MLF Experimental Report	提出日 Date of Report 2010.1.5
課題番号 Project No. 2009A0027 実験課題名 Title of experiment High Magnetic Field Neutron Diffractions in Frustrated Multi-ferroics 実験責任者名 Name of principal investigator Hiroyuki Nojiri 所属 Affiliation Institute for Materials Research, Tohoku University	装置責任者 Name of responsible person Fujio Maekawa 装置名 Name of Instrument/（BL No.10） BL10 実施日 Date of Experiment 2009.5.28.9:00-2009.5.29.9:00 2009.6.13.10:00-2009.6.20.10:00

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.

NaCl single crystal
$CuFeO_2$ single crystal
$MnWO_4$ single crystal

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 purpose of our experiment is to conduct neutron diffraction in very high magnetic field above 40 T and to investigate the mechanism of multi-ferroic compounds. In the previous proposal:2008B018, we have made the first application of pulsed magnetic field above 30 T and have shown the feasibility of our system. On the other hand, the statistic of the data was not enough to examine the system performance such as time and space resolution, counting rate etc. The most difficult point was the low intensity of the neutron beam. Considering the result of the 2008B term, we have decided to start from very simple measurements on single crystals such as NaCl and $CuFeO_2$ to examine the system performance in the given condition of the beam. Note that the neutron intensity is as low as that in 2008B in the period of May-June, 2008. In fact, the present result is much different and limited from that we proposed at Feb. 1st. It is because the expected beam intensity is much weaker than that announced when we submitted the proposal. We believe that, however, the present result is the important and the indispensable step for the establishment of the neutron diffraction in extremely strong magnetic field.

Figure 1 shows the result of the TOF spectrum on NaCl single crystal under the pulsed magnetic field of 35 T. The sample volume is 0.7 cm_3. The TOF spectrum is obtained by accumulating 134 shots over 22 hours. The sample is chosen because of the strong intensity and of the sharp peak.

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

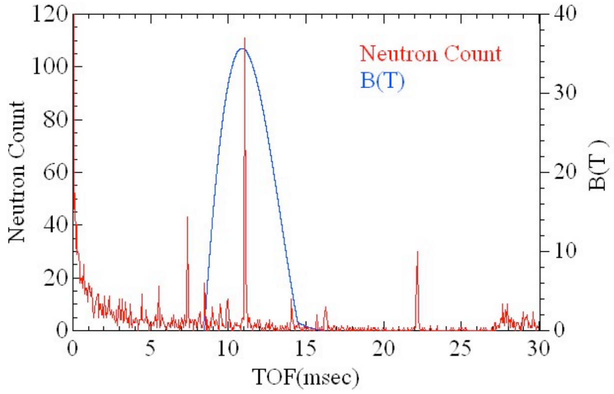

Fig. 1 TOF spectrum and waveform of the pulsed magentic field. The sample is NaCl single crystal.

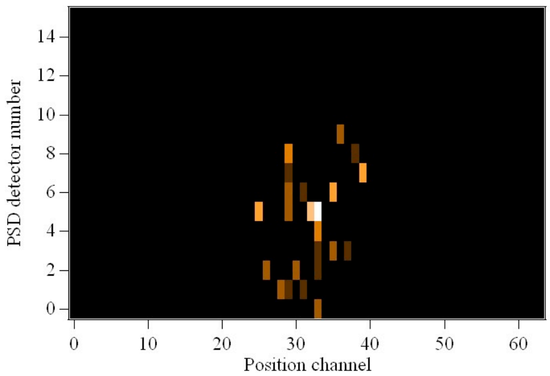

Fig. Image of the two-dimensional distribution of the Bragg peak in $CuFeO_2$.

We have compared the [400] nuclear Bragg peak taken at 35 T with that at zero field and found no clear difference. It means that the performance of the system is maintained even in such high magnetic fields. The background of the TOF spectrum is very high because we have conducted the experiment with the coarse arrangements of the slits and the beam narrower. It can be improved easily by an order of magnitude.

Figure 2 shows the two-dimensional image of the [0012] peak in multi-ferroic compound $CuFeO_2$ in 32 T and at 5.5 K. The spectrum is integrated over 1 ms in the TOF spectrum at each pixel. In the time average, the field value changes as small as 3.5 % and this variation is negligible in most of the experiments. The detector is the PSD arrays and the each array consists of 16 half-inch PSD. The distance between the PSD and the sample is 1.25 m. The coverage of the PSD array is 9 degree by 28 degree and they are set in the forward and backward positions. In case of the solenoid coil, the incident beam direction is almost parallel to the magnetic field direction. In the forward direction, the scattering vector is perpendicular to the magnetic field. On the other hand, the scattering vector is parallel to the magnetic field in the backscattering arrangement. By combining those two conditions, we can separate the scattering intensities between the field parallel and the perpendicular components. It is not as perfect as that of polarized neutron beam but is still useful to construct the magnetic models. The pixel size in 0.57 and 0.46 degree in horizontal and vertical direction. The present result shows the first neutron diffraction under pulsed magnetic field in a wave-vector resolved manner. It enables us to trace the magnetic field variation of the wave vector-magnetic Bragg peak. Such measurement is useful to investigate the non-trivial magnetic structure in frustrated multi-ferroic compounds. It opens the new stage of high magnetic field neutron diffraction.

As the next step, we will conduct a realistic experiment on $MnWO_4$ in 2009B period in the better neutron beam intensity of 100 kW. The magnetic field range will be also increased up to 40 T. In conclusion, we have established the technique of neutron diffraction in pulsed magnetic fields of 35 T at J-PARC and it can be extended up to 40 T or higher without difficulty. The planed experiment for several compounds will be re-attacked in successive beam periods.