A Monte Carlo study of single baryon reconstruction method

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Abstract: A Monte Carlo study for single baryon reconstruction method is presented based on two-body baryonic decays of charmonium, $J/\psi$, $\psi(3686)$ into $\Xi^0\Xi^0, \Xi^-\Xi^+$ at BESIII experiment. As a result, we find that the detection efficiency for single baryon reconstruction method can be increased by a factor of $\sim 4$ relative to the traditional full-reconstruction method. It indicates that single baryon reconstruction method could be used in the other two-body baryonic decays of charmonium, such as $J/\psi$, $\psi(3686) \rightarrow \Xi(1530)\Xi(1530)$, $\Xi(1530)\bar{\Xi}$, whose expected yields are estimated based on single baryon reconstruction method. The expected uncertainties for the measurements of the angular distribution parameters are also discussed.

Key words: Single baryon reconstruction, charmonium decay, Monte Carlo

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1 Introduction

Study of two-body decays of $\psi$ [in the following, $\psi$ denotes the charmonium states $J/\psi$ and $\psi(3686)$] into the baryon anti-baryon ($BB$) pairs in $e^+e^-$ annihilation plays an important role in the test of perturbative quantum chromodynamics (pQCD) \cite{1}. However, due to the low detection efficiency for the traditional full-reconstruction method (all tracks in an event are required to be reconstructed), many two-body decays of charmonium into $BB$ pairs are either measured with the poor precisions, or remain unobserved. It hinders people to understand the corresponding QCD theory well. Hence, the improvement of measurement precisions to the existing branching fractions, angular distribution parameters, hyperon decay parameters, as well as the search for the unknown baryonic decay of charmonium, are desirable based on the current data taken at BESIII detector \cite{2, 3}.

In this paper, we present a Monte Carlo (MC) study of single baryon reconstruction method based on some two-body baryonic decays $\psi \rightarrow \Xi^0\Xi^0, \Xi^-\Xi^+$ at BESIII experiment. The results indicates that the detection efficiency of single baryon reconstruction method increases significantly compared with that of the full-reconstruction one. In addition, the expected yields for the processes $J/\psi, \psi(3686) \rightarrow \Xi(1530)\Xi(1530), \Xi(1530)\bar{\Xi}$ are estimated, as well as the expected uncertainties for the measurement of angular distribution for these modes are presented.

To determine the detection efficiencies of two-body decays for $\psi \rightarrow \Xi\Xi, \Xi(1530)\Xi(1530)$ and $\Xi(1530)\bar{\Xi}$, 1,000,000 MC events are generated for each reconstructed mode with the consideration of angular distribution and branching fractions based on the BOSS environment \cite{4} and generator \cite{5}, where the subsequent decays are simulated according to the respective branching fraction from PDG \cite{6}.

2 Single reconstruction

To achieve a high efficiency, we develop a single baryon reconstruction method to select the signal event, i.e. only one baryon or anti-baryon is reconstructed using its dominant decay mode, just like the single-tag method in charm meson study \cite{7}. In this section, we will focus on the event selection for single baryon reconstruction method for either baryon or anti-baryon by taking the control decays $\psi \rightarrow \Xi^0\Xi^0, \Xi^-\Xi^+$ as the examples, and then we will expand this method to another two-body decays of $\psi \rightarrow \Xi(1530)\Xi(1530)$ and $\Xi(1530)\bar{\Xi}$.

2.1 $\psi \rightarrow \Xi^0\Xi^0$

The charged tracks should be reconstructed in the MDC with good helix fits, and within the angular coverage of the MDC ($|\cos \theta| < 0.93$, where $\theta$ is the polar angle with respect to the $e^+$ beam direction). Information from the specific energy loss measured in the MDC ($dE/dx$) and from the TOF are combined to form particle identification (PID) confidence levels for the hypotheses of a pion, kaon, and proton. Each track is assigned to the particle type with the highest confidence level. At least one

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charged pion and one proton are required with the consideration of the opposite electric charge. Photons are reconstructed from isolated showers in the EMC. The energy deposited in the nearby TOF counter is included to improve the reconstruction efficiency and energy resolution. Photon energies are required to be greater than 25 MeV in the EMC barrel region ($|\cos\theta| < 0.8$) and greater than 50 MeV in the EMC end cap ($0.86 < |\cos\theta| < 0.92$). The showers in the angular range between the barrel and the end cap are poorly reconstructed and excluded from the analysis. Furthermore, the EMC timing of the photon candidate must be in coincidence with collision events, $0 \leq t \leq 700$ ns, to suppress electronic noise and energy deposits unrelated to the events.

