郑州大学
ZHENGZHOU UNIVERSITY

Cross section measurement of $e^+e^- \to K_S^0 K^\mp\pi^\pm$

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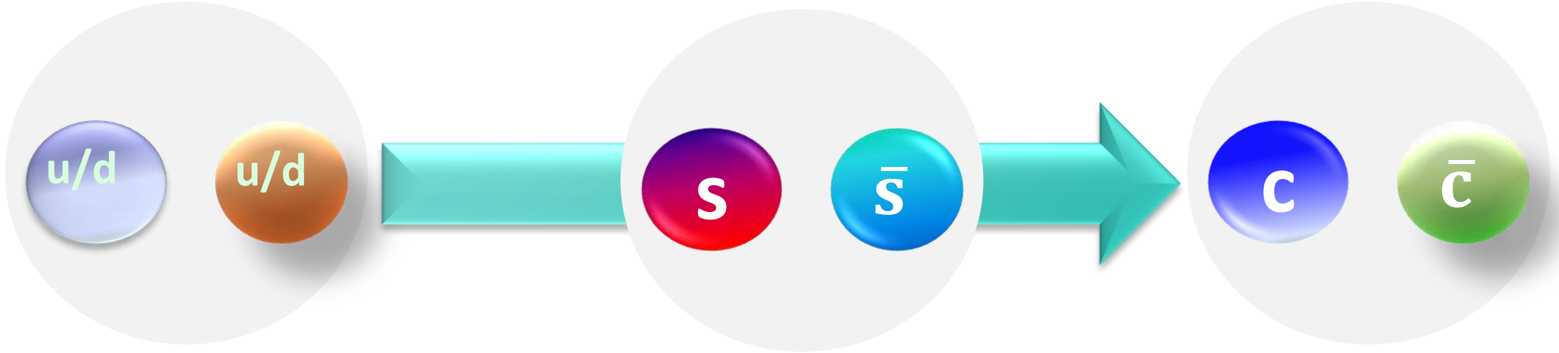
Outline

- **Motivation**
- **Data sets and MC samples**
- **Event selection**
- **Background analysis**
- **Partial wave analysis**
- **Cross section**
- **Systematic uncertainty**
- **Summary & Next to do**

Motivation

Hadron Spectroscopy: Precision SM tests & rare phenomena

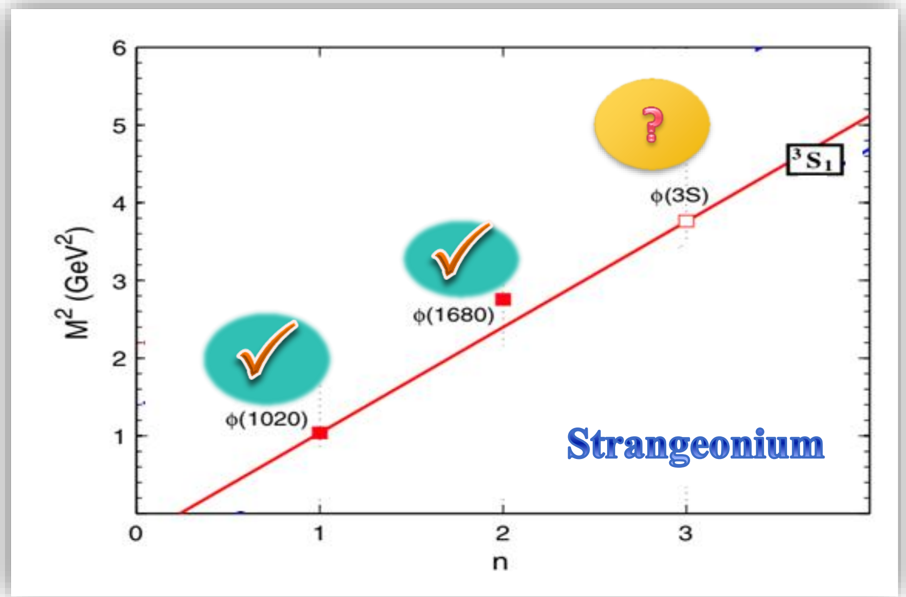


- Nonrel. potential model
- Conventional cc meson fit well with potential model below Open charm

The study of strangeonium is of particular interest since they are a bridge between the light u, d quarks and the heavy c, b quarks

Motivation

Vector Strangeonium



$\phi(2170)$ $\quad I^G(J^{PC}) = 0^-(1^{--})$

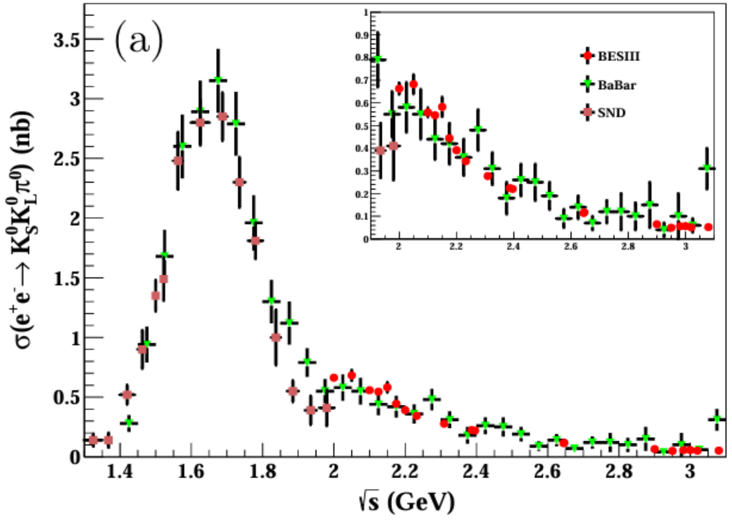
$\phi(2170)$ MASS

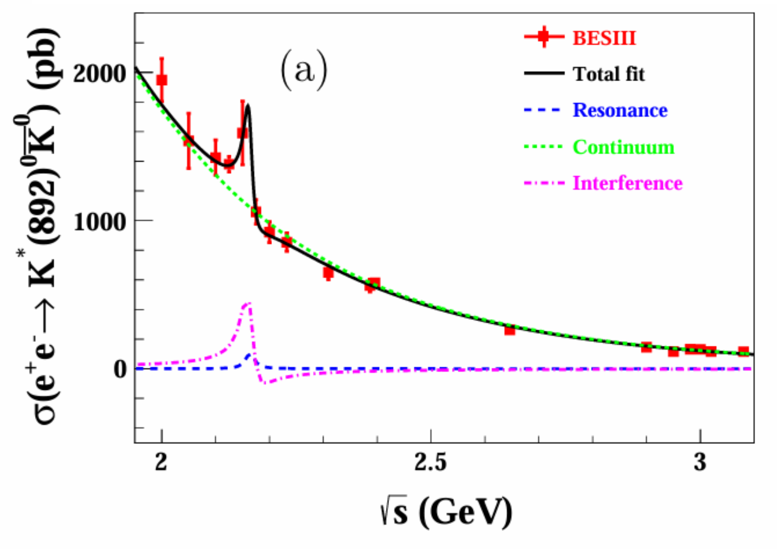
VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
2159 ±17 OUR AVERAGE		Error includes scale factor of 1.4. See the ideogram below.			
2176 ±24 ± 3		[1] ABLIKIM	21A	BES3	$e^+e^- \to \omega\eta$
2177.5± 4.8±19.5		[2] ABLIKIM	20M	BES3	$e^+e^- \to \eta'\phi$
2126.5±16.8±12.4		[3] ABLIKIM	20S	BES3	$e^+e^- \to K^+K^-\pi^0\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2135 ± 8 ± 9	95	ABLIKIM	19I	BES3	$e^+e^- \to \eta\phi f_0(980)$
2239.2± 7.1±11.3		[4] ABLIKIM	19L	BES3	$e^+e^- \to K^+K^-$
2200 ± 6 ± 5	471	ABLIKIM	15H	BES3	$J/\psi \to \eta\phi\pi^+\pi^-$
2180 ± 8 ± 8		[5,6] LEES	12F	BABR	10.6 $e^+e^- \to \phi\pi^+\pi^-\gamma$
2079 ±13 $^{+79}_{-28}$	4.8k	[7] SHEN	09	BELL	10.6 $e^+e^- \to K^+K^-\pi^+\pi^-\gamma$
2186 ±10 ± 6	52	ABLIKIM	08F	BES	$J/\psi \to \eta\phi f_0(980)$
2125 ±22 ±10	483	AUBERT	08S	BABR	10.6 $e^+e^- \to \phi\eta\gamma$
2192 ±14	116	[8] AUBERT	07AK	BABR	10.6 $e^+e^- \to K^+K^-\pi^+\pi^-\gamma$
2169 ±20	149	[8] AUBERT	07AK	BABR	10.6 $e^+e^- \to K^+K^-\pi^0\pi^0\gamma$
2175 ±10 ±15	201	[6,9] AUBERT,BE	06D	BABR	10.6 $e^+e^- \to K^+K^-\pi\pi\gamma$

- More excitations, e.g., $\phi(3S)$, still **missing** in experiment
- $\phi(2170)$, containing strange quarkonium, is controversial

Motivation

JHEP01(2024)180





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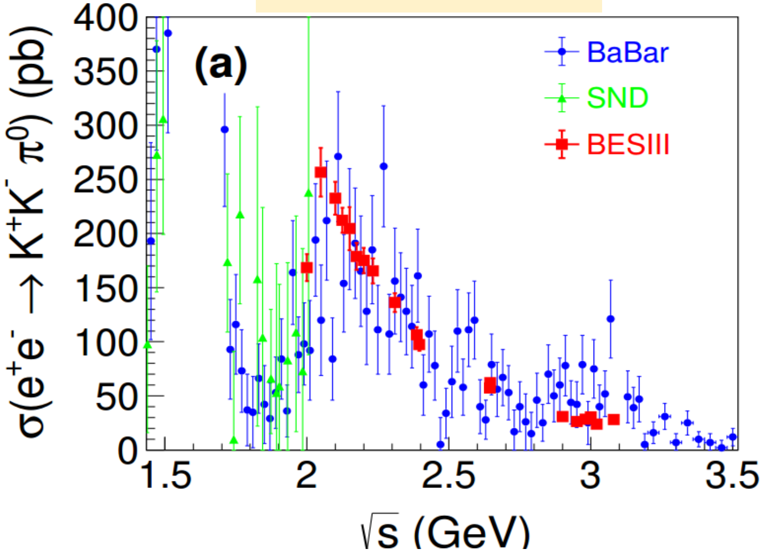
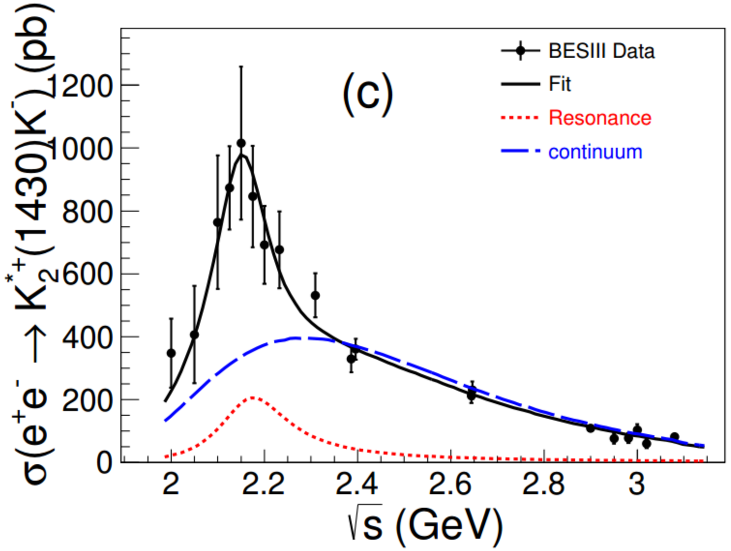




- ➢ The $K^{(*)}K^{(*)}$ channels are important to distinguish the $\phi(2170)$ properties.
- ➢ Using2.0-3.08 GeV data on BESIII, a series of analyses has performed.
- ➢ More decay channels are needed.

Data sets and MC samples

- **BOSS version:** 6.6.5.p01、7.1.3
- **Data:**

  listed in the right table.

- **Signal MC:**

  1M events each energy point.(PHSP)

- **Inclusive MC:**

  hadron: about 40 million events.

- **Decay mode:** $e^+e^- \to K_S^0 K^\mp \pi^\pm;\ K_S^0 \to \pi^+\pi^-$

$\sqrt{S}(GeV)$	$L(pb^{-1})$	$RunNo$	$\sqrt{S}(GeV)$	$L(pb^{-1})$	$RunNo$
1.844	1.501	81849~81970	2.000	10.074	41729~41909
1.874	2.002	81971~82104	2.050	3.343	41911~41958
1.876	2.014	82543~82656	2.100	12.167	41588~41728
1.878	2.019	82657~82783	2.125	108.49	42004~43253
1.879	1.485	82835~82909	2.150	2.841	41533~41570
1.880	2.035	82105~82203	2.175	10.625	41416~41532
1.881	1.341	82784~82834	2.200	13.699	40989~41121
1.882	2.021	82204~82261	2.2324	11.856	41122~41239
1.886	2.033	82262~82310	2.3094	21.089	41240~41411
1.890	2.031	82311~82358	2.3864	22.549	40806~40951
1.904	2.022	82359~82404	2.396	66.869	40459~40769
1.9437	2.040	82405~82462	2.644	34.003	40128~40298
1.9735	2.229	82463~82530	2.646	33.722	40300~40435
			2.900	105.253	39775~40069
			2.950	15.942	39619~39650
			2.981	16.071	39651~39679
			3.000	15.881	39680~39710
			3.020	17.290	39711~39738
			3.080	126.185	39355~39618

Event selection

- **Good charged track selection:**

  $|V_r| < 10.0\ cm\ \&\&\ |V_z| < 20.0\ cm\ \&\&\ |cos\theta| < 0.93, Ngood\ \geq 4.$

