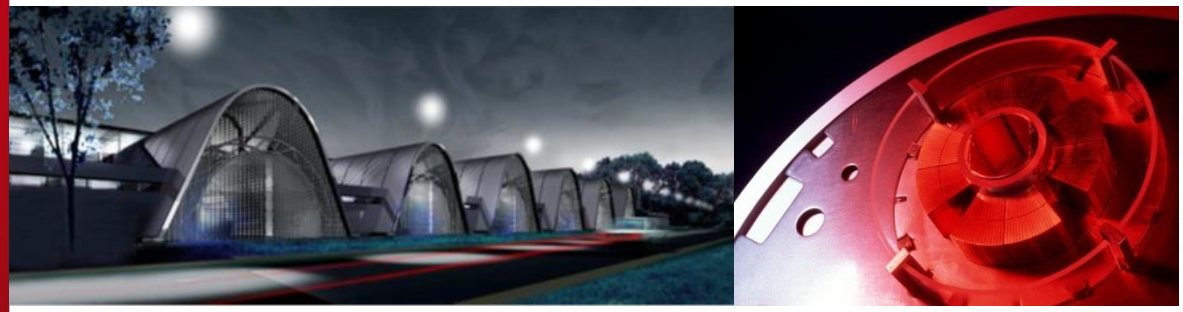
FROM RESEARCH TO INDUSTRY

CRYOGENIC INFRASTRUCTURES @ CEA SACLAY



R. Vallcorba, H. Felice

Workshop on the Magnet Test Stands, CERN 13-14 June 2016

CONTENTS

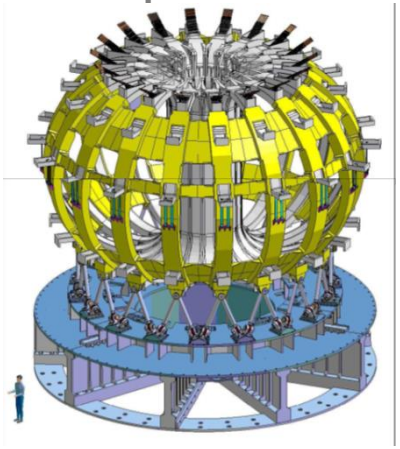
CEA test facilities

- **For superconducting magnets and large size components**
  - ✓ In operation
    - JT 60 -SA
  - ✓ Under development
    - **« Vertical Cryostat » for MQYYM**
  - ✓ Required to be updated
    - **« Vertical Cryostat » for MQYY prototype**
    - « Horizontal Cryostat» SCHEMa
    - Saclay facility W7X

