An Analysis Note on

Study of Exclusive Hadronic Decays for $D^0 \to K_S^0\pi^+\pi^-$ and $K_S^0K^+K^-$ in e^+e^- Anihilation at $\sqrt{s} = 4.03$ GeV *

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Abstract

We report a measurement of non-resonant and resonant decay branching fractions for $D^0 \to K_S^0\pi^+\pi^-$ and $D^0 \to K_S^0K^+K^-$ using the data collected with BES detector at BEPC. We have measured the decay branching fraction for $D^0 \to \overline{K^0}\pi^+\pi^-$ to be $(5.10 \pm 0.61 \pm 0.46)\%$. Using a coherent amplitude analysis we measured the decay branching fractions for $D^0 \to K^{*-}\pi^+$ and $D^0 \to \overline{K^0}\rho^0$ to be $(5.61 \pm 0.30 \pm 0.65)\%$ and $(1.15 \pm 0.16 \pm 0.21)\%$ respectively. We have measured the decay branching fractions $Br(D^0 \to f)$ to be $(1.17 \pm 0.31 \pm 0.09)\%$ for $f = \overline{K^0}K^+K^-$, $(1.03 \pm 0.29 \pm 0.08)\%$ for $f = \overline{K^0}\phi$, and $(0.36 \pm 0.13 \pm 0.03)\%$ for $f = \overline{K^0}(K^+K^-)_{\mathrm{non}-\phi}$.

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*Throughout this paper, charge conjugation of all particles is implied.

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1 Introduction

It is still not yet possible to describe exclusive nonleptonic decays of the charmed hadrons in theory based on general principles. In theory there are some approximate methods or decay models used to describe the charm meson decays. For example, Bauer, Stech and Wirbel [1] have used a factorization approach to predict decay branching fractions for some two-body decays. To test the theoretical models we need to measure some exclusive hadronic decay branching fractions of D mesons, since the measurements of exclusive hadronic decays of D mesons can provide information on decay process of the mesons. For instance, measurements of decay branching fractions for $D^0 \to K^{*-}\pi^+$ and $D^0 \to \overline{K^0}\rho^0$ can help estimate strength a_1 of external W-emission (see figure 1a) and strength a_2 of internal W-emission (see figure 1b), respectively; while measurements of decay branching fraction for $D^0 \to \overline{K^0}\phi$ can help estimate the contributions of W-exchange diagram (see figure 1c) to the D^0 decays.

QCD potential model based on valence quarks expects that such W-exchange process are helicity and color suppressed. But other models predict that this suppression is removed or reduced by non-perturbative aspects of QCD. A crucial test for these ideas would be observation of the decay $D^0 \to \overline{K^0}\phi$ and more precise measurement of its branching fraction. Although this decay was previously observed and branching fraction for the decay was previously measured by other experiments already, in view of the important decay process $D^0 \to \overline{K^0}\phi$, we made one more measurement of the decay branching fraction for $D^0 \to \overline{K^0}\phi$ with BES data.

To fully understand the decay mechanisms of the D mesons, it is essential to measure decay branching fractions for various decay modes and improve the precise of the measurements of branching fractions of the D mesons, especially for some special decay modes, such as $D^0 \to \overline{K^0}\phi$ ...

In this paper we present decay branching fractions and resonant substructure measurements of $D^0 \to K^0_S\pi^+\pi^-$, and $D^0 \to K^0_S K^+K^-$ with an integrated luminosity of 22.3 pb^{-1} of data collected using BES detector at $\sqrt{s} = 4.03$ GeV at BEPC e^+e^- collider during the years 1992-1994.

2 The BES Detector

BES is a conventional cylindrical magnetic detector operated at the Beijing Electron Positron Collider (BEPC)[2]. A four-layer central drift chamber (CDC) surrounding the beam pipe provides an event trigger. A forty-layer main drift chamber (MDC) located just outside the CDC provides measurements of charged tracks and ionization energy loss (dE/dx) with a solid angle coverage of 80% of 4π for charged tracks. Momentum resolution of $1.7\%\sqrt{1+p^2}$ (p in GeV/c) and dE/dx resolution of 8.5% for Bhabha electrons are obtained for the data taken at $\sqrt{s} = 4.03$ GeV. An array of 48 scintillation counters surrounds the MDC and measures the time of flight (TOF) of charged tracks with a resolution of about 350 ps for Bhabha electrons. Surrounding the TOF is a 12-radiation-length, lead-gas barrel shower counter (BSC) operated in limited streamer mode, that measures the energy of electrons and photons over 80% of the total solid angle, with an energy resolution of $\sigma_E/E = 0.22/\sqrt{E}$($E$ in GeV), and spatial resolution of $\sigma_\phi = 4.5$ mrad and $\sigma_Z = 2$ cm for the electrons. Outside the BSC is a solenoidal magnet providing a 0.4 T magnetic field for the central tracking region of the detector. Three double-layer muon counters instrument the magnet flux return, and serve to identify muons of momentum greater than 500 MeV/c. They cover 68% of the total solid angle with longitudinal (transverse) spatial resolution of 5 cm (3 cm). End-cap time-of-flight and shower counters extend coverage to the forward and backward regions.

3 Event Selection

In this measurement, events are required to contain at least four reconstructed charged tracks with good helix fits. In order to ensure good momentum resolution and charged particle identification, the tracks are required to be within $|cos\theta| < 0.8$, where θ is the polar angle. All tracks, save those from K_S^0 decays, must originate from the interaction region. Pions and Kaons are identified by means of TOF and dE/dx measurements. Identification requires consistency with the pion or kaon hypothesis at a confidence level greater than 1%. In order to reduce misidentification, kaon candidates are further required to have a larger confidence level for the kaon hypothesis than for the pion hypothesis.

For the K_S^0 reconstruction, we require the momentum vector of the two oppositely charged pions to be aligned with the position vector of the secondary vertex in the xy plane within 37^0. The secondary vertex is required to be greater than 0.4 cm away from the collision point in xy plane, and the z coordinates of the two pion tracks to be within 5 cm of the secondary vertex. Figure 2 shows the invariant mass distribution for inclusive $\pi^+\pi^-$ combination for events satisfied the criteria. Using a Gaussian function with a second polynomial background to fit the mass distribution, we obtain the measured K_S^0 mass to be 0.497 GeV/c^2 with a standard deviation of $\sigma_{M_{K_S^0}} = 6.7$ MeV/c^2. In the analysis we use $\pm 3\sigma_{M_{K_S^0}}$ cut to select the K_S^0 events.

