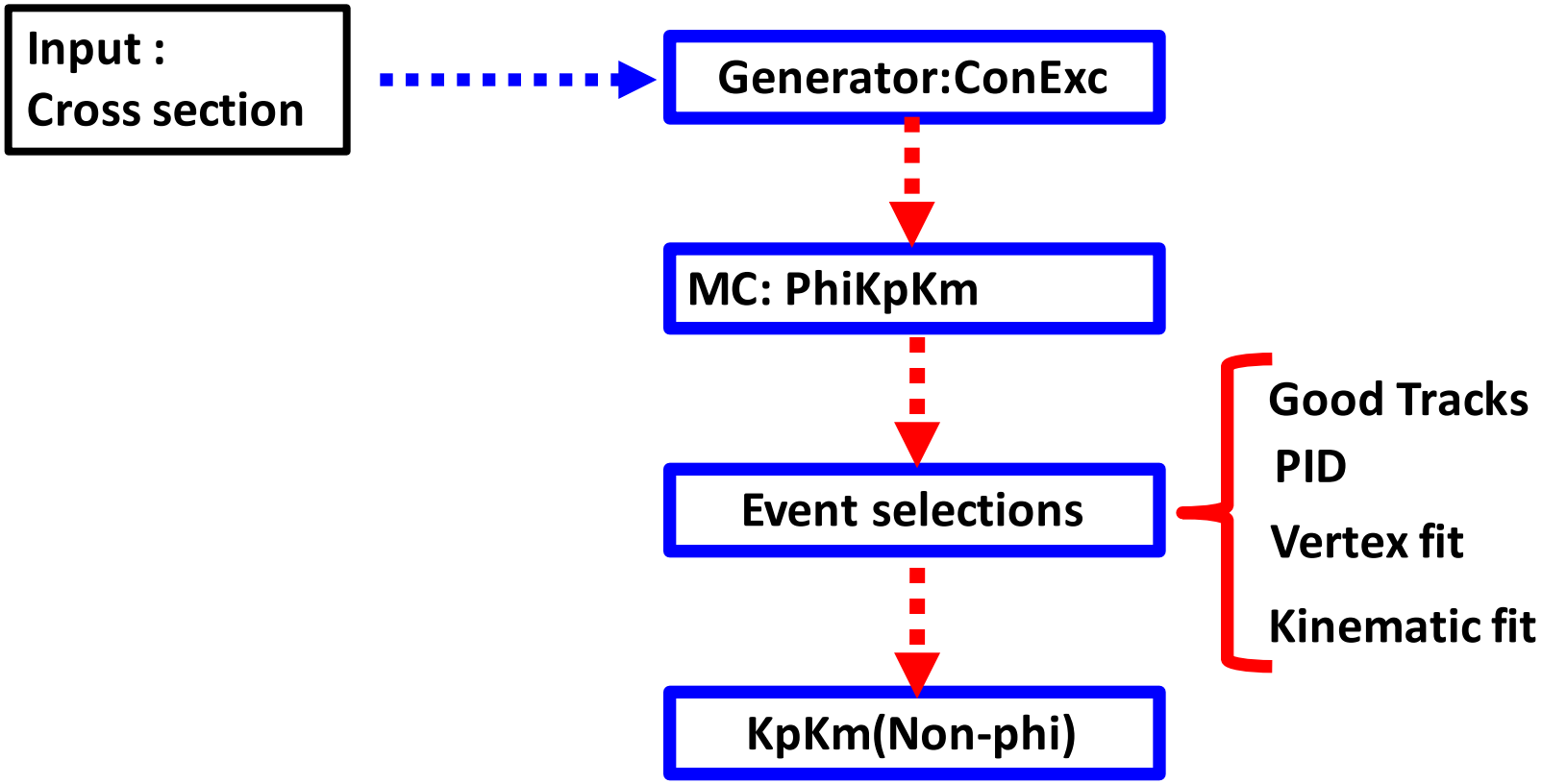
Measurements of $e^+e^- \to \phi K^+ K^-$ and $K^+K^- K^+K^-$ cross sections

(R-Scan Data: $\sqrt{s}$=2.0GeV~3.08GeV)

$e^+e^- \to \phi K^+K^-$


Input :
Cross section
Generator:ConExc
MC: PhiKpKm
Event selections
KpKm(Non-phi)
Good Tracks
PID
Vertex fit
Kinematic fit

