Advanced Concepts and Technologies Group   July 27, 2019
Combat Systems Branch of the Air and Missile
Defense Sector

Dear Team Hiring Manager,

As a budding and motivated physicist, I am extremely interested in the Research Associate position to join your team in the study of nuclear weapons effects. I would like to apply for the position.

I am currently a post-doctoral scholar at the University of California, Berkeley with expertise in particle transport simulations working with the CUORE (Cryogenic Underground Observatory for Rare Events) experiment.

With regard to my ability to meet the specific requirements of this job:

- **Education and experience:** Received PhD in 2016 with 6 years of experience working on particle transport simulations and algorithm development for novel dark matter detection technologies.
- **Ability to obtain secret clearance:** US citizen by birth.
- **Familiar programming languages:** C, C++, Python, Mathematica, Fortran, SolidWorks.
- **Knowledge of nuclear physics, particle physics:** 8 years of experience in particle physics and 2 years of experience in nuclear physics both working with particle/radiation interactions.
- **Experience in radiation transport code:** 8 years of experience working with Geant4.
- **Experience with transport problems in atmosphere or within structures:** Simulation work with CUORE involves nuclear decay radiation through various materials such as steel, lead, copper, Teflon. Other past work involved atmospheric muon and their decay daughter simulations with the KamLAND neutrino detector experiment in Japan. Was responsible for debugging volume overlaps in simulations with 1000's of parts to mitigate "ghost" effects of photon leakage in detector. Work at UCLA involved study of particle transport step size on energy deposition in materials.
- **Familiarity with command line programming in Linux environment:** Was Linux server administrator for research group during 3 years of graduate work. All of my professional career has involved working with the command line in a Linux environment.
- **Demonstrated written and verbal communication skills:** Contributed work published in journals such as International Journal of Modern Physics A, Physical Review Letters, European Physical Journal. Talks given at various institutions such as Lawrence Livermore National Laboratory, Fermilab, Argonne National Laboratory.

I would appreciate an opportunity to meet and discuss my application at an interview. I have also sent my resume and other relevant documents for your consideration. Please feel free to let me know if you have any questions.

Thank you for your time,

Michinari Sakai

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Summary

- Expertise in Geant4 particle transport simulations with 8 years of experience.
- Experience with cosmogenic radiation and nuclear decay radiation in 3 major particle physics experiments.
- Innovative problem solving skills with the ability to interface original work with larger collaboration.

Experience

UC Berkeley — Post-doctoral Scholar   June 2018 — *Current*
- Lead researcher for characterization of micro-physical optical properties of wavelength shifter thinfilms.
- Supervisor for Geant4 modeling of photon interactions with wavelength shifters and detector materials.

UCLA — Post-doctoral Scholar   2016 — 2018
- Lead developer of precision α decay spectrum model to improve characterization of backgrounds in $0\nu\beta\beta$ decay searches.
- Mentor for 2 PhD students to simulate radiation shielding structures in Geant4 to mitigate γ/β backgrounds for next generation $0\nu\beta\beta$ searches requiring ultra-low backgrounds.

University of Hawaii at Manoa — Research Assistant   2009 — 2016
- Spearheaded development of a novel directional neutrino detection technology 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. Paper in preparation.
- Lead developer of Geant4 detector simulation to conducted case studies of neutron capture doping agents in solid scintillator. Simulation results were later used to oversee detector design and construction.

Skills

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

Leadership

Mentor — *UC Berkeley, UCLA*   March 2016 — *Current*
- Advised 2 students with Geant4 based optical simulation for current hardware project. Students are now undertaking independent research tasks and contribution original work.
- Taught weekly Geant4 tutorials to 3 PhD-level students for a semester. Students successfully learned to take on independent simulation projects.

Teaching Assistant — *University of Hawaii at Manoa*   2007 — 2009
- Planned coursework and taught 2 weekly physics laboratory curriculum for classes of over 20 students each for 3 semesters. Received especially positive reviews for clarity of explanation of material, and teaching style.

Education

PhD, Experimental Particle 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.

Talks and Presentations

- Talk: Results from the CUORE experiment   May 2019
  Sanford Underground Research Facility (SURF), South Dakota - Conference on Science at SURF 2019

- Seminar: Search for Physics Beyond the Standard Model with Neutrinos   May 2018
  Lawrence Livermore National Laboratory

- 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] M. Sakai (corresponding author) *et al.*, "Directional Neutrino Detection and Topological Event Reconstruction Methods for GeV Scale Neutrinos in KamLAND," *Draft currently in preparation*, 2019 (tentative).

[2] C. Alduino *et al.*, "Study of Rare Nuclear Processes with CUORE," *Submitted to: Int. J. Mod. Phys. A*, 2018. https://arxiv.org/abs/1801.05403.

[3] 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. https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.120.132501.

[4] C. Alduino *et al.*, "Search for Neutrinoless β^+EC Decay of ^{120}Te with CUORE-0," 2017. https://journals.aps.org/prc/abstract/10.1103/PhysRevC.97.055502.

