Study of Exclusive Hadronic Decays for $D^0 \to K_S^0 \pi^+ \pi^-$ and $D^0 \to K_S^0 K^+ K^-$ and Their Resonant Structures *

BES Collaboration

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Received 25 February 2003, Revised 11 September 2003

* Supported by NSFC (19991480), National Natural Science Funds for Distinguished Young Scholar(10225524, 10225525), Major Subject of Chinese Academy of Sciences(KJ95T-03), 100 Talents Program of CAS(U-24, U-25), Knowledge Innovation Project of CAS(U-602, U-34)

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Abstract We report the results of an experimental study of the exclusive hadronic decays for $D^0 \to K_s^0\pi^+\pi^-$ and $K_s^0K^+K^-$ and their resonant structures using BES-Ⅰ detector at the BEPC Collider. Using the data sample of 22.3 pb^{-1} collected at the center-of-mass energy $\sqrt{s} = 4.03$ GeV, we measured the branching fraction for $D^0 \to \overline{K}^0\pi^+\pi^-$ to be $(5.32 \pm 0.53 \pm 0.40)\%$, the branching fractions for the decays $D^0 \to K^{*-}\pi^+$, $D^0 \to \overline{K}^0\rho^0$ and $D^0 \to \overline{K}^0(\pi^+\pi^-)_{non\text{-}resonant}$ to be $(6.05 \pm 0.32 \pm 0.49)\%$, $(1.17 \pm 0.17 \pm 0.13)\%$ and $(1.35 \pm 0.22 \pm 0.17)\%$, respectively. We measured the branching fractions $Br(D^0 \to f)$ to be $(1.04 \pm 0.24 \pm 0.16)\%$ for $f = \overline{K}^0K^+K^-$, $(1.12 \pm 0.34 \pm 0.15)\%$ for $f = \overline{K}^0\phi$, and $(0.27 \pm 0.13 \pm 0.03)\%$ for $f = \overline{K}^0(K^+K^-)_{non\text{-}\phi}$.

Key words BES, BEPC, D^0 meson, branching fraction

1 Introduction

It is still not yet possible to describe exclusive non-leptonic decays of the charmed hadrons for theory based on general principles. In the factorization[1] and nonfactorization effective calculations[2], the determination of the hadronic matrix elements of the weak currents are all model dependent. To test the theoretical assumptions the measurements of some two body hadronic decay branching fractions of D mesons are important. For instance, measurements of the branching fractions for $D^0 \to K^{*-}\pi^+$ and $D^0 \to \overline{K}^0\rho^0$ can help to clarify the theoretical aspects of the effective strengths a_1 and a_2 of color favored (see Fig. 1(a)) and suppressed (see Fig. 1(b)) amplitudes, respectively. Measurement of the branching fraction for $D^0 \to \overline{K}^0\phi$ is useful in estimation of the contributions of W-exchange diagram (see Fig. 1(c)) to D^0 decay. QCD potential models based on valence quarks expect that such W-exchange process are helicity and color suppressed[3]. However, emission of soft gluons in the initial state or explicit presence of gluons in the wave function may remove the helicity suppression. Some theoretical models predict that the contribution of W-exchange diagram to D^0 decay range from 1 % to 60 % of the total D^0 width[4]. Further experiment input is crucial.

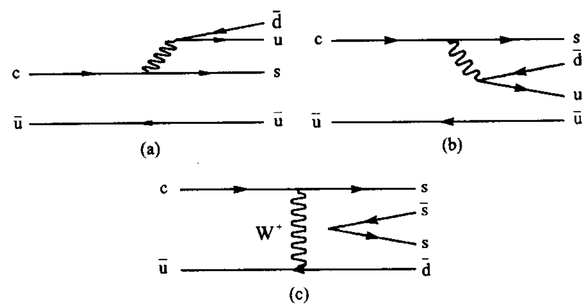

Fig.1. Decay diagram.

ARGUS[5], MARK-Ⅲ[6], CLEO[7] and E687[8] experiments measured the branching fractions for the decays, and some of them studied the resonant structures in the decays. In this paper we present decay branching fractions and resonant substructure measurements of $D^0 \to K_s^0\pi^+\pi^-$, and $D^0 \to K_s^0K^+K^-$ with an integrated luminosity of 22.3 pb^{-1} of data collected using BES-Ⅰ detector at $\sqrt{s} = 4.03$ GeV at BEPC e^+e^- collider during the years 1992—1994.

