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

Gu Shan

2017.7.27

JC 25 report

Motivation

☐ Two charged bottomoniumlike particles, dubbed Z_b (10610) and Z_b (10650), have been observed in the $\pi^{\pm}\Upsilon(nS)$ and $\pi^{\pm}h_b(mS)$ mass spectra at the Belle experiment . The masses of Z_b (10610) and Z_b (10650) are close to the $B\overline{B}^*$ and $B^*\overline{B}^*$ thresholds .This is supported by the subsequent observations of the decays $Z_b(10610) \rightarrow B\overline{B}^*$ and $Z_b(10650) \rightarrow B^*\overline{B}^*$ from the Belle experiment.

☐ As anticipated, a charged charmoniumlike structure Z_c (3900) and Z_c(4020) were observed. The masses of them are slightly higher than the $D D^*$ and the $D^*\overline{D}^*$ mass thresholds. Therefore, a search of Zc candidates via their direct decays into $D^*\overline{D}^*$ pairs is strongly motivated.

Software and dataset

☐Reconstructed data with BOSS 663p01

☐525pb-1 @4260MeV

☐ISR is included in the simulation.

Analysis method

Partial reconstruction technique
For $e^+ e^- \rightarrow D^{*+}\overline{D}^{*0} \pi^-, D^{*+} \rightarrow D^+ \pi^0$:

➤ Tag a D^+ meson in an event

➤ find an additional charged π^-

➤ recoil the system of $D^+ \pi^-$ to identify the process of $e^+ e^- \rightarrow D^{*+}\overline{D}^{*0} \pi^-$

➤ study the spectra of recoil π^-

Event selection

- To tag a D^+ using the decay of $D^+ \to K^- \pi^+ \pi^+$

  - $|\delta r| < 1\,\text{cm}$, $|\delta z| < 10\,\text{cm}$
  - kaon PID requirements: $\text{prob}(K) > 0$ and $\text{prob}(K) > \text{prob}(\pi)$
  - pion PID requirements: $\text{prob}(\pi) > 0$ and $\text{prob}(\pi) > \text{prob}(K)$
  - at least two π^+ candidates and one K^- candidate
  - Vertex Fit (VF) of the three tracks: $\chi^2_{\text{VF}} < 100$
  - invariant mass $M(K^- \pi^+ \pi^+)$ lies in $(1.854, 1.884)\,\text{GeV/c}^2$

- to find at least one charged track for candidates of prompt π^-

  - $|\delta r| < 1\,\text{cm}$, $|\delta z| < 10\,\text{cm}$
  - Pion PID requirements: $\text{prob}(\pi) > 0$ and $\text{prob}(\pi) > \text{prob}(K)$

- Multi-combination in an event is allowed.

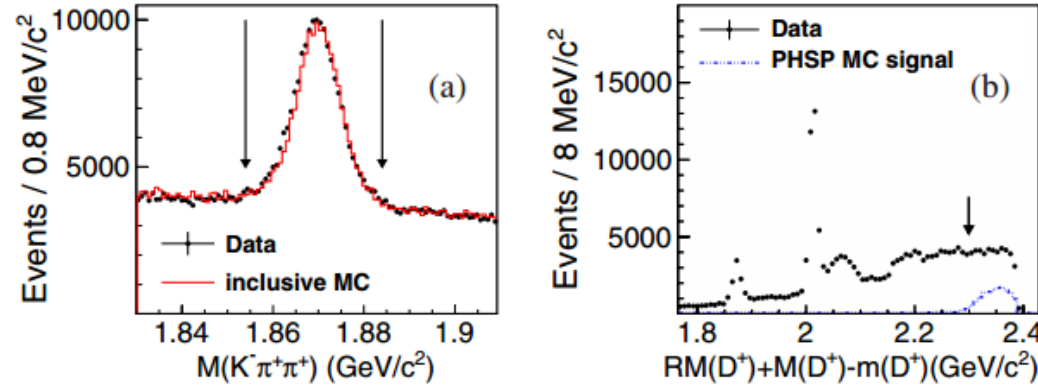# To reject $e^+e^- \to D^{(*)} D^{(*)}$ and select P_{π^0}

