Development of the cadmium zinc TElluride Radiation Imager (TERI)

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Abstract

The cadmium zinc TElluride Radiation Imager (TERI), is an instrument to space qualify large-volume 4×4×1.5 cm^3 pixelated CdZnTe (CZT) detector technology. The CZT's anode is composed of a 22×22 array of pixels while the cathode is planar. TERI will contain four of those crystals with each pixel having an energy range of 40 keV up to 3 MeV with a resolution of 1.3% full-width-at-half maximum at 662 keV. As the detectors are 3D position sensitive, TERI can Compton image events. TERI is fitted with a coded-aperture mask which permits imaging low energy photons in the photoelectric regime. TERI's aims to space-qualify large-volume CZT and measure its degradation in a space environment. Its secondary mission includes detecting and localizing astrophysical gamma-ray transients. TERI is manifested on DoD's STP-H10 mission which is currently undergoing environmental testing in NASA MSFC/JSC. It is slated to launch on SpaceX CRS-32 to the International Space Station in early 2025.

The cadmium zinc TElluride Radiation Imager (TERI)

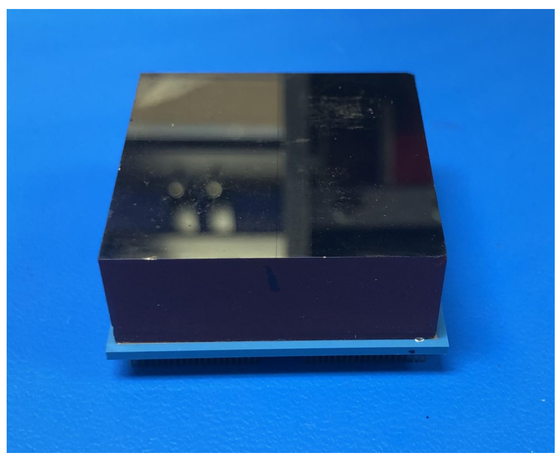

Fig. 1: A single CdZnTe crystal (1 of 4) on TERI. Its dimension is 4×4×1.5 cm^3 and has 484 anode pixels.

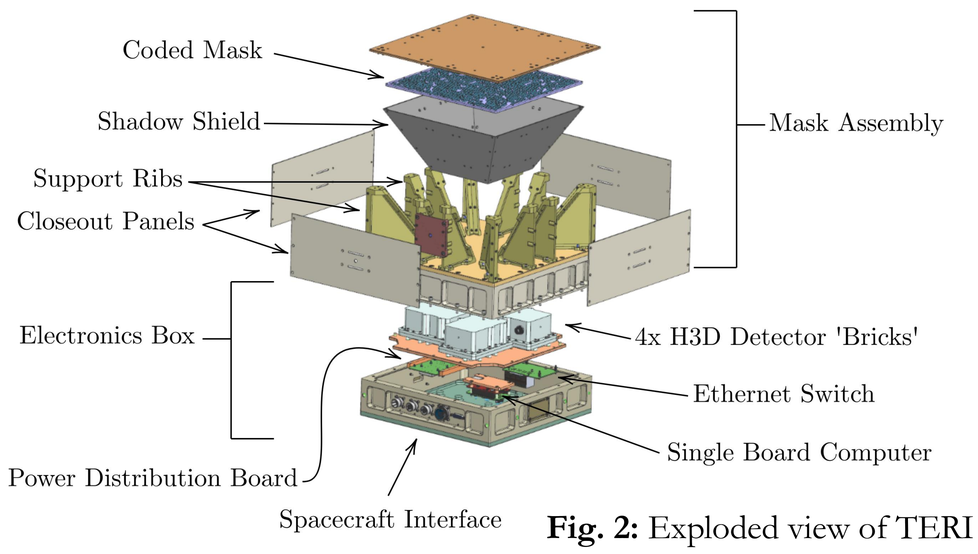

Fig. 2: Exploded view of TERI

Fig. 3: Assembled TERI with dimensions 35(L)×35(W)×31(H) cm^3

Coded-Aperture Imaging

TERI is fitted with a rank 54 pseudorandom-coded aperture mask. We chose a pseudorandom mask, rather than utilize a (M)URA type pattern, as TERI's detectors are sparsely placed. The mask is made of ~2mm tantalum square tiles, each 5.31 mm wide. The resulting coded field of view is 1.63 steradians.

Fig. 6: Optimized coded mask design.

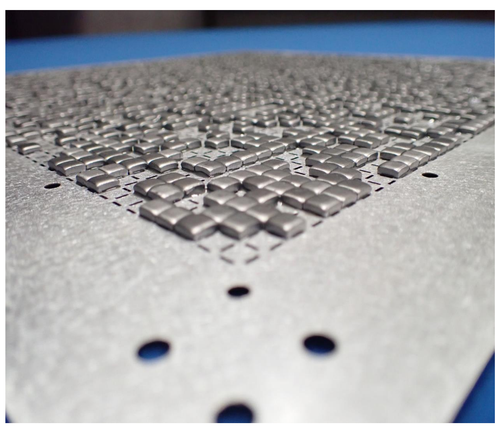

Fig. 7: TERI's Coded Mask. Each tile was hand placed and adhered.

