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Updated nominal result and Uncertainty

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Outline

- Background estimation by Q-weight method
- Fit result
- I/O check of extracting N_{obs}
- Systematic uncertainty
- Summary

Q-weight Method

- A space spanned by the n-dimension coordinates ξ is defined and normalized.

  (For some coordinate the normalization can defined as the standard deviation)

  (Better shows a large difference between Signal and background)

- For each event, a certain number of nearest events are selected and to generate a dataset.

$$d_{i,j}^2 = \sum_k^n \left[\frac{\xi_k^i - \xi_k^j}{\Delta_k} \right]^2$$

- A m-dimension conference coordinates ξ_r is defined, these coordinates should shows a large difference between Signal and background, and should be easily modeled with analytic functions.

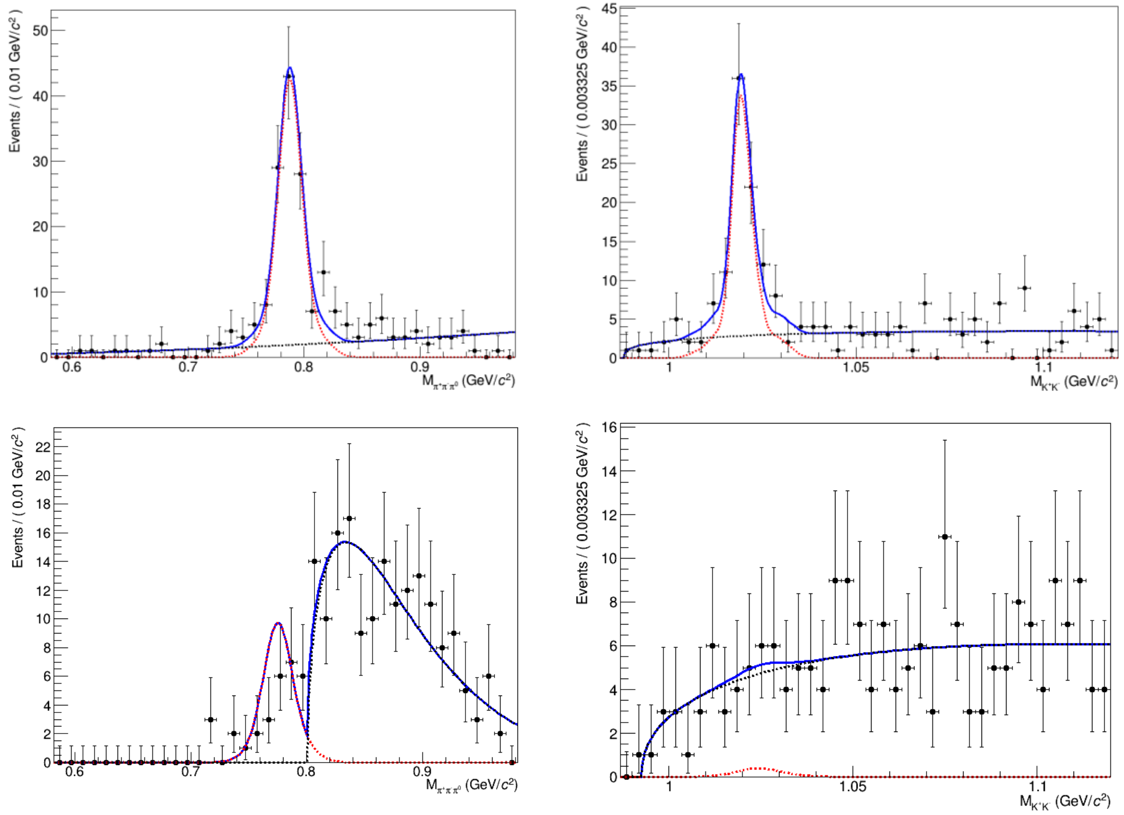
coordinate	Normalization
$m_{\omega\phi}^2$	0.3937
$m_{\gamma\phi}^2$	0.272
$m_{\gamma\omega}^2$	0.297
$\cos(\theta_\omega)$	2
$\cos(\theta_\phi)$	2
$\cos(\theta_\gamma)$	2
$\lambda_\omega/\lambda_{max}$	1

