$K_L \to e^+e^-\gamma$ at Panic

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KTeV Supplemental Meeting

October 14, 2005

Overview

- Overview of the work to be presented
- Branching Ratio Measurement
- Selected Branching Ratio Plots
- Form Factor Measurement
- Selected Form Factor Plots
- Summary

Work to be Presented

- I will be presenting a poster on the $K_L \to e^+e^-\gamma$ branching ratio and form factor measurements
- Most of the work that was required to produce these results was done by Jason Ladue and is presented in his thesis
- I have written an addendum to Jason's thesis that describes the modifications I have made to Jason's branching ratio measurement
- The form factor measurement is identical to what is presented in Jason's thesis

Branching Ratio Measurement

- The branching ratio measurement is different from Jason's thesis in the folllowing ways:
  - The $K_L \to 3\pi^0_D$ data run 8578 was put back into the analysis
  - The number of $K_L \to e^+e^-\gamma$ data events in the summer was corrected
  - The Monte Carlo events were reweighted to correct to total kaon energy slope in both the signal and normalization modes
  - The Monte Carlo energy was smeared to match the data
  - A systematic error from using different triggers for the signal and normalization modes was calculated

Change to BR Calculation Since the Last KTeV Collaboration Meeting

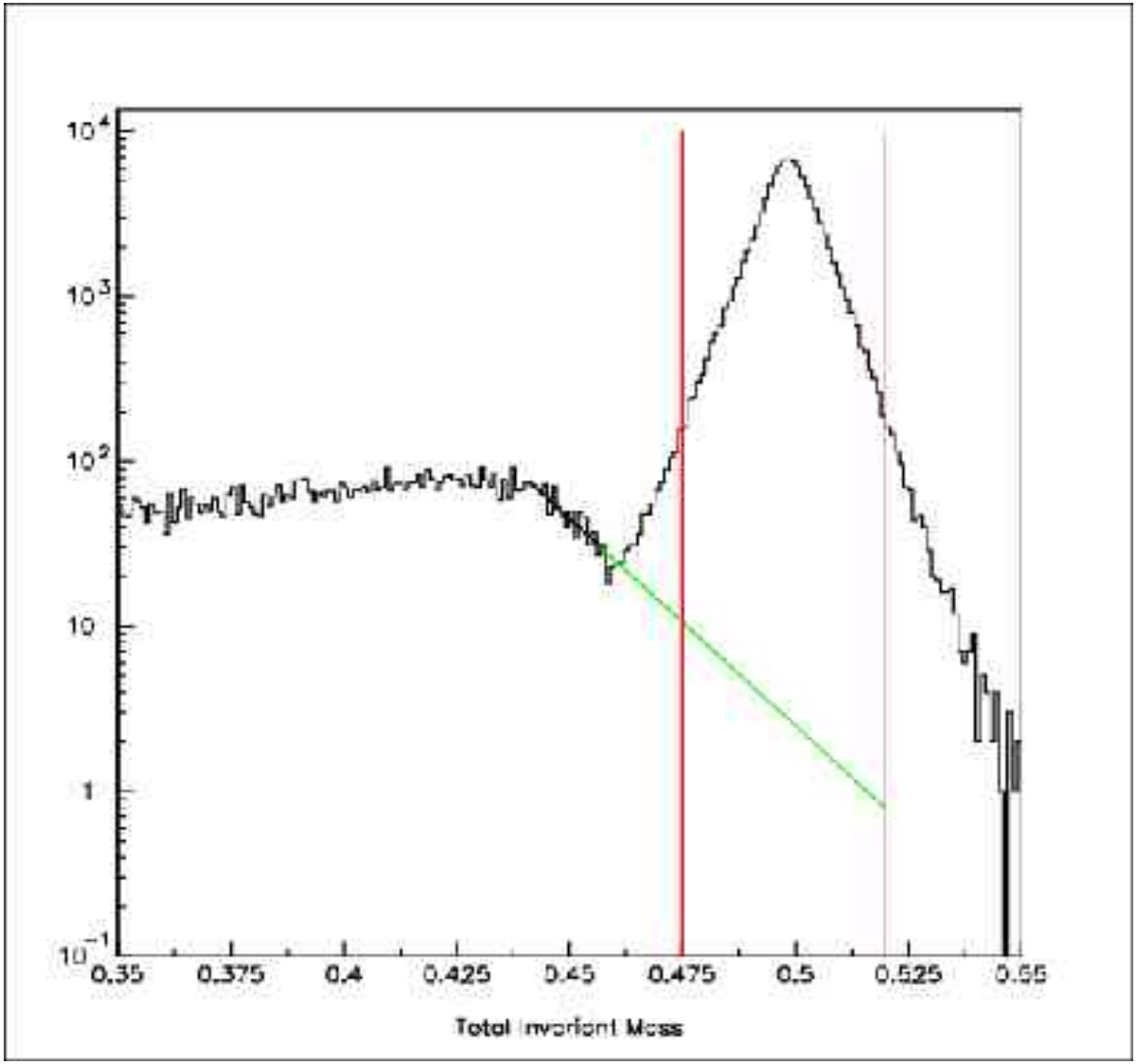
- Jason generated summer 97 and winter 97 Monte Carlo separately
- However, the ratio of events generated was set by the measured flux in each run period
- Then the BR is given by:
  - $(N_{data,win}+N_{data,sum})/(N_{MC,win}+N_{MC,sum})*(N_{generated,win}+N_{generated,sum})$
- Jason's win/sum flux ratio was 1.412, but the signal mode generated win/sum ratio was 1.375, and the normalization mode generated win/sum ratio was 1.385
- I now calculate the BR separately for winter and summer and take a weighted average to get the combined result

Branching Ratio Results

- old $BR(K_L \to e^+e^-\gamma)/BR(KL \to 3\pi^0{}_D)$
  $= 1.3462 \pm 0.0045_{stat} \pm 0.0104_{syst}$
- new $BR(K_L \to e^+e^-\gamma)/BR(KL \to 3\pi^0{}_D)$
  $= 1.3478 \pm 0.0045_{stat} \pm 0.0104_{syst}$
- old $BR(K_L \to e^+e^-\gamma)$
  $= 9.186 \pm 0.031_{stat} \pm 0.071_{syst} \pm 0.260_{ext.syst}$
- new $BR(K_L \to e^+e^-\gamma)$
  $= 9.196 \pm 0.031_{stat} \pm 0.071_{syst} \pm 0.260_{ext.syst}$
- These results are 2.32% lower than Jason's thesis results

