The relative phase measurement task force

Francesca

Model dependent experimental evidences

from J/ψ decays

SU3 and SU3 Breaking in **1⁻0⁻**[1,2,3,4], **0⁻0⁻**[1,2,3], **1⁻1⁻**[1], **1⁺0⁻**[5], $\boldsymbol{B\bar{B}}$[2,6,7] decays show the phase in J/ψ decays between A_g and A_γ is $\Phi \sim \mathbf{90^\circ}$

- $PP(0^-0^-)(\pi^+\pi^-, K^+K^-, K_SK_L)$: $\Phi = (90 \pm 10)^\circ$ [2]
- $VP(1^-0^-)(\rho\pi, \omega\pi^0, \phi\pi^0, \rho\eta, \omega\eta, \phi\eta, \rho\eta', \omega\eta', \phi\eta', \bar{K}^*K)$
- $VP(1^+0^-)\left(K_1^\pm(1400)K^\mp, K_1^\pm(1270)K^\mp\right)$
- $VV\ (1^-1^-)(\rho^+\rho^-, K^{*+}K^{*-}, K^{*0}\bar{K}^{*0})$
- $B\bar{B}(p\bar{p}, n\bar{n}, \Lambda\bar{\Lambda}, \Sigma^0\bar{\Sigma}^0, \Sigma^+\Sigma^-, \Xi^0\bar{\Xi}^0, \Xi^+\Xi^-, \Sigma^0\bar{\Lambda} + \bar{\Sigma}^0\Lambda)$

Some are based on very old experimental results, but the conclusion keeps the same

pQCD forsee real Amplitudes and 180°/0° phases

Process $J/\psi \to PV$	SOZI amplitude		DOZI correction
$\rho^+\pi^-, \rho^0\pi^0, \rho^-\pi^+$	$g + e$		
$K^{*+}K^-, K^{*-}K^+$	$g(1 - s_g) + e$		
$K^{*0}\bar{K}^0, \bar{K}^{*0}K^0$	$g(1 - s_g) - 2e$		
$\omega\eta$	$(g + e)X_\eta$	+	$\sqrt{2}rg(\sqrt{2}X_\eta + Y_\eta)$
$\omega\eta'$	$(g + e)X_{\eta'}$	+	$\sqrt{2}rg(\sqrt{2}X_{\eta'} + Y_{\eta'})$
$\phi\eta$	$[g(1 - 2s_g) - 2e]Y_\eta$	+	$rg(\sqrt{2}X_\eta + Y_\eta)$
$\phi\eta'$	$[g(1 - 2s_g) - 2e]Y_{\eta'}$	+	$rg(\sqrt{2}X_{\eta'} + Y_{\eta'})$
$\rho\eta$	$3eX_\eta$		
$\rho\eta'$	$3eX_{\eta'}$		
$\omega\pi^0$	$3e$		
$\phi\pi^0$	0		

An example

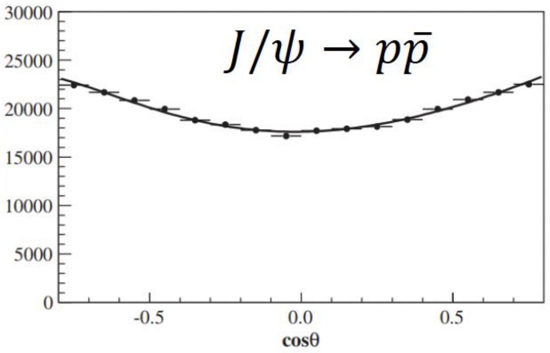
$g -\ A_{3g}; e -\ A_\gamma$

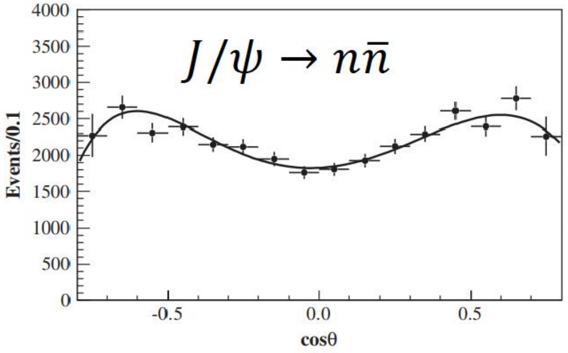
X_η, Y_η, s_g – SU(3)breaking items

[1] L. Köpke and N. Wermes, Phys. Rep. 174, 67 (1989)
[2] G. Lopez Castro, J. L. Lucio M. and J. Pestieau, hep-ph/9902300v1 (1999)
[3] Mahiko Suzuki, Physical Review D 57, 5717 (1998)
[4] P. Wang, C.Z. Yuan, X.H. Mo, Phys. Rev. D 69, 057502 (2004)
[5] Mahiko Suzuki, Physical Review D 63, 054021 (2001)
[6] R. Baldini et al, Physics Letters B 444, 111-118 (1998)
[7] K. Zhu et al., Int. J Mod. Phys. A30, 1550148 (2015).

Model dependent experimental evidences

from J/ψ decays @BESIII





Study of $J/\psi \to p\bar{p}$ and $J/\psi \to n\bar{n}$

(BESIII Collaboration) Phys. Rev. D 86, 032014 (2012)

$$\boxed{\begin{aligned}\phi &= \cos^{-1}[(\mathcal{B}(J/\psi \to p\bar{p}) - S^2 - E_p^2)/(2SE_p)] \\ &= (88.7 \pm 8.1)^\circ.\end{aligned}}$$

$Br(J/\psi \to p\bar{p}) = (2.112 \pm 0.004 \pm 0.031) \times 10^{-3}$

$\alpha = 0.595 \pm 0.012 \pm 0.015$

$Br(J/\psi \to n\bar{n}) = (2.07 \pm 0.01 \pm 0.17) \times 10^{-3}$

$\alpha = 0.50 \pm 0.04 \pm 0.21$

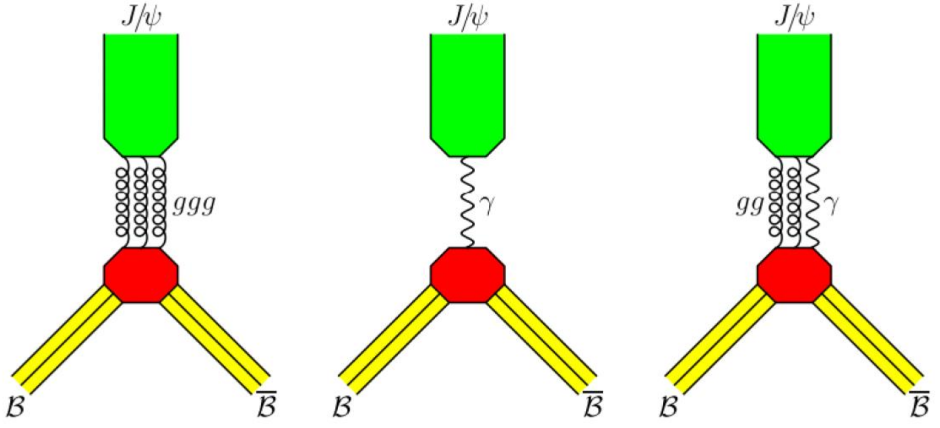
- $E_p(E_n)$ and S are EM and strong amplitudes of $J/\psi \to p\bar{p}$ $(n\bar{n})$, ϕ is the phase angle between $E_p(E_n)$ and S.
- Assumption:
  - $E_n = -E_p$ and $S_p = S_n = S$

- The strong interaction is dominant.
- $\boldsymbol{\Phi = (-85.9 \pm 1.7)^\circ}$ **or** $\boldsymbol{(+90.8 \pm 1.6)^\circ}$ combined with other baryon decays from BES, MarkII, DMII, BESII, BESIII experiments. *K. Zhu, X. H. Mo, C. Z. Yuan, Inter. J. Mod. Phys. A, 30, 1550148 (2015)*

Model dependent experimental evidences

from J/ψ decays

R. Baldini, A. Mangoni, S. Pacetti, K. Zhu;
Phy. Lett. B 799, 135041 (2019)



$\mathcal{B}\overline{\mathcal{B}}$	$\mathrm{BR}^{\mathrm{exp}}_{\mathcal{B}\overline{\mathcal{B}}} \times 10^3$	$\mathrm{BR}_{\mathcal{B}\overline{\mathcal{B}}} \times 10^3$
$\Sigma^0\overline{\Sigma}^0$	1.164 ± 0.004	1.160 ± 0.041
$\Lambda\overline{\Lambda}$	1.943 ± 0.003	1.940 ± 0.055
$\Lambda\overline{\Sigma}^0 +$ c.c.	0.0283 ± 0.0023	0.0280 ± 0.0024
$p\overline{p}$	2.121 ± 0.029	2.10 ± 0.16
$n\overline{n}$	2.09 ± 0.16	2.10 ± 0.12
$\Sigma^+\overline{\Sigma}^-$	1.50 ± 0.24	1.110 ± 0.086
$\Sigma^-\overline{\Sigma}^+$	/	0.857 ± 0.051
$\Xi^0\overline{\Xi}^0$	1.17 ± 0.04	1.180 ± 0.072
$\Xi^-\overline{\Xi}^+$	0.97 ± 0.08	0.979 ± 0.065

- Consider the small contribution from $A_{gg\gamma}$
- Assume $A_{gg\gamma}$ has the same phase as A_g to A_γ
- Perform SU(3) analysis based on experimental branching ratios of J/ψ decaying to baryons

$$\boxed{\Phi = (73 \pm 8)^\circ}$$

Br result from SU(3) very close to PDG

By Yadi@HADRON2025

Model dependent experimental evidences

from $\psi(2S)$ decays

From the analysis of BESIII data made by R. Baldini[1]:

- $\psi(2S) \rightarrow VP\ (1^-0^-)$: $\Phi = (159 \pm 12)^\circ$
- $\psi(2S) \rightarrow K^*K$ only: $\Phi = (159 \pm 24)^\circ$
- $\psi(2S) \rightarrow PP\ (0^-0^-)$: $\Phi = (95 \pm 11)^\circ$

Analysis by Mahiko Suzuki[2] with Babar data:

- $\psi(2S) \rightarrow 1^-0^-$: tends to have large phase,
- $\psi(2S) \rightarrow 1^+0^-$: $\Phi \sim 0^\circ$
- Difference could be caused by lower statistics of Babar data than that of BESIII.

PP(0^-0^-) mode from BES result[3]:

- $\psi(2S) \rightarrow K_S K_L, K^+K^-, \pi^+\pi^-$:

$\Phi = (-82 \pm 29)^\circ$ or $(121 \pm 27)^\circ$

Analysis[4] of $\psi(2S)$ decaying to baryon pairs from CLEO and BESII:

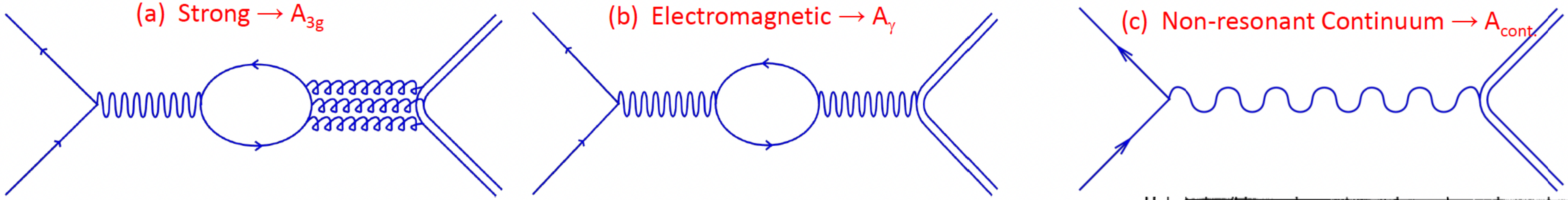
- **baryon pairs:**

$\Phi = (-98 \pm 25)^\circ$ or $(+134 \pm 25)^\circ$

[1] Rinaldo Baldini Ferroli, Orsay (France), 2014
[2] Mahiko Suzuki, Phys. Rev. D 63, 054021 (2000)
[3] BES Collaboration, Phys. Rev. Lett. 92, 052001 (2004)
[4] K. Zhu, X. H. Mo, C. Z. Yuan, Inter. J. Mod. Phys. A, 30, 1550148 (2015)

Rinaldo is one of the
top-players in the field
and triggered most
of the resonance scans
thatare used in these
analyes in BESIII

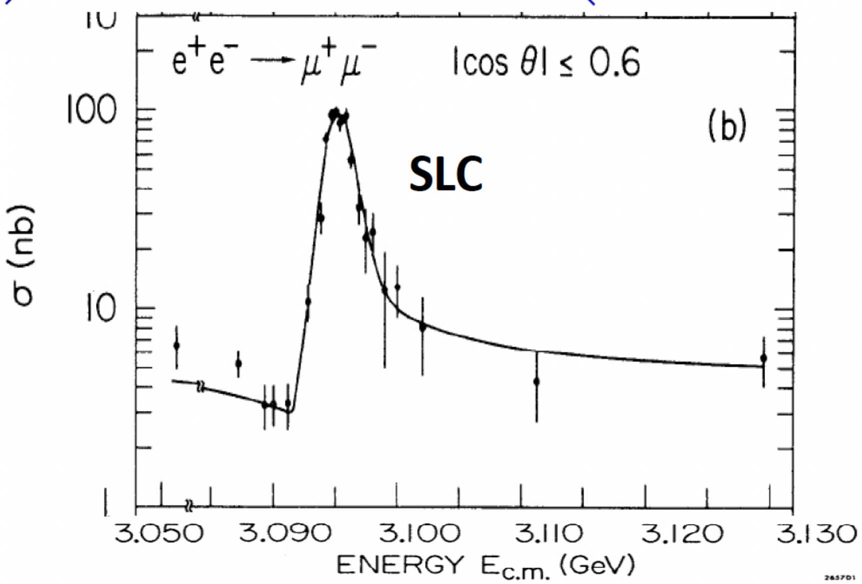
SU(3) independent--Scan method



$$\sigma^0(W) \propto |[A_g(W)e^{i\Phi_{g,\gamma}} + A_\gamma(W)]e^{i\Phi_{\gamma,\mathrm{cont}}} + A_{\mathrm{cont}}(W)|^2.$$

$$if\ \Phi_{\gamma,cont} = 0$$

$$\sigma^0(W) \propto |A_g(W)e^{i\Phi_{g,\mathrm{EM}}} + A_\gamma(W) + A_{\mathrm{cont}}(W)|^2,$$



By Yadi@HADRON2025

Scan method and measurement

- The born cross section: $$\sigma^0(W) = \left(\frac{\mathcal{A}}{W^2}\right)^2 \frac{4\pi\alpha^2}{W^2}\left|1 + \frac{3W^2\sqrt{\Gamma_{ee}\Gamma_{\mu\mu}}(1+\mathcal{C}e^{i\Phi_{\mathrm{g,EM}}})}{\alpha M(W^2 - M^2 + iM\Gamma)}\right|^2$$
- The observed cross section:

$$\sigma^{\text{theory}}(W) = \int_{W-nS_E}^{W+nS_E} GS(W-W'')dW'' \int_0^{x_f} dx F(x,s)\sigma^0(s(1-x))$$

- Minimization method: $$\chi^2 = \sum_{i=1}^{16} \frac{\left[\sigma_i^{\text{obs}} - f\sigma''(W_i)\right]^2}{(\Delta\sigma_i^{\text{obs}})^2 + \left[\Delta W_i \cdot \frac{d\sigma''(W)}{dW}\right]^2} + \left(\frac{1-f}{\Delta f}\right)^2$$

Punto di attenzione:
la dipendenza del continuo da s (pQCD asintotica o fit fuori dalla risonanza)

By Yadi@HADRON2025

J/ψ measurements @BESIII

- Poche pubblicazioni
- Molte analisi iniziate, alcune a buon punto

Scan method and measurement

BESIII Collaboration, Phys. Lett. B 791, 375 (2019)

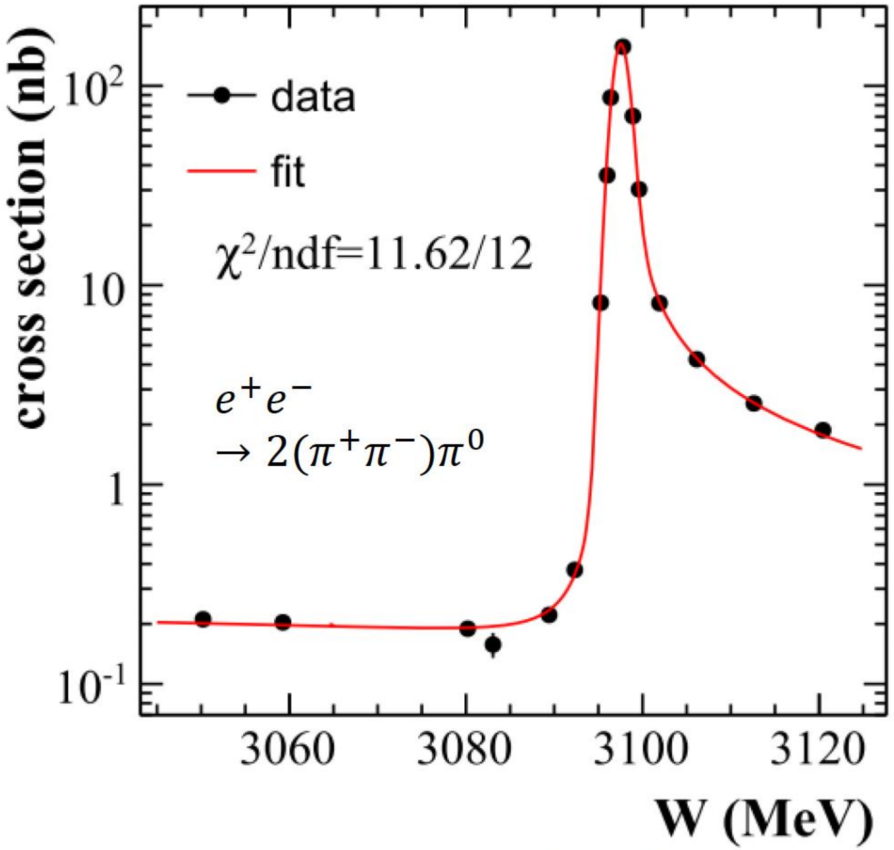
$e^+e^- \to J/\psi \to 2(\pi^+\pi^-)\pi^0$

J/ψ scan data (16 data points) of 100 pb^{-1} collected in 2012 is used

Detection efficiency is simulated with MCGPJ generator for the ISR effect around J/ψ narrow peak

Intermediate resonances are considered in simulation without interference

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



$\mathcal{B}_{PDG} = (4.1 \pm 0.5)\%$

The phase between A_γ and A_{3g} is found being consistent with 90°.

Ad oggi l'unica misura che abbiamo pubblicato.

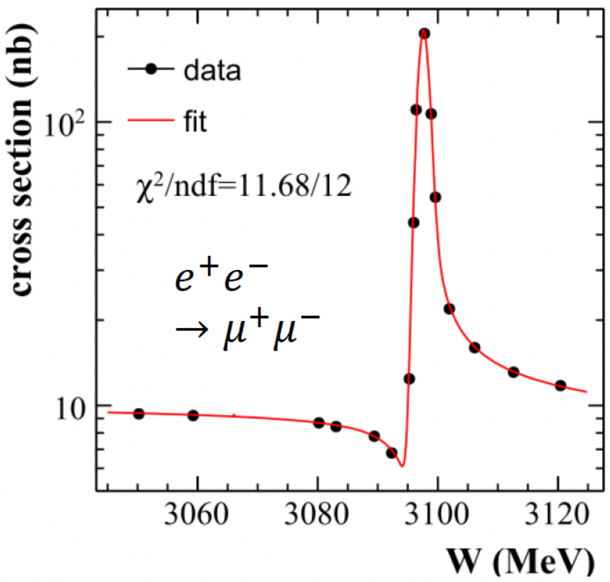
By Yadi@HADRON2025

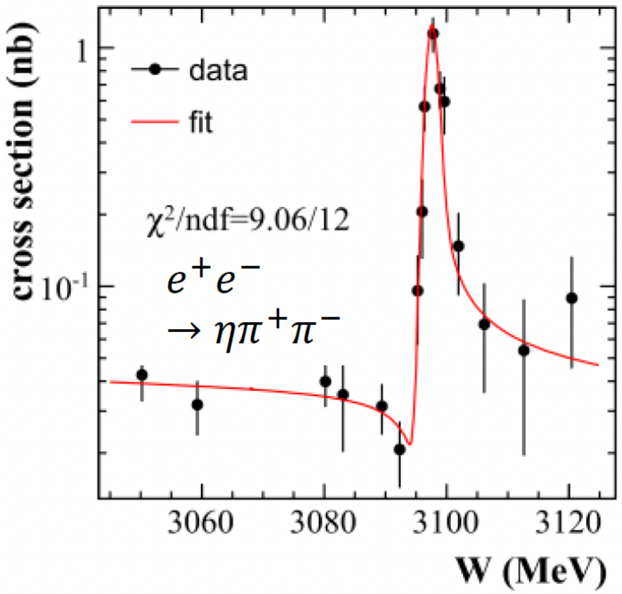
Scan method and measurement

By Yadi@HADRON2025

BESIII Collaboration, Phys. Lett. B 791, 375 (2019)

$e^+e^- \to J/\psi \to \mu^+\mu^-, \eta\pi^+\pi^-$





Φ represents the interference between $J/\psi \to \eta\rho$ and $J/\psi \to \rho\omega$

$$\sigma^0(W) = \frac{4\pi\alpha^2}{W^2}\left|1 + \frac{3W^2\sqrt{\Gamma_{ee}\Gamma_{\mu\mu}}e^{i\Phi_{\gamma,\mathrm{cont}}}}{\alpha M(W^2 - M^2 + iM\Gamma)}\right|^2$$

- $\Phi_{\gamma,cont.} = (3.0 \pm 10.0)^\circ$
- $S_E = (0.90 \pm 0.03)$ MeV

$$\sigma^0(W) = \left(\frac{\mathcal{A}}{W^2}\right)^2 \frac{4\pi\alpha^2}{W^2}\left|1 + \frac{3W^2\sqrt{\Gamma_{ee}\Gamma_{\mu\mu}}C_1 e^{i\Phi_{\gamma,\mathrm{cont}}}(1 + C_2 e^{i\Phi})}{\alpha M(W^2 - M^2 + iM\Gamma)}\right|^2$$

- $\Phi_{\gamma,cont.} = (-2 \pm 36)^\circ$ *or* $(-22 \pm 36)^\circ$
- $Br(J/\psi \to \eta\pi^+\pi^-) = (3.78 \pm 0.66) \times 10^{-4}$
- $Br_{PDG}(J/\psi \to \eta\pi^+\pi^-) = (4.0 \pm 1.7) \times 10^{-4}$

Once again, the phase between A_γ and $A_{cont.}$ is confirmed to be ZERO.

