# MLF Experimental Report	提出日 Date of Report July 29, 2010
課題番号 Project No. 2009A0081 実験課題名 Title of experiment Research and development of energy selective neutron imaging technique 実験責任者名 Name of principal investigator Masahito MATSUBAYASHI 所属 Affiliation Japan Atomic Energy Agency	装置責任者 Name of responsible person Fujio MAEKAWA 装置名 Name of Instrument/(BL No.) NOBORU / BL10 実施日 Date of Experiment 2009/6/3 – 2010/5/30

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.

Metallic foils: In, Co, Au, Ta, Cd

Industrial materials

ASTM sensitivity indicator (Aluminum, Lead, Acrylic resin)

D_2O sealed in an aluminum sample holder ca. 10 mm in diameter and 45 mm in height

Portland cement

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 "Research and development of energy selective neutron imaging technique" was continued by sub-groups in the project research group.

<u>R&D on Single Gate and Serial Gate TOF Imaging Method</u>

We newly developed two kinds of neutron transmission imaging system introducing the time-axis into radiography with pulsed neutrons. One system is named SERIAL GATE TOF which serially takes time-of-flight information to transmission images by synchronizing a high-speed camera to JSNS. It consists of a NR converter, an imaging intensifier, a lens system, a time gated high-speed video camera and post-processing softwares developed to visualize objects from a large number of images. The experiments were performed to visualize typical samples at the BL10. Using the system, we could obtain contrast-enhanced images at neutron resonances for nucleus in the sample materials, and found that the system had a capability for practical application. The other system is named SINGLE GATE TOF. Through the experiments, it was confirmed that the high spatial resolution with the order of 5-55 micro meter /pixel could be achieved by selecting macro lens system and consecutive uptake imaging on a single gate TOF region. Additionally, we could obtain high spatial resolution images for neutron resonance regions.

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

R&D on High-speed Video Camera

A high-speed video camera system was used as a pulsed-neutron imaging detector. Transmission neutron images of ASTM sensitivity indicator were taken to evaluate sensitivity of the system. The result shows that the system has enough sensitivity with good time resolution.

Application of Bragg-edge Imaging - Discrimination of Ice & Water -

A direct visualization of freezing of water in an object is very attractive field in neutron imaging. A Bragg edge analysis is one of the promising method to deal with this matter because the frozen water, i.e. ice, is known to crystallize in ice-VII phase at normal pressure. To investigate the visualization of freezing of water, an imaging test experiment was done at BL10 using D_2O to eliminate incoherent scattering from H. The sample was mounted in a refrigerator, and the refrigerator was set on the sample position of the BL10. A 2D position sensitive detector RPMT was set in the direct-beam position for transmission measurement, and a ^{3}He detector was set in the backward position for diffraction measurement. Incident neutron was attenuated by a rotary collimator, and a B_4C narrower at 12.7 m was adjusted to limit the beam illumination area. 2D transmission images and diffraction data of the sample were collected at 300 and 246 K. Some Bragg edges were observed in a 1D TOF data at 246 K, which were attributed to the ice-VII phase. Taking transmission images in the limited wavelength would be possible in principle, however, adequate statistics were not obtained with the current experimental setup, especially limitation of the counting rate of RPMT. Water was crystalline at low temperature, however, powder-like condition was not obtained. This is the reason why the Bragg edge positions were somewhat different from the expected ones.

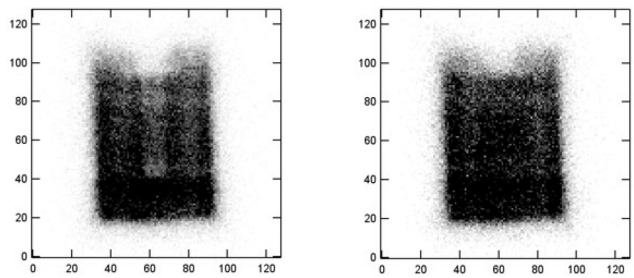

Fig. 1 Transmission images of cold neutrons with and without the sample (left and right).

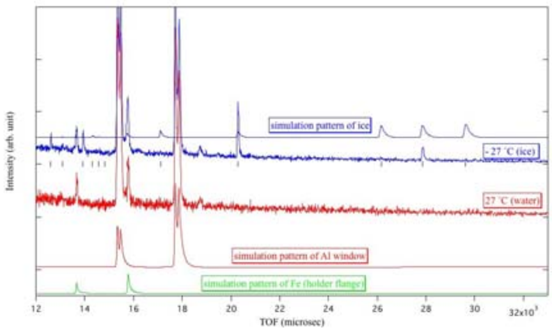

Fig. 2 Comparison of observed and simulated patterns of diffraction data.

