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 MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2016B0202 実験課題名 Title of experiment Measurement of Angular distribution of Prompt Gamma-rays using unpolarized neutron beam 実験責任者名 Name of principal investigator Katsuya Hirota 所属 Affiliation Nagoya University	装置責任者 Name of responsible person Atsushi Kimura 装置名 Name of Instrument/(BL No.) ANNRI/BL04 実施日 Date of Experiment 2016 12/1-12/6

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. The ^{nat}La target foil, whose size is $40 \times 40 \times 1$ mm, is used in this experiment. The purity of ^{nat}La targets is 99.9%. ^{nat}La consists of 0.09% of ^{138}La and 99.91% of ^{139}La .

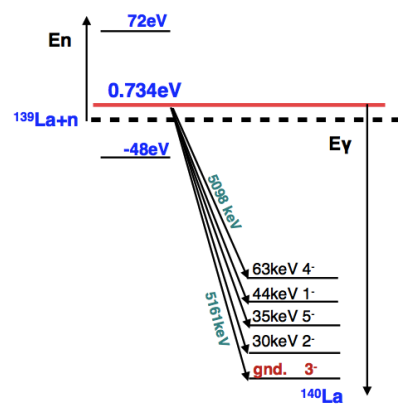
2. 実験方法及び結果 (実験がうまくいかなかった場合、その理由を記述してください。) Experimental method and results. If you failed to conduct experiment as planned, please describe reasons. We measured angular distribution in $\text{La}(n, \gamma)$ reaction to determine $\kappa(\text{J})$ with 4π germanium spectrometer in BL04. In this experiment, the pulsed neutron beam was collimated to a diameter of 22- mm at the La target position. The total measurement time at ANNRI was about 60 h (5.0×10^6 shot). The spectrometer was located at 21.5 m flight length and consists of 22-channel germanium crystals detectors. Each crystal was installed at 36, 71, 72, 90, 108, 109, 144 degree with respect to the neutron beam line and we can measure angular distribution of γ -ray at these angles. The deposit energy in germanium crystal and time of flight(TOF) of γ -rays were acquired as LIST mode DAQ system.	
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Fig1. Transitions from $^{139}\text{La}+n$ to ^{140}La

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

^{nat}La target has 3 neutron resonances in lower energy epithermal region. The γ -ray transition in $^{139}\text{La} + n \rightarrow ^{140}\text{La}$ are shown in Fig1.

The γ -ray spectrum and TOF spectrum are shown in Fig2 and Fig3. In γ -ray spectrum, almost all the intense photo peaks for $^{139}\text{La}(n,\gamma)$ reaction were observed. TOF spectrum was corrected by the beam spectrum measured with ^{10}B target. 0.734 eV p-wave peak, 72.3 eV s-wave peak of ^{139}La and 2.99 eV s-wave peak of ^{138}La were observed in TOF spectrum.

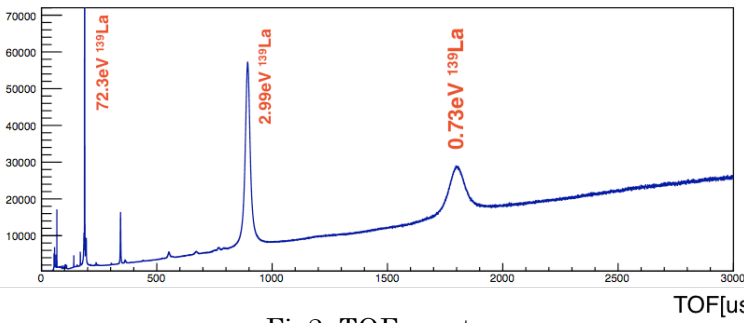


Fig2. TOF spectrum

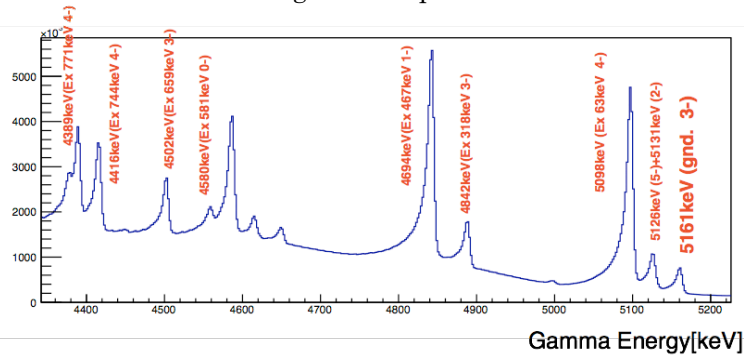


Fig3. Gamma ray spectrum

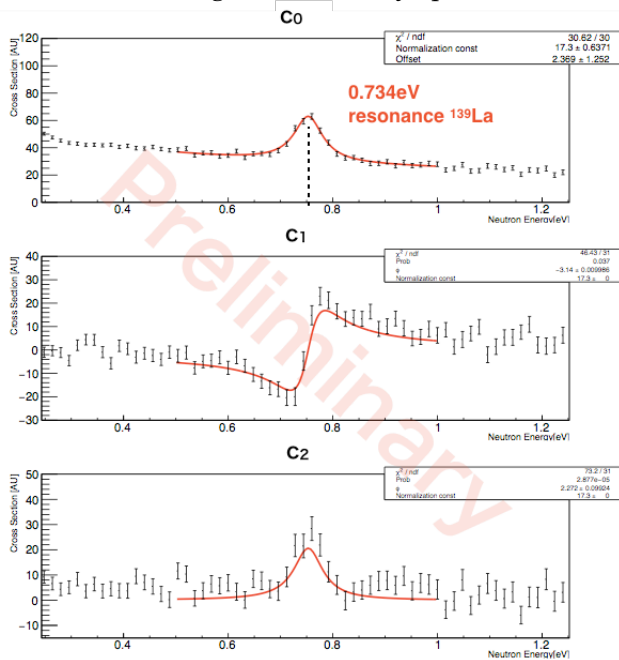


Fig4. Legendre polynomials of angular distributions of 5161keV γ ray

We measured angular distribution in 5161 keV γ ray transitioned from 0.734 eV p-wave resonance (transition to F=3 ground state). The detection efficiency of each germanium crystal was calibrated with 1596 keV delayed γ ray from radiated ^{140}La and a simulation of germanium detectors with Geant4.

We obtained clear angular distributions of 5161 keV γ ray and this angular distributions was expanded with Legendre polynomial. The neutron energy distributions of Legendre coefficients are shown in Fig4.

The Legendre coefficients are fit with theoretical calculations predicted by s-p mixing which is shown as red line in Fig4. From this analysis, we first confirmed the angular distributions are consistent with s-p mixing.

The $\kappa(J)$ value of ^{139}La were estimated as $\kappa(J) \sim 1$ as a preliminary results from this analysis. Therefore we confirmed $\kappa(J)$ value of ^{139}La is not small and ^{139}La is suitable nucleus for T-violation search.