Study of $e^+ e^- \to \phi(1020) K^+ K^-$

R-Scan @2.230GeV ~ @3.080GeV

Zhihong Wang† Wenbiao Yan Guangshun Huang
Haiping Peng Yingchun Zhu Zhengguo zhao

(BESIII-USTC Group)

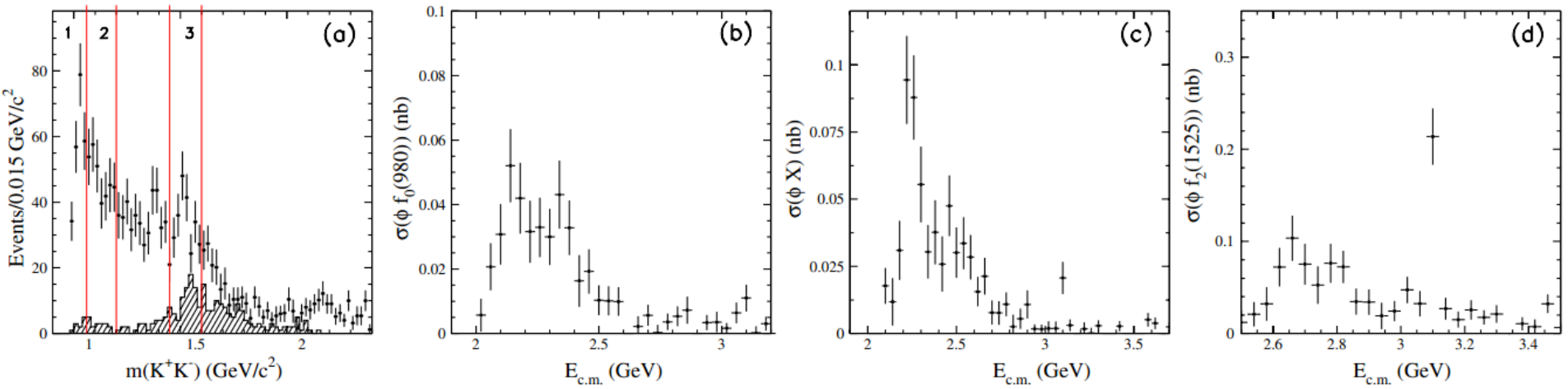
Outline

1. Introduction.
2. Data sample and MC simulation.
3. Event selection.
4. Cross section measurement.
5. Possible intermediate states.
6. Systematic error estimation.
7. Summary.

Introduction

(Cross section Line shape)

- Cross section line shape of $e^+ e^- \rightarrow \phi(1020)\, K^+ K^-$.
- Search of $Y(2175) \rightarrow \phi(1020)\, K^+ K^-$.



Data sets and MC simulation

1. BOSS664p01 and BOSS665.

2. R-scan data sets: (in 2012 and 2015)

$\sqrt{s}$ (GeV)	2.396	2.644	2.900	2.950	2.981	3.000	3.020	3.080
Lum. (pb^{-1})	~64.8	~57.4	~102.1	~15.7	~15.4	~15.3	~16.6	~123.0

3. 100K Signal MC by "ConExc" at each energy point.

(1) $e^+ e^- \to K^+K^- K^+K^-$
(2) $e^+ e^- \to \phi K^+K^-$

Event selection

- **Good Charged Track:**

  $|V_z| < 10.0$ && $|V_r| < 1.0$ && $|\cos\theta| < 0.93$;

  $N_{Good} >= 4$;

- **PID:**

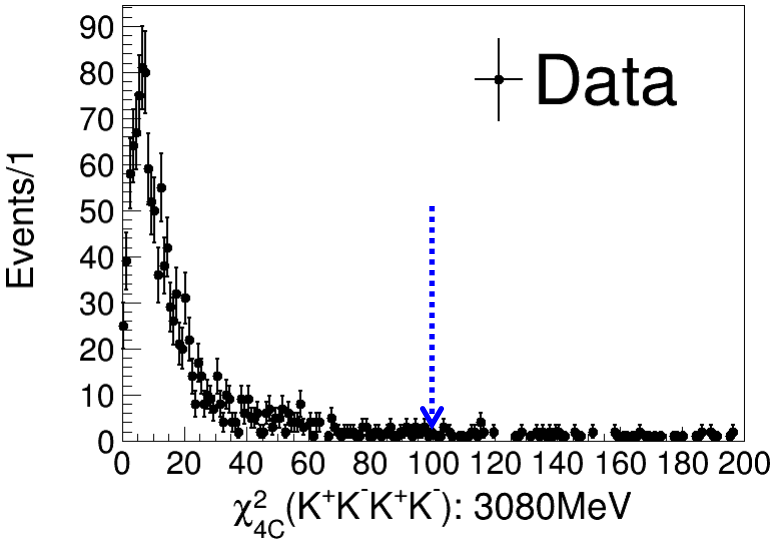
  $N(K^+) = N(K^-) = 2$; prob_K>prob_p && prob_K>prob_π;

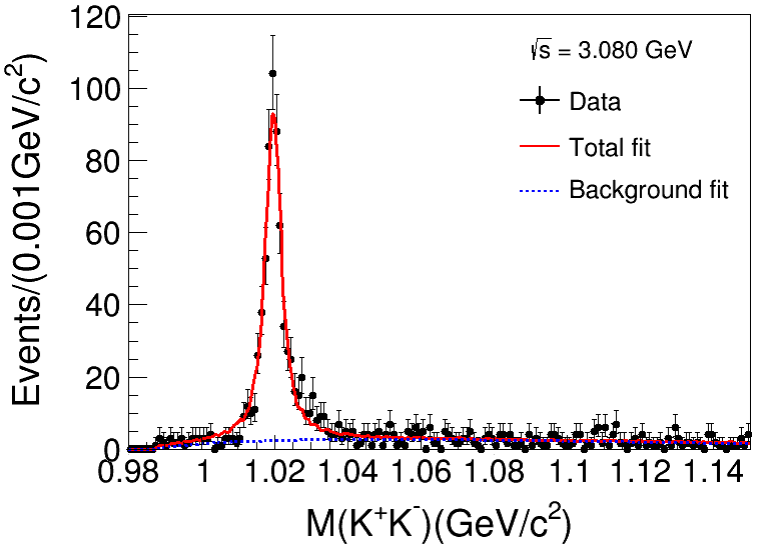
- **Vertex fit (K^+K^- K^+K^-).**

- **4C kinematic fit (K^+K^- K^+K^-):**

  $\chi^2_{4C}(K^+K^-\,K^+K^-) < 100$;

@3080MeV: L=~123.0pb^{-1}





(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

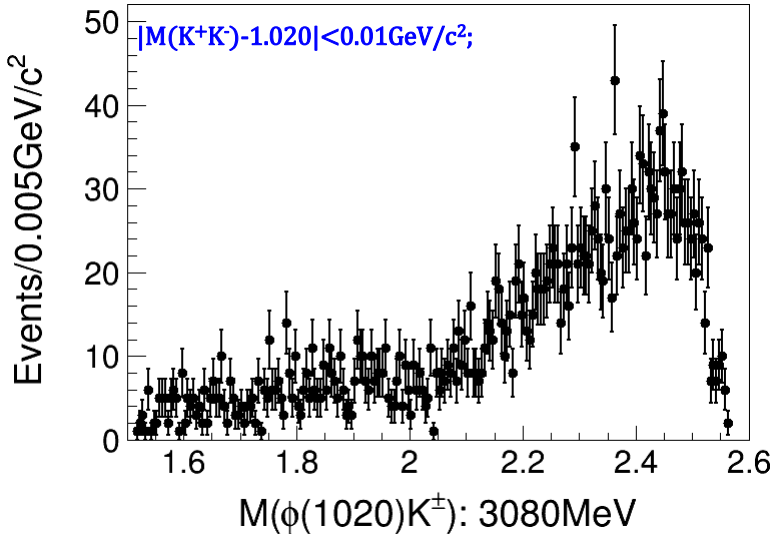
Signal: MC shape ⊗ Gaussian;

Background: Argus;

N=699.3 ± 30.8

ΔM=0.2 ± 0.1 MeV

σ = 0.2 ± 0.3MeV



@3080MeV: L=~123.0pb^{-1}

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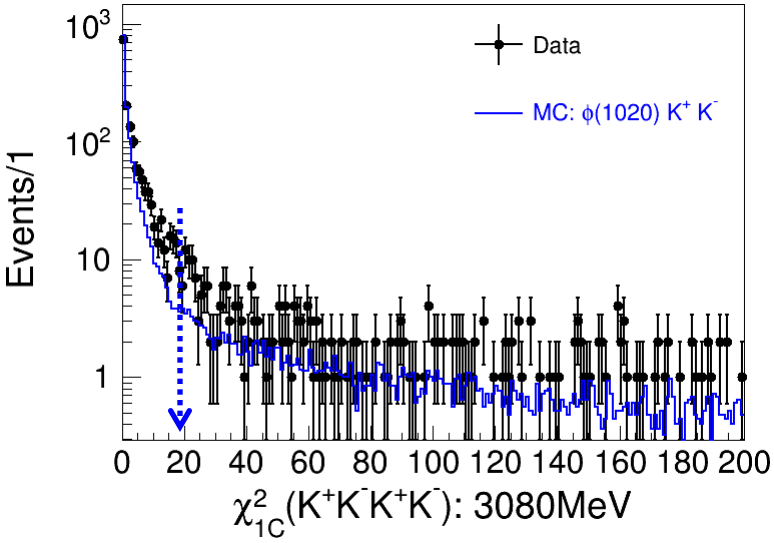
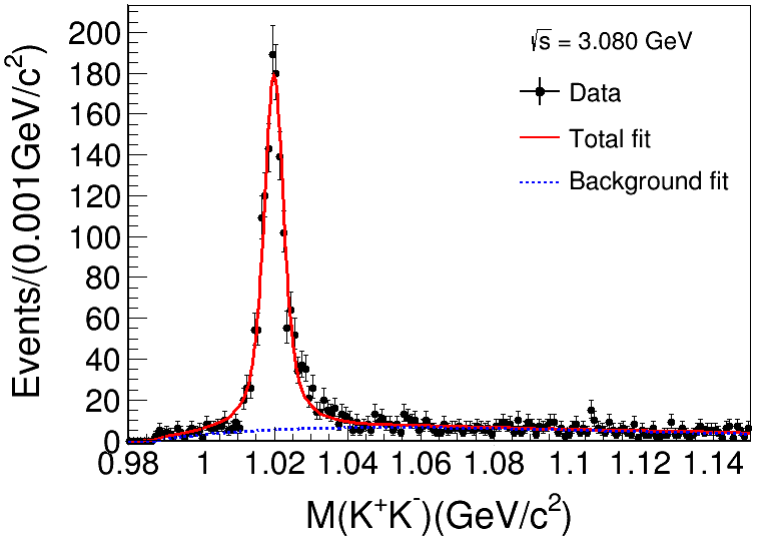