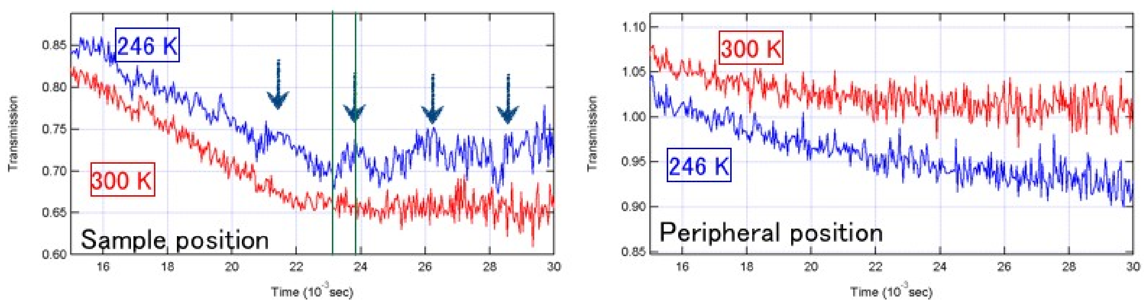

Fig. 3 Transmission data of the sample position (left) and the peripheral position (right) at 300 K and 246 K.

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

Visualization of Magnetic Field with Polarized Neutrons

We have performed a magnetic field imaging experiments. A magnetic field in a small solenoid coil was produced. Pulsed neutrons polarized with magnetic super-mirrors were transmitted through the magnetic field, and change of polarization was analyzed. Accordingly, we have successfully obtained two-dimensional images of the change of neutron polarization after passing through the solenoid coil, which clearly indicate decrease of the polarization at the position of the solenoid. Furthermore, the change of the polarization at the solenoid coil was plotted as a function of neutron wavelength, and was fitted with a sinusoidal function. From the obtained parameters, we succeeded to quantify not only the field strength but also the magnetic field direction.

Existent State of Water Molecules in Solids

The existent state of water molecules in solids is still the subject for bulk materials. Since a neutron has characteristic cross sections of hydrogen, we have a possibility to make it clear nondestructively using the neutron transmission technique. For the purpose we carried out the neutron TOF imaging experiment about cement samples, which were stiffen bulks but the wet and dry ones. Figure 4 shows the imaging results for the samples. The wet sample shows small transmission factors comparing to the dry one. That is considered because of the larger fraction of water in the wet sample. Both images show the similar spatial distribution that the sample center has small transmission factors contrast to the rim. The reason of this tendency is not yet clear, because the effect of multiple scattering is not eliminated. The trends of the obtained cross sections are under analysis to clear the existent state of water in the samples.

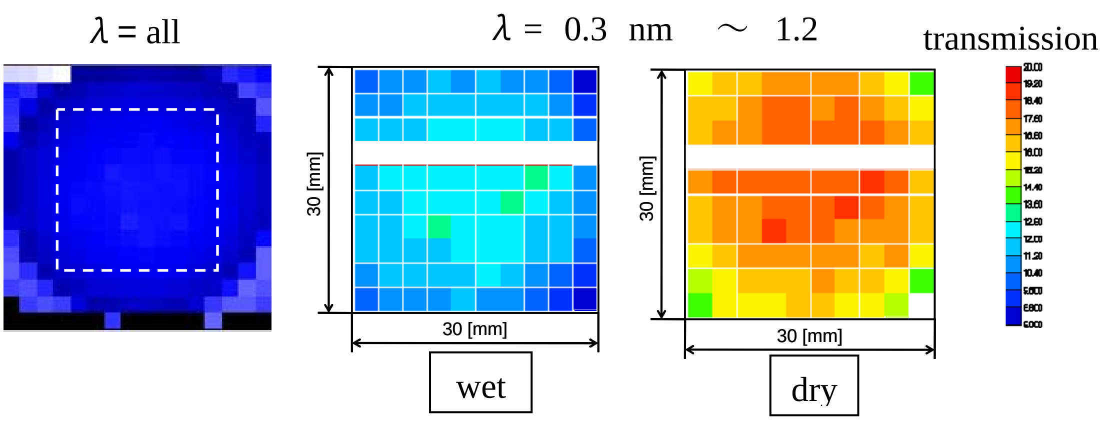

Figure 4. Transmission TOF images for the bulk cement samples. The left image is a whole sample image, and the center and right ones are corresponded to the square area in the left.