

# $K_L \rightarrow \pi^0 \mu \mu$ and $K_L \rightarrow \mu \mu \gamma \gamma$ Update

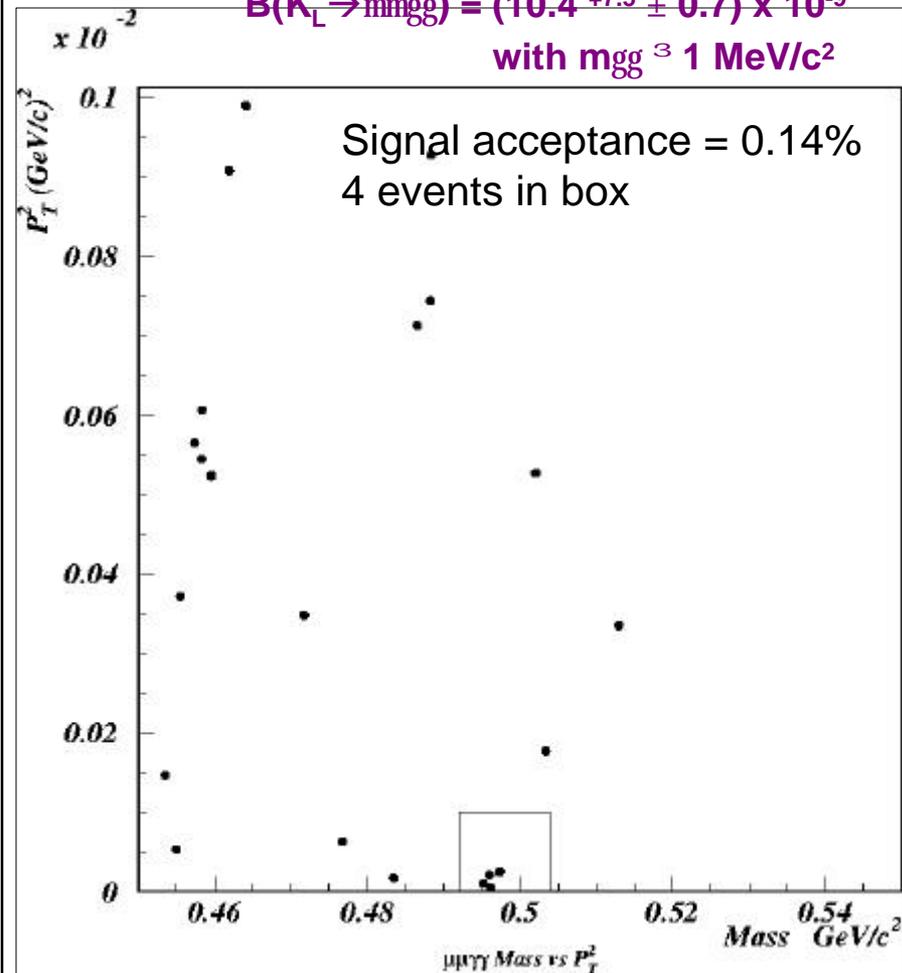
- Outline
  - Issues from last meeting
    - Extra events in 1997  $\mu \mu \gamma \gamma$  analysis
    - Larger backgrounds in 1999  $\pi^0 \mu \mu$  analysis
  - Plans