To reconstruct the $\pi^0$ candidates, an one-constraint (1C) kinematic fit is employed for all $\gamma\gamma$ combinations by constraining the invariant mass of two photons to the $\pi^0$ nominal mass, combined additionally with the requirement of $|\Delta E|/P_{\pi^0} < 0.95$ ($\Delta E$ is the energy difference between two photons, $P_{\pi^0}$ is the $\pi^0$ momentum). If there are more than one combinations surviving the 1C kinematic fit, the one with the minimum $\chi^2$ is kept. Furthermore, $\chi^2 < 20$ is required to suppress the background.

To reconstruct the $\Lambda(\bar{\Lambda})$ candidates, a vertex fit is applied to all $p\pi^{-}(\bar{p}\pi^+)$ combinations; the ones characterized by $\chi^2 < 500$ are kept for further analysis. The $\Lambda(\bar{\Lambda})$ signal is required to be within 5 MeV/$c^2$ of the nominal $\Lambda(\bar{\Lambda})$ mass. To further suppress the potential backgrounds, the decay length of $\Lambda(\bar{\Lambda})$ is required to be larger than zero.

The $\Xi^0(\Xi^0)$, is selected by minimizing $|M_{\pi^0\Lambda(\bar{\Lambda})} - M_{\Xi^0(\Xi^0)}|$, where $M_{\pi^0\Lambda(\bar{\Lambda})}$ is the invariant mass of $\pi^0\Lambda(\bar{\Lambda})$ combination. To further suppress background, the mass of $\pi^0\Lambda(\bar{\Lambda})$ is required to be $\pm 10$ MeV/$c^2$ for $J/\psi \rightarrow \Xi^0\Xi^0$ and $\pm 11$ MeV/$c^2$ for $\psi(3686) \rightarrow \Xi^0\Xi^0$, around the nominal mass of $\Xi^0(\Xi^0)$, as shown in Fig. 1.

The another baryon is selected by the recoil mass of $\pi^0\Lambda(\bar{\Lambda})$ against the tagged baryon mass, see the below Eq.

$$M_{\text{recoil}}^B = \sqrt{(E_{\text{CM}} - E_B)^2 - \vec{p}_B^2},$$  \hspace{1cm} (1)

where $E_B$ and $\vec{p}_B$ are the energy and the momentum of the selected $\pi^0\Lambda(\pi^0\bar{\Lambda})$ system, and $E_{\text{CM}}$ is the center of mass (CM) energy. For the decays $\psi(3686) \rightarrow \Xi^0\Xi^0$, the requirements of $|M_{\text{recoil}}^\psi - M_{\psi/\phi}| > 0.005$ GeV/$c^2$ and $|M_{\text{recoil}}^\psi - M_{\psi/\phi}| > 0.015$ GeV/$c^2$, are used to suppress the potential backgrounds $\psi(3686) \rightarrow \pi\pi J/\psi$, where the $M_{\text{recoil}}^\psi (M_{\text{recoil}}^\psi)$ are the recoil mass of all $\pi^+\pi^- (\pi^0\pi^0)$ combinations, and $M_{J/\psi}$ is the nominal mass of $J/\psi$ according to the PDG [6].

