Measure of the Branching Ratio of the process $\eta_c \to K_S^0 K\pi$ via the decay $\psi(3686) \to \pi^0 h_c, h_c \to \gamma\eta_c$

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The purpose of our work

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

The process we study

$$\psi(3686) \to \pi^0 h_c, h_c \to \gamma \eta_c, \eta_c \to K_S^0 K \pi$$
$$\pi^0 \to \gamma\gamma, K_S^0 \to \pi^+ \pi^-$$

Method to do it

- Fit η_c signal with invariant mass 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(Corresponding to N_{Obs2} and ϵ_2);
- The branching fraction will be acquired as the ratio of the two η_c signals as

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

Data Set

- inclusive MC: 106M(2009)
- signal MC: 200K for each of the inclusive process and exclusive process
- BOSS version: 664p01

the Exclusive Process

Charged and Neutral Track Selection Criteria

Charged Tracks Selection Criteria

- $|\cos\theta| < 0.93$
- $|R_z| < 10cm, R_{xy} < 1cm$ (for the charged tracks NOT from K_S^0)
  $2 \leq N_{good} \leq 4$
- No vertex cut for the charged tracks from K_S^0 && $N_{goodL} \geq 4$

Neutral Tracks Selection Criteria

- $E_\gamma > 25MeV, |\cos\theta| < 0.8$ (barrel region)
- $E_\gamma > 50MeV, 0.86 < |\cos\theta| < 0.92$ (end-cap region)
- $0 \leq t \leq 14$ (in unit of 50 ns)
- $N_\gamma \geq 3$

π^0 List, $\gamma\pi^0$ List and Reconstruction of K_S^0

π^0 List and $\gamma\pi^0$ List

π^0 list
- $0.08 < M_{\gamma\gamma} < 0.2$ (With 1-C)
- $N_{\pi^0} \geq 1$

$\gamma\pi^0$ list
- $2.8 < M^{recoil}_{\gamma\pi^0} < 3.2$
- $3.3 < M^{recoil}_{\pi^0} < 3.7$

Reconstruction of K_S^0

- A primary vertex fit and a secondary vertex fit are performed
- $|M_{\pi\pi} - m_{K_S^0}| < 20 MeV/c^2$

Other Selection Criteria

Other Selection Criteria

- Vertex Fit
- 4-C Kinematic Fit
- Minimum combined $\chi^2 = \chi^2_{4C} + \chi^2_{1C} + \chi^2_{pid} + \chi^2_{vertex}$ cut
- $0.125 < m_{\pi^0} < 0.138$ (after 4-C)
- $0.45 < E(\gamma_{E1}) < 0.53$ (after 4-C)
- $3.5 < M^{recoil}_{\pi^0} < 3.55$