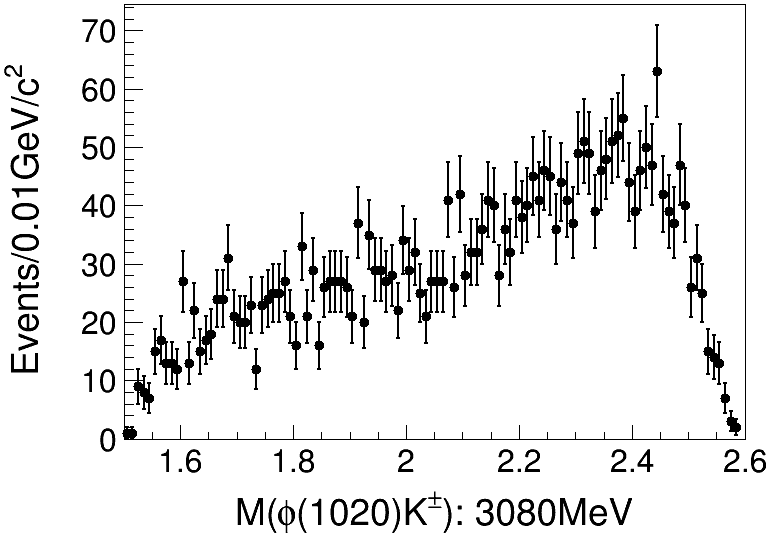
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)φ(1020) Fitting :

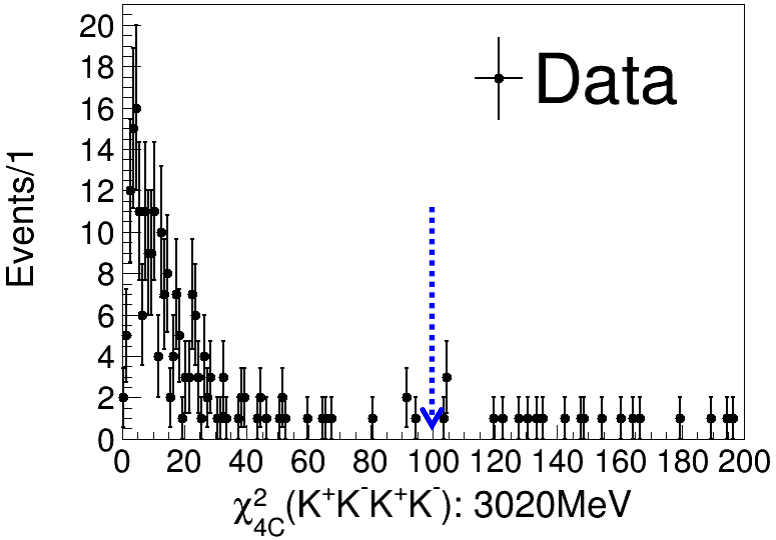
Signal: MC shape ⊗ Gaussian;

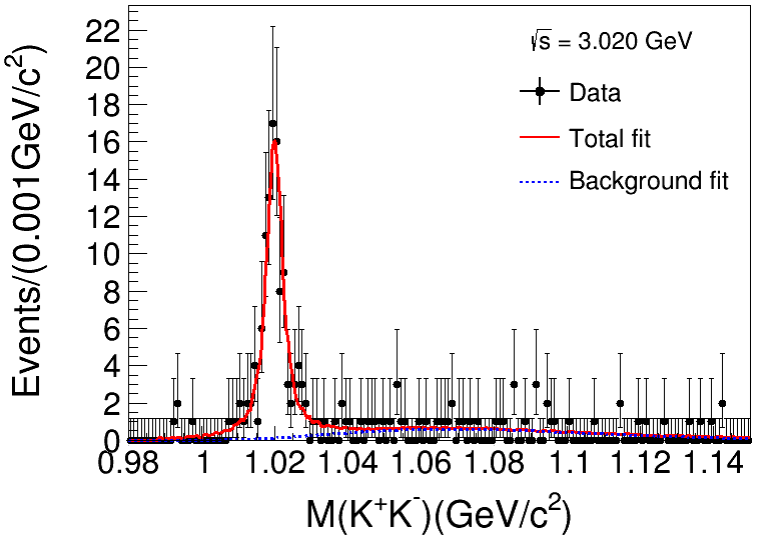
Background: Argus;

N=1569.9 ± 48.6



@3020MeV: L=~16.6pb^{-1}





(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

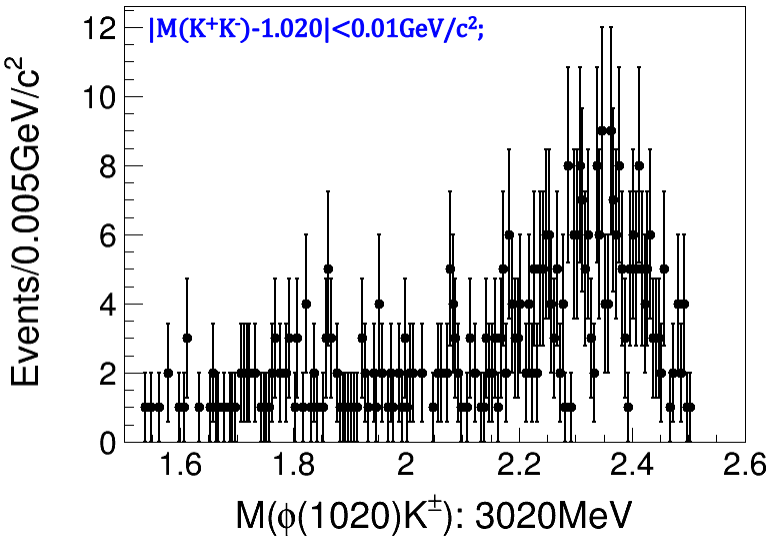
Signal: MC shape $\otimes$ Gaussian;

Background: Argus;

N=122.8 $\pm$ 12.4

ΔM=0.5 $\pm$ 0.4 MeV

σ= 0.6 $\pm$ 0.6MeV



@3020MeV: L=~16.6pb^{-1}

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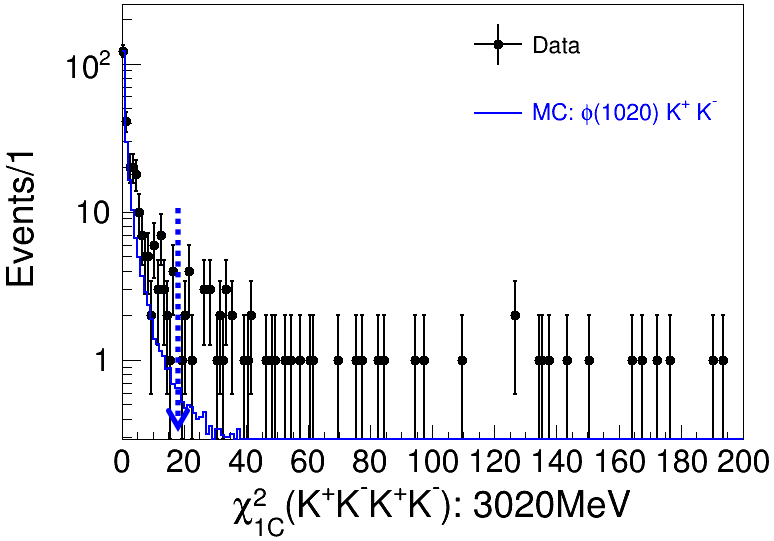
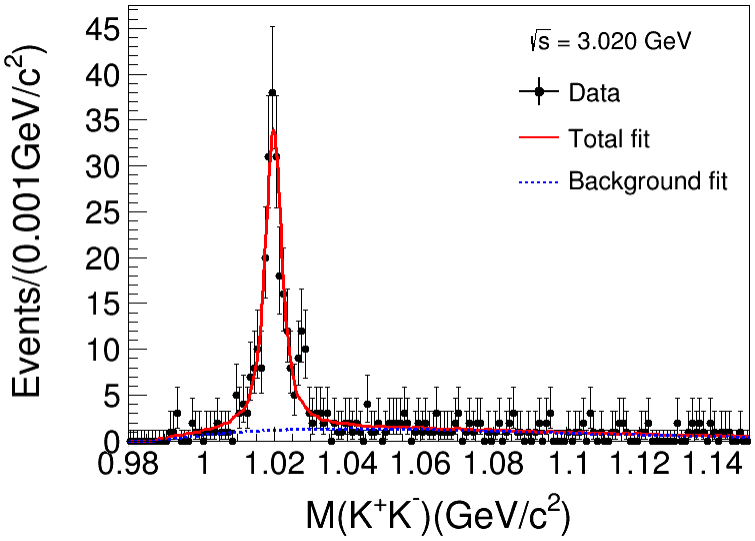




