Commissioning the KamLAND Experiment

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Solar LMA solution within reach

- KamLAND (Kamioka Liquid-scintillator AntiNeutrino Detector)
- Liquid-scintillator allows us to probe lower neutrino energies than water Cherenkov detectors
- KamLAND is studying the disappearance of electron antineutrinos produced in nuclear reactors
- The reactor baseline is limited with 85.3% of the signal coming from reactors with a baseline of 140 km to 344 km giving an expected $\Delta m^2$ sensitivity of $7 \times 10^{-6}$ eV$^2$
The Detector

1km Overburden

Electronics hut

H$_2$O Cerenkov veto counter

225 20" PMTs

Steel sphere

Buffer oil

1kton Liquid-scintillator

PMTs

1325 17" fast
554 20" large
34% coverage

Acrylic Sphere

Ropes

Balloon

PMTs

1325 17" fast
554 20" large
34% coverage

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The LBL Electronics

- Waveforms for each PMT are recorded using Analogue Transient Waveform Digitizers (ATWDs) Allowing multi p.e. resolution
- The ATWDs are self launching with a threshold ~1/3 p.e.
- Each PMT is connected to 2 ATWDs Reducing deadtime
- Each ATWD has 3 gains (20, 4, 0.5) Allowing a dynamic range of ~1mV to ~1V
- There are 128 samples per waveform with a sample time of 1.5ns
The Trigger

- The trigger receives the number of PMTs above threshold on each FEE board every 25ns ~4 Gbytes/s

- Based on the PMT hit pattern a capture command is sent to the LBL and MACRO electronics within 200 ns
  - Delayed trigger > ~0.5MeV less than 1ms after Prompt
  - Pre-scaled trigger > ~0.5MeV for 0.1ms every second
  - Prompt trigger > ~0.8MeV

- Non physics triggers
  - Muon events all PMTs fire
  - Supernova “burst trigger”
    - 48 events > 4MeV in 1s
KamLAND uses KINOKO for DAQ

- KINOKO is a Linux-based DAQ system developed for KamLAND
- Each VME crate is connected to a separate front end PC running a KINOKO process
- The data from each front end PC is sent to a control PC
- The control PC is responsible for setting the run conditions, recording, and displaying the data
Gain Calibration

- Gain calibration has been done at 1p.e. level with peripheral LEDs
- Very good quality single p.e. peak

- For gain calibration at higher p.e.'s we used a nitrogen laser
- The laser intensity was controlled within 15% using different filters
Timing Calibration

Timing calibration was done using a dye laser $\lambda = 500\text{nm}$.

The liquid scintillator is transparent at 500nm.

This correction is waveform analysis dependent, we may be able to do better.
Energy Calibration

$^{60}$Co 2.505 MeV $\gamma+\gamma$ source

- So far two sources have been placed in the detector, $^{60}$Co & $^{65}$Zn
- The light yield is very high 241 p.e./MeV

$^{65}$Zn 1.115 MeV $\gamma$ source

- Soon we will deploy a $^{137}$Cs 0.662 MeV $\gamma$ source and a AmBe 4.4 MeV neutron source
Following muons we get neutron events, these allow us to calibrate the energy for neutrons.

The energy of this peak is consistent with a 2.2 MeV n-capture.

The capture time of 189±19 μs is consistent with the expected value of 180 μs.

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Data is now coming in smoothly...

stay tuned for results...

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