Improved transmission of OEDO

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The optimized energy degrading optics (OEDO) system[1)] was installed at RIBF in 2017. The principle aim of OEDO is to decelerate and focus medium-heavy radioactive ion beams provided by BigRIPS from approximately 200 to 15–50 MeV/nucleon. The system was commissioned in the day 0 campaign by studying transfer reactions on ^{77}Se, ^{93}Zr, and ^{107}Pd. During this, the transmission from F3 decreased from 61% at FE9 to 18% at S0, despite the effective focusing effort of the RF-Deflector (RFD) at FE10. This poor transmission was attributed to the small bore radius of the quadrupole magnet, *i.e.* QE19, located at FE11, and thus, during 2021, the OEDO beamline was reconfigured. The QE20 (STQ18) magnet was installed upstream of FE11 (FE12), and the QE19 magnet was entirely removed from the beamline. The impact to OEDO's low-energy focusing capabilities was tested in April 2022 during the machine study "MS22-1" followed by the SHARAQ18 experiment[2)] measuring ^{130}Sn$(d,p)^{131}$Sn. This report summarises the new low-energy optics of the OEDO beamline, including the improved transmission.

The ion-optical transport code COSY-Infinity (v 9.0) was used to simulate the beam transport through the updated F3–S1 beamline. The beam trajectories in X and Y planes are shown in Fig. 1. Compared with the previous beam trajectories,[1)] the new magnet setup between the RFD and S0[a)] should enable higher transmission to the secondary target. In addition, the QE20 magnet placed downstream of the RFD enables the fine tuning of the parallel beam condition, which was not possible in the previous configuration.

COSY matrix elements for the new OEDO transport were incorporated into the CNS-developed Monte Carlo simulation code. The simulation used the measured condition at F3 from MS22-1 and included beamline materials, the opening of the beam pipes, and the RFD. The simulated spot size at S0 was $X(Y) = \pm 5$ (10) mm, within the target radius of 25 mm. The estimated F3–S0 transmission was 97% till third-order aberrations.

Following optics tuning in April 2022, the measured ^{130}Sn beam spot at S0 is shown in Fig. 2. The beam was centred at $X(Y) = -2(-1)$ mm with a spot size of ± 8 (12) mm, within the CD_2 target's radius of 25 mm. The beam energy was degraded to 23.3 ± 1.1 MeV/nucleon at S0. The measured F3–S0 transmission of 85% is lower than the calculated value of 97%; however, it still improves OEDO's transmission by a factor of 4.7 over the previous condition.[1)] Following this improved transmission of low-energy beam, we performed the OEDO experiment[2)] to measure ^{130}Sn$(d,p)^{131}$Sn.

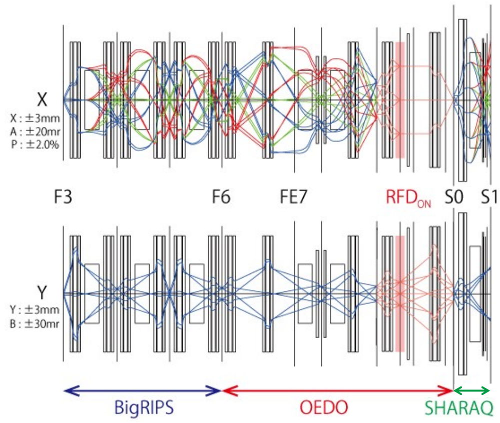

Fig. 1. COSY-calculated beam trajectories in the X and Y planes between F3 and S1 for low energy tuning in OEDO.

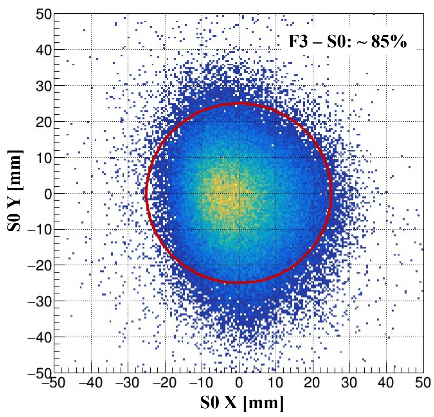

Fig. 2. ^{130}Sn Beam focus at S0. Red circle represents the CD_2 target's radius of 25 mm.

References

1) S. Michimasa *et al.*, Prog. Theor. Exp. Phys. **2019** 043D01 (2019).
2) N. Imai *et al.*, in this report.

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a) S0 focal plane = target position in the TINA silicon-detector array, as used in the ^{130}Sn experiment.