TOKAI CROSS Experimental Report J-PARC	提出日 Date of Report 10/03/2013
課題番号 Project No. 2012A0148 実験課題名 Title of experiment Direct observation of entire two-triplon continuum in spin-ladder system BiCu2PO6. 実験責任者名 Name of principal investigator Masaki Fujita 所属 Affiliation Institute for Materials Research, Tohoku University	装置責任者 Name of responsible person Ryoichi Kajimoto 装置名 Name of Instrument/(BL No.) 4SEASONS(BL01) 実施日時 Date and time of Experiment 06/12/2012, 10am. -12/12/2012, 9am.

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.

$BiCu_2PO_6$

$BiCu_{1.9}Cu_{0.1}PO_6$

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.

To study the overall spin excitation spectrum $BiCu_2PO_6$, in which S=1/2 quantum spins from Cu^{2+} ions form two-leg spin-ladder, we performed the first high-energy neutron scattering measurement at 4SEASONS. As shown in Fig. 1, the magnetic excitations were successfully observed in a wide momentum and energy spaces. The excitation along the crystallographic b-axis shows clear dispersion with the energy band between 1 meV and 28 meV, while that along c-axis and a-axis (not shown) is non-dispersive. Therefore, the spin correlation is of one-dimensional, consistent with the result for antiferromagnetic two-leg spin-ladder model. Importantly, spin-gap opens at the incommensurate (0, 1±0.45, 0.75) momentum position long the leg direction. This result suggests the existence of large next nearest neighbor interaction, namely the spin frustration along the leg. Thus, the $BiCu_2PO_6$ system was confirmed to be a frustrated spin-ladder system, which gives unique opportunity to study the novel nature of the quantum spin system.

We, furthermore, investigated the temperature dependence of entire spin excitation to characterize the

thermal evolution of spin correlation in this frustrated spin-ladder system. We peaks at 15 meV and 28 meV orrespond to the maximum energies of two different branches. The intensity at 28 meV decreases with increasing the temperature and the peak disappears around 70 K. This temperature is consistent with the temperature where the magnetic susceptibility shows a peak. Therefore, the thermal evolution of magnetic branch extending 28 meV closely correlates with the change of magnetic ground state, and the degradation of spin-singlet formation at high temperature.

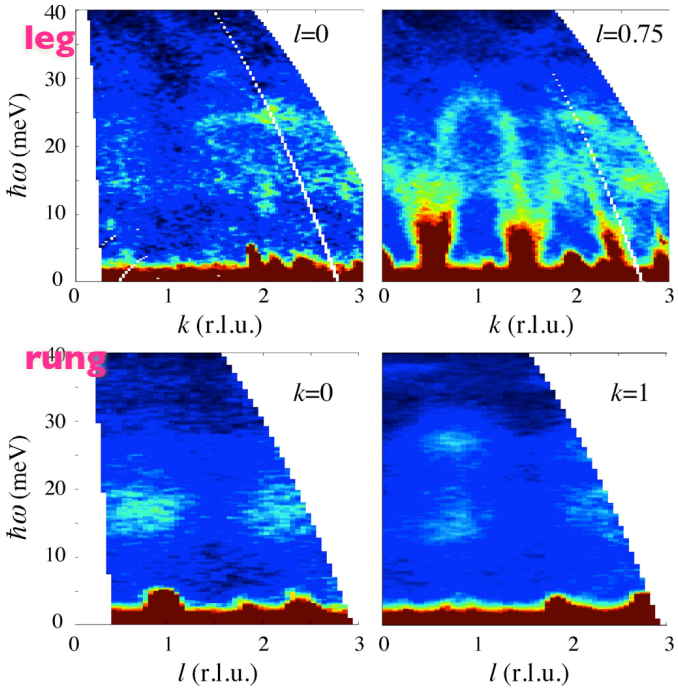

Fig. 1. The excitation spectrum in $BiCu_2PO_6$ along the leg-direction at l=0 (upper left figure) and l=0.75 (upper right figure), and along the rung-direction at k =0 (lower left figure) and k=1 (lower right figure). Clear dispersion was observed along b-direction with the maximum energy of ~28 meV. The minimum energy of ~1 meV was observed at (0, 1±0.45, 0.75) incommensurate position, suggesting the existence of frustration between the antiferromagnetic nearest and next-nearest neighbor interactions.

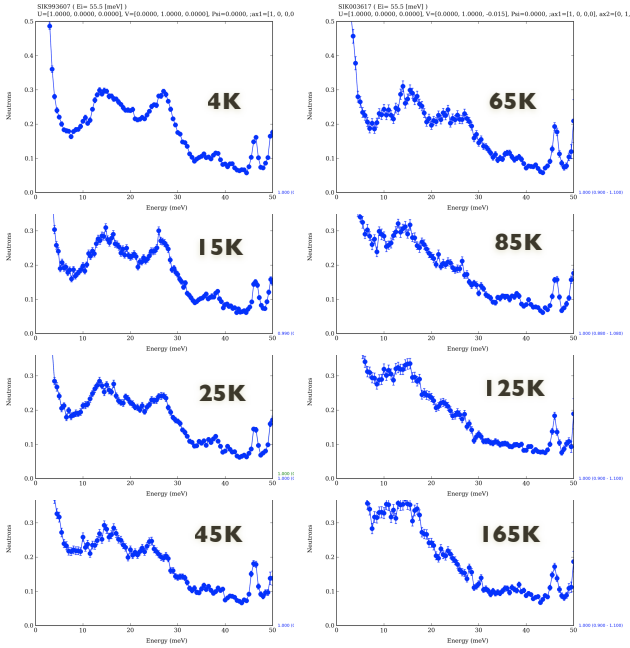

Fig. 2. The temperature dependence of constant momentum spectrum at (0, 1, 0.75) in $BiCu_2PO_6$. Peaks at 15 meV and 28 meV correspond to the maximum energy of two different magnetic branches. The peaks at higher energy degrades the intensity with increasing the temperature and disappears above ~70 K, suggesting the close relation with the deformation of spin-singlet against the temperature.