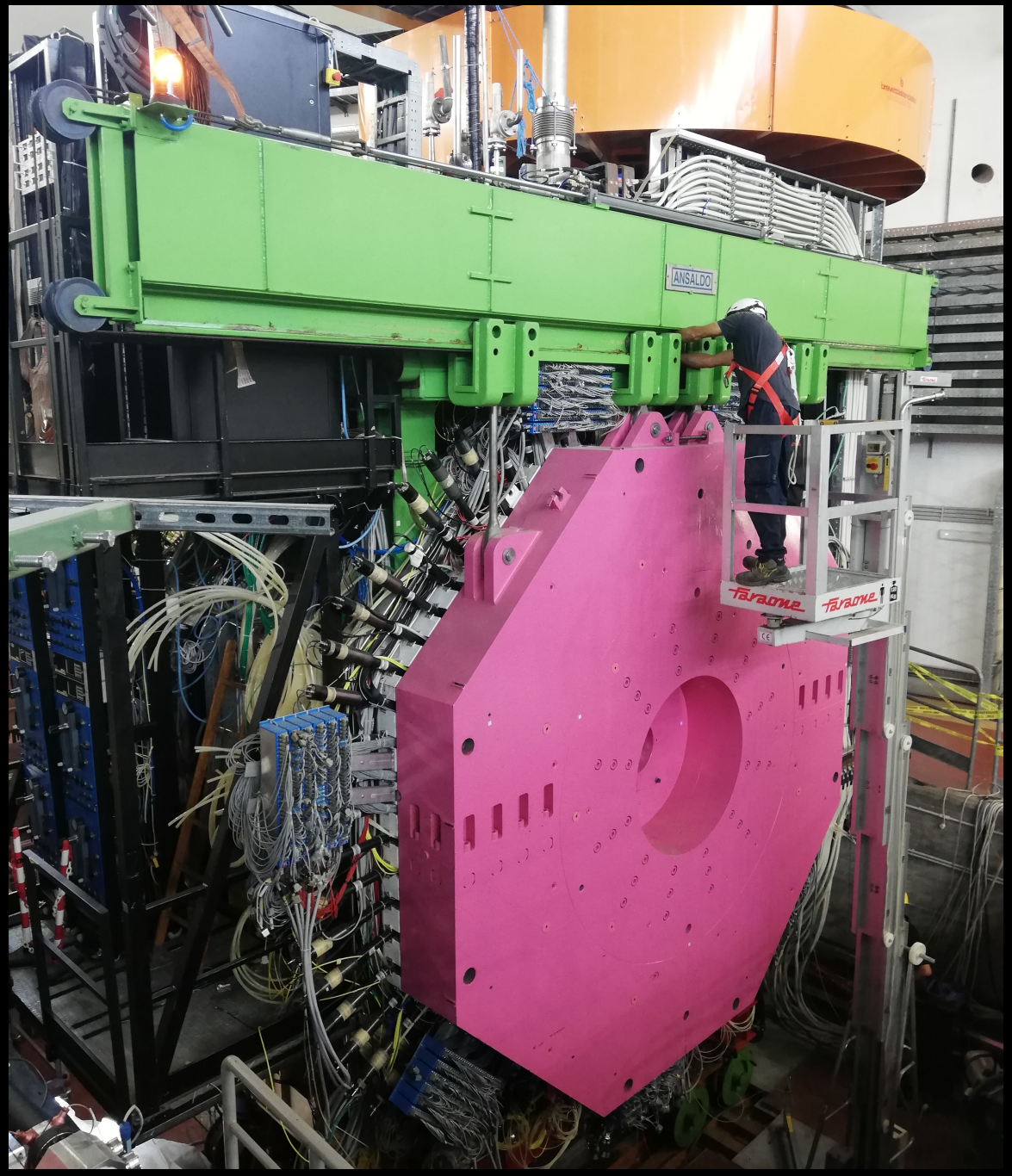
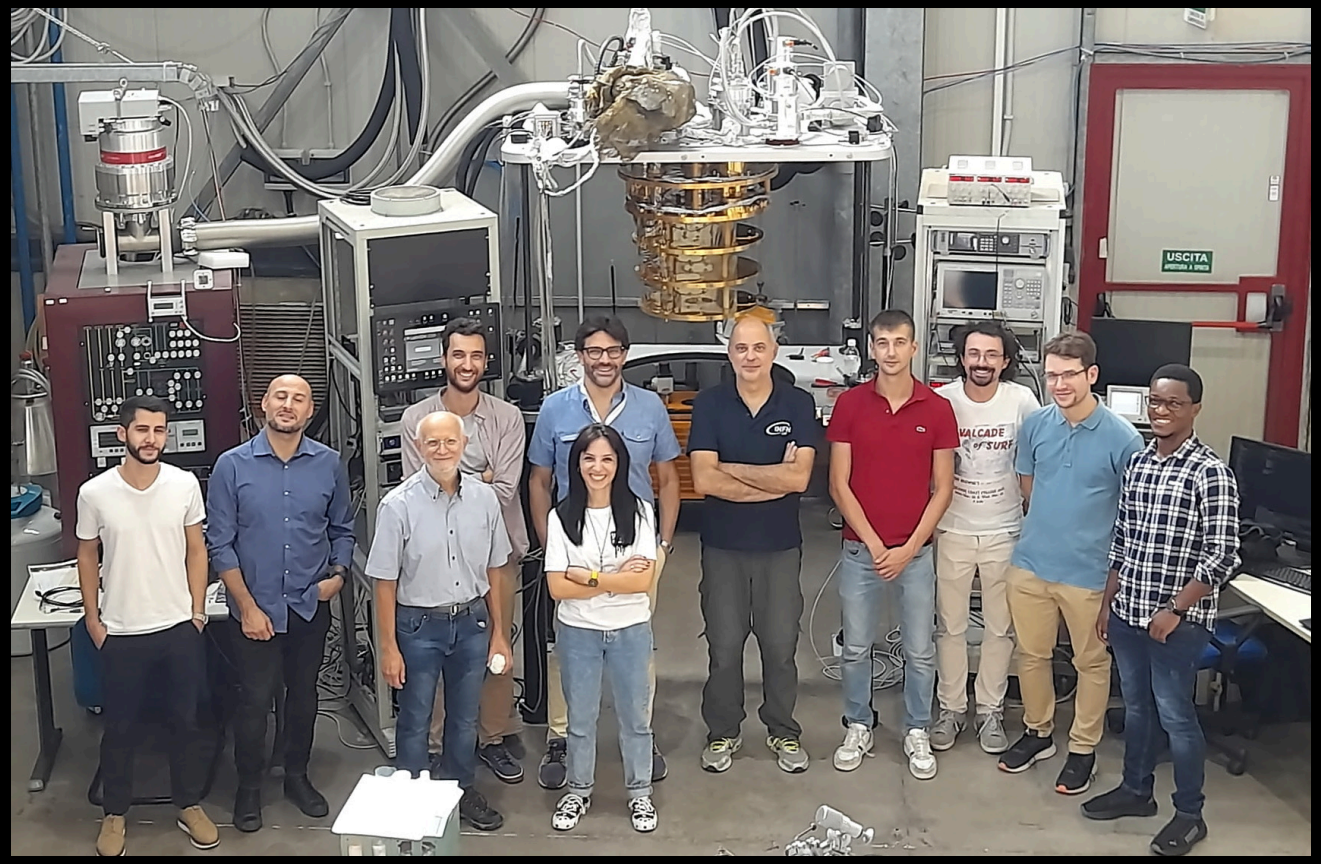


INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

COLD
Activity Report

Carlo Ligi – INFN-LNF

66th LNF Scientific Committee Meeting – 8 Nov 2023



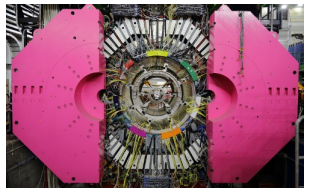
COLD - Cryogenic Laboratory for Detectors

- Axion Experiments
- Superconducting Quantum Devices
- Superconducting Cavities
- Magnetic Measurements

EXPERIMENTS

QUAX – QUest for AXions

Search for galactic axions with Sikivie's Haloscopes at 10 GHz (Ongoing experiments at LNL and LNF).



FLASH

Search for galactic axions with a Sikivie's Haloscope at 100 MHz (Design Study).

Networking Projects

CA21106 - COSMIC WISPers in the Dark Universe: Theory, astrophysics and experiments (CosmicWISPers)
1st general meeting, Bari – 5-8 Sept 2023
COST Action (European Cooperation in Science & Technology)

PNRR Projects

ICSC National Center of HPC Big Data and Quantum Computing

NQSTI National Quantum Science and Technology Institute

Superconducting Devices

Qub-IT Quantum Sensing with superconducting qubits (Second year)

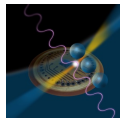
DART WARS (Detector Array Readout with Travelling Wave AmplifieRS)
Development of wide band quantum amplifiers for multi-channel detector readout (Third year)

Supergalax FET H2020 Project
SC-qubits array photon-detector for axion experiments (Third year)

SQMS USA DOE Project
Superconducting Quantum Materials and Systems (0ngoing)

Resilience Grant Giovani CSNV Magnetic field resilient microwave single photon detector based on van der Waals Josephson junctions (First year)

SAMARA Superconducting materials for cavities and haloscopes (Second year)



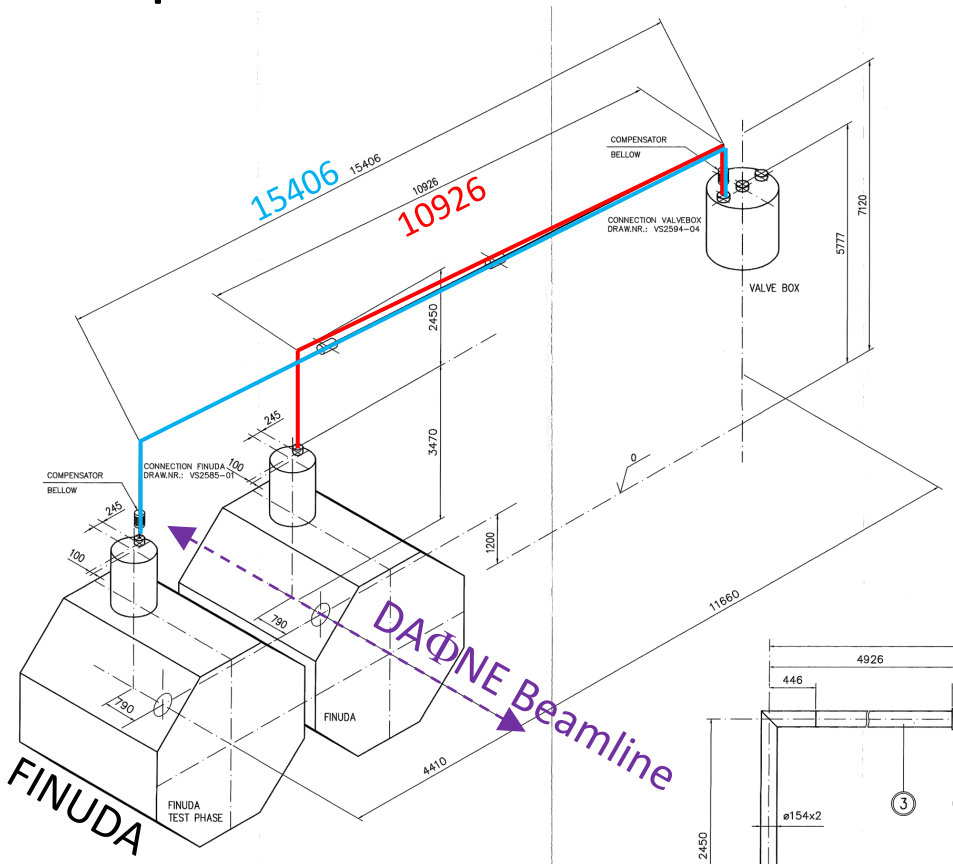
SIMP (Single Microwave Photon detectors)
Development of single-microwave photon detector (Completed)

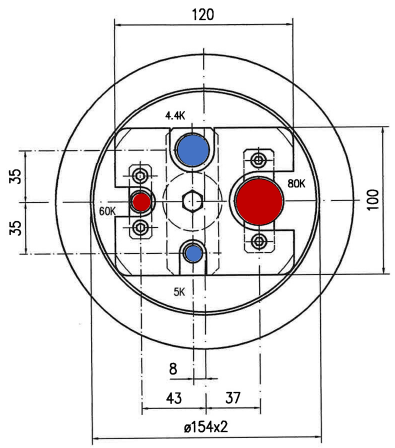
FLASH – Preparation for the FINUDA cooling

