# study of $e^+e^- \to e^+/e^-+K^+K^-$

2026.7.7

# Event selection ($e^+e^- \rightarrow e^+/e^-+K^+K^-$)

- Good charged tracks:

  Vxy<1cm, Vz<10cm

  |cosθ| < 0.93

  nGood = 3, Net charge = ±1

- Particle Identification
  - For Kaon: Prob(K) > Prob(e), Prob(K) > Prob(pi), Prob(K) > Prob(p)
  - For Electron: Prob(e) > Prob(pi), Prob(e) > Prob(K), Prob(e) > Prob(p)
    Prob(e) > Prob(μ), Prob(e) >0.001
  - Event Requirement: n$K^+$ = 1, n$K^-$ = 1, n$e^{\pm}$= 1

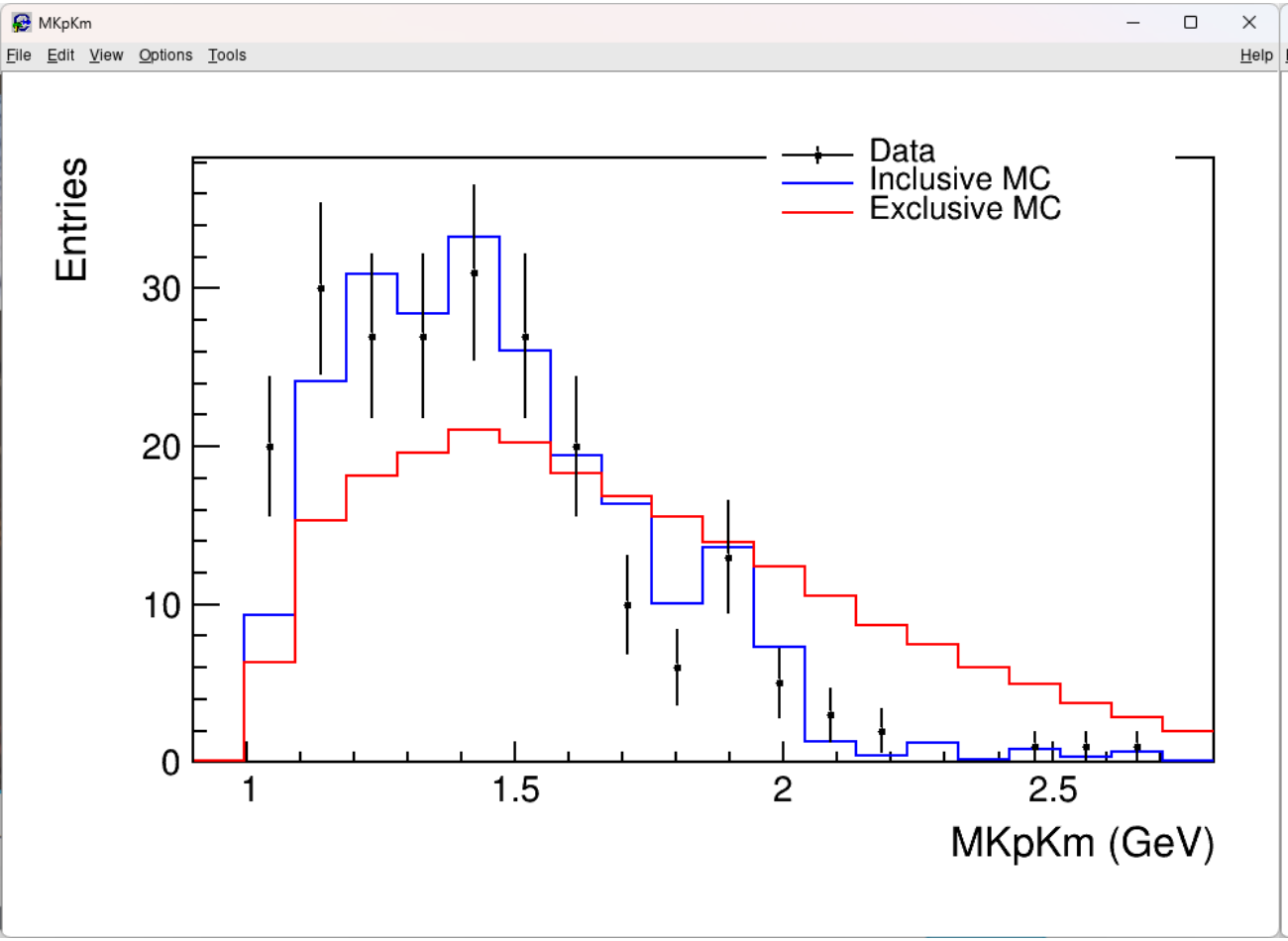
# Event selection ($e^+e^- \to e^+/e^-+K^+K^-$)

- 蒙特卡洛模拟器产生子:hadrontops  68w events
- 数据样本

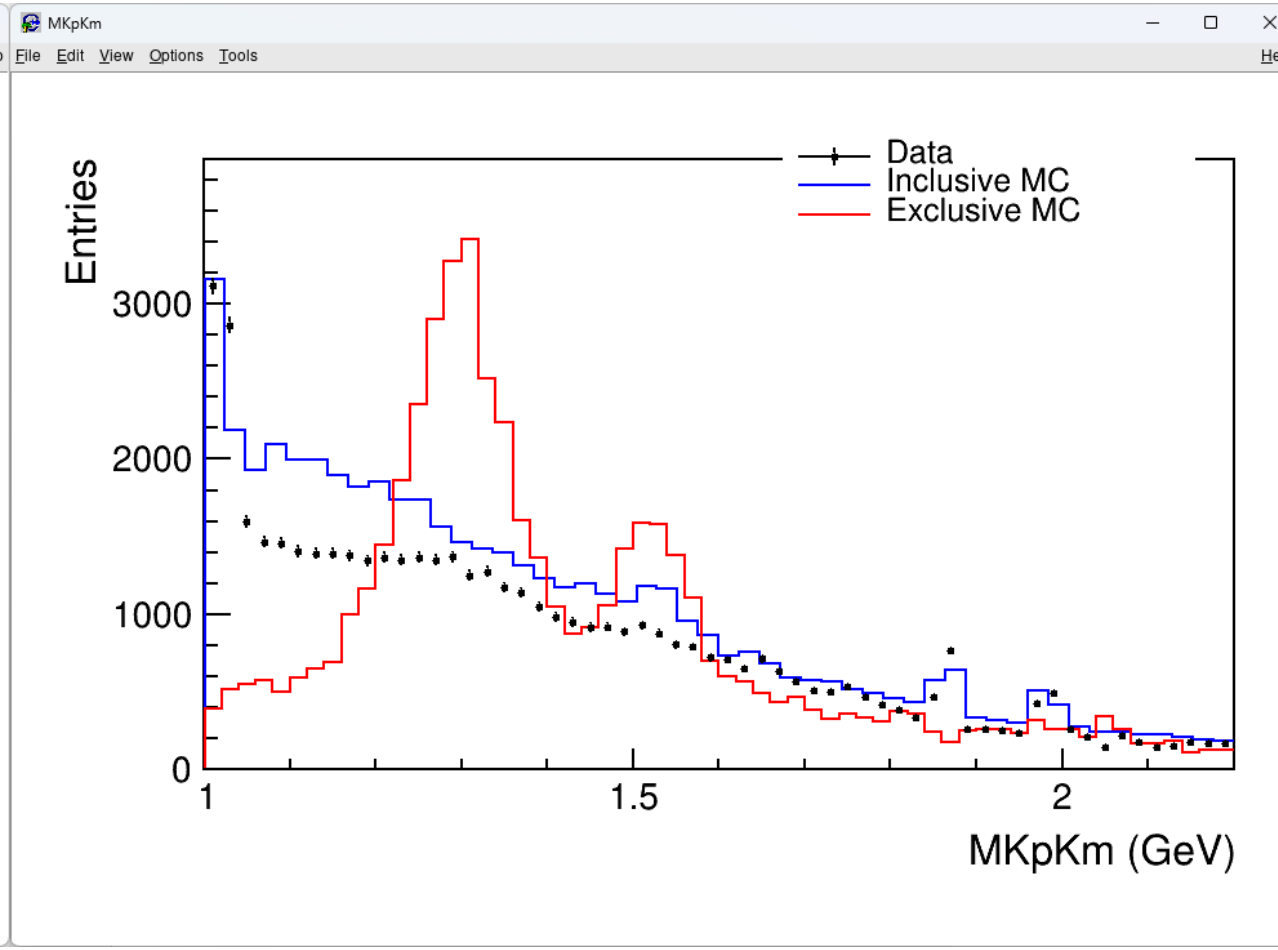
  data： all 3773

  inclusivemc：
  /besfs5/offline/data/tauqcd/bes3gen/712/psipp/round0304,15-17/Hadron_Hybrid

# Event selection ($e^+e^- \to e^+/e^- + K^+K^-$)

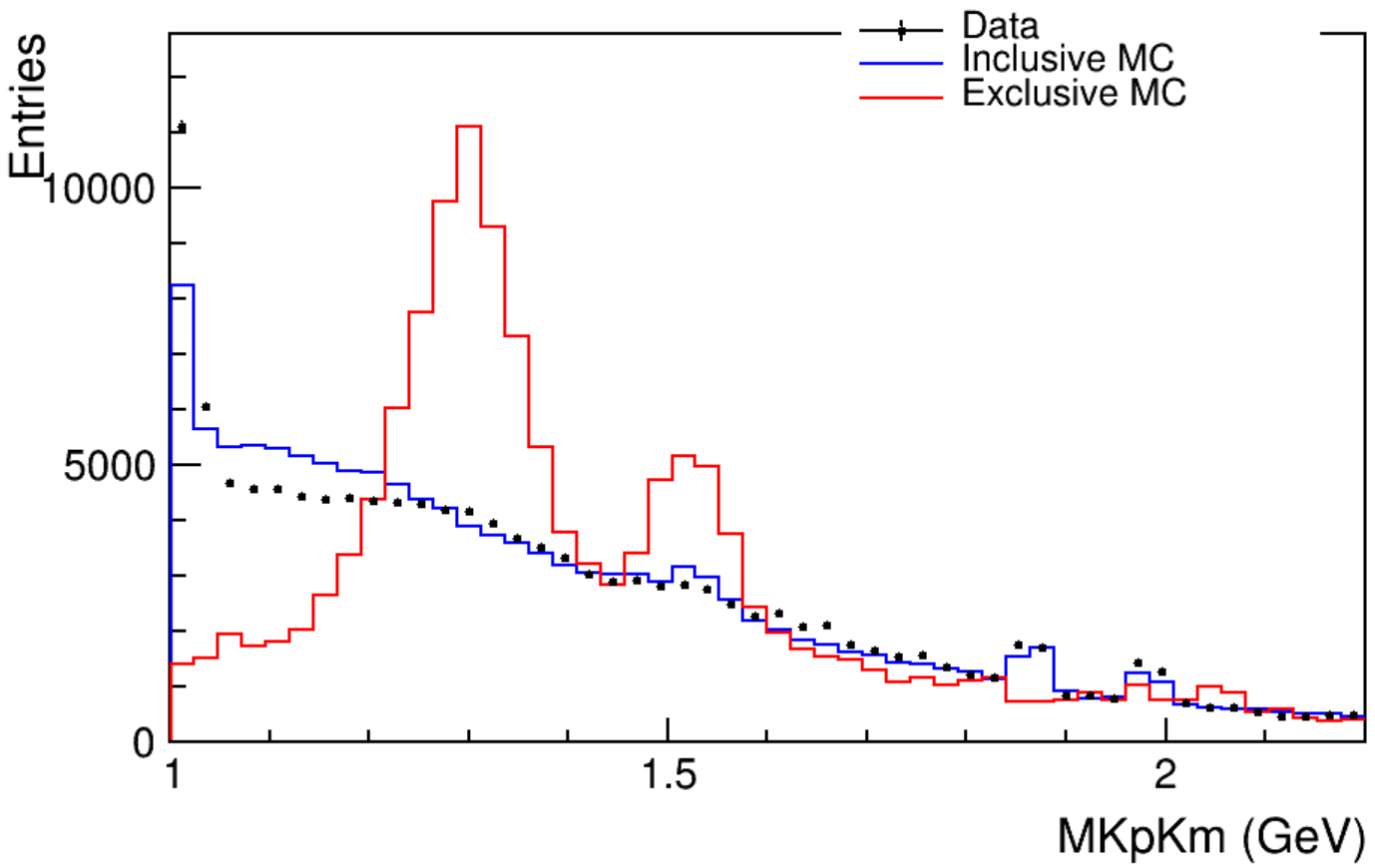


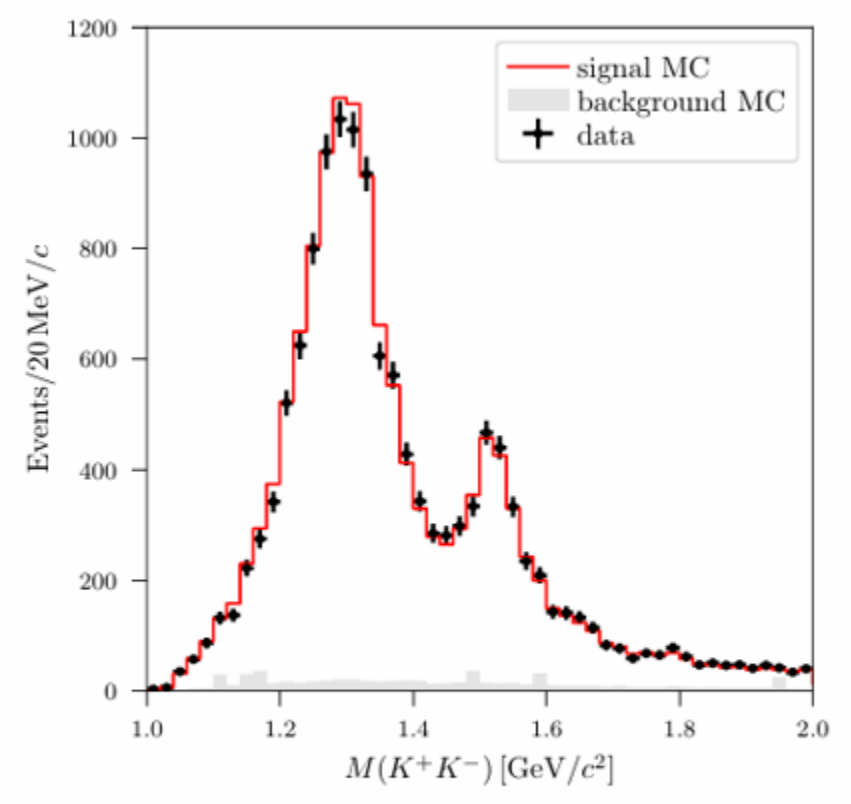

cppgamgam




HardonTops

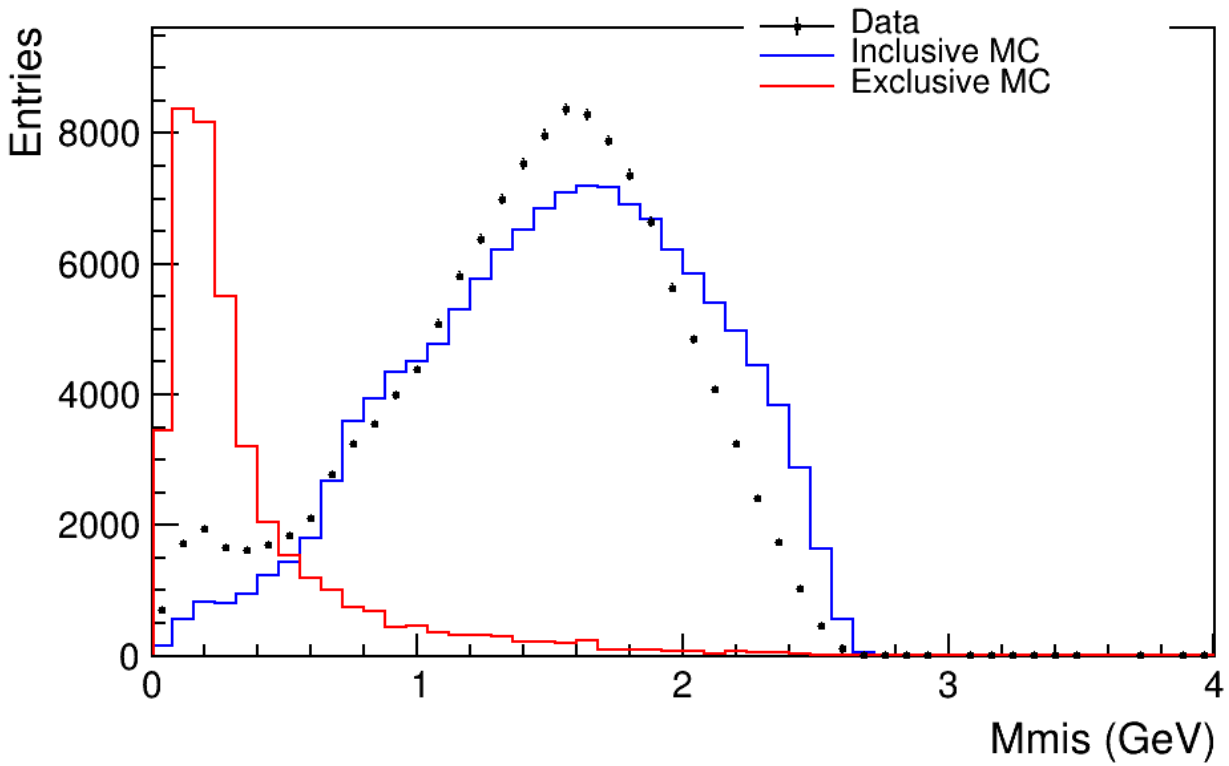
# Event selection ($e^+e^- \rightarrow e^+/e^- + K^+K^-$)

