



EURISOL DS Project

Task 8: SC cavity development

Deliverable D1

Cryostat design and fabrication

Authors :

S. Bousson, G. Olry, F. Chatelet, P. Duthil, D. Grolet, F. Lutton, R. Martret, G. Michel, H. Saugnac, P. Szott, CNRS/IN2P3/IPN Orsay (France).

Planned Date (month): 29

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I. Introduction

In the intermediate energy part of the EURISOL driver, the superconducting accelerating structures of the “spoke” type are investigated to accelerate the different species (proton, deuteron and He3) between 40 and 120 MeV. To assess that spoke cavities are capable to efficiently accelerate particles with the designed performances, one key test consists in a cold test of a superconducting spoke cavity fully equipped with all its ancillaries systems:

- Helium tank
- Power coupler
- Cold tuning system

Such a test allows addressing almost all potential difficulties in the operation of a superconducting cavity in a real accelerator. The mechanical, thermal, and RF behaviour of the full system is tested in a cavity configuration close to the final one in the accelerator.

In order to perform this test, a cryomodule needs to be designed to host the fully equipped cavity. This document reports on the conception of the spoke cryomodule designed and construction within the EURISOL-DS program.

II. Overall specifications


The spoke cryomodule is composed of two main components

- The vacuum tank, which is hosting the cavity and its ancillaries, an helium dewar, the cryogenic piping and instrumentations.
- The “cold box”, external to the cryomodule, which provide the module with the cryogenic fluids (liquid, gas).

The module was designed to be a laboratory test stand to test several spoke cavity types under several configurations. The main requirements were the following:

- The cryomodule was conceived to have dimensions long and wide enough to host a fully equipped spoke cavity, low or medium β .
- The temperature operation point is 4.2 K but both module and cold box have the possibility to operate using a depressed helium bath to perform cavity tests at lower temperature (typically 2K).
- The power coupler could be mounted with 2 different configurations:
 - a vertical position (the power coupler is located on the top of the cryomodule), which is the best mechanical situation. But in this configuration, the cavity spoke bar is horizontal, and there might be a risk of a non-efficient cooling of the spoke bar due to the difficulty of the helium gaz to be evacuated.
 - a 45° inclination with respect to the vertical position: in this configuration, the cavity spoke bar has also a 45° inclination wit respect to the horizontal plane. This backup configuration is potentially more efficient for the spoke bar cooling and could be used in case of cooling difficulties in the other configuration.

A scheme of the cryomodule and its cold box is shown in figure 1.

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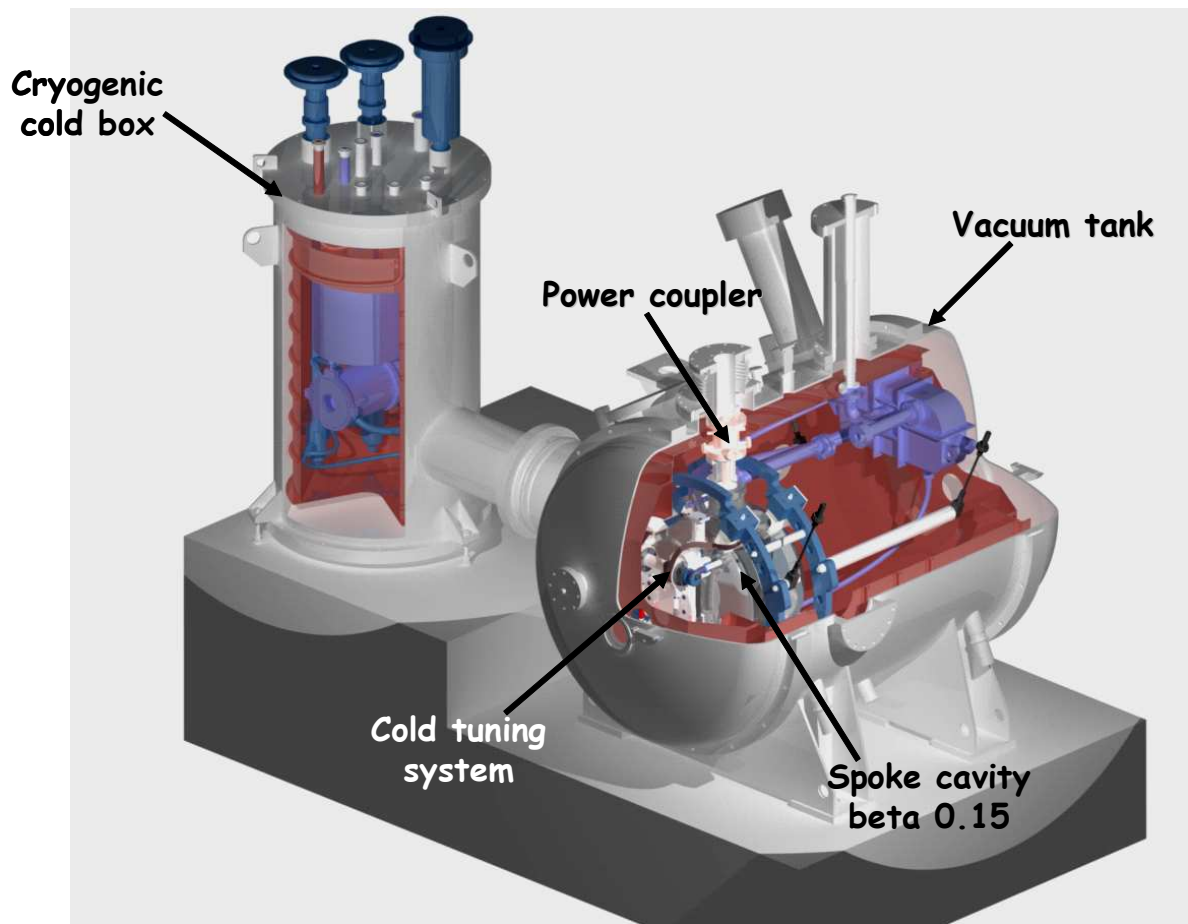



