Study of $J/\psi \to \gamma K_s K_s \pi^0$ at BESIII experiment

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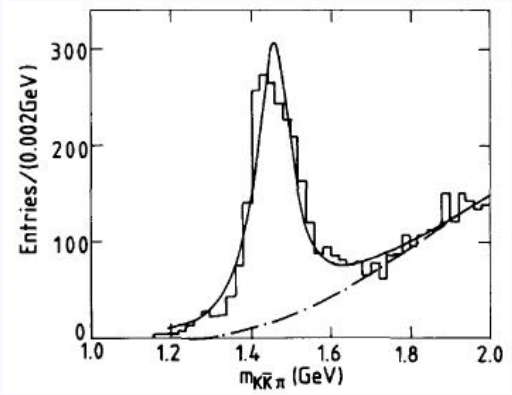
Outline

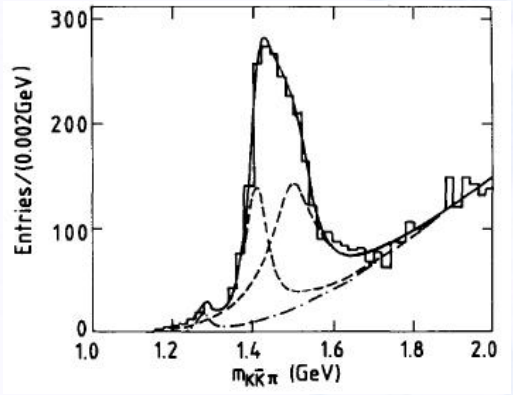
- Motivation
- BEPCII & BES-III
- Data sets
- Event selection and Background study
- Work in the future

Motivation

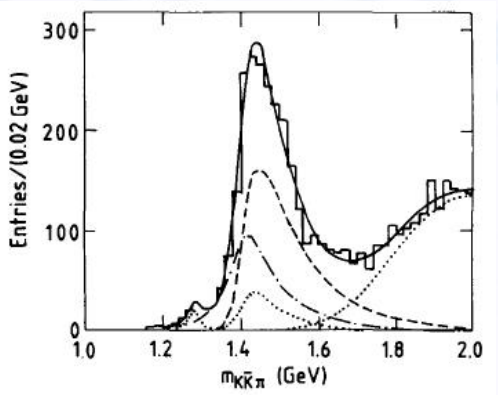
- η(1405)and η(1475) both can decay into $K\bar{K}\pi$ as suggested by the Mark III analysis. However, BES-II analysis suggests that if an energy-dependent width is applied, it is not necessary to have two states in $J/\psi \to K\bar{K}\pi$. We want to study η(1405) and η(1475) using high-statistics J/ψ samples at BESIII.



