Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INFN

The project IR0000003 – IRIS is supported by the Next Generation EU-funded Italian National Recovery and Resilience Plan with the Decree of the Ministry of University and Research # 124 (21/06/2022) for the Mission 4 - Component 2 - Investment 3.1.

PNRR_IRIS e le tecnologie superconduttive per la sostenibilità

Lucio Rossi

Università di Milano – Dip. di Fisica
& INFN – sezione di Milano

Laboratorio LASA – Milan

Workshop Transizione Energetica
INFN-A & INFN-E , Catania LNS 22 Mar 2024

Innovative Research Infrastructure on applied Superconductivity

IRIS

IRIS - Innovative Research Infrastructure on applied Superconductivity

WP1 – Milano LASA
Project Management and Technical coordination

WP2 - Frascati
Magnetic Measurement Laboratory

WP3 - Genova
Superconducting Cables and Material Laboratory

WP4 – Milano LASA
Superconducting Magnet Laboratory

WP5 - Napoli
Advanced Instrumentation Laboratory

WP6 - Salento
Laboratory for Superconductivity and Magnetism

WP7 - Salerno
Test Facility for Large Magnets and Superconducting line

WP8
Green Superconducting Line at Zero Emissions

WP9
Energy Saving HTS Magnets for Sustainable Accelerators

Innovative Distributed Research Infrastructures

Demonstrators for Green Energy

INFN Istituto Nazionale di Fisica Nucleare

SPIN

IRIS timeline

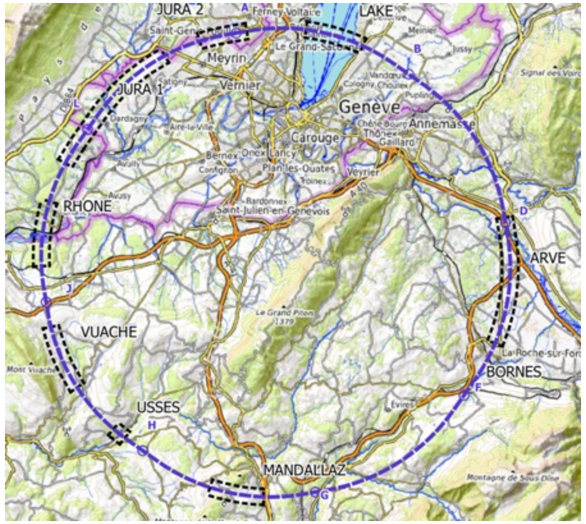
- *Unusually fast for Italian standard…*
- *Avviso MUR n. 3264 del 28-12-20221*
- **Application on 25 February 2022**
- Negotiation phase with MUR: **10 to 17 June 2022** (resubmission new proposal : 17 June 2022)
- Decree of approval: n. 124 of **21 June 2022**
- Start date of the project: **1 November 2022** (however early expenditure may be admissible for reimbursement)
- End of project: 28 April 2025
  → 6 month extension to **30 October 2025** (mentioned in the call)

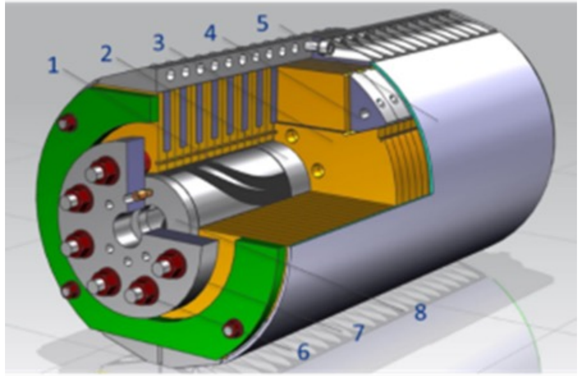
IRIS project scope -1
Fundamental Physics instrumentation

Superconductivity has been instrumental for the discovery of the Higgs boson and its development will be critical for future accelerators and we need of adequate infrastructure to sustain this.

LHC dipoles (8 T) in the tunnel

HiLumi MQXF quad (12 T)



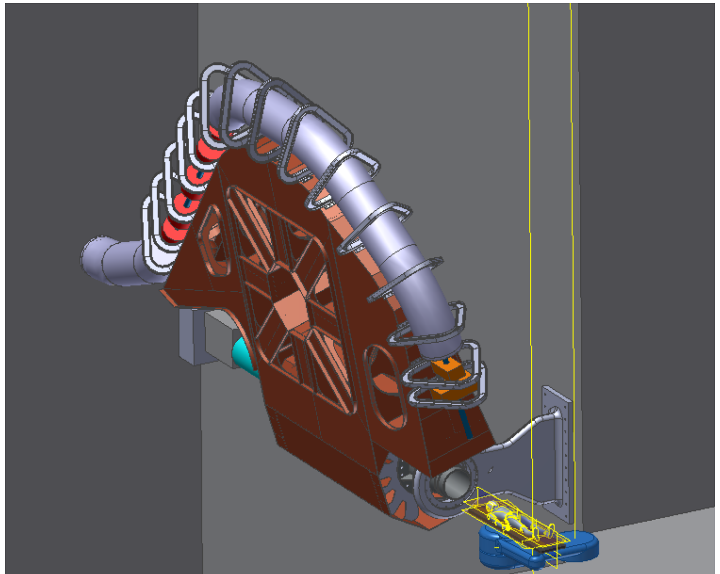


FCC (12-16 T)

IRIS project scope -2 Societal Applications

- **Green Energy** and **Medical**
- Green : 1) energy transport – **Triple Gain** (***Triplete***)
  2) energy saving magnets - **Double Gain**
  - important for society but also for the sustainability of our research infrastructure
- Medical: Superconductivity could play a key role in heavy ion therapy by enabling a rotatable gantry
  - HITRIplus and IFAST – EuroSIG (4 T , 80 mm dia, R_{ben}= 1.3 m) in Cosϑ - CCT (**Nb-Ti rope and HTS ta**pe), 0.4 T/s
  - Also compact SC synchrotron may be enabled by similar SC magnets but ramping may be faster
  - Cyclotrons for PET radioisotope (similar to CIEMAT-AMIT but in HTS)


Courtesy A. Ballarino - CERN


Courtesy M. Pullia (CNAO –Italy)

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TRAINING; buy an instrument and after 20 y is obsolete: form a person, will work for 40+ years: also financially-wise people is the best investment…

- IAS International Accelerator School 2023 in Saskatoon (Canada), July 2023 on: *Superconducting Science and Technology for Particle Accelerators* ; **9** attendees (out of 25)
- INFN International School of Particle Accelerator in Erice, July 2023, on *Novel accelerator technology*: **9** IRIS attendees (out of 23)
- EUCAS 2023 in Bologna, September 2023: **20** IRIS attendees
- MT28 2023 in Aix-en-Provence, Sept. 2023: **12**
- CAS (CERN Accelerator School) Course on NCM and SCM, Poelten (At), November 2023: **23** (out of 85)
- JUAS (Joint University Accelerator School), Archamps (Fr), Jan-Mar 2024: **4**
- CAS Course on Materials, Sint-Michielsgestel (NL), June 2024: **10**
- ASC2024, Salt lake City (USA), Sept 2024: **25**


THE CERN
ACCELERATOR SCHOOL
NORMAL- AND SUPERCONDUCTING MAGNETS
2023- SANKT PÖLTEN, AUSTRIA

WP2 – Frascati INFN-LNF

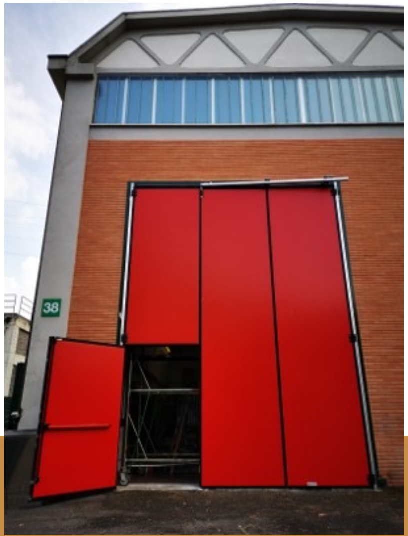
WP2- Magnetic Measurements Laboratory @ LNF

The INFN-LNF magnetic measurements laboratory, about 200 m^2, with 15 T crane has already :

- a Hall effect digital teslameter with a 5-axes movement device on a granite bench;
- a stretched wire bench for integral measurements of fields and mechanical fiducialization;
- a rotating coil multipole measurement system; an NMR teslameter.

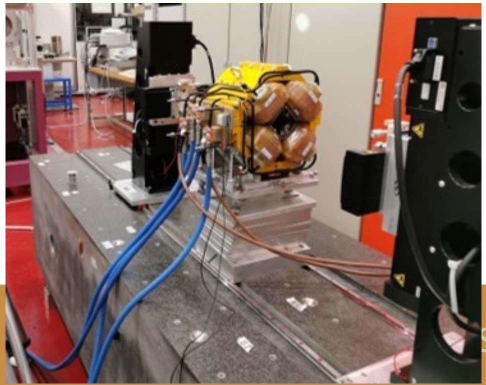
Several other ancillary instruments are available, such as gaussmeters, integrators, etc…

Courtesy of L. Sabbatini, INFN-LNF



Hall probe mounted on the coordinatometer

Stretched wire bench



Rotating coil bench

General status

COORDINATOMETER

Movement system

Alignement tools (T-probe)

PULSED WIRE BENCH

Movement system

Granite benches

Electronics

CALIBRATION SYSTEM

2T magnet

(0,02% hom.)