After applying the above cuts, signals for D^0 are clearly evident in the momentum spectra for the mode $D^0 \rightarrow K_S^0\pi^+\pi^-$ as shown in Figure 3. The lower momentum peak in the figure corresponds to D mesons from the $\mathrm{D}^*\overline{\mathrm{D}^*}$, and the hight momentum peak is due to $\mathrm{D}\overline{\mathrm{D}^*}$.

To reduce combinatorial backgrounds in these inclusive D^0 meson samples, events from which the $K^+K^-\pi^+\pi^-$ or $\pi^+\pi^-\pi^+\pi^-$ momentum being within intervals from 0.06 to 0.26 or from 0.42 to 0.62 GeV/c are used to select the inclusive decays $D^0 \rightarrow K_S^0\pi^+\pi^-$ and $D^0 \rightarrow K_S^0K^+K^-$.

4 Analysis and Results

4.1 The decay $D^0 \to K_S^0\pi^+\pi^-$

4.1.1 The branching fraction for $D^0 \to K_S^0\pi^+\pi^-$

The invariant mass spectrum for the $K_S^0\pi^+\pi^-$ combinations satisfying these selection criteria and analysis cuts described in section 3 is shown in figure 4. Fitting to this mass spectrum with a Gaussian function plus a polynormial background, we obtain 771.9 ± 74.2 events for the $D^0 \to K_S^0\pi^+\pi^-$ decay. After subtracting sideband background we obtained a number of 673.5 ± 78.6 events for the decay. The MC efficiency of reconstructing the decay $D^0 \to \overline{K^0}\pi^+\pi^-$ is $\epsilon(D^0 \to \overline{K^0}\pi^+\pi^-) = 0.0507 \pm 0.002$.

In order to measure the relative branching ratio of $D^0 \to \overline{K^0}\pi^+\pi^-$ over $D^0 \to K^-\pi^+$, we reconstruct the decay $D^0 \to K^-\pi^+$. Figure 5 shows the $K^+\pi^-$ invariant mass distribution for events for which the momentum of the $K^-\pi^+$ combinations are within the ranges of $60MeV \leq P \leq 260MeV$ or $420MeV \leq P \leq 620MeV$. Fitting to this mass spectrum, we obtain 3948.3 ± 95.6 events. The MC efficiency of reconstructing the $D^0 \to K^-\pi^+$ is $\epsilon(D^0 \to K^-\pi^+) = 0.394 \pm 0.020$. Using these numbers and efficiencies we obtain the relative branching ratio of $D^0 \to \overline{K^0}\pi^+\pi^-$ over $D^0 \to K^-\pi^+$ to be

$$\frac{Br(D^0 \to \overline{K^0}\pi^+\pi^-)}{Br(D^0 \to K^-\pi^+)} = 1.32 \pm 0.16 \pm 0.12.$$

Using the PDG98 value of $Br(D^0 \to K^-\pi^+) = (3.85 \pm 0.09)\%$, we obtain the branching fraction for $D^0 \to \overline{K^0}\pi^+\pi^-$ decay of

$$Br(D^0 \to \overline{K^0}\pi^+\pi^-) = (5.10 \pm 0.61 \pm 0.46)\%.$$

For more detail information about the analysis, please see Reference[3].

4.1.2 The resonant substructure for $D^0 \to K_S^0\pi^+\pi^-$

A maximum likelihood fit to Dalitz plot is used to determine the the decay branching fractions and relative phases into the modes $K^{*-}\pi^+$,$\overline{K^0}\rho^0$,and three-body non-resonant. For each decay mode, we define a complex amplitude in the three-body phase space as:

$$A(D \to rc, r \to ab) = F_D F_r BW(r) M(abc|r)$$

where the Blatt and Weisskopf form factors F_D and F_r take the forms as [4]. The relativistic Breit-Wigner propagator $BW(r)$ as[5]:

$$\frac{-1}{m^2 - m_0^2 + i\Gamma m_0}$$

where Γ is the energy dependence width, given by

$$\Gamma = \Gamma_0 (\frac{q}{q_0})^{2J+1} \frac{m_0}{m} \frac{F_X^2(q^2)}{F_X^2(q_0^2)}$$

the relevant value m_0 and Γ_0 are taken from [6]. The angular momentum part $M(abc|r)$ are given in Helicity Formalism,

$$M(D \to rc, r \to ab) = \sum_{\lambda_r} D^0_{0\lambda_r}(-\phi_r, \theta_r, \phi_r) p_D^{J_r} D^{J_r}_{\lambda_r 0}(-\phi_a, \theta_a, \phi_a) p_a^{J_r} = (p_D p_a)^{J_r} d^{J_r}_{00}(\theta_a)$$

where, p_D and p_a is the momentum of D and a in r rest frame, J_r is the spin of particle r, and θ_a is the helicity angle. The likelihood function L is defined as:

$$L = \prod_{events} \frac{R_{S/B} \frac{F_S}{N_{F_S}} + \frac{F_B}{N_{F_B}}}{R_{S/B} + 1}$$

where F_S is the probability density function (p.d.f.) of signal, which contains a coherent sum of amplitudes,

$$A_S(D^0) = f_1 e^{i\alpha_1} + A(K_S^0 \pi^- \pi^+ | K^{*-}) + f_3 e^{i\alpha_3} A(\pi^+ \pi^- K_S^0 | \rho^0)$$

$$A_S(\overline{D^0}) = f_1 e^{i\alpha_1} + A(K_S^0 \pi^+ \pi^- | K^{*+}) + f_3 e^{i\alpha_3} A(\pi^- \pi^+ K_S^0 | \rho^0)$$

weighted by detector efficiency ϵ and phase space. F_B is the p.d.f. of background,contains a set of functions which model the $K^{*\pm}$,ρ^0 and non-resonant content of the events outside the signal region. The ratio of signal to background $R_{S/B}$ is a function of the invariant mass of the $K_S^0 \pi^+ \pi^-$ combination,which calculated event-by-event. N_{F_S} and N_{F_B} are the overall normalization of F_S and F_B,which evaluated by Monte Carlo techniques.

