Report on Recent Work from 2014.9 to 2014.12

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Work Been Done

Software Learning

- BOSS (Including Analysis Code of $\rho\pi$)
- ROOT && RooFit

Investigation on the Subject

- Study of $\psi(3686) \to \pi^0 h_c, h_c \to \gamma\eta_c$ via η_c exclusive decays (PRL **104**, 132002 (2010))
- Measurements of $h_c(1^P_1)$ in $\psi\prime$ Decays (PRL **86**, 092009 (2012))

Research Been Done(Measure of the branching ratio of $\eta_c \to K^0_S K\pi$)

- Exclusive Process of $\psi\prime \to \pi^0 h_c, h_c \to \gamma\eta_c, \eta_c \to K^0_S K\pi$
- Inclusive Process of $\psi\prime \to \pi^0 h_c, h_c \to \gamma\eta_c, \eta_c \to$ *anything*

Software Learning

Learn about the Software Environment

- The installation of BOSS
- The difference between different version.

Learn about the Analysis Code of $\rho\pi$

- The acquisition of the data from different sub-detectors
- The usage of different classes of the program, such as PID, vertex fit and kinematics fit

Learn about the ROOT and RooFit

- Do histogram analysis in the self-build compiler
- Write some ROOT/RooFit micros to analyze the data

Investigation on the Subject

Study of $\psi(3686) \to \pi^0 h_c, h_c \to \gamma\eta_c$ via η_c exclusive decays

In this paper the authors studied the η_c exclusive decays.
The branching ratio of the process of $\eta_c \to K_S^0 K\pi$ is measured in this paper, the value is $2.60 \pm 0.29 \pm 0.34 \pm 0.25\%$.
The error is relatively large.

Measurements of $h_c(1_1^P)$ in $\psi\prime$ Decays

In this paper the authors studied h_c via the inclusive process of

$$\psi\prime \to \pi^0 h_c, h_c \to \gamma\eta_c, \eta_c \to anything.$$

The purpose of our work

Measure the branching ratio of the process $\eta_c \to K_S K \pi$, reducing the relative error measured before.

Methods

- Fit η_c with K_S^0, K and π, requiring the reconstruction of K_S^0, K and π(Corresponding to N_{Obs1} and ϵ_1);
- Fit η_c signal with the recoil mass of γ and π^0, requiring the reconstruction of π^0 and γ_{E1}(Corresponding to N_{Obs2} and ϵ_2);
- The branching fraction will be acquired as the ratio of the two η_c signal as

$$Br(\eta_c \to K_S^0 K \pi) = \left(\frac{N_{Obs1}}{N_{Obs2}} \cdot \frac{\epsilon_2}{\epsilon_1} \cdot \frac{1}{Br(K_S^0 \to \pi^+\pi^-)}\right)^{\frac{1}{2}}$$

Preliminary Selection

Selection of γ and π^0

- $E_\gamma > 25MeV, |\cos\theta| < 0.8$ (barrel region)
- $E_\gamma > 50MeV, 0.86 < |\cos\theta| < 0.92$ (end-cap region)
- $|M_{\gamma\gamma} - m_{\pi^0}| < 15MeV/c^2$ (With 1C)

Selection of charged tracks

- $|\cos\theta| < 0.93$
- $|R_z| < 10cm, R_{xy} < 1cm$
- $|M_{\pi\pi} - m_{K_S^0}| < 20MeV/c^2$

