FIVE ELECTRODE ECR PROTON SOURCE FOR LEHIPA

P. Roychowdhury, S. R. Ghodke, D. P. Chakravarthy,
Accelerator and Pulse Power Division, BARC, Mumbai
Abhay Kumar, J. J. Roy, and S. Guha
Centre for Design and Manufacturing, BARC, Mumbai

Abstract

A five electrode Electron Cyclotron Resonance (ECR) Proton Source is under development for Low Energy High Intensity Proton Accelerator (LEHIPA). The beam parameters of the ion source are the following: beam energy: 50 keV, beam current: 50 mA, beam emittance ≤ 0.2 π mm-mrad, and proton fraction: ≥ 80%. The five electrode extractor has been designed using PBGUNS to optimize the beam quality and the extracted ion current. The five electrodes and the plasma chamber have been fabricated using OFHC copper. The plasma chamber and the two ground electrodes are water cooled. The details of design and fabrication status of the ion source are presented.

INTRODUCTION

The high beam power (MW) proton accelerators of GeV energy are now being built in several countries for ADS applications. As a first step towards this goal in India, a 20 MeV, 30 mA proton accelerators LEHIPA [1] (Low Energy High Intensity Proton Accelerator) is under development at BARC. LEHIPA consists of H^+ ion source at 50 keV will be accelerated to 3 MeV by Radio Frequency Quadrupole (RFQ) and to 20 MeV by an Alvarez type DTL.

High intensity cw ECR proton source with good beam quality and high reliability is the essential requirement of LEHIPA. A desirable property of such source is that the proton fraction of the extracted beam be as high as possible so as to avoid the need for selection of the desired ion i.e. to enable direct injection into RFQ accelerating structure.

A microwave based ECR proton source has been designed and indigenously developed for LEHIPA [2-3]. The key components of ECR proton source are plasma chamber, vacuum systems, microwave system, solenoid magnets and power supplies, beam extraction electrodes and power supplies, and beam measuring devices. Detailed description of this source is presented in this article.

SOURCE DEVELOPMENT

The schematic of ECR proton source is shown in Fig. 3. The microwave system in Fig.3 has been designed using WR-284 waveguide section. The microwave system is sourced by a variable power magnetron (2 kW) at a frequency 2.45 GHz.

A circulator was used to protect the magnetron from load (plasma) reflection. The four stub auto tuner was used for waveguide to plasma impedance matching. The microwave power was monitor using a directional coupler with diode detector and a calibrated analog meter. A ridge waveguide developed in house was used for optimizing the coupling between the microwave generator and the plasma chamber.

The five electrode extraction geometry for 50 mA / 50 keV beam energy was designed and fabricated to extract the proton ion beam from the source. The parameters of the extraction geometry viz. electrode apertures, electrode gaps and electrode shapes were optimized to reduce beam divergence and emittance using beam trajectory simulation software PBGUNS (Fig. 1). The space charge effect of the beam is incorporated in the simulation.

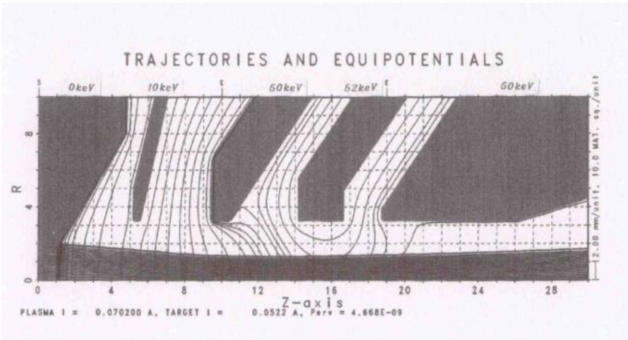

Fig 1. Beam extraction simulation

The solenoid coils placed around the plasma chamber produces the necessary magnetic field of 875 G for ECR resonance condition.