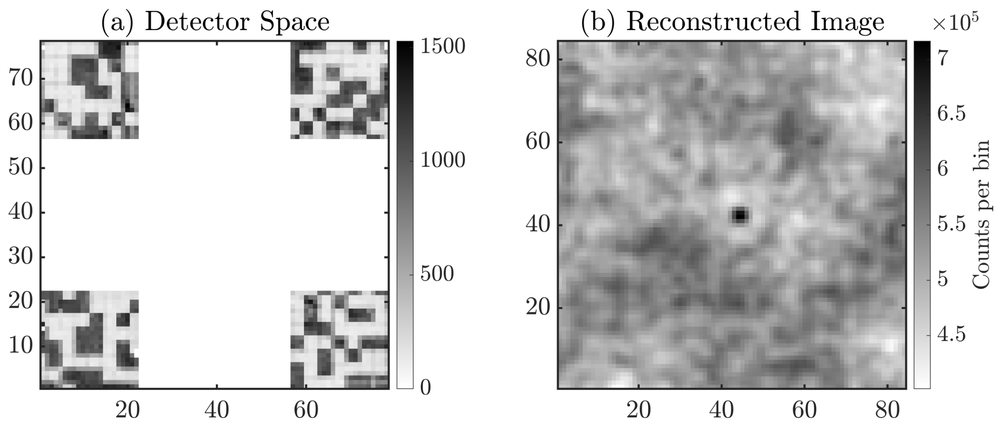

Fig. 8: (a) is the recorded pattern by the TERI detectors when a Co-57 source is placed in the central axis. (b) is the reconstructed image.

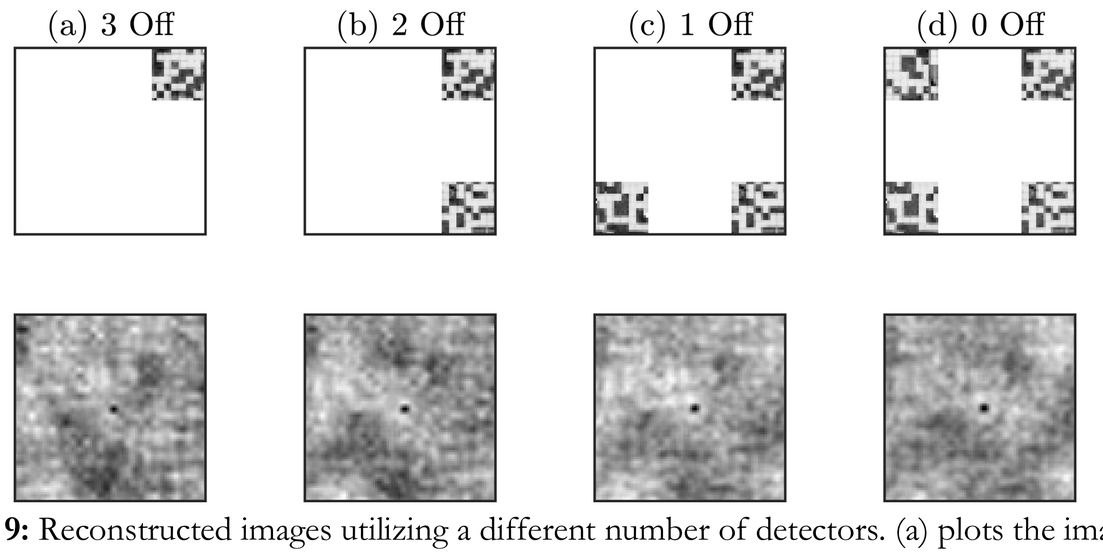

Fig. 9: Reconstructed images utilizing a different number of detectors. (a) plots the image when 3 detectors are off, (b) 2 are off, (c) 1 is off, while (d) has all detectors operational.

Spectral Performance

Each crystal receives a 3D voxel-by-voxel energy calibration that is also temperature dependent. The measured full width at half maximum (FWHM) at 662 keV is 1.3% using all events and 1.2% using single-pixel events.

