THE DESIGN OF THE MEDICAL CYCLOTRON RF CAVITY*

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Abstract

In the cyclotron, RF system as an essential component provides energy for the ions is accelerated. However, the RF cavity is the most important equipment which produced the accelerating field. According to the physical requirements, RF cavity, the resonant frequency of that is 31.02 MHz, was designed in the paper.

THE RF CAVITY DESIGN AND SIMULATION WITH CST

On the basis of the physical design requirements, the relevant physical parameters of the RF cavity have been given, as shown in Table. 1.

Table 1: Basic Parameter of the Cavity

Name	Results
Resonant Frequency	31.02
Dee Voltage	60-70KV
Dee Angle	33°
Extraction Radius	750mm
Injection Radius	35mm
Phase Stability	≤±1o
Amplitude Stability	≤5×10-4
Frequency Stability	≤1×10-6

The Structural Design of the Cavity

The cyclotron RF cavity adopts half-wave resonant structure, which of the accelerate gap is 8mm. Its structure diagram is shown in Fig. 1.

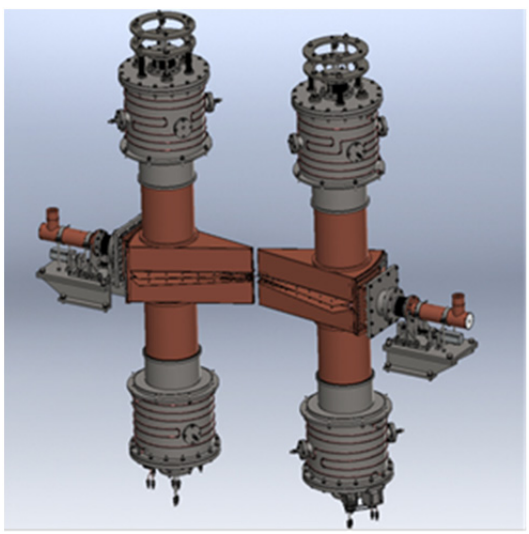

Figure 1: The cavity structure.

Simulation with CST

According to the structure parameter, the three-dimensional model is founded with CST. The simulation results show that the resonant frequency is 30.95 MHz, Q value is 7400 and power loss is 20 kW. The field distribution is shown in Fig. 2.

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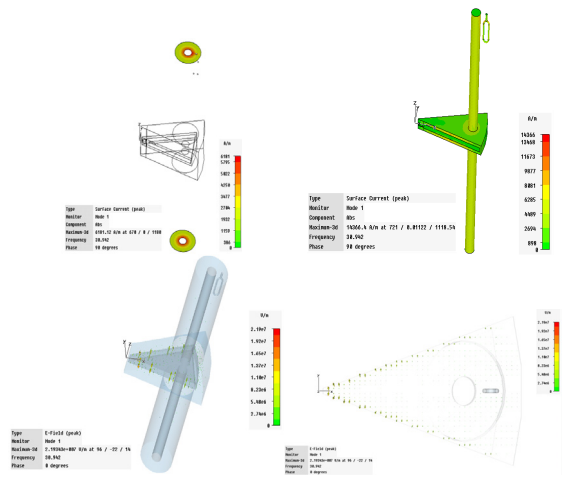

Figure 2: Electric-magnetic field and surface current distribution.

The tuning mode of the resonant cavity includes coarse-tune with short-plate and fine-tuning. The height of the short plate influences the frequency and Q value of the cavity. The curve is shown in the Fig. 3.

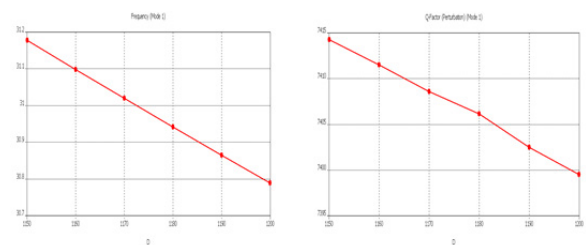

Figure 3: The change curve of the Q value and frequency.

MEASUREMENT RESULT OF THE CAVITY

Finally, the measured and commissioning results are shown in Table 1. The system has been operational for about 2 years. The system is stable and reliable.

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Table 1 The Measured and Commissioning Results

Parameter	Calculated Value	Measure Value Cavity1	Cavity2
Frequency, MHz	31.02	31.054	31.036
Q value	7400	6200	6020
S11	0.055	0.023	0.010
Fine tuner range, kHz	40	38	40
The cavity loss power/kW	70	70	70.5
Temperature rise, ℃	8	6	6.5
Shun Imped., kΩ	245	232	220

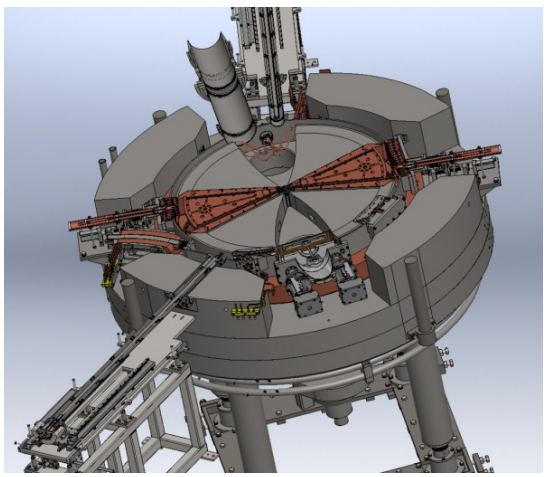

Figure 4: Cyclotron internal structure.

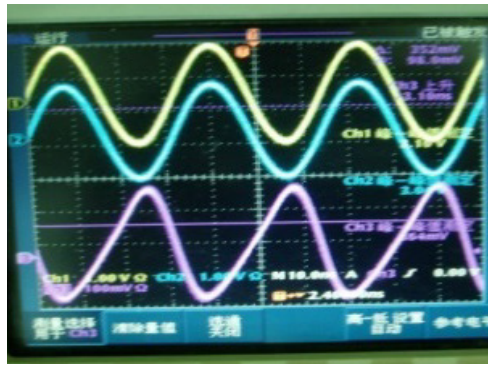

Figure 5: The cavity sampling signal.

CONCLUSION

The paper introduces the RF design of the 31.02MHz cyclotron cavity, including RF cavity simulation. At the same time, when the cavity machining had been completed in May 2013.the cyclotron RF system include 2 sets 50 kW power amplifier and LLRF as well as cavity, the RF system has finished commissioning. The cyclotron has also finished commissioning, the extraction beam has reached 10uA, to satisfy the physics demands.at present the cyclotron has been detecting for EMC and electrical safety.

REFERENCES

[1] Xianwu Wang *et al.*, “Calculation and measurement of Q-factor for RF D-circuit of cyclotron”, *High Power Laser and Particle Beams*, vol. 17, no. 12, China, Dec. 2005, pp. 1885-1887.

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