

SOME CHARACTERISTICS OF THE HIGHER-ORDER-MODES IN THE PHOTON FACTORY ACCELERATING CAVITY

MASAAKI IZAWA, SHUICHI TOKUMOTO, SHYOGO SAKANAKA
and HISASHI KOBAYAKAWA

Photon Factory, National Laboratory for High Energy Physics,
Tsukuba-shi, Ibaraki, 305 Japan

Abstract The coupling between the higher order mode of the cavity and a resonance of the tuner structure, which has important influence on the characteristics of the cavity mode, is discussed.

INTRODUCTION

Four single-cell accelerating cavities¹ are operated in the Photon Factory storage ring. Each cavity has a tuning plunger to control the resonance point of the accelerating mode (500 MHz). The plunger together with its housing makes a coaxial structure, thus, the tuner has coaxial mode resonances. The coupling between the cavity mode and the tuner resonance was observed. Since such coupling changes the characteristics of the cavity mode which is one of the causes the coupled-bunch instability², it was investigated in detail. The results are presented.

COUPLING BETWEEN CAVITY MODE AND TUNER MODE

Figure 1 shows the resonance frequency dependence of the TM₀₁₁ mode of the cavity on the position of the plunger (referred to as the tuner position in this paper, which is defined as the intruded length from the surface of the cavity inner wall). The resonance frequency of this mode is expected to decrease monotonously with inserting the tuning plunger. However, as illustrated in the figure, it has a minimum value at some tuner position. Moreover, a rapid decrease of the Q-value with increase of the tuner position was also observed. The same behavior of the resonance frequency was observed with a test bench cavity which is the same type as the one operating in the ring, as shown in Fig. 2 (curve B). The data of curve A in the same figure was obtained when half of the extra space due to the shape

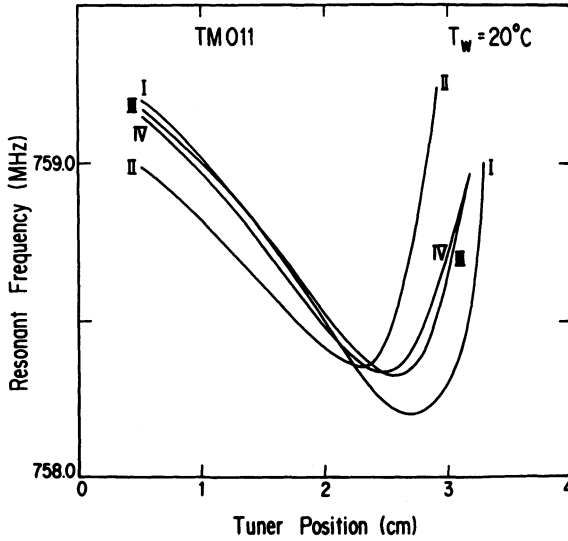


FIGURE 1 Resonance frequency dependence of TM011 mode on tuner position. I-IV represent the cavity number.

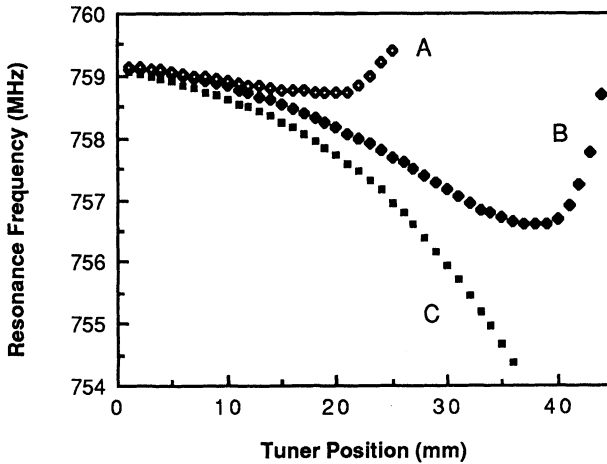


FIGURE 2 Resonance frequency dependence of TM011 on tuner position measured with a test bench cavity.

of the vacuum flange (Fig. 3) was filled up with metal. On the other hand, curve C was obtained when whole of the extra space was filled up. Thus, it is clear that the unexpected behavior of the resonance frequency of the TM011 is related to the tuner structure. Figure 4 shows the output of SUPERFISH³ by