Signal events

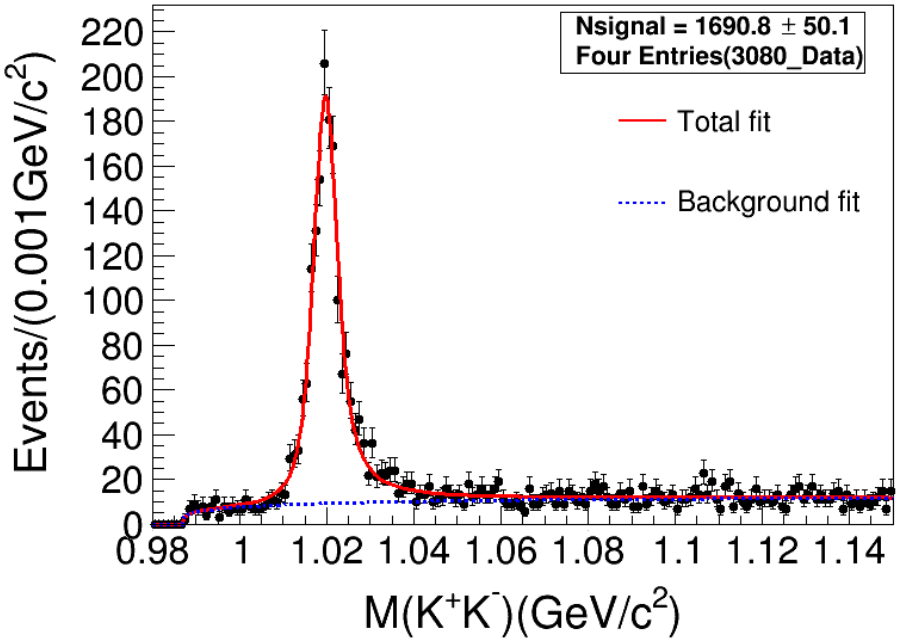
(1) $\chi^2_{1C}(K^+K^-K^+K^-) < 20$;

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

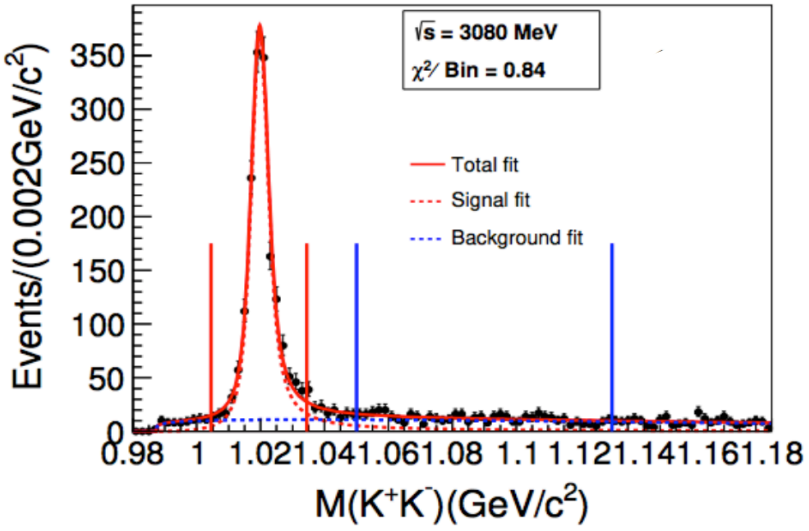
Signal: P-wave BW$\otimes$ Gaussian;

Background: Argus;