Power supply

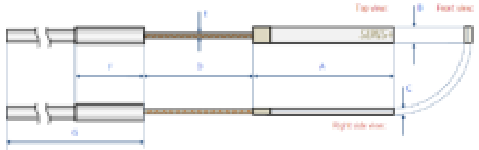
3 NMR probes

Gaussmeter

PROBES

3-axis Hall magnetometers

Compact & thin Hall probe



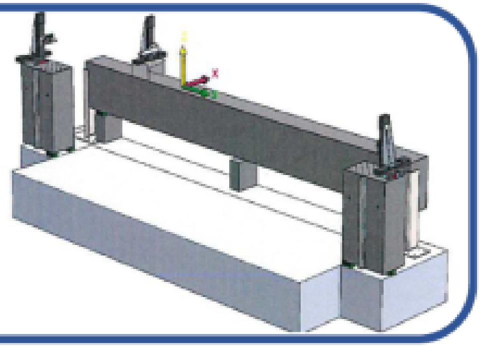
MOLE BENCH

Movement system

3-axis probe + Keysight digital multimeter

Pc with GUI program

Set of measurement procedures



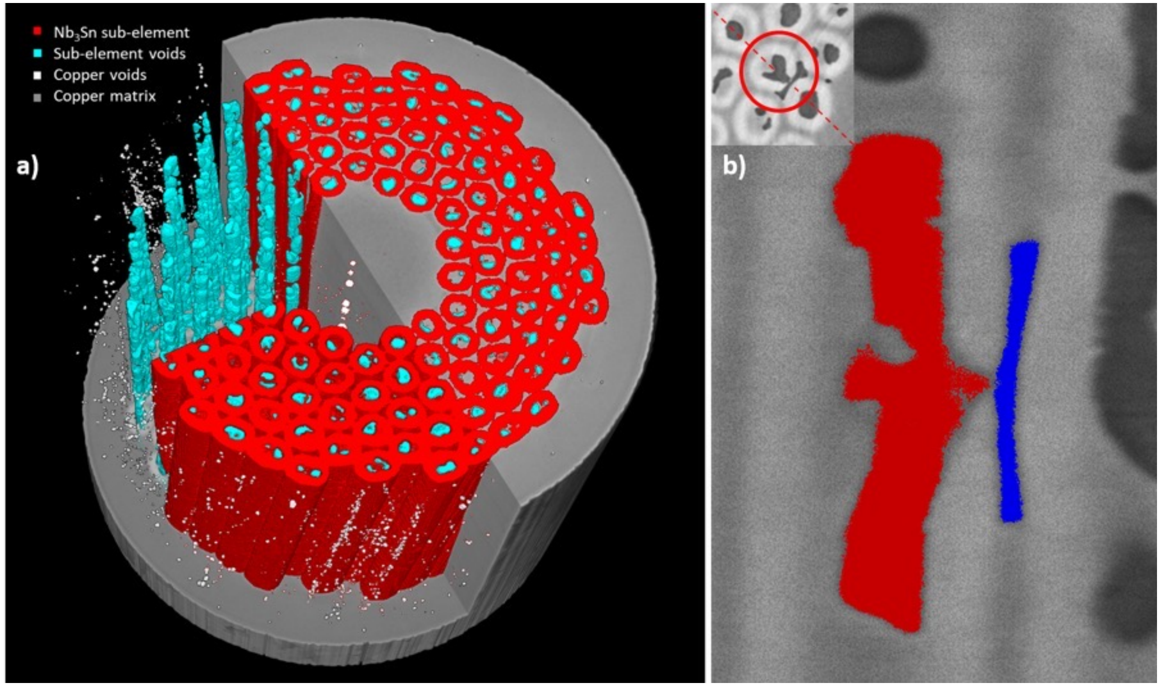
WP3 – Genova INFN, CNR-SPIN, UNIGE-DIFI

- Collaboration among the three Institutes has been formalized (ante-IRIS) with a new **Joint Research Lab : LabCoR**
- INFN
  - **Characterization of very high current cable (>50 kA)**
  - Design of SC magnets for accelerators and Detectors
  - R&D on future Magnets
- CNR-SPIN
  - Study of SC material for applications
  - Development of SC wires
- UniGe – Phsics Dept.
  - Research on SC material

Courtesy R. Musenich A. Bersani , INFN-GE

~~Ma.Ri.S.A. insert~~ → Micro-tomograph - WP3 Genova INFN

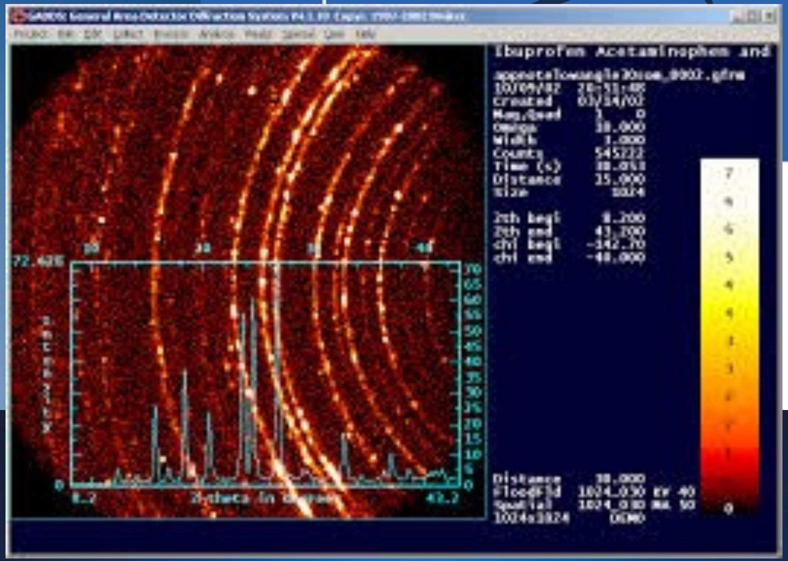
We will procure a new instrument of great interest for the lab, a micro-tomograph to monitor the (mico)status o Superconductors under various strain characteristics.



Tomography Nb_3Sn wire (ESFR)

www.esrf.fr/home/news/spotlight/content-news/spotlight/spotlight388.html

CNR-SPIN Lab



X-Ray diffractometer

Structural analysis of Superconducting materials

Courtesy A. Malagoli, CNR-SPIN GE

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3.4 New high field measurement station

- Cost 825.000,00 €
- The order has been confirmed (8/06/23)
- The delivery is expected Jun-24

Magnet Configurations
- 14 T, longitudinal solenoid

Measurement Options
- **Magnetometry:**
VSM + Large Bore
- **Thermal Measurements:**
Heat Capacity.
- **Sub-Kelvin Capabilities:**
Dilution Refrigerator.

Quantum Design

WP4 – Milano LASA - INFN-Milano, UNIMI-DIFI

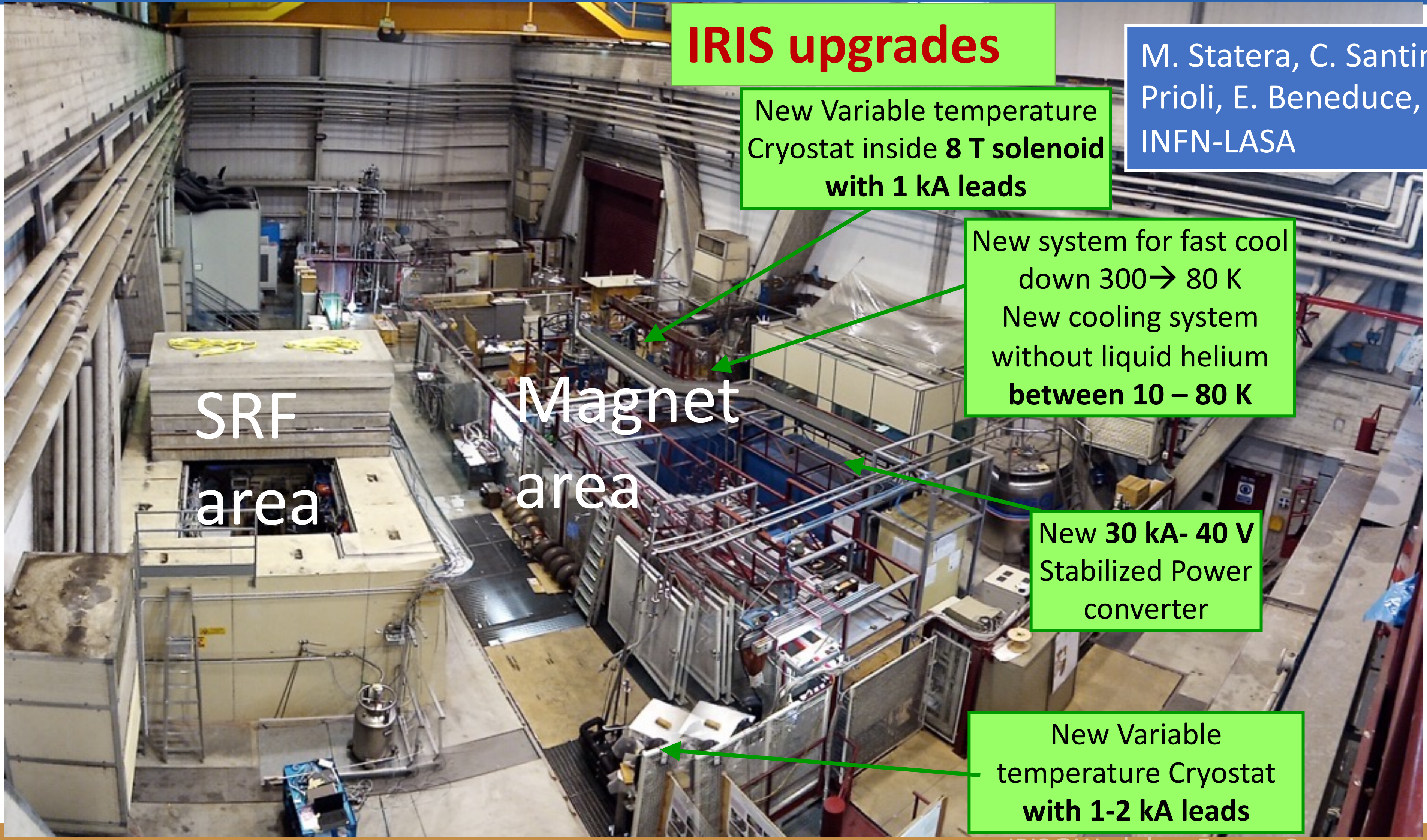
- Laboratorio Acceleratori & Superconduttività Applicata
  - SC magnets and SRF cavities
- Also photocathodes and other activities (BriXino, radionuclides studies)
- (old) LHe plant to be renewed in the next 2 years (order on the way)
- **About 25 people active in applied superconductivity (before IRIS)**
- It is "only" a building, not an Institution: it belongs to Unimi, co-managed by INFN-Milano and Unimi-DIFI
  - Situation may change in the next future…
- It is National R.I. as INFN infrastructure (in the list of PNIR as medium priority)

LASA Hall: 800 m^2

→ 100 l/h new liquefier will help to boost measurements for High Field Magnets and Hadrontherapy

Test up to 15 kA possible NOW in LHe

IRIS will contribute to rationalize and modernize the infrastructure and to have Cryogen-free cryostat for 10-50 K operation and test of HTS magnets



