Phase Summary

Prof. Francesca De Mori

Intro

- The aim of the "task force" is to join the efforts and share the available expertise inside BESIII
- The " first mission" is to create a "fertile environment" to make these analyses blooming and to reach common good practices and to stimulate dedicated discussion to validate the results.
- The group meetings are scheduled usually once a month
- They have started in March 2021.
- The list and material of the meetings are available @ https://indico.ihep.ac.cn/category/820/
- These analyses both in Tau-Qcd and Charmonium

Numbers

- Many channels with on-going analysis.
- One published result
- 3 RC
- 3 AG

Channels

J/psi scan

- (5pi,etapi+pi-,mumu) (YADI)
- ppbar (Marco)
- Σ^+anti-Σ^- (Jaijun)
- $\Sigma^0\bar{\Sigma}^0$ (Muzaffar)
- Phi eta (Yuri et al)
- K+K-(Francesca, TBR)
- Lambda/Lambdabar+X(Qu)

Psi(2s) scan

- ppbar (Yanan/Yadi)
- $\Sigma^0\bar{\Sigma}^0$ (Muzaffar)
- $\Lambda\Lambda$bar
- Xi+Xi-bar (Congyu Li)
- K^+K^- (Yadi)
- Omega$^+$Omega$^-$ (Zequing)
- Omega pi^0 (Baoxin)
- Pipijpsi (Giulio)

Two observables can be checked:

- *The Born xs far from the resonance*
- *the BF*

What is expected?

$$\delta\mathcal{B} = 2\sqrt{\frac{\sigma_0}{\sigma_\psi}}A_s \sin\varphi.$$

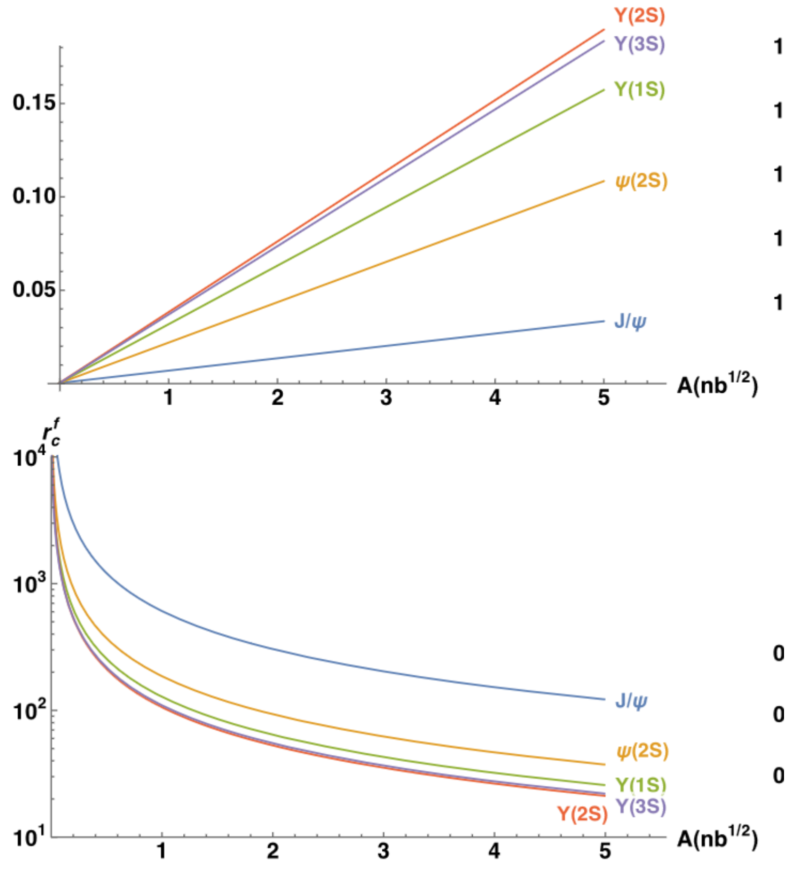
nonresonant cross section

$$\sigma_\psi = (12\pi/m^2)\mathcal{B}(\psi \to e^+e^-),$$

Impact of the interference between the resonance and continuum amplitudes on vector quarkonia decay branching fraction measurements

Y. P. Guo and C. Z. Yuan
Phys. Rev. D **105**, 114001 – Published 2 June 2022

"….depends on the relative size and phase between the resonance and continuum amplitudes. Two ratios are defined to estimate the size of these effects, the ratio of the contribution of the interference term to the resonance term and that to the continuum term. We find that the first could be as large as a few percent for narrow resonances, and both could be large for broad resonances. This indicates that the interference effect is crucial for the measurements of the branching fractions aiming at the percent level or better precision and needs to be measured or estimated properly."



https://doi.org/10.1103/PhysRevD.105.114001

$$A = \sqrt{\sigma_c^f(s)/\mathcal{B}_f}$$

Measurement of the phase between strong and electromagnetic amplitudes of J/ψ decays(5pi,etapi+pi-,mumu) (YADI)

No.	$\mu^+\mu^-$ N_i	$\mu^+\mu^-$ $\epsilon_i(\%)$	$\mu^+\mu^-$ σ_i^{obs} (nb)	5π N_i	5π $\epsilon_i(\%)$	5π σ_i^{obs} (nb)
1	76553±277	54.52 ± 0.16	9.411±0.034±0.217	734±29	23.60 ± 1.28	0.211±0.008±0.017
2	76058±276	54.53 ± 0.16	9.261±0.034±0.213	723±28	23.88 ± 1.43	0.204±0.008±0.017
3	81532±286	53.30 ± 0.16	8.794±0.031±0.202	765±29	23.54 ± 1.25	0.189±0.007±0.015
4	21584±147	53.74 ± 0.16	8.42± 0.06 ±0.20	180±14	24.31 ± 3.02	0.158±0.012±0.021
5	63674±252	52.76 ± 0.16	7.758±0.031±0.177	858±30	25.16 ± 1.27	0.222±0.008±0.017
6	51677±227	51.12 ± 0.16	6.780±0.030±0.155	1434±39	26.09 ± 1.02	0.373±0.010±0.027
7	15929±126	58.84 ± 0.16	12.63± 0.10 ±0.30	4962±71	28.69 ± 0.60	8.16± 0.12 ±0.53
8	52001±228	63.23 ± 0.17	45.28± 0.20 ±1.07	18120±140	28.37 ± 0.40	35.59± 0.27 ±2.26
9	154741±393	63.87 ± 0.15	113.47± 0.29 ±2.67	52380±230	28.42 ± 0.35	87.4± 0.4 ±5.5
10	281713±531	63.99 ± 0.16	212.8± 0.4 ±5.1	90560±310	28.19 ± 0.31	157.1± 0.5 ±9.9
11	155118±394	64.07 ± 0.16	109.90± 0.28 ±2.60	43520±210	28.32 ± 0.36	70.57± 0.34 ±4.47
12	26646±163	62.62 ± 0.15	56.29± 0.35 ±1.39	6424±81	28.41 ± 0.52	30.3± 0.4 ±2.0
13	21893±148	60.51 ± 0.15	22.44± 0.15 ±0.54	3440±60	26.57 ± 0.68	8.13± 0.14 ±0.54
14	20184±142	58.74 ± 0.16	16.32± 0.12 ±0.38	2468±50	27.89 ± 0.79	4.25± 0.09 ±0.29
15	13173±115	57.72 ± 0.16	13.27± 0.12 ±0.32	1160±35	26.72 ± 1.11	2.55± 0.08 ±0.19
16	8550±93	56.40 ± 0.16	11.99± 0.13 ±0.29	623±26	26.63 ± 1.43	1.87± 0.08 ±0.15

No.	$\eta\pi^+\pi^-$ N_i	$\eta\pi^+\pi^-$ $\epsilon_i(\%)$	$\eta\pi^+\pi^-$ σ_i^{obs} (nb)
1	32±6	21.16 ± 0.11	0.045± 0.009 ±0.006
2	24±6	21.08 ± 0.11	0.034± 0.008 ±0.004
3	34±6	20.78 ± 0.10	0.042± 0.008 ±0.006
4	8±3	21.07 ± 0.11	0.037± 0.015 ±0.005
5	25±6	21.11 ± 0.11	0.033± 0.007 ±0.004
6	15±5	21.14 ± 0.11	0.0216±0.0064±0.0025
7	10±4	21.25 ± 0.11	0.100± 0.039 ±0.013
8	19±7	20.94 ± 0.11	0.218± 0.076 ±0.027
9	60±11	21.00 ± 0.11	0.59± 0.11 ±0.07
10	118±15	20.79 ± 0.10	1.21± 0.15 ±0.15
11	74±11	20.83 ± 0.10	0.709± 0.105 ±0.088
12	22±6	20.50 ± 0.10	0.63± 0.16 ±0.08
13	12±4	20.84 ± 0.10	0.155± 0.056 ±0.020
14	7±3	20.71 ± 0.10	0.072± 0.034 ±0.009
15	5±3	20.58 ± 0.10	0.057± 0.036 ±0.007
16	6±3	20.63 ± 0.10	0.094± 0.045 ±0.012

- https://www.sciencedirect.com/science/article/pii/S0370269319301558

First and last phase paper published by BESIII

Table 3: Fit results for the lineshape of $e^+e^- \to 5\pi$. Solution I is with $\Phi_{g,\mathrm{EM}} > 0^\circ$ and solution II is with $\Phi_{g,\mathrm{EM}} < 0^\circ$.

	$\Phi_{g,\mathrm{EM}}$	$\mathcal{B}_{5\pi}$ (%)	χ^2/ndf
Solution I	$(84.9 \pm 3.6)^\circ$	4.73 ± 0.44	11.62/12
Solution II	$(-84.7 \pm 3.1)^\circ$	4.85 ± 0.45	11.62/12

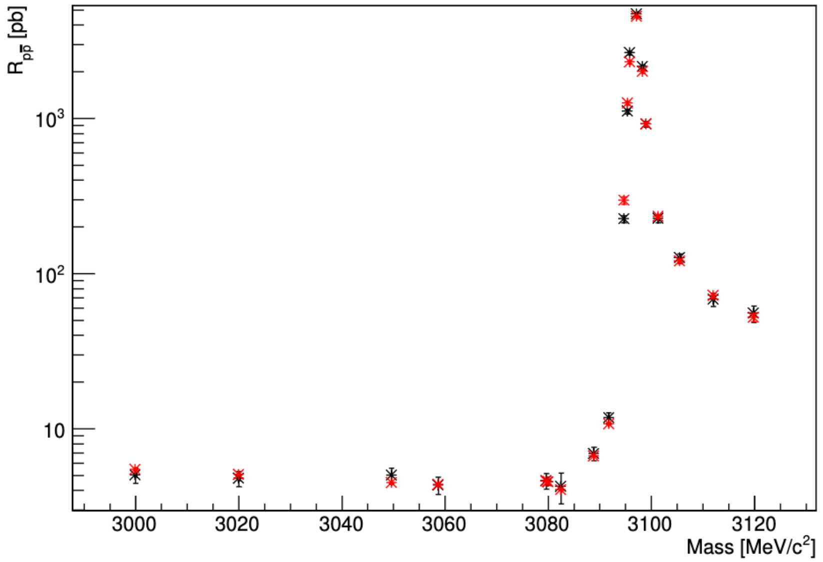
The branching fraction of $J/\psi \to \eta\pi+\pi-$
is $(3.78\pm0.68)\times10-4$, which is more accurate than the existing world average value of $(4.0\pm1.7)\times10-4$

the branching fraction of J/ψ decays to 5π is measured to be (4.73 ± 0.44)% or (4.85 ± 0.45)%, which is consistent with the world average value of (4.1 ± 0.5)%

