**Quantifying the Effect of Cosmic Ray Showers on the X-IFU Energy Resolution**


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Abstract: The X-ray Integral Field Unit (X-IFU) will operate an array of more than 3000 Transition-Edge Sensor pixels at 90 mK with an unprecedented energy resolution of 2.5 eV at 7 keV. In space, primary cosmic rays and secondary particles produced in the instrument structure will continuously deposit energy on the detector wafer and induce fluctuations on the pixels’ thermal bath. We have investigated by simulation of the X-IFU readout chain how these fluctuations eventually influence the energy measurement of the science photons. Realistic timelines of thermal bath fluctuations at different positions in the array are generated as a result of a thermal model and the expected distribution of the deposited energy of the charged particles. These are then used to model the TES response to these thermal perturbations and their influence on the on board energy reconstruction process. Overall, we show that with adequate heat sinking, the main energy resolution degradation effect remains minimal and within the associated resolution allocation of 0.2 eV. We further study how a dedicated triggering algorithm could be put in place to flag out the rarer large thermal events.

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**Cosmic Ray Environment**

Cosmic rays present at the future X-ray Integral Field Unit (X-IFU) orbit (mostly protons) will interact with the instrument structure and induce energy depositions in:
- the X-IFU pixels creating fake X-ray events: the non X-ray background
- the detector wafer inducing heat waves perturbing the pixels signal (similar to spikes observed in Planck HFI).
- the wafer thermal response, and, in the muntin structure below the pixels.

- The X-IFU will operate an array of more than 3000 Transition Edge Sensor (TES) microcalorimeters integrated in a Si wafer. The TES themselves are deposited on a thin SiN membrane. The back of the array is etched up to the SiN membrane, forming a muntin structure. This structure is coated in gold to improve the array heatsinking to the cold bath.
- The wafer thermal response was modeled and characterized by GSFC for two heattinking configurations (see more details in Poster 128 by A. Miniussi) as a function of the CR impact position for a pixel at the center and at the edge of the array:
- The muntin structure below the TES array (partially etched Si frame, see Fig. 2) was also simulated with a finely meshed model to handle the wafer response to energy depositions in the muntins.
- The TES array deposition structure.
- Made a comparison between the energy at which the optimal trigger can detect the perturbation and the trigger limit.
- The standard X-ray trigger cannot detect these thermal events as it is optimized to pick up much faster signals.

- Studied with xisufim how a trigger on a decimated and low-pass filtered signal could make easier trigger cosmic ray events.
- Optimum window found to be at ~1 ms for the current best estimate pixel and noise level.
- Simulations show that the standard X-ray trigger cannot detect these thermal events as it is optimized to pick up much faster signals.
- Associated dead time computed to be <40%.
- Made a comparison between the energy at which the optimal trigger can detect the perturbation and the level at which such an event can create a certain energy offset.

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**Triggering Capability**

A trigger on edge pixels could remove >1 eV offsets generated by frame hits Relevant muntin hits cannot be triggered out

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**References:**