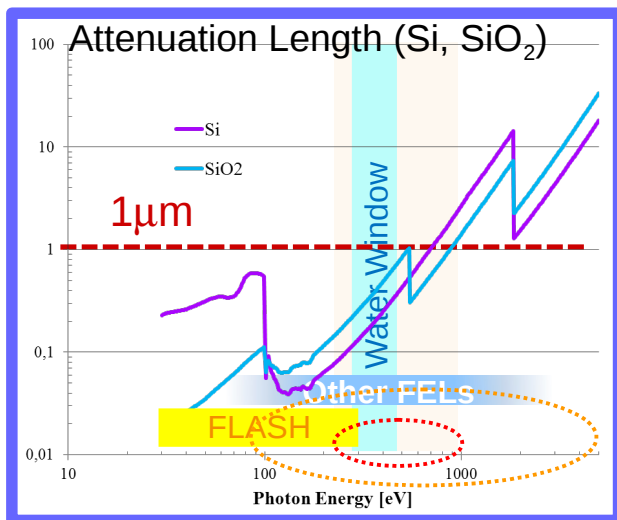
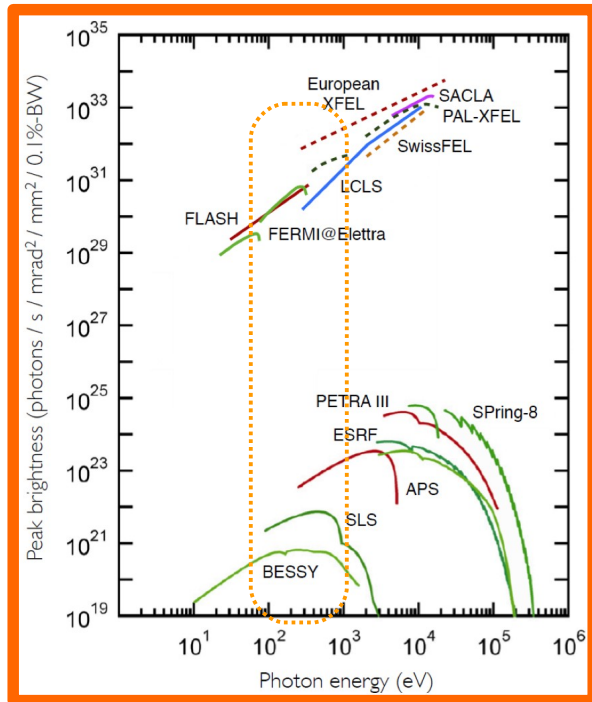