- *Yadi &co stanno preparando un articolo che descrive la funzione analitica di fit..poi sara' disponibile per la collaborazione.*

Measurement of the phase between strong and electromagnetic amplitudes of J/ψ → ppbar (MARCO)

@RC



PDG

$(2.120 \pm 0.029) \times 10^{-3}$

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BF w/o interference with the cont
Interf. effect seems to be 9 10^-5
PDG is not in the middle
Waiting for analysis in psi(2s)→
PipiJ/psi (already started)
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- φ = -95.0° ± 3.9°,
- σ_{cont} = 9.91 pb ± 0.63 pb,
- $B_{out} = (2.103 \pm 0.030) \cdot 10^{-3}$,

- φ = 95.1° ± 2.8°,
- σ_{cont} = 9.91 pb ± 0.40 pb,
- $B_{out} = (1.918 \pm 0.022) \cdot 10^{-3}$,

In RC

Comparisons with the literature

xs(3050 MeV)=(10.1±1.1±0.6 pb)

at 3.0 GeV σ_B=(9.9±0.9)pb (MARCO)and σ_B(9.2±1.0±0.3 pb) (Phys. Rev. Lett. 124, 042001 (2020))
In agreement

$$\mathcal{B}(J/\psi \to p\bar{p}) = (2.33 \pm 0.08 \pm 0.09) \times 10^{-3},$$
$$\mathcal{B}(\psi(2S) \to p\bar{p}) = (3.14 \pm 0.28 \pm 0.18) \times 10^{-4}$$

https://doi.org/10.1103/PhysRevD.88.072009

untagged

2.950–3.000	$29 \pm 7 \pm 2$	0.170 ± 0.005	8.57	$20 \pm 5 \pm 2$
3.000–3.200	$25 \pm 12 \pm 9$	0.168 ± 0.008	36.19	$4.2 \pm 2.0 \pm 1.6$

tagged

$$\mathcal{B}(J/\psi \to p\bar{p}) = (2.04 \pm 0.07 \pm 0.07) \times 10^{-3},$$
$$\mathcal{B}(\psi(2S) \to p\bar{p}) = (2.86 \pm 0.51 \pm 0.09) \times 10^{-4}.$$

https://doi.org/10.1103/PhysRevD.87.092005

$\mathrm{B}_{out} = (2.103 \pm 0.030)\cdot 10^{-3},$

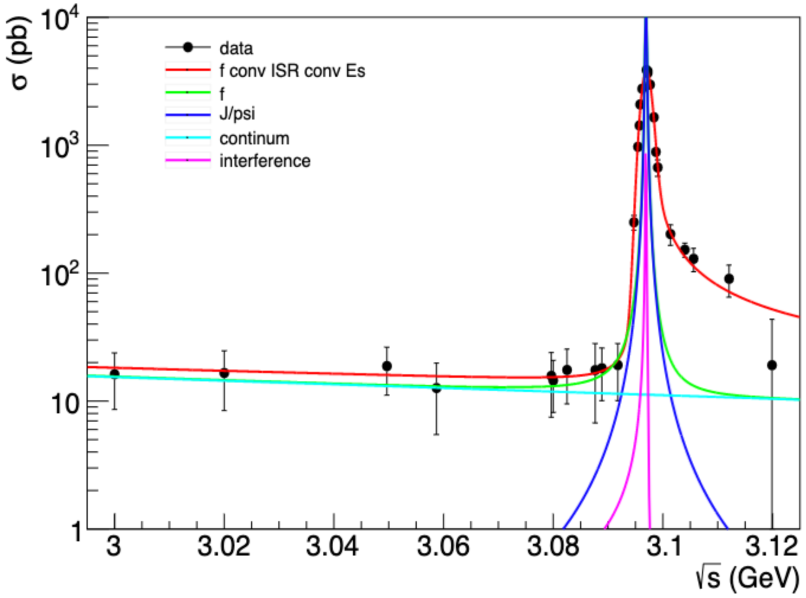
- $\mathrm{B}_{out} = (1.918 \pm 0.022)\cdot 10^{-3},$

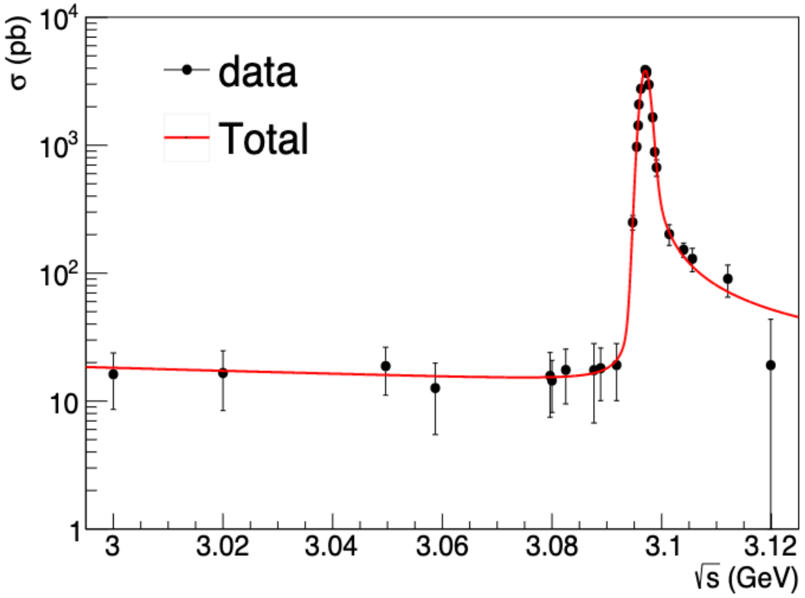
MARCO

J/ψ →Σ⁺anti-Σ⁻ decay (Jaijun)

@RC

$$\sigma[pb] = \left| \sqrt{3\pi\Gamma^2 B_{in}[\frac{\hbar c}{W}]^2 \cdot 10^{10}} \cdot \frac{\sqrt{B_{out}}}{(M_\psi - W) - i\Gamma/2} + C \right|^2$$





Solution	$\Phi_{3g,\gamma}(^\circ)$	$\sigma_{\text{cont.}}$(3.000 GeV) pb	$\mathcal{B}_{\text{out}}(J/\psi \to \Sigma^+\bar{\Sigma}^-)$	χ^2/ndf
I	107.9 ± 24.9	15.4 ± 3.1	$(1.14 \pm 0.02) \times 10^{-3}$	17.4/24
II	-107.6 ± 24.3	15.4 ± 3.1	$(1.19 \pm 0.02) \times 10^{-3}$	17.4/24

In RC

Jaijun changed experiment (still trying to finish)

Literature comparisons

Problem with BF

Solution	$\Phi_{3g,\gamma}(°)$	$\sigma_{\text{cont.}}(3.000\ \text{GeV})$ pb	$\mathcal{B}_{\text{out}}(J/\psi \to \Sigma^+\bar{\Sigma}^-)$	χ^2/ndf
I	107.9 ± 24.9	15.4 ± 3.1	$(1.14 \pm 0.02) \times 10^{-3}$	17.4/24
II	-107.6 ± 24.3	15.4 ± 3.1	$(1.19 \pm 0.02) \times 10^{-3}$	17.4/24

Table 2. The numbers of signal events, detection efficiencies and branching fractions of $\Psi \to \Sigma^+\overline{\Sigma}^-$, where the uncertainties are statistical only.

Channel	N_{sig}	$\epsilon_{cor}(\%)$	Branching fraction (10^{-4})
$J/\psi \to \Sigma^+\overline{\Sigma}^-$	86976 ± 314	24.1 ± 0.7	10.61 ± 0.04
$\psi(3686) \to \Sigma^+\overline{\Sigma}^-$	5447 ± 76	18.6 ± 0.5	2.52 ± 0.04

Both lower
Than PDG!

Liang on psi/psi' sample

PDG: **$(1.50\pm0.24)*10^{-3}$**

https://www.sciencedirect.com/science/article/pii/S0370269321000502?via%3Dihub

$\sqrt{s}$ (GeV)	$\mathscr{L}$ (pb^{-1})	ϵ_A(%)	ϵ_B(%)	σ^{Born} (pb)	$\lvert G_{\text{eff}}\rvert(\times 10^{-2})$	$\lvert G_E/G_M\rvert$
2.3864	22.6	5.8	12.6	$58.2 \pm 5.9^{+2.8}_{-2.6}$	$16.5 \pm 0.9 \pm 0.9$	-
2.3960	66.9	9.5	14.1	$68.6 \pm 3.4 \pm 2.3$	$15.0 \pm 0.4 \pm 0.5$	$1.83 \pm 0.26 \pm 0.24$
2.5000	1.10	18.4	21.6	$130 \pm 29 \pm 11$	$14.0 \pm 1.6 \pm 0.6$	–
2.6444	33.7	24.4	20.5	$59.9 \pm 3.6 \pm 3.2$	$8.6 \pm 0.3 \pm 0.2$	$0.66 \pm 0.15 \pm 0.11$
2.6464	34.0	24.2	20.7	$58.9 \pm 3.5 \pm 2.4$	$8.5 \pm 0.3 \pm 0.2$	
***2.7500**	2.04	25.0	19.7	$36.9 \pm 12.8 \pm 3.2$	$6.7 \pm 1.2 \pm 0.3$	–
2.9000	105.	26.5	20.6	$16.7 \pm 1.2 \pm 1.1$	$4.5 \pm 0.2 \pm 0.2$	$1.06 \pm 0.36 \pm 0.09$
***2.9884**	65.2	25.5	21.4	$12.4 \pm 1.3 \pm 1.3$	$3.9 \pm 0.2 \pm 0.2$	–

$e^+e^- \to \Sigma^+\bar{\Sigma}^-$

Solution	$\Phi_{3g,\gamma}(^\circ)$	$\sigma_{\text{cont.}}$(3.000 GeV) pb	$\mathcal{B}_{\text{out}}(J/\psi \to \Sigma^+\bar{\Sigma}^-)$	χ^2/ndf
I	107.9 ± 24.9	15.4 ± 3.1	$(1.14 \pm 0.02) \times 10^{-3}$	17.4/24
II	-107.6 ± 24.3	15.4 ± 3.1	$(1.19 \pm 0.02) \times 10^{-3}$	17.4/24

Sigma born ..in agreement (large uncertainties)