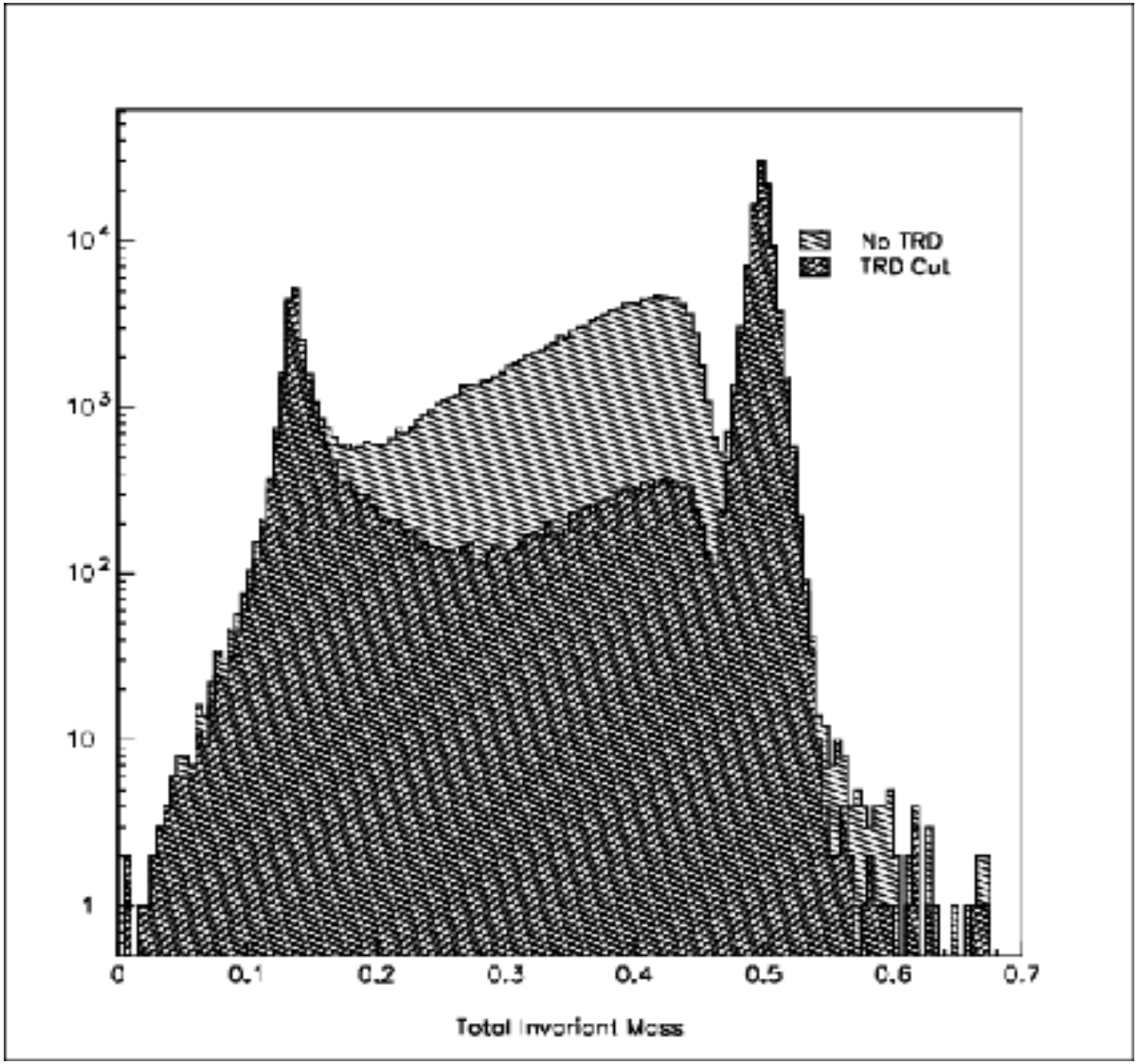
Branching Ratio Plots

Background Determination



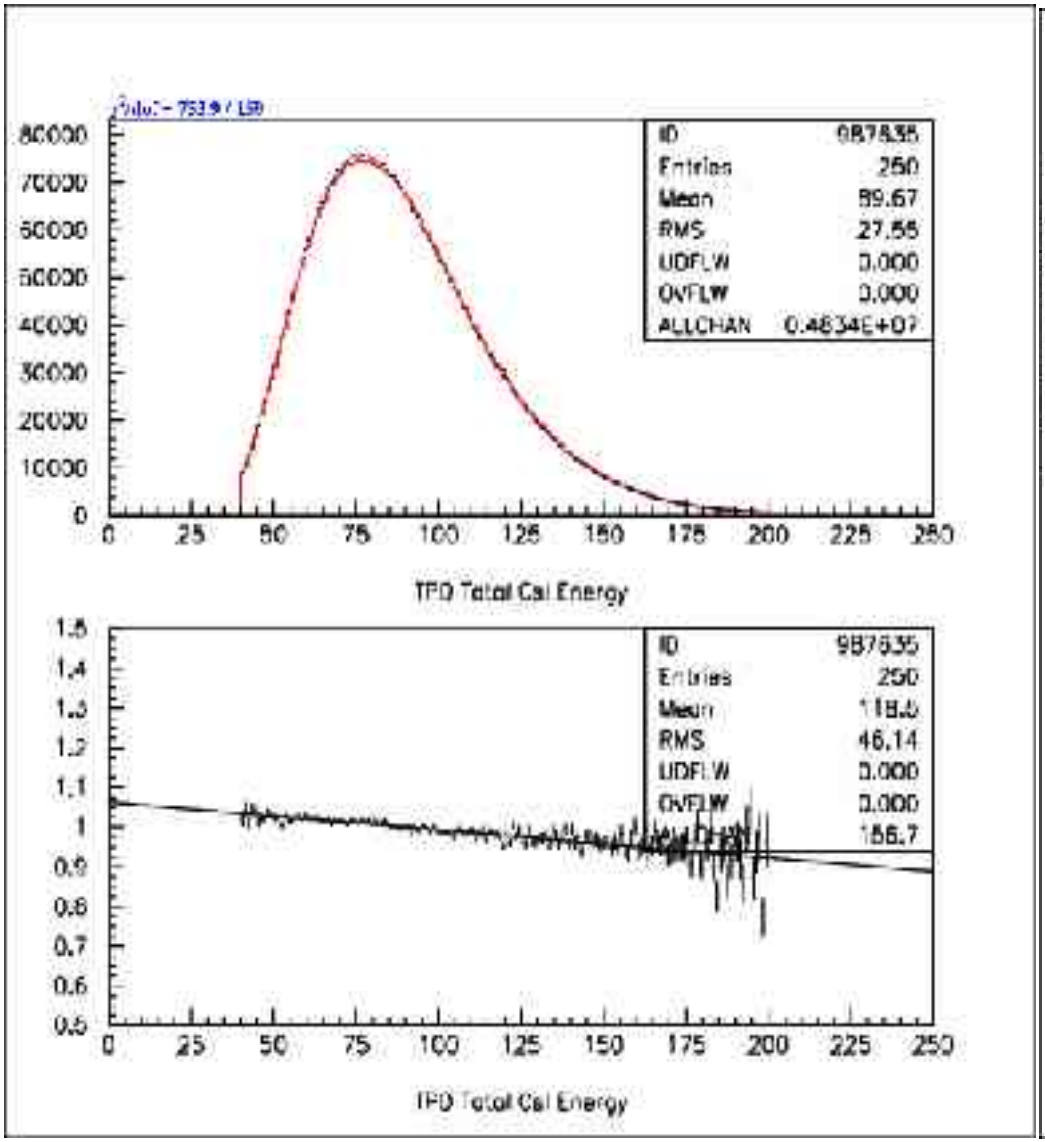
Branching Ratio Plots

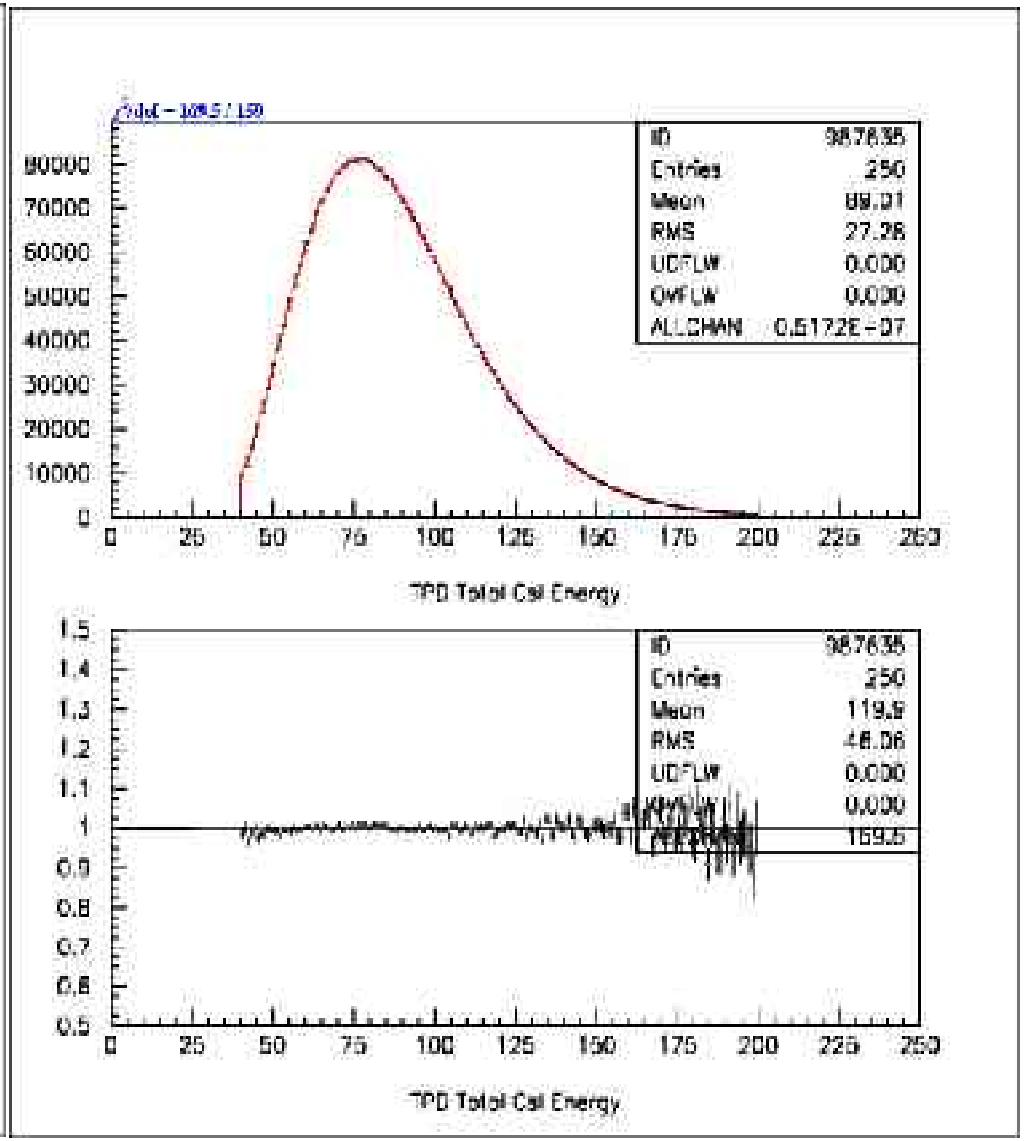
TRD Cut



Branching Ratio Plots

Total Energy in $3\pi^0_D$ events before/after reweighting



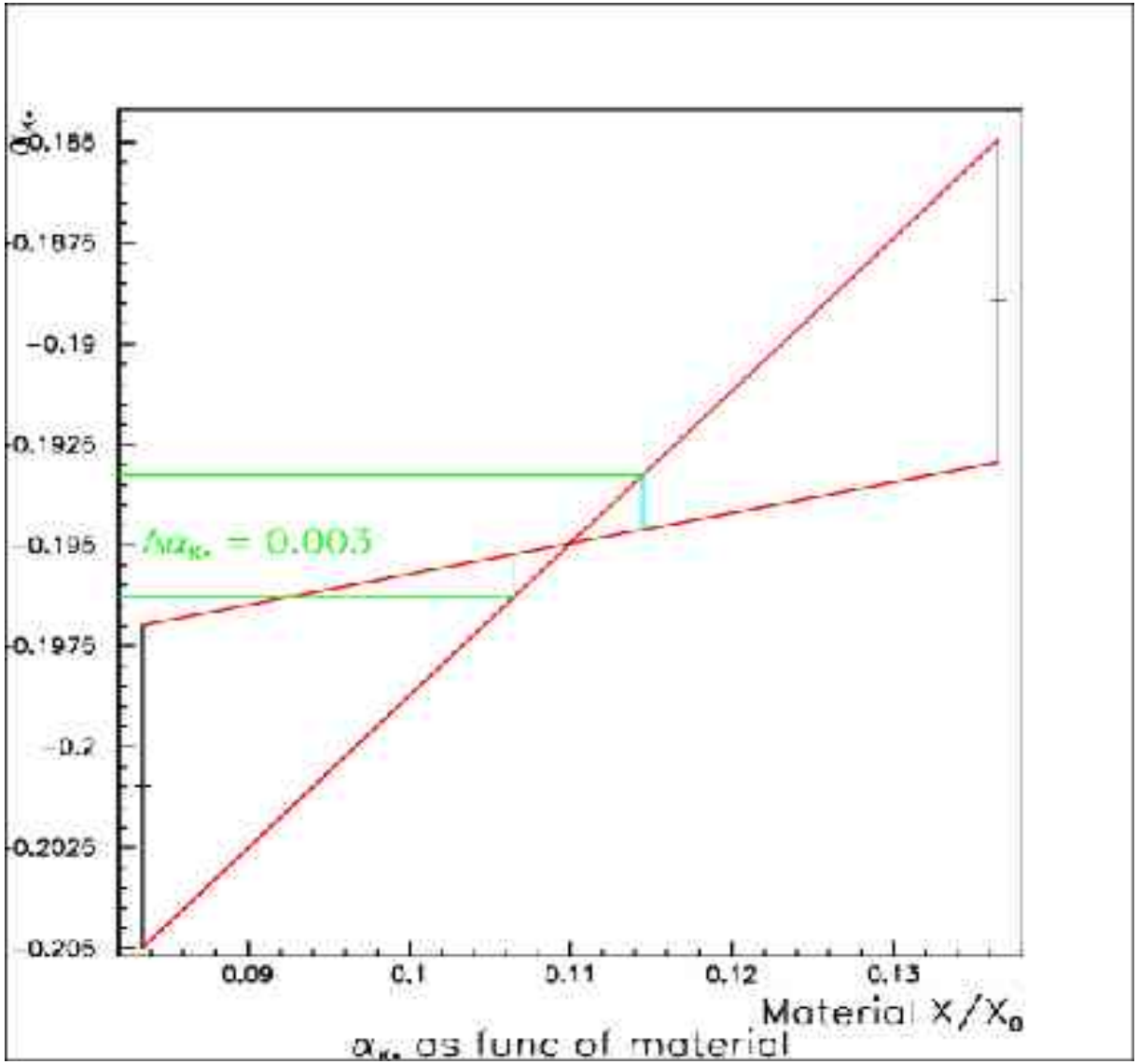


Form Factor Measurement

- The form factor result has been unchanged since Jason's thesis
- I have verified that the modifications to the BR result (i.e. energy reweighting and smearing) do not affect the form factor result
