Test stations for mechanical manufacturing and test
(at warm and cryogenic temperatures)

CRYOMECHA FACILITY

On-going mechanical and thermal testing stand

Some test achievements (presentation by S. Perraud)

Upgrade perspectives

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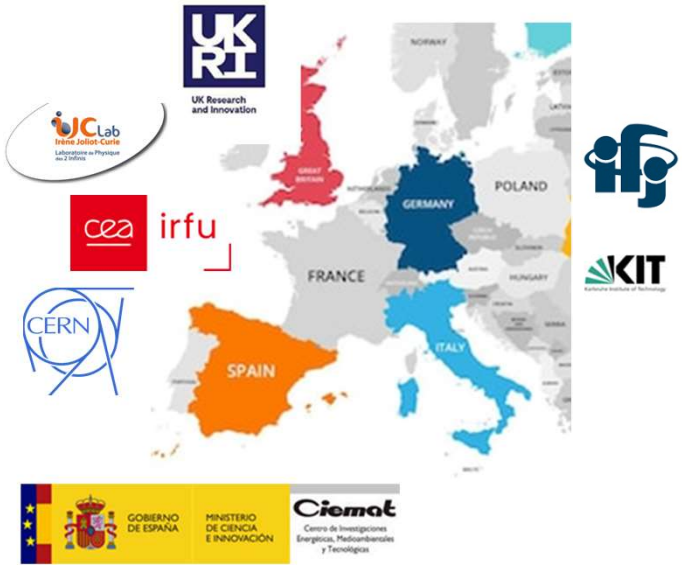
Context

The recent development of High-Temperature Superconductors (HTS) and the Nb_3Sn, the challenge of the future generation of particle accelerators and the new design of compact magnetic fusion power plants require the exploration of new materials, techniques and technologies to take a step forward compared to the current state of the art.

R&D and developments in platforms would make possible to operate at higher temperatures of 20 K and to reach high magnetic fields of up to:

16 T for Nb_3Sn
20 T for HTS.



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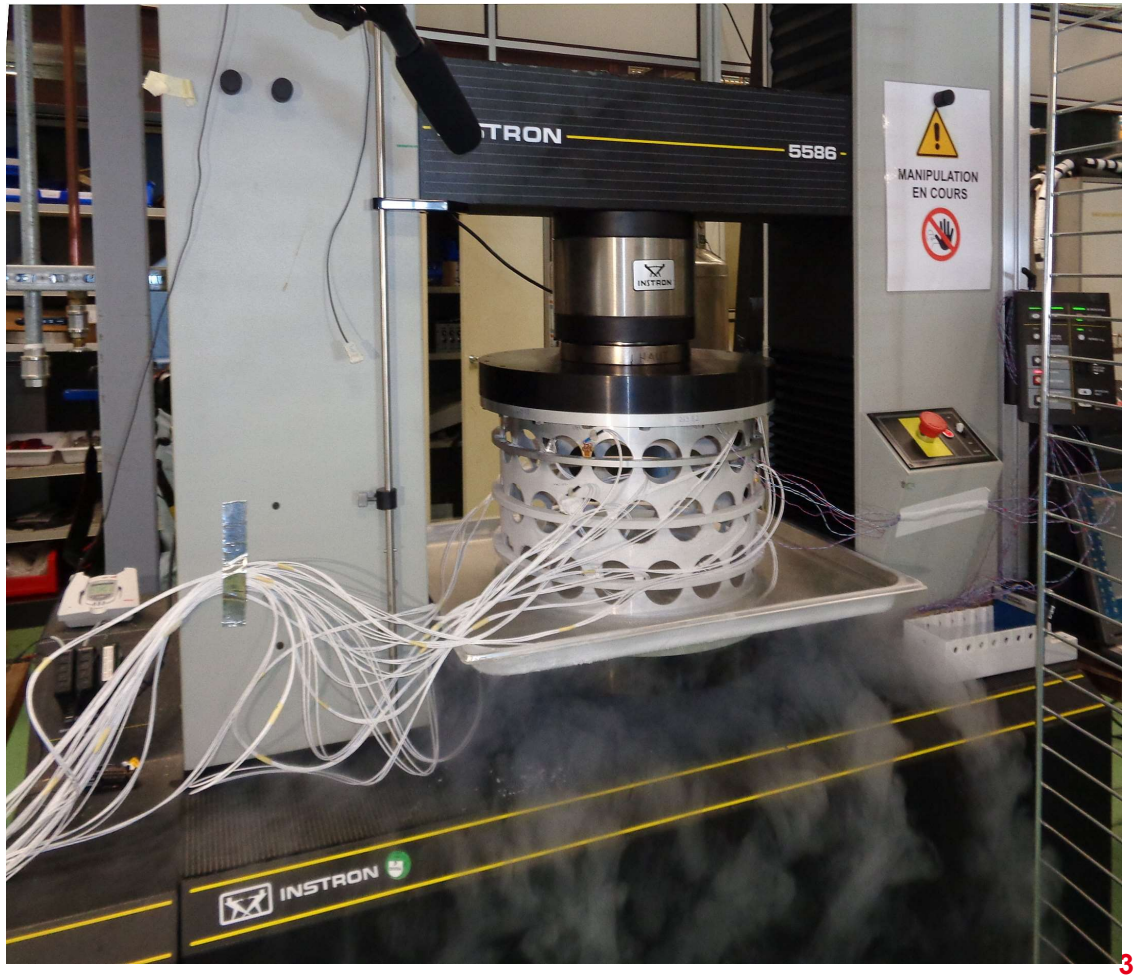
Mechanical testing machines



