Isomer identification under high-rate-counting environment

S. Terashima,[*1,*2] J. Zenihiro,[*1] S. Ota,[*3] A. Bracco,[*4,*5] F. Camera,[*4,*5] S. Chebotaryov,[*1] M. Dozono,[*3] T. Harada,[*6] C. Iwamoto,[*3] K. Kawata,[*3] N. Kitamura,[*3] M. Kobayashi,[*3] A. Krasznahorkay,[*8] S. Leblond,[*8] T. Lokotko,[*8] Y. Maeda,[*9] S. Masuoka,[*3] Y. Matsuda,[*10] M. Matsushita,[*3] S. Michimasa,[*3] E. Milman,[*1] T. Murakami,[*1,*11] H. Nasu,[*10] J. Okamoto,[*10] H. Sakaguchi,[*12] S. Sakaguchi,[*13] M. Takaki,[*3] K. Taniue,[*9] H. Tokieda,[*3] M. Tsumura,[*11] T. Uesaka,[*1] O. Wieland,[*5] Z.H. Yang,[*1] Y. Yamaguchi,[*3] and R. Yokoyama[*3]

RIBF can provide a new opportunity to study small-cross-section measurement with a highly intense secondary beam. In spring 2016, a series of experiments RIBF113 and RIBF79 with a ^{132}Sn secondary beam was performed with a new technique called the TOF-Bρ-Bρ method[1]. Full identification of atomic number Z and mass over charge A/Q can be achieved by a combination of time-of-flight(TOF) between F3 and F7 and magnetic rigidity(Bρ) by tracking detectors before and after the degrader at F5, even under an extremely high counting rate of approximately 200 kHz at F7. In RIBF79, the μs isomer ^{132}Sn(8$^+$) identification was also investigated. The existence of the isomer in ^{132}Sn forms a potential background for the study of density distribution by proton elastic scattering. The isomer ratio of ^{132}Sn in U-fission products had already been measured at RIKEN several years ago to be of the order of 3%[2].

Four large-volume LaBr(Ce) detectors called Hector$^+$ which was developed by INFN-Milano[3], were installed around the plastic stopper where all ejectiles from the secondary hydrogen target were stopped. The distance between the stopper to the detector surface is about 10 cm. Signals from the PMT output of the Hector$^+$ were connected to a flash-ADC SIS3350(FADC). The total time window was approximately 8 μs with 2048 samplings with 250-MHz frequency used for analysis, which is sufficiently long for our isomer of interest ^{132}Sn(8$^+$), the half life of which is 2.04 μs. The DAQ for FADC was operated separately with a common trigger from the main system. The typical trigger rate and dead time were 100 Hz and 1.5 ms, respectively. Separately obtained data are merged with the time-stamp information of the LUPO module[4]. The single rate of one Hector$^+$ was typically 50 kHz for a beam condition with a total intensity of 200 kHz. The purity of ^{132}Sn was approximately 30%.

*1 RIKEN Nishina Center
*2 School of Physics and Nuclear Energy Engineering, Beihang University
*3 Center for Nuclear Study, University of Tokyo
*4 Dipartimento di Fiscia dell Universit degli Studi di Milano
*5 Istituto Nazionale di Fisica Nucleare Serione di Milano
*6 Department of Physics, Toho University
*7 MTA ATOMKI, Debrecen
*8 Department of Physics, University of Hong Kong
*9 Department of Applied Physics, University of Miyazaki
*10 CYRIC, Tohoku University
*11 Department of Physics, Kyoto University
*12 RCNP, Osaka University
*13 Department of Physics, Kyushu University

Figure 1 shows a typical waveform of the FADC. An FFT filter is applied to eliminate high-frequency components in the waveform. We can identify each sequential γ-ray correctly, even under a high single rate. Figure 2 shows an example plot of time-energy correlation of one Hector$^+$ gated by ^{132}Sn with the TOF-Bρ-Bρ method as shown in the right panel of Fig. 2. Delayed sequential γ-decays of 133/299/374 keV from ^{132}Sn(8$^+$), which are indicated by red arrows, are observed weakly following prompt timings within a huge background. Further analysis combined with proton scattering is in progress.

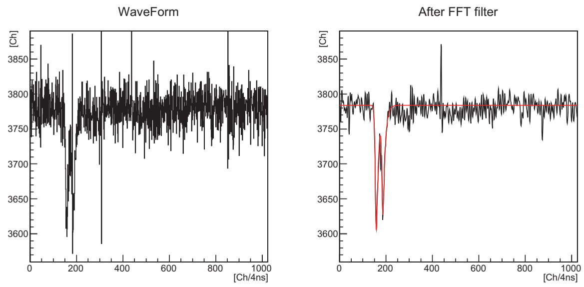

Fig. 1. Sample of raw waveform(left) and after FFT filter(right) with fitting in Hector$^+$ for a sequential event with an energy of approximately 100 keV with 200-ns time difference.

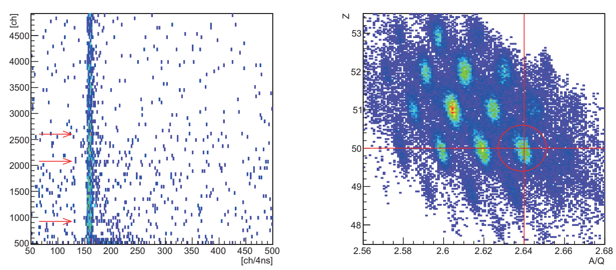

Fig. 2. Time-energy correlation in FADC(left) with ^{132}Sn gate by TOF-Bρ-Bρ method(right). Arrows indicate the expected γ-decay line from ^{132}Sn(8$^+$).

References

1) S. Ota et al. RIKEN Accel. Prog. Rep. **49**, 15 (2015).
2) D. Kameda et al. RIKEN Accel. Prog. Rep. **43**, 1 (2010).
3) A. Gias et al. Nucl.Instr. Meth. A **729**, 910 (2013).
4) H. Baba et al. Nucl.Instr. Meth. A **777**, 75 (2015).