



SAPIENZA  
UNIVERSITÀ DI ROMA

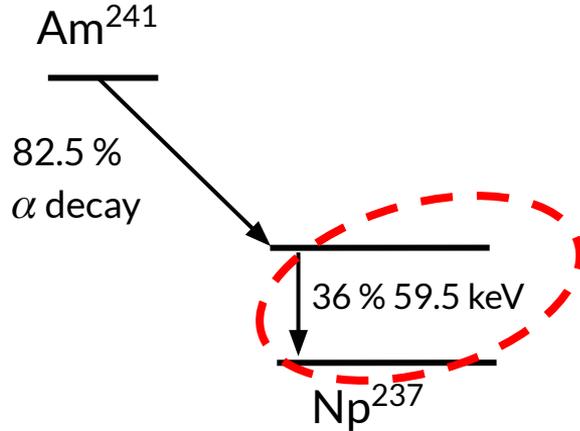


# Energy calibration with $\text{Am}^{241}$

BULLKID-DM Collaboration Meeting in Pisa  
Matteo Folcarelli - 16/01/2025

# Purpose of the measurement

With the acquisition of an external  $\text{Am}^{241}$  radioactive source, we want, primarily, to **validate the actual energy calibration based on LED pulses.**



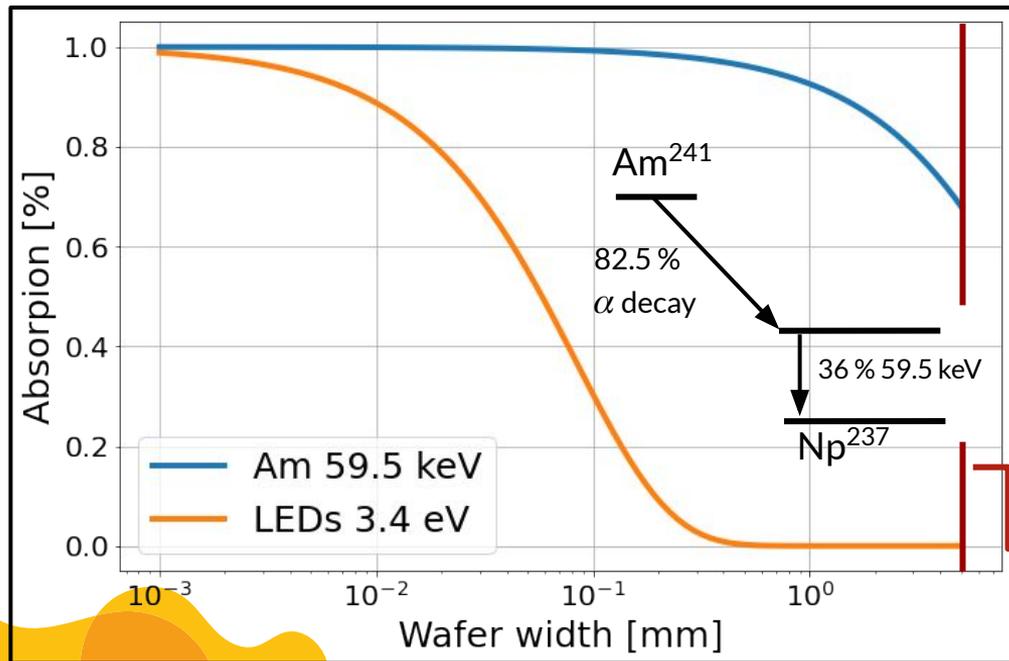
Americium emits a **59.5 keV gamma ray** that is able to penetrate the shields of the cryostat and allows an external calibration of the wafers.

