

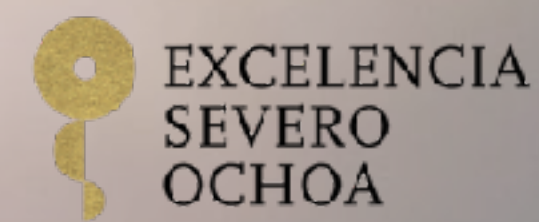
# The Quantum Computing Technology Group at IFAE

Pol Forn-Díaz

IFAE - Tsung-Dao Lee Institute, 18/05/2026



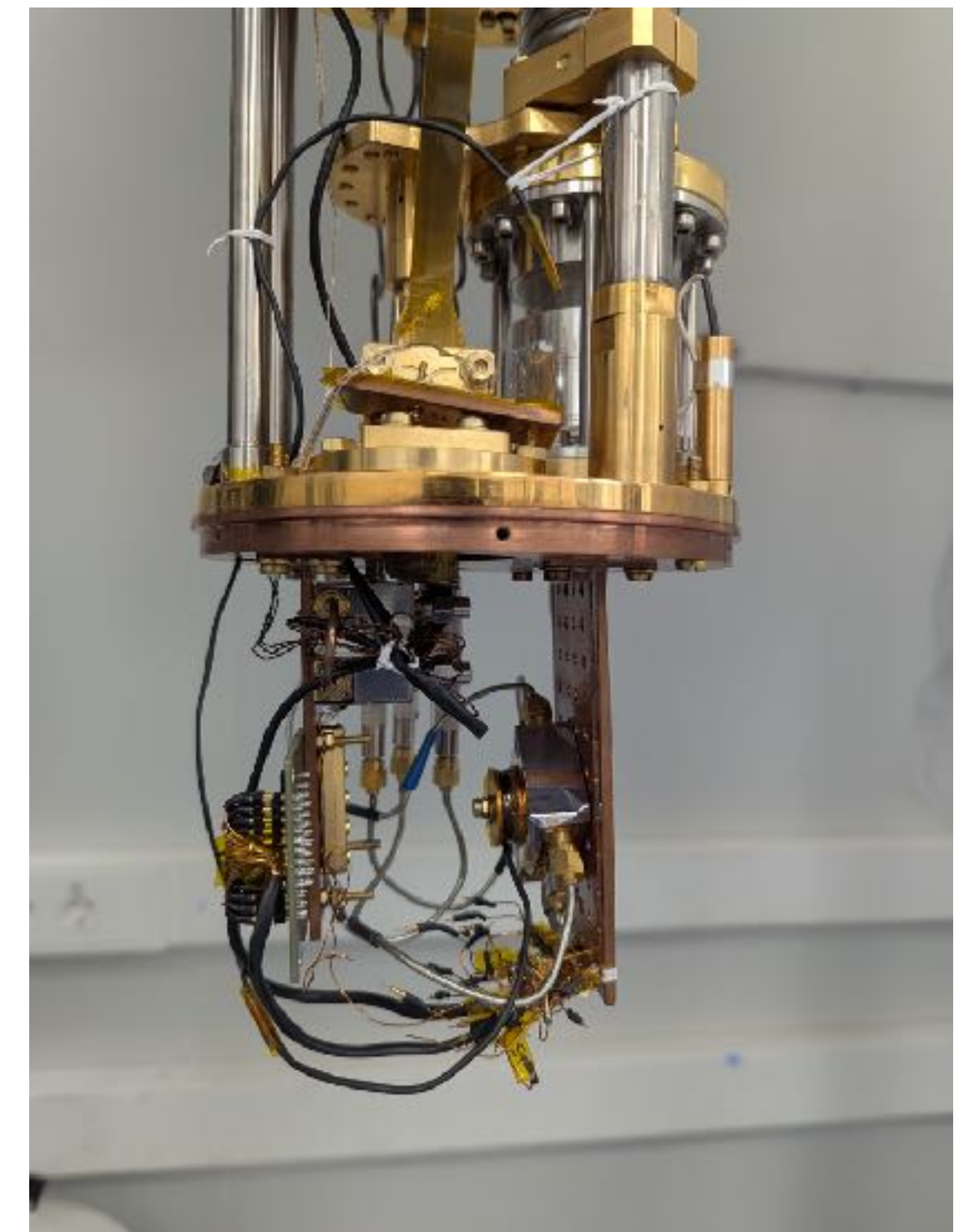
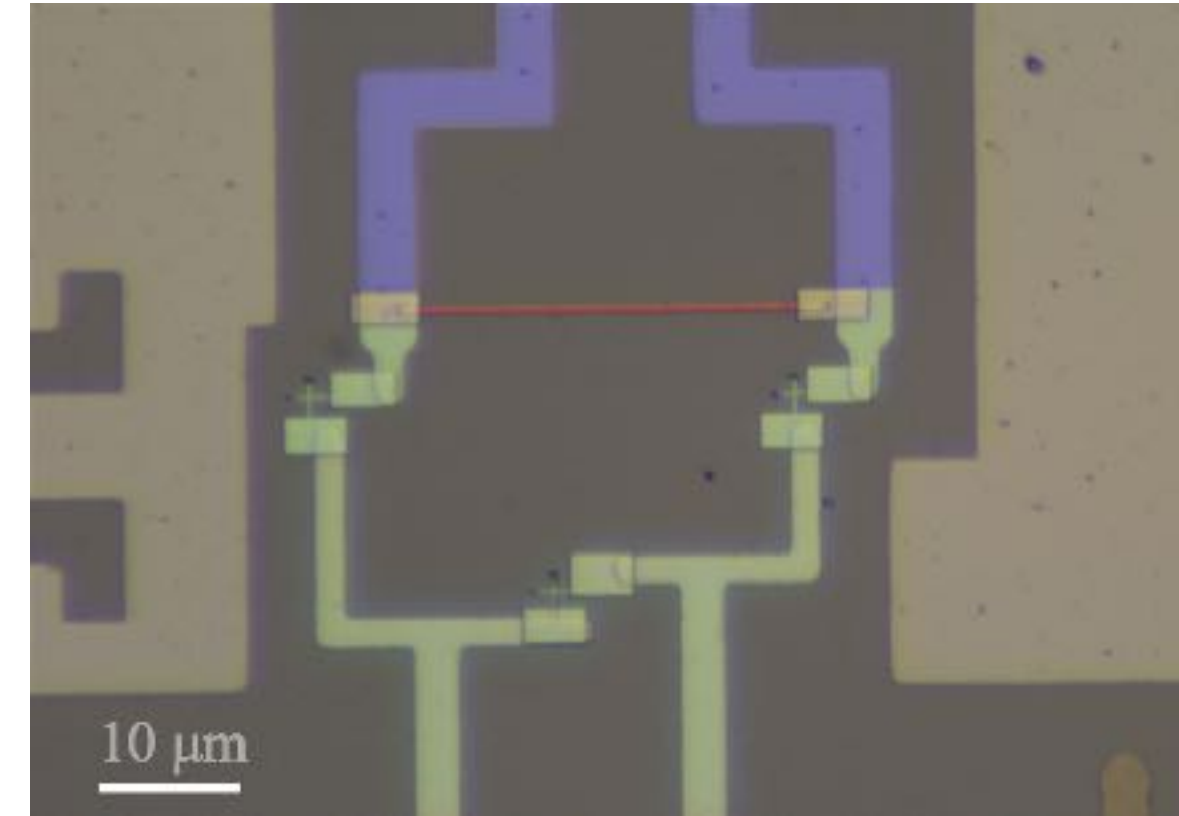
Institut de Física  
d'Altes Energies



