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Beam Optics for Typical Part of ISOL Beam Lines

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1. Introduction

KOMAC (Korea Multi-purpose Accelerator Complex) is doing a project, the detailed design of the ISOL beam lines for the heavy ion accelerator project of IBS (Institute of Basic Science) from August 2013 to February 2014. The ISOL includes a lot of important equipment such as a TIS (Target Ion Source), an MRS (Medium Resolution Separator), an RF-cooler, an HRMS (High Resolution Mass Separator), a charge breeders like ECR and EBIS, and an A/q separator as shown in Fig. 1 [1]. The heavy ion beams are transported by using the electrostatic quadrupoles and electrostatic benders between the equipment. The work-scope of the project is the beam optics design of the beam lines and the detailed design of the beam optics components, the electrostatic quadrupoles and the electrostatic bender. This work summarized the initial result of beam optics design of the beam line.

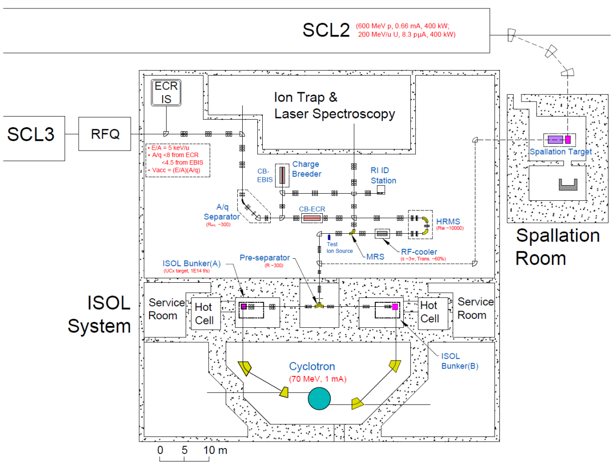


Fig. 1. Layout of the ISOL beam line.

2. Methods and Results

For beam optics simulation we used the COSY Infinity code [2] because it can include the electrostatic quadrupoles and the electrostatic bender. The bender has two options, the cylindrical and the spherical shapes.

2.1 Beam Information

The reference particle is $^{132}Sn^{+1}$ with the kinetic energy of 50 keV from TIS to charge breeders, $^{132}Sn^{+19}$ with the kinetic energy of 5 keV/u from ECR charge breeder to RFQ (Radio-Frequency Quadrupole), $^{132}Sn^{+33}$ with the kinetic energy of 5 keV/u from EBIS charge breeder to RFQ. Table I summarized the beam information at the entrance and exit parts of the important equipment which was provided by the ISOL team.

Table I: Beam information

Equipment	Beam size [±mm]	Emittance [π mm-mrad]
TIS output	3	30
RF-cooler input	3	30
RF-cooler output	1	3
HRMS input	1	3
HRMS output	1	3
ECR/EBIS input	1	3
ECR output	1	80
EBIS output	1	20

2.2 Beam Optics from TIS to MRS

We used the electrostatic triplet lattice in the beam line in order to get a symmetric beam in the horizontal and vertical directions. The effective length of the quadrupoles is 10 cm and they are separated by 5 cm gap as shown in Fig. 2. The aperture radius of quadrupoles are 5 cm. The For the beam optics study from TIS to MRS, we need the beam information at the entrance part of the bending magnet of MRS. We assumed that 2 bending magnets are used with the achromatic condition. The magnetic rigidity of the reference particle is 0.37 T-m and we used the magnetic field of 0.7T. The achromatic condition was obtained by TRACE3D [3] code as shown in Fig. 3. The voltage values at pole tips are -3.18 kV for outer quadrupoles and 5.94 kV for the middle quadrupole.

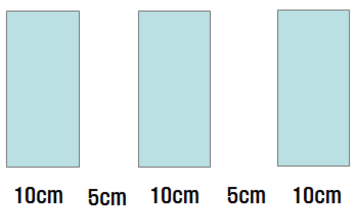


Fig. 2. Schematic plot of the electrostatic triplet.

