Study of neutron-unbound states of ^{19}C at SAMURAI

J.W. Hwang,[*1,*2] Y. Satou,[*1] S. Kim,[*1,*2] N. A. Orr,[*3] T. Nakamura,[*4,*2] Y. Kondo,[*4,*2] N. L. Achouri,[*3] T. Aumann,[*5] H. Baba,[*2] F. Delaunay,[*3] P. Doornenbal,[*2] N. Fukuda,[*2] J. Gibelin,[*3] N. Inabe,[*2] T. Isobe,[*2] D. Kameda,[*2] D. Kanno,[*4,*2] N. Kobayashi,[*4,*2] T. Kobayashi,[*6,*2] T. Kubo,[*2] S. Leblond,[*3] J. Lee,[*2] F. M. Marques,[*3] R. Minakata,[*4,*2] T. Motobayashi,[*2] D. Murai,[*7] T. Murakami,[*8] K. Muto,[*6] N. Nakatsuka,[*8] T. Nakashima,[*4,*2] A. Navin,[*9] S. Nishi,[*4,*2] S. Ogoshi,[*4,*2] H. Otsu,[*2] H. Sato,[*2] Y. Shimizu,[*2] H. Suzuki,[*2] K. Takahashi,[*6] H. Takeda,[*2] S. Takeuchi,[*2] R. Tanaka,[*4,*2] Y. Togano,[*10,*13] A. G. Tuff,[*11] M. Vandebrouck,[*12] and K. Yoneda[*2]

The neutron-unbound region of the nuclear level structure has been investigated extensively in recent years, especially for nuclei near the neutron drip line. In this report, we provide the result of the experiment to study neutron-unbound states in ^{19}C by usin a one-neutron knockout reaction. The report contains the outcome of the succeeding research following the report in the previous year.[1)]

The experiment was performed at the RIBF facility. A ^{20}C secondary beam at 280 MeV/nucleon separated by BigRIPS impinged on a 1.8 g/cm^2-thick carbon target. Neutron-unbound states of ^{19}C produced by one-neutron knockout decays into a ^{18}C ion and a neutron. ^{18}C was identified and its momentum was measured using the SAMURAI spectrometer[2)] with the help of its experimental appratus. Arrays of plastic scintillators for neutron detection (NEBULA) were used to measure the momenta of decay neutrons.[3)] The experimental setup is identical to that of Ref.[4)].

A preliminary relative energy spectrum for the system of $^{18}\mathrm{C}+n$ is shown in Fig. 1 with the result of fitting analysis. Acceptance was corrected for considering the effect of the geometry of the detector system, which was estimated using a Monte-Carlo simulation. Error bars are statistical ones. Briet-Wigner shape functions were used as response functions generated using a simulation code taking the detector resolution into account. The background consists of a Boltzmann-type distribution for non-resonant continuum and a distribution for uncorrelated $^{18}\mathrm{C}+n$ pairs reconstructed using the event mixing technique. A different scale from 0.5 MeV is taken in the y-axis be-

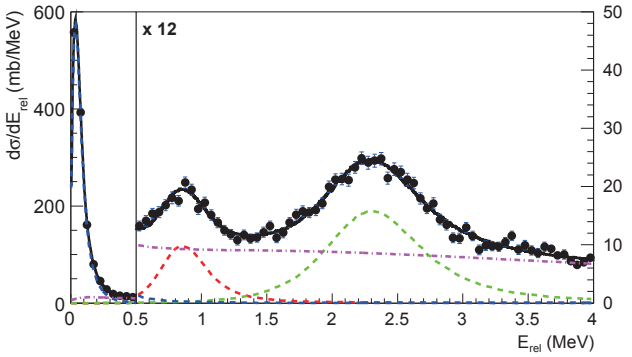

Fig. 1. Preliminary relative energy spectrum for the system of $^{18}\mathrm{C}+n$ (filled circles). The black solid line is the result of the fit; the dashed lines are for the two resonances; the dot-dashed line is the assumed background. (see details in the text)

cause of the significant threshold resonance. Three resonances were observed at $E_{\mathrm{rel}} = 36\pm1$ keV, 0.84 ± 0.02 MeV and 2.33 ± 0.01 MeV, corresponding to the states of $E_x = 0.62(9)$ MeV, 1.42(9) MeV, and 2.91(9) MeV, respectively, based on the formula: $E_x = E_{\mathrm{rel}} + S_n$, where S_n is the one-neutron separation energy of ^{19}C (0.58(9) MeV[5)]). Note that all values are preliminary. While the first and second resonances are consistent with the $5/2^+_1$ and $5/2^+_2$ states reported by the knockout experiment[6)] and the inelastic scattering measurement[7)], respectively, the third one was observed for the first time in the present study. A next step of analysis is planned to obtain the parallel momentum distribution of the knockout residue to investigate spins and parities of the observed states.

*1 Department of Physics and Astronomy, Seoul National University
*2 RIKEN Nishina Center
*3 LPC-Caen, ENSICAEN, Université de Caen, CNRS/IN2P3
*4 Department of Physics, Tokyo Institute of Technology
*5 Institut für Kernphysik, Technische Universität Darmstadt
*6 Department of Physics, Tohoku University
*7 Department of Physics, Rikkyo University
*8 Department of Physics, Kyoto University
*9 GANIL, CEA/DSM-CNRS/IN2P3
*10 ExtreMe Matter Institute (EMMI) and Research Division, GSI
*11 Department of Physics, University of York
*12 Institut de Physique Nucléaire, Université Paris-Sud, IN2P3-CNRS
*13 Present address:Department of Physics, Tokyo Institute of Technology

References

1) J. W. Hwang et al.: RIKEN Accel. Prog. Rep. **47**, xix (2014).
2) T. Kobayashi et al.: Nucl. Instr. Meth. B **317**, 294 (2013).
3) Y. Kondo et al.: RIKEN Accel. Prog. Rep. **45**, 131 (2012).
4) Y. Kondo et al.: RIKEN Accel. Prog. Rep. **46**, 6 (2013).
5) M. Wang et al: Chin. Phys. C **36**, 1603 (2012).
6) M. Thoennessen et al.: Nucl. Phys. A **912**, 1 (2013).
7) Y. Satou et al.: Phys. Lett. B **660**, 320 (2008)