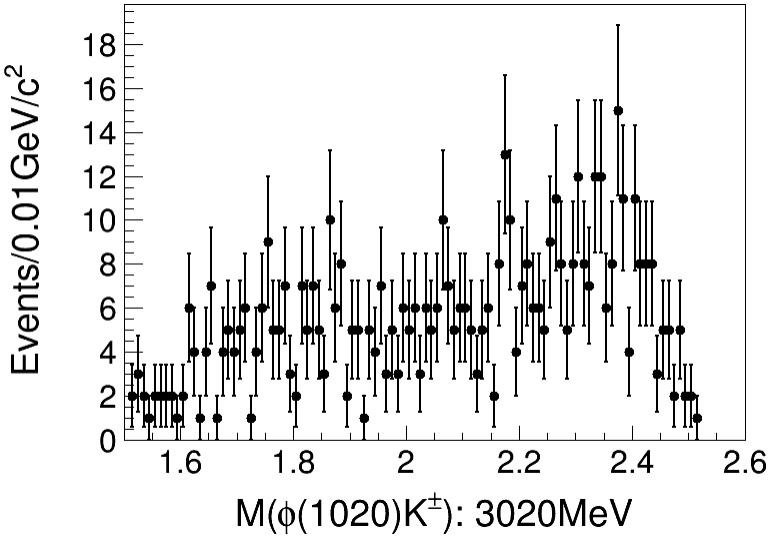
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)φ(1020) Fitting :

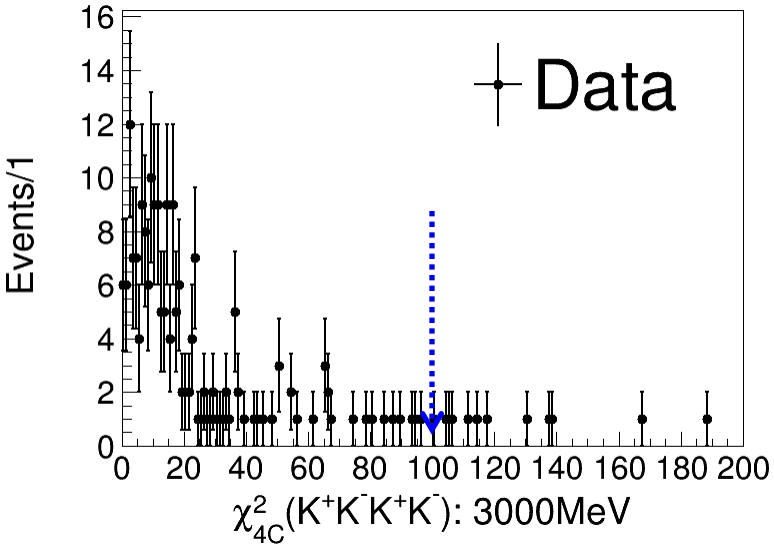
Signal: MC shape ⊗ Gaussian;

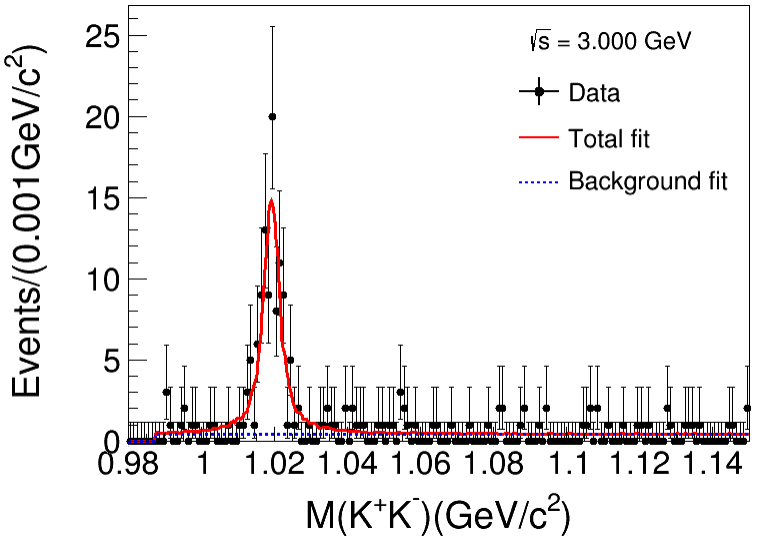
Background: Argus;

N=260.4 ± 19.7



@3000MeV: L=~15.3pb^{-1}





(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

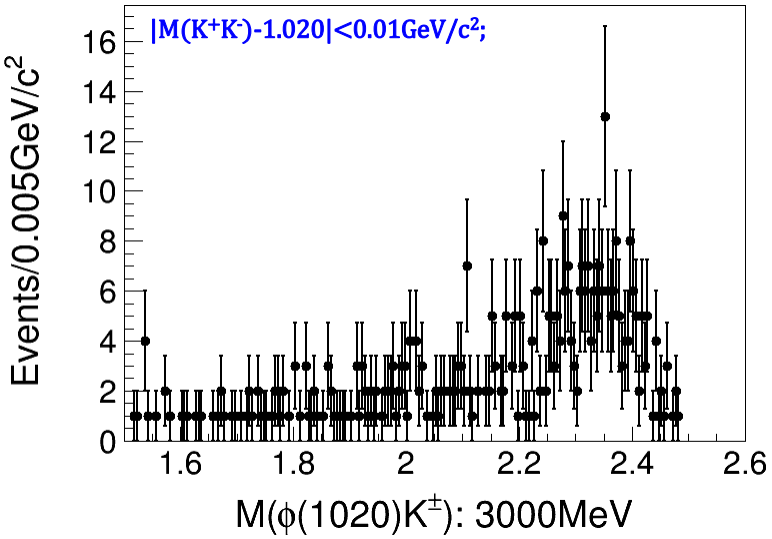
Signal: MC shape ⊗ Gaussian;

Background: Argus;

N=113.2 ± 12.1

ΔM=-0.2 ± 0.3 MeV

σ= 0.0 ± 1.5MeV



@3000MeV: L=~15.3pb^{-1}

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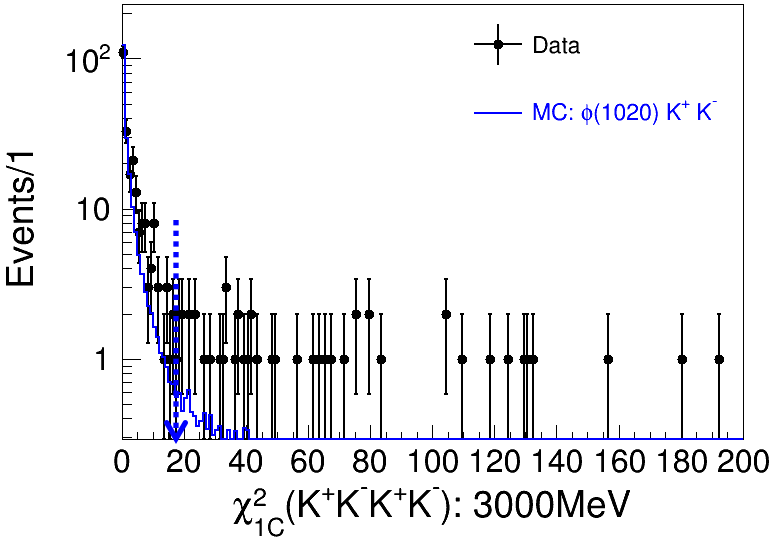
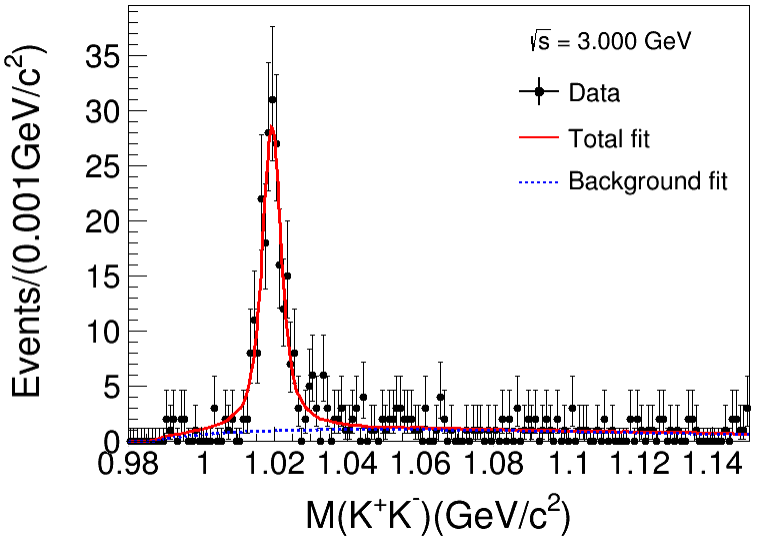




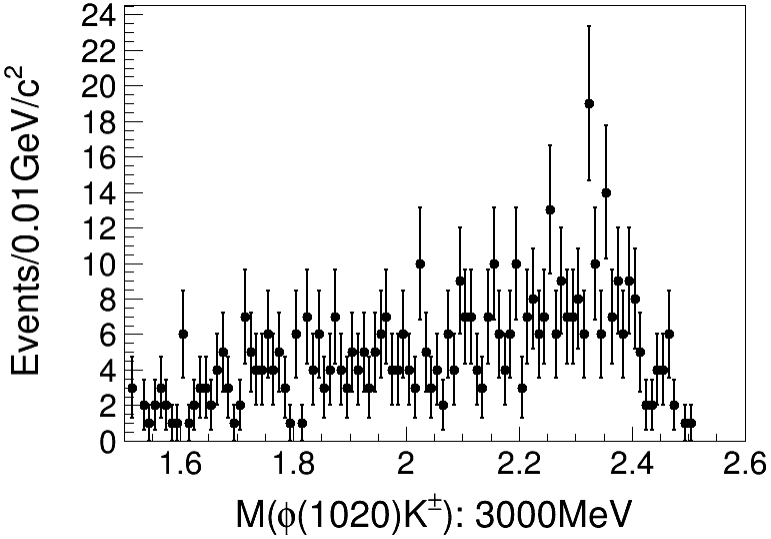
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)φ(1020) Fitting :