Both $\Xi^0$ and $\Xi^0$ decay final states include a $\pi^0$ with almost same momenta. It can cause some wrong combination background (WCB) in the $\Xi^0(\Xi^0)$ reconstruction. The WCB is subtracted by employing a modeled requirement based on the MC simulation, i.e. an angle between reconstructed and generated pion, where the angle requirements $\leq 20^\circ$ for $J/\psi \rightarrow \Xi^0\Xi^0$ and $\leq 35^\circ$ for $\psi(3686) \rightarrow \Xi^0\Xi^0$ are used to veto WCB events. Figure 2 shows the recoiling mass of $\pi^0\Lambda(\pi^0\bar{\Lambda})$. Clear $\Xi^0(\Xi^0)$ is seen.

![Fig. 1. Distribution of $M_{\pi^0\Lambda(\bar{\Lambda})}$ for $J/\psi \rightarrow \Xi^0\Xi^0$ (Top) and $\psi(3686) \rightarrow \Xi^0\Xi^0$ (Bottom). Arrows denote the applied requirements.](image1)

![Fig. 2. Distribution of $M_{\pi^0\Lambda(\bar{\Lambda})}$ for $J/\psi \rightarrow \Xi^0\Xi^0$ (Top) and $\psi(3686) \rightarrow \Xi^0\Xi^0$ (Bottom). Arrows denote the applied requirements.](image2)

### 2.2 $\psi \rightarrow \Xi^-\Xi^+$

Unlike the neutral $\Xi$, the charged $\Xi$ decays to charged pion together with a $\Lambda$. Therefore, there is almost no WCB in reconstructing charged $\Xi$ due to the opposite charge in pion track. The charged $\Xi$ is reconstructed by a vertex fit and minimizing $|M_{\pi^-\Lambda(\pi^+\bar{\Lambda})} - M_{\Xi^-(\Xi^+)}|$. To further suppress the backgrounds, the requirements of $M_{\pi^-\Lambda(\pi^+\bar{\Lambda})} \in [1.312, 1.332]$ GeV/$c^2$ for $J/\psi \rightarrow \Xi^-\Xi^+$, $[1.308, 1.338]$ GeV/$c^2$ for $\psi(3686) \rightarrow \Xi^-\Xi^+$ are employed as shown in Fig. 3. Furthermore, the requirements of $|M_{\text{recoil}}^\psi - M_{\psi/\phi}| > 0.005$ GeV/$c^2$ are used to suppress the potential backgrounds $\psi(3686) \rightarrow \pi^+\pi^- J/\psi$
for $\psi(3686) \to \Xi^0\bar{\Xi}^0$. The mass recoiling against the selected $\pi^-\Lambda(p^+\bar{\Lambda})$ system is extracted by Eq. (1) as shown in Fig. 4.

![Image](Fig. 4. Distribution of $M_{\pi^-\Lambda(p^+\bar{\Lambda})}^{\text{recoll}}$ for $J/\psi \to \Xi^-\Xi^+$ (Top) and $\psi(3686) \to \Xi^-\Xi^+$ (Bottom). Arrows denote the applied requirements.)

Fig. 4. Distribution of $M_{\pi^-\Lambda(p^+\bar{\Lambda})}^{\text{recoll}}$ for $J/\psi \to \Xi^-\Xi^+$ (Top) and $\psi(3686) \to \Xi^-\Xi^+$ (Bottom). Arrows denote the applied requirements.

For $\psi \to \Xi(1530)^0\Xi(1530)^0$, $\Xi(1530)^0\Xi^0$

The $\Xi(1530)^0$ is tagged either by $\pi^+\Xi^-$ or $\pi^0\Xi^0$ final states by minimizing the variable $|M_{\Xi^-} - M_{\Xi(1530)}|$. The reconstruction for charged and neutral pion, $\Xi$ have been introduced before. The WCB can be also treated as what is introduced in Sec. 2.1. There are two similar matching angles between the truth and reconstructed $\pi^0$. One is from $\Xi(1530)^0 \to \pi^+\Xi^0$. The other is from $\Xi^0 \to p^+\Lambda$. The former is required to be less than 15°, while the latter is 25°. The $\Xi(1530)^0$ and $\Xi^0$ are selected by the recoil mass of tagged $\pi^+\Xi^-$ or $\pi^0\Xi^0$ against the $\Xi(1530)^0$ mass region, as shown in Fig. 5.