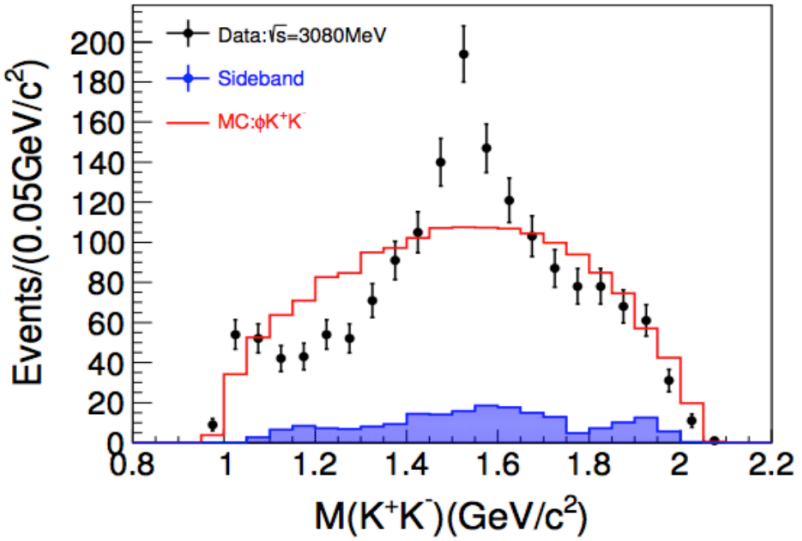
N=1690.8± 50.1

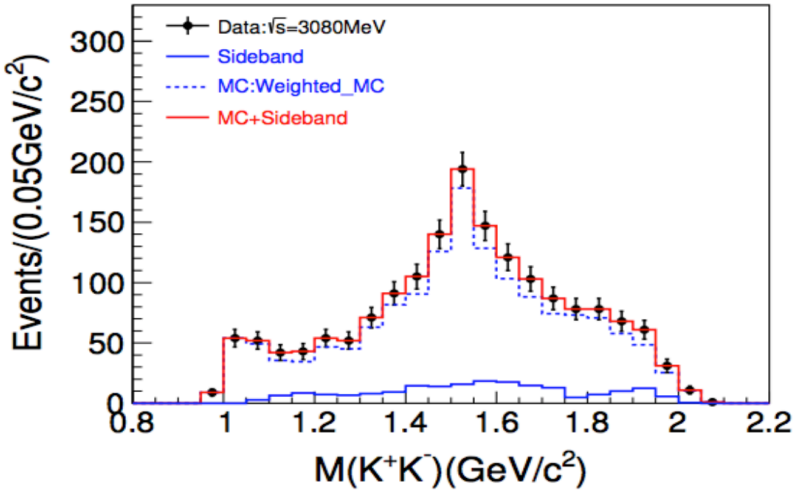


Weighted efficiency



$$|M(K^{+}\mathrm{K}^{-}) - 1.01946| \leq 0.015\mathrm{GeV}$$





Weighted efficiency

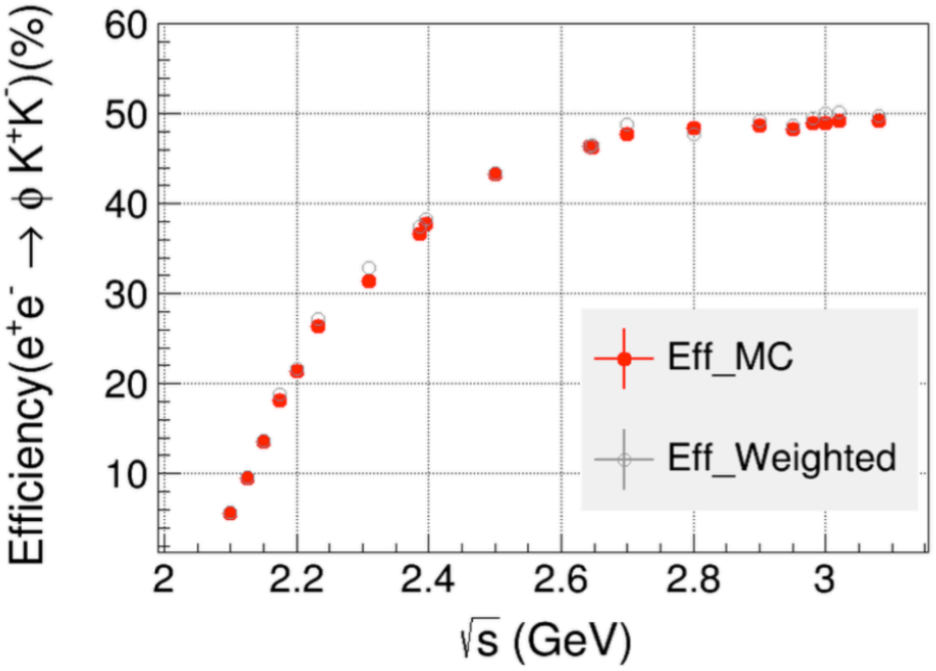
Table 1: Efficiency of different generator models.

