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Direct measurements of the non-$D\bar{D}$ cross section $\sigma_{\psi(3770)\to \text{non-}D\bar{D}}$ at $E_{\text{cm}} = 3.773$ GeV and the branching fraction for $\psi(3770) \to$ non-$D\bar{D}$

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By analyzing the data collected at the center-of-mass energy $E_{\text{cm}} = 3.773$ GeV and below the $D\bar{D}$ meson pair production threshold with the BES-II detector at the BEPC Collider, we directly measured the observed non-$D\bar{D}$ cross section of $\psi(3770)$ decay to be $\sigma^{\text{obs}}_{\psi(3770)\to\text{non-}D\bar{D}} = (0.95 \pm 0.35 \pm 0.29)$ nb at $E_{\text{cm}} = 3.773$ GeV, and the branching fraction $BF[\psi(3770) \to \text{non-}D\bar{D}] = (13.4 \pm 5.0 \pm 3.6)\%$ for inclusive non-$D\bar{D}$ decay of $\psi(3770)$. We also determined the cross section for $D\bar{D}$ meson pair production to be $\sigma^{\text{obs}}_{D\bar{D}} = (6.12 \pm 0.37 \pm 0.23)$ nb at $E_{\text{cm}} = 3.773$ GeV.

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$\psi(3770)$ is the lowest mass charmonium resonance above the $D\bar{D}$ meson pair production threshold. Since the measured leptonic width [1–5] of $\psi(3770)$ is larger than the expected one of the pure 1^3D_1 state calculated in the charmonium model [6], $\psi(3770)$ is believed to be a mixture of the D-wave and S-wave of the angular momentum eigenstates of the $c\bar{c}$ system [6]. Because the total width [1–5] of $\psi(3770)$ is almost 2 orders of magnitude larger than the one of $\psi(3686)$, $\psi(3770)$ is expected to decay almost entirely to pure $D\bar{D}$ meson pairs [2]. However, there has been a long-standing puzzle in the understanding of the $\psi(3770)$ production and decays. Before 2005, historically published data indicated that about 38% of $\psi(3770)$ does not decay into $D\bar{D}$ meson pairs [7]. In the last two years, many efforts were undertaken by the BES [8] and CLEO [9] Collaborations to search for the non-$D\bar{D}$ decays of $\psi(3770)$. Based on two analysis methods and independent data samples, the BES Collaboration recently measured the branching fraction for $\psi(3770) \to$ non-$D\bar{D}$ to be $(14.5 \pm 1.7 \pm 5.8)\%$ [10] and $(16.4 \pm 7.3 \pm 4.2)\%$ [4], respectively. However, these measurements of the branching fraction were all based on comparing the cross sections for inclusive hadronic event production and $D\bar{D}$ meson pair production with two different kinds of estimations of the detection efficiencies.

In this paper, we report a first direct measurement of the cross section for $\psi(3770) \to$ non-$D\bar{D}$ at 3.773 GeV and a direct measurement of the branching fraction for $\psi(3770) \to$ non-$D\bar{D}$ by analyzing the cross section for $e^+e^- \to$ hadrons, where the hadrons do not come from $D\bar{D}$ meson pair decays, and analyzing the cross sections measured below the $D\bar{D}$ meson pair production threshold. The data samples used in the analysis were taken with the BES-II detector [11] at the BEPC Collider.

The observed hadronic cross section is determined by

$$\sigma^{\rm obs}_{{\rm had-non-}D\bar{D}} = \frac{N^{\rm obs}_{{\rm had-non-}D\bar{D}}}{L\epsilon_{{\rm had-non-}D\bar{D}}\epsilon^{\rm trig}_{\rm had}}, \qquad (1)$$

where $N^{\rm obs}_{{\rm had-non-}D\bar{D}}$ is the number of the observed inclusive hadronic events not coming from $D\bar{D}$ meson pair decays, L is the integrated luminosity of the data, $\epsilon_{{\rm had-non-}D\bar{D}}$ is the efficiency for detection of the inclusive non-$D\bar{D}$ hadronic events and $\epsilon^{\rm trig}_{\rm had}$ is the trigger efficiency for collecting hadronic events in the online data acquisition system.

