Phase Measurement Task Force Report ..and KK phase reloaded

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.
- The group meetings are scheduled usually once a month
- They have started in March.
- The list and material of the meetings are available @ https://indico.ihep.ac.cn/category/820/
- Zoom meetings (till now Simone, Alessio, Giulio, Rinaldo invited)->if interested, please ask!!!

List of the analyses I

- <u>Relative phase angle measurement for:</u>

- J/ψ -> $\Sigma^+\bar{\Sigma}^-$
- J/ψ -> $\Sigma^0\bar{\Sigma}^0$
- ψ(2S)-> $\Sigma^0\bar{\Sigma}^0$
- ψ(2S)-> $\Sigma^+\bar{\Sigma}^-$
- ψ(2S)->K^+K^-
- ψ(2S)-> pi+pi-J/psi
- ψ(2S)-> $\Lambda\bar{\Lambda}$
- Ψ(2S) -> $\Xi^+\bar{\Xi}^-$
- J/ψ -> $\pi^0\omega$ ALESSIO
- J/ψ ->$p\ \bar{p}$ (in RC)
- J/ψ ->K^+K^- (in standby)

Status of of $J/\psi \to \Sigma^+\bar{\Sigma}^-$ Decay

By Jiajun Liu

Fittano 15 punti alla jpsi ..manca 3079.649. check needed!

Channel: $e^+e^- \to \Sigma^+\bar{\Sigma}^-$(Subsequent Decays:$\Sigma^+ \to p\pi^0; \bar{\Sigma}^- \to \bar{p}\pi^0$)

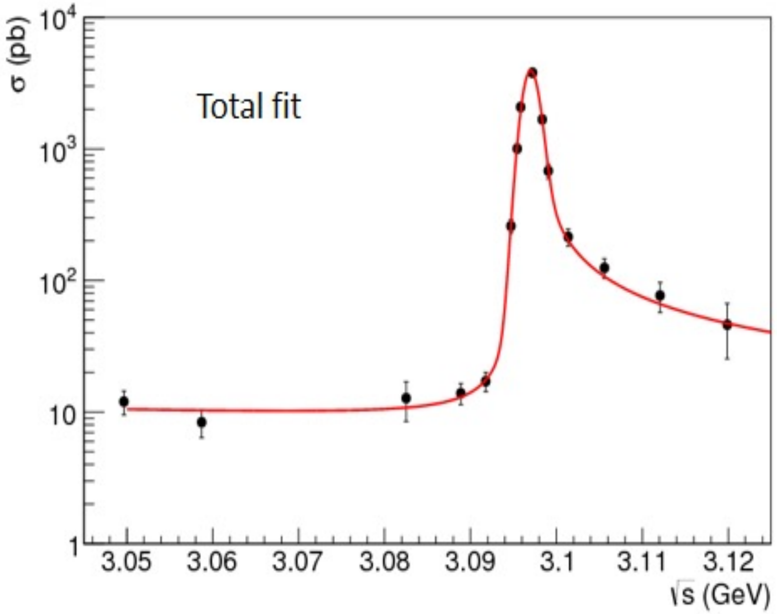
- **2C fit imposed by missing π^0 to get the signal efficiency**

- **Fitting Result**

PDG: **$(1.50\pm0.24)*10^{-3}$**
This Work: **$(1.21\pm0.04)*10^{-3}$**

Solution	Strong	Continuum	$\Delta\Phi_{3g,\gamma}{}^\circ$	S_E (MeV)	BF($J/\psi \to \Sigma^+\bar{\Sigma}^-$)	χ^2/ndf
positive	686.9±35.6	919.3±81.3	101.2±14.7	0.92±0.03	$(1.21\pm0.04)*10^{-3}$	4.0/11.0

Normalization unclear



Summary and next to do:

- ❑ The phase study of **$J/\psi \to \Sigma^+\bar{\Sigma}^-$** is partially completed and the current BF result is deviated from PDG value but consistent with BESIII within 2σ.
- ❑ Systematic uncertainty is on-going.
- ❑ Memo is being prepared.

Table 6. Approximate values of moduli of the ratios between sub-amplitudes $\mathscr{A}^{\gamma}_{\mathscr{B}\overline{\mathscr{B}}}$ and $\mathscr{A}^{ggg}_{\mathscr{B}\overline{\mathscr{B}}}$ (second column), and between $\mathscr{A}^{gg\gamma}_{\mathscr{B}\overline{\mathscr{B}}}$ and $\mathscr{A}^{ggg}_{\mathscr{B}\overline{\mathscr{B}}}$ (third column).

$\mathscr{B}\overline{\mathscr{B}}$	$\lvert\mathscr{A}^{\gamma}_{\mathscr{B}\overline{\mathscr{B}}}/\mathscr{A}^{ggg}_{\mathscr{B}\overline{\mathscr{B}}}\rvert$	$\lvert\mathscr{A}^{gg\gamma}_{\mathscr{B}\overline{\mathscr{B}}}/\mathscr{A}^{ggg}_{\mathscr{B}\overline{\mathscr{B}}}\rvert$
$\Sigma^0\overline{\Sigma}^0$	~0.09	0
$\Lambda\overline{\Lambda}$	~0.07	0
$p\overline{p}$	~0.20	~0.1
$n\overline{n}$	~0.14	0
$\Sigma^+\overline{\Sigma}^-$	~0.25	~0.1
$\Sigma^-\overline{\Sigma}^+$	~0.07	~0.1
$\Xi^0\overline{\Xi}^0$	~0.15	0
$\Xi^-\overline{\Xi}^+$	~0.06	~0.1

We should influence these studies

S/C

Strong and electromagnetic amplitudes of the J/ψ decays into baryons and their relative phase

https://arxiv.org/abs/1905.01069v1 Simone, Alessio, Rinaldo et al

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

$\mathcal{B}\overline{\mathcal{B}}$	$\lvert\mathcal{S}_{\mathcal{B}\overline{\mathcal{B}}}\rvert \times 10^3$	$\lvert\mathcal{A}^{\gamma}_{\mathcal{B}\overline{\mathcal{B}}}\rvert \times 10^4$	$\varphi_{\mathcal{B}\overline{\mathcal{B}}}$
$\Sigma^0\overline{\Sigma}^0$	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	$\pi - \varphi$

Prediction for strong and
Em amplitudes available
(Simone? Alessio?)
And on phase sign??

Strong and electromagnetic amplitudes of the J/ψ **decays into baryons and their relative phase**

We can argue the same continuum amplitude for sigma 0 sigma0bar and lambda lambdabar
Same continuum for ppbar and sigma+ sigma-bar???

Other result from BESIII (Liang Liu et al USTC)

A mDIY MC are generated according to the $\alpha_{J/\psi}$, $\Delta\Phi$ and $\alpha_{\pm}$ to estimate the selection efficiecny. The efficiency is corrected to the real data according to w_{total}.
The branching fraction of $J/\psi \to \Sigma^-\bar{\Sigma}^+$ is calculated according to

$$\mathscr{B}(J/\psi \to \Sigma^-\bar{\Sigma}^+) = \frac{N_{\rm sig}}{\varepsilon \times N_{\rm total} \times \Pi_i \mathscr{B}_i} = (15.055 \pm 0.016) \times 10^{-4}$$

The updated result with new method are consistent with our previous result $\mathscr{B}(J/\psi \to \Sigma^-\bar{\Sigma}^+) = (1.481 \pm 0.0012 \pm 0.03) \times 10^{-3}$.

<u>Without interference effect….</u> +- 2S(gamma/2)C/D and +-2SE

O anche

$$\delta\mathcal{B} = 2\sqrt{\frac{\sigma_0}{\sigma_\psi}} A_s \sin\varphi. \qquad (10)$$

1.5 e-7 (??+-3 e-6)

Status of $J/\psi(\psi(2S) \to \Sigma^0\bar{\Sigma}^0)$

❑ $J/\psi \to \Sigma^0\bar{\Sigma}^0$

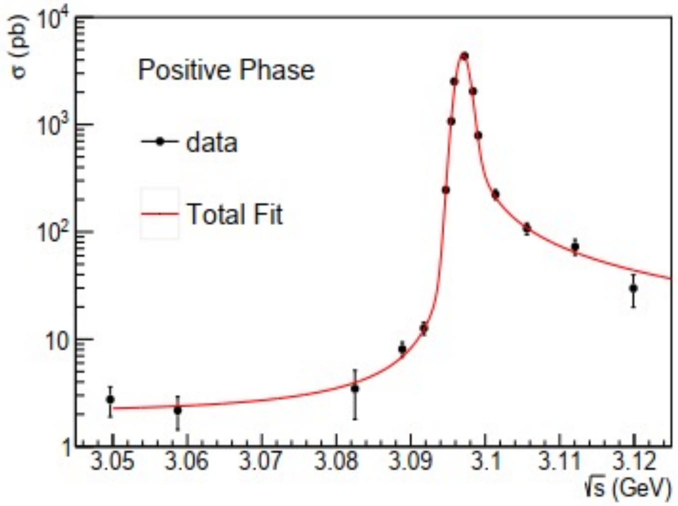
This Work

- **In PDG: BF =** $(1.172 \pm 0.031) \times 10^{-3}$
- **For +ve phase: BF** $=(1.403 \pm 0.086) \times 10^{-3}$
- **For -ve phase: BF** $=(1.421 \pm 0.083) \times 10^{-3}$
- Parameters are floating in fit such as; Strong, Continuum, $\Phi_{3g,\gamma}$ and S_E

Solution	$\Delta\Phi_{3g,\gamma}(^\circ)$	SE (MeV)	BF$(J/\psi \to \Sigma^0\bar{\Sigma}^0)$	χ^2/ndf
Sol-I	144.7 ± 33.7	0.885 ± 0.015	$(1.403 \pm 0.086) \times 10^{-3}$	20.6/11.0
Sol-II	-144.4 ± 33.5	0.885 ± 0.015	$(1.421 \pm 0.083) \times 10^{-3}$	20.6/11.0

Fitting results on J/ψ lineshape from $\Sigma^0\bar{\Sigma}^0$

Too low?



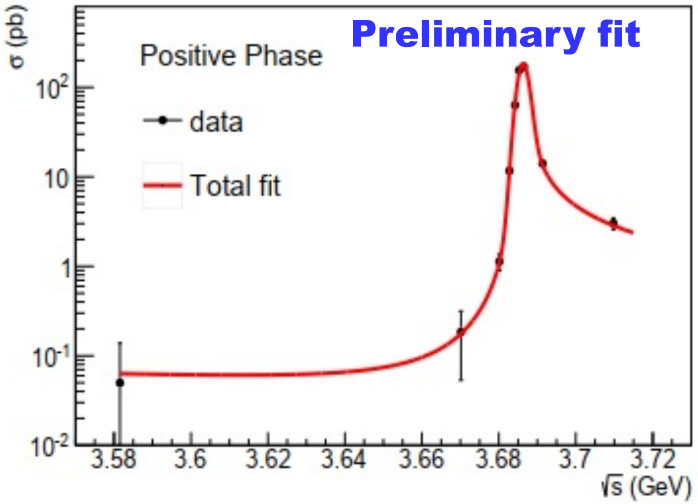
❑ $\psi(2S) \to \Sigma^0\bar{\Sigma}^0$

This Work

- **In PDG: BF =** $(2.35 \pm 0.09) \times 10^{-4}$
- **For +ve phase: BF** $=(2.94 \pm 0.06) \times 10^{-4}$
- **For -ve phase: BF** $=(2.99 \pm 0.05) \times 10^{-4}$
- Parameters are floating in fit such as; Strong, Continuum, $\Phi_{3g,\gamma}$ and S_E

Solution	$\Delta\Phi_{3g,\gamma}(^\circ)$	SE (MeV)	BF$(J/\psi \to \Sigma^0\bar{\Sigma}^0)$	χ^2/ndf
Sol-I	86.6 ± 28.0	1.36 ± 0.026	$(2.94 \pm 0.06) \times 10^{-4}$	18.09/5.0
Sol-II	86.6 ± 28.0	1.36 ± 0.026	$(2.94 \pm 0.06) \times 10^{-4}$	18.09/5.0

Fitting results on $\psi(2S)$ lineshape from $\Sigma^0\bar{\Sigma}^0$



BF from parameters variation   They are sistematically higher than PDG (20%)   By Muzzafar

Table 6

Strong (second column), EM (third column) and mixed (fourth column) BRs for the $\psi(2S)$ meson under the 2-R hypothesis.

