DEVELOPMENT OF A CENTER REGION FOR NEW SUMITOMO CYCLOTRON

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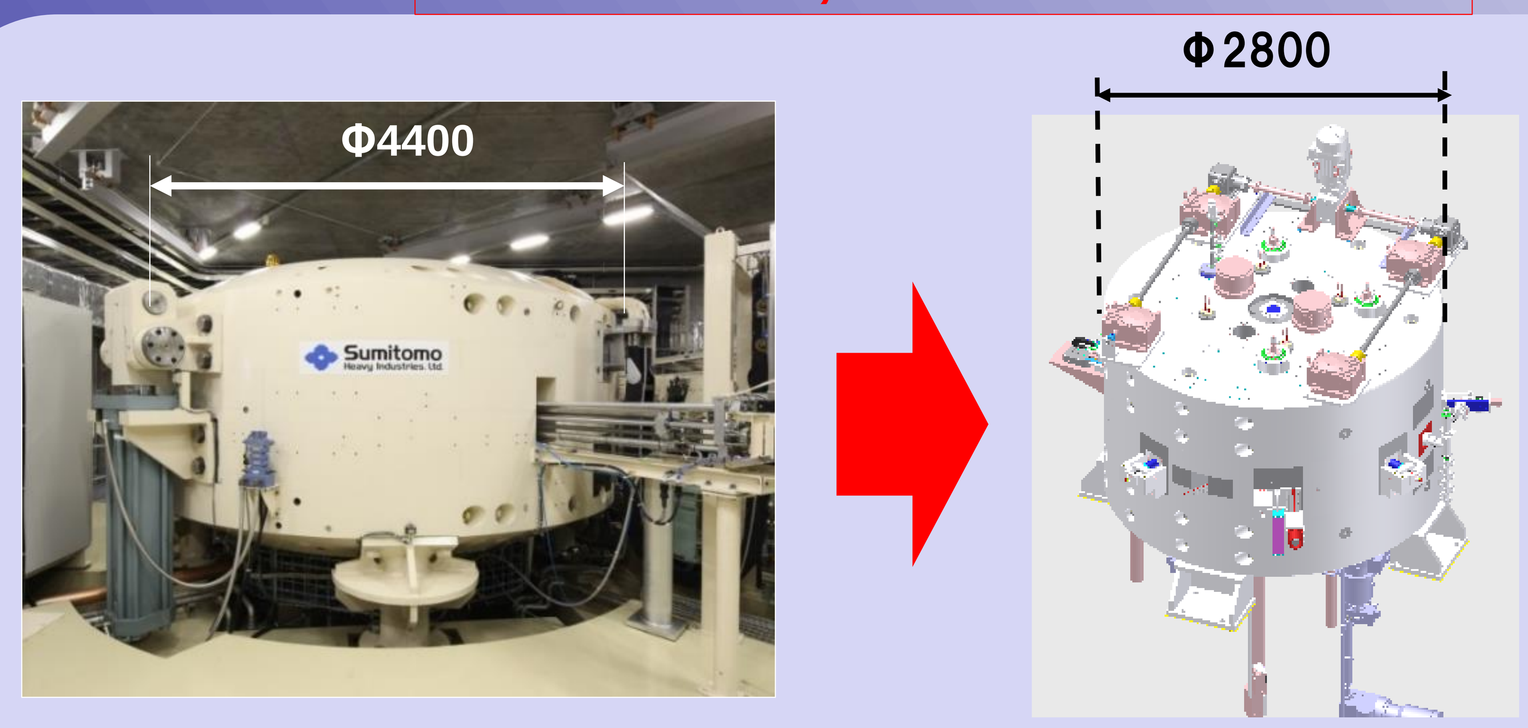
Introduction

We Sumitomo Heavy Industries, Ltd. have been newly developing an AVF cyclotron which employs the super-conducting 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 Bz1 harmonic (C-H coils). These components were finished manufacturing and await the component test after the assembly.

New SUMITOMO Cyclotron

This cyclotron is upgraded to a compact cyclotron which has a 2.8 m diameter yoke from 4.4 m diameter of conventional one (Fig. 1). Also that center region becomes compact. Figure 2 shows external view of a whole center region.