- **PID:**

  K: $Prob(K) > Prob(\pi)\ and\ Prob(K) > Prob(P)$

  π: $Prob(\pi) > Prob(K)\ and\ Prob(\pi) > Prob(P)$

  $N(K^{-(+)}) \geq 1, N(\pi^{+(-)}) \geq 2, N(\pi^{-(+)}) \geq 1.$

- **Vertex fit and secondary vertex fit for K_s^0:**

  loop all pairs of $\pi^+$and π^-choose the minimum of $\chi^2(K_s^0)$

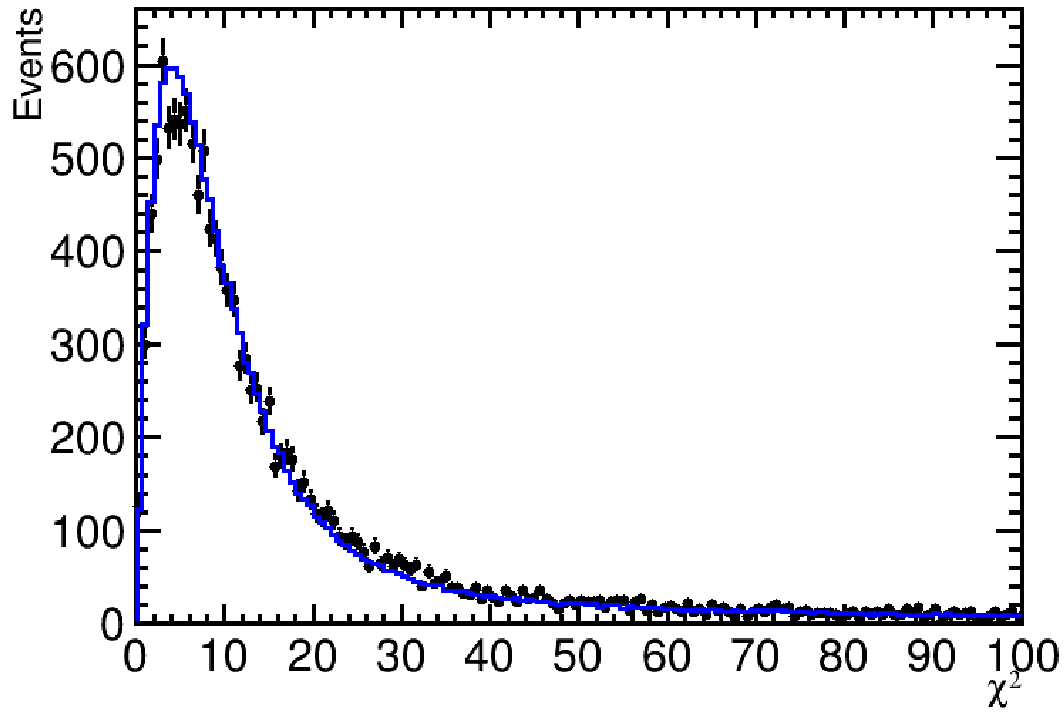
- **Exclude extra $\pi^{+(-)}$and $K^{-(+)}$particles with $V_z < 10\ cm$ and $V_r < 1\ cm$**

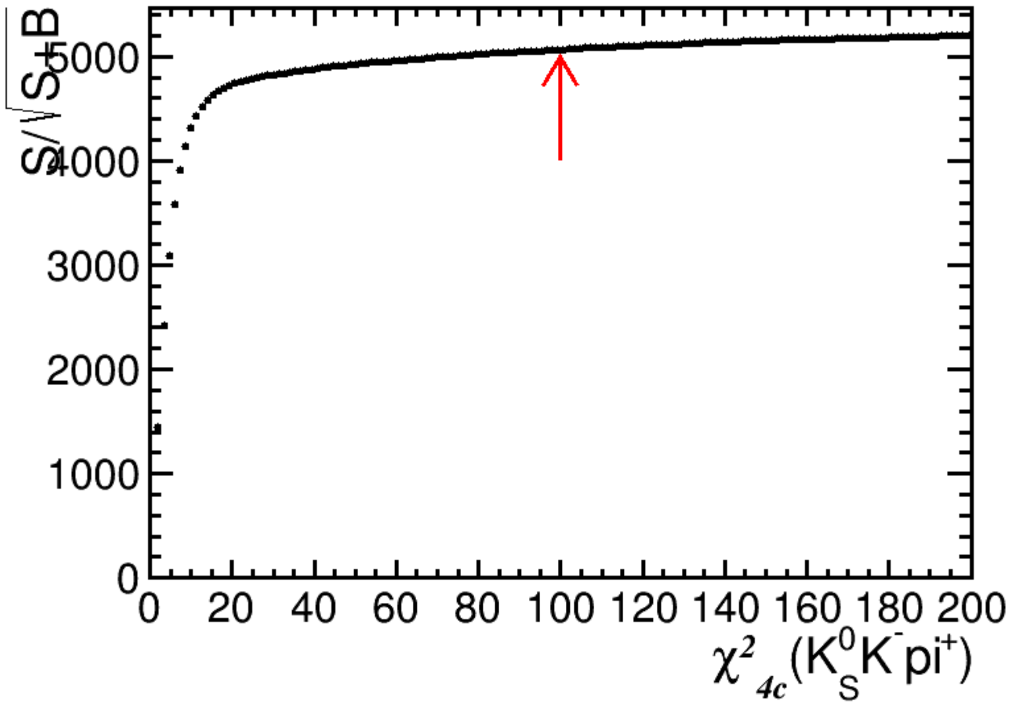
- **4C kinematic fit: ($K_s^0 K^{\mp} \pi^{\pm}$)**

  remain one $\pi^{+(-)}$ and one $K^{-(+)}$ with 4C kinematic fit.

Further selection

The 4C chi-square cut varies at different energy points.





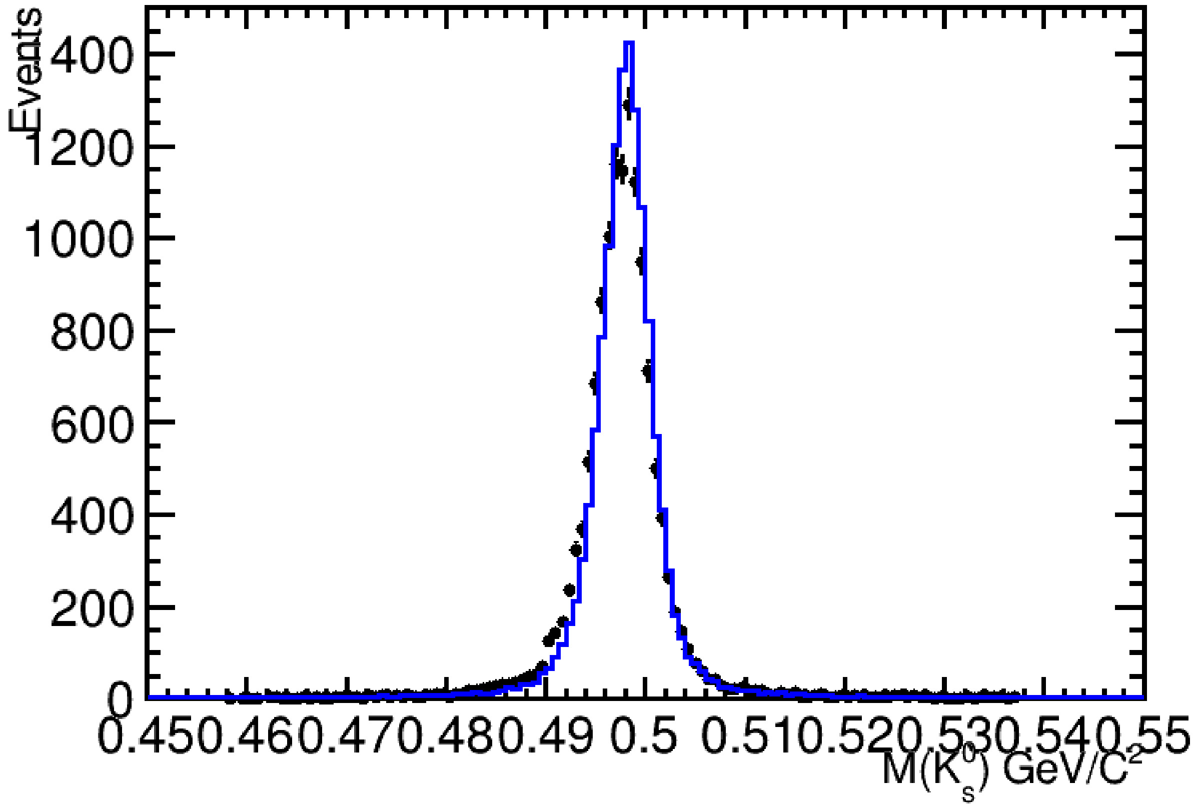
$\chi^2 < 100$

2.125GeV

FOM: $\frac{S}{\sqrt{S+B}}$

S: normalized yield of signal MC based on preliminary results
B: inclusive MC

Further selection



Signal region

|M($\pi^+\pi^-$)-M(K_S^0)|≤0.015 GeV/C^2

Background analysis

Table 1: Decay trees and their respective final states.

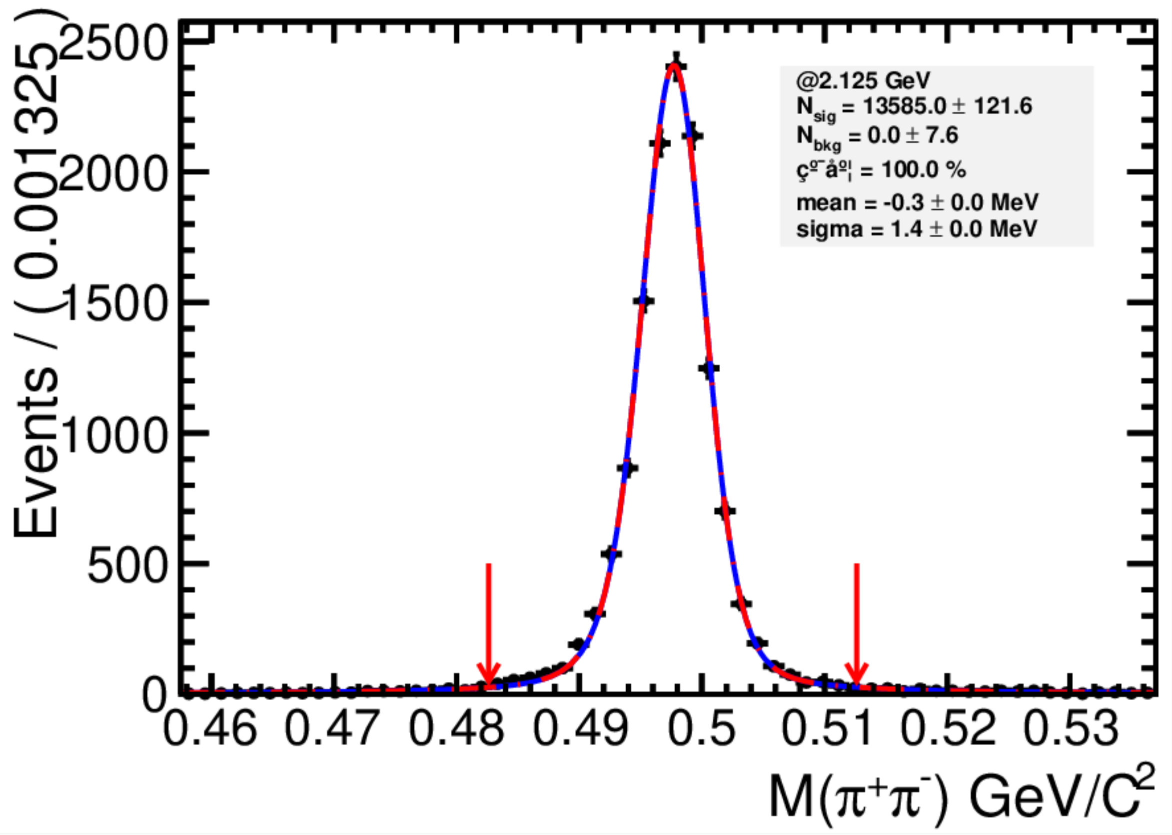
rowNo	decay tree	decay final state	iDcyTr	nEtr	nCEtr
1	$e^+e^- \to \pi^+K_S^0K^-, K_S^0 \to \pi^+\pi^-$	$\pi^+\pi^+\pi^-K^-$	1	15434	15434
2	$e^+e^- \to vgam\gamma^I, vgam \to \pi^+K_S^0K^-, K_S^0 \to \pi^+\pi^-$	$\pi^+\pi^+\pi^-K^-\gamma^I$	0	6296	21730
3	$e^+e^- \to K_L^0\pi^+K^-$	$K_L^0\pi^+K^-$	6	7	21737
4	$e^+e^- \to \pi^+\pi^+\pi^-\pi^-\gamma^I$	$\pi^+\pi^+\pi^-\pi^-\gamma^I$	4	6	21743
5	$e^+e^- \to \pi^+a_2^-, a_2^- \to \bar{K}^0K^-, \bar{K}^0 \to K_S^0, K_S^0 \to \pi^+\pi^-$	$\pi^+\pi^+\pi^-K^-$	10	4	21747
6	$e^+e^- \to \pi^+a_2^-\gamma^f, a_2^- \to \bar{K}^0K^-, \bar{K}^0 \to K_S^0, K_S^0 \to \pi^+\pi^-$	$\pi^+\pi^+\pi^-K^-\gamma^f$	11	2	21749
7	$e^+e^- \to vgam\gamma^I, vgam \to \pi^+K_S^0K^-, K_S^0 \to \pi^+\pi^-\gamma^F$	$\pi^+\pi^+\pi^-K^-\gamma^I\gamma^F$	3	1	21750
8	$e^+e^- \to vgam\gamma^I, vgam \to \pi^+\pi^-K^+K^-$	$\pi^+\pi^-K^+K^-\gamma^I$	7	1	21751
9	$e^+e^- \to \pi^+\pi^+\pi^-\pi^-\gamma^I\gamma^I$	$\pi^+\pi^+\pi^-\pi^-\gamma^I\gamma^I$	8	1	21752
10	$e^+e^- \to vgam\gamma^I, vgam \to K_L^0\pi^+K^-$	$K_L^0\pi^+K^-\gamma^I$	9	1	21753
11	$e^+e^- \to \pi^-K_S^0K^+, K_S^0 \to \pi^+\pi^-$	$\pi^+\pi^-\pi^-K^+$	2	1	21754
12	$e^+e^- \to vgam\gamma^I, vgam \to \pi^-K_S^0K^+, K_S^0 \to \pi^+\pi^-$	$\pi^+\pi^-\pi^-K^+\gamma^I$	5	1	21755
13	$e^+e^- \to \pi^0\pi^+\pi^-\gamma^I\gamma^I$	$\pi^0\pi^+\pi^-\gamma^I\gamma^I$	12	1	21756

- signal channel

No significant background

I used events from all energy points

Background analysis

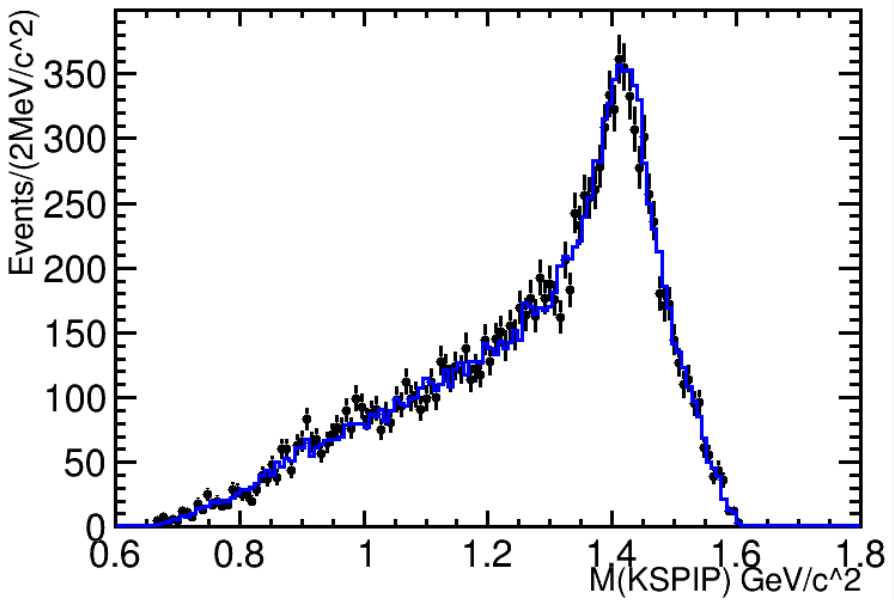


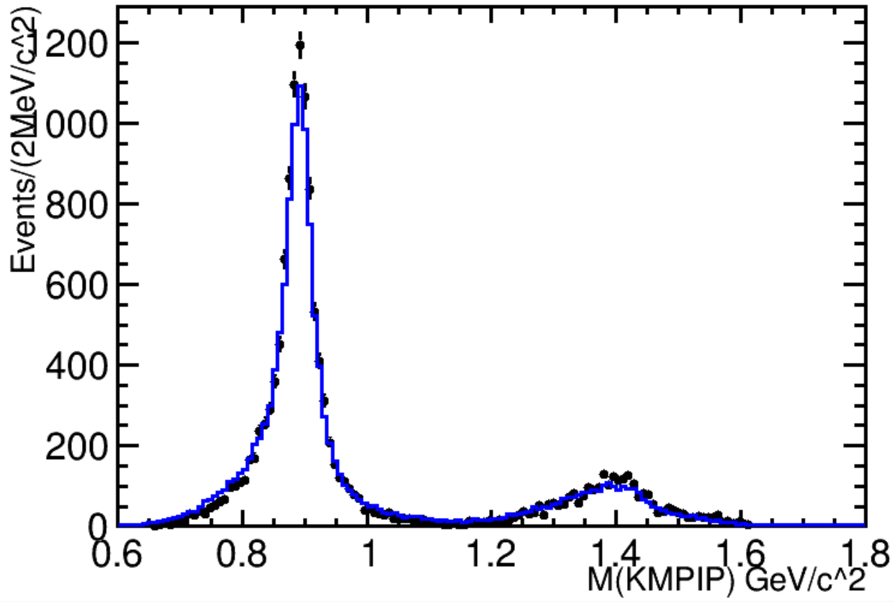
I use MC shape convolution Gaussian to describe the signal. and use the second-order Chebyshev to describe the background.