$e^+e^- \to \phi\eta.$

Yuri, Zequn

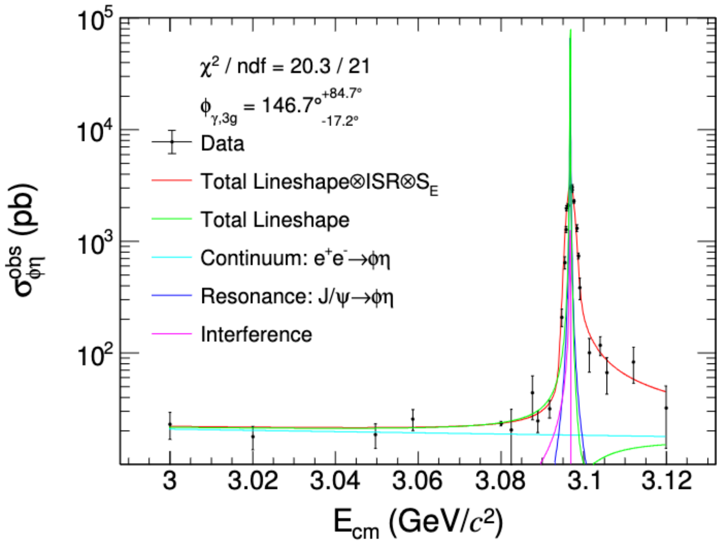
@AG

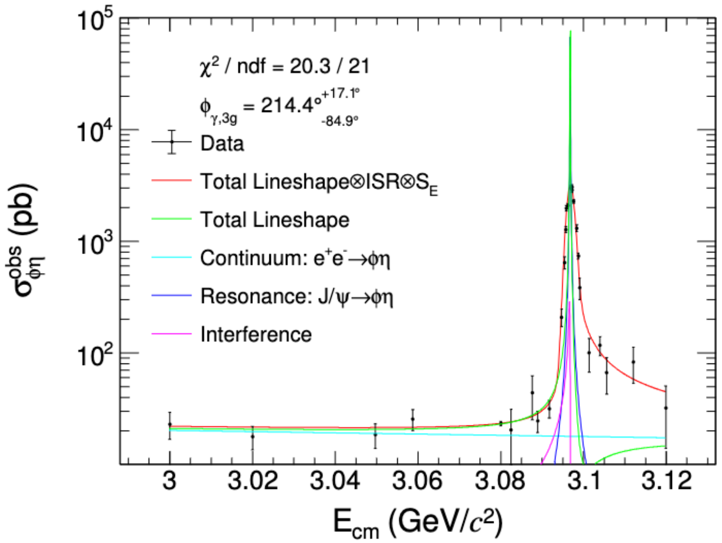
@J/psi

$\sqrt{s}$ (MeV)	$\mathcal{L}$ (pb^{-1})	N_{sig}	ε (%)	σ^{obs} (pb)
3000.000±0.200	15.850±0.111	25.7±6.9	36.3±0.2	23.1±6.2
3020.000±0.200	17.320±0.120	22.0±5.2	36.9±0.2	17.8±4.2
3049.658±0.028	14.919±0.161	20.0±5.0	37.3±0.2	18.6±4.6
3058.709±0.028	15.060±0.161	28.0±5.6	37.5±0.2	25.6±5.5
3080.000±0.200	294.488±2.302	497.4±23.3	37.5±0.2	23.3±1.1
3082.512±0.043	4.769±0.055	7.1±3.8	37.9±0.2	20.4±10.8
3087.593±0.130	2.470±0.020	8.0±3.4	38.1±0.2	43.8±18.6
3088.870±0.022	15.558±0.165	28.3±6.1	38.0±0.2	24.7±5.3
3091.776±0.025	14.910±0.160	34.9±6.1	38.2±0.2	31.7±5.7
3094.713±0.084	2.143±0.025	34.5±6.2	39.9±0.2	209.1±37.6
3095.446±0.081	1.816±0.021	90.9±10.8	40.1±0.2	645.9±78.7
3095.726±0.080	2.920±0.020	291.6±18.0	40.4±0.2	1278.7±78.8
3095.842±0.075	2.135±0.025	328.4±18.8	40.2±0.2	1979.3±113.4
3096.203±0.070	4.980±0.030	827.7±31.7	41.0±0.2	2095.3±80.0
3096.986±0.080	3.100±0.020	756.4±29.5	41.3±0.2	3056.7±119.5
3097.226±0.100	1.680±0.010	418.0±21.8	41.9±0.2	3071.3±160.6
3097.229±0.076	2.069±0.026	473.3±22.0	41.1±0.2	2880.7±135.1
3097.654±0.080	4.660±0.030	861.0±31.8	41.8±0.2	2288.9±84.7
3098.356±0.075	2.203±0.025	230.0±15.6	41.1±0.2	1314.2±89.0
3098.728±0.080	5.640±0.030	335.5±19.5	41.6±0.2	739.8±43.1
3099.058±0.093	0.756±0.011	23.0±5.0	41.0±0.2	384.4±83.6
3101.375±0.106	1.612±0.021	13.0±4.3	41.3±0.2	100.9±33.7
3104.000±0.080	5.720±0.030	53.3±10.3	41.2±0.2	117.3±22.5
3105.596±0.090	2.106±0.025	10.9±3.4	40.4±0.2	66.6±24.0
3112.067±0.093	1.720±0.021	11.0±3.7	39.9±0.2	82.9±29.4
3119.894±0.115	1.264±0.016	3.0±1.7	38.1±0.2	32.3±18.3

$$\sigma(s) = \mathcal{P}_{\phi\eta}(s) \cdot \left(\frac{\mathcal{F}}{s^{a_0}}\right)^2 \cdot \frac{4\pi\alpha^2}{3s} \cdot \left|1 + \frac{3}{\alpha}\frac{s}{M}\frac{\Gamma_{ee}\cdot(1 + C\cdot e^{i\phi_{\gamma,3g}})}{(s-M^2)+iM\Gamma}\right|^2,$$

The positive phase is $(146.7^{+84.7}_{-17.2})^\circ$ and the negative case is $(214.4^{+17.1}_{-84.9})^\circ$.





$$e^+e^- \to \phi\eta.$$

	Positive phase	Negative phase
$\phi_{\gamma,3g}$ (°)	$146.7^{+84.7}_{-17.2}$	$214.4^{+17.1}_{-84.9}$
$\mathcal{B}_{\phi\eta}$ ($\times10^{-4}$)	$8.6^{+0.6}_{-0.5}$	$9.0^{+0.5}_{-0.6}$
C	3.3 ± 0.4	3.3 ± 0.4
S_E (MeV)	0.88 ± 0.03	0.88 ± 0.03
f	0.99 ± 0.04	0.99 ± 0.04
M (MeV)	3096.89±0.03	
Γ (keV)	92.6±0.1	
Γ_{ee} (keV)	5.53±0.06	
χ^2/ndf	20.3/21	20.3/21

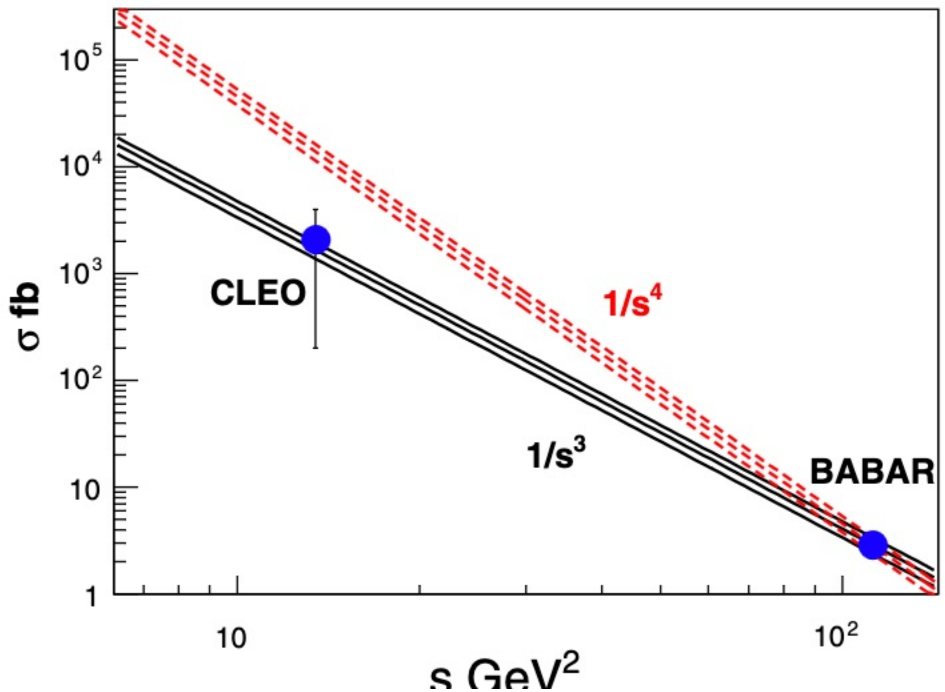
PDG

$(7.4 \pm 0.6) \times 10^{-4}$

https://journals.aps.org/prd/pdf/10.1103/PhysRevD.76.092005

Both higher!

https://journals.aps.org/prd/pdf/10.1103/PhysRevD.74.111103



$\sigma(e^+e^- \to \phi\eta) = 2.9 \pm 0.5(\text{stat}) \pm 0.1(\text{syst})$ fb. @10.8 GeV

CLEO, $(\sigma = 2.1^{+1.9}_{-1.2} \pm 0.2$ pb) @3.687 GeV

Needed Born xs to compare

$J/\psi \to \Sigma^0\bar{\Sigma}^0$ Decay.

BESIII Analysis Memo

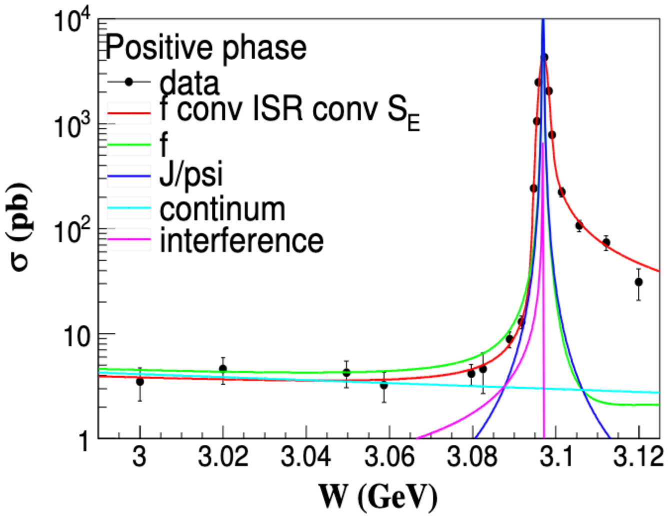
BAM-00612

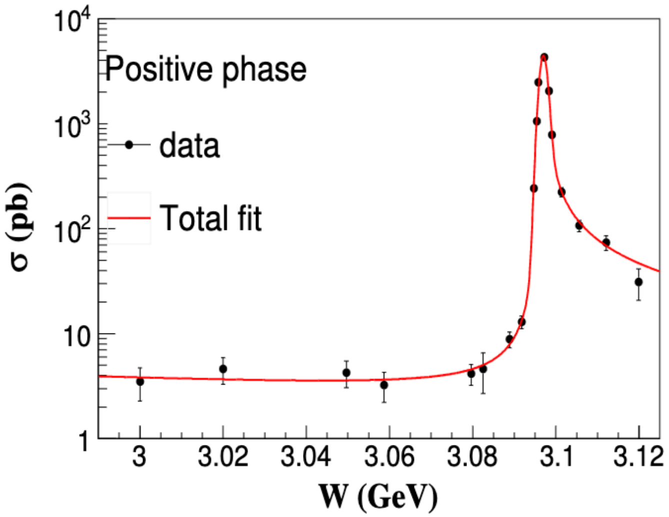
June 26, 2022

https://docbes3.ihep.ac.cn/DocDB/0011/001118/005/Memo_jpsi.pdf

W (MeV)	N^{sig}	ϵ (%)	$\mathcal{B}$ (%)	$\mathcal{L}$ (pb^{-1})	σ^{obs} (pb)
3000.000	16.37 ± 5.45	22.5	63.9	15.849 ± 0.111	3.60 ± 1.20 ± 0.16
3020.000	21.85 ± 6.36	22.6	63.9	17.315 ± 0.120	4.39 ± 1.27 ± 0.27
3049.665	20.24 ± 5.54	24.9	63.9	14.919 ± 0.161	4.27 ± 1.17 ± 0.30
3058.709	15.27 ± 4.77	25.4	63.9	15.060 ± 0.161	3.12 ± 0.99 ± 0.21
3079.647	45.28 ± 8.89	28.9	63.9	30.942 ± 0.341	3.97 ± 0.78 ± 0.47
3082.512	8.35 ± 3.37	30.5	63.9	4.769 ± 0.055	4.50 ± 1.81 ± 0.55
3088.870	59.72 ± 8.85	34.3	63.9	15.558 ± 0.165	8.76 ± 1.30 ± 0.73
3091.776	89.82 ± 11.07	36.2	63.9	14.910 ± 0.160	13.0 ± 1.60 ± 0.70
3094.713	250.6 ± 18.12	37.8	63.9	2.143 ± 0.025	242.1 ± 17.5 ± 12.1
3095.446	931.0 ± 34.56	37.7	63.9	1.816 ± 0.021	1042.7 ± 39.5 ± 57.3
3095.842	2589 ± 58.76	37.6	63.9	2.135 ± 0.025	2524.0 ± 57.3 ± 136.3
3097.229	4290 ± 74.87	37.4	63.9	2.069 ± 0.026	4342.7 ± 75.8 ± 221.5
3098.356	2170 ± 53.41	37.4	63.9	2.203 ± 0.025	2058.5 ± 50.7 ± 115.3
3099.058	289.2 ± 19.74	37.4	63.9	0.756 ± 0.011	791.9 ± 54.1 ± 42.8
3101.375	173.0 ± 14.90	36.8	63.9	1.612 ± 0.021	228.3 ± 19.7 ± 12.3
3105.596	108.8 ± 12.17	36.4	63.9	2.106 ± 0.025	111.0 ± 12.4 ± 5.8
3112.067	57.03 ± 8.76	34.6	63.9	1.720 ± 0.021	74.9 ± 11.5 ± 3.8
3119.894	16.91 ± 5.12	28.9	63.9	1.264 ± 0.016	36.3 ± 11.0 ± 1.6