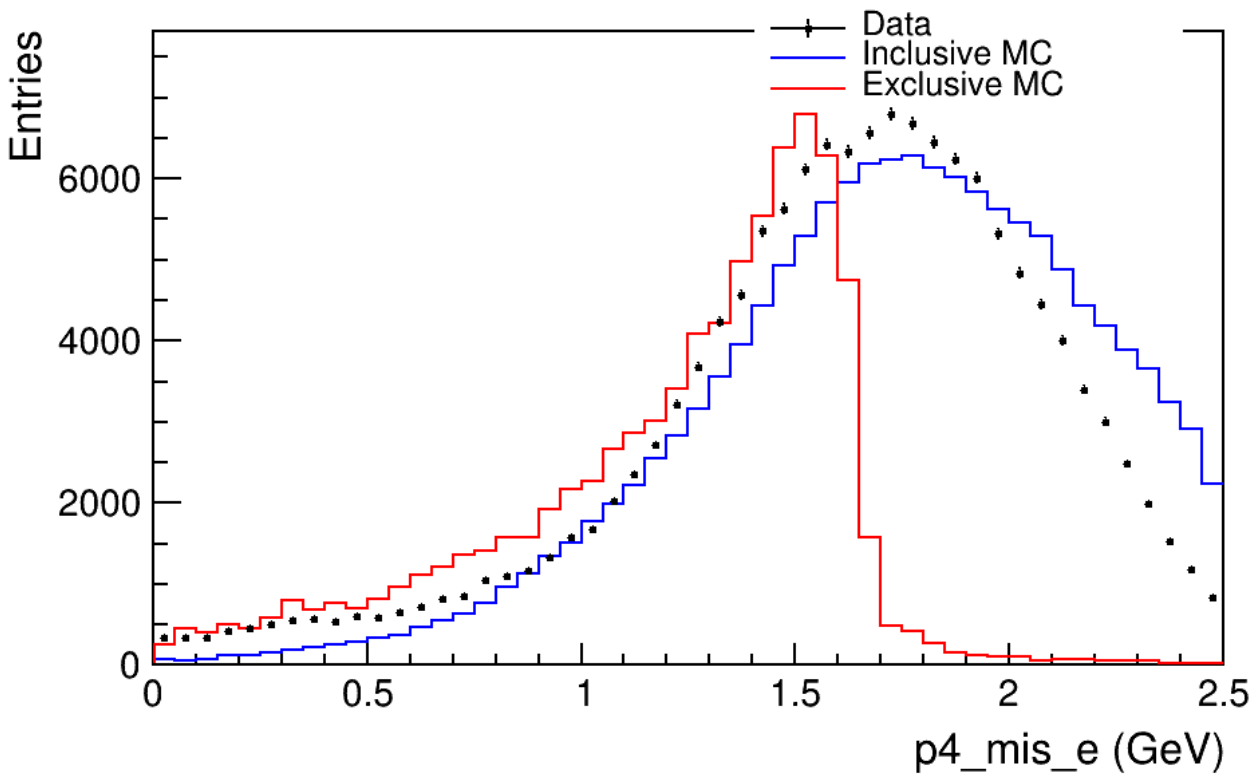


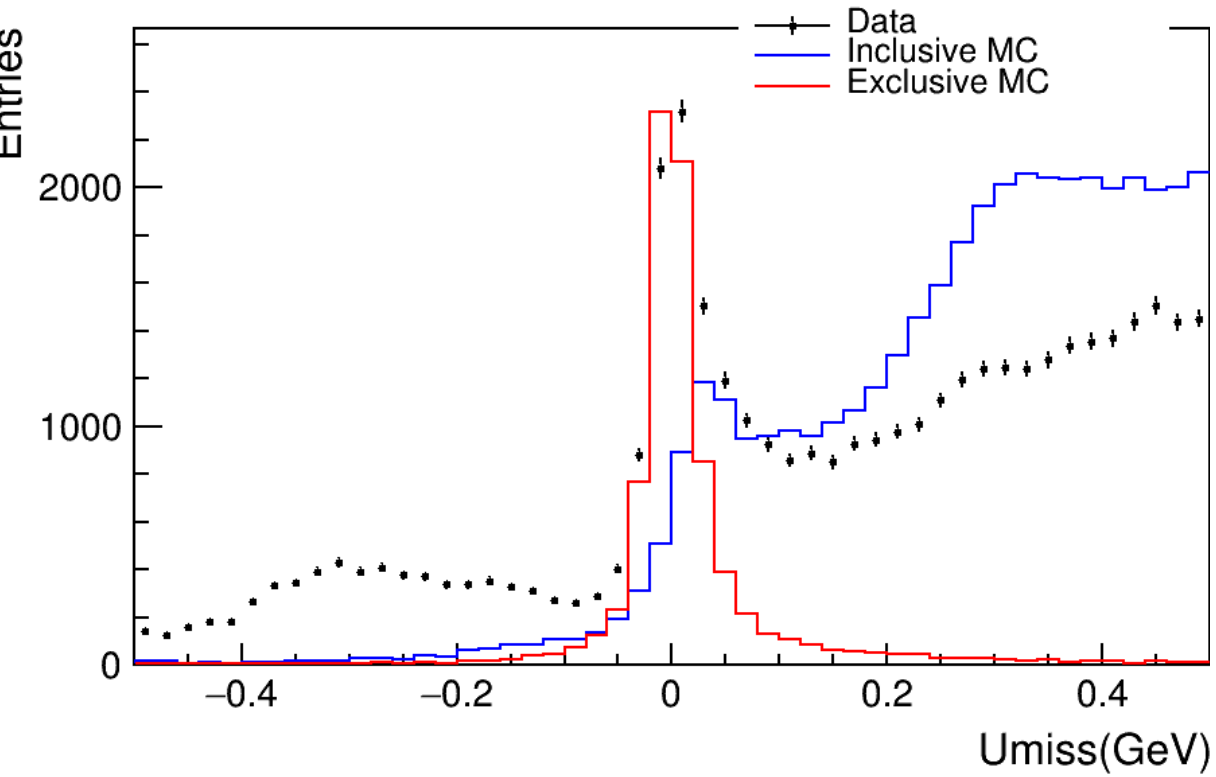

(d) Resulting invariant $K^+K^-$ mass distribution after all criteria are applied

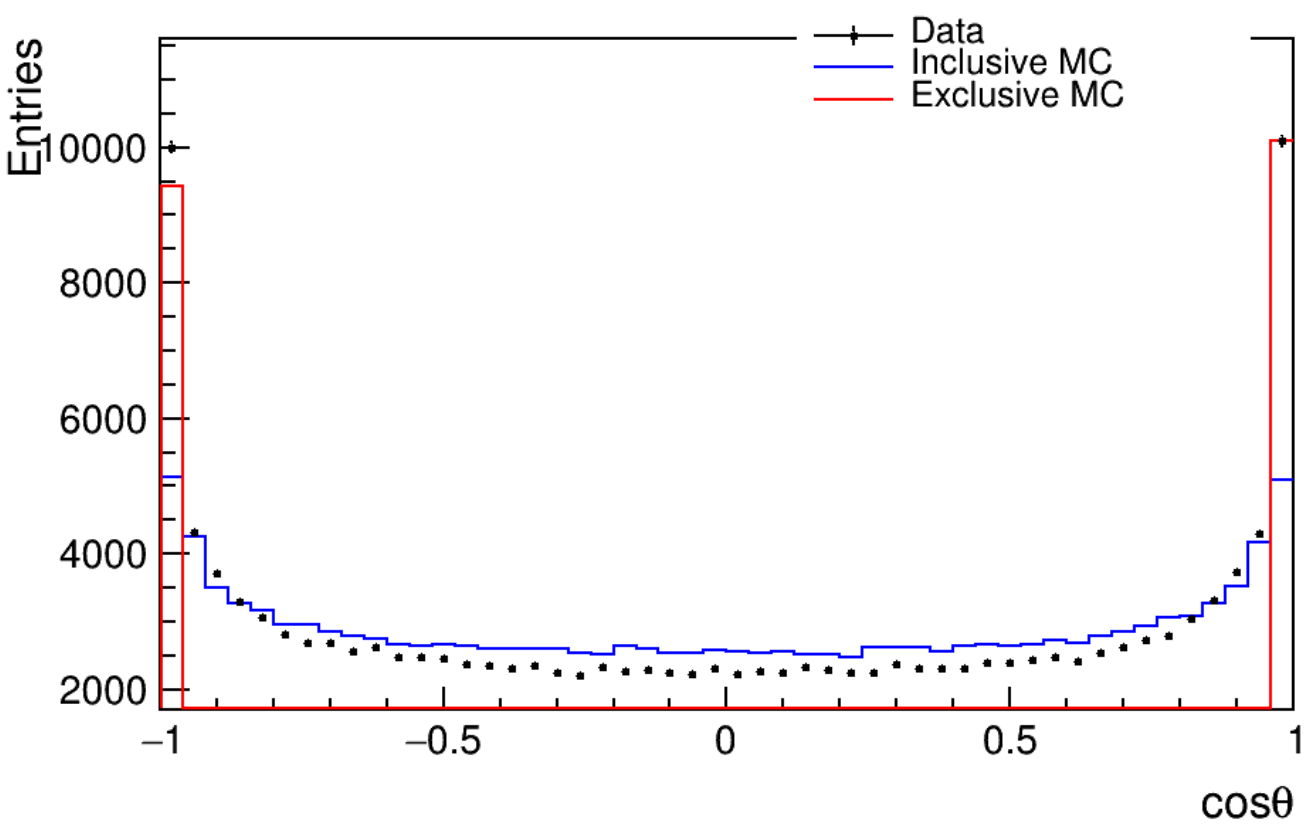
# Event selection ($e^+e^- \to e^+/e^- + K^+K^-$)



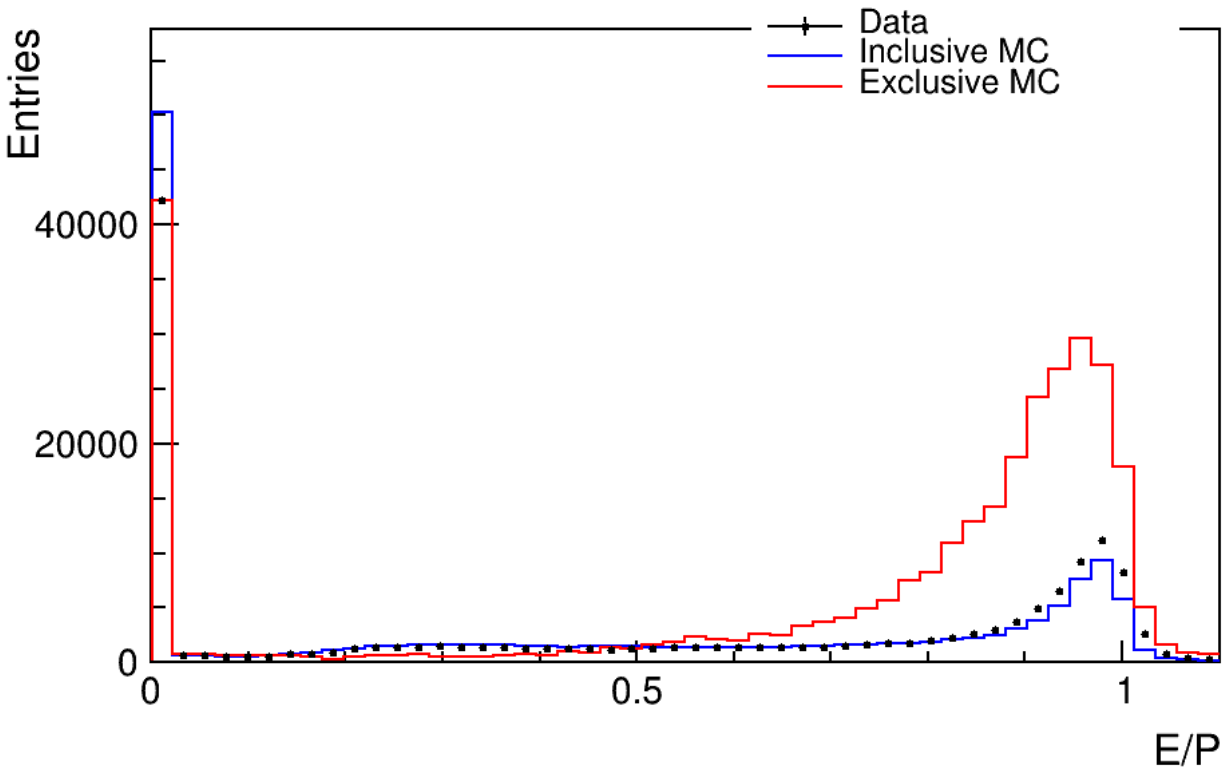



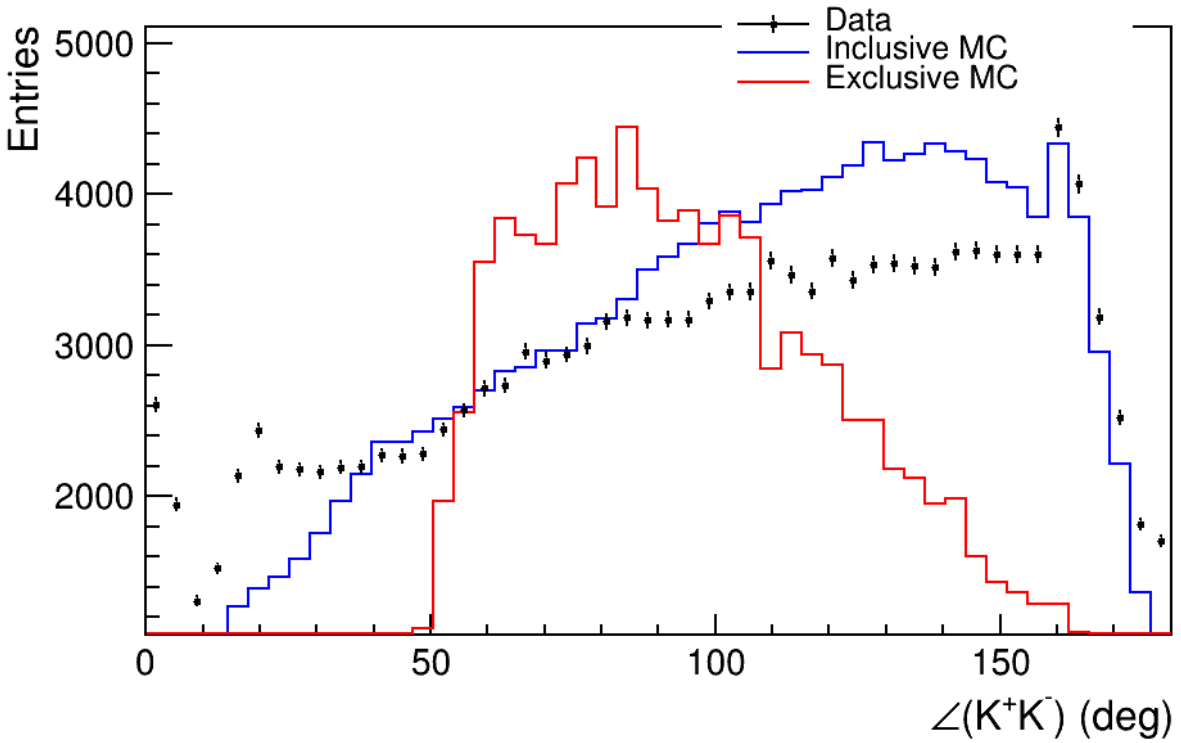
# Event selection ($e^+e^- \to e^+/e^- + K^+K^-$)

