Microcalorimeter readout of NewAthena/X-IFU prototype electronics on a cryogenic test bench

Alexeï Molin

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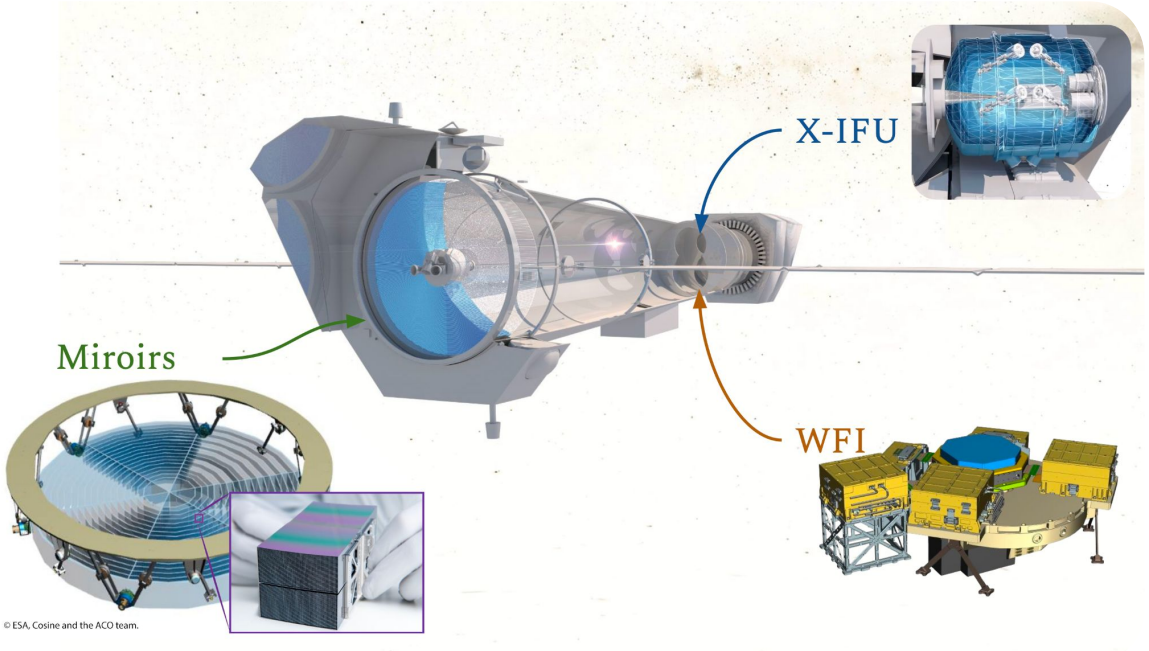
with Baptiste Sigal, Sophie Beaumont, François Pajot, François Mernier, Gilles Roudil @ IRAP, Toulouse
& the X-IFU CNES team

NewAthena

ESA's second next large class mission, to be launched by the end 2030s

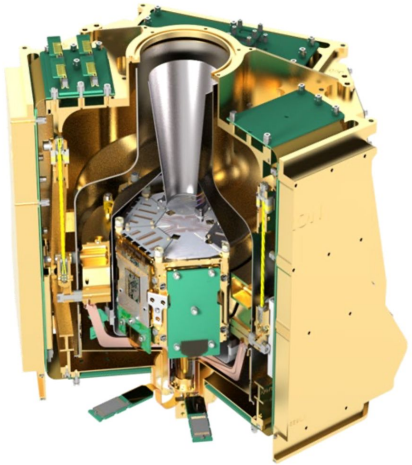


(X-Ray Integral Field Unit)
Integral Field spectrometer

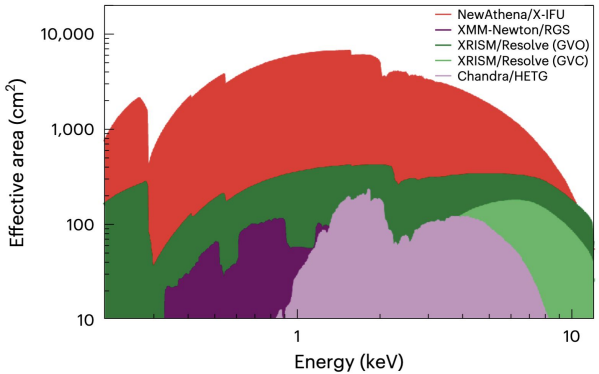
(Wide Field Imager)
DEPFET-based imager with a large field of view

