Study of $K_L \rightarrow \pi e \nu e e$

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Things to do at end of previous presentation

- Analyze Pm0dal decay mode (Normalization)

  $\longrightarrow$ Made Progress , but a puzzle remains

- Add exchange term to Ke3ee MC matrix

  $\longrightarrow$ Done (Small effect to MC)

- Integrate PHOTOS into Ke3ee MC

  $\longrightarrow$ Done (radiative correction will be done)

- Systematic error analyses $\rightarrow$Not yet

- including Study about Pion loss in $\rightarrow$Not yet

Trigger 4, NZF002~038

For both Ke3ee (singal)
and pm0dal (normalization)

- 3V_TIGHT * 2DC12_MED * ET_THR1 * !MU2 * PHVBAR1* 34HCY * HCC_GE2 *YTF_UDO * HC2XDUM
- ‘97 winter (NZF002~NZF038)

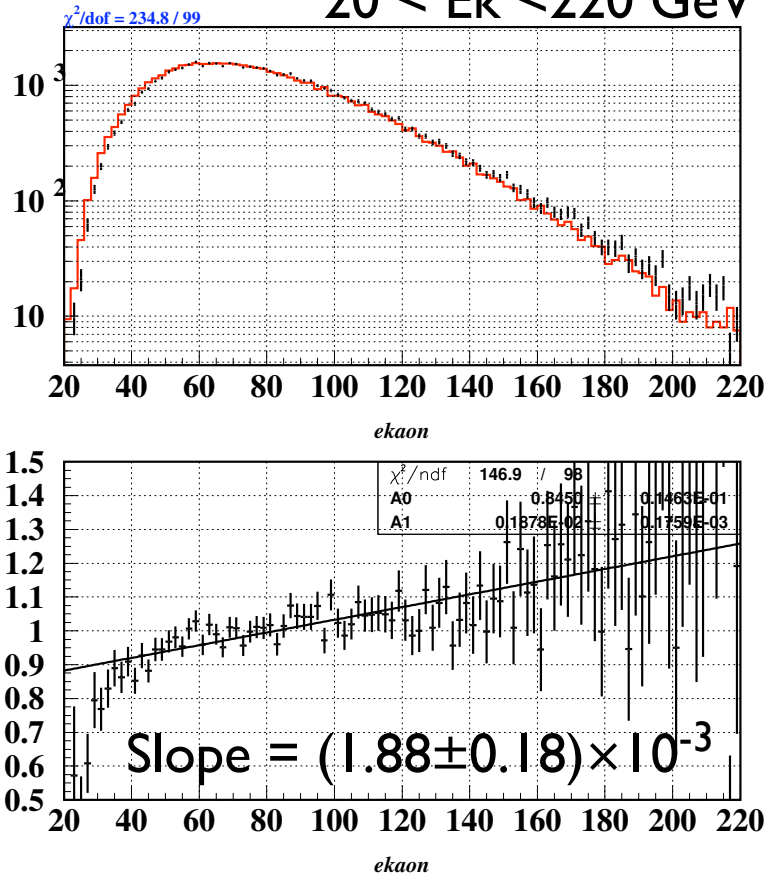
Cuts for Norm. mode (pm0dal)

40 GeV/c^2 < EKaon(min), EKaon(max) < 180 GeV/c^2
95 m < VertexZ < 150 m
Vertex χ^2 < 40
0.95 < E/p < 1.05 for electron tracks
E/p < 0.8 for pion tracks
TRD probability < 0.02 for electron tracks
TRD probability > 0.1 for pion tracks
Me+e- > 0.004 GeV/c^2
0.4915 < Mppeeg < 0.5035 GeV/c^2
0.13 < Me+e-g < 0.14 GeV/c^2
PTSQ < 0.00025 GeV/c
Veto extra clusters away 0.15 m from π, 0.05 m from electrons

Norm.mode

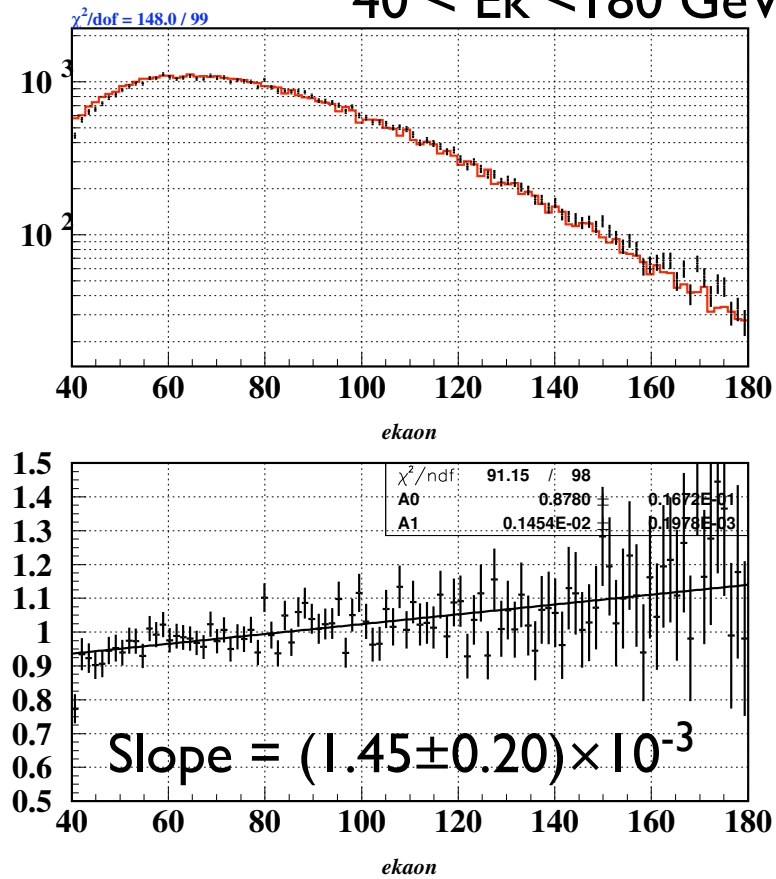
Kaon energy cut

20 < Ek <220 GeV



Kaon Energy (GeV)

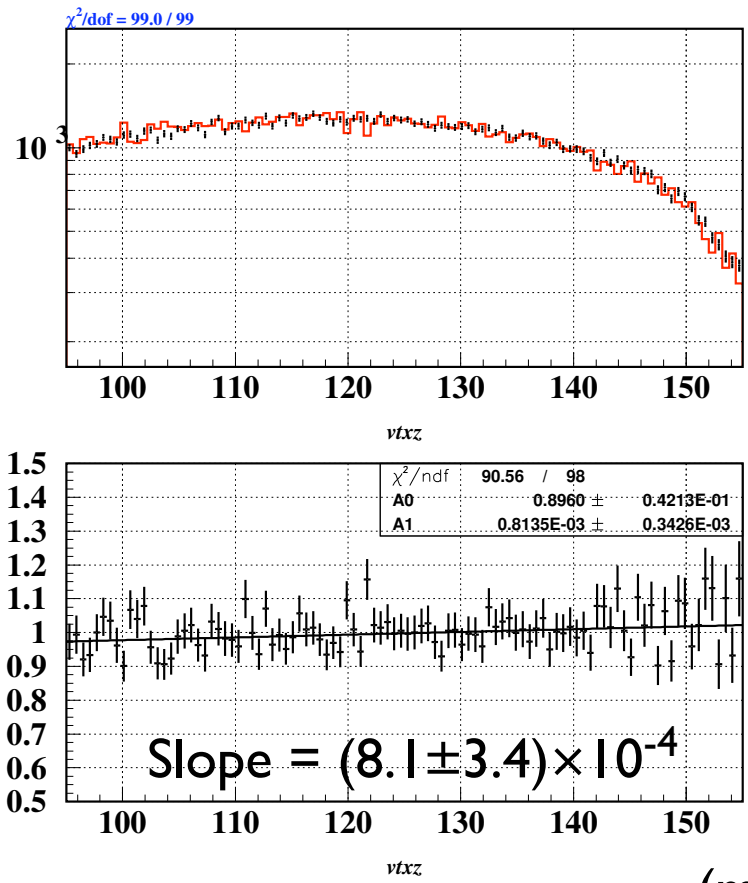
40 < Ek <180 GeV



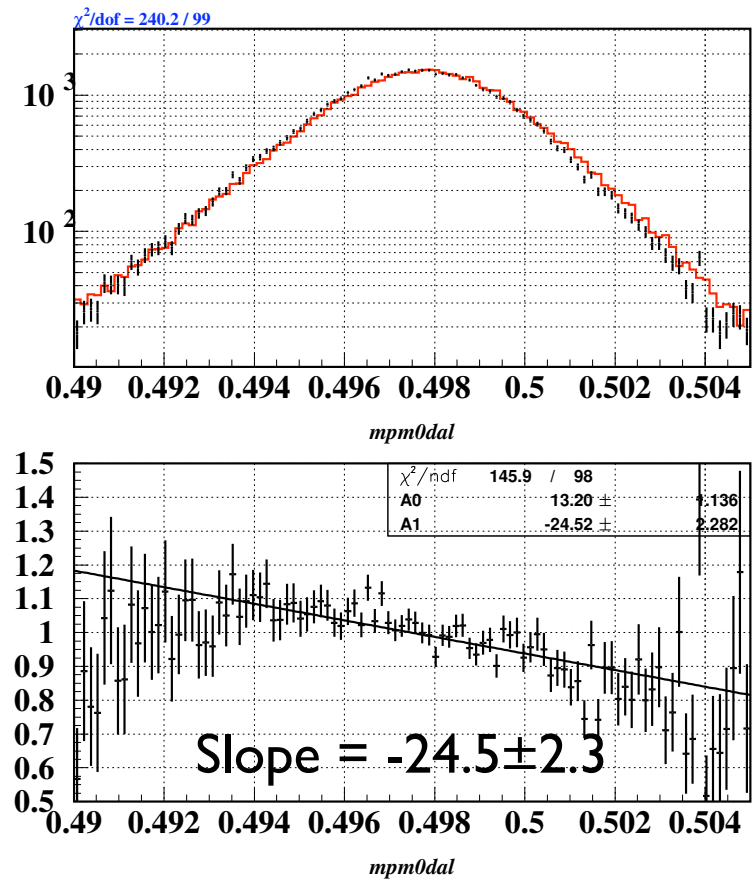
Kaon Energy (GeV)