- **Under magnetic field**
  - ✓ Séjos
  - ✓ SETH

JT- 60SA COLD TEST FACILITY 1/3

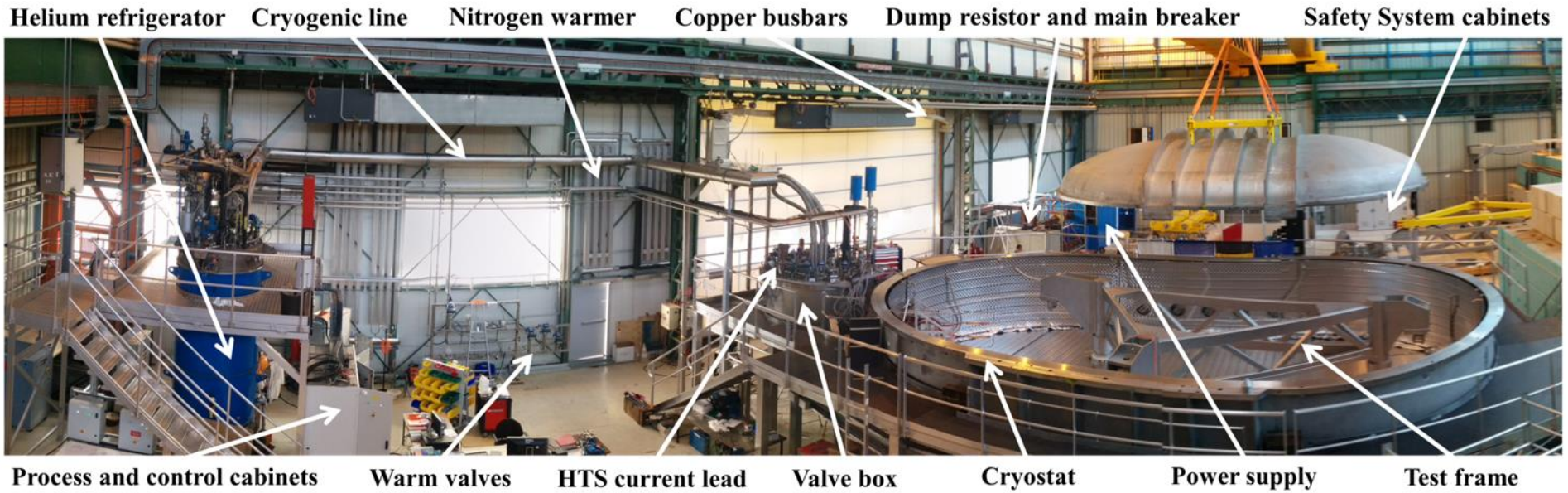
JT-60 Super Advance



The facility cryogenic system testing the 18 TF coils

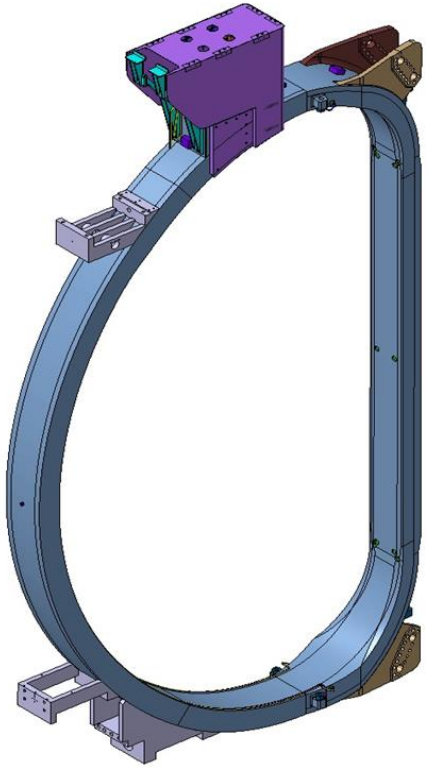
As part of the agreement between Europe (F4E, Fusion For Energy) and Japan (JAEA, Japan Atomic Energy Agency), Europe is in charge of testing the 18 new superconducting toroidal coils used for the magnetic containment of plasma. CEA was in charge of the design, construction of the cold test facility and testing of these 18 coils.

Cryogenics:
Dedicated refrigerator:
500 W @ 4.5K
+ 3.6 g/s from 50 K to 300 K
Coils cooled with supercritical forced helium flow (cold circulator) between 5 K et 7.5 K.



Overview of the JT60 SA test environment

JT- 60SA TEST FACILITY: ID CARD 2/3



Location	CEA Saclay (Gif-sur-Yvette, France)
Surface of the test stand	Hall 126, 800 m²
Dedicated refrigerator	Yes
LN2 tank	25 000 liters
Helium buffer	100 m3
Cold circulating pump	centrifugal pump: working point : 600 mbar / 30 g/s
Operating temperature	From 5 K to 7.5 K
Cooling phases	300–80K, 80-4.5K
Cooling capacity	500 W@4.5 K + 3.6 g/s from 50 K to 300 K
Current leads	HTS / 3.6 g/s GHe at 50 K
Operating current	25.7 kA
Power supply caracteristics	25.7 kA x 10 V
Nr of cryostats	1
Capacity of cryostat	11 m useful length, x 6 m useful diameter,
Handeling tools	32 t overhead crane
Magnet Safety System	Independant protection of each double pancake with redundancy
Quench antena	No
Magnet measurements capability	No
DAQ Cards and used soft	about 300 signals / up to 20 kHz acquisition
Data acquisition for cryogenics sensors	up to 10 Hz