$\sqrt{s}$ (GeV)	Weighted-Efficiency-100Bins(%)	Weighted-Efficiency-28Bins(%)	Raw-Efficiency(%)	Difference
3.080	49.7	49.7	49.2	0.5
3.020	49.8	50.2	49.2	1.0
3.000	49.7	50.0	49.0	1.0
2.981	49.6	49.5	49.0	0.5
2.950	48.7	48.6	48.2	0.4
2.900	49.3	49.2	48.6	0.6
2.800	47.4	47.7	48.4	−0.7
2.700	48.9	48.8	47.7	1.1
2.646	46.4	46.5	46.2	0.2
2.644	46.4	46.4	46.3	0.1
2.500	44.2	43.4	43.2	0.2
2.396	38.0	38.2	37.7	0.5
2.386	37.5	37.4	36.7	0.7
2.309	33.1	32.8	31.3	1.5
2.232	27.4	27.2	26.4	0.8
2.200	21.7	21.7	21.4	0.3
2.175	18.7	18.8	18.1	0.7
2.150	13.6	13.7	13.6	0.1
2.125	9.7	9.6	9.6	0.0
2.100	5.8	5.7	5.6	0.1

Weighted efficiency

Table 1: Efficiency of different generator models.

$\sqrt{s}$ (GeV)	Raw-Efficiency(%)	Weighted-Efficiency(%)	Difference
3.080	49.7	49.2	0.5
3.020	50.2	49.2	1.0
3.000	50.0	49.0	1.0
2.981	49.5	49.0	0.5
2.950	48.6	48.2	0.4
2.900	49.2	48.6	0.6
2.800	47.7	48.4	−0.7
2.700	48.8	47.7	1.1
2.646	46.5	46.2	0.2
2.644	46.4	46.3	0.1
2.500	43.4	43.2	0.2
2.396	38.2	37.7	0.5
2.386	37.4	36.7	0.7
2.309	32.8	31.3	1.5
2.232	27.2	26.4	0.8
2.200	21.7	21.4	0.3
2.175	18.8	18.1	0.7
2.150	13.7	13.6	0.1
2.125	9.6	9.6	0.0
2.100	5.7	5.6	0.1



Weighted efficiency

$\sqrt{s}$ (GeV)	L_{int} (pb^{-1})	N^{obs}	$(1+\delta)$	ϵ(%)	σ^{B} (pb)
2.100	12.17	12.9±6.1	0.8346	5.7	45.6±21.6±8.3
2.125	108.49	309.6±31.5	0.8555	9.6	71.1±7.2±4.9
2.150	2.84	15.8±5.9	0.8714	13.7	95.3±35.6±14.9
2.175	10.62	84.5±15.6	0.8835	18.8	97.9±18.1±7.0
2.200	13.70	137.7±18.7	0.8898	21.7	106.5±14.5±8.0
2.232	11.86	260.0±22.3	0.8543	27.2	193.0±16.6±15.2
2.309	21.09	377.0±26.0	0.9465	32.6	118.5±8.2±8.3
2.386	22.55	573.4±31.6	0.9598	37.4	144.9±8.0±13.6
2.396	66.87	1841.6±56.2	0.9618	38.2	153.3±4.7±12.0
2.500	1.10	25.5±6.9	0.9846	43.4	111.1±30.1±10.0
2.644	33.72	883.1±37.5	1.0211	46.4	113.0±4.8±7.0
2.646	34.00	901.3±37.7	1.0217	46.5	114.1±4.8±6.5
2.700	1.03	26.0±6.1	1.0376	48.8	101.6±23.8±9.6
2.800	1.01	13.2±4.5	1.0702	47.9	52.2±17.8±4.5
2.900	105.25	2010.8±54.4	1.1013	49.2	72.1±2.0±4.0
2.950	15.94	282.2±20.4	1.1099	48.6	67.1±4.9±3.6
2.981	16.07	245.9±20.0	1.1098	49.5	57.0±4.6±3.1
3.000	15.88	242.6±18.8	1.1064	50.0	56.5±4.4±3.5
3.020	17.29	253.7±19.9	1.0996	50.2	54.4±4.3±3.3
3.080	126.19	1690.8±50.1	1.0065	49.7	54.8±1.6±2.8

SysErr-efficiency

✓ MC statistic:

$$\Delta_{MC} = \frac{1}{\sqrt{N^{gen}}} \cdot \sqrt{\frac{1-\epsilon}{\epsilon}}$$

$$\Delta_{MC} = \frac{1}{\sqrt{\sum^{N^{gen}}}} \cdot \sqrt{\frac{1-\epsilon_{Cor}}{\epsilon_{Cor}}}$$

