$K_L \rightarrow 3\pi^0$ Dalitz Analysis (PRD draft under review)

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History

- Started in ~2000 to repeat Sunil's analysis … nagging problem prevents publication.
- Kaon 2005 Conference at Northwestern U: learn about interference between $K_L \to 3\pi^0$ and $K_L \to \pi^+\pi^-\pi^0 \to 3\pi^0$

  ($\pi^+\pi^-$ re-scatters to $\pi^0\pi^0$)
- Update Dalitz fitter using Cabibbo/Isidoro model.
- Wait for ε' analysis to finish to take advantage of all neutral mode improvements.
- Final analysis uses 68 million $K_L \to 3\pi^0$ from 96+97+99.

Begin Tour of
Phys Rev D Draft

Note: PRD = long write-up & paper in one.

Intro to Dalitz Phase Space

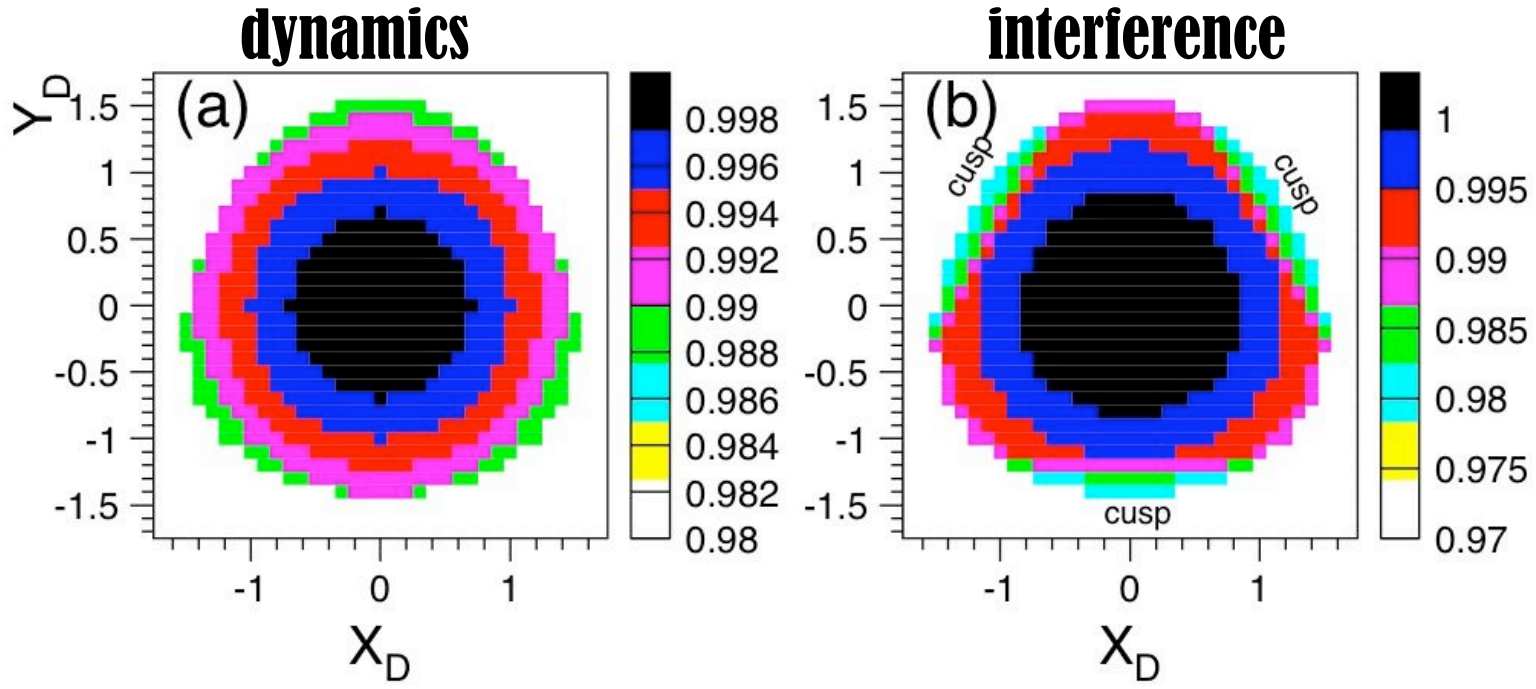
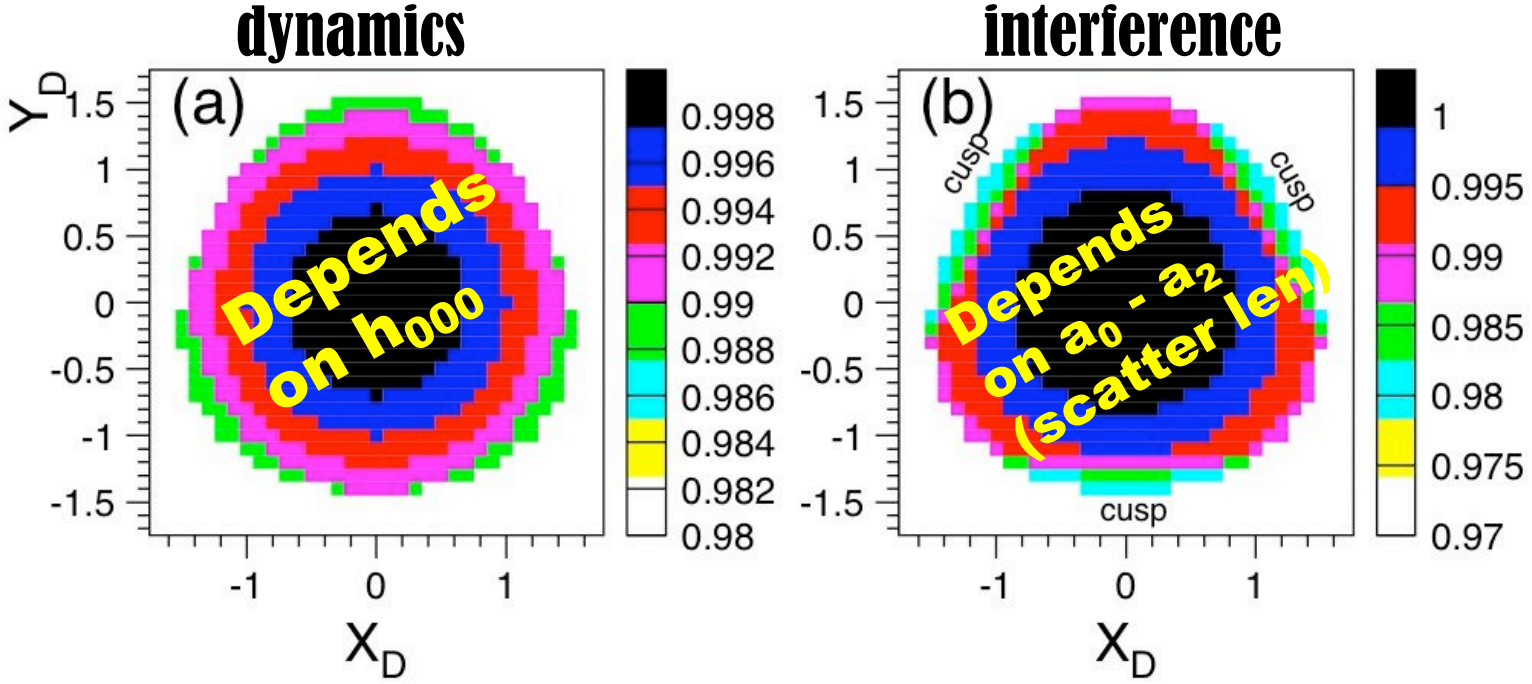