# $K_L \rightarrow \mu\mu\gamma\gamma$ : 1997 Crosscheck

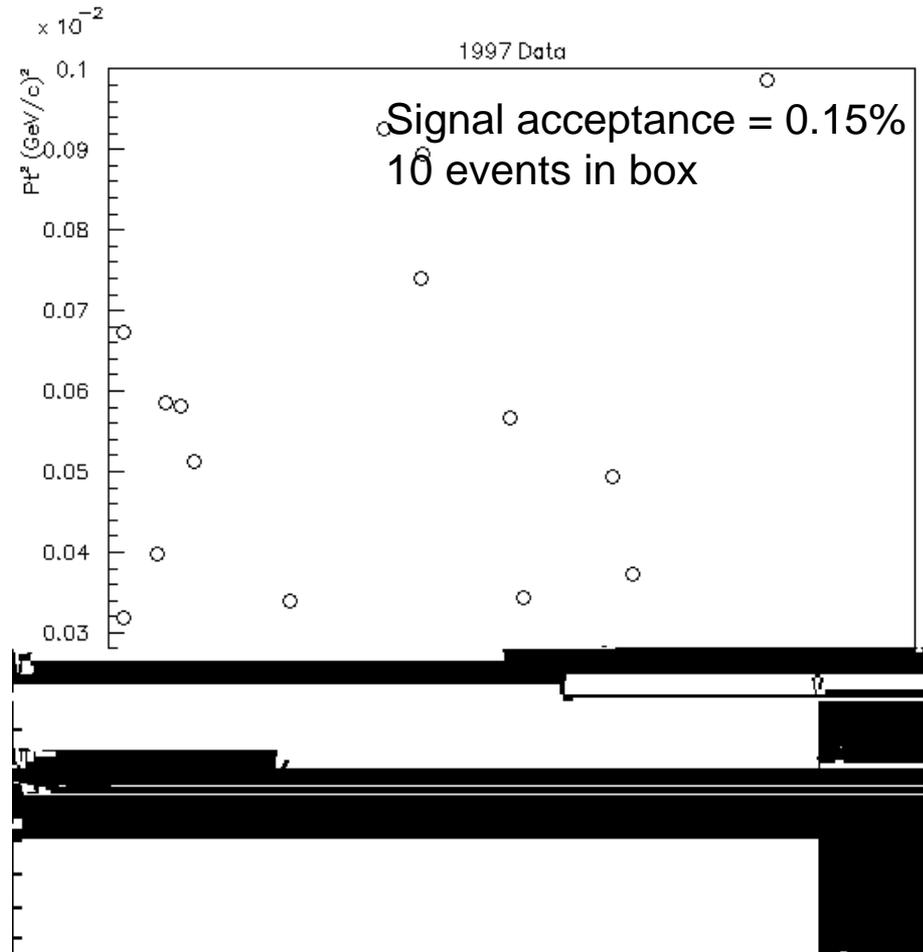
## Published - 1997 Data

$$B(K_L \rightarrow \mu\mu\gamma\gamma) = (10.4^{+7.5}_{-0.7}) \times 10^{-9}$$

with  $m_{gg} \geq 1 \text{ MeV}/c^2$



## JAWS Analysis: 1997 Data



# $K_L \rightarrow \mu\mu\gamma\gamma$ : CsI Thresholds

- Energy thresholds in CSI799 option = 01 ( $\mu$ s + EM showers)
  - Block Threshold = 50 MeV
  - Cluster Threshold = 100 MeV
- Hot bits Events
  - Increase Block Thresh = 100 MeV
  - Increase Cluster Thresh = 250 MeV

## KTeV Event Display

/usr/kpasa/fnal03/jaws/strip\_mmgg\_NQDM04.dat

Run Number: 8327  
Spill Number: 273  
Event Number: 38191993  
Trigger Mask: 30

### All Slices

### Track and Cluster Info

HCC cluster count: 2

ID Xcsi Ycsi P or E

[ T 1: -0.0067 0.0504 +17.41

C 2: -0.0130 0.0597 0.39

[ T 2: 0.0698 0.2315 -20.93

C 1: 0.0824 0.2352 0.37

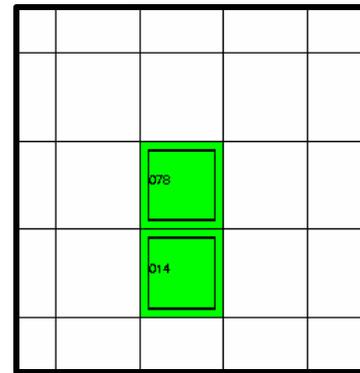
C 3: -0.6004 -0.2457 15.15

### Vertex: 2 tracks

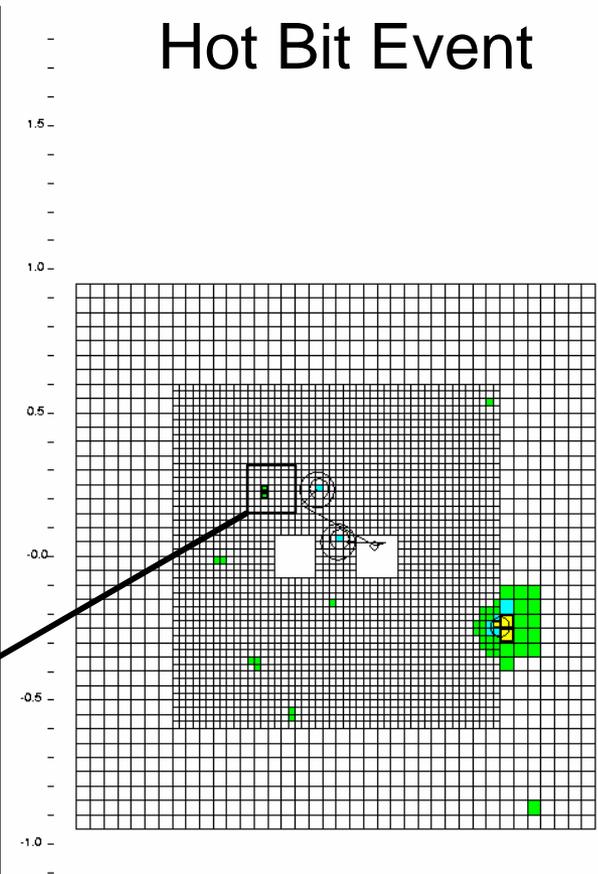
X Y Z  
-0.1039 0.0284 137.484

Mass=0.3337 (assuming pions)