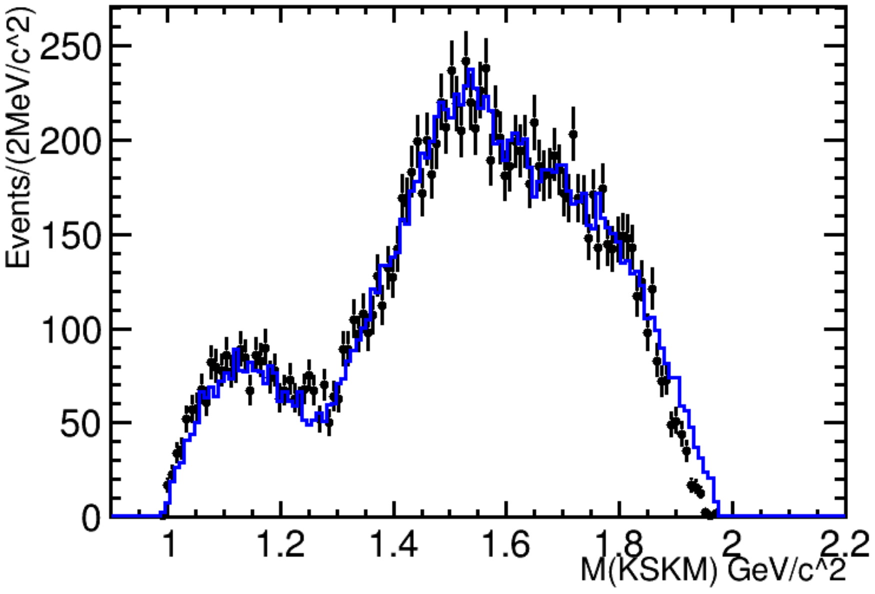
Amplitude analysis

Many resonance states can be observed from the two-body invariant mass plot.

So we will proceed with the amplitude analysis next.







Amplitude analysis

- Helicity formalization (BNL-76975-2006-IR) used, based on $TF-PWA$
- The amplitude for particle with spin J and z-component M decay into two particles with helicities

λ_1 and λ_2:

$$A = N_J F^J_{\lambda_1\lambda_2} D^{J*}_{M\lambda_1-\lambda_2}(\phi,\theta,0)$$

- The helicity decay amplitude is expanded of the partial-wave amplitudes and rewritten using the LS recoupling coefficient:

$$F^J_{\lambda_1\lambda_2} = \sum_{ls}\left(\frac{2\ell+1}{2J+1}\right)^{\frac{1}{2}} a^J_{\ell s}(\ell 0 s\lambda\,|\,J\lambda)(s_1\lambda_1 s_2-\lambda_2|s\lambda)$$

Where the partial-wave amplitude a^J_{ls} is defined by

$$a^J_{\ell s} = 4\pi\left(\frac{\omega}{p}\right)^{\frac{1}{2}} < JM\ell s|\mathcal{M}|\,JM >$$

- For resonances, relativistic Breit-Wigner (RBW) formula is used, the mass and width parameters are fixed to PDG

$$BW(m) = \frac{1}{m_0^2-m^2-im_0\Gamma(m)}, \quad \Gamma(m) = \Gamma_0\left(\frac{q}{q_0}\right)^{2l+1}\frac{m_0}{m}B_l'^2(q,q_0,d)$$

Fit Method

An unbinned maximum likelihood fit is performed in this amplitude analysis. The likelihood function L is constructed as:

$$-\ln L = -\alpha[\sum \omega_i \ln |A|^2 + (\sum \omega_i) \ln \int |A|^2 \, d\phi]$$

Strategy:

- The criteria we use to select the optimal solution are: significance greater than 5 times sigma
- I divided the 32 energy points into five intervals, and the partial wave results for each interval were determined by the energy point with the highest luminosity.

Fit Method

2.125: 1.844, 1.874, 1.876, 1.878, 1.879, 1.880, 1.881, 1.882, 1.886, 1.890, 1.904, 1.9437, 1.9735, 2.000, 2.050, 2.100, 2.150, 2.175, 2.200.

2.396: 2.2324, 2.3094, 2.3864.

2.644: 2.646.

2.900: 2.950.

3.080: 2.981, 3.000, 3.020.

Partial wave analysis

$R(K_s^0K^{\mp})+\pi^{\pm}$	$R(K_s^0\pi^{\pm})+K^{\mp}$	$R(K^{\mp}\pi^{\pm})+K_s^0$
PHSP	$K^*(892)^{\pm}$	$K^*(892)^0$
$a_2(1320)^{\mp}$	$K^*(1410)^{\pm}$	$K^*(1410)^0$
$\rho(1450)^{\mp}$	$K_2^*(1430)^{\pm}$	$K_2^*(1430)^0$
$\rho(1570)^{\mp}$	$K^*(1680)^{\pm}$	$K^*(1680)^0$
$\rho_3(1690)^{\mp}$	$K_3^*(1780)^{\pm}$	$K_3^*(1780)^0$
$\rho(1700)^{\mp}$	$K_2^*(1980)^{\pm}$	$K_2^*(1980)^0$
$a_4(1970)^{\mp}$	$K_4^*(2045)^{\pm}$	$K_4^*(2045)^0$
	$K_5^*(2380)^{\pm}$	$K_5^*(2380)^0$

Partial wave analysis

We obtain the most suitable several resonance states through rounds of screening

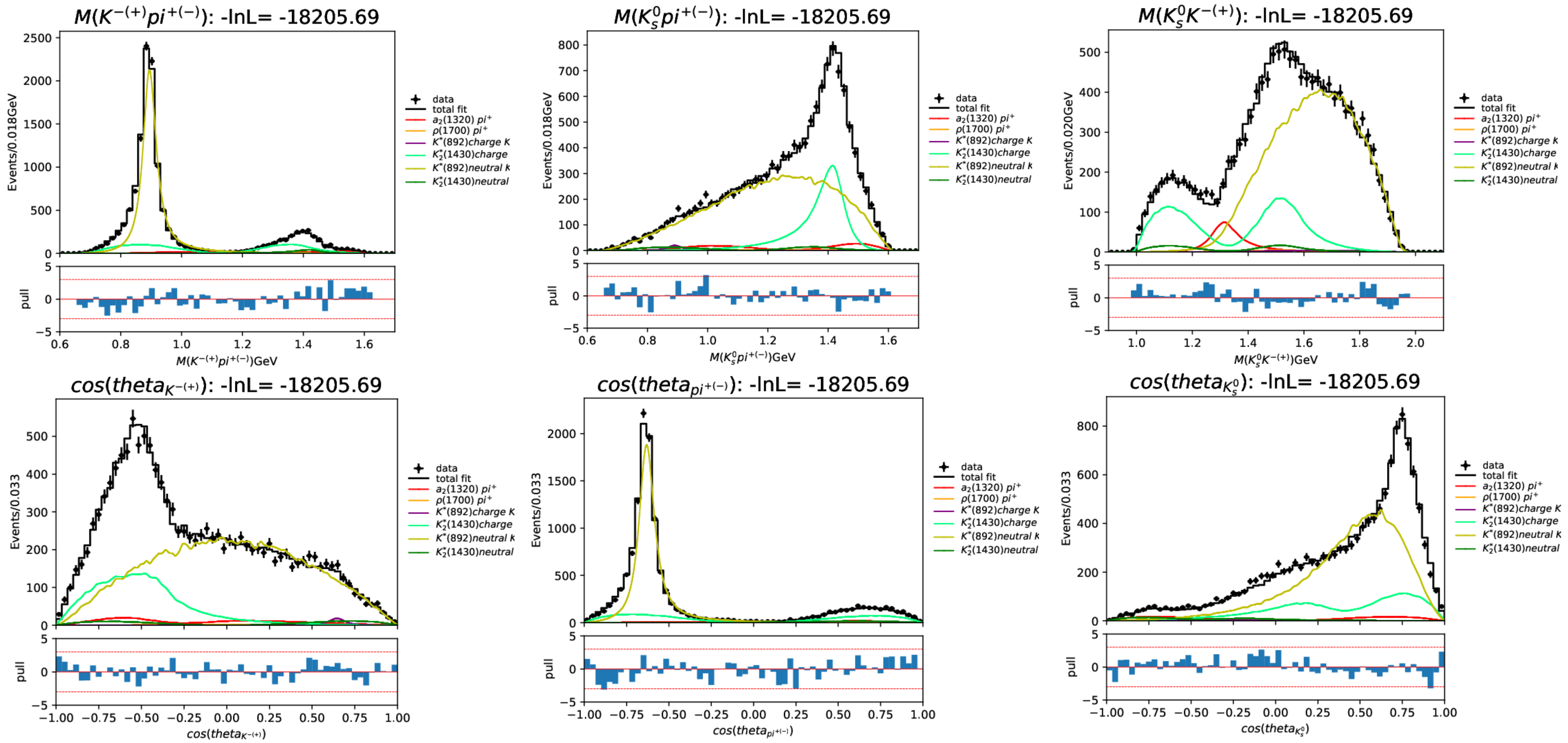
108 pb^{-1}@ 2.125GeV

The significance level of each resonance is studied by comparing the fit results with and without the resonance.

process	significance
$K^*(892)^0$	$> 8\sigma$
$K^*(892)^\pm$	4.66σ
$K_2^*(1430)^0$	$> 8\sigma$
$K_2^*(1430)^\pm$	$> 8\sigma$
$a_2(1320)^\mp$	$> 8\sigma$
$\rho(1700)^\mp$	6.40σ

