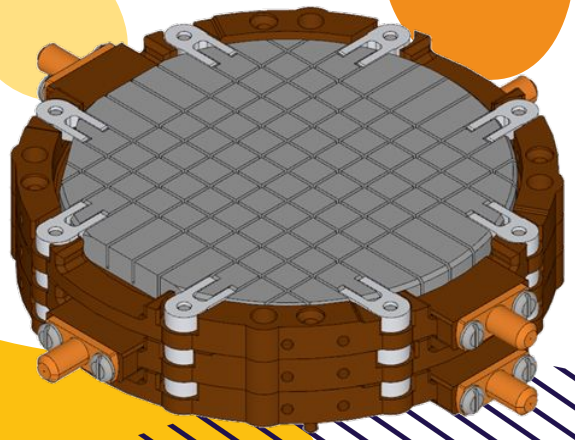
BULLKID_DM Digest - Status of the demonstrator

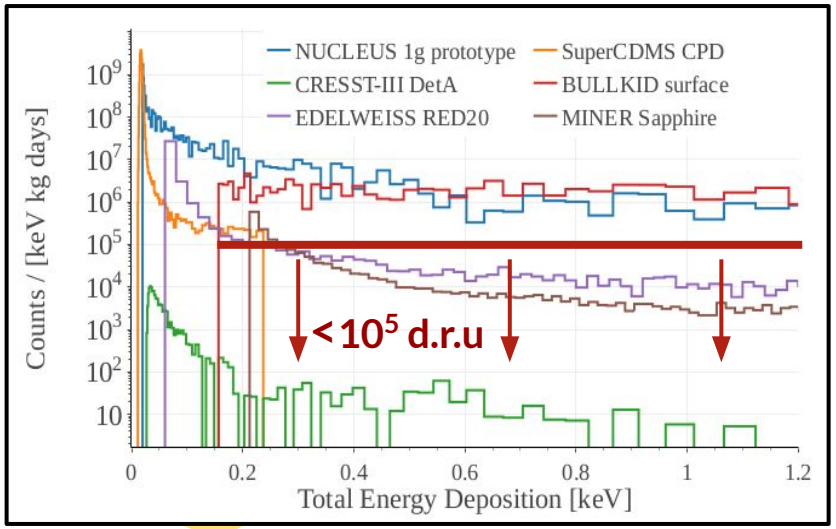
Matteo Folcarelli
02/10/2024

Demonstrator milestone

The demonstrator consists of a stack of **three wafers**, each **3 inches** in diameter, housed in a mild lead shield, for the technological **demonstration of multi-wafer readout and background study**.

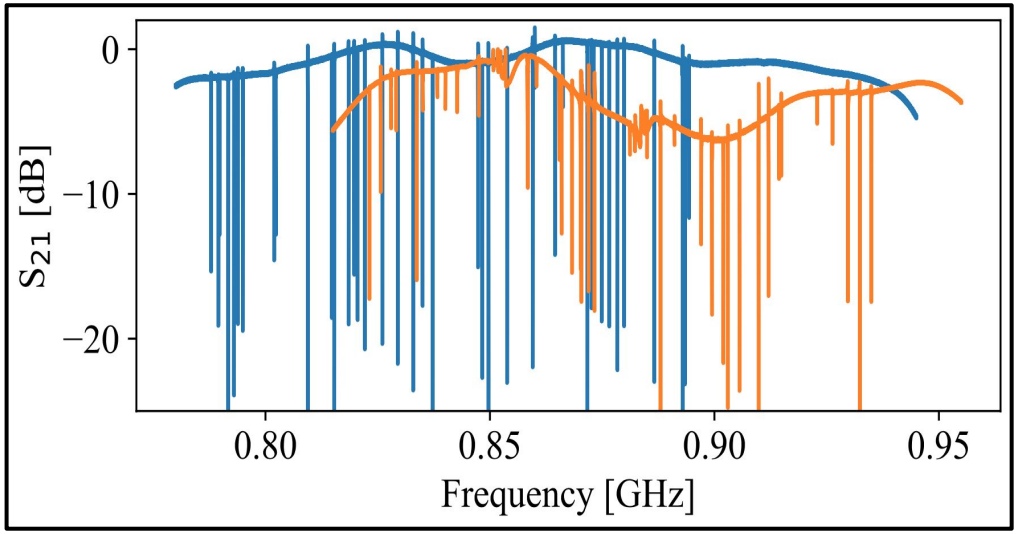
The goal is to demonstrate, by the end of 2024, **the flatness of the background** down to the energy threshold in an environment of less than **10^5 DRU** . Concurrently, we aim to prove **the capability to read out a 60-pixel array**.

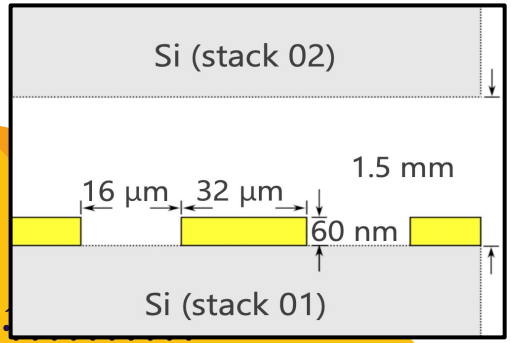


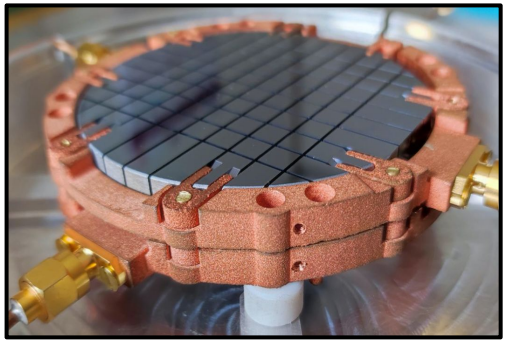


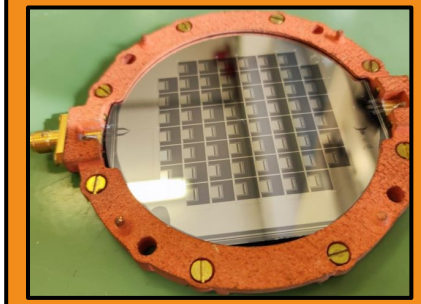
A further technical run of the demonstrator is planned in the cryogenic facility at LNGS (2025 - 2026)

