Selected recent results on charm hadronic decays from BESIII

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I report BESIII preliminary results on:
1. Measurement of $\sigma(e^+e^- \to D\bar{D})$ at $E_{cm} = 3.773$ GeV
2. Study of the $D\bar{D}$ production line shape near $E_{cm} = 3.773$ GeV
3. The first observation of singly Cabibbo-suppressed decay, $D \to \omega\pi$
4. Measurement of $\mathcal{B}(D_S^+ \to \eta'X)$ and $\mathcal{B}(D_S^+ \to \eta'\rho^+)$.

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1 Hadronic decays of charm mesons

Studies of hadronic decays of charm mesons play an important role in understanding the weak interactions at the $c$-sector and provide inputs for the beauty physics. Two of samples accumulated by the BESIII detector [1] that are taken at $E_{\text{cm}} = 3.773$ GeV and 4.009 GeV are very useful to study decays of $D$ and $D_S^\pm$ mesons.

The former is the largest $e^+e^-$ annihilation sample in the world to date, 2.92 $fb^{-1}$ [2], that is taken around the nominal mass of $\psi(3770)$ resonance which predominantly decays into a pair of $D$ mesons. The latter, consisting of 482 $pb^{-1}$ [3], also produces a pair of $D_S^\pm D_S^\mp$ with a sizable production rate ($\sigma(e^+e^- \to D_S^\pm D_S^\mp) \sim 269$ pb), providing a clean event environment to study decays of $D_S^\pm$.

In this proceeding, I report four preliminary measurements from the BESIII collaboration based on the above two $e^+e^-$ annihilation data. The first two results are studies about $D$-pair productions at the vicinity of the $\psi(3770)$ resonance, a measurement of observed $\sigma(e^+e^- \to D\bar{D})$ at $E_{\text{cm}} = 3.773$ GeV and a study of Born-level line shape of $\sigma(e^+e^- \to D\bar{D})$. I then present the first observation of the singly Cabibbo-suppressed decays (SCSD), $D \to \omega\pi$, and end this report with the measurements of $\mathcal{B}(D_S^\pm \to \eta'\pi)$ and $\mathcal{B}(D_S^\pm \to \eta'\rho^+)$.

2 $\sigma(e^+e^- \to D\bar{D})$ at $E_{\text{cm}} = 3.773$ GeV

Measuring observed $\sigma(e^+e^- \to D\bar{D})$ allows us to estimate the number of $D\bar{D}$ pairs produced in our sample by using the integrated luminosity of the corresponding sample[2]. This can then be used to normalize the measured signal yields to obtain a branching fraction.

As done by the CLEO collaboration [4], we measure the observed cross section by a double-tag technique, pioneered by the MARK III Collaboration [5]. This takes advantage of the fact that $D$-meson production near the $\psi(3770)$ resonance is solely through $D\bar{D}$.

Reconstructing one $D$ meson in the pair provides a single-tag yield, $N_{ST}^i$, with a final state, $i$. We seek 9 different final states: $D^0 \to (K^-\pi^+, K^-\pi^+\pi^0, K^-\pi^+\pi^+\pi^-)$, and $D^+ \to (K^-\pi^+\pi^+, K^-\pi^+\pi^+\pi^0, K^0\pi^+, K^0\pi^+\pi^0, K^0\pi^+\pi^-\pi^+, K^+K^-\pi^-)$. (Unless otherwise noted, charge conjugate modes are implied throughout this report.) The detail reconstruction criteria can be found in other BESIII publications, such as Ref. [6].

$N_{ST}^i$ can be written as $N_{ST}^i = N_{DD}\cdot\mathcal{B}(D \to i)\cdot\epsilon_i$, where $N_{DD}$ is the number of $D\bar{D}$ produced and $\epsilon_i$ is the reconstruction efficiency for the decay mode, $D \to i$. Similarly, one can have $N_{ST}^j = N_{DD}\cdot\mathcal{B}(D \to j)\cdot\epsilon_j$. When the pair decays explicitly into two final states, $D \to i$ and $\bar{D} \to j$, we have $N_{DT}^{ij} = N_{DD}\cdot\mathcal{B}(D \to i)\cdot\mathcal{B}(\bar{D} \to j)\cdot\epsilon_{ij}$. Here, $N_{DT}^{ij}$ is the double tag yield when we simultaneously reconstruct the two mesons in
the final states of $i$ and $j$. $\epsilon_{ij}$ is the corresponding reconstruction efficiency. Solving these for $N_{DD}$, one arrives at:

$$N_{DD} = \frac{N_{ST}^i \cdot N_{ST}^j \cdot \epsilon_{ij}}{N_{DT}^j \cdot \epsilon_i \cdot \epsilon_j}.$$ 

The observed cross section is readily obtained by dividing $N_{DD}$ by the total integrated luminosity.

