COMPOL: a gamma-ray polarimeter in a nanosat

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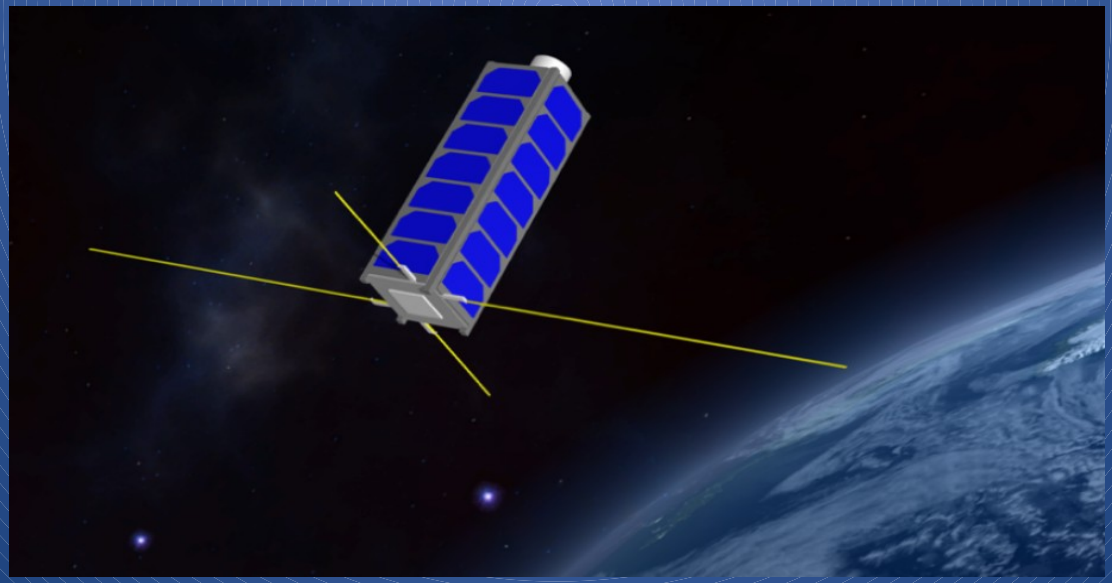
The COMPOL project

- *The goal of the COMPOL project is to fly a Compton polarimeter in a 3U nanosat.*
- *Its small effective area will be compensated by a very long observation time, one year or more. COMPOL is thus dedicated to one source, Cygnus X-1.*
- *It is a collaboration between CEA (France), MPP, TUM, LRSM (Germany) and Politecnico di Milano (Italy).*



COMPOL : a Compton polarimeter

- *A Compton polarimeter is based on Compton effect, the dominant effect between photons and matter in the range of 50 keV - some MeV.*
- *In a Compton polarimeter, we use two spectro-imager detection planes, a scatterer and a calorimeter. The photons are first scattered in the scatterer and then absorbed in the calorimeter.*

The COMPOL payload thus consists of:

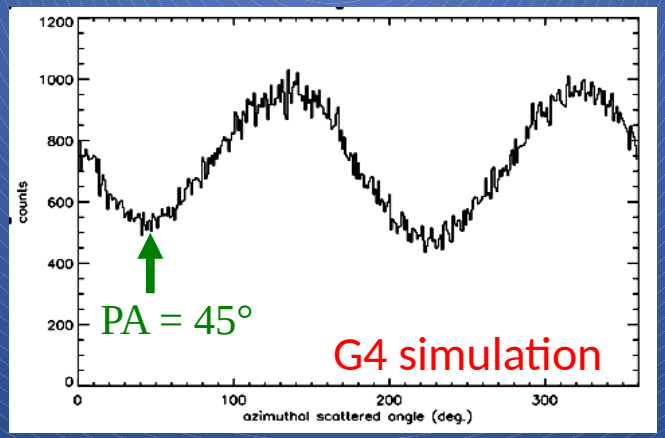
- ***silicon SDD detectors** derived from the KATRIN/TRISTAN neutrino mass experiment (scatterer, MPP, TUM, Polimi).*
- ***a CeBr3 scintillator** coupled with a SiPM Hamamatsu 36 pixels matrix (calorimeter, CEA).*

