CZT Imager Made Operational

The Cadmium Zinc Telluride Imager (CZTI) instrument onboard the Astrosat satelite was made operational on Oct 5, 2015, exactly one week after the launch of Astrosat. CZTI has 64 detector modules arranged in 4 quadrants (called Q1, Q2, Q3, and Q4) of 16 detectors each. Each quadrant also has a Veto detector for background reduction and an alpha detector for onboard calibration.

Temperatures: CZTI uses large area pixelated semiconductor detectors and one of the challenges was to keep them at a steady temperature in the range of 0 - 15 C. Heaters were used to keep them at above 0 C, but there was an orbital swing of 2 to 8 C. Once the instrument was switched ON, extra care was taken to keep the temperatures steady, and, as can be seen from the figure below, all four quadrants of the instrument gave a stable temperature within a degree, vindicating the elaborate thermal modelling and care taken to operate the instrument.

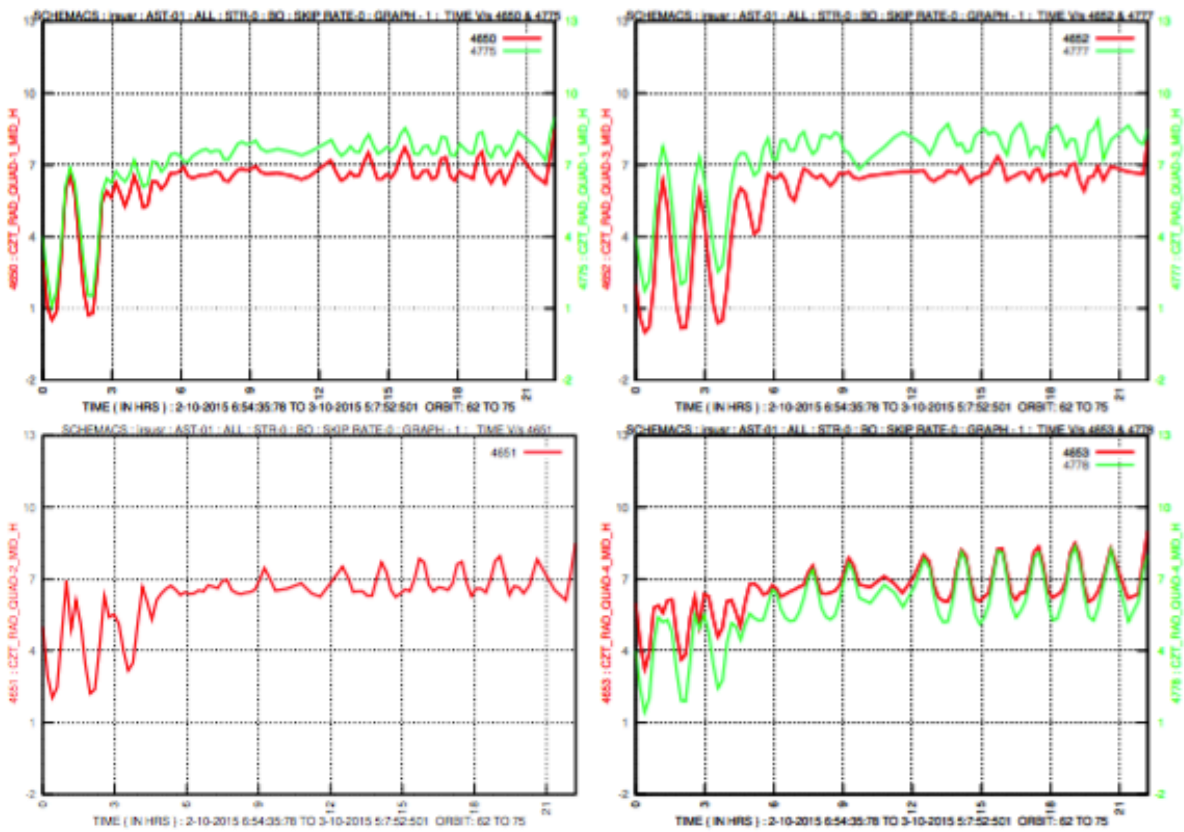

Fig 1: CZT temperatures, quadrant-wise.

