Michinari Sakai

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Research Experience

KamLAND (Kamioka Liquid Scintillator Antineutrino Detector) 2009 - 2016
Research Assistant, University of Hawaii at Manoa

- Spearheaded development of novel directional neutrino detection technique in scintillator and demonstrated with data for the first time that this can be applied to conduct indirect dark matter searches in scintillator; first ever physics application of neutrino directionaly in scintillator
- Led unprecedented particle ID capability studies in scintillator using track profile reconstruction techniques using never before observed T2K events spilling into KamLAND
- Was responsible for high energy ($\gtrsim$1 GeV) energy calibration using cosmic ray muons and applying this to neutrino analysis for first time

Mini-TimeCube (World's Smallest Portable Neutrino Detector) 2009 - 2016
Research Assistant, University of Hawaii at Manoa

- Led development of Geant4 detector simulation with team of 3 undergraduate students to conducted case studies of neutron capture doping agents in solid scintillator. Simulation results were later used to guide overall detector design during construction
- Was responsible for background studies associated with long lived cosmogenic isotopes ^{8}He/^{9}Li to quantitatively determine effect on detector live time

CUORE (Cryogenic Underground Observatory for Rare Events) Apr. 2016 - *Current*
Post-doctoral Scholar, University of California, Los Angeles (UCLA)

- Spearheading development of precision α background modeling in collaboration with a graduate student with goal for further background reduction to cover inverted neutrino mass hierarchy of $0\nu\beta\beta$ decay in ^{130}Te
- Mentored and worked with 2 undergraduate students for investigation of shielding structures to mitigate γ/β backgrounds for next generation $0\nu\beta\beta$ decay searches requiring ultra-low background levels

Leadership and Teaching Experience

Mentor, *UCLA* 2016 - *Current*

- Taught weekly Geant4 tutorials to 3 PhD students and 3 undergraduate students for 1 semester; students are now able to take on simulation projects of their own and make original contribution

Teaching Assistant, *University of Hawaii at Manoa* 2007 - 2009

- Planned classwork and taught 2 weekly undergraduate Physics Laboratory classes of over 20 students each for 3 semesters, received "excellent" reviews
- Mentored undergraduate students in undergraduate Physics classwork for 2 hours each week for 3 semesters

Skills

Human Languages:	English (native), Japanese/Korean (trilingual proficiency)
Programming Languages:	Proficient in C, C++, Python, Fortran, Mathematica, Bash
Software/Tools:	ROOT, Geant4, Pads, AutoCAD

Education

PhD, Experimental Neutrino Physics 2016
GPA: 4.0/4.0, University of Hawaii at Manoa
Dissertation: High Energy Neutrino Analysis at KamLAND and Application to Dark Matter Search

Graduate Program in Mathematics 2006
GPA: 4.5/4.5, Sun Moon University, S. Korea

Double BS, Physics and Mathematics 2005
GPA: 4.3/4.5, Sun Moon University, S. Korea
President's Award 2005, Award for Outstanding Academic Achievement – Samsung Corp.

Talks and Presentations

- (Tentative) Monte Carlo Tools for Beyond the Standard Model Physics, Durham, UK — Apr 2018
  Invited Talk: Monte Carlo Tools in CUORE
- Argonne National Laboratory — Feb 2018
  Seminar: CUORE: A Bolometric Search for Lepton Number Violation
- Division of Nuclear Physics, Pittsburgh/Carnegie Mellon University — Oct 2017
  Talk: CUORE and Background Reduction Case Studies for CUPID
- Conference on Science at SURF, South Dakota — May 2017
  Invited talk: Status of the CUORE $0\nu\beta\beta$ Decay Search
- Fermilab - Frontiers of Liquid Scintillator Technology — Mar 2016
  Invited talk: Particle ID and event reconstruction algorithms in scintillator
- Los Alamos National Laboratory — Nov 2015
  Seminar: High Energy Analysis at KamLAND and Application to Dark Matter Search
- California Institute of Technology — Nov 2015
  Seminar: High Energy Analysis at KamLAND and Application to Dark Matter Search
- University of California, Los Angeles — Oct 2015
  Seminar: High Energy Analysis at KamLAND and Application to Dark Matter Search
- DOE project review, Honolulu, Hawaii — Jul 2015
  Talk: High Energy Analysis and Application to Dark Matter Search in KamLAND
- Neutrino, Kyoto, Japan — Jun 2012
  Poster: Indirect Dark-Matter Detection Through KamLAND
- University of Hawaii Campus Open-house — Nov 2010, 2011
  Talks: What is a Neutrino?, mini-TimeCube: The World's Smallest Neutrino Detector
- Applied Antineutrino Physics, Sendai, Japan — Aug 2010
  Talk: mini-TimeCube: A Portable Directional Neutrino Detector
- DOE project review, Honolulu, Hawaii — Sep 2009
  Talk: KamLAND Summary
- Fermilab - International Neutrino Summer School — Jul 2009
  Talk: Student presentation: How to solve θ_{23} degeneracy