FIG. 1: Expected deviation from $K_L \to \pi^0\pi^0\pi^0$ phase-space based on (a) $h_{000} = -0.005$ and no interference, and (b) $K_L \to \pi^+\pi^-\pi^0$ interference as calculated by Cabibbo and Isidori [7], with $h_{000} = 0$.

X_D ~ Ecm(pi01) with scale and offset

Y_D ~ Ecm(pi02) " "

Intro to Dalitz Phase Space



✲ ChPTh offers precise (2%) prediction for $a_0 - a_2$.

✲ $K \rightarrow 3\pi$ decays provides possibility for precise experimental measurement to check ChPTh (charged K has much more sensitivity than K_L)

Show-off Plots

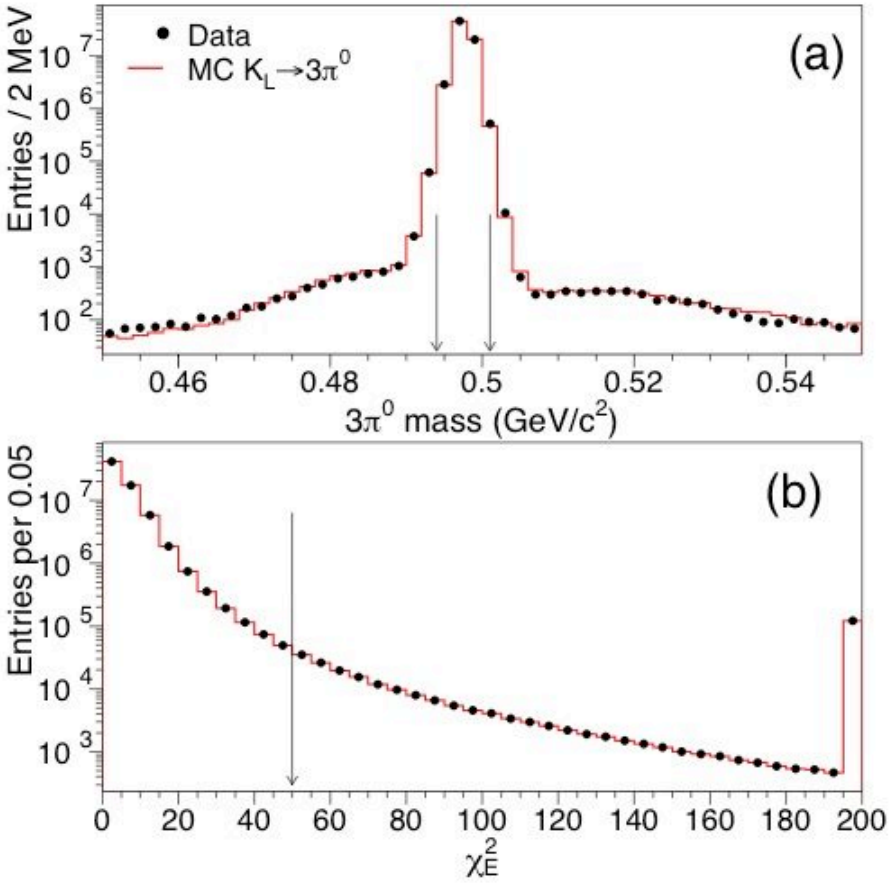


FIG. 4: (a) Invariant $\pi^0\pi^0\pi^0$ mass with all selection requirements except for the $\pi^0\pi^0\pi^0$-mass and χ^2_E. The $\pi^0\pi^0\pi^0$ mass resolution (from Gaussian fit) is 0.94 MeV/c^2. (b) shows χ^2_E distribution with all other selection requirements. Dots are data and the histogram is MC. Vertical arrows show the selection requirements.

