

Construction of OEDO beamline

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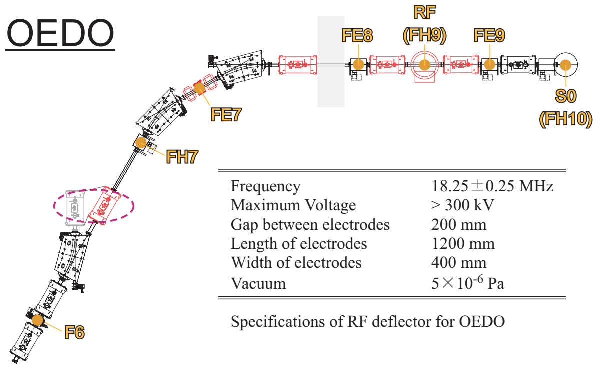
The OEDO system is a new beamline proposed for high-quality slow-down RI beams[1]. The OEDO is an abbreviation of **O**ptimized **E**nergy **D**egrading **O**ptics for RI beam. The idea behind it is to manipulate the timing degree-of-freedom in the phase space of RI beam. To obtain a high-quality beam with a small spot size and a small energy spread, the OEDO system shifts the spreads of positions and angles to the timing spread of the beam, which corresponds to the rotation of the phase space ellipse on the position- (angle-)timing plane to obtain a small position (angle) spread. Radiofrequency (RF) electric ion-optical elements can rotate a phase space ellipse of spatial and timing components, as beams from a cyclotron have an RF bunch structure.

The main components of the OEDO system are: An RF deflector[2] synchronized with the cyclotron's RF and 2 sets of triplet quadrupole (TQ) magnets to achieve point-to-parallel/parallel-to-point ion optics. The OEDO system is to be installed downstream of a momentum-dispersive focus with a reasonable dispersion. The first TQ associates the beam energy with beam angle at the RF deflector, and the second TQ makes a small achromatic focus. This dispersion condition is fulfilled in the first half of the High-Resolution (HR) beamline[3]. Therefore, the OEDO system will be implemented in the HR beamline by installing new electric/magnetic elements and rearranging the existing magnets. In FY2014, the main part of the construction budget was funded and the OEDO project was launched. We are continuously improving the design of the beamline with respects to the magnet configuration and an ion-optics.

Figure 1 shows the magnet arrangement for the OEDO beamline downstream of the F6 focal plane of the BigRIPS. The specifications of the RF deflector for the OEDO system are shown in the inset table of Fig. 1. The magnet configuration was confirmed to function as a phase-space rotator for slow-down beams by ion optics calculation. The slow-down scheme of the OEDO beamline is shown in Fig. 2. In Fig.2(a),an RI beam at 250 MeV/u is transported to FE8, where the momentum dispersion is tuned to be 1 m. A mono-energetic degrader is installed at FE8 to slow RIs down to 50 MeV/u, which corresponds to a rotation of the phase space ellipse on the plane of the beam energy (δ) and flight time (t). In Fig.2(b), the first half of the OEDO system, set to be point-to-parallel optics, rotates the phase space ellipse on the x-a plane. Then, the RF deflector reduces the timing (t) dependence of angle (a). In Fig.2(c), the second half of the OEDO system, also set to be parallel-to-point optics, rotates the phase space ellipse on the x-a plane in the reverse direction. Finally, a small beam spot and a small energy spread are achieved at the FE9 and S0 foci.



Frequency	18.25±0.25 MHz
Maximum Voltage	> 300 kV
Gap between electrodes	200 mm
Length of electrodes	1200 mm
Width of electrodes	400 mm
Vacuum	5×10^{-6} Pa

Specifications of RF deflector for OEDO

Fig. 1. Magnet configuration of the OEDO beamline

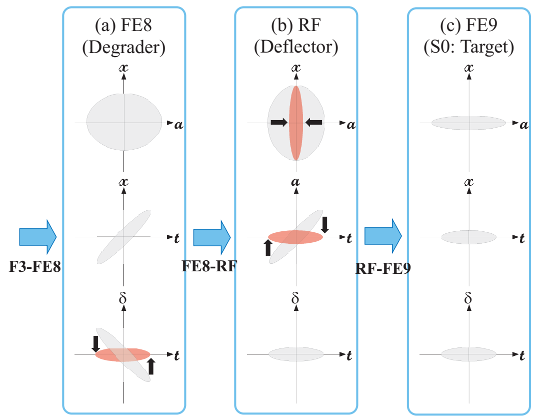


Fig. 2. Phase space rotation in OEDO beamline

Based on the result, we estimated the higher order aberrations of the OEDO beamline using a Monte-Carlo simulation[5].

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References

1) S. Shimoura *et al.*, CNS Annual Report 2013, CNS-REP-93, 56 (2015) 56.
2) K. Yamada *et al.*, Nucl. Phys. A **746**, 156c (2004).
3) S. Michimasa *et al.*, Nucl. Instrum. Meth. in Phys. Res. **B317**, 305 (2013).
4) T. Kubo *et al.*, Nucl. Instrum. Meth. in Phys. Res. **B204**, 97 (2003).
5) M. Matsushita *et al.*, In this report.

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