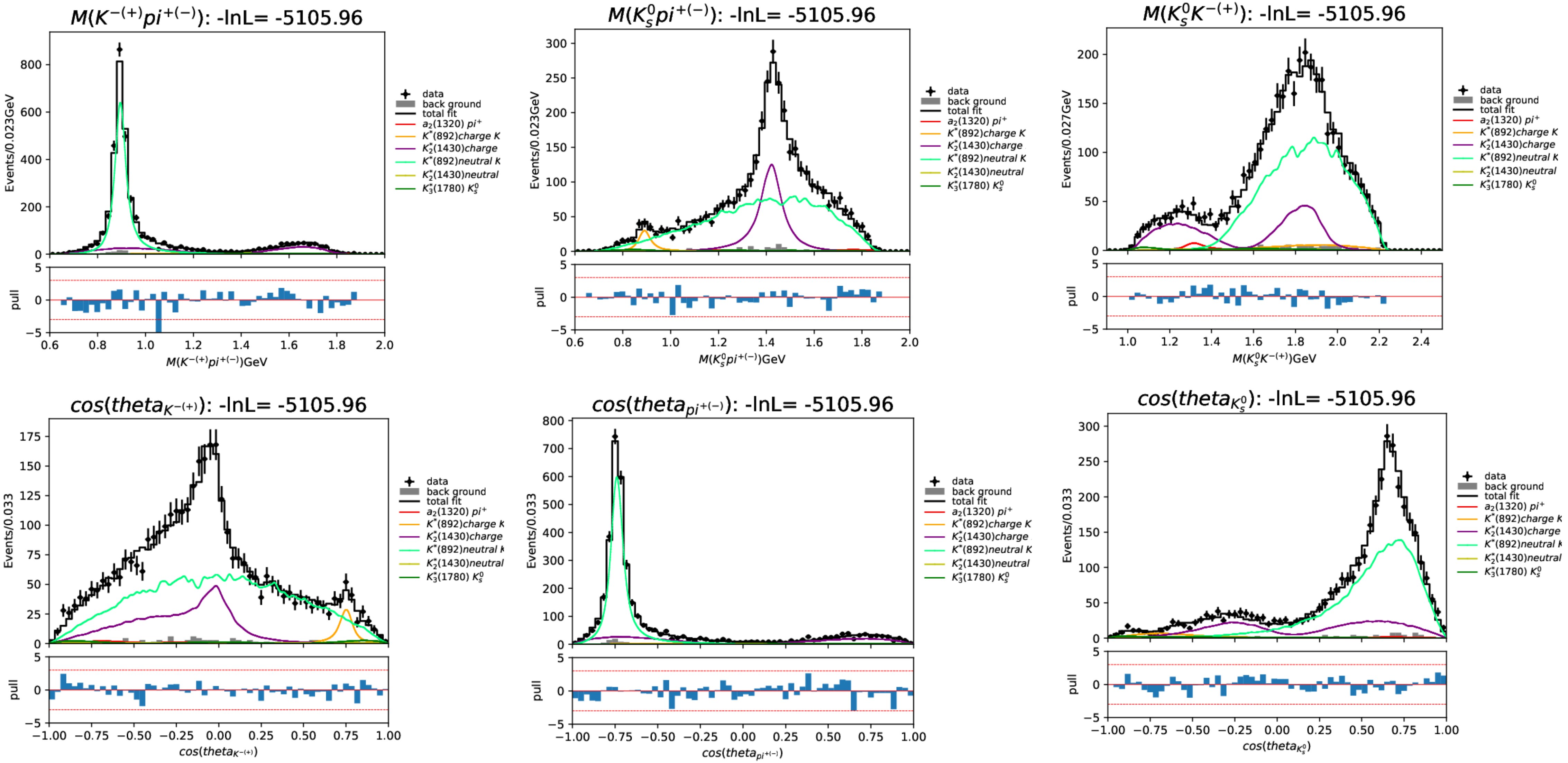
Partial wave analysis

2.125 GeV



Partial wave analysis

2.396 GeV

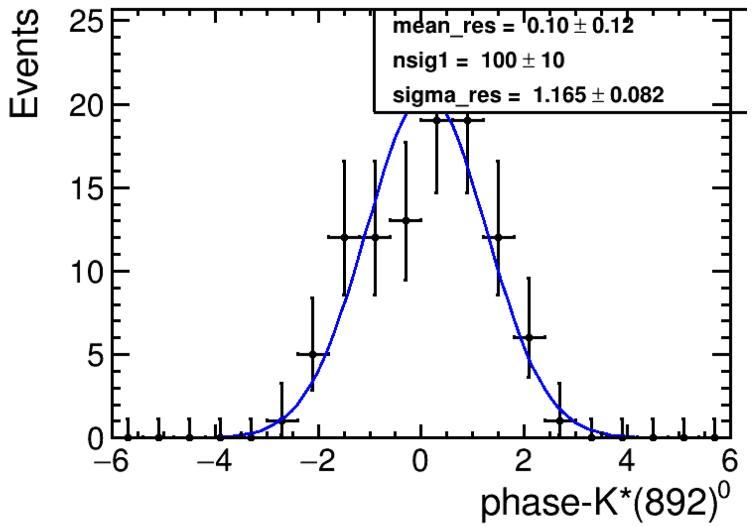


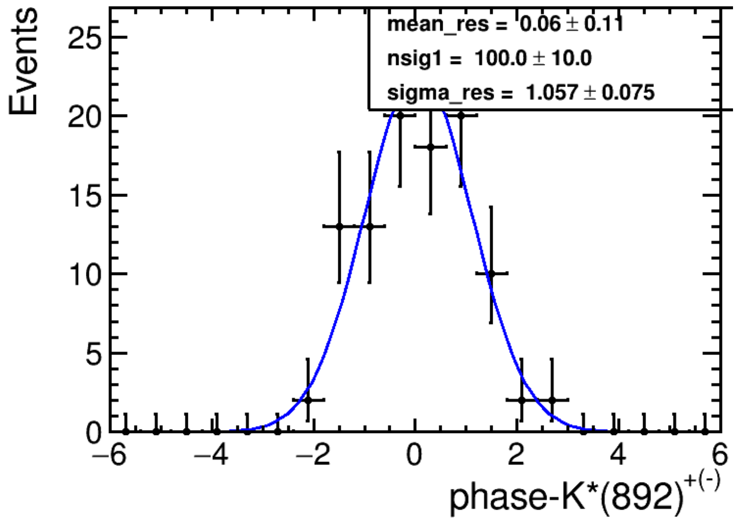
IO check

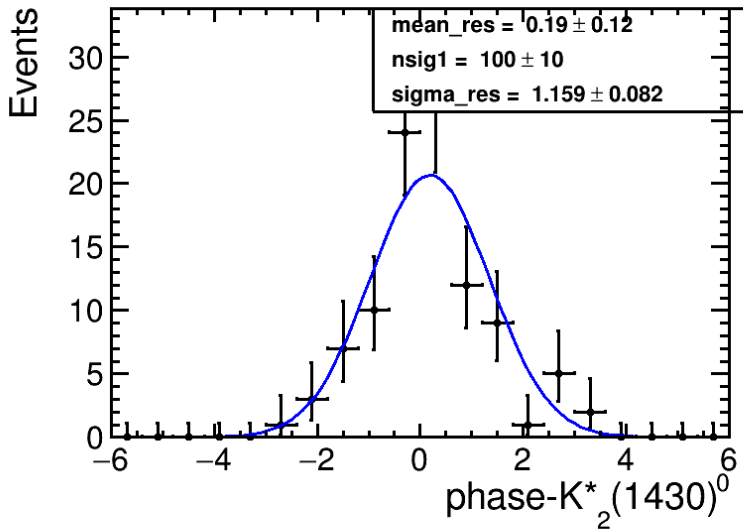
I first perform a PWA of data, and then use the results as the input parameters to validate the PWA procedure.100 MC samples with the size equaling to data are used to perform the pull distribution check.

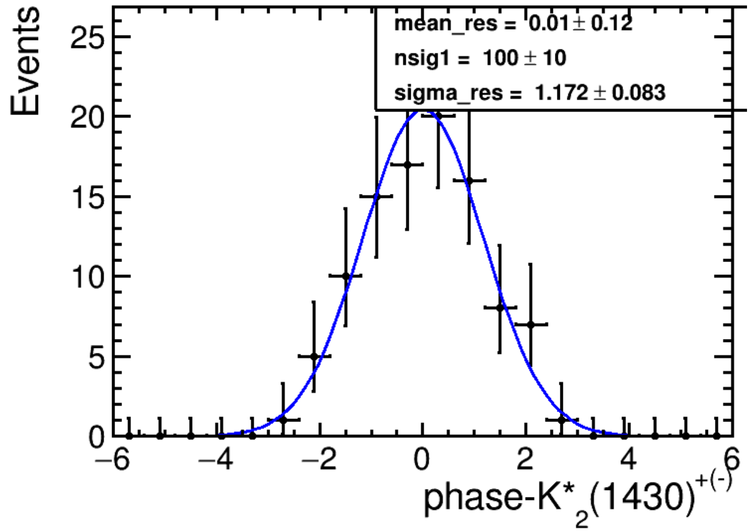
$$\rho = \frac{(\mu_{in} - \mu_{out})}{\sigma_{out}}$$

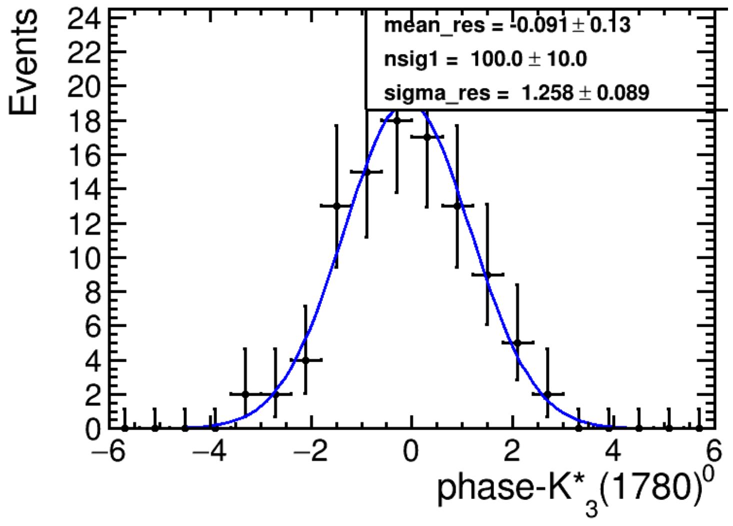
$\sqrt{s}$ = **2.396 GeV**



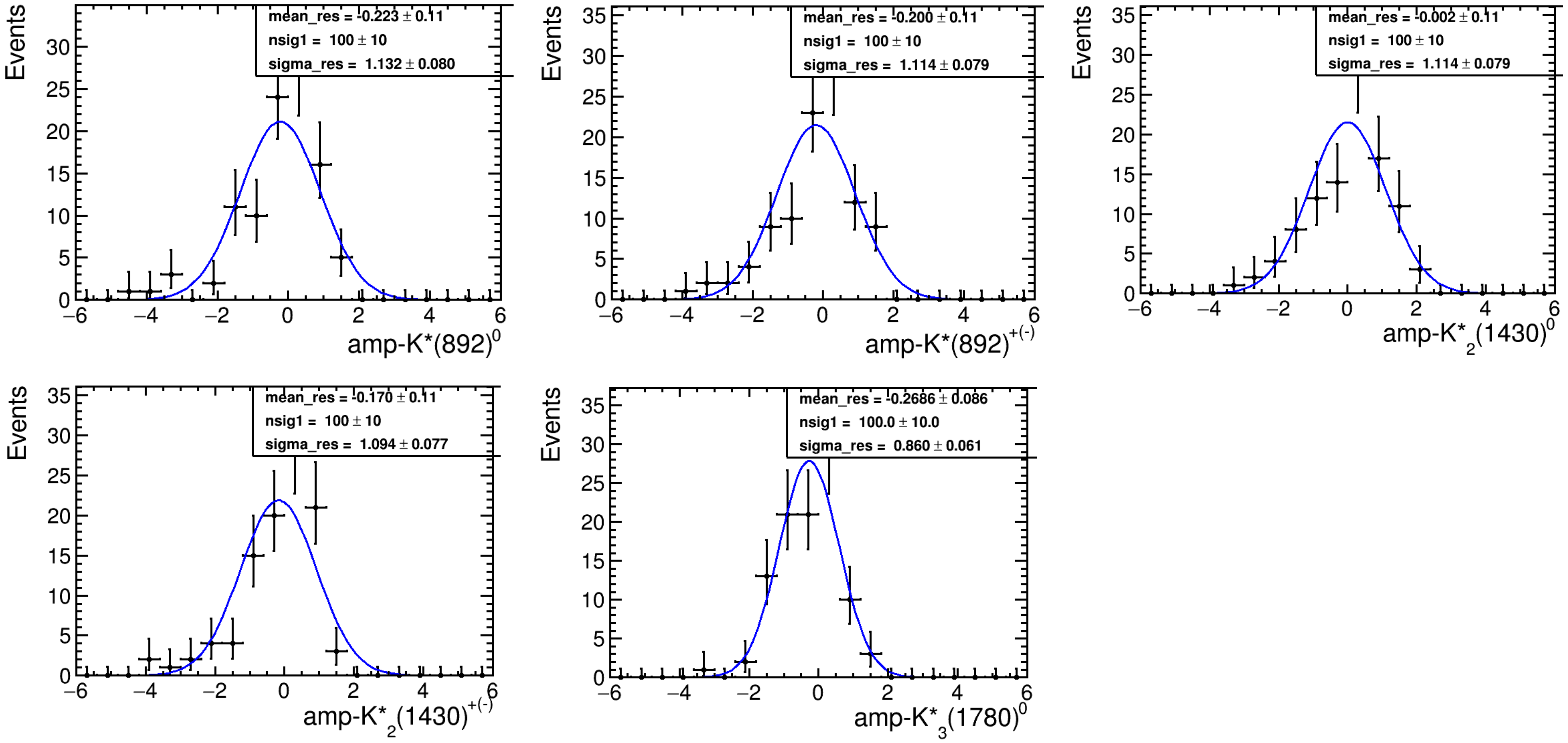






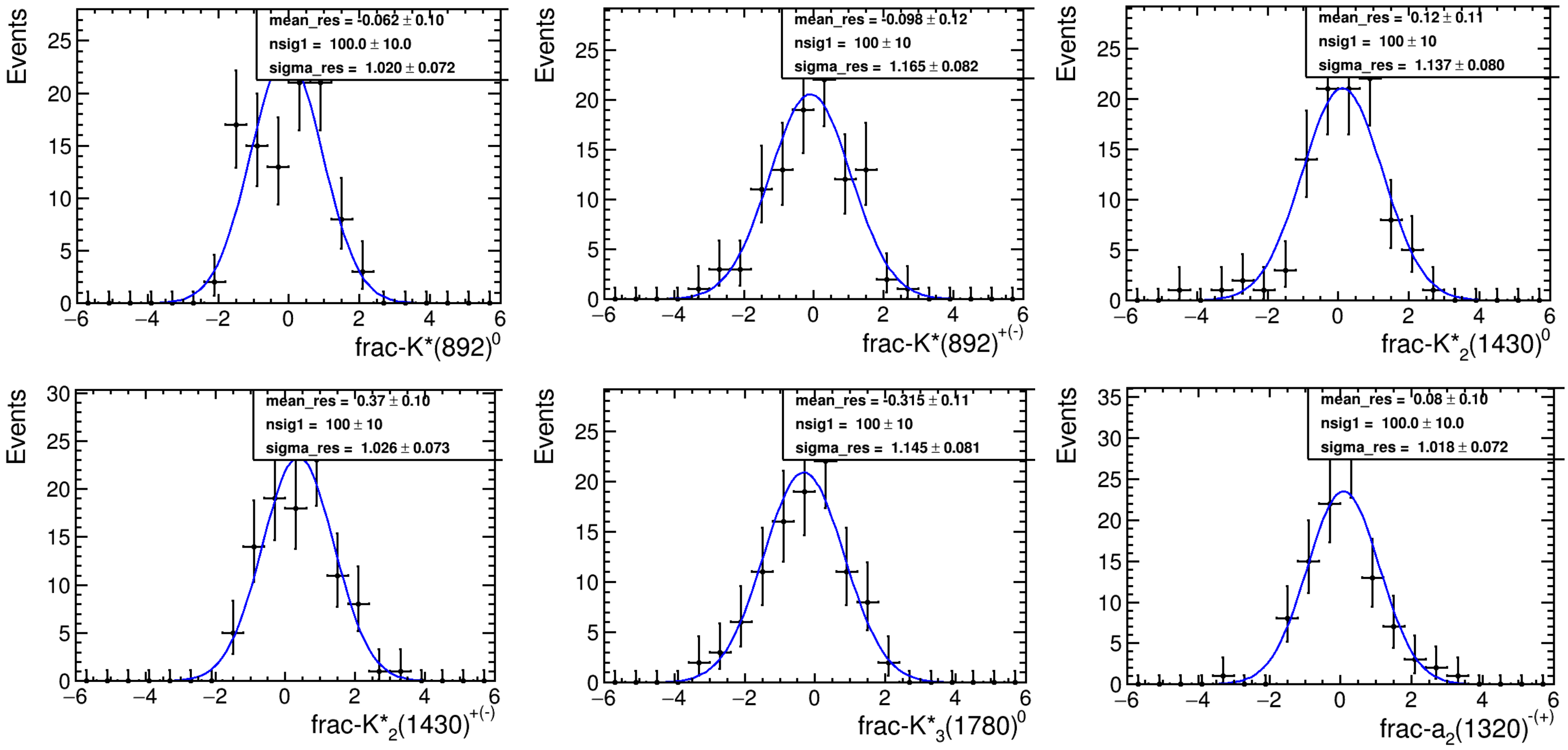


IO check



mean_res = -0.223 ± 0.11
nsig1 = 100 ± 10
sigma_res = 1.132 ± 0.080
Events
amp-K*(892)^0
mean_res = -0.200 ± 0.11
nsig1 = 100 ± 10
sigma_res = 1.114 ± 0.079
Events
amp-K*(892)^+(-)
mean_res = -0.002 ± 0.11
nsig1 = 100 ± 10
sigma_res = 1.114 ± 0.079
Events
amp-K*_2(1430)^0
mean_res = -0.170 ± 0.11
nsig1 = 100 ± 10
sigma_res = 1.094 ± 0.077
Events
amp-K*_2(1430)^+(-)
mean_res = -0.2686 ± 0.086
nsig1 = 100.0 ± 10.0
sigma_res = 0.860 ± 0.061
Events
amp-K*_3(1780)^0

