The PERCIVAL soft X-ray detector.

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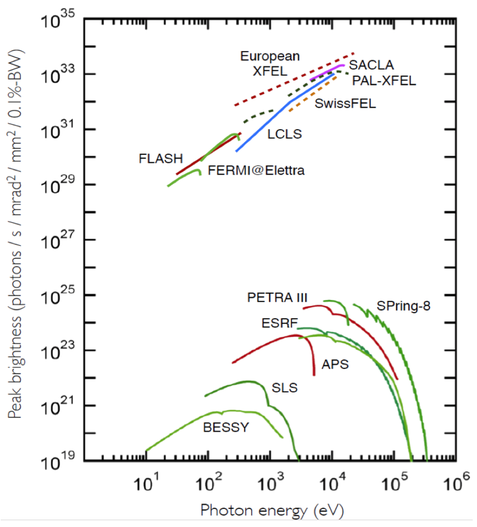
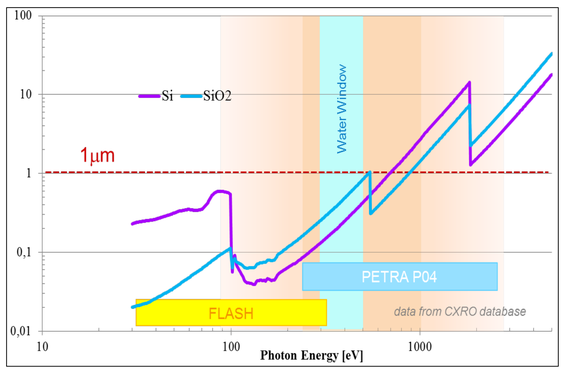
Motivations and Goals



Brilliance of photon sources increases and thus detectors are required to simultaneously provide:
- **high dynamic range**
- **single-photon discrimination**

Attenuation Length of Photons in Si and SiO_2



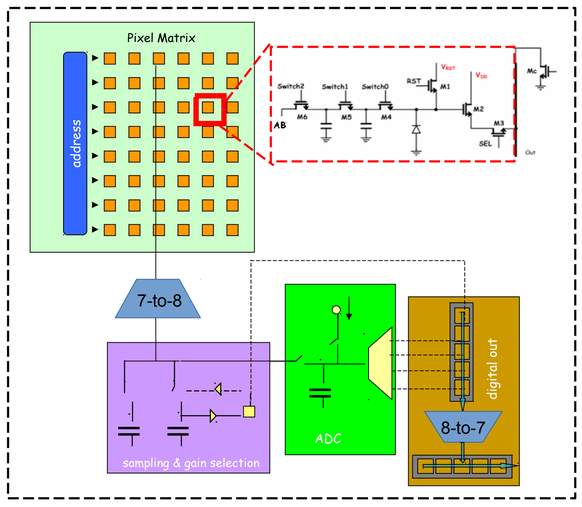
Detecting photons in the water window is challenging due to the sub-µm absorption lengths for Si and SiO_2.
The Entrance window needs to be minimised while ensuring a **suitable field geometry near the surface**.

New detectors needed!

PERCIVAL: a collaboration between DESY, STFC, ELETTRA, DLS and PAL.

- Primary energy range: < 250 eV to 1 keV
- Single photon sensitivity
- High dynamic range
- 100 % fill factor (back-thinned, thinned passivation layer for optimal backside-illumination)
- Multi-Megapixel, small pixels(10s µm)
- High and uniform QE

Monolithic Active Sensor CMOS



Lateral Overflow and Parallelisation

The pixel is based on a 3T structure enhanced with a series of switches and capacitors connected in parallel. Embedded lateral overflow circuitry increases the capacity of each individual pixel on a frame-to-frame basis, adapting to the photon flux.

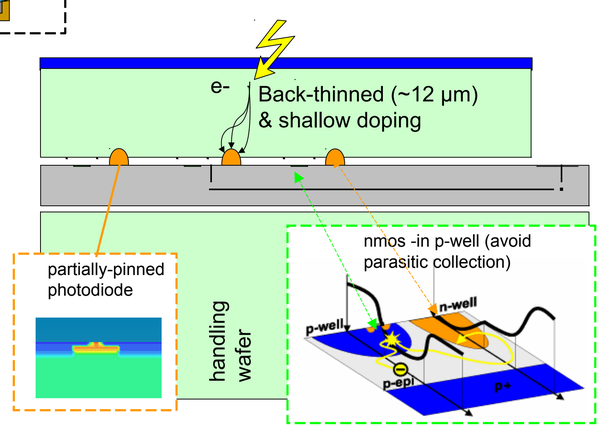
Each column is equipped with 7 (+1) ADCs consisting of three stages: coarse, fine and gain with a total of 12 + 2 (+1) = 15 bits to be read out per pixel.

Correlated Double/Multiple Sampling (CDS/CMS) is performed to reduce the noise.

