Partial wave analysis(PWA) of $e^+e^- \rightarrow \pi^+\pi^- J/\Psi$

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IHEP

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◆Introduction

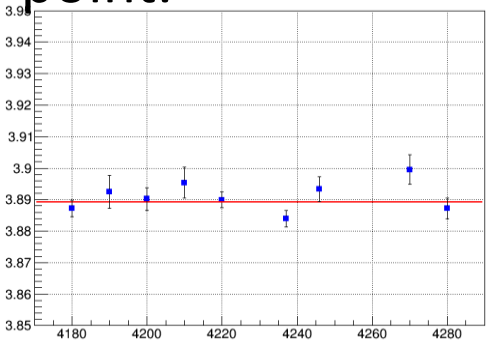
We have given separately fit results of each energy point, already. And for the reason of statistic and hardware support, we can only apply simultaneously fit with four energy point.

And from the I/O check, we know that we can obtain the mass, fraction ratio and G1 of Flatte with current statistic more accurately.

We have compare our results with former work and found some problems, and consistent with pi0pi0jpsi analysis results.

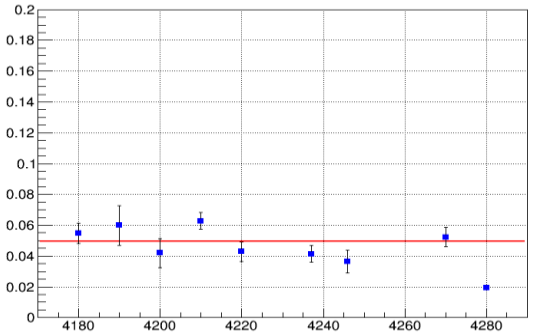
◆ Review

In previous workshop, we have given the invariant mass, width and cross section distribution of Zc with separately fit of each energy point.



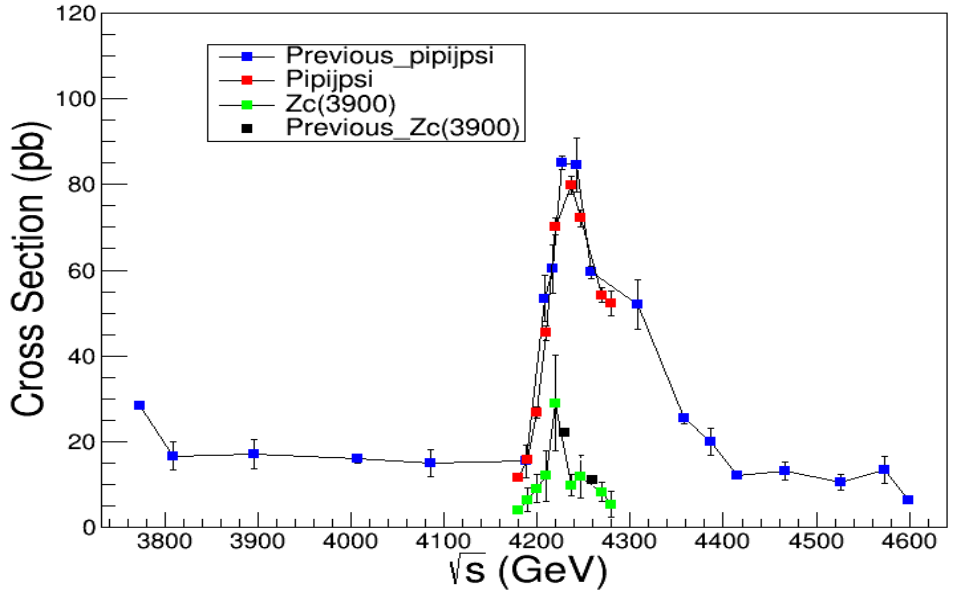
$M_{Z_c(3900)} = 3.8893 \pm 0.0011\ \mathrm{GeV/c^2}$

chi2/ndf=1.43979



$\Gamma_{Z_c(3900)} = 0.0494 \pm 0.0024\ \mathrm{GeV/c^2}$

chi2/ndf=1.6383



Cross section of Zc(3900)

◆Simultaneous fit

◆ Data sets

Signal region: Mjpsi>3.09&&Mjpsi<3.11
Sideband region: (Mjpsi>3.02&&Mjpsi<3.07)||(Mjpsi>3.13&&Mjpsi<3.16)

Energy points	Sig_ee	Bkg_ee	Ratio_ee*1/4	Sig_mm	Bkg_mm*1/4	Ratio_mm
4180	602	55	9.14%	833	66.25	7.95%
4190	138	12	8.70%	177	10.5	5.93%
4200	223	16.25	7.29%	296	12.5	4.22%
4210	317	14.5	4.57%	481	16.75	3.27%
4220	538	16.25	3.02%	683	14	2.05%
4230	1356	24.5	1.81%	1851	35	1.89%
4237	648	13.75	2.12%	926	20	2.16%
4246	593	14.75	2.49%	834	16.25	1.95%
4260	803	23	2.86%	1084	25.5	2.35%
4270	458	15.25	3.33%	654	18.25	2.79%
4280	133	6.25	4.70%	208	4.75	2.28%
4360	236	10.25	4.34%	284	20.5	7.22%

