



BULLKID-DM

Federico Ferraro

on behalf of BULLKID_DM LNGS team

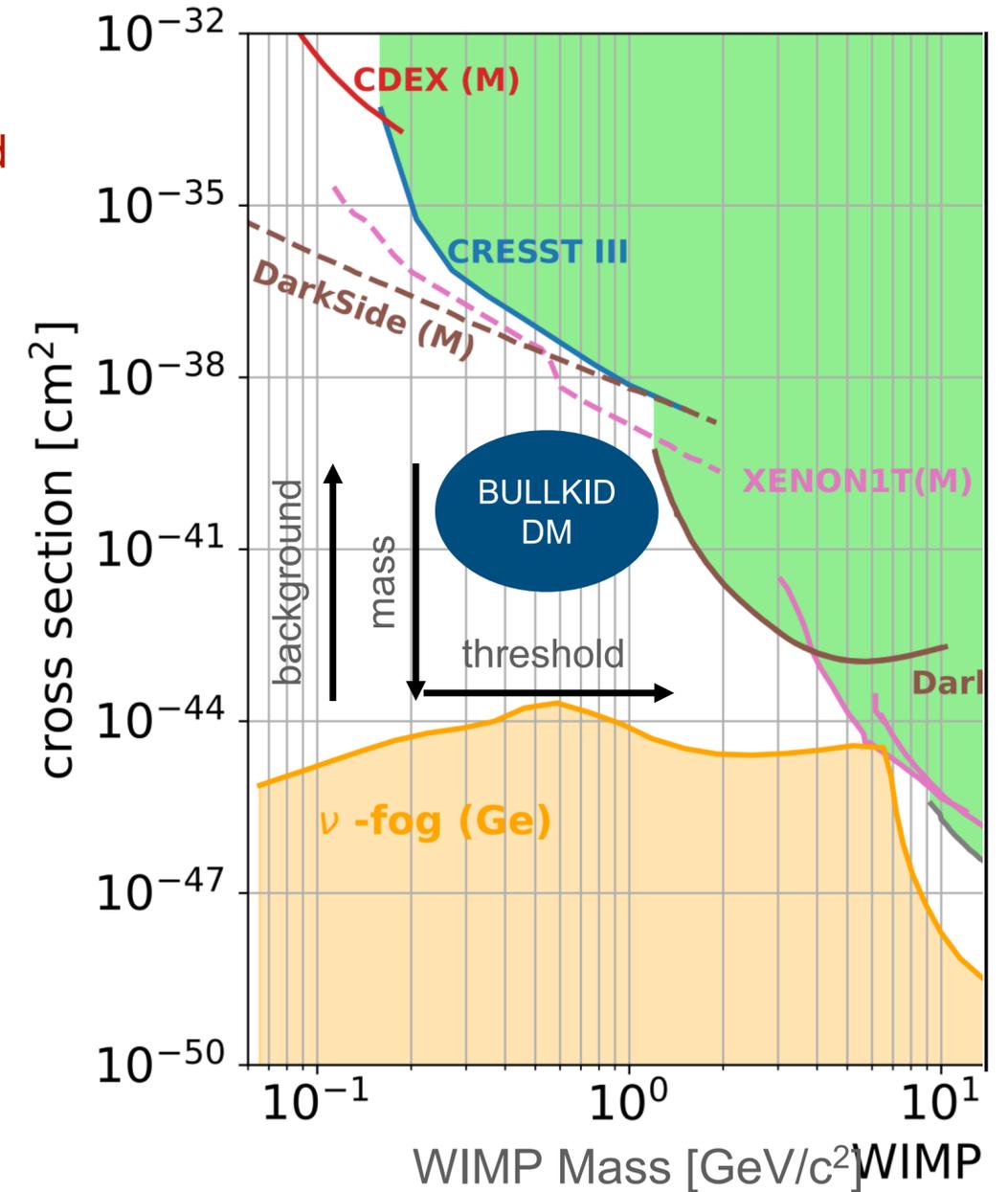
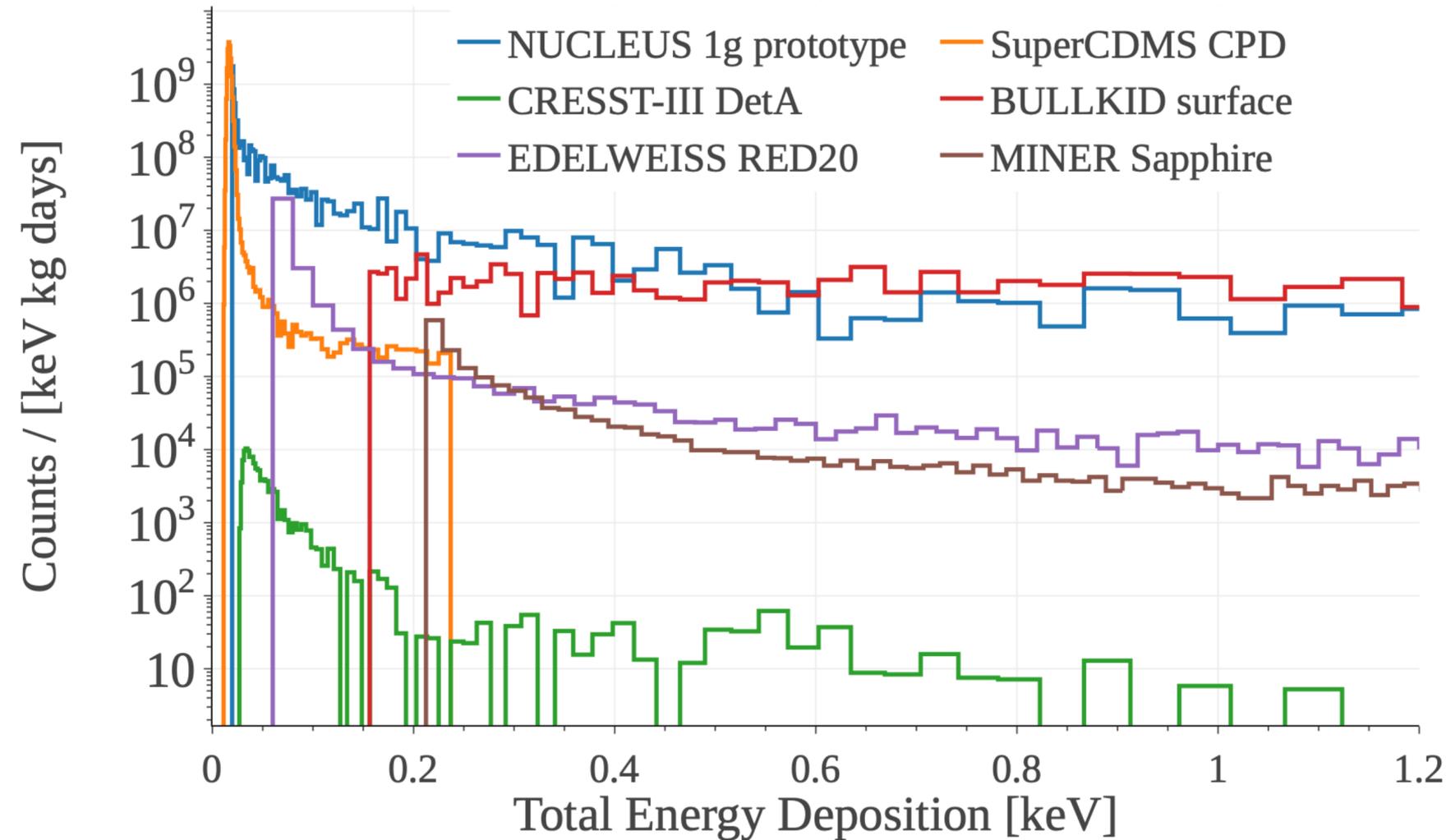
GSSI Science Fair

