

Study of the decay $\psi' \rightarrow \phi \Lambda X, \psi' \rightarrow \Lambda \bar{\Lambda} X$

Aonan Zhu¹, Limin Gu², Hai-Bo Li¹

1.IHEP

2.Nanjing University

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Outline

- Motivation
- Dataset
- Analysis Method
- Event selection
- Signal Yield and Efficiency
- Systematic uncertainty
- Summary and next to do

$$\psi' \rightarrow \phi \Delta X$$

Analysis Method

1. Part reconstruction
2. observe the mass spectrum of recoil of $\phi\Lambda$, obtain signal yield.

Data set

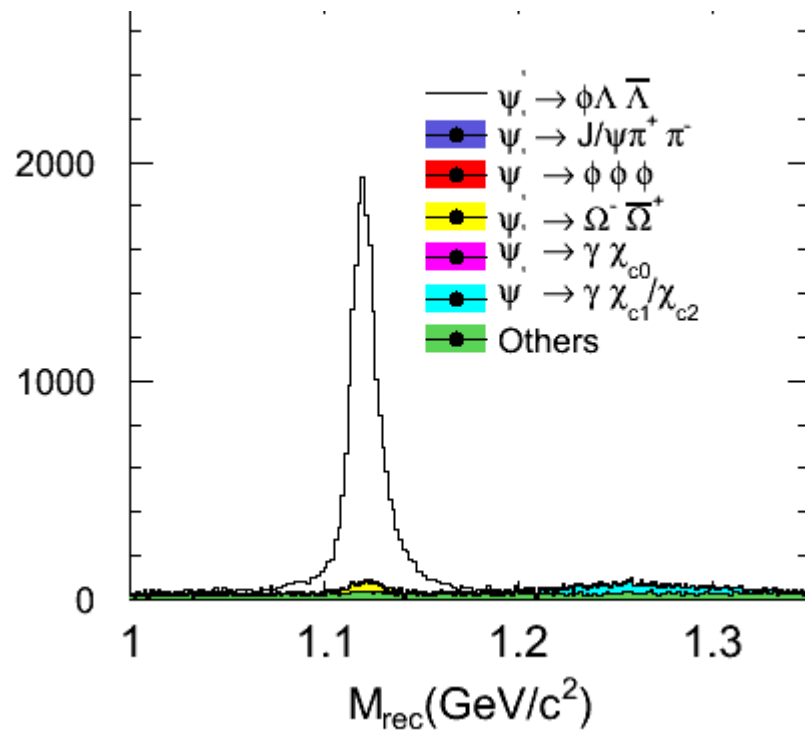
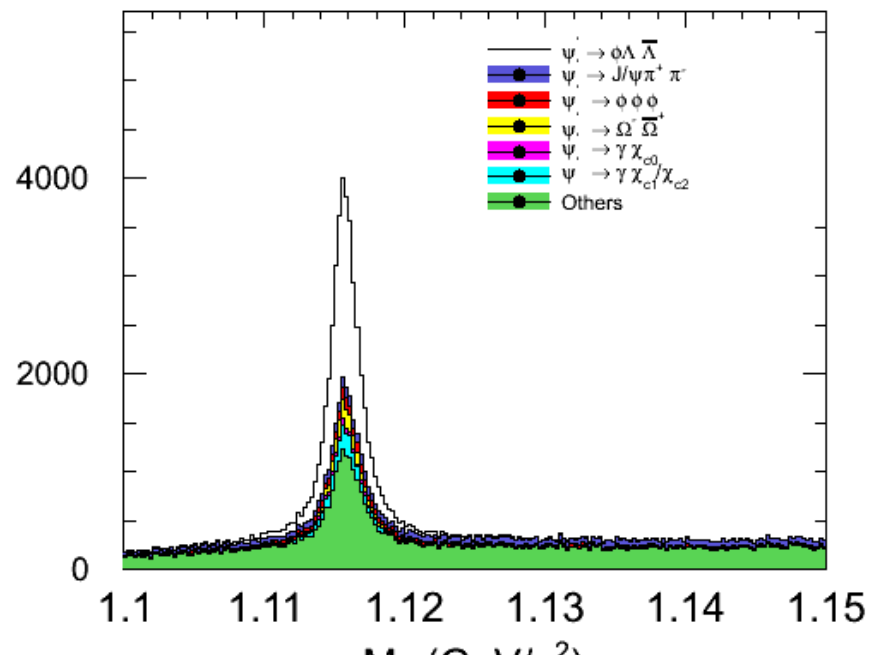
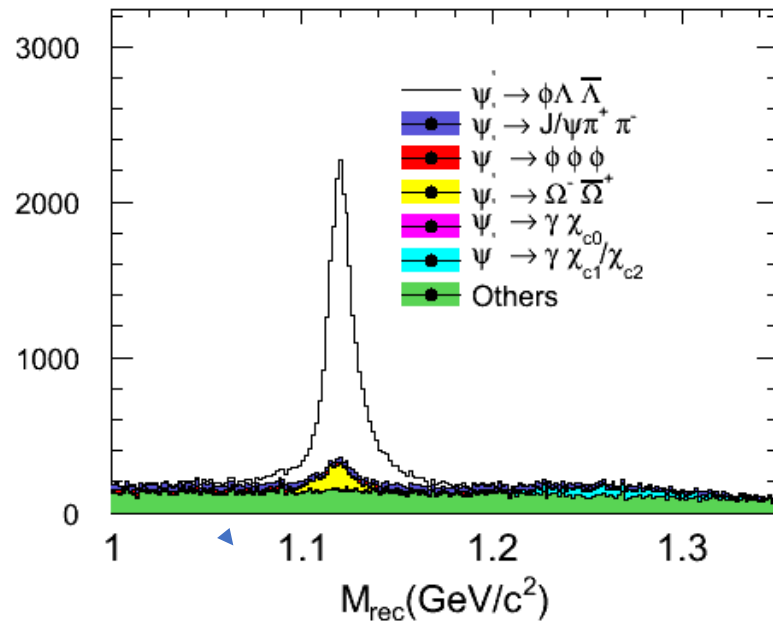
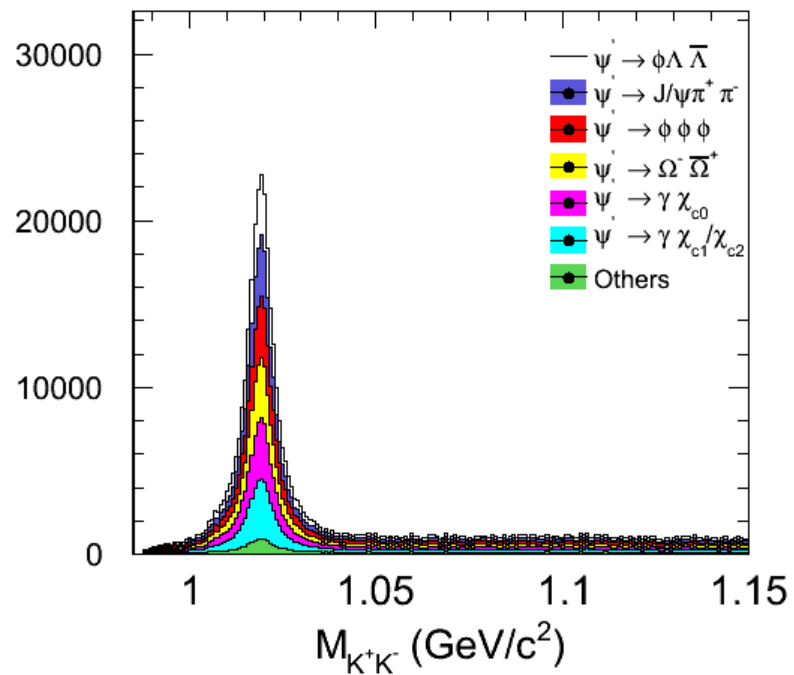
- BOSS version: 6.6.4.p03
- Data: $(448.1 \pm 2.9) \times 10^6$ ψ' events(2009+2012)
- Inclusive MC : 5.06×10^8 (2009+2012)
analysis the background events;
- Signal MC : study the efficiency (4.16×10^5 per channel)
 1. $\psi' \rightarrow \phi f_2(2340), f_2(2340) \rightarrow \Lambda \bar{\Lambda}, \phi \rightarrow K^+ K^-, \Lambda \rightarrow p \pi^-, \bar{\Lambda} \rightarrow \bar{p} \pi^+$;
 2. $\psi' \rightarrow \phi X(\Lambda \bar{\Lambda}), X(\Lambda \bar{\Lambda}) \rightarrow \Lambda \bar{\Lambda}, \phi \rightarrow K^+ K^-, \Lambda \rightarrow p \pi^-, \bar{\Lambda} \rightarrow \bar{p} \pi^+$;
 3. $\psi' \rightarrow \phi \Lambda \bar{\Lambda}$ (PHSP), $\phi \rightarrow K^+ K^-, \Lambda \rightarrow p \pi^-, \bar{\Lambda} \rightarrow \bar{p} \pi^+$