The events of $K_S^0 \pi^+ \pi^-$ combinations having invariant mass within 1.5 σ of D^0 signal peak were selected for the Dalitz plot analysis. Figure 6-9 show the Dalitz plot and mass-squared projections for the decay $D^0 \to K_S^0 \pi^+ \pi^-$. In the figure 7-9 the 'cross' indicates the data, the higher histograms represent the expected values, and the lower histograms are expected background distribution from the fit. To evaluate the p.d.f. of background contribution, we defined two sidebands (low and high) as $4\sigma < |M - M_D| < 7\sigma$. For each entry,the momenta are recalculated using a kinematical fit according to the D^0 mass.

Since we can not tell the charm quantum number by K_S^0,the data were fit to the average p.d.f. of D^0 and $\overline{D^0}$.The fit results are summarized in Table 1. In Table 2, the decay branching fraction into a given mode is compared to results from other experiments.

The systematic errors are estimated by varying the events selection criteria, the method of background determination, the uncertainty of Monte Carlo efficiency. The largest source of systematic error comes from the parameterization of the background. To calculate systematic error due to the events selection, we change the

Table 1: Fit result. Using the world average branching ratio $Br(D^0 \to \overline{K^0}\pi^+\pi^-) = (5.4 \pm 0.5)\%$ we covert the fraction to branching ratio.

Decay Mode	relative fraction	relative phase	branching ratio(%)
$K^{*-}\pi^+$ ($K^{*-} \to K^0\pi^-$)	$0.693 \pm 0.037 \pm 0.049$	$0°$(fixed)	$5.61 \pm 0.30 \pm 0.65$
$\overline{K^0}\rho^0$	$0.213 \pm 0.030 \pm 0.033$	$(-138 \pm 9)°$	$1.15 \pm 0.16 \pm 0.21$
non-resonant	$0.205 \pm 0.038 \pm 0.045$	$(-110 \pm 9)°$	$1.11 \pm 0.21 \pm 0.26$

Table 2: Results from other experiments on the fraction and relative phase of the main contributions to $D^0 \to \overline{K^0}\pi^+\pi^-$.

$D^0 \to$	ARGUS	MarkIII	E687(92)	BES
$K^{*-}\pi^+$	$(71.8 \pm 4.2 \pm 3.0)\%$ $0°$(fixed)	$(56 \pm 4 \pm 5)\%$ $0°$(fixed)	$(64 \pm 8 \pm 5)\%$ $0°$(fixed)	$(69.3 \pm 3.7 \pm 4.9)\%$ $0°$(fixed)
$\overline{K^0}\rho^0$	$(22.7 \pm 3.2 \pm 0.9)\%$ $(-137 \pm 7)°$	$(12 \pm 1 \pm 7)\%$ $(90 \pm 30)°$	$(20 \pm 6 \pm 3)\%$ $(-143 \pm 29)°$	$(21.3 \pm 3.0 \pm 3.3)\%$ $(-138 \pm 9)°$
NR	—	$(33 \pm 5 \pm 10)\%$ incoherent	$(26 \pm 8 \pm 5)\%$ $(-126 \pm 17)°$	$(20.5 \pm 3.8 \pm 4.5)\%$ $(-110 \pm 9)°$

window of the momentum cut and signal region definition, K^0_S selection. The uncertainty of Monte Carlo efficiency is estimated to be 5%. The systematic error due to the background is determined from a comparison of fits to the signal events using either a backgrounds with shape determined from the low sideband,the high sideband, no populated K^* and ρ^0 band, or the different order of polynomial fit to the mass plot.

For more detail information about the analysis, please see Reference[7].

4.2 The decay $D^0 \to \overline{K^0}K^+K^-$

4.2.1 The branching fraction for $D^0 \to \overline{K^0}K^+K^-$

The analysis of $D^0 \to K^0_S K^+K^-$ is similar to that of $D^0 \to \overline{K^0}\pi^+\pi^-$ with substituting the two pions not coming from the K^0_S by Kaons subject to using the same momentum cuts and K^0_S selection criteria. Figure 10 shows the distribution of the invariant masses of $K^0_S K^+K^-$ combinations. Fitting to the mass spectrum with two Gaussian functions representing the D^0 signals (the smaller peak at the higher energy side is probably due to misidentification of a pion as a kaon from the decay $D^0 \to K^0K^-\pi^+$.) and 2 order polynomial describing the background gives signal of 42.4 ± 9.9 events for $D^0 \to K^0_S K^+K^-$ decay after double counting events corrected. A Monte Carlo study gives the detection efficiency of $\epsilon^{MC}_{D^0 \to \overline{K^0}K^+K^-} = 0.0147$.

The ratio of branching fractions for $D^0 \to \overline{K^0}K^+K^-$ over $D^0 \to \overline{K^0}\pi^+\pi^-$ is given by

$$\frac{Br(D^0 \to \overline{K^0}K^+K^-)}{Br(D^0 \to \overline{K^0}\pi^+\pi^-)} = 0.217 \pm 0.057.$$

Using the world averaged branching fraction for $D^0 \to K^0_S\pi^+\pi^-$, we obtain

$$B(D^0 \to \overline{K^0}K^+K^-) = (1.17 \pm 0.31 \pm 0.09)\%,$$

where the first error is statistical and the second systematic due to the uncertainty in the branching fraction for $D^0 \to K^0_S\pi^+\pi^-$.

4.2.2 The branching fraction for $D^0 \to \overline{K^0}\phi$

The ϕ mesons were reconstructed in its decay to K$^+$K$^-$ and selected by using the events selection criteria described in section 2. In this measurement a ϕ candidate was required to have $1.0044 < m_{K^+K^-} < 1.0344$ GeV/c^2. We then computed ϕ and K^0_S invariant mass. To enhance the $D^0 \to \phi K^0_S$ candidates a cut on the helicity angle, θ_K^+ of the K^+ was required to the $K^0_S\phi$ candidates; we required $|cos\theta_{K^+}| > 0.3$. The resulting invariant mass of the $K^0_S\phi$ spectrum is shown in figure 11. A fit to this distribution with a Gaussian function and a polynomial background gives a signal of 16.6 ± 4.7 events with a standard deviation of 10.7 MeV/c^2 after double counting correction made.

