KTeV
Progress Report on the Search for
$K_L \rightarrow \mu^{\pm} e^{\mp} e^{\pm} e^{\mp}$

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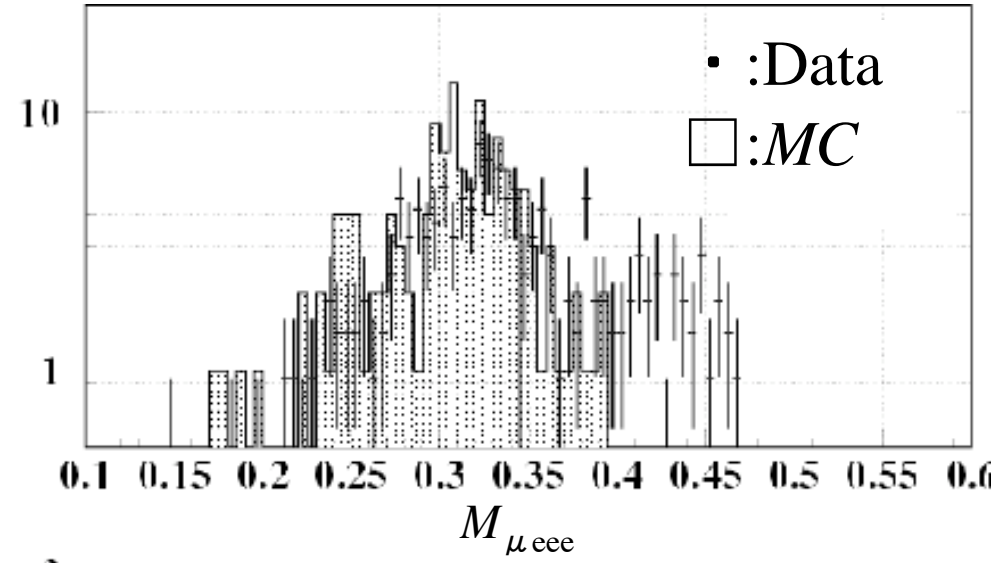
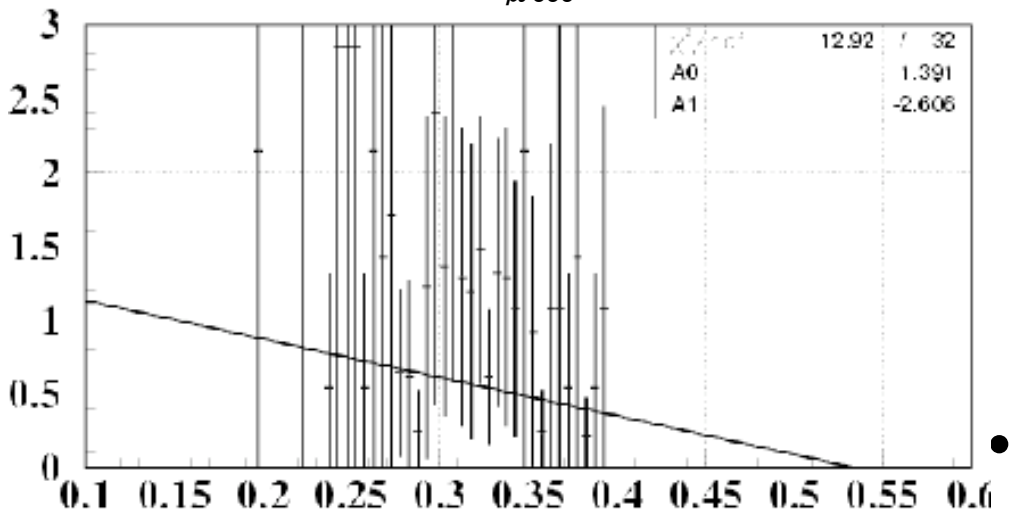
at Fermilab.

At Last Meeting $M_{eee\mu}$





- '97 winter
  20<p3kaon<120 (GeV/c)
  90<vtxz<158 (m)
  ptsq<0.00025 (GeV^2/c^2)
  0.95<E/p<1.05
  for electron track
  vtxchi<40
  Track separation at DC1
  >0.001 (m)
  nhclus 3~5
  -0.001<magoff<0.001 (m)
  for μ track
  vtx projected to the Csi;
  vtxxcsi, vtxycsi (m)
  ||vtxxcsi|-0.15|<0.05
  |vtxycsi|<0.05
- MC $\pi^{\pm}\pi^{+}\pi^{0}{}_{d}$:Scaled

•At last meeting I assumed that the background was dominated by $K_L \rightarrow \pi^{\pm}\pi^{+}\pi^{0}{}_{d}\,(\pi^{0} \rightarrow ee\gamma)$

•In this case one of $\pi^{\pm}$ has to be misidentified as an $e^{\pm}$.

