MEASUREMENTS ON THE RF CAVITY FOR THE ALBA STORAGE RING

M.Langlois, P. Sanchez, M.Cornelis, F.Perez ALBA, SPAIN

Abstract

ALBA storage ring will use 6 ambient temperature nose cone HOM damped cavities tuned at 500 MHz, designed at BESSY and known as the EU cavity. A first one, manufactured by ACCEL, was delivered in 2007 to investigate on its behaviour. This paper describes the data collected during investigation. First, bead-pull measurements were performed to assess impedance, both on fundamental and high order modes. Emphasis was put on E011, due to the discrepancy between expected values and results for this mode. The vacuum bake-out and related pressure are shown. Then, the cavity was conditioned and observations were made on multipacting levels, conditioning time and surface temperatures. The latter were found inhomogeneous and leads are detailed to avoid local overheating.

INTRODUCTION

The pre-series cavity for the ALBA storage ring was delivered in June 2007. First, bead-pull tests were performed, which confirmed the results obtained at the Willy Wien lab, Berlin, in a similar cavity [3]. All modes were damped, as predicted by simulations, except the E011 mode. The cavity was then baked out at 130ºC for five days and conditioning started. Overheating was detected on the flanges of the dampers, confirming again the results at Willy Wien. Power cycles were performed to assess the power limit which was found at about 40 kW.

BEAD PULL MEASUREMENT

Set-up

The set-up, kindly lent to ALBA by Daresbury lab., is shown in Figure 1. It makes for the alignment of the wire, its constant tension, and the bead motion at constant speed.

Coupling

The RF signal could be coupled to the cavity in several ways. We used the WATRAX transition (see Figure 1) to evaluate the E010 impedance and changed it for a coaxial 50 Ω straight to keep a broadband coupling. The signal was picked up with a small loop at the bottom of the cavity. To access other modes, we had antennas protruding from the beam ports, the length of which has been varied.

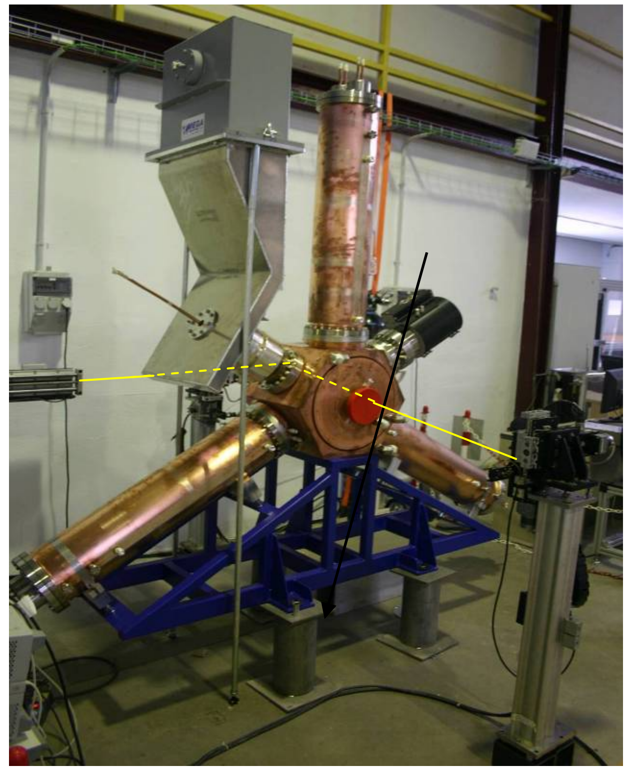

Figure 1: Cavity and bead pull system

Measurement

Frank Marhauser described the method profusely in [2]. We had two cylinders and one disc made of alumina. They were calibrated in a pill box cavity lent by BESSY. Calibration and computed values matched reasonably well. The bead size is a compromise between sensitivity and modification of the stored energy. Dry nitrogen was continuously blown into the cavity to avoid possible dust contamination.

RESULTS AND COMPUTATION

E010, fundamental mode

Impedance was measured with various inputs, outputs and beads. The impedance values (transit time corrected) range between 3.21 MΩ and 3.55 MΩ, with a small cluster around 3.3 MΩ.

E011, first HOM mode

Due to the field pattern of this mode, see figure 2, the cavity's input window as well as the RF pick-up are not adequate to couple to this mode. So, we have used antennas in the beam ports and in the plane between the nose cones.

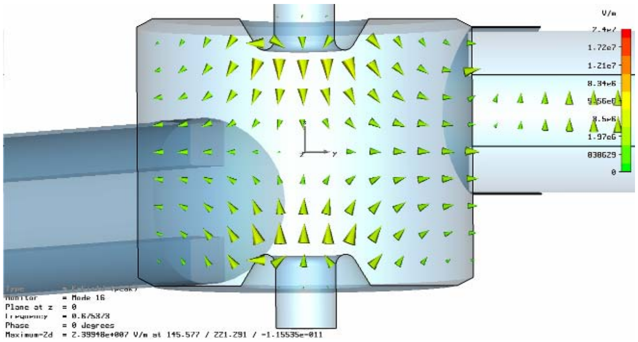

Figure 2: E011 electric field pattern

The impedance values we found were all between 9.2 kΩ and 12.3 kΩ. Measurements are shown in figure 3. F. Marhauser found 10.7 kΩ at BESSY [3], even though computation was far more optimistic, yielding 2.7 kΩ, due to a lower quality factor.

