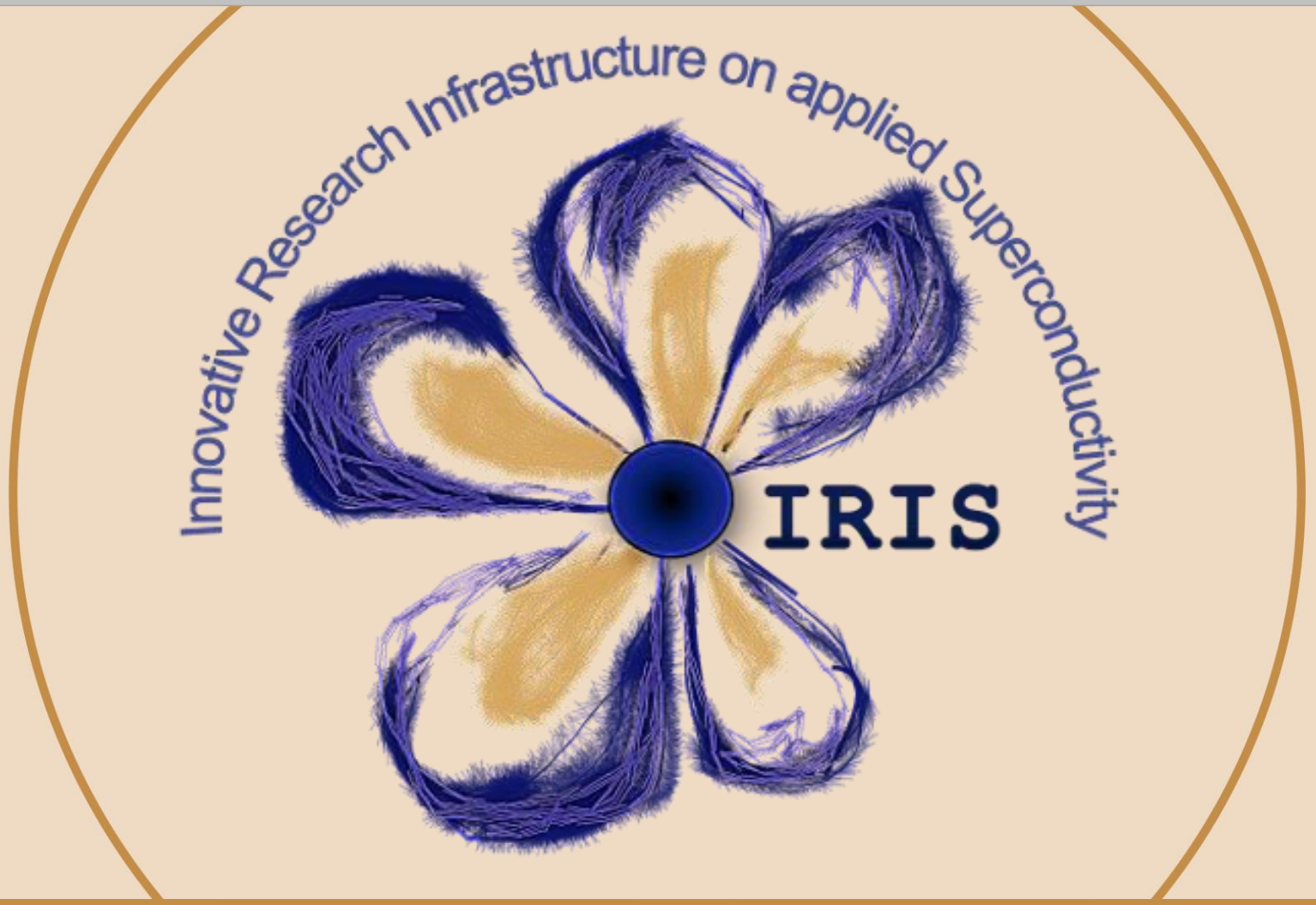
Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INFN

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.

The IRIS Infrastructure in Italy



Lucio Rossi

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

Laboratorio LASA – Milano

CERN, HFM annual meeting 2 Nov 2023

HFM
High Field Magnets

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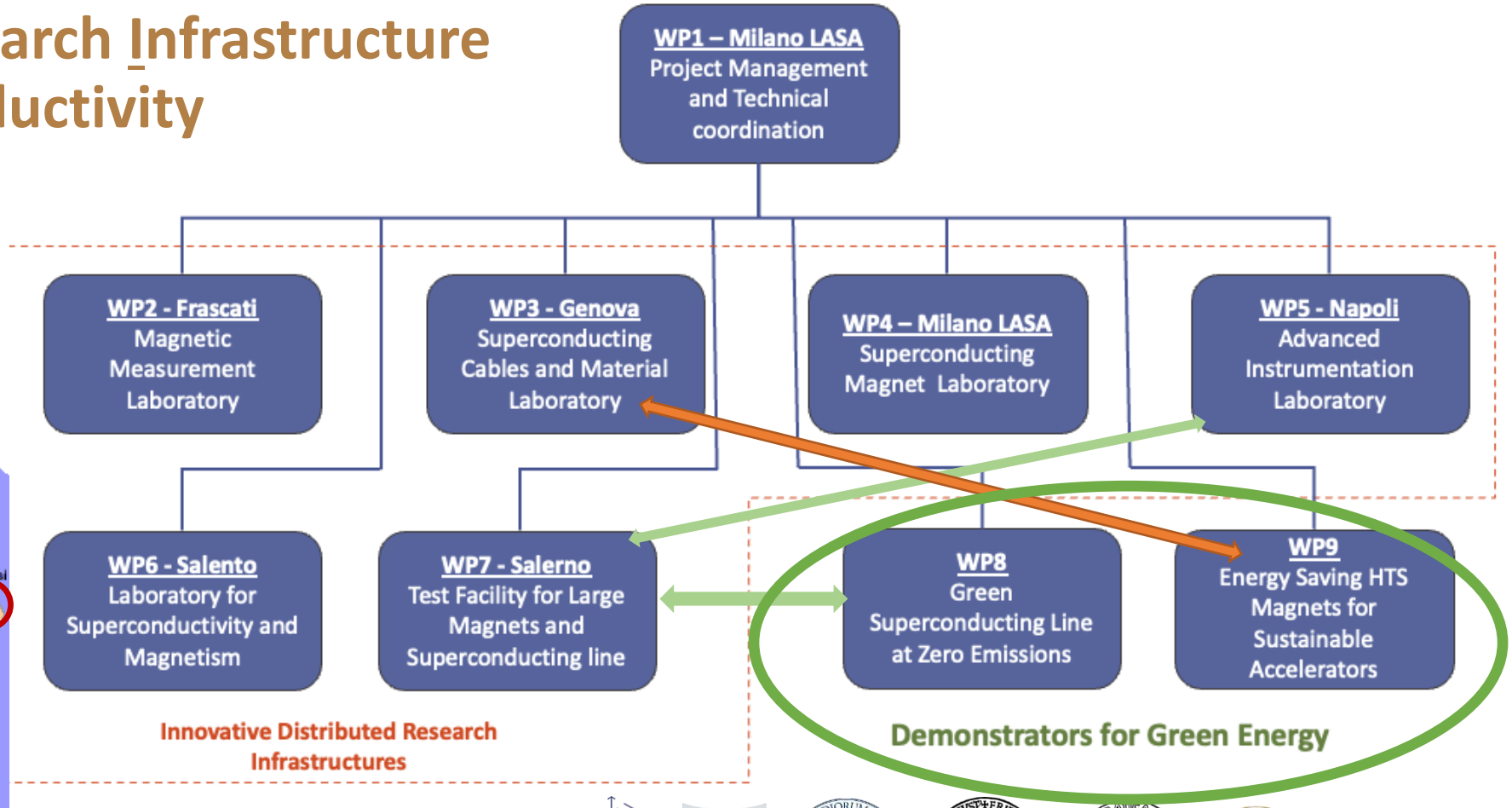
INFN

