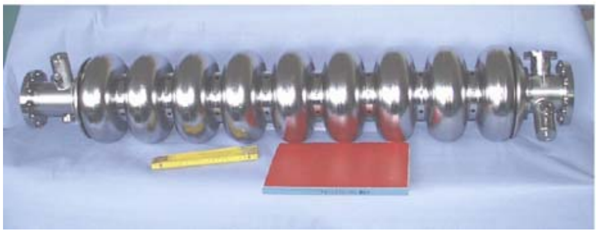
SRF



WP10 - Cryostat Integration Tests

Final Evaluation - Deliverable 10.6.3

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Abstract

Cry-Ho-Lab, the horizontal cryostat facility at Saclay has been suggested in CARE program for testing of components within two different Joint Research Activities: “SRF” and “HIPPI” JRAs.

Concerning SRF-JRA, new “high power couplers” and a “cold tuning system” equipped with different fast tuners previously designed in work packages WP7 and WP8, were planned to be tested at high RF power (1.5 MW pulsed – 1 ms – 10 Hz) on a fully equipped 9cell cavity (1300 MHz).

Acknowledgements

We acknowledge the support of the European Community-Research Infrastructure Activity under the FP6 “Structuring the European Research Area” programme (CARE, contract number RII3-CT-2003-506395)

Qualifying Tests

Before ensuring RF power tests some modifications of the cryostat were necessary. The first one was to perform the right positioning of the 9cell cavity by a shift out off the main axis of CryHoLab due to fixed connection distance between coupler and RF waveguide. A new rail system to support the cavity has been drawn and the mechanical assembly performed for September 2004. In parallel, the truck for cavity handling, flanges and vacuum connections for the cavity connection to the He circuit, wave guides between the klystron and the cryostat have been purchased and installed during the year 2004 (see Fig.1).

The “C45” 9cell cavity (-E_{acc}=20 MV/m) and warm part of the high power coupler (TTF-III type without RF conditioning) have been provided by DESY and LAL-Orsay respectively. Some preliminary tests have been performed to verify the 9cell cavity well running at 2K and then at full RF power. To this end, the cavity has been equipped with thermal sensors and a multi layer super-insulator (see Fig.2)

