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Abstract

Using the ARGUS detector at the e^+e^- storage ring DORIS II at DESY, we have observed the decays $D^+ \to K^-K^0\pi^+\pi^+$ and $D_s^+ \to K^-K^0\pi^+\pi^+$. The branching ratios were determined to be $BR(D^+ \to K^-K^0\pi^+\pi^+) = (1.0\pm0.5\pm0.3)\%$ and $BR(D_s^+ \to K^-K^0\pi^+\pi^+)/BR(D_s^+ \to \phi\pi^+) = 1.2 \pm 0.2 \pm 0.2$. These decays are found to proceed mostly via the $\bar{K}^{*0}\, K^{*+}$ decay channel, with $BR(D^+ \to \bar{K}^{*0}\, K^{*+}) = (2.6 \pm 0.8 \pm 0.7)\%$ and $BR(D_s^+ \to \bar{K}^{*0}\, K^{*+})/BR(D_s^+ \to \phi\pi^+) = 1.6 \pm 0.4 \pm 0.4$.

Two-body decay modes are well known to dominate hadronic D^0 and D^+ decays [1]. The majority of observed two-body decays have pseudoscalar-pseudoscalar (PP) or pseudoscalar-vector (PV) mesons in the final states. Considerably less information is available about the vector-vector (VV) decay modes. This is due, in part, to the need for the resonance analysis of multi-body final states, which requires a large sample of events.

In general, even less is known experimentally about decays of the D_s^+ meson. For example, the question of whether the two-body decay modes dominate, as has been observed in D^+ and D^0 decays, remains open. Only about 30% [1] of all D_s^+ decay modes have been observed so far and each new channel is of much interest. The only indication of a VV decay mode has been reported by the ACCMOR group [2], who have presented evidence for a signal of 7 ± 3 candidates for the decay mode [1] $D_s^+ \to \bar{K}^{*0}\, K^{*+}$, leading to an estimate of 2.4 ± 1.6 for the ratio $BR(D_s^+ \to \bar{K}^{*0}\, K^{*+})/BR(D_s^+ \to \phi\pi^+)$.

Recently there has been considerable theoretical interest in VV decays, following the observation that the branching ratios for the three decays $D^0 \to K^{*-}\rho^+$, $D^+ \to \bar{K}^{*0}\rho^+$ [3] and $D_s^- \to \phi\rho^+$ [4,2] are much smaller than model predictions [5]. In addition, experimental results on the semileptonic $D \to K^*l\nu$ transition [6,7] seem to be in conflict with quark model expectations [8-11]. These results have stimulated a reinvestigation of theoretical predictions for semileptonic exclusive D and B decays. Within the framework of the relativistic quark model approach, a new model parameter describing polarization effects has been introduced [12]. The only place in the hadronic sector where the new parameter can be estimated appears to be VV decays of $D_{(s)}$ and $B_{(s)}$ mesons. The most recent contributions to the study of VV meson production in D decays came from CLEO [13] and E691 [14] who reported contradictory results on the decay $D^0 \to K^{*0}\bar{K}^{*0}$.

In this paper we present the first observation of D^+ decays into the Cabibbo-suppressed channel $K^-K^0\pi^+\pi^+$, and a detailed study of the $D_s^+ \to K^-K^0\pi^+\pi^+$ de-

[1] References in this paper to a specific charged state are to be interpreted as implying the charged-conjugate state also.

cay mode where the K^0 is reconstructed in the K^0_S state. It is shown, using certain assumptions, that these modes are dominated by the $\bar{K}^{*0}\,K^{*+}$ channel, where the $\bar{K}^{*0}$ and K^{*+} decays into $K^-\pi^+$ and $K^0\pi^+$ respectively. We also present upper limits for all other decay channels reaching the same final state $K^-K^0\pi^+\pi^+$, as well as for decays of the D^+ and the D_s^+ into $K^+\bar{K}^0\pi^+\pi^-$, where the $\bar{K}^{*0}\,K^{*+}$ mode does not contribute.

Our analysis is based on a data sample of 432 pb^{-1} taken at an average center-of-mass energy of 10.4 GeV on the $\Upsilon(1S)$, $\Upsilon(2S)$, $\Upsilon(4S)$ resonances and in the nearby continuum using the ARGUS detector at the e^+e^- storage ring DORIS II. The ARGUS detector is a 4π spectrometer described in detail elsewhere [15]. Charged particles from the main event vertex were required to have a polar angle, θ, in the range $|\cos(\theta)| < 0.92$. These particles, identified on the basis of specific ionization, time of flight, energy deposition in the shower counters and penetration to the muon chambers, were treated as a $\pi^\pm$ or $K^\pm$ if the likelihood ratio for the appropriate mass hypothesis exceeded 1%. A K^0_S candidate was defined as a $\pi^+\pi^-$ pair with an invariant mass within ± 30 MeV/c^2 of the K^0_S mass coming from a secondary vertex [15]. In addition it was required that $\cos(\alpha) > 0.9$, where α is the angle between the K^0_S momentum and the vector which points from the main vertex to the decay vertex. This provided a cleaner sample of K^0_S with almost no loss in acceptance.

The momentum spectrum of charmed mesons from the continuum is relatively hard compared to the combinatorial background. Therefore in the search for D^+ and D_s^+ decays, each $K^-K^0_S\pi^+\pi^+$ combination was required to have $x_p > 0.6$, where $x_p = p/p_{max}$ and $p_{max} = \sqrt{E^2_{beam} - m(K^-K^0_S\pi^+\pi^+)^2}$. The mass spectrum of all accepted $K^-K^0_S\pi^+\pi^+$ combinations is shown in Figure 1. A signal at the D_s^+ mass and an enhancement at the D^+ mass are observed.

