

KamLAND Calibration Systems

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The scientific goals of the [KamLAND](#) experiment require careful calibration of the detector. In order to measure neutrino oscillation parameters precisely, it is essential that the energy and position of physics events be measured accurately. In order to achieve this goal, the timing and gains of the KamLAND phototubes must be measured in situ.

LBNL is involved in the KamLAND calibration effort in several different ways. Our group bears primary responsibility for the design and construction of the systems for deploying calibration devices inside the detector. Such devices include radioactive sources (^{60}Co , ^{137}Cs , and ^{22}Na sources), LED's, and laser pulses. In addition, the LBL group has been involved in the development of LED sources and in the calibration of the KamLAND front-end electronics.

During 2001 much of the calibration infrastructure was installed on the KamLAND detector. The primary element is a fishline "z-axis" deployment system. This system is installed in a glovebox mounted on top of the detector. Figure 1 shows the system in use. The z-axis system allows calibration sources to be lowered to any position along the vertical axis of the detector.

The current source deployment system requires sources to be manually lowered on a fishline. We have been developing an motorized, computer-controlled upgrade to this system. Future upgrades will include a composite cable with both electrical and optical connections. Work is also being done on a "4" deployment system which will allow sources to be positioned anywhere within the detector volume.

The peripheral LED system consists of 30 blue LED's installed around the inside surface of the

detector. This system was put in place during the PMT installation effort in 2000. In 2001, these LED's were used as a light source for initial commissioning run. Data collected using these LED's as a source has been used to tune the high voltages on the inner detector PMT's. Peripheral LED data will also be used to crosscheck PMT timing calibrations.

A high-intensity standalone LED flasher with very good timing characteristics (order 2ns) was developed at LBL during 2002. This light source is designed to be deployed on the z-axis system, and will be used for timing and vertex reconstruction calibrations.

Finally, our group is intimately involved in the calibration of the KamLAND front-end electronics, which were developed at LBL. This effort includes understanding pedestals, discriminator thresholds, calibration of sampling speed, and the ADC gains.



Figure 1. The calibration deck and glovebox installed on top of the KamLAND detector.