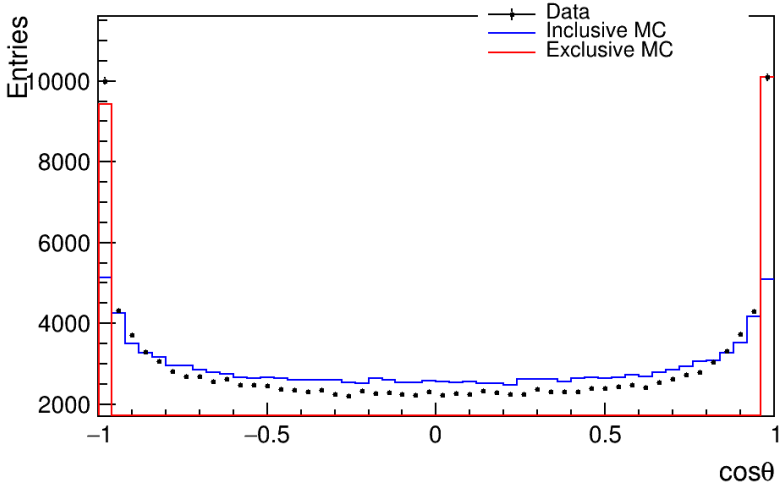


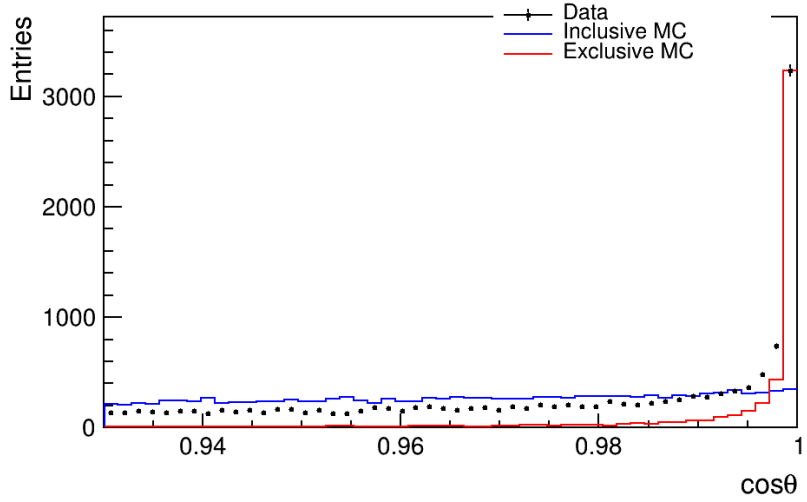



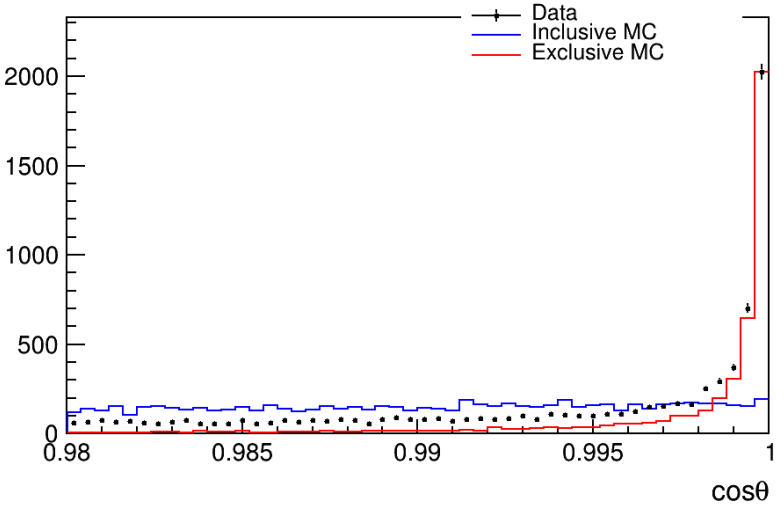
# Event selection ($e^+e^- \to e^+/e^- + K^+K^-$)

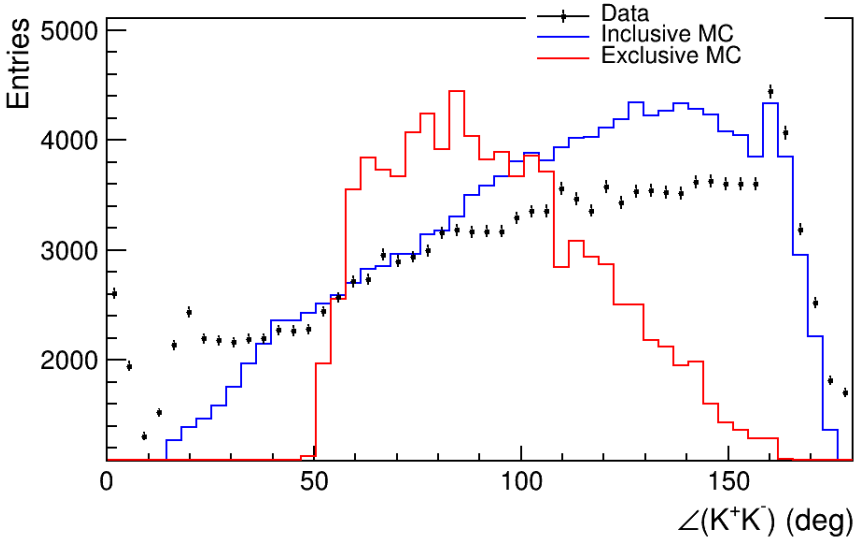


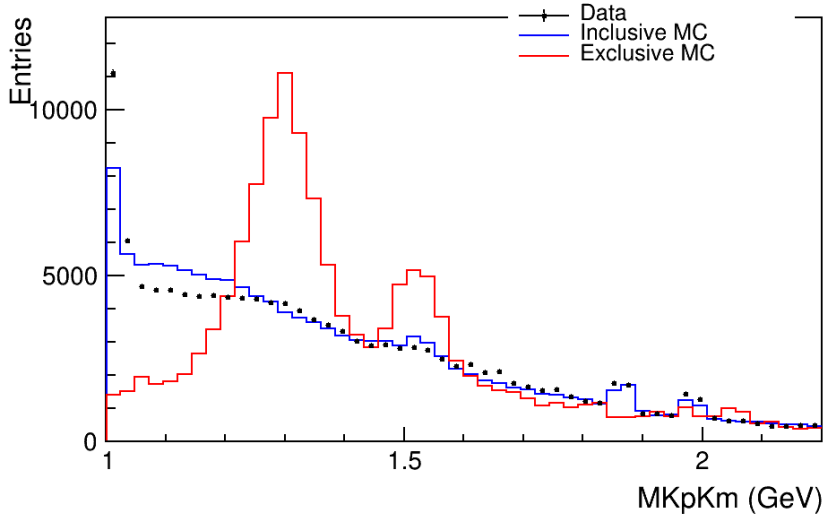



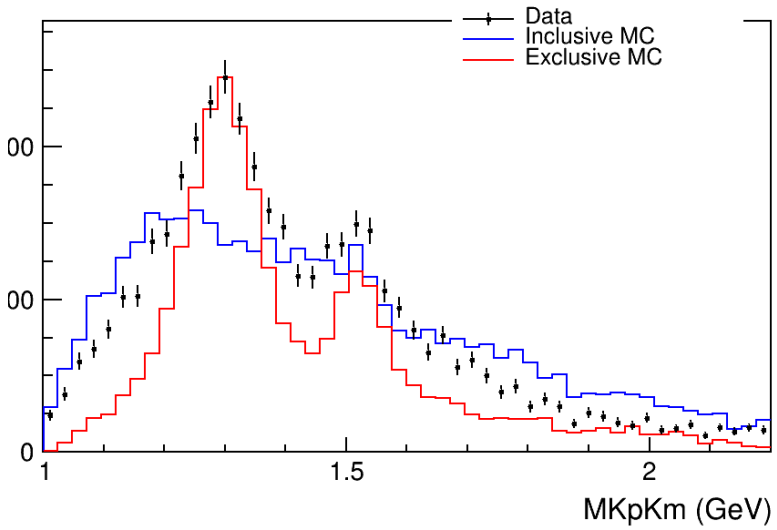


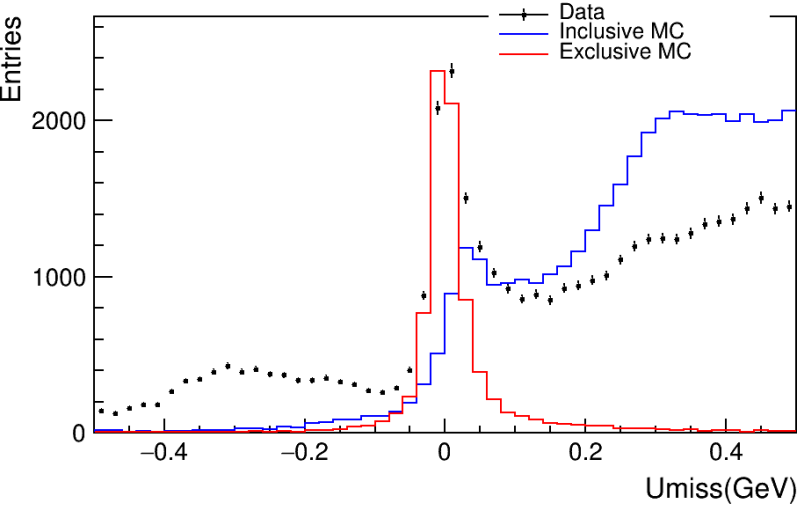

before

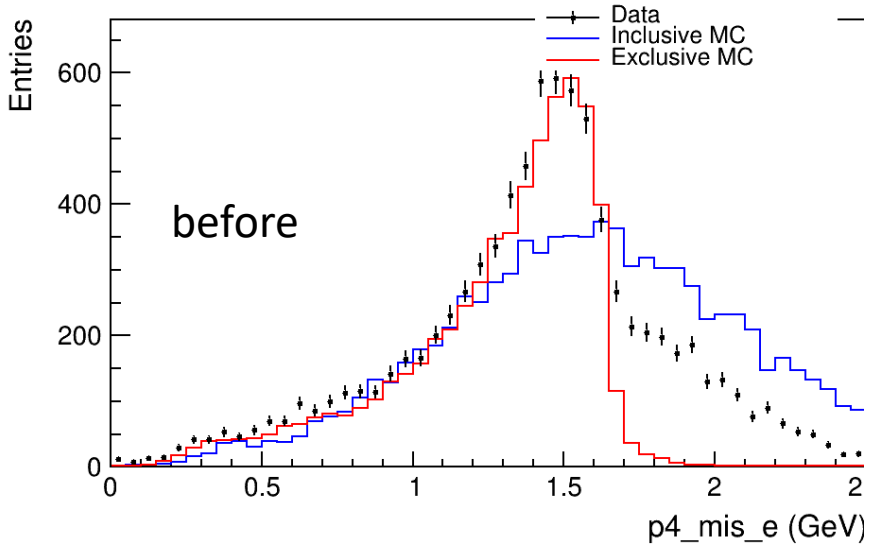
after

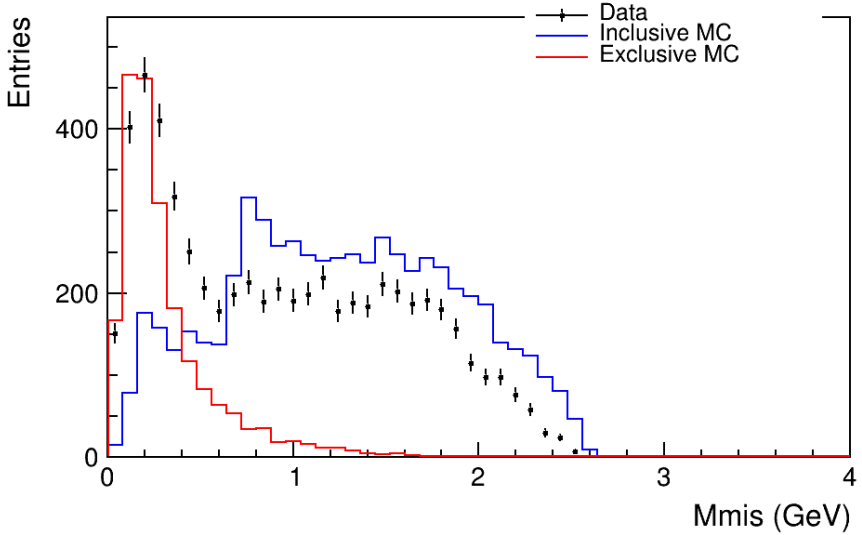
Cosθ（miss） > 0.98

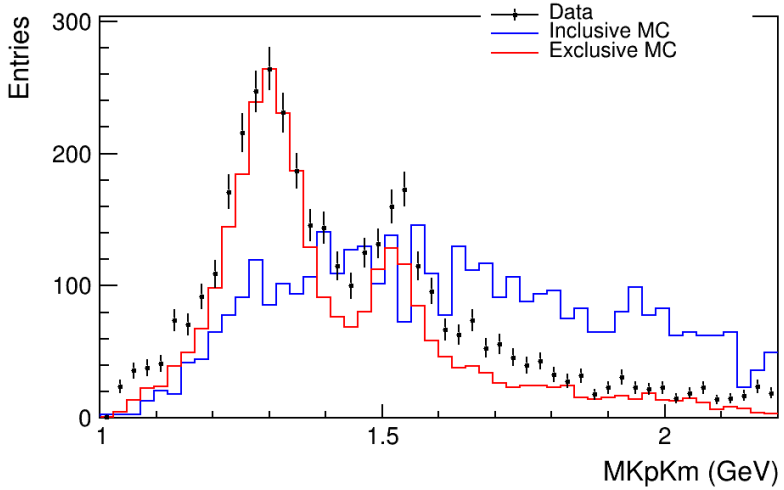
50.0> Angle_KpKm >= 150.0

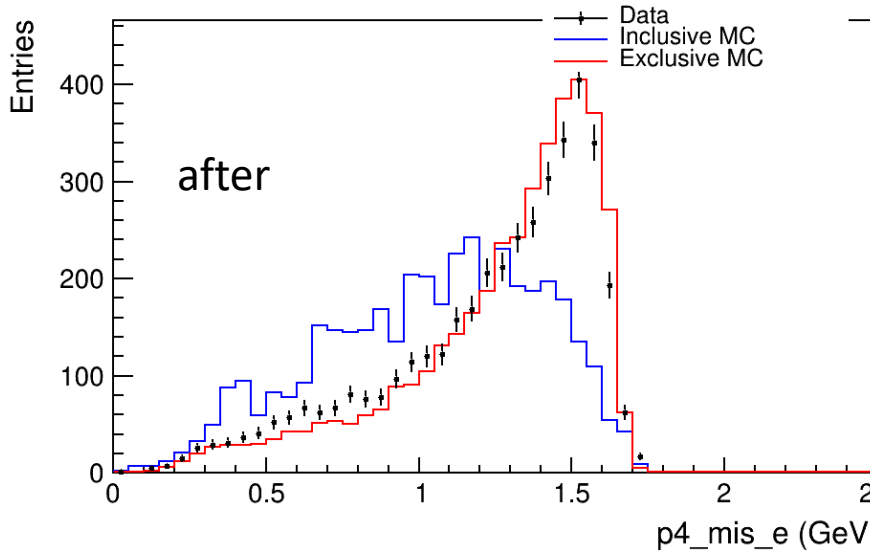
Event selection ($e^+e^- \to e^+/e^-+K^+K^-$)