# Superconducting qubits for quantum technology applications

## Main QCT group goals

- Study and improve **superconducting qubit quality** by novel material exploration and decoherence sources.
- Improve **scalability** of superconducting qubit quantum computing technology with novel design approaches in small-scale prototypes.
- Apply superconducting qubits for **fundamental physics exploration** through **sensing** applications of high energy physics events and quantum optics.



## Current lines of research

1. **Quantum Computing with coherent quantum annealing:** coherent flux-based qubits. New qubit types, new materials, new qubit couplers.  
Funded by EuroQHPC-I, SUPREME.
2. **Superinductive materials** for quantum technologies: new materials for computation and sensing with qubits.  
Funded with Quanterra/Spanish Ministry funds.
3. **Qubits as detectors of HEP:** detection of single microwave photons for fundamental physics applications.  
Funded with Quanterra/Spanish Ministry funds.



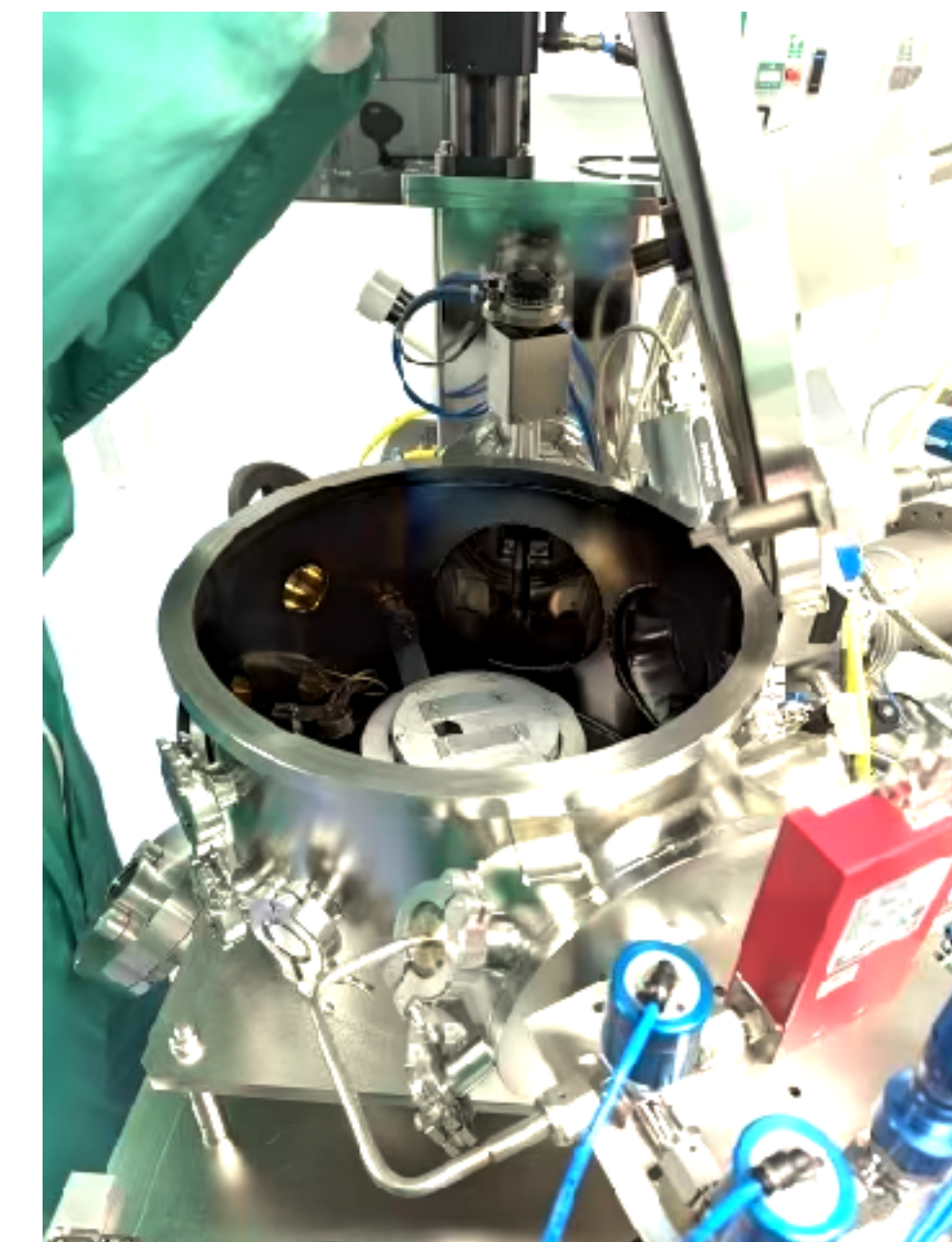
# Laboratory space: Dilution refrigerators + Cleanroom