Percival: a Soft X-Ray Imager for Synchrotron Rings and Free Electron Lasers

Alessandro Marras

on behalf of the Percival Collaboration

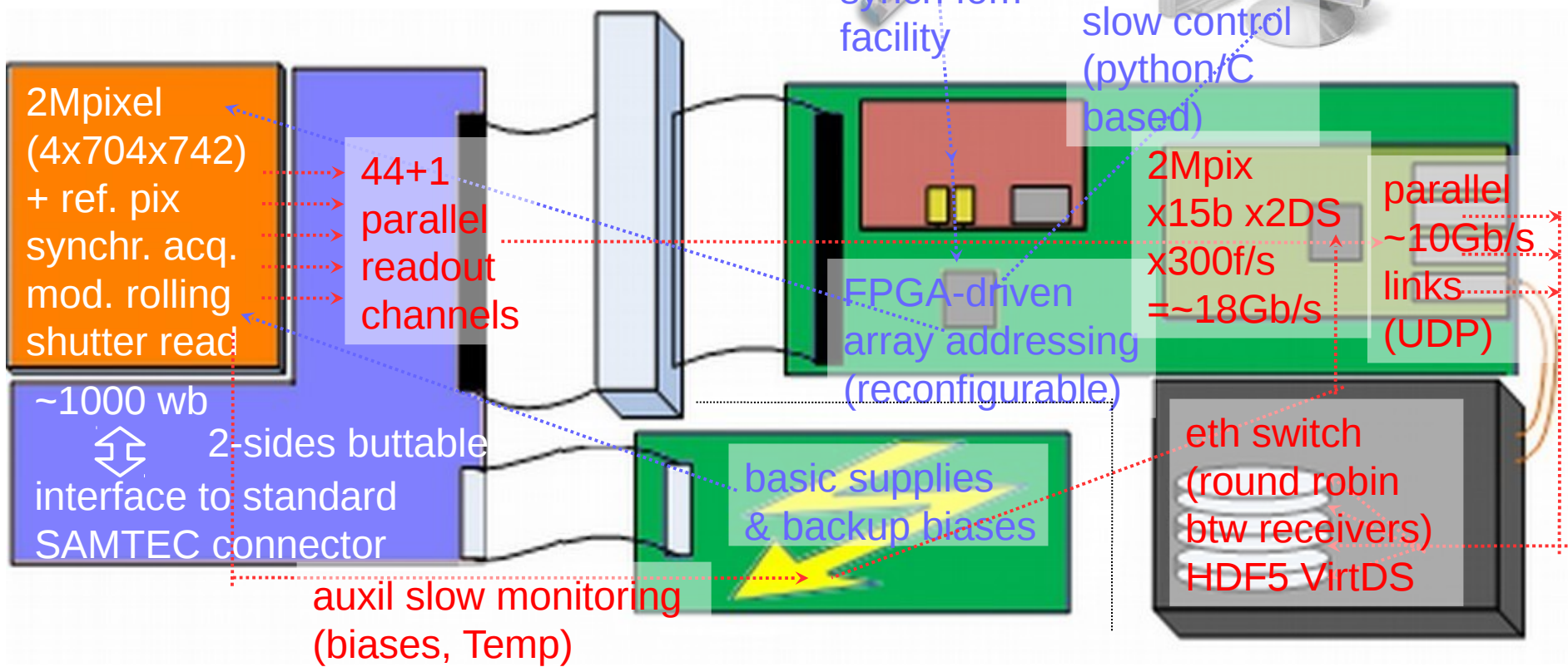