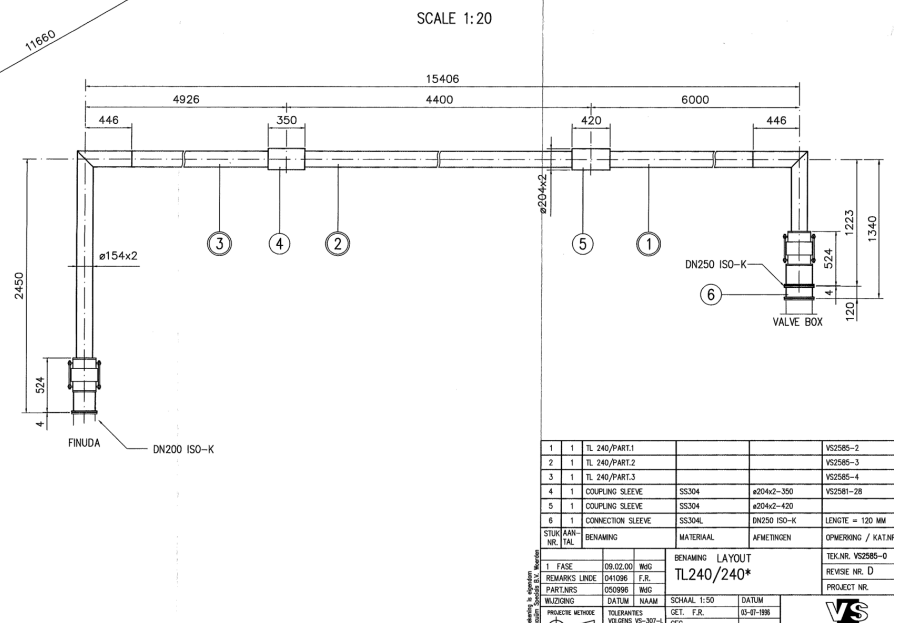
- The DAΦNE cryogenic plant is almost ready to start for the FINUDA cooling
- Several preliminary operations have been carried out:
  - modification and mounting of the cryogenic transfer lines to FINUDA
  - repairing and restart of the FINUDA cryogenic control system electronics
  - restarting of the FINUDA vacuum system
  - closing of the FINUDA magnet end-caps
  - checking of the plant pneumatic/electrical valves functioning
  - restarting/cleaning of the water cooling tower for the plant compressor

FLASH – Preparation for the FINUDA cooling

- Dismounting / Modification / Remounting of the cryogenic Transfer Lines inside the Dafne Hall (May 2023)







FLASH – Preparation for the FINUDA cooling

- **Dismounting** / Modification / Remounting of the cryogenic Transfer Lines inside the Dafne Hall (May 2023)

FLASH – Preparation for the FINUDA cooling

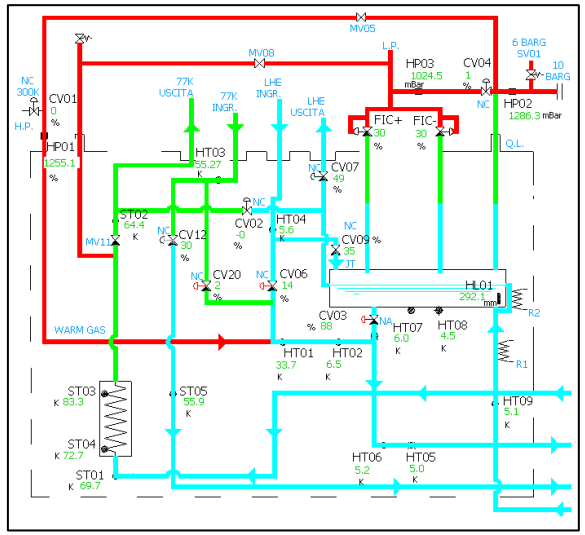
- Dismounting / **Modification** / Remounting of the cryogenic Transfer Lines inside the Dafne Hall (May 2023)

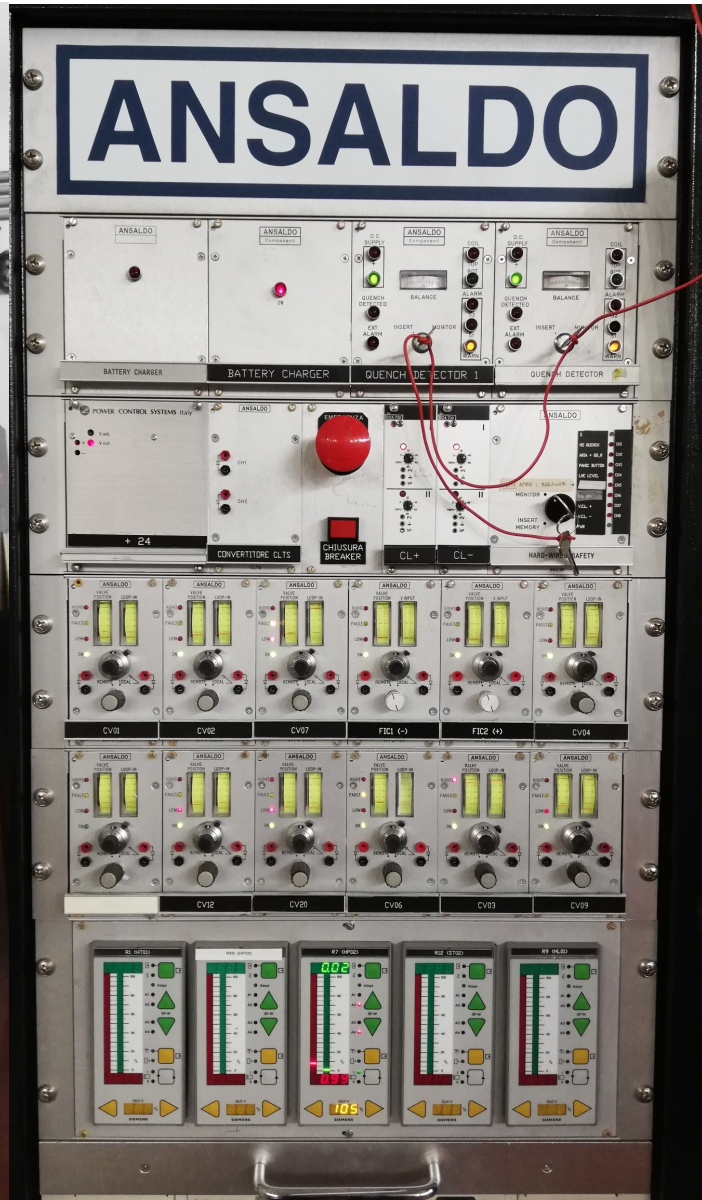
FLASH – Preparation for the FINUDA cooling

- Dismounting / Modification / **Remounting** of the cryogenic Transfer Lines inside the Dafne Hall (May 2023)
- Leak test carried out on all pipes