IO check

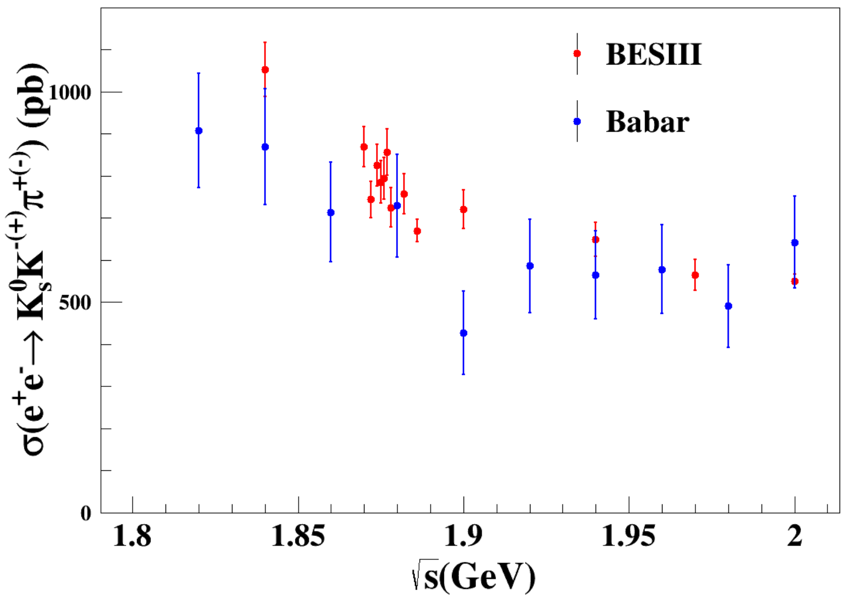


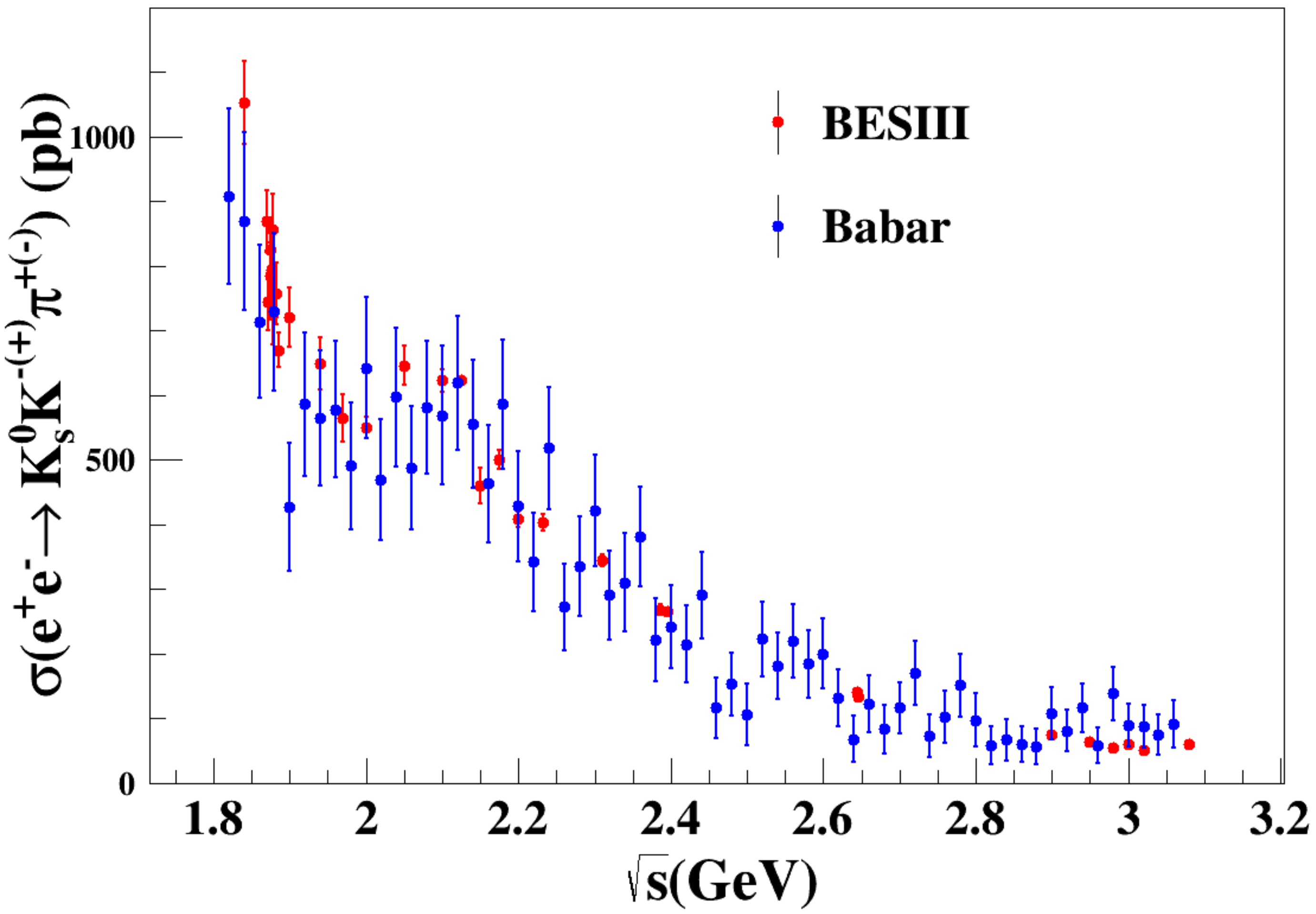
mean_res = -0.062 ± 0.10
nsig1 = 100.0 ± 10.0
sigma_res = 1.020 ± 0.072
Events
frac-K*(892)^0
mean_res = -0.098 ± 0.12
nsig1 = 100 ± 10
sigma_res = 1.165 ± 0.082
Events
frac-K*(892)^+(-)
mean_res = 0.12 ± 0.11
nsig1 = 100 ± 10
sigma_res = 1.137 ± 0.080
Events
frac-K*_2(1430)^0
mean_res = 0.37 ± 0.10
nsig1 = 100 ± 10
sigma_res = 1.026 ± 0.073
Events
frac-K*_2(1430)^+(-)
mean_res = -0.315 ± 0.11
nsig1 = 100 ± 10
sigma_res = 1.145 ± 0.081
Events
frac-K*_3(1780)^0
mean_res = 0.08 ± 0.10
nsig1 = 100.0 ± 10.0
sigma_res = 1.018 ± 0.072
Events
frac-a_2(1320)^-(+)

Total cross section

I obtained reliable detection efficiencies and ISR correction factors using an iterative method.

$$\sigma^B = \frac{N_{obs}}{L_{\text{int}} \cdot (1+\delta) \cdot \frac{1}{|1-\Pi|^2} \cdot B_r \cdot \varepsilon}$$



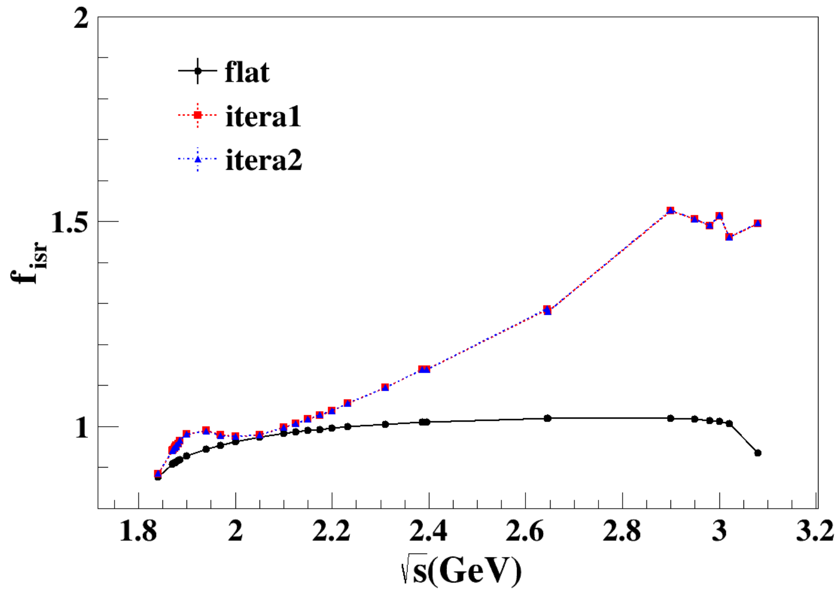


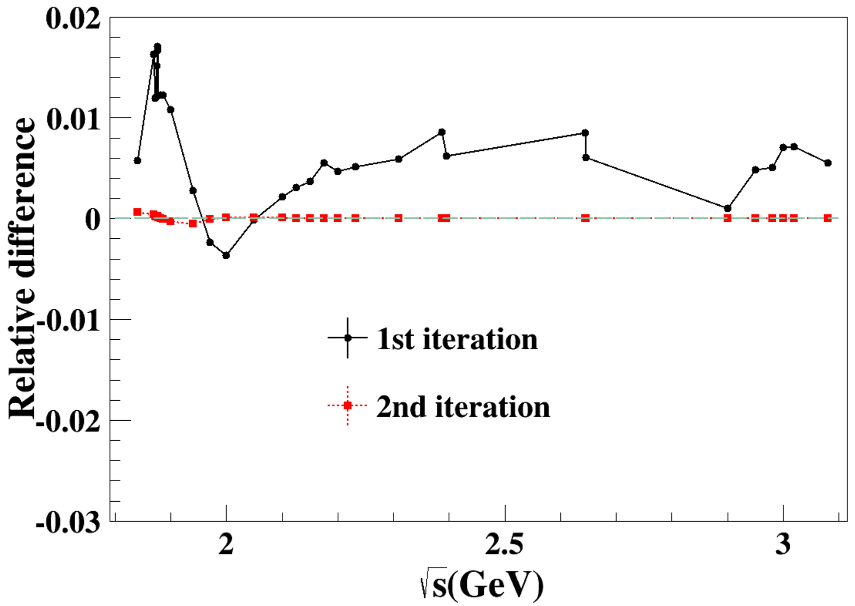
Total cross section

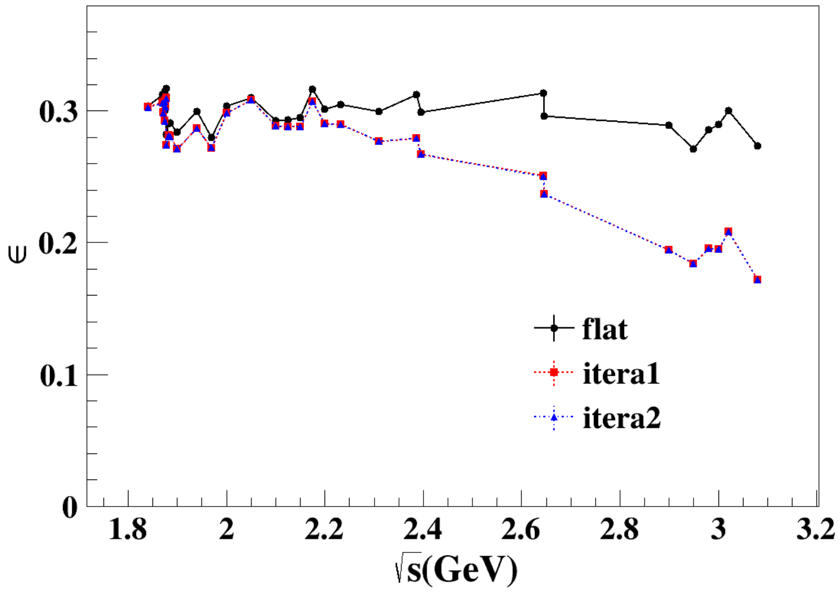
$\sqrt{s}(GeV)$	N_{sig}	ε(%)	Br(%)	$L(pb^{-1})$	$\sigma_{obs}(pb)$	$\sqrt{s}(GeV)$	N_{sig}	ε(%)	Br(%)	$L(pb^{-1})$	$\sigma_{obs}(pb)$	$\sqrt{s}(GeV)$	N_{sig}	ε(%)	Br(%)	$L(pb^{-1})$	$\sigma_{obs}(pb)$
1.844	293±18	30.27	69.2	1.501	1052.8±64.7	**2.000**	1114±33	29.88	69.2	10.074	550.2±16.3	**2.900**	1601±44	19.44	69.2	105.253	74.0±2.0
1.874	347±19	30.62	69.2	2.002	868.9±47.6	**2.050**	451±21	30.81	69.2	3.343	645.8±30.1	**2.950**	197±14	18.38	69.2	15.942	64.5±4.6
1.876	292±17	29.84	69.2	2.014	743.8±43.3	**2.100**	1509±42	28.86	69.2	12.167	622.5±17.3	**2.981**	174±15	19.54	69.2	16.071	53.7±4.6
1.878	319±19	29.20	69.2	2.019	825.3±49.2	**2.125**	13480±121	28.79	69.2	108.49	623.9±5.6	**3.000**	193±17	19.49	69.2	15.881	59.5±5.2
1.879	235±15	30.71	69.2	1.485	785.3±50.1	**2.150**	265±16	28.79	69.2	2.841	460.0±27.8	**3.020**	188±16	20.81	69.2	17.290	51.6±4.4
1.880	322±20	30.31	69.2	2.035	793.4±49.3	**2.175**	1162±35	30.72	69.2	10.625	500.4±15.1	**3.080**	1354±42	17.20	69.2	126.185	60.3±1.9
1.881	234±15	30.96	69.2	1.341	855.7±54.8	**2.200**	1166±34	29.04	69.2	13.699	407.9±11.9						
1.882	265±17	27.39	69.2	2.021	725.1±46.5	**2.2324**	1013±32	28.97	69.2	11.856	403.4±12.7						
1.886	287±18	28.11	69.2	2.033	756.9±47.5	**2.3094**	1526±42	27.67	69.2	21.089	344.9±9.5						
1.890	255±16	28.04	69.2	2.031	670.1±26.3	**2.3864**	1328±40	27.92	69.2	22.549	267.7±8.1						
1.904	268±17	27.10	69.2	2.022	720.5±45.7	**2.396**	3724±65	26.70	69.2	66.869	264.7±4.6						
1.9437	260±16	28.70	69.2	2.040	648.7±39.9	**2.644**	1062±33	25.04	69.2	34.003	140.1±4.4						
1.9735	232±15	27.22	69.2	2.229	564.8±36.5	**2.646**	950±31	23.70	69.2	33.722	134.1±4.4						

Total cross section

Those are iterative plot of the ISR factor and efficiency and Relative difference.