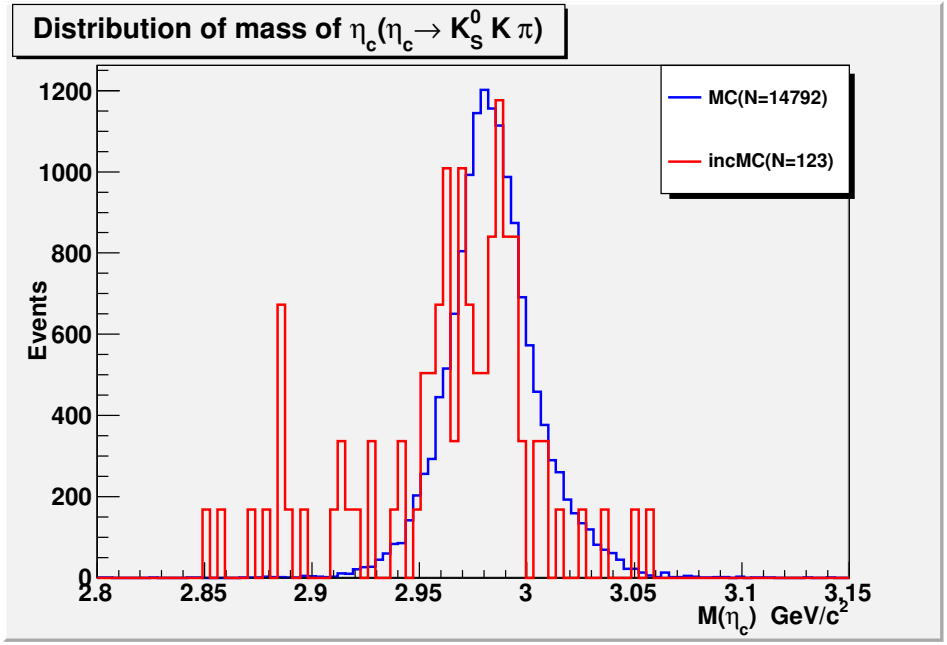
We accept the ones with the minimum $\chi^2 = \chi^2_{4C} + \chi^2_{1C} + \chi^2_{pid} + \chi^2_{vertex}$.

Optimized Selection

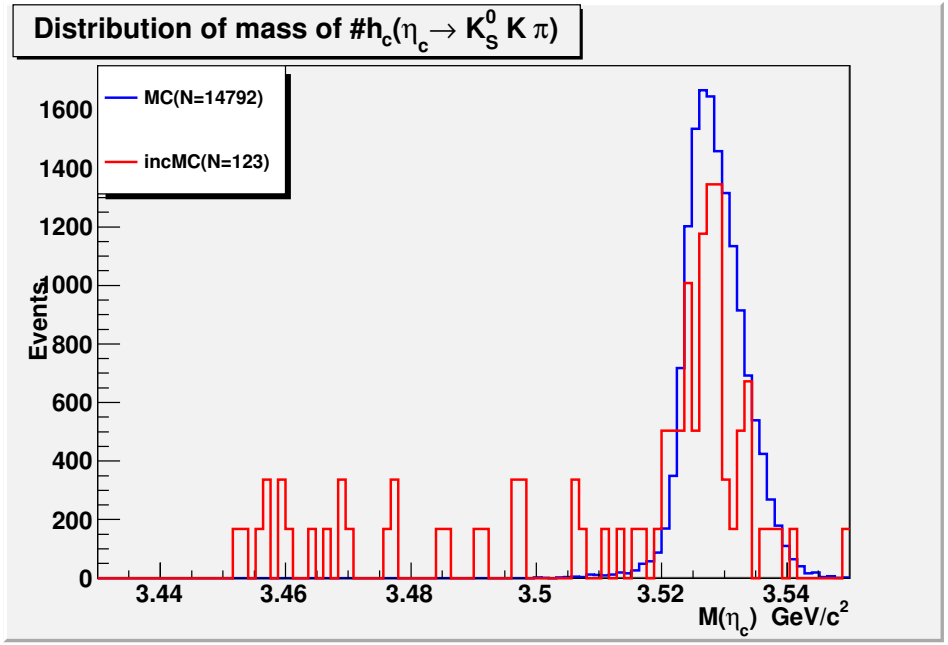
Using ROOT scripts, we got the Optimized Selection as below:

- $0 < \chi^2_{4C} < 25$;
- $0.125 < m_{\pi^0} < 0.138$;
- $0.45 < E(\gamma_{E1}) < 0.53$;
- $|m_{recoil}(\pi^0\pi^0) - M_{J/\psi}| < 0.033$;
- $|m_{recoil}(\gamma) - M_{\chi_{c0}}| < 0$;
- $|m_{recoil}(\gamma) - M_{\chi_{c1}}| < 0.004$;
- $|m_{recoil}(\gamma) - M_{\chi_{c2}}| < 0.002$;
- $|m_{recoil}(\pi^+\pi^-) - M_{J/\psi}| < 0.004$.

