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R&D OF CEPC CAVITY*

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Abstract

CEPC will use 650 MHz cavities for the collider (Main Ring) and 1.3 GHz cavities for the Booster. Each booster cryomodule contains eight 1.3 GHz 9-cell cavities, which is similar as LCLS-II, E-XFEL and ILC. Each collider cryomodule contains six 650 MHz 2-cell cavities, which is totally new. So our R&D of CEPC cavity mainly focuses on the 650 MHz 2-cell cavity. A cryomodule which consists of two 650 MHz 2-cell cavities has began in early 2017. In this thesis, the RF and mechanical design is displayed with Helium vessel. Besides, multipacting is analyzed. In order to achieve high Q, N-doping is also studied [1, 2].

INTRODUCTION

Baseline layout and parameters for CEPC Main Ring SRF system have been public [3]. There're two SRF sections in total, and each one has two SRF stations. There're 14 cryomodules per station, which consist of six 650MHz 2-cell cavities each. So there're 336 650MHz 2-cell cavities in total. RF and Mechanical design of these cavities have been completed. And fabrication of prototype cavities would start soon. The vertical test goal is 4E10@22 MV/m, while the horizontal one is 2E10@16 MV/m. Both these targets are extremely high to reach, so N-doping would be adopted. In recent years, it has been proposed and proven to increase *Q* of superconducting cavity obviously, which lowers the BCS surface resistance. It was discovered in 2012 at FNAL, which has been promoted by FNAL, JLAB and Cornell together. Since 2013, there have been over 60 cavities nitrogen doped in USA laboratories. After N-doping, *Q* of 650 MHz single-cell cavities for PIP-II increased to $7*10^{10}$ at E_{acc}=17 MV/m, which doubled from no N-doping, as Figure 1 [4].

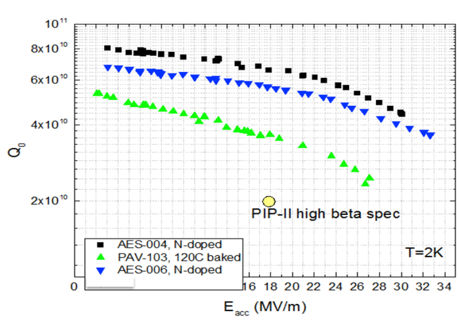

Figure 1: Vertical test results of 650 MHz high beta single-cell cavities for PIP-II.

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RF DESIGN OF 650 MHz 2-CELL CAVITY

The goal of RF design is to minimize B_{peak}/E_{acc} and E_{peak}/E_{acc}, maximize R/Q and k (cell to cell coupling). Elliptical cavity is characterized by different geometrical parameters, as Figure 2. The values of Riris, b/a and alpha have been optimized to achieve this goal.

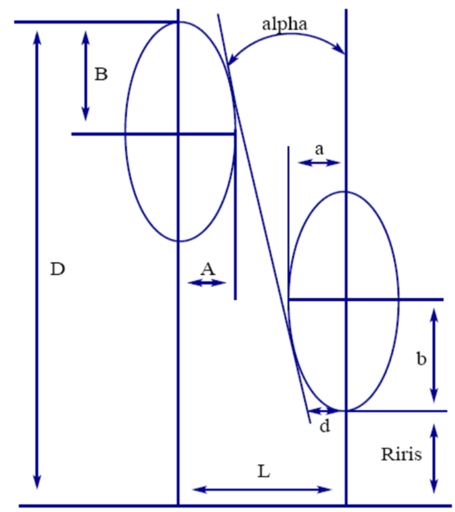

Figure 2: Profile of cell shape.

Larger Riris results to larger k and easier HOM damping, but increases B_{peak}/E_{acc} and E_{peak}/E_{acc}, as Figure 3.