LNGS, 12 February 2026



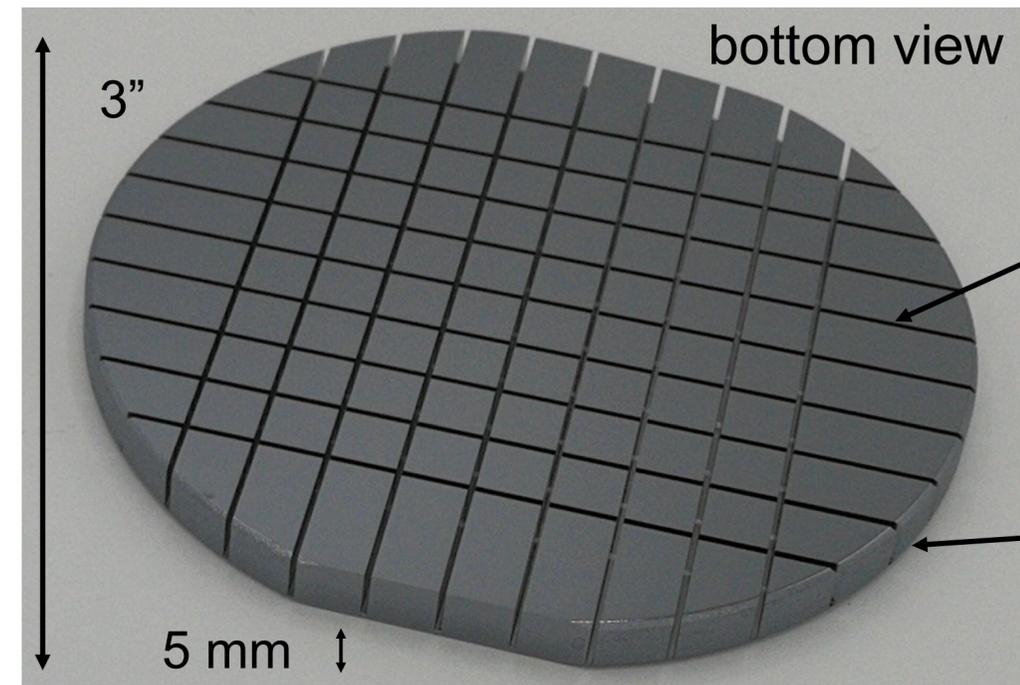
BULLKID-DM in a nutshell

- BULLKID-DM searches WIMP-like particles with mass < 10 GeV
- BULLKID-DM can also be used to search for coherent neutrino-nucleus scattering
- It will be the first experiment to be hosted in the new LNGS Cryo-Platform
- Not understood *low energy excess* in many DM experiments using solid-state low-T detectors
- BULLKID detector does not show excess aboveground, soon new measurement underground



