Angle-tunable wedge degrader for an energy-degrading RI beamline†

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The Optimized Energy-Degrading Optics (OEDO) beamline[1] was established at RIBF to produce 10–50-MeV/nucleon beams by slowing down secondary beams from the BigRIPS separator. This beamline can extend the energy range of RI beams that can be produced in RIBF to optimize nuclear reactions such as nucleon transfer and Coulomb excitation.

The angle-tunable degrader, one of the key elements in the OEDO beamline, is a monoenergetic degrader that reduces the beam energy and spread of a beam. It consists of two Al sheets with a quadratic cross section, the quadratic coefficients of which have opposite signs. While its central thickness is fixed at 3 mm, the wedge angle varies from 0 to 40 mrad according to the relative positions of the two sheets. The effective area is ±30 mm (H) × ±50 mm (V), which is wide enough for the typical beam width, ±20 mm. The average thickness deviations for sheets 1 and 2 are 33 and 58 μm, respectively. The total central thickness can be increased by introducing an additional Al flat degrader immediately behind our system.

Figure 1 shows the whole system. For parallel and separate movement of the sheets, the system includes guides for the sheets, two parallel rails, and two linear stepper motors. Each motor drives each Al sheet along the corresponding rail. Because the motors operate independently by remote control, we can optimize the wedge angle using real-time data.

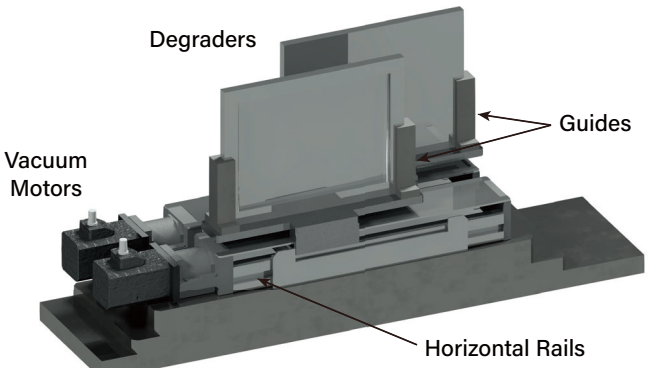

Fig. 1. 3D design of the angle-tunable degrader system.

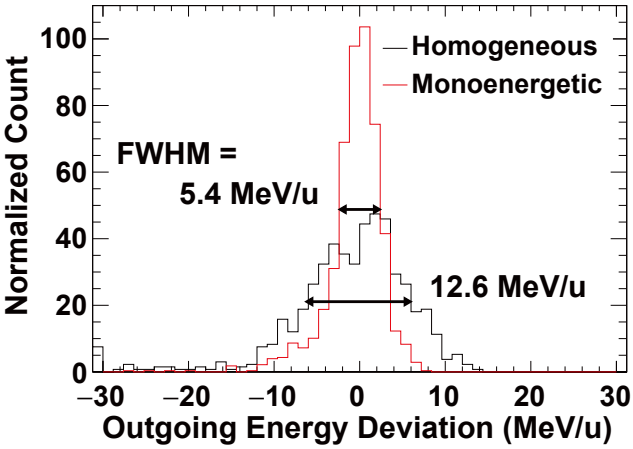

Fig. 2. Distributions of the outgoing energy spread using a homogeneous and monoenergetic degrader. All distributions were normalized to have the same number of events.

An experiment for evaluating the system performance was carried out at the OEDO beamline in RIBF. A 171-MeV/nucleon ^{79}Se beam was produced by the in-flight fission of a 345-MeV/nucleon ^{238}U beam impinged on a 5-mm-thick Be target and was transported to the OEDO beamline. The degrader system at the dispersive focus (FE9) in the OEDO beamline was optimized to obtain the 40-MeV/nucleon beam. The central thickness was set to 6 mm by placing a 3-mm-thick flat Al plate behind the system.

The performance of energy compression was evaluated by comparing the outgoing energy deviations using a monoenergetic degrader (the optimized wedge angle) to a homogeneous degrader (0 mrad setting). Figure 2 shows that the spread in the homogeneous case is 12.6 MeV/nucleon in full width at half maximum (FWHM). The monoenergetic degrader reduced the spread to 5.4 MeV/nucleon, which is similar to the estimated value of 5.2 MeV/nucleon. The performance of the system was estimated as satisfactory and its flexible wedge angle is useful to deal with many different nuclides and energies for various purposes.

Reference

1) S. Michimasa *et al.*, Prog. Theor. Exp. Phys. **2019**, 043D01 (2019).

† Condensed from the article in Prog. Theor. Exp. Phys. **2019**, 043D02 (2019), see also references therein

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