Search for $Z_c(3900)$ in $\Upsilon(1,2S) \rightarrow \pi^+ D^0 D^{*-}$ decay at Belle

Group meeting

Wang Zhang

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Data and MC samples

$$\Upsilon(1S,2S) \to \pi^+ Z_c(3900)[Z_c(3900) \to D^0 D^{*-}]$$

Data samples

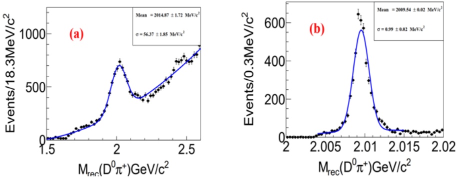
- $5.8\ \text{fb}^{-1}$ data sample collected at $\Upsilon(1S)$ peak $\sqrt{s} = 9.46$ GeV.
- $24.9\ \text{fb}^{-1}$ data sample collected at $\Upsilon(2S)$ peak $\sqrt{s} = 10.02$ GeV.
- $89.5\ \text{fb}^{-1}$ data sample collected at off-resonance $\sqrt{s} = 10.52$ GeV.(to be added)

MC simultion

- 4×10^5 signalMC(using results of PRL 112, 022001 about $Z_c(3885)$ with 0 Γ)
- 4×10^5 no-$Z_c(3900)$ MC
  - prompt D^0 decays to $K^+\pi^-$ and $K^+\pi^+\pi^+\pi^-$(each mode generated half of the sample)
  - inclusive $\bar{D}^0$ from $D^{*-} \to \bar{D}^0\pi^-$

Analysis Strategy

- We do this analysis in BASF2 with b2bii, BASF2 version: **release 09-00-01**
- We reconstruct the π^+, D^0 and also reconstruct $\pi^-_{\rm slow}$ which decays from the $D^{*-}(\to \pi^- \bar{D}^0)$ to improve the resoluton of the recoil mass of $\pi^+ D^0$ system.



- Recoil method

$$M(D^{*-}) = M_{\rm rec}(\pi^+ D^0) = \sqrt{(E_{\rm cms} - E_{\pi^+} - E_{D^0})^2 - (\vec{p}_{\pi^+} + \vec{p}_{D^0})^2}$$

$$M(\bar{D}^0) = M_{\rm rec}(\pi^+ D^0 \pi^-_{\rm slow}) = \sqrt{(E_{\rm cms} - E_{\pi^+} - E_{D^0} - E_{\pi^-_{\rm slow}})^2 - (\vec{p}_{\pi^+} + \vec{p}_{D^0} + \vec{p}_{\pi^-_{\rm slow}})^2}$$

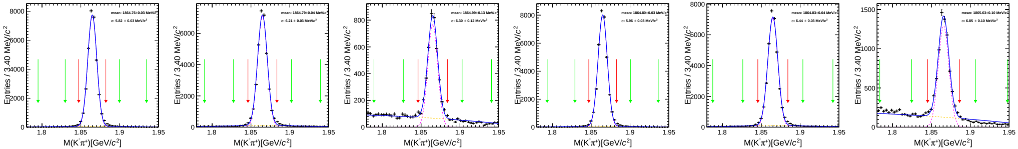
Basic Selection

- For tracks
  - $dr < 0.5$ cm and $|dz| < 2.0$ cm
  - for kaons: $\frac{\mathcal{L}(K^{\pm})}{\mathcal{L}(K^{\pm})+\mathcal{L}(\pi^{\pm})} > 0.6$ and for pions: $\frac{\mathcal{L}(K^{\pm})}{\mathcal{L}(K^{\pm})+\mathcal{L}(\pi^{\pm})} < 0.4$
- For reconstructed D^0 candidates
  - Mass Constraint with kFit
- Require $M_{\rm rec}(\pi^+ D^0) - M_{\rm rec}(\pi^+ D^0 \pi^-_{\rm slow}) < 0.15$ GeV$/c^2$ and 1.0 GeV$/c^2 < M_{\rm rec}(\pi^+ D^0) < 3.0$ GeV$/c^2$ to reduce the combinatorial background of D^{*-} candidates.
- Require $M_{\pi^+ D^0} > 2.025$ GeV$/c^2$ to veto the background from $\Upsilon(1,2S) \to D^{*+} D^{*-}$ decay.