$\downarrow$

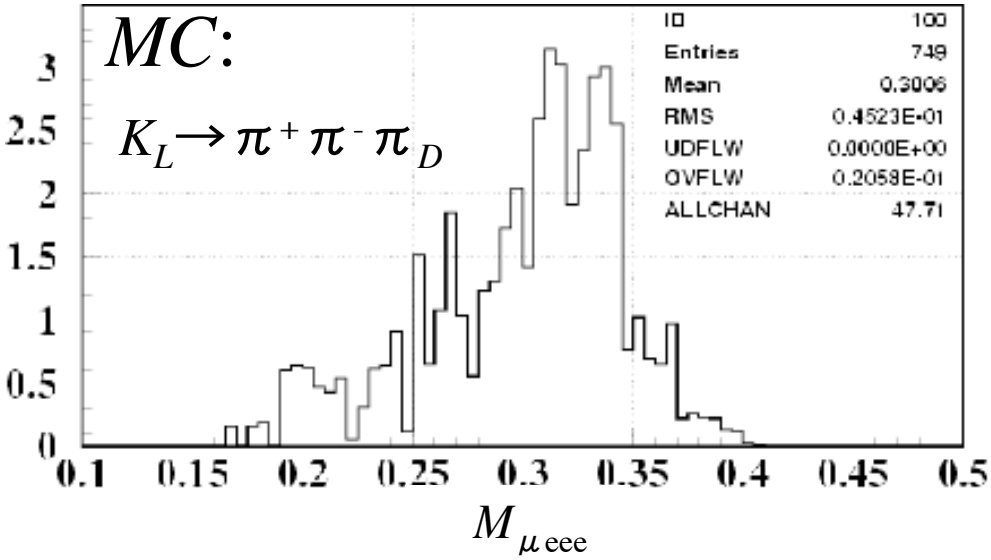
•TRDcut mostly rejects this background

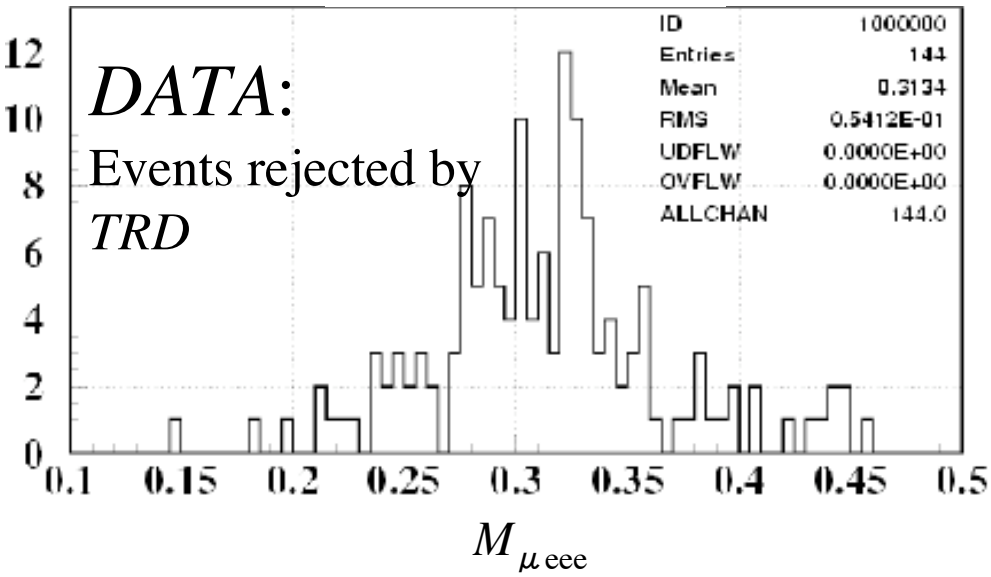
$\downarrow$

We required The Pion Probability for electron tracks to be

Pion Probability < 0.03

MC of $K_L \rightarrow \pi^+\pi^-\pi^0{}_D$

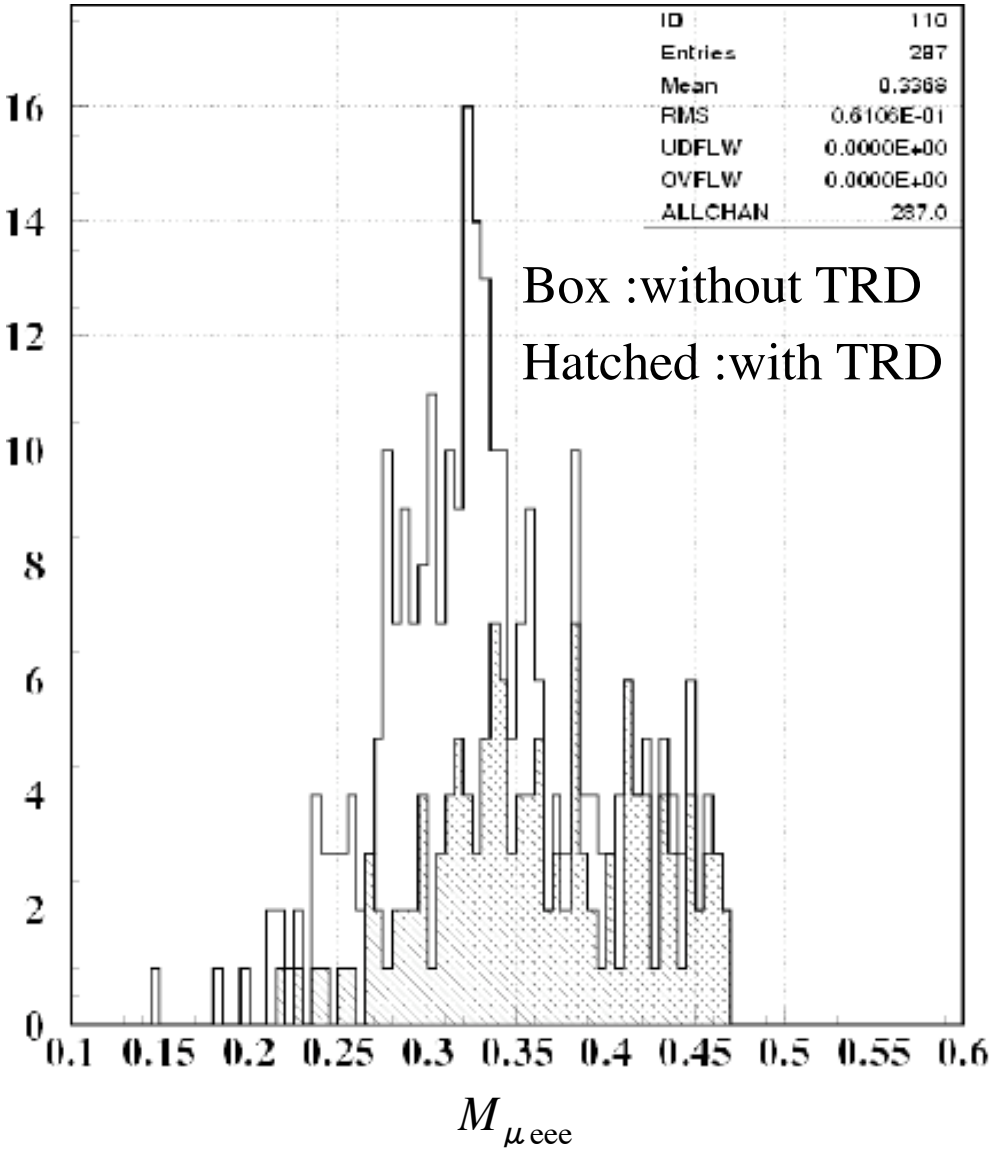