Muzaffar still working on it





Solution	$\Phi_{3g,\gamma}(^\circ)$	$\sigma_{\text{cont.}}$(3.0000 GeV) pb	$\mathcal{B}_{\text{out}}(J/\psi \to \Sigma^0\bar{\Sigma}^0)$	χ^2/ndf
I	124.2 ± 14.7	4.07 ± 0.84	$(1.367 \pm 0.047) \times 10^{-3}$	8.31/15.0
II	−123.9 ± 14.6	4.07 ± 0.84	$(1.391 \pm 0.048) \times 10^{-3}$	8.31/15.0

PDG

$(1.172 \pm 0.031) \times 10^{-3}$,

Both higer!

$\sqrt{s}$ (GeV)	$\mathscr{L}$ (pb^{-1})	ε (%)	$1+\delta$	$N_{\text{obs}}(N_{\text{U.L.}})$	σ^B (pb)
2.3864	22.55	11.1	0.65	11.7 ± 5.8 (<28.0)	17.6 ± 8.73 ± 1.58(<42.4)
2.3960	66.87	7.7	0.75	45.1 ± 11.2	28.6 ± 7.10 ± 3.26
2.5000	1.10	32.3	0.94	12.7 ± 6.4	59.6 ± 30.3 ± 7.15
2.6444	33.72	47.1	1.10	221 ± 25	19.8 ± 2.23 ± 1.21
2.6464	34.00	46.4	1.10	195 ± 24	17.6 ± 2.13 ± 1.20
2.9000	105.23	40.2	1.44	116 ± 17	2.98 ± 0.45 ± 0.22
2.9884	65.18	34.9	1.62	78.7 ± 13.9	3.34 ± 0.59 ± 0.20

https://doi.org/10.1016/j.physletb.2022.137187

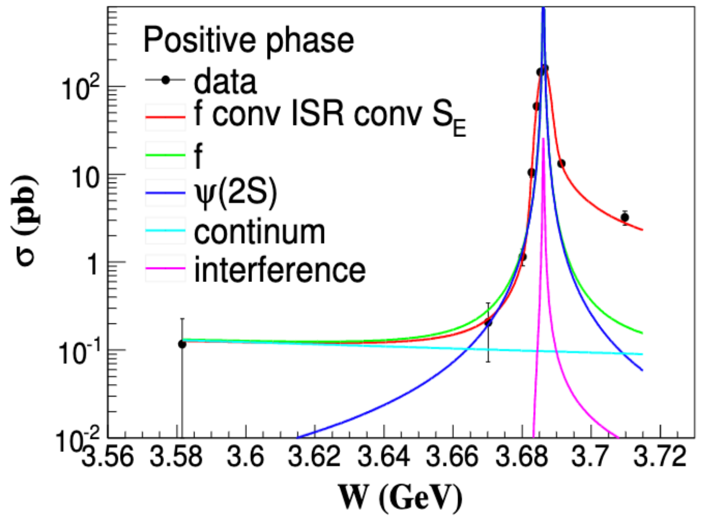
In agreement (large uncertainties)

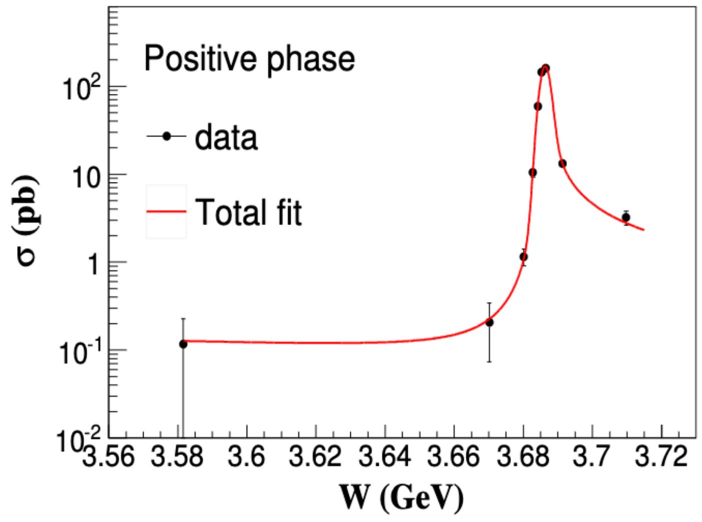
$(\psi(2S) \to \Sigma^0\bar{\Sigma}^0)$

W [MeV]	$N^{\rm sig}$	ϵ [%]	$\mathcal{B}$ [%]	Int. L [pb^{-1}]	$\sigma^{\rm obs}$ [pb]
3581.54	3.1 ± 2.9	24.3	63.9	84.604 ± 0.082	0.12 ± 0.11 ± 0.01
3670.16	5.8 ± 3.7	25.9	63.9	83.582 ± 0.084	0.21 ± 0.13 ± 0.02
3680.14	34.9 ± 7.2	28.5	63.9	83.060 ± 0.083	1.16 ± 0.24 ± 0.08
3682.75	111.1 ± 12.5	29.3	63.9	28.175 ± 0.049	10.5 ± 1.2 ± 0.53
3684.22	615.5 ± 29.0	29.2	63.9	27.840 ± 0.048	59.3 ± 2.8 ± 3.0
3685.26	1372 ± 43.3	29.3	63.9	25.342 ± 0.046	145.0 ± 4.6 ± 8.4
3686.50	1475 ± 44.9	29.4	63.9	24.481 ± 0.045	160.3 ± 4.9 ± 8.3
3691.36	336.3 ± 21.2	28.9	63.9	68.647 ± 0.076	13.3 ± 0.84 ± 0.73
3709.76	66.8 ± 11.3	23.5	63.9	69.326 ± 0.077	3.21 ± 0.55 ± 0.22

Muzaffar

IN AG review





Solution	$\Phi_{3g,\gamma}[^\circ]$	$\sigma_{\rm cont}$[3.582 GeV] pb	S_E [MeV]	$B_{\bf out}$ ($\psi' \to \Sigma^0\bar{\Sigma}^0$)	χ^2/ndf
I	88.6 ± 25.7	0.13 ± 0.11	1.36 ± 0.006	$(2.66 \pm 0.10) \times 10^{-4}$	2.71/5.0
II	-87.9 ± 25.4	0.13 ± 0.11	1.36 ± 0.006	$(2.73 \pm 0.10) \times 10^{-4}$	2.73/5.0

PDG $(2.35 \pm 0.09) \times 10^{-4}$

Lower!!

$\psi(3686) \rightarrow K^+K^-$

@RC

YADI

$$\Phi_{g,EM} = (113.4 \pm 7.6)^\circ \text{ and } \Phi_{g,EM} = (-109.6 \pm 6.5)^\circ.$$

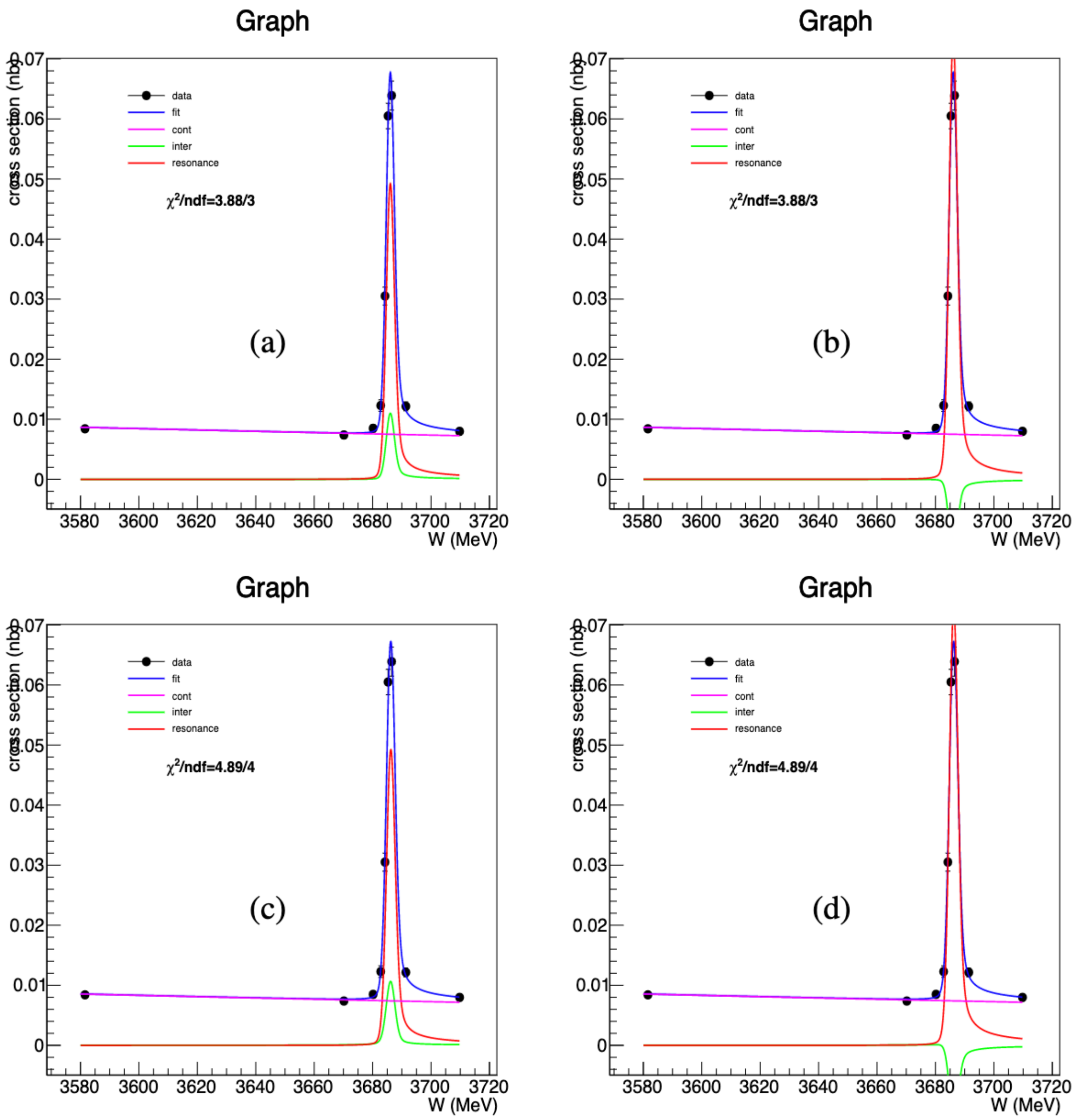
$$\mathcal{B} = (7.67 \pm 0.31) \times 10^{-5} \text{ and } \mathcal{B} = (11.33 \pm 0.37) \times 10^{-5},$$

Large relative difference btw the values

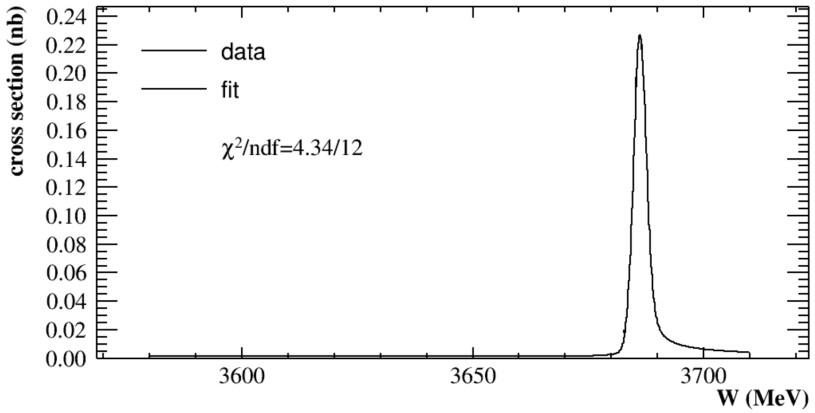
PDG VALUE

$(7.5 \pm 0.5) \times 10^{-5}$

Lower!!!