Ci consegna il mass shift per i dati dello scan e la conferma della fase continuo/EM uguale a 0 oltre alla misura del beam energy spread

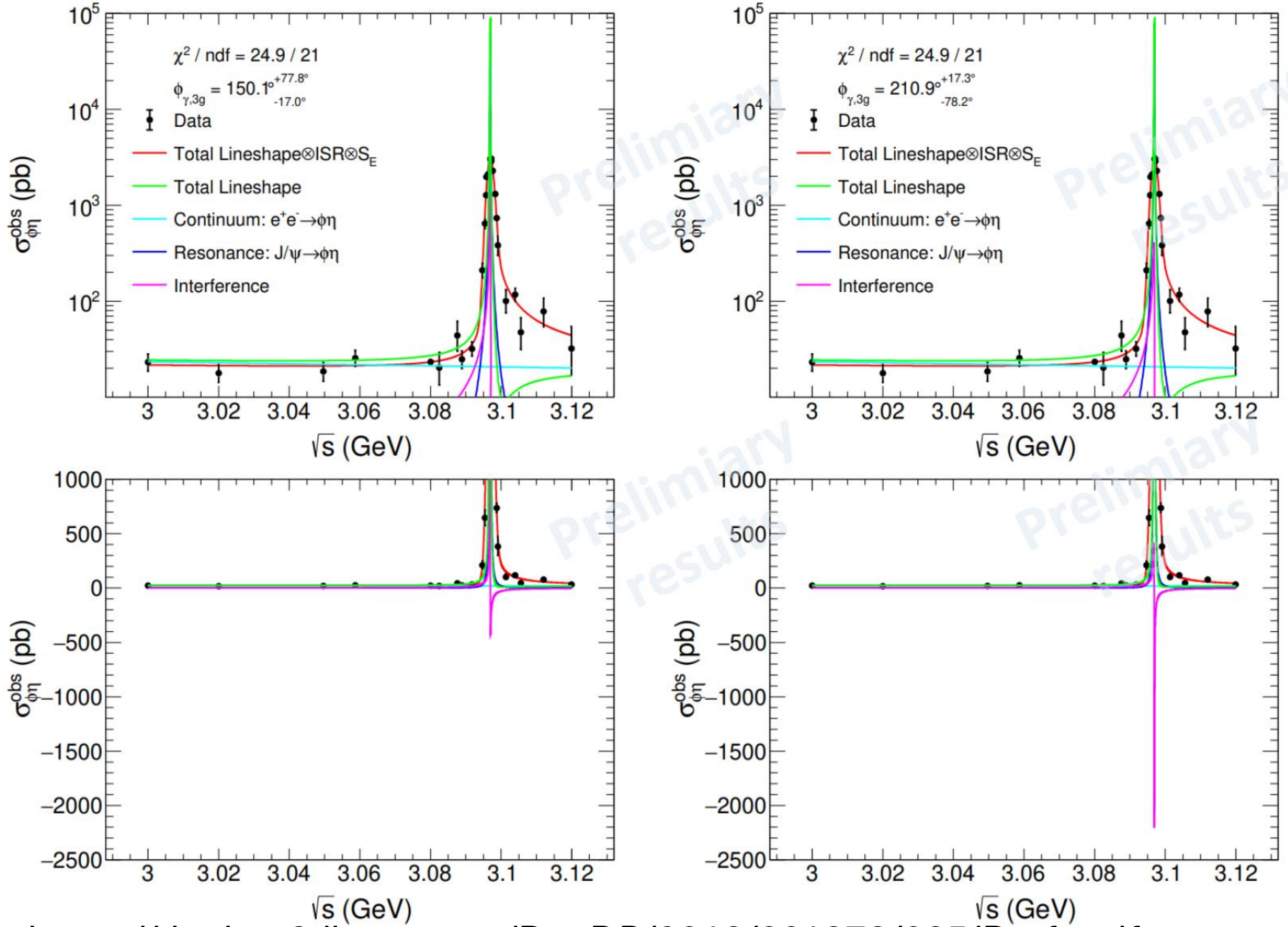
the differences among different approaches and parameterizations, we obtain $\Phi_{\gamma,\mathrm{cont}} = (3.0 \pm 10.0)^\circ$, $S_E = (0.90 \pm 0.03)$ MeV and $\Delta M = (0.57 \pm 0.05)$ MeV/c^2, which will be used in the fit for the hadronic final state.

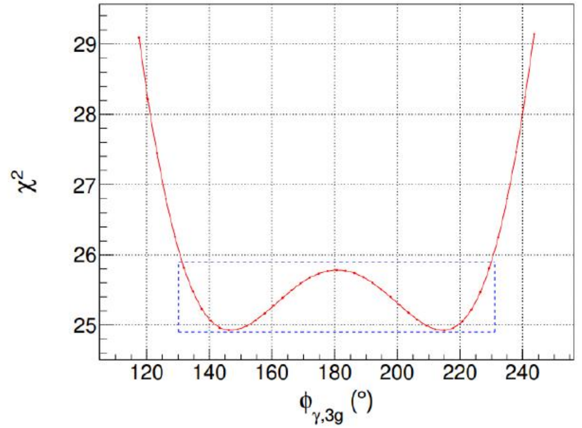
Scan method and measurement

VP

$e^+e^- \rightarrow J/\psi \rightarrow \phi\eta$

BESIII Collaboration, to be submitted





- Two solutions
- Indistinguishable within 1σ confidence
- $\Phi_{3g,\gamma} \in [133.1^\circ, 229.2^\circ]$

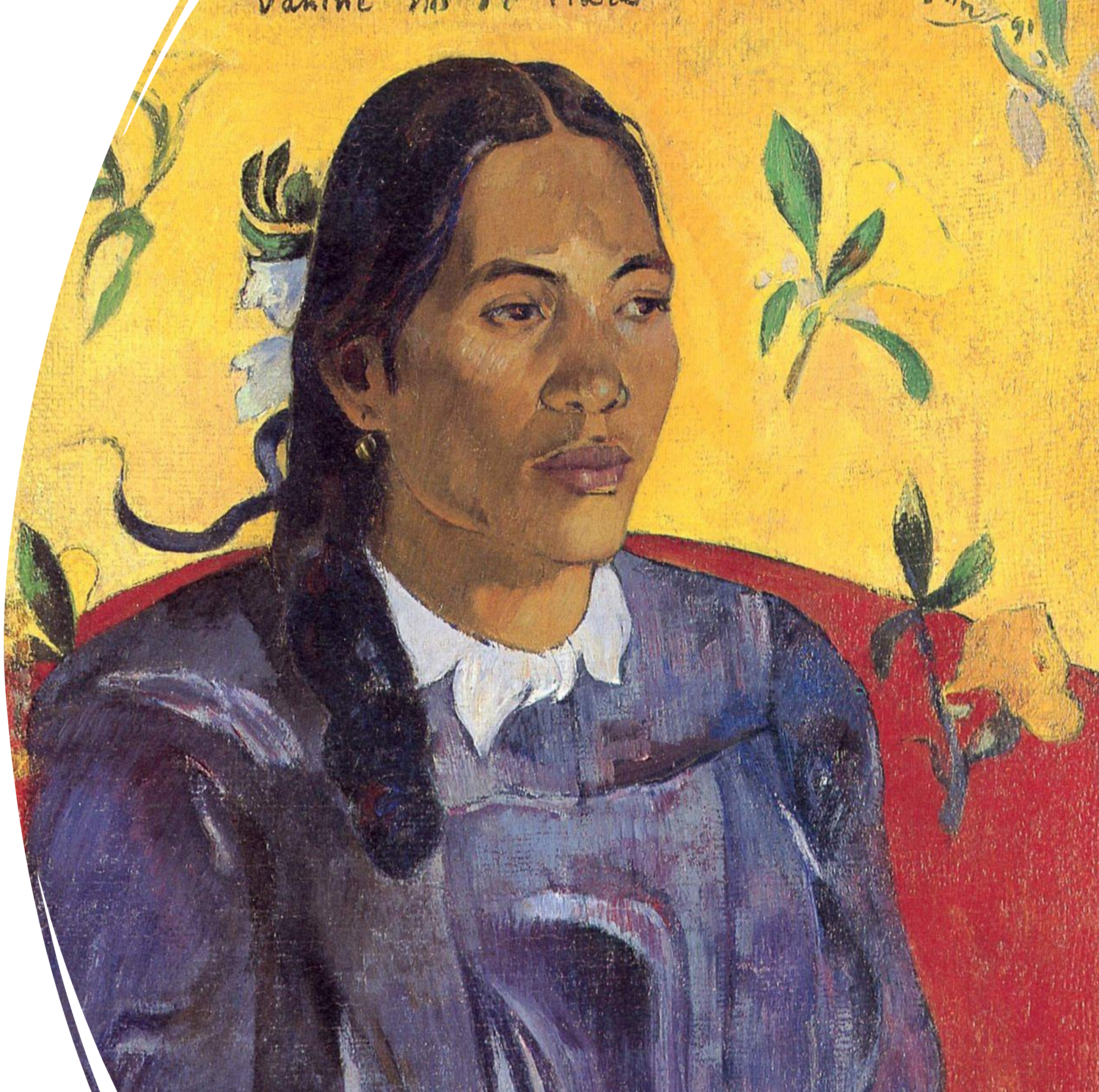
Interference between A_{3g} and A_γ?

https://docbes3.ihep.ac.cn/DocDB/0012/001272/035/Draft.pdf

SP approval→done, not submitted yet

By Yadi@HADRON2025

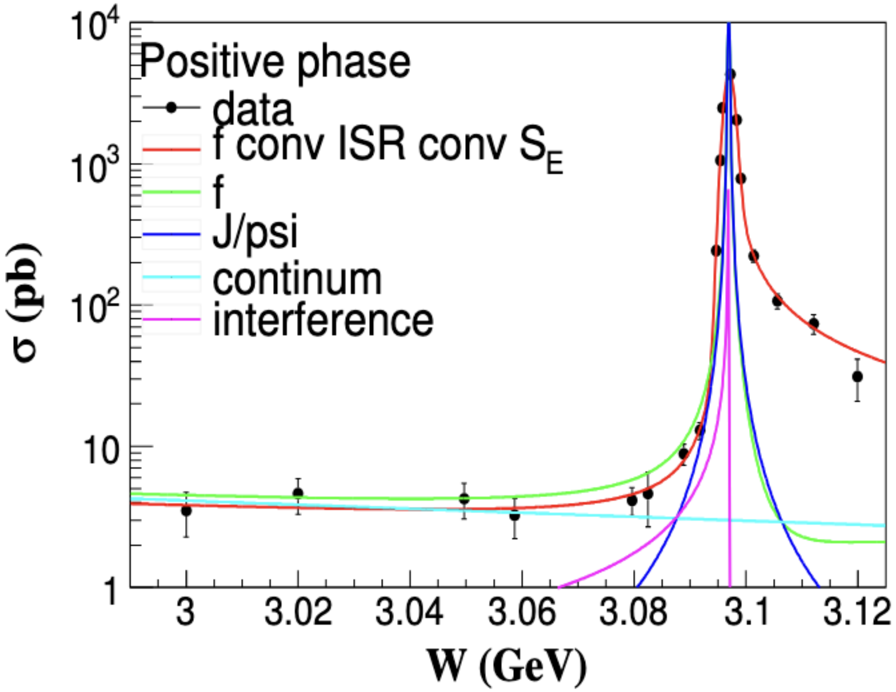
Analisi in corso e "vive"



$J/\psi \to \Sigma^0\overline{\Sigma^0}$

Started by Muzaffar, taken over by Hao Zhang (USTC)

me 2012+2 cme 2015



Solution	$\Phi_{3g,\gamma}(°)$	$\sigma_{\rm cont}$**(3.0000 GeV) pb**	$\mathcal{B}_{\rm out}(J/\psi \to \Sigma^0\bar{\Sigma}^0)$	χ^2**/ndf**
I	127.7 ± 18.6	2.90 ± 0.61	$(1.368 \pm 0.047) \times 10^{-3}$	8.62/15.0
II	-127.4 ± 18.5	2.90 ± 0.61	$(1.387 \pm 0.048) \times 10^{-3}$	8.62/15.0

	Mode (*)	Fraction (Γ_i/Γ)	Scale Factor/ Conf. Level	P(MeV/c)
Γ_{234}	$J/\psi(1S) \to \Sigma^0\overline{\Sigma}^0$	$(1.172 \pm 0.032) \times 10^{-3}$	S=1.4	988

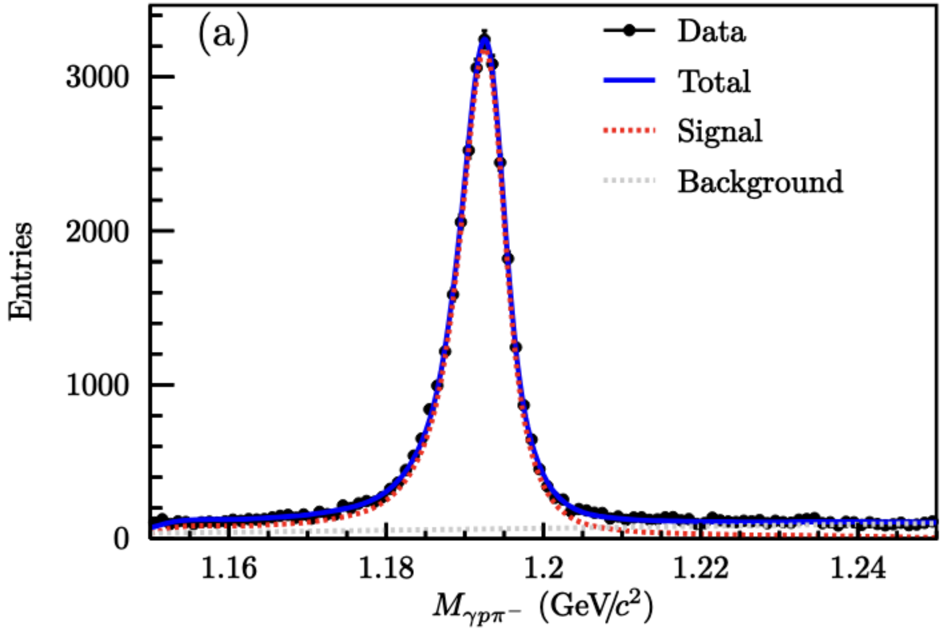
Non rel BW

Inconsistent by more than 3s with PDG
The interference contribution is tiny. POINT OF attention!

https://hnbes3.ihep.ac.cn/HyperNews/get/paper612.html

1.172 ± 0.032	**OUR AVERAGE** Error includes scale factor of 1.4.				
1.164 ±0.004 ±0.023	111k	ABLIKIM	2017L	BES3	$J/\psi \to \Sigma^0\overline{\Sigma}^0$
1.33 ±0.04 ±0.11	1.7k	ABLIKIM	2006	BES2	$J/\psi \to \Sigma^0\overline{\Sigma}^0$
1.06 ±0.04 ±0.23	884	PALLIN	1987	DM2	$e^+e^- \to \Sigma^0\overline{\Sigma}^0$
1.58 ±0.16 ±0.25	90	EATON	1984	MRK2	$e^+e^- \to \Sigma^0\overline{\Sigma}^0$
1.3 ±0.4	52	PERUZZI	1978	MRK1	$e^+e^- \to \Sigma^0\overline{\Sigma}^0$

Cross check of branching fraction of $\psi(3686) \to \pi^+\pi^- J/\psi$, $J/\psi \to \Sigma^0\bar{\Sigma}^0$



$\mathcal{B}(J/\psi \to \Sigma^0\bar{\Sigma}^0)$
$(1.336 \pm 0.008) \times 10^{-3}$

In agreement with previous result

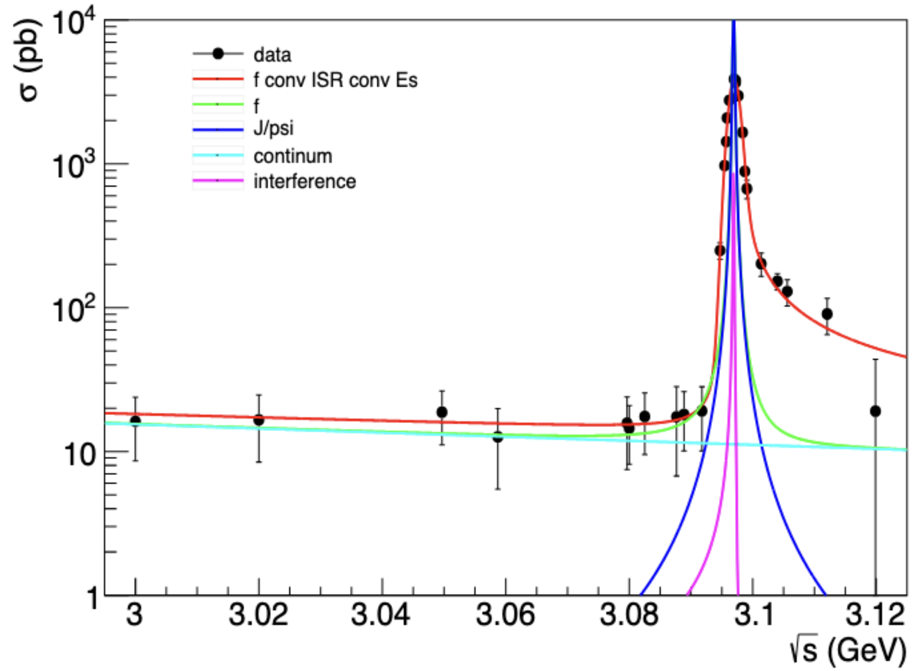
Only stat

	Mode (*)	*Fraction* (Γ_i / Γ)	*Scale Factor/ Conf. Level*	*P(MeV/c)*
Γ_{234}	$J/\psi(1S) \to \Sigma^0\overline{\Sigma}^0$	$(1.172 \pm 0.032) \times 10^{-3}$	S=1.4	988

$J/\psi \to \Sigma^+\overline{\Sigma^-}$

cme (tau-mass scan added)

By Jiajun



Solution	$\Phi_{3g,\gamma}(^\circ)$	$\sigma_{\text{cont.}}(3.000\text{ GeV})$ 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	$(1.19 \pm 0.02) \times 10^{-3}$	$17.4/24$

$\Gamma(\ J/\psi(1S) \to \Sigma^+\overline{\Sigma}^-)/\Gamma_{\text{total}}$ Γ_{233}/Γ

VALUE (10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
1.07 ± 0.04 OUR AVERAGE					
$1.061 \pm 0.004 \pm 0.036$	87k	ABLIKIM	2021AT	BES3	$J/\psi \to p\pi^0\bar{p}\pi^0$
$1.50 \pm 0.10 \pm 0.22$	399	ABLIKIM	2008O	BES2	$e^+ e^- \to J/\psi$

In agreement within 2 s the positive phase value

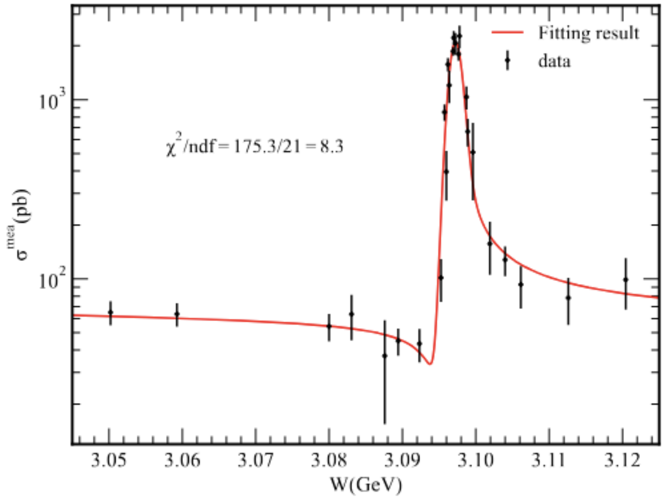
Fixed mass shift &SE

https://hnbes3.ihep.ac.cn/HyperNews/get/paper729.html

Last memo version by November 25th

Cross sections of $e^+e^- \to \omega\pi^0$ around J/ψ

DU Yiqi[1], LIU Baoxin[1], KANG Xiaosheng[2], GONG Li[2], ZHANG Bingxin[3], ZHANG Zhenyu[1], ZHOU Xiang[1]



