SUPERCONDUCTING R.F. ACTIVITIES AT SACLAY

B. Aune, M. Boloré, J. Bourbonneux, J.M. Cavedon, J.P. Charrier, Ph. Damsin,
J. Fagot, A. Godin, J. Gratadour, B. Hervieu, M. Juilliard, F. Koechlin, Ph. Leconte,
B. Mahut, A. Mosnier, C. Magne, J. Rodriguez, A. Veyssière.
Service de L'Accélérateur Linéaire, CEN Saclay, 91191 Gif/Yvette Cedex France.

S. Buhler, T. Junquera, J. Le Scornet. A. Liébe.
IPN, (CNRS-IN2P3) Université Paris-Sud, 91400 Orsay France.

Introduction

In 1986, it was decided at Saclay to build a facility to study and test Niobium superconducting 1.5 GHz electron accelerating structures. Since then, several laboratories have been set up to master all the parts of the process : computer modeling, R.F. surface preparation, cryogenic testing, helium handling, and R.F. testing at both room and liquid helium temperatures. All of these facilities are now in operation and numerous tests have been carried out on single-cell cavities with and without HOM couplers. In addition, first tests have been performed on a five-cell cavity, and superfluid thermometry has been developed on a rotating system. This paper gives the main results for these topics.

Single-cell cavities

Since November 1987, eight single-cell cavities have been built by the French firm, Lemer, and more than 20 cryotests have been performed .

Figure 1 shows the maximum surface electric field (Ep) reached before and after helium processing. Most of these tests were limited by electron loading. Thirty minutes of helium processing was applied systematically in order to improve the Q values at high fields ; longer processing did not help. Qo values between 7×10^9 to 2×10^{10} were found.

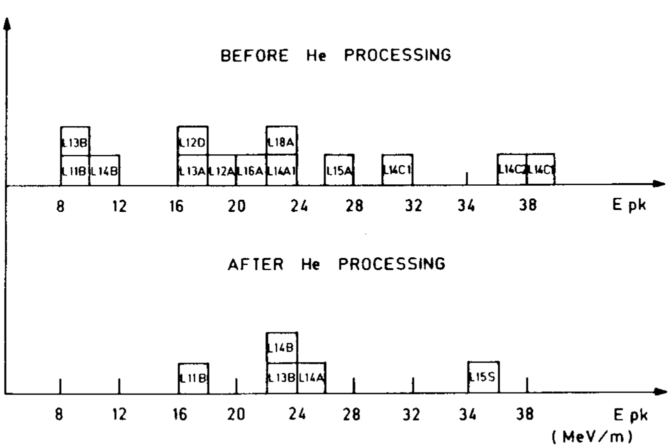

Fig. 1 - Maximum surface field reached in several single-cell cavities tests.

Five-cell cavity

A first five-cell structure without coupler has been successfully tested. Figure 2 shows the results which were limited by electron loading. Figure 3 shows the temperature map, where two hot spots located on the 1st and 4th iris can be seen. They are probably due to electron emission.

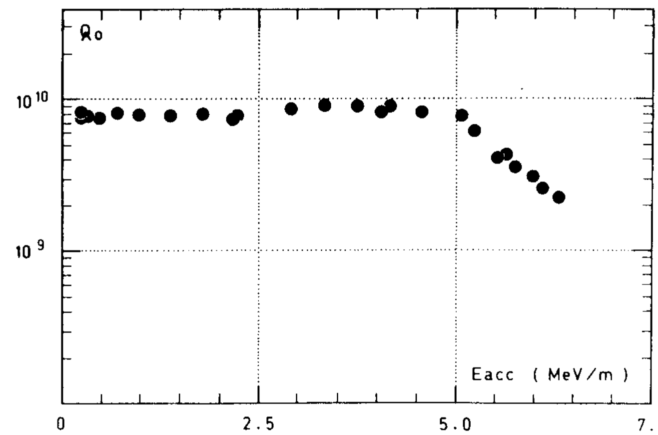

Fig. 2 - Five-cell cavity test at T=2K.