In order to estimate other sources of background contamination to the signal of $D^0 \to K^0_S\phi$, the signal for $D^0 \to K^0_SK^+K^-$ from ϕ sidebands was examined. The ϕ side bands were defined from 0.986 to 1.000 and 1.05 to 1.2 GeV/c^2 In the figure 11 the shaded histogram shows the distribution of the invariant mass of $K^0_SK^+K^-$ by means of requiring the invariant mass of K^+K^- to be within the ϕ side bands, and the number of events in each bin was normalized to signal events to evaluate the number of background in the ϕ signal interval of ± 15 MeV/c^2. Fitting to this distribution with a Gaussian function and a polynomial background yields a signal of 0.7 ± 0.5 events at the D^0 mass. After subtracting these side band background events, we obtained $N(D^0 \to K^0_S\phi) = 15.9 \pm 4.7$ events for $D^0 \to K^0_S\phi$ decay.

To check the signal of $D^0 \to K^0_S\phi$ observed, the dependence of helicity angle θ_{K^+} of K^+ in the ϕ rest frame was examined. Because the spin of the ϕ meson is 1 and K^0_S is zero, in the decay $D^0 \to K^0_S\phi$, angular momentum conservation required that the ϕ meson be polarized in the helicity-zero state which results in that the angular distribution of the θ_{K^+} should exhibit a $cos^2\theta_{K^+}$ dependence. While the background events under the D^0 signal must evidently are a uniform distribution. Figure 12 shows the distributions for $D^0 \to K^0_SK^+K^-$ decay where the K^+K^- invariant masses lie in the ϕ mass region. The angular distributions exhibit the expected $cos^2\theta_{K^+}$ behavior.

A Monte Carlo simulation of the decay $D^0 \to \overline{K^0}\phi$ was used to determine the detection efficiency. This yields the efficiency of $\epsilon^{MC}_{D^0 \to \overline{K^0}\phi} = 0.0063$. The ratio of branching fractions for $D^0 \to \overline{K^0}\phi$ and $D^0 \to \overline{K^0}\pi^+\pi^-$ is given by

$$\frac{Br(D^0 \to \overline{K^0}\phi)}{Br(D^0 \to \overline{K^0}\pi^+\pi^-)} = 0.1899 \pm 0.0551.$$

Using the world averaged branching fraction for $D^0 \to \overline{K^0}\pi^+\pi^-$, we obtain

$$Br(D^0 \to \overline{K^0}\phi) = (1.03 \pm 0.29 \pm 0.08)\%,$$

where the first error is statistical and the second systematic, resulting from the uncertainty in the branching fractions for $D^0 \to \overline{K^0}\pi^+\pi^-$. Our result is consistent with those from ARGUS[8], MARK-III[9], CLEO[10] and E687[11] measurements.

4.2.3 The branching fraction for $D^0 \to \overline{K^0}(K^+K^-)_{\mathrm{non}-\phi}$

In order to estimate the decay branching fraction of $D^0 \to \overline{K^0}(K^+K^-)_{\mathrm{non}-\phi}$ we required the invariant mass of the K^+K^- outside of the ϕ mass region $|M_{K^+K^-} - M_\phi| > 0.022$ GeV$/c^2$. Figure 13 shows the $K_S^0(K^+K^-)_{\mathrm{non}-\phi}$ invariant mass distribution. Using two Gaussian signal functions plus a polynomial background to fit this mass spectrum with considering double counting correction, we obtain signal of 18.1 ± 6.2 events. A corresponding Monte Carlo efficiency for detection of this decay is 0.0207. The ratio of branching fractions for $D^0 \to \overline{K^0}(K^+K^-)_{non-\phi}$ over $D^0 \to \overline{K^0}\pi^+\pi^-$ is given by

$$\frac{Br(D^0 \to \overline{K^0}K^+K^-_{non-\phi})}{Br(D^0 \to \overline{K^0}\pi^+\pi^-)} = 0.066 \pm 0.024.$$

Using the world average decay branching fraction for $D^0 \to \overline{K^0}\pi^+\pi^-$, we obtain the decay branching fraction of

$$Br(D^0 \to \overline{K^0}(K^+K^-)_{\mathrm{non}-\phi}) = (0.36 \pm 0.13 \pm 0.03)\%.$$

The first error is statistical and the second systematic, reflecting the uncertainty in the $D^0 \to \overline{K^0}\pi^+\pi^-$ branching fraction.

For more detail information about the analysis, please see Reference[12].

4.3 Discussion of the results and comparison with that measured by other experiments

Figure 14-21 show the experimental results measured by this and other experiments. The results obtained by other experiments and plotted in the figures were used to calculate the world average by Particle Data Group (PDG98)[6]. Comparing our results with that measured by other experiments we find that the precision of our measured values of the decay branching fractions for the hadronic decays are all at world level. So our experimental results on the branching fraction measurements would be beneficial to calculate the new world averaged values of the decay branching fractions.

In BSW model [1], the ratio of

$$\frac{B_r(D^0 \to K^{*-}\pi^+)}{B_r(D^0 \to \overline{K^0}\rho^0)} = \frac{5.12 a_1^2}{3.14 a_2^2} \tag{1}$$

can be used to estimate the ratio of the effective QCD parameter a_1 and a_2. From our result, we find

$$\left|\frac{a_1}{a_2}\right| = 1.82 \pm 0.21$$

which is smaller than the value 2.4 expected by BSW model [1].

Several theoritical models [13] predict the decay branching fraction for $D^0 \to \overline{K^0}\phi$ to be in a range from 0.2% to 1.1%. An enhancement W-exchange model [14] predicts a relation of

$$\frac{Br(D^0 \to \overline{K^0}\phi)}{Br(D^0 \to \overline{K^0}\rho^0)} = (0.56 - 1.36)\%.$$

From our measured branching fraction value of 1.15 ± 0.26 for $D^0 \to \overline{K^0}\rho^0$, we expect that the value of the branching fraction for the decay $D^0 \to \overline{K^0}\phi$ should be in the range of $(0.64 - 1.56)\%$ according to the Enhancement W-exchange model [14]. Our measured value of branching fraction $Br(D^0 \to \overline{K^0}\phi) = (1.03 \pm 0.29 \pm 0.07)\%$ is consistent within the error with the Enhancement W-exchange model prediction.