◆Simultaneous fit

◆ Parameterization of Zc

For Zc: Flatter formula: $\mathrm{F} = \frac{1}{\mathrm{M}^2 - \mathrm{s} - \mathrm{i}(\mathrm{g1}\rho_{\pi J/\psi}(\mathrm{s}) + \mathrm{g2}\rho_{\mathrm{D}^*\bar{\mathrm{D}}}(\mathrm{s}))}$

For $\mathrm{f}_0(980)$, the Flatte formula: $\mathrm{f} = \frac{1}{\mathrm{M}^2 - \mathrm{s} - \mathrm{i}(\mathrm{g1}\rho_{\pi\pi}(\mathrm{s}) + \mathrm{g2}\rho_{\mathrm{K}\bar{\mathrm{K}}}(\mathrm{s}))}$

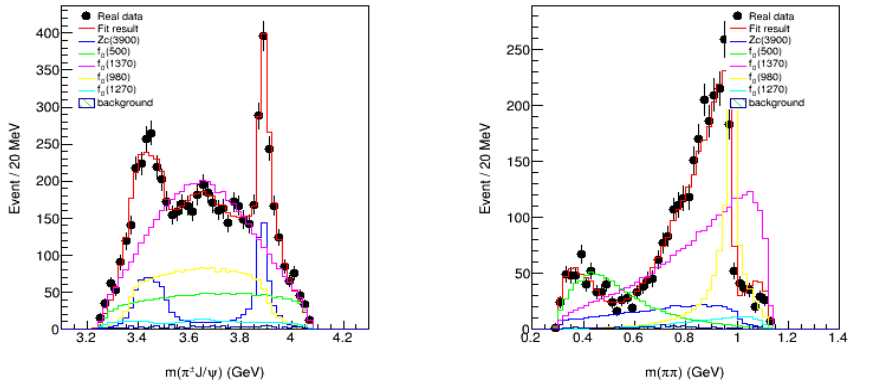
For $\mathrm{f}_0(1370)$, $\mathrm{f}_2(1270)$ and σ_0, the relativisitic Breit-Wigner function:

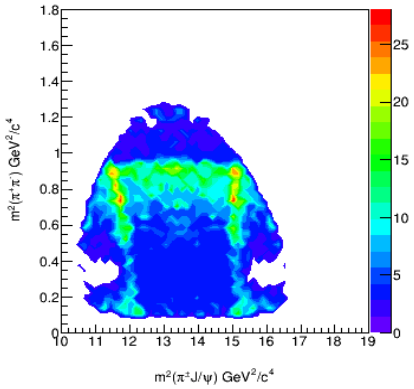
$$\mathrm{BW}(\mathrm{m}) = \frac{1}{\mathrm{m}^2 - \mathrm{m}_0^2 + \mathrm{im}\Gamma_{\mathrm{X}}(\mathrm{m})}$$

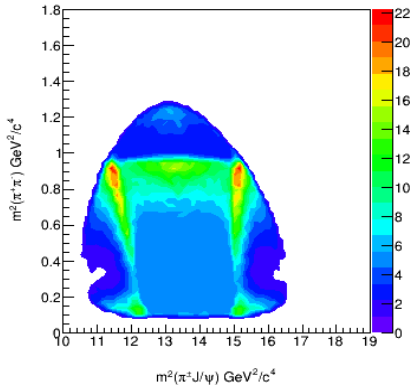
And for σ_0 : we use E791 type : $\Gamma_{\mathrm{X}}(\mathrm{s}) = \sqrt{1 - \frac{4\mathrm{m}_\pi^2}{\mathrm{s}}}\,\Gamma$

