

# Cryogenic facilities at INFN Pisa

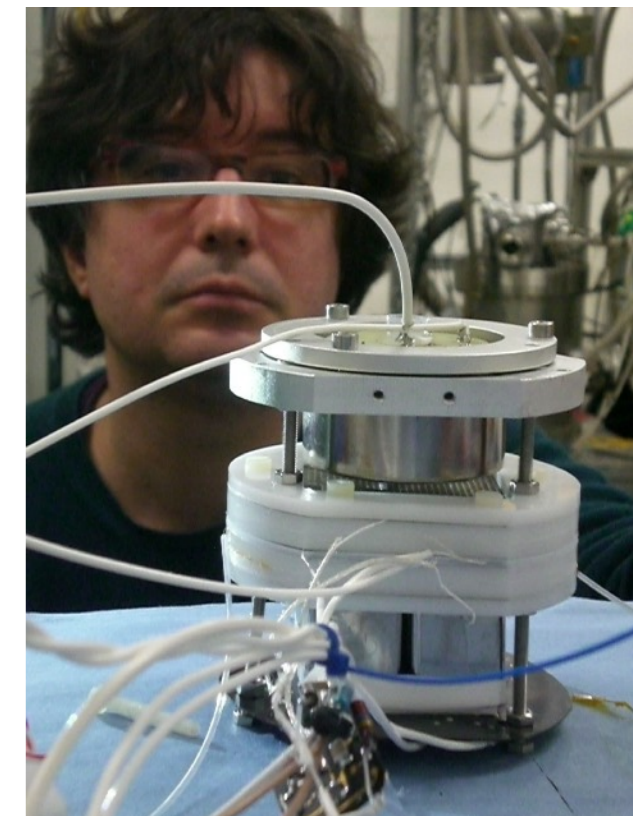
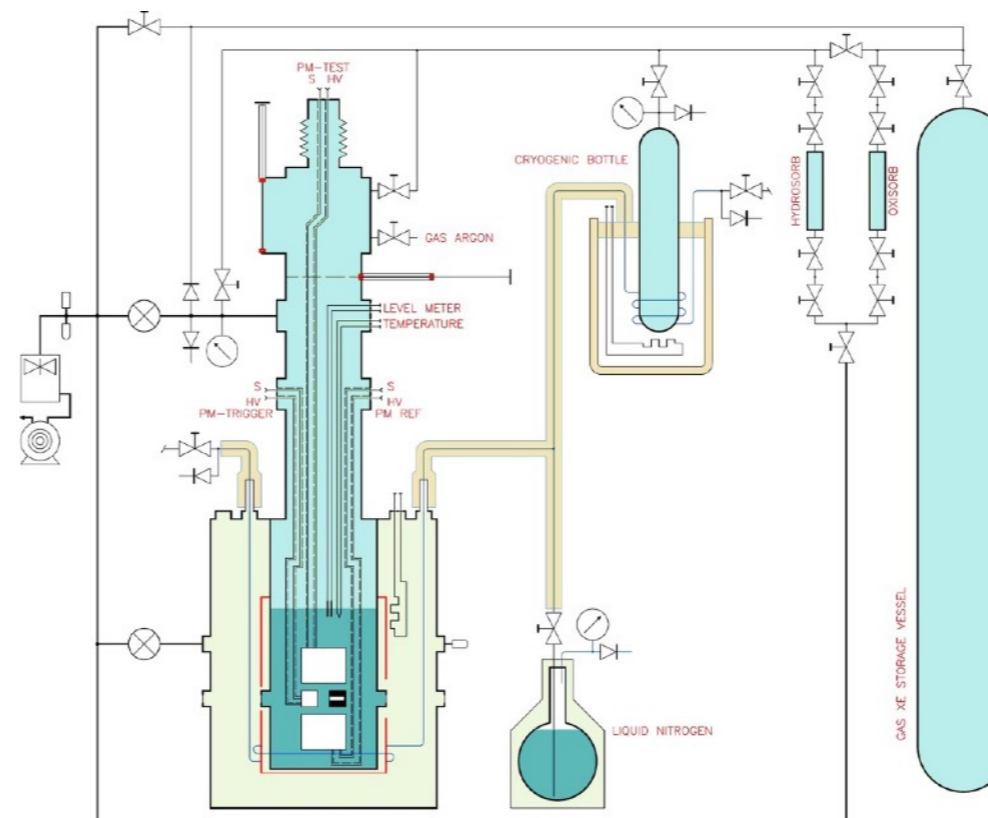
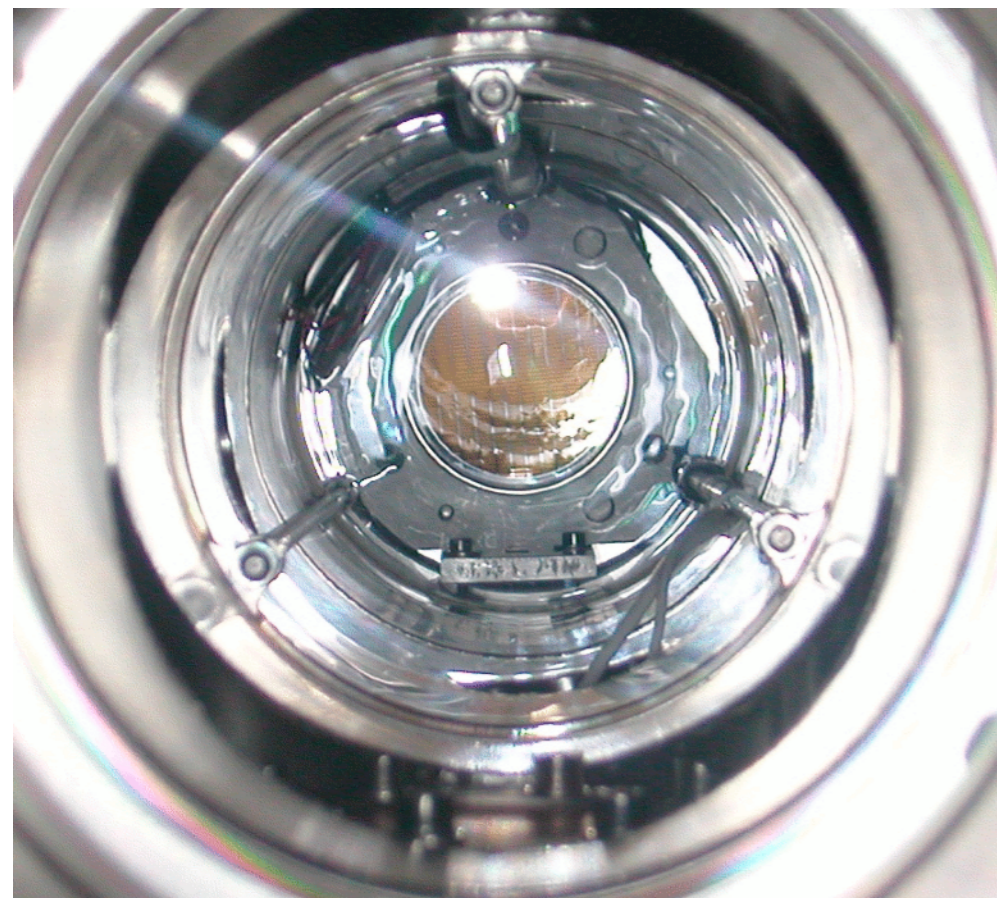
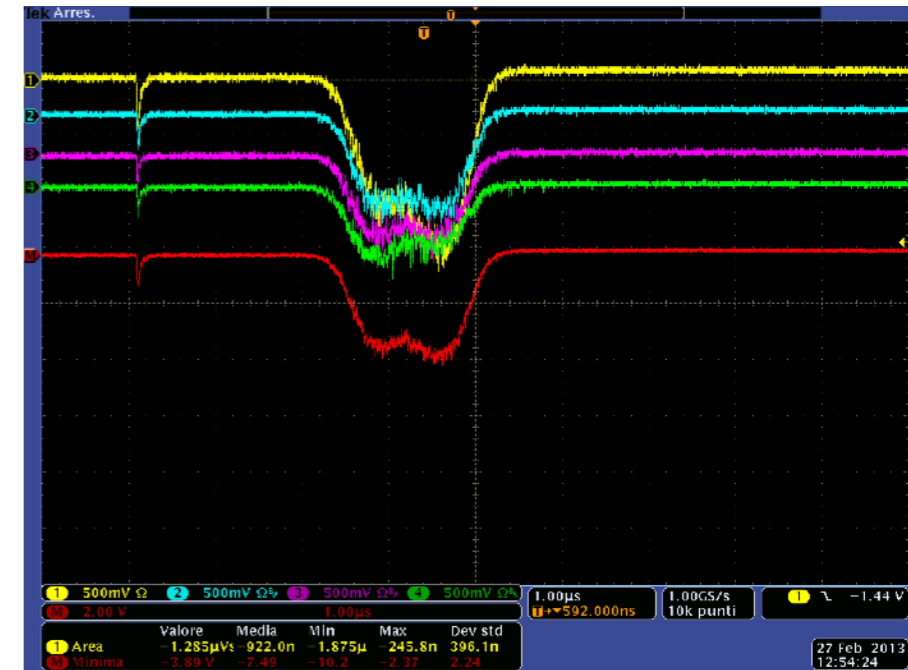


Giovanni Signorelli  
UniPI & INFN



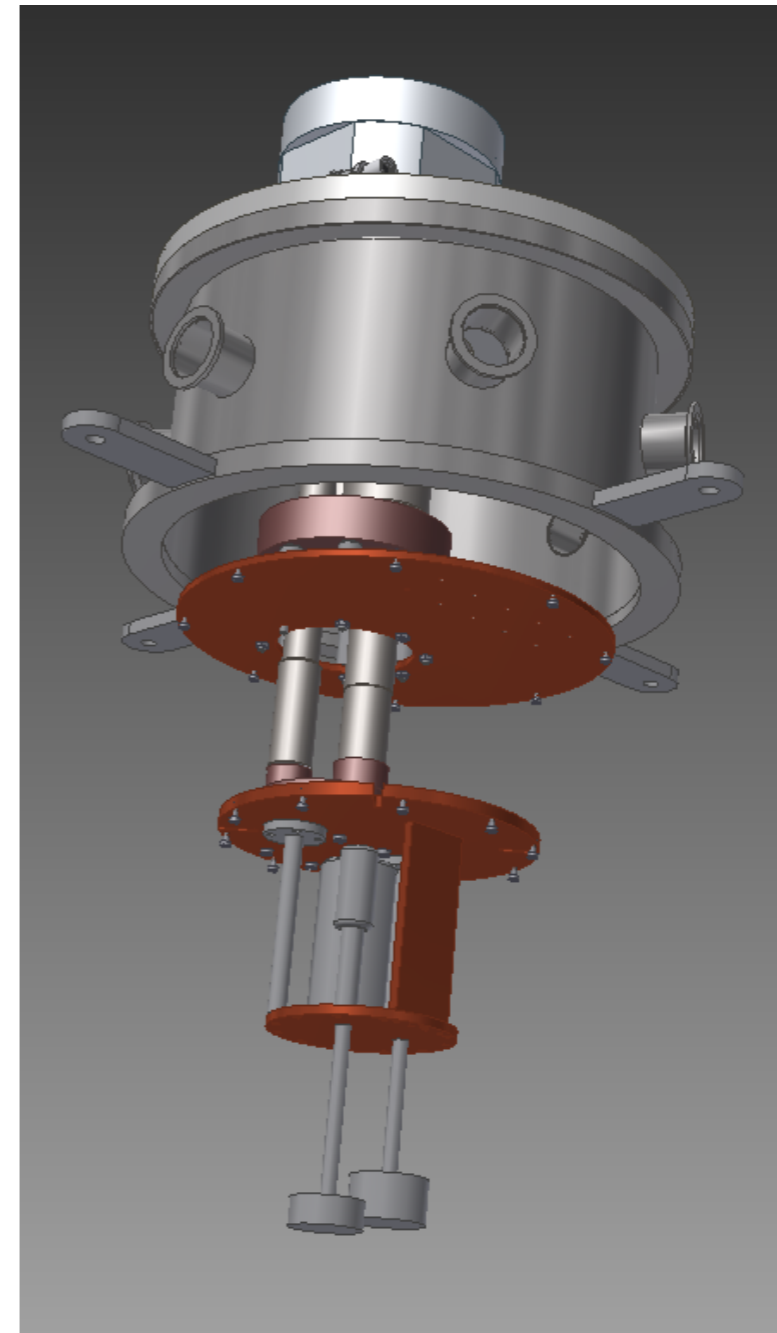
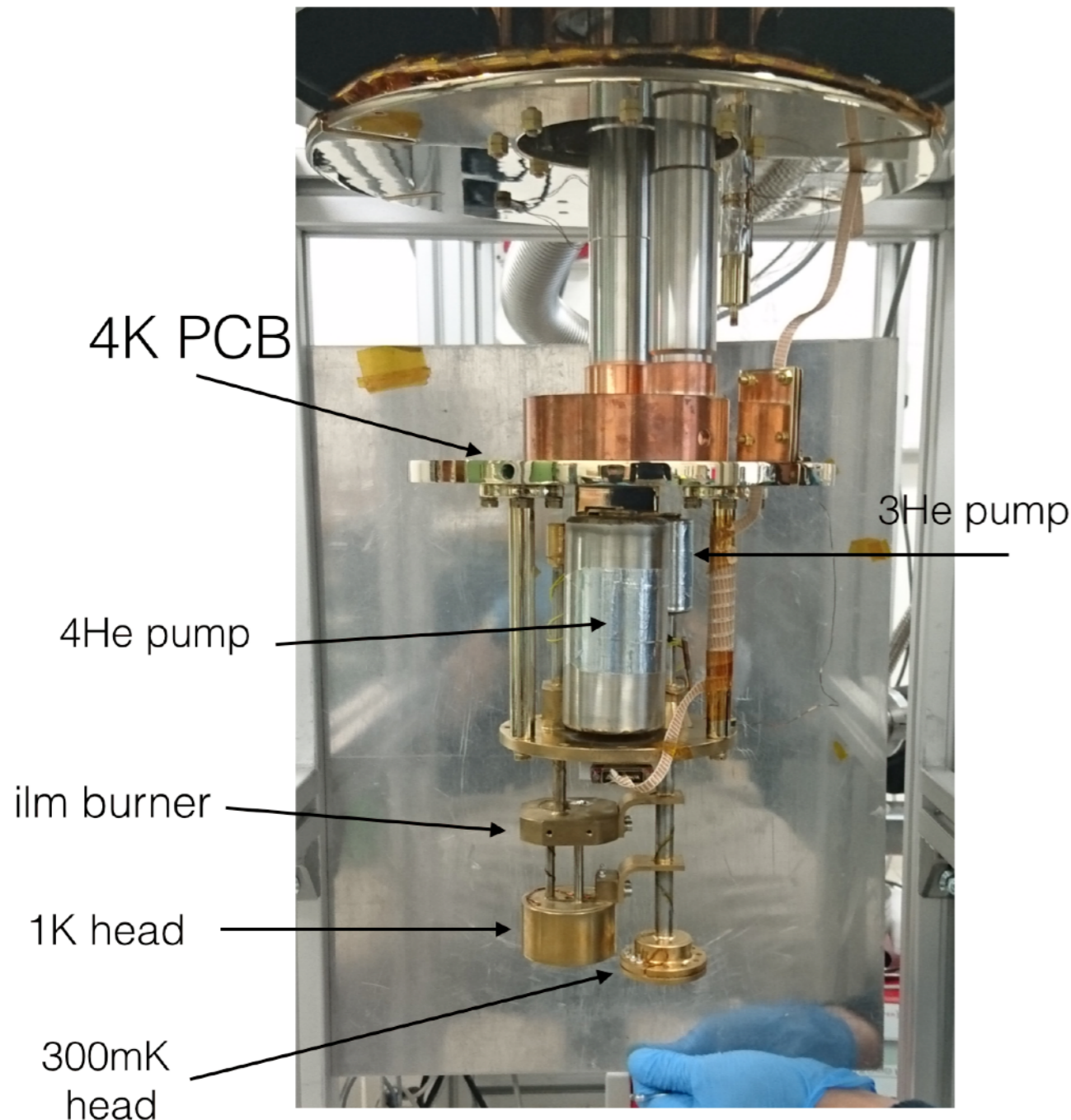
BULLKID-DM meeting, 19-20 March 2024  
LNGS