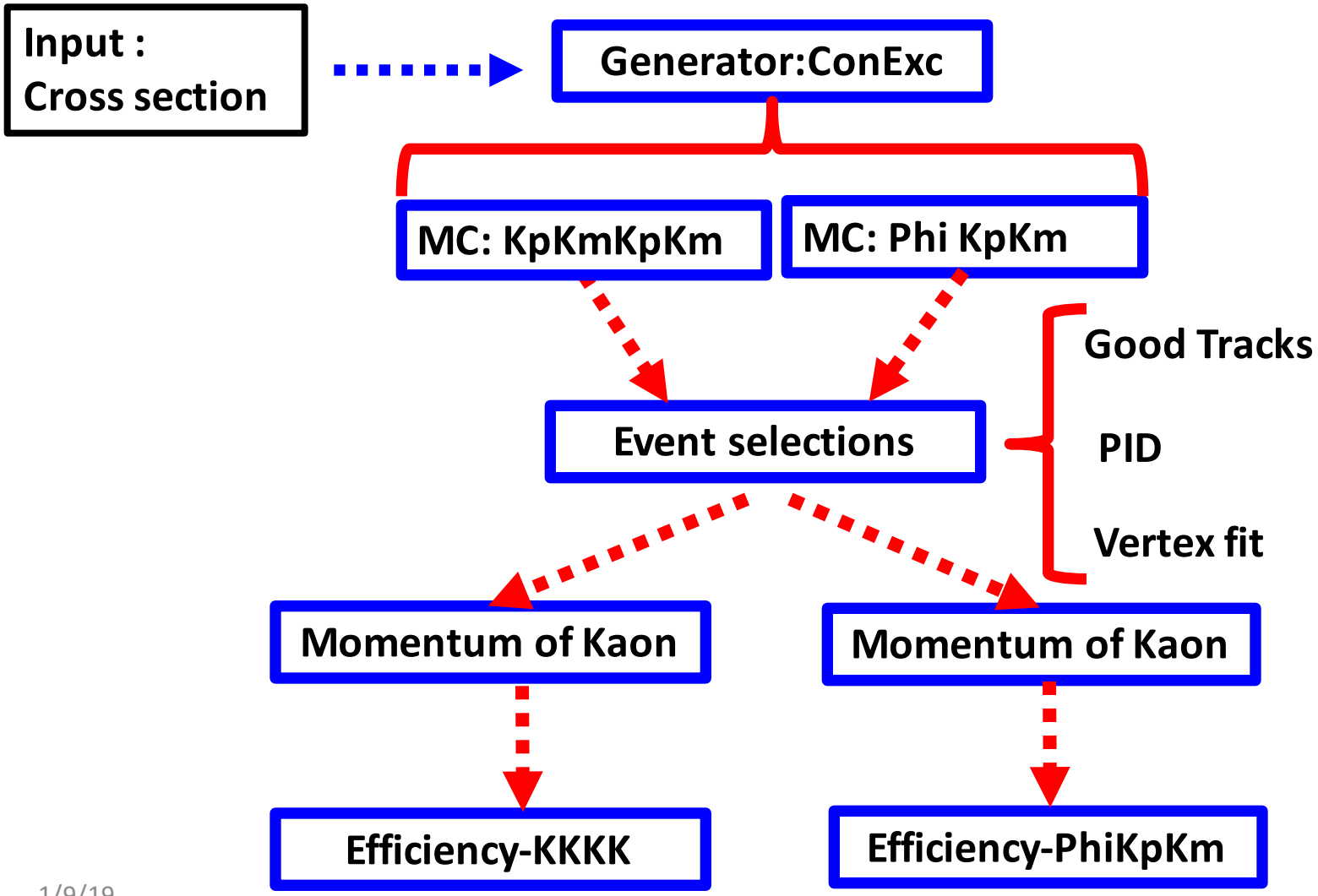
✓ Efficiency method

$$\Delta_{\epsilon} = \frac{\epsilon_{Cor} - \epsilon_{Raw}}{\epsilon_{Cor}}$$

Table 1: Efficiency of different generator models.