- The invariant mass distributions look similar.
- The number of *MC* background events is < 1/2 of data.
- $K_L \rightarrow \pi^+\pi^-\pi^0{}_d$ does not dominate to background.

１０．０cm

Effect of TRD



- '97 Data set
  winter + summer

  287 events
  ↓
  137 events

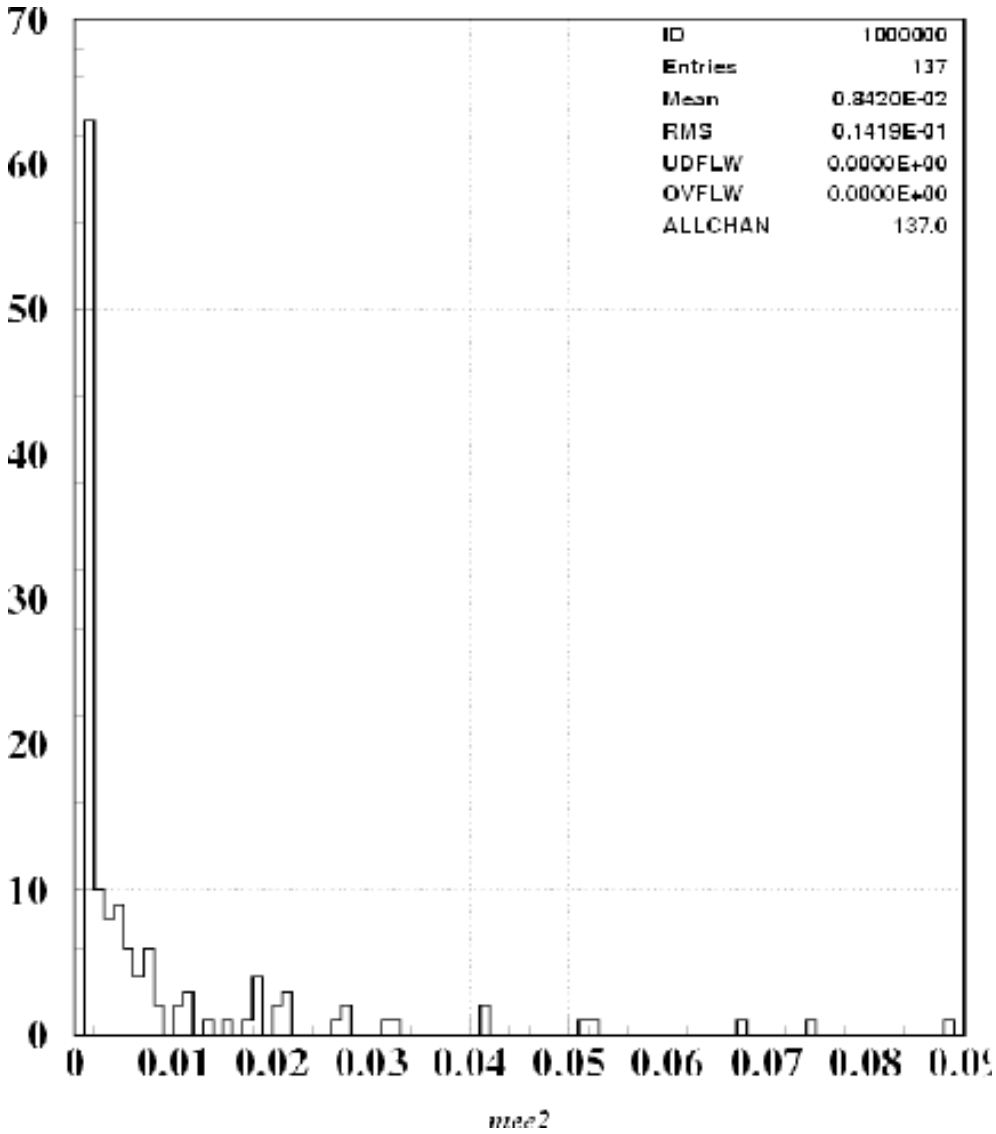
- Events near M_{kaon} almost remained.