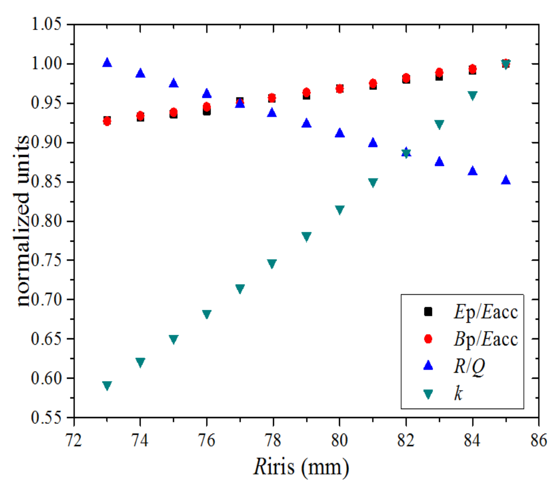

Figure 3: Optimization of Riris.

The iris ellipse ratio (b/a) is determined by the local optimization of the peak electric field, as Figure 4.

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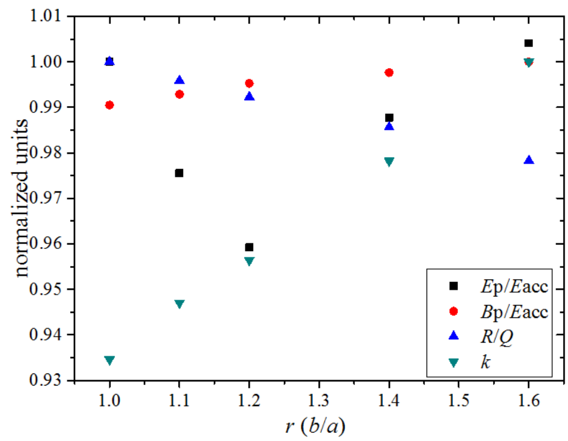

Figure 4: Optimization of b/a.

Smaller alpha decreases B_{peak}/E_{acc}. Meanwhile k increases, as Figure 5.

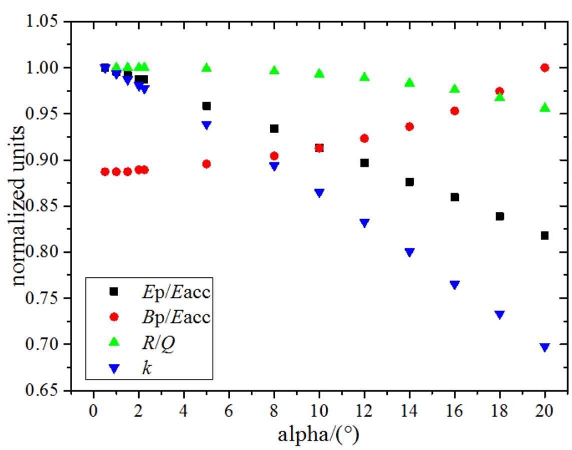

Figure 5: Optimization of alpha.

After the optimization above, the final RF parameters are listed in Table 1.

Table 1: Main Parameters of 650 MHz 2-cell Cavity

Parameters	Value	Units
D	204.95	mm
Riris	78	mm
b/a	1.1	
alpha	3.2	degree
R/Q	105.5	Ω
G	284	Ω
E_{peak}/E_{acc}	2.38	
B_{peak}/E_{acc}	4.17	mT/(MV/m)
k	3.05	%

MECHANICAL DESIGN OF 650 MHz 2-CELL CAVITY

The mechanics of cavity is analyzed with Helium vessel to minimize the Lorentz force detuning (LFD), df/dp and the peak stress. Thickness of cavity wall is adopted as 4 mm, and stiff rib 3 mm. After optimization, final mechanical design has reached the requirements. Detailed is introduced in another article [5]. The cryomodule consists of 2 cavities has started in early 2017, as Figure 6.

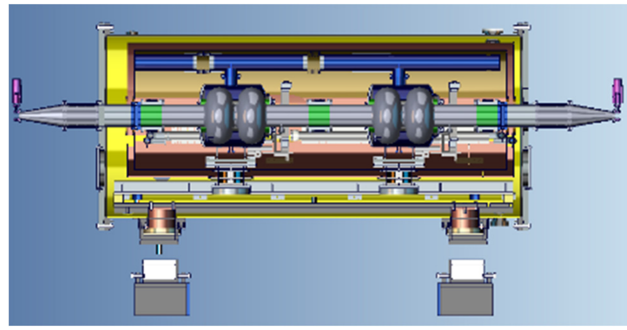

Figure 6: A cryomodule with two 650 MHz 2-cell cavities inside.