◆Simultaneous fit

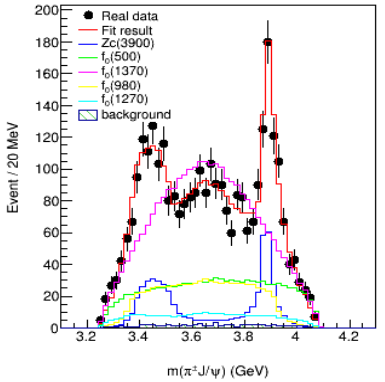
◆ Fitting result

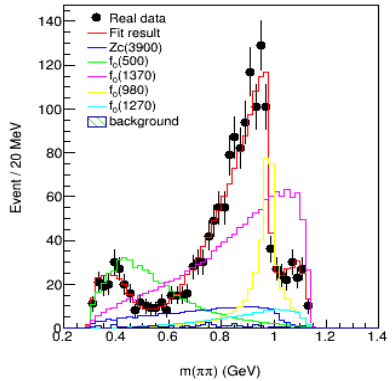


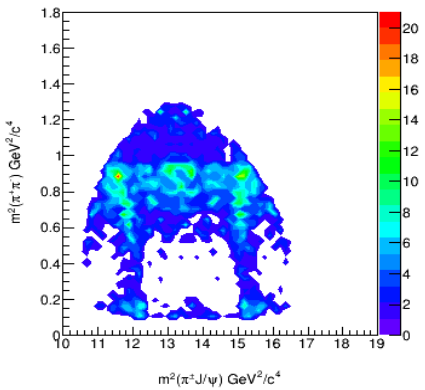


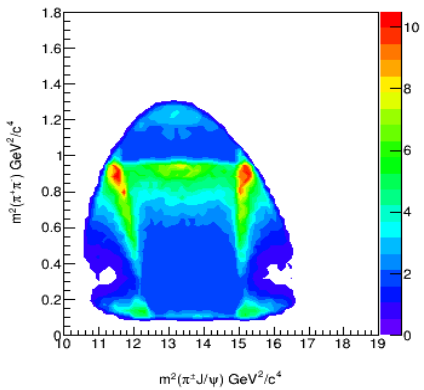


4230





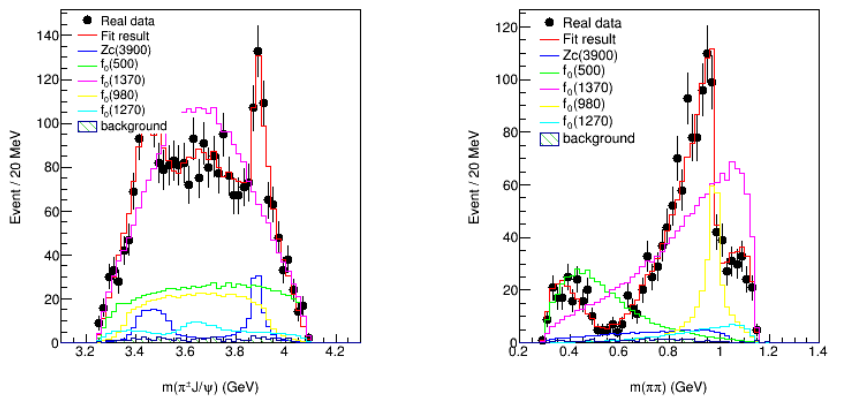




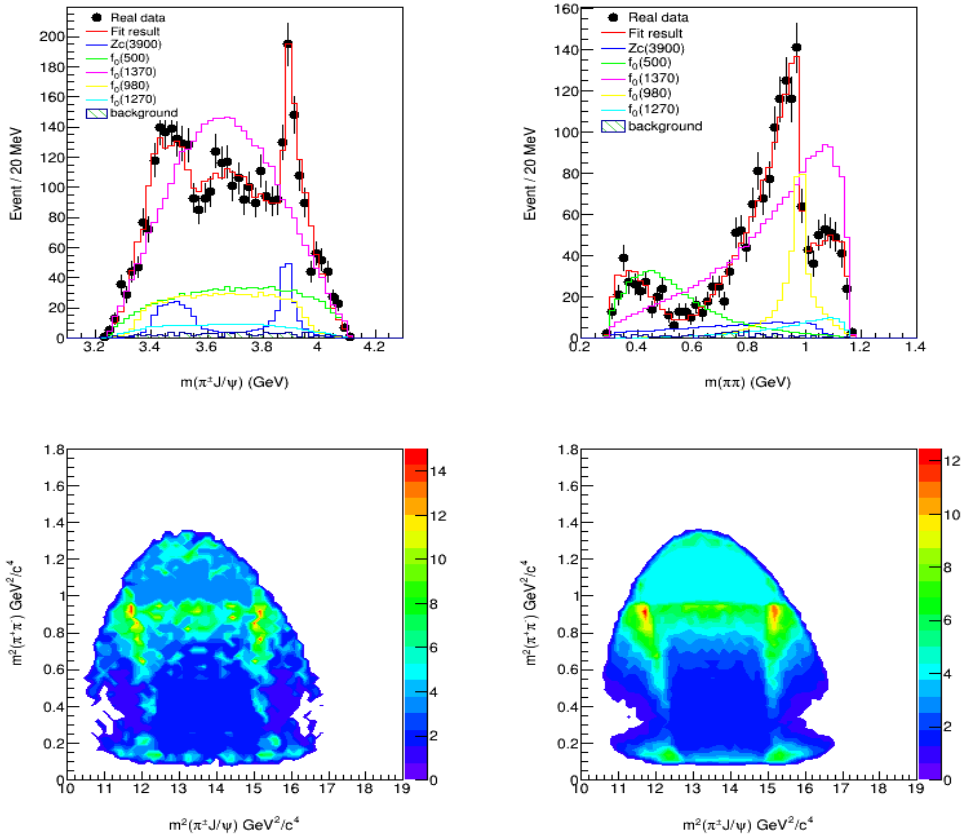
4237

◆Simultaneous fit

◆ Fitting result



4246



4260

◆Simultaneous fit

◆ Fitting result

Energy	4230	4237	4246	4260
Zc	0.1783+/-0.0351	0.1561+/-0.0323	0.0906+/-0.0215	0.1070+/-0.0227
figma(500)	0.3187+/-0.0327	0.3962+/-0.0502	0.3983+/-0.0572	0.3599+/-0.0443
f0(1370)	0.8324+/-0.0732	0.8985+/-0.0882	1.0188+/-0.0923	1.0313+/-0.0935
f0(980)	0.3326+/-0.0326	0.2536+/-0.0371	0.2150+/-0.0282	0.2202+/-0.0309
f2(1270)	0.0714+/-0.0155	0.0885+/-0.0296	0.0755+/-0.0253	0.0692+/-0.0253