Parameter	Result
$M(\mathrm{MeV})$	3097.10 ± 0.03
$\mathcal{F}_{\omega\pi^0}(\mathrm{GeV}^{1/2})$	$(4.50 \pm 0.15) \times 10^{-1}$
$\mathcal{C}$	1.21 ± 0.04
$\Phi_{\gamma,\mathrm{cont}}(\mathrm{rad})$	-0.03 ± 0.46

$$\mathcal{B}(J/\psi \to \omega\pi^0) = (3.97 \pm 0.26) \times 10^{-4}$$

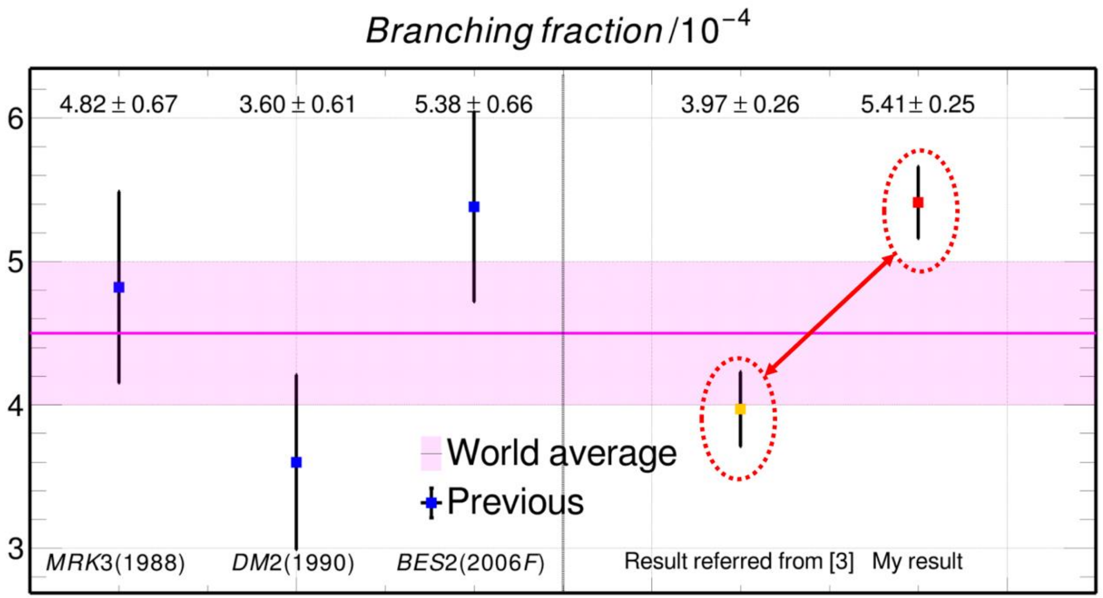
PDG: $(4.5 \pm 0.5) \times 10^{-4}$

https://indico.ihep.ac.cn/event/23307/contributions/173419/attachments/85787/109974/DYQ_20241204_collaboration_parallel_RQCD.pdf

Jia-bao Gong, Gang Li

Study of $\psi(2S) \to \pi^+\pi^- J/\psi\,,\ \ J/\psi \to \omega\pi^0$

BESIII P&S Workshop in Spring 2025

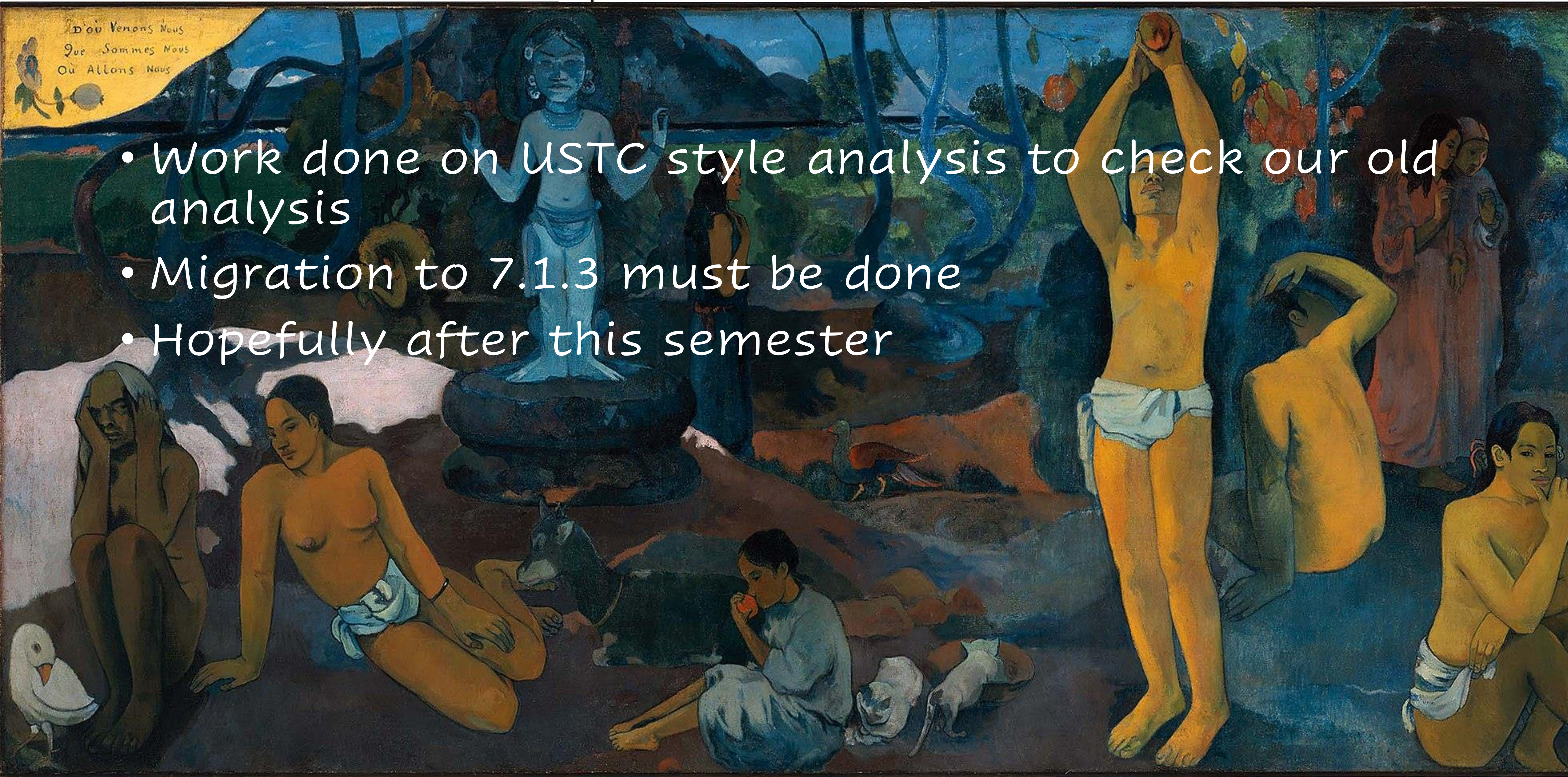


Different methods ,
but different results!

Both results are very preliminary

https://indico.ihep.ac.cn/event/23817/contributions/182785/attachments/88822/114831/talk_of_Jiabao_Gong.pdf

$$J/\psi \to K^+K^-$$

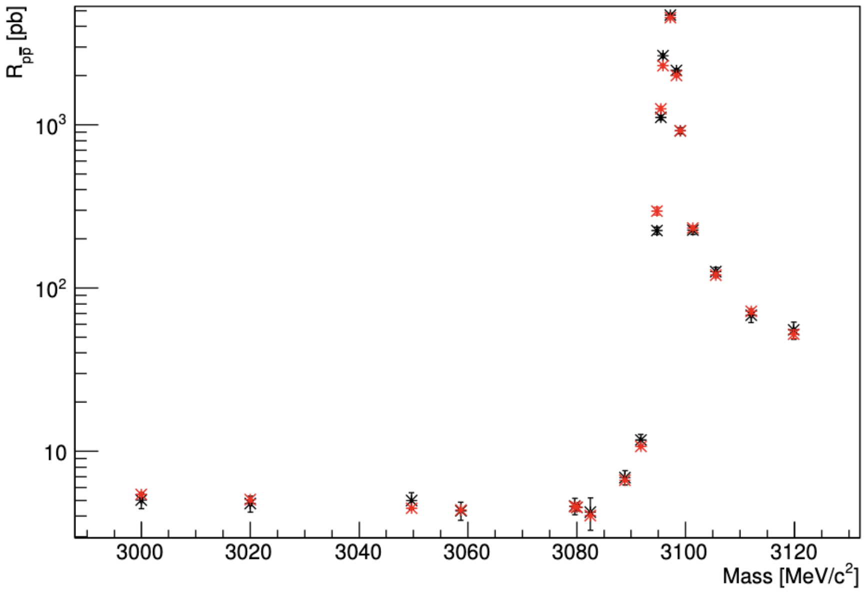


- Work done on USTC style analysis to check our old analysis
- Migration to 7.1.3 must be done
- Hopefully after this semester

Analisi al draft stage

$J/\psi \to p\bar{p}$

Marco D. dovrebbe avere pronto il draft



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

and

- $\varphi = -95.0° \pm 3.9°$,
- $\sigma_{cont} = 9.91$ pb $\pm$ 0.63 pb,
- $B_{out} = (2.103 \pm 0.030)\cdot 10^{-3}$.

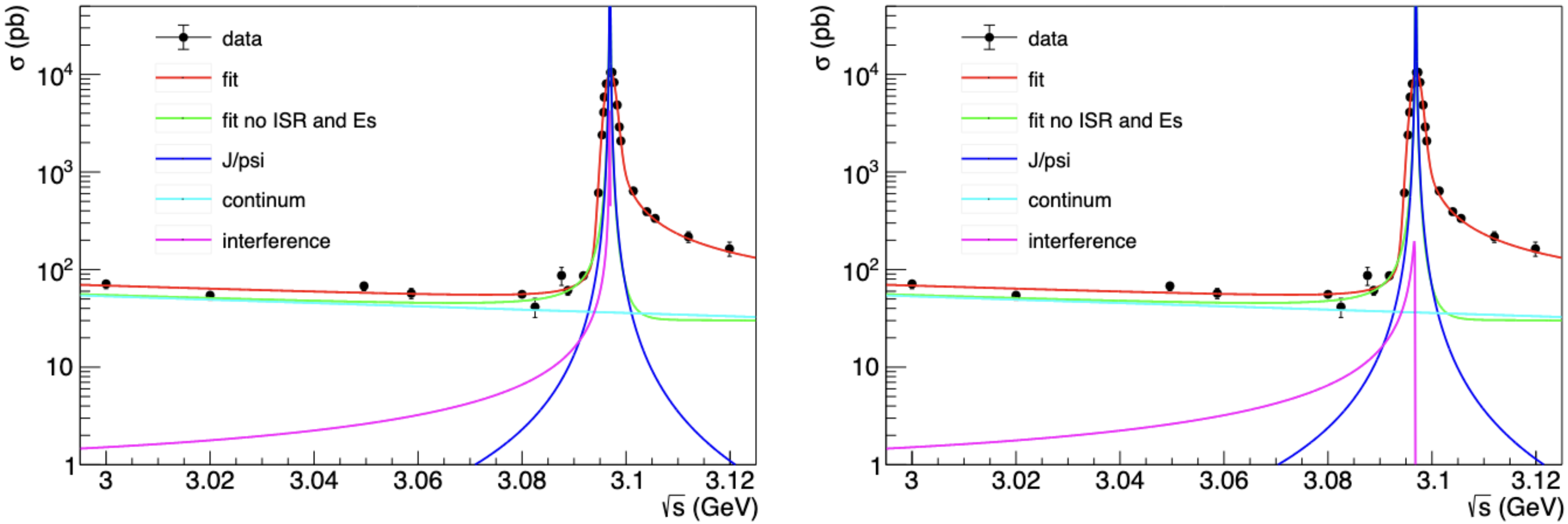
https://hnbes3.ihep.ac.cn/HyperNews/get/paper106.html

https://docbes3.ihep.ac.cn/DocDB/0002/000222/003/memo_v10.pdf

On going three body analyses

Study of the $e^+e^- \to K^+K^-\pi^0$ process around J/ψ

Tianyou Li[a,b], Chen Xie[b,c], Hailong Ma[b], and Minggang Zhao[a]



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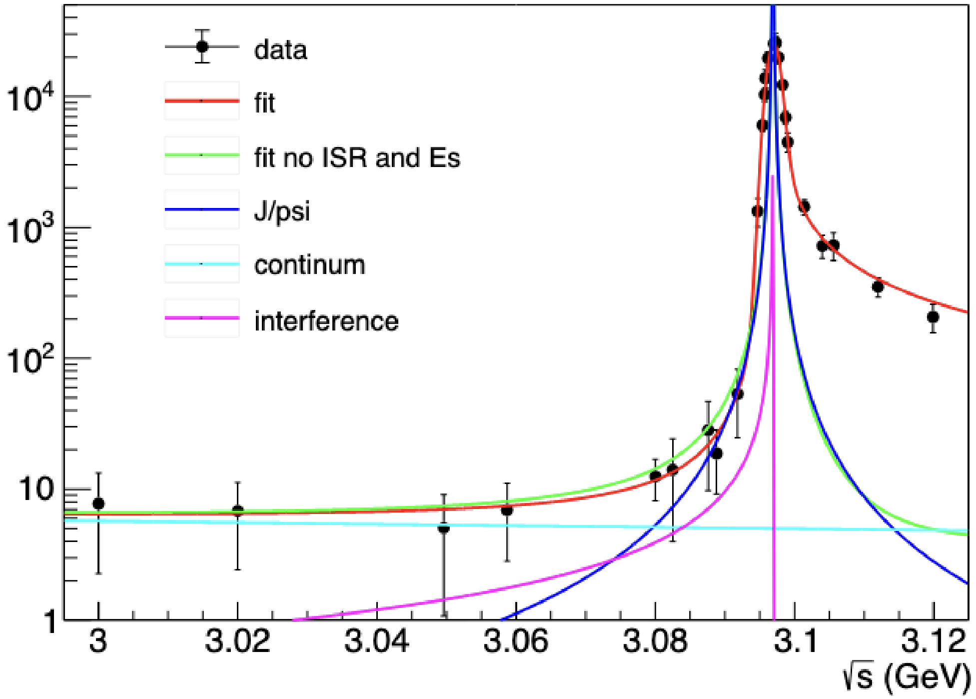
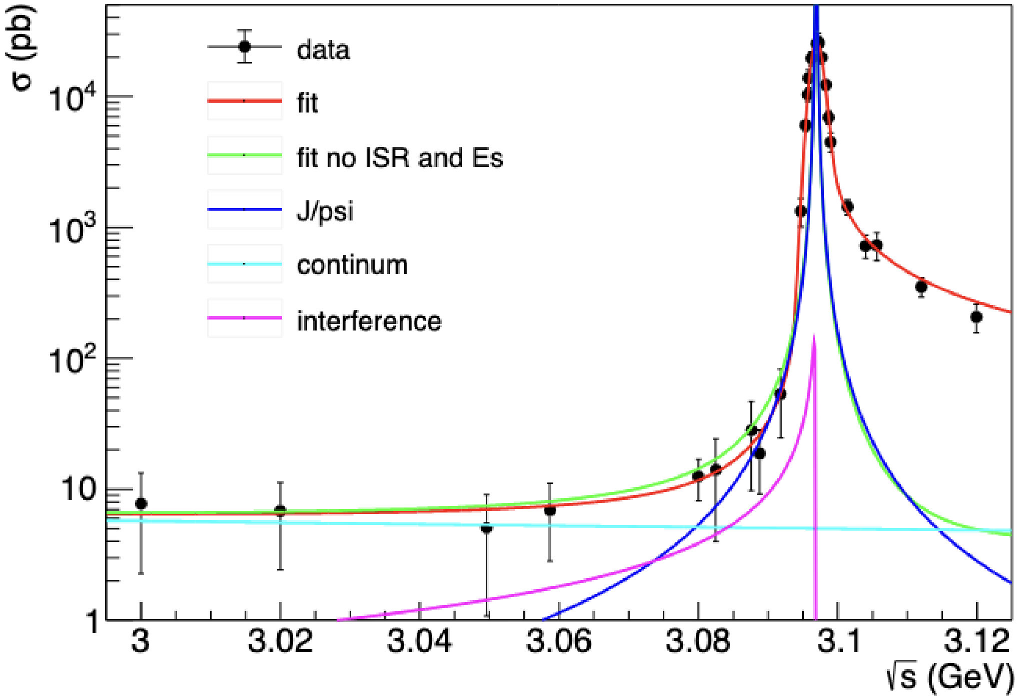
$$e^+e^- \rightarrow K^{*\pm}(892)K^{\mp}$$





Using FF from PWA

Experiment	$\mathcal{B}(J/\psi \to K^+K^-\pi^0)$ (10^{-3})	$\mathcal{B}(J/\psi \to K^{*\pm}(892)K^{\mp})$ (10^{-3})
DM2 [7]	...	$4.57 \pm 0.17 \pm 0.70$
MARKIII [8]	...	$5.26 \pm 0.13 \pm 0.53$
BABAR [57]	$1.97 \pm 0.16 \pm 0.13$	$5.22 \pm 0.3 \pm 0.3$
BESIII [48]	$2.88 \pm 0.01 \pm 0.12$	$8.07 \pm 0.04^{+0.38}_{-0.61}$
PDG [33]	2.88 ± 0.12	$6.0^{+0.8}_{-1.0}$
This work	3.19 ± 0.05 or 3.32 ± 0.05	7.70 ± 0.14 or 7.78 ± 0.14

Study of the $e^+e^- \to K_S^0 K^+\pi^- + c.c.$ process around J/ψ

Chen Xie[a,b], Shenjian Chen[a], Hailong Ma[b], Yadi Wang[c], and Lei Zhang[a]