FLASH – Preparation for the FINUDA cooling

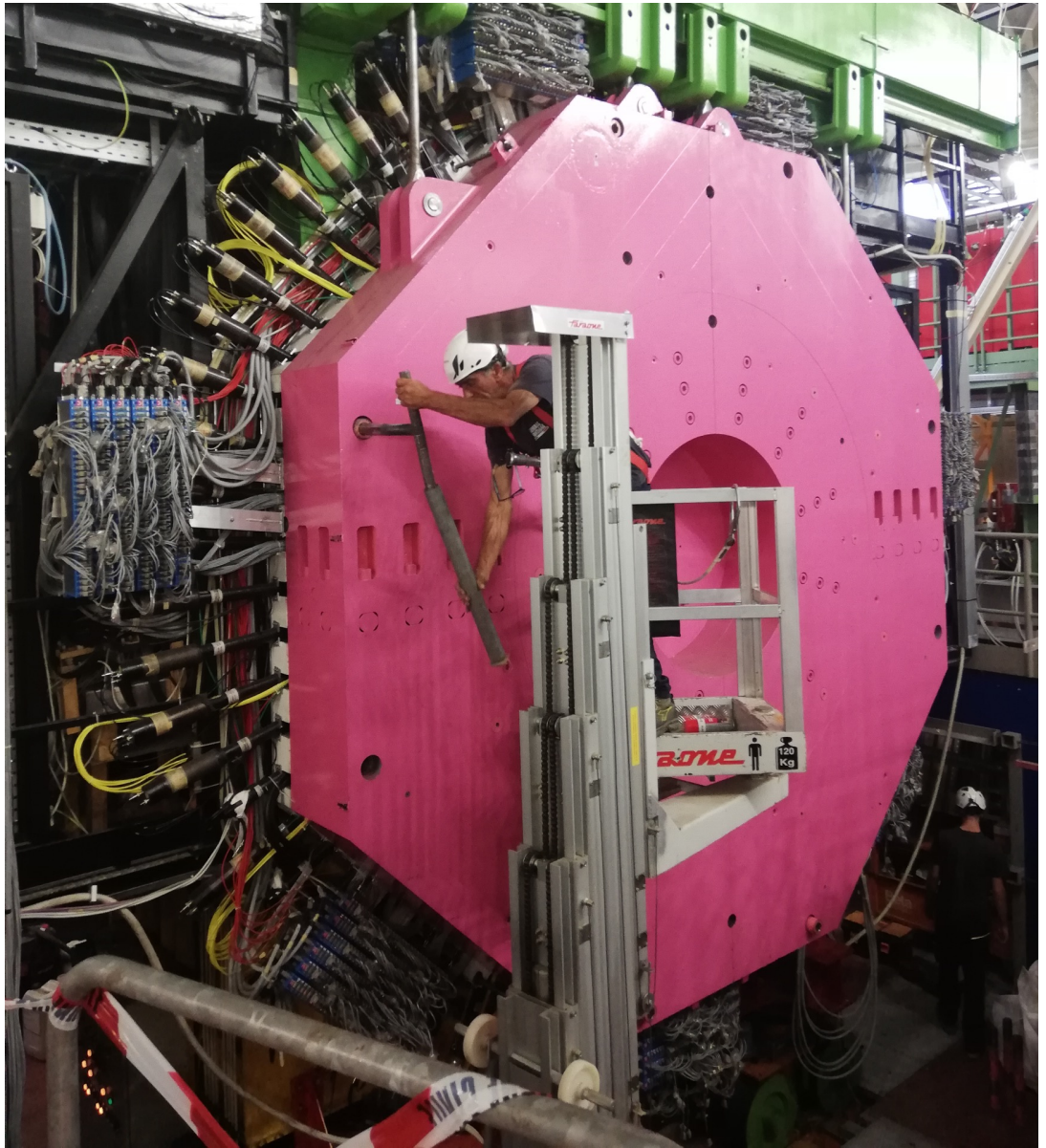
- Refurbishing of the cryogenic control system (PXI, valves control, PID etc.)
- Checking for the magnet power supply functioning
- Checking for the control system software