We obtain $N_{ST}^i$ from distributions of beam-constrained mass, $M_{BC}$, defined as $M_{BC} \equiv \sqrt{E_{beam}^2 - |\vec{p}_{D}|^2}$. Figure 1 shows fits to $M_{BC}$ distributions based on singly tagged events for the 9 different final states. We use a signal shape predicted by Monte Carlo (MC) simulation. Each of these are convoluted with a Gaussian to take into account a discrepancy in resolution between data and MC, while using an ARGUS background function [7] to represent the background component.

![Figure 1: Fits to $M_{BC}$ distributions of singly tagged events based on the entire $\psi(3770)$ sample. Red curves represent the overall fitted shapes and blue dashed curves correspond to the fitted ARGUS background functions.](image)

As for obtaining $N_{DT}^{ij}$, we look at a two-dimensional space, $M_{BC}^i$ vs $M_{BC}^j$. Due to the small background of the doubly tagged events, we simply count the yields after using the sidebands of $M_{BC}$ to estimate backgrounds.

Averaging the resultant observed cross sections over different final states ($D \rightarrow j$ and $\bar{D} \rightarrow j$), we have our preliminary result shown in Table 1. Our cross sections are consistent with the ones measured by the CLEO collaboration [4]. We expect our final results to be dominated by systematic uncertainties.
| Experiment     | $\sigma(e^+e^- \to D^0\bar{D}^0)$ (nb) | $\sigma(e^+e^- \to D^+D^-)$ (nb) |
|----------------|-------------------------------------|----------------------------------|
| This work      | $3.641 \pm 0.010$                   | $2.844 \pm 0.011$               |
| CLEO [4]       | $3.607 \pm 0.017\pm 0.056$         | $2.882 \pm 0.018 \pm 0.042$     |

Table 1: Comparison of the measured cross sections between the BESIII preliminary results and the ones measured by the CLEO collaboration. Only statistical uncertainties are shown in the BESIII results.

3 Line shape of $\sigma(e^+e^- \to D\bar{D})$

In the previous section, I report our preliminary result of observed cross section, $\sigma(e^+e^- \to D\bar{D})$, at $E_{cm} = 3.773$ GeV. It is of great interest to examine this production line shape near the nominal mass of $\psi(3770)$ resonance. This is done using the BESIII scan data which was taken in 2010, along with the main on-resonant $\psi(3770)$ sample, in a range of $3.642 < E_{cm} < 3.890$ GeV with the total accumulated luminosity of $\sim 70$ pb$^{-1}$. Such a line shape distribution allows one to extract the $\psi(3770)$ resonance parameters. Table 2 shows some of the recent experimental measurements on the nominal mass of $\psi(3770)$ resonance. There is a definite (and expected) shift in the mass when an interference effect is taken into account.

| Experiment     | $M_{\psi(3770)}$ (MeV/c$^2$) |
|----------------|-------------------------------|
| BES (2008) [8] | $3772.0 \pm 1.9$             |
| Belle (2008) [9]| $3776.0 \pm 5.0 \pm 4.0$    |
| BABAR (2007) [10]$^\dagger$| $3778.8 \pm 1.9 \pm 0.9$  |
| BABAR (2008) [11]| $3775.5 \pm 2.4 \pm 0.5$  |
| KEDR (2012) [12]$^\dagger$| $3779.2^{+1.8+0.5+0.3}_{-1.7-0.7-0.3}$ |

$^\dagger$ includes interference

Table 2: Recent experimental measurements on the mass of the $\psi(3770)$ resonance.