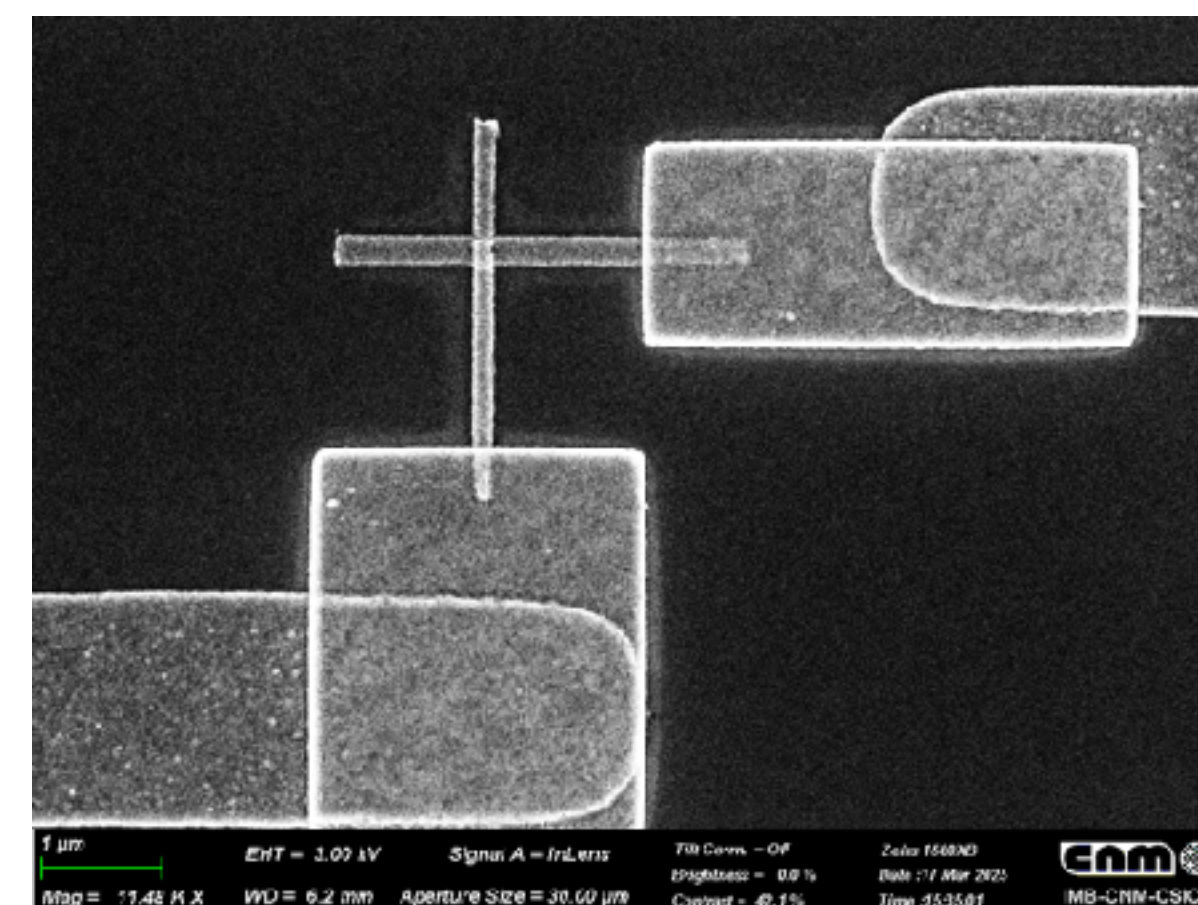
[www.qilimanjaro.tech](http://www.qilimanjaro.tech)



- 2 dilution refrigerators, both functional attaining temperatures **10-20mK**.
- 1 complete qubit measurement setup, second setup under construction.
- Quantum limited amplifier for ultimate qubit readout.
- Engine room in upper floor containing He compressors.
- Microwave equipment for generation of fast, low-level GHz signals for qubit control and readout.