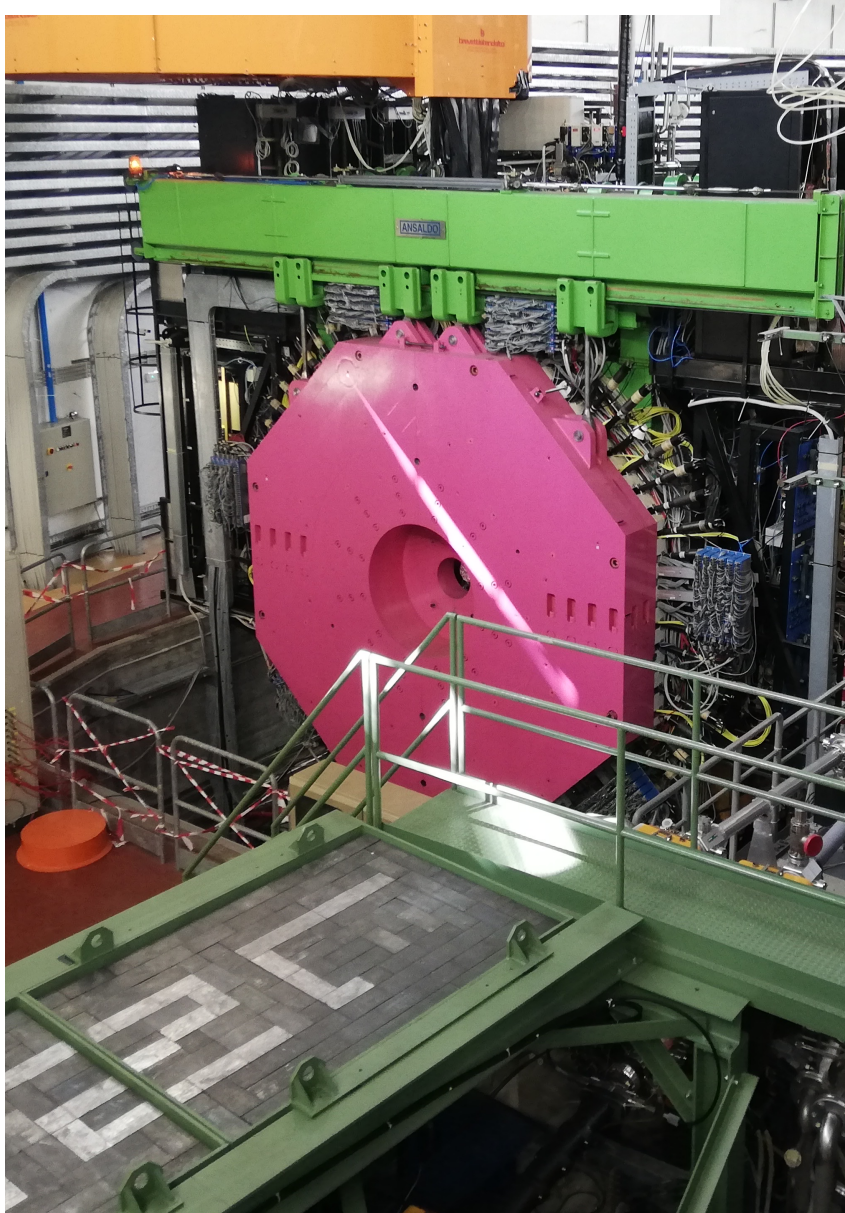




FLASH – Preparation for the FINUDA cooling

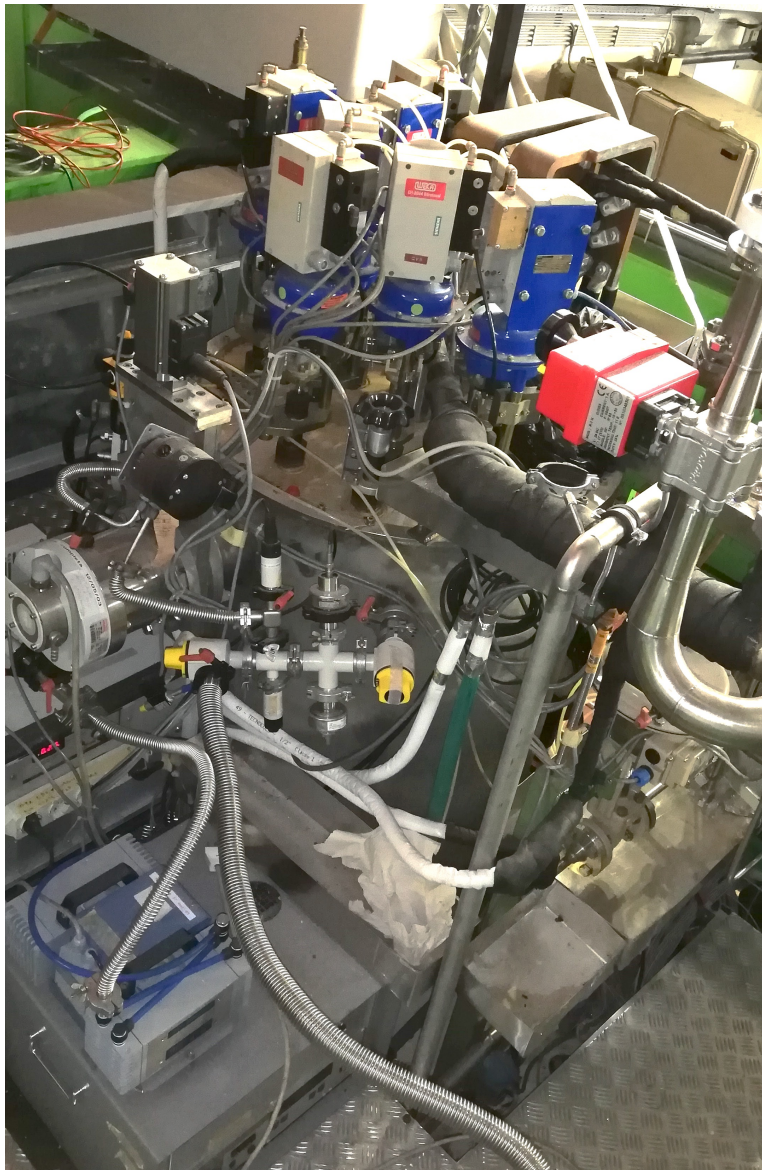
- **Closing of the FINUDA end-caps** (July 2023)
- It is the first time since 2007 that the magnet end-caps have been closed



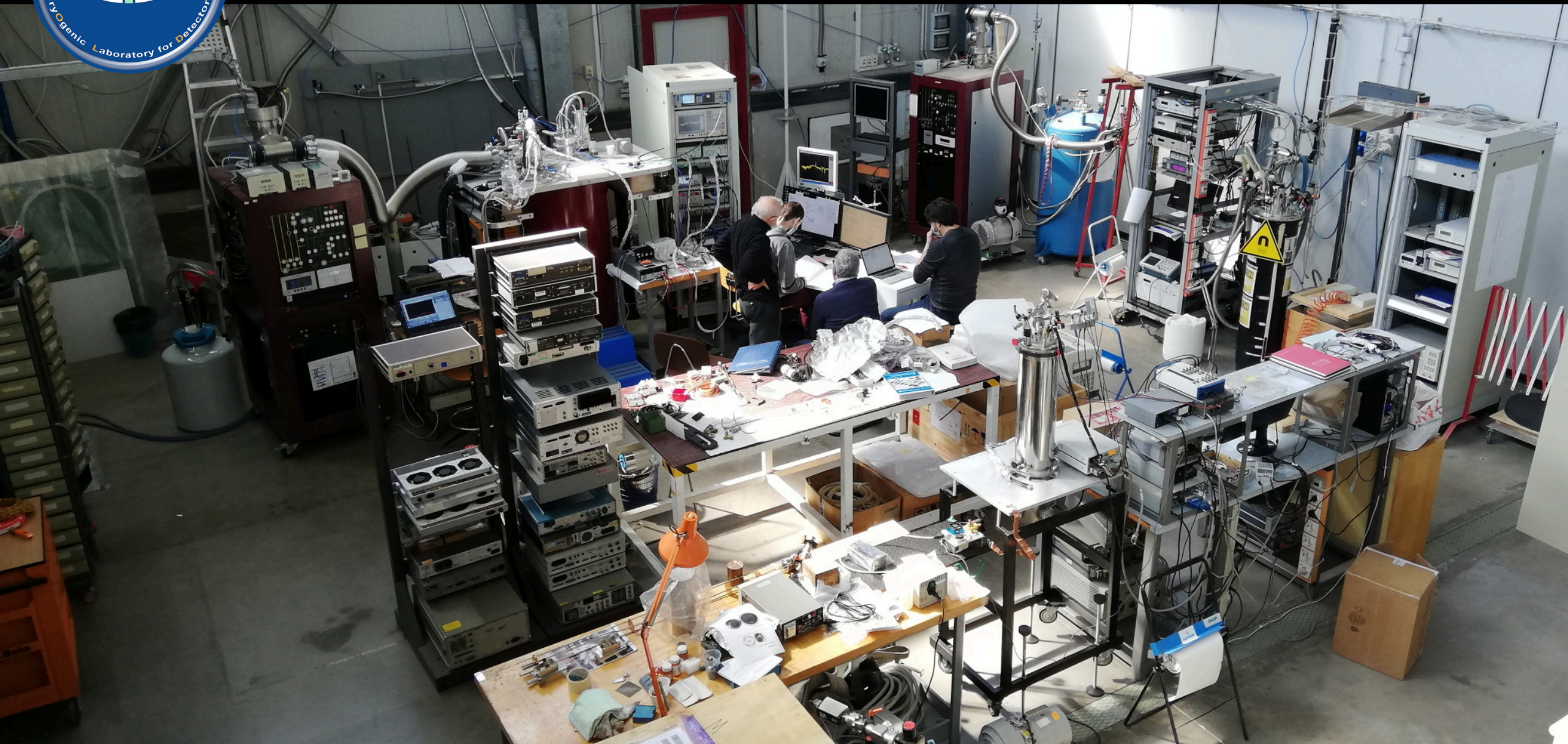


FLASH – Preparation for the FINUDA cooling

- Checking of the FINUDA pneumatic valves
- Replacement of the FINUDA and cryoplant safety valves
- Cleaning and reconnection of the water cooling for the plant compressor (KAESER ESD442, 250 kW)
- We plan to cool and energize the magnet between December and January