Publications

[1] C. Alduino *et al.*, "Study of Rare Nuclear Processes with CUORE," *Submitted to: Int. J. Mod. Phys. A*, 2018.

[2] C. Alduino *et al.*, "First Results from CUORE: A Search for Lepton Number Violation via $0\nu\beta\beta$ Decay of ^{130}Te," 2017.

[3] C. Alduino *et al.*, "Search for Neutrinoless $\beta^{+}EC$ Decay of ^{120}Te with CUORE-0," 2017.

[4] N. Moggi *et al.*, "Results from CUORE and CUORE-0," *AIP Conf. Proc.*, vol. 1894, no. 1, p. 020016, 2017.

[5] C. Alduino *et al.*, "Low Energy Analysis Techniques for CUORE," *Eur. Phys. J.*, vol. C77, no. 12, p. 857, 2017.

[6] C. Alduino *et al.*, "CUORE sensitivity to $0\nu\beta\beta$ decay," *Eur. Phys. J.*, vol. C77, no. 8, p. 532, 2017.

[7] C. Alduino *et al.*, "The projected background for the CUORE experiment," *Eur. Phys. J.*, vol. C77, no. 8, p. 543, 2017.

[8] A. Gando *et al.*, "A search for electron antineutrinos associated with gravitational wave events GW150914 and GW151226 using KamLAND," *Astrophys. J.*, vol. 829, no. 2, p. L34, 2016. [Erratum: Astrophys. J.851,no.1,L22(2017)].

[9] V. A. Li *et al.*, "Invited Article: miniTimeCube," *Rev. Sci. Instrum.*, vol. 87, no. 2, p. 021301, 2016.

[10] K. Asakura *et al.*, "Search for the proton decay mode $p \to \overline{\nu}K^{+}$ with KamLAND," *Phys. Rev.*, vol. D92, no. 5, p. 052006, 2015.

[11] K. Asakura *et al.*, "KamLAND Sensitivity to Neutrinos from Pre-Supernova Stars," *Astrophys. J.*, vol. 818, no. 1, p. 91, 2016.

[12] C. Lane *et al.*, "A new type of Neutrino Detector for Sterile Neutrino Search at Nuclear Reactors and Nuclear Nonproliferation Applications," 2015.

[13] K. Asakura *et al.*, "Study of electron anti-neutrinos associated with gamma-ray bursts using KamLAND," *Astrophys. J.*, vol. 806, no. 1, p. 87, 2015.

[14] T. I. Banks *et al.*, "A compact ultra-clean system for deploying radioactive sources inside the KamLAND detector," *Nucl. Instrum. Meth.*, vol. A769, pp. 88–96, 2015.

[15] A. Gando *et al.*, "^{7}Be Solar Neutrino Measurement with KamLAND," *Phys. Rev.*, vol. C92, no. 5, p. 055808, 2015.

[16] S. Abe *et al.*, "Measurement of the 8B Solar Neutrino Flux with the KamLAND Liquid Scintillator Detector," *Phys. Rev.*, vol. C84, p. 035804, 2011.

[17] J. Kumar, J. G. Learned, M. Sakai, and S. Smith, "Dark Matter Detection With Electron Neutrinos in Liquid Scintillation Detectors," *Phys. Rev.*, vol. D84, p. 036007, 2011.

Statement of Research

I developed a novel directional event reconstruction algorithm for high-energy $\gtrsim$GeV scale neutrinos while working with KamLAND (Kamioka Liquid Scintillation Antineutrino Detector), and demonstrated with data that this technique can be applied to indirect dark matter search by looking for a directional flux of neutrinos from the core of the Sun and Earth. Studies done with Monte Carlo suggest that the accuracy of deducing the neutrino direction using this new method is better than that of water-Cherenkov detectors (the conventional method for directional neutrino detection) by $\sim$10° in this energy regime. This method was verified using never before observed neutrino events spilling into KamLAND from the T2K neutrino beam-line. The results were consistent with expectation. According to my knowledge, this is the first ever physics application of neutrino directionality in scintillator.