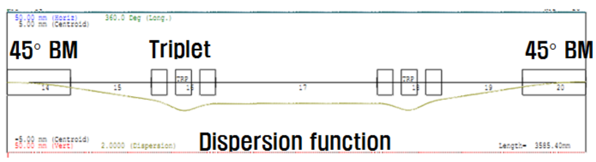
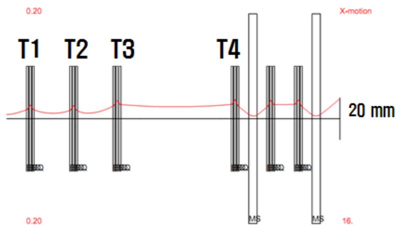
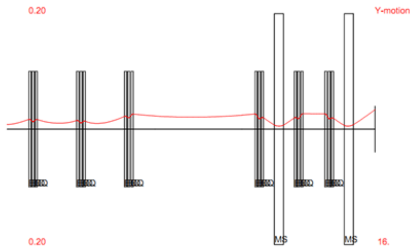


Fig. 3. Achromatic condition of the MRS dipole magnets.

The simulation results of the COSY-Infinity code are given in Fig. 4. The voltage values at pole-tip position are given in Table II. We found that beam envelops are less than 2 cm through the beam line. In order to get the symmetric beam in both horizontal and vertical directions, we position the beam waist around the centers of bending magnets.



(a) Horizontal direction



(b) Vertical direction

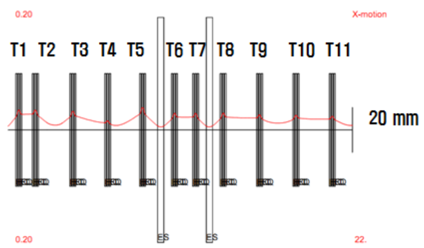
Fig. 4. Beam optics result in the beam line from TIS to MRS.

Table II: Voltage at the pole-tip positions

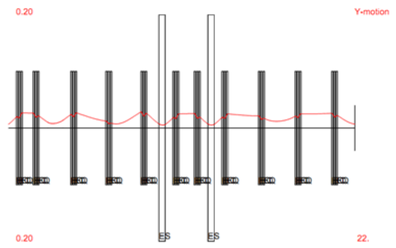
Triplet in Fig. 4	Outer quad. [kV]	Middle quad. [kV]
T1	-3.76	6.79
T2	-4.38	7.69
T3	-2.73	5.15
T4	-3.33	6.14

2.3 MRS to RF-cooler

In the region between MRS and RF-cooler, there is a 90-degree electrostatic bender. In this study, we used the same geometry of the bender as the bending magnet in MRS. We used the electrostatic bender with a spherical geometry. We found that the beam envelope is less than 2 cm in this region as shown in Fig. 5. The voltage values at pole-tip position are given in Table III.



(a) Horizontal direction



(b) Vertical direction

Fig. 5. Beam optics result in the beam line from MRS to RF-cooler.

Table III: Voltage at the pole-tip positions

Triplet in Fig. 5	Outer quad. [kV]	Middle quad. [kV]
T1, T3, T4, T6, T7	-3.18	5.94
T2, T9	-2.66	5.04
T5	-3.60	6.59
T8	-3.33	6.14
T10	-2.60	5.04
T11	-2.53	4.87

3. Conclusions

We performed the beam optics simulation in two regions of ISOL beam lines and found that beam envelope is less than 2 cm. We will check that the pole-tip file values are reasonable or not in near future, and we also applied this method to the other parts of the ISOL beam line and optimize them. The result will be used the detailed design of the electrostatic quadrupoles and benders.

REFERENCES

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[3] K. R. Crandall and D.P. Rusthoi, TRACE 3-D Documentation, LA-UR-97-886.