DESIGN & DEVELOPMENT OF LEBT FOR LEHIPA PROJECT

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Abstract

A magnetic, 2 solenoid based Low Energy Beam transport (LEBT) has been designed for LEHIPA. It uses two steering magnets for centroid control of the beam at the RFQ match point. The beam in the LEBT will be space charge compensated and hence needs an electron trap at the RFQ entrance to decompensate the beam before it enters the RFQ. The design of various components of the LEBT like solenoids, steerers and electron trap has been done. The solenoids have been fabricated and tested and the other components are being fabricated. The LEBT will have diagnostics for monitoring the beam position, shape and current. The present status of the LEBT and its components is discussed in this paper.

INTRODUCTION

A 20 MeV, 30 mA Low Energy High Intensity Proton Accelerator (LEHIPA) [1] is under construction at BARC, Mumbai. It will consist of 3 MeV RFQ and 20 MeV DTL accelerating structures. The LEBT system transports and matches the beam from the ion source into the RFQ with minimum emittance growth and loss of beam current. A solenoid based magnetic LEBT line is being used to match a 50 keV, 30 mA proton beam from ECR ion source to the RFQ. The LEBT is about 3m long and its functions include beam focusing and steering at the RFQ match point, dc beam current diagnosis and beam profile measurement through CCD monitors. The LEBT will also have a water-cooled collimator and an electron trap at the RFQ entrance.

BEAM DYNAMICS CALCULATION

The computer code TRACE2D was used for an initial design of the LEBT for a 50 keV, 30 mA DC H^+ beam. The LEBT was used to transport the phase space ellipse at the exit of the ion source to the entrance of the RFQ and match it to the acceptance of the RFQ. The beam from the ion source was matched to the RFQ match point using TRACE2D to get a mismatch factor of zero in x and y. This matching was done using 2 solenoids and 3 drift spaces.

The Twiss parameters at the entrance of the last electrode of the ion source, obtained from the preliminary ion source design [2], are as follows: $\alpha_x = \alpha_y = -1.8$, $\beta_x = \beta_y = 24.768$ cm/rad, for an emittance of 0.02π cm mrad, which correspond to a beam size of 4.39 mm and beam divergence of 36.44 mrad. The Twiss parameters at the RFQ match point are $\alpha_x = \alpha_y = 1.8$, $\beta_x = \beta_y = 6.63$ cm/rad. With these input parameters, the beam from the ion source was matched into the RFQ to get a mismatch factor close to zero in x and y. The optimized design as obtained in TRACE2D is shown in Table 1 and the beam trajectory is shown in Fig.1.

Table 1: LEBT Parameters

Element	Length (cm)	Strength (kG)
Drift	90	
Solenoid	30	1.6
Drift	90	
Solenoid	30	1.9
Drift	18	

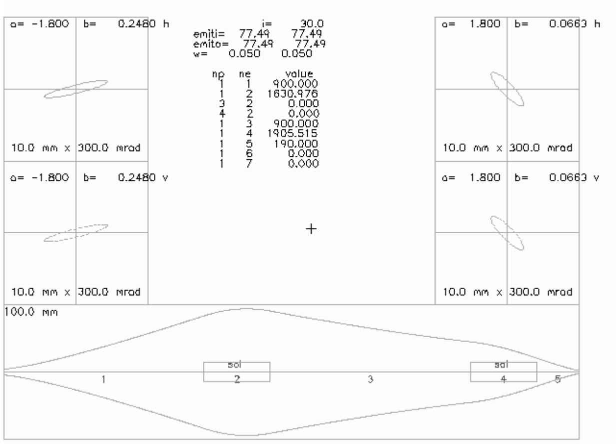

Fig.1. Beam trajectory and phase space ellipse in the LEBT.

Simulations were also done using the analytical KV beam envelope equations to compare the results from the code. The results were found to be similar.

SOLENOID DESIGN

Based on the beam dynamics simulations, the two solenoids for LEHIPA were designed for a maximum peak field 3.5 kG and effective length of 30 cm. The solenoid design was done in POISSON [3]. The solenoid simulated in POISSON is shown in Fig.2. A 3 cm thick core made of magnetic material is used to increase the magnetic field of the solenoid by providing a low resistance path to the magnetic flux lines, with a lower value of current in the solenoid coils. The maximum Amp-turns is 89500 and the total power dissipation is

9.5 kW. The magnetic field profile in the designed solenoid is shown in Fig.3. Based on this design these solenoids have been fabricated and tested at RRCAT. The results are in good agreement with the simulations.

