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The DSSC soft X-ray Detectors with Mega-frame Readout Capability for the European XFEL

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The DSSC camera [1] was developed for photon science applications in the energy range 0.25-6 keV at the European XFEL in Germany. The first 1-Megapixel DSSC camera is available and is successfully used for scientific experiments at the "Spectroscopy and Coherent Scattering"and the "Small Quantum System"instruments. The detector is currently the fastest existing 2D camera for soft X-rays.
The camera is based on Si-sensors and is composed of 1024×1024 pixels. 256 ASICs provide full parallel readout, comprising analog filtering, digitization and data storage. In order to cope with the demanding X-ray pulse time structure of the European XFEL, the DSSC provides a peak frame rate of 4.5MHz. The first megapixel camera is equipped with Miniaturized Silicon Drift Detector (MiniSDD) pixels. The intrinsic response of the pixels and the linear readout limit the dynamic range but allow one to achieve noise values of ˜60 electrons r.m.s. at 4.5MHz frame rate.
The challenge of providing high-dynamic range (˜10⁴ photons/pixel/pulse) and single photon detection simultaneously requires a non-linear system, which will be obtained with the DEPFET active pixels foreseen for the advanced version of the camera. This technology provides lower noise and a non-linear response at the sensor level. The readout ASICs and the camera-head electronics are compatible with both type of sensors. We will present the architecture of the whole detector system with its key features, focusing on the sensors and the integrated electronics. We will summarize the main experimental results obtained with the MiniSDD-based camera and give a short overview of the performed user experiments. We will present for the first time the experimental results with complete sub-modules of the DEPFET camera which is in the final stages of assembly. Measurements obtained with full size sensors and the complete readout electronics have shown an unprecedented mean noise of ˜10 el. rms with 1.1 MHz frame rate and ˜20 el. rms with 2.25 MHz frame rate. The obtained dynamic range is more than one order of magnitude higher with respect to the MiniSDD camera.

[1] M. Porro et al., IEEE TNS , vol. 68, no. 6, pp. 1334-1350, June 2021, doi: 10.1109/TNS.2021.3076602
[2] S. Aschauer, et al. Journal of Instrumentation, Volume 12, November 2017

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