Event Selection

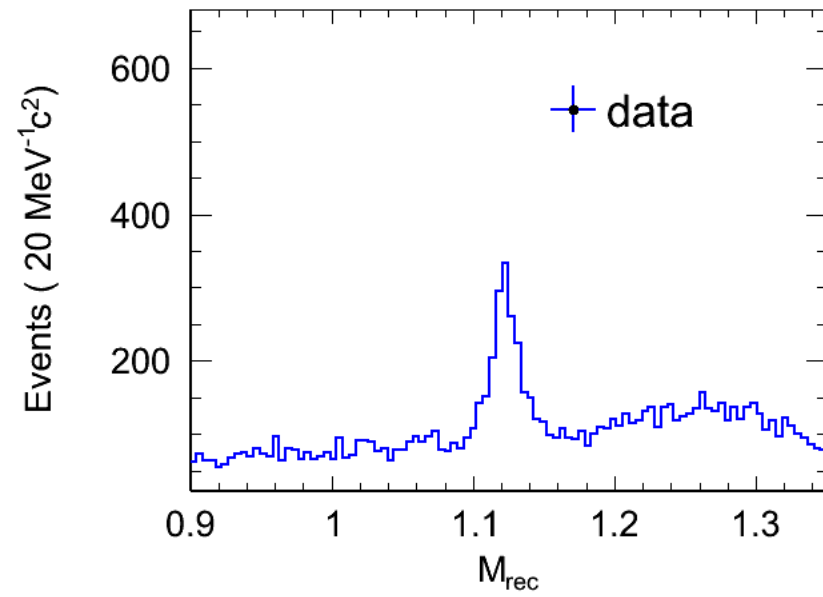
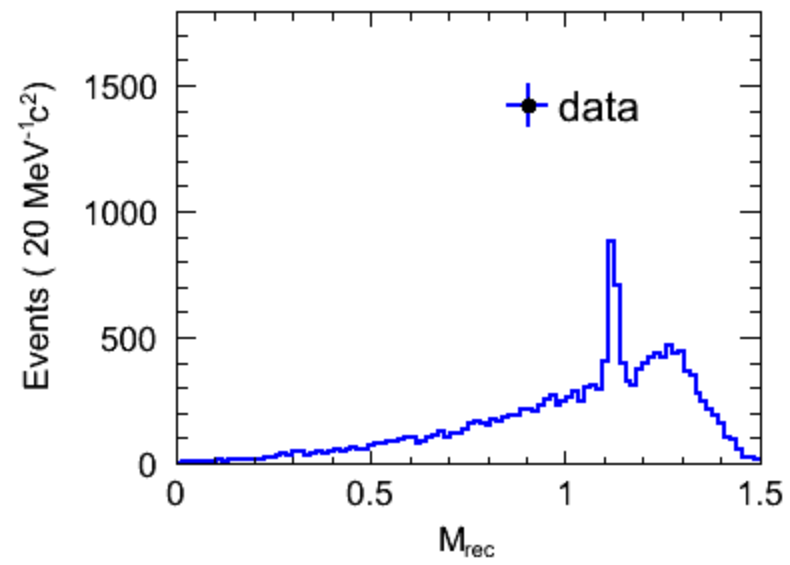
- Good charged tracks:
 $|V_z| < 20$ cm, $\cos(\theta) < 0.93$;
Number of good charged tracks : $4 < n$
- PID (dE/dx and TOF):
For (anti)proton: $\text{prob}(p) > \text{prob}(K), \text{prob}(p) > \text{prob}(\pi)$;
For Kaon: $\text{prob}(K) > \text{prob}(p), \text{prob}(K) > \text{prob}(\pi)$;
For pion: $\text{prob}(\pi) > \text{prob}(p), \text{prob}(\pi) > \text{prob}(K)$;
- $\Lambda/\bar{\Lambda}$ candidates:
- Second vertex fit , $\chi^2 < 200, L/2$