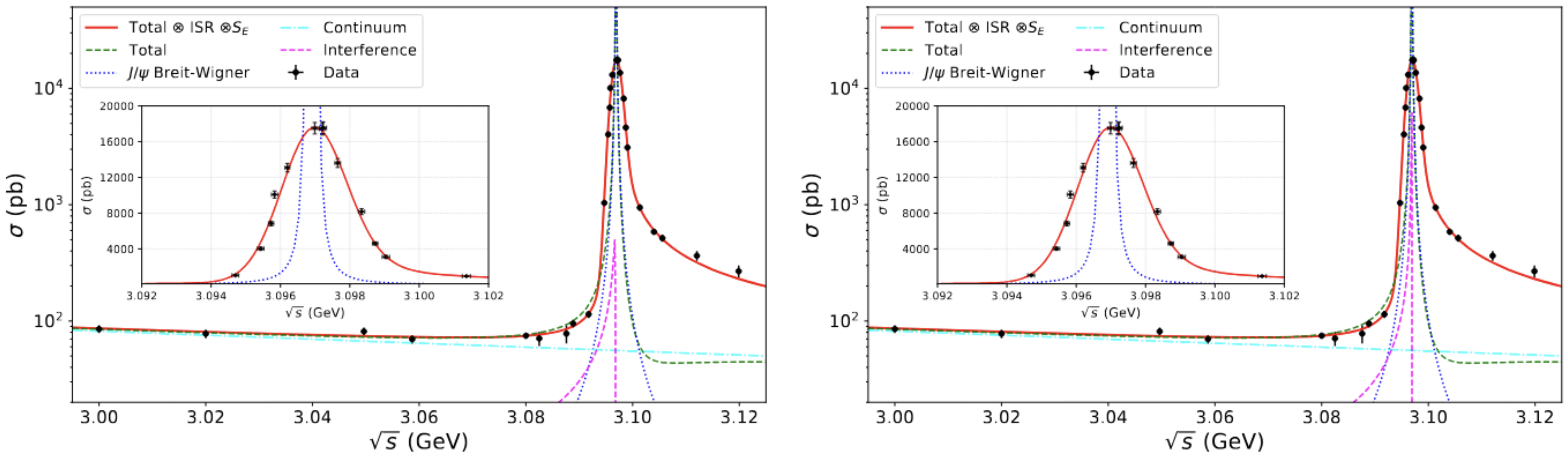
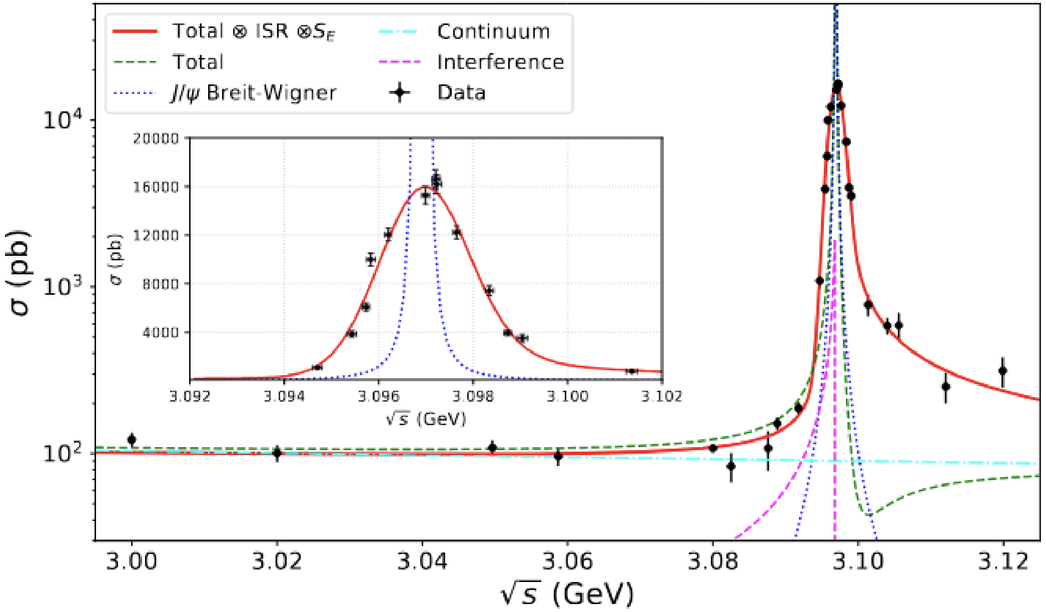
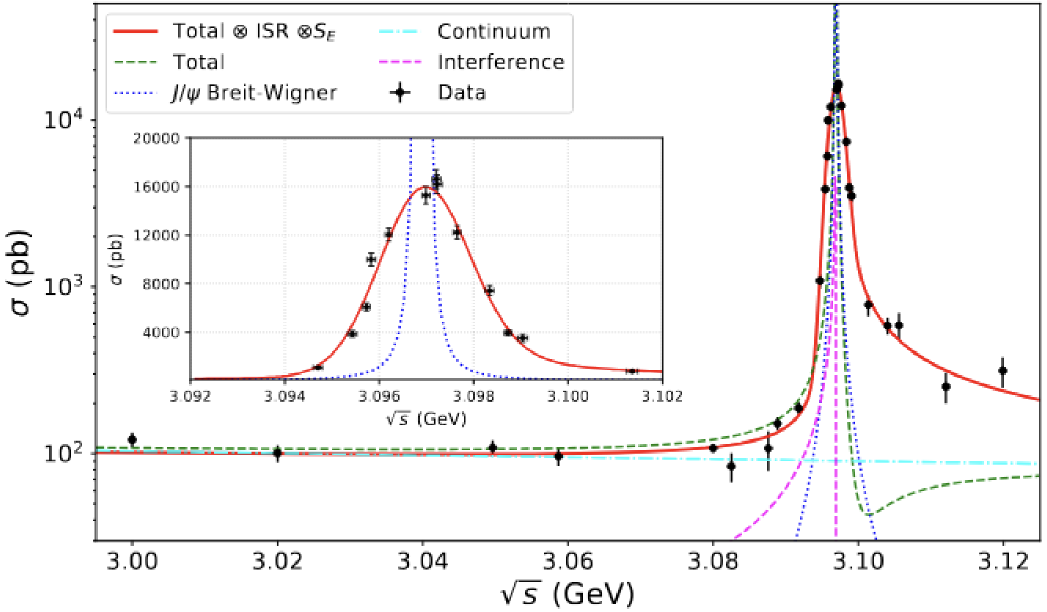


Fig. 28: Fits to observed cross sections of $e^+e^- \to K_S^0 K^+\pi^-$ with negative (left) and positive (right) phase hypotheses.

$$e^+e^- \to K^0\bar{K}^{*0}$$





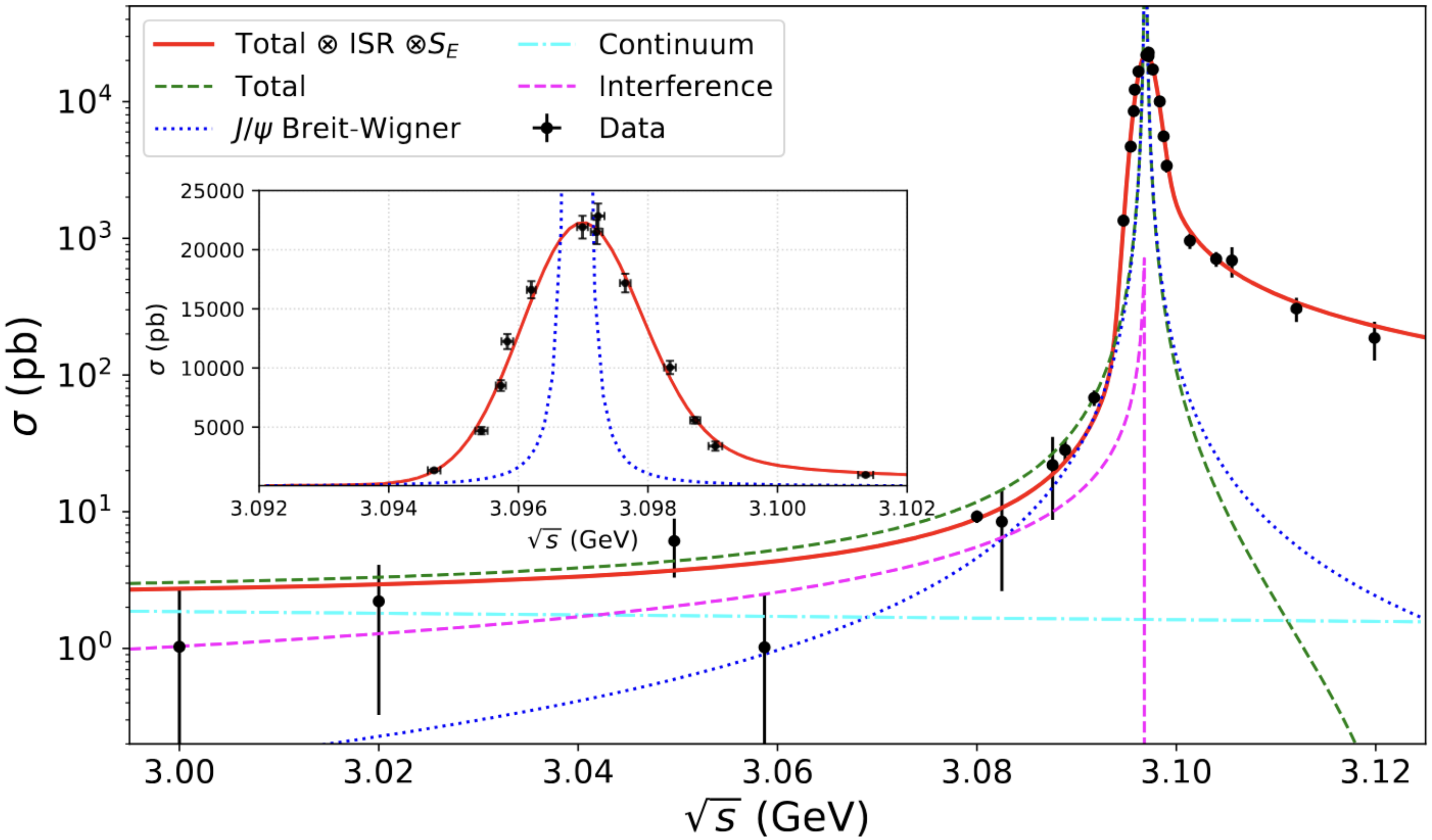
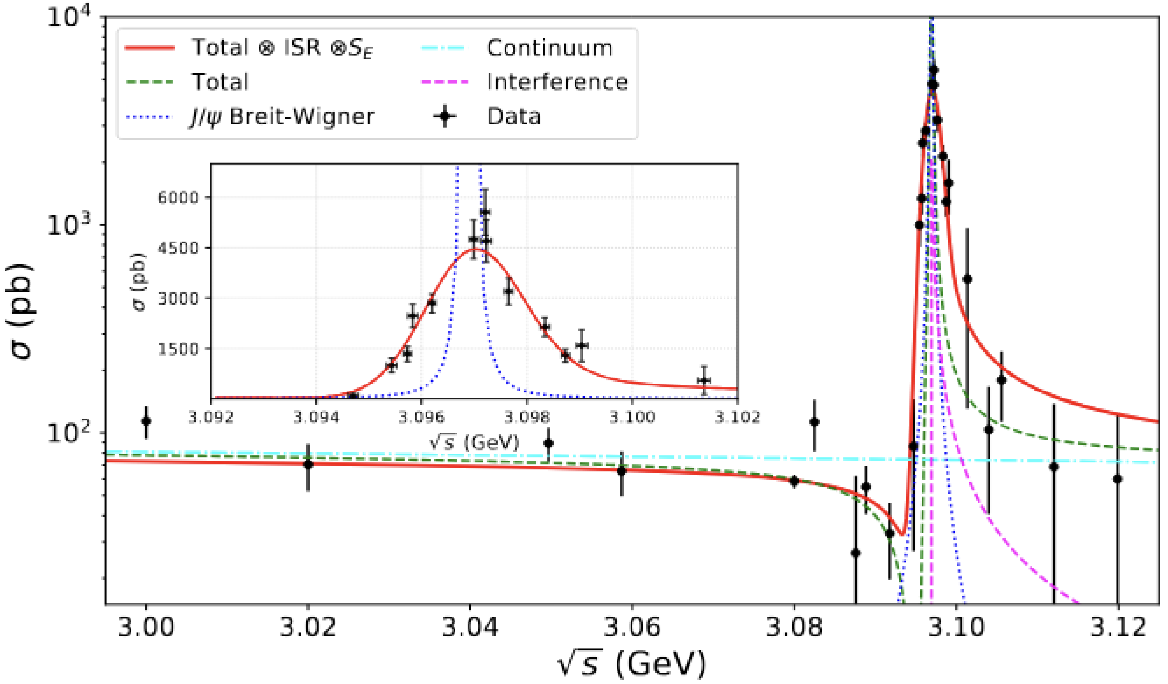
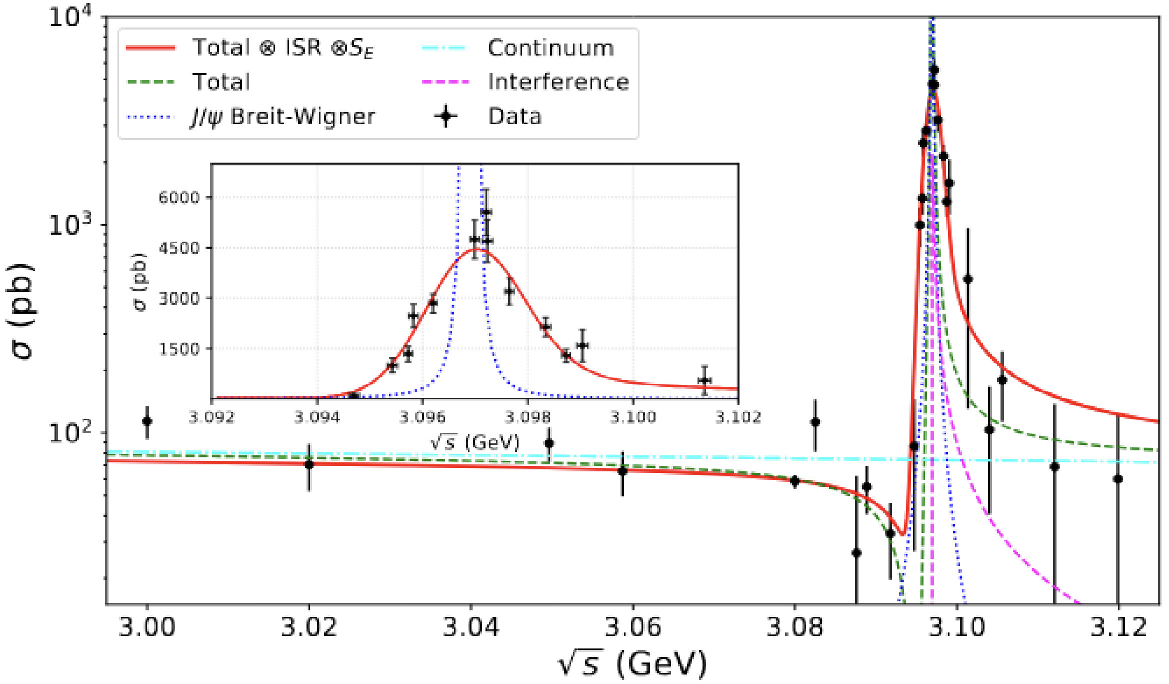


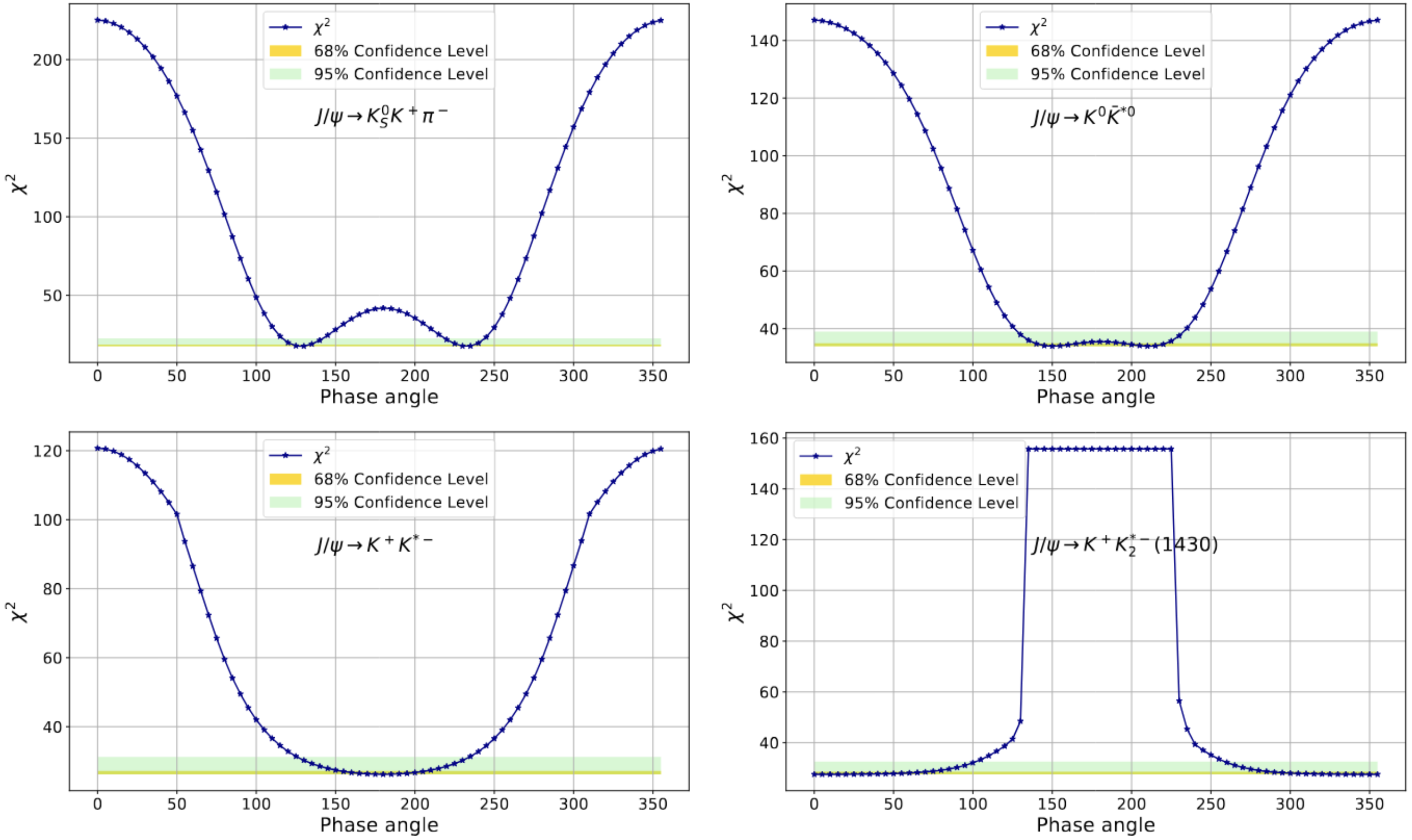
Fig. 30: Fits to observed cross sections of $e^+e^- \to K^+K^{*-}$.

$e^+e^- \rightarrow K^+K_2^{*-}(1430)$





Solution	A	$\mathcal{B}(\times 10^{-3})$	$\phi(^\circ)$	S_E (MeV)	χ^2/ndf
		$J/\psi \to K_S^0 K^+ \pi^-$			
Positive	4.17 ± 0.17	(5.15 ± 0.20)	128.0 ± 5.5	0.91 ± 0.02	15.1/22
Negative	4.24 ± 0.16	(5.35 ± 0.21)	-127.4 ± 5.5	0.91 ± 0.02	15.1/22
		$J/\psi \to K^0 \bar{K}^{*0}$			
Positive	3.57 ± 0.23	(4.67 ± 0.20)	149.9 ± 12.5	0.91 ± 0.02	31.1/22
Negative	3.61 ± 0.22	(4.85 ± 0.20)	-148.8 ± 12.4	0.91 ± 0.02	31.1/22
		$J/\psi \to K^+ K^{*-}$			
-	25.39 ± 2.51	(6.50 ± 0.26)	180.1 ± 28.6	0.89 ± 0.02	24.4/22
		$J/\psi \to K^+ K_2^{*-}(1430)$			
Positive	0.57 ± 0.06	(1.26 ± 0.08)	0.0 ± 123.4	0.90	29.7/22
Negative	0.57 ± 0.09	(1.26 ± 0.09)	-4.2 ± 170.7	0.90	29.7/22



phase angle scans

Channel	This work		PDG
	Positive	Negative	
$\mathcal{B}(J/\psi \to K_S^0 K^+ \pi^-) \times 10^{-3}$	(5.15 ± 0.24)	(5.35 ± 0.25)	(5.3 ± 0.5)
$\mathcal{B}(J/\psi \to K^0 \bar{K}^{*0}) \times 10^{-3}$	(4.67 ± 0.26)	(4.85 ± 0.26)	(4.2 ± 0.4)
$\mathcal{B}(J/\psi \to K^+ K^{*-}) \times 10^{-3}$	(6.50 ± 0.33)		$(6.0^{+0.8}_{-1.0})$
$\mathcal{B}(J/\psi \to K^+ K_2^{*-}(1430)) \times 10^{-3}$	(1.26 ± 0.10)	(1.26 ± 0.11)	$1.62^{+0.15}_{-0.11}$

Analyses already presented

$$J/\psi \to \Lambda\overline{\Lambda}$$

$$J/\psi \to \Xi\overline{\Xi}$$

Channel	Relative Phase	
	Positive	Negative
This work($J/\psi \to K_S^0 K^+ \pi^-$)	128.0 ± 9.2	-127.4 ± 9.2
($J/\psi \to K^0 \bar{K}^{*0}$)	149.9 ± 14.8	-148.8 ± 14.7
($J/\psi \to K^+ K^{*-}$)	180.1 ± 28.6	
($J/\psi \to K^+ K_2^{*-}(1430)$)	0.0 ± 123.4	-4.2 ± 170.7
$J/\psi \to 5\pi$ [16]	84.9 ± 3.6	-84.7 ± 3.1
$J/\psi \to \Sigma^+ \bar{\Sigma}^-$ [62]	107.9 ± 24.9	-107.6 ± 24.3
$J/\psi \to \eta\phi$ [63]	150^{+78}_{-17}	211^{+17}_{-78}
$J/\psi \to \Sigma^0 \bar{\Sigma}^0$ [64]	127.7 ± 21.5	-127.4 ± 21.4

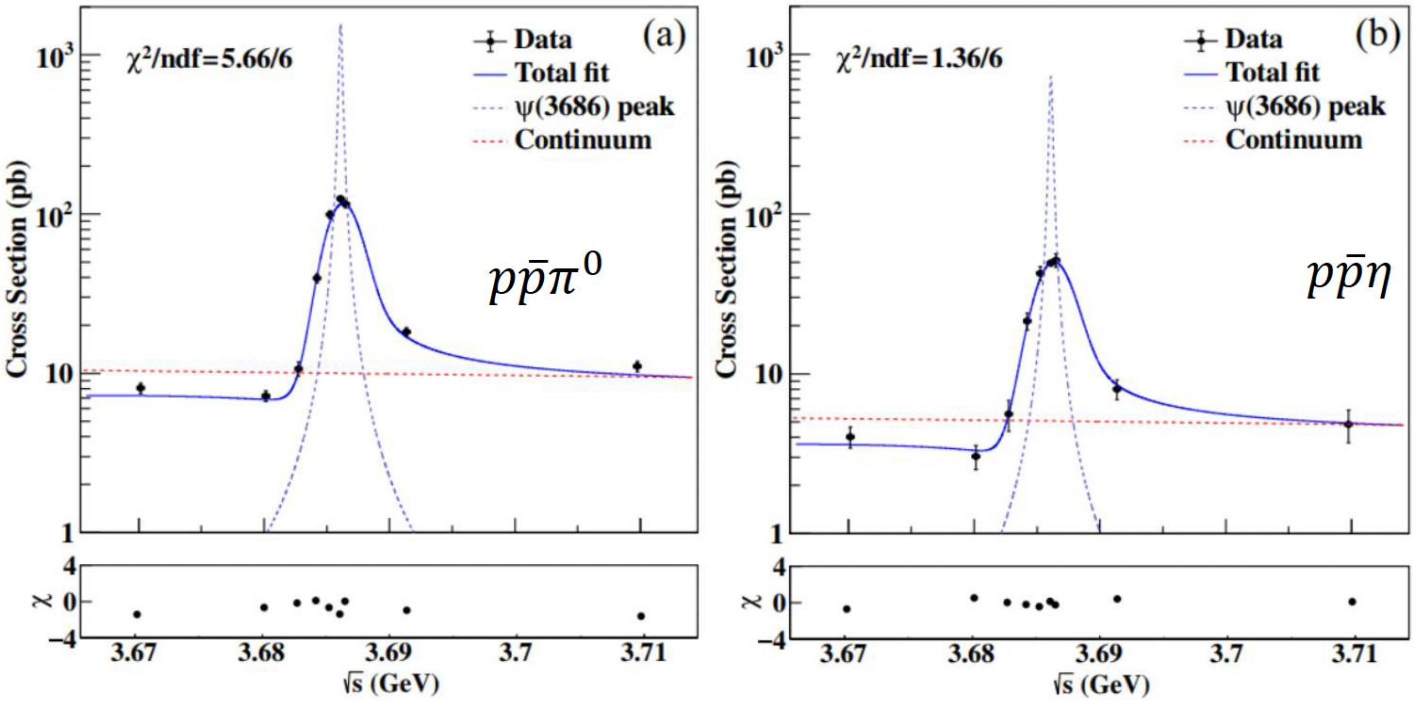
ψ' measurements @BESIII

Scan method and measurement

By Yadi@HADRON2025

BESIII Collaboration, Phys. Rev. D 111, 032011 (2025)

$e^+e^- \to \psi(2S) \to p\bar{p}\pi^0$



$$\sigma_{\mathrm{Born}} = |A_{\mathrm{con}} + A_{\mathrm{res}} \times e^{i\phi}|^2$$

$$A_{\mathrm{con}}(s) = a/s^n$$

$$A_{\mathrm{res}}(s) = \frac{\sqrt{12\pi\Gamma_{ee}\Gamma_{\mathrm{tot}}\mathcal{B}_f}}{s - M^2 + iM\Gamma_{\mathrm{tot}}}$$

- Phase is consistent with $\pm 90°$ after converting.

channel	Solution	ϕ (°)	Br ($\times 10^{-6}$)	Φ (°)	Br_{PDG}($\times 10^{-6}$)
$\psi($	Constructive	65.0 ± 6.7	$133.9 \pm 11.2 \pm 2.3$	75.0 ± 8.9	153 ± 7
				7.1	
$\psi(2S) \to p\bar{p}\eta$	Constructive	58.9 ± 14.1	$61.5 \pm 6.5 \pm 1.1$	69.8 ± 22.1	60 ± 4
	Destructive	-63.8 ± 12.1	$84.4 \pm 6.9 \pm 1.4$	-73.6 ± 17.5	

MOLTE ANALISI DELLA ψ'' sono fatte in questo modo (Changzheng style)

- The branching fractions deviate from PDG if considering the interference.

