KamLAND Status and Prospects

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Work on the first phase of the KamLAND experiment has culminated in the recent appearance, in Physical Review Letters [1], of results corresponding to a 145.1 day reactor anti-neutrino sample. Fifty-four inverse beta decay-like events consistent with electron anti-neutrino interactions were observed while the no-oscillation hypothesis predicts 86.8 ± 5.6 within the sample time period. Assuming a two-flavor oscillation model and CPT invariance, this result is strong evidence (99.95% CL) that neutrino oscillation parameters fall within the Large Mixing Angle (LMA) region of parameter space (Figure 1). Data taking continues and an analysis of the solar $\overline{\nu}_e$ flux is forthcoming.

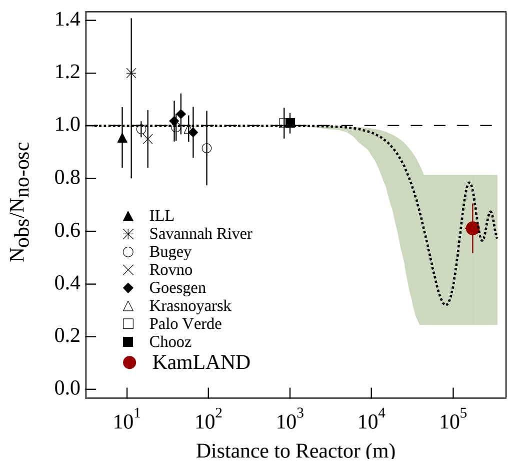

FIG. 1: $N_{obs}/N_{no-oscillations}$ as a function of baseline

In addition to ongoing work on the reactor phase of the experiment, the collaboration is now considering embarking on a solar neutrino measurement which would constitute the first direct observation of ^{7}Be $\overline{\nu}_e$s. Such a measurement would require a substantial increase in scintillator purity as the energy threshold for solar ν_e events is extremely low (280 keV), necessitating further purification efforts. The feasibility of such an extended program is currently being studied. KamLAND is also preparing to make a measurement of the geo-neutrino flux. In order to avoid low energy background from geological $\overline{\nu}_e$s, the reactor analysis cuts include a requirement that the positron visible energy be greater than 2.6 MeV. These $\overline{\nu}_e$s are decay products of Uranium and Thorium in the earth's crust and mantle and their distributions are not yet well understood. The current KamLAND best-fit (associated with the first oscillation result) is consistent with 4 $\overline{\nu}_e$ events from ^{238}U and 5 from ^{232}Th, corresponding to 40 TW of radiated heat assuming model Ia in Figure 2. In order to properly analyze the lower end of the energy spectrum a detailed survey of the local distribution of Uranium and Thorium in the rocks surrounding the KamLAND site is necessary. When this is completed, KamLAND will be in a position to make important contributions to geo-physics as well as neutrino astrophysics [2]. One further category of anti-neutrinos, those from supernovæ, will also be observable by KamLAND. These $\overline{\nu}_e$s carry with them a great amount of information about the formation of the early universe as well as the mechanics of neutrino oscillations. Measurements of this supernovæ relic neutrino (SRN) flux will be sensitive to the arrangement of the neutrino mass hierarchy as well as thle last unmeasured neutrino mixing angle, θ_{13}. For the purposes of an SRN measurement, KamLAND's sensitivity to $\overline{\nu}_e$ interactions is supplemented by the fact that no scintillator purification or infrastructure development beyond the levels already achieved is necessary, since the energies of $\overline{\nu}_e$s originating from supernovæ are much higher than those KamLAND has already successfully observed in the reactor measurement.

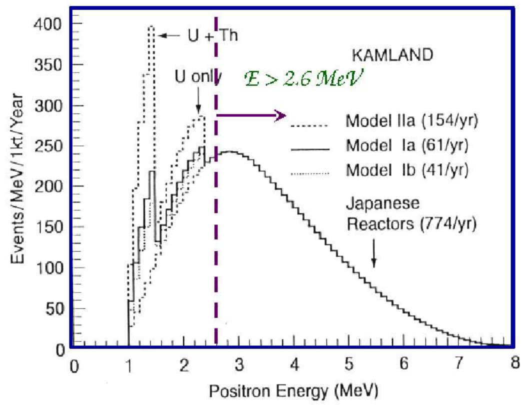

FIG. 2: KamLAND visible energy spectrum and geo $\overline{\nu}_e$ spectrum from theory

[1] K. Eguchi *et al.*, Phys. Rev. Lett. **90**, 021820, 2003
[2] R.S. Raghavan *et al.*, Phys. Rev. Lett. **80**, 635-638, 1998