FRESCA2 TEST PLANS @ CERN

by Marta Bajko

on behalf of

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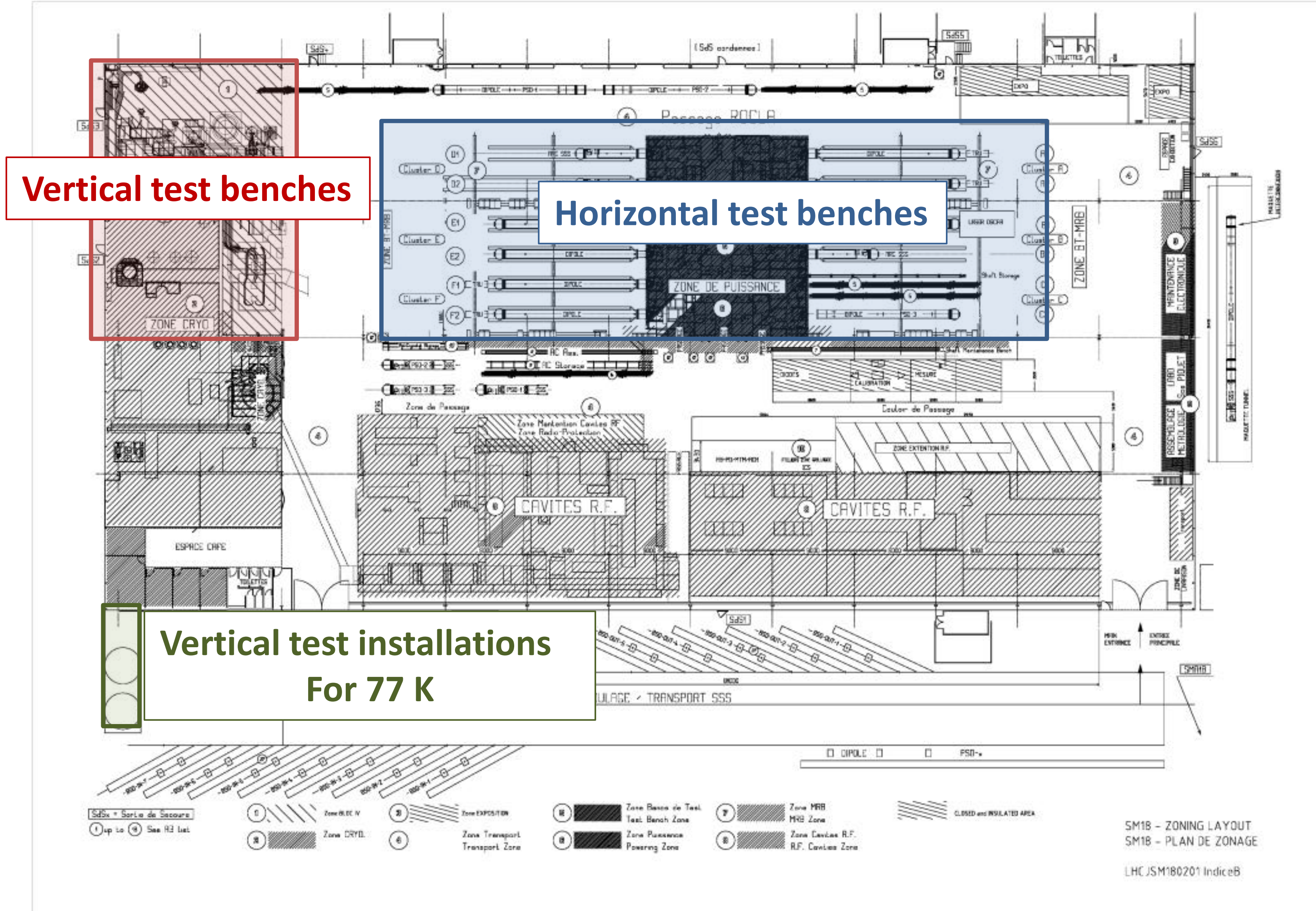
For ESAC Review @ CEA- February 2013

Summary

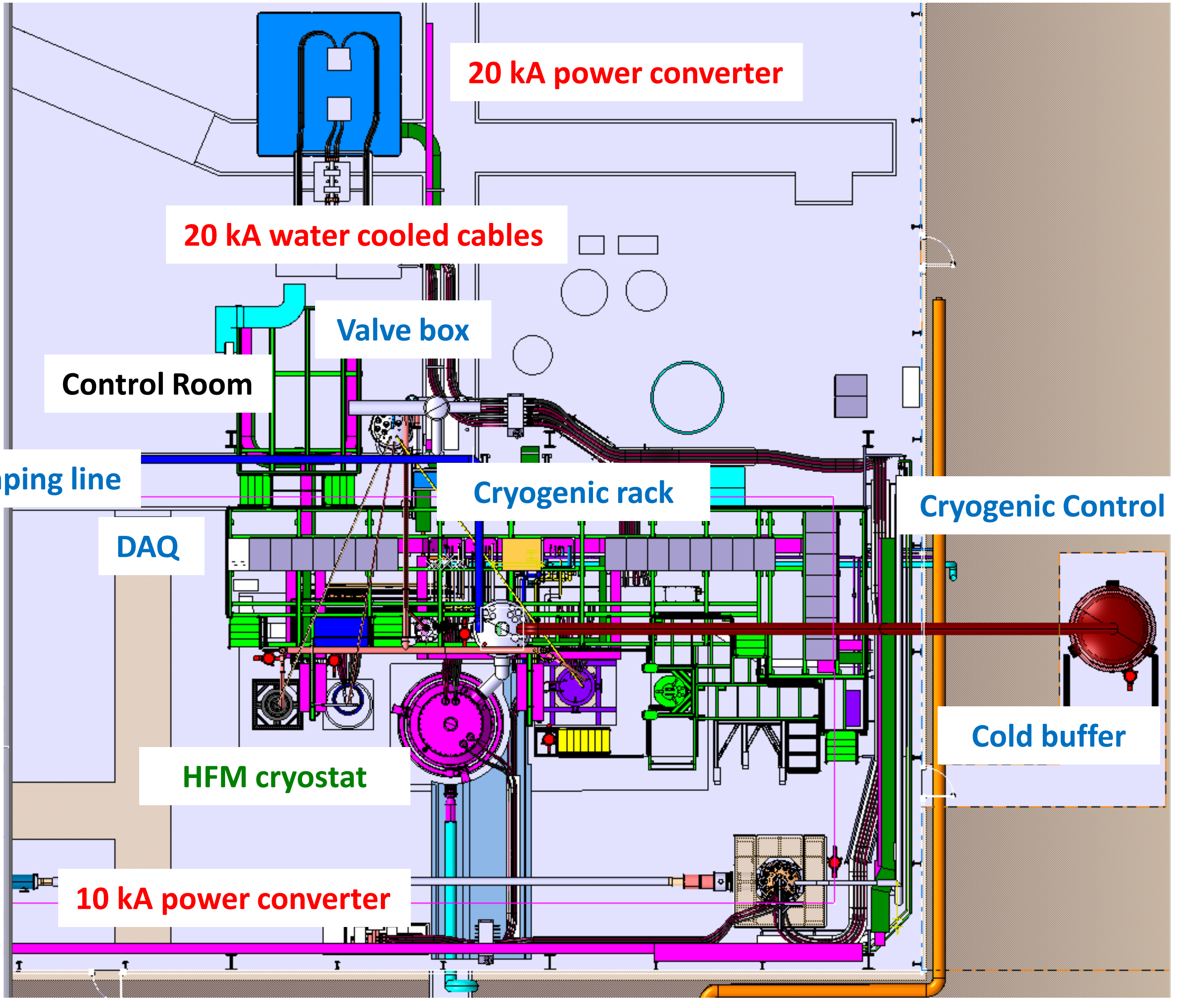
- Cryogenic test station layout
  - 1.9 K test station
  - 77 K test station
- Inputs and constraints for the test station design
- Main ingredients of the HFM test station
- Status of the main ingredients
- Update of the planning