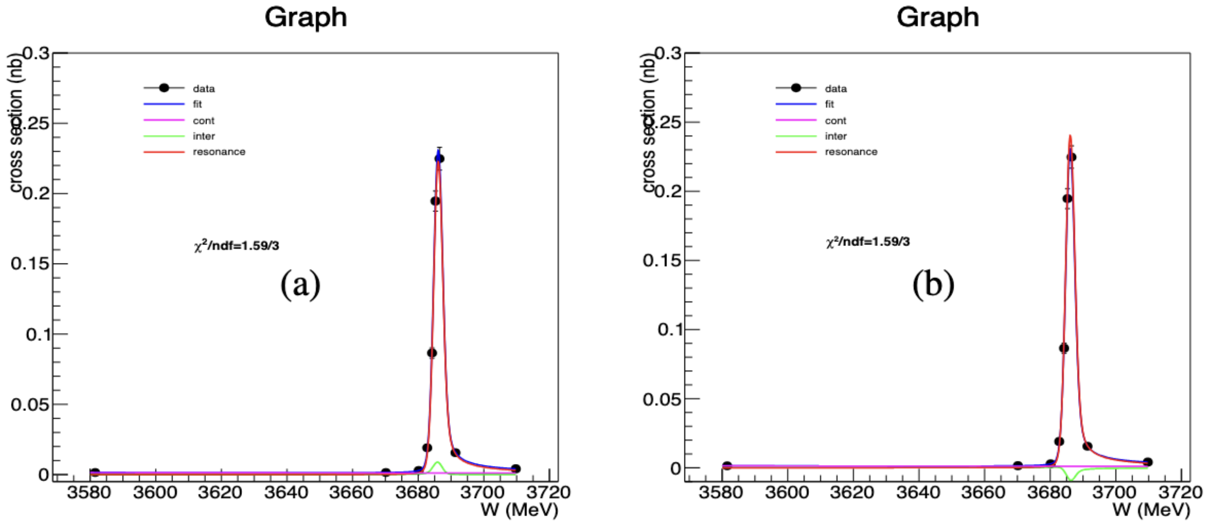
Sfortunatamente non reindirizzato sulla TF-fase→Misura la fase tra continuo e risonanza, non quella tra EM e forte

$\psi(2S) \to p\bar{p}$

Yadi, Yannan

Parameter	positive	negative
$\Phi_{g,EM}$ (°)	106.0 ± 9.3	-105.4 ± 9.0
M (MeV/c^2)	3685.99 ± 0.09	3685.99 ± 0.09
E_{spread}(MeV)	1.30 ± 0.05	1.30 ± 0.05
C	15.7 ± 1.2	16.3 ± 1.2
$\mathcal{F}$	2.4 ± 0.1	2.4 ± 0.1
f	0.9997 ± 0.0168	0.9997 ± 0.0168

VALUE (10^{-4})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{2.94 \pm 0.09}$	**OUR FIT** Error includes scale factor of 1.3.				
$\mathbf{3.02 \pm 0.08}$	**OUR AVERAGE**				
$3.05 \pm 0.02 \pm 0.12$	19k	ABLIKIM	2018T	BES3	$e^+ e^- \to \psi(2S) \to p\bar{p}$
$3.08 \pm 0.05 \pm 0.18$	4.5k	[1] DOBBS	2014		$e^+ e^- \to \psi(2S) \to p\bar{p}$
$3.36 \pm 0.09 \pm 0.25$	1.6k	ABLIKIM	2007C	BES	$e^+ e^- \to \psi(2S) \to p\bar{p}$
$2.87 \pm 0.12 \pm 0.15$	557	PEDLAR	2005	CLEO	$e^+ e^- \to \psi(2S) \to p\bar{p}$
1.4 ± 0.8	4	BRANDELIK	1979C	DASP	$e^+ e^- \to \psi(2S) \to p\bar{p}$
2.3 ± 0.7		FELDMAN	1977	MRK1	$e^+ e^- \to \psi(2S) \to p\bar{p}$



: $\mathcal{B} = (3.242 \pm 0.065_{\text{tot.}}) \times 10^{-4}$ and $\mathcal{B} = (3.497 \pm 0.058_{\text{tot.}}) \times 10^{-4}$ $= \quad (\frac{\mathcal{F}}{M^2})^2|1 + Ce^{i\Phi_{g,EM}}|^2,$

https://hnbes3.ihep.ac.cn/HyperNews/get/AUX/2024/05/12/20.30-37994-memo_v3.pdf

https://hnbes3.ihep.ac.cn/HyperNews/get/paper822.html

+/-7%

Tension with PDG

Yadi

$\psi(2S) \to K^+K^-$

@ memo stage (comments by Simone and me), request for CWR

Parameter	positive	negative
$\Phi_{g,EM}(^\circ)$	114.1 ± 6.5	-110.2 ± 5.6
S_E (MeV/c^2)	1.39 ± 0.08	1.39 ± 0.08
$\mathcal{C}$	3.18 ± 0.15	3.76 ± 0.13
$\mathcal{F}$	0.476 ± 0.009	0.476 ± 0.009
$\mathcal{B}$ (10^{-5})	7.41 ± 0.39	10.90 ± 0.47

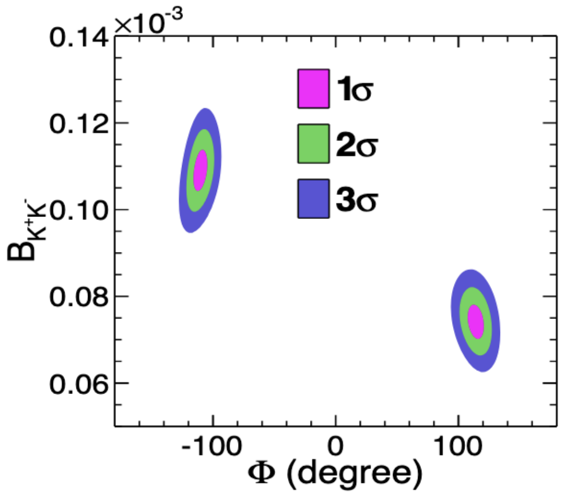
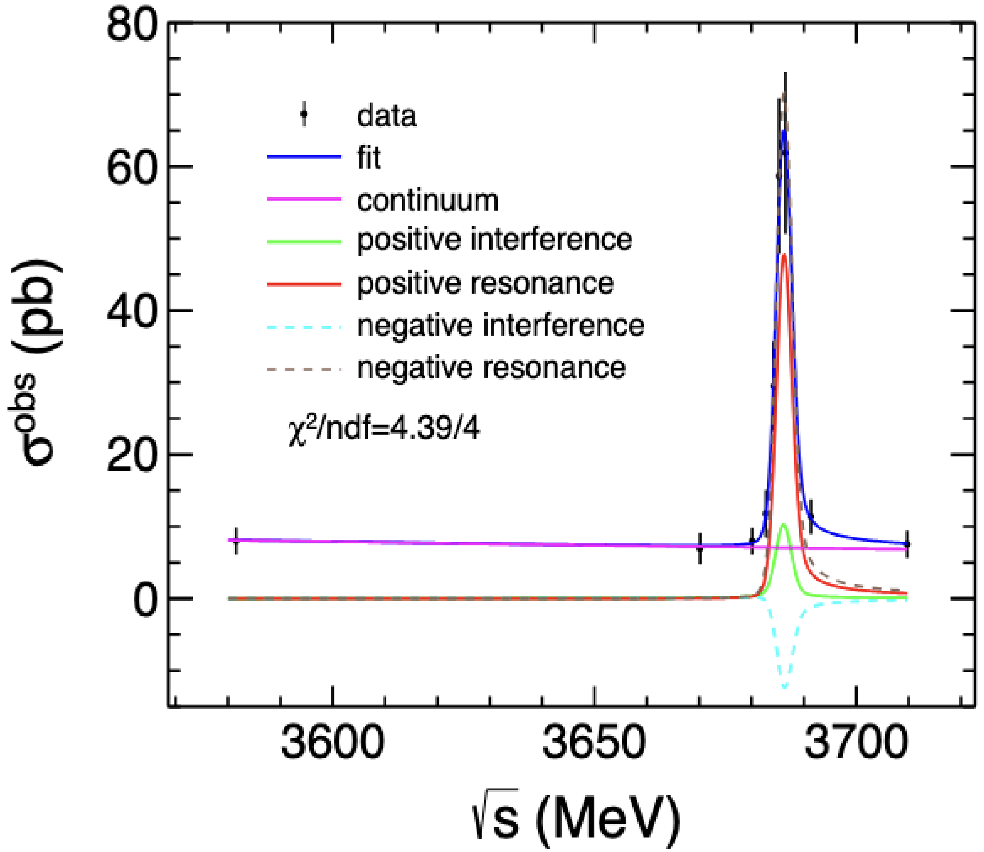


FIG. 3: The contours in the $\mathcal{B}(\psi(2S) \to K^+K^-)$ and the relative phase Φ plane. The filled areas are up to 3σ contours.



https://docbes3.ihep.ac.cn/DocDB/0012/001218/019/ph
e_psip2KK_draft_v6.pdf

Large effect of the interference

$\Gamma(\psi(2S) \to K^+K^-)/\Gamma_{total}$ Γ_{59}/Γ

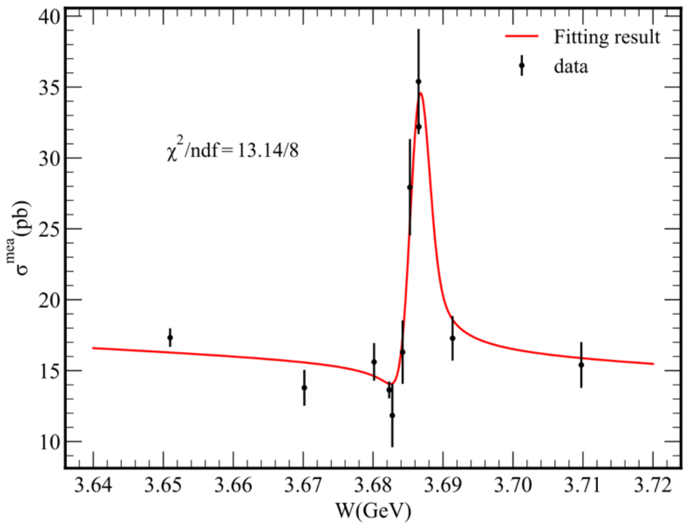
VALUE (10^{-5})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$7.48 \pm 0.23 \pm 0.39$		1.3k	[1] METREVELI	2012		$\psi(2S) \to K^+K^-$

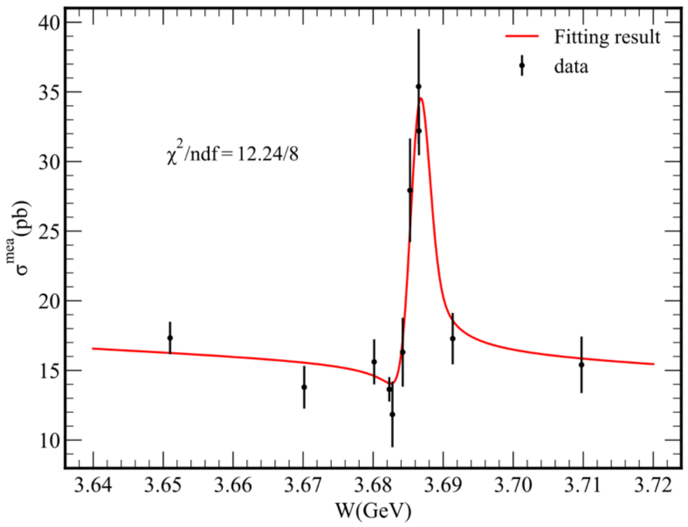
section lineshape.

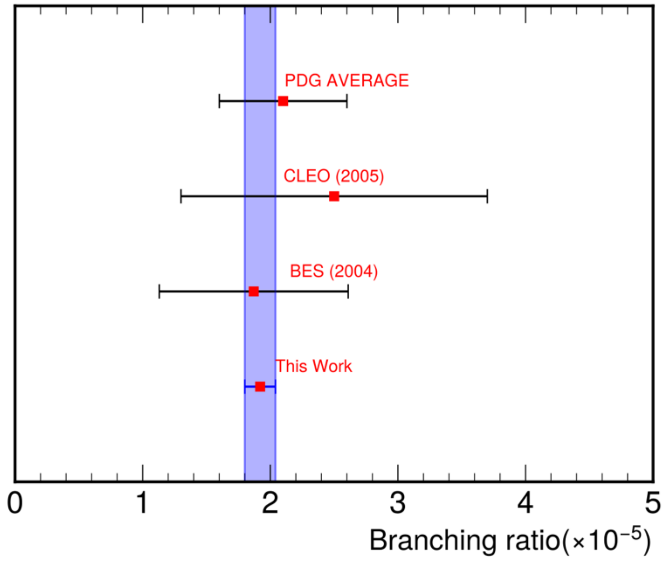
Parameter	positive	negative
$\Phi_{g,EM}(^\circ)$	114.1 ± 6.5	-110.2 ± 5.6
S_{E} (MeV/c^2)	1.39 ± 0.08	1.39 ± 0.08
$\mathcal{C}$	3.18 ± 0.15	3.76 ± 0.13
$\mathcal{F}$	0.476 ± 0.009	0.476 ± 0.009
$\mathcal{B}$ (10^{-5})	7.41 ± 0.39	10.90 ± 0.47

Interference effect about +/- 20%

Measurement of the ωπ0 final state cross section in the near-threshold energy region of ψ(2*S*)







https://docbes3.ihep.ac.cn/DocDB/0015/001587/001/Measurement_of_the_omega_pi0_final_state_cross_section_in_the_near_threshold_energy_region_of_psi_2S_%20%281%29.pdf

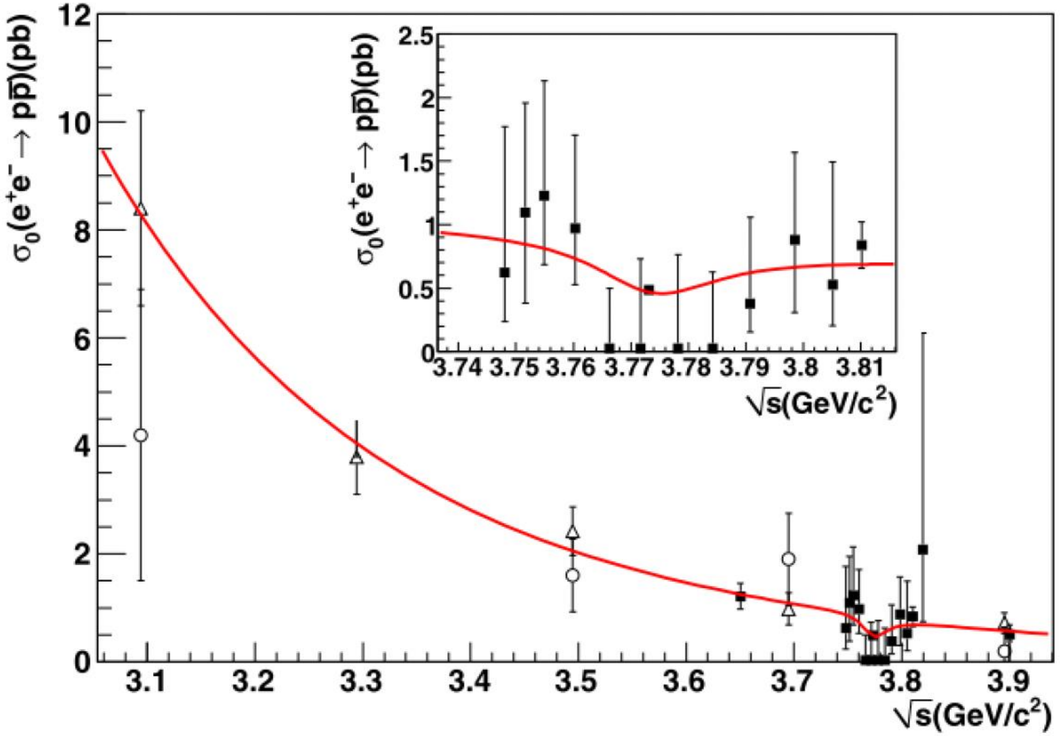
ψ'' measurements @BESIII

Scan method and measurement

BESIII Collaboration, Phys. Lett. B 735, 101 (2014)

$e^+e^- \to \psi(3770) \to p\bar{p}$

Destructive interference observed, fit with BABAR +BESIII data



$$\sigma_{con}(s) = \frac{4\pi\alpha^2 v}{3s}\left(1+\frac{2m_p^2}{s}\right)|G(s)|^2,$$

$$|G(s)| = \frac{C}{s^2 \ln^2(s/\Lambda^2)}.$$

$$\sigma(s) = \left|A_{con} + A_\psi e^{i\phi}\right|^2 = \left|\sqrt{\sigma_{con}(s)} + \sqrt{\sigma_\psi}\frac{m_\psi \Gamma_\psi}{s - m_\psi^2 + i m_\psi \Gamma_\psi} e^{i\phi}\right|^2$$