→See FRA02,: Hiroshi Tsutsui



Conventional normal conducting cyclotron

New super conducting cyclotron

Fig.1 Introduction of Sumitomo Cyclotrons

Ion Source

Fig. 7 SC magnet and test chamber

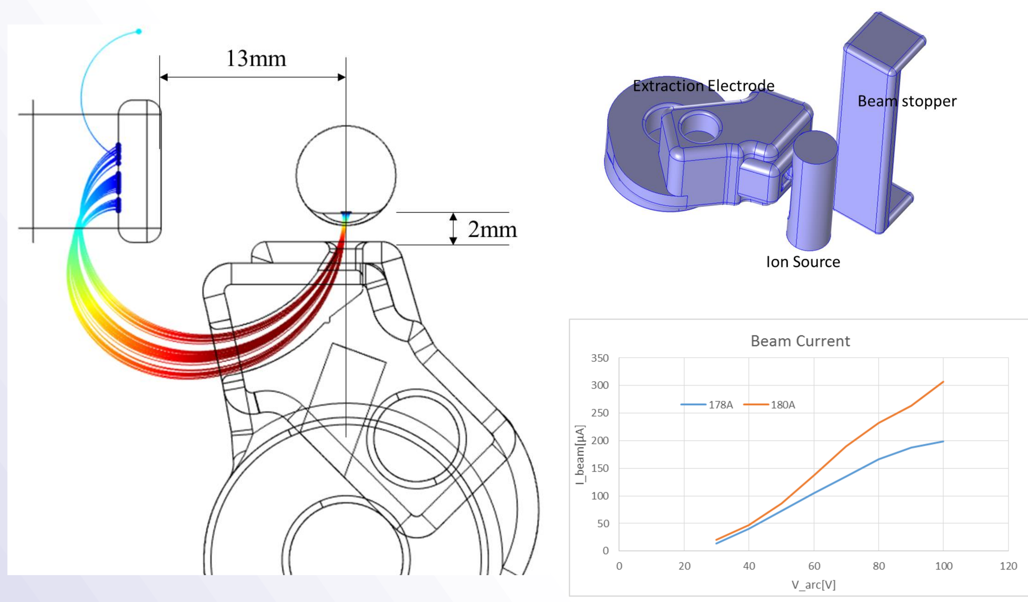


Fig. 8 The geometry of the beam transport calculation

The performance of this ion source have been con-firmed on our test bench (Fig. 7). 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.8)

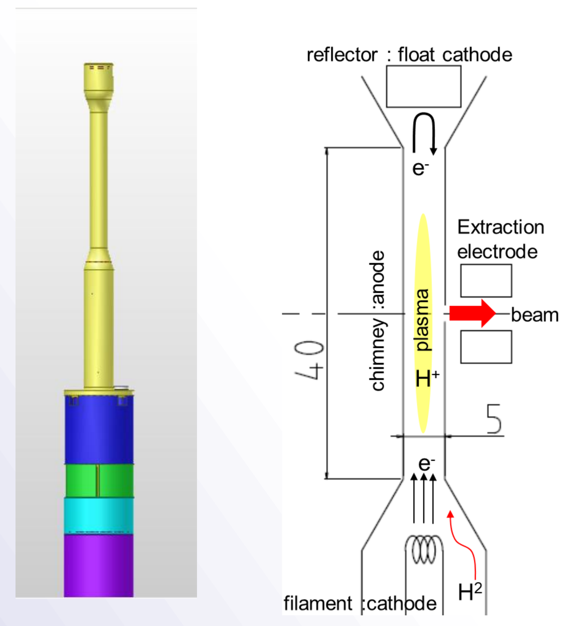


Fig. 8 Shape of Ion Source

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.