Norm.mode

Vtx-Z, Mppeeg



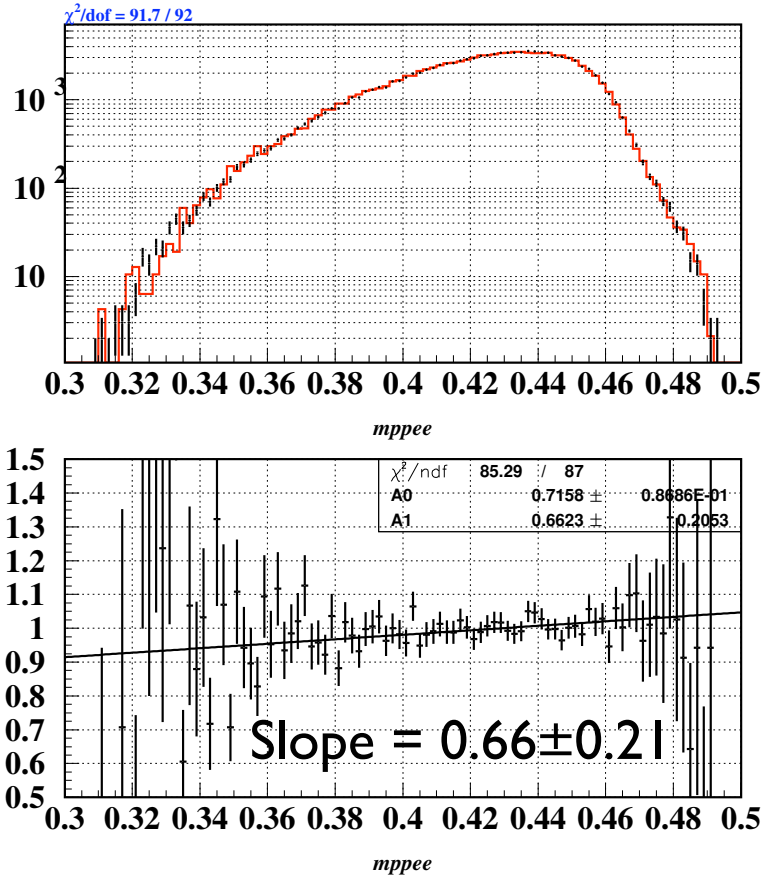
Vtx-Z (m)



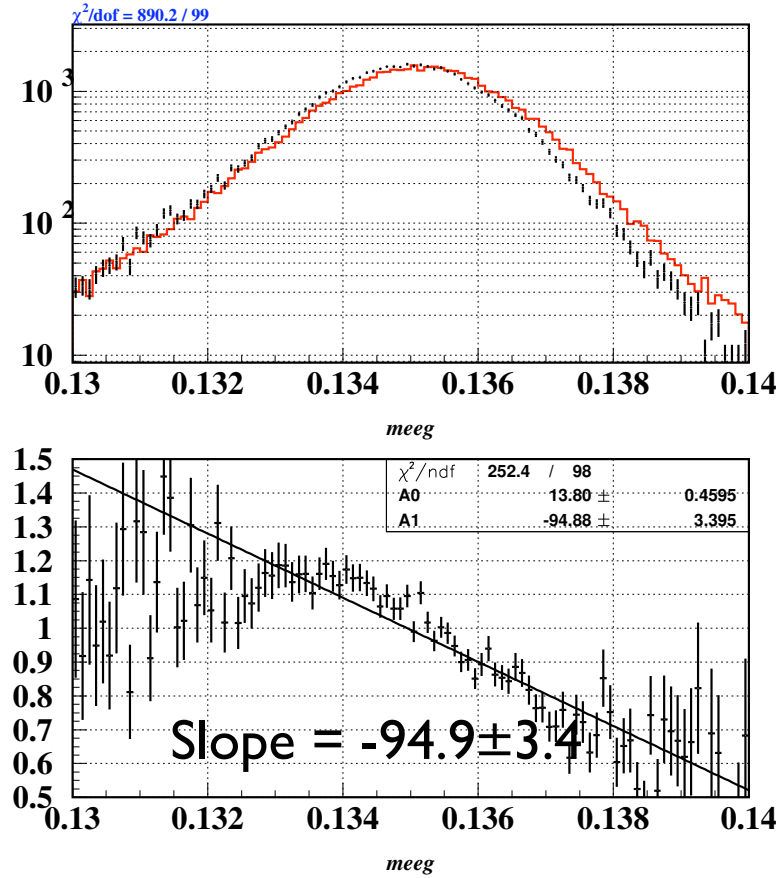
Mppeeg (GeV/c^2)

Norm.mode

Mppee, Meeg



Mppee (GeV/c^2)



Meeg (GeV/c^2)

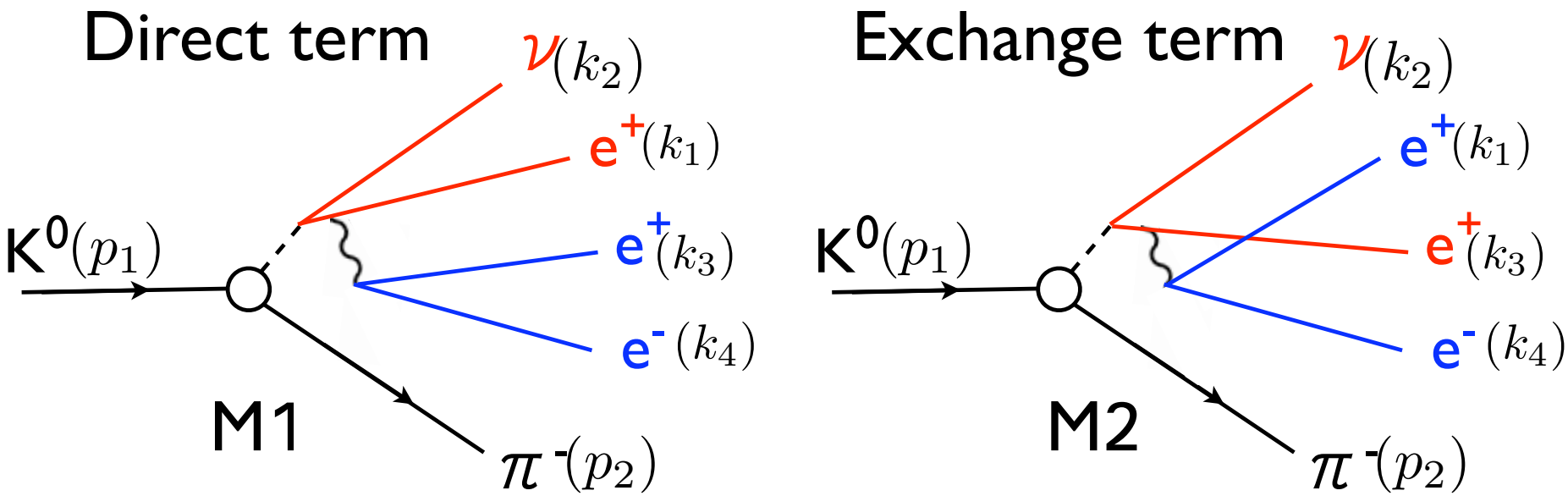
Summary about Normalization mode

- There are disagreements between data and MC, especially in clustering issues
- Temporary Kaon yield in '97 winter data;

$(1.419 \pm 0.008)\times 10^{11}$ --($1.421\times 10^{11}$by Seyno)

Error is statistics only now.