M. Statera, C. Santini, M. Prioli, E. Beneduce, et al. INFN-LASA

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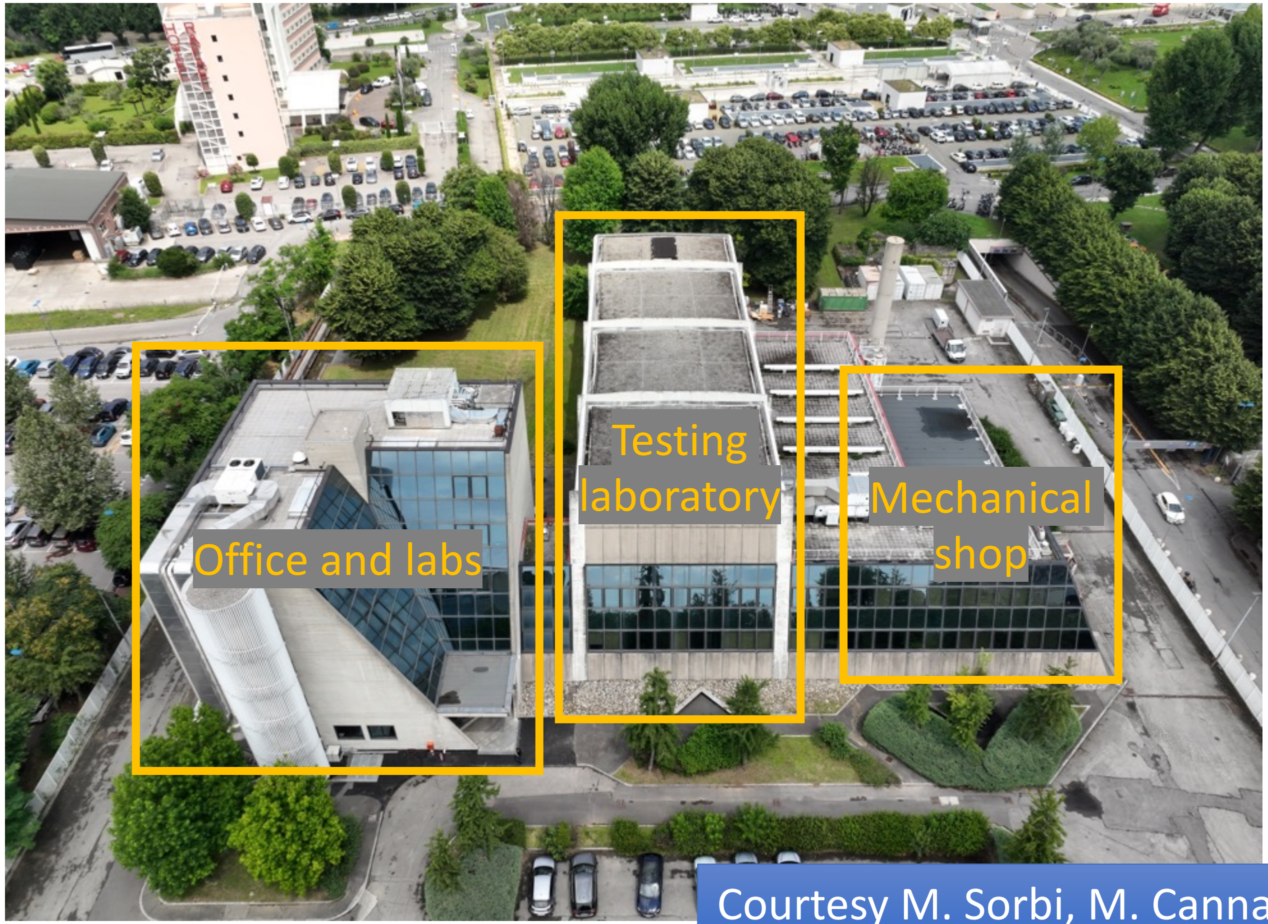
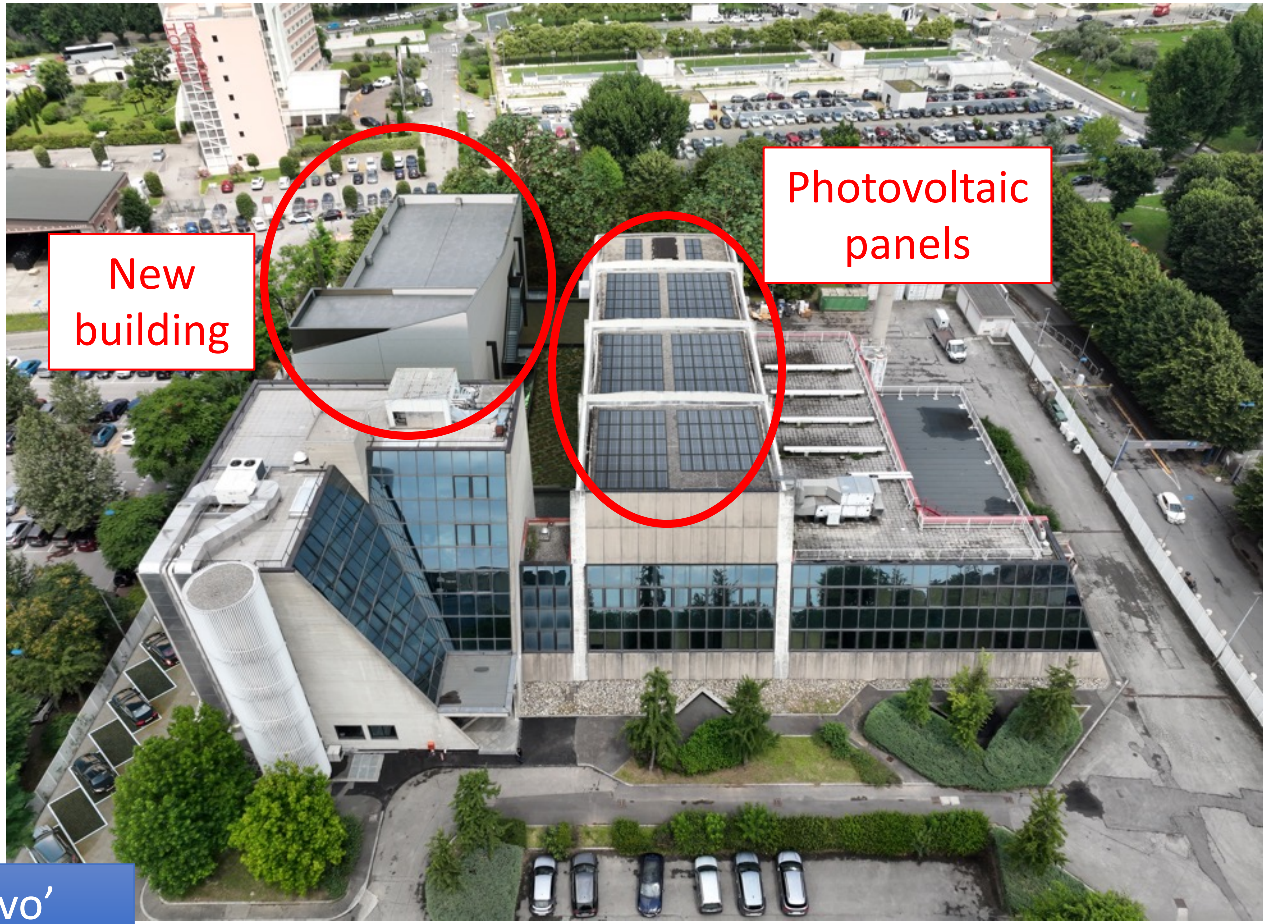
NOW

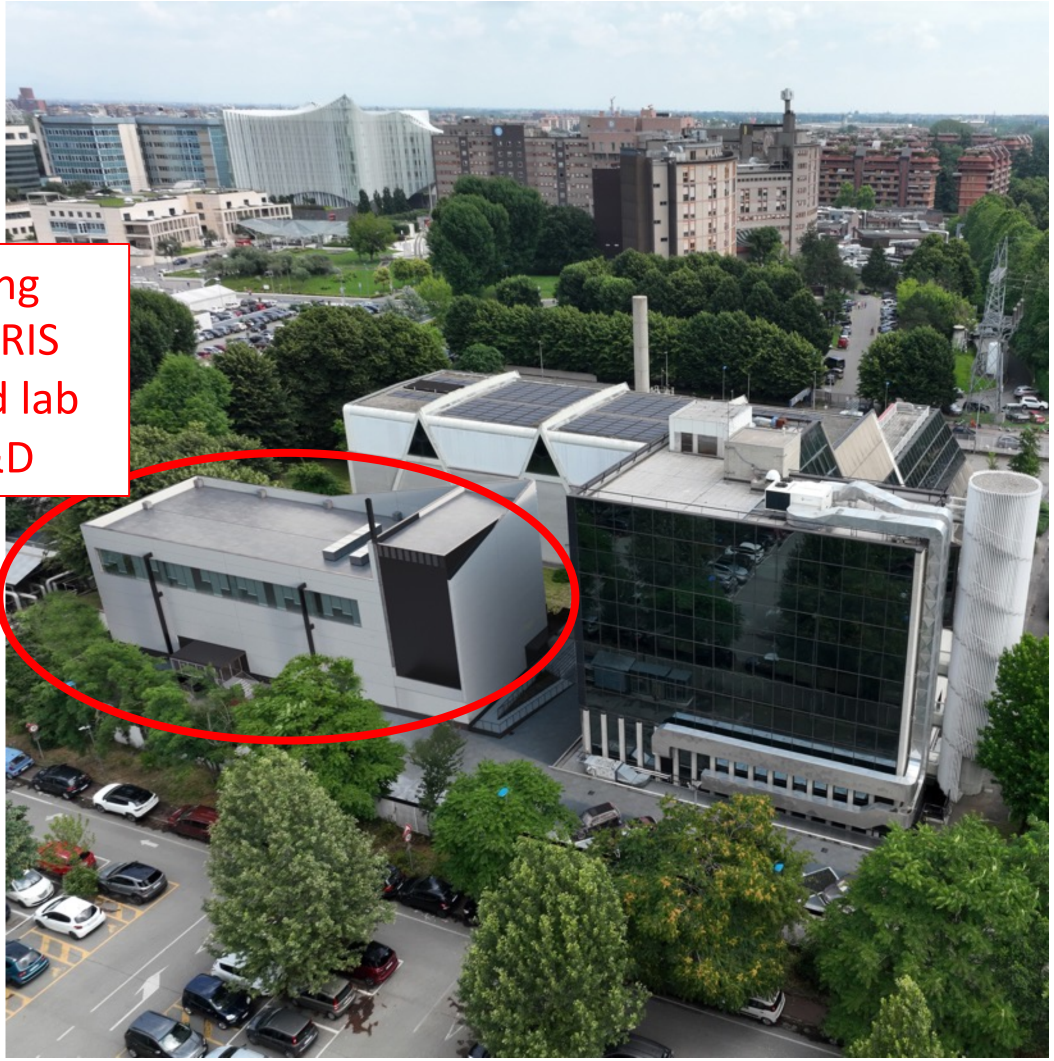


FUTURE



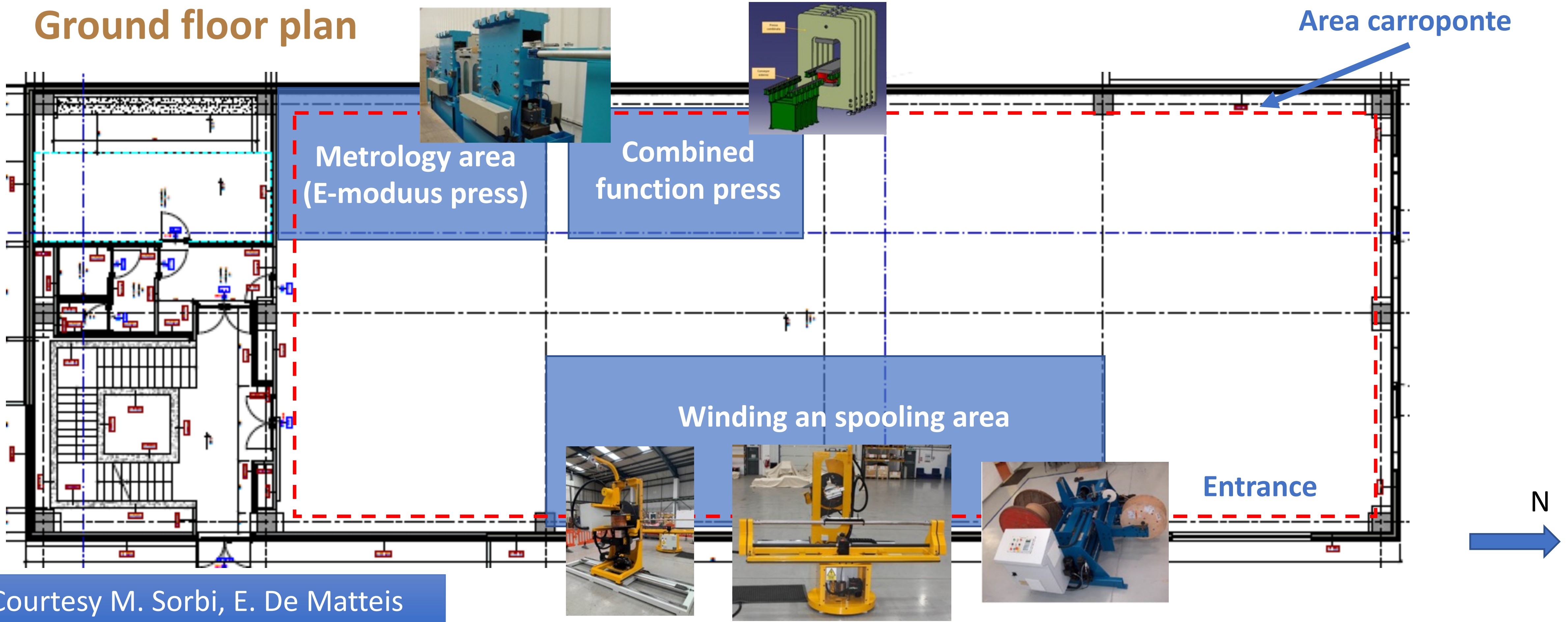
Courtesy M. Sorbi, M. Cannavo'
Univ. of Milano and INFN-MI-LASA