Preliminary Results



Mass distribution of η_c



Mass distribution of h_c

Topology analysis

No.	decay chain	final states	iTopo	nEvt	nTot
0	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^0\pi^- K^+,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	2	38	38
1	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^-\pi^+ K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	6	35	73
2	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \bar{K}^0\rho^- K^+,\ \bar{K}^0 \to K_S,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	24	6	79
3	$\psi' \to K^-\bar{K}^*\gamma\pi^+,\ \bar{K}^* \to \bar{K}^0\pi^0,\ \bar{K}^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	1	5	84
4	$\psi' \to \pi^-\gamma K^* K^+,\ K^* \to \pi^0 K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	5	4	88
5	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^-\rho^+ K^0,\ \rho^+ \to \pi^0\pi^+,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	14	3	91
6	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \bar{K}^* K^*,\ \bar{K}^* \to K^-\pi^+,\ K^* \to \pi^0 K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	11	2	93
7	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \pi^0 K^0 K^*,\ K^0 \to K_S,\ K^* \to \pi^- K^+,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	12	2	95
8	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to K^-\rho^+ K^0,\ \rho^+ \to \pi^0\pi^+,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	13	2	97
9	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^{*-} K^{*+},\ K^{*-} \to \bar{K}^0\pi^-,\ K^{*+} \to \pi^0 K^+,\ \bar{K}^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	0	2	99
10	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^{*-} K^{*+},\ K^{*-} \to K^-\pi^0,\ K^{*+} \to \pi^+ K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	16	2	101
11	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \bar{K}^0\rho^- K^+,\ \bar{K}^0 \to K_S,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	3	2	103
12	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to K^-\pi^+ K^*,\ K^* \to \pi^0 K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	26	2	105
13	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \bar{K}^0\pi^- K^{*+},\ \bar{K}^0 \to K_S,\ K^{*+} \to \pi^0 K^+,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	8	1	106
14	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \bar{K}^*\pi^0 K^0,\ \bar{K}^* \to K^-\pi^+,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	9	1	107
15	$\psi' \to \gamma\eta_c,\ \eta_c \to K^-\pi^+ K^*,\ K^* \to \pi^0 K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	15	1	108
16	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \bar{K}^*\pi^- K^+,\ \bar{K}^* \to \bar{K}^0\pi^0,\ \bar{K}^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	10	1	109
17	$\psi' \to K^- K_1^+,\ K_1^+ \to \rho^+ K^0,\ \rho^+ \to \pi^0\pi^+,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^- K^-$	17	1	110
18	$\psi' \to \bar{K}^*\pi^0 K_2^{*0},\ \bar{K}^* \to \bar{K}^0\pi^0,\ K_2^{*0} \to \pi^- K^+,\ \bar{K}^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	18	1	111
19	$\psi' \to K^- K_1^+,\ K_1^+ \to \rho^+ K^0,\ \rho^+ \to \gamma_{FSR}\pi^0\pi^+,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma_{FSR}\pi^+\pi^+\pi^- K^-$	19	1	112
20	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \pi^- K^* K^+,\ K^* \to \pi^0 K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	20	1	113
21	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to K^{*-} K^{*+},\ K^{*-} \to K^-\pi^0,\ K^{*+} \to \pi^+ K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	21	1	114
22	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \bar{K}^0\pi^0 K^*,\ \bar{K}^0 \to K_S,\ K^* \to \pi^- K^+,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	22	1	115
23	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^-\pi^0 K^{*+},\ K^{*+} \to \pi^+ K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	23	1	116
24	$\psi' \to \bar{K}^*\gamma K^*,\ \bar{K}^* \to K^-\pi^+,\ K^* \to \pi^0 K^0,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	4	1	117
25	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to K^-\bar{K}^0\pi^0\pi^+,\ \bar{K}^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	25	1	118
26	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \bar{K}^*\pi^0 K^0,\ \bar{K}^* \to K^-\pi^+,\ K^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma\pi^+\pi^+\pi^- K^-$	7	1	119
27	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^{*-}\pi^0 K^+,\ K^{*-} \to \bar{K}^0\pi^-,\ \bar{K}^0 \to K_S,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma\gamma K^+\pi^+\pi^-\pi^-$	27	1	120
28	$\psi' \to \pi^-\pi^+ K_S K_S,\ K_S \to \pi^-\pi^+,\ K_S \to \pi^0\pi^0,$	$\psi' \to \gamma\gamma\gamma\gamma\pi^+\pi^+\pi^-\pi^-$	28	1	121
29	$\psi' \to K_1^- K^+,\ K_1^- \to \bar{K}^0\rho^-,\ \bar{K}^0 \to K_S,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+,$	$\psi' \to \gamma\gamma K^+\pi^+\pi^-\pi^-$	29	1	122