Compton polarimeter principles

- *For a given scattering angle, the photons describe a circle on the calorimeter plane. If the source is not polarized, this circle is evenly filled.*
- *If polarized, one part of the circle is brighter than the others. The distribution of photons according to this circle follows a cosine law:*

$$S = \bar{S}\left[1 + a.\cos(2(\varphi - \varphi_0))\right]$$

$\Rightarrow$ *mean count rate* $a \Rightarrow$ *polarization fraction* $\varphi_0 \Rightarrow$ *polarization angle*



The COMPOL 3U mission

- *Mission duration : 1+ year; mission dedicated to a single source.*
- *Low Earth Equatorial Orbit (< 5°) is preferred to minimize the background.*
- *The nanosat will need to rotate slowly around the pointing axis to avoid systematic errors in polarization measurements.*
- *Launch : 2026*

Geant4 Monte-Carlo simulations have shown that COMPOL should achieve a MDP ≃ 18% (10 – 300 keV)

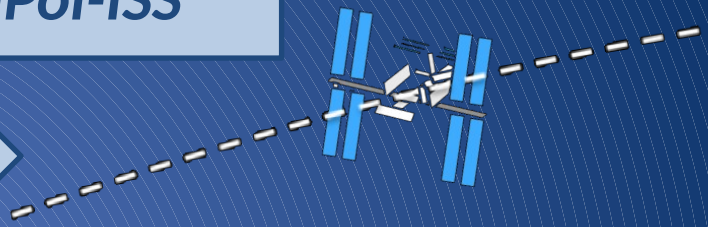
in six months of Cygnus X-1 observation !

