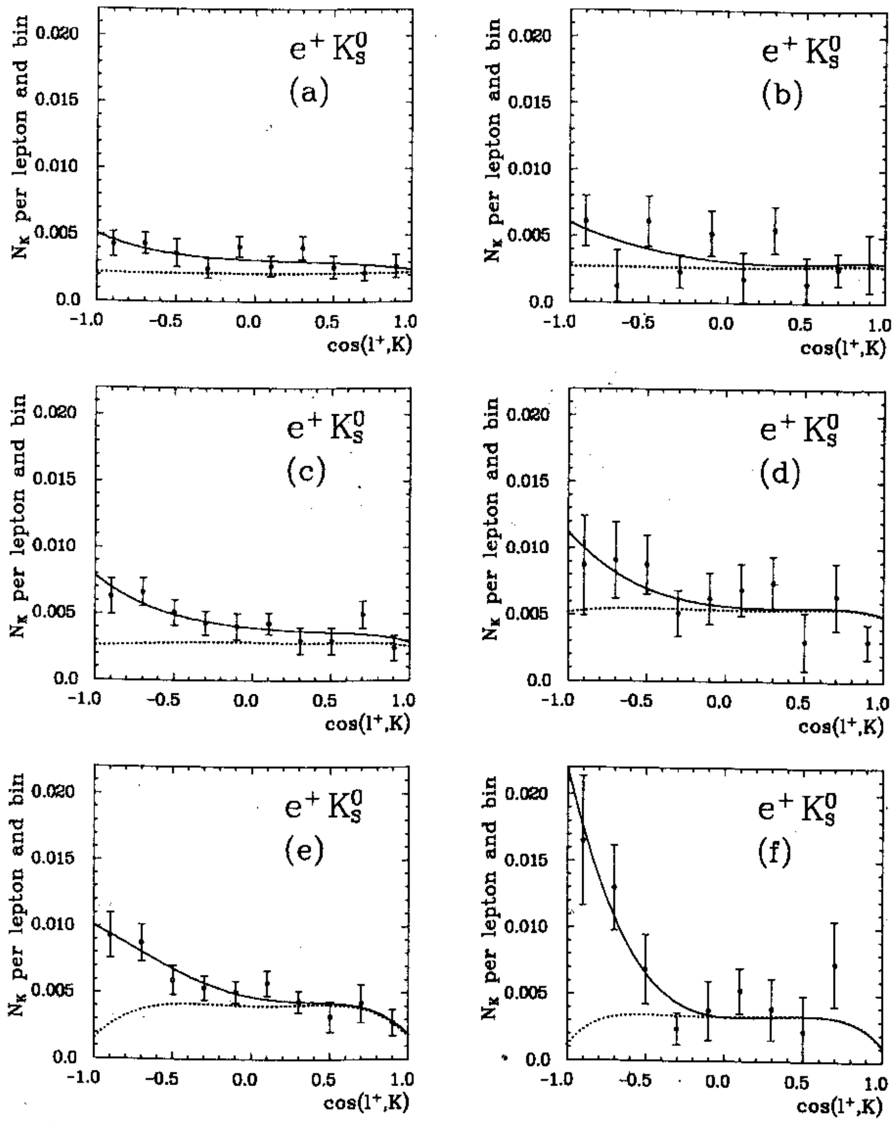

Figure 7: Angular distributions of $e^+K^0_S$ pairs after subtraction of continuum and fakes. The dotted line marks the size of the uncorrelated component, as obtained in the fit described in the text. Lepton momentum: 1.4-1.9 GeV/c in (a,c,e), and 1.9-2.8 GeV/c in (b,d,f). Kaon momentum: 0.2-0.5 GeV/c in (a,b), 0.5-0.8 GeV/c in (c,d) and 0.8-3.0 GeV/c in (e,f).

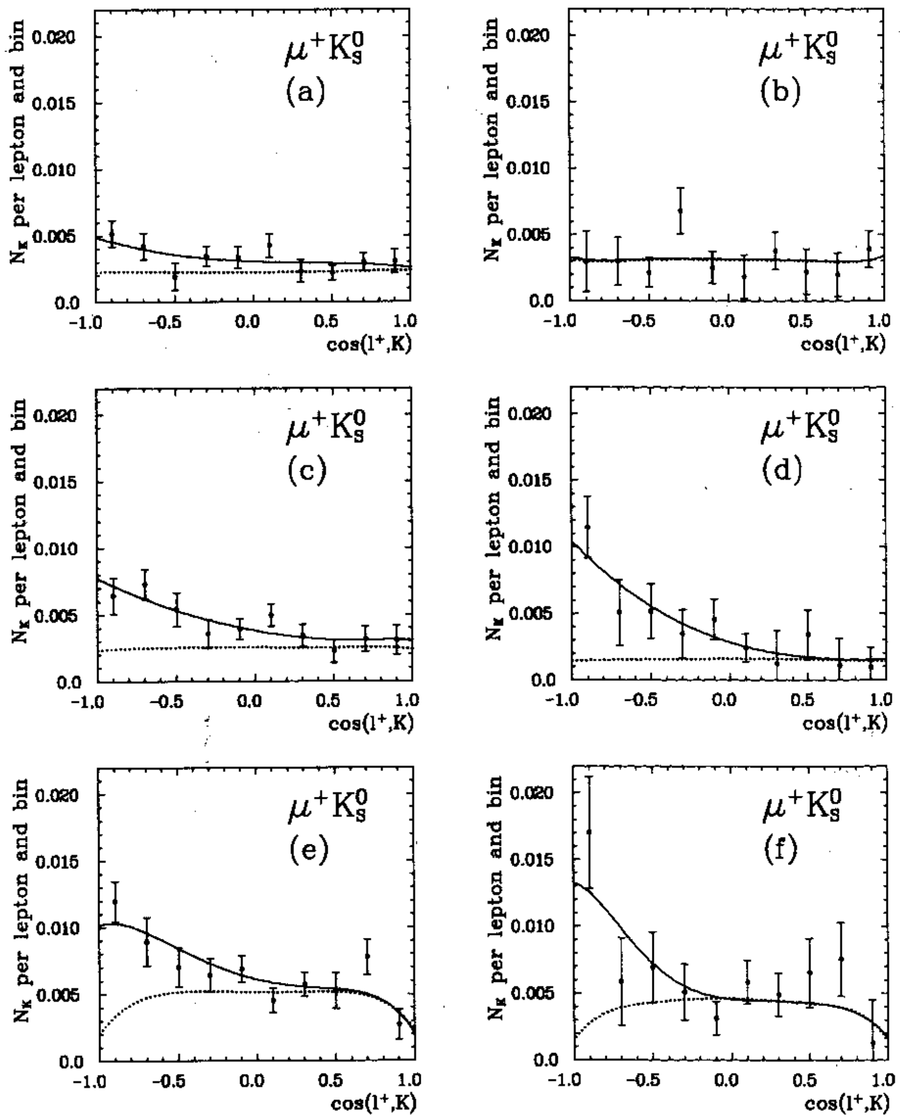

Figure 8: Angular distributions of $\mu^+ K_S^0$ pairs after subtraction of continuum and fakes. The dotted line marks the size of the uncorrelated component, as obtained in the fit described in the text. Lepton momentum: 1.4-1.9 GeV/c in (a,c,e), and 1.9-2.8 GeV/c in (b,d,f). Kaon momentum: 0.2-0.5 GeV/c in (a,b), 0.5-0.8 GeV/c in (c,d) and 0.8-3.0 GeV/c in (e,f).