Hadronic decays of $D^{0(+)}$ and $D_s^+$ at BESIII

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In this talk, we present a selection of recent results on hadronic decays of $D^{0(+)}$ and $D_s^+$ from BESIII collaboration, including the amplitude analyses of $D^0 \rightarrow K^- \pi^+ \pi^+ \pi^-$, $D^+ \rightarrow K^0_s \pi^+ \pi^+ \pi^-$, $D^0 \rightarrow K^- \pi^+ \pi^0 \pi^0$ and $D_s^+ \rightarrow \pi^+ \pi^0 \eta$, as well as the measurements of absolute branching fractions for $D_s^+ \rightarrow p \bar{n}$, $D_s^+ \rightarrow \omega \pi^+$ and $D_s^+ \rightarrow \omega K^+$, and $D$ mesons decays into two pseudoscalar mesons. These results are based on the data samples collected with the BESIII detector at the energies of $\psi(3770)$ and $\psi(4160)$.
1. Introduction

Hadronic decays of \(D^0(+)+\) and \(D_s^+\) mesons are an important tool for understanding the dynamics of the strong interaction in the low energy regime. BESIII experiment has collected the world’s largest samples at \(\psi(3770)\) and \(\psi(4160)\) resonances. Based on these samples, BESIII has performed the amplitude analyses of \(D^0 \to K^{-}\pi^{+}\pi^{+}\pi^{-}\) [1] and \(D^+ \to K^0_{S}\pi^{+}\pi^{+}\pi^{-}\) [2], as well as the measurements of absolute branching fractions (BFs) for \(D_s^+ \to p\bar{n}\) [3], \(D_s^+ \to \omega\pi^+\) and \(D_s^+ \to \omega K^+\) [4], and \(D\) mesons decays into two pseudoscalar mesons [5]. In this proceeding, we present the preliminary results of amplitude analyses of \(D_s^+ \to \pi^+\pi^0\eta\) and \(D^0 \to K^-\pi^+\pi^0\pi^0\) (the inclusion of charge conjugate reactions is implied).

2. Amplitude analysis of \(D_s^+ \to \pi^+\pi^0\eta\) (preliminary)

We perform the first amplitude analysis of \(D_s^+ \to \pi^+\pi^0\eta\) with a data sample of 3.19 fb\(^{-1}\) collected with the BESIII detector at a center-of-mass energy of 4.178 GeV. The double tag (DT) method is used to reconstruct the \(D_s\) mesons. Seven single tag (ST) modes are used: \(D_s^- \to K^0_{S}\pi^+\pi^-\), \(D_s^- \to K^{-}\pi^+\pi^-\), \(D_s^- \to K^+K^-\pi^-\pi^0\), \(D_s^- \to K^+K^-\pi^-\pi^0\), \(D_s^- \to K^0_{S}\pi^+\pi^-\), \(D_s^- \to \pi^-\eta\), and \(D_s^- \to \pi^+\eta^\prime\). In which, \(K^0_{S}\), \(\eta\), and \(\eta^0\) are reconstructed with \(\pi^+\pi^-\), \(\gamma\gamma\) and \(\pi^+\pi^-\eta\), respectively. The DT events are reconstructed \(D_s^+D_s^-\) pairs with \(D_s^-\) in a tag mode combined with \(D_s^+ \to \pi^+\pi^0\eta\), where \(\pi^0\) and \(\eta\) are reconstructed with \(\gamma\gamma\). A multi-variable analysis is performed to suppress the background from fake \(\eta\). A sample of 1239 events with a purity of (97.7 \pm 0.5)\% is obtained to perform the amplitude analysis. The magnitudes, phases and fit fractions (FFs) of the intermediate processes obtained from the amplitude analysis are listed in Table 1. The Dalitz plot of \(M_{\pi^0\eta}^2\) versus \(M_{\pi^+\pi^-}\) for data is shown in Fig. 1(a). The projections for the data, total fit, and the contributions from individual components of the full sample and the sub-sample with \(M_{\pi^+\pi^-}\) larger than 1.0 GeV/\(c^2\) are shown in Figs. 1(b-d) and Figs. 1(e,f), respectively. Obvious \(a_0(980)\) peaks are observable in Fig. 1(e) and Fig. 1(f).