COMPOL 3U mission timeline

In-Orbit-Verification (IOV) mission ***ComPol-ISS***

Preparation

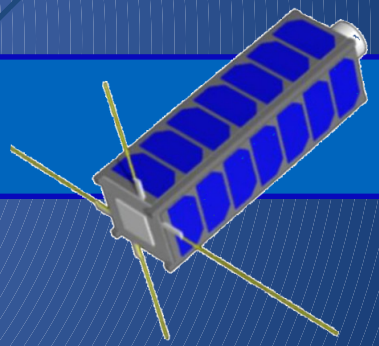
ISS operation



Launch 2023

Learnings

CubeSat Science Mission ***ComPol***



Studies

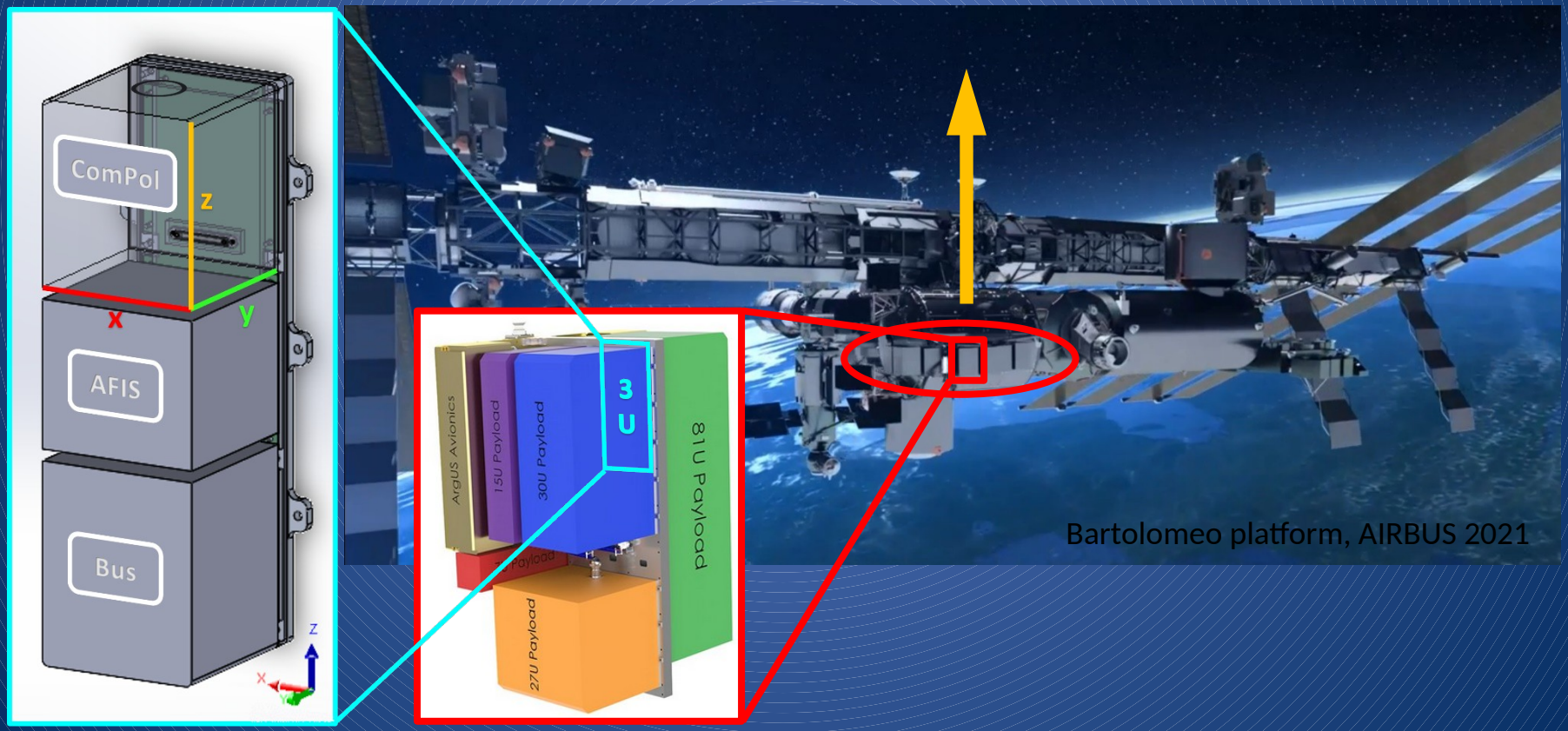
Implementation

CubeSat

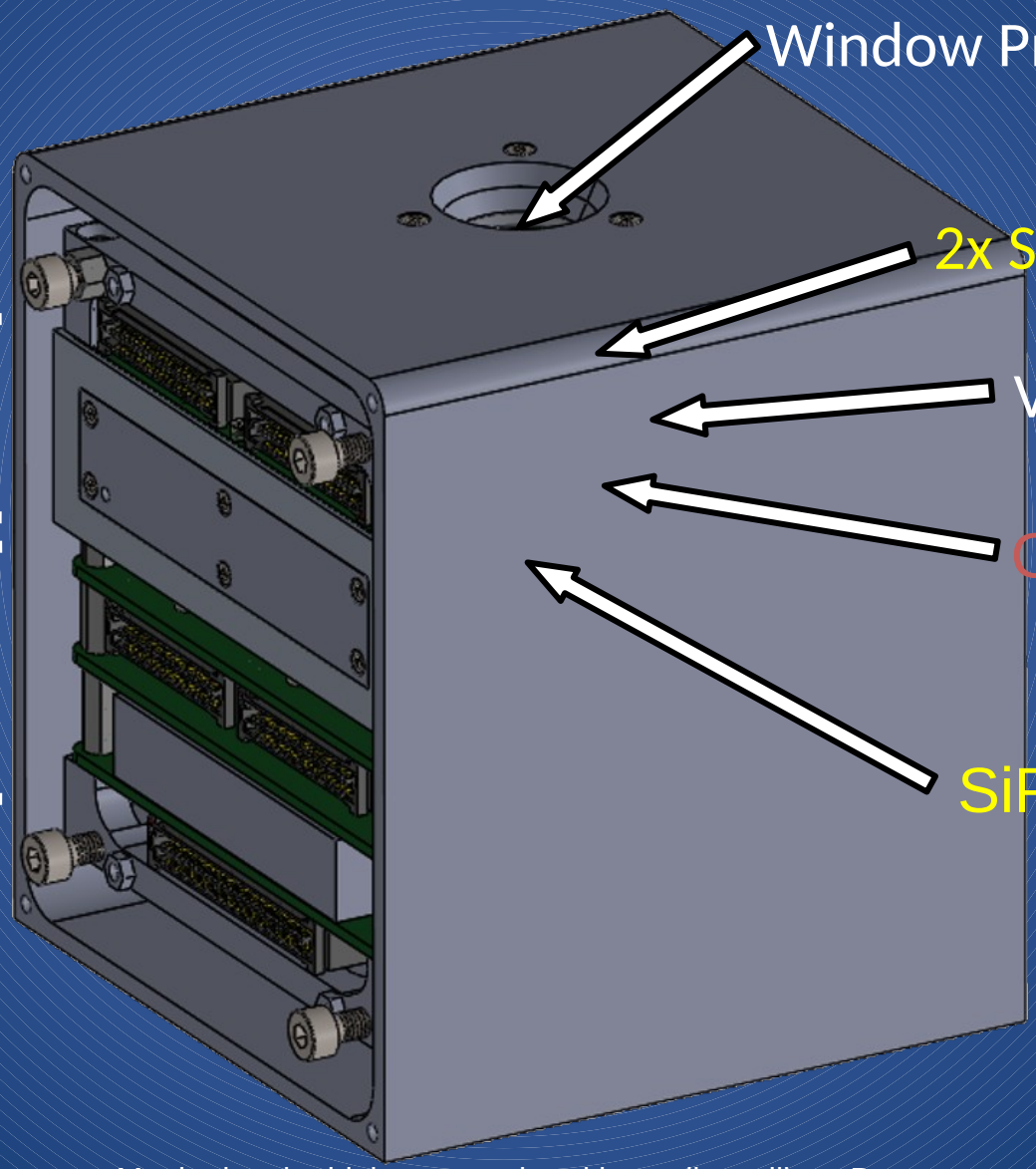
Launch before 2026

The IOV-mission ComPol-ISS

- *External platform aboard ISS*
- *Clear view to the zenith*
- *Joint IOV-mission with 3U structure*



