MLF Experimental Report	提出日 Date of Report 2010.4.13
課題番号 Project No. 2009B0019 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 H. 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.） BL10 実施日 Date of Experiment 2010.1.23.10:00-2010.1.26.10:00

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.

$MnWO_4$ single crystal

$CuFeO_2$ single crystal

NaCl 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: 2009A0027, we have made the first application of pulsed magnetic field up to 35 T. Considering the weak beam intensity of 20 kW, we have made a very simple measurements on single crystals such as NaCl and $CuFeO_2$ to examine the system performance. With a NaCl single crystal of 0.7 cm_3, a TOF spectrum is obtained by accumulating 134 shots over 22 hours in the pulsed magnetic field of 35 T. 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. It was the highest magnetic field for neutron diffraction.

In the 2009B, the beam intensity has been around 100 kW, which is 5 times stronger. There are two major achievements in the present run. (1) We have succeeded in the neutron diffraction up to 40 T on the standard sample of NaCl. (2)We have examined the magnetic structure of multi-ferroic compound $BiFeO_3$.

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

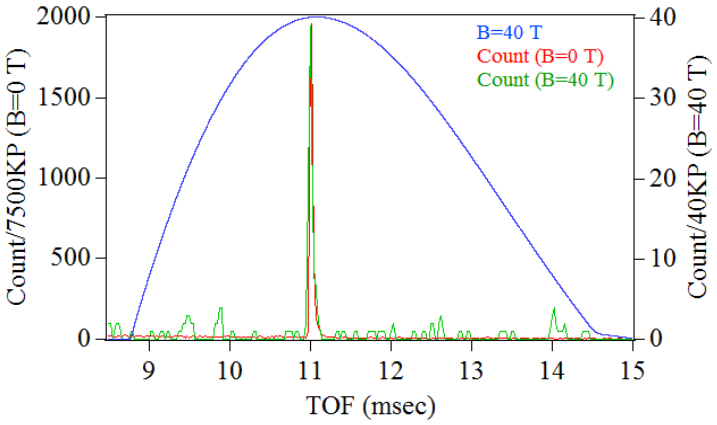

Fig. 1 Comparison of TOF spectrum in 40 T with zero field spectrum.

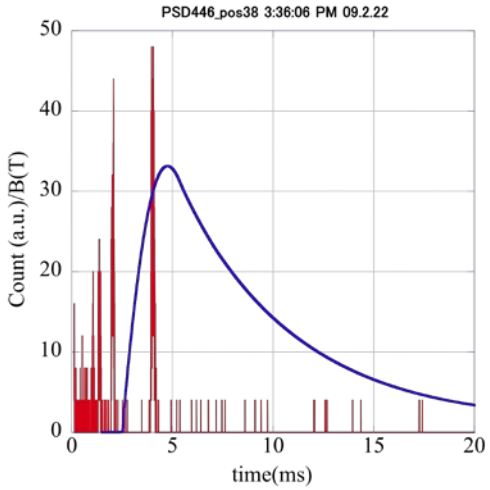

Fig. 2 Field pulse waveform for stretched mode.

The former has established the neutron diffraction in very strong magnetic field. The latter has been made as the first international proposal from J. G. Park group from Korea of our system, which indicates the uniqueness of the system. The detail of the second part is given in the separate report.

Figure 1 shows the TOF spectrum of [400] nuclear Bragg peak of NaCl single crystal as the standard. The proton beam power was 100 kW. There is no difference of TOF spectrum between 0 and 40 T. It indicates that the performance of the system is maintained even in such high magnetic fields. The number of the shots is 40 and it takes about 8 hours. The sufficient S/N ratio can be obtained in 20 shots and thus the diffraction at 40 T can be made in several hours with the beam power of 100 kW. If we scale it to 500 kW, a few shots are enough for data accumulation. It means that much detailed experiments becomes possible. It demonstrates that neutron diffraction up to 40 T has been established at J-PARC, which is very unique among neutron facilities.

Figure 2 shows the waveform of the stretched mode. In this case, the total pulse width can be as long as 20 msec. It is very useful to cover the different Brgg peak in one scan.

We have also examined other compounds such as $MnWO_4$ and $CuFeO_2$. Unfortunately, we could not get a complete result for these compounds. A serious problem is that the sample check cannot be made in advance because of the absence of the sample transport protocol from JRR3 and other neutron facilities as a radio isotope.

In conclusion, in 2009B, we have established the 40 T neutron diffraction system by using pulsed magnetic fields. The system is now ready for determination of the magnetic structure of various compounds in high magnetic fields.