LASA
Laboratorio Acceleratori Superconduttività Applicata

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1st International WORKSHOP of the Superconducting Magnets Test Stands, CERN 13-June-2013

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INFN Istituto Nazionale di Fisica Nucleare

UNIVERSITÀ DEGLI STUDI DI MILANO

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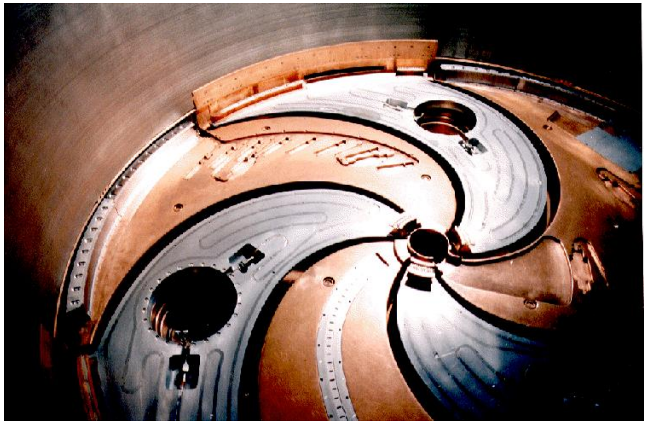
1st International WORKSHOP of the Superconducting Magnets Test Stands

Infrastructure and people

Founded in 1987 for the Superconducting Cyclotron K800 construction, actually in operation at LNS Catania.

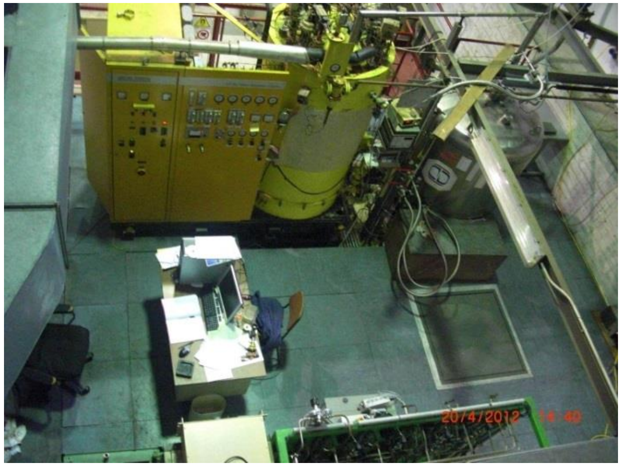
People: about 40 persons

(3 experienced researchers and 5 experienced technicians directly involved in the magnet activities)

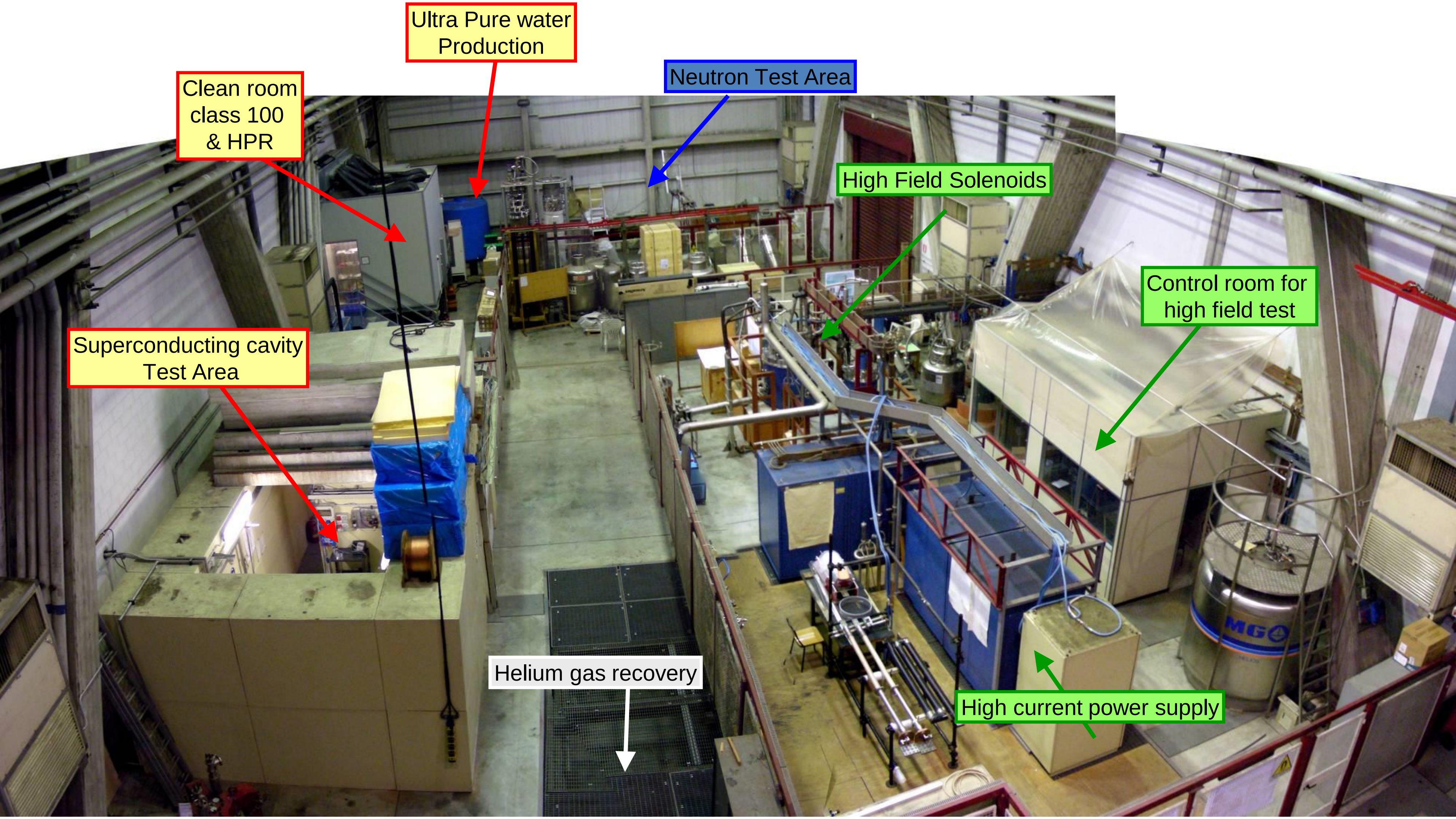


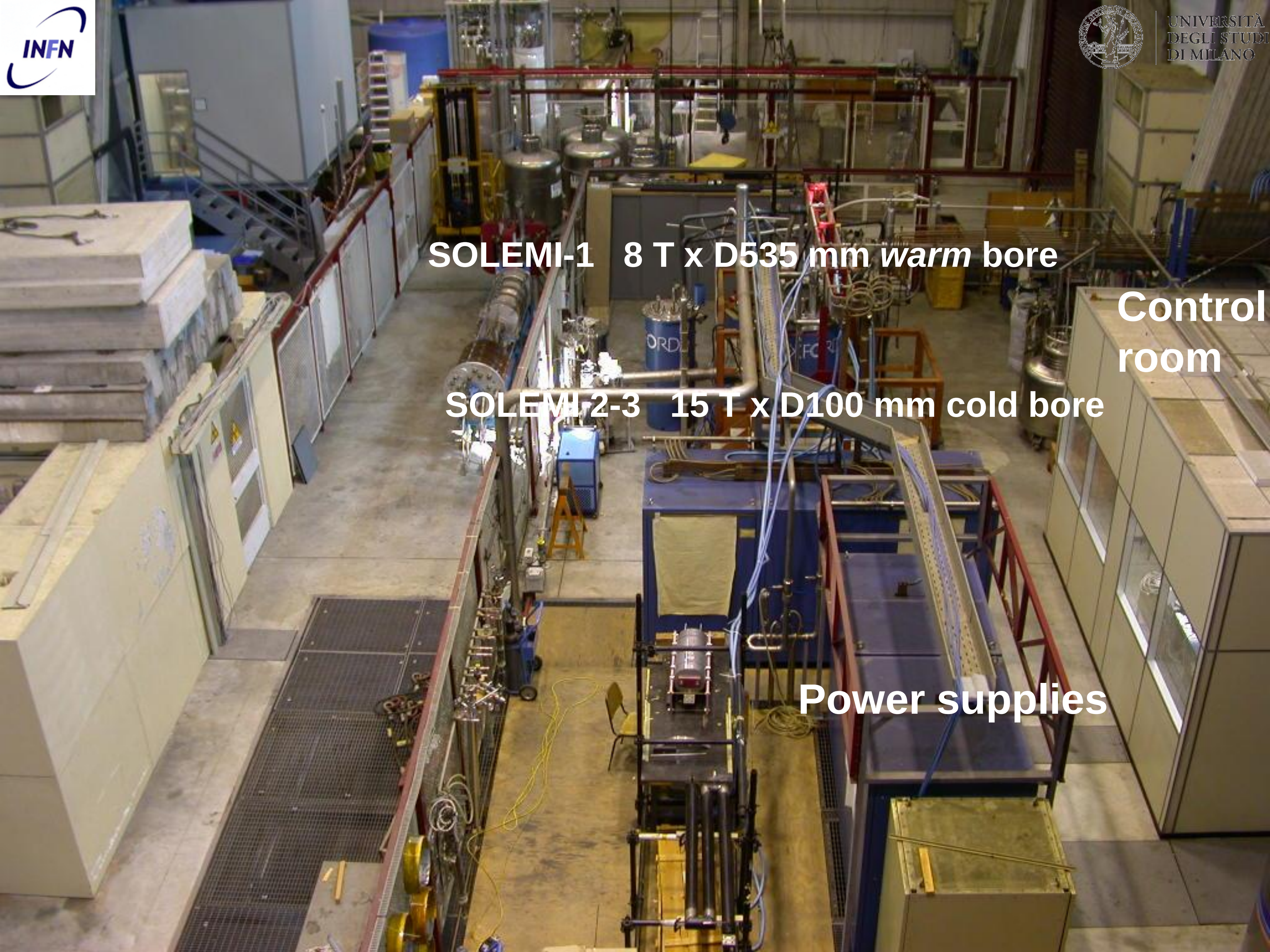
Infrastructure: Experimental area 2000 m^2, with a 50 t crane.