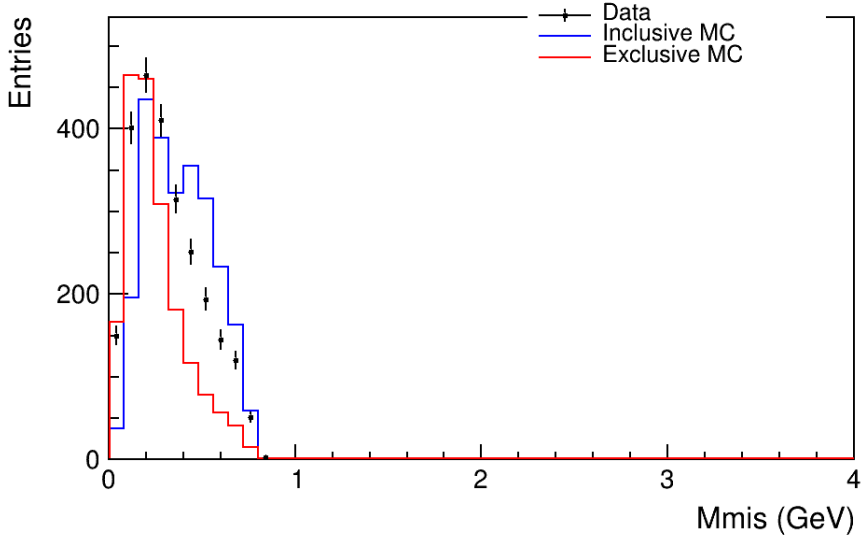


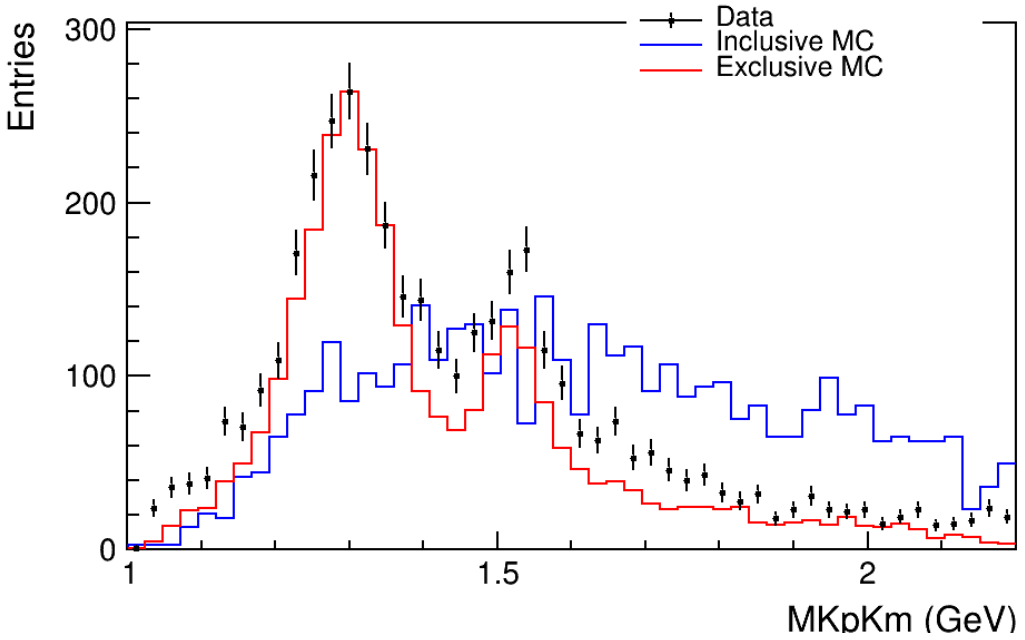




Cosθ（miss） > 0.98

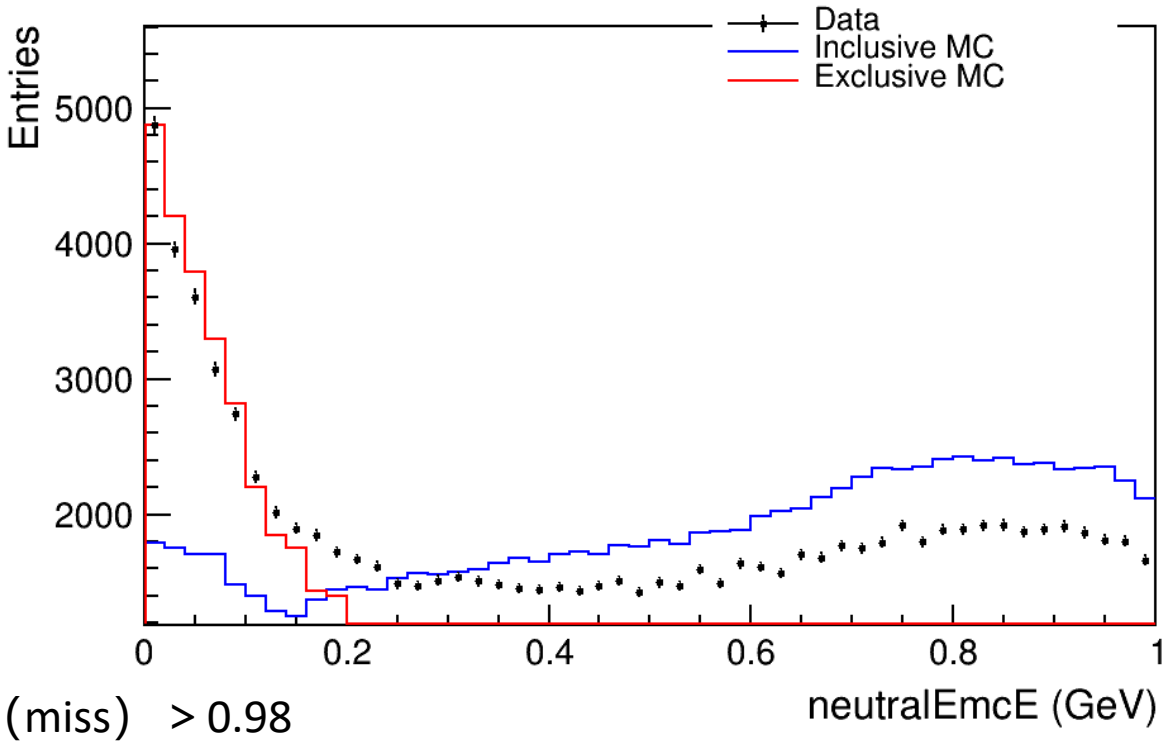
50.0> Angle_KpKm >= 150.0

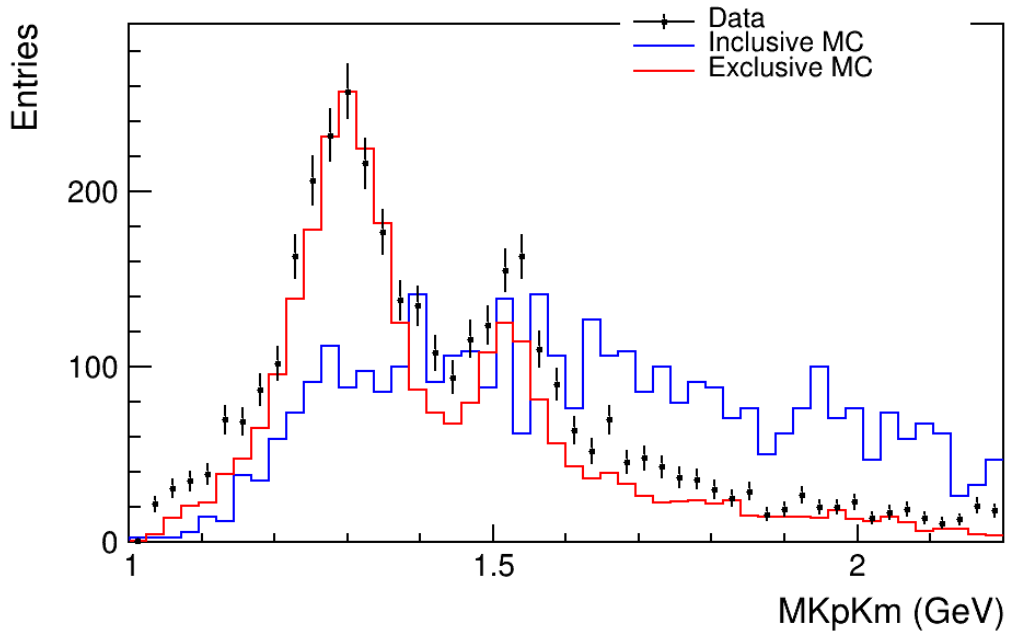
Umiss <= 0.2

Event selection ($e^+e^- \to e^+/e^-+K^+K^-$)



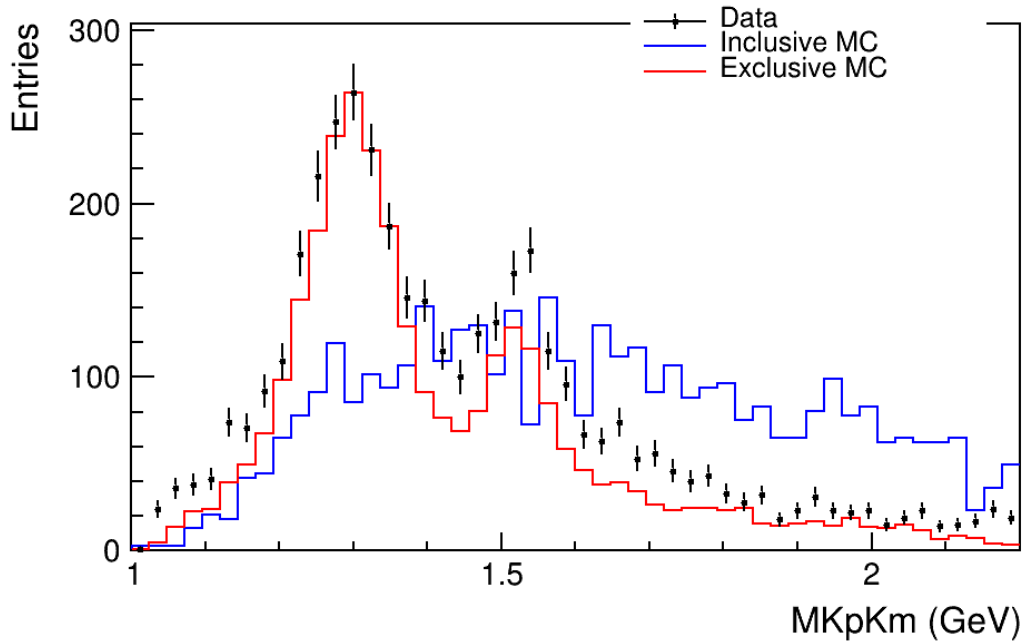

Cosθ（miss） > 0.98
50.0> Angle_KpKm >= 150.0
Umiss <= 0.2



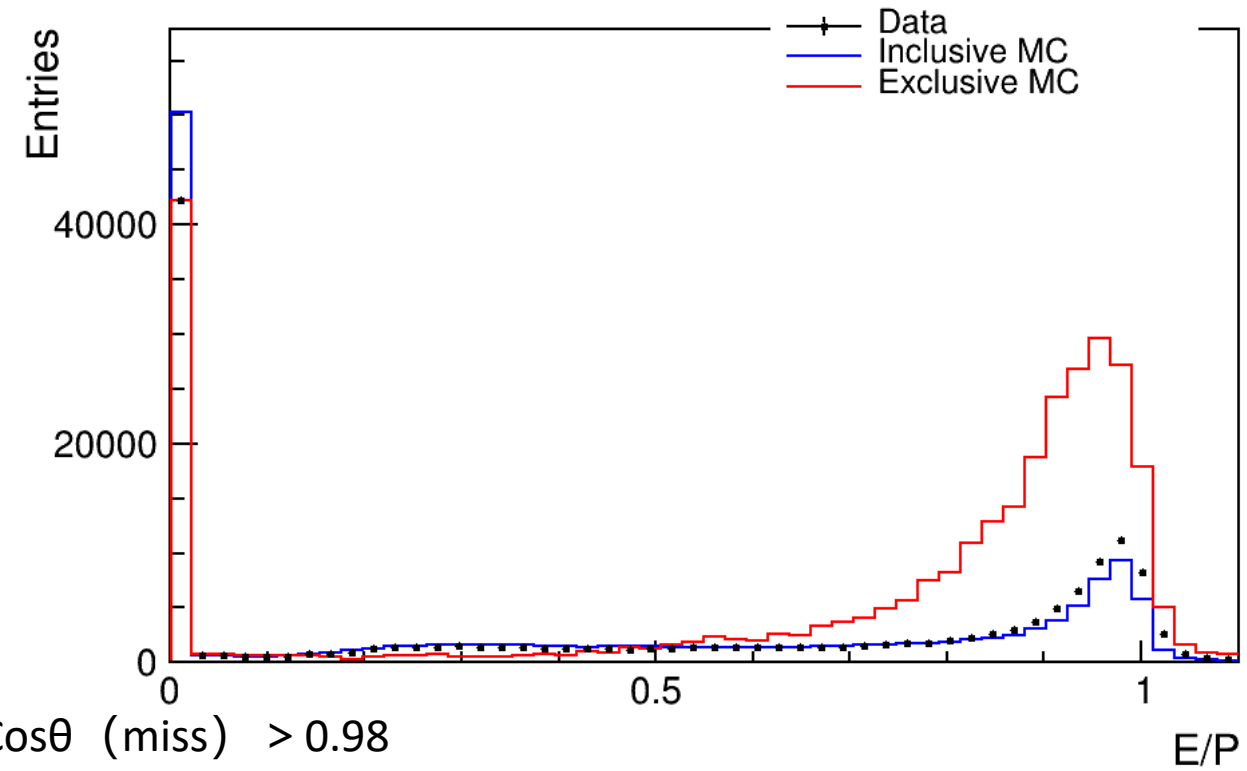



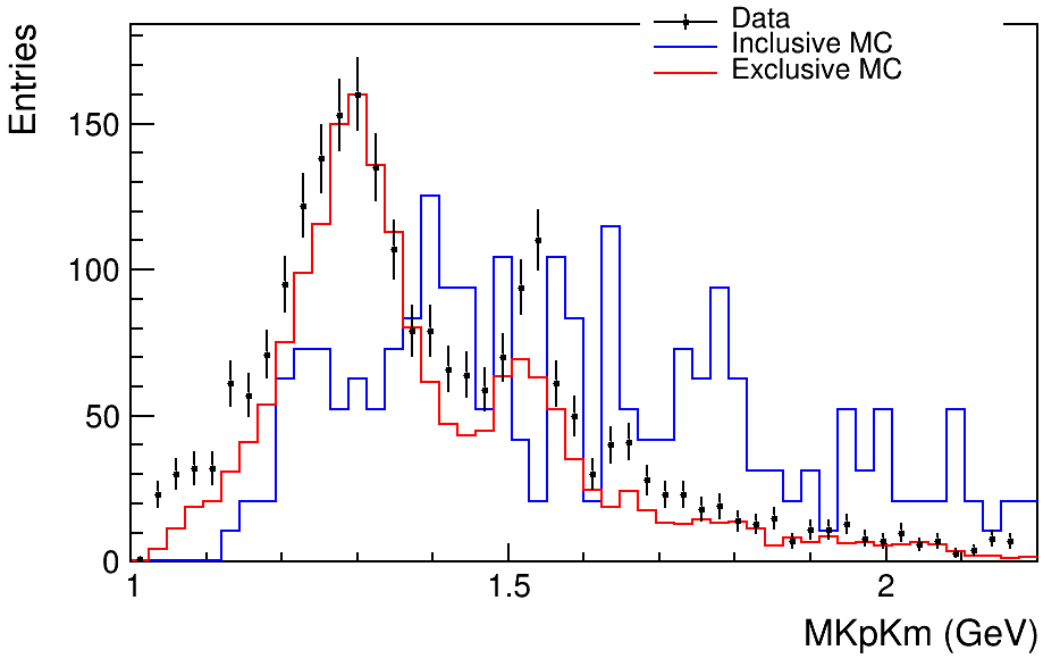

Cosθ（miss） > 0.98
50.0> Angle_KpKm >= 150.0
Umiss <= 0.2
neutralEmcE >= 0.2

Event selection ($e^+e^- \to e^+/e^-+K^+K^-$)