Fig. 2. Extractor electrodes and plasma chamber

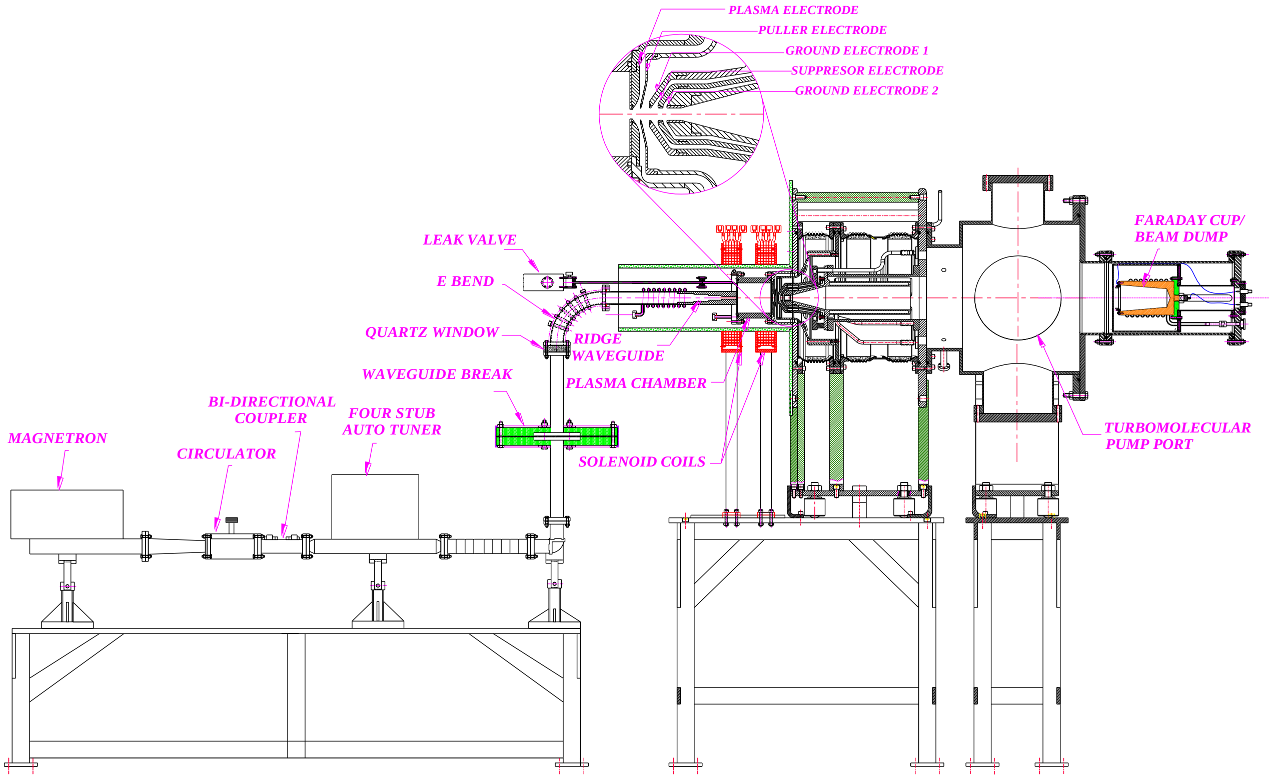

Fig. 3. Schematic of five electrode ECR proton source

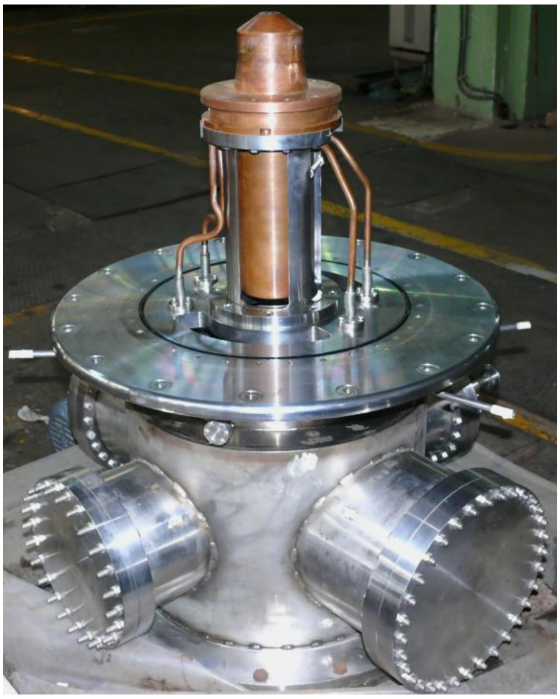

Fig. 4. Assembly of ECR proton source

The ultimate vacuum requirement of the source is better than 1 x 10^{-6} mbar. Turbo molecular pump, with the hydrogen pumping capacity of 2000 l/s, and a dry roughing pump was selected by considering gas throughput (≈ 2 x 10^{-3} mbar l/s) to maintain a pressure of the order of 10^{-4} - 10^{-3} mbar in plasma chamber, 10^{-6} - 10^{-5} mbar in extractor chamber, and to get hydrocarbon free clean vacuum. The gas dosing system used in the ion source consists of a high purity gas cylinder, a pressure regulator, precision leak valve and a flow meter.

The fabricated ion source components are shown in Fig. 2. The assembly of the ion source is shown in Fig. 4.

CONCLUSIONS

The five electrode ECR proton source has been designed and under development. The five electrodes and the plasma chamber have been fabricated using OFHC copper. The support structures of the ion source are under fabrication. The assembly and testing of the source will start soon.

REFERENCES

[1]. P. Singh, “Activities of high Intensity Proton Accelerator at BARC”, InPAC’09, RRCAT, Feb. 10-13 (2009)

[2] P. Roychowdhury and D. P. Chakravarthy, Rev. Sci. Instr. 80,123305 (2009).

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