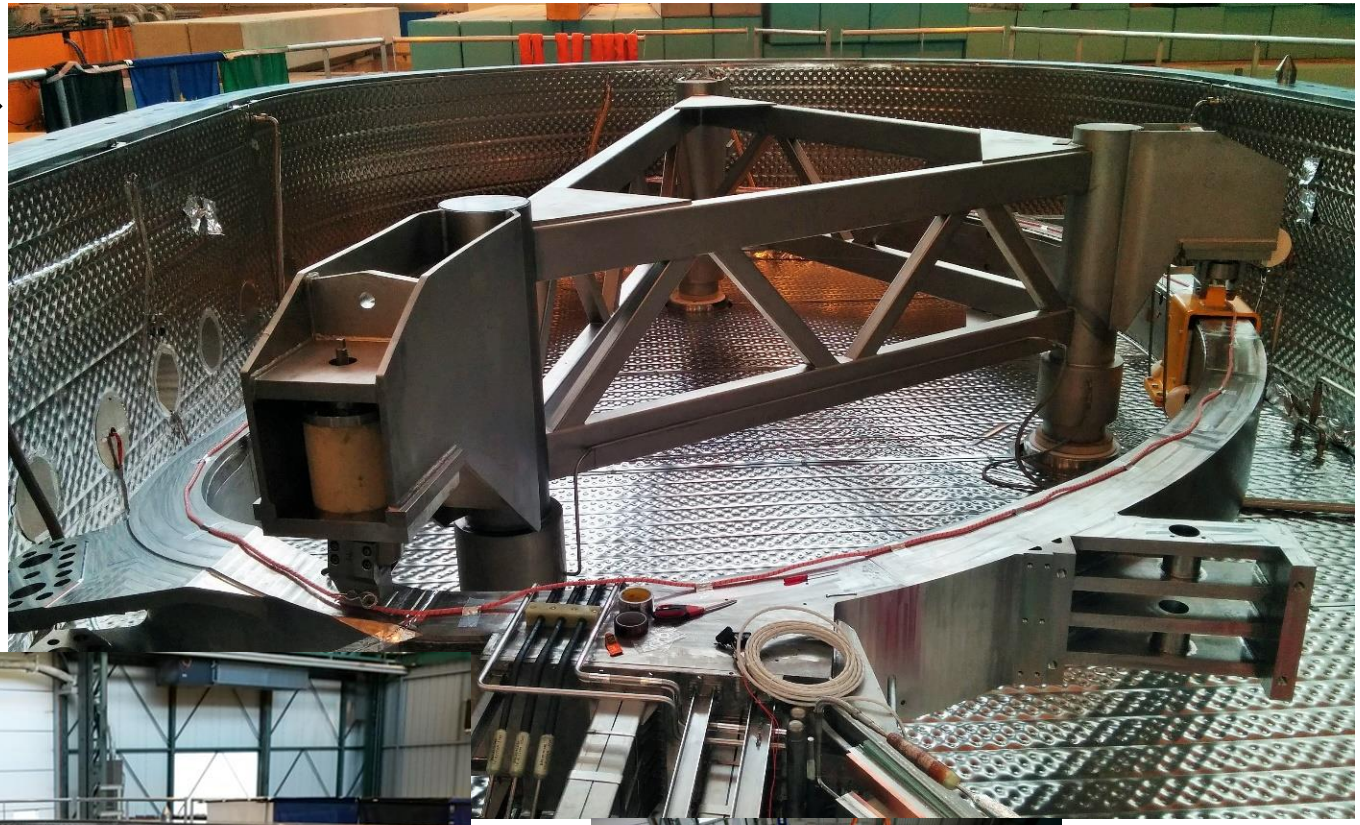
- Heat loads : 235 W @ 5 K and 326 W @ 7.5 K
- Pressure drop in the coil : 440 mbar @ 5 K and 601 mbar @ 7.5 K

ongoing test of « the third coil»

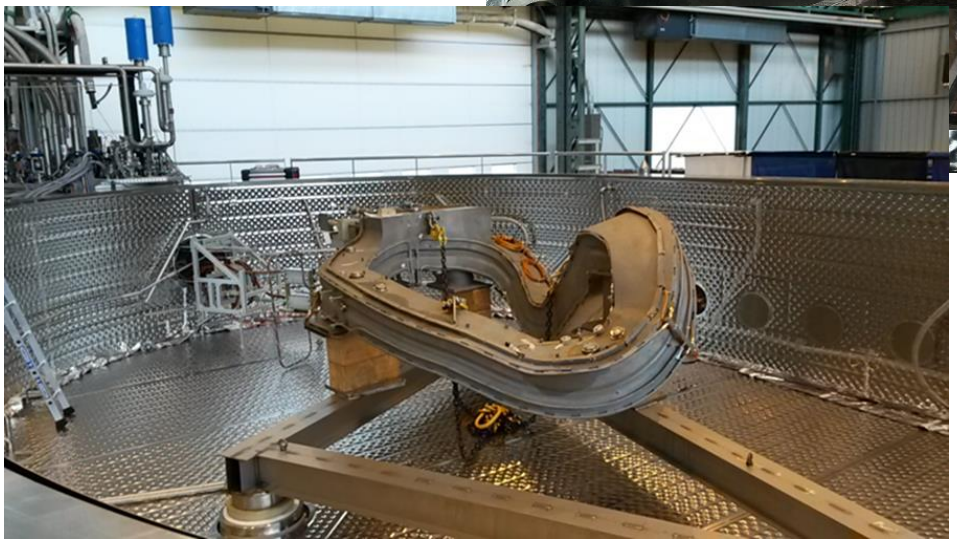
JT- 60SA COLD TEST FACILITY 3/3

Some views

Toroidal Field Coil
in the Cold Test Facility



Study of the W7X Demo
coil integration inside
the JT-60SA CTF Cryostat



CEA test facilities

- For superconducting magnets and large size components
  - ✓ In operation
    - JT 60 -SA
  - ✓ Under development
    - « Vertical Cryostat » for MQYYM
  - ✓ Required to be updated
    - « Vertical Cryostat » for MQYY prototype
    - « Horizontal Cryostat» SCHEMa
    - Saclay facility W7X

