EURISOL DS Project
Task 8: SC cavity development

Deliverable D6
Cryomodule: preparation, assembly & test
Complete cryomodule prototype

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The cryomodule assembly starts with the insertion of the copper shield inside the vacuum tank. Then the helium dewar and the cavity cradle are placed, in order to have the final position of these elements: this allows to take all the final measurements for the cryofluids piping, which are fabricated in house. The sheme of the cryofluids circulation is given in figure 1.

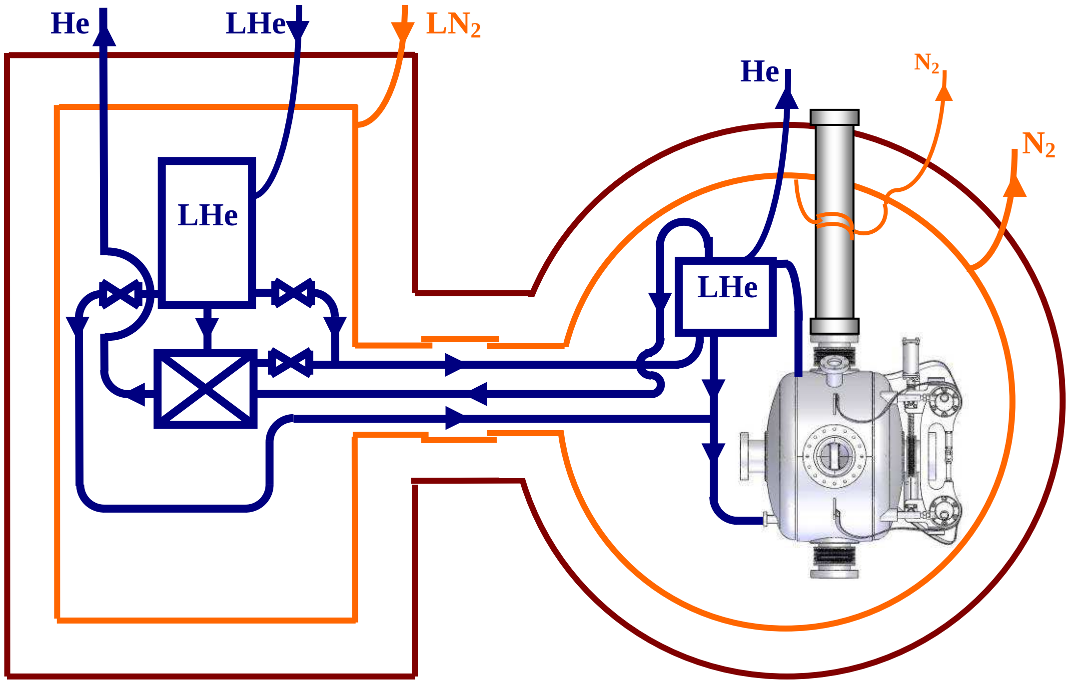

Fig. 1 Cryogenic fluids circulation

The cavity inside its cradle is inserted using a dedicated trolley (fig. 2). When the cavity is equipped with its power coupler, the insertion is not performed horizontally, but with a given angle allowing coming out the upper part of the coupler thru the cryostat coupler port.