- Helium liquefier: 40 l/h
- LN distribution (10000 l dewar)
- Installed electrical power: 1.6 MVA
- 1 Gbit/s LAN
- Ultra High purity water plant (18 MΩ cm)
- Machine workshop
- Class II Radiochemistry Lab.
- Physical measurements Lab. (α, β, γ spectroscopy)
- Bunker for RF superconductive cavity tests with 700 mm diameter , 4500 mm height cryostat
- Low temperature (>2K) Mechanical Measurements Lab

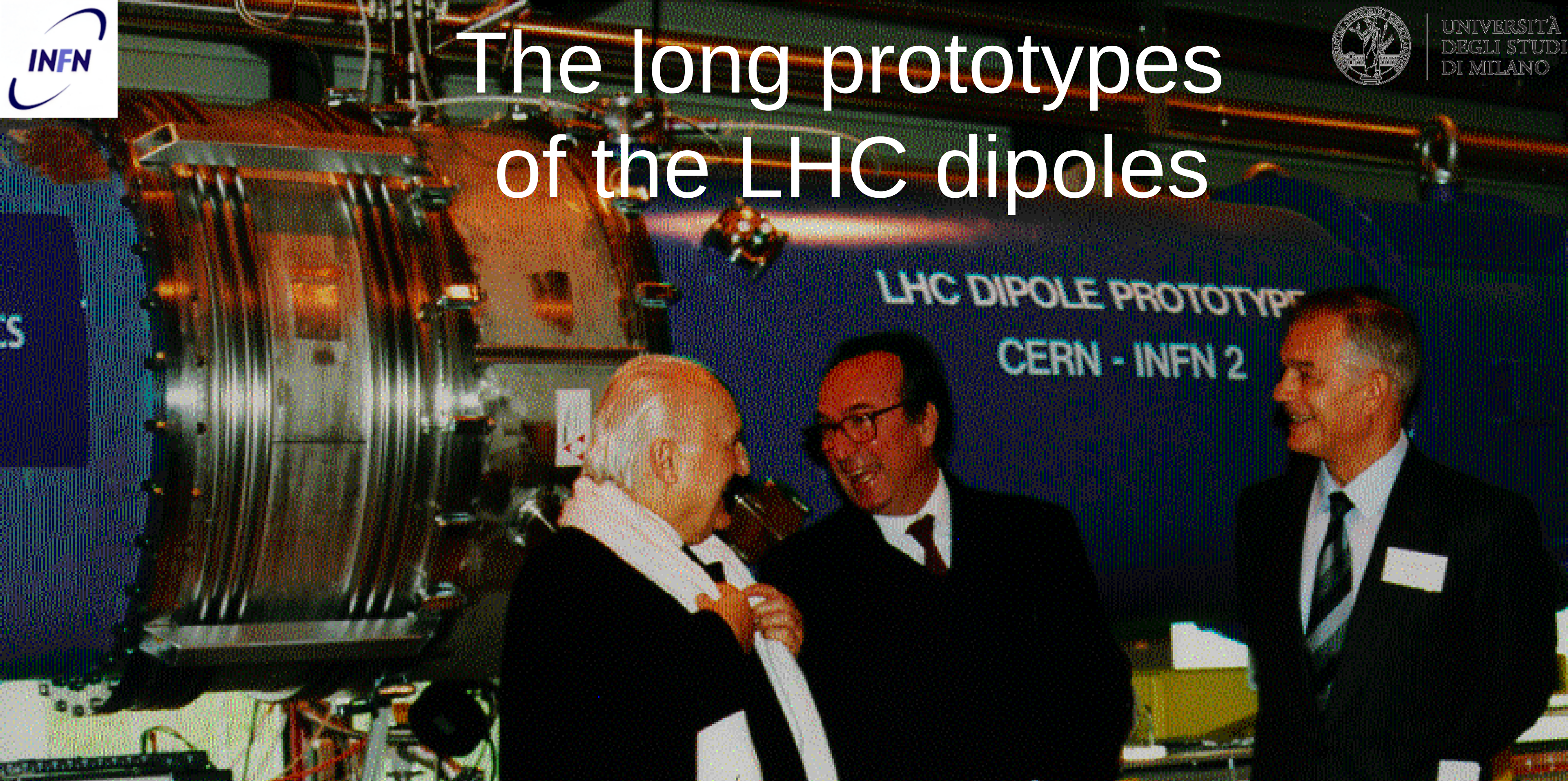


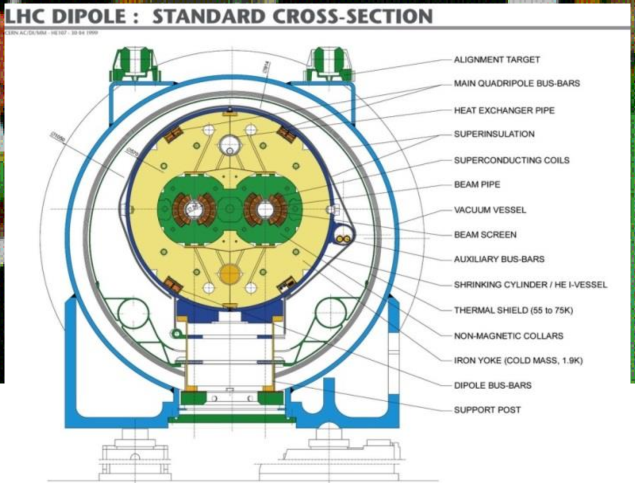
Experimental area




SOLEMI-1 8 T x D535 mm *warm* bore
Control room
SOLEMI-2-3 15 T x D100 mm cold bore
Power supplies

