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DEVELOPMENT OF A CENTER REGION FOR NEW SUMITOMO CYCLOTRON

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Abstract

We Sumitomo Heavy Industries, Ltd. have been newly developing an AVF cyclotron which employs the superconducting magnet. This cyclotron purposes medical use, especially proton therapy fields and is most compact and high intensity among AVF cyclotrons which can accelerate to the energy for proton therapy. In this paper we report and focus on its center region. The center region consists of an ion source, a beam shaper, RF electrodes and two functional pair of centering coils that use Bz 1st harmonic (C-H coils). These components were finished manufacturing and await the component test after the assembly.

INTRODUCTION

This cyclotron is a compact cyclotron which has a 2.8 m diameter and 1.7 m height yoke, thus also that center region becomes compact and is equipped into a tiny space of it within about 0.2 m diameter [1]. Figure 1 shows external view of a whole center region. There are many small components in the center region and these components will be introduced in the following sections.

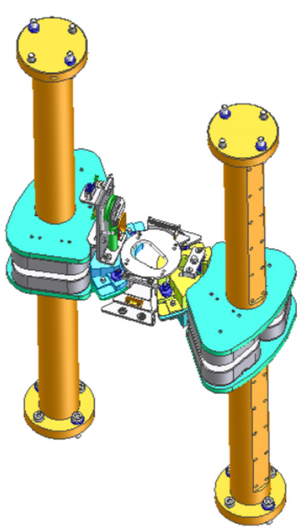

Figure 1: 3D schema of a whole center region.

COMPONENTS OF CENTER REGION

Ion Source

The PIG ion source with hot cathode is applied and located at the center of the cyclotron as an internal ion source. The structure of the ion source is classic and simple PIG ion source because of tiny space of the center region. An anti-cathode which is set against the filament and floating on the ground reflects thermal electron. As this cyclotron has 3.0 T magnetic field, the filament heated by current receives the Lorentz force strongly. It may be a problem that this force deforms the filament. To avoid the deformation, AC current heating is newly introduced into this ion source. This method made application of hot cathode PIG ion source under high magnetic field possible.

The performance of this ion source have been confirmed on our test bench (Fig. 2). The performance test was conducted under the condition that 3.2 T magnet field and static extraction. The H^+ beam current was measured about 300 μA at most (Fig. 3) [2].

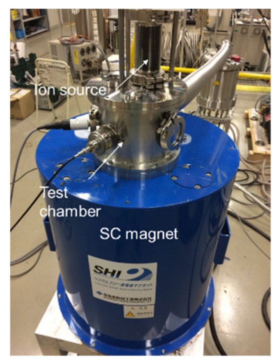

Figure 2: Test bench of ion source.

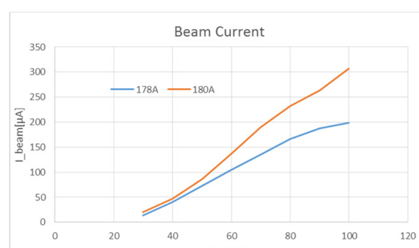

Figure 3: Extracted beam current on the test bench. This shows arc voltage vs extracted beam current in case of two type of filament current.

In case of hot cathode type PIG ion sources, filaments are supplies and must be exchanged periodically. As the mechanical driving system which evacuate the ion source from the cyclotron without broking vacuum is equipped under the cyclotron, a maintenance of ion source is possible to be performed easily and rapidly.

Dee and Counter Dee Electrode

The extraction of the proton beam from the ion source is conducted with RF electric field made by the dee electrode. The voltage of 50 kV is loaded between the puller and the ion source and the beam is extracted to accelerated orbits. Extracted beams turn around 15 mm radius and RF field

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accelerates beam gradually. Figure 4 shows actual Dee and C-Dee electrodes.

On one counter dee electrode, beam chopper (electrostatic vertical deflector) is equipped and on the other counter dee electrode, phase slits, a pair of vertical beam dumpers and a beam measurement prove are equipped.