5 Conclusion

In summary, using the data collected with BES detector at BEPC Collider we have measured the decay branching fraction for $D^0 \to \overline{K^0}\pi^+\pi^-$ to be $(5.10 \pm 0.61 \pm 0.46)\%$. Using a coherent amplitude analysis we measured decay branching fractions for decays $D^0 \to K^{*-}\pi^+$, $D^0 \to \overline{K^0}\rho^0$ and $D^0 \to \overline{K^0}\pi^+\pi^-_{non-resonant}$ to be $(5.61 \pm 0.30 \pm 0.65)\%$, $(1.15 \pm 0.16 \pm 0.21)\%$ and $(1.11 \pm 0.21 \pm 0.26)\%$, respectively. We have measured the decay branching fractions $Br(D^0 \to f)$ to be $(1.17 \pm 0.31 \pm 0.09)\%$ for $f = \overline{K^0}K^+K^-$, $(1.03 \pm 0.29 \pm 0.08)\%$ for $f = \overline{K^0}\phi$, and $(0.36 \pm 0.13 \pm 0.03)\%$ for $f = \overline{K^0}(K^+K^-)_{\text{non}-\phi}$. Based on our measured values of decay branching fractions for $D^0 \to K^{*-}\pi^+$ and $D^0 \to \overline{K^0}\rho^0$ decays, we have extracted the ratio of $|\frac{a_1}{a_2}|$ to be 1.82 ± 0.21 which is smaller than the value of 2.4 expected by BSW model [1]. Our result confirms earlier observations and is consistent with results from ARGUS[8], MARK-III[9], CLEO[10] and E687[11] experiments. Our measured value of branching fraction $Br(D^0 \to \overline{K^0}\phi) = (1.03 \pm 0.29 \pm 0.07)\%$ is also consistent within the error with the Enhancement W-exchange model[14] and some other models[13] predictions.

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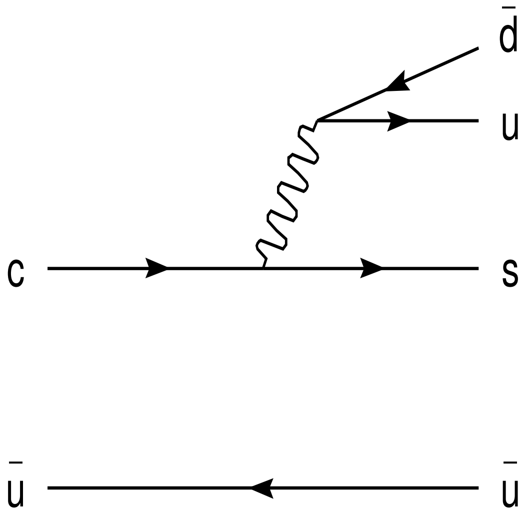
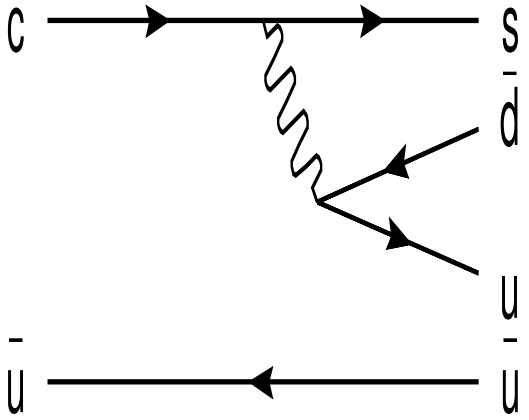


(a)



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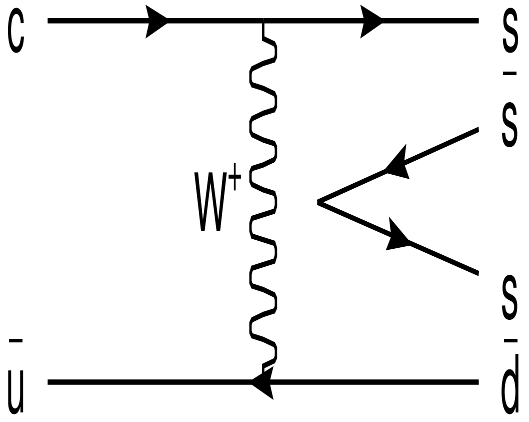

(c)

Figure 1: Feman digram.

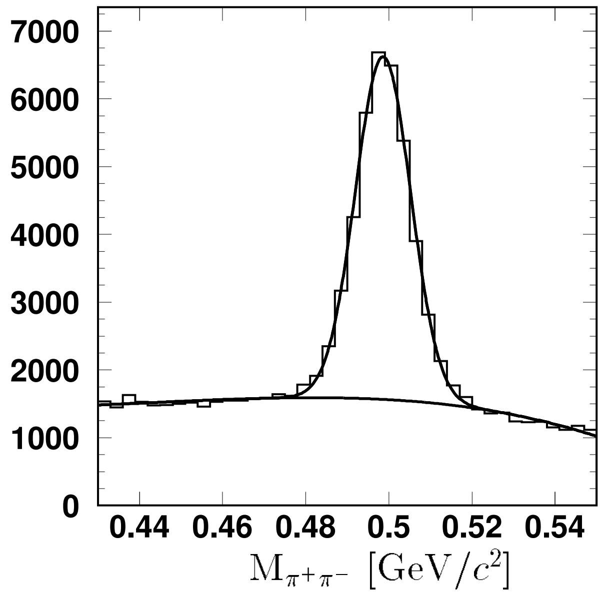

Figure 2: Invariant mass distribution of $\pi^+\pi^-$.

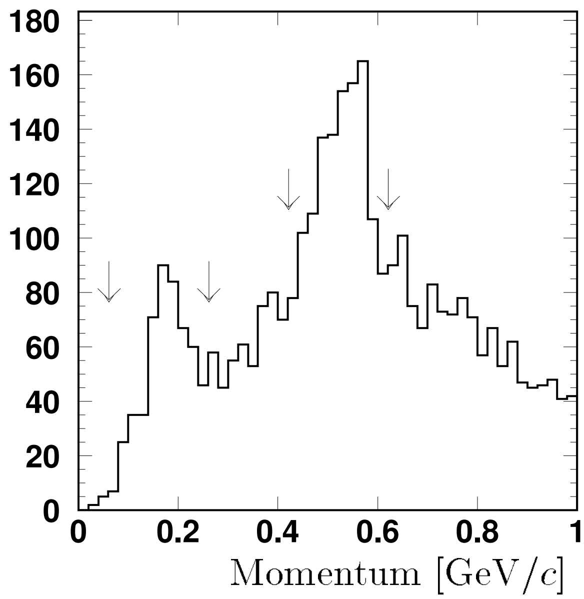

Figure 3: Momemtum distribution of $\overline{K^0}\pi^+\pi^-$.

