DESIGN OF A 2.45 GHz PERMANENT MAGNET FREE ECR ION SOURCE FOR 1^+ ION PRODUCTION IN RIB FACILITY AT VECC

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Abstract
A 2.45 GHz ECR Ion Source (ECRIS) coupled to the target will be used as one of the ion sources in the charge breeder scheme of Radioactive Ion Beam (RIB) production. This ECR will produce singly charged ions which will be further injected into a 6.4 GHz ECRIS for multiply charged ion production of RIB. This paper describes the study and design of the 2.45 GHz on line ECRIS.

INTRODUCTION

The RIB facility presently being constructed in VECC will consist of a thick production target coupled to an ECR Ion Source (ECRIS) for the production of radioactive ions. The RIB thus produced will be sent to an online isotope separator and appropriate post-accelerators to achieve the desired final energy. If the ECRIS is placed in the hostile environment of the target, the vacuum inside the ion source cannot be kept sufficiently high for efficient production of multiply charged ions [1]. For gaseous activity, it is possible to use long transfer tubes between target and ECRIS but for non-gaseous activity it becomes necessary to heat the transfer tube to high temperatures which again gives rise to complications in coupling of the transfer tube to the ECRIS. For this reason, the charge breeder concept [2] which uses two ion sources in tandem will be employed. An ECRIS producing singly charged ions will be placed close to the target and the ions from this source will then be injected into another ECR ion source kept far away from the target for further stepwise ionization to multiple charged states.

In this paper we present the detailed design of the target coupled ECRIS that will be used for 1^+ ion production

DESIGN CONSIDERATIONS

Since this ECR will be mainly used for 1^+ ion production we use a cyclotron resonance frequency of 2.45 GHz corresponding to a resonance magnetic field of 875 Gauss in the plasma chamber. Owing to its vicinity to the high radiation environment of the target, no permamemt magnets have been used in the design.This is because the high neutron flux during beam irradiation demagnetizes the permanent magnets of an ECR, severely restricting its life time. Both the axial and radial confinement of the plasma has therefore been effected by the use of solenoidal coils [3].

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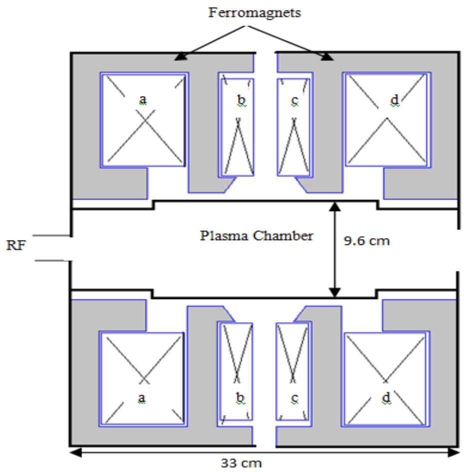

Fig 1: Coil Strucure of the 2.45 GHz ECRIS.Direction of current for coils a & d is into of the plane of paper while it is reverse for coils b & c.

A.Physics design

Two symmetric pair of coils a, b and c, d surrounded by ferromagnetic structure (Fig 1 & 2) has been used to create the magnetic field structure for plasma confinement. Coils a & d mainly produce the magnetic mirror in the axial direction. The curvature in magnetic field created due to the presence of two additional coils b & c produces a radial component of the magnetic field in the chamber and thereby causes radial confinement. The coils are made from copper conductors of 1 cm outer diameter and having a 6mm inner diameter for water- cooling. Considering a packing fraction of 60% for the coils, the maximum current that coils a & b

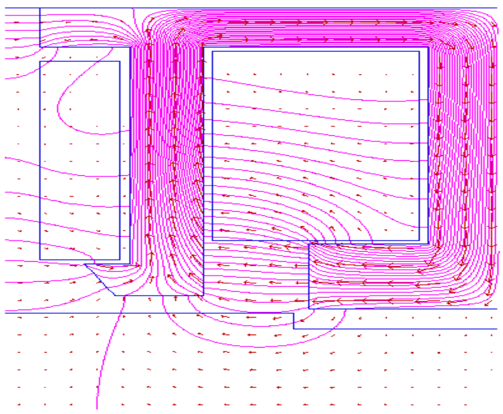

Fig 2 : POISSON simulation of magnetic field in one quarter of the source would carry are 639A and 700 A respectively while the values are slightly lower for coils C and D. The maximum axial field on the axis of the chamber is 0.28 T on the injection end and 0.25 T at the extraction end (Fig 3). The mirror ratio between the maximum axial field and the resonance magnetic field in our case is ~3. The outer dimensions of the chamber are 33 cm (axial length) x 41 cm (diameter). A total of ~ 5 KW power will be required to drive the current in the coils.