On the other hand, we are looking for a peak pretty far away our energy range of interest: **outside the fully modeled and linear regime of the detector**



# Purpose of the measurement

In addition the 59.5 keV gammas of Americium produce **bulk events**, i.e. events that penetrates deeply in the wafers and don't interact just with its surface

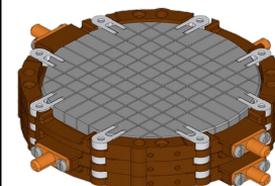


Silicon wafers are  
5 mm thick

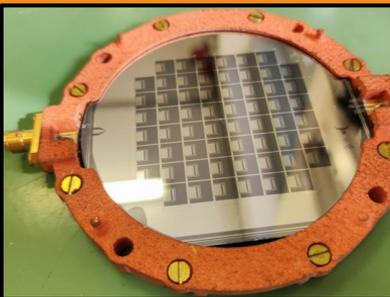
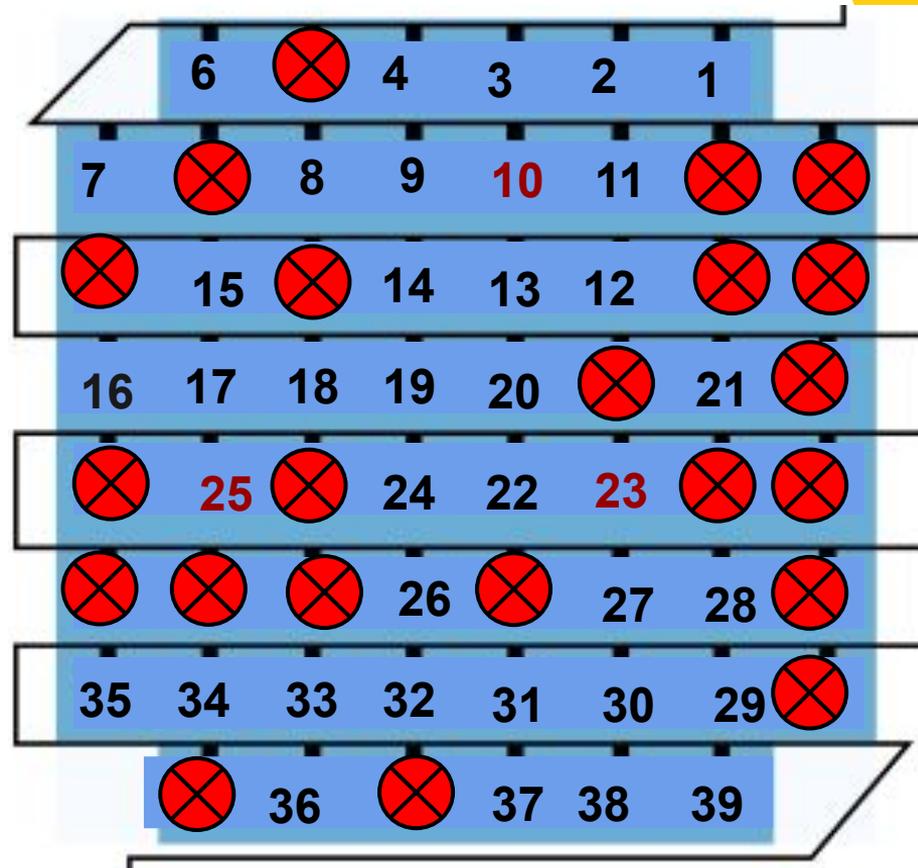
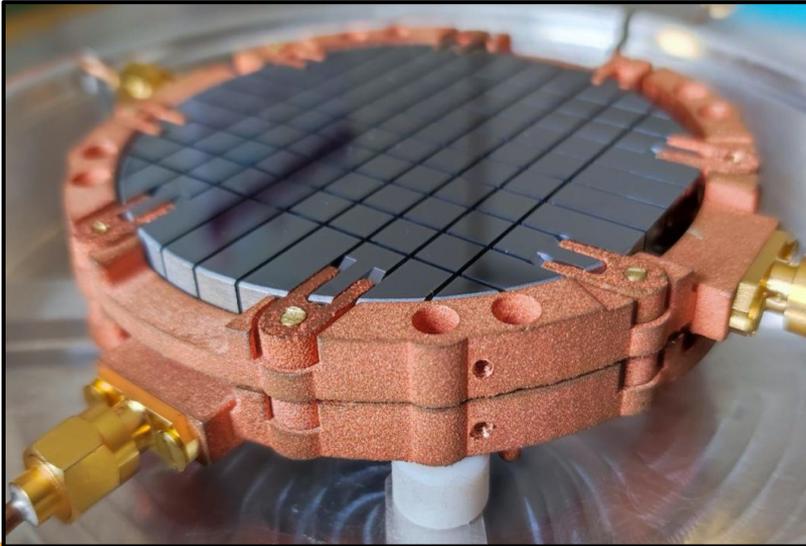