Center Region

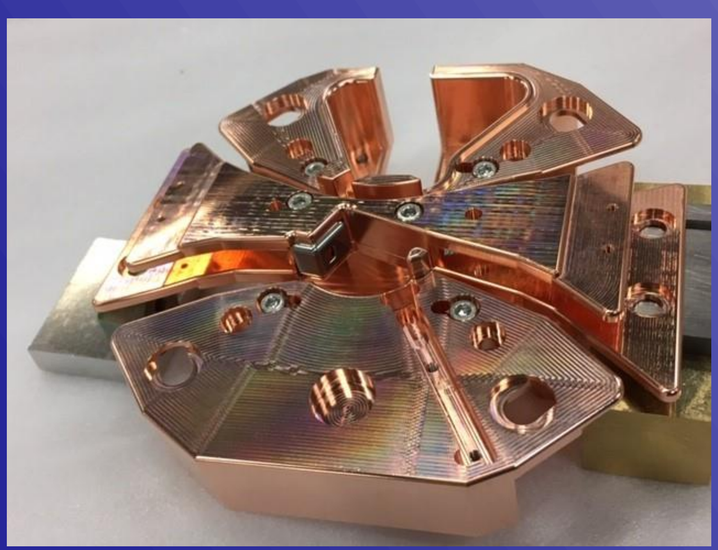


Fig.3 RF electrode in center region

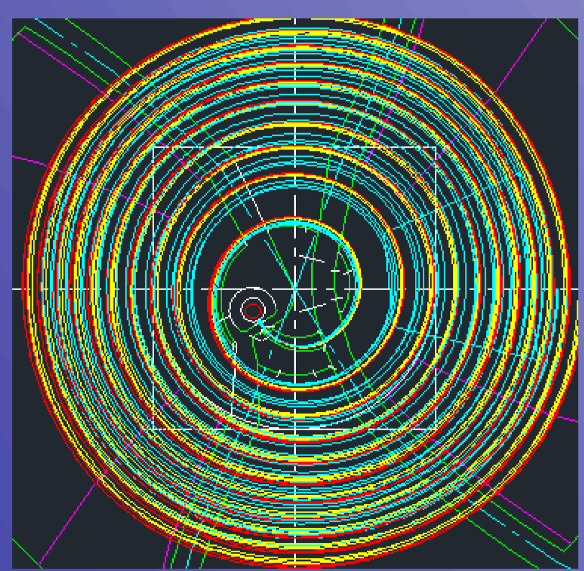


Fig.4 RF calculated orbit on electrode CAD

Fig. 3 shows actual Dee and C-Dee electrodes. The extraction of the proton beam from the ion source is conducted with RF electric field made by the dee electrode. 50 kV voltage is loaded between the puller and the ion source. Extracted beams turn around 15 mm radius and RF field accelerates beam gradually (Fig.4)

On one counter dee electrode, beam chopper (electro-static 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.

