

**SUPERCONDUCTING RF ACTIVITIES FOR ELECTRONS AT SACLAY**

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**INTRODUCTION**

A group named GECS (Groupe d'Etudes des Cavités Supraconductrices) has been created in Saclay in July 86 to study SC cavities for electron accelerator application. Approximately 20 people from Saclay and Orsay are now working in this group which uses the technical support from the laboratory of the Saclay Electron Linac (ALS) (1). The main goal of this group is to design and test a cavity with its couplers suitable for electron acceleration in a machine of the CEBAF type, to build a test laboratory and to test SC cavities made by French industry. We describe the present status of this work.

**DESIGN OF A CAVITY**

The RF frequency of the cavity was chosen to be the CEBAF frequency i.e. 1.5 GHz. Numerous studies for the optimisation of the cavity have been done, mainly concerning the importance of the dipole higher order modes. The main results are described in ref. [1]. Calculations for BBU in a recirculating electron linac gave estimations for the maximum impedances of these higher order modes [2,3].

A copper model for a 5 cell cavity has been fabricated and the properties of the modes have been measured without coupler, and compared to the results of URMEL calculations.

We found very good agreement between measurements and calculations for both the frequencies of the modes and for the coupling impedances.

Measurements for the dipole modes were made on-axis using two metallic objects (sphere and disc) and off-axis using three metallic objects (needle L = 5mm,  $\phi = 0.45$ mm, sphere  $\phi = 4$ mm and disc  $\phi = 4$ mm, e = 0.3 mm). We are now considering measurements off-axis using two ceramic objects of  $\epsilon_r = 140$  (needle and disc).

As an example, fig.1 gives the frequency perturbation produced by the sphere at 25mm from the axis calculated from the fields given by URMEL [1a] and the measured one [1b], for the  $TE_{111}$  (1/2 cavity) mode. Table 1 gives a comparison of URMEL predictions and measurements for some of the dipole modes.

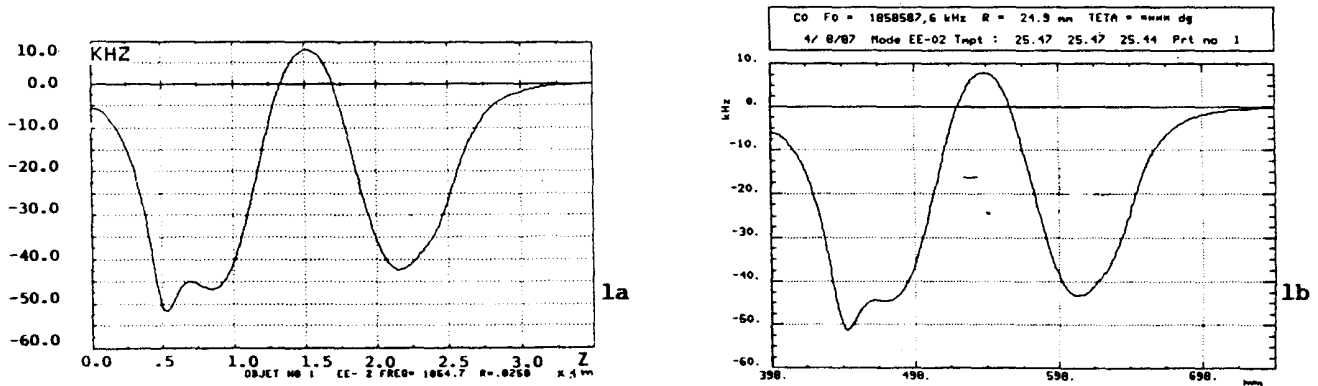


Fig. 1

HOM COUPLER

Calculations on BBU showed that, in order to accelerate a current of the order of 100  $\mu$ A in a recirculating linac of final energy 2 to 4 GeV, the external Q's should not be greater than  $10^5$  for dipole modes having the highest coupling impedance ( $Z''/Q = 10^5 \Omega/m^3$ ). We have applied the concept of beam tube couplers to damp these modes and we designed a coaxial coupler, following the work done at CERN and DESY. The main concern, for a frequency of 1.5 GHz, is the great sensitivity of the notch filter against mechanical tolerances. We have chosen to use a two-cell filter design in order to get a large bandwidth leading to lower sensitivity. The attenuation for the fundamental mode should be greater than 40 dB to guarantee an external Q greater than  $5 \cdot 10^{10}$ . The frequency of the first dipole mode ( $TE_{111}$ ) is around 1.75 GHz, and this mode should be damped. Figure 2 gives an equivalent circuit of the coupler and Fig.3 the mechanical design. A copper model has been fabricated and tested on a 5 cell cavity. Fig.4 shows the transmission curve calculated from the equivalent circuit analysis (4a) and the measured curve (4b). Fig. 4c shows an enlargement of central part of the curve. The bandwidth of the filter at 40 dB is seen to be rather large. For the fundamental mode we measured external Q higher than  $10^{13}$  by carefully adjusting the filter.