- The godparent committee has raised some concerns about the material systematic error

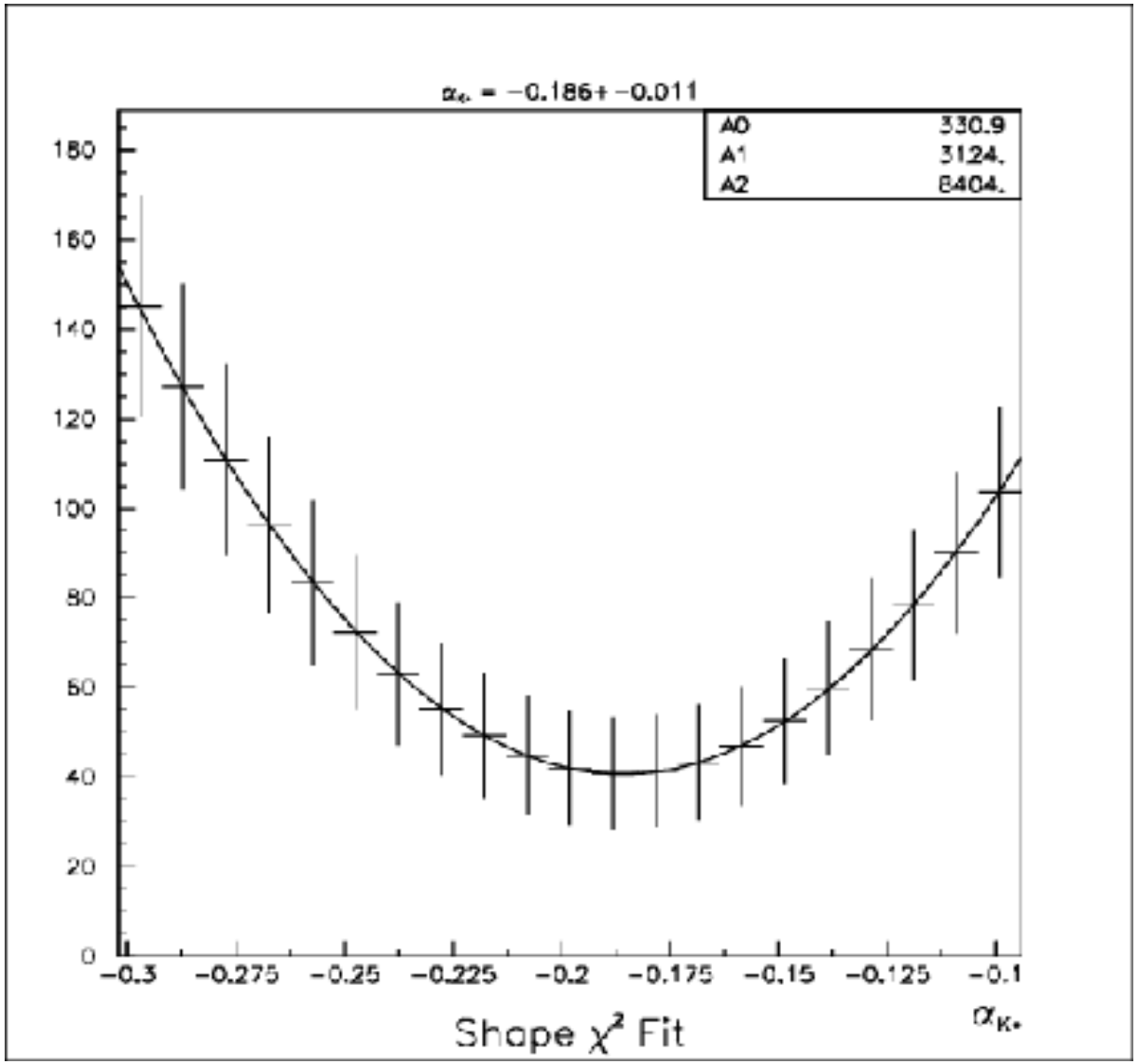
Form Factor Material Systematic

- MC samples with 7σ more and less material than the nominal value were generated
- The systematic uncertainty was given by the extrapolation of the errors to the 1σ level
- The central value indicated by this plot does not match the measured value of -0.186
- The error bars on the +/-7σ points are smaller than the statistical error