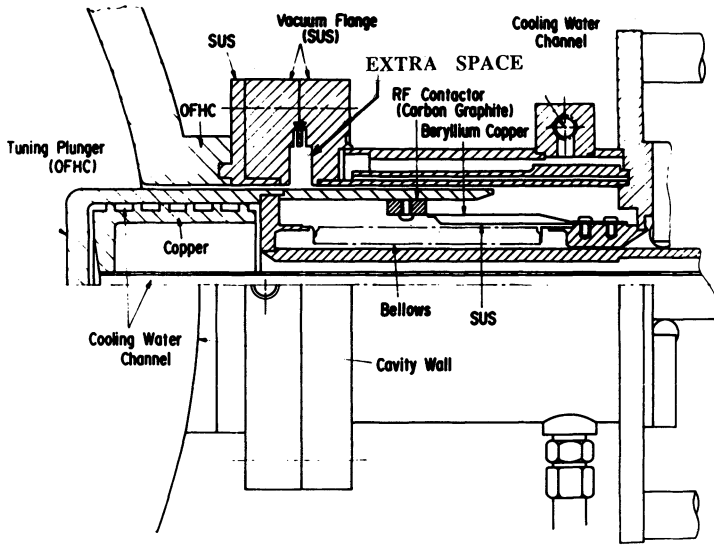


FIGURE 3 Cross sectional view of tuner.

which the coaxial mode resonance ($\lambda/2$ resonance) of the tuner for two different structures are computed. As shown in Fig. 4, when the tuner has the extra space in its housing, its resonance frequency is around 700 MHz which is close to that of TM₀₁₁, while it becomes around 1000 MHz when the extra space is removed. Also, with increasing the tuner position, the resonance frequency of this coaxial mode becomes high since the length of the coaxial part becomes short. The measured frequency variation of the

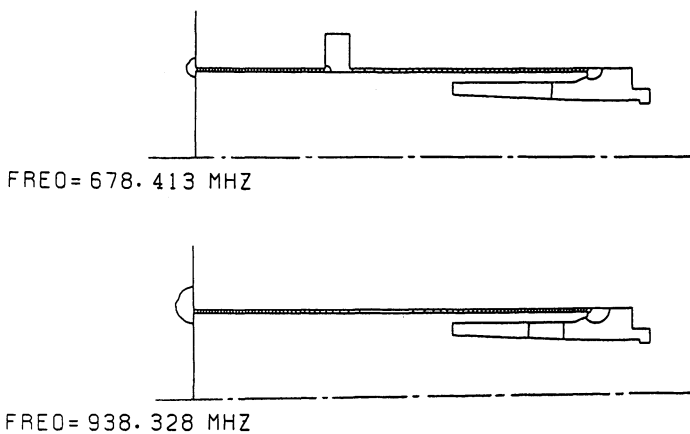


FIGURE 4 Results of computation of tuner mode by SUPERFISH.

TM011 is explained as follows. If the TM011 does not couple the tuner mode, its resonance frequency coincides with that of the tuner mode at some tuner position. In this case, the frequency dependence of the TM011 and the tuner mode on the tuner position would be such as shown schematically with the straight lines in Fig. 5. However, since there exists the coupling between them, they can not have the same resonance frequency, as well known, but split into two different frequencies around the crossing point. In fact, the measured data plotted in Fig. 5 shows an avoided crossing, thus, the minimum of the curve shown in Fig. 1 appears.

The tuner and its housing are partly made of stainless steel. Carbon graphite is also used as RF contactor. Therefore, the Q-value of the tuner resonance is much lower than the cavity mode. This is the reason why the rapid decrease of Q-value was observed when the plunger was deeply inserted where the TM011 has no longer the character of the cavity mode but the tuner mode.

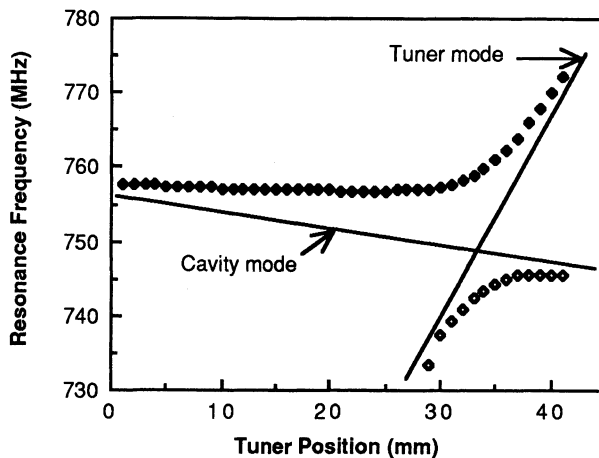


FIGURE 5 Resonance frequency dependence of TM011 on tuner position measured with cavity II for wider frequency range than Fig. 1.