- INFN Pisa **cryogenic lab** dates back to **2002** when we installed a test station
  - **LXe calorimetry** studies for the MEG experiment ( $T=170\text{ K}$ )
    - LN<sub>2</sub> cooling
    - single stage GM cooler + pulse tube cooler
  - test of **>400 PMTs** submerged in LXe
  - radioactive **sources in liquid** for testing purposes
  - **charge & light** collection in liquid Xenon (FIRB project)
    - **dual phase** TPC
    - **single phase** TPC with light amplification in Xe



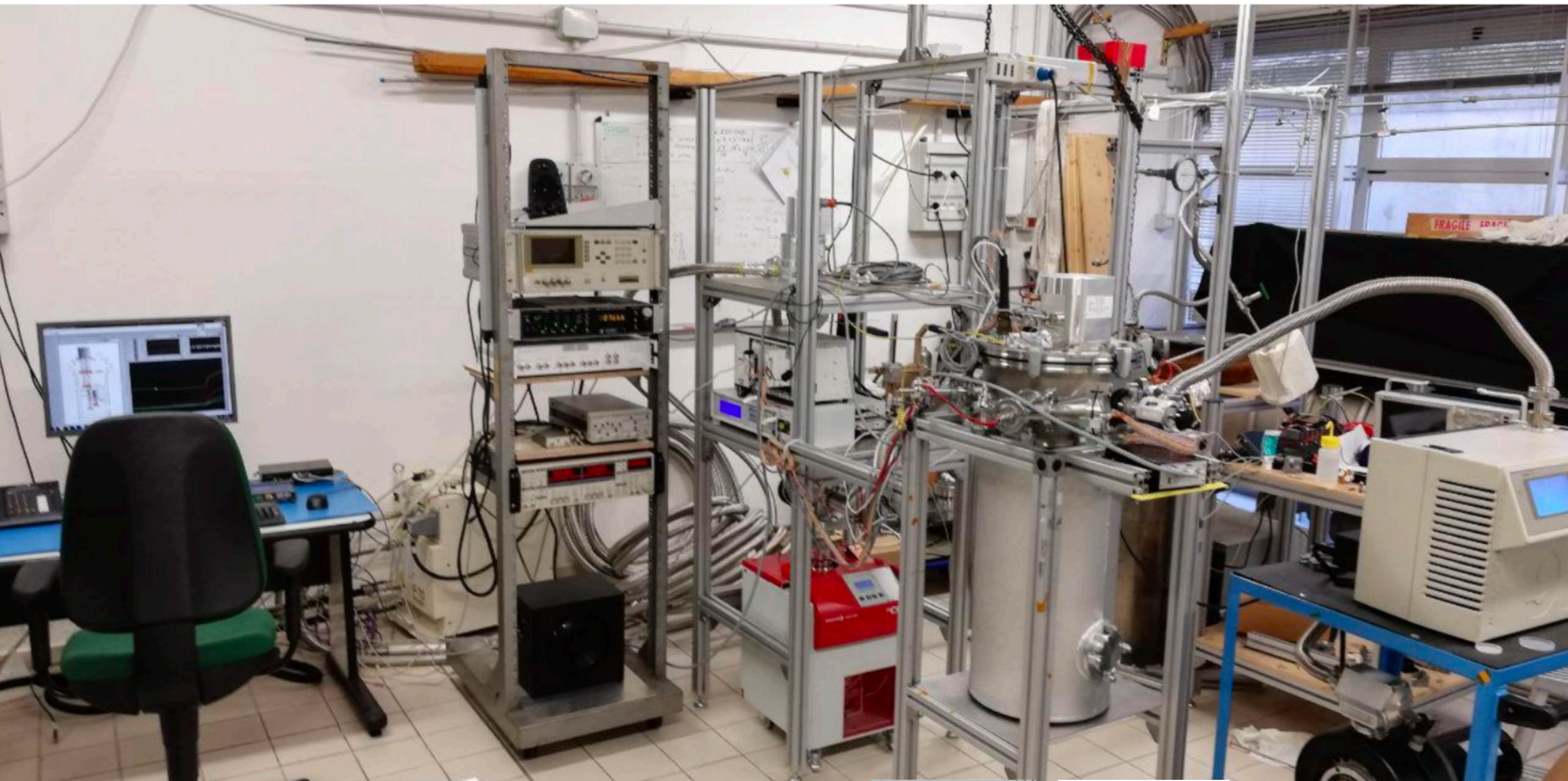


- Starting from 2014, we started collaborating to a project in **Experimental Cosmology**
  - **LSPE/SWIPE** for CMB polarization.
- **Readout** of **SQUIDs** with frequency-domain multiplexed **TES** detectors at **300 mK**
  - We designed and assembled a **custom cryostat** with a 300 mK sorption cooler
    - 4K cold head from Sumitomo → 1W @4K
    - 260 mK stage by Chase Cryogenics (20μW @300 mK, 200 μW @900mK)



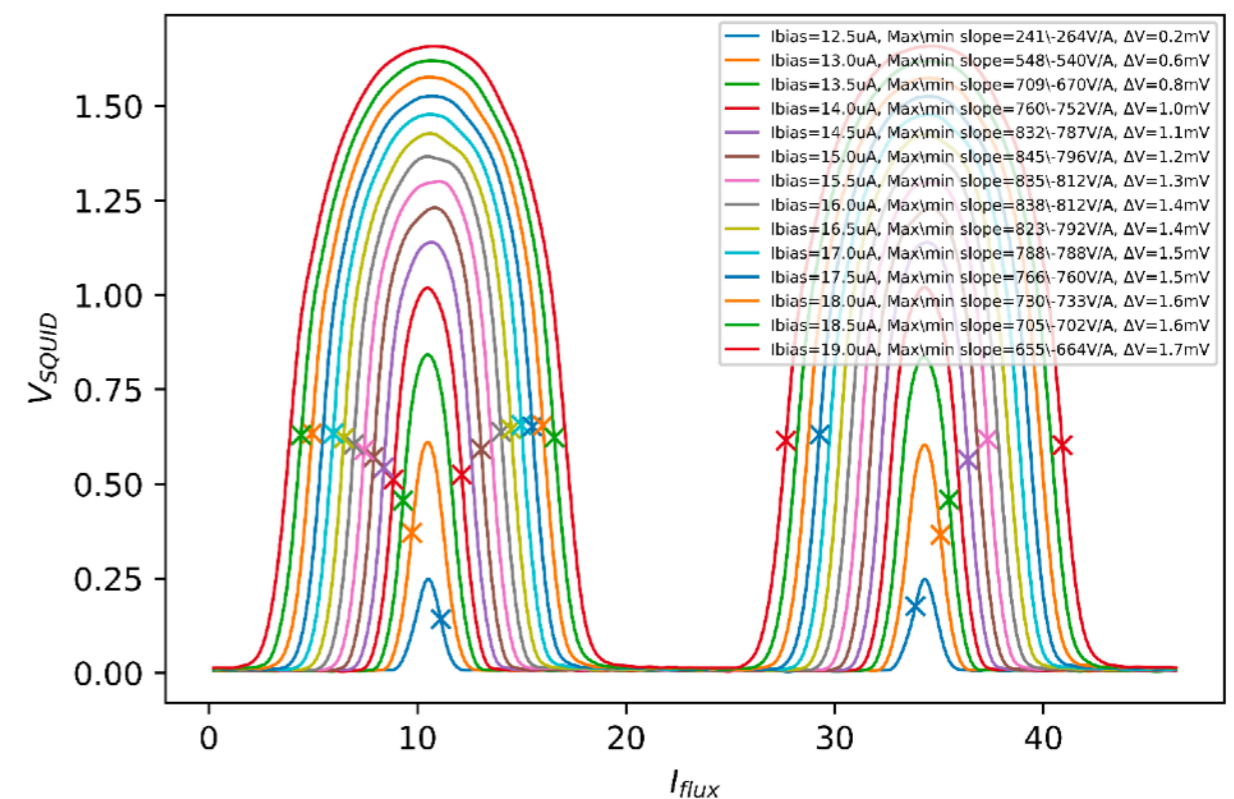
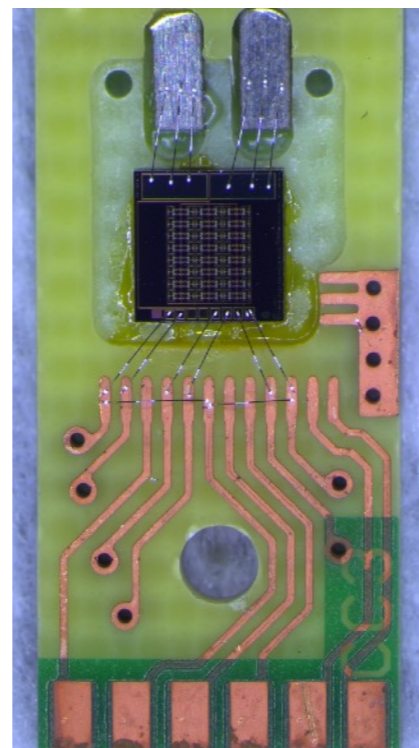
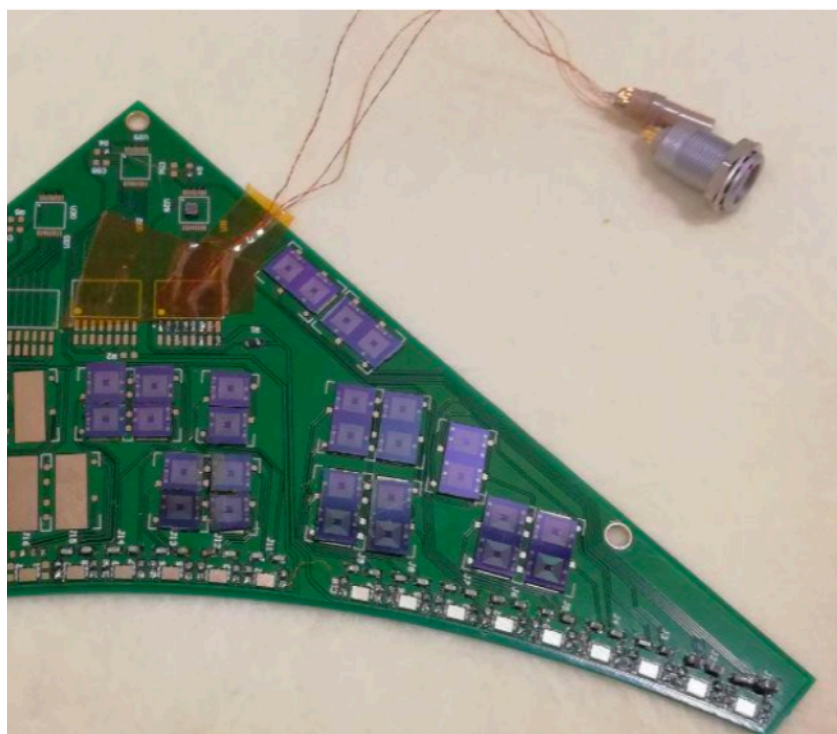
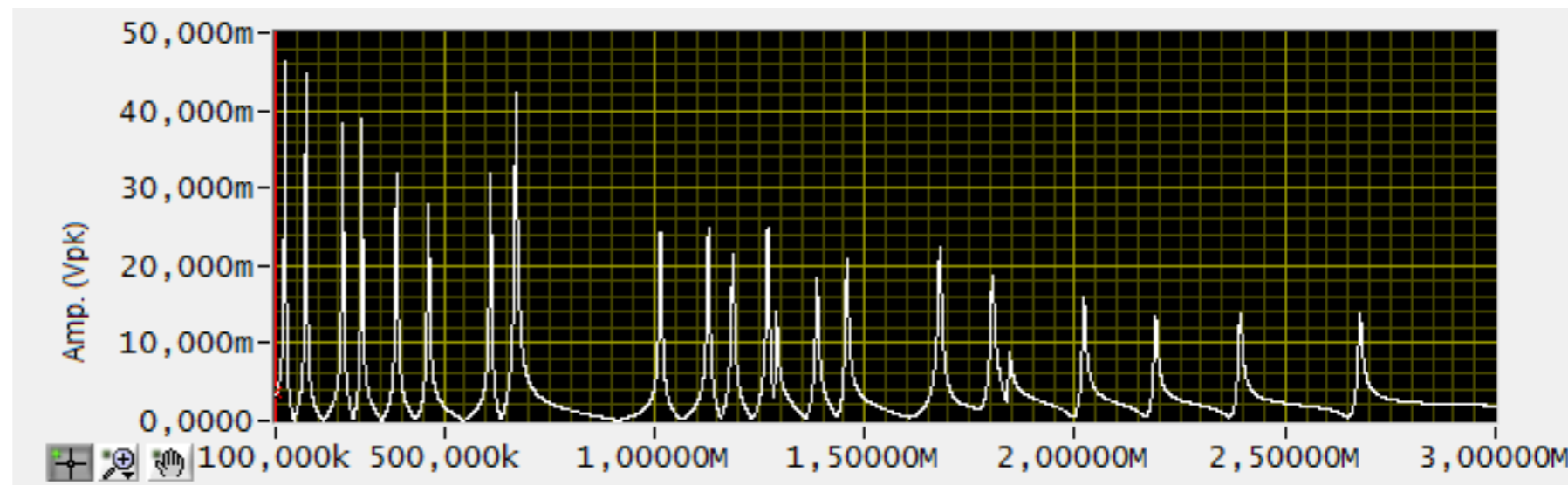


- 300 mK instrumentation lab
  - DB37, MDM connectors, SMA flanges already procured
  - Lock-in amplifiers, network analyzers, LNAs, Resistance bridges...
  - characterization of cryogenic sensors and electronics