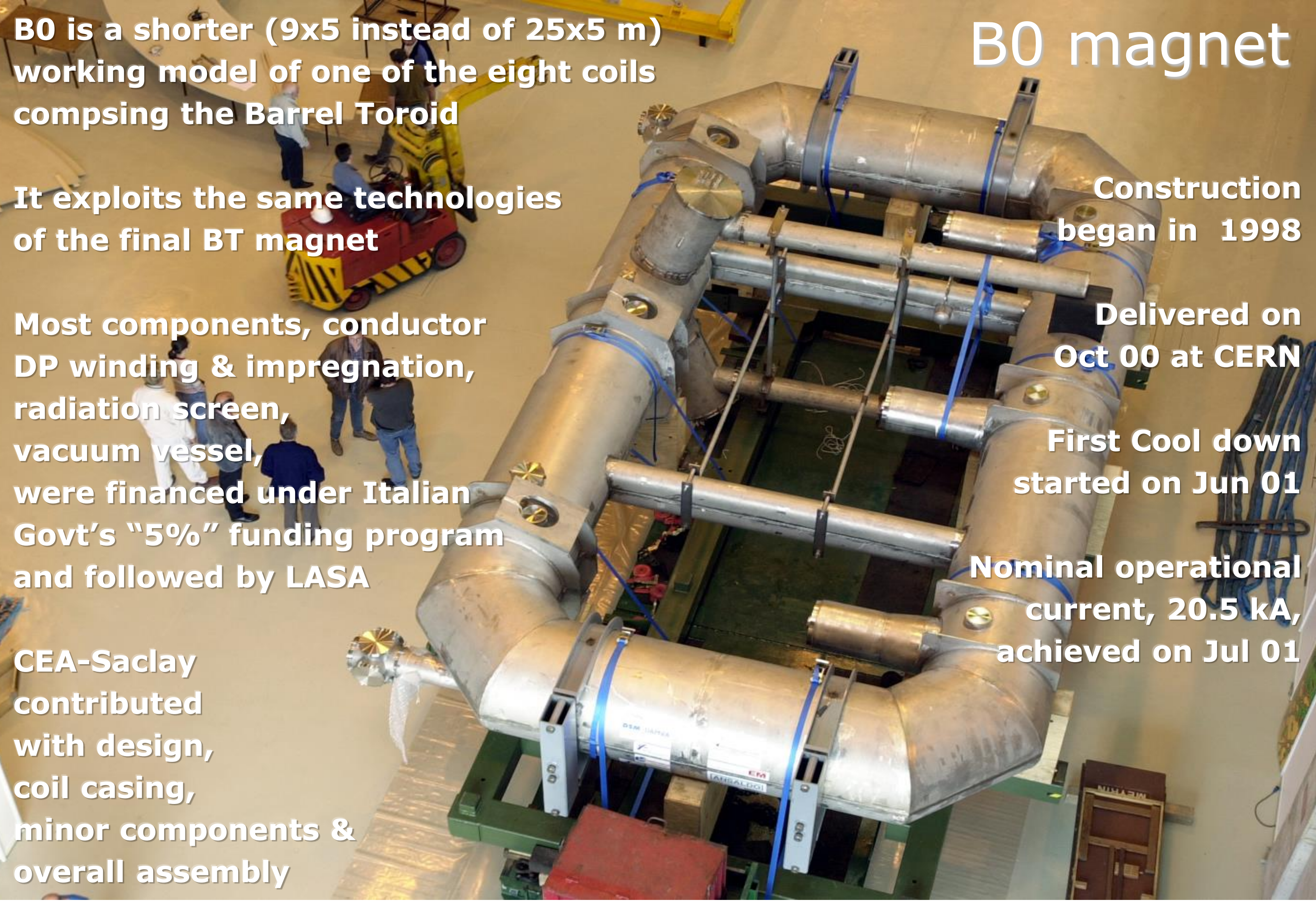
The long prototypes of the LHC dipoles





INFN has collaborated with CERN since 1990, funding and following the construction in the Italian industries of the first two 10-m-long dipole prototypes. Their excellent performances paved the way to the LHC project approval in 1994.

B0 magnet



B0 is a shorter (9x5 instead of 25x5 m) working model of one of the eight coils compsing the Barrel Toroid

It exploits the same technologies of the final BT magnet

Most components, conductor DP winding & impregnation, radiation screen, vacuum vessel, were financed under Italian Govt's "5%" funding program and followed by LASA

CEA-Saclay contributed with design, coil casing, minor components & overall assembly

Construction began in 1998

Delivered on Oct 00 at CERN

First Cool down started on Jun 01

Nominal operational current, 20.5 kA, achieved on Jul 01

ATLAS Tie-Rod test apparatus

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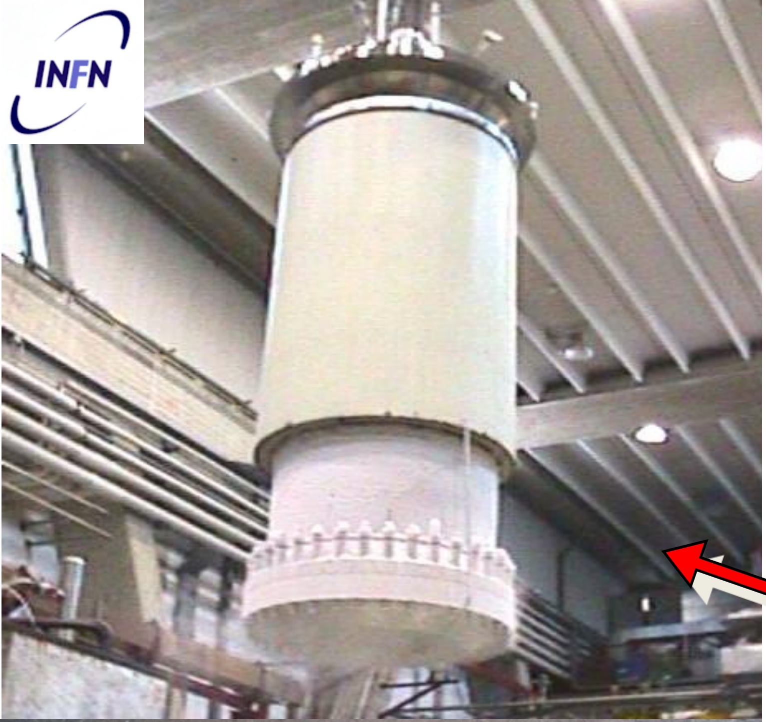
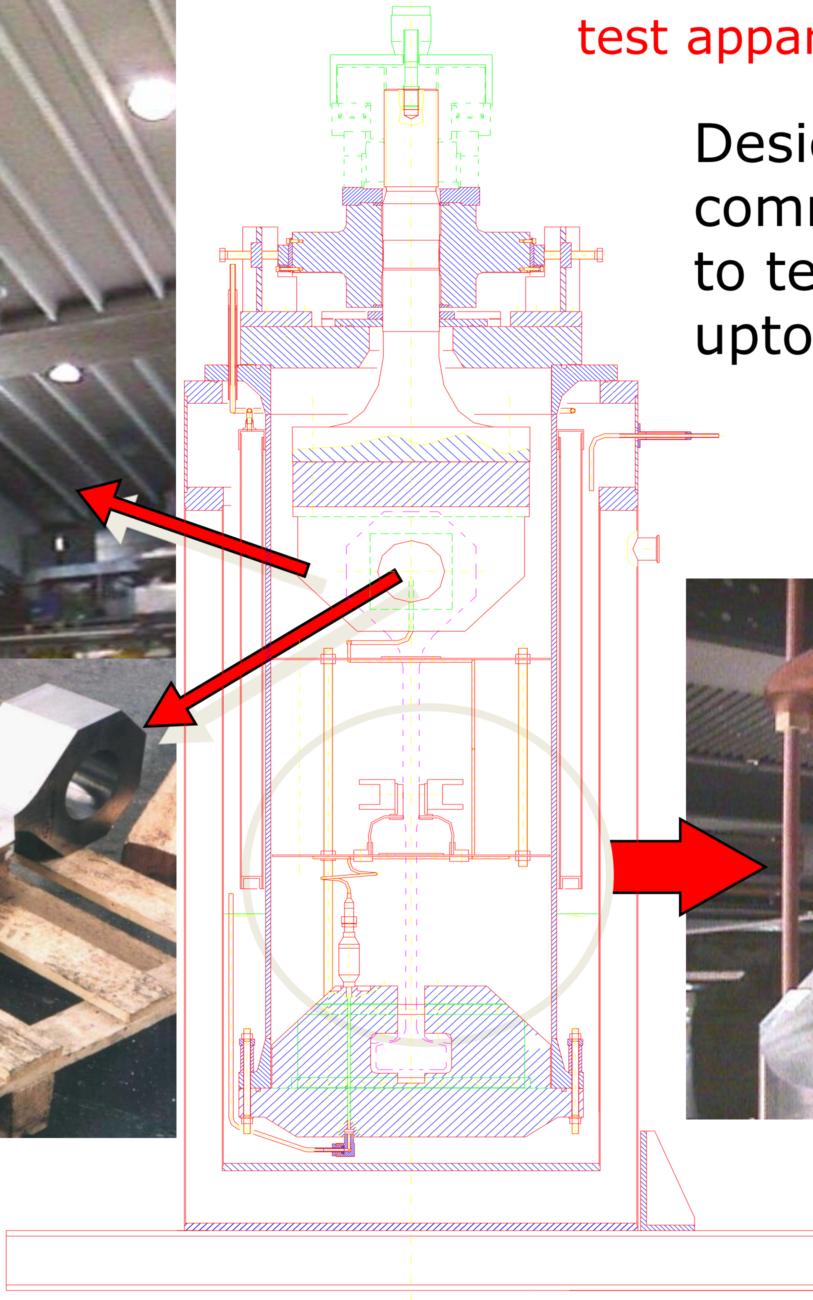
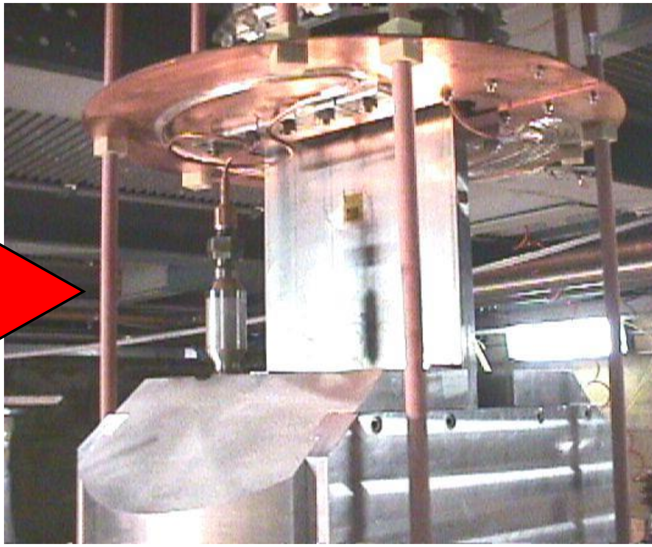
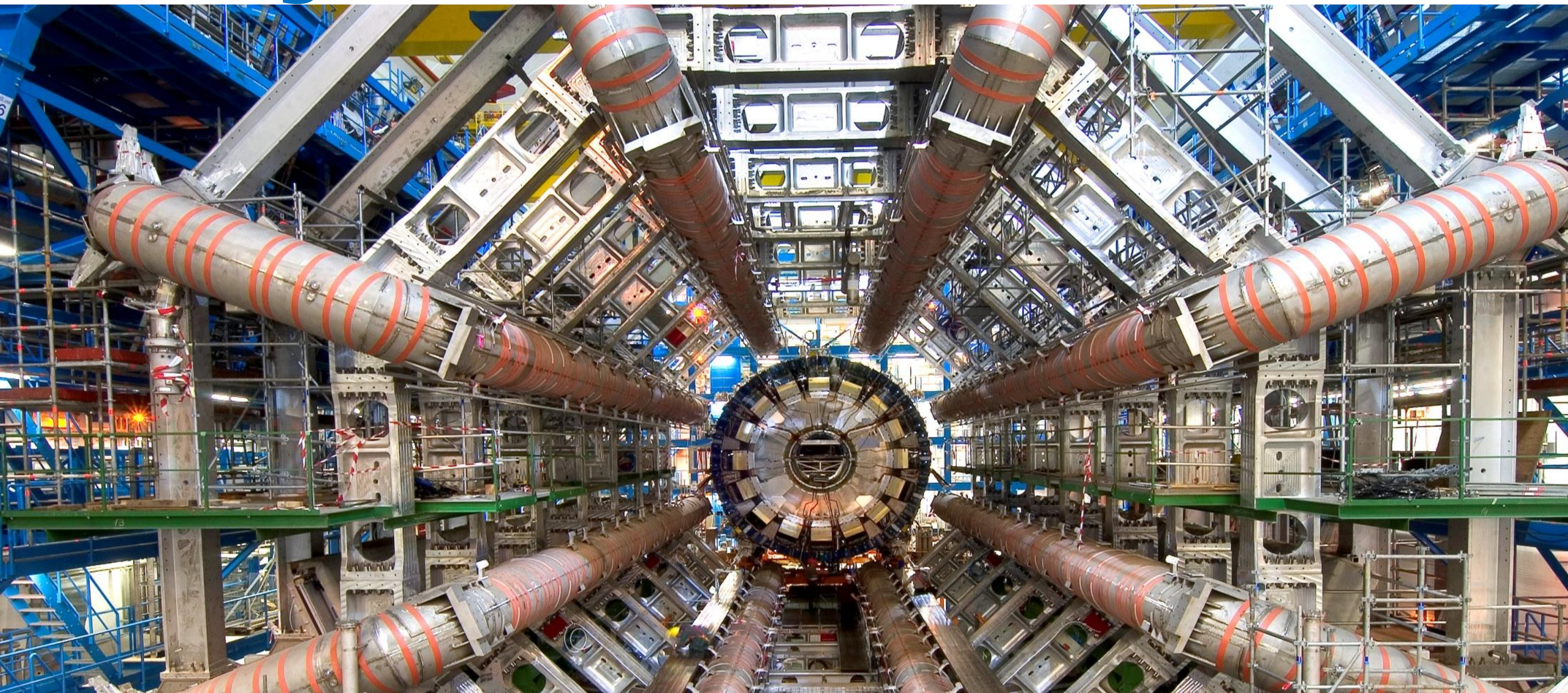