The hadronic events are required to have more than 2 good charged tracks. Each of the charged tracks is required to have well-measured momenta and to satisfy the selection criteria as described in Ref. [10]. In order to select the hadronic events not coming from the $D\bar{D}$ meson pair decays, the events are examined for the largest energy $E_{\rm K\,max}$ of a charged track under the assumption that it is a kaon from the final state. If a charged track satisfies the selection criterion of $1.15\ {\rm GeV} < E_{\rm K\,max} < 2.00\ {\rm GeV}$ from an event, the event is kept for further analysis. The lower $E_{\rm K\,max}$ cut removes about 99% $D\bar{D}$ events away and the upper $E_{\rm K\,max}$ cut removes most cosmic rays away from the selected inclusive non-$D\bar{D}$ hadronic events. Figure 1(a) shows the distributions of $E_{\rm K\,max}$ for Monte Carlo samples of $D\bar{D}$ events (hatched histogram) and for Monte Carlo samples of $e^+e^- \to$ hadrons (histogram) events, which are generated at the energies around the peak of $\psi(3770)$ with a special Monte Carlo generator for $e^+e^- \to$ hadrons [12]. The latter one includes 85% $D\bar{D}$ and 15% inclusive non-$D\bar{D}$ of $\psi(3770)$ decays. It also includes the continuum light hadronic events and the hadronic events coming from both the $\psi(3686)$ and J/ψ decays. Figure 1(b) shows a comparison of $E_{\rm K\,max}$ for the hadronic events satisfying the selection criteria as discussed in Ref. [10]. These hadronic events are from the Monte Carlo sample (histogram) generated and the data sample (points with errors) collected at 3.773 GeV. The comparison between the Monte Carlo samples and the data is in good agreement, which allows us to select the inclusive non-$D\bar{D}$ hadronic events and measure the non-$D\bar{D}$ cross section by tagging $E_{\rm K\,max}$ of the event for $e^+e^- \to$ hadrons. To separate some beam-gas associated background events and cosmic ray background events from the hadronic events, we calculate the event vertex in the beam line direction. Figure 1(c) shows the distribution of the accepted event vertex in z from the data taken at $E_{\rm cm} = 3.6648$ GeV, which satisfy the selection

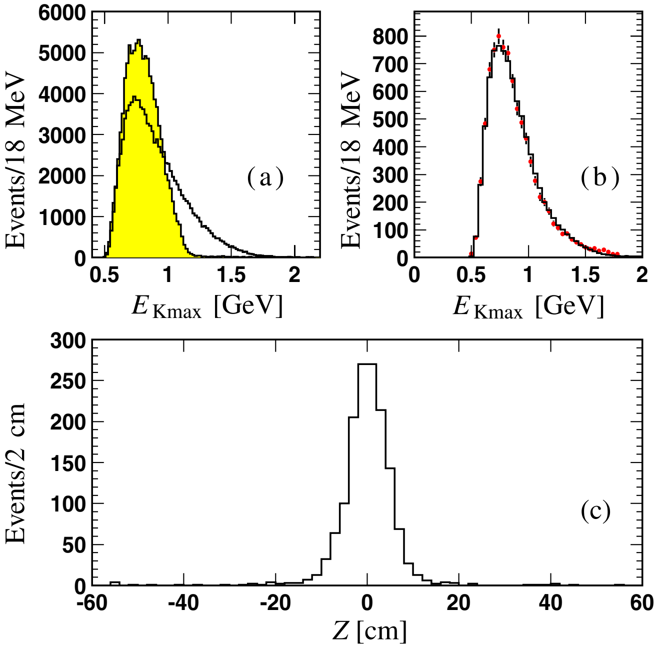

FIG. 1 (color online). (a) and (b) are the distributions of $E_{\rm K\,max}$ for the inclusive hadronic events $e^+e^- \to$ hadrons, where the hatched histogram is for Monte Carlo samples of $\psi(3770) \to D\bar{D}$ events; the open histogram is for Monte Carlo samples of 15% $\psi(3770) \to$ light hadrons and 85% $\psi(3770) \to D\bar{D}$, it also includes continuum light hadronic events and the hadronic events from both the $\psi(3686)$ and J/ψ decays; the dot with error bars is for the data; (c) is the distribution of the accepted event vertex in z (beam line direction).

