2022年9月-12月研究生考核报告

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目录

目前正在参与BESIII上的物理分析工作

- $\psi' \rightarrow \gamma\chi_{c1}, \chi_{c1} \rightarrow \pi^+ \pi^- \eta'$ 分析
- $\psi' \rightarrow \pi^+\pi^- J/\psi, J/\psi \rightarrow \mu^+\mu^-$ 分析

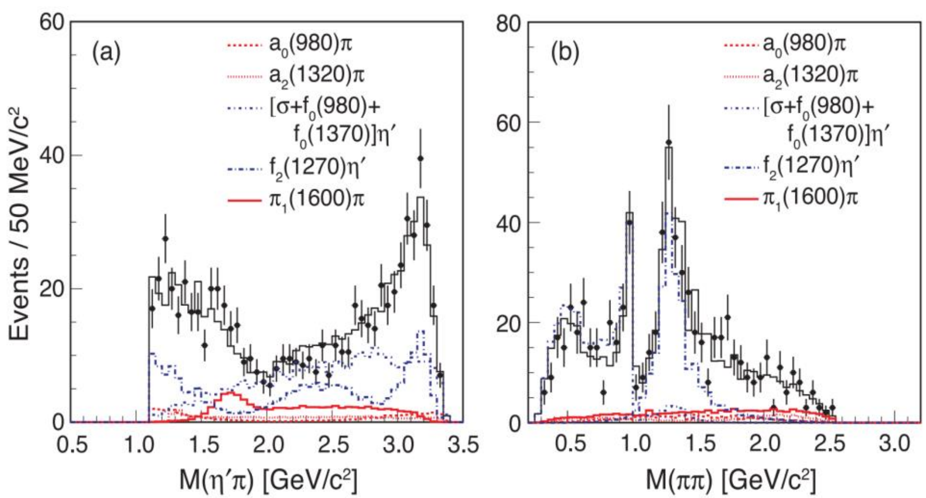
$\psi' \to \gamma\chi_{c1}, \chi_{c1} \to \pi^+\pi^-\eta'$ 分析

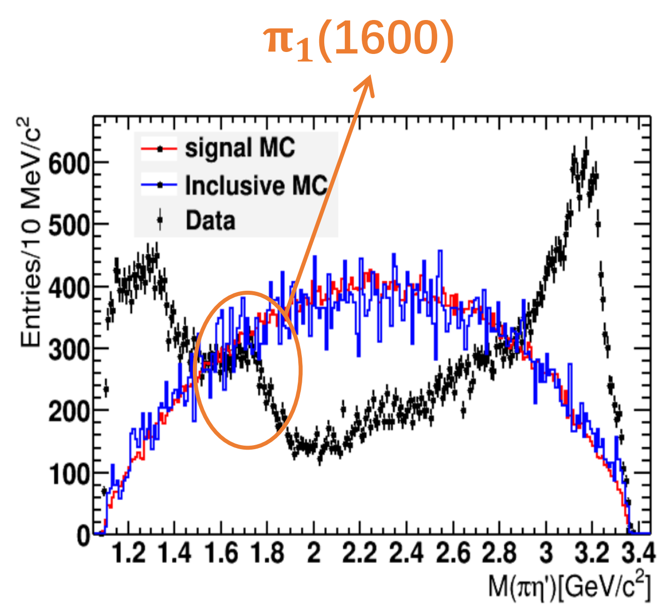
➢ 研究动机

- 用分波分析方法寻找和研究$\psi' \to \gamma\chi_{c1}, \chi_{c1} \to \pi^+\pi^-\eta'$ 过程中的混杂态候选者$\pi_1(1600)$。

➢ 研究进展

- 用M($\pi^+\pi^-\eta'$) sideband 估计 non- χ_{c1} 本底。
- 在今年冬季的 BESIII Collaboration Meeting 报告初步结果。
- 对$f_0(500)$， $a_0(980)$尝试不同的参数化进行分波分析。