The extraction system will consist of a grounded plasma electrode and an extraction electrode at a certain positive potential. The finer details of the electrodes are being worked out through the simulation software PBGUN.

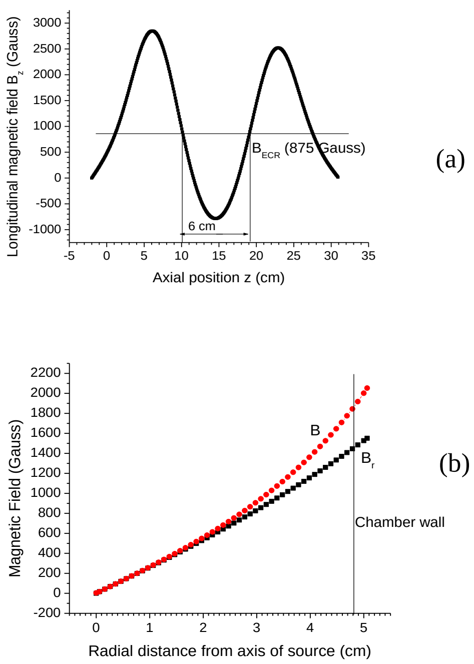

Fig 3: (a) Longitudinal component of magnetic field (B_z) on the axis of the source. (b) Radial component (B_r) and absolute value (B) of magnetic field vs. radial position, at an axial distance of 3 cm from the centre of the source.

B. Radiofrequency Injection Line

The dimension of the plasma chamber has been kept slightly larger than the minimum dimension required for the sustenance of TE11 mode in a cylindrical cavity. The RF feeding into the plasma chamber is realised using a coaxial-antenna in a tunable position [3-4] as shown in Fig 4. RF power at a frequency of 2.45 GHz will be fed from a magnetron into a rectangular waveguide of dimension 8.6 x 4.3 cm^2 . The RF power transfer from rectangular to coaxial antenna is made effective through a door-knob transition method (Fig 5). A movable tuner plate is connected with the waveguide to ensure maximum power transfer in the transition method. The inner cylinder of the coaxial antenna projects inside the plasma chamber in a cone like structure. The inner and outer diameter of the coaxial antenna is 6.8 and 15.6 mm respectively. The distance between the centre of the source and the extremity of the antenna is made adjustable so as to maximize the RF coupling into the chamber. The simulation for design of coupling antenna and waveguide to coaxial transition has been done using CST microwave studio.

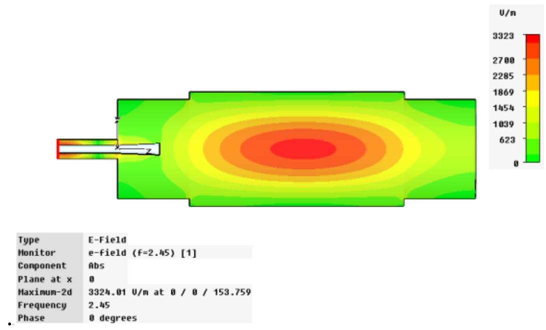

Fig 4: CST simulation of the coaxial-antennna coupling to the plasma chamber

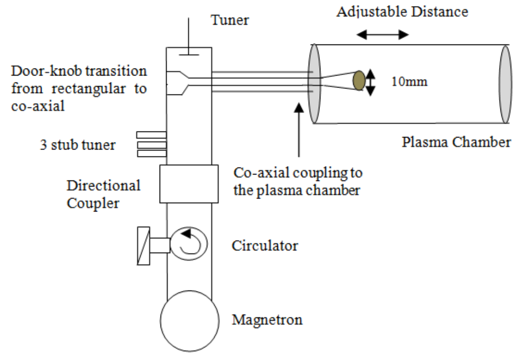

Fig 5: Schematic of the RF injection line of the ECRIS

CONCLUSION:

The design details of an online 2.45 GHz ECRIS has been presented. The design is intended to produce a compact and yet efficient ion source for 1^+ ion production. Since the source is fully made of electromagnetic coils, the RF power required to produce the same magnetic field structure in the plasma chamber is more than conventional ECR sources. But at the same time the proposed design doesnot suffer from the drawback of high radiation caused damages on the ECR which is extremely important in an RIB environment.

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