Table 1 gives some measured values of HOM external Q's on the 5 cell copper cavity equipped with two couplers.

The Q's for the first 4 passbands are always lower than  $10^5$ . For the 5 th band, both calculations and measurements showed that the field level in the beam tube is very low. As a consequence the Q obtained is very large and the impedance  $\frac{Z''}{Q} \times Q$  is the highest of all the dipole modes. The property of this mode seems independent of the shape of the cell. We are studying a way to solve this problem.

f URMEL	f meas.	$\frac{R}{Q}$ URMEL	$\frac{R}{Q}$ meas	$Q_{ext} \times 10^4$
1703	1702	0.02	0.1	
1733	1735	1.69	1.5	4.1
1784	1788	1.43	1.1	
1854	1859	21.25	20.7	0.6
1937	1941	20.90	22.2	0.45
2004	2001	2.34	2.6	
2085	2088	11.58	12.2	2.2
2131	2133	14.20	13.7	5.8
2154	2155	3.90	2.5	10.8
2163	2163	0.01	0.1	
2805	2809	1.58	3	
2844	2845	9.20	10.0	1.6
3357	3351	2.7	2	
3389	3385	1.0	0.6	4.5
3455	3461	0.08	0.1	2400
3464	3473	0.38	0.2	
3476	3480	0.28	0.7	