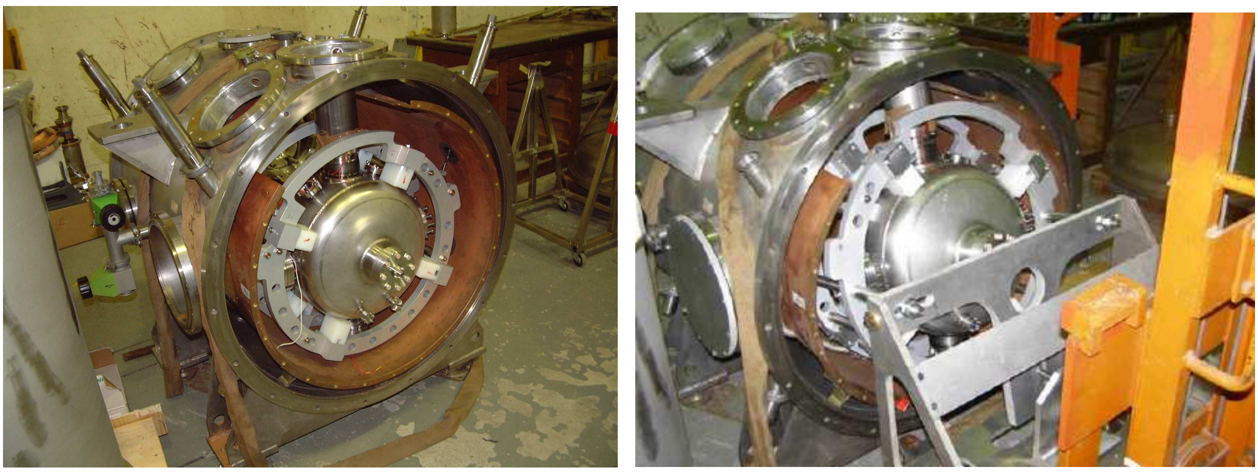

Fig. 2 Cryostat during assembly

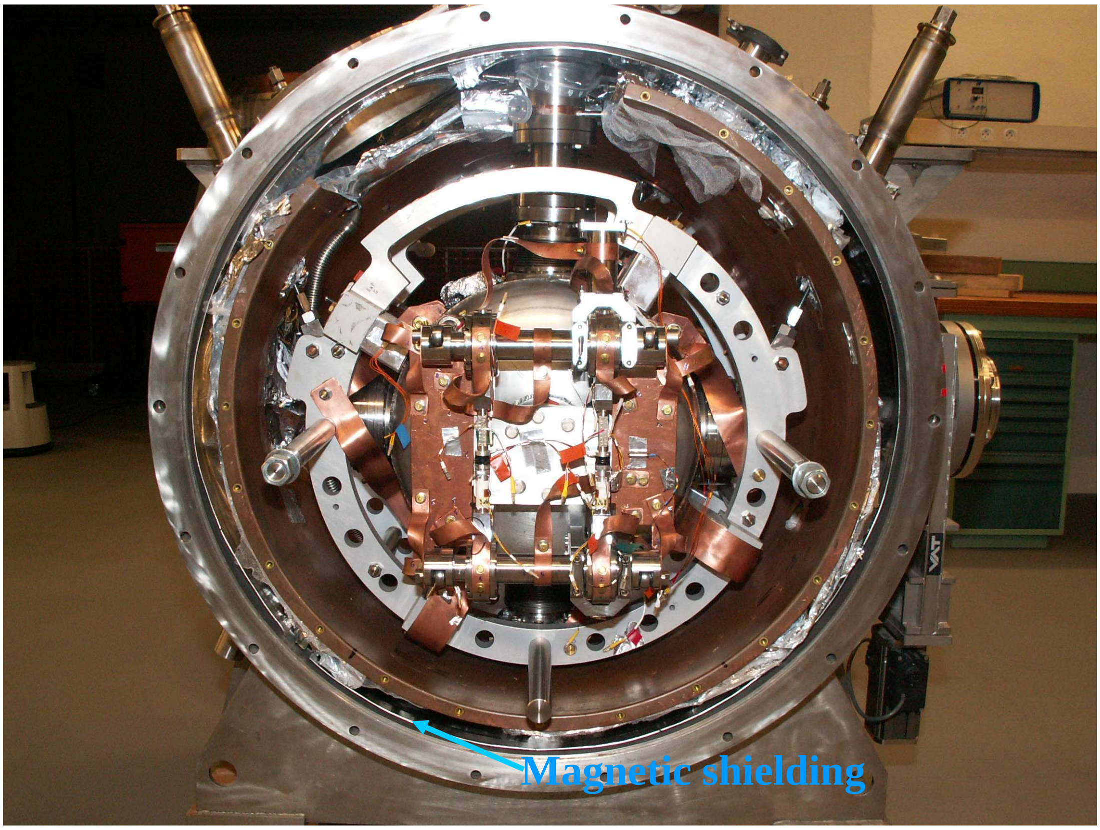

Fig. 3: Cryostat internal view

Multilayer super-insulation is used between the magnetic shielding and the copper shield, but also around the helium dewar and the cavity tank volume.