Chisq=0.00 Pt2v=0.026910

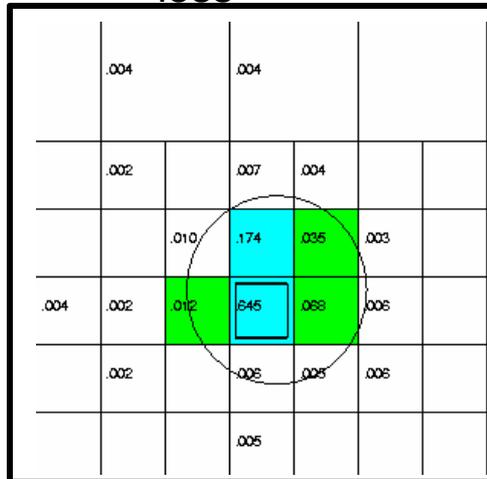


## Hot Bit Event

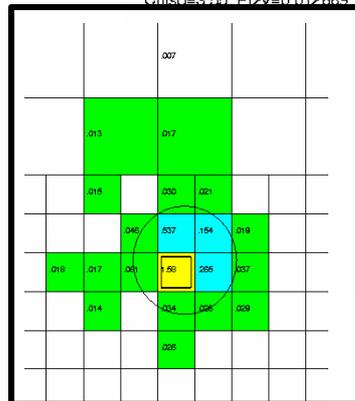


# $K_L \rightarrow \mu\mu\gamma\gamma$ : CsI Thresholds

- Low threshold events
  - Not a problem if they are modeled in MC
  - But high threshold events could be a problem since I do not impose a minimum  $E_\gamma$  cut
- Minimum energy cut of  $\sim 2$  GeV
  - Most  $\mu\mu\gamma\gamma$  evts have 1 low  $E_\gamma$
  - 2 GeV cut:  $\sim 17\%$  additional signal loss



3.12 GeV

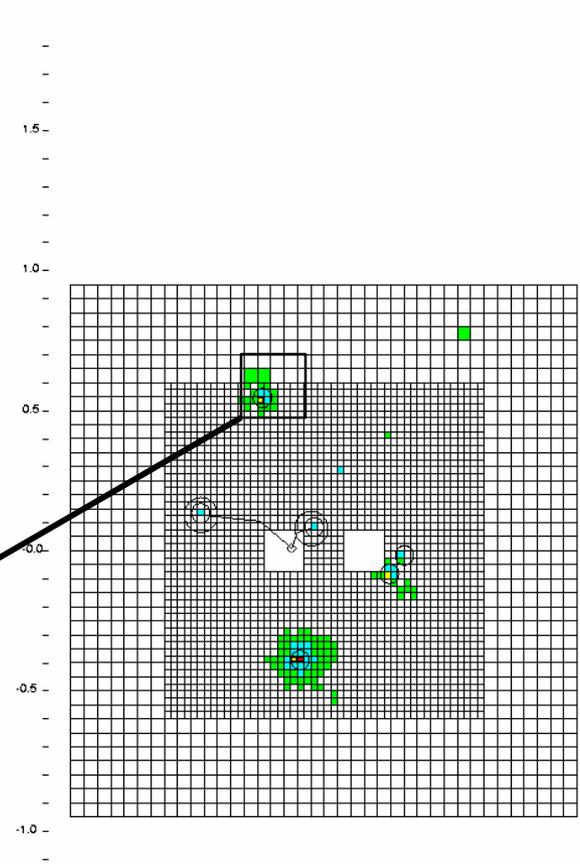


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KTeV Event Display
/usr/kpasa/fnal03/jaws/strip
_mmkg_NQDM25.dat
Run Number: 10493
Spill Number: 54
Event Number: 7818700
Trigger Mask: 10
All Slices

