Delafossite compound CuFeO$_2$ is one of the model materials of triangular lattice antiferromagnet (TLA), and its magnetic properties were extensively investigated in the last fifteen years. Recent studies on the diluted system CuFe$_{1-x}$Al$_x$O$_2$ ($x<0.050$) revealed that various magnetically ordered phases are induced in the low-Al$^{3+}$-concentration region, owing to partial release of spin frustration.[1] In contrast, in the high Al$^{3+}$-concentration region of $x>0.040$, only the oblique-partially-disordered (OPD) state, whose local spin structure is a sinusoidally amplitude-modulated structure with incommensurate wave number, shows up, and the local magnetic structure does not changes depending on the amount of nonmagnetic impurity.[2] However, our preliminary neutron diffraction measurements revealed that the width of the diffraction profile broadens with increasing Al$^{3+}$ concentration. We thus investigate how the spin correlation in CuFe$_{1-x}$Al$_x$O$_2$ is modified depending on amount of nonmagnetic impurity, by high-Q resolution neutron diffraction measurements.

In present experiments, we performed neutron diffraction measurements using the single-crystal CuFe$_{1-x}$Al$_x$O$_2$(x=0.10) at the triple-axis spectrometer HQR(T1-1) installed at JRR-3M. The incident neutron wavelength is 2.44Å and collimation open-‘40-‘40-‘60 was employed. We firstly obtained the diffraction profiles of (qOPD,qOPD,1.5) and (qOPD,qOPD,4.5) magnetic reflections with qOPD≠0.19 along six directions illustrated in Fig.1 (e). Next, we numerically calculated the diffraction profiles for these directions by convoluting a functional form of $S(q)$, and found that the scattering function of the magnetic reflection is described as the sum of a Lorentzian term and a Lorentzian-squared term with anisotropic widths. The Lorentzian-squared term dominating at low temperature is indicative of the domain state in the prototypical random-field Ising model. Taking account of the magnetic structure in OPD phase, we conclude that the effective random field arises even at zero-field, owing to the combination of site-random magnetic vacancies and the sinusoidal magnetic structure. The details of the present study will be seen in the coming paper.[3]

Fig. 1. (a)-(d) Scattering profiles at $T=2K$. The dotted, dashed and solid lines depict the profiles calculated with Lorentzian-(LRZ), Lorentzian-squared-(LSQ) and LSQ+LRZ-type of $S(q)$, respectively. (e) scan directions corresponding to (a)-(d)