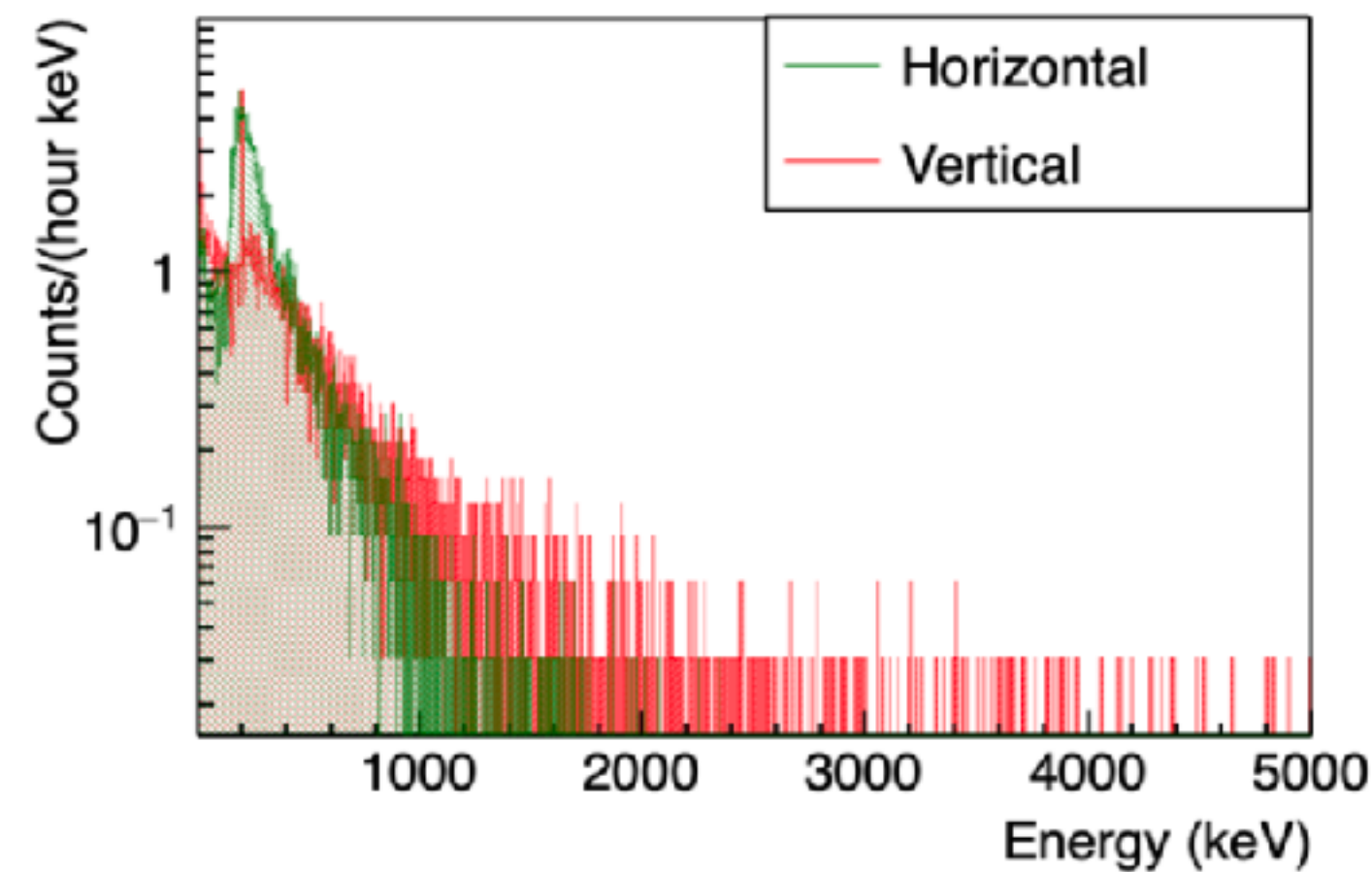
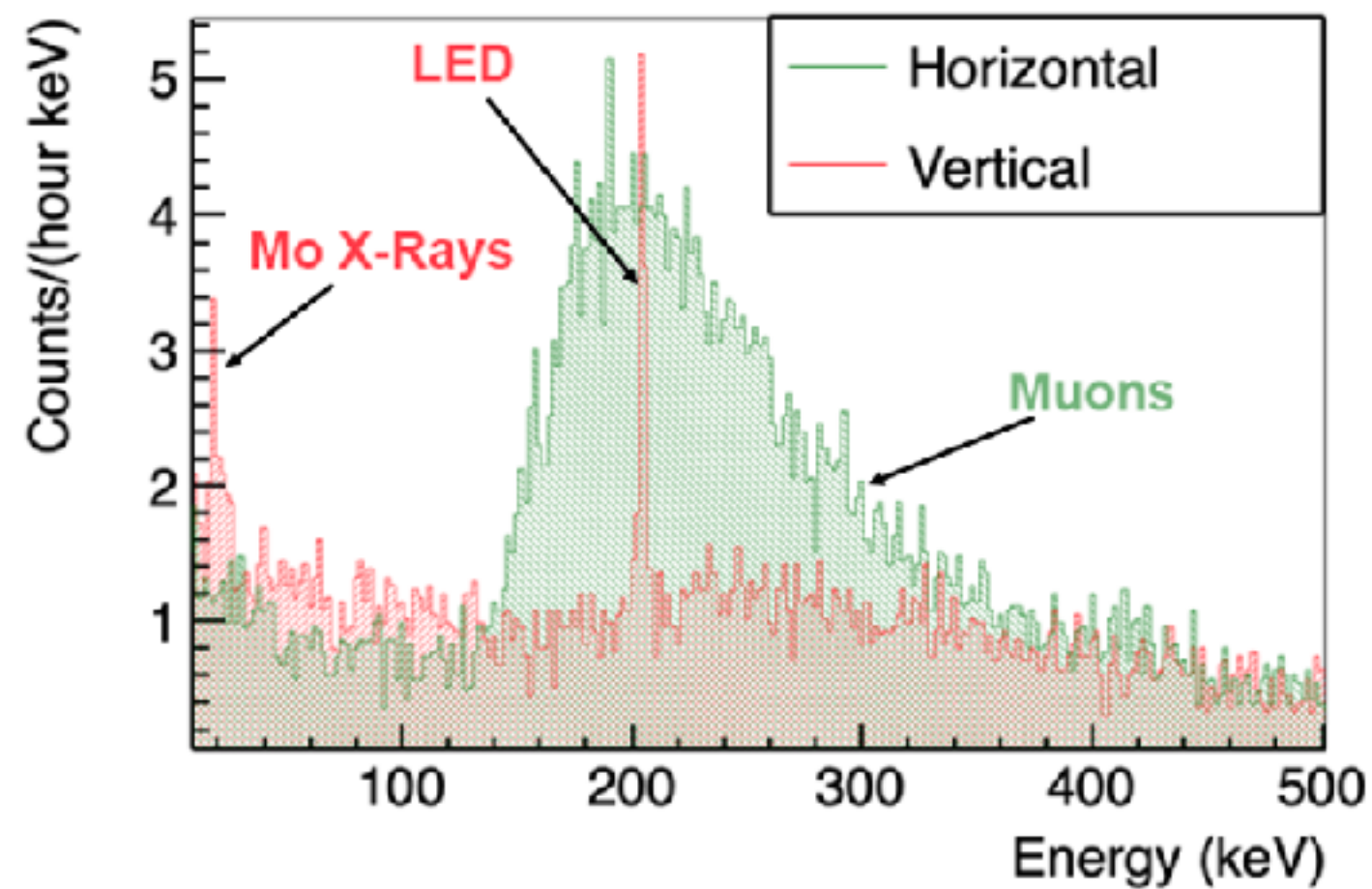
- Metal deposition instrument for qubit device production.
- First working qubits produced fully in-house in 2024.
- Evaporator owned by startup Qilimanjaro, shared with IFAE.
- Fabrication facility includes wet bench + optical microscope.



# Project ICRQ: Interaction of Cosmic Radiation with Qubits

## Cosmic muon flux attenuation: Angular muon incidence

IJC Lab Prof. A. Giuliani in Orsay (France)



