

Status update on $K_{\mu 3}$ / $K_{e 3}$ analysis



Mario Vormstein
NA62 Collaboration Meeting
04.09.2014
Ferrara

Overview

Short reminder

$K_{\mu 3}$ without MUV

Backgrounds

Kaon momentum spectrum

Data/MC agreements

Short reminder

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Measure branching ratios

$$K_{\mu 3} = K^+ \rightarrow \pi^0 \mu^+ \nu$$

$$K_{e 3} = K^+ \rightarrow \pi^0 e^+ \nu$$

Short reminder

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$$K_{e 3} = K^+ \rightarrow \pi^0 e^+ \nu$$

Normalization channel

$$K_{2\pi} = K^+ \rightarrow \pi^+ \pi^0$$

Short reminder

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$$K_{e 3} = K^+ \rightarrow \pi^0 e^+ \nu$$

Normalization channel

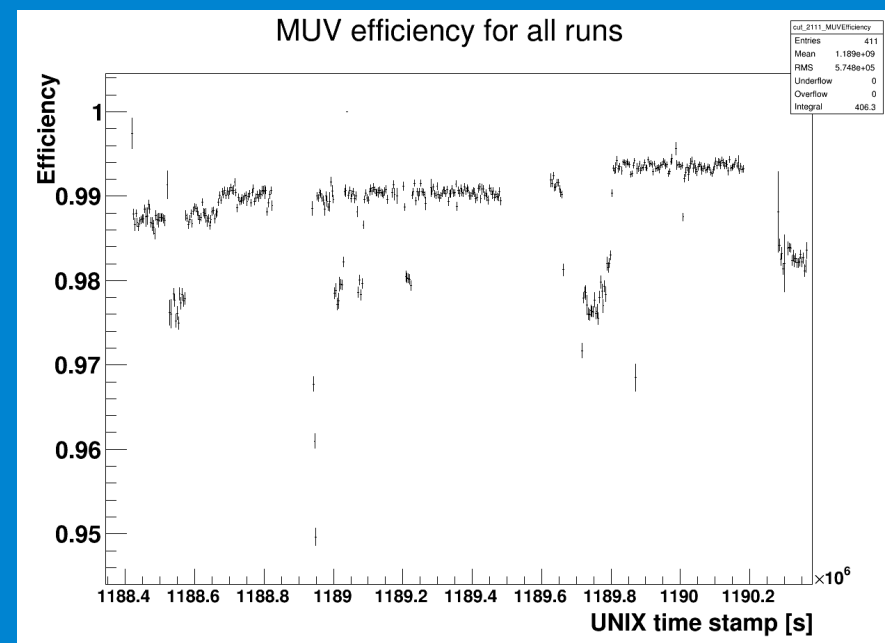
$$K_{2\pi} = K^+ \rightarrow \pi^+ \pi^0$$

2007 Period 5 data

$K_{\mu 3}$ without MUV

$K_{\mu 3}$ without MUV (1)

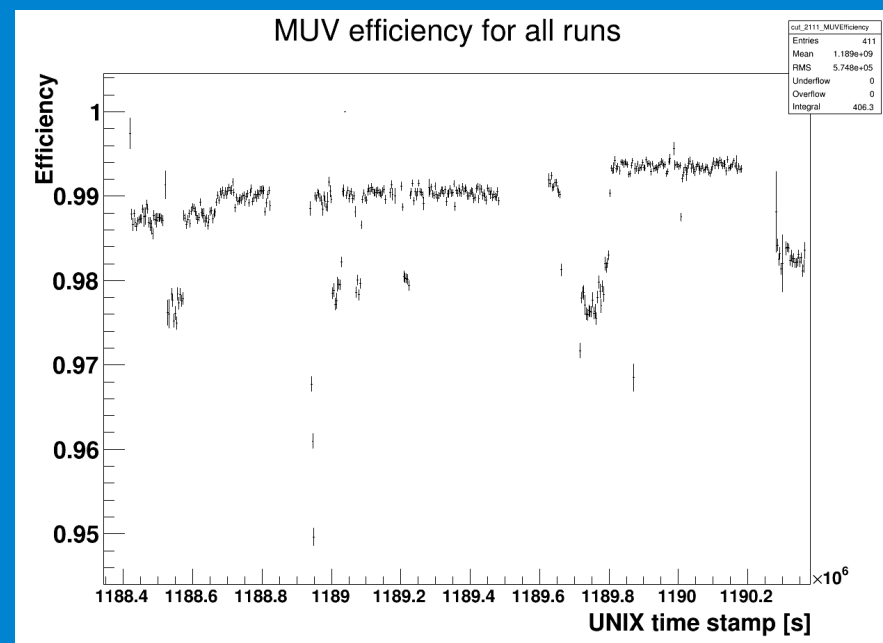
MUV: ~15% of events < 0.98 efficiency



$K_{\mu 3}$ without MUV (1)

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In $K_{\mu 3}$ selection this events rejected

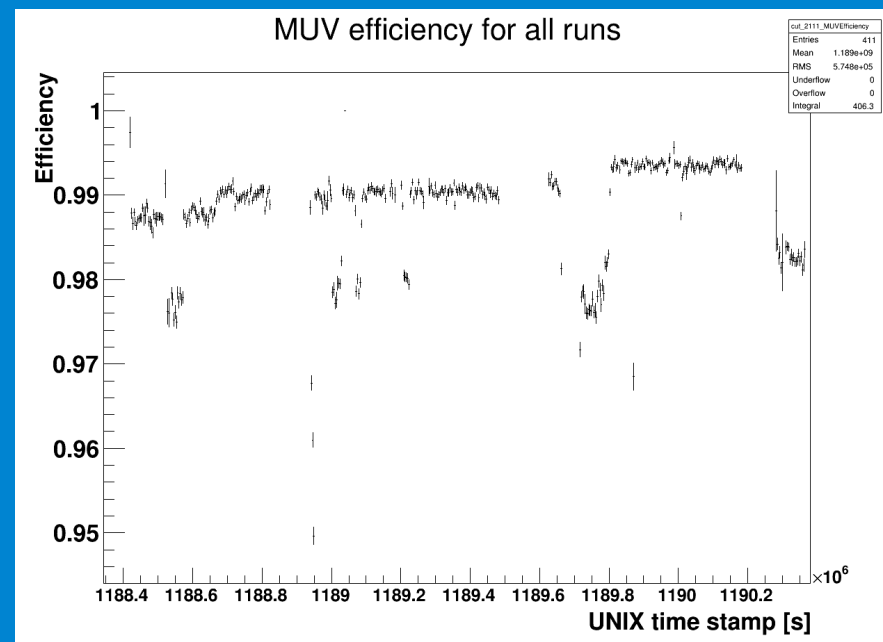


$K_{\mu 3}$ without MUV (1)

MUV: ~15% of events < 0.98 efficiency

In $K_{\mu 3}$ selection this events rejected

Source of systematics



$K_{\mu 3}$ without MUV (2)

Main background $K_{2\pi}$

$K_{\mu 3}$ without MUV (2)

Main background $K_{2\pi}$ $\longrightarrow$ Make use of 2 vs 3 body decay

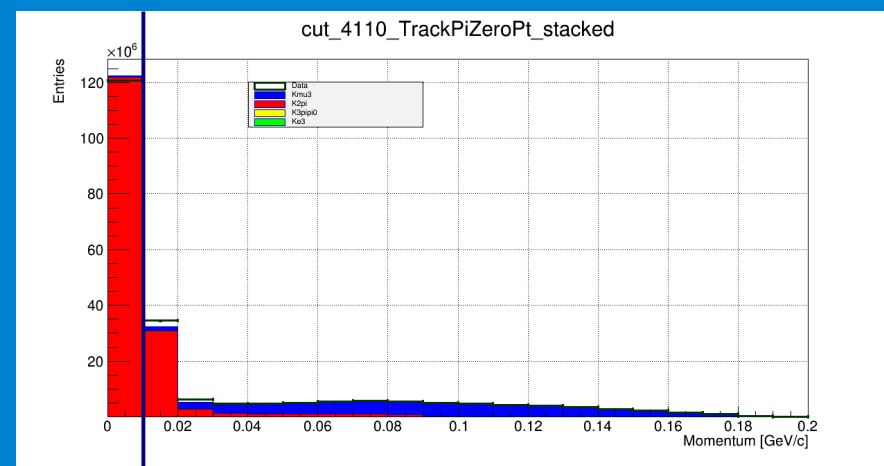
$K_{\mu 3}$ without MUV (2)

Main background $K_{2\pi}$



Make use of 2 vs 3 body decay

$Pt \text{ of } P(\mu) + P(\pi^0) > 0.015$



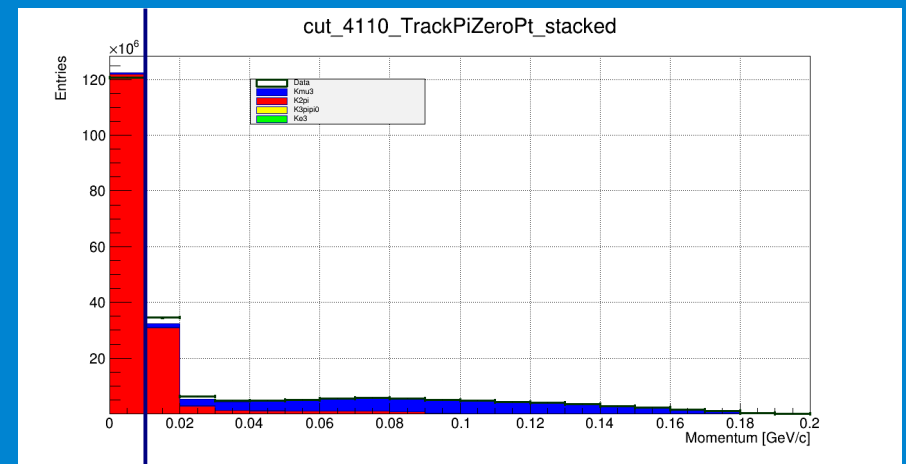
$K_{\mu 3}$ without MUV (2)

Main background $K_{2\pi}$

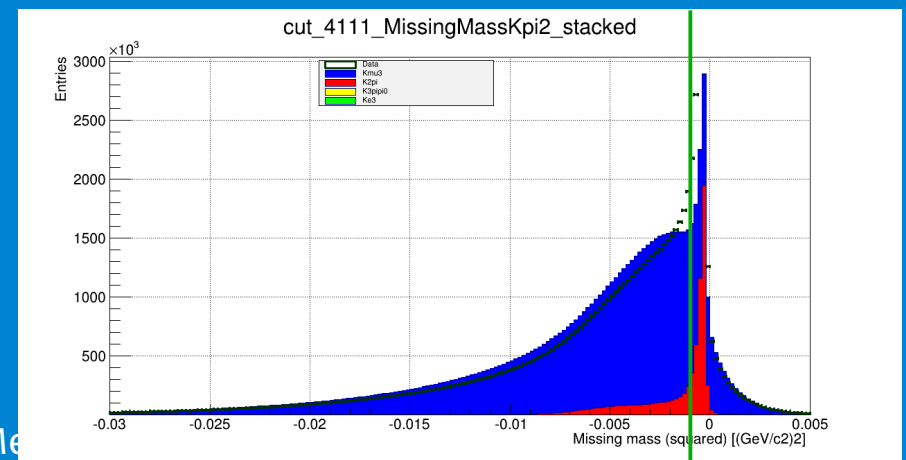


Make use of 2 vs 3 body decay

$P_t \text{ of } P(\mu) + P(\pi^0) > 0.015$



Missing Mass² (π hyp) < -0.001



$K_{\mu 3}$ without MUV (3)

	MUV	No MUV
Acceptance [%]	14.9	12.9
Candidates	34,145,221	34,770,067

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Almost same amount candidates

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	MUV	No MUV
Acceptance [%]	14.9	12.9
Candidates	34,145,221	34,770,067

MUV: 15% of events rejected

Almost same amount candidates

But one detector less

Backgrounds

Backgrounds

E/p: Mis-id for $\pi \rightarrow \mu$, $\pi \rightarrow e$ and $\mu \rightarrow e$

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$K_{2\pi}$: $\pi \rightarrow \mu$ and $\pi \rightarrow e$

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E/p : Mis-id for $\pi \rightarrow \mu$, $\pi \rightarrow e$ and $\mu \rightarrow e$

$K_{2\pi}$: $\pi \rightarrow \mu$ and $\pi \rightarrow e$

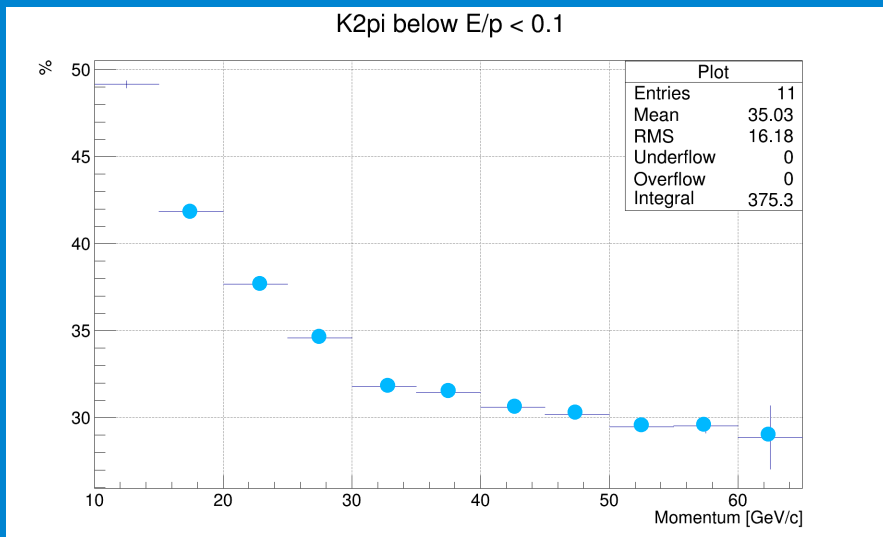
$K_{\mu 2}$: $\mu \rightarrow e$

Backgrounds

E/p: Mis-id for $\pi \rightarrow \mu$, $\pi \rightarrow e$ and $\mu \rightarrow e$

$K_{2\pi}$: $\pi \rightarrow \mu$ and $\pi \rightarrow e$

$K_{\mu 2}$: $\mu \rightarrow e$



$\pi \rightarrow \mu$ misID prob.