NewAthena/X-IFU

Field of view	4 arcminutes
Angular resolution	9 arcseconds (PSF HEW at 1 keV)
Energy range	0.2-12 keV
Energy resolution	< 4eV (goal to 3 eV)
Pixel number	1504
Expected lifetime	5 years
Orbit	Lagrange L1



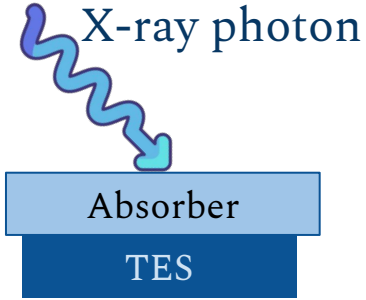
Focal Plane Array DM 1.1
Credit : SRON

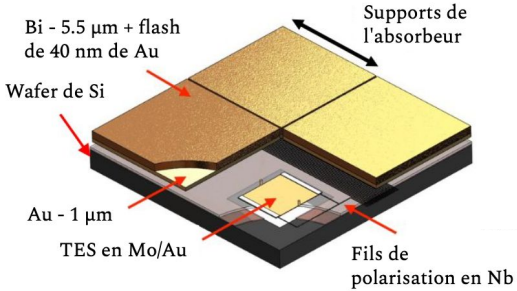


Cruise et al. 2025

X-IFU pixel design

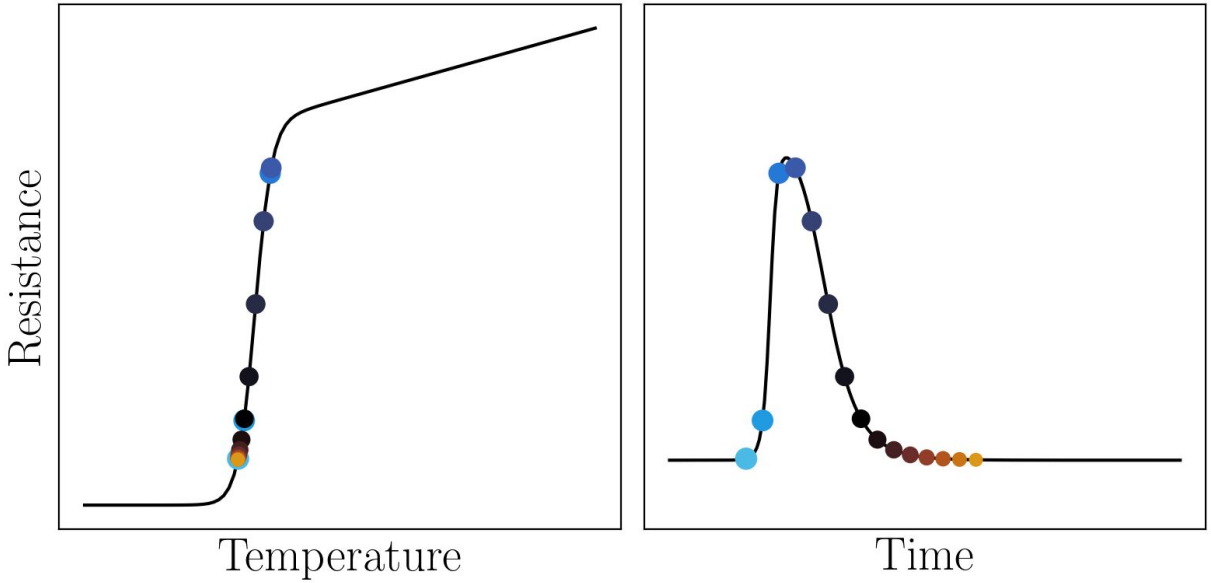