2 The BES-Ⅰ detector

BES-Ⅰ is a conventional cylindrical magnetic detector operated at the Beijing Electron Positron Collider (BEPC)[9]. 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 85 % 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 and 450 ps for hadrons. Surrounding the TOF is a 12-radiation-length, lead-gas barrel shower counter (BSC) operated in limited streamer mode, which 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, but we do not use information from the end-cap counters in this analysis.

3 Event selection

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 likelihood 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°. 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. The invariant mass of $\pi^+\pi^-$ pair is required to be within ± 13 MeV/c^2 of K_s^0 nominal mass.

After applying the above cuts, signals for D^0 are clearly evident in the momentum spectra for the mode $D^0\to K_s^0\pi^+\pi^-$ as shown in Fig.2. The lower momentum peak in the figure corresponds to D mesons from the $D^*\bar{D}^*$, and the higher momentum peak is due to $D\bar{D}^*$.

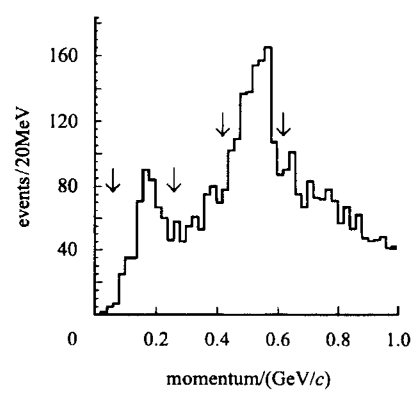

Fig.2. Momemtum distribution of $\bar{K}^0\pi^+\pi^-$.

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 are within the intervals from 0.06 to 0.26 or from 0.42 to 0.62 GeV/c are used to select the inclusive decays $D^0\to K_s^0\pi^+\pi^-$ and $D^0\to K_s^0K^+K^-$.

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 Fig.3. Fitting to this mass spectrum with a Gaussian function plus a 2nd order polynomial background, we obtain 755.7 ± 65.0 events for the $D^0\to K_s^0\pi^+\pi^-$ decay after correcting to doubly counted events. After subtracting K_s^0 sideband background we obtained a number of 685.0 ± 67.1 events for the decay. The MC efficiency of reconstructing the decay $D^0 \to \overline{K}^0\pi^+\pi^-$ is $\epsilon(D^0 \to \overline{K}^0\pi^+\pi^-) = 0.049 \pm 0.001$, where the error is statistical. The branching fraction for the decay $\overline{K}^0 \to \pi^+\pi^-$ is included in the efficiency.

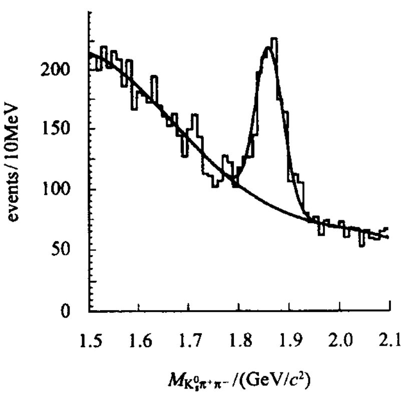

Fig.3. Invariant mass distribution of $\overline{K}^0\pi^+\pi^-$.

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 $D^0 \to K^-\pi^+$ by selecting K^- and π^+ charged tracks using the same events selection criteria as mentioned in Section 3. Fig.4. shows the $K^+\pi^-$ invariant mass distribution for events for which the momenta of the $K^-\pi^+$ combinations are within the same intervals as that used to select the inclusive decay events for $D^0 \to K_s^0\pi^+\pi^-$. Fitting to this mass spectrum, we obtain 3948.3 ± 95.6 events. The MC efficiency of reconstructing the $D^0 \to K^-\pi^+$ is $\epsilon(D^0 \to K^-\pi^+) = (0.394 \pm 0.007)$. 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

$$\frac{Br(D^0 \to \overline{K}^0\pi^+\pi^-)}{Br(D^0 \to K^-\pi^+)} = 1.40 \pm 0.14 \pm 0.10,$$