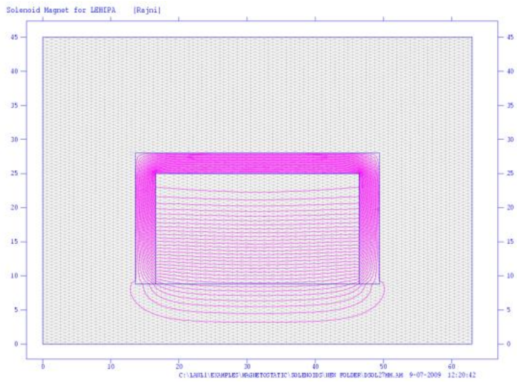

Figure 2: Solenoid simulated in POISSON

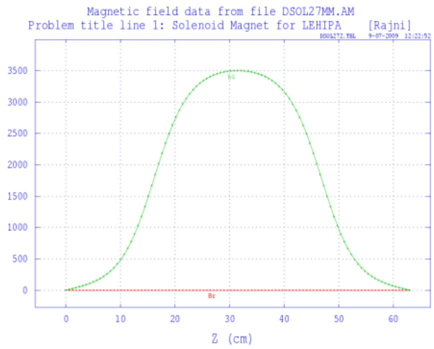

Figure 3: Magnetic field profile in the simulated solenoid

ELECTRON TRAP DESIGN

The beam coming from the ion source contains, in addition to the H^+, H_2^+ and H_3^+ ions. In addition, there is also an electrons contamination due to neutralization which is necessary to compensate the space charge effects. All these contaminant have to be removed before entering the RFQ. The H_2^+ and H_3^+ ions, having a greater momentum than proton, and hence are less focused by the solenoids. A fraction of these is lost after the second solenoid. To maximize the lost fraction, a collimator is needed just before RFQ entrance. In addition an electron trap is needed to prevent the electron from the neutralized beam to enter the RFQ. The electron trap is a ring with a negative 1-2 kV potential placed at the entrance of the RFQ through which the beam passes. The potential from this ring prevents low-energy plasma electrons from going through it, but not 50 keV protons. The electron trap has been designed for a potential of -1.5 kV in POISSON. The electron trap simulated in POISSON is shown in Fig.4.

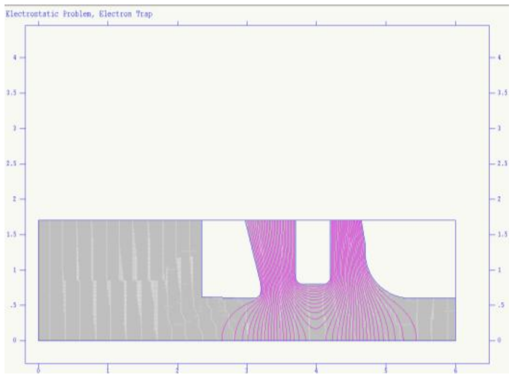

Figure 4: Electron trap simulated in POISSON

STEERER DESIGN

A magnetic steerer has been designed for steering the 50 keV proton beam into the RFQ. The requirement is beam steering of ±3 cm in horizontal and vertical directions from the axis of the beamline at a distance of 75 cm from the entrance of the steering magnet. For this, the design has been done for B = 95 Gauss for a steerer length of 15 cm. The steerer was designed using the code POISSON. The magnetic field profile in the steerer is shown in Fig.5.

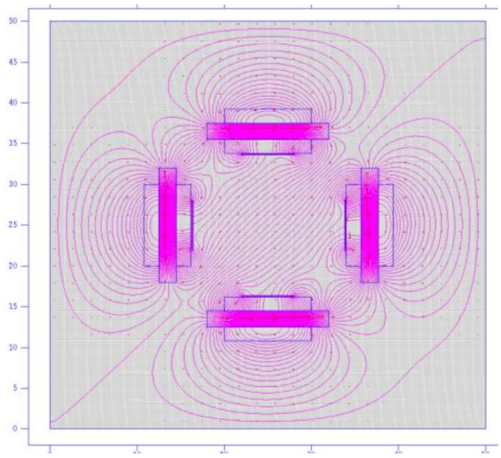

Figure 5: Magnetic field profile in the steerer

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