![Image](Fig. 5. Distributions of $M_{\Xi^0}^{\text{recoll}}$ for $\psi \to \Xi(1530)^0\Xi(1530)^0$, $\Xi(1530)^0\Xi^0$ from $\pi^+\Xi^-$ and $\pi^0\Xi^0$ modes (Top) and $\psi \to \Xi(1530)^0\Xi(1530)^0$, $\Xi(1530)^0\Xi^0$ from $\pi^0\Xi^0$ and $\pi^0\Xi^-\Xi^0$ modes (Bottom).)

Fig. 5. Distributions of $M_{\Xi^0}^{\text{recoll}}$ for $\psi \to \Xi(1530)^0\Xi(1530)^0$, $\Xi(1530)^0\Xi^0$ from $\pi^+\Xi^-$ and $\pi^0\Xi^0$ modes (Top) and $\psi \to \Xi(1530)^0\Xi(1530)^0$, $\Xi(1530)^0\Xi^0$ from $\pi^0\Xi^0$ and $\pi^0\Xi^-\Xi^0$ modes (Bottom).

3 Full reconstruction

In this section, we will focus on introducing the event selection for the traditional full-reconstruction method by taking $\psi \to \Xi^0\Xi^0$, $\Xi^-\Xi^+$ as examples. The resulting efficiencies can be used to compare with the single reconstruction one.

3.1 $\psi \to \Xi^0\Xi^0$

The final states are $\pi^0\pi^0\Lambda\bar{\Lambda}(\gamma\gamma\gamma\mu\mu^-\pi^-\pi^-)$. Thus, the candidate events should contain at least two positive charged track, two negative charged track and four photons, where the descriptions of the tracks reconstruction in the MDC combined with PID performance and photon reconstruction are the same as above.

The $\Lambda$ and $\bar{\Lambda}$ candidates are reconstructed from the identified $p\pi^-(-\bar{p}\pi^+)$ combinations, which are constrained to secondary vertices and have invariant masses closest to the nominal $\Lambda$ mass with the minimization of $\chi^2 = (M_{\pi^-} - M_{\Lambda})^2 + (M_{\bar{p}^+} - M_{\bar{\Lambda}})^2$. The $\chi^2$ of the secondary vertex fit must be less than 500. To further suppress the potential backgrounds, the decay lengths of $\Lambda$ and $\bar{\Lambda}$ is required to be larger than zero. The candidates for four photons and the $\Lambda\bar{\Lambda}$ pairs are subjected to a six constraint (6C) kinematic fit under the hypothesis of $\psi \to \Xi^0\Xi^0$ to reduce background and improve the mass resolution. When additional photons are found in
an event, all possible combinations are iterated over, and the one with the best kinematic fit $\chi_{6C}$ is kept with the requirement of $\chi_{6C} < 200$. After performing the 6C kinematic fit, the $\Xi^0$ and $\Xi^0$ candidates are reconstructed by the $\pi^0\Lambda$ and $\pi^0\bar{\Lambda}$ combinations with the minimization of $\sqrt{(M_{\pi^0\Lambda} - M_{\Xi^0})^2 + (M_{\pi^0\bar{\Lambda}} - M_{\Xi^0})^2}$. To further suppress the backgrounds, the requirements $|M_{\pi^0\Lambda} - M_{\Xi^0}| < 0.01$ GeV/$c^2$ or $|M_{\pi^0\bar{\Lambda}} - M_{\Xi^0}| < 0.01$ GeV/$c^2$ are employed. Figure 6 shows the corresponding invariant mass of $\pi\Lambda$. Clear $\Xi$ signals are seen.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig6.png}
\caption{Distribution of $M_{\pi\Lambda(\Xi^0)}$ for $J/\psi \to \Xi^0\Xi^0$ (Top) and $\psi(3686) \to \Xi^0\Xi^0$ (Bottom). Arrows denote the applied requirements.}
\end{figure}

3.2 $\psi \to \Xi^-\Xi^+$

For full reconstruction of the decay $\psi \to \Xi^-\Xi^+$, the final states are $\pi^+\pi^-\Lambda\bar{\Lambda}(p\bar{p}\pi^+\pi^-\pi^-)$. Thus, the candidate events should contain at least three positive charged track, and three negative charged track, where the descriptions of track reconstruction combined with PID performance are same as above.