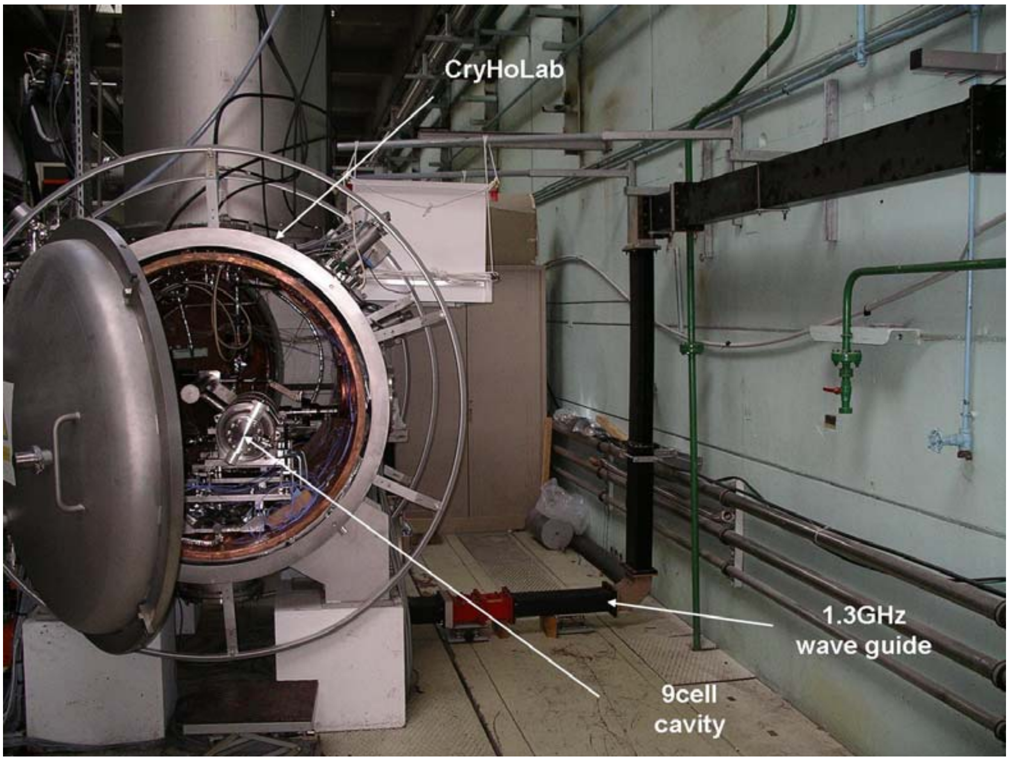

Figure 1: 9-cell cavity installed in CryHoLab - 1.3GHz RF wave guide connection between klystron and high power coupler.

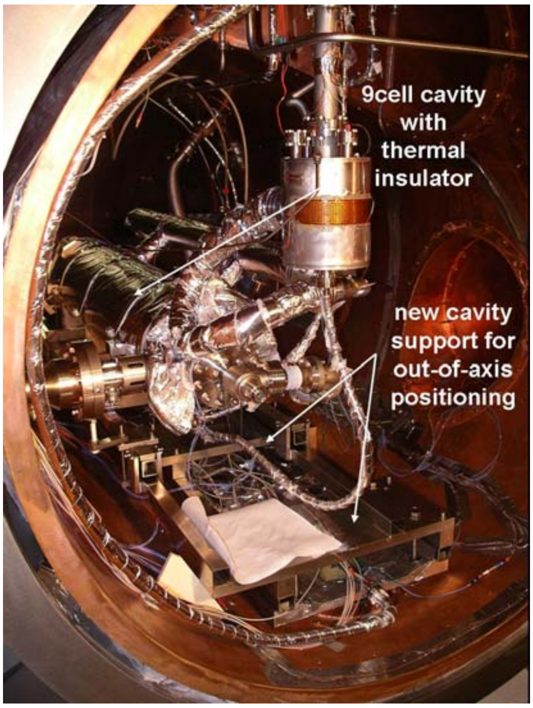

Figure 2: 9-cell cavity in CryHoLab dressed with multilayer thermal insulator.

The first cool-down to helium temperature has been planned in January 2005 to identify eventual cryogenic drawbacks (helium tank filling, coupler cool down, temperature measurements and helium bath pumping…) and to measure the static helium consumption at 4.2 and 1.8 K. After this step and prior to the testing of different cold tuning systems, the qualification of "Cavity-Coupler-CryHoLab" system was required. This qualification was successfully achieved during the RF power test in March 2005.

After the high power coupler conditioning (300 K, 1 MW, 1 ms, 3.8 Hz), the pulsed RF power was injected in the 9-cell cavity cooled at 4K. We can see on Fig. 3 the reflected and transmitted power signals from pick-up probes. In the RF pulsed mode at 4 K (900 kW, 250 μs, 0.8 Hz), the maximum accelerating field reached 18 MV/m with a limitation due to a strong field emission. The amount of X-rays detected was 7 μsV/h around the cryostat.

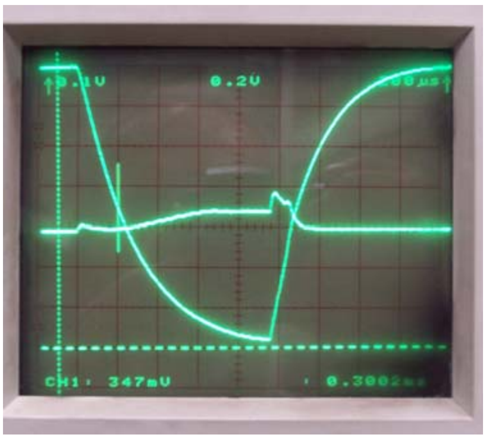

Figure 3: Oscilloscope signal of transmitted (upper trace) and reflected power (lower).