$\sqrt{s}$ (GeV)	Raw-Efficiency(%)	Weighted-Efficiency(%)	Difference
3.080	49.7	49.2	0.5
3.020	50.2	49.2	1.0
3.000	50.0	49.0	1.0
2.981	49.5	49.0	0.5
2.950	48.6	48.2	0.4
2.900	49.2	48.6	0.6
2.800	47.7	48.4	−0.7
2.700	48.8	47.7	1.1
2.646	46.5	46.2	0.2
2.644	46.4	46.3	0.1
2.500	43.4	43.2	0.2
2.396	38.2	37.7	0.5
2.386	37.4	36.7	0.7
2.309	32.8	31.3	1.5
2.232	27.2	26.4	0.8
2.200	21.7	21.4	0.3
2.175	18.8	18.1	0.7
2.150	13.7	13.6	0.1
2.125	9.6	9.6	0.0
2.100	5.7	5.6	0.1

$e^+e^- \rightarrow K^+K^-K^+K^-$

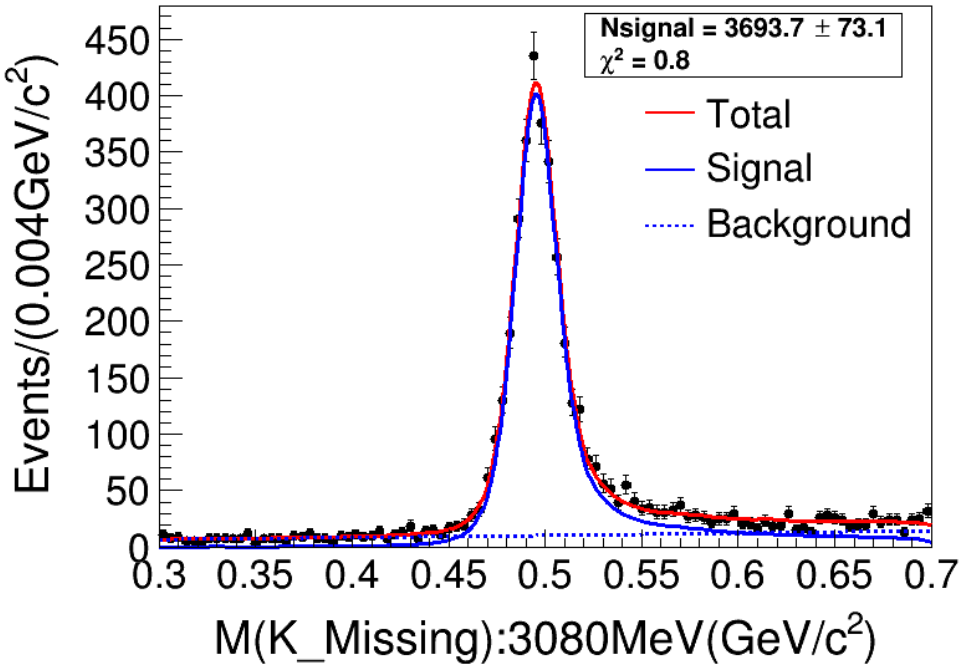


Signal extraction

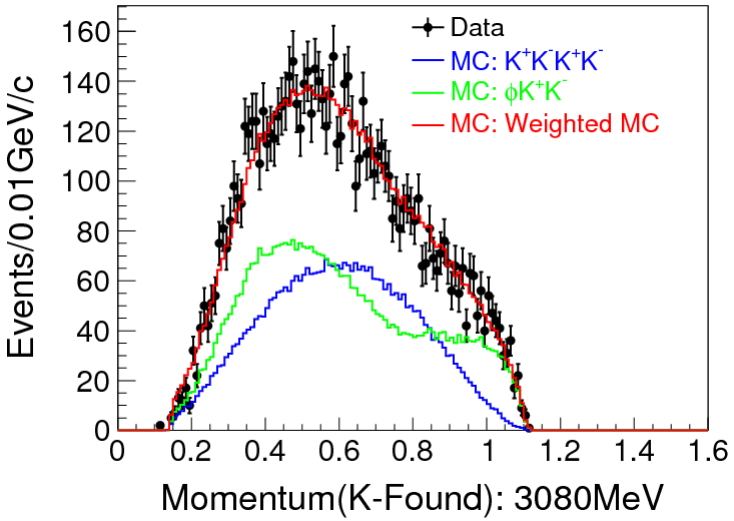
(1) K_Missing Fitting :

