BEAM DYNAMICS SIMULATIONS OF HIGH CURRENT INJECTOR OF IUAC USING TRACK CODE

Sarvesh Kumar, G. Rodrigues, A. Mandal, D. Kanjilal
Inter University Accelerator Centre, New Delhi

Introduction

The high current injector being developed at IUAC consists of high temperature superconducting electron cyclotron resonance ion source (HTS-ECRIS), 48.5Mhz radiofrequency quadrupole (RFQ) and 97Mhz drift tube linac (DTL). This will act as an alternate injector to superconducting linac (SC-LINAC). The ions of mass to charge (A/q) ratio 6 extracted from HTS-ECRIS will be accelerated by electrostatic column to 8keV/u followed by RFQ to 180keV/u and finally by DTL to 1.8MeV/u. The beam transport system consists of three sections mainly the low energy beam transport section (LEBT), medium energy beam transport (MEBT) section (RFQ to DTL) and a high energy beam transport section (HEBT). The detailed beam optics analysis has been carried out using TRANSPORT, GICOSY and TRACE 3D codes. This paper describes a possible design to optimize the transport of the beam from exit of HTS-ECRIS to the entrance of SC-LINAC. The beam optics has been optimized by considering geometrical constraints and radiation safety issues. The growth of emittance, beam loss and flexibility in transverse and longitudinal beam optics are studied using multi particle beam dynamics simulation code TRACK.

ION OPTICAL DESIGN OF HCI

The ion optical parameters of three different sections LEBT [1,2], MEBT [3] and HEBT [4,5] are given in Table-1. The ions extracted from HTS-ECRIS [6] using a magnetic quadrupole doublet [7] are analyzed by a large acceptance dipole magnet [8] with mass to charge ratio equal to 6 which are focussed by an electrostatic quadrupole triplet to a transverse waist where a 12.125Mhz multiharmonic buncher (MHB) is placed. The ion beam is bunched by applying suitable potential of different harmonics at the MHB and is focussed at the entrance of RFQ by a set of magnetic quadrupoles. The ion beam accelerated by RFQ to energy of 180keV/u is transported to DTL by a set of quadrupole magnets with field gradients less than 17T/m. The purpose of MEBT section is to match the beam to DTL in all phase spaces along with suitable space for beam diagnostics. The double gap 48.5Mhz spiral buncher due to its high shunt impedance and compact structure is used at the middle of MEBT section to provide appropriate phase matching to the DTL. Then the ion beam accelerated by DTL to 1.8MeV/u is transported to SC-LINAC through HEBT section. The aim of HEBT design is to transport the beam to SC-LINAC entrance without beam loss and emittance growth and to provide flexibility in the transverse and longitudinal beam matching at the input of existing SC-LINAC. The various designs for this section have been studied and one such design based on geometrical constraints and tested radiation safety planning is being reported here. The DTL produces beam with an energy spread of 1 to 1.5%. The bending of such beam at high energy (MeV) leads to dispersion and thus a bigger spot size. So we have decided to go for achromat bends in which dispersion due to one magnet gets cancelled by another magnet. To meet the design criteria, there are three achromat bends of 90^o, 180^o and 90^o which are interconnected with suitable magnetic quadrupole triplets whose gradients are less than 10T/m for transverse matching of beam size. The phase spread introduced in the beam from exit of DTL will be compensated by a 48.5MHz spiral buncher placed at the first achromat image point. The next 97Mhz buncher is at the second achromat focusing point and provides a proper phase matching to superbuncher before the SC-LINAC.

Table 1: Ion optical specification of HCI

Parameters	LEBT	MEBT	HEBT
Emittance (ε_x & ε_y) π mm-mrad, ε_z (π deg. keV)	100, 18	35, 300	12, 700
Mass to charge ratio (A/q)	6	6	6
Max. magnetic rigidity (Bρ) Tm	0.09	0.36	1.15
Initial energy (E) keV/u	5	180	1800

The transverse and longitudinal beam dynamics has been studied by various codes like TRANSPORT, GICOSY and TRACE 3D [9] in different sections of HCI which are based on matrix formalism but they don't provide a full description of beam dynamics through all the components of HCI. So we present the calculations using TRACK [10] code which is a specially developed ray-tracing code for detailed studies of beam losses throughout the system. The beam dynamics simulations of LEBT, MEBT and HEBT sections using code TRACK and TRACE 3D is shown in Fig. 1, 2 and 3 respectively.