- Under magnetic field
  - ✓ Séjos
  - ✓ SETH

" VERTICAL CRYOSTAT": ID CARD ONGOING ADAPTATION FOR MQYYM

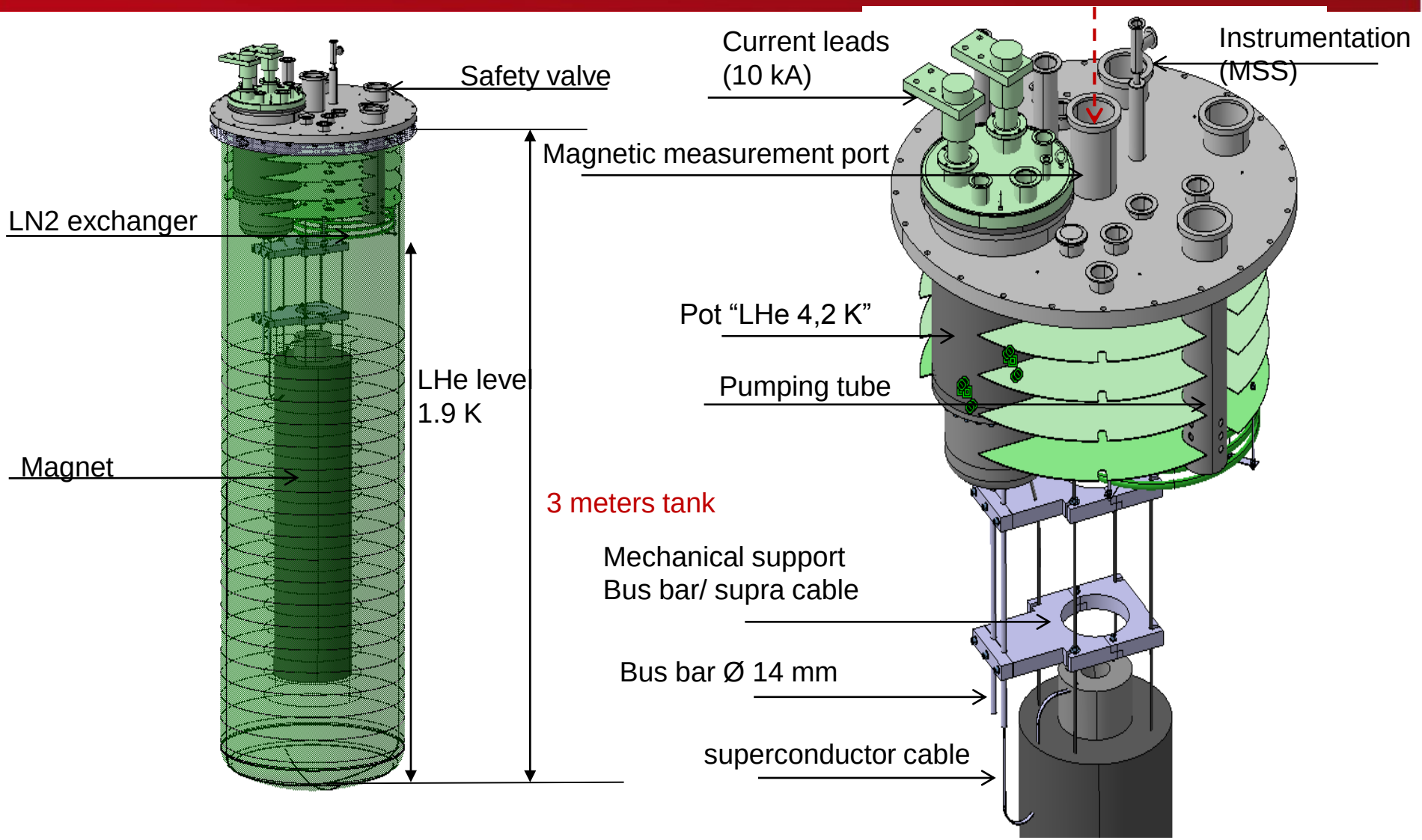
MQYYM

Tests of superconducting magnets at temperature between 4.2 K and 1.9 K
(the magnetic measurement equipment is not included)