Journal of Instrumentation, 4(10):P10003, 2009

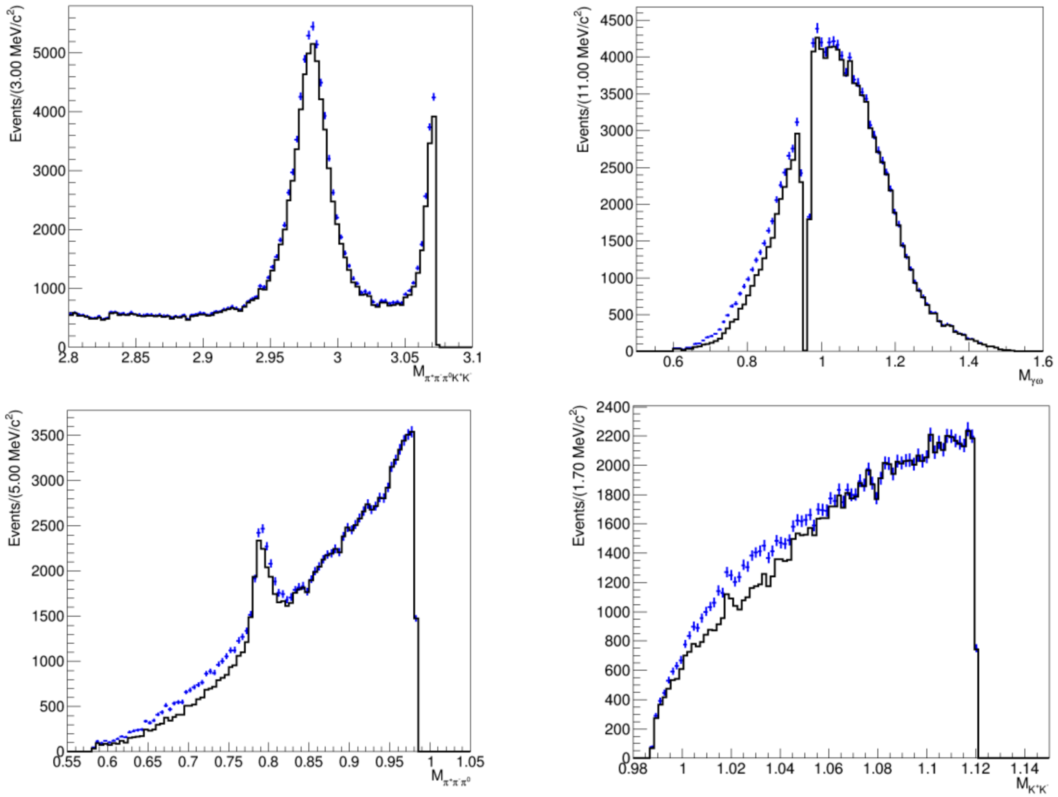
Q-weight Method

- For each event, fit on conference coordinates to the generated dataset is performed, to determine the Q-weight for the event.

Example

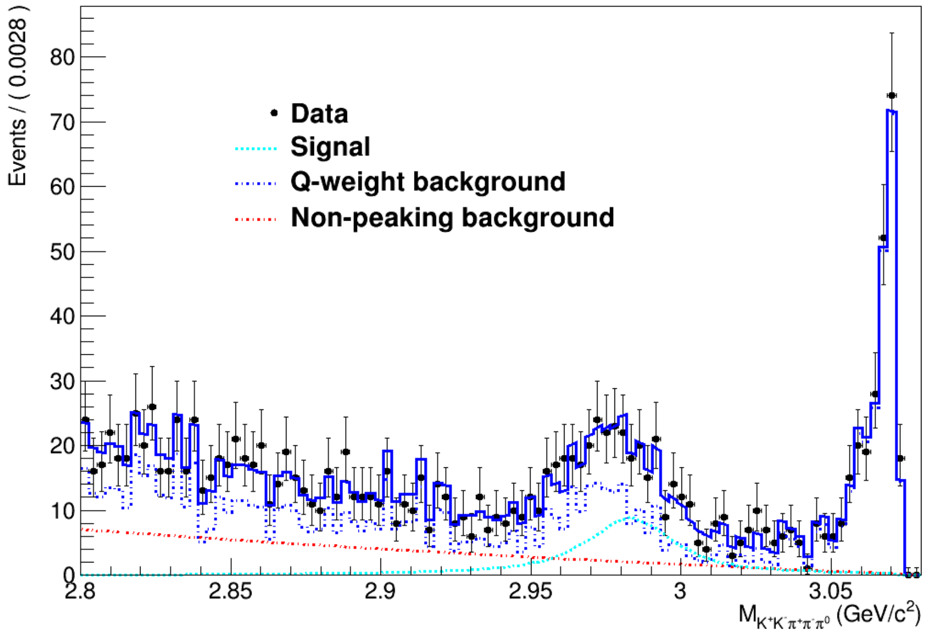


- The pre-known background (black dot), and the identified background (blue line) in MC sample.