where the first error is statistical and the second systematic. The systematic error is estimated based on changes in the ratio due to the uncertainties in the number of the observed events for the decay $D^0 \to K^-\pi^+$, in Monte Carlo efficiencies due to statistics for detection of the decays $D^0 \to K^-\pi^+$ and $D^0 \to \overline{K}^0\pi^+\pi^-$, due to varying the cuts on the K_s^0 mass window, the range of the K_s^0 sideband, the fit range, bin size and varying the background shape from 2 sd to 5 th order in the fit to the invariant masses of $K^-\pi^+$. These uncertainties are independent in the two decay modes. Some common systematic uncertainties due to tracking, particle identification, Monte Carlo simulation and D productions are canceled. Monte Carlo study shows that the uncertainty in estimation of the double counting correction is about 3 %. The final systematic error is obtained by adding these uncertainties in quadrature, which yields a total systematic error of ±0.103.

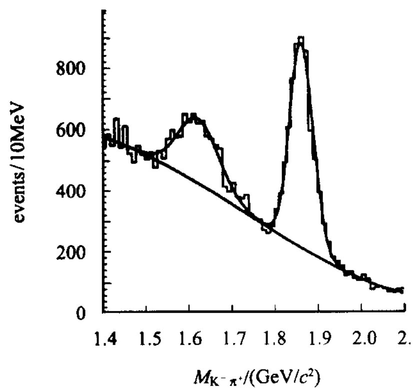

Fig.4. Invariant mass distribution of $K^-\pi^+$.

Using the world averaged value of $Br(D^0 \to K^-\pi^+) = (3.80 \pm 0.09)\%$, we obtain the branching fraction for $D^0 \to \overline{K}^0\pi^+\pi^-$ decay of

$$Br(D^0 \to \overline{K}^0\pi^+\pi^-) = (5.32 \pm 0.53 \pm 0.40)\%,$$

where the first error is statistical and the second systematic. The systematic uncertainty includes the systematic uncertainty in the ratio of the branching fractions for $D^0 \to K_s^0\pi^+\pi^-$ and $D^0 \to K^+\pi^-$, and the uncertainty in the branching fraction for the decay $D^0 \to K^+\pi^-$.

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

A maximum likelihood fit to the Dalitz plot (Fig. 5(a)) is used to determine the decay branching fractions, 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 [10]. The relativistic Breit-Wigner propagator $BW(r)$ as[11]:

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

where Γ is the energy dependent width, given by

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

The relevant value m_0 and Γ_0 are taken from Ref.[12]. The angular momentum part $M(abc|r)$ are given in Helicity Formalism,

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

with $r \to ab$ and where, r is a resonant particle, a, b and c are pseudo-scalar mesons, p_D and p_a is the momentum of D and a in r rest frame, J_r is the spin of particle r, λ_r is the helicity of particles r, and θ_a is the helicity angle. The likelihood function L is defined as:

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

where F_S is the p.d.f. (probability density function) of signal. Since we can not determine 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 F_S contains a coherent sum of amplitudes,

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

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

weighted by detector efficiency ϵ and phase space. F_B is the p.d.f. of background, containing 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, and is calculated for each event. N_{F_S} and N_{F_B} are the overall normalization of F_S and F_B, which are evaluated by using Monte Carlo techniques.

The events of $K_s^0\pi^+\pi^-$ combinations with invariant masses within 1.5 σ_{D^0} of D^0 nominal mass were selected for the Dalitz plot analysis. Fig.5. shows the Dalitz plot and the mass-squared projections for the decay $D^0 \to K_s^0\pi^+\pi^-$. In the Fig.5(b)—(d) the 'cross' indicates the data, the higher histograms represent the values, and the lower histograms are the background component from the fit. To evaluate the p.d.f. of the 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.