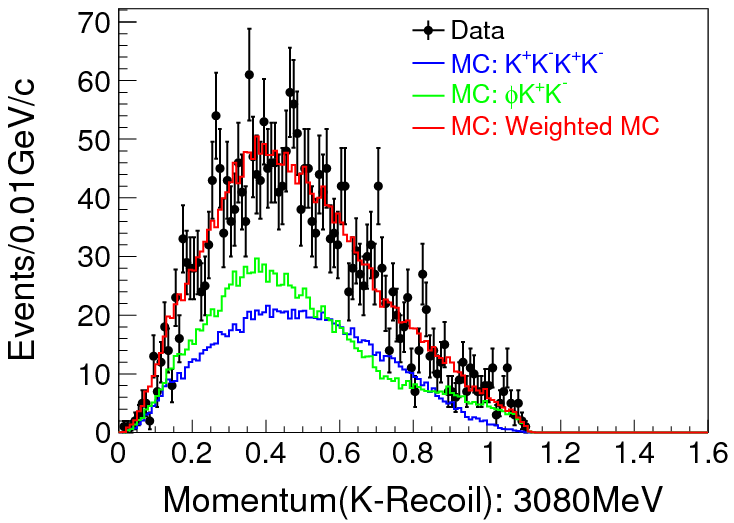
Signal: MCShape⊗ Gaussian;
Background:
Chebyshev Polynominal;

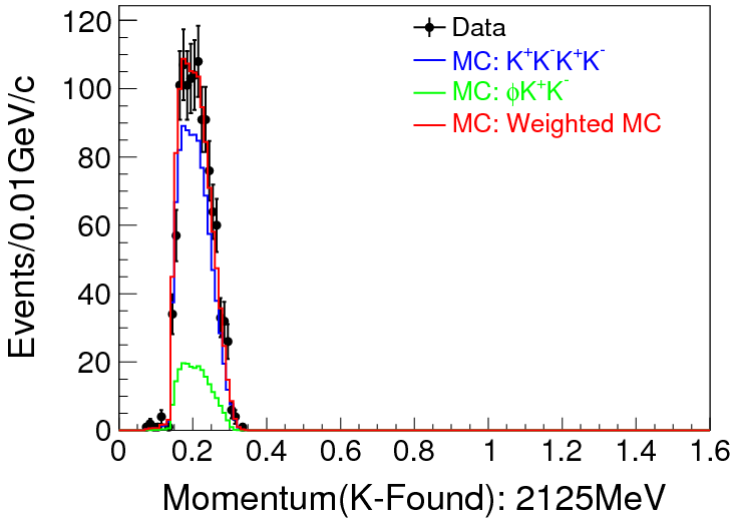
N=3693.7±73.1

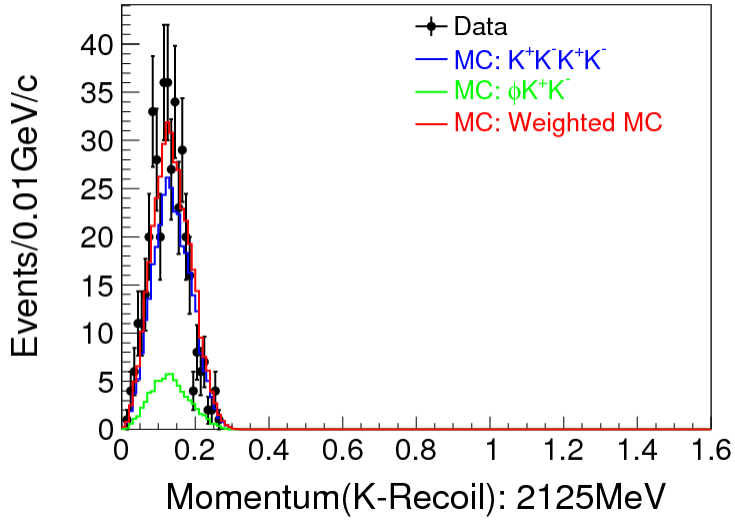


Weighted efficiency









Weighted efficiency

✓ **Efficiency**

$$\epsilon = \frac{N_1^{obs}}{N^{total}} \cdot \epsilon_1 + \frac{N^{total} - N_1^{obs}}{N^{total}} \cdot \epsilon_2$$