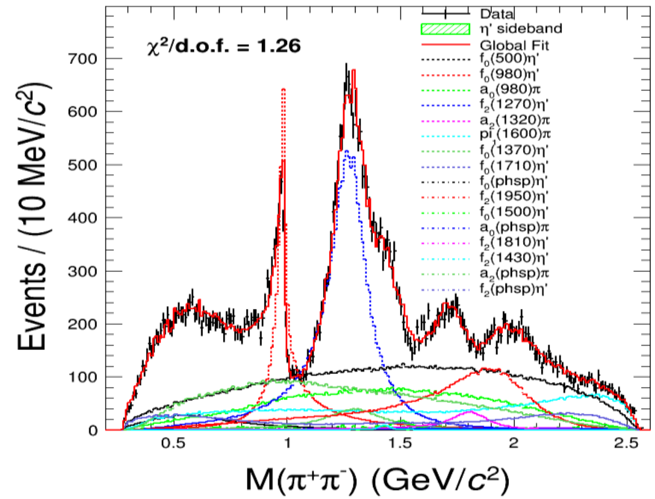
CLEO-c:Phys. Rev. D 84, 112009 (2011)

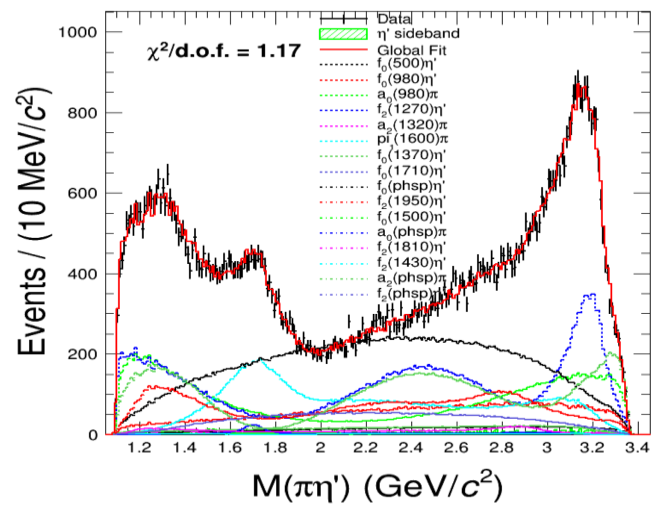
$\psi' \to \gamma\chi_{c1}, \chi_{c1} \to \pi^+\pi^-\eta'$ 分析

➢ 目前的分波解

resonance	Mass[GeV]	Width[GeV]	Fraction	Significance
$\pi_1(1600)$	1.7012	0.3252	18.66%	32.63σ
$f_0(500)$	/	/	3.07%	8.78σ
$f_0(980)$	/	/	13.21%	>30σ
$a_0(980)$	/	/	21.76%	13.83σ
$f_2(1270)$	1.2755	0.1867	30.89%	>30σ
$a_2(1320)$	1.3220	0.1190	0.66%	6.95σ
$f_0(1370)$	1.2973	0.3000	3.49%	8.27σ
$f_0(1710)$	1.7040	0.123	0.56%	8.87σ
$f_0(phsp)$	1.8000	150	41.93%	14.26σ
$f_2(1950)$	1.9360	0.4420	16.88%	16.72σ
$f_0(1500)$	1.5060	0.1120	0.61%	7.59σ
$a_0(phsp)$	1.8000	150	0.83%	15.07σ
$f_2(1810)$	1.8150	0.1970	2.15%	9.42σ
$f_2(1430)$	1.4300	0.0460	0.15%	5.58σ
$f_2(phsp)$	1.8000	150	24.88%	21.34σ
$a_2(phsp)$	1.8000	150	8.84%	10.87σ

