Neutral Mode Status Report

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May 12, 2007

Overview

- Review of changes to analysis
- Data-MC comparisons
  - 3pi0 bg problem
- Systematics
  - level 2 trigger
  - energy linearity
  - energy scale
  - cut variations
  - z slope
  - current table of systematics
- Fit results
- Outstanding questions and plan

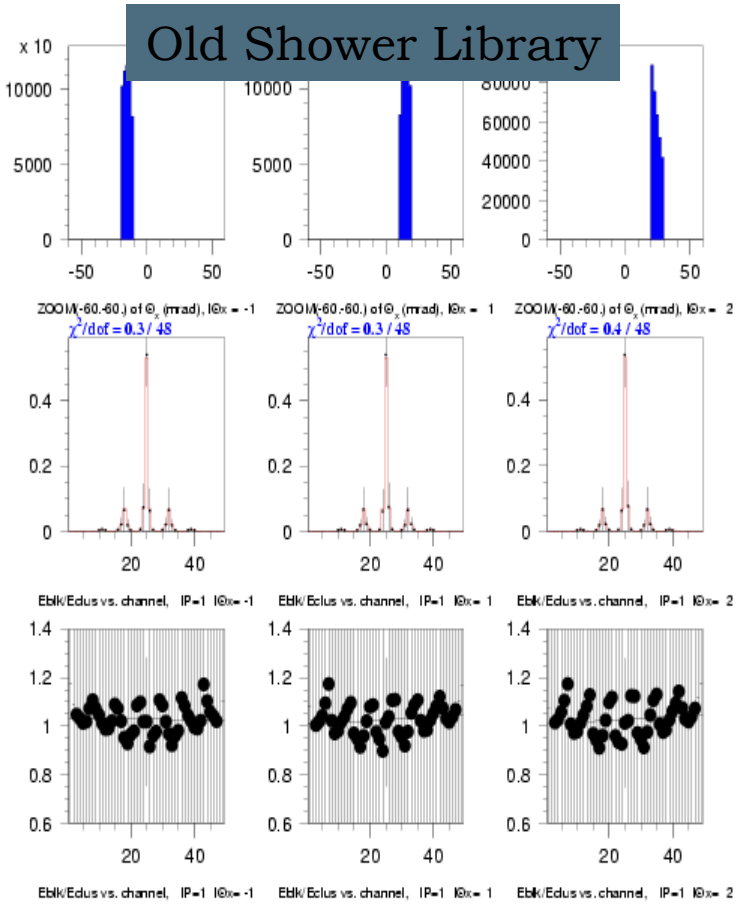
Changes to Analysis

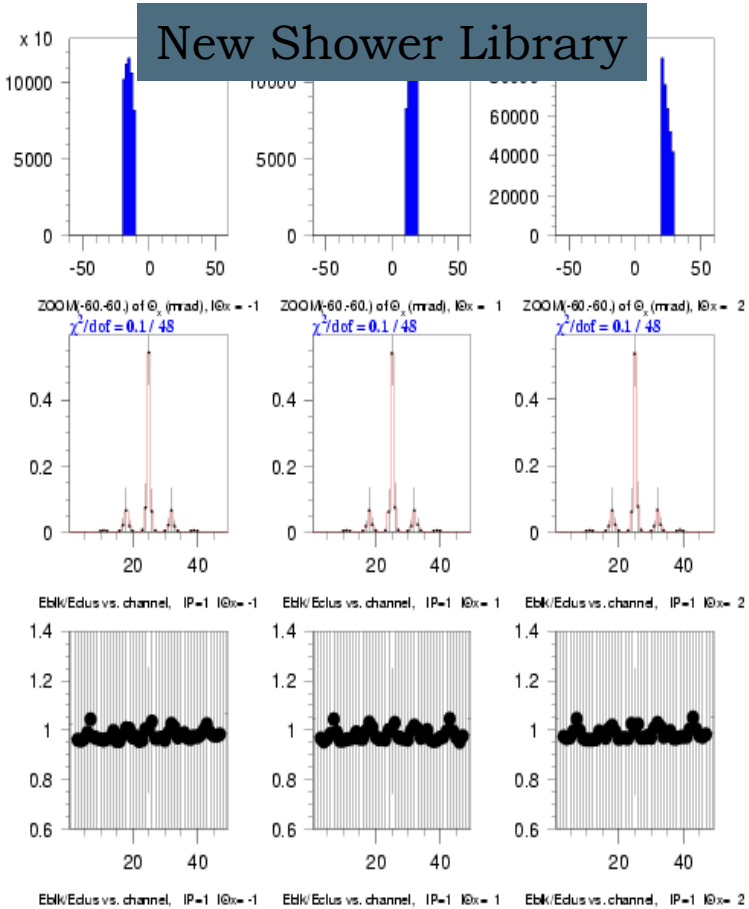
- Out of cone correction
  - parameterized as a function of position and energy
  - separate parameterization for photons and electrons
  - wrapping treated correctly
- Uniformity correction
  - applied block by block
- 2pi0/3pi0 photon calibration
  - corrects for electron-photon differences in calibration
- Cuts
  - SMLRING2 > 4
    - new cut
    - removes events w/ a cluster seed in 1st ring of blocks around beamhole
  - pair chi2 < 50
    - loosened from old nominal cut at 12

Changes to MC

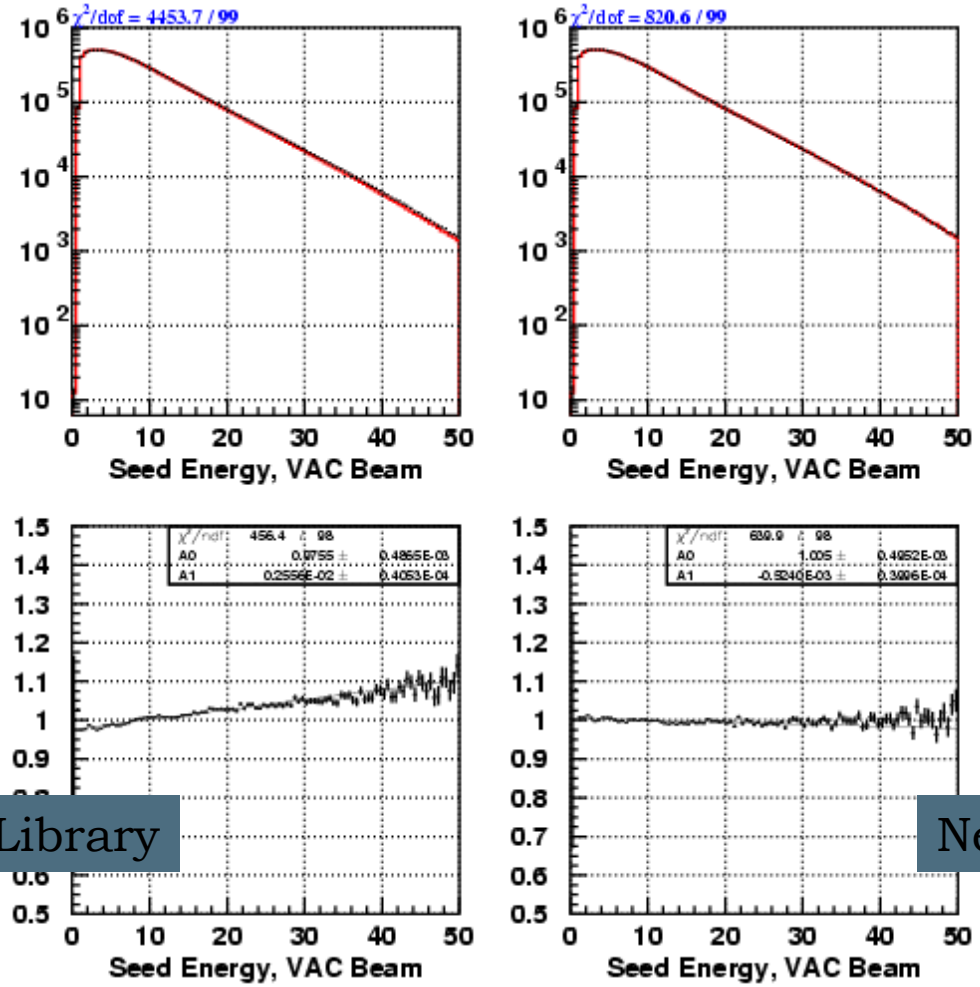
- Shower library w/ angles
- Wrapping and shims simulated
- Kaon parameters updated
  - τ_L: KLOE + PDG
  - τ_S: KTeV + NA48
  - $|\varepsilon|$: KTeV
  - m_K: 1σ lower than PDG value
- MA aperture reduced by 50 μm
- RC/SA thresholds updated
  - thresholds measured using $K_L \rightarrow \pi^+\pi^-\pi^0$
  - not implemented yet for 1999