COMPOL-ISS Modular mechanical model

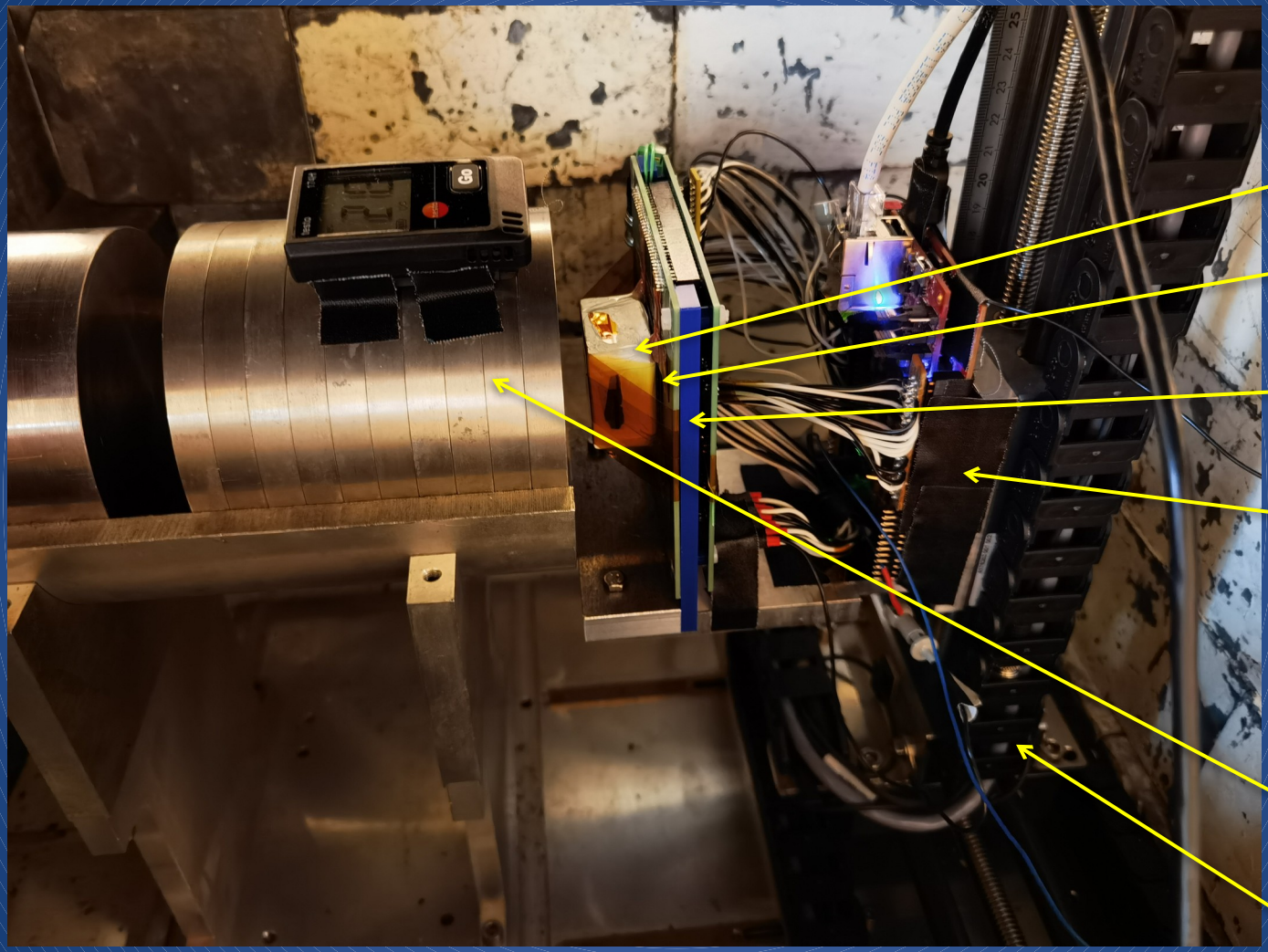


Detachable without disassembling

K. Geigenberger MS study

COMPOL DETECTORS STATUS

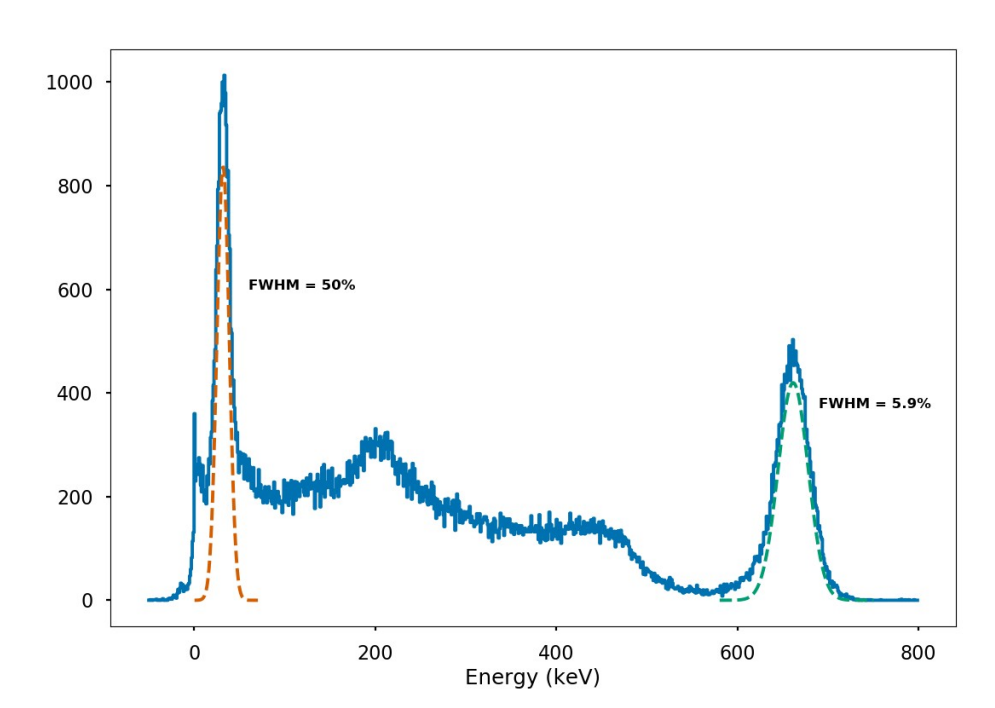
Calibration of the COMPOL calorimeter (CEA)



