NEW POSSIBLE CONFIGURATION OF 3.9 GHz COUPLER*

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Abstract

The LCLS-II superconducting accelerator supposedly will use 3.9 GHz (3-d harmonic) superconductive cavities. A new possible configuration of 3.9 GHz main coupler is presented in the paper. This configuration contains two coaxial ceramic windows, a cold and a warm one. Inner conductors of windows are connected through the capacitive gap and have no mechanical no thermal contacts. It allows to avoid using bellows and thus avoid the problem of heating and cooling. The windows have shields protecting shields against the electron, and this prevents the window ceramics from charging. Results of computer simulation of the new coupler are posted.

INTRODUCTION

The main coupler is the key element of a superconducting accelerator. The purpose of the coupler is to transmit RF power from a room temperature RF source to a cold superconducting cavity. The coupler must have a small ohmic losses in order to prevent a cold cavity from heating. At the same time, the coupler should have small thermal conductivity in order to minimize the heat flow from a room temperature environment to a superconductive cavity. Common elements of a coupler are bellows. There are two major purposes of bellows usage. The first one is to compensate thermal shrinking-expansion and movements of accelerator parts. The second one is to reduce the thermal conductivity of the coupler's conductors. However, utilizing the bellows has several drawbacks. In a high power coupler, the bellows themselves may reach high temperatures due to their low thermal conductivity and the ohmic losses. This is especially true for the inner conductor of the coaxial coupler. The inner conductor has a smaller size, hence its losses density is higher. In addition, bellows make the coupler more expensive. Moreover, if the coupler includes two windows, it is necessary to provide a reliable and demountable electrical contact between the two parts of inner conductor. We suggest a new approach which eliminates the drawbacks described above.

We propose using a capacitive gap instead of bellows. The gap has no thermal conductivity (except thermal radiation, which is small). There are no ohmic losses, no electrical or mechanical contacts, no high temperatures, and there is no need to cool it. The gap tolerates displacements that can compensate for the thermal shrinking-expansion. We used this approach to design the 3.9 GHz coupler. The structure of the coupler is presented on Figure 1. This coupler still has bellows, but all of them are placed in the air, room temperature side. It reduces requirements to bellows and simplifies the cooling. The design includes the shields in front of windows to protect the ceramics from charged particles coming from the cavity. The shields also match the windows.

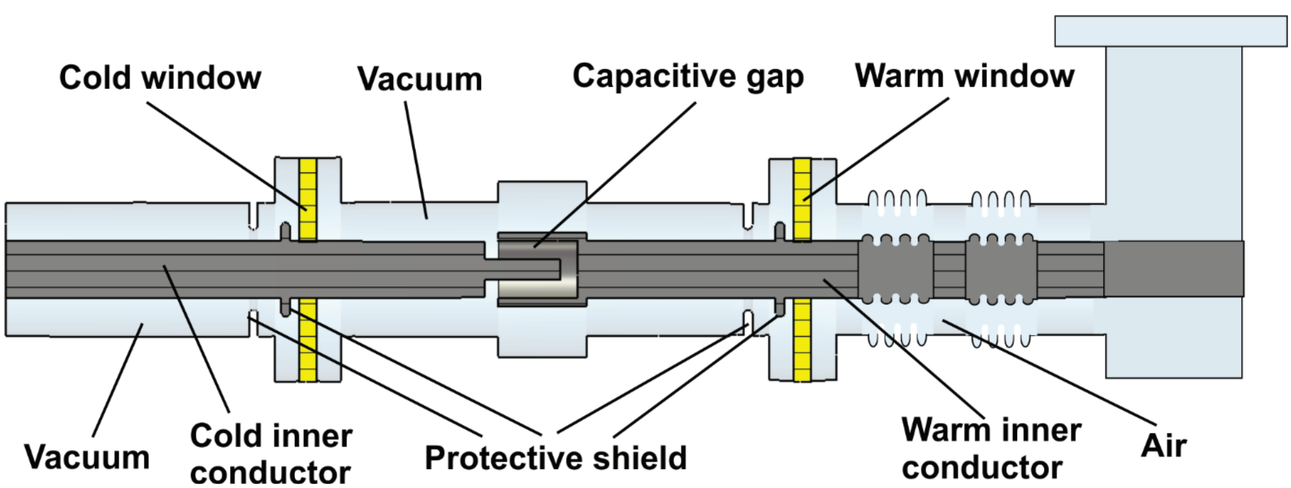

Figure 1: Structure of the coupler. The coupler contains two coaxial ceramic windows, a cold and a warm one. The inner conductors of windows are connected through the capacitive gap, i.e. have no mechanical contact.

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PASSBANDS

Gap (see Figure 2) has a wide passband of about 1 GHz (~ 25%) for S11 < -20 dB level. The passband is not sensitive to conductors' displacements. The graph on Figure 3 demonstrates these low sensitivities. A conductor can move +2 mm ÷ -5 mm in Z direction and 1.5 mm in Y, X directions (radius direction) keeping S11 ≤ 30 dB.

Each window with protecting shields is matched. The distances between the windows and the gap were chosen to provide maximum the bandwidth. Figure 4 shows the geometry of two windows and the gap. Figure 5 presents the passband. The passband is about 350 MHz (~ 9%) at level -20 dB..

