Measurement of the near-threshold $e^+ e^- \to D\bar{D}$ cross section using initial-state radiation

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Introduction

- The parameters of the $J^{PC} = 1^{--}$ charmonium states obtained from fits to the inclusive cross section are poorly understood theoretically.

- **Interference between different resonant structures depends upon the specific final states, studies of exclusive cross sections for charmed meson pairs in this energy range are needed to clarify the situation.**

- **In this paper we report measurements of the exclusive cross sections for the processes** $e^+ e^- \to D^0 \overline{D}^0$ **and** $e^+ e^- \to D^+ D^-$ **using ISR that are a continuation of our studies of the near-threshold exclusive open-charm production.**

Event selection

We select $e^+e^- \to D\bar{D}\gamma_{\rm ISR}$ signal events by reconstructing both the D and $\bar{D}$ mesons, where $D\bar{D} = D^0\bar{D}^0$ or D^+D^-. In general, the $\gamma_{\rm ISR}$ is not required to be de-

constraint and considered as a π^0 candidate. D^0 candidates [16] are reconstructed using five decay modes: $K^-\pi^+$, K^-K^+, $K^-\pi^-\pi^+\pi^+$, $K^0_S\pi^+\pi^-$ and $K^-\pi^+\pi^0$. D^+ candidates are reconstructed using the decay modes $K^0_S\pi^+$ and $K^-\pi^+\pi^+$. A ± 15 MeV/c^2 mass window is used for all modes except for $K^-\pi^-\pi^+\pi^+$, where a ± 10 MeV/c^2 requirement is applied ($\sim 2.5\sigma$ in each case). To improve the momentum resolution of D meson candidates, final tracks are fitted to a common vertex and a D^0 or D^+ mass constraint is applied. The D candidates from a sideband region are refitted to the mass, corresponding to the center of the sideband region with the same width as the signal window.

Mass distribution of $D\bar{D}$

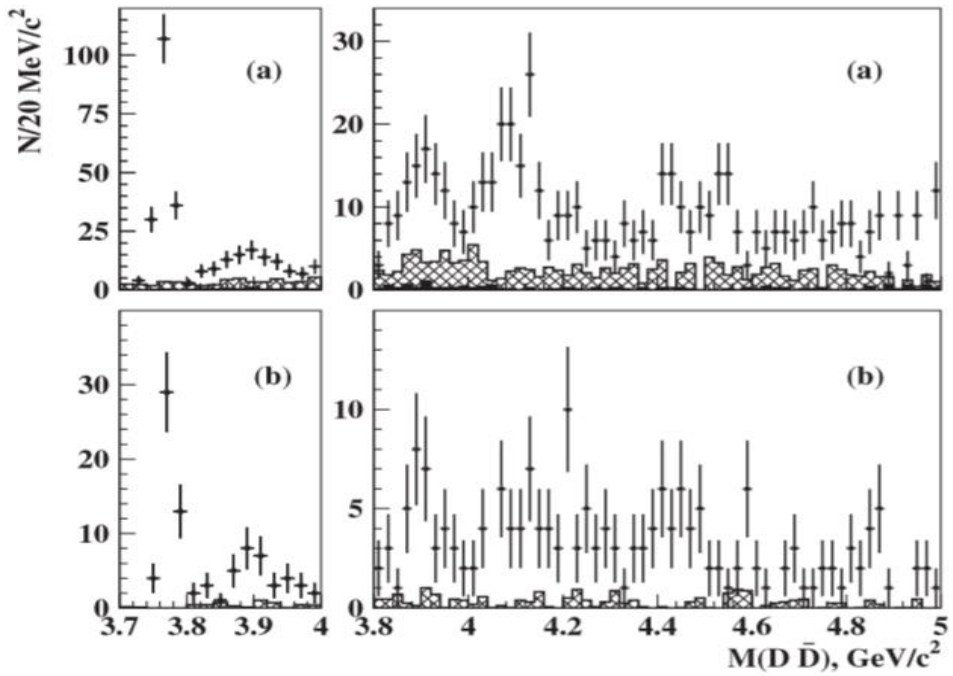

FIG. 2. The mass spectra of $D\bar{D}$ combinations (points with error bars): (a) $D^0\bar{D}^0$; (b) D^+D^-. The total contribution from combinatorial background (1–2) is shown as the hatched histogram, the contribution from background (4) is shown as the (barely visible) solid histogram.

