MLF Experimental Report	提出日 Date of Report 2014/7/04
課題番号 Project No. 2013B0235 実験課題名 Title of experiment Measurement of neutron capture by Be-9 up to 1 keV 実験責任者名 Name of principal investigator Hiroyuki Makii 所属 Affiliation Japan Atomic Energy Agency	装置責任者 Name of responsible person Hideo Harada 装置名 Name of Instrument/(BL No.) ANNRI / BL-04 実施日 Date of Experiment 2014 3/5-7

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

In this experiment, we used a following sample.

Name of sample	chemical formula	from shape	Quantity
Beryllium	Be	solid	20 mg

We also used B and C samples to estimate the neutron flux and to identify the background events, respectively.

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

The experiment has been carried out with use of the ANNRI installed at beam line BL-04. The Ge spectrometer consists of two cluster Ge detectors surrounded by BGO anti-Compton shields set at the neutron flight length position of L = 21.5 m was used to detect the γ-rays from the samples. A Be sample with a diameter of 5 mm and a thickness of 0.8 mm were located in the beam duct made of aluminum. The purpose of this study was to deduce the excitation function of ^{9}Be(n,γ)^{10}Be reaction and the γ-ray branching ratio of transitions from a neutron capture state to low-lying states in ^{10}Be in the energy region of E_n = 1.4 meV – 1.0 keV using time-of-flight (TOF) technique. Because of small cross section was expected for the ^{9}Be(n,γ)^{10}Be reaction, particular attention should be given to identify the background due to neutron scattered by the sample. For this purpose, a C sample and an empty case were irradiated in the same arrangement. Here, neutron flux was obtained by ^{10}B(n, αγ)^{7}Li reaction by using a B sample since the cross section of this reaction is well known. Measuring time, total dose of protons for each sample are summarized in Table 1. Proton beam power in this study was 300 kW.

Due to the simple structure of the nuclear levels of ^{10}Be, the ^{9}Be(n,γ)^{10}Be cross section can be obtained

2. 実験方法及び結果（つづき） Experimental method and results (continued)

Table 1: Measurement time and total dose of proton beam.

sample	Measuring time [hours]	Proton dose (10^{19} protons)
Be	20.1	3.25
C	10.1	1.03
Empty	8.2	1.46
B	4.8	0.87

by summing the partial cross sections. Here the neutron capture in ^{9}Be is expected to proceed through direct radiative transitions to the ground ($J^{\pi} = 0^{+}$), 1st excited (2^{+}), and 2nd excited (2^{+}) states in ^{10}Be as shown in Figure 1. In this study, we will deduce the partial cross sections and γ–ray branching ratio from the intensities of 6.81 MeV, 3.44 MeV, and 0.85 MeV γ–ray peaks due to the direct neutron capture into the ground, 1st excited, and 2nd excited states in ^{10}Be, respectively. Figure 2 shows γ–ray spectra for the Be sample [(a), (c), and (e)] and the C sample [(b), (d), (f)] obtained by gating the neutron energy regions of $20 \leq E_n \leq 80$ meV [(a) and (b)], $80 \leq E_n \leq 120$ meV [(c) and (d)], and $500 \leq E_n \leq 1500$ meV [(e) and (f)]. Here, the spectra obtained with the C sample contained the background events due to the neutrons scattered from the sample. In the spectra of the Be sample, we clearly see the 6.81 MeV peaks. On the other hand, in the spectra of the C sample, we did not observe any γ–ray peaks in the 6.81 MeV peak region, although the strong background peak at 6.86 MeV due to ^{207}Pb(n,γ)^{208}Pb reaction is seen in the spectra of each sample. From Fig. 2, we found that the background due to neutrons would not provide any problems to yield estimation of the 6.81 MeV peak. The study of the background event due to neutrons for other γ–ray peaks and the analysis to determine the absolute partial cross section values are now in progress.

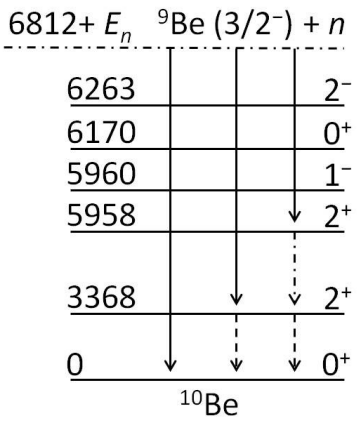

Figure 1. Level scheme of ^{10}Be.

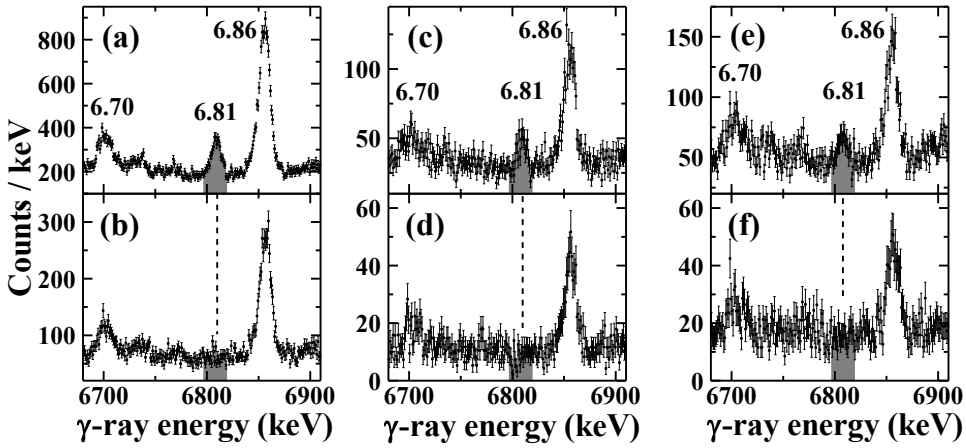

Figure 2. γ–ray spectra taken by the Ge spectrometer with the Be sample [(a), (c), and (e)] and the C sample [(b), (d), and (f)]. These spectra were obtained by gating the neutron energy regions of $20 \leq E_n \leq 80$ meV [(a) and (b)], $80 \leq E_n \leq 120$ meV [(c) and (d)], and $500 \leq E_n \leq 1500$ meV [(e) and (f)]. Here 6.81 MeV γ–ray peak is due to the ^{9}Be(n,γ)^{10}Be reaction. On the other hand, 6.86 MeV one is due to the ^{207}Pb(n,γ)^{208}Pb reaction.