Improvement of the maintenance environment for Ge detectors

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During the delivery of the secondary beams at the BigRIPS separator, we usually confirm and calibrate the particle identification by detecting delayed γ rays emitted from known isomers by using two clover-type germanium (Ge) detectors placed at F7.[1,2] We mainly use ORTEC GMX-clover-S Ge detectors, which are tagged as ORTEC#1, #2, #3, and #4. Each clover Ge detector consists of four pure Ge crystals, each with its own output channel. Radiative backgrounds (such as fast neutrons) could damage the detectors, leading to a reduction in energy resolution during usage. In addition, a good vacuum is required for low temperature operation with liquid nitrogen (LN_2). Therefore, periodic annealing and vacuum pumping should be applied to the detectors. For this purpose, we have started the maintenance of the clover Ge detectors since 2016.

First of all, preparation room No.1 on B2F at the Nishina building was cleaned up. At first, when we checked each detector, channels 2, 3 and 4 of ORTEC#4 did not output any signals. The FETs and hybrid-ICs on the preamplifiers were replaced, and then the signal outputs for each channel were recovered. Next, we prepared a new vacuum pumping system (dry pump: 250 L/min, and TMP: 51 L/s), which has three ports for parallel pumping operation. We also designed and produced a vacuum valve operator, which is used when pumping the detector, at much lower cost than the commercially available ones. The ORTEC Ge detector does not have a heater inside the detector cryostat. Therefore a rod heater and a temperature controller were designed and produced for annealing. The rod heater is inserted into an LN_2 dewar from the top port and the bottom of the dewar is heated. The crystals are heated indirectly via a cold finger (a copper rod) connecting the crystals and the bottom of the dewar. A photo of this vacuum pumping and annealing system is shown in Fig. 1.

In the annealing process, the vacuum is typically kept at 10^{-6} to 10^{-7} Torr. The end cap is wrapped by a ribbon heater and aluminum foils to help the heating of the crystals. We tried a few annealing conditions, and found out that typically, annealing at 80°C for 3 to 4 weeks is suitable for our case. The cooling time to reach room temperature (∼22°C) is typically 30 hours. The example of the effect of the annealing process is shown in Fig. 2. Figure 2(a) shows the spectrum of ^{60}Co taken before using the Ge detector in the experiments. Figure 2(b) shows the spectrum taken after usage from 2017.4.3 to 2017.5.7 (primary beam was ^{70}Zn in this period). By annealing over a 35 day period, with initial temperature of 22°C, maximum temperature of 80°C, and final temperature of 22°C, the resolution was recovered as shown in Fig. 2(c). As the next step, we will try to tune and modify the electrical components including preamplifiers since annealing alone did not completely recover the intrinsic energy resolution (several keV).

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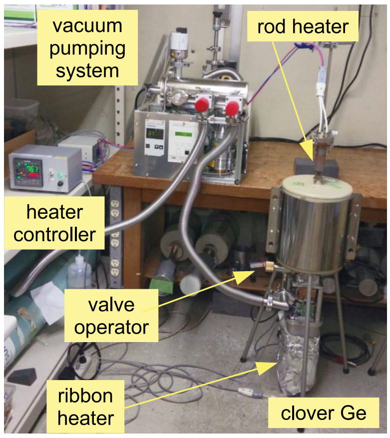

Fig. 1. The pumping and annealing system.

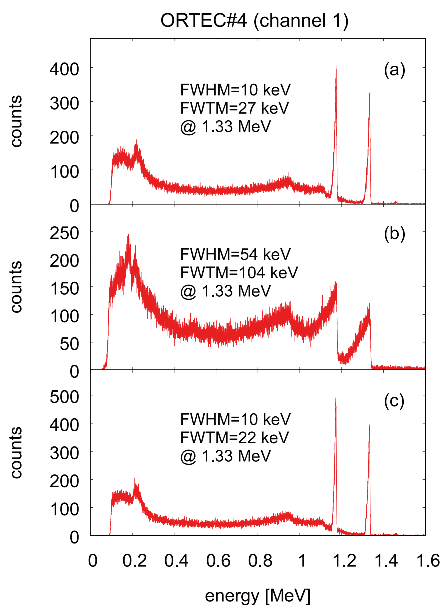

Fig. 2. Example of ^{60}Co spectrum: (a) before MT, (b) after MT, (c) after annealing process.

References
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2) http://ribf.riken.jp/BigRIPSInfo/chamber/f7.html