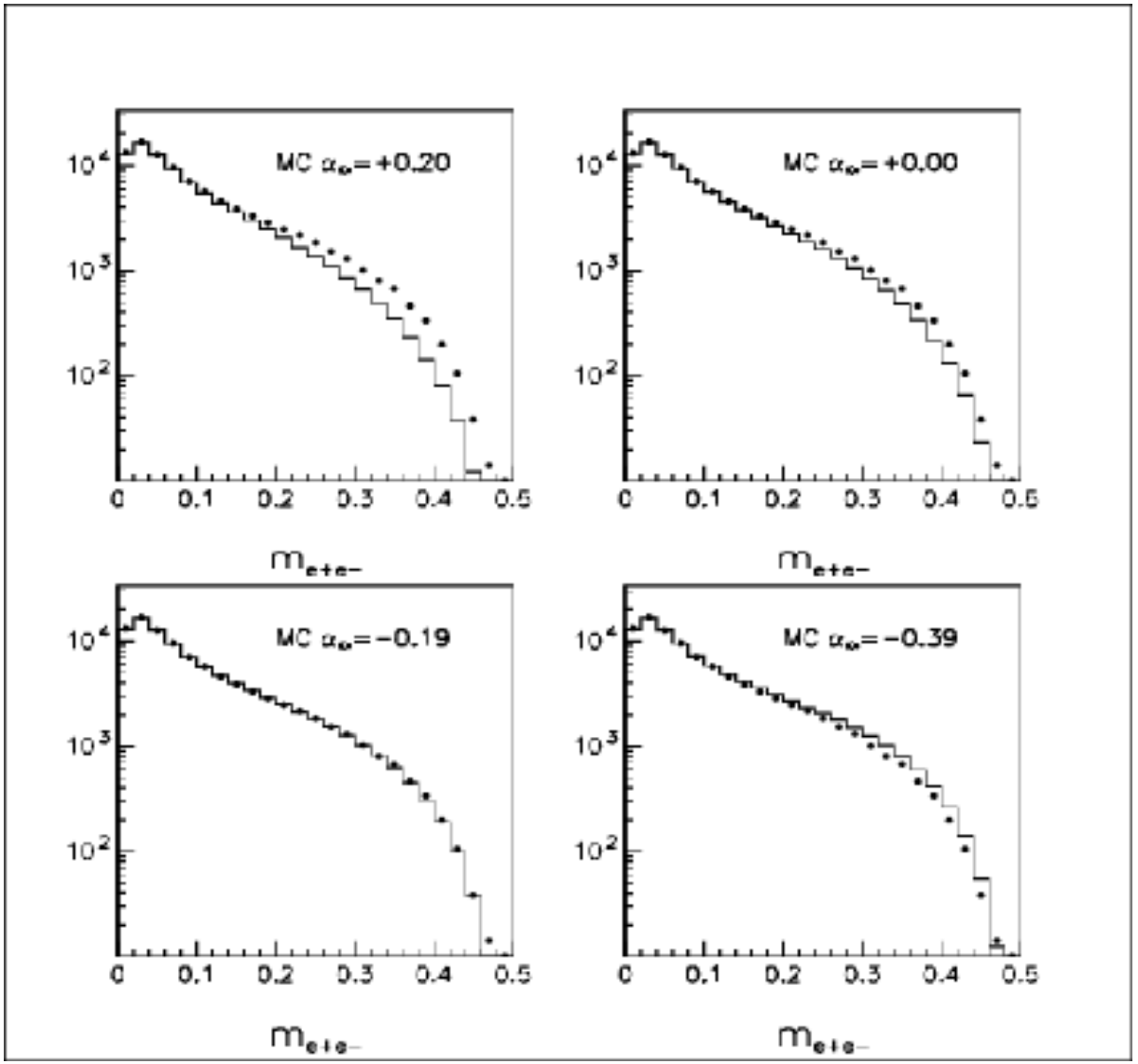
Form Factor Determination

- A shape χ^2 fit is performed on the e^+e^- mass distributions between data and MC with different values of α_{K*}
- α_{K*} if found by minimizing the shape χ^2 vs. α_{K*} distribution



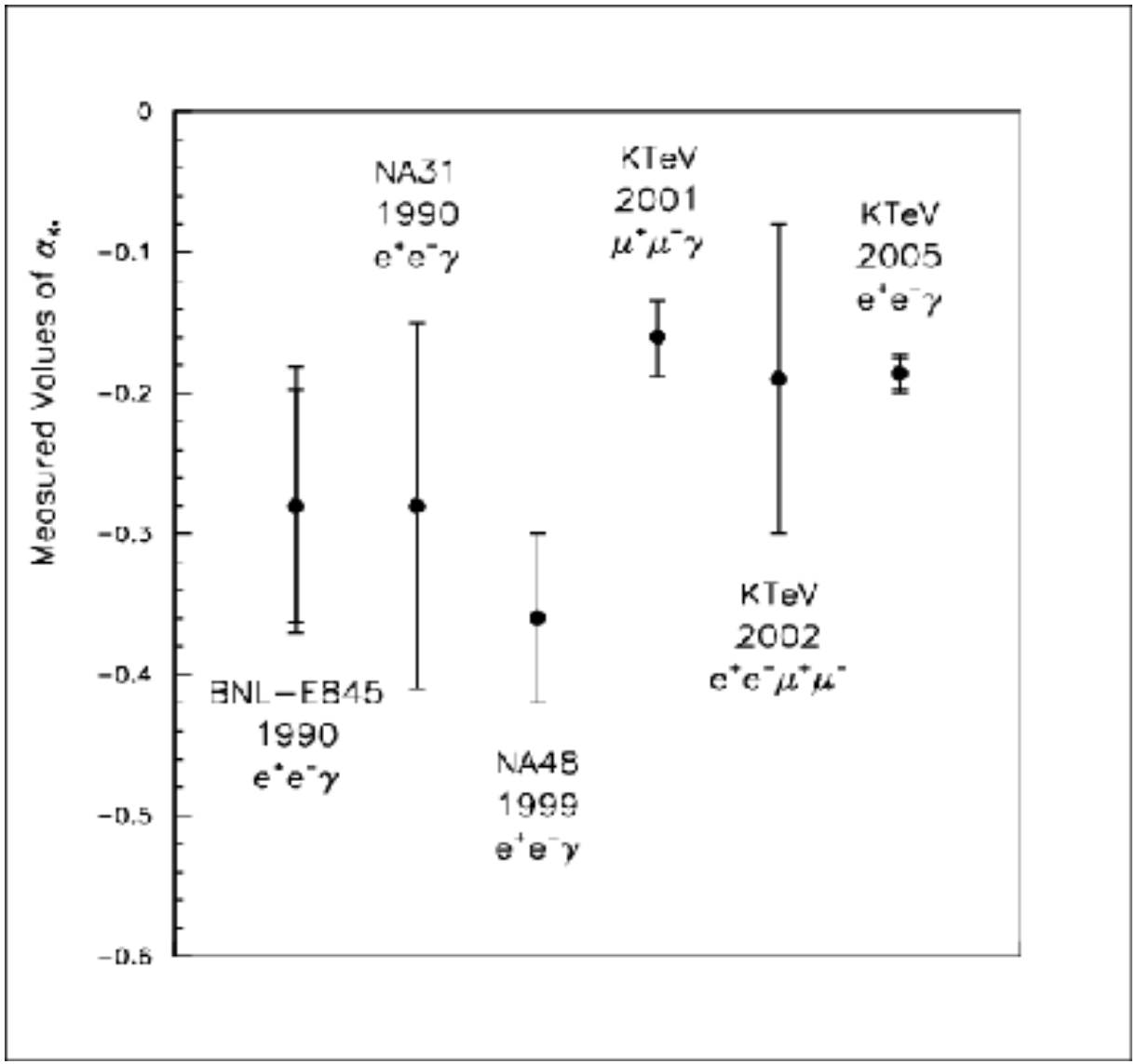
Form Factor Plots

M_{ee} distributions used in the form factor fit



Form Factor Plots

Comparison to Other Results



Summary

- The poster will contain results (hopefully the final results) for the branching ratio and form factor
- The analysis procedure will be described
- The table of errors for each measurement will be shown along with some description of the main systematics
- The plots I showed today will be included (and possibly a few others)

The End

Reproducing Jason's Numbers

		Jason' s Thesis	My result	difference	% difference
K->eeg data	winter	50487	50467	-20	-0.040%
	summer	41468	41452	-16	-0.039%
	total	91955	91919	-36	-0.039%
K->eeg mc	winter	257453	257507	54	0.021%
	summer	215930	215929	-1	0.000%
	total	473383	473436	53	0.011%
3pi0d data	winter	2778007	2810189	32182	1.158%
	summer	2023181	2023461	280	0.014%
	total	4801188	4833650	32462	0.676%
3pi0d mc	winter	1371152	1371379	227	0.017%
	summer	1019088	1019154	66	0.006%
	total	2390240	2390533	293	0.012%

