DEVELOPMENT OF 352.2 MHz POWER COUPLER WINDOW FOR R&D PURPOSE*

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Abstract

IPNO and Thales are conducting power couplers research and development. This paper presents a new window design that fulfills European Spallation Source (ESS) requirements (400 kW RF peak power). The results of electromagnetic, thermal, thermomechanical, multipacting simulations and the consequences of the new ceramic window of power coupler will be reported. The multipacting simulations were performed with Musicc3D, software developed by IPNO. The new design overcome ceramics weakness in tension and allows stronger constraints in the power coupler window.

INTRODUCTION

High-power RF coupler is a keystone of superconducting accelerator. It is the connecting part between the RF transmission line and the RF cavity and provides the electromagnetic power to the cavity and the particle beam. In addition to this RF function it also has to provide the vacuum barrier for the beam vacuum. High-power couplers are one of the most critical parts of the RF superconducting cavity system in an accelerator. RF and mechanical designs are as important as fabrications process, Thales Electrons Devices and IPNO are collaborating in order to improve these aspects and two prototypes are studied.

Multipacting is a parasite phenomenon that is problematic in RF superconducting structure. In power coupler, it could lead to a dramatic failure as ceramic window is delicate component. Developed at IPNO, Musicc3D is a 3D code for modeling Multipacting in RF structures.

DESIGN OF THE CERAMIC WINDOW

The ceramic window developed is a coaxial window with water cooling in the capacitive antenna. A ceramic disc composed of alumina AL300 [1] realise the sealing between the vaccum of the cavity and the air of the coaxial waveguide as shown in Fig. 1. Figure 2 show chokes localised on each conductors and both side of the ceramic disk.

Main specification of the ceramic window are presented Table 1.

Electromagnetic Design

A study of electromagnetic design was performed with HFSS [2]. The last design simulations results are presented here. Figure 3 gives the electric field simulated in the ceramic window for 400 kW CW full reflected power. The highest field (0.74 MV/m) is localise on the chokes tip. The electric field where defaut is suceptible to be problematic for spark as been lowered to 0.3 MV/m by the chokes. It is three times lower than standard electric field maximum requirement [3].

Figure 4 gives the S11 parameter of the window. S11 is −76 dB at a frequency of 352.2 MHz, it show a good adaptation of the ceramic window to the needed frequency.

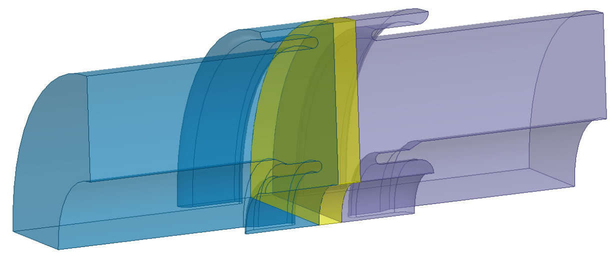

Figure 1: Perceptive view of a quarter of the ceramic window, air is in blue, vacuum in grey and ceramic in yellow.

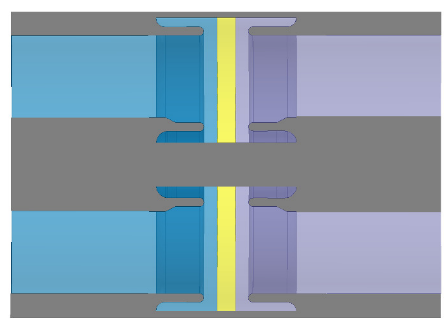

Figure 2: Cross-section of the ceramic window.

Table 1: Main Specification of the Ceramic Window

Main requirements	Values
frequency	352.2 Hz
Repetition frequency	14 Hz
Peak power	400 kW
Duty cycle	5 %

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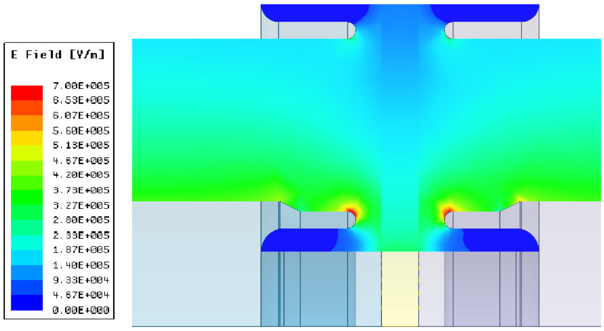

Figure 3: Simulated electric field distribution in coupler window.