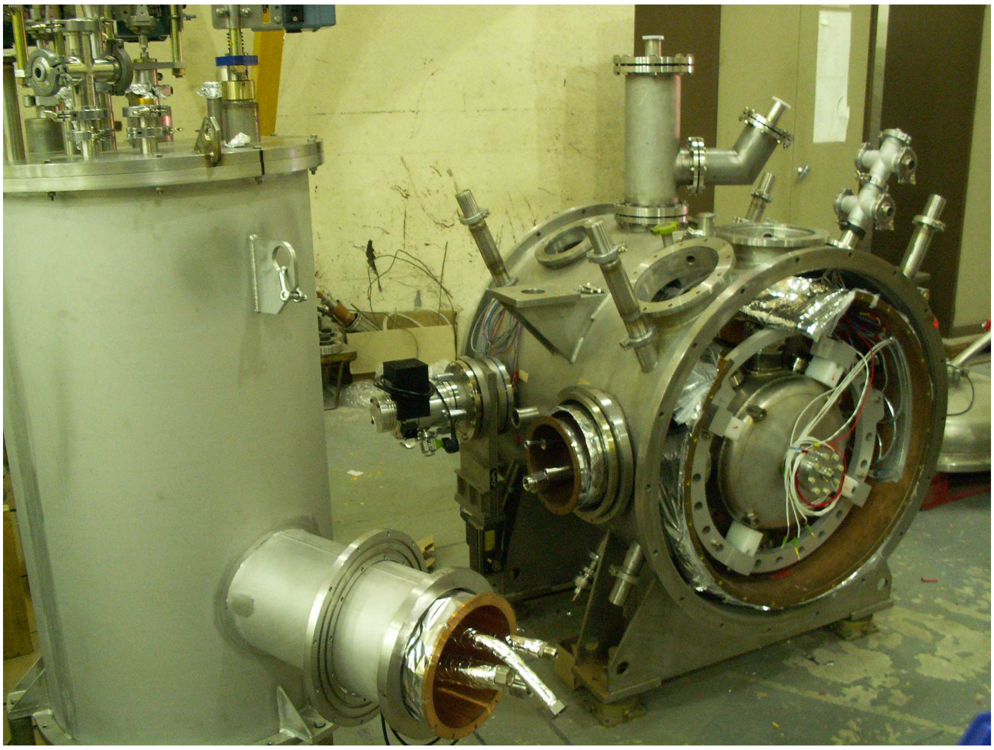

Fig. 4 Assembly of the cold box and cryogenic lines connexions

Cryogenic instrumentation:

In order to monitor the cryogenic behaviour of both the module and the cold box, an important instrumentation is used to measure the temperatures, pressure, helium levels and vacuum levels inside the system:

- 9 pressure measurements.
- 24 temperature sensors, of different types, adapted to the measurement over several temperature ranges, and located at carefully chosen place (see fig. 5)
- 2 volumetric flow meter and 1 mass flow meter, for helium.
- 2 sets (one for the cryomodule, one for the cold box) of liquid helium level measurement composed of superconducting wires and several resistors.

