



VIRGO
LIGO

GravNet

Claudio Gatti



GravNet

A Global Network for the Search of High Frequency Gravitational Waves



This MoU aims to extend the network beyond ERC participants.

Memorandum of Understanding of the GravNet Collaboration

1. Purpose of this Memorandum

1.1. This Memorandum establishes a common basis among the Participants for the collaborative effort required to set up a global network for the search for high-frequency gravitational waves.

Initial sites: Mainz, Bonn, Frascati



Radio haloscope



Quantum Sensing



X-band haloscope

GravNet is now a Recognized Experiment at CERN

GravNet CDR - available on arXiv

arXiv > astro-ph > arXiv:2603.24645

Search...
Help |

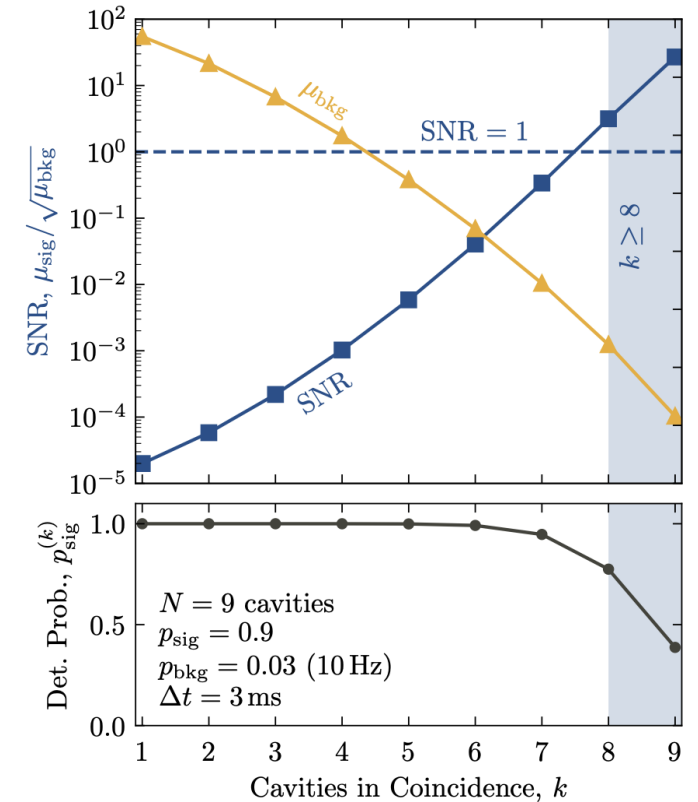
Astrophysics > Instrumentation and Methods for Astrophysics

[Submitted on 25 Mar 2026]

Global detector network to search for high-frequency gravitational waves (GravNet): conceptual design

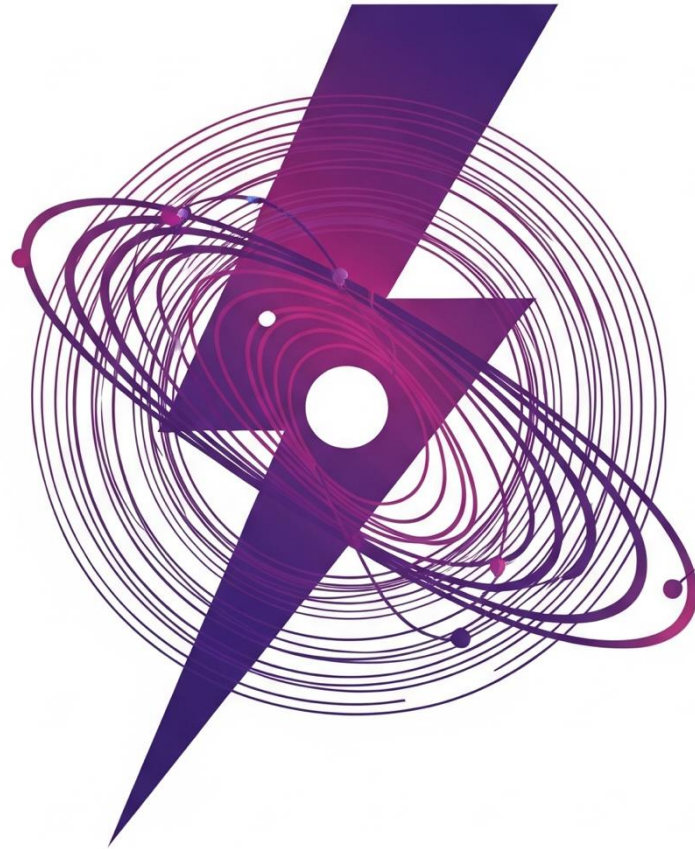
Setup	f_0 [GHz]	Q_0	T_{sys} [K]	P_{noise} [W]	h^{min}
HF C-band	5.0	3.0×10^5	0.3	4×10^{-20}	1.7×10^{-20}
FLASH Radio	0.15	7.5×10^5	2.2	6×10^{-21}	2.2×10^{-21}

$$P_{\text{sig}} = \frac{\beta}{1 + \beta} \frac{\omega_g}{2\mu_0} h_{\times,+}^2 \langle B_0^2 \rangle Q_l C_{\text{GW}}^{\times,+} V$$



GravNet-CAPP Collaboration:

Y. Kim et al. "Search for high-frequency gravitational waves via reanalysis of cavity axion data," PHYSICAL REVIEW D 113, 072015 (2026).



FLASH

FLASH Founding Meeting

The FLASH founding meeting will be held in July to formalize the collaboration.

FLASH Founding and General Meeting

1 Jul 2026, 09:00 → 2 Jul 2026, 18:00 Europe/Rome

LNF ed.36 - Salvini (LNF)

WEDNESDAY 1 JULY

09:30 → 09:40 **Welcome** 🕒 10m

13:30 → 14:30 **Lunch at LNF canteen** 🕒 1h

14:30 → 16:30 **General Seminar: SungWoo Youn "Axion dark matter searches at IBS with cavity haloscopes"** 📄
<https://agenda.infn.it/event/51866/>

THURSDAY 2 JULY

09:30 → 09:50 **Morning session** 🕒 20m

13:30 → 14:30 **Lunch at LNF canteen** 🕒 1h

14:30 → 16:30 **Visit to LNF** 📄

Bylaws of the FLASH Collaboration

May 2026

Contents

1	General considerations	2
1.1	The FLASH Collaboration	2

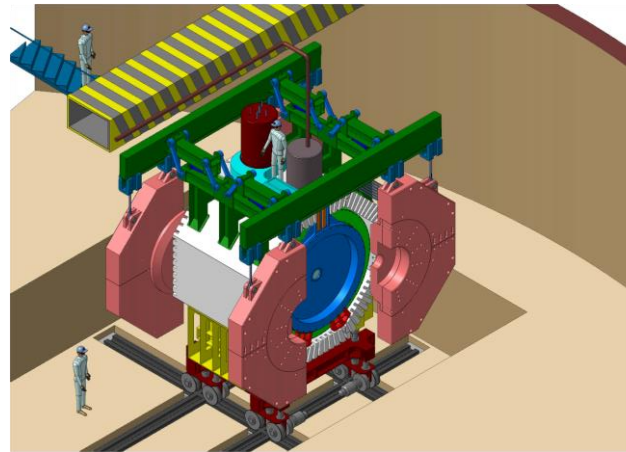
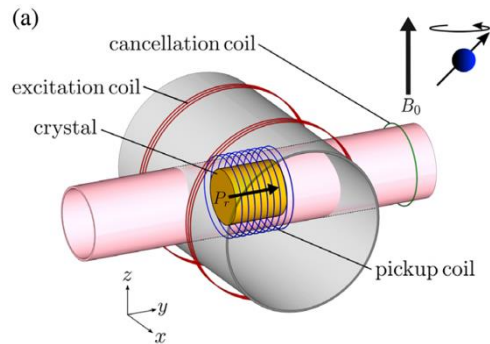


WP1 Physics Reach

(L. Visinelli and F. Mescia)

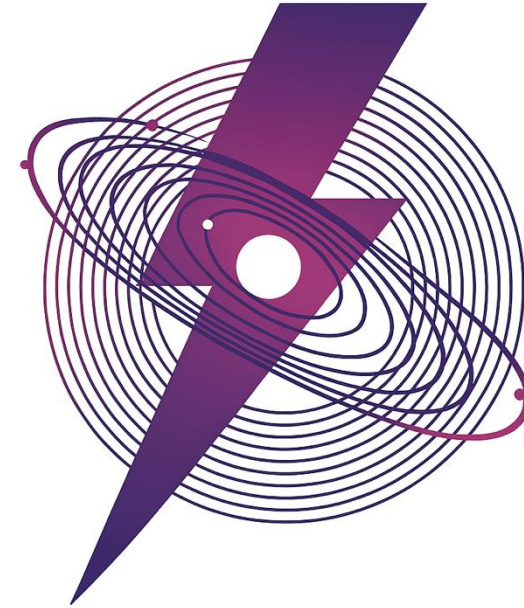
“Cross correlation”

What do we gain if we correlate “axion” signals measured at the same frequency with NMR and cavity experiments within one De Broglie wavelength (10Km)? (Sreemanti Chakraborti)



NMR axion experiment: Deniz Aybas (Bilkent University); R&D in Uni Camerino cryostat at 1.5K in a 12T magnet (J. Rezvani).

Frascati National
Laboratories



FLASH
THEORY WORKING
GROUP

Physics Reach for FLASH TDR

For the TDR writing, we are simulating the cavity modes with the new geometry and recalculating the couplings.