What can be the Background ?

Let's look at the kinematical feature of the residual events.

1) Invariant mass of e^+e^- pair.

Minimum Invariant mass of e^+e^- pair.

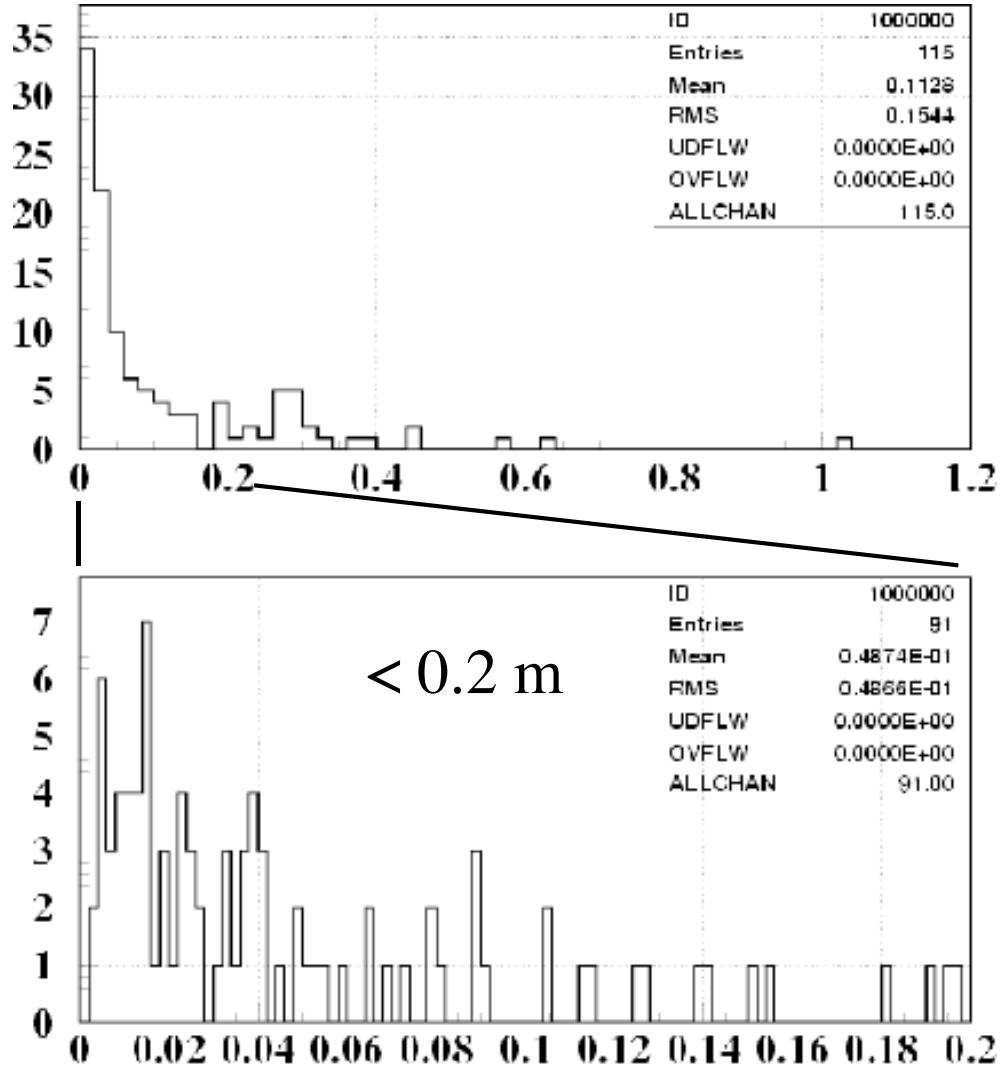


- Most of them have near 2 electron masses

  $\rightarrow$ e^+ e^- pair is due to Conversion of γ
- External conversion ?

  or
- Internal conversion ?

Where did the conversion occur ?



Track separation at DC1

Conversions did not occur at the Vacuum window

Which decay mode has a virtual gamma

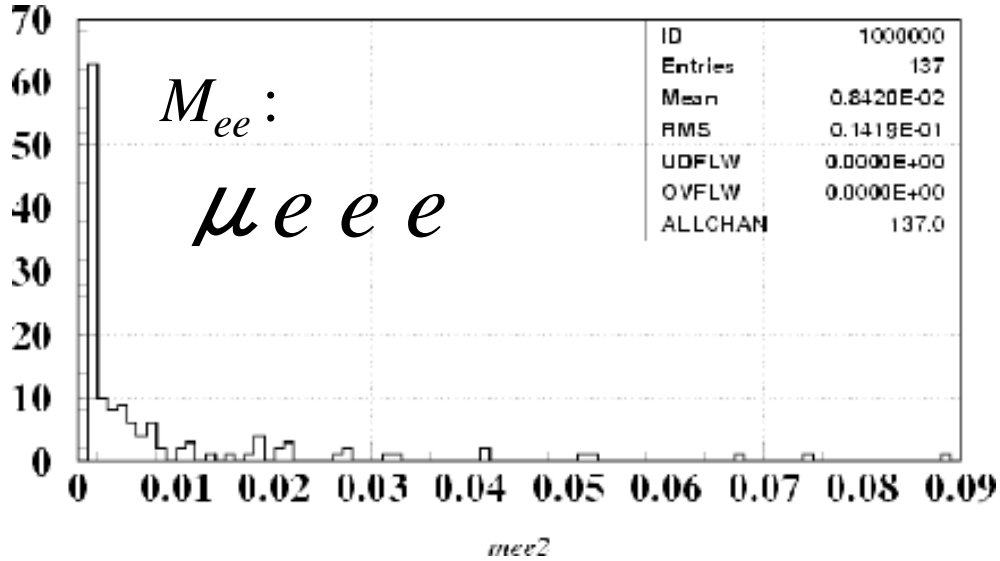
and can be background ?