FIG. 1 (color online). (a) A comparison of invariant mass $M(K^-\pi^+\pi^+)$ between data and MC simulation. The MC component is normalized to the area of the histogram of the data. Arrows indicate the mass region requirement. (b) A comparison of D^+ recoil mass distributions between data and the MC simulated three-body process $e^+e^- \to D^{*+}\bar{D}^{*0}\pi^-$ (PHSP signal). The level of the PHSP MC sample is scaled arbitrarily. The arrows show the position of the requirement $RM(D^+)+M(D^+)-m(D^+) > 2.3$ GeV/c^2. See the text for a detailed description.
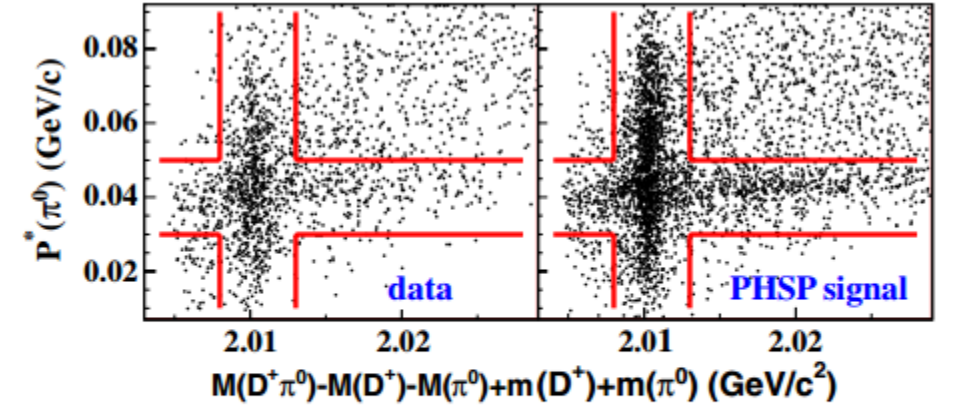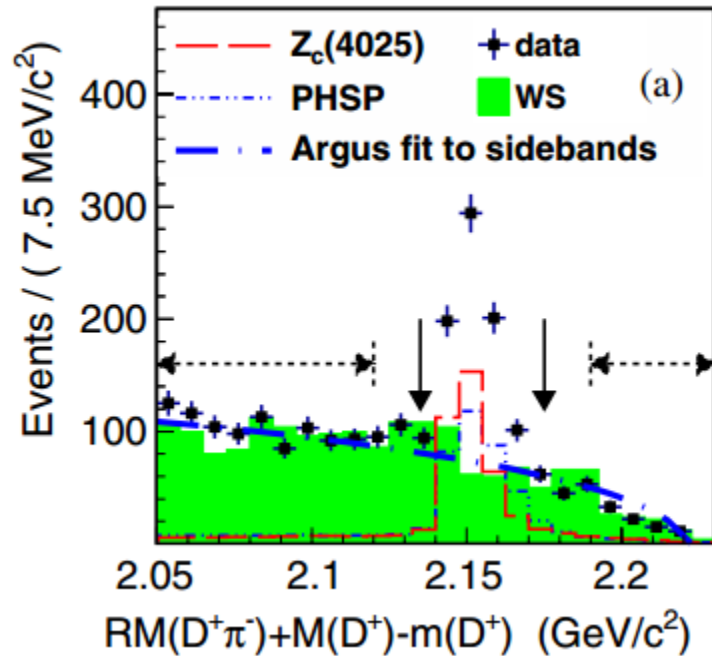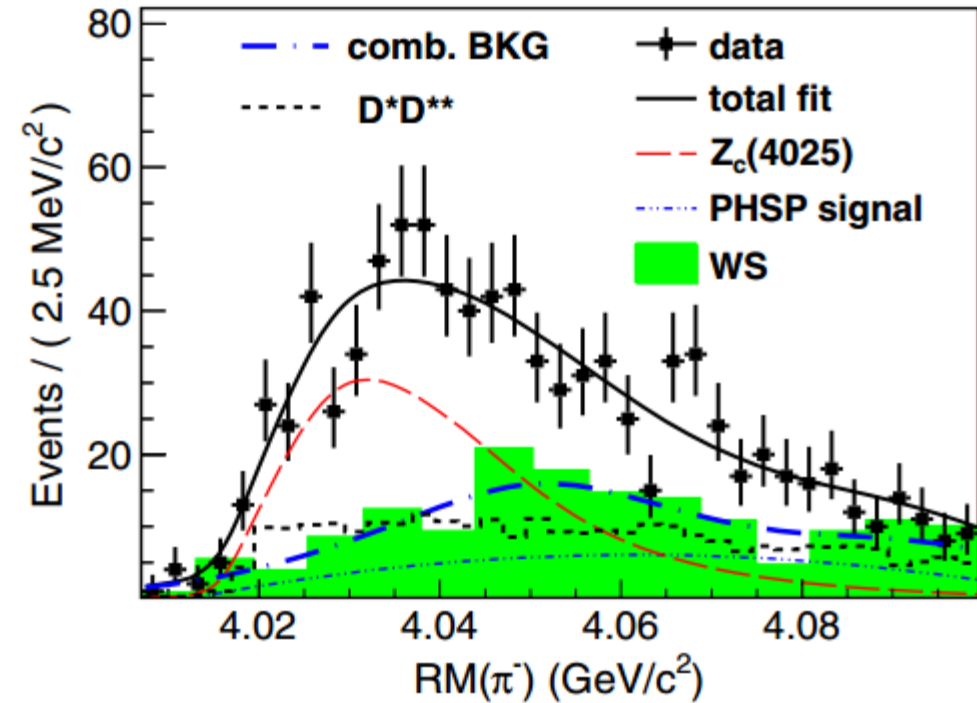
FIG. 2 (color online). Scatter plot of $P^*(\pi^0)$ versus invariant mass of $D^+\pi^0$ in data (left) and in PHSP signal MC simulations (right).