A single B-W fit

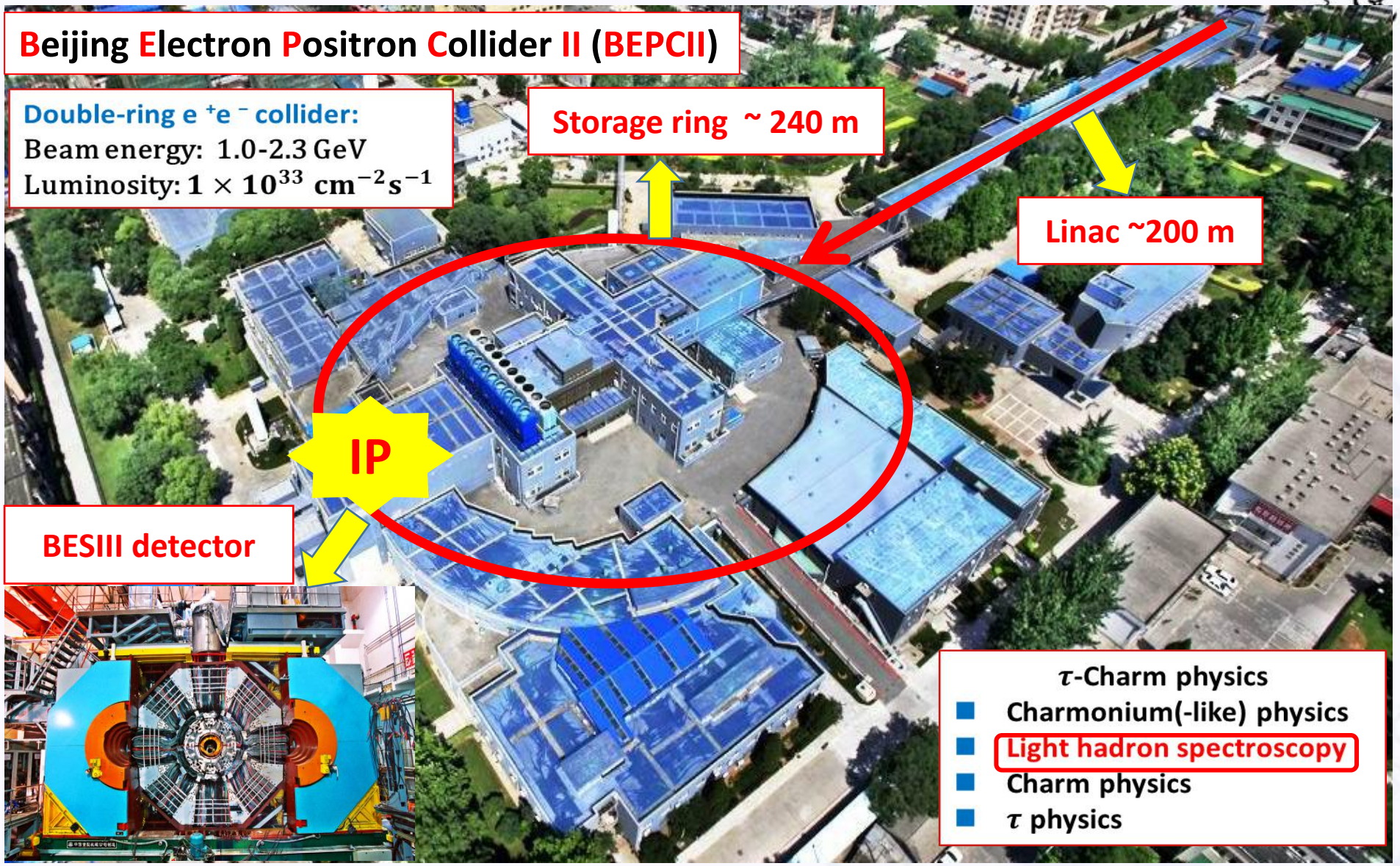


Two interfering B-W fit

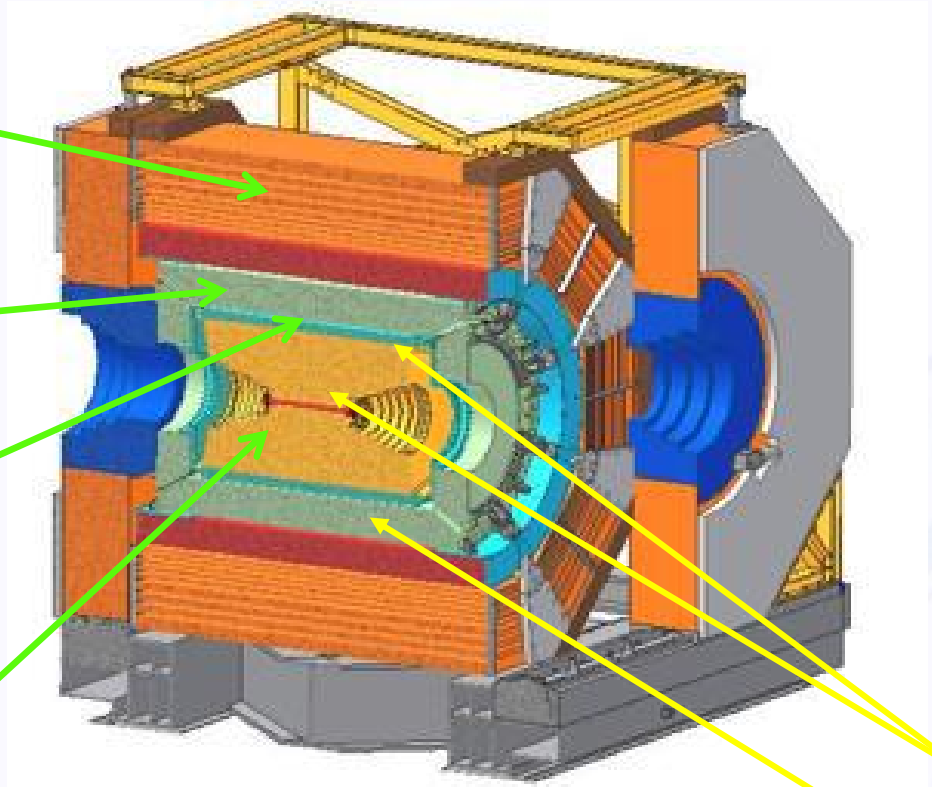


Coupled channel B-W fit

Bird view of BEPCII



The BESIII Detector



$J/\psi \to \gamma K\bar{K}\pi$

- $J/\psi \to \gamma K_s K^{\pm}\pi^{\mp}$
  $K_s \to \pi^+\pi^-$
- $J/\psi \to \gamma K^+K^-\pi^0$
  $\pi^0 \to \gamma\gamma$
- $J/\psi \to \gamma K_s K_s \pi^0$
  $K_s \to \pi^+\pi^-$
  $\pi^0 \to \gamma\gamma$