Topology Results

No.	decay chain	final states	iTopo	nEvt	nTot
0	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \pi^- K_S K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	3	368	368
1	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to K^-\pi^+ K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^- K^-$	4	340	708
2	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to K^- K^{*+},\ K^{*+} \to \pi^+ K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^- K^-$	27	288	996
3	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to K^{*-} K^+,\ K^{*-} \to \pi^- K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	28	279	1275
4	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \bar{K}^* K_S,\ \bar{K}^* \to K^-\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^- K^-$	39	260	1535
5	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to K_S K^*,\ K_S \to \pi^-\pi^+,\ K^* \to \pi^- K^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	40	234	1769
6	$\psi' \to \pi^-\pi^+ K_S K_S,\ K_S \to \pi^-\pi^+,\ K_S \to \pi^0\pi^0$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^-\pi^-$	11	200	1969
7	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \pi^-\pi^+ K_S K_S,\ K_S \to \pi^-\pi^+,\ K_S \to \pi^0\pi^0$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^0\pi^-\pi^-$	5	168	2137
8	$\psi' \to \gamma\chi_{c0},\ \chi_{c0} \to \rho^- K_S K^+,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	8	162	2299
9	$\psi' \to \gamma\chi_{c0},\ \chi_{c0} \to K^-\rho^+ K_S,\ \rho^+ \to \pi^0\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^- K^-$	31	131	2430
10	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^-\rho^+ K_S,\ \rho^+ \to \pi^0\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^- K^-$	14	102	2532
11	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to K^-\rho^+ K_S,\ \rho^+ \to \pi^0\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^- K^-$	46	94	2626
12	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \rho^- K_S K^+,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	107	94	2720
13	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \rho^- K_S K^+,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	71	90	2810
14	$\psi' \to \gamma\chi_{c0},\ \chi_{c0} \to \pi^-\pi^0 K_S K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	77	76	2886
15	$\psi' \to \gamma\chi_{c0},\ \chi_{c0} \to K^-\pi^0\pi^+ K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^- K^-$	242	74	2960
16	$\psi' \to K^- K_1^+,\ K_1^+ \to \rho^+ K_S,\ \rho^+ \to \pi^0\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^- K^-$	38	68	3028
17	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^-\pi^+ K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^- K^-$	125	64	3092
18	$\psi' \to \bar{K}^*\pi^-\pi^0 K^+,\ \bar{K}^* \to \pi^0 K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	79	64	3156
19	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \pi^- K_S K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	16	62	3218
20	$\psi' \to K^-\pi^0\pi^+ K^*,\ K^* \to \pi^0 K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^- K^-$	12	62	3280
21	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \gamma J/\psi,\ J/\psi \to K^{*-} K^+,\ K^{*-} \to \pi^- K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma K^+\pi^+\pi^-\pi^-$	97	61	3341
22	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \gamma J/\psi,\ J/\psi \to K^-\pi^+ K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^- K^-$	69	61	3402
23	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \gamma J/\psi,\ J/\psi \to K^- K^{*+},\ K^{*+} \to \pi^+ K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^- K^-$	114	60	3462
24	$\psi' \to \bar{K}^*\rho^- K^+,\ \bar{K}^* \to \pi^0 K_S,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	51	59	3521
25	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \gamma J/\psi,\ J/\psi \to \bar{K}^* K_S,\ \bar{K}^* \to K^-\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^- K^-$	63	57	3578
26	$\psi' \to \gamma\chi_{c0},\ \chi_{c0} \to \pi^-\pi^+ K_S K_S,\ K_S \to \pi^-\pi^+,\ K_S \to \pi^0\pi^0$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^0\pi^-\pi^-$	133	56	3634
27	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \gamma J/\psi,\ J/\psi \to \pi^- K_S K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma K^+\pi^+\pi^-\pi^-$	75	53	3687
28	$\psi' \to K^-\rho^+ K^*,\ \rho^+ \to \pi^0\pi^+,\ K^* \to \pi^0 K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^- K^-$	0	50	3737
29	$\psi' \to \pi^0\pi^0 J/\psi,\ J/\psi \to \gamma\eta_c,\ \eta_c \to \pi^- K_S K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	134	48	3785

Table 1:

From the topology result we can see the main backgrounds are:

- $\psi\prime \to \pi^0\pi^0 J/\psi$
- $\psi\prime \to \gamma\chi_{c0}$
- $\psi\prime \to \gamma\chi_{c1}$
- $\psi\prime \to \gamma\chi_{c2}$