$\sqrt{s}$ (GeV)	L_{int} (pb^{-1})	N^{obs}	$(1+\delta)$	ϵ(%)	σ^B (pb)
2.100	12.17	12.9±6.1	0.8346	5.7	45.6±21.6±8.3
2.125	108.49	309.6±31.5	0.8555	9.6	71.1±7.2±4.9
2.150	2.84	15.8±5.9	0.8714	13.7	95.3±35.6±14.9
2.175	10.62	84.5±15.6	0.8835	18.8	97.9±18.1±7.0
2.200	13.70	137.7±18.7	0.8898	21.7	106.5±14.5±8.0
2.232	11.86	260.0±22.3	0.8543	27.2	193.0±16.6±15.2
2.309	21.09	377.0±26.0	0.9465	32.6	118.5±8.2±8.3
2.386	22.55	573.4±31.6	0.9598	37.4	144.9±8.0±13.6
2.396	66.87	1841.6±56.2	0.9618	38.2	153.3±4.7±12.0
2.500	1.10	25.5±6.9	0.9846	43.4	111.1±30.1±10.0
2.644	33.72	883.1±37.5	1.0211	46.4	113.0±4.8±7.0
2.646	34.00	901.3±37.7	1.0217	46.5	114.1±4.8±6.5
2.700	1.03	26.0±6.1	1.0376	48.8	101.6±23.8±9.6
2.800	1.01	13.2±4.5	1.0702	47.9	52.2±17.8±4.5
2.900	105.25	2010.8±54.4	1.1013	49.2	72.1±2.0±4.0
2.950	15.94	282.2±20.4	1.1099	48.6	67.1±4.9±3.6
2.981	16.07	245.9±20.0	1.1098	49.5	57.0±4.6±3.1
3.000	15.88	242.6±18.8	1.1064	50.0	56.5±4.4±3.5
3.020	17.29	253.7±19.9	1.0996	50.2	54.4±4.3±3.3
3.080	126.19	1690.8±50.1	1.0065	49.7	54.8±1.6±2.8

$\sqrt{s}$ (GeV)	L_{int} (pb^{-1})	N^{obs}	$(1+\delta)$	ϵ(%)	σ^B (pb)
2.100	12.17	18.9±8.8	0.8186	7.18	26.4±12.3±3.6
2.125	108.49	378.7±19.3	0.8437	12.24	33.8±1.7±4.0
2.150	2.84	18.3±4.6	0.8616	17.45	42.8±10.8±3.7
2.175	10.62	95.6±9.9	0.8750	23.24	44.2±4.6±3.9
2.200	13.70	206.6±15.3	0.8824	27.58	62.0±4.6±5.5
2.232	11.86	369.2±19.8	0.8505	33.29	110.0±5.9±5.2
2.309	21.09	682.3±28.0	0.9388	42.33	81.4±3.3±5.6
2.386	22.55	934.6±32.0	0.9515	46.10	94.5±3.2±4.4
2.396	66.87	2838.7±57.4	0.9534	50.00	89.0±1.8±6.9
2.500	1.10	55.3±8.0	0.9741	57.35	90.2±13.0±10.1
2.644	33.72	1819.9±47.0	1.0044	61.43	87.5±2.3±4.0
2.646	34.00	1817.6±47.1	1.0049	61.25	86.8±2.3±3.9
2.700	1.03	33.1±7.1	1.0173	62.65	50.2±10.8±4.4
2.800	1.01	37.2±7.3	1.0424	64.45	54.9±10.8±3.5
2.900	105.25	4366.4±76.1	1.0686	63.98	60.7±1.1±2.8
2.950	15.94	629.1±29.5	1.0799	63.14	57.9±2.7±2.7
2.981	16.07	555.6±28.1	1.0846	63.57	50.1±2.5±2.5
3.000	15.88	557.3±28.1	1.0860	63.31	51.0±2.6±2.3
3.020	17.29	591.4±29.2	1.0854	63.28	49.8±2.5±2.5
3.080	126.19	3693.7±73.1	1.0185	61.91	46.4±0.9±2.1

Weighted efficiency

$\sqrt{s}$ (GeV)	Weighted-Efficiency-28Bins(%)	Efficiency-PhiKK(%)	Efficiency-KKKK(%)	Difference
3.080	49.7	60.9	62.8	−1.9
3.020	50.2	62.1	64.2	−2.1
3.000	50.0	62.0	64.3	−2.3
2.981	49.5	62.5	64.4	−1.9
2.950	48.6	62.0	64.1	−2.0
2.900	49.2	62.6	65.1	−2.5
2.800	47.7	62.8	65.4	−2.5
2.700	48.8	61.7	64.0	−2.2
2.646	46.5	60.0	62.5	−2.5
2.644	46.4	60.2	62.6	−2.5
2.500	43.4	55.8	58.7	−2.9
2.396	38.2	49.0	51.8	−2.8
2.386	37.4	48.0	50.7	−2.7
2.309	32.8	41.2	43.7	−2.4
2.232	27.2	32.7	34.8	−2.1
2.200	21.7	27.1	28.5	−1.4
2.175	18.8	23.2	23.8	−0.7
2.150	13.7	17.4	17.5	−0.1
2.125	9.6	12.3	12.0	0.2
2.100	5.7	7.3	6.9	0.3

Weighted efficiency