MLF Experimental Report	提出日 Date of report 2014/6/19
実験課題番号 Project No. 2013P0701 実験課題名 Title of experiment Research on nuclear astrophysics, nuclear data, and trace-element analysis using pulsed neutrons 実験責任者名 Name of principal investigator Hideo Harada 所属 Affiliation Japan Atomic Energy Agency	装置責任者 Name of responsible person Harada Hideo 装置名 Name of Instrument/(BL No.) ANNRI/BL04 利用期間 Dates of experiments 2013/4/1～2014/4/7

1．研究成果概要（試料の名称、組成、物理的・化学的性状を明記するとともに、実験方法、利用の結果得られた主なデータ、考察、結論、図表等を記述してください。

Outline of experimental results (experimental method and results should be reported including sample information such as composition, physical and/or chemical characteristics.

The ANNRI installed at BL04 of J-PARC/MLF was applied for researches of nuclear astrophysics, nuclear data, and trace-element analysis. In this report, representative results in this project are presented.

Prompt gamma-ray analysis (PGA) is an analytical technique for elemental determinations. This method is known as a rapid, non-destructive and multi-element analytical method in a wide variety of sample types. The time-of-flight (TOF) technique is a method for determining the kinetic energy of a traveling neutron, by measuring time it takes to fly between a neutron source and a sample. In this project, we try to combines PGA with TOF for developing a novel analytical method (TOF-PGA). This year we have performed preliminary experiments using ANNRI. The samples were sealed in envelopes (30 x 40 mm) of FEP (Fluorinated ethylene propylene) film. The germanium detector-array, which consists of two cluster-Ge detectors and BGO Compton suppressors surrounding cluster-Ge detectors has used in the measurements. PGA, TOF and TOF-PGA etc. spectrum obtained in the measurements of standard samples. Prompt gamma-ray peaks and neutron capture resonance peaks are clearly observed in the spectrum.

Accurate data of the neutron-capture cross section for 126Sn are required in the study of nuclear transmutation. However, an ordinary 126Sn sample for a nuclear data experiment contains a large amount of its stable isotopes because they also have large fission yields and the sample is normally prepared only through a chemical process from spent fuel. The stable isotopes have large effects on the experiment. To obtain accurate neutron-capture cross section data for 126Sn, those for the stable isotopes are also required. Therefore, A series of neutron-capture cross section measurements for the tin stable isotopes have been started with Accurate Neutron-Nucleus Reaction measurement Instrument (ANNRI) at J-PARC.

1．研究成果概要（つづき） Outline of experimental results (continued).

The preliminary results of the neutron-capture cross sections for ^{112}Sn and ^{118}Sn were obtained in the energy range from 10 meV to 2 keV with the array of Ge detectors in ANNRI. Thirteen new resonances for ^{112}Sn were observed. The prompt γ-ray distributions gated at the 112Sn and ^{118}Sn resonances were obtained. Twenty three new prompt γ-ray emissions were observed in the ^{112}Sn (n, γ) reactions.

Measurement of the neutron capture cross sections of ^{107}Pd and ^{241}Am was carried out using the NaI(Tl) spectrometer of ANNRI. The neutron capture cross sections of those nuclides are important in study of nuclear transmutation of long-lived radioactive material in nuclear waste. The sample was placed at a flight path length of 27.9m. Prompt gamma-rays emitted from the sample were detected with an NaI(Tl) detector located at an angle of 90 degrees with respect to the neutron beam axis. Neutron capture yields were determined by the pulse height weighting technique. The absolute cross section value of ^{107}Pd was determined by normalizing the experimental results to an evaluated value of JENDL-4.0 at a resonance of 44 eV. For ^{241}Am, The incident neutron spectrum was determined by detecting 478-keV gamma-rays from the ^{10}B(n,αγ)^{7}Li reaction. For ^{107}Pd, the neutron capture cross section was determined from the thermal neutron energy to keV energies. The results show that the energy dependence of the cross section in the thermal energy region is similar to the evaluation of JENDL-4.0. For ^{241}Am, the absolute cross section was determined by a saturated resonance of ^{197}Au(n,γ)^{198}Au at 4.9 eV. The ^{241}Am(n,γ)^{242}Am cross section was determined in energies from the thermal to 100 eV. Preliminary results show that the present data and the JENDL-4.0 evaluation are in good agreement in the resonance energy region. Detailed data analysis is ongoing.

The measurement of Tc-99 neutron-capture cross section was performed. The Tc-99 sample was put at 21.5 m from the neutron source, sealed in an aluminum case. The sample is pure metal of 78 mg, 6.3 mm in diameter, and a thickness of 0.28 mm. The neutron beam bombarded on the sample was 15 mm in diameter. Prompt gamma rays were detected by the Ge spectrometer. By analyzing the gamma ray energy spectra, we found the effectiveness of our experimental method. Fig. 1 shows the effect on the TOF spectrum of selecting gamma ray. The residual nucleus Tc-100 has energy levels of 200.67 and 243.95 keV. These levels are isomers, of which half life are 8.32 and 3.2 μs, and decay to 172.15-keV level by the internal conversion. Therefore, we could obtain the accurate TOF spectrum, which was not affected by the isomers, by removing the gamma ray of 172.15 keV.

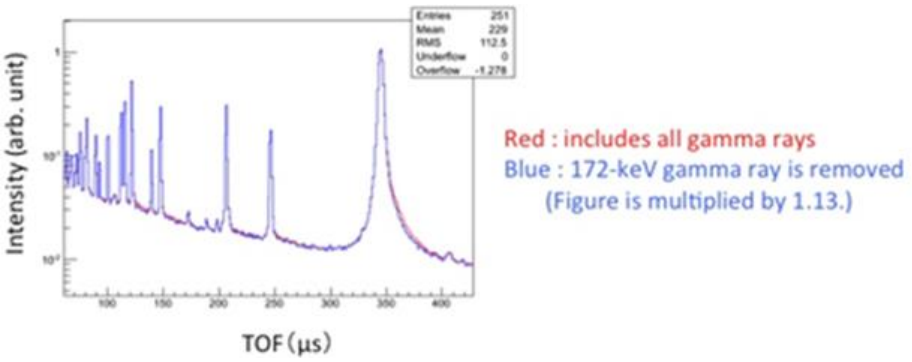

Fig.1 Effect of the gamma ray selection on TOF spectrum.

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