Optimized Selection

FOM

We used the figure of merit(FOM),

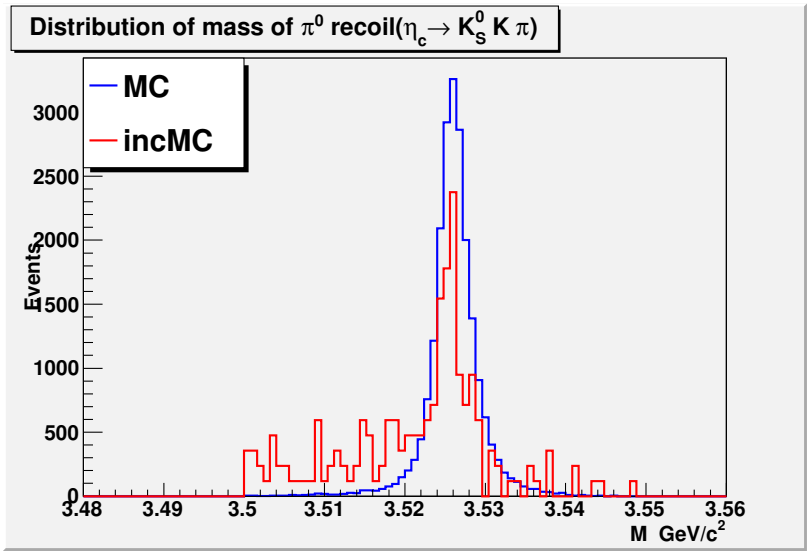
$$FOM = \frac{S}{\sqrt{S+B}}$$

where S denotes the singal MC events, and $S+B$ denotes the inclusive MC events

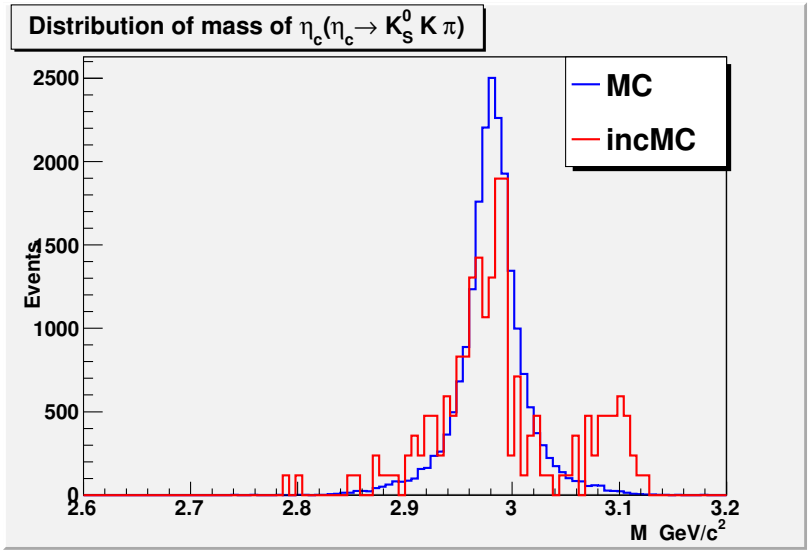
Using ROOT micros, we got the Optimized Selection as below

- $0 < \chi^2_{4C} < 55$;
- $|m^{recoil}_{\pi^0\pi^0} - M_{J/\psi}| < 0.03$;
- $|m^{recoil}_{\gamma} - M_{\chi_{c0}}| < 0.027$;
- $|m^{recoil}_{\gamma} - M_{\chi_{c1}}| < 0.028$;
- $|m^{recoil}_{\gamma} - M_{\chi_{c2}}| < 0.001$;
- $|m^{recoil}_{\pi^+\pi^-} - M_{J/\psi}| < 0.004$.

Distribution of the pi^0 recoil mass and the η_c mass



Mass distribution of π^0 recoil



Mass distribution of M(K_S^0 K π)

Efficiency Study

Event Selection	signal MC survival	Efficiency 1 (%)	Efficiency 2 (%)
None	200K	100	100
$N_{GoodL} \leq 20 \&\& N_{charge} = 0$	104709	52.35	52.35
$3 \leq N_{\gamma} \leq 100$	75919	72.50	37.96
$N(E_{\gamma_{E1}} \in (0.3, 0.7)) \geq 1$	48607	64.02	24.30
$N_{\gamma\pi^0 list} \geq 1$	43773	90.05	21.89
$2 \leq N_{Good} \leq 4, N_{GoodL} \geq 4, N_{\gamma} \geq 3, N_{\pi^0} \geq 1$	38043	86.91	19.02
$\chi^2 \leq 1000$	27927	73.40	13.96
$3.5 < M^{recoil}_{\pi^0} < 3.55 GeV$	26721	95.68	13.36
$\chi^2_{4C} \leq 55$	23314	87.25	11.66
$120 < M_{\pi^0} < 150 MeV$	23314	100	11.66
$0.4 < E_{\gamma_{E1}} < 0.6 GeV$	22617	97.01	11.30
$\lvert m^{recoil}_{\pi^0\pi^0} - M_{J/\psi} \rvert < 0.03$	22553	99.72	11.28
$\lvert m^{recoil}_{\gamma} - M_{\chi_{c0}} \rvert < 0.027$	21403	94.90	10.70
$\lvert m^{recoil}_{\gamma} - M_{\chi_{c1}} \rvert < 0.028$	21263	99.35	10.63
$\lvert m^{recoil}_{\gamma} - M_{\chi_{c2}} \rvert < 0.001$	21184	99.63	10.59
$\lvert m^{recoil}_{\pi^+\pi^-} - M_{J/\psi} \rvert < 0.004$	21131	99.75	10.57

