VECC Cryogenic Penning Ion Trap Status and Simulation Results

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Introduction

At VECC, we are building a cryogenic Penning Ion trap for mass measurements of stable and radioactive nuclei and beta decay studies. The working principle of a Penning Ion Trap and the basic design of VECC Cryogenic Penning Ion Trap have been reported earlier [1,2,3,4]. Several experiments being planned using this trap facility have been discussed [1] The present status in this developmental work is reported here.

Penning Ion Trap Magnet-Cryostat

The VECC Penning Ion trap facility has a specially designed Cryostat and a superconducting magnet assembly. The design and the special features of the system was described and reported earlier [1]. A special SCAN TUBE has been designed, fabricated and tested at liquid nitrogen temperature at VECC. The scan tube will be inserted in the liquid He filled bore of the magnet cryostat but there would be room temperature inside the inner chamber where a NMR probe would be inserted for field measurements.

The SCAN TUBE is a double walled hollow chamber of 1630.35 mm height as shown in Fig.1. The outer chamber is a 2 mm thick hollow cylinder made of stainless steel with outer diameter is 86.9 mm and inner chamber 3.3 mm thick cylinder with inner diameter 69.4 mm.

The outer wall of the inner aluminum cylinder is wrapped with 15 layers of super insulations and then placed inside the outer chamber and vacuum sealed to 10^{-5} mbar level. When the SCAN TUBE is immersed in liquid nitrogen and hot air flow is circulated along the surface of the top flange, the temperature at the bottom of the inner chamber is maintained around room temperature for indefinite period. If the air flow is cutoff, then the temperature at the bottom of the inner chamber goes down to about 0^{o}C after 12hours.

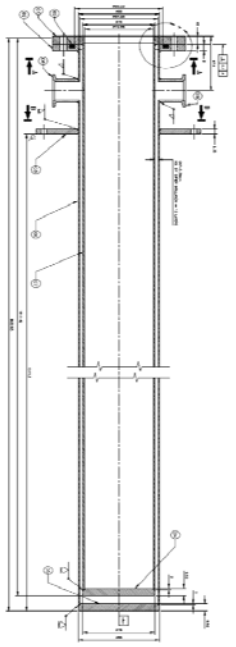

Fig. 1 SCAN TUBE to be inserted within magnet bore

Penning Ion Trap Electrode Arrangement

The VECC Penning Ion trap electrode arrangement for ion generation and trapping is

shown in Fig.2. The electrons required for ion generation will be produced by Field Emission Probes (FEP). These FEPs are being fabricated in VECC and characteristics have been studied. A prototype of the electrode arrangement will be fabricated soon. In the first prototype we shall have the electron source and a nine electrode assembly for trapping electrons and the simulations results are presented below.

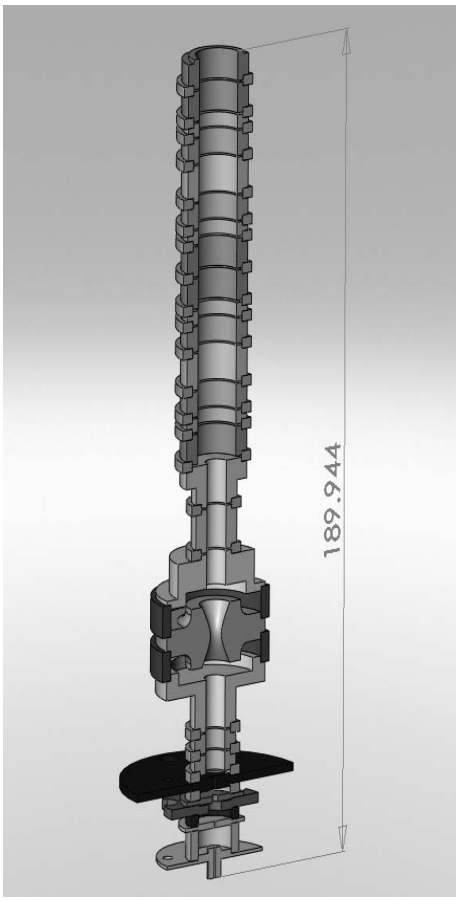

Fig. 2 Cross-section of the 3D model of VECC Penning Trap electrode arrangement.

One of the challenges in this project is regeneration of ions from the host carrier inside the trap. In order to study the ion regeneration rate of the ions of interest from the host carrier surface, a setup has been designed and fabricated. Recently ^{100}Pd was produced at VECC for regeneration rate study and preliminary results are reported [5].

Simulation Results

The potential within the nine electrode prototype trap was calculated by solving Laplace's equation with boundary conditions using the iterative, relaxation technique using SIMION 8.0 code [6]. The calculated potential was expanded in a even order Legendre Polynomial $P_k(\cos\theta)$ multipled by r^k,

$$V_{cal} = \tfrac{1}{2}V_0 \sum_{k=0,even} C_K \left[\frac{r}{d}\right]^k P_k(\cos\theta)$$

The expansion coefficient C_2 and C_4 which determines the quadrupolar nature to the trap was found to be 1.026 and -0.0253 respectively. The potential profile inside the nine element trap assembly and the quadrupolar field at the centre of the trap assembly is shown in Fig 3.

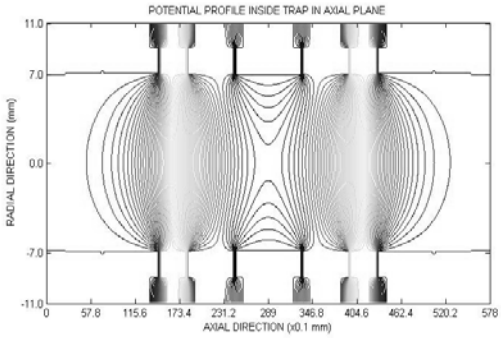

Fig. 3 Potential profile inside trap assembly

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[6] SIMION 8.0 user manual.