$\mathcal{B}\overline{\mathcal{B}}$	$\mathrm{BR}^{ggg}_{\mathcal{B}\overline{\mathcal{B}}} \times 10^4$	$\mathrm{BR}^{\gamma}_{\mathcal{B}\overline{\mathcal{B}}} \times 10^5$	$\mathrm{BR}^{gg\gamma}_{\mathcal{B}\overline{\mathcal{B}}} \times 10^5$
$\Sigma^0\overline{\Sigma}^0$	2.01 ± 0.12	0.41 ± 0.79	0
$\Lambda\overline{\Lambda}$	4.22 ± 0.18	0.43 ± 0.81	0
$\Lambda\overline{\Sigma}^0$+ c.c.	0	1.25 ± 0.24	0
$p\overline{p}$	3.74 ± 0.14	0.207 ± 0.098	0.90 ± 0.33
$n\overline{n}$	3.73 ± 0.14	1.85 ± 0.35	0
$\Sigma^+\overline{\Sigma}^-$	2.02 ± 0.12	0.186 ± 0.088	0.043 ± 0.059
$\Sigma^-\overline{\Sigma}^+$	2.01 ± 0.12	0.73 ± 0.17	0.044 ± 0.060
$\Xi^-\overline{\Xi}^+$	3.31 ± 0.12	0.67 ± 0.16	0.80 ± 0.29
$\Xi^0\overline{\Xi}^0$	3.33 ± 0.12	1.50 ± 0.29	0

https://arxiv.org/pdf/2005.11265.pdf

Some cross checks

- Fist attempt test fitting bias tested with different approaches:

"Sampling Method" (old)

$$B(J/\psi \to \Sigma^0\bar{\Sigma}^0) = (1.30 \pm 0.05)\times 10^{-03}$$

$$\Delta\Phi = 136 \pm 25.9$$

Analytic Approach (to be refined)

$$B(J/\psi \to \Sigma^0\bar{\Sigma}^0) = \boxed{(1.33 \pm 0.86)}\times 10^{-03}$$

$$\Delta\Phi = (144.1 \pm 34.3)^o$$

The different approches seem topoint in the same direction.
(NDR or the error is propagated)

- ❑ For $J/\psi \to \Sigma^0\bar{\Sigma}^0$ study is completed. .
- ❑ Efficiency optimization for $\psi(2S) \to \Sigma^0\bar{\Sigma}^0$ analysis is done.
- ❑ Systematic study is on-going.
- ❑ Memo is being prepared.

The systematic difference in B needs further investigation
I/O check forseen

Private communication with Muzaffar.. On thursday

1	BR	1.41830e-03
2	phi_s	154.434
3	c_cn	1.88201e+00
4	spread	9.00378e-04

Copying parametrization from Marco's memo
REFERENCE is very important

Incertezza sul continuo al 100%

Status of $e^+e^- \rightarrow \Lambda\Lambda$ using ψ′ scan data

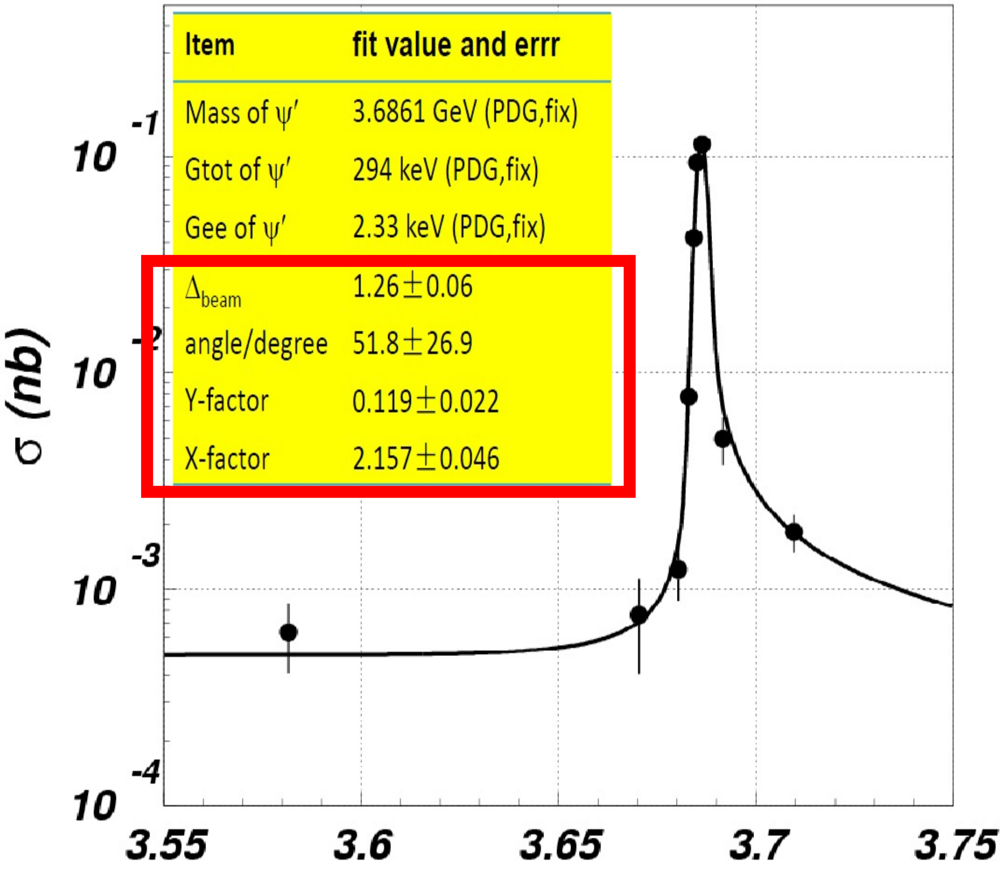
Preliminary results

X/Y=S/E

Needed S/C for comparisons..

BR is not given. Asked for, no answer!

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



- Optimization of event selection and systematic uncertainty are in progress

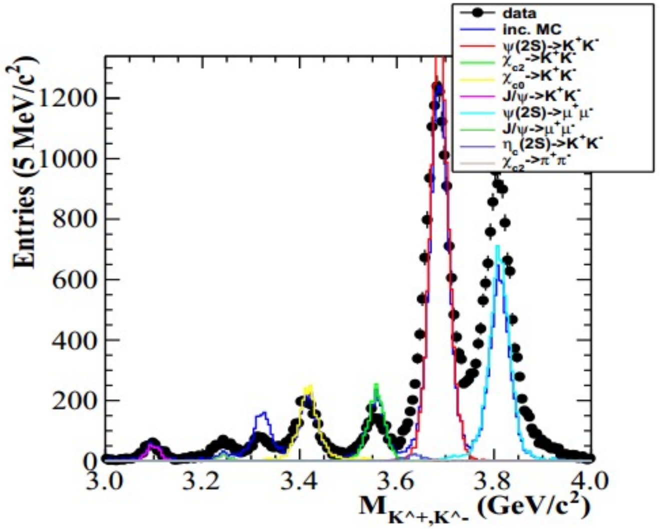
Status of $\psi(2S)$->K^+K^-

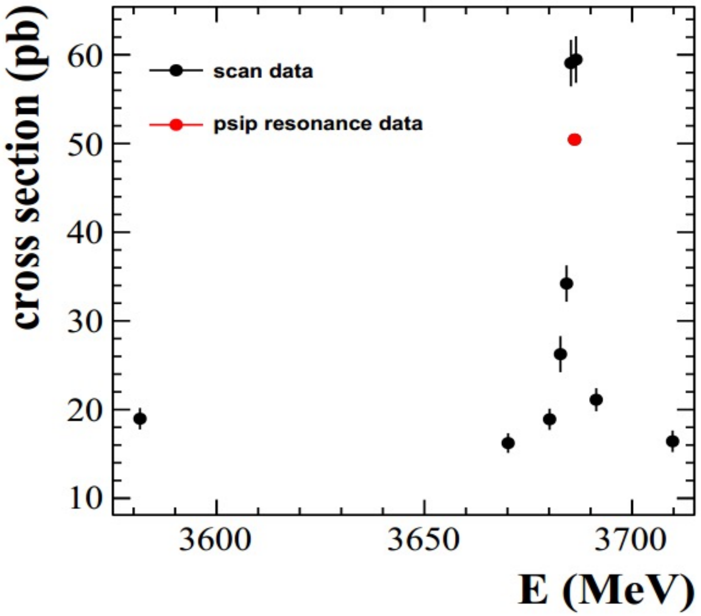
By Yadi (Wang)

Background analysis has been finished

- Bhabha, $\mu^+\mu^-$, $q\bar{q}$, $\pi^+\pi^-$, $p\bar{p}$ are analysed, only $\mu^+\mu^-$ contributes

- From inclusive MC, $J/\psi, \chi_{c0,c2}, \eta_c(2S) \rightarrow K^+K^-$ $and J/\psi \rightarrow \mu^+\mu^-$ contribute





The first tuning MC sample are generated, and more iteration are needed

- It should be interesting for comparison purposes with K+K- by J/psi

Status of $\psi(2S) \to \pi^+ \pi^- J/\psi$

By Giulio (Mezzadri)

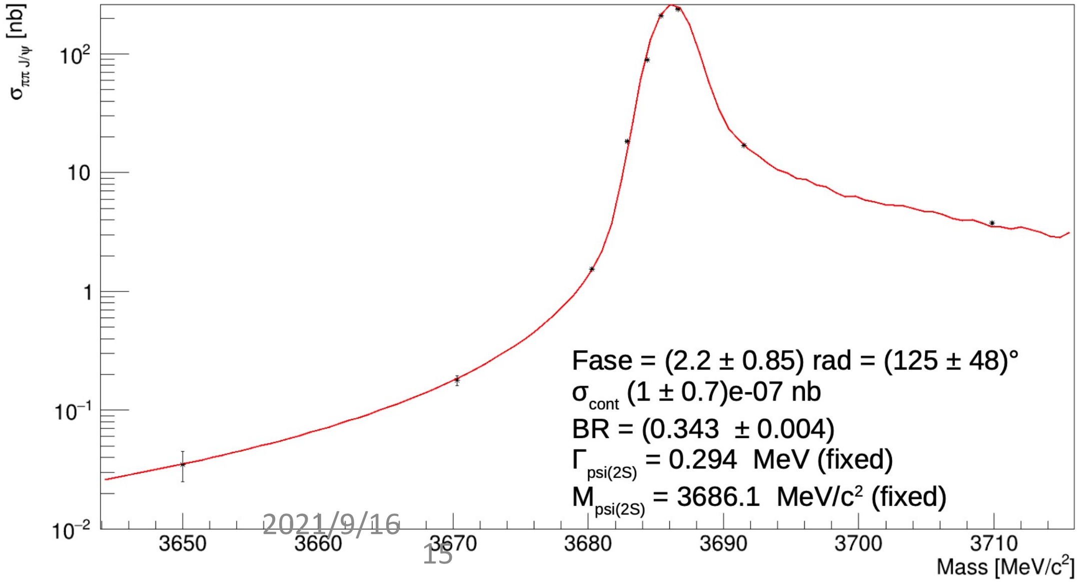
- Based on the experience at the J/psi, we know that, measured the cross sections, one shall be able to fit the data to the nominal values of mass and width of ψ(2S)
- Two parameters ought to be optimized to do so:
  - Center of mass spread
  - Global shift

PRESENTATION TODAY WITH THE UPDATES!!!

Found values:	Center of mass spread = 1.26 MeV Global shift = 0.127 MeV

SE in agreement with $\Lambda\bar{\Lambda}$

Fit!



Towards the best practice

- studies of generators (KKMC+Evtgen/Conexc/Babayaga….)
- study and comparison of the measurement methods→
- towards a strict collaboration and sharing.

- Up to now 3 methods, at least, available with differences in the chosen output parameters.
- The modified Babayga (not available for all channels) allows

- to iterate with the output parameters (FF, phase…)
- ISR, VP, Beam Energy spread at generator level can be important
- Yadi's check with the old sampling method (Rinaldo's fatherhood, Marco's development) shows compatible, but less precise results for the parameters after fitting.