My work with KamLAND further involved demonstration of 3-dimensional topological event imaging techniques, originally developed in the LENA (Low Energy Neutrino Astronomy) collaboration, using data for the first time. The $\sim$3.5 ns timing resolution of the PMTs (photomultiplier tubes) employed in KamLAND are not good enough to do a detailed imaging of all the individual tracks in a neutrino event. Nevertheless $\gtrsim$GeV muon tracks and high enough energy tracks in a neutrino event were imaged as well as the overall direction of the final state particles to resolve the incoming neutrino direction. In addition $\frac{\mathrm{d}E}{\mathrm{d}x}$ profiles were investigated to perform unprecedented particle ID studies in scintillator at these energies. A paper employing these techiques I developed to conduct an indirect dark matter search is currently under preparation.

I have been involved with the CUORE (Cryogenic Underground Observatory for Rare Events) experiment at the University of California, Los Angeles since early 2016. The main objective of the CUORE experiment is to hunt for lepton number violation by observing neutrinoless double beta ($0\nu\beta\beta$) decay in ^{130}Te. CUORE employs an almost 20 fold increase in detector mass compared to its previously successful pilot experiment CUORE-0. My work in the collaboration currently involves development of a precision background model together with a graduate student colleague to better understand the radioactive contaminations in the detector. The energy spectrum of the backgrounds in the so called α region ($\gtrsim$ 2.5 MeV) exhibit peculiar features that, if understood correctly, will better explain the types of contamination sources and their distributions in the materials comprising the experiment. This can help us to better understand our backgrounds and extrapolate this new knowledge to the energy region of interest (2465 keV to 2575 keV) for $0\nu\beta\beta$ decay in ^{130}Te. I have previously also mentored 2 undergraduate students and worked together with them to simulate and investigate new radioactivity shielding schemes for further background reduction in future $0\nu\beta\beta$ decay experiments that will cover the inverted hierarchy region of the effective Majorana neutrino mass. A paper for our first $0\nu\beta\beta$ analysis using CUORE data was submitted for publication to PRL in late 2017, and is currently under review (https://arxiv.org/abs/1710.07988).

In addition, I have worked as the lead Geant4 simulation designer for the mini-TimeCube collaboration at University of Hawaii at Manoa. mini-TimeCube is an ambitious project to build the world's smallest portable neutrino detector. In this project, I mentored 3 undergraduate students and worked in collaboration with them to conduct case studies for optimizing the detector design, test candidate neutron capture doping elements in plastic scintillator, and simulate the response of the multi-channel-plate (MCP) PMTs deployed in the detector. The studies were used during construction of the detector, and to develop directional algorithms that are now being tested in analyses of neutrons from test sources as well as neutrinos from nuclear reactors at NIST. Working with the mini-TimeCube project has further involved designing and fabricating PCB boards as well as contributing to the FPGA firmware for the readout electronics. A paper summarizing our accomplishments was published in 2016 (V. A. Li et al. Invited Article: miniTimeCube. Rev. Sci. Instrum., 87(2):021301, 2016, 1602.01405).

Finally, my work in scintillator R&D for HanoHano, a proposed 10 kt-scale deep-sea based neutrino detector, involved designing and building apparatuses using CAD for measuring light output of Linear alkylbenzene (LAB) based liquid scintillators when put in large electric potential gradients as well as testing their light transmissivities under extreme temperatures and pressures such as those found in deep-sea environments. This project included mentoring an undergraduate student on techniques for shielding electronic apparatuses and working with another graduate student on designing and operating the cold high pressure environment device.

As a prospective postdoctoral researcher at Lawrence Livermore National Laboratory, I would like to continue to build upon my experience in the field of neutrino physics, namely neutrino oscillation and neutrinoless double beta decay. My past milestones in spearheading the development of and seeing through to the final analysis using novel methods in neutrino event reconstruction as well as experience in the commissioning phase of a world-class $0\nu\beta\beta$

decay experiment makes me a strong and unique candidate to apply for your position. I believe that I can make a significant impact in your team of scientific prowess at LLNL. My career goal is to establish myself as a senior scientist at LLNL to eventually lead a team of scientists to solve the mysteries of neutrino masses.

References

Supplied upon request or please contact in person.

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