$K^{\pm}, \pi^{\pm}$: TOF, MDC

γ: EMC

Muon Counter:
Resistive Plate Chamber;
σ(xy) < 2 cm

Superconducting solenoid (1T)

CsI(Tl) Calorimeter :
σ_E /E < 2.5% @ 1 GeV (barrel)
σ_E / E < 5% @ 1 GeV (end caps)
σ_{xy} = (6 mm) /$\sqrt{E(GeV)}$

Time of Flight:
σ_t = 80 ps (barrel)
σ_t = 65 ps (end caps)

Drift Chamber :
σ_r = 130 μm (single wire)
σ_{pt}/pt = 0.5 % @ 1 GeV

Light hadron Spectroscopy

◆Light hadron Spectroscopy plays a crucial role in examining and understanding the QCD theory in non-perturbative energy regime.

◆ J/ψ, χ_{c1}(the lowest 1^{--},1^{++} $c\bar{c}$ states) decays provide an ideal place to study the light hadron spectroscopy.

◆$\eta(1405)$ and $\eta(1475)$ is one or two states? (problem not solved by MARKIII and BESII) My work is to to study them using high-statistics J/ψ samples at BESIII.

Data Sets

- Boss Version 664.p01;
- Inclusive samples of 2009(225M) + 2012(1000M) J/ψ;
- 1.31×10^{9} J/ψ data samples;

Event Selection for $J/\psi \to \gamma K_s K_s \pi^0$

- **Charged Tracks**

  $|\mathrm{Cos}\theta|<0.93$; $N_{charged} \geq 4$;

- **Good Photon**

  $E_{barrel}>25$ MeV; $E_{endcap}>50$ MeV;

  $\theta(\gamma,\mathrm{charge})>10^{\circ}$;

  $0 \leq \mathrm{TDC} \leq 14$;

  $N_{good}(\gamma) \geq 3$;

- **PID**

  Pion: $\mathrm{Prob}(\pi) > \mathrm{Prob}(P)$ and $\mathrm{Prob}(\pi) > \mathrm{Prob}(K)$;

  $N(\pi^+) \geq 2$; $N(\pi^-) \geq 2$;

- **K_s Selection ($K_s \to \pi^+\pi^-$)**

  $\chi^2_{vtx} = \chi^2_{vtx0} + \chi^2_{vtx1}$ has minimal value;

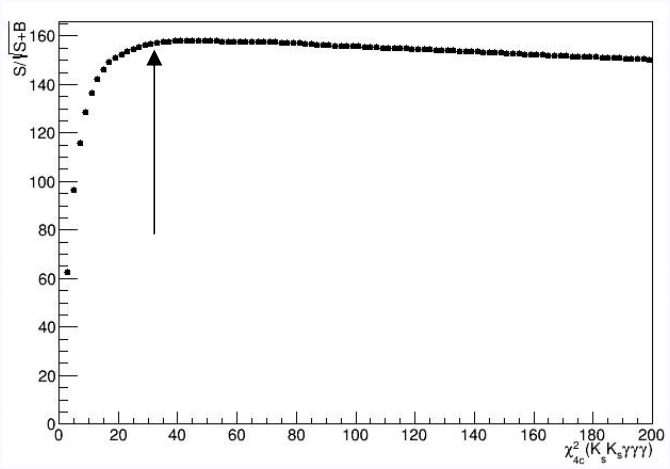
  We choose best one and second best one;