What is the exchange term

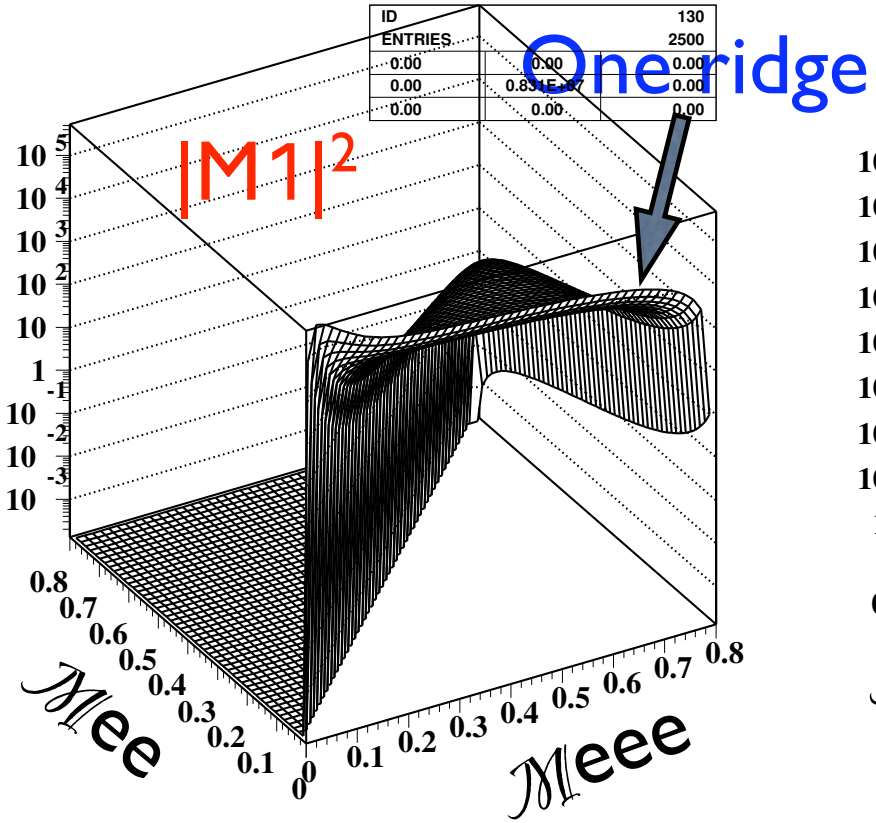


Same phase space but different Matrix(M1≠M2)

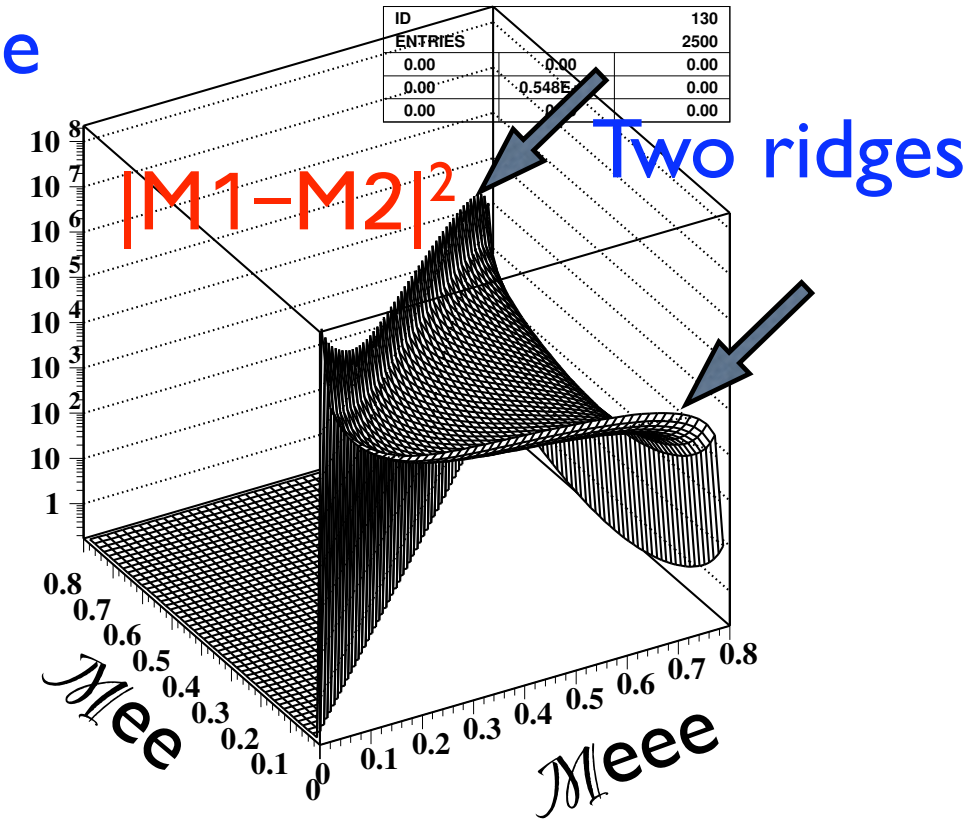
We never know which action
is occurring right now !

We need $|M1-M2|^2$

Shape of $|M1-M2|^2$



Easy to integrate



Difficult to integrate

Second ridge is due to $\mathcal{M}$ee = $\mathcal{M}$eee

How to treat this difficulty

Considering M1-M2 case and M2-M1 case

- In event generation the first stage is to generate a pure phase space event, then calculate the direct term, and then calculate the exchange term.
- Both cases have same phase space.

→ (1) Both cases are occurring as same probability in the first stage of event generation (in pure phase space).

(2) Both cases have same prob. $|M1-M2|^2 = |M2-M1|^2$.

(3) If one case have small $\mathcal{M}$ee(the first ridge), the other case is in the second ridge ($\mathcal{M}$eee=$\mathcal{M}$ee), not true as reverse.

(4) In my analysis I define that $\mathcal{M}$ee is invariant mass of e+e- pair which has smallest invariant mass.

How to treat this difficulty

Considering the issues in the previous slide.

We can reject the event, $|M1-M2|^2$, which have larger $\mathcal{M}_{ee}$ in the direct term than in the exchange term, because we can expect that $|M2-M1|^2$ event occurs as same possibility.

This process removes the second ridge !

Comparison between MC with exch. and without exch.

	MCex/MC slope	χ^2/dof of MCex vs MC
Mpeee	$(-3.2\pm1.7)\times10^{-2}$	1.04
Meee	$(-2.7\pm1.2)\times10^{-2}$	0.87
Mee	$(-4.1\pm4.8)\times10^{-1}$	1.02
Ee(notpaired)	$(-3.6\pm4.9)\times10^{-4}$	1.02
Ee+	$(-4.7\pm1.2)\times10^{-3}$	1.02
Ee-	$(-2.2\pm1.2)\times10^{-3}$	0.82
Epi	$(2.8\pm3.8)\times10^{-4}$	0.95
Ee+e-*	$(-6.3\pm2.4)\times10^{-1}$	0.86
cos θ $e^{\pm}$-(e+e-)	$(-2.7\pm1.3)\times10^{-2}$	0.84
Pv//*2	-4.4 ± 1.3	1.02
Vtx-Z	$(-2.3\pm5.0)\times10^{-3}$	0.80

Ke3ee mode

Acceptance by L3 depending on the cutoff value of energy of soft photon in PHOTOS

	Without	10.0 MeV	1.5 MeV	1.0 MeV	0.3 MeV
Acceptance (%)	1.547 ± 0.011	1.306 ± 0.011	1.325 ± 0.010	1.323 ± 0.010	1.333 ± 0.010
Radiation (%)	-	5.04 ± 0.02	12.44 ± 0.03	14.15 ± 0.03	19.20 ± 0.04

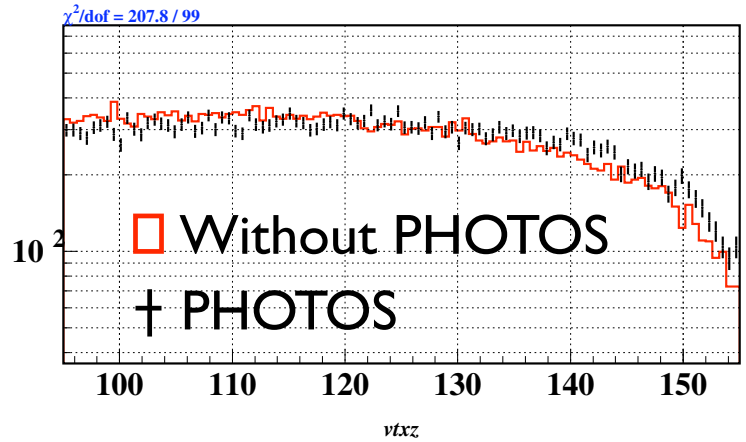
Radiation reduces acceptance.

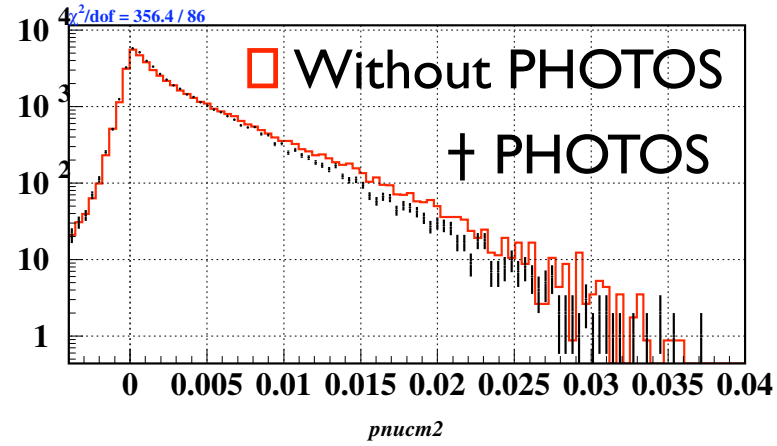
Acceptance is not sensitive to the value of cutoff around 1.0MeV.