Am<sup>241</sup>

OXFORD  
INSTRUMENTS



# About the data taking

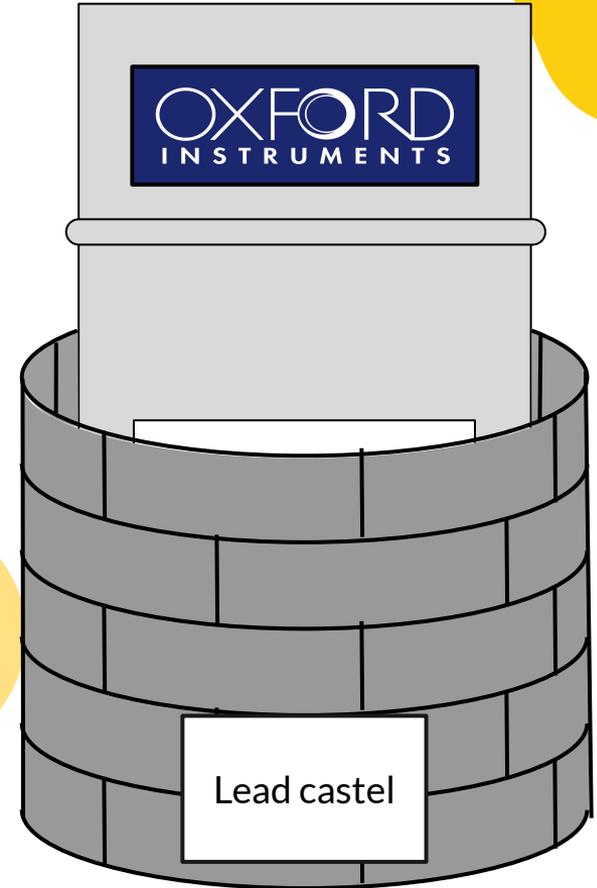


Stack-01: 60nm Al  
 38 working pixels out  
 of 60  
 Quality factor  
 (median) 185k



# About the data taking

- Americium source located at  $\sim 25$  cm from the wafer (assuming perfect alignment)
- No copper shield around the detector (to avoid signal suppression)
- All the internal shields of the cryostat present a hole aligned to the radioactive source (covered by aluminum foils for IR shielding)
- No external mu-metal shield (adopted only during the superconducting transition of the KIDs)
- External lead castel (5 layers of bricks) to suppress external radioactivity