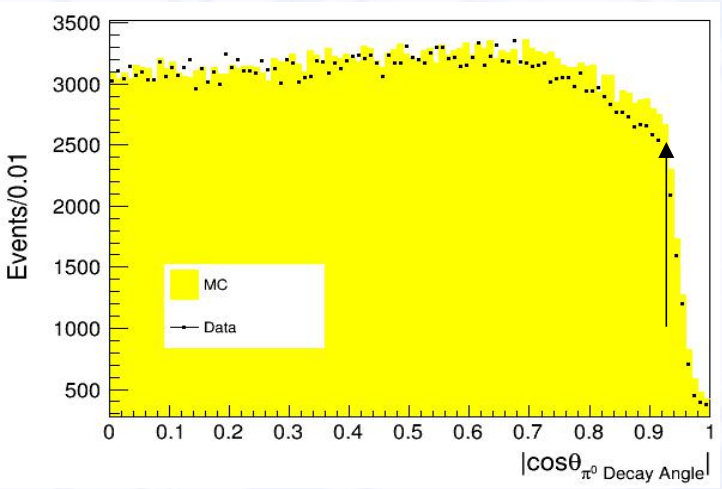
- **4C Kinematic fit**

  $\chi^2_{4C}(3\gamma K_s K_s)<200$;

Selection1

- $\left|M_{\pi_1^+\pi_1^-} - M_{K_S}\right| < 0.012\text{GeV}$, $\left|M_{\pi_2^+\pi_2^-} - M_{K_S}\right| < 0.012\text{GeV}$; (Fit M_{K_S})
- $\left|M_{\gamma_{good1}\gamma_{good2}} - M_{\pi^0}\right| < 0.020\text{GeV}$; (Fit M_{π^0})
- $\chi^2_{4C}(3\gamma_{good}K^+K^-) < 40$;
- $\frac{\left|E_{\gamma_{good1}} - E_{\gamma_{good2}}\right|}{P_{\gamma_{good1}\gamma_{good2}}} < 0.93$; ($\pi^0$ decay angle)

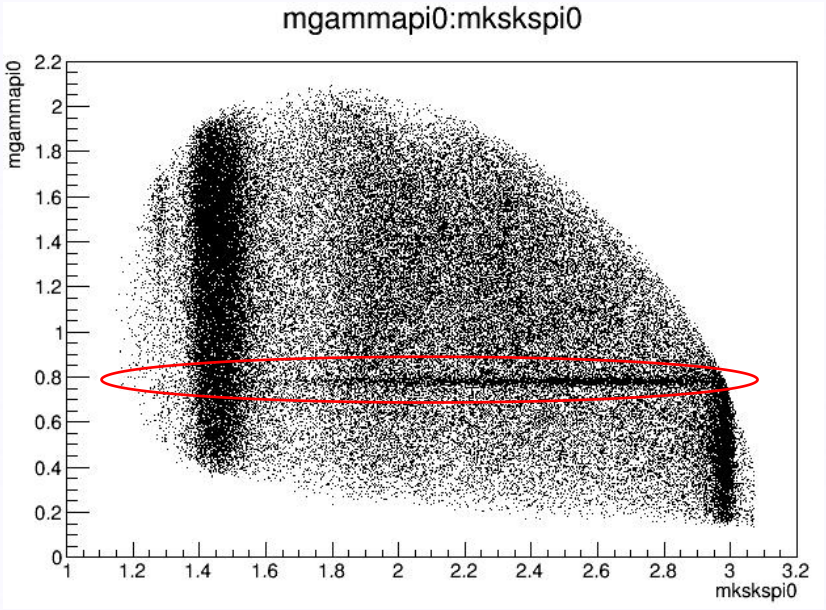


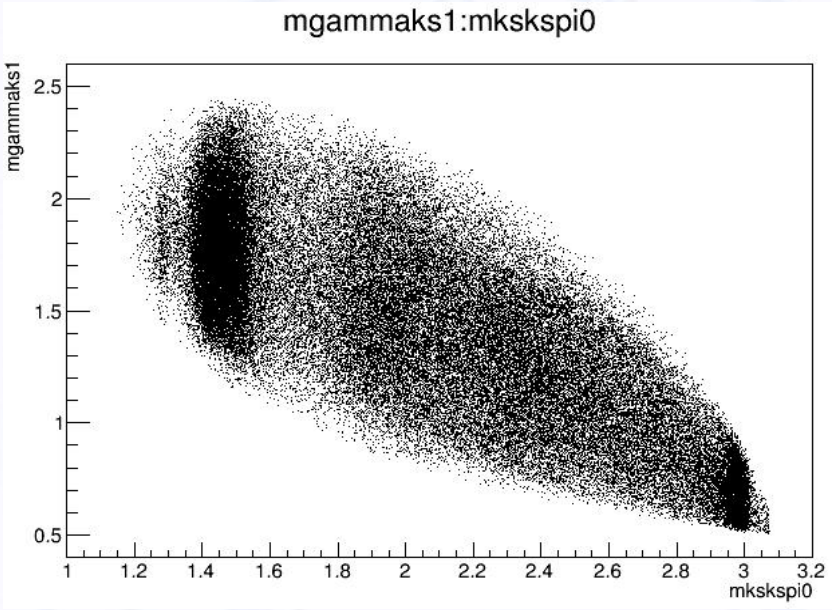


Selection2

We want to focus on J/ψ radiative decay. So $\gamma\pi^0$ and γK_s resonance should be vetoed.

