Transition Edge Sensors devices 'Made in Spain': from fabrication to photon energy measurements

M.T. Ceballos[1], A. Camón[2], L. Fábrega[3], C. Pobes[2], P. Strichovanec[2], J. Bolea[2], B. Cobo[1], N. Cardiel[4]

1 Instituto de Física de Cantabria (CSIC-UC) / 2 Instituto de Ciencia de Materiales de Aragón (CSIC-UZ)
3 Instituto de Ciencia de Materiales de Barcelona / 4 Universidad Complutense de Madrid

Under the coordinated national project RTI2018-096686-B-C2, the collaboration among research groups at ICMA(CSIC-UZ), ICMAB(CSIC) and IFCA(CSIC-UC)+UCM has developed for the first time in Spain an instrumental setup to fabricate Transition Edge Sensors (TES), measure the detected X-ray pulses in the lab and reconstruct those pulses to establish the photons energies.

TES are very sensitive detectors, with a high spectral resolution specially optimized for X-ray energies, like the ones that are the base for the X-IFU instrument that will be on board the ESA mission *Athena*. But they can be also designed to work at other wavelengths.

This achievement opens the path in Spain for the local development of this cutting-edge technology specially suited for the astronomical research.

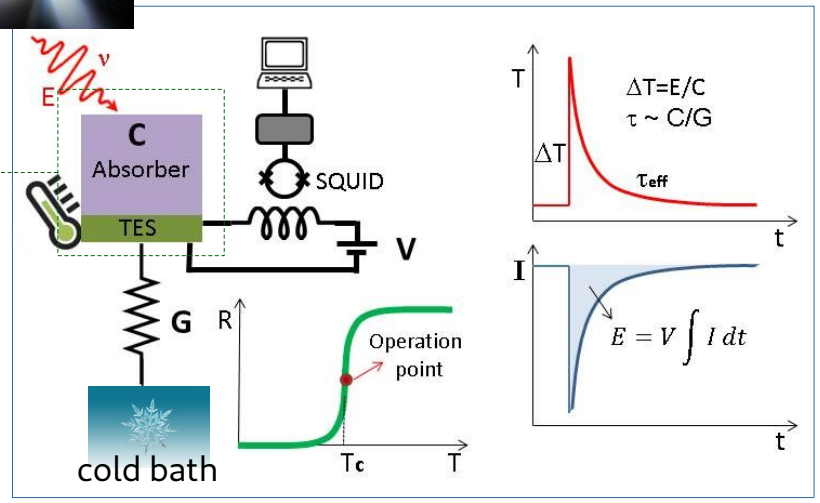
The context

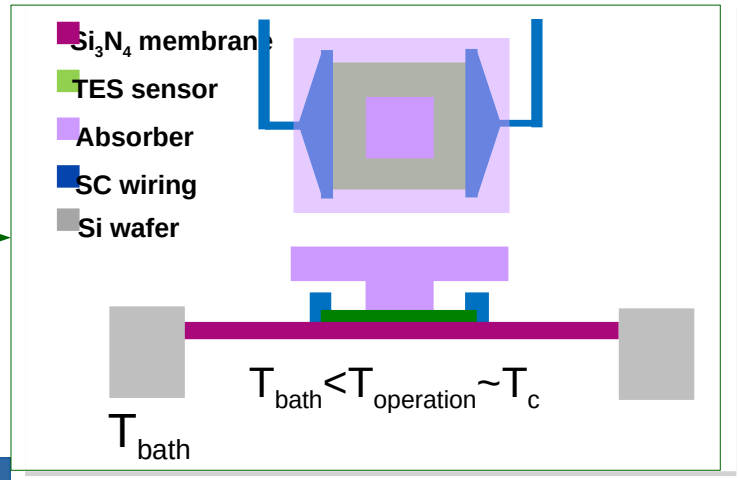
- TES-based detectors are a forefront instrumentation technology, particularly –but not only– for space.
- The capability of fabricating, testing and understanding their behavior to change designs in order to meet specific requirements will enable Spain to develop advanced instrumentation and increase its presence in future missions.
- The reduced activity on TES for space in Europe (basically restricted to SRON/NL) reveals the importance of having the capability of producing high performance TES Mo/Au-based in Spain, contributing to the independence of Europe on this technology.

Collaboration of ICMA, ICMAB and IFCA teams demonstrates for the first time in Spain, the capability to produce these sensors, measure the detected pulses in the lab and reconstruct the photon energies.