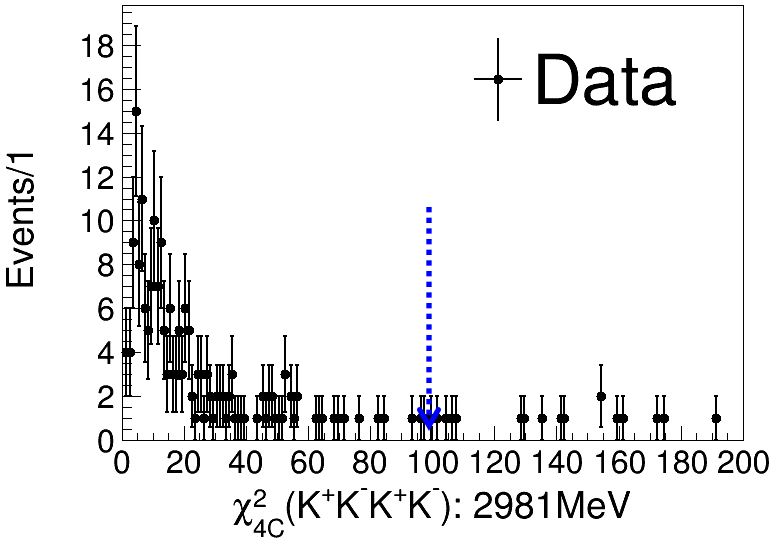
Signal: MC shape ⊗ Gaussian;

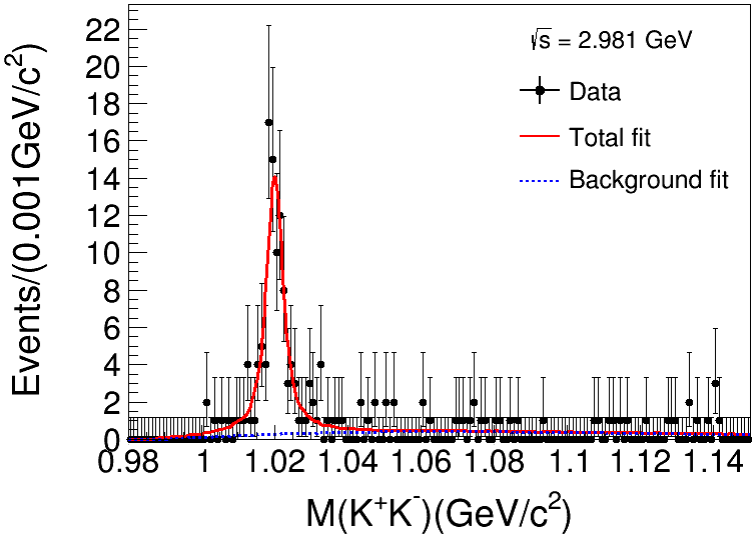
Background: Argus;

N=240.6 ± 18.3



@2981MeV: L=~15.4pb^{-1}



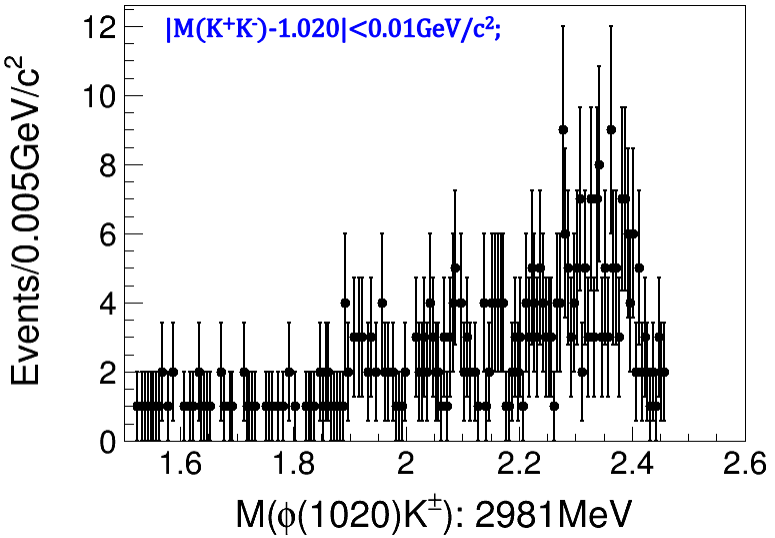


(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

Signal: MC shape ⊗ Gaussian;

Background: Argus;



N=108.8 ± 12.1

ΔM=0.6 ± 0.3 MeV

σ= 0.5 ± 0.7MeV

@2981MeV: L=~15.4pb^{-1}

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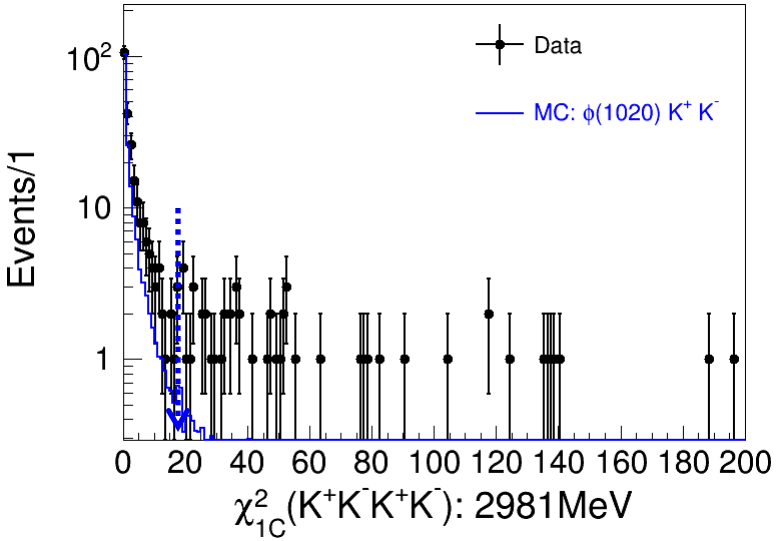
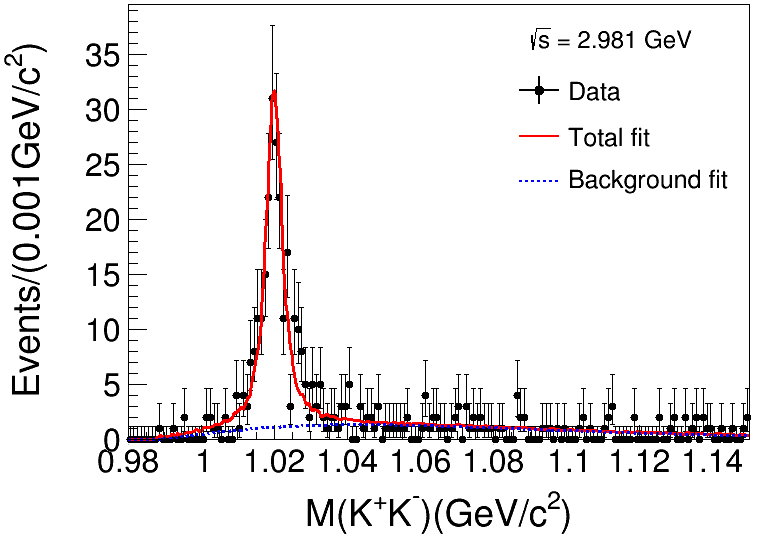




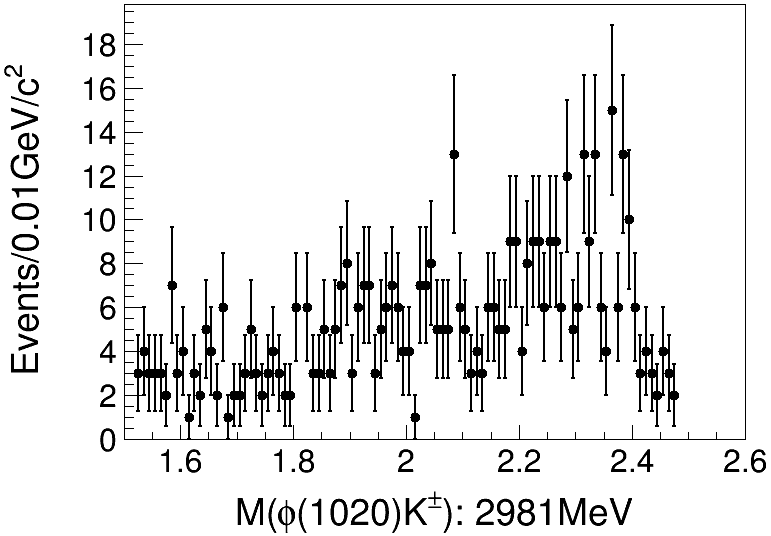
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)φ(1020) Fitting :

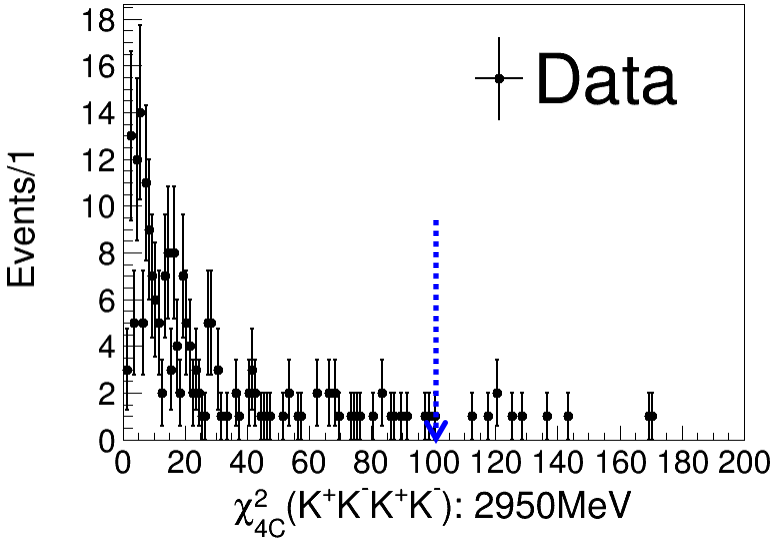
Signal: MC shape ⊗ Gaussian;