- γK_s :None
- $\gamma\pi^0$:$\left|M_{\gamma\pi^0} - M_\omega\right| > 0.030\text{GeV}$ (Fit M_ω)





Background Study

No.	decay chain	final states	iTopology	nEvt	nTot
0	$J/\psi \to \gamma\eta(1405), \eta(1405) \to K^0\bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	0	5723	5723
1	$J/\psi \to \gamma f_1(1420), f_1(1420) \to K^0\bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	1	3651	9374
2	$J/\psi \to \gamma K^0\bar{K}^*, \bar{K}^* \to \bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	2	3282	12656
3	$J/\psi \to \gamma K^*\bar{K}^0, K^* \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	3	3133	15789
4	$J/\psi \to \gamma\eta_c, \eta_c \to K^0\bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	13	2012	17801
5	$J/\psi \to K^0K^*\pi^0, K^* \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	7	1633	19434
6	$J/\psi \to \pi^0K^*\bar{K}^0, K^* \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	9	1612	21046
7	$J/\psi \to \gamma\bar{K}^0K_0^0, K_0^0 \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	8	1447	22493
8	$J/\psi \to \gamma K^0\bar{K}_0^{*0}, \bar{K}_0^{*0} \to \bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	4	1434	23927
9	$J/\psi \to \gamma\pi^0\bar{K}^0K^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	25	651	24578
10	$J/\psi \to \gamma K_2^{*0}K^0, K_2^{*0} \to \bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	10	516	25094
11	$J/\psi \to \gamma K_2^{*0}\bar{K}^0, K_2^{*0} \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	16	504	25598
12	$J/\psi \to \gamma f_1(1510), f_1(1510) \to \bar{K}^*K^0, \bar{K}^* \to \bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	20	382	25980
13	$J/\psi \to \gamma f_1(1510), f_1(1510) \to K^*\bar{K}^0, K^* \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	11	339	26319
14	$J/\psi \to \gamma f_1(1285), f_1(1285) \to K^0\bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	37	290	26609
15	$J/\psi \to \omega f_2(1270), \omega \to \pi^0\gamma, f_2(1270) \to K_SK_S, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	36	288	26897
16	$J/\psi \to K^*K_2^{*0}, K^* \to K^0\pi^0, K_2^{*0} \to \bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	27	252	27149
17	$J/\psi \to \bar{K}^*K_2^{*0}, \bar{K}^* \to \bar{K}^0\pi^0, K_2^{*0} \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	51	214	27363
18	$J/\psi \to K_2^{*0}\pi^0K^0, K_2^{*0} \to \bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	29	212	27575
19	$J/\psi \to \bar{K}^0K_2^{*0}\pi^0, K_2^{*0} \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	5	211	27786
20	$J/\psi \to \gamma\eta_2(1870), \eta_2(1870) \to a_0^0\pi^0, a_0^0 \to K_SK_S, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	6	157	27943
21	$J/\psi \to \gamma f_1(1285), f_1(1285) \to a_0^0\pi^0, a_0^0 \to K_SK_S, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	47	155	28098
22	$J/\psi \to \gamma f_2(1270)\pi^0, f_2(1270) \to K_SK_S, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	42	144	28242
23	$J/\psi \to f_2(1270)K^0\bar{K}^0, f_2(1270) \to \pi^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	38	110	28352
24	$J/\psi \to \gamma\pi^0a_2^0, a_2^0 \to K_SK_S, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	63	109	28461
25	$J/\psi \to \pi^+\pi^-\pi^0\pi^+\pi^-\pi^0$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	24	107	28568
26	$J/\psi \to \bar{K}^0\pi^0K^*, K^* \to K^0\gamma, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	45	96	28664
27	$J/\psi \to \gamma\eta(1405), \eta(1405) \to K^0\bar{K}^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-\gamma_{FSR}$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	53	95	28759
28	$J/\psi \to \gamma a_0^0\pi^0, a_0^0 \to K_SK_S, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	84	90	28849
29	$J/\psi \to \bar{K}_0^{*0}K^*, \bar{K}_0^{*0} \to \bar{K}^0\pi^0, K^* \to K^0\pi^0, K_S \to \pi^+\pi^-, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	43	89	28938