IRIS - Innovative Research Infrastructure on applied Superconductivity



IRIS timeline

- ***Unusually fast for Italian standard…***

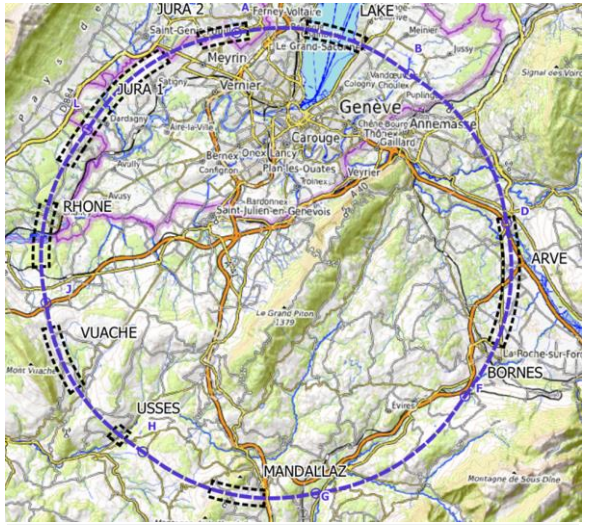
- *Avviso MUR n. 3264 del 28-12-20221*
- **Application on 25 February 2022**
- Negotiation phase with MUR: **10 to 17 June 2022** (resubmission new proposal : 17 June 2022)
- Decree of approval: n. 124 of **21 June 2022**
- Start date of the project: **1 November 2022** (however early expenditure may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

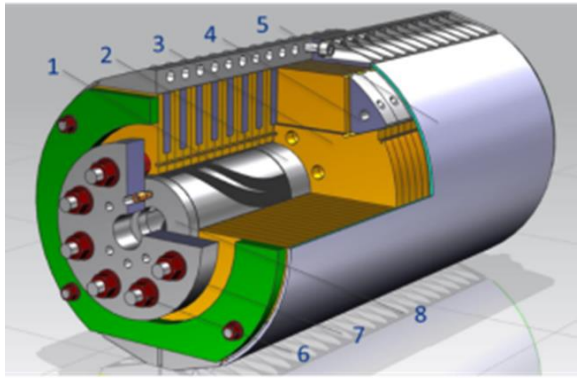
IRIS project scope -1
Fundamental Physics instrumentation

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)



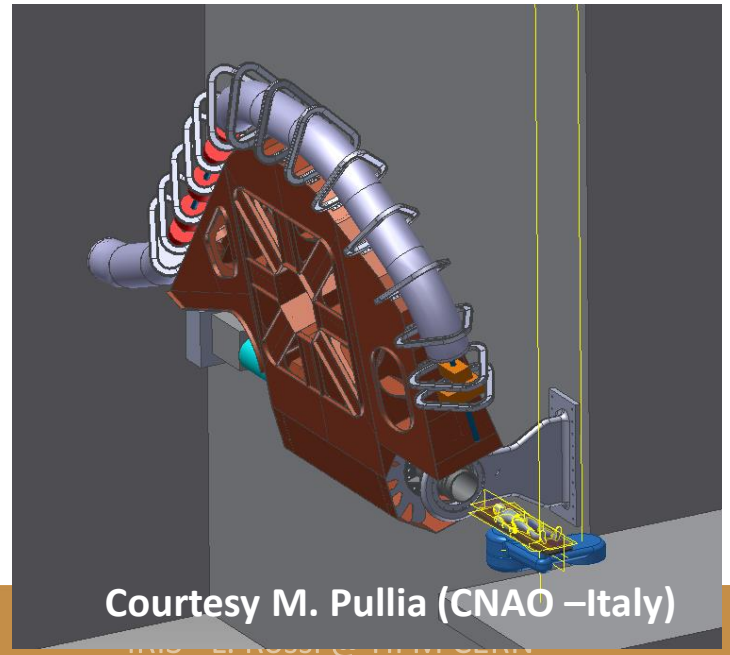


FCC (12-16 T)

IRIS project scope -2 Societal Applications

- **Green Energy** and **Medical**
- Green : energy transport at **0^3** emission and energy saving magnets.
  - 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
- **Training**:
  - **9** people to Int. Acc School and **9** to Erice Acc. School
  - **20** people at Eucas2023, **12** at MT28, **23** at CAS-Magnets


Courtesy A. Ballarino - CERN


Courtesy M. Pullia (CNAO –Italy)

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 :

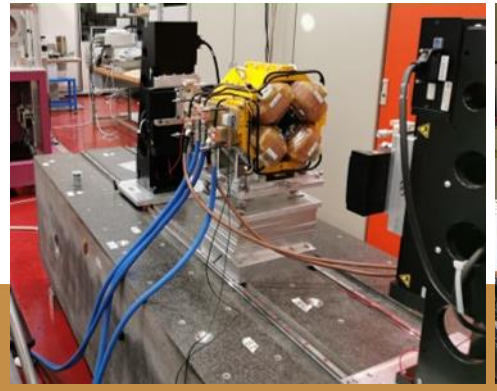
- a Hall effect digital teslameter with a 5-axes movement device on a granite bench;
- a stretched wire bench for integral measurements of fields and mechanical fiducialization;
- a rotating coil multipole measurement system; an NMR teslameter.