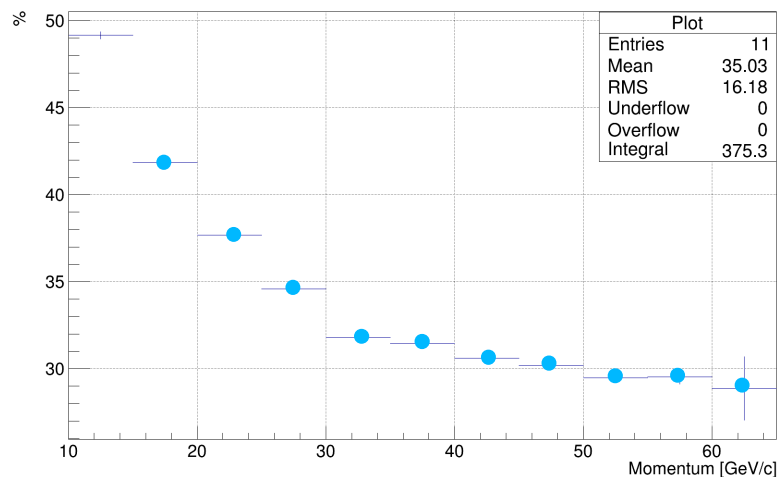
Backgrounds

E/p: Mis-id for $\pi \rightarrow \mu$, $\pi \rightarrow e$ and $\mu \rightarrow e$

$K_{2\pi}$: $\pi \rightarrow \mu$ and $\pi \rightarrow e$

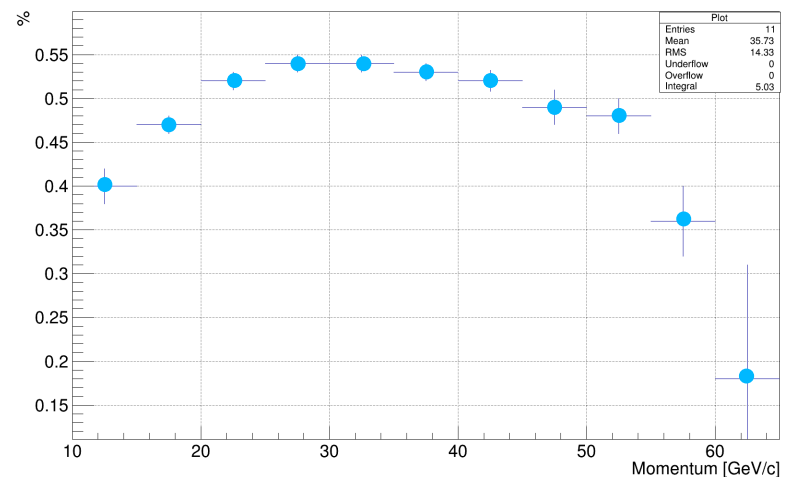
$K_{\mu 2}$: $\mu \rightarrow e$

K2pi below E/p < 0.1



$\pi \rightarrow \mu$ misID prob.

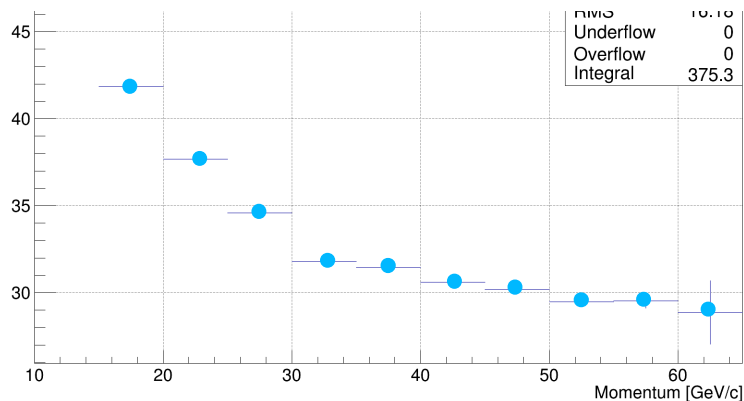
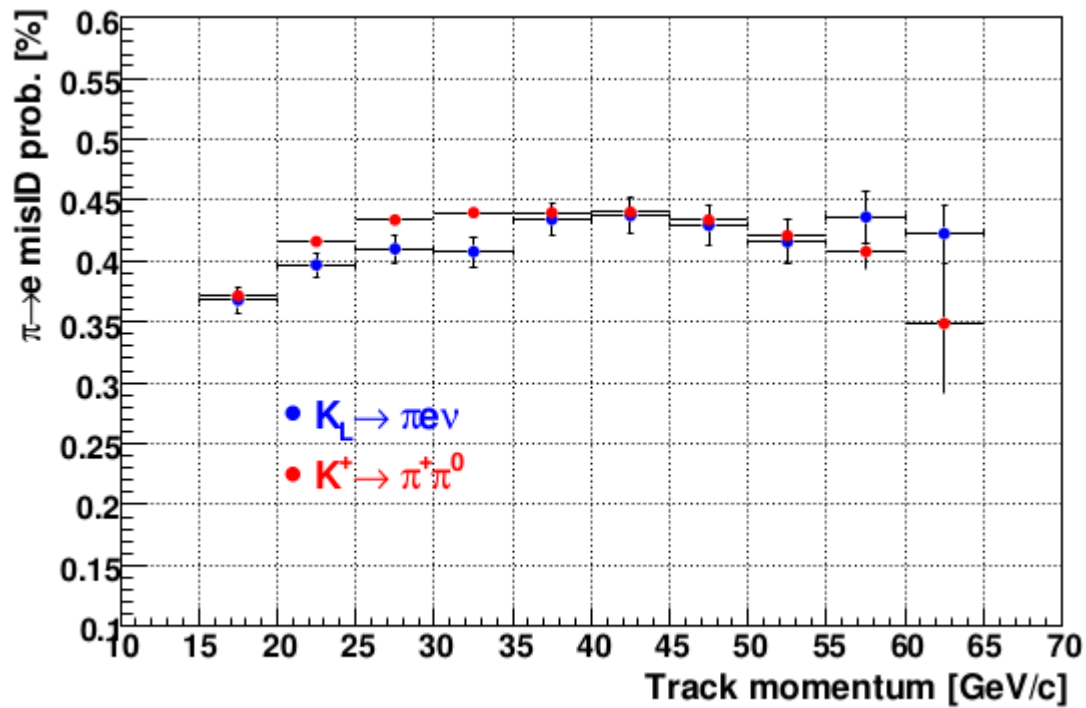
K2pi E/p > 0.95 && E/p < 1.1



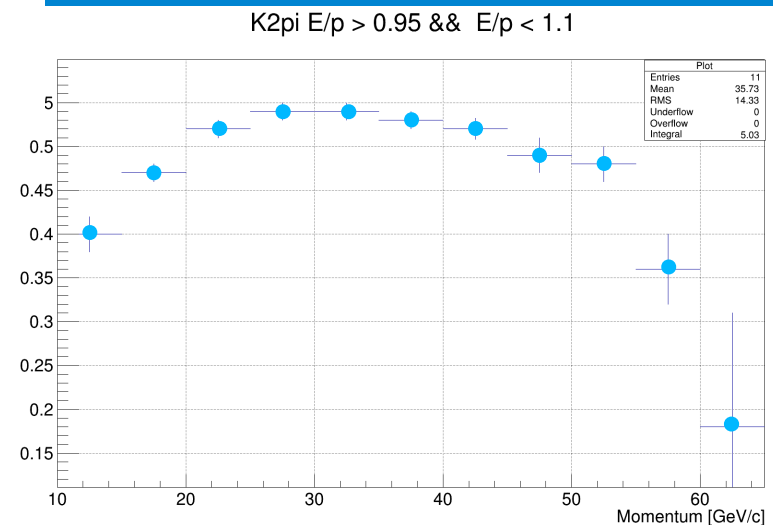
$\pi \rightarrow e$ misID prob.

Backgrounds

A.Winhart
Weekly Meeting
09.02.2009

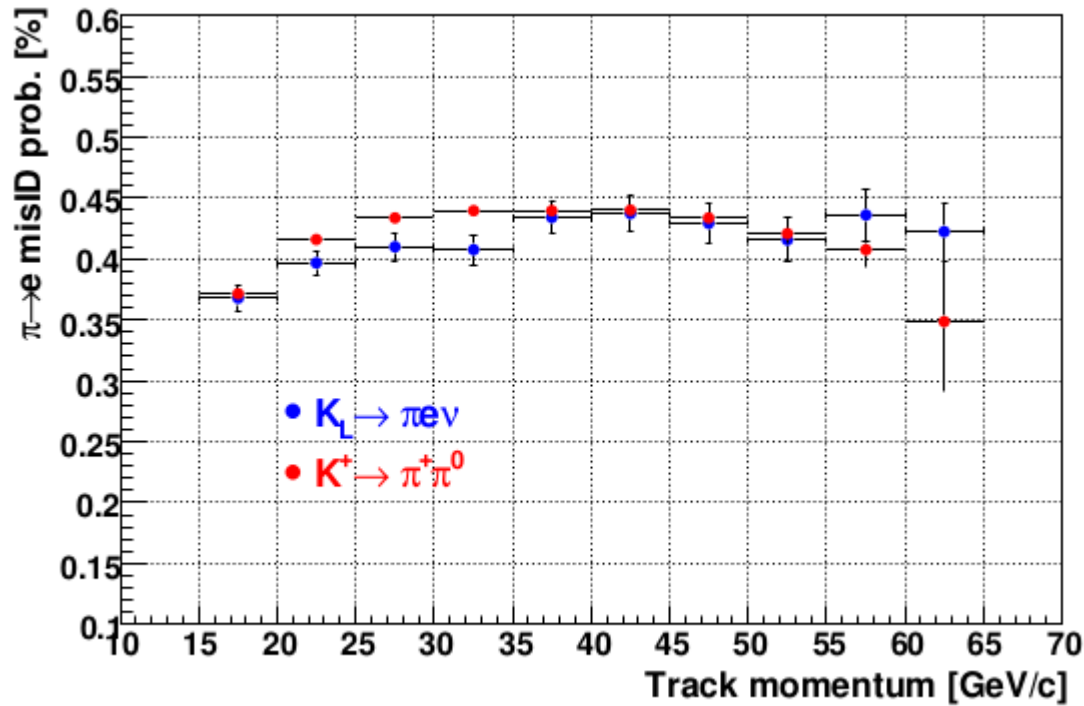


$\pi \rightarrow \mu$ misID prob.



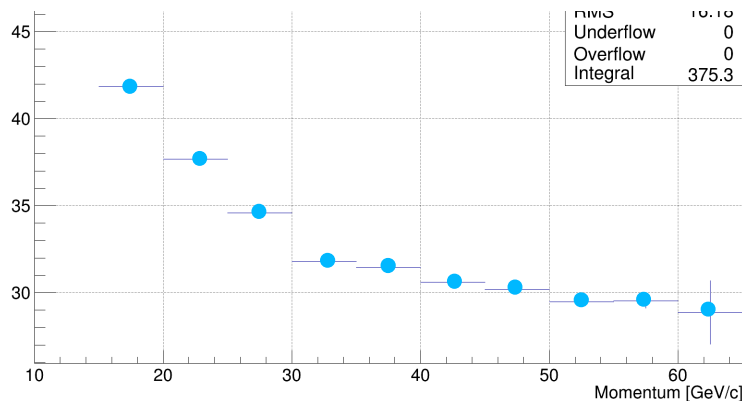
$\pi \rightarrow e$ misID prob.

Backgrounds

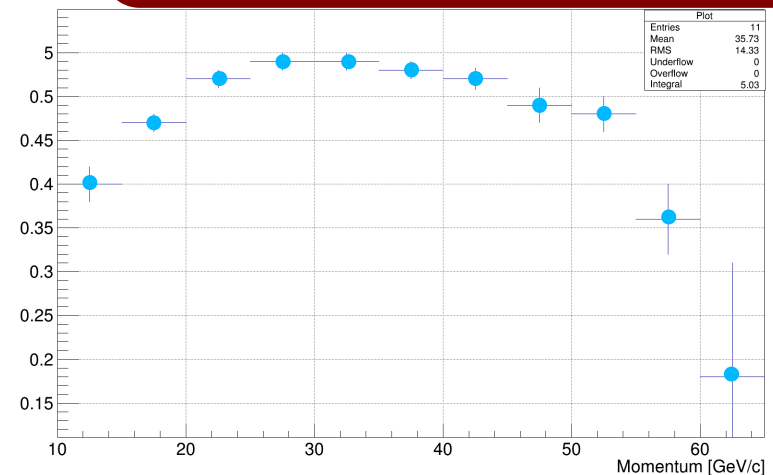


A.Winhart
Weekly Meeting
09.02.2009

Improvement needed



$\pi \rightarrow \mu$ misID prob.



$\pi \rightarrow e$ misID prob.

Backgrounds

Work in progress!

Selection	$K_{\mu 3}$		K_{e3}	$K_{2\pi}$
	MUV	No MUV		
Acceptance [%]	14.9			
Candidates	34,145,221			
Background [%]				
$K_{2\pi}$	0.292			
$K \rightarrow \pi^+ \pi^0 \pi^0$	0.071			
$K_{\mu 3}$	-			
K_{e3}	0			

Backgrounds

Work in progress!

Selection	$K_{\mu 3}$		K_{e3}	$K_{2\pi}$
	MUV	No MUV		
Acceptance [%]	14.9	12.9		
Candidates	34,145,221	34,770,067		
Background [%]				
$K_{2\pi}$	0.292	0.097		
$K \rightarrow \pi^+ \pi^0 \pi^0$	0.071	0.029		
$K_{\mu 3}$	-	-		
K_{e3}	0	0.084		

Backgrounds

Work in progress!

Selection	$K_{\mu 3}$		K_{e3}	$K_{2\pi}$
	MUV	No MUV		
Acceptance [%]	14.9	12.9	12.97	
Candidates	34,145,221	34,770,067	53,417,702	
Background [%]				
$K_{2\pi}$	0.292	0.097	0.162	
$K \rightarrow \pi^+ \pi^0 \pi^0$	0.071	0.029	0.003	
$K_{\mu 3}$	-	-	0	
K_{e3}	0	0.084	-	

Backgrounds

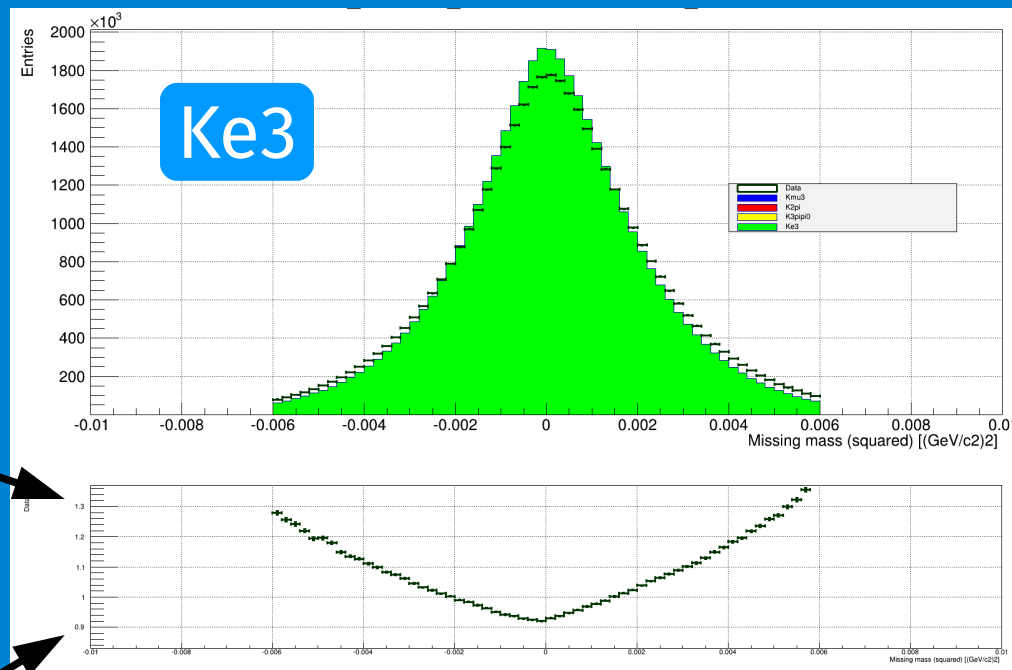
Work in progress!