New building
2 floors for IRIS
1 undergroud lab
for Acc. R&D



Courtesy M. Sorbi, M. Cannavo'
Univ. of Milano and INFN-MI-LASA

IRIS SML - Superconducting Magnet Laboratory
Ground floor plan



Courtesy M. Sorbi, E. De Matteis
Univ. of Milano and INFN-MI-LASA

Facilities for the new Sc Magnet Laboratory (SML) in LASA-Milano

- AM metals Al, AISI 316, also Cu, Ti ($250x250x300mm^3$)
- AM for plastic – Fused Filament Fabrication, ABS, Nylon, PLA, Ultem, PEEK in 350mmx350mm x350mm

Courtesy : Massimilano Cannavo' Univ. and INFN-Mi-LASA

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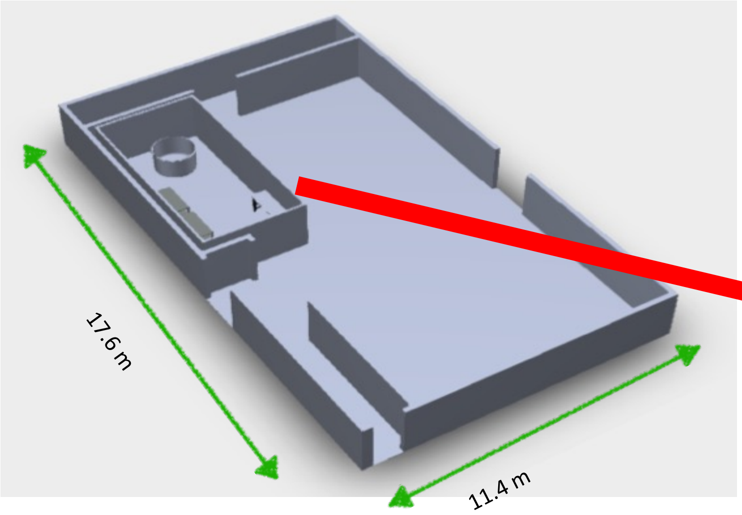
IMPALAB

WP5 – Napoli – CIRMIS
IMPALAB expertise

**Courtesy P. Arpaia, G. Fiorillo
Univ. of Naples**

- Magnetic measurements
- Measurements on superconducting cables
- Cryogenics
- Aims new lab
  - Extend the current instrumentation and measurement procedure for superconducting magnets and cable
  - Improve the metrological feature of the measure
  - Develop new procedures for facing the state of the hard challenge for LTS and HTS



nature SCIENTIFIC REPORTS

eli nuclear physics

CERN

2x IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT

3x NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH

2x SENSORS and ACTUATORS A

3x IOP Journal of Physics Conference Series

7x JINST

Measurement

13x AIP Review of Scientific Instruments

Fermilab

SLAC

IRIS

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WP5 – Naples CRYOLAB

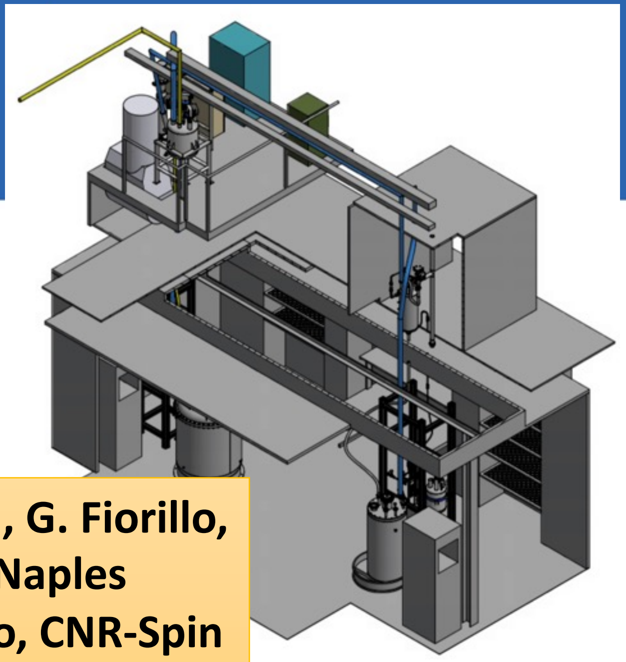
- Light Detectors Test
- Stand alone cryo system
- Vacuum and cryogenic equipment
- New
  - Clean area for vacuum system and material deposition (Hardwall clean room approx. 6x4 m2)
  - Liquid nitrogen cryostat
  - Cryoprobe
  - Low-temperature calibration system
  - Dry system for low-temperature characterisation

Dipartimento di Fisica "Ettore Pancini"

Consiglio Nazionale delle Ricerche

SPIN

P. Arpaia, G. Fiorillo, Univ. of Naples
F. Miletto, CNR-Spin Naples



WP6 – Laboratory of Superconductivity and Magnetism

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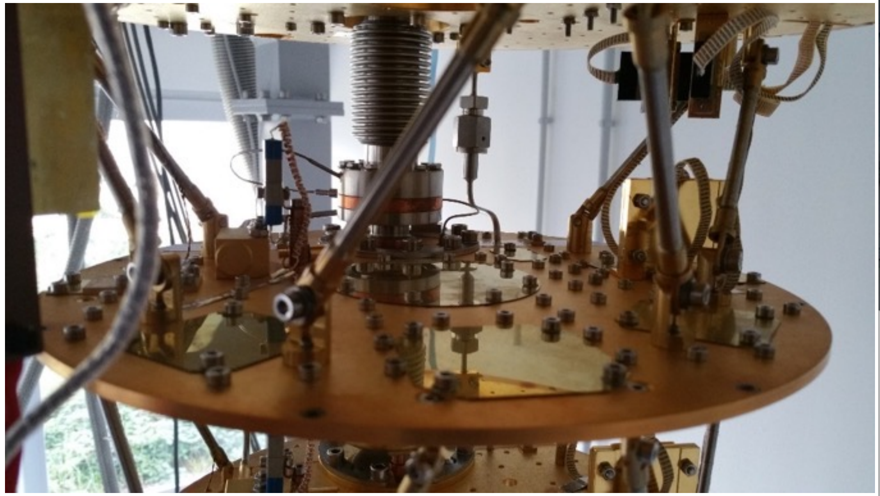
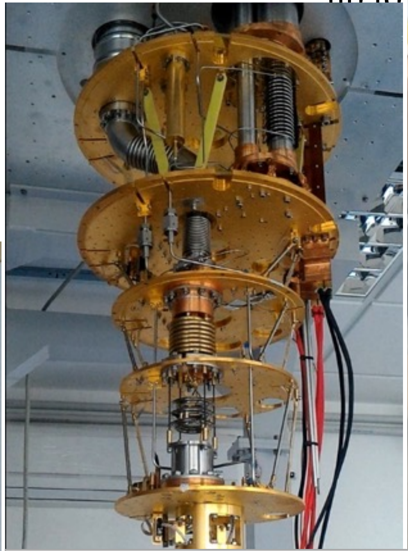
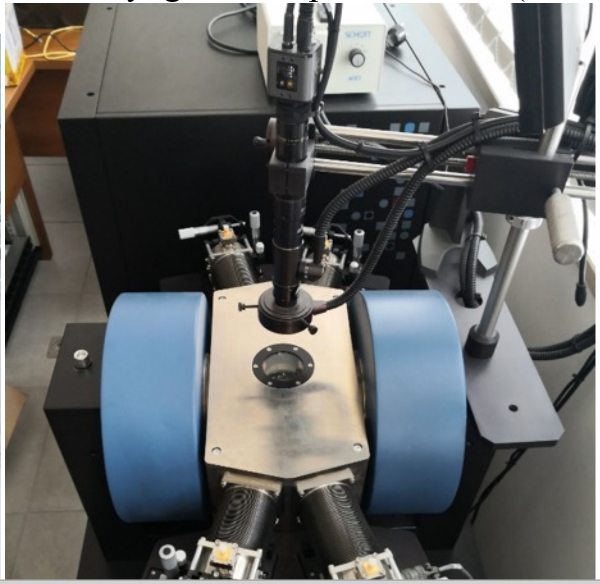
Courtesy of G. Maruccio, Univ. of Salento



- Cryogenic superconducting magnet (10.5 T, 0.3-300 K)
- Oxford dilution refrigerator (down to 10 mK, vector magnet 6T/1T/1T)
- Lakeshore Cryogenic RF probe station (down to 8 K and up to





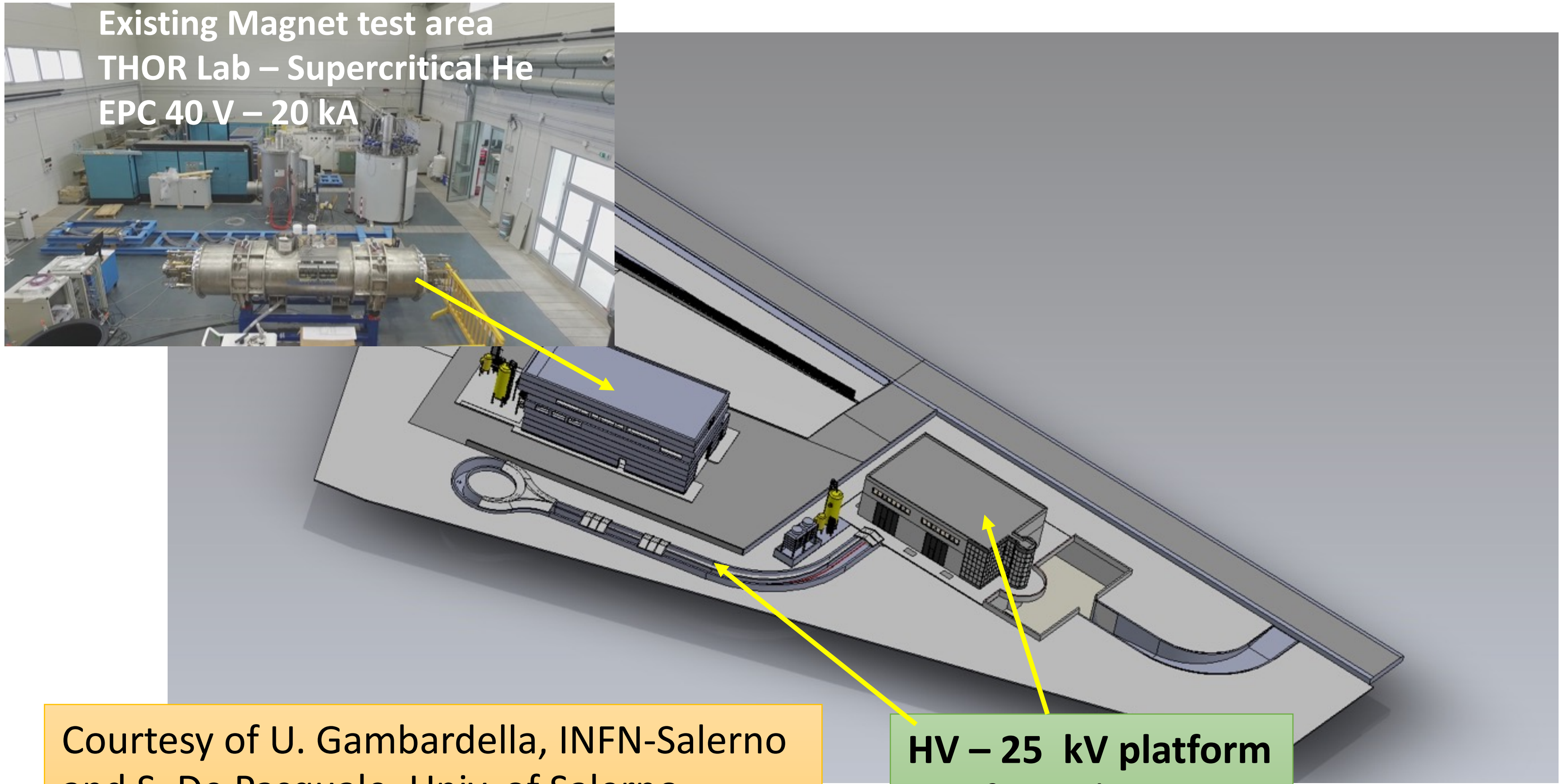
Italian node of the European Infrastructure on Magnetism EMHFL-ISABEL (funded within ISABEL project, H2020-INFRADEV-2018-2020, Grant No. 871106).