TABLE 1  
Comparison between measured and calculated dipole modes

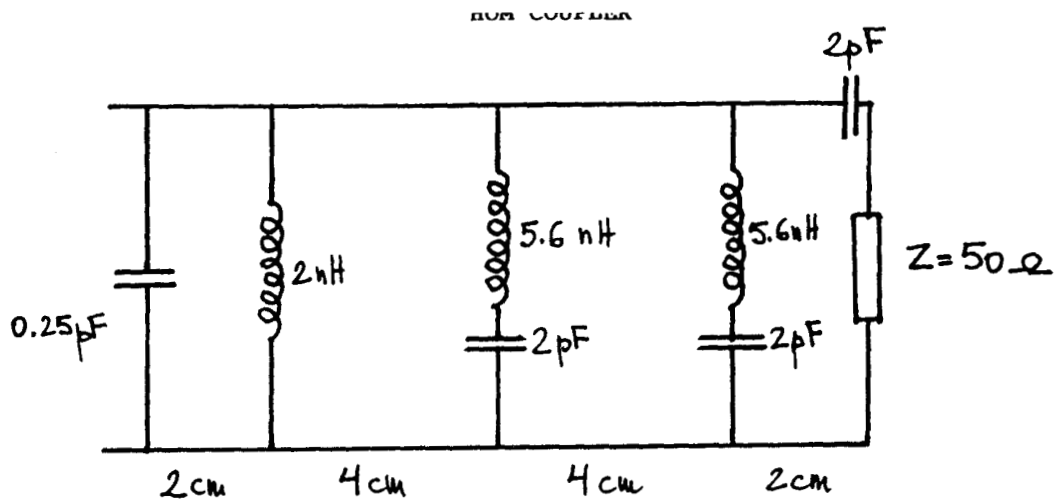


Fig. 2 - Equivalent circuit

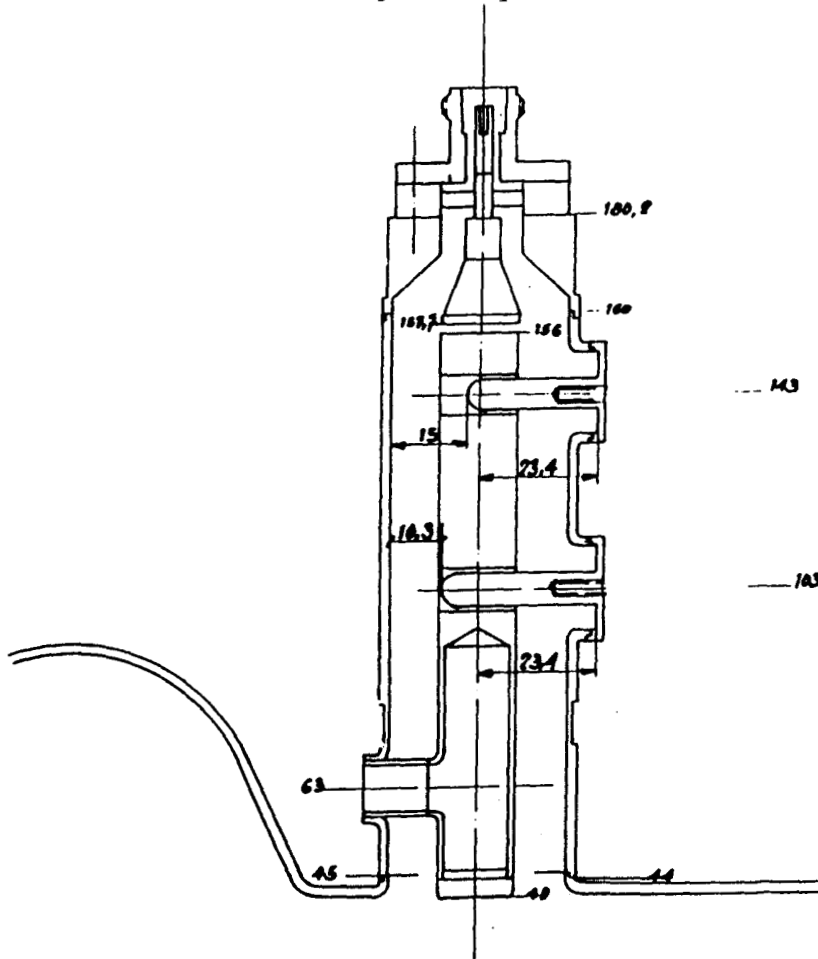


Fig. 3 - Mechanical design

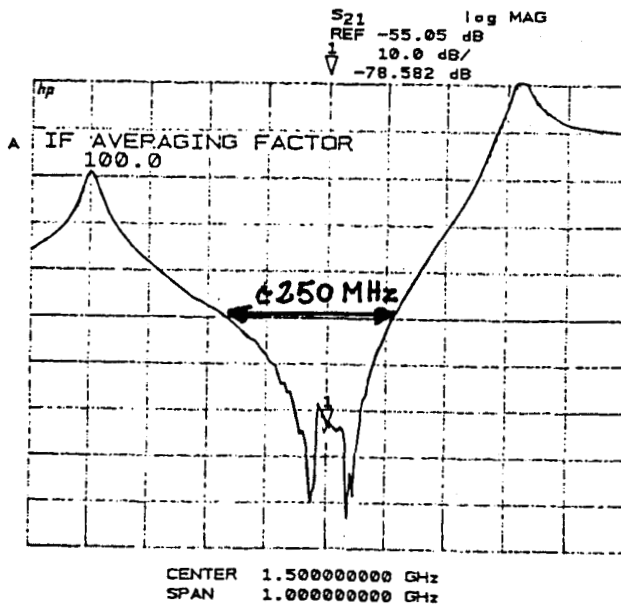
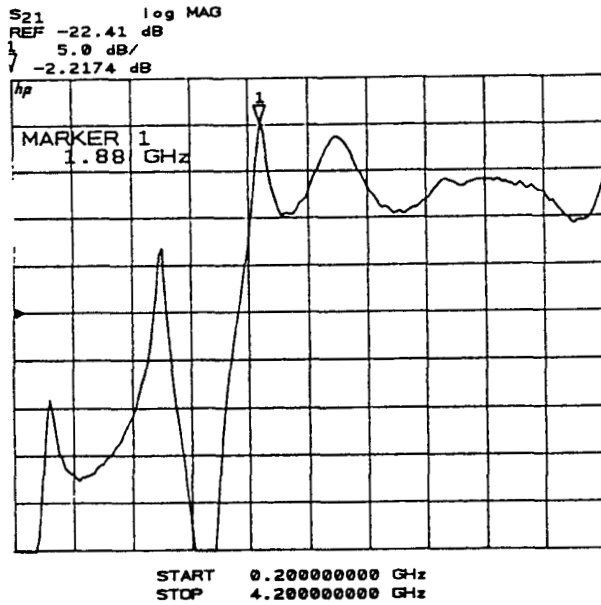
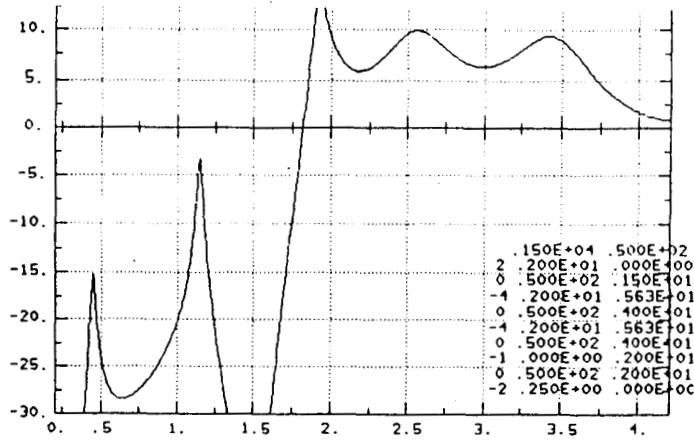