➢ M(π⁺π⁻) 和 M(πη') 投影图

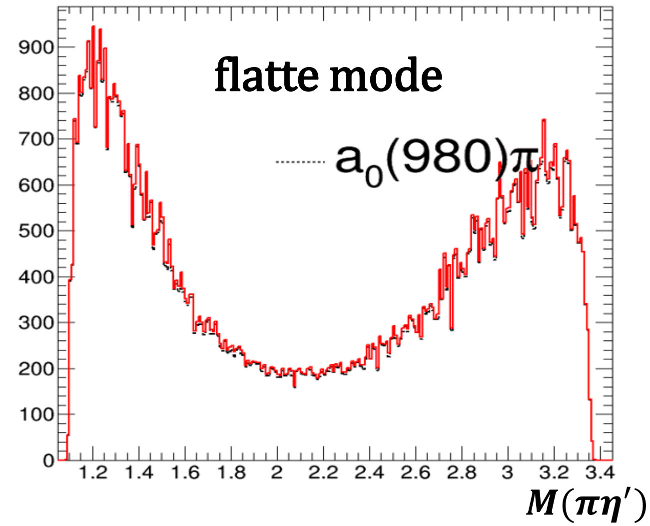


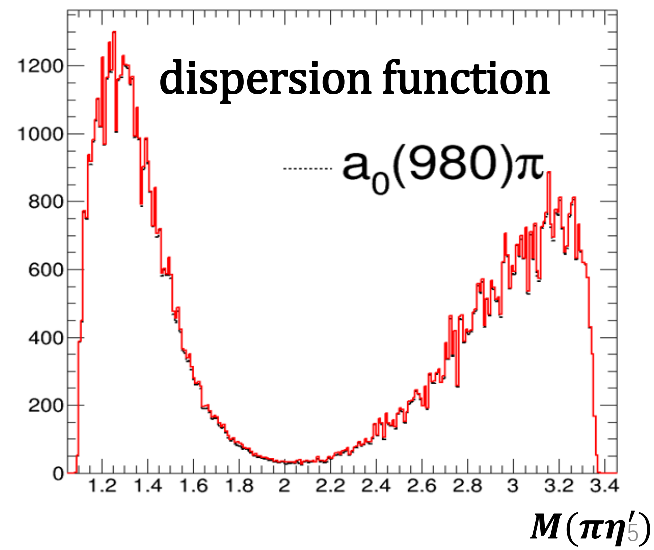


$\psi' \to \gamma\chi_{c1}, \chi_{c1} \to \pi^+\pi^-\eta'$ 分析

- 把$a_0(980)$参数化从flatte mode 变成dispersion function, 不同成分的fraction改变明显。

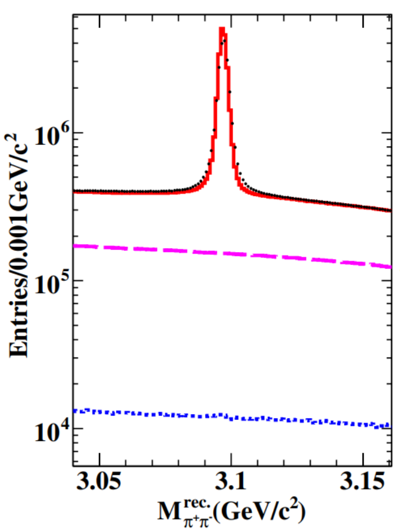
resonance	flatte mode		dispersion function	
/	Fraction	Significance	Fraction	Significance
$\pi_1(1600)$	18.66%	32.63σ	17.14%	30.28σ
$f_0(500)$	3.07%	8.78σ	3.39%	7.08σ
$f_0(980)$	13.21%	>30σ	0.15%	>30σ
$a_0(980)$	21.76%	13.83σ	6.85%	9.04σ
$f_2(1270)$	30.89%	>30σ	30.02%	>30σ
$a_2(1320)$	0.66%	6.95σ	0.39%	5.98σ
$f_0(1370)$	3.49%	8.27σ	2.93%	7.72σ
$f_0(1710)$	0.56%	8.87σ	0.74%	9.70σ
$f_0(phsp)$	41.93%	14.26σ	21.66%	14.36σ
$f_2(1950)$	16.88%	16.72σ	14.33%	13.83σ
$f_0(1500)$	0.61%	7.59σ	0.68%	8.04σ
$a_0(phsp)$	0.83%	15.07σ	1.09%	16.58σ
$f_2(1810)$	2.15%	9.42σ	1.69%	6.49σ
$f_2(1430)$	0.15%	5.58σ	0.13%	5.02σ
$f_2(phsp)$	24.88%	21.34σ	14.87%	17.67σ
$a_2(phsp)$	8.84%	10.87σ	8.68%	22.59σ