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

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

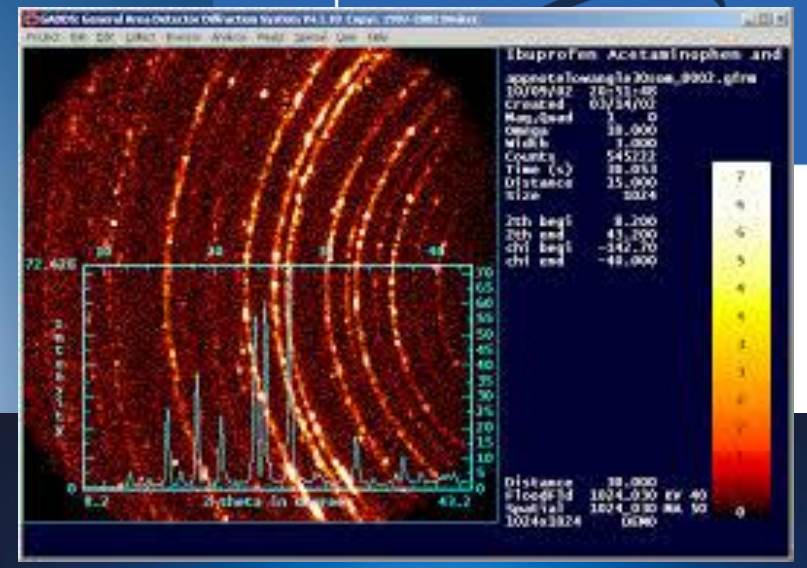
Courtesy R. Musenich
A. Bersani , INFN-GE

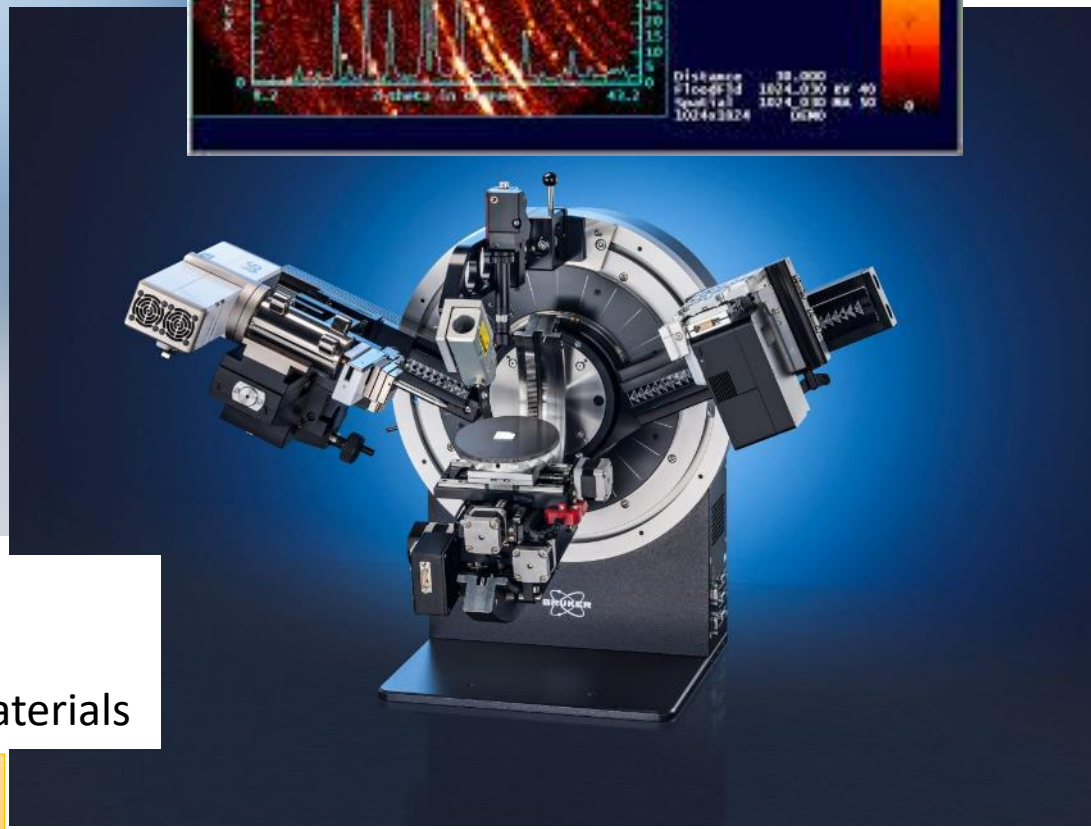
WP3 – Genova –INFN

- Renewal and better efficiency of the LHe plant
- Renewal of part of the existing laboratory
- Purchase and installation of new modern equipment
  - New test station for Ic measurements: two companies were contacted.
  - New insert and new cryostat for the Ma.Ri.S.A. test facility. The required design by INFN is severely delayed due to lack of personnel
  - 2 kA power supply for superconducting magnet. The specification is going to be written. at least one reliable supplier has been identified. Order procedure started.

Courtesy R. Musenich
A. Bersani , INFN-GE

CNR-SPIN Lab





X-Ray diffractometer

Structural analysis of Superconducting materials

Courtesy A. Malagoli, CNR-SPIN GE

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
- 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
- It is National R.I. as INFN infrastructure (in the list of PNIR as medium priority)

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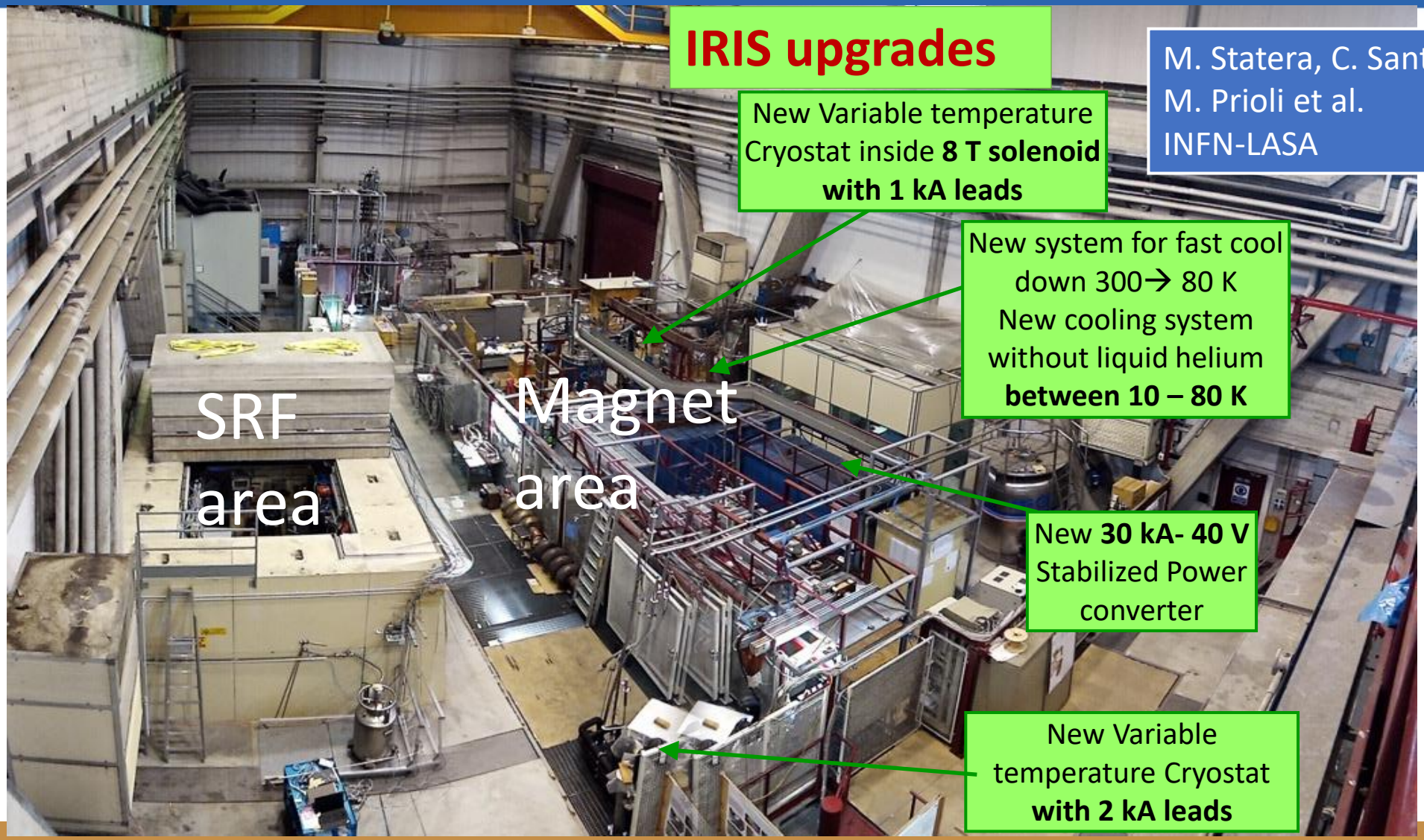
INFN