Mode	f_r (MHz)	L_{inM_0} (mm)	β
TM ₀₁₀	129.18	45	1.05
TM ₀₁₁	163.31	40	0.98
TM ₁₁₀	204.17	40	0.96
TM ₁₁₁	227.30	36	0.99
TM ₀₁₂	237.97	43	0.97
TM ₂₁₀	259.26	61	1.03
TM ₂₁₁	277.83	55	0.96
TM ₁₁₂	285.69	37	1.04
TM ₀₂₀	289.97	29	0.97
TM ₂₁₂	327.33	56	1.00

Axion, Dark Photons, HFGW

HFGW

Axion, Dark Photons

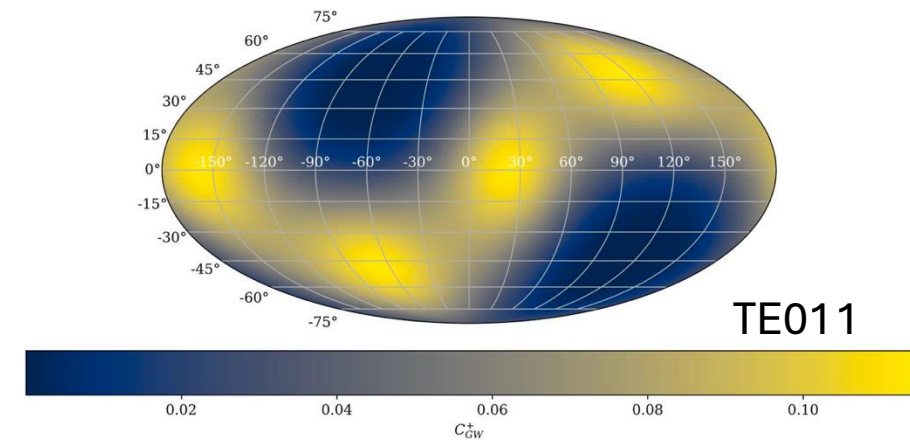
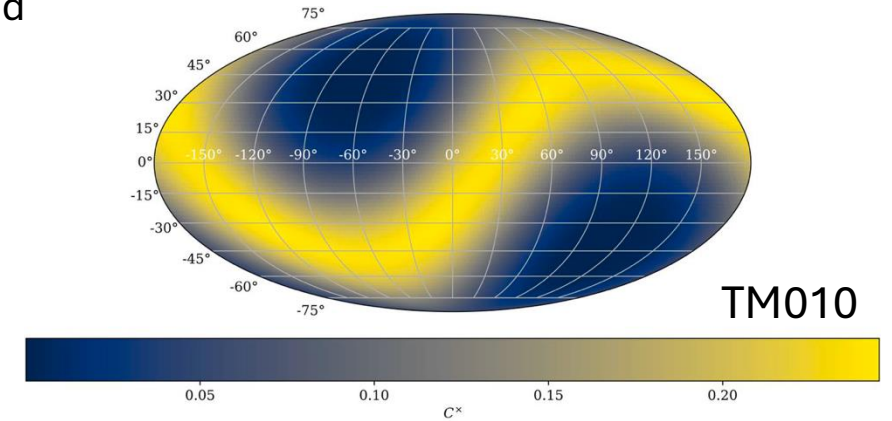
HFGW

Mode	f_r (MHz)	β	BW_{-3dB} (KHz)	$Q_L (\cdot 10^5)$	$Q_0 (\cdot 10^5)$
TE ₁₁₁	135.891	0.775	0.53	2.83	5.02
TE ₂₁₁	190.583	0.665	0.70	2.75	4.58
TE ₀₁₁	218.340	0.718	1.00	2.34	4.03
TE ₁₁₂	220.057	0.681	1.20	2.19	3.69
TE ₂₁₂	257.449	1.500	1.10	2.63	6.58

Scalars

HFGW

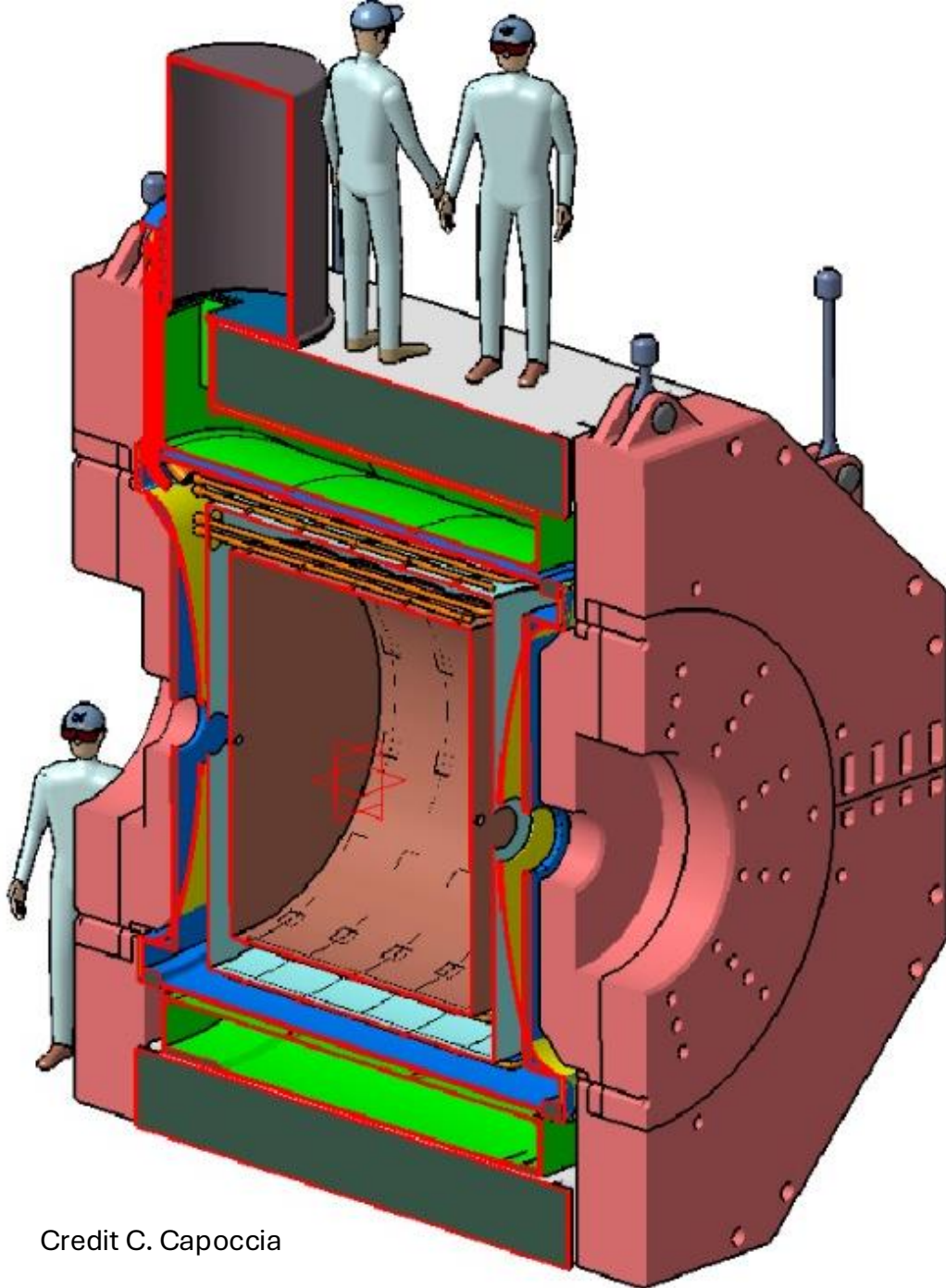
Chameleons,
HFGW, Scalars



Credit Younggeun Kim (Mainz)

WP2 Cryogenic Design

(C. Ligi)

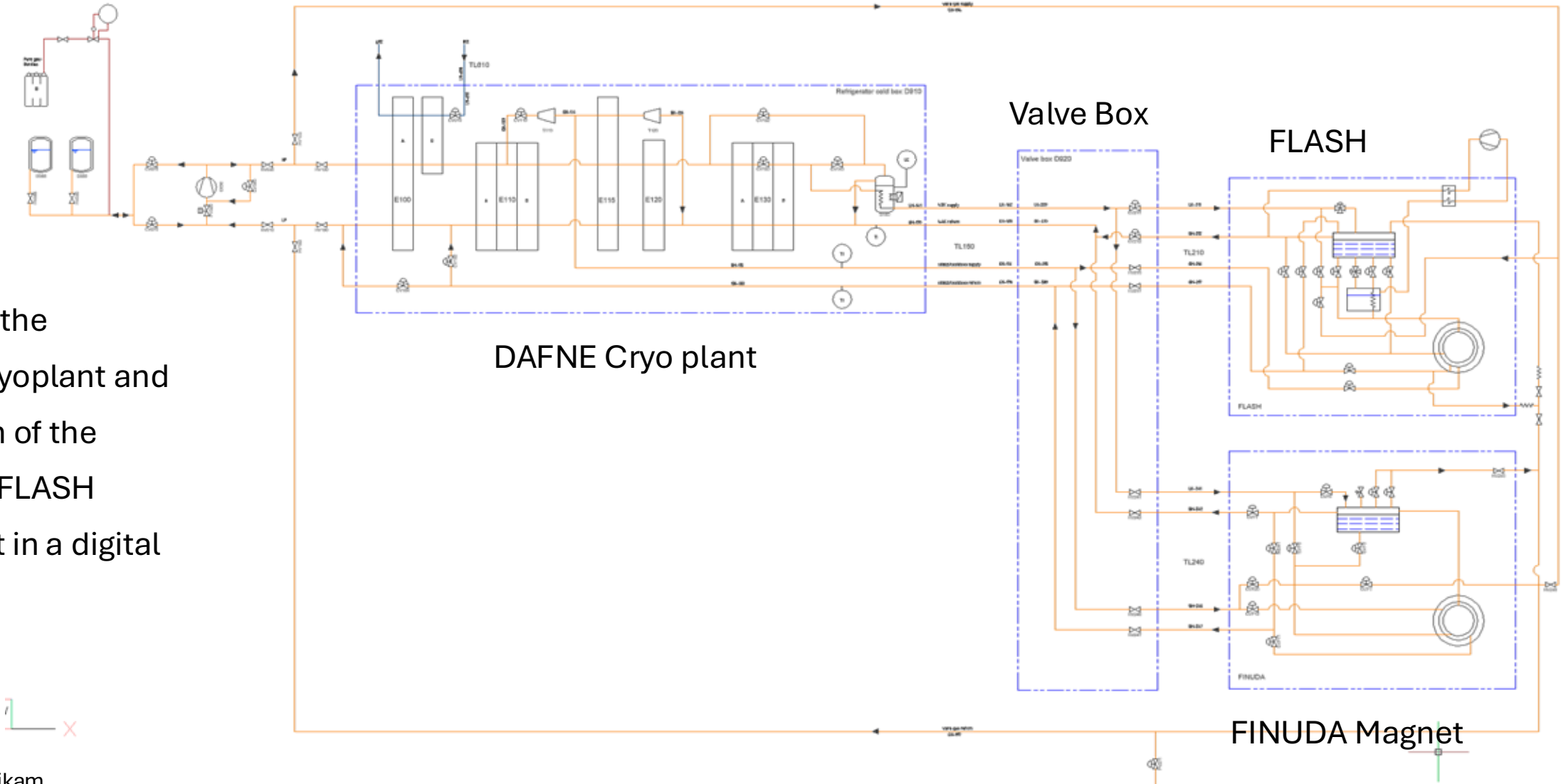


Credit C. Capoccia

- Definition of the RF cavity cryostat general layout details
- Cryostat cryo/mechanical design of
 - RF cavity
 - vacuum shield
 - 70 K radiation shield
- Cryogenic turret cryo/mechanical design
- Cryogenic transfer lines design
- 4K cryostat for the prototype

P&ID for the FLASH Plant

Update of the existing cryoplant and Integration of the proposed FLASH cryo-turret in a digital P&ID