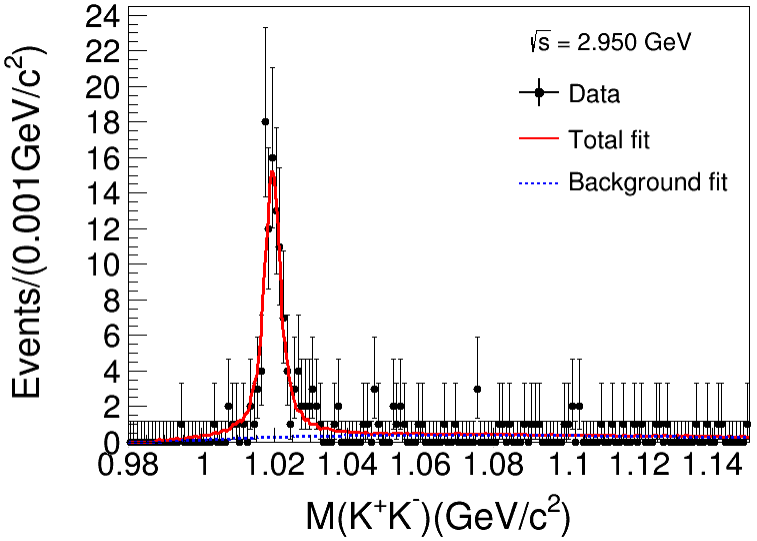
Background: Argus;

N=236.1 ± 19.9



@2950MeV: L=~15.7pb^{-1}





(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

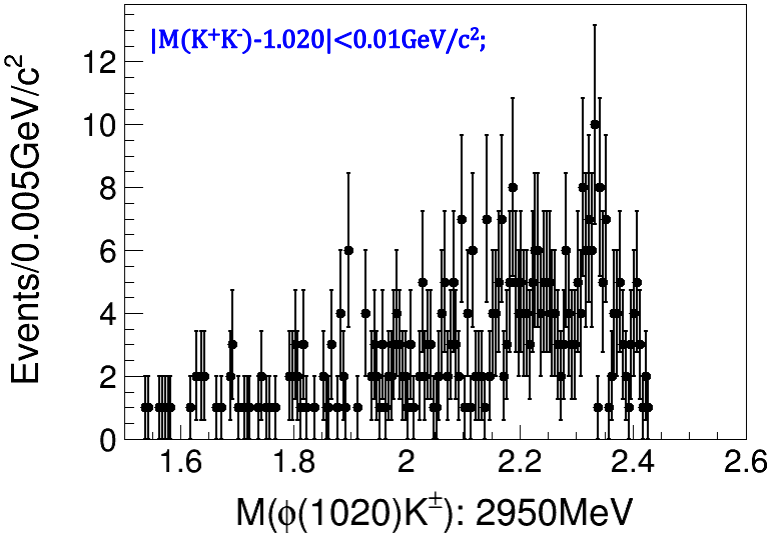
Signal: MC shape ⊗ Gaussian;

Background: Argus;

N=118.5 ± 12.6

ΔM=0.4 ± 0.4 MeV

σ= 0.8± 1.3MeV



@2950MeV: L=~15.7pb^{-1}

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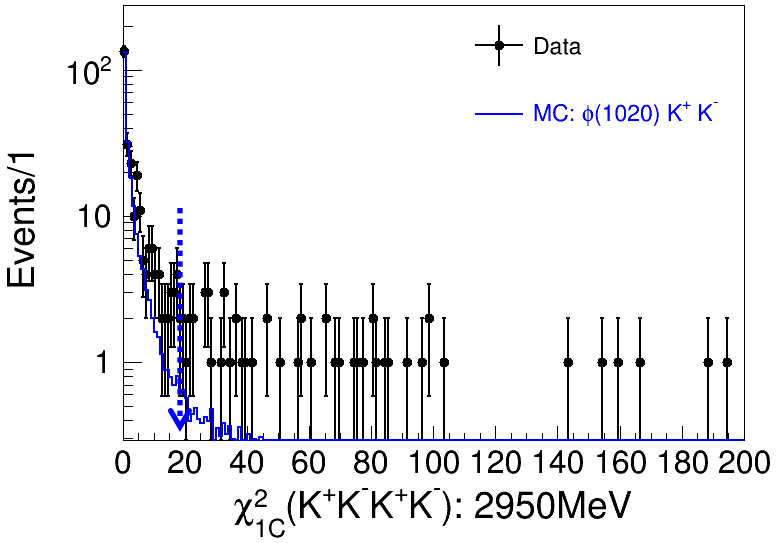
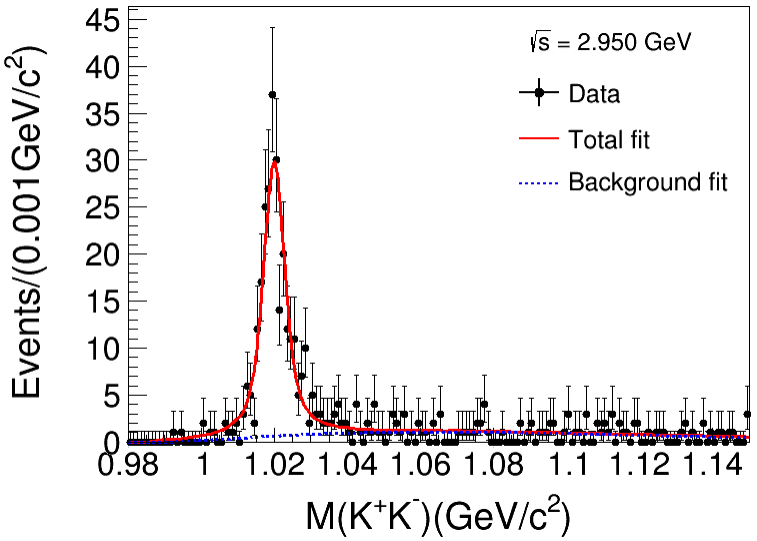




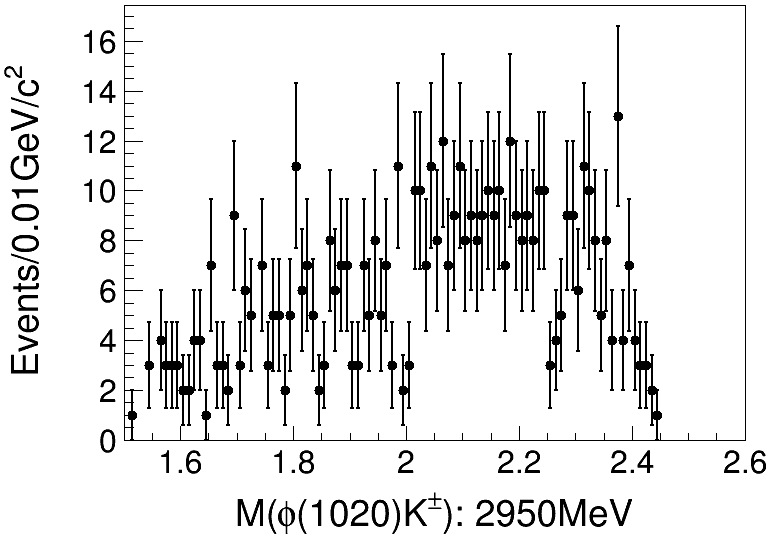
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)$\phi(1020)$ Fitting :

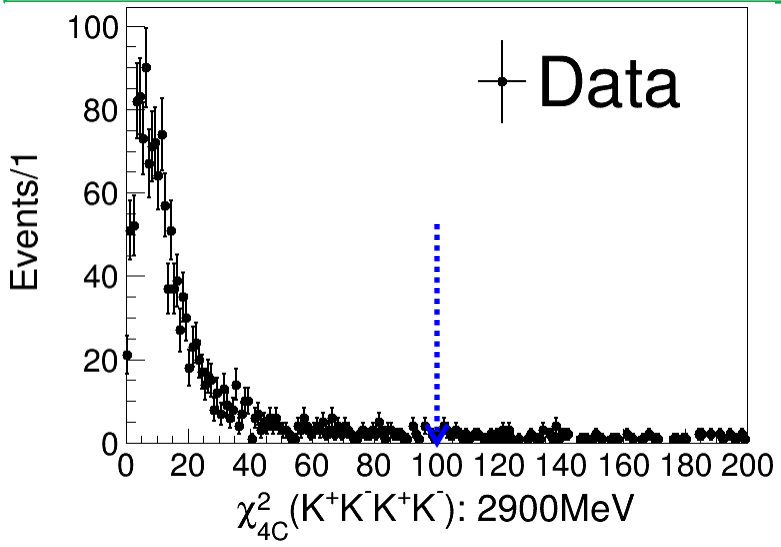
Signal: MC shape ⊗ Gaussian;

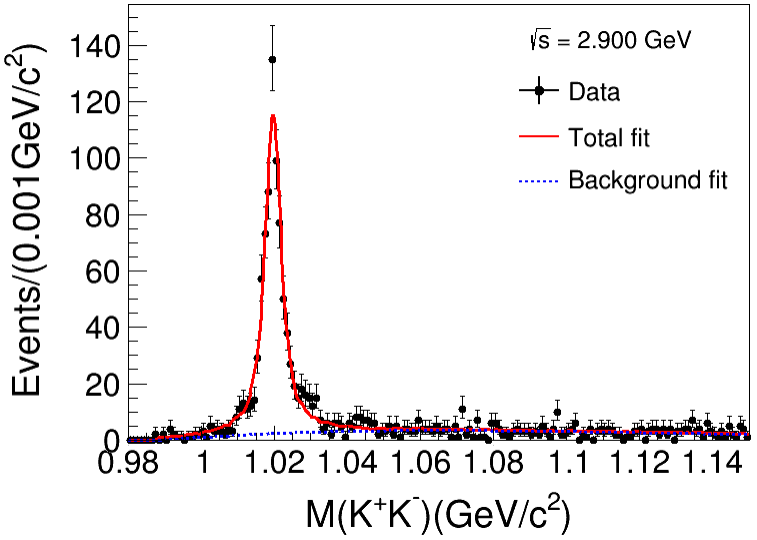
Background: Argus;