=2810189-31386

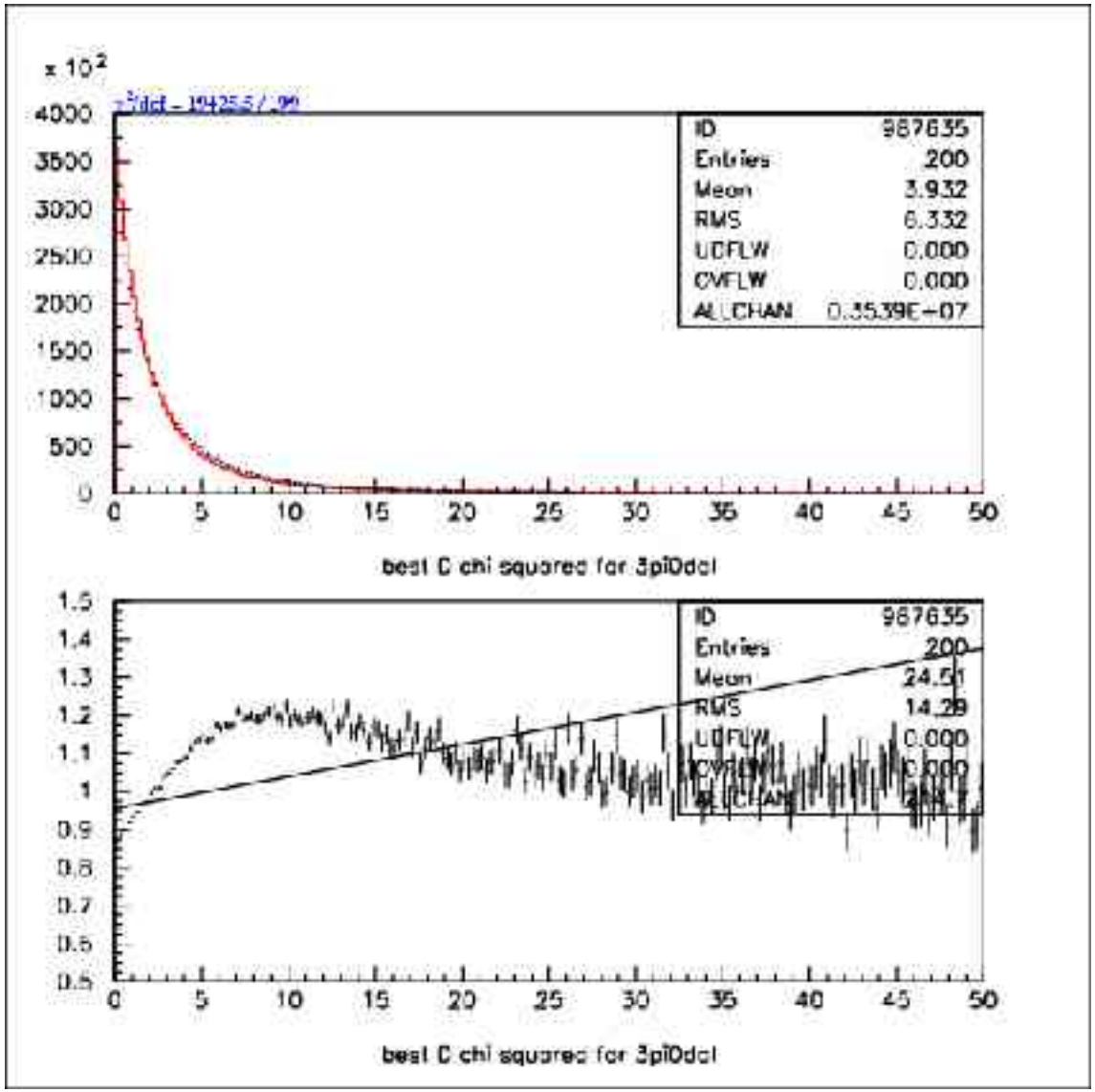
- There is a discrepancy in the winter $3\pi^0_D$ data due to a missing normalization run in Jason's analysis
- I am able to reproduce the numbers in Jason's thesis

Energy Smearing / Reweighting

- The analysis I used to reproduce Jason's thesis numbers did not including energy smearing or reweighting
- It should have
- Using the non-energy-reweighted Monte Carlo changes the branching ratio by 0.23%
- non-energy-smeared Monte Carlo retains 1% more $3\pi^0_D$ events after the pairing χ^2 cut

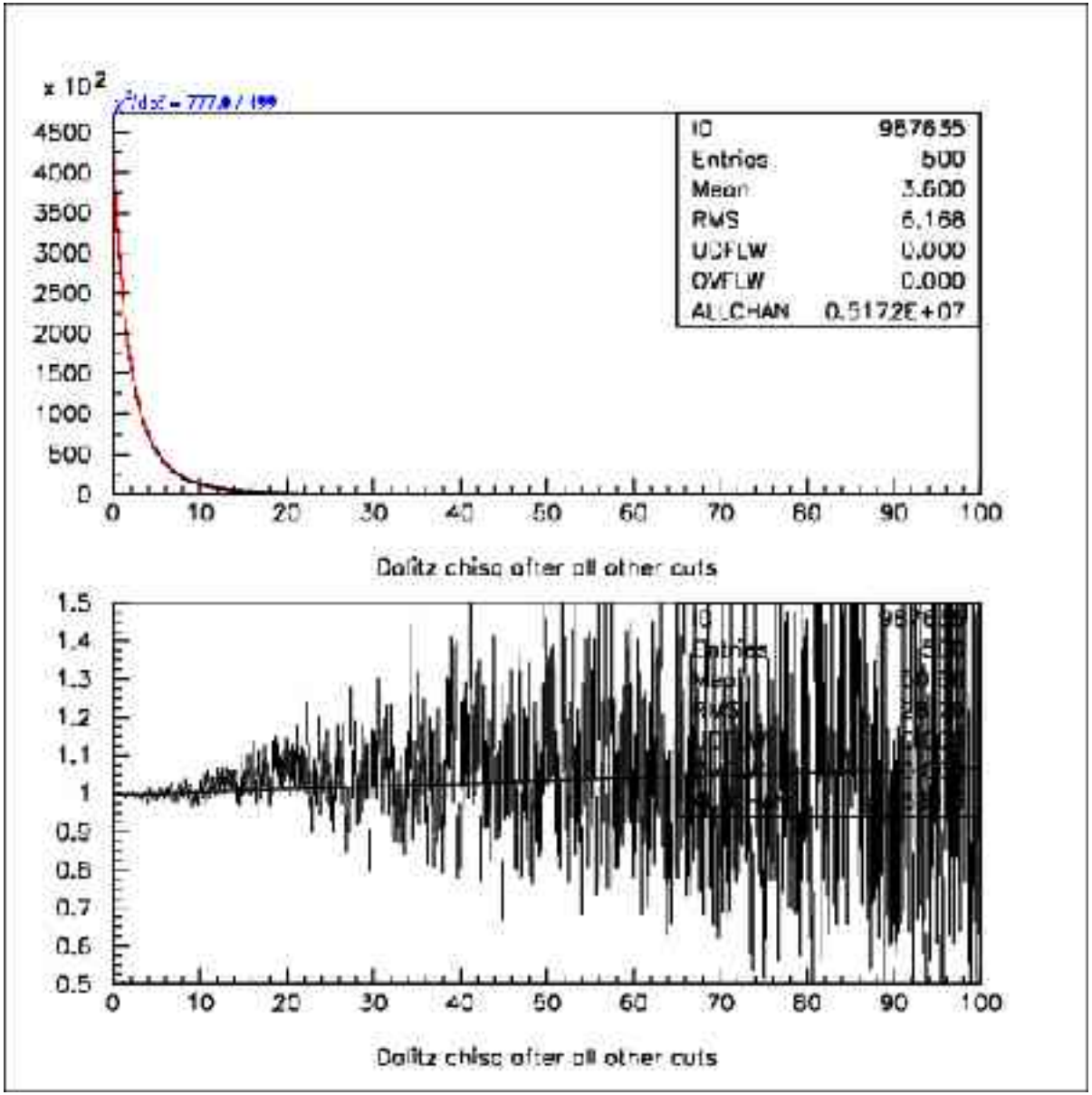
$3\pi^0$ Dalitz Pairing χ^2

- Dots: smeared Monte Carlo
- Histogram: unsmeared Monte Carlo
- Jason's cut is at 10