Nevertheless during these tests some specific problems appeared:

- a too long structure thermalisation forced us to improve the thermal connections between the cavity support and the cryostat base;
- some breakdown of the klystron high voltage required some repair and the complete cleaning of the modulator with the change of the insulating-oil (Fig.4)
- necessity to change DI water of the klystron cooling circuit.

These complications induced a two months delay in the WP10 schedule, without any consequences anyway for the first integrated test: the "Saclay II tuner" was only ready for test in September 2005.

Figure 4: After repair and cleaning, modulator components are transferred in the oil-tank refilled with 4300 litres of new oil.

Integrated Tests

1- Microphonics studies.

Following these qualifying tests, the "Saclay II" Cold Tuning System (CTS) equipped with a *Noliac Piezoelectric fast tuner* has been mounted on the 9cell cavity (see Fig.5). Measurements of "microphonic" resonances have been performed in CryHoLab by the characterization of the piezo to piezo transfer function to identify the sharp mechanical resonances of the cavity. During November 2005 first measurements were performed at room temperature and then at helium temperature (4.2 K): as shown in Fig. 6 the transfer function is modified after cooling down [1].

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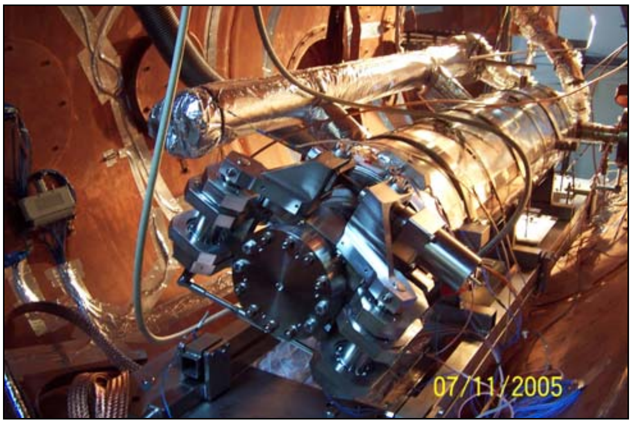
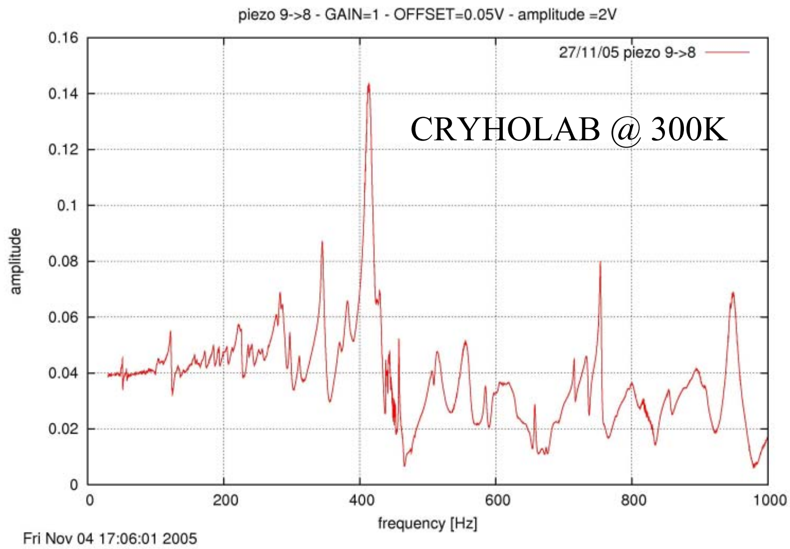
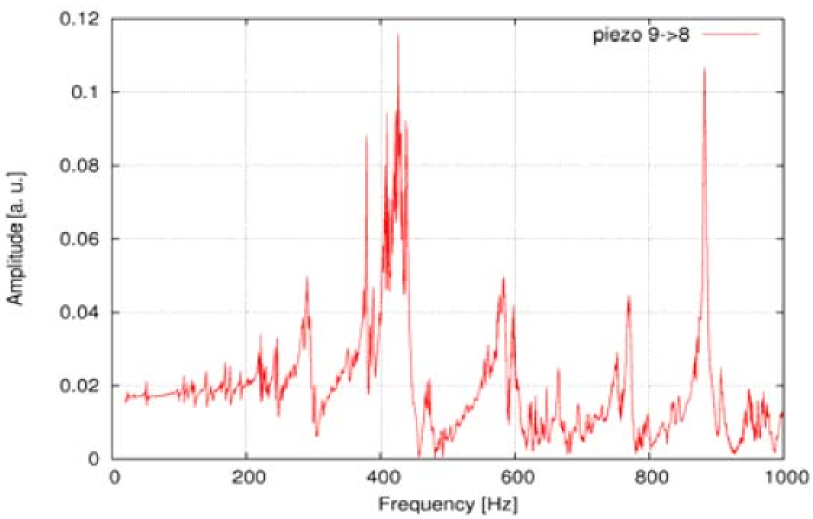