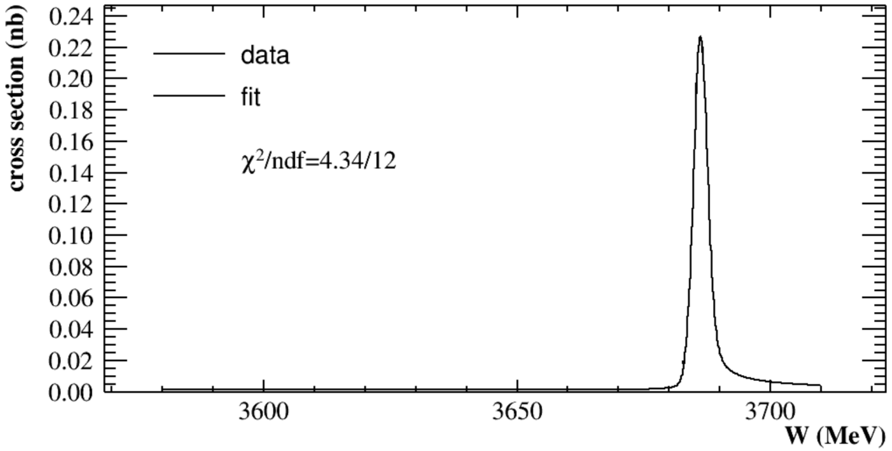


```
FCN=0.0306493 FROM MINOS     STATUS=PROBLEMS     6249 CALLS        6642 TOTAL
                    EDM=1.55304e-05    STRATEGY= 1     ERROR MATRIX ACCURATE
 EXT PARAMETER                PARABOLIC         MINOS ERRORS
 NO.   NAME      VALUE          ERROR       NEGATIVE      POSITIVE
  1  MJ          3.68600e+00   constant
  2  Gt          2.94000e-04   constant
  3  Ge          2.33000e-06   constant
  4  Sp          1.11813e-03   3.96092e-04                4.09570e-04
  5  Phi         1.82227e+02   8.64718e+01   at limit     at limit
  6  ATE         9.51678e+00   1.46935e+01                at limit
  7  FF          3.10850e-01   5.11518e-01  -2.84478e-01  4.05963e-01
  8  FE          1.00000e+00   constant
```



Yanan $\psi(3686) \rightarrow$ppbar

```
FCN=0.0306933 FROM MINOS     STATUS=PROBLEMS     3139 CALLS        3901 TOTAL
                    EDM=3.85145e-05    STRATEGY= 1     ERROR MATRIX ACCURATE
 EXT PARAMETER                PARABOLIC         MINOS ERRORS
 NO.   NAME      VALUE          ERROR       NEGATIVE      POSITIVE
  1  MJ          3.68600e+00   constant
  2  Gt          2.94000e-04   constant
  3  Ge          2.33000e-06   constant
  4  Sp          1.11922e-03   4.04749e-04  -3.37926e-04  4.38446e-04
  5  Phi         1.78687e+02   1.36217e+02   at limit     at limit
  6  ATE         9.54853e+00   1.53761e+01  -6.13937e+00
  7  FF          3.09084e-01   5.29992e-01                4.07732e-01
  8  FE          1.00000e+00   constant
```



Preparing memo

Measurement of the branching fractions of $J/\psi \to \Lambda/\bar{\Lambda} + X$

Z. H. Qu[a], P. Guo[a], and B. Zheng[a], J. J. Qin[a], J. J. Liu[a], and Y. D. Wang[b]

$J/\psi \to \Lambda + X,$

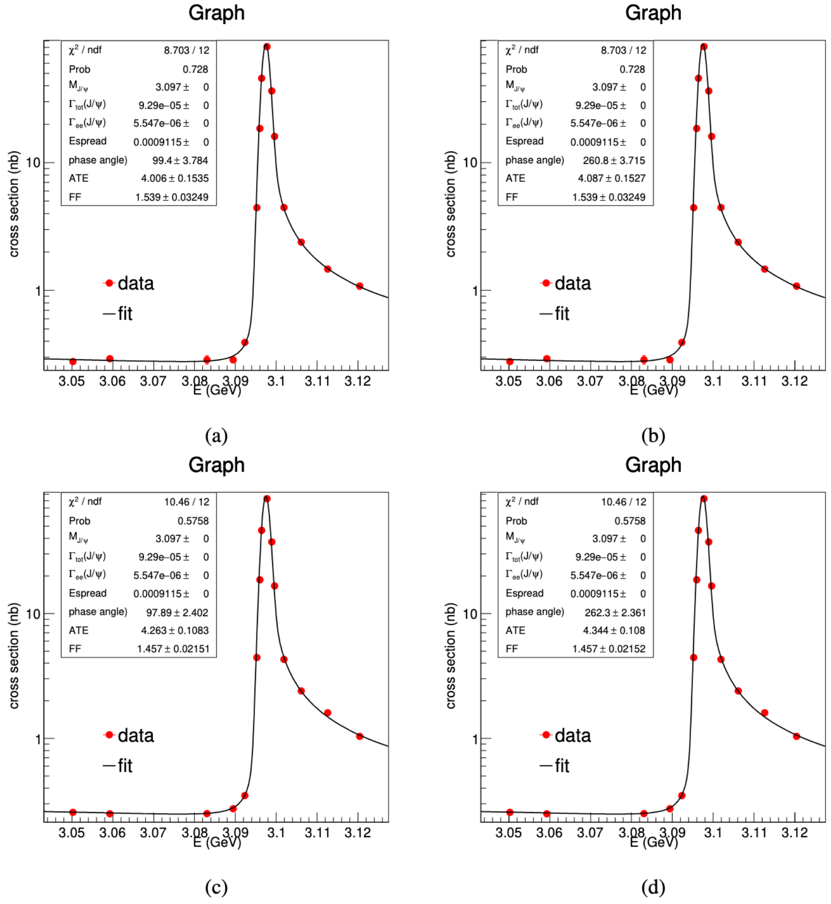
$$\sigma^0(W) = \left(\frac{\mathcal{A}}{s}\right)^2 \frac{4\pi\alpha^2}{s} \left| 1 + \left(1 + Ce^{i\Phi}\right) \times \frac{3s\sqrt{\Gamma_{ee}\Gamma_{\mu\mu}}}{\alpha M} \frac{1}{s - M^2 + iM\Gamma} \right|^2$$

Memo ready

https://docbes3.ihep.ac.cn/DocDB/0012/001234/002/Jpsi_to_ambda_lambdabar%2BX_memo_V1_0.pdf

Table 5: Fit result on J/ψ lineshape.

	Fit	phase angle	BF(%)
$J/\psi \to \Lambda + X$	(a)	99.40±3.78	2.42±0.22
	(b)	260.80±3.72	2.52±0.23
$J/\psi \to \bar{\Lambda} + X$	(c)	97.90±2.40	2.48±0.15
	(d)	262.30±2.36	2.57±0.16



summed branching fractions of J/ψ exclusive decays containing Λ/ ¯Λ is less than 1.7%

$e^+e^- \rightarrow \Lambda\bar{\Lambda}$bar using ψ' scan data

Jianyong Zhang

- ✓ By studying the relative phase between strong and electromagnetic amplitude , one can deeply understand the dynamic mechanism of quarkonium decay
- ✓ So far, no theory can give a satisfactory explanation for the origin or constraint of the phase between electromagnetic and strong decay

Event selection

- |cosθ|<0.93, Ngood≥2
- PID, TOF and dE/dx

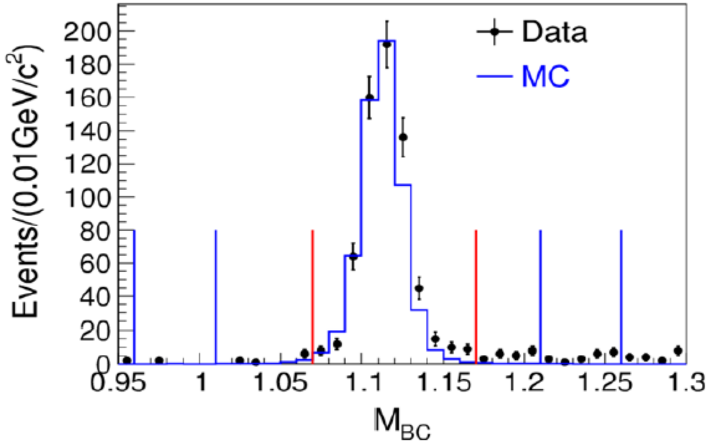
  P: prob(P)>prob(π), prob(P)>prob(K)

