Istituto Nazionale di Fisica Nucleare

# INFN Technological Infrastructure for Superconducting Magnets

Riccardo Musenich

INFN features a distributed infrastructure devoted to the development of magnets and accelerator components, located in several INFN structures:

- Laboratori Nazionali di Frascati
- Laboratori Nazionali di Legnaro
- Sezione di Genova
- Sezione di Milano – LASA
- Gruppo collegato di Salerno
- Sezione di Padova
- Laboratori Nazionali del Sud

Riccardo Musenich: *INFN Technological Infrastructure*


# LASA Laboratory

The **LASA High Magnetic Field Laboratory** has the capability to provide magnetic field for research purposes, and to develop and test magnet prototypes.

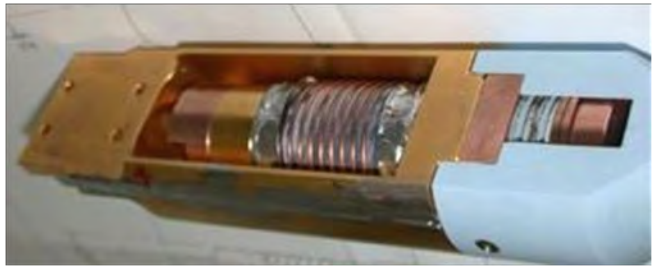
## Research Magnets

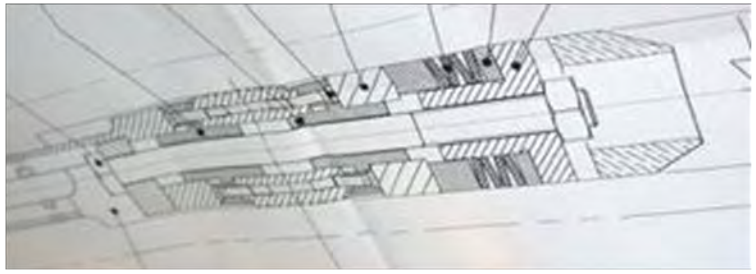
- SOLEMI 1: solenoid NbTi
  **8 T, 535 mm** *room temperature* bore
- SOLEMI 2+3: solenoid $Nb_3Sn$
  **15 T, 100 mm** cold bore @ 4.2/2.2 K
  **75 mm** cold bore in gas flow 2-300 K
- Solenoid NbTi + $Nb_3Sn$
  **13.5 T, 50 mm** cold bore @ 4.2/2.2 K
- Cryocooler-operated magnet
  **8 T, 75 mm** cold bore cryogen-free
- Resistive Dipole
  **1 T, 120 mm** room temperature gap

# Test Station for Superconducting Wire Characterization

## Critical current measurement of S.C. wires

- Facilities to test superconducting wires
- Back-ground magnetic field up 15 T
- Temperature variable from 1.9 K to 50 K
- Iper-stabilized power supply 3000 A, 6 V (battery bank to cancel ripple noise)
- Several supports for many types of conductor
- New impulse on the activity for $Nb_3Sn$ with **ASTRACT** CSN5





# Test Station for long magnets LTS and HTS

**LHe Cryostats**

Ø 690 mm, **6500 mm depth** a rather unique feature
Ø 515 mm, **3300 mm depth** for medium-size
Ø 480 mm, **1200 mm depth** for small-medium size
other smaller cryostat

**Power Supplies**

3 x Power supply up to 10 kA, 6 V
(i.e. up 30 kA – 6 V or 10 kA – 18 V)
2 x Power supply up to 1.2 kA, 36 V
1 x Power supply up to 500 A, 125 V
1 x Power supply up to 600 A, 15 V, IGBT based polarity switch
1 x Power supply up to 2 kA, 4 V
(low noise, battery based)

**Magnet Protection System**

including discharge resistor, switch, Quench Detection Electronics
**10kA IGBT fast switch** <1 ms to open