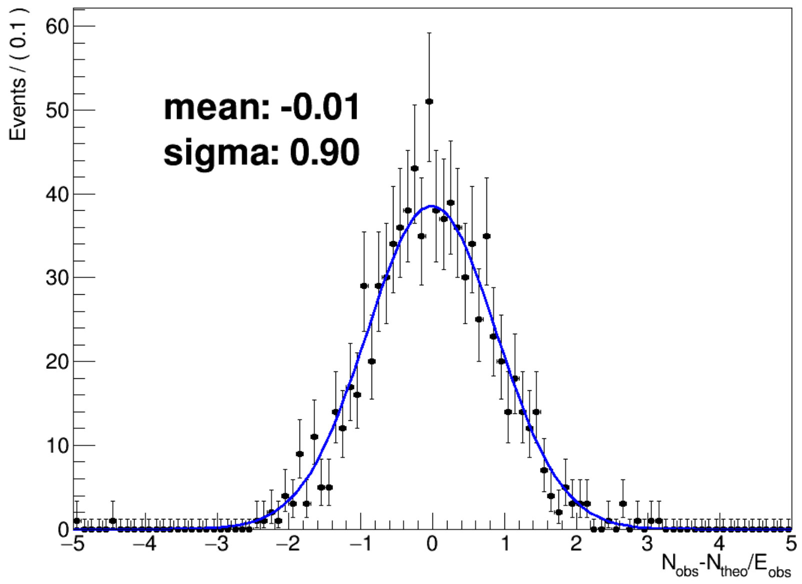
Fit Result

- $N_{\text{sig}} = 152 \pm 33$
- Fit method:
  - ✓ Signal MC shape + Argus distribution+ Q-weight background (floated)
- Significance : 5.04σ
- (PDG upper limit: 2.5×10^{-4} @ 90% C.L.)
- $Br(\eta_c \to \omega\phi) = \frac{N_{obs}}{\epsilon \times N_{total} \times Br(J/\psi \to \gamma\eta_c) \times Br(\omega \to \pi^+\pi^-\pi^0) \times Br(\phi \to K^+K^-) \times Br(\pi^0 \to \gamma\gamma)} = (4.06 \pm 0.90_{stat} \pm 1.23_{syst}) \times 10^{-5}$
  - ✓ $\epsilon = 5.02\%$
  - ✓ $N_{total} = 1.009 \times 10^{10}$



I/O check result

- Use generated data-like MC sample, randomly sampling to generate 1000 sets of MC samples one times size of data.
- Each sample has input a pre-known signal event number, perform the same fit procedure to extract N_{obs}, $(N_{obs} - N_{theo})/\delta_{N_{obs}}$ are calculated and fitted into a Gaussian distribution to draw the Pull distribution:



Systematic Uncertainty

Sources	Uncertainty(%)
Number of J/ψ event	0.5
Intermediate branching ratio	23.6
Tracking efficiency	4.0
Photon detection	3.0
Particle identification	4.0
Kinematic fit	3.0
Mass window for ω	0.4
Mass window for ϕ	0.01
Decay angle cut of π^0	7.0
Veto η'	0.1
Signal MC shape of η_c	1.0
Fit range	13.5
Background estimation and fitting method	8.5
Total	30.2