Table: Efficiency of event selections in the exclusive process

Topology Analysis after the Optimized Selection

No.	decay chain	final states	iTopo	nEvt	nTot
0	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to K^-\pi^+K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	5	47	47
1	$\psi' \to \pi^0 h_c,\ h_c \to \gamma\eta_c,\ \eta_c \to \pi^-K_SK^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	0	46	93
2	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \gamma J/\psi,\ J/\psi \to \pi^-K_SK^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma K^+\pi^+\pi^-\pi^-$	6	8	101
3	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \rho^-K_SK^+,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	15	6	107
4	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^-\rho^+K_S,\ \rho^+ \to \pi^0\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	3	5	112
5	$\psi' \to K_1^-K^+,\ K_1^- \to \rho^-K_S,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^-\pi^-$	12	4	116
6	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \gamma J/\psi,\ J/\psi \to K^-\pi^+K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^-K^-$	21	4	120
7	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^-\pi^0K^{*+},\ K^{*+} \to \pi^+K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	2	3	123
8	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \gamma J/\psi,\ J/\psi \to K^-K^{*+},\ K^{*+} \to \pi^+K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma\pi^+\pi^+\pi^-K^-$	8	3	126
9	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^{*-}K^{*+},\ K^{*-} \to K^-\pi^0,\ K^{*+} \to \pi^+K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	17	3	129
10	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to \rho^-K_SK^+,\ \rho^- \to \pi^-\pi^0,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	11	3	132
11	$\psi' \to K^-\bar{K}^*\gamma\pi^+,\ \bar{K}^* \to \pi^0K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	1	2	134
12	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \bar{K}^*K^*,\ \bar{K}^* \to K^-\pi^+,\ K^* \to \pi^0K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	16	2	136
13	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \gamma J/\psi,\ J/\psi \to K^{*-}K^+,\ K^{*-} \to \pi^-K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\gamma K^+\pi^+\pi^-\pi^-$	9	2	138
14	$\psi' \to \pi^-\pi^+K_SK_S,\ K_S \to \pi^-\pi^+,\ K_S \to \pi^0\pi^0$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^-\pi^-$	20	2	140
15	$\psi' \to \gamma\chi_{c1},\ \chi_{c1} \to K^-\rho^+K_S,\ \rho^+ \to \pi^0\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	13	2	142
16	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \gamma J/\psi,\ J/\psi \to K_SK^*,\ K_S \to \pi^-\pi^+,\ K^* \to \pi^-K^+$	$\psi' \to \gamma\gamma K^+\pi^+\pi^-\pi^-$	22	2	144
17	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to \bar{K}^*\pi^-K^+,\ \bar{K}^* \to \pi^0K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	23	2	146
18	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^{*-}\pi^0K^+,\ K^{*-} \to \pi^-K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	27	2	148
19	$\psi' \to \pi^-\gamma K^*K^+,\ K^* \to \pi^0K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	29	2	150
20	$\psi' \to K^-K_1^+,\ K_1^+ \to \rho^+K_S,\ \rho^+ \to \pi^0\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^-K^-$	30	2	152
21	$\psi' \to \gamma\chi_{c2},\ \chi_{c2} \to K^-\pi^+K^*,\ K^* \to \pi^0K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma\pi^+\pi^+\pi^0\pi^-K^-$	4	1	153
22	$\psi' \to \bar{K}^*\pi^0K_2^{*0},\ \bar{K}^* \to \pi^0K_S,\ K_2^{*0} \to \pi^-K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	7	1	154
23	$\psi' \to K^{*-}\gamma K^{*+},\ K^{*-} \to \pi^-K_S,\ K^{*+} \to \pi^0K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \gamma K^+\pi^+\pi^0\pi^-\pi^-$	10	1	155
24	$\psi' \to K^{*-}K^{*+},\ K^{*-} \to K^-\pi^0,\ K^{*+} \to \pi^+K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^-K^-$	24	1	156
25	$\psi' \to K_2^-\pi^+K_S,\ K_2^- \to \pi^-K_S,\ K_S \to \pi^-\pi^+,\ K_S \to \pi^0\pi^0$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	25	1	157
26	$\psi' \to \bar{K}^*\pi^-K^+,\ \bar{K}^* \to \pi^0K_S,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^-\pi^-$	26	1	158
27	$\psi' \to K^-K_2^{*0},\ K_2^{*0} \to \pi^-K_S,\ K_2^{*0} \to \pi^0K_S,\ K_S \to \pi^-\pi^+,\ K^- \to \pi^-K^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	18	1	159
28	$\psi' \to K_2^{*-}\pi^0K^{*+},\ K_2^{*-} \to \pi^-K_S,\ K^{*+} \to \pi^0K^+,\ K_S \to \pi^-\pi^+$	$\psi' \to K^+\pi^+\pi^0\pi^0\pi^-\pi^-$	28	1	160
29	$\psi' \to \pi^0\pi^0J/\psi,\ J/\psi \to K_2^{*0}K_S,\ K_2^{*0} \to K^-\pi^+,\ K_S \to \pi^-\pi^+$	$\psi' \to \pi^+\pi^+\pi^0\pi^0\pi^-K^-$	19	1	161