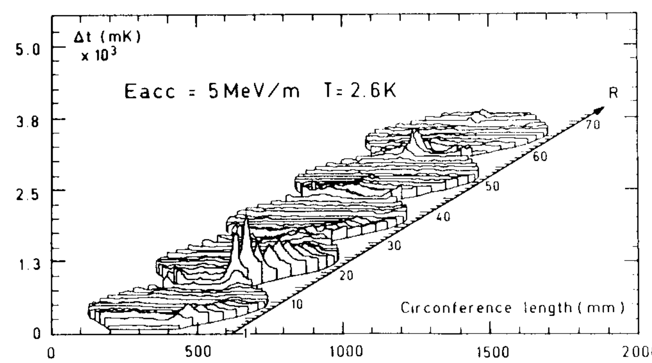

Fig. 3 - Temperature map of a 5-cell cavity.

Superfluid thermometry

In collaboration with the University of Wuppertal (Dr. Müller), we have developed a rotating system similar to our standard subcooled arrangement. It is made of 13 resistors embedded in stycast and supported on a rotating arm. The thermal connection between the resistor and the surface of the cavity consists of a small copper rod, sticking out of the stycast by 0.2 mm (Figure 4). In order to test the reliability of this set-up, more than 100 rotations and 20 temperature maps have been carried out.

No damage was visible, neither on the rod nor on the surface of the cavity. From a Kapitza's resistance equal to 10 $mK/mW.cm^2$, the calculated efficiency of these thermometers is 1 to 2%. At Wuppertal University, sliding thermometers of the same type have been tested and the results are roughly the same. Figure 5 shows a temperature map measured at 15 MeV/m in a superfluid helium bath. The spatial resolution along the equator is good enough to localize a defect with an absolute error of ± 1° (± 1.5 mm).

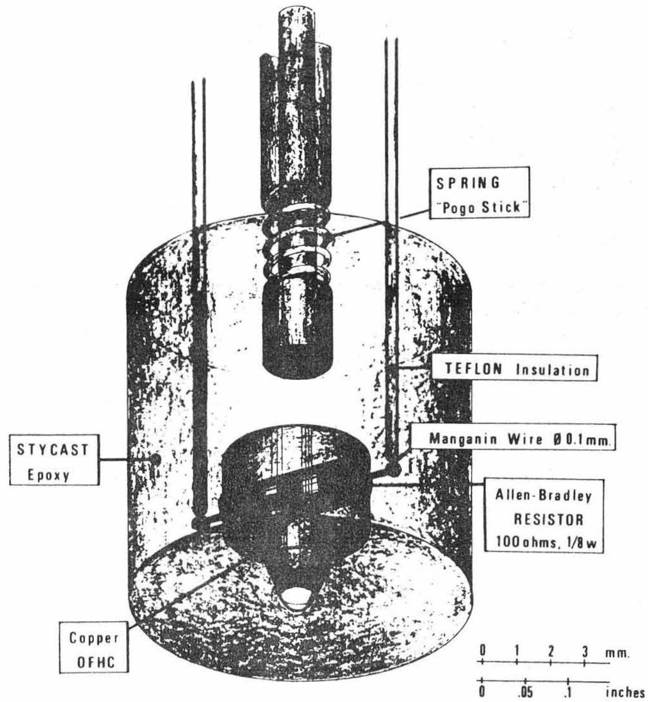

Fig. 4 - Superfluid He scanning thermometer.

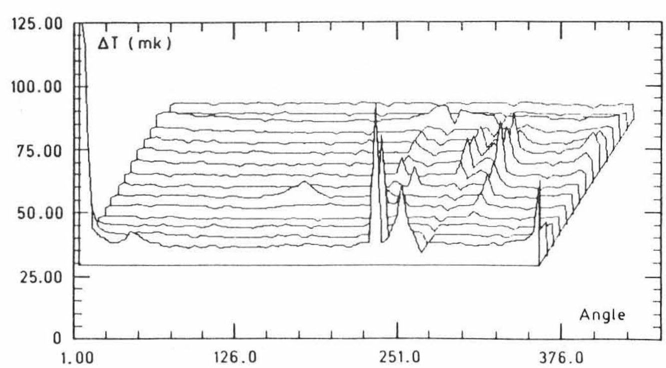

Fig. 5 - Temperature map in superfluid helium at 1.8 K and Eacc = 15 MeV/m.