$$\chi^2_E = \sum_{i=1}^{6} \frac{(E_i - E_i^{fit})^2}{\sigma_i^2} ,$$

with four constraints:

$m_{6\gamma} = M_K$ &

$m_{\gamma\gamma} = M_{\pi 0}$

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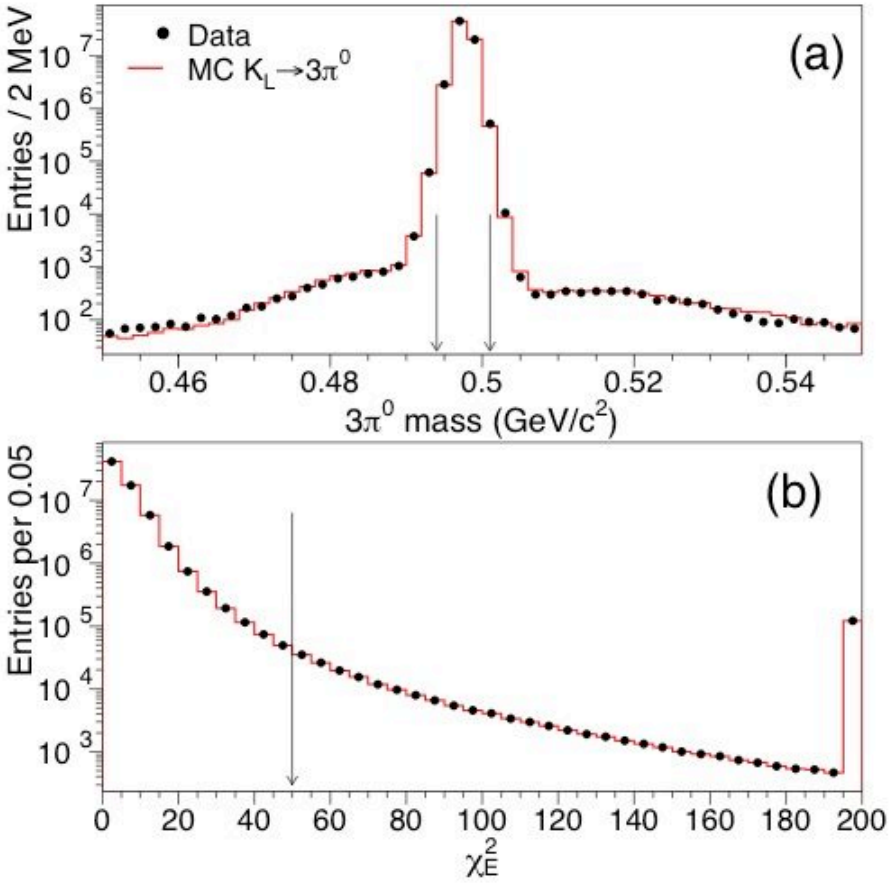

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Tail fractions:
* 0.21% for data
* 0.20% for MC

Tail fractions:
* 0.43% for data
* 0.47% for MC

Photon Calibration for ε' Analysis (by-product of $3\pi^0$ Dalitz analysis)

