New Design of Central Region in KIRAMS-13 Cyclotron

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1. Introduction

The central region design in a cyclotron accelerator is important to get the high intensity of the extracted beams because most of beam loss arise from the defocusing and scattering effect in the central region. The First KIRAMS-13 cyclotron has the maximum beam current of about 50 uA of external beams with 30 degree of RF phase acceptance in the central region[1] which is enough for the conventional target system such as a double foil target system.

Recently KIRAMS has developed the double grid target system which has the beam capacity of about 70 uA more with 13 MeV[2]. For other types of target system, such as C-11 gas target, the higher beam current is more efficient for the radioisotope production.

This paper describes the results of the new design of the central region of KIRAMS-13 cyclotron for the higher RF phase acceptance satisfied in horizontal and vertical direction simultaneously to achieve the more external beam currents.

2. Methods and Results

2.1 The New Central Region

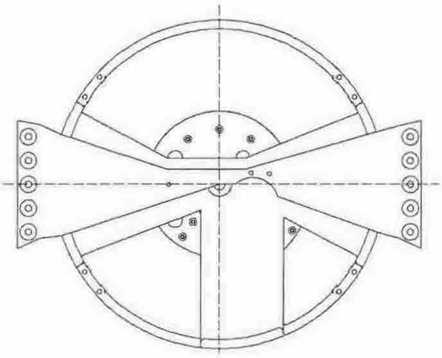

Figure 1. The drawing of new central region. This figure contains dee and dummy dee in the central region.

Using the theory of the horizontal motion of ions through the successive acceleration gaps in the case of a static magnetic field and time-varying electric field[3], we can obtain the relative positions of the gaps which satisfy the best centered ion trajectory and the maximum energy gain through the gaps. In this approximation, the fundamental cyclotron parameters of harmonic number, RF frequency, Dee voltage except the magnetic field distribution and gap distances have the same values with the previous design[1]. The magnetic field distribution of the second and third KIRAMS-13 cyclotron has lower values than that of the first one in the central region. The gap distance from ion source to puller is larger than the first KIRAMS-13 about 2 mm for a stable RF condition.

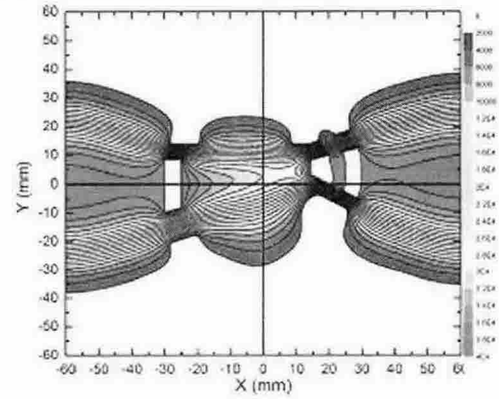

Figure 2. The electric potential map of new central region. There are 3 pullers on the y-axis, 4 guides, and an ion source.

Figure 1 shows the drawing of new design of the central region, and Figure 2 shows the electric potential map which is obtained from RELAX3D program.

2.2 Horizontal and Vertical ion trajectories

In the beam trajectory simulation, we have used the measured magnetic field distribution and the calculated electric potential distribution.

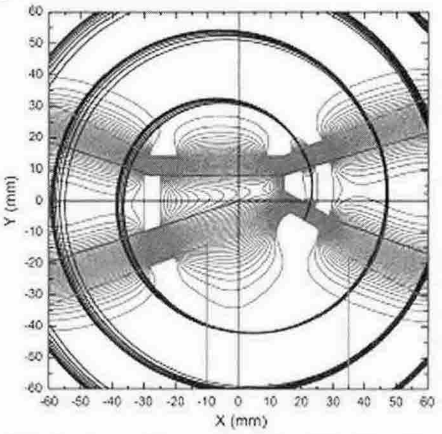

Figure 3. The horizontal ion trajectories. The blue line means the center dee, The red lines center cap or dummy dees.

Figure 3 and 4 show the horizontal and vertical trajectories of the ions respectively. The RF phase acceptance in horizontal and vertical motion is about 55 degrees from 271 to 325. In the First KIRAMS-13 cyclotron the RF phase acceptance in horizontal motion is about 30 degree. Considering both of the horizontal and vertical motion simultaneously, it is about 20 degree. However new central region has about 55 degree of RF phase acceptance in both directions.

The maximum vertical displacement from the median plane is about 6.8 mm. The vertical height of the center dee from the median plane is 8 mm. Therefore the scattering in the vertical direction with the center dee has been avoided by the vertical focusing which is achieved by the relative acceleration gap configuration from first to third gap[4,5].

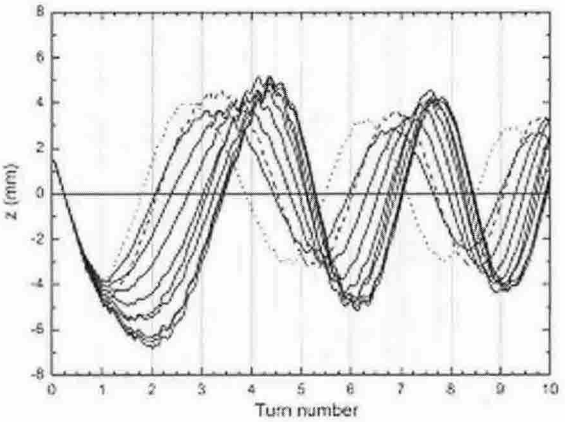

Figure 4. The vertical ion trajectories. The starting position is z=1.5 mm from the median plane and the initial direction is parallel to the median plane.

2.3 Centering of the ion trajectory

Figure 5 shows the motion of the center of the ion trajectory. The initial RF phase is 271 degree. From this centering motion during the first 2 turns we can see that the position of the center during the acceleration process converges to one point rapidly. After the first 2 turns the centering motion is affected by the magnetic flutter configuration.

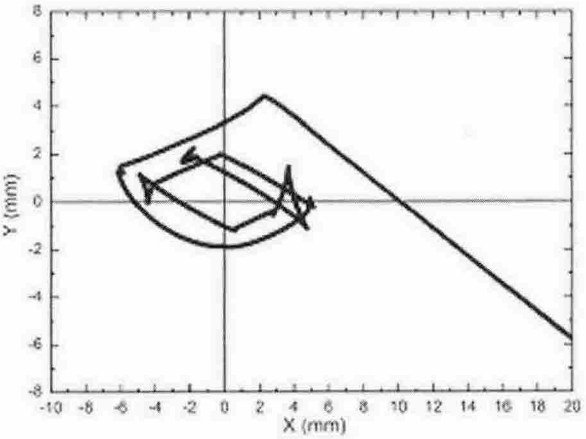

Figure 5. The motion of the center of the ion trajectory during the 2 turns.

3. Conclusion

To obtain the higher intensity of external beams, we have designed the new central region of KIRAMS-13 cyclotron. The RF phase acceptance is more than doubled in the new central region. In addition, the motion of the center of the ion trajectory is well converged to the cyclotron center in a few turns.

From this simulation we can expect that the external beam intensity is enough to support the new double grid target system and other gas target system.

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