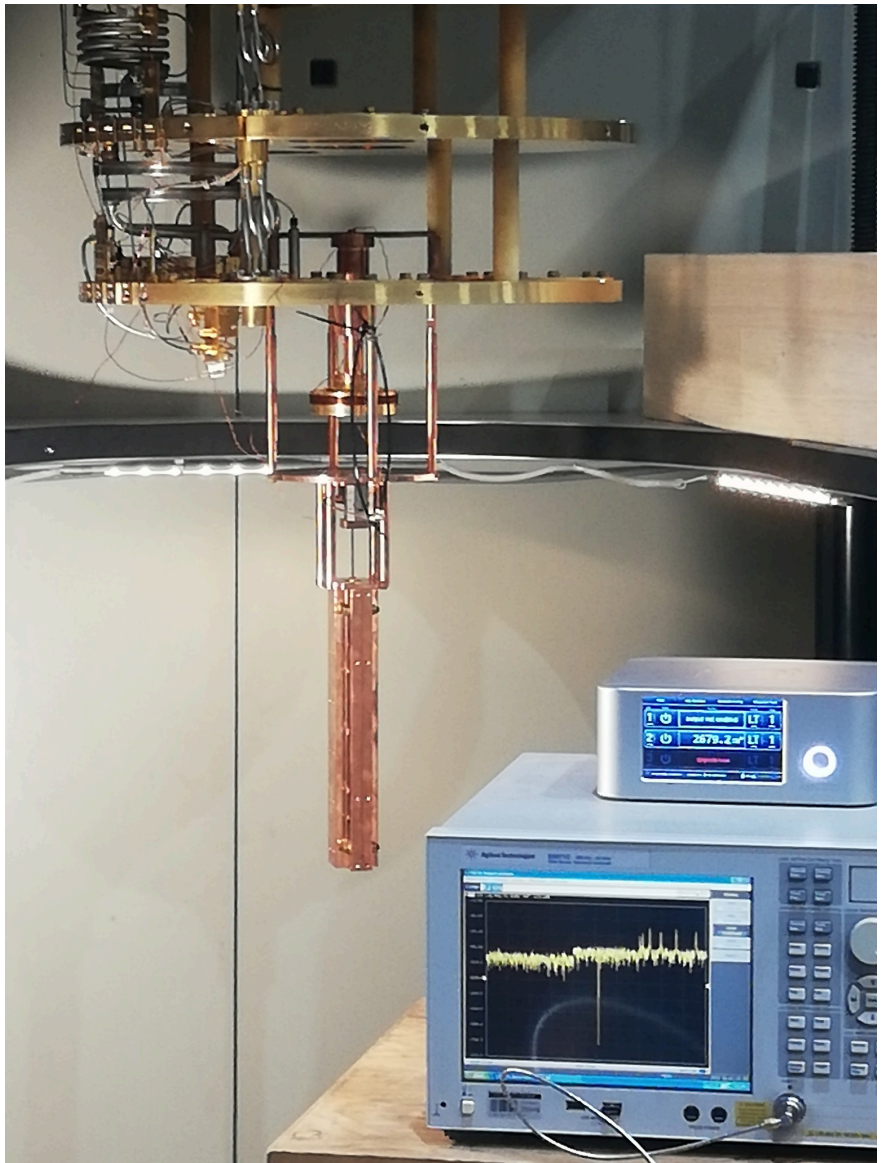


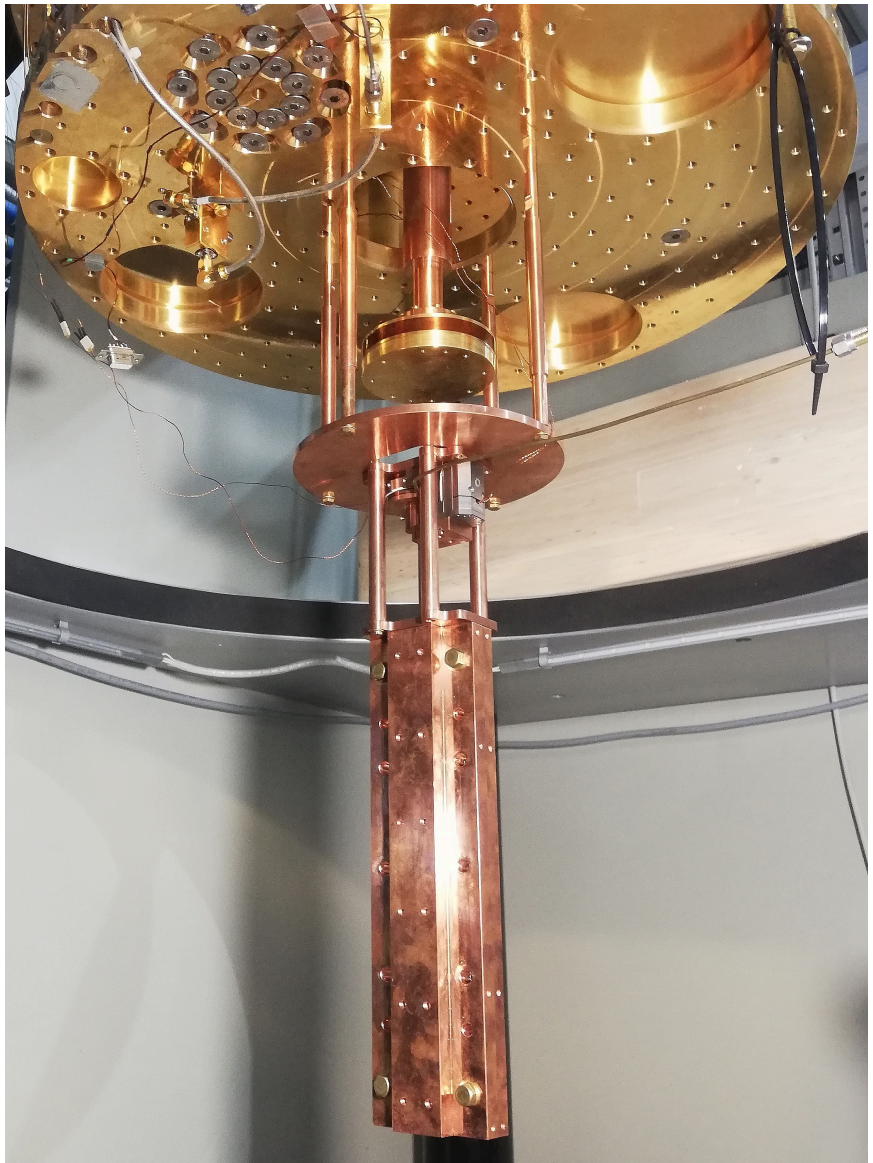
COLD Lab



QUAX – (8.5 GHz cavity run preparation)

- The setup for the first run with the tunable cavity is almost ready.
- Cryogenic motors have been procured and mounted
- Copper rod design under optimization
- Almost ready to start the cooling (end of November)