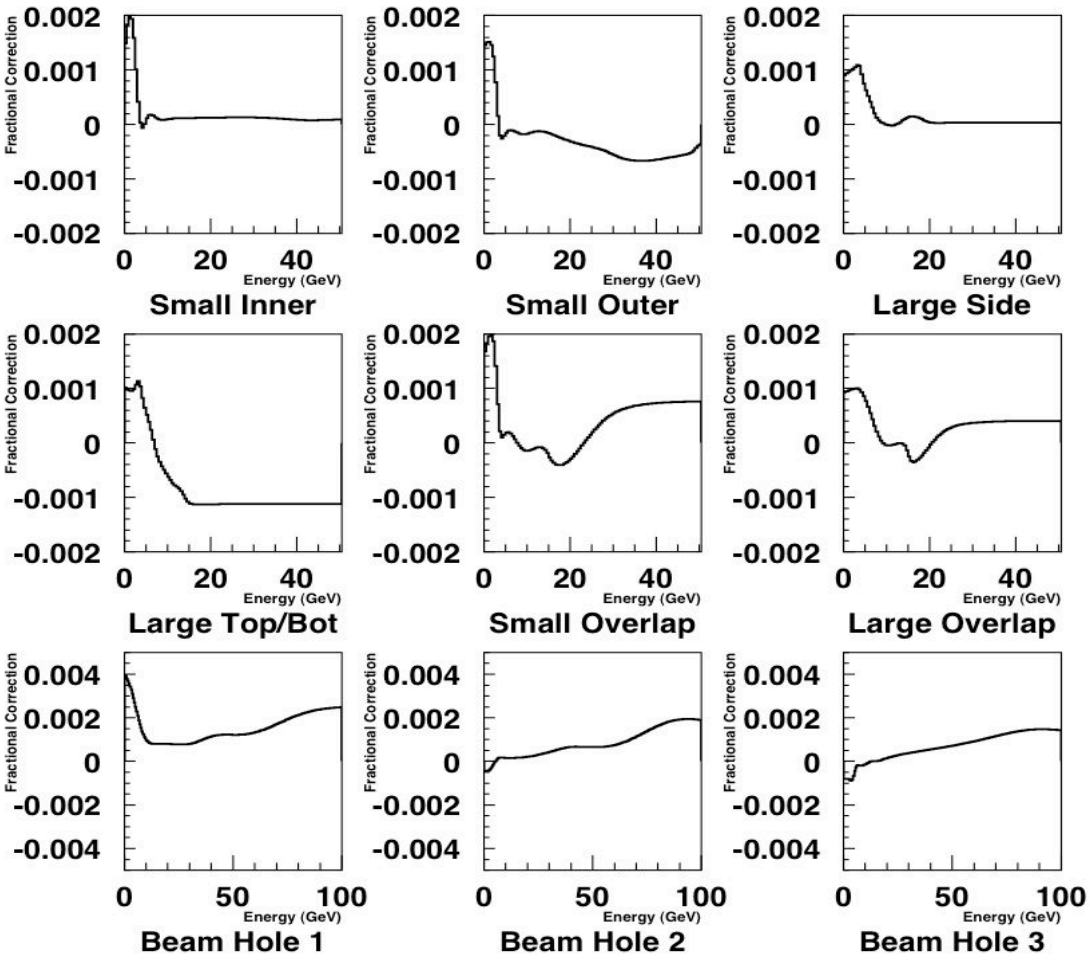

Figure 3.18: Photon correction in nine regions for 1999. The three beam hole regions correspond to rings of crystals around the beam holes, where "Beam Hole 1" is the first ring, "Beam Hole 2" is the second ring, and "Beam Hole 3" is the third ring. Note the different vertical scale for the beam hole regions.

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Dazzling Dalitz Plot

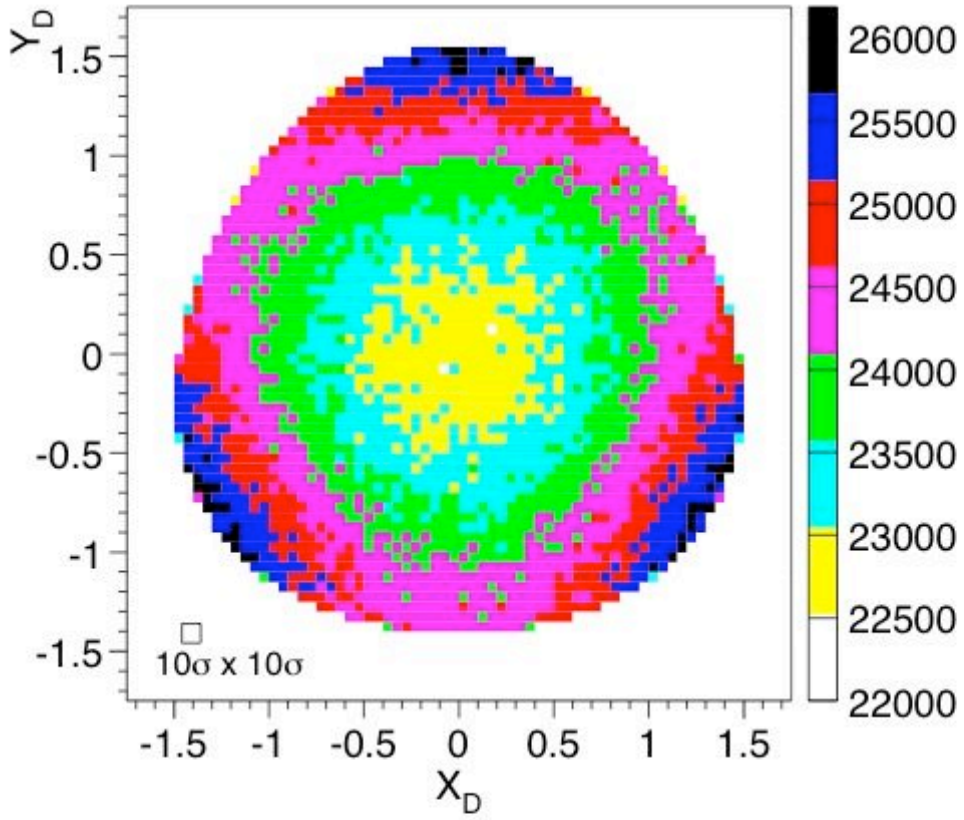
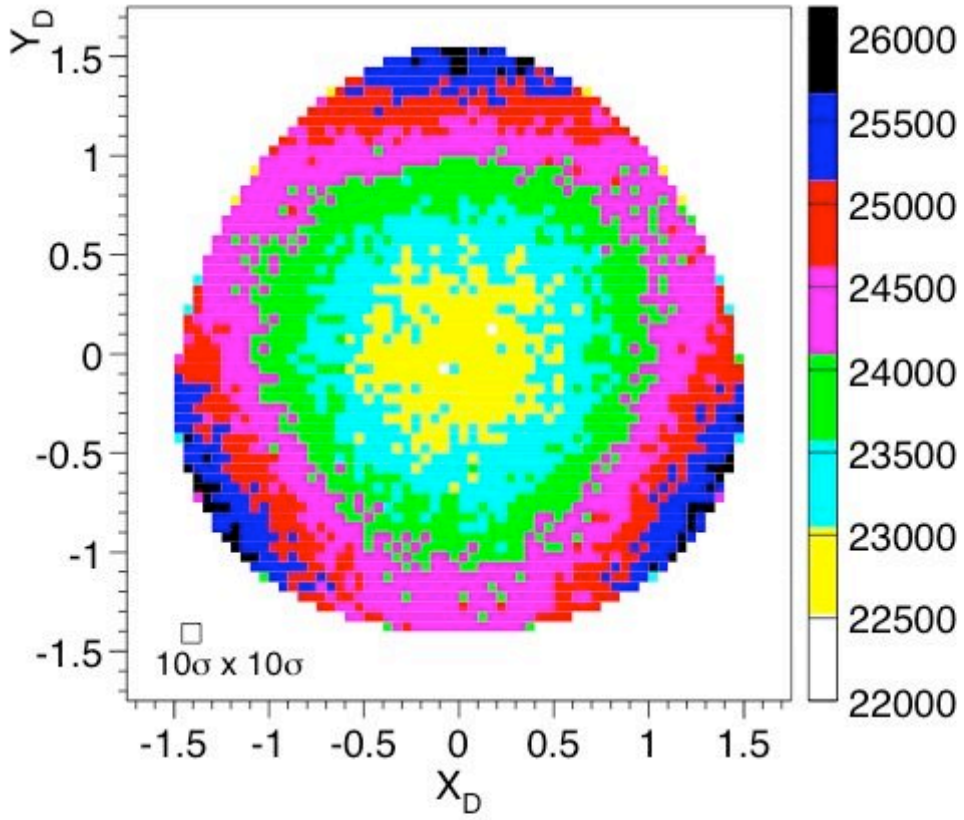