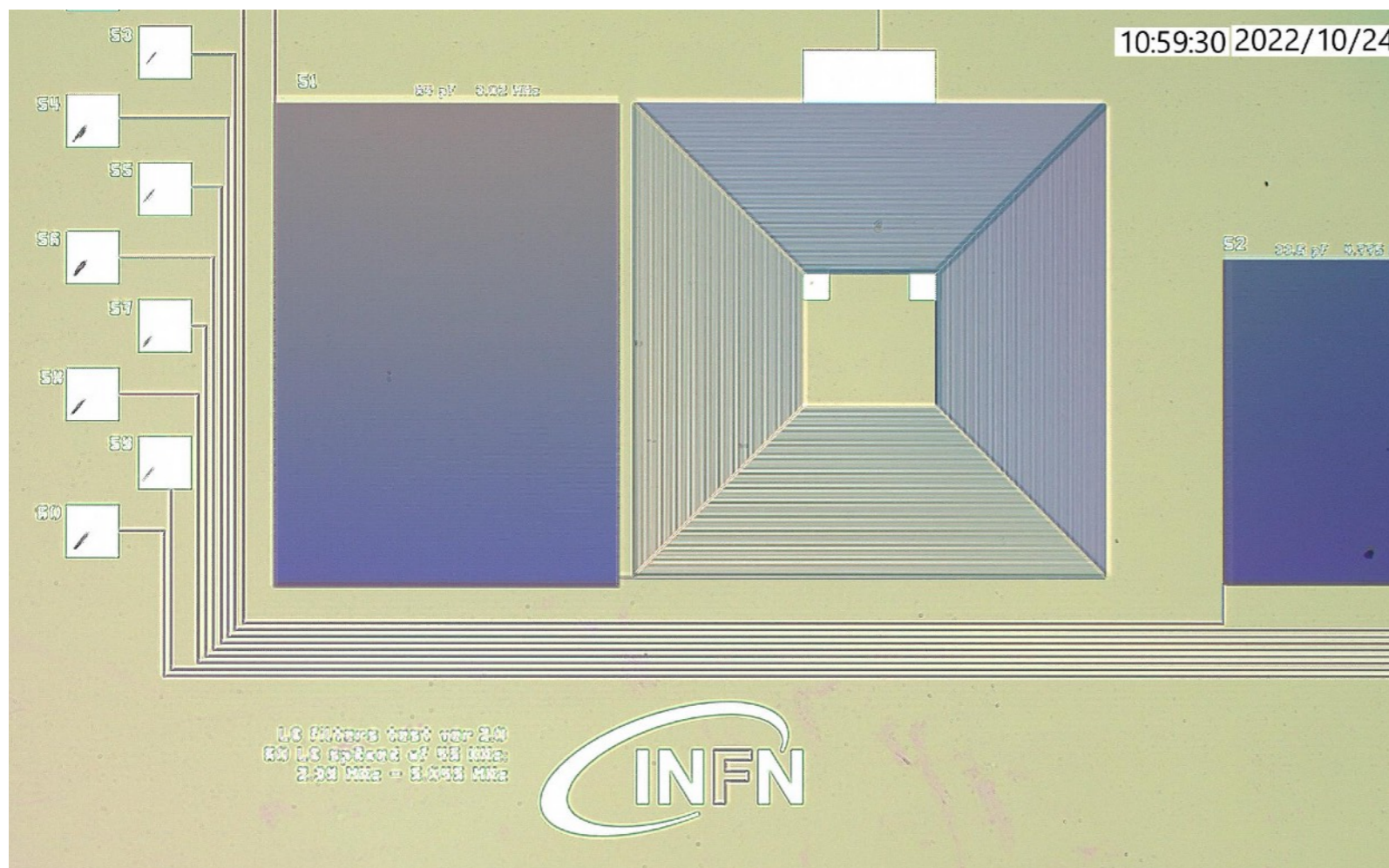
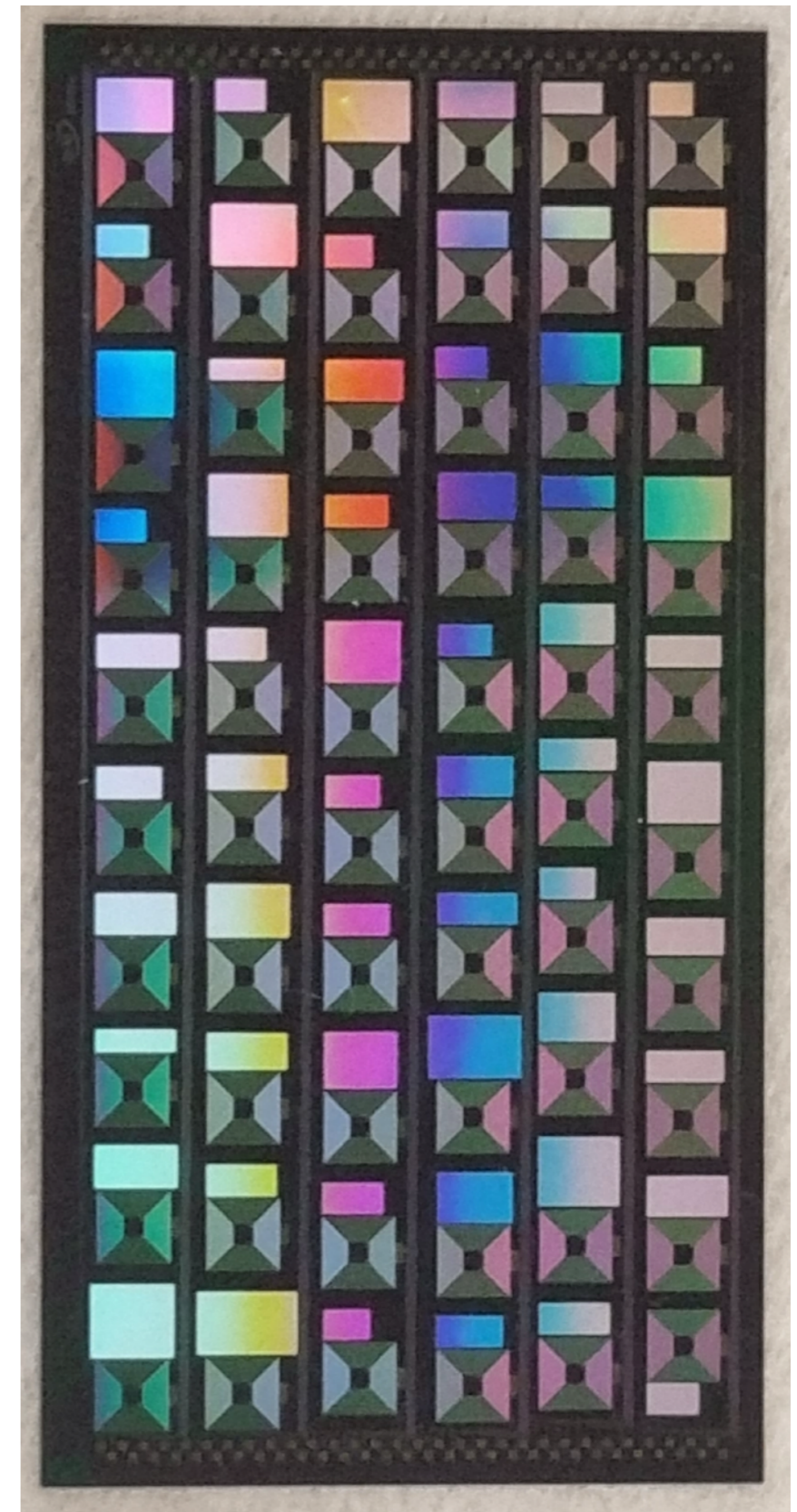
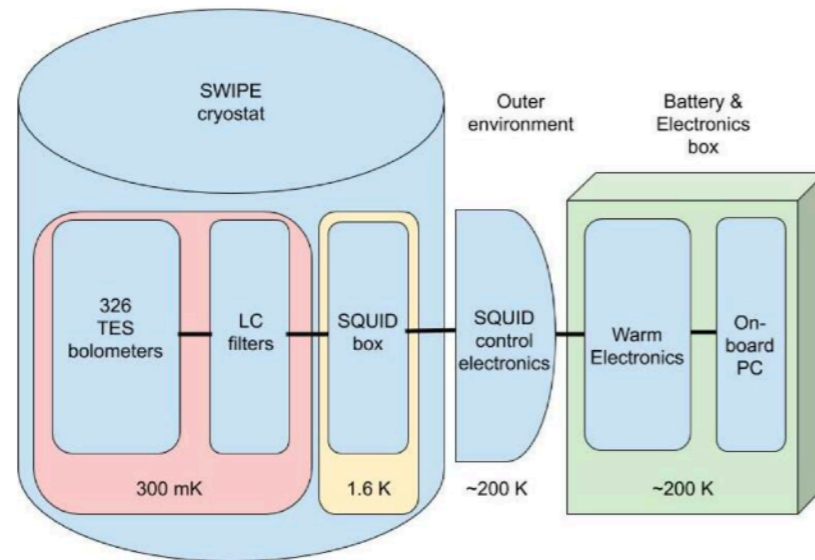


- Our  $> 500 \text{ m}^2$  **clean room** technical personnel is well experienced in **assembling** silicon detectors for HEP experiments
- Smoothly helped in designing PCBs, **gluing**, **bonding** sensors and superconducting electronics (LCs, SQUIDs) for our cryogenic experiments.
- Measurement of **MUX** schemes