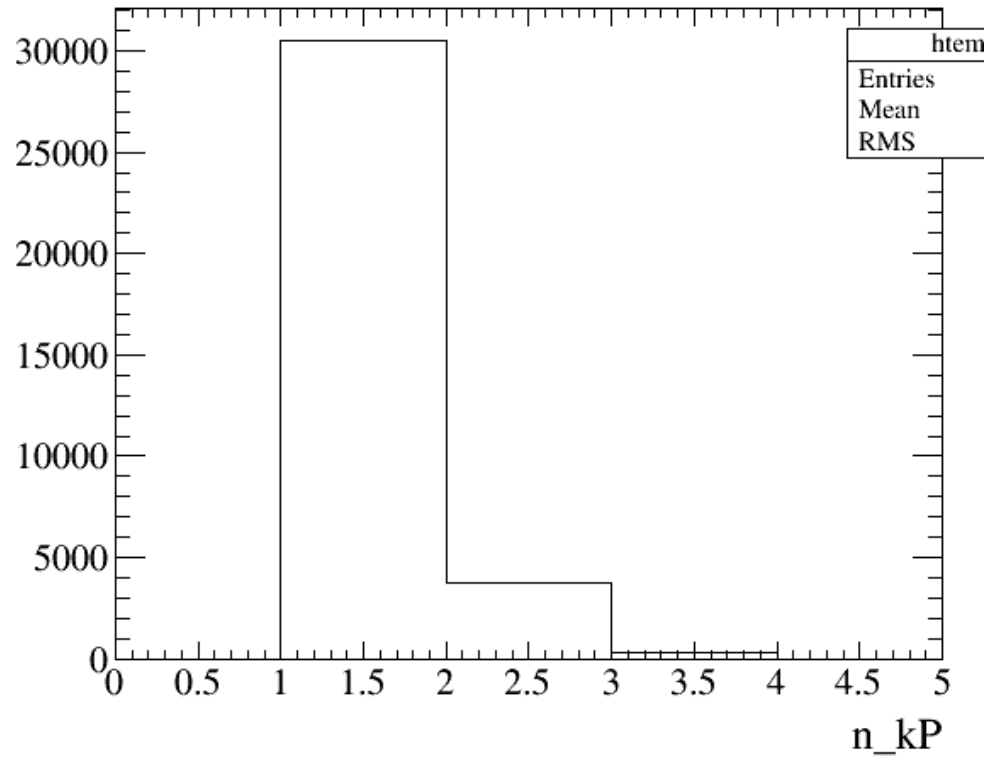
$$\frac{(M^{K^+K^-} - m_\phi)^2}{\sigma_\phi^2} + \frac{(M^{p\pi^-} - m_\Lambda)^2}{\sigma_\Lambda^2} \text{ to select best candidate.}$$