Designed and commissioned at LASA to test B0’s Tie-Rods upto 260 tons



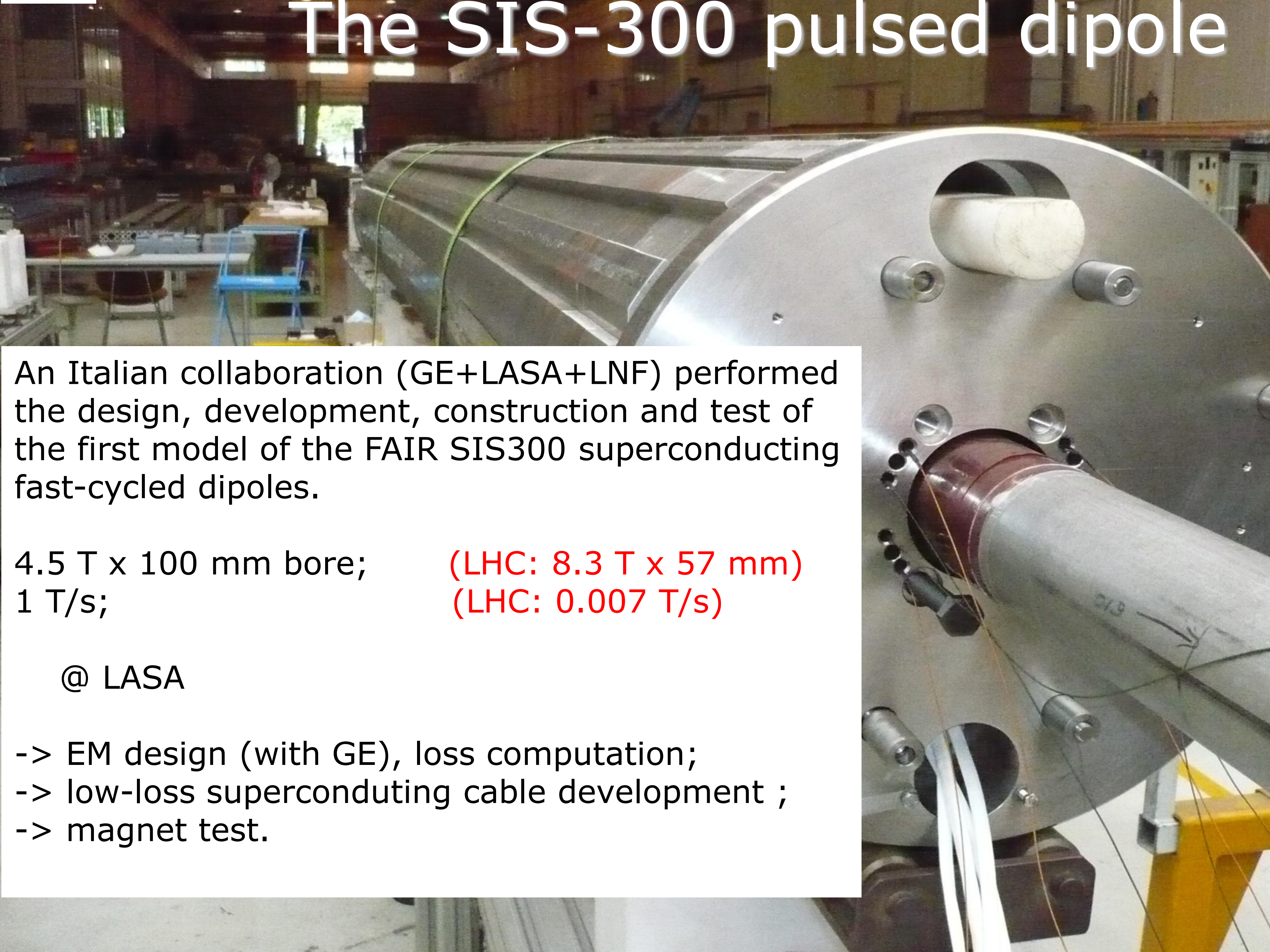
The superconducting toroidal magnets of the ATLAS detector



INFN was co-responsible, together with CEA, of the construction of the Barrel Toroidal Magnet of ATLAS.

Full responsibility on 1/4 of the superconducting cable (EM Fornaci di Barga), of the superconducting coils (ASG Genova), of the thermal screens (Ettore Zanon, Schio), of the dump and protection system of the magnet.

The SIS-300 pulsed dipole



An Italian collaboration (GE+LASA+LNF) performed the design, development, construction and test of the first model of the FAIR SIS300 superconducting fast-cycled dipoles.

4.5 T x 100 mm bore; (LHC: 8.3 T x 57 mm)
1 T/s; (LHC: 0.007 T/s)

@ LASA

-> EM design (with GE), loss computation;
-> low-loss superconduting cable development ;
-> magnet test.