Selection	$K_{\mu 3}$		K_{e3}	$K_{2\pi}$
	MUV	No MUV		
Acceptance [%]	14.9	12.9	12.97	24.7
Candidates	34,145,221	34,770,067	53,417,702	2,850,361
Background [%]				
$K_{2\pi}$	0.292	0.097	0.162	-
$K \rightarrow \pi^+ \pi^0 \pi^0$	0.071	0.029	0.003	0
$K_{\mu 3}$	-	-	0	0.132
K_{e3}	0	0.084	-	0.002

Kaon momentum spectrum

Kaon momentum spectrum

Agreement of Data/MC in Missing Mass under investigation



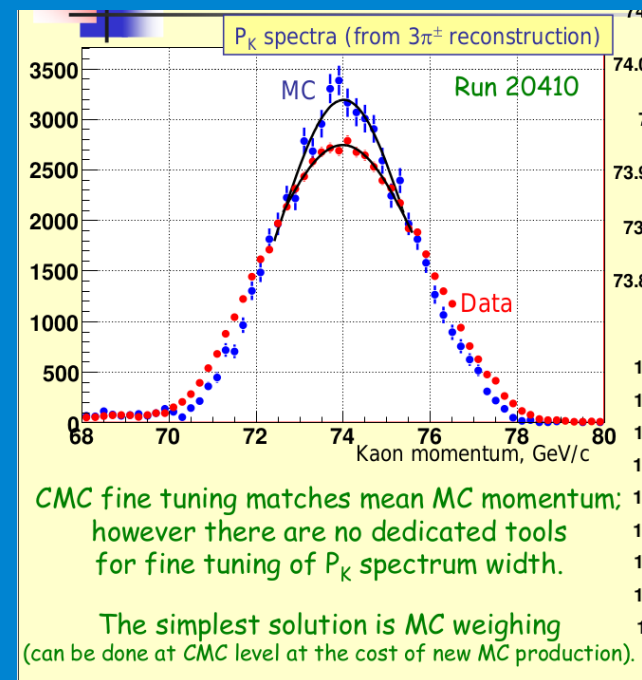
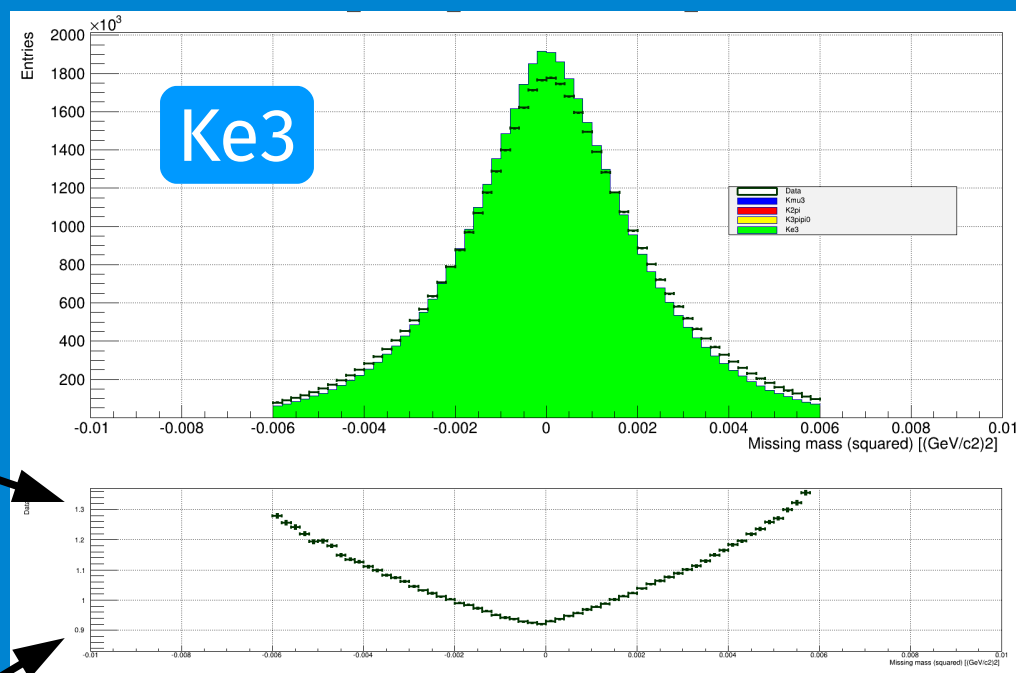
1.3

0.9

Kaon momentum spectrum

Agreement of Data/MC in Missing Mass under investigation

Found information about correction done in analysis before

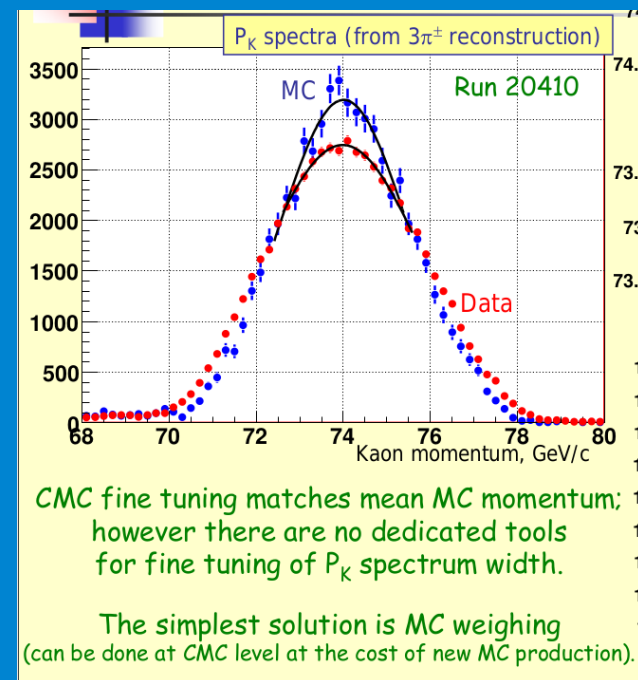
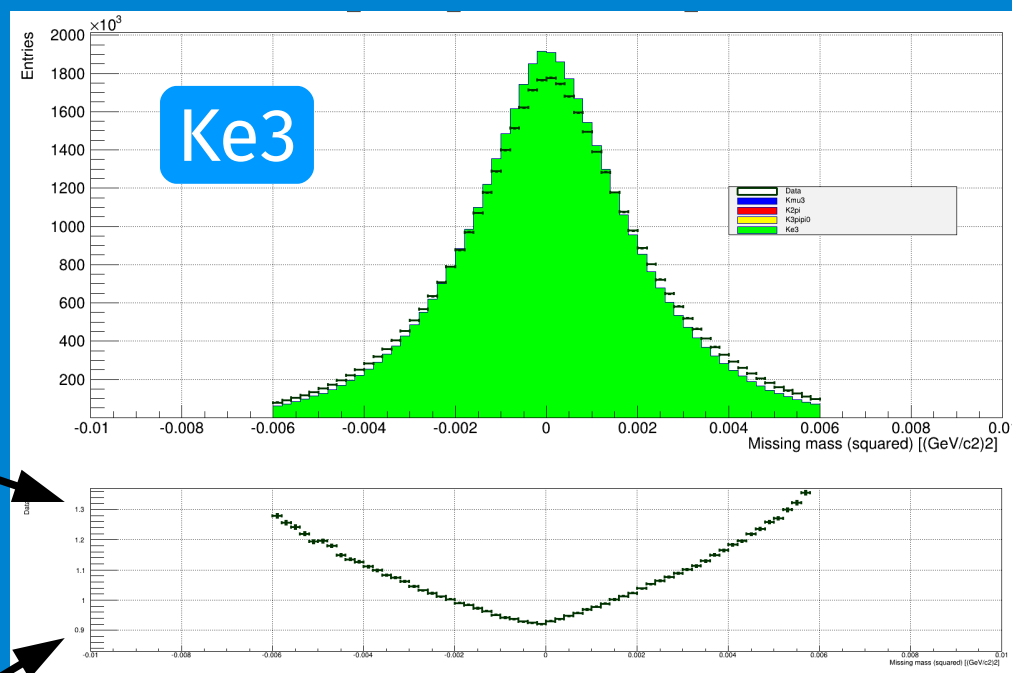


Kaon momentum spectrum

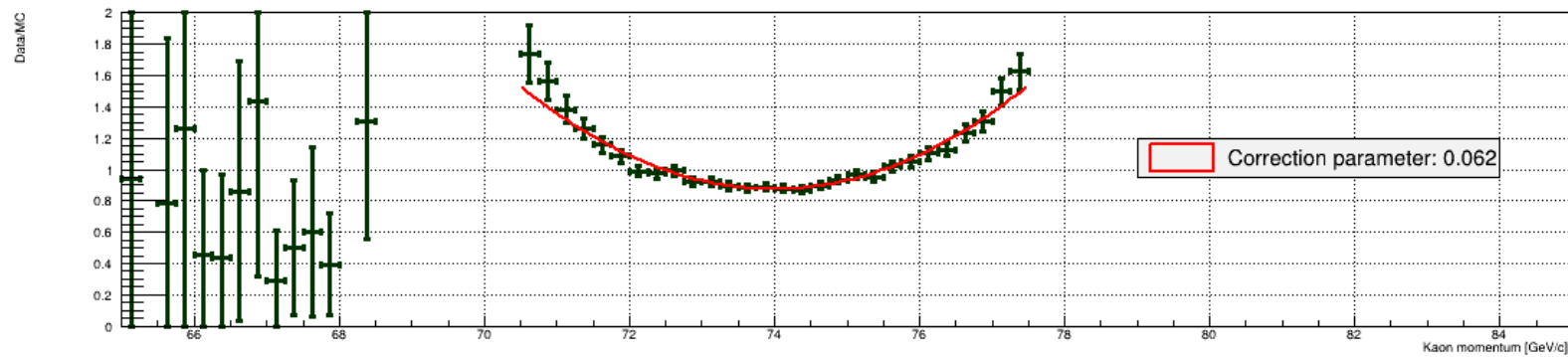
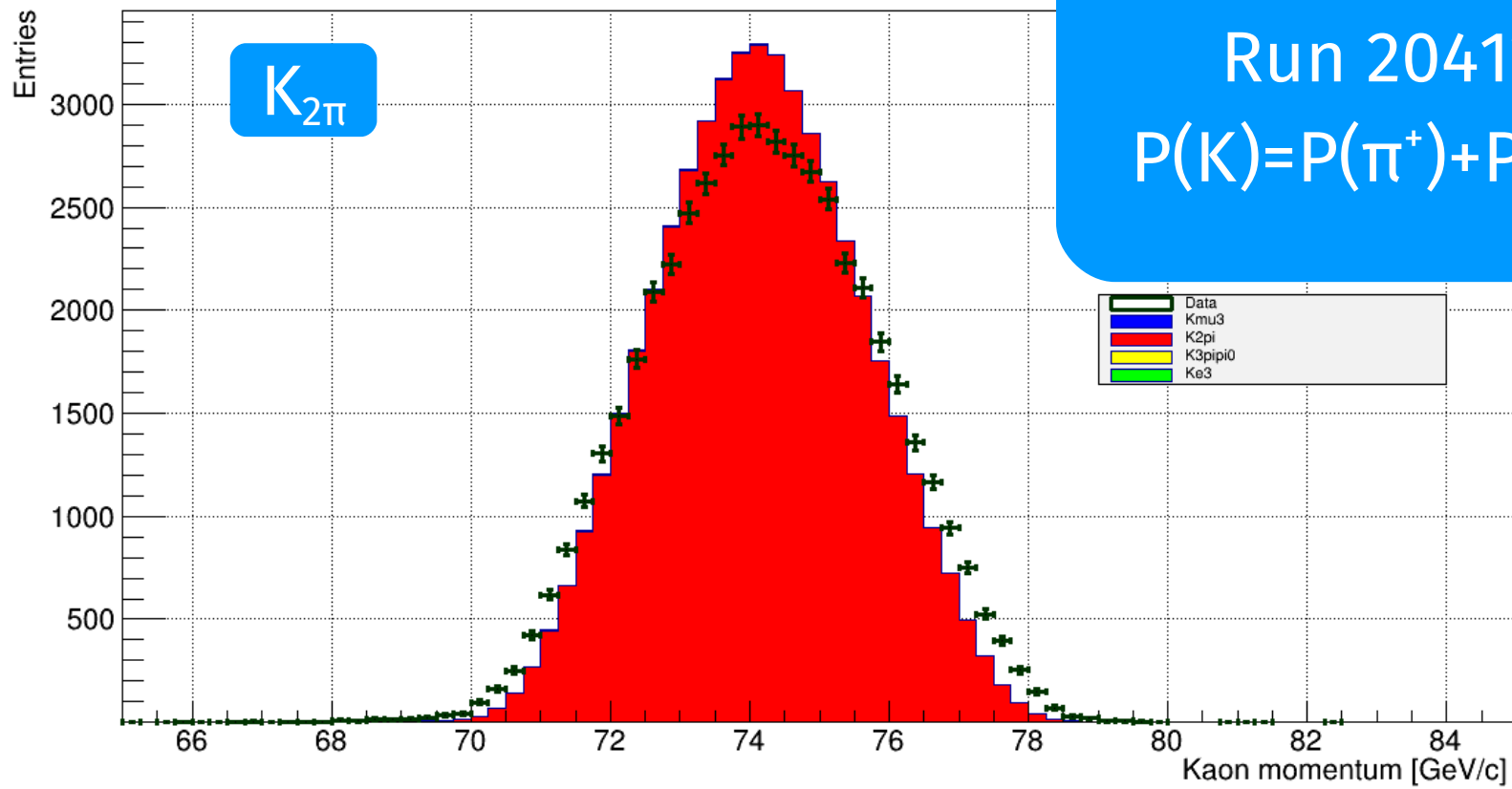
Agreement of Data/MC in Missing Mass under investigation