We can see that after the optimized selection, the backgrounds are greatly suppressed

IO check

As we haven't fit the η_c signal, so we take the results from the Topology Analysis after the Optimized Selection.

$$N^{obs}_{signal} = 46 + 47 = 93$$

N_{tot}	106M
$Br(\psi\prime \to \pi^0 h_c)$	8.6×10^{-4}
$Br(\pi^0 \to \gamma\gamma)$	98.8%
$Br(h_c \to \gamma\eta_c)$	51%
$Br(\eta_c \to K^0_S K\pi)$	2.88 %
$Br(K^0_S \to \pi^+\pi^-)$	69.2%
ϵ	10.57%
N^{theory}_{signal}	91

We can see that N^{obs}_{signal} is basically corresponding to N^{theory}_{signal}

the Inclusive Process

Preliminary Event Selection

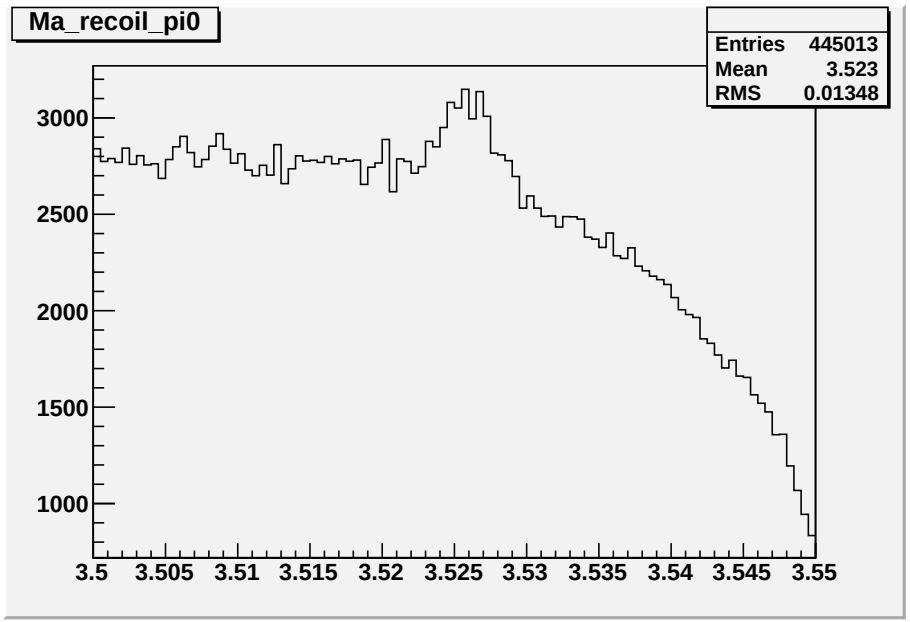
Selection of γ_{E1} and π^0 candidates

- $E_\gamma > 25MeV, |\cos\theta| < 0.8$ (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 keep the events with only 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:

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



π^0 recoil mass distribution

Summery

Work been done

- We have done the exclusive process of $\eta_c \to K_S^0 K\pi$, and got some pleasant results
- We have been looking for the signal of $\gamma\ \pi^0$ recoil, yet the results are not so pleasant

Work to do

- Find the signal we want and Fit the $\gamma\ \pi^0$ recoil mass
- Do IO check for inclusive process
- Add other decay channels into our research
- Run data to get the branching ratio

References

- PRD **86**, 092009 (2012).
- PRL **104**, 132002 (2010).