（別紙様式５）

変革を駆動する先端物理・数学プログラム（FoPM）

国外連携機関長期研修　報告書

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I stayed at SLAC National Accelerator Laboratory in California, US for two months. I engaged in developing calibration method in liquid argon time projection chamber (LArTPC) detectors as a member of the neutrino group in SLAC. In this report, I first describe my research in SLAC, and then focus on other exciting experiences during the stay.

I joined the near detector group in Deep Underground Neutrino Experiment (DUNE). DUNE is a long-baseline accelerator neutrino oscillation project going in US. They will produce neutrinos in an accelerator located at Fermi national accelerator laboratory (Fermilab) and will observe the neutrinos at a large detector 1300 km apart from Fermilab to observe the change in neutrino flavor, or neutrino oscillation. The near detector will be constructed at Fermilab to measure the neutrinos just after production. The near detector works as a LArTPC, where liquid argon is filled in a cryostat. Particles going through the detector ionize atoms on their tracks and the ionization electrons are corrected by electric filed and detected. Drift time of the ionization electrons depends on the path length, so three-dimensional particle tracks can be reconstructed in TPC.

To calibrate displacement and diffusion of the electrons in the drift, photoelectrons emitted from metal pieces on the cathode by laser radiation will be used. To understand how many photoelectrons will be observed, ①quantum efficiency of the metal pieces and ②electron lifetime in LArTPC are important, so I engaged in measuring those points.

I measured quantum efficiency (QE) of the metal pieces in a small setup built in a laboratory. It holds a metal sample in vacuum chamber, emits high-power UV-LED on the surface, applies bias voltage to anode, and then measures how much charge is emitted from the sample. I made several modifications on the setup to make the system simpler to understand and to improve reproducibility of the measurement. I also developed analysis method of the data to obtain QE.

The measurement was performed after sanding the sample surface to remove impurities on the surface. Then QE of the sample was measured repeatedly to monitor how the QE gets worse in time. As a result, I observed QE aging in several days in all samples kept in air. In one sample kept in vacuum to avoid contamination, the aging was slower. As a follow-up study, I build glove bags to perform experiments in nitrogen-purged environment. I found that QE aging was slower in nitrogen purge than in air and similar to aging in vacuum.

I also measured the electron lifetime in LArTPC. Liquid argon in TPC is purified but still contains impurities, which result in decrease of the number of observed electrons in TPC. I measured the time scale of the decrease, which is called electron lifetime. For the measurement, I used cosmic ray muon tracks always seen in the detector. I decided conditions to select cosmic ray muons from the observed events, calculated $\mathrm{d}Q/\mathrm{d}x$ (observed charge per track length) at each segment on the tracks, and compared $\mathrm{d}Q/\mathrm{d}x$ with drift time to derive electron lifetime. I succeeded in monitoring the history of electron lifetime in several days, and found the observed change met our expectation from the detector condition.

Apart from the research activities, I had exciting days with the members of the neutrino group. We went three-day camping in the Sequoia National Park, where I enjoyed hiking up to 3000 m mountain still covered with snow and seeing world-largest trees called Giant Sequoia. It was a great time to talk with group people until midnight around fire. I was surprised to see wild bears during the hiking. Wild bears are not rare around the area, and we used bear cans to put food in to avoid attracting bears. On our way to the park, I saw very Californian roads, with olive trees in a vast dry plain. This kind of nature in California is one of the most impressive things I encountered during the stay.

In the last weekend of my stay, we had a BBQ party in my host professor’s house. We enjoyed a variety of food from group members, playing with cats, listening to vinyl records, and talking to each other. I feel they have much more parties and gatherings in and out of the laboratory than we do in Japan. I was impressed that all the group members including professors join the gatherings.

As a whole, I had wonderful experiences in the two months in California. I learned a new experimental technique in particle physics and different research cultures in SLAC. I felt the society is made up of various people from various countries and the society is made to accept those varieties. Some of the differences from Japan were comfortable for me, but at the same time, I recognized what is good in Japan. I believe those experiences during the stay will help me a lot to work internationally in the future.

I deeply appreciate Prof. Hirohisa Tanaka and other members in the neutrino group to accept me as an intern. I also thank KEK for the fund for the stay in Ozaki Exchange Program.