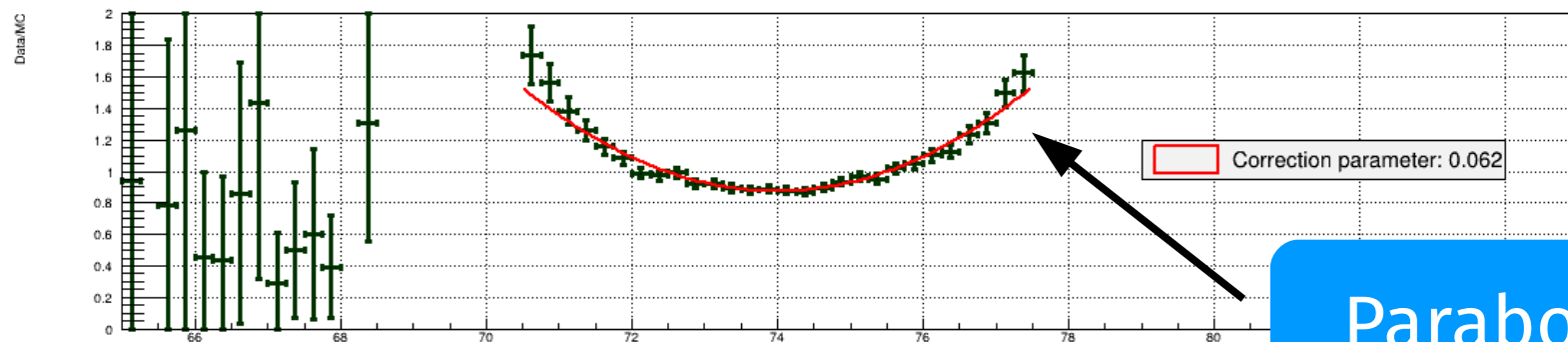
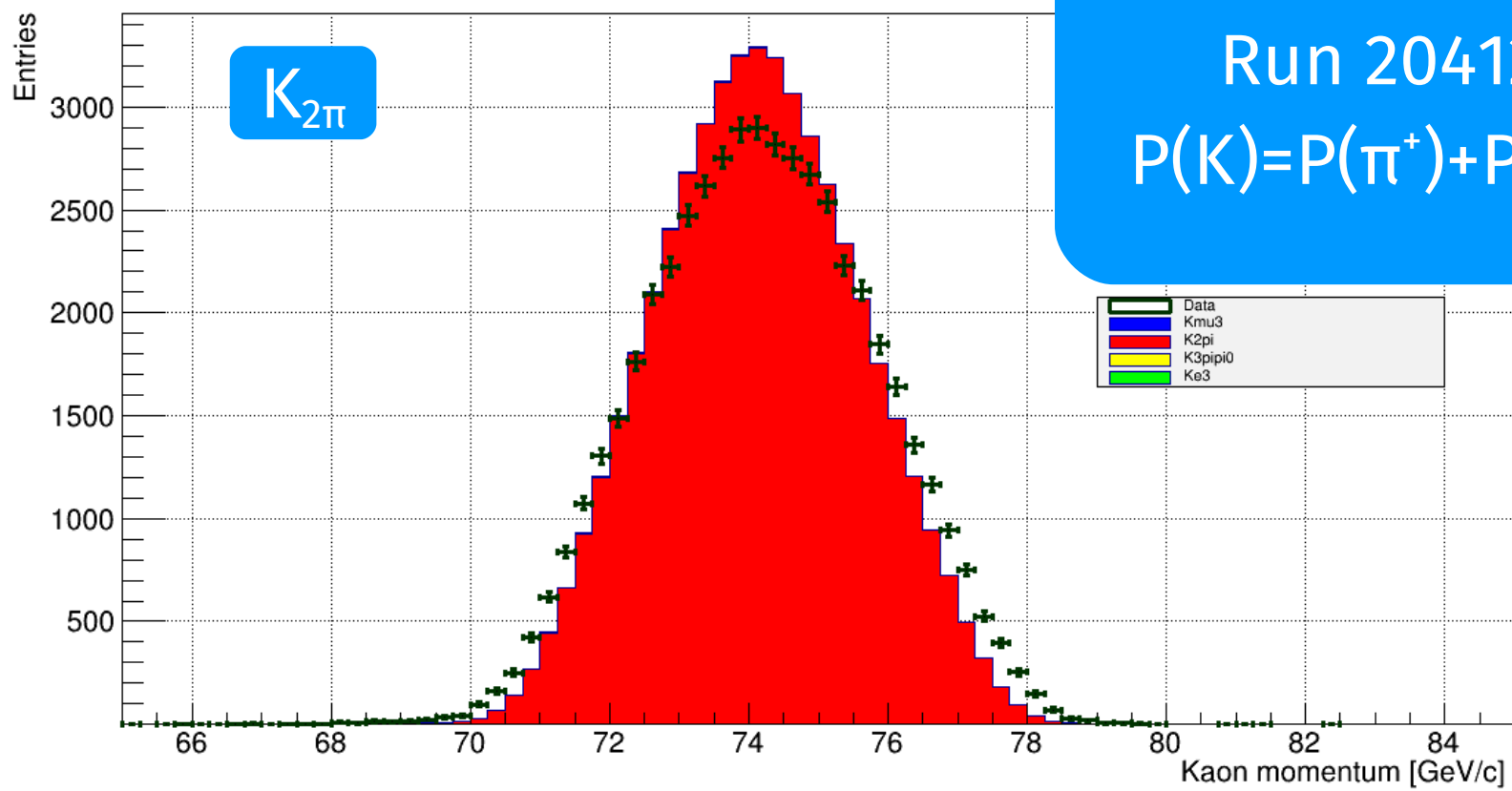
Found information about correction done in analysis before

Checkout myself using my $K \rightarrow \pi^+ \pi^0$ selection



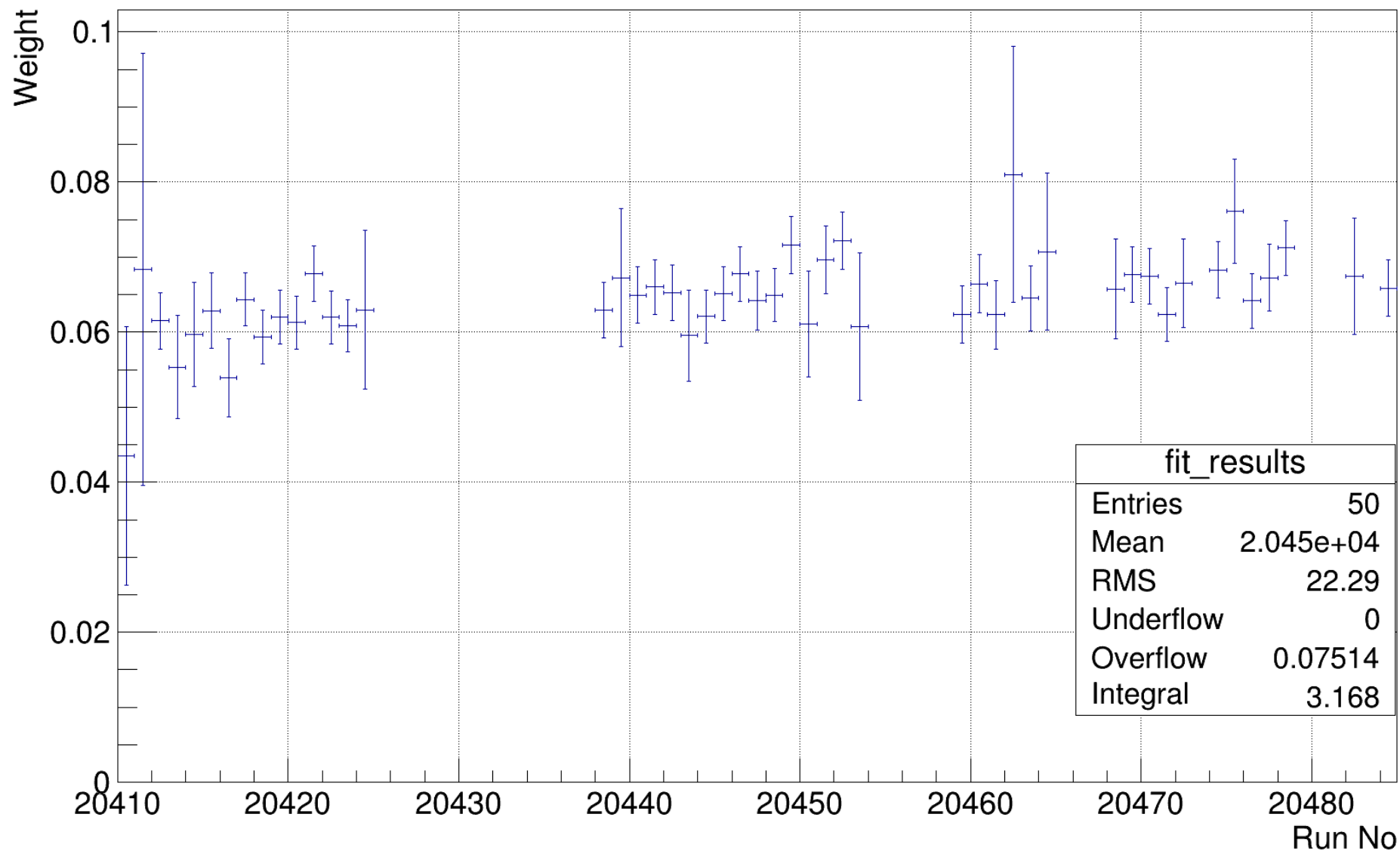
Run 20412
 $P(K) = P(\pi^+) + P(\pi^0)$





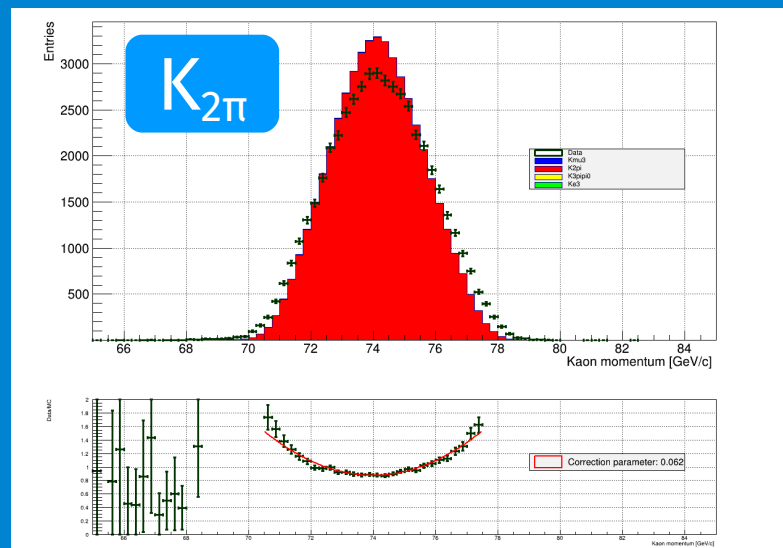
Parabolic fit

Fit results for all runs



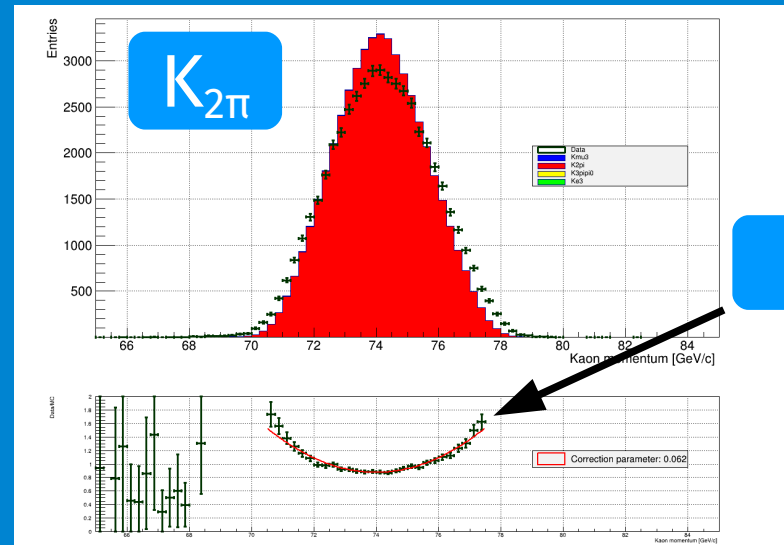
Kaon momentum spectrum

Fit value ~ 0.06 compatible to previous results



Kaon momentum spectrum

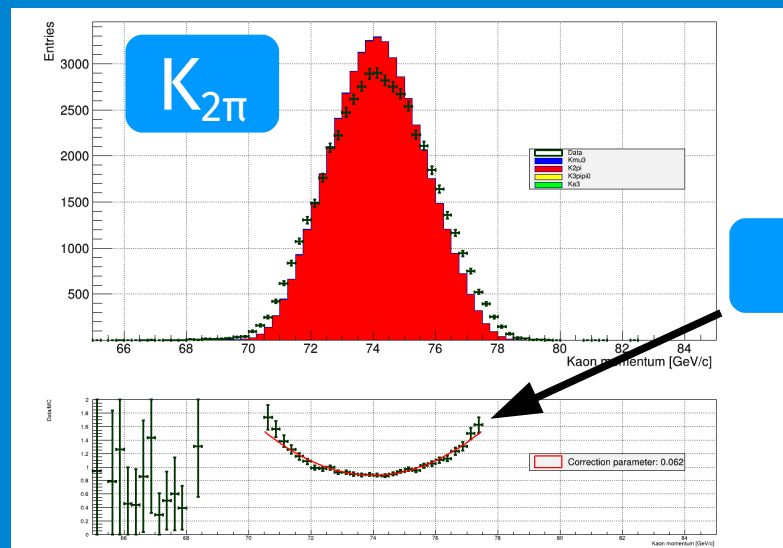
Fit value ~ 0.06 compatible to previous results