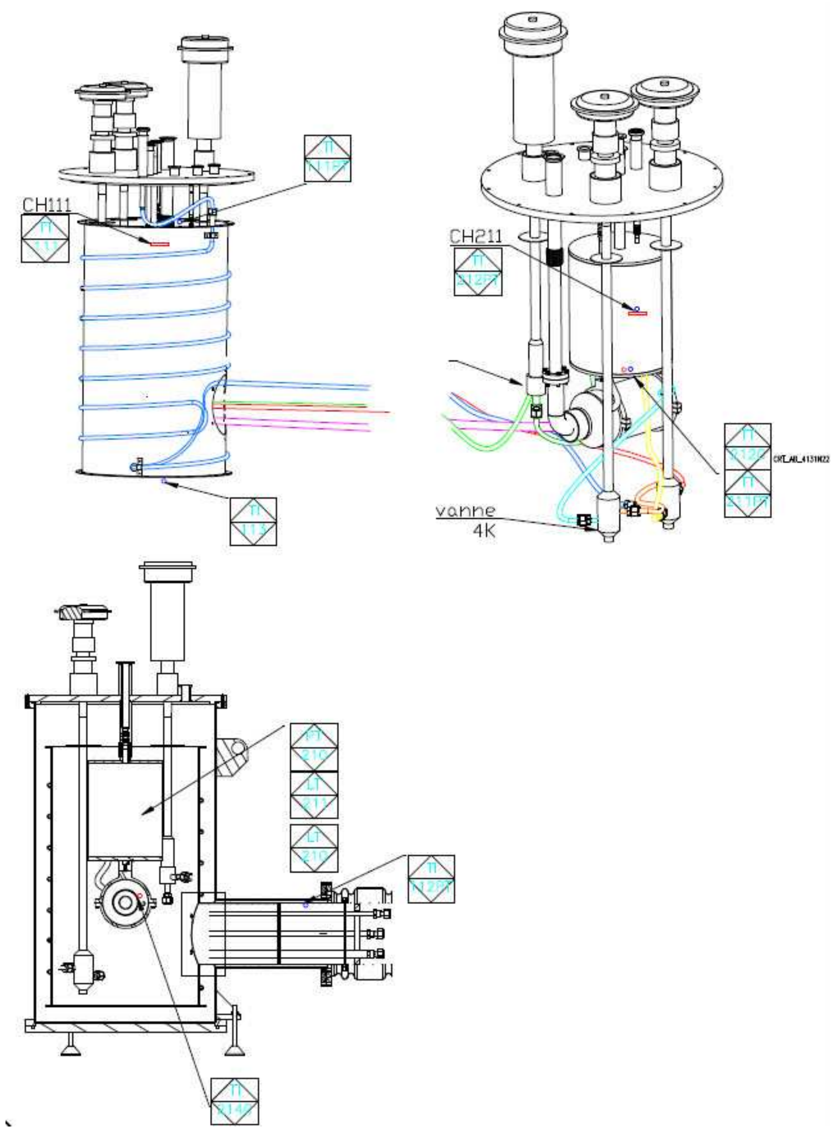

Fig. 5a Temperature sensor position in the cold box

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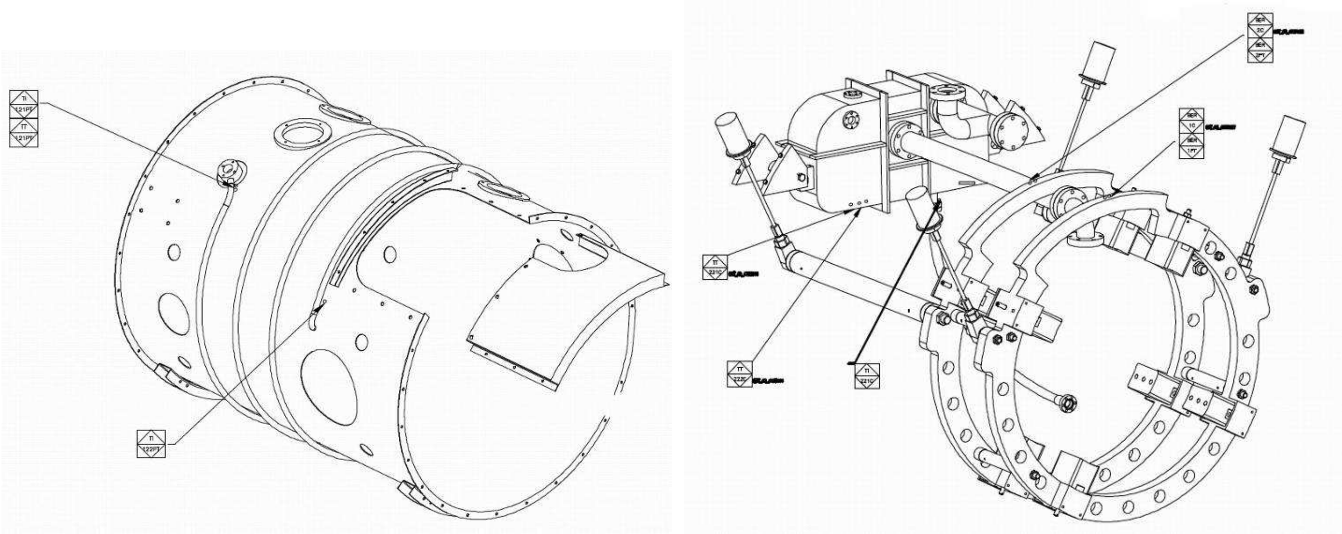

Fig. 5b Temperature sensor position in cryomodule

Fig. 6: Spoke Cryomodule and its cold box just before the cryogenic test.