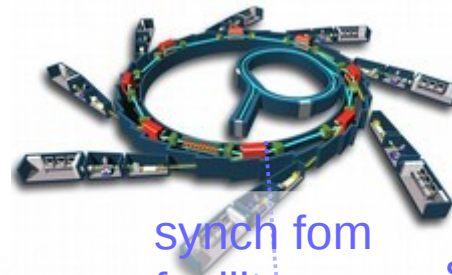




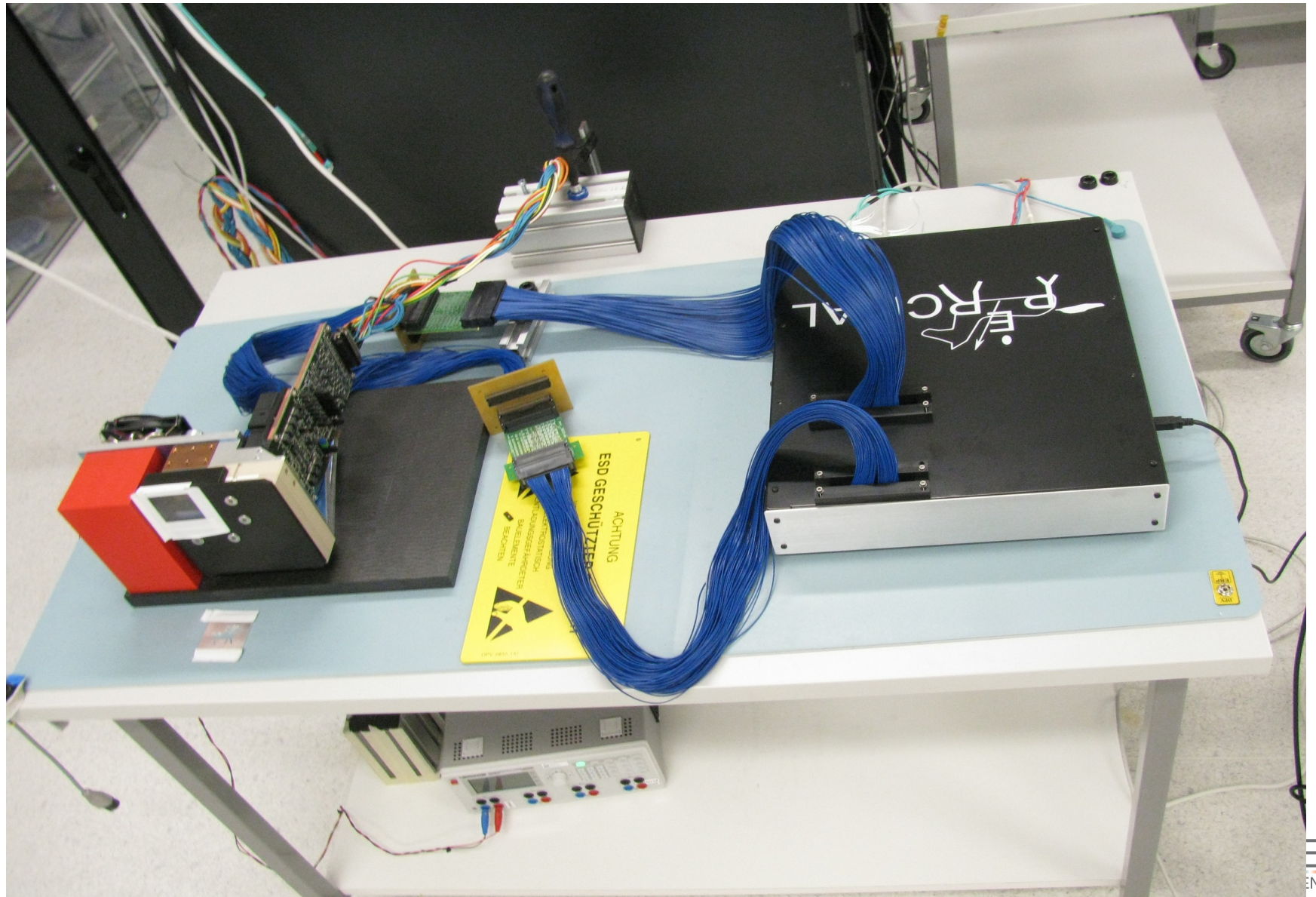
development of a 2D pixelated detector for low-energy-X-rays