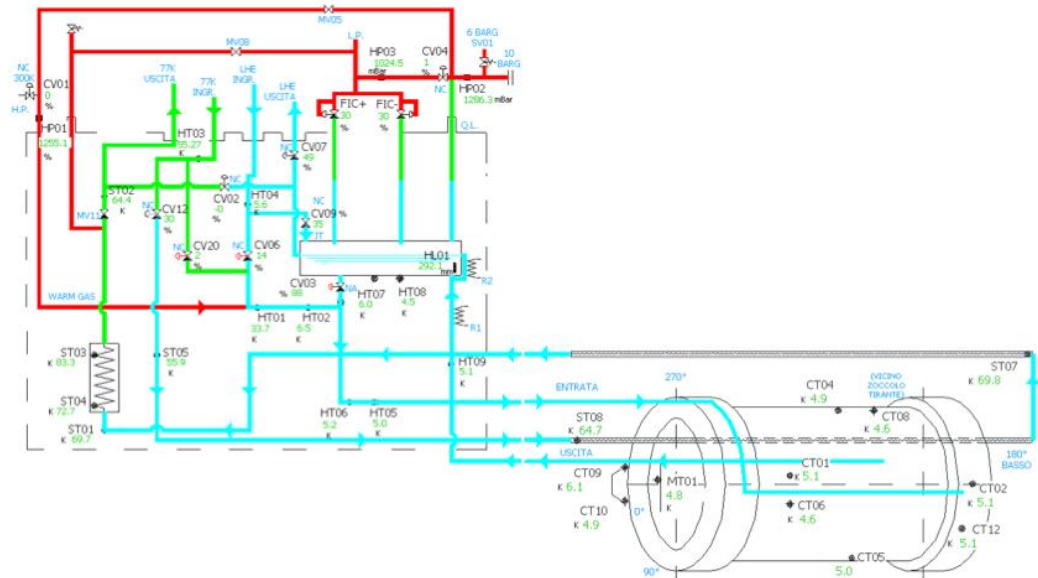
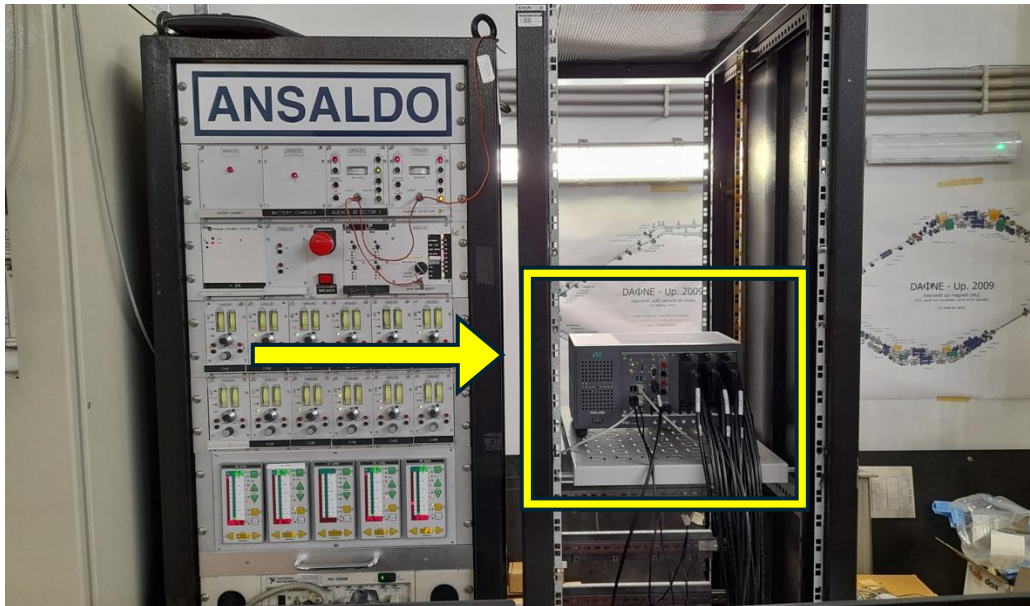


New Magnet Cryogenics Control System

The new FINUDA Magnet cryogenics control system (NI compact RIO – 9045) was delivered last month

Technicians are working in these weeks to

- Move the wiring (some hundreds of wires) from the old control system to the new one – A new flange needed with several connectors (purchase order in progress).
- Update the old Labview software to the new 2025 version on the new PLC



FLASH Cryogenic Plant - Infrastructure Status and Open Items

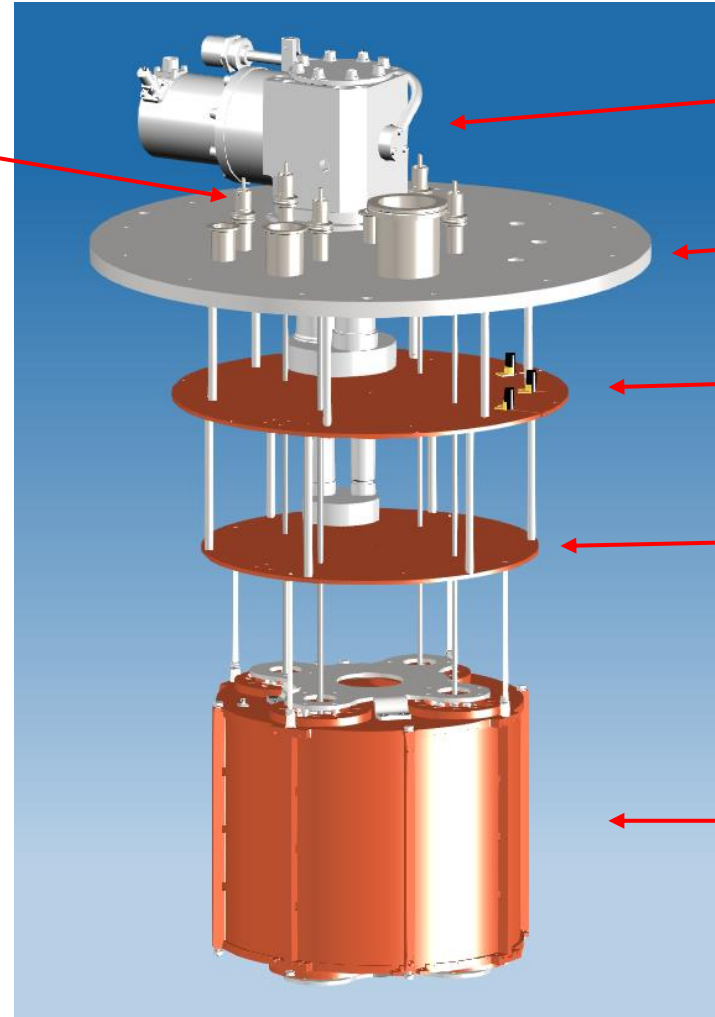
- **PED** (pressure equipment directive) **Certification**
 - **Cold box opening** scheduled for May for inspections and non-destructive tests.
 - Includes recertification of more than 20 **safety valves** from the cryogenic plant and FINUDA magnet turret — offer requested. (*In progress — pending budget approval for valves*)
- **Plant Maintenance (Vorbuchner Company - Germany)** Quote received — maintenance feasible by end of 2026 or early 2027. (*Order to be placed upon budget confirmation*)
- **Water Cooling Infrastructure** The cryogenic compressor (200 kW) and ancillary systems require dedicated water cooling. Three open items:
 - **Compressor cooling tower:** damaged — evaluating replacement. Study ongoing.
 - FINUDA magnet power supply: former **DAΦNE cooling circuit** no longer available — dedicated solution required. Study ongoing.
 - Turbomolecular pumps: **new chiller** to be procured.
- **Plant Control System (Siemens Simatic S7-400 PLC)** Full replacement exceeds current budget. Existing system maintained with available spare boards.

4K Cryostat for the Cavity Prototype

- The design of the cryostat for the prototype is almost completed

Feedthroughs for cavity tuning

- 300K SS flange design is complete – it will be machined by an external company (waiting for budget to be available)
- The rest will be machined at LNF's mechanical workshop
- Rotary/linear Feedthroughs to be purchased from Pfeiffer (same as above for budget)
- Wiring:
 - 4 RF lines
 - 54 DC wires



Pulse Tube refrigerator

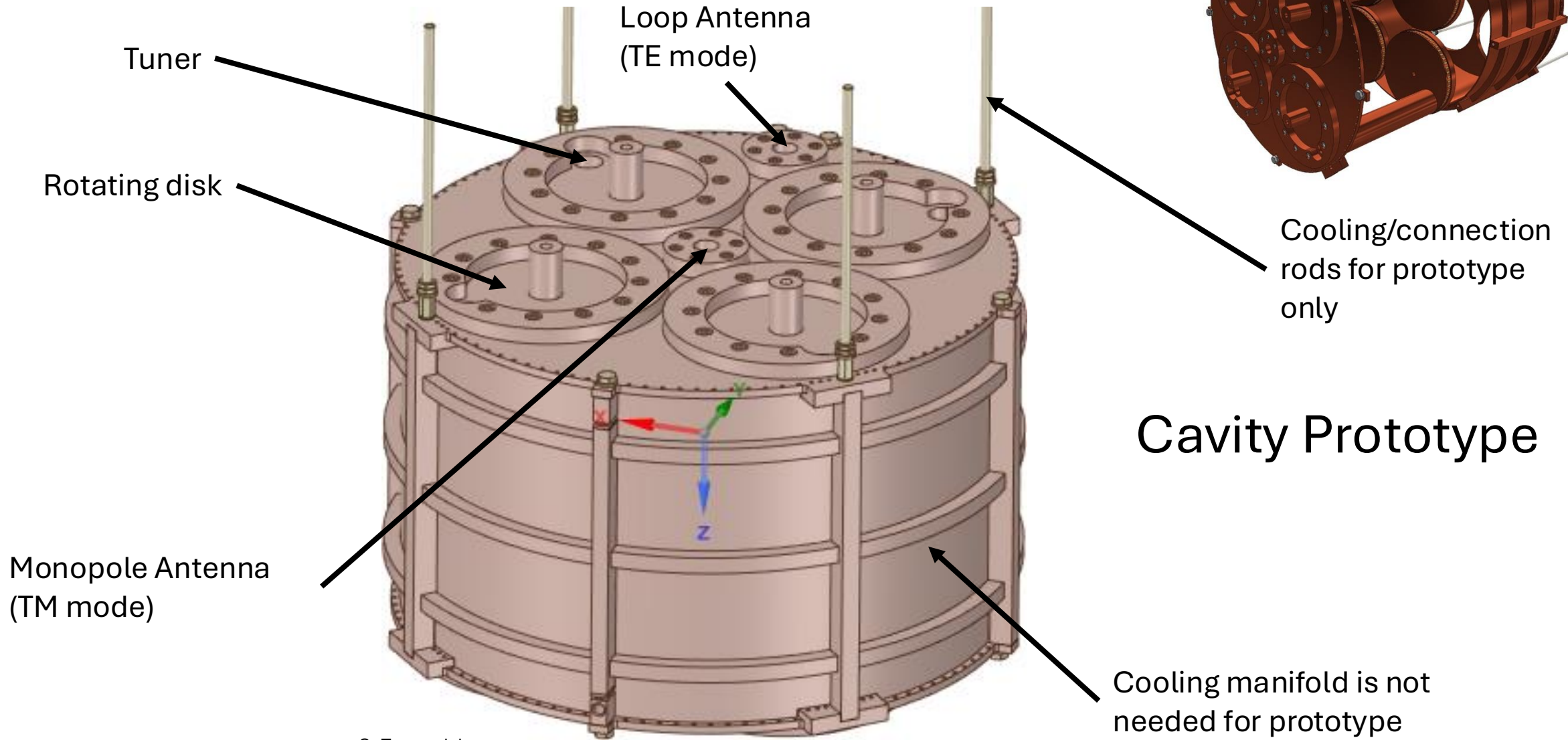
300K Stainless Steel Flange

50K Copper Flange (+ Al Shield)