FCN=-125683

Flatte:

Mass: 3.8911+/- 0.0025

G1: 0.4929+/- 0.0393

G2: 1.4346+/-0.2756

◆I/O check

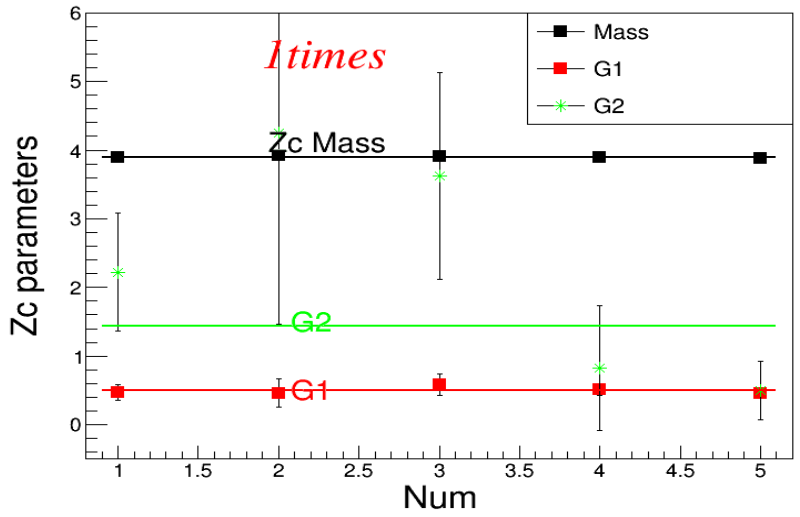
We use the fitting result to generate a toymc sample of 4237 energy point and it's about 70 times with the data of each channel
Toymc: Total 106757 ee channel: 46376 mumu channel: 66944

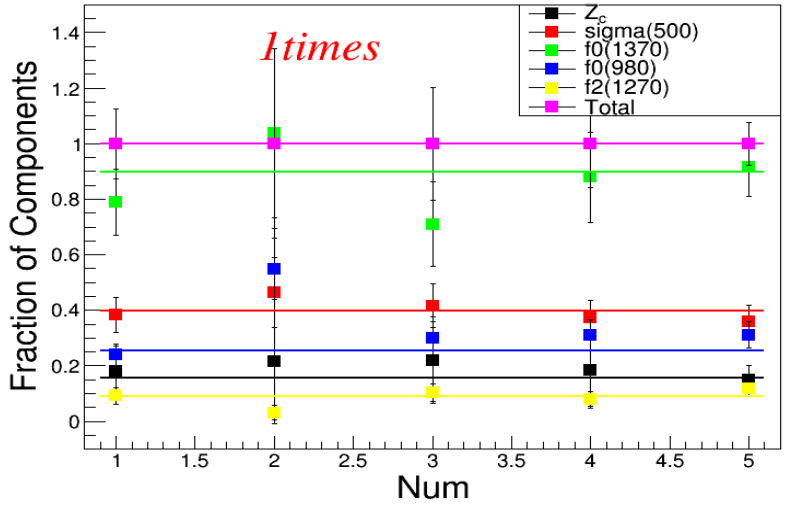
Input
Mass: 3.8911
G1: 0.4929
G2: 1.4346
component0 0.1561
component1 0.3962
component2 0.8985
component3 0.2536
component4 0.0885

Output:
Mass: 3.8921 +/- 0.0010
G1: 0.5319 +/- 0.0129
G2 : 1.2452 +/- 0.1187
component0 0.1582+/-0.0073
component1 0.4043+/-0.0071
component2 0.9118+/-0.0135
component3 0.2469+/-0.0047
component4 0.0809+/-0.0035