LASA Hall: 800 m²

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

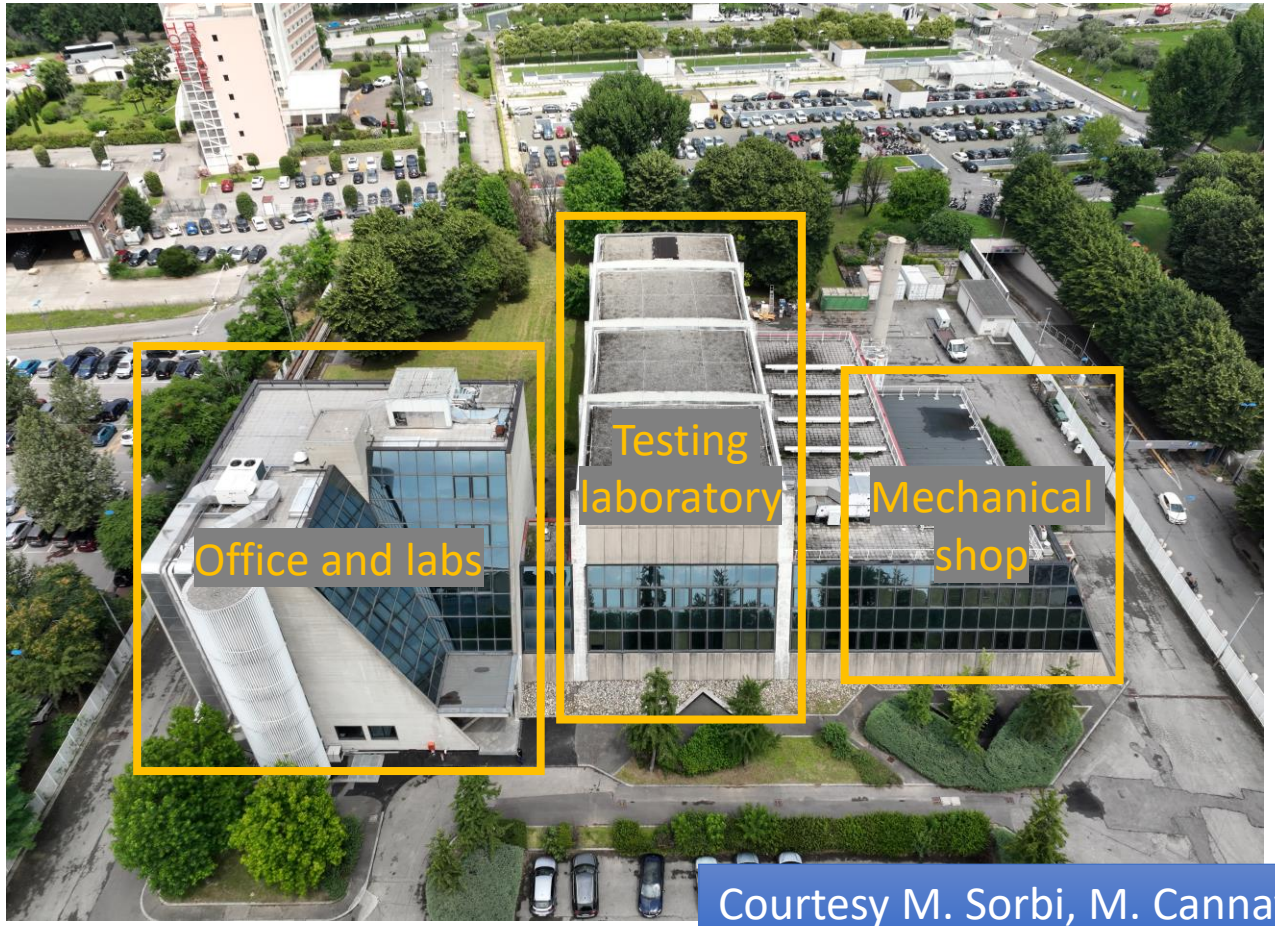
Test up to 15 kA possible NOW in LHe

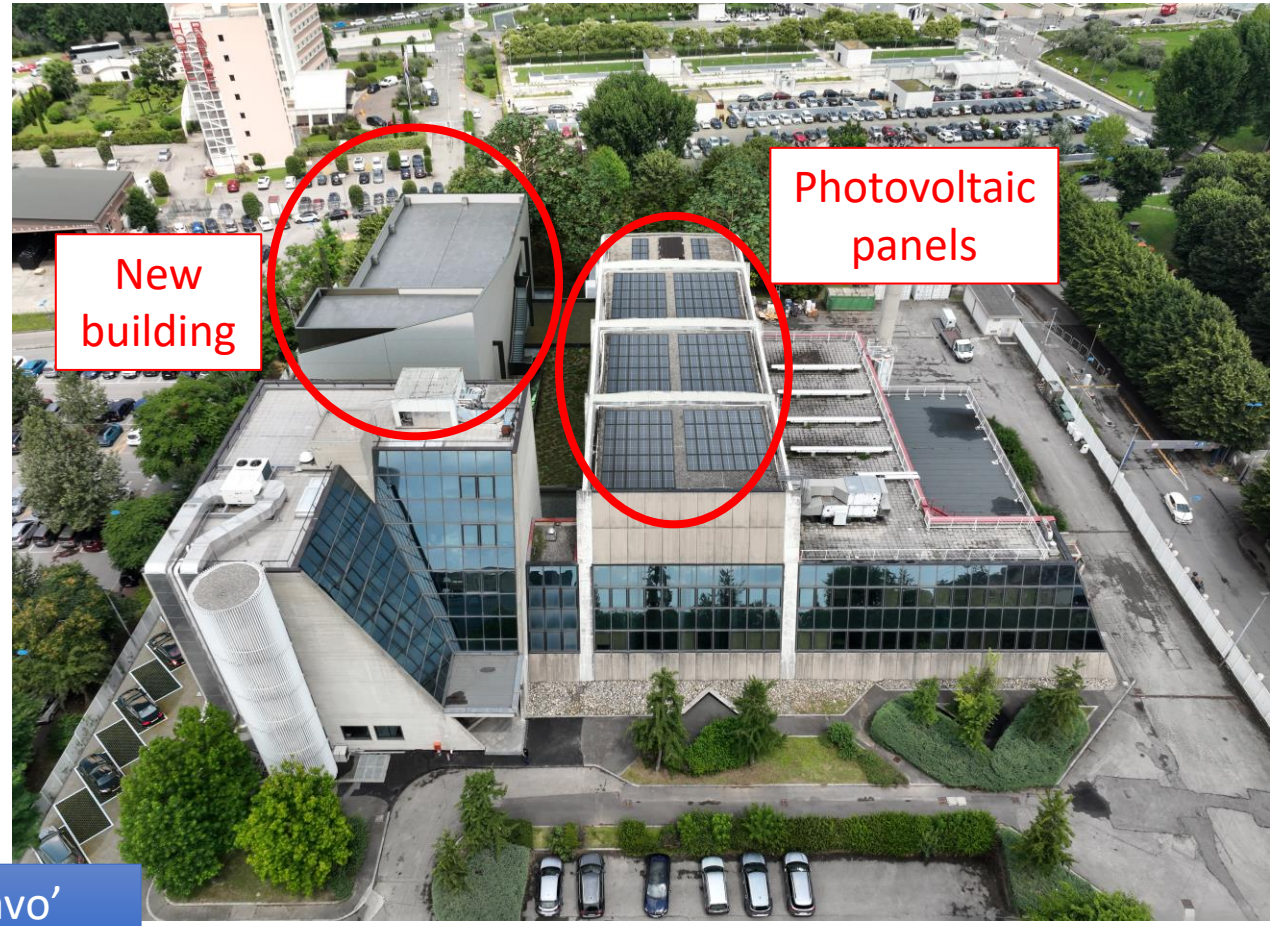
IRIS will contribute to rationalize and modernize the infrastructure and to have Cryogen-free cryostat for 10-50 K operation and test of HTS magnets



NOW

FUTURE



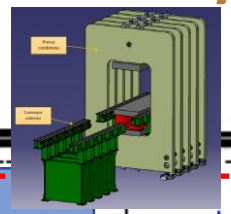


Courtesy M. Sorbi, M. Cannavo'
Univ. of Milano and INFN-MI-LASA

New building

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

IRIS SML - Superconducting Magnet Laboratory
Ground floor plan



Area carroponte