Formalisms

- Different formalisms
- Same physical content
- Different ISR treatments (sampling, analytical-various approx)
- Different continuum treatment (power law,analytical)

BORN CROSS SECTION

The starting formula is the Born cross section of the process $e^+e^- \to h$

$$\sigma(W) = |\mathscr{A}(W)|^2 \,,$$

with the amplitude

$$\mathscr{A}(w) = D\frac{Se^{i\phi}+E}{M-W-iG} - C\left(\frac{3\,\text{GeV}}{W}\right)^{\text{PWW}},$$

and the real and positive parameters

$$G=\Gamma/2\,, \qquad D=\frac{\Gamma/2}{M}\sqrt{12\pi B_{\text{in}}}\,, \qquad C=\sqrt{\sigma_{\text{cont}}}\,, \qquad E=\sqrt{C^2\frac{B_{\text{in}}}{\sigma_{\mu\mu}}}=\sqrt{\frac{\sigma_{\text{cont}}B_{\text{in}}}{\sigma_{\mu\mu}}}\,.$$

Continuum by power law

$$\sigma_0 = (3000)^{PWW}\sigma(3000)$$

Used by italian groups and USTC

PWW depends on the final state

Credits: Simone Pacetti

$$
\begin{aligned}
\sigma(W;B_{\text{out}},\phi,\sigma_{\text{cont}}) &= \text{Re}^2\left[\mathscr{A}(W)\right] + \text{Im}^2\left[\mathscr{A}(W)\right] \\
&= \left\{ D\frac{\left[\left(\sqrt{B_{\text{out}}-E^2\sin^2(\phi)}-E\cos(\phi)\right)\cos(\phi)+E\right](M-W)}{(M-W)^2+G^2} \right. \\
&\qquad \left. - D\frac{\left(\sqrt{B_{\text{out}}-E^2\sin^2(\phi)}-E\cos(\phi)\right)\sin(\phi)G}{(M-W)^2+G^2} - \sqrt{\sigma_{\text{cont}}}\left(\frac{3\,\text{GeV}}{W}\right)^3 \right\}^2 \\
&\qquad + \left\{ D\frac{\left(\sqrt{B_{\text{out}}-E^2\sin^2(\phi)}-E\cos(\phi)\right)\sin(\phi)(M-W)}{(M-W)^2+G^2} \right. \\
&\qquad \left. + D\frac{\left[\left(\sqrt{B_{\text{out}}-E^2\sin^2(\phi)}-E\cos(\phi)\right)\cos(\phi)+E\right]G}{(M-W)^2+G^2} \right\}^2 .
\end{aligned}
$$

Sampling method (but from Babayaga simulation)

For each $W = W_{ISR}$ the $\sigma(W_{ISR})$ is obtained from the formula previously defined and the visible cross section at the nominal energy E is obtained as

$$\sigma_{vis}^{calc}(E) = \frac{\sum_i^{N_s} \sigma(W_{ISR}^i) * w_{BB}^i}{N_{gen}}$$

where N_s is the number of selected events, N_{gen} is the number of generated events and $w_{i\ BB}$ is the weight of the i_{th} event obtained from MC sample (BB used for J/psi).

Fit of the visible cross section, efficiency taken into account inside the fitting algorithm.

To Fit the Line-Shape: To incorporating the the effect of radiative function $F(x, W)$ and Energy Spread S_E in the fit, the dressed Born cross section is modified as;

1. Incorporating the radiative correction $F(x, W)$:

$$\sigma'(W) = \int_0^{1-\left(\frac{W_{\min}}{W}\right)^2} dx F(x, W) \sigma(W\sqrt{1-x})$$

NOT FOUND IN THE ALGORITHM

2. Energy spread S_E is included by convolving with Gaussian function by set the width of S_E. The Born cross section becomes:

$$\sigma''(W) = \int_{W-nS_E}^{W+nS_E} \frac{1}{\sqrt{2\pi}S_E} \exp\left(\frac{-(W-W')^2}{2S_E^2}\right) \sigma'(W') \, dW$$

Observed xs

Minimization Function: The fitting parameters are obtained by means of χ^2-minimization as:

$$\chi^2_{\min} = \sum_{i=1}^{15} \frac{\left(\sigma_i^{\text{obs}} - \sigma''(W_i)\right)^2}{\left(\Delta\sigma_i^{\text{obs}}\right)^2 + \left[\left(\sigma''\left(W_i + \frac{\Delta W_i}{2}\right) - \sigma''\left(W_i - \frac{\Delta W_i}{2}\right)\right)\right]^2},$$

where error along X-axis, is projected along the Y-axis.

Credits: Muzaffar

Born Cross section:

For baryons

Credits:Yadi

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

where $\mathcal{C}$ is the ratio of $\frac{|A_g|}{|A_\gamma|}$

$\frac{\mathcal{A}}{W^2}$ is the form factor

Decay width J/psi to BBar

$$(\frac{\mathcal{A}}{W^2})^2\Gamma_{\mu\mu}|\mathcal{C}e^{i\Phi_{g,EM}} + 1|^2$$

Branching Fraction:

$$B(J/\psi \to B\bar{B}) = \Gamma_{BB}/\Gamma$$

Chi-square for Minimization:

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

Analytic Formula of radiation corrected cross section can be found → Physics Letters B 791 (2019) 375-384

Credits: ZHANG Jianyong

Another approach

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

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

∞

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

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

Chosen + sign

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

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

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

X/Y= S/E

More complicated S/C for comparison purposes

https://arxiv.org/abs/1505.03930v2

ISR HANDLING

$p\bar{p}\gamma$ analysis used

$$\frac{d\sigma_{p\bar{p}\gamma}(q^2)}{dq^2} = \frac{1}{s}W(s,x)\sigma_{p\bar{p}}(q^2),$$
$$W(s,x) = \frac{\alpha}{\pi x}(\ln\frac{s}{m_e^2} - 1)(2 - 2x + x^2), \quad (4)$$
$$x = \frac{2E_\gamma^*}{\sqrt{s}} = 1 - \frac{q^2}{s},$$

where E_γ^* is the ISR photon energy in the e^+e^- c.m. frame, $W(s,x)$ [21] is the radiator function which gives the probability of ISR photon emission and m_e is the electron mass.

$e^+e^- \to \pi^+\pi^-\pi^0\gamma_{ISR}$ analysis used

Credits (yadi)

The effective luminosity is related to the mass spectrum through

$$\frac{dL}{dm} = \frac{2\cdot m}{s}\cdot F(s,m)\cdot L, \quad (8)$$

where m is the $\pi^+\pi^-\pi^0$ mass, $s = 4E^2$, E is the beam energy, L is The integrated luminosity, and $F(s,m)$ is the probability function of the photon emission which can be written as [11]

$$\beta = \frac{2\cdot\alpha}{\pi}\cdot[ln(\frac{s}{m_e^2}) - 1],$$
$$x = 1 - \frac{m^2}{s},$$
$$\frac{dL}{dm} = \{\beta x^{\beta-1}[1 + \frac{\alpha}{\pi}(\frac{\pi^2}{3} - \frac{1}{2}) + \frac{3}{4}\beta + \beta^2(\frac{37}{96} - \frac{\pi^2}{12} - \frac{1}{72}ln\frac{s}{m_e^2})] - \beta(1 - \frac{1}{2}x)$$
$$+ \frac{1}{8}\beta^2\cdot[4(2-x)ln\frac{1}{x} - \frac{1+3(1-x)^2}{x}\cdot ln(1-x) - 6 + x]\}\cdot L, \quad (9)$$

where, $\alpha = \frac{1}{137}$ is the fine structure constant, $m_e = 0.5110034\times10^{-3}$ GeV$/c^2$ is the mass for electron, $\sqrt{s} = 3.773$ GeV is the center of mass energy for the primary e^+e^- system, s' is that after the ISR, and L is the total integrated luminosity.

wangping

$$\sigma'(W) = \int_0^{1-(\frac{W_{\min}}{W})^2} dx F(x,W)\sigma^0(W\sqrt{1-x}),$$

where $W_{\min}$ is the minimum invariant mass of the $\mu^+\mu^-$ system, $x = \frac{2E_\gamma}{\sqrt{s}}$, E_γ is the energy of the radiation photon, and $F(x,W)$ is approximated as [36]:

$$F(x,W) = x^{\beta-1}\beta\cdot(1+\delta) - \beta(1-\frac{x}{2}) + \frac{1}{8}\beta^2\Big[4(2-x)\ln\frac{1}{x} - \frac{1+3(1-x)^2}{x}\ln(1-x) - 6 + x\Big],$$

with $\delta = \frac{3}{4}\beta + \frac{\alpha}{\pi}(\frac{\pi^2}{3} - \frac{1}{2}) + \beta^2(\frac{9}{32} - \frac{\pi^2}{12})$ and $\beta = \frac{2\alpha}{\pi}(2\ln\frac{W}{m_e} - 1)$.

Phase measurement (wangyadi)

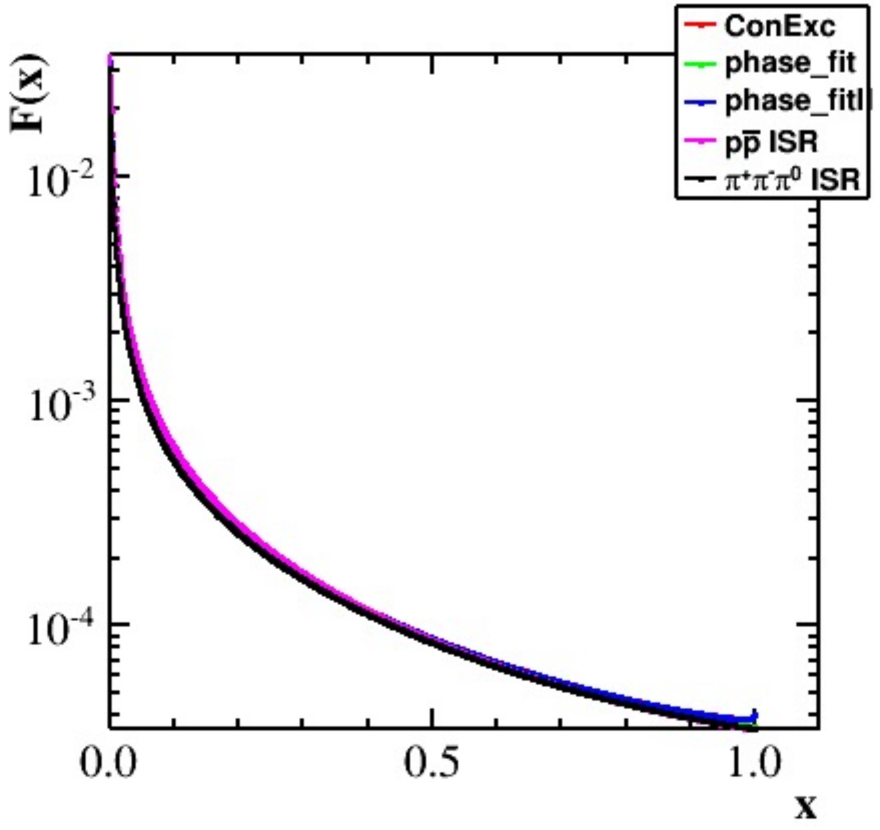
hotons. Let $1+\delta = 1 + \frac{\alpha}{\pi}(\frac{\pi^2}{3} - \frac{1}{2}) + \frac{3}{4}t + t^2(\frac{9}{32} - \frac{\pi^2}{12})$. $t = \frac{2\alpha}{\pi}(\ln\frac{s}{m_e^2} - 1)$.

$$F(x,s) = x^{t-1}\cdot t(1+\delta) + x^t(-t - \frac{t^2}{4}) + x^{t+1}(\frac{t}{2} - \frac{3}{8}t^2)$$

ConExc (pingronggang)

$$W(s,x) = \Delta\cdot\beta x^{\beta-1} - \frac{\beta}{2}(2-x) + \frac{\beta^2}{8}\{(2-x)[3\ln(1-x) - 4\ln x] - 4\frac{\ln(1-x)}{x} - 6 + x\},$$
$$L = 2\ln\frac{\sqrt{s}}{m_e},$$
$$\Delta = 1 + \frac{\alpha}{\pi}(\frac{3}{2}L + \frac{1}{3}\pi^2 - 2) + (\frac{\alpha}{\pi})^2\delta_2,$$
$$\delta_2 = (\frac{9}{8} - 2\xi_2)L^2 - (\frac{45}{16} - \frac{11}{2}\xi_2 - 3\xi_3)L - \frac{6}{5}\xi_2^2 - \frac{9}{2}\xi_3 - 6\xi_2\ln 2 + \frac{3}{8}\xi_2 + \frac{57}{12},$$
$$\beta = \frac{2\alpha}{\pi}(L-1),\ \xi_2 = 1.64493407,\ \xi_3 = 1.2020569.$$