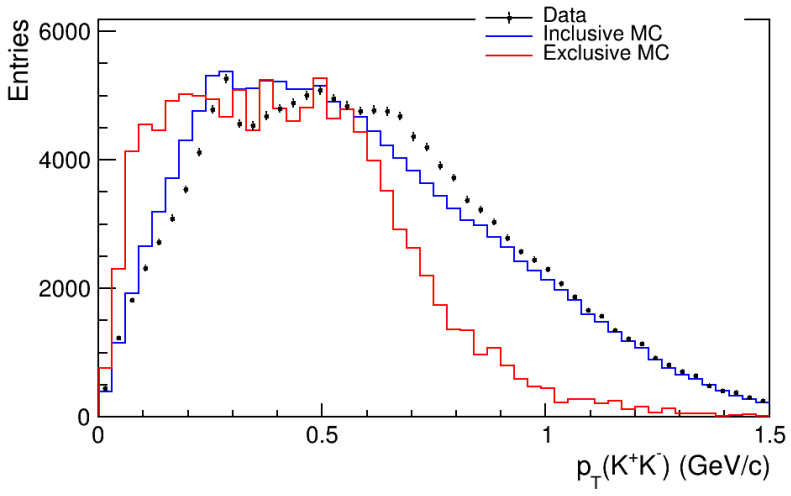

Cosθ (miss) > 0.98
50.0> Angle_KpKm >= 150.0
Umiss <= 0.2

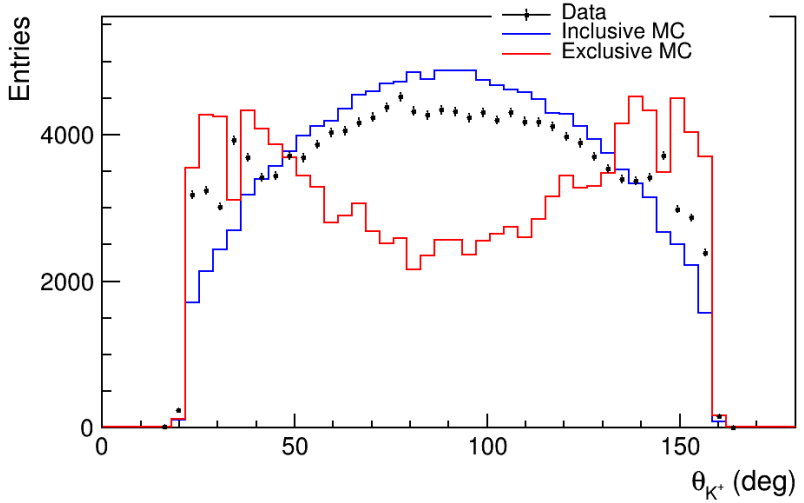


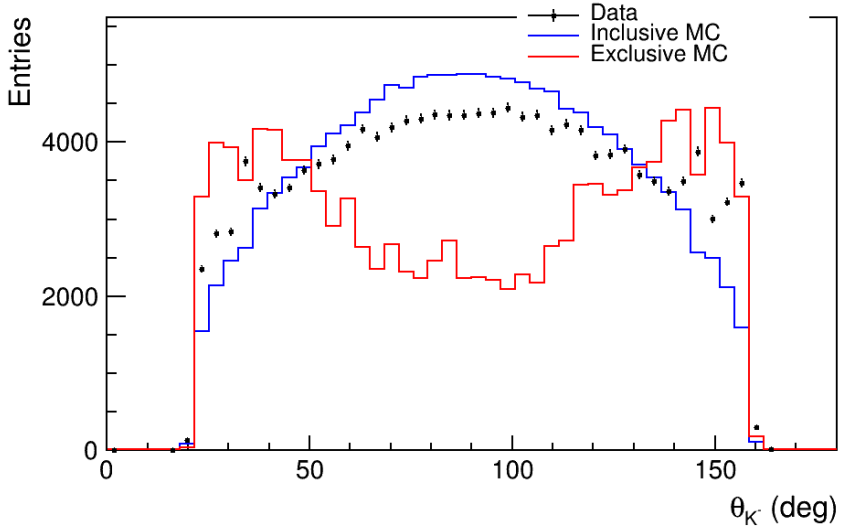



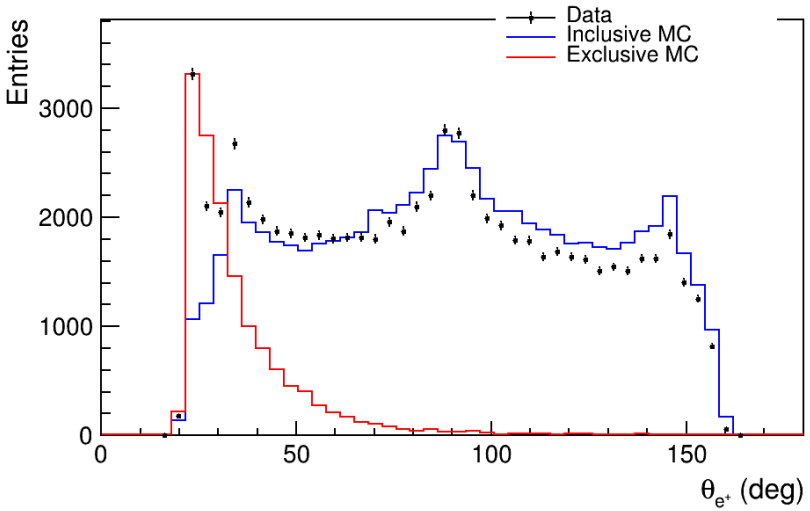

Cosθ (miss) > 0.98
50.0> Angle_KpKm >= 150.0
Umiss <= 0.2
eop > 0.8

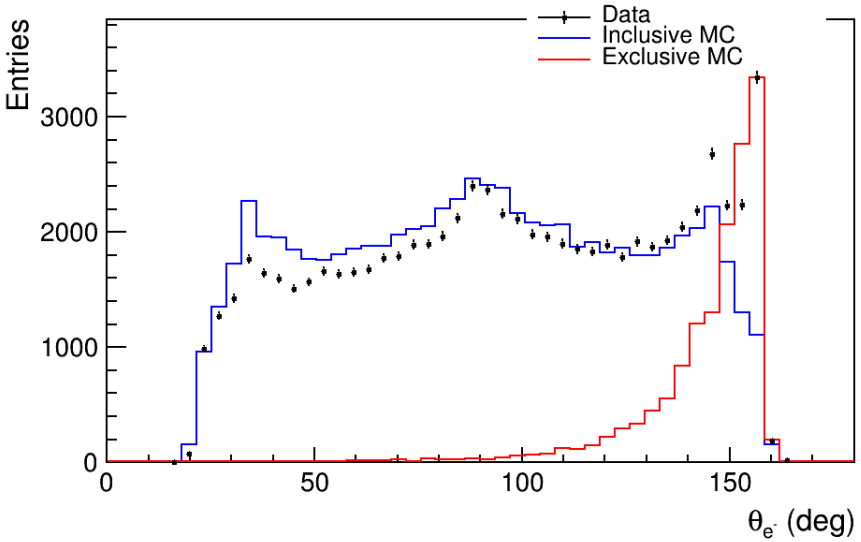
Event selection ($e^+e^- \to e^+/e^-+K^+K^-$)



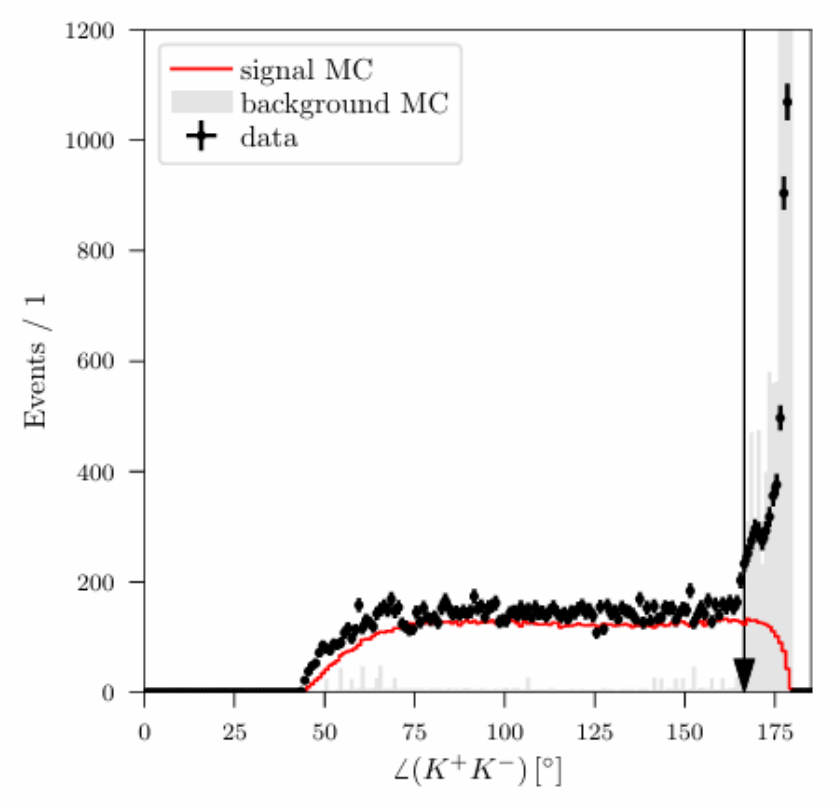



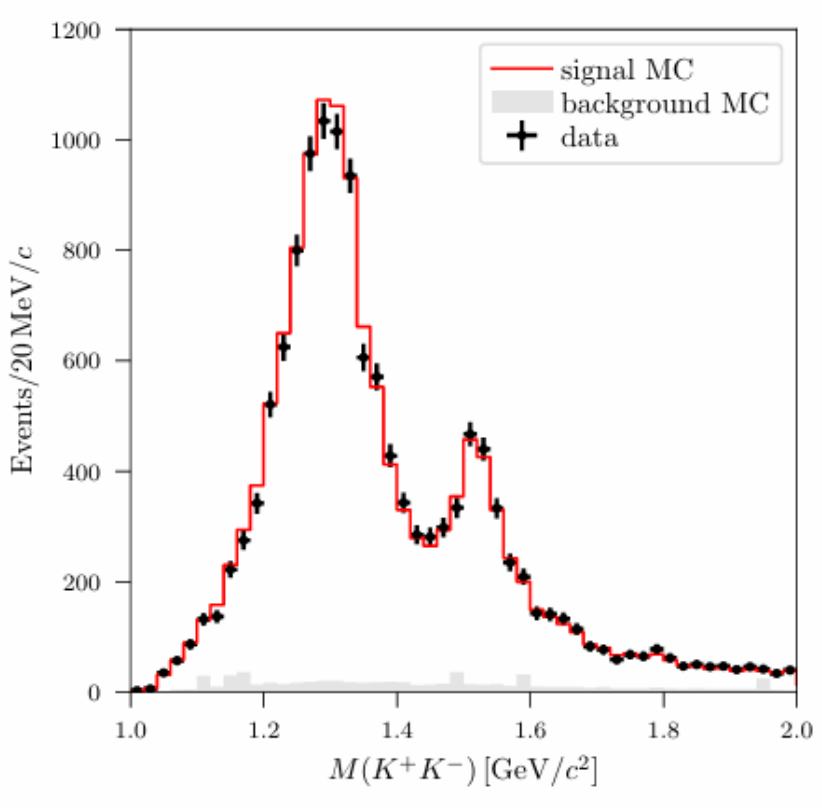



# Event selection ($e^+e^- \rightarrow e^+/e^-+K^+K^-$)




(c) Distribution of the relative angle between the two kaons in the lab-system




(d) Resulting invariant $K^+K^-$ mass distribution after all criteria are applied

Event selection by Meike Küßner

# Event selection ($e^+e^- \to e^+/e^-+K^+K^-$)

Good charged tracks:

Vxy<1cm, Vz<10cm

|cosθ| < 0.93

nGood = 3, Net charge = ±1

Particle Identification

- For Kaon: Prob(K) > Prob(e), Prob(K) > Prob(pi), Prob(K) > Prob(p)
- For Electron: Prob(e) > Prob(pi), Prob(e) > Prob(K), Prob(e) > Prob(p)
  Prob(e) > Prob(μ), Prob(e) >0.001
- Event Requirement: n$K^+$ = 1, n$K^-$ = 1, n$e^{\pm}$= 1

vertex fit： success

Kinematic Fit: 4C fit

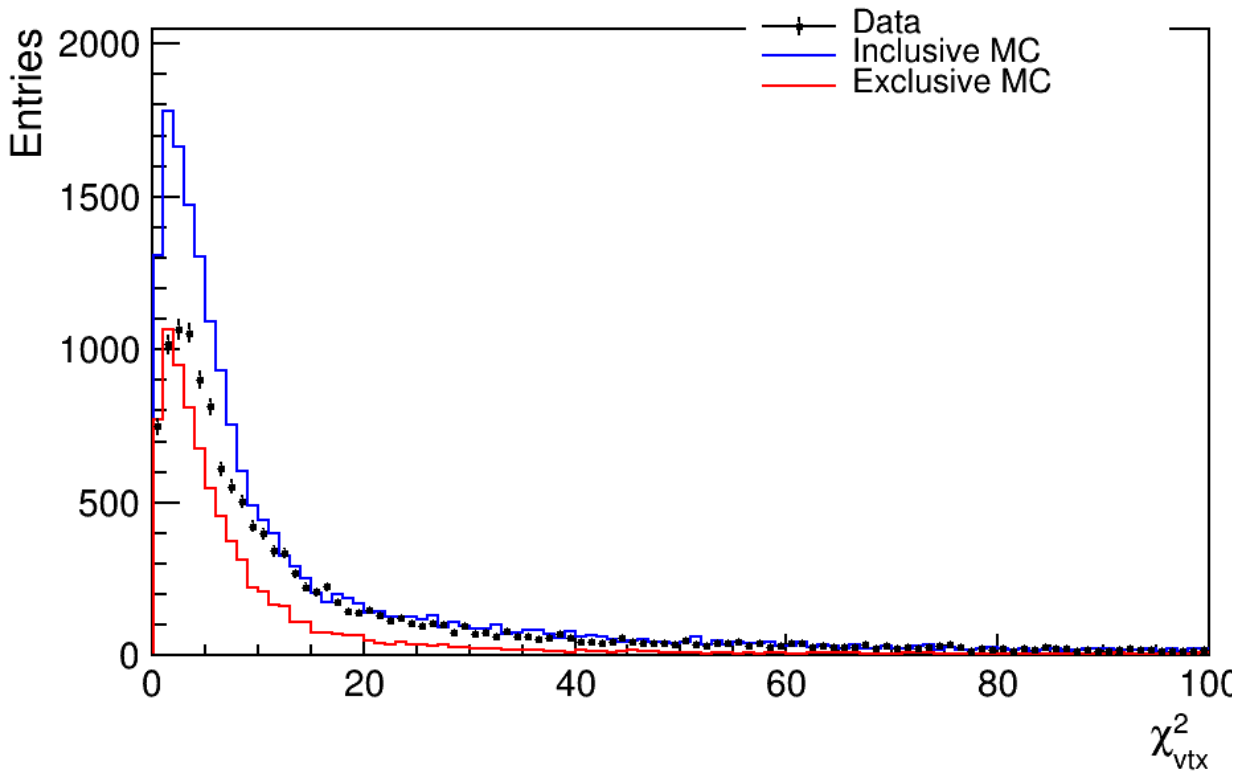
# 蒙特卡洛模拟器产生子:hadrontops 68w events

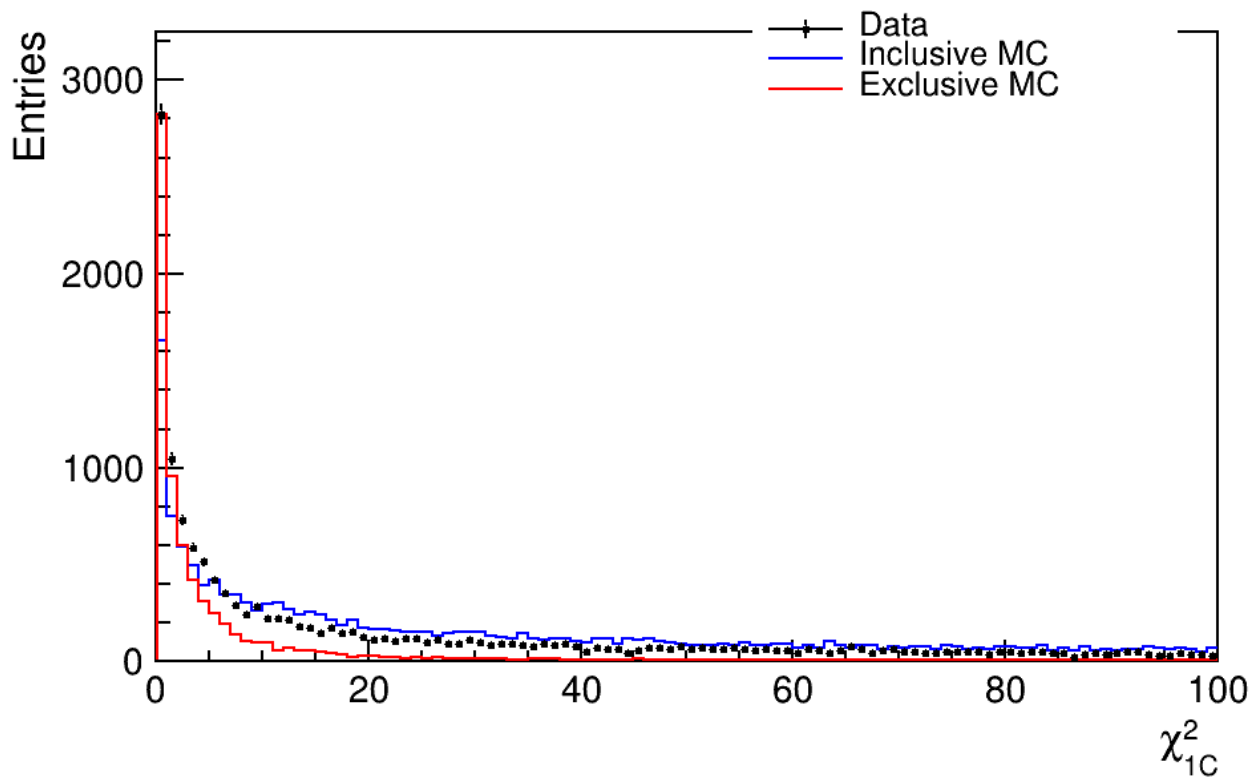
# 数据样本

data： psipp/round0304,15-17

inclusivemc： tauqcd/psipp/round0304,15-17/Hadron_Hybrid

Event selection ($e^+e^- \to e^+/e^-+K^+K^-$)