Location	CEA Saclay (Gif-sur-Yvette, France)
Surface of the test stand	Hall 198, aprox. 300 m²
Dedicated refrigerator	Not currently avalaible
Operating temperature	from 4.2 K to 1.9 K (saturated helium)
Cooling phases	300–80K, 80-4.2K, 4.2 K – 1.9 K
Shared cryogenics? Or other equipment?	No, Yes helium tank 1000 l
Operating and mx. Current, max voltage	10 kA, 5 V
Current leads helium consomption	25 l/h @ 4.2 K
Nr of cryostats	1 (adjustable with dedicated tank named « chaussette »)
Capacity of cryostat	8 m useful length, 0.8 m useful diameter,
Handeling tools	10, 20 and 50 t overhead crane
Interlock safety	MSS
Quench antena	No
Magnet measurements	No
Cards and used soft	will be comunicated later on
Data acquisition for cryogenics sensors	

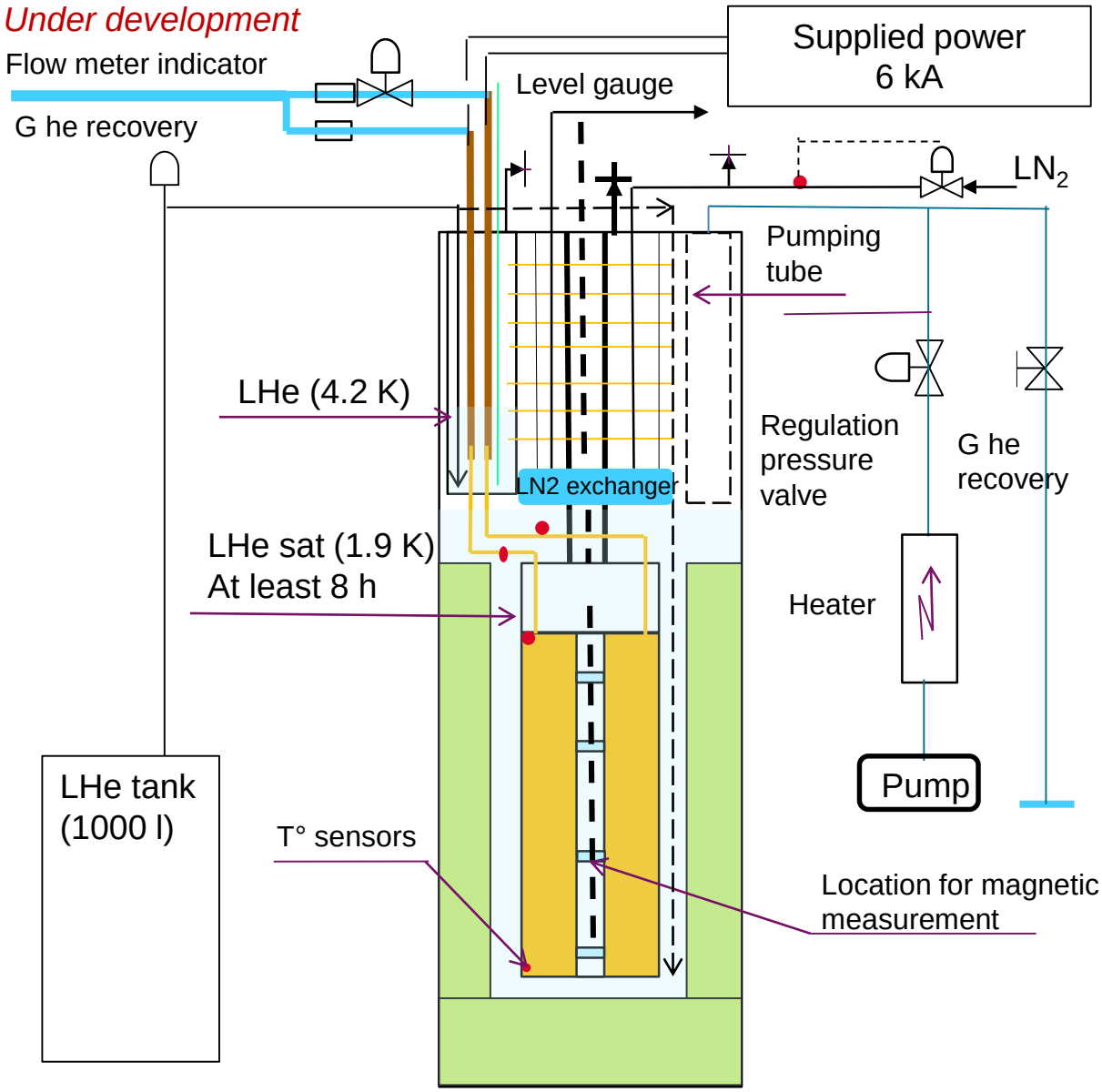
Adaptation of the facility to the « MQYYM quadrupole »