The BULLKID phonon-detector array

carving of dice in a thick silicon wafer

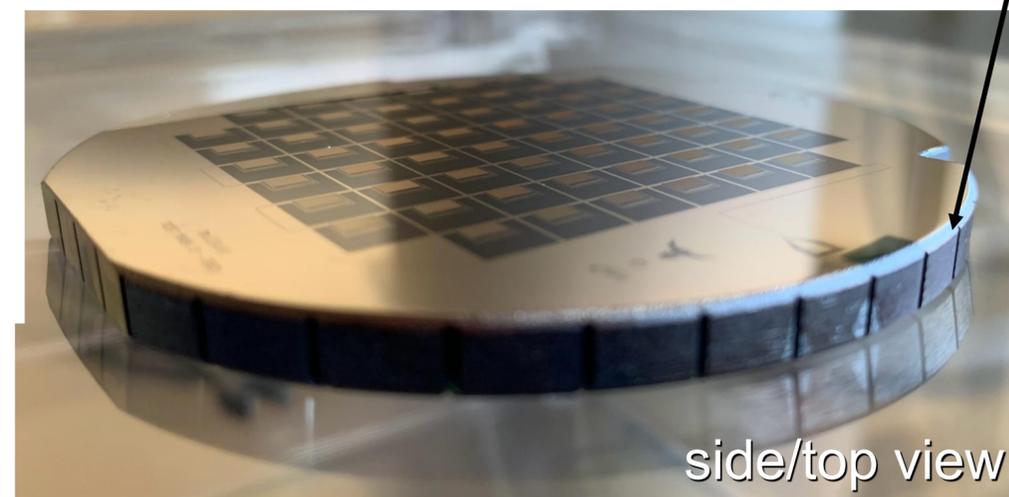


✓ monolithic

4.5 mm deep grooves
- 6 mm pitch
- chemical etching

0.5 mm thick common disk:
- holds the structure
- hosts the sensors

lithography of KID sensors

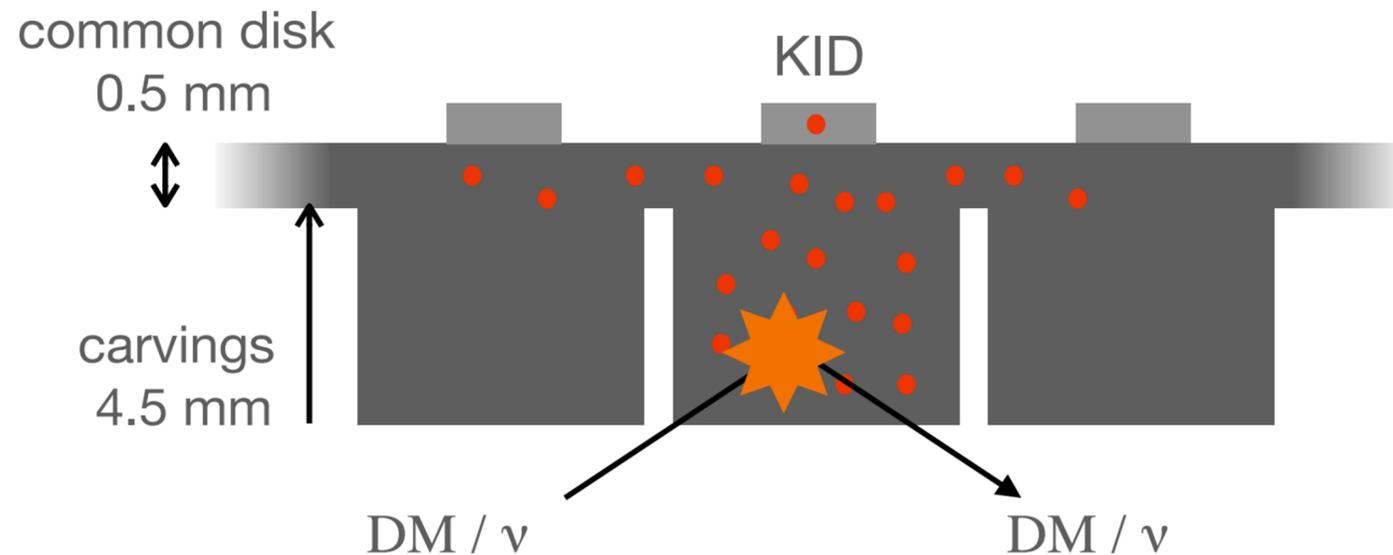


KID sensor array:
- 60 nm thick aluminum film
- 60 elements (1 per die)

