Michinari Sakai

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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

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.

Leadership and Research

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 that this can be used to conduct 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 solely responsible for high energy ($\gtrsim$1 GeV) energy calibration using cosmic ray muons and applying this to neutrino analysis for the 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 for various neutron capture doping agents. Simulation results were used to guide overall detector design
- Was responsible for background studies associated with long lived cosmogenic isotopes 8He/9Li, 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 alpha 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 and beta backgrounds for next generation $0\nu\beta\beta$ decay searches requiring ultra-low background levels

Teaching Experience

Mentor, *UCLA* — 2016 - *Current*

- Taught weekly Geant4 simulation tutorials to 3 PhD students and 3 undergraduate students for 1 semester, students are now able to take on simulation tasks and collaborate in the group
- Led weekly Physics paper discussion groups for 3 PhD students, and promoted team work to increase dialogue and productivity within team

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, got students repeatedly seeking my particular tutoring

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

Invited Talks and Presentations

- 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
- 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] S. Abe et al. Measurement of the 8B Solar Neutrino Flux with the KamLAND Liquid Scintillator Detector. *Phys. Rev.*, C84:035804, 2011.

[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] K. Asakura et al. Search for the proton decay mode $p \to \overline{\nu}K^+$ with KamLAND. *Phys. Rev.*, D92(5):052006, 2015.

[4] K. Asakura et al. Study of electron anti-neutrinos associated with gamma-ray bursts using KamLAND. *Astrophys. J.*, 806(1):87, 2015.

[5] K. Asakura et al. KamLAND Sensitivity to Neutrinos from Pre-Supernova Stars. *Astrophys. J.*, 818(1):91, 2016.

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

[7] A. Gando et al. ^{7}Be Solar Neutrino Measurement with KamLAND. *Phys. Rev.*, C92(5):055808, 2015.

[8] A. Gando et al. Search for electron antineutrinos associated with gravitational wave events GW150914 and GW151226 using KamLAND. *Astrophys. J.*, 829(2):L34, 2016.

[9] Jason Kumar, John G. Learned, Michinari Sakai, and Stefanie Smith. Dark Matter Detection With Electron Neutrinos in Liquid Scintillation Detectors. *Phys. Rev.*, D84:036007, 2011.

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

[11] V. A. Li et al. Invited Article: miniTimeCube. *Rev. Sci. Instrum.*, 87(2):021301, 2016.

References

Supplied upon request or please contact in person.

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Yury Kolomensky	Professor, University of California, Berkeley, +1-510-642-9619 ygkolomensky@lbl.gov
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Statement of Teaching Philosophy and Experience

Throughout my academic career, I have been heavily involved in teaching and mentoring students from a wide range of cultures and backgrounds. This has included working as a teaching assistant during my graduate studies at University of Hawaii at Manoa where I organized and led 2 undergraduate Physics Laboratory classes of over 20 students each for a total of 3 semesters. In addition, I have also led weekly, 2 hour long, one-on-one tutoring sessions for 3 semesters. Student evaluations for the effectiveness of my teaching and ability to communicate information were "excellent".

My philosophy for teaching can be summarized in two points: self motivated drive through curiosity, and mastering through iteration. Fist, when teaching at any level, and especially at the undergraduate level, it is very important to never get bogged down by the equation or numbers. When I begin a class or introduce a new concept to students, I always first demonstrate the experiment itself or introduce the context in an illustrative way. This is to engage the students interest and entice their curiosity to develop a long lasting self motivated drive to learn. Curiosity is where science is born from and curiosity is what drives science forward. This is true whether one is an freshman student or a Nobel laureate. Second, iteration is the key to mastering a topic. No matter how gifted one may be, no one is able to perfectly master a topic instantaneously in a single trial. On the other hand, this also means that even if one is not naturally gifted at something, it can be mastered through repetitive iteration and failure. The process of iterative learning is how the human brain naturally works and is the key to effective learning.

As an example of the above, there was a Physics Laboratory class in which I needed to introduce damping of a driven harmonic oscillator in a medium with finite viscosity. I knew that the equations describing the physics behind this process could be tedious and difficult to grasp at the freshman level I was teaching at. But I also knew that the concepts themselves were not inherently hard because we all intuitively know from our experiences swimming in a pool, how viscous media affects forces. Before going through the equations, I turned on the experimental apparatus first, and asked the students what they thought would happen when the frequency of the driving force was modified in different ways, while at the same time, observing their satisfaction and surprise when their predictions were confirmed or debunked. This effectively created a vastly more engaged and thoughtful atmosphere for the class and let the students concentrate on the "physics" of the class while helping them to more intuitively understand the equations involved. Of course, it is equally important for the instructor to not "give away" all the answers by doing all the work. The students were left to make multiple failed attempts until they were able to get just the right settings to take successful measurements.