Table 1:

Preliminary Event Selection

Selection of γ_{E1} and π^0 candidates

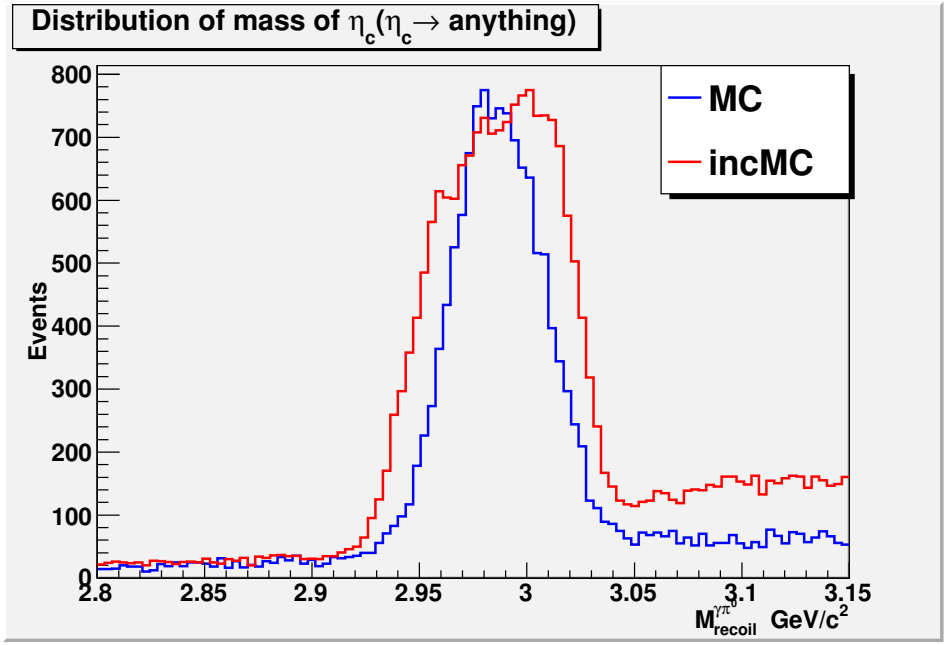
- $E_\gamma > 25MeV, |\cos\theta| < 0.8$ (barrel region)
- $E_\gamma > 50MeV, 0.86 < |\cos\theta| < 0.92$ (end-cap region)
- $465MeV < E(\gamma_{\mathrm{E1}}) < 535MeV$
- $120 < M_{\gamma\gamma} < 145MeV/c^2$ (With 1C)
- photons used in γ_{E1} candidates cannot form π^0 with another good photon
- We keep the π^0 candidates with the minimum 1-C fit χ^2 even if the daughter photons can be used in more than one π^0 candidates
- We exclude the events with more than one π^0 in the $3.517 - 3.535GeV/c^2$ recoil-mass region.