High Order Modes coupler developements

A first higher order mode coupler (HOM) has been developed and is described in ref. 1. This coaxial antenna coupler has been designed to guarantee an external Q greater than 5×10^{12} for the fundamental mode, without severe mechanical tolerances. It consists of a two-cell notch filter which exhibits a large stopband (Figure 6) around the accelerating mode frequency (300 MHz for an attenuation of 40 dB) and a very flat response for the higher modes. Such a coupler has been built out of niobium and welded on the beam-tube of a mono-cell cavity. During cold measurements, the accelerating field at 1.8 K was limited to 14 MeV/m due to field emission and not to the HOM coupler. The external Q was around 1.3×10^{12} which is equivalent to 7×10^{12} for a five-cell cavity. This value can easily be increased by a fine adjustment without opening the cavity.

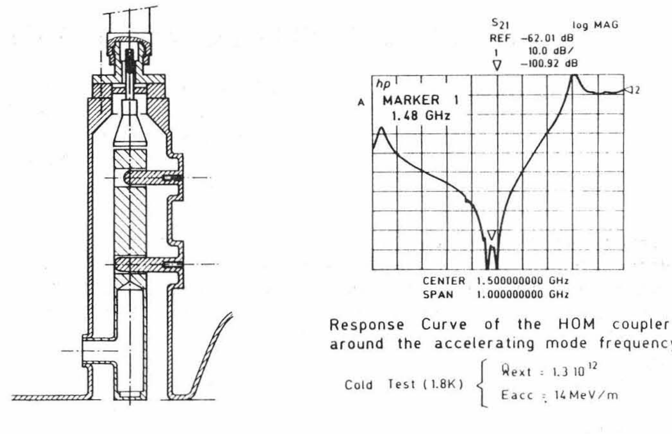

Fig. 6 - H.O.M. coupler.

New cavity and couplers design

A study on new structures with smaller numbers of cells and smaller iris diameters was started a few months ago. The main concepts are described in ref. 2. The higher order modes, especially the 5th dipole passband, can be more easily extracted, and several features of the accelerating π-mode are improved by reducing the number of cells (larger average accelerating field for the muticell cavity, higher shunt impedance, and reduced peak field to accelerating field ratio). The length and the diameter of the beam-tube which joins two cavities in the same cryostat have also been adjusted for a maximun field level and the proper placement of HOM couplers for the most dangerous modes has been determined. We are developing a simple-loop coupler which is more efficient than an antenna for the damping of the higher order modes. We present here the first measurements performed at room temperature on three-cell cavities made out of copper (Table 1). The next measurement will test the behaviour of a niobium loop coupler on a niobium cavity.

Table 1

Measured Q_{ext} values for the most dangerous dipole modes on copper 3-cell cavities equipped with their simple HOM loop couplers

Passband	$Z''/Q(k\Omega/m^3)$	$Q_{max}(10^4)$	$Z''_{max}(M\Omega/m^3)$
$2(TM_{110})$	230	1.5	3500
$2(TM_{110})$	66	4.7	3100
$1(TE_{111})$	183	1.6	2900
3	663	0.25	1700
$2(TM_{110})$	115	1.05	1200
$1(TE_{111})$	190	0.6	1100
$1(TE_{111})$	11	3.3	400
5	1	3.0	300

Acknowledgments

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References

[1] A. Mosnier et al., Damping of the HOM's in a multi-cell superconducting cavity. European particle conference, Roma.

[2] B. Aune et al., Superconducting RF activities for electrons at Saclay, Workshop on RF superconductivity, Argonne, 1987.