Alpha, Veto and general health: The structured onboard software worked like magic, in an autonomous fashion, and one glance at the few bytes of data available in the satellite telemetry showed that the general health of the instrument is perfect. Still, to be on the cautious side, the main detectors were switched on and examined in a staggered way, detector by detector and quadrant by quadrant, critically examining the full instrument data, dumped every orbit at ISSDC, at each and every stage. The genaral behaviour of the alpha and Veto counts are found to be steady. The Veto detectors were switched off during the passage through South Atlantic Anomaly (SAA) and amusingly, the alpha detectors (designed to detect the alpha particle emitted simultaneously with the 60 keV photons from an Am-241 radioactive calibration source) also acted as a Charged Particle Monitor, showing an increase in the count rate at SAA.

CZT Detectors: Operationalising the CZT detectors was a totally different ball game. As mentioned before, CZTI has 64 detector modules, and each module has 256 individual X-ray sensors called pixels. Thus the geometric area of CZTI (~1000 cm^2) is made of 16384 individual pixels: each is an independent X-ray sensor. Depending on the manufacturing and handling care, it was noticed during the ground calibration, that a small fraction of these pixels (3 – 5%) can go `mad' giving large number of false triggers and flooding the data. About 4% of the pixels were already `disabled' before launch and one of the important tasks was to identify further `bad' pixels, understand their behaviour, disable a small fraction of them (~0.5% - about 100 pixels), and tune the thresholds. After an elaborate `circus', because these pixels have to be handled with care (***pyaar se***), a stable and steady operation of CZT detectors was achieved.

CZTI is sensitive to X-rays in the 10 – 100 keV region for spectroscopy and in the 100 – 300 keV region for polarisation and sky monitoring. In this `hard X-ray' region, such large area detectors have to battle with the background generated by the omnipresent Cosmic-ray particles. Astrosat is in a very low inclination (6 degrees) orbit, operating, most of the time, in low background region. CZTI sends data for every photon it detects: position (each pixel – 2.5 mm X 2.5 mm), time of detetion (correct to 20 micro-seconds) and energy of incident photons. These information can be used to `prune' the data: geniune X-rays from the cosmos would be truly random in time and space whereas locally produced background has some `clustering'. After `pruning' the data the count rate was found to be steady.

Data Handling: The instrument spouts out a large amount of data and one of the important tasks is to have a robust data analysis `pipe-line' to quickly understand this information and attack the science problems. This is done at the Payload Operation Centre (POC) of the CZT Imager, located at IUCAA, Pune. The POC is tasked with routine analysis of the instrument data to generate science products, monitor system health and perform calibration. A data fetch and analysis chain has been set up at the POC which started operating immediately as the first dataset from CZTI became available. After every download the data are now passing through this chain automatically and level 2 data products, including event files, are being created. The POC is geared up to generate science results including images, spectra and light curves as soon as the data from sky observations start arriving.

Sky Observations: CZTI instrument is ready to observe the Cosmos. The first source is the celebrated pulsar in the Crab Nebula and the second one is the bright black hole source Cygnus X-1. Simultaneously, *Swift* and *NuSTAR* satellites of NASA and the *Integral* satellite of ESA will observe these source(s), and radio telecopes at Ooty will measure the pulsations from Crab. Will we measure the polarisation from these sources and fix the vexed problem of geometry of the emission ? Will we be able to map the pulsar beam of Crab in multiple energies and measure its size? Will we be able to measure Quasi-periodic oscillations in the black hole source at higher energies and learn about the accretion disk and jet emission connection ? Watch this space (***aage parde pe***)