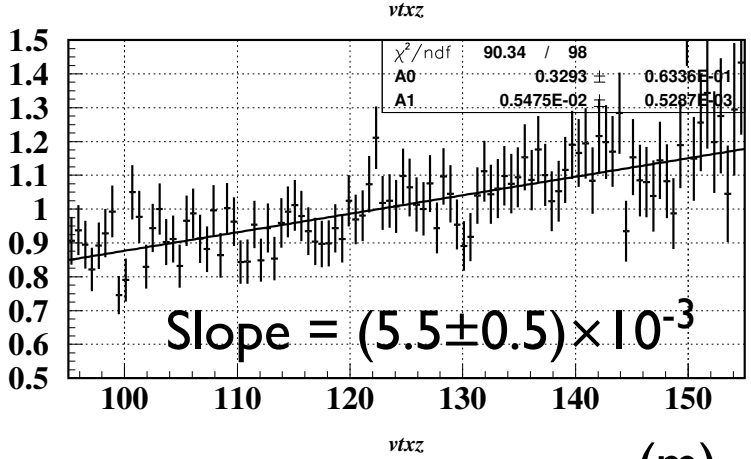
Radiation is much dependent on cutoff value.

Ke3ee mode

Comparison between MC with PHOTOS and without PHOTOS

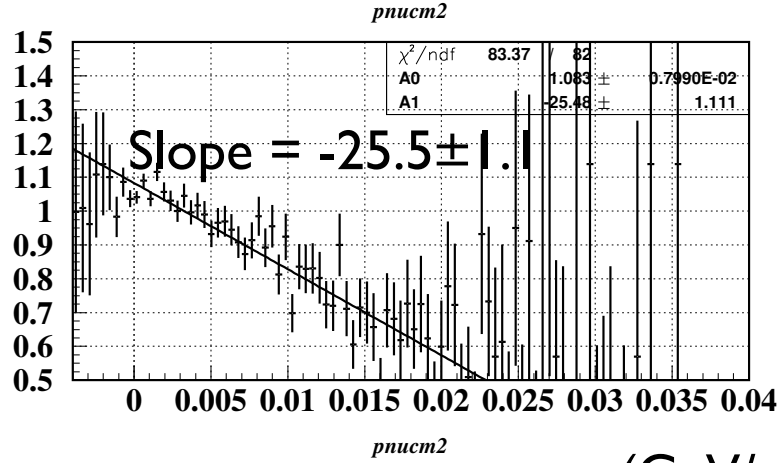






(m)

