KamLAND Energy Resolution Requirements

C.E. Okada, A.W.P. Poon, B.K. Fujikawa, K.T. Lesko, S.J. Freedman, Y.D. Chan, and X. Chen

The question of the level of uncertainty in the energy response required for the KamLAND experiment to acheive all its physics goals should be addressed. For this purpose, a simple Monte Carlo was built to see how our interpretation of the results may be effected when there is some level of uncertainty in the energy calibration. This exercise will help guide the development of an energy calibration program, and best insure that whatever the calibration system is that is put into the detector will be able to handle our eventual needs.

The $\bar{\nu}_e$ energy spectrum from nuclear reactors was taken from a parameterization[1]. The cross section for the $\bar{\nu}_e$ capture on protons was taken to be proportional to $p_e E_e$ where $E_e = E_\nu - (m_n - m_p)$ is the energy of the positron produced in the $\bar{\nu}_e$ capture. The $\bar{\nu}_e$ were assumed to have been distributed among the different reactors according to the fluxes expected at KamLAND.

One thousand trials of 3000 positrons events were examined (3000 events roughly corresponds to 3 kT years). For each event, the known positron energy was converted to a detected number of photoelectrons (p.e.) based on an assumed number of p.e. per MeV of energy deposited in the detector. The number of p.e. was varied according to Poisson statistics, then converted back to a "calibrated energy" using a conversion from observed p.e. to energy based on values which will be obtained by the energy calibration system. The shape of the resulting spectrum was compared to the expected spectrum via a χ^2. The distribution of χ^2's for the 1000 trials when the actual and calibrated responses were both 100 p.e. per MeV was used to determine 95 and 90% confidence levels (C.L.).

The procedure of comparing the observed and expected spectra was repeated with a fixed value for the calibrated response of 100 p.e. per MeV, but different values for the actual response. Changing the actual response will squeeze or stretch the reconstructed energy spectrum and shift the peak of the spectrum. Thus, the reconstructed energy spectrum was shifted up or down to force the mean reconstructed positron energy to match the expected mean energy before calculating the χ^2. The shift in energy may be seen as another statement of our uncertainty in the response of the detector. Figure 1 shows the fraction of trials which would be consistent with the expected spectrum at the 95 and 90% C.L. as the actual energy response is varied relative to the calibrated response. From this we determined that the calibration must be good to a few percent or we risk calling a result inconsistent with our expectations even if there is nothing amiss with the underlying data.

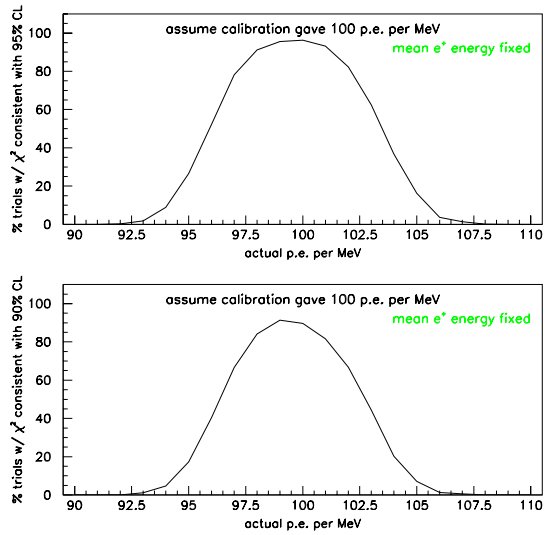

Figure 1: Figures show the percent of trials which would have χ^2's below the 95 and 90% C.L. as a function of the actual energy response of the detector.

The exercise was repeated allowing for the possibility that the positron spectrum had been distorted as a result of ν-oscillations with oscillation parameters taken from the solar ν Large Mixing Angle solution region. This too indicated a need to have the energy response known to within a few percent.

Footnotes and References

[1] P. Vogel and J. Engel, Phys. Rev. **D39**, 3378 (1989).