FIG. 5: Dalitz plot density, Y_D vs. X_D, for 68.3 million $K_L \to \pi^0\pi^0\pi^0$ decays in the KTeV data sample after all selection requirements. The color-scale at right shows the number of events in each 0.05×0.05 pixel. The reconstruction resolution on X_D and Y_D is $\sigma \sim 0.01$ as determined by the MC; the box in the lower-left corner shows $10\sigma \times 10\sigma$ for illustration.

Dazzling Dalitz Plot



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Dick Dalitz was also dazzled, but unfortunately I lost his e-mail response.

1925 - 2006

Dazzling Fit Chi2:
Fit for h_{000} with a_0 - a_2 fixed to NA48 value

VII. RESULT AND CROSSCHECKS

The result from minimizing the χ^2 in Eq. 12 is

$$h_{000} = (0.78 \pm 0.19_{stat}) \times 10^{-3} \quad (14)$$

$$\chi^2/\mathrm{dof} = 3010.4/2951 \quad \text{(all pixels)} \quad (15)$$

$$\chi^2/\mathrm{dof} = 240.8/226 \quad \text{(edge pixels)} \; . \quad (16)$$

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⇨ 348 / 230 without kinematic fit per event

Fit for h_{000} (fix a_0 - a_2 to NA48 value)

