Longitudinal beam dynamics of high current injector at IUAC

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Introduction

The main components of high current injector (HCI) for accelerating and bunching the ion beam are high voltage deck (30kV), 12.125Mhz multiharmonic buncher (MHB), 48.5Mhz radio frequency quadrupole (RFQ) and 97Mhz drift tube linac (DTL). The low and medium energy beam transport sections (LEBT and MEBT) are respectively connects high temperature superconducting ECR ion source (HTSC-ECR) with RFQ and DTL. The high energy beam transport section (HEBT) of HCI delivers the beam from DTL to Superconducting LINAC. This requires the beam to rotate around 360^o which is accomplished by a set of four 45-45deg. achromatic bends with suitable beam diagnostics and magnetic quadrupole triplet between them. The first three achromats are similar but last one is different so as to preserve the existing material science beam line of 15UD pelletron. The whole beam line is according to existing geometrical layout with proper radiation safety measures. The simulation results from TRACE 3D and TRACK code are summarized here for full facility.

Longitudinal beam dynamics

The HTSC-ECR ion source produces dc beam of multiply charged ions with an energy spread of 0.2% which are analyzed by large acceptance dipole magnet for mass to charge ratio (A/q) equal to 6. The MHB bunches such beam at the entrance of RFQ. The outgoing beam from RFQ is also compensated in terms of phase growth by a spiral buncher placed at the middle of MEBT section. An energy spread of 0.5% is expected from DTL which leads to higher dispersion and growth in emittance while bending such beam. So we have decided to go for achromat bends in which dispersion due to one magnet gets cancelled by another magnet. The initial ion beam parameters used for beam optics simulations of all transport sections are section given in Table 1. The spiral bunchers have been used due to their compact structure and high shunt impedance. The HEBT section contains two bunchers so as to match right phase of incoming beam to superconducting LINAC. The beam dynamics results have been optimized using code TRACE 3D [1] and further checked by multiple particle simulation code TRACK [2].

Table 1: Ion optical parameters of different transport section of HCI

Parameters	LEBT	MEBT	HEBT
Emittance (εx & εy) π mm-mrad, εz (π deg. keV)	100, 18	35, 300	12, 700
Max. magnetic rigidity ($B\rho$) Tm	0.09	0.36	1.15
Initial energy (E) keV/u	5	180	1800
Total Length L (mm)	8609	2474	60921

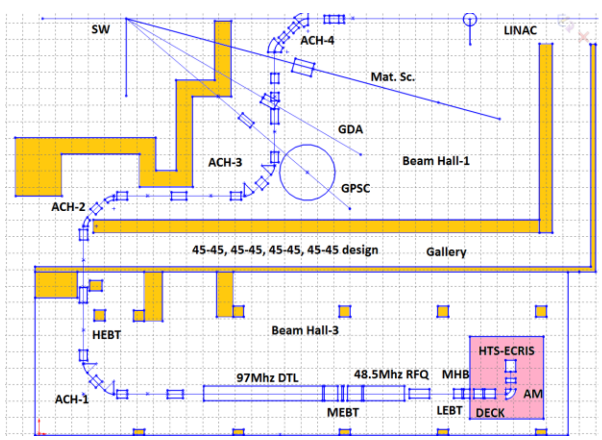

Fig. 1 Layout of Full HCI

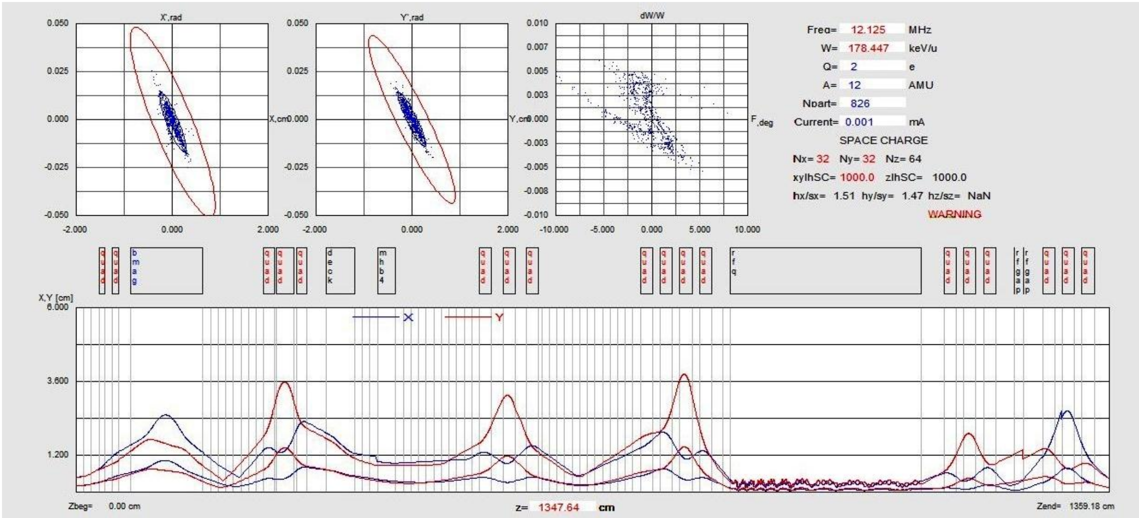

Fig. 2 Beam dynamics of LEBT + MEBT section of HCI using TRACK code

The layout of full HCI with all the transport sections is shown in Fig. 1. The beam dynamics using code TRACK for LEBT and MEBT section is shown in Fig. 2. The beam dynamics for HEBT section using TRACE3D code is shown in Fig. 3.

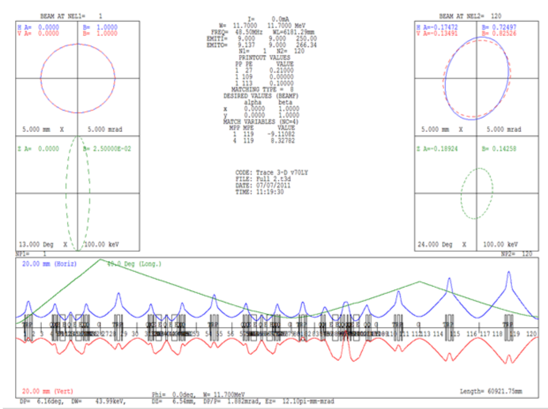

Fig. 3 Beam dynamics of HEBT section of HCI

Conclusion:

The whole ion optics of beam transport system of HCI is optimized by using standard beam optics codes like TRANSPORT, GICOSY and TRACE 3d. The results are crosschecked by multi particle beam dynamics code TRACK. Here we have presented the beam dynamics of transport sections of HCI in different energy regimes using code TRACE 3D and TRACK which ultimately leads to design of component layout of whole facility.

References

[1] K.R.Crandall, TRACE 3-D Documentation, Report LA-11054-MS, Los Alamos, 1987.

[2] TRACK: THE NEW BEAM DYNAMICS CODE, Proceedings of 2005 Particle Accelerator Conference