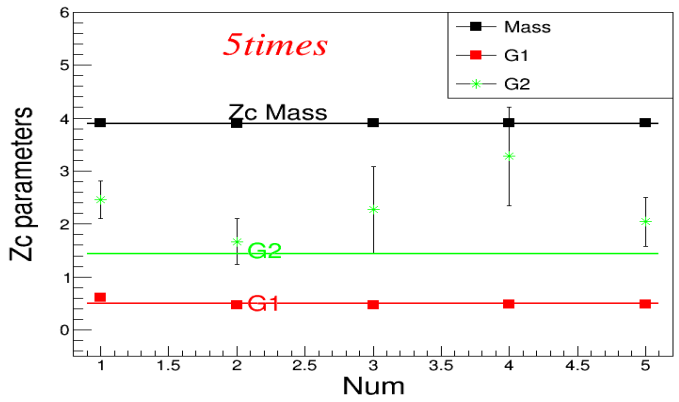
◆ Stability check of the fit

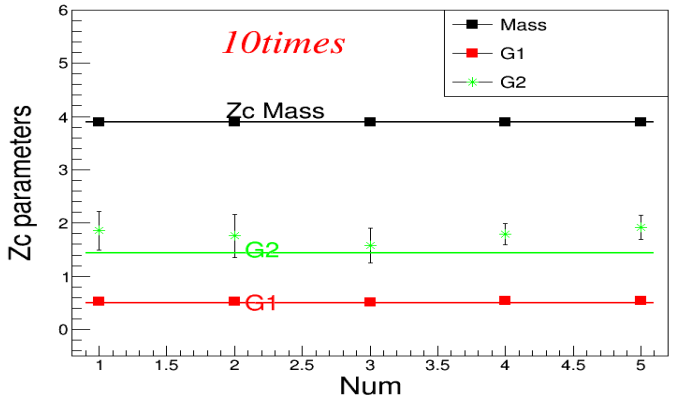
We have randomly sampling 5 samples with 1, 5, 10, 20, 40 times of 4237 data sample from the large toymc sample (about 70 times), and getting the fit results.