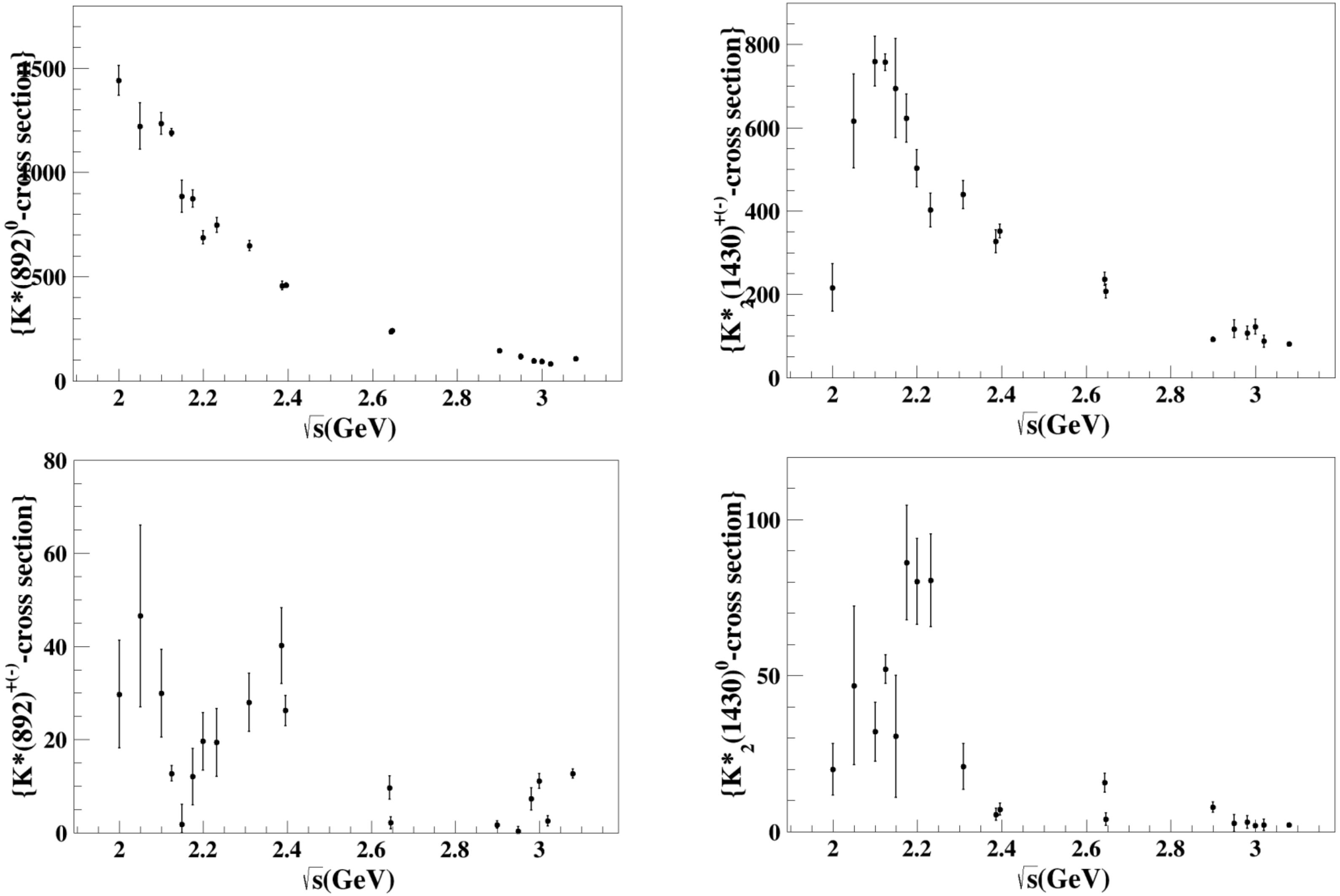


Cross section of intermediate resonance state

The cross section of each intermediate resonance state is equal to the total cross section multiplied by the fit fraction and then divided by the branching fraction.

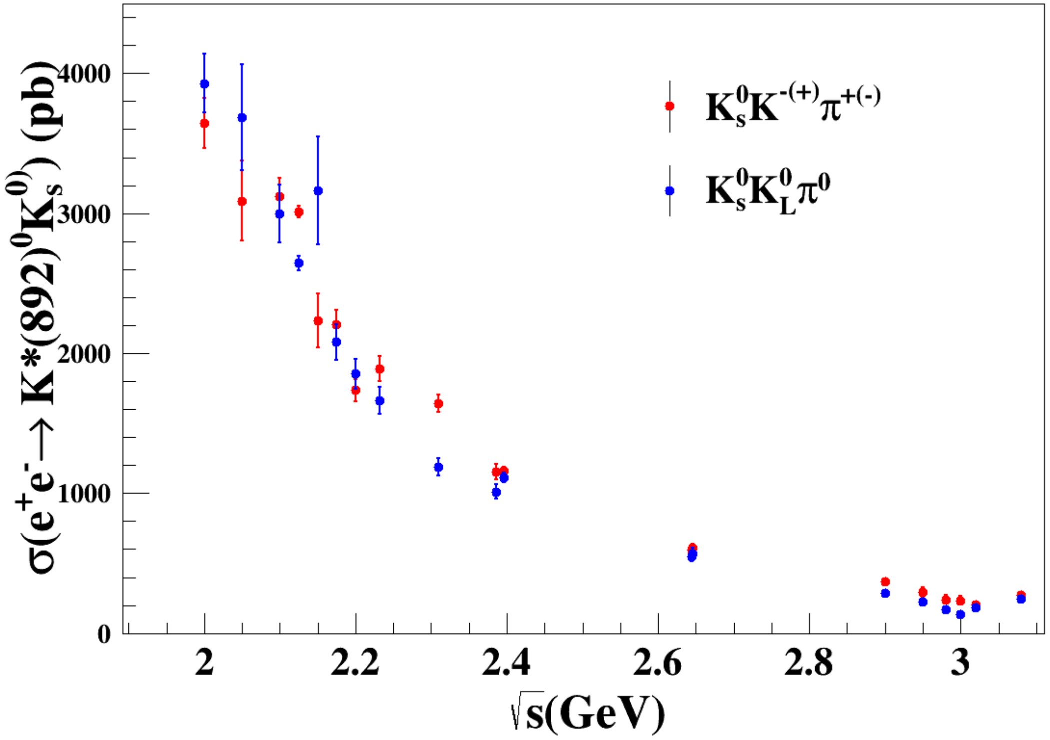
$$\sigma^B = \frac{N_{obs} \cdot f}{L_{\text{int}} \cdot (1+\delta) \cdot \frac{1}{|1-\Pi|^2} \cdot B_r \cdot \varepsilon}$$

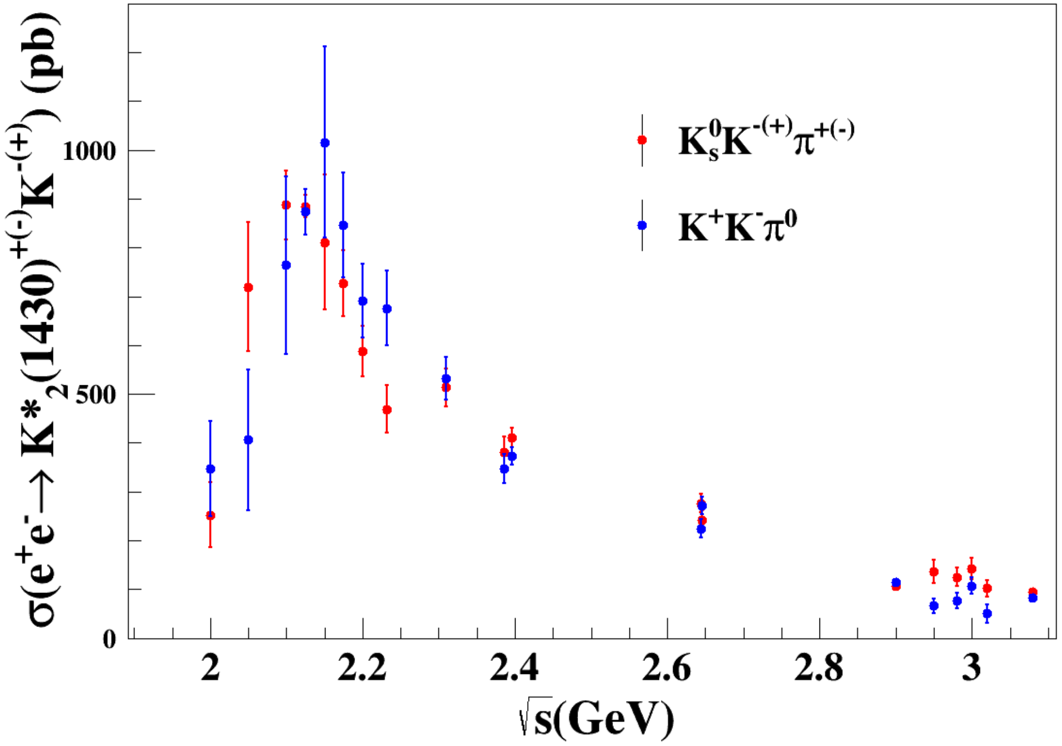
I did not calculate the resonance state's cross sections for energy points below 2.000 GeV.



Cross section of intermediate resonance state

I compared the cross-sections of the intermediate resonance states with $K^+K^-\pi^0$ study and the $K_sK_l\pi^0$ study respectively.





Fit to the cross section

Fit to the cross section: $\sigma_{fit} = |f_1 + e^{i\theta} f_2|^2$

$$f_1 = C_0 \cdot \sqrt{PS(\sqrt{s})e^{-p_0(\sqrt{s}-M_{th})}}$$

$$f_2 = \frac{\sqrt{12\pi B_r \Gamma_R^{e^+e^-} \Gamma(\sqrt{s})}}{s - M_R^2 + iM_R\Gamma(\sqrt{s})}$$

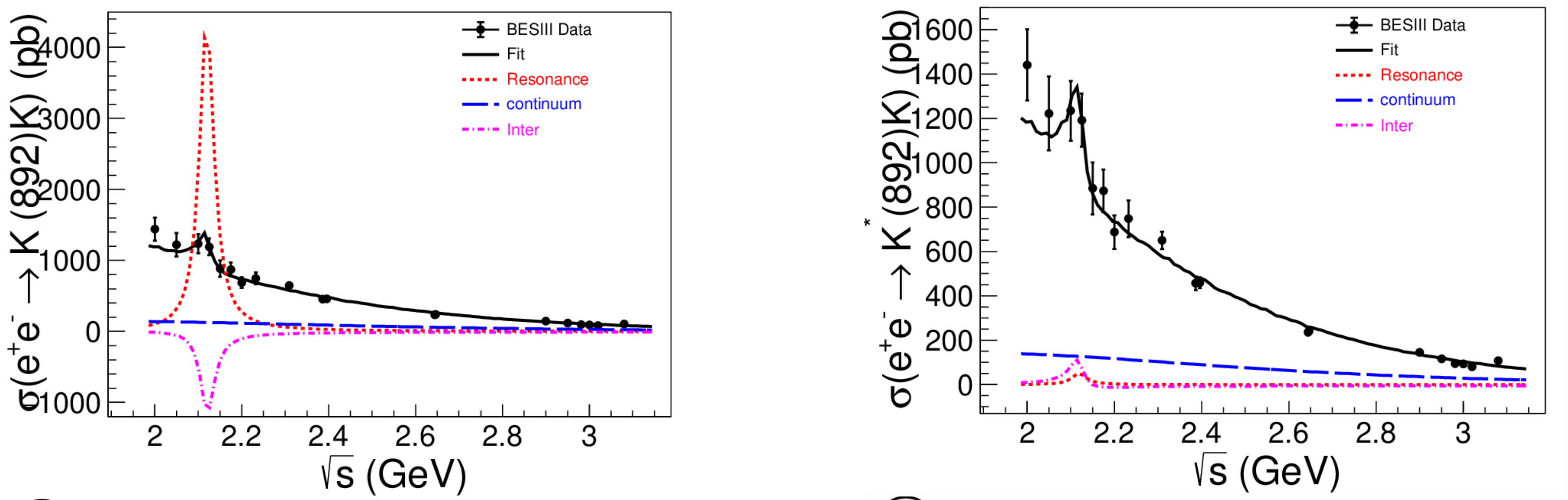
$$PS(\sqrt{s}) = \int |A_{K^{*0}(892)K_S^0, K_2^{*\pm}(1430)K^{\mp}}|^2 d\Phi_3$$

$$\Gamma(\sqrt{s}) = \Gamma_R \frac{\Phi(\sqrt{s})}{\Phi(M_R)}$$

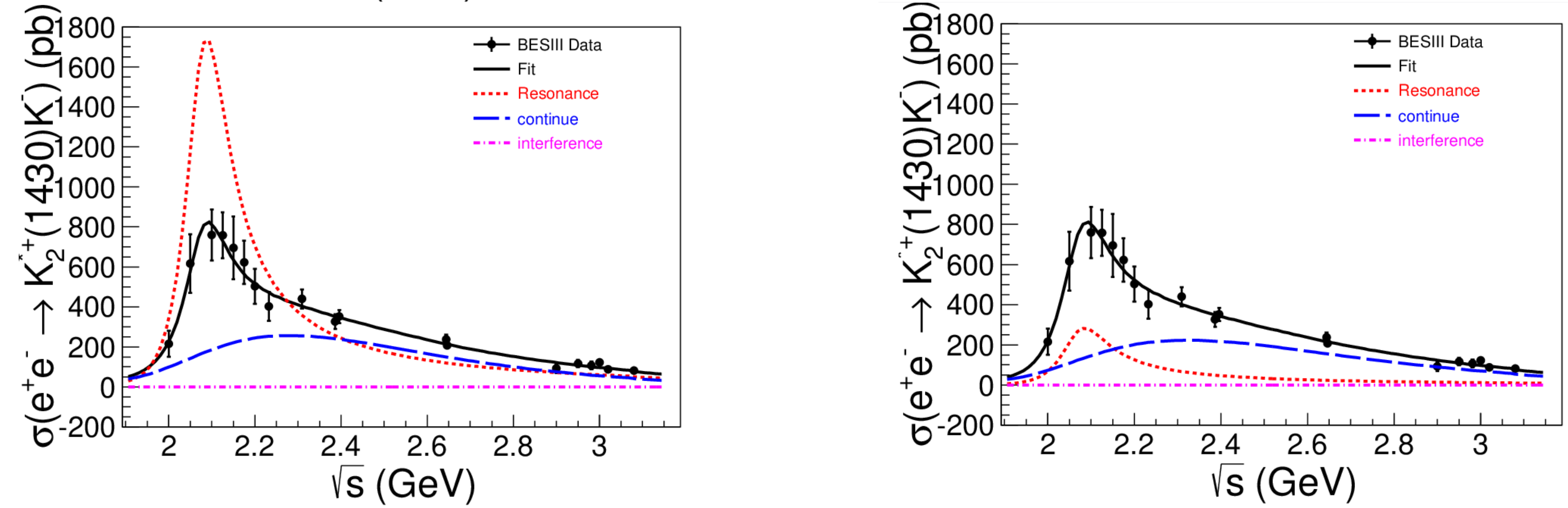
where M_{th} is the mass threshold, A is partial wave amplitude in the covariant Rarita-Schwinger tensor formalism, Φ_3 is threebody phase space. M_R is the mass of the resonance, Γ_R is the constant width, $\Gamma_R^{e^+e^-}$ is its partial width to e^+e^-, and B_r is the decay branching fraction to a given final state.

Fit to the cross section

Then, fit the cross sections of $K^{*}(892)^{0}$ and $K_2^{*}(1430)^{\pm}$. Each of $K^{*}(892)^{0}$ and $K_2^{*}(1430)^{\pm}$ will have two solutions, as shown in the figure below.



Mass = 2120.0±6.3MeV
Width = 40.0±6.0MeV
Sig.($\boldsymbol{\sigma}$) = 2.6



Mass = 2064.6±18.5MeV
Width = 135.0±28.0MeV
Sig.($\boldsymbol{\sigma}$) = 6.5

Systematic uncertainty

1. ***Luminosity***: 1%

2. ***Tracking efficiency***: 1%

3. ***PID***: 1%

4. K_s^0 ***reconstruction***: 1.5%.

5. ***Kinematic fit***:

For the kinematic fit, the PULL distribution of charged tracks parameters are corrected to make MC agree with data better. The efficiency difference is estimated as systematic uncertainty.

Systematic uncertainty

6. ISR correction:

1000 determined values of $f_{1sr} \cdot \varepsilon$ are obtained, then a Gaussian function is fitted to the plot to extract the mean (μ) and standard deviation (σ). The ratio of the standard deviation to the mean (σ/μ), together with the contribution from the accuracy of the radiation function, are collectively taken as the systematic uncertainty.