Status at 05/24 digest

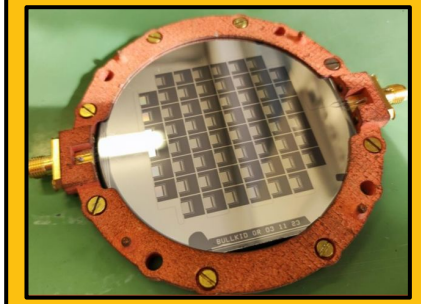








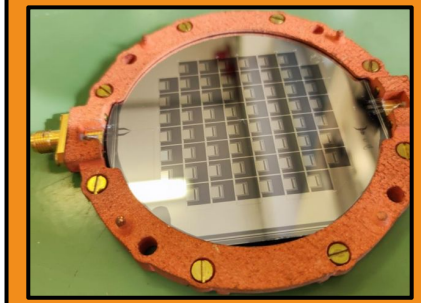
Stack-01: 60nm Al
40 working pixels out of 60
Quality factor (median) 185k



Stack-02: 90nm Al
44 working pixels out of 60
Quality factor (median) 80k

Successful cooldown of a two wafers stack

Status at 05/24 digest



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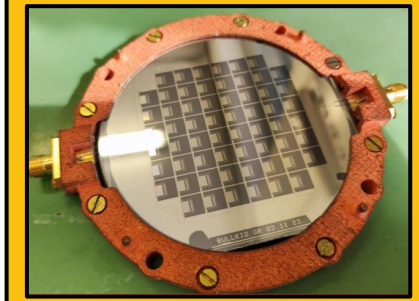

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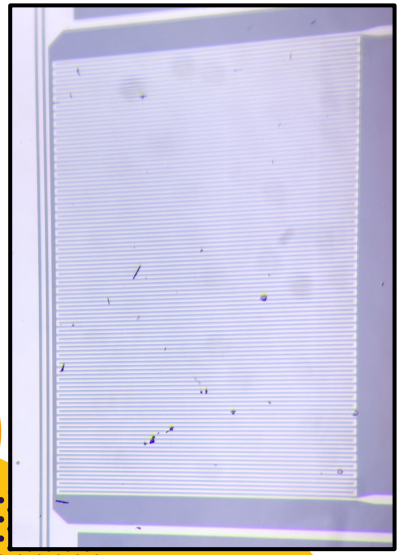
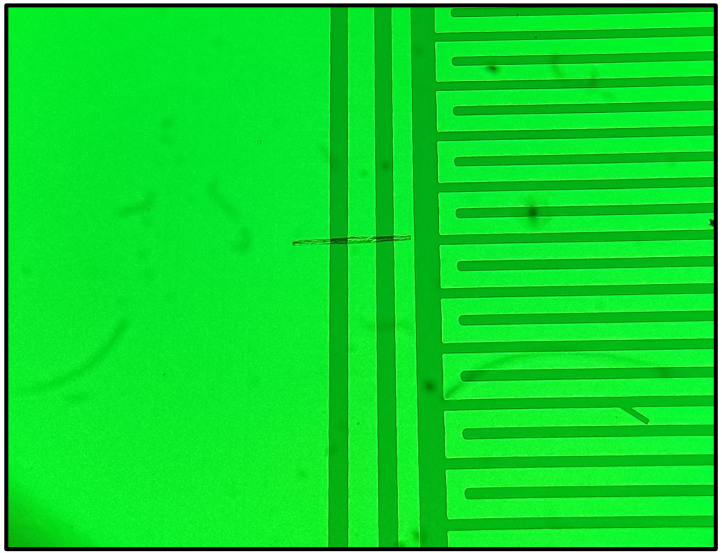
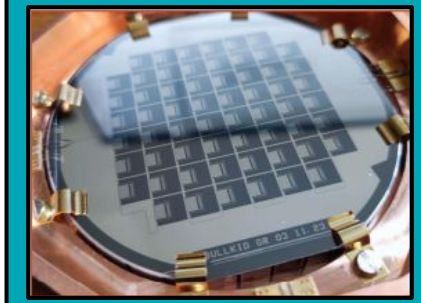