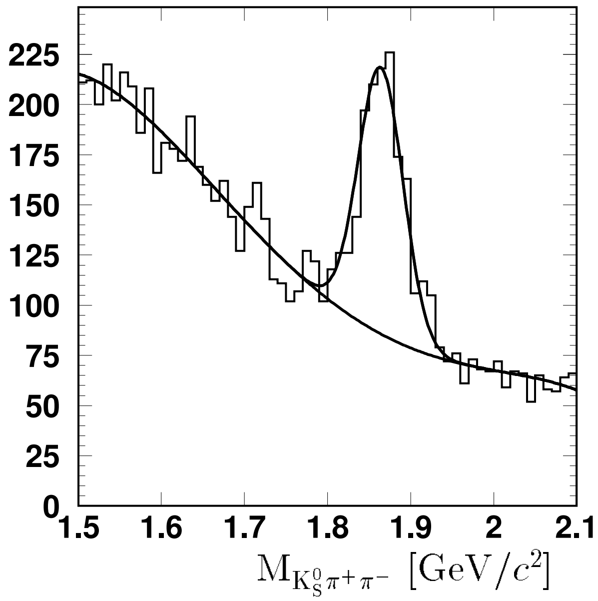

Figure 4: Invariant mass distribution of $\overline{K^0}\pi^+\pi^-$.

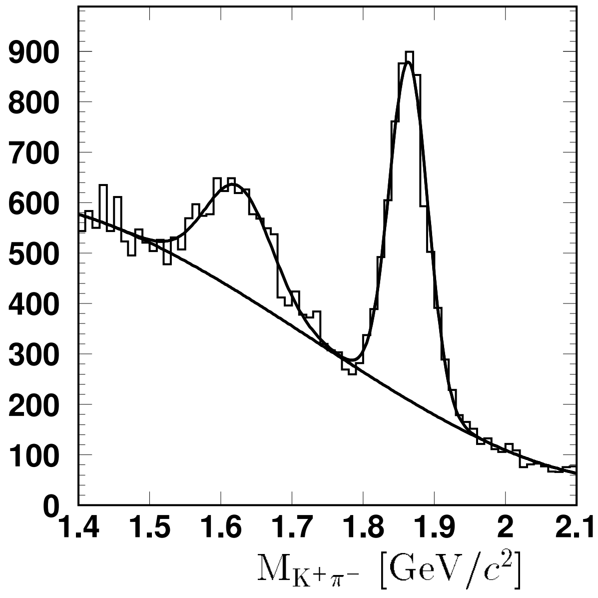

Figure 5: Invariant mass distribution of $K^+\pi^-$.

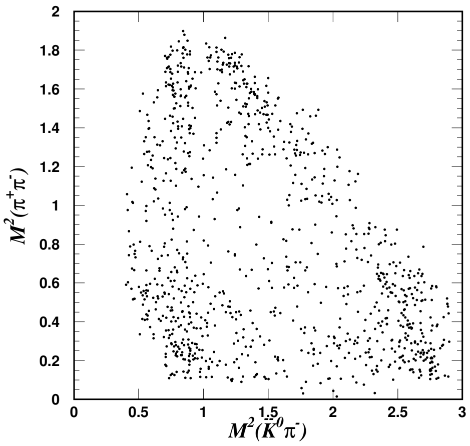

Figure 6: Dalitz plot of the $M^2_{\pi^+\pi^-}$ VS $M^2_{\overline{K}^0\pi^-}$.

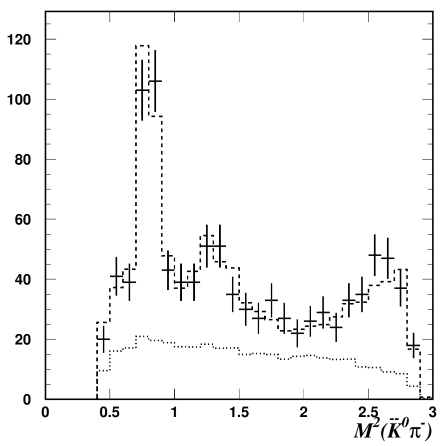

Figure 7: Mass-squared projections of the $M^2_{\overline{K}^0\pi^-}$.

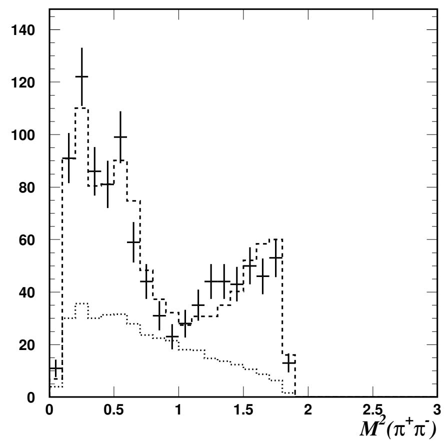

Figure 8: Mass-squared projections of the $M^2_{\pi^+\pi^-}$.

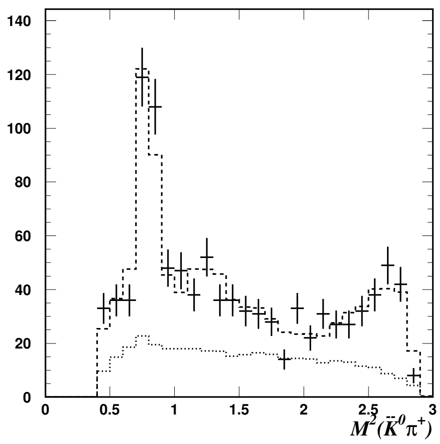

Figure 9: Mass-squared projections of the $M^2_{\overline{K}^0\pi^+}$.