4K Copper Flange

Cavity prototype

WP3: RF Cavity (S. Tocci and A. Diaz)



S. Tomassini
S. Tocci

Status of Cavity Prototype

Mode	Theory f_r (GHz)	Simulation f_r (GHz)	$Q_0 \cdot (10^5)$
TM ₀₁₀	0.65	0.71	1.43
TM ₀₁₁	0.85	0.89	1.16
TM ₁₁₀	1.04	1.12	1.90
TM ₁₁₁	1.17	1.24	1.50
TM ₀₁₂	1.28	1.29	1.47
TM ₂₁₀	1.40	1.41	2.06
TM ₂₁₁	1.50	1.51	1.59
TM ₁₁₂	1.51	1.55	2.46
TM ₀₂₀	1.51	1.58	2.07
TM ₂₁₂	1.77	1.78	1.68

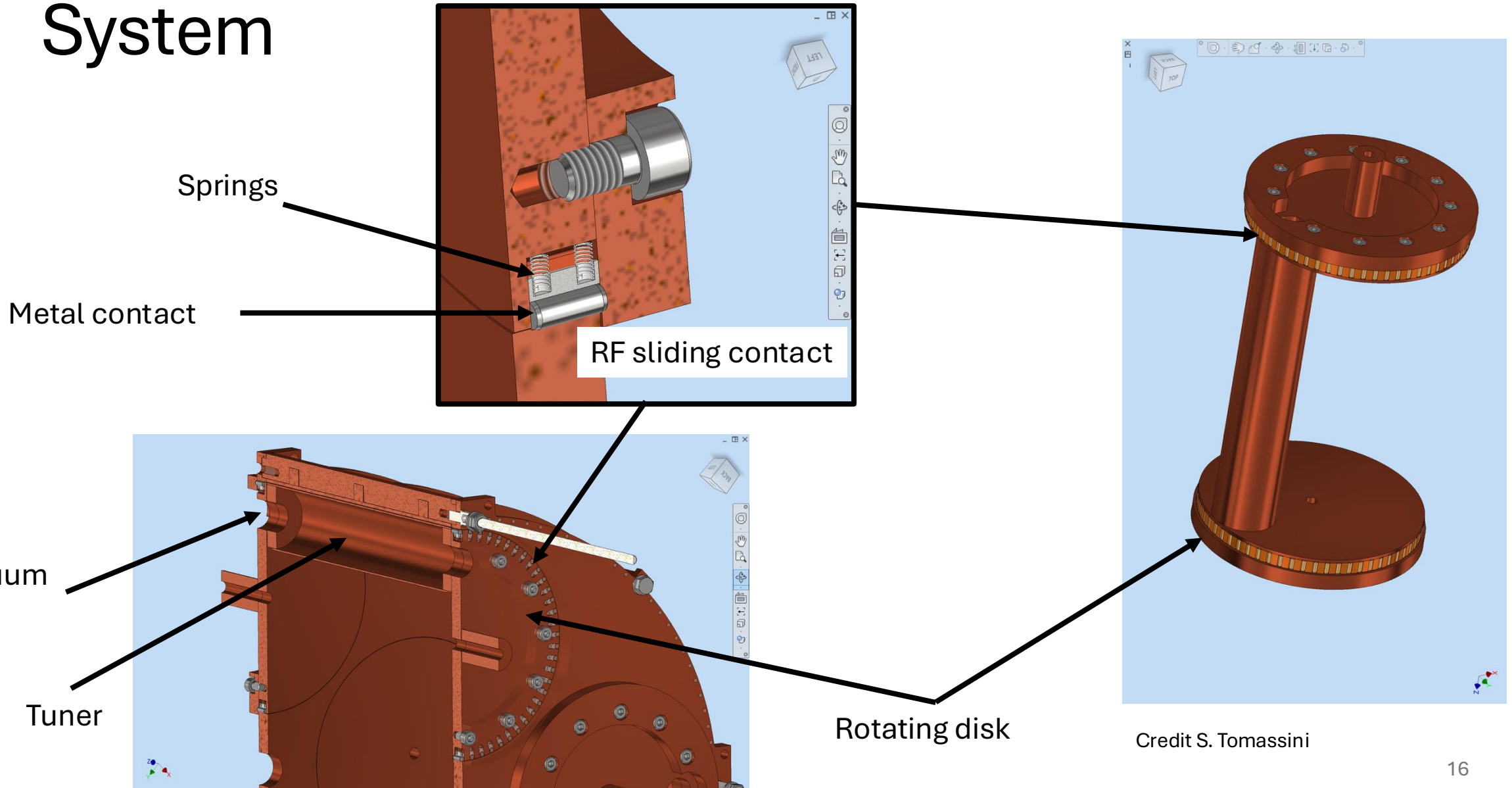
Credit Adrián Muñoz Urán



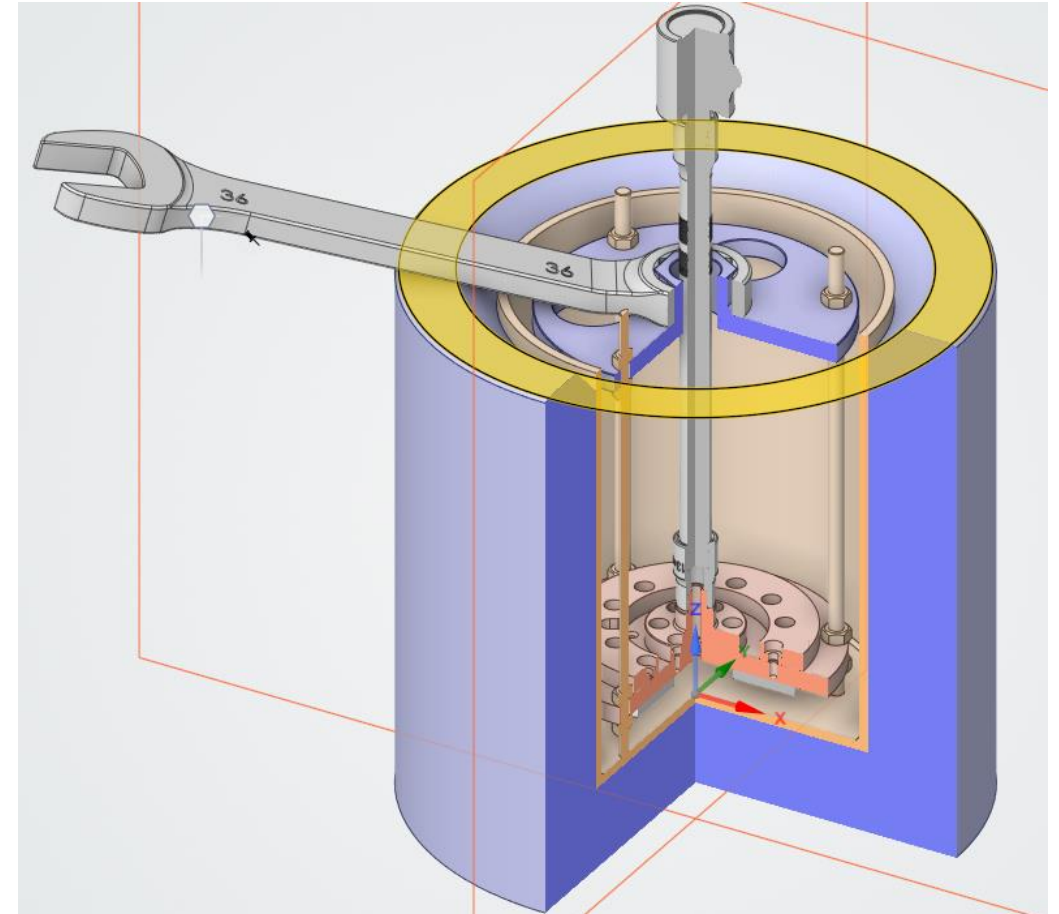
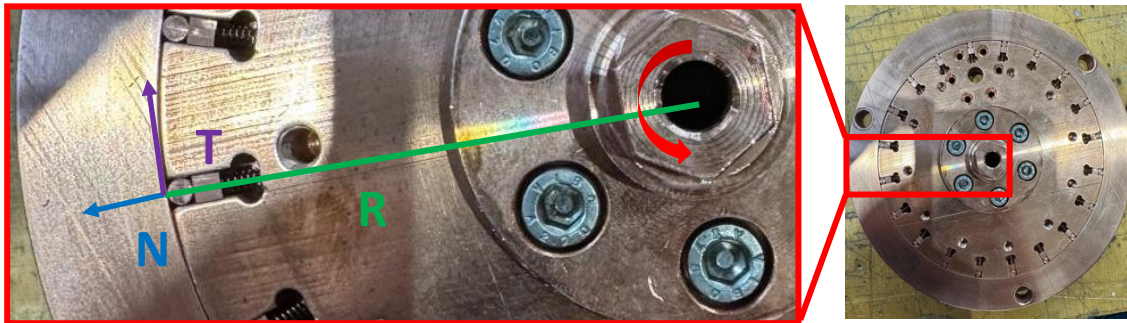
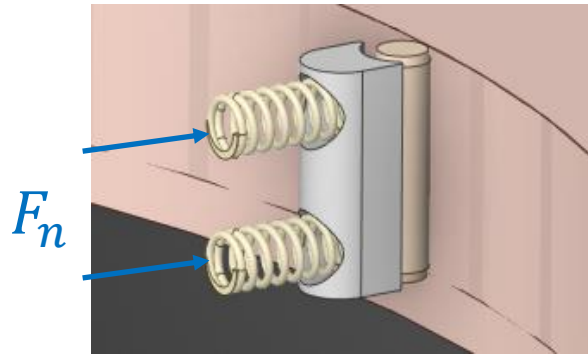
Credit F. Quattrocioni

- RF Simulations completed
- Mechanical design completed
- Copper purchased
- Copper roughness measured (Ra <0.6 micron)
- Chemical solution for surface treatment tested on a Cu sample at LNL (target Ra<0.4 micron)
- Cu packed and ready to be shipped (with many delays!) to Bonn for fabrication. Then to LNL for surface treatment and back to LNF for measurements.