Mechanical test Laboratory



- Testing machines
  - ✓ Two electro-mechanical machines of 150 and 300 kN
  - ✓ One hydraulic machine of 1600 kN

- Load cells plugged on the machine (300, 150, 10 and 2 kN)

- Cryogenic inserts (on the 150 kN machine)
  - ✓ "Small" insert (300 K, 77 K, 4.2 K)

  Usable volume: Φ 50 mm x 200 mm

  45 kN in traction or flexion

  - ✓ "Big" insert (300 K, 77 K, 4.2 K)

  Usable volume: Φ 150 mm x 140 mm

  80 kN in traction

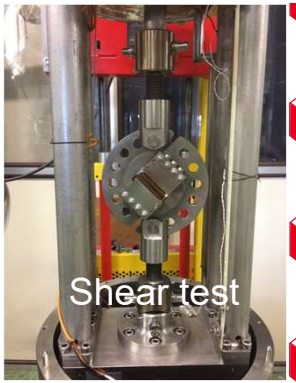
  150 kN in compression

- Instrumentation
  - ✓ Extensometers, displacement sensors, strain gauges

Mechanical test Laboratory

➢ Tensil test

The typical tensile test uses samples extracted from raw material or directly the component to test until rupture.



➢ Shear test (orientable support)

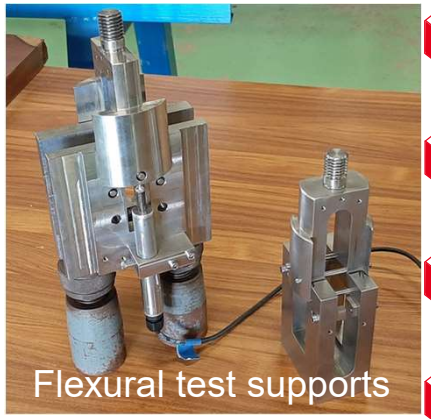
. It is possible to adapt the sample support of the sample itself to perform a shear test with a tensile solicitation.

Tensil test

Rutheford cable

➢ Flexural test

In some case (impossibility to attach the sample), it is possible to obtain some material characteristics with a flexural test instead of a tensile one. The small insert can be equipped with flexural test support in three of four points

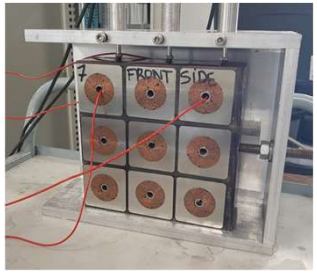


➢ Compressive test

In the major part of compressive test, it is not possible to measure the sample. Then the sensors are put on the compression pieces.
To increase the measurement accuracy, the test campaign includes a reference test on well-known sample (pure material of stainless steel for example). The sample characteristics are obtained by subtraction , that eliminate the machine perturbations.

➢ Thermal shrinkage measurement

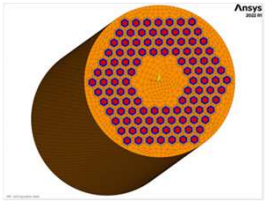
The thermal shrinkage is measure by
a compressive test with
a reference test at constant loading force or by direct Measurement of the sample expansion

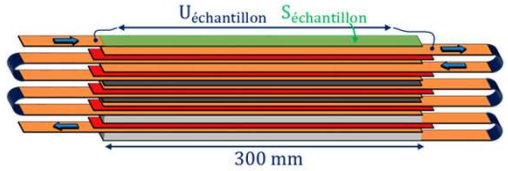


Thermal shrinkage test bench

Tests on on mechanical test machines

- Stacks compression tests – Rutherford cables
- Tensile test on NB3Sn strand
- Behaviour study of metal-resin interface
- Contact resistance under compression on HTS REBCO tapes
- Mechanical characterization on NbTi (WiC)
- Tensile test on CICC copper jackets





