CANDLES group activities in 2012

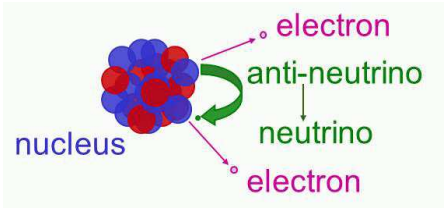
CANDLES is the project to search for neutrino-less double beta decay ($0\nu\beta\beta$) of ^{48}Ca. The experimental study of $0\nu\beta\beta$ is advanced by a long time measurement with a low background detector system. In 2012, CANDLES collaborators, which include 14 staff members and 22 student members, proceeded with development for the low background detector system.

Double Beta Decay :

The neutrino-less double beta decay ($0\nu\beta\beta$) is acquiring great interest after the confirmation of neutrino oscillation which demonstrated nonzero neutrino mass. Measurement of $0\nu\beta\beta$ provides a test for the Majorana nature of neutrinos and gives an absolute scale of the effective neutrino mass.

For measurement with sensitivity to the mass region indicated by neutrino oscillation measurements we have to prepare several hundred kg of double beta decay nuclei. Then we proposed CANDLES system. In the CANDLES system, CaF_2(pure) scintillators, which are main detectors, are immersed in liquid scintillator. The liquid scintillator acts as a 4 π active shield to veto backgrounds. These scintillator are installed in a water tank. We installed the detector system CANDLES III at Kamioka underground laboratory (2700 m.w.e.) as shown in figure 1-b).

a)Neutrino-less double beta decay



b)CANDLES III system

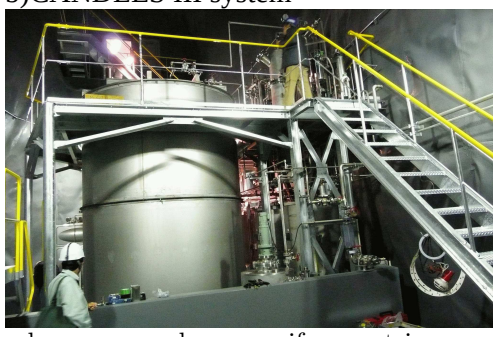


Figure 1: a) Neutrino-less double beta decay. The decay can only occur if a neutrino converts to an anti-neutrino. b) The CANDLES III system at the Kamioka underground laboratory.

CANDLES III system :

In 2012, we improved the CANDLES III system for a high sensitive measurement. In the CANDLES III system, the photomultiplier tubes had small photo-coverage. In order to increase the photo-coverage, the light-concentration system was set between the photomultiplier tubes and the liquid scintillator vessel. The light-concentration system is shown in figure 2-a). As the result of the performance test, we found that the light collection efficiency with the light-concentration system is 1.8 times larger than the one without the light-concentration system. The position resolution is also important performance for the background rejection. The result of the position reconstruction is shown in figure 2-b). We can find that the events distribute at the positions of each CaF_2 module. The peaks by the reconstructed position have 6 σ separation for each CaF_2(pure) scintillator. The separation satisfies requirement for the high sensitive measurement.

a)Inside view of water tank

b) Position reconstruction

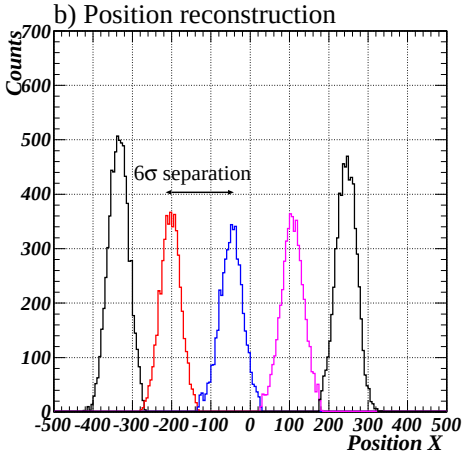


Figure 2: a) Inside view of the water tank. The light-concentration system, which has mirror-reflector films, are installed in front of the photomultiplier tubes. b)Result of the position reconstruction analysis. The peaks of the reconstructed position have 6 σ separation for each CaF_2(pure) scintillator.