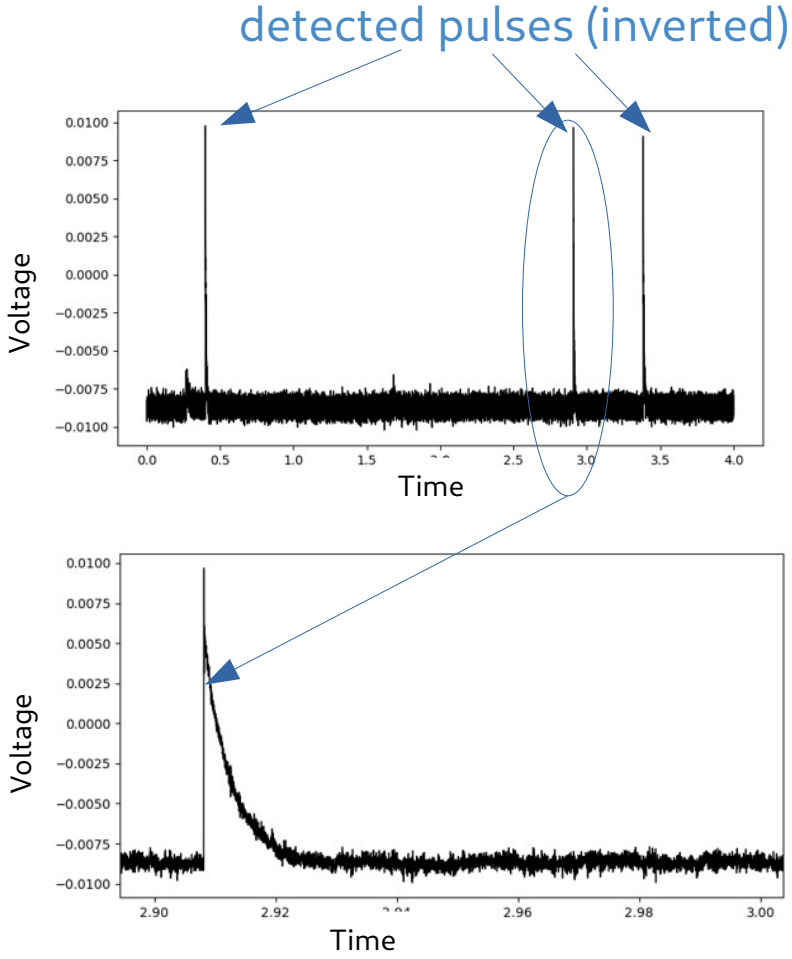
©IRAP, CNES, ESA, ACO: Artistic view of *Athena* mission

Description of the work (I)





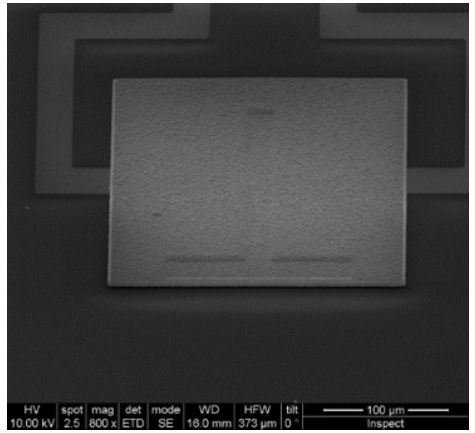
TES detectors working principle: every astronomical X-ray photon absorbed by the absorber rises its temperature. The system operates at a critical point with T~100mK (T_c) and it is permanently linked to a cold bath at T_{bath} < 100mK. The absorber is in contact with the *TES superconductive* detector and the temperature increase makes the resistance in the circuit increase. As the circuit is voltage biased, this increase in resistance translates into a decrease of current: a (inverted) **PULSE is produced**.



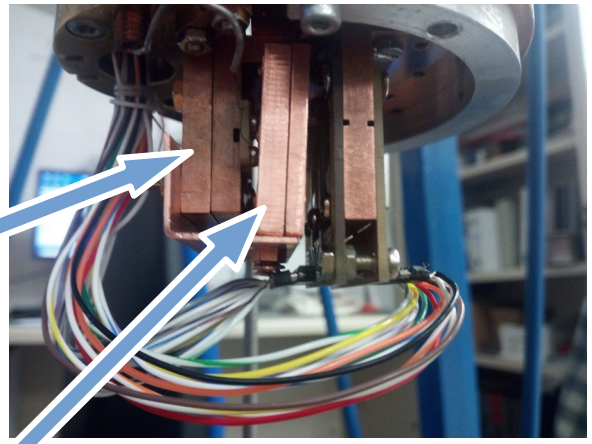
Photon Energy ~ Area of PULSE

Description of the work (II)