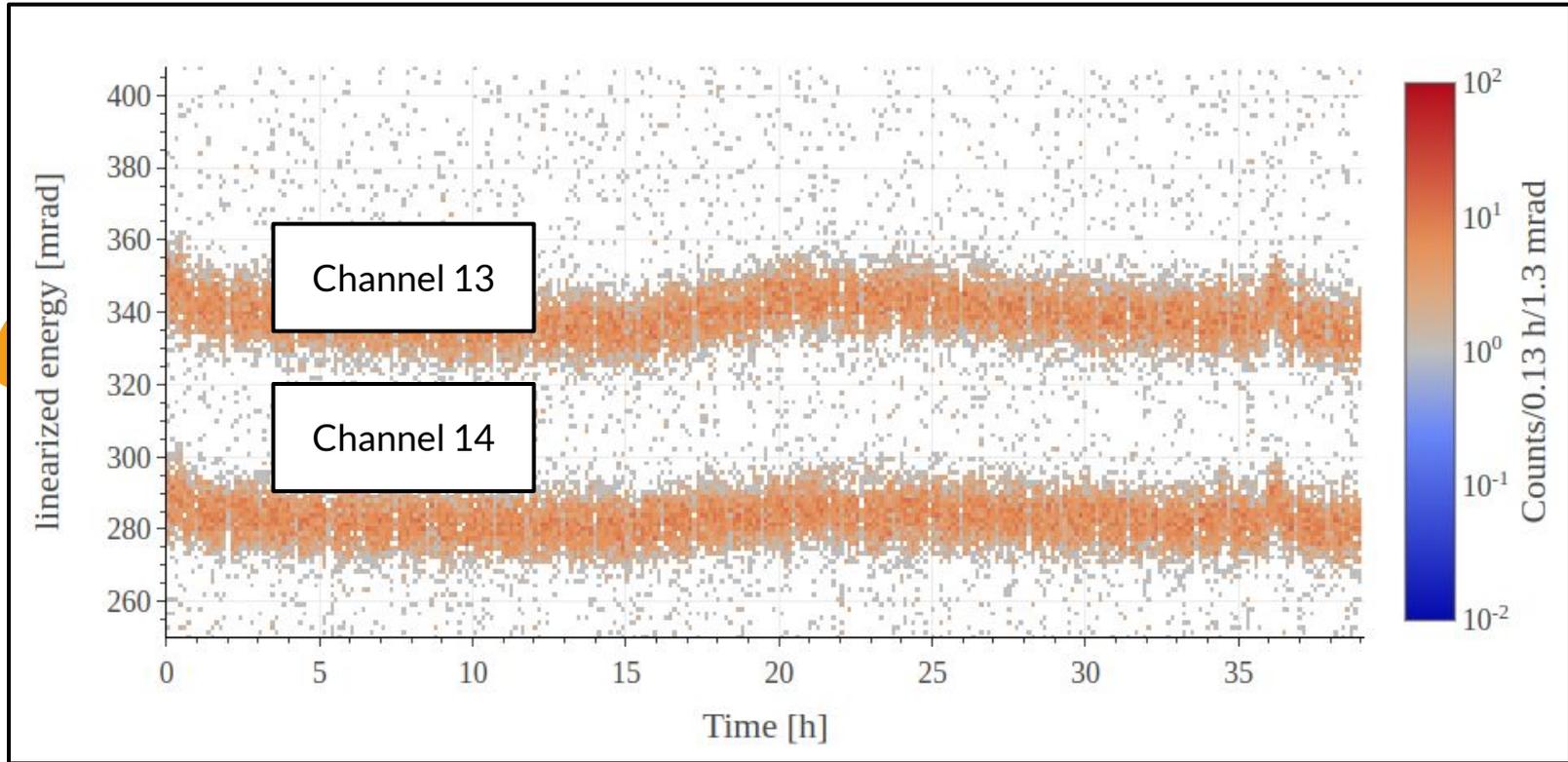
# LED calibration

At the beginning and at the end of the acquisition, a calibration with LEDs of 400 nm has been performed

Pixel	Start Cal (400 nm)	End Cal (400 nm)
13	$25.8 \pm 0.71$ mrad/keV	$26.22 \pm 0.76$ mrad/keV
14	$30.15 \pm 0.84$ mrad/keV	$29.18 \pm 0.87$ mrad/keV

Pixel	Start Linearity (400 nm)	End Linearity (400 nm)
13	$(-1.00 \pm 0.03) \times 10^{-4}$ mrad <sup>-1</sup> (-15% @ Am)	$(-1.03 \pm 0.02) \times 10^{-4}$ mrad <sup>-1</sup> (-15% @ Am)
14	$(-0.91 \pm 0.03) \times 10^{-4}$ mrad <sup>-1</sup> (-16% @ Am)	$(-0.91 \pm 0.03) \times 10^{-4}$ mrad <sup>-1</sup> (-16% @ Am)

