Report of the joint usage/research of RCNP

(Ultra-low background environment)

Title of research:

Establishment of low background techniques for neutron measurements in underground laboratories

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III. Period of research: September, 2019 to March, 2020

IV. Main location: Lab-D in the Kamioka Underground Observatory

V. Publication list including any kinds of papers, talks and so on:

Paper

1. "Measurement of ambient neutrons in an underground laboratory at Kamioka Observatory and future plan", Keita Mizukoshi, Ryosuke Taishaku, Keishi Hosokawa, Kazuyoshi Kobayashi, Kentaro Miuchi, Tatsuhiro Naka, Atsushi Takeda, Masashi Tanaka, Yoshiki Wada, Kohei Yorita、Journal of Physics: Conference Series 1468 (2020) 1, 012247

Talks

1. 「液体シンチレータと 6Li ドーププラスチック シンチレータを用いた中性子測定」、小津龍吉、第 9 回高エネルギー物理春の学校 2019、2019/05/18、滋賀県大津市北小松 湖邸滋びわこクラブ

2. “Measurement of ambient neutrons in an underground laboratory at Kamioka Observatory”、Keita Mizukoshi、TAUP2019l、2019/9/9、Toyama、Japan
3. 「地下環境中性子測定のための 6Li 添加プラスチックシンチレータの特性評価」、小津龍吉、JPS 2019 秋季大会、2019/09/19、山形大学
4. 「液体シンチレータを用いた地下環境中性子測定」、小津龍吉、26thICEPPSymposium、2020/02/16、志賀レークホテル

VI. Description of the results and outputs:

Understandings of environmental neutron backgrounds is a key to the success of low background experiments in underground laboratories. In the CANDLES experiment, which has been operated in the Lab-D at the Kamioka Underground Observatory, neutron-induced gamma rays are one of the major backgrounds. Thus, the CANDLES group had estimated this neutron-induced background by event rate at high energy above Q-value of $0\nu\beta\beta$. To estimate the background more accurately, we performed environmental neutron measurements in the Kamioka Underground Observatory using a ^{3}He proportional counter and its moderators and have published the result as a scientific paper [1]. In this research, as a next step, we developed a prototype of a liquid scintillator detector that can directly observe fast neutrons without the moderators.

The specific way of conducting this research is as follows. In order to make the best use of the equipment and technology for lowering the background in liquid scintillator that Osaka University has developed for the CANDLES experiment, the detector construction was conducted at the Lab-D in the Kamioka Underground Observatory. In addition, since alpha-ray background rate from glass windows used for PMT readout was found to be high by the measurement of the alpha-particle imaging detector [2], they were replaced with quartz windows. As a result of these improvements, for one day immediately after the

completion of the detector, we succeeded in reducing the alpha-ray background rate, the main background for the neutron measurement, to 0.2 mBq as Bi-Po rate, 1/20 of the levels previously achieved. After that, the emission of radon from the detector material raised the alpha-ray background rate gradually. Finally, the alpha-ray background rate was stabilized at 1 mBq as Bi-Po rate, 1/4 of the levels previously achieved.

We would like to continue this research in FY2020 and reduce the alpha-ray background rate to 0.4 mBq as Bi-Po rate , ~1/3 of the level achieved in this research. To achieve this goal, we plan to put a film of radon seal on the inner wall of the detector. Once the alpha-ray background rate is achieved, we will start long-term environmental neutron measurements using the detector in the Kamioka underground Observatory.

[1] K. Mizukoshi, R. Taishaku et al., Prog. Theor. Exp. Phys. **2018**, 123C01 (2018).

[2] H. Ito, T. Hashimoto, K. Miuchi et al., Nucl. Inst. and Meth. A **953**, 163050 (2020).