TES : Transition Edge Sensor





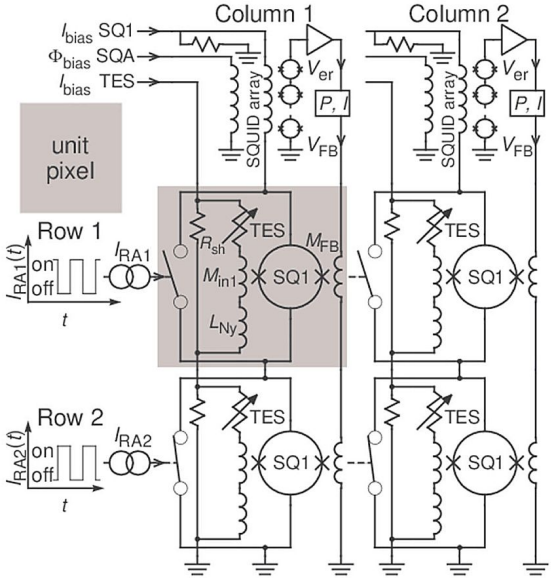
Crédit : Smith et al. 2024

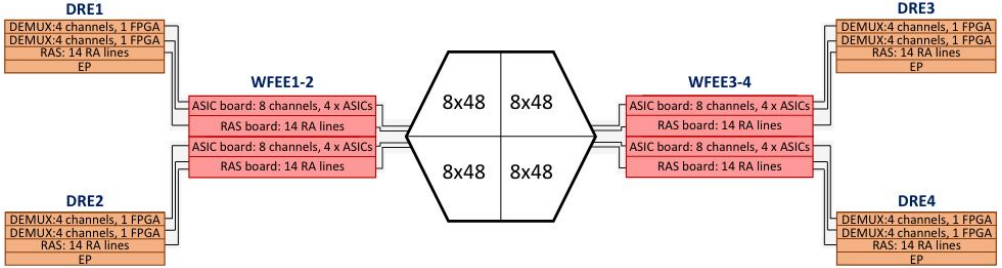
Superconducting transition at **80 mK**



X-IFU readout

Multiplexed readout of detector array, by dividing into 32 columns of 48 rows





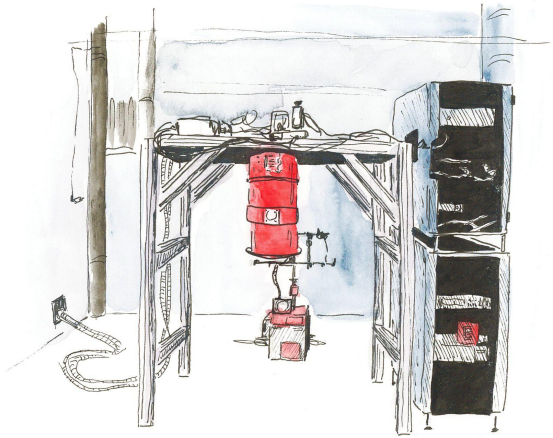
Using TDM : Time Division Multiplexing

50mK test bench at IRAP

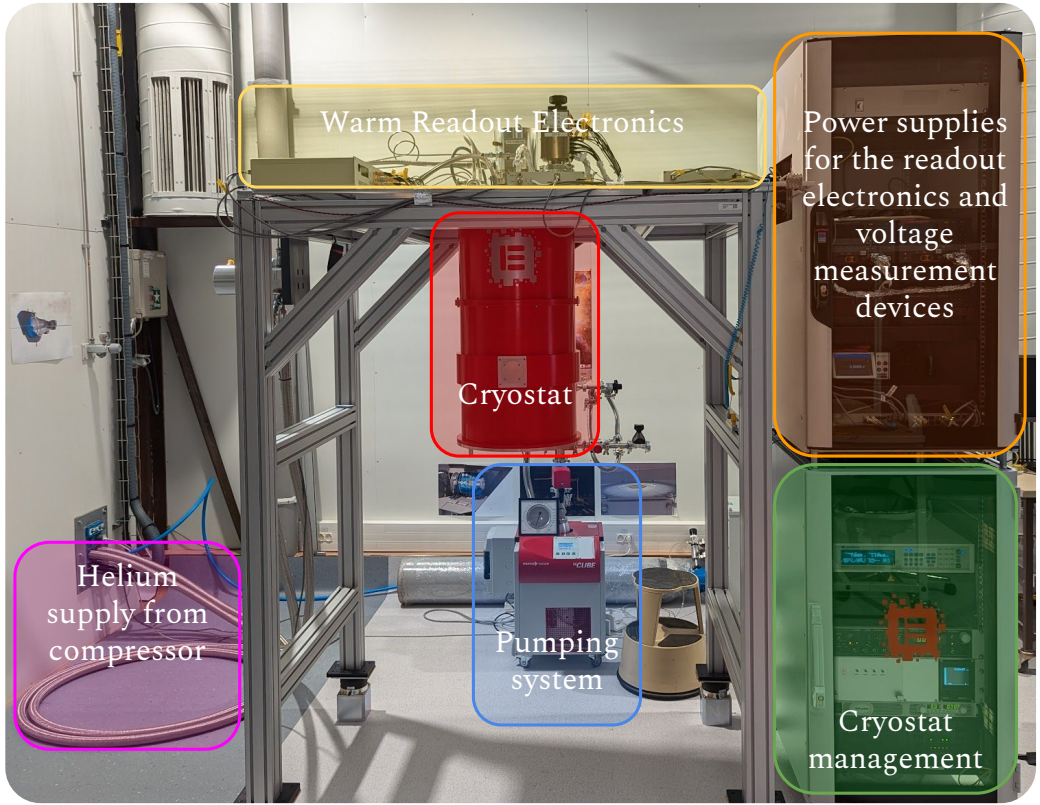
Goals :