# Detector stability

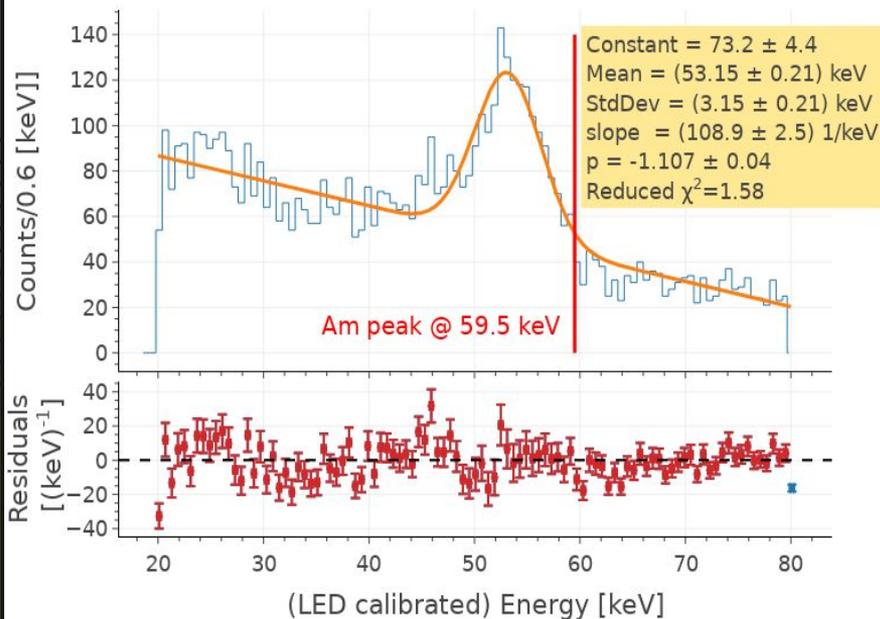


During the acquisition, two LEDs signals were acquired in order to monitor the detector stability

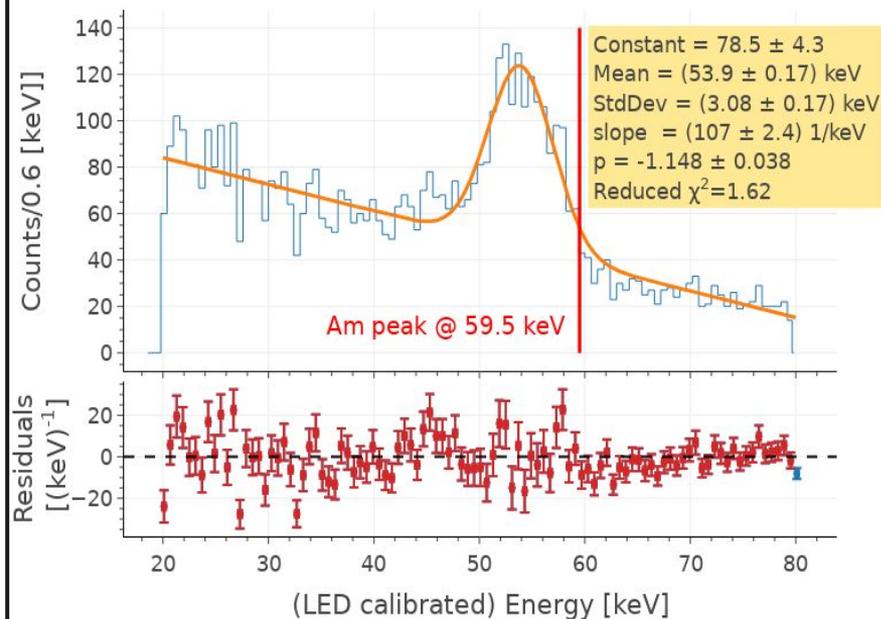
# Americium Peak

After some analysis cuts based on the pulse shape of the events and the usual neighbour analysis, we are able to clearly reconstruct the Americium peak