To obtain the resonance parameters, we follow the procedure carried out by the KEDR collaboration [12] in which we assume that there are two sources that produce $D\bar{D}$ final states: one from the decay of $\psi(3770)$ and the other from non-$\psi(3770)$ decays. To represent the non-$\psi(3770)$ decays, we form its amplitude as a linear combination of a constant term, which represents the possible contributions from higher $c\bar{c}$ resonant states such as $\psi(4040)$, and a Breit-Wigner form, that corresponds to the $\psi(3686)$ tail above the $D\bar{D}$ mass threshold [13]. This approach is known as a Vector-Dominance Model (VDM), but we also try an exponential form, instead of the Breit-Wigner form, to see how much an alternate form affects the resultant $\psi(3770)$ resonance parameters.
The Born-level cross section, $\sigma_{\text{born}}$, and experimentally determined observed cross section, $\sigma_{\text{obs}}$, are related as:

$$\sigma_{\text{obs}}(W) = \int z_{DD}(W\sqrt{1-x})\sigma_{\text{born}}(W\sqrt{1-x})F_{\text{ISR}}(x,W^2)dx.$$ 

Here, $z_{DD}$ is a factor for the coulomb interaction for $D^+D^-$, $F_{\text{ISR}}(x,W^2)$ is the ISR radiator [14], and $G(W,W')$ (a Gaussian) is there to take into account the beam spread at the initial $E_{\text{cm}} = W$. More details can be found in Ref. [12].

We extract $\sigma_{\text{born}}(W)$ based on $\sigma_{\text{obs}}(W)$ with the above relation. $\sigma_{\text{obs}}(W)$ is based on the singly tagged events by fitting to two-dimensional space, $\Delta E$ vs $M_{\text{BC}}$, where $\Delta E \equiv E_D - E_{\text{beam}}$ with both signal and background shapes are fixed based on MC samples. As an example, Fig. 2 shows projections onto the $M_{\text{BC}}$ axes of such two-dimensional fits at $E_{\text{cm}} \sim 3.7735$ GeV (left) and $E_{\text{cm}} \sim 3.7984$ GeV (right) based on the sum of the three $D^0$ decays (see the 3rd column of Fig. 1). Notice that the left plot of Fig. 2 peaks at nominal mass of $D^0$, while the right plot of Fig. 2 has a 2nd peak on the higher side. This is due to the larger ISR effect at this particular $E_{\text{cm}}$, which our MC-based signal shape (green) reproduces quite well.

![Figure 2](image-url)

Figure 2: Projections onto the $M_{\text{BC}}$ axes (in GeV/$c^2$) of the two-dimensional fits ($\Delta E$ vs $M_{\text{BC}}$) at $E_{\text{cm}} \sim 3.7735$ GeV (left) and $E_{\text{cm}} \sim 3.7984$ GeV (right) based on the sum of the three $D^0$ decay modes. The blue histograms represent the overall fits, while dashed red and solid green histograms correspond to the fitted background and signal shapes, respectively.

From these fits at each $E_{\text{cm}}$, we construct the spectrum of the observed cross section, $\sigma_{\text{obs}}$. As an example, we show $\sigma_{\text{obs}}$ distribution for the case of $D^+D^-$ (red points) in Fig 3. There, the solid blue curve is the fitted shape to $\sigma_{\text{obs}}$, while the corresponding $\sigma_{\text{Born}}$ is represented by the dashed brown curve. The dashed orange and green curves are the fitted resonant and non-resonant components (here, we use the VDM to represent the non-resonant component).

Table 3 shows our preliminary results on the nominal mass, total width, electronic partial width of the $\psi(3770)$ resonance. The 4th column shows $\Gamma_{ee}^{\psi(3770)} \times B_{DD}$, where $B_{DD} = B(\psi(3770) \to D\bar{D})$. This is because our fit is only sensitive to the product of...
Figure 3: Observed cross section, $\sigma_{\text{obs}}$ is plotted in the red points based on the $D^+D^-$ events in which $D^\pm$ decays into the 6 different final states (see the 1st and the 2nd columns of Fig. 1). The corresponding $\sigma_{\text{Born}}$ curve is shown in dashed brown.

| Source               | $M^{\psi(3770)}$ (MeV/$c^2$) | $\Gamma^{\psi(3770)}$ (MeV) | $\Gamma^{\psi(3770)}_{ee} \times B_{D\bar{D}}$ (eV) |
|----------------------|-----------------------------|----------------------------|----------------------------------|
| BESIII$_{VDM}$       | $3781.5 \pm 0.3$            | $25.2 \pm 0.7$             | $230 \pm 18$                    |
| BESIII$_{\text{Exponential}}$ | $3783.0 \pm 0.3$            | $27.5 \pm 0.9$             | $270 \pm 24$                    |
| KEDR[12]             | $3779.3^{+1.5}_{-1.7}$      | $25.3^{+4.4}_{-3.9}$       | $160^{+78}_{-58}$, $420^{+70}_{-80}$ (a) |
| PDG[15]              | $3773. \pm 0.3$            | $27.2 \pm 1.0$             | $[262 \pm 18] \times B_{D\bar{D}}$ |

(a) Two solutions were obtained from their fit.