Four possible channels could contribute to observed signals: non-resonant $K^-K^0\pi^+\pi^+$ production, $\bar{K}^{*0}K^0\pi^+$, $K^{*+}K^-\pi^+$ and $\bar{K}^{*0}\,K^{*+}$ [2]. Monte Carlo cal-culations demonstrated that mass resolutions and efficiencies for all four channels were approximately the same. This conclusion is unchanged, even if the K^0K^-, $K^{*+}K^-$ or $\bar{K}^{*0}K^0$ are produced from higher mass resonances, such as the $\phi(1680)$ meson. The calculated widths for the D^+ and D_s^+ signals were 9.8 MeV/c^2 and 10.2 MeV/c^2 respectively. The efficiency was found to be 26%, not including the proba-bility for the $K^0 \to K^0_S$ transition and $K^0_S \to \pi^+\pi^-$, or the effect of the momentum cut $x_p > 0.6$ [3]. A systematic error of 10% was assigned to these values.

The spectrum shown in Figure 1 was fitted using two gaussians with fixed widths

[2]We neglect any possible interference effects between these four channels.

[3]The efficiency of this cut is about 63% for D_s^+ meson [16]

to parameterize the signals and a third-order polynomial to describe the background. Monte Carlo calculations were used to study a possible reflection from the decay mode $D^+ \to \bar{K}^0\pi^+\pi^+\pi^-$ due to π^- misidentification as a K^-. The channel $D^+ \to \bar{K}^0 a_1(1260)$, which gives the largest contribution to the process $D^+ \to \bar{K}^0\pi^+\pi^+\pi^-$ [17], and phase-space decays into $\bar{K}^0\pi^+\pi^+\pi^-$ were generated. In both cases the reflection produces a satellite bump in the region 2020–2080 MeV/c^2. Therefore this region was excluded from the fit. The signals were determined to be 80 ± 33 events for D^+ and 223 ± 40 for D_s^+ at masses of 1865 ± 5 MeV/c^2 and 1973 ± 2 MeV/c^2 respectively. The significance of the D^+ enhancement is only about 2.4 standard deviations. However restricting the $K\pi$ mass to lie within the K^* region, as described below, enhances the signal and confirms its existence.

In order to extract branching ratios for D^+ and D_s^+ signals, other known decay channels were used for normalization. Thus, for D_s^+ decays the ARGUS measurement [16] of:

$$\sigma(D_s^+ + D_s^-) \cdot BR(D_s^+ \to \phi\pi^+) = 7.8 \pm 0.8 \pm 1.3\ pb$$

at 10.15 GeV was used, scaled to the appropriate center-of-mass energy. Note that the systematic error on this result includes a large contribution (± 11%) due to extrapolation to zero momentum from $x_p = 0.5$, which mostly cancels in the ratio $BR(D_s^+ \to K^-K^0\pi^+\pi^+)/BR(D_s^+ \to \phi\pi^+)$. For D^+ decays, the $\bar{K}^0\pi^+\pi^+\pi^-$ decay mode was chosen for normalization as it has approximately the same efficiency as the $K^-K^0\pi^+\pi^+$ mode. Using identical cuts, the mass spectrum for all $K^0_S\pi^+\pi^+\pi^-$ combinations shown in Figure 2 was obtained. There are two peaks due to the $D^+ \to \bar{K}^0\pi^+\pi^+\pi^-$ and the $D^{*+}(2010) \to D^0\pi^+$, $D^0 \to \bar{K}^0\pi^+\pi^-$ decay modes. A fit to this spectrum with two gaussians to parameterize signals and a third-order polynomial to describe the background finds 543 ± 91 and 239 ± 73 events at masses of 1872 ± 3 MeV/c^2 and 2010 ± 2 MeV/c^2. The region $1760 - 1840$ MeV/c^2 was excluded from the fit because of a reflection from $D_s^+ \to K^-K^0\pi^+\pi^+$ decay channel, where the K^- is misidentified as a π^-. A Monte Carlo study of the decay sequence $D^+ \to \bar{K}^0 a_1^+(1260)$, $a_1^+(1260) \to \rho^0\pi^+$, $\rho^0 \to \pi^+\pi^-$ was used to determine the efficiency and width. The mass resolution was determined to be 14.0 ± 1.0 MeV/c^2, in a good agreement with the experimental result of 15.2 ± 2.7 MeV/c^2. Using the value of $BR(D^+ \to \bar{K}^0\pi^+\pi^+\pi^-) = (7.0 \pm 1.5)\%$ [1] one can obtain:

$$BR(D^+ \to (K^-K^0\pi^+\pi^+)_{all}) = 1.0 \pm 0.5 \pm 0.3,$$

$$BR(D_s^+ \to (K^-K^0\pi^+\pi^+)_{all})/BR(D_s^+ \to \phi\pi^+) = 1.2 \pm 0.2 \pm 0.2.$$

The quoted systematic errors include contributions from uncertainties in the Monte Carlo simulation, errors in the $\sigma(D_s^+ + D_s^-) \cdot BR(D_s^+ \to \phi\pi^+)$ and

$BR(D^+ \to \bar{K}^0\pi^+\pi^+\pi^-)$, and variation of the fit parameters.