IMPROVEMENT OF TUNER STRUCTURE

As mentioned above, if the extra space in the tuner port is removed, it is expected that the tuner mode does not couple the TM011 since it has the resonance frequency too different to couple the TM011. However, the cavity has the TM111 mode with the resonance frequency of about 1070 MHz, which is known to be one of the causes of the horizontal instabilities².

Its resonance frequency is close to that of the tuner without the extra space in the port. With considering the field pattern of the TM111, it has possibility to couple the tuner mode. In fact, after removing the extra space of the tuner port⁴, the coupling between the TM111 and the tuner mode was observed as shown in Fig. 6 though the coupling between the TM011 and the tuner disappeared as shown in Fig. 7.

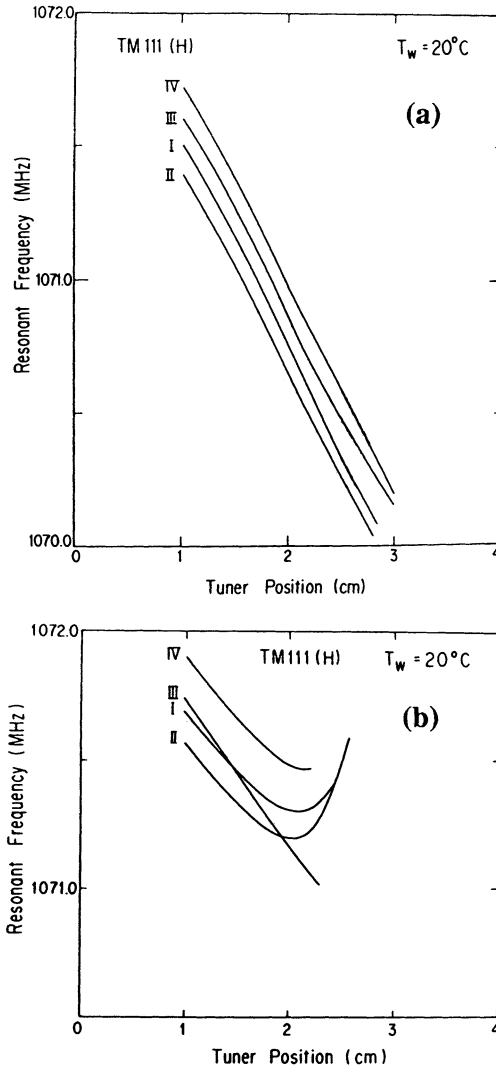


FIGURE 6 Resonance frequency dependence of TM111 on tuner position. (a) : before improvement of the tuner port, (b) : after improvement.

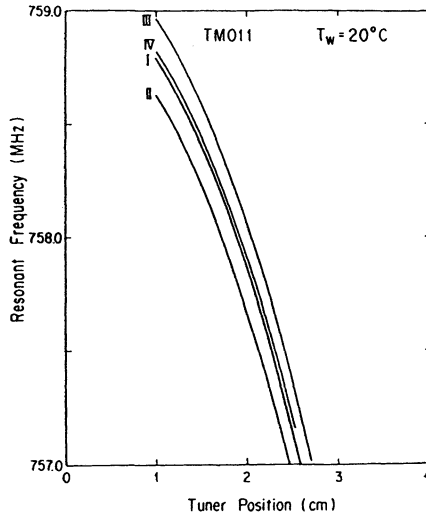


FIGURE 7 Resonance frequency dependence of TM011 on tuner position measured after the improvement of the tuner port.

The cavities are operated normally at the tuner position of around 2 cm. In Figs. 1, 6 and 7, One can see the difference of the resonance frequencies of these cavity modes at this tuner position between before and after the improvement. Note that the difference is caused by changing the resonance frequency of the tuner structure. During summer shutdown in 1987, we tried a new method to avoid the coupled-bunch instabilities due to the higher-order-modes by carefully trimming their resonance frequencies so as not to coincide with the frequency of the coupled-bunch mode^{4,5,6}. Understanding the coupling between the cavity mode and the tuner mode was very important to carry out the frequency trimming.

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