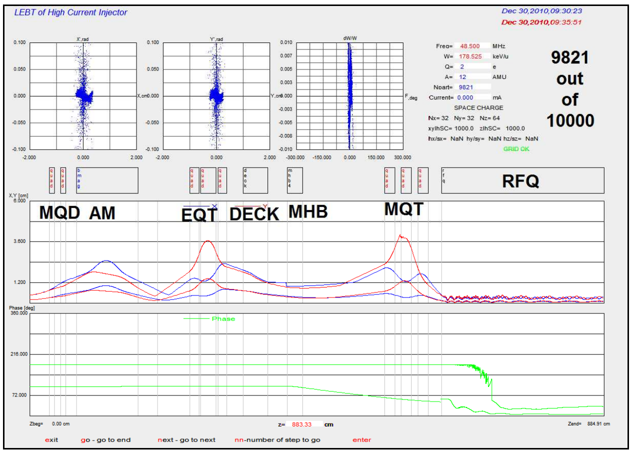

Figure 1: Beam optics of LEBT section along with RFQ using TRACK code

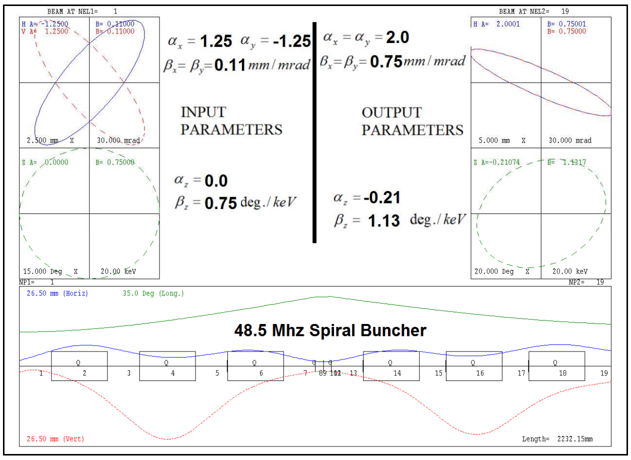

Figure 2: Beam optics of RFQ to DTL section using code TRACE 3D

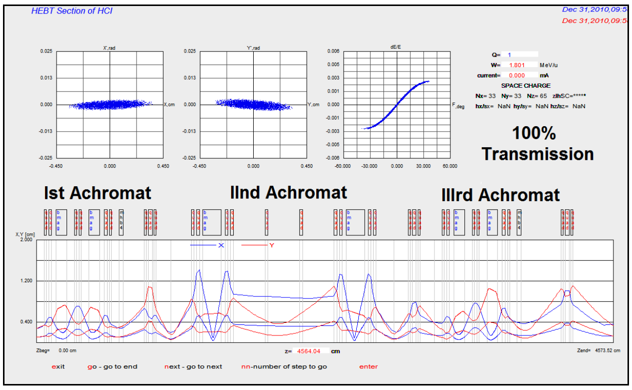

Figure 3: Beam optics of full HEBT section using TRACK code

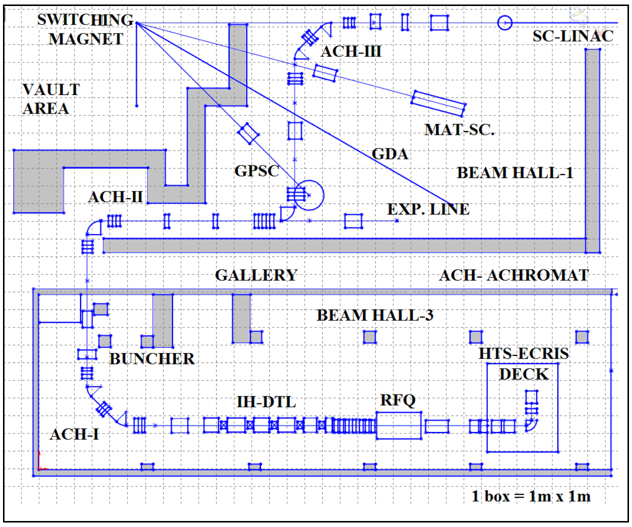

Figure 4: Layout of full HCI

CONCLUSION

The whole ion optics of beam transport system of HCI is simulated by using standard beam optics codes like TRANSPORT, GICOSY and TRACE 3d. The results are crosschecked by multi particle beam dynamics code TRACK. There is only 2% beam loss inside the RFQ and almost 100% beam transmission through MEBT and HEBT sections. The layout of full HCI based upon all these beam optics calculations is shown in Fig. 4.

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