$J/\psi \to K_SK_S\pi^0\pi^0$ and $J/\psi \to K_SK_S\pi^0$: Forbidden here(C-Parity Violation)

$\pm\gamma$ Background

Background Study

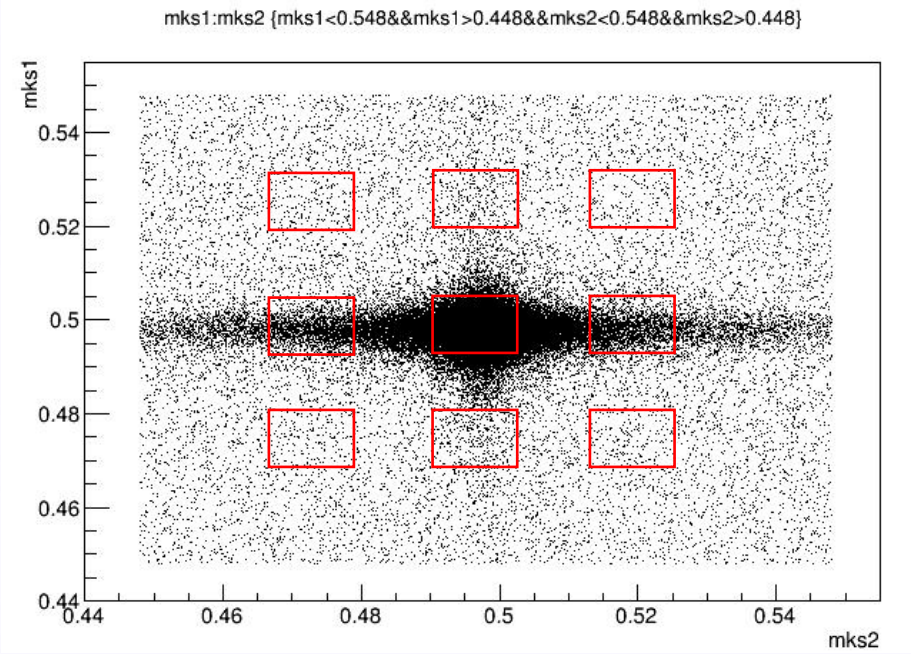
- Non_K_s Background (dominant): estimated by sideband
  - $\pi^0\pi^0\pi^+\pi^-\pi^+\pi^-$
  - $\pi^0\pi^+\pi^-\pi^+\pi^-$
  - ……
- Non_π^0 Background:
  - $\gamma K_s K_s \eta$: order of magnitude~0.4%

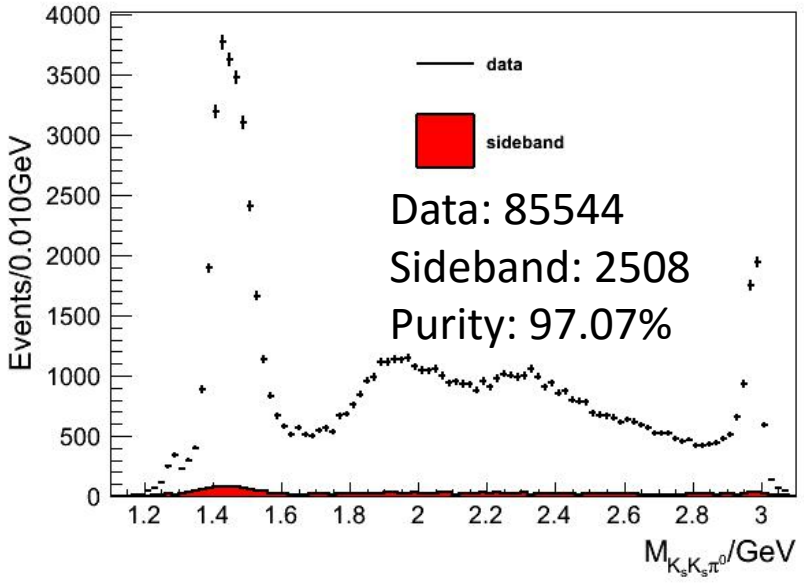
$$\left[B(N_{\gamma K_s K_s \eta})\right]_{estimate} = \left[B(N_{\gamma K_s K_s \eta})/S(N_{\gamma K_s K_s \eta})\right]_{Sigal\_MC} * \left[S(N_{\gamma K_s K_s \eta})\right]_{Data}$$

- Number of $\gamma\eta K_s K_s$ (pass $\gamma\eta K_s K_s$ selection criteria): $S(N_{\gamma\eta K_s K_s})$;
- Number of $\gamma\eta K_s K_s$ (pass $\gamma\pi^0 K_s K_s$ selection criteria): $B(N_{\gamma\eta K_s K_s})$;