Information about the resonant substructure in the $K^-K^0\pi^+\pi^+$ final state can be obtained first from a comparison of D^+ and D_s^+ decays into $K^+\bar{K}^0\pi^+\pi^-$, where the $\bar{K}^{*0}\ K^{*+}$ mode does not contribute. Note that the modes $K_1^+(1270)\bar{K}^0$, $\bar{K}_1^0(1270)K^+$ and $K^+\bar{K}^0\rho^0$, if they exist, would contribute to D^+ or D_s^+ signals in this case. The corresponding mass distribution is shown in Figure 3. A Monte Carlo simulation was used to prove that a possible reflection from $K^-K^0\pi^+\pi^+$ mode due to K^- misidentification as π^- and π^+ as K^+ is negligible. The spectrum in Figure 3 was fitted with a third-order polynomial as before to describe the background and two gaussians with fixed widths to parameterize D^+ and D_s^+ signals. The masses of the D^+ and D_s^+ were fixed to their table values. A fit to the spectrum in the whole mass region 1700–2200 MeV/c^2 gave a poor χ^2 which was dominated by the contribution from the range 2020–2200 MeV/c^2. Excluding this region from the fit yields 89 ± 46 and 67 ± 53 D^+ and D_s^+ events respectively. This led to the upper limits:

$$BR(D^+ \to (K^+\bar{K}^0\pi^+\pi^-)_{all}) < 2.0\% \quad \text{at } 90\%\text{CL},$$

$$BR(D_s^+ \to (K^+\bar{K}^0\pi^+\pi^-)_{all})/BR(D_s^+ \to \phi\pi^+) < 0.77 \quad \text{at } 90\%\text{CL}.$$

Our upper limit for the $D_s^+ \to K^+\bar{K}^0\pi^+\pi^-$ mode is close to the value of $BR(D_s^+ \to K^+\bar{K}^0\pi^+\pi^-)/BR(D_s^+ \to \phi\pi^+) = 0.7^{+0.4}_{-0.3}$ obtained by the ACCMOR group [2].

The resonant substructure in the $K^-K_S^0\pi^+\pi^+$ final state was studied further using the mass spectrum of $\bar{K}^{*0}\ K^{*+}$ combinations. K^* candidates were defined as $K\pi$ pairs with an invariant mass lying within ± 50 MeV/c^2 of the nominal K^* mass. Two peaks are observed at the D^+ and D_s^+ masses, as shown in Figure 4. The potential for double counting in such a selection procedure was avoided by ensuring that each $K^-K_S^0\pi^+\pi^+$ combination was only counted once. Superimposed on Figure 4 is the result of a fit using two gaussians to parameterize signals and a third-order polynomial to describe the background. The fit was performed using an unbinned distribution. Widths of gaussians were fixed as previously to 9.8 MeV/c^2 and 10.2 MeV/c^2 for D^+ and D_s^+ respectively. Monte Carlo techniques were also used to demonstrate that restrictions on the $K\pi$ masses are tight enough to eliminate a possible reflection from the decay mode $D^+ \to \bar{K}^0\pi^+\pi^+\pi^-$. The fit gives 74 ± 16 and 101 ± 17 events for D^+ and D_s^+ mesons at masses of 1866 ± 3 MeV/c^2 and 1968 ± 2 MeV/c^2 respectively.

In an analogous study of D^+ and D_s^+ signals using K^* sidebands, all $K^-K_S^0\pi^+\pi^+$ combinations were considered which do not have $K^-\pi^+$ and $K_S^0\pi^+$ pairs with

$$|m(K_S^0\pi^+) - m(K^{*+})| < 50\ MeV/c^2 \quad and \quad \left|m(K^-\pi^+) - m(\bar{K}^{*0})\right| < 50\ MeV/c^2.$$

The resulting spectrum shown in Figure 5 was fitted with a third-order polynomial and two gaussians. After excluding the region 2020–2080 MeV/c^2 from the fit, -2 ± 29 and 101 ± 35 events were obtained for the D^+ and D_s^+ mesons respectively.

The combination of signals with and without a resonant K^* requirement (Figures 4 and 5) may be used to extract the contributions from the four possible channels. Taking the D_s^+ as an example, the following two equations can be obtained:

$$\sum_{i=1,3} N_i\epsilon_{i,1} = 101 \pm 17, \qquad \sum_{i=1,3} N_i\epsilon_{i,2} = 101 \pm 35$$

where the N_i are the numbers of events produced in the channels K^*K^*, $K^*K\pi$, $KK\pi\pi$ (index i=1,3), and the $\epsilon_{i,j}$ are their reconstruction efficiencies in the K^* mass region ($j = 1$) and the K^* sidebands ($j = 2$). The $\bar{K}^{*0}K^0\pi^+$ and $K^{*+}K^-\pi^+$ channels have been combined here, since $\epsilon_{1,2}(\bar{K}^{*0}K^0\pi^+)$ and $\epsilon_{1,2}(K^{*+}K^-\pi^+)$ are approximately equal.

The efficiencies $\epsilon_{1,2}$ have been determined through Monte Carlo studies, assuming that all decays proceed via phase space. For the $\bar{K}^{*0}\ K^{*+}$ mode this is well justified, since it has been shown in reference [18] that the K^*'s are produced mostly in an s-wave state. Lacking a theoretical suggestion to the contrary, we assume the same for the $K^*K\pi$ and $K^-K^0\pi^+\pi^+$ modes. The resulting values for $\epsilon_{1,2}$ are collected in Table 1, where the $BR(K^* \to K\pi^+) = 2/3$ is not included.

Table 1. Efficiency $\epsilon_{1,2}$ for $\bar{K}^{*0}\ K^{*+}$, $K^*K\pi^+$ and $K^-K^0\pi^+\pi^+$ channels in D^+ and D_s^+ decays. Index 1 corresponds to K^*K^* mass region, index 2 to K^* sidebands

	D^+		
	$\bar{K}^{*0}\ K^{*+}$	$K^*K\pi$	$K^-K^0\pi^+\pi^+$
ϵ_1	0.184 ± 0.005	0.063 ± 0.006	0.029 ± 0.005
ϵ_2	0.078 ± 0.004	0.182 ± 0.009	0.224 ± 0.013
	D_s^+		
ϵ_1	0.163 ± 0.005	0.068 ± 0.007	0.030 ± 0.004
ϵ_2	0.089 ± 0.004	0.209 ± 0.010	0.222 ± 0.011

There are three unknowns and two equations in the system described above. In order to obtain the largest non-$\bar{K}^{*0}\ K^{*+}$ contribution one should assume complete dominance of the $K^*K\pi$ modes. These channels have a larger fraction relative to the $K^-K^0\pi^+\pi^+$ mode in the K^*K^* mass region and give a smaller contribution to the