[5] C. Alduino *et al.*, "Low Energy Analysis Techniques for CUORE," *Eur. Phys. J.*, vol. C77, no. 12, p. 857, 2017. https://link.springer.com/article/10.1140/epjc/s10052-017-5433-1.

[6] C. Alduino *et al.*, "CUORE sensitivity to $0\nu\beta\beta$ decay," *Eur. Phys. J.*, vol. C77, no. 8, p. 532, 2017. https://link.springer.com/article/10.1140/epjc/s10052-017-5098-9.

[7] C. Alduino *et al.*, "The projected background for the CUORE experiment," *Eur. Phys. J.*, vol. C77, no. 8, p. 543, 2017. https://link.springer.com/article/10.1140/epjc/s10052-017-5080-6.

[8] V. A. Li *et al.*, "Invited Article: miniTimeCube," *Rev. Sci. Instrum.*, vol. 87, no. 2, p. 021301, 2016. https://aip.scitation.org/doi/abs/10.1063/1.4942243.

[9] A. Gando *et al.*, "Search for electron antineutrinos associated with gravitational wave events GW150914 and GW151226 using KamLAND," *Astrophys. J.*, vol. 829, no. 2, p. L34, 2016. https://aip.scitation.org/doi/abs/10.1063/1.4942243.

[10] K. Asakura *et al.*, "Search for the proton decay mode $p \rightarrow \overline{\nu}K^+$ with KamLAND," *Phys. Rev.*, vol. D92, no. 5, p. 052006, 2015. https://journals.aps.org/prd/abstract/10.1103/PhysRevD.92.052006.

[11] K. Asakura *et al.*, "KamLAND Sensitivity to Neutrinos from Pre-Supernova Stars," *Astrophys. J.*, vol. 818, no. 1, p. 91, 2016. https://iopscience.iop.org/article/10.3847/0004-637X/818/1/91.

[12] C. Lane *et al.*, "A new type of Neutrino Detector for Sterile Neutrino Search at Nuclear Reactors and Nuclear Nonproliferation Applications," 2015. https://arxiv.org/abs/1501.06935.

[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. https://iopscience.iop.org/article/10.1088/0004-637X/806/1/87/meta.

[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. https://www.sciencedirect.com/science/article/pii/S0168900214011000.

[15] A. Gando *et al.*, "^{7}Be Solar Neutrino Measurement with KamLAND," *Phys. Rev.*, vol. C92, no. 5, p. 055808, 2015. https://journals.aps.org/prc/abstract/10.1103/PhysRevC.92.055808.

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[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. https://journals.aps.org/prd/abstract/10.1103/PhysRevD.84.036007.

STATEMENT OF RESEARCH

I have a strong background in radiation/particle transport simulations and how they affect real particle detector hardware. My expertise also involves processing and analyzing large-scale physics data using analysis tools such as ROOT and Python. I have experience working in 3 multinational collaboration physics experiments where I spearheaded independent research initiatives and successfully interfaced my original work with the larger team. Some of my past accomplishments that I take pride in include development of unprecedented particle detection algorithms that I project will open whole new physics searches by the collaborations that I have worked with.

I have been involved with the CUORE (Cryogenic Underground Observatory for Rare Events) experiment at the University of California, Los Angeles, and University of California, Berkeley since 2016. The main objective of the CUORE experiment is to observe neutrinoless double beta ($0\nu\beta\beta$) decay in ^{130}Te, one of the most rarest processes thought to occur in nature. My work in the collaboration involves developing a GEANT4 based precision background model together with a PhD student colleague to better understand the radioactive contaminations in the detector that undergo α decay. The energy spectrum of the background isotopes that produce α dauthers ($\gtrsim 2.7$ 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 background sources and extrapolate this understanding 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 published in March 2018 (https://arxiv.org/abs/1710.07988).

I led the development of the GEANT4 simulation code for the mini-TimeCube (mTC) experiment at the University of Hawaii at Manoa from 2009 to 2016. mTC was an ambitious project to build the world's smallest portable neutrino detector. In this project, I mentored 3 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) photomultiplier tubes (PMTs) deployed in the detector. The studies were used to develop directional particle detection algorithms and to guide the overall design of the detector during its construction phase. I have also conducted simulation studies for cosmic-ray muons and long-lived cosmogenic background isotopes such as ^{8}He and ^{9}Li. These backgrounds are extremely difficult to tag due to their long life-time ($\gtrsim$ s scale) and travel distances. The studies have been vital to the project. A paper summarizing our accomplishments was published in 2016 (V.A. Li et al. Feb 3, 2016. 19 pp. Rev.Sci.Instrum. 87 (2016) no.2, 021301).

While working at the University of Hawaii at Manoa, I also 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.

In summary my strong background in radiation/particle transport simulations and how they affect real particle detectors, as well as, my comfort in using tools to analyze large-scale physics data makes me a strong candidate. Also I would like to reemphasize my previous accomplishments in innovating novel particle detection techniques to solve complex problems and interface my original work with a large team of collaborators. I believe I can make a significant impact in your team.

References

Supplied upon request or please contact in person.

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