MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2015A0010 実験課題名 Title of experiment Upgrade of a negative muon X-ray analysis system 実験責任者名 Name of principal investigator Takahito OSAWA 所属 Affiliation Japan Atomic Energy Agency	装置責任者 Name of responsible person Yasuhiro Miyake 装置名 Name of Instrument/(BL No.) D2 実施日 Date of Experiment March 18 to 20, 2016

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.

Pellets of organic materials

Zinc

Nickel

Jbilet Winselwan (CM2 chondrite)

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 have developed a new analysis system, which is financially supported by Grant-in-Aid for Young Scientists (A) from the Japan Society for the Promotion of Science. In the previous works [2013B0039 and 2014A0001], we tested the new analysis system. In the first trial of 2013B, no good x-ray spectrum was obtained because the profile of muon beam cannot be taken and appropriate exciting current was unknown. Then I totally improved the system to mend the defects before 2014A; three removable collimators, an adaptor of collimator, a new trellis window with a Kapton foil, and an acrylic fiber flange were manufactured. In 2014A, beam profile could be taken and appropriate exciting current was empirically determined and the performance of the devise has improved greatly. S/N ratio was much improved and beautiful muonic x-ray spectra were recorded because the background level was significantly suppressed. The accuracy of the analysis has tripled compared with previous works. The analysis system was reformed to further improve its performance. Concretely, a large-scale repair of the frame was conducted to improve the accuracy of the beam alignment. In addition, to set up more Ge detectors, the shield body will be added. The aim of this study is evaluate the performance of the upgraded analytical system.

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

The upgraded device was carefully installed onto D-2 port and the position of the device and the alignment of muon beam was adjusted precisely.

In the first step of the experiment, the condition of magnet and muon beam was adjusted. The device is designed to use negative muon whose momentum is up to 50 MeV/c. While changing the momentum of negative muon and the current of the bending magnet, beam profiles were recorded by a CCD camera. Beam profile can be recorded through an acrylic fiber flange installed to the sample chamber. A plastic scintillator (2T × 120 × 120 mm) was horizontally put on a sample holder in the sample chamber and the picture of the luminescence from the scintillator was taken by a CCD camera equipped with an image intensifier. The CCD camera was installed with its optical axis inclined to the scintillator by 45 degree. Reflecting light from the inner surface of the sample chamber is prevented by a black film that is treated by alumite. The beam profiles were recorded in seven conditions shown below.

1. Muon momentum: 45 MeV/c, Excitation current: 62 to 74 A, Exposure time: 10 sec, Collimator: 30Φ
2. Muon momentum: 45 MeV/c, Excitation current: 65 to 71 A, Exposure time: 30 sec, Collimator: 20 × 30 mm
3. Muon momentum: 40 MeV/c, Excitation current: 55 to 62 A, Exposure time: 60 sec, Collimator: 20 × 30 mm
4. Muon momentum: 35 MeV/c, Excitation current: 47 to 53 A, Exposure time: 60 sec, Collimator: 20 × 30 mm
5. Muon momentum: 35 MeV/c, Excitation current: 47 to 52 A, Exposure time: 60 sec, Collimator: 15 × 21 mm
6. Muon momentum: 40 MeV/c, Excitation current: 55 to 62 A, Exposure time: 60 sec, Collimator: 15 × 21 mm
7. Muon momentum: 45 MeV/c, Excitation current: 65 to 71 A, Exposure time: 30 sec, Collimator: 15 × 21 mm

Beam profiles were successfully recorded and best excitation currents for the magnet were empirically determined. In the next step we measured muonic x-ray for Ni and Zn plated (10 × 10 mm) in order to detect their isotopes. The momentum was 35 MeV/c and 15 × 21 mm collimator was used for all analyses. Although Kα lines of Ni and Zn were clearly determined, it is difficult to distinguish each isotope because isotope shift was not large. Next we measured Jbilet Winselwan (CM2) for 9 hours and obtained good muonic x-ray spectrum. All major elements, including carbon, were detected. Only Be plate was measured in the blank analysis.

Since it is important to verify the effect of muon irradiation for organic materials in extraterrestrial materials, we test the effect of muon irradiation. In the case of the analysis for Asteroidal samples collected by Hayabusa2, the damages for organic materials in the samples due to destructive analysis will not be tolerated. We prepare 10 small pellets which was a mixture of several organic matters and they were irradiated by negative muon beam with the momentum of 35 MeV/c for 13 hours. The samples were measured by FTIR after the muon experiment and no significant effect was observed, showing that the damage of organic materials by muonic x-ray analysis is negligible.