Figure 5: "Saclay II" CTS with Noliac Piezo Tuner mounted on 9-cell cavity.





Figures 6: Piezo to piezo transfer functions @ 300K and 4.2 K.

2- Compensation of Lorentz Force Detuning with Piezoelectric devices

To shorten the cavity filling time by RF power and in order to achieve an 800 µs flat top (see Fig.7), an electronic device has been developed to generate a 200 µs pre-pulse. During this period of time, the RF power provided by the klystron is multiplied by four.

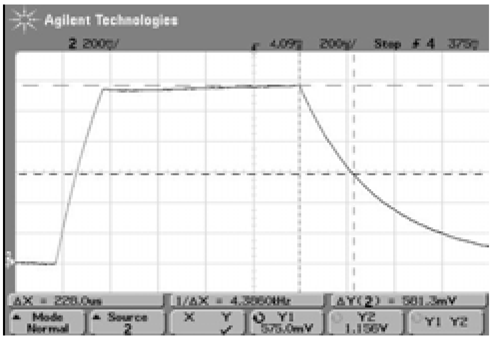


Figure 7: Flat top on transmitted RF power with pre-pulse

After coupler conditioning, the pulsed RF power (P=70 to 130 kW, 800 µs, 6.25 Hz) with pre-pulse (4P, 200 µs) was injected in the 9cell cavity cooled down at 1.7 K. We got the Q_0 vs. (E_{acc}) curve using transmitted power (P_t) and cryogenic measurements to determine the cavity losses (P_{cav}). The maximum accelerating field (22 MV/m) is limited by field emission with X-rays detected (Fig. 8).

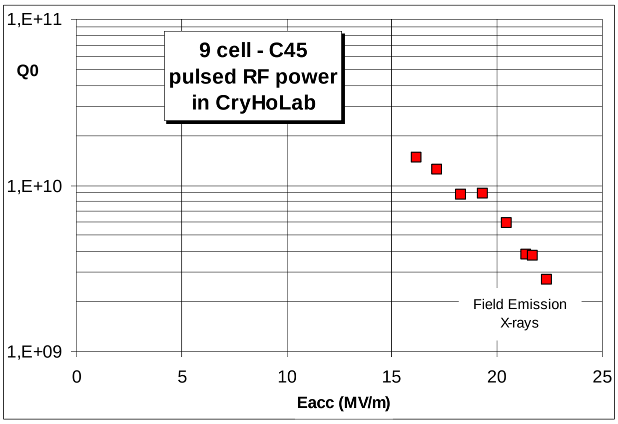


Figure 8: Q_0 vs. E_{acc} for C45 cavity

Under these conditions, compensation of the Lorentz Force detuning has been achieved (Fig. 9) using NOLIAC piezoelectric tuners assembled on the cold tuning system [2].

