The 21 Century COE Project
Exploring New Science by Bridging Particle-Matter Hierarchy

Short-term Foreign Researchers

Research Report

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Your Stay Period in Japan: From Feb. 25, 2004 to March 13, 2004
Title of Research in Japan:
Calculating KamLAND Neutron Background

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Please write a research report of one or more pages and submit it with this cover to your host researcher till the end of this March.

Calculating KamLAND Neutron Background

The primary purpose of the KamLAND Outer Detector is to suppress neutron backgrounds due to spallation caused by cosmic ray muons. Spallation neutrons that enter the Inner Detector can scatter off protons and capture, giving rise to a 'fake' coincident signal indistinguishable from the anti-neutrino signal.

Neutrons from tagged muons are eliminated by virtue of spatial and time cuts around the muon path. The muon-tagging efficiency in the Outer Detector was found to be 98.8% based on GEANT calculations. Due to the liquid scintillator, the muon-tagging efficiency in the Inner Detector is considered 100%.

However, neutrons from untagged muons cannot be detected and constitute a potential problem. Simulations are therefore important in determining the background caused by these muons. To simulate the interactions of neutrons within KamLAND and determine the number of 'fake' events, the GEANT code was used. The simulation data produced a total neutron background of less than 1.0 neutron at 95% confidence over 145.1 days, consistent with the background cited by Eguchi *et al.* [Egu03].

We have considered the question whether KamLAND can increase the rate of neutrino detection by increasing the fiducial volume. To determine the viability of this suggestion with respect to the neutron background, the same simulations were performed with a fiducial volume the size of the balloon (R = 650 cm). We found 748 neutrons from 394 events tagged as capturing within the balloon. These neutrons gave rise to 25 fake events with the total energy deposited in the range $2.5 < E_{vis} < 8.0$ MeV with an additional 15 fake events when the E_{vis} was lowered to 0.5 MeV.

As the distance from the center increases, the number of neutron captures rises rapidly. Table I shows the number of fake events for different fiducial volumes. A fiducial volume with $R \leq 575$ cm does not increase the background count while allowing for an increase in the neutrino counting rate. However, larger fiducial volumes increase the background count rate faster than the rate for neutrino detection. Thus, for $R > 575$ cm, the benefits of enlarging the fiducial volume are outweighed by a substantial increase in background.

[Egu03] K. Eguchi *et al. First Results from KamLAND: Evidence for Reactor*

Anti-Neutrino Disapperance. Physical Review Letters **90**, 021802 (2003).

Table I: The number of fake events for different fiducial volumes. The table lists fake events that result from the reactor neutrino data cuts as ‘reactor fakes’ and those that result from geo-neutrino data cuts as ‘geo-neutrino fakes.’

Radius of Fiducial Volume	Reactor Fakes	Geo-neutrino Fakes
550 cm	1	0
575 cm	1	0
600 cm	3	0
625 cm	9	1
650 cm	25	15