Cryogenic test station SM18 layout



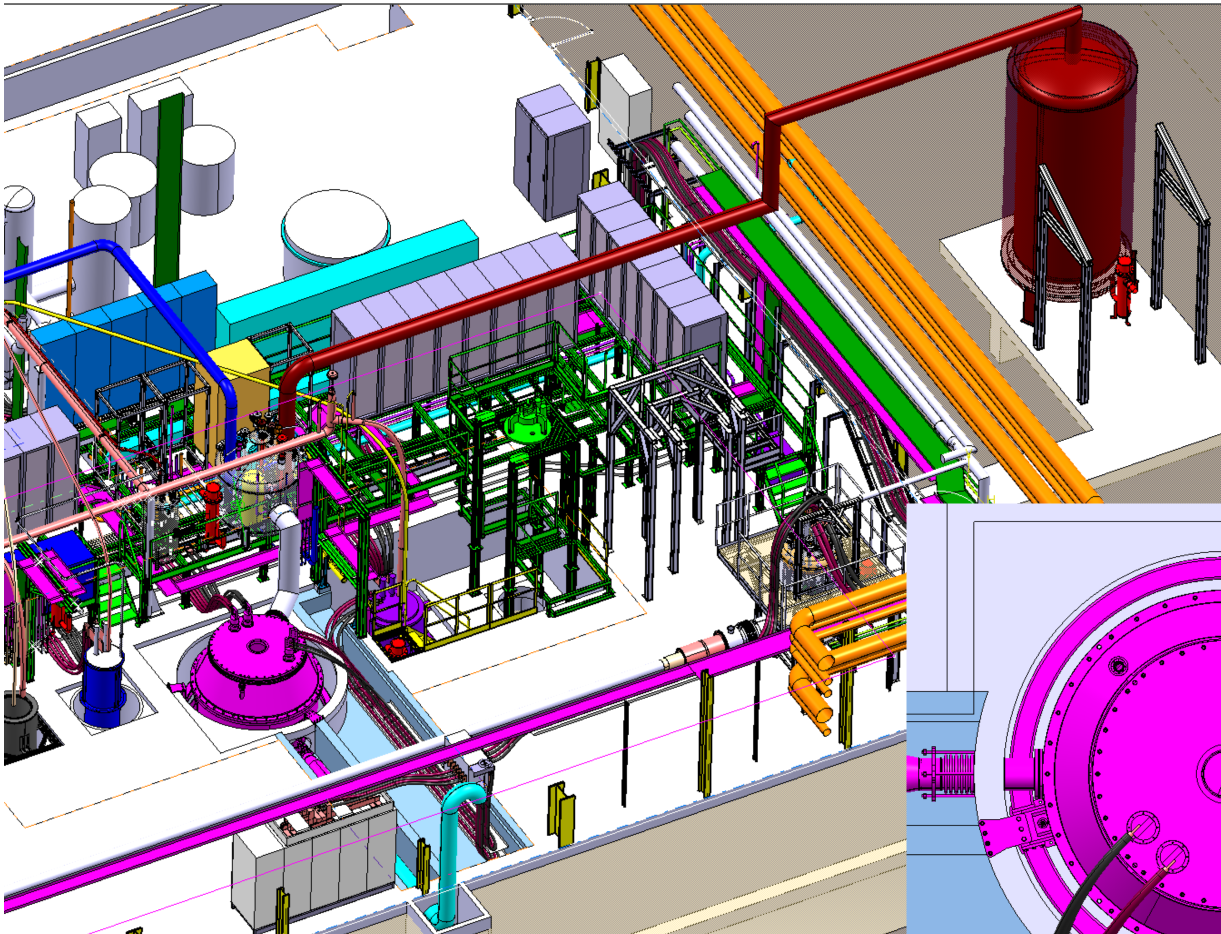
The Vertical Test station in SM18.

The integration of the HFM station is completed.



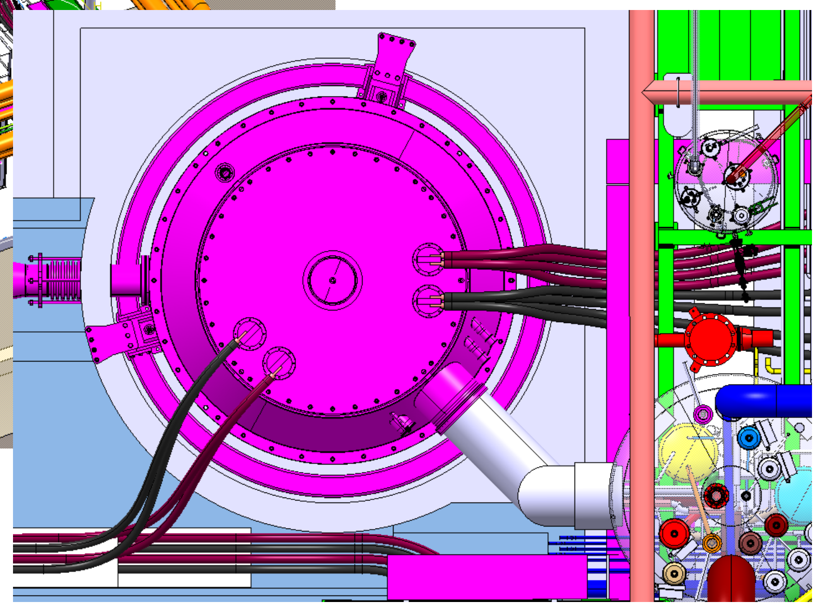
Civil engineering work inside the hall is finished

Water cooled cables, switches and current leads



<u>HTs current leads</u> will be design on purpose for the test station. The current leads fabrication time: 1 year from t_0.(will be in the shadow of the cryogenics)

In the 20 kA circuit current **<u>distribution switch</u>** is integrated, tested up to 17 kA. A second, smaller one, is needed for the 10 kA circuit.

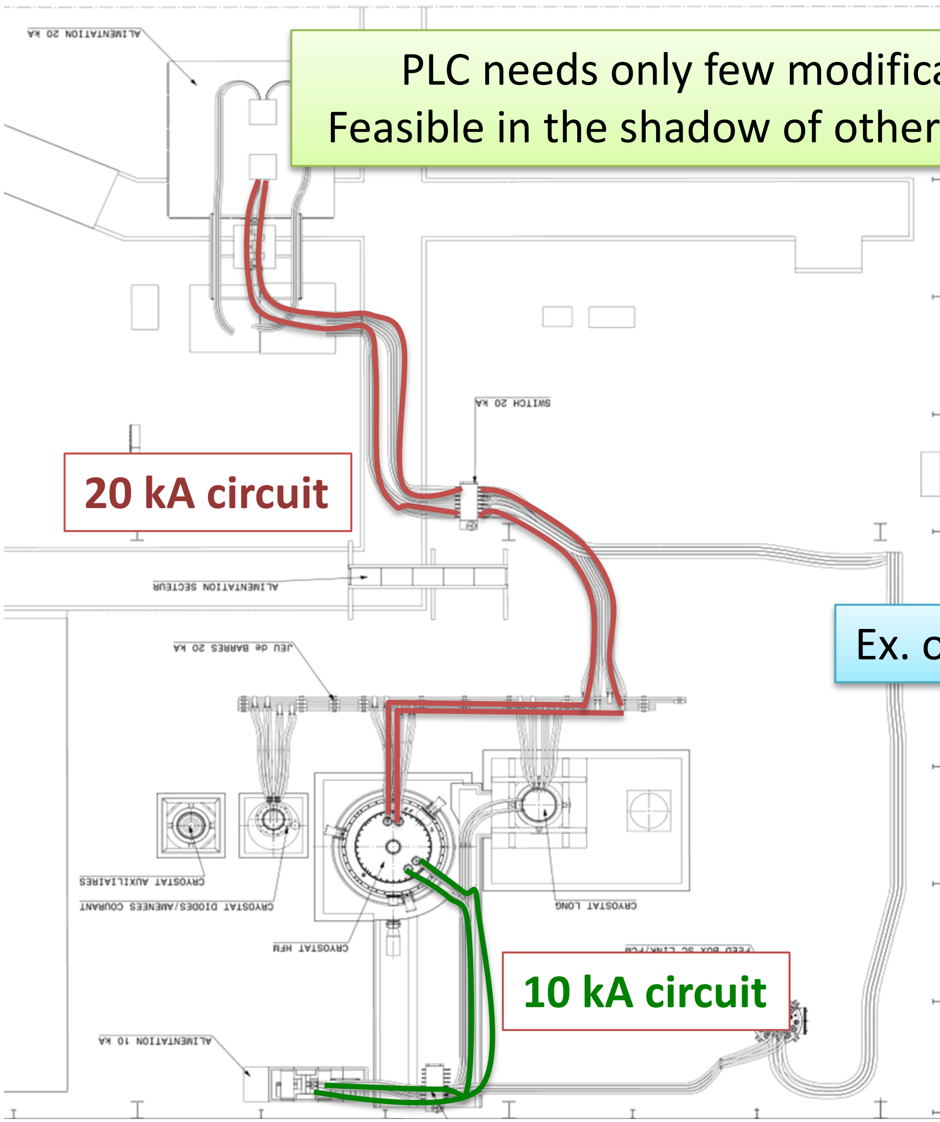


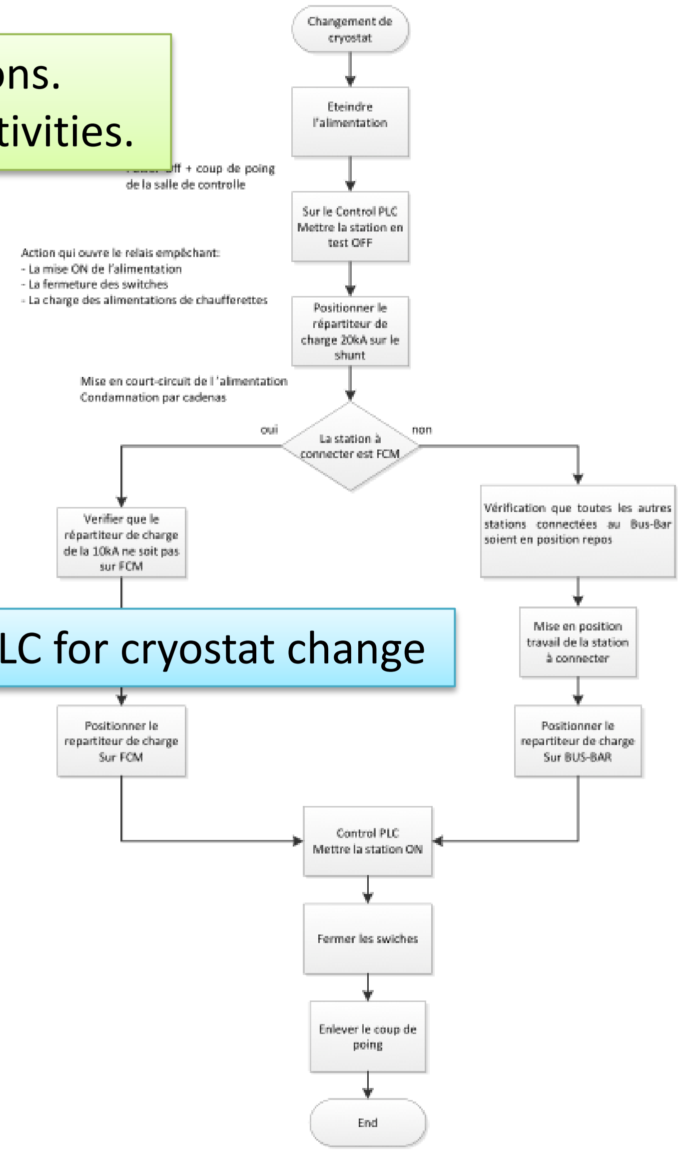
We are in the phase of defining the interface between current leads and **<u>water cooled cables</u>**. Fabrication time: 9 mounts from t_0

8 x 500 mm copper water cooled cables between bus bars and current leads for the 20 kA circuit
4 x 500 mm Cu water cooled cables between 10 kA power converter and inserts trough a dedicated switch (< than the existing 16 kA)

Electrical distribution of vertical test facility

PLC needs only few modifications.
Feasible in the shadow of other activities.