- Develop skills for microcalorimeter chain readout operation
- Test X-IFU prototype electronics on a full readout chain
- Characterize calibration sources for X-IFU's future calibration

2018 : *Construction*
2021 : *First light*
2022 : *DRE prototype test*
2025 : *WFEE prototype testing (ongoing)*



50mK test bench at IRAP



Min. pressure	10^-7 mbar
Cooling	Temperature stages
Pulse-tube (Stirling cycle with He)	35 K
	2.5 K
ADR (Adiabatic Demagnetization Refrigerator)	500 mK (GGG)
	50 mK (FAA)

50mK test bench at IRAP

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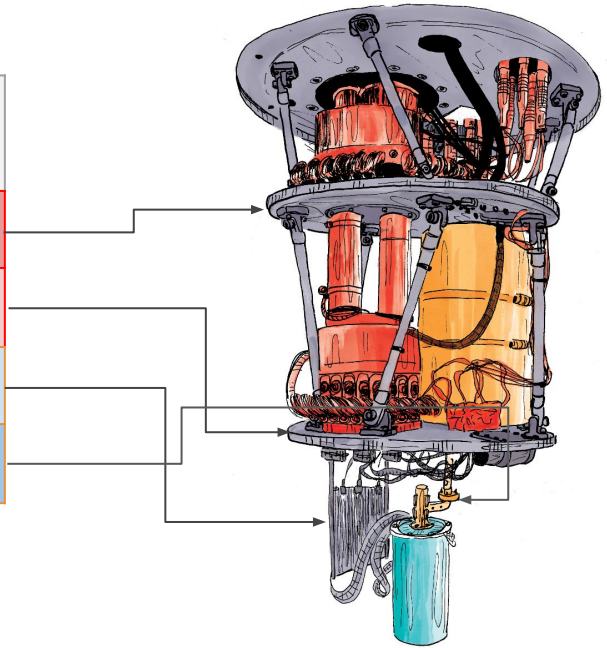
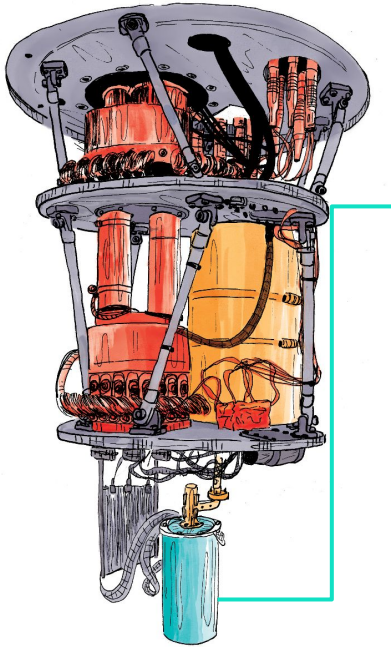
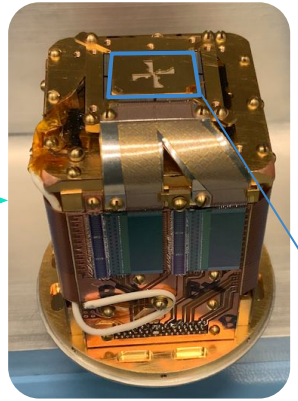
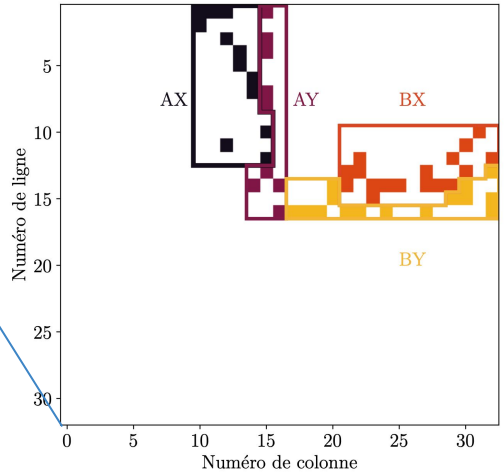