Fig. 1 Scheme of the spoke cryomodule and its associated cold box

III. Cryostat design

The cryostat integrates the following elements:

- A mechanical system to maintain the spoke cavity in the cryostat, with a “loose” end allowing the differential thermal contraction to happen without inducing any mechanical constraints to the system. The cavity is inserted inside a cradle, blocked by means of Teflon pads (see fig. 2).
- The cavity cradle is fixed to the vacuum tank by means of carbon rods, chosen for their robustness and their high thermal insulation capacity (see fig. 3).
- A copper shield is placed inside the vacuum tank, integrating a circulation of liquid nitrogen in order to provide an intermediate thermal barrier between the 300 K of the tank and the 4.2 K (or 2 K) of the cavity.
- A 20 l capacity helium dewar is located inside the vacuum tank volume: it is directly fed from the cold box, and insure a constant filling of the cavity helium tank with helium. The helium level regulation is performed on this dewar, which has been equipped with two different helium level measurement systems: a superconducting wire and a set of 4 resistors distributed on the dewar height.
- A magnetic shielding, used to provide a magnetic insulation of the cavity from the earth magnetic field is placed between the vacuum tank and the copper shield. It is made of a 1 mm thick CO-NETIC cylinder.

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Overall drawings of the cryostat are given in Annex 2.



Fig. 2 Spoke cavity inside its cradle, blocked by Teflon pads.

