

Measurement of Absolute Hadronic Branching Fractions of D^0 and D^+ , and $\sigma(e^+e^- \rightarrow D\bar{D})$ at $E_{\text{cm}} = 3.77$ GeV

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Abstract. Using 57.2 pb^{-1} of data collected with the CLEO-c detector at the $\psi(3770)$ resonance, we measure absolute branching fractions for three D^0 and two D^+ Cabibbo-allowed hadronic decay modes, and the cross section for $e^+e^- \rightarrow D\bar{D}$ at $E_{\text{cm}} = 3.77$ GeV. We report preliminary measurements of branching fractions $\mathcal{B}(D^0 \rightarrow K^-\pi^+) = (3.92 \pm 0.08 \pm 0.23)\%$, $\mathcal{B}(D^0 \rightarrow K^-\pi^+\pi^0) = (14.3 \pm 0.3 \pm 1.0)\%$, $\mathcal{B}(D^0 \rightarrow K^-\pi^+\pi^+\pi^-) = (8.1 \pm 0.2 \pm 0.9)\%$, $\mathcal{B}(D^+ \rightarrow K^-\pi^+\pi^+) = (9.8 \pm 0.4 \pm 0.8)\%$, and $\mathcal{B}(D^+ \rightarrow K_S^0\pi^+) = (1.61 \pm 0.08 \pm 0.15)\%$. and the cross sections $\sigma(e^+e^- \rightarrow D\bar{D}) = (6.06 \pm 0.13 \pm 0.22) \text{ nb}$.

1. Introduction

We present preliminary absolute measurements of the D^0 and D^+ branching fractions, $\mathcal{B}(D^0 \rightarrow K^-\pi^+)$, $\mathcal{B}(D^0 \rightarrow K^-\pi^+\pi^0)$, $\mathcal{B}(D^0 \rightarrow K^-\pi^+\pi^+\pi^-)$, $\mathcal{B}(D^+ \rightarrow K^-\pi^+\pi^+)$, and $\mathcal{B}(D^+ \rightarrow K_S^0\pi^+)$. Two of these branching fractions, $\mathcal{B}(D^0 \rightarrow K^-\pi^+)$ and $\mathcal{B}(D^+ \rightarrow K^-\pi^+\pi^+)$ are particularly important because essentially all other D^0 and D^+ branching fractions are determined from ratios to one or the other of these two branching fractions. Furthermore, these reference branching fractions appear in many measurements of CKM matrix elements for c and b quark decays.

In this analysis, we use the double tagging technique pioneered by MARK III collaboration [1] to determine the number of $D\bar{D}$ pairs accurately. At $E_{\text{cm}} = 3.77$ GeV, the peak of the $\psi(3770)$ resonance, no additional hadrons accompany the $D^0\bar{D}^0$ and $D^+\bar{D}^-$ pairs that are produced.

For mode i , the number of D and \bar{D} single tags depends on the efficiency ϵ_i , branching ratio \mathcal{B}_i , and the number of $D\bar{D}$ pairs.

$$N_i = N_{D\bar{D}} \mathcal{B}_i \epsilon_i \quad \bar{N}_i = N_{D\bar{D}} \mathcal{B}_i \bar{\epsilon}_i$$

The number of double tags, when the D is reconstructed in mode i and \bar{D} is reconstructed in mode j , is

$$N_{ij} = N_{D\bar{D}} \mathcal{B}_i \mathcal{B}_j \epsilon_{ij},$$

Hence, the ratios of double tag events (N_{ij}) to single tag events (N_i and N_j) provide the branching fraction \mathcal{B}_i and the number of $D\bar{D}$ pairs.

$$\mathcal{B}_i = \frac{N_{ij}}{N_j} \frac{\epsilon_j}{\epsilon_{ij}} \quad N_{D\bar{D}} = \frac{N_i N_j}{N_{ij}} \frac{\epsilon_{ij}}{\epsilon_i \epsilon_j}$$

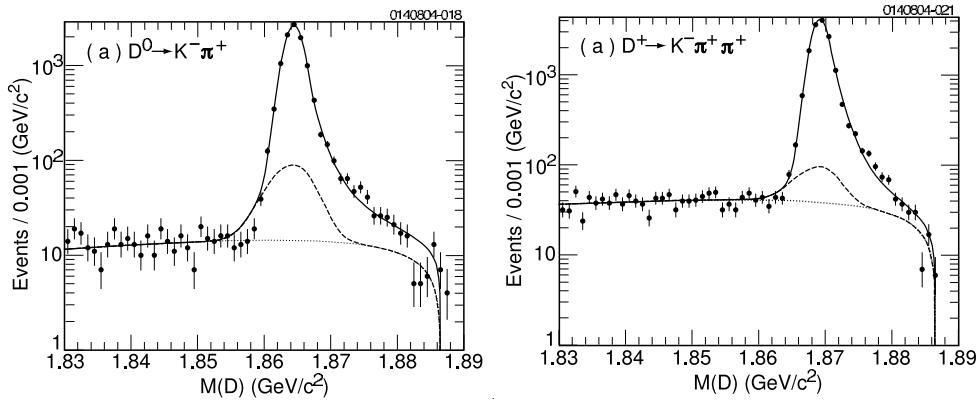


Figure 1. Example of the fits for the single tag yields in the modes $D^0 \rightarrow K^-\pi^+$ and $D^+ \rightarrow K^-\pi^+\pi^+$. The tail on the high side of the mass is due to initial state radiation in e^+e^- interaction.