Radiator function comparison



Except the model used in ppbar ISR analysis, the others are almost the same

By yadi

FIT PROCEDURE

BR, σ_0 can be compared with literature

ITALIAN outputs: BR, phase, σ_0 (3000 MeV), SE (fixed for J/psi)

USTC outputs: C, S, phase, SE →BR from parameters variation

IHEP outputs: X, Y, phase, SE

YADI outputs: *C, A,* phase, SE

ITALIAN way

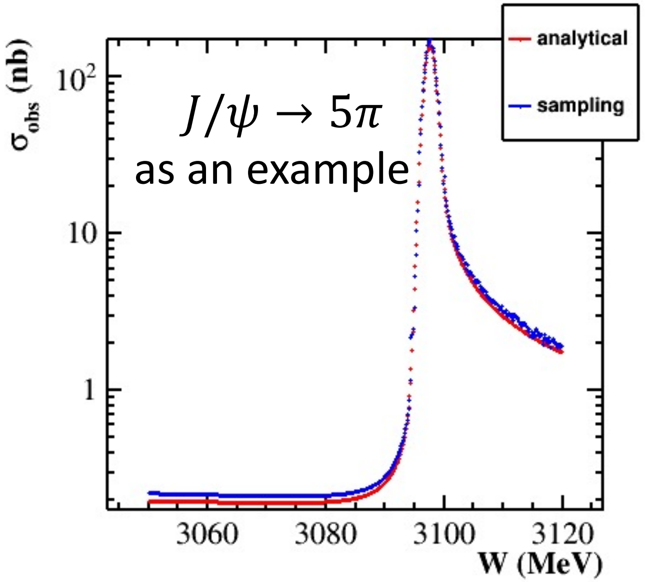
-past and preliminary pipijpsi - Monte-Carlo method It accounts for gaussian beam spread (0.93 MeV) and ISR with max radiation 100 MeV

-more recent→ BabaYaga as generator for ISR and BES→sampling

PWW-power low estimated (but in the energy range may not be crucial)

Test and comparison on-going by Yadi
(with primordial italian fitting algorithm)

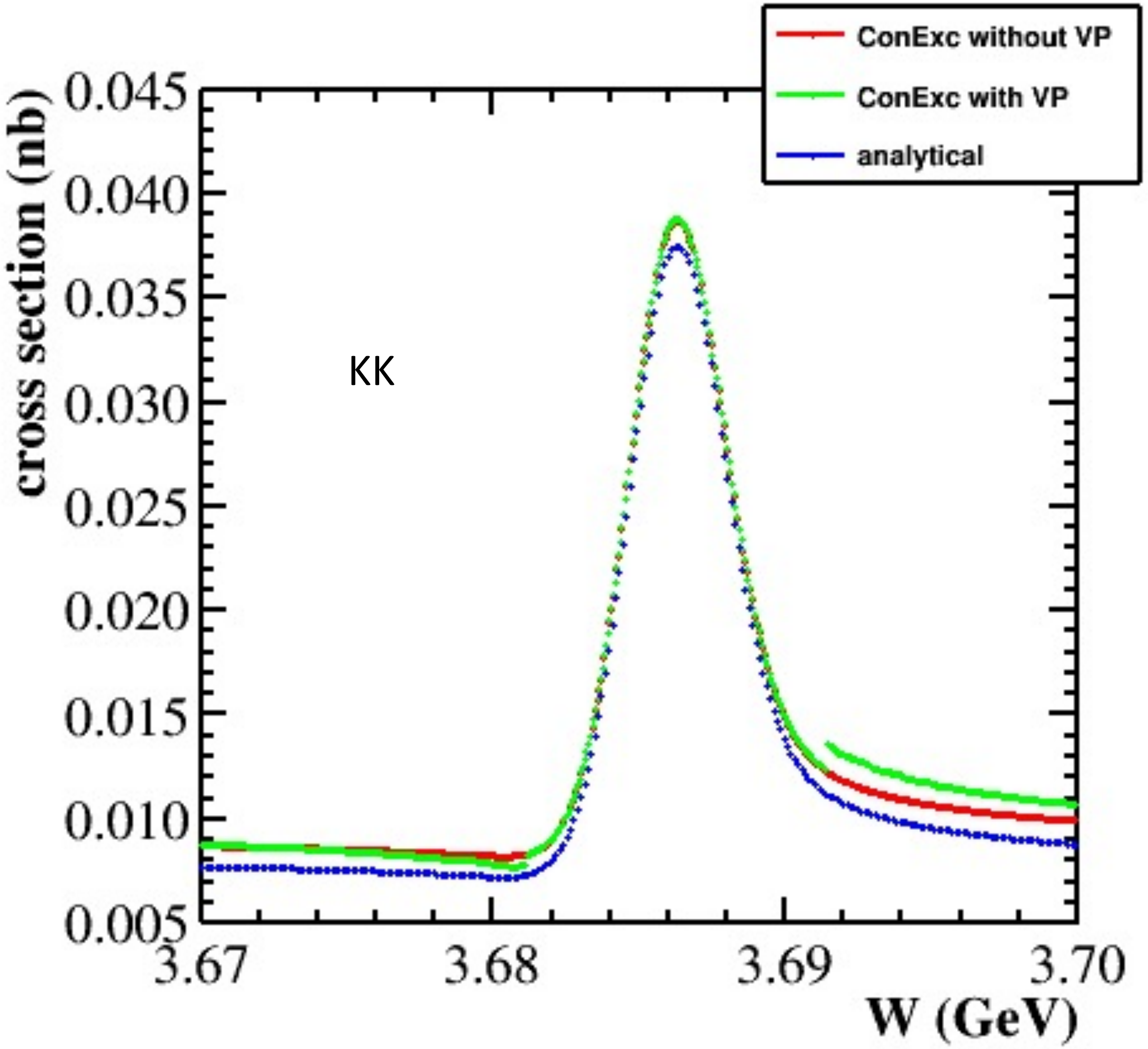
To be refined,
Continuum check



ISR/VP with ConExc and analytical fitting program

yadi

Comparison between



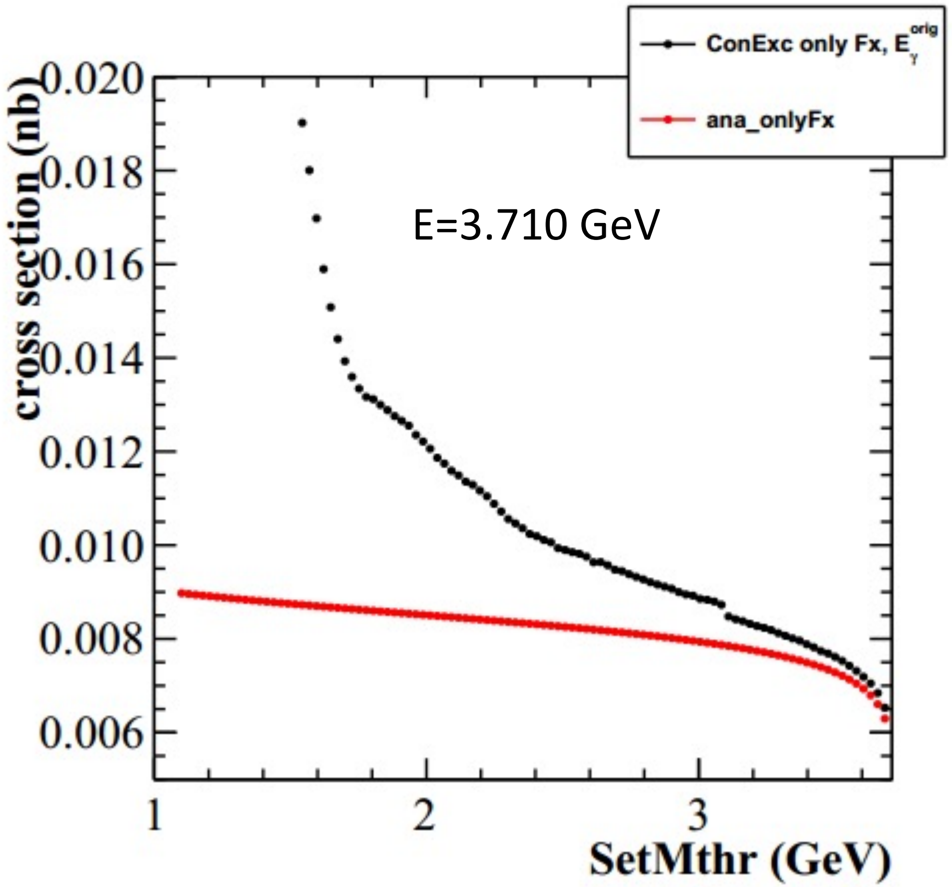

```
#include "$OFFLINEEVENTLOOPMGRROOT/share/OfflineEventLoopMgr_Option.txt"

//*************job options for EvtGen***************
#include "$BESEVTGENROOT/share/BesEvtGen.txt"
EvtDecay.userDecayTableName = "kk.dec";
EvtDecay.ParentParticle = "vpho";
EvtDecay.SetMthrForConExc = 1.7;

ApplicationMgr.DLLs += { "BesServices"};

//**************job options for random number************************

BesRndmGenSvc.RndmSeed = 1000;
////**************job options for detector simulation******************
//#include "$BESSIMROOT/share/G4Svc_BesSim.txt"
//
////configure for calibration constants
//#include "$CALIBSVCROOT/share/calibConfig_sim.txt"

// run ID
RealizationSvc.RunIdList = {55375,0,55461};

// OUTPUT PRINTOUT LEVEL
// Set output level threshold (2=DEBUG, 3=INFO, 4=WARNING, 5=ERROR, 6=FATAL )
MessageSvc.OutputLevel  = 6;

// Number of events to be processed (default is 10)
ApplicationMgr.EvtMax = 100000;

//#include "$ROOTIOROOT/share/jobOptions_Digi2Root.txt"
//RootCnvSvc.digiRootOutputFile = "kk_10.rtraw";
~
```

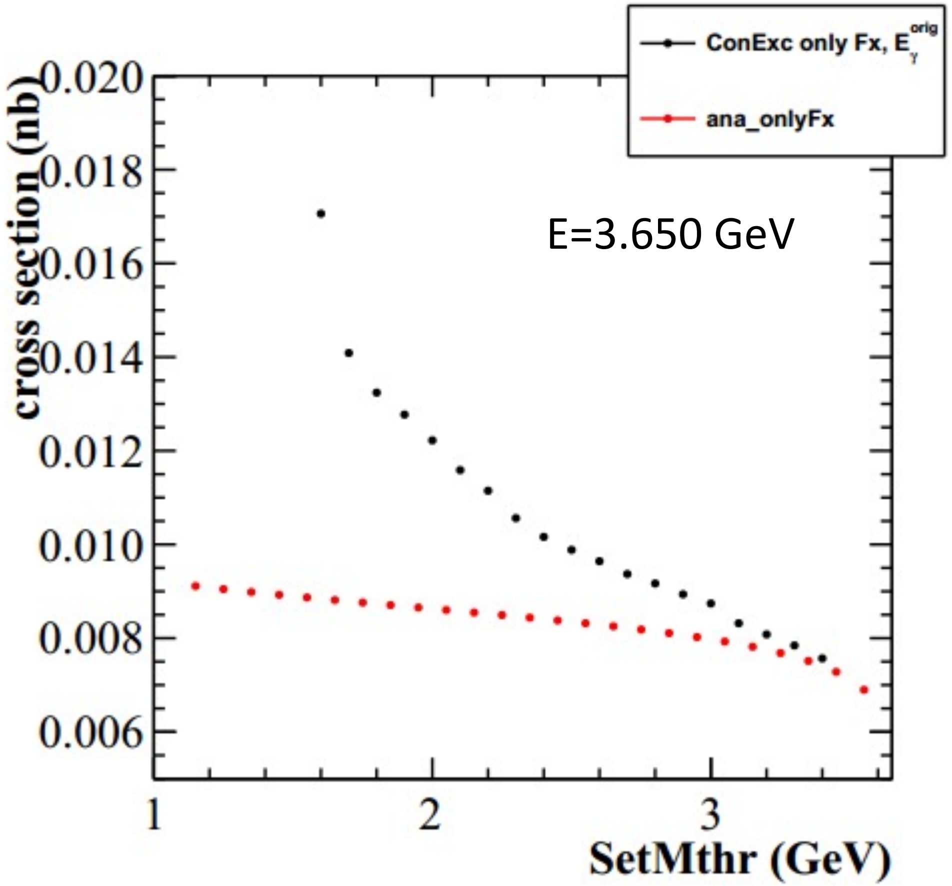
By YAdi

The VP from Berends is used currently, maybe substituted by the VP from Jegerlehner
Deep understanding of the different ISR dealing method is needed