Improvements: Shower Shape





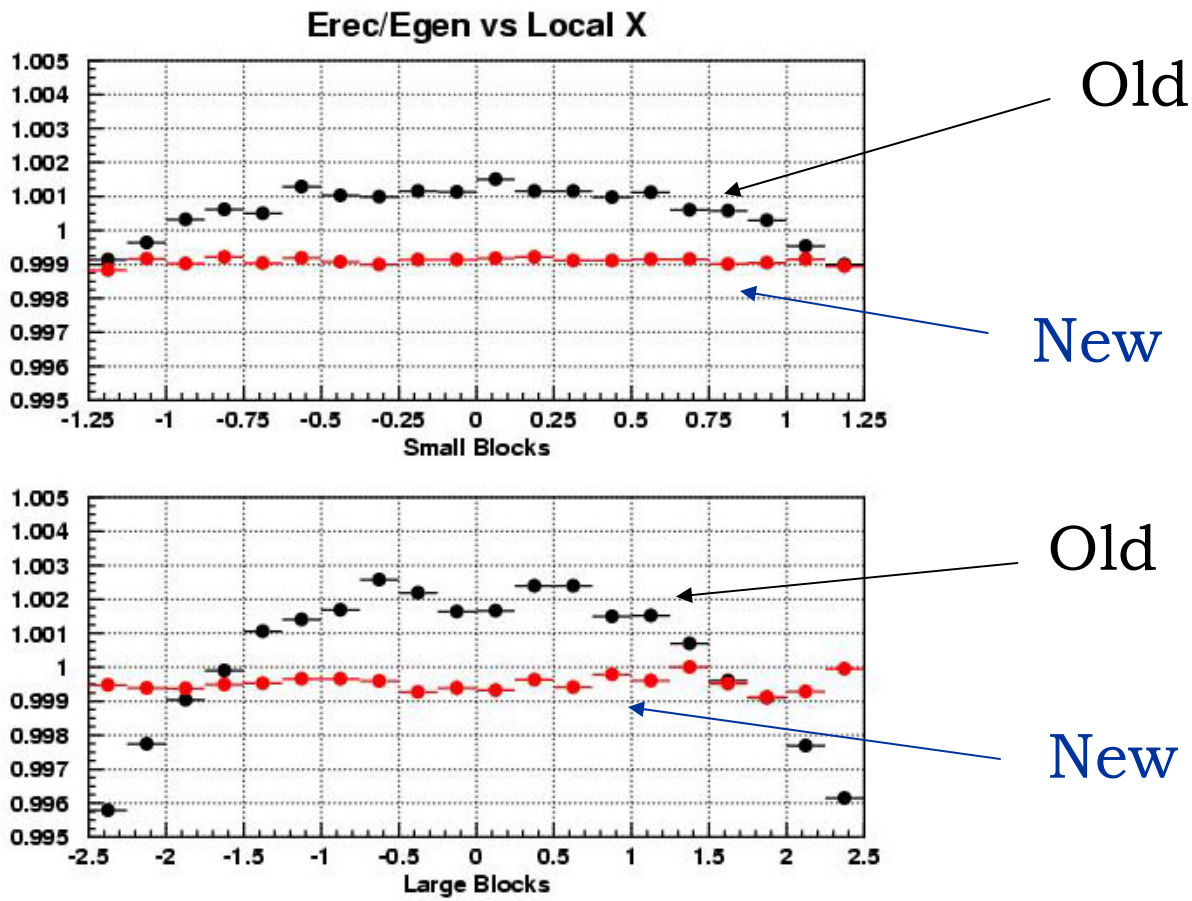
Improvements: Shower Shape



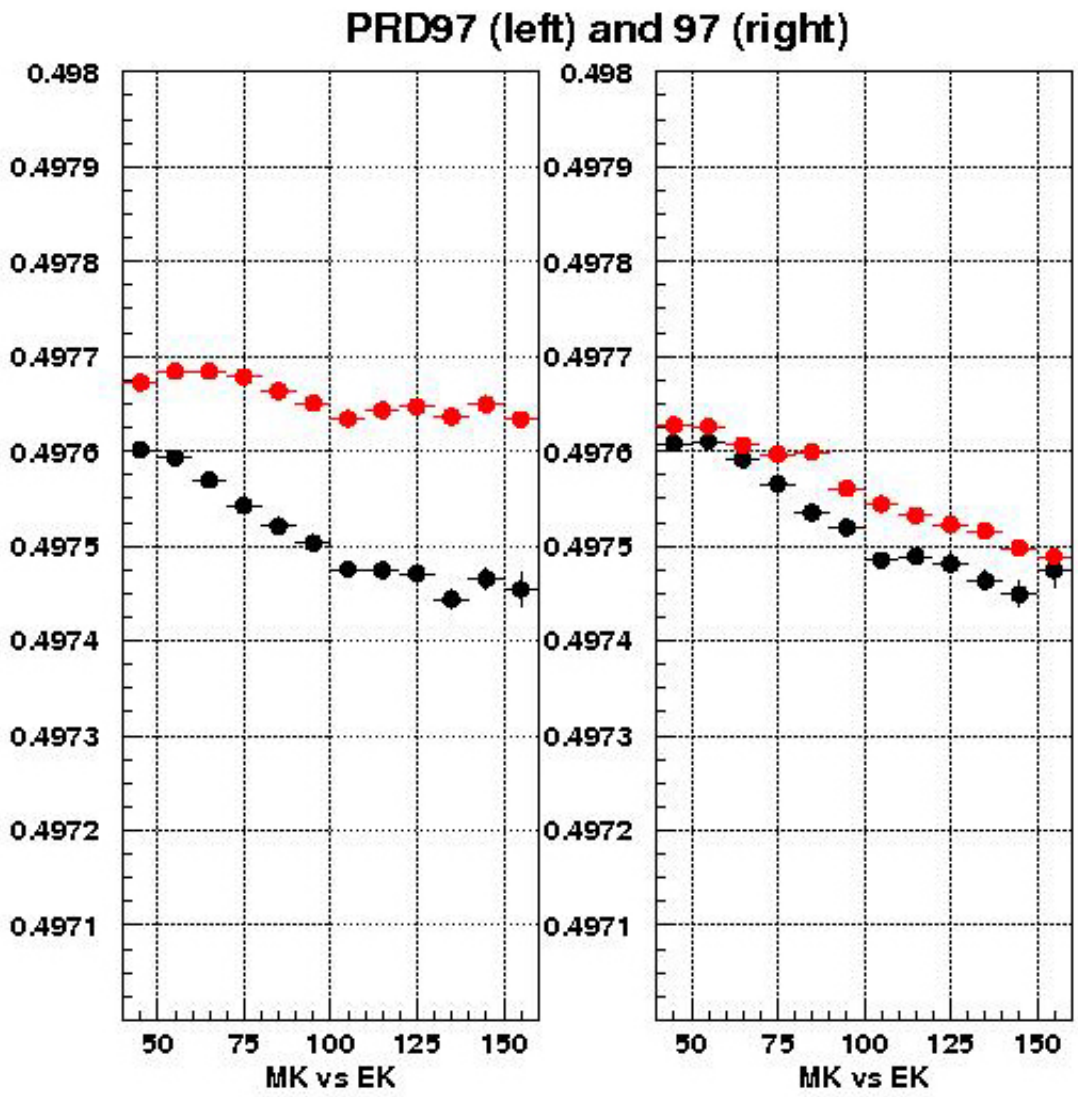
Old Shower Library

New Shower Library

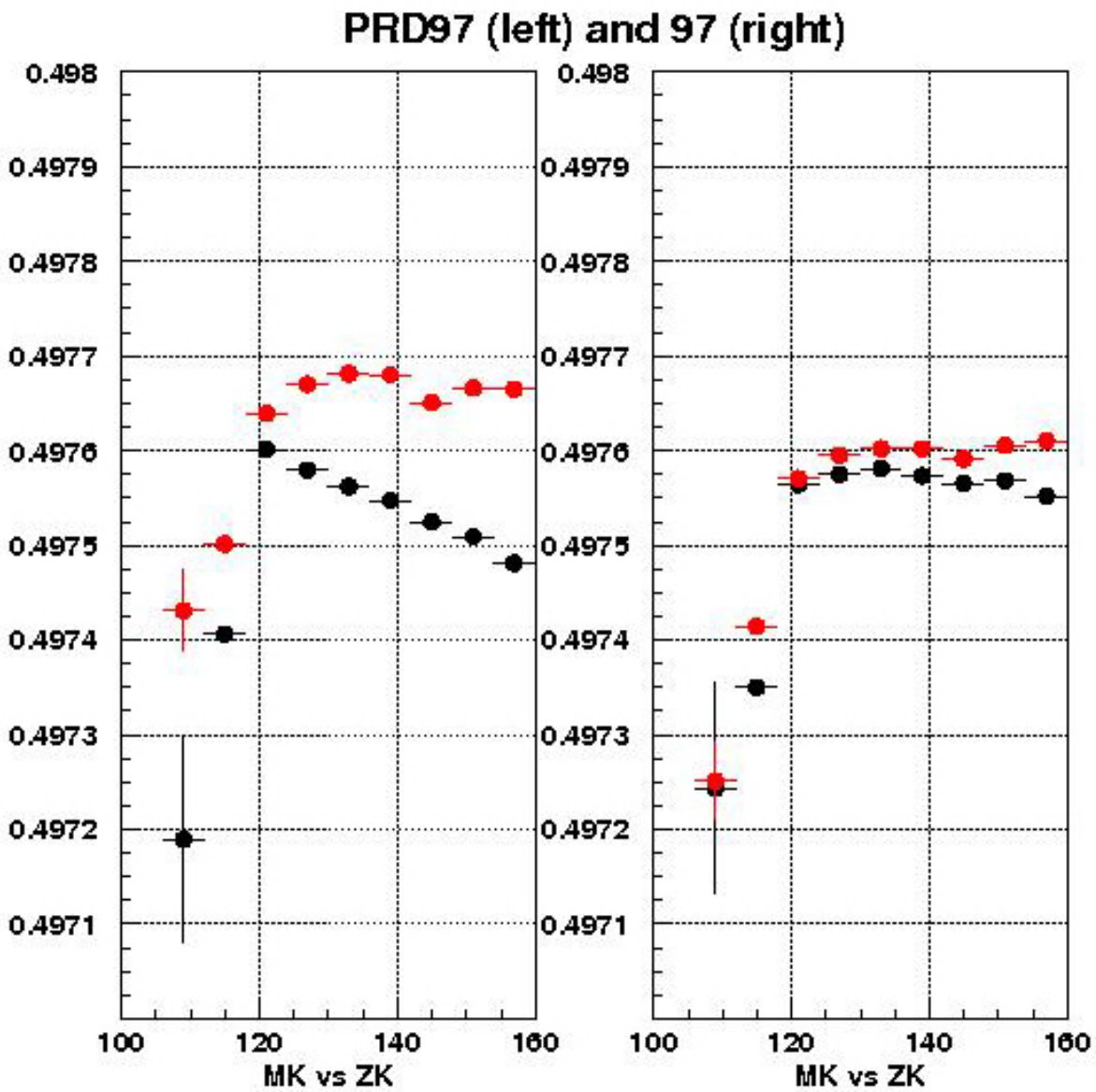
Improvements: Reconstructed Energy



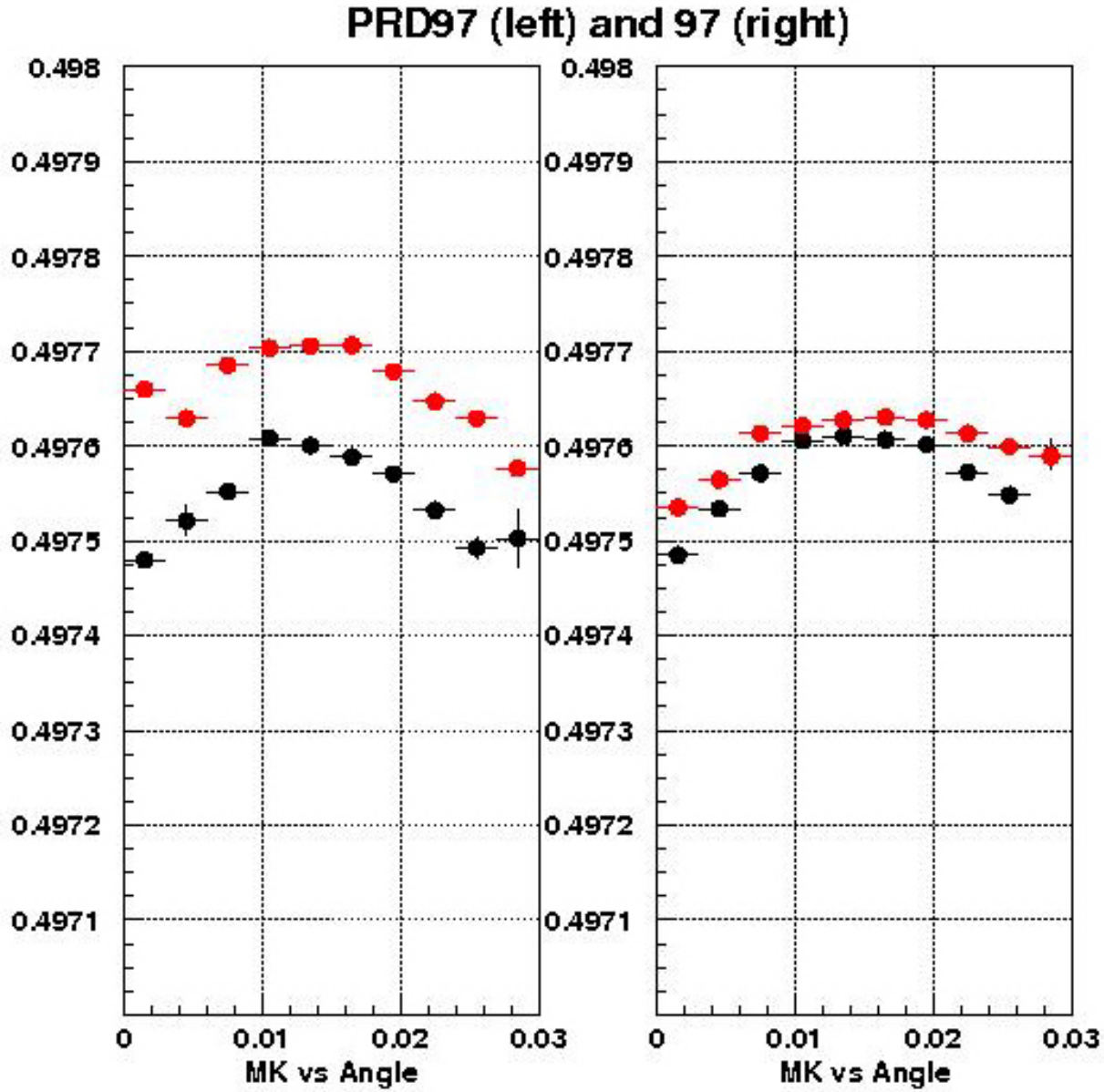
Improvements: M_K vs E_K



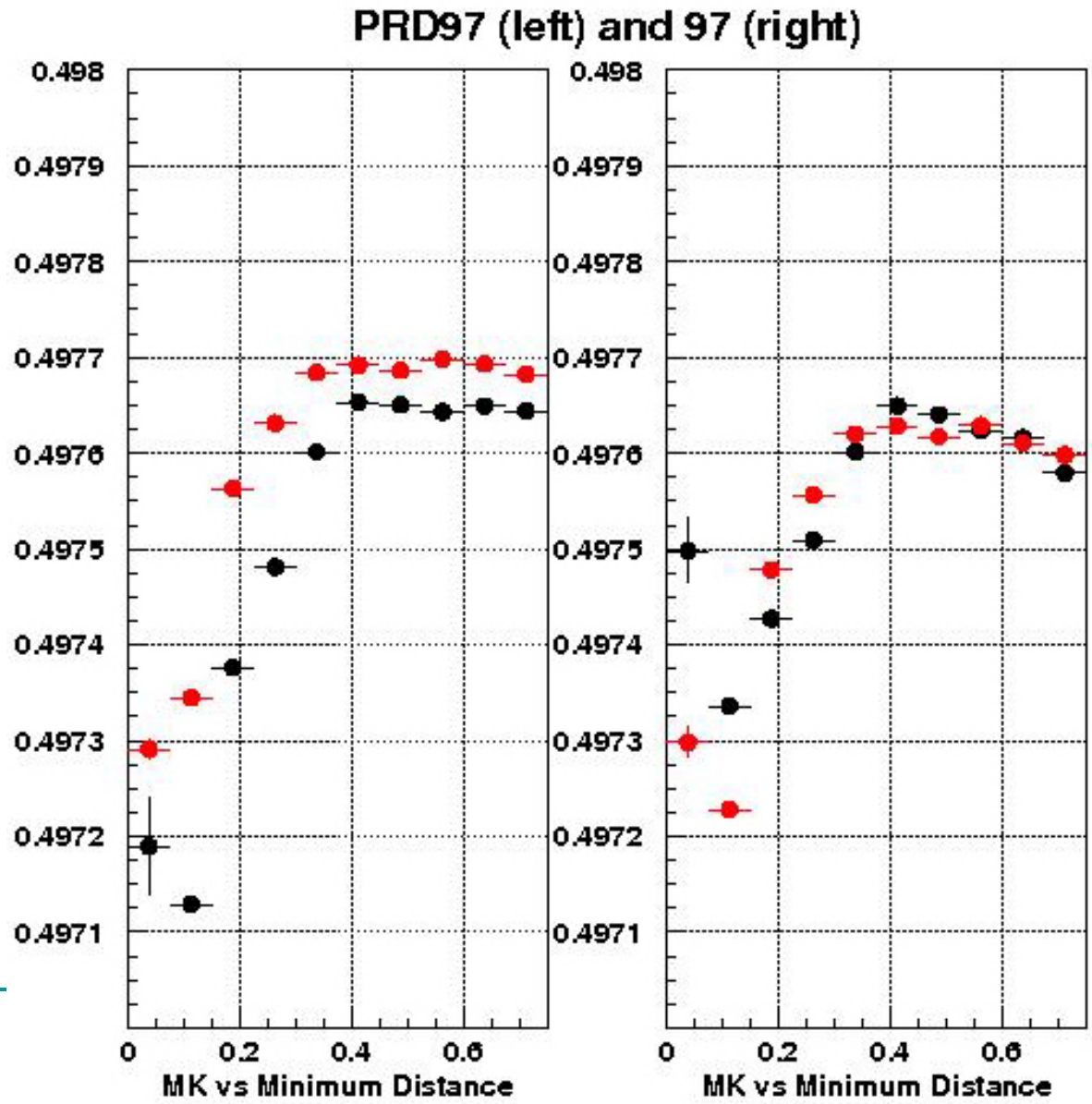
Improvements: M_K vs Z_K



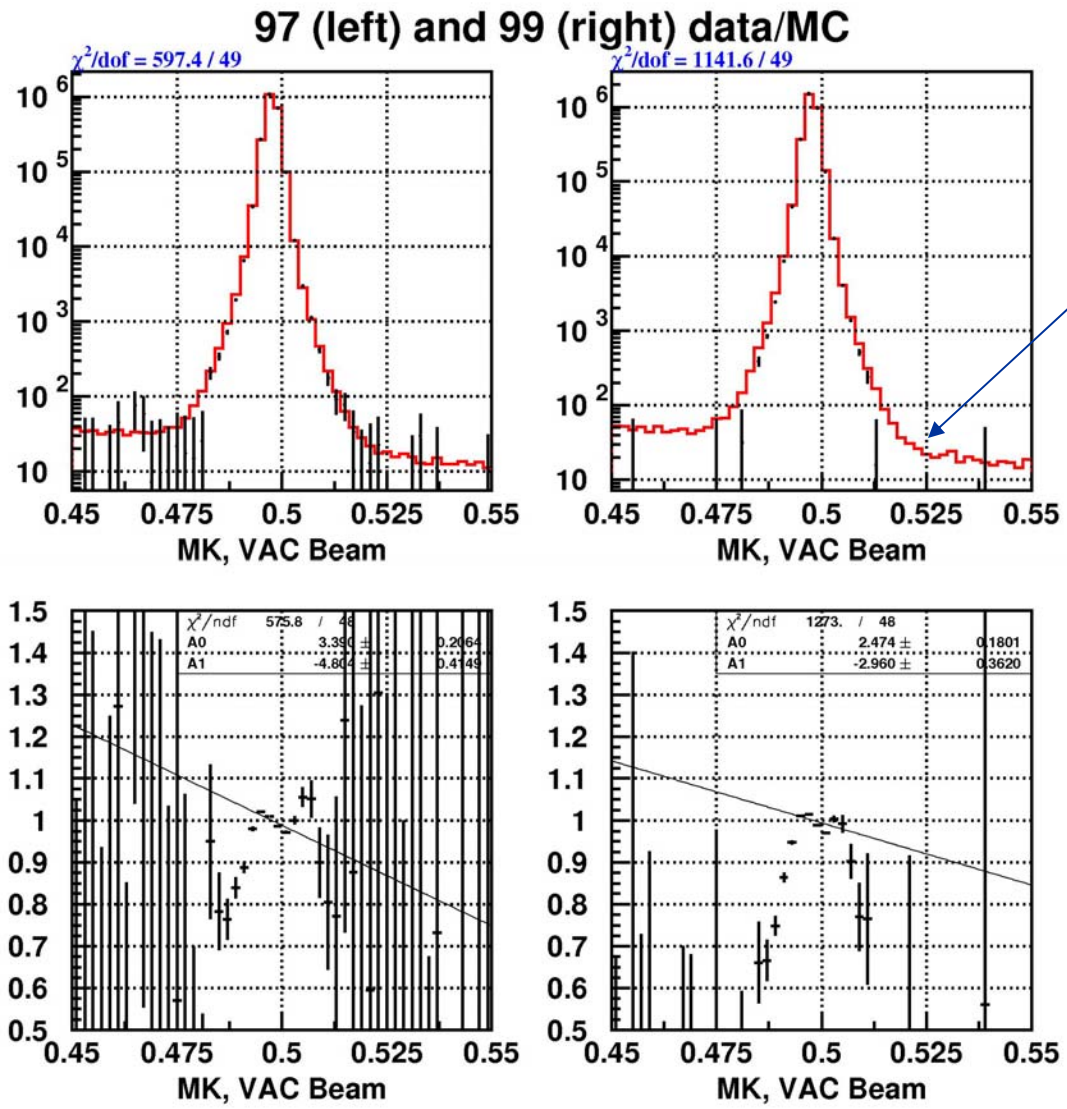
