DESIGN OF THE CENTRAL REGION IN THE KIRAMS-13 CYCLOTRON

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Abstract

This paper describes the design of the central region in the KIRAMS-13 cyclotron with an internal cold PIG ion source. The electric field distribution in the central region has been numerically calculated from an electric potential map produced by the program RELAX3D. The magnetic field distribution has been measured experimentally. The geometry of the central region has been tested with the computations of orbits carried out by means of the acceleration beam tracking method. The optical properties and acceleration characteristics in the central region were studied by using the information obtained from the beam tracking code and beam traces obtained experimentally.

INTRODUCTIONS

KIRAMS-13 cyclotron [1] is a fixed frequency (77.3MHz) and sector focused isochronous cyclotron with harmonic number 4. This cyclotron had been developed for a production of ^{18}F radioisotope for a medical PET (Positron Emission Tomography) use. The central region of KIRAMS-13 cyclotron is composed of an internal ion source of cold cathode PIG type, the central dee as a puller, and guides. KIRAMS-13 cyclotron accelerates negative hydrogen ions and extracts positive proton ions of 13 MeV by a stripping carbon foil.

This paper describes the design of the central region in the KIRAMS-13 cyclotron. The magnetic field map has been obtained by a hall probe measurement.[2] The electric field map has been calculated based on the electrode design by RELAX3D.[3] Beam trajectories of radial and vertical motion are obtained from the conventional beam trajectory code with the beam traces.

CENTRAL REGION DESIGN

Figure 1 shows the design of central region of KIRAMS-13 cyclotron. The initial plot is generated by the RELAX3D. The left picture in Fig. 1 is the plot of the median plane, z=0, and the right one is that of the whole range at the dee height.

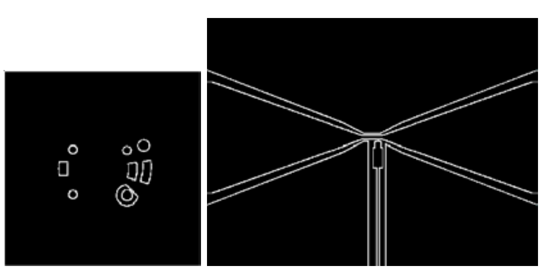

Figure 1: Design of central region of KIRAMS-13

This central region design has been obtained in a iterative way to maximize the RF phase acceptance and the angular divergency of initial ion beam in the center of cyclotron. Figure 2 and 3 shows the electric field map on the median plane, z=0, calculated with RELAX3D. In the central region, the basic mesh size is 0.25mm x 0.25mm x 0.25mm. The mesh size of the whole region is 1.00mm x 1.00 mm x 1.00 mm.

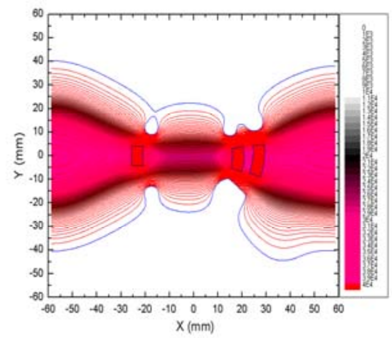

Figure 2: Electric field map in the central region

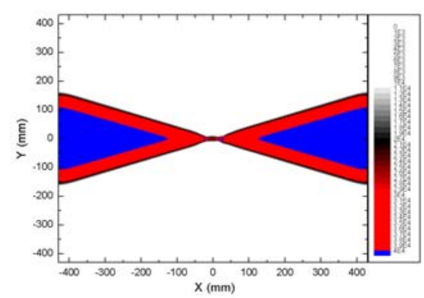

Figure 3: Electric field map in the whole region

Figure 4 shows the measured magnetic field map. In the measurement, the hall probe scans the whole range and takes the magnetic field data on the median plane with Cartesian coordinates. The RF frequency of KIRAMS-13 cyclotron is 77.3 MHz.[4] To get the magnetic field matched with RF frequency, we have scanned the coil current from 124.8 A to 158.4 A. The resultant magnetic field map with 141.6 A presents in Fig. 4.