By yadi

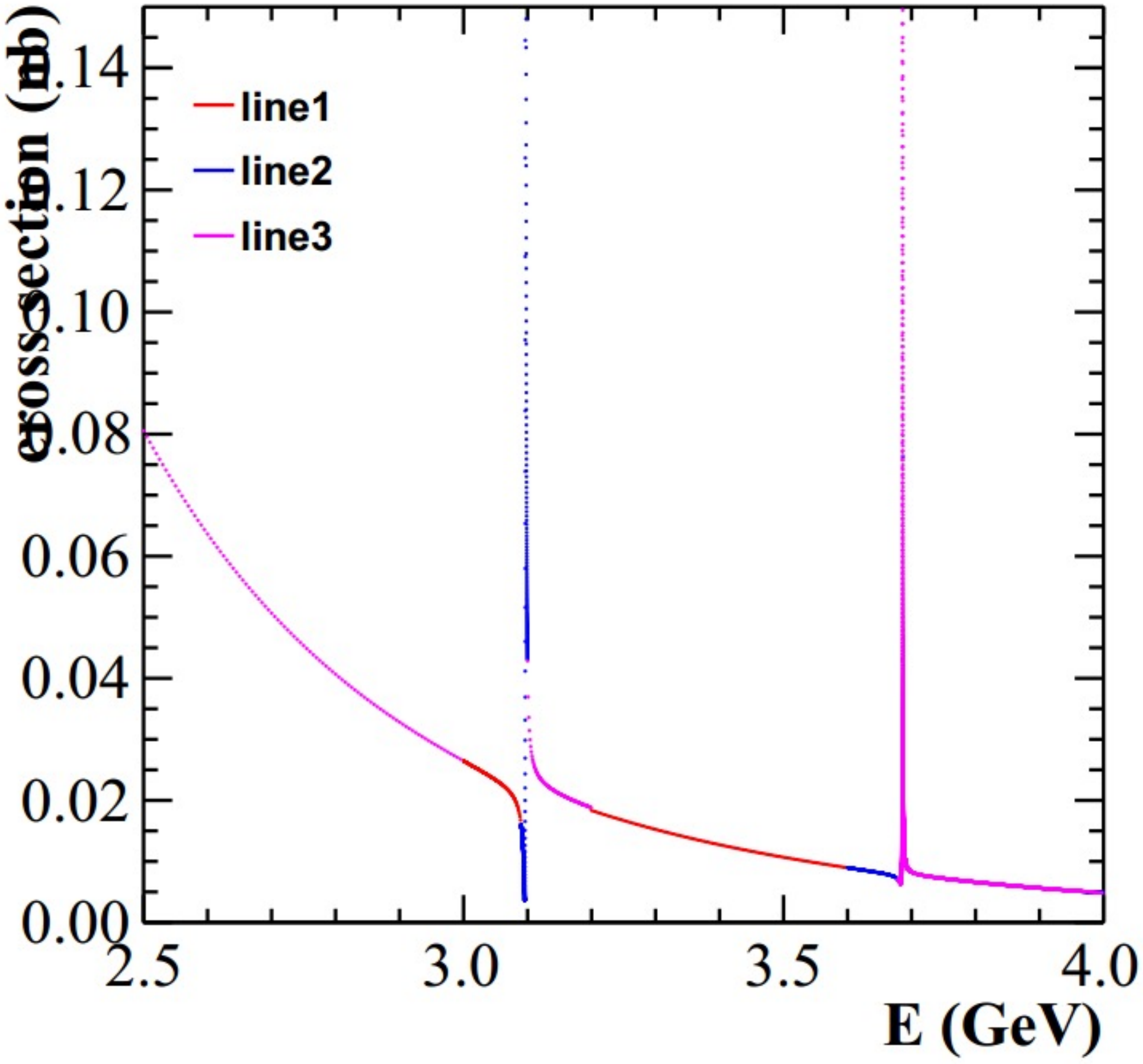
Difference ConExc and analytical





Going to threshold for generation in Conexc close to the resonance (→3.3 GeV)→ differences acceptable (around 6%)

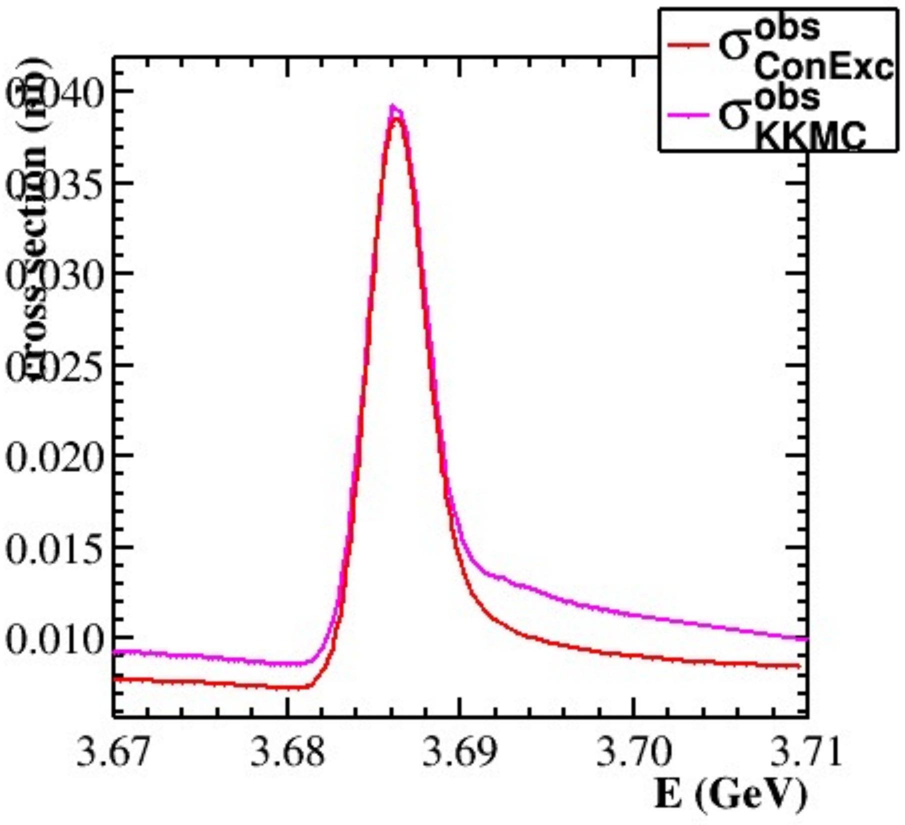
The input model for ConExc



By Yadi

Comparison between ConExc and KKMC

- There is a discrepancy between, the reason is under hunting.



By Yadi

Phase masurements ghosts

Branching Ratio:

FROM CLEO-c (2.86+-0.21) X10^{-4} ($\psi(2S) \rightarrow J/\psi\pi\pi$ .. interference free)

FROM BABAR(PRD92,072008 (2015))

BR=3.50+-0.20+-0.12 X10^{-4} (with interference correction $\rightarrow$3.36 is measured)

BR=3.22+-0.20+-0.12 X10^{-4}

First attempt with USTC code

- I tried to understand it
- First Fit with their parametrization→BR is not from fit (sampling the parameters)
- I modified the parametrization (sigma(3.0 GeV), phase, BR) And other little errors
- Second attempt to fit

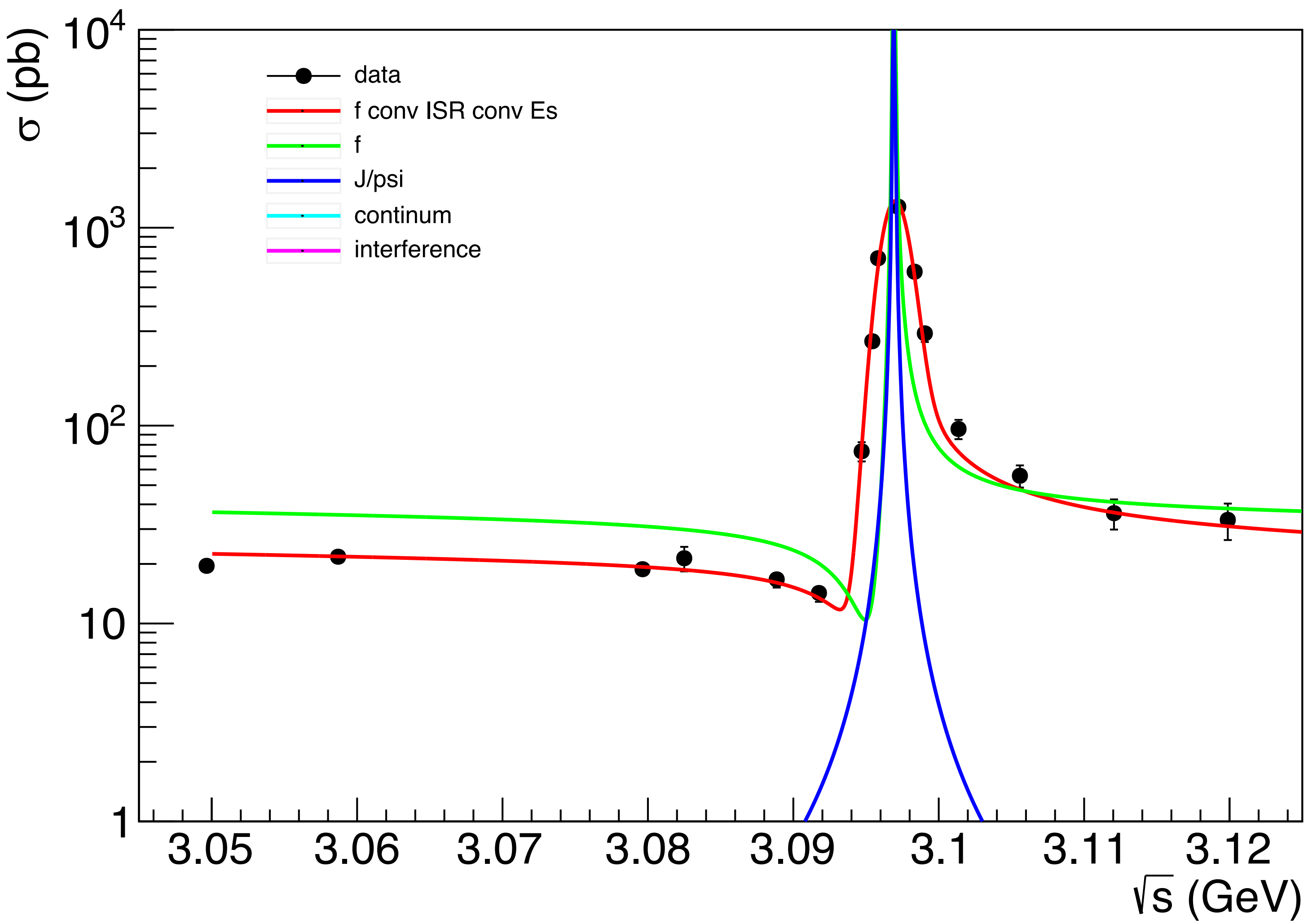
Redo sigma0antisigma0 (probably)

c_s = 790.254 +/- 12.6799
phi_s = 83.9544 +/- 11.5485
c_cn = 1169.6 +/- 87.7741 it is not the amplitude, from algorithm
spread = 0.000955622 +/- 3.11048e-05
790.254, 83.9544, 1169.6,
number of points is 15

BF result is = 0.00160889 +/- 5.22237e-05

```
// Calculate Prob of Egaama at x[0]
// unit MeV, prob not normalized
double ProbISR(double *x, double *par) {
        double Ecm = par[0];
        double kk = x[0];//yadi aveva la frazione Egamma/Eecm

        double Ee = Ecm/2.0;
        double beta = Beta(Ee);
        double k=k/Ee;
        double pk = beta*pow(k,beta-1);

                return pk/Ee*0.5;}
```