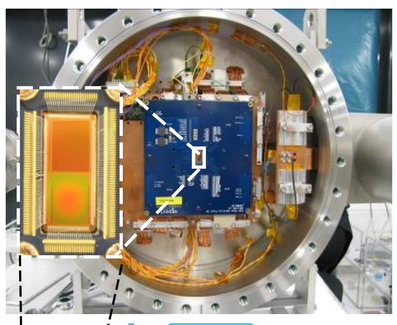
Wafer Post-Processing

Different wafer post-process options have been investigated:

- **δ-doping** implemented by JPL/NASA consists of Low Temperature Molecular Beam Epitaxy to bring the window entrance thickness to few nm
- Alternatively, a combination of **shallow doping and laser annealing** made by IBS/EMFT could reach ~ 20-30 nm thickness

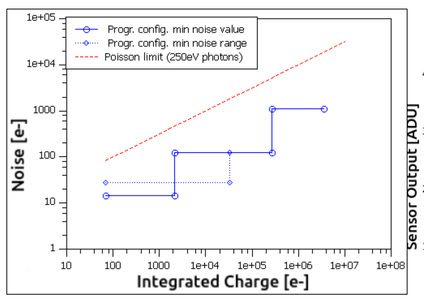


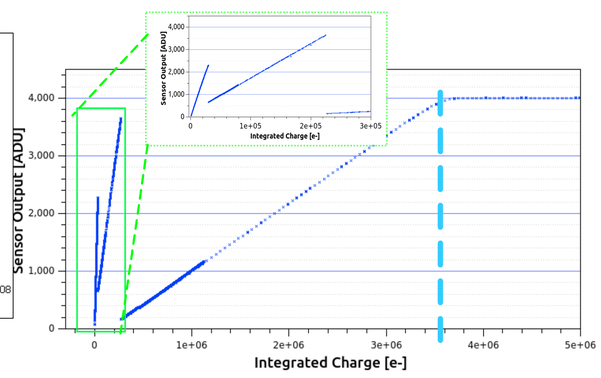
Prototype Characterisation

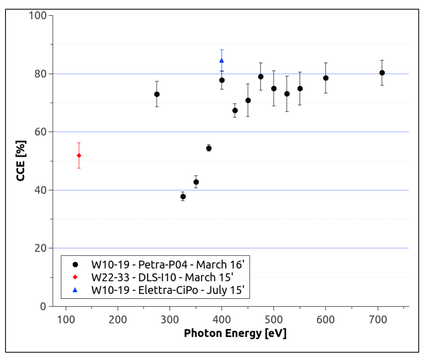


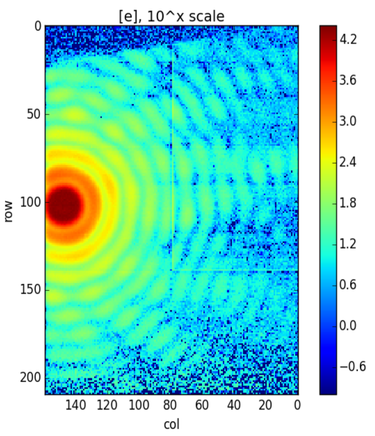
Prototype chip on a similar scale

scaling up from prototype to full P2M



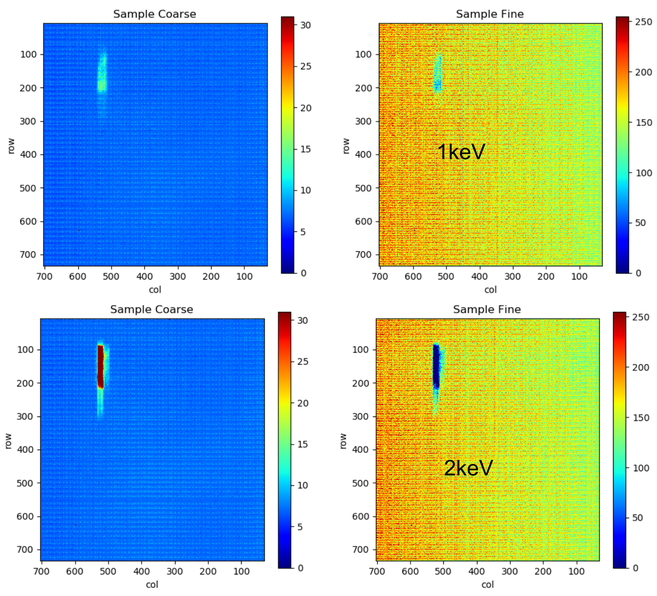


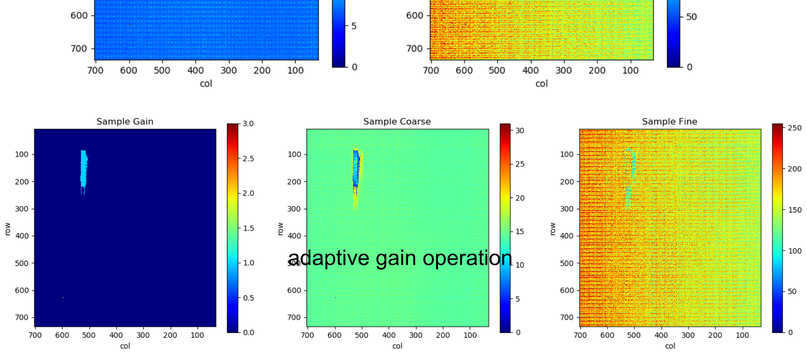


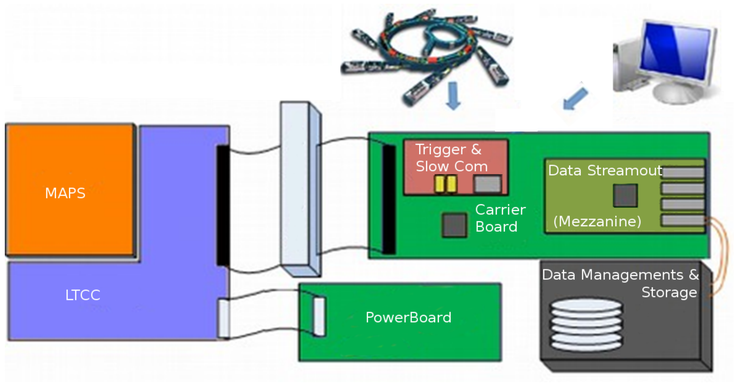


Full P2M System, under test

- 2 Megapixels (~ 4x4 cm² imaging area, layout stitching)
- 27 µm pixel pitch
- Auto-adaptive gain to incoming flux, per pixel, real time
- 2-side buttable: cloverleaf arrangement of 4 modules possible

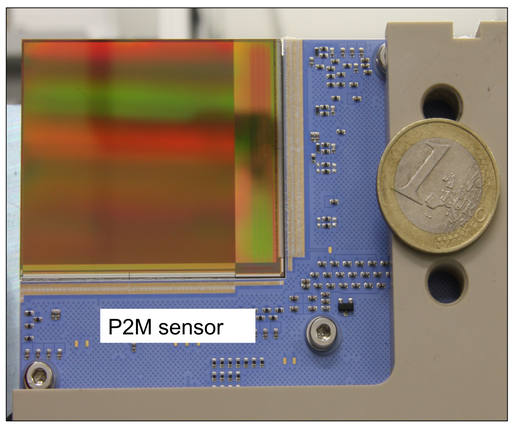