In society today, there is an unfortunate misconception that Physics is a difficult subject only for *smart* students. Nothing could be further from the truth. When students feel that they are not smart enough, it is important to let them know that Physics is not about intelligence, but about curiosity driven iterative learning. All professional Physicists stand on the shoulders of past giants, and almost no research today is conducted solely alone, but through collaboration and teamwork. No one is *smart* enough to do all the work alone. I usually use myself as an example. I come from a small regional college in South Korea with very little opportunity, but through diligence and iterative trial, I have had the opportunity to eventually work with some of the brightest minds in some of the most innovative projects in the field of neutrino physics.

Mentoring higher level graduate students may be slightly different but I believe the same overall approach remains the same. I have taught Geant4 Monte Carlo particle simulations to 3 undergraduate and 3 Ph.D. students at the University of California, Los Angeles (UCLA). My method for teaching this toolkit is to learn together with the students by going into the details of the code and doing this repetitively every week. Not all the concepts may be clear to students in just the first trial, but through iteratively going through and encountering similar problems multiple times, students will eventually understand and learn basic coding techniques as well as tricky concepts that may not have been evident at first. Here, it is important to be immersed in the task along with the students instead of teaching from a conventional top-down approach because learning how to code is not just about acquiring the skill to code, but about learning the culture of coding. By this I mean that there are certain useful tools and methods of accomplishing a task that can only be learned through going into gritty details and getting *dirty*. As students grow and become more knowledgeable, they can start to develop and choose their own methods and tools. Through this approach, my students have successfully been able to take on simulation tasks of their own and contribute effectively to the collaboration.

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 alpha 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 follow CUORE to eventually probe 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).

As an assistant professor at UC Irvine, I would like to continue my endeavors in experimental neutrino physics. My current interests include further development of my already established work with track reconstruction techniques in scintillator neutrino detectors such as KamLAND, and further background control of $0\nu\beta\beta$ experiments in ultra-pure radioactivity environments. New techniques and insights such as these will be the for the future of neutrino physics. I believe that my past accomplishments and experience developing unprecedented experimental methods highlights me as a promising future asset at your institution.

Statement of Contribution to Diversity

Having spent 15 years of my adolescent life in South Korea, and being fully Japanese by descent, while being born in the United States, I have had the unique opportunity to develop an *international* perspective of things from a very young age. My ability to converse fluently in 3 languages has also greatly helped me to view different people and situations from multiple angles. With this sort of upbringing, I have learned from an early age that not only is diversity important, but tolerant diversity is just as important. Somehow it is the human tendency in a diverse environment, whether it may be in terms of race, culture, language, or ideas, when proper communication cannot be made, for people to lump the "other group" into one generic category. This can be for better or for worse, but often times manifests itself in unproductive ways when team work is required to reach a common goal. Due to my background and abilities, I have countless times served as a mediator of sorts between opposing groups often times as an interpreter, translator, or just simply as a arbitrator.

This way of thinking has served me invaluably also in my professional career to put myself in other peoples' shoes. I have contributed to the education of a diverse body of students through Physics Laboratory courses that I taught at University of Hawaii at Manoa for 3 semesters from 2007 to 2009. The ethnic and cultural atmosphere in Hawaii is one of the most diverse on the planet. The University of Hawaii system not only attracts students internationally from Asia and from around the globe, but also serves as the hub of higher learning for minority students coming from nations in the Pacific Rim such as the Marshall Islands and Micronesia. In this cultural melting pot, instructors are required to effectively convey information in an inclusive and efficient way while understanding each of the students' cultures and needs as best as possible. For example, these needs may include supplemental instruction if English is not the student's primary language, or specific attention if the student comes from a background where STEM is not traditionally emphasized.

In addition, my research has allowed me to live and work in various countries around the globe such as Japan and Italy giving me the opportunity to work with a wide range of ethnicities and cultures. For example, during my time in Japan, I volunteered to be a presenter to introduce and explain about the various research activities conducted by our neutrino experiment (KamLAND) to Japanese undergraduate students at Tohoku University. Through this event, I was able appeal to diversity by conveying the importance of international collaboration that our experiment requires to successfully operate the experiment.

I believe that my multi-cultural upbringing and experiences working in very diverse teams of international collaborators, can significantly contribute to the spectrum of diversity and inclusive excellence that UCI cherishes.