Probing the Time-Resolving Capabilities of XIDer Assemblies with CdTe and CZT sensors

M. Williams[1], P. Busca[1], M. Collonge[1,2], P. Fajardo[1], P. Fischer[2], T. Martin[1], M. Ritzert[2], M. Ruat[1], and D. Schimansky[2]

1 European Synchrotron Radiation Facility. 2 Heidelberg University.

Corresponding author: morag-jean.williams@esrf.fr

Through the upgrade to a 4th-generation storage ring, the **Extremely Brilliant Source** (EBS), the X-ray beam at the European Synchrotron (ESRF) is x100 more brilliant, has a x40 coherent fraction, and can reach photon energies of ≤100keV.

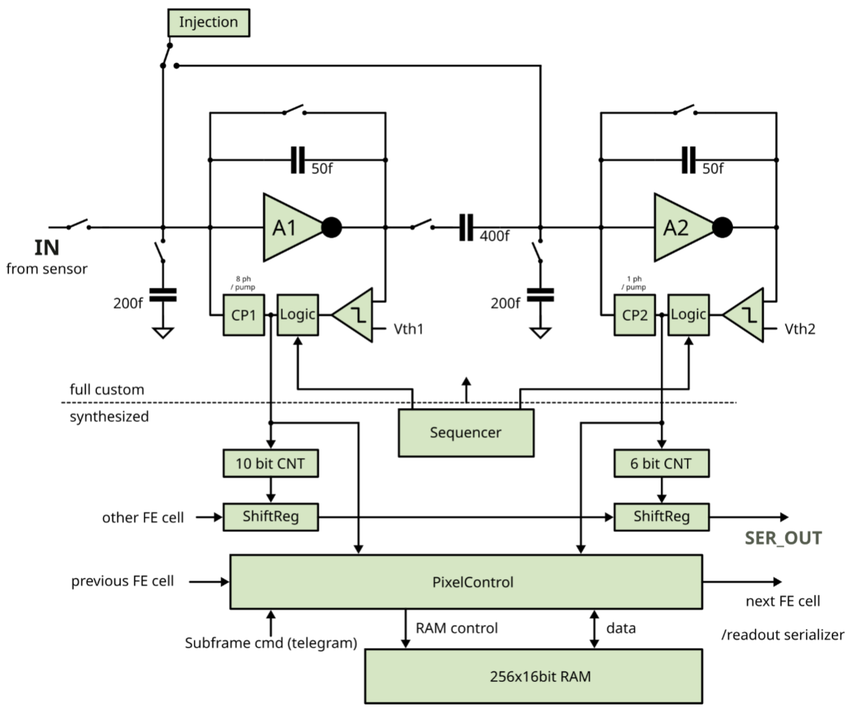
The **XIDer** R&D project between the ESRF and Heidelberg University is developing 2D pixelated detectors for **time-resolved scattering and diffraction experiments** for EBS beam-lines focusing on, for example, material properties under dynamic pressure, monitoring chemical processes in 4D, and protein folding. These new research opportunities opened by the EBS require state-of-the-art detectors.

1. XIDer architecture

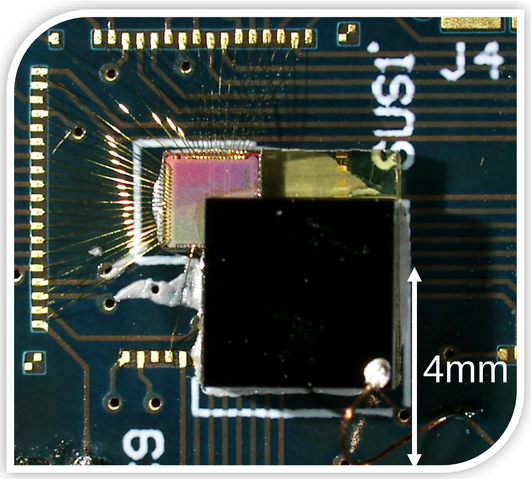
- Novel on-chip **incremental digital integration** readout is implemented with per-pixel digital data output per subframe.
- **Two-stage** pipelined ADC: In each stage, while amplified signal > threshold, a packet of charge is removed

