The Demonstration Model of the ATHENA X-IFU Cryogenic AntiCoincidence Detector (CryoAC)

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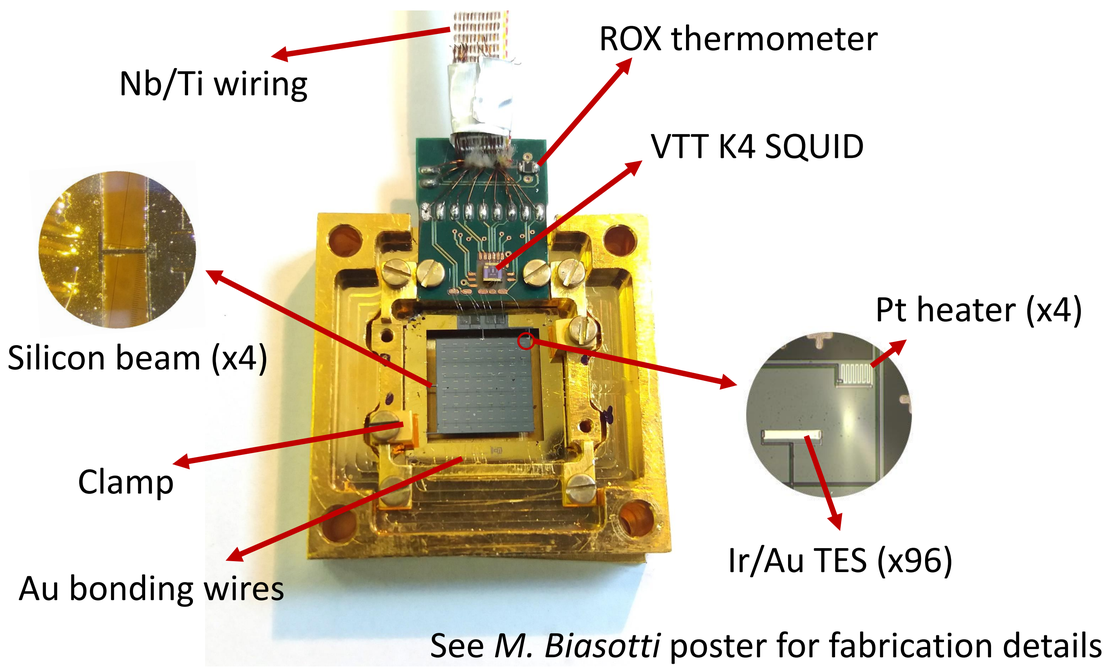
The Cryogenic AntiCoincidence Detector (CryoAC) of ATHENA X-IFU is designed to reduce the particle background of the instrument and to enable the mission science goals. It is a 4-pixels silicon microcalorimeter sensed by an Ir/Au TES network. Here we present the CryoAC Demonstration Model (DM), a prototype aimed to probe the detector critical technologies.

The CryoAC Demonstration Model



See *M. Biasotti* poster for fabrication details

CryoAC DM requirements:

- Suspended absorber with 1 cm^2 active area;
- Low energy threshold < 20 keV;
- Operation at 50 mK thermal bath;
- Power dissipation at 50 mK < 40 nW.

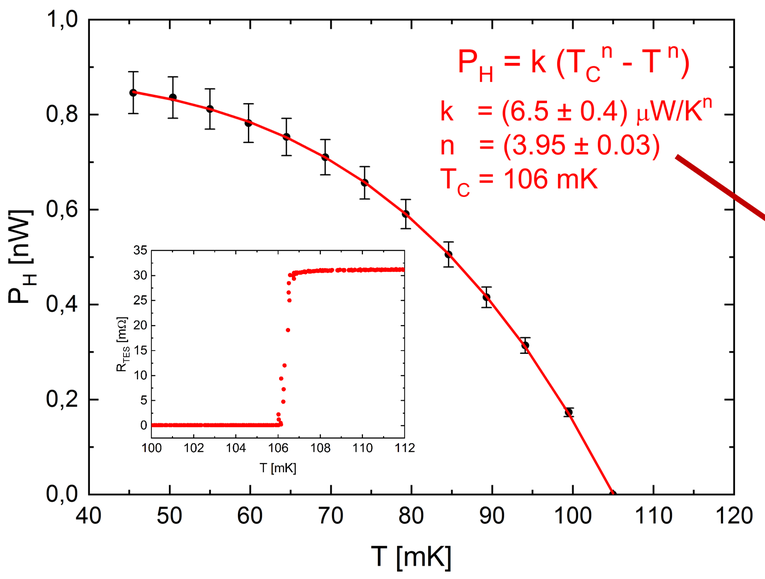
CryoAC DM (AC-S10 sample) specifications