Further Selection



After cut

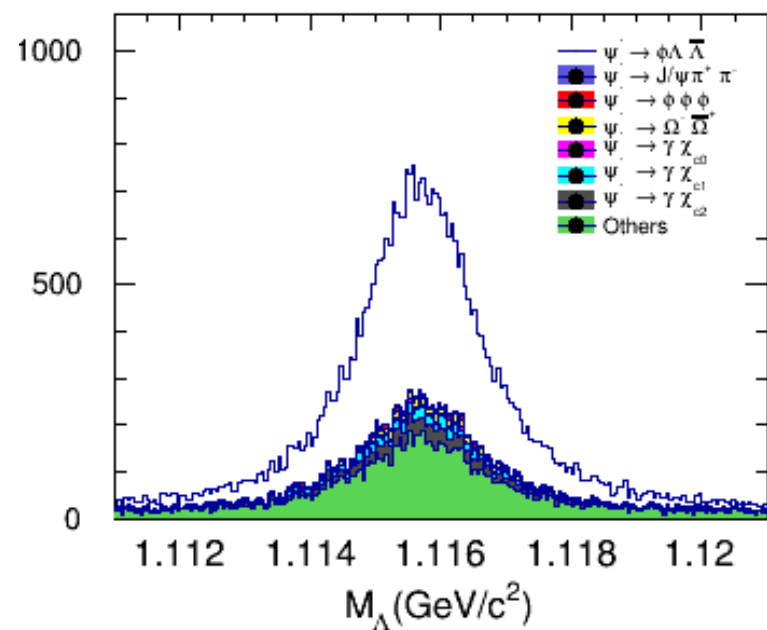
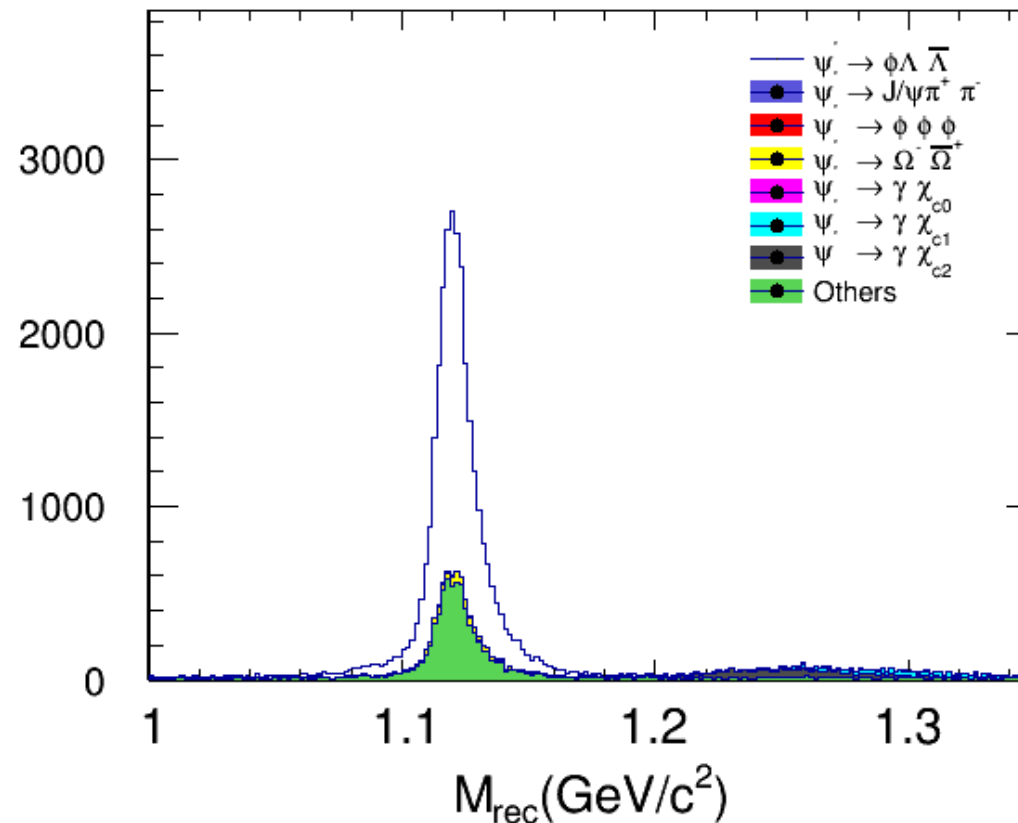
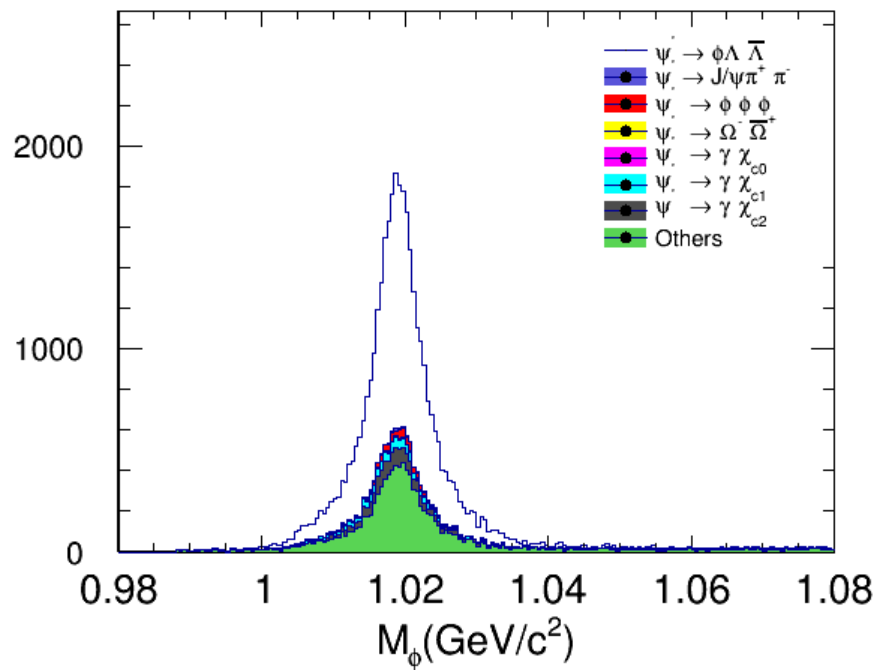