The final assembly step consists in the cable assembly of all instrumentation to the electric connector distributed on the vacuum tank ports all along the cryomodule.

Cryogenic behaviour of the module:

The 80 K circuit cooldown took 6 hours (Fig. 7): 2 to 3 hours were needed for the copper shield to reach its nominal temperature, while the connection element between the copper shield and the cold box took about 6 hours. The observed fluctuations are linked to the opening and closure of the liquid nitrogen valve.

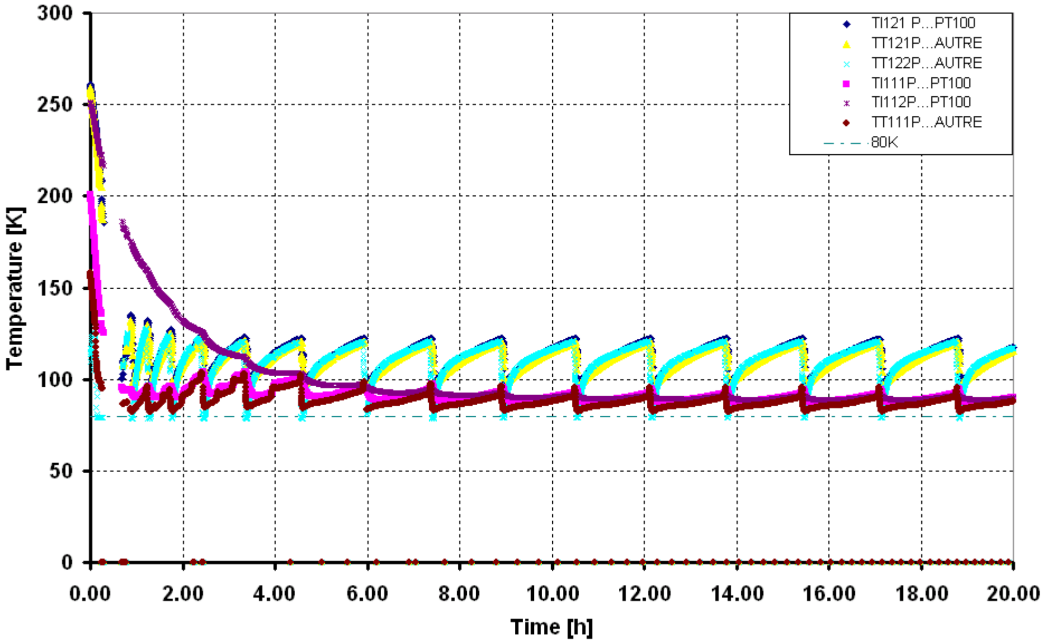

Fig. 7: Temperature located on the 80 K circuit measured during cooldown

The cavity cooldown with helium was also satisfactory: the whole cavity was cold within 7 hours (see fig. 8a and 8b).

