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Calibration of the DSSC Camera at the European XFEL

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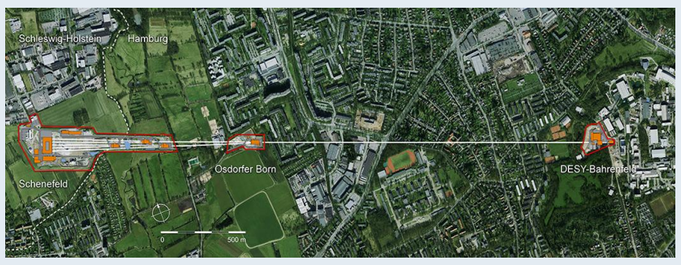
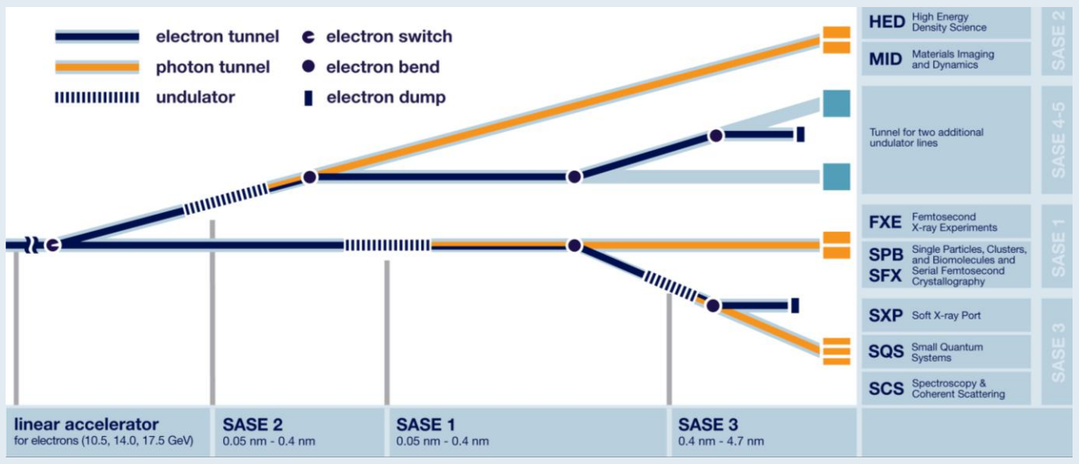
Abstract

The DSSC (DEPFET Sensor with Signal Compression) is a large-area, ultra-fast soft X-ray detector developed for the European X-ray Free Electron Laser. Assembly of a full 1-megapixel DSSC camera is ongoing, with calibration performed in parallel. Using a laboratory X-ray source, the low-intensity linear response of the detector has been assessed. The results show uniform gain and low noise performance across all tested configurations.

European XFEL[1]

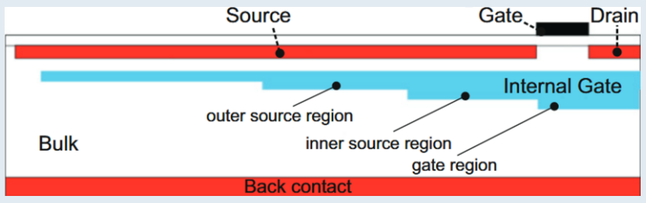
- X-ray Free Electron Laser,
- Pulsed beam up to 4.5 MHz,
- Photon energy 0.25 – 25 keV,
- 7 beamlines/instruments,
- Varied user experiments,
- Various detector technologies.

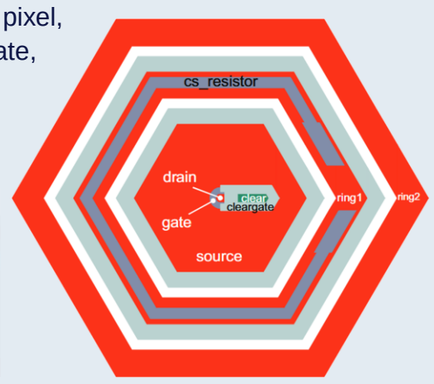




DSSC: DEPFET Sensor with Signal Compression[2]

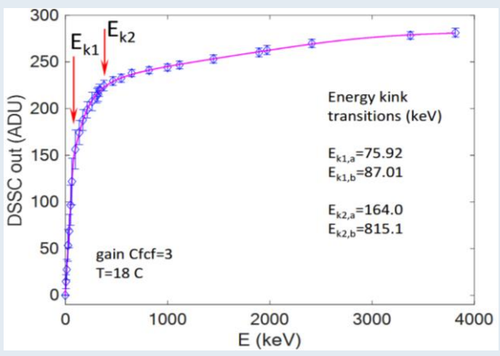
- Depleted p-channel field effect transistor (DEPFET) pixel,
- Signal compression via extended, graded internal gate,
- Hexagonal pixels, 219 µm square equivalent pitch,
- 725 µm thick, fully depleted bulk silicon,
- Sensitive to 0.25 – 6 keV (soft X-rays).