2nd order

Kaon momentum spectrum

Fit value ~ 0.06 compatible to previous results

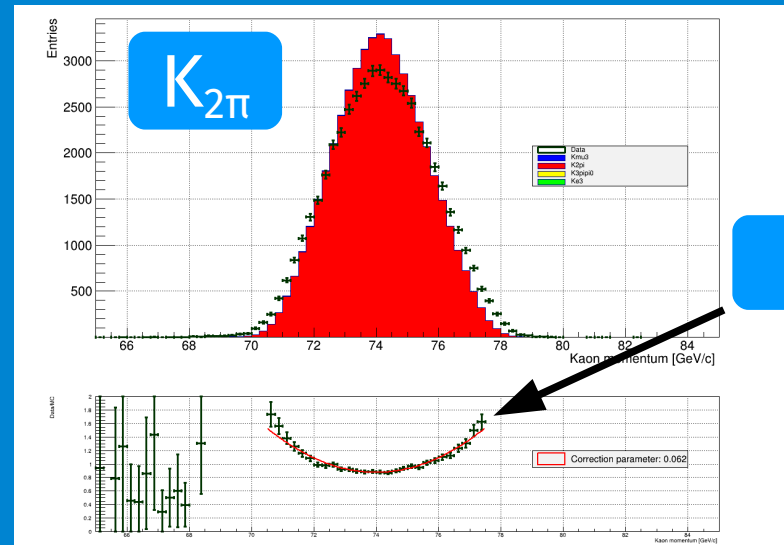


2nd order

Value is time dependent

Kaon momentum spectrum

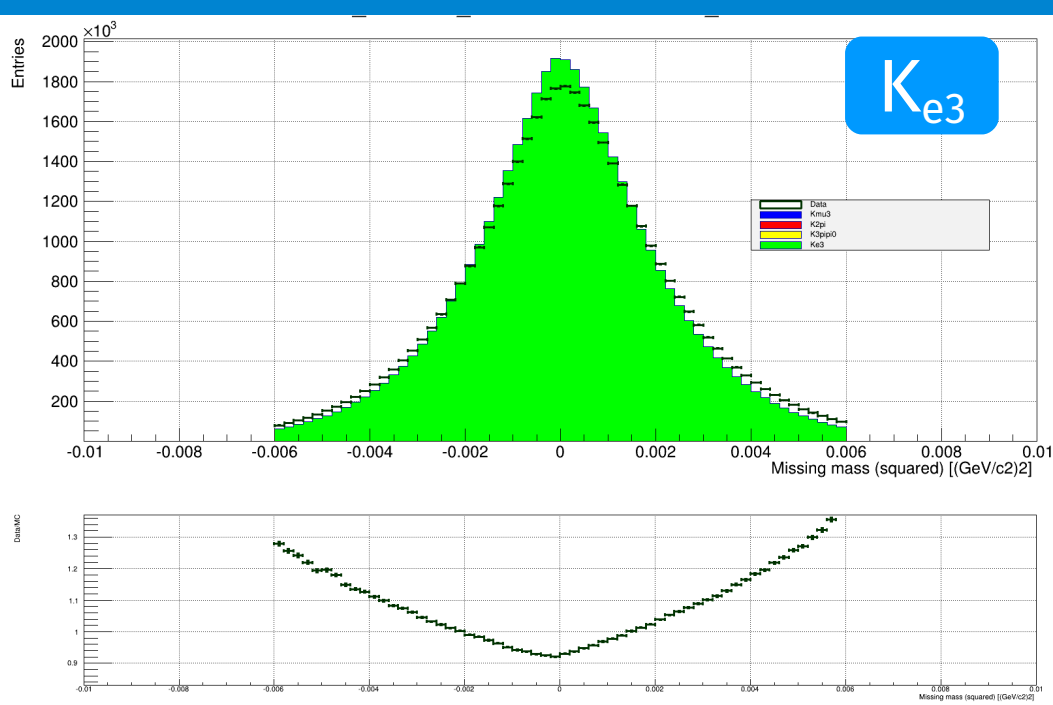
Fit value ~ 0.06 compatible to previous results



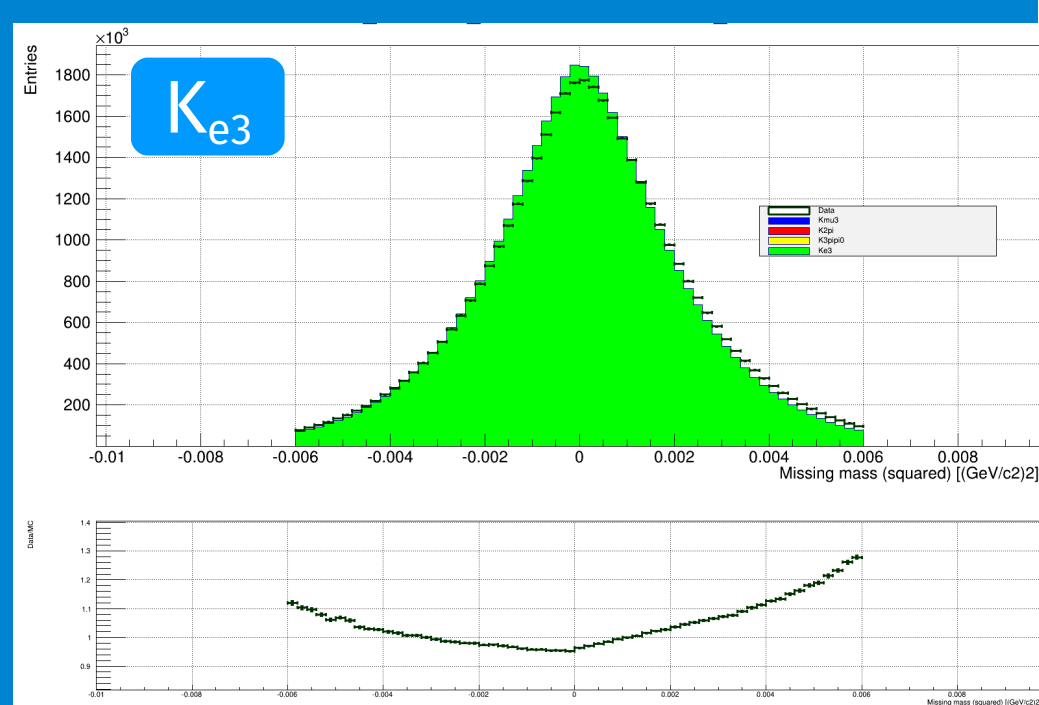
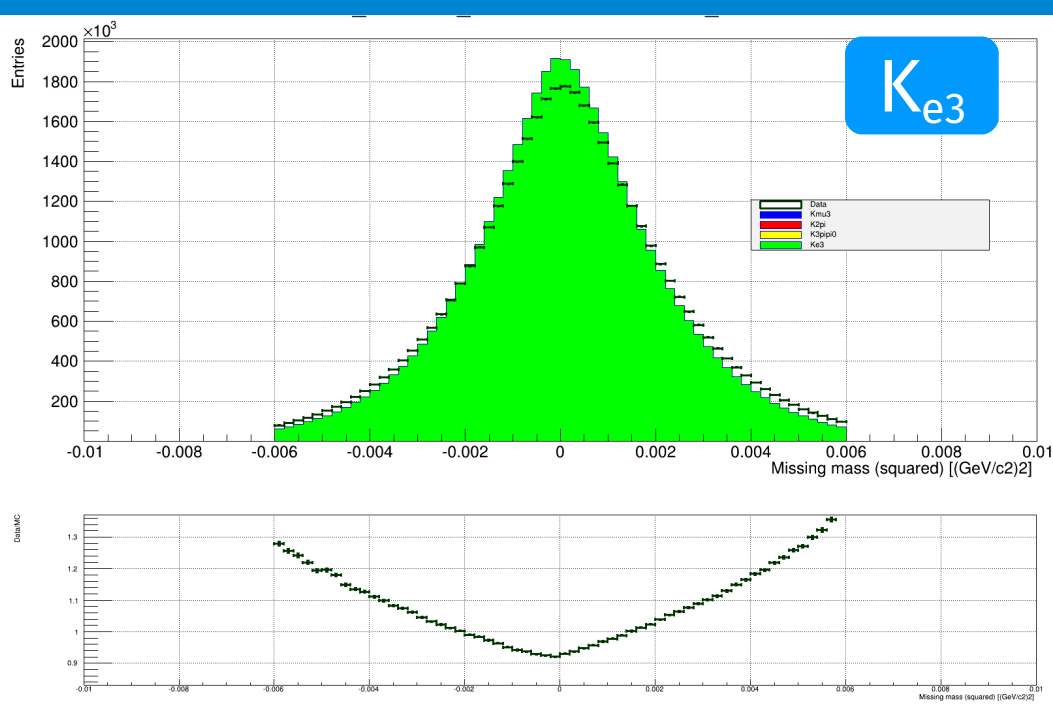
2nd order

Value is time dependent

2nd order correction provided by Evgueni

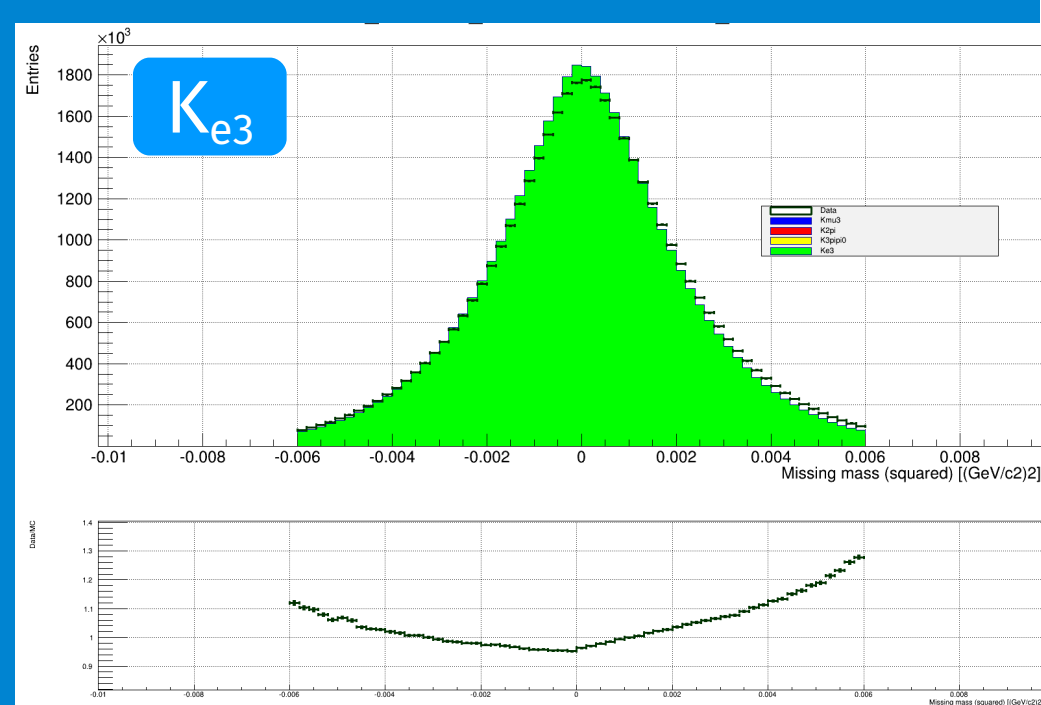
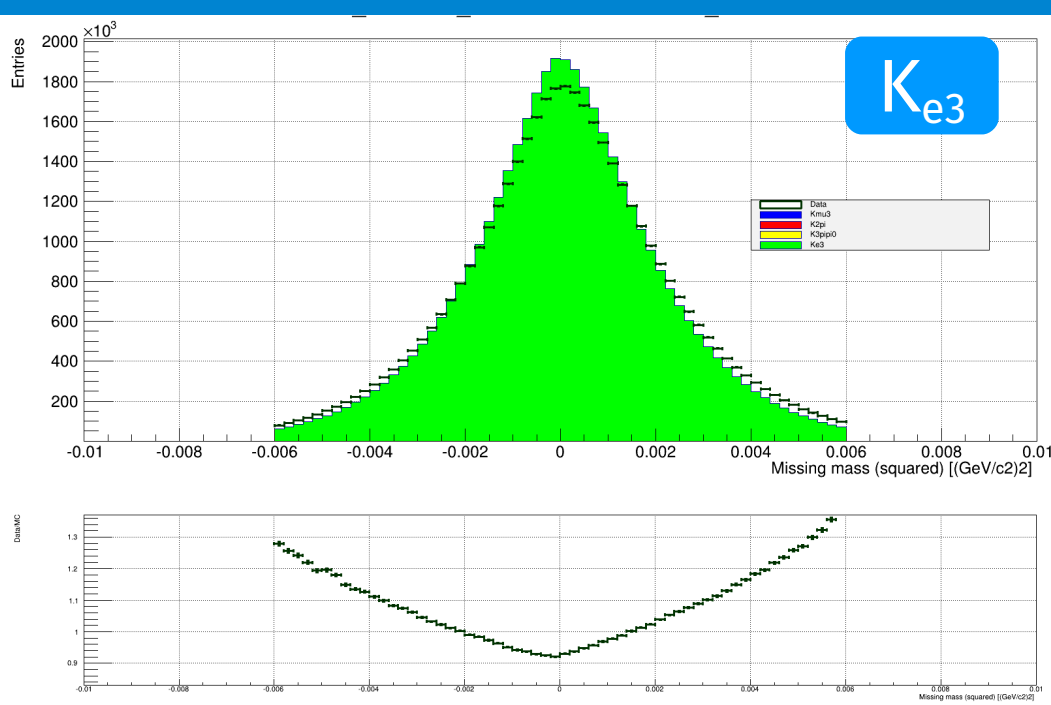