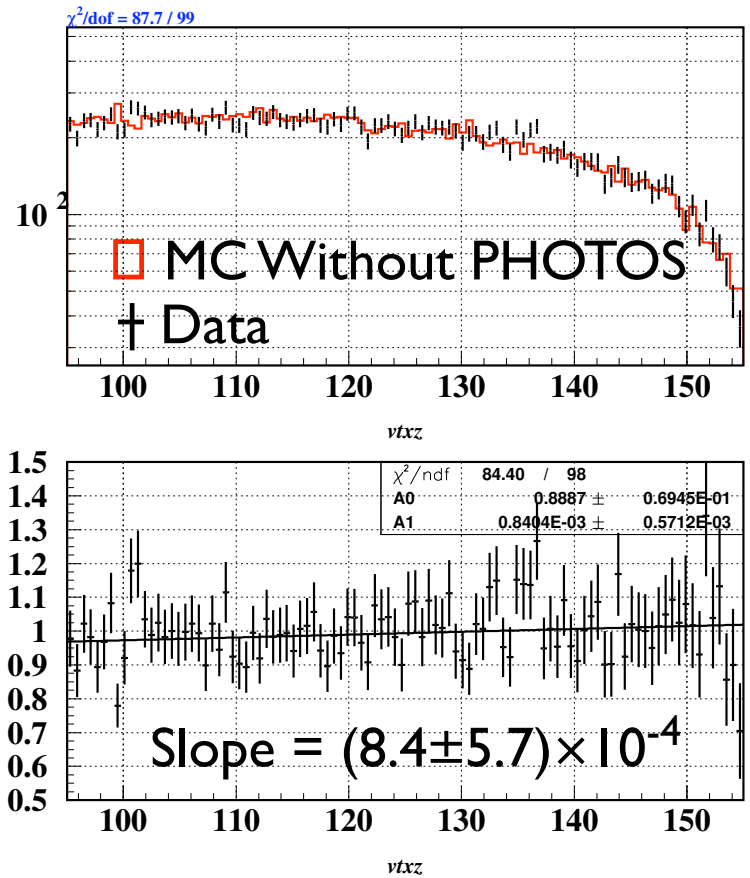
Vtx-Z



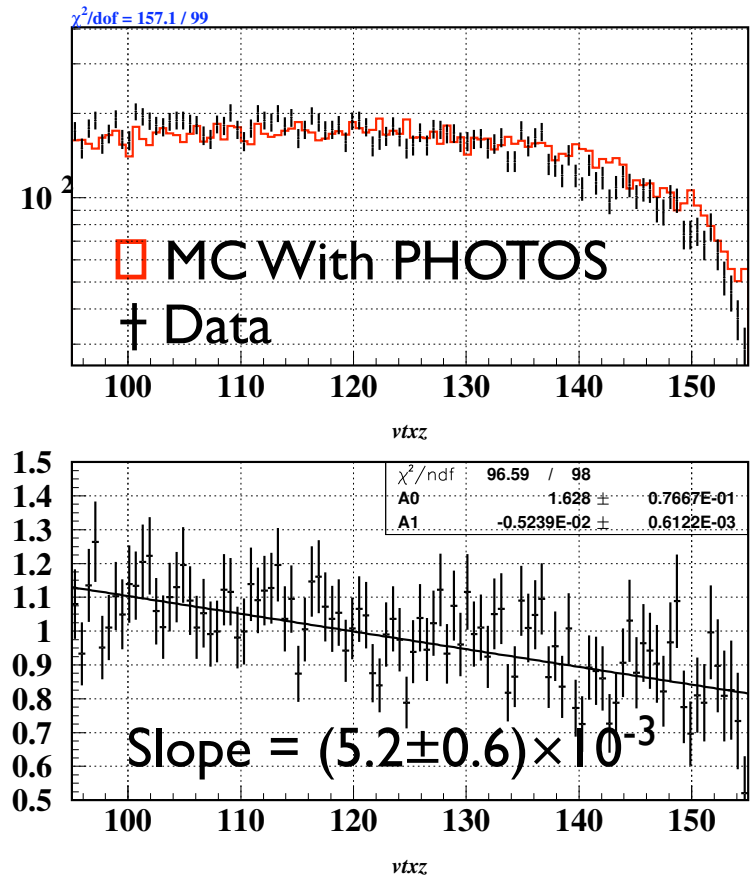
$(GeV/c)^2$

Pv//*^{2}

Comparison between Data/MC with PHOTOS and without PHOTOS



Vtx-Z



Vtx-Z

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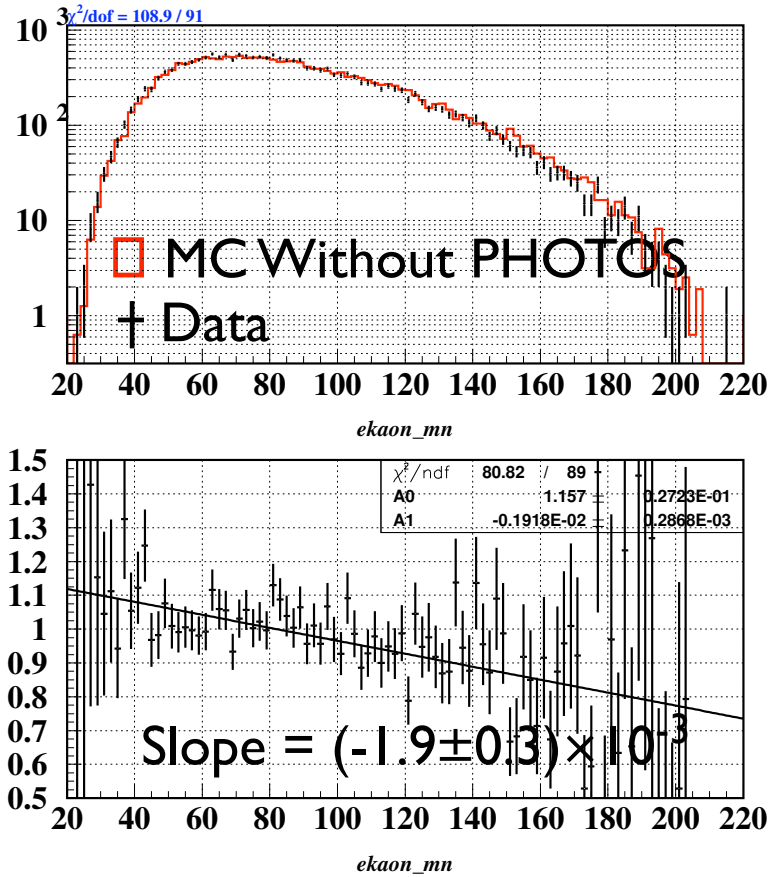
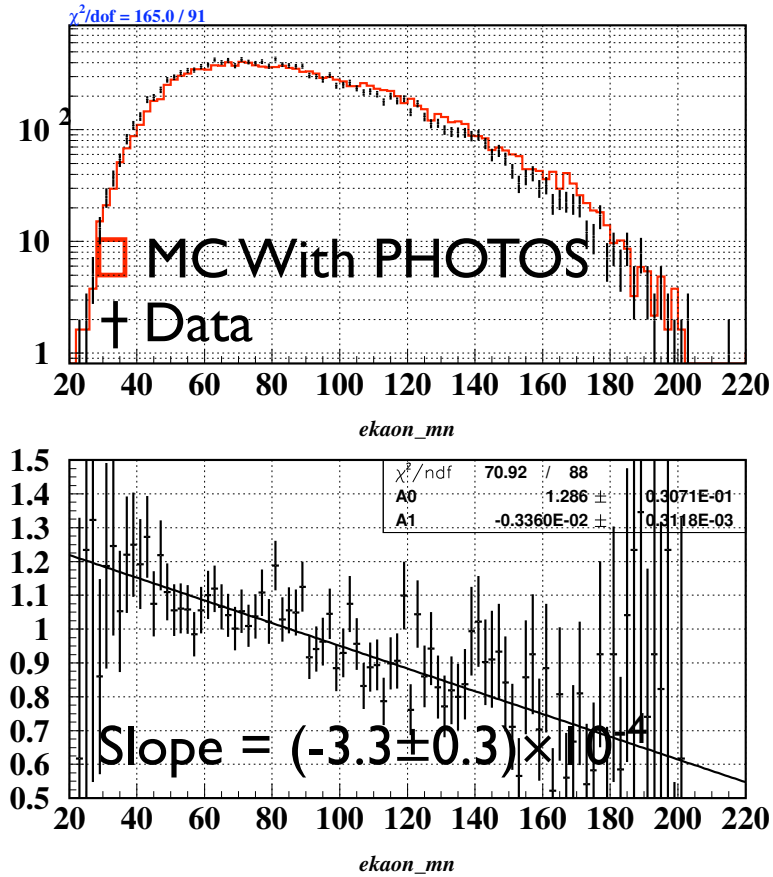
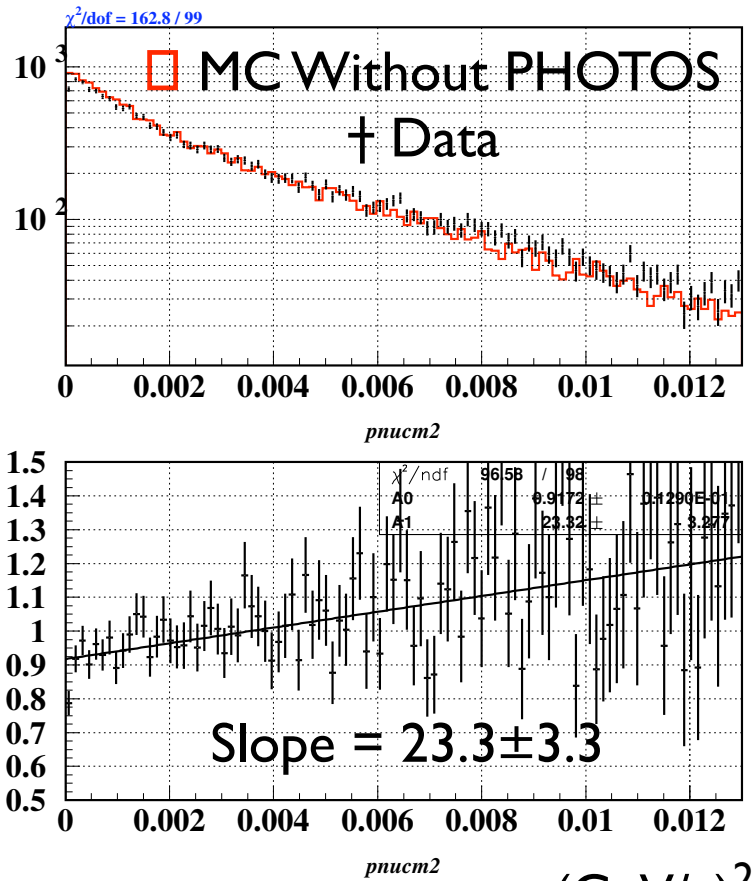


Ekaon(Smaller) (GeV)

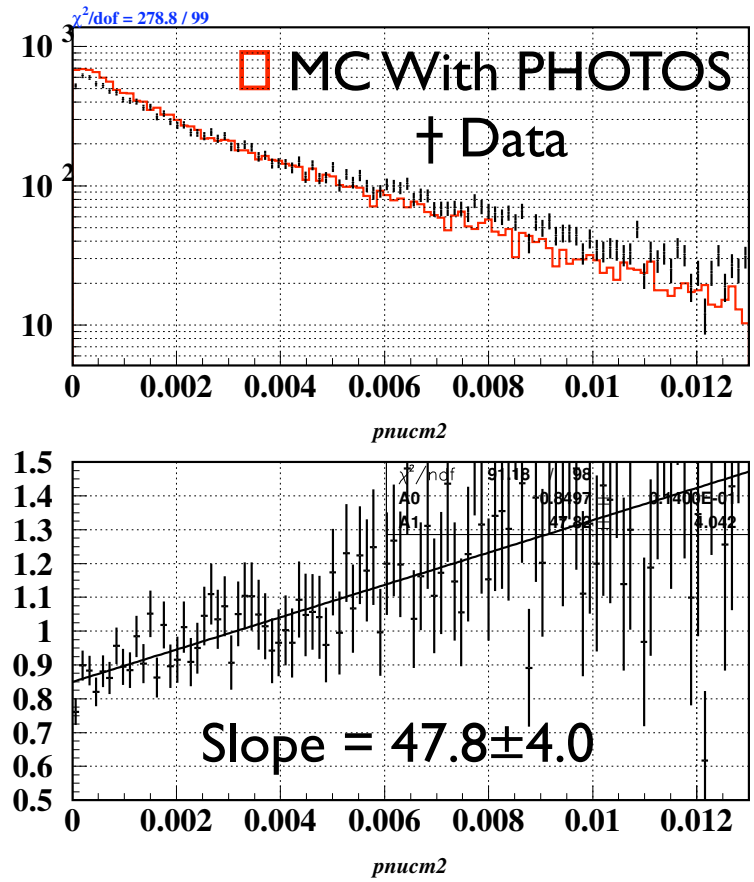


Ekaon(Smaller) (GeV)