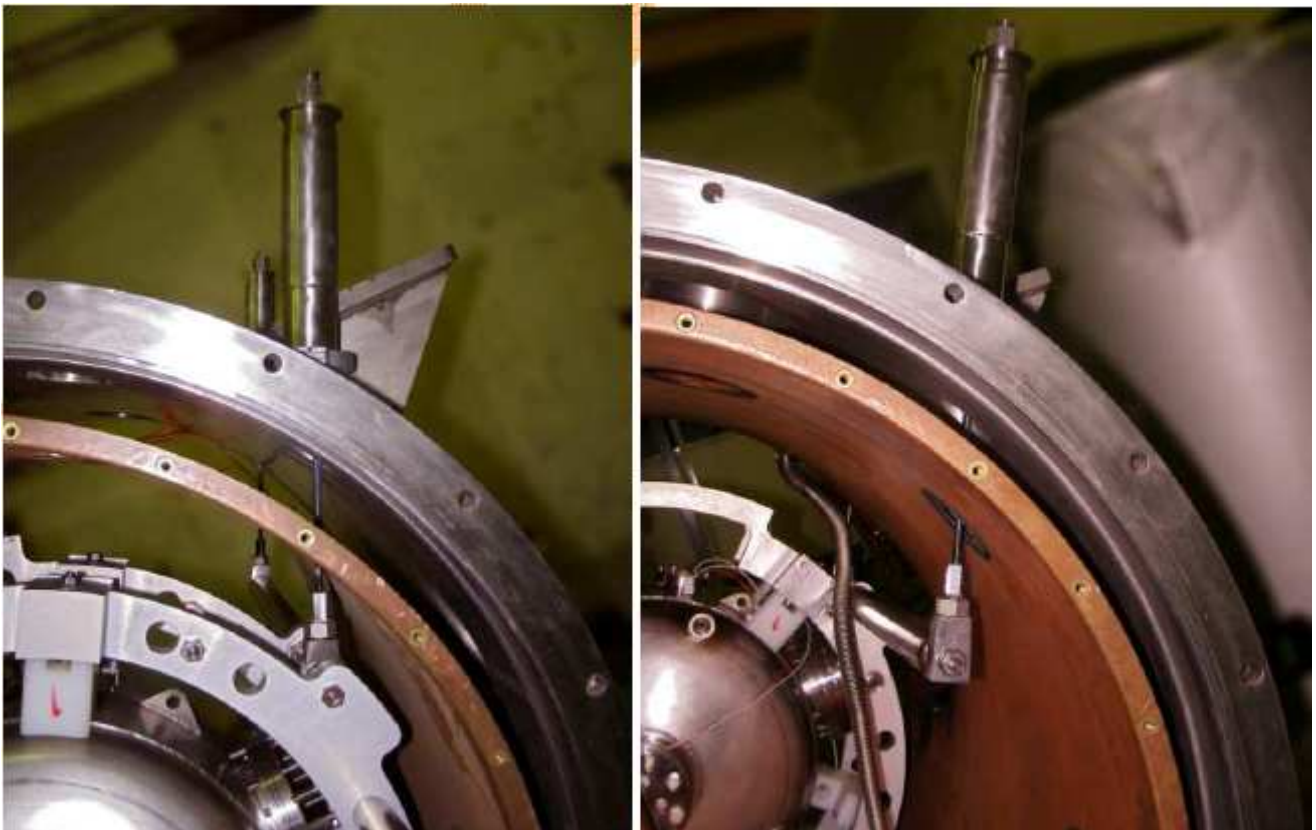



Fig. 3: Details off the carbon rods attaching the cavity cradle to the vacuum tank (front and rear view).

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IV. Cryostat assembly

The 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 scheme of the cryofluids circulation is given in figure 4.

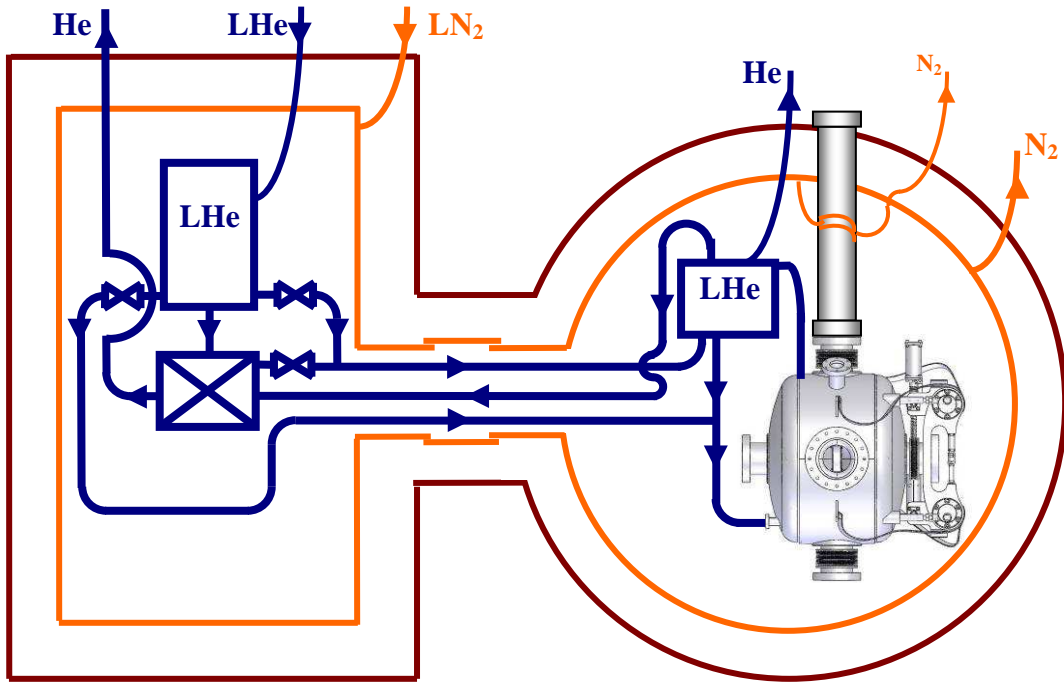


Fig. 4 Cryogenic fluids circulation

The cavity inside its cradle is inserted using a dedicated trolley (fig. 5). 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.