N=281.1 ± 19.9



@2900MeV: L=~102.1pb^{-1}





(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

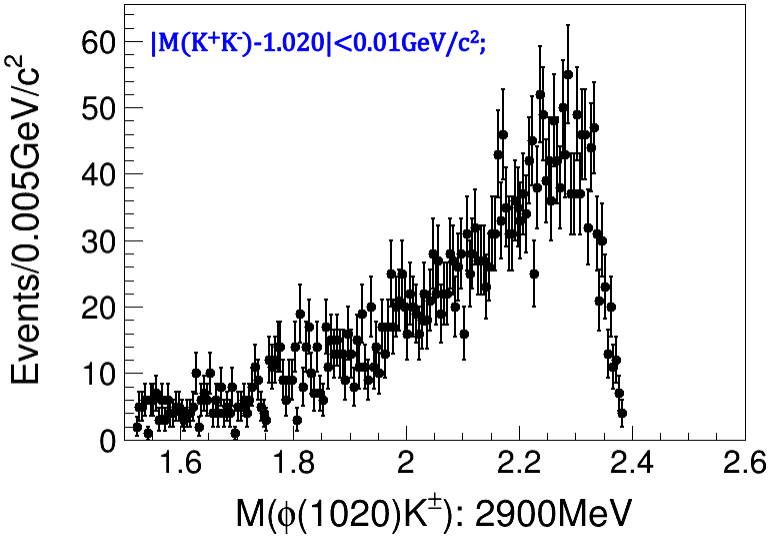
Signal: MC shape ⊗ Gaussian;

Background: Argus;

N=891.1 ± 34.8

ΔM=0.2 ± 0.2 MeV

σ= 0.4± 0.4MeV



@2900MeV: L=~102.1pb^{-1}

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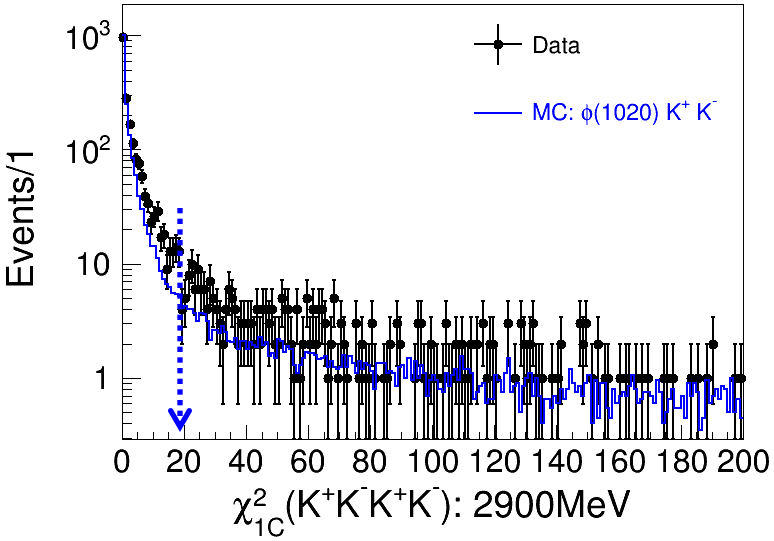
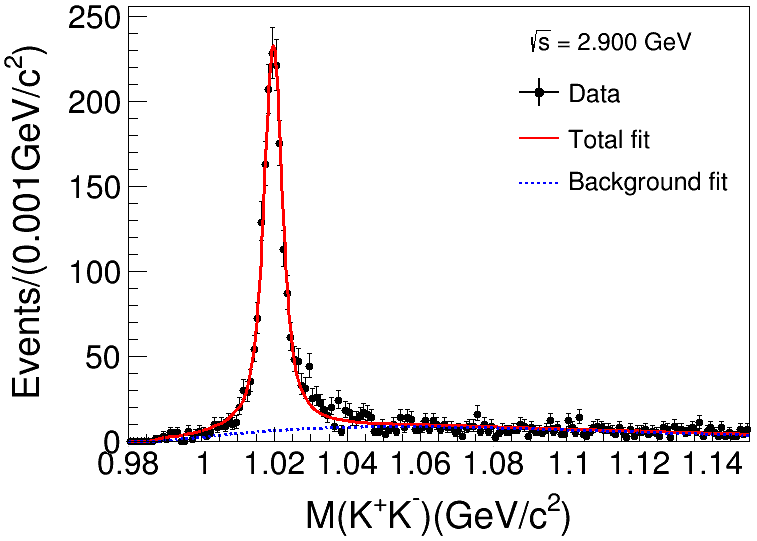




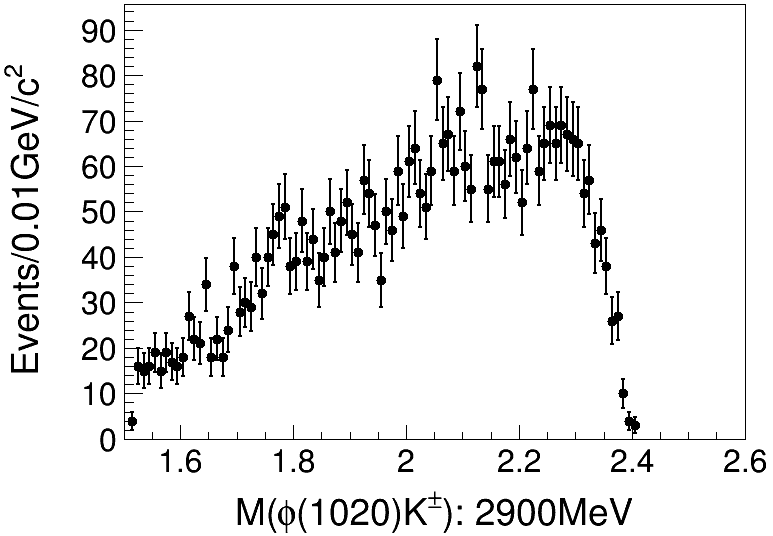
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)φ(1020) Fitting :

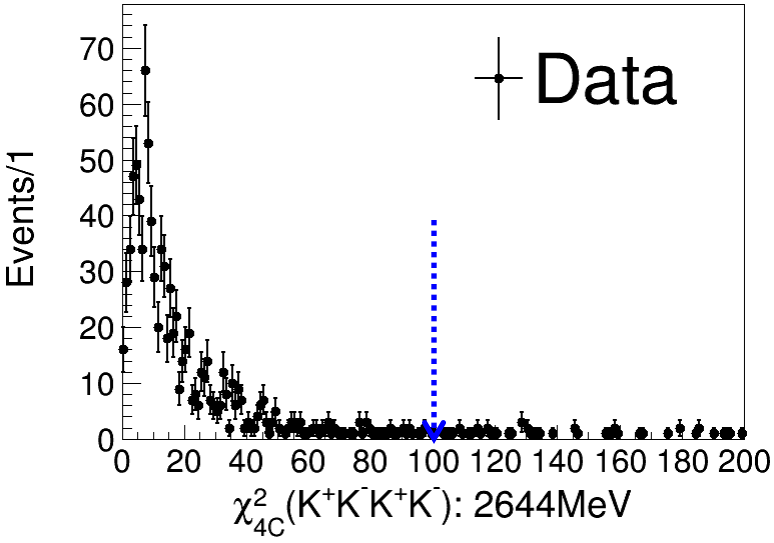
Signal: MC shape ⊗ Gaussian;

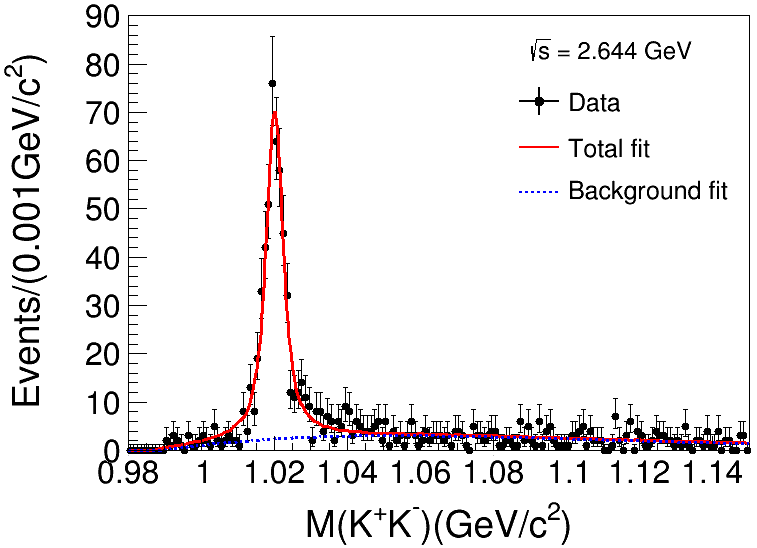
Background: Argus;