The Magnet Cold Mass

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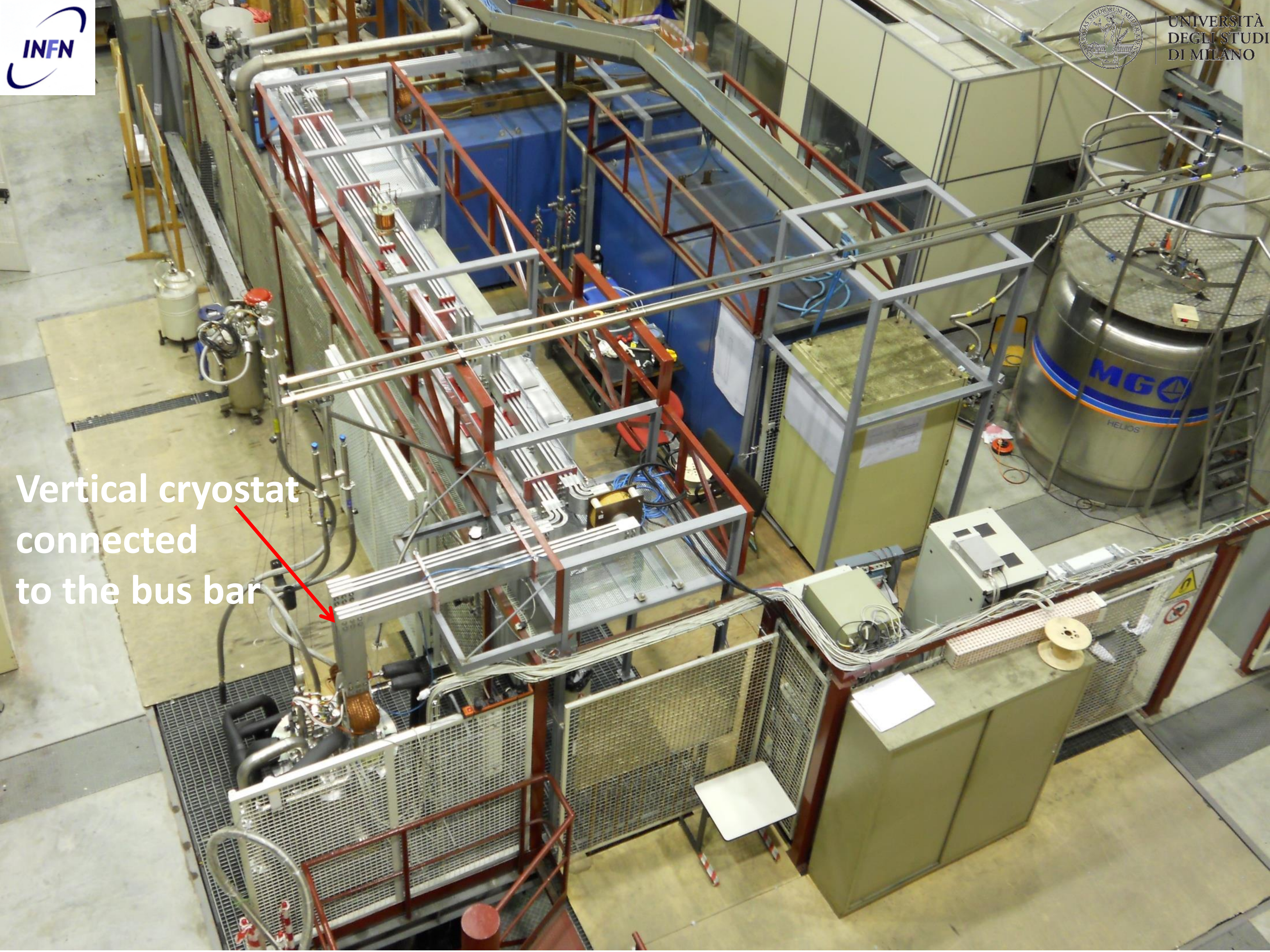
DISCORAP

In July 2012 at LASA the test on the first «fast cycled» magnet for FAIR SIS-300 have been performed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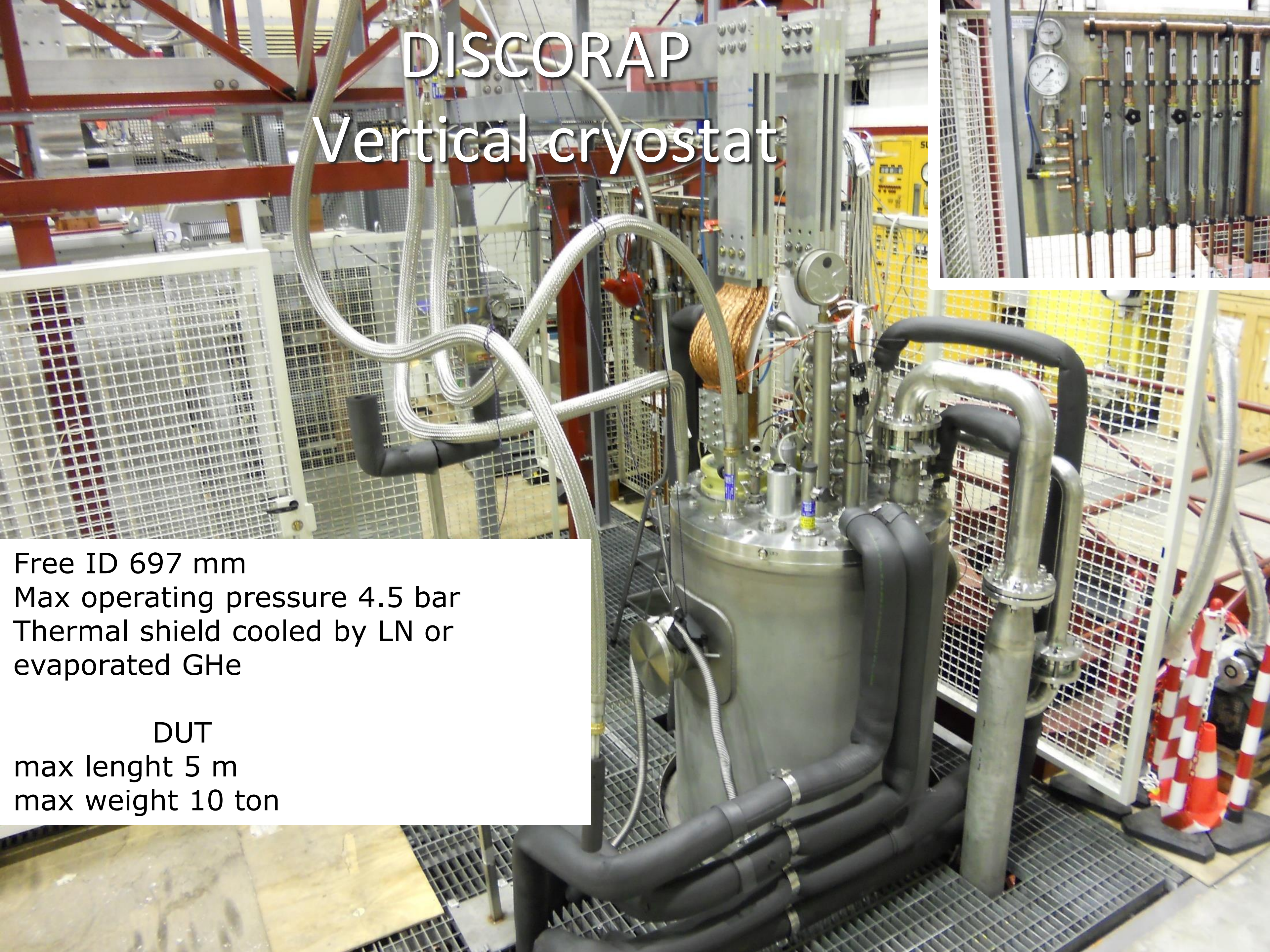
Vertical cryostat connected to the bus bar