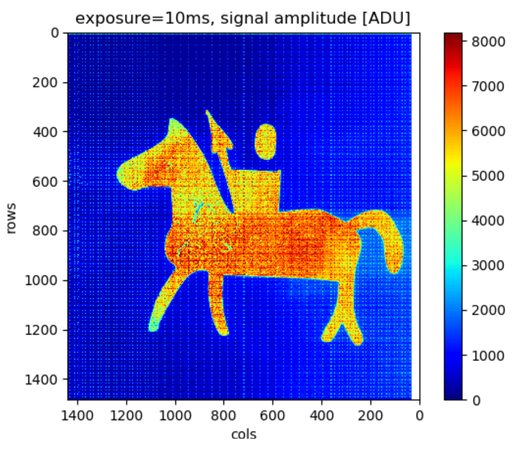




- Carrier board (re-configurable clocks & control)
- PowerBoard (bias & monitoring)
- Mezzanine board (stream-out data // 10Gb ports)

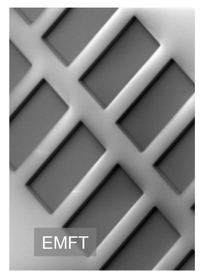
20Gb/s data out, (or x4 if cloverleaf):
- DAQ interface (deep switch & multiple DELL R630)
- VirtualHDF5 dataset data organisation (presenting data as a simplified array to the user)
- Calibration procedure (tested in prototype)
- Data elaboration Framework (under developement)



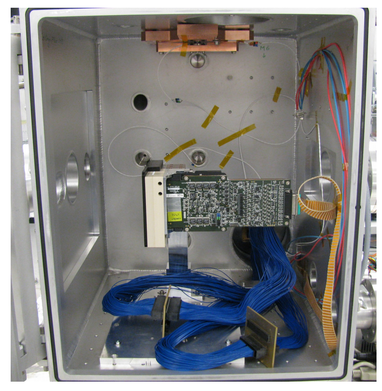


1st image acquired on P2M sensor (visible light, 660 nm, FSI)

P04 beamline (Petra III), end of 2018:
First tender X-ray images (1-2keV, FSI sensor)
Many thanks to P04 staff for the support:
Frank Scholz, Kai Bagschik and Moritz Hoesch



First BSI wafer processed
First soft X-ray image (BSI sensor)
expected early~mid-2019



HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

a) DESY b) c) Elettra Sincrotrone Trieste d) e) PAL f) CFEL SCIENCE g) SOLEIL SYNCHROTRON h) i) Mittuniversitetet MID SWEDEN UNIVERSITY

DESY