N=1963.6 ± 53.1



@2644MeV: L=~57.4pb^{-1}





(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

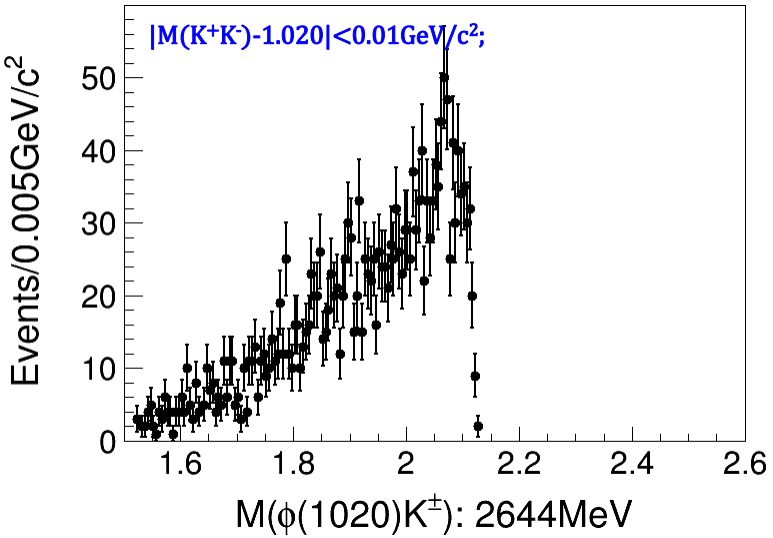
Signal: MC shape ⊗ Gaussian;

Background: Argus;

N=554.4 ± 28.5

ΔM=0.6 ± 0.2 MeV

σ= 0.7± 0.4MeV



@2644MeV: L=~57.4pb^{-1}

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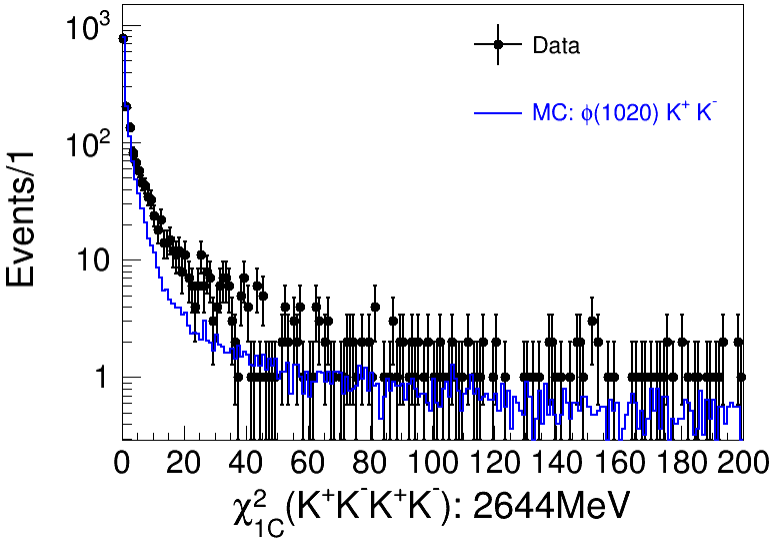
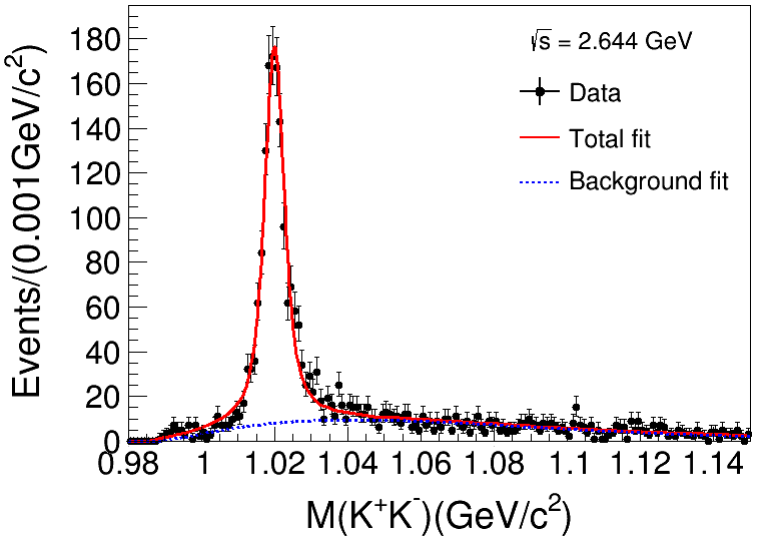




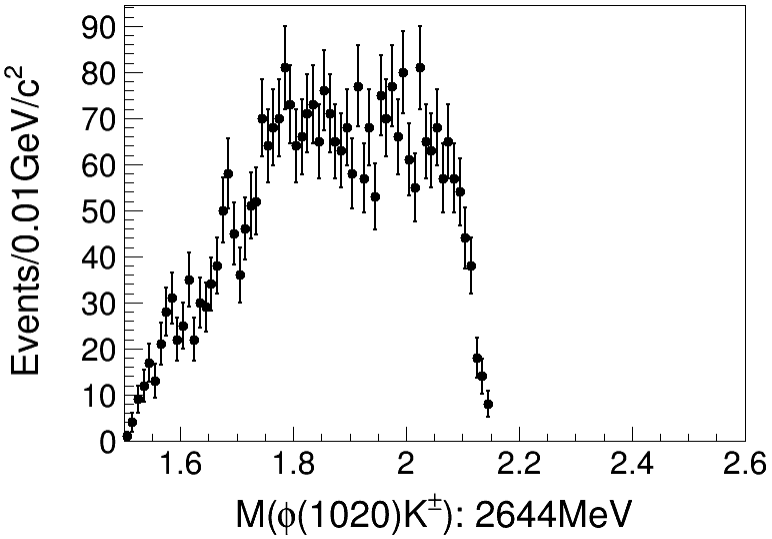
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)φ(1020) Fitting :

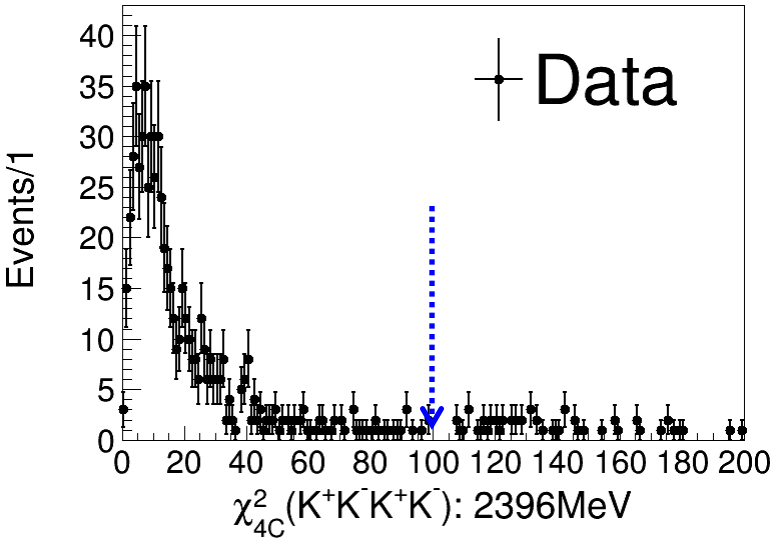
Signal: MC shape ⊗ Gaussian;

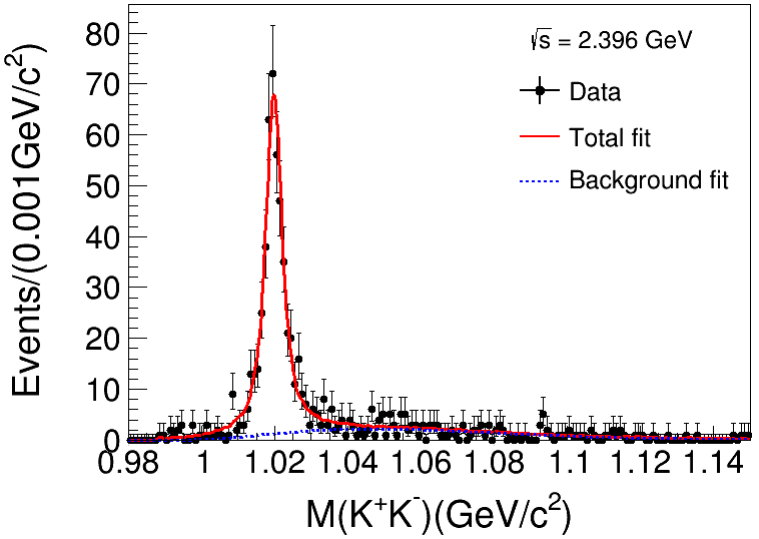
Background: Argus;

N=1527.4 ± 49.5



@2396MeV: L=~64.8pb^{-1}





(1) $\chi^2_{4C}(K^+K^-K^+K^-) < 100$;

(2)ϕ(1020) Fitting :

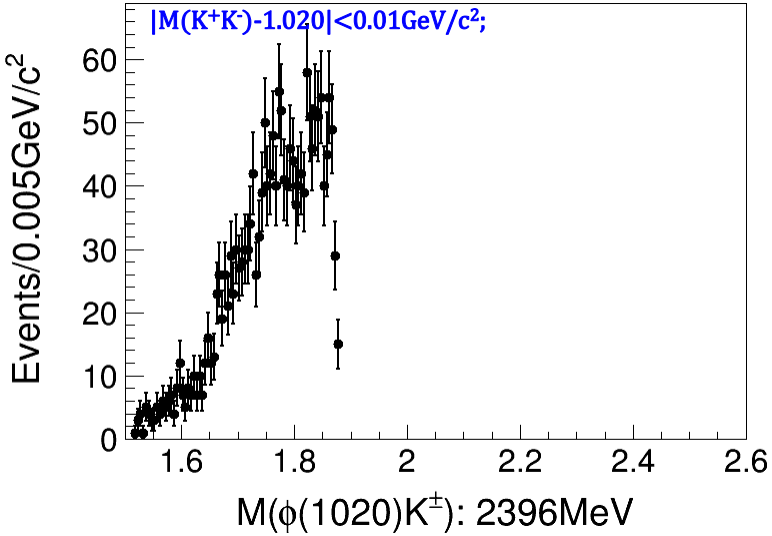
Signal: MC shape ⊗ Gaussian;

Background: Argus;