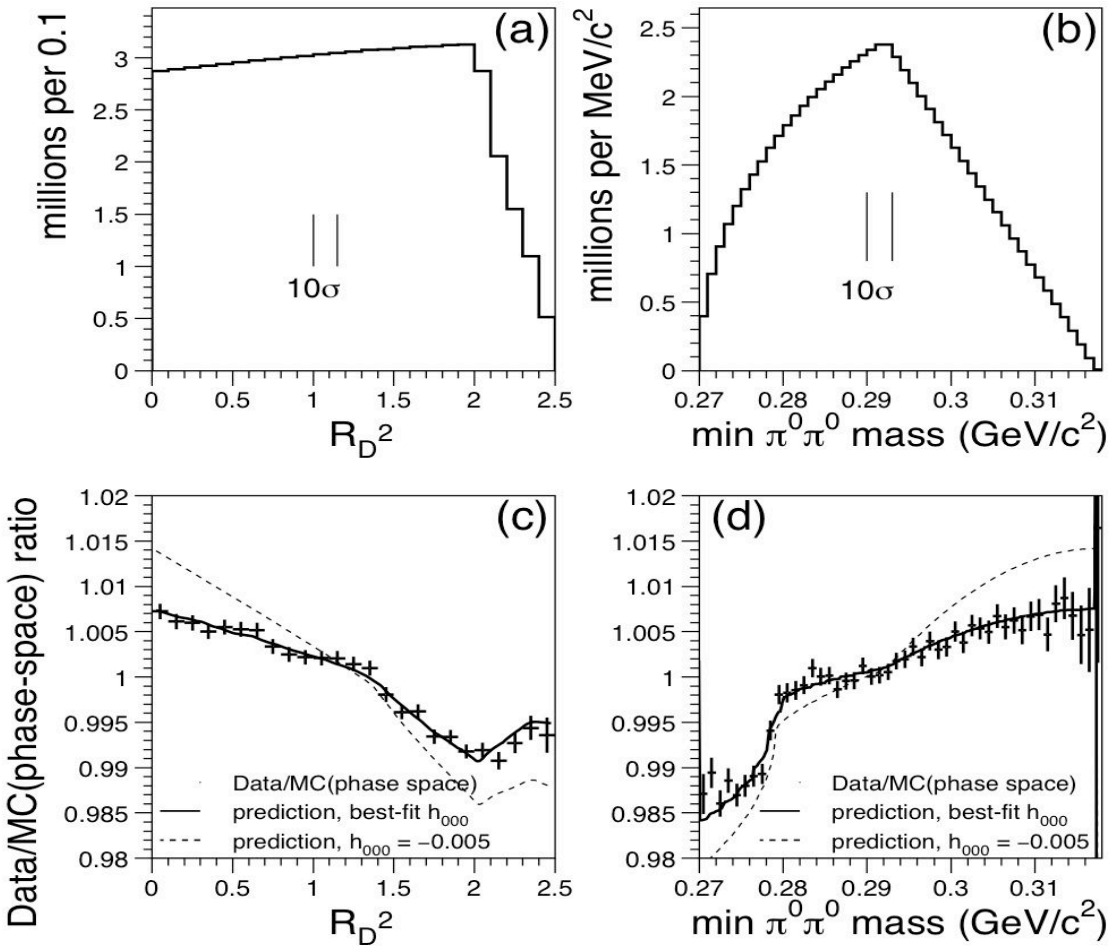
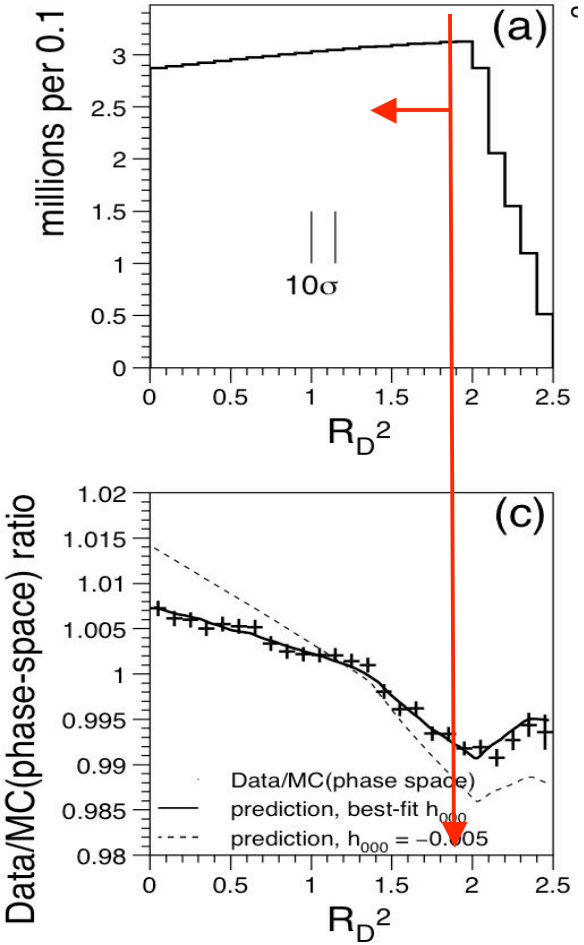


FIG. 6: For the 68.3 million $K_L \to \pi^0\pi^0\pi^0$ in the KTeV sample, projected Dalitz distributions are shown for (a) R_D^2 and (b) minimum $\pi^0\pi^0$-mass. The average reconstruction resolution determined by the simulation is $\sigma(R_D^2) \sim 0.014$ and $\sigma(\min m_{\pi^0\pi^0}) \sim 0.3$ MeV: these resolutions are indidated by a 10σ marker on each plot. The data/MC(phase-space) ratio is shown as a function of (c) R_D^2 and (d) minimum $\pi^0\pi^0$-mass (points with error bars). The solid curve is the prediction from our best fit h_{000}. The dashed curve is the prediction using $h_{000}(\text{PDG06}) = (-5.0 \pm 1.4) \times 10^{-3}$. Note that previous analyses [4, 5] ignored interference and excluded $R_D^2 > 1.9$; the corresponding data/MC ratio is a straight line with slope of -0.005.