Optimized Event Selection

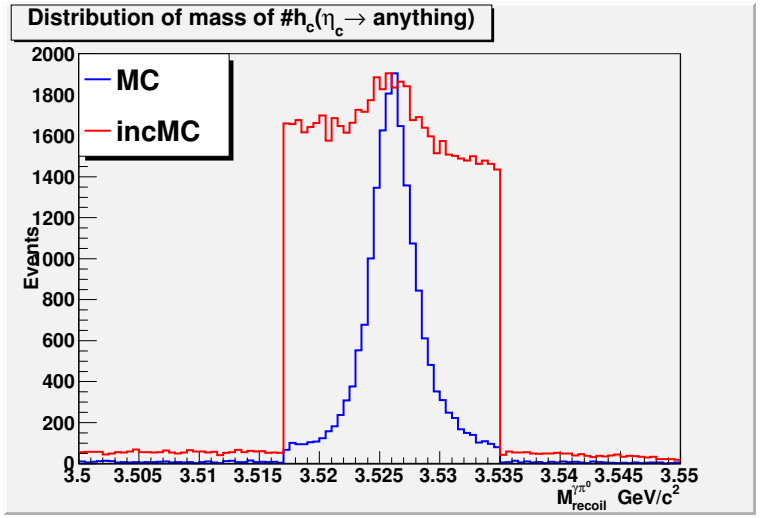
Using ROOT scripts, we got the Optimized Selection as below:

- $E(deposition) < 0.6 GeV$;
- $|m_{recoil}(\pi^0\pi^0) - M_{J/\psi}| < 0.02$;
- $|m_{recoil}(\gamma) - M_{\chi_{c0}}| < 0.004$;
- $|m_{recoil}(\gamma) - M_{\chi_{c1}}| < 0.004$;
- $|m_{recoil}(\gamma) - M_{\chi_{c2}}| < 0.003$;
- $|m_{recoil}(\pi^+\pi^-) - M_{J/\psi}| < 0.01$.