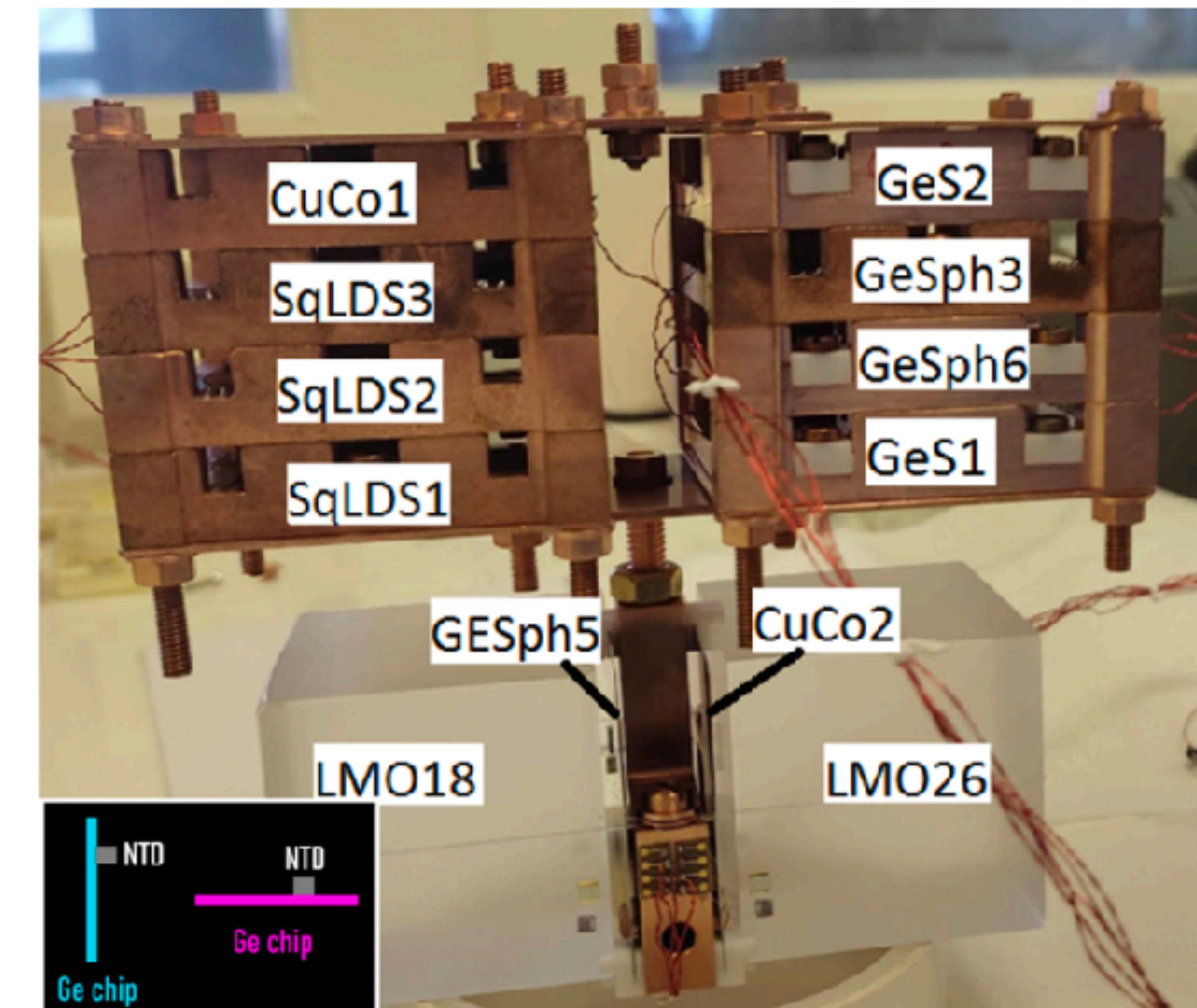
Excess counts in horizontal at lower energies < 500keV

	Counts/hour	
	Vertical (no LED)	Horizontal
100-500 keV	$5894 \pm 77$	$12237 \pm 111$
>100 keV	$9058 \pm 95$	$14111 \pm 119$
>500 keV	$3164 \pm 56$	$1874 \pm 43$

Excess counts in vertical at higher energies (travel length of the chip)

Future plans to use NTDs for vetoing impact of cosmic rays

Neutron transmutation-doped (NTD) Ge sensors for radiation detection.



# Project ICRQ: Interaction of Cosmic Radiation with Qubits

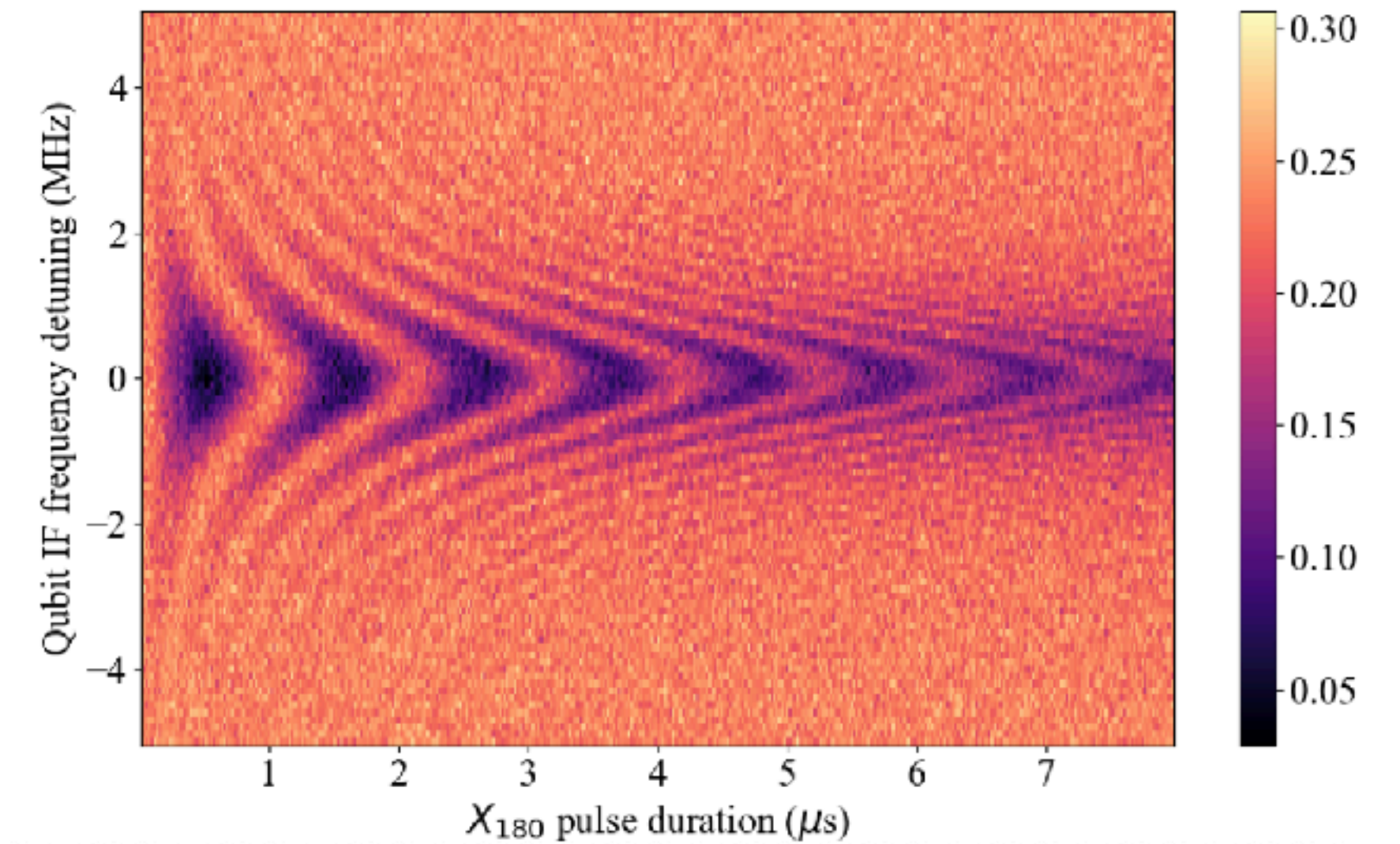
## Next steps: color of radiation vs qubit impact