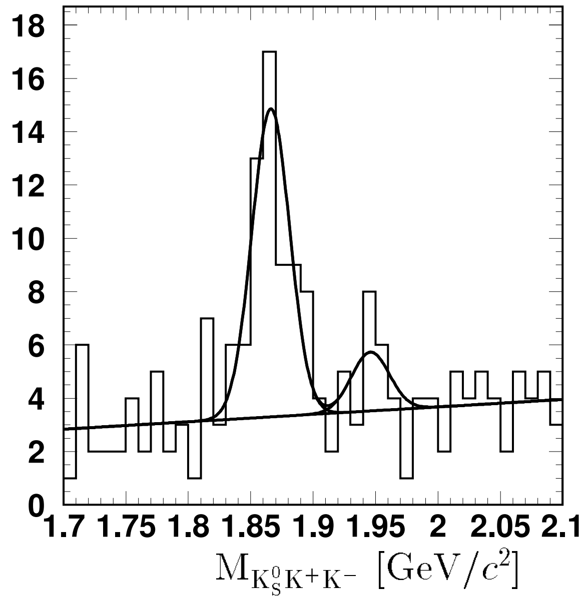

Figure 10: Invariant mass distribution of $K_S^0 K^+ K^-$.

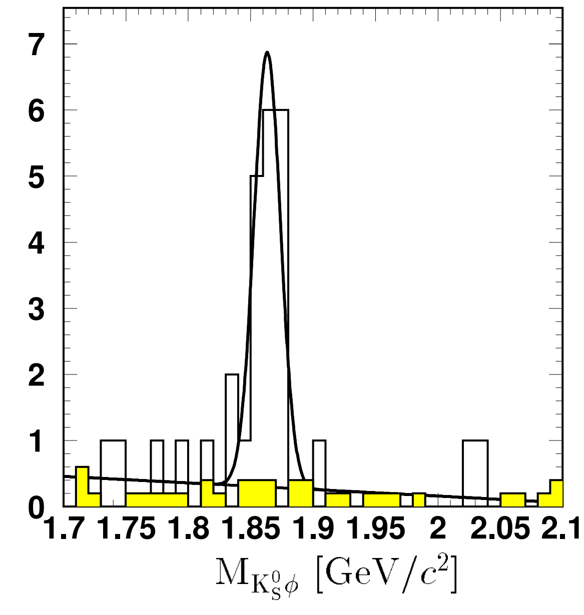

Figure 11: Invariant mass distribution of $K_S^0 \phi$.

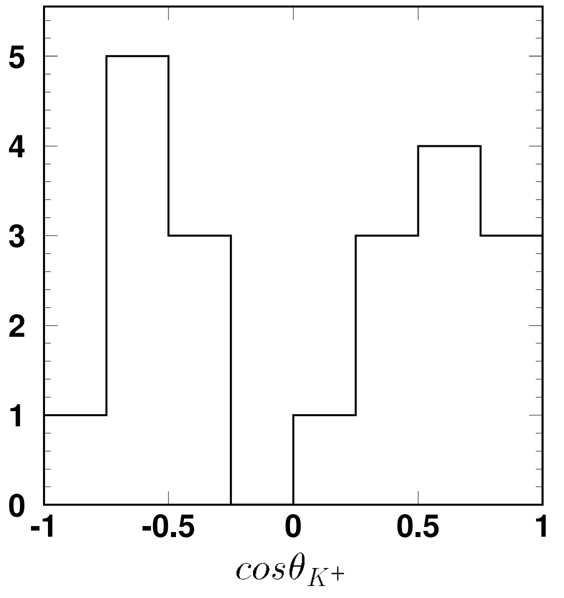

Figure 12: Distribution of $cos\theta_{K+}$.

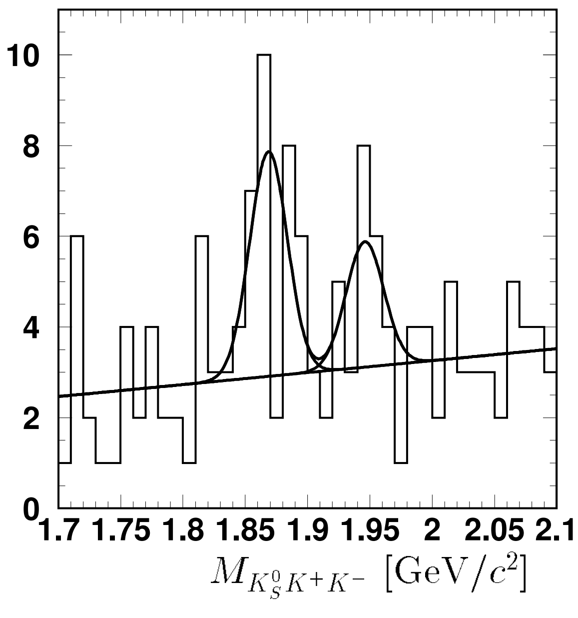

Figure 13: Invariant mass distribution of $\overline{K^0}(K^+K^-)_{non-\phi}$.

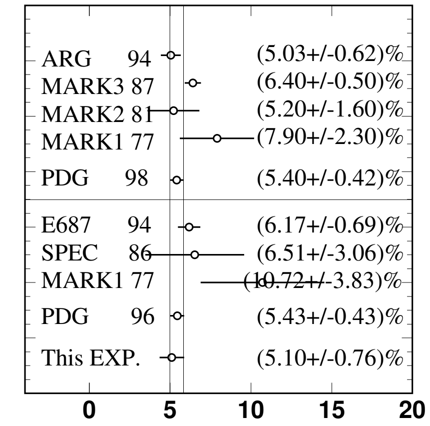

Figure 14: Values of branching fraction measure in percentage for $D^0 \to \overline{K}^0\pi^+\pi^-$.

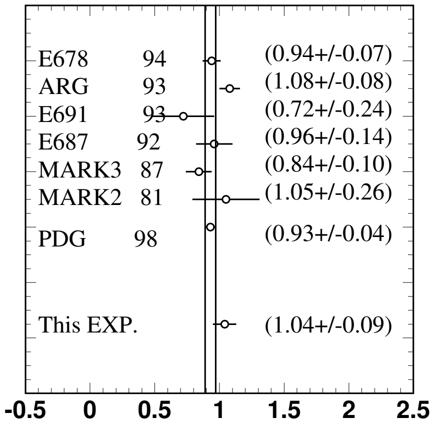

Figure 15: Value of the ratio $Br(D^0 \to \overline{K}^{*-}\pi^+)/Br(D^0 \to \overline{K^0}\pi^+\pi^-)$ measured by a few experiments.