Improvements: M_K vs Angle



Improvements: M_K vs Min Distance



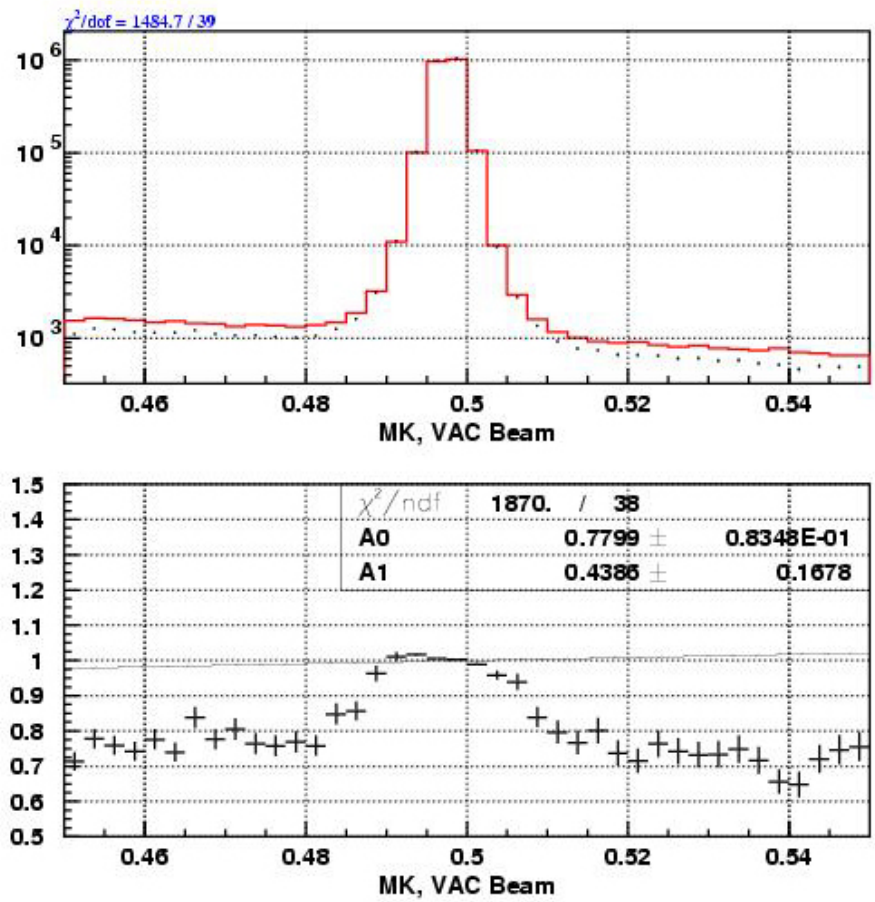
Data-MC Comparison: M_K



over-subtraction in mass sidebands

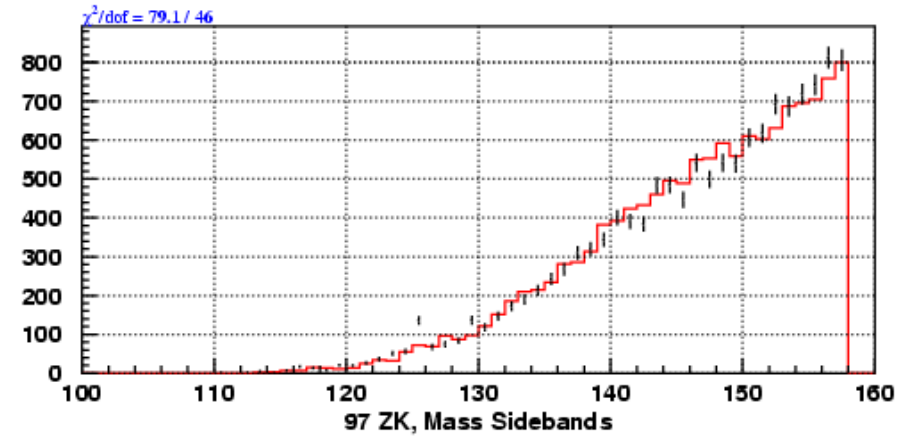
3pi0 bg problem

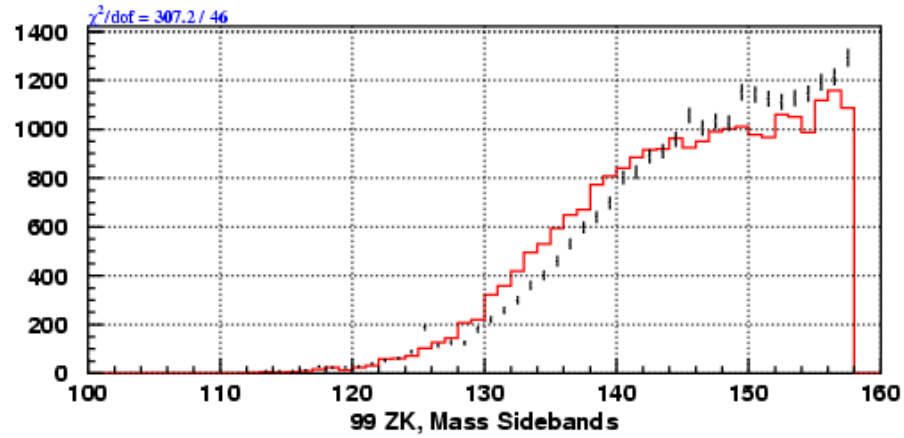
- 3pi0 bg level measured using 3pi0 MC normalized in mass sidebands
- use z=140-160 m for normalization
- 3pi0 bg level (vac)
  - 1997: 0.21%
  - 1999: 0.31%