Table 3: BESIII preliminary results based on the two different forms of the non-$\psi(3770)$ amplitudes, VDM ($\psi(3686)$) and an exponential shape, are shown, along with the result from the KEDR collaboration as well as the current PDG value. In the 4th column, $B_{DD} = B(\psi(3770) \to D\bar{D})$.

the two, but not individually. Our preliminary result is consistent with the KEDR measurement. In Tab. 3 we also show a result based on the exponential form to represent the non-$\psi(3770)$ amplitude. As can be seen, this would likely be one of the dominant sources of the systematic uncertainty.

4 $D \to \omega\pi$

For Cabibbo-suppressed charm decays, such as the yet to be observed SCSD $D \to \omega\pi$, measurements are difficult due to low signal statistics and high backgrounds. For the case of $D \to \omega\pi$, the most recent experimental search was carried out by the CLEO collaboration [16]. They set upper limits, $B(D^+ \to \omega\pi^+) < 3.0 \times 10^{-4}$ and
\[ \mathcal{B}(D^0 \rightarrow \omega \pi^0) < 2.6 \times 10^{-4} \] at 90\% confidence level (C.L.). In the mean time, H. Y. Cheng and C. W. Chiang predict the \[ \mathcal{B}(D \rightarrow \omega \pi) \] could be at an order of \[ 1 \times 10^{-4} \] \cite{17}.

We start with reconstructing one of the \( D \bar{D} \) pairs with the same 9 final states (see Fig. 1). Then in the other \( D \) decay, we look for \( D^{+((0))} \rightarrow \omega \pi^{+((0))} \), where \( \omega \rightarrow \pi^+\pi^-\pi^0 \) and \( \pi^0 \rightarrow \gamma\gamma \). To improve the signal-to-noise ratio, we also select a certain range on the helicity-like angle of \( \omega \), \( \theta_{\text{helicity}} \), which is defined as an opening angle between the direction of the normal to the \( \omega \rightarrow \pi^+\pi^-\pi^0 \) plane and the direction of the parent \( D \) meson in the \( \omega \) rest frame. We require \( |H_\omega| = |\cos \theta_{\text{helicity}}| > 0.54(0.51) \) for \( D^+ (D^0) \) that are optimized based on a MC study.

With additional requirements on \( M_{\text{BC}} \) and \( \Delta E \) to be consistent with a \( D \bar{D} \) pair production, we extract our signal yields by fitting to the distributions of invariant mass of \( \omega \rightarrow \pi^+\pi^-\pi^0 \) as shown in Fig. 4. We use MC-based signal shapes, along with polynomials to represent their background shapes. Figure 4 also shows the expected peaking backgrounds (represented by filled histograms) which are estimated by the sidebands of \( M_{\text{BC}} \) distributions. The extracted signal yields correspond to a statistical significance of 5.4\( \sigma \) (4.1\( \sigma \)) for \( D^+(D^0) \rightarrow \omega \pi^+(\pi^0) \), respectively.

![Figure 4: Distributions of invariant mass of \( \omega \rightarrow \pi^+\pi^-\pi^0 \) for \( D^+ \rightarrow \pi^+\pi^-\pi^0 \) (left) and \( D^0 \rightarrow \pi^+\pi^-\pi^0 \pi^0 \). The solid red lines are the overall fits, while the dashed blue lines represent the fitted polynomials. The filled histograms represent the peaking backgrounds, estimated by the sidebands of \( M_{\text{BC}} \) distributions.](image-url)

We also check to see if the \( D \rightarrow \omega \pi \) candidates produce the expected distribution of the helicity angle. Figure 5 shows the distributions of \( |H_\omega| \) in which we can see the expected \( H^2_\omega = \cos^2 \theta_{\text{helicity}} \).

In Fig. 4, we can also see peaks that correspond to \( D \rightarrow \eta \pi \) candidates. We extract these candidates by fitting to the same invariant mass distributions of \( \omega \rightarrow \pi^+\pi^-\pi^0 \) with much narrower fit ranges, and without the requirement on the \( |H_\omega| \). Figure 6 shows such fits from which we also measure \( \mathcal{B}(D \rightarrow \eta \pi) \).
Figure 5: Efficiency-corrected signal yields in the $|H_\omega|$ bins for candidates of $D^+ \rightarrow \omega \pi^+$ (left) and $D^0 \rightarrow \omega \pi^0$ (right). The black lines are the fitted quadratic shapes.