« Vertical Cryostat » for MQYYM: 3D VIEW



« Vertical Cryostat » for MQYYM: SCHEMATIC

Under development



Heat load:
5 W (3+2 for margin) – 5.5 l/h
(needs to pay attention to the magnetic measurement system)

Cryogenic:
Cryostat 1.9 K@ 23 mbars ABS

LN_2 heat exchanger will be used for a pre-cooling down to 100 K

1000 l LHe required for 1 test of 8 h without quench.

Consumption in the quench mode under study

Pumping system:
600 available /250 m^3/h (useful)

CEA test facilities

- For superconducting magnets and large size components
  - ✓ In operation
    - JT 60 -SA
  - ✓ Under development
    - « Vertical Cryostat » for MQYYM short model
  - ✓ **Required to be updated**
    - **« Vertical Cryostat » for MQYY prototype**
    - « Horizontal Cryostat» SCHEMa
    - Saclay facility W7X

- Under magnetic field
  - ✓ Séjos
  - ✓ SETH

"VERTICAL CRYOSTAT" PROPOSAL FOR MQYY PROTOTYPE: ID CARD

Tests of superconducting magnets at temperature between 4.2 K and 1.9 K

(the magnetic measurement equipment is not included)

Location	CEA Saclay (Gif-sur-Yvette, France)
Surface of the test stand	Hall 198, aprox. 300 m²
Dedicated refrigerator	**Yes, several option can be considered**
Operating temperature	from 4.2 K to 1.9 K
Cooling phases	300–80K, 80-4.2K, 4.2 K – 1.9 K
Shared cryogenics? Or other equipment?	Yes or could be dedicated
Operating and mx. Current, max voltage	10 kA, 5 V
Current leads helium consomption	25 l/h @ 4.2 K
Nr of cryostats	1
Capacity of cryostat	8 m useful length, 0.8 m useful diameter,
Handeling tools	10 t, 20 t and 50 t overhead crane
Interlock safety	MSS
Quench antena	No
Magnet measurements	No
Cards and used soft	
Data acquisition for cryogenics sensors	

A dedicated refrigerator could be connected to the facility.

CEA test facilities

- For superconducting magnets and large size components
  - ✓ In operation
    - JT 60 -SA
  - ✓ Under development
    - « Vertical Cryostat » for MQYYM short model
  - ✓ Required to be updated
    - « Vertical Cryostat » for MQYY prototype
    - **« Horizontal Cryostat» SCHEMa**
    - Saclay facility W7X

- Under magnetic field
  - ✓ Séjos
  - ✓ SETH

SCHEMA ID CARD

***S**tation **C**ryogenique **H**orizontale **E**ssais **Ma**gnetiques*

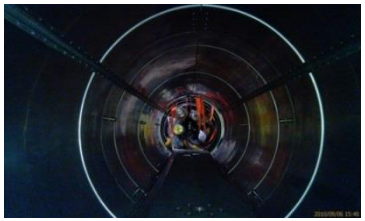
Tests of cryostated superconducting magnets or magnets with helium vessel at temperature between 4.2 K and 1.8 K with magnetic measurements capability in warm bore.