- data-data comparison also shows more bg in 99 than 97



3pi0 bg problem (cont)

- change z range for bg normalization to 125-160 m
  - 97 nom bg: 0.21%
  - 97 all z bg: 0.21%
  - 99 nom bg: 0.31%
  - 99 all z bg: 0.29%
- ε' changes by 0.6×10^{-4}
- MC does not simulate bg shape in z for 99, shape matches well for 97

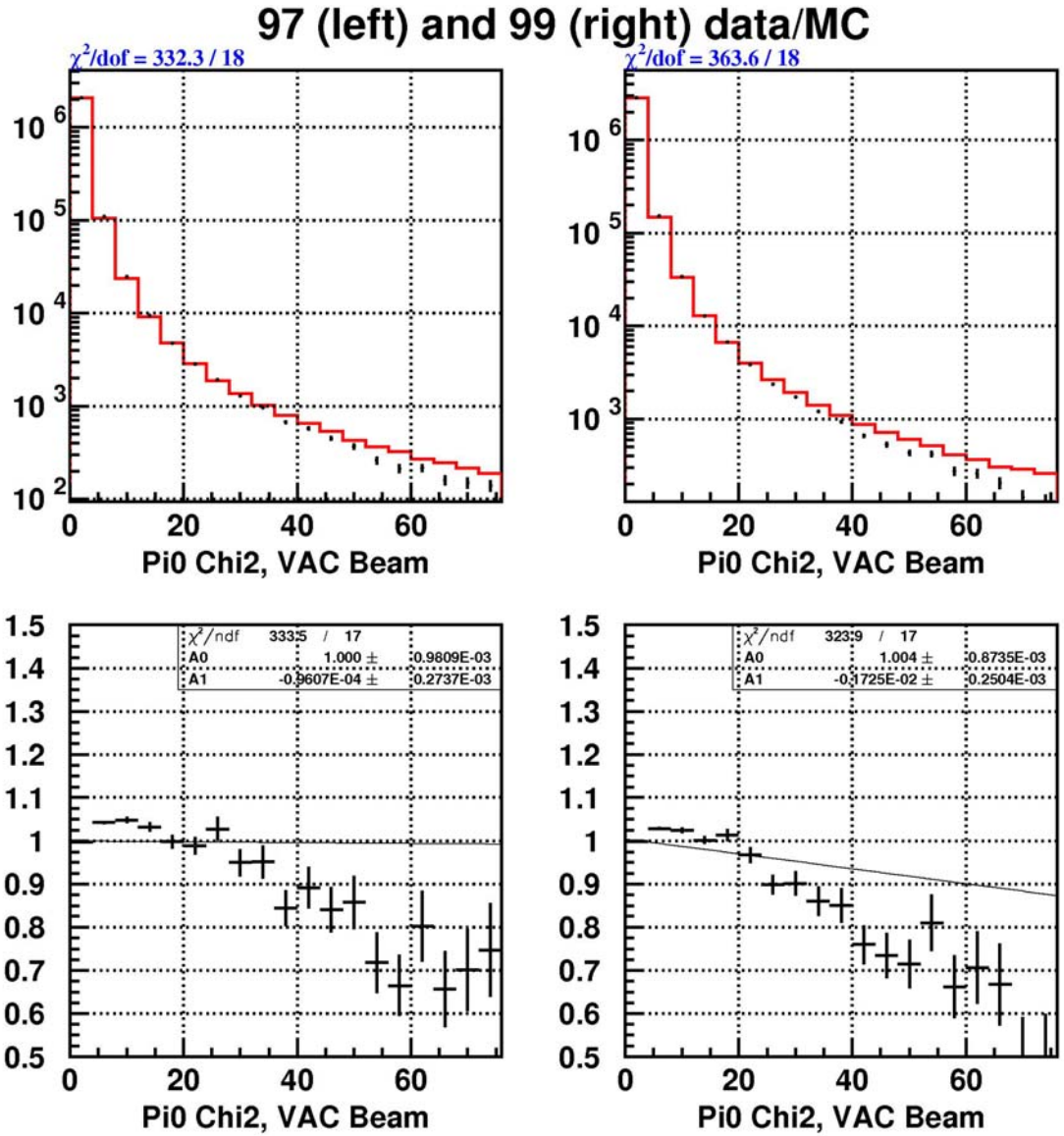




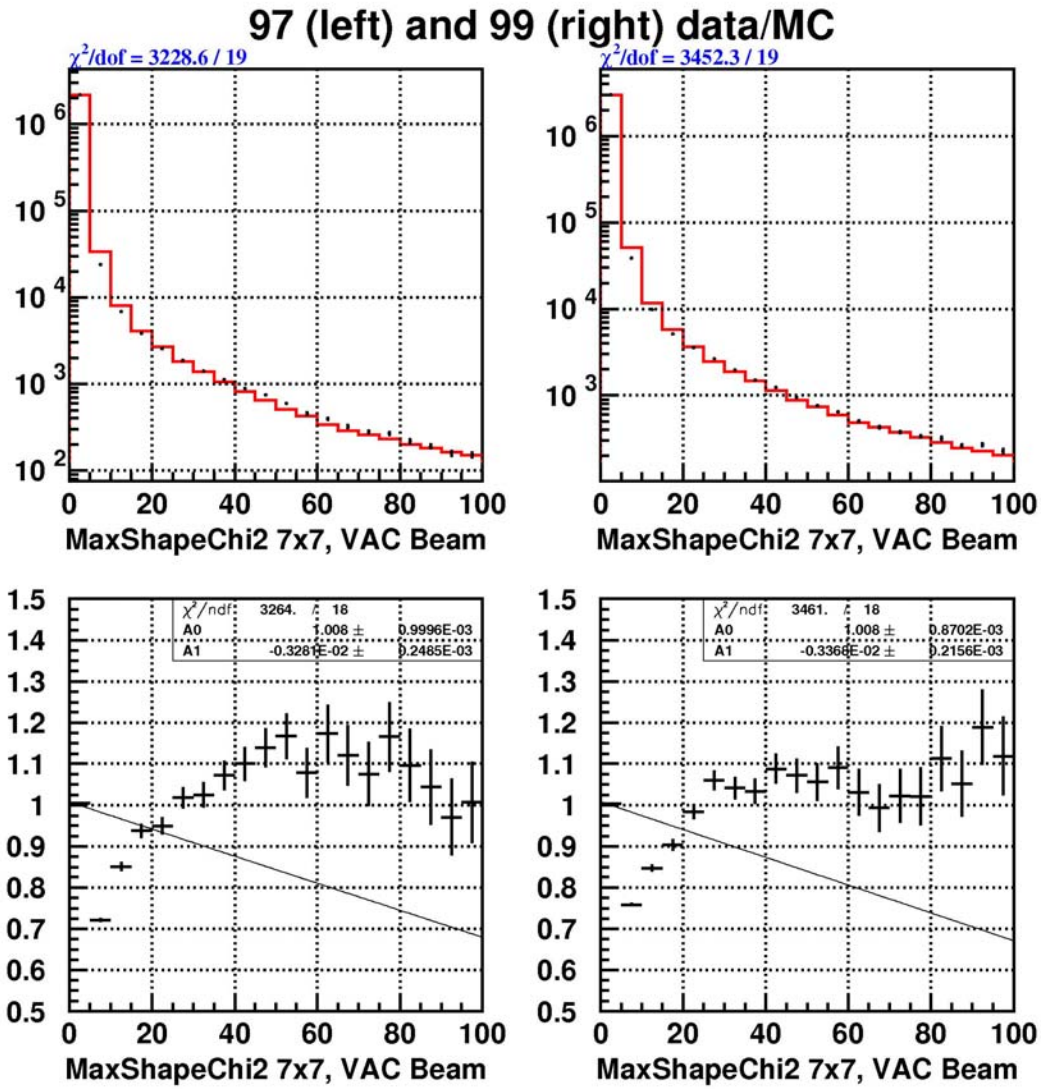
3pi0 bg problem (cont)