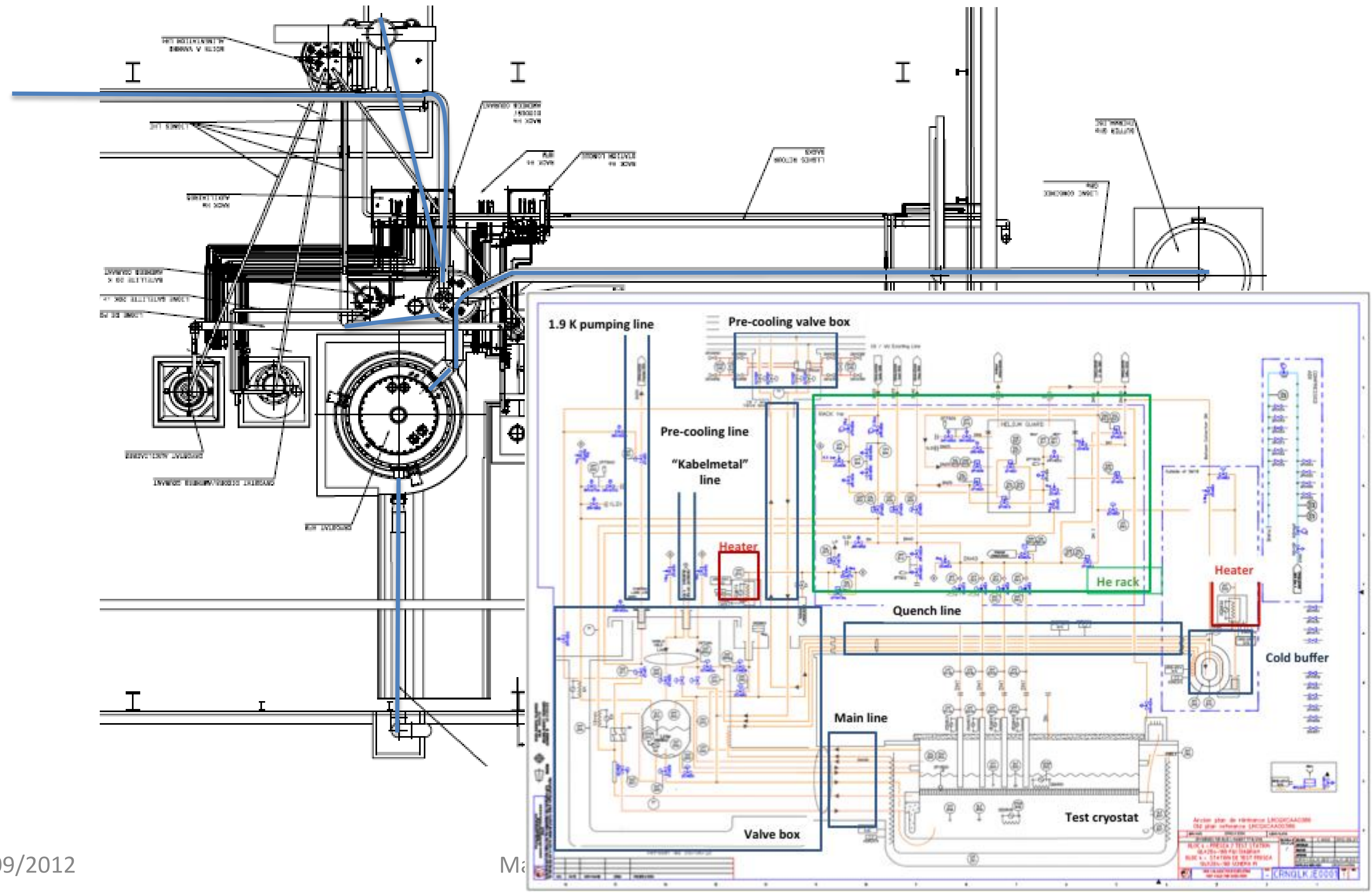




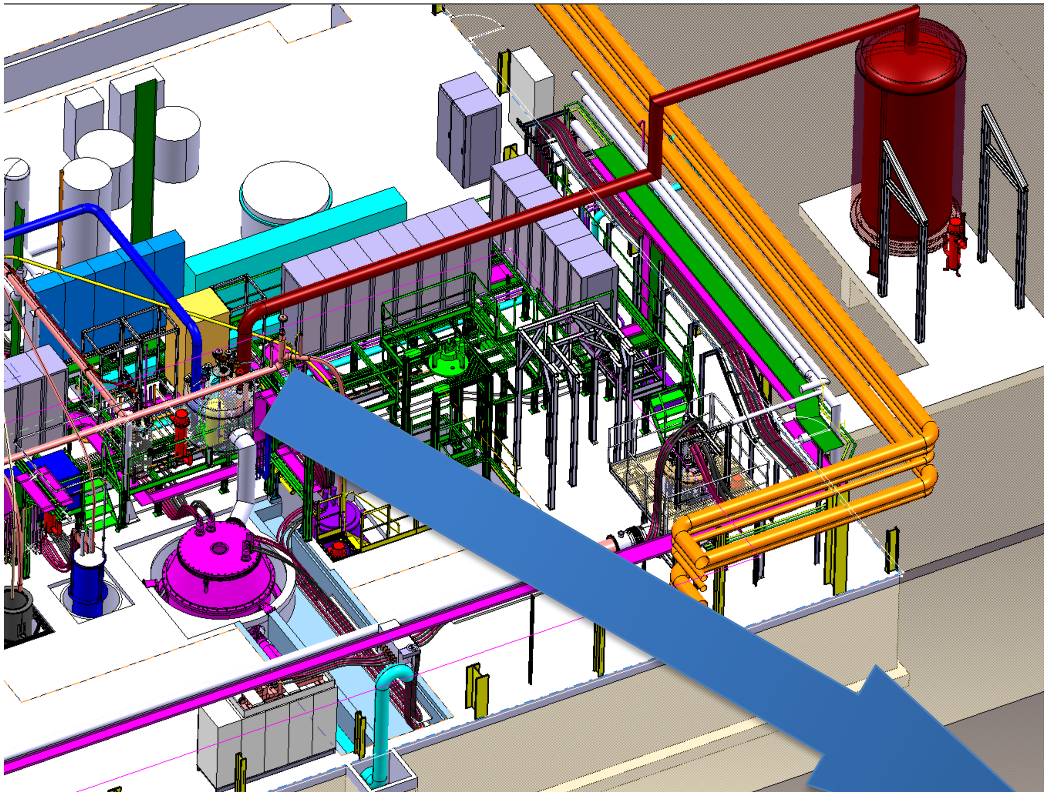
Ex. of PLC for cryostat change

Cryogenic distribution of the vertical test facility

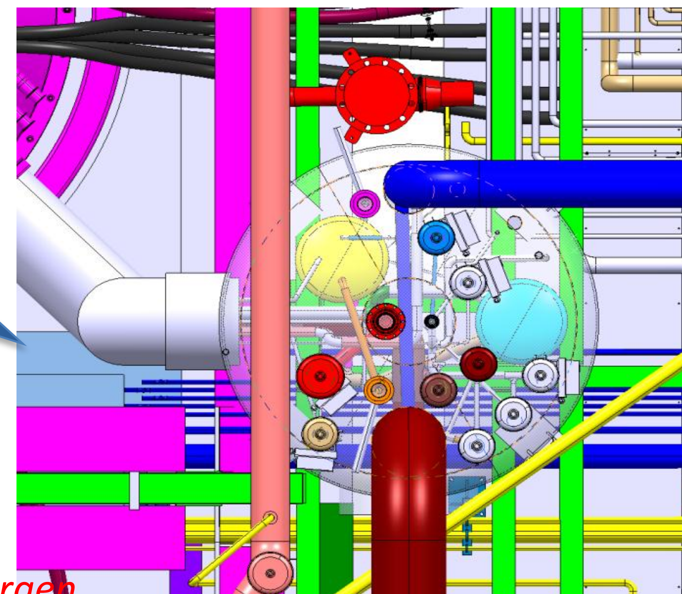
The HFM lines and the P&I diagram



Cryogenic items of the HFM



Item	Group	Contracts
Cryostat	TE-MSC	-
Valve Box	TE-CRG	Contract 1
Main Line		
Pre-cooling Line		
Quench Line		
Cold Buffer		
Pre-cooling Valve Box		
He Rack		Contract 2
1.9K Pumping Line		Contract 3
Kabelmetal Line		
15kW Heater		Contract 4
General Assembly		TE-CRG



End of the installation of cryogenic items: Jun 2014

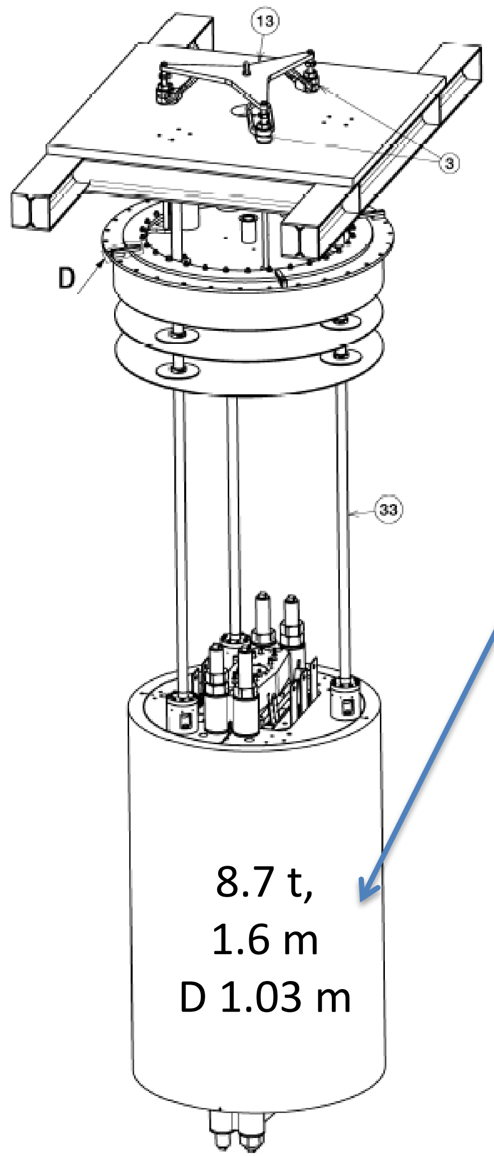
For cryostat design and manufacturing see slides of A. Vande Craen

LN_2 test station : goals and constrains

GOAL

Before summer 2013 the **study, of the thermo mechanical behaviour** of the structure at different pre-stress is, required.