Measurement of Friction in the FLASH Tuning System



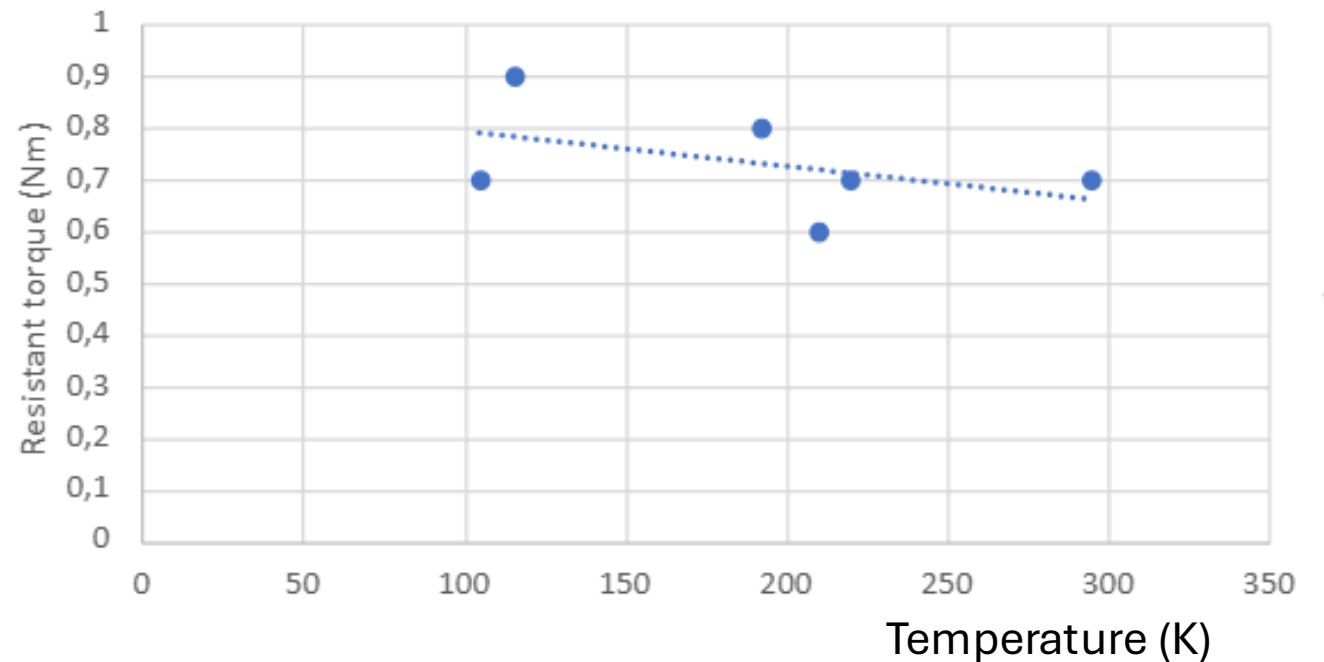
Measurement of Friction in the FLASH Tuning System



Measurement of Friction in the FLASH Tuning System

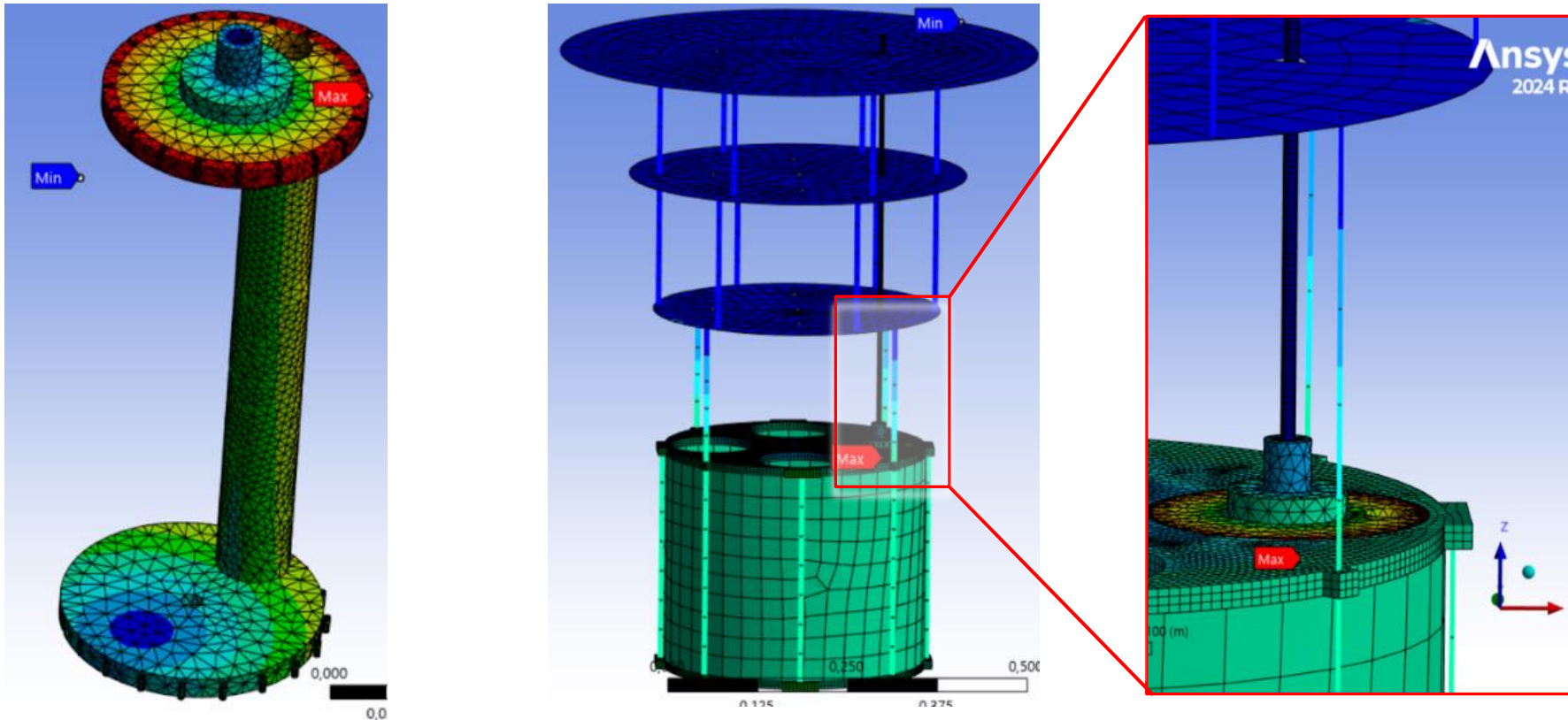


- Preliminary results in liquid nitrogen compatible with expectations.
- Tests will be repeated in vacuum.



Impact of Friction on Torsional Deformations

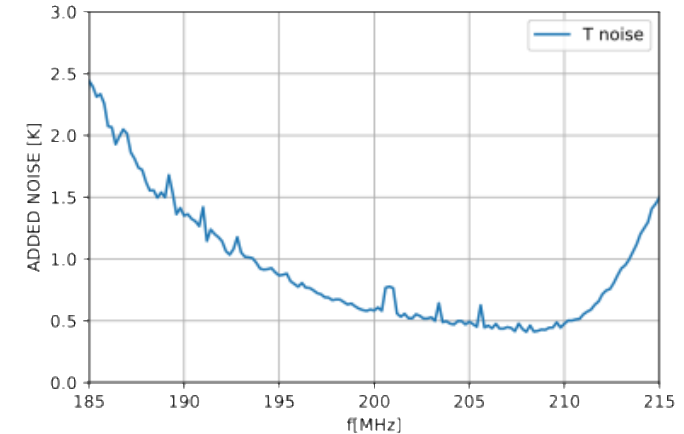
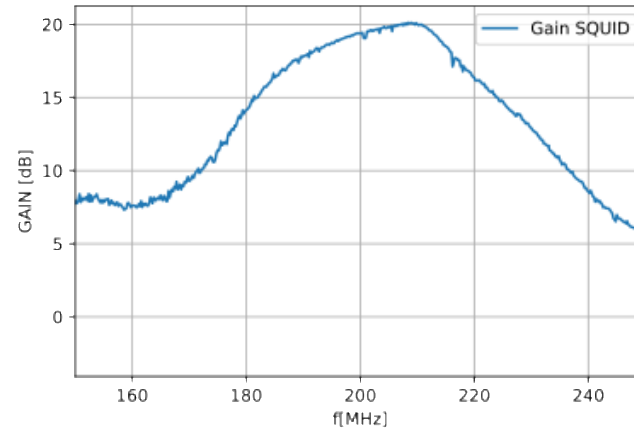
Ongoing simulations to understand the impact of the measured torque on the tuning system and the impact on the cavity tunability.



WP4: Signal Amplification and Acquisition

(P. Falferi and G. Lamanna)

Setup in Camerino University
Cryostat temperature $T=1.6$ K



$$T_{noise} = 1.6K + 0.5K \left(\frac{f}{210 \text{ MHz}} \right) \left(\frac{T}{1.6K} \right)$$

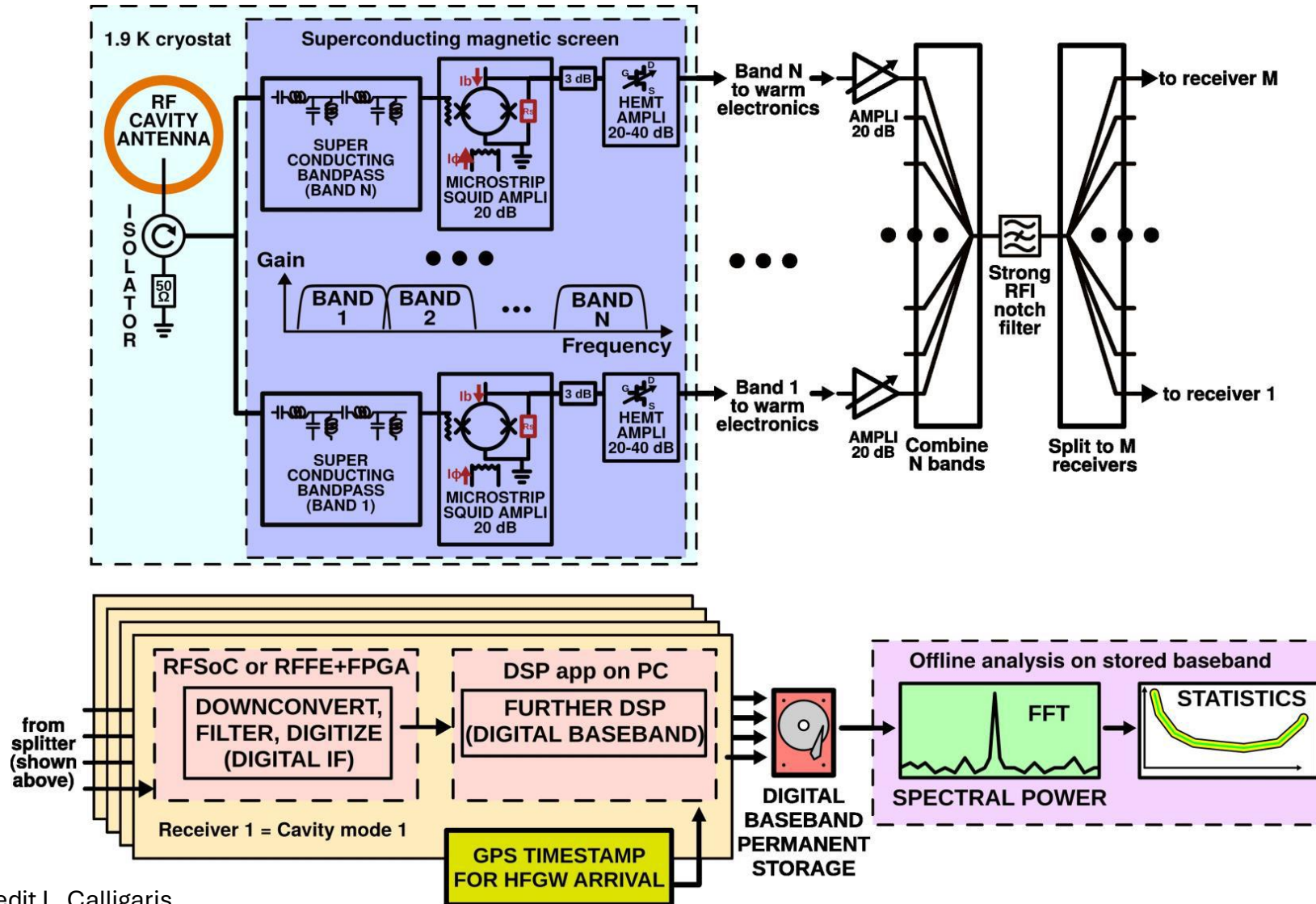
- Similar results obtained in Trento by P. Falferi
- We now expect 2.2 K total noise in FLASH at 120 MHz.
- No need to cool SQUID to lower T (e.g. 300 mK)!