Parameter	Value
Silicon chip thickness	525 µm
Total chip area	16.6 x 16.6 mm^2
Suspended Absorber area	10.0 x 10.0 mm^2
Beams dimensions	1000 x 100 µm^2
Ir/Au TES size (x 96)	50 x 500 µm^2
Ir/Au TES thikness	320 nm (Ir 240 nm + Au 80 nm)
Pt heater resistance	307 Ω

Thermoelectric characterization

We have operated the on-board heater to heat the absorber and drive the unbiased TES into the transition, thus evaluating the thermal conductance of the system:

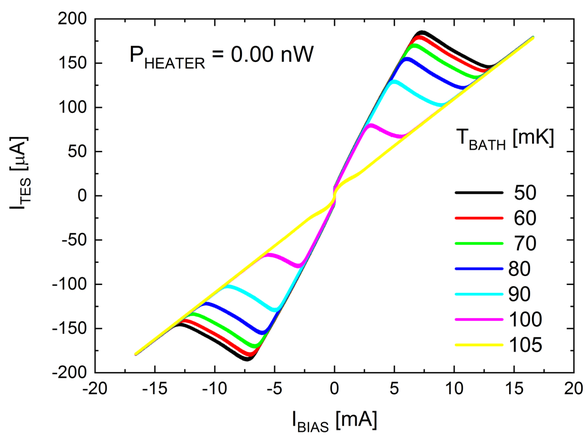
$$G = k\,n\,T^{(n-1)} = 34\,nW/K \text{ @ } T = T_C = 106 \text{ mK}$$



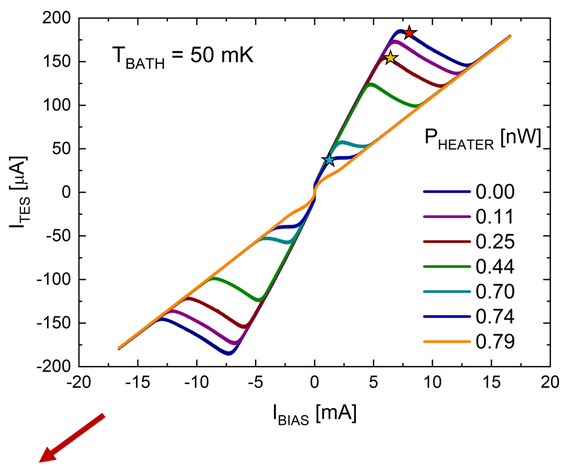
n~4, as expected in a phonon-mediated material

We have acquired two different families of characteristic curves:

Sweeping the thermal bath temperature



Fixing T_B = 50 mK and sweeping the heater power



The use of the heater allows to reduce the TES bias current and the shunt power dissipation. The cost is a loop gain reduction.

#	P_H [nW]	I_{BIAS} [mA]	I_{TES} [µA]	P_{SHUNT} [nW]	Loop Gain
★ 1	0.00	8.10	181	30.1	195
★ 2	0.25	6.75	150	20.7	135
★ 3	0.74	0.80	39	0.3	9

(In each point $R_{TES} \sim 3$ mΩ, P_{SQUID} = 1.5 nW and $P_{HEATER} + P_{TES} + P_{PARASITIC}$ = 0.8 nW)

