MLF Experimental Report	提出日 Date of Report 2013/4/19
課題番号 Project No. 2012B0169 実験課題名 Title of experiment Measurement of ^{6}Li(n,γ)^{7}Li cross section 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 2012/12/1 - 6

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 the following samples.

Name of sample	chemical formula	form shape	Qantity
Lithium-6 oxide	Li_2O	solid	20mg
Lithium-7 oxide	Li_2O	solid	40mg
Lithium-7 oxide	Li_2O	solid	20mg
Lithium-6 carbonate	Li_2CO_3	solid	40mg
Lithium carbonate	Li_2CO_3	solid	40mg

We also used B and C samples to estimate the neutron flux and to identify the background, 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 flight length position of L = 21.5 m was used to detect the γ-rays from the samples. Enriched $^{6}Li_2O$ sample (95.5 % enrichment in ^{6}Li) with a diameter of 5 mm and a thickness of 0.5 mm are located in a beam duct made of aluminum. The purpose of this study was to deduce the excitation function of ^{6}Li(n,γ)^{7}Li reaction and the γ-ray branching ratio of transitions from a neutron capture state to low-lying states in ^{7}Li in the energy region of E_n = 1.5 meV - 1.0 keV using a time-of-flight (TOF) technique. Because of small cross section is expected for the ^{6}Li(n,γ)^{7}Li reaction, particular attention should be given to identify the background due to neutron scattered by the sample. For this purpose, $^{7}Li_2O$ (98.2 % enrichment in ^{7}Li) and C samples, and an empty case are irradiated in the same arrangement. Here, neutron flux is 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, proton beam power, and total dose of protons for each sample are summarized in Table 1. Note that, the proton beam power has been changed from 200 kW to

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

300 kW during the experiment.

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

sample	Measuring time [hours]	proton beam power (kW)	Proton dose (10^{19} protons)
$^{6}Li_2O$	56.0	200	7.68
$^{7}Li_2O$	28.3	200	3.86
C	12.3	300	2.30
Empty	13.4	300	2.41
B	13.0	300	2.48

Due to the simple structure of the nuclear levels of ^{7}Li, the ^{6}Li(n,γ)^{7}Li cross section can be obtained simply by summing the partial cross sections. Here the neutron capture in ^{6}Li proceeds through direct radiative transitions to the ground ($J^{\pi} = 3/2^{-}$) and to the first excited ($J^{\pi} = 1/2^{-}$) states in ^{7}Li as shown in Fig. 1. In this study, we deduce the partial cross sections and the γ-ray branching ratio from the intensities of 6.77 MeV and 7.25 MeV γ rays due to the direct neutron capture into the first excited and ground states in ^{7}Li, respectively. Fig. 2 shows three γ-ray pulse-height spectra for (a) $^{6}Li_2O$ sample, (b) $^{7}Li_2O$ sample, and (c) C sample obtained by the Ge spectrometer. One can see clearly 6.77 MeV and 7.25 MeV γ-ray peaks due to the direct neutron capture into the first excited and ground states in ^{7}Li. However, small background peaks (6.78 MeV and 7.24 MeV) due to the ^{55}Mn(n,γ) reaction were observed as shown in Figs. 2 (b) and (c). Here the ^{55}Mn is considered to be contained in the beam duct made of aluminum as impurities, and therefore the ^{55}Mn(n,γ) reaction occurred in the beam duct and γ-ray peaks due to the ^{55}Mn(n,γ) reaction were shown in the Figs. (b) and (c). In order to deduce the ^{6}Li(n,γ)^{7}Li cross section accurately, it must be certain that the characteristic γ-ray peaks from ^{6}Li(n,γ)^{7}Li reaction are free from any contaminant γ-ray events. Therefore, it is necessary to study the background γ-ray event due to neutron scattered by the sample. This study remains to be done.

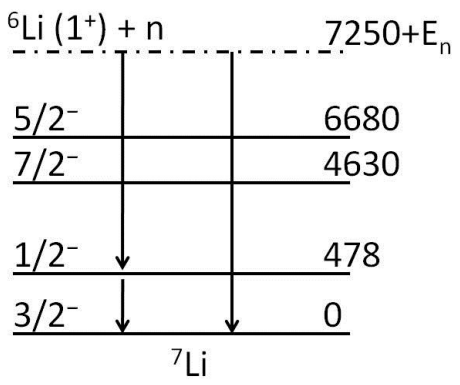

Fig. 1. Level scheme of ^{7}Li

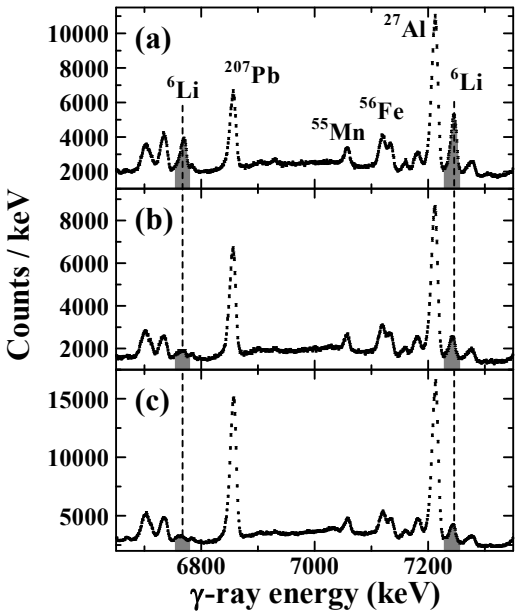

Fig. 2. γ-ray pulse-height spectra from $^{6}Li_2O$ sample (a), $^{7}Li_2O$ sample (b), and C sample (c), respectively.