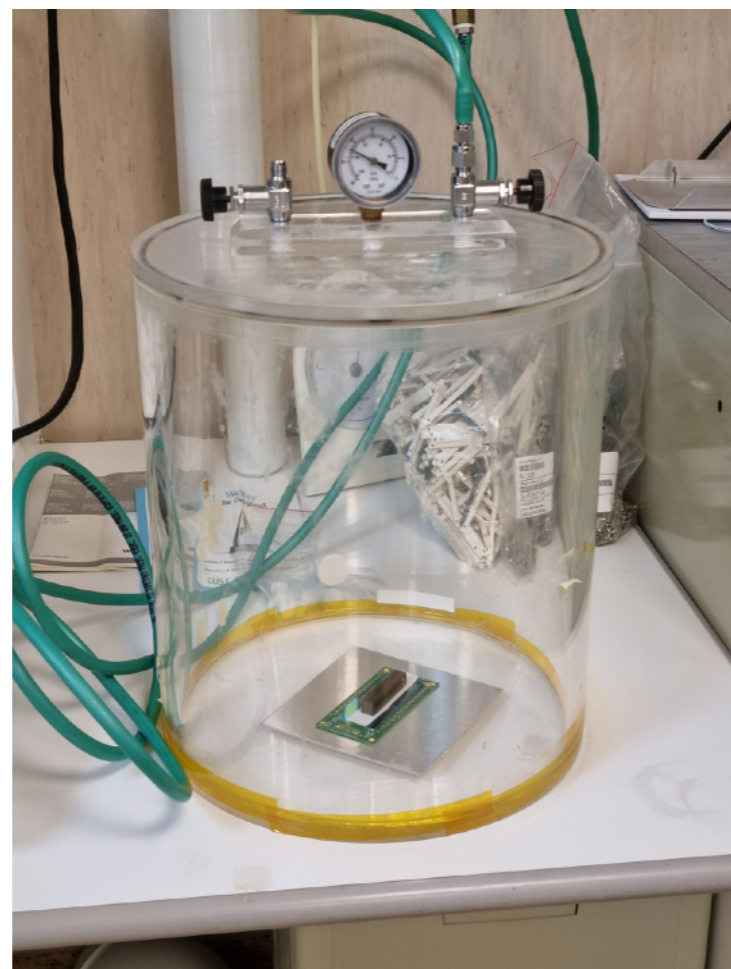
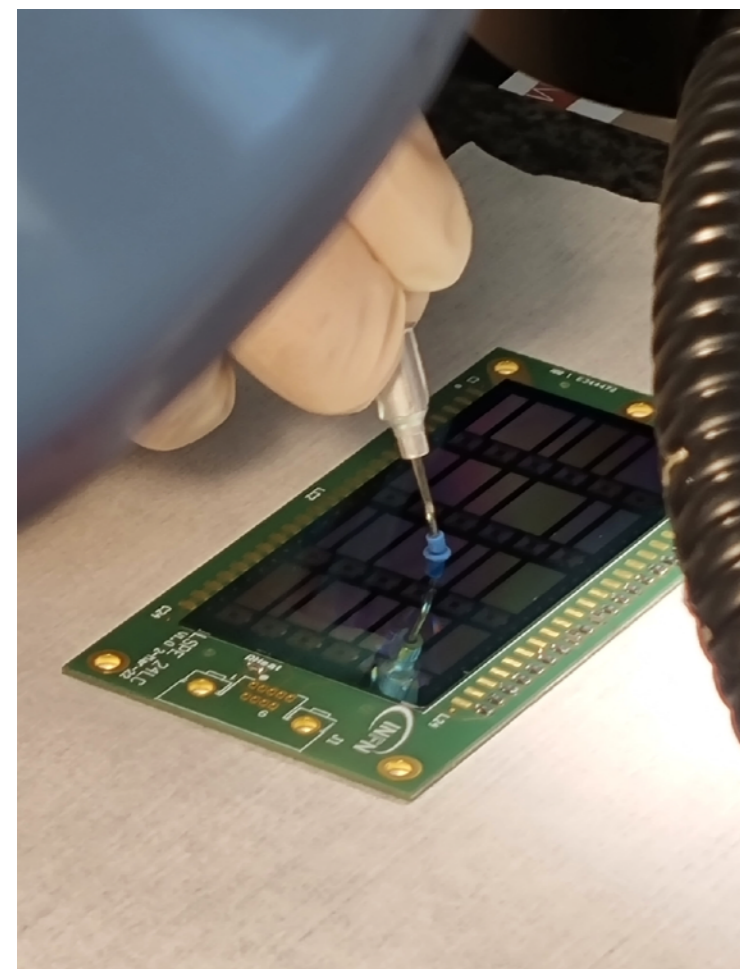
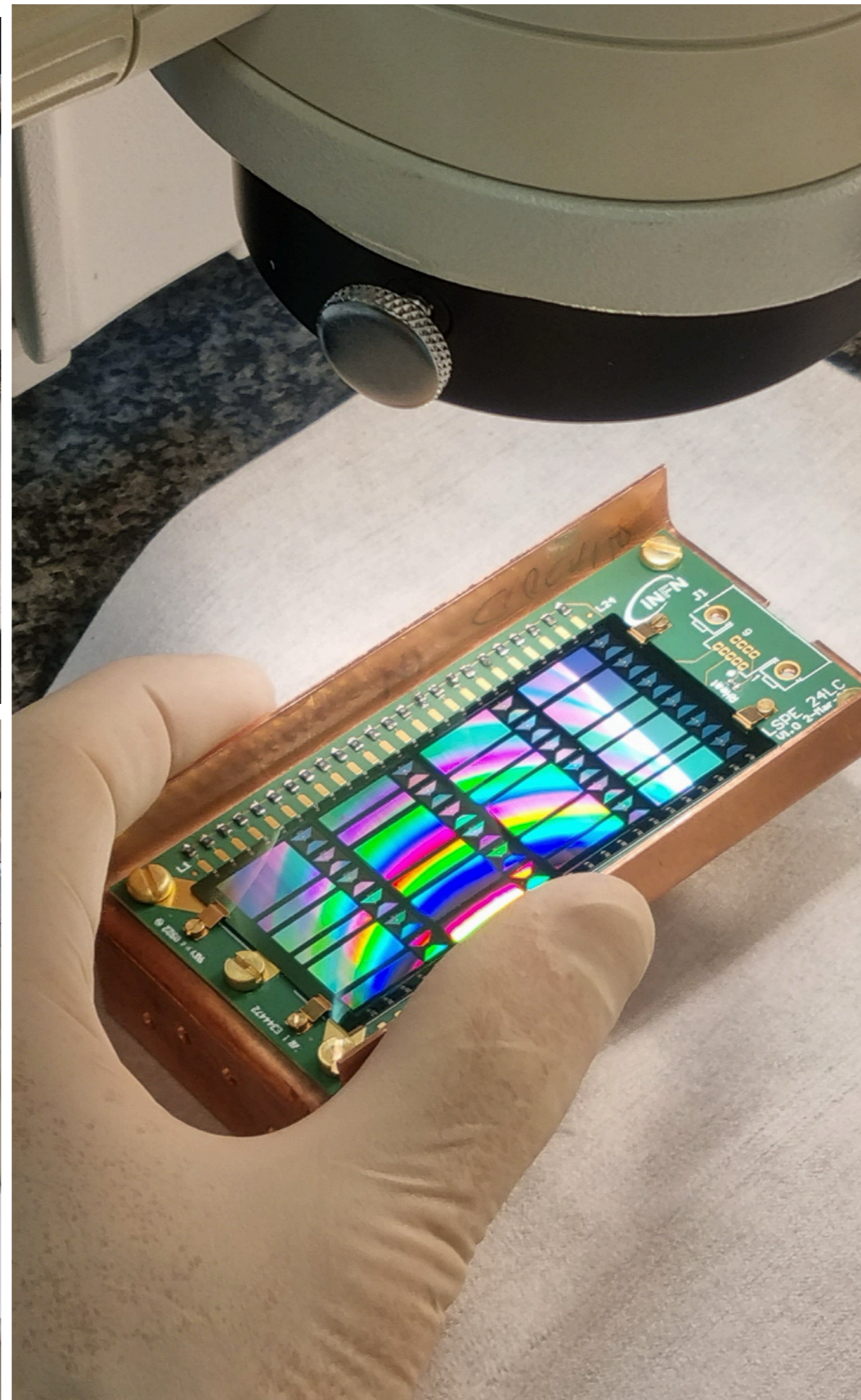
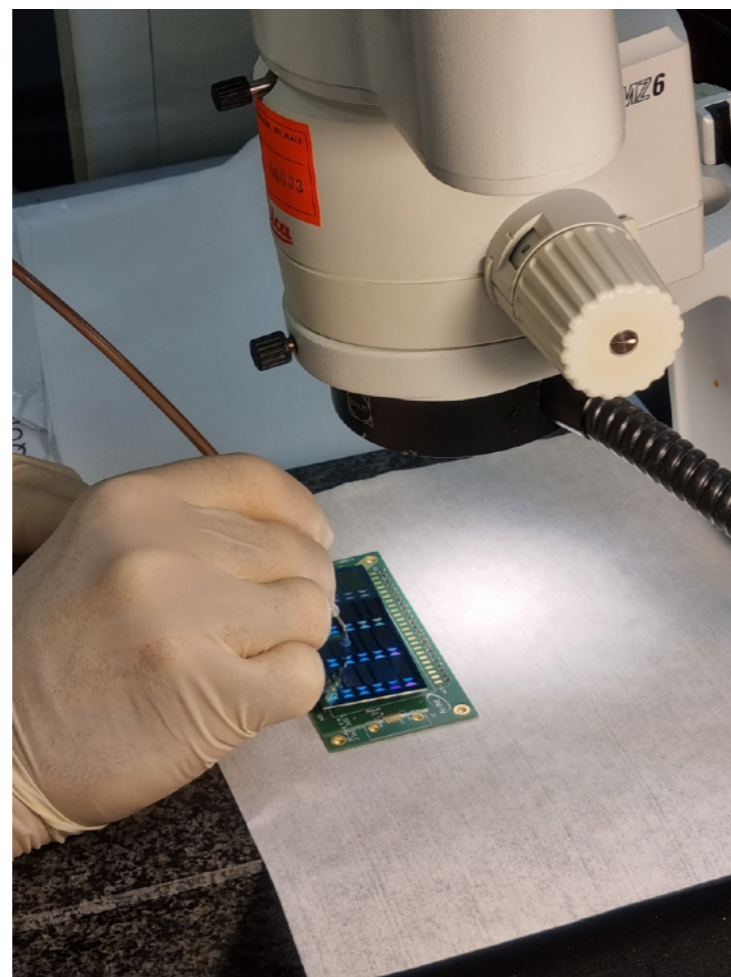
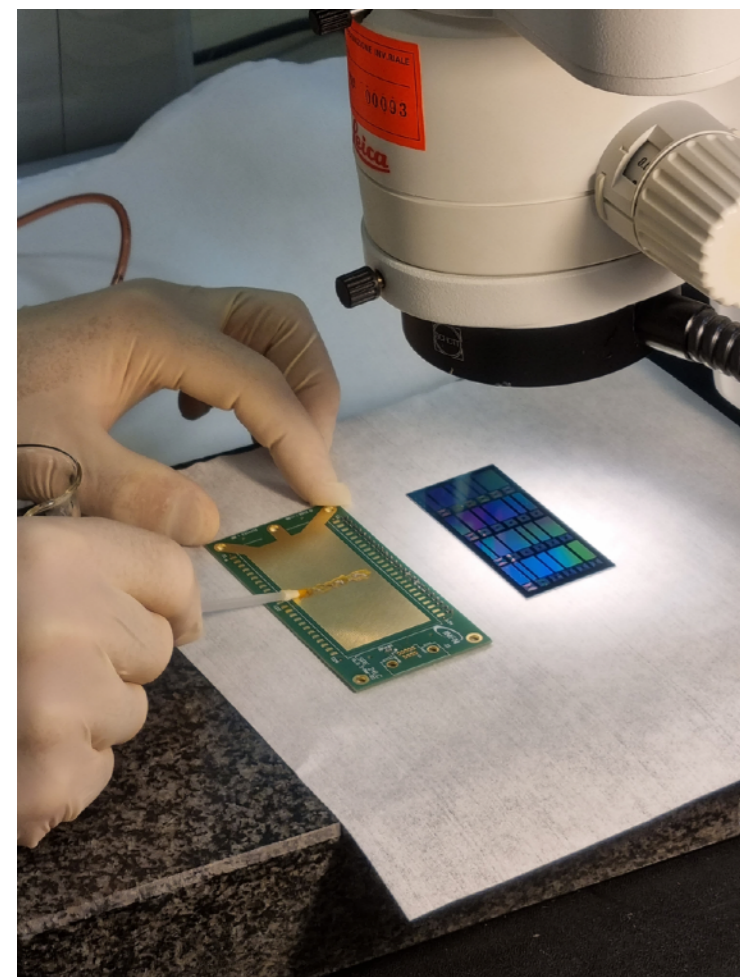




- LC filters for TES multiplexing
- 60x MUX for TES readout in the 1 → 5 MHz range

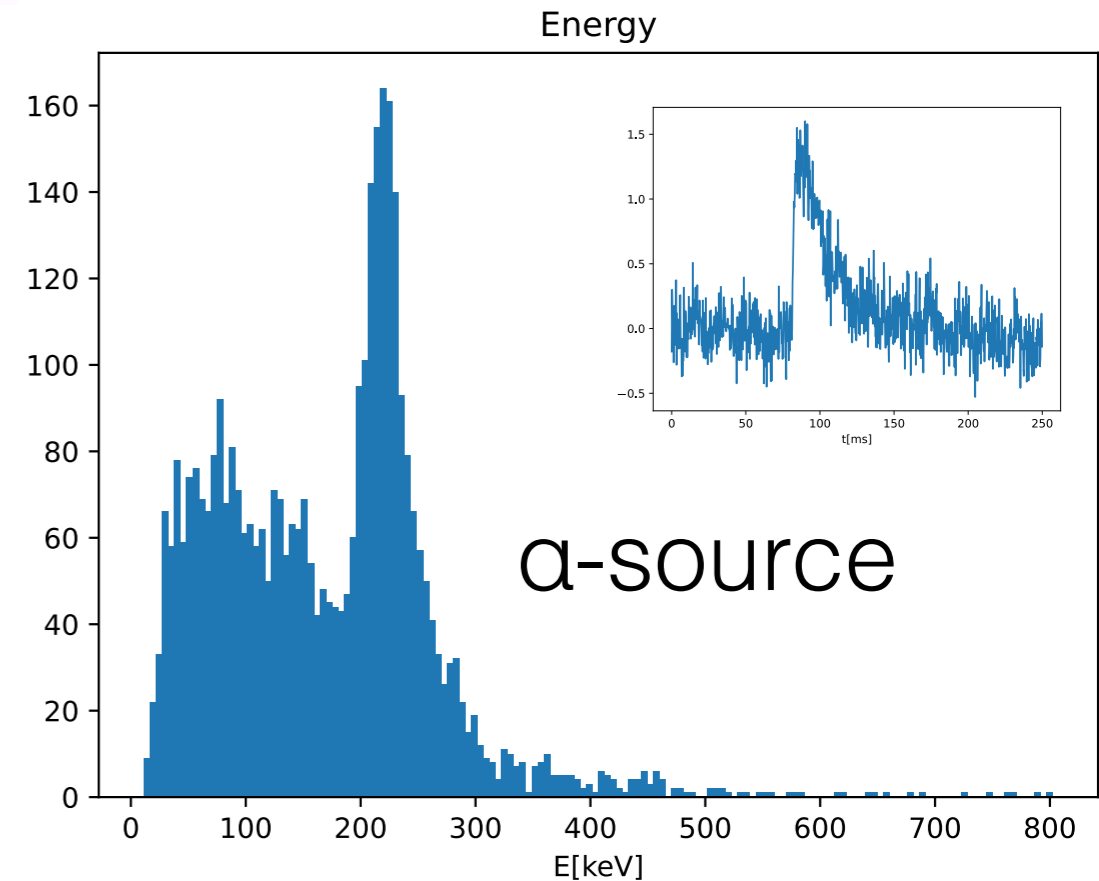
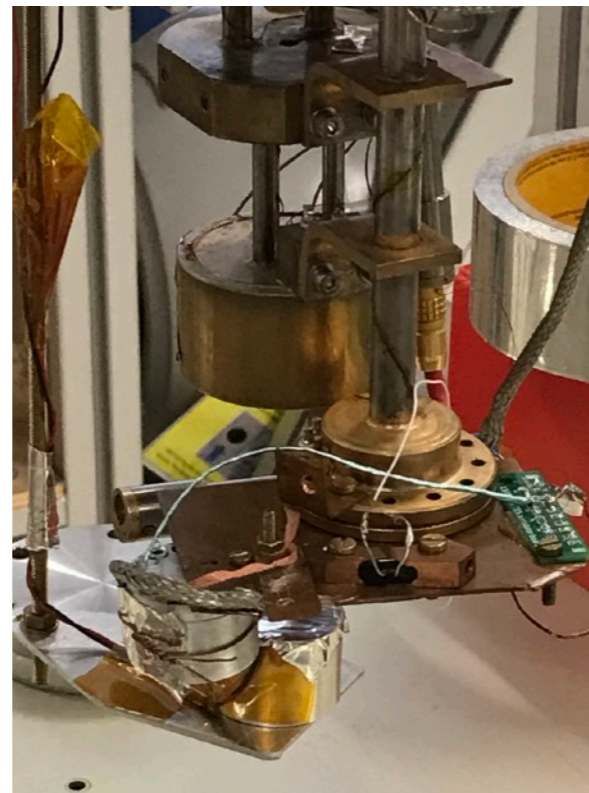
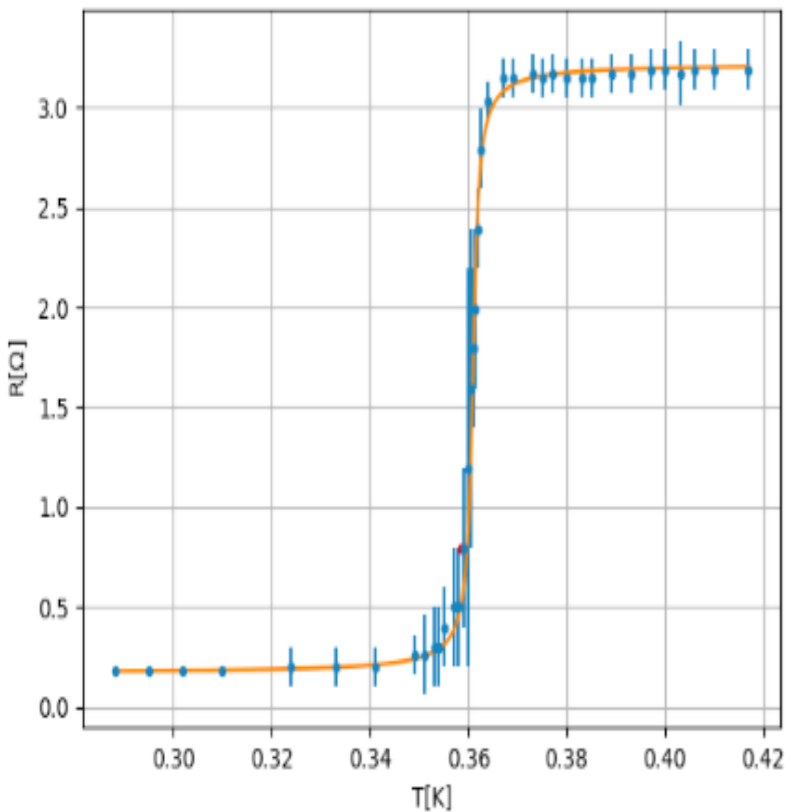
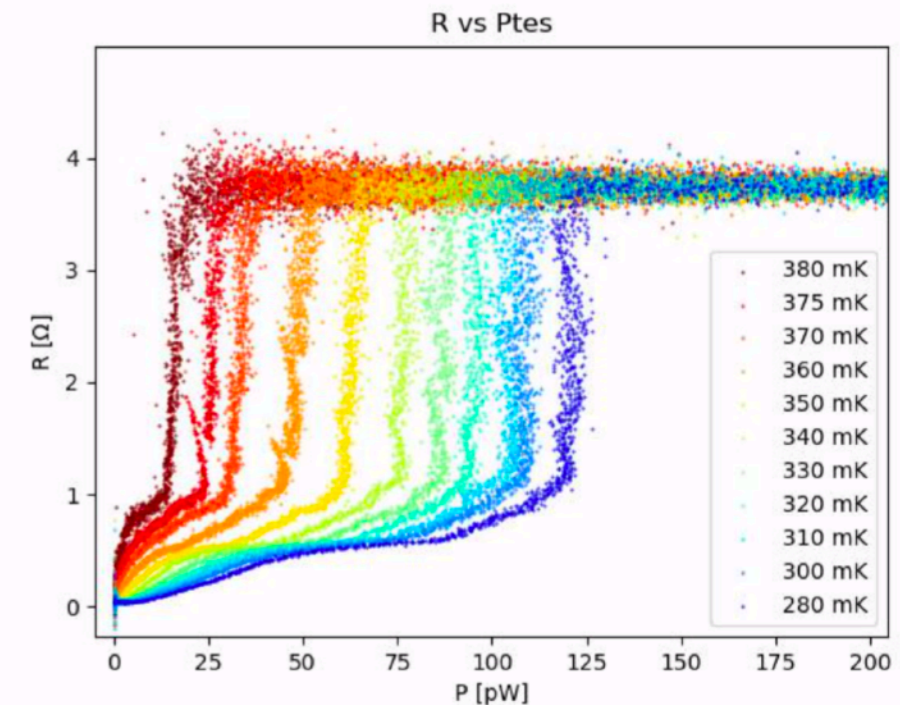
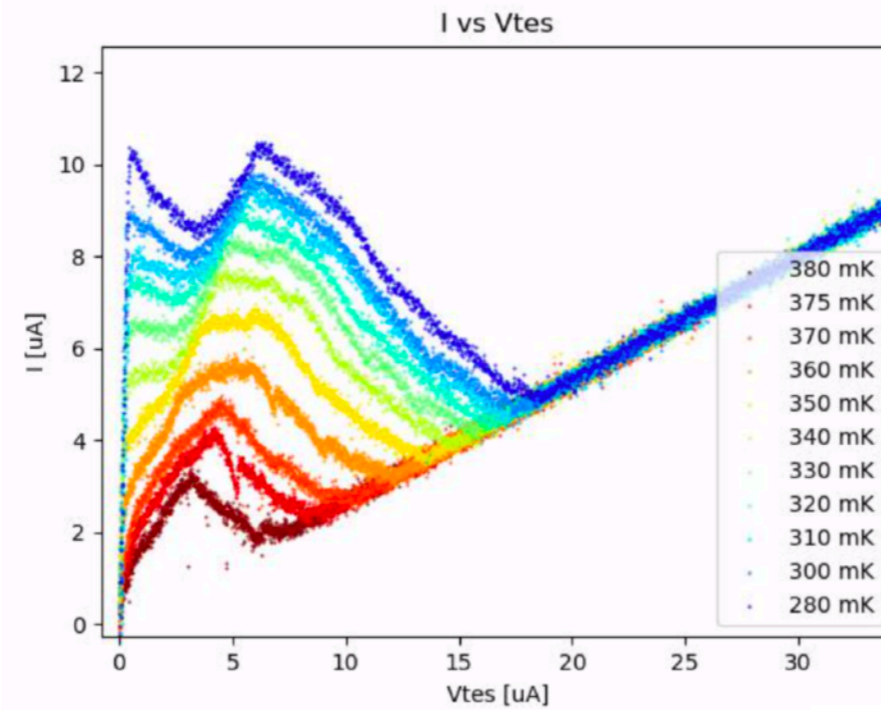
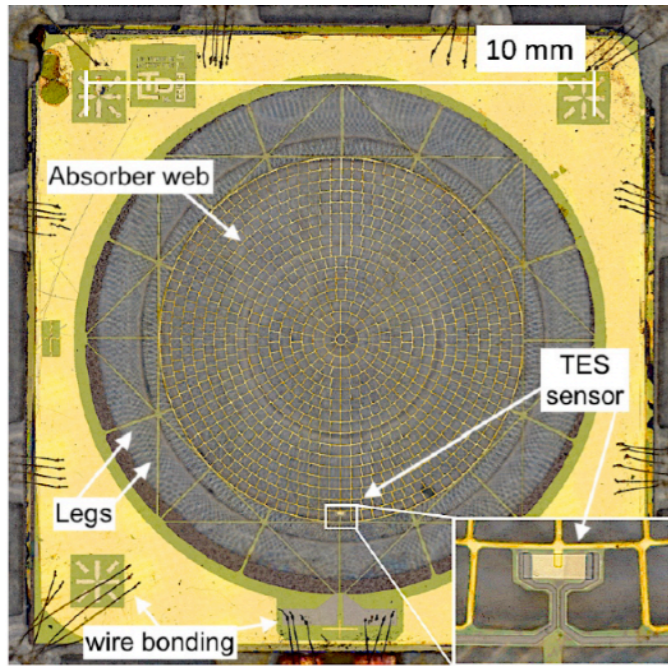