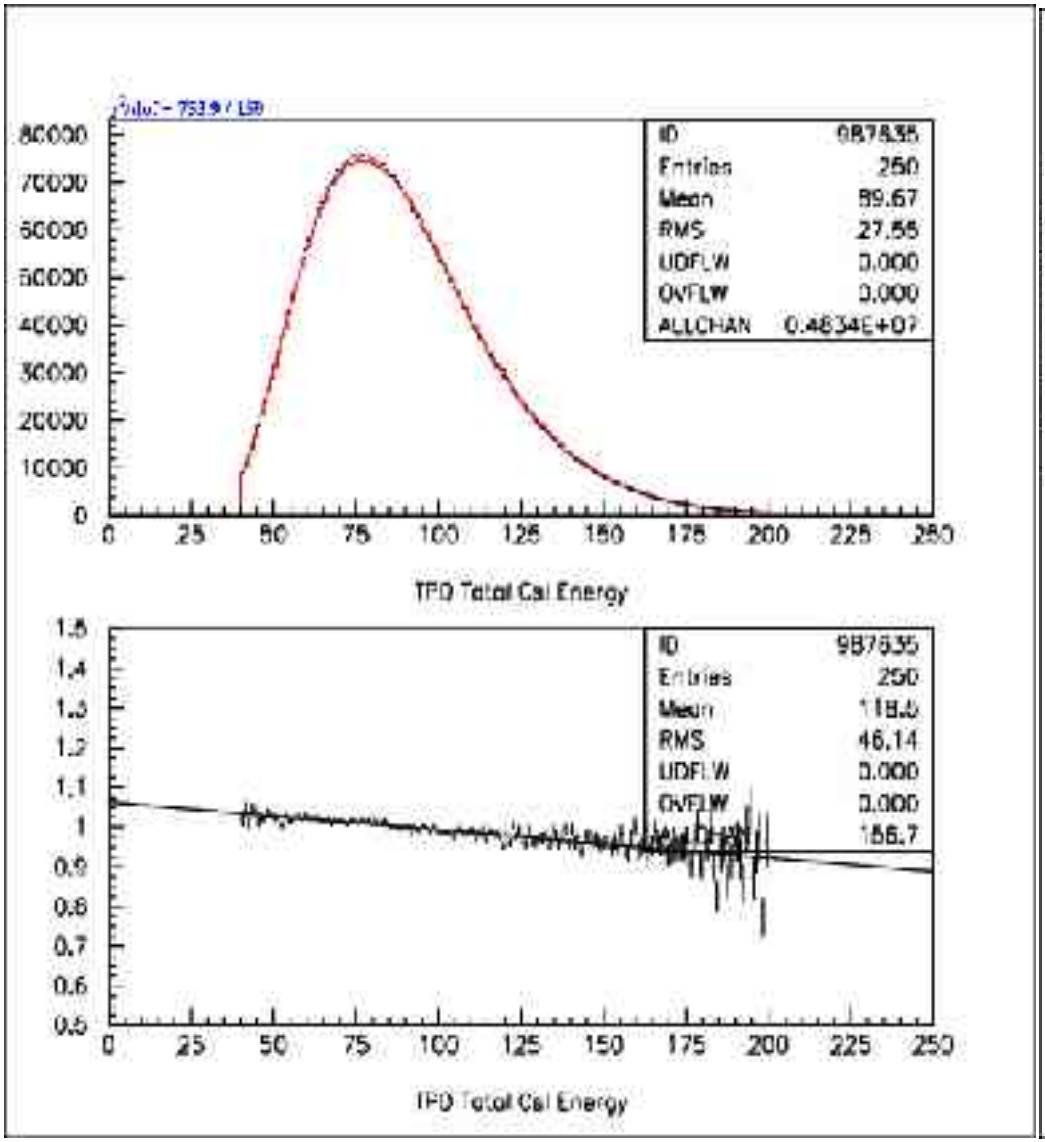
$3\pi^0$ Dalitz Pairing χ^2

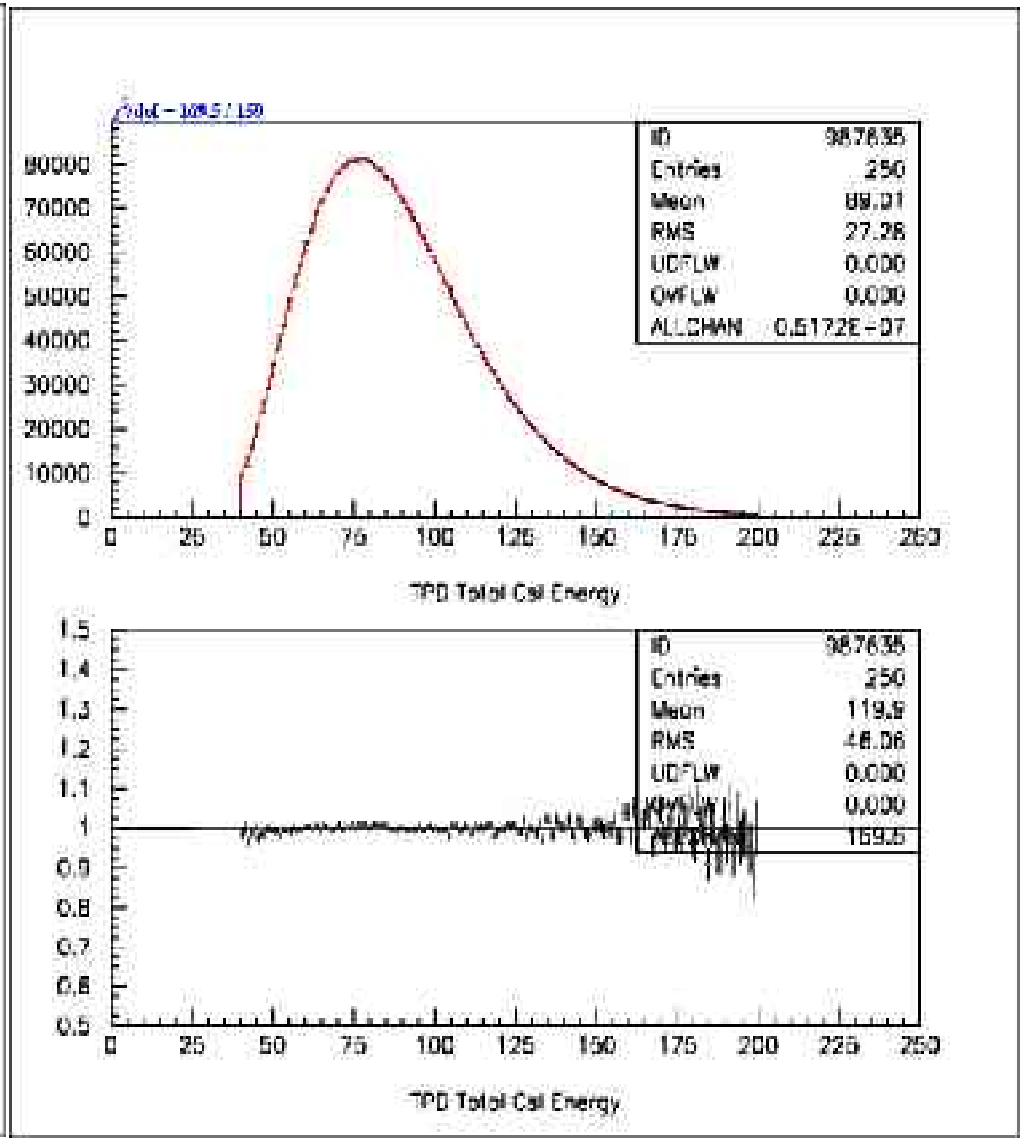
- Dots: Data
- Histogram: smeared Monte Carlo
- I've moved the cut from 10 to 100
- The cut now only removes 0.12% of events