No correction



No correction

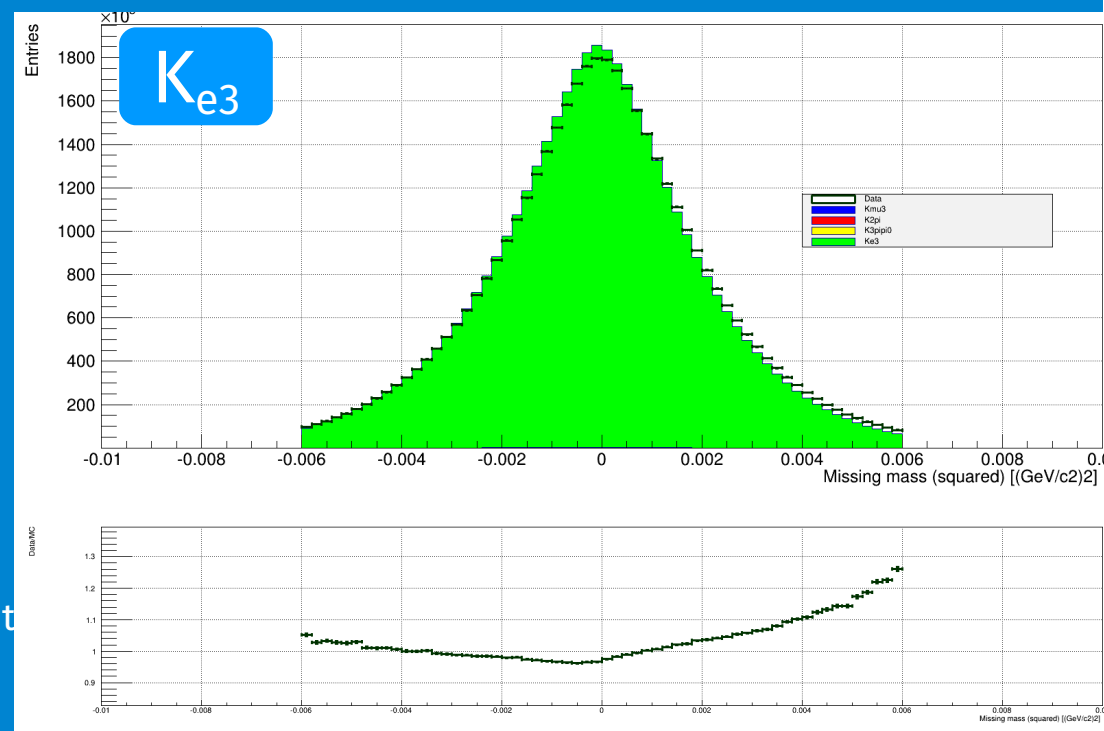
1st order

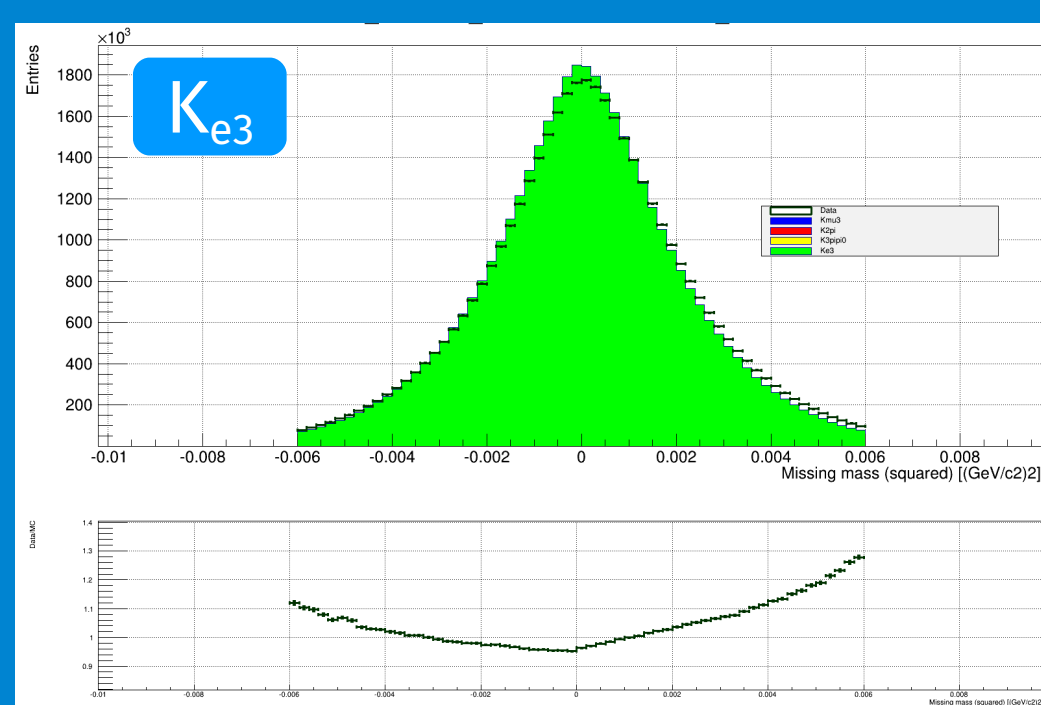
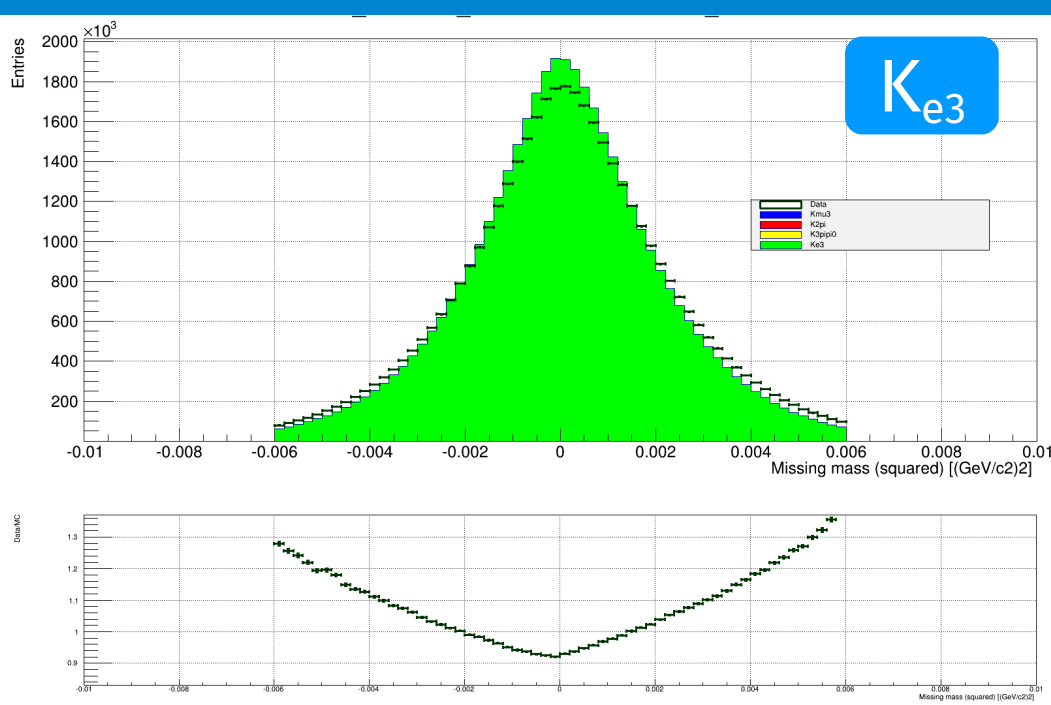