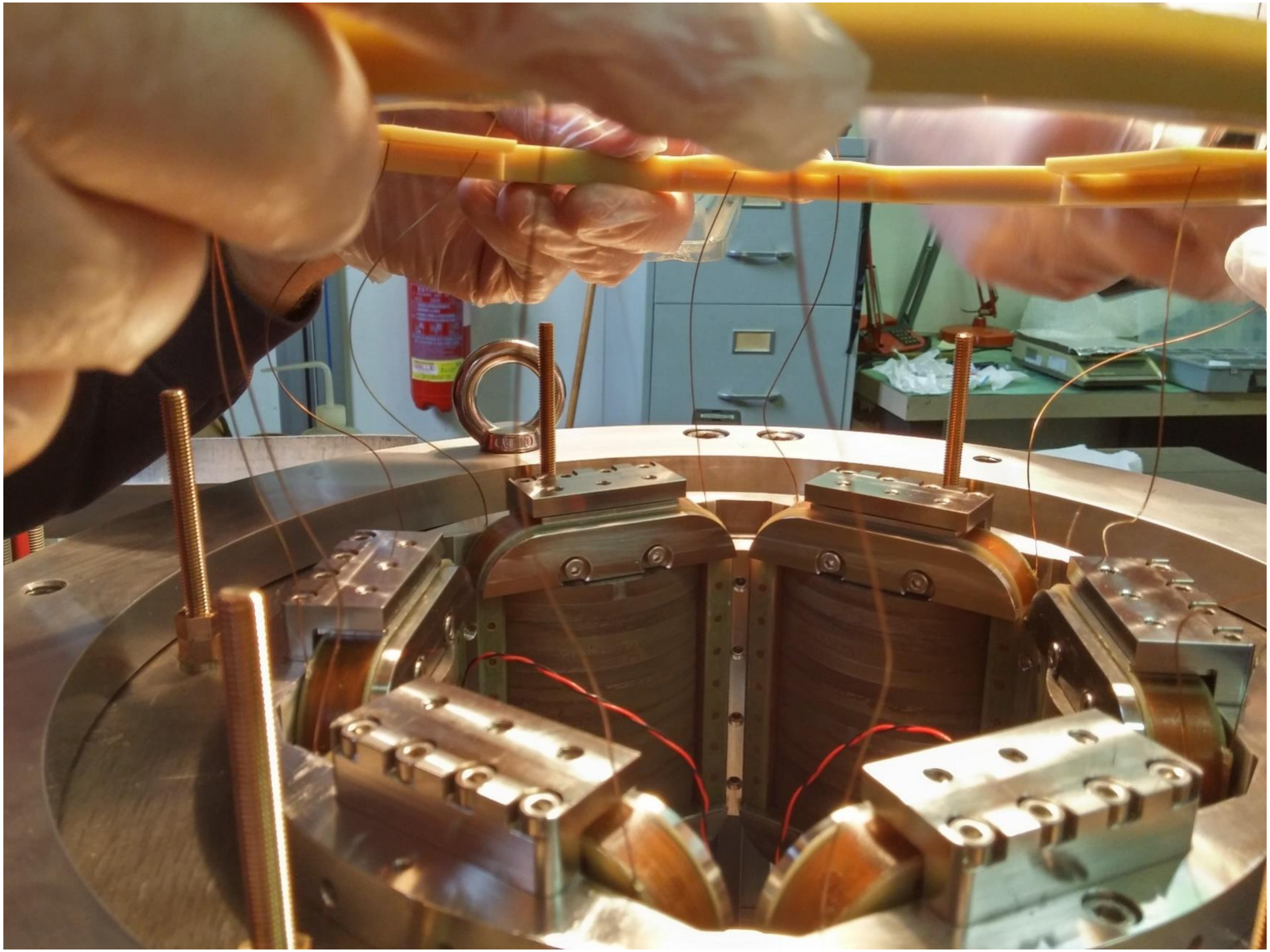
DISCORAP
Vertical cryostat



Free ID 697 mm
Max operating pressure 4.5 bar
Thermal shield cooled by LN or evaporated GHe

DUT
max lenght 5 m
max weight 10 ton

MAGIX



In February 2016 the first of the five prototypes of the super-ferric magnet for MAGIX have been succesfully tested.
(in the photo an assembly phase)

High Magnetic Field Laboratory

The 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
  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

Ancillary equipment & Prototype development tooling

Power supply up 30 kA 6V (swicthing)
" 2 kA 4V (low noise, battery based)
Winding machine
Oven up to 700 °C in vacuum (Nb_3Sn reaction)
Oven up to 900 °C in atmosphere (HTSC reaction)

Next slide the details

High Magnetic Field Laboratory

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Vertical Test Station

Can accomodate magnets up to 700 mm dia x 6500 mm in length

Soon to be integrated by a 515 mm dia x 3300 mm vertical cryostat for medium-size magnets/samples

480 mm dia x 1200 mm, and other smaller cryostat

Power Supplies

3 x Power supply up to 10 kA, 6 V
(series and parallel operation possible)
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 2 kA, 4V (low noise, battery based)

Magnet Protection System including discharge resistor, switch, Quench Detection Electronics

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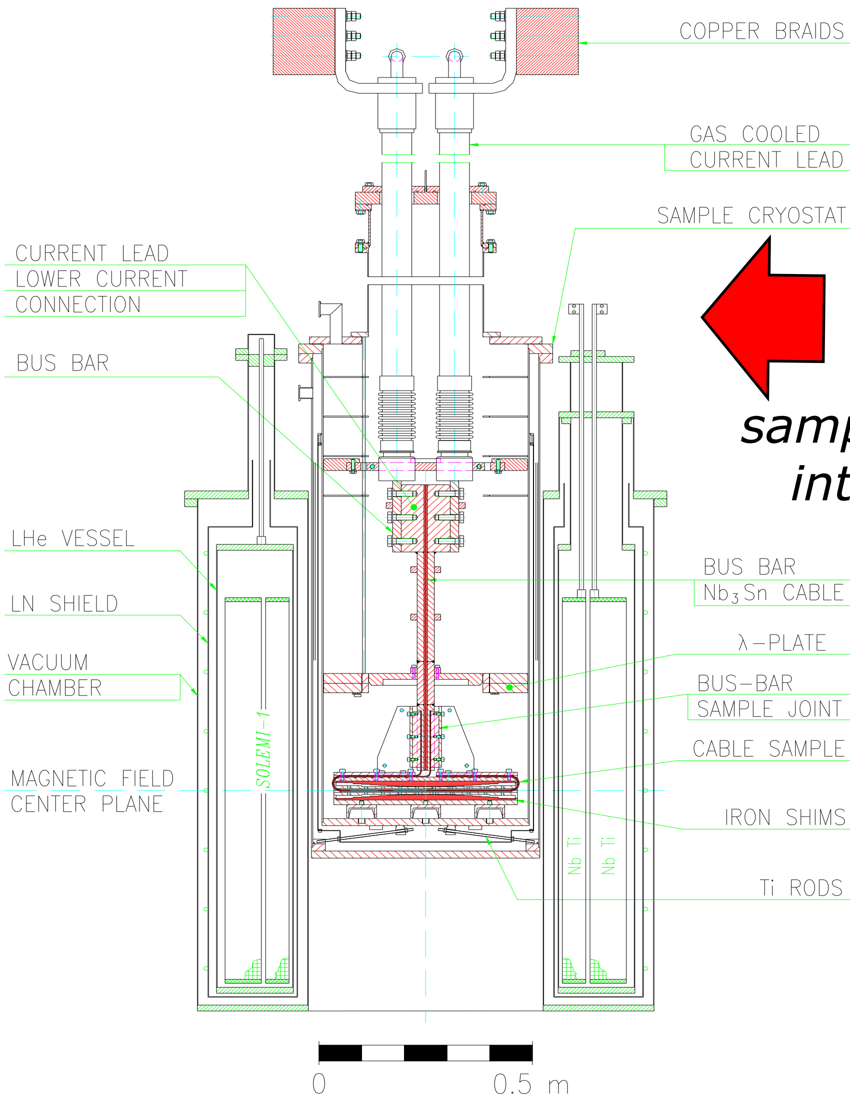
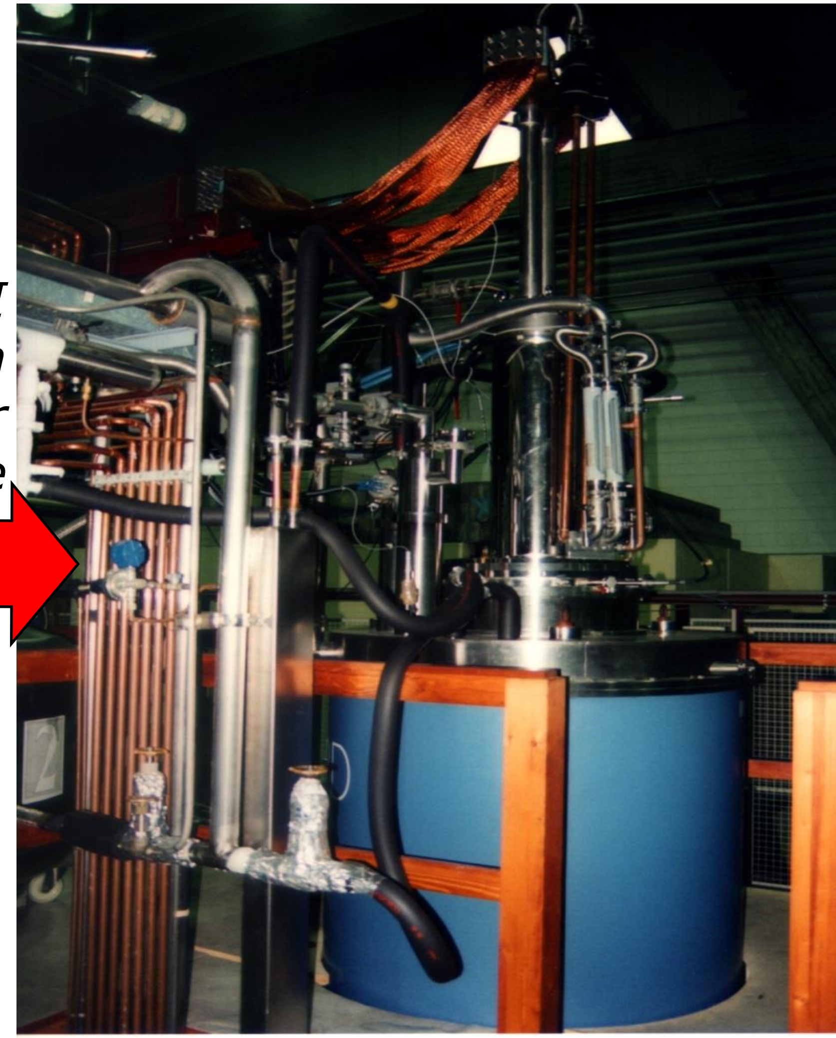
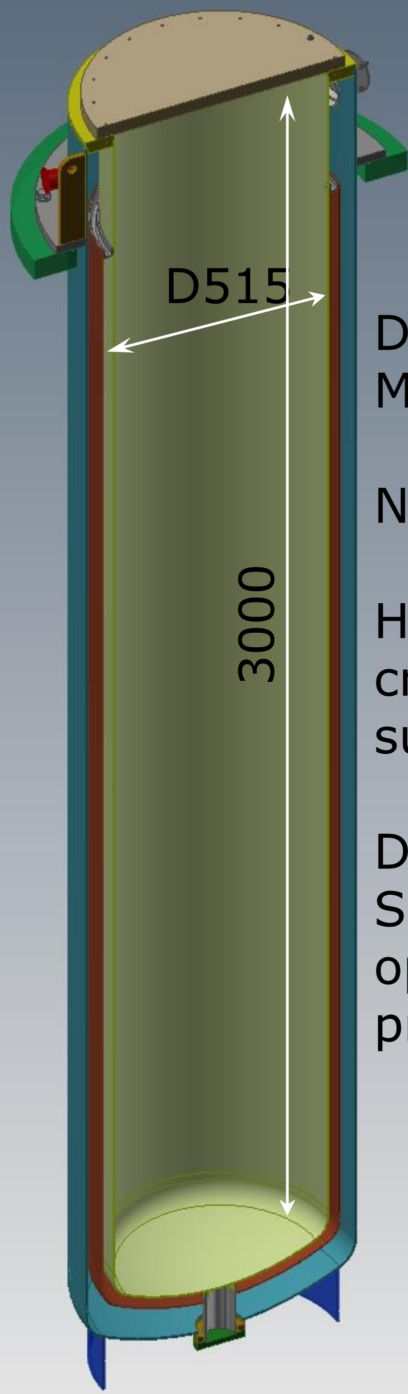
SOLEMI 1 magnet