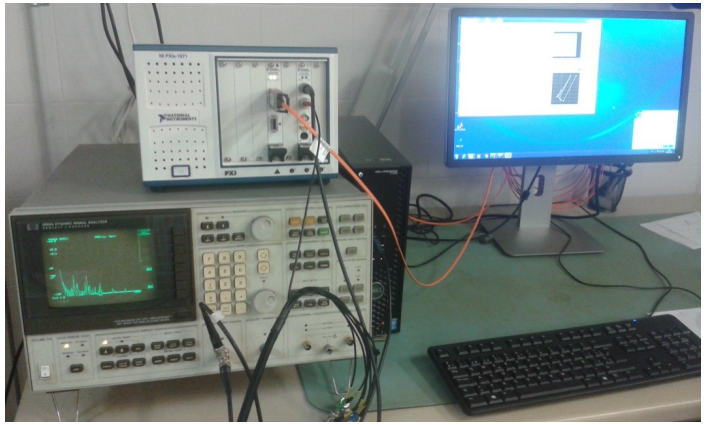
(Externally provided)
Radioactive X rays source ^{55}Fe



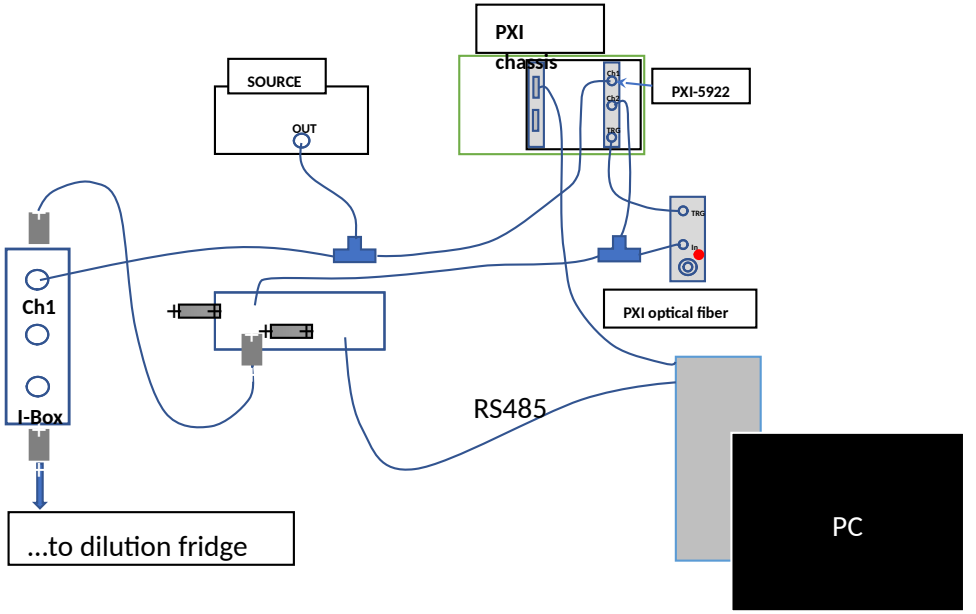
TES detector fabricated by



Source + TES
in dilution fridge



Acquisition electronics

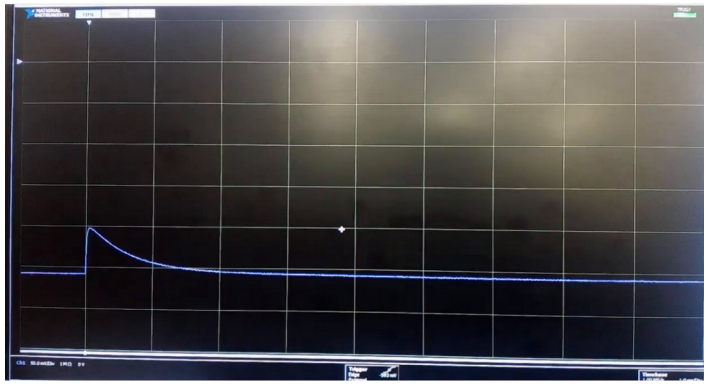


Lab setup scheme @

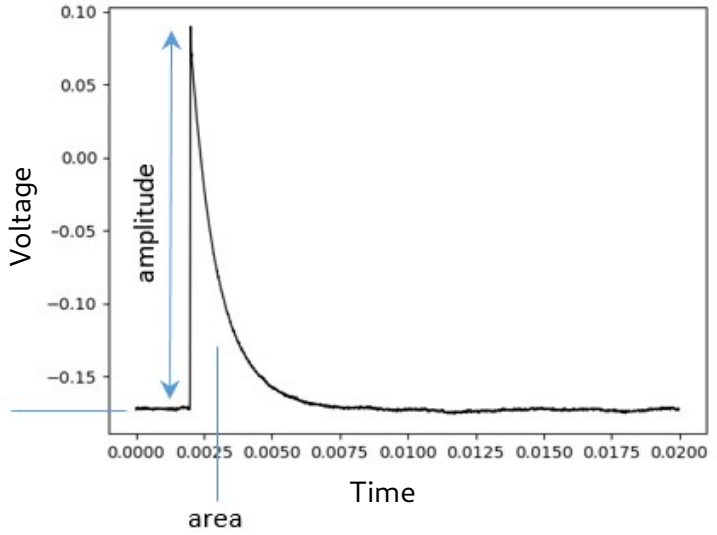
icma
Instituto de Ciencia
de Materiales de Aragón