Figure 6: Fits to distributions of invariant mass of $\omega \rightarrow \pi^+ \pi^- \pi^0$ for the candidates of $D^+ \rightarrow \eta \pi^+$ (left) and $D^0 \rightarrow \eta \pi^0$ (right). The filled histograms represent the peaking backgrounds which are estimated by the sideband regions of both signal and tag sides of $M_{BC}$ distributions.

Table 4 shows our preliminary branching fraction measurements. The measured $B(D \rightarrow \eta \pi)$ are consistent with the known values [15], while $B(D \rightarrow \omega \pi)$ are measured for the first time.

5 $D^+_S \rightarrow \eta X$ and $D^+_S \rightarrow \eta \rho^+$

The situation of $B(D_S^+ \rightarrow \eta' \rho^+)$ is rather interesting. If we sum the all known exclusive rates with $\eta'$ in $D_S^+$ decays in the PDG [15], we arrive at $(18.6 \pm 2.3)\%$, while $B(D_S^+ \rightarrow \eta' X) = (11.7 \pm 1.7)\%$ [18]. Among the $D_S^+$ decays that involve $\eta'$, the largest single exclusive rate is $B(D_S^+ \rightarrow \eta' \rho^+) = (12.5 \pm 2.2)\%$ [19]. However, a recent measurement is about a half of it, $B(D_S^+ \rightarrow \eta' \pi^+ \pi^0) = (5.6 \pm 0.5 \pm 0.6)\%$ [20] which appears to
solve the inconsistency mentioned above. B. Bhattacharya and J. L. Rosner come up with two predictions, $\mathcal{B}(D_S^0 \rightarrow \eta' \rho^+) = (2.9 \pm 0.3)\%$ and $(1.89 \pm 0.20)\%$ [21], while F. S. Yu et al. predict $(3.0 \pm 0.5)\%$ [22] by factorization methods.

We can use our sample taken at $E_{\text{cm}} = 4.009$ GeV to measure these branching fractions to confirm the recent measurement. At this energy, the $D_S^+$ is produced in a pair. To measure the inclusive rate, $D_S^+ \rightarrow \eta' X$, we employ a double-tag technique in which we reconstruct its tag side in 9 decay modes shown in Fig. 7. From these $M_{BC}$ distributions, the single-tag yields are readily obtained.

Table 4: Preliminary result on the measured $\mathcal{B}(D \rightarrow \omega \pi)$.

| Decay mode       | This work                  | PDG value [15]       |
|------------------|----------------------------|----------------------|
| $D^+ \rightarrow \omega \pi^+$ | $(2.74 \pm 0.58 \pm 0.17) \times 10^{-4}$ | $< 3.4 \times 10^{-4}$ at 90% C.L. |
| $D^0 \rightarrow \omega \pi^0$  | $(1.05 \pm 0.41 \pm 0.09) \times 10^{-4}$ | $< 2.6 \times 10^{-4}$ at 90% C.L. |
| $D^+ \rightarrow \eta \pi^+$    | $(3.13 \pm 0.22 \pm 0.19) \times 10^{-4}$ | $(3.53 \pm 0.21) \times 10^{-3}$ |
| $D^0 \rightarrow \eta \pi^0$   | $(0.67 \pm 0.10 \pm 0.05) \times 10^{-4}$ | $(0.68 \times 0.07) \times 10^{-3}$ |

Figure 7: Fits to $M_{BC}$ distributions of the selected 9 different final states of $D_S^+$ decays. The red curves correspond to the total fits, while the blue dashed curves represent the fitted background shapes by the ARGUS background functions [7].

To obtain the double-tag yields, we reconstruct the 9 final states of $D_S^+$ decays and look for the other $D_S^+$ decays in the final states with $\eta' \rightarrow \pi^+ \pi^- \eta (\rightarrow \gamma \gamma)$ based
on the remaining particles. If there is more than one $\eta'$ candidate, we choose the one that gives the minimum $|M_{\pi^+\pi^-\eta} - M_{\eta'}(PDG)|$. We fit to a two-dimensional space, $M_{\pi^+\pi^-\eta}$ vs $M_{BC}$, to extract the signal yields, where $M_{BC}$ is the tag side of the beam-constrained mass. Figure 8 shows such fits, projected onto the $M_{BC}$ axis (left) and onto the $M_{\pi^+\pi^-\eta}$ axis (right). We use MC-based distributions to represent the signal shape. As for the background shapes, an ARGUS background function [7] is used on the $M_{BC}$ direction, while the smooth and peaking backgrounds on the $M_{\pi^+\pi^-\eta}$ axis are represented by a polynomial plus double Gaussian shapes.