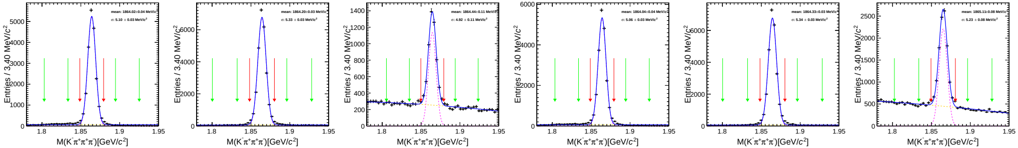
reconstructed D^0 mass fit

Signal Region: $|M(D^0_{\rm rec}) - m(D^0)| < 3\sigma_{DT}$ and Sideband Region: $|M(D^0_{\rm rec}) - m(D^0) \pm 9\sigma_{DT}| < 3\sigma_{DT}$

$D^0 \to K^-\pi^+$ mode



$D^0 \to K^-\pi^+\pi^+\pi^-$ mode



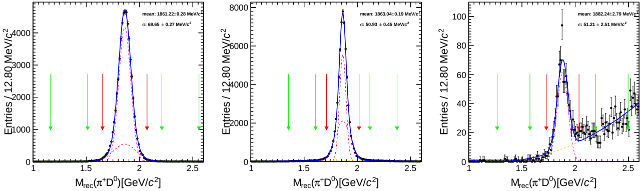
$\Upsilon(1S)$ on the left and $\Upsilon(2S)$ on the right, signal MC, PHSP MC and real data

Recoil mass of $\pi^+ D^0 \pi^-_{\rm slow}$

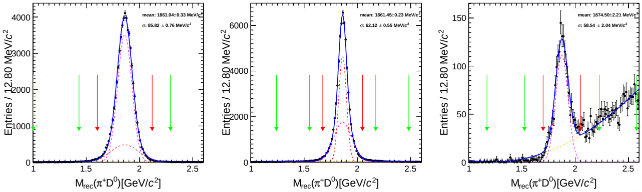
Signal Region: $|M(\bar{D}^0) - m(\bar{D}^0)| < 3\sigma_{DT}$ and Sideband Region: $|M(\bar{D}^0) - m(\bar{D}^0) \pm 9\sigma_{DT}| < 3\sigma_{DT}$

$$M(\bar{D}^0) = M_{\rm rec}(\pi^+ D^0 \pi^-_{\rm slow}) = \sqrt{(E_{\rm cms} - E_{\pi^+} - E_{D^0} - E_{\pi^-_{\rm slow}})^2 - (\vec{p}_{\pi^+} + \vec{p}_{D^0} + \vec{p}_{\pi^-_{\rm slow}})^2}$$

$\Upsilon(1S)$:signal MC, PHSP MC and real data



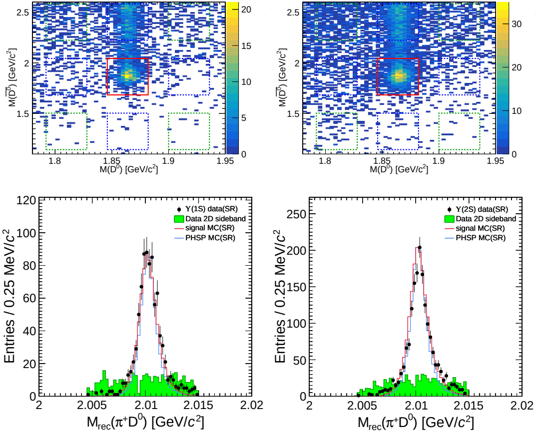
$\Upsilon(2S)$:signal MC, PHSP MC and real data



Recoil mass of $\pi^+ D^0$

$$M(D^{*-}) = M_{\mathrm{rec}}(\pi^+ D^0) = M_{\mathrm{rec}}(\pi^+ D^0) - M_{\mathrm{rec}}(\pi^+ D^0 \pi^-_{\mathrm{slow}}) + m(\bar{D}^0)$$

$\Upsilon(1S)$ $\Upsilon(2S)$



Preliminary results

not any events observed in the signal region

$$M(D^0 D^{*-}) = M_{\rm rec}(\pi^+) = M_{\rm rec}(\pi^+) - M_{\rm rec}(\pi^+ D^0) + m(D^{*-})$$

$$\Upsilon(1S) \qquad \qquad \Upsilon(2S)$$

$$\varepsilon(D^0 \to K^- \pi^+ mode) = 16.0\%(16.5\%)$$

$$\varepsilon(D^0 \to K^- \pi^+ \pi^+ \pi^- mode) = 9.6\%(9.4\%)$$