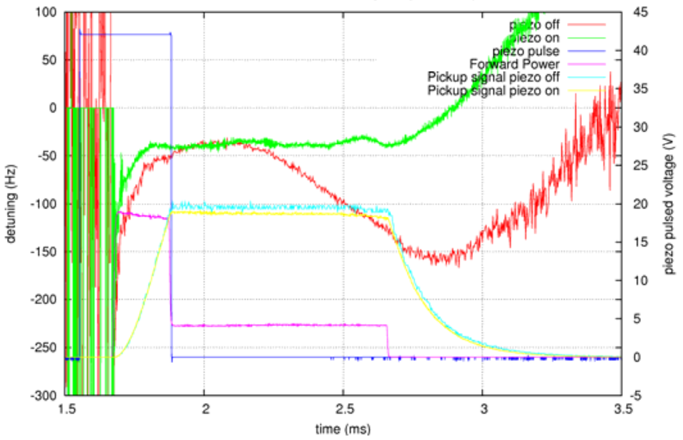


Figure 9: Lorentz Force Detuning for E_{acc} = 20 MV/m (red curve). Compensation using Cold Tuning System equipped with Noliac PZT (green curve)

Similar experiments have been reproduced with a second type of piezoelectric device (PICMA from PI manufacturer) [3].

All results achieved using NOLIAC and PICMA piezoelectric fast tuners are described in references [4-5].

3- Magnetostrictive Fast Tuner

Another type of a fast tuner was planned to be tested on the cold tuning system where the piezoelectric active element is replaced by magnetic smart material. Nevertheless a mechanical adaptation was necessary: one part of the cold tuning system had to be modified (see Fig. 10). This device was ready to be tested in CryHoLab in May 2006.

Figures 10: Modified mechanical part of the CTS for Magnetostrictive Actuator use (left); Integration on 9-cell cavity (right).

RF Infrastructure displace

Experiments with CryHoLab and more generally all RF tests have been adjourned at the end of May 2006 due to the transfer of the RF Infrastructure from “l’Orme des Merisiers” site to the main Saclay Centre (Fig. 12). One year later, after several months of delay compared to the initial schedule, the RF test facility was only ready for tests with vertical cryostats. Tests with CryHoLab are only workable in October 2007. Unfortunately due to the important delay in the transfer schedule, priority has been given to the CARE HIPPI program: the klystron modulator and CryHoLab have been dedicated to 700 MHz frequency and RF tests with 5cell proton cavities. As a consequence, the test of the magnetostrictive fast tuner at 1.3GHz on 9cell cavity has been cancelled.

Figure 12: New RF test Facility at Saclay

Conclusion

The impact of the European CARE SRF program and specifically of WP10 is very important. This program allowed pushing forward the development of the horizontal cryostat by high power RF tests. Until now, only RF tests at low power have been performed on cavities in CryHoLab.

Moreover, synergy with CARE HIPPI gives now the possibility to test easily in this RF facility different sizes of multi-cell cavities at 700 and 1300 MHz with ease. Two separate waveguide lines are installed with different high power coupler ports on the cryostat. A common modulator connected to 1.3 GHz Thales and 700 MHz CPI klystrons complete the RF platform as a power supply.

At this time, CryHoLab at CEA forms with CHECCHIA at DESY and HoBiCaT at BESSY a horizontal cryostat set, able to test multi-cell superconducting cavities in similar conditions to an accelerator cryomodules.

References

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[2] **Compensation of Lorentz Force Detuning of a TTF 9-cell Cavity with a New Integrated Piezo Tuner -** G. Devanz, P. Bosland, M. Desmons, E. Jacques, M. Luong, B. Visentin - CARE Conf-06-016-SRF - Contribution to the EPAC'06, Edinburgh, UK

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