Stage 1: 8ph packet size

Stage 2: 1ph packet size



2. Prototypes

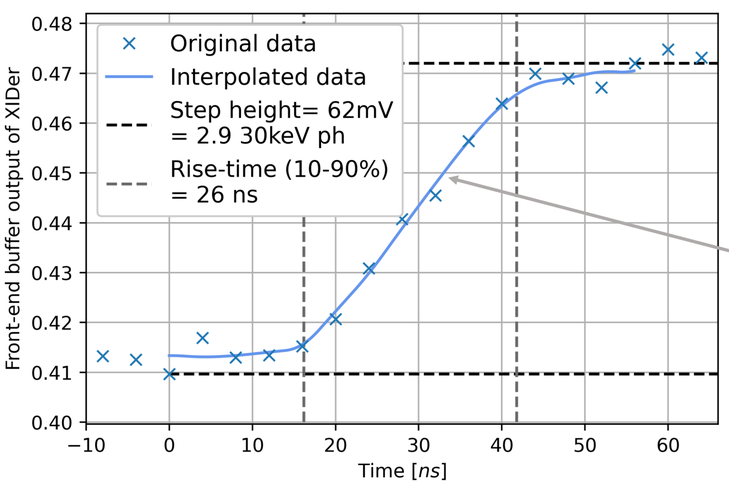


- **Sensor:** CdTe-Ohmic (Acrorad) or CZT (Due2Lab & Redlen)
- **Pixels:** 4x4 matrices of 100 or 200µm pitch
- **ASIC**: TSMC CMOS 65nm technology (version T4)
- **Interconnection:** by Polymer Assembly Technology
- **Readout:** PETA system from Heidelberg University

3. Proof-of-principle single-bunch isolation

X-ray measurements performed at BM05, ESRF as **proof-of-principle** bunch isolation measurements using CdTe-O sensors: **front-end buffer output** analysis using an oscilloscope.

36µs (σ=7.2ns) av. rise-time, negligibly effected by the use of a buffered output.



Isolated bunch example of 30keV photon X-ray beam

Charge-pump disabled to see voltage step due to incident photons

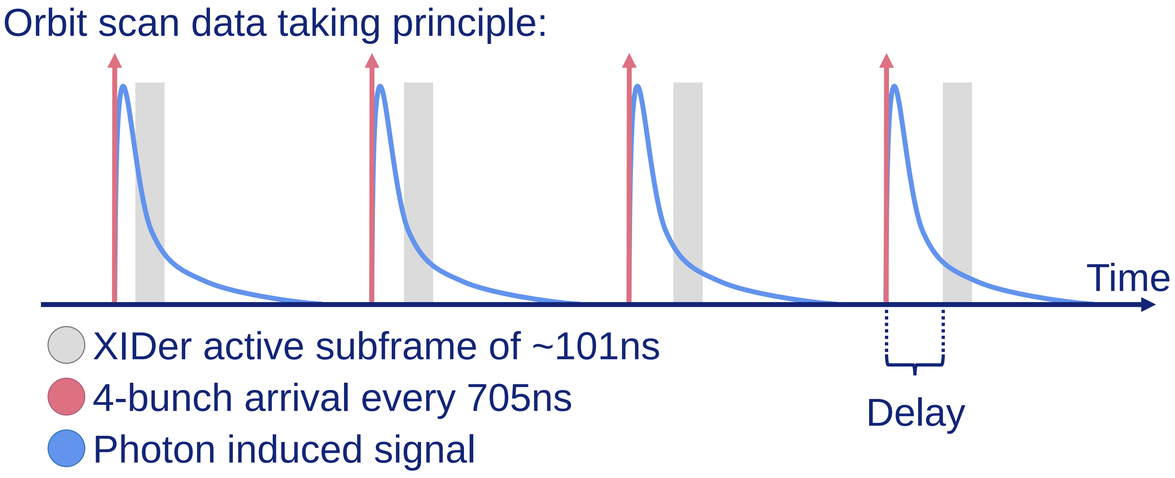
A 30keV 4-bunch X-ray beam, attenuated to 1-4ph pix^{-1} subframe^{-1}

This work is part of the ESRF EBS Upgrade Programme. The authors thank P. Cook and the scientists of BM05 at the ESRF for their assistance, S. Zanettini and their colleagues at Due2Lab for supplying the CZT sensors, and J. Clayton from Polymer Assembly Technology for bump-bonding the assemblies used in this study.

