Detector Performance in the Micro-X Telescope

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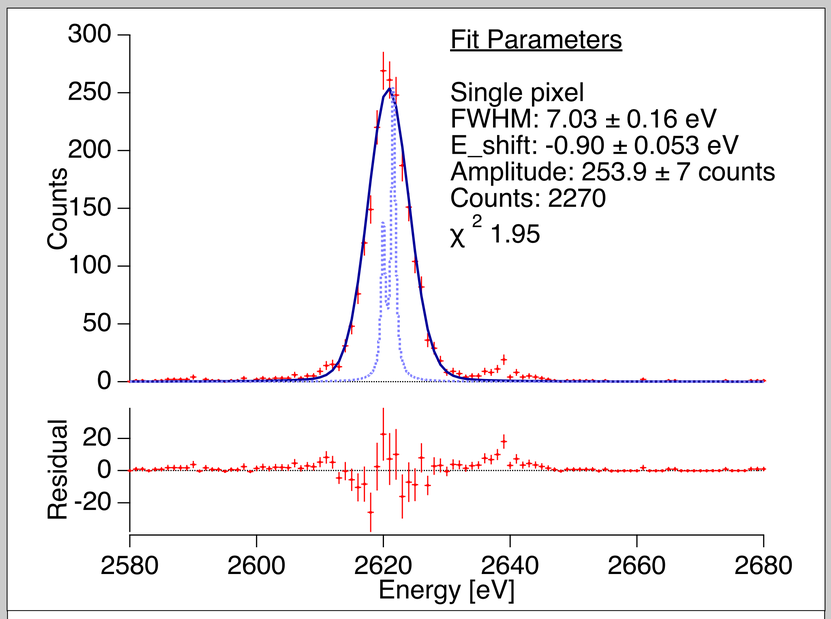
Instrument Overview

Micro-X is a sounding rocket borne telescope, that uses Transition Edge Sensor microcalorimeters to do imaging spectroscopy. It is equipped with a Wolter-I imaging optic for focusing the X-rays on the TES array. The array is read out with SQUID time-division multiplexing, which is split into two fully independent circuits for redundancy. Temperature control is achieved with an Adiabatic Demagnetization Refrigerator. The mirror can be removed for dark matter searches, see Antonia Hubbard's poster for more information.

- Apogee =299 km
- Exposure = 300 s
- 128 pixel array
- Effective area = 300 cm^2
- PSF = 2.6'
- Field of View = 11.8'
- Base temperature = 75 mK

Ground Performance

- In flight configuration, 117 pixels were operational, most failures due to wiring issues.
- In laboratory testing, over 90% of the array recorded an integrated NEP <10 eV.
- In flight configuration, only 40% of the detectors met that threshold.
- Baseline resolution of the array in a pristine environment is 4.5 eV.
- A key difference between laboratory and field testing is the operation of both halves of the science chain readout simultaneously. Using both sides leads to coherent noise that seems to arise from the independent master clocks.
- Future work will include an analysis of the complete data set to remove the coherent noise, potentially imporoving performance.



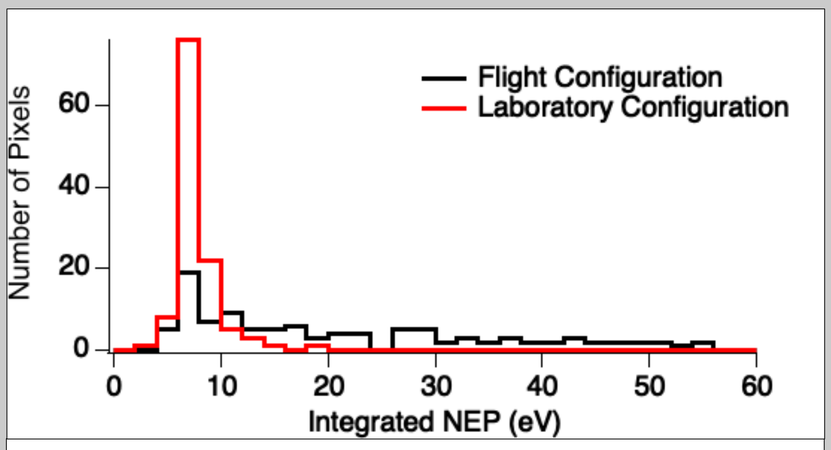
Spectrum from a single pixel in the Micro-X detector, measured while observing the internal calibration source over an extended continuous period. The instrument was in flight configuration with both sides of the readout operating.