Uncertainty from External Parameters

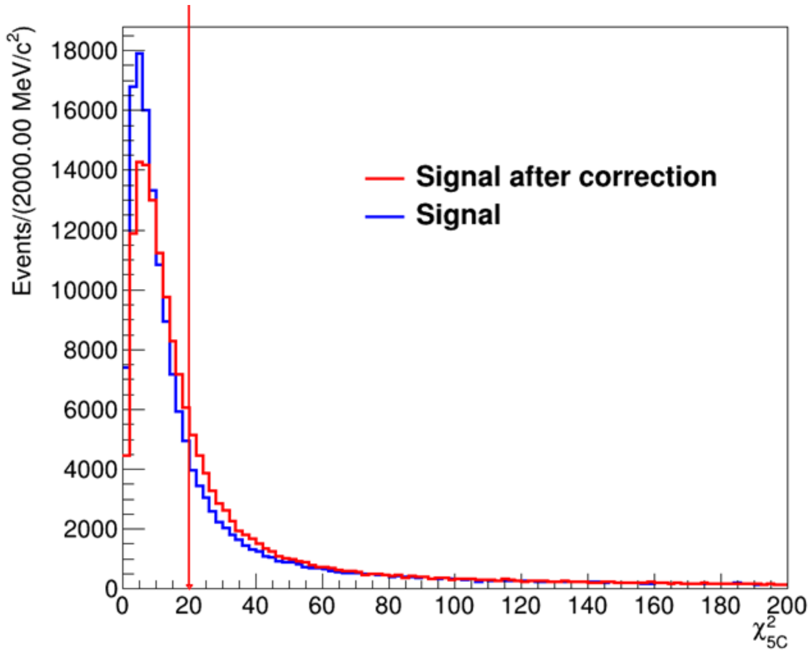
- Number of J/ψ event:
  - ✓ $N_{J/\psi} = (10087 \pm 44) \times 10^6$
  - ✓ Uncertainty: 0.5%
- Intermediate branching ratio
  - ✓ $J/\psi \to \gamma\eta_c$: $1.7 \pm 0.4\%$
  - ✓ $\omega \to \pi^0\pi^+\pi^-$: $89.2 \pm 0.7\%$
  - ✓ $\phi \to K^+K^-$: $49.2 \pm 0.5\%$
  - ✓ $\pi^0 \to \gamma\ \gamma$: $98.823 \pm 0.034\%$
  - ✓ Uncertainty: 23.6% (1.3% for excluding $J/\psi \to \gamma\eta_c$ Br)

Uncertainty from Signal efficiency

- Tracking efficiency
  - ✓ 1.0% per pion track and per kaon track, 4.0% in total
- Photon detection
  - ✓ 1.0% per photon, 3.0% in total
- Particle identification
  - ✓ 1.0% per pion and per kaon, 4.0% in total

Uncertainty from Signal efficiency

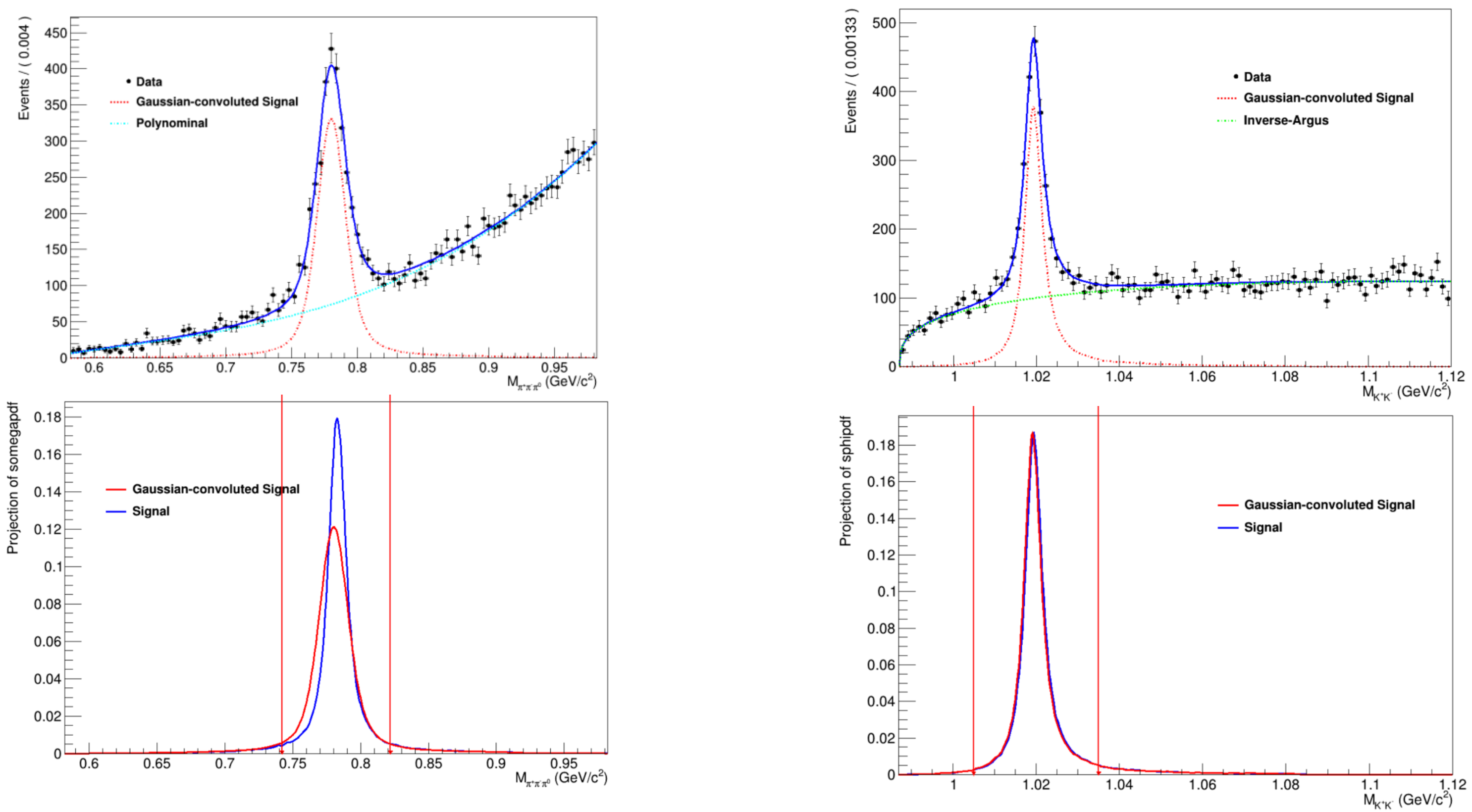
- **Kinematic Fit:**
  - ✓ Use helix parameter correction to study the difference on χ^2_{5C} between MC and data. The corresponding Br difference is considered as uncertainty.
  - ✓ Uncertainty: 3.0%