N-DOPING RESEARCH AT IHEP

Firstly, niobium samples were nitrogen doped at OTIC, as Figure 7 [6, 7]. The furnace in Figure 7 is equipped with two cryo-pumps in order to keep clean, which is key for N-doping. Different methods were used to achieve that nitrogen enters into niobium surface and exists for long. To verify that, experiments of secondary ion mass spectrometry (SIMS) were done, as Figure 8.

Figure 7: Furnace for N-doping at OTIC.

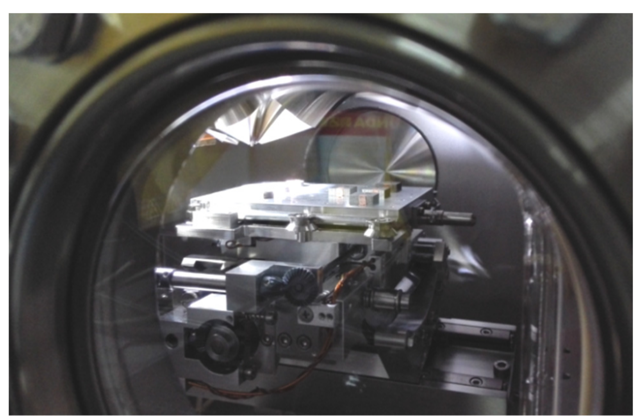

Figure 8: Nb samples during SIMS experiment.

Results of SIMS is shown as Figure 9 and Figure 10. After N-doping, intensity of N has increased obviously, as well as NbN. Further experiments and research are undergoing.

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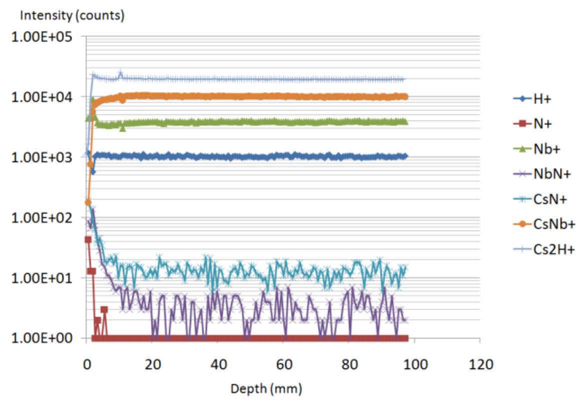

Figure 9: SIMS results before N-doping.

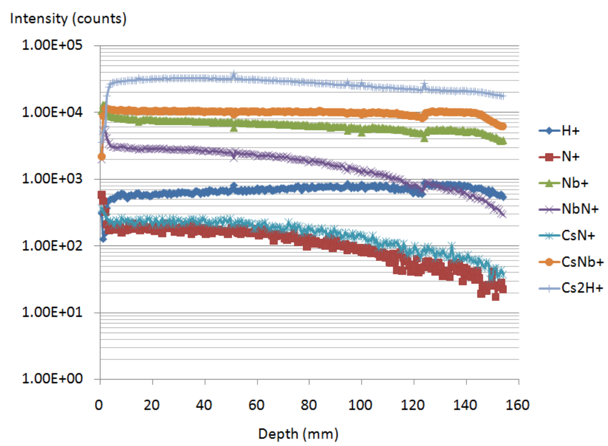

Figure 10: SIMS results after N-doping.

CONCLUSION

The R&D of CEPC cavity mainly focuses on 650 MHz 2-cell cavity. A cryomodule with two cavities has been started [8]. RF and mechanical design have been completed for the cavity. In order to achieve high Q, N-doping research is undergoing, which would be adopted in future.

ACKNOWLEDGEMENT

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