ORBIT CALCULATIONS

With the calculated electric field map and the measured magnetic field map, beam trajectory calculation was carried out. First we check the beam traces at 3 points in the central region for the real dee voltage. The maximum energy of beams which passed first two accelerated gaps can be easily obtained from those traces. In comparison with the maximum energy of those traces and the

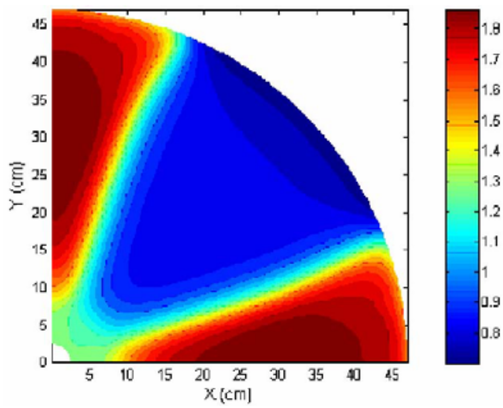

Figure 4: Measured magnetic field map.

calculated maximum energy of beams, the dee voltage at the central region can be found to be about 45 kV.

The initial beam directions with respect to the dee axis and the initial RF phases have been scanned from 30^o to 60^o and from 290 to 350, respectively. The Accepted beams to the extraction foil have angular distributions of 30-50^o and RF phase ranges of 290-330. The resultant beam trajectories are shown in figure 5.

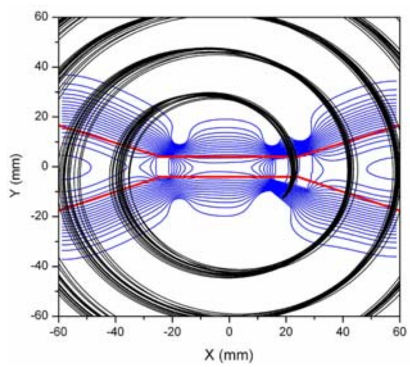

Figure 5: The resultant beam trajectories.

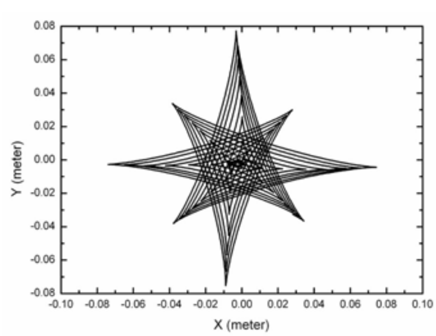

Figure 6: The positions of the orbit centers during first ten turns

The figure 6 shows the positions of the orbit centers during first ten turns for the RF phase 320 and the angular direction 40^o from the x-axis. All the other beams have the same patterns about the positions of the orbit centers.

For the calculation of the vertical motion of the whole beam trajectories, the beam traces at the puller have been used. At the entrance of the puller the vertical beam size is about 3.0 mm, and at the exit of the puller the size is about the 2.3 mm. From the entrance and the exit, the beam traces are gradually decreased. This beam traces are reconstructed by using the initial conditions of the beam that vertical displacement at the exit of slit are ±1.7mm and the direction of the beam is ±0.07 rad. In fact, the vertical slit size is ± 2.0 mm from the median plane. The results of the vertical motion during one turn are described in figure 7. The whole vertical motion will be used in the stripping extraction system.[5] In Figure 7 the length of the vertical blue lines (at the puller entrance and at the puller exit) mean the size of the vertical traces on the puller.

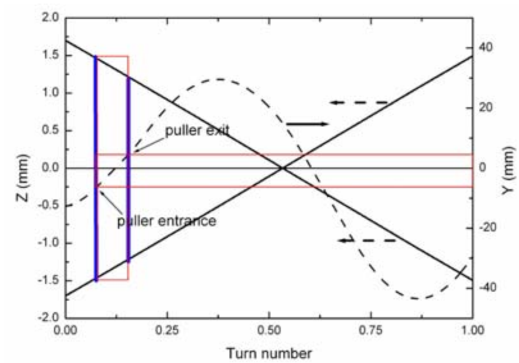

Figure 7: The vertical motion during one turn. The left axis means the vertical displacement, and the right axis the y-coordinates of the beam position.

CONCLUSIONS

The central region of KIRAMS-13 have been studied with the calculated electric potential map, the measured magnetic field map, and the beam traces on the puller and the copper tape obtained experimentally. These results of initial conditions of radial motion and vertical motion will be used for an analysis of the stripping extraction system.

REFERENCES

[1] Yu Seok Kim et al., APAC 2004, Gyeongju, March 2004.

[2] Seung Hwan Shin et al., APAC 2004, Gyeongju, March 2004.

[3] H. Houtman and C. Kost, *Proc. Of the Europhysics Conference, Computing in Accelerator Design and Operations, Lect. Notes in Physics 215* (Springer Verlag, Berlin, 1983) pp. 93-103

[4] In Su Jeong et al., APAC 2004, Gyeongju, March 2004

[5] Dong Hyun An et al., APAC 2004, Gyeongju, March 2004.