Ex. 4 m configuration

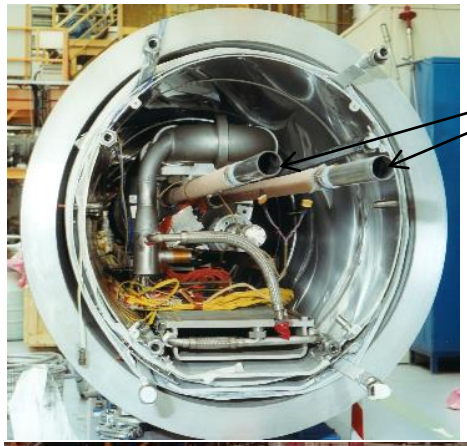
Updating required

Location	CEA Saclay (Gif-sur-Yvette, France)
Surface of the test stand	Hall 198, aprox. 400 m²
Dedicated refrigerator	Not currently avalaible, could be avalaible
from W7X facility	
Operating temperature	from 1.8 K to 4.2 K
Cooling phases	300–80K, 80-4.2K, 4.2 K – 1.8 K
Cooling capacity	450 W at 4.2 K, 25 W at 1.8 K
Shared cryogenics? Or other equipment?	Yes but can be dedicated
Operating and mx. Current, max voltage	20 kA, 5 V
Nr /length of cryostats	0 (cryostated magnet) ,1 (4m), 1 (8 m)
Capacity of cryostats (util)	8 m useful length, 0.6 m useful diameter,
Handeling tools	10 t and 50 t overhead crane
Interlock safety	MSS available
Quench antena	Yes
Magnetic measurements	Yes, at 300 K (warm bore)
Cards and used soft	QNX system with homemade acquisition
Data acquisition for cryogenics sensors	160 measuring channels up to 20 kHz

view of the horizontal cryostat opened with a LHC bus bar measurements



SCHEMA: TESTS



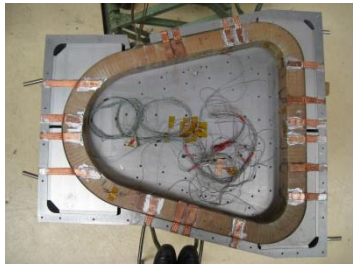
Warm bore magnetic measurements (2x4 W)

Principal tests

In the past

- ✓ Twin-Aperture Prototype Dipole (TAP) – Ex. cryostat de distribution
- ✓ SSS5 prototype quadripoles
- ✓ Race Track ATLAS (1/20)
- ✓ Bus bar1 (section et forme du bus), Bus bar2 (validation du concepte de réalisation industrialisé)

Latest test into facility



R^3B-Glad coil prototype

pay attention to the fact that the magnet must be either cryostated or assembled in a cold mass

CEA test facilities

- For superconducting magnets and large size components
  - ✓ In operation
    - JT 60 -SA
  - ✓ Under development
    - « Vertical Cryostat » for MQYYM
  - ✓ Required to be updated
    - « Vertical Cryostat » for MQYY prototype
    - « Horizontal Cryostat» SCHEMa
    - **Saclay facility W7X**

- Under magnetic field
  - ✓ Séjos
  - ✓ SETH

SACLAY FACILITY ‘W7X’ ID CARD

Saclay facility « W7X »

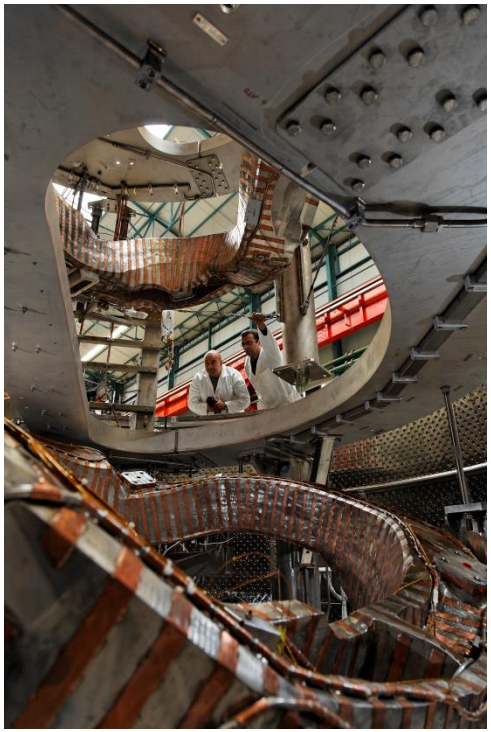
Updating required

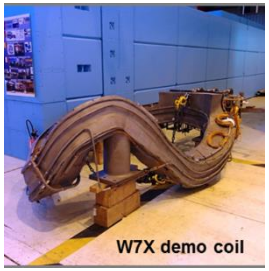
Test on current intensity, isolating voltage, mechanical stress, pressure drop and temperature for magnets cooled with supercritical helium forced flow between 4.5 K and 7.6 K

Location	CEA Saclay (Gif-sur-Yvette, France)
Surface of the test stand	aprox. 400 m^2
Dedicated refrigerator	Yes, liquefier/refrigerator Helial 4003 ✓ liquefaction capacity ~70 l/h ✓ refrigeration capacity ~200 W at 4.2 K
Operating temperature	5 K
Cooling phases	300–80K, 80-4.2K
Cooling capacity	15 g/s liquide production
Shared cryogenics? Or other equipment?	No (dedicated)
Operating and mx. Current, max voltage	20 kA
Nr of cryostats	2
Nr of experiments by cryostat	2 (for each cryostat)
Capacity of cryostats (util)	5 m useful diameter, 4.1m useful height.
Handeling tools	20 t overhead crane
Max. isolating voltage	10.4 kV
Interlock safety	MSS to be upgraded,
Cards and used soft	EPICS
Quality control tools	to be upgraded
Data acquisition for cryogenics sensors	
Data acquisition for voltage-measurements	
Magnetic measurements capability	No