The LHe test station IS NOT AVAILABLE yet, therefore it was decided to set up a dedicated test station at LN_2.



CONSTRAINS

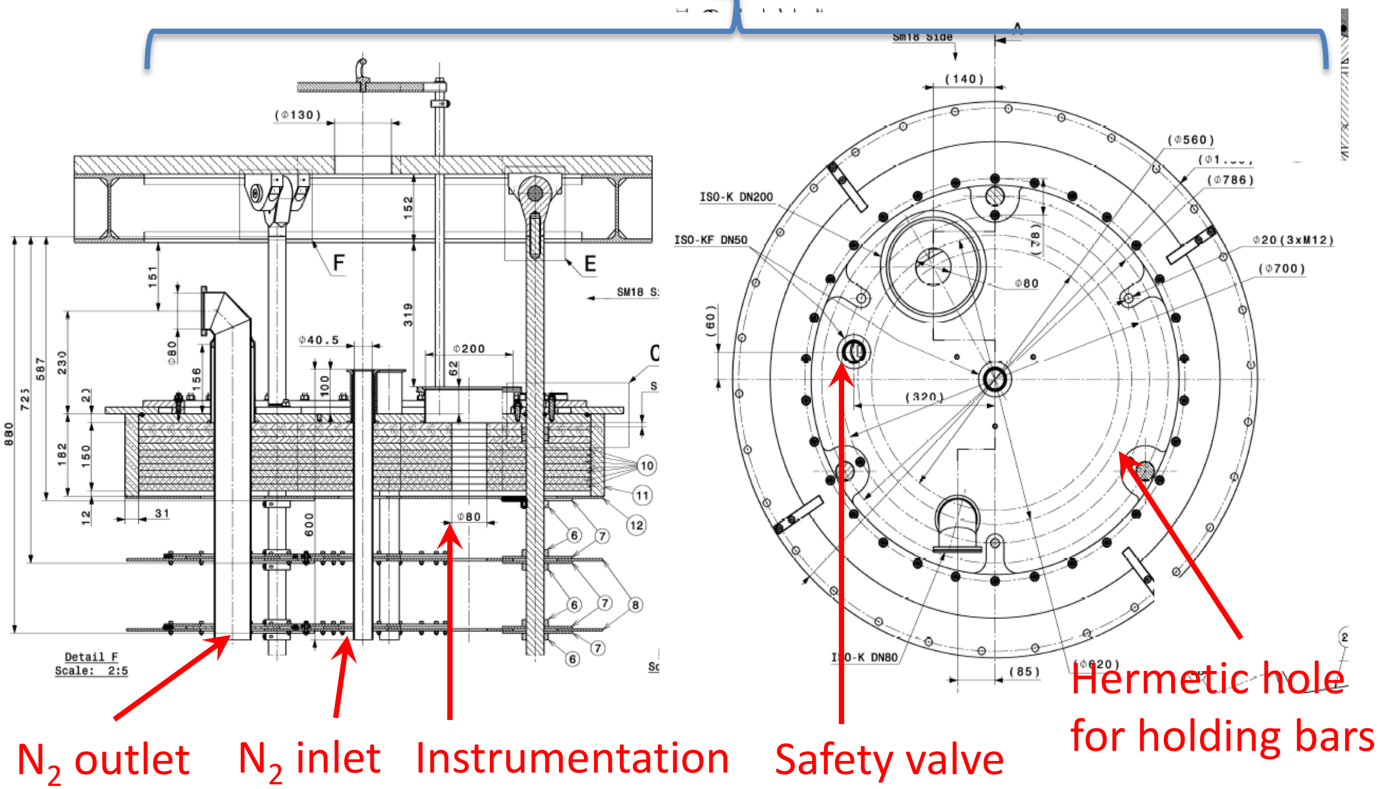
Huge mass and **large dimension** of the magnet requires optimized cooling scenario.

Due to differential thermal shrinkage of Al and steel, the maximum temperature difference between two points of the structure was limited to max. **100 K**.

See presentation of Paolo, Jorge and Juan Carlos

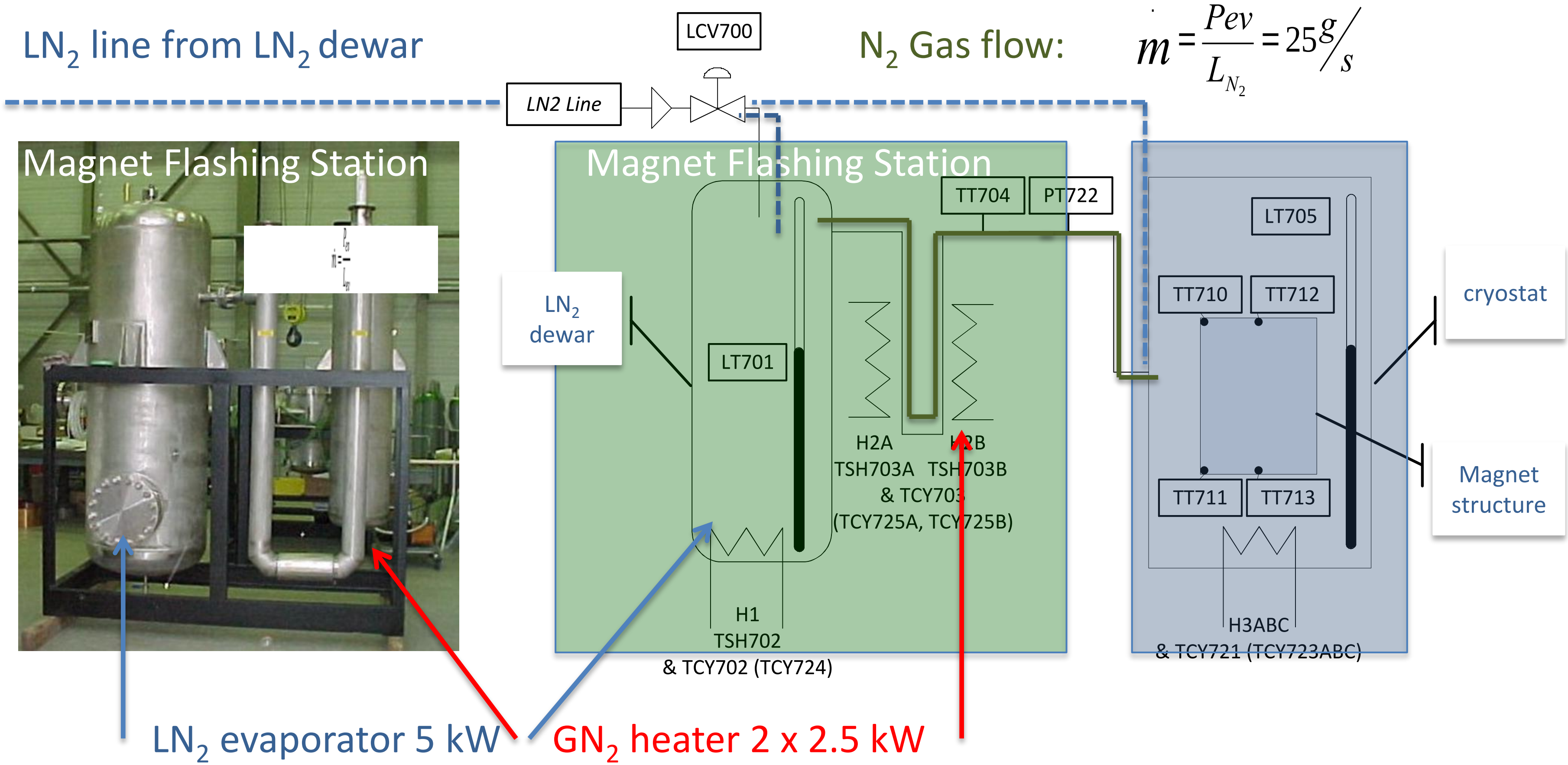
LN_2 test station issues: cryostat and top plate

Need of an **insulated cryostat** with a **top-plate** to limit nitrogen consumption, to improve cooling time and prevent ice formation.



LN_2 test station issues: nitrogen gas or liquid nitrogen?