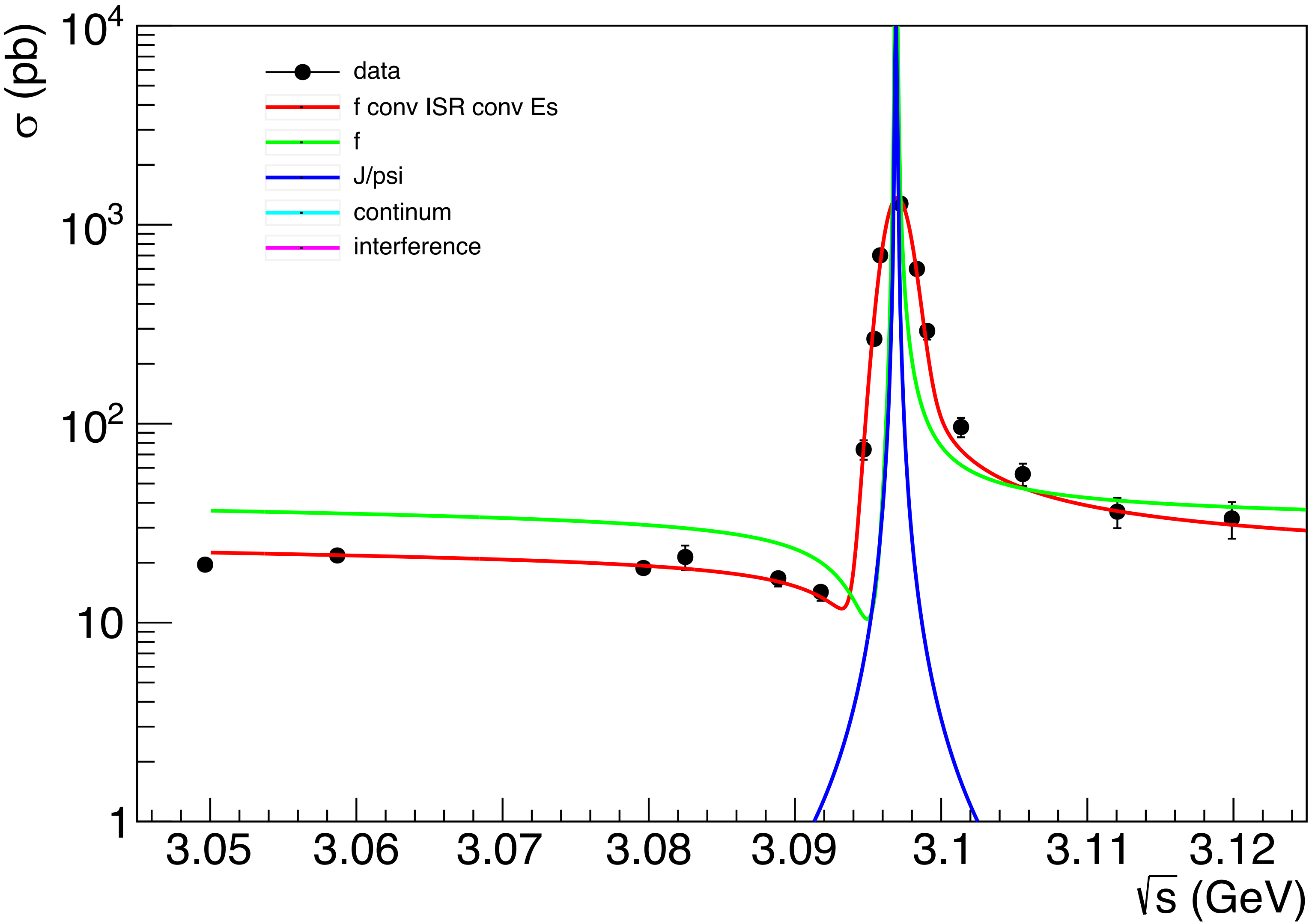
USTC FIT with their parametrization (for our KK channel in psi scan)



Strong = 0.0135322 +/- 0.00305914
phi_s = -69.3123 +/- 15.8484
c_cn = 0.00033125 +/- 7.44956e-06
spread = 0.000911 +/- 0

Fixed SE from
Physics Letters B 791 (2019) 375–384

BF result is = 0.000492999 +/- 2.74871e-05



chi2 is 17.3106

Print results from minuit

c_s = 0.0123712 +/- 0.00295157

phi_s = 67.2403 +/- 17.8698

c_cn = 0.000331258 +/- 7.45456e-06

spread = 0.000911 +/- 0

Strong decreasing, sigma Continuum almost constant

BF result is = 0.000458051 +/- 3.01945e-05

Very large BF from parameters variation

Modified prob ISR

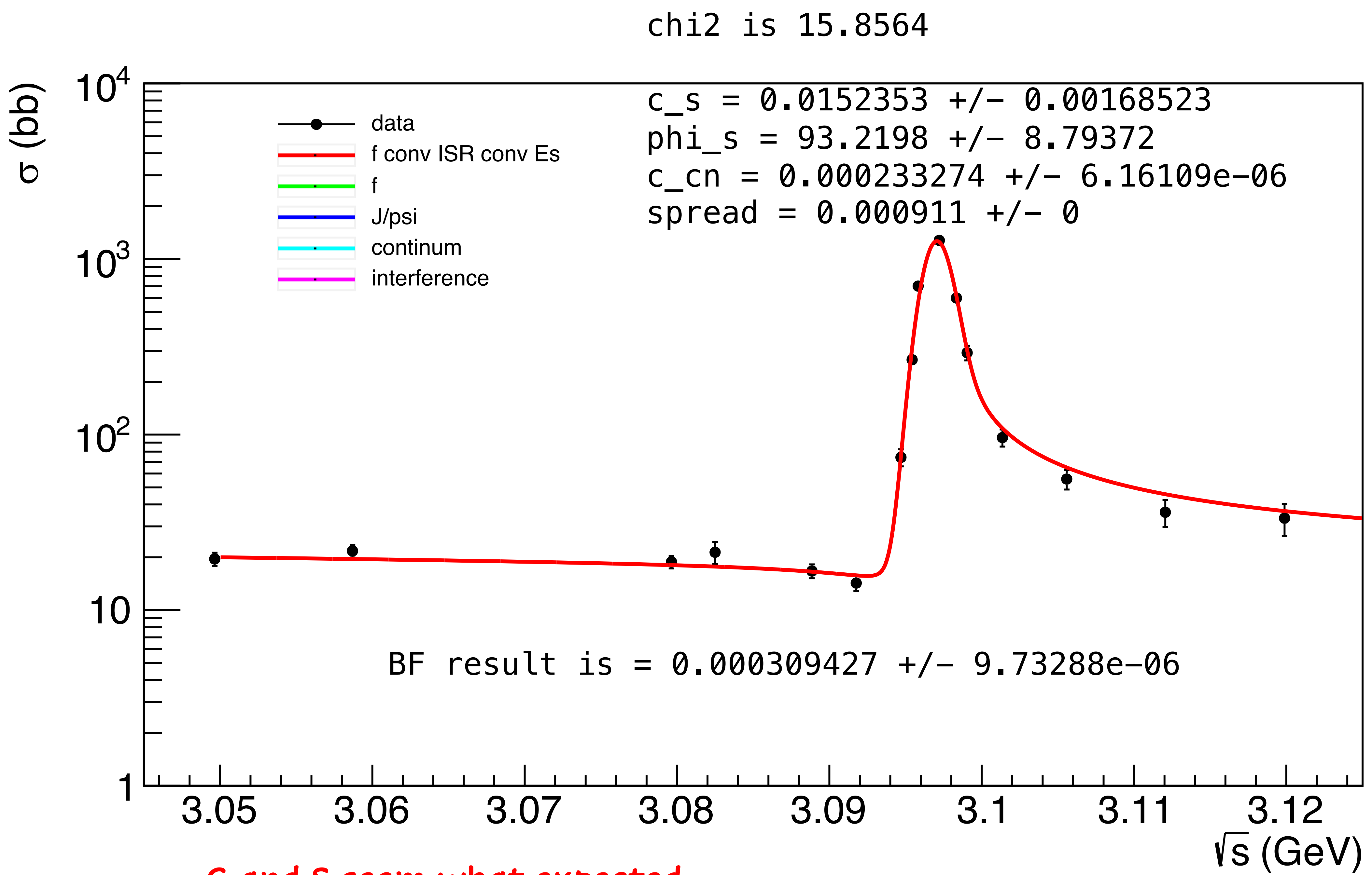
ISR treatment

$$F(x,s) = x^{\beta-1}\beta \cdot (1+\delta) + x^{\beta}(-\beta - \frac{\beta^2}{4}) + x^{\beta+1}(\frac{\beta}{2} - \frac{3}{8}\beta^2) + \mathcal{O}(x^{\beta+2}\beta^2)$$

ISR2

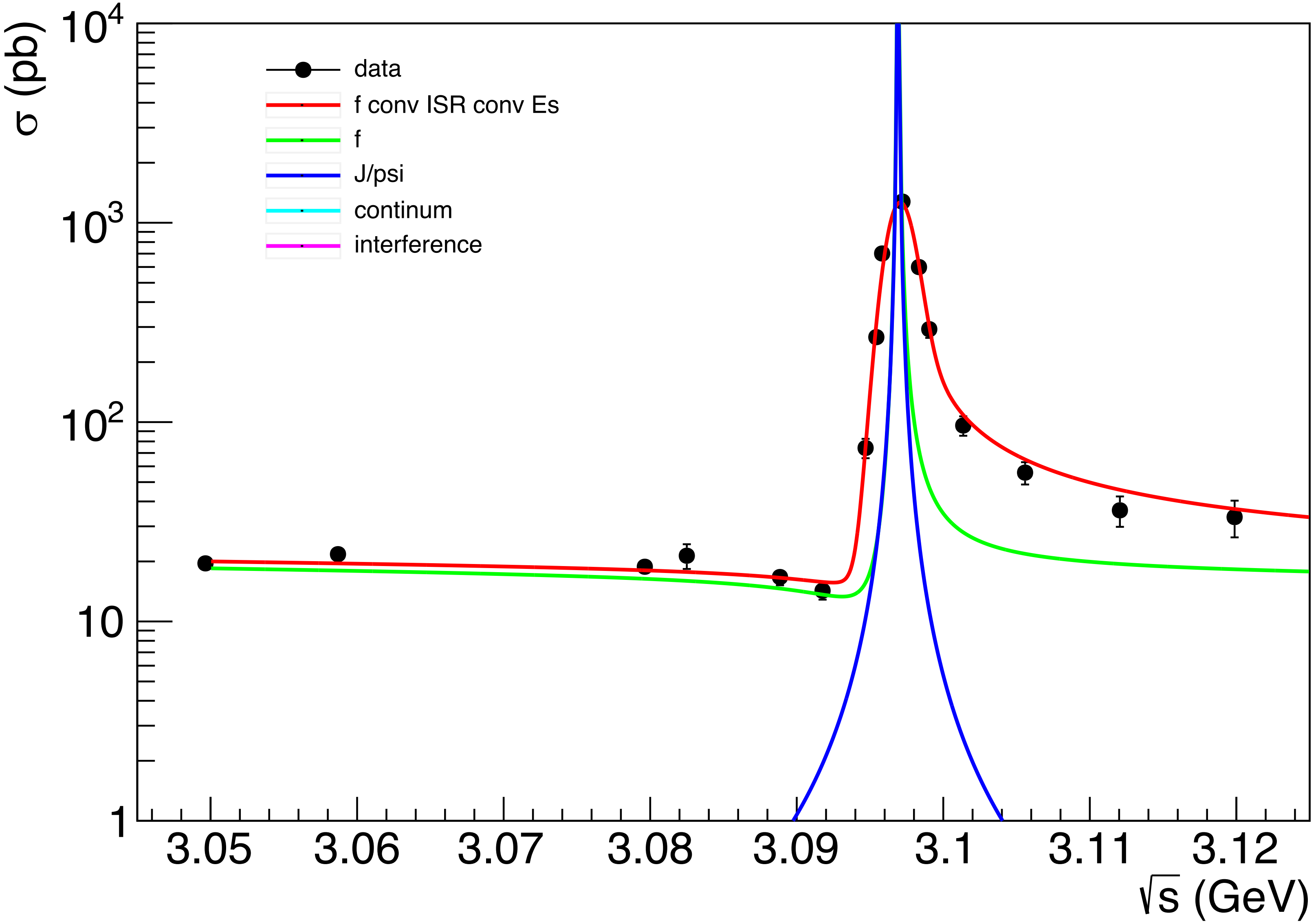
$$\delta = \frac{3}{4}\beta + \frac{\alpha}{\pi}(\frac{\pi^2}{3} - \frac{1}{2}) + \beta^2(\frac{9}{32} - \frac{\pi^2}{12})$$

$$\beta = \frac{2\alpha}{\pi}(\ln \frac{s}{m_e^2} - 1)$$



C and S seem what expected

BF decrease



chi2 is 15.8564

Print results from minuit
c_s = 0.0161102 +/- 0.00166146
phi_s = −93.05 +/− 8.33707
c_cn = 0.000233274 +/− 6.1607e−06
spread = 0.000911 +/− 0