h_{000} is consistent with zero …

Previous Fits for h_{000}



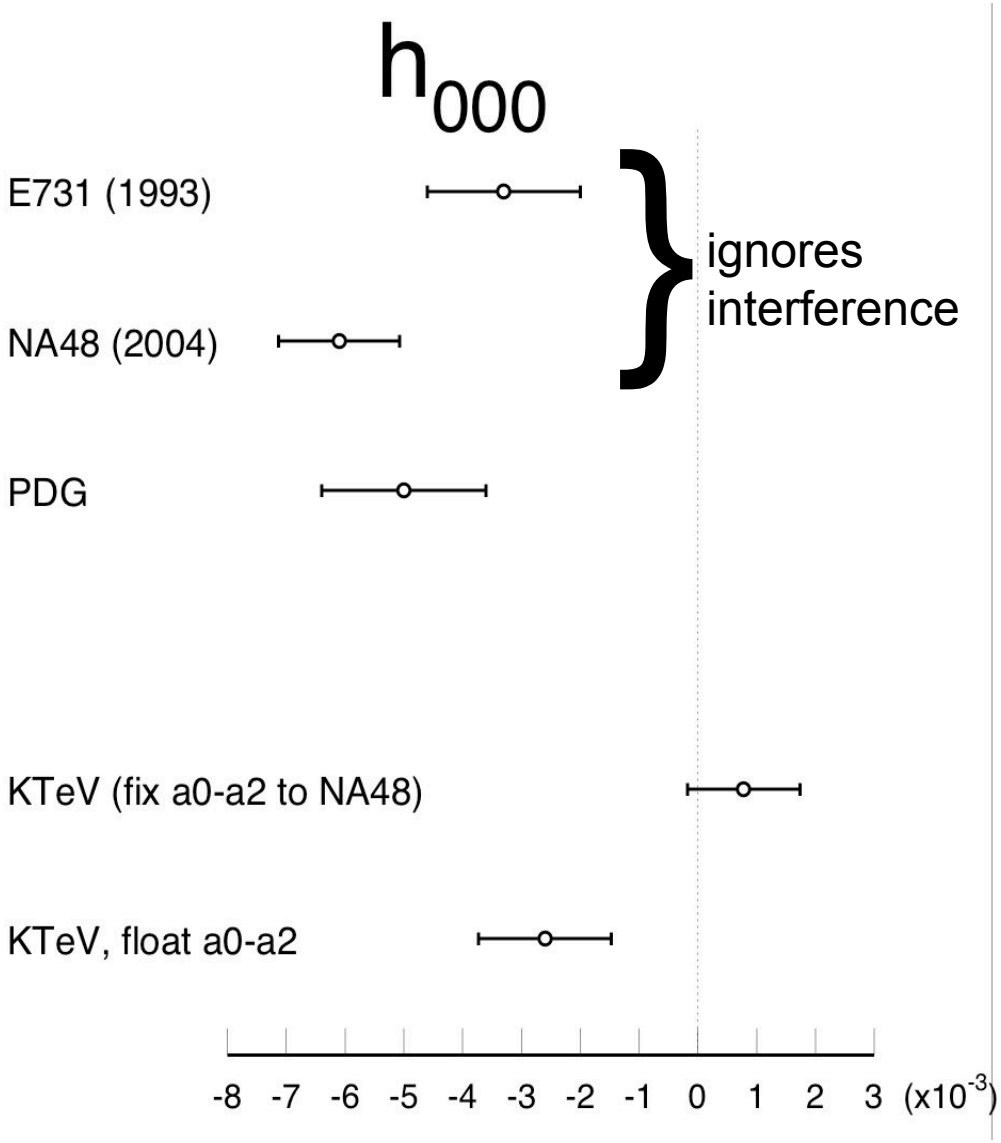
Previous analyses (E731 & NA48) made linear fit to data/MC for $R_D^2 < 1.9$ and set h_{000} = slope. (interference not known)

Cusp region $R_D^2 > 1.9$ was totally ignored; R_D plots truncated at 1.9.

Same linear fit to KTeV data has χ^2/dof = 73 / 36

➳ reason for not publishing earlier.

Summary/History



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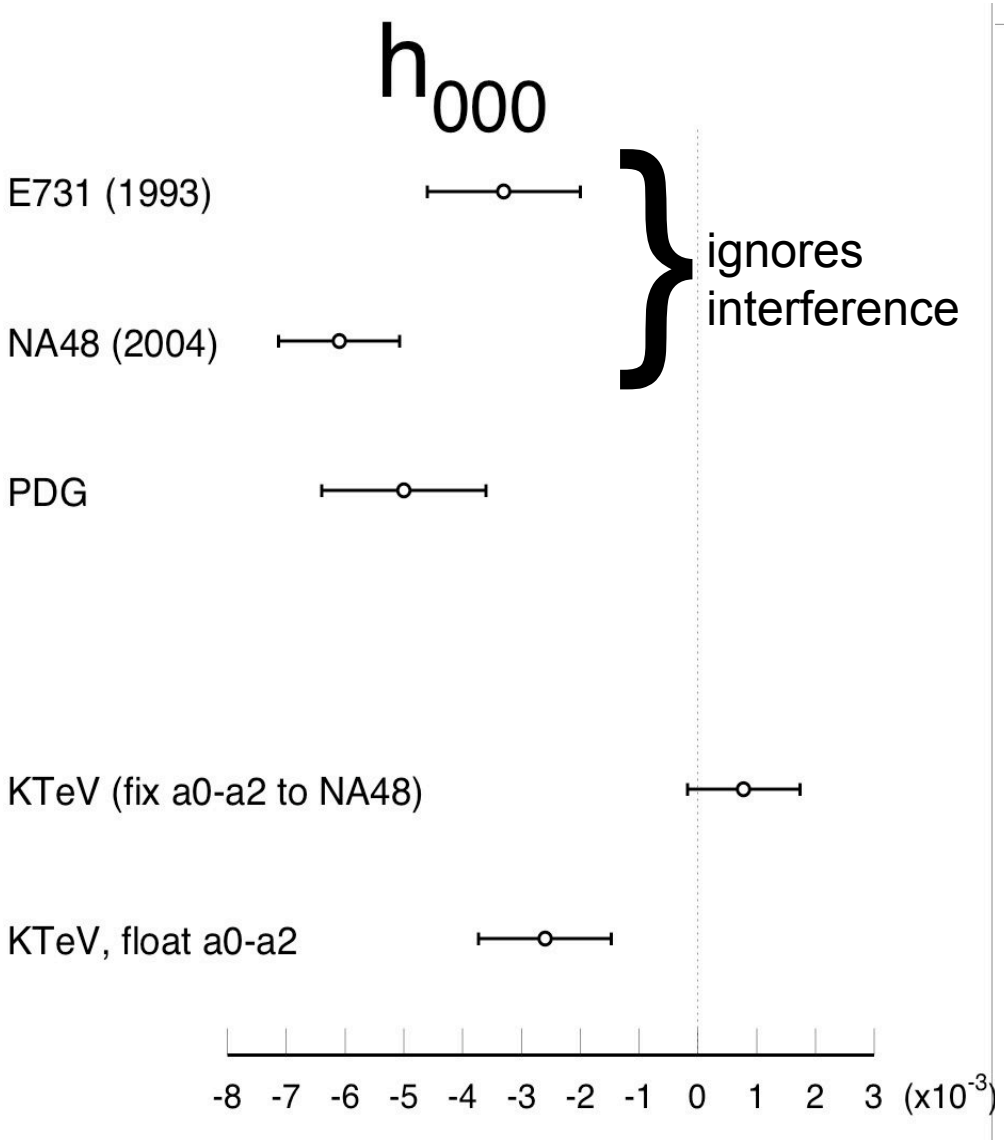