✓ 60 detectors in 1

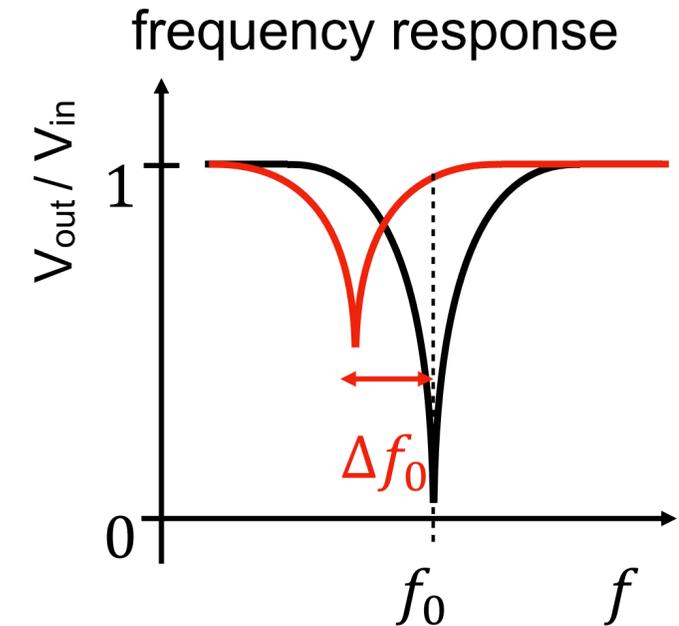
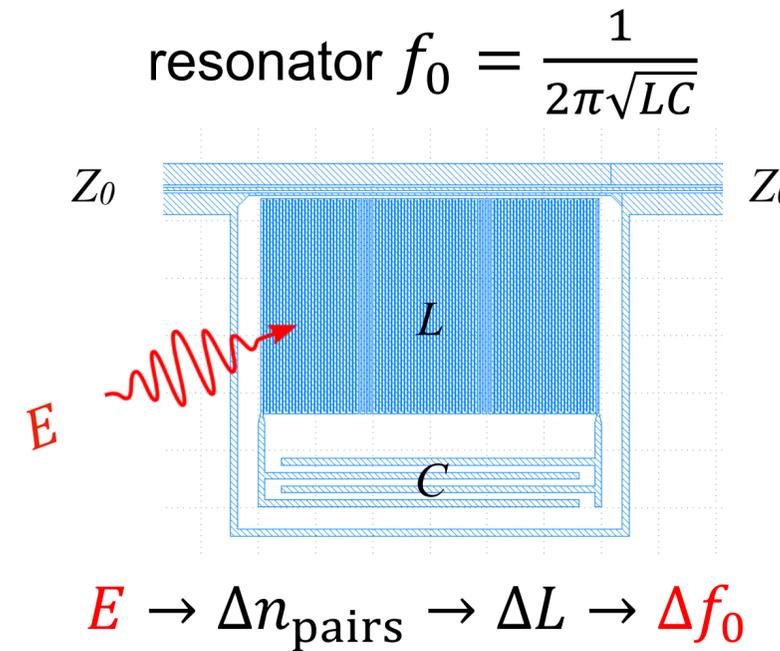
Fully multiplexed
(single readout line)

Phonon mediation
detect phonons created by nuclear recoils
in a silicon die

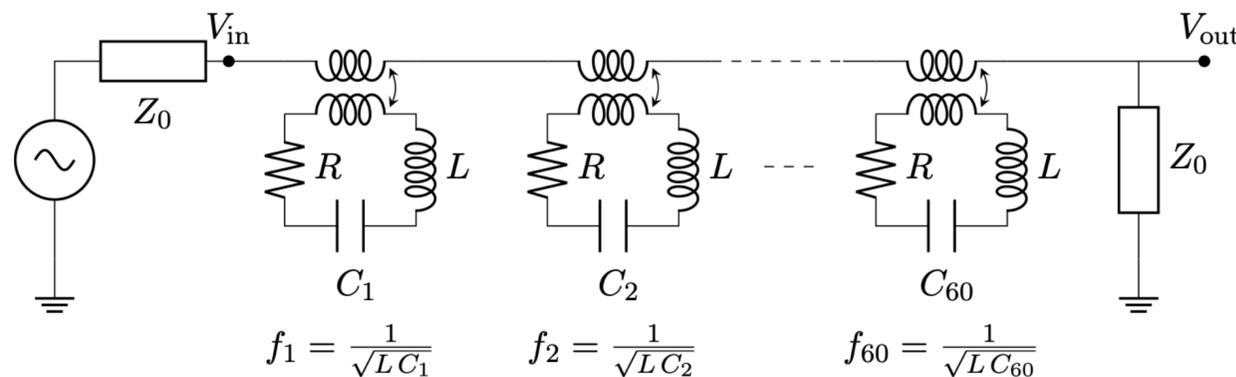
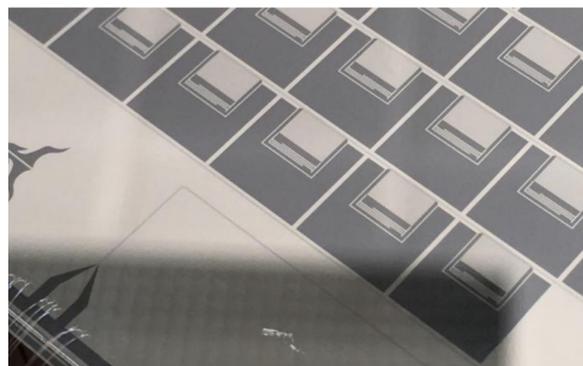


