HIGH HOM DAMPING STRUCTURE STUDY FOR CEPC *

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Abstract

Both large circular collider such as CEPC and high current ERL facility need high HOM damping superconducting cavity. The slotted cavity is an option for such applications. It has three slotted waveguides which can highly damp the HOM and extract high HOM power out. However, the HOM absorbers for such facility are usually put outside of the cryomodule to decrease the influence of HOM power on the cryogenic system. Large slot waveguide need to make smaller transition structure to adapt this situation. A rectangular waveguide to coaxial waveguide structure was designed to the slotted cavity. In this paper, we will show the cavity HOM damping design scheme with this structure.

INTRODUCTION

Higgs particle was discovered on the Large Hadron Collider at CERN finally [1, 2]. It is depending on the powerful collider which can accelerate the proton particles to hundreds of GeV. For the future large circular colliders, a large amount of superconducting cavity will be needed to accelerate the particles to the final energy and compensate the synchrotron radiation power. High order mode extracting and damping is the key problem of the cavity in such colliders with a high beam current. Both the FCC-ee and CEPC need to develop superconducting cavity with high order mode (HOM) damping, high accelerating efficiency and low cost.

Energy Recovery Linac (ERL) is a green way to save energy and provide high beam current which can accelerate up to ampere class beam current with a limited power consuming. However, the beam current of the ERL is limited by the beam break-up threshold (BBU) which is depending on the HOM damping effect. Several ERL projects are under developing with a final energy from several GeV to tens of GeV. It was used as electron cooling, light source and collider etc..

a series of cavities was developed for such projects with high HOM damping. Slotted cavity is an option of such applications of future colliders and ERL as its intrinsic behaviour of extremely high HOM damping effect. Since there are several cavities such as four or eight in one cryomodule, a compact design is a favourable choice. In this paper we will show a cavity HOM damping scheme with rectangular waveguide to coaxial waveguide structure.

METHOD

CEPC is a large circular collider with 54.4 km circumference. In the main ring, 650 MHz 5-cell cavity will be employed to compensate the energy loss by synchrotron radiation. Four 650 MHz 5-cell cavities will be put in one cryomodule. 384 cavities will be put on eight RF stations. Figure 1 shows the layout of RF stations. There are 8 arcs and 8 straight sections. Four straight sections, about 1 km each, are for the interaction regions and RF; another four, about 850 m each, are for the RF, injection, beam dump, etc.

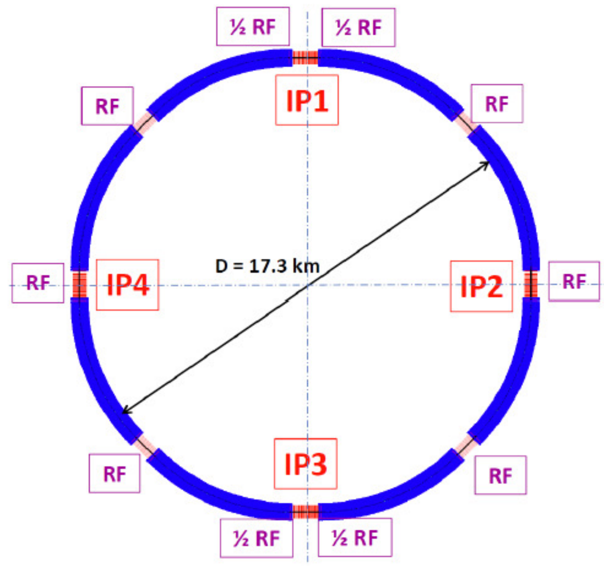

Figure 1: CEPC layout.

The impedance for the CEPC main ring is limited by

$$R_L^{thresh} = \frac{2(E_0/e)\nu_s}{N_c f_L I_0 \alpha_p \tau_z} = \frac{28.7M\Omega\cdot GHz}{f_L(GHz)} \quad (1)$$

$$R_T^{thresh} = \frac{2(E_0/e)}{N_c f_{rev} I_0 \beta_{x,y} \tau_{x,y}} = 9.77M\Omega/m \quad (2)$$

It is a little stringent for the elliptical 5-cell cavity, especially on the dipole threshold [3]. Slotted cavity has a very low Q for HOMs [4]. To absorb the high HOM power in the room temperature. a compact HOM extraction structure is more favourable to use.

Fig. 2 shows a 3-cell slotted cavity. It has three waveguide ports and two of them will be connected to HOM coupler. As the 650 MHz superconducting cavity can be scaled from 1.3 GHz superconducting cavity and the HOM damping of slotted cavity will not be affected by cell numbers. We shows a 1.3GHz design which can be scaled to 650MHz.