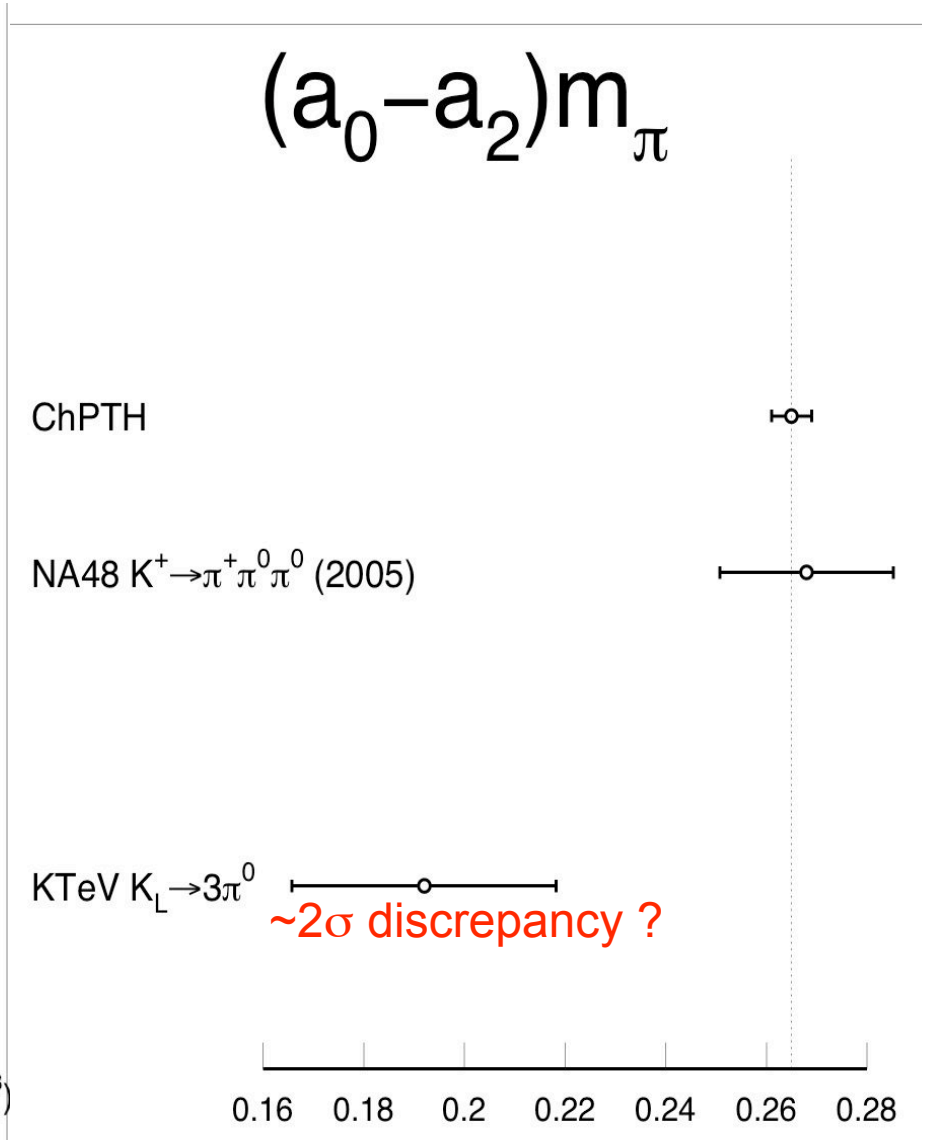

Plans

- Gino Isidori knows the situation, and promised not to tell non-KTeV people.
- I asked Gino for independent calculation of model to verify implementation … response is “maybe”
- If you see Gino, nag him to verify $3\pi^0$ model-calc.
- Once model-calc is verified … publish and release data & MC Dalitz plots.