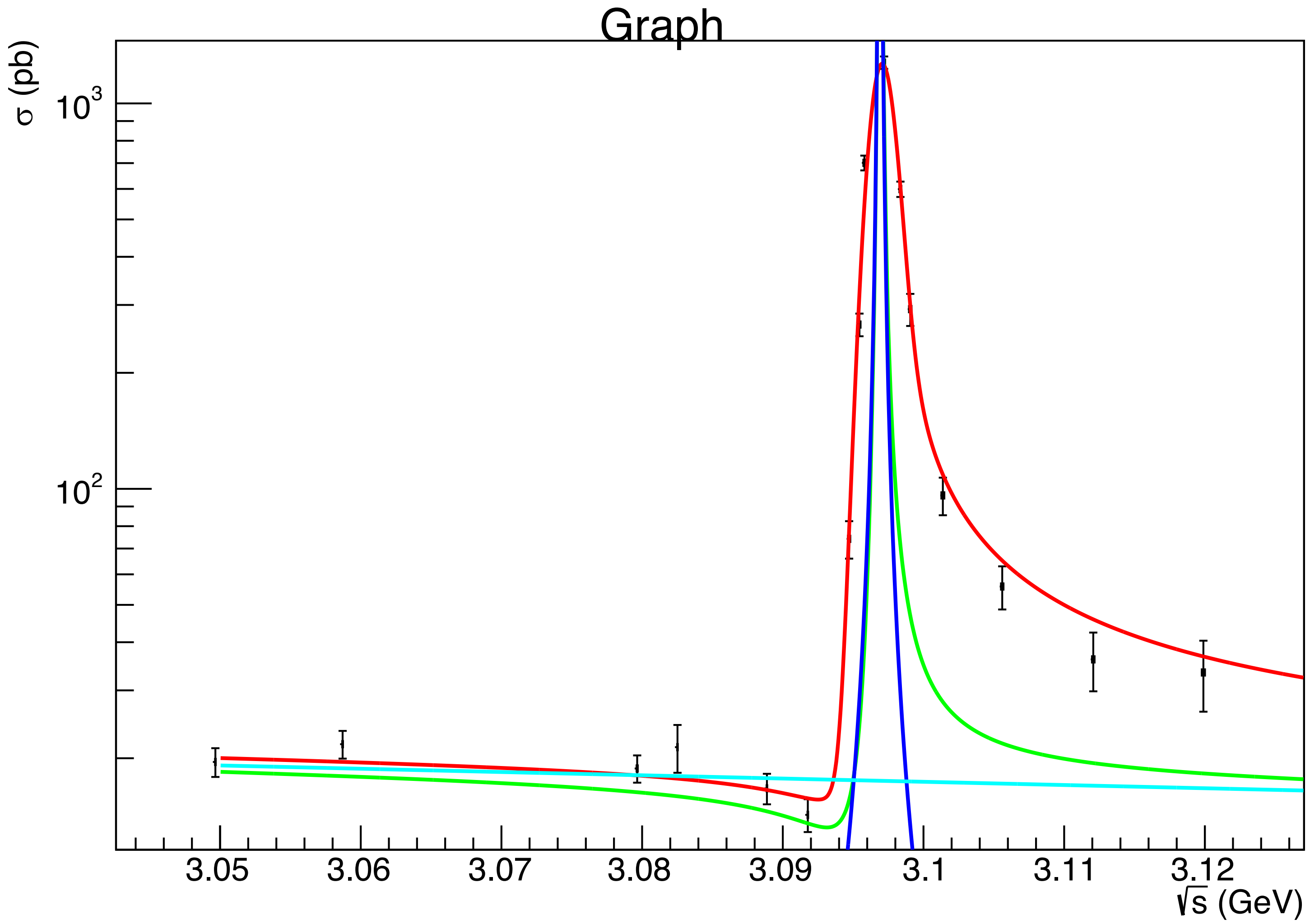
E/S=0.78

BF…acceptable

BF result is = 0.000338066 +/− 1.05392e−05

```
double xs_sqreb(double *x, double *par)
{

        double s = pow(x[0],2);     // x[0]: Ecm
        double m2 = pow(jpsipar[0],2); // par[0]: mass of resonance
        double BR=par[0];

        double Continuum_3geV=sqrt((2.57/1000000000.)*par[2]);//C(3GeV) in GeV-1
        double sigma_jpsi = par[2]*pow(3.0,6)/pow(jpsipar[0],6);//in pb
        double C_jpsi=sqrt(sigma_jpsi*(2.57/1000000000.));//par[2]*pow(3.0,6)/pow(jpsipar[0],6); in GeV-1
        double sigma_continum_AtJ = pow(C_jpsi,2);
        double sigma_contW= par[2]*pow(3.0,6)/pow(x[0],6);//
        double Continum= sqrt(sigma_contW*pb2GeV);//Continuum_3geV*(pow(3.0,3)/pow(x[0],3));
        double Em = sqrt( (sigma_jpsi/sigma_uuAtJ)*branch_j2uu);///continum o atJ????
        double phi = (par[1]/180)*TMath::Pi();
        double Strong = 0;

        if(BR-pow(Em,2)*pow(sin(phi),2)>0.){
          Strong=sqrt(BR-(pow(Em,2)*pow(sin(phi),2)))-Em*cos(phi);
        }
        if(Strong==0)  return 0;
        TComplex br = ((Strong*TComplex(cos(phi),sin(phi))+Em))/TComplex(jpsipar[0]-x[0],-width0/2);
                TComplex M = D*br - Continum;


                                return (GeV2pb * M.Rho2());
}
```

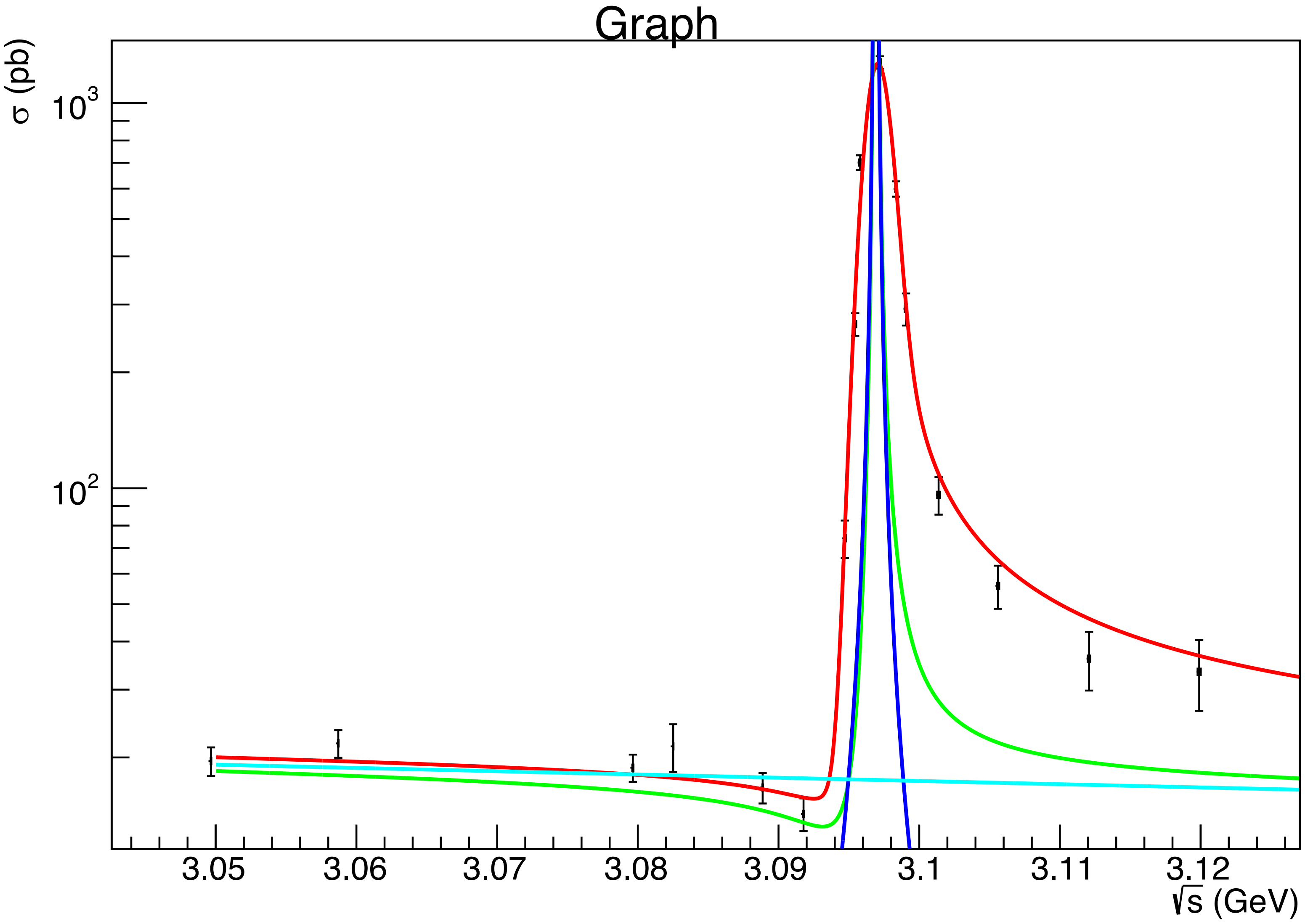
OUR PARAMETRIZATION
INSERTED




```
chi2 is 17.6545/(16-3)

Print results from minuit
BR = 0.000311388 +/- 9.57757e-06
phi_s = 59.3715 +/- 9.81403
s_cn = 21.1526 +/- 1.11367
spread = 0.000911 +/- 0
```

USTC base program with our parametrization
And other modifications (ISR treatment in primis)

Not too bad, PHASE NOT 90



Negative phase

```
chi2 is 17.6545

Print results from minuit
BR = 0.000338739 +/- 1.02829e-05
phi_s = -60.7655 +/- 9.38169
s_cn = 21.1528 +/- 1.11359
spread = 0.000911 +/- 0
0.000338739, -60.7655, 21.1528,
```

My old results (in my memo ready)

My

χ^2 def	Data Points	phase angle range	$B_{out} \times 10^{-4}$	ϕ	$\sigma_c(pb)$	χ^2/NDF
1	16	pos and neg	3.40±0.08	(-94.2±6.9)°	23.9± 1.2	2.24
1	16	pos	3.13 0±0.08	94.5±7.4	23.9± 1.2	2.24
1	16	neg	3.40 0±0.08	-94.2±6.9	23.9± 1.2	2.24
1	15 (except 9th)	pos and neg	3.22±0.09	(-88.6±8.4)°	24.8± 1.3	0.44
1	15 (except 9th)	pos	2.98 ±0.08	88.4±9.1	24.8± 1.3	0.44
1	15 (except 9th)	neg	3.22 ±0.09	-88.6±8.5	24.8± 1.3	0.44
1	14 (except 8th and 9th)	neg	3.22 ±0.09	-88.2±8.9	24.8± 1.3	0.5
2	16	pos and neg	3.47±0.14	(-83.6±9.7)°	25.3± 1.3	0.79
2	16	pos	3.22 0±0.13	83.6±9.9	25.3± 1.3	0.79
2	16	neg	3.47 0±0.14	-83.6±9.9	25.3± 1.3	0.79