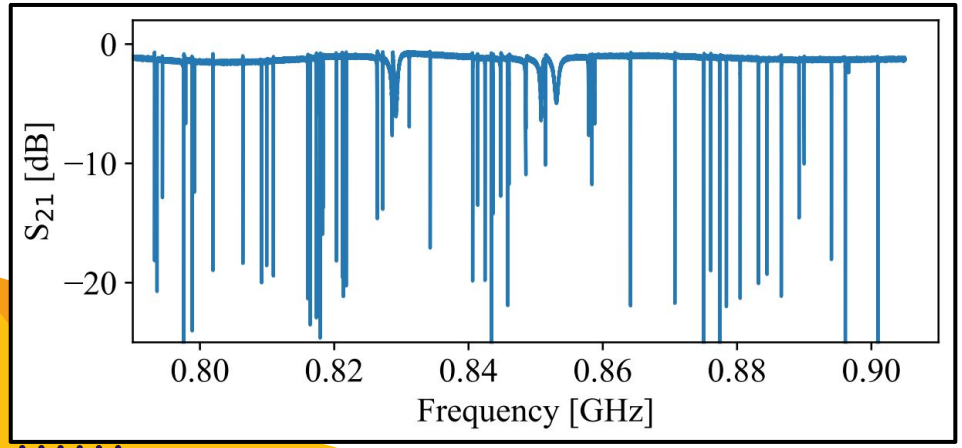


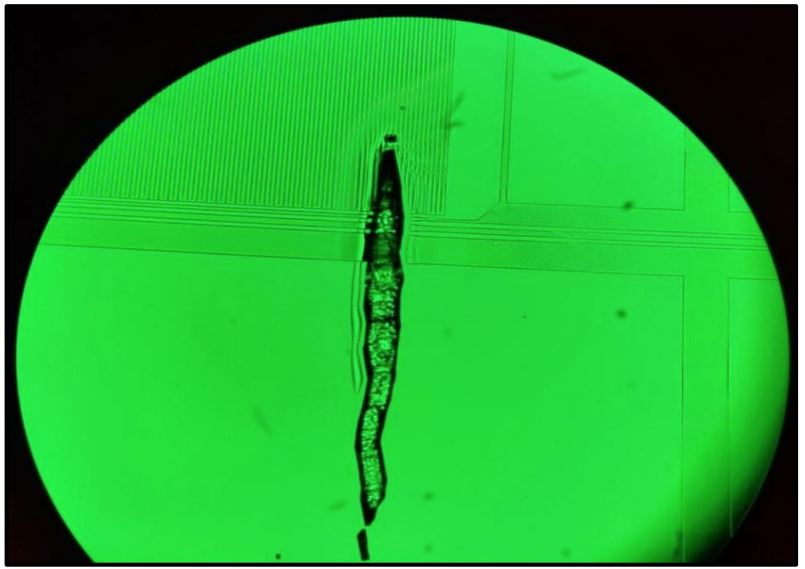
New entries - Spring 2024



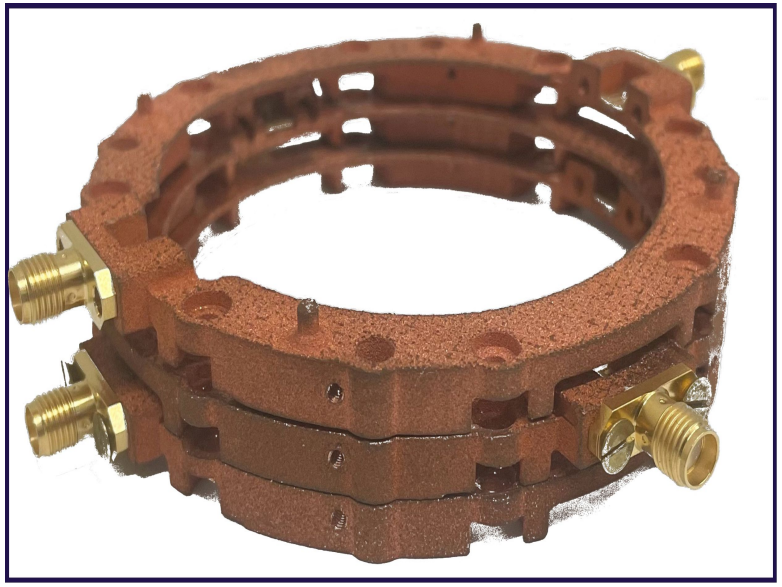
Stack-03: 60nm Al
55 working pixels out of 60
Quality factor (median) 90k

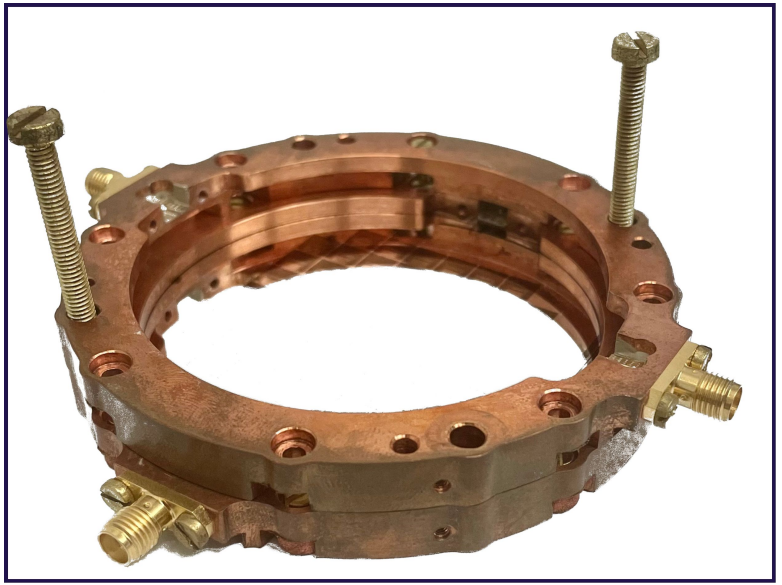
Stack-04:
Production failure: defects prevented a successful litography