- primary range 250eV to 1keV
(extended: below 100eV~2keV)
- noise low enough to allow 1-photon discrimination (~15e)
- high dynamic range to be compatible with FEL/high flux SR (several Me)
- fast enough to allow 1-shot experiments (120~300 frame/s)
- good detection efficiency (back-side illumination, thin entrance window)
- many (multi-M) pixels
- with no gaps of blind areas
- reasonably small pixels (27um)

The full PERCIVAL system (at a glance)

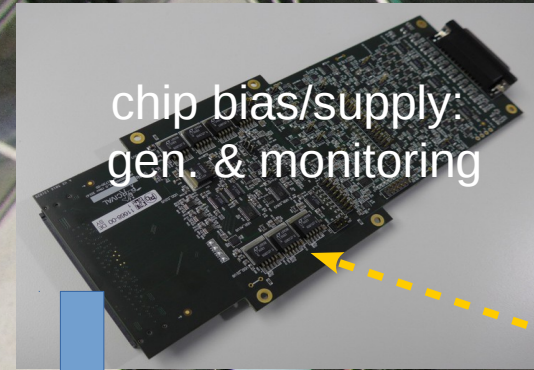


The full PERCIVAL system (at a glance)



The full PERCIVAL system (at a glance)

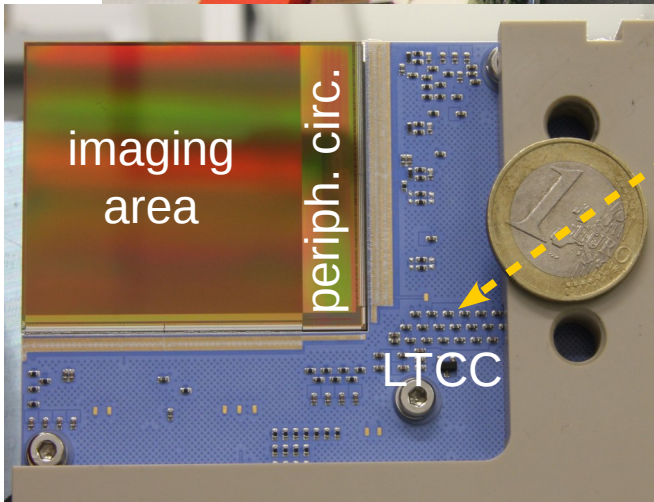
chip bias/supply gen. & monitoring



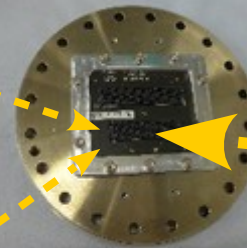
imaging area

periph. circ.

