

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 $\sim 10^\circ$ 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 ~ 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 $\frac{dE}{dx}$ 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.

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 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).

As a postdoctoral researcher at Caltech, I would like to continue my endeavors in probing the fundamental properties of neutrinos as well as topological event imaging techniques in detectors such as NO ν A and DUNE. My past experience developing unprecedented methods in neutrino event reconstruction as well as experience in the commissioning phase of 2 major startup experiments makes me a promising candidate. I believe that I can make a significant impact in your team of scientific prowess at Caltech.