7.Signal shape:

Signal shape is changed from a MC-simulated shape convoluted with a Gaussian function to a pure MC .The difference of the yields between them is considered as systematic due to the signal shape.

8.Fitting range:

For this systematical test, which changes the fitting range, the final cross section is different. Based on the magnitude of the significance indicator for deviation, we judge whether the "change in fitting range" has caused a significant deviation. If the deviation is significant, it indicates that the "fitting range" is a source of systematic uncertainty that needs to be considered.

Systematic uncertainty

9.PWA related uncertainties

I am still calculating this systematic uncertainty at present.

Systematic uncertainty

$\sqrt{s}$(Gev)	$L(pb^{-1})$	Tracking	PID	K_s^0 rec	signal shape	isr	fitting range	kmfit
2.000	1.0%	2.0%	2.0%	1.5%	0.773%	0.064%	0.124%	0.163%
2.050	1.0%	2.0%	2.0%	1.5%	0.773%	0.037%	0.124%	0.067%
2.100	1.0%	2.0%	2.0%	1.5%	0.773%	0.022%	0.124%	0.111%
2.125	1.0%	2.0%	2.0%	1.5%	0.773%	0.025%	0.124%	0.182%
2.150	1.0%	2.0%	2.0%	1.5%	0.773%	0.027%	0.124%	0.050%
2.175	1.0%	2.0%	2.0%	1.5%	0.773%	0.037%	0.124%	0.101%
2.200	1.0%	2.0%	2.0%	1.5%	0.773%	0.027%	0.124%	0.077%
2.2324	1.0%	2.0%	2.0%	1.5%	0.773%	0.024%	0.124%	0.144%
2.3094	1.0%	2.0%	2.0%	1.5%	0.773%	0.024%	0.124%	0.146%
2.3864	1.0%	2.0%	2.0%	1.5%	0.773%	0.048%	0.124%	0.088%
2.396	1.0%	2.0%	2.0%	1.5%	0.773%	0.035%	0.124%	0.084%
2.644	1.0%	2.0%	2.0%	1.5%	0.773%	0.025%	0.124%	0.074%
2.646	1.0%	2.0%	2.0%	1.5%	0.773%	0.018%	0.124%	0.069%
2.900	1.0%	2.0%	2.0%	1.5%	0.773%	0.025%	0.124%	0.048%
2.950	1.0%	2.0%	2.0%	1.5%	0.773%	0.017%	0.124%	0.115%
2.981	1.0%	2.0%	2.0%	1.5%	0.773%	0.017%	0.124%	0.080%
3.000	1.0%	2.0%	2.0%	1.5%	0.773%	0.023%	0.124%	0.090%
3.020	1.0%	2.0%	2.0%	1.5%	0.773%	0.023%	0.124%	0.165%
3.080	1.0%	2.0%	2.0%	1.5%	0.773%	0.016%	0.124%	0.032%

Summary & Next to do

Summary

We obtained the significance of the above two resonance states and calculated the systematic uncertainty of each part.

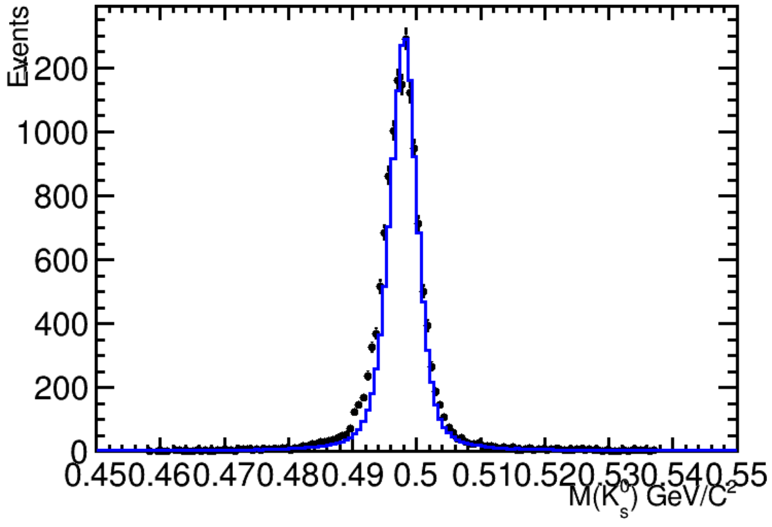
Next to do

- Prepare the memo.

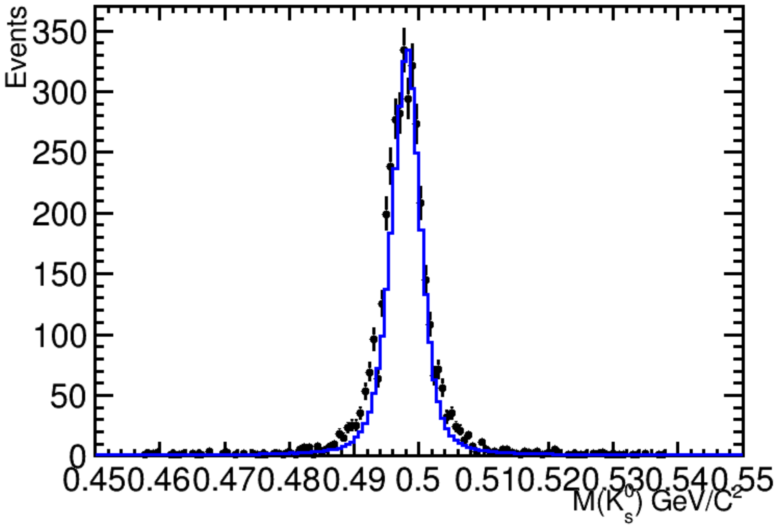
Thank you !