Metrology area (E-moduus press)

Combined function press

Winding an spooling area

Entrance

N

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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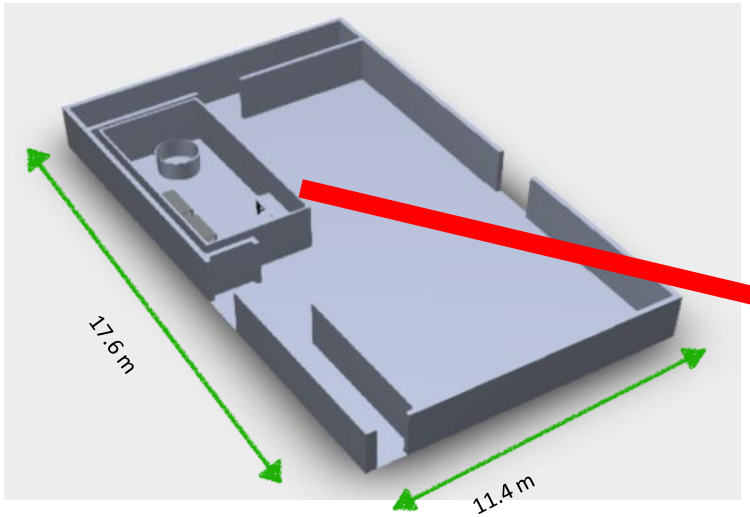
WP5 – Napoli – CIRMIS
IMPALAB expertise

- 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

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



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
Measurement
7x JINST
13x AIP Review of Scientific Instruments
Fermilab
SLAC

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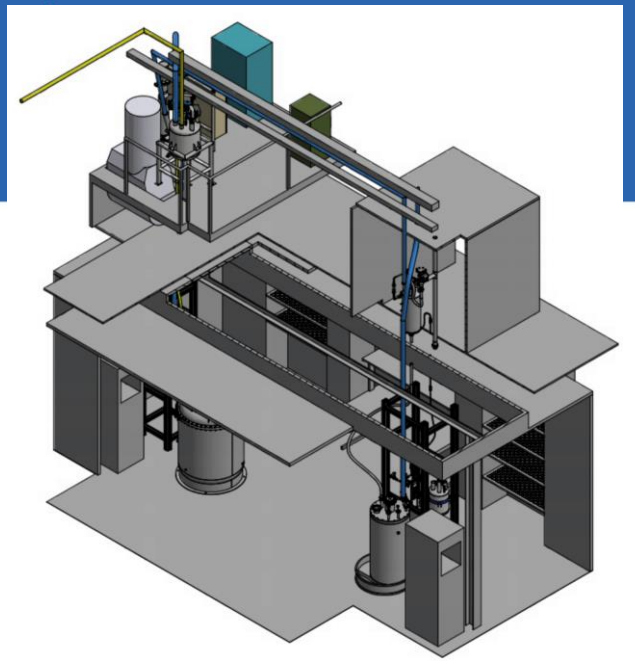
WP5 – Naples CRYOLAB