Future needs on mechanical tests

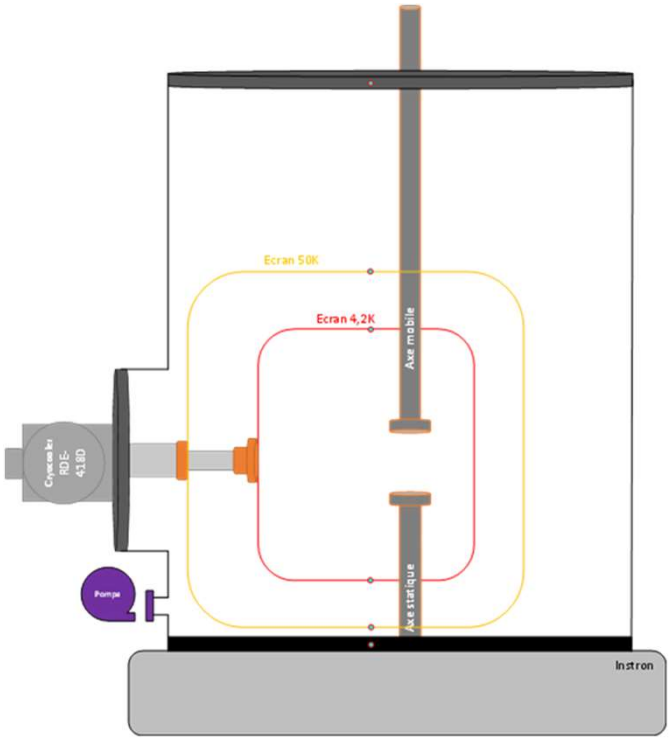
Mechanical Test Bench at variable cryogenic temperatures (from 150 to 4.2 K)

(Currently under development)

Design of cryostat devoted to mechanical test on samples at high stress level

Why?

The increasing use of superconductors HTS will require their mechanical characterization at a temperature not accessible in current stations. The mechanical characterization should extend to composite blocks comprising the superconductor and its insulation.at a controlled temperature between 4 K and 150 K, or even more if possible using the 300 kN electromechanical traction machine that the laboratory already has.



Sketch of the platform

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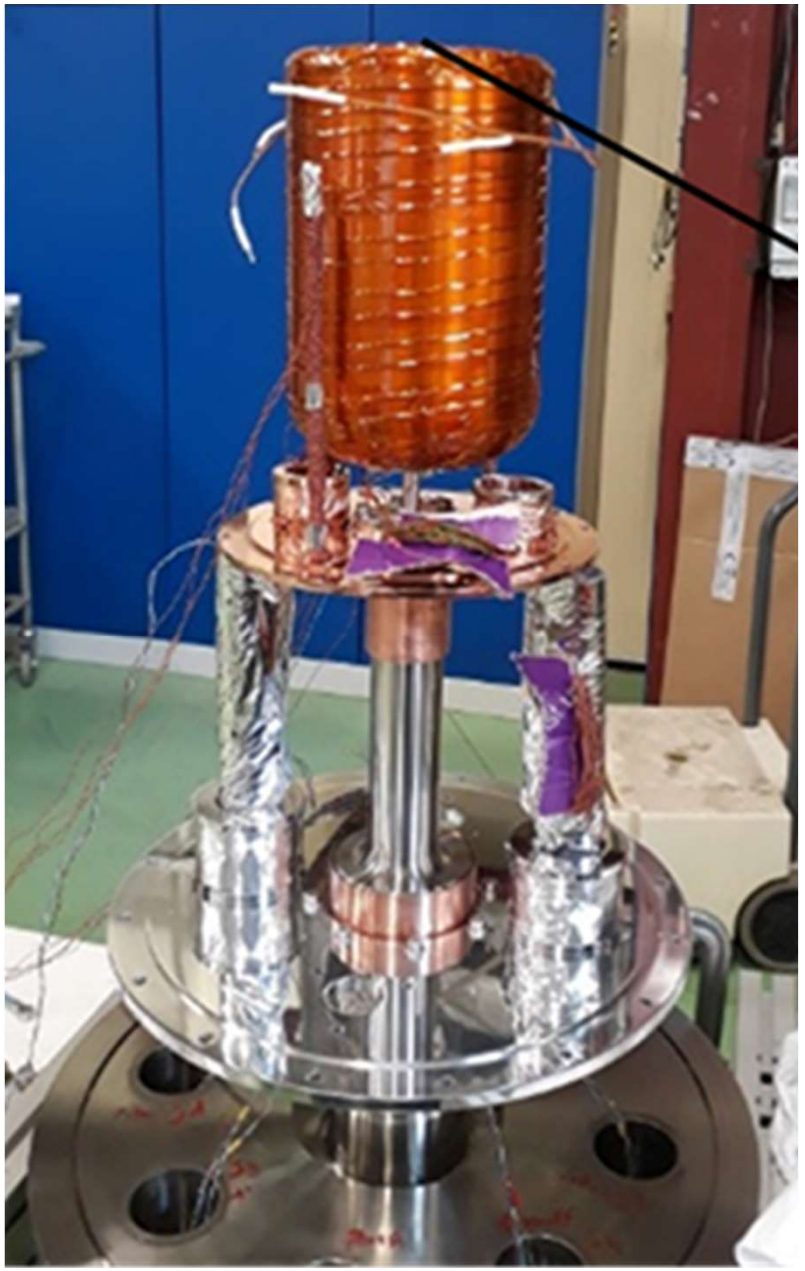
Cryogenics test stations