K^* sidebands. Using the additional constraint that all variables must be positive, a likelihood function was constructed for the number of $K^*K\pi$ combinations, thus leading to the upper limit of $BR(D^+ \to (K^-K^0\pi^+\pi^+)_{non-\bar{K}^{*0}K^{*+}}) < 0.79\%$ at 90% CL and to the value of $BR(D_s^+ \to (K^-K^0\pi^+\pi^+)_{non-\bar{K}^{*0}K^{*+}})/BR(D_s^+ \to \phi\pi^+) = 0.38 \pm 0.31$ which we convert to the upper limit of 0.80 at 90% CL. Using the same technique for the $\bar{K}^{*0}\ K^{*+}$ mode we obtain

$$BR(D^+ \to \bar{K}^{*0}\ K^{*+}) = (2.6 \pm 0.8 \pm 0.7)\%,$$

$$BR(D_s^+ \to \bar{K}^{*0}\ K^{*+})/BR(D_s^+ \to \phi\pi^+) = 1.6 \pm 0.4 \pm 0.4.$$

The systematic errors noted above arise mainly from the errors in the $\sigma(D_s^+ + D_s^-) \cdot BR(D_s^+ \to \phi\pi^+)$ and $BR(D^+ \to \bar{K}^0\pi^+\pi^+\pi^-)$, and from the effect of attributing the origin of the non-$\bar{K}^{*0}\ K^{*+}$ contribution to the $K^-K^0\pi^+\pi^+$ mode instead of to $K^*K\pi$. They also include errors in the Monte Carlo calculation, and uncertainties associated with variation of the fit parameters.

As a check of these results, the invariant mass distributions of $K^-\pi^+$ and $K_S^0\pi^+$ pairs from the D_s^+ region ($|m(K^-K_S^0\pi^+\pi^+) - m(D_s^+)| < 10$ MeV/c^2), and from D_s^+ sidebands (20 MeV/c^2 $< |m(K^-K_S^0\pi^+\pi^+) - m(D_s^+)| <$ 40 MeV/c^2), were studied. It was also required that the mass of the other K^* combination lie within ± 50 MeV/c^2 of the nominal K^* mass. The resulting spectra are presented in Figures 6. The numbers of K^* mesons obtained from fitting the four spectra with a relativistic Breit-Wigner function for the K^* signal, and a second-order polynomial multiplied by phase space to describe the background, are listed in Table 2.

Table 2. Numbers of K^{*+} and $\bar{K}^{*0}$

	K^{*+}	$\bar{K}^{*0}$
D_s^+ region	126 ± 27	80 ± 27
D_s^+ side band	57 ± 28	< 33 at 90% CL
signal for D_s^+	97 ± 30	80 ± 30

The numbers of K^* mesons remaining after side-band subtraction is consistent with the expected 71 ± 22 events which can be obtained from the number of $\bar{K}^{*0}\ K^{*+}$ pairs $N(\bar{K}^{*0}\ K^{*+})$ in the system described above.

In conclusion, we have observed the decays $D^+ \to K^-K^0\pi^+\pi^+$ and $D_s^+ \to K^-K^0\pi^+\pi^+$ and have determined the branching ratios to be $BR(D^+ \to K^-K^0\pi^+\pi^+) =$

$(1.0 \pm 0.5 \pm 0.3)\%$ and $BR(D_s^+ \to K^-K^0\pi^+\pi^+)/BR(D_s^+ \to \phi\pi^+) = 1.2 \pm 0.2 \pm 0.2$. These channels are found to be dominated by the two-body mode $\bar{K}^{*0}\ K^{*+}$ with $BR(D^+ \to \bar{K}^{*0}\ K^{*+}) = (2.6 \pm 0.8 \pm 0.7)\%$ and $BR(D_s^+ \to \bar{K}^{*0}\ K^{*+})/BR(D_s^+ \to \phi\pi^+) = 1.6 \pm 0.4 \pm 0.4$. Upper limits have been obtained for the sum of branching ratios to non-$\bar{K}^{*0}\ K^{*+}$ decay modes: $BR(D^+ \to (K^-K^0\pi^+\pi^+)_{non-\bar{K}^{*0}K^{*+}}) < 0.79\%$ at 90% CL and $BR(D_s^+ \to (K^-K^0\pi^+\pi^+)_{non-\bar{K}^{*0}K^{*+}})/BR(D_s^+ \to \phi\pi^+) < 0.80$ at 90% CL. Finally, upper limits have been obtained for the D^+ and D_s^+ decays into the $K^+\bar{K}^0\pi^+\pi^-$ final state where the $\bar{K}^{*0}\ K^{*+}$ mode does not contribute: $BR(D^+ \to K^+\bar{K}^0\pi^+\pi^-) <$ 2.0% at 90% CL and $BR(D_s^+ \to K^+\bar{K}^0\pi^+\pi^-)/BR(D_s^+ \to \phi\pi^+) < 0.77$ at 90% CL.

Our measurements of D^+ and D_s^+ decays into the vector-vector final state $\bar{K}^{*0}\ K^{*+}$ can be compared with theoretical predictions obtained within the framework of the factorization scheme:

$$BR(D^+ \to \bar{K}^{*0}\ K^{*+}) = 2.7\%,$$

$$BR(D_s^+ \to \bar{K}^{*0}\ K^{*+})/BR(D_s^+ \to \phi\pi^+) = 1.6 \quad [5]$$

and

$$BR(D^+ \to \bar{K}^{*0}\ K^{*+}) = (0.6 - 1.8)\%,$$

$$BR(D_s^+ \to \bar{K}^{*0}\ K^{*+})/BR(D_s^+ \to \phi\pi^+) = 0.5 - 1.5 \quad [18],$$

where $BR(D_s^+ \to \phi\pi^+)$ was assumed to be 2.8% in both cases [5]. Our values may also be used to fix parameters in the model based on the SU(3) symmetry by Kamal *et al.* [18].

