Study for Double Beta Decay of ^{48}Ca with CANDLES at Kamioka

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CANDLES is the project to search for neutrino-less double beta decay ($0\nu\beta\beta$) of ^{48}Ca. 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.

The CANDLES III system is currently developed in the Kamioka underground observatory, ICRR. Figure 1 shows a schematic view of the system. The system consists of the 96 CaF_2 scintillators, which are immersed in liquid scintillator as 4π active shield. Both scintillation lights are viewed by 62 photomultiplier tubes.

For experimental studies of $0\nu\beta\beta$, background reduction is essential. The CANDLES III system can achieve the low background measurement by the 4π active shield. The further background reduction can be realized by good energy resolution and a shielding system.

Firstly we aimed the good energy resolution. In 2014, we made two upgrades to the CANDLES III system in order to increase collected light yield by the photomultiplier tubes. The one is a cooling system and the other one is a magnetic cancellation coil. The CaF_2 scintillator is known that its light emission increases at low temperature. The cooling system makes low temperature ($\sim$ 6 °C) condition for the CANDLES III system. And the magnetic cancellation coil is for increasing of photo-electron collection efficiency of the photomultiplier tubes. After these upgrade, commissioning data was taken from Aug. to Dec. in 2014. Figure 2 shows peak position of 2.6 MeV γ-ray from ^{208}Tl. The peak position is correspondent to the collected light yield by the photomultiplier tubes. The collected light yield was increased to 1000 p.e./MeV, which is 1.6 times larger than before the upgrades.

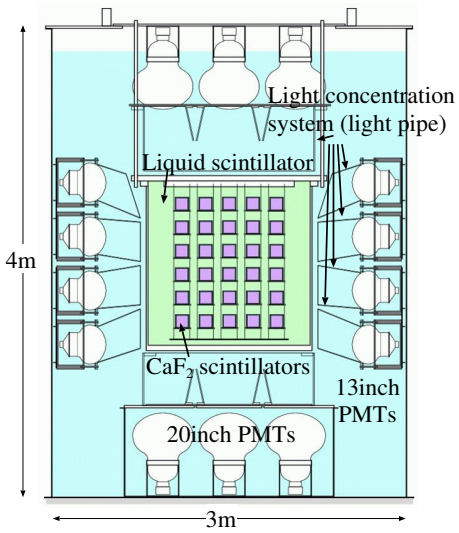

Figure 1: Schematic view of the main tank of the CANDLES III system. CaF_2 scintillators are immersed in liquid scintillator. The liquid scintillator acts as 4π active shield for the CaF_2 scintillators.

Secondly we are now trying to reduce the background events by installing neutron and γ-ray shields, because we found that γ-rays from neutron captures on nuclei (e.g. ^{56}Fe, ^{58}Ni) inside the surrounding materials are background candidates in the CANDLES III system. Now Pb blocks of 7 $\sim$ 12 cm thickness are arrayed for shielding external neutron capture γ-rays. Figure 3 shows side view of the main tank of the CANDLES III system. In addition, boron sheet, which has a large cross section to capture neutrons, will be placed on surface of the main tank to prevent thermal neutrons from being captured by Fe or Ni nuclei inside the tank material. We expect the background reduction of two orders of magnitude with this shielding system. We will start the low background measurement, after the construction of the shielding system will be complete.

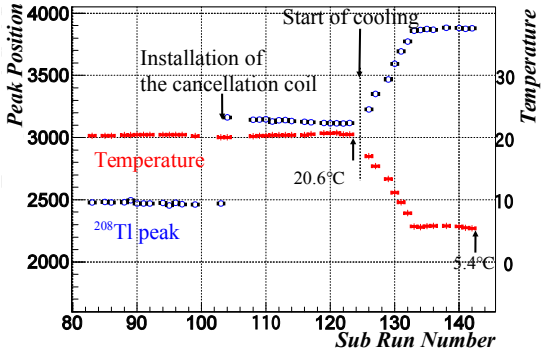

Figure 2: Temperature of the CANDLES system and peak position of 2.6 MeV γ-ray from ^{208}Tl. Peak position was changed after installation of the magnetic cancellation coil and start of operation of the cooling system.

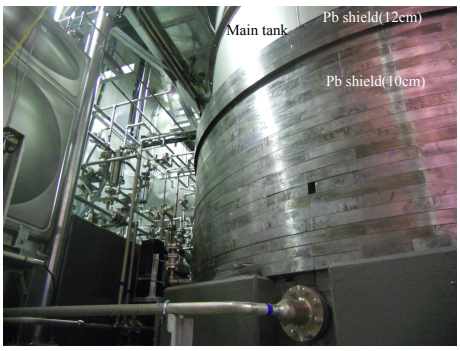

Figure 3: The shielding system for the CANDLES system. The system is installed in order to reduce background events by γ-rays from neutron captures. The system is now under construction and the construction will be completed in early 2016.