FLASH	FREQUENZE	AGGRESSOR
107,900	RADIO FM PIU' VICINA	
114,000	SPURIA	127,800 SWITCH
115,290	"	132,010
116,000	"	128,764 DATA
118,000	"	131,825 AEROPOR
120,000	PORTANTE SPURIA SP.	131,725 ACARS
128,000	SPURIA	131,825 "
144,000	SPURIA	132,570 SPURIA
168,000	SPURIA	132,300 SPURIA
119,072	AEROPORTO (AM)	133,335 ACARS
120,503	"	134,378 SPURIA
118,758	SPURIA	135,150 SPURIA
117,961	SPURIA	136,000 SPURIA
120,000	"	137,621 (NON)
122,876	"	134,200 AEROPOR
121,878	"	140,630 SPURIA
123,025	SPURIA CHE SI MUOVE	142,055 BALL
123,802	AEROPORTO (AM)	148,535 SPURIA
123,421	" "	142,478 DATA
124,203	" "	143,761 SPURIA
124,000	SPURIA	144,000 PORTA
125,500	AEROPORTO (AM)	144,800 DATA
125,000	SPURIA	147,463 PORTA
127,800	"	147,708 SPURIA
126,458	AEROPORTO (AM)	150,000 PORTA
127,350	"	150,024 DATA
		144,851 HAM
		151,45 BALL
		152,365 SPURIA
		155,000 TRUN
		156,000 (QUA



RF Interference Survey of the DAFNE/FLASH Hall

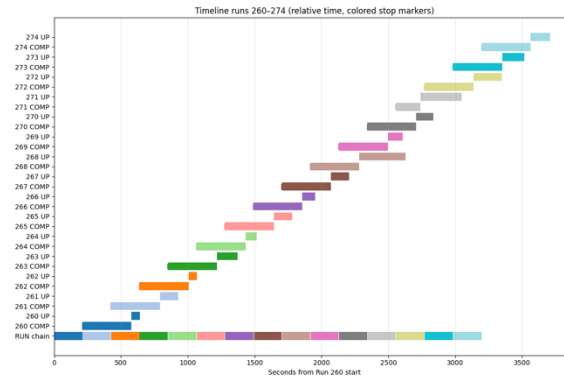
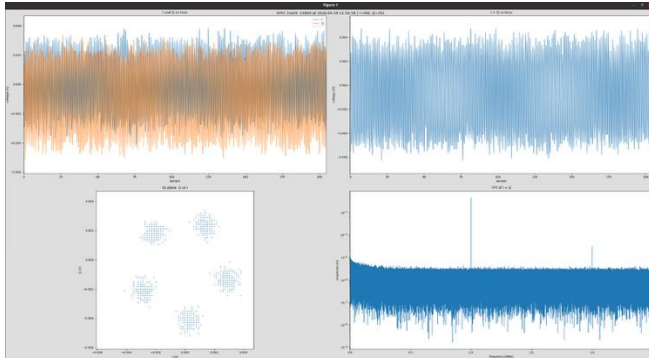
Readout Electronics Scheme



1. RF signal from cavity antennas are multiplexed to proper SQUID and amplified
2. Several options for room temperature electronics are considered to take into account requirements on: number of channels; tunability; bandwidth.
3. Plan to test it on the prototype.

WP5: Data Analysis and Computing

(K. Schmieden and G. Mazzitelli)



Run Status

Run: 243
Start: Fri Apr 24 17:23:51 2026
Running time: 66h19m37s
Alarms: On
Restart: Off
Data dir: /home/cold/data/

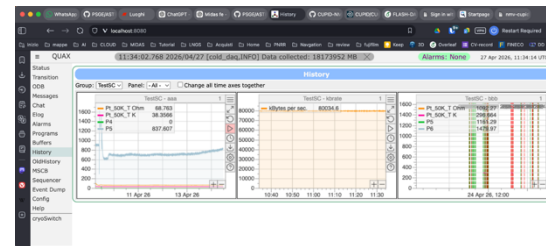
Experiment Name: QUAX
Write data: Free continuous run test - no write
Run description: 1777282979 11:42:59.638 2026/04/27 [cold_daq_INFO] Data collected: 18214912 MB

Equipment	Status	Events	Events/s	Data[MB/s]
Temp_Mercury	OK	11925	0.0	0.000
Temp_TF	OK	11925	0.0	0.000
Temp_AVS	OK	11925	0.0	0.000
NetBox	cold_daq@localhost	1.139M	4.8	79.892
timestampGPS	Running	0	0.0	0.000
CryoSwitch	Running	0	0.0	0.000

Channel	Events	MB written	Compr.	Disk Level
#0: run00238.mid	0	0.000	0.0%	13.3%

Lazy Label	Progress	File Name	# Files	Total
mhttpd [localhost]		Logger [localhost]		timestampGPS [localhost]
CryoSwitch [localhost]		cold_daq [localhost]		SC Frontend [localhost]

Clients



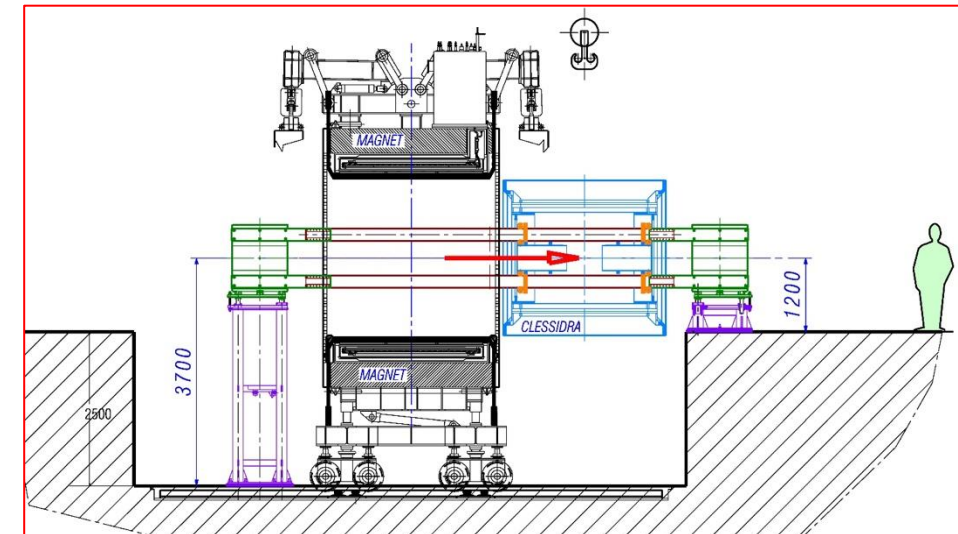
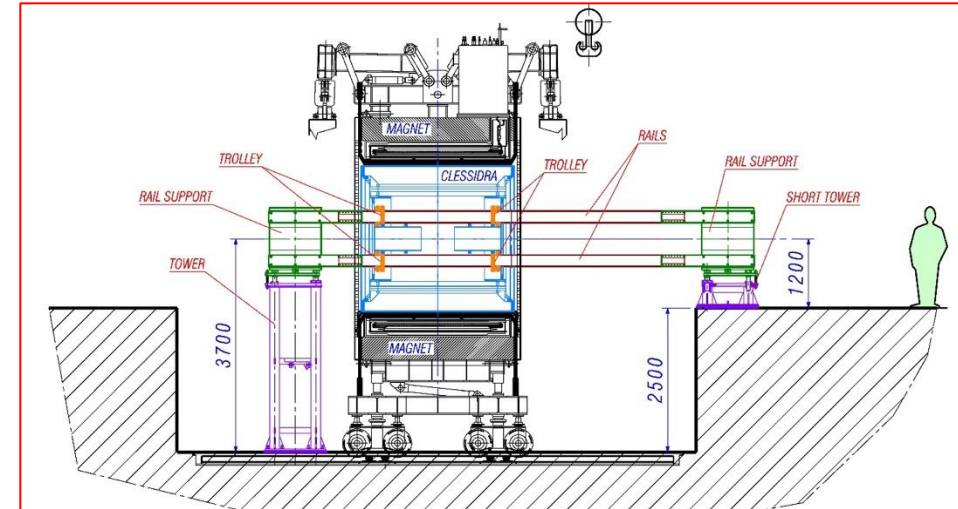
```
[root@83e91532f20e ~]# rucio did list data:* --filter type=file
SCOPE:NAME | [DID TYPE]
data:LNF/run00249.mid.gz | FILE
data:LNF/run00250.mid.gz | FILE
data:LNF/run00260.mid.gz | FILE
data:LNF/run00261.mid.gz | FILE
data:LNF/run00262.mid.gz | FILE
data:LNF/run00263.mid.gz | FILE
data:LNF/run00264.mid.gz | FILE
data:LNF/run00265.mid.gz | FILE
data:LNF/run00266.mid.gz | FILE
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data:LNF/run00270.mid.gz | FILE
data:LNF/run00271.mid.gz | FILE
data:LNF/run00272.mid.gz | FILE
data:LNF/run00273.mid.gz | FILE
data:LNF/run00274.mid.gz | FILE
data:run00245.mid.gz | FILE
```