  π: prob(π)>prob(P), prob(π)>prob(K)
- Good photon

  Ngam=0

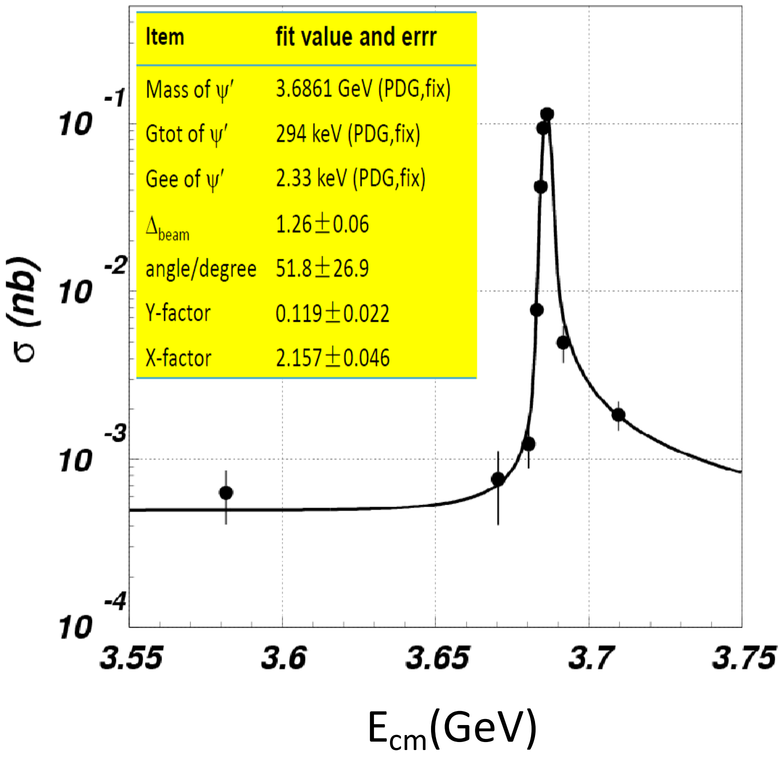
M_{BC} method is used

$$M_{BC} = \sqrt{E_{bm}^2 - P^2},$$



Preliminary results

No	Ecm (MeV)	Lum.(pb-1)	$N_{Evt. +/-err}$	Effi. (%)
1	3581.5±0.1	84.604±0.082±0.888	12.9±4.5	24.1
2	3670.2±0.1	83.582±0.084±0.878	14.9±7.0	23.4
3	3680.1±0.1	83.060±0.083±0.864	24.8±7.0	24.2
4	3682.8±0.1	28.175±0.049±0.293	52.9±9.5	24.2
5	3684.2±0.1	27.840±0.048±0.290	275.4±20.4	23.5
6	3685.3±0.1	25.342±0.046±0.264	568.8±40.0	23.9
7	3686.5±0.1	24.481±0.045±0.259	668.7±49.9	24.0
8	3691.4±0.1	68.647±0.076±0.735	84.5±21.2	24.8
9	3709.8±0.1	69.326±0.077±0.728	31.0±6.0	24.3



Only one phase angle

- Optimization of event selection and systematic uncertainty are in progress

No elements to compare xs and BF

Phase measurement in $e^+e^- \to \Xi^-\bar{\Xi}^+$ using $\psi(2S)$ scan data

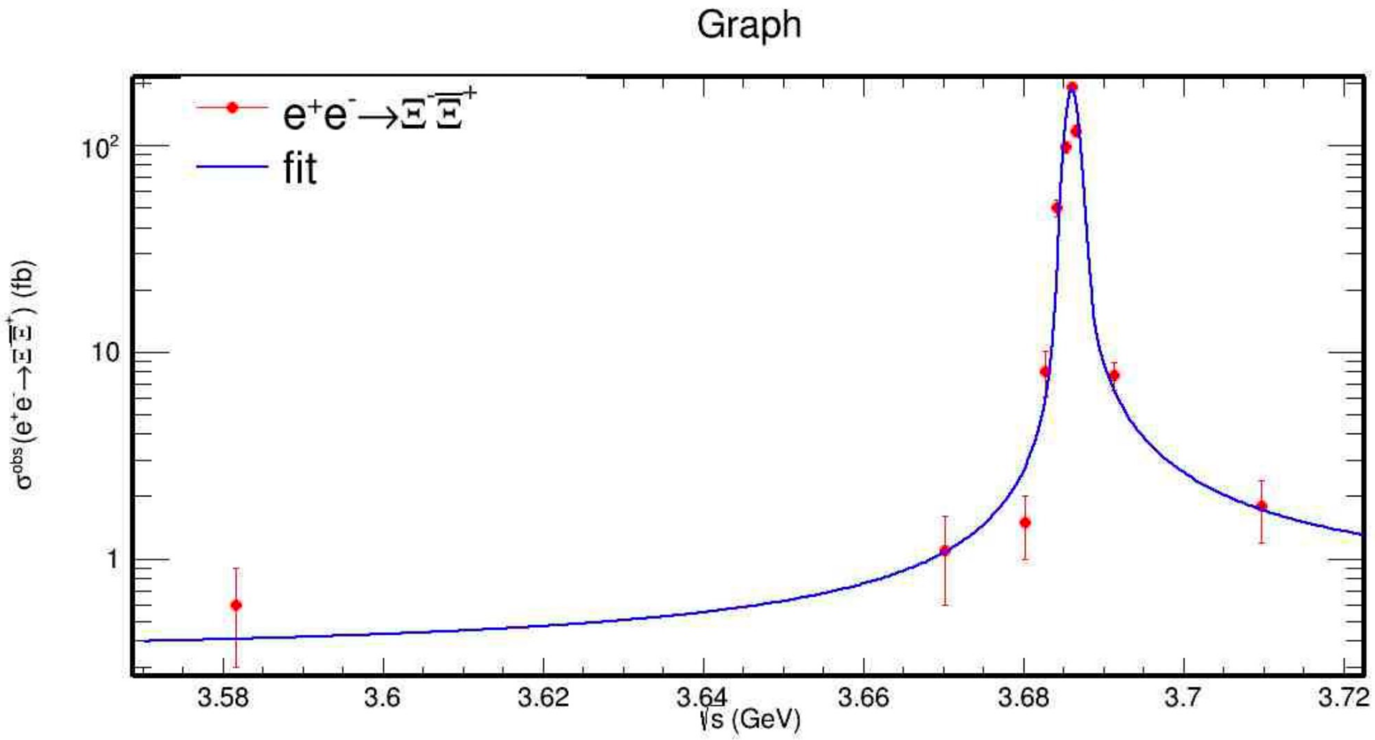
$$\sigma^B = \frac{N_{obs}}{2\,\mathcal{L}(1+\delta)\frac{1}{|1-\Pi|^2}\epsilon\mathcal{B}(\Xi\to\pi\Lambda)\mathcal{B}(\Lambda\to p\pi)},$$

$$\sigma^{obs} = \frac{N_{obs}}{2\mathcal{L}\epsilon\mathcal{B}(\Xi\to\pi\Lambda)\mathcal{B}(\Lambda\to p\pi)},$$

Congyu Li, Jingxu Zhang, Xiongfei Wang

$\sqrt{s}$ (MeV)	$L(pb^{-1})$	$\frac{1}{\lvert 1-\Pi\rvert^2}$	$1+\delta_{\rm ISR}$	N_{obs}	ϵ	σ^{obs} (pb)	σ^B (pb)
3581	85.7	1.04	0.97	$22.5^{+5.2}_{-4.3}$	32.8	$0.6^{+0.3}_{-0.2}$	$0.6^{+0.3}_{-0.2}$
3670	84.7	0.99	1.03	$34.0^{+6.8}_{-5.9}$	27.4	$1.1^{+0.5}_{-0.4}$	$0.6^{+0.3}_{-0.2}$
3680	84.8	0.89	1.08	$44.5^{+7.1}_{-6.2}$	26.6	$1.5^{+0.5}_{-0.4}$	$1.6^{+0.5}_{-0.4}$
3682	28.7	1.00	1.04	$78.0^{+9.8}_{-8.9}$	26.4	$8.1^{+2.0}_{-1.8}$	$7.8^{+1.9}_{-1.8}$
3684	28.7	1.00	1.03	$486.0^{+23.0}_{-22.1}$	26.6	$49.9^{+4.7}_{-4.5}$	$48.4^{+4.6}_{-4.4}$
3685	26	1.00	1.03	$850.5^{+29.6}_{-29.7}$	26.2	$97.8^{+6.8}_{-6.8}$	$95.0^{+6.6}_{-6.6}$
ψ(2S)	668.6	1.00	1.18	$45709.0^{+220.0}_{-220.0}$	28.0	$191.3^{+1.8}_{-1.8}$	$155.9^{+1.5}_{-1.5}$
3686	25.1	1.00	1.04	$983.0^{+32.3}_{-31.4}$	26.2	$117.1^{+7.7}_{-7.5}$	$95.4^{+6.3}_{-6.1}$
3691	69.4	1.25	0.86	$183.5^{+14.0}_{-13.1}$	26.8	$7.7^{+1.2}_{-1.1}$	$7.2^{+1.1}_{-1.0}$
3709	70.3	1.09	1.03	$41.5^{+6.9}_{-6.0}$	25.6	$1.8^{+0.6}_{-0.5}$	$1.7^{+0.6}_{-0.5}$

Fit results to the relative phase



No elements to compare xs and BF

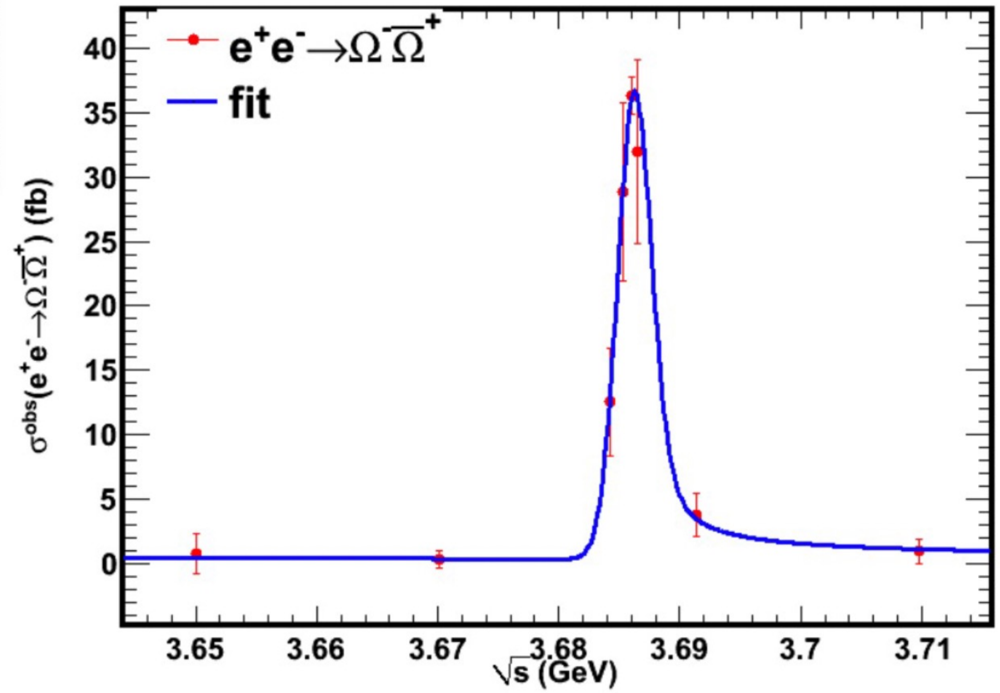
NO.	NAME	VALUE	ERROR	NEGATIVE	POSITIVE
1	Psi(2S) mass	3.68610e+00	fixed		
2	Psi(2S) totalwidth	2.94000e-04	fixed		
3	Psi(2S) ee width	2.33000e-06	fixed		
4	resolution	7.87562e-04	8.63928e-05	-6.14013e-05	5.93719e-05
5	BfKsX	1.65208e-01	1.38164e-02	-1.00123e-02	9.58385e-03
6	hs	1.73751e-01	1.49140e-01	-1.48171e-01	1.48163e-01
7	phase	1.23043e+02	9.47626e+00	-8.51760e+00	9.43444e+00