Updating of the holders





3D printed copper

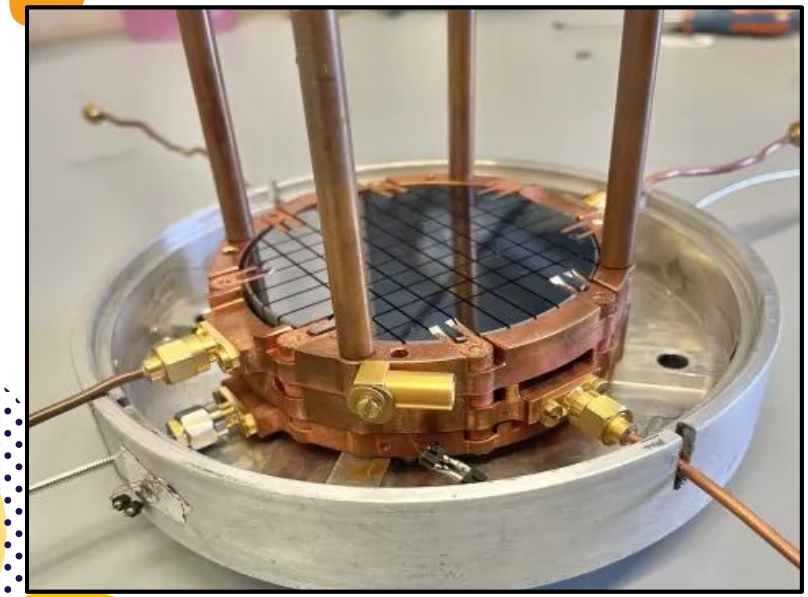
- Easier to produce
- Allows the stability of the stack without external supports
- Worse thermalization properties

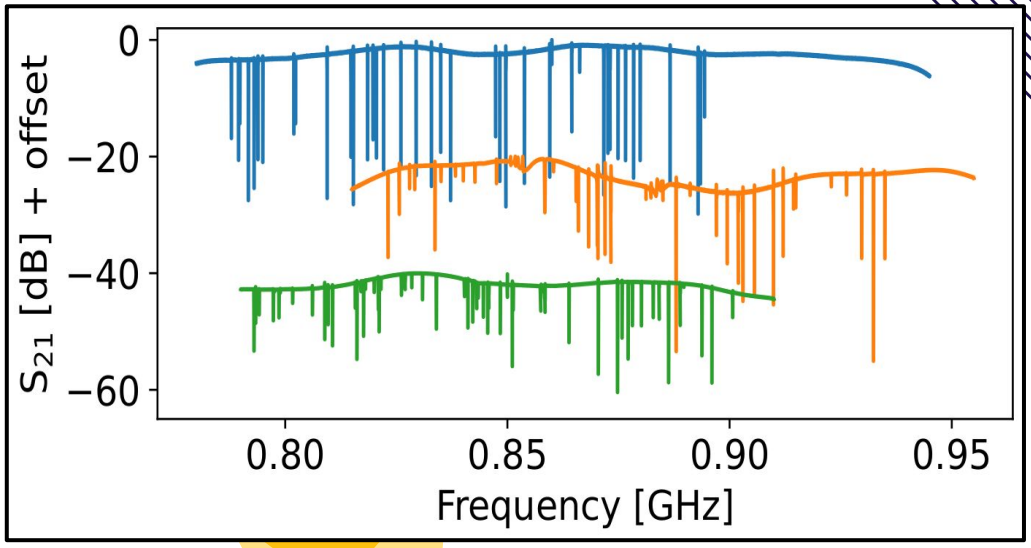
Milled copper

- Rigid and flat
- Needs external supports for the stability of the stack
- Excellent thermalization properties

Three wafers stack

Successful cooldown of a three wafers stack

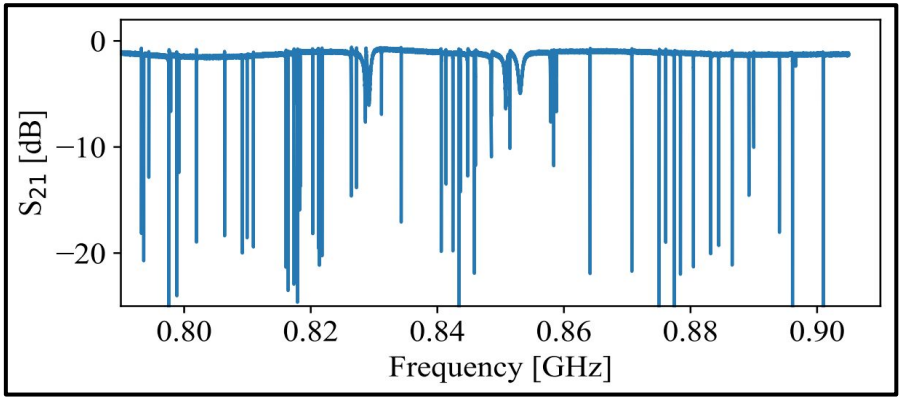




stack_01 stack_02 stack_03

Stack_03: loss in performances

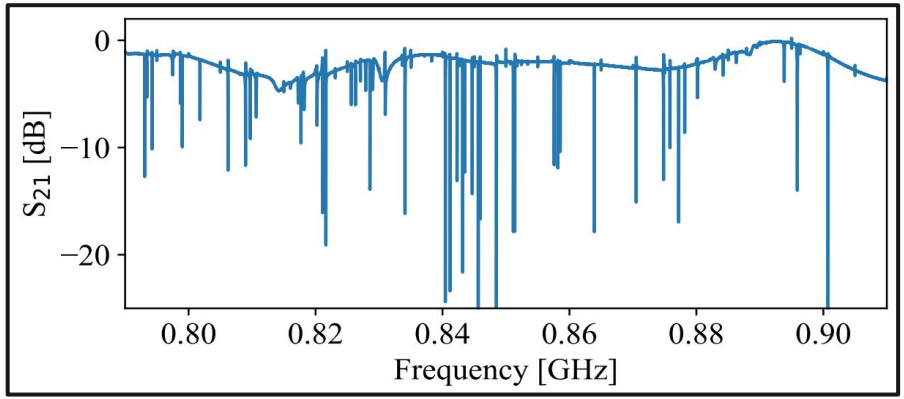
Grenoble



Total QF (median) : 9.39×10^4
Coupling QF (median) : 1.12×10^5
Internal QF (median) : 1.02×10^6