Americium peak Channel 13

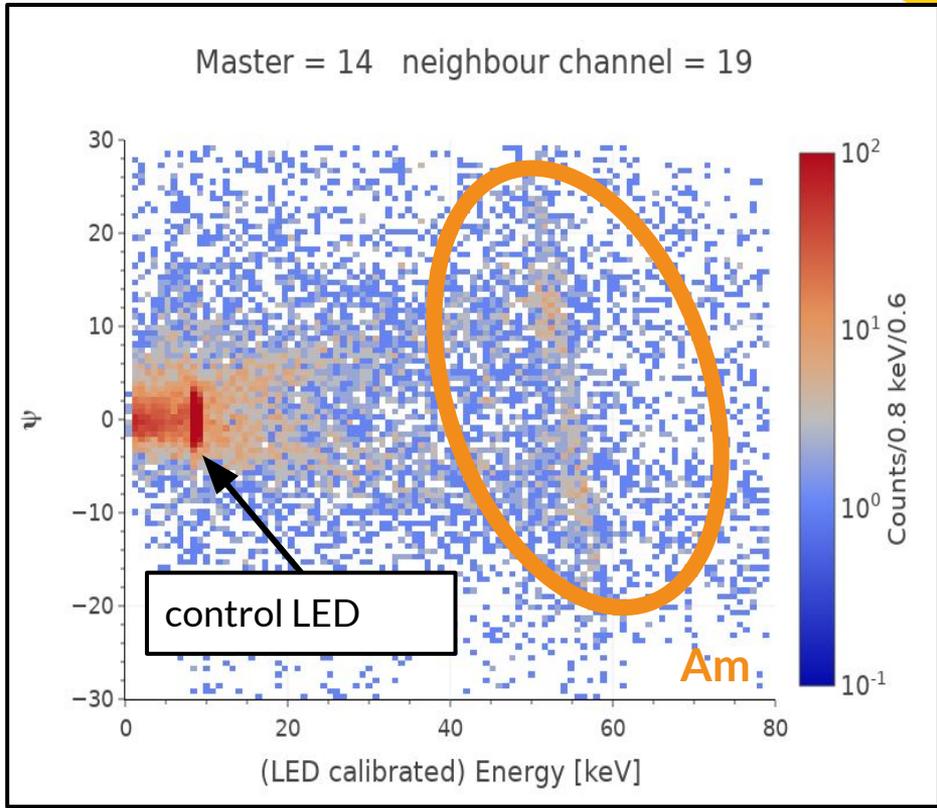
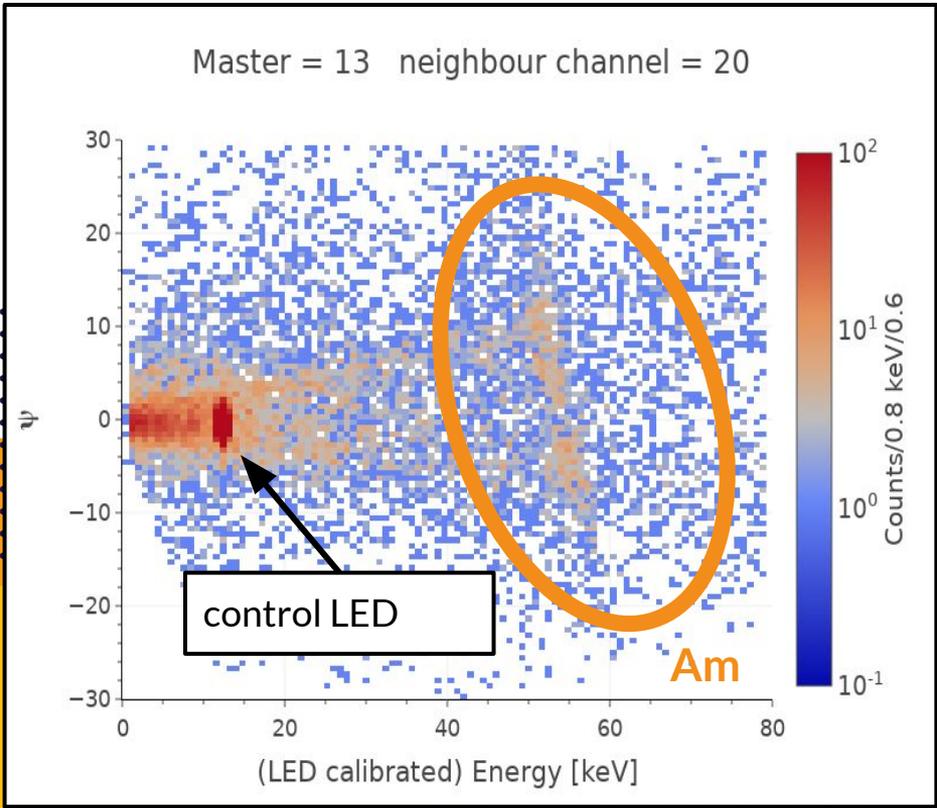


