Simulation of Ion Beam Extraction from a Single Aperture Triode Extraction Column: A comparison of the beam transport code PBGUNS with the test stand data

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Introduction

Beam transport codes are invariably utilized to facilitate the design of low-energy, high current ion beam extraction systems. In this paper, we compare the results of simulations of extraction of high-current ion beams from a plasma ion source with experimental data obtained on test stands. The particle beam transport code PBGUNS was used to model single aperture triode extraction system that was originally characterized on well equipped ion source test stands. The behavior of a hydrogen ion beam extracted from a high-current microwave-driven ion source was studied for fixed extraction geometry. The extraction geometry is shown in Fig.1.

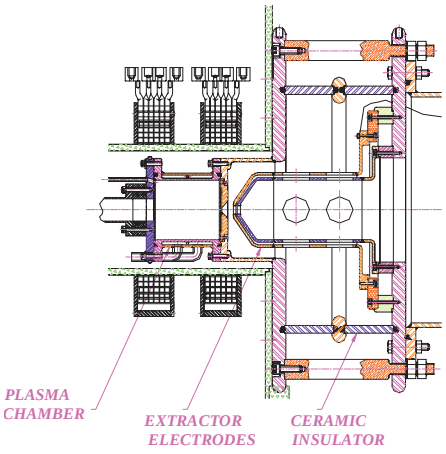

Fig. 1. Schematic of ion source extraction system.

Test stand data

The intent of this study was to determine the optimum geometry for a single aperture three electrode extraction system. The hydrogen ion beam was extracted from a microwave ion source that was designed and developed in-house with a single aperture triode extraction column operating at extraction voltage of 20-40 kV[1]. The ion source was installed on a test stand equipped with water-cooled Fadaray cup of aperture 5 cm that intercept the beam at a distance of 30 cm from the plasma electrode.

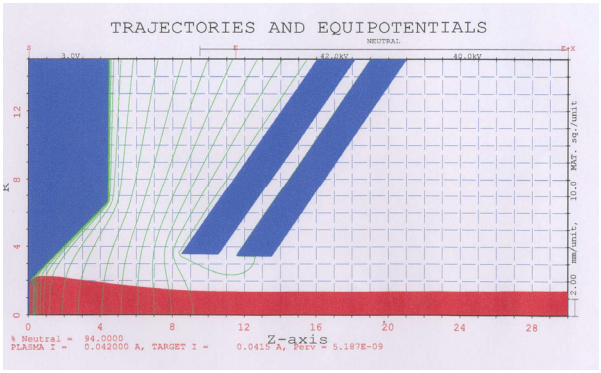

Fig. 2. Trajectory plot of a 42 mA hydrogen beam modeled in PBGUNS. The plasma aperture is biased at 40 kV, the accel electrode -2 kV and the decel electrode is grounded.

The pressure of the background gas in the test stand was kept constant for each measurement. The beam current was checked from the Faraday cup with secondary electron suppression and was also inferred from the acceleration supply drain current.

Simulation

In the initial setup of the extraction problem, the electrode geometry is described by line segments sketched onto a grid. The geometry was defined in axis symmetric terms. The axial magnetic field for the microwave ion source was entered by specifying a series of breakpoints along the beam axis. The program then interpolates between these points to give a distribution. It has been observed that the presence of an axial magnetic field did not appear to affect the beam trajectories in the PBGUNS simulations.

PBGUNS simulation utilizes a self-consistent solver to define the shape of the ion emission surface at the extraction aperture. PBGUNS require initial ion energies of 10-20 eV