DESIGN STUDY OF THE LOW ENERGY BEAM TRANSPORT SYSTEM AT RISP

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Abstract

We present the design status of LEBT for the RISP that consists of two 90 degree dipoles, a multi-harmonic buncher, pair solenoids, electrostatic quadrupoles and a high voltage platform. After ECR-IS with an energy of 10 keV/u, heavy-ion beams are selected by achromatic bending systems and then be bunched in the LEBT. A multi-harmonic buncher is used to achieve a small longitudinal emittance in the RFQ. We show the results on the optics design by using the TRANSPORT code and the beam tracking of two-charge beams by using the code IMPACT. We present the results and issues on beam dynamics simulations in the designed LEBT system.

INTRODUCTION

As a part of the Rare Isotope Science Project (RISP)[1], we have designed injector to provide high intensity uranium ion beam. In order to achieve high intensity beam, we designed multi-charge beam transport system. The injector consists of two electron cyclotron resonance ion sources (ECRIS), low energy beam transport (LEBT), RFQ, medium energy beam transport (MEBT) (see Fig. 1). The multiharmonic buncher with fundamental rf frequency of 40.625MHz is used.

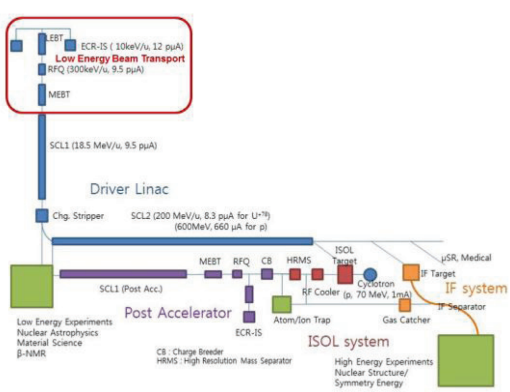

Figure 1: The layout of the RISP.

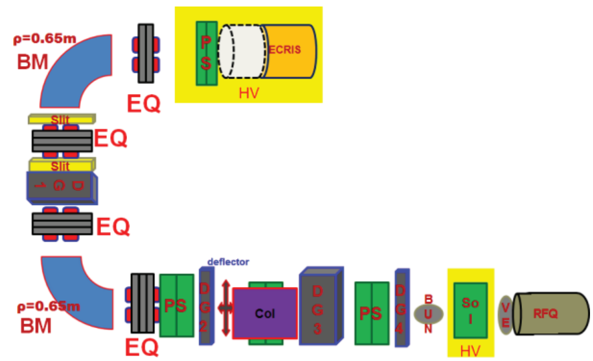

Figure 2: The RISP LEBT design.

The magnets for LEBT system consist of dipole magnets for selection and beam separation (BM), electrostatic quadrupole magnets for beam focusing in the transverse direction (ESQ) and pair solenoid(PS) and solenoids (Sol). It also includes a multi harmonic buncher (MHB) and a velocity equalizer (VE). It includes the diagnostic chamber (DG) to measure the emittance and beam current and beam profile (see Fig. 2). The matrix of solenoid consists of rotational matrix and focusing matrix[2]. Beam rotation makes horizontal and vertical emittances couple. The solenoid series in structure of the pair solenoid provide the same current but opposite direction. Thus pair solenoid decouples horizontal and vertical beam emittances.

INITIAL BEAM PARAMETERS

Beam simulation code of IMPACT-Z[3] is utilized for 6-dimension tracking that includes effect of space charge force. The radius size of the ECR beam extraction hole is 5mm. Normalized rms emittance in Uranium beam is assumed by 0.08 for 34+ ion and 0.07 for 33+ ion and intrinsic energy spread of 0.05% are considered. Initially particles generated in 4-dimensional water-bag transverse distributions with a uniform longitudinal distribution are tracked in the beam simulation (Fig. 3).