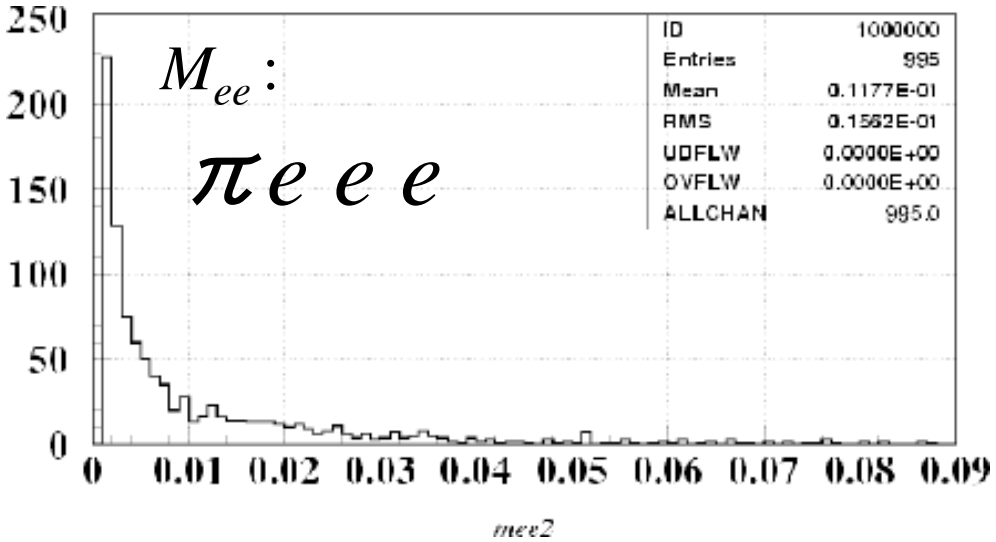
$$K_L \to \pi e \nu \gamma^* \hookrightarrow e\, e \Big\} \boxed{K_L \to \pi\, e\, e\, e} \Big\} K_L \to \mu\, e\, e\, e$$

$$\boxed{K_L \to \pi\, e\, e\, e} \hookrightarrow \mu$$

Let's study directly $\pi^{\pm} e^{+} e^{\pm} e^{+}$ events in the data.

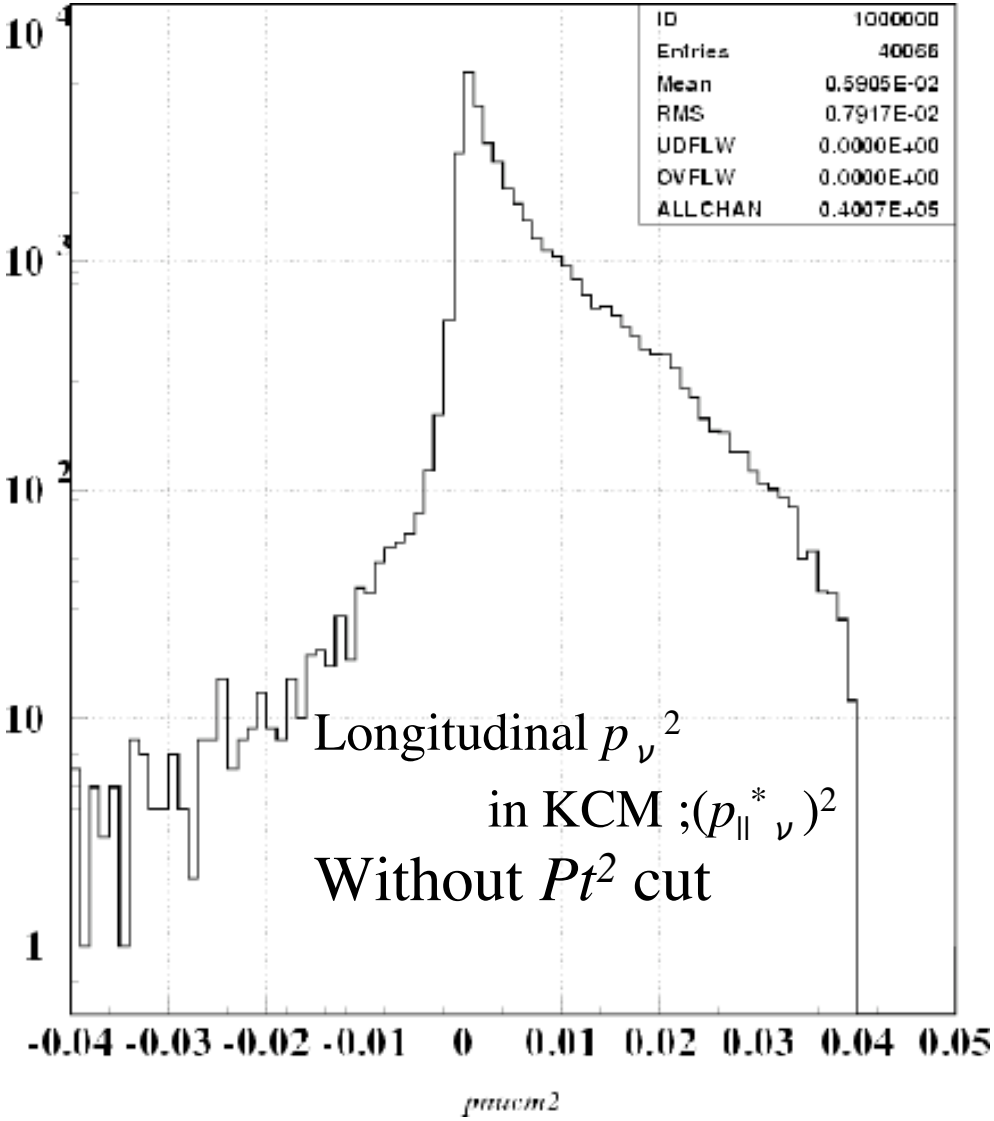
π eee has small invariant mass of e^+e^- pair system too ?