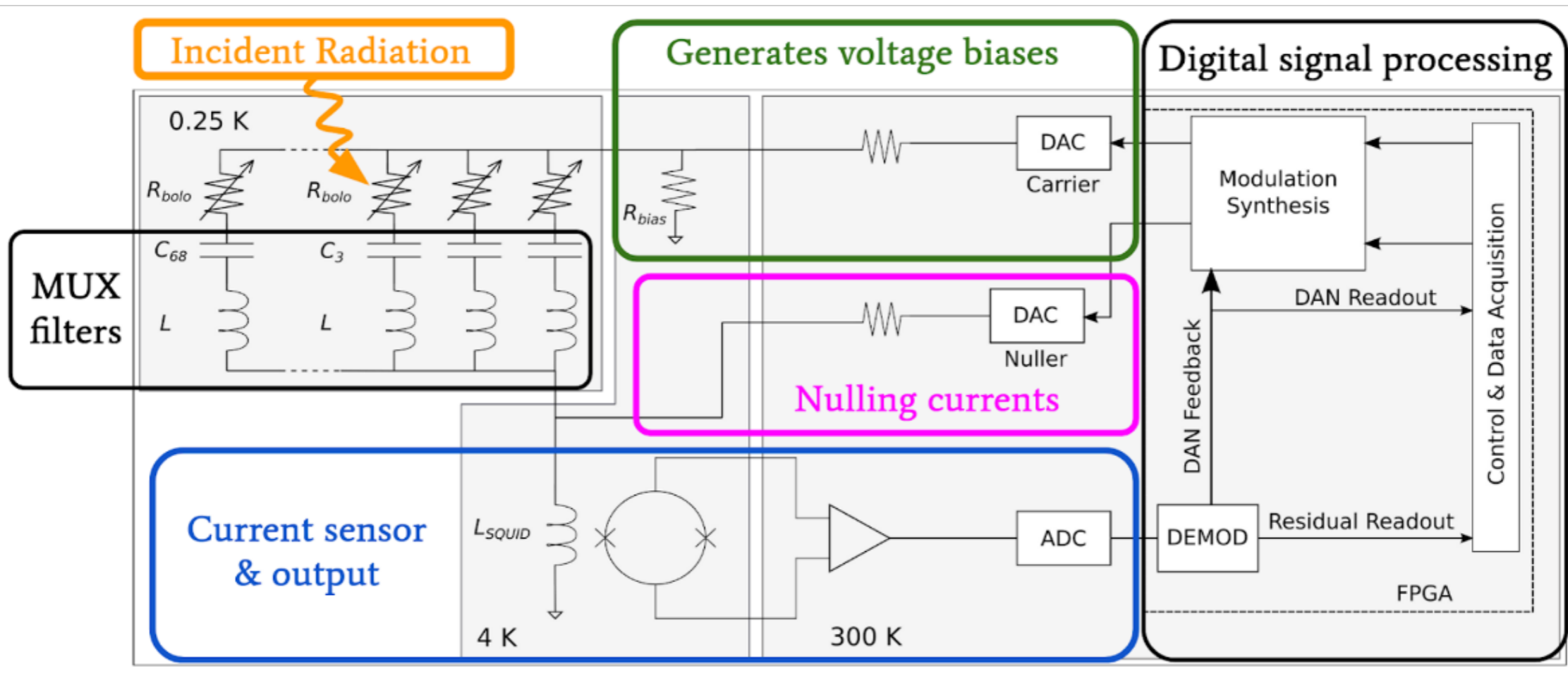
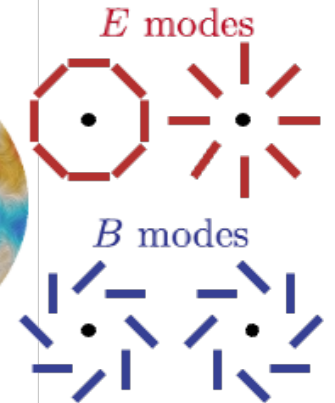
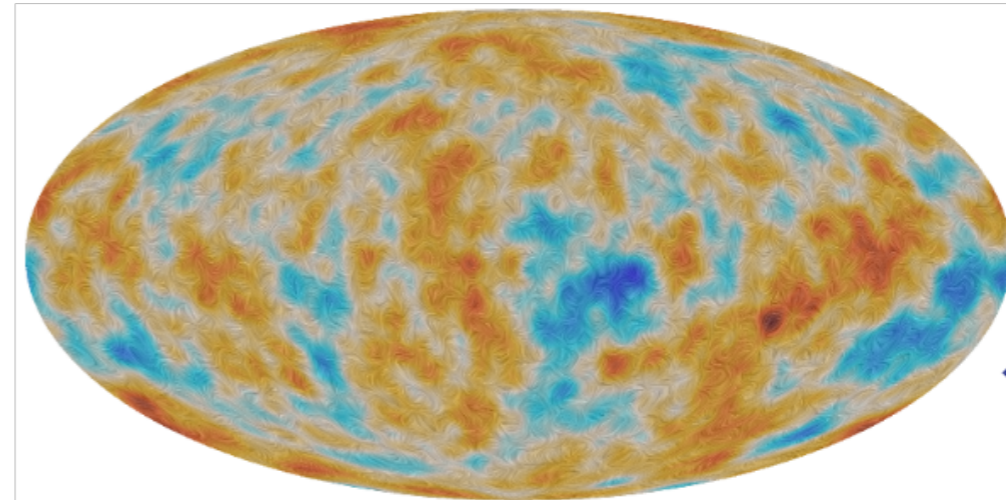
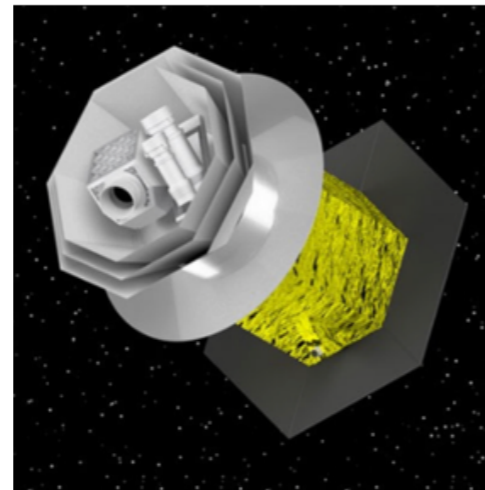
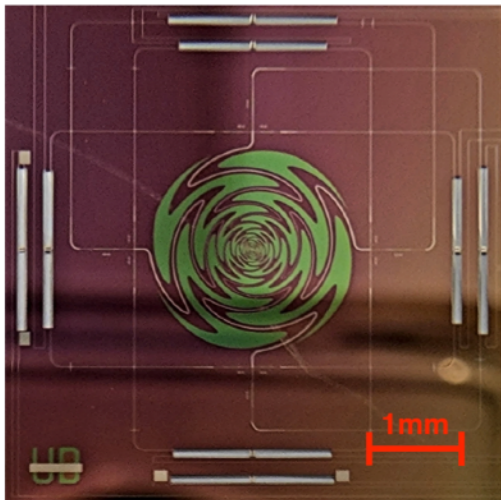


- We characterized TES on a spiderweb sensor for LSPE/SWIPE,
  - measurements of  $T_c$ ,  $G$ ,  $C$
  - $\tau$  characteristic time from LED and  $\alpha$ -source at 300mK

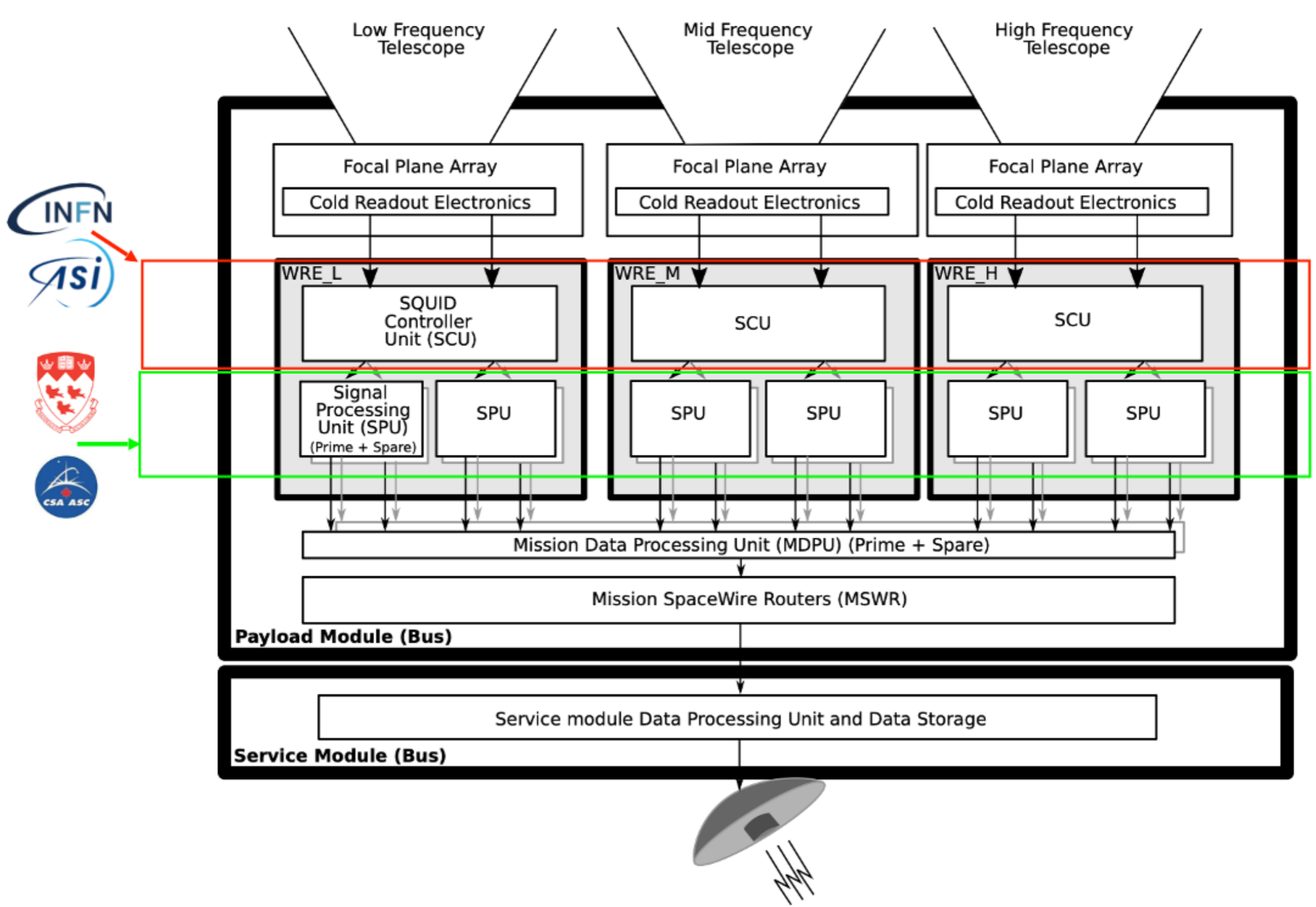




- We gained experience in **cryogenic devices** and **electronics**
- Responsibility of the delivery of the **SQUID Controller Units** for the LiteBIRD CMB polarization experiment