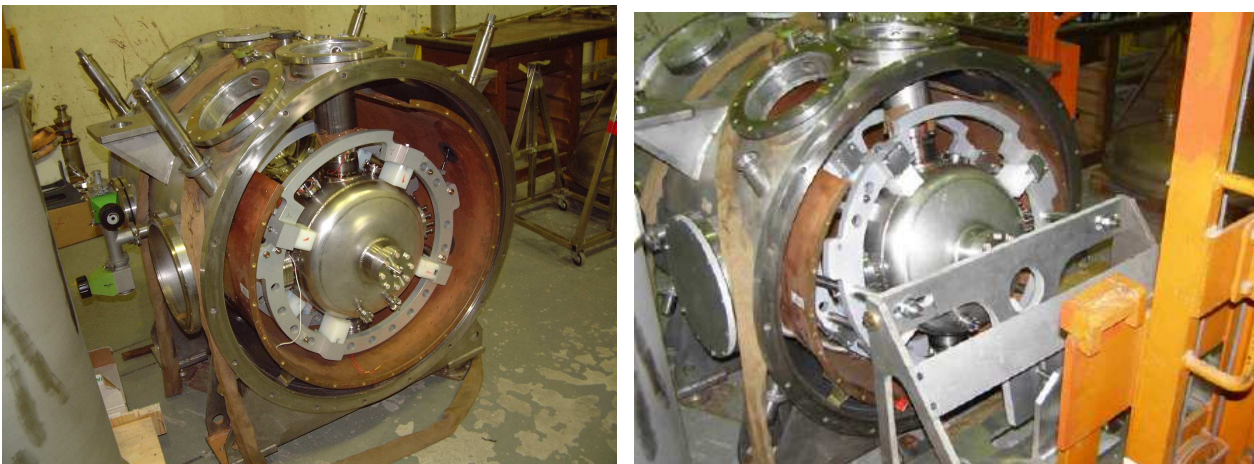



Fig. 5 Cryostat during assembly

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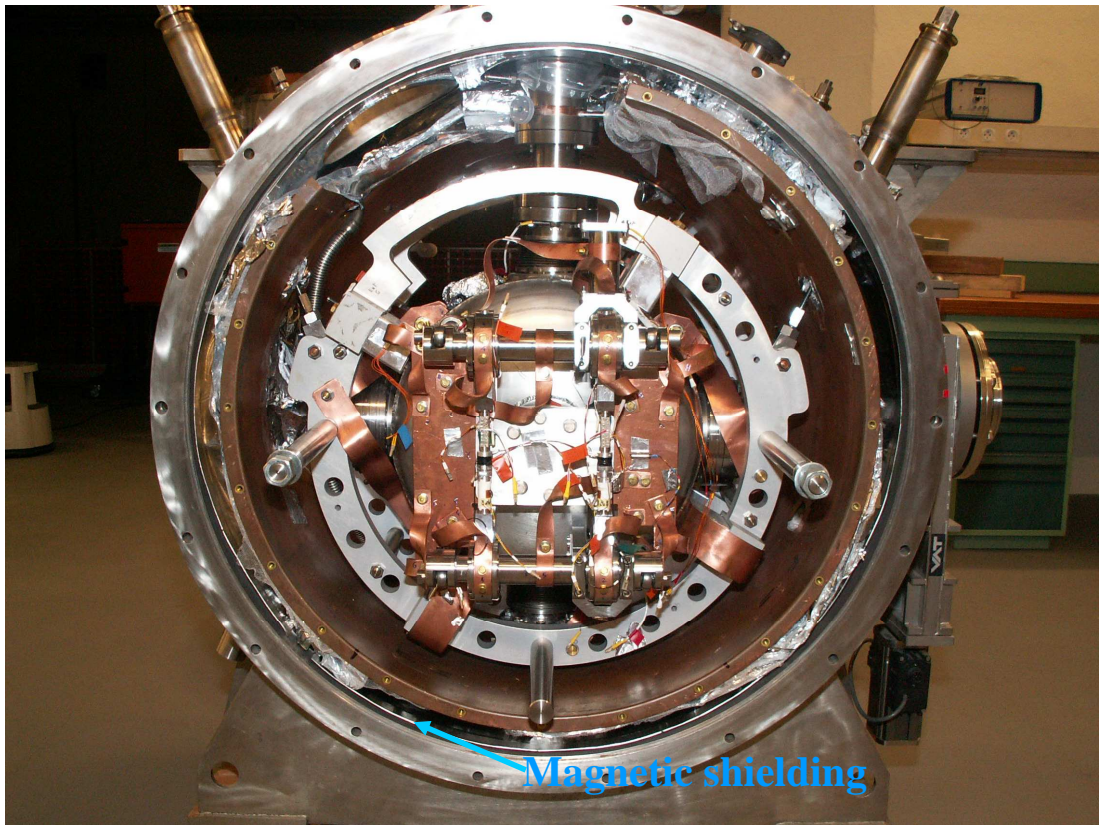


Fig. 6: Cryostat internal view

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

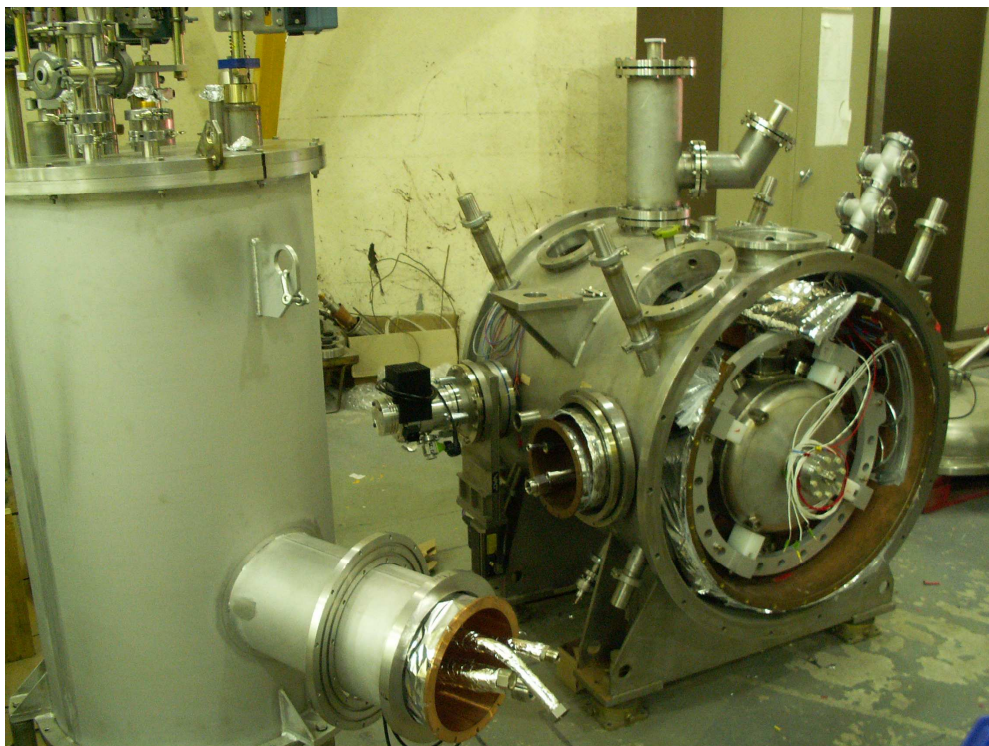



Fig. 7 Assembly of the cold box and cryogenic lines connexions

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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.
- 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.