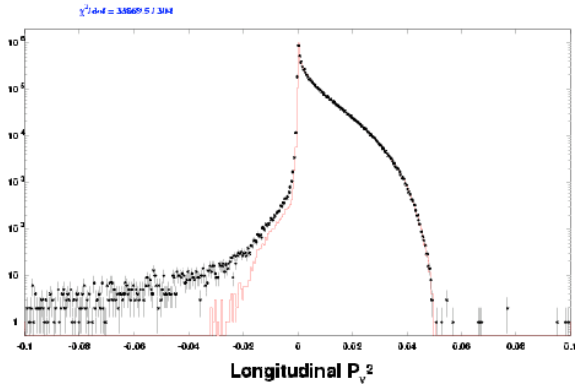
- Both peaks at $M_{ee} \sim 2 \times Me$

Is [π eee] event due to $K_L \rightarrow \pi e \nu \gamma^*$?

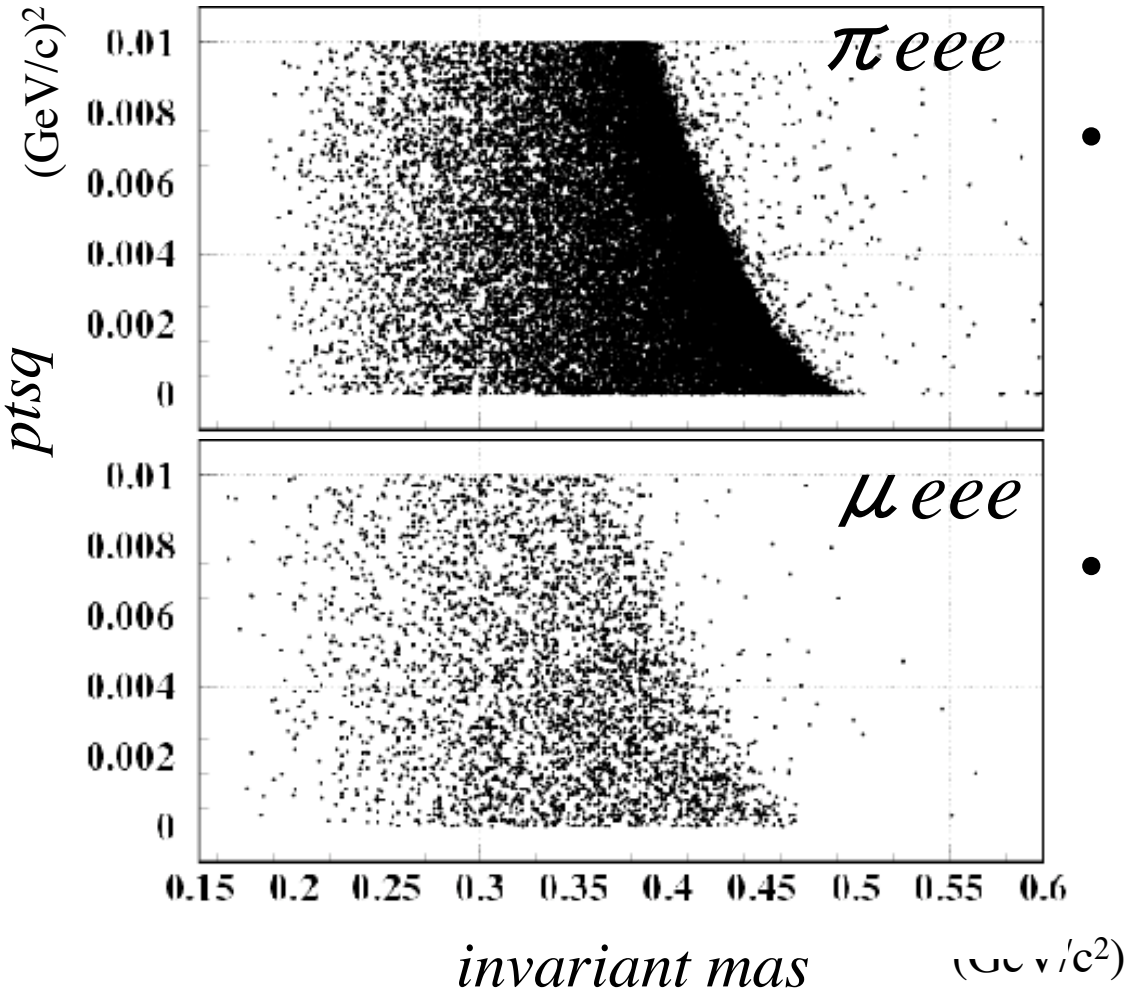


- $(p_{\parallel}^{*}{}_\nu)^2$ of data is close to that of Ke3.