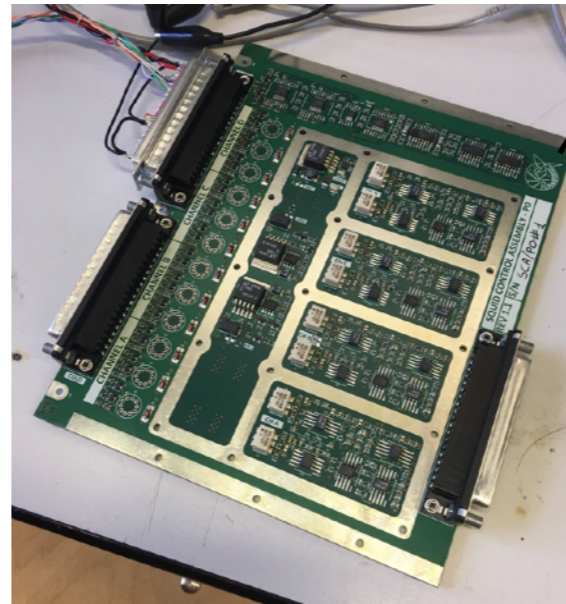
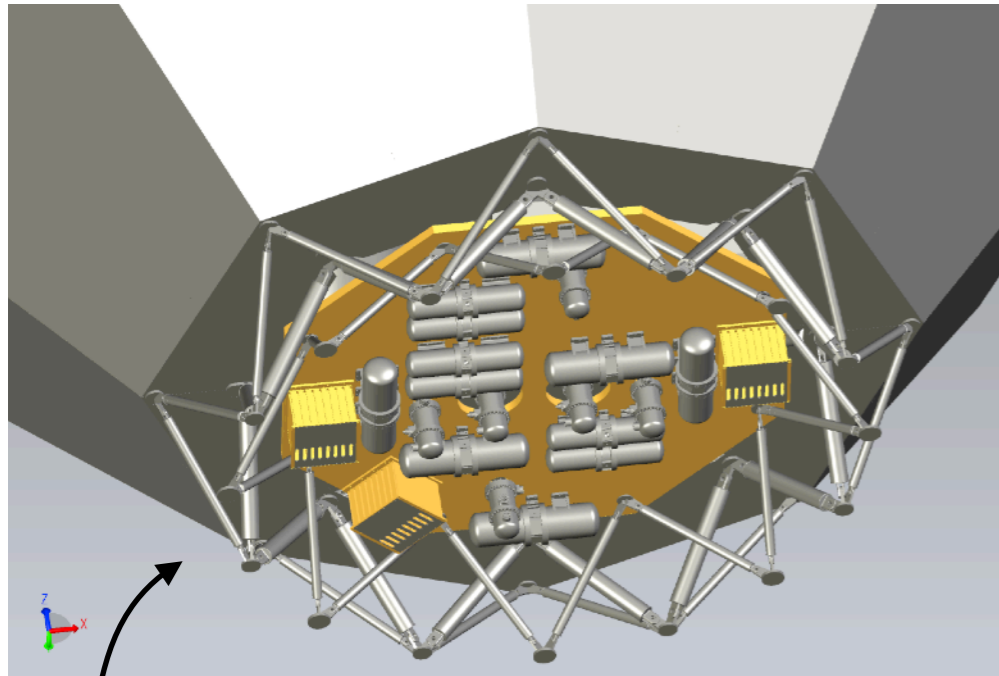


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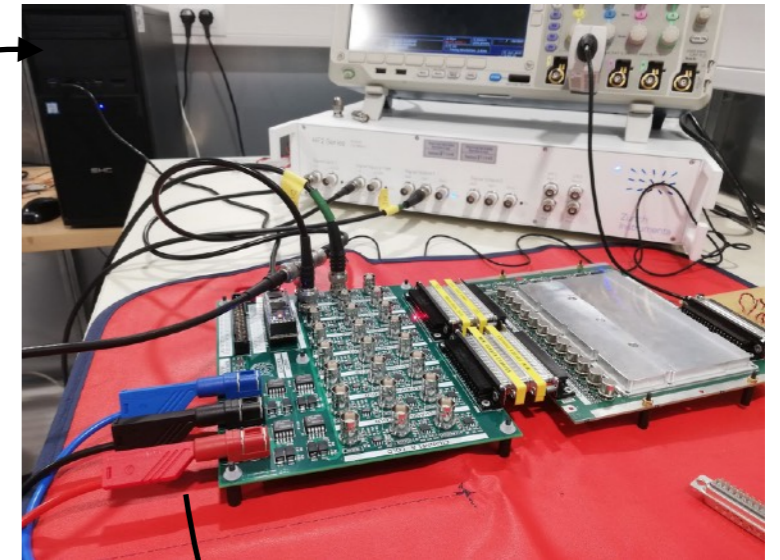




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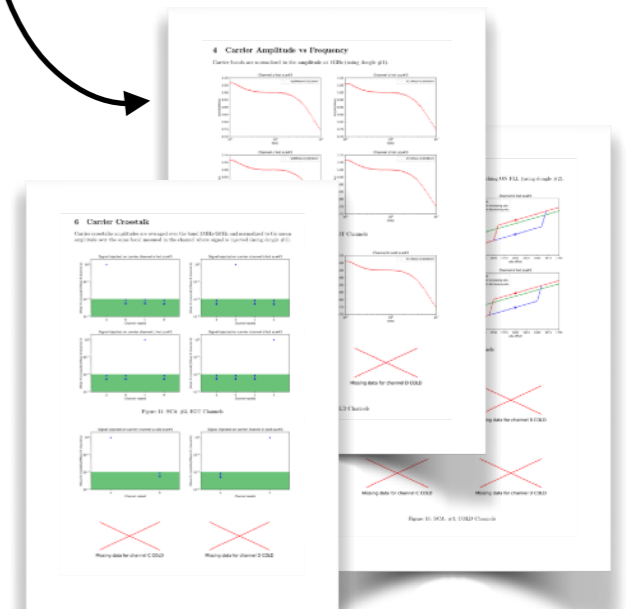


Electronics design

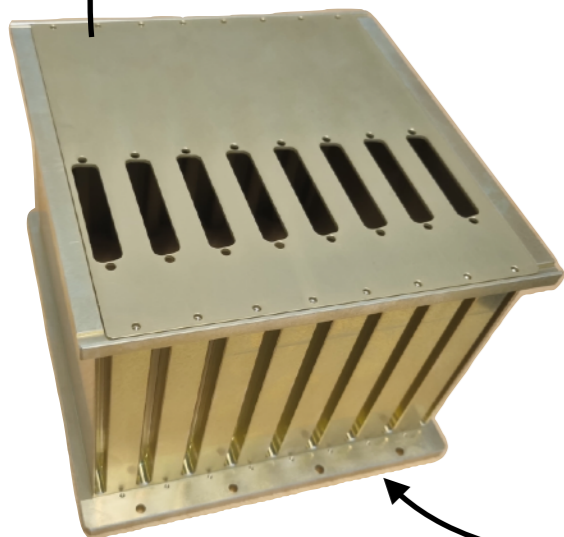
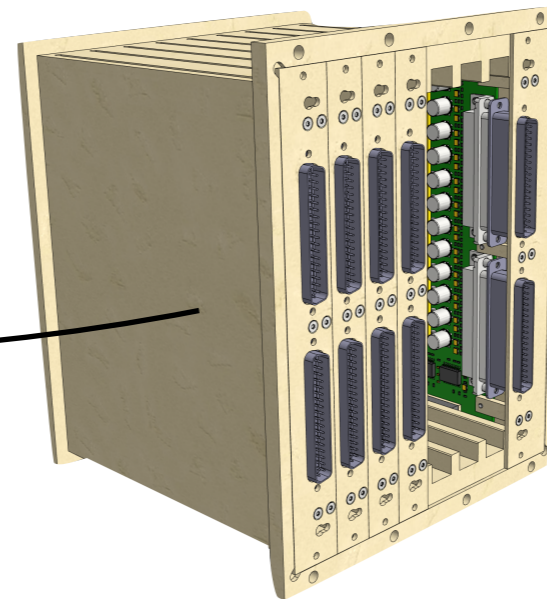
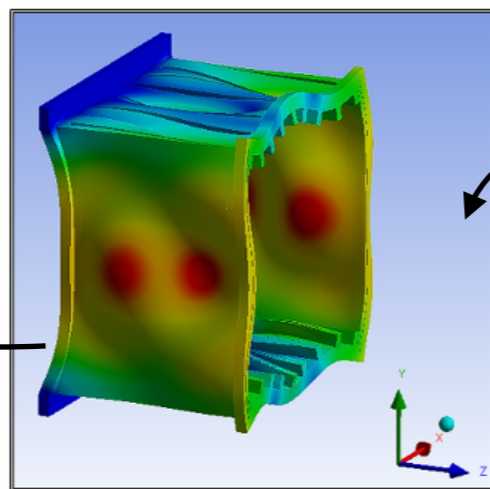


Tests

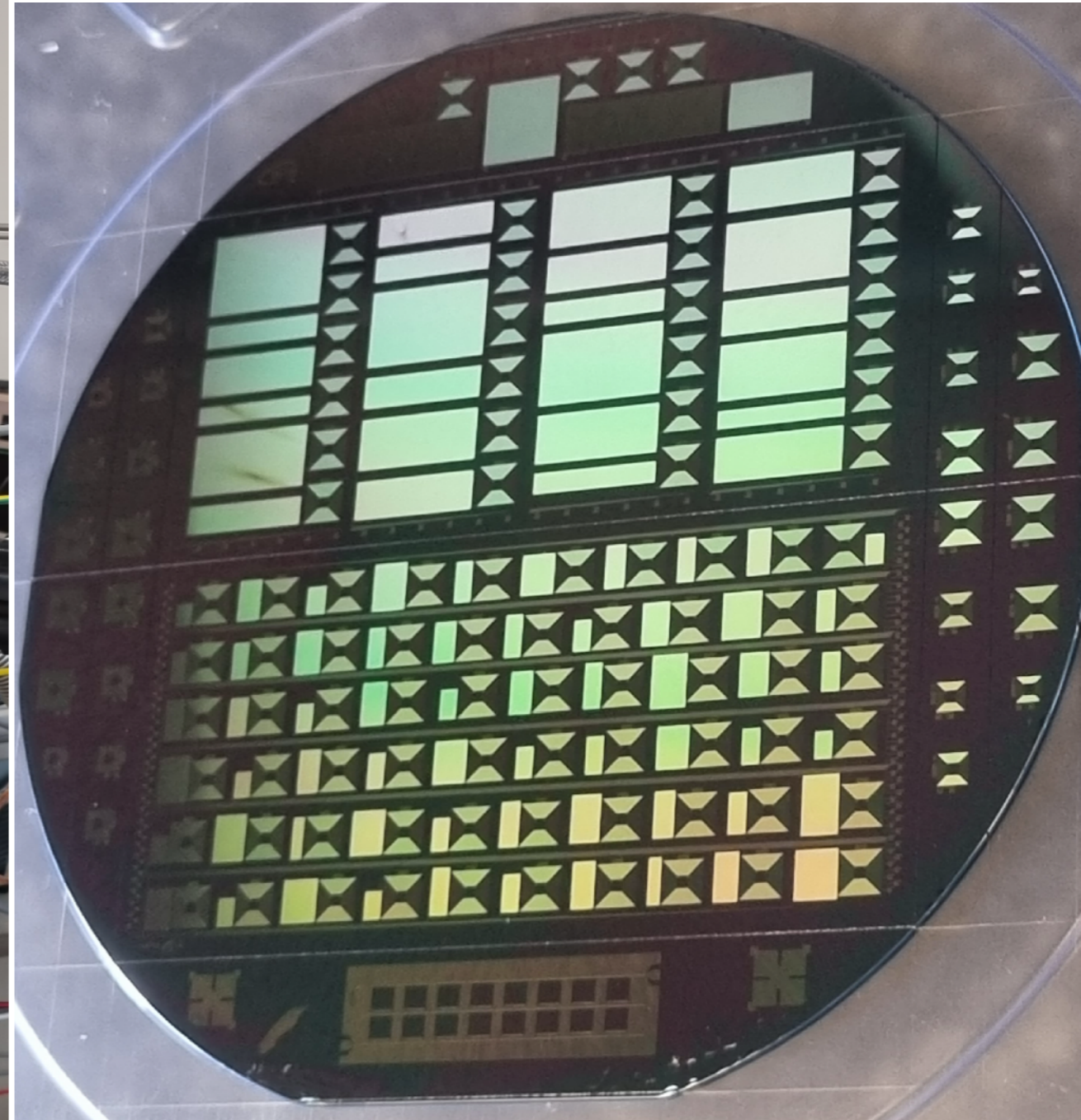
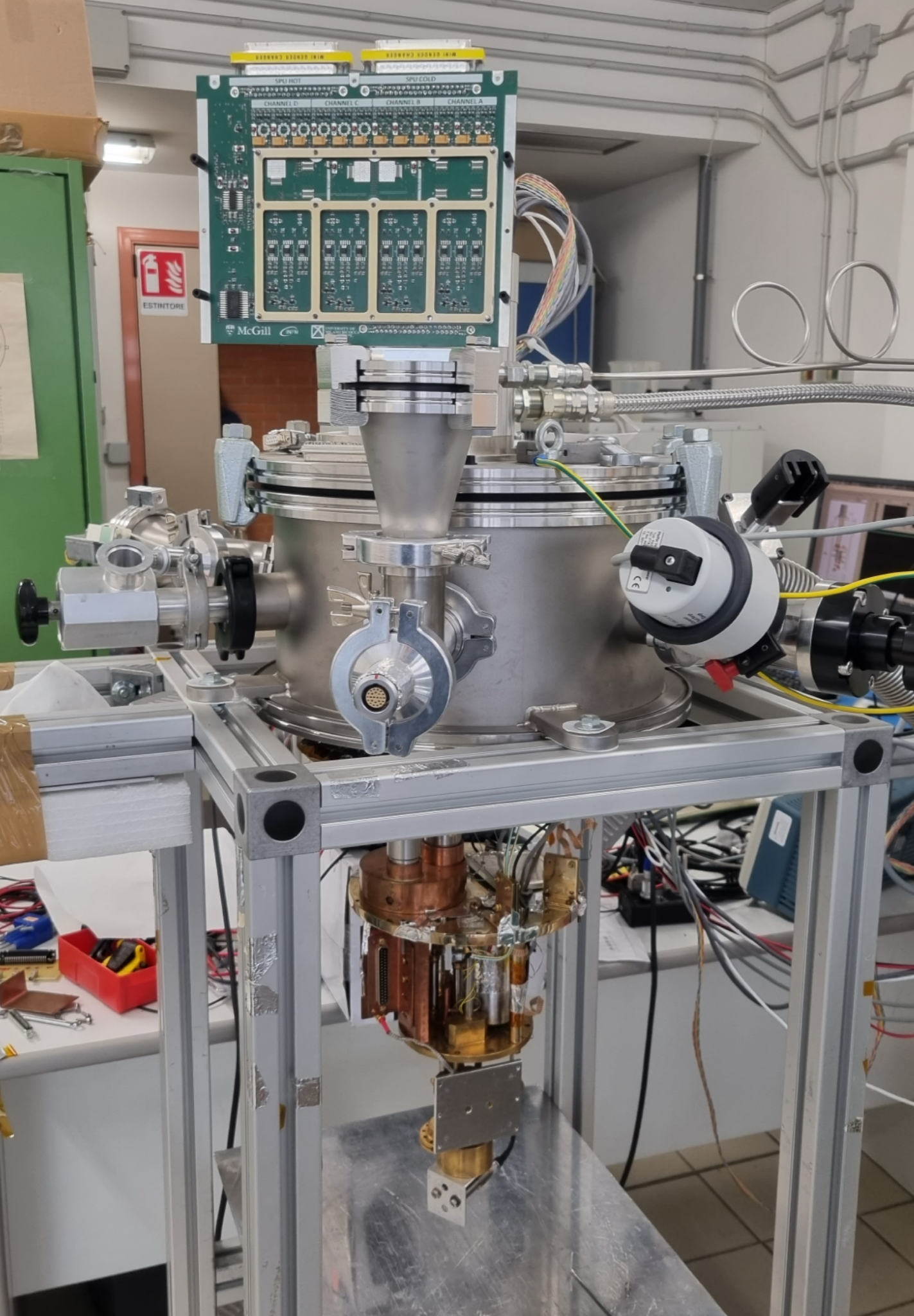
Mechanical design