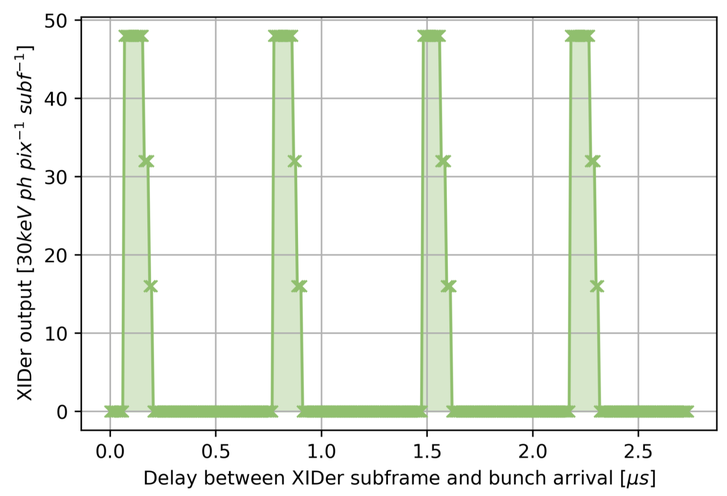
4. Time-synchronous orbit scan measurements

X-ray measurements performed at BM05, ESRF with XIDer subframes **time-synchronous to the bunch arrival**. By changing the **delay** between the bunch arrival signal and the subframe start, different portions of photon-induced signal from the sensor can be probed.

Orbit scan data taking principle:



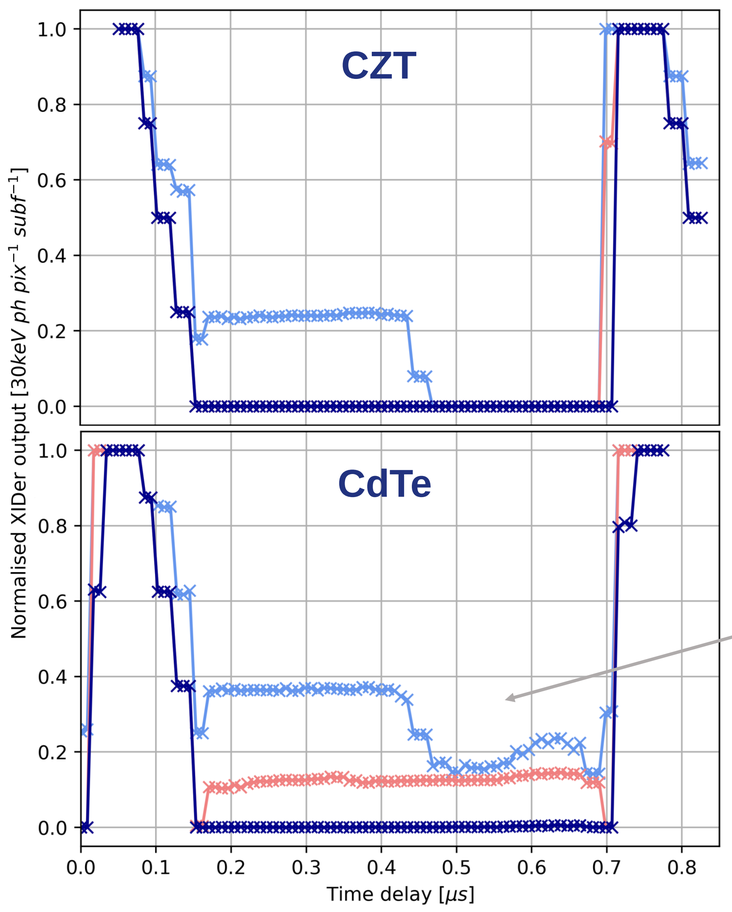
Data taking: 30keV 4-bunch X-ray beam incident on XIDer assembly, attenuated to different fluxes using planar Al filters.



Example of 4-bunch full orbit scan using CdTe-O assembly

Flux of 76.1 30keV Mph mm^{-2} s^{-1}.

Mean inter-bunch time: **707**ns +/- **4**ns.



CZT and CdTe-O inter-bunch comparison

Fluxes for datasets: [30keV Gph mm^{-2} s^{-1}]

	CZT	CdTe
●	42.4	39.5
●	20.9	19.0
●	10.8	10.0

Significantly higher signal recorded between bunches for CdTe sensor compared to CZT.

5. Conclusion

- Time-resolving capabilities of XIDer tested with readout-beam synchronisation using 4-bunch EBS beam of 30keV photons
- Assemblies with CZT and CdTe-O sensors compared using XIDer-bunch orbit scan, showing higher inter-bunch signal for an assembly with a CdTe sensor compared to CZT.