50mK test bench at IRAP





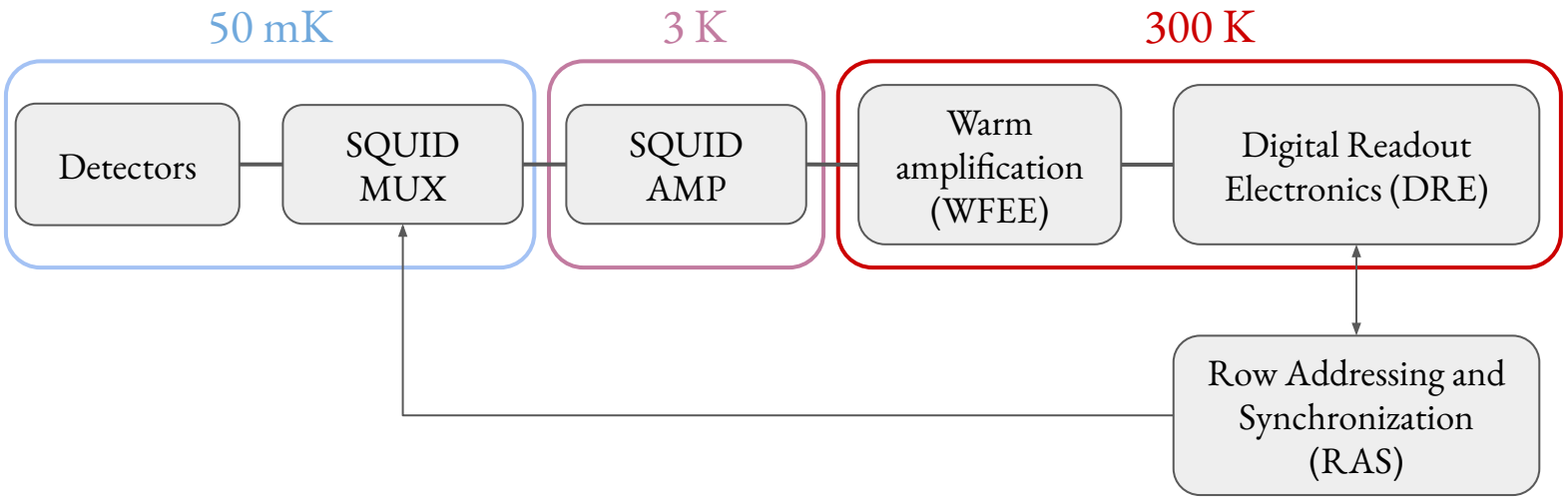
Snout



Readout columns	4 (AX, AY, BX, BY)
Nr. of pixels	49

50mK test bench at IRAP

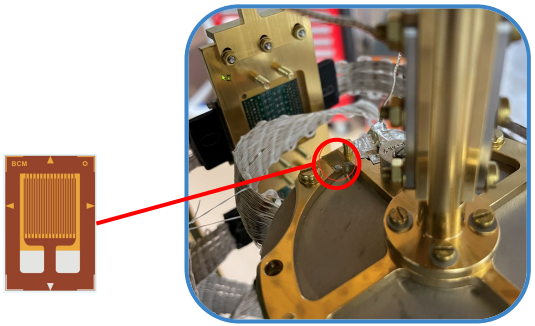
Readout chain layout



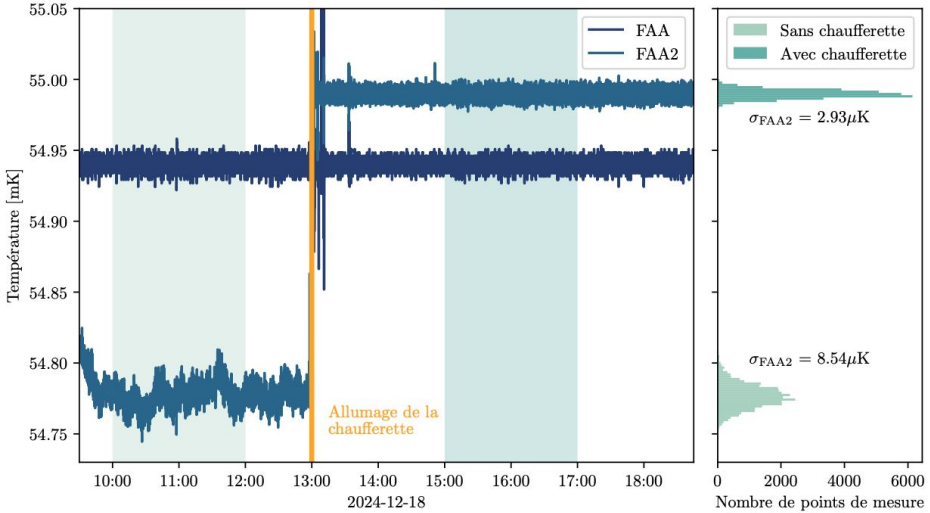
50mK test bench at IRAP

Main results on reference configuration **before adding X-IFU prototype electronics**:

- Temperature stability under 3 µK obtained with controlled sample heater