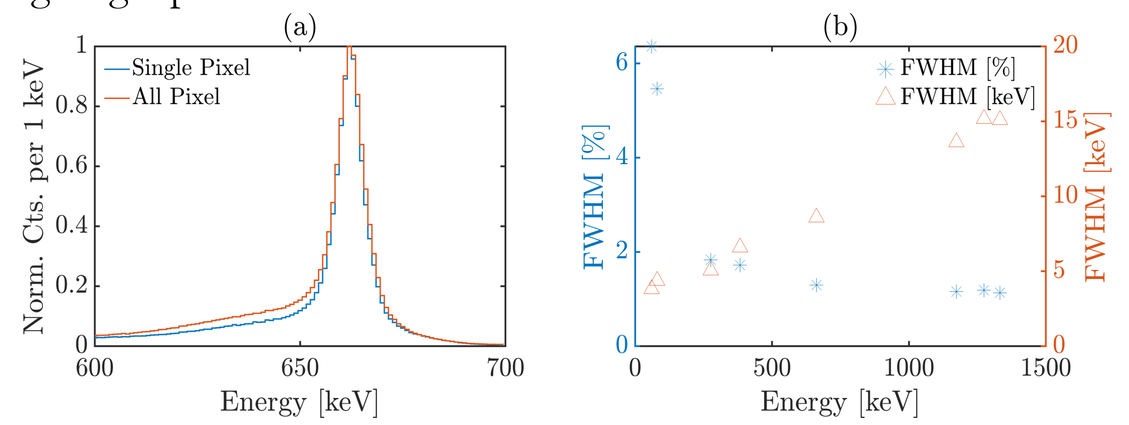

Fig. 4: (a) Cs-137 spectra demonstrating the difference in resolution between single pixel and all events. (b) FWHM as a function of energy using all events.

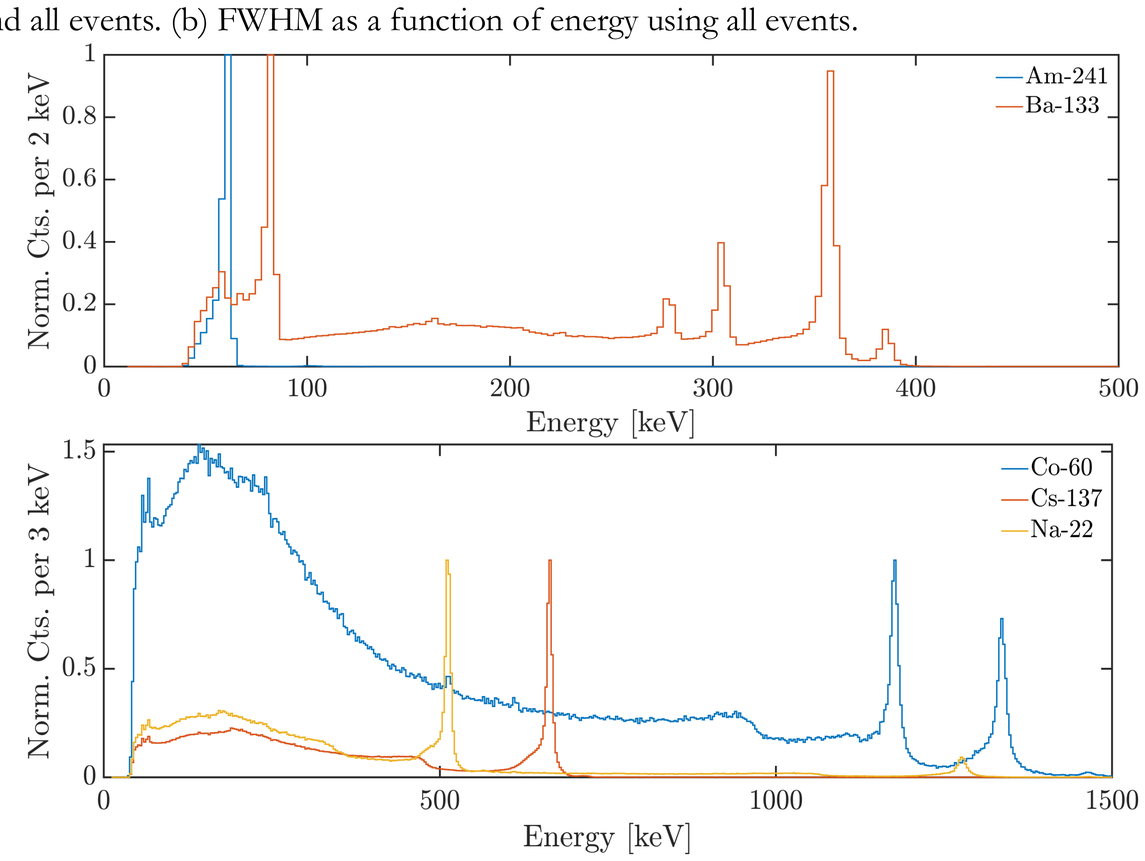

Fig. 5: (Top) Energy spectra of Am-241 and Ba-133. **(Bottom)** Energy spectra of Co-60, Cs-137, and Na-22. All pixel events are plotted.

Acknowledgements

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