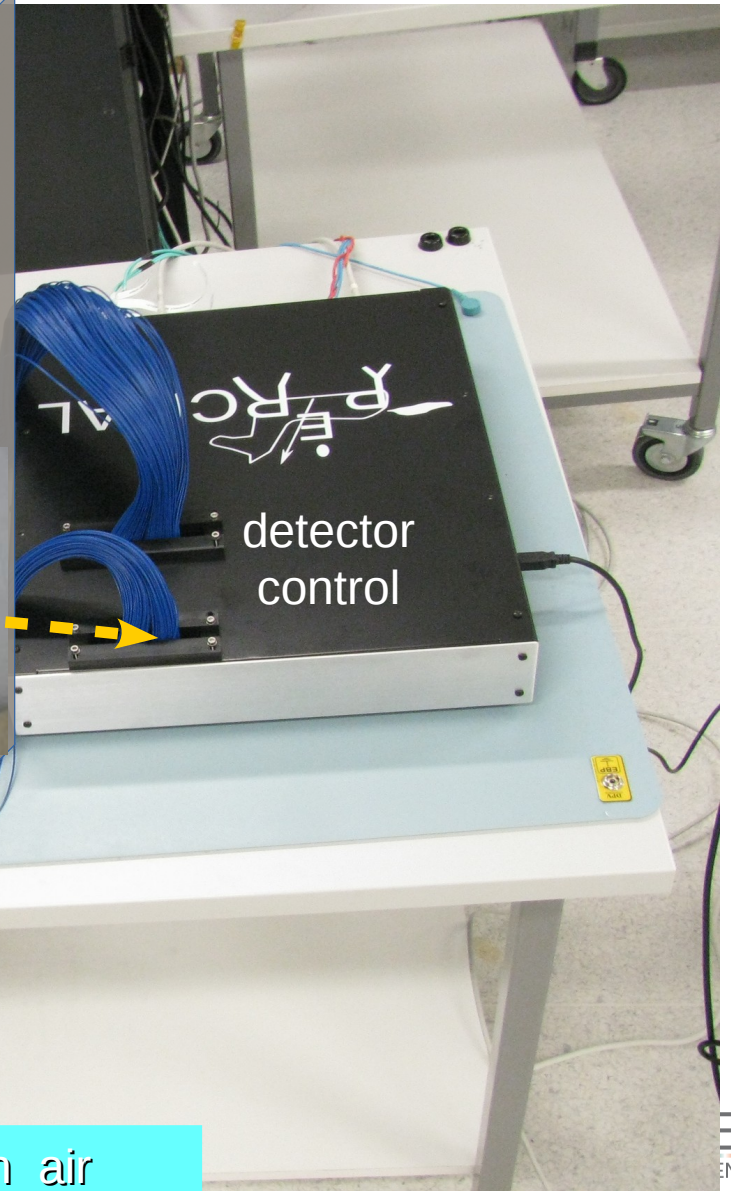
LTCC



in vacuum

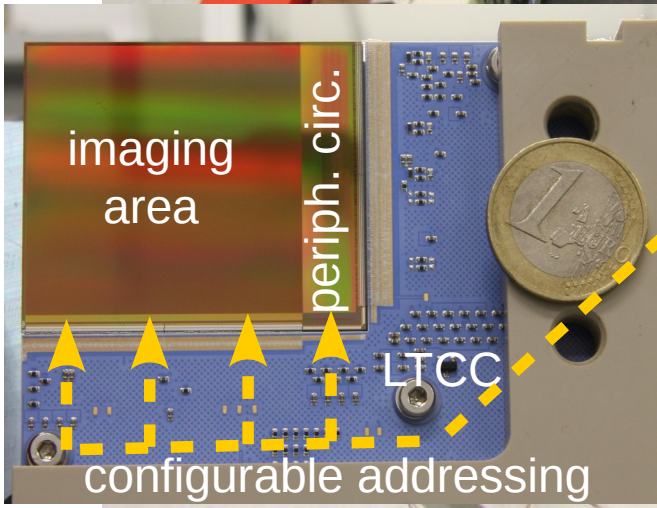
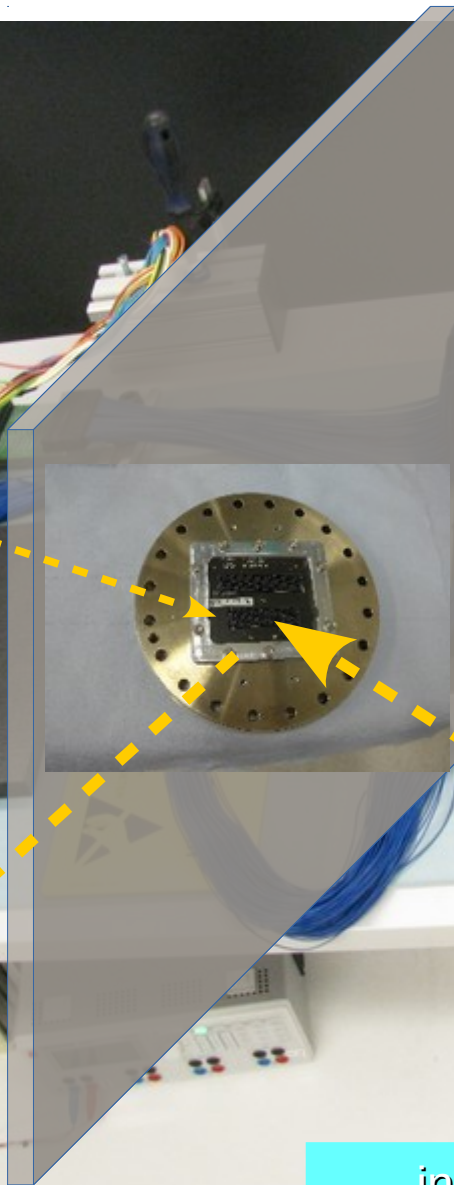
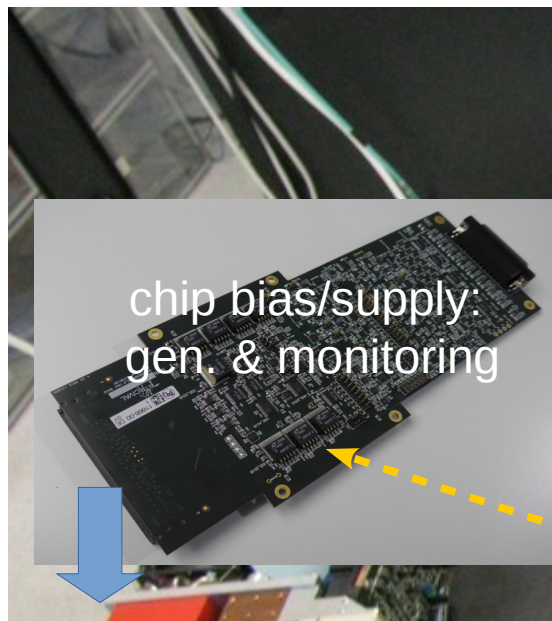