$$\frac{n_{KP} > 1 | n_{KM} > 1}{n_{KP} > 0 \&\& n_{KM} > 0} = 13.6\%$$

| No. | decay chain | final states | iTopology | nEvt | nTot |
|-----|---|---|-----------|-------|-------|
| 0 | $\psi' \rightarrow \Lambda\phi\Lambda, \Lambda \rightarrow p\pi^-, \phi \rightarrow K^+K^-, \bar{\Lambda} \rightarrow \bar{p}\pi^+$ | $\pi^-\bar{p}K^-\pi^+pK^+$ | 1 | 16735 | 16735 |
| 1 | $\psi' \rightarrow \phi\bar{\Lambda}\Lambda, \phi \rightarrow K^+K^-, \bar{\Lambda} \rightarrow \bar{p}\pi^+, \Lambda \rightarrow n\pi^0$ | $\bar{p}K^-\pi^0\pi^+nK^+$ | 3 | 6704 | 23439 |
| 2 | $\psi' \rightarrow \bar{\Lambda}\phi\Lambda, \bar{\Lambda} \rightarrow \bar{n}\pi^0, \phi \rightarrow K^+K^-, \Lambda \rightarrow p\pi^-$ | $\pi^-\bar{n}K^-\pi^0pK^+$ | 0 | 6703 | 30142 |
| 3 | $\psi' \rightarrow \gamma\chi_{c2}, \chi_{c2} \rightarrow \phi\Lambda\bar{\Lambda}, \phi \rightarrow K^+K^-, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{p}\pi^+$ | $\pi^-\bar{p}K^-\pi^+\gamma pK^+$ | 9 | 1018 | 31160 |
| 4 | $\psi' \rightarrow \gamma\chi_{c1}, \chi_{c1} \rightarrow \phi\Lambda\bar{\Lambda}, \phi \rightarrow K^+K^-, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{p}\pi^+$ | $\pi^-\bar{p}K^-\pi^+\gamma pK^+$ | 33 | 625 | 31785 |
| 5 | $\psi' \rightarrow \Omega^-\bar{\Omega}^+, \Omega^- \rightarrow \Lambda K^-, \bar{\Omega}^+ \rightarrow \bar{\Lambda}K^+, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{p}\pi^+$ | $\pi^-\bar{p}K^-\pi^+pK^+$ | 40 | 442 | 32227 |
| 6 | $\psi' \rightarrow \gamma\chi_{c2}, \chi_{c2} \rightarrow \phi\Lambda\bar{\Lambda}, \phi \rightarrow K^+K^-, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{n}\pi^0$ | $\pi^-\bar{n}K^-\pi^0\gamma pK^+$ | 11 | 418 | 32645 |
| 7 | $\psi' \rightarrow \gamma\chi_{c2}, \chi_{c2} \rightarrow \Lambda\bar{\Lambda}\phi, \Lambda \rightarrow n\pi^0, \bar{\Lambda} \rightarrow \bar{p}\pi^+, \phi \rightarrow K^+K^-$ | $\bar{p}K^-\pi^0\pi^+n\gamma K^+$ | 14 | 405 | 33050 |
| 8 | $\psi' \rightarrow \phi\phi\phi, \phi \rightarrow K^+K^-, \phi \rightarrow K^+K^-, \phi \rightarrow K^+K^-$ | $K^-K^-K^-K^+K^+K^+$ | 42 | 309 | 33359 |
| 9 | $\psi' \rightarrow \gamma\chi_{c1}, \chi_{c1} \rightarrow \Lambda\bar{\Lambda}\phi, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{n}\pi^0, \phi \rightarrow K^+K^-$ | $\pi^-\bar{n}K^-\pi^0\gamma pK^+$ | 12 | 222 | 33581 |