Only one phase angle

Zeqing Mu, Xiongfei Wang

Study of $e^+e^- \to \Omega^-\bar{\Omega}^+$ using $\psi(2S)$ scan data

$\sqrt{s}$(MeV)	3650	3670	3684	3685	$\psi(2S)$	3686	3691	3709
N_{obs}	1^{+2}_{-0}	1^{+2}_{-0}	12^{+4}_{-3}	25^{+6}_{-4}	644^{+26}_{-25}	27^{+6}_{-5}	9^{+4}_{-2}	2^{+2}_{-1}
$\mathcal{L}$(1/pb)	43.88	84.7	28.7	26.0	668.55	25.1	69.4	70.3
N_{cut}	6806	7721	7698	7700	24508	7771	7900	6756
ϵ	6.806%	7.721%	7.698%	7.700%	6.127%	7.771%	7.900%	6.756%
B($\Omega^- \to K^-\Lambda$)	67.8%							
$B(\Lambda \to p\pi^-)$	63.9%							
σ^{obs}(pb)	$0.773^{+1.546}_{-0}$	$0.353^{+0.706}_{-0}$	$12.537^{+4.179}_{-3.134}$	$28.823^{+6.918}_{-4.612}$	$36.289^{+1.465}_{-1.409}$	$31.951^{+7.100}_{-5.917}$	$3.789^{+1.684}_{-0.842}$	$0.972^{+0.972}_{-0.486}$



$$\sigma_B(s) = \frac{4\pi\alpha^2}{3s}|a_{3g}(s)e^{i\varphi}+a_\gamma(s)+a_c(s)|^2 P(s)$$

$$\mathcal{P} = v(3-v^2)/2\,,\quad v \equiv \sqrt{1-\frac{(m_{B1}+m_{\bar{B}2})^2}{s}}$$

$$a_c(s) = \frac{Y}{s}$$

$$a_\gamma(s) = \frac{3Y\Gamma_{ee}/(\alpha\sqrt{s})}{s-M^2+iM\Gamma_t}$$

$$a_{3g}(s) = \frac{3X\Gamma_{ee}/(\alpha\sqrt{s})}{s-M^2+iM\Gamma_t}$$

$$\sigma_{r.c.}(s) = \int_0^{x_m} dx F(x,s)\frac{\sigma_{Born}(s(1-x))}{|1-\Pi(s(1-x))|^2}$$

$$\sigma_{obs}(W) = \int_0^{\infty} dW'\sigma_{r.c.}(W')G(W',W)$$

$$G(W,W') = \frac{1}{\sqrt{2\pi}\Delta}e^{-\frac{(W-W')^2}{2\Delta^2}}$$

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS ERRORS NEGATIVE	MINOS ERRORS POSITIVE
1	Psi(2S) mass	3.68610e+00	fixed		
2	Psi(2S) totalwidth	2.94000e-04	fixed		
3	Psi(2S) ee width	2.33000e-06	fixed		
4	resolution	1.31300e-03	2.39463e-04	-2.35996e-04	2.48583e-04
5	BfKsX	6.79759e-02	9.11273e-03	-9.55702e-03	9.29890e-03
6	hs	3.28509e-01	3.44905e-01	-3.45195e-01	3.44671e-01
7	phase	-8.00783e+01	2.56322e+01	-2.64681e+01	2.79214e+01

chi2 0.529854190537 ndf 4 prob 0.970530347451

No elements to compare xs and BF

Only one phase angle

Fitting results(First iteration)

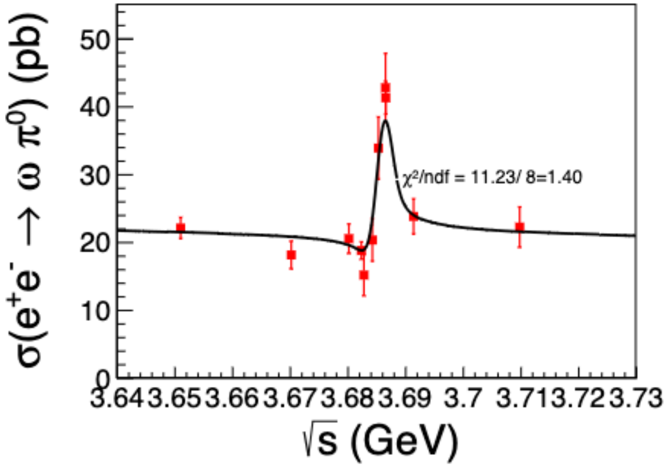
Measurements of $\psi(3686) \to \omega\pi^0$

LIU Baoxin[1], KANG Xiaosheng[2], GONG Li[2], ZHANG Zhenyu[1], ZHOU Xiang[1]

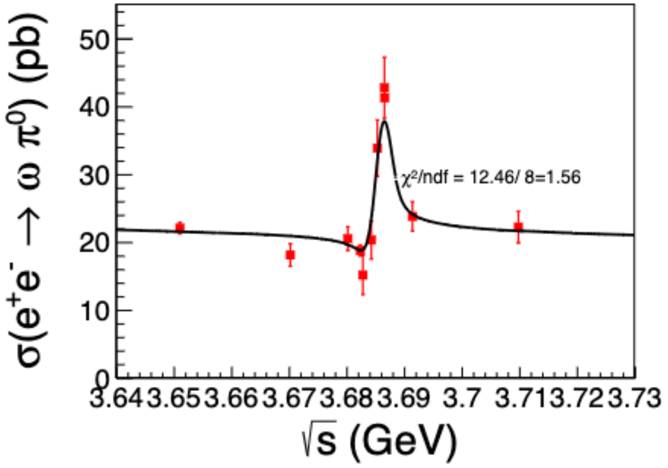
[1]Wuhan University [2]Liaoning University

$$\sigma(s) = \frac{4\pi\alpha^2}{3s}\frac{\Gamma_{\omega\pi^0}}{\Gamma_{ee}}\left|1 + \frac{3\sqrt{s}\Gamma_{ee}}{\alpha\left(s - M^2 + iM\Gamma\right)}e^{i\phi}\right|^2 .$$

$$\sigma^{\mathrm{Obs}}(s) = \int_{\sqrt{s'}-nSE}^{\sqrt{s'}+nSE} \mathrm{d}\sqrt{s'} \int_0^{1-\left(\frac{s'_{\min}}{s'}\right)} \mathrm{d}xF(x,s')\sigma(s'(1-x))G(\sqrt{s},\sqrt{s'}),$$



(a) Total uncertainty



(b) Statistical uncertainty

Only positive phase

Parameter	Result (total uncertainty)	Result (statistic uncertainty)	Result (stat.±sys.)
M(MeV)	3685.93 ± 0.32	3685.92 ± 0.30	$3685.93 \pm 0.30 \pm 0.11$
$\Gamma_{\omega\pi^0}(\times 10^{-9})$	5.84 ± 0.35	5.88 ± 0.15	$5.84 \pm 0.15 \pm 0.30$
ϕ(rad)	0.29 ± 0.43	0.25 ± 0.42	$0.29 \pm 0.42 \pm 0.09$

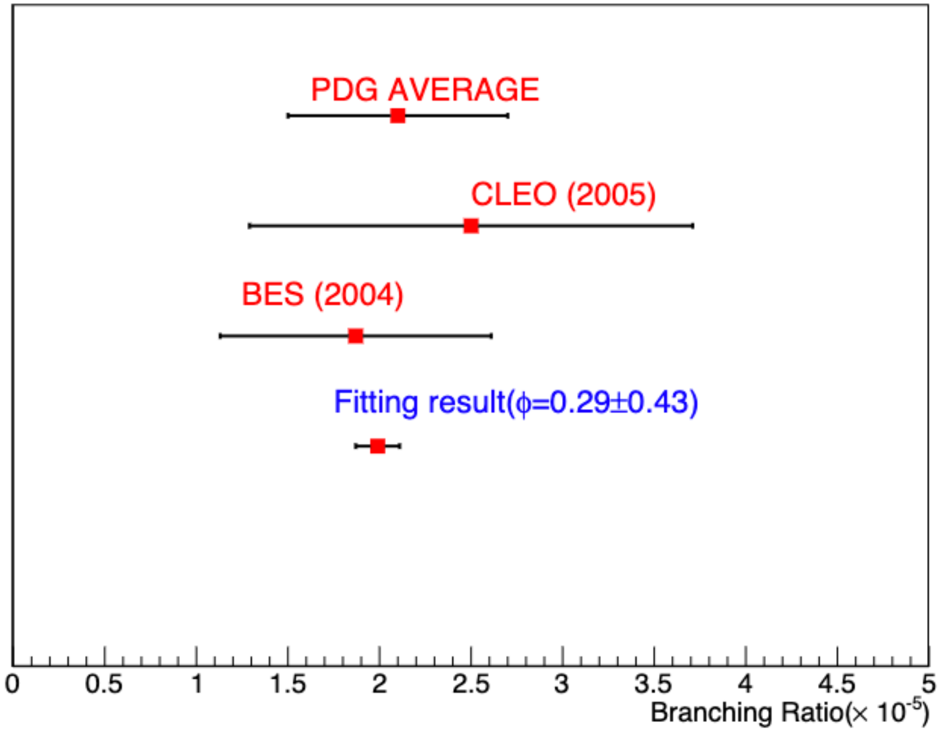
The middle values are different between the total uncertainty result and statistic result. Use the relative statistic uncertainty to take the total uncertainty apart.

Results of branching ratio

Because $\mathcal{B}(\psi(2S) \to \omega\pi^0) = \Gamma_{\omega\pi^0}/\Gamma$,

$$\mathcal{B}(\psi(2S) \to \omega\pi^0) = (1.99 \pm 0.12) \times 10^{-5}$$

Only one value (?????)



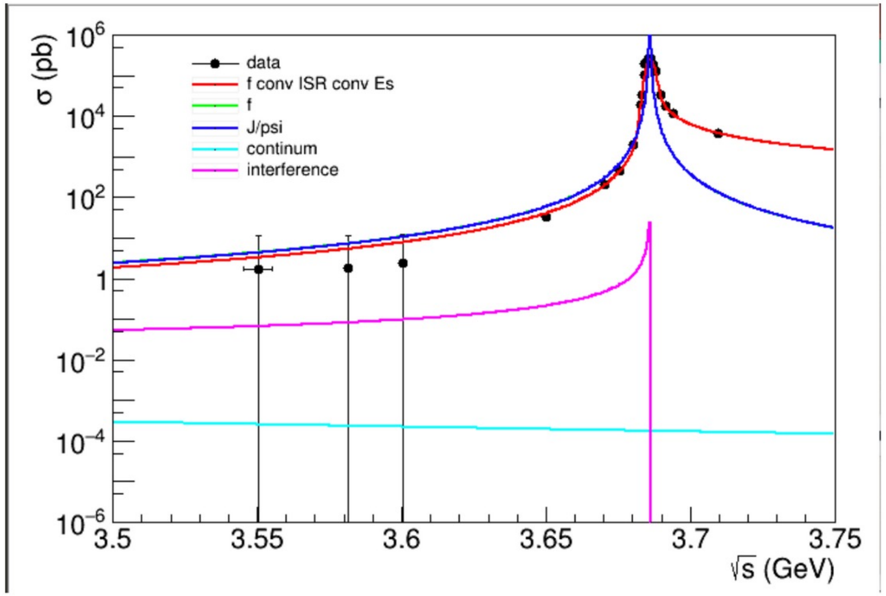
The cross sections between 3.65-3.71 GeV have been measured.

$\sqrt{s}$ GeV	$N^{\mathrm{obs.}}$	$\mathcal{L}(\mathrm{pb}^{-1})$	ϵ	$\sigma^{\mathrm{Exp.}} \pm$ stat. $\pm$ sys.(pb)
3.65	937 ± 33	410 ± 4.10	0.10	$22.15 \pm 0.83 \pm 1.18$
3.67016	154 ± 10	83.58 ± 0.08	0.10	$18.18 \pm 1.67 \pm 1.01$
3.68014	165 ± 14	83.06 ± 0.08	0.10	$20.59 \pm 1.75 \pm 1.12$
3.682	670 ± 28	404 ± 4.04	0.10	$18.84 \pm 0.81 \pm 0.90$
3.68275	47 ± 7	28.18 ± 0.05	0.10	$15.21 \pm 2.88 \pm 0.94$
3.68422	59 ± 8	27.84 ± 0.05	0.10	$20.38 \pm 2.80 \pm 1.17$
3.68526	101 ± 11	25.34 ± 0.05	0.10	$33.93 \pm 3.14 \pm 2.00$
3.686	18566 ± 146	3400 ± 34.00	0.10	$41.35 \pm 0.36 \pm 2.18$
3.68650	137 ± 12	24.45 ± 0.05	0.11	$42.83 \pm 4.49 \pm 2.53$
3.69136	172 ± 14	68.65 ± 0.08	0.10	$23.85 \pm 2.17 \pm 1.29$
3.70976	170 ± 14	69.33 ± 0.08	0.09	$22.28 \pm 2.34 \pm 1.15$

Table: Cross sections of $e^+e^- \to \omega\pi^0$.