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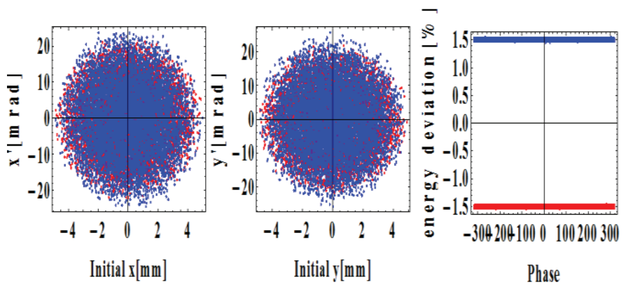

Figure 3: Beam distributions at ECR extraction.

DESIGN RESLUT

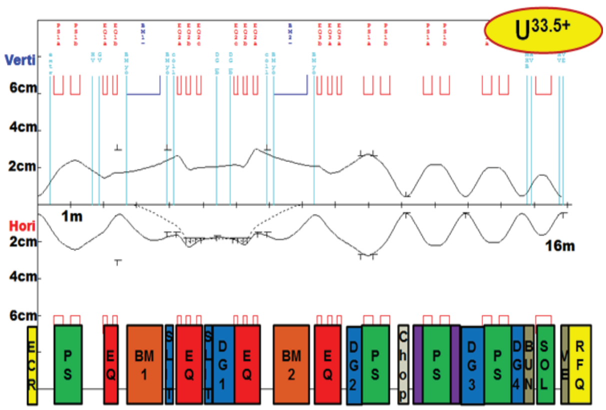

Figure 4: Designed optics for the LEBT.

TRANSPORT code[4] is used for the design of the beam transport line from the beam extraction electrode of the ECRIS to RFQ entrance. For this reason, we set an initial momentum deviation of 0.75 % in the 33.5 + uranium beam. LEBT is designed to have achromatic condition. Maximum beam envelope is around 3 cm and beam envelope is 5mm at the entrance of RFQ. as in Fig. 4.

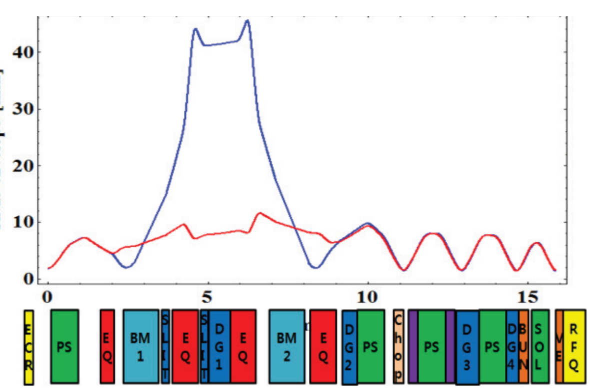

Figure 5: The beam envelopes in the LEBT.

We utilized the IMPACT-Z code to investigate the beam dynamics in LEBT. Blue and red lines in Fig. 5 denote horizontal and vertical envelopes. As aperture in the entrance of RFQ is narrow, the LEBT beam size is designed not to lose the beam at the RFQ entrance. LEBT system is designed to be achromatic bending system. Electrostatic quadrupole magnets are utilized to focus the beam regardless of the charge to mass ratio.

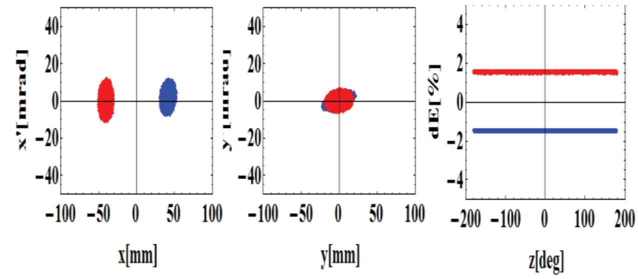

Figure 6 : Beam separation at slit.

Charges of 33+ and 34+ in uranium beam are well separated between the dipole magnets (Fig. 6).

