

Soft X-ray Imaging at up to 4.5 Mega-frames/s with the DSSC Camera: MiniSDD and Ultra-Low Noise DEPFET Sensors

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The DSSC camera system was developed for soft X-ray photon science applications in the 0.25–6 keV energy range at the European XFEL in Germany. Two sensor implementations are available: a 1-megapixel camera with MiniSDD sensors, delivered in 2019, and a recently completed version equipped with DEPFET active pixels. The first DSSC camera, based on MiniSDD pixels, has been successfully used for scientific experiments at two instruments. It is composed of 1024×1024 silicon pixels, with 256 ASICs enabling full parallel readout, including analog filtering, digitization, and data storage. The system achieves a peak frame rate of 4.5 MHz. It delivers noise levels of ~ 60 electrons rms. at 4.5 MHz and 40 electrons at 2.25 MHz, though its linear response limits the dynamic range. To achieve both high dynamic range ($\sim 10^4$ photons/pixel/pulse) and single-photon sensitivity, the second version employs DEPFET active pixels, which provide a calibrated non-linear response at the sensor level and enable ultra-low noise soft X-ray imaging. The readout ASICs and camera-head electronics are compatible with both types of sensors. We will present the system architecture, key features, and beamline results from both versions. Several user experiments have been conducted with the MiniSDD camera, demonstrating its versatility under diverse experimental constraints. A highlight is the first single-shot acquisition of a diffraction pattern from a photoactive protein at 2.5 keV and 2.2 MHz. We will also present the first complete experimental characterization of the DEPFET camera, performed with a pulsed lab X-ray source and during two dedicated beamtimes at the European XFEL. Single 1.48 keV photons were resolved with $S/N > 50$ at 1.125 MHz. Average noise was $\sim 7 e^-$ rms, with best sensors reaching $\sim 4 e^-$, and a dynamic range one order of magnitude higher than the MiniSDD camera was achieved.

Author: Prof. PORRO, Matteo (European XFEL GmbH - Ca' Foscari, University of Venice)

Presenter: Prof. PORRO, Matteo (European XFEL GmbH - Ca' Foscari, University of Venice)

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