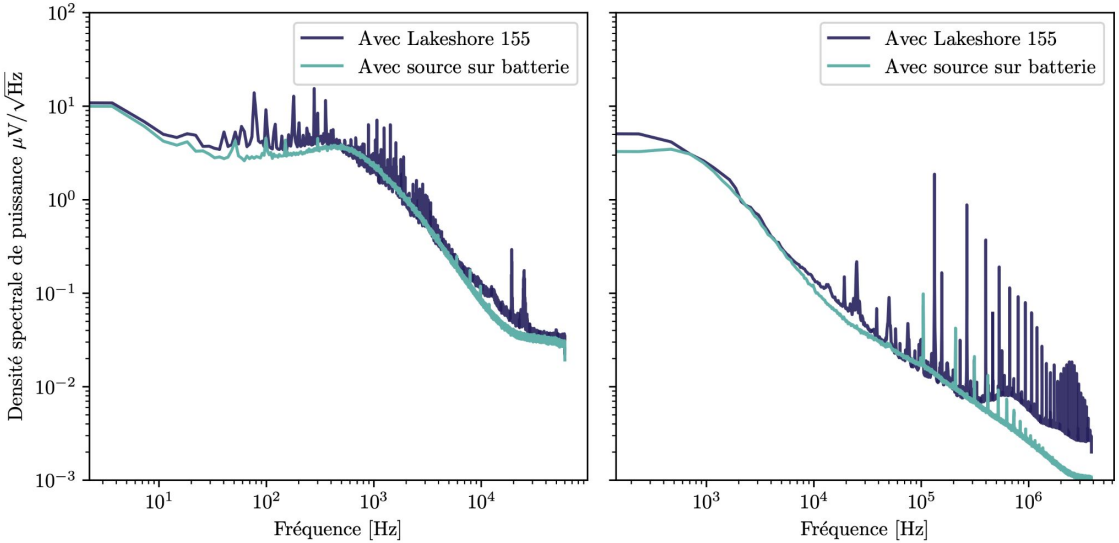
Before/ After switching on the sample heater



50mK test bench at IRAP

Main results on reference configuration **before adding X-IFU prototype electronics**:

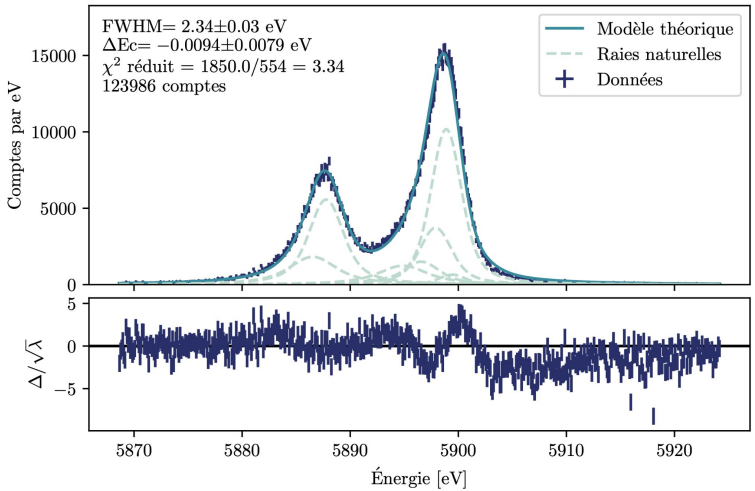
- Temperature stability under 3 µK obtained with controlled sample heater
- Optimized electromagnetic compatibility, leading to optimal noise level