<table>
<thead>
<tr>
<th>Amplitude</th>
<th>Magnitude</th>
<th>Phase</th>
<th>FF</th>
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<tr>
<td>(D_s^+ \to \rho^-\eta)</td>
<td>1.0 (fixed)</td>
<td>0.0 (fixed)</td>
<td>0.783 \pm 0.050 \pm 0.021</td>
</tr>
<tr>
<td>(D_s^+ \to (\pi^+\pi^0)_V\eta)</td>
<td>1.234 \pm 0.272 \pm 0.329</td>
<td>0.612 \pm 0.172 \pm 0.342</td>
<td>0.054 \pm 0.021 \pm 0.026</td>
</tr>
<tr>
<td>(D_s^+ \to a_0(980)\pi)</td>
<td>0.788 \pm 0.058 \pm 0.046</td>
<td>2.794 \pm 0.087 \pm 0.041</td>
<td>0.232 \pm 0.023 \pm 0.034</td>
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The DT yield is determined by the fit to the \(M_{\pi^+\pi^-\eta}\) distribution, which is shown in Fig. 2. We obtain the total BF of \(D_s^+ \to \pi^+\pi^0\eta\) to be \((9.50 \pm 0.28_{\text{stat.}} \pm 0.41_{\text{sys.}})\%\). With the FFs listed in Table 1, the BFs for \(D_s^+ \to \rho^+\eta\) and \(D_s^+ \to a_0(980)^{(+/-)}\pi^0/\pi^+\) are calculated to be \((7.44 \pm 0.48_{\text{stat.}} \pm 0.44_{\text{sys.}})\%\), and \((1.46 \pm 0.15_{\text{stat.}} \pm 0.23_{\text{sys.}})\%\), respectively. The measured BF of \(D_s^+ \to a_0(980)^{(+/-)}\pi^0/\pi^+\) is larger than other measured pure W-annihilation decays [3, 4] by one order. This provides theoretical challenge to understand such a large W-annihilation contribution.
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3. Amplitude analysis of $D^0 \to K^-\pi^+\pi^0\pi^0$ (preliminary)

We perform the first amplitude analysis of $D^0 \to K^-\pi^+\pi^0\pi^0$ with a data sample of 2.93 fb$^{-1}$ collected with the BESIII detector at $\psi(3770)$ resonance. The DT candidates are required to have $D^0 \to K^-\pi^+\pi^0\pi^0$ as the signal and the $\bar{D}^0 \to K^+\pi^-$ as the tag. A sample of 5950 events with a purity of 98.9% is obtained to perform the amplitude analysis. We find that 26 amplitudes are needed to describe the substructures of the final states. The projections of data sample and the fit on the invariant masses squared and the cosines of helicity angles for the $K^-\pi^+, K^-\pi^0, \pi^+\pi^0$ and $\pi^0\pi^0$ systems are shown in Fig. 3.

The DT yield is determined by the fit to the $M_{BC}$ distributions of the DT of data, which are shown in Figs. 4(a) and (b). The ST yield is determined by the fit to the $M_{BC}$ distribution of the ST of data, which is shown in Fig. 4(c). The ST and DT data yields are determined to be
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**Figure 3:** Projections of data and the fit on the (a)-(d) invariant masses squared and the (e)-(h) cosines of helicity angles. The solid lines indicates the fit results, while the dots with error bars indicate data.

$$534581 \pm 769 \text{ and } 6101 \pm 83, \text{ respectively. We obtain the total BF of } D^0 \rightarrow K^- \pi^+ \pi^0 \pi^0 \text{ to be } (8.98 \pm 0.13 \text{(stat)} \pm 0.40 \text{(syst)})\%.$$  

**Figure 4:** Fits to the $M_{BC}$ distributions of the DT of the data sample projected to the (a) signal side and the (b) tag side, and fit to (c) the $M_{BC}$ distributions of the ST of the data sample. The dots with error bars are data, the solid lines are the total fit, the (green) dashed lines are the signal, and dotted lines are the background.

**4. Summary and Outlook**

BESIII has produced a large amount of results on hadronic decays of $D^{0(+)}$ and $D_s^+$ based on the world’s largest samples at $\psi(3770)$ and $\psi(4160)$ resonances. Many new and precision measurements are expected to be coming soon.

**References**