Kinetic Inductance Detectors (KIDs)

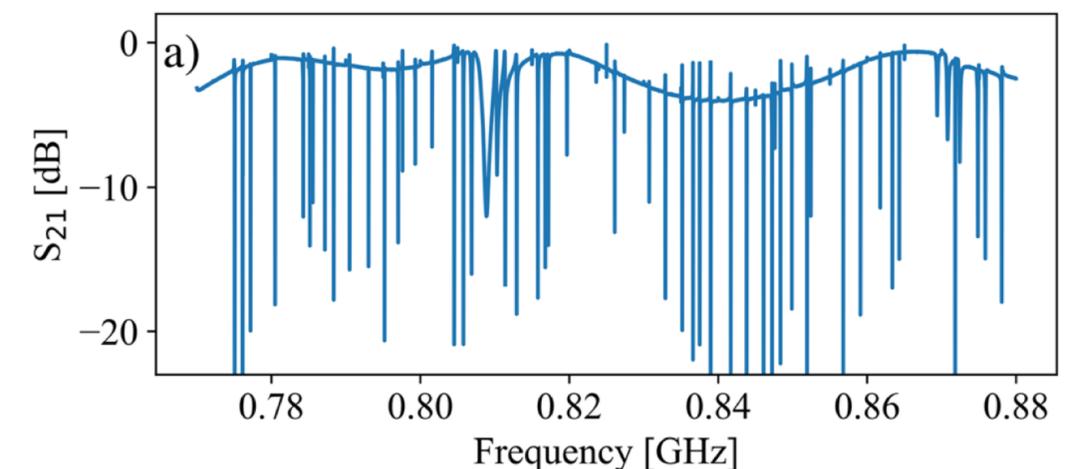
- Superconductor at $T < 200$ mK (Al)
- LC resonator
- Cooper pairs inductance $L_k = \frac{m_e}{2e^2 n_{\text{pairs}}}$
- Absorbed energy breaks Cooper pairs



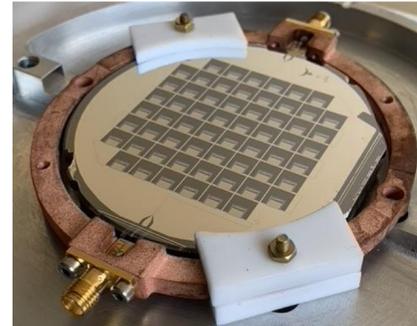
Readout: different KIDs coupled to a the same line



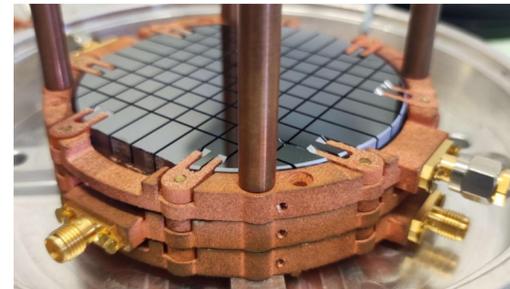
frequency scan of the 60 KIDs of BULLKID



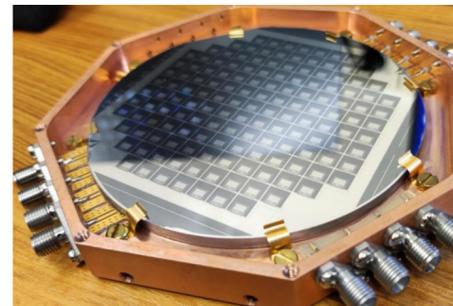
Towards the full experiment



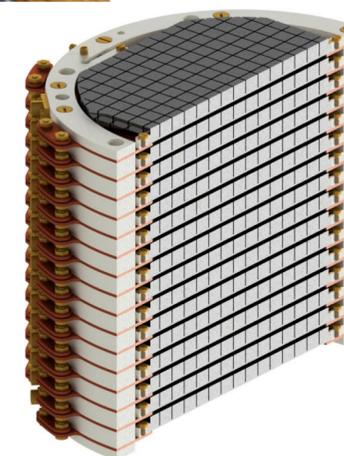
Prototype - 20 g / 60 dice
single 3" wafer
2022-2023, Sapienza



Demonstrator - 60 g / 180 dice
3-layer stack of 3" wafers
2024-2026, Sapienza/LNGS