Preliminary Results



Mass distribution of η_c



Mass distribution of h_c

Topology analysis

No.	decay chain	final states	iTopo	nEvt	nTot
0	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \pi^-\pi^-\pi^0\pi^+\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^0\pi^-\pi^-$	54	153	153
1	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^- K_L \pi^+$	$\psi' \to \gamma\pi^+ K_L \pi^0 K^-$	391	84	237
2	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^-\pi^-\pi^0\pi^+ K^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^0\pi^- K^-$	218	80	317
3	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \pi^- K_L K^+$	$\psi' \to \gamma K^+ K_L \pi^0 \pi^-$	309	77	394
4	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to K^-\pi^-\pi^0\pi^+ K^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^0\pi^- K^-$	210	73	467
5	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^0\pi^0\pi^-\pi^-$	69	63	530
6	$\psi' \to \bar{p}\pi^0\pi^+ n$	$\psi' \to n\pi^+\pi^0\bar{p}$	172	61	591
7	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \pi^-\pi^-\pi^+\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-\pi^-$	617	58	649
8	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \bar{p}\pi^+ n$	$\psi' \to \gamma n\pi^+\pi^0\bar{p}$	519	57	706
9	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \pi^-\pi^-\pi^-\pi^0\pi^+\pi^+\pi^+$	$\psi' \to \pi^+\pi^+\pi^+\pi^0\pi^0\pi^0\pi^-\pi^-\pi^-$	185	53	759
10	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to e^- e^+$	$\psi' \to \pi^0\pi^0 e^+ e^-$	196	52	811
11	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to b_1^-\pi^0\pi^0\pi^+,\ b_1^- \to \pi^-\omega,\ \omega \to \pi^-\pi^0\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^0\pi^0\pi^0\pi^-\pi^-$	124	51	862
12	$\psi' \to \gamma\chi_{c0},\ \chi_{c0} \to b_1^-\pi^0\pi^+,\ b_1^- \to \pi^-\omega,\ \omega \to \pi^-\pi^0\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^0\pi^-\pi^-$	718	51	913
13	$\psi' \to \eta J/\psi,\ \eta \to \pi^0\pi^0\pi^0,\ J/\psi \to \pi^-\pi^-\pi^0\pi^+\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^0\pi^0\pi^-\pi^-$	645	49	962
14	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \pi^-\eta b_1^+,\ \eta \to \gamma\gamma,\ b_1^+ \to \pi^+\omega,\ \omega \to \pi^-\pi^0\pi^+$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^0\pi^0\pi^0\pi^-\pi^-$	173	49	1011
15	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \pi^-\gamma\pi^0\pi^0\pi^+$	$\psi' \to \gamma\pi^+\pi^0\pi^0\pi^0\pi^0\pi^-$	215	48	1059
16	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \pi^-\pi^-\pi^-\pi^+\pi^+\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^+\pi^0\pi^-\pi^-\pi^-$	98	47	1106
17	$\psi' \to \gamma\chi_{c0},\ \chi_{c0} \to \pi^-\pi^+ b_1^0,\ b_1^0 \to \pi^0\omega,\ \omega \to \pi^-\pi^0\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^0\pi^-\pi^-$	342	44	1150
18	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to b_1^-\pi^+\eta,\ b_1^- \to \pi^-\omega,\ \eta \to \gamma\gamma,\ \omega \to \pi^-\pi^0\pi^+$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^0\pi^0\pi^0\pi^-\pi^-$	582	43	1193
19	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^-\pi^+ K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^- K^-$	475	43	1236
20	$\psi' \to \pi^-\pi^0\pi^0 b_1^+,\ b_1^+ \to \pi^+\omega,\ \omega \to \pi^-\pi^0\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^0\pi^-\pi^-$	205	42	1278
21	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \bar{n}\pi^+\Delta^-,\ \Delta^- \to \pi^- n$	$\psi' \to n\pi^+\pi^0\pi^0\pi^-\bar{n}$	756	41	1319
22	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^{*-}\pi^+ K^*,\ K^{*-} \to \pi^- K_L,\ K^* \to \pi^- K^+$	$\psi' \to \gamma K^+\pi^+ K_L \pi^0\pi^-\pi^-$	200	39	1358
23	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \pi^- K_S K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	123	38	1396
24	$\psi' \to \bar{n}K^*\Lambda,\ K^* \to \pi^- K^+,\ \Lambda \to \pi^0 n$	$\psi' \to nK^+\pi^0\pi^-\bar{n}$	104	37	1433
25	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \bar{K}^*\pi^- K^{*+},\ \bar{K}^* \to K^-\pi^+,\ K^{*+} \to K_L\pi^+$	$\psi' \to \gamma\pi^+\pi^+ K_L\pi^0\pi^- K^-$	134	35	1468
26	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \bar{n}\pi^-\pi^+ n$	$\psi' \to n\pi^+\pi^0\pi^0\pi^-\bar{n}$	369	35	1503
27	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \pi^-\pi^+ b_1^0,\ b_1^0 \to \pi^0\omega,\ \omega \to \pi^-\pi^0\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^0\pi^-\pi^-$	151	35	1538
28	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \rho^0\rho^0,\ \rho^0 \to \pi^-\pi^+,\ \rho^0 \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-\pi^-$	250	35	1573
29	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \bar{K}^*\pi^- K^+,\ \bar{K}^* \to K^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^- K^-$	79	35	1608

Table 1:

Work to do

- Background study for the inclusive process
- Fit the γ π^0 recoil mass
- Do IO check for inclusive process
- Run data to get the branching ratio