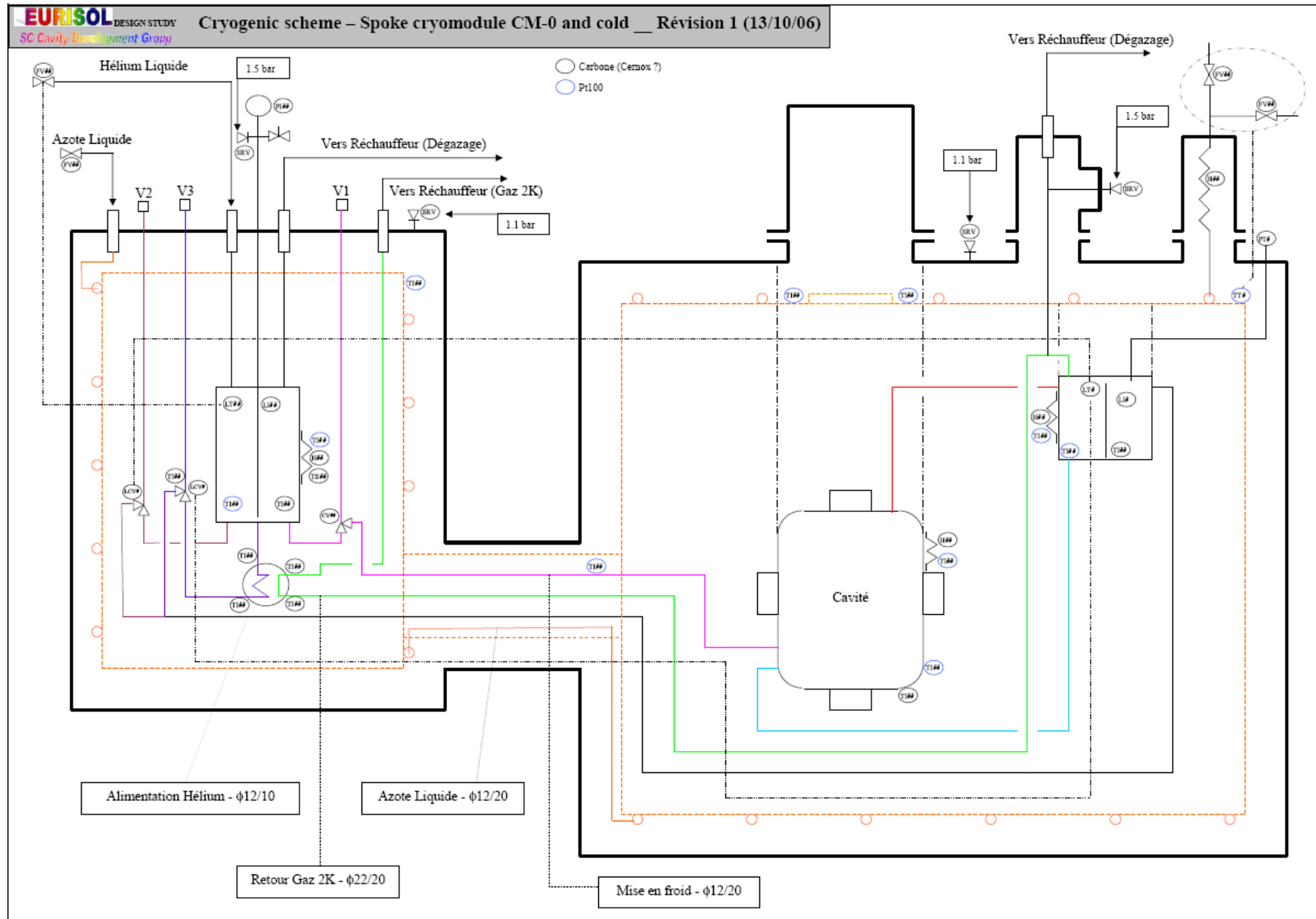


Fig. 8: Spoke Cryomodule and its cold box just before the cryogenic test.

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.