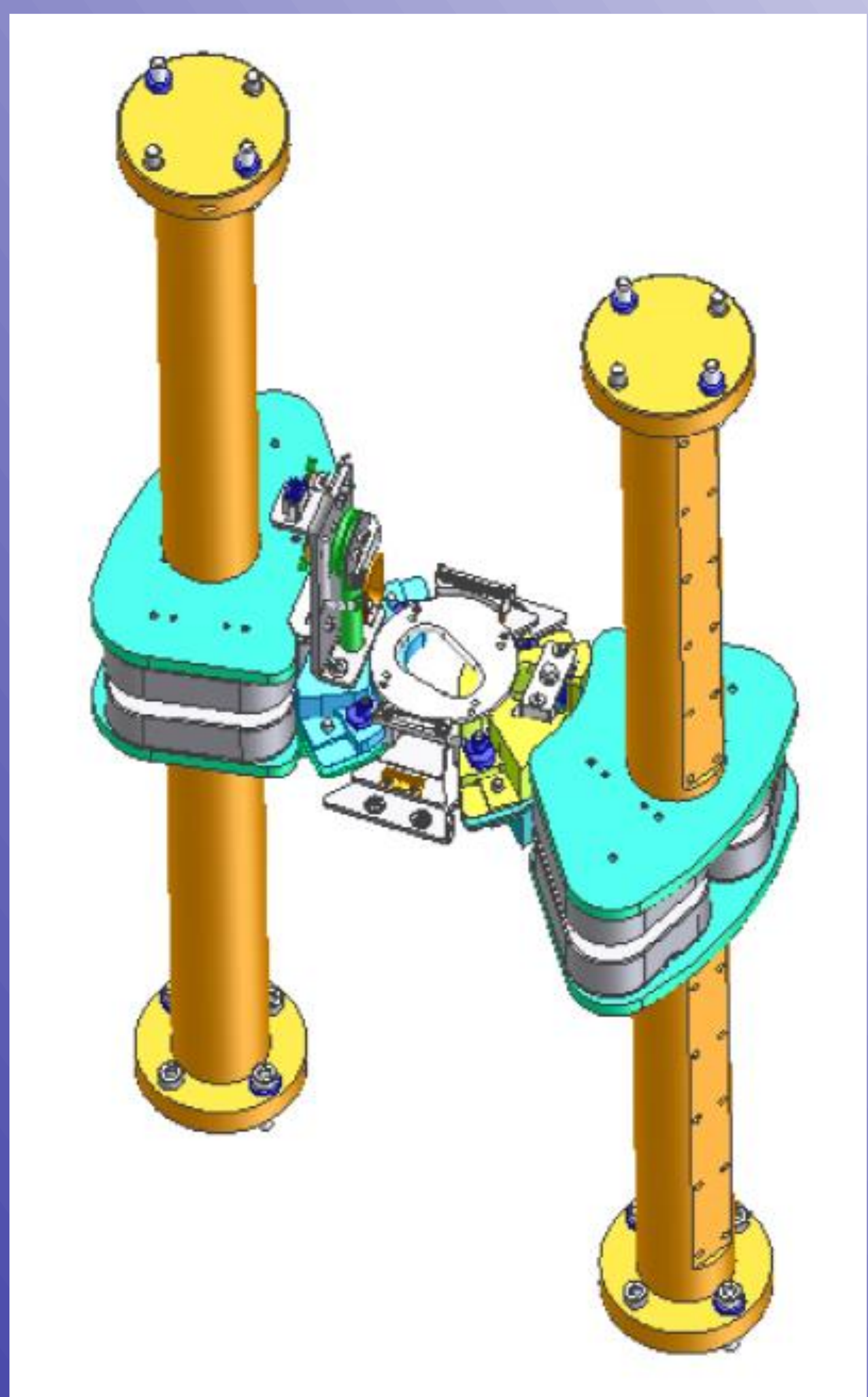


Fig.2 a whole schema of center region

Vertical Deflector : Chopper

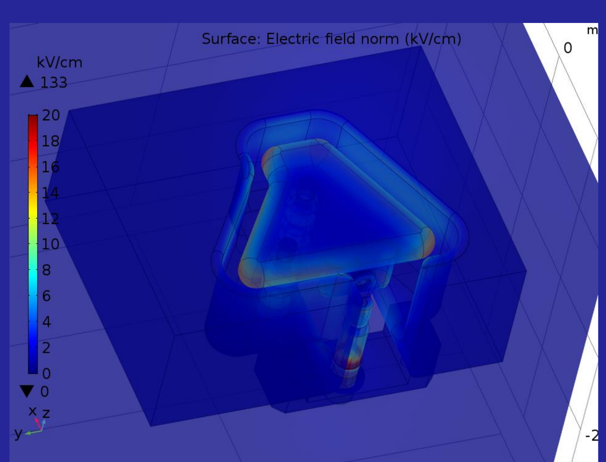


Fig.5 3D calculation of electric field

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.