First Flight

- First flight of Micro-X took place on July 22, 2018 from White Sands, New Mexico.
- The science objective was to observe the Cassiopeia A supernova remnant.
- An in-flight software glitch in the NASA provided ACS system led to the telescope getting no time on target.
- For the flight performance of all other systems, attend Noemie Bastidon's talk Thursday afternoon.

In-flight Resolution

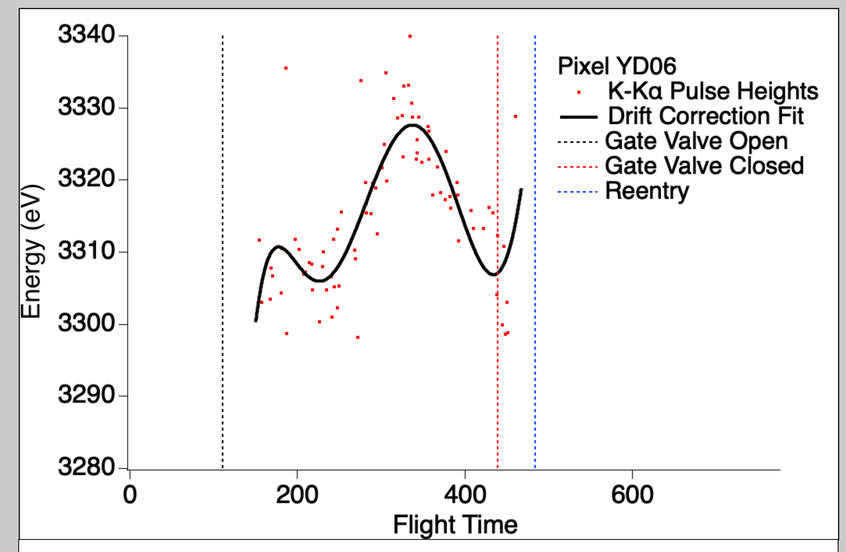
- To generate a flight spectrum, we have the observation of the internal calibration source.
- The source is fairly dim, so we coadded the spectra from all active pixels with <15 eV energy resolution.
- Gain drift with time was larger than expected, likely due to the rocket tumbling. The small number of counts limits the quality of the fit, so a brighter calibration source will be used for the next flight.



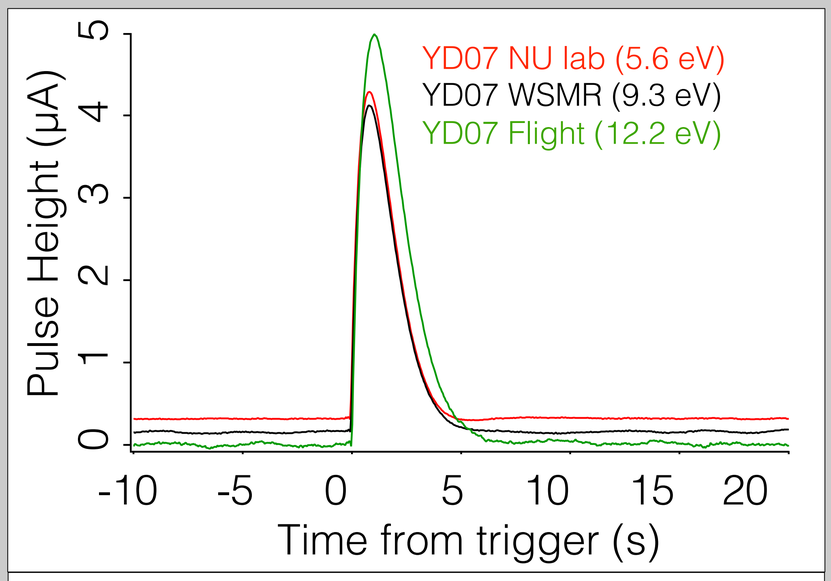
Depicted here is a histogram of the integrated NEP within the Micro-X TES array during laboratory (red) and field testing (black). The laboratory measurement was conducted in two parts, sampling each half of the array separately while the measurement from the field in flight configuration read out both sides simultaneously.