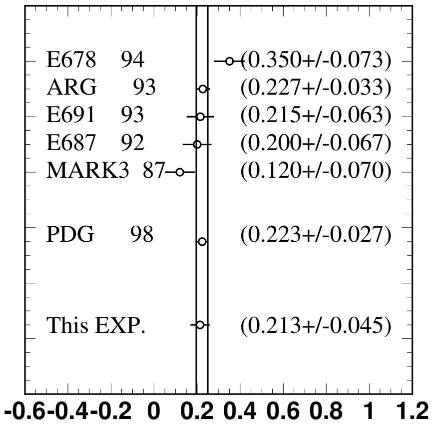

Figure 16: Values of the ratio $Br(D^0 \to \overline{K}^0\rho^0)/Br(D^0 \to \overline{K^0}\pi^+\pi^-)$ measured by a few experiments.

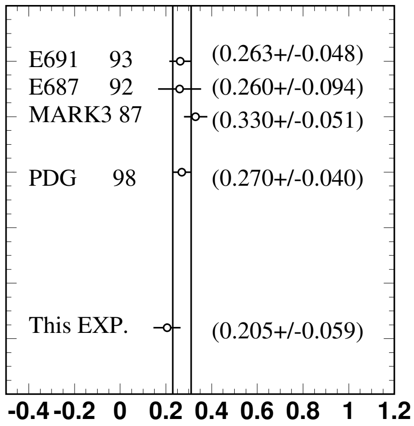

Figure 17: Values of the ratio $Br(D^0 \to \overline{K^0}(\pi^+\pi^-)_{non-resonant})/Br(D^0 \to \overline{K^0}\pi^+\pi^-)$ measured by a few experiments.

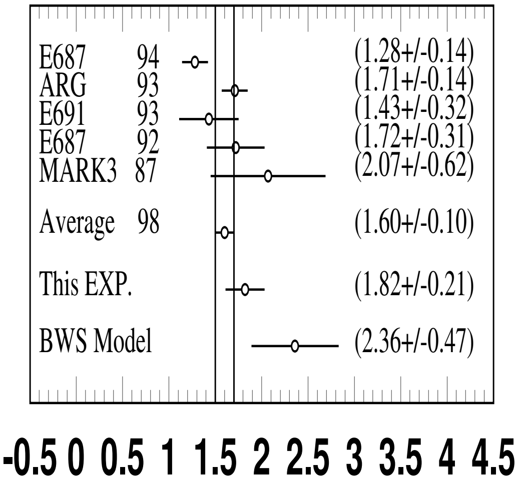

Figure 18: The values of $|\frac{a_1}{a_2}|$ calculated by using values of decay branching fractions (see text) measured by a few experiments. The values of the branching fractions quoted from PDG98.

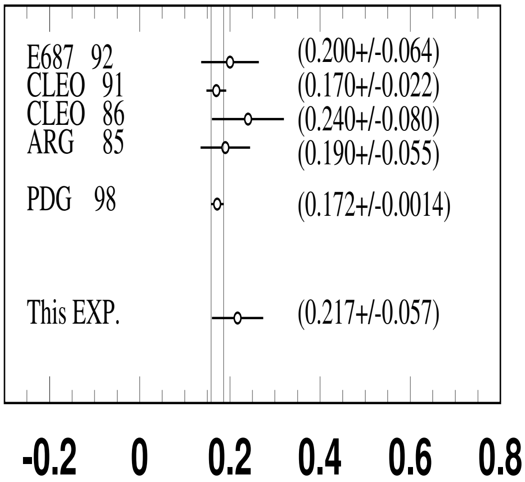

Figure 19: Values of the ratio $Br(D^0 \to \overline{K}^0 K^+ K^-)/Br(D^0 \to \overline{K^0}\pi^+\pi^-)$ measured by a few experiments.

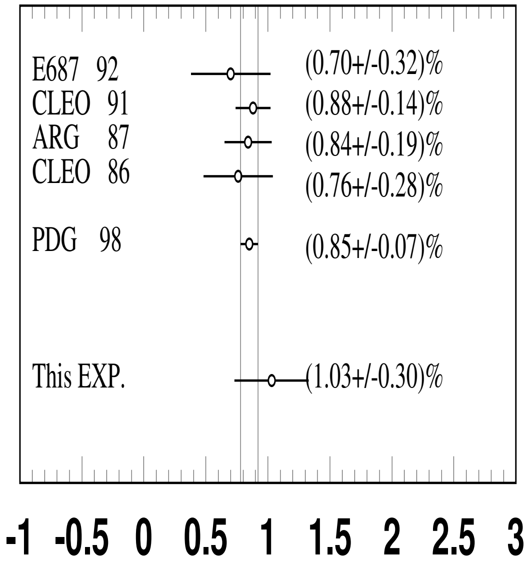

Figure 20: Values of branching fraction measured in percentage for $D^0 \to \overline{K^0}\phi$.

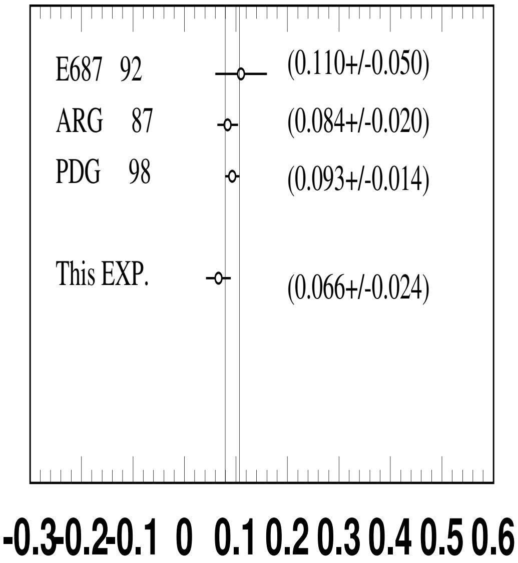

Figure 21: Values of the ratio $Br(D^0 \to \overline{K}^0 (K^+K^-)_{non-\phi})/Br(D^0 \to \overline{K^0}\pi^+\pi^-)$ measured by a few experiments.