detector control

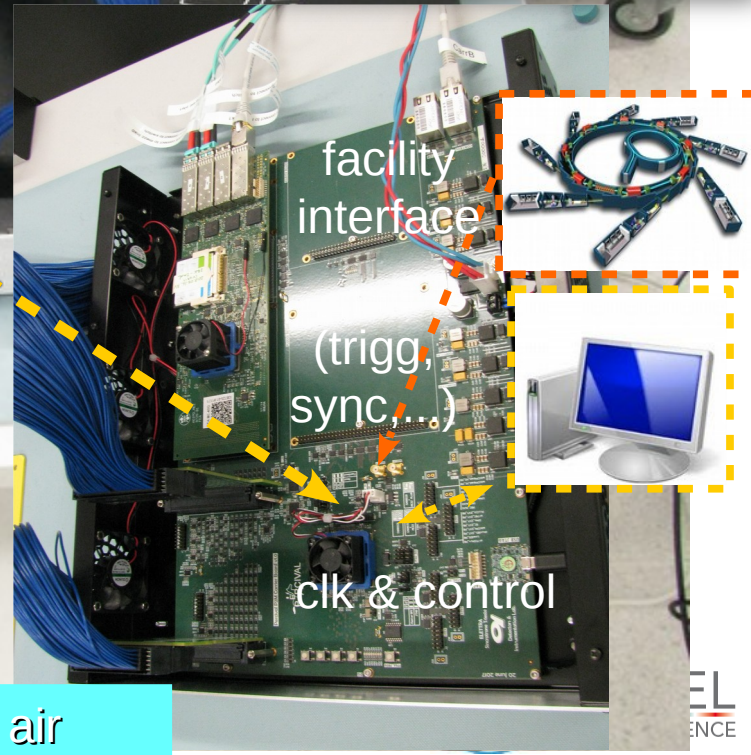
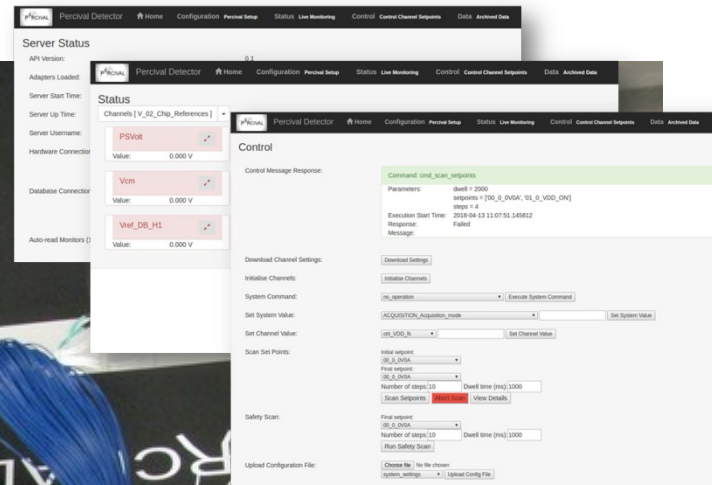


in air

The full PERCIVAL system (at a glance)