- 3pi0 bg z distribution sensitive to RC/SA thresholds
  - measurement of thresholds using $K_L \rightarrow \pi^+\pi^-\pi^0$
  - updated thresholds for 99 did not solve problem
- can do bg subtraction using mass sidebands to avoid problem with MC but . . .
- need to find out whether or not this problem indicates a significant problem with 99 MC

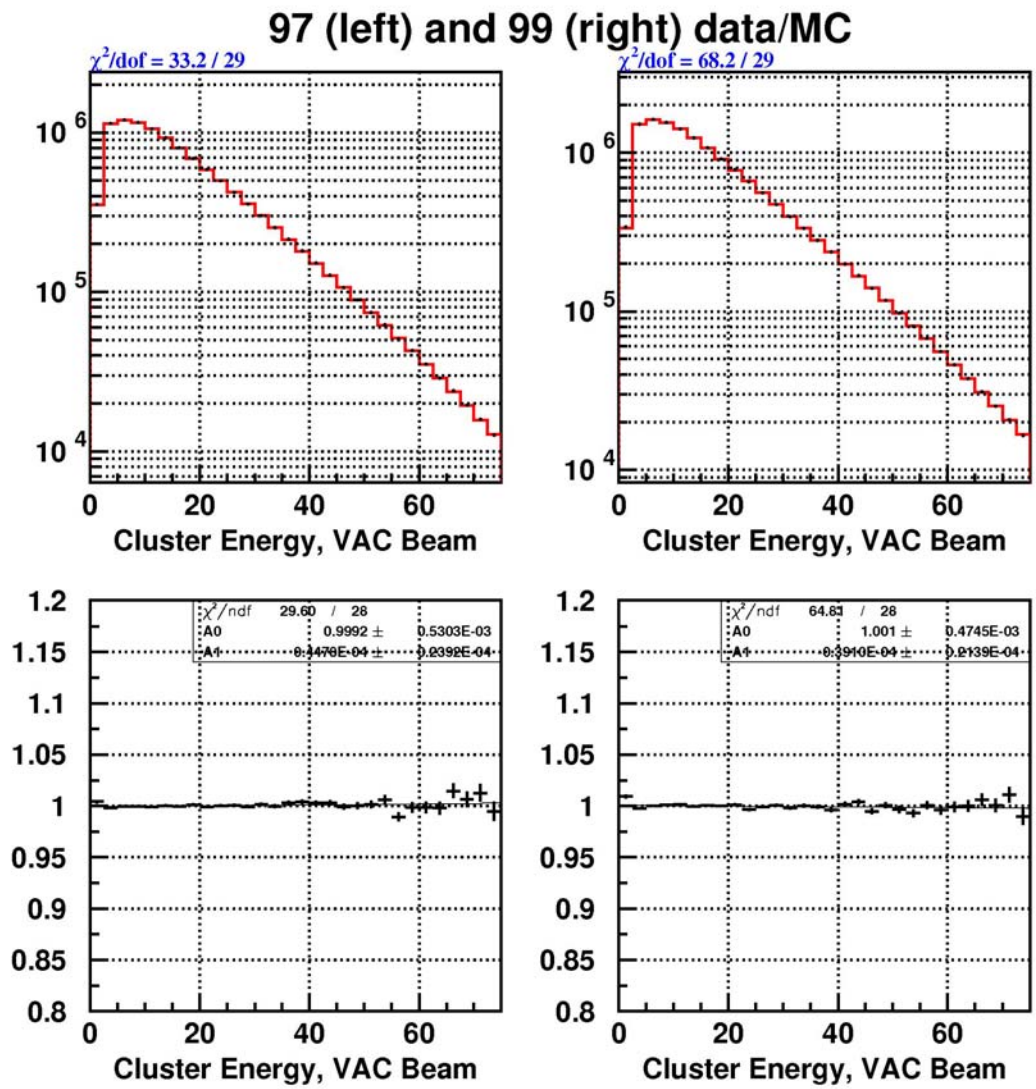
Data-MC Comparison: Pair Chi2



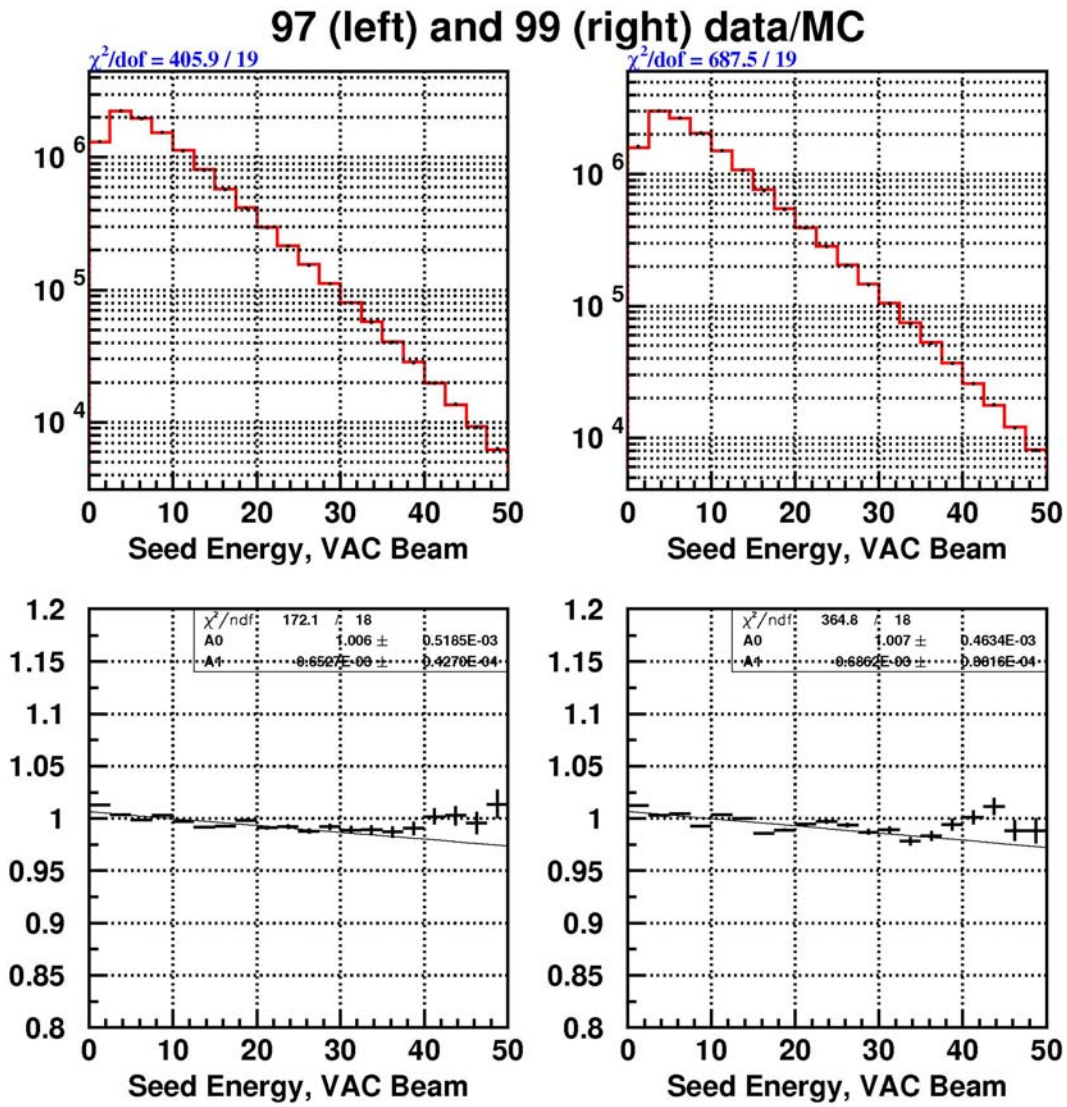
Data-MC Comparison: Shape Chi2



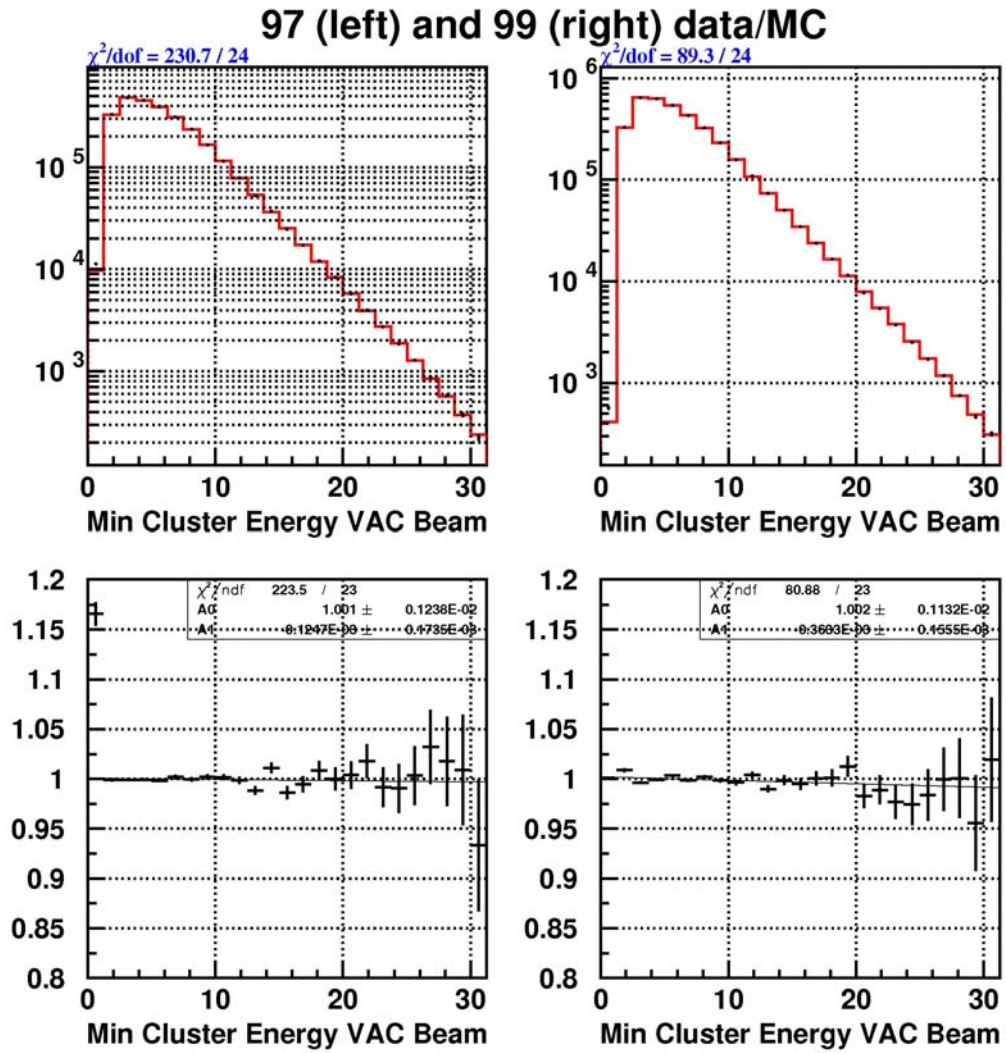
Data-MC Comparison: Cluster Energy



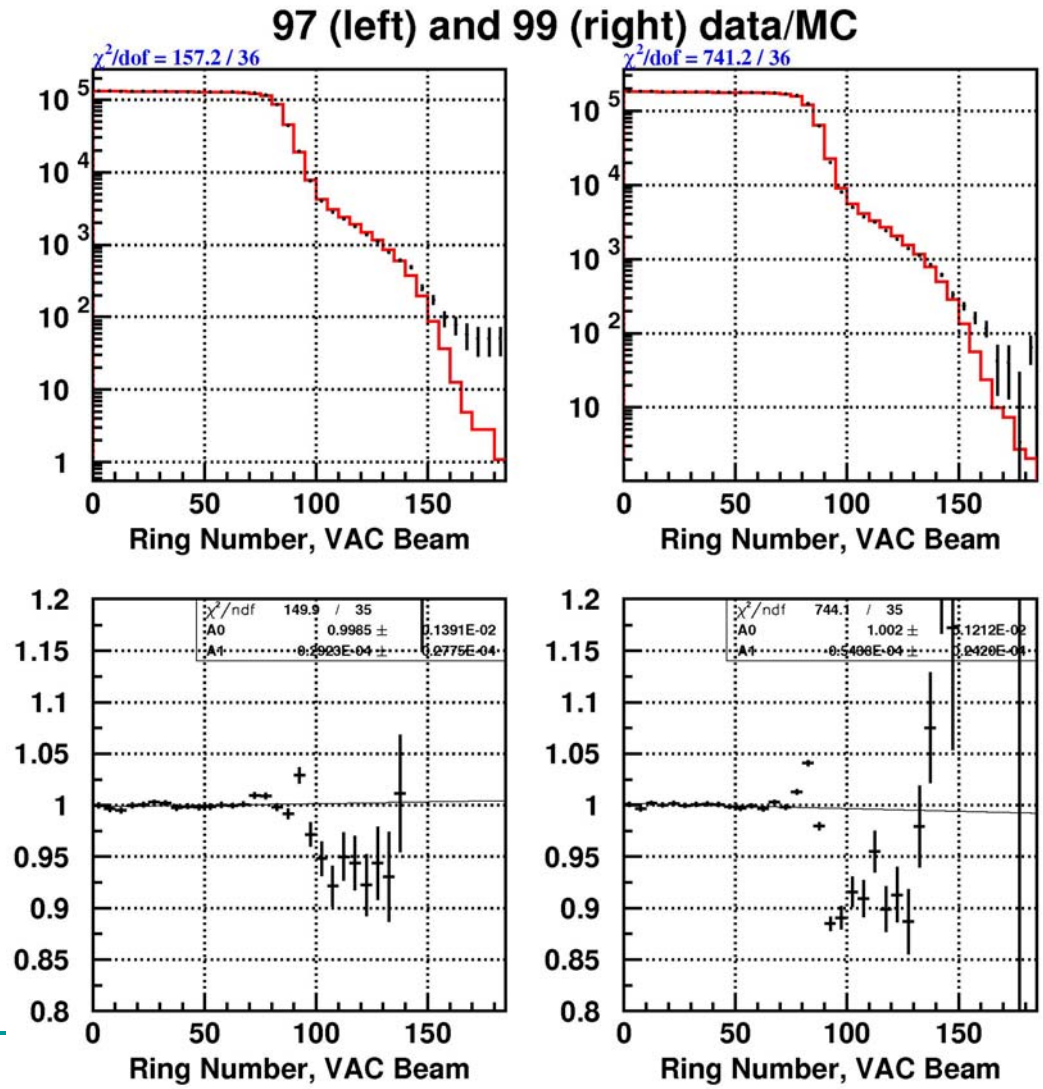
Data-MC Comparison: Seed Energy