Qubit sensor of charge effects as on-chip radiation detector

Transmon qubit in 3D copper cavity to detect charge fluctuations

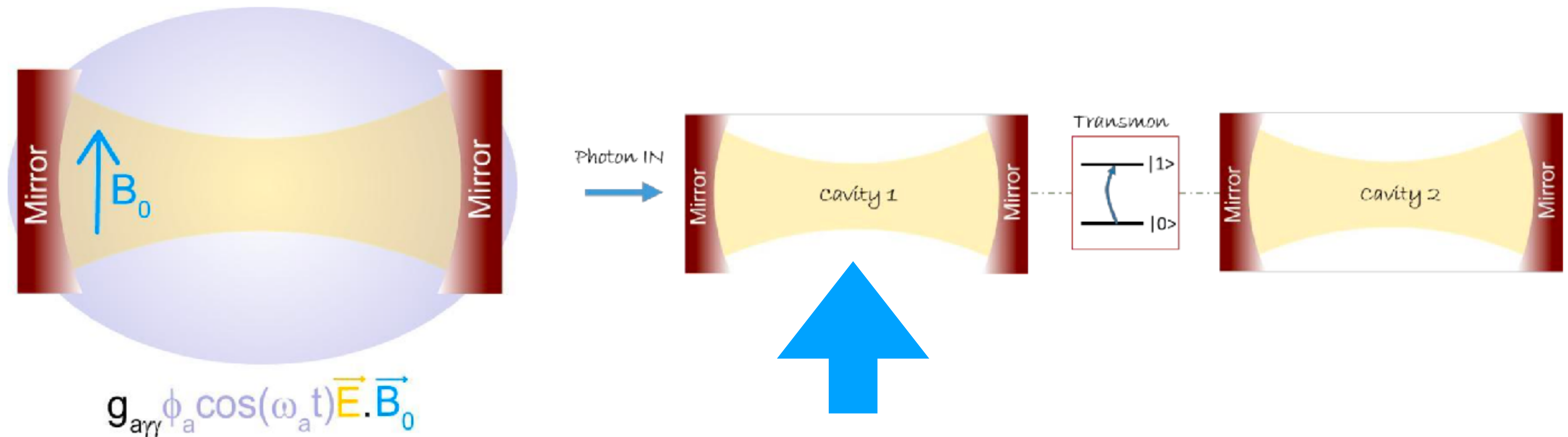


Qubit coherent oscillations in cavity



# Project QRADES: Quantum Relic Axion DEtection Sensors

Turning qubits into sensors with superinductors



Dark matter  
requires magnetic  
fields to interact

We need magnetic field-resilient qubits:

- Granular aluminum
- Thin aluminum
- Other material (Nb)?

# Project QRADES: Quantum Relic Axion DEtection Sensors

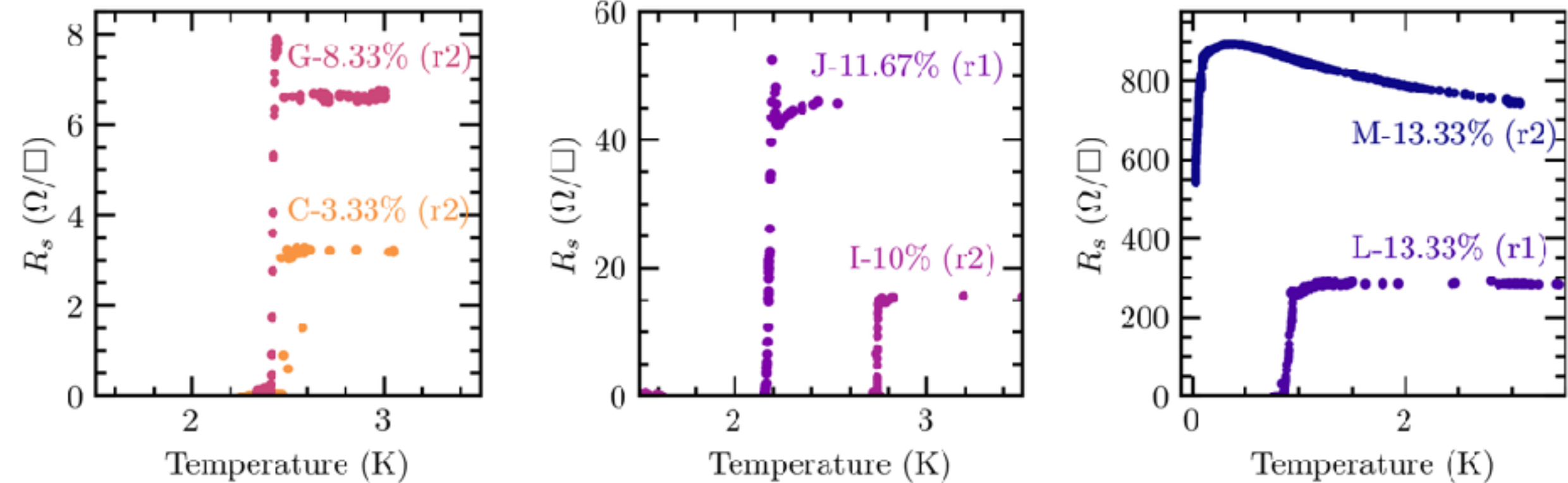
Nitridized Aluminum (NitrAl)