## Strategic Tooling for High Field Programs

# Cryogenic test availability

## Small Magnets Test Cryostat (**SMTT**)

- HO correctors protoypes
  - 6P MCSXFP
  - 8P MCOXFP
  - 10P MCDXFP

## High Current Test Station (**DISCORAP**)

- DISCORAP and HTS magnets

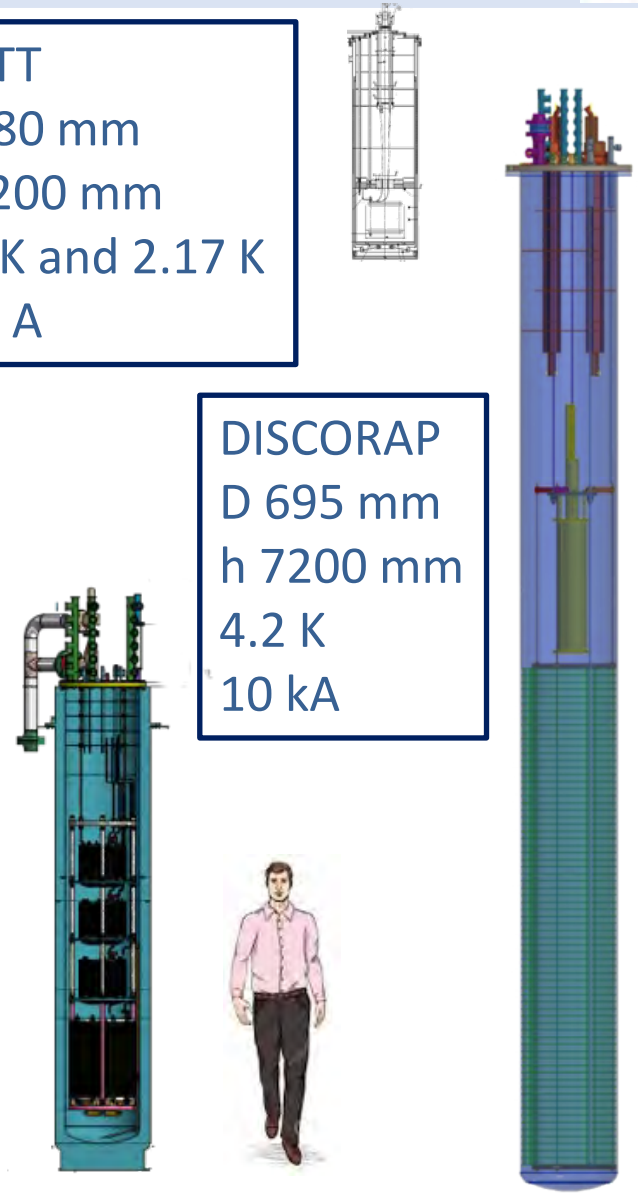
## HiLumi Correctors series (**HOC**)

- All HO correctors series

SMTT
D 480 mm
h 1200 mm
4.2 K and 2.17 K
500 A

DISCORAP
D 695 mm
h 7200 mm
4.2 K
10 kA

HiLumi HOC
D 515 mm
H 2950 mm
4.2 K
500 A




Genova Laboratory
The **Genova Laboratory** has the capability to provide magnetic field for research purposes, and to characterize high currentconductors .

# Characterization of conductors

- Critical current measurements up to 100 kA
- RRR measurements
- Joint resistance measurements

# Test Station for Superconducting Cables

**MaRiSA – Magnete per Ricerca Superconduttività Applicata**

Critical current measurements of high current superconducting cable up to 8T in a bore up to 440 mm and current up to 100 kA with a transformer method.

- Magnetic Field of 8T in 330 mm bore with VTI (1K<T<300 K);
- Magnetic Field  of 6T in 440 mm with VTI (1K<T<300 K);
- Sample shaped as a ring with low resistance joint;
- Maximum current 100 kA.

# Test Stations for Superconducting Wires

- 14 T, 80 mm bore solenoid equipper with VTI
- 5 T, 50 mm bore split coil equipper wit VTI (samples can be rotated to vary the orientation respect to magnetic field)
- 2 low ripple power supplies (10 V, 1000 A)
- 3000 A battery powered power supply (in construction)

Among the **most significant measurement campaigns**, critical current measurements of:

- 30 conductors used for HERA superconducting dipoles
- All Al stabilized conductors (6) involved in BaBar Superconducting Solenoid (SLAC)
- All Al stabilized conductors (20) involved in CMS Superconducting Solenoid (CERN)
- All Al stabilized conductors involved in Mu2e superconducting solenoids (43 tests)
- Al stabilized conductors for MPD solenoid (commissioned by Furukawa Electric)*

* Between 4.2 K and 7.2 K

Ma.Ri.S.A. test facility

## Helium liquefier


Salerno Laboratory
The **Salerno Laboratory** has the capability to provide magnetic field for research purposes, and to develop and test magnet prototypes.