The mode $D^+ \to \bar{K}^{*0}\ K^{*+}$ is the strongest among all known Cabibbo-suppressed D^+ decays. The sum of our value of $(2.6 \pm 0.8 \pm 0.7)\%$ for its branching ratio and branching ratios of all Cabibbo-suppressed decays currently known [1] ($\sim$ 2.5%) is almost twice as large as the naive spectator model expectation of $\sin^2\theta_c \cdot BR(D^+ \to hadrons) \simeq 3\%$, where θ_c is the Cabibbo angle. One should recall that such an excess could be caused by suppression of Cabibbo-allowed D^+ decay modes due to interference between the spectator $\bar{d}$-quark and $\bar{d}$ produced in the virtual W^- decay. This interference should reduce the contribution from Cabibbo-allowed decays to the total width of the D^+ meson, resulting in a larger D^+ lifetime and higher branching ratios for the Cabibbo-suppressed decays.

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Figure Captions

Figure 1: $K^-K^0_S\pi^-\pi^+$ invariant mass distribution. The curve corresponds to the fit described in the text.

Figure 2: $K^0_S\pi^+\pi^-\pi^-$ invariant mass distribution. The curve corresponds to the fit described in the text.

Figure 3: $K^-K^0_S\pi^+\pi^-$ invariant mass distribution. The curve corresponds to the fit described in the text.

Figure 4: Mass spectrum of all $\bar{K}^{*0}$ K^{*+} combinations. K^* candidates were defined as $K\pi$ pairs with an invariant mass lying within ± 50 MeV/c^2 of the nominal K^* masses. The curve corresponds to the fit described in the text.

Figure 5: Mass spectrum of all $K^-K^0_S\pi^+\pi^+$ combinations which do not have $K^0_S\pi^+$ and $K^-\pi^+$ pairs from the K^* mass region. The curve corresponds to the fit described in the text.

Figure 6: $K^0_S\pi^-$ invariant mass distributions: (a) from D^+_s region ($|m(K^-K^0_S\pi^+\pi^+) - m(D^+_s)| < 10\,\mathrm{MeV}/c^2$) and (b) from D^+_s sidebands ($20\,\mathrm{MeV}/c^2 < |m(K^-K^0_S\pi^-\pi^+) - m(D^+_s)| < 40\,\mathrm{MeV}/c^2$) when the invariant mass of K^- and another π^+ meson lies within ± 50 MeV/c^2 of the nominal $\bar{K}^{*0}$ mass. Figures (c) and (d) are the analogous distributions for $K^-\pi^+$ combinations. The curves correspond to the fits described in the text.

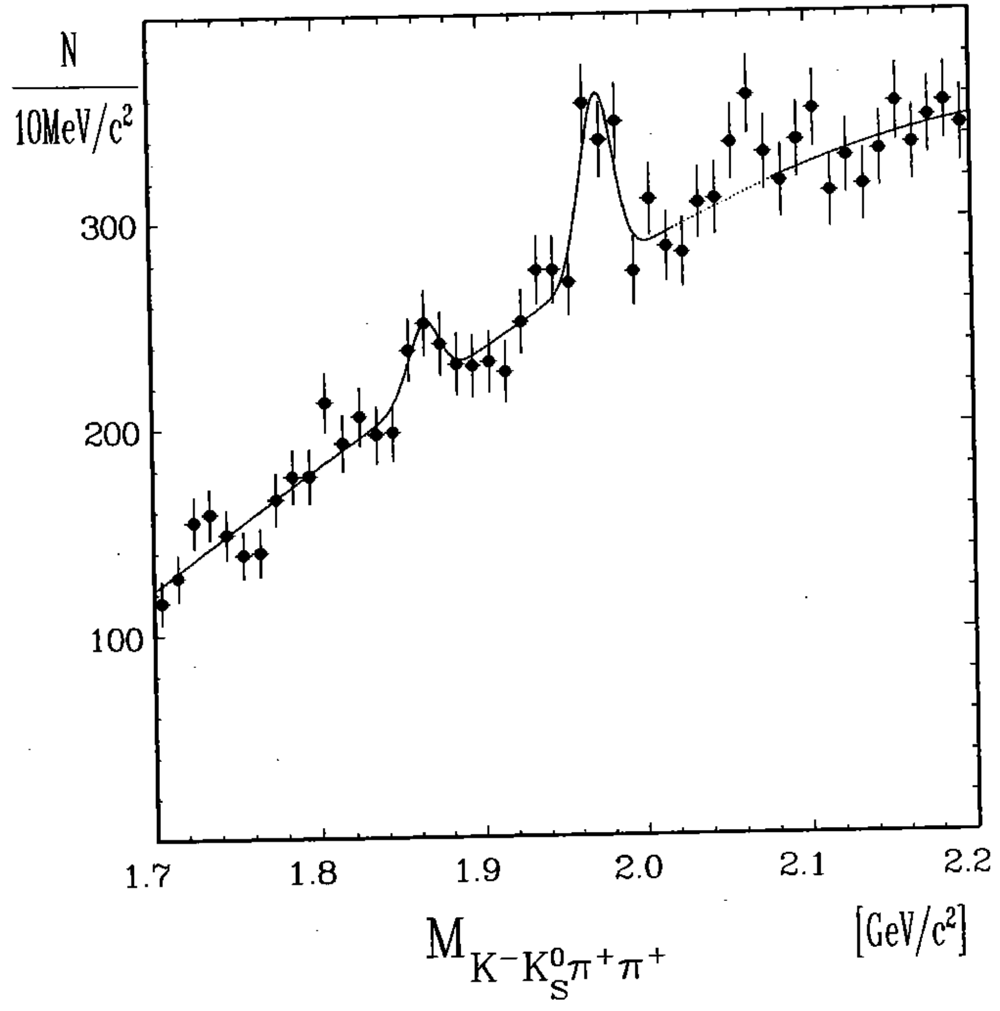


Figure 1.