Back up

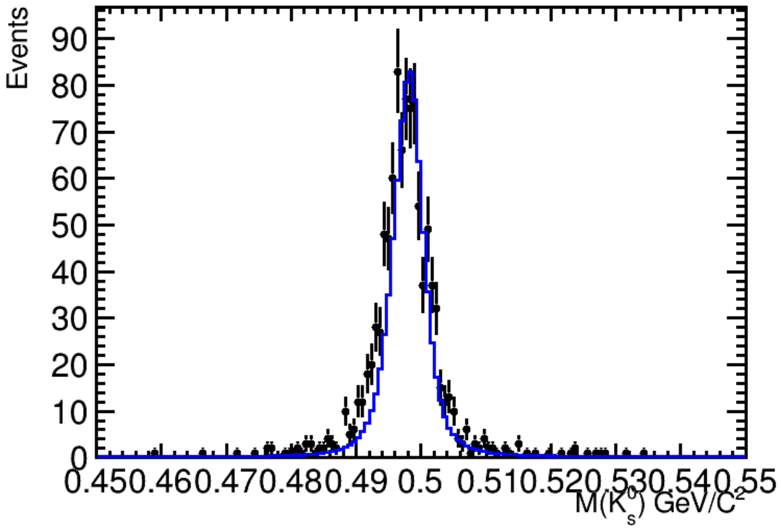
Further selection



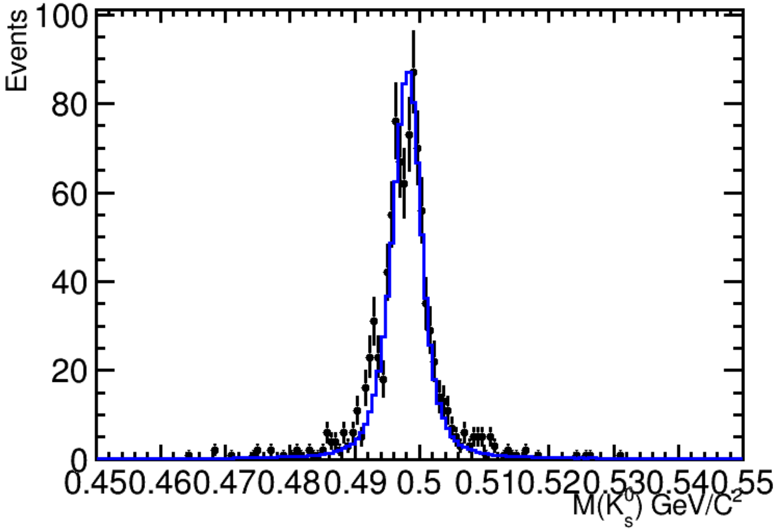
2.125GeV



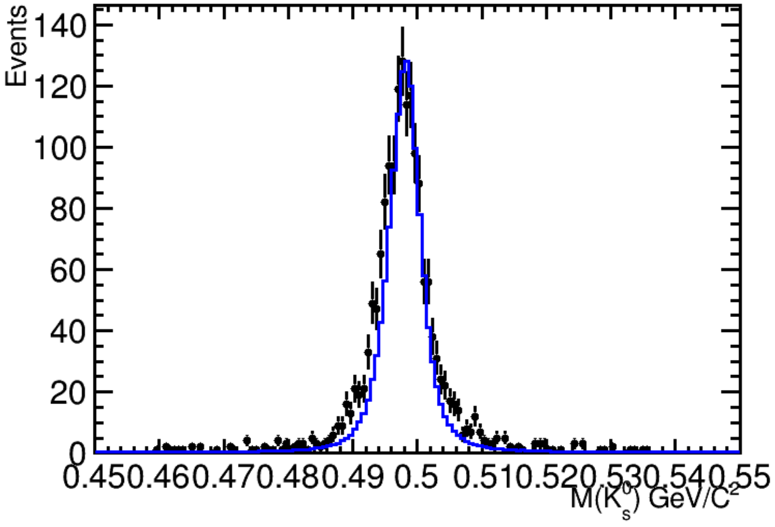
2.396GeV



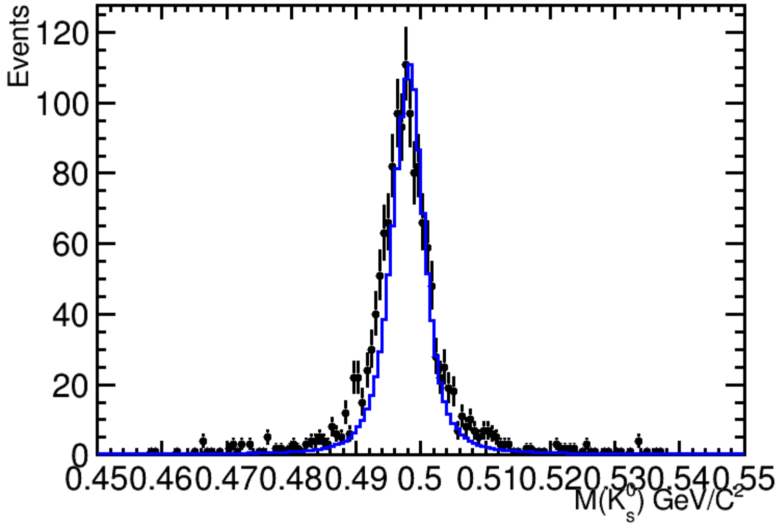
2.644GeV



2.646GeV

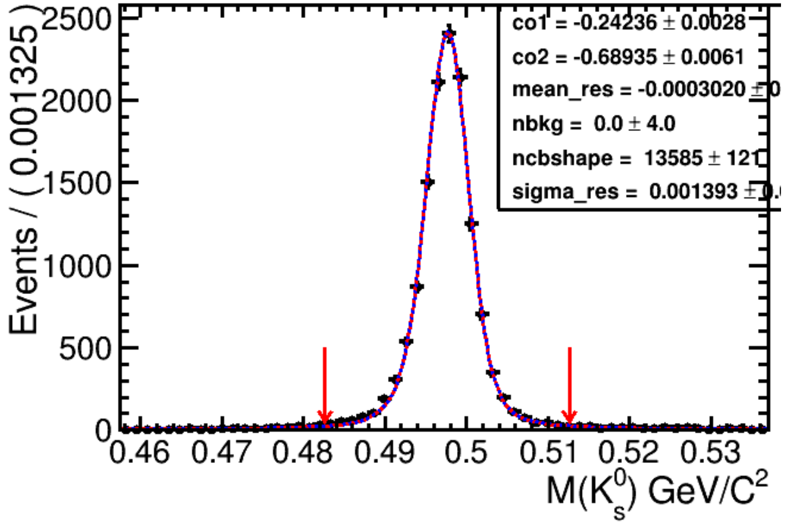


2.900GeV

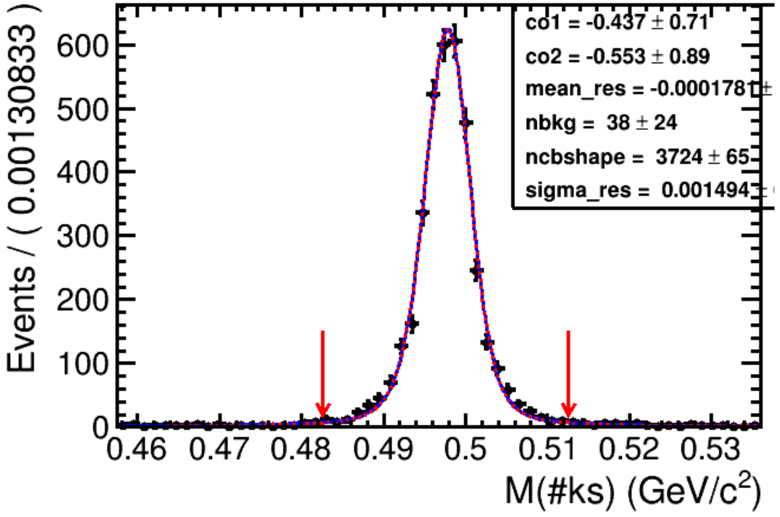


3.080GeV

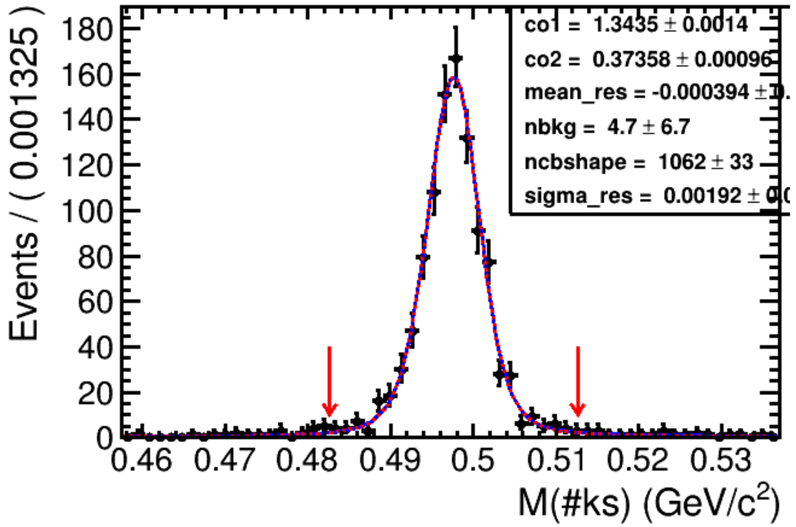
sideband



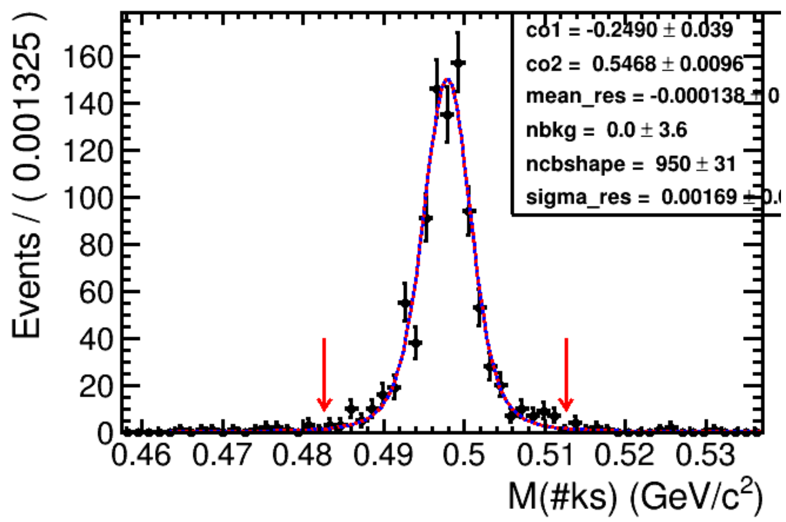
2.125GeV



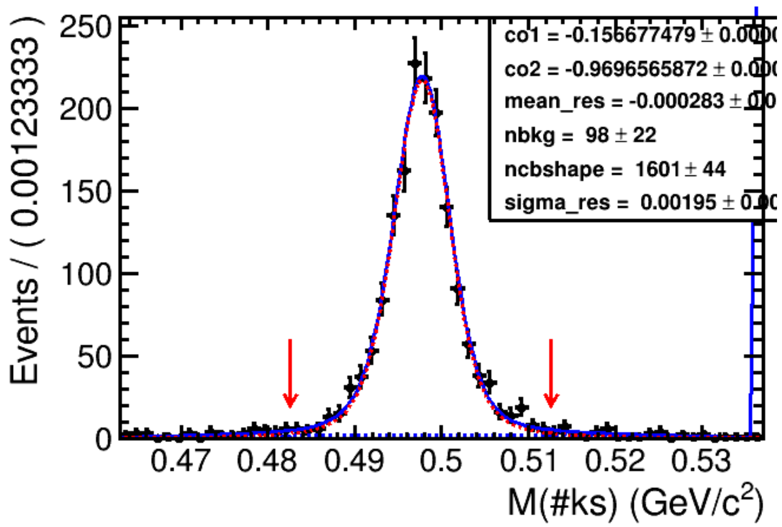
2.396GeV



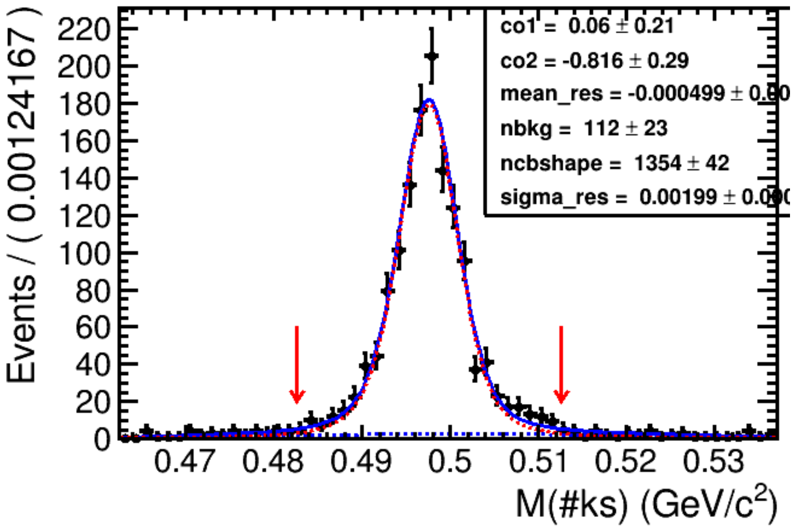
2.644GeV



2.646GeV



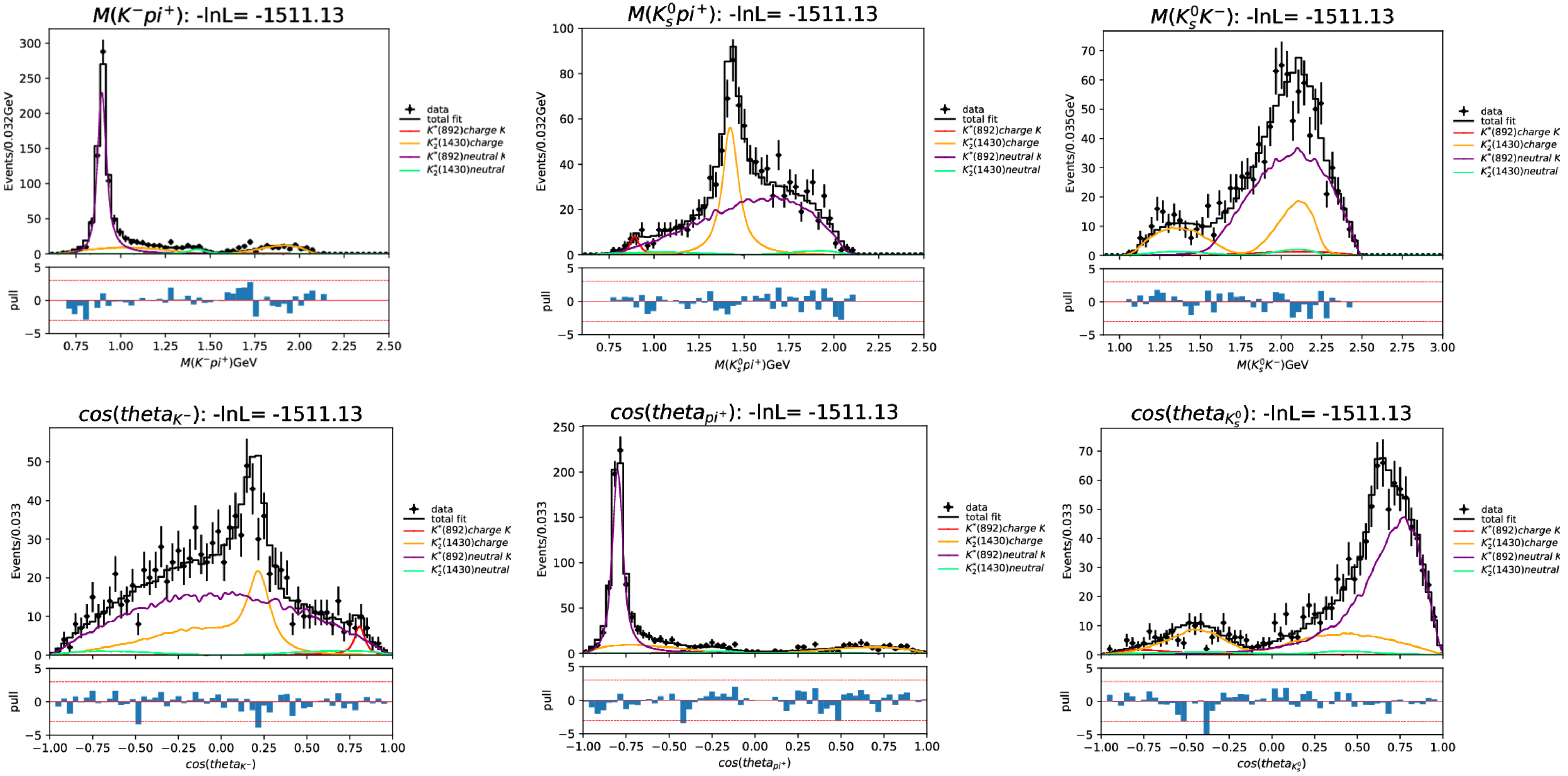
2.900GeV



3.080GeV

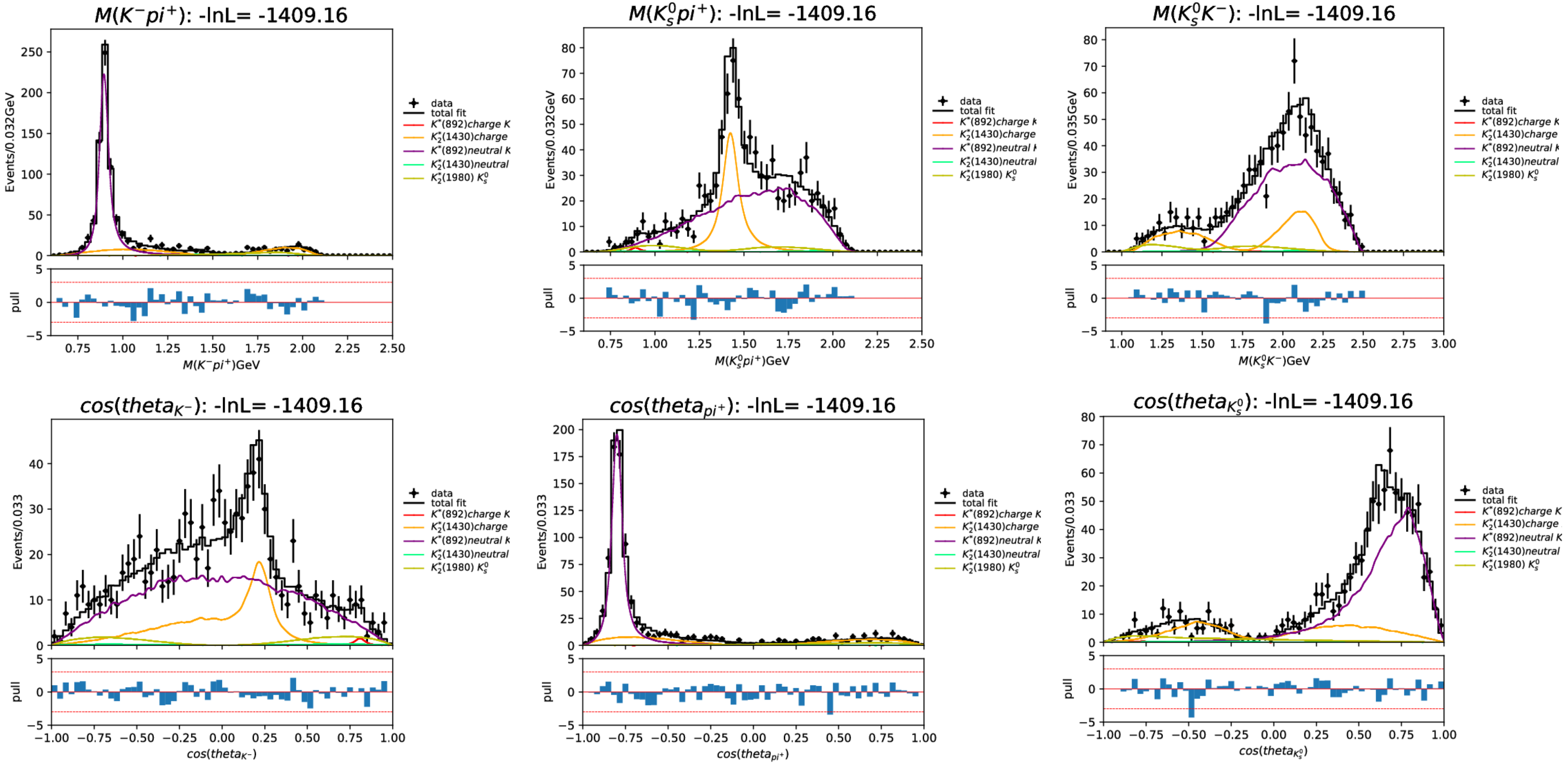
Partial wave analysis

2.644GeV



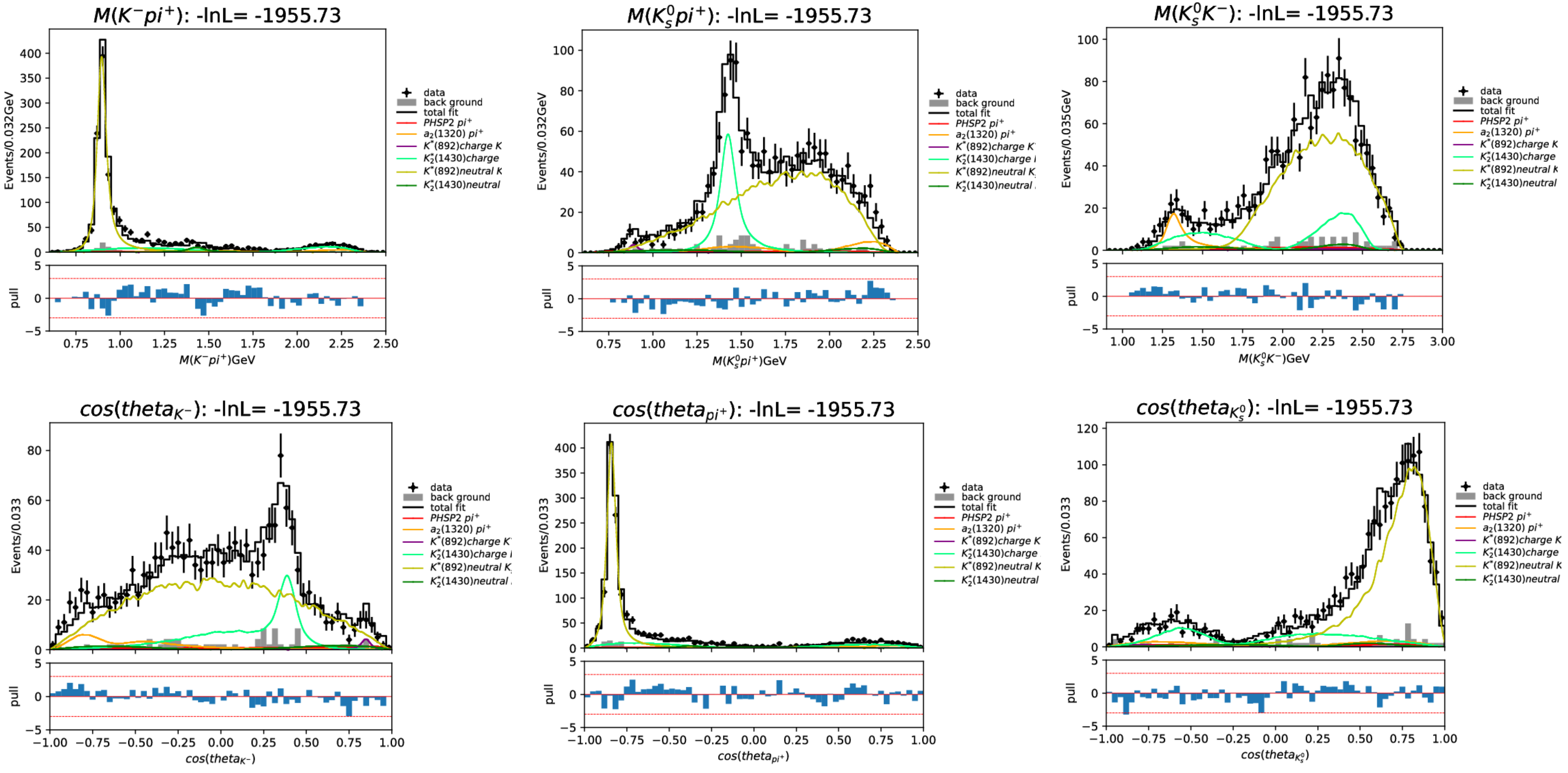
Partial wave analysis

2.646GeV



Partial wave analysis

2.900GeV



Partial wave analysis

3.080GeV