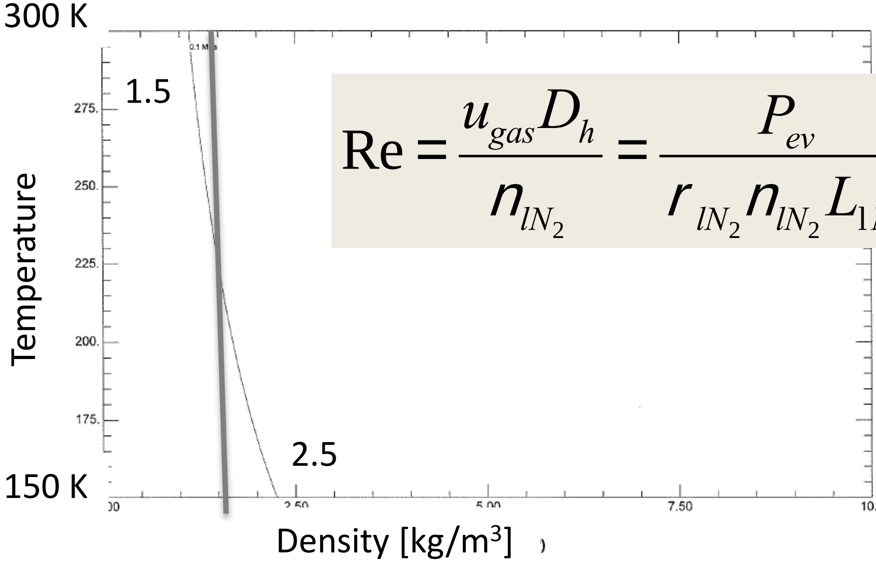
$\Delta T = 100$ K → Liquid nitrogen can not directly be used for cooling.
Nitrogen gas should be used with descent flow (high power evaporator) and at controlled temperature (gas heater).



LN_2 test station issues: cooling

Analytical transient thermal model shows:

1. Nitrogen gas flow *cannot be turbulent* with the given mass flow rate and geometry.

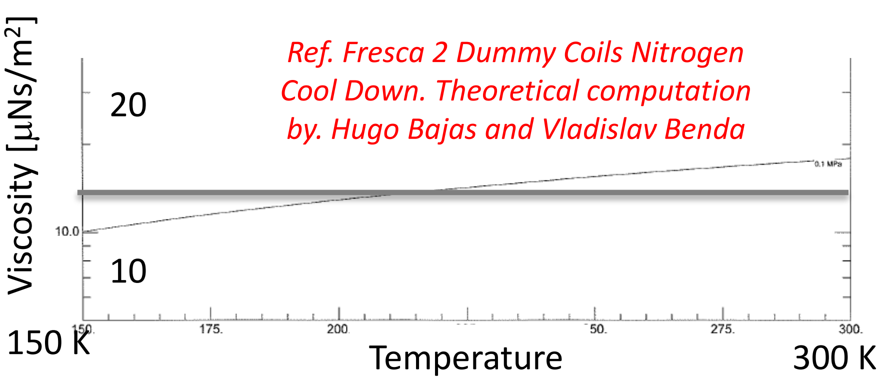


$$Re = \frac{u_{gas} D_h}{\nu_{lN_2}} = \frac{P_{ev}}{\rho_{lN_2} \nu_{lN_2} L_{lN_2}} \frac{2D}{A_c(D_m, D)}$$

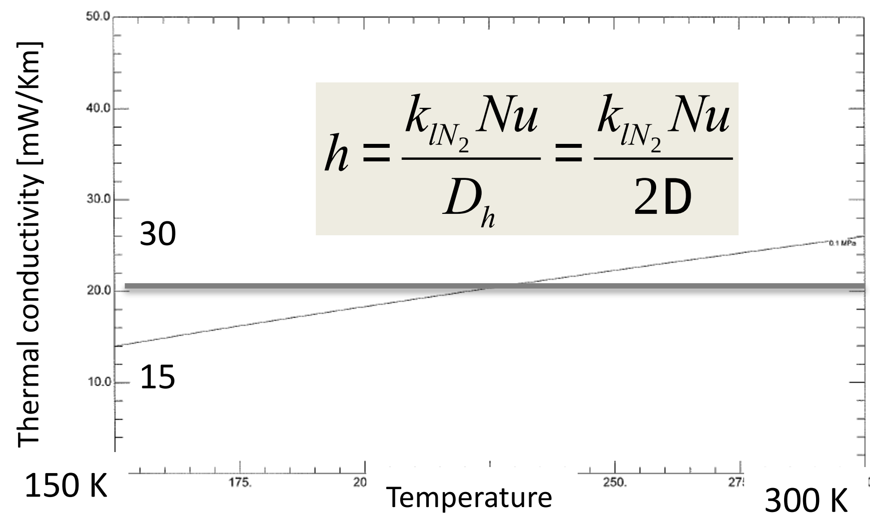
2. The heat convection coefficient is quite low as compared to boiling nitrogen.

$$Nu \cong const$$

$$h = \frac{k_{lN_2} Nu}{D_h} = \frac{k_{lN_2} Nu}{2D}$$



Ref. Fresca 2 Dummy Coils Nitrogen Cool Down. Theoretical computation by. Hugo Bajas and Vladislav Benda



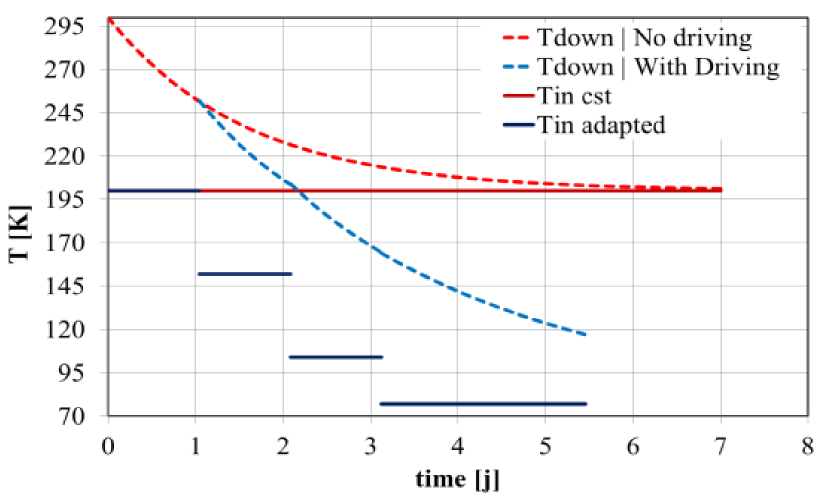
LN_2 test station issues: cooling time

According to the value of the Biot number (< 0.1), the *Lumped Capacitance Method* can be used. Then the temperature can be assumed uniformly distributed within the structure at any time of the transient process.

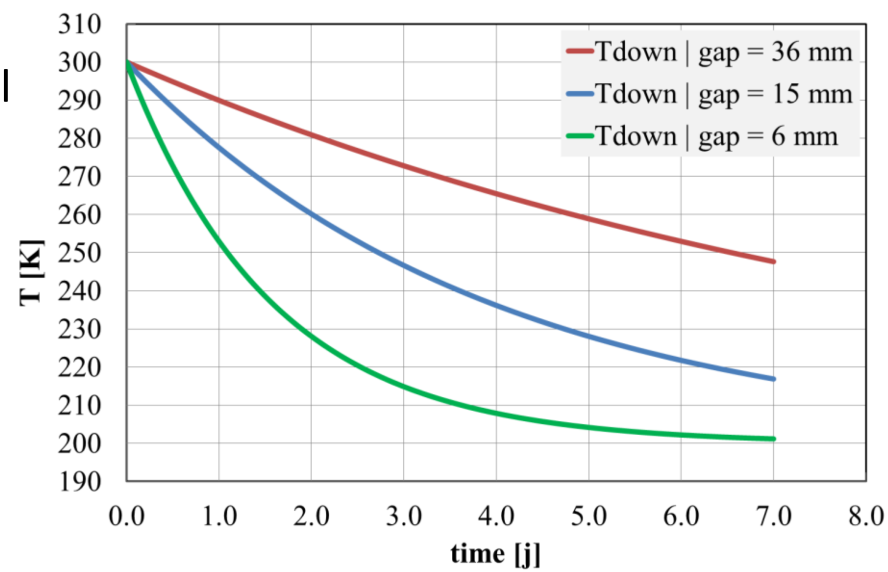
$$r_M V_M C_{pM} \frac{dT}{dt} = hA_s \left(T_{¥} - T_M\right)$$

the temperature evolution is an exponential decay with the time constant τ [s]

$$t = \frac{r_M V_M c_{pM}}{p D_M L_M h} \qquad h = \frac{k_{lN_2} Nu}{D_h} = \frac{k_{lN_2} Nu}{2D}$$



The temperature at the bottom of the magnet

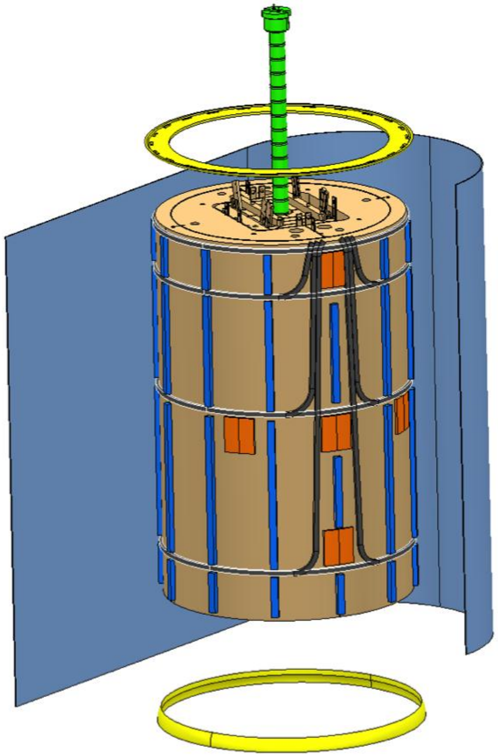


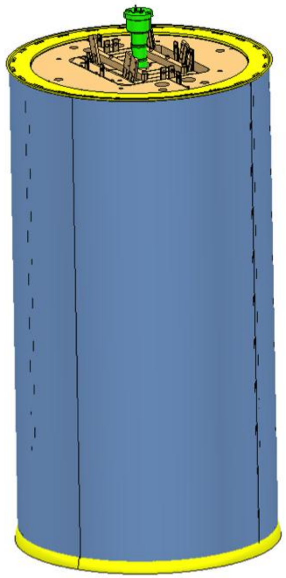
With 36 mm gap the cooling to 180 K would take about 20 days while with 6 mm, 5 days. From this moment LN_2 can be used and in less than 1 day, everywhere in the structure, the 77 K will be achieved.
Then the filling of about 1000 l of LN_2 will take an additional day .