Track and Cluster Info
HCC cluster count: 2
ID Xcsi Ycsi P or E
T 1: 0.0480 0.0788 +71.71
C 3: 0.0372 0.0848 0.38
T 2: 0.4825 0.1277 -16.73
C 1: 0.4631 0.1349 0.38
C 2: 0.2315 0.5451 3.12
C 4: 0.0903 -0.3902 21.14
C 5: -0.3012 -0.0169 0.11
C 6: -0.2463 -0.0826 1.98

Vertex: 2 tracks
X Y Z
0.0812 0.0060 123.940
Mass=0.3700 (assuming pion)
Chisq=3.55 Pt2v=0.012689
    
```

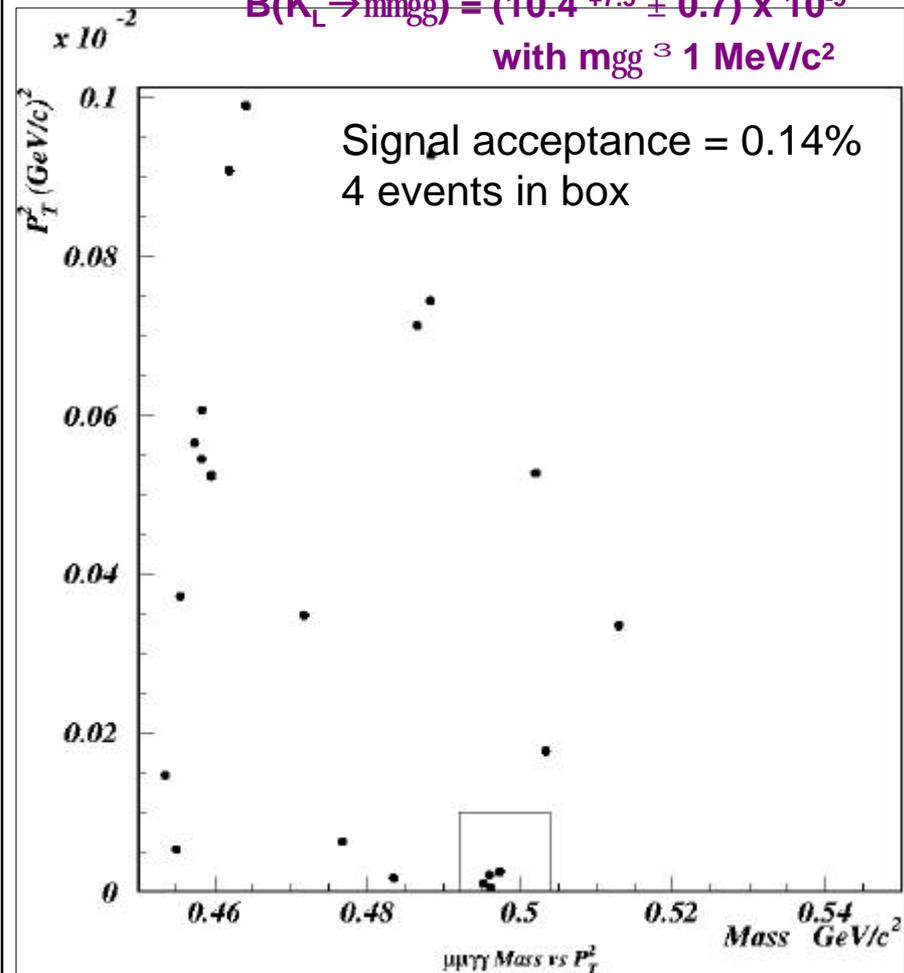


# $K_L \rightarrow \mu\mu\gamma\gamma$ : 1997 Crosscheck

## Published - 1997 Data

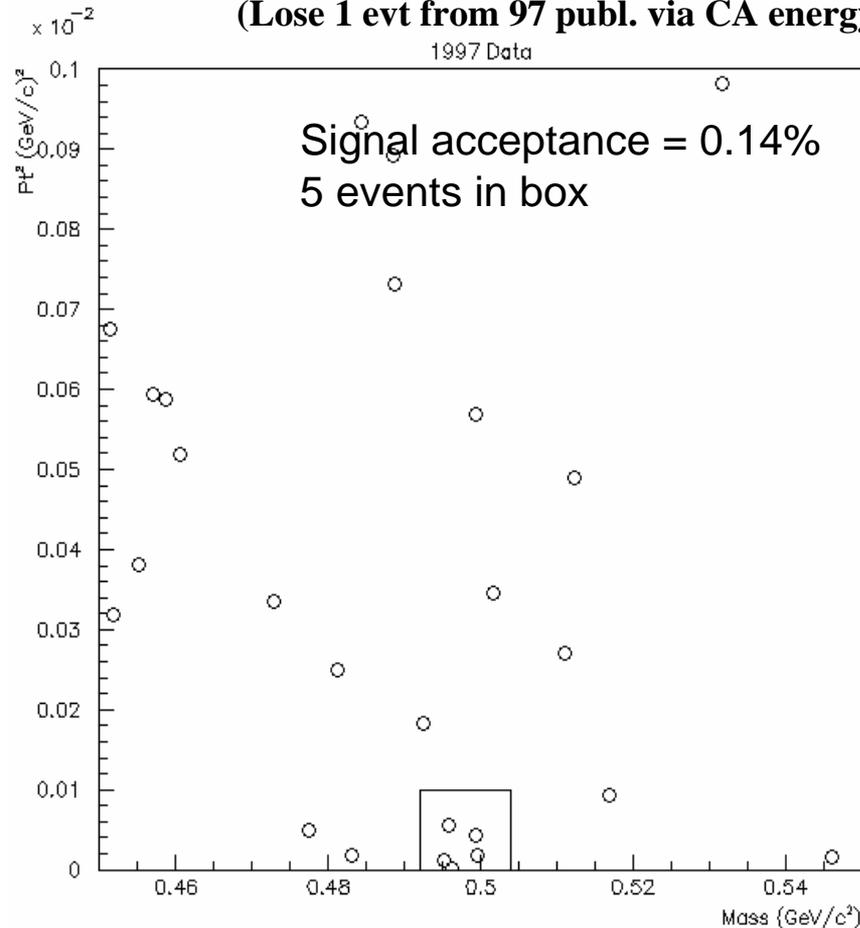
$$B(K_L \rightarrow \mu\mu\gamma\gamma) = (10.4^{+7.5}_{-0.7}) \times 10^{-9}$$