R&D on large wafer 50 g / 145 dice
single 100 mm wafer
2024-2027, Sapienza

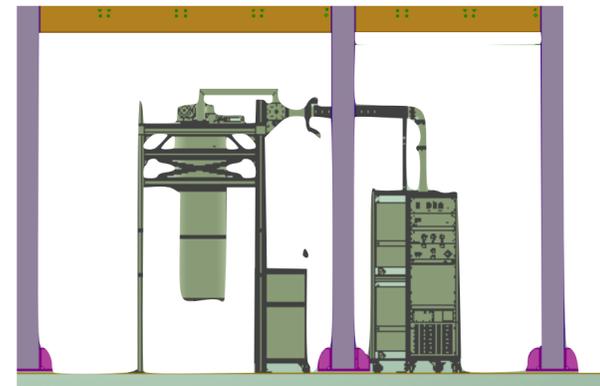
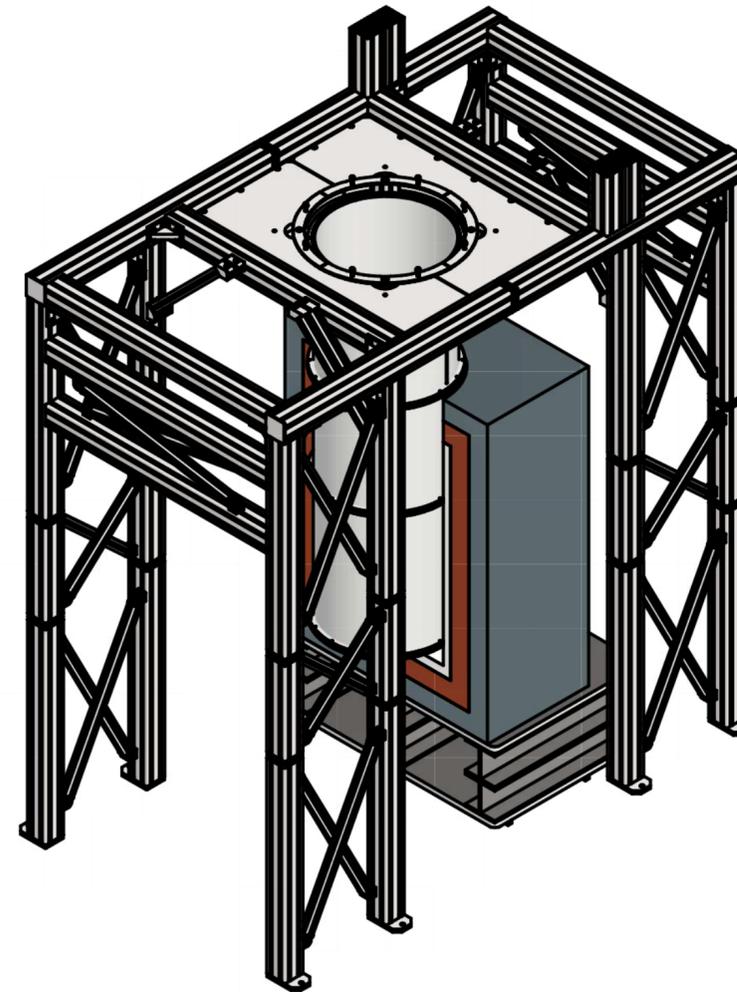


BULLKID-DM - 800 g / ~2300 dice
16-layer stack of 100 mm wafers
2027, LNGS

	BULLKID prototype	BULLKID-DM demonstrator		BULLKID-DM
mass	20 g	60 g		800 g
# of sensors	60	180		2300
threshold	160 eV	200 eV		200 eV or lower
bkg (c/keV kg d)	2×10^6	$< 10^5$		1 - 0.01
laboratory	Sapienza	Sapienza	LNGS	LNGS
installation	2023	2024	2026	2027

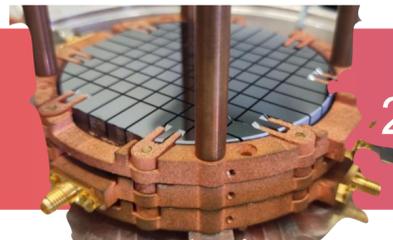
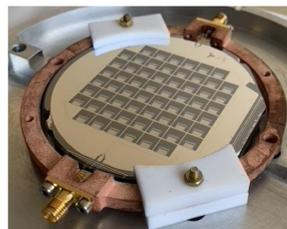
Current status and activities at LNGS

- **Cryo-Platform installation**
cryostat commissioned 18 July 2025
- Preliminary drawings of the **room temperature shields** completed
- **Material radiopurity assay**
tests ongoing on copper and lead



Prototype works

demonstrator (3 wafer)



