Observation of a Charged Charmoniumlike Structure in $e^+e^- \to (D^*\overline{D}^*)^{\pm}\pi^{\mp}$ at $\sqrt{s} = 4.26$GeV

Yumo Su

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Motivation

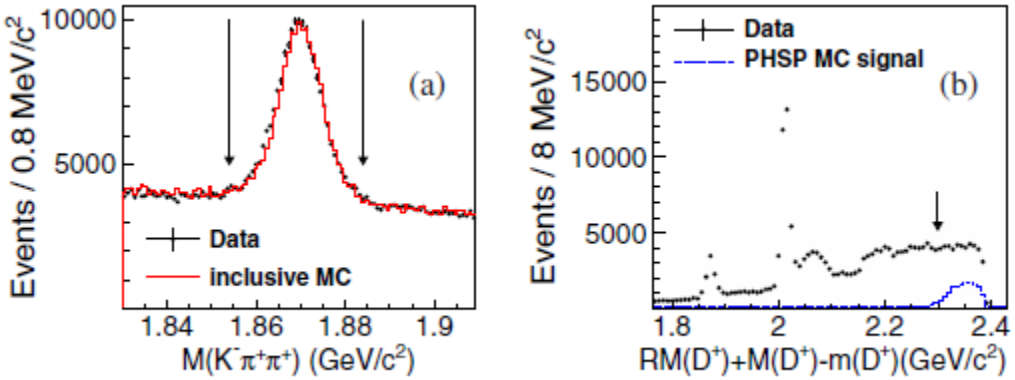
- BESIII has observed a number of XYZ states. The masses of these states are slightly higher than the $D^*\overline{D}^*$ mass thresholds.
- Therefore, a search of Z_c candidates via their direct decays into $D^*\overline{D}^*$ pairs is strongly motivated.

reconstruction

unless explicitly stated. We use a partial reconstruction technique to identify the $D^{*+}\bar{D}^{*0}\pi^-$ final states. This technique requires that only the π^- from the primary decay (denoted as the *bachelor* π^-), the D^+ decaying from $D^{*+} \to D^+\pi^0$, and at least one soft π^0 from $D^{*+} \to D^+\pi^0$ or $\bar{D}^{*0} \to \bar{D}^0\pi^0$ decay are reconstructed. By reconstructing the D^+ particle, the charges of its mother particle D^{*+} and the bachelor π^- can be unambiguously identified.

$$e^+e^- \to D^{*+} \quad \bar{D}^{*0} \quad \pi^-$$
$$\downarrow$$
$$D^+ \qquad\qquad \pi^0$$
$$\downarrow \qquad\qquad \downarrow$$
$$K^-\pi^+\pi^+ \qquad\qquad \gamma\gamma$$

Some distributions of observable quantity in data



All these cuts are to select signal channel

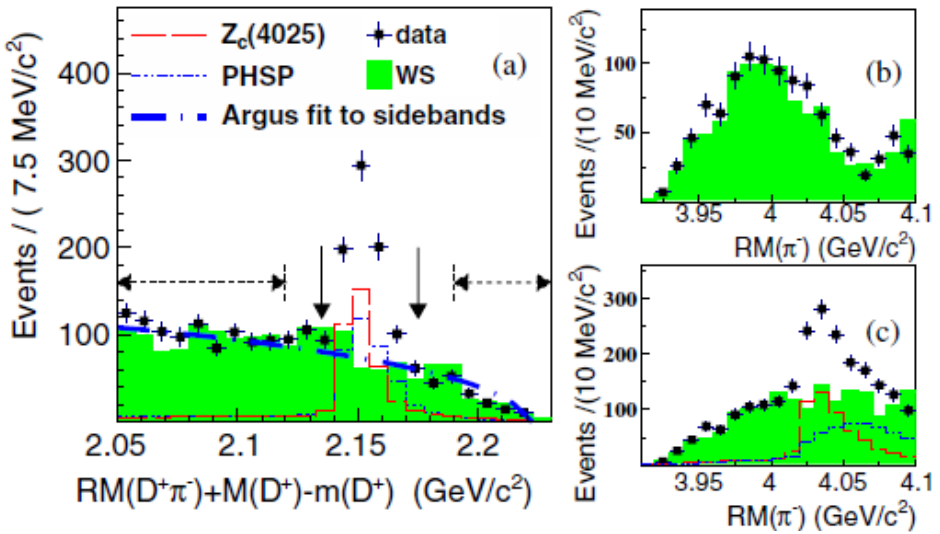
Figure 1(a) shows the $M(K^-\pi^+\pi^+)$ distribution where a D^+ peak is clearly evident. All combinations with invariant mass in the region $(1.854, 1.884)$ GeV/c^2 are identified as candidate D^+ mesons. The three peaks in the D^+ recoil