Vtx+4c

chiq < 50

Cosmiss > 0.99

∠KpKm>50°

Umiss <= 0.2

Eop > 0.8

信号mc事例数68w

符合条件事例占比3.22%，事例数21896

符合条件选事效率28.16%

CutFlow : Data

| Cut | Remaining | Rejected | Step eff.(%) | Total eff.(%) |
|---|---|---|---|---|
| Initial entries | 17414 | 0 | 100.00 | 100.00 |
| E/P > 0.80 [ON] | 9483 | 7931 | 54.46 | 54.46 |
| neutralEmcE < 0.40 GeV [OFF] | 9483 | 0 | 100.00 | 54.46 |
| 50 <= Angle(K+K-) < 180 deg [ON] | 4561 | 4922 | 48.10 | 26.19 |
| \|cos(theta_miss)\| > 0.99 [ON] | 2323 | 2238 | 50.93 | 13.34 |
| \|Umiss\| < 0.20 GeV [ON] | 2168 | 155 | 93.33 | 12.45 |
| kfit_chisq < 50 [ON] | 1944 | 224 | 89.67 | 11.16 |

CutFlow : Inclusive MC

| Cut | Remaining | Rejected | Step eff.(%) | Total eff.(%) |
|---|---|---|---|---|
| Initial entries | 21055 | 0 | 100.00 | 100.00 |
| E/P > 0.80 [ON] | 4737 | 16318 | 22.50 | 22.50 |
| neutralEmcE < 0.40 GeV [OFF] | 4737 | 0 | 100.00 | 22.50 |
| 50 <= Angle(K+K-) < 180 deg [ON] | 3641 | 1096 | 76.86 | 17.29 |
| \|cos(theta_miss)\| > 0.99 [ON] | 170 | 3471 | 4.67 | 0.81 |
| \|Umiss\| < 0.20 GeV [ON] | 145 | 25 | 85.29 | 0.69 |
| kfit_chisq < 50 [ON] | 83 | 62 | 57.24 | 0.39 |

CutFlow : Exclusive MC

| Cut | Remaining | Rejected | Step eff.(%) | Total eff.(%) |
|---|---|---|---|---|
| Initial entries | 12213 | 0 | 100.00 | 100.00 |
| E/P > 0.80 [ON] | 8097 | 4116 | 66.30 | 66.30 |
| neutralEmcE < 0.40 GeV [OFF] | 8097 | 0 | 100.00 | 66.30 |
| 50 <= Angle(K+K-) < 180 deg [ON] | 7594 | 503 | 93.79 | 62.18 |
| \|cos(theta_miss)\| > 0.99 [ON] | 6528 | 1066 | 85.96 | 53.45 |
| \|Umiss\| < 0.20 GeV [ON] | 6427 | 101 | 98.45 | 52.62 |
| kfit_chisq < 50 [ON] | 6167 | 260 | 95.95 | 50.50 |

无Vtx+4c

Cosmiss > 0.99

50.0> Angle_KpKm >= 150.0

Umiss <= 0.2

Eop > 0.8

信号mc事例数68w

符合条件事例占比3.22%，事例数21896

符合条件选事效率29.96%

CutFlow : Data

| Cut | Remaining | Rejected | Step eff.(%) | Total eff.(%) |
|---|---|---|---|---|
| Initial entries | 145010 | 0 | 100.00 | 100.00 |
| E/P > 0.80 [ON] | 59335 | 85675 | 40.92 | 40.92 |
| neutralEmcE < 0.40 GeV [OFF] | 59335 | 0 | 100.00 | 40.92 |
| 50 <= Angle(K+K-) < 180 deg [ON] | 43154 | 16181 | 72.73 | 29.76 |
| \|cos(theta_miss)\| > 0.99 [ON] | 3547 | 39607 | 8.22 | 2.45 |
| \|Umiss\| < 0.20 GeV [ON] | 2322 | 1225 | 65.46 | 1.60 |

CutFlow : Inclusive MC

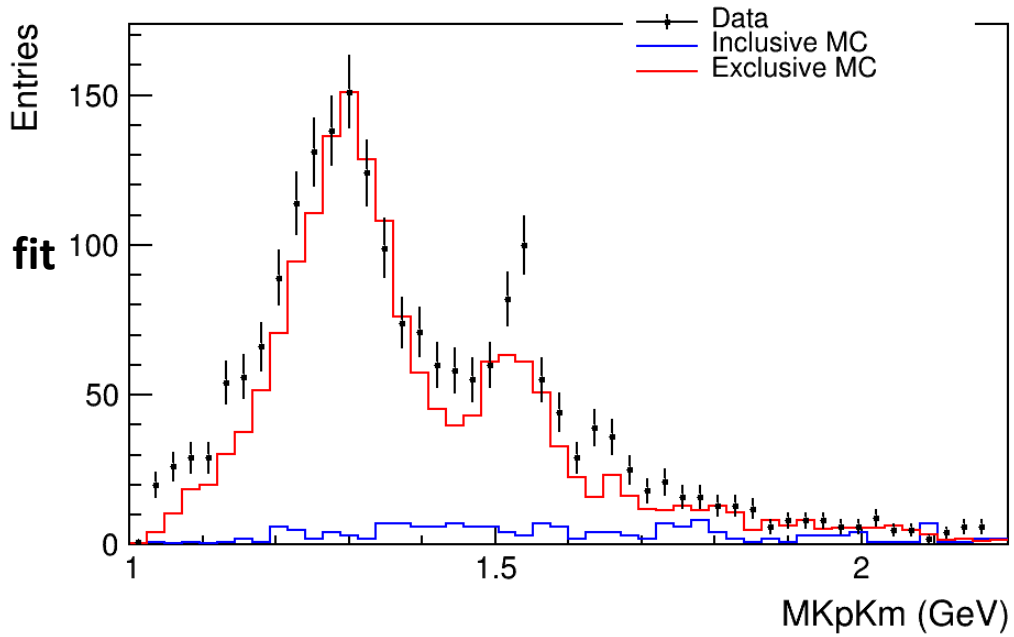
| Cut | Remaining | Rejected | Step eff.(%) | Total eff.(%) |
|---|---|---|---|---|
| Initial entries | 405385 | 0 | 100.00 | 100.00 |
| E/P > 0.80 [ON] | 130862 | 274523 | 32.28 | 32.28 |
| neutralEmcE < 0.40 GeV [OFF] | 130862 | 0 | 100.00 | 32.28 |
| 50 <= Angle(K+K-) < 180 deg [ON] | 109703 | 21159 | 83.83 | 27.06 |
| \|cos(theta_miss)\| > 0.99 [ON] | 1533 | 108170 | 1.40 | 0.38 |
| \|Umiss\| < 0.20 GeV [ON] | 208 | 1325 | 13.57 | 0.05 |

CutFlow : Exclusive MC

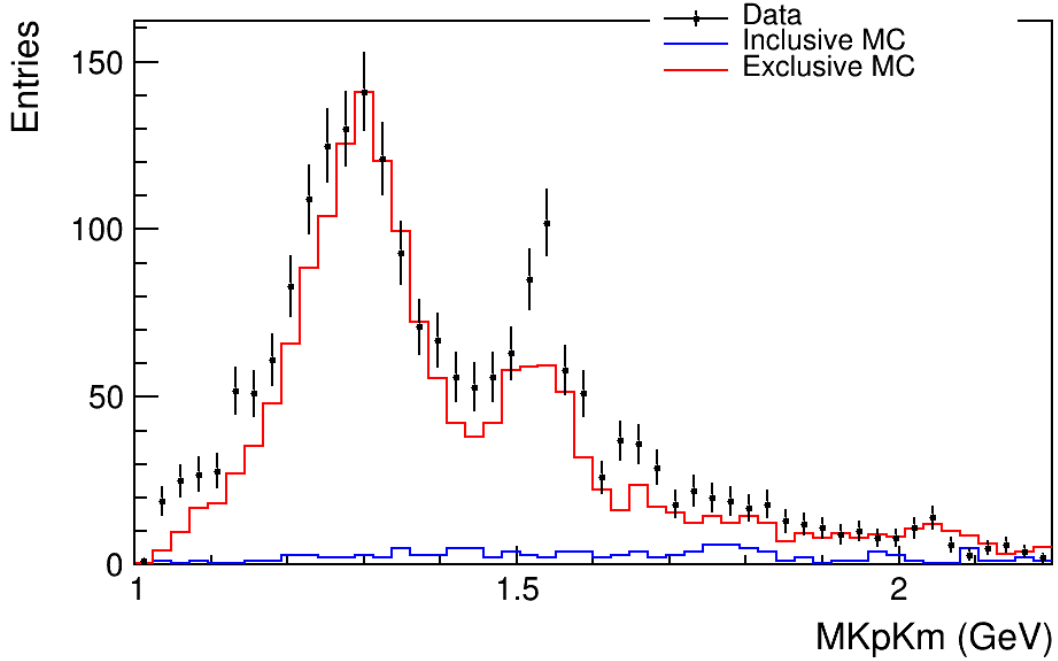
| Cut | Remaining | Rejected | Step eff.(%) | Total eff.(%) |
|---|---|---|---|---|
| Initial entries | 13588 | 0 | 100.00 | 100.00 |
| E/P > 0.80 [ON] | 8902 | 4686 | 65.51 | 65.51 |
| neutralEmcE < 0.40 GeV [OFF] | 8902 | 0 | 100.00 | 65.51 |
| 50 <= Angle(K+K-) < 180 deg [ON] | 8339 | 563 | 93.68 | 61.37 |
| \|cos(theta_miss)\| > 0.99 [ON] | 6911 | 1428 | 82.88 | 50.86 |
| \|Umiss\| < 0.20 GeV [ON] | 6561 | 350 | 94.94 | 48.29 |

| No. | decay chain | final states | iTopology | nEvt | nTot |
|---|---|---|---|---|---|
| 0 | $Init \to Init\psi(3770)\gamma, \psi(3770) \to D^0\bar{D}^0, D^0 \to K^-e^+\nu_e, \bar{D}^0 \to K^+\pi^-$ | $e^+\pi^-K^-\nu_e\gamma K^+$ | 6 | 7 | 7 |
| 1 | $Init \to InitK^+K^-\pi^+\pi^-$ | $\pi^-K^-\pi^+K^+$ | 1 | 5 | 12 |
| 2 | $Init \to InitK^+K^-\gamma\gamma$ | $K^-\gamma\gamma K^+$ | 7 | 4 | 16 |
| 3 | $Init \to Initunknown_80022\gamma, unknown_80022 \to K^+K^-\pi^0$ | $K^-\pi^0\gamma K^+$ | 12 | 3 | 19 |
| 4 | $Init \to Init\psi(3770)\gamma, \psi(3770) \to D^0\bar{D}^0, D^0 \to K^-\pi^+, \bar{D}^0 \to K^+e^-\bar{\nu}_e$ | $\bar{\nu}_eK^-e^-\pi^+\gamma K^+$ | 16 | 3 | 22 |
| 5 | $Init \to Init\bar{K}^{*0}K^+\pi^-, \bar{K}^{*0} \to K^-\pi^+$ | $\pi^-K^-\pi^+K^+$ | 19 | 3 | 25 |
| 6 | $Init \to Initunknown_80022\gamma, unknown_80022 \to \bar{K}^{*0}K^+\pi^-, \bar{K}^{*0} \to K^-\pi^+$ | $\pi^-K^-\pi^+\gamma K^+$ | 11 | 2 | 27 |
| 7 | $Init \to Init\psi(3770)\gamma, \psi(3770) \to D^0\bar{D}^0, D^0 \to K^-e^+\nu_e, \bar{D}^0 \to K^+\mu^-\bar{\nu}_\mu$ | $e^+\bar{\nu}_\mu K^-\nu_e\mu^-\gamma K^+$ | 17 | 2 | 29 |
| 8 | $Init \to Init\psi(3770)\gamma, \psi(3770) \to D^0\bar{D}^0, D^0 \to K^-e^+\nu_e, \bar{D}^0 \to K^+e^-\bar{\nu}_e$ | $e^+\bar{\nu}_eK^-e^-\nu_e\gamma K^+$ | 8 | 2 | 31 |
| 9 | $Init \to InitK^{*0}K^-\pi^+, K^{*0} \to K^+\pi^-$ | $\pi^-K^-\pi^+K^+$ | 9 | 1 | 32 |
| 10 | $Init \to InitK_2^{*0}K^+\pi^-, K_2^{*0} \to K^-\pi^+$ | $\pi^-K^-\pi^+K^+$ | 10 | 1 | 33 |
| 11 | $Init \to InitJ/\psi\gamma, J/\psi \to \gamma f_0(1710), f_0(1710) \to K^-K^+$ | $K^-\gamma\gamma K^+$ | 4 | 1 | 34 |
| 12 | $Init \to InitK_2^{*-}K_0^{*+}, K_2^{*-} \to K^-\pi^0, K_0^{*+} \to K^+\pi^0$ | $K^-\pi^0\pi^0K^+$ | 5 | 1 | 35 |
| 13 | $Init \to Init\phi K^+K^-, \phi \to e^+e^-$ | $e^+K^-e^-K^+$ | 13 | 1 | 36 |
| 14 | $Init \to InitJ/\psi\gamma, J/\psi \to K^+K^-\pi^0$ | $K^-\pi^0\gamma K^+$ | 14 | 1 | 37 |
| 15 | $Init \to InitJ/\psi\gamma, J/\psi \to K^{*-}K^+, K^{*-} \to K^-\pi^0$ | $K^-\pi^0\gamma K^+$ | 15 | 1 | 38 |
| 16 | $Init \to InitJ/\psi\gamma, J/\psi \to \rho^0\pi^0, \rho^0 \to \pi^+\pi^-$ | $\pi^-\pi^0\pi^+\gamma$ | 0 | 1 | 39 |
| 17 | $Init \to Initunknown_80022\gamma, unknown_80022 \to K^+K^-\rho^0, \rho^0 \to \pi^+\pi^-$ | $\pi^-K^-\pi^+\gamma K^+$ | 2 | 1 | 40 |
| 18 | $Init \to Init\eta' f_2', \eta' \to \pi^+\pi^-\eta, f_2' \to K^+K^-, \eta \to \gamma\gamma$ | $\pi^-K^-\pi^+\gamma\gamma K^+$ | 18 | 1 | 41 |
| 19 | $Init \to Initunknown_80022\gamma, unknown_80022 \to K_2^{*0}K^-\pi^+, K_2^{*0} \to K^+\pi^-$ | $\pi^-K^-\pi^+\gamma K^+$ | 3 | 1 | 42 |
| 20 | $Init \to InitK_0^0K_2^{*0}, K_0^0 \to K^+\pi^-, K_2^{*0} \to K^-\pi^+$ | $\pi^-K^-\pi^+K^+$ | 20 | 1 | 43 |
| 21 | $Init \to Initunknown_80022\gamma, unknown_80022 \to K^+K^-\pi^0$ | $K^-\pi^0\gamma K^+$ | 21 | 1 | 44 |
| 22 | $Init \to InitK^+K^-\eta, \eta \to \pi^-\pi^+\pi^0$ | $\pi^-K^-\pi^0\pi^+K^+$ | 22 | 1 | 45 |