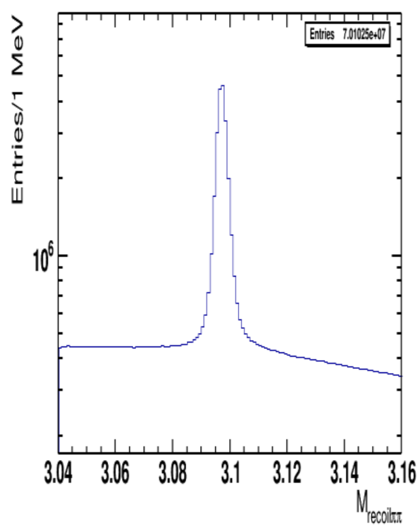


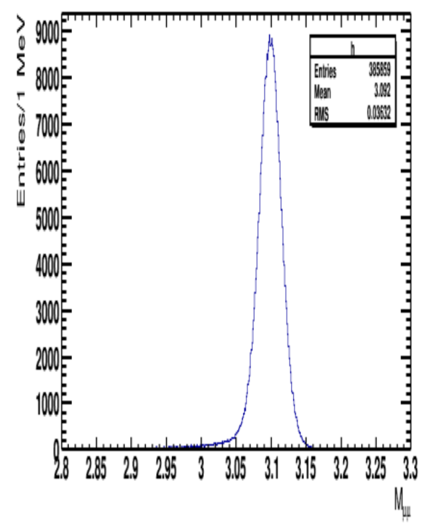


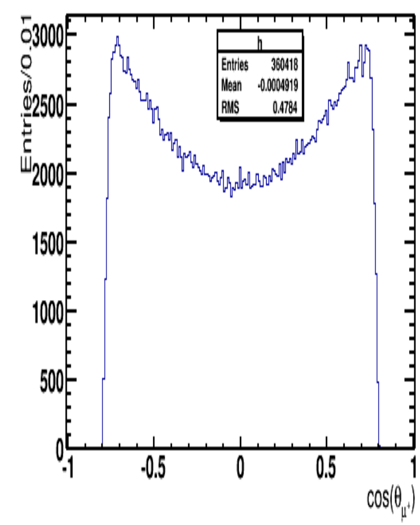
$\psi' \to \pi^+\pi^- J/\psi, J/\psi \to \mu^+\mu^-$分析

- **研究动机**
  - 测量$\psi' \to \pi^+\pi^- J/\psi$和$J/\psi \to \mu^+\mu^-$分支比。
- **研究进展**
  - 研究和初步确定选择条件
    - 利用运动学相空间动量选择π候选者。
    - 利用$\pi^+\pi^-$反冲质量谱选择$\pi^+\pi^- J/\psi$过程。
    - 利用E/p选择$\mu^+\mu^-$pair, 且$M(\mu^+\mu^-)$在J/ψ质量区间。
    - Inclusive MC 显示本底率在0.19%左右。
    - 计划进一步压低本底，对$\pi^+\pi^-$反冲质量谱做拟合得到分支比。









PRD 88 032007(besIII 2013)

总结

- $\psi' \to \gamma\chi_{c1}, \chi_{c1} \to \pi^+\pi^-\eta'$ 分析
  - 在今年冬季的BESIII Collaboration Meeting报告初步结果。
  - 目前正在尝试不同的参数化形式。
- $\psi' \to \pi^+\pi^- J/\psi, J/\psi \to \mu^+\mu^-$分析
  - 研究和初步确定选择条件。
  - 计划得到初步分支比结果，下一步测量，$J/\psi \to \gamma\mu^+\mu^-$ 分支比。

Thanks

Back up

current a0980 parameterization

PHYSICAL REVIEW D VOLUME 50, NUMBER 7 1 OCTOBER 1994

Coupled channel analysis of data on $\bar{p}p \to 3\pi^0$, $\eta\eta\pi^0$, and $\eta\pi^0\pi^0$ at rest, with the N/D method

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$$M(a) = \frac{1}{M^2_{a_0^0} - s - i\sqrt{s}[\Gamma^{a_0^0}_{\eta\pi}(s) + \Gamma^{a_0^0}_{K\overline{K}}(s)]} \quad (1)$$

$$\Gamma^{a_0^0}_{\eta\pi^0}(s) = \frac{g^2_{\eta\pi^0}}{16\pi\sqrt{s}}\rho_{\eta\pi^0}(s) \quad (2)$$

$$\Gamma^{a_0^0}_{K\overline{K}}(s) = \frac{g^2_{K^+K^-}}{16\pi\sqrt{s}}(\rho_{K^+K^-} + \rho_{K^0\overline{K^0}}(s)) \quad (3)$$

$$\rho_{bc}(s) = \sqrt{([1-(m_b-m_c^2)/s][1-(m_b+m_c)^2/s])} \quad (4)$$

Here ρ is Lorentz invariant phase space. $M_{a_0^0}$ is the invariant mass of $a_0^0(980)$, g_{abc} is the coupling constant, and here they are fixed: $M_{a_0^0} = 999$ MeV$/c^2$, $g_{a_0^0\eta\pi^0} = 3.33$, $g_{a_0^0K^+K^-} = 2.54$ (quoted from Crystal Barrel experiment results from Ref. [20] and Ref.[2]).

TABLE I. $a_0^0(980)$ mass and coupling constants $g_{a_0\pi\eta}$, $g_{a_0K^+K^-}$, $g_{f_0K^+K^-}$ from several models (A–D) and experimental measurements (E–H).