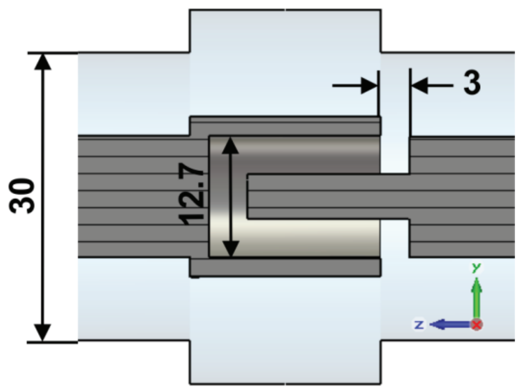

Figure 2: The geometry of the capacitive gap.

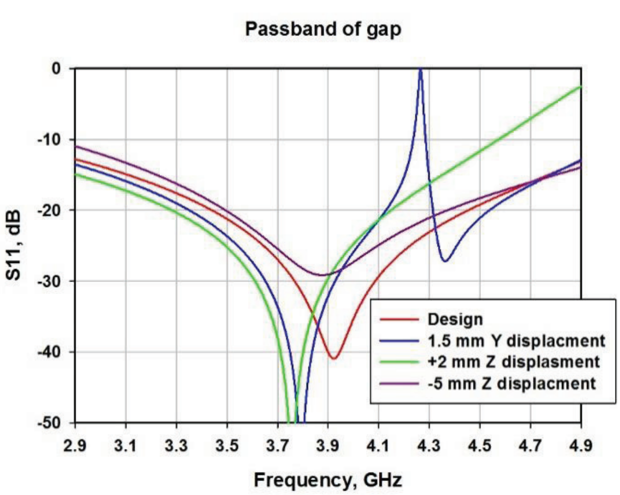

Figure 3: The passband of the gap. Passband width ~ 1 GHz. Passband is not sensitive to the conductors' displacements.

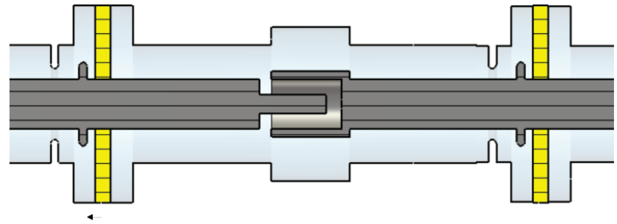

Figure 4: Two windows and the gap.

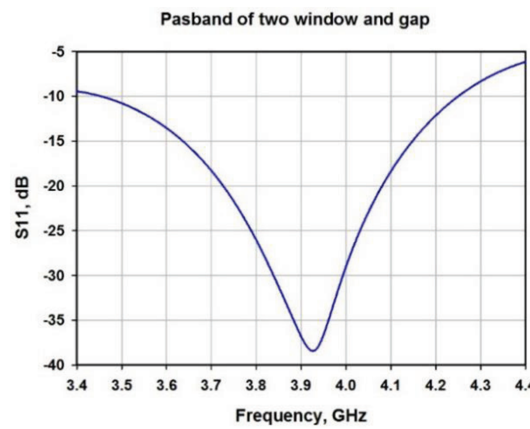

Figure 5: The passband of two windows and the gap.

MULTIPACTOR SIMULATIONS

Multipactor was simulated by CST code for the windows and for the gap. Figure. 6 shows the example of trajectories for the window simulation, Figure 7 - for the gap simulations. It was assume that the ceramics was coated with the material with low second electron emission (SEE) coefficient (e.g. TiN). SEE of the ceramics was considered equal to SEE of copper. Under this condition the multipactor threshold for the window was about 35 kW, TW. The multipactor threshold of the gap depends on radial displacement. The threshold without displacement was about 30 kW, TW, for displacement 1 mm – 20 kW, for displacement 1.5 mm – 12 kW.

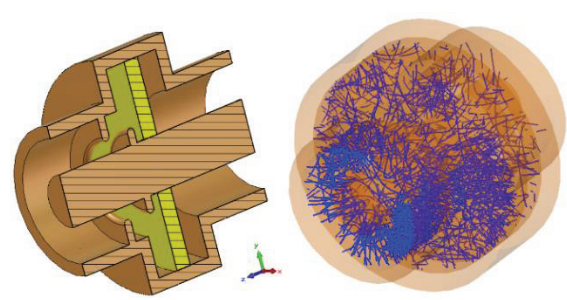

Figure 6: The geometry of the window for multipactor simulations and an example of trajectories. The multipactor threshold for the window is 35 kW, TW.

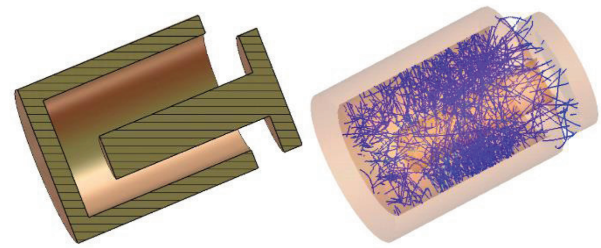

Figure 7: The geometry of the gap for multipactor simulations and an example of trajectories. The gap conductors are shifted. The multipactor threshold depends on the displacement.

CONCLUSION

A new structure of 3.9 GHz main coupler is suggested. The structure does not include the bellows in the inner conductor, between warm and cold windows. The bellows are replaced by the capacitive gap. The gap has zero thermal conductivity and does not require cooling. It also eliminates the problem of reliable mechanical contact. The structure has a wide passband and can tolerate mm-rang displacements. The simulations show that the coupler can work without multipactor up to ~ 10 kW, TW RF power level.

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