The cross section of $D\bar{D}$

The $e^+e^- \to DD$ cross sections are extracted from the $D^0\bar{D}^0$ and D^+D^- mass distributions [17]

$$\sigma(e^+e^- \to D\bar{D}) = \frac{dN/dm}{\eta_{\rm tot} dL/dm}, \qquad (2)$$

where $m \equiv M_{D\bar{D}}$, dN/dm is the obtained mass spectra, while $\eta_{\rm tot}$ is the total efficiency. The factor dL/dm is the differential ISR luminosity

$$dL/dm = \frac{\alpha}{\pi x}\left((2 - 2x + x^2)\ln\frac{1+C}{1-C} - x^2 C\right)\frac{2m\mathcal{L}}{E^2_{\rm c.m.}}, \qquad (3)$$

where $x = 1 - m^2/E^2_{\rm c.m.}$, $\mathcal{L}$ is the total integrated luminosity and $C = \cos\theta_0$, where θ_0 defines the polar angle range for the $\gamma_{\rm ISR}$ in the e^+e^- c.m. frame: $\theta_0 < \theta_{\gamma_{\rm ISR}} < 180° - \theta_0$. The total efficiency determined by MC simulation grows linearly with $M_{D\bar{D}}$ from 0.095% near threshold to 0.46% at 5 GeV/c^2 for the $D^0\bar{D}^0$ and from 0.038% to 0.17% for the D^+D^- mode. The resulting $e^+e^- \to D^0\bar{D}^0$, $e^+e^- \to D^+D^-$ and $e^+e^- \to D\bar{D}$ exclusive cross sections, averaged over the bin width, are shown in Fig. 3 with statistical uncertainties only.

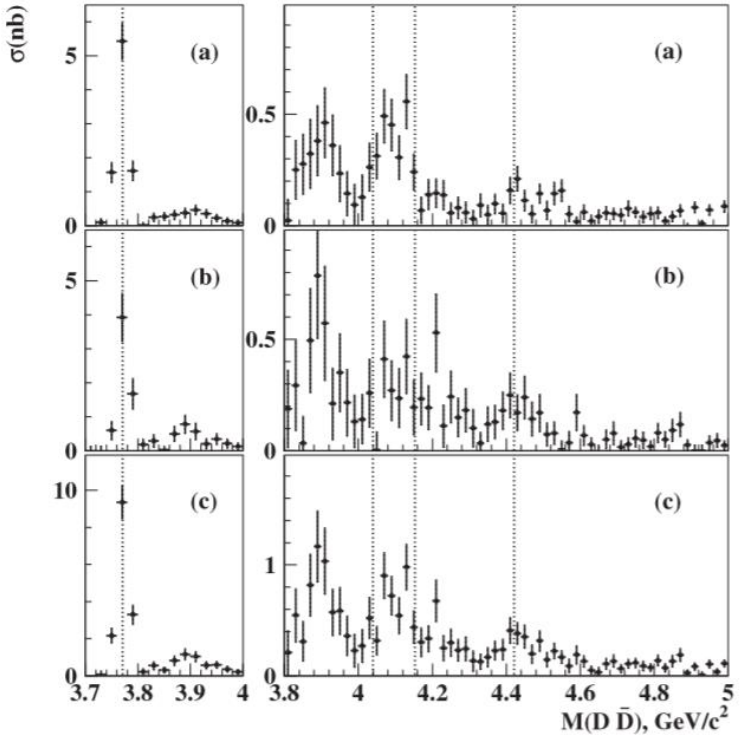

FIG. 3. The exclusive cross sections for (a) $e^+e^- \to D^0\bar{D}^0$; (b) $e^+e^- \to D^+D^-$; (c) $e^+e^- \to D\bar{D}$. The dotted lines correspond to the $\psi(3770)$, $\psi(4040)$, $\psi(4160)$ and $\psi(4415)$ masses [20].

- Question from Yuzhen
- 1. What is the near-threshold mean in the title of this paper?
- 2. In Fig.3, why do the authors add the four dotted lines correspond to the 3770, 4040, 4160 and 4415 masses, while not all of the lines are at the peak position?

- Answer:
- 1, threshold: the lowest energy that the decay can happen.

For example: $e^+ e^- \rightarrow D^0 \bar{D}^0$, the mass of D0 is 1.86484GeV, the same for $\bar{D}^0$, so the threshold of this decay is 1.86484+1.86484=3.73 GeV. Near-threshold in this paper means this measurement happen at the energy from 3.73 to 5GeV.

2, here they just indicate the mass position of these resonance to make a judgement whether these structures can be seen in this decay. They can see the PSI(3770)Not ant peak position means in this measurement , they can't see the structure.

- **Question from Amit**
- In table-I, Why is the systematic error for RECONSTRUCTION (+- 7 , +- 6 , +- 7) is high compared to other error sources, in the cross-section (%) measurement? Is this because they have used a partial reconstruction technique for the measurement of cross-section?
- Answer:

of the nominal π^0 mass, the pair is fit with a π^0 mass constraint and considered as a π^0 candidate. D^0 candidates [16] are reconstructed using five decay modes: $K^-\pi^+$, K^-K^+, $K^-\pi^-\pi^+\pi^+$, $K^0_S\pi^+\pi^-$ and $K^-\pi^+\pi^0$. D^+ candidates are reconstructed using the decay modes $K^0_S\pi^+$ and $K^-\pi^+\pi^+$. A ± 15 MeV/c^2 mass window is used for all

butions is taken into account. A second source of systematic error comes from the uncertainties in track and photon reconstruction efficiencies, which are 1% per track, 1.5% per photon and 5% per K^0_S, respectively. The systematic