criteria [10] and the energy selection criterion of $1.15\ \text{GeV} < E_{\text{K max}} < 2.00\ \text{GeV}$. By counting the numbers of the events within signal region ($|V_z| < 3.5\sigma$, where σ is the standard deviation of the event vertex distribution in z) and sideband regions ($4.0\sigma < |V_z| < 9.0\sigma$), we obtain $N^{\text{zcnt}}_{\text{had-non-}D\bar{D}} = 1418 \pm 39$ candidates for the inclusive non-$D\bar{D}$ hadronic events. Applying the procedure to the data sets taken at $E_{\text{cm}} = 3.650$ GeV and at $E_{\text{cm}} = 3.773$ GeV, we obtain the numbers of the candidates for the inclusive non-$D\bar{D}$ hadronic events. These numbers are listed in the third column of Table I. The systematic uncertainty in measurement of the hadronic cross section due to the hadronic event selection criteria is estimated to be ~2.5% [10].

These numbers of candidates for the inclusive non-$D\bar{D}$ hadronic events contain contaminations from some background sources such as $e^+e^- \to \tau^+\tau^-$, $e^+e^- \to (n\gamma)e^+e^-$, $e^+e^- \to (n\gamma)\mu^+\mu^-$, two-photon exchange processes, as well as a small amount of the $D\bar{D}$ meson pair events. The numbers of these background events can be estimated by using theoretical or experimental cross sections of these processes, the rates of misidentifying these processes as the inclusive non-$D\bar{D}$ hadronic events and the integrated luminosities of the data sets. For each of the processes, the number of the backgrounds is given by

$$n_{\text{mode}} = L\sigma_{\text{mode}}\eta_{\text{mode}}, \tag{2}$$

where σ_{mode} is the cross section for the process, mode represents the process in question, η_{mode} is the corresponding misidentification rate. The calculations of the cross sections for the first four processes and generations of these Monte Carlo samples are discussed in Ref. [10] in more detail. We use the observed $D\bar{D}$ meson pair production cross section $\sigma^{\text{obs}}_{D\bar{D}} = 6.14 \pm 0.51$ nb measured by the BES Collaboration [13] from the same data sample to calculate the number $n_{D\bar{D}}$ of the $D\bar{D}$ backgrounds. To generate the Monte Carlo samples for $\psi(3770) \to D^0\bar{D}^0$, D^+D^-, we set the rate of the $D^0\bar{D}^0$ yield over the total $D\bar{D}$ yield to be 0.58 and let the $D^0\bar{D}^0$ and D^+D^- meson pairs decay into all possible final states according to the known decay modes and their branching fractions listed in PDG [14]. The rates of misidentifying the above five processes as the inclusive non-$D\bar{D}$ hadronic events are obtained by analyzing these Monte Carlo samples. For example, analyzing the Monte Carlo events for $\psi(3770) \to D^0\bar{D}^0$, D^+D^- yields the misidentification rate $\eta_{D\bar{D}} = 0.814\%$, which indicates that there are 865 ± 72 $D\bar{D}$ meson pair events in the sample of the selected candidates for inclusive non-$D\bar{D}$ hadronic events. Similarly, we can measure other misidentification rates, such as $\eta_{l^+l^-}$ ($l = e$, μ, τ), $\eta_{e^+e^-l^+l^-}$ and $\eta_{e^+e^-h}$, by analyzing the corresponding Monte Carlo samples. With the theoretical cross sections for these processes, the corresponding misidentification rates and the luminosities of data sets, we obtain the numbers of these backgrounds. The 4th, 5th, and 6th columns of Table I give the estimated numbers ($n_{l^+l^-}$, $n_{e^+e^-l^+l^-\&e^+e^-h}$, and $n_{D\bar{D}}$) of the background events from $e^+e^- \to l^+l^-$, two-photon exchange processes and $\psi(3770) \to D\bar{D}$, which are misidentified as the inclusive non-$D\bar{D}$ hadronic events.