Simulations



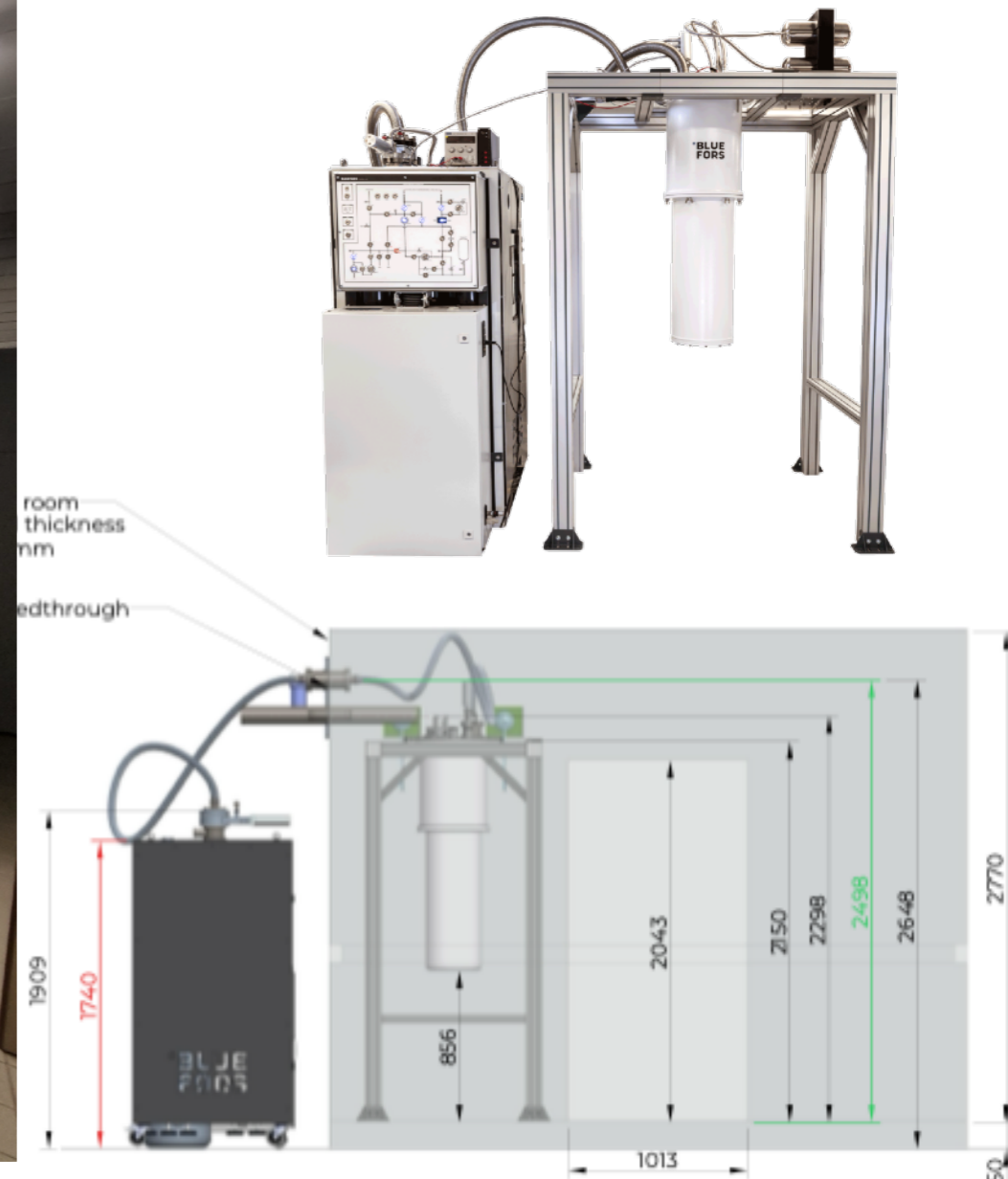
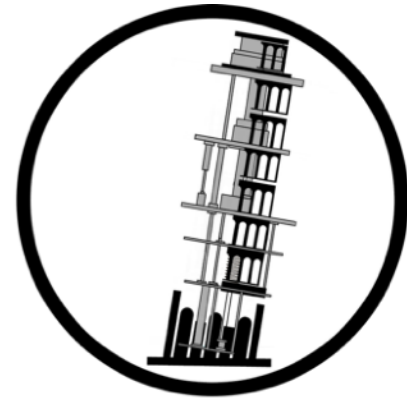






# New cryogenic laboratory

- To **fully accept** the readout boards → need to test in a **representative environment**
- Assembled new **Pisa Cryolab** (<https://sites.google.com/unipi.it/pisalab> in progress)
  - Designed to be compliant with tests for **space applications**
  - financed under **ASI** “Space characterization of electronics and devices” + INFN
  - test of **LiteBIRD readout chain** (TES @100 mK, sub-K SQUID stage)
- **Bluefors SD** to be installed in EMI shielded room (delivered today 20 March!)





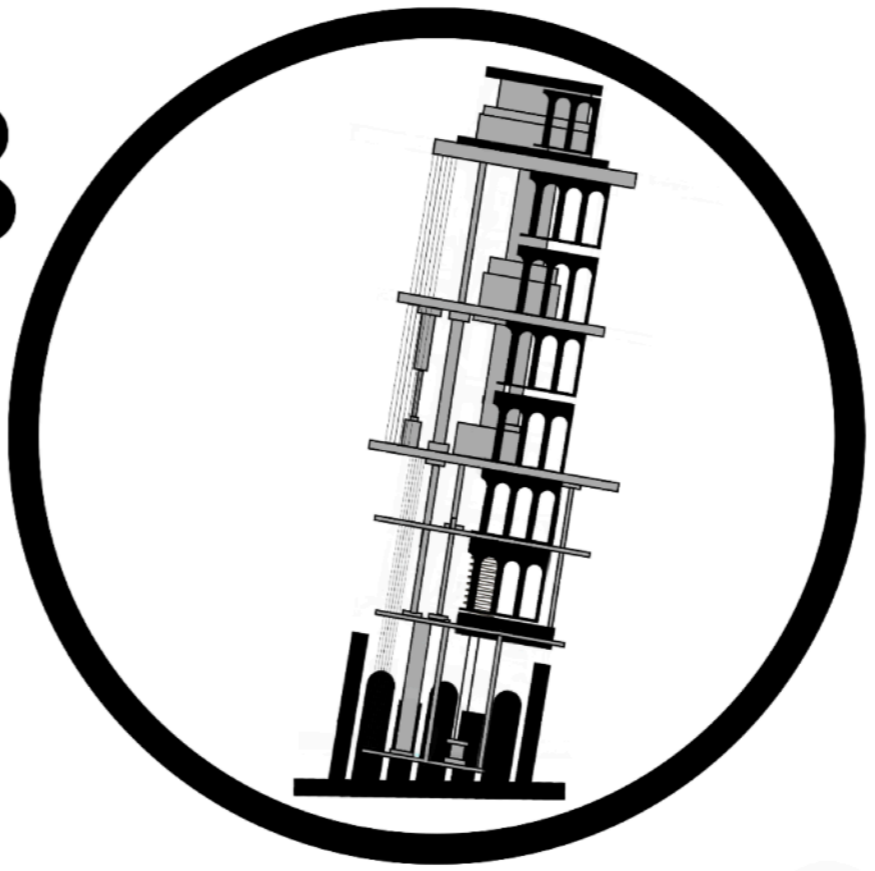


# PISA LAB

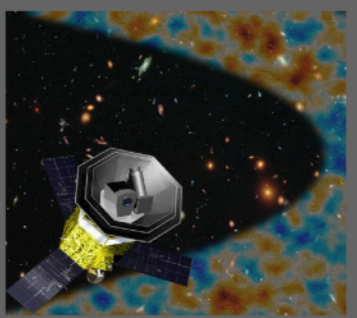
Physics Investigations with  
Sub-Kelvin Apparatus

<https://sites.google.com/unipi.it/pisalab>

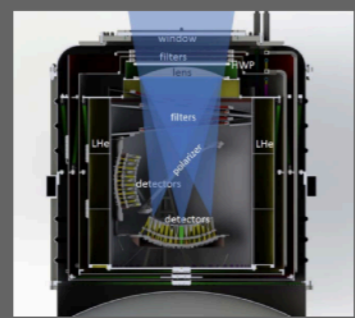
Largo Bruno Pontecorvo,  
56127 Pisa (PI)



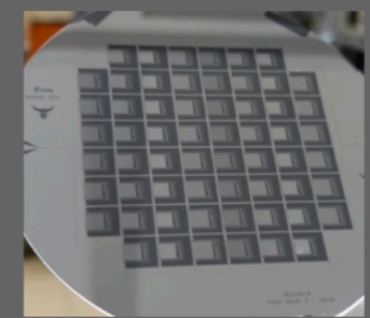
## Research Areas:



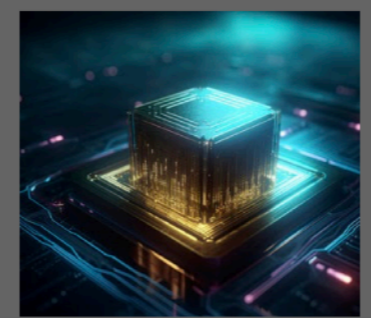
LiteBIRD



LSPE



BULKID



Qub-IT



Publications



Team Members





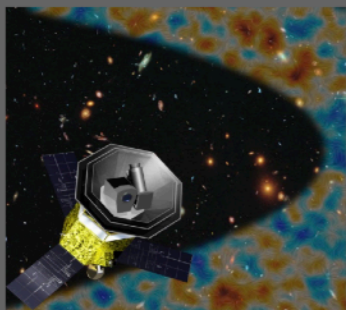
# PISA LAB

Physics Investigations with Sub-Kelvin Apparatus

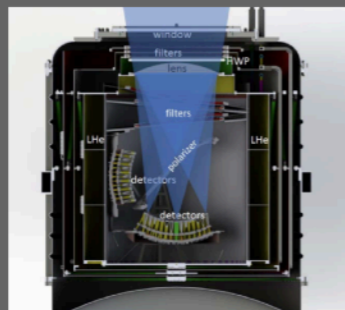
<https://sites.google.com/unipi.it/pisalab>

Largo Bruno Pontecorvo,  
56127 Pisa (PI)

## Research Areas



LiteBIRD



LSPE



BU



Publications

## Team Members

### Staff



Federico Paolucci



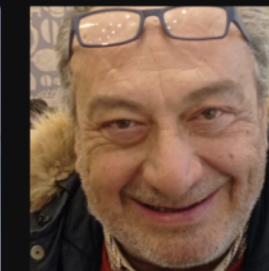
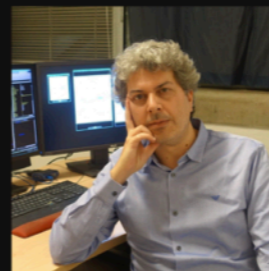
Michele Pinchera