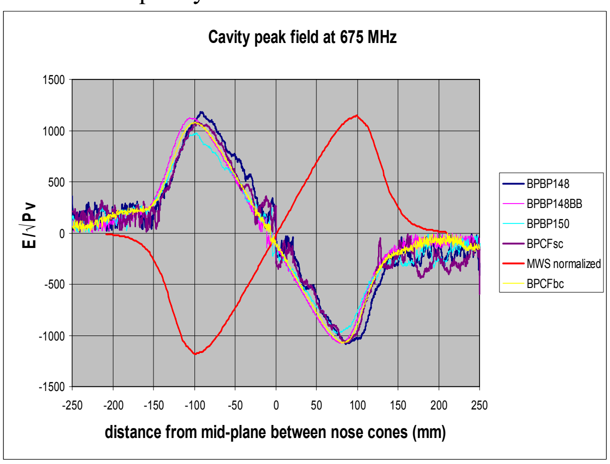

Figure 3: Bead pull measurements for the E011 mode

Other HOMs

Above 600 MHz, many modes may be observed. The sharper peaks between 600 MHz and 1.1 GHz were investigated. No longitudinal impedance could be measured but at 675 MHz, due to very small phase difference.

SHORT CIRCUITS BETWEEN RIDGES AND CAVITY BODY

Why short-circuits?

MWS computations had shown for both E010 and E011 large electric fields in the gap between the ridges of the dampers and the cavity body. E011 impedances computed with this gap removed were lower.

Implementation

V-shaped copper strips were inserted between the ridges of the dampers and the cavity body as shown on figure 4.

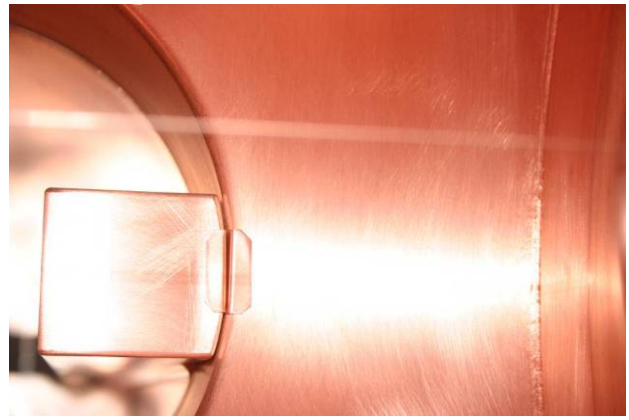

Figure 4: Implementation of a low power short circuit in the ridge's gap.

Frequency domain

The short circuits do have an influence on the frequency. The E010 mode frequency dropped from 499.770 MHz to 499.080 MHz. The effect on high order mode frequencies is even more drastic.

Impedances

The impedance of E010 does not change, but that of E011 is divided by 2.2 when shorts are inserted as had been foreseen by MWS computations. Implementing these shorts for power operation involves much more effort since high currents flow through this area...

LOADED RADIAL ANTENNA

Set-up

A radial antenna loaded with 50 Ω was implemented in the CF16 port, as indicated in Figure 5. The length of the antenna was measured from the cavity circular wall to the tip of the antenna.

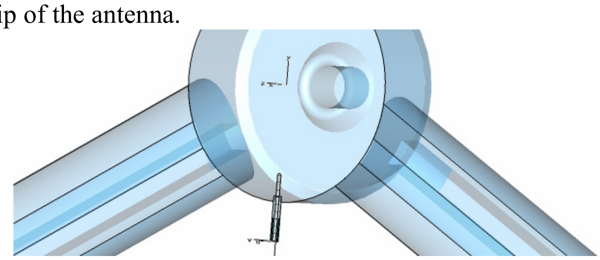

Figure 5: E011 coupled antenna.

Impedances

This antenna couples nicely to E011 and should not couple to E010. Figure 6 shows this statement only holds for short antennas. This remedy may only be used to decrease the E011 impedance by 20%. Larger effects would be detrimental to fundamental impedance. The impedance variations are due to Q0 modifications. R/Q keeps roughly constant.