- **Spectrum digitizer** successfully integrated into the FLASH/QUAX DAQ, together with all required auxiliary equipment (thermometers, cryogenic switch, etc.).
- **DAQ pipeline** optimised strongly reducing the latency.
- **Storage and tape** for the experiment are now available and ready to be used (handled by RUCIO)
- **Slow control** of auxiliary variables are being integrated
- **Online monitor and GPS** have been introduced



WP6: FINUDA Decommissioning and FLASH Commissioning (S. Gazzana)

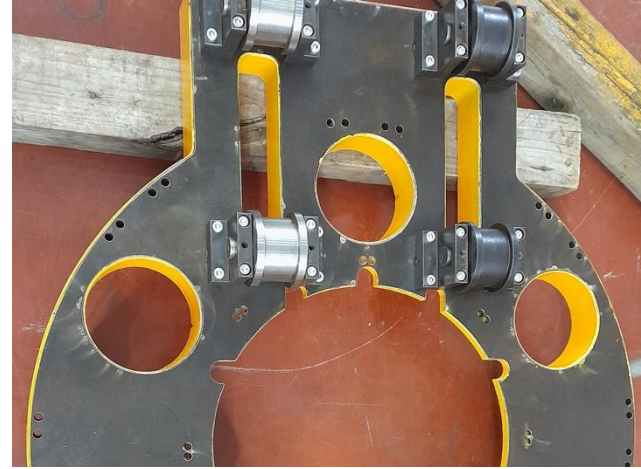
- **Mar 2025** Decommissioning start
- **Apr 2025** Endcaps opened
- **May 2025** Electrical/gas cabling & racks removed
- **Oct 2025** Assembly tools collected & inspected
- **NOW (Jan26- ..)** Tools refurbishment ~80% complete
- **This monday** ~~NEXT~~ Detector survey → define reference quotes
- **May 2026** Complete remaining tooling (<20%)
- **May/June 2026** Clepsydra extraction



Refurbishment of Extraction Tools

- Original FINUDA assembly tools retrieved from outdoor storage near the DAFNE area
- Tools had to to be checked for corrosion and structural integrity





Refurbishment of Extraction Tools

- Work entrusted to an external company
- Tools refurbishing 80% completed
- Survey to establish reference geometry for tools alignment done!





Work is underway to complete the “Clessidra” extraction by summer.

Safety Analysis

What we are doing:

- **Mapping all risks** of the FLASH+FINUDA integrated system
- **Ranking them by severity:** direct safety risks, equipment protection, operational issues
- Using the well-established **FINUDA safety architecture** as our starting point

How we are doing it:

- **Preliminary Hazard Analysis** (done) — first screening of all potential hazards, filtering out non-credible scenarios
- **HAZOP** — systematic review of how the system can deviate from normal operation and what the consequences are
- **Fault Tree Analysis** — detailed logic analysis of the most critical scenarios to understand root causes and verify that barriers are adequate

Integrated Safety Case

Ongoing — collects all analyses

Structured Risk Analysis (FTA + HAZOP)

Next step — targeted to retained scenarios

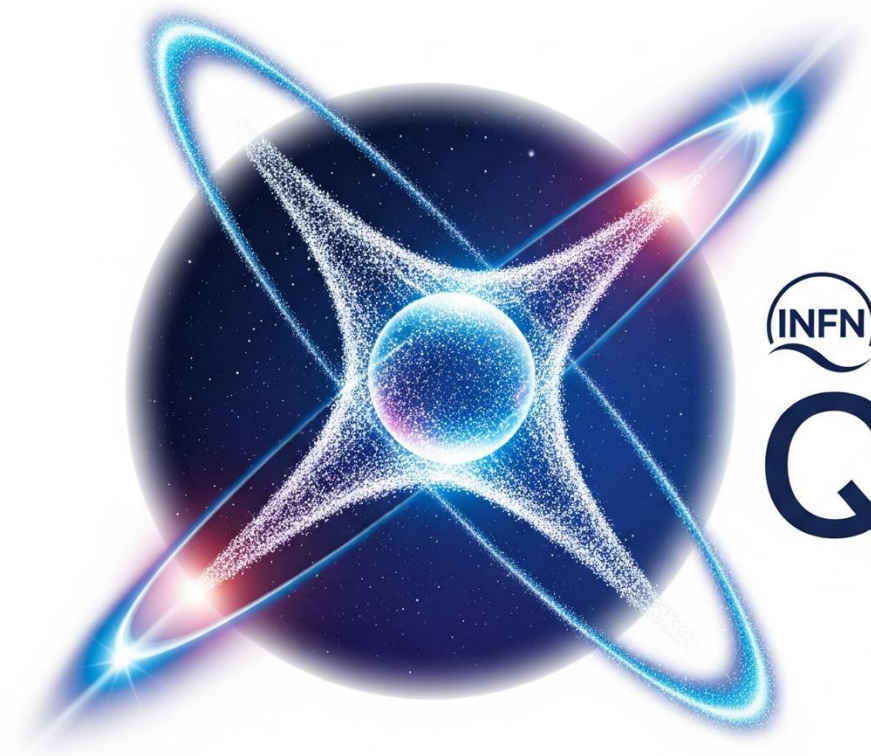
Preliminary Hazard Analysis (PHA rev.2)

Complete — modification-based, screened scenarios

FINUDA Safety Baseline

Legacy architecture — preserved & extended

Consultancy contract currently underway for the preparation of a Risk Analysis (RA) relating to the FLASH experiment



(INFN) INFN
QUAX

QUAX@LNF



- Successful test of new tuning system ($T=4K$)
- Heat switch repaired and installed
- Improved calibration of HEMT and TWPA amplifiers with cryogenic noise-source



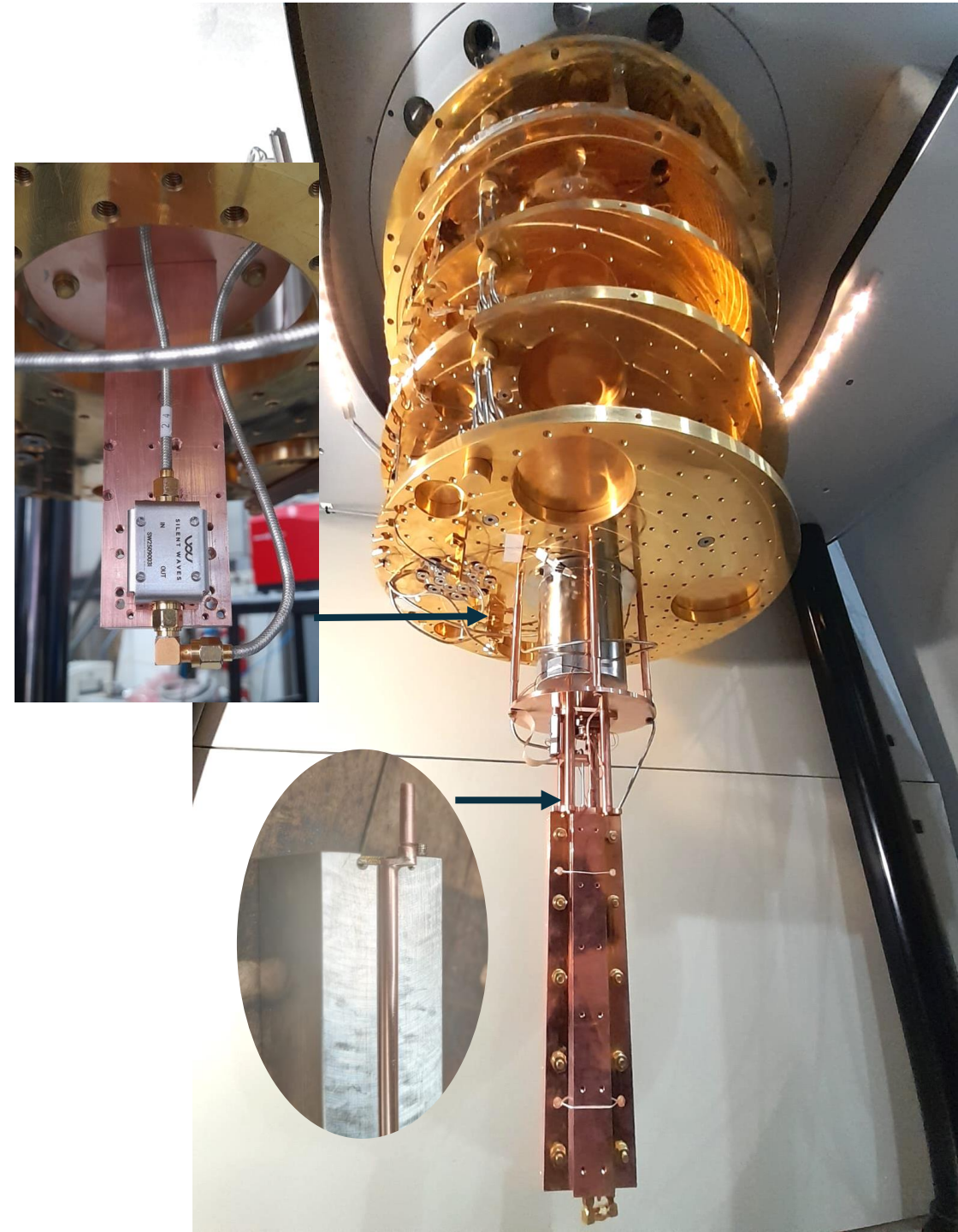
- Successful test of TWPA with $B=8.5T$
- Test of multi-mode acquisition for HFGW