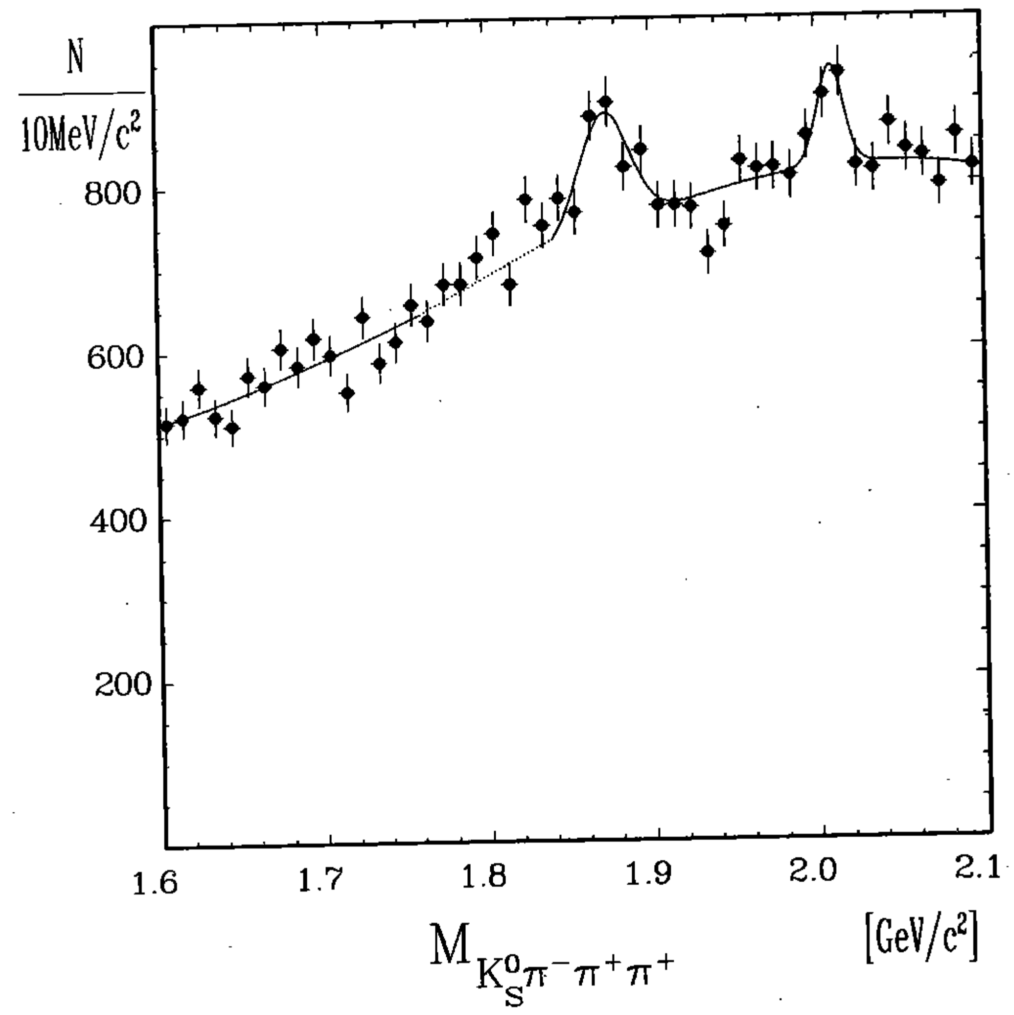
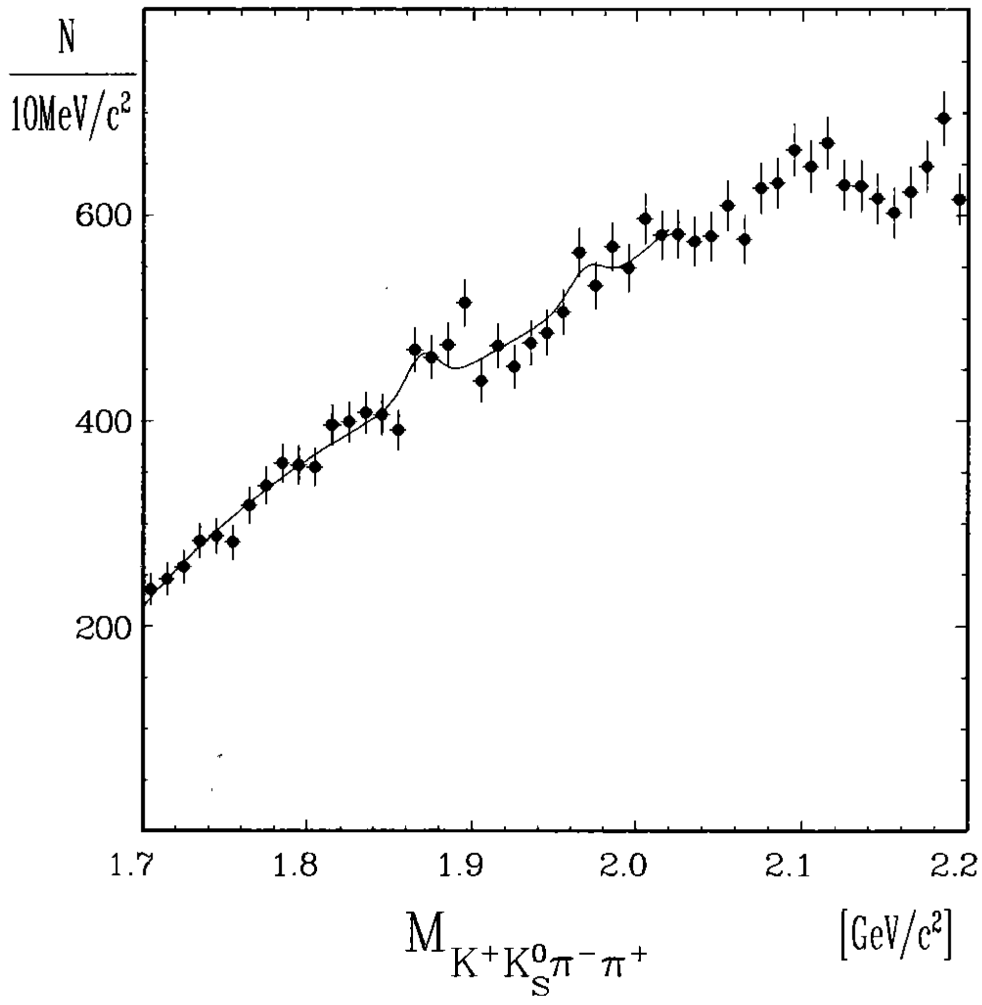


