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The front-end electronics of the Spectrometer Telescope for Imaging X-Rays (STIX) on-board the ESA Solar Orbiter satellite

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The front-end electronics design and interface to the data processing unit of the STIX X-ray spectrometer on the ESA Solar Orbiter satellite is presented. Solar Orbiter will be launched in 2017 to study sun/heliosphere interactions. STIX detects X-rays with Cadmium Telluride crystals in the energy range 4-150 keV. An ASIC (IdeF-X HD) with separate ADC is used for read-out. To achieve 1 keV FWHM resolution at 6 keV, cooling of the crystals to -20 deg C is necessary. This implies an electronics and mechanical design limiting the heat load to the cold unit.

Summary

The Spectrometer Telescope for Imaging X-rays (STIX) is the X-ray spectrometer on-board the ESA Solar Orbiter satellite (launch 2017). Solar Orbiter will study sun/heliosphere interactions with ten in-situ and remote sensing instruments from an orbit with a perihelion of 0.28 AU.

STIX will in particular detect X-rays from flaring regions of the Sun, studying the intensity, spectrum, timing, and location of accelerated energetic electrons though their non-thermal emissions. STIX will also determine the size and morphology of hot (>10 MK) thermal plasmas with a resolution of 1400 km at 0.28 AU. Due to very low backgrounds, STIX is sensitive to small flares, and thus potentially can aid in understanding the coronal heating mechanism.

STIX uses a Fourier-imaging technique. 32 pairs of Tungsten grids, separated in an imaging tube by 55 cm, cast a Moiree pattern of X-rays onto coarsly pixelized Cadmium Telluride (CdTe) crystals. Sampling the pattern allows reconstruction of a particular Fourier component, in turn allowing reconstruction of the Solar image.

The CdTe crystals are 1 mm thick to cover the energy range from 4 to 150 keV, which includes both thermal and non-thermal components of the X-ray spectrum. The crystal area of 10x10 mm2 is subdivided into 8 large and 4 small pixels.

The steep thermal spectrum at lower energies requires an energy resolution of 1 keV FWHM. A low-noise, low-power space-qualified ASIC (IdeF-X HD) is used for signal amplification, triggering and multiplexed analog read-out.

The sensor leakage current must be below 60 pA per pixel to achieve the resolution goal, requiring cooling of the sensors to -20 deg C. A spacecraft provided radiator to deep space, thermally connected to the detector front-end, allows this within the warm internal environment of Solar Orbiter (up to +50 deg C at perihelion). The heat load to the radiator has to be strictly limited as it influences its size, and thus the electronics is designed with only a minimum number of components mounted on the cooled front-end. All others components are placed in thermal contact with the warm environment where the heat load is less restricted. Unavoidable connections between warm and cold parts need about 200 wires that are thin (AWG36) and long (50 cm) to limit the thermal bridge.

The 32 detectors will independently sample with a rate of about 30000 counts per second. Clocks of the ASIC and of the ADC need to run in the range of 20 MHz, thus differential transmission is used for all fast signals.

All digital read-out and control is performed by the Instrument Data Processing Unit, located in the warm part of STIX. The IDPU interfaces to the spacecraft systems. The power supplies are located in the same compartment as the IDPU.

The STIX electronics will be subject to a total ionizing dose of about 30 krad(Si) over the 10 year mission.

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