The fit results are summarized in Table 1. In Table 2, the decay branching fraction into a given mode is compared to the results from other experiments. The systematic errors are estimated by varying the events selection criteria, the method of background determination and 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 window of the momentum cut, signal region definition and K_s^0 selection. The uncertainty of Monte Carlo efficiency is estimated to be 5 %. The systematic error due to the background is determined

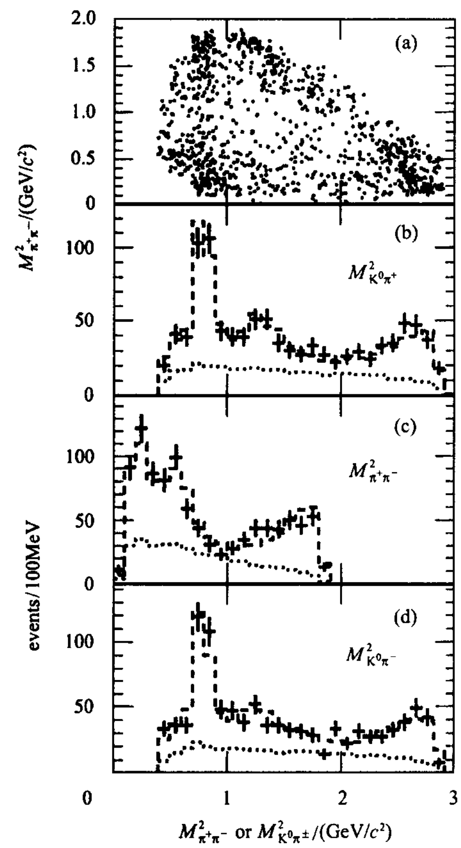

Fig.5. Dalitz plot and mass-squared projections for the decay $D^0 \to K_s^0\pi^+\pi^-$. See text.

Table 1. Fit result. Using the world average branching ratio $Br(D^0 \to \overline{K}^0\pi^+\pi^-) = (5.92 \pm 0.35)\%$ [12] we convert the fraction to branching ratio.

Decay Mode	relative fraction(%)	relative phase/(°)	branching ratio(%)
$K^{*-}\pi^+$ ($K^{*-} \to K^0\pi^-$)	68.1 ± 3.6 ± 3.8	0(fixed)	6.05 ± 0.32 ± 0.49
$\overline{K}^0\rho^0$	19.8 ± 2.9 ± 1.8	− 138 ± 9	1.17 ± 0.17 ± 0.13
non-$K^{*-}\pi^+$ and non-$\overline{K}^0\rho^0$	22.7 ± 3.8 ± 2.5	− 114 ± 9	1.35 ± 0.22 ± 0.17

from a comparison of fits to the signal events using either backgrounds with a shape determined from the low sideband, the high sideband, the dalitz plot excluding the K^* and ρ^0 bands, or the varying the order of the background polynomial fit to the mass plot.

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	MARK-Ⅲ	BES-Ⅰ
$K^{*-}\pi^+$	$(71.8 \pm 4.2 \pm 3.0)\%$ $0°$(fixed)	$(56 \pm 4 \pm 5)\%$ $0°$(fixed)	$(68.1 \pm 3.6 \pm 3.8)\%$ $0°$(fixed)
$\overline{K}^0\rho^0$	$(22.7 \pm 3.2 \pm 0.9)\%$ $(-137 \pm 7)°$	$(12 \pm 1 \pm 7)\%$ $(90 \pm 30)°$	$(19.8 \pm 2.9 \pm 1.8)\%$ $(-138 \pm 9)°$
non-$K^{*-}\pi^+$ and non-$\overline{K}^0\rho^0$	—	$(33 \pm 5 \pm 10)\%$ incoherent	$(22.7 \pm 3.8 \pm 2.5)\%$ $(-114 \pm 9)°$

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 $D^0 \to K^0_s \pi^+ \pi^-$ with the substitution of Kaons for the non-K^0_s pions. Fig.6. shows the distribution of the invariant masses of $K^0_s K^+ K^-$ combinations. Fitting to the mass spectrum with a Gaussian function representing the D^0 signal and a second order polynomial describing the background gives signal of 34.3 ± 8.1 events for $D^0 \to K^0_s K^+ K^-$ decay after correcting to doubly counted events and subtracting the non-resonant ($D^0 \to (\pi^+\pi^-)_{\text{non-}K^0_s} K^+ K^-$) background. A Monte Carlo study gives the detection efficiency of $\epsilon^{MC}_{D^0 \to \overline{K}^0 K^+ K^-} = 0.0140 \pm 0.0008$, where the error is statistical.