Americium peak Channel 14



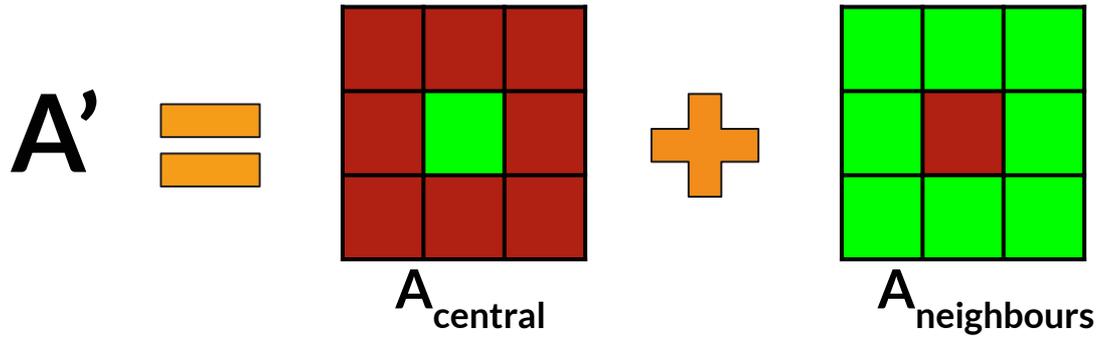
# Neighbours analysis

Americium events present a clear anti-correlation in the neighbours variables suggesting **position effects**



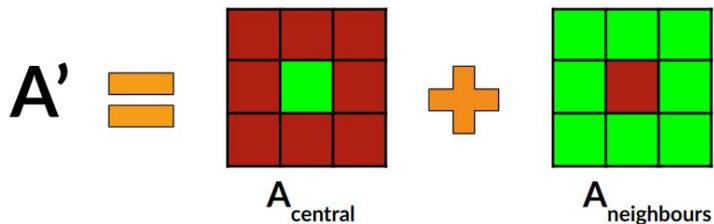
# Neighbours analysis

This anti-correlation suggests that a better resolution could be achieved by **summing the amplitudes of the central and the neighbour pixels**



