Paper Evaluation and Summary

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Paper: Eguchi/Araki/Abe et al. (kamLAND experiment, 2002/2004/2008)

- Motivation Motivated to solve the solar Neutrino problem (total neutrino flux measured by Davies Jr. only made up only one third of the expected flux calculated by Bahcall) the KamLAND detector was designed to detect anti electron-neutrinos produced by reactors to verify the Large Mixing Angle solution.

- What is the main finding of this paper and why is it important?
  The KamLAND experiment measured the disappearance of reactor anti electron-neutrions for the very first time at a high confidence level. The measured rate divided by the expected rate (if no neutrino oscillation would take place) is roughly 0.61. With this experiment the parameters for the oscillation theory could be better constraint.

- Describe at a high level the basic technique used. Try a series of "steps" here if necessary, if there is a sequence to be followed (like a recipe).

  Detector setup:

  - Location: Kamiokande, Japan, 2700 m.w.e.
  - 13m-diameter nylon/EVOH balloon, 135µm thick, supported by kevlar ropes
  - Vessel holds 1000 tonnes of ultra pure liquid scintillator (80% dodecane, 20% pseudocumene), $1.52\,\mathrm{g\,L^{-1}}$ PPO as fluor
  - 1879 PMTs observe liquid scintillator and mounted in the containment vessel.
  - The containment vessel is immersed in ultra pure water which is monitored by several PMTs facing outwards to detect background events in water

  If a reactor anti electron-neutrino passes through the detector and gets captured by a proton, the inverse beta decay produces a positron and a neutron. The positron annihilates promptly and releases two 511 keV while the neutron thermalizes and gets captured by a proton, releasing a 2.2 MeV gamma-ray. Background can be suppressed by triggering on this delayed coincidence event.

- Choose an interesting technical aspect of the experiment and describe its relation and importance to the measurement.
  Interesting is that, instead of using high purity light water as a buffer like the SNO experiment, the KamLAND experiment used oil (dodecane, isoparaffin).

- Pick one systematic uncertainty issue that you find interesting and describe its importance and the author's method of addressing it.
  The whole principle of applying data cuts is quite impressive: cuts were used to discriminate events outside the fiducial volume, a certain time frame, a certain vertex window, a delayed energy window, delayed vertex window, and a prompt energy window. Also, setting systematic uncertainties on various (exotic in my opinion) background events is kind of hard to do.

- Where did you get lost? Was there anything you did not understand?:

  1. Purification process: nitrogen bubbling method, PPO prepurification
  2. Specific gravity of buffer
  3. Resolution for cobalt calibration source not high enough to distinguish the the photons?