WP7 – Salerno – Test Facility for Large SC Magnets and SC Lines

Figura 1 – Vista aerea del Campus ed individuazione del lotto su cui sarà realizzato l'edificio

Figura 2 – Lotto su cui sarà realizzato l'edificio

Cable protototype to be installed in Salerno – IRIS WP7 station INFN and UNISA



Courtesy of U. Gambardella, INFN-Salerno and S. De Pasquale, Univ. of Salerno

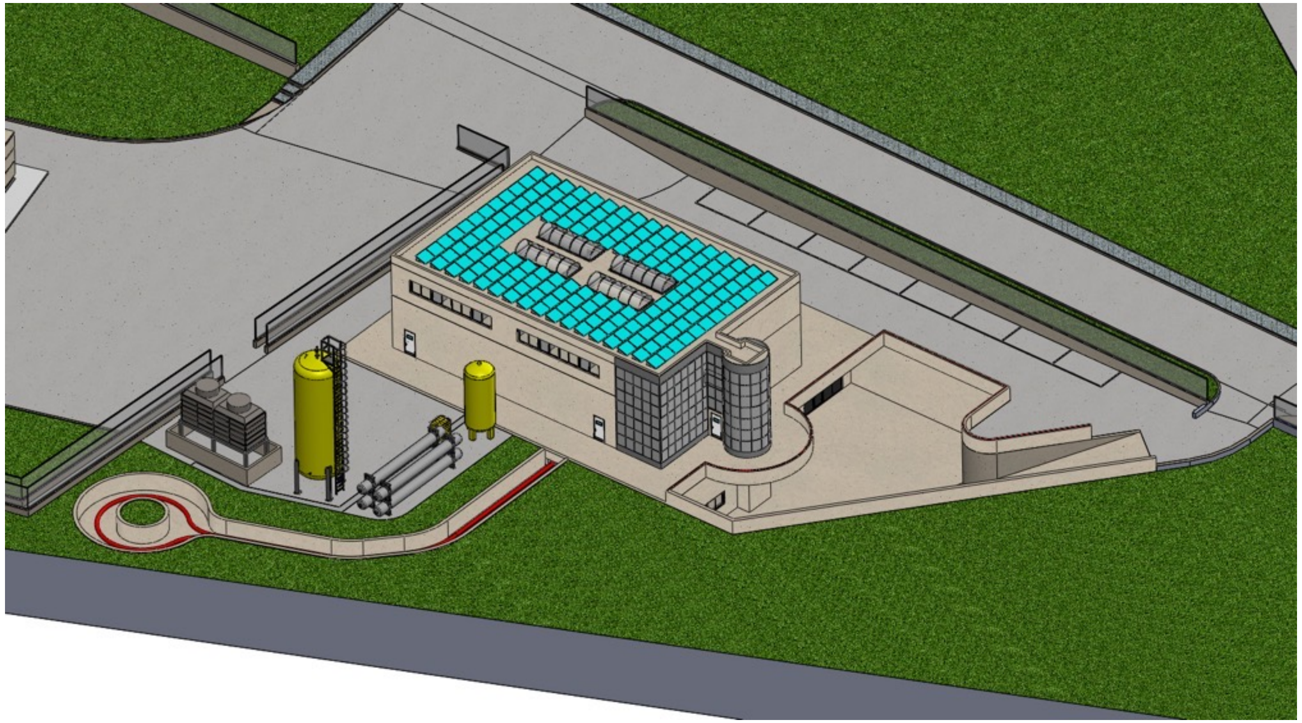
HV – 25 kV platform
EPC for 40 kA-10 V

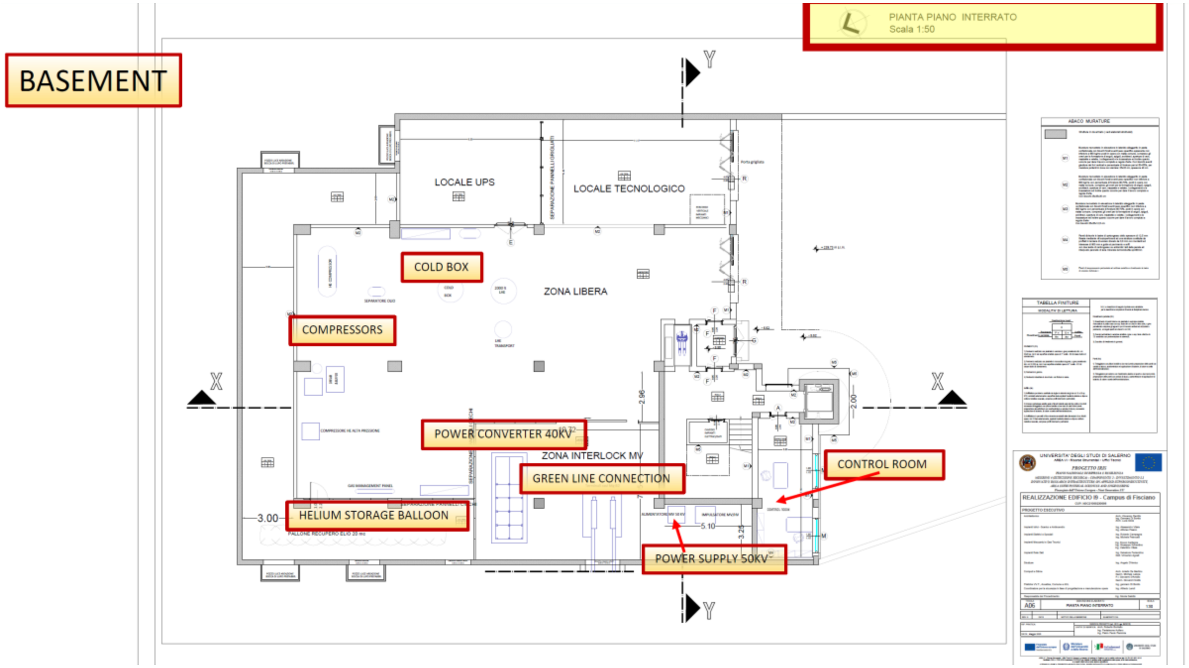
The test station is open to external use, too.

The cable produced in IRIS will serve as "debugging" and qualification of the test station itself.

- Support by CESI (Milano) for the test protocols and procedures
- Collaboration with RSE (Milano) for matching the electric gris needs

General design status





2 floors + basement

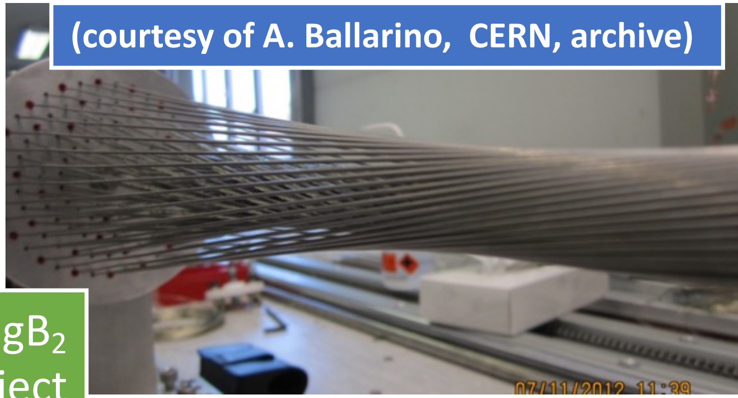
WP7 – Salerno CNR-SPIN

- The SPIN Salerno Unit aims to acquire and setting up a magneto-transport measurement system including the application of strain and stress.
- The equipment for magneto-transport (e.g. Quantum Design PPMS) consists of a variable temperature (1.9 to 300 K)-field (up to ±9 T) system, designed to perform a variety of automated measurements.
- Additional elements to be acquired within IRIS are cryogenic strain and stress cells (e.g. Razorbill Instruments), which are fully compatible with the PPMS probe.
- The main goal is to strengthen the capacity for investigating the role of strain/stress on the transport properties of superconducting materials.

Courtsy of A. Cuoco
CNR-SPIN, SA

(courtesy of A. Ballarino, CERN, archive)

Demo 1 : Green Sc Line - GSL



(courtesy of A. Ballarino, CERN, archive)

Left: Superconducting Line, in its flexible cryostat, 60 m , 120 kA – low voltage, during successful test in 2020 at CERN for the High Luminosity LHC Project

Right: cabling a sub-element of a MgB_2 cable for High Luminosity LHC Project

Scope: Manufacturing a demonstrator capable of **1 GW DC, operated at 20 K** and test it in "operative" conditions in a test facility that will then be available for other projects. 25 kV-40kA, operativ condition **- use of round wire MgB_2**

Use: **beside long-distance large electrical power transmission, significant place in the electric system for HVDC back-to-back system** (study for placing the demonstrator in an Italian facility after the PNRR).

We will design the facility and this demo for **cooling with He gas**; however, **in second stage after IRIS,** compatibility with LH cooling will be investigated, too.