In collaboration with for material production:

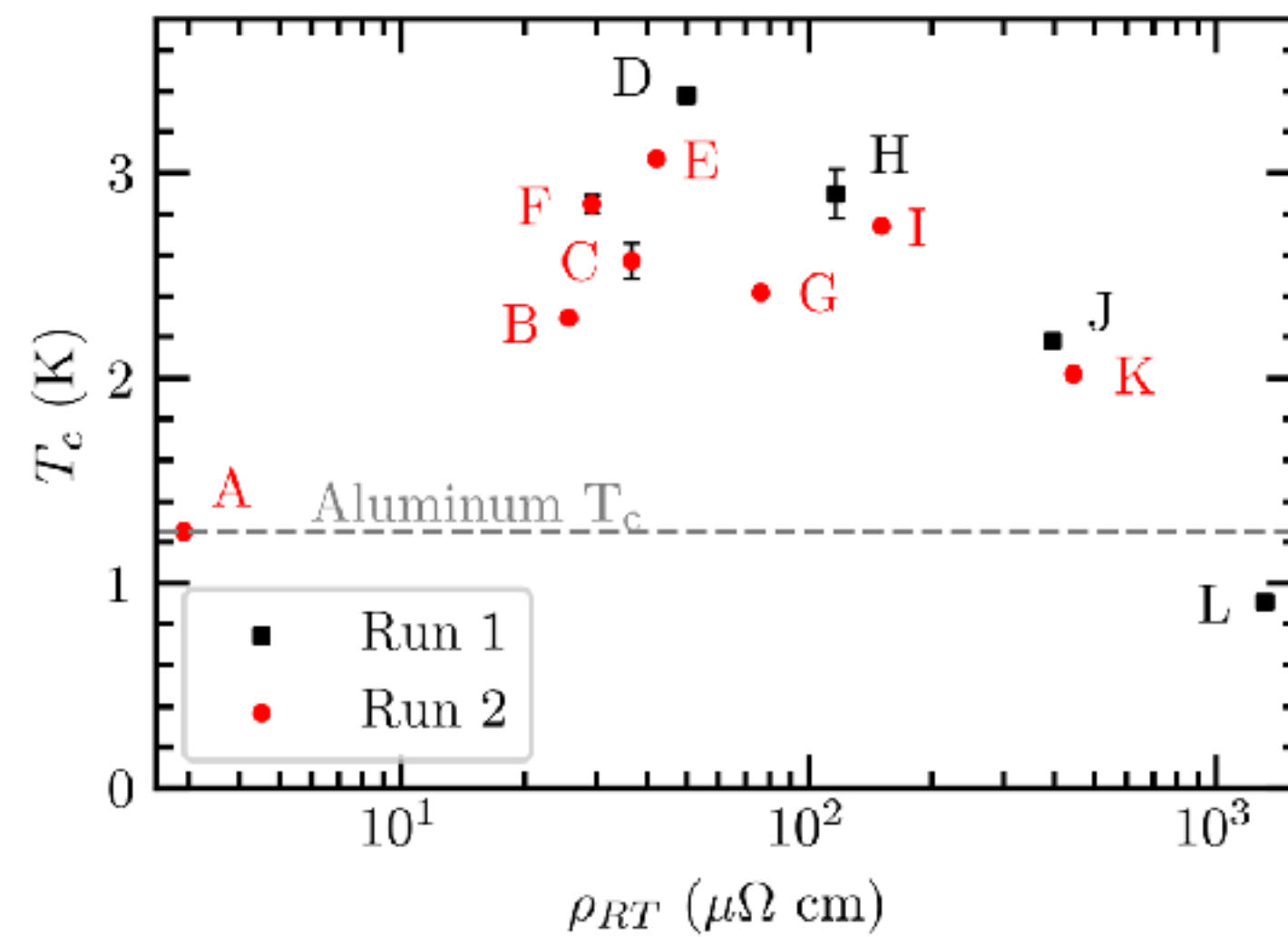
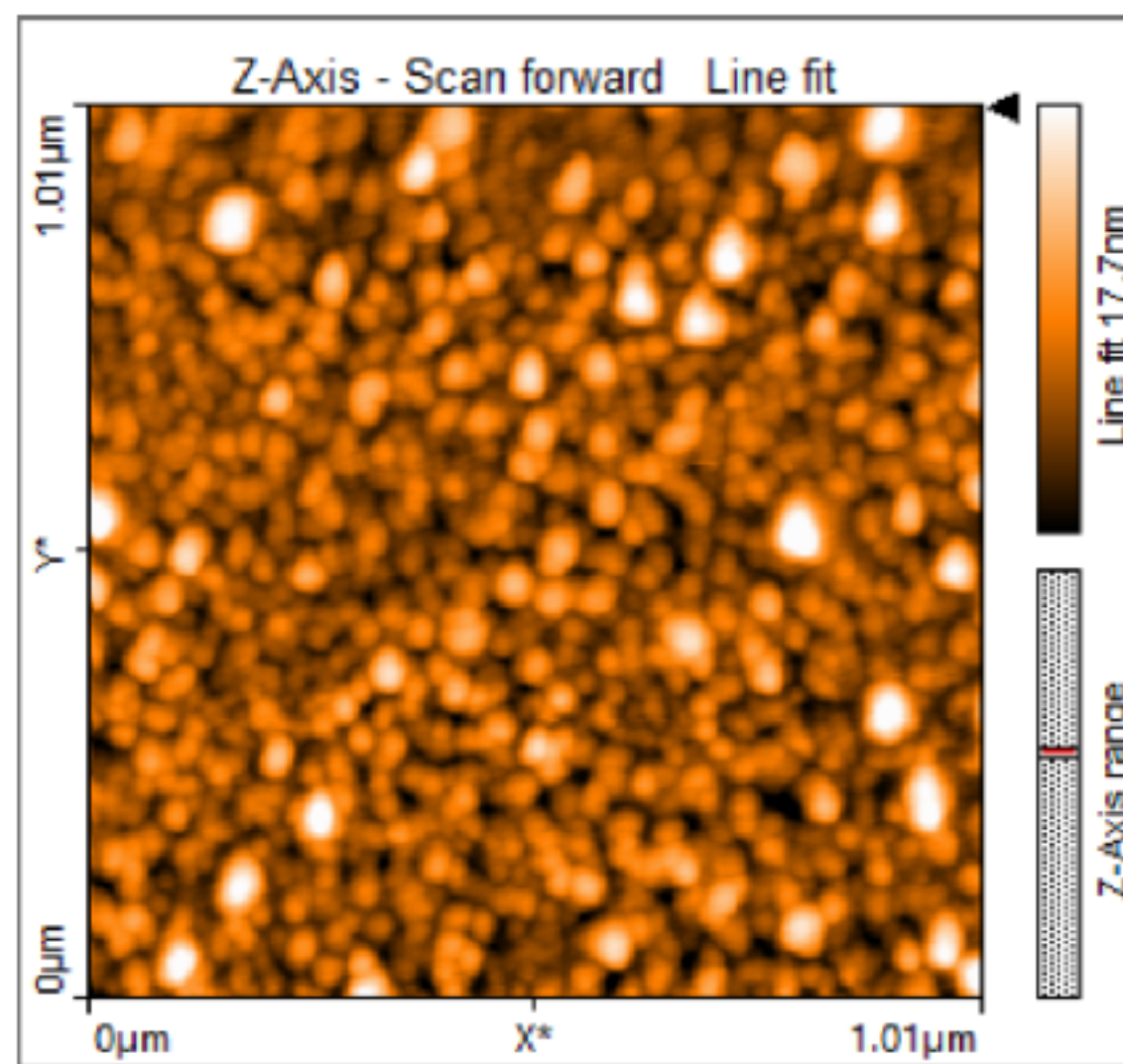


