BEAMLINE FOR EMITTANCE AND SPECIE MEASUREMENT IN ECR PROTON SOURCE

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Abstract

A three electrode ECR proton source has been developed for LEHIPA [1] and 42 mA of hydrogen beam current was extracted at 40 keV. A beam line has been designed and under development that will be a test bench for measuring beam profile, beam emittance and proton fraction. The beam line consists of solenoid magnets, dipole bending magnet and steering magnets. The beam diagnostics incorporated in the beam line are DCCT and ACCT, Faraday cups, Emittance measurement unit, CCD cameras and spectrograph. Detail status of the beam line and the diagnostics are presented.

INTRODUCTION

The high current ECR proton source is generally used as an injector for high power proton accelerators that is being developed [2, 3] in several countries for ADS applications. A three electrode high current microwave based ECR proton source has been developed for LEHIPA. To measure beam parameters i.e., beam emittance and proton fractions, a beam line has been designed and under development as shown in Fig. 4. The required values of these parameters are 0.2 π mm - mrad and > 80%. The beam line consists of two focusing solenoids, two steering magnets, dipole bending magnet, pumping systems and diagnostics (DCCT, ACCT, emittance measurement unit, CCD cameras, spectrograph, four grid energy analyzer and Faraday cup / beam dump). These items are at various stages of development / procurement.

DESIGN

The design of beam line was done using TRANSPORT and GPT code. The TRANSPORT output of beam envelope is shown in Fig. 1. The simulation was performed for proton beam current of 30 mA and the beam line of Fig. 4. The field requirements on the magnets for the transport simulation of proton beam are the following: solenoid 1: 1.4 kG, dipole bending magnet: 1.75 kG and solenoid 2: 3 kG. The beam is focused on the first slit of the emittance meter. The steering magnets are incorporated in the beam line for trajectory corrections. The solenoid magnets and the dipole bending magnets were designed using OPERA 3D code. The bending magnet has radius 300 mm and bending angle 90 degree. The total Ampere turn is 22176. The maximum filed in the bending magnet is 2.3 kG. The solenoid magnet 1 has maximum field 3 kG and solenoid magnet 2 is 4 kG. The magnetic length is 500 mm and the aperture 150 mm. The field homogeneities in these magnets are better than 10^{-3}.

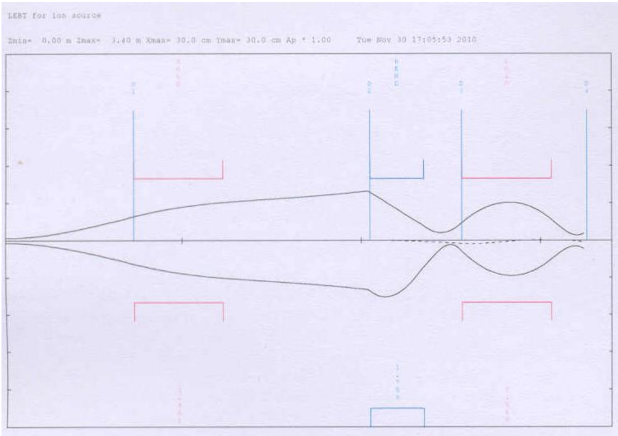

Fig 1. Beam transport using two solenoids and dipole bending magnet

The beam transport using GPT code was performed using one and two solenoids and the results are shown in Figures 2 and 3.