I. Cojocari PHD thesis

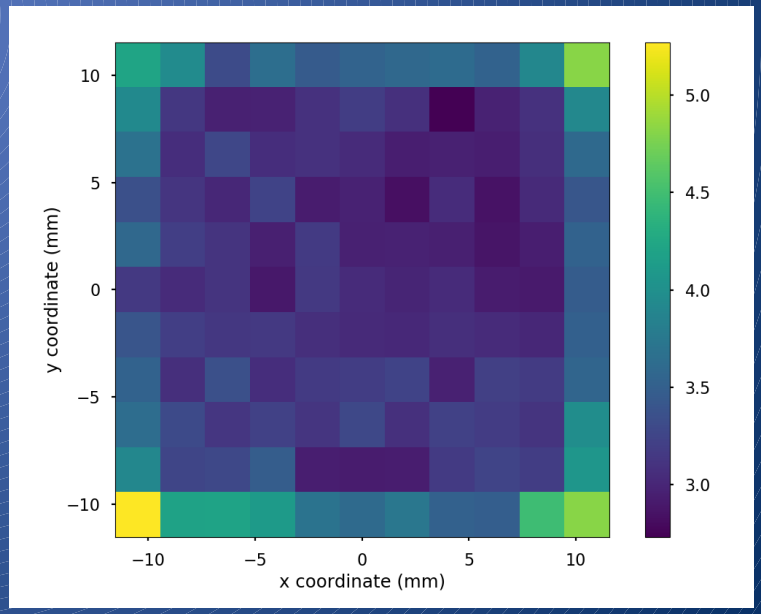
CeBr3 calibration at IJCLab (Orsay)

Calibration of the COMPOL calorimeter (CEA)



CeBr3 energy spectrum (sum of all SiPM matrix pixels) : 5.9% @ 662 keV

CeBr3 position obtained by analysing the light distribution in the pixels through a Neural Network software : resolution ~ 3 mm depending on the interaction point position.



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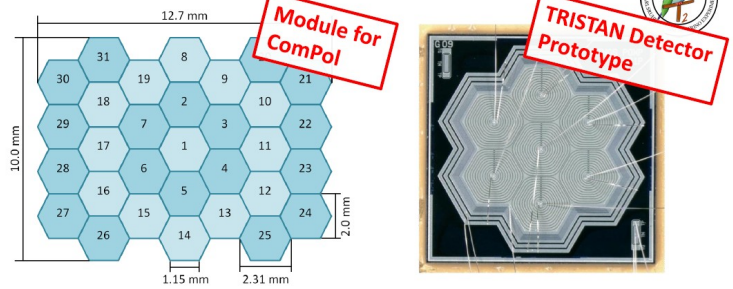
The COMPOL scatterer (TUM+Polimi)