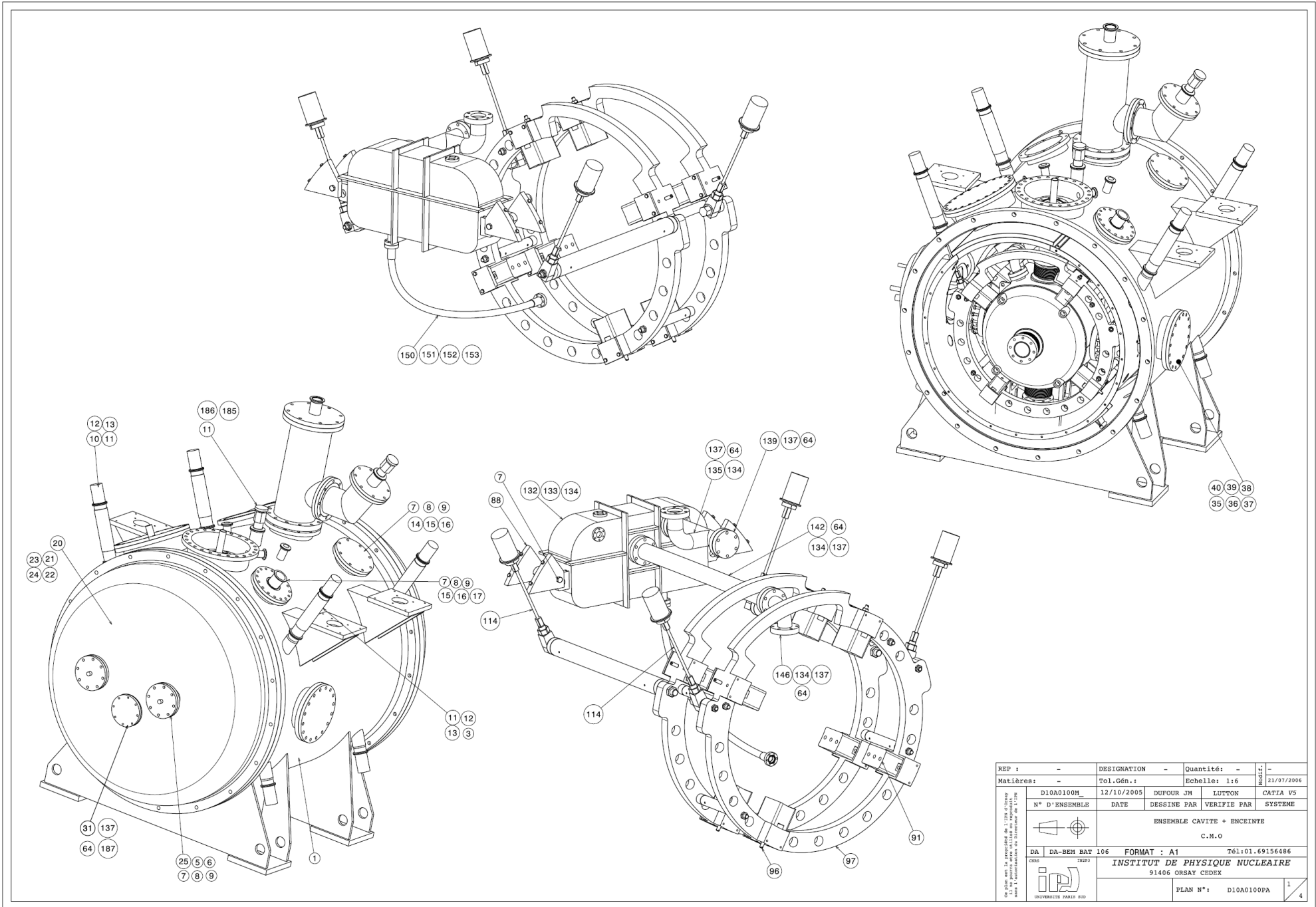
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ANNEX 1 : Spoke cryomodule cryogenic scheme