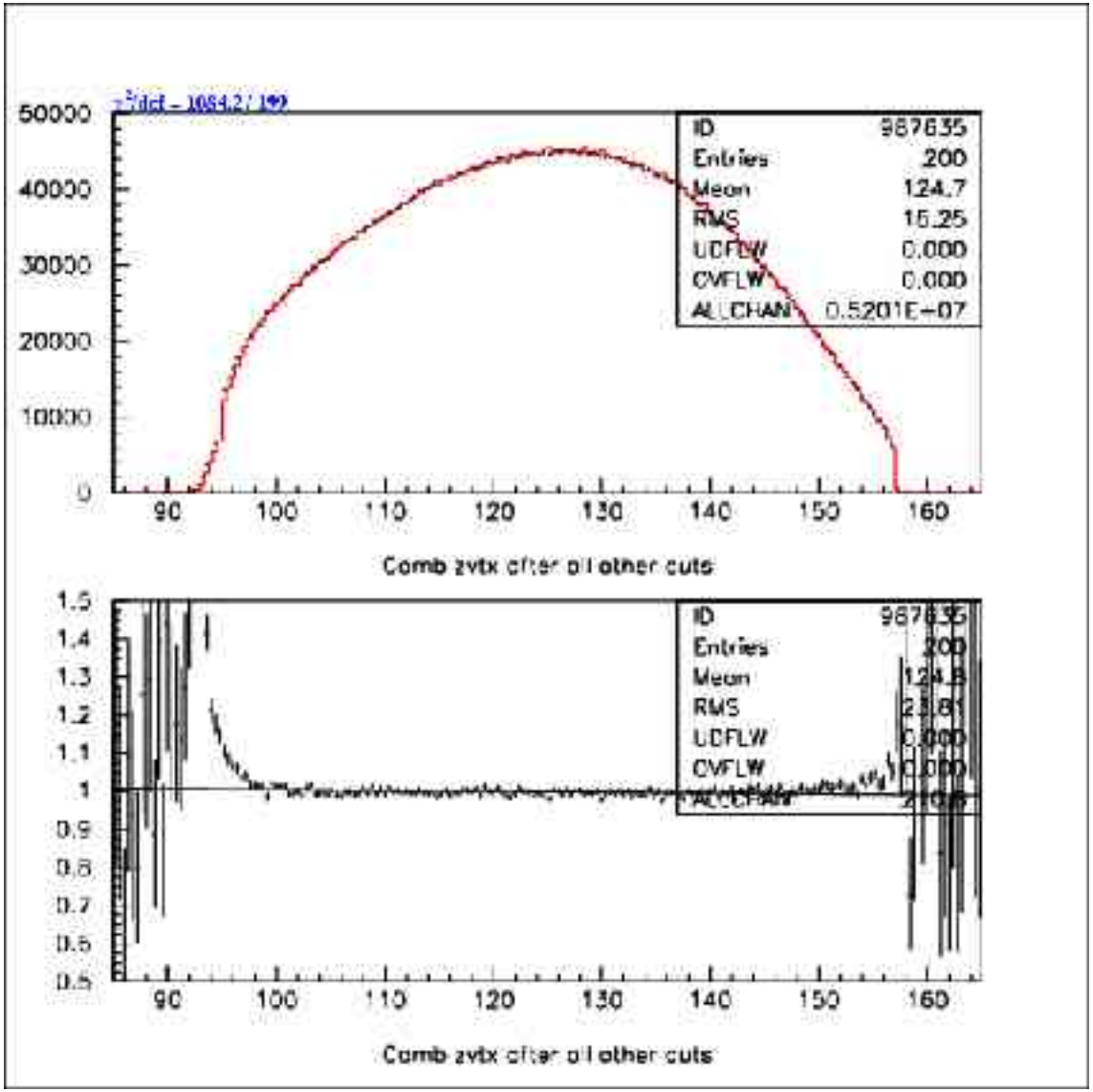
Energy Reweighting

Total Energy in $3\pi^0_D$ events before/after reweighting



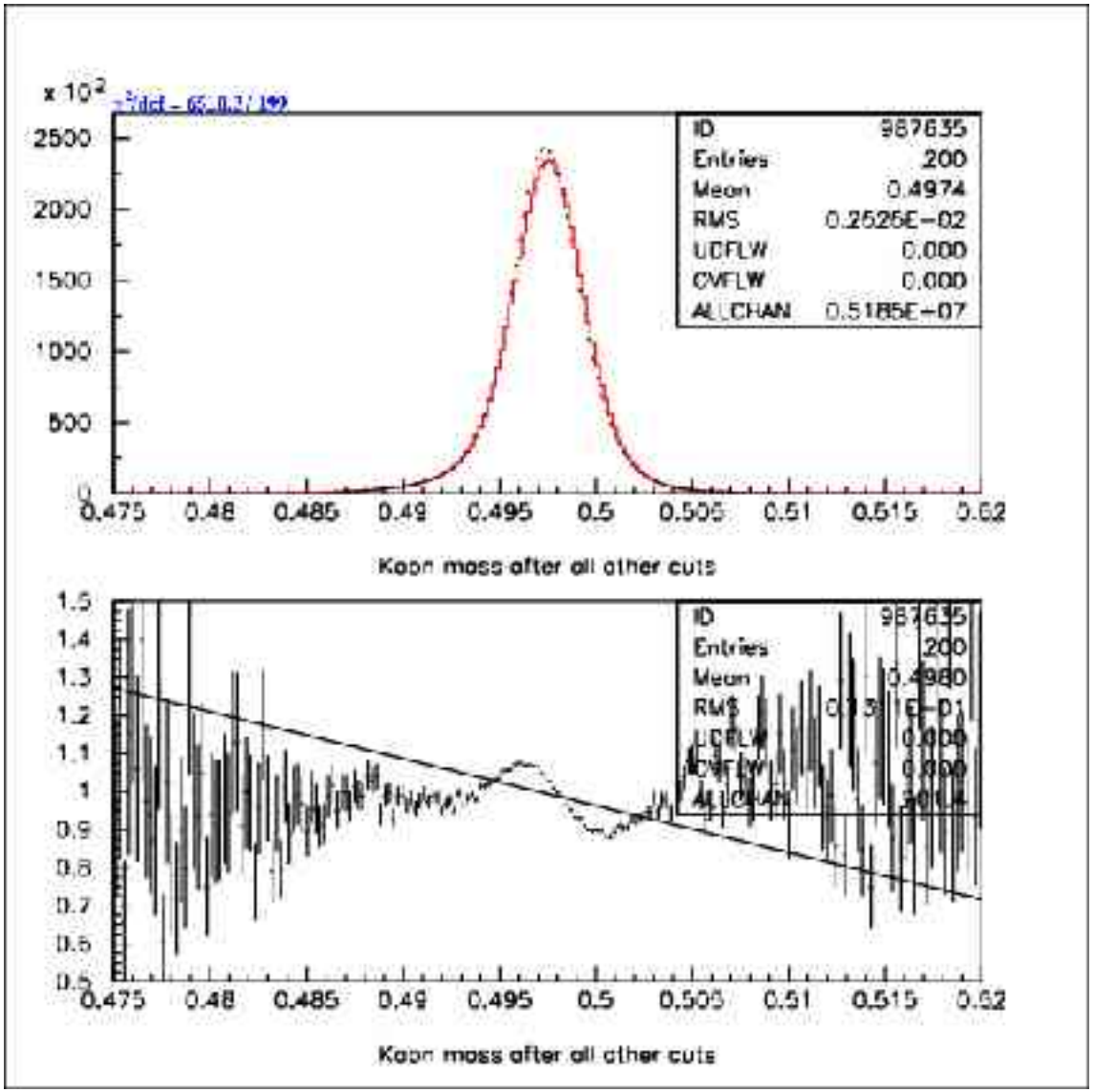


Combined $3\pi^0_D$ Z-vertex After Smearing and Reweighting

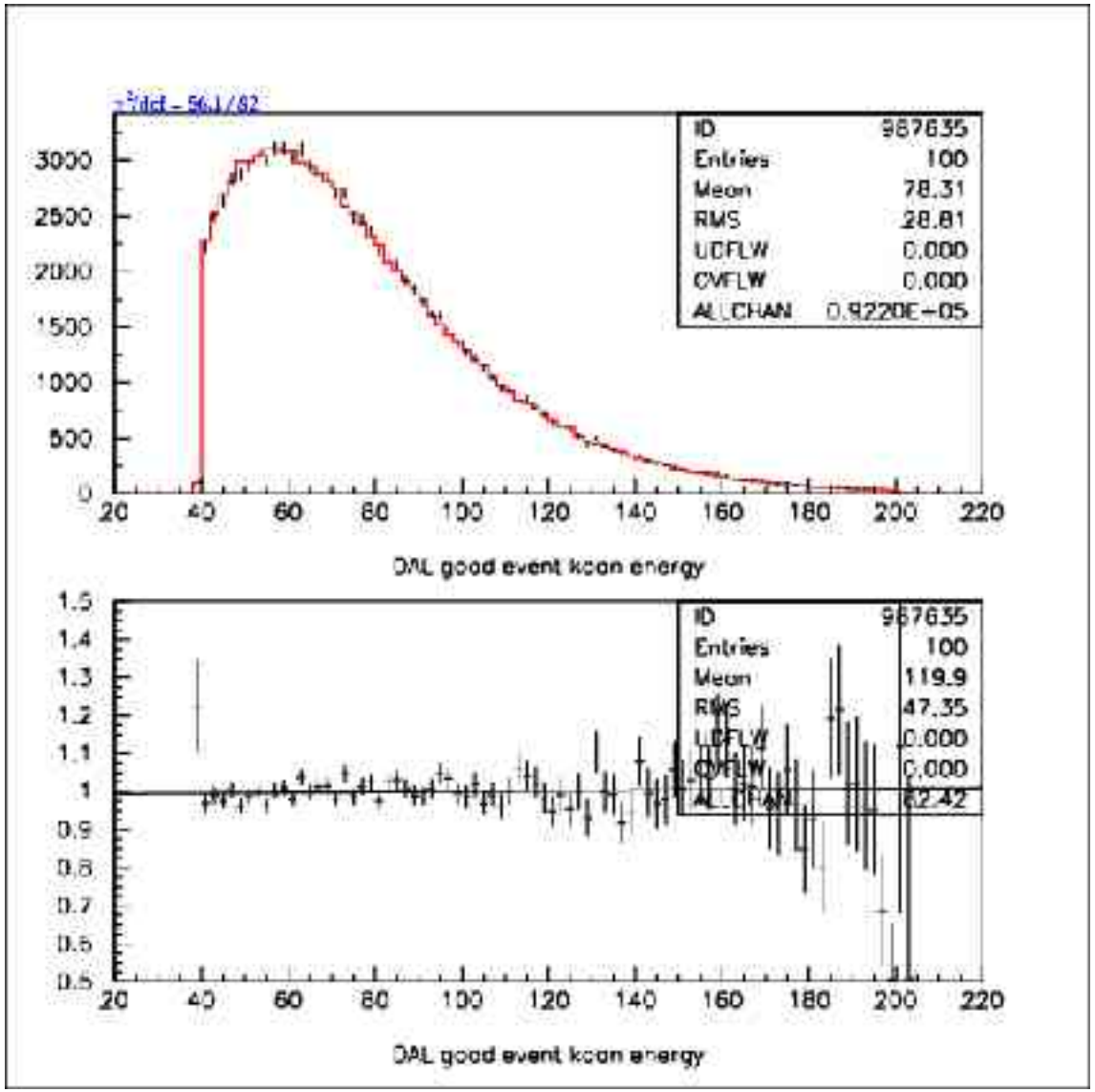


Kaon Mass after smearing/reweighting

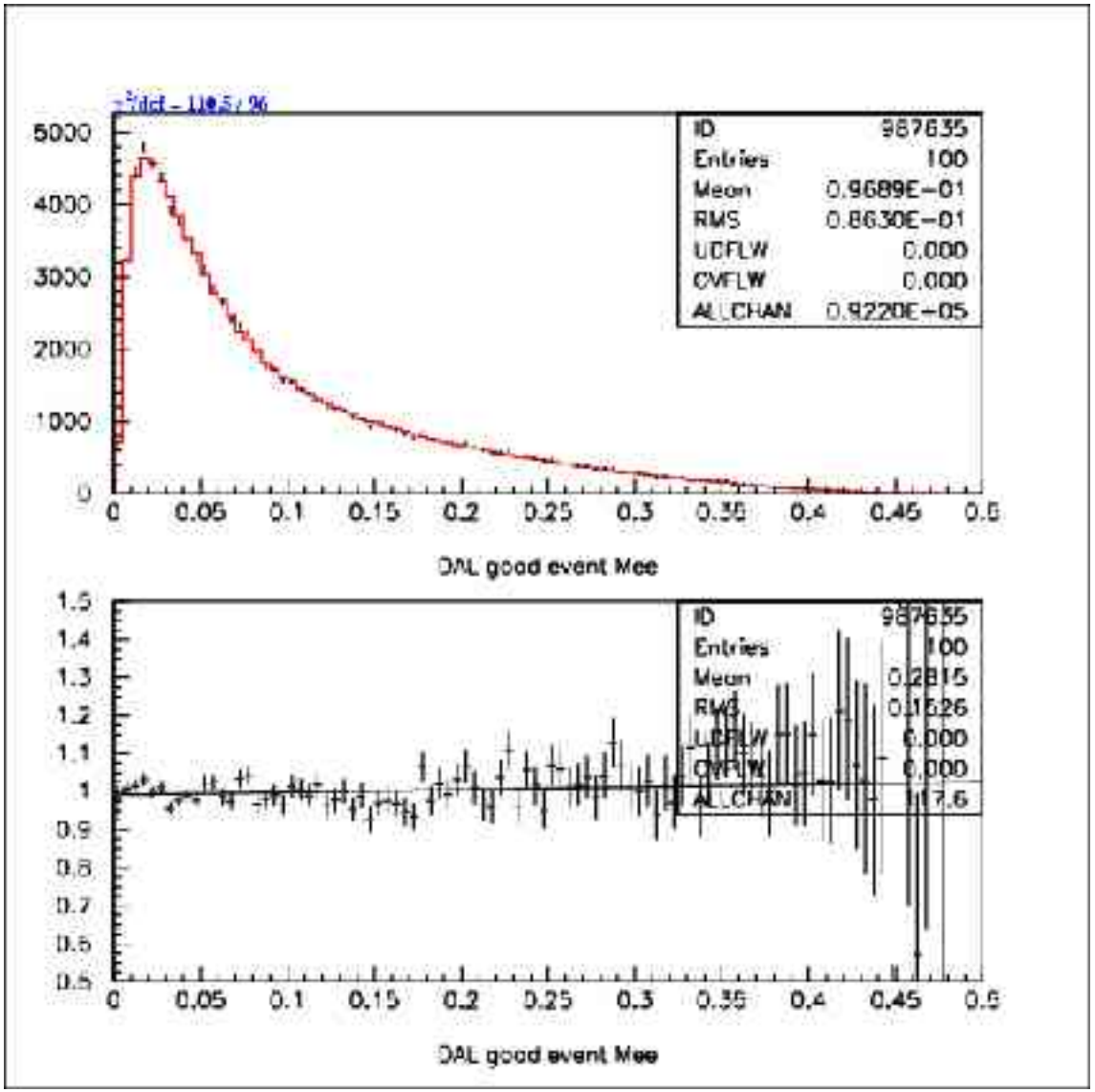
- after energy smearing and reweighting, there is still a shift in the kaon mass
- the cuts are at [0.485, 0.510]



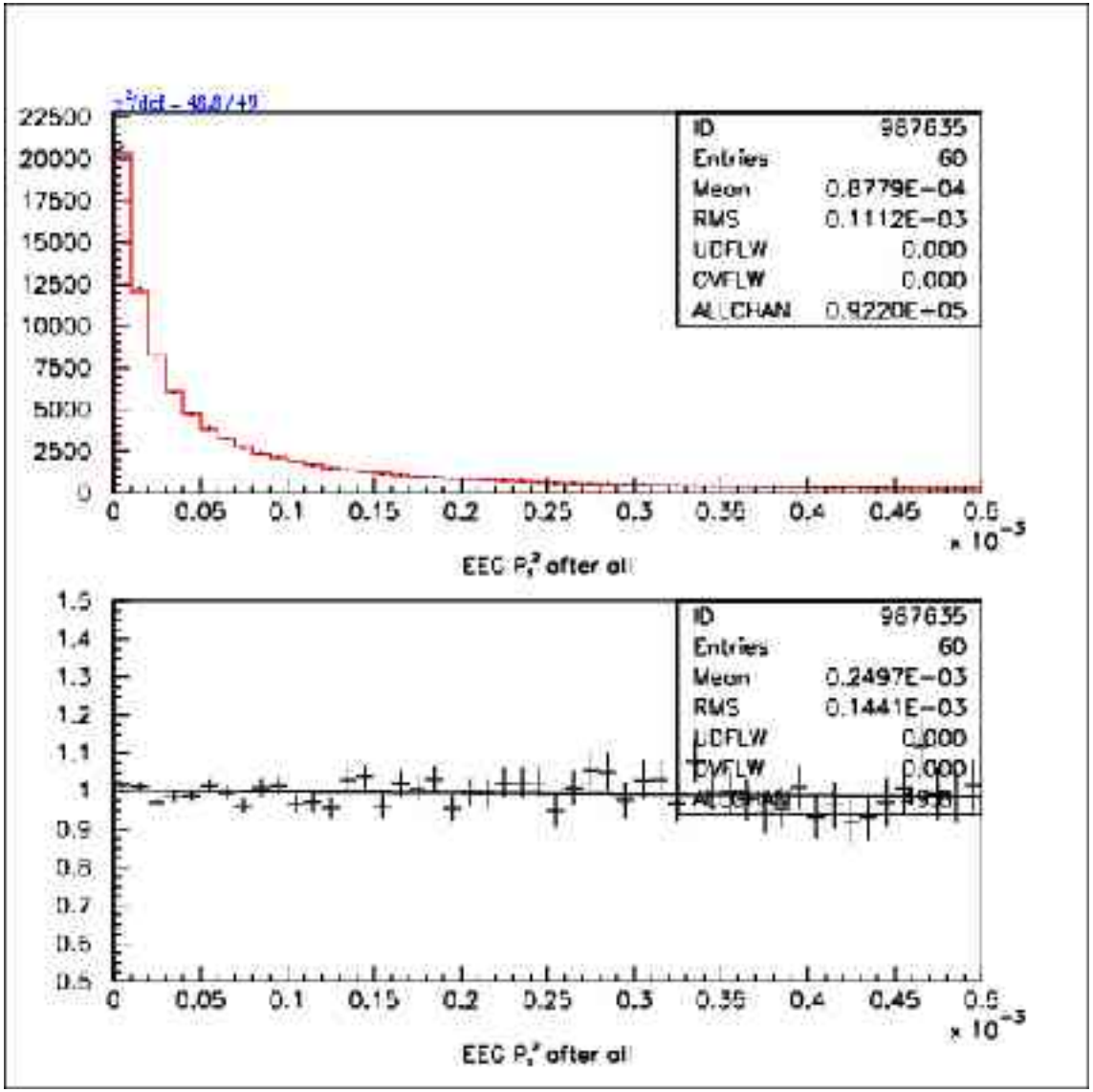
$K_L \to e^+e^-\gamma$ Total Kaon Energy



$K_L \to e^+e^-\gamma$ e^+e^- Mass



$K_L \to e^+e^-\gamma$ p_t^2



Systematics

Uncertainty Source	% of BR
Statistical	0.33
$3\pi 0D$ Branching Ratio	2.83
photon inefficiency	0.43
DC Inefficiency	0.37
Cut Variations	0.33
Energy Slope	0.23
Trigger 3 Inefficiency	0.2
MC Statistics	0.16
Energy Resolution	0.14
Backgrounds	0.08
Upstream Material	0.07
Trigger 1 Inefficiency	0.06
DC Hit Resolution	0.04
Radiative Corrections	0.03
Form Factor Dependence	0.03
Total Systematic	0.77

Comparison to Jason's Thesis

- Using the PDG value for $BR(K_L \to 3\pi^0_D)$ (as was done in Jason's thesis):
- My Result:
  $BR(K_L \to e^+e^-\gamma)$
  $= (9.941 \pm 0.033 \pm 0.076 \pm 0.287) * 10^{-6}$
- Jason's Thesis:
  $BR(K_L \to e^+e^-\gamma)$
  $= (10.192 \pm 0.036 \pm 0.073 \pm 0.285) * 10^{-6}$
- difference = 2.46% decrease

Current Status / Future Plans

- The analysis work is now complete
- I have written most of a paper draft
- I have written most of a more detailed addendum to Jason's thesis
- I'd like to hand this analysis off to a Godparent committee in the very near future