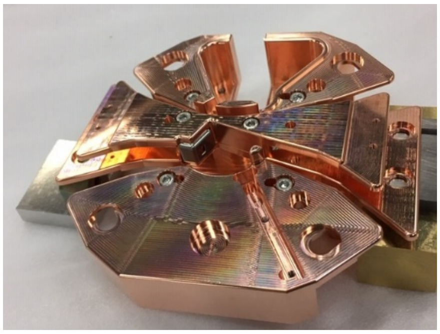

Figure 4: Pre-assembled electrode. This can be included within 100 mm diameter.

To control the beam current from the cyclotron, static electric beam chopper deflects the beam direction vertically. The beam is kicked out from 1st turn and is dumped within 4 turns before accelerated to 1 MeV (Fig. 5 and Fig. 6). Thus, there is no matter of the activation.

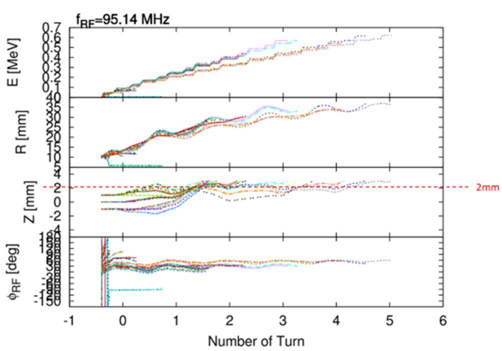

Figure 5: Parameters of deflected beam orbit till the beam dumps.

The phase slit limits the phase acceptance of extracted beam and vertical beam dumpers cut off unnecessary beam to improve the extraction efficiency of the cyclotron.

The beam measurement probe is located at 42 mm radius and can measures the beam current at the center region to perform the Smith – Garren measurement and to confirm the status of the ion source.

Central Harmonic Coil: C-H Coil

C-H coils are put on outside of the center region in the valley. Because of limited vacant space, all pairs of C-H coils are put into a pair of the valley though they are ordinarily put on each sectors in case of other cyclotrons. Though C-H coils do not form the 90° symmetric alignment but 180° symmetric one in this composition, Bz output is possible to be gained enough by organizing the output of magneto motive force (Fig. 7).

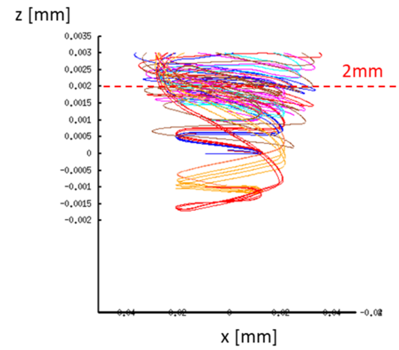

Figure 6: Schema of chopping beam.

C-H coils have been already winded around their bobbins as shown in Fig. 8 and unit test has been completed.

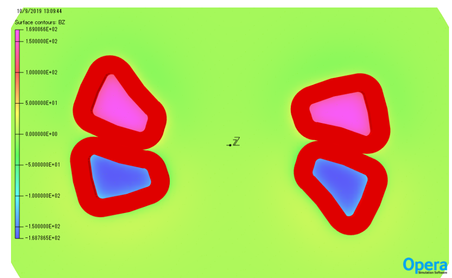

Figure 7: Bz 1st harmonic element calculation with 3D calculator. This case shows 1st harmonic condition for y-axis direction.

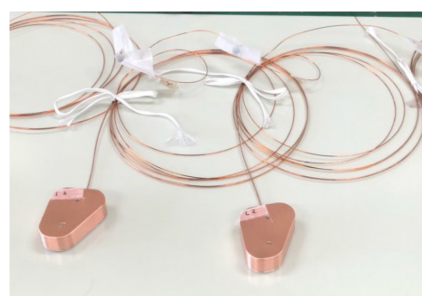

Figure 8: Processed C-H coil.

CONCLUSION

The design of the components of the center region for new Sumitomo Super-conducting cyclotron have been completed and manufacturing them have already been finished.

The component tests are going to be planed and these components will be installed into the inside of cyclotron after passing the tests and the assembly in Ehime works of ours.

REFERENCES

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