The detection efficiency for the inclusive non-$D\bar{D}$ hadronic events is determined via the Monte Carlo generator [12] in which the radiative corrections to α^2 order are taken into account. The generated events are simulated with the GEANT3-based Monte Carlo simulation package [15]. As mentioned above, the good agreement of the $E_{\text{K max}}$ distributions between the data and Monte Carlo samples [see Fig. 1(b)] allows us to correctly estimate the efficiency for selection of the inclusive non-$D\bar{D}$ hadronic events by tagging the largest energy of assumed kaon in the final state and directly measure the inclusive non-$D\bar{D}$ branching fraction of $\psi(3770)$ decays. The systematic uncertainty in the efficiencies due to the generator is estimated to be ~2.0% (~ 0.7%) [10] for reconstruction of the hadronic events from $\psi(3770)$ and $\psi(3686)$ decays (from continuum process). The 7th column of Table I gives the detection efficiencies for observation of the inclusive non-$D\bar{D}$ hadronic events at 3 energy points, where the errors are the statistical only.

The integrated luminosities of the data sets are determined using large-angle Bhabha scattering events as described in Ref. [10]. The systematic uncertainty in the measured luminosities is estimated to be ~2.1% [10]. The second column of Table I lists the integrated luminosities of the data sets.

The trigger efficiencies are measured to be $\epsilon_{\text{trig}} = (100.0^{+0.0}_{-0.5})\%$ for both the $e^+e^- \to (n\gamma)e^+e^-$ and $e^+e^- \to$ hadrons events [10].

The observed cross section for the inclusive non-$D\bar{D}$ hadronic event production can be determined with Eq. (1) by substituting $N^{\text{obs}}_{\text{had-non-}D\bar{D}}$ with $N^{\text{zcnt}}_{\text{had-non-}D\bar{D}} - N_{\text{b}}$, where $N_{\text{b}} = n_{l^+l^-} + n_{e^+e^-l^+l^-\&e^+e^-h} + n_{D\bar{D}}$ is the number of the background events as summarized in Table I. Inserting $N^{\text{zcnt}}_{\text{had-non-}D\bar{D}}$, $\epsilon_{\text{had-non-}D\bar{D}}$, N_{b} as summarized in Table I, $\epsilon^{\text{trig}}_{\text{had}}$ and L in Eq. (1), we obtain the inclusive non-$D\bar{D}$ cross sections $\sigma^{\text{obs}}_{\text{had-non-}D\bar{D}}$ which are listed in the last column of Table I, where the first errors are statistical and the second point-to-point systematic uncertainties arising from the relative uncertainty (~ 0.9%) in $\epsilon_{\text{had-non-}D\bar{D}}$ and relative statistical error (~ 0.3%) of the luminosity.

At $E_{\text{cm}} = 3.773$ GeV, the observed cross section for inclusive hadronic event production has four components: (1) continuum light hadron production, (2) J/ψ production due to ISR (initial state radiative), (3) $\psi(3686)$ production due to ISR, and (4) $\psi(3770)$ production [16]. With the parameters of $\psi(3686)$ [4,14] and J/ψ resonances [14], and taking into account the ISR corrections and VP (vacuum polarization) effects, we can calculate the expected experimentally observed cross sections for the $\psi(3686)$ and J/ψ production. At $E_{\text{cm}} = 3.773$ GeV, the expected cross sections for $\psi(3686)$ and J/ψ production are

TABLE I. Summary of the luminosities of the data sets, the numbers of the selected candidates for $e^+e^- \to$ non-$D\bar{D}$ hadrons, the estimated numbers for the processes $e^+e^- \to l^+l^-$ ($l = \tau, e, \mu$), $e^+e^- \to e^+e^-l^+l^-$, $e^+e^- \to e^+e^-$hadrons, and $e^+e^- \to D\bar{D}$ which are misidentified as the events of $e^+e^- \to$ non-$D\bar{D}$ hadrons, the detection efficiencies, and the observed non-$D\bar{D}$ cross sections.