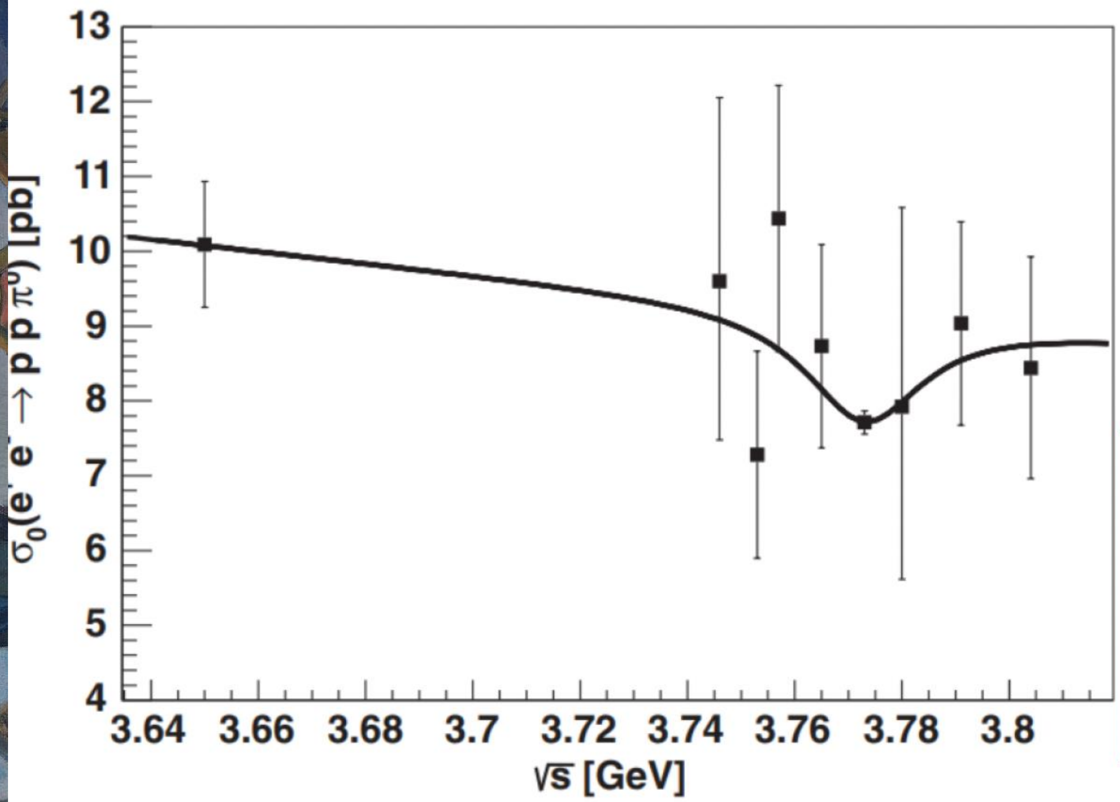
$\sigma^{dressed}_{(\psi(3770)\to p\bar{p})}$ (pb)	$Br(\times 10^{-4})$	$\phi(^\circ)$
$0.059^{+0.070}_{-0.020} \pm 0.012$ (< 0.166 at 90% C.L.)	$7.1^{+8.6}_{-2.9}$	$255.8^{+39.0}_{-26.6} \pm 4.8$
$2.57^{+0.12}_{-0.13} \pm 0.12$	3.1 ± 0.3	$266.9^{+6.1}_{-6.3} \pm 0.9$

Even the interference is between A_{con} and A_ψ, the phase $\Phi_{3g,\gamma}$ is still close to -90° since A_g is much larger than A_γ

Scan method and measurement

BESIII Collaboration, Phys. Rev. D 90, 032007 (2014)

$e^+e^- \to \psi(3770) \to p\bar{p}\pi^0$



$$\sigma(s) = \left| \sqrt{\sigma_{\rm con}} + \sqrt{\sigma_\psi} \frac{m\Gamma}{s - m^2 + im\Gamma} \exp(i\phi) \right|^2$$

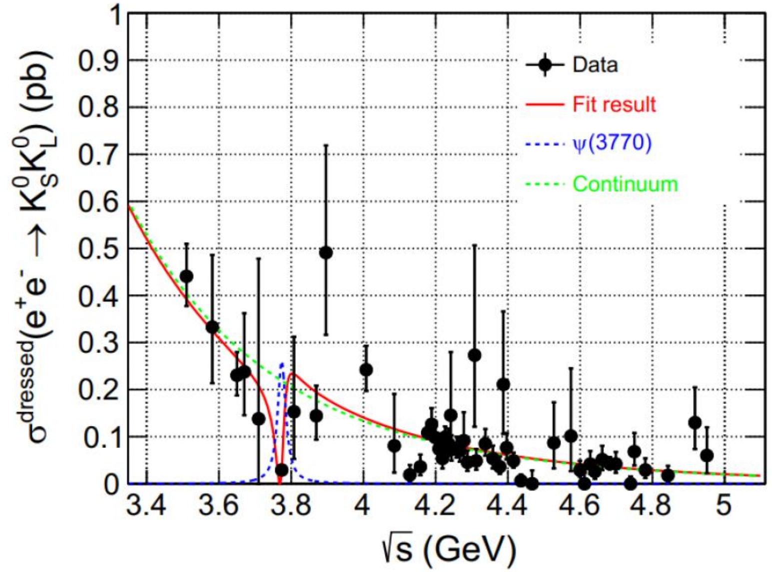
Solution	$\sigma_0^{\psi(3770)\to p\bar{p}\pi^0}$ [pb]	$\phi_{\rm Fit}$ [°]	$\sigma_0^{p\bar{p}\to\psi(3770)\pi^0}$ [nb] at 5.26 GeV
1	< 0.22	$269.8^{+52.4}_{-48.0} \pm 11.0$	< 0.79
2	$33.8 \pm 1.8 \pm 2.1$	$269.7 \pm 2.3 \pm 0.3$	122 ± 10

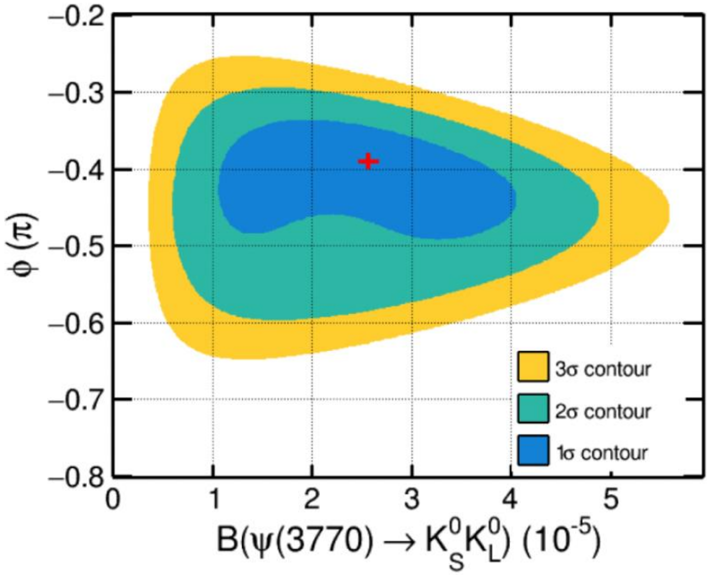
- The phase $\Phi_{3g,\gamma}$ is still close to -90° since A_g is much larger than A_γ
- Significance for $\psi(3770)$ resonance ~ $\mathbf{1.5}\ \boldsymbol{\sigma}$

Scan method and measurement

BESIII Collaboration, Phys. Rev. Lett. 132, 131901 (2024)

$e^+e^- \rightarrow \psi(3770) \rightarrow K_S K_L$





Fase=$(80^{+9}_{-18})^o$

$$\sigma^{\text{dressed}} = \left| BW \cdot e^{i\phi} + \frac{a}{(\sqrt{s})^n} \cdot \sqrt{\Phi(\sqrt{s})} \right|^2$$

$$BW = \frac{\sqrt{12\pi\Gamma_{ee}\Gamma B}}{s - M^2 + iM\Gamma} \sqrt{\frac{\Phi(s)}{\Phi(M)}}, \; \Phi(s) = \frac{q^3}{s}$$

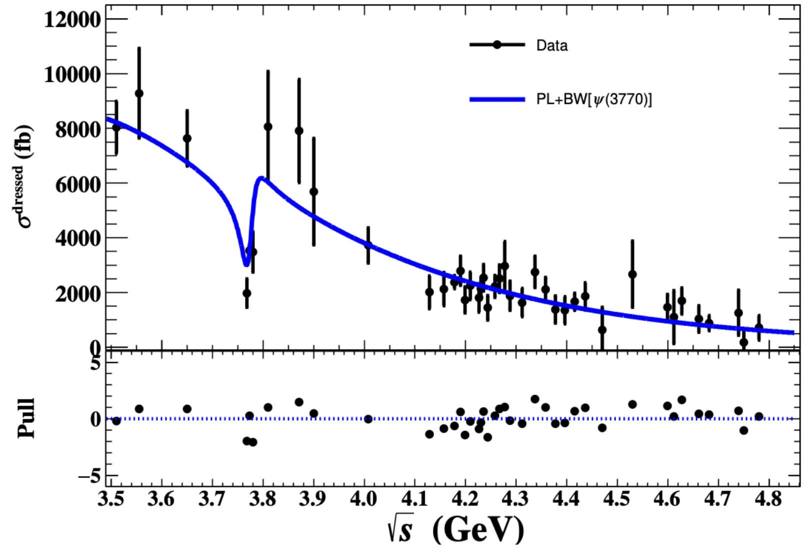
determine $a = (0.016 \pm 0.007)$ GeV$^{n-0.5}$ pb$^{0.5}$ and $n = 4.60 \pm 0.31$. By including the data at $\sqrt{s} = 3.774$ GeV

- $\mathcal{B} = (2.63^{+1.40}_{-1.59}) \times 10^{-5}$ and $\phi = (-0.39^{+0.05}_{-0.10})\pi$ within 1σ likelihood contour.
- Significance of $\psi(3770)$ resonance contribution determined to be $\mathbf{10\sigma}$.
- First observe the charmless decay $\psi(3770) \rightarrow K_S K_L$.

2024 result!!!!

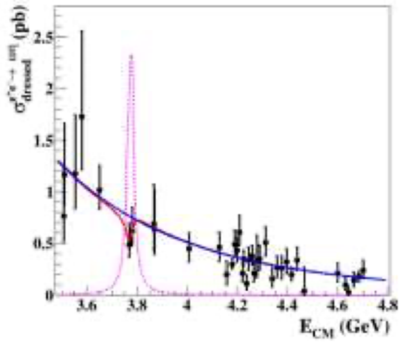
- Measurement of Born cross-section for $e^+e^- \to K^+\Xi^0\bar{\Sigma}^- + c.c.$ between 3.5 and 4.9 GeV
  Minghang Cai

https://docbes3.ihep.ac.cn/DocDB/0015/001590/001/memo_KXISIG_V1.00.pdf

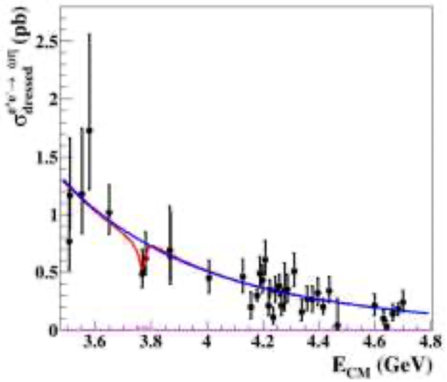


Resonance	$\Gamma_{ee}\mathcal{B}$ (10^{-3}eV)	ϕ (rad)	χ^2	$S\,(\sigma)$
$\psi(3773)$(Solution I)	17.8 ± 6.2	-0.80 ± 0.12	41.23	5.5
$\psi(3773)$(Solution II)	479.8 ± 20.3	-1.46 ± 0.04	41.17	5.5

$\psi(3770) \to \omega\eta$



$\Gamma_{ee}B$	$(6.65 \pm 0.48) \times 10^{-8}$
ϕ	-1.54 ± 0.16
a	0.55 ± 0.34
N	5.13 ± 0.46



$\Gamma_{ee}B$	$(7.67 \pm 4.16) \times 10^{-10}$
ϕ	-1.14 ± 0.98
a	0.54 ± 0.33
N	5.13 ± 0.45

Measurement of $e^+e^- \to \phi\eta'$ cross sections at center-of-mass energies from 3.508 to 4.951 GeV and search for the decay $\psi(3770) \to \phi\eta'$

https://journals.aps.org/prd/pdf/10.1103/PhysRevD.108.05

$$\sigma^{\mathrm{dressed}}(\sqrt{s}) = \left| \frac{a}{(\sqrt{s})^n} \sqrt{\mathrm{PS}(\sqrt{s})} + e^{i\Phi}\mathrm{BW}(\sqrt{s}) \right|^2,$$

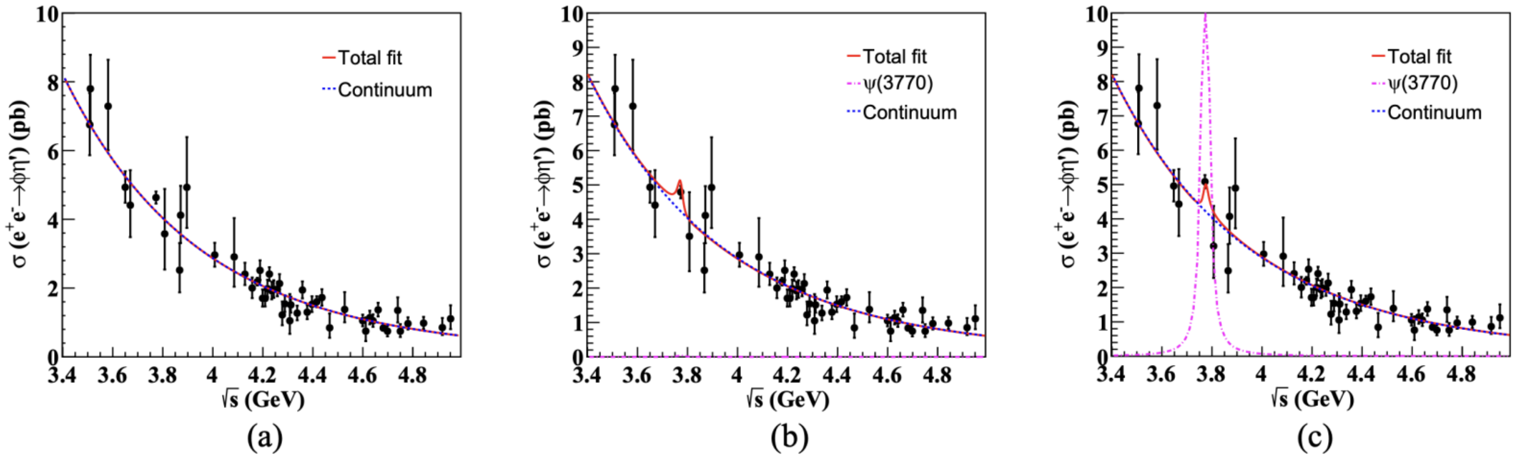
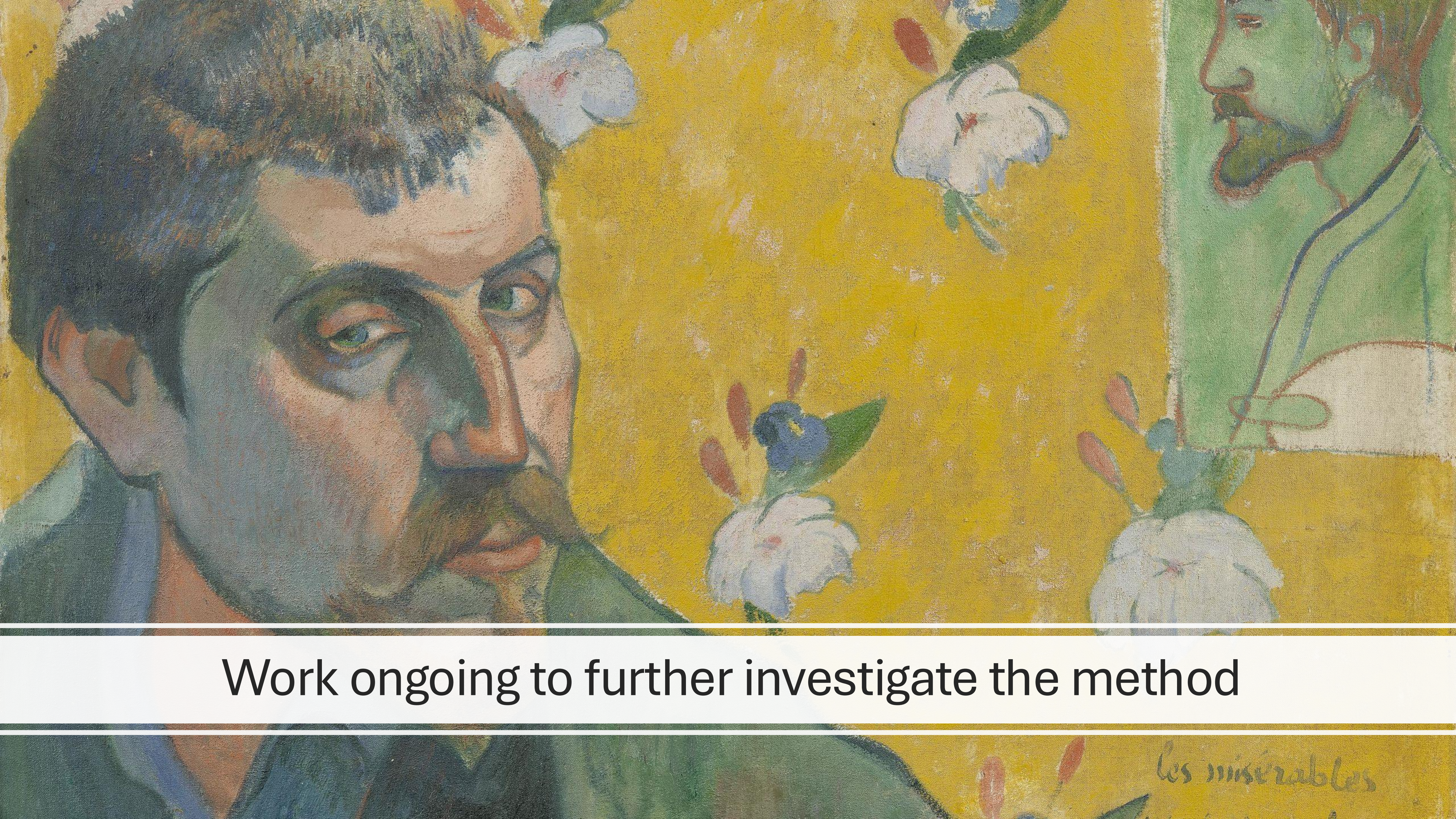


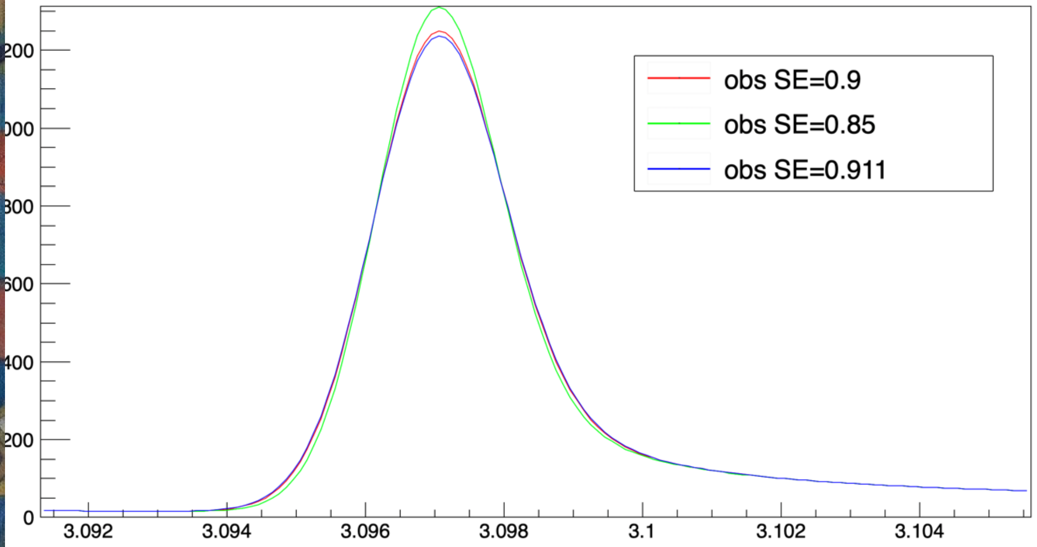
FIG. 3. Dressed cross sections of the $e^+e^- \to \phi\eta'$ process and the fits under different assumptions: (a) continuum amplitude only; (b) coherent sum of continuum and $\psi(3770)$ amplitudes, the solution with $\Phi = 2.0$ rad, $\mathcal{B}_{\phi\eta'} = 4.6 \times 10^{-6}$, and the significance of the $\psi(3770) \to \phi\eta'$ decay is 1.5σ; (c) coherent sum of continuum and $\psi(3770)$ amplitudes, the solution with $\Phi = 4.7$ rad, $\mathcal{B}_{\phi\eta'} = 1.9 \times 10^{-3}$, and the significance of the $\psi(3770) \to \phi\eta'$ decay is 1.6σ. The black dots with error bars are data. The red solid lines are the total fits, the magenta dot dashed lines represent the $\psi(3770)$ component, and the blue dashed lines the continuum process.