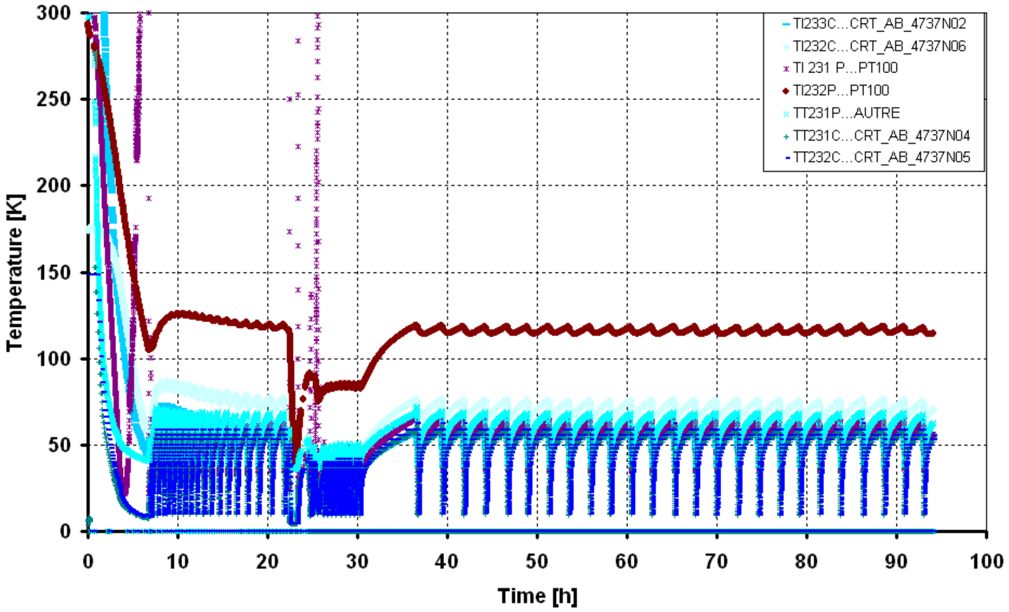

Fig. 8a: Temperature measured on the cavity during cooldown

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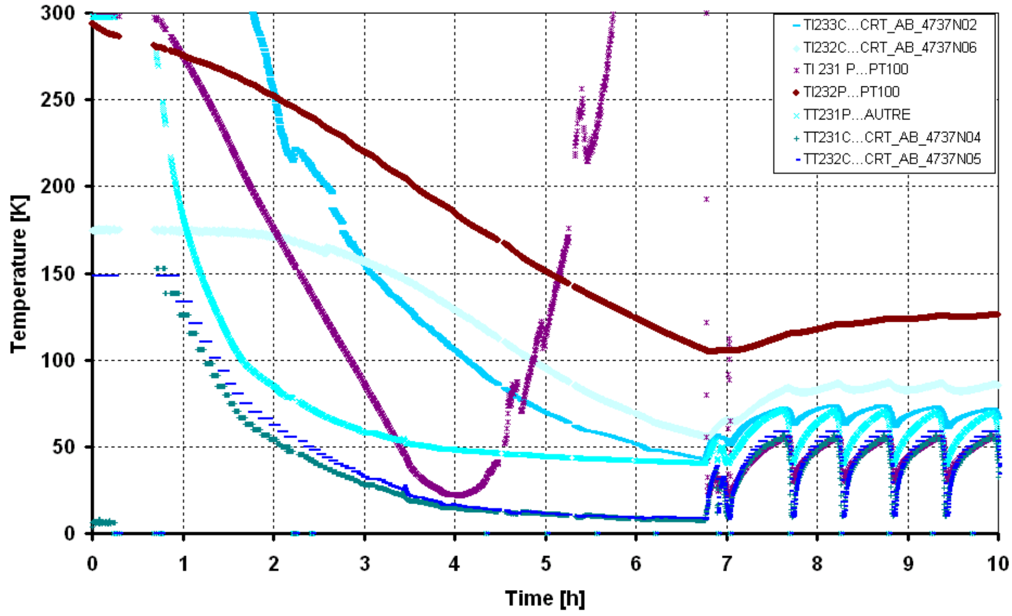

Fig. 8b: Temperature measured on the cavity during cooldown (zoomed between 0 and 10 hours)

The cryogenic static losses have been measured under several regulation conditions. On the average the measured losses are 1.8 W (without RF), which is quite good taking into account the difficulty to perform an efficient thermal insulation of the coupler, due to the very short distance between the warm window and the cavity flange.

In order to avoid gas condensation on the window (air side), a circulation of warm water was performed (T=30 °C). This was mandatory to avoid this phenomenon. A lower water temperature was tried, but it was not sufficient to keep the window temperature above the dangerous zone of 15°C.

The most important difficulty was the very long cooling time of the cold tuning system (CTS) in the first experiment. After 2 days at 4.2 K, the CTS had not reached its equilibrium temperature. A later modification, consisting on the addition of copper scales between the CTS and the cavity helium tank allowed us to solve the problem and to reduce the CTS cooling time to a few hours only.

Conclusion:

The spoke cryomodule assembly procedure has been set and the cryomodule cryogenic behaviour was satisfactory after the second test. The module has been qualified and is now ready for the fully equipped cavity test.