$E_{\rm cm}$ [GeV]	L [nb^{-1}]	$N^{\rm zcnt}_{\rm han\text{—}non\text{-}D\bar{D}}$	$n_{l^+l^-}$	$n_{e^+e^-l^+l^-\&e^+e^-h}$	$n_{D\bar{D}}$	$\epsilon_{\rm had\text{—}non\text{-}D\bar{D}}$[%]	$\sigma^{\rm obs}_{\rm had\text{—}non\text{-}D\bar{D}}$ [nb]
3.650	5537.7	7622 ± 88	238	27	0	7.11 ± 0.06	18.69 ± 0.22 ± 0.18
3.6648	998.2	1418 ± 39	45	6	0	7.19 ± 0.06	19.05 ± 0.54 ± 0.18
3.773	17 300	30 787 ± 177	943	77	865 ± 72	7.75 ± 0.07	21.56 ± 0.13 ± 0.21

$\sigma^{\rm expect}_{\psi(3686)} = 2.778 \pm 0.239$ nb and $\sigma^{\rm expect}_{J/\psi} = 0.968 \pm 0.088$ nb. While the expected cross section for the light hadron production can be obtained based on the measured cross sections at $E_{\rm cm} = 3.650$ GeV and $E_{\rm cm} = 3.6648$ GeV.

Taking into account the ISR and VP corrections, the observed inclusive non-$D\bar{D}$ cross section $\sigma^{\rm obs}_{\rm had\text{—}non\text{-}D\bar{D}}$ for $e^+e^- \to$ hadrons measured at 3.650 and 3.6648 GeV can be transferred into the zero order cross section $\sigma^0_{\rm had}$ for the inclusive hadron production, which are

$$\sigma^0_{\rm had1} = (14.48 \pm 0.22 \pm 0.55)\ {\rm nb} \quad \text{for } E_{\rm cm} = 3.650\ {\rm GeV}$$

and

$$\sigma^0_{\rm had2} = (15.08 \pm 0.45 \pm 0.57)\ {\rm nb} \quad \text{for } E_{\rm cm} = 3.6648\ {\rm GeV},$$

where the first errors are combined from statistical and point-to-point systematic uncertainties and the second common systematic arising from the uncertainties in hadronic event selection (~ 2.5%), in measurement of the luminosity (~ 2.1%) and in Monte Carlo modeling (~ 2.0%). These cross sections still include the contributions from $\psi(3686)$ and J/ψ. The amounts of these contributions are $\sigma^0_{\psi(3686)} = 0.136 \pm 0.012$ nb and $\sigma^0_{J/\psi} = 0.001 \pm 0.000$ nb at $E_{\rm cm} = 3.650$ GeV, and $\sigma^0_{\psi(3686)} = 0.390 \pm 0.033$ nb and $\sigma^0_{J/\psi} = 0.001 \pm 0.000$ nb at $E_{\rm cm} = 3.6648$ GeV. Subtracting the contributions of $\psi(3686)$ and J/ψ from $\sigma^0_{\rm had}$ yields the zero order cross sections $\sigma^0_{\rm lt\ had}$ for the light hadron production in continuum e^+e^- annihilation. Dividing $\sigma^0_{\rm lt\ had}$ by the zero order cross sections for $e^+e^- \to \mu^+\mu^-$ yields the $R_{\rm uds}$ values for continuum light hadron production at the two energy points to be

$$R_{\rm uds1} = 2.200 \pm 0.034 \pm 0.084 \quad \text{for } E_{\rm cm} = 3.650\ {\rm GeV}$$

and

$$R_{\rm uds2} = 2.272 \pm 0.070 \pm 0.088 \quad \text{for } E_{\rm cm} = 3.6648\ {\rm GeV},$$

where the errors are, respectively, the combined statistical and point-to-point systematic errors and the common systematic uncertainty. Averaging $R_{\rm uds1}$ and $R_{\rm uds2}$ by weighting the combined statistical and point-to-point systematic errors, we obtain

$$\bar{R}_{\rm uds} = 2.214 \pm 0.031 \pm 0.088 \pm 0.033,$$

where the first error is combined from statistical and point-to-point systematic errors, the second is common systematic, and the third is the systematic error (~ 1.5%) due to ISR and VP corrections. This averaged $\bar{R}_{\rm uds}$ is well consistent with $\bar{R}_{\rm uds} = 2.218 \pm 0.019 \pm 0.089$ measured by the BES Collaboration [10] by analyzing the same data sample without tagging the largest assumed kaon energy.