Comparison between MC with PHOTOS and without PHOTOS

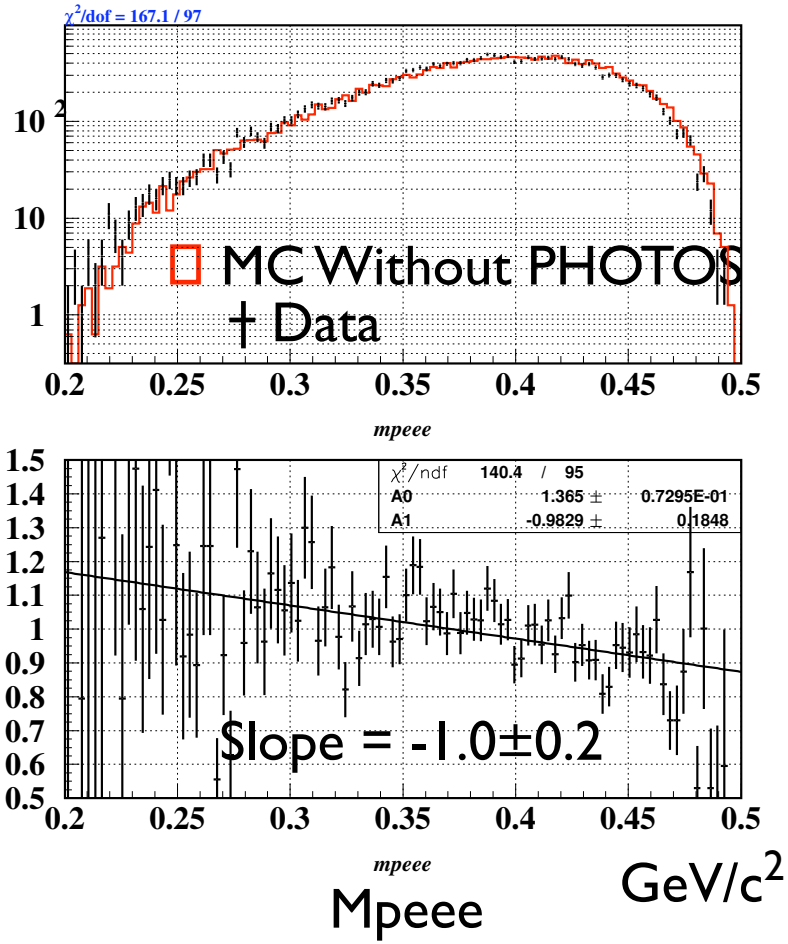


Pv//*2 (GeV/c)^2

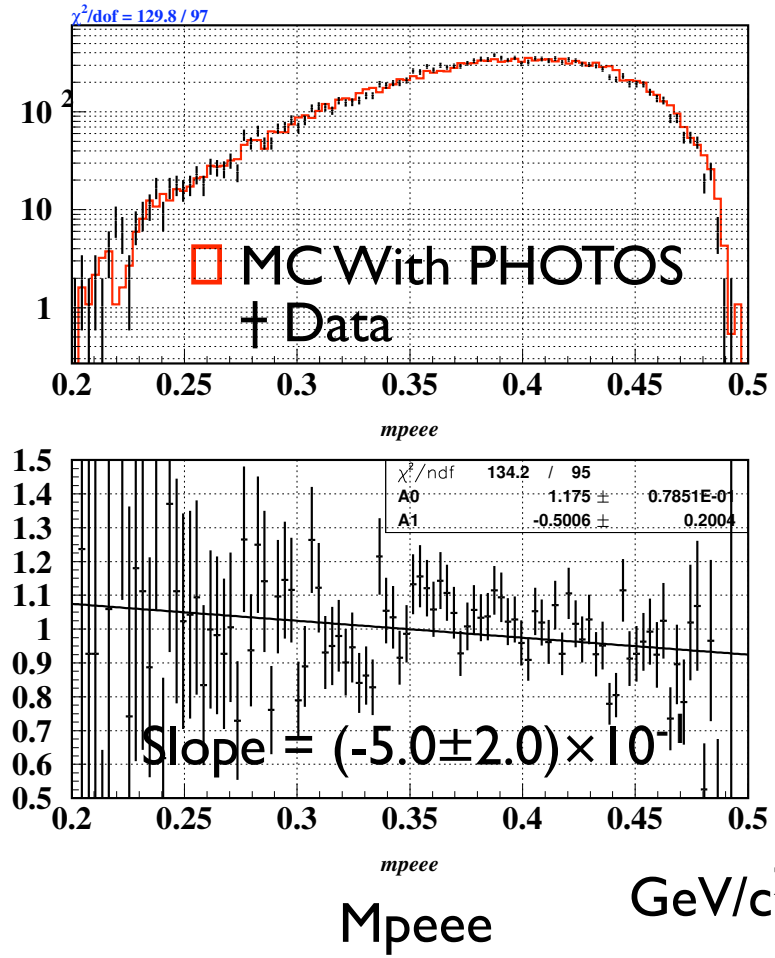


Pv//*2 (GeV/c)^2

Comparison between MC with PHOTOS and without PHOTOS

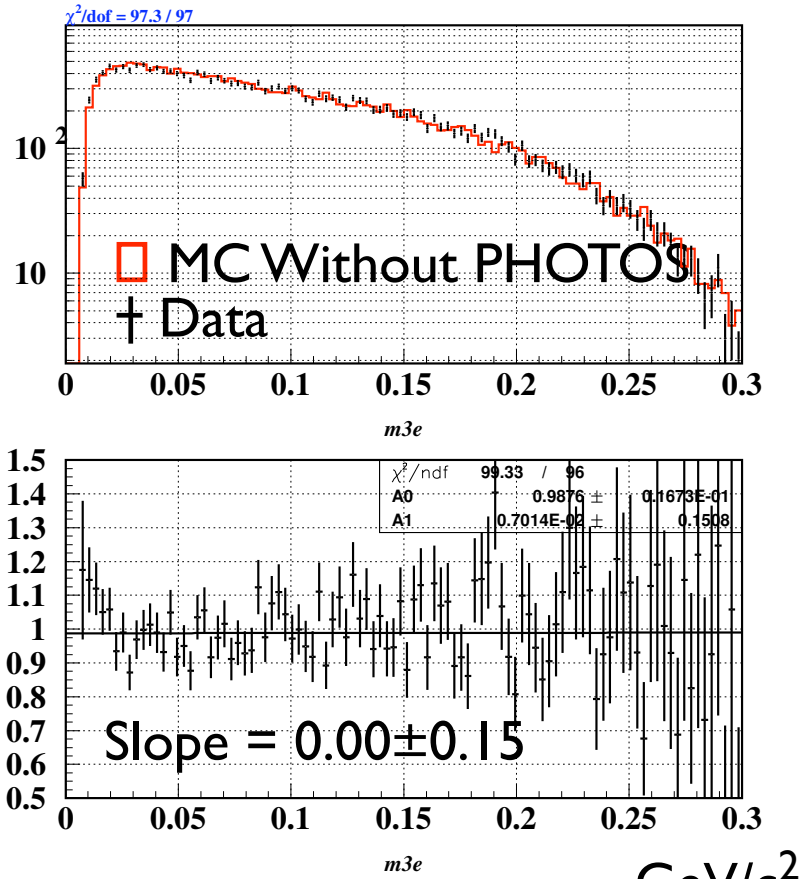


Mpeee GeV/c^2

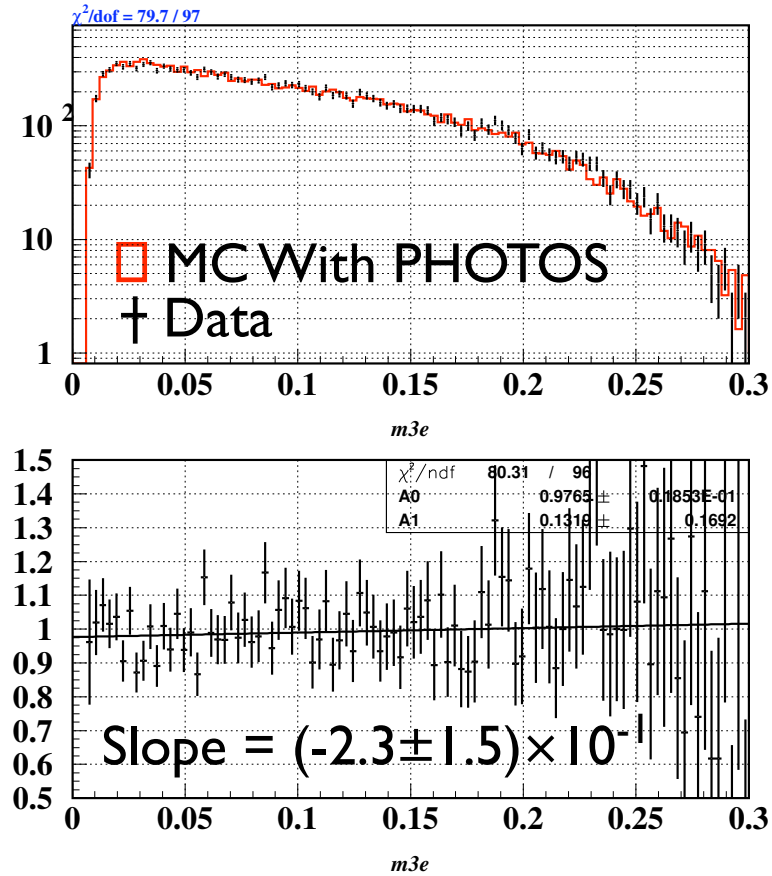


Mpeee GeV/c^2