Uncertainty from Signal efficiency

- **Mass window**

  ✓ Use Gaussian-convoluted signal MC shape fit to data, to study difference of mass resolution between MC and data.



  ✓ Uncertainty: 0.4% for omega and 0.01% for phi

Uncertainty from Signal efficiency

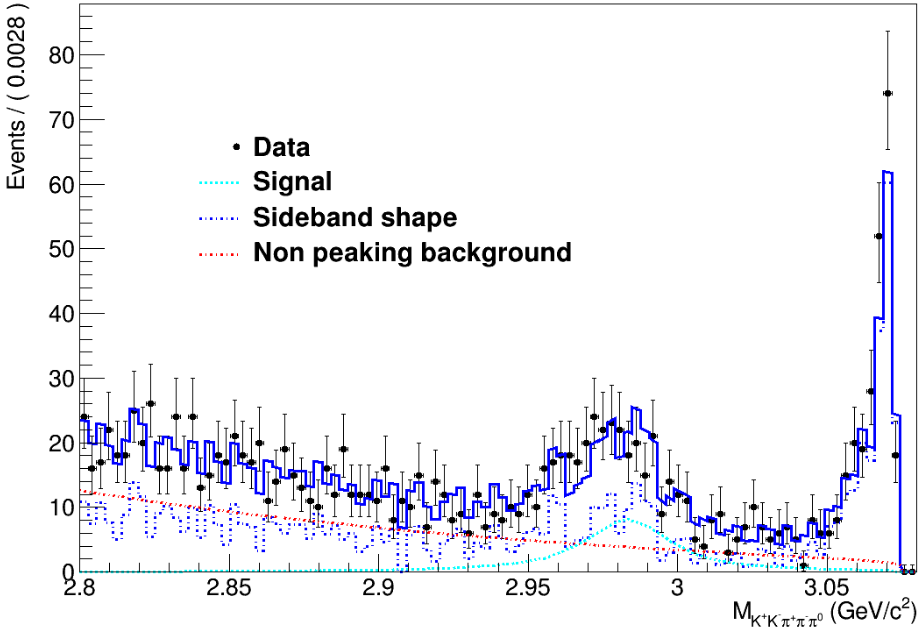
- **Decay angle cut of $\boldsymbol{\pi^0}$**
  - ✓ Alternative cut range ($|\cos(\theta_{decay})| \leq 0.925$ and $|\cos(\theta_{decay})| \leq 0.975$) is applied. The corresponding Br difference is considered as uncertainty.
  - ✓ Uncertainty: 7.0%
- **Veto $\boldsymbol{\eta'}$**
  - ✓ Alternative generator model is applied, The corresponding efficiency difference is considered as uncertainty.
  - ✓ Uncertainty: 0.1%