**No fit**




**Vtx+4c**

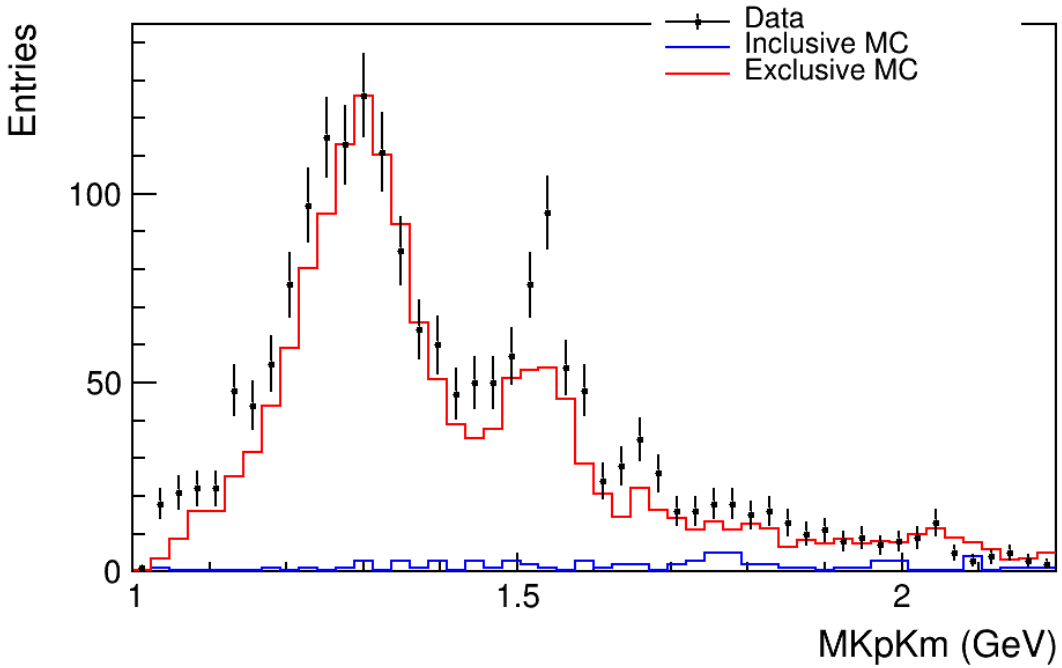



Cosmiss > 0.99

Angle_KpKm > 50.0

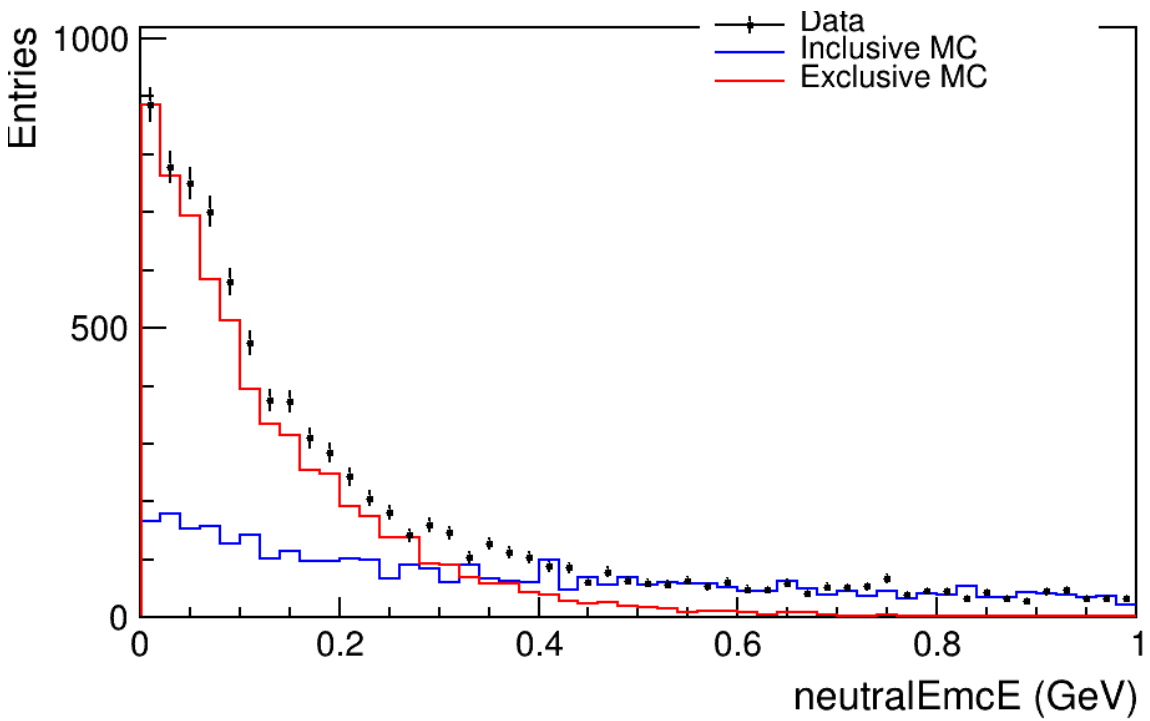
Umiss <= 0.2

Eop > 0.8

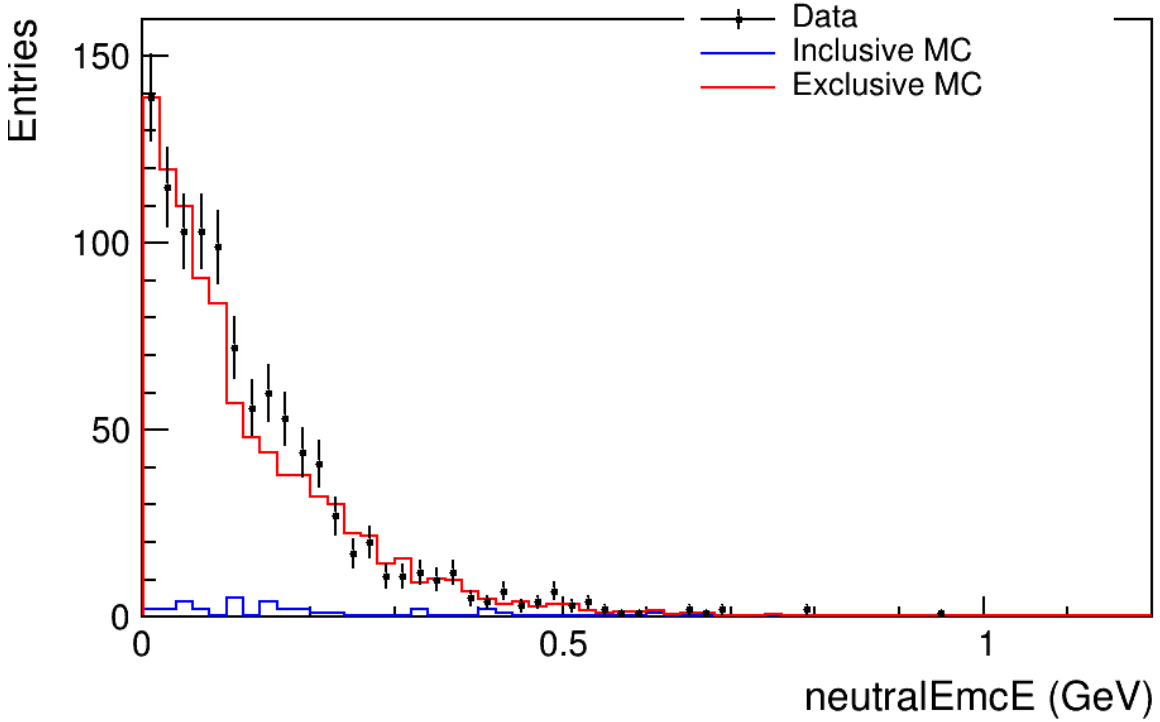



**Vtx+4c**

**chiq < 50**

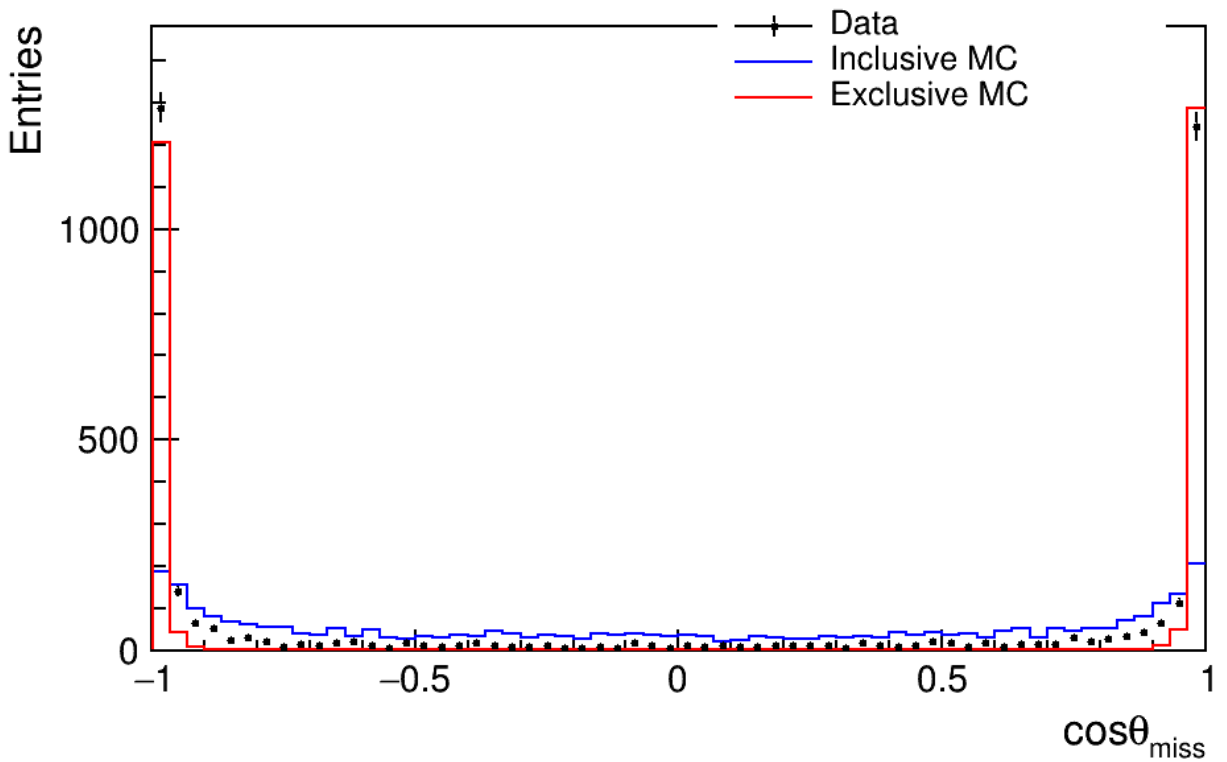


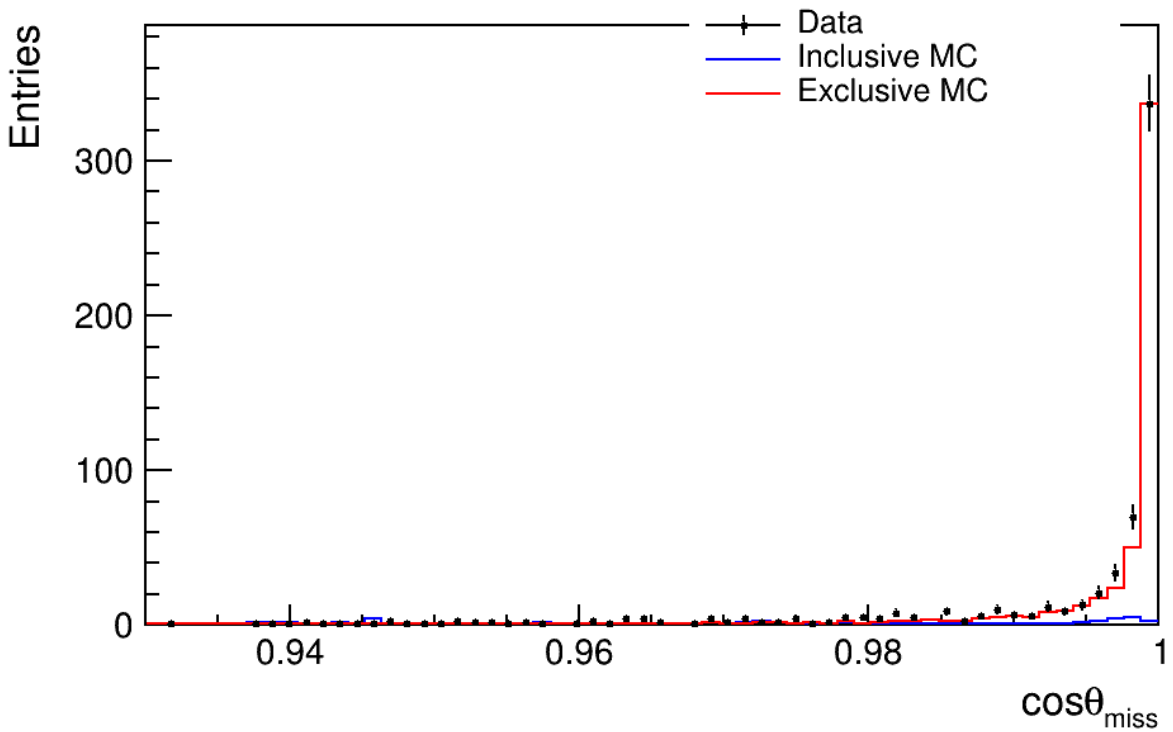

Cut前




Cut后

Cosmiss > 0.99
50.0> ∠KpKm >= 150.0
Umiss <= 0.2
Eop > 0.8
//neutralEmcE < 0.4



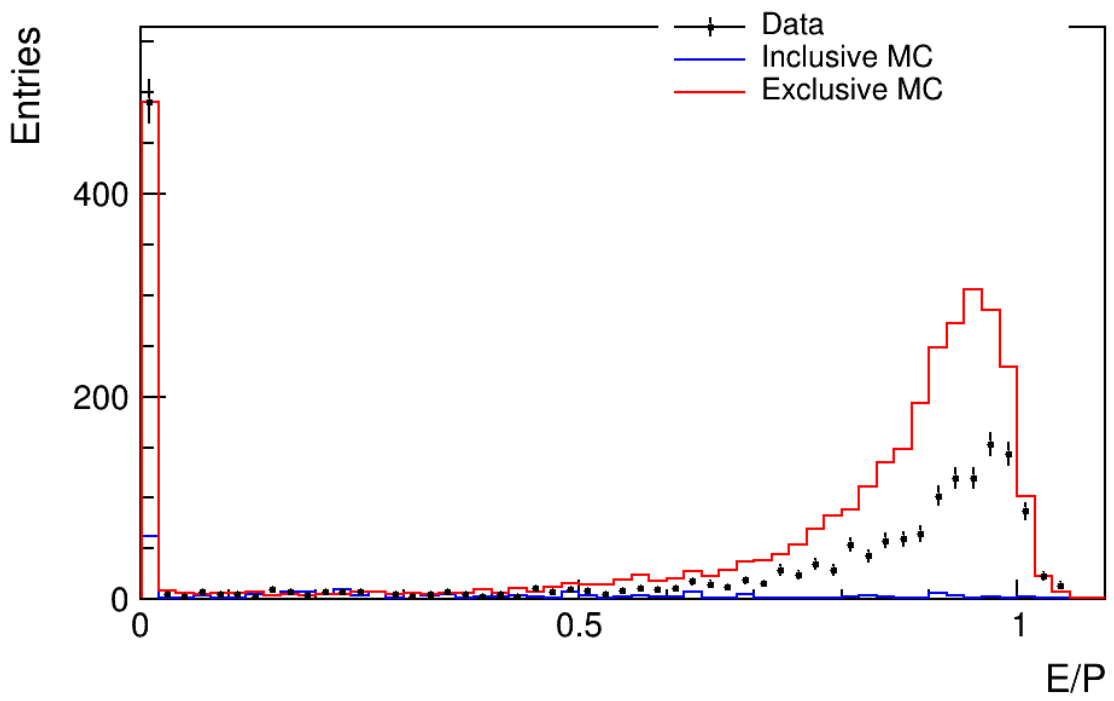

//Cosmiss > 0.99

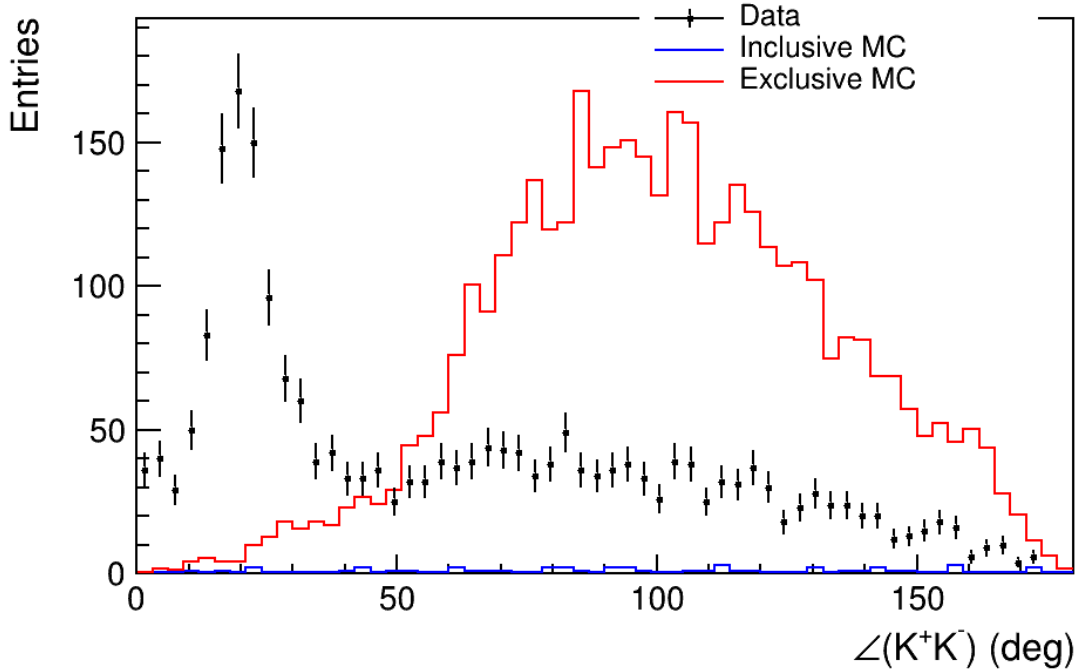
50.0> ∠KpKm >= 150.0