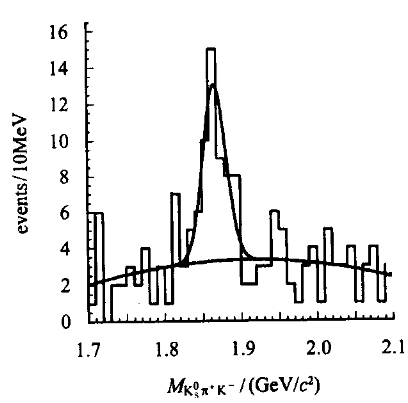

Fig.6. Invariant mass distribution of $K^0_s K^+ K^-$.

Using the numbers of the observed events for the decays $D^0 \to K^0_s K^+ K^-$, $D^0 \to \overline{K}^0 \pi^+ \pi^-$ and the relative detection efficiencies, the ratio of branching fractions for $D^0 \to \overline{K}^0 K^+ K^-$ and $D^0 \to \overline{K}^0 \pi^+ \pi^-$

$$\frac{Br(D^0 \to \overline{K}^0 K^+ K^-)}{Br(D^0 \to \overline{K}^0 \pi^+ \pi^-)} = 0.175 \pm 0.041 \pm 0.024$$

is obtained, where the first error is statistical and the second systematic. The systematic error is estimated based on the changes in the ratio due to the uncertainties in the number of the observed events for the decay $D^0 \to \overline{K}^0 \pi^+ \pi^-$, in the Monte Carlo efficiencies for detection of the decays $D^0 \to \overline{K}^0 \pi^+ \pi^-$, $D^0 \to \overline{K}^0 K^+ K^-$ and the uncertainties in doubly counted corrections.

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

$$B(D^0 \to \overline{K}^0 K^+ K^-) = (1.04 \pm 0.24 \pm 0.16)\%,$$

where the first error is statistical and the second systematic. The systematic error includes the systematic uncertainty in the ratio of branching fractions for $D^0 \to \overline{K}^0 K^+ K^-$ and $D^0 \to \overline{K}^0 \pi^+ \pi^-$, and 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 are reconstructed in its decay to K^+K^- and selected by using the event selection criteria described in Section 3. In this measurement the region $1.0044 < m_{K^+K^-} < 1.0344$ GeV/c^2 is defined as the ϕ signal region, and the intervals 0.98—1.00 GeV and 1.05—1.2 GeV are considered as background regions for the ϕ. We then compute 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^+ is required to the $K^0_s\phi$ candidates; we require $|\cos\theta_{K^+}| > 0.3$. The resulting invariant mass of the $K^0_s\phi$ spectrum is shown in Fig.7. The $K^0_s\phi$ mass regions from 1.8348 to 1.8948 GeV within the $\pm 2\sigma_{m_{D^0}}$ mass region is defined as D^0 signal region, and the regions from 1.7 to 2.1 GeV/c^2 excluding the region from 1.81 to 1.91 GeV are defined as sideband background control regions for the D^0 meson. As shown in the Fig.7, 17 events are found as $D^0 \to \overline{K}^0\phi$ candidates, and 6 events are selected as $D^0 \to \overline{K}^0\phi$ side band events. Using the D^0 side band events, a total of 1.2 ± 0.5 events has been estimated as the background among the D^0 candidates. In the Fig.7. the shaded histogram shows the distribution of the invariant masses of $K^0_s K^+ K^-$ combinations by means of requiring the invariant mass of K^+K^- to be within the ϕ side bands, and requiring that the number of events in each bin is normalized to evaluate the number of background in the ϕ signal interval of ± 15 MeV/c^2. Using the ϕ side band events, a total of 0.8 ± 0.6 events has been estimated as the $D^0 \to \overline{K}^0(K^+K^-)_{\text{non-}\phi}$ background among the D^0 candidates. Subtracting the background contributions to both the D^0 and the ϕ and subtracting 1 event due to double counting, we obtain 14.0 ± 4.3 $D^0 \to \overline{K}^0\phi$ events.