Uncertainty from Extracting N_{obs}

- **Signal MC shape of $\boldsymbol{\eta_c}$**
  - ✓ $J/\psi \rightarrow \gamma\eta_c$ is generated with modified JPE model referred from CLEO result. Change the model parameter $\pm1\sigma$ given in reference, to vary the MC shape of η_c. The corresponding Br difference is considered as uncertainty.
  - ✓ Uncertainty: 1.0%
- **Fit range**
  - ✓ Alternative fit range ($M_{\omega\phi} \geq 2.750$, $M_{\omega\phi} \geq 2.775$ and $M_{\omega\phi} \geq 2.825$) is applied. The corresponding Br difference is considered as uncertainty.
  - ✓ Uncertainty: 13.5%

Uncertainty from Extracting N_{obs}

- **For background estimation and fitting method, use Br difference between Q-weight method and 2-D sideband method as the Uncertainty.**
  - ✓ Uncertainty:8.5%



Summary and next to do

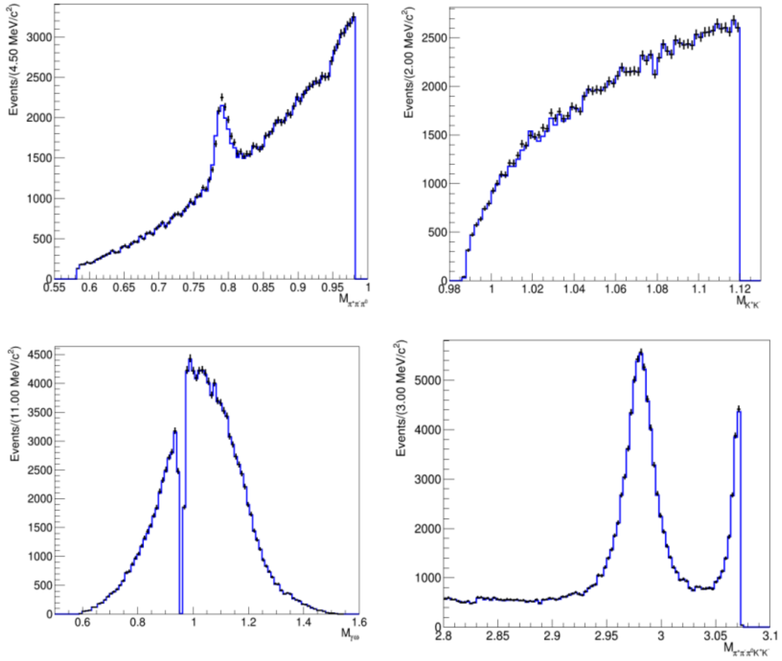
- **The nominal result and corresponding uncertainty is updated**
  - ✓ Nominal result:
    - $Br(\eta_c \to \omega\phi) = (4.06 \pm 0.90_{stat} \pm 1.23_{syst}) \times 10^{-5}$
    - Significance : 5.04σ (statistical only)
- **Next to do:**
  - ✓ update memo

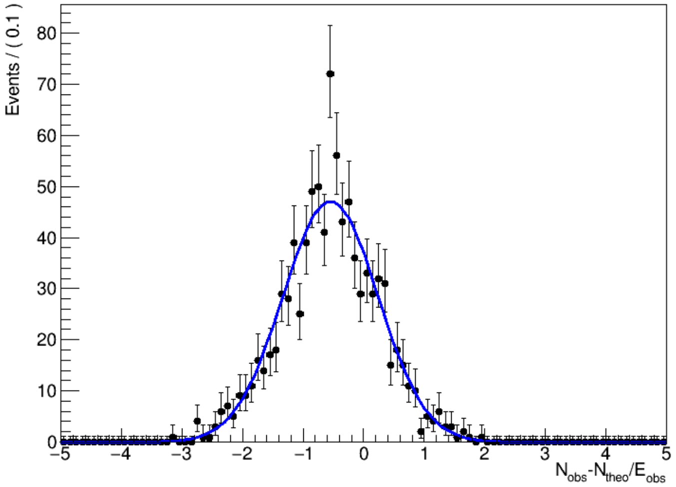
Thank you!