$(p_{\parallel}^{*}{}_\nu)^2$ Data and *MC* of *Ke3* from *'Long Writeup for Measurement of* δ_L *in 1997 KTeV Data'* Hogan



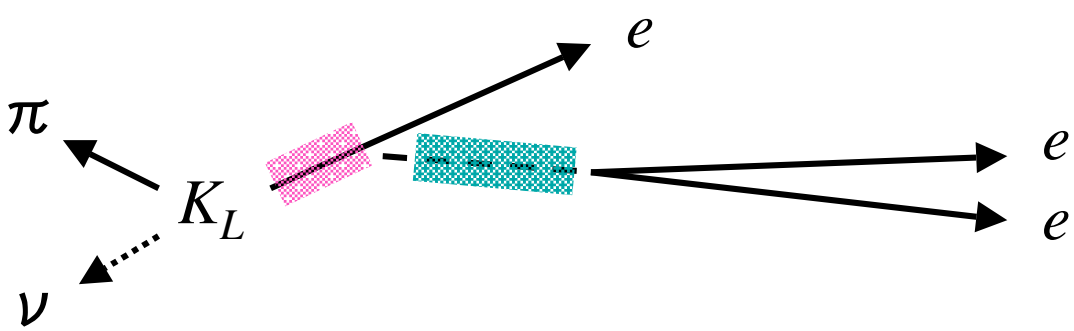
How about the correlation between *ptsq* and *Invariant mass*($M_{\mu eee}, M_{\pi eee}$)



- The distributions look similar.
- Missing particle(s) take away some momentum and then corresponding mass is lost from invariant mass.
- These support the prediction that the events remaining as μeee are due to πeee.

How about 3-electron *invariant mass* ?

- If *Ke3* emits a gamma by *Inner Brem.*,
  the energy of gamma is following the low of $1/E_{\gamma}$.

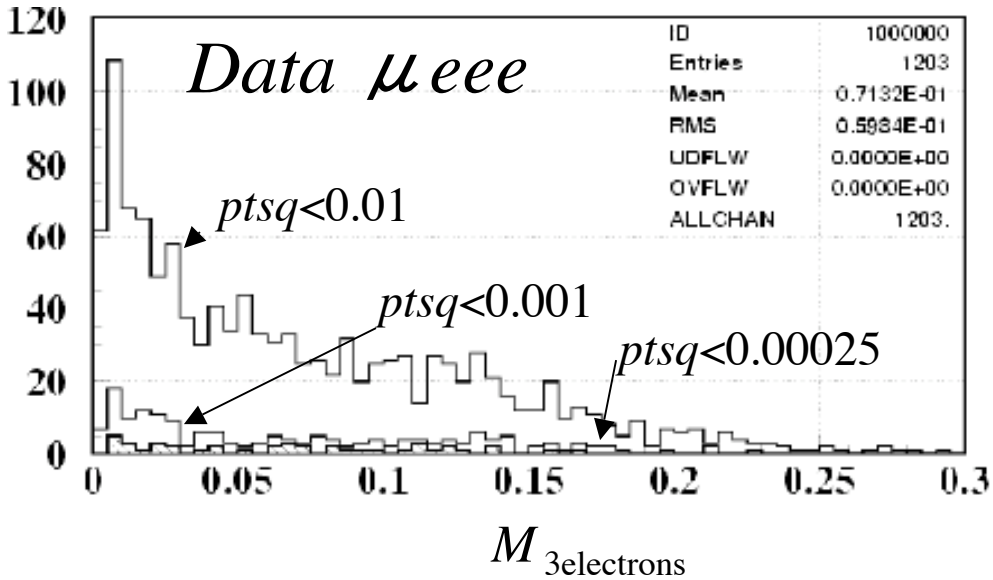


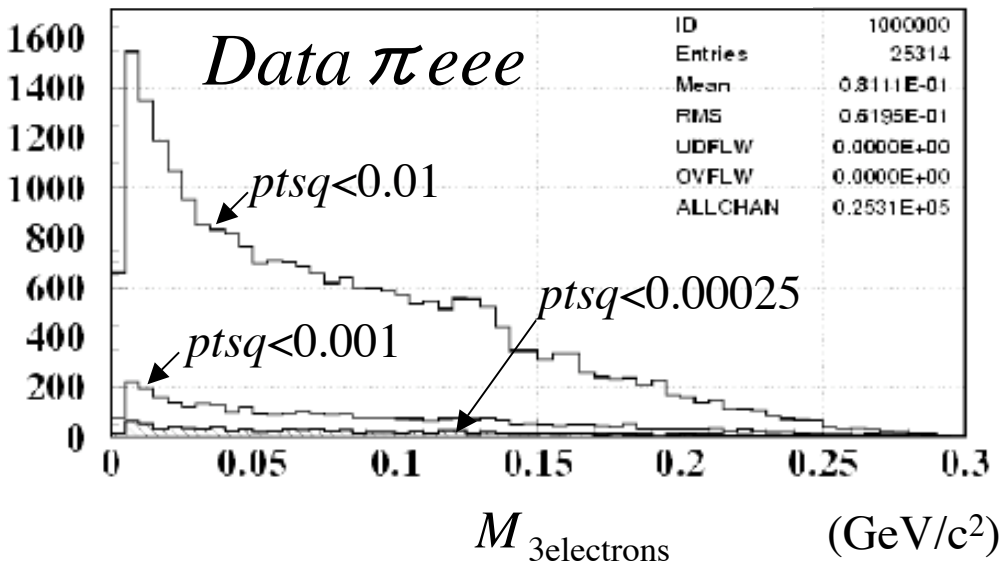
$M_{ee\ pair} \sim 2\ Me$

M_{3elec} Distribution should be affected by $1/E_{\gamma}$
→ Much small M_{3elec} →**See E_{γ}***