No correction

1st order

2nd order

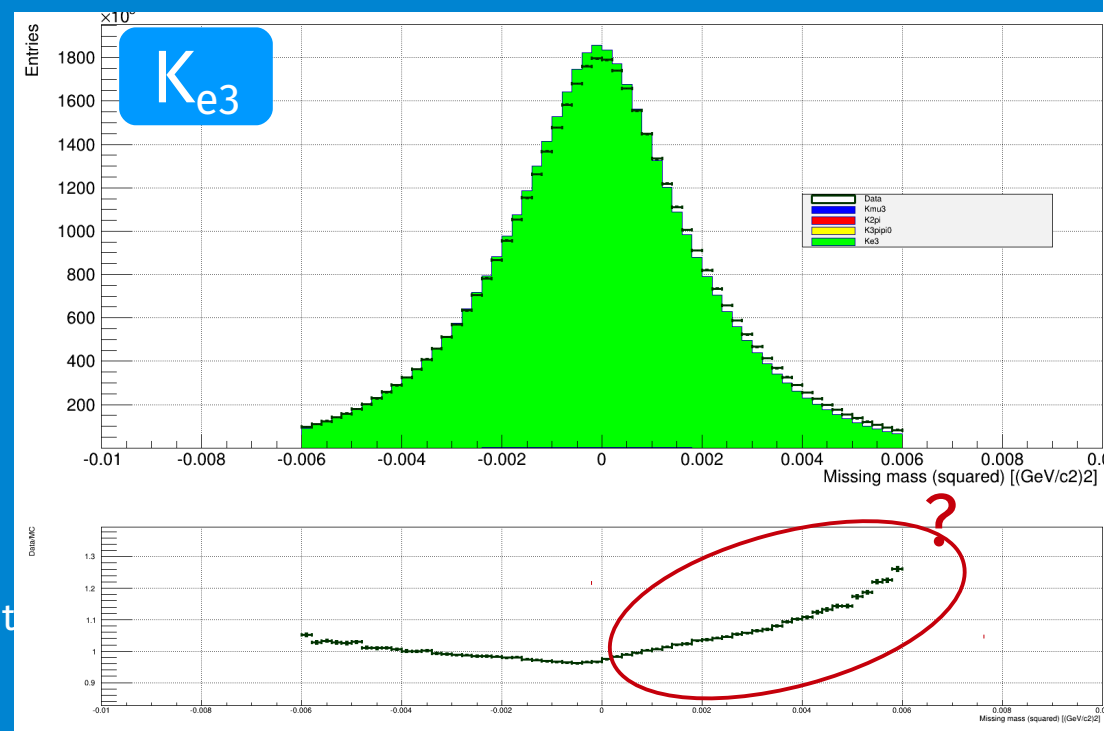


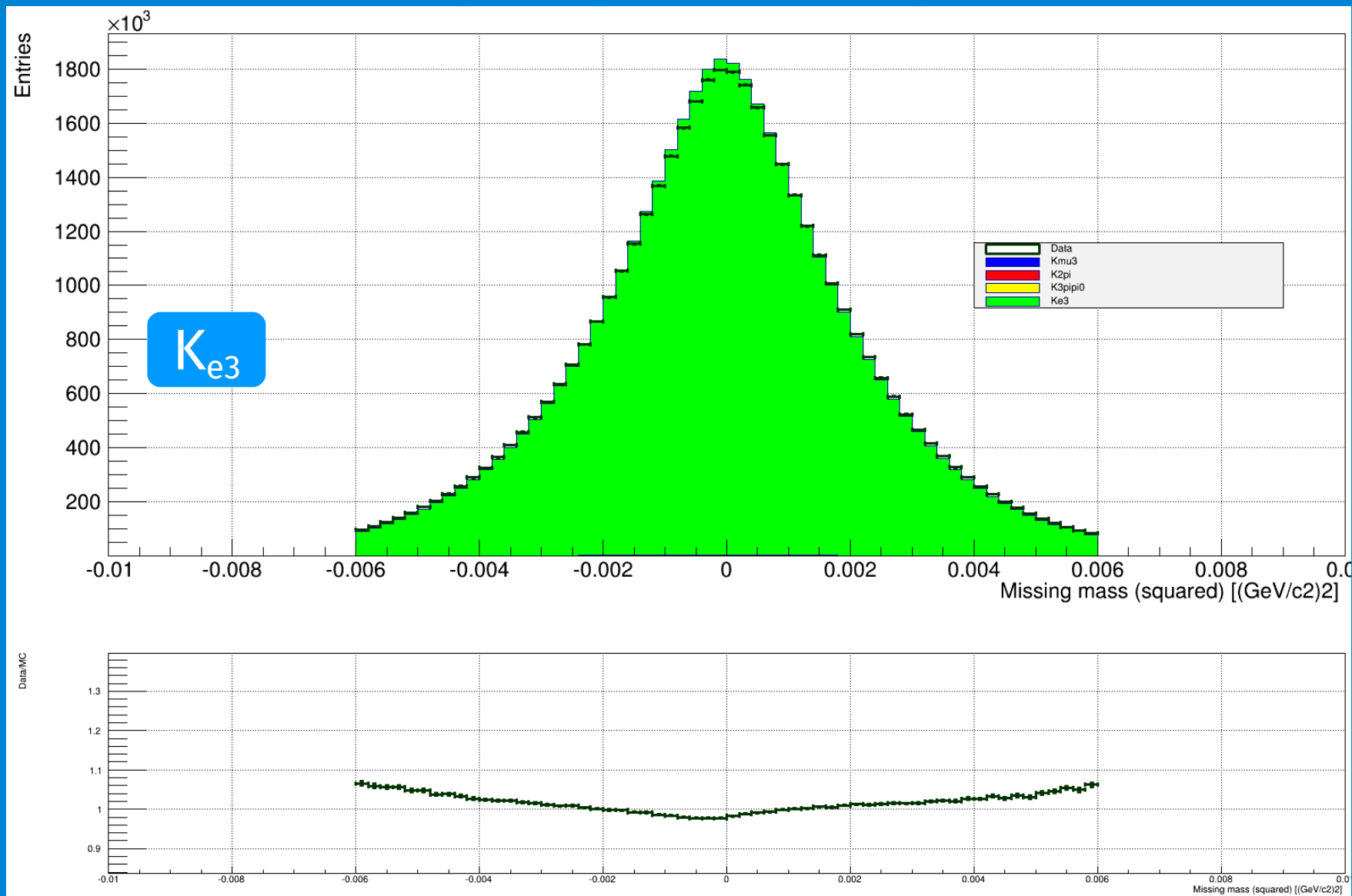


No correction

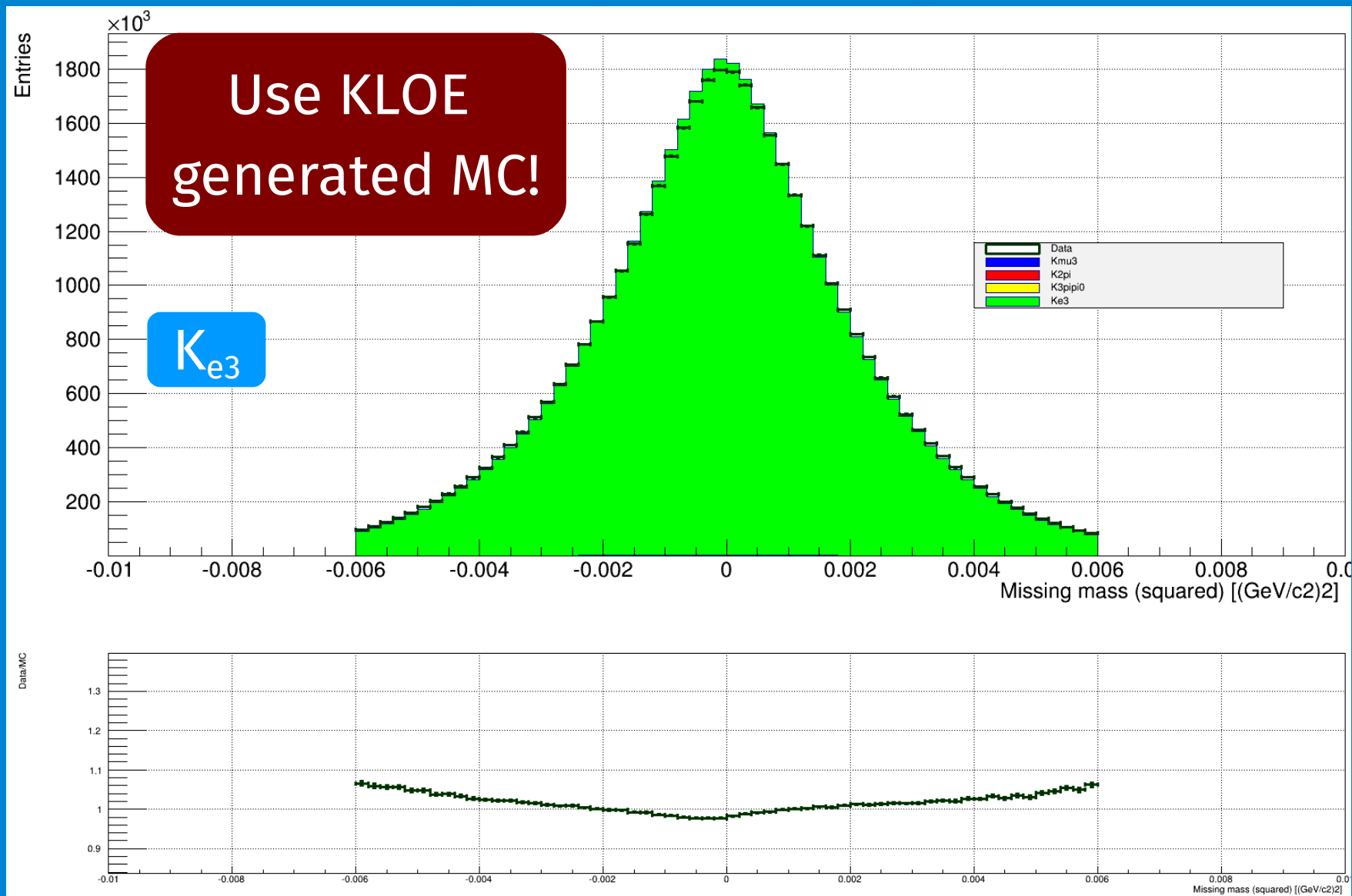
1st order

2nd order





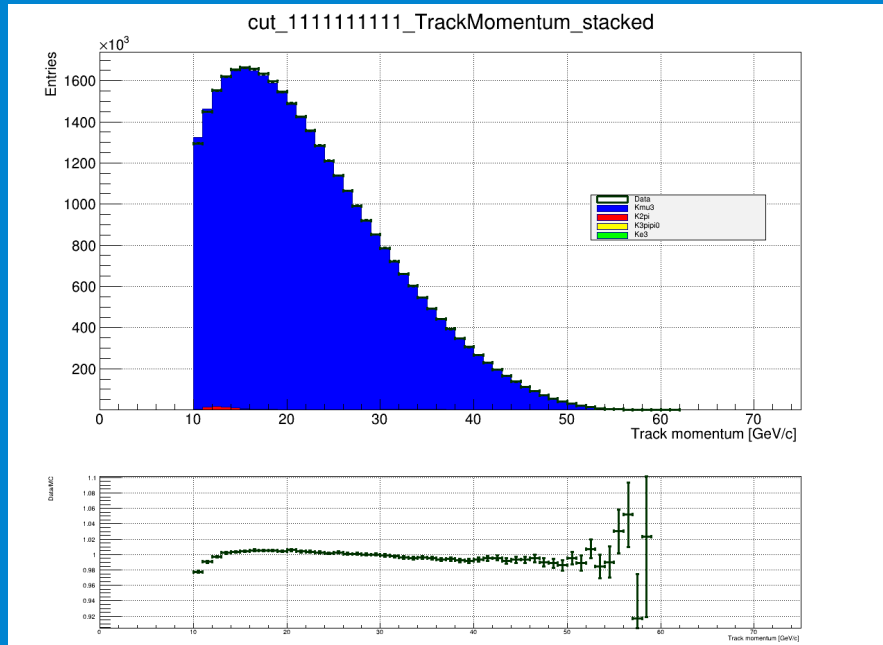
Agreement of Data/MC improved!



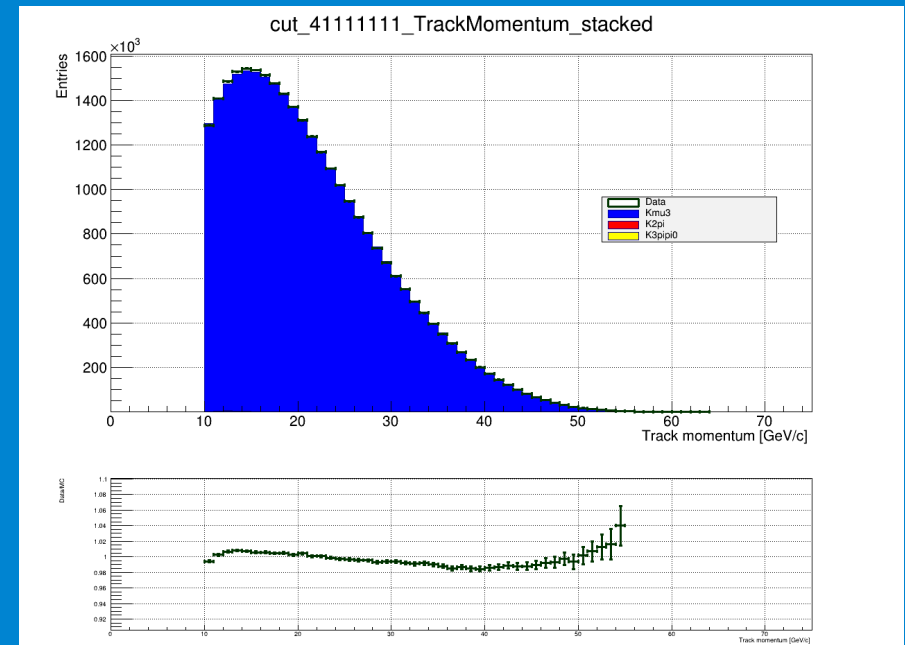
Agreement of Data/MC improved!

Some more Data/MC

Track momenta (1)

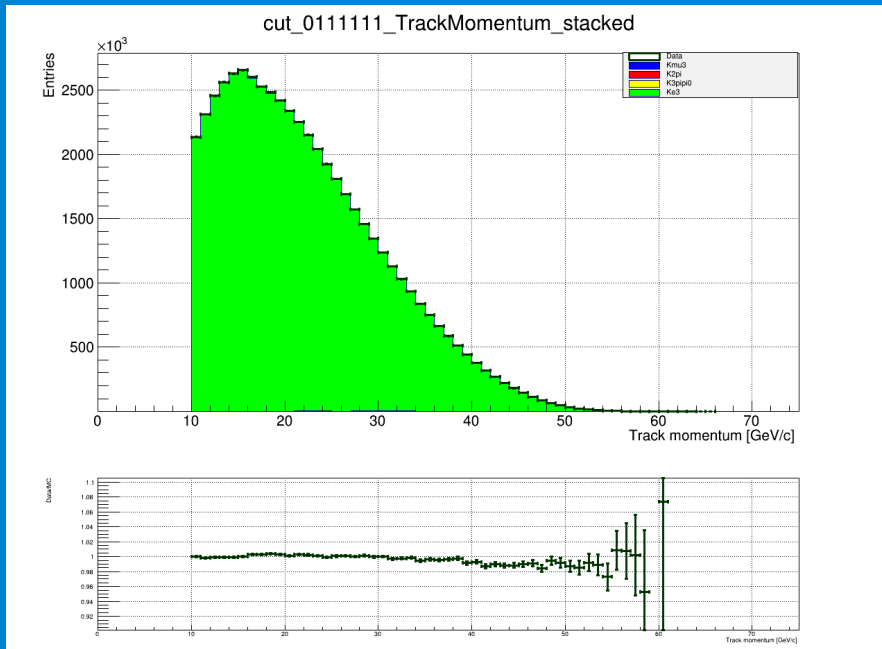


$K_{\mu 3}$ with MUV

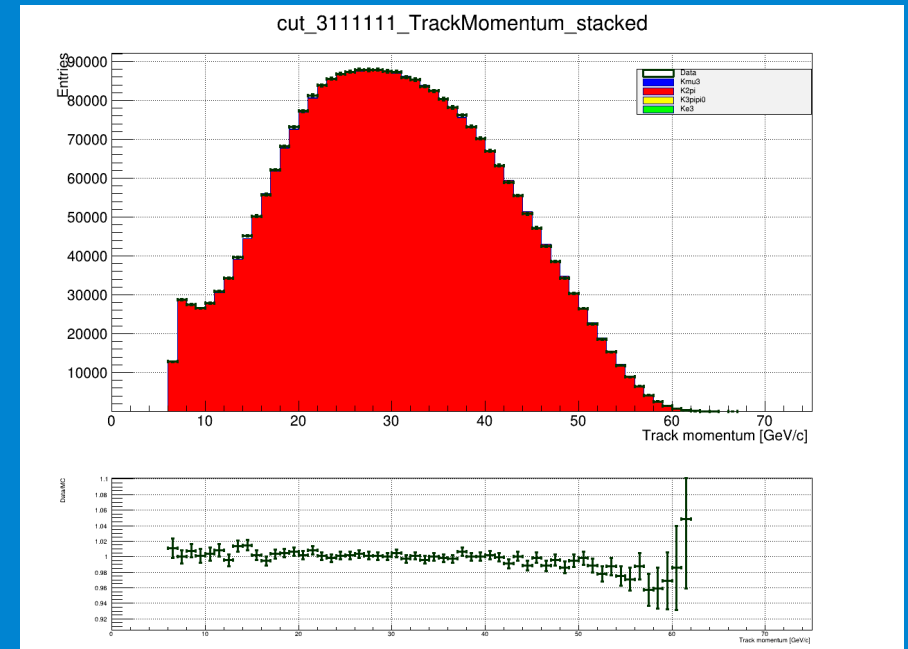


$K_{\mu 3}$ without MUV

Track momenta (2)

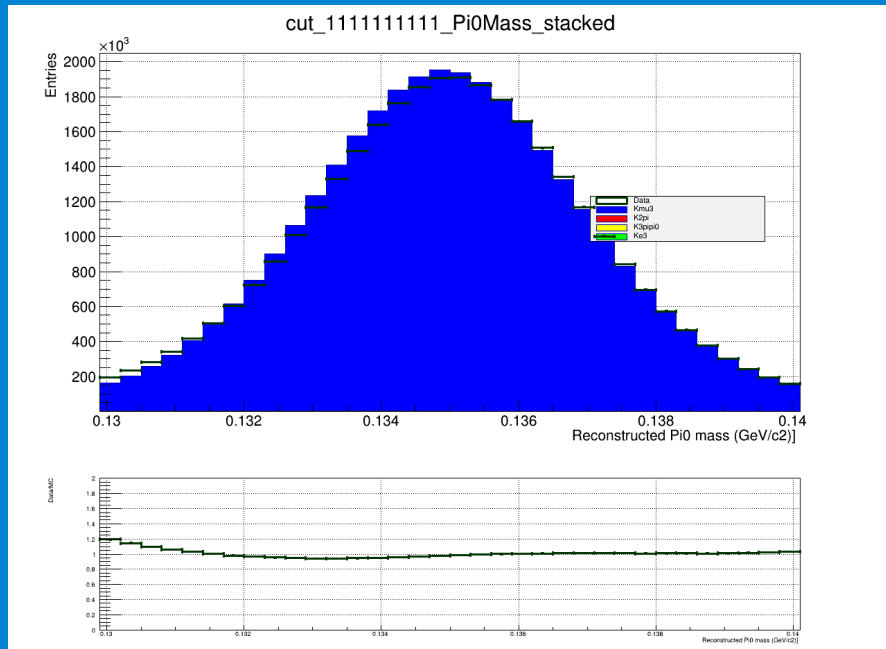


K_{e3}

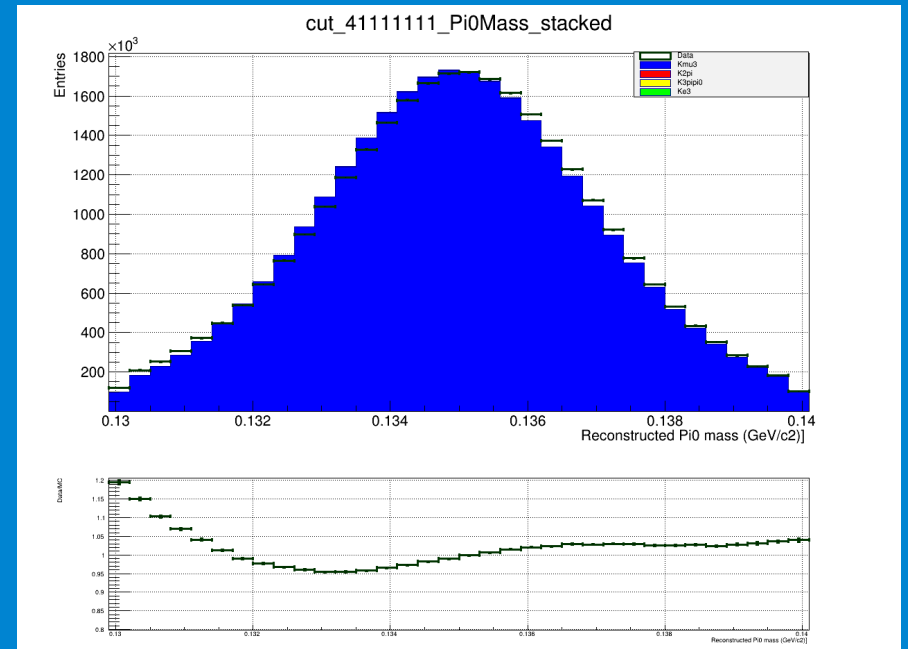


$K_{2\pi}$

π^0 Mass (1)