with  $m_{gg} \approx 1 \text{ MeV}/c^2$



## JAWS Analysis: 1997 Data

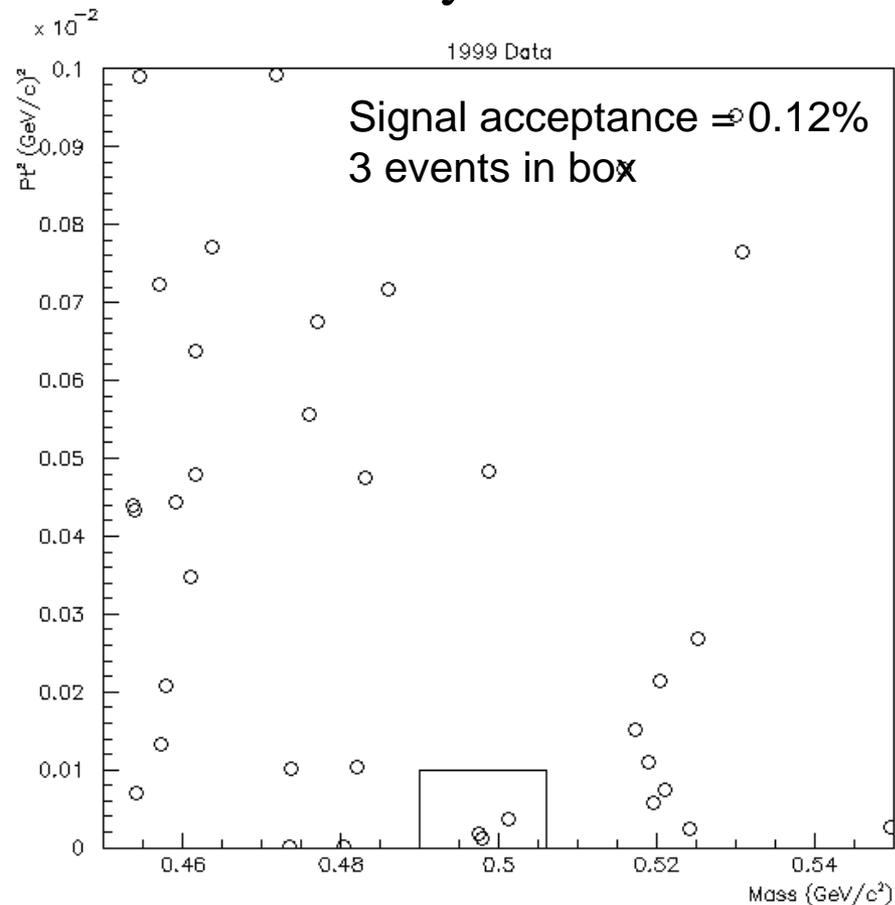
5 events – 3 (Overlap with 1997 publ.) + 2 new events  
(Lose 1 evt from 97 publ. via CA energy cut)



# 1999 Data: $K_L \rightarrow \mu\mu\gamma\gamma$

- Using cuts from 1997 published analysis
  - 1999 Signal Acceptance = 0.12%
    - (JAWS 1997 re-analysis – 0.14%)
  - 3 events in box
    - More high mass background

## JAWS Analysis: 1999 Data

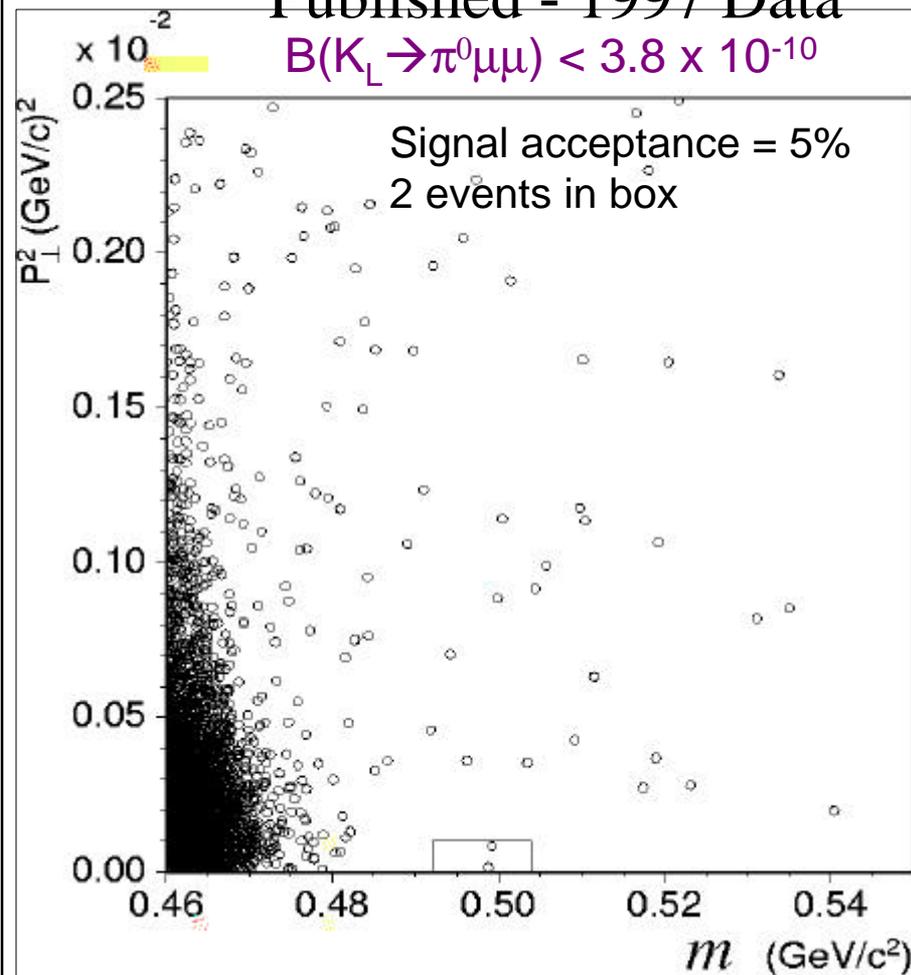


# 1997 Data: $K_L \rightarrow \pi^0 \mu \mu$ Crosscheck

Published - 1997 Data

$$B(K_L \rightarrow \pi^0 \mu \mu) < 3.8 \times 10^{-10}$$