IRIS WP8 – DEMO 1 - GSL specifications

Courtesy M. Statera

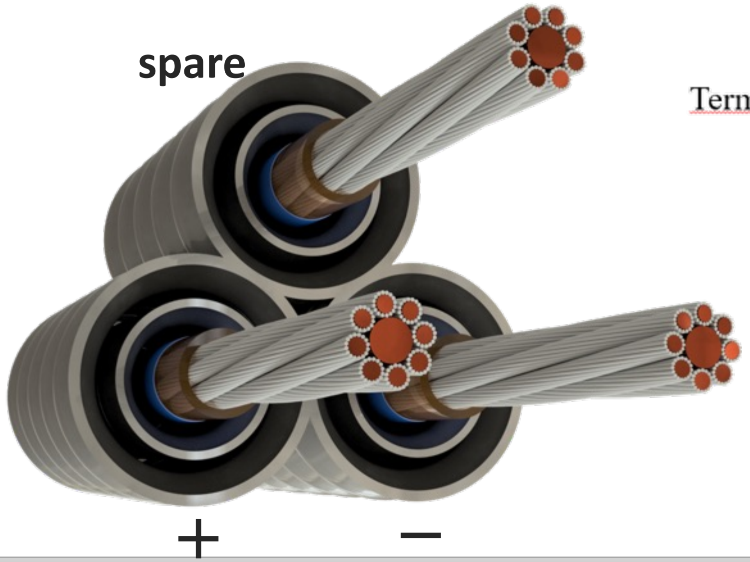
Scope:

- Design and supply of the 1Gw GSCL, the cryostat and the power leads
- Delivery and installation to Salerno **to commission the Test Station**

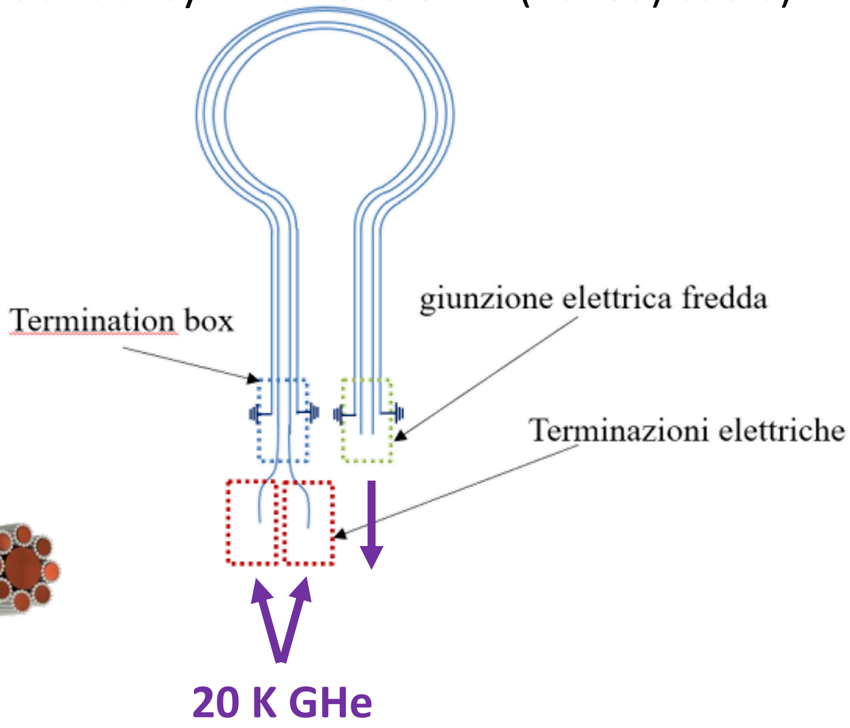
Contract signed December 2023 with ASG

- Redundancy: 1 full cable + 1 (naked) cable)

Power transport	1 GW
Voltage	25 kV
Operating temperature	20 K
Line length	130 m
Expected losses	3.0 W/m
Overall cable diamater	105 mm
Cryostat diameter	250 mm
Bending radius	2.2 m
Inner pressure	10 bar



Courtesy S. Maffezzoli Felis, Univ. La Sapienza Roma, & INFN-Milano-LASA



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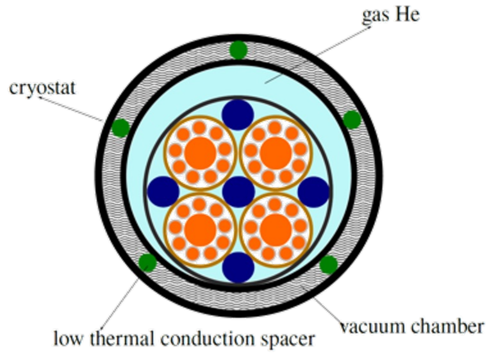
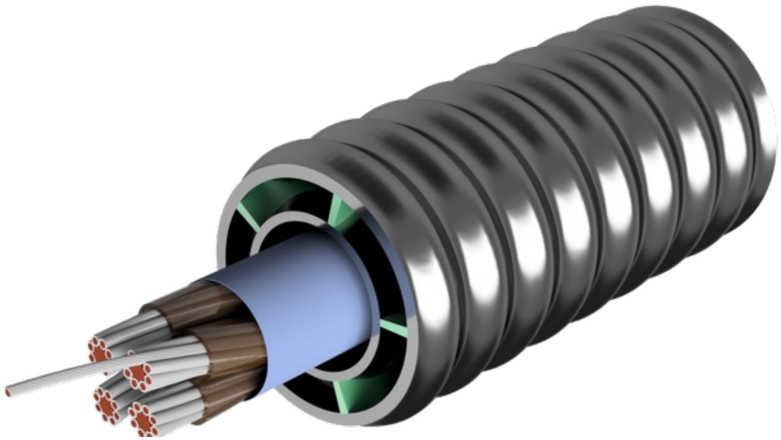
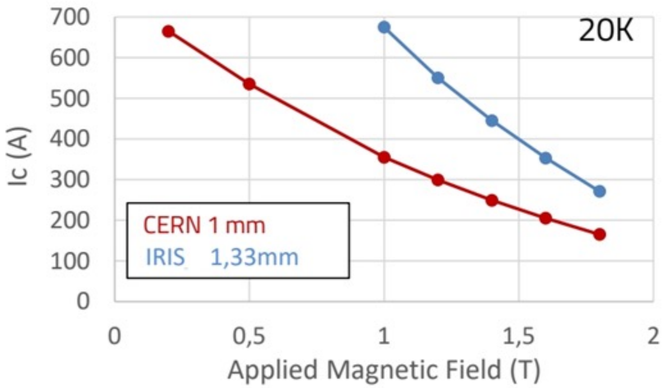
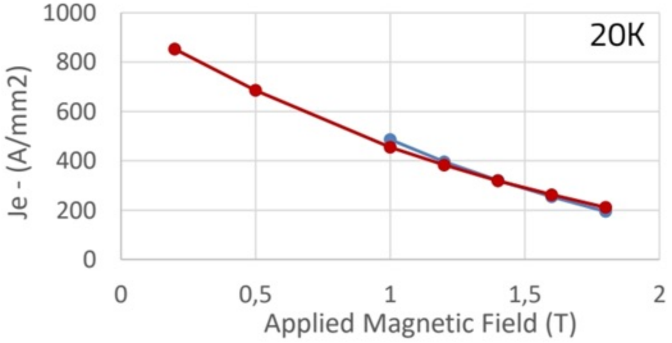
Older (first) design: optimized for power consumption, however more vulnerable vs. faults… so abandoned for the proto in favor of single cable cryostat

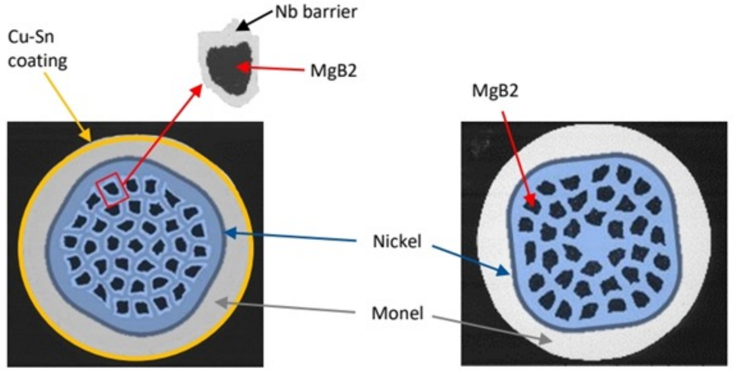




CORDATURA: SCELTA DEL FILO







CERN wire	Value
Diameter [mm]	1
Fill Factor [%]	12%
Minimum bending radius [mm]	100
Number of filaments	37

IRIS wire	Value
Diameter [mm]	1.33
Fill Factor [%]	17,5%
Minimum bending radius [mm]	130
Number of filaments	36

Collaboration INFN - RSE, Ricerca Sistemi Energetici

INFN LASA

RSE Ricerca Sistema Energetico

A collaboration with RSE, is ongoing. Even if the **contract** has **to be signed**. **Goals:**

- **Potential applications of a DC superconducting cable in the Italian grid**

Back-to-Back DC in AC/DC-DC/AC stations, to potentially decouple critical AC grid portions → very short distances.

Connecting nearby DC terminal stations, for potential power flow control/transit and coordination, *e.g.* 1000 MW → few kms distances.

Connecting a cluster of offshore wind power plants via offshore DC cable section to shore, *e.g.* 1000-3000 MW → few/some kms distances.

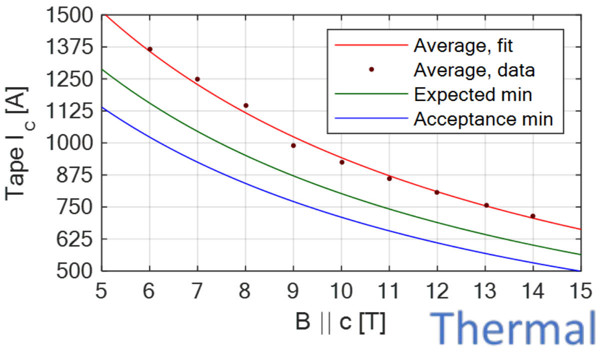
- Thermo-fluid dynamic modelling of cryogenic fluids in superconducting cables

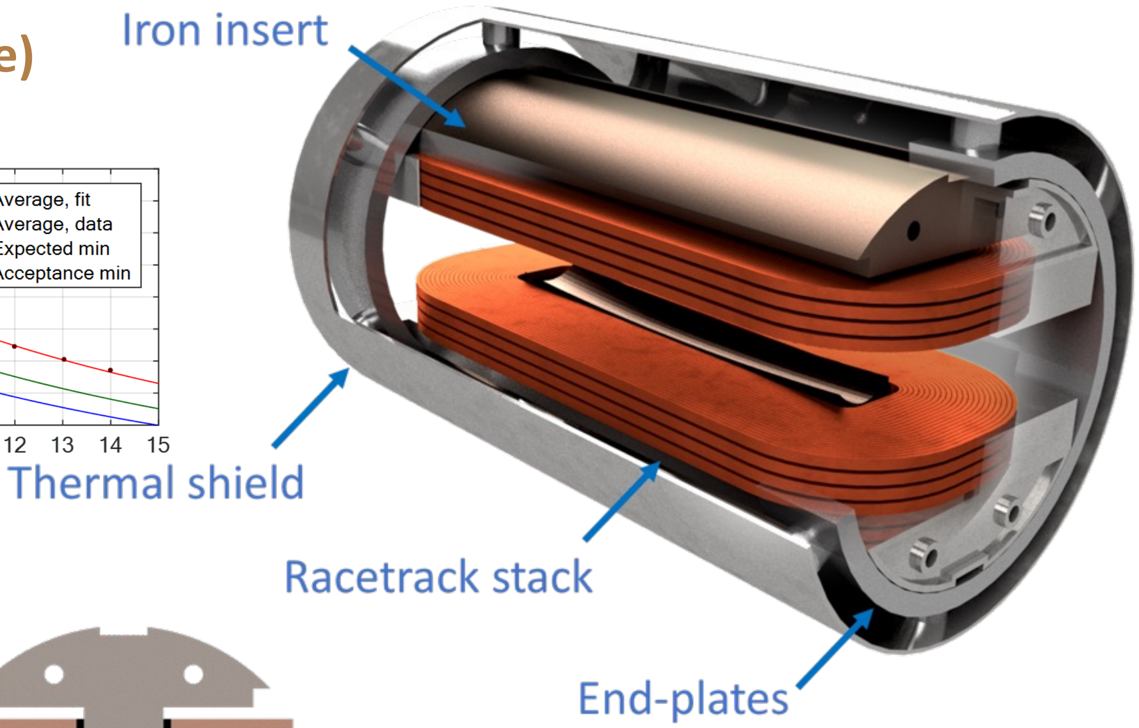
determine the optimized cable design according to the operating parameters selected by the user (*e.g.* active power, voltage level, line length).