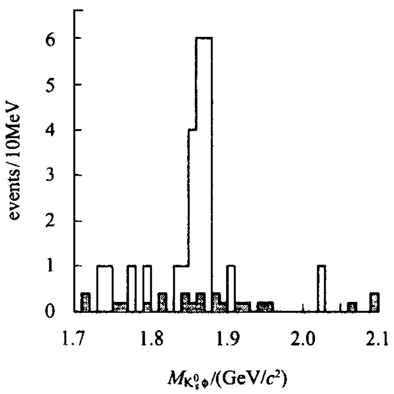

Fig.7. Invariant mass distribution of $K_s^0\phi$.

A Monte Carlo simulation of the decay $D^0 \to \overline{K}^0\phi$ is used to determine the detection efficiency. This yields the efficiency of $\epsilon^{MC}_{D^0 \to \overline{K}^0\phi} = (0.0053 \pm 0.0003)$. 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

$$\frac{Br(D^0 \to \overline{K}^0\phi)}{Br(D^0 \to \overline{K}^0\pi^+\pi^-)} = 0.189 \pm 0.058 \pm 0.022,$$

where the first error is statistical and the second systematic. The systematic error arises from the uncertainties in the numbers of the observed events for the decay $D^0 \to \overline{K}^0\pi^+\pi^-$, in the Monte Carlo efficiencies for detection of the decays $D^0 \to \overline{K}^0\pi^+\pi^-$ and $D^0 \to \overline{K}^0\phi$, and the uncertainties due to varying the helicity angle θ_K and the ϕ mass cuts.

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

$$Br(D^0 \to \overline{K}^0\phi) = (1.12 \pm 0.34 \pm 0.15)\%,$$

where the first error is statistical and the second systematic, which results from the uncertainty in the ratio of branching fractions for $D^0 \to \overline{K}^0\phi$ and $D^0 \to \overline{K}^0\pi^+\pi^-$, and the uncertainty in the branching fractions for $D^0 \to \overline{K}^0\pi^+\pi^-$.

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

In order to estimate the decay branching fraction of $D^0 \to \overline{K}^0(K^+K^-)_{\text{non-}\phi}$ we require the invariant mass of the K^+K^- outside of the ϕ mass region $|M_{K^+K^-} - M_\phi| > 0.022$GeV/$c^2$. Fig.8. shows the $K_s^0(K^+K^-)_{\text{non-}\phi}$ invariant mass distribution. Using a Gaussian signal function plus a second order polynomial background to fit this mass spectrum with correcting to the doubly counted events and subtracting the number of background events $0.0^{+0.05}_{-0.00}$ for the decay $D^0 \to K^+K^-(\pi^+\pi^-)_{\text{non-}K^0}$, we obtain the signal of 12.5 ± 6.2 events. A corresponding Monte Carlo efficiency for detection of this decay is 0.0200 ± 0.0010. Based on the 12.5 ± 6.2 $D^0 \to \overline{K}^0(K^+K^-)_{\text{non-}\phi}$ events, the ratio of the branching fractions for $D^0 \to \overline{K}^0(K^+K^-)_{\text{non-}\phi}$ over $D^0 \to \overline{K}^0\pi^+\pi^-$

$$\frac{Br(D^0 \to \overline{K}^0 K^+ K^-_{\text{non-}\phi})}{Br(D^0 \to \overline{K}^0\pi^+\pi^-)} = 0.045 \pm 0.022 \pm 0.004$$

is obtained, where the first error is statistical and the second systematic. The systematic error is estimated based on the changes of the ratio due to the uncertainties in the number of the observed events for the decay $D^0 \to \overline{K}^0\pi^+\pi^-$, in the Monte Carlo efficiencies for detection of the decays $D^0 \to \overline{K}^0\pi^+\pi^-$ and $D^0 \to \overline{K}^0(K^+K^-)_{\text{non-}\phi}$, and the double counting corrections for the decays $D^0 \to \overline{K}^0\pi^+\pi^-$ and $D^0 \to \overline{K}^0(K^+K^-)_{\text{non-}\phi}$. The combined effect of these sources is obtained by adding in the uncertainties in quadrature, which yields a total systematic error of ± 0.004.