50mK test bench at IRAP

Main results on reference configuration **before adding X-IFU prototype electronics**:

- Temperature stability under 3 µK obtained with controlled sample heater
- Optimized electromagnetic compatibility, leading to optimal noise level
- **Better than 3 eV FWHM energy resolution on 8 multiplexed pixels**

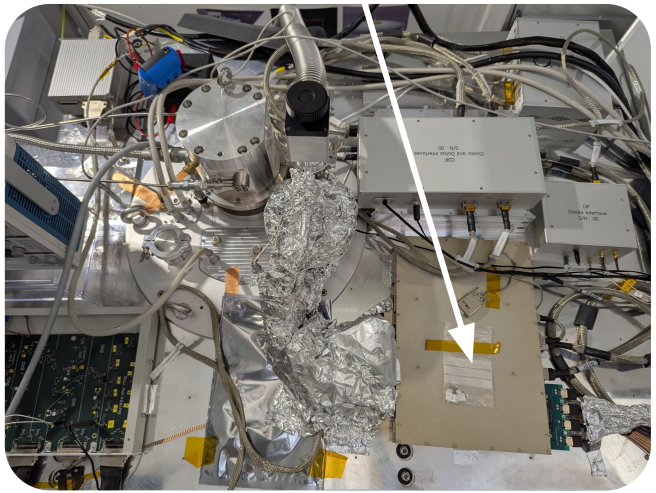


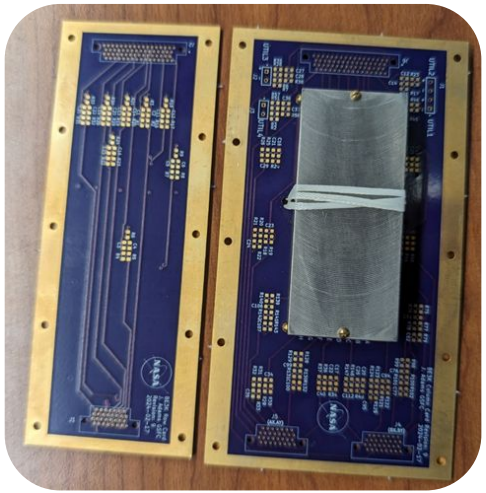
Spectrum of MnKα at 5.9 keV

50mK test bench at IRAP

Ongoing tests :

- Differential readout of the array
- Testing the WFEE Demonstration Model prototype





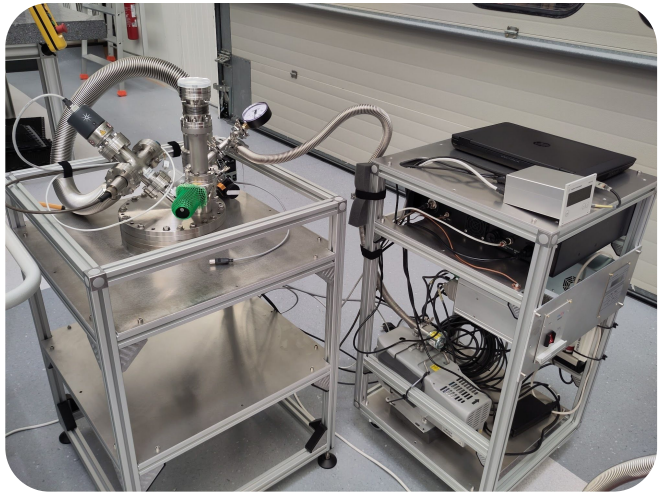
<u>Current status :</u>

Readout functional with promising noise level, but unsolved issues with gain scale stability in time

50mK test bench at IRAP

Future prospects :

- Stabilizing the energy gain scale
- Testing a calibration source build at IRAP, with many energies & full validation
- Testing the Digital Readout Electronics prototype



Thank you for your attention

Conclusions :

- Test bench capable of hosting and testing prototype electronics in Toulouse

Future prospects :

- Functional validation of prototype WFEE and DRE
- Characterization of calibration source for X-IFU