Fig. 4 - Transmission curves of the HOM coupler

EXPERIMENTAL FACILITY - FIRST MEASUREMENTS

A test laboratory for SC cavities is now fully equipped. It has been installed in an experimental room for nuclear physics which is thus shielded. A 200 MeV electron beam from the ALS could easily be directed in that room for further tests on a SC cavity in a horizontal cryostat.

We have in operation two vertical cryostats - one for single cell cavities and a larger one suitable for testing multicell cavities. The pumping station is able to tolerate a power dissipation of  $2 \times 20$  W at 1.8K. Temperature mapping in subcooled helium is available. In addition an installation for measurement of RRR of samples is in operation.

The first measurement on a SC cylindrical, 1.5 GHz cavity was performed in May 87.

This cavity was used to measure the RF properties of a small pellet of YBaCuO. The pellet was simply put in the bottom of the cavity, near a place of maximum magnetic field. We measured the  $Q_0$  of the cavity alone and of the cavity plus pellet for a temperature between 4K and 200 K by letting the temperature increase very slowly. fig. 5 gives the resulting  $1/Q_0$  VS  $1/T$  curves. The transition is seen to appear around 95K. From the field level and the  $Q$  measured at 4K we estimated the surface resistance to be of the order of  $20\text{m}\Omega$  at 4 K. The fig.5 shows the dependance of  $Q$  as a function of the magnetic field at 4K We were able to reach a value of 370 A/m, which corresponds to a current density of the order of  $210^5\text{A/cm}^2$

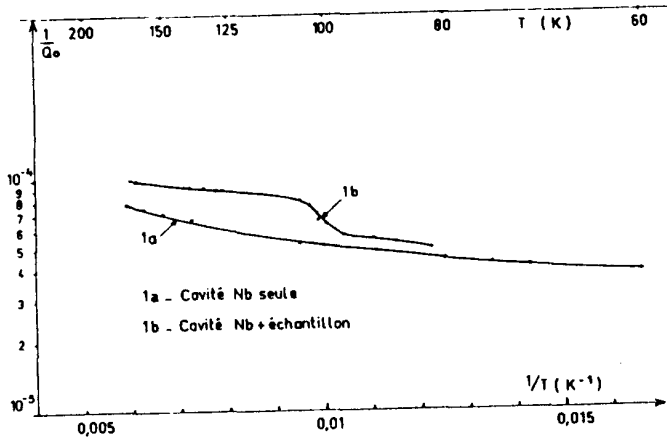
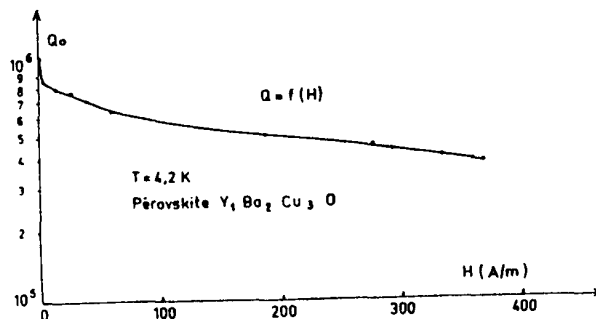


Fig. 5



An elliptical single cell cavity borrowed from CORNELL was then used to test our complete facility.

Starting in November 87 a program for testing several single cell cavities made by French industry is scheduled. In addition two cavities were bought to Interatom. The first one was tested at Wuppertal and gave a maximum field of 10 MeV/m (limited by a quench) and a Qo in excess of  $10^{10}$ .

A 5 cell cavity without coupler should be ready for test in January 88 and a single cell equipped with HOM coupler next.

#### FUTURE EQUIPMENT

A laboratory including a chemical facility and a clean room for cavities assembly is under construction.

An effort to develop temperature mapping in superfluid helium is starting.

We also plan to build a TE<sub>011</sub> cavity to make systematic studies on residual surface resistance.

#### ACKNOWLEDGMENT

All the work reported here would not have been possible without the permanent support and advices from the CERN SRF group. We also largely benefited from the experience acquired by our colleagues in Saclay who are in charge of the heavy ion SC Linac.

#### REFERENCES

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