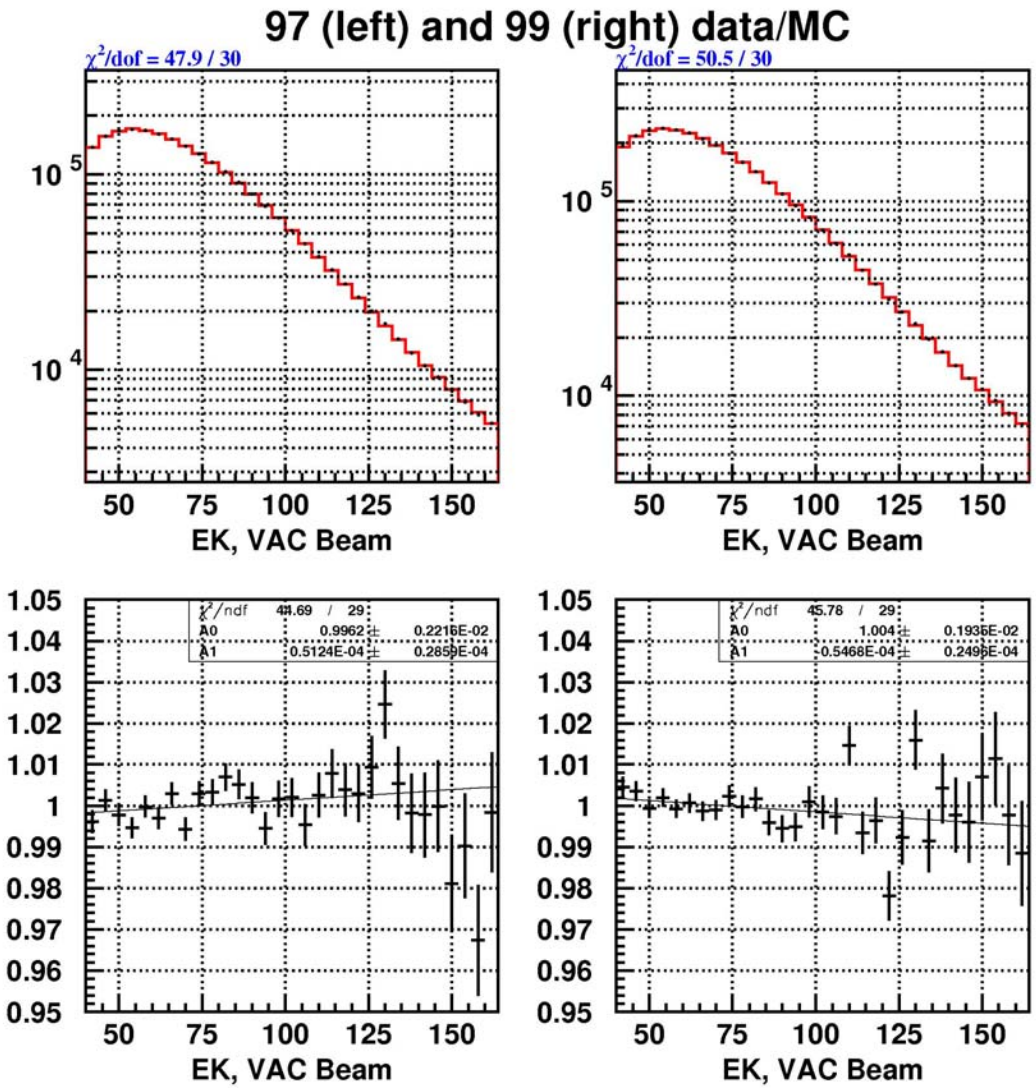
Data-MC Comparison: Min Ecl



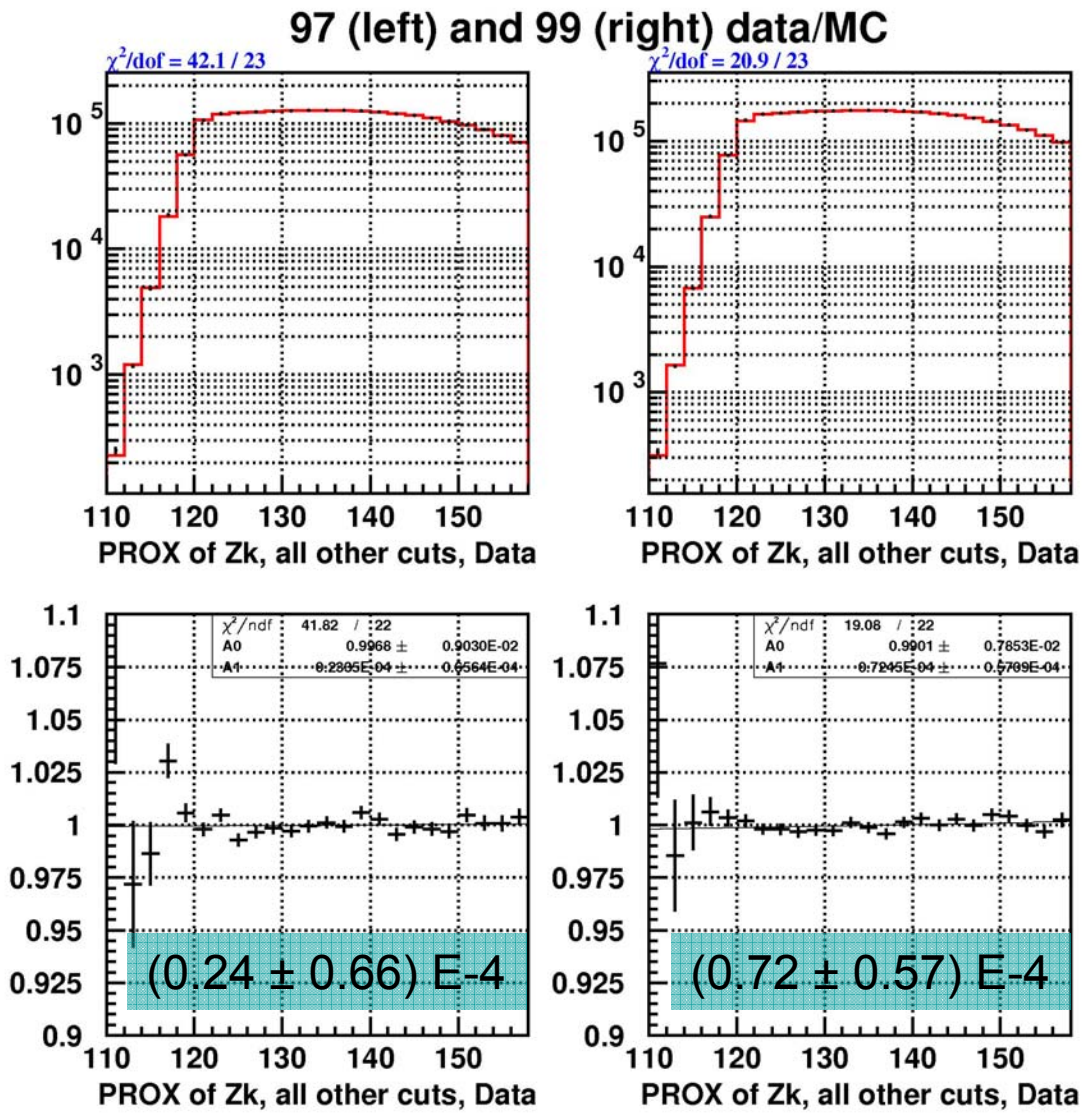
Data-MC Comparison: Ring Number



Data-MC Comparison: E_K

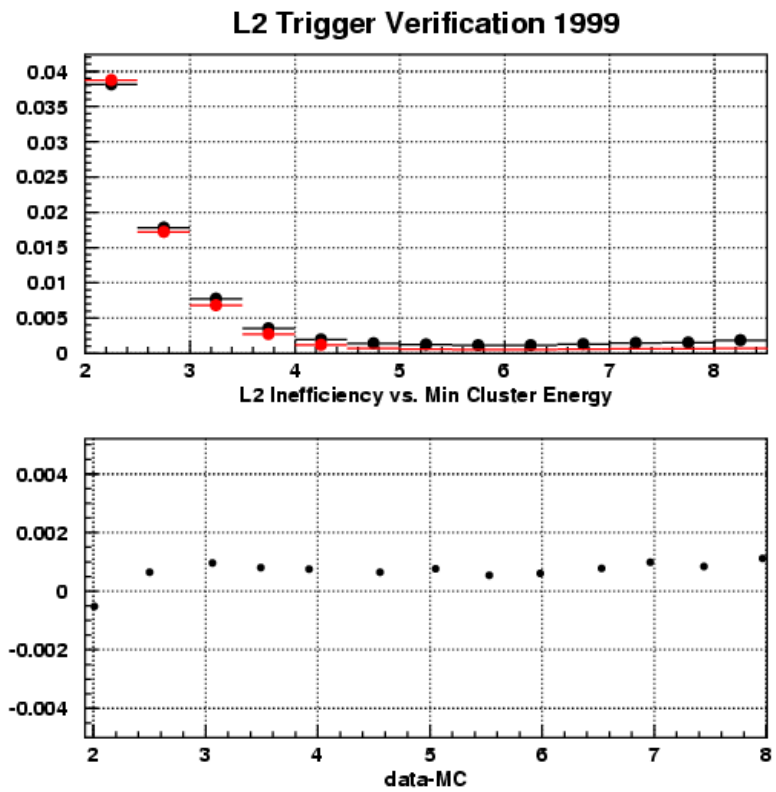


Data-MC Comparison: Z_K



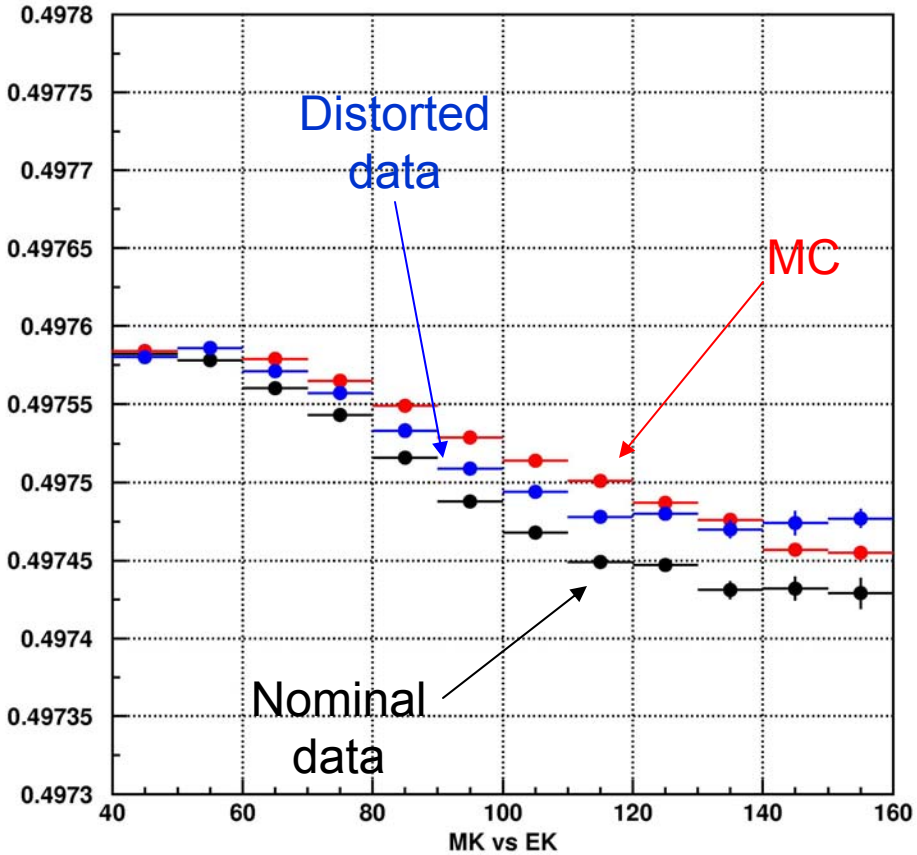
Systematics: L2 trigger

- studied using 3pi0 decays from B05
- 1997 trigger inefficiency
  - data: 0.29%
  - MC: 0.24%
  - ε' syst = 0.12×10^{-4}
- 1999 trigger inefficiency
  - data: 0.77%
  - MC: 0.68%
  - further MC study required to determine systematic error



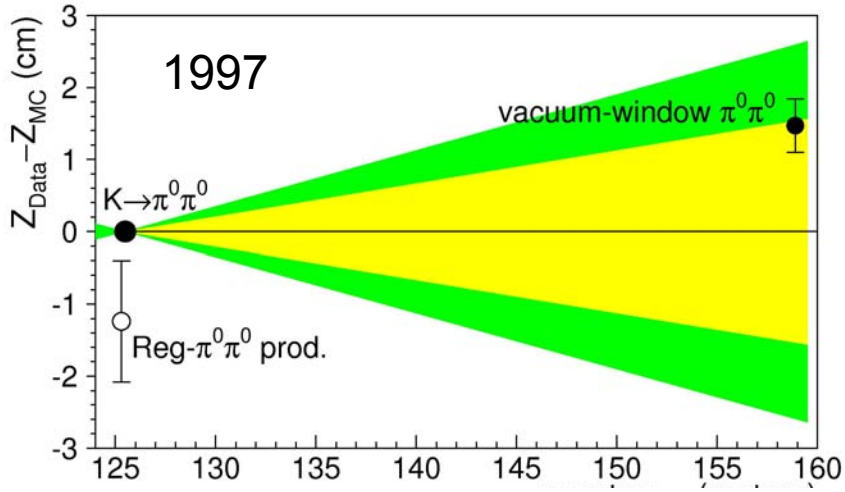
Systematics: Energy Non-Linearity