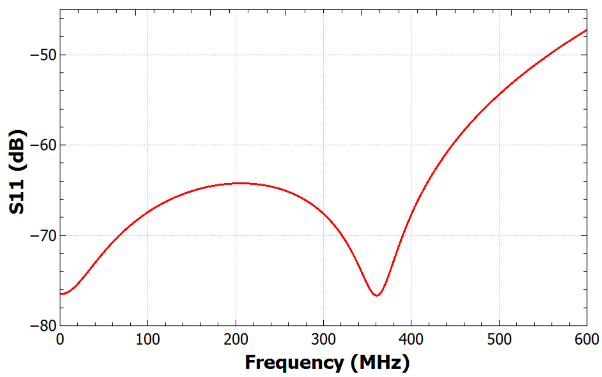

Figure 4: Simulated S11 parameter of the window.

Multipacting Simulation

Multipacting simulations were computed with MUSICC3D [4]. It is a program developed at IPNO. It enables the study of Multipacting for any 3D geometries with one or more materials.

The ceramic window show two areas for multipacting. Figure 5 gives the computed barriers of the first area. It describe multipacting bands like in a simple coaxial line [5].

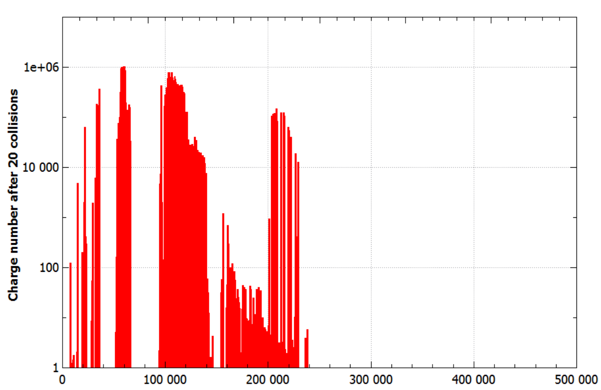

Figure 5: Multipacting barriers for the ceramic window localised in the coaxial area.

The barrier of the second area is localised between inner and outter chokes. Figure 6 gives the computed barriers of this area. It show a large band of multipacting that occur between 190 kW and 380 kW.

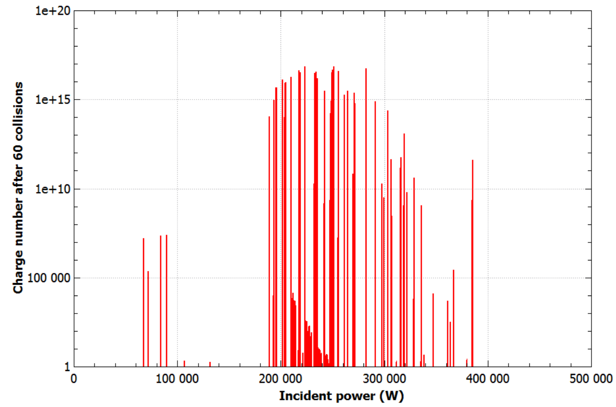

Figure 6: Multipacting barrier for the ceramic window corresponding of inner to outter chokes trajectories.

Some barriers were calculated under the inner choke in a low electric field area. More calculations will be need to characterise it but its situation seems to make it difficult to measure during processing.

CONDITIONING TEST BENCH

Test Bench Configuration

The test bench used for RF processing of the power couplers was developed for ESS project [6].

It includes a mobile cart to receive a conditioning cavity (Fig. 7) with two power couplers and transition to waveguide. The cart is clean-room compatible and it houses valve and turbo pump.

RF High Power

The RF power station is composed of a RF power amplifier integrating one klystron associated to its modulator, a RF waveguide network integrating RF circulators, measurement coupling devices and water-cooled RF loads. Ancillaries systems are also required to operate the station: a powerful cooling system of 400 kW and an electrical power supply of 440 kW. Figure 8 shows the klystron (TH2179A). it was developed in collaboration between IPNO and THALES Electron Devices and its mains characteristics are presented Table 2.

Table 2: Main Specification of the Klystron

Main requirements	Values	
frequency	352.21 Hz	
Peak power	2.8 MW	
Repetition frequency	14 Hz	50 Hz
duty cycle	5 %	7.5 %

Figure 7: Power coupler with doorknob transition mounted on the test bench.

Figure 8: Klystron TH2179A.

The modulator was produce by SigmaPhi Electronics and Diversifed Technologies Inc. The main characteristic of the modulator are given Table 3. The modulator is composed of a high-voltage solid-state switch, and an optimized pulse transformer and capacitor bank, combined with an regulator circuit shows Figure 9.

Table 3: Main Specifications of the Klystron

Main requirements	Values	
High Voltage	110 kV	
Current	50 A	
Repetition frequency	14 Hz	50 Hz
Pulse width	1.6 ms	3.6 ms
Average power	460 kW	
Ripple	1 %	

Figure 9: Modulator

CONCLUSION

Ceramic windows developements are still in progress. RF facility and test bench are operational. The comparison between computed and mesured multipacting barriers will be possible thanks to futur tests and finally linked the barriers amplitudes with processing times.

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