BACKUP

Q-weight problems

- **Better estimation have worse IO result**





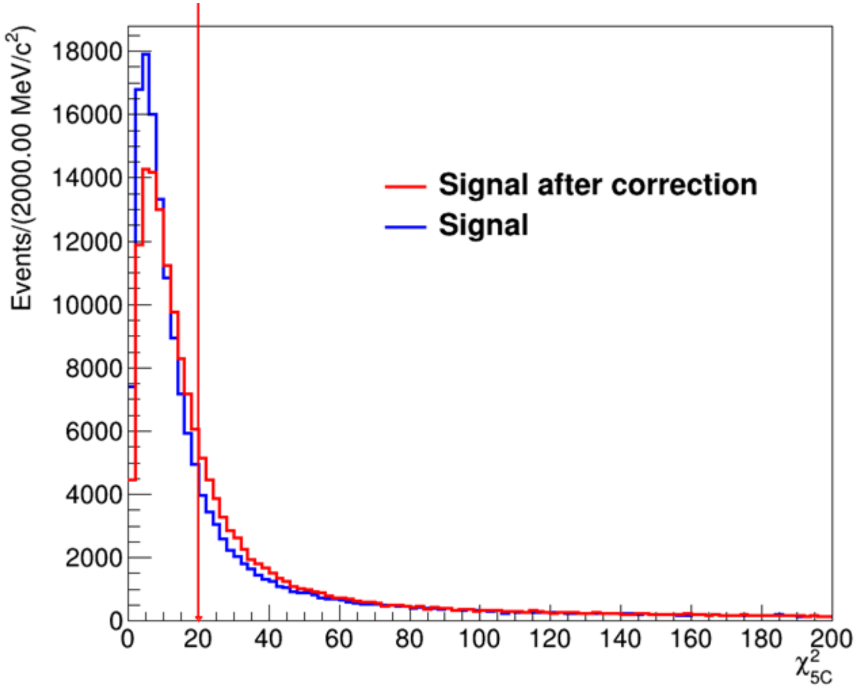

```
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=1091.89 FROM HESSE     STATUS=OK              10 CALLS          65 TOTAL
                    EDM=3.29088e-09    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR       STEP SIZE       VALUE
  1  mean0      -5.48946e-01   2.58048e-02   2.81640e-05  -5.81102e-01
  2  sigma0      7.85794e-01   1.82492e-02   1.04826e-05  -6.52410e-01
                             ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  2    ERR DEF=0.5
 6.661e-04  9.518e-09
 9.518e-09  3.330e-04
PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1       2
        1  0.00002   1.000  0.000
        2  0.00002   0.000  1.000
```

Q-weight problems

- **Bad fit for about ¼ for omega fit and 1/3 for phi fit**

Uncertainty

- Kinematic Fit:
  - ✓ Use helix parameter correction to study the difference on χ^2_{5C} between MC and data.

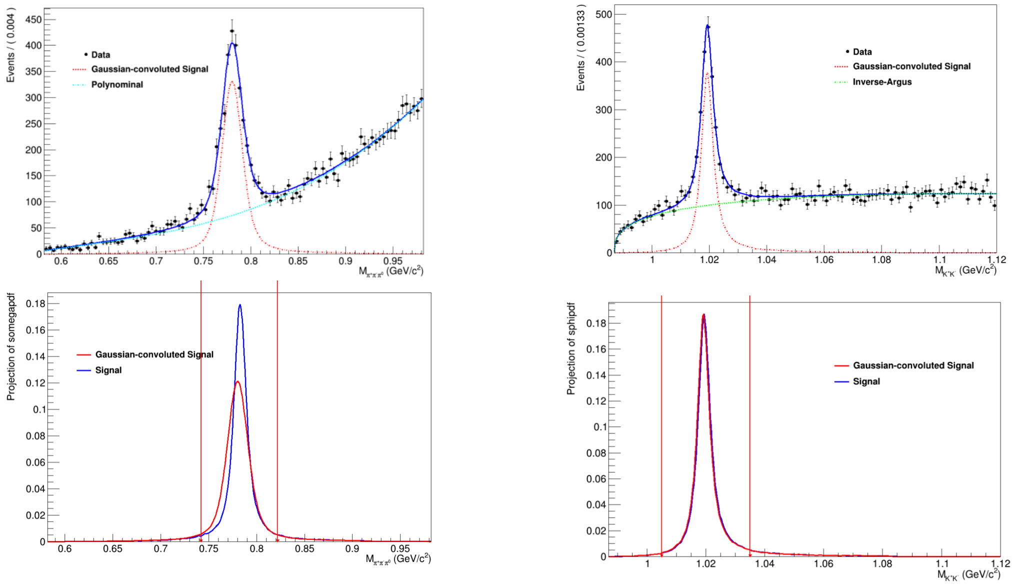


  - ✓ Signal efficiency for χ^2_{5C} cut 67.4%
  - ✓ Signal efficiency after correction for χ^2_{5C} cut 62.0%
  - ✓ Difference 8.1%
  - ✓ Signal efficiency total 5.02%
  - ✓ Signal efficiency after correction total 4.86%
  - ✓ Difference 3.2%

Uncertainty

- Mass window

  ✓ Use Gaussian-convoluted signal MC shape fit to data, to study difference of mass resolution between MC and data.