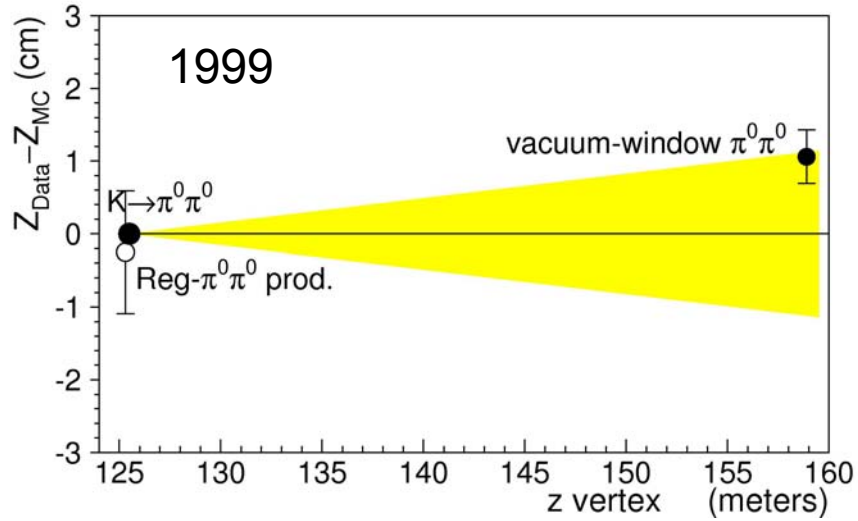
- use M_K vs E_K plot to determine distortion which provides best data-MC match
- 0.1%/100 GeV nonlinearity applied to data for 1997 and 1999
- change in ε'
  - 1997: -0.1×10^{-4}
  - 1999: 0.2×10^{-4}



Systematics: Energy Scale

- use junk produced in regenerator and vacuum window
- data-MC at regenerator edge
  - 1997: -1.24 ± 0.46 cm
  - 1999: -0.25 ± 0.42 cm
- data-MC at vacuum window
  - 1997: 1.47 ± 0.19 cm
  - 1999: 1.06 ± 0.17 cm
- error on ε'
  - 1997: 0.82×10^{-4}
  - 1999: 0.59×10^{-4}
  - PRD: 1.27×10^{-4}

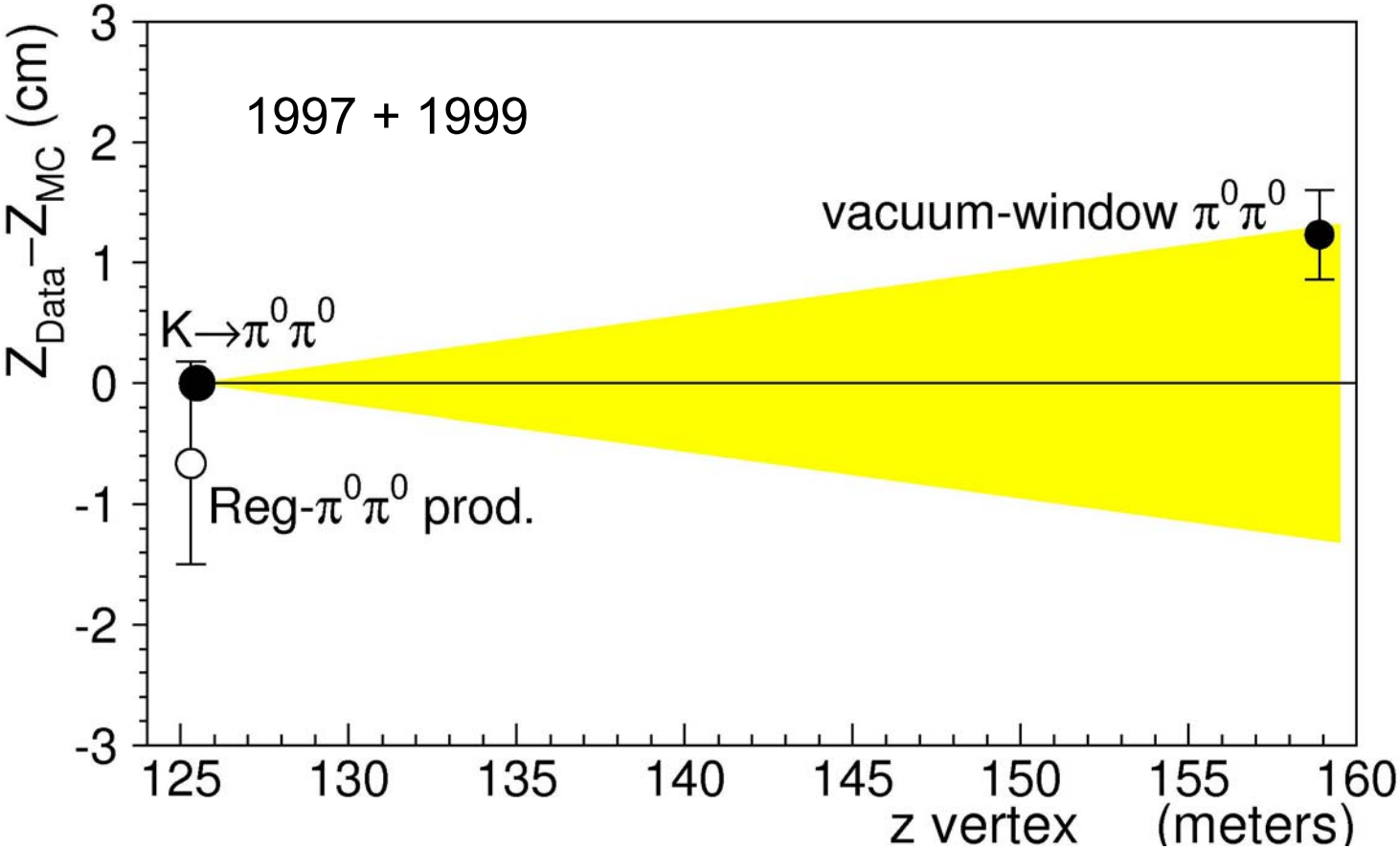




Systematics: Energy Scale (cont)