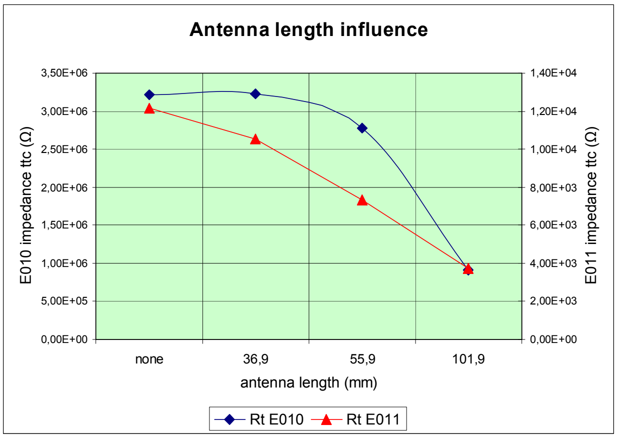

Figure 6: Impedance measurements as a function of the antenna length.

BAKE OUT

Bake out was established to last 5 days at 130ºC, but an incident occurred. The valve to the roughing station closed, leaving the heaters on without pumping during 55 h. Despite it, after cool down and with ion pump operation, the equilibrium pressure went down to $1.7*10^{-9}$ mbar.

With the 1h test, outgassing rate was $1.8*10^{-12}$ mbar*l/(s*cm^2). A 12h test yielded $0.28*10^{-12}$ mbar*l/(s* cm^2).

After some conditioning, pressure stabilized at $6*10^{-10}$ mbar.

CONDITIONING

Multipacting

The cavity was conditioned at 20% duty cycle, 10 Hz with a coupling factor set to 1.

In around one week we reached 80 kW, with frequent interruptions due to transmitter, cooling circuit and control system debugging.

We could identify critical multipactoring values around 2, 12, 15, 22 and 33 kW for which pressure rose significantly.

Overheating

From the Willy Wien experience we expected an overheating at the dampers flanges which could cause a vacuum leak. So, we switched to cw operation and increased the power slowly, measuring at the same time the temperature on the dampers flange.

We opened a leak on one of the side damper gasket at 30 kW. The flange temperature was 55°C in the vicinity of the ridges. The same flange, 90° away, has a temperature of only 30°C.

We replaced the CF damper gaskets by customized RF ones, shorting part of the current path as shown in figure 7. The benefit of this modification is seen in figure 8 where on can see that the temperature of the flange decreased significantly. But still a leak opened during the 45 kW CW cycling. The temperature was then 65°C and 37°C on the damper flange. These leaks close partially after RF is switched off.

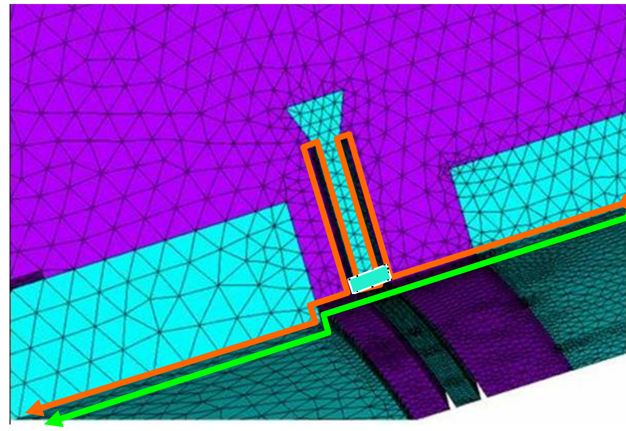

Figure 7: Customised RF gasket effect: short circuit part of the current through the stainless steel flange

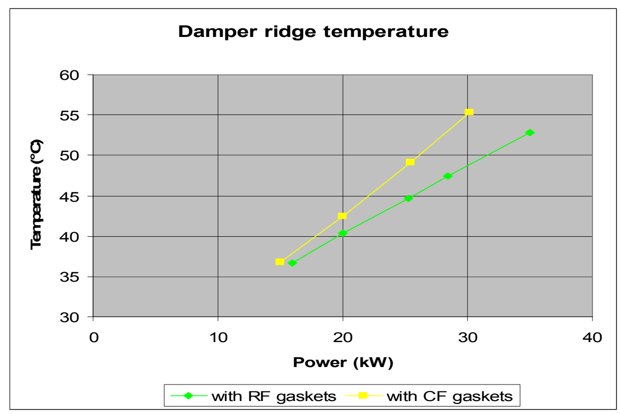

Figure 8: Temperature of the damper's flange with standard and RF gasket as a function of RF power

CONCLUSIONS

- The cavity is HOM damped as expected, except for the mode E011.
- Short circuits bridging the gap between the ridges and the cavity body decrease the E011 impedance and probably avoid overheating in damper's flanges.
- The cavity could be cycled up to 40 kW cw with custom made RF gaskets.
- Stainless steel will be partially replaced by copper in the vicinity of the damper flanges to provide better heat transfer.

REFERENCES

[1] F.Marhauser and E.Weihreter. "Final Impedance Measurements of the Low Power EU-Cavity with 615MHz CWCT's". BESSY Internal Report.

[2] F. Marhauser. "Bead Pull Measurements for the BESSY Prototype Cavity". BESSY Internal Report.

[3] F. Marhauser and E. Weihreter. „Impedance Measurements of the HOM-Damped Metrology Light Source Cavity". BESSY Internal Report