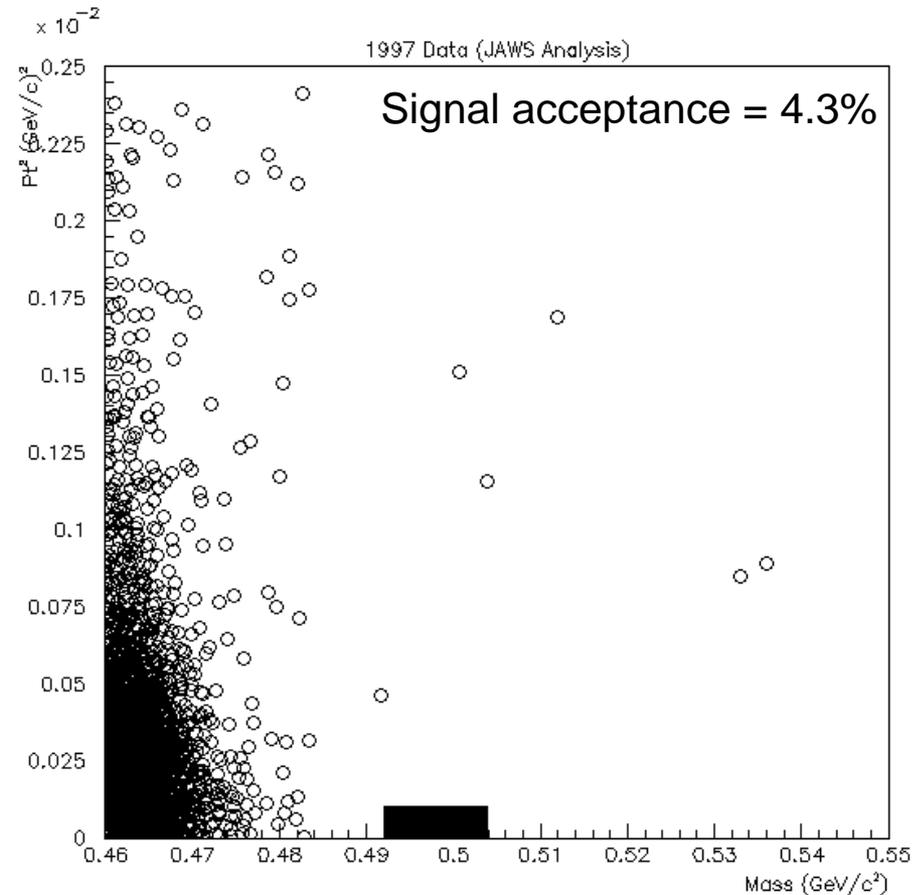
Signal acceptance = 5%  
2 events in box



JAWS Re-analysis - 1997 Data

1997 Data (JAWS Analysis)

Signal acceptance = 4.3%

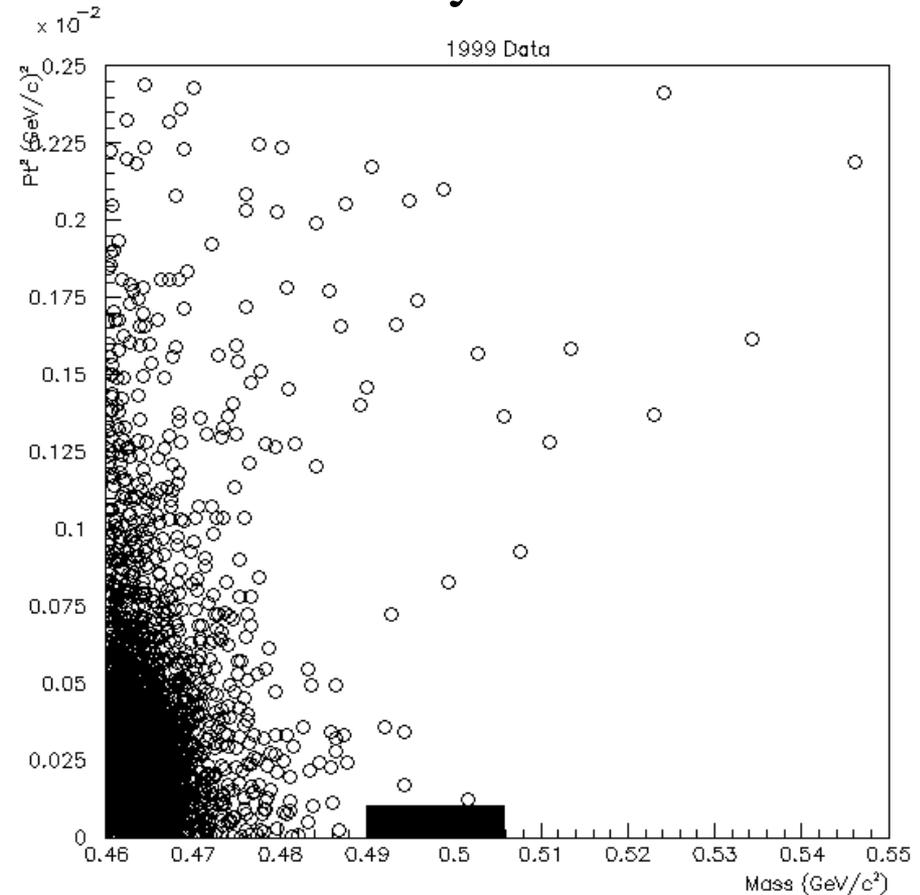


$K_L \rightarrow \pi^0 \mu \mu$

# 1999 Data: $K_L \rightarrow \pi^0 \mu \mu$

- Apply **1997 analysis cuts** to 1999 data (w/ new bad spill mask)
  - Signal acceptance = 4%
  - Background level is higher near the box than in either published 1997 analysis or my re-analysis
    - More background close to box due to lowered B-field
    - Low mass background is from  $K_L \rightarrow \pi^+ \pi^- \pi^0$
