Achromatic Beam Transport Design of High Current Injector Facility at IUAC Delhi

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Abstract

The medium energy beam transport (MEBT) section of high current injector (HCI) will accept the beam from high temperature superconducting electron cyclotron resonance ion source (HTS-ECRIS) accelerated by radio frequency quadrupole (RFQ) and a drift tube linac (DTL). It will deliver the beam to the entrance of superconducting linear accelerator (SC-LINAC). At the output of DTL, the maximum energy of the beam will be 1.8 MeV/u for the ions having mass to charge (M/q) ratio of 6. This paper describes a possible design study to transport the beam from exit of DTL to SC-LINAC entrance without beam loss and emittance growth and to provide flexibility in the transverse and longitudinal beam optics.

Introduction to MEBT

The DTL is expected to produce beam with an energy spread of 1 to 1.5%. The bending of such energy dispersed beam leads to higher dispersion and growth in emittance 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 MEBT section are given in Table 1.

Table 1: Initial beam parameters of MEBT

Emittance (ε_x , ε_y and ε_z)	9 π mm-mrad, 700 π deg. keV
Mass to Charge ratio (M/q)	6
Max. ME/q^2	63.8 MeV.amu
Initial Energy (E)	1.8 MeV/u

Various options have been exercised to transport the beam from DTL exit to SC-LINAC. This paper describes one option that demands a total bending of 360° to reach SC-LINAC without disturbing the existing radiations shielding walls. To meet the design criteria, we have decided to design three achromat bends of 90°, 180° and 90° which are interconnected with suitable magnetic quadrupole triplets for transverse matching of beam size.

Transverse and longitudinal beam optics of MEBT section:

The transverse beam optics has been studied using beam optics codes like TRANSPORT [1], GICOSY [2] and TRACE 3D [3] codes. The designing parameters have been adjusted in order to give 1:1 object to image transport in beam size and according to geometry constraints. All the quadrupole field gradients have been optimized to less than 10T/m for focusing the beam. The edge angles of bending magnets involved in the achromat design are optimized to have moderate focusing in both axial and radial planes. In 90° achromat, maximum dispersion takes place at the symmetry plane whereas in 180° achromat, zero dispersion at the symmetry plane because two 90° dipole magnets bend the beam in opposite direction. The result from these simulations has also been crosschecked with multi particle simulation code TRACK. The transverse beam optics of 90° achromatic bend from GICOSY is as shown in Fig. 1. 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 third achromatic bend of 90° has been designed to accommodate the existing material science beam line comfortably. The next buncher is 97MHz which is at the third achromat focusing point and provide good phase matching to superbuncher before the SC-LINAC. The longitudinal beam optics using code TRACE 3D is as shown in Fig. 2. The design details of full

MEBT section has been given in Table 2. Finally the technical layout of full high current injector facility is shown in Fig. 3.

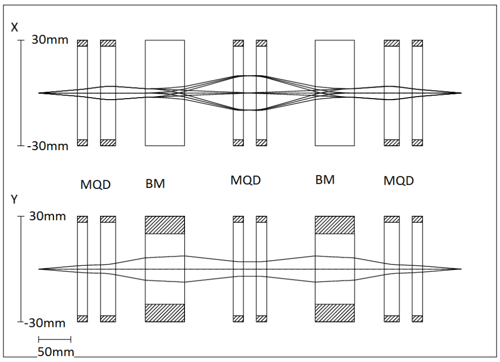

Fig. 1 Beam optics of 45-45 deg. achromatic bend using GICOSY code

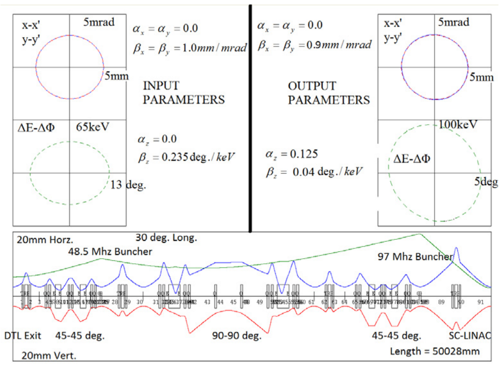

Fig. 2 Beam optics of full MEBT section using TRACE 3D code

Table 2: Design parameters and components

Total length	50m
Number of achromatic bends, quadrupole triplets, singlets, dipole magnets, RF bunchers	3, 6, 22, 6, 2
Maximum Magnetic Rigidity	1.15Tm
Radius of Bending magnets	0.775m
Maximum Quadrupoles gradient	10T/m
Quadrupoles Aperture Diameter	53 mm

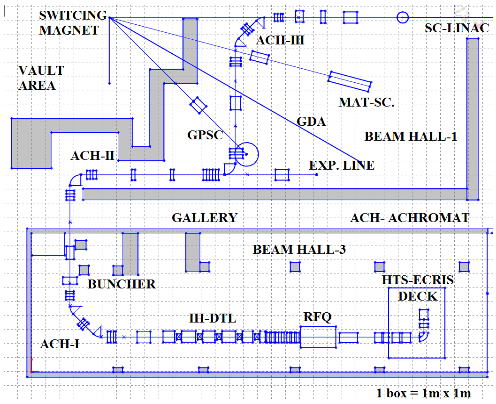

Fig. 3 Layout of full HCI facility

Conclusion

The detailed transverse and longitudinal ion optics of MEBT section of HCI has been studied using various beam simulation codes to design the optimum beam transport system. The calculations show that the output beam of DTL can be successfully transported to SC-LINAC without losses and appreciable increase in the longitudinal and transverse size.

Reference

[1] K.L. Brown, D.C. Carey, Ch. Iselin and F. Rothacker: Transport, a Computer Program for Designing Charged Particle Beam Transport Systems. See yellow reports CERN 73-16 (1973) & CERN 80-04 (1980).

[2] H.Weick, GICOSY homepage, http://www.linux.gsi.de/~weick/gicosy

[3] K.R. Crandall, "TRACE: An Interactive Beam-Transport Program," Los Alamos Scientific Laboratory report LA- 5332 (October 1973).