

S. Di Domizio Milano – November 20, 2023

## COLD

#### PRIN 2020 – 2020H5L338

- "Thin films and radioactivity mitigation to enhance superconducting quantum processors and low temperature particle detectors"
- 3 years project: May 2022-May 2025
- 4 research units: INFN, GSSI, UniGe, UniMiB

#### COLD: Coatings for Optimized Low temperature Devices

• Just another name for the same project

# PROJECT GOALS

1.Enhance the performance of superconducting qubits by suppressing the decoherence and correlated errors induced by radioactivity

2.Propose an innovative design of cryogenic calorimeters for rare events searches, featuring at the same time higher performance and simplified hardware implementation

3.Develop a simulation framework to model and optimize the thermal behavior of qubits and cryogenic detectors

### ORGANIZATION

WP1 - Thin films	WP2 - Radioactivity
T.1.1 - Thin films applied to resonators T.1.2 - Thin films applied to qubits	T.2.1 - Measurement and modelling of radioactivity in qubits
T.1.3 - Thin films applied to crystals	T.2.2 - Radioactivity mitigation in qubits UniMiB
T.1.4 - Thin film coating for cryogenic calorimetersGSSI	T.2.3 - Radiopurity in detectors coating
WP3 - Thermal model	
T.3.1- Modelling the phonon transmission in superconducting quantum circuits INFN	
T.3.2- Modelling thermal properties of cryogenic detectors UniMiB	Management and Dissemination

### **PROJECT SCHEDULE**

		YEAR 1			YEAR 2				YEAR 3				
	WP	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36
WP1 Thin films at low temperatures	T.1.1 Thin films applied to resonators							D.1.1					
	T.1.2 Thin films applied to qubits												D.1.2
	T.1.3 Thin films applied to crystals								D.1.3				
	T.1.4 Thin film coating for calorimeters												D.1.4
WP2 Radioactivity in low temperature devices	T.2.1 Measurement and modelling of radioactivity in qubits				D.2.1								
	T.2.2 Radioactivity mitigation in qubits								D.2.2				
	T.2.3 Radiopurity in detectors coating							D.2.3					D.2.4
WP3 Thermal model	T.3.1 Modelling the phonon transmission in superconducting quantum circuits												D.3.1
	T.3.2 Modelling thermal properties of cryogenic detectors												D.3.2
Gantt chart: Timing of the three WPs (D = deliverable)							toc	lay					

## Deliverables

#### WP1 – Thin films at low temperature

- D.1.1 (Q7): A superconducting resonator with phonon traps, featuring an internal quality factor an order of magnitude better
- D.1.2 (Q12): A qubit with phonon traps operated in a radiopure environment, featuring a coherence time in the millisecond scale
- D.1.3 (Q8): Definition of a protocol for crystal coating (thin film material and deposition technique)
- D.1.4 (Q12): Low temperature calorimetric test of an array of coated CUPID-like and COSINUS-like crystals

#### WP2 – Radioactivity in low temperature devices

- D.2.1 (Q4): Model describing how materials constituting the qubit contribute to its radioactive rate
- D.2.2 (Q8): Radiopure qubit prototype
- D.2.3 (Q7): Preliminary selection of the materials for coatings
- D.2.4 (Q12): Background produced in COSINUS/CUPID by contamination in coating materials

#### WP3 – Thermal model

- D.3.1 (Q12): Model of phonon propagation in qubits including the effect of phonon traps
- D.3.2 (Q12): Model of thermal properties of cryogenic detectors

#### COMMUNICATION AND DISSEMINATION

- Website: https://cold.unimib.it/
- Internal communication: slack
- Publications
  - L. Cardani et al., "Disentangling the sources of ionizing radiation in superconducting qubits", Eur.Phys.J.C 83 (2023) 1, 94
  - Reference to PRIN 2020H5L338 will appear in future CUPID papers
- Dissemination: towards the scientific community and the general public

### TODAY'S MEETING

COLD Meeting Monday Nov 20, 2023, 10:00 AM → 4:00 PM Europe/Rome V1-14 (INFN-MiB)							
<b>10:45 AM</b> → 12:30 PM	Presentazion	i					
	10:45 AM	COLD Speaker: Sergio Di Domizio (Istituto Nazionale di Fisica Nucleare)	<b>③</b> 10m				
	11:00 AM	Update sulle misure qubit underground Speaker: Laura Cardani (Istituto Nazionale di Fisica Nucleare)	<b>()</b> 20m				
	11:25 AM	Impatto del coating di Al sui calorimetri LMO Speaker: Massimo Girola (Istituto Nazionale di Fisica Nucleare)	<b>()</b> 20m				
	11:50 AM	Titanium phonon traps fabrication Speakers: Mourad El Idrissi (Istituto Nazionale di Fisica Nucleare), Oscar Azzolini (Istituto Nazionale di Fisica Nucleare)	<b>()</b> 20m				
12:30 PM → 2:00 PM		Lunch	<b>()</b> 1h 30m				
2:00 PM → 3:30 PM	<b>Discussione</b> Pianificazione, de	eposizioni, misure, AOB					

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