From this fit, $68 \pm 14$ events are observed as signal candidates. This translates into $B(D^+ \to \eta'\rho) = (8.8 \pm 1.8 \pm 0.5)\%$ which agrees with the known value [15].

Figure 8: Fit to two-dimensional space, $M_{\pi^+\pi^-\eta}$ vs $M_{BC}$, where $M_{BC}$ is the tag side of the beam-constrained mass. Shown here are the fitted result, projected onto the $M_{BC}$ axis (left) and onto the $M_{\pi^+\pi^-\eta}$ axis (right). Solid red curves correspond to the overall fit, while dashed blue and green curves are fitted peaking backgrounds.

To measure $B(D_S^+ \to \eta'\rho^+)$, we simply use the single-tag method by reconstructing $D_S^+ \to \eta'\rho^+$, where $\rho^+ \to \pi^+\pi^0$. We require the reconstructed $\eta'$ mass to be within $3\sigma$ of the known mass [15], the invariant mass $M_{\pi^+\rho}$ be within $0.17$ GeV/$c^2$ of the known $\rho$ mass [15], and finally its $\Delta E$ be consistent with zero.

The signal yield is extracted by fitting to two-dimensional space, $M_{BC}$ vs $\cos\theta_{\pi^+}$, where $\theta_{\pi^+}$ is the helicity angle of the $\pi^+$ from the $\rho$ decay. We expect to see $\cos^2\theta_{\pi^+}$ for $D_S^+ \to \eta'\rho^+$, while $D_S^+ \to \eta'\pi^+\pi^0$ events should be independent of $\theta_{\pi^+}$.

Figure 9 shows projections onto the $M_{BC}$ axis (left) of such two dimensional fit. On the right, a projection onto the $\cos\theta_{\pi^+}$ axis with an additional requirement of $(1.960 < M_{BC} < 1.980)$ GeV/$c^2$ is shown. Signal shapes are based on MC simulation. To represent the background shapes, an ARGUS background function [7] is used on the $M_{BC}$ axis, while a fixed non-$D_S^+$ background shape is employed on the $\cos\theta_{\pi^+}$ axis, estimated from the $M_{BC}$ sidebands.
The fit yields 210 ± 50 and −13 ± 56 events for $D^+_S \to \eta'\rho^+$ and $D^+_S \to \eta'\pi^+\pi^0$ candidates, respectively. We normalize the rate by $D^+_S \to K^+K^−\pi^+$ mode to obtain $\mathcal{B}(D^+_S \to \eta'\rho^+)/\mathcal{B}(D^+_S \to K^+K^−\pi^+) = 1.04 \pm 0.25 \pm 0.07$. Or with the known $\mathcal{B}(D^+_S \to K^+K^−\pi^+) [15]$, we arrive at $\mathcal{B}(D^+_S \to \eta'\rho^+) = (5.8 \pm 1.4 \pm 0.4)\%$ which confirms the recent measurement by the CLEO collaboration [20]. We also set an upper limit on the non-resonant decay, $\mathcal{B}(D^+_S \to \eta'\pi^+\pi^0) < 5.1\%$ at 90% C.L.

![Figure 9: Projections onto the $M_{BC}$ axis (left) and the $\cos \theta_{\pi^+}$ axis with an additional requirement of $(1.960 < M_{BC} < 1.980)$ GeV/$c^2$ (right) of the two-dimensional fit.](image)

6 Conclusion

Four preliminary results on the hadronic final states in the decays of $D^\pm$ and $D^+_S$ mesons based on the two recent BESIII samples are reported. The measurements based on the world’s largest $e^+e^-$ annihilation sample taken at $E_{cm} = 3.773$ GeV provide statistically superior results than the previous experimental results, while the study of decays of $D^+_S$ based on the sample at $E_{cm} = 4.009$ GeV shows the very clean event environment at BESIII. It would be very exciting to pursue our $D_S$ program as the collaboration plans to take a few fb$^{-1}$ of $e^+e^-$ annihilation sample at $E_{cm} = 4.180$ GeV in 2015 – 2016, where the production rate of $D^+_S$ is much higher, $\sigma(e^+e^- \to D^+_S)$ $\sim$ 900 pb.

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