Background Study

- Signal Region for two K_s: $|M_{\pi^+\pi^-} - 0.498| < 0.012$
- Sideband for two K_s: $0.028 < |M_{\pi^+\pi^-} - 0.498| < 0.052$





Work in the future

$J/\psi \to \gamma K_s K_s \pi^0$ (Resonances considered)

- $K_s K_s : J^{PC} = 0^{++}\ \ 2^{++}\ \ 4^{++}\ \ \ (I^G = 1^-)$

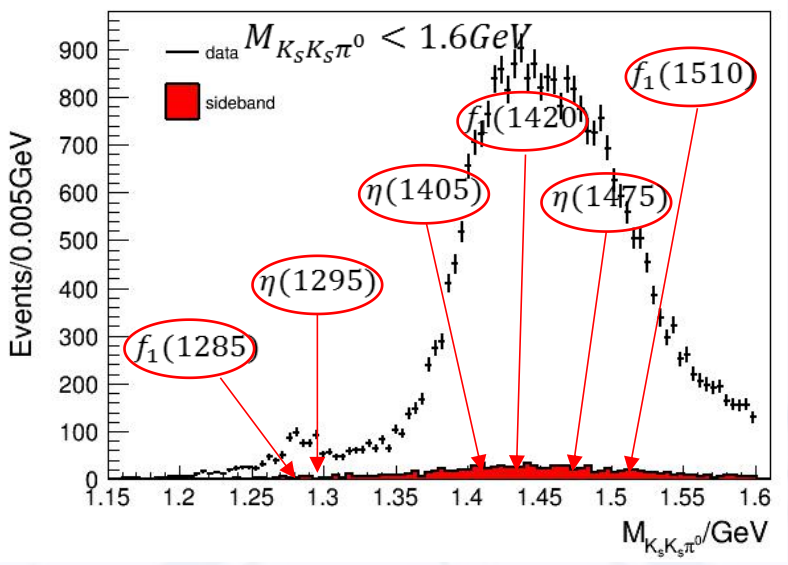
$a_0(980); a_2(1320); a_0(1450);$

- $K_s\pi^0 : 0^{+-}\ 1^{--}\ 2^{+-}\ 3^{--}\ 4^{+-}\ \ (I^G = 1/2)$

$K^*(892); Kappa(K^*(800))$

- $K_s K_s \pi^0 : 0^{-+}\ \ J^{*+}\ \ \ (I^G = 0^+)$

$f_1(1285); \eta(1295); \eta(1405); f_1(1420); \eta(1475); f_1(1510);$

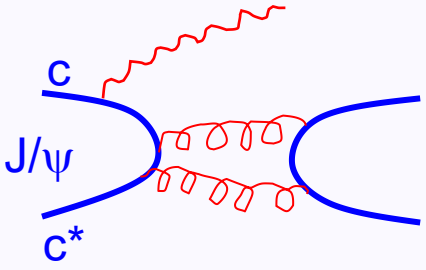


Work in the future

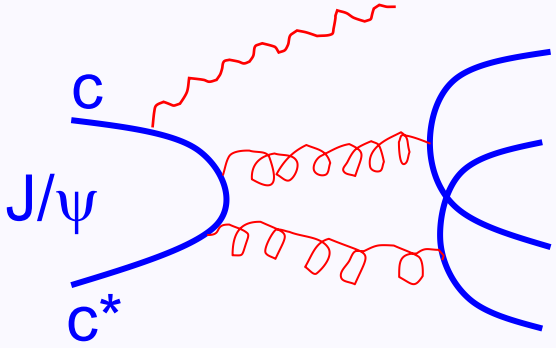
✓ PWA global fit for low mass region

Thank You!

Back up

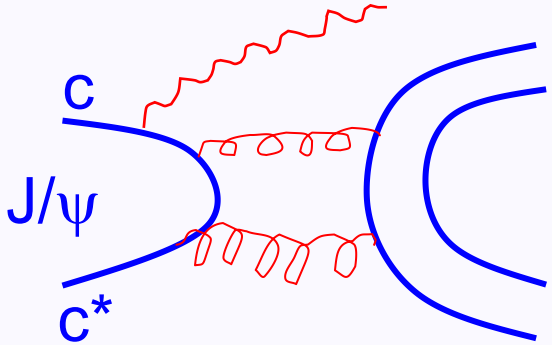


$\eta/f\ldots$ (ss*/uu*/dd*/cc*)