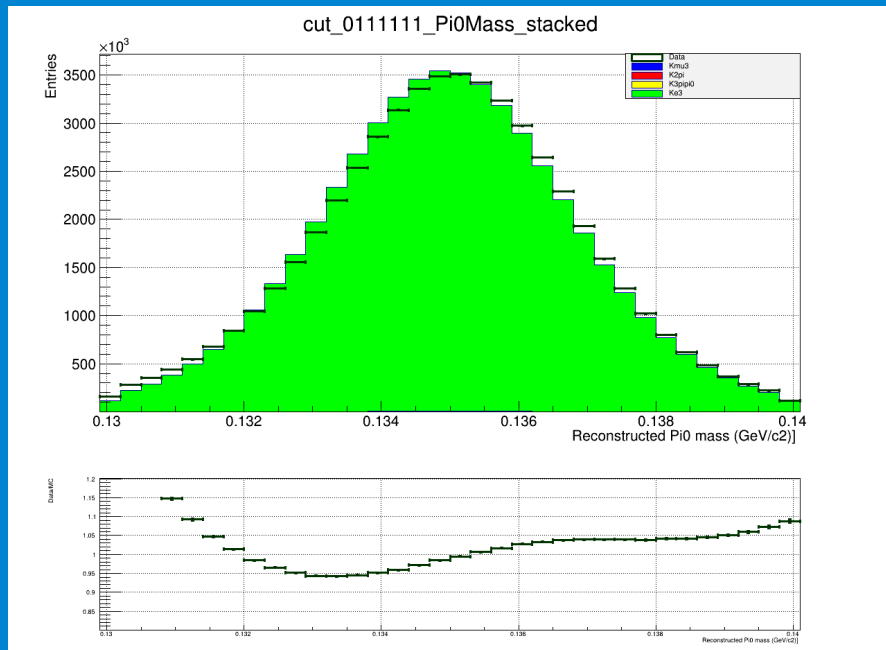


$K_{\mu 3}$ with MUV

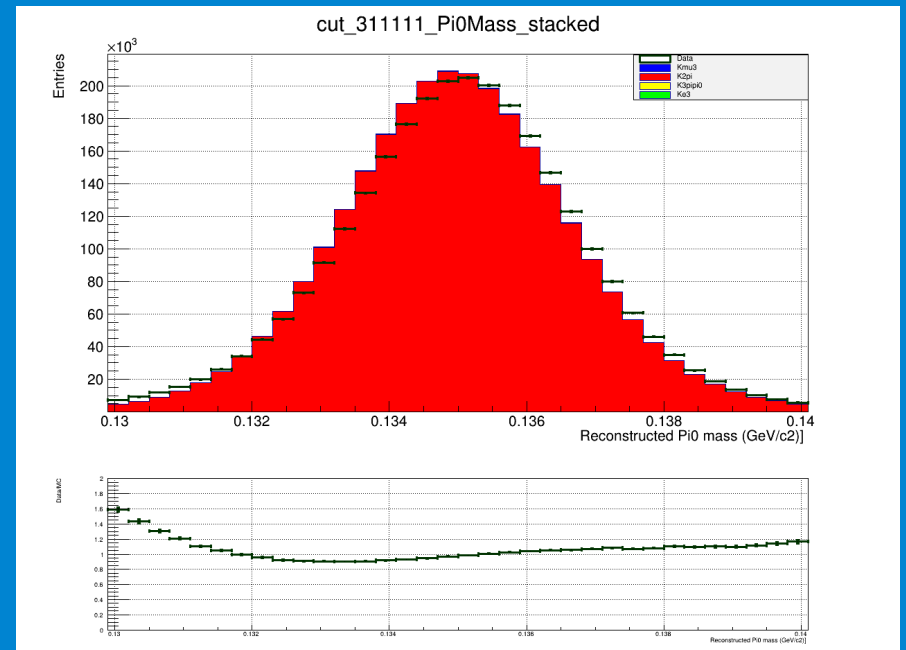


$K_{\mu 3}$ without MUV

π^0 Mass (2)

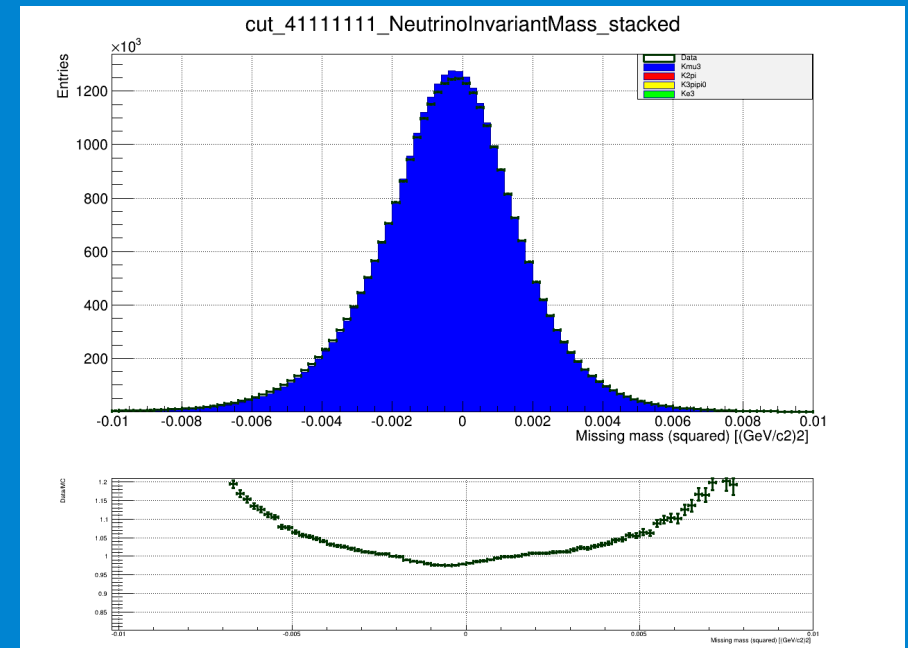
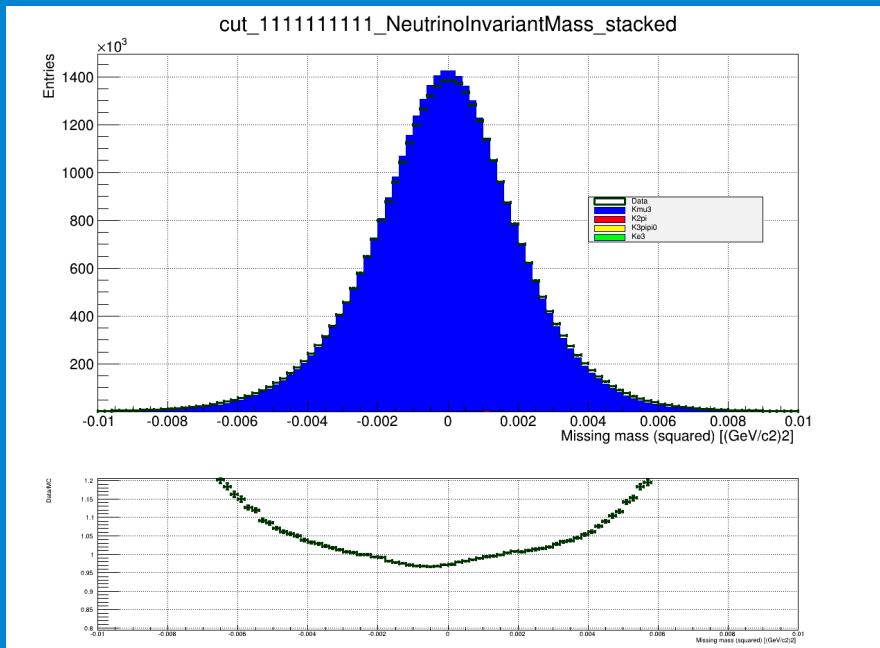


K_{e3}



$K_{2\pi}$

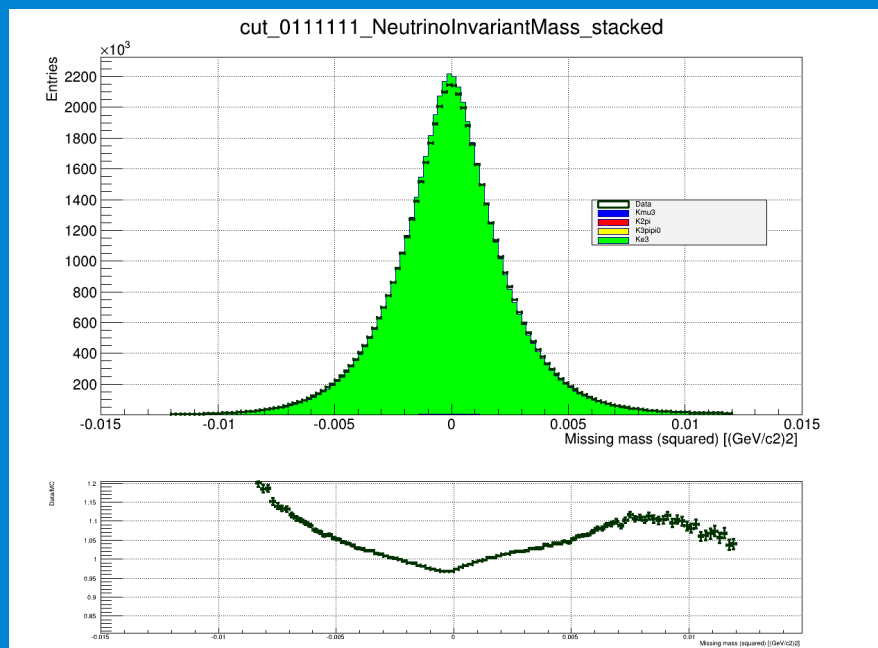
Missing Mass (1)



$K_{\mu 3}$ with MUV

$K_{\mu 3}$ without MUV

Missing Mass (2)



1.2

0.8

K_{e3}

Conclusions

$K_{\mu 3}$ selection without MUV introduced

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$K_{\mu 3}$ selection without MUV introduced

All backgrounds well below 1%

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$K_{\mu 3}$ selection without MUV introduced

All backgrounds well below 1%

Correction of kaon momentum spectrum improves MM^2

Conclusions

$K_{\mu 3}$ selection without MUV introduced

All backgrounds well below 1%

Correction of kaon momentum spectrum improves MM^2

Data/MC: Pion mass show shift $\rightarrow$ Vertex shift?

Conclusions

$K_{\mu 3}$ selection without MUV introduced

A  Thanks for your attention!

Correction of kaon momentum spectrum improves MM^2

Data/MC: Pion momentum shift $\rightarrow$ Vertex shift?

Any questions?

Backup

Selections

Kmu3 (MUV)

Track:

1 track

Track Quality > 0.7

$10 \text{ GeV}/c < p_{\text{track}} < 70 \text{ GeV}/c$

$-1800 \text{ cm} < \text{Charged Vertex} < 8000 \text{ cm}$

$cda < 3.5 \text{ cm}$

Cut on distance of extrapolated track to nearest non assoc. cluster > 12 cm

Acceptance cuts:

$12 \text{ cm} < \text{DCH1Radius} < 115 \text{ cm}$

$14 \text{ cm} < \text{DCH4Radius} < 115 \text{ cm}$

$15 \text{ cm} < \text{MUVRadius} < 130 \text{ cm}$

Timing:

Time between DCH and LKr for track particle < 12 ns

Time difference between clusters < 2 ns

Track Alignment to trigger $118 \text{ ns} < \text{HOD} < 158 \text{ ns}$
or DCH time as fallback

Pi0:

ClusterEnergy > 5 GeV

Min. distance between cluster > 20 cm

Cluster ...

... distance to dead cell > 2 cm

... inside LKR acceptance (Parameter = 8)

... distance to each other > 20 cm

... distance to next cluster > 20 cm

DCH1 radius for photons > 12 cm

$\text{Pi0Mass} - \text{PDG_Pi0_Mass} < 0.01 \text{ GeV}/c^2$

MUV cuts:

Reject inefficient MUV events

Request MUV hit within 10ns to HOD time

Distance of extrapolated position in reco.
position < 30 cm

Further cuts:

Cut in the plane of $M(\pi^+\pi^0)$ and Pi0.Pt

Missing Mass squared < $0.01 (\text{GeV}/c^2)^2$

Total LKr energy - Pi0 cluster energy < 5 GeV

Total LKr energy > 15 GeV

Kmu3 (No-MUV)

Track:

1 track

Track Quality > 0.7

$10 \text{ GeV}/c < p_{\text{track}} < 70 \text{ GeV}/c$

$-1800 \text{ cm} < \text{Charged Vertex} < 8000 \text{ cm}$

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DCH1 radius for photons > 12 cm

$\text{Pi0Mass} - \text{PDG_Pi0_Mass} < 0.01 \text{ GeV}/c^2$

Further cuts:

$P(\text{Muon Pi0}).Pt > 0.015 \text{ GeV}/c$

$(P(\text{Kaon}) - P(\text{Pi}+) - P(\text{Pi0})).M2 < -0.001 \text{ GeV}/c$

Cut in the plane of $M(\text{pi}+\text{pi0})$ and $\text{Pi0}.Pt$

Missing Mass squared < $0.01 (\text{GeV}/c^2)^2$

$E/p < 0.1$

Ke3 (1)

Track:

1 track

Track Quality > 0.7

$10 \text{ GeV}/c < p_{\text{track}} < 70 \text{ GeV}/c$

$-1800 \text{ cm} < \text{Charged Vertex} < 8000 \text{ cm}$

$cda < 3.5 \text{ cm}$

Cut on distance of extrapolated track to nearest non assoc. cluster > 12 cm

Cluster ...

... distance to dead cell > 2 cm

... inside LKR acceptance (Parameter = 8)

Distance track own cluster < 1.5 cm ($P > 25 \text{ GeV}/c$) and < 5 cm ($P < 25 \text{ GeV}$)

Distance track other cluster > 20 cm

Timing:

Time between DCH and LKr for track particle < 12 ns

Time difference between clusters < 2 ns

Track Alignment to trigger $118 \text{ ns} < \text{HOD} < 158 \text{ ns}$
or DCH time as fallback

Track time to own cluster < 4 ns

Acceptance cuts:

$12 \text{ cm} < \text{DCH1Radius} < 115 \text{ cm}$

$14 \text{ cm} < \text{DCH4Radius} < 115 \text{ cm}$

$15 \text{ cm} < \text{MUVRadius} < 130 \text{ cm}$

Ke3 (2)

Pi0:

ClusterEnergy > 5 GeV

Min. distance between cluster > 20 cm

Cluster ...

- ... distance to dead cell > 2 cm

- ... inside LKR acceptance (Parameter = 8)

- ... distance to each other > 20 cm

- ... distance to next cluster > 20 cm

DCH1 radius for photons > 12 cm

Pi0Mass - PDG_Pi0_Mass < 0.01 GeV/c²

Further cuts:

P(Muon Pi0).Pt > 0.015 GeV/c

(P(Kaon)-P(Pi+)-P(Pi0)).M2 < 0.006 GeV/c

Missing Mass squared < 0.012 (GeV/c²)²

0.9 < E/p < 1.1

K2pi

Track:

1 track

Track Quality > 0.7

$10 \text{ GeV}/c < p_{\text{track}} < 70 \text{ GeV}/c$

$-1800 \text{ cm} < \text{Charged Vertex} < 8000 \text{ cm}$

$cda < 3.5 \text{ cm}$

Cut on distance of extrapolated track to nearest non assoc. cluster > 12 cm

Acceptance cuts:

$12 \text{ cm} < \text{DCH1Radius} < 115 \text{ cm}$

$14 \text{ cm} < \text{DCH4Radius} < 115 \text{ cm}$

$15 \text{ cm} < \text{MUVRadius} < 130 \text{ cm}$

Timing:

Time between DCH and LKr for track particle < 12 ns

Time difference between clusters < 2 ns

Track Alignment to trigger $118 \text{ ns} < \text{HOD} < 158 \text{ ns}$
or DCH time as fallback

Pi0:

ClusterEnergy > 5 GeV

Min. distance between cluster > 20 cm

Cluster ...

... distance to dead cell > 2 cm

... inside LKR acceptance (Parameter = 8)

... distance to each other > 20 cm

... distance to next cluster > 20 cm

DCH1 radius for photons > 12 cm

$\text{Pi0Mass} - \text{PDG_Pi0_Mass} < 0.01 \text{ GeV}/c^2$

Further cuts:

$P(\text{Pi}^+ \text{ Pi}^0).Pt < 0.0025 \text{ GeV}/c$

$M(K) - P(\text{Pi}^+ \text{ Pi}^0).M < 0.01 \text{ GeV}/c$

$E/p < 0.95$