LN_2 test station issues: reducing the cooling time

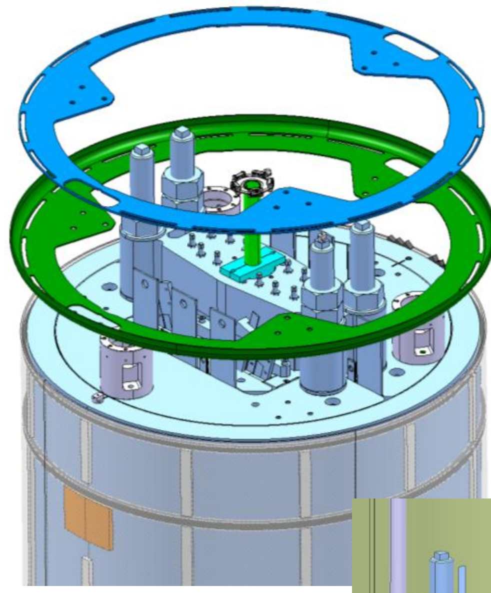
Special preparation of the magnet is needed to create cooling channels. The **gap** is reduced **to 10 mm** and the gas flow is forced towards the magnet outer shell.

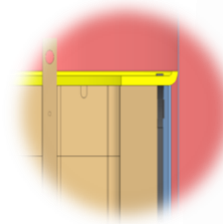
The dressed magnet with 3 mm thick “Teflon skirt”

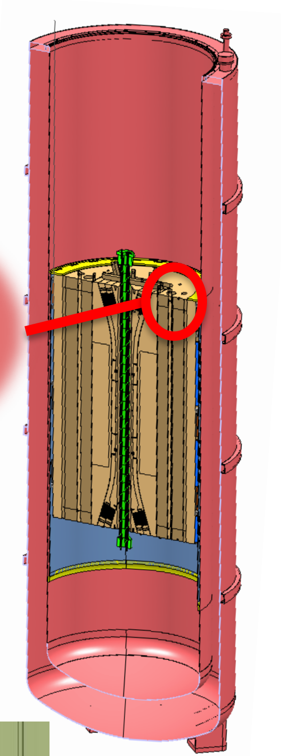


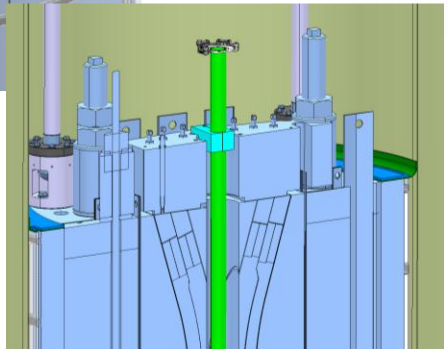


Leak tightness to force the LN_2 flow in between the magnet and the skirt







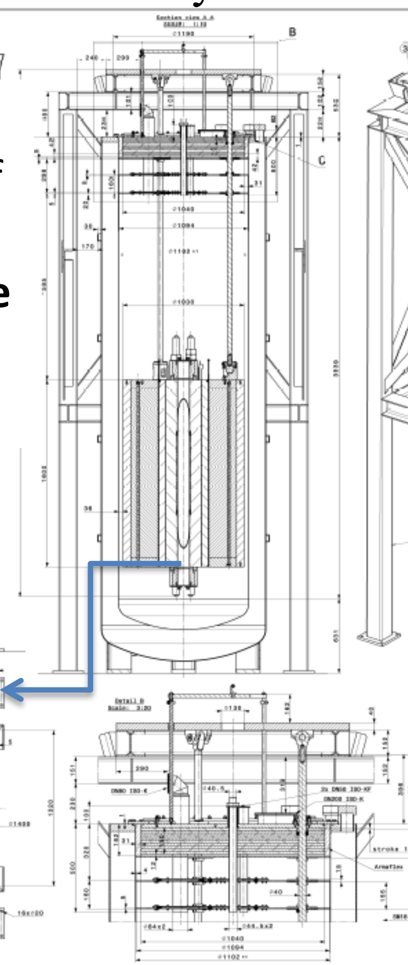


This is a good solution to solve the thermal problem!

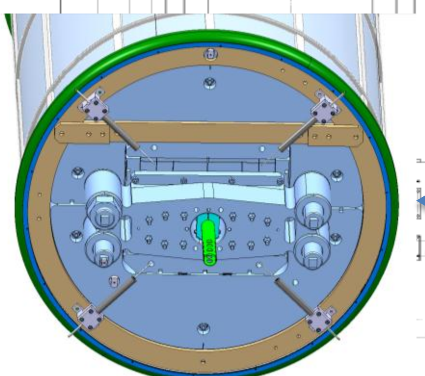
LN_2 test station issues: reducing the cooling time

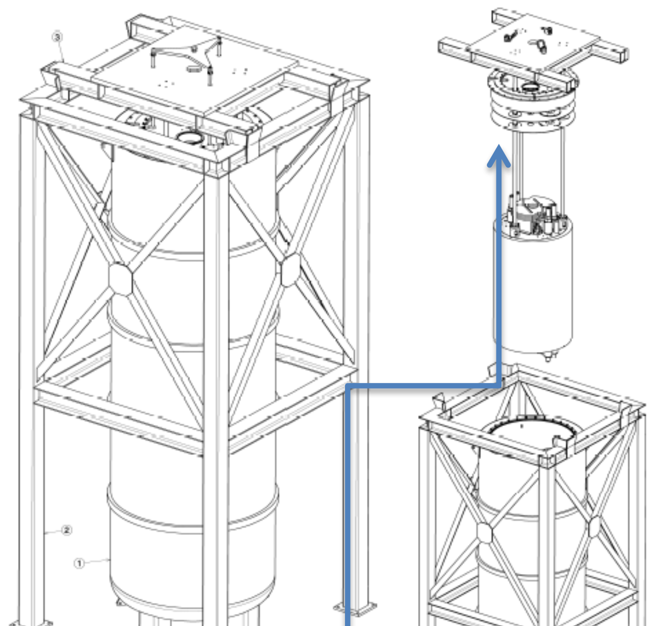
But is a problem for the installation!

As a consequence of the dressing, the distance between the magnet outer diameter and the cryostat inner diameter will be reduced !

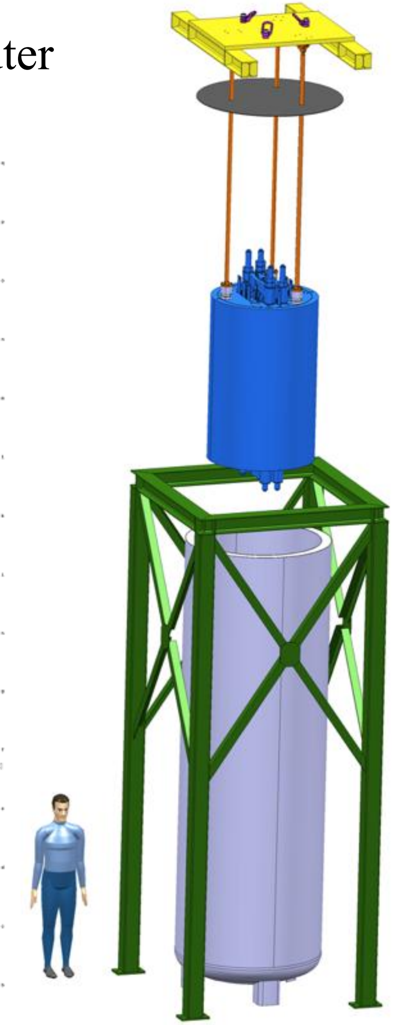


During insertion in the cryostat the position of the magnet will be monitored via **inductive gauges**, mounted on the bottom end plate