SACLAY FACILITY ‘W7X’ TESTS

Principal tests





70 W7X superconducting coils tested at 4.5 K

In the recent past - 2014

R^3B-Glad inside the Saclay facility

ISEULTshim coils qualified (insulation, inductance, mutual)

CEA test facilities

- For superconducting magnets and large size components
  - ✓ In operation
    - JT 60 -SA
  - ✓ Under development
    - « Vertical Cryostat » for MQYYM short model
  - ✓ Required to be updated
    - « Vertical Cryostat » for MQYY prototype
    - « Horizontal Cryostat» SCHEMa
    - Saclay facility W7X

- **Under magnetic field (for information)**
  - ✓ **Séjos**
  - ✓ **SETH**

TEST FACILITIES UNDER MAGNETIC FIELD: SEJOS

Séjos - Station d'Essais de JOnctions Supraconductrices (Test station for superconducting splices)

Tests of electrical jonctions at 4.2 K

Location	CEA Saclay (Gif-sur-Yvette, France)
Surface of the test stand	
Dedicated refrigerator	no
Operating temperature	4.2 K
Power unit	600 A, 1.2 kA, 3 kA
Maximum magnetic field	4.7 T
Magnet useful diameter	90 mm
Useful diameter of the sample cryostat	76 mm

A superconductiong transformer allows testing conductors at current intensity up to 70 kA, Currently at CERN

SEHT – EIGHT TESLA STATION

Tests of prototypes or large scale components under magnetic field (8T)

Useful diameter of 587 mm at room temperature.

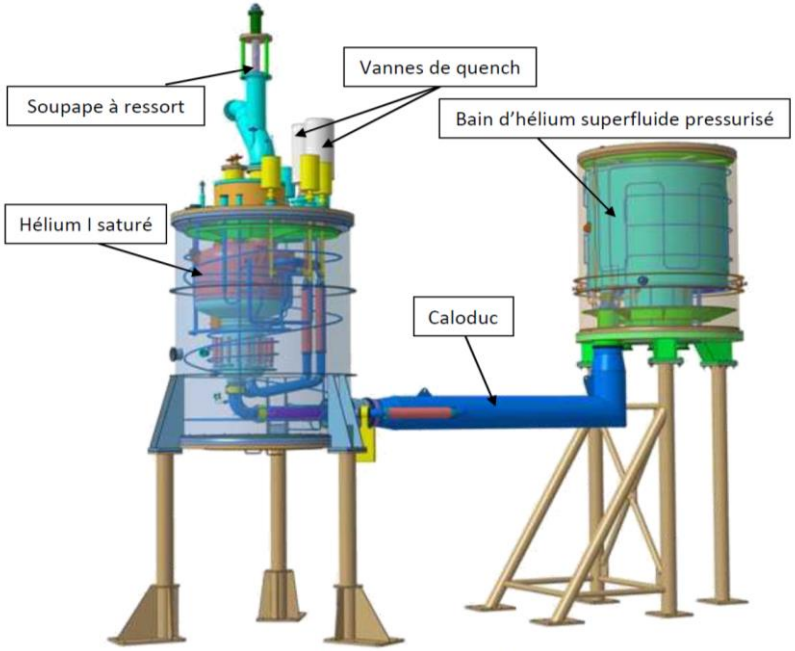


Figure 3.2 – Image 3D de la station d'essai Seht

Latest test into facility

Quench experiments were performed on an 8-T (Seht) superconducting coil cooled by a superfluid helium bath. These experiments allowed to make a detailed analysis of the physical mechanisms which drive the global pressure rise in case of quench as well as the strong coupling between this pressure rise and the normal zone propagation.

SUMMARY

- ✓ Two large scale facilities avalaible at 4.5 K
  - ✓ Saclay facility « W7X »
  - ✓ JT60-SA

- ✓ Two facilities for accelerator magnets from 4.2 K to 1.9 K:
  - ✓ Horizontal (requiring modifications or upgrades)
  - ✓ Vertical
    - ✓ Vertical facility is being modified to test MQYYM
    - ✓ It could be adapted to test MQYY prototypes and series

Supported by a proven technology know-how