SOLEMI with sample holder into its bore



MAGIX Cryostat



D515 x L 3000 mm
Maximum LHe level 2300 mm

Now being manufacture

Hosted within DISCORAP cryostat (which acts as a support)

Designed for 4K operation
Study for lower temperature operation, 1.9K or 2.2 K in progress

Cryo-Mechanical Lab

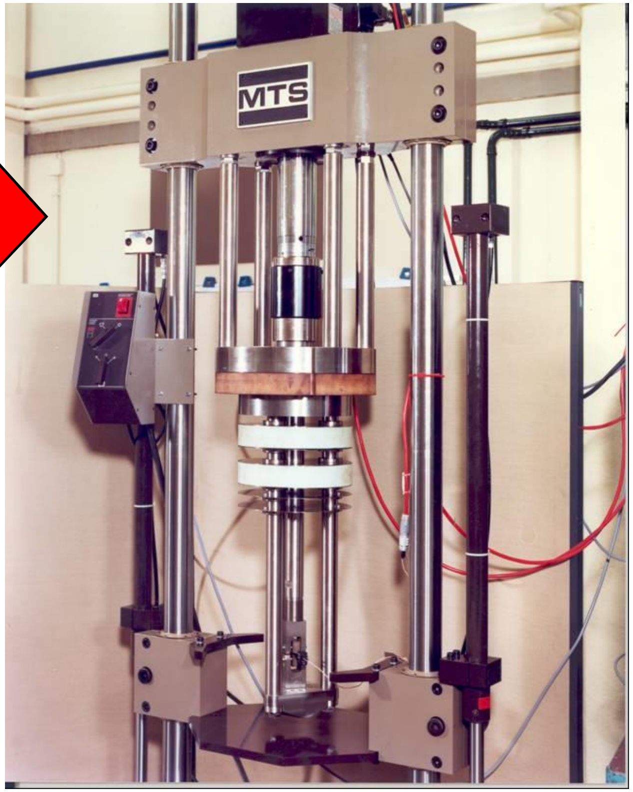
Goal: perform room temperature and cryogenic (down to 2K) mechanical test, both in quasistatic and cyclic conditions.
Commercial test machines have been fitted with home-designed cryostats.

Tensile and compression tests on INSTRON testing machine, model 6027.

max load, tension	**100 kN**
max load, compression	**50 kN**
temperature range	**3 – 300 K (flow of helium gas)**

Tests in cyclic conditions on MTS testing machine

load +/- 125 kN
temp. range 2-300 K



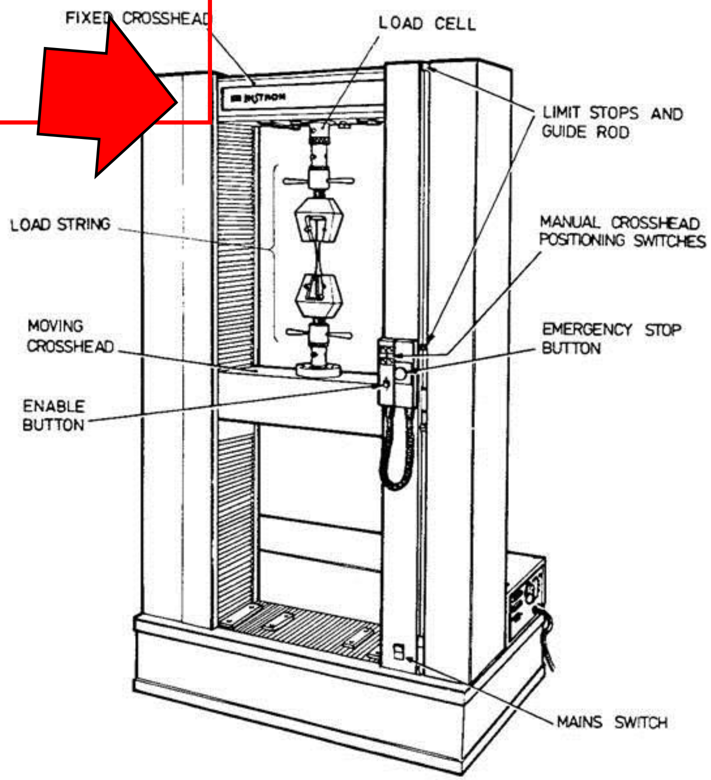


Figure 1 - Instron test machine

Control & Data Acquisition Architecture

1. QDS (MSS Magnet Safety System)
Initiates a fast discharge or switches off the power supply incase some voltage thresholds on the magnet or on its electrical connection are exceeded. Includes a capacitor bank for firing quench heaters.

2. Current Control & Slow Acquisition
Two different functions, implemented in the same hardware & software system.
Slow acquisition monitors and records most important data (temperatures, current, voltage along critical items) from the cooldown to the operation. Data are avalilable to the operator and recorded at about 1 Hz.

3. Fast Acquisition
Records voltages across the magnet under test with 1 kHz sampling frequence, in coincidence with a fast discharge

4. V*I AC losses measurement system
A dedicated system which measures the AC losses by numerical integration of V*I product, measured by a couple of synchronized VMM.

It is completely independent from other systems, from the voltage taps on.
This allows to perform checks, modification on the ground, etc. without affecting other safety-critical systems.

Quench Detection System

A system similar to the POTAIM cards.

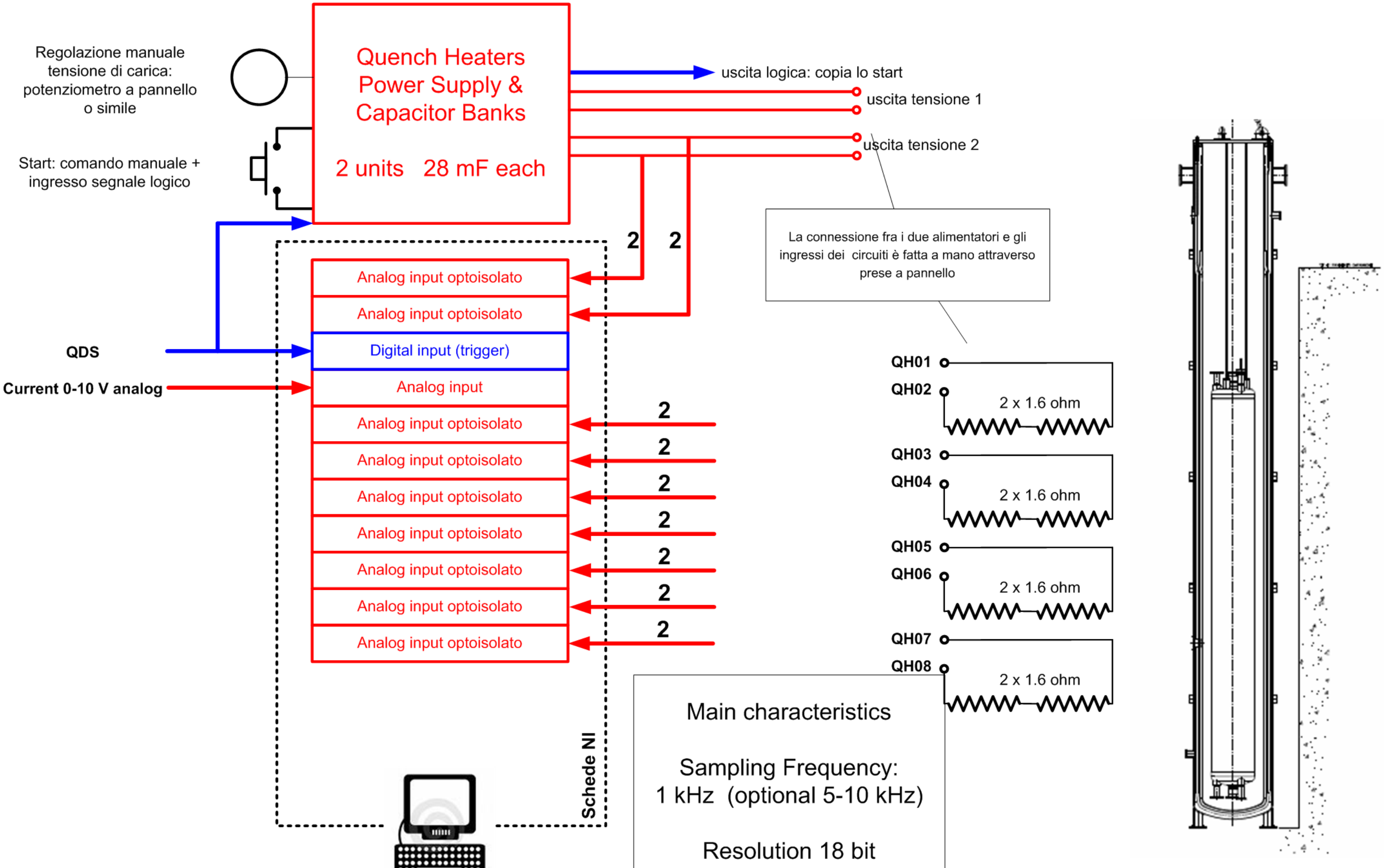
Engineered and built at LASA, it has successfully tested in field conditions during the MAGIX test