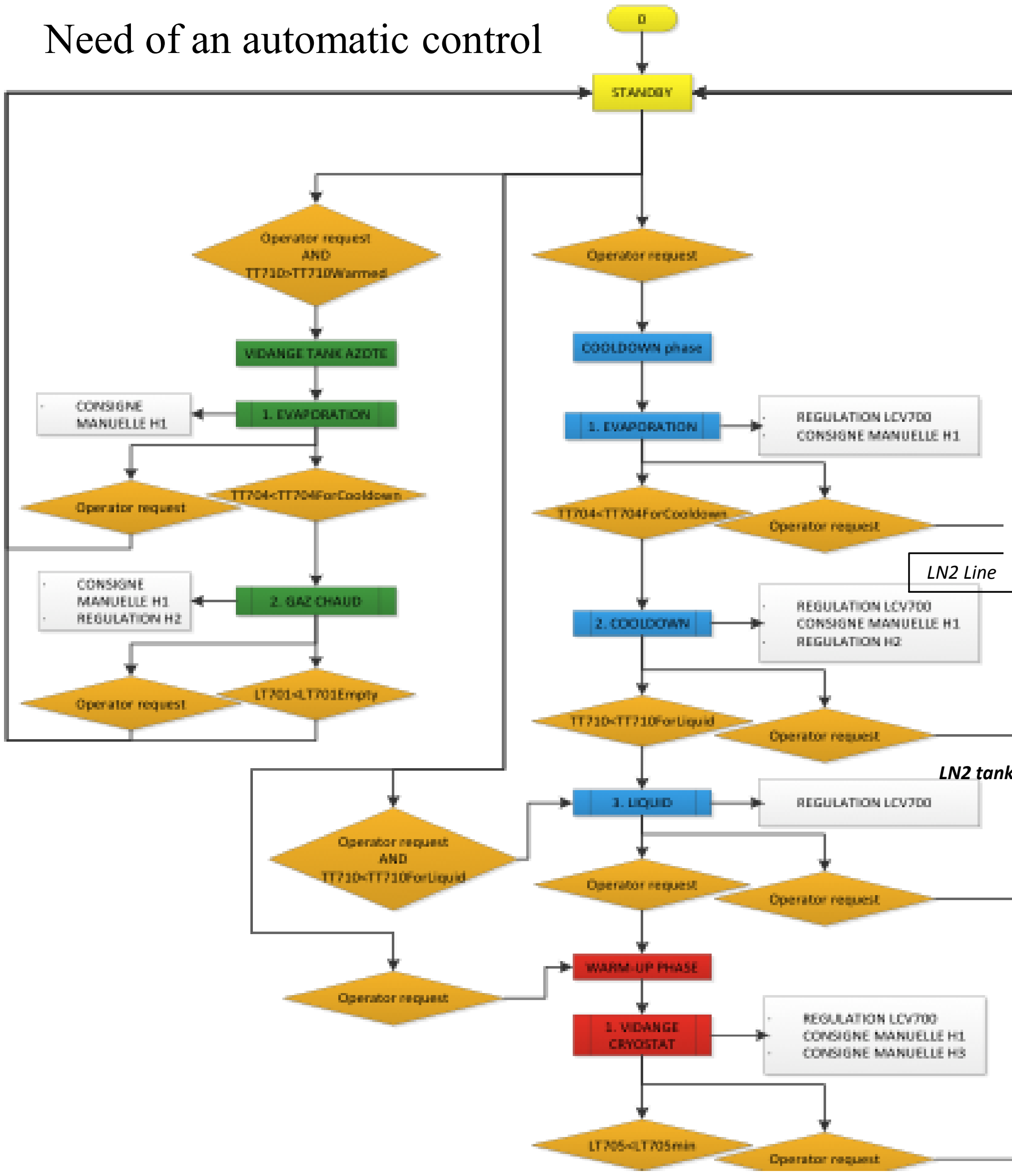


In order to be **flexible** during the magnet insertion in the cryostat, the top-plate is free to move by **2 cm** in its transverse plane.



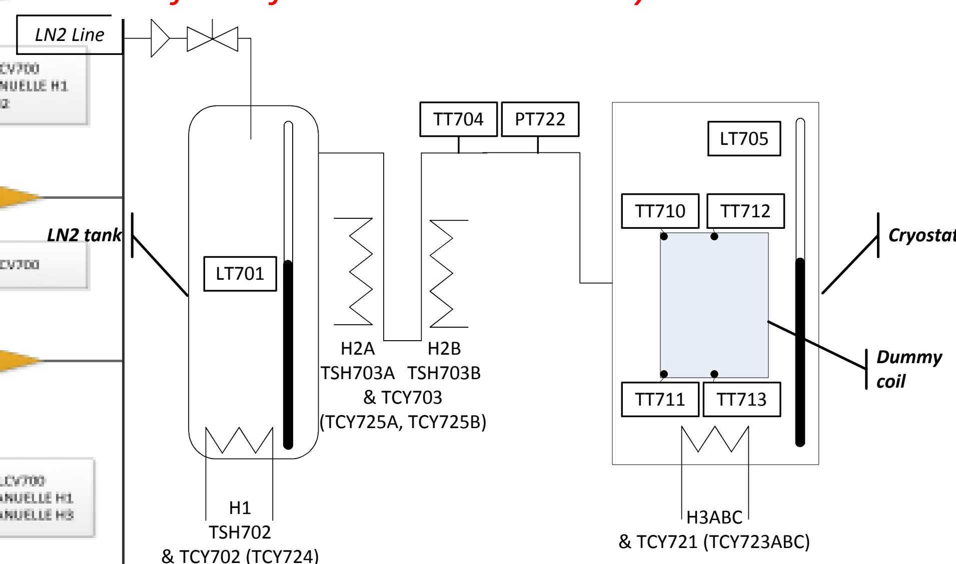
LN_2 test station issues: PLC during cooling time

Need of an automatic control



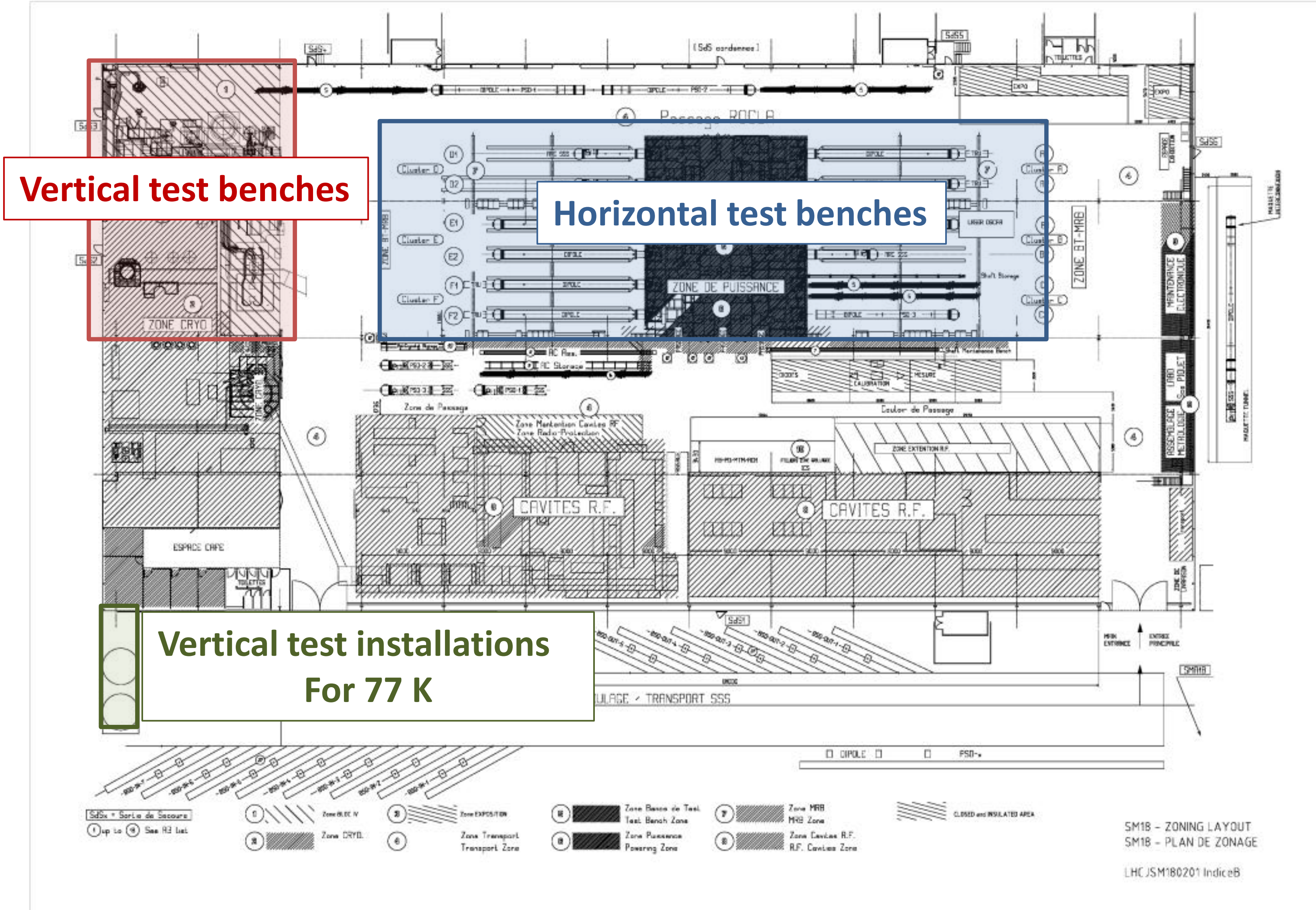
- Regulation made with UNICOS standard
- User interface in control room via TechNet
- Management of interlocks & alarms
- Default limit parameters can be configured
- Operator **can exit manually** every (sub-)phase in case of need
- Operator **can start manually** cool-down, liquid (under conditions), warm-up, and emptying phase (under conditions)