| 10 | $\psi' \rightarrow \gamma\chi_{c1}, \chi_{c1} \rightarrow \Lambda\bar{\Lambda}\phi, \Lambda \rightarrow n\pi^0, \bar{\Lambda} \rightarrow \bar{p}\pi^+, \phi \rightarrow K^+K^-$ | $\bar{p}K^-\pi^0\pi^+n\gamma K^+$ | 65 | 216 | 33797 |
| 11 | $\psi' \rightarrow \Omega^-\bar{\Omega}^+, \Omega^- \rightarrow \Lambda K^-, \bar{\Omega}^+ \rightarrow \bar{\Lambda}K^+, \Lambda \rightarrow n\pi^0, \bar{\Lambda} \rightarrow \bar{p}\pi^+$ | $\bar{p}K^-\pi^0\pi^+nK^+$ | 15 | 183 | 33980 |
| 12 | $\psi' \rightarrow \gamma\chi_{c0}, \chi_{c0} \rightarrow \phi\Lambda\bar{\Lambda}, \phi \rightarrow K^+K^-, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{p}\pi^+$ | $\pi^-\bar{p}K^-\pi^+\gamma pK^+$ | 19 | 179 | 34159 |
| 13 | $\psi' \rightarrow \Omega^-\bar{\Omega}^+, \Omega^- \rightarrow \Lambda K^-, \bar{\Omega}^+ \rightarrow \bar{\Lambda}K^+, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{n}\pi^0$ | $\pi^-\bar{n}K^-\pi^0pK^+$ | 6 | 172 | 34331 |
| 14 | $\psi' \rightarrow \phi\phi\phi, \phi \rightarrow K^+K^-, \phi \rightarrow K^+K^-, \phi \rightarrow K_LK_S, K_S \rightarrow \pi^+\pi^-$ | $\pi^-K^-K^-K_L\pi^+K^+K^+$ | 51 | 162 | 34493 |
| 15 | $\psi' \rightarrow \bar{n}\Lambda K^{*0}, \Lambda \rightarrow p\pi^-, K^{*0} \rightarrow K^+\pi^-$ | $\pi^-\pi^-\bar{n}pK^+$ | 28 | 142 | 34635 |
| 16 | $\psi' \rightarrow \bar{K}^{*0}n\bar{\Lambda}, \bar{K}^{*0} \rightarrow K^-\pi^+, \bar{\Lambda} \rightarrow \bar{p}\pi^+$ | $\bar{p}K^-\pi^+\pi^+n$ | 56 | 140 | 34775 |
| 17 | $\psi' \rightarrow \bar{\Sigma}^0\phi\Sigma^0, \bar{\Sigma}^0 \rightarrow \gamma\bar{\Lambda}, \phi \rightarrow K^+K^-, \Sigma^0 \rightarrow \gamma\Lambda, \bar{\Lambda} \rightarrow \bar{p}\pi^+, \Lambda \rightarrow p\pi^-$ | $\pi^-\bar{p}K^-\pi^+\gamma\gamma pK^+$ | 39 | 116 | 34891 |
| 18 | $\psi' \rightarrow \phi\phi\phi, \phi \rightarrow K_LK_S, \phi \rightarrow K^+K^-, \phi \rightarrow K^+K^-, K_S \rightarrow \pi^0\pi^0$ | $K^-K^-\pi^0\pi^0K_LK^+K^+$ | 32 | 105 | 34996 |
| 19 | $\psi' \rightarrow \gamma\chi_{c0}, \chi_{c0} \rightarrow \Lambda\bar{\Lambda}\phi, \bar{\Lambda} \rightarrow \bar{n}\pi^0, \Lambda \rightarrow p\pi^-, \phi \rightarrow K^+K^-$ | $\pi^-\bar{n}K^-\pi^0\gamma pK^+$ | 93 | 76 | 35072 |