- 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

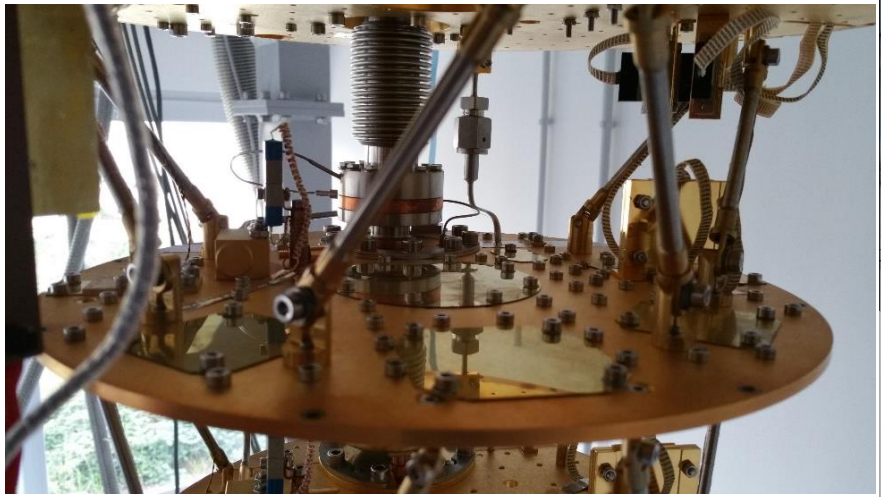
P. Arpaia, G. Fiorillo, Univ. of Naples

Consiglio Nazionale delle Ricerche

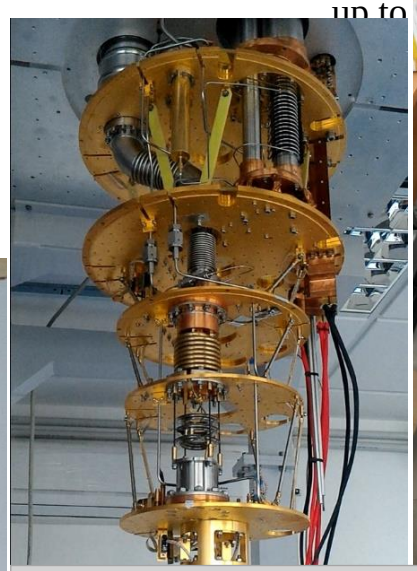
SPIN

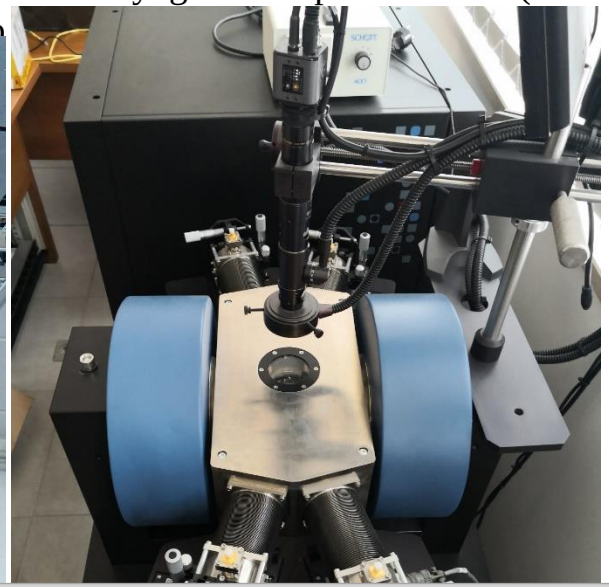
WP6 – Laboratory of Superconductivity and Magnetism

Courtesy of G. Maruccio, Univ. of Salento



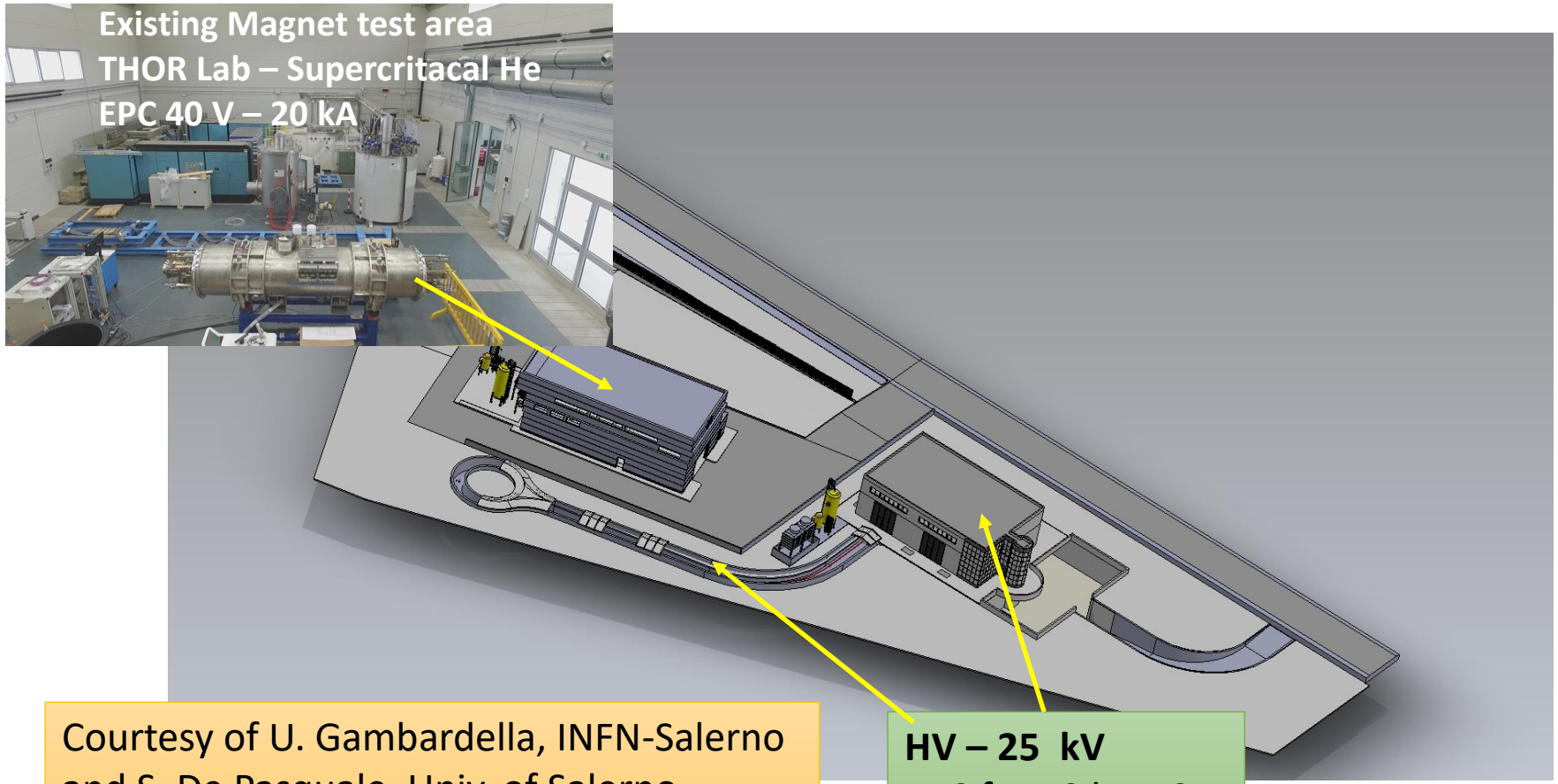
- Cryogenic superconducting magnet (10.5 T, 0.3-300 K)
- Oxford dilution refrigerator (down to 10 mK, vector magnet 6T/1T/1T)
- Lakeshore Cryogenic RF probe station (down to 8 K and up to





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

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



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

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

WP7 – Salerno CNR-SPIN

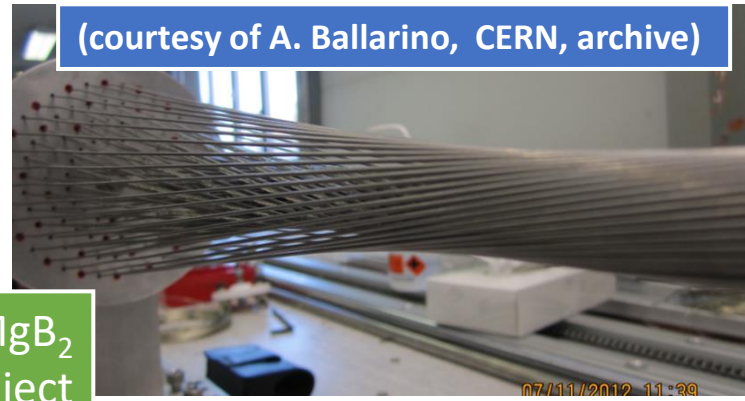
- The SPIN Salerno Unit aims to acquire and setting up a magneto-transport measurement system including the application of strain and stress.
- The equipment for magneto-transport (e.g. Quantum Design PPMS) consists of a variable temperature (1.9 to 300 K)-field (up to ±9 T) system, designed to perform 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