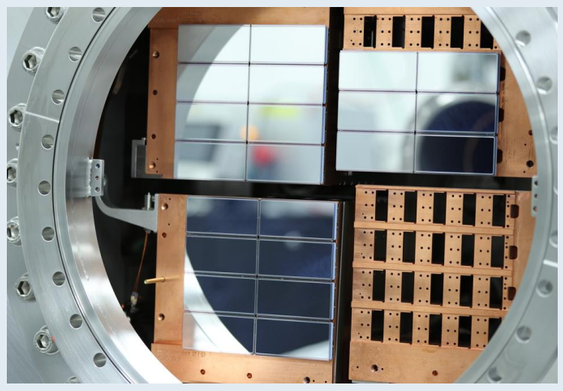
Previous studies[3][4] using a single DSSC module (512 x 128 pixels) confirmed:

- Fast frame rate (up to 4.5 MHz),
- Low noise (<10 e^-),
- High dynamic range (~10^4),
- Non-linear photo-response.



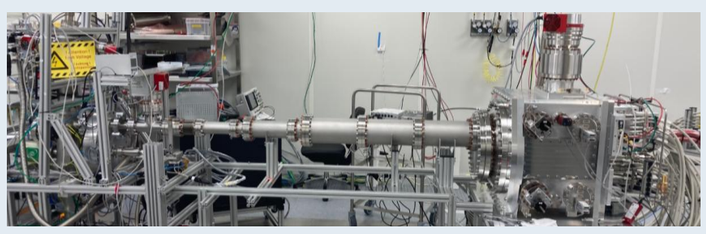
1M (1024 x 1024, 4 x 8 modules) camera:

- Assembly ongoing,
- Integration ongoing,
- Calibration ongoing.



PulXar

- Pulsed electron gun,
- Target X-ray fluorescence,
- Bremsstrahlung filter,
- Mimics EuXFEL beamline,
- Lower intensity.



Method

PulXar:

- Operated at 25 kV,
- Cu (8047 eV K_α) fluorescence target,
- Al (50 µm) bremsstrahlung filter.

Exp.	Freq. [MHz]	T_{int} [ns]	Nominal Gain* [eV/ADU]
1	2.2	50	525.0
2	2.2	100	105.0†
3	2.2	100	105.0†
4	2.2	100	105.0†
5	2.2	100	262.5
6	2.2	100	514.5

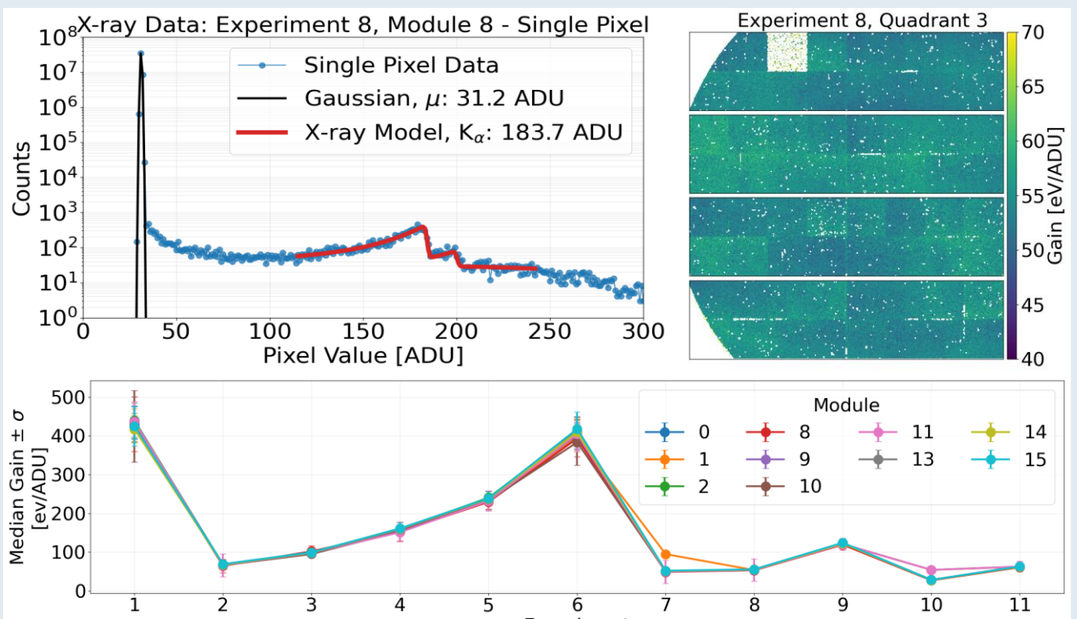
DSSC:

- Partially assembled,
- Operated at 15 °C,
- Varying frequency, integration time, gain.

Exp.	Freq. [MHz]	T_{int} [ns]	Nominal Gain* [eV/ADU]
7	2.2	100	52.5
8	1.1	250	63.0
9	1.1	250	142.8
10	1.1	250	31.5
11	1.1	250	74.1

*Irmp = 21 †RmpFineTrm: 5/21/52

Results



Summary / Outlook

- DSSC assembly ongoing,
- Linear regime calibration methods proven,
- Uniform gain and low noise.
- Non-linear regime calibration,
- 1M DSSC integration and calibration,
- User operation.

References

[1] XFEL GmbH, The European XFEL, http://www.xfel.eu/. (June 2026)
[2] M. Porro, et al., NIM-A, 624, doi:10.1016/j.nima.2010.02.254. (2010)
[3] S. Maffessanti, et al., Sci Rep, 13, doi:10.1038/s41598-023-38508-9. (2023)
[4] A. Castoldi, et al., IEEE NSS/MIC, doi:10.1016/j.nima.2023.168686. (2022)

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