Chi2 definition to be checked in USTC

BR compatible/cont within 1 sigma
To be investigated phase

- Other checks

With SE=0.93

Changes about 0.006%-negligible

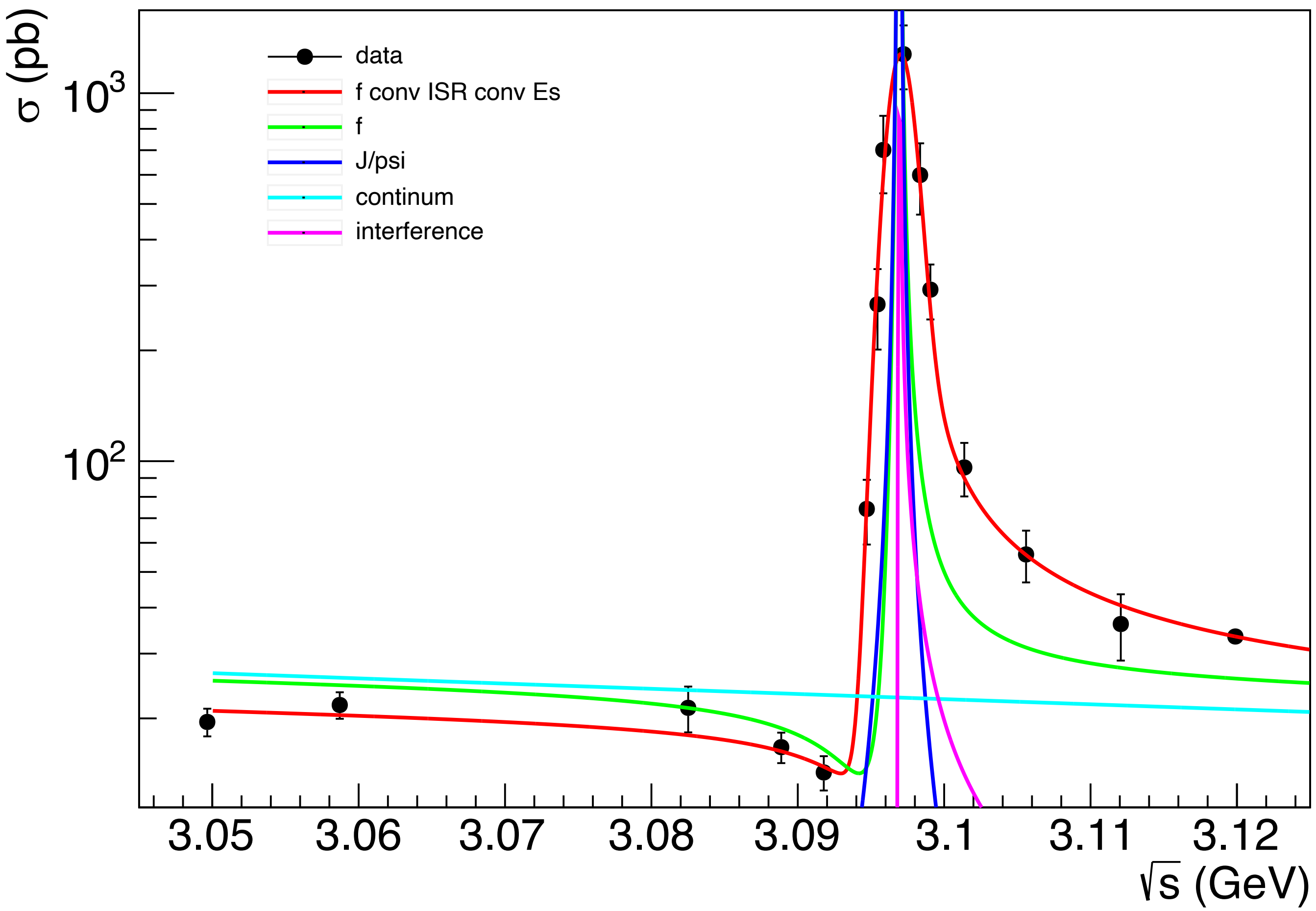
```
chi2 is 18.7846

Print results from minuit
BR = 0.000313751 +/- 9.69263e-06
phi_s = 58.7697 +/- 9.86675
s_cn = 21.239 +/- 1.11877
spread = 0.00093 +/- 0
```

Integral for energy spread from 5*SE to 20*SE (Yadi)

```
BR = 0.000313772 +/- 9.69324e-06
phi_s = 58.7705 +/- 9.86649
s_cn = 21.2393 +/- 1.1188
spread = 0.00093 +/- 0
```

negligible

Last attempt on Thursay (last version Muzzafar with our parametrization (from Marco's memo))



BR = 0.000379858 +/- 2.75214e-05

phi_s = 89.1232 +/- 8.59979

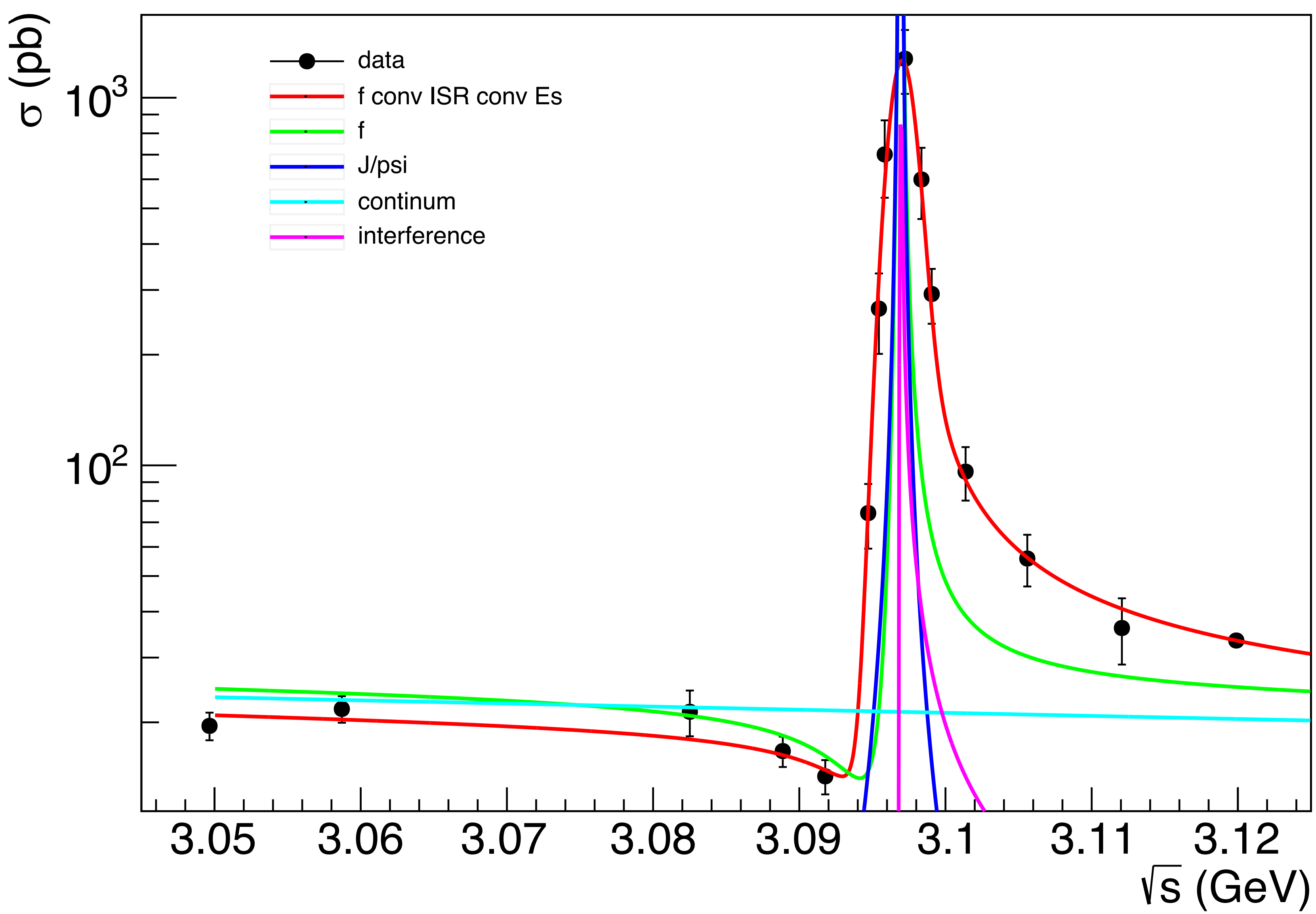
cont(3GeV) = 26.543 +/- 1.0453

spread = 0.000911 +/- 0

SE FIXED

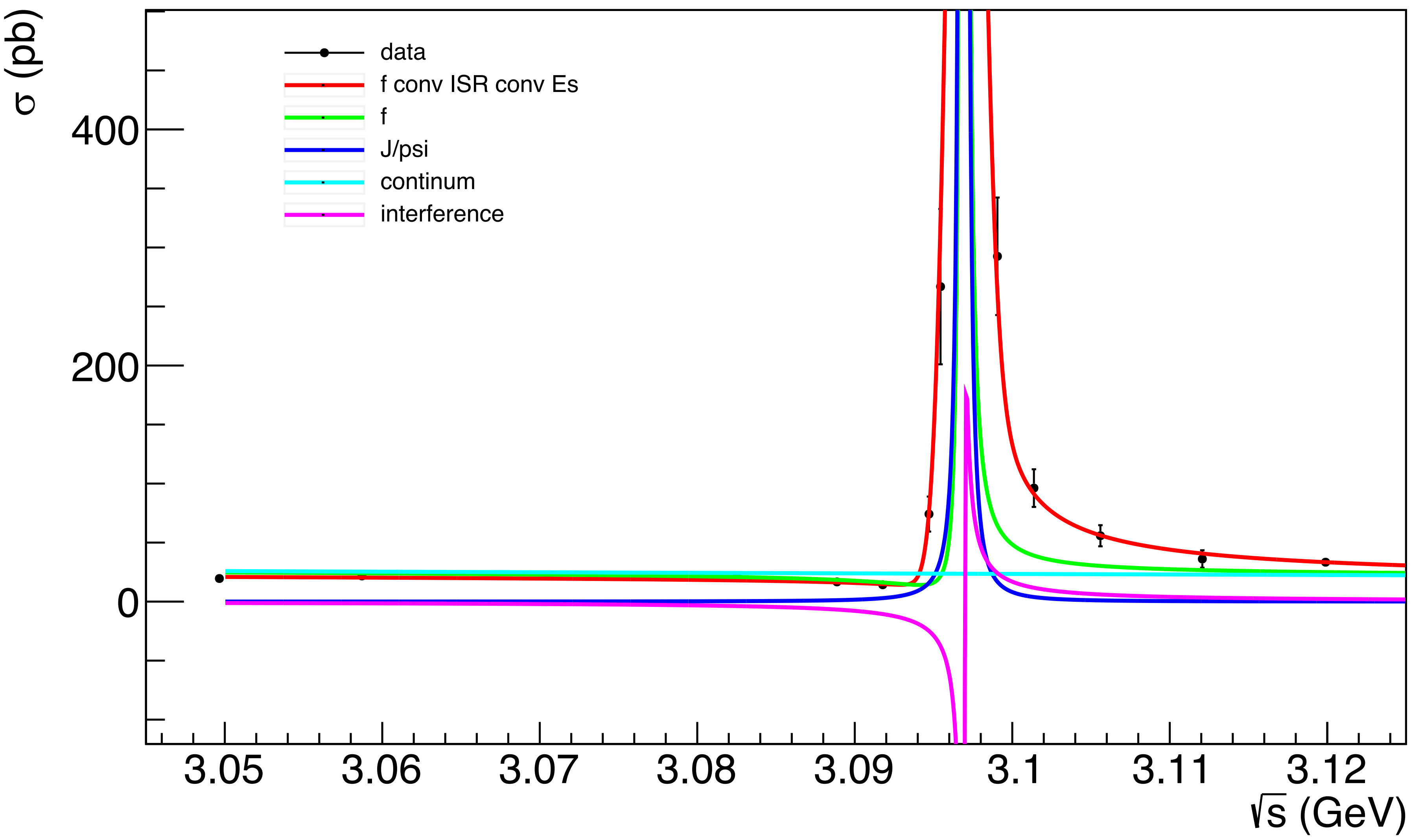
ProbISR USTC

High BR/pos phase



With ProbISR
Kuraev/Fadin like

BR = 0.000368649 +/- 2.67047e-05
phi_s = 89.9113 +/- 8.45131
cont(3GeV) = 25.8451 +/- 1.02502
spread = 0.000911 +/- 0



BR= 0.000399329 +/- 3.0292e-05

phi_s = -89.9221 +/- 7.8776

cont(3GeV) = 28.54 +/- 1.1232

spread = 0.000911 +/- 0

Aumenta il cont con neg phase

Conclusions and outlook

- Disclaimer: Checks have be done quickly (one week almost)
- I DECIDED to resume K+K- analysis
- It will be useful, anyway! Giulio cannot use our nominal method (BB not available)→our old algorithm till now !!
- Test useful to understand problems in USTC analysis.. (HIGH BF's first!!)
- Phase problem with our parametrization→ the error will be found ;-)
- Fitting seem in any case to be good...different outputs.. Careful checks needed.

The XS digged up..should be recalculated→most of the work needed by the fitting algorithm.

It will be fun!!!!