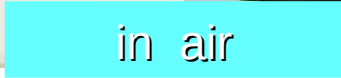
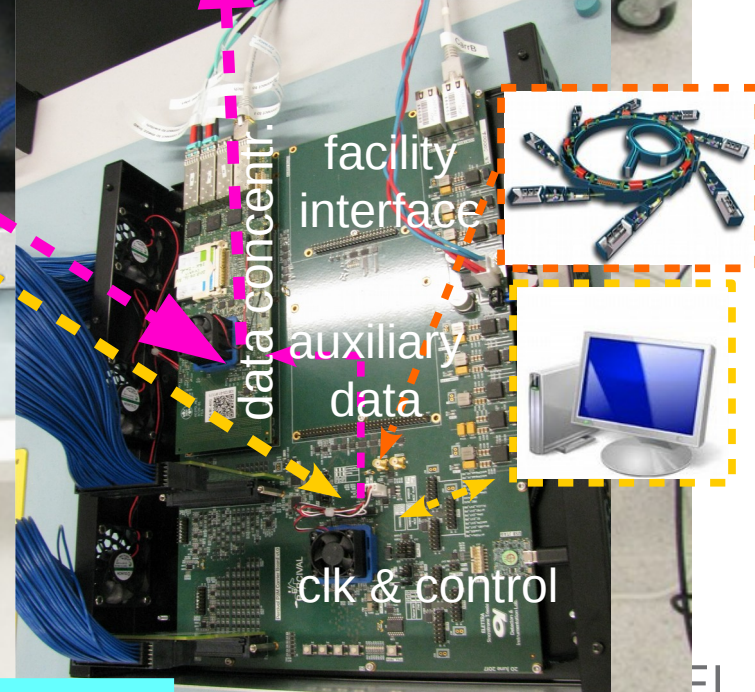
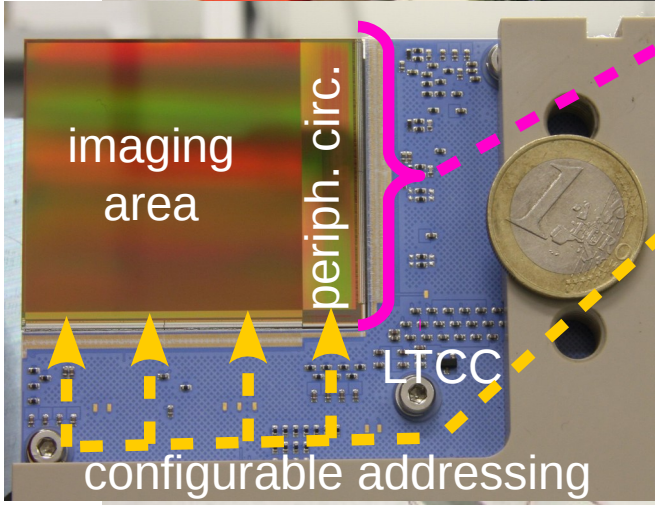
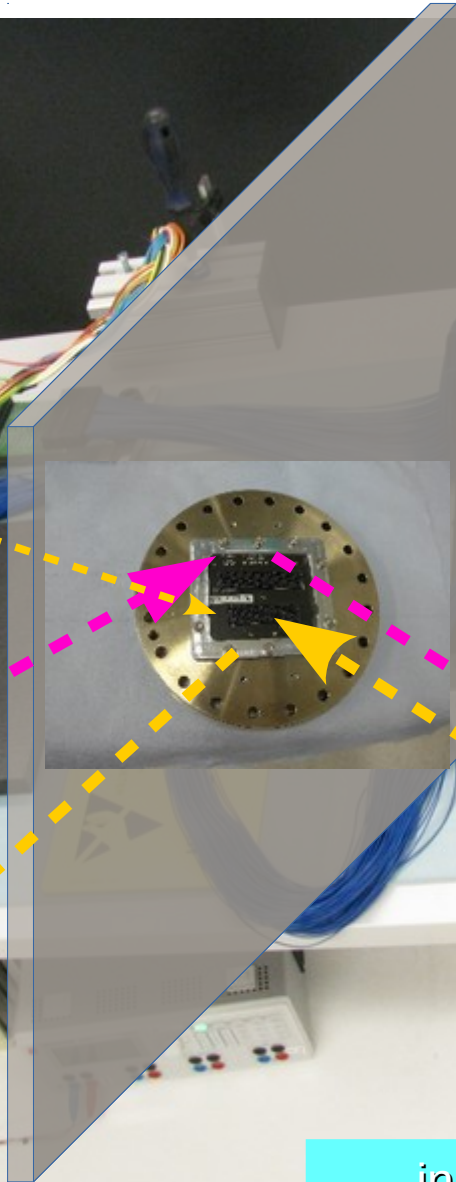
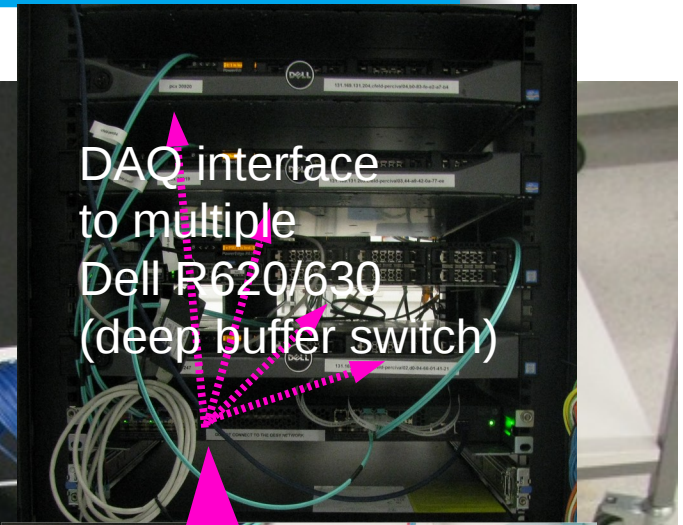
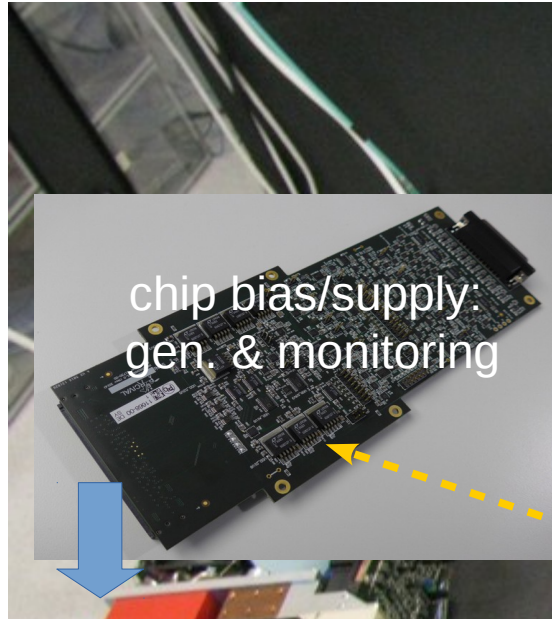