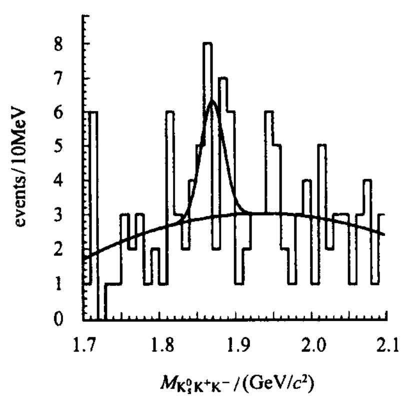

Fig.8. Invariant mass distribution of $\overline{K}^0(K^+K^-)_{\text{non-}\phi}$.

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

$Br(D^0 \to \overline{K}^0(K^+K^-)_{non\text{-}\phi}) = (0.27 \pm 0.13 \pm 0.03)\%$. The second error is systematic, reflecting the systematic uncertainty in the ratio of branching fractions for $D^0 \to \overline{K}^0(K^+K^-)_{non\text{-}\phi}$ and $D^0 \to \overline{K}^0\pi^+\pi^-$, and the uncertainty in the branching fraction for $D^0 \to K_s^0\pi^+\pi^-$.

5 Conclusion

In summary, using the data collected with BES-Ⅰ detector at BEPC Collider we have measured the branching fraction for $D^0 \to \overline{K}^0\pi^+\pi^-$ to be $(5.37 \pm 0.52 \pm 0.40)\%$. Using a coherent amplitude analysis we measured the branching fractions for the decays $D^0 \to K^{*-}\pi^+$, $D^0 \to \overline{K}^0\rho^0$ and $D^0 \to \overline{K}^0\pi^+\pi^-_{non\text{-}resonant}$ to be $(6.05 \pm 0.32 \pm 0.49)\%$, $(1.17 \pm 0.17 \pm 0.13)\%$ and $(1.35 \pm 0.22 \pm 0.17)\%$, respectively. We have measured the branching fractions $Br(D^0 \to f)$ to be $(1.04 \pm 0.24 \pm 0.16)\%$ for $f = \overline{K}^0K^+K^-$, $(1.12 \pm 0.34 \pm 0.15)\%$ for $f = \overline{K}^0\phi$, and $(0.27 \pm 0.13 \pm 0.03)\%$ for $f = \overline{K}^0(K^+K^-)_{non\text{-}\phi}$.

Our results are consistent with those from ARGUS[5], MARK-Ⅲ[6], CLEO[7] and E687[8] measurements. Our measured value of branching fraction $Br(D^0 \to \overline{K}^0\phi) = (1.12 \pm 0.34 \pm 0.15)\%$ is also consistent within the error with the Enhancement W-exchange model[13] and some other models[14] predictions.

The BES collaboration thanks the BEPC staff for their strong efforts and thanks the member of the IHEP computing center for their helpful assistance.

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遍举衰变过程$D^0\to K_s^0\pi^+\pi^-$和$D^0\to K_s^0K^+K^-$及其共振态结构的实验研究*

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2003－02－25 收稿，2003－09－11 收修改稿

＊国家自然科学基金(19991480)，国家杰出青年科学基金(10225524，10225525)，中国科学院九五重大及特别支持项目(KJ95T－03)，中国科学院百人计划基金(U－24，U－25)，中国科学院知识创新基金(U－602，U－34)资助

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摘要 利用北京谱仪(BES-Ⅰ)在北京正负电子对撞机(BEPC)e^+e^-质心系能量为4.03GeV处采集的积分亮度为$22.3pb^{-1}$的数据,研究了$D^0\to K_s^0\pi^+\pi^-$,$D^0\to K_s^0K^+K^-$的衰变及其末态的共振结构.实验测得$D^0\to K_s^0\pi^+\pi^-$过程的分支比为(5.32±0.53±0.40)%;$D^0\to K^{*-}\pi^+$,$D^0\to\overline{K}^0\rho^0$和$D^0\to K_s^0(\pi^+\pi^-)_{non\text{-}resonance}$过程的分支比分别为(6.05±0.32±0.49)%,(1.17±0.17±0.13)%和(1.35±0.22±0.17)%;测得$D^0\to K_s^0K^+K^-$,$D^0\to\overline{K}^0\phi$和$D^0\to\overline{K}^0(K^+K^-)_{non\text{-}\phi}$的分支比分别为(1.04±0.24±0.16)%,(1.12±0.34±0.15)%和(0.27±0.13±0.03)%.

关键词 北京谱仪 北京正负电子对撞机 D介子 分支比

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