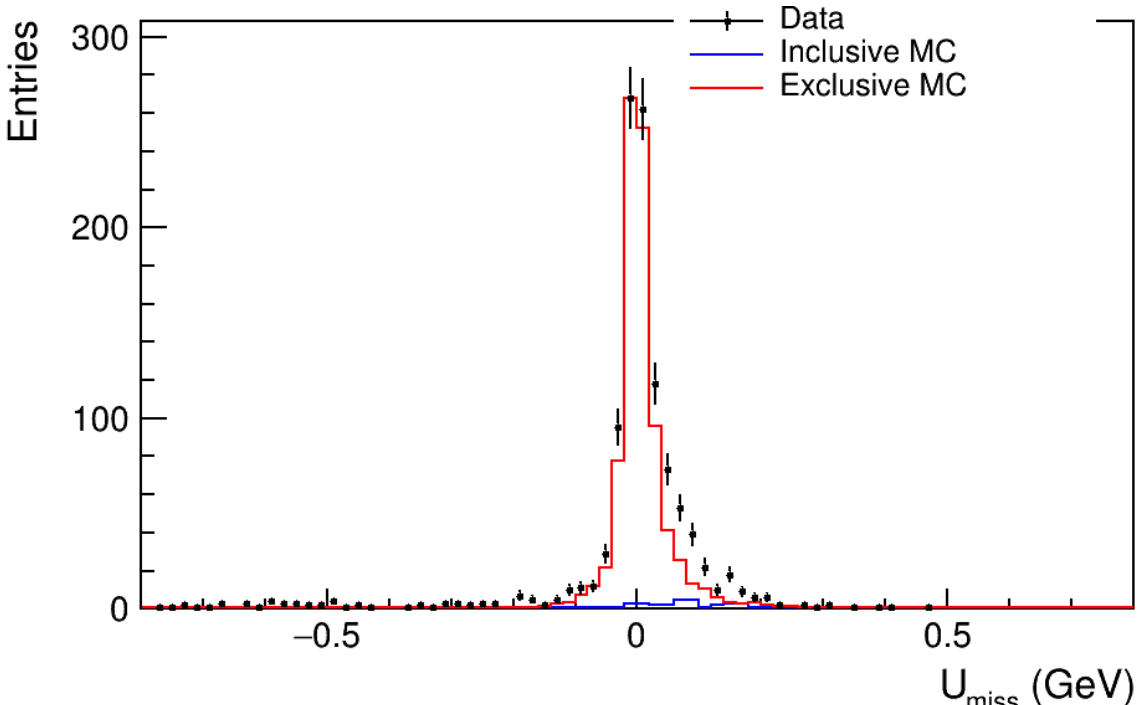
Umiss <= 0.2

Eop > 0.8

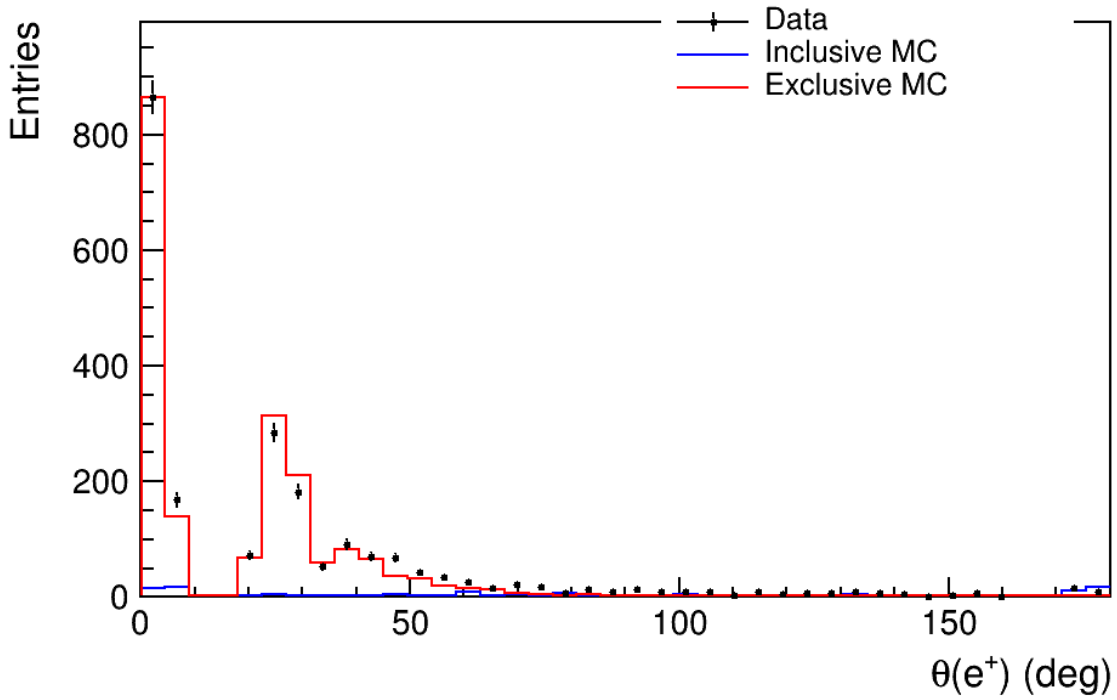
neutralEmcE < 0.4

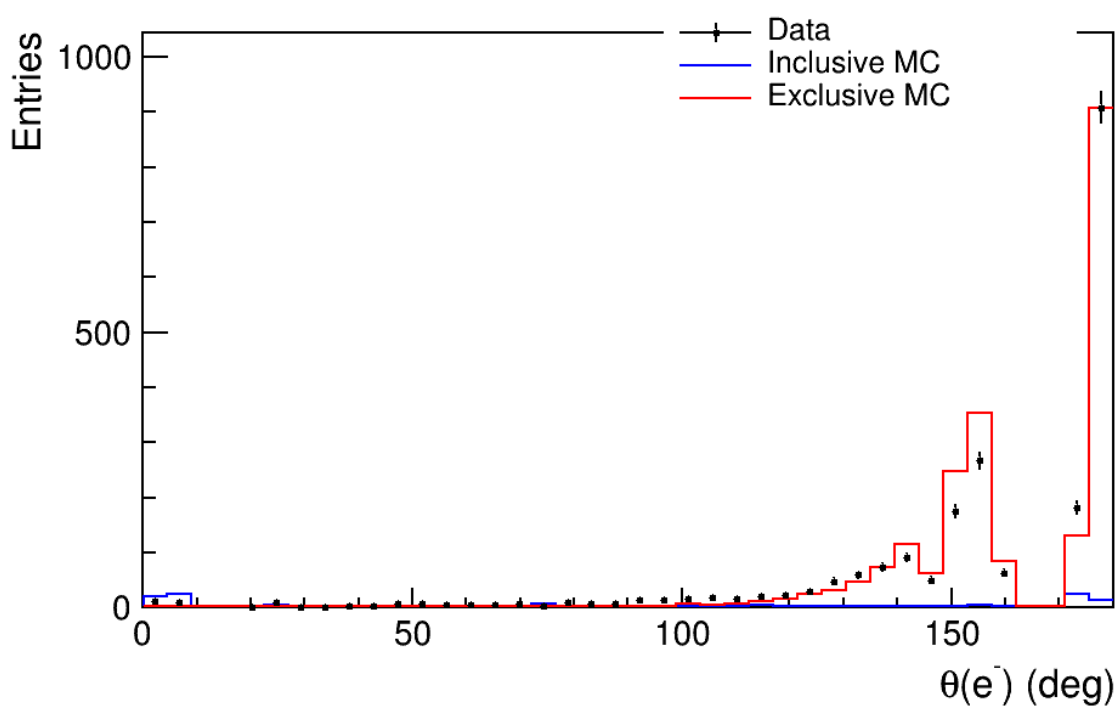


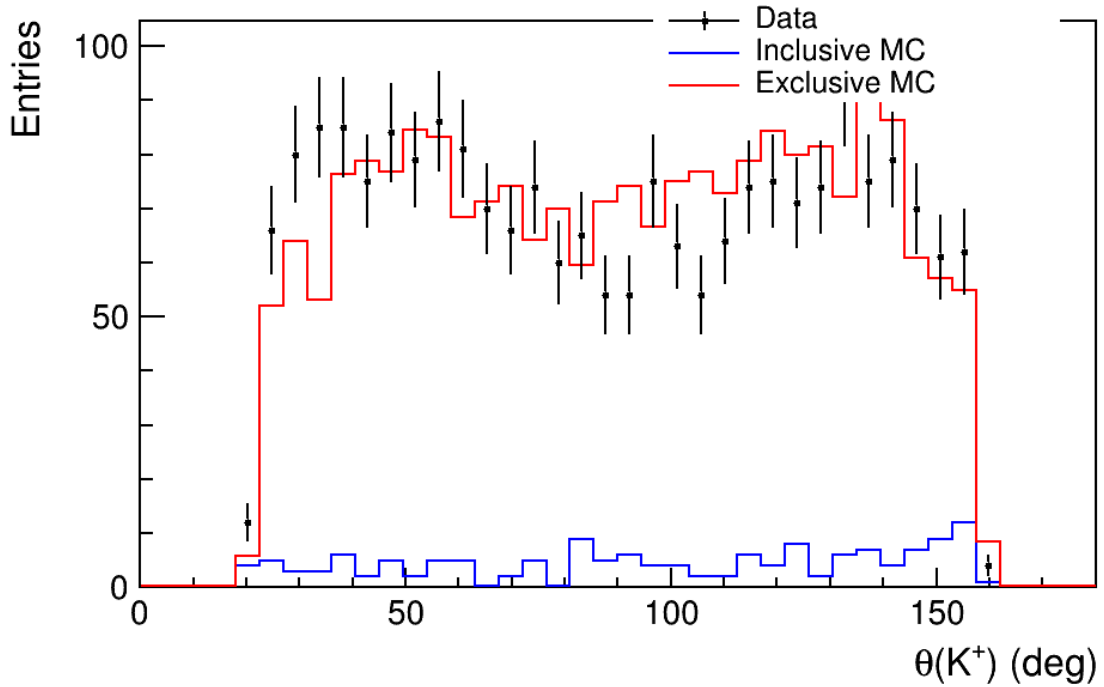



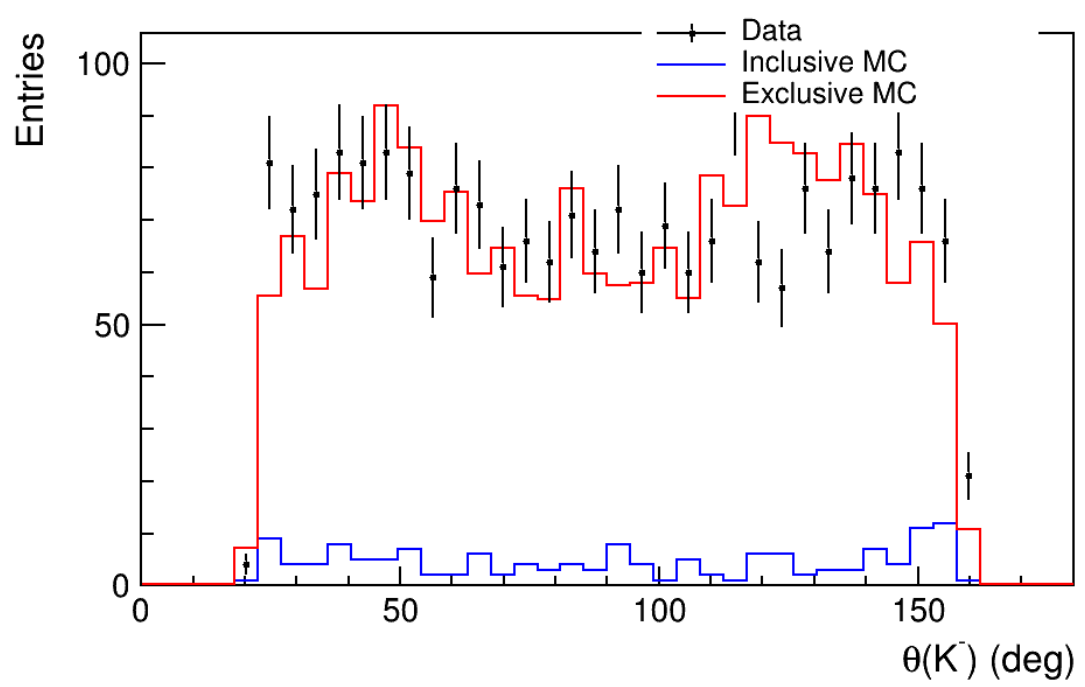




Cosmiss > 0.99
50.0> ∠KpKm >= 180.0
Umiss <= 0.2
Eop > 0.8
neutralEmcE < 0.4


Entries
Data
Inclusive MC
Exclusive MC
θ(e+) (deg)


Entries
Data
Inclusive MC
Exclusive MC
θ(e-) (deg)


Entries
Data
Inclusive MC
Exclusive MC
θ(K+) (deg)


Entries
Data
Inclusive MC
Exclusive MC
θ(K-) (deg)