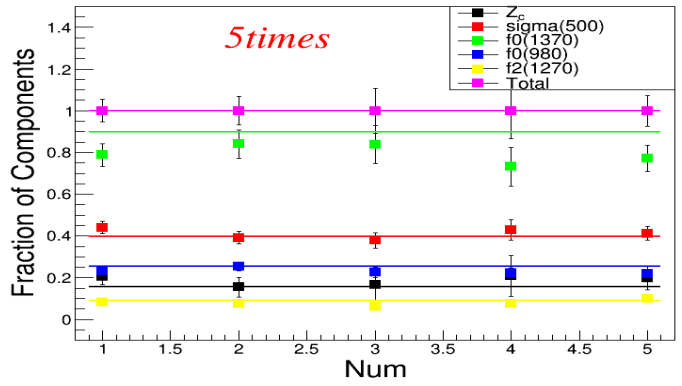


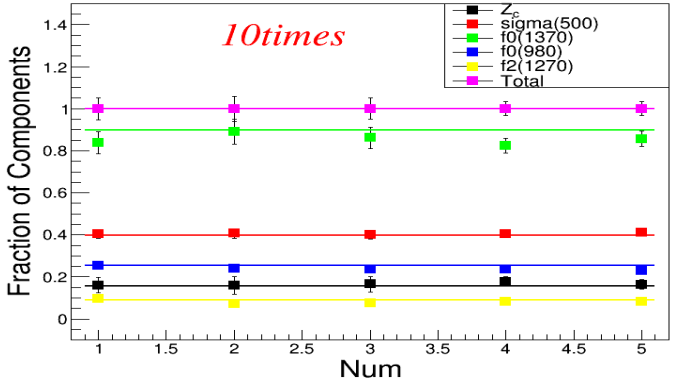


◆Stability check of the fit

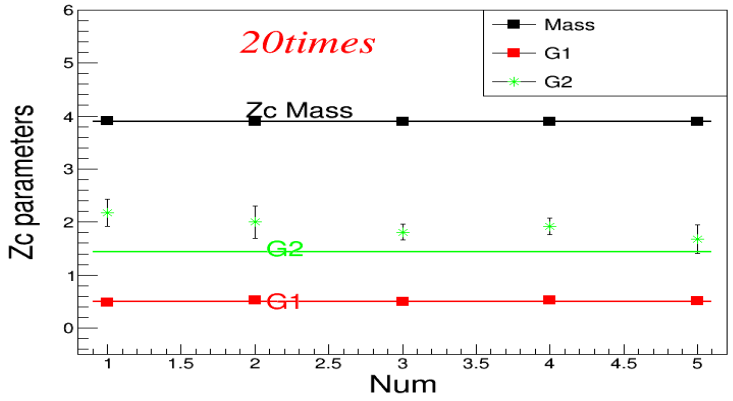


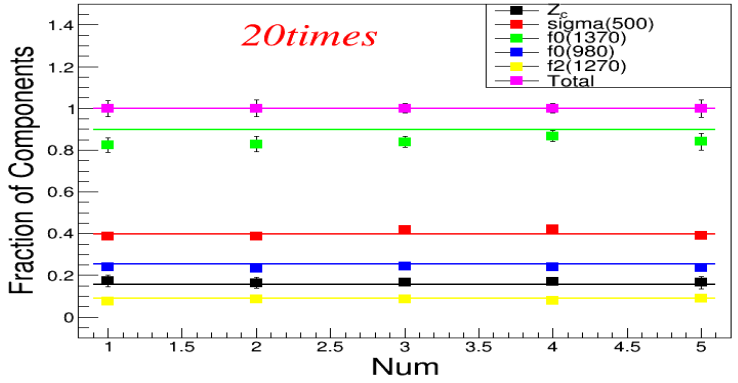


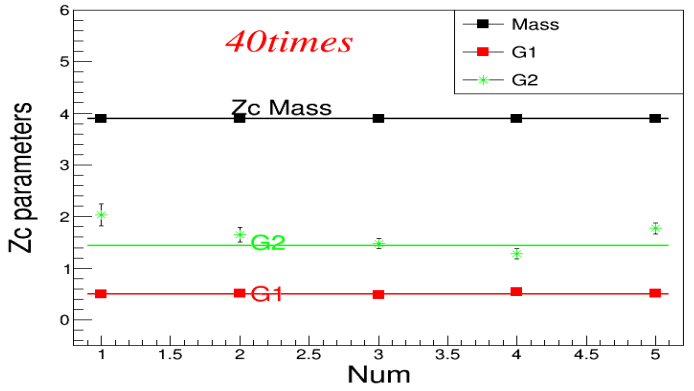


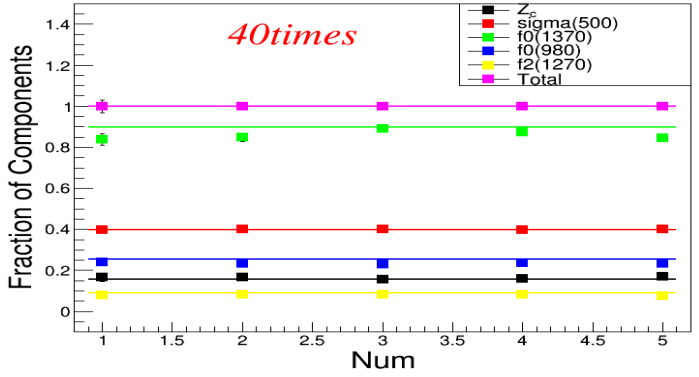


◆Stability check of the fit



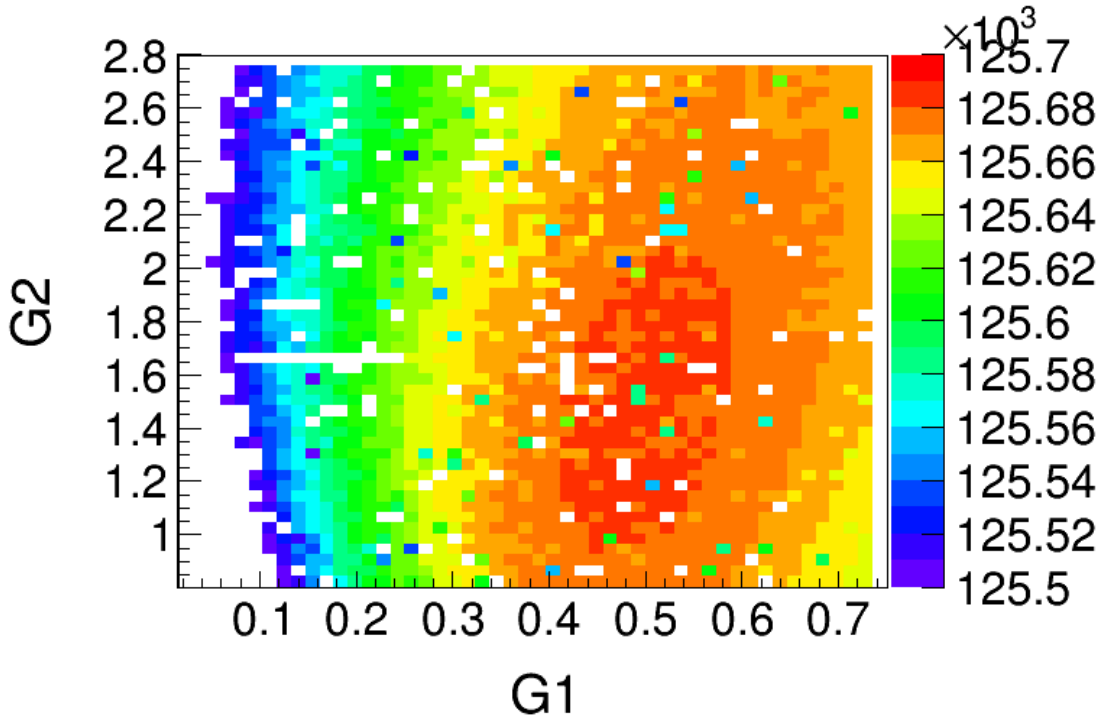






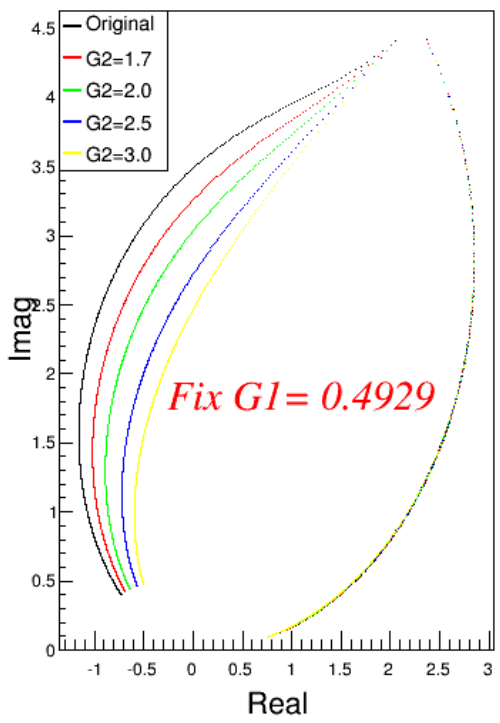