in vacuum

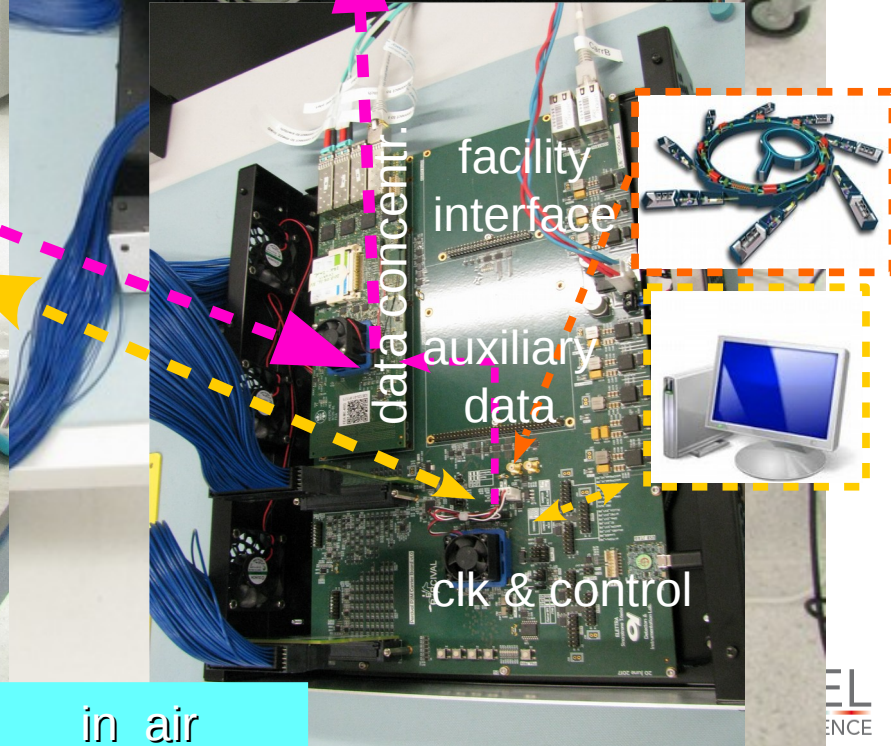
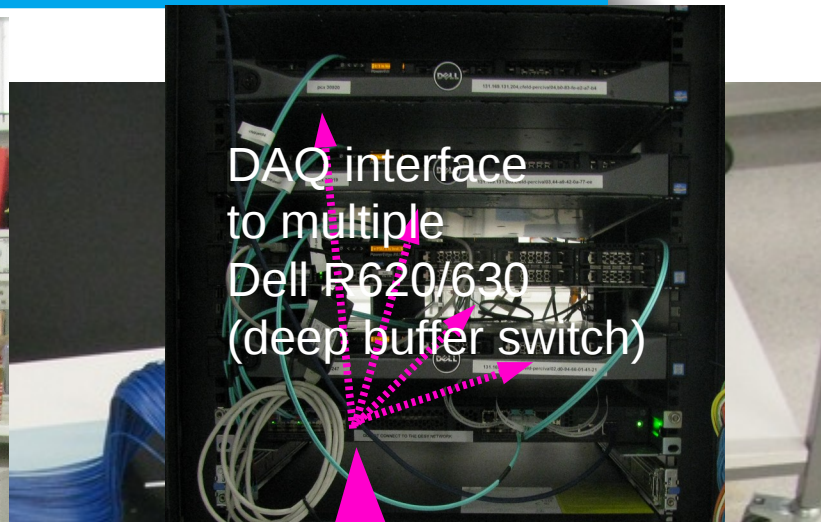