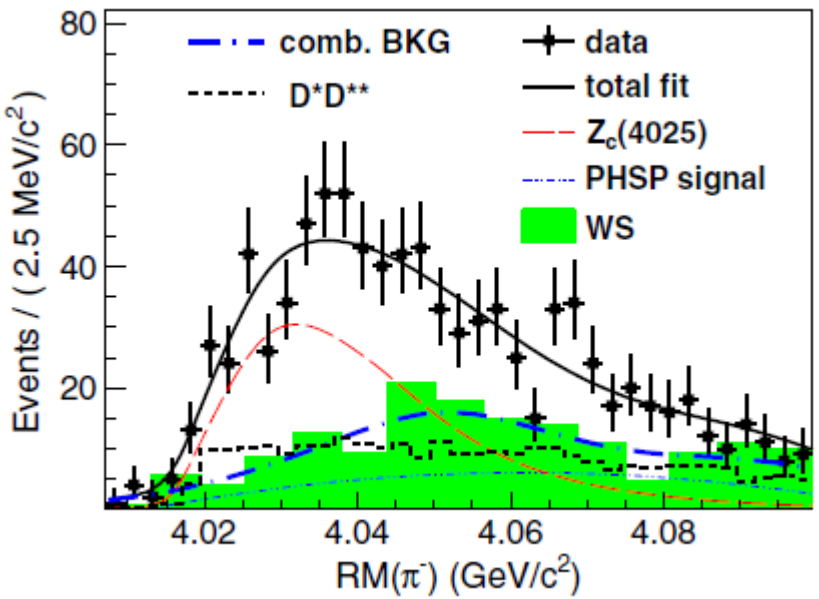
butions presented in this Letter. Backgrounds from the two-body process $e^+e^- \to D^{(*)}D^{(*)}$ are reduced by requiring $RM(D^+) + M(D^+) - m(D^+) > 2.3\text{GeV}/c^2$.

$\bar{D}^{*+} \to D^+\pi^0$ or $\bar{D}^{*0} \to \bar{D}^0\pi^0$ decay. In the case where the π^0 is from $D^{*+} \to D^+\pi^0$, the $D^+\pi^0$ invariant mass peaks at the D^{*+} mass and a mass region requirement $2.008\,\text{GeV}/c^2 < M(D^+\pi^0) - M(D^+) + m(D^+) - M(\pi^0) + m(\pi^0) < 2.013\,\text{GeV}/c^2$ is used, corresponding to the vertical band in Fig. 2. In the case where the π^0 is from

$\bar{D}^{*0} \to \bar{D}^0\pi^0$, its momentum in the $D^+\pi^-$ recoil system, $P^*(\pi^0)$, peaks at 43 MeV/c and a momentum requirement in the range $(0.03, 0.05)$ GeV/c is applied, corresponding to the horizontal band in Fig. 2. As verified by MC

Fit





computation of the recoil mass. For other nonsignal processes that have the same final state, such as $e^+e^- \to D^+\pi^0\bar{D}^{*0}\pi^-$, $D^{*+}\bar{D}^0\pi^0\pi^-$ and $D^+\pi^0\bar{D}^0\pi^0\pi^-$, MC simulations of the phase space (PHSP) model do not produce narrow structures. The distribution of combinatorial backgrounds is estimated by combining a reconstructed D^+ with a pion of the wrong charge, referred to as wrong-sign (WS) events. The $D^+\pi^-$ recoil mass

In Fig. 3(c), a clear enhancement above the WS background is evident. To study the enhancement, the events of the $D^{*+}\bar{D}^{*0}\pi^-$ final states within the signal region $(2.135, 2.175)$ GeV/c^2 in Fig. 3(a) are selected and displayed in Fig. 4. The enhancement cannot be attributed to the PHSP $e^+e^- \to D^{*+}\bar{D}^{*0}\pi^-$ process. We simulate the

The observed enhancement is very close to the $m(D^{*+}) + m(\bar{D}^{*0})$ mass threshold. We assume that the enhancement is due to a particle, labeled as $Z_c^+(4025)$, and

Fit results

$$m(Z_c^+(4025)) = (4026.3 \pm 2.6)\ \mathrm{MeV}/c^2,$$
$$\Gamma(Z_c^+(4025)) = (24.8 \pm 5.6)\ \mathrm{MeV}.$$

A goodness-of-fit test gives a $\chi^2/\mathrm{d.o.f.} = 30.4/33 = 0.92$. The $Z_c^+(4025)$ signal is observed with a statistical significance of 13σ, as determined by the ratio of the maximum likelihood value and the likelihood value for a fit with a null-signal hypothesis. When the systematic uncertainties are taken into account, the significance is evaluated to be 10σ.