Note that $\epsilon_{ij}/\epsilon_i\epsilon_j \approx 1$ and many systematic uncertainties cancel for the number of $D\bar{D}$ pairs.

The yields for D and \bar{D} are extracted separately. We measure 10 single tag and $13(3^2 + 2^2)$ double tag yields. From these 23 measurements, we extract the five hadronic branching fractions as well as the number of $D^0\bar{D}^0$ and D^+D^- .

2. Data sample and Event Selection

Our measurement is based on $\mathcal{L} = 57.2 \pm 1.7 \text{ pb}^{-1}$ of $\psi(3770)$ data collected with the CLEO-c detector at the Cornell Electron Storage Ring(CESR). The CLEO-c detector is a modified version of the CLEO III detector [2].

Events are reconstructed in the following way. The charged track candidates must pass the basic quality requirements. They are identified as pions or kaons using a combined dE/dx and RICH particle identification information. Neutral pion candidates have to pass a mass cut, and a subsequent kinematic fit is applied. K_S^0 candidates are built with pairs of tracks that pass a mass cut. To select D candidates, we apply a cut on the absolute value of the energy difference, $\Delta E \equiv E(D) - E_{beam}$, where $E(D)$ is the total energy of the particles in the D candidate. For the single tag yields, if there is more than one D candidate in a particular mode, we chose the candidate with smallest $|\Delta E|$ per mode per D flavor. For double tag yields, we select only one double tag candidate in a particular combination of D and \bar{D} modes. This best candidate is defined as the one which has an average mass closest to the nominal D mass. A Monte Carlo study demonstrates that this procedure does not generate false peaks in the $M(D) \text{ vs. } M(\bar{D})$ distributions.

3. Results

We used binned likelihood fits to extract single tag yields. Examples of fits are shown Fig. 1. The combinatorical background is modeled with a threshold (ARGUS) function [3]. The signal is modeled using a Crystal Ball function [4] plus a bifurcated Gaussian to model the longer tails in the $M(D)$ distribution due to misreconstruction of signal.

To extract the double tag yields, we perform an unbinned likelihood fit to the 2-D $M(D)$ distribution. The components are similar to those in single tag fits but much more complicated. In total, we have 2480 $D^0\bar{D}^0$ and 502 D^+D^- double tag events.

We have developed a χ^2 fitting procedure which fits simultaneously all charged and neutral D branching fractions and the numbers of charged and neutral $D\bar{D}$ pairs. We perform corrections

for backgrounds, efficiency, and crossfeed among modes directly in the fit. The fitter includes both statistical and systematic uncertainties, as well as their correlations. Also, the fitter deals with the correlations between single and double tag samples and correlations between measurements of \mathcal{B}_j using different tagging modes i . The χ^2 fitter was tested with generic Monte Carlo events. The test results were in excellent agreement with the input values.

We have considered many sources of systematic uncertainty. Among all these uncertainties, tracking efficiency, 3 % per-track, dominates.

Table 1. Preliminary fitted branching fractions, $D\bar{D}$ pair yields and cross sections. Uncertainties are statistical and systematic, respectively.

Parameter	Fitted Value	Cross section (nb)
$N_{D^0\bar{D}^0}$	$(1.98 \pm 0.04 \pm 0.03) \times 10^5$	$3.47 \pm 0.07 \pm 0.15$
$\mathcal{B}(D^0 \rightarrow K^-\pi^+)$	$0.0392 \pm 0.0008 \pm 0.0023$	
$\mathcal{B}(D^0 \rightarrow K^-\pi^+\pi^0)$	$0.143 \pm 0.003 \pm 0.010$	
$\mathcal{B}(D^0 \rightarrow K^-\pi^+\pi^+\pi^-)$	$0.081 \pm 0.002 \pm 0.009$	
$N_{D^+\bar{D}^-}$	$(1.48 \pm 0.06 \pm 0.04) \times 10^5$	$2.59 \pm 0.11 \pm 0.11$
$\mathcal{B}(D^+ \rightarrow K^-\pi^+\pi^+)$	$0.098 \pm 0.004 \pm 0.008$	
$\mathcal{B}(D^+ \rightarrow K_S^0\pi^+)$	$0.0161 \pm 0.0008 \pm 0.0015$	
$\sigma(e^+e^- \rightarrow D\bar{D})$		$6.06 \pm 0.13 \pm 0.22$
$\sigma(e^+e^- \rightarrow D^+D^-)/\sigma(e^+e^- \rightarrow D^0\bar{D}^0)$		$0.75 \pm 0.04 \pm 0.02$

The results of the fit to the data are shown in Table 1. All five branching fractions are consistent with - but also higher than - the current PDG averages [5]. The PDG values don't include Final State Radiation (FSR). If FSR is not included in our simulations to calculate signal efficiencies, then all the measured branching fractions would be 0.5 % to 0.2 % lower. Using the fitted number of $D\bar{D}$ events along with the luminosity, we find preliminary values of the production cross sections at $E_{\text{cm}} = 3770$ MeV. Our results are in good agreement with a recent BES result [6]. We expect to significantly reduce our systematic uncertainties in the near future.

4. Conclusion

Based on 57.2 pb^{-1} of data collected with the CLEO-c detector at the $\psi(3770)$ resonance in a pilot run, we measured absolute branching fractions for three D^0 and two D^+ Cabibo-allowed hadronic decay modes, and the $D\bar{D}$ cross section at $E_{\text{cm}} = 3770$ MeV.

Reference

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