

Les Coupleurs de puissance RF

Dans le cadre de la R&D sur les cavités supraconductrices, les coupleurs de puissances RF sont une thématique importante puisque ce composant transmet la puissance RF à la cavité. Plusieurs aspects hors RF rentrent en jeu et nécessitent une forte interaction avec le Bureau d'études mécaniques notamment. Voici le détail des développements réalisés depuis 2006 et ceux en cours.

1 RF coupler 10KW@352MHz

In the framework of the European project EURISOL (2006-2008), a 352 MHz capacitive power coupler has been developed for the 2-gap spoke cavities to be mounted on the 56 mm diameter port. The coupler geometry is coaxial, at 50 using a warm disk ceramic window, as shown on figure 5. The coupler is designed to be able to transfer 20 kW of RF power to the cavity. Two pipes located on the outer diameter of the window give the possibility to water-cool the ceramic. Several window geometries were studied: cylindrical, disk (with and with-out chokes), travelling wave. For each geometry, the HFSS software (Ansys) was used to calculate the RF parameters, the surface field on the ceramics, the bandwidth and the RF losses. Finally, the design based on a disk ceramic without a choke was chosen because it was the best compromise between good RF performances and simplicity, leading to a reliable and cost-effective design.

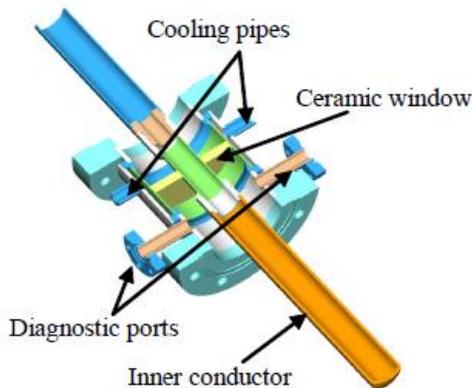


Figure 1 Drawing of the spoke cavity input coupler

The computed S_{11} parameter is shown on figure 2: a value of -57dB is obtained at the nominal frequency. The coupler exhibits a very large bandwidth, allowing to have standard fabrication tolerances. Two ceramic window prototypes were

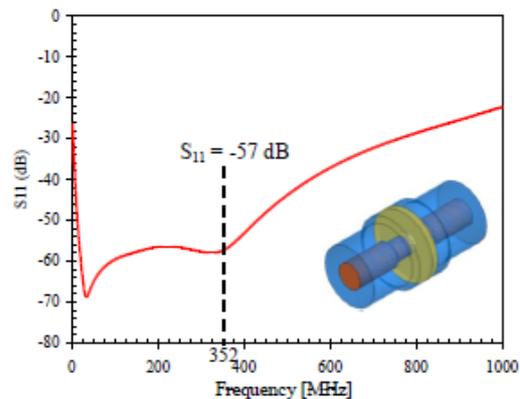


Figure 2 The power coupler computed S_{11}

manufactured by the SCT Company. They were characterized at low power (measurement of RF parameters) before the antenna welding. After reception of the two complete power coupler prototypes, the assembly of the conditioning test bench was achieved after careful cleaning and final assembly of the important parts (RF ceramic windows, coaxial part between the cavity and the window, conditioning cavity) in the IPN Orsay clean room.

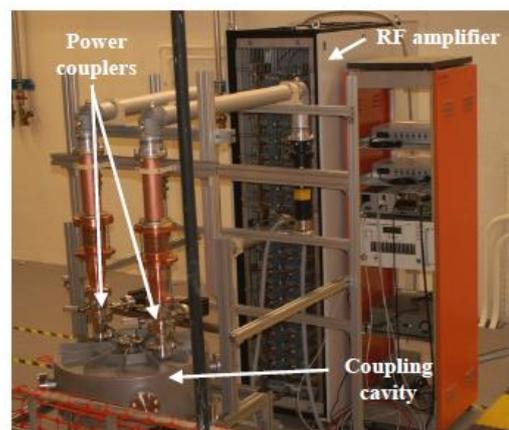


Figure 3 The power coupler conditioning bench at

The conditioning of the power coupler started on the warm test bench. This important stage consists in

feeding, step by step, the 2 power couplers mounted in series with an increasing RF power, from 0 to 10 kW. The aim is to condition the RF surface to get rid of any electron emission or multipacting in the coupler. The conditioning procedure consists in starting with a low RF power level and gradually increasing it.

2 CW 80kW@704MHz RF power coupler

A Fundamental Power Coupler (FPC) development has been carried out at IPN Orsay. Based on the SNS power coupler design, it was adapted and optimized to transmit to the cavity up to 150 kW RF power at 704.4MHz with a capacitive coupling of $Q_{ext} = 1.107$, adapted to the experimental needs (i.e. without the beam).