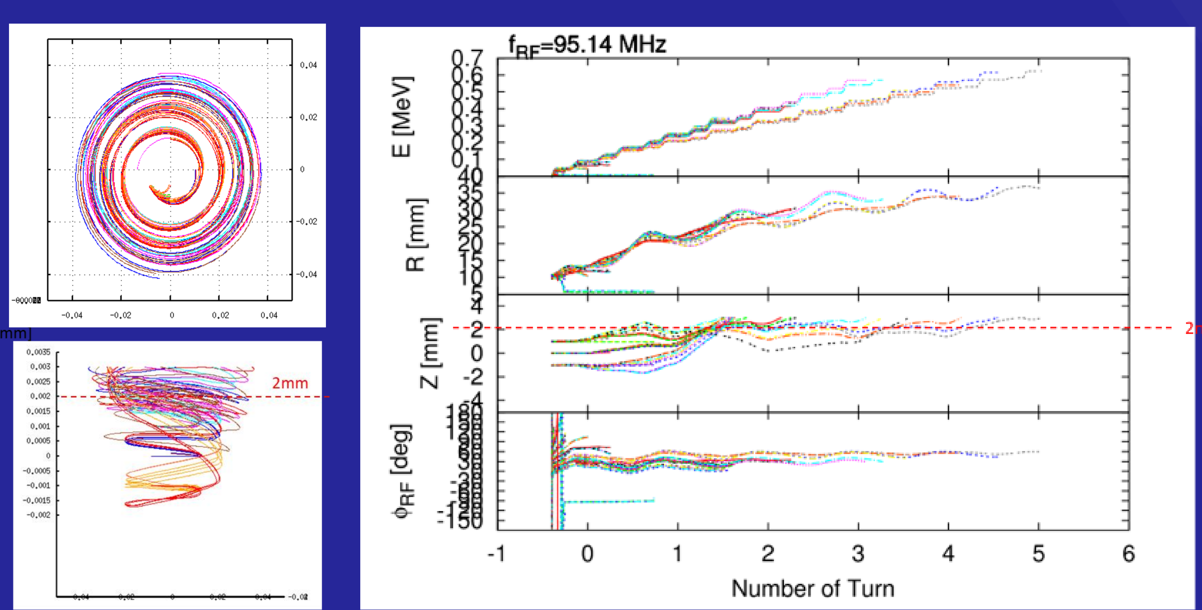


Fig.6 beam tracking for vertical deflector

Centering H coil: C-H coil

C-H coils are put on outside of the center region in the valley (Fig.9). Because of limited vacant space, all pairs of C-H coils are put into a pair of the valley.

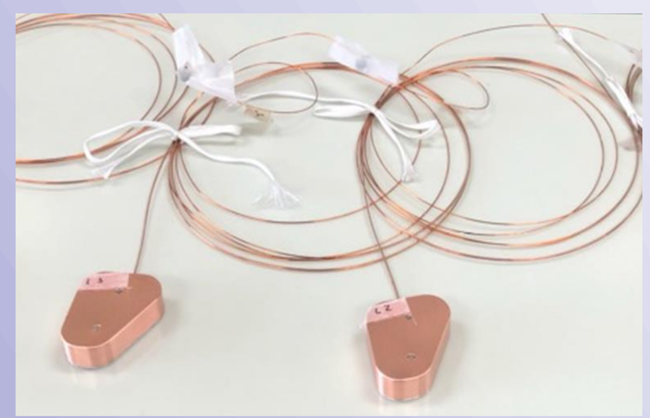


Fig.9 C-H coil

Though C-H coils do not form the 90 degrees symmetric alignment but 180 degrees symmetric one in this composition, Bz1 output is possible to be gained enough by organizing the output of magnetomotive force (Fig. 10). C-H coils have been already winded around their bobbins and unit test has been completed.

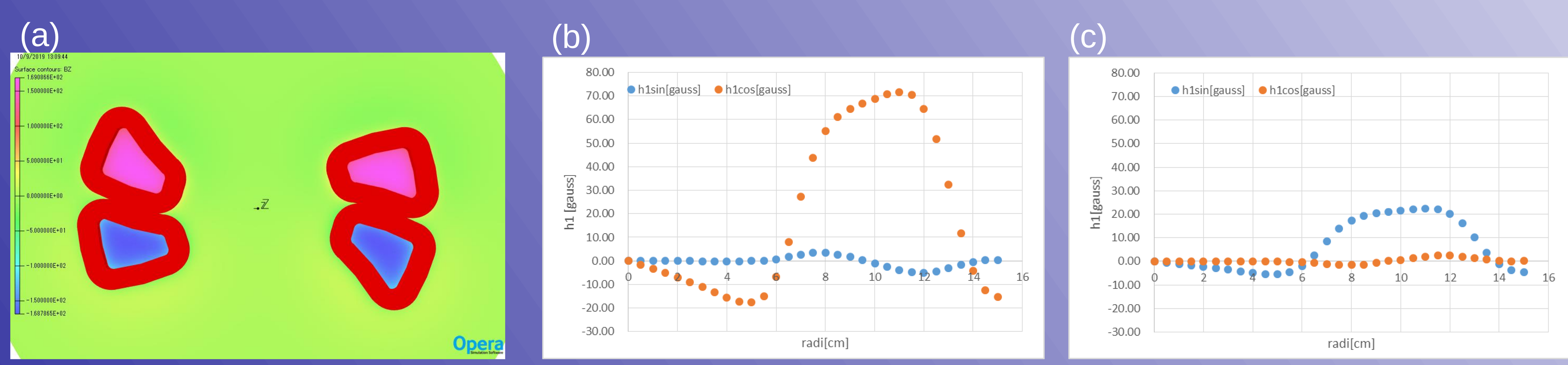


Fig.10 Calculation of Bz 1st harmonic (a) 3D calculation, (b) cosine (=x) direction, (c) sin (=y) direction

Conclusion

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