Figure 2.



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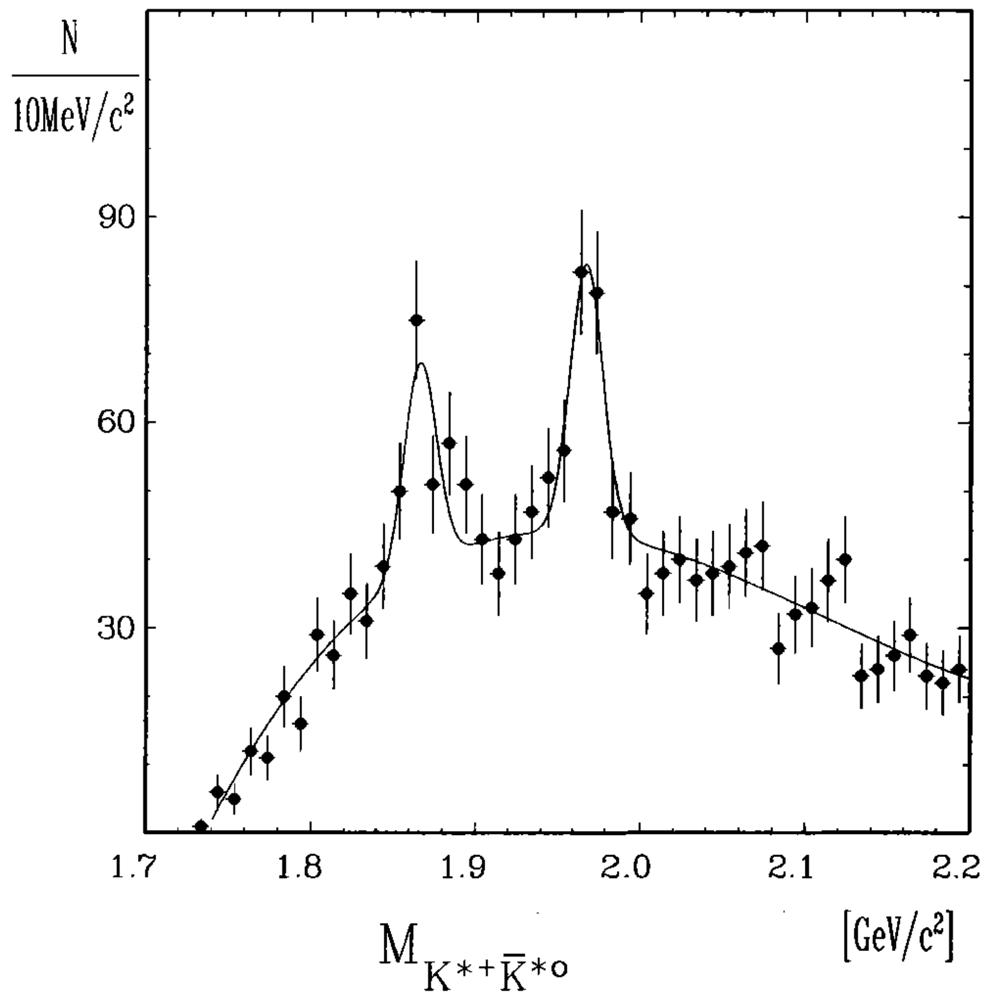