	Model or experiment	a_0 mass (MeV)	$g_{a_0\pi\eta}$ (GeV)	$g_{a_0K^+K^-}$ (GeV)	$g_{f_0K^+K^-}$ (GeV)
A	$q\bar{q}$ model [14]	983	2.03	1.27	1.80
B	$q^2\bar{q}^2$ model [14]	983	4.57	5.37	5.37
C	$K\bar{K}$ model [16,17]	980	1.74	2.74	2.74
D	$q\bar{q}g$ model [18]	980	2.52	1.97	1.70
E	SND [19,20]	995	3.11	4.20	5.57
F	KLOE [21,22]	984.8	3.02	2.24	5.92
G	BNL [23]	1001	2.47	1.67	3.26 [24]
H	CB [25]	999	3.33	2.54	4.18 [15]

a0980 parameterization

PHYSICAL REVIEW D **95**, 032002 (2017)

Amplitude analysis of the $\chi_{c1} \to \eta\pi^+\pi^-$ decays

discussion at the end of this section). The $a_0(980)$ amplitude is constructed using the following denominator:

$$D_a(s) = m_0^2 - s - \sum_{ch} \Pi_{ch}(s), \tag{4}$$

where m_0 is the $a_0(980)$ mass and $\Pi_{ch}(s)$ in the sum over channels is a complex function, with imaginary part

$$\mathrm{Im}\Pi_{ch}(s) = g_{ch}^2 \rho_{ch}(s) F_{ch}(s), \tag{5}$$

while real parts are given by principal value integrals,

$$\mathrm{Re}\Pi_{ch}(s) = \frac{1}{\pi} P \int_{s_{ch}}^{\infty} \frac{\mathrm{Im}\Pi_{ch}(s')ds'}{(s'-s)}. \tag{6}$$

In the above expressions $\rho_{ch}(s)$ is the available phase space for a given channel, obtained from the corresponding decay momentum $q_{ch}(s)$: $\rho_{ch}(s) = 2q_{ch}(s)/\sqrt{s}$. The integral in Eq. (6) is divergent when $s \to \infty$, so the phase space is modified by a form factor $F_{ch}(s) = e^{-\beta q_{ch}^2(s)}$, where the parameter β is related to the root-mean-square (rms) size of an emitting source [20]. We use $\beta = 2.0[\mathrm{GeV}/c^2]^{-2}$ corresponding to rms $= 0.68$ fm, and we verify that our results are not sensitive to the value of β. The integration in Eq. (6) starts from the threshold for a particular channel, s_{ch}, which conveniently solves the problem of the analytical continuation in special cases of final state configurations like the $a_0(980) \to \eta'\pi$, when the decay momentum below the threshold ($s < m_{\eta'} + m_\pi$) becomes real again for $s < m_{\eta'} - m_\pi$. Figure 4 shows the shapes of (a) $\mathrm{Im}\Pi_{ch}(s)$ and (b) $\mathrm{Re}\Pi_{ch}(s)$, for the $K\bar{K}$ and $\eta'\pi$ channels, for arbitrary values of the coupling constants. In the final form, the real parts in the denominator of Eq. (4) are adjusted by $\mathrm{Re}\Pi_{ch}(m_0)$ terms: $\mathrm{Re}\Pi_{ch}(s) \to \mathrm{Re}\Pi_{ch}(s) - \mathrm{Re}\Pi_{ch}(m_0)$.

Interference table

dispersion

Total=139.39%

- Table below shows the fraction of interference terms between any two resonance.

