Design of the vertical steering magnets for Rare-RI Ring

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It is known that the beam position tends to shift along the vertical axis at the focal plane, F3, at BigRIPS. This vertical shift deteriorates the injection efficiency into Rare-RI Ring (R3), considering the vertical shift causes the deviation from the acceptance of R3. Because there are no steering magnets in the vertical direction between BigRIPS and R3, correcting this vertical shift is difficult. Thus, we started developing a pair of vertical steering magnets.

First, the upstream magnet (ST1) and downstream magnet (ST2) were assumed to be installed 2700 mm after the focal plane, FE11, at OEDO and 950 mm after the focal plane, S2, at SHARAQ due to geometrical constraints. Next, we investigated the required deflection angle with the magnetic rigidity ($B\rho$) of 6.4 Tm, which is the maximum $B\rho$ of R3 using COSY Infinity[1] and LISE++.[2] The considered vertical shift is −3 mm in position and +6.5 mrad in angle, which is a combination of the worst deviations previously observed. As a result, the required deflection angle is estimated to be approximately 2 mrad. In this simulation, the transmission efficiency from F3 to R3, which decreases due to the vertical shift, is recovered by the beam trajectory correction. And finally, we studied the location dependence of the required deflection angle within a range of a few hundred millimeters from the assumed installation location. The result indicates that the location dependence is less than 0.2 mrad, which should be covered by the magnets.

Based on the required deflection angle, we decided a typical product of magnetic flux density and pole length to be 0.0128 Tm. Additionally, the homogeneity of the magnetic field in the Y-direction should be within ±1% over a range of the beam diameter. To satisfy these requirements, the magnetic pole geometry was simulated using Opera software.[3] Consequently, ST1 was designed, as shown in Fig. 1. The simulated X-directional magnetic field of ST1 along Y-direction is shown in Fig. 2. The red arrow indicates the beam diameter in the Y-direction, and magnetic field meets the requirement. ST2 has a similar geometry and magnetic field distribution to ST1 but is a little smaller overall, considering the beam diameter at ST2 is smaller than that at ST1, resulting in a narrower gap for ST2 compared to ST1. The specifications of fabricated ST1 and ST2 are listed in Table 1. We will test the magnets soon and the improvement of the injection efficiency will be investigated using the beam.

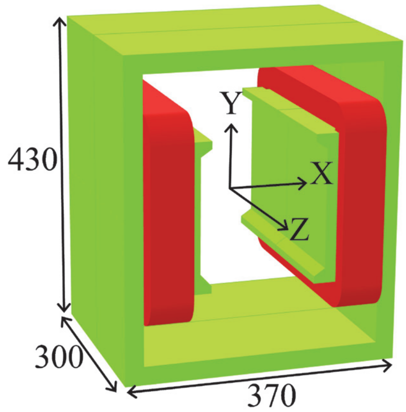

Fig. 1. Schematic view of ST1.

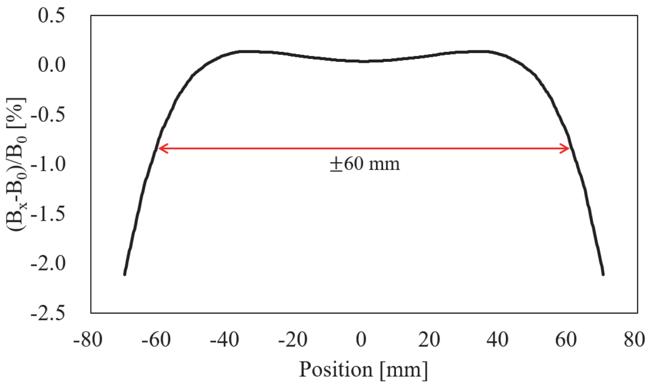

Fig. 2. Homogeneity of the X-directional magnetic field, plotted against Y-directional pole length. B_0 denotes the average within a range of ±60 mm. The red arrow shows the beam diameter.

Table 1. Specifications of ST1 and ST2. Listed magnetic fields and current are typical values.

	ST1	ST2
Magnetic flux density	0.043 T	0.051 T
Current	15 A	13 A
Size	370×430×300 mm	310×360×250 mm
Pole gap	170 mm	125 mm
Pole length	300 mm	250 mm
Weight	180 kg	110 kg

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