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Figure 2: Niobium slotted cavity.

Figure 3 shows the extraction scheme by using a rectangular waveguide to coaxial waveguide structure to absorb the main dipole. A waveguide at the beam pipe is used to absorb the monopole power. Figure 4 shows the dimension parameters of the extracting structure. The main parameters are given in table 1. The parameters are optimized to extracting the main dipole out from the cavity.

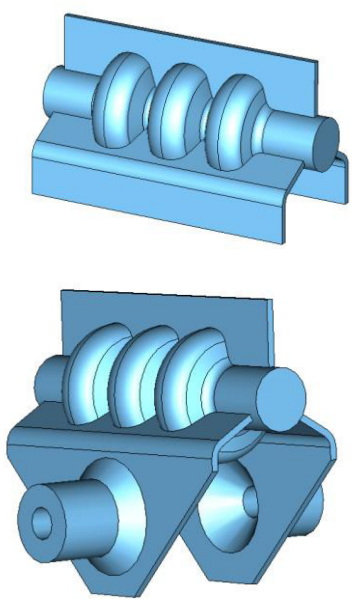

Figure 3: The slotted cavity with HOM extracting structure. Up: slotted cavity with rectangular waveguide (RW). Down: slotted cavity with rectangular waveguide to coaxial waveguide structure (WC).

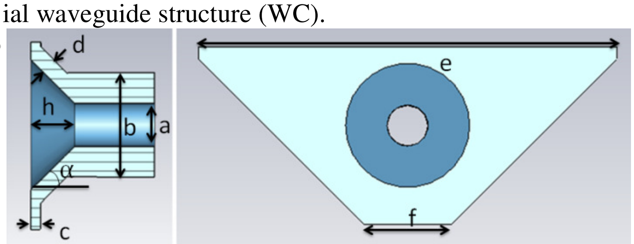

Figure 4: The dimension parameters of the transition structure.

Table 1: The Dimension Parameters of the Transition Structure

Symbol	Length (mm)
a	50
b	120
c	11
d	18.4
e	506.2
f	106.2
h	50
α (degree)	45

Table 2 shows the main dipole Q external at the coaxial waveguide port shown in Fig. 5. The dipole external Q is still at a low level by using the rectangular waveguide to coaxial waveguide structure. Fig. 5 shows the S parameter of the transition structure. The S21 is about -3dB to -10dB at the frequency of TM110 mode. It is larger than -15dB under 4 GHz.

Table 2: Most Dangerous Dipole Mode

Mode	Frequency (GHz)	R/Q (Ω)	Qe of WC
TM110	1.803	14.8	128
TM110	1.841	22.2	54.3
TM110	1.853	4.97	911.1

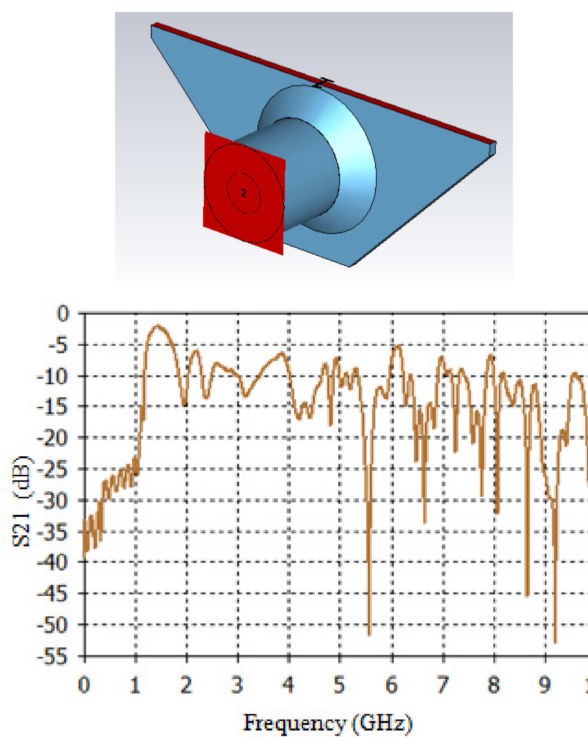

Figure 5: S21 (down) of the transition structure (up).

CONCLUSION

To damp the high order mode of CEPC, we developed a high efficiency HOM extracting structure of rectangular waveguide to coaxial waveguide. The Q external of the most dangerous mode were compared between the rectangular waveguide and the transition structure. It shows that the transition structure is good to use for the HOM damping.

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