# Horizontal test station for accelerator magnets

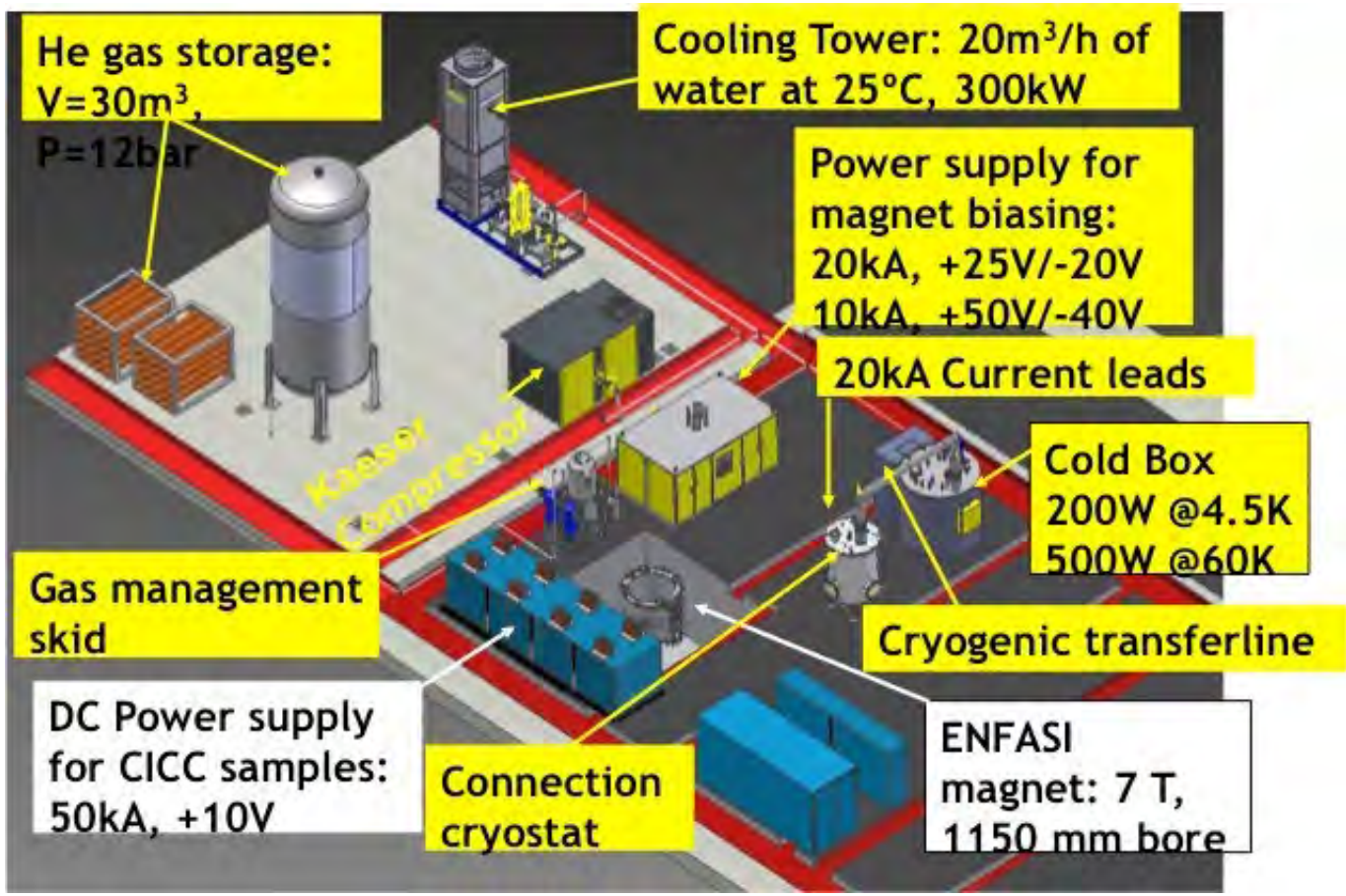
Test of superconducting accelerator magnets in their own horizontal cryostat, cooled by 4.5 K He stream at pressure up to 7 bar (supercritical He), and powered up to 20 kA also in ramped mode.

The test station is new (partially commissioned in 2016).

Technical steps and expertise:

- Construction of magnet interface according the specific requirements,
- Cool-down of the magnet by means of closed cycle GHe for the measurement run,
  - 4 channel QDS system
  - 24 ch temperature monitoring for the magnets
  - HV insulation tests, flow tests on the magnets
  - NI fast DAQ

**Testing of FAIR SIS100 quadrupole doublets started in early 2022 (2 tested, 80 planned)**




- 120 l/h helium liquefaction capability;
- He gas storage 360 mc (30 mc @12bar);
- SFC 200 kW He compressor (70 g/s flow rate);
- Cooling power of 200W plus 500W at shield temperature;
- Two quadrants power converter of 20 kA +50/-40V, 3kA/s ramp rate;
- 20kA HTS current leads;
- 20 ton crane, 9 m clearance, in the laboratory.

# Conclusion


The three labs are complementary (with some redundancy) and can provide a complete characterization of magnets including the properties of their main components (wires and cable.)

The test facilities in the labs are the base for R&D as well as a strong support to superconducting magnets design .