The $\Lambda$ and $\bar{\Lambda}$ candidates are reconstructed with the same as before. The $\Xi^-$ and $\Xi^+$ candidates are reconstructed by minimizing $\sqrt{(M_{\pi^-\Lambda} - M_{\Xi^-})^2 + (M_{\pi^+\bar{\Lambda}} - M_{\Xi^+})^2}$. Furthermore, the requirements $M_{\pi\Lambda} \in [1.312,1.332]$ GeV/$c^2$ for $J/\psi \to \Xi^-\Xi^+$ and $M_{\pi\bar{\Lambda}} \in [1.308,1.338]$ GeV/$c^2$ for $\psi(3686) \to \Xi^-\Xi^+$ are used to suppress the background. Figure 7 shows the corresponding invariant mass of $\pi\Lambda$. Clear $\Xi$ signals are seen.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig7.png}
\caption{Distribution of $M_{\pi^-\Lambda(\Xi^0)}$ for $J/\psi \to \Xi^-\Xi^+$ (Top) and $\psi(3686) \to \Xi^-\Xi^+$ (Bottom). Arrows denote the applied requirements.}
\end{figure}

4 Determination of detection efficiency

The detection efficiencies of tow-body decays $\psi \to \Xi\Xi, \Xi(1530)\Xi(1530), \Xi(1530)\Xi$ can be determined by

$$\epsilon = \frac{N_{\text{selected}}}{N_{\text{generated}}}. \quad (2)$$

The statistical uncertainties of the efficiencies for above processes are determined by a binomial distribution:

$$\sigma_\epsilon = \sqrt{\frac{\epsilon(1-\epsilon)}{N_{\text{generated}}}}, \quad (3)$$

where $N_{\text{generated}} = 1,000,000$ is the generated simulation events, $N_{\text{selected}}$ denotes the selected simulation events after performing the event selection. Table 1 summaries the corresponding numerical results.

Table 1. Summary of the selection efficiencies for single baryon reconstruction $\epsilon_s$ and traditional full reconstruction $\epsilon_t$, where the final states for subsequent decays are simulated exclusively according to the corresponding branching fractions taken from PDG [3].
4.1 Background estimation

Using a total of $350 \times 10^6$ $\psi(3686)$ inclusive MC events, the background level for single baryon reconstruction method are studied by taking the process $\psi(3686) \rightarrow \Xi^0 \Xi^0$ as an example. Figure 3 shows the distribution of the recoil mass of $\pi^- \Lambda$. One can find that the background level is not large and the background shape is very smooth and can be described by a polynomial. It indicates that the signal events can be well separated from the background events based on single baryon reconstruction method.

![Fig. 3. Distribution of the recoil mass of $\pi^- \Lambda$ for the process $\psi(3686) \rightarrow \Xi^0 \Xi^0$.](image)

According to the results listed in Table 1, one can obtain the efficiency ratio with the consideration of subsequent decays differences for single and full reconstruction as below:

$$R = \frac{\epsilon_s}{\epsilon_f} \times \prod_i B_i \simeq 4, \quad (4)$$

which implies that the statistics with single baryon reconstruction method can be increased roughly by a factor of $\sim 4$ relative to the full-reconstruction method for the two-body baryonic decay of charmonium, where the $\prod_i B_i$ stands for the product of the branching fractions for the anti-baryon subsequent decays taken from PDG [6]. In addition, the detection efficiencies for another two-body decays $\psi \rightarrow \Xi(1530)\Xi(1530)$, $\Xi(1530)\Xi(1530)$ are also obtained based on single baryon reconstruction according to MC simulation, as listed in Table 2.