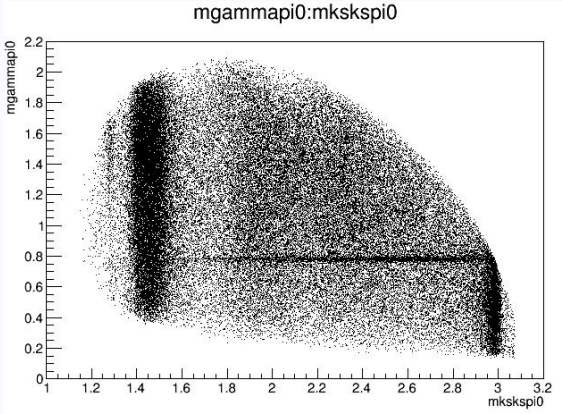
a (uu*/dd*)

π^0 (uu*/dd*)



a (uu*/dd*)

π^0 (uu*/dd*)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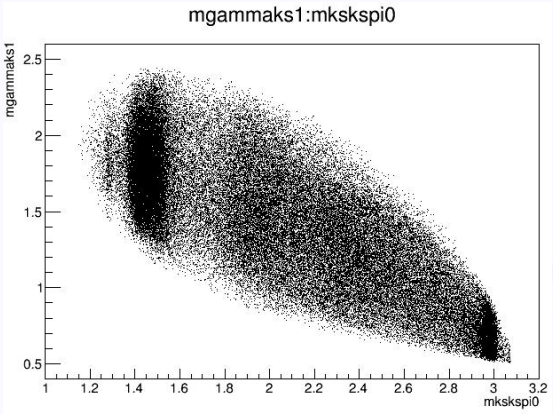
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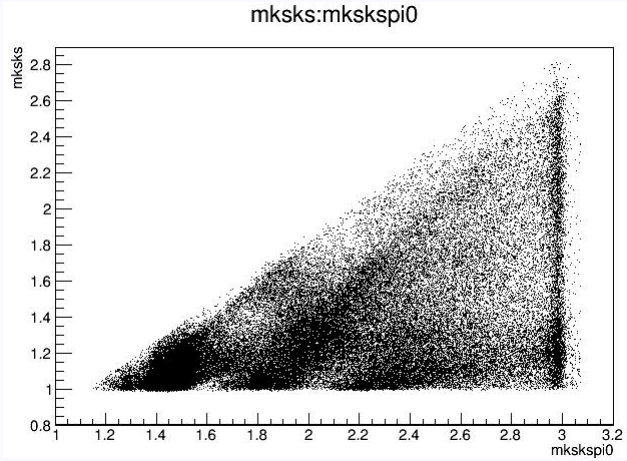
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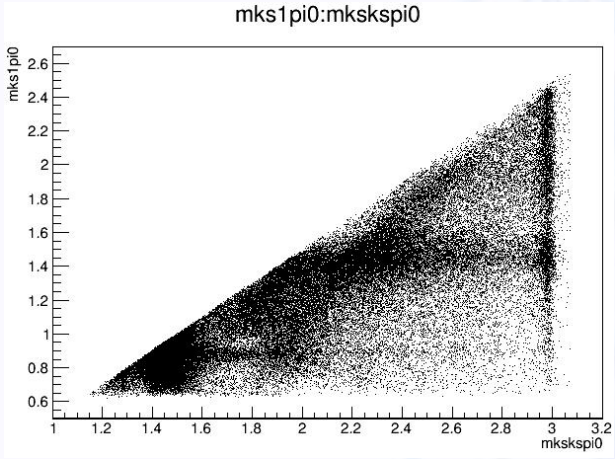
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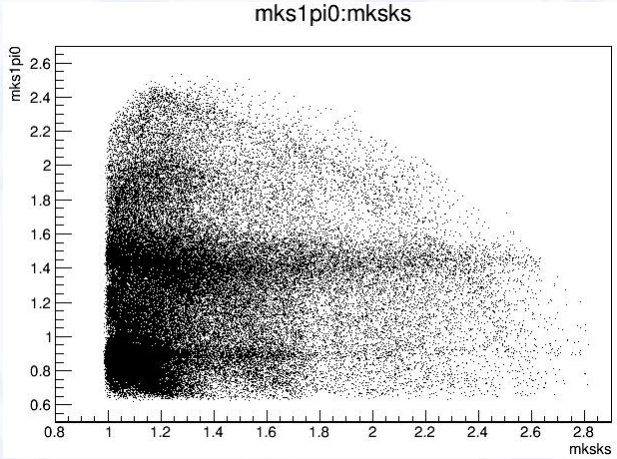
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