It includes:

16 channels (may be expanded), each:

- optoinsulated input,
- bridge/single end
- independently configurable
- Voltage thresholds:
  ±4V, ±1.25V, ±500mV, ±100mV
- Time validation ranges:
  0-10 ms, 0-100 ms, 0-1 s
- Input signal made available in copy
- Memory of channels fired

Fast Acquisition

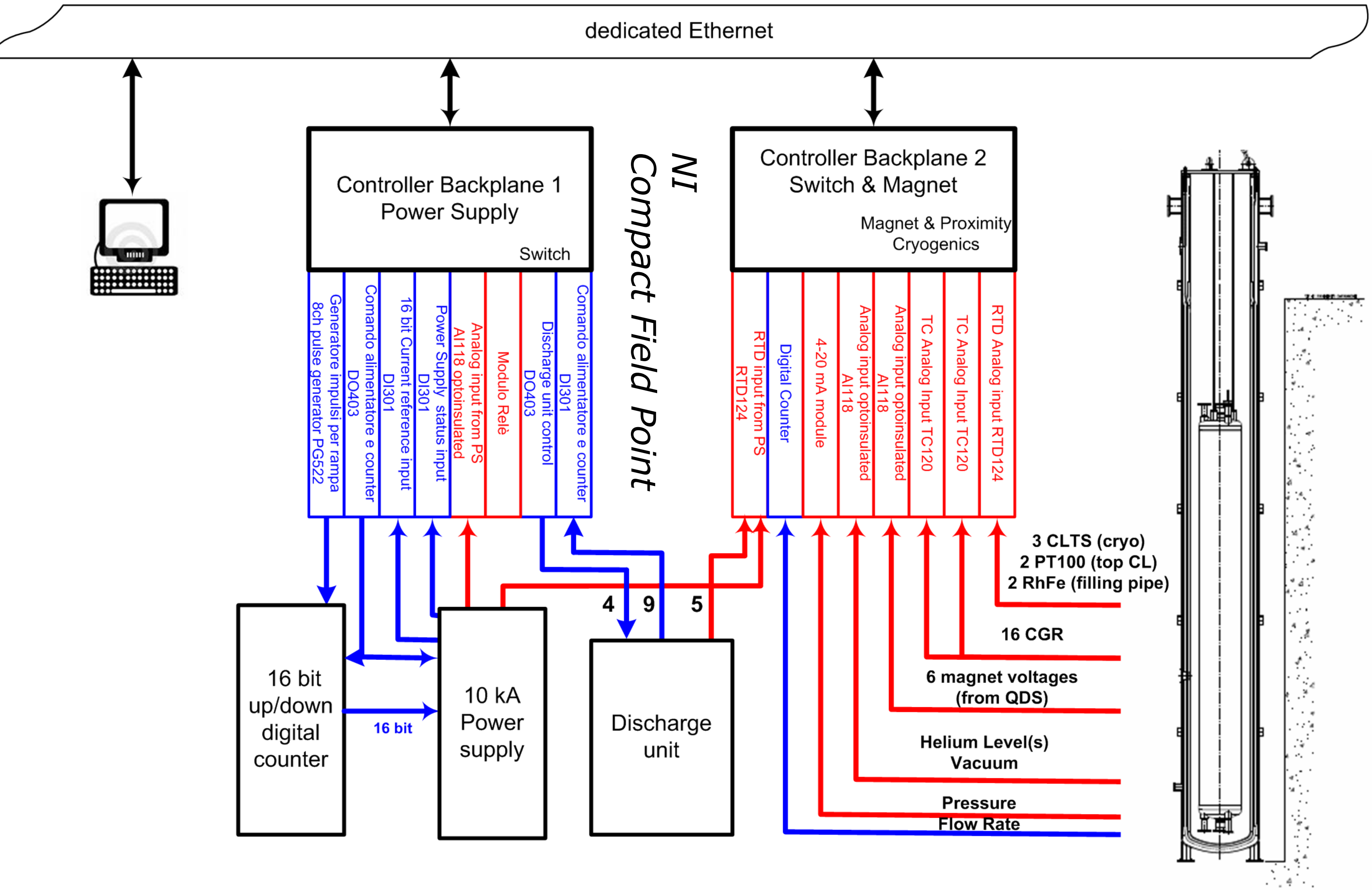


Main characteristics

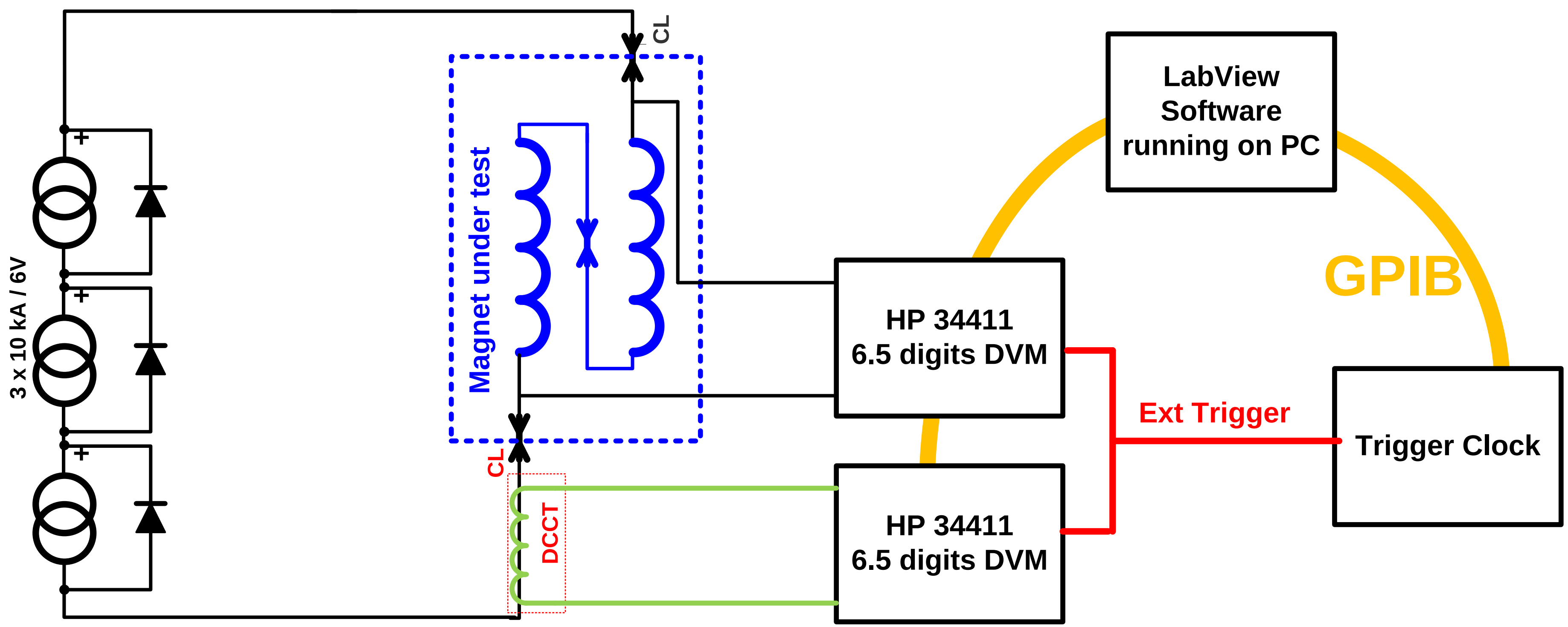
Sampling Frequency:
1 kHz (optional 5-10 kHz)

Resolution 18 bit
Pretrigger & Post-trigger selectable

Slow Acquisition



AC losses measurement system



Net work Q performed by the power supply on the magnet between t_0 and t_1.

$$Q(t_1, t_0) = \int_{t_0}^{t_1} V \cdot I \, dt \approx \Delta t \sum_{j=1}^{n} V_j \cdot I_j$$