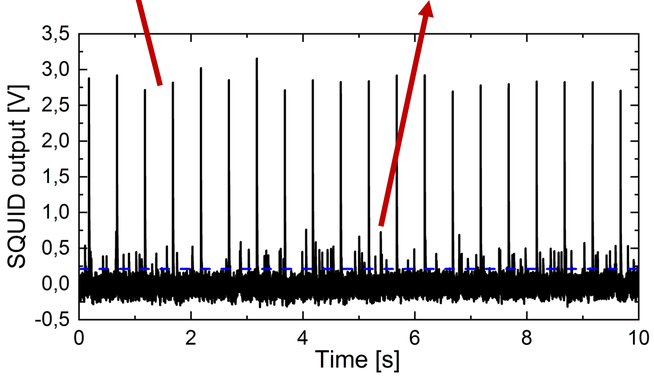
Operation at T_B = 50 mK

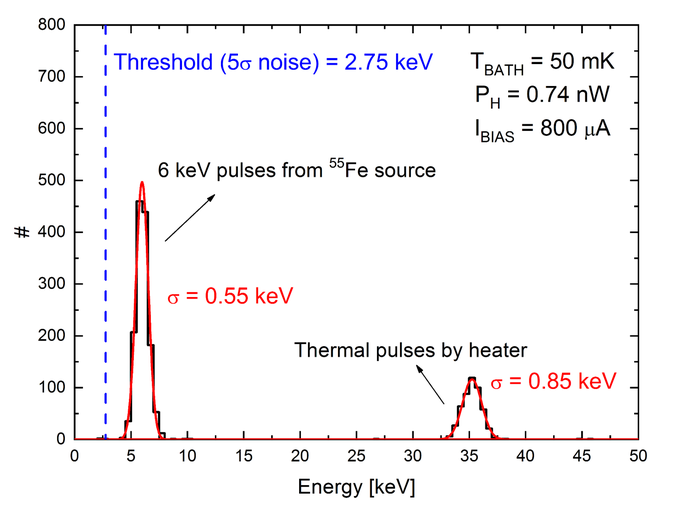
The sample is fully compliant with its requirements:

- Low energy threshold: E_{THR} = 2.75 keV
- Power dissipation : P_{TOT} = 2.6 nW

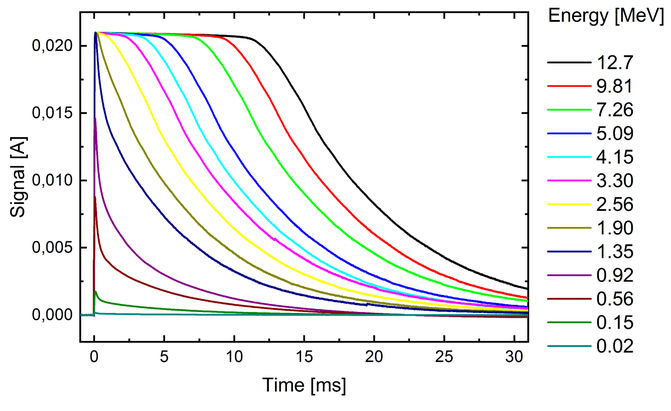
Calibration pulses by heater (35 keV)

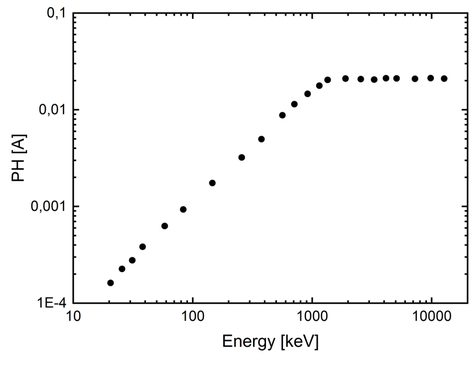
6 keV photons (^{55}Fe source)



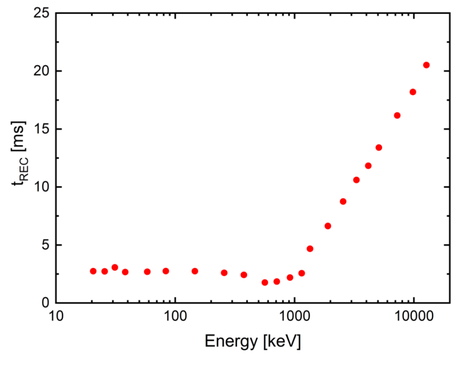


Pulse response up to the saturation regime





Important to assess the detector Dead Time



We have used the on-board heater to stimulate the detector in its whole energy band. We have found:

- Saturation threshold ~ 1.3 MeV;
- The Recovery Time in saturation grows roughly logarithmic with the deposited energy.

After this first stand-alone test performed at INAF/IAPS, the CryoAC DM has been delivered to SRON, for integration at the chipset level with the TES array. This will be the first compatibility test for the two detectors, representing a milestone on the path towards the X-IFU development.

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