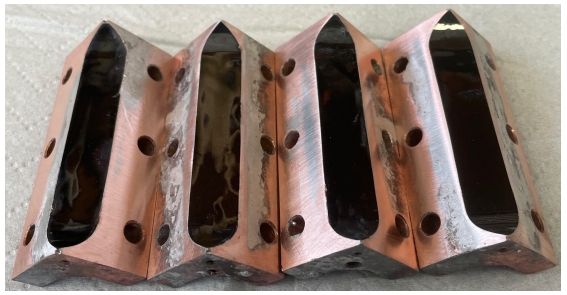
Cu/ReBCO (HTSC) tape RF cavity

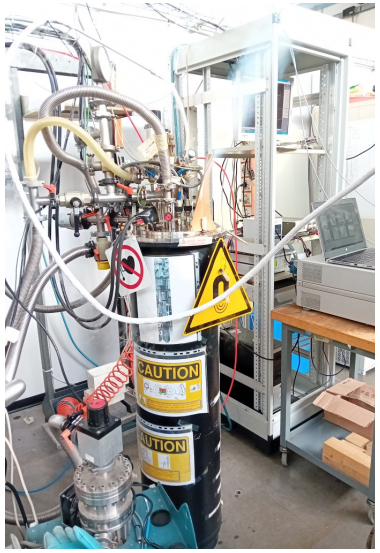
Rare-earth Barium Copper Oxide

f = 17.8 GHz (TM110)

Assembling and RF Tests

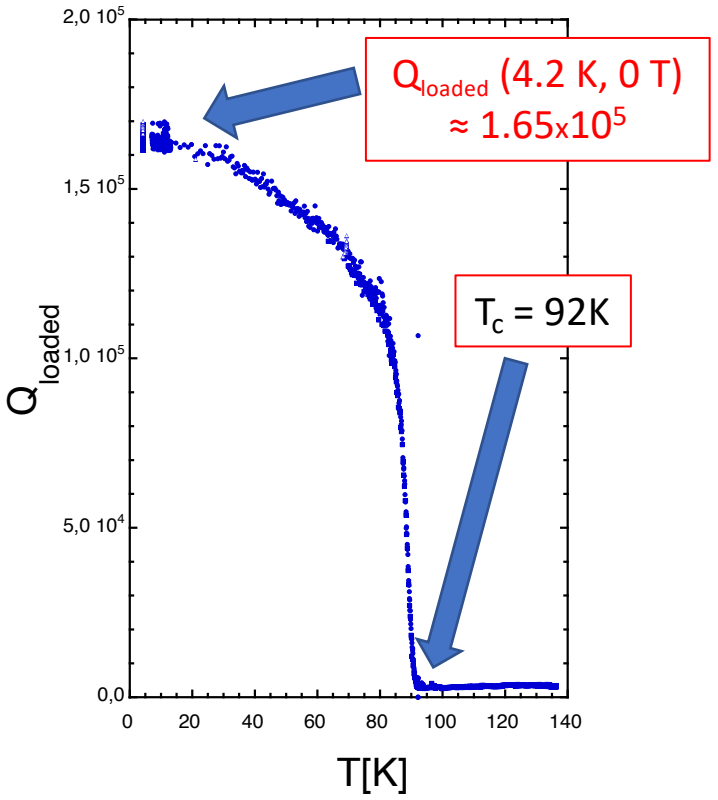
4-section cavity

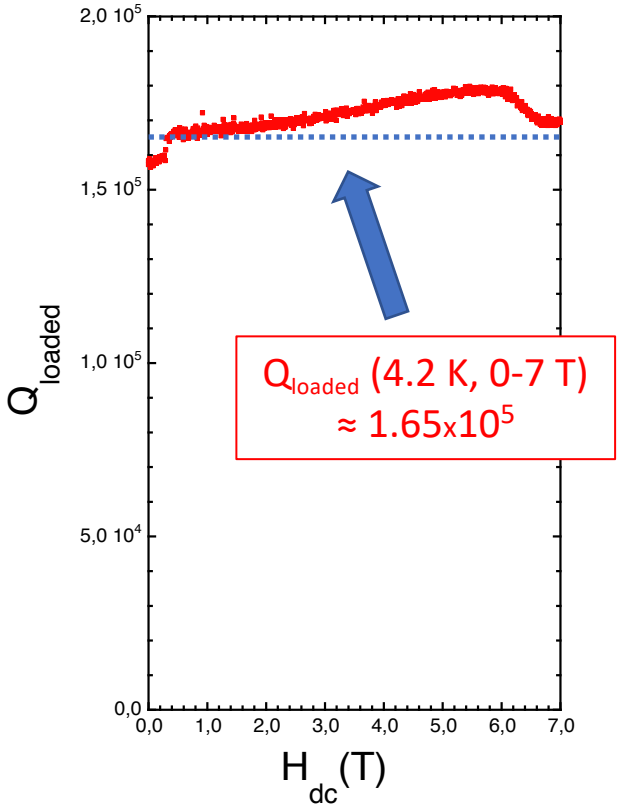




Results

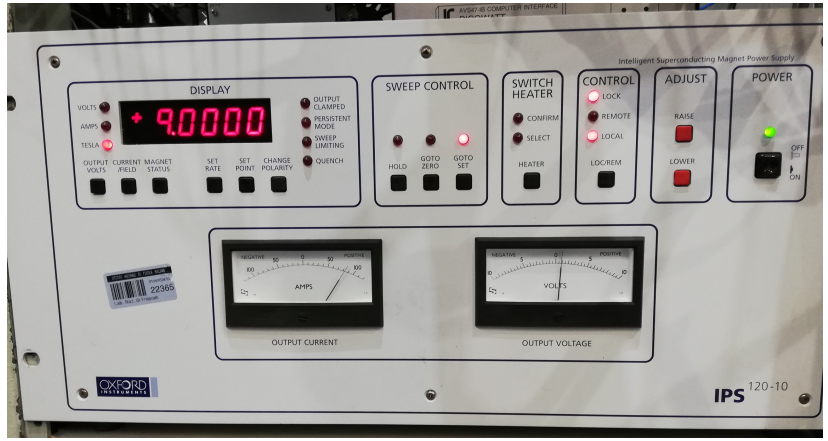
(expected optimized Q ≈ 0.5÷1x10^6,
but 3x10^5 is enough to reach the KSVZ band)