At $E_{\rm cm} = 3.773$ GeV, the ISR and VP correction factor for continuum light hadron production is 1.248. Taking into account these effects in calculation of the observed cross section for continuum light hadron production at $E_{\rm cm} = 3.773$ GeV, we obtain

$$\sigma^{\rm obs}_{\rm lt\ had} = (16.86 \pm 0.24 \pm 0.67)\ {\rm nb}.$$

Summing over the three components yields the totally observed cross section except $\psi(3770)$ production at 3.773 GeV to be

$$\sigma^{\rm obs}_{{\rm lt\ had}+\psi(3686)+J/\psi} = (20.61 \pm 0.24 \pm 0.67 \pm 0.25)\ {\rm nb}.$$

Subtracting $\sigma^{\rm obs}_{{\rm lt\ had}+\psi(3686)+J/\psi}$ from the totally observed inclusive non-$D\bar{D}$ cross section $\sigma^{{\rm non}\text{-}D\bar{D}}_{\rm had} = (21.56 \pm 0.25 \pm 0.82)$ nb at 3.773 GeV, where the first error is combined from statistical error and point-to-point systematic uncertainty, and the second is the common systematic uncertainty, yields the observed inclusive non-$D\bar{D}$ cross section

$$\sigma^{\rm obs}_{\psi(3770)\to{\rm non}\text{-}D\bar{D}} = (0.95 \pm 0.35 \pm 0.15 \pm 0.25)\ {\rm nb},$$

where the errors are the combined statistical and point-to-point systematic uncertainties, the uncanceled common systematic uncertainty, and the systematic error of the combined uncertainties of $\sigma^{\rm expect}_{\psi(3686)}$ (0.239 nb) and $\sigma^{\rm expect}_{J/\psi}$ (0.088 nb), respectively. Since the relative systematic uncertainties of the two cross sections, $\sigma^{\rm obs}_{\rm lt\ had}$ and $\sigma^{{\rm non}\text{-}D\bar{D}}_{\rm had}$, are the same and these arise from the same sources of the systematic uncertainties, the same amount of the systematic uncertainty of $\sigma^{\rm obs}_{\psi(3770)\to{\rm non}\text{-}D\bar{D}}$ obtained by subtracting $\sigma^{\rm obs}_{{\rm lt\ had}+\psi(3686)+J/\psi}$ from $\sigma^{{\rm non}\text{-}D\bar{D}}_{\rm had}$ is canceled out.

The BES Collaboration measured the observed inclusive cross section for $e^+e^- \to$ hadrons at 3.773 GeV to be $\sigma^{\rm obs}_{\rm had} = (27.68 \pm 0.27 \pm 1.05)$ nb [10] obtained by analyzing the same data sample, where the first error is combined from statistical and point-to-point systematic uncertainties and the second the common systematic error. To measure the observed cross section for $\psi(3770)$ production at $E_{\rm cm} = 3.773$ GeV, we subtract $\sigma^{\rm obs}_{\rm lt\,had+\psi(3686)+J/\psi}$ from the $\sigma^{\rm obs}_{\rm had}$, which yields

$$\sigma^{\rm obs}_{\psi(3770)} = (7.07 \pm 0.36 \pm 0.38 \pm 0.25)\ {\rm nb},$$

where the errors are the combined statistical and point-to-point systematic uncertainties, the uncanceled common systematic uncertainty, and the systematic error of the combined uncertainties of $\sigma^{\rm expect}_{\psi(3686)}$ and $\sigma^{\rm expect}_{J/\psi}$, respectively. This cross section is consistent with $\sigma^{\rm obs}_{\psi(3770)} = (7.15 \pm 0.27 \pm 0.27)$ nb [4,5,17], where the errors are, respectively, the combined statistical and point-to-point systematic uncertainties, and the common systematic uncertainty.