Performances published on the EPJC paper:
Responsivity: 49 mrad / keV -> Noise RMS: 27 eV

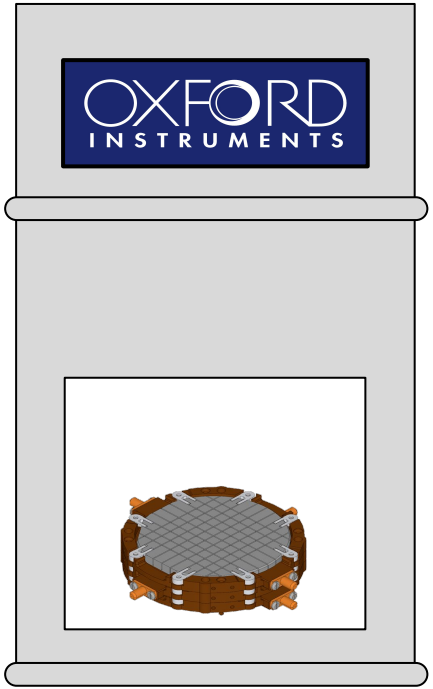
RM1



Total QF (median) : 6.82×10^4
Coupling QF (median) : 1.48×10^5
Internal QF (median) : 1.55×10^5

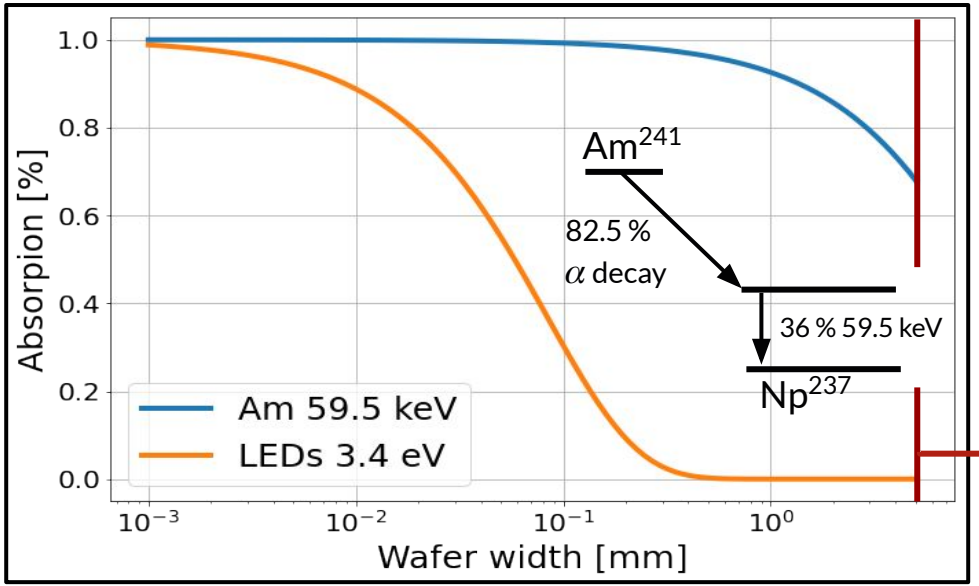
Responsivity: 20 mrad / keV -> Noise RMS: 60 eV