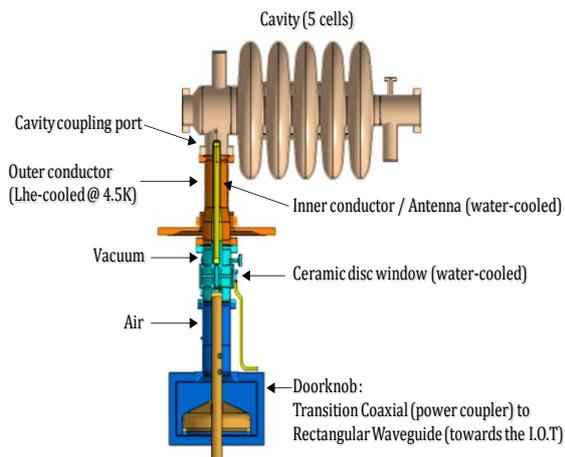


Figure 4 Sectional main RF power coupler view

The Figure 4 is a section of the final Coupler design. A doorknob type transition performs the waveguide geometrical transition. In order to minimize thermal losses (Joule and dielectric losses), the inner conductor and the ceramic window are water cooled. The FPC outer conductor RF and static losses are removed by a supercritical helium heat exchanger ($P=3\text{bar}$, $T=6\text{K}$) in order to minimize heat loads to the cold extremity of the cavity maintained at 2 K, to ensure the transition between 300K and 6K.

To ensure the waveguide geometrical transition between rectangular waveguide (WR1150) and the coaxial power coupler, a Doorknob type impedance matching structure was designed. The transition alone must have good impedance matching to enable

good performances when integrated with the RF ceramic.

The coaxial window is a planar annular disk made of 97% aluminum ceramic. The windows were manufactured by the French company SCT. A deposit of TiN was made on one of the two windows.



Figure 5 80KW@704MHz RF coupler

The FPC conditioning had been performed in the 700 MHz experimental area of IPNO. The experimental bench was designed to condition a pair of power couplers in travelling wave mode at room temperature. The RF power was transferred from the RF source (IOT THALES 793-1) towards the water cooled load, through the two FPC prototypes.

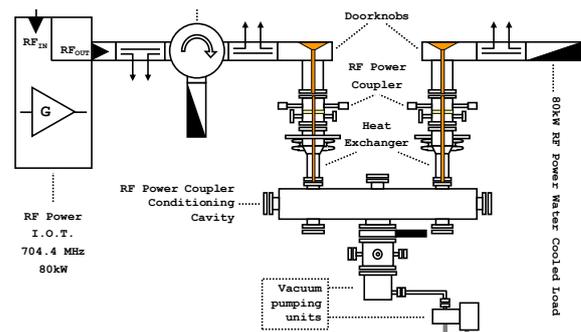


Figure 6 Schematic view of the conditioning bench

During the first RF conditioning campaign (November 2012) the ceramic window of one of the FPCs failed. To resume the conditioning procedures it was then chosen to use as spare RF window initially manufactured by TOSHIBA Company. The couplers conditioning was carried out in pulsed mode and the duty cycle had been gradually increased. Finally, in June 2013, the FPCs were successfully conditioned up to 62 kW in CW mode. Recently, the power coupler, with the TOSHIBA

window, had been assembled to the 5-cell elliptical cavity and tested with success in the cryomodule in “machine configuration”.

Article :

http://accelconf.web.cern.ch/AccelConf/SRF2009/papers/tu_ppo008.pdf

3 300kW pulsed@352MHz RF power coupler

For the future European Spallation source, a new RF power design has been realized. The design is based on the coupler developed for the superconducting SPOKE cavities in the framework of the EURISOL Design Study. To adapt to the ESS power coupler requirements, a water cooling system is integrated in the inner antenna and the water cooling system of the ceramic window has been modified to direct the water flow more effectively.

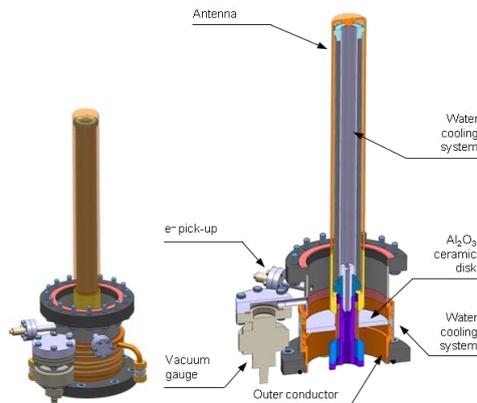
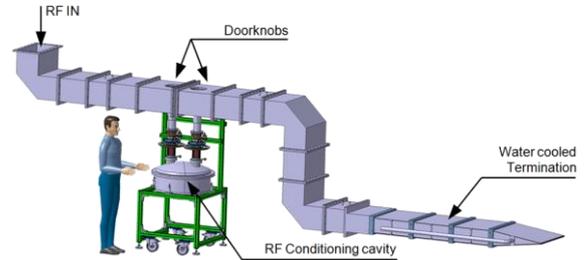


Figure 7 Views of the RF power coupler

The ESS Fundamental Power Coupler (FPC) is matched to a rectangular WR2300 waveguide via a waveguide doorknob transition. Currently, two manufacturers are in charge to fabricate two power couplers each without doorknob. In parallel, as other RF coupler design, the design of the conditioning cavity has been realized and the first implementation of the power coupler conditioning test stand is in progress.

Article: <http://ipnweb.in2p3.fr/srf2013/papers/thp065.pdf>



4 RF power coupler industrial design

In the framework of collaboration with THALES company, a PhD student is working since the end of last year on a new design of a 700MHz power coupler taking into account aspects connected to the industrialization.