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X-ray performance of a large-format soft X-ray optimised charge-coupled device for astronomy

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For the upcoming European Space agency SMILE mission, launching in 2025, large-format soft X-ray optimised CCDs have been manufactured by Teledyne e2v, named the CCD370. The CCDs are approximately 8 cm x 8 cm, and are comprised of 4510 × 4510 18 μm pitch pixels, with a store shield covering approximately 6/7s of the active imaging area to facilitate frame-transfer operation mode. To optimise quantum efficiency within the soft X-ray energy band, the device is 16 μm thick, back illuminated, and has an additional back surface passivation process. The focal plane of the soft X-ray imager on the SMILE spacecraft will be comprised of 2 CCD370s, operating in a frame-transfer readout mode with 6x6 on-chip binning to mitigate against CTI-induced charge transfer losses and charge spreading throughout the 3-year mission lifetime.

As part of the pre-flight testing and calibration, a CCD370 was characterised at the PTB beamline at the BESSY 2 synchrotron in Berlin, and key metrics such as quantum efficiency and energy resolution in the 0.2 –1.9 keV energy band were assessed. The quantum efficiency measurements show expected performance, within specification for the instrument, and also match a transmission-layer QE model. The energy resolution shows near fano-limited performance, which is similar to the current generation of X-ray telescopes such as XMM-Newton, Chandra, and SWIFT XRT. Although competing technologies such as DEPFETs and sCMOS now have similar performance to CCDs, the performance shown here can still easily satisfy requirements for novel scientific instruments, and can still be useful in future astronomy missions given the rich heritage, high technology-readiness-level, and maturity of the technology.

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