From all the fitting results, we can see that except for G2 and fraction of f0(1370), we can obtain the input value always.

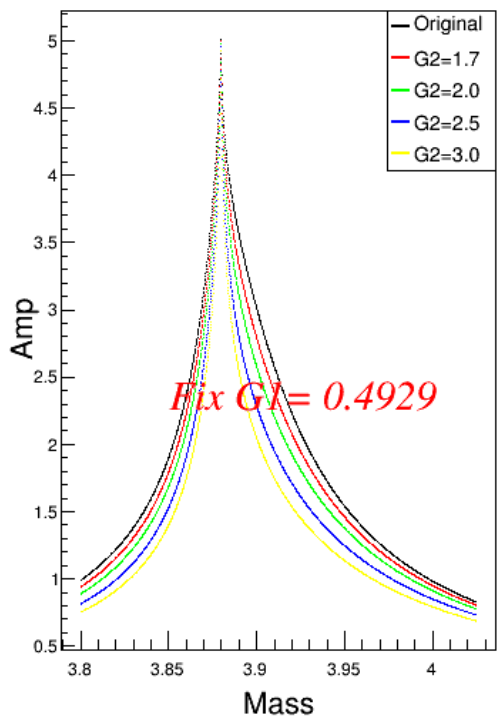
◆Scan the distribution of G1 Vs G2

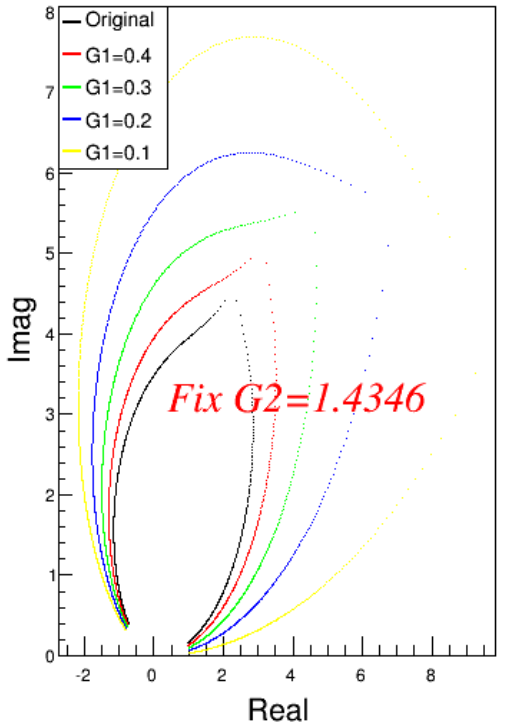


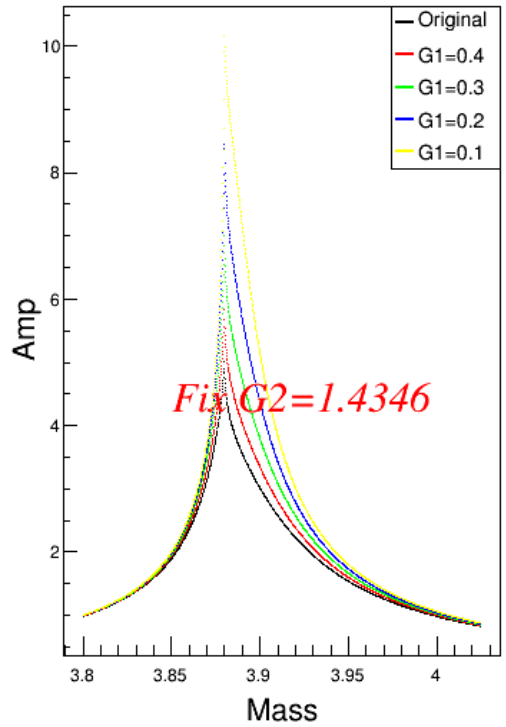
We using the 4 energy points data samples with simultaneous fit to scan the G1 and G2, the color stands for absolute value of FCN. And the optimal value is in a wide range.