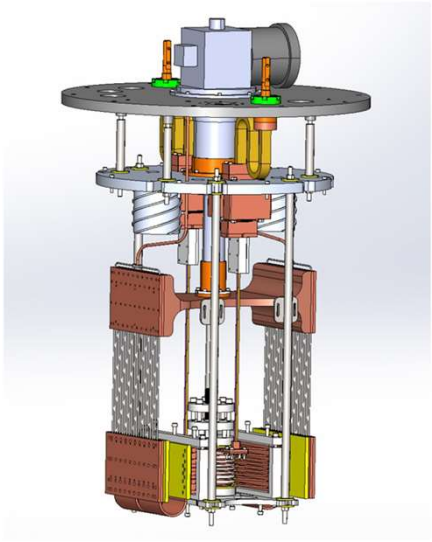
The Lab is equipped with several cryogenic stands designed for the characterization of materials and fluid flows

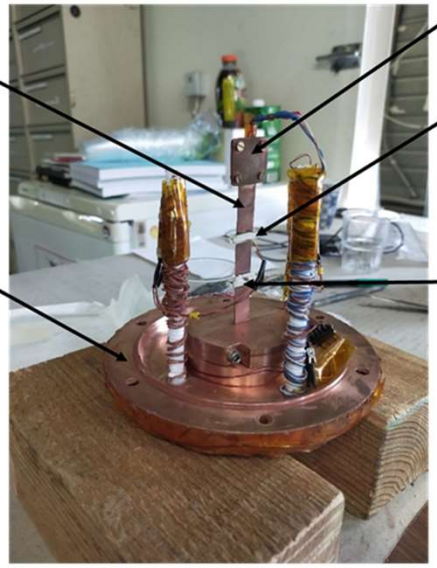


MectiX – Thermal measurement facility

cryogenerator-cooled variable temperature measurement cell for carrying out thermal conductivity measurements using either the differential or the integral method on samples of around 10 cm in length in a temperature range from 4.2 K to 300 K.

cell is isothermal within 50 mK over the entire temperature range (4 K to 50 K)





Future needs on cryogenic test stations

Cryogeny on Cooling Disturbance in Liquid Helium for accelerator magnets beyond 15 T

(Currently under development)

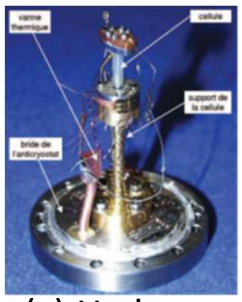
One of the major challenges for the development of future hadron-hadron colliders is to manufacture and operate superconducting magnets reaching magnetic inductions higher than 15 T

In the past, it was already demonstrated the significant influence of strong magnetic fields (>15 T) on the variation of the critical flux in liquid helium

Goal: In this context one needs to better characterize and quantify disturbances induced by high magnetic fields on diamagnetic refrigerants such as liquid helium

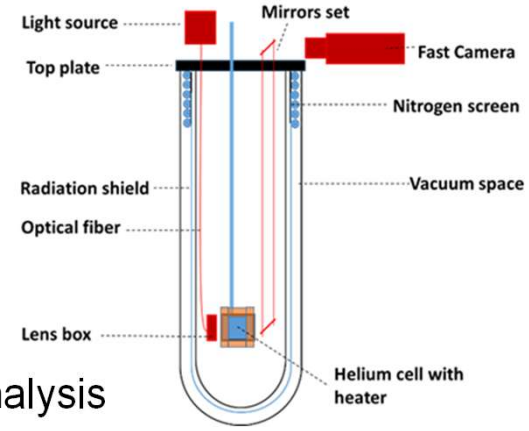
(a) Helium

(b) Oxygen



(c) Hydrogen

Set of cells which have enabled analysis under magnetic field in the past.



Sketch of the CroCoDILHe test station

❑ Development of a modular test station allowing to carry out various cryo-magnetic studies

✓ Study of single-phase natural convection regimes as well as boiling convective regimes with different configurations reproducing the cooling channel orientation in the magnets with respect to the residual forces

Thank you for your attention