- Very small ν momentum imposes large $M_{\pi eee}$
  →Large M_{3elec} ? → see*MC*

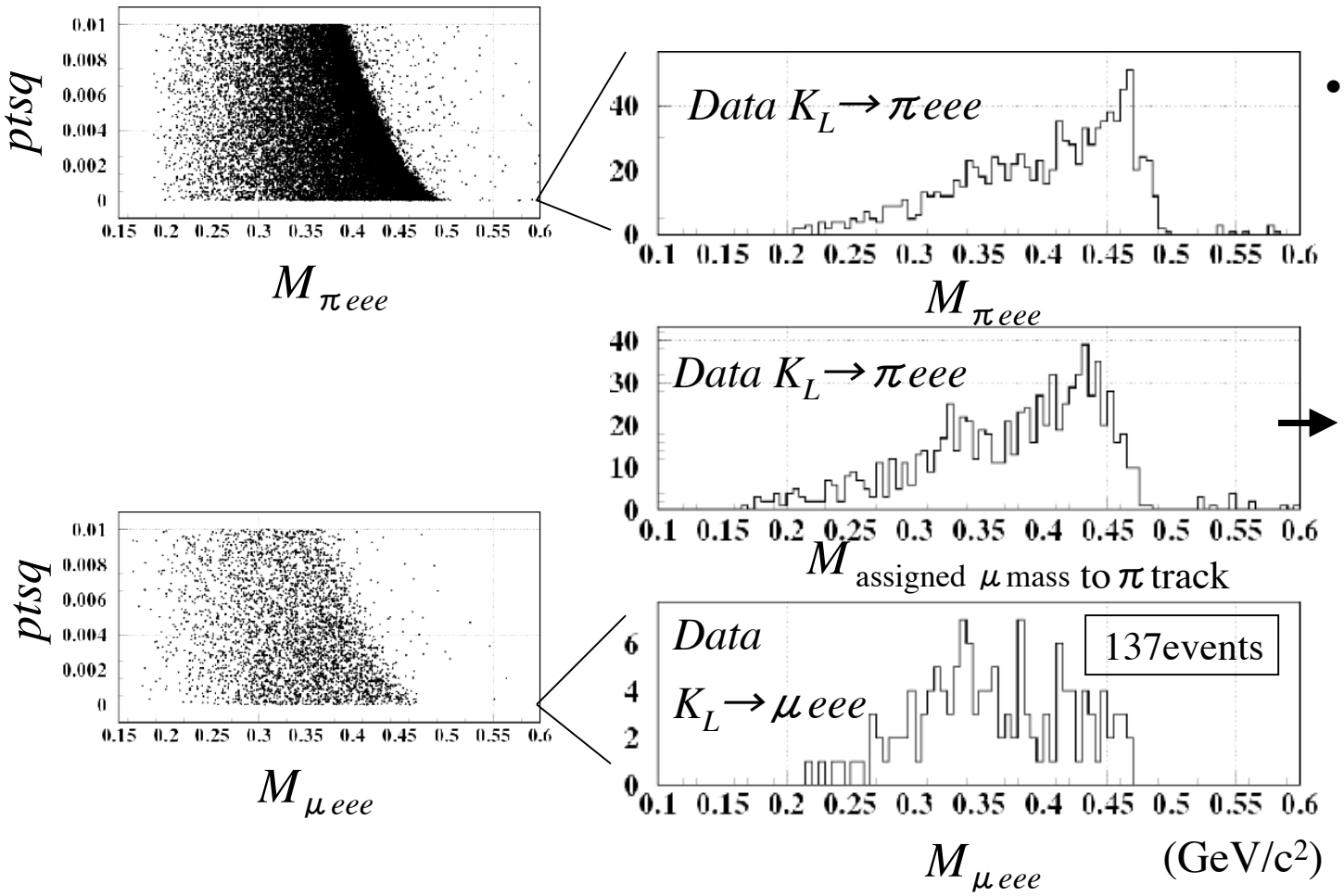
$M_{3electrons}$





- M_{3elec} of μeee and πeee samples behave similarly as we cut on *ptsq*
- M_{3elec} of residual events after *ptsq* cut has a broad distribution.

$M_{\pi eee}$ with small *ptsq*(0.00025 (GeV/c)^2)



- Number of πeee events $\times < \pi$ decay/punch through prob> ~155

Tracks identified as π were assigned μ mass

Conclusions and Next steps

Conclusions

- $K_L \rightarrow \pi^{\pm}\pi^{+}\pi^{0}{}_{d}$ is not main background.
- $K_L \rightarrow \pi e \nu \gamma^{*}$ is likely to be the background, especially the component of near M_{Kaon}
- $M_{\gamma^{*}}$ is about 2 *Me*
- Remaining events have a broad M_{3elec} distribution.

Next Steps

- Study of $E_{\gamma^{*}}$ in $K_L \rightarrow \pi e \nu \gamma^{*}$
- *MC* of $K_L \rightarrow \pi e \nu \gamma^{*} \rightarrow K_L \rightarrow \pi e e e$ and $K_L \rightarrow \mu e e e$.