Michinari Sakai

michsakai@ucla.edu • 808-206-4357

Experience

KamLAND (Kamioka Liquid Scintillator Antineutrino Detector) - *University of Hawaii* 2009 - 2016

- 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 directionality in scintillator
- Led unprecedented particle ID capability studies in scintillator using track profile reconstruction techniques and never before observed T2K events spilling into KamLAND

Mini-TimeCube (World's Smallest Portable Neutrino Detector) - *University of Hawaii* 2009 - 2016

- 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

Hanohano (Deep Sea-based monolithic Scintillator Neutrino Detector) - *University of Hawaii* 2009 - 2010

- Used CAD to design and assemble apparatus to measure light output of various LAB based scintillators from ionizing radiation as well as test light yield changes in extreme electric potential gradients ($\sim$1 kV/cm)
- Operated, took data, and analyzed light transmissivity of LAB based scintillator when put in near freezing temperatures and high pressure environments (for potential deep sea deployment scenarios) in custom made pressurizer chamber

CUORE (Cryogenic Underground Observatory for Rare Events) - *UCLA* 2016 - *Current*

- 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

Skills

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

Leadership

Mentor - *UCLA* 2016 - *Current*

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

Teaching Assistant - *University of Hawaii* 2007 - 2009

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

Education

PhD, Experimental Neutrino Physics May 2016

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

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

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

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," *Phys. Rev. Lett.*, vol. 120, no. 13, p. 132501, 2018.

[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 for the first time that this technique can be applied to indirect dark matter searches 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, but applying this to 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 final state particle 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 average 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 techniques I developed to conduct an indirect dark matter search is currently under preparation.

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).

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.

I have been involved with the CUORE (Cryogenic Underground Observatory for Rare Events) experiment at the University of California, Los Angeles (UCLA) since early 2016. The main objective of the CUORE experiment is to search for Majorana neutrinos 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 α 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 ($\gtrsim$ 2.7 MeV) exhibit peculiar features that, if understood correctly, will better explain the types of contamination sources and their physical distributions in the materials comprising the experiment. This can help us to better understand our backgrounds and extrapolate this understanding to the energy region of interest (2465−2575 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 published in March 2018 (https://arxiv.org/abs/1710.07988).

As a postdoctoral researcher at Lawrence Livermore National Laboratory, I would like to continue my research in the field of (anti)neutrino physics. I am particularly interested in the directional neutrino detection capability of gadolinium-doped (Gd) medium and the integration of fast timing optical sensors such as LAPPDs towards unprecedented high-resolution event reconstruction capabilities. My work in KamLAND and mini-TimeCube involved development of novel topological event reconstruction methods using the readout of first-photon hits in PMTs ($\sim$3.5 ns resolution) and MCPs ($\lesssim$ 50 ps resolution). The project in your team is a natural extension of my previous endeavors and it would be a dream come true to play a critical role in the development of these technologies toward future applications such as THEIA. I believe I can make a significant impact in your team.

References

Supplied upon request or please contact in person.

Huan Z. Huang — Professor, University of California, Los Angeles, +1-310-825-9297
huang@physics.ucla.edu
475 Portola Plaza #5-136, Los Angeles, CA 90095-1547, USA

John G. Learned — Professor, University of Hawaii at Manoa, +1-808-956-2964
jgl@phys.hawaii.edu
2505 Correa Rd. #327, Honolulu, Hawaii 96822, USA

Yury Kolomensky — Professor, University of California, Berkeley, +1-510-642-9619
ygkolomensky@lbl.gov
LeConte Hall #319, Berkeley, CA, 94720-7300, USA

Brian K. Fujikawa — Staff Scientist, Lawrence Berkeley National Laboratory, +1-510-486-4398
bkfujikawa@lbl.gov
1 Cyclotron Rd MS 50R5008, Berkeley, CA 94720-8158, USA

Lindley Winslow — Jerrold R. Zacharias Assistant Professor, MIT, +1-617-253-2332
lwinslow@mit.edu
77 Massachusetts Avenue, Bldg. 26-569, Cambridge, MA 02139, USA

Thomas O'Donnell — Assistant Professor, Virginia Tech, +1-540-231-3308
tdonnell@vt.edu
850 West Campus Drive #313, Blacksburg, VA 24061, USA