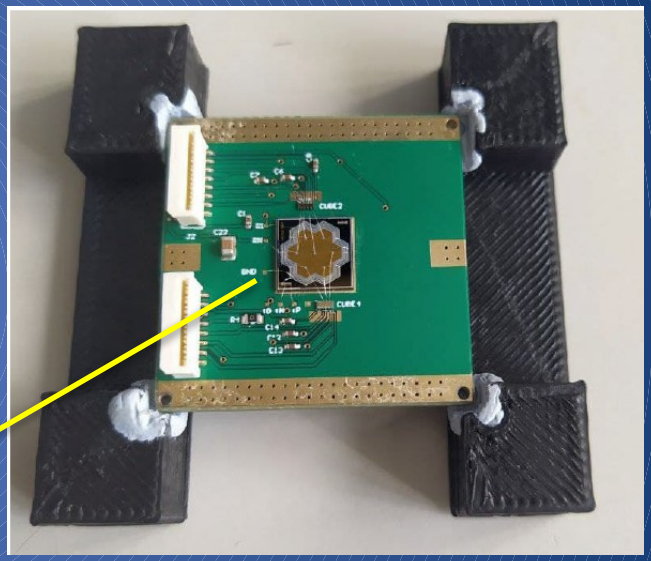
Silicon Drift Detector

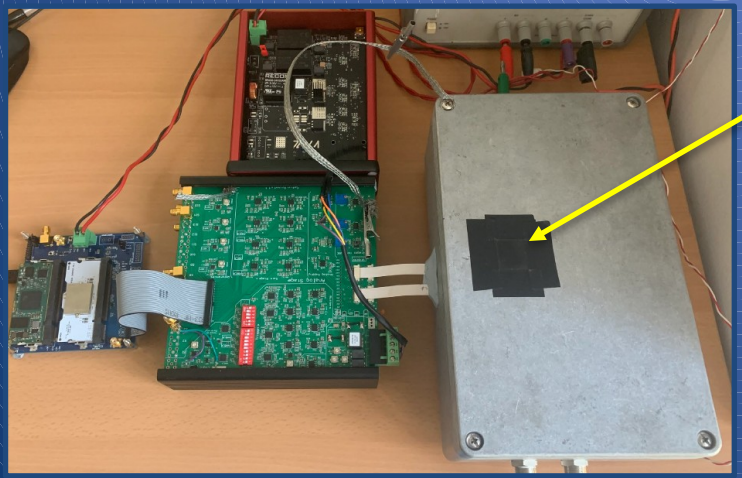
- Used for KATRIN/**TRISTAN** (Neutrino mass experiment)
- Excellent energy resolution (300 eV @ 20 keV)



TRISTAN matrix (7 pixels) and SDD foreseen for COMPOL (31 pixels)