A. Musso et al., IEEE TAS , vol. 32, no. 9, 2022
A. Musso et al., IEEE TAS., vol. 33, no. 5, 2023

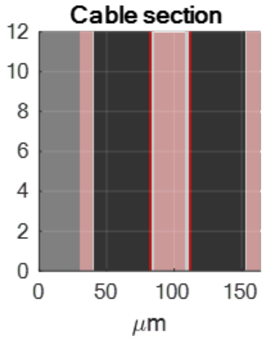
WP9 IRIS DEMO-2 : an HTS dipole (split coil racetrack) - ESMA
Nominal present design (controlled insulation with metal tape)
To be installed in the pole of GENOVA for Sc cable test

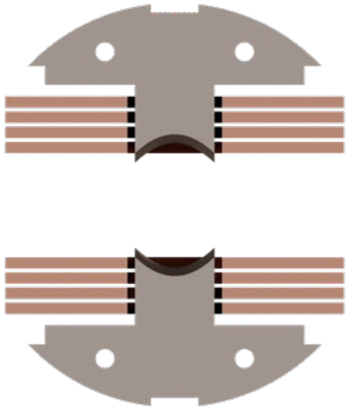
Dimensions	**12 mm × 67 µm**
Substrate	40 µm of Hastelloy C276
Copper stabilizer	2 × 10 µm, RRR>20
Easy-way minimum bend	10 mm
Allower longitudinal strain	-0.4 % to 0.3 %
I_c, 77 K, self-field **Ic, 20 K, 15 T**	Min. 400 A, average 470 A Min 500 A





Parameter	Unit	Value
Central field	tesla	10
Free bore dimensions	mm	H80 x V50
Magnet length	mm	1000
Good field region uniformity	N/A	1.5%
Good field region extension	mm	H50xV30xL400
Operating temperature	K	20
Minimum op. temper. for test	K	10
Maximum current	A	<1000





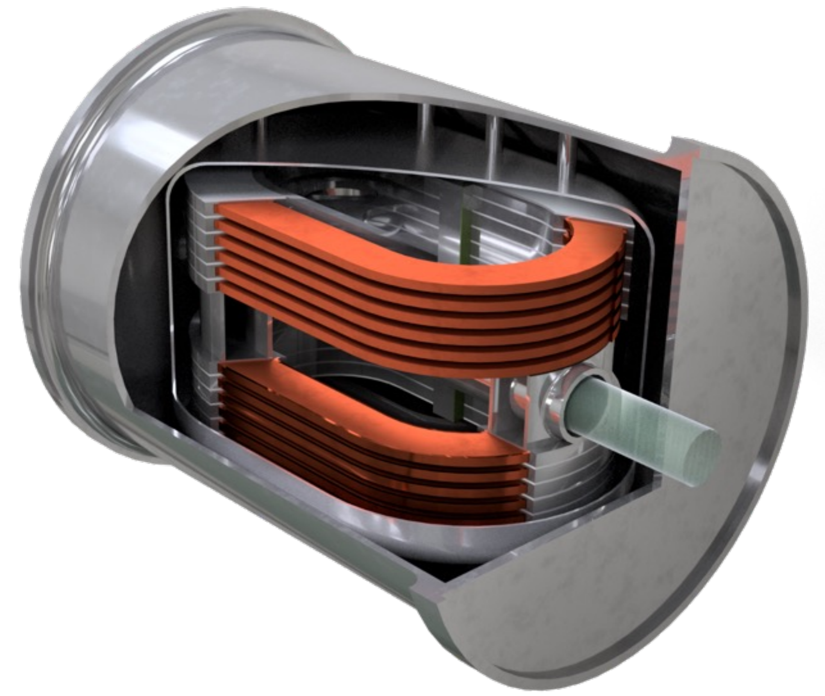
Courtesy S. Sorti and L. Balconi
Univ. of Milano & INFN-Milano-LASA

Design has been updated – simplified – still 2-6 months tehcn. decision

Keeping Energy Saving HTS magnet main goals:

- Test operation with *cryogen-free technology*
- Test insulation technology for *magnet protection*
- Fulfil the following performances:

Central field B_0 (min. accept)	tesla	**10** (8)
Free aperture	mm	Ø70
Good field region uniformity	N/A	±1.5%
Good field region extension	mm	H50xV30xL350
Operating temperature	K	20



Finanziato dall'Unione europea
NextGenerationEU

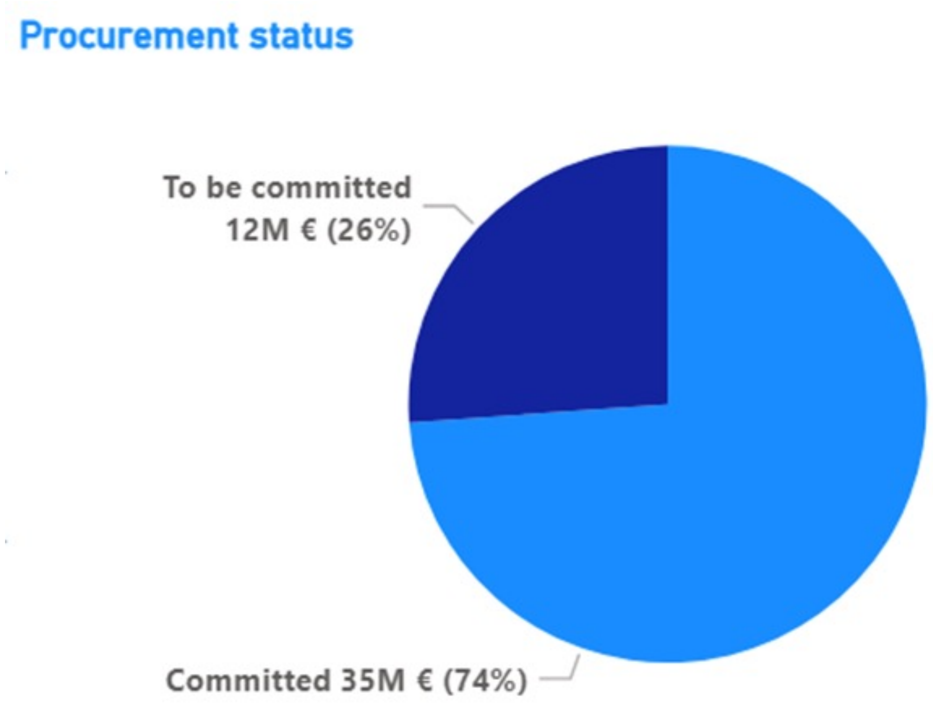
Tx included! (20% taxes)
This include the personnel specifically hired
It does not include the existing staff working on IRIS

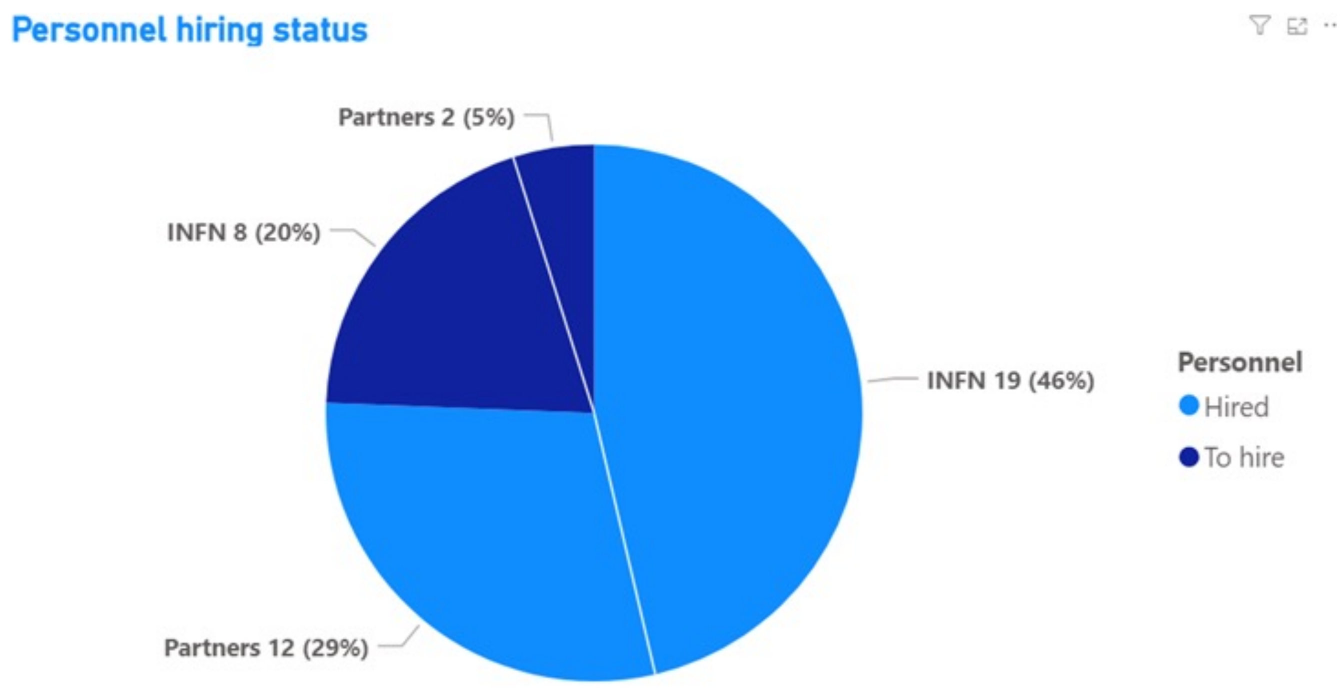
IR	tot rev
INFN	€ 39,572,238.37
SPIN	€ 2,416,027.45
UniGE	€ 1,182,350.94
UniMI	€ 5,532,061.30
UniNA	€ 2,044,395.50
UniSalento	€ 3,605,900.00
UniSA	€ 5,643,994.61
Totale	**€ 59,996,968.17**

