Simulation study of a new energy-degrading beamline, OEDO

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The OEDO (**O**ptimized **E**nergy **D**egrading **O**ptics for RI beam) beamline is one of the solutions to degrade intense RI beams provided in RIBF, which will make possible further research on exotic nuclei/states by using the transfer reaction in the energy region around a few tens MeV, fusion reaction in around a few MeV and others [1]. The application of a material energy degrader is a general method to degrade a fast beam, while it induces momentum- and angular aberrations that lead to broadenings of beam spot[2]. The OEDO beamline employed an RF electric beam deflector (RF deflector) to cancel the aberrations based on the time structure of the secondary beams[3]. Simulation of this beamline has been performed for optimization and feasibility studies.

In the simulation, beam transportations by magnetic devices were reconstructed by beam transfer matrix obtained in COSY infinity[4], while interactions with materials and electric fields were simulated by the code based on GEANT4[5]. Conditions of the simulation are schematically shown in Figure 1, where a neutron-rich nucleus ^{132}Sn and neutron-deficient nucleus ^{56}Ni were used as typical examples. Initial momentum and angular distributions were generated by using the LISE++ code[6] to estimate the production via a projectile-fission reaction of the ^{238}U primary beam and a projectile-fragmentation reaction of the ^{124}Xe primary beam for ^{132}Sn and ^{56}Ni, respectively. Secondary beams separated by BigRIPS[7] were transported to OEDO beamline with energies of 250 MeV/u and 210 MeV/u ($\Delta P/P = \pm 3\%$) for ^{132}Sn and ^{56}Ni, respectively. Secondary beams were degraded to 50 MeV/u by a mono-energetic degrader located at FE8 focus, and transported to the RF deflector with point-to-parallel optics to convert from position to angular dispersion. In order to make beams focused at FE9, the RF deflector compensates the angular aberrations by its dynamic electric field oscillating with a cyclotron resonance frequency. If an additional deceleration is required, another energy degrader is employed at FE9.

The OEDO beamline consisting of the RF deflector works as a separator using a velocity filter. Timing differences from the focusing phase of the RF deflector are transformed to position differences at FE9. As shown in Figure 2, a clear separation obtained for Ni isotopes indicates large enough differences in time-of-flight (TOF) caused by the velocity differences. In the case of ^{132}Sn, on the other hand, it cannot be obtained due to insufficient TOF differences and bending power of the RF deflector against a particle with large A/Q ratio. Development of an alternative transport is on going, which consciously enhances the capability of beam purification for neutron-rich nuclei in medium/heavy mass region, such as ^{132}Sn.

This work was funded by ImPACT Program of Council for Science, Technology and Innovation (Cabinet Office, Government of Japan).

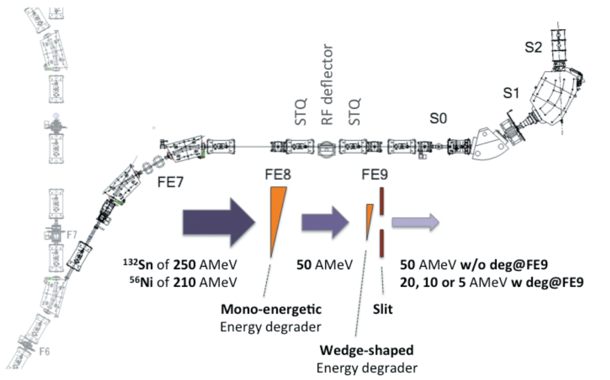

Fig. 1. Simulation condition and a scheme of two-staged energy deceleration in OEDO.

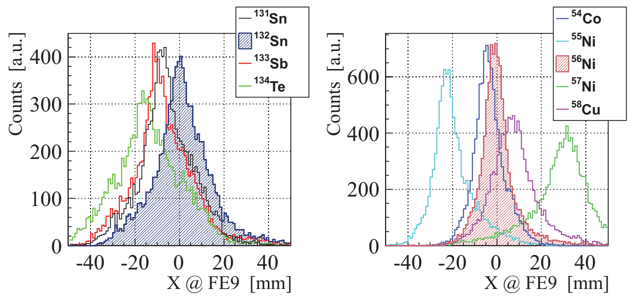

Fig. 2. Position distribution at FE9 obtained for ^{132}Sn (^{56}Ni) and contaminants are shown in left (right) panel.

References
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