Comparison between MC with PHOTOS and without PHOTOS

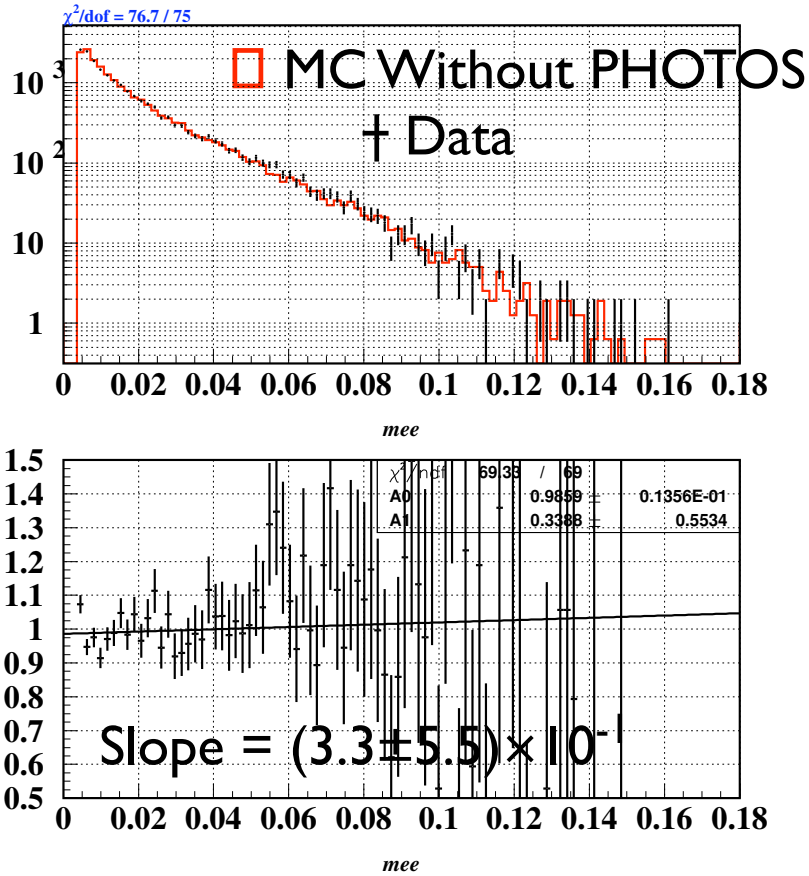


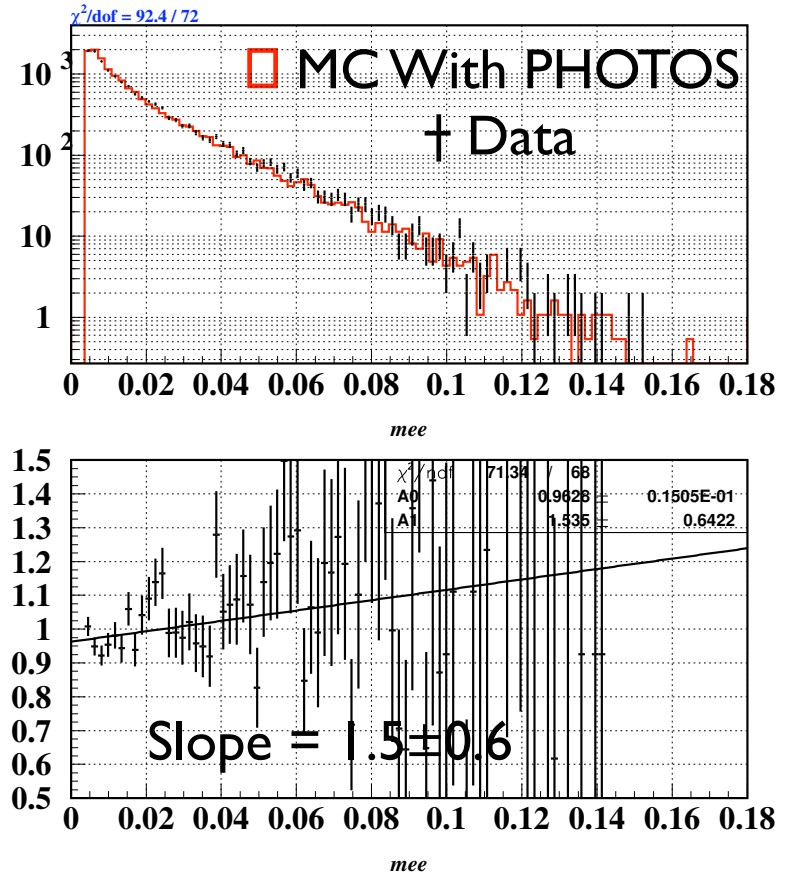
Meee GeV/c^2



Meee GeV/c^2

Comparison between MC with PHOTOS and without PHOTOS

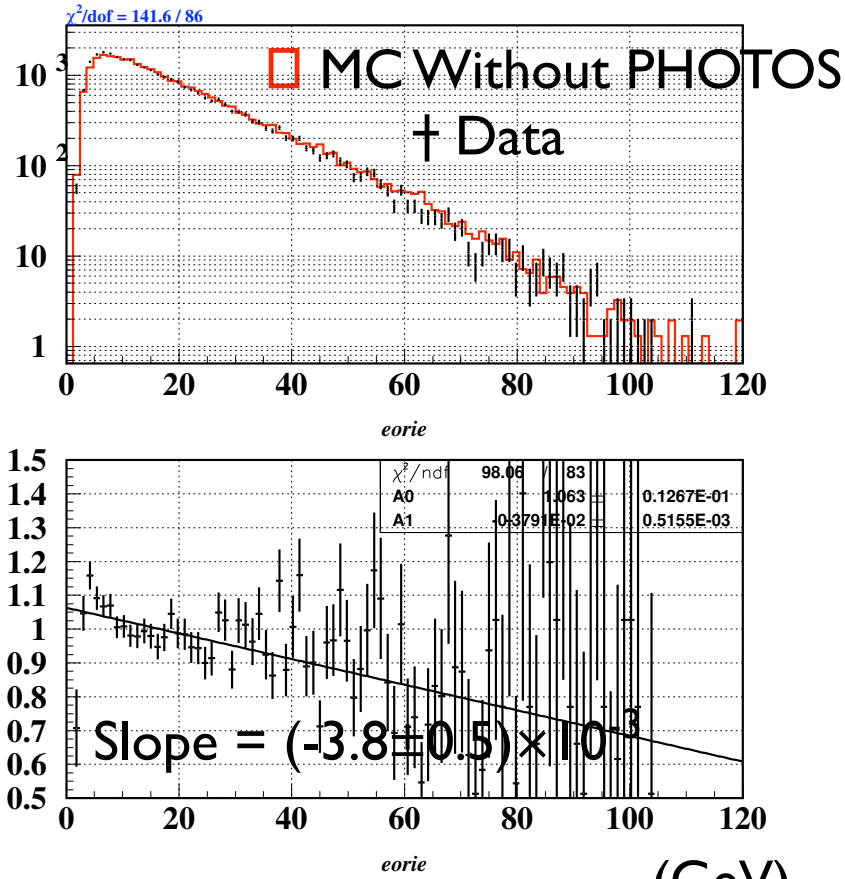


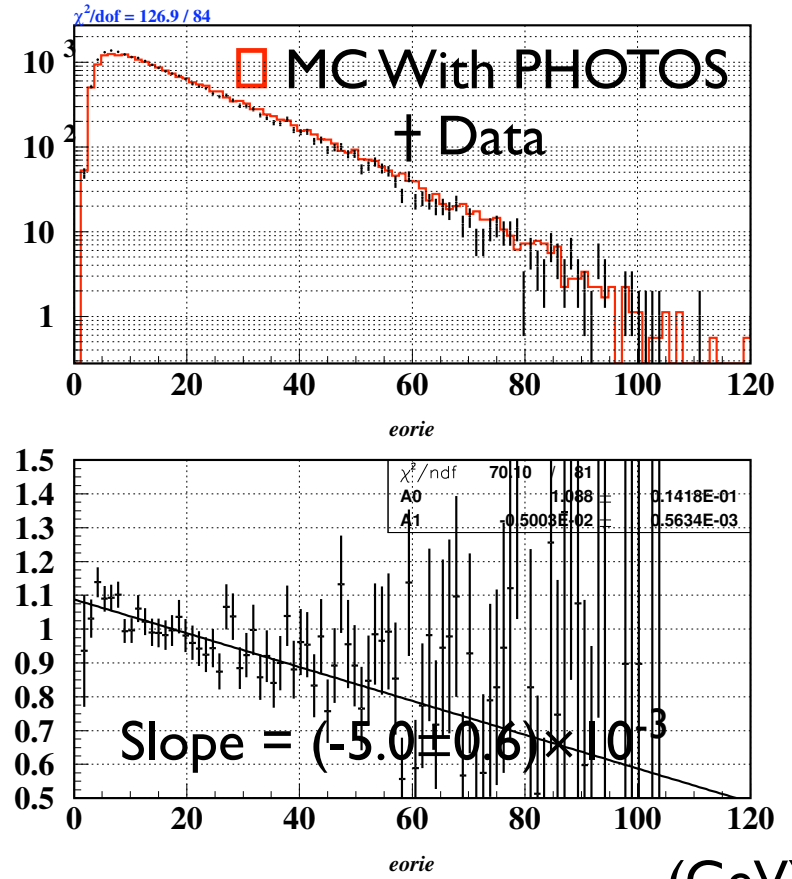


Mee (GeV/c^2)

Mee (GeV/c^2)