Leader	WP	description	Reported	Indirect costs	Total grant
P. Campana	1	Project Management and Technical Coordination	4,300,009.70 €	301,000.68 €	4,601,010.38 €
L. Rossi	1	INFN-Milano	4,300,009.70 €	301,000.68 €	4,601,010.38 €
L. Sabbatini	2	Innovative distributed R.I. POLO FRASCATI	1,046,760.00 €	73,273.20 €	1,120,033.20 €
L. Sabbatini	2	INFN-LNF	1,046,760.00 €	73,273.20 €	1,120,033.20 €
R. Musenich	3	Innovative distributed R.I. POLO GENOVA	5,407,000.26 €	378,490.02 €	5,785,490.28 €
R. Musenich	3	INFN- Sez. GE	3,211,899.80 €	224,832.99 €	3,436,732.79 €
A. Malagoli	3	SPIN-GE	1,090,099.58 €	76,306.97 €	1,166,406.55 €
M. Putti	3	UNIGE-DIFI	1,105,000.88 €	77,350.06 €	1,182,350.94 €
M. Sorbi	4	Innovative distributed R.I. POLO MILANO (LASA)	8,227,151.08 €	575,900.58 €	8,803,051.65 €
M. Statera	4	INFN-Milano	3,722,000.55 €	260,540.04 €	3,982,540.59 €
M. Sorbi	4	UNIMI-DIFI	4,505,150.53 €	315,360.54 €	4,820,511.07 €
P. Arpaia	5	Innovative distributed R.I. POLO NAPOLI	2,390,670.00 €	167,346.90 €	2,558,016.90 €
F. Miletto	5	SPIN-NA	480,020.00 €	33,601.40 €	513,621.40 €
P. Arpaia	5	UNINA (Federico II) - CIRMIS	1,410,650.00 €	98,745.50 €	1,509,395.50 €
G. Fiorillo	5	UNINA (Federico II) - DIFI	500,000.00 €	35,000.00 €	535,000.00 €
G. Maruccio	6	Innovative distributed R.I. POLO SALENTO	3,370,000.00 €	235,900.00 €	3,605,900.00 €
G. Maruccio	6	UNISALENTO-DMF	3,370,000.00 €	235,900.00 €	3,605,900.00 €
U. Gambardell	7	Innovative distributed R.I. POLO SALERNO	13,285,441.52 €	929,980.91 €	14,215,422.43 €
U. Gambardell	7	INFN-Napoli-GC Salerno	7,322,830.20 €	512,598.11 €	7,835,428.31 €
M. Cuoco	7	SPIN-SA	687,850.00 €	48,149.50 €	735,999.50 €
S. De Pasquale	7	UNISA-DIFI	5,274,761.32 €	369,233.29 €	5,643,994.61 €
L. Rossi	8	Green Superconducting Line at zero emission	11,968,400.10 €	837,788.01 €	12,806,188.10 €
L. Rossi	8	INFN-Milano	11,968,400.10 €	837,788.01 €	12,806,188.10 €
L. Rossi	9	Energy Saving HTS Magnet for Sustainable Accelerator	6,076,500.22 €	425,355.02 €	6,501,855.24 €
L. Rossi	9	INFN-Milano	5,411,500.00 €	378,805.00 €	5,790,305.00 €
L. Rossi	9	UNIMI-DIFI	665,000.22 €	46,550.02 €	711,550.24 €
		TOTAL PROGRAM	56,071,932.87 €	3,925,035.30 €	59,996,968.17 €

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA | INFN

Main contracts to: REBCO tape → Faraday Factory Japan
GSLine general contractor & HTS dipole construction → ASG Genova





Courtesy of B. Di Girolamo – M. Della Torre, INFN-Mi-LASA, IRIS Project

Personnel status (cost category a.)

Hired personnel

Institute	Principal Technologist	RTDA	Technician	Technologist	**Total**
CNR SPIN				3	**3**
INFN Genova				1	**1**
INFN LNF Frascati			2	1	**3**
INFN Milano	1		4	6	**11**
INFN Napoli		1			**1**
INFN Salerno	1		1	1	**3**
Università di Genova			1		**1**
Università di Milano		1	2	2	**5**
Università di Napoli Federico II		1			**1**
Università di Salerno		2			**2**
Total	**2**	**5**	**10**	**14**	**31**

Being hired personnel

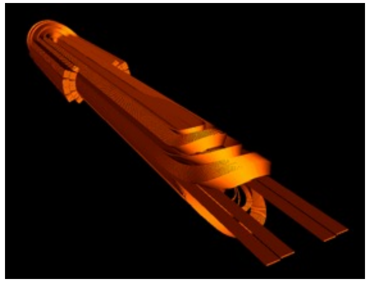
Institute	Technician	Technologist	**Total**
CNR SPIN		1	**1**
INFN Genova	2	1	**3**
INFN Milano	2	2	**4**
INFN Salerno	1		**1**
Università di Salerno	1		**1**
Total	**6**	**4**	**10**

Outlook to the future of IRIS

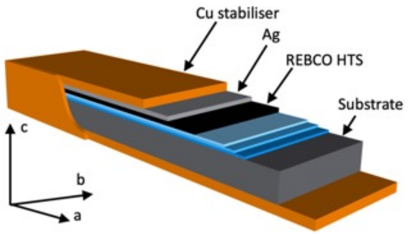
- **Construction Phase:2023-2025,**
- **Operation 2026 → 2036 hopefully longer…**

- Must be partially self-financing
  - 50% operational money from participating Institutes
  - 50% external Funding : INFN and Minister (MUR) competitive projects, EU projects, International projects, Industrial partnership)
    - **Fundamental Physics (accelerators, detectors: performance but also sustainability)**
    - **Energy and Green transition**
    - **Medical applications**

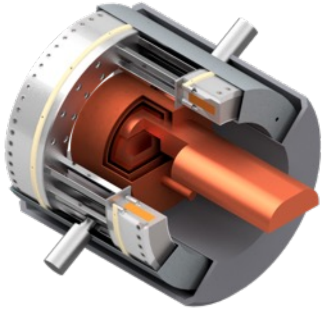
Projects for IRIS operation:
1. HEP accelerators and detectors



FCC-hh with HTS:
Pcryo 300→ <100MW
FCC-ee with HTS
P (350GeV) : 30 MW reduction



- High Field Magnets
  - **Nb_3Sn costheta** dipole for highest field **14 – 16 T range** (post FalconD)
  - HTS Magnets for FCC-ee, FCC-hh and Muon-C
- Special RFMFTF project inside Muon Collider : (Radio Frequency in Magnetic Field Test Facility);
  - First exercise on Cooling Cell integration
  - Precursor of the Cooling Cell Demonstrator
  - HE-INFRA next call HTS (INFN & UMIL) + Contribution from HFM



- EIC contribution (to be discussed)
  - Special IR Magnets for a second IR experiment @ Electron Ion Collider (BNL)
  - Timing: 2025-2028 (NbTi, **few special complex magnets**, ideal for IRIS for size
- Future Experiments : Measurements of Dipole Moment @ LHC P3 Twocryst
  - Spectrometers: 4 T – 2 m long wide aperture (NbTi or HTS technology)

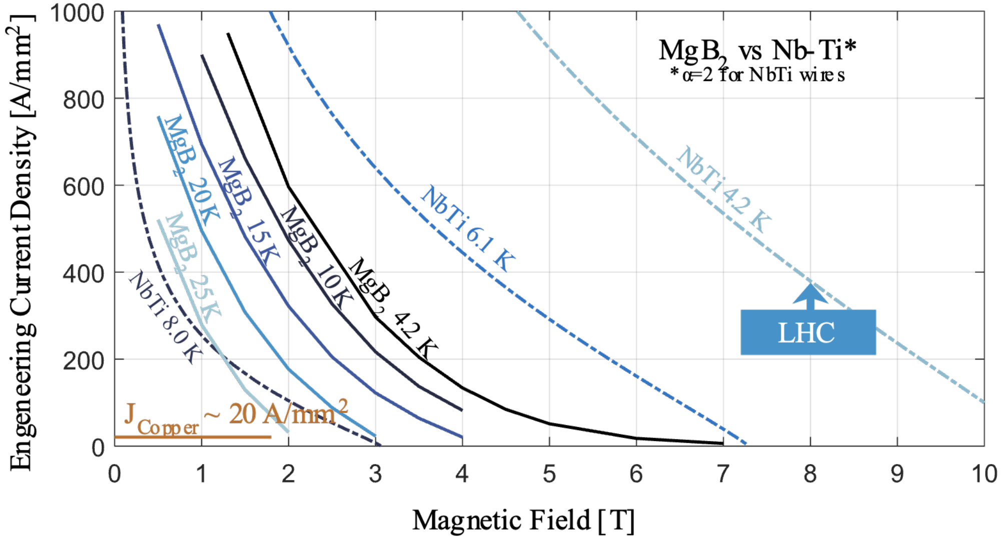
A. Bianchi INFN-Mi-LASA

Energy Saving Magnets - ESABLIM

Need for «Improvement of energy efficiency»
European Strategy for Particle Physics 2020

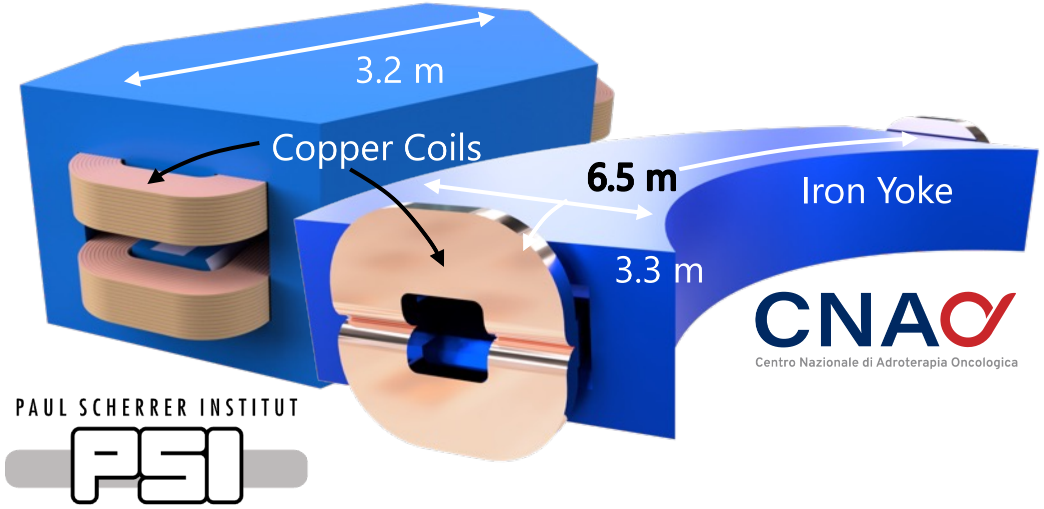
Revamp of common resistive magnets for heavy particles beam lines with **Cryogen-free superconducting magnets.**

- Use of **MgB_2 or HTS** conductors **reusing iron yoke**;
- Obtain **energy** consumption **5-20 time reduction;**
- Work @ **T=8-20 K** with **solid conduction cooling** to reduce cryogenic power consumption;



Two case studies: research and medical applications

	PSI (Steady State)	CNAO (Ramped)
Magnetic Field	1.45 T	1.74 T
Weight	50 tons	75 tons
Air Gap	100 mm	200 mm
Max. Current	1 kA	2.28 kA
Max. Power	95 kW	700 kW
Cond. Dimensions	18.5 x 18.5 mm²	39.8 x 14.3 mm²
Energy Consumption	715 MWh/year	262 MWh/year



Courtesy of S. Mariotto (Dep. of Physics, Univ. of Milan)
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Outlook to the future of IRIS
SUMMARY of possible future projects portfolio (dream list)

1. Fundamental Physics (accelerators, detectors: performance but also sustainability)
2. Energy and Green transition
3. Medical applications

IRIS: engagement to keep it operative at least 2026-2035
Possibly much more …

Status and rules of operations still to be defined

Tipology	Project	Device	period	Ext.Funds (M€)	TOT cost (M€)
Fundamental Physics	HFM/FCC	16 T Nb3Sn Dipole	2025-2028	3.5	7
	HTM/FCC-MuCol	HTS	2025-2028	1.5	3
	HFM-MuCol°°	Magnet of RFMFTF	2025-2028	1	2
	EIC**	magnest for 2nd IR	2026-2030	5	5
	Physics detector*	Dipole for LHCb	2026-2030	2	2
Green/Sustainability	Esablim *	Demo dipole	2024-2025	0.5	1
	Fusion Magnets*	Demo and design	2025-2030	5	5
	Green Sc lines^	Desing/Test subelem.	2026-2030	2	2
Medical	SC Gantry **	Main bend SC dipoles	2026-2030	6	6
				23 M€	

* Hypothetical
** To be discussed