| 20 | $\psi' \rightarrow \Lambda\bar{\Lambda}\phi, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{n}\pi^0, \phi \rightarrow K^+K^-$ | $\pi^-\bar{n}K^-\pi^0pK^+$ | 210 | 71 | 35143 |
| 21 | $\psi' \rightarrow \bar{\Lambda}\Lambda\phi, \bar{\Lambda} \rightarrow \bar{p}\pi^+, \Lambda \rightarrow n\pi^0, \phi \rightarrow K^+K^-$ | $\bar{p}K^-\pi^0\pi^+nK^+$ | 74 | 65 | 35208 |
| 22 | $\psi' \rightarrow \gamma\phi\phi, \phi \rightarrow K^+K^-, \phi \rightarrow K^+K^-$ | $K^-K^-\gamma K^+K^+$ | 101 | 64 | 35272 |
| 23 | $\psi' \rightarrow \gamma\chi_{c0}, \chi_{c0} \rightarrow \Lambda\bar{\Lambda}\phi, \Lambda \rightarrow n\pi^0, \bar{\Lambda} \rightarrow \bar{p}\pi^+, \phi \rightarrow K^+K^-$ | $\bar{p}K^-\pi^0\pi^+n\gamma K^+$ | 107 | 61 | 35333 |
| 24 | $\psi' \rightarrow J/\psi\pi^+\pi^-, J/\psi \rightarrow K^{*0}\phi\bar{K}^{*0}, K^{*0} \rightarrow K^+\pi^-, \phi \rightarrow K^+K^-, \bar{K}^{*0} \rightarrow K^-\pi^+$ | $\pi^-\pi^-K^-K^-\pi^+\pi^+K^+K^+$ | 66 | 60 | 35393 |
| 25 | $\psi' \rightarrow \Sigma^0\phi\bar{\Sigma}^0, \Sigma^0 \rightarrow \gamma\Lambda, \phi \rightarrow K^+K^-, \bar{\Sigma}^0 \rightarrow \gamma\bar{\Lambda}, \Lambda \rightarrow p\pi^-, \bar{\Lambda} \rightarrow \bar{n}\pi^0$ | $\pi^-\bar{n}K^-\pi^0\gamma\gamma pK^+$ | 92 | 55 | 35448 |
| 26 | $\psi' \rightarrow J/\psi\pi^+\pi^-, J/\psi \rightarrow \phi K^{*-}K^{*+}, \phi \rightarrow K^+K^-, K^{*-} \rightarrow K^-\pi^0, K^{*+} \rightarrow K^+\pi^0$ | $\pi^-K^-K^-\pi^0\pi^0\pi^+K^+K^+$ | 75 | 54 | 35502 |
| 27 | $\psi' \rightarrow J/\psi\pi^+\pi^-, J/\psi \rightarrow \phi\bar{K}^{*0}K^{*0}, \phi \rightarrow K^+K^-, \bar{K}^{*0} \rightarrow K^-\pi^+, K^{*0} \rightarrow K^0\pi^0$ | $\pi^-K^-K^-\pi^0K_L\pi^+\pi^+K^+$ | 145 | 47 | 35549 |
| 28 | $\psi' \rightarrow J/\psi\pi^+\pi^-, J/\psi \rightarrow K^{*-}K^{*+}\phi, K^{*-} \rightarrow K^-\pi^0, K^{*+} \rightarrow K^0\pi^+, \phi \rightarrow K^+K^-$ | $\pi^-K^-K^-\pi^0K_L\pi^+\pi^+K^+$ | 215 | 46 | 35595 |
| 29 | $\psi' \rightarrow J/\psi\pi^0\pi^0, J/\psi \rightarrow \phi K^{*+}K^{*+}, \phi \rightarrow K^+K^-, K^{*+} \rightarrow K^-\pi^0, K^{*+} \rightarrow K^+\pi^0$ | $K^-K^-\pi^0\pi^0\pi^0\pi^0K^+K^+$ | 63 | 45 | 35640 |

Table 1:



Method1:24.2%
Method2:21.7%

