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Thermal impact of cosmic ray interaction with X-ray microcalorimeter array

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The X-ray Integral Field Unit (X-IFU) instrument on the Athena mission will be positioned at the Lagrangian point L1 or L2 and be subject to cosmic rays generated by astrophysics sources, primarily composed of protons. Previous simulations have shown that particles of energy higher than 30 GeV will make it through the outer layers of the satellite and will reach the focal plane and it's detectors with a rate of 3 cts.cm-2.s-1 and a peak of energy at 150 keV.

We have been developing superconducting transition-edge sensor (TES) arrays for the focal plane array of X-IFU. These detectors, made from Mo/Au and suspended on a Si frame by a SiN membrane will be exposed to the energy deposition of this flux of cosmic rays which can impact the scientific data. An anti-coincidence detector, located right below the TES array will remove the coincident events hitting the detectors of the array but not the events generated in the frame surrounding the detectors.

In order to limit such effects, several features are studied in this paper such as a layer of copper on the back side of the array that increases the heat capacity and improves the thermal conductance to the heat bath. The use of an additional layer of palladium to increase the heat capacity is also studied, as well as thermally disconnecting some regions of the detector array substrate from that in the region of the detector.

To study these features and their impacts on the detector performance at the focal plane, we have been developing a 2D thermal model of the TES array and its frame that we have validated by comparing it to measurements performed on the Hitomi array. We have shown that by using a combination of different thermal design options, the number of events of an amplitude greater than 1 uK can be reduced from 44 counts per second to 2 counts per second. At this rate, simulations have shown that the impact of cosmic ray events on resolution can be kept lower than the requirement of 0.2 eV.

Less than 5 years of experience since completion of Ph.D

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