◆ Argand plot and Flatte parameters









From the plot we can see that the Argand plot and Flatte are sensitive to G1 and not to G2.

◆Check with former work

From the work of Ronggang of pi+pi-jpsi, we can get the J^P of Zc and Flatte parameters, but it constrained the G2/G1 near 27.1 in his PWA frame. And we just bounded it to the range of (0, 50). And fitting to about 10 times toymc of the data of 4237， the toymc generated in our PWA frame.

Input:	
Zc:	0.1561
Sigma:	0.3962
F0(1370):	0.8985
F0(980) :	0.2536
F2(1270):	0.0885
Mass:	3.8911
G1:	0.4929
G2:	1.4346

Output:	
Zc:	0.2286 +/- 0.0078
Sigma:	0.3586 +/- 0.0193
F0(1370):	0.9093 +/- 0.0346
F0(980):	0.2518 +/- 0.0171
F2(1270):	0.0831 +/- 0.0128
Mass:	3.9250 +/- 0.00365
g1 :	0.0689 +/- 0.00588
g2/g1 :	50 + 31.5637

The results shows only Zc not agree to the input value.

◆Check with former work

And we have tried to constrain the G2/G1 near to our input value and fitted in his frame. The toymc always generated in our frame.

Input:	
Zc:	0.1561
Sigma:	0.3962
F0(1370):	0.8985
F0(980) :	0.2536
F2(1270):	0.0885
Mass:	3.8911
G1:	0.4929
G2:	1.4346

Output:		
Zc:	0.1662	+/-0.00617
Sigma:	0.3269	+/- 0.02031
F0(1370):	1.0831	+/- 0.03843
F0(980):	0.2742	+/- 0.01827
F2(1270):	0.1035	+/- 0.01297
Mass:	3.8951	+/- 0.00181
g1 :	0.2122	+/- 0.03218
g2/g1 :	6.0471	+/- 1.79151

There are also some big difference with some parameters.

◆Comparing with $\pi^0\pi^0 J/\Psi$

Pi+pi-jpsi: Mass: 3.8911+/- 0.0025, G1: 0.4929+/- 0.0393, G2: 1.4346+/-0.2756

Energy	4230	4237	4246	4260
Zc	0.1783+/-0.0351	0.1561+/-0.0323	0.0906+/-0.0215	0.1070+/-0.0227
figma(500)	0.3187+/-0.0327	0.3962+/-0.0502	0.3983+/-0.0572	0.3599+/-0.0443
f0(1370)	0.8324+/-0.0732	0.8985+/-0.0882	1.0188+/-0.0923	1.0313+/-0.0935
f0(980)	0.3326+/-0.0326	0.2536+/-0.0371	0.2150+/-0.0282	0.2202+/-0.0309
f2(1270)	0.0714+/-0.0155	0.0885+/-0.0296	0.0755+/-0.0253	0.0692+/-0.0253

Pi0pi0jpsi: Mass: 3.894+/- 0.055, G1: 0.441+/- 0.140, G2/G1: 0.456+/-2.535

Energy	4230	4237	4246	4260
Zc	15.9+/-9.6	19.2+/-10.6	14.6+/-8.8	8.1+/-5.1
figma(500)	42.4+/-9.2	58.3+/-12.4	53.5+/-13.6	53.8+/-11.6
f0(1370)	135.0+/-23.3	98.2+/-22.5	115.9+/-24.3	143.9+/-21.6
f0(980)	24.6+/-5.6	31.2+/-9.2	18.5+/-5.2	21.7+/-7.4
f2(1270)	-	-	-	-

◆Summary

From our analysis, we know that the G2 and fraction of f0(1370) has a large of uncertainty with current statistic of data samples and we can obtain the Zc mass, G1 and other fraction ratios with more accuracy.

And we will generate more samples to confirm our analysis.

Thank you!

◆Backup

◆ Sigma parameterization

When we use other two types of parameterization of sigma(500), we can't get reasonable results of Zc.

Zou and Bugg

Bounded parameters

Mass	4.4367	0.0243
G1	0.0007	0.6896
G2	49.821	43.989 upper limit

PKU

Bounded parameters

Mass	3.925	0.0038
G1	3.524e-11	0.0184 lower limit
G2	3.1798	0.2248

And we have applied those two methods to ours toymc from E791 type, and can't get the input parameters, too.

◆ Sigma parameterization

Fitting to 4237 toymc, which is about 70 times of the data.

Input
E791
Mass: 3.8911
G1: 0.4929
G2: 1.4346

output
Zou and Bugg

Mass	3.9896	0.00292
G1	1.4044	0.07321
G2	10	0.02034

upper limit

output
PKU

Mass	3.886	0.00053
G1	0.42414	0.00823
G2	0.36794	0.06006

From the current analysis, we can't use those two parameterization methods to do the systemic error analyze of sigma parameterization.