Maurizio Massa



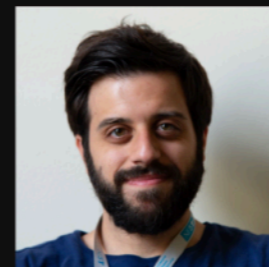
Andrea Moggi



### Adjunct



Mario De Lucia



Claudio Puglia



Kateryna Leonova

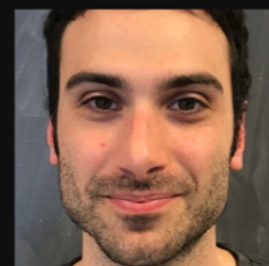


Andrea Sabatucci

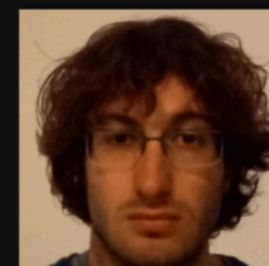
### PhD Students



Eugenia Di Giorgi



Tommaso Lari

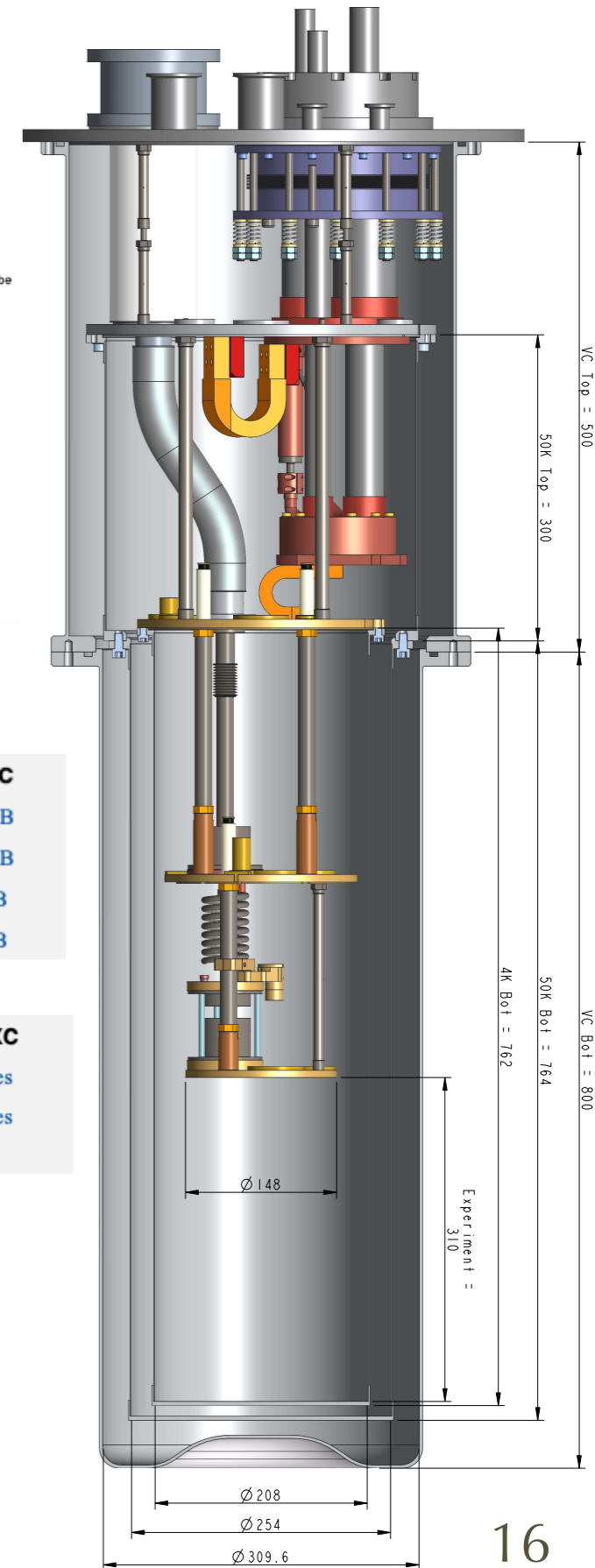
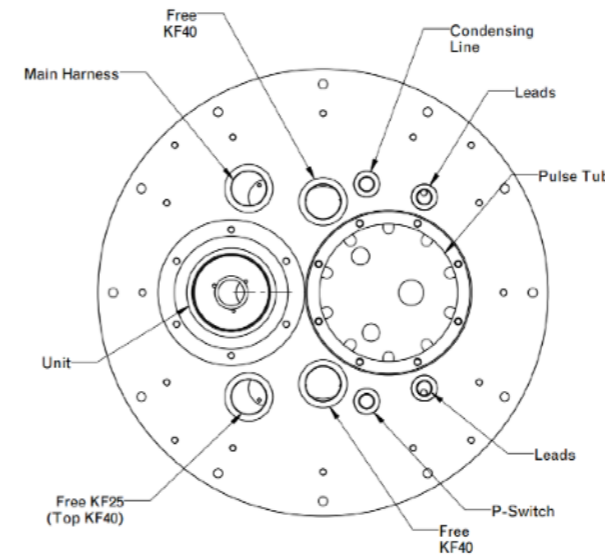


Paolo Del Bo

### Former Members



- Characteristics
  - Base temperature  $< 30$  mK
  - $250 \mu\text{W}$  Cooling power at  $100$  mK
  - $< 12$  h cool-down time
- Ports and connectors
  - 2 x KF40 + 1 x KF25
  - DC wiring: 12x twisted NbTi/CuNi to MXC
  - DC wiring: 12x twisted PhBr to MXC
  - DC wiring: 12x twisted PhBr to 4K
  - 4x SMA to MXC sCuNi 0.86 mm w/cryo attenuators



RF Installation set

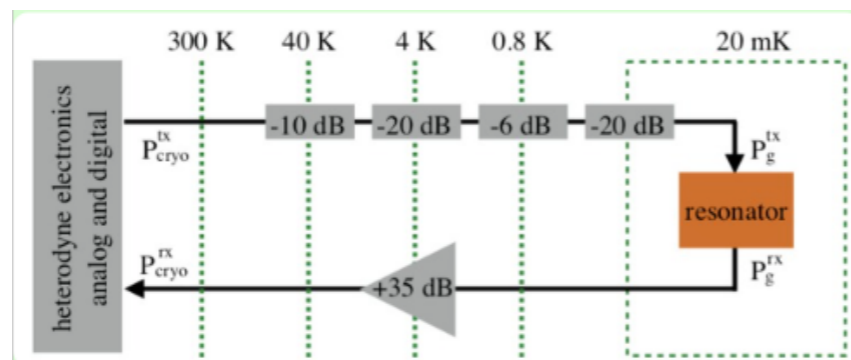
Attenuators

	Connector type	RT-50K	50K-4K	4K-Still	Still-CP	CP-MXC	50K	4K	Still	MXC
1.1	SMA	SN086	SN086	SN086	SN086	SN086	1dB	20dB	20dB	20dB
1.2	SMA	SN086	SN086	SN086	SN086	SN086	10dB	20dB	6dB	20dB
1.3	SMA	SN086	SN086	SN086	SN086	SN086	0dB	0dB	0dB	0dB
1.4	SMA	SN086	SN086	SN086	SN086	SN086	0dB	0dB	0dB	0dB

DC lines

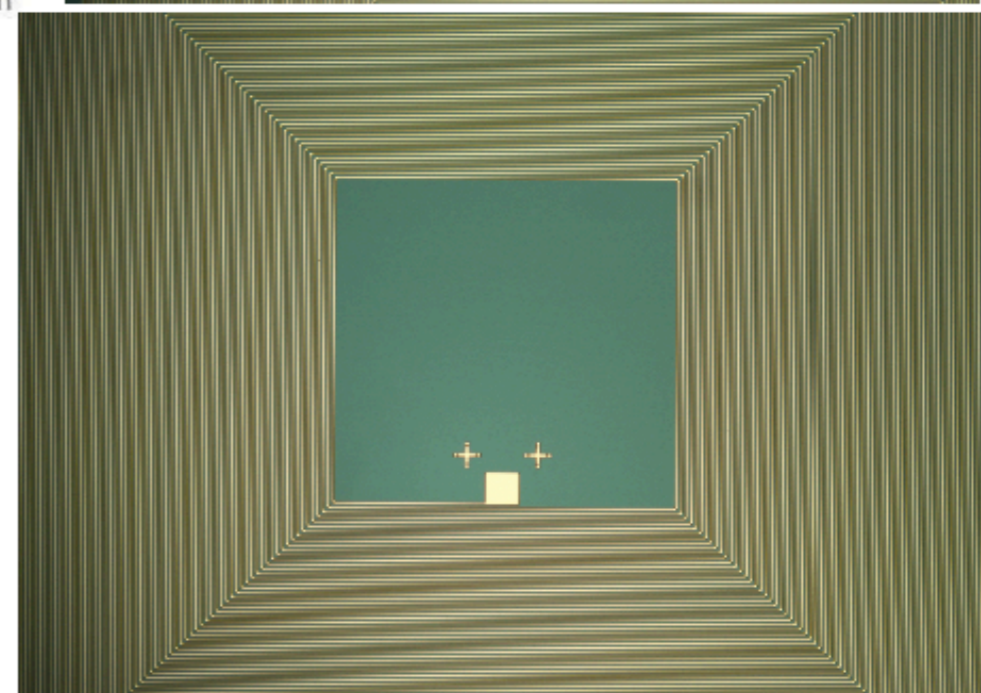
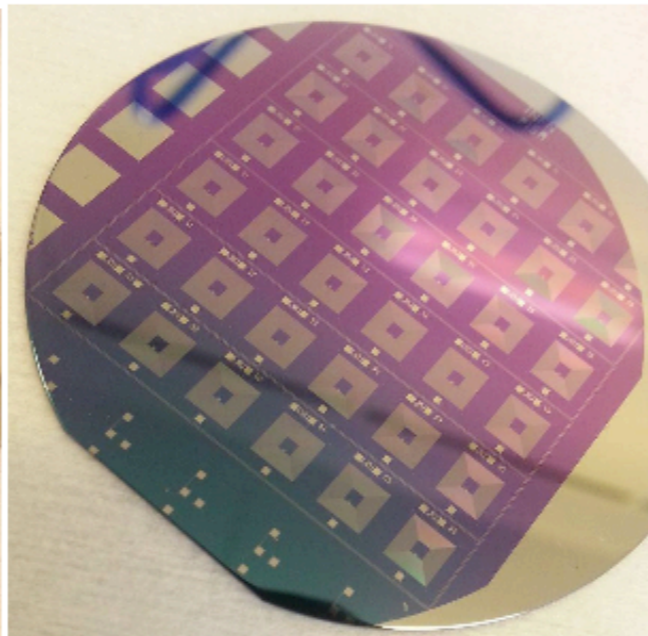
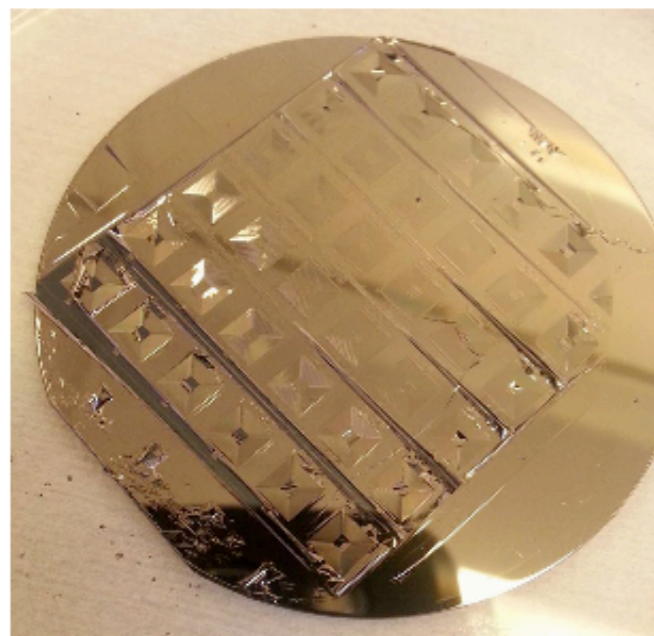
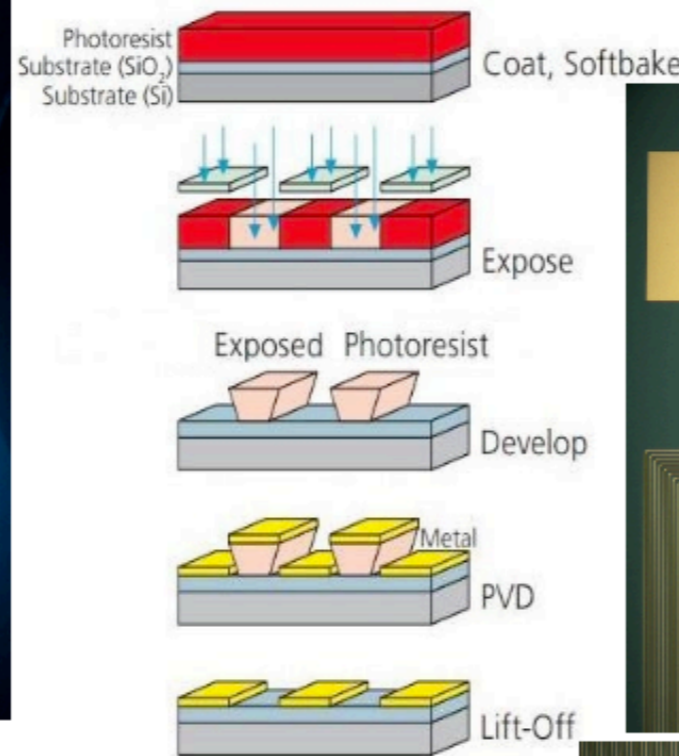
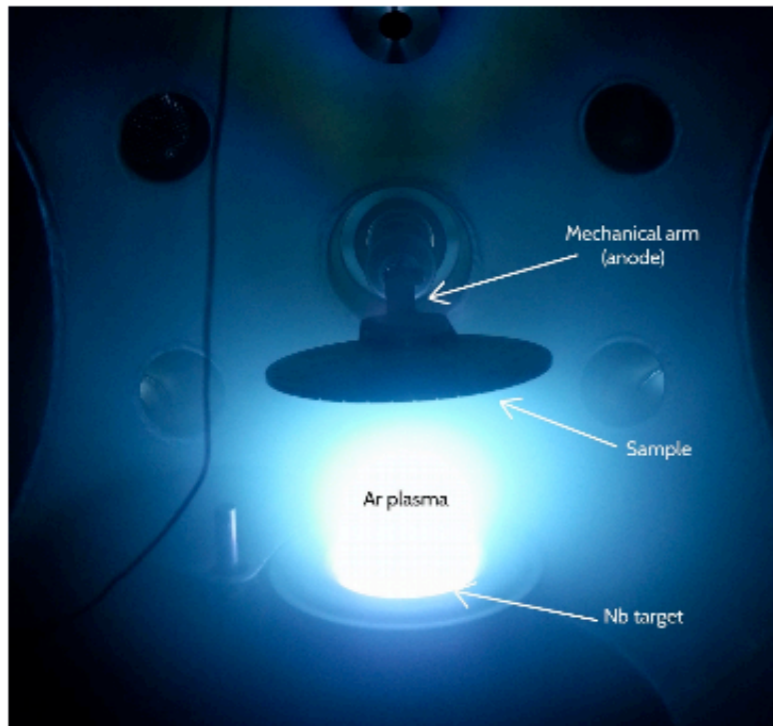
Break.out

	EM Shielding	RT-50K	50K-4K	4K-Still	Still-CP	CP-MXC	50K	4K	Still	MXC
1.1	Yes	Cu		NbTi/CuNi	NbTi/CuNi	NbTi/CuNi		Yes		Yes
1.1	Yes	PhBr		PhBr	PhBr	PhBr		Yes		Yes
1.1	Yes	PhBr						Yes		





- At the beginning of the LSPE project we realized Nb inductors at NEST-SNS Laboratories in Pisa
- We gained knowledge on fabrication and processes.
- Lately we just designed patterned structures and had them fabricated elsewhere
  - StarCryo SantaFe (NM)





- Possibility to **fabricate structures** in our clean rooms in a collaboration between University and INFN (Dipartimento di Eccellenza)
  - DMO **Microwriter Baby+** (1  $\mu\text{m}$  resolution, 4’’)
  - Zeiss **Focussed-ion beam**
  - Kurt J Lesker **PVD75 Thermal evaporator** (Al, Au, Ti, Ni, Cr)
  - Spin **coater**, **MJB4** mask aligner
  - realize **SC detectors in house** (KIDs, TESs, nanowires...)





- **Cryogenic lab** with
  - 300 mK **sorption cooler**
    - DC lines
    - SQUID, TES tests
  - 30 mK **dilution fridge** inside EMI chamber
    - DC lines
    - RF lines for KIDs readout
  - **Training** of people
    - Students
    - Reserchers/Technologists
    - Technicians.
- **Clean room** facilities
  - Gluing, Bonding, support
- **Wet laboratory**
  - Newly set-up
  - start **sensor production** before the summer.
- INFN **Mechanical workshop**
  - EDM
  - standard machines and tools