Calibration with an external americium source



Am^{241}

First measurement of an external radioactive source

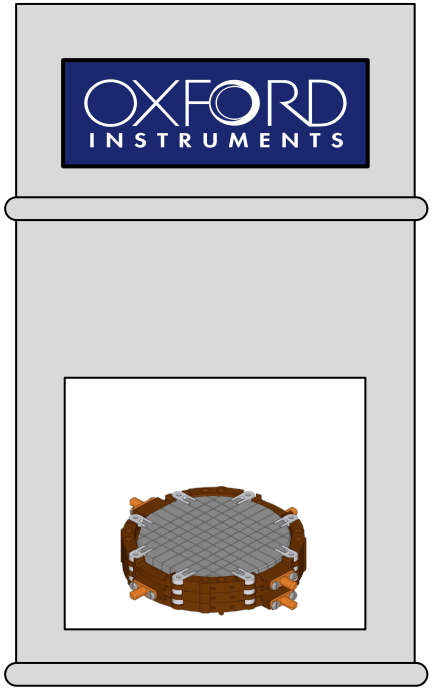


Bulk events: they penetrate in the silicon wafer

Away from the energy range of interest

Silicon wafers are 5 mm thick

Calibration with an external americium source



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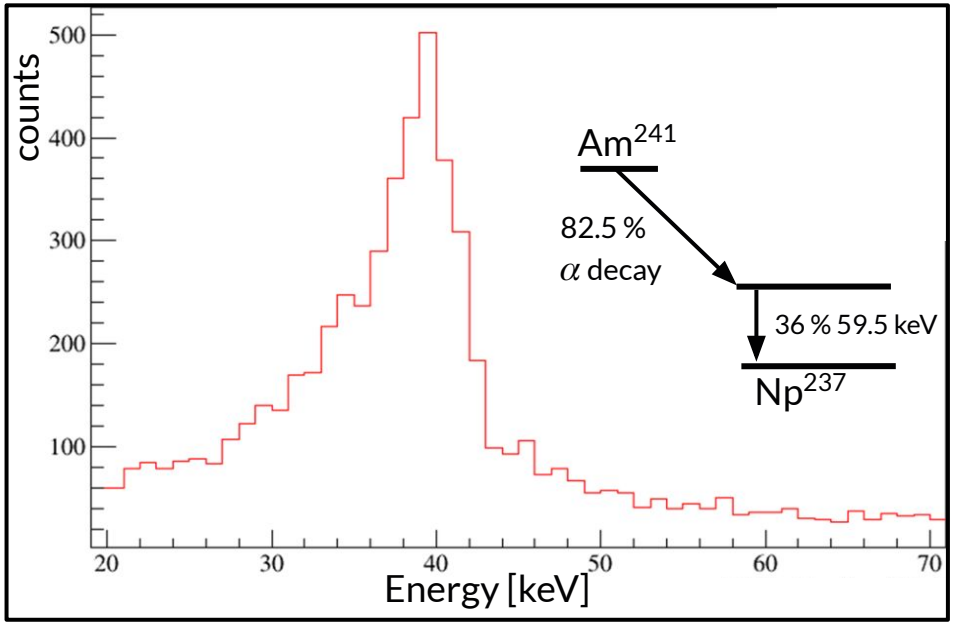


Bulk events: they penetrate in the silicon wafer

Away from the energy range of interest

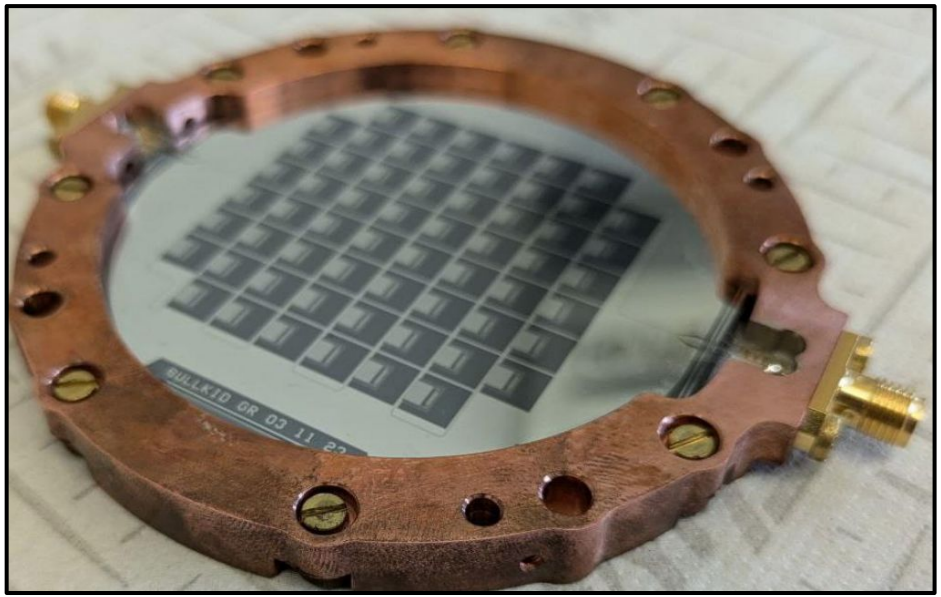
LED calibration doesn't match with Americium calibration

We need a new data acquisition with more exposure and

Stack_03: loss in performances

Possible culprits: something happened after testing in Grenoble

- Silicon (resistivity at room temp greater than other samples)
- Stray IR light in the cryostat
- Thermalization
- **Vacuum grease used for thermalization with copper holder**



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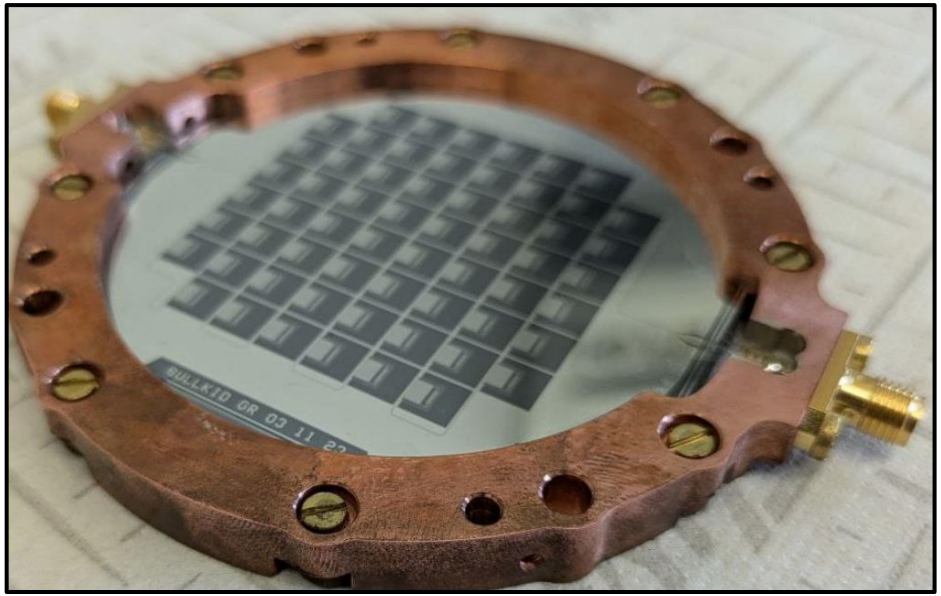
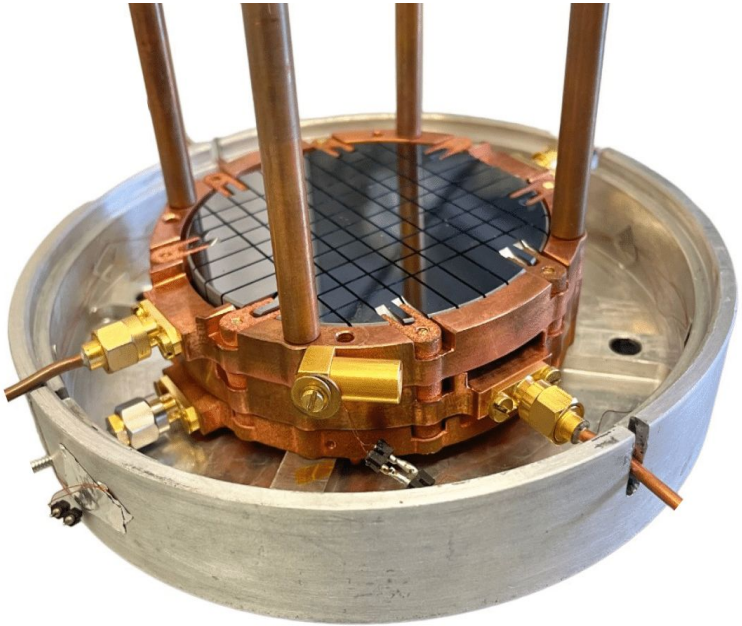
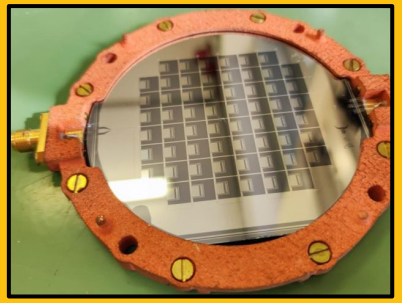