UNIVERSITY OF COLOGNE

First demonstration of superconductivity in NitrAl:

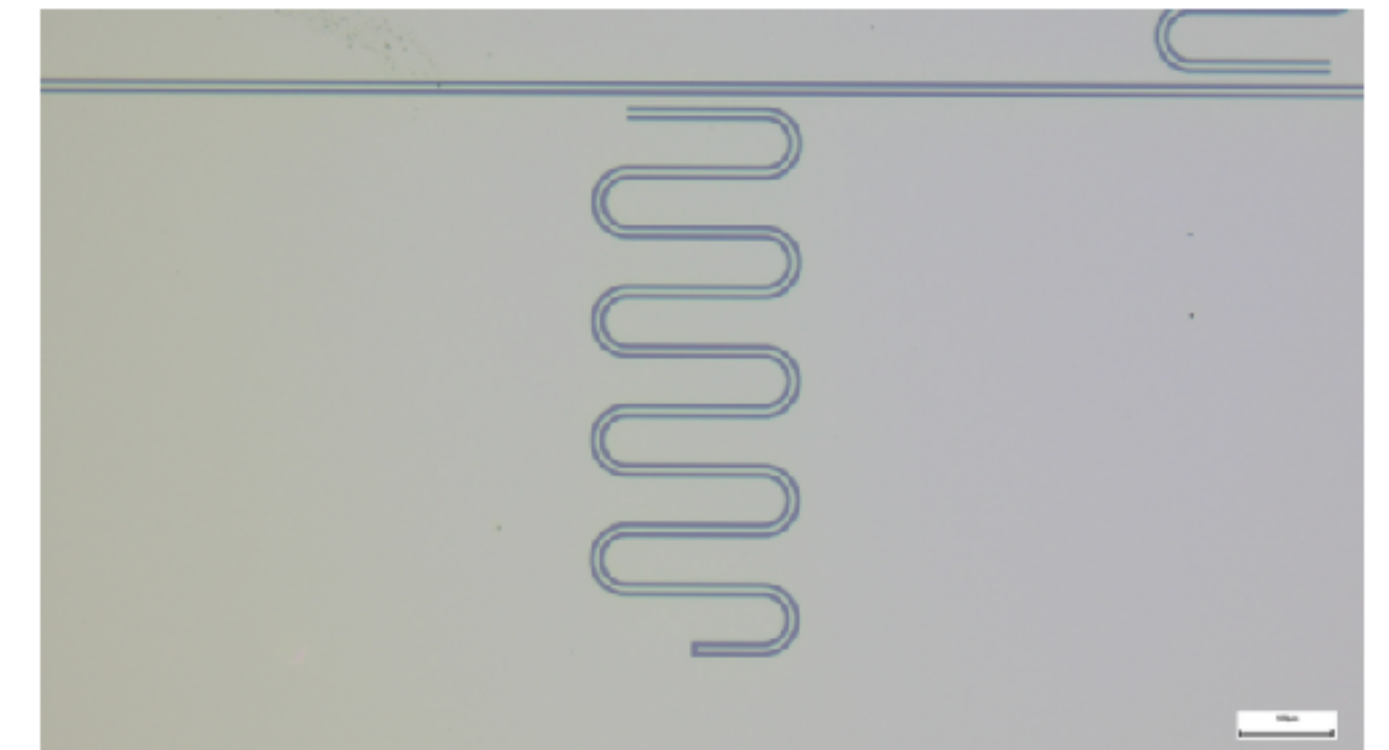


(a)



(c)

First resonator devices ready



Next steps making superconducting qubits with NitrAl

# QCT Team members



P. Forn-Díaz, PI



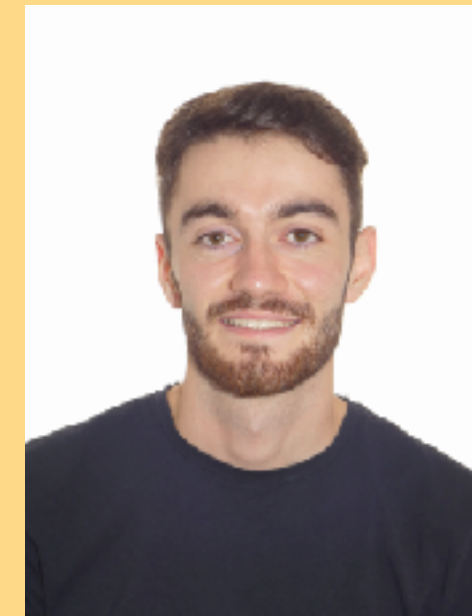
Manel Martínez, staff



Elia Bertoldo, Postdoc



Ariadna Gómez del Pulgar Martínez, PhD



Guillermo del Riego, PhD



Elsa Herranz, TFM



Pau Jimenez, TFM



<https://qct.ifae.es>



THANK YOU!



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European Commission

Horizon 2020  
European Union funding  
for Research & Innovation



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