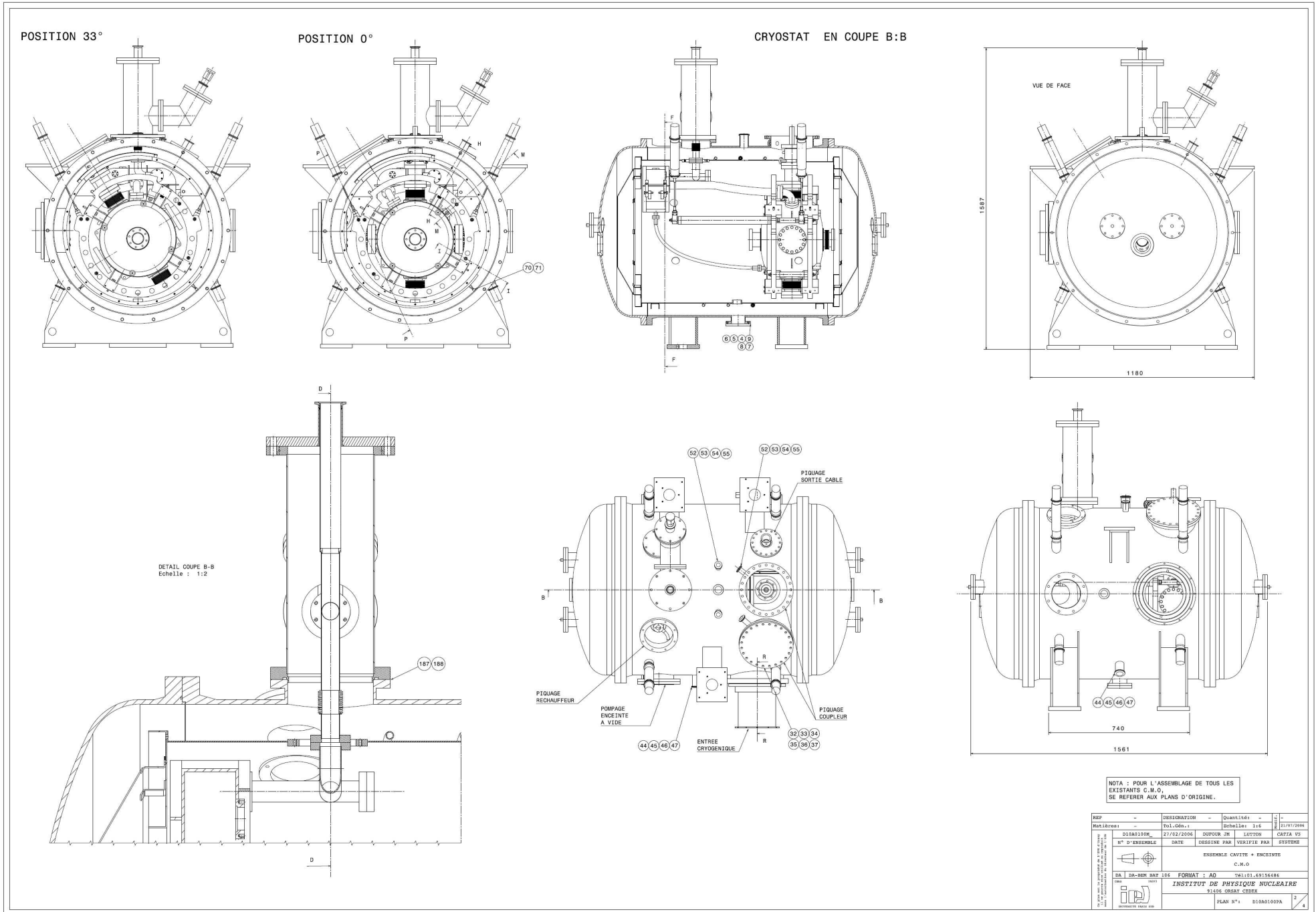
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ANNEX 2 : Spoke cryomodule overall drawings