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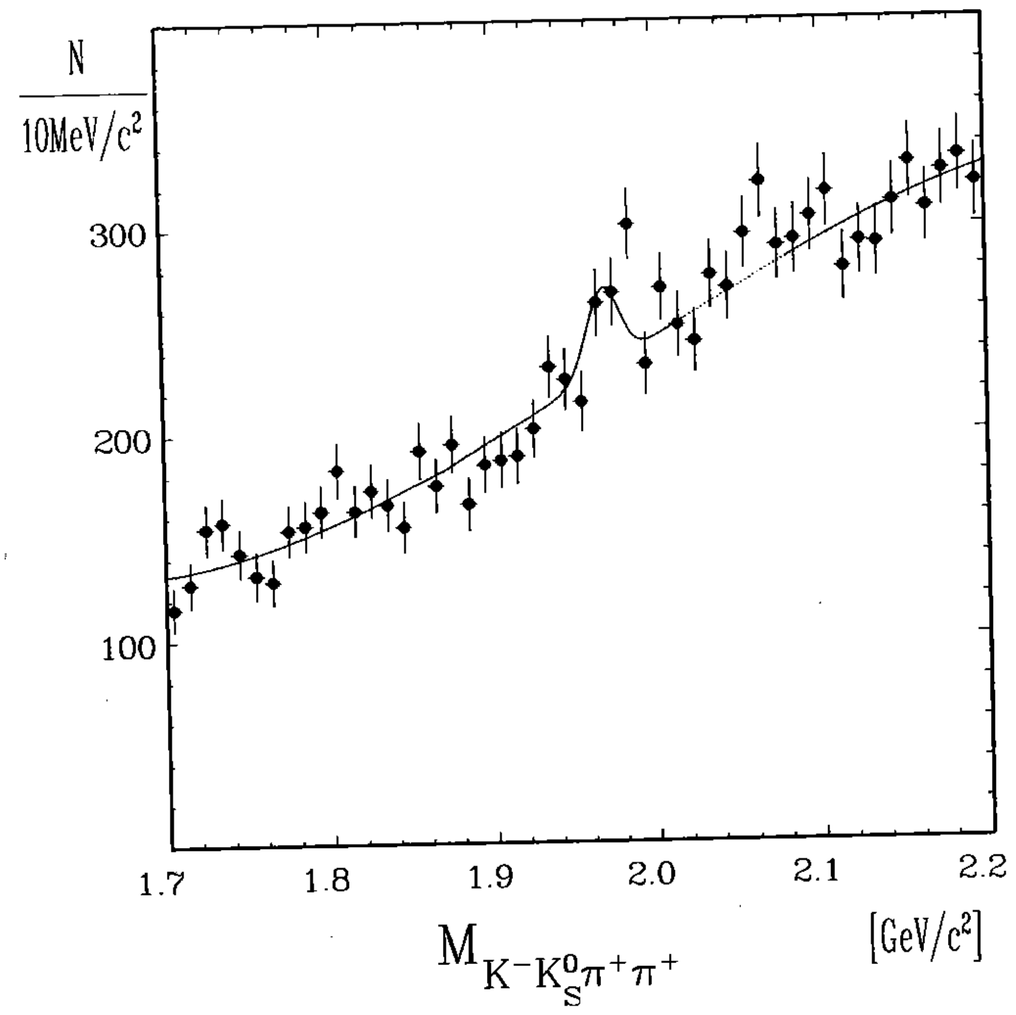

Figure 5.

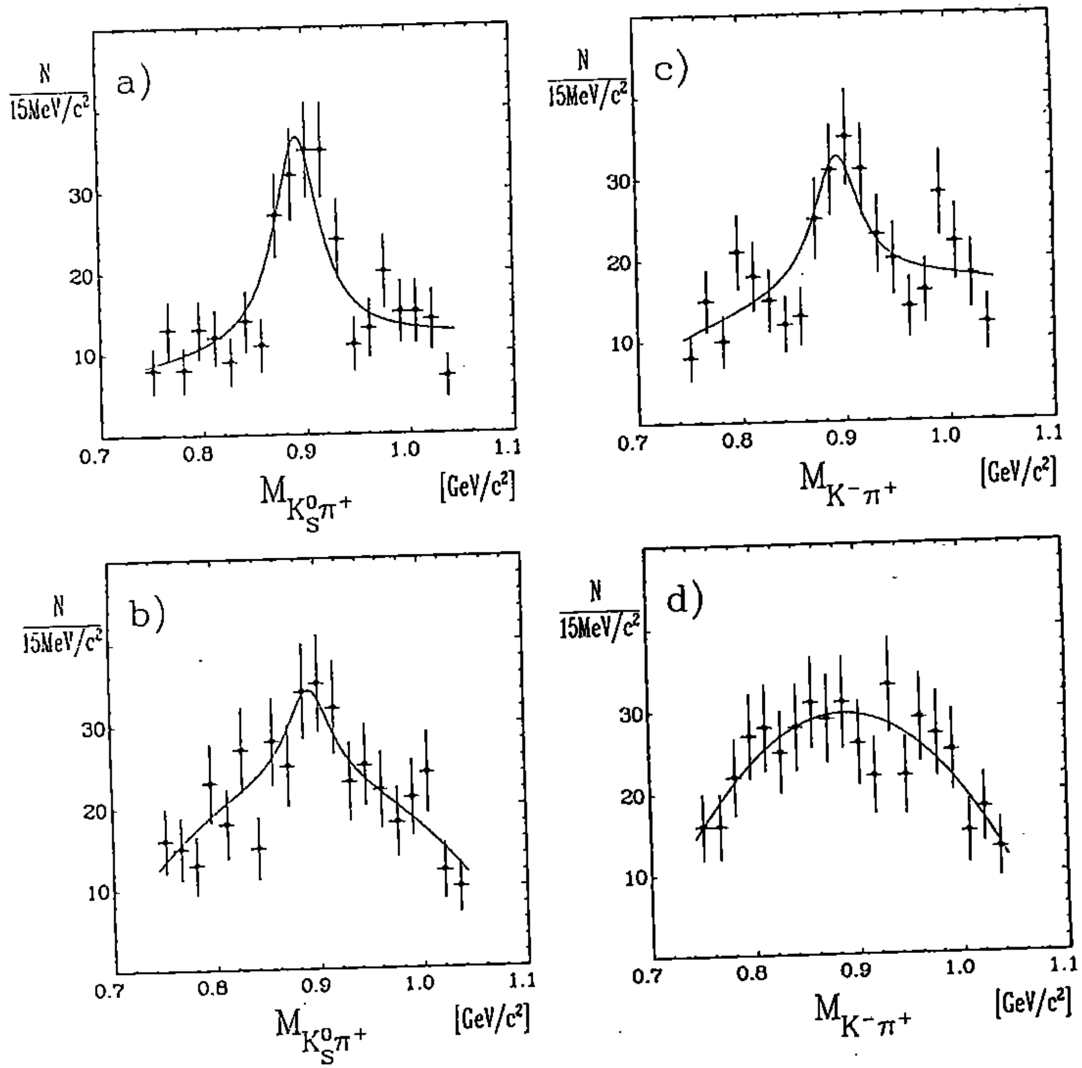

Figure 6(a,b,c,d).