Online results for the injection ion optics of the Rare RI Ring

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The Rare RI Ring (R3) is a cyclotron-like storage ring designed for mass measurements of exotic nuclei far from stability at Radioactive Ion Beam Factory in RIKEN1). In order to successfully transport the nuclei of interest individually1) to the central orbit of the Rare RI Ring, we calculated the injection ion optics for the Rare RI Ring beam line, which connects the Rare RI Ring spectrometer to the BigRIPS separator. For the upstream optics from F3 to S_0, the target position of the SHARAQ spectrometer, the standard high-resolution achromatic mode is used2). The total optical matrix is calculated from S_0 to the kicker magnet position3), and two important foci, ILC1 and ILC2, are shown in Fig. 1, where 2 PPACs are placed to evaluate the matrix elements for beam tuning quantitatively.

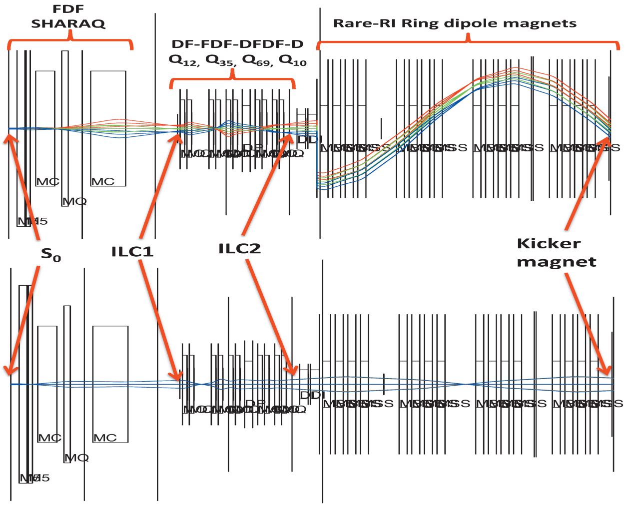

Fig. 1. Envelopes of the beam transport from SHARAQ S_0 to kicker magnet in the horizontal and vertical plane by third order calculation using *COSY INFINITY*.

During online beam tuning, we chose the configuration of the three SHARAQ quadrupoles (SQ1-3)2) and the ten quadrupoles (Q1-10) between ILC1 and ILC2 to be FDF-DF-FDF-DFDF-D (D indicts indicates "Defocus" and F indicates "Focus") configuration in the lateral direction, which is suited for the small vertical acceptance as shown in Fig. 1 (bottom) for fast tuning of the beam. To complete the fast tuning method developed for SHARAQ spectrometer2), we first design the optics of the injection line with many focus planes. Then we calculate the response functions of each quadruple magnet by *COSY INFINITY*. During beam tuning, we cancelled the momentum-dispersion effects by combining information at the dispersive focal plane. Once the matrix elements of the experimental values are evaluated, it is used for correcting the magnet setting precisely.

Table 1. Currents (C_{SQ1-3} and C_{Q1-10}) of the quadrupole magnets (SQ1-3 and Q1-10) of the injection line

Condition	Configuration	EXP. (A)	Cal. (A)
F	C_{SQ1}	33.28	33.1
D	$-C_{SQ2}$	61.20	61.0
F	C_{SQ3}	61.59	61.3
DF	$-C_{Q1}=C_{Q2}$	226.8	480.8
FDF	$C_{Q3}=-C_{Q4}=C_{Q5}$	715.4	723.8
DFDF	$-C_{Q6}=C_{Q7}=-C_{Q8}$ $=C_{Q9}$	200.9	295.7
D	$-C_{Q10}$	25.8	27.4

Table 2. Matrix elements of ILC1 and ILC2 evaluated from the experiment and calculated by *COSY INFINITY*

Matrix Element	EXP. (ILC1)	Cal. (ILC1)	EXP. (ILC2)	Cal. (ILC2)
$(x\|a)$	0.02 ± 0.007	0	0.19 ± 0.010	0.04
$(y\|b)$	5.40 ± 0.007	0	-6.66 ± 0.010	-0.07

We performed the tuning method using the designed ion-optical mode for the first commissioning run of Rare RI Ring in June 2015, for which we use the ^{78}Kr^{36+} beam with the energy of 168 MeV/nucleon. With this ion-optical mode we successfully carried out the individual injection of the Rare RI Ring, and we succeeded in storing the ^{78}Kr^{36+} ions for a few seconds.

Table 1 indicates the measured magnet current values and their corresponding calculated values via *COSY INFINITY* (the magnetic fields corresponding to the currents of the magnets here). The transfer matrix element of the two important focal planes ILC1 and ILC2 are listed in Table 2. The measured values of the matrix elements after beam tuning are consistent with the calculated values for the horizontal direction, while they differ in the vertical direction due to a misalignment in the beamline.

References
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