- Largest background expected comes from  $K_L \rightarrow \mu^+ \mu^- \gamma \gamma$ 
  - Dangerous background that peaks at kaon mass

## JAWS Analysis: 1999 Data



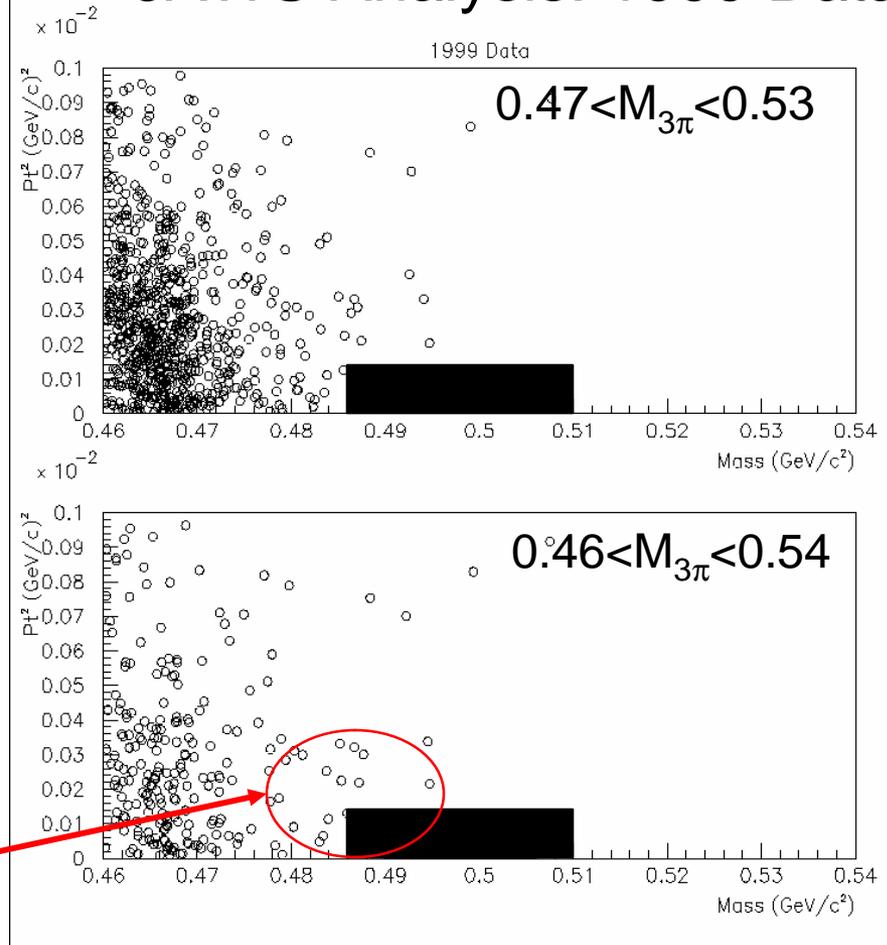
$$K_L \rightarrow \pi^0 \mu \mu$$

# $K_L \rightarrow \pi^0 \mu \mu$ 1999 Data

- Cut on track inv mass assuming  $K_L \rightarrow \pi^+ \pi^- \pi^0$  event
  - $0.47 < M_{3\pi} < 0.53 \rightarrow$  45% drop in background near box with no signal loss
  - $0.46 < M_{3\pi} < 0.54 \rightarrow$  75% drop in background near box with  $\sim 10\%$  signal loss

There are still events in this region that I need to deal with

## JAWS Analysis: 1999 Data



Inceased box size during cut tuning

# Plans

- Work on optimizing cuts
  - Cuts too tight for pt2, fusechi2, offmag
  - Can we reduce backgrounds near box in  $K_L \rightarrow \pi^0 \mu \mu$
- Generate MC ( $K_L \rightarrow \pi^+ \pi^- \pi^0$  DD;  $K_L \rightarrow \pi \mu \nu + \gamma_{acc}$  )
  - Problem with pion decay in MC
  - Reduce generation time for  $K_L \rightarrow \pi \mu \nu + \gamma_{acc}$  – strip off evts with higher energy in Csl (Code from RickK/Edivaldo)
- Get background estimates (MC + data)
- Combine new 1997 result + new 1999 result