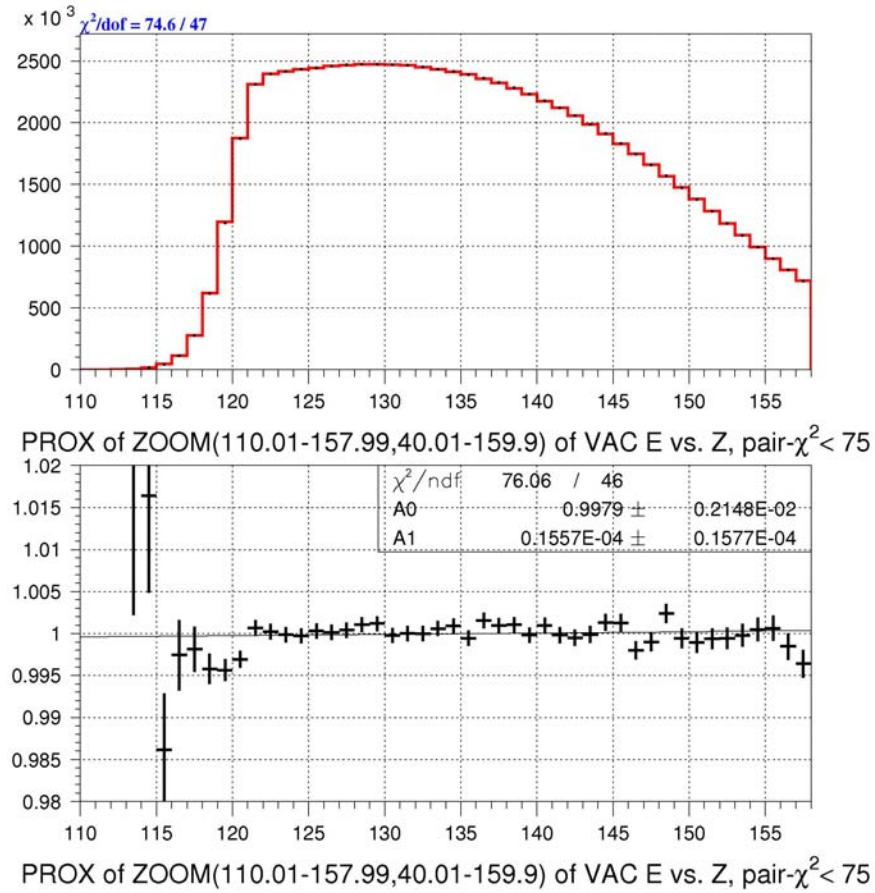
Reg junk data-MC: -0.66 cm

Vacwin junk data-MC: 1.23 cm

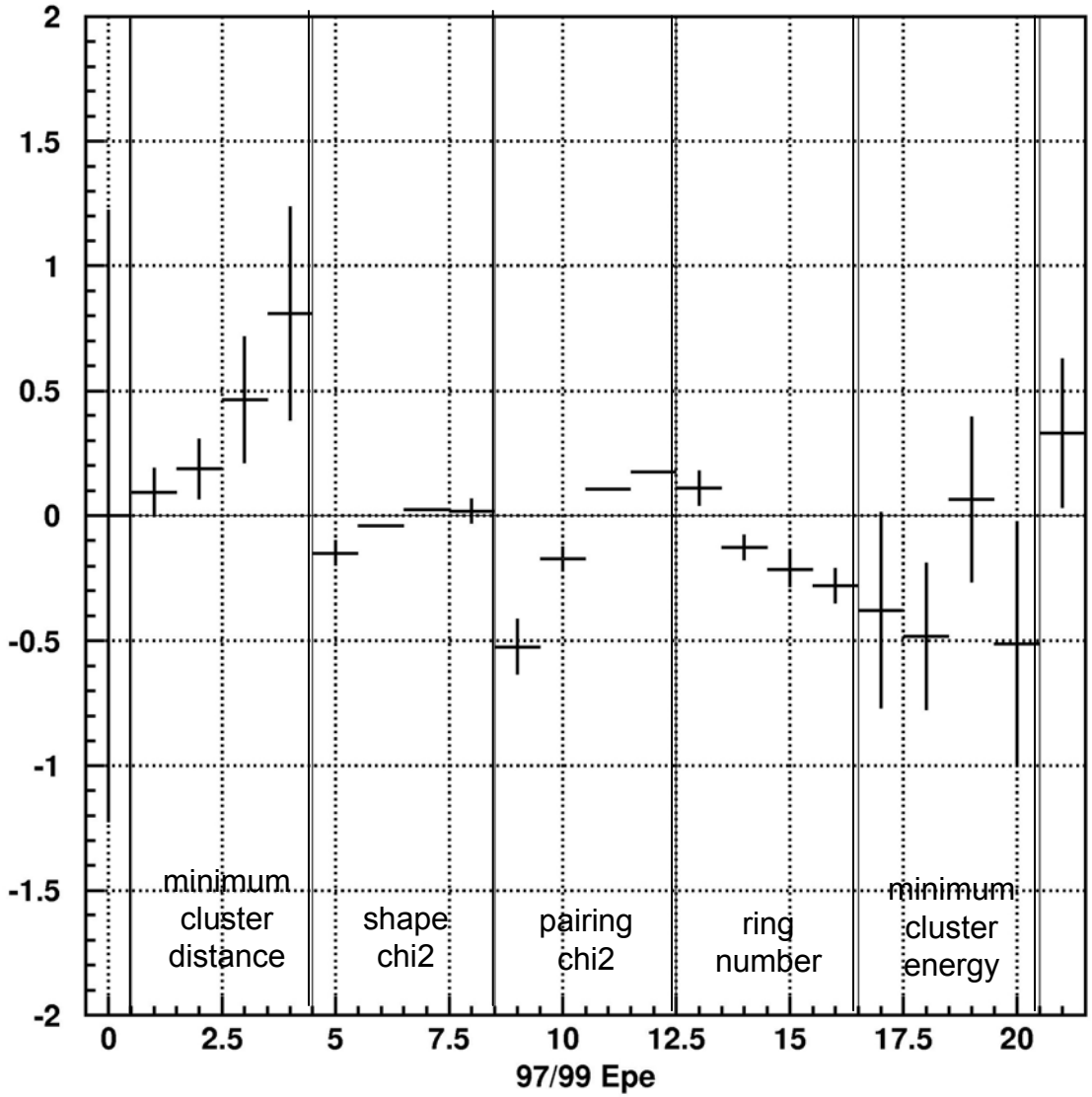


Systematics: Z Slope

- all z slopes are energy reweighted
- 2pi0 z slope (97+99)
  - $(0.56 \pm 0.43) \times 10^{-4}$
- 3pi0 z slope (97+99)
  - $(0.16 \pm 0.16) \times 10^{-4}$
- use slope and error from 3pi0 for systematic
  - 97+99: 0.30×10^{-4}
  - 96+97 PRD: 0.39×10^{-4}



Systematics: Cut Variations



Systematics: Current Status

Table 2: Summary of Neutral Mode Systematic Errors

Source	Error on $Re(\epsilon'/\epsilon)(\times 10^{-4})$				
	PRD	1996	1997	1999	Total
L1 Trigger	0.10	0.07	0.10		
L2 Trigger	0.13	0.20	0.12		
L3 Trigger	0.08	0.20	0.05	0.05	0.07
Energy Nonlinearity	0.66	0.66			
Energy Scale	1.27	1.08	0.82	0.59	0.74
Position Reconstruction	0.35	0.35			0.35
Ring Number	0.24	0.24			
Pairing χ^2	0.20	0.20			
Shape χ^2	0.20	0.20			
Background	1.07	1.14	1.06		1.06
Acceptance	0.39	1.04	0.30		0.40
CA Aperture	0.42	0.42			0.42
MA Aperture	0.18	0.18			0.18
Reg Edge	0.04	0.04			0.04
CsI Size	0.15	0.15			0.15
MC Statistics	0.40	0.55			
Total	2.01	2.20			

Fit Results (statistical errors only)

	PRD	97	99	97+99
Δm (neut) ($\times 10^6\ \hbar s^{-1}$)	5237.3 ± 10.6	5247.6 ± 14.0	5271.8 ± 11.9	5261.5 ± 9.1
τ_S (neut) ($\times 10^{-12}$ s)	89.637 ± 0.050	89.643 ± 0.065	89.715 ± 0.056	89.685 ± 0.043
Chi2/dof	195/199	216/199	214/199	252/199

Compare PRD charged mode values: Δm = 5266.7(5.9), τ_S = 89.650(0.028)

Fit Results (statistical errors only)

	PRD	97	99	97+99
Re(ε'/ε) ($\times 10^{-4}$)	20.71 ± 1.48	17.71 ± 1.87		
Chi2/dof	27.6/21	21.7/21	20.8/21	21.6/21
Im(ε'/ε) ($\times 10^{-4}$)	-22.9 ± 12.8	-18.5 ± 15.6	-16.1 ± 13.3	-16.6 ± 9.9
Chi2/dof	425/398	406/399	426/397	442/399

Fit Results (statistical errors only)

	PRD	97	99	97+99
Re(ε'/ε) ($\times 10^{-4}$)	20.71 ± 1.48	17.71 ± 1.87	18.86 ± 1.61	18.38 ± 1.23
Chi2/dof	27.6/21	21.7/21	20.8/21	21.6/21
Im(ε'/ε) ($\times 10^{-4}$)	-22.9 ± 12.8	-18.5 ± 15.6	-16.1 ± 13.3	-16.6 ± 9.9
Chi2/dof	425/398	406/399	426/397	442/399

Outstanding Questions

- 3pi0 bg simulation
  - can do bg subtraction using mass sidebands
  - need to know why the shape is poorly simulated for 1999
- change in 1999 z-binned fit from $|\varepsilon|$ update
- L2 trigger inefficiency
- upstream problem in 3pi0 z overlays
- junk mismatch at regenerator edge in 1997

Plan

- Preliminary result very soon
  - present at summer conferences
  - finish everything for “preliminary” result
- 1996 analysis
  - calibration complete
- 1999 L1 trigger systematic
- Final cut variation systematics
- Crosschecks
  - intensity
  - run ranges