Development of a slowed-down beam of ^{82}Ge at RIBF

T. Sumikama,[*1] D. S. Ahn,[*1] N. Fukuda,[*1] N. Inabe,[*1] T. Kubo,[*1] Y. Shimizu,[*1] H. Suzuki,[*1] H. Takeda,[*1] N. Aoi,[*2] D. Beaumel,[*3] K. Hasegawa,[*4] E. Ideguchi,[*2] N. Imai,[*5] T. Kobayashi,[*4] M. Matsushita,[*5] S. Michimasa,[*5] H. Otsu,[*1] S. Shimoura,[*5] and T. Teranishi[*6]

RI beams with around 15 MeV/u are necessary for the study of the nuclear shell structure using the nucleon transfer reaction. The RI-beam energy at RIBF is typically 250 MeV/u after the first stage of the BigRIPS[1]. The RI beam is slowed down using energy degraders. However, the control of the energy spread and the beam size becomes difficult due to the increase in the beam emittance after the use of energy degraders. Two methods were proposed to efficiently produce a slowed-down beam at RIBF. One is the slowed-down method with the momentum-compression scheme[2], and the second method is the use of an RF deflector, called OEDO (Optimized Energy Degrading Optics for RI beams).[3] This paper reports on the first test experiment to produce a slowed-down beam of ^{82}Ge with the energy of 13 MeV/u using the momentum-compression scheme.

The RI beam of ^{82}Ge was produced by the projectile fragmentation of the ^{238}U beam with the energy of 345 MeV/u. The primary target of beryllium with a thickness of 7 mm was used. A wedge degrader was placed at the momentum-dispersive focus F1 to purify the RI beam, as shown in Fig. 1. The thickness for the central trajectory was 5 mm. A second wedge-shaped degrader with a thickness of 2.0 mm was placed at the momentum-dispersive focus F5. The wedge angle was designed to compress the momentum spread. The ion-optics mode obtained after using this degrader was changed to achieve the momentum achromat. The momentum spread of 6% was compressed to 3%, as shown in Fig. 2. Three energy degraders were also placed at the achromatic foci, F2, F3, and F7. The energy after beam-line detectors at F8 was measured by using the time of flight between F8 and F9, as shown in Fig. 3. The ^{82}Ge beam with the energy of 13 MeV/u at the central trajectory was successfully produced. The transmission efficiency from F2 to F8 was 2%. There was a reduction of 1/10 mainly due to out of focus at F7.

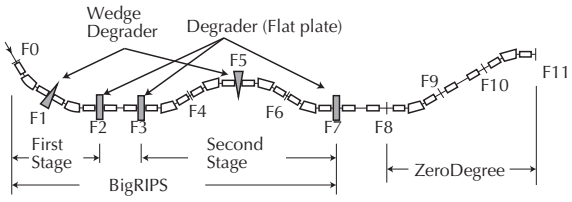

Fig. 1. Schematic view of the combination of degraders in the BigRIPS and ZeroDegree separators. The wedge-shaped degrader was placed at the momentum dispersive foci, F1 and F5, of BigRIPS.

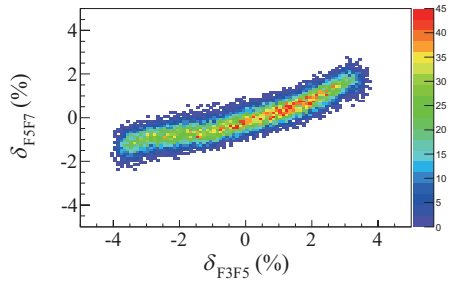

Fig. 2. Results of the momentum compression at the second stage of BigRIPS. δ_{F3F5} and δ_{F5F7} are $(p-p_0)/p_0$ before and after using the momentum-compressive degrader, where p is the momentum and p_0 is the momentum at the central trajectory.

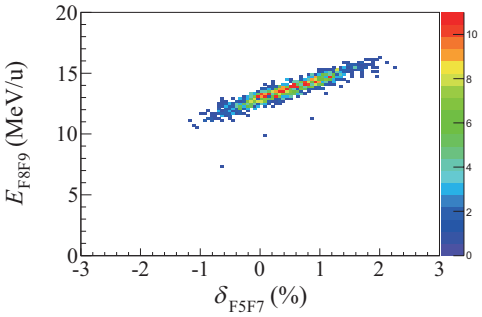

Fig. 3. Energy after all beam-line detectors at F8 as a function of δ_{57}. The particle with $-0.6 < \delta_{57} < 1.5\%$ was transported to the ZeroDegree spectrometer.

*1 RIKEN Nishina Center
*2 RCNP, Osaka University
*3 INPO, CNRS/IN2PS
*4 Department of Physics, Tohoku University
*5 CNS, University of Tokyo
*6 Department of Physics, Kyushu University

References

1) T. Kubo et al.: Prog. Theor. Exp. Phys. (2012) 03C003.
2) T. Sumikama et al.: Energy focusing and RI-beam purification using two energy degraders at fragment separator BigRIPS, RNB8 conference, Grand Rapids, Michigan, May 26 − 30, 2009.
3) M. Matsushita et al.: New energy-degrading scheme for low-energy reaction measurements of rare isotope beams, EMIS conference, Grand Rapids, Michigan, May 11 − 15, 2015.