

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

**Short-term Foreign Researchers**

**Research Report**

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Host Researcher in Tohoku University: A. Suzuki. , RCNS

Your Stay Period in Japan: February 9 - 20, 2004

**Title of Research in Japan :**

“Discussion of Future Reactor Neutrino Oscillation Experiments at the workshop NOON04 and Preparations for the Installation of a Novel Off-Axis Calibration System for KamLAND.”

## Research Report

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Karsten Heeger

In February 2004 I visited Japan for 11 days for a discussion of future reactor neutrino oscillation experiments at the NOON04 workshop (<http://www-sk.icrr.u-tokyo.ac.jp/noon2004/>) in Tokyo and to work on preparations for the installation of a novel off-axis calibration system in the Kamioka Liquid Scintillator Antineutrino Detector (KamLAND).

I am Chamberlain Fellow in the Physics Division at Lawrence Berkeley National Laboratory and a collaborator on the KamLAND experiment.

Recent results from the atmospheric and solar neutrino experiments have provided unambiguous evidence for the flavor transformation. In combination with the observation of reactor neutrino disappearance at KamLAND, these experiments have provided evidence for the phenomenon of neutrino oscillation and allowed a measurement of the difference of the neutrino mass states and two of the three neutrino mixing angles. The third neutrino mixing angle and the sign of the mass hierarchy are not known yet, and the search for CP violation in the lepton sector is one of the future goals of this field.

Over the course of the past year the neutrino group at Berkeley Lab has pursued studies towards a future reactor neutrino oscillation experiment to measure the yet unknown neutrino mixing angle  $\theta_{13}$ . As one of the organizers of the effort at Berkeley Lab and as the principal investigator of a Berkeley Lab LDRD grant to develop a proposal for this project I was invited to report at the NOON04 conference on the US activities towards a reactor  $\theta_{13}$  experiment. Participating in the NOON04 conference allowed me to discuss our studies of a future reactor neutrino experiment with colleagues from Japan and abroad. This conference visit helped strengthen the interaction between our group and colleagues in Japan on questions related to the design and physics potential of future reactor neutrino experiments. In particular, I had several interesting discussions with Prof. H. Minakata whose insight into the synergy of reactor and accelerator experiments has helped promote the case for a new reactor neutrino experiment to make a measurement of the mixing angle  $\theta_{13}$ .

As part of my research work for KamLAND I have coordinated at Lawrence Berkeley Laboratory the development of a novel off-axis calibration system that will allow KamLAND to calibrate the detector response throughout the entire detector volume. This new system will provide KamLAND with the calibration data needed for an independent determination of the fiducial volume, for a measurement of the position-dependent energy response of the detector, as well as a precision measurement of the energy spectrum of reactor antineutrinos. A precision measurement of the energy spectrum with reduced systematics will allow KamLAND to search for spectral distortions as a direct signature of neutrino oscillations. A measurement of the energy spectrum will also improve on the precision of the neutrino oscillation parameters derived from the spectrum measured in KamLAND, and may help distinguish better the

LMA-I and LMA-II regions of oscillation parameters.

The development and fabrication of this novel off-axis calibration system for KamKAND is nearing completion at Berkeley Lab and we have started making preparations for the on-site installation and commissioning of this calibration system. The commissioning, installation, and deployment of this new calibration system will proceed in several phases. It is our goal to deploy this new calibration system in the summer 2004.

In February a team of several scientists and technicians from Berkeley Lab visited KamLAND to prepare the existing calibration glovebox, the calibration tent, and the dome area for the new calibration hardware. An axial support system that will provide additional stability for the glovebox and its extension was positioned and centered over the detector. A new computer and software for the readout of the CCD cameras was installed and partially tested.

The travel support through this program has been invaluable for advancing critical activities on the KamLAND detector as well as promoting our interaction with colleagues in Japan at the NOON04 conference.

### **Travel Itinerary**

February 9	Travel to Tokyo, Japan.
February 10 – 15	Invited talk at the NOON04 conference and discussions on future neutrino oscillation experiments at the NOON04 workshop in Tokyo, Japan.
February 15	Travel to Mozumi.
February 15 – 20	Preparations for the installation of a novel off-axis calibration system in KamLAND.
February 20	Departure from Mozumi.