（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。 ）

| # MLF Experimental Report | 提出日 Date of Report<br>4 Oct. 2016 |
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| 課題番号 Project No.: 2015A0173<br>実験課題名 Title of experiment: Novel high-energy spin excitation at sub-eV region in electron-doped high-Tc cuprate<br>実験責任者名 Name of principal investigator: Fujita Masaki<br>所属 Affiliation: Institute for Materials Research, Tohoku University | 装置責任者 Name of Instrument scientist<br>Shinichi Itoh<br>装置名 Name of Instrument/（BL No.）<br>HRC BL. 12<br>実施日 Date of Experiment<br>2015/6/15 – 2016/6/25 |

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.

As grown $Pr_{1.4-x}La_{0.6}Ce_xCuO_4$ ($x$ = 0.12)

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.

Experimental method : Inelastic neutron scattering
Measured temperature : 6 K
Incident neutron energies : 457, 122 and 24 meV

We performed inelastic neutron scattering measurements on as-grown $Pr_{1.4-x}La_{0.6}Ce_xCuO_{4+\delta}$ ($x$ = 0.12) in order to clarify the electron-doping effect on the spin excitation in cuprate oxide. It is reported that the dispersion of high-energy spin excitation is robust against the hole-doping. However, our recent resonant inelastic X-ray scattering and inelastic neutron scattering (INS) measurements on the electron-doped system revealed an evidence of elongation of excitation spectrum along the energy direction, suggesting the electron-hole symmetry in the spin correlation [1]. Therefore, the detailed study of high-energy spin excitation in the electron-doped compound by INS is required.

Figure 1 (a - c) shows the observed spectrum sliced at (a) 220 meV, (b) 60 meV and (c) 4 meV, respectively. We successfully observed the spin excitation spectrum up to 300 meV. The sharp peak centered at the antiferromagnetic zone center (0.5, 0.5) can be seen in the low energy region,

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

and the peak broadens with increasing energy transfer, which is consistent with the outwardly dispersive spin-wave excitation with the strong dumping. We analyzed the constant-energy spectra with assuming single Gaussian and evaluated the peak-width as a function of energy transfer. Figure 2 shows the spin excitation spectrum and the evaluated peak-width in the full-with at the half-maximum is over-plotted by the horizontal bars. The peak-positions reported for the annealed sample with comparable Ce concentration is also plotted by circles [2]. In the present study, we clarified the existence of high-energy excitation and the zone boundary energy exceeds 300 meV. This result indicates that the spin excitation is indeed shift to high energy upon electron-doping. The overall shape of excitation in as-grown and annealed systems is almost same in the measured energy region suggest that the spectral shape is weakly affected by oxygen reduction, while the superconductivity emerges after annealing. The evaluation of absolute value of dynamical susceptibility is important to understand the relationship between magnetism and superconductivity in this system.

[1] K. Ishii *et al*., Nature. Communication. **5**, 3714 (2015).
[2] S. D. Wilson *et al*., Phys. Rev. Lett. **96**, 157001 (2006)

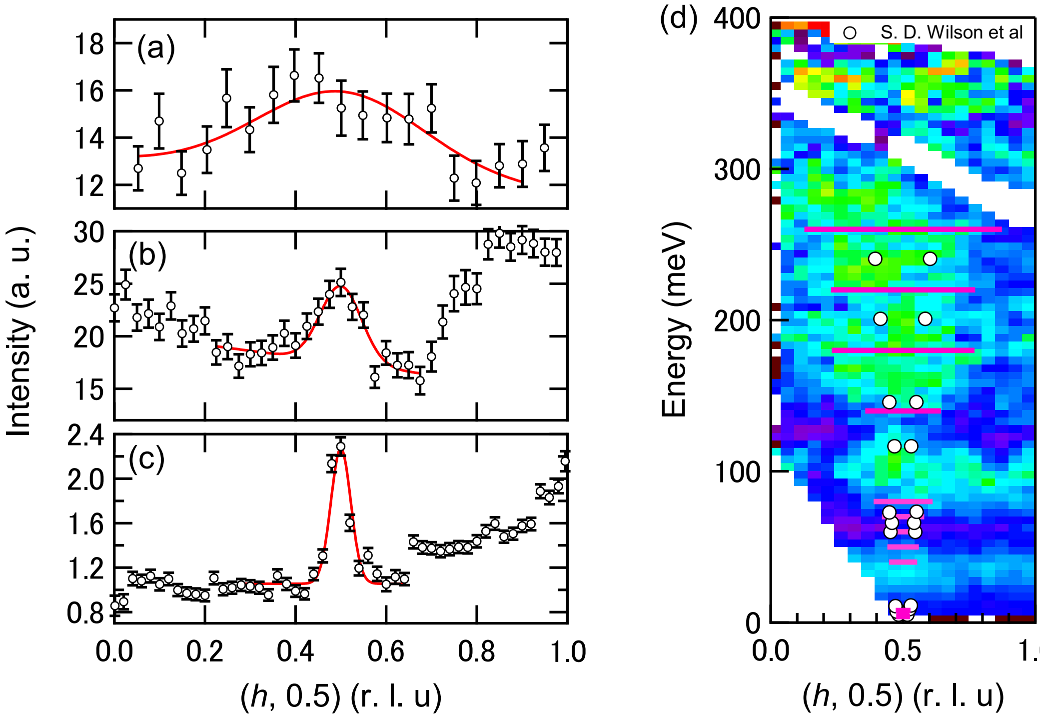


Fig 1 Spin excitation spectrum measured at 6 K and at (a) 220 meV, (b) 60 meV and (c) 4 meV. Red lines are the result of fitting with assuming single Gaussian and slope background. In the right figure, the horizontal bars indicate the peak-width (FWHM) evaluated from the analysis. The with circles are the peak-positions reported for the annealed $Pr_{1-x}LaCe_xCuO_4$ ($x$ = 0.12) [2].