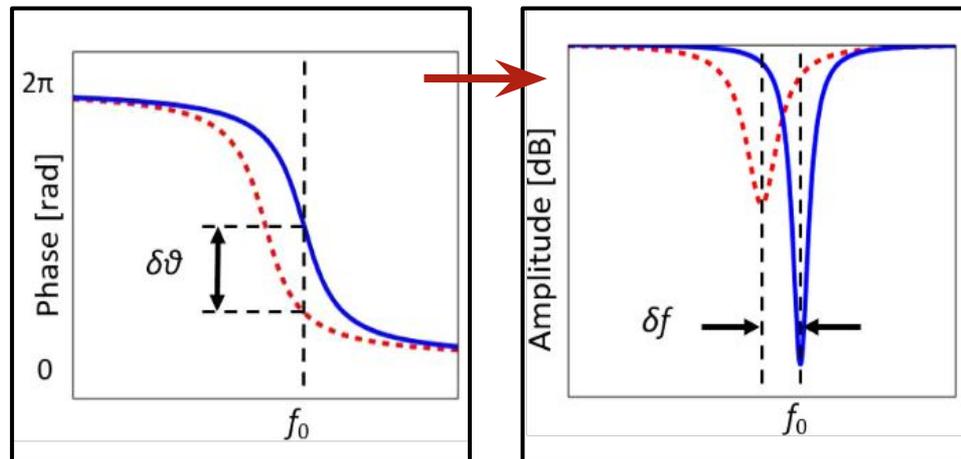
# Neighbours analysis

This anti-correlation suggests that a better resolution could be achieved by **summing the amplitudes of the central and the neighbour pixels**



$$\frac{d\phi}{dE} = \eta Q \frac{\alpha S_{\phi}(f_0, T)}{N_0 V \Delta_0^2} \rightarrow \frac{d\Delta f}{dE} = \eta \frac{\alpha f_0 S_2(f_0, T)}{4 N_0 V \Delta_0^2}$$

This step requires the evaluation of the **shift of the resonance frequency** as observable since it is **pixel independent**

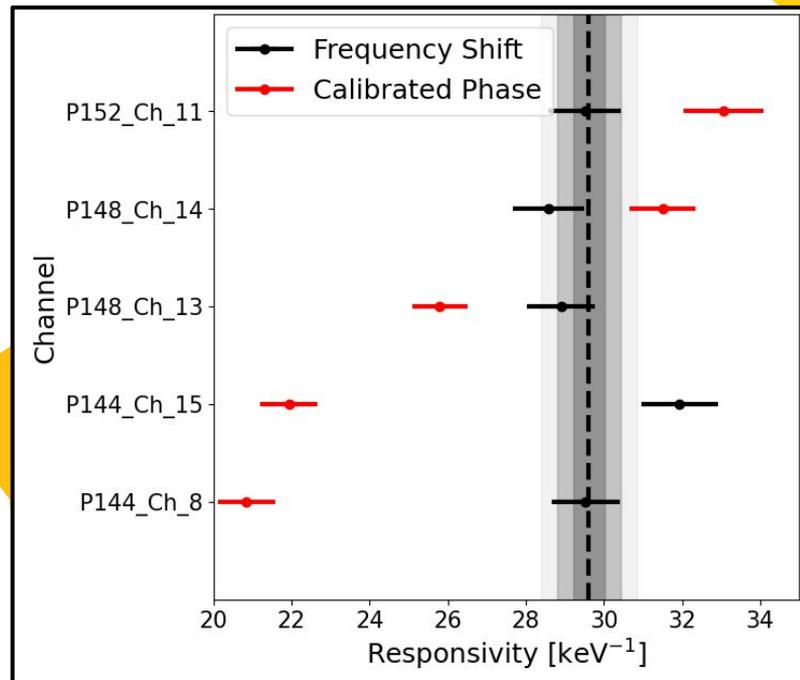


# Conclusions and next steps

- The LED calibration is validated **up to 10% of accuracy**.  
Shared between the evaluation of the responsivity and of the linearity of the pixels

- Position effects appears, limiting our resolution of the Americium peak to  $\sim 5\%$

- We are developing a new observable, that is pixel independent, to correctly evaluate the correlation between neighbour pixels due to the phonon leakage





# **Thank you for the attention**

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