### Table 2. Summary of yields estimation.

| Mode | Cut Range (GeV/$c^2$) | $\epsilon_s(\%)$ | Cut Range (GeV/$c^2$) | $\epsilon_f(\%)$ |
|------|----------------------|-----------------|----------------------|-----------------|
| $J/\psi \rightarrow \Xi^0 \Xi^0$ | $M_{\psi(3686)} \in [1.1,1.55]$ | 14.47 ± 0.04 | $M_{\psi(3686)} \in [1.1,1.55]$ | 4.31 ± 0.02 |
| $\omega(3415)$ | $M_{\omega(3415)} \in [1.1,1.55]$ | 13.59 ± 0.03 | $M_{\omega(3415)} \in [1.1,1.55]$ | 4.35 ± 0.02 |
| $\psi(3686) \rightarrow \Xi^0 \Xi^0$ | $M_{\psi(3686)} \in [1.1,1.55]$ | 14.34 ± 0.04 | $M_{\psi(3686)} \in [1.1,1.55]$ | 5.09 ± 0.02 |
| $J/\psi \rightarrow \Xi^- \Xi^+$ | $M_{\psi(3686)} \in [1.2,1.45]$ | 27.47 ± 0.04 | $M_{\psi(3686)} \in [1.2,1.45]$ | 10.86 ± 0.03 |
| $\psi(3686) \rightarrow \Xi^- \Xi^+$ | $M_{\psi(3686)} \in [1.2,1.45]$ | 25.26 ± 0.04 | $M_{\psi(3686)} \in [1.2,1.45]$ | 10.82 ± 0.03 |

5 Yields expectation

Based on the detection efficiencies listed in Table 2, the expected yields are estimated as below:

$$N^{\exp}_\psi = N^{\text{total}}_\psi \times B(\psi \rightarrow B \bar{B}) \times \epsilon \times \prod_i B_i, \quad (5)$$

where $N^{\text{total}}_\psi$ denotes the total number of $J/\psi$ and $\psi(3686)$ events $N^{\text{total}}_{J/\psi} = (1310.6 \pm 7.0) \times 10^6$ [3], $N^{\text{total}}_{\psi(3686)} = (448.1 \pm 2.9) \times 10^6$ [4], $B(\psi \rightarrow B \bar{B})$ denotes the branching fraction for two-body decays taken from PDG [6] listed in Table 2, $\epsilon$ represents the corresponding selection. The $\prod_i B_i$ stands for the product of the branching fractions for the subsequent decays taken from the PDG [6]. The corresponding results combined with the expected yields are summarized in Table 2.
6 Sensitivity of angular distribution

According to the hadron helicity conservation \[9\], angular distribution for the process \(e^+e^- \rightarrow \psi(3686) \rightarrow B\bar{B}\) can be given by

\[
\frac{dN}{d\cos \theta} \times 1 + \alpha \cos^2 \theta_B,
\]

(6)

where \(\theta_B\) is the angle between one of the baryons and the beam directions in the \(e^+e^-\) center-of-mass system, and \(\alpha\) is the parameter of angular distribution. Based on the expected yields obtained using single baryon reconstruction method listed in Table 2 combined with the MC simulation with an assumption of \(\alpha_{\text{input}} = 0.5\) via EVTGEN \[10\], the angular distribution after event selection for the processes \(J/\psi, \psi(3686) \rightarrow \Xi(1530)\bar{\Xi}(1530), \Xi(1530)\bar{\Xi}\) is studied, and the sensitivity of measurement of angular distribution is also estimated. Figure 9 shows the fitted angular distributions for the processes \(J/\psi, \psi(3686) \rightarrow \Xi(1530)\bar{\Xi}(1530), \Xi(1530)\bar{\Xi}\) based on the simulated MC sample. Table 3 lists the fitted \(\alpha\) value of angular distributions and the corresponding sensitivity. The output is generally consistent with the input.