$$a = 1.97 \pm 0.40 (GeV^{n-0.5} pb^{0.5})$$
$$n = 4.35 \pm 0.14$$

$$\Phi = 1.49\, rad$$



Work ongoing to further investigate the method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obs SE=0.85
obs SE=0.911
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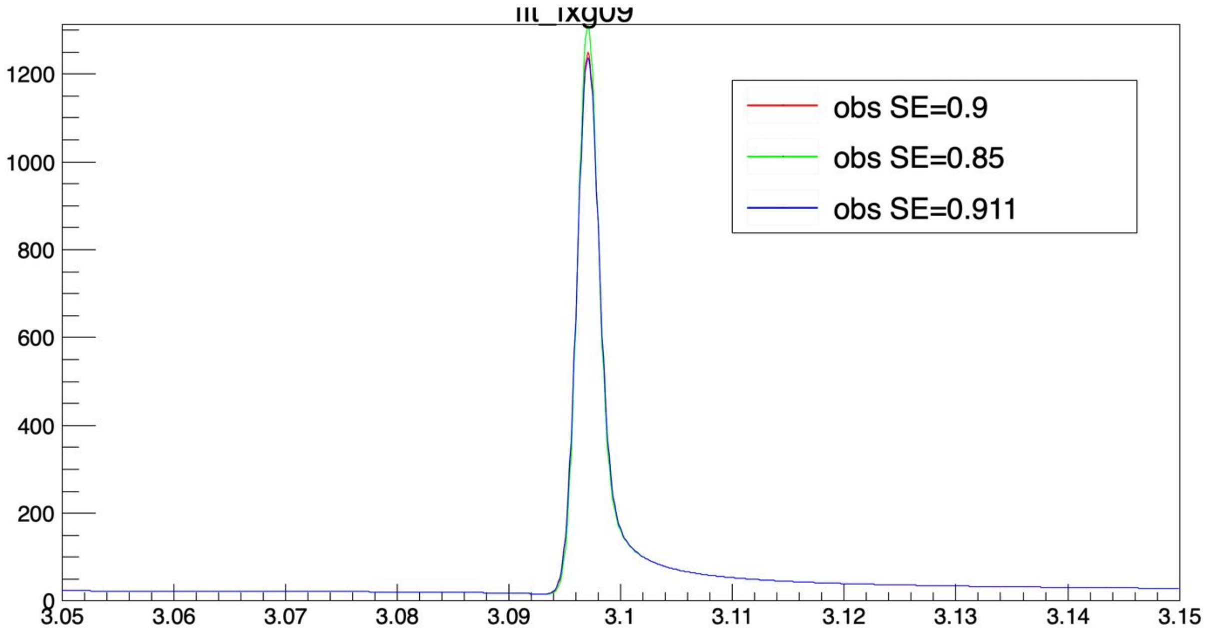
3.092
3.094
3.096
3.098
3.1
3.102
3.104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obs SE=0.85
obs SE=0.911
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1000
800
600
400
200
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3.06
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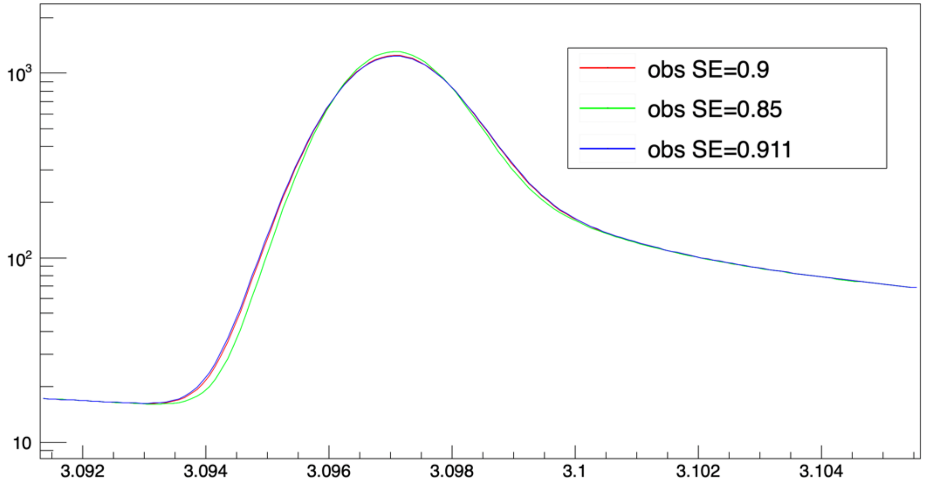
3.08
3.09
3.1
3.11
3.12
3.13
3.14
3.15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obs SE=0.85
obs SE=0.911
10^3
10^2
10
3.092
3.094
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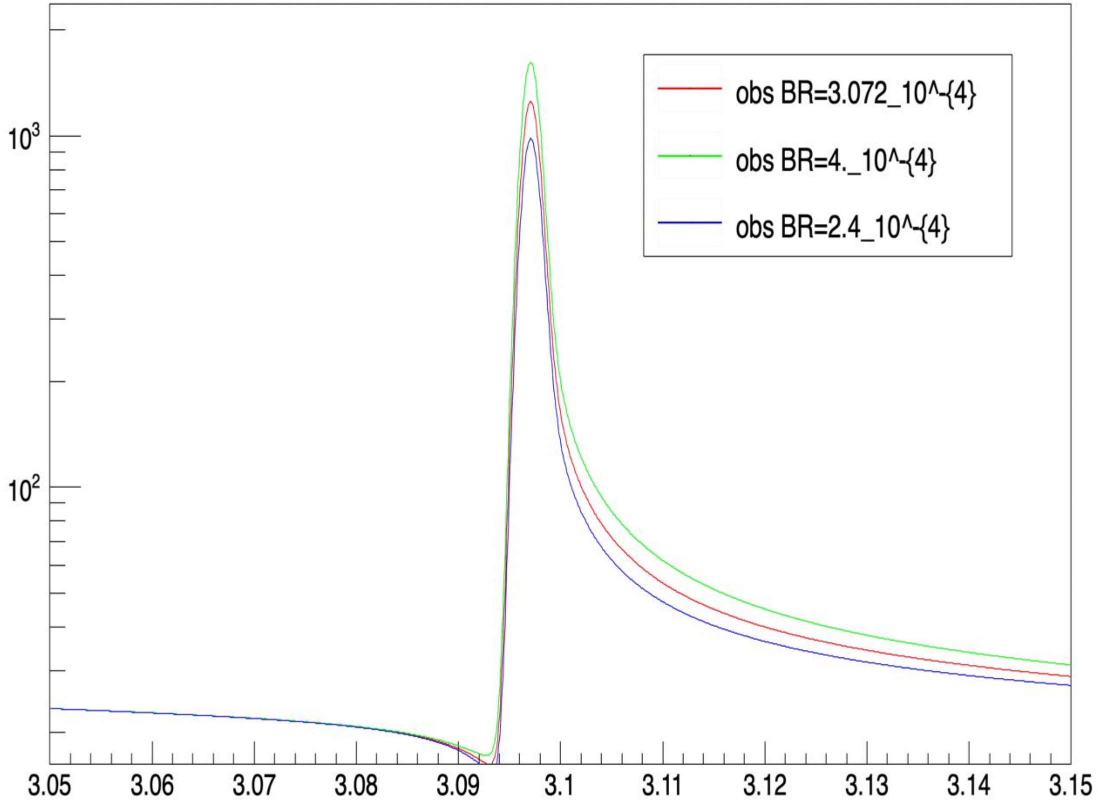
3.098
3.1
3.102
3.104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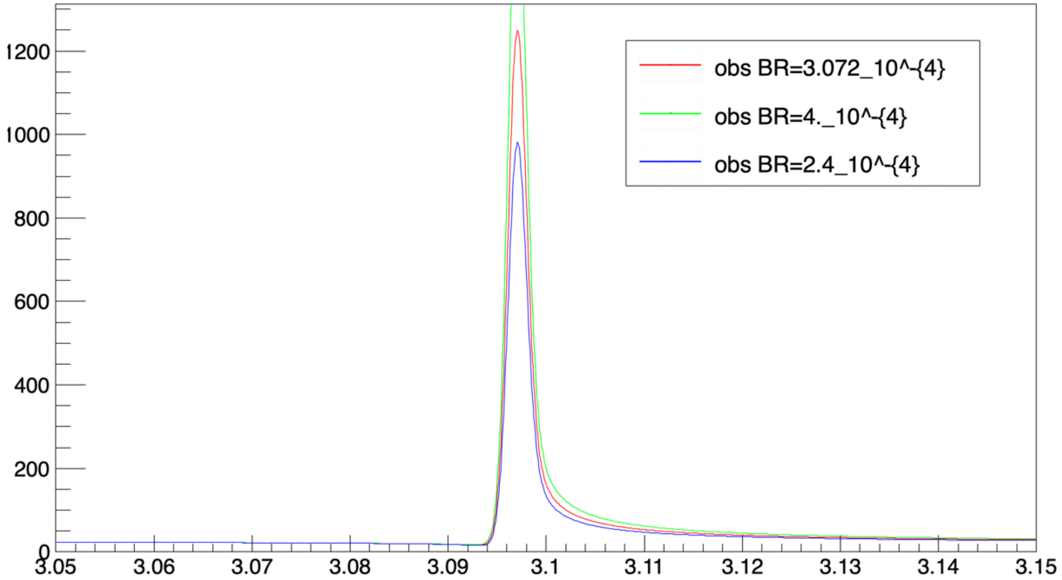
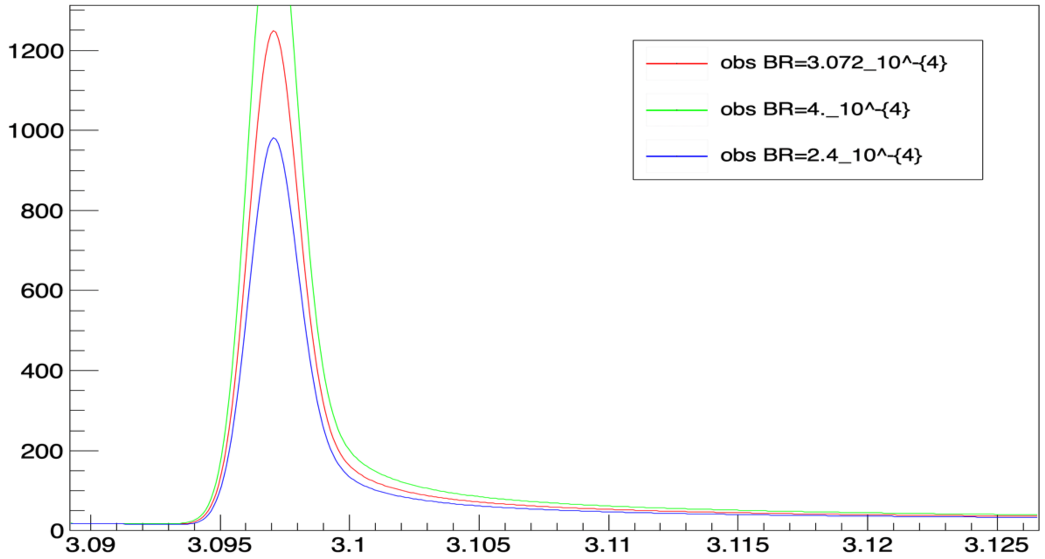
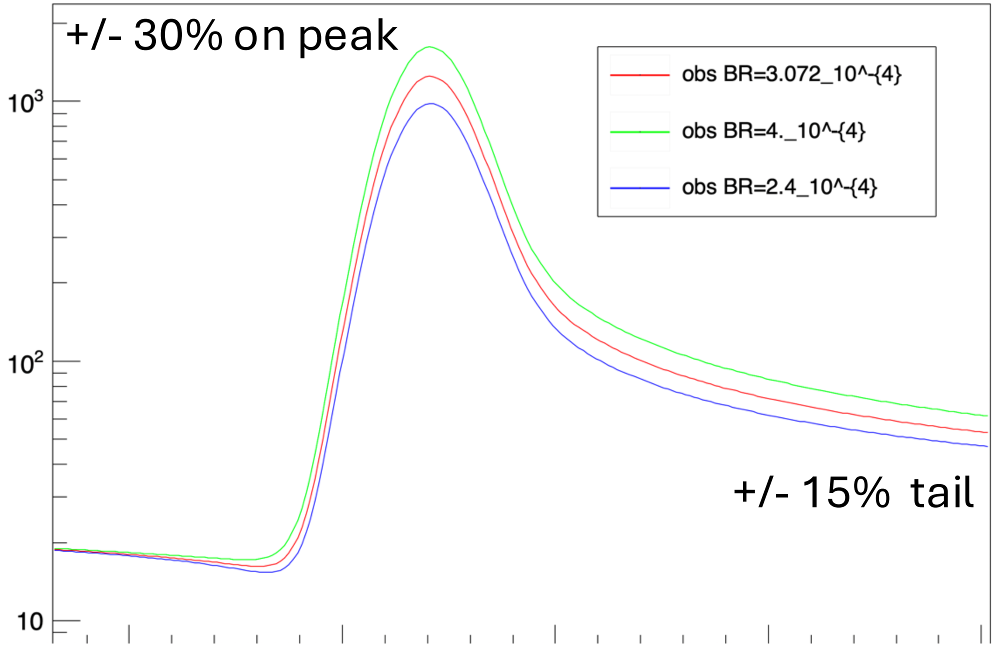
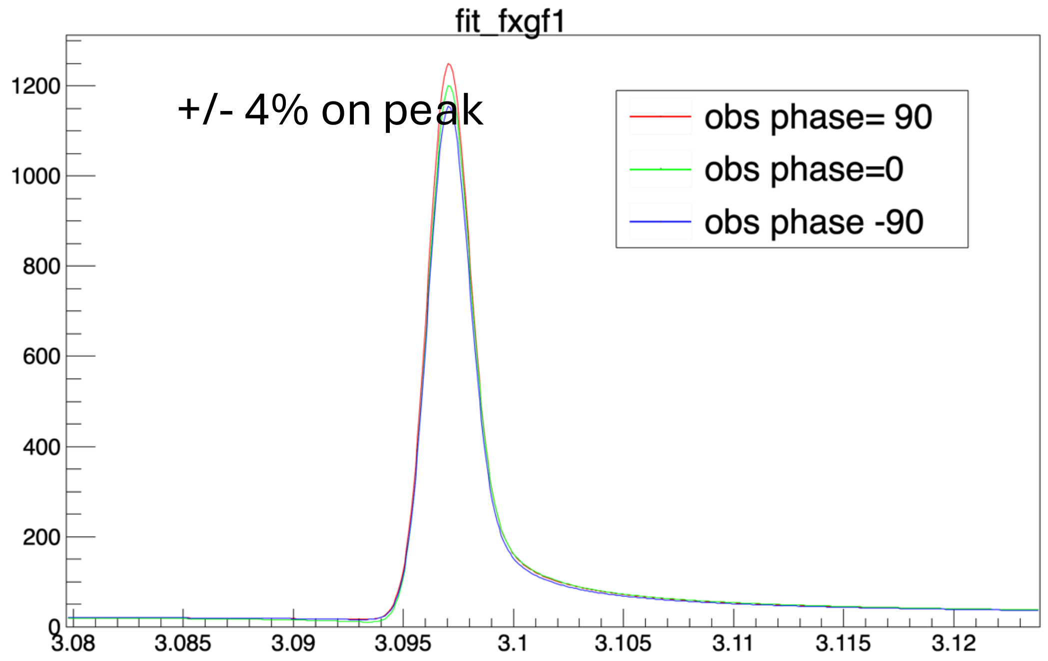
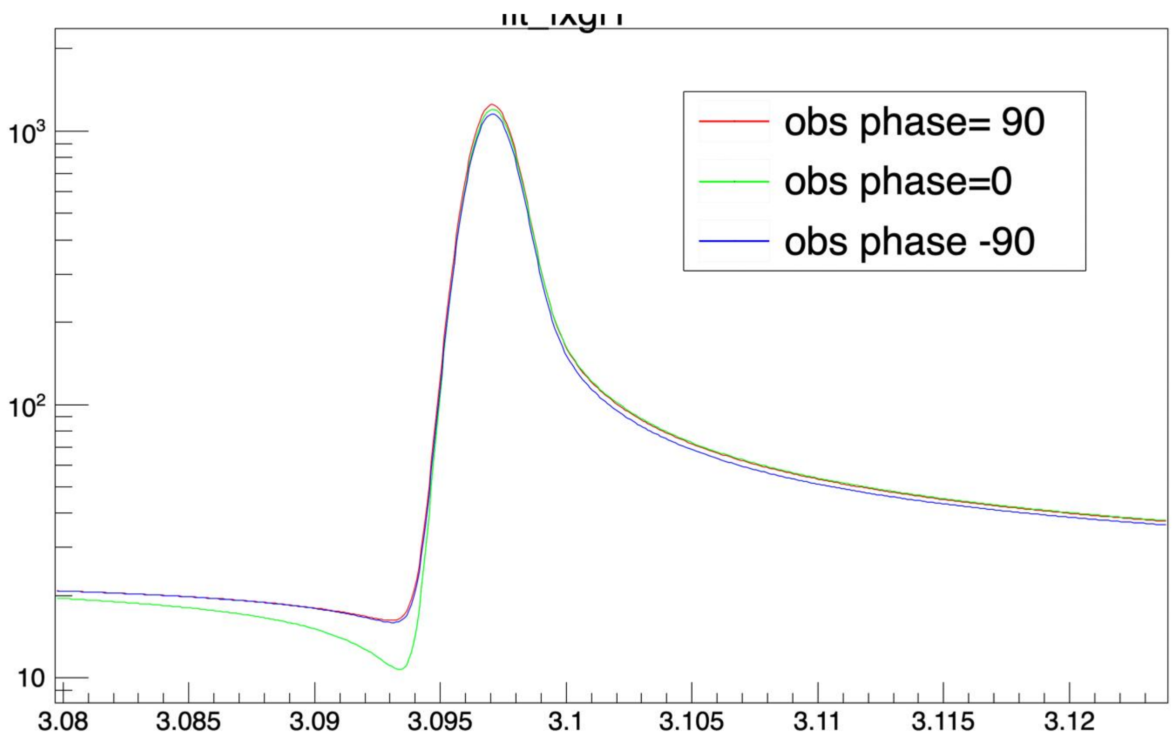
obs BR=4._10^-{4}
obs BR=2.4_10^-{4}
10^3
10^2
3.05 3.06 3.07 3.08 3.09 3.1 3.11 3.12 3.13 3.14 3.15


obs BR=3.072_10^-{4}
obs BR=4._10^-{4}
obs BR=2.4_10^-{4}
1200 1000 800 600 400 200 0
3.05 3.06 3.07 3.08 3.09 3.1 3.11 3.12 3.13 3.14 3.15


obs BR=3.072_10^-{4}
obs BR=4._10^-{4}
obs BR=2.4_10^-{4}
1200 1000 800 600 400 200 0
3.09 3.095 3.1 3.105 3.11 3.115 3.12 3.125


+/- 30% on peak
obs BR=3.072_10^-{4}
obs BR=4._10^-{4}
obs BR=2.4_10^-{4}
10^3
10^2
10
+/- 15% tail