N=524.5 ± 17.1

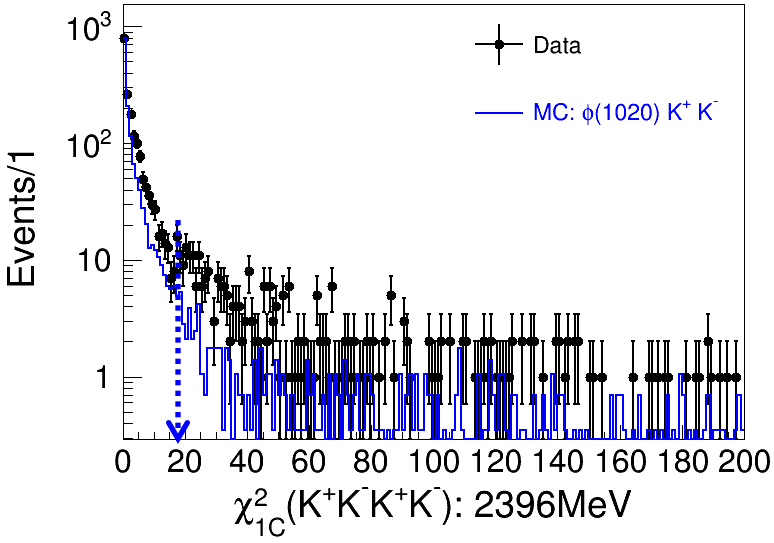
ΔM=0.4 ± 0.2 MeV

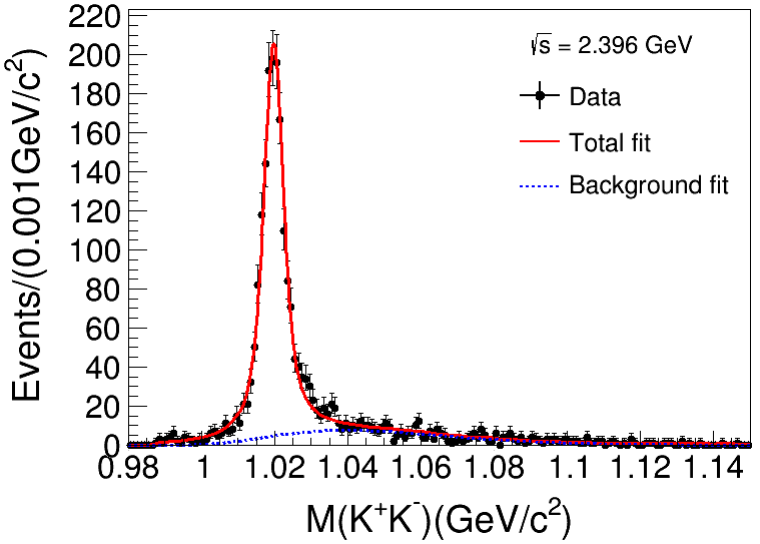
σ= 0.5± 0.3MeV



@2396MeV: L=~64.8pb^{-1}

(Missing one Kaon)





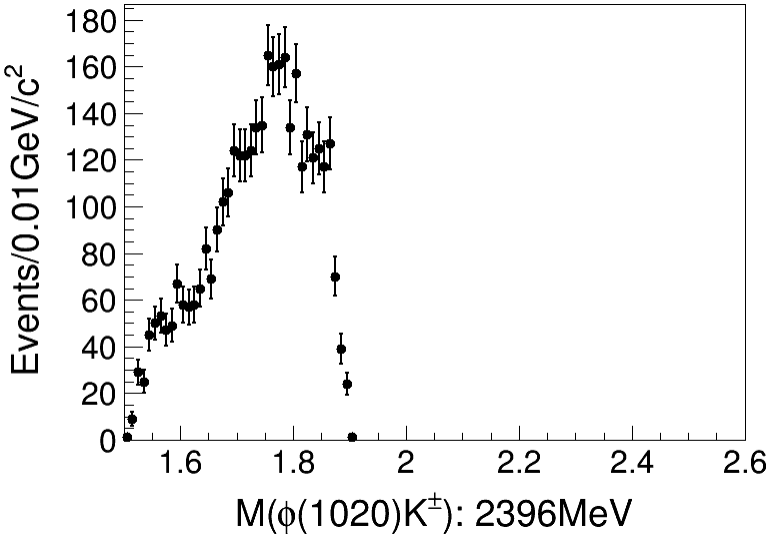
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

(2)φ(1020) Fitting :

Signal: MC shape ⊗ Gaussian;

Background: Argus;

N=1836.2 ± 55.2

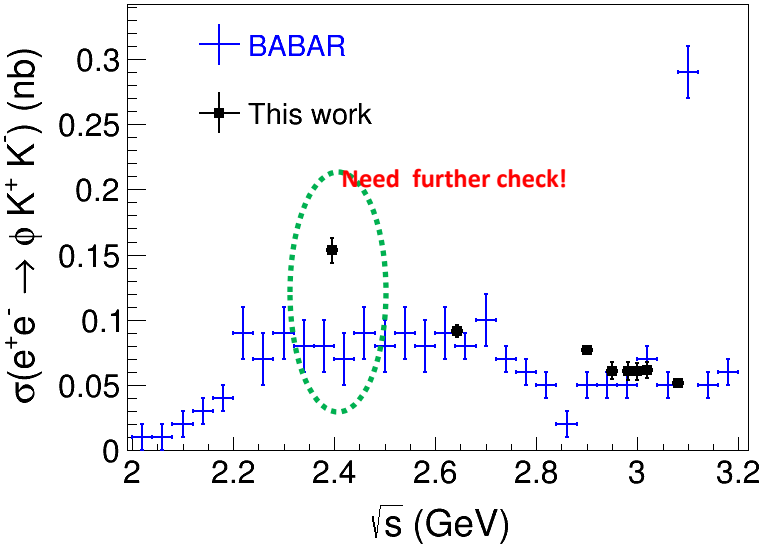


Cross section: $\sigma(e^+e^- \to \phi(1020)\, K^+K^-)$

$$\sigma = \frac{N^{obs}}{L \times (1+\delta)^{VP} \times (1+\delta)^{ISR} \times \varepsilon \times Br}$$

➢ $(1+\delta)^{ISR}$, by using BABAR's line shape.

$\sqrt{s}$ (GeV)	Lum. (pb^{-1})	N	$(1+\delta)^{ISR}$	ε(%)	Br	σ (pb)
2.396	64.8	529.0 ± 33.4	1.1967	9.1	0.489	153.3±9.7
2.644	67.2	550.8 ± 28.1	1.3630	13.5	0.489	91.1±4.6
2.900	102.1	888.8 ± 34.9	1.5075	15.4	0.489	76.7±3.0
2.950	15.7	113.9 ± 12.0	1.5301	15.9	0.489	61.0±6.4
2.981	15.4	109.5 ± 12.1	1.4637	16.3	0.489	60.9±6.7
3.000	15.3	111.2 ± 12.0	1.5102	16.3	0.489	60.4±6.5
3.020	16.6	123.1 ± 12.3	1.5167	16.2	0.489	61.7±6.2
3.080	123.0	701.9 ± 31.6	1.3739	16.4	0.489	51.8±2.3



➢ Good agreement with BABAR's results.

➢ Significantly improved precision.

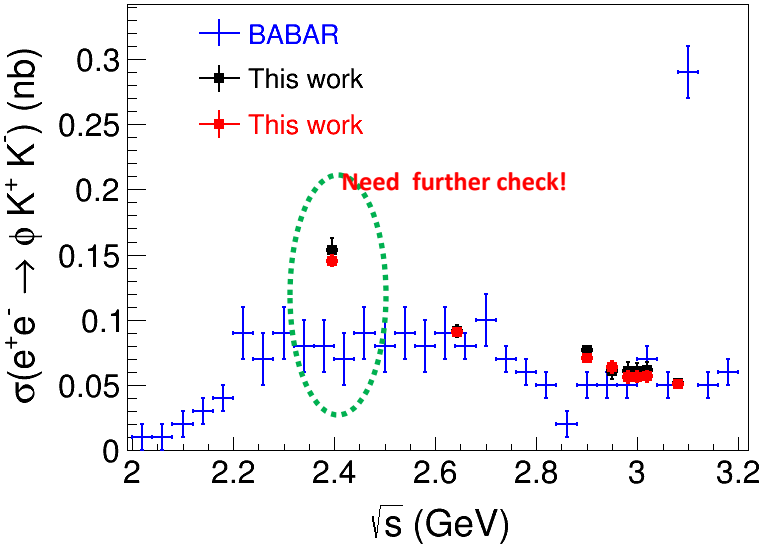
Cross section: $\sigma(e^+e^- \to \phi(1020)\, K^+K^-)$

(Missing one Kaon)

$$\sigma = \frac{N^{obs}}{L \times (1+\delta)^{VP} \times (1+\delta)^{ISR} \times \varepsilon \times Br}$$

➢ $(1+\delta)^{ISR}$, by using BABAR's line shape.

$\sqrt{s}$ (GeV)	Lum. (pb^{-1})	N	$(1+\delta)^{ISR}$	ε(%)	Br	σ (pb)
2.396	64.8	1836.2 ± 55.2	0.9424	42.3	0.489	145.4±4.4
2.644	67.2	1527.4 ± 49.5	1.3630	37.5	0.489	90.9±2.9
2.900	102.1	1963.6 ± 53.1	1.5075	36.7	0.489	71.1±1.9
2.950	15.7	281.1 ± 19.9	1.5301	37.6	0.489	63.6±4.5
2.981	15.4	236.1 ± 19.9	1.4637	38.3	0.489	55.9±4.7
3.000	15.3	240.6 ± 18.3	1.5102	37.7	0.489	56.5±4.3
3.020	16.6	260.4 ± 19.7	1.5167	37.4	0.489	56.6±4.3
3.080	123.0	1569.9 ± 48.6	1.3739	37.2	0.489	51.1±1.6



➢ Good agreement with BABAR's results.

➢ Significantly improved precision.

Backup