| Mode                                      | \(\epsilon'(\%)\) | \(B(\times 10^{-4})\) | \(N^{\exp}\) |
|-------------------------------------------|--------------------|-----------------------|--------------|
| \(J/\psi \rightarrow \Xi(1530)^-\Xi(1530)^+\) | 6.8 ± 0.1 (5.3 ± 0.1) | 10 \times (5.9 ± 1.5) | 306,904 ± 78,027 |
| \(J/\psi \rightarrow \Xi(1530)^0\Xi(1530)^0\) | 6.2 ± 0.1 (6.0 ± 0.1) | 10 \times (3.2 ± 1.4) | 162,053 ± 70,898 |
| \(J/\psi \rightarrow \Xi(1530)^0\Xi^+\)     | 9.8 ± 0.1 (11.5 ± 0.1) | 5.9 ± 1.5 | 50,501 ± 12,839 |
| \(J/\psi \rightarrow \Xi(1530)^0\Xi^-\)     | 15.9 ± 0.2 (11.2 ± 0.1) | 3.2 ± 1.4 | 37,871 ± 16,568 |
| \(\psi(3686) \rightarrow \Xi(1530)^-\Xi(1530)^+\) | 9.1 ± 0.1 (11.3 ± 0.1) | 0.52 \pm 0.12 | 1,444 ± 944 |
| \(\psi(3686) \rightarrow \Xi(1530)^0\Xi(1530)^0\) | 14.7 ± 0.2 (6.5 ± 0.1) | 0.52 \pm 0.12 | 1,756 ± 1,145 |
| \(\psi(3686) \rightarrow \Xi(1530)^0\Xi^-\)  | 9.1 ± 0.1 (11.9 ± 0.1) | \(\frac{1}{10} \times (0.52 \pm 0.12)\) | 147 ± 96 |
| \(\psi(3686) \rightarrow \Xi(1530)^0\Xi^+\)   | 15.9 ± 0.2 (7.4 ± 0.1) | \(\frac{1}{10} \times (0.52 \pm 0.12)\) | 192 ± 125 |

Table 3. Summary of estimation of sensitivity of angular distribution, where \(\alpha_{\text{Fitting}}\) denotes the fitted \(\alpha\) values and their uncertainties based on the simulated exclusive MC for individual decays.

\begin{tabular}{|l|c|c|}
\hline
Mode & \(\alpha_{\text{Fitting}}\) & Sensitivity (%) \\
\hline
(a) \(J/\psi \rightarrow \Xi(1530)^-\Xi(1530)^+\) & 0.455 ± 0.006 & 1.3 \\
(b) \(J/\psi \rightarrow \Xi(1530)^0\Xi(1530)^0\) & 0.471 ± 0.007 & 1.5 \\
(c) \(J/\psi \rightarrow \Xi(1530)^0\Xi^-\) & 0.488 ± 0.015 & 3.1 \\
(d) \(J/\psi \rightarrow \Xi(1530)^0\Xi^+\) & 0.479 ± 0.017 & 3.5 \\
(e) \(\psi(3686) \rightarrow \Xi(1530)^-\Xi(1530)^+\) & 0.410 ± 0.079 & 19.3 \\
(f) \(\psi(3686) \rightarrow \Xi(1530)^0\Xi(1530)^0\) & 0.409 ± 0.081 & 19.8 \\
(g) \(\psi(3686) \rightarrow \Xi(1530)^0\Xi^-\) & 0.403 ± 0.256 & 63.5 \\
(h) \(\psi(3686) \rightarrow \Xi(1530)^0\Xi^+\) & 0.562 ± 0.248 & 44.1 \\
\hline
\end{tabular}
7 Summary and prospects

Based on a single baryon reconstruction method, a MC study by taking two-body decays $\psi \to \Xi \Xi$ as examples is performed. The comparison of the detection efficiencies between single-reconstruction and full-reconstruction method concludes that the statistics of single baryon reconstruction method can increase by more than a factor of $\sim 4$ relative to the full-reconstruction one. With this method, we can improve the existing measurement precision of branching fractions and angular distribution parameters for some two-body baryonic decay of charmonium and search for the unknown decay based on the existing data sample. It will help people understand well the pQCD related to the theoretical predictions.

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