Final states and fit results

The peak position roughly corresponds to the sum of the mass of $\overline{D}^{*0}$ and the mass of a π^0

$$m(Z_c^+(4025)) = (4026.3 \pm 2.6) \text{ MeV}/c^2,$$

$$\Gamma(Z_c^+(4025)) = (24.8 \pm 5.6) \text{ MeV}.$$

Systematic Uncertainties

Source	$m(\mathrm{MeV}/c^2)$	$\Gamma(\mathrm{MeV})$	$\sigma_{\mathrm{tot}}(\%)$	$R(\%)$
Tracking			4	
Particle ID			5	
Tagging π^0			4	
Mass scale	1.8			
Signal shape	1.4	7.3	1	5
Backgrounds	1.5	0.6	5	5
Efficiencies	0.9	2.2	1	5
D^{**} states	2.2	0.7	5	2
Fit range	0.9	0.9	1	1
$D^{*+}\bar{D}^{*0}\pi^-$ line shape			4	
PHSP model			2	2
Luminosity			1.0	
Branching fractions			2.6	
Total	3.7	7.7	11	9

Summary

- A structure near the $(D^* \bar{D}^*)^{\pm}$ threshold in the $\pi^{\mp}$ recoil mass spectrum is observed, and it is denote as $Z_c^{\pm}(4025)$.

- The measured mass and width of the structure are $(4026.3 \pm 2.6 \pm 3.7)$ MeV/c^2 and $(24.8 \pm 5.6 \pm 7.7)$ MeV, respectively.