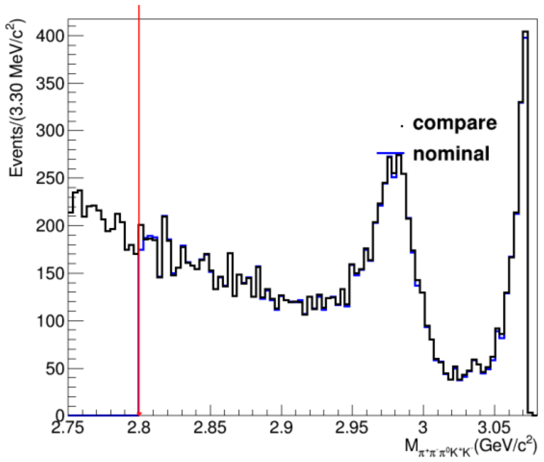
omega:mean-2.31mev sigma8.21mev
phi:mean -0.06mev sigma 0.31mev

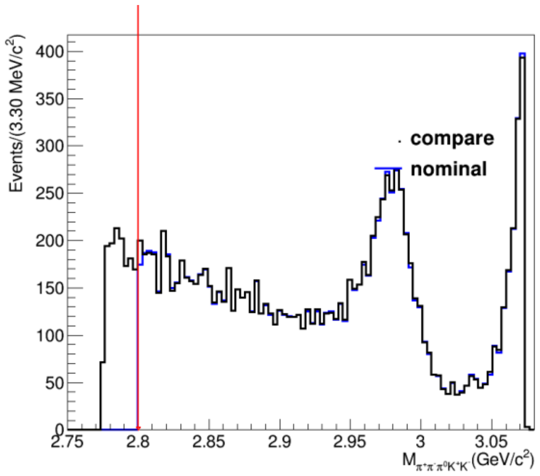
Uncertainty

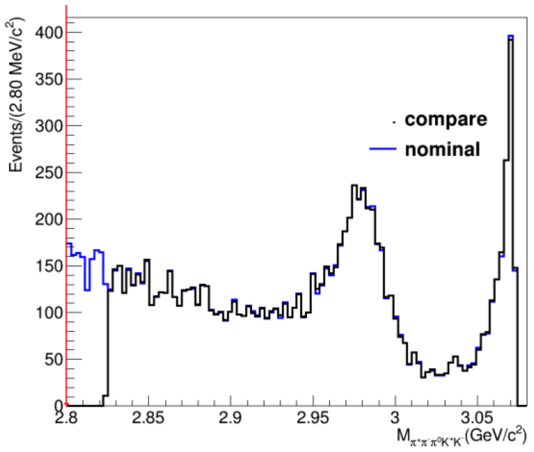
States	N_obs	ϵ(%)	Br(10-5)	significance	notes
Nominal result	151+-33	5.02	4.06+-0.89	5.03	
Kinematic fit	151+-33	4.86	4.18+-0.91	5.05	Change signal shape
Etac shape(larger one)	150+-27	5.01	4.03+-0.72	5.02	Change signal shape
Fit range 2.75	172+-28	5.02	4.61+-0.74	5.9	Change dataset
Fit range 2.775	172+-30	5.01	4.61+-0.80	5.7	Change dataset
Fit range 2.825	168+-32	5.01	4.50+-0.86	5.4	Change dataset
π^0decay angle 0.925	160+-33	4.93	4.34+-0.90	5.08	Change dataset
π^0decay angle 0.975	161+-32	5.04	4.29+-0.85	4.98	Change dataset
sideband	139+-30	5.02	3.72+-0.8	4.3	Different method

Detail

- **In Fit range, the background estimation is almost the same:**
- **pics shows the estimated background by Q-weight**







Fit range in 2.75,2.775 and 2.825