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



(courtesy of A. Ballarino, CERN, archive)

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

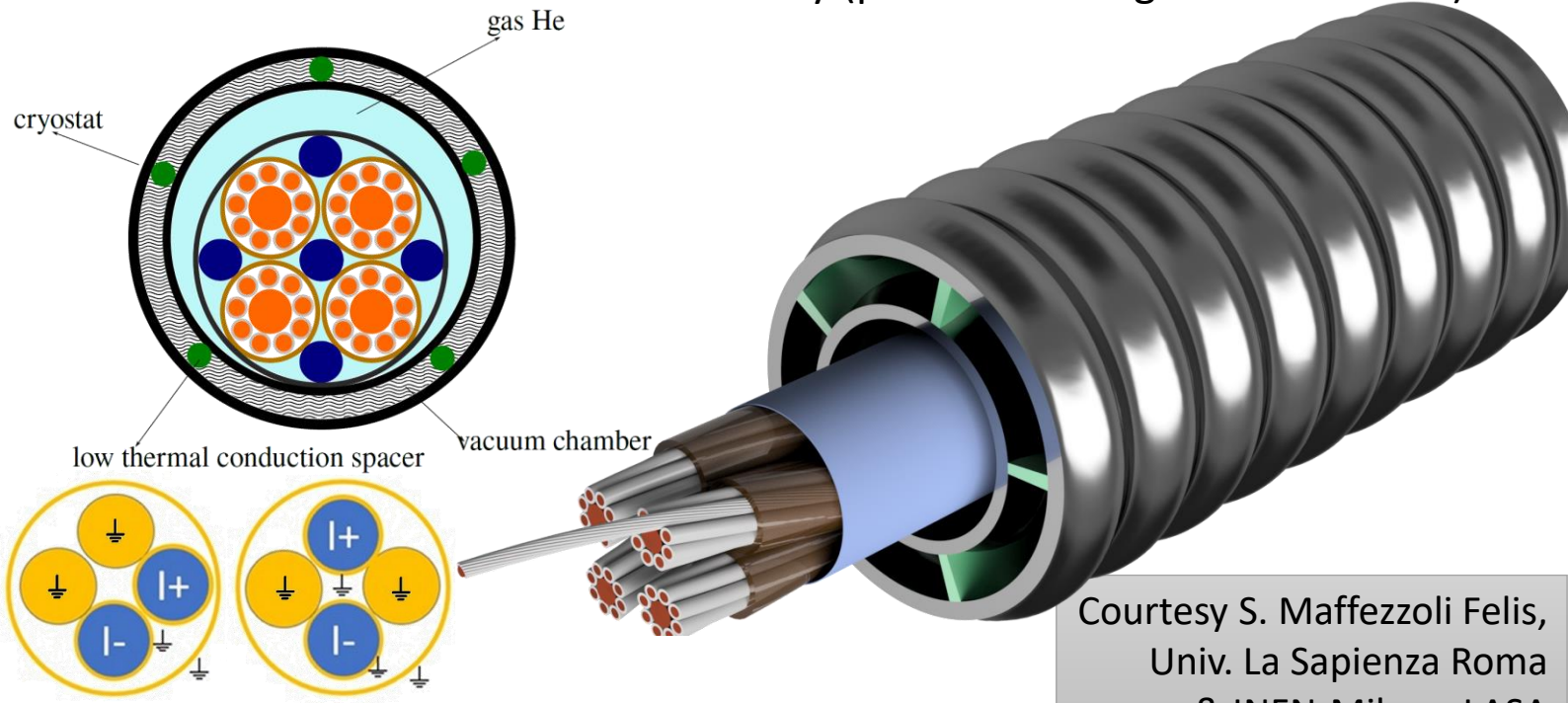
Scope:

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

Tender awarded on 26.05.2023 INFN G.E. 13553
To ASG Superconductors S.p.A.

- 4 x MgB2 conductors
- Full redudancy (potential change in connection)

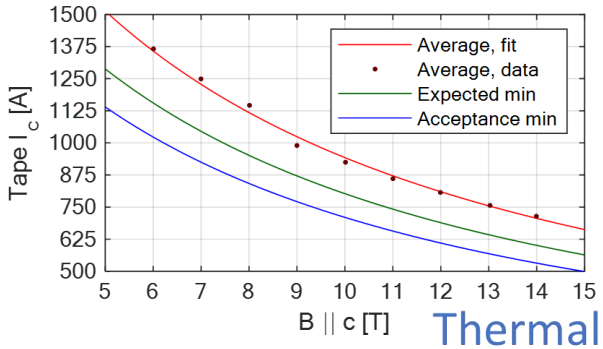
Power transport	**1 GW**
Voltage	25 kV
Operating temperature	20 K
Line length	130 m
Expected losses	3.0 W/m
Overall cable diamater	105 mm
Cryostat diameter	250 mm
Bending radius	2.2 m
Inner pressure	10 bar



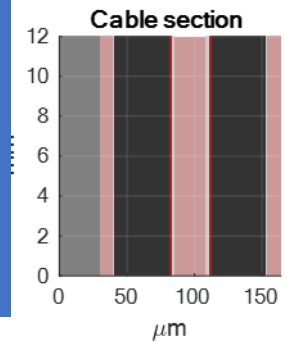
Courtesy S. Maffezzoli Felis,
Univ. La Sapienza Roma
& INFN-Milano-LASA

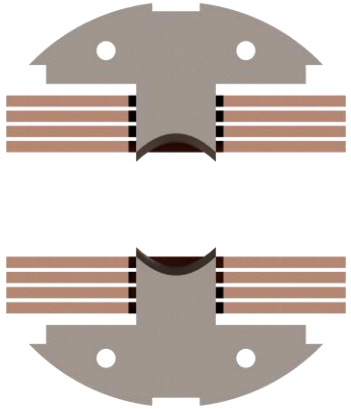
WP9 IRIS DEMO-2 : an HTS dipole (split coil racetrack)
Nominal present design (controlled insulation with metal tape)