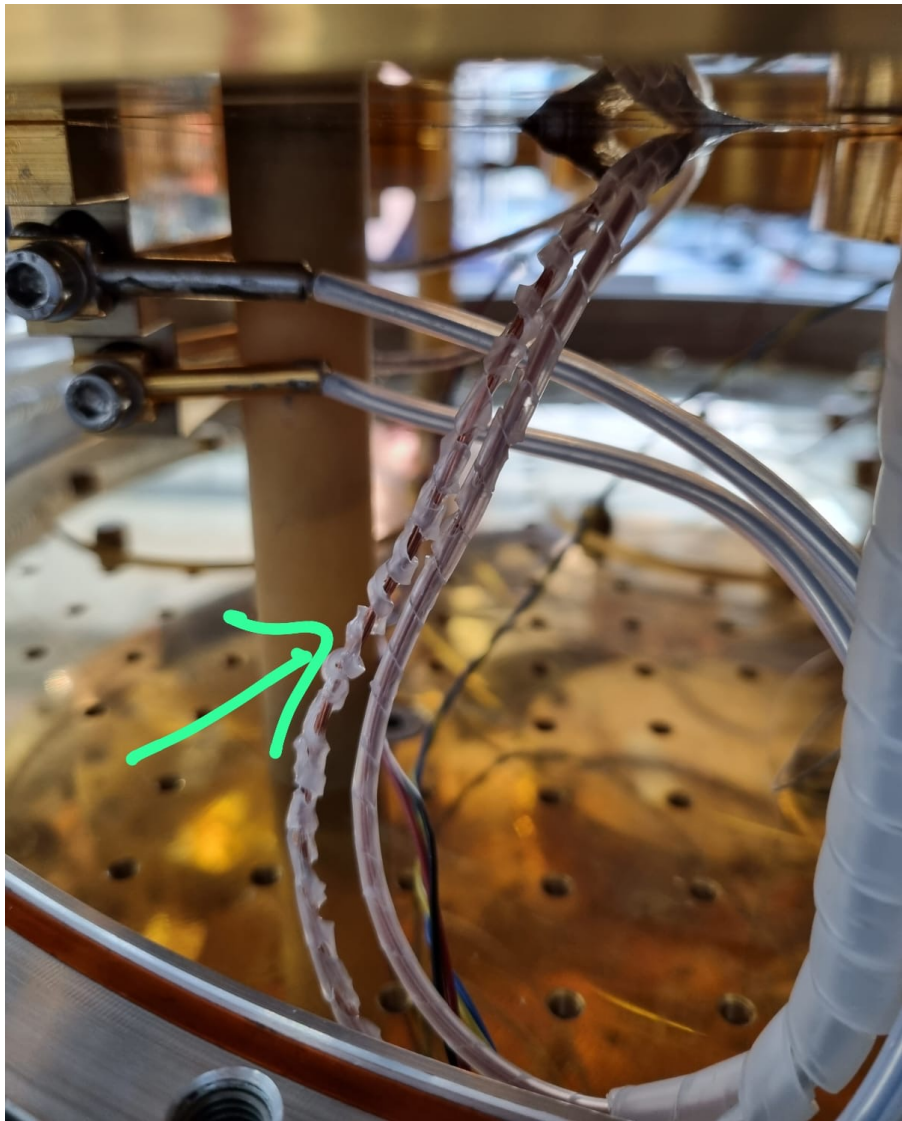




SC Magnet now operating at 9 T

- On June we finally reached the nominal field (9 T) of the cryostat's magnet.
- We noticed sistematic quenches of the magnet at 5-6 T
- We find out that it was due to a malfunctioning of one of the current leads (a NbTi section on the 4K plate was melted).
- Replacing the current leads fix the issue.





Publication 2nd half 2023

https://doi.org/10.1103/PhysRevD.108.062005
Arxiv : 2304.07505

PHYSICAL REVIEW D **108,** 062005 (2023)

Search for galactic axions with a traveling wave parametric amplifier

R. Di Vora, A. Lombardi, A. Ortolan, R. Pengo, and G. Ruoso*
INFN, Laboratori Nazionali di Legnaro, 35020 Legnaro (Padova), Italy

C. Braggio
INFN. Sezione di Padova. 35100 Padova. Italy

instruments

MDPI

Article

Microwave Photon Emission in Superconducting Circuits

Alessandro D'Elia [1], Alessio Rettaroli [1,*], Fabio Chiarello [1,2], Daniele Di Gioacchino [1], Emanuele Enrico [3,4], Luca Fasolo [3,5], Carlo Ligi [1], Giovanni Maccarrone [1], Federica Mantegazzini [4,6], Benno Margesin [4,6], Francesco Mattioli [1,2], Simone Tocci [1], Andrea Vinante [4,6,7] and Claudio Gatti [1]

https://doi.org/10.3390/instruments7040036
(open access)

Contents lists available at ScienceDirect

Physics of the Dark Universe

journal homepage: www.elsevier.com/locate/dark

Full Length Article

The future search for low-frequency axions and new physics with the FLASH resonant cavity experiment at Frascati National Laboratories

David Alesini [a], Danilo Babusci [a], Paolo Beltrame [b], Fabio Bossi [a], Paolo Ciambrone [a], Alessandro D'Elia [a,*], Daniele Di Gioacchino [a], Giampiero Di Pirro [a], Babette Döbrich [c], Paolo Falferi [d], Claudio Gatti [a], Maurizio Giannotti [e,f], Paola Gianotti [a], Gianluca Lamanna [g], Carlo Ligi [a], Giovanni Maccarrone [a], Giovanni Mazzitelli [a], Alessandro Mirizzi [h,i], Michael Mueck [j], Enrico Nardi [a,k], Federico Nguyen [l], Alessio Rettaroli [a], Javad Rezvani [m,a], Francesco Enrico Teofilo [n], Simone Tocci [a], Sandro Tomassini [a], Luca Visinelli [o,p], Michael Zantedeschi [o,p]

https://doi.org/10.1016/j.dark.2023.101370
Arxiv : 2309.00351

Publication 2nd half 2023

- *High kinetic inductance NbTiN films for travelling wave parametric amplifiers* *(DART-WARS)*
- *SQN as single microwave photon detector for Galactic Axion Search* *(SUPERGALAX)*
- *Experimental characterization of RF-SQUIDs based JTWPA exploiting RPM scheme* *(DART-WARS)*
- *Quantum sensing with superconducting qubits for fundamental physics* *(QUB-IT)*
- *Nonlinear behavior of a Josephson Traveling Wave Parametric Amplifier* *(DART-WARS)*
- *Development of KITWPA amplifiers for the DARTWARS project* *(DART-WARS)*

Proceedings from EUCAS 2023, accepted for publication in IEEE Trans. Appl. Sup.

EUCAS2023
Bologna, Italy
3rd-7th September
16th European Conference on Applied Superconductivity

Conclusion

- The FINUDA magnet is almost ready for the cooling / energizing test. We will start the preliminary operations on the cryogenic plant in the next days.
- The setup for the QUAX run for axion search with the tunable cavity is foreseen in the next weeks.
- The 9T SC magnet mounted on the dilution refrigerator is now operating at the nominal field.
- Test on the ReBCO cavity was quite successful and gives promising expectations for the next runs.

A special thanks for the FINUDA preparation to: Sandro Tomassini, Giampiero Di Pirro, Daniele Di Bari, Giuseppe Ceccarelli, Marco Beatrici, Marco Martini, Antonio Sorgi, General Montaggi, Cryosystem Engineering