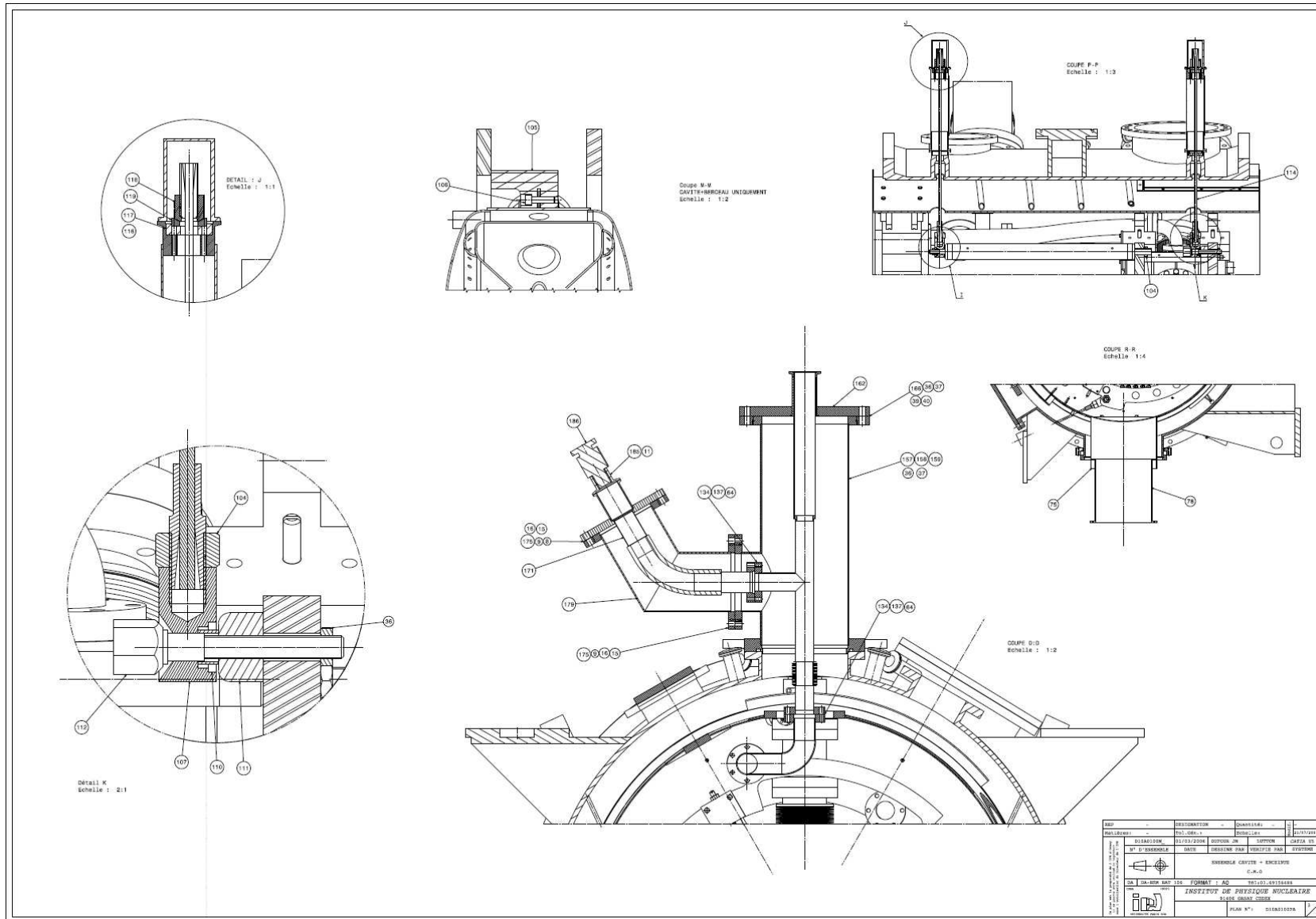


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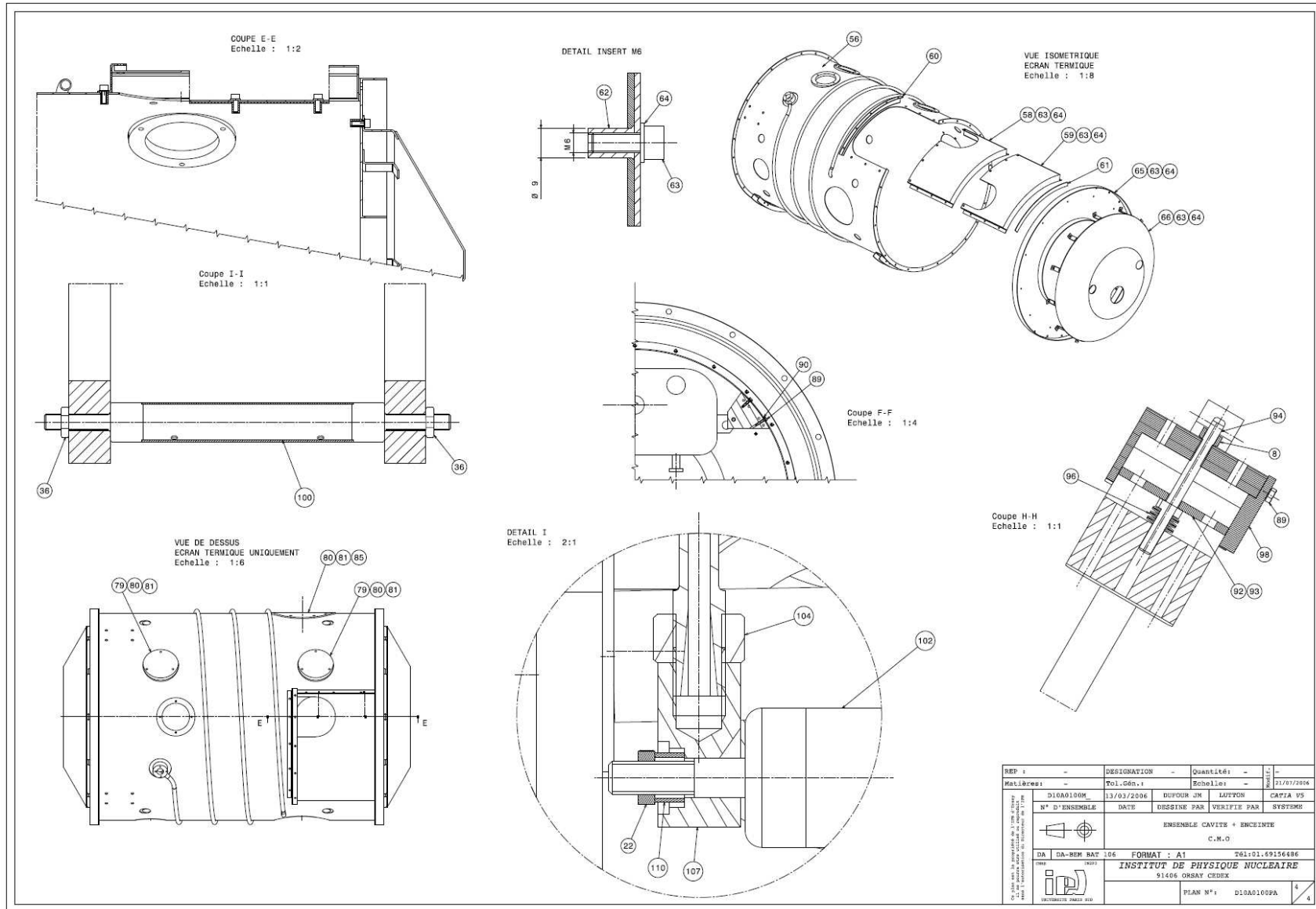
ANNEX 2 : Spoke cryomodule overall drawings



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ANNEX 2 : Spoke cryomodule overall drawings



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