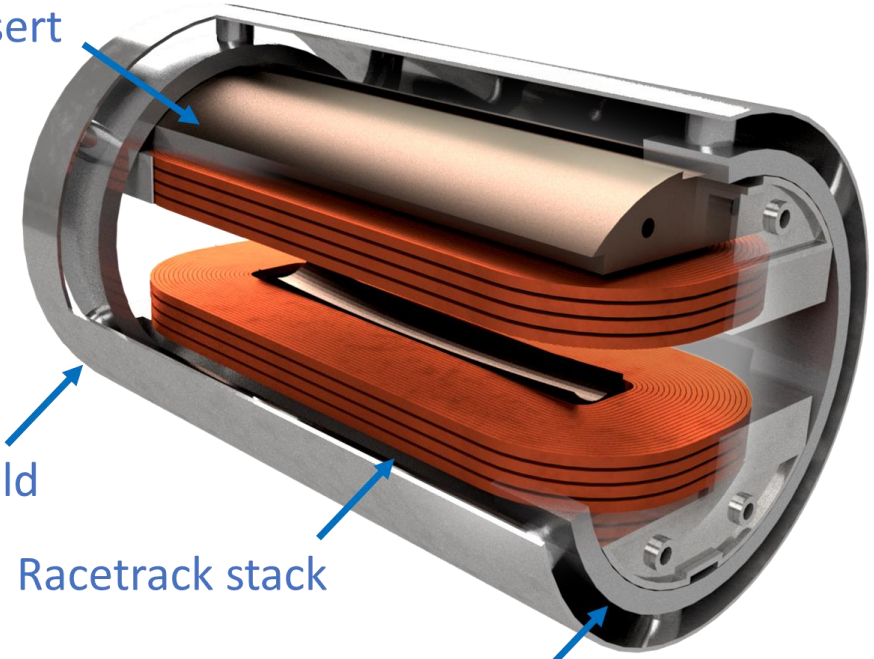
Dimensions	**12 mm × 67 µm**
Substrate	40 µm of Hastelloy C276
Copper stabilizer	2 × 10 µm, RRR>20
Easy-way minimum bend	10 mm
Allower longitudinal strain	-0.4 % to 0.3 %
I_c, 77 K, self-field	Min. 400 A, average 470 A
Ic, 20 K, 15 T	Min 500 A



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

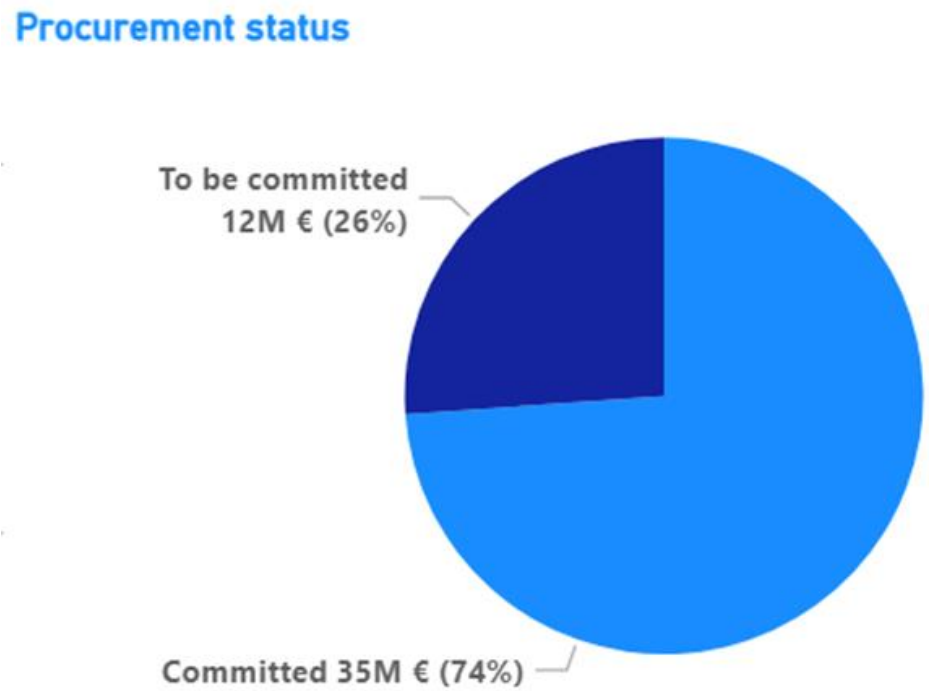
Finanziato dall'Unione europea
NextGenerationEU

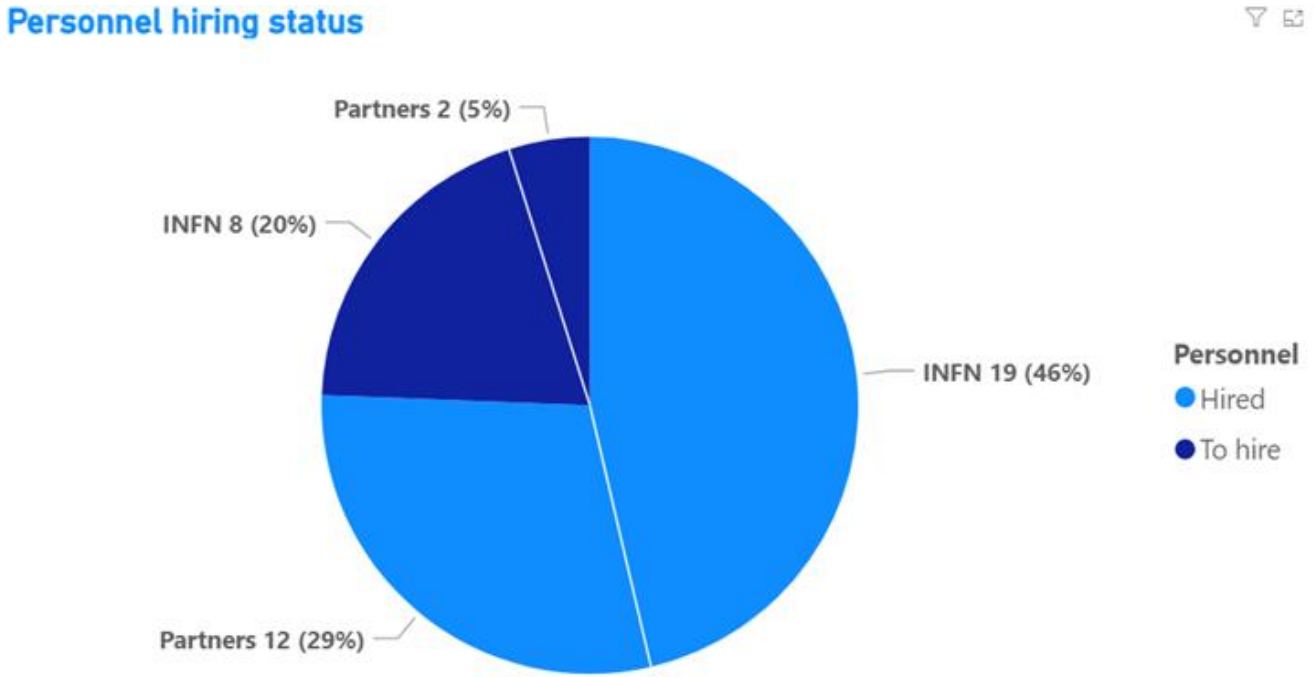
Tx included! (20% taxes)
This include the personnel specifically hired
It does not include the existing staff working on IRIS

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 €

Main tender being contracted 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**