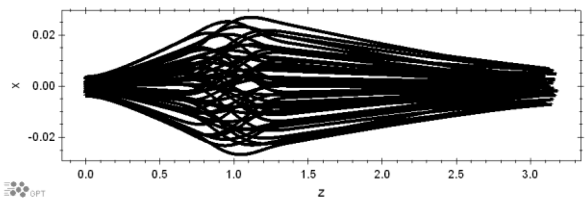

Fig. 2. Beam transport using one solenoid

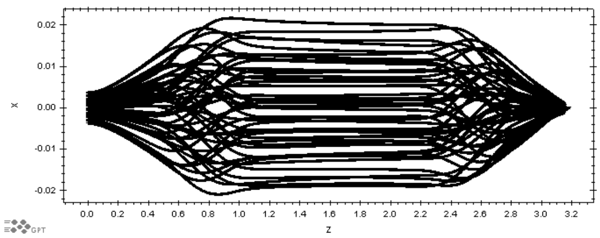

Fig. 3. Beam transport using two solenoids

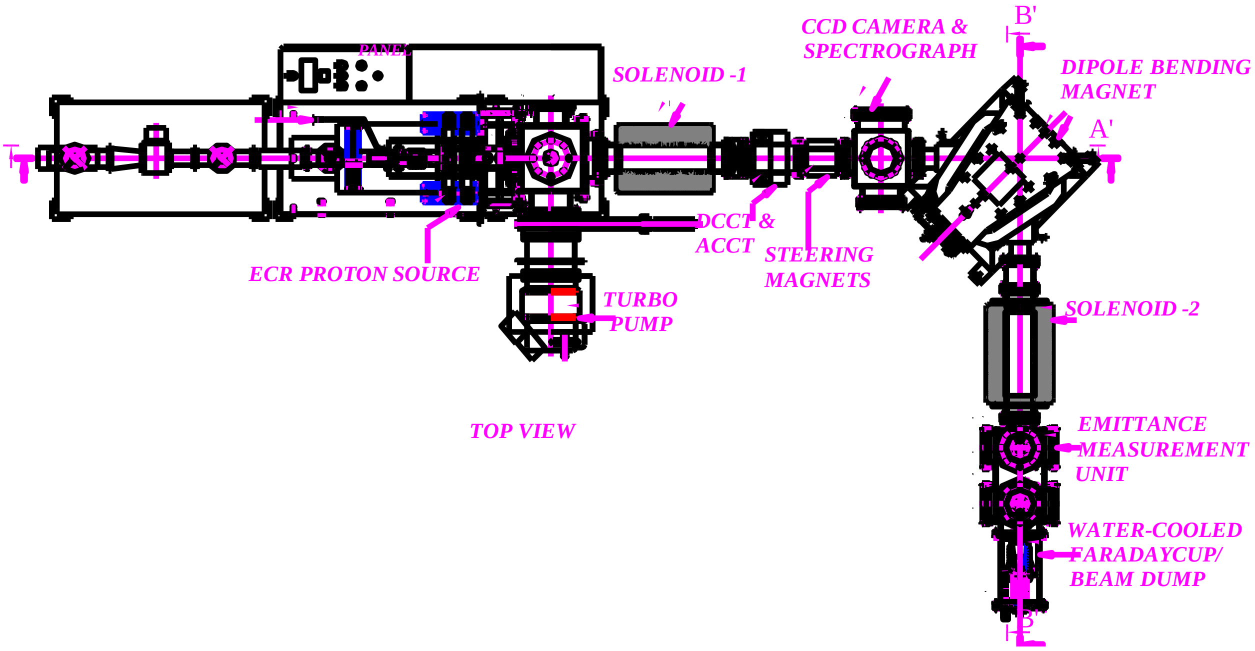

Fig. 4. Schematic of beam line for emittance and specie measurement

BEAM LINE COMPONENTS AND DIAGNOSTICS

The solenoid 1, the dipole bending magnet and the steering magnets have been fabricated and tested. The CCD cameras and a spectrograph are under procurement to measure the beam profile and proton fraction. The DCCT and ACCT are incorporated in the beam line to measure the total beam current and fluctuations in the beam current. The two slit emittance measurement unit has been designed and under fabrication as shown in Fig. 5. The first slit is water – cooled and made of tantalum. The second slit having a Faraday cup attached to it. The slits are driven via stepper motors and controllers. For high average power beam (>20 mA), measuring the profile with an interceptive system is problematic so the profiler based on light emission / absorption are used. Also, the beam compositions (proton fraction) is determined from the quantity of light associated with each Doppler – shifted line.

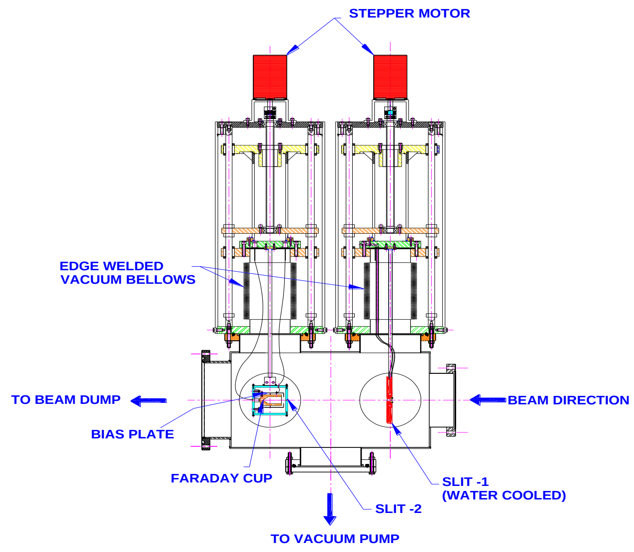

Fig. 5. Two slits emittance measurement unit

CONCLUSIONS

A beam line has been designed and under development to characterize the ion beam in terms of emittance and specie of the high current three electrodes ECR proton source that has been developed in housed. The beam line consists of two solenoid magnets and a dipole bending magnet. Several diagnostics are incorporated in the beam line to characterize the beam. A two slit emittance meter has been designed and under development.

REFERENCES

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[3] P. Roychowdhury et al, “High Intensity ECR Proton Source Development for LEHIPA”, InPAC’09, RRCAT, Feb. 10-13 (2009).