# Finding the needle in the haystack: The Cryogenic AntiCoincidence

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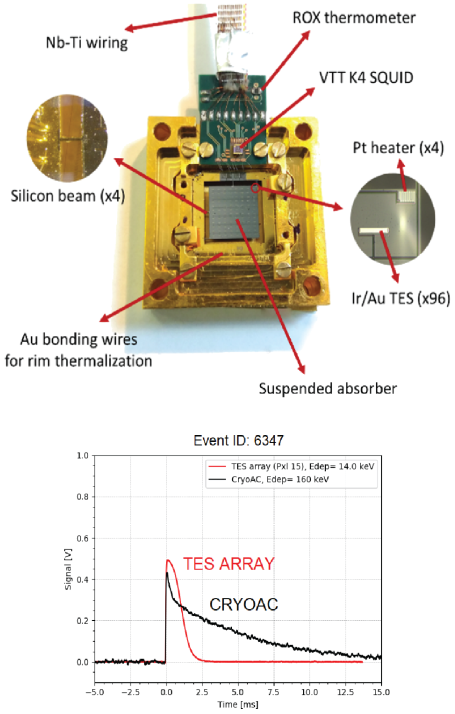

*The Demonstration Model CryoAC (single-pixel detector), and a muon-coincidence detected in combination with the Demonstration Model TES-Array (credits SRON).*

Beating down the X-IFU particle background is fundamental to enable several core *Athena* science goals, in particular those relevant to high-resolution spectroscopy of faint sources. The criticality of this was already discussed in "*Athena* community Newsletter #3" and in "#*Athena* Nuggets 15". The X-IFU Geant4 simulations indicate that the Galactic cosmic ray induced background (from primary, and related secondary showers) on the instrument without any precaution would be > 30 times above the level allowed by the science requirement. Now it is time to talk about the hardware that will take care of reducing this background to the required value. It relies on a Cryogenic AntiCoincidence detector (CryoAC) that will detect all particles crossing both the Transition Edge Sensor (TES) array and the CryoAC with an efficiency of >99.98%. This means that only two particles every 10.000 are allowed to be missed: now you understand what the title implies!

The TES array cannot disentangle if an in-band energy deposition is caused by background particles or X-ray photons from a celestial source. The CryoAC will raise a flag each time it will detect an event above its working energy threshold and, if an event occurred on the TES array at the same time, it will be vetoed as likely due to particles.

To perform this task, the anticoincidence detector must be very close to the TES array (< 1 mm), and thus must operate in the same cryogenic environment and at a similar temperature. Further, to minimize possible issues related to interface, electromagnetic compatibility, etc…, the CryoAC is also based on TES technology, i.e. 4 Silicon absorbers, 500µm thick and with an area of about 1.2 cm$^2$ each, independently sensed by a network made of more than 100 Ir/Au TES connected in-parallel. Each network is read out by a single SQUID. The CryoAC signal ramps up exceedingly fast, thanks to the so-called "a-thermal" component which behaves like a "heat shock wave" generated by an energetic particle in Si sub-K temperature. The use of the fast detector response using a-thermal signals has been inspired by their application in large volume detectors built to find Majorana neutrinos and the elusive dark matter particles. The detector concept and related prototypes are designed and developed by an Italian consortium made of INAF institutes, University of Genova Phys. dpt., CNR/IFN Roma, and with the support of ASI.

The most recent detector prototype is the Demonstration Model of the CryoAC, developed to demonstrate the key critical technologies: operation at 50 mK; 20 keV low energy threshold; suspended absorber; operation of on-absorber deposited heater. An important step is to demonstrate the combined operation with the TES array. Therefore the CryoAC Demonstration Model was integrated with the Demonstration Model of the TES array in a dedicated setup at SRON in The Netherlands. The first results are very good and show that the two detectors are working together fine, including the first proof of coincidences from cosmic-ray muons. Our next steps in the technology demonstration include a trade-off to define the layout configuration of the absorbers: monolithic (one pixel only) vs segmented. This trade-off should be concluded by the end of this year, pending the development of Covid-19 restrictions, but we are in full swing for our Demonstration Plan. Stay tuned!

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