Wafer broken during the chemical cleaning from the vacuum grease

Current prototype of the demonstrator





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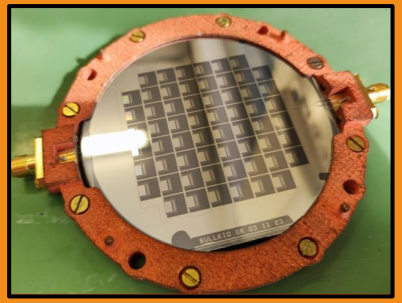

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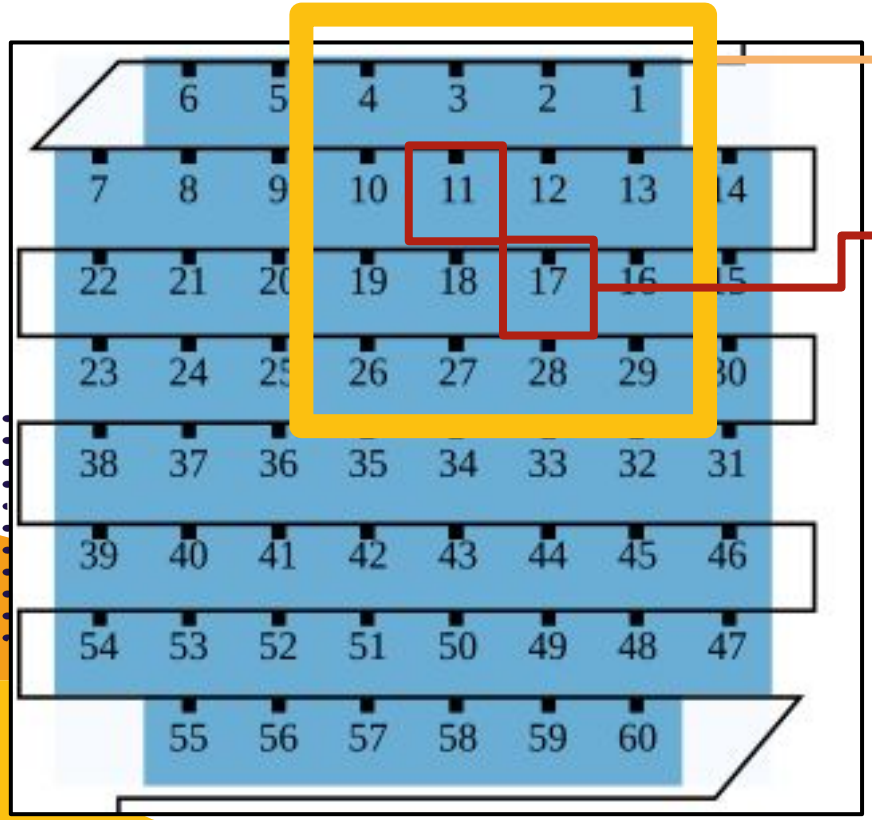
First multi-pixel data-taking



Neighbour pixels

Triggering pixels

First long data-taking with **two independent triggering pixels**, with most of their relative neighbours (**11 pixels in total**)

Long run data-taking for a total amount of **43 h**

First multi-pixel data-taking

First long data-taking with **two independent triggering pixels**, with most of their relative neighbours (**11 pixels in total**)

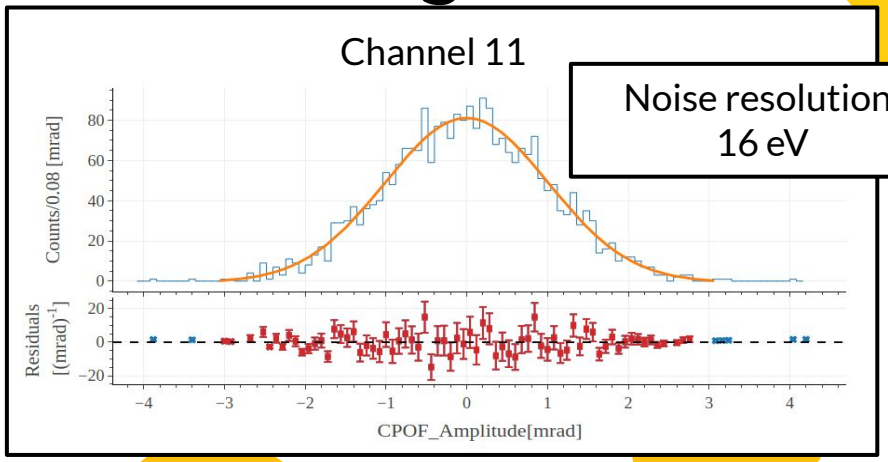
Performances published on the EPJC paper:

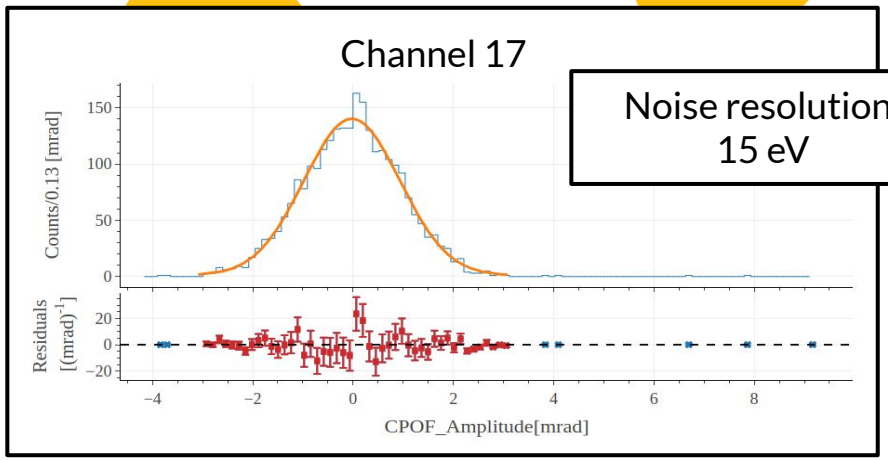
Responsivity: **49 mrad / keV**
Noise RMS: **27 eV**

Current multi-pixel run:

Responsivity 11: **64 mrad / keV**
Noise RMS 11: **16 eV**

Responsivity 17: **61 mrad / keV**
Noise RMS 17: **15 eV**





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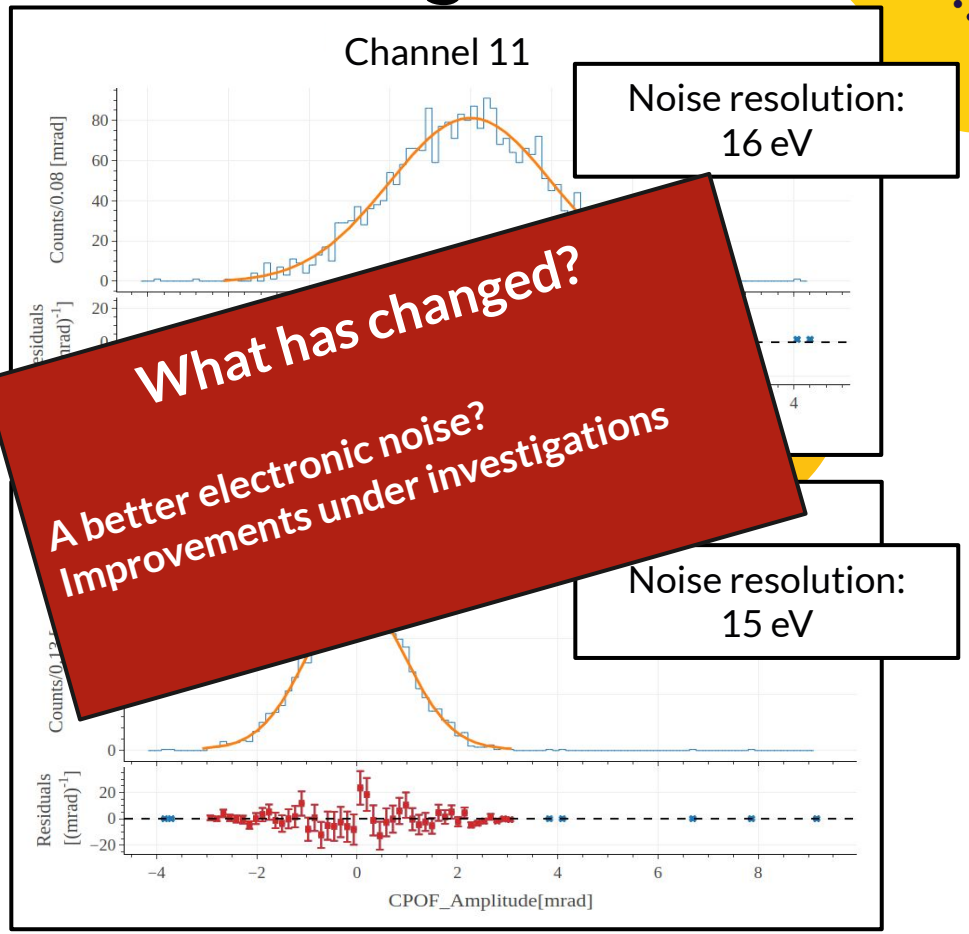

Ongoing and future activities

Work in progress	Programmed steps	Demonstrator milestone
• Complete analysis of the multi-pixel run • Complete identification of the pixels of stack_01	• Tests on the new electronics (end of October; see Timo's presentation) • Arrival of the lead holder (middle of October) • New Americium run (November 2024) • 5 new wafers in fabrication (November 2024)	Low background run (End of the year)

INFN Ferrara Roma LNGS Pisa

KIT Karlsruher Institut für Technologie

NÉEL institut

Thank you for the attention

Matteo Folcarelli

02/10/2024