Similarly, subtracting the observed inclusive non-$D\bar{D}$ cross section $\sigma^{{\rm non}\text{-}D\bar{D}}_{\rm had} = (21.56 \pm 0.25 \pm 0.82)$ nb measured in this work from $\sigma^{\rm obs}_{\rm had} = (27.68 \pm 0.27 \pm 1.05)$ nb [10] yields the expected cross section for $D\bar{D}$ meson pair production observed at $E_{\rm cm} = 3.773$ GeV to be

$$\sigma^{\rm obs}_{D\bar{D}} = (6.12 \pm 0.37 \pm 0.23)\ {\rm nb},$$

which is consistent with $\sigma^{\rm obs}_{D\bar{D}} = (6.14 \pm 0.12 \pm 0.50)$ nb measured by analyzing the singly tagged D mesons [13] from the same data sample, where the errors are, respectively, the combined statistical and point-to-point systematic uncertainties, and the common systematic uncertainty.

The inclusive non-$D\bar{D}$ branching fraction of $\psi(3770)$ decay can directly be obtained by

$$BF[\psi(3770) \to {\rm non}\text{-}D\bar{D}] = \frac{\sigma^{\rm obs}_{\psi(3770)\to{\rm non}\text{-}D\bar{D}}}{\sigma^{\rm obs}_{\psi(3770)}}. \qquad (3)$$

Inserting the observed cross sections in Eq. (3) yields

$$BF[\psi(3770) \to {\rm non}\text{-}D\bar{D}] = (13.4 \pm 5.0 \pm 3.6)\%,$$

where the errors are the combined statistical and point-to-point systematic uncertainties, and the common systematic uncertainty, respectively. In estimation of the common systematic error, some of the common errors are canceled. This branching fraction yields the branching fraction for $\psi(3770) \to D\bar{D}$ to be

$$BF[\psi(3770) \to D\bar{D}] = (86.6 \pm 5.0 \pm 3.6)\%.$$

In summary, by tagging the largest energy of assumed kaon from the final state of $e^+e^- \to$ hadrons, we directly measured the branching fraction for $\psi(3770) \to$ non-$D\bar{D}$ decay. This measured branching fraction does not depend on the observed cross sections for $D^0\bar{D}^0$ and D^+D^- meson pair production. Since the observed cross sections for $D^0\bar{D}^0$ and D^+D^- meson pair production are normally measured based on analyzing some exclusive decay modes of the D^0 and D^+ mesons, comparing the inclusive hadronic cross sections with the $D\bar{D}$ meson pair cross sections to determine the inclusive non-$D\bar{D}$ branching fraction of $\psi(3770)$ decays may suffer from some systematic shifts due to the different estimations of the efficiencies for detection of the exclusive decay modes of D meson decays and the inclusive hadronic events. In this work, we directly observed an enhancement of the inclusive non-$D\bar{D}$ hadronic event production and measured its cross section to be $\sigma^{\rm obs}_{{\rm non}-D\bar{D}} = (0.95 \pm 0.35 \pm 0.29)$ nb at $E_{\rm cm} = 3.773$ GeV. Assuming that there is no new structure or effects except the $\psi(3770)$ resonance in the range from 3.70 to 3.87 GeV, we directly measured the branching fraction for $\psi(3770)$ inclusive non-$D\bar{D}$ decay to be $BF[\psi(3770) \to {\rm non}\text{-}D\bar{D}] = (13.4 \pm 5.0 \pm 3.6)\%$, corresponding the branching fraction $BF[\psi(3770) \to D\bar{D}] = (86.6 \pm 5.0 \pm 3.6)\%$. These are well consistent within error with those indirectly measured by the BES Collaboration based on analysis of the inclusive and exclusive decay modes of $\psi(3770)$ together [4,10].

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