In realta' ..qui a parita' di BF, ma il BF cambia con la fase

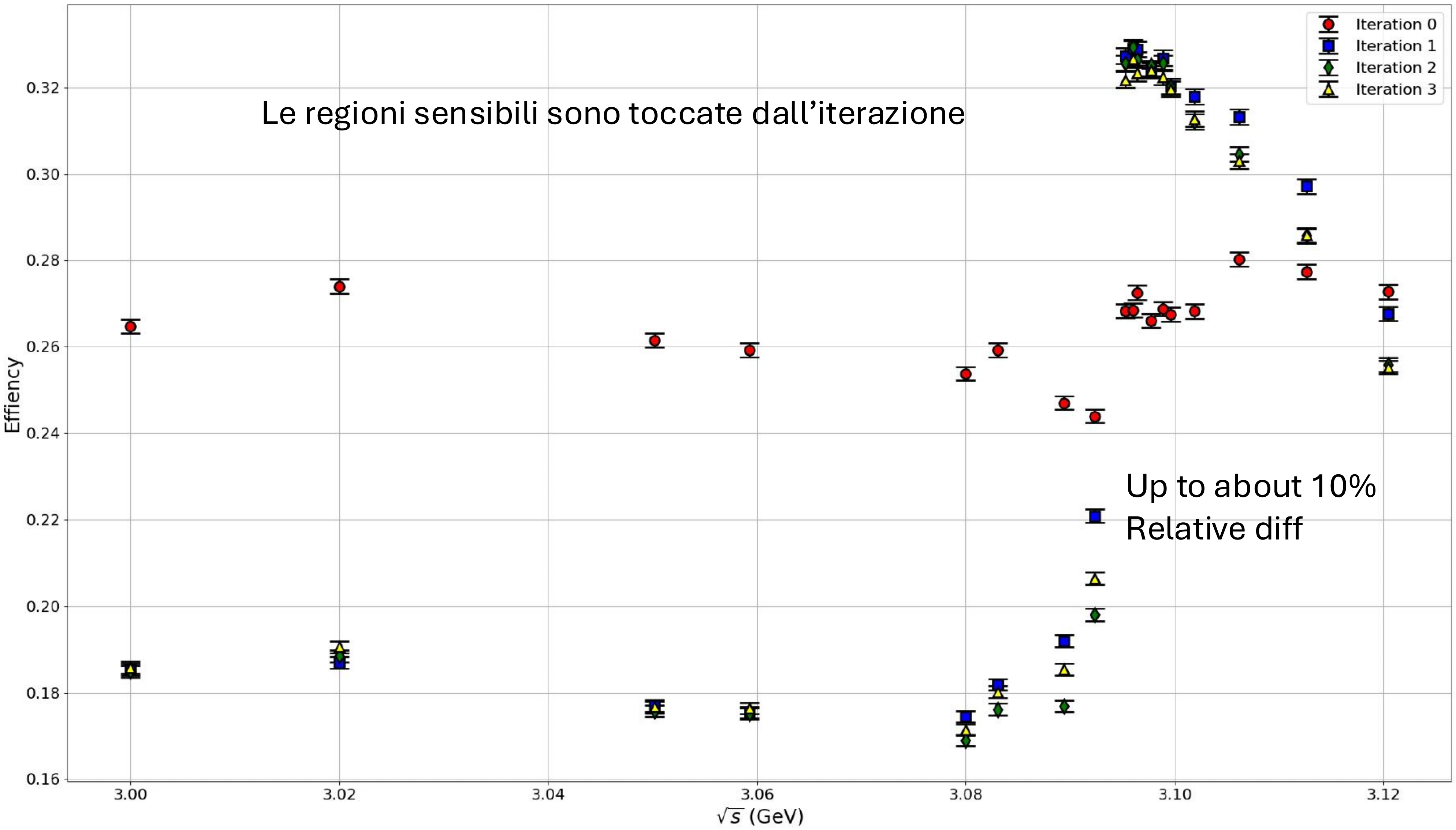
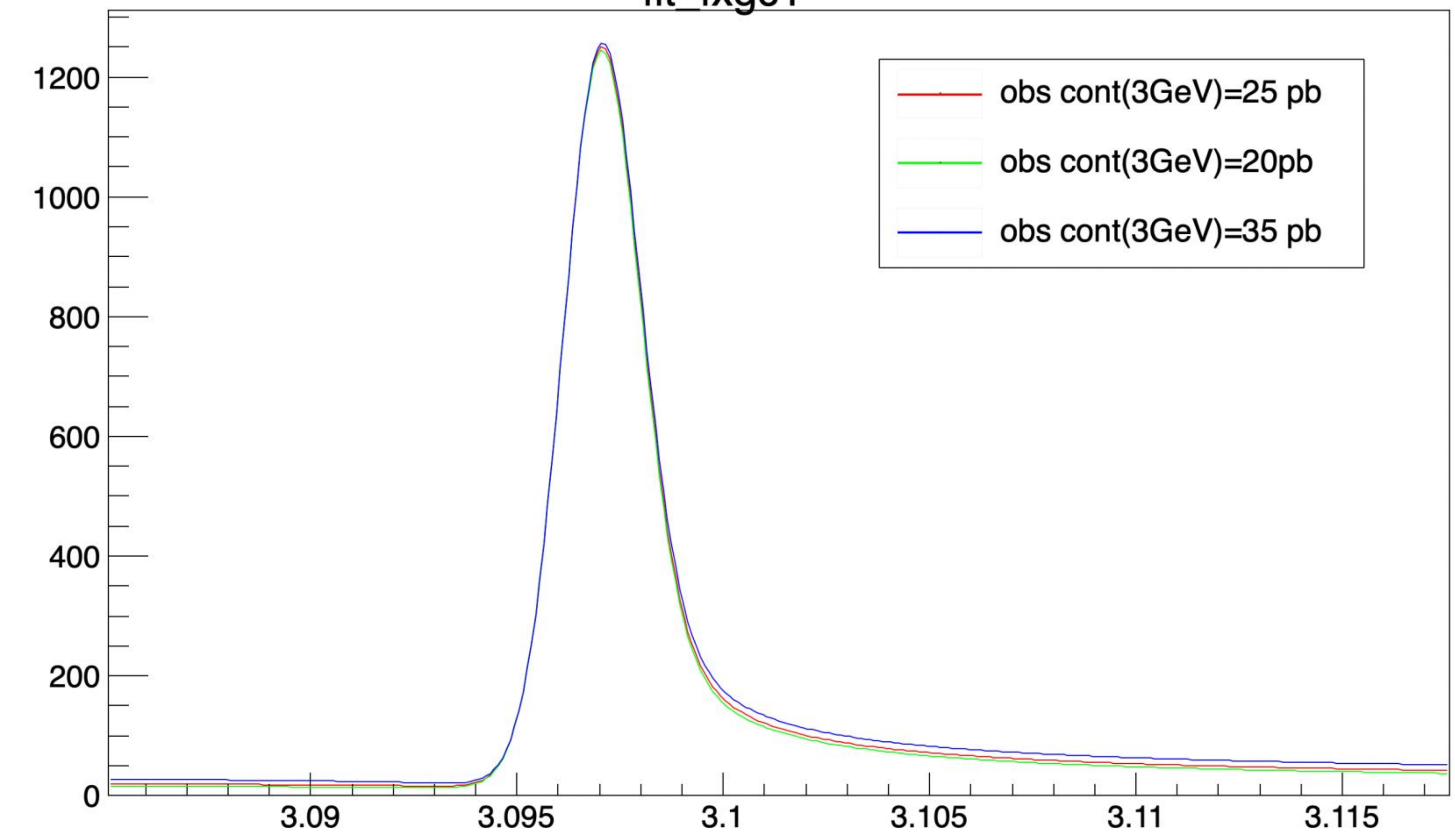
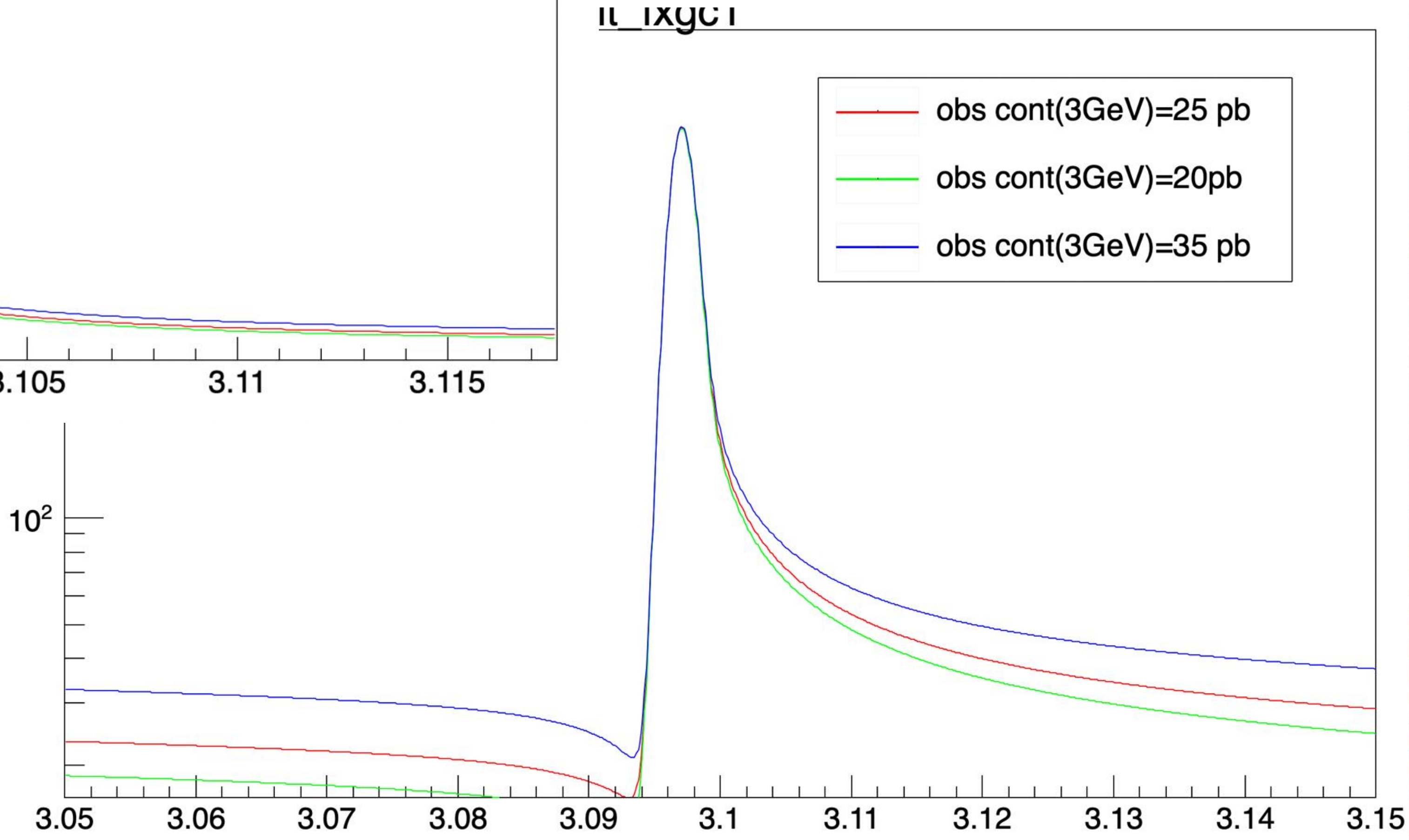


Fig. 12: The comparisons of efficiencies for $e^+e^- \to K^+K^-\pi^0$ in each iteration.


obs cont(3GeV)=25 pb
obs cont(3GeV)=20pb
obs cont(3GeV)=35 pb
0
200
400
600
800
1000
1200
3.09
3.095
3.1
3.105
3.11
3.115


obs cont(3GeV)=25 pb
obs cont(3GeV)=20pb
obs cont(3GeV)=35 pb
10^2
3.05
3.06
3.07
3.08
3.09
3.1
3.11
3.12
3.13
3.14
3.15

The problem of lack of documentation

Some groups use Born xs with SE effect as input to Conexc-->
<u>This has to be done because SE seems to be simulated but is not!</u>

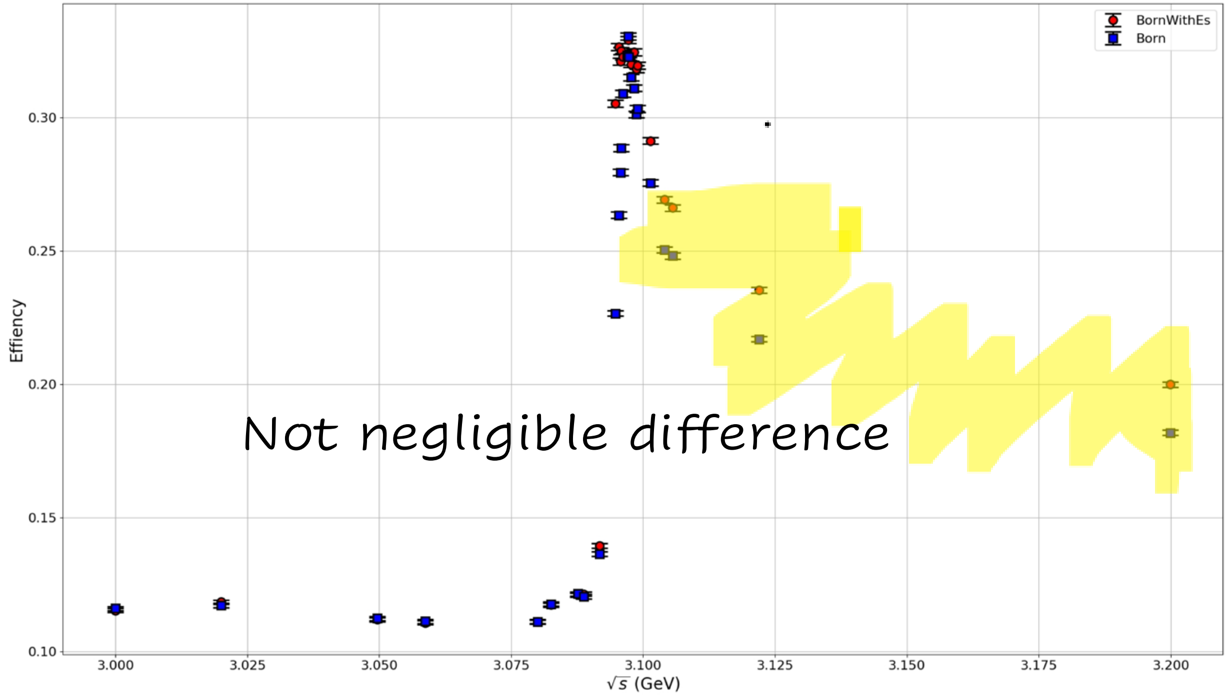
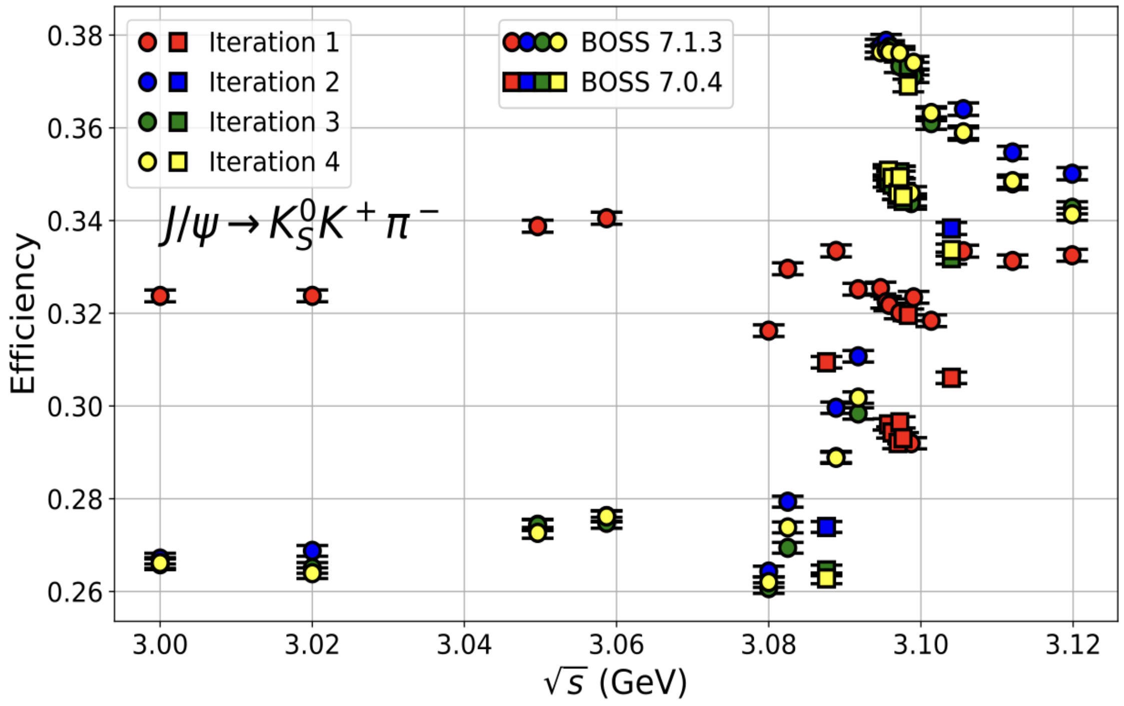
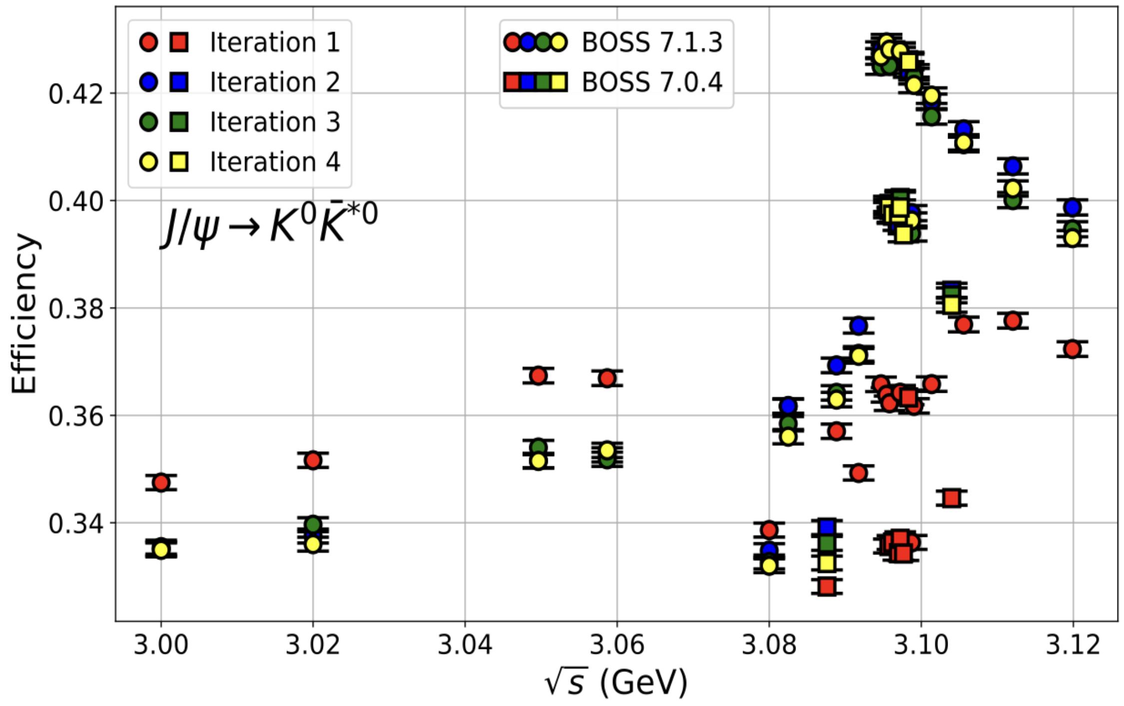


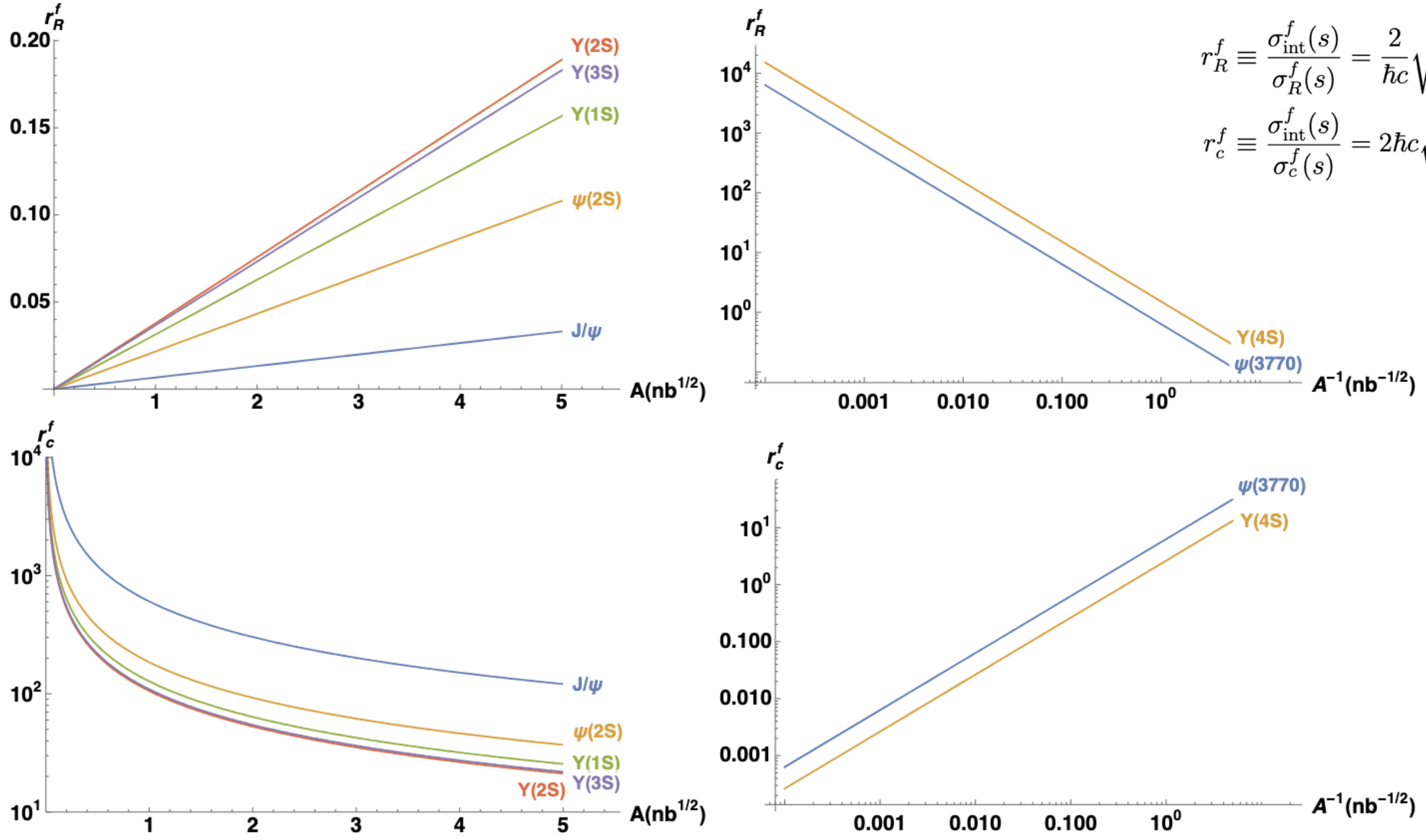
Figure 1: The comparisons of efficiencies for $e^+e^- \to K^+K^-\pi^0$ of input cross section as Born with energy spread effect and Born.





The issue of different boss versions

Ricordiamoci



$$r_R^f \equiv \frac{\sigma_{\rm int}^f(s)}{\sigma_R^f(s)} = \frac{2}{\hbar c}\sqrt{\frac{\sigma_c^f(s)}{\mathcal{B}_f}}\frac{M}{\sqrt{12\pi\mathcal{B}_{ee}}}\sin\varphi \equiv \frac{2}{\hbar c}AB\sin\varphi,$$

$$r_c^f \equiv \frac{\sigma_{\rm int}^f(s)}{\sigma_c^f(s)} = 2\hbar c\sqrt{\frac{\mathcal{B}_f}{\sigma_c^f(s)}}\frac{\sqrt{12\pi\mathcal{B}_{ee}}}{M}\sin\varphi \equiv 2\hbar c A^{-1}B^{-1}\sin\varphi.$$

ratio of cross section
from the interference term
with respect to the resonance
and continuum term,

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

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

Summary

- Results and on going analyses were presented
- On going studies on the analyses methods were presented as well
- A lot of work to follow the on-going analyses is needed
- The effect can be large, the precision is high…the check needs to be done

Thanks!!!!