2023

2024

2025

2026

CDR submitted



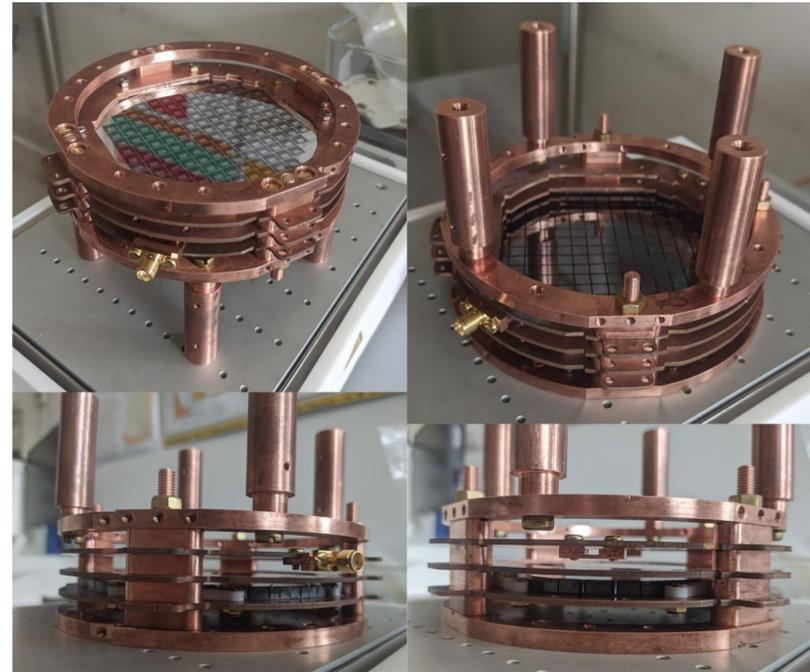
Future activities at LNGS

- Demonstrator at LNGS in 2026

- ✓ pivotal to assess the capabilities of the BULLKID underground setup
- ✓ 100 mm stack assembly (completed)
- ✓ Helpful for unknown backgrounds identification

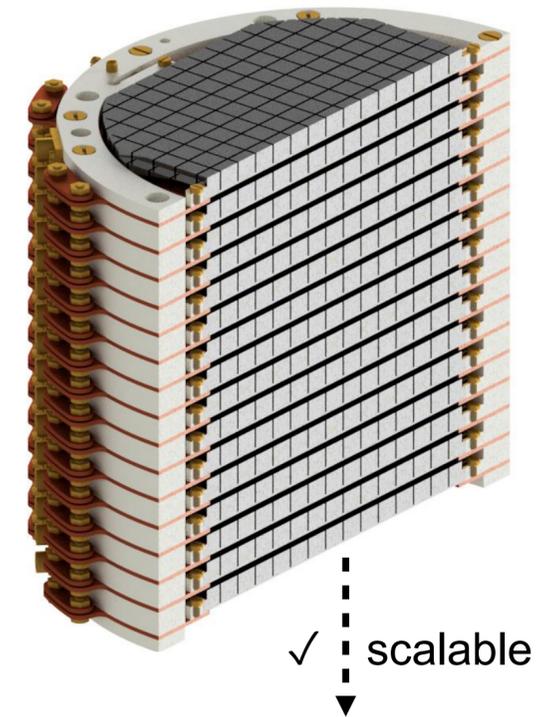
External shields in place

- ✓ 10 cm copper (4320 kg)
- ✓ 10 cm lead (8300 kg)
- ✓ space for outer polyethylene



- Deployment of full BULLKID-DM detector in 2027

- ✓ 0.8 kg of silicon target
- ✓ 2300 detector units (dices) based on Kinetic Inductance Detectors
- Unique features for bkg suppression
 - ✓ No inert material in detector volume
 - ✓ fully active
 - ✓ fiducialization (0.6 kg)



Prototype works

demonstrator (3 wafer)