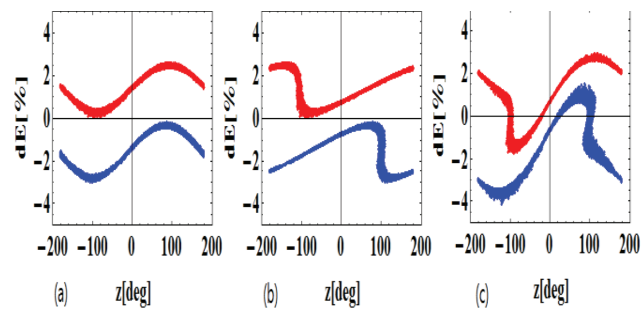

Figure 7: Longitudinal beam distributions (a) Downstream MHB, (b) Upstream VE, (c) RFQ entrance.

Three rf frequencies in multi harmonic buncher are used and the fundamental rf frequency is 40.625 MHz that is a half frequency of the RFQ. Multi harmonic buncher provides a saw-tooth wave to get high efficient longitudinal bunching. Fig. 7 shows that velocity equalizer is a device to make two charge beams exist at the same bucket. Fig. 8 shows the horizontal, vertical and longitudinal beam distributions at the entrance of RFQ.

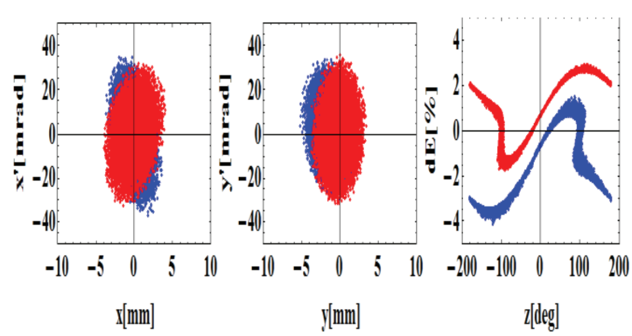

Figure 8: Beam distribution at RFQ entrance.

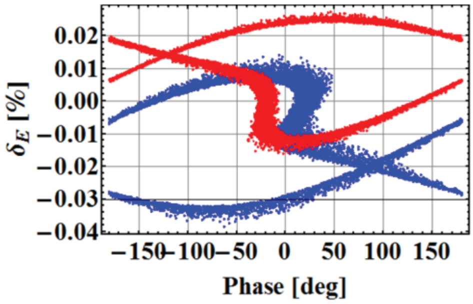

Figure 9: longitudinal distribution (81.25MHz).

Figure 9 shows the longitudinal distribution at the entrance of RFQ with 81.25MHz frequency. Two charge beams passed through the Velocity Equalizer satisfiy RFQ acceptance in both longitudinal and transverse directions. The designed LEBT shows beam transmission of 99.8 % and growth rate in emittance of 9.8% in Uranium beam with charges of 33+ and 34+. (Fig. 10)

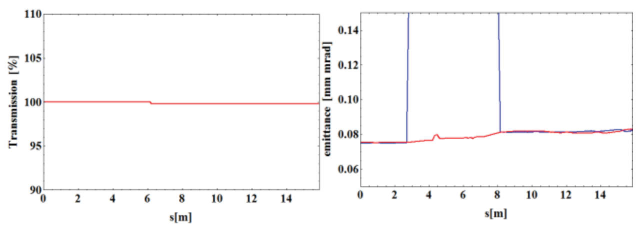

Figure 10: Beam transmission (left) and beam emittance growth (right) in the LEBT.

CONCLUSION

In order to design the LEBT system with achromatic optics, we used TRANSPORT code and IMPACT-Z code. LEBT system consists of electrostatic quadrupole magnets and two dipole magnets, solenoids, collimation system, a multiharmonic buncher, velocity equalizer and beam diagnostics. Pair solenoid eliminates transverse coupling.

The designed LEBT satisfies RFQ acceptance at the entrance of RFQ entrance. The LEBT shows high beam transmission of 99.8% and emittance growth of 9.8%.

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[4] PSI Graphic Transport Framework by U. Rohrer based on a CERN-SLACFERMILAB version by K.L. Brown et al.

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