Needed Born xs to compare........

$e^+e^- \to \pi\pi J/\psi$ with $\psi(2S)$ scan data



chi2 is 233.901

BR = 0.401214 +/- 0.00174886

phase = 180 +/- 133.937

cont(3.8GeV) = 0.000128093 +/- 0.000530082

spread = 0.00132747 +/- 8.55279e-06

Giulio ce ne parla…

Comments:

- Continuum compatible with 0 at 3.8 GeV
- Error on the phase very large!
- BR higher than PDG

$\sqrt{s}$/MeV	3807.7 ± 0.6	3867.408 ± 0.031	3871.31 ± 0.06	3896.2 ± 0.8
$\int \mathcal{L}\,dt/\text{pb}^{-1}$	50.5 ± 0.5	108.9 ± 1.3	110.3 ± 0.8	52.6 ± 0.5
$(1+\delta)$	0.895	0.895	0.895	0.895
$N_{\text{obs}}^{e^+e^-}$	19 ± 5	30 ± 7	24 ± 6	16 ± 5
$\epsilon^{e^+e^-}$/%	31.78 ± 0.08	31.34 ± 0.08	31.29 ± 0.08	31.68 ± 0.08
$\sigma^{e^+e^-}$/pb	22.0 ± 6.4	16.4 ± 3.6	12.7 ± 3.3	17.0 ± 5.2
$N_{\text{obs}}^{\mu^+\mu^-}$	18 ± 5	40 ± 8	29 ± 6	17 ± 5
$\epsilon^{\mu^+\mu^-}$/%	45.38 ± 0.10	44.90 ± 0.09	44.72 ± 0.09	45.14 ± 0.10
$\sigma^{\mu^+\mu^-}$/pb	14.8 ± 4.0	15.3 ± 2.9	10.9 ± 2.4	13.4 ± 4.1
$\sigma^{\ell^+\ell^-}$/pb	16.9 ± 3.4	15.7 ± 2.3	11.6 ± 1.9	15.0 ± 3.2

PRD 107 (2023), 3,032007 cont

Which channels would be interesting to investigate?

Few years ago………………

Simone & Alessio

Table 1. Comparison of the experimental measurements ($\mathcal{B}_{\text{pdg}}$) [5] and phenomenological calculations ($\mathcal{B}_{\text{cal}}$) [3, 4] for the branching fractions of J/ψ decays to baryon octet final states, where $\Delta(\sigma)$ is the difference in terms of the total uncertainty. Dash (–) represents no experimental measurement.

$B\overline{B}$	$\mathcal{B}_{\text{pdg}}(10^{-3})$	$\mathcal{B}_{\text{cal}}(10^{-3})$	$\Delta(\sigma)$
$\boxed{\Sigma^0\overline{\Sigma}^0}$	1.164 ± 0.004	1.160 ± 0.041	~ 0.09
$\boxed{\Lambda\overline{\Lambda}}$	1.943 ± 0.003	1.940 ± 0.055	~ 0.05
$\Lambda\overline{\Sigma}^0$ + c.c.	0.0283 ± 0.0023	0.0280 ± 0.0024	~ 0.06
$\boxed{p\overline{p}}$	2.121 ± 0.029	2.10 ± 0.16	~ 0.1
$n\overline{n}$	2.09 ± 0.16	2.10 ± 0.12	~ 0.04
$\boxed{\Sigma^+\overline{\Sigma}^-}$	1.50 ± 0.24	1.110 ± 0.086	~ 1
$\Sigma^-\overline{\Sigma}^+$	–	0.857 ± 0.051	–
$\Xi^0\overline{\Xi}^0$	1.17 ± 0.04	1.180 ± 0.072	~ 0.09
$\Xi^-\overline{\Xi}^+$	0.97 ± 0.08	0.979 ± 0.065	~ 0.06

TABLE VIII. Non-resonant $e^+e^- \to B\overline{B}$ Born cross sections at $q^2 = M^2_{J/\psi}$.

$e^+e^- \to B\overline{B}$	Cross section at the $q^2 = M^2_{J/\psi}$
$e^+e^- \to \Sigma^0\overline{\Sigma}^0$	(1.37 ± 0.12) pb
$e^+e^- \to \Lambda\overline{\Lambda}$	(1.49 ± 0.13) pb
$e^+e^- \to (\Lambda\overline{\Sigma}^0 + \text{c.c.})$	(4.30 ± 0.36) pb
$e^+e^- \to p\overline{p}$	(12.9 ± 1.4) pb
$e^+e^- \to n\overline{n}$	(6.84 ± 0.58) pb
$e^+e^- \to \Sigma^+\overline{\Sigma}^-$	(10.4 ± 1.1) pb
$e^+e^- \to \Sigma^-\overline{\Sigma}^+$	(0.79 ± 0.30) pb
$e^+e^- \to \Xi^0\overline{\Xi}^0$	(4.54 ± 0.38) pb
$e^+e^- \to \Xi^-\overline{\Xi}^+$	(0.65 ± 0.24) pb

TABLE VII. Moduli of sub-amplitudes $\mathcal{S}_{B\overline{B}}$, $\mathcal{A}^{\gamma}_{B\overline{B}}$ and phase $\varphi_{B\overline{B}}$, defined in Eq. (6).

$B\overline{B}$	$\lvert\mathcal{S}_{B\overline{B}}\rvert \times 10^3$	$\lvert\mathcal{A}^{\gamma}_{B\overline{B}}\rvert \times 10^4$	$\varphi_{B\overline{B}}$
$\Sigma^0\overline{\Sigma}^0$	4.987 ± 0.065	4.52 ± 0.19	φ
$\Lambda\overline{\Lambda}$	6.483 ± 0.065	4.52 ± 0.19	$\pi - \varphi$
$\Lambda\overline{\Sigma}^0$ + c.c.	0	7.83 ± 0.33	φ
$p\overline{p}$	5.74 ± 0.14	12.43 ± 0.65	φ
$n\overline{n}$	6.351 ± 0.037	9.04 ± 0.38	$\pi - \varphi$
$\Sigma^+\overline{\Sigma}^-$	4.50 ± 0.12	12.43 ± 0.65	φ
$\Sigma^-\overline{\Sigma}^+$	4.50 ± 0.12	3.39 ± 0.65	$\pi - \varphi$
$\Xi^0\overline{\Xi}^0$	5.867 ± 0.037	9.04 ± 0.38	$\pi - \varphi$
$\Xi^-\overline{\Xi}^+$	5.30 ± 0.13	3.39 ± 0.65	$\pi - \varphi$

https://doi.org/10.48550/arXiv.1905.01069

Long time ago……………….

Table 3: J/ψ Vector + Pseudoscalar (a).

Decay	Amplitude	PDG $[10^{-4}]$	Fit $[10^{-4}]$	$\Delta\chi^2$
$\rho^0\pi^0$	$ge^{i\varphi}$ + e	169.0 ± 15.0	133.00	1.13
$K^{*+}K^-$	g(1-s)$e^{i\varphi}$+e	51.2 ± 3.0	51.5	0.01
$K^{*0}K^0$	g(1-s)$e^{i\varphi}$-2e	43.9 ± 3.1	48.5	0.48
$\omega\eta$	(gX+d)$e^{i\varphi}$+eX	17.4 ± 2.0	18.5	0.06
$\phi\eta$	(g(1-2s)Y+d)$e^{i\varphi}$-2eY	7.5 ± 0.8	3.9	4.02
$\rho\eta$	3eX	1.9 ± 0.2	2.2	0.30
$\omega\pi$	3e	4.5 ± 0.5	4.1	0.11
$\omega\eta'$	(gX'+d')$e^{i\varphi}$+eX'	7.0 ± 7.0	11.9	0.10
$\phi\eta'$	(g(1-2s)Y' +d')$e^{i\varphi}$-2eY'	4.0 ± 0.7	6.1	1.87
$\rho\eta$	3eX'	1.1 ± 0.2	1.1	0.04

https://docbes3.ihep.ac.cn/DocDB/0003/000327/001/psip_scan_note.pdf

BR7 proposed…

Decay	Continuum [pb]	$\psi(3770)$ [pb]	Sign	
$\rho\pi$	13.1±2.8	7.4±1.3	-	CLEOc, PRD 73(2006)012002
$\phi\eta$	2.1±1.6	4.5±0.7	+	CLEOc, PRD 73(2006)012002
$p\bar{p}$	0.74±0.08	0.4±0.02	-	BESIII Y.Liang, Nov (2012)

Table 6: ψ' Vector + Pseudoscalar (a).

Decay	Amplitude	PDG $[10^{-4}]$	Fit $[10^{-4}]$	$\Delta\chi^2$
$\rho^0\pi^0$	$ge^{i\varphi}$ + e	0.32 ± 0.13	0.28	0
$K^{*+}K^-$	g(1-s)$e^{i\varphi}$+e	0.17 ± 0.08	0.19	0
$K^{*0}K^0$	g(1-s)$e^{i\varphi}$-2e	1.09 ± 0.20	1.15	0.04
$\omega\eta$	(gX+d)$e^{i\varphi}$+eX	0.00 ± 0.11	0.08	0.06
$\phi\eta$	(g(1-2s)Y+d)$e^{i\varphi}$-2eY	0.28 ± 0.90	0.24	0.10
$\rho\eta$	3eX	0.22 ± 0.06	0.15	0.22
$\omega\pi$	3e	0.21 ± 0.06	0.26	0.10
$\omega\eta'$	(gX'+d')$e^{i\varphi}$+eX'	0.32 ± 0.25	0.03	0.23
$\phi\eta'$	(g(1-2s)Y' +d')$e^{i\varphi}$-2eY'	0.31 ± 0.16	0.29	0.02
$\rho\eta$	3eX'	0.19 ± 0.17	0.08	0.11

BR7 proposed….

What else?

$J/\psi(1S)$ $I^G(J^{PC}) = 0^-(1^{--})$

Decays in ...

Γ_8	$\rho\pi$	$(1.69 \pm 0.15)\%$
	$\omega\eta$	$(1.74 \pm 0.20) \times 10^{-3}$
	$\pi^+\pi^-$	$(1.47 \pm 0.14) \times 10^{-4}$
	$K_S^0\ K_L^0$	$(1.95 \pm 0.11) \times 10^{-4}$
	$\Lambda\overline{\Lambda}$	$(1.89 \pm 0.09) \times 10^{-3}$
	$\Xi^0\overline{\Xi}^0$	$(1.17 \pm 0.04) \times 10^{-3}$
Γ_{67}	$\overline{K}K^*(892)$ +c.c. $\to K_S^0\ K^\pm\pi^\mp$	$(5.0 \pm 0.5) \times 10^{-3}$
Γ_{68}	$K^+K^*(892)^-$ + c.c.	$(6.0^{+0.8}_{-1.0}) \times 10^{-3}$

$\psi(2S)$ $I^G(J^{PC}) = 0^-(1^{--})$

One/ two order of magnitude lower

$K_1(1270)^{\pm}K^{\mp}$ $(1.00 \pm 0.28) \times 10^{-3}$

K*(892)0K0

4 particles final state
K+K-pi+pi-