Ref. PLc for LN2 test station by M. Charrondiere



H3 is a heater for warm up or for direct cooling with LN_2

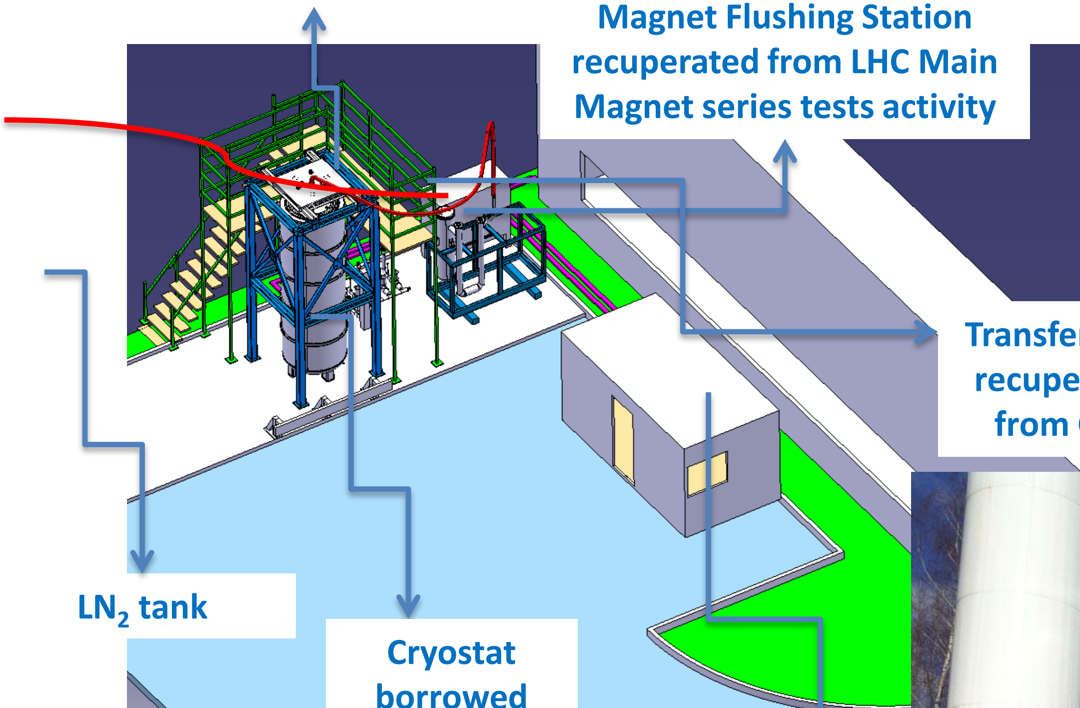
Cryogenic test station SM18 layout



LN_2 Test station layout in Sm18

Holding structure and scaffolding

Magnet Flushing Station recuperated from LHC Main Magnet series tests activity



Transfer lines recuperated from CRG

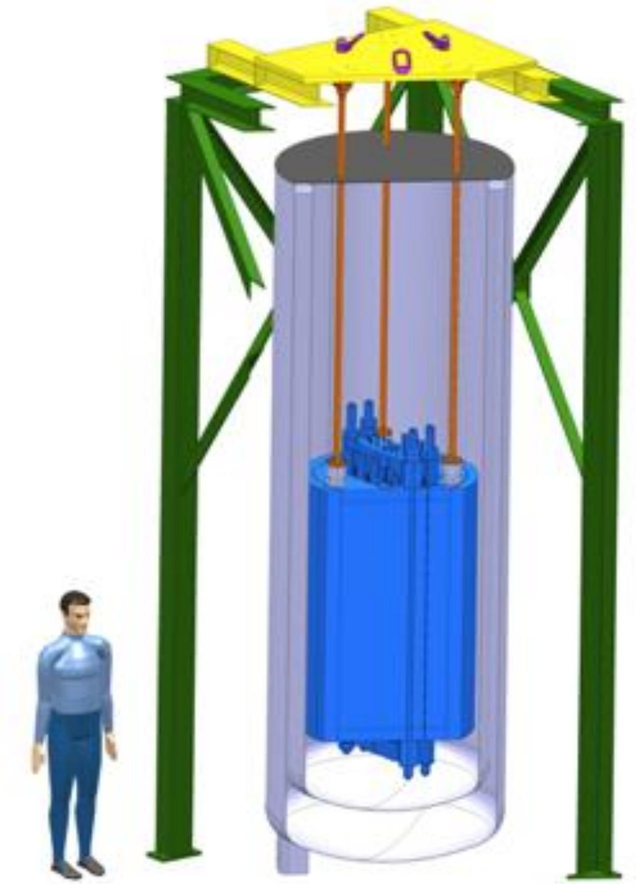
LN_2 tank

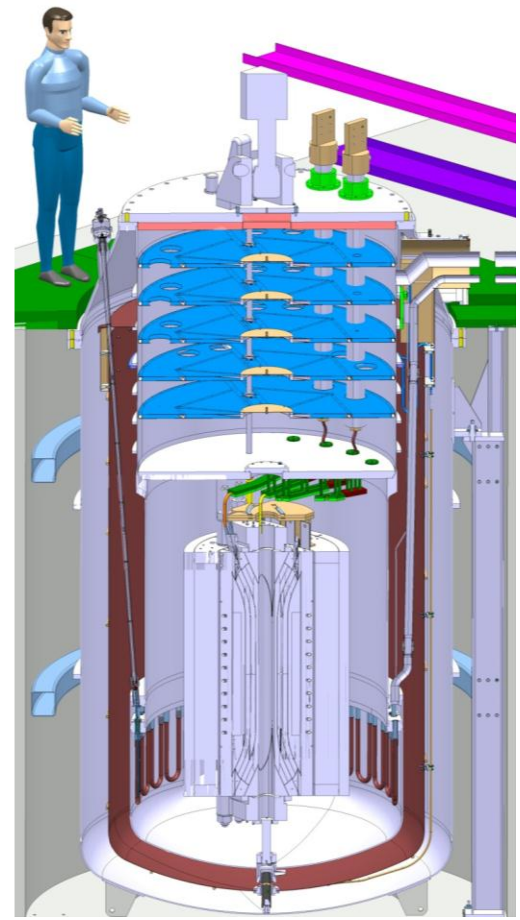
Cryostat borrowed from RF

Control Room Temporary placed in the parking area

When can we test?

@ 77 K: end of April 2013





@ 1.9 K: end of September 2014

Acknowledgement

Christian Giloux, Patrick Viret, Maryline Charrondiere

Pierre Minginette, Philippe Perret,

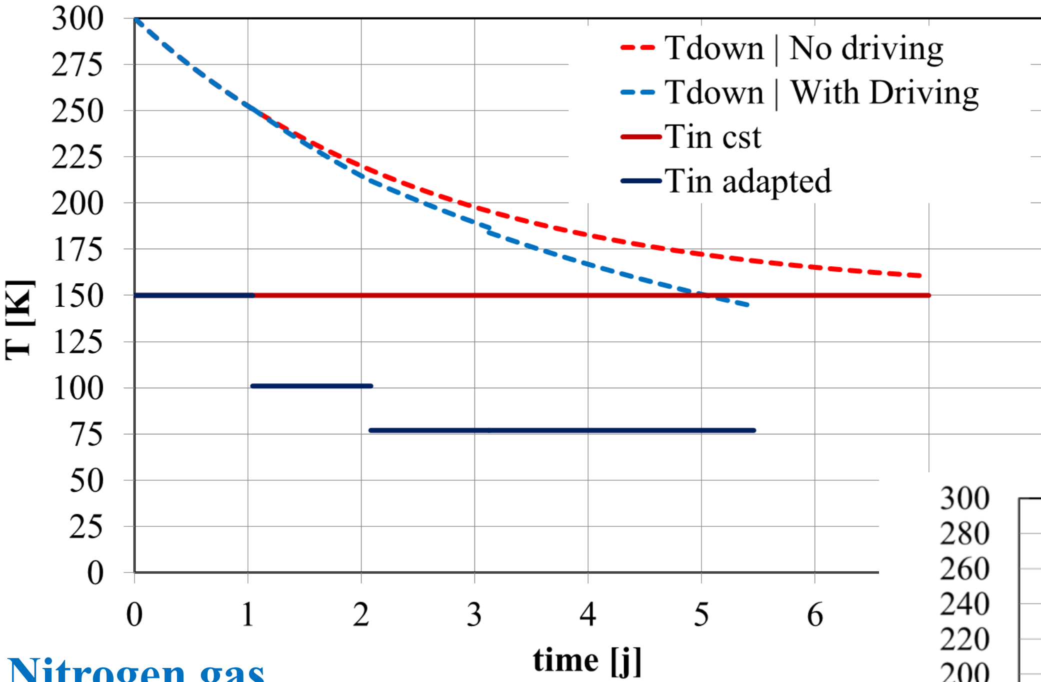
Gijs De Rijk, Nicolas Peray,

Olivier Pirotte

And many other for the construction of the test station

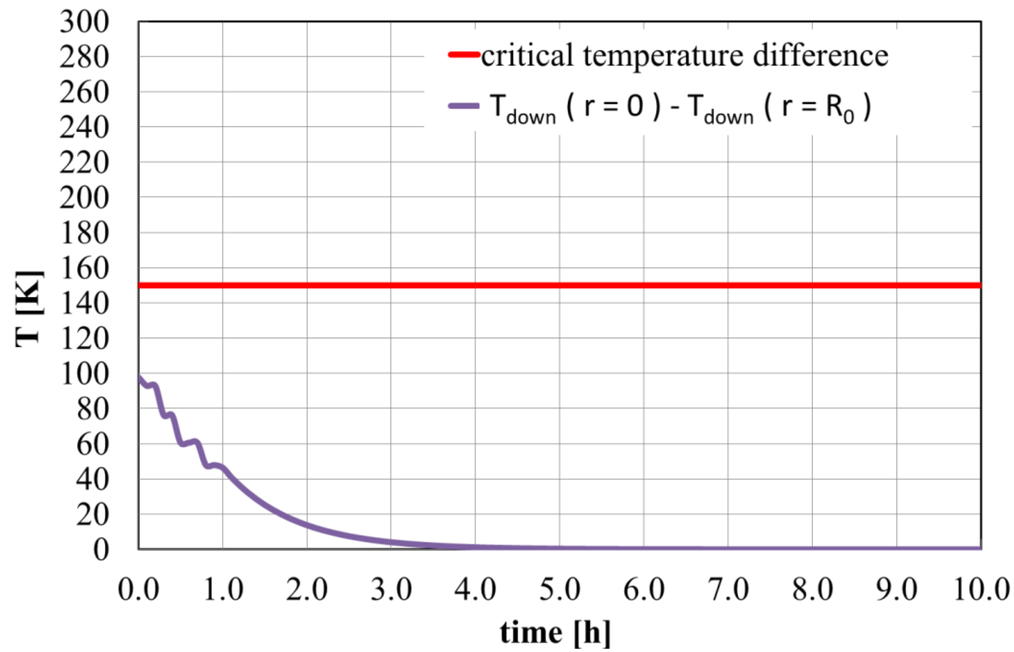
(up to 20 sections across CERN)

CERN



Nitrogen gas injection

Nitrogen liquid injection



In case 150 K difference is allowed with a 10mm gap, we inject the 1st day gas at T_{in} = 150 K then the 2nd day at T_{in} = 100 K, the 3rd day liquid can be injected safely.

In 4 days, the magnet is cold.