TDR

BULLKID-DM full detector installation at LNGS

2023

2024

2025

2026

2027

CDR submitted

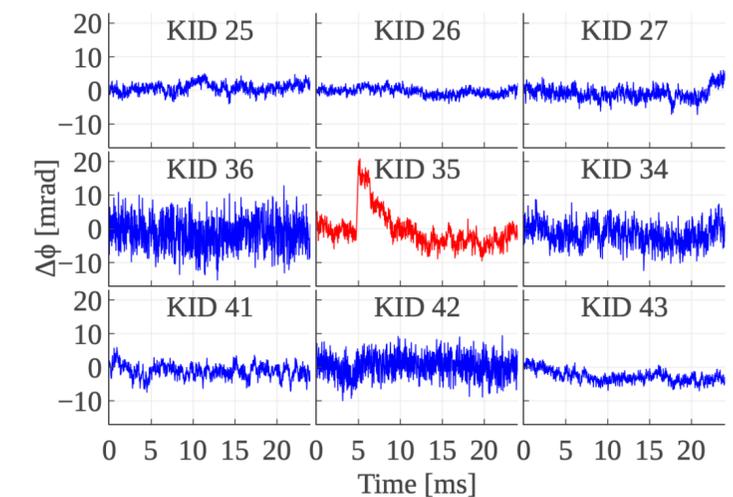
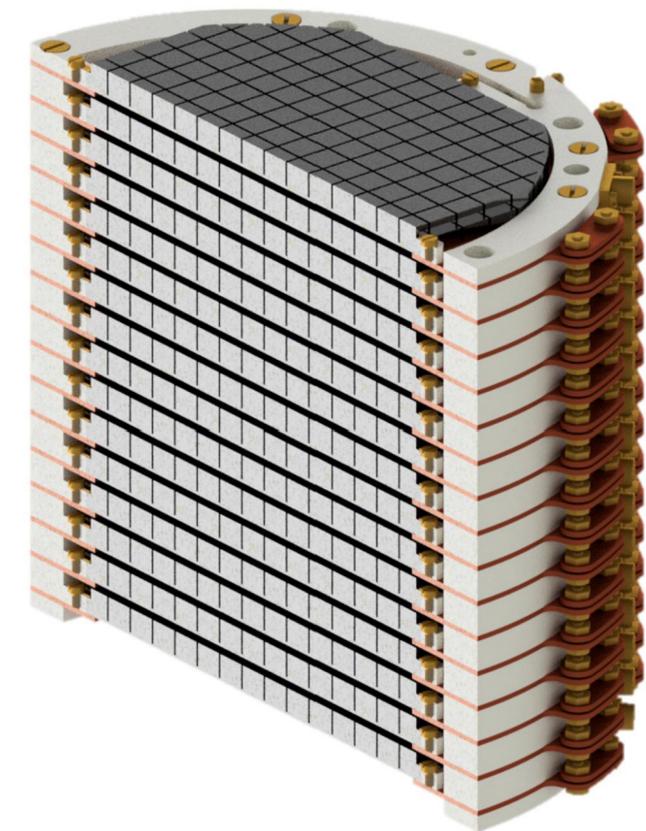
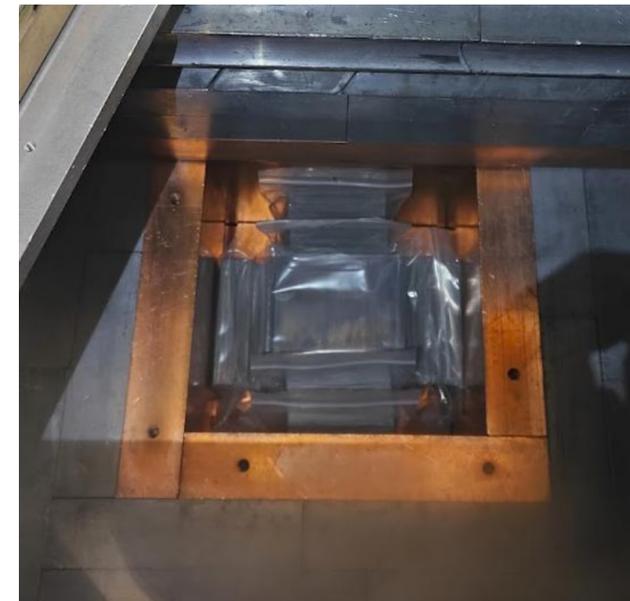
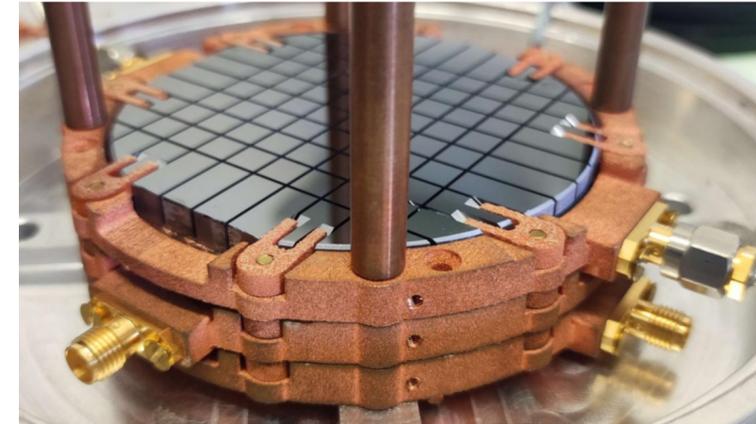
demonstrator at LNGS

Local team

- ✓ Antonio D'Addabbo (technologist @LNGS)
- ✓ Dounia Helis (technologist @LNGS)
- ✓ Federico Ferraro (researcher @LNGS)
- ✓ Shihong Fu (post-doc @LNGS)
- ✓ Kangkang Zhao (post-doc @GSSI)
- ✓ Jacopo Brunetti (Assistant Professor @UnivAq)
- ✓ Walter D'Ambrogio (Full Professor @UnivAq)

Our tasks

- ✓ Radiopurity assays
- ✓ Mechanical simulations
- ✓ Assembling and running the demonstrator and the experiment
- ✓ Data analysis



Contacts

Federico Ferraro
Antonio D'Addabbo

federico.ferraro@lngs.infn.it
antonio.daddabbo@lngs.infn.it



Roma
Ferrara
LNGS
Pisa



Thank you!

See our poster
for further details!