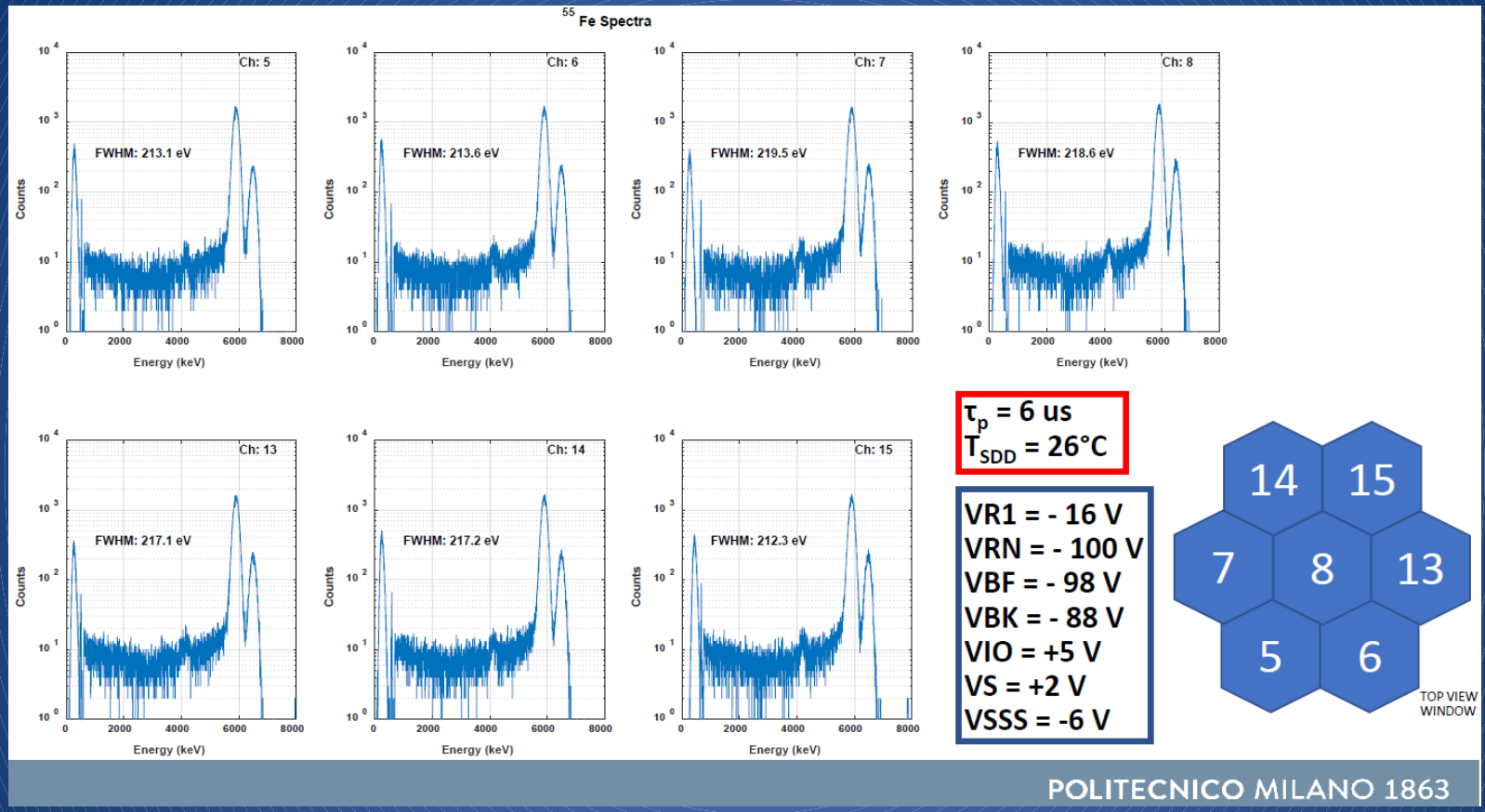
COMPOL-ISS SDD matrix
First prototype
(7 hexagonal pixels ~ 2mm)





Acquisition chain @ Polimi

Calibration of the COMPOL scatterer (TUM+Polimi)



SDD 7 pixels spectra : ~ 200 eV @ 6 keV
(^{55}Fe source)

THANKS !

Extra info : BEES !

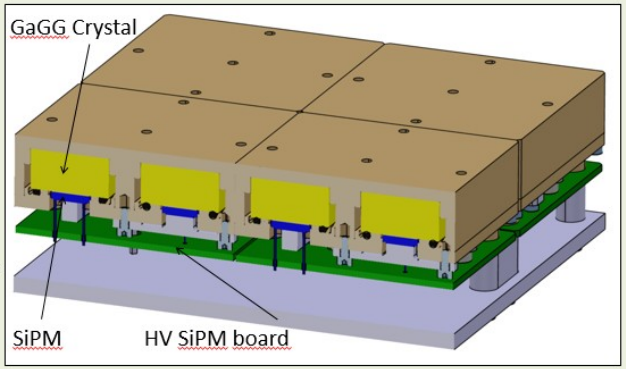
After the TARANIS failure, CNES (with APC and LESIA) has decided to launch a program to have a new TGF mission around 2030 : BEES

This mission will be based upon a constellation of 6/8 nanosats, at 100 km distance on low Earth orbits, hosting each a gamma-ray and radio instrument (stereoscopic view).

The gamma-ray instrument will be based upon 16 GAGG + SiPM pixels + IDEAS/APOCAT ASIC.

Phase A study on-going: We will keep you informed !!

- **GaGG scintillator**
  Supplier : C&A, EPIC
  Type : GaGG-F, GaGG-T, GaGG HR
  State surface effect : polished/ non polished.
- **Wrapping**
  ESR-3M.
  Crystal coating by sputtering.
- **SiPM**
  Several type of SiPM (Hamamatsu, Onsemi, FBK) are presently studied at CNES.
- **Readout electronics :**
  APOCAT ASIC under tests at LESIA.



Detection unit