Comparison between MC with PHOTOS and without PHOTOS





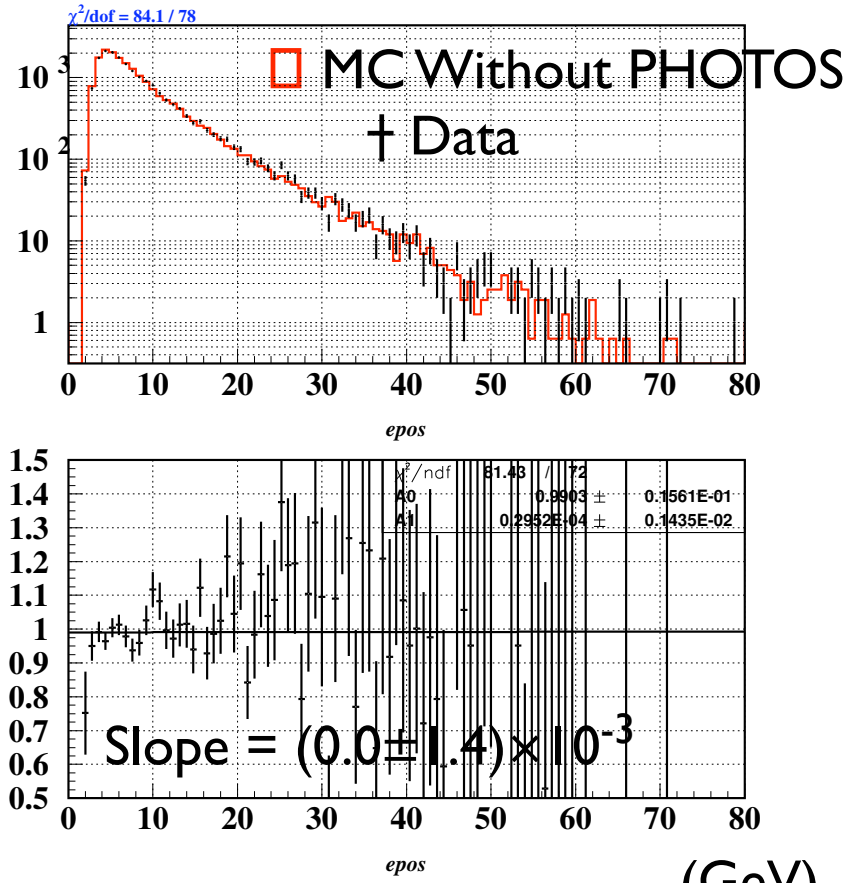
(GeV)

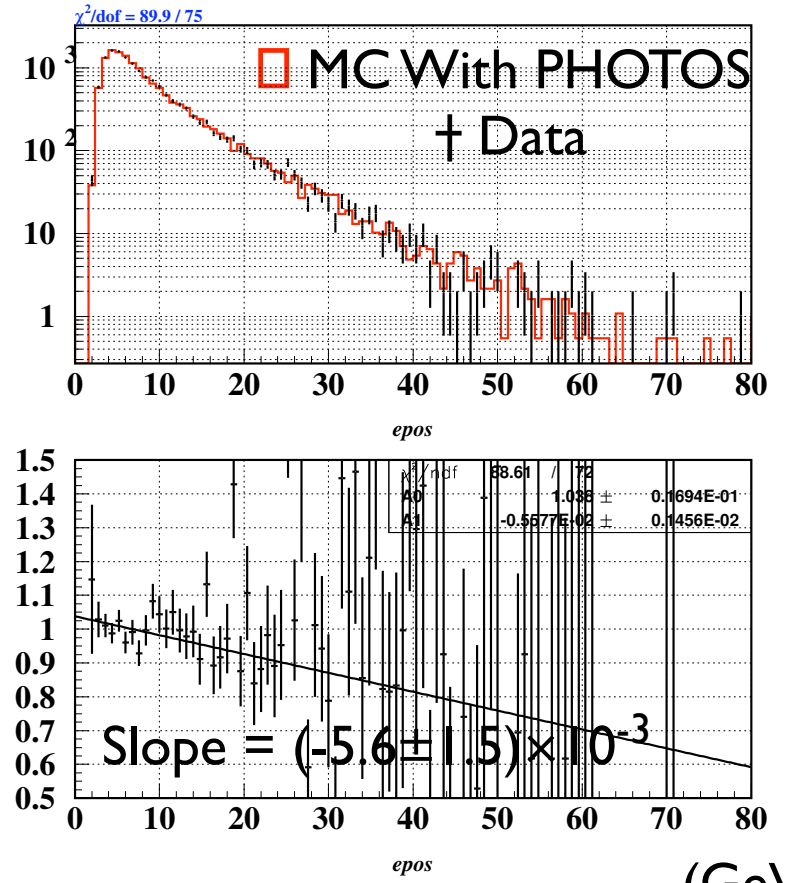
Ee±(not smallest mass pair)

(GeV)

Ee±(not smallest mass pair)

Comparison between MC with PHOTOS and without PHOTOS





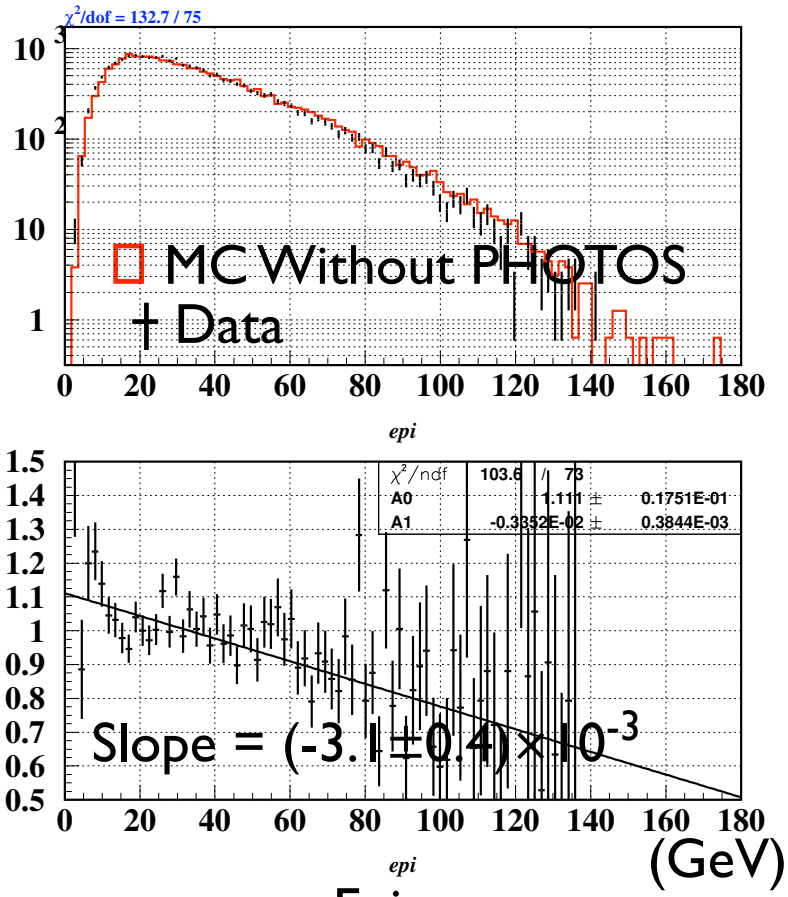
(GeV)

Ee^+(of the pair which has smallest mass)

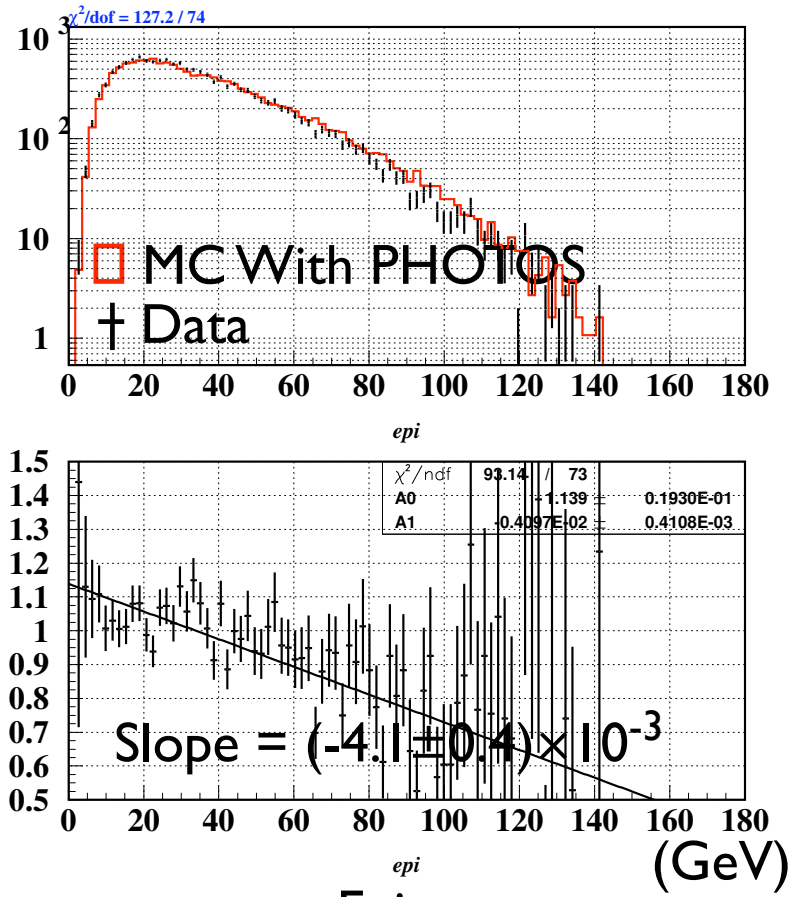
(GeV)

Ee^+(of the pair which has smallest mass)

Comparison between MC with PHOTOS and without PHOTOS



Epi



Epi

Conclusion

- Kaon yield in '97 winter data by pm0dal is

  $(1.419 \pm 0.008) \times 10^{11}$.

  Error is statistics only.

- Exchange term does not affect distributions.
- PHOTOS changes many distributions of variables; Data/MC gets worse than wihtout PHOTOS except Mpeee.

Plan

- Fixing the probrem in Crunch.
- Systematic error analyses of the both ke3ee mode and normalization mode.
- Radiative correction and studying of the mechanism of how the distributions are changed by PHOTOS.