In-flight Readout

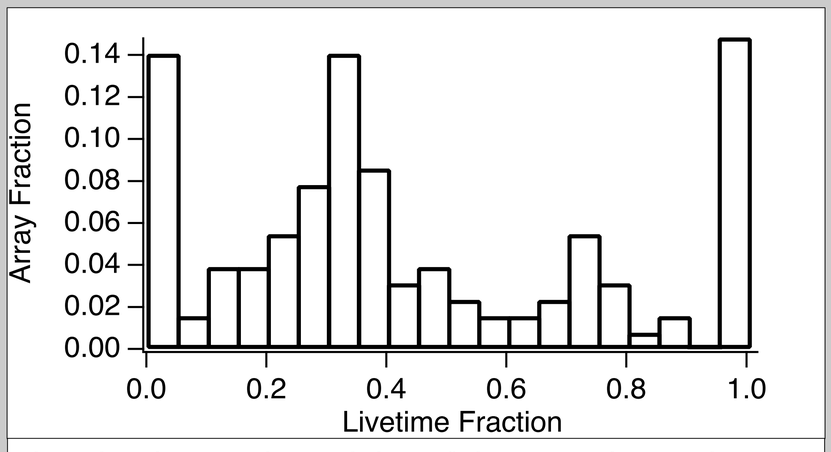
- Detector readout depends on a flux locked loop to linearize the detector gain. Many pixels within the array lost lock during flight, so the impacted detectors did not produce data during that time.
- Hypotheses for the loss of lock include varying magnetic flux from the tumbling motion of the rocket in Earth's field or RF pickup when the gate valve is open. Micro-X uses an older generation SQUID amplifier that is more susceptible to pickup.
- Laboratory testing shows that magnetic fields of this magnitude can lead to loss of lock, but it is a highly hysteretic effect so it is difficult to quantify the precise relationship.
- Only one readout column was consistently locked, so we focus on those pixels for the flight spectrum.



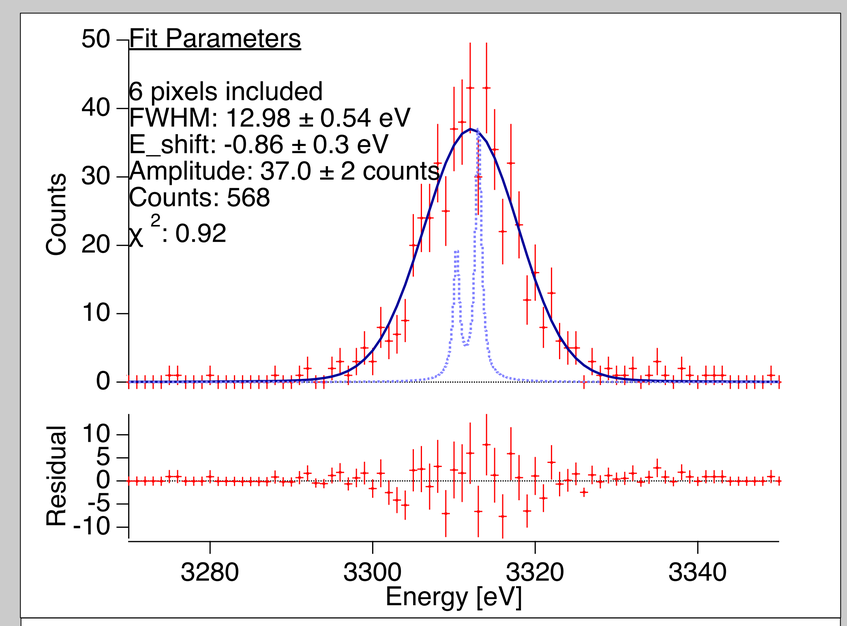
Filtered data from a single pixel during flight, prior to the correction for time varying gain, alongside the best fit curve used for drift correction.



Pulses from one Micro-X pixel, measured in the lab, during preflight testing at WSMR and during flight. Baseline oscillations from the simultaneous operation of both science chains are visible in the latter two traces.



This plot depicts the stability of the array during the science portion of the Micro-X flight. One of the eight columns was live for the entire observation and another was inactive for the entire observation, with a spread of values on other columns.



Flight spectrum from 6 coadded pixels in the Micro-X detector, measured from the internal calibration source.

Acknowledgements

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