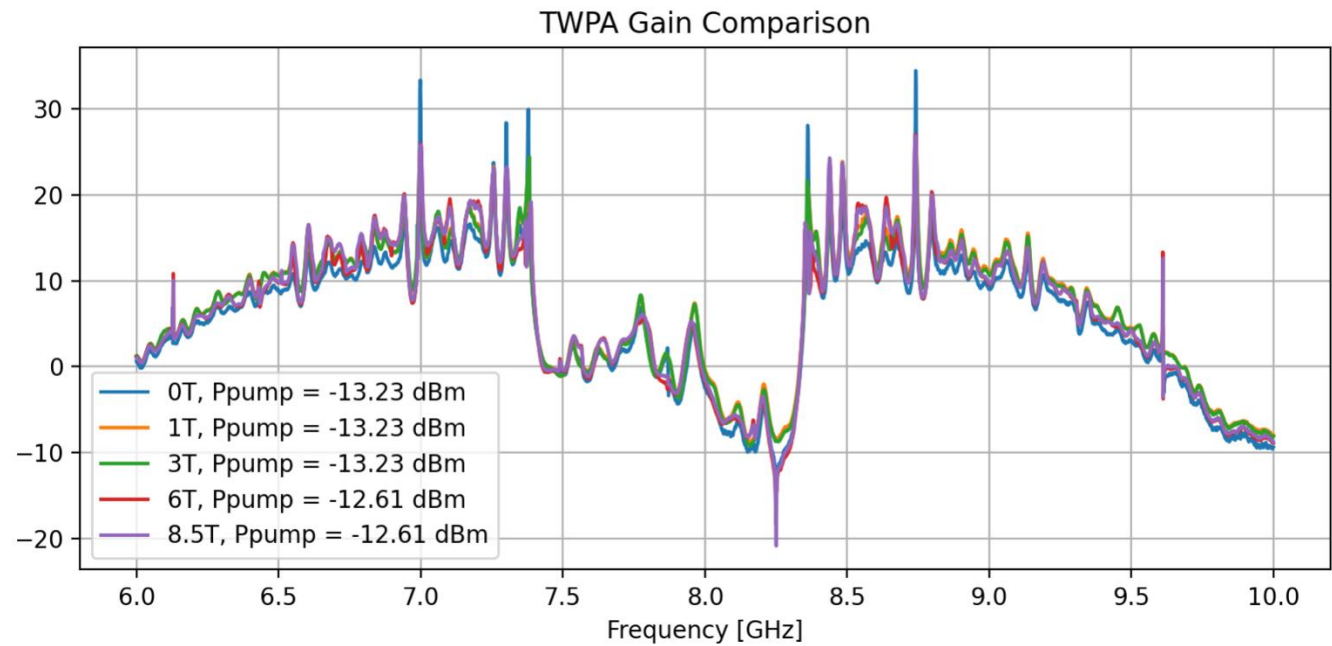
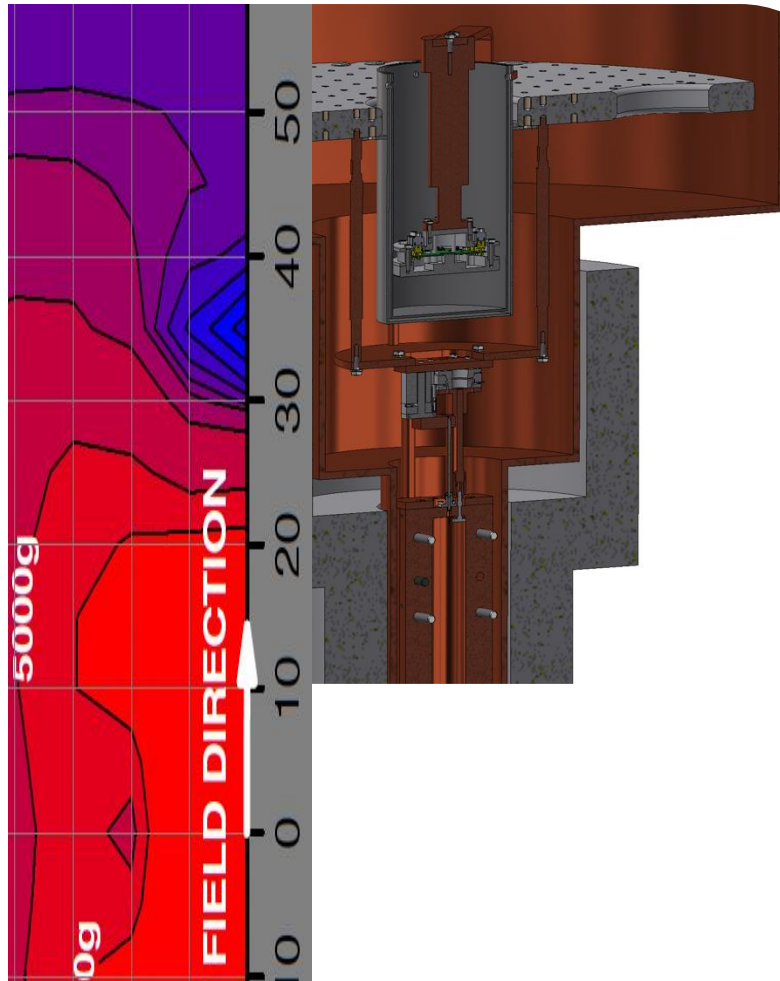
- Anti-vibration jaw (G. Pileggi)



If no further problems arise, we plan to begin data taking by the end of May!

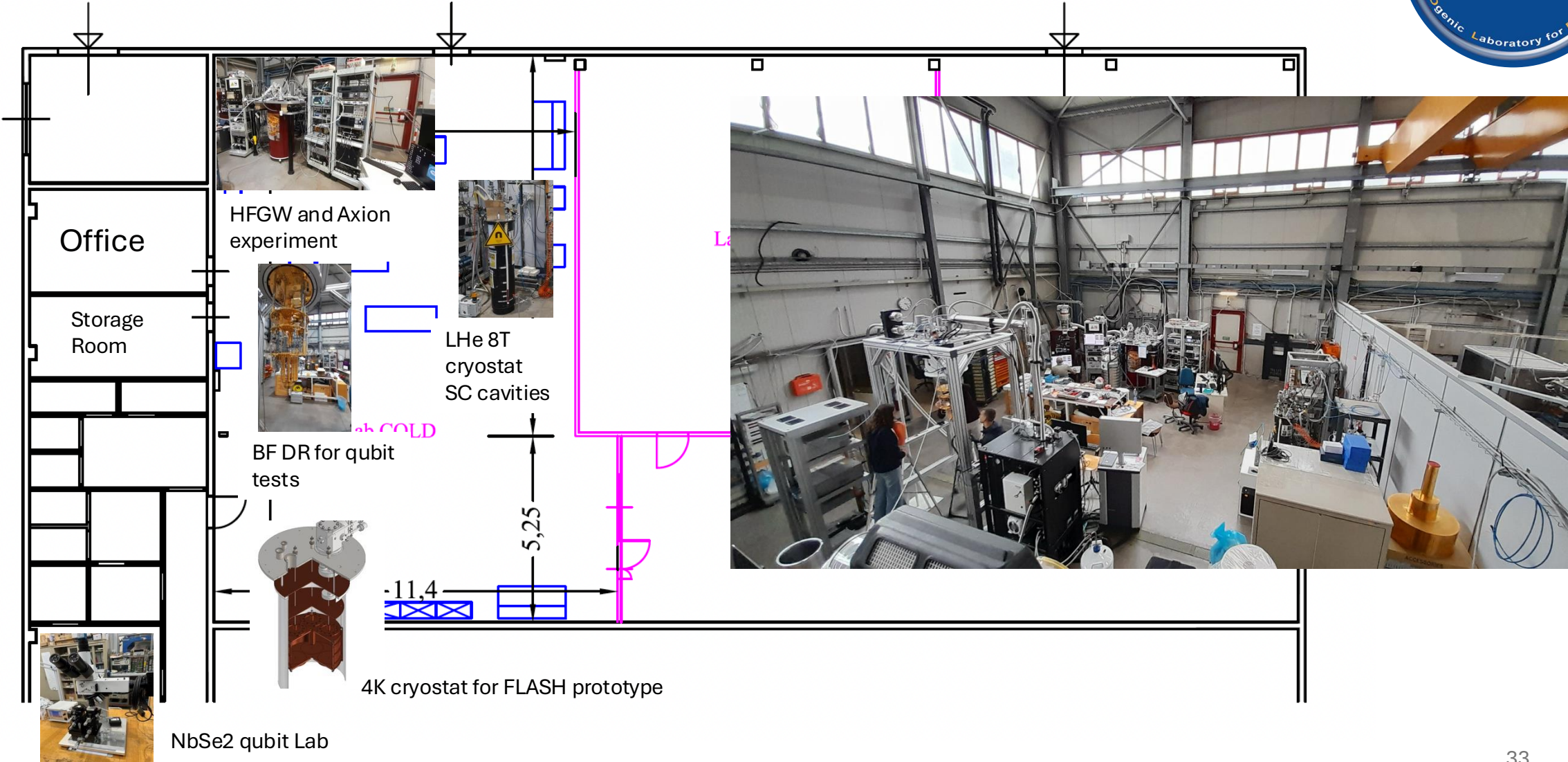


Successful test of TWPA with $B=8.5\text{T}$

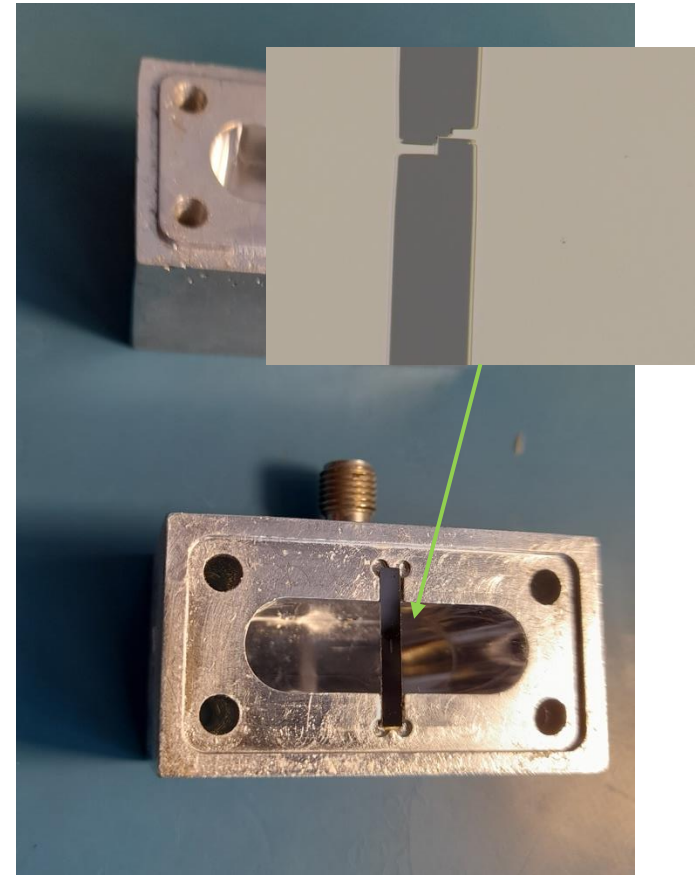




COLD Lab Expansion Completed



New BlueFors Dilution Refrigerator in Operation



- Testing now new qubit production from CNR IFN
- Purchasing qubits from ConScience (Chalmers)

In summary

Next steps in 2026:

1. Start QUAX Run as soon as possible (50 MHz scan)
2. Extraction of FINUDA “Clessidra” before summer
3. FLASH Prototype fabrication within summer
4. Quantum sensing experiments within fall
5. FLASH TDR by the end of the year

Pros:

- New Staff positions (Tocci, Dho (50% FLASH))
- New PostDoc positions (Rettaroli, D’Elia, Nikam)
- PhD Student (Santoni)
- New Undergrad. students (Spasiano, Doglia)

Cons:

- Too much bureaucracy
 - Too much “bad” digitalization
- Too many delays (lost 4 months of COLD activity) and higher costs



SAPIENZA
UNIVERSITÀ DI ROMA

RELIC

A new lab class on light dark matter

With M. Vignati and A. Cruciani