Results

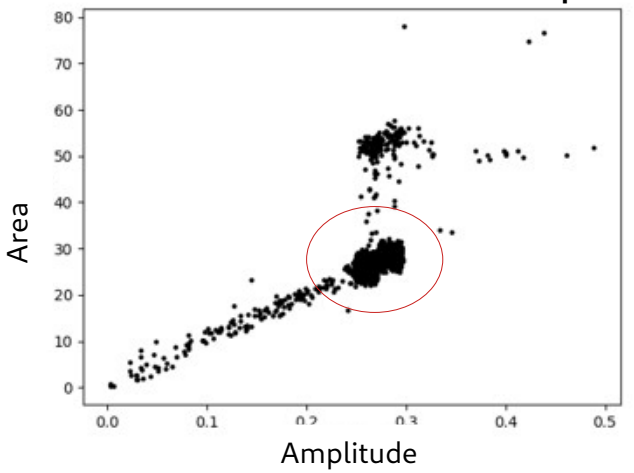
Lab setup scheme @ icma Instituto de Ciencia de Materiales de Aragón



First X-ray pulses at lab!

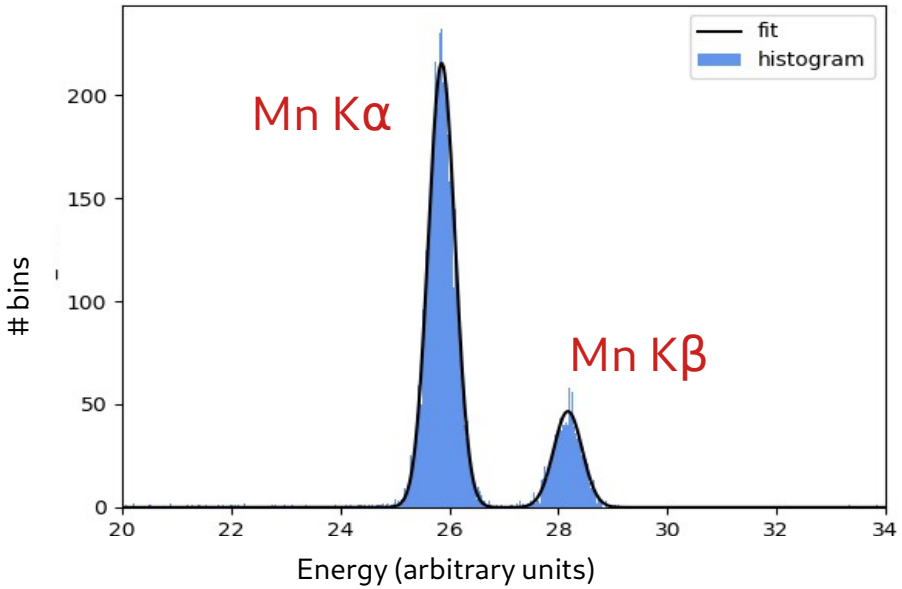


Selection on ^{55}Fe → **Mn Kα** pulses



Reconstruction performed with sw package SIRENA (git, doc) inside SIXTE simulator

IFCA Instituto de Física de Cantabria — EXCELENCIA MARÍA DE MAEZTU



Impact and future prospects

- First complete lab setup of a TES detector in Spain: radioactive source + TES detector (fabrication-ICMA+ICMAB) + acquisition system (ICMA)+ reconstruction software (IFCA+UCM)
- Demonstration of added value in multidisciplinary research projects
- Future steps:
  - Setup modifications to remove environmental factors, improve stability and obtain energy resolutions according to current missions requirements
  - Diversify detectors applications to other systems and astronomical detectors in other wavelengths

Refs:
SIXTE: http://www.sternwarte.uni-erlangen.de/research/sixte/index.php
SIRENA: https://sirena.readthedocs.io/ and https://github.com/bcobo/SIRENACobo

This work has been funded by the Spanish Ministry MCIU under project RTI2018-096686-B-C21 (MCIU/AEI/FEDER, UE), co-funded by FEDER funds. Funded by the Agencia Estatal de Investigación, Unidad de Excelencia María de Maeztu, ref. MDM-2017-0765