Angle-tunable degrader system for OEDO

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An angle-tunable degrader system was developed for the OEDO beamline,[1)] which slows down a beam separated by BigRIPS[2)] to produce a beam of 10–50 MeV/nucleon. This system is used as a monoenergetic degrader to reduce the beam energy and its spread. Since the system was designed to adjust its wedge angle and thickness, it has high versatility to deal with various experimental conditions. In this report, we present the structure and experimental verification of the system.

The degrader part consists of a pair of Al sheets with quadratic cross sections, and their quadratic coefficients for thickness differ only in their signs. Their overlap, therefore, functions as the wedge degrader, and the wedge angle is changed according to their relative position. The thickness can be also adjusted by introducing an additional plate. The overall system was constructed as shown in Fig. 1, which has a fixed central thickness of 3 mm and a wedge angle from 0 mrad to 40 mrad. The effective area is $\pm$ 30 mm(H) $\times$ $\pm$ 50 mm(V). The averages of thickness deviations from the machining precision for each Al sheet are 33 and 58 μm, respectively. The uncertainty of the angle originating from these deviations is 2 mrad.

The commissioning experiment of this system was carried out at the OEDO beamline.[1)] ^{79}Se of 171 MeV/nucleon, separated by BigRIPS,[2)] was delivered to the degrader system installed at the dispersive FE9 focus. The central thickness of the system was set to 6 mm to slow down the beam to about 40 MeV/nucleon.

The spread of the outgoing energy distribution for the monoenergetic-beam case with an optimized wedge angle was compared with that for the case using the homogeneous degrader, where the wedge angle is 0 mrad, to evaluate the performance of the degrader system. As shown in Fig. 2, while the energy spread in the homogeneous case was measured to be 12.6 MeV/nucleon in full width at half maximum, the spread was reduced to 5.4 MeV/nucleon in the case of the optimized monoenergetic degrader, which is consistent with the estimation by a simulation.

In summary, we developed an angle-tunable degrader system for the OEDO beamline for a low-energy RI beam. The performance of the system was experimentally verified using ^{79}Se beam at 171 MeV/nucleon, and we successfully obtained a low-energy beam at 42 $\pm$ 2.7 MeV/nucleon with the suppressed spread. We expect that this system can be used for various purposes and conditions thanks to its flexible wedge angle.

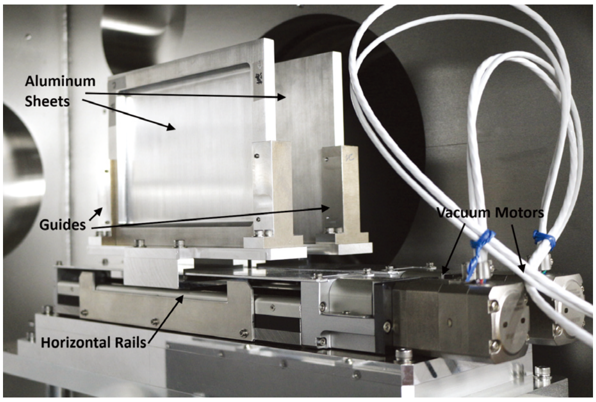

Fig. 1. Picture of the angle-tunable degrader system.

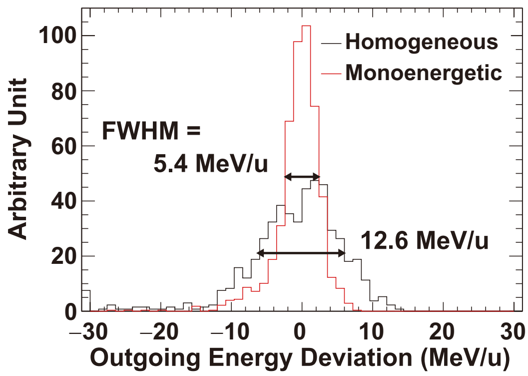

Fig. 2. Distributions of the outgoing energy deviation using a homogeneous degrader (black) and an optimized monoenergetic degrader (red). All the distributions were normalized to have the same number of events.

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