Resonance	$f_0(500)$	$f_0(980)$	$a_0(980)$	$f_2(1270)$	$a_2(1320)$	$\pi_1(1600)$	$f_0(1370)$	$f_0(1710)$	$f_0(phsp)$	$f_2(1950)$	$f_0(1500)$	$a_0(phsp)$	$f_2(1810)$	$f_2(1430)$	$f_2(phsp)$	$a_2(phsp)$
$f_0(500)$	3.39%	-0.01%	-0.01%	-0.26%	-0.06%	2.09%	1.69%	-0.43%	0.70%	-0.12%	-0.59%	-0.40%	0.08%	-0.01%	0.20%	2.12%
$f_0(980)$		0.15%	0.05%	-1.01%	0.68%	3.07%	0.46%	1.48%	-12.27%	-0.39%	1.65%	0.46%	-0.07%	-0.03%	0.90%	-0.56%
$a_0(980)$			6.85%	6.99%	-0.01%	1.58%	2.03%	0.85%	-12.78%	7.66%	-0.09%	2.05%	-0.62%	0.15%	-6.71%	3.10%
$f_2(1270)$				30.02%	0.03%	-6.10%	-0.81%	-0.12%	1.23%	11.96%	-0.15%	1.29%	1.68%	1.43%	-15.49%	1.63%
$a_2(1320)$					0.39%	0.13%	0.22%	0.22%	0.21%	-0.35%	0.09%	-0.01%	0.16%	-0.01%	-0.13%	0.28%
$\pi_1(1600)$						17.14%	4.61%	0.25%	-17.18%	-1.64%	-1.26%	-0.83%	-0.81%	-0.18%	0.19%	5.62%
$f_0(1370)$							2.93%	1.11%	-6.64%	-0.32%	-0.25%	-0.09%	0.03%	-0.02%	0.54%	1.84%
$f_0(1710)$								0.74%	-1.73%	-0.11%	-0.28%	0.11%	0.00%	0.00%	0.11%	-0.11%
$f_0(phsp)$									21.66%	0.53%	0.64%	-0.87%	0.13%	0.04%	-1.23%	-3.14%
$f_2(1950)$										14.33%	0.04%	1.64%	-6.24%	0.17%	-18.03%	3.28%
$f_0(1500)$											0.68%	0.09%	-0.02%	-0.01%	-0.04%	-0.70%
$a_0(phsp)$												1.09%	-0.29%	0.02%	-2.27%	0.69%
$f_2(1810)$													1.69%	0.11%	2.85%	-0.55%
$f_2(1430)$														0.13%	-0.25%	0.03%
$f_2(phsp)$															14.87%	-2.21%
$a_2(phsp)$																8.68%

Interference table

flatte

Total=188.57%

- Table below shows the fraction of interference terms between any two resonance.

Resonance	$f_0(500)$	$f_0(980)$	$a_0(980)$	$f_2(1270)$	a_2 (1320)	$\pi_1(1600)$	$f_0(1370)$	$f_0(1710)$	f_0(phsp)	$f_2(1950)$	$f_0(1500)$	a_0(phsp)	$f_2(1810)$	$f_2(1430)$	f_2(phsp)	a_2(phsp)
$f_0(500)$	3.07%	1.15%	-1.71%	-0.56%	0.19%	3.67%	2.96%	0.01%	-0.65%	-0.34%	-0.63%	-0.46%	0.08%	0.00%	0.76%	3.20%
$f_0(980)$		13.21%	9.65%	-0.91%	0.92%	1.74%	-1.73%	1.09%	-14.60%	-0.36%	1.40%	0.41%	-0.10%	-0.02%	1.03%	0.94%
$a_0(980)$			21.76%	6.94%	-0.10%	6.40%	4.40%	1.54%	-47.18%	10.16%	-0.59%	2.56%	-1.57%	0.18%	-16.26%	1.77%
$f_2(1270)$				30.89%	0.27%	-6.64%	-0.71%	-0.11%	1.82%	12.54%	-0.12%	1.11%	2.16%	1.57%	-18.73%	1.40%
$a_2(1320)$					0.66%	0.10%	0.20%	0.26%	0.65%	-0.63%	0.10%	-0.02%	0.39%	0.01%	-0.38%	-0.73%
$\pi_1(1600)$						18.66%	5.43%	0.19%	-24.81%	-1.87%	-1.50%	-0.78%	-1.15%	-0.20%	2.69%	6.38%
$f_0(1370)$							3.49%	1.00%	-9.66%	-0.40%	-0.85%	-0.16%	0.06%	-0.02%	0.72%	1.94%
$f_0(1710)$								0.56%	-2.13%	-0.10%	-0.35%	0.08%	0.00%	0.00%	0.13%	-0.02%
f_0(phsp)									41.93%	0.89%	1.77%	-0.94%	0.23%	0.05%	-2.55%	-3.75%
$f_2(1950)$										16.88%	0.07%	1.60%	-7.89%	0.19%	-25.23%	4.09%
$f_0(1500)$											0.61%	0.06%	-0.03%	-0.01%	-0.09%	-0.38%
a_0(phsp)												0.83%	-0.28%	0.02%	-2.46%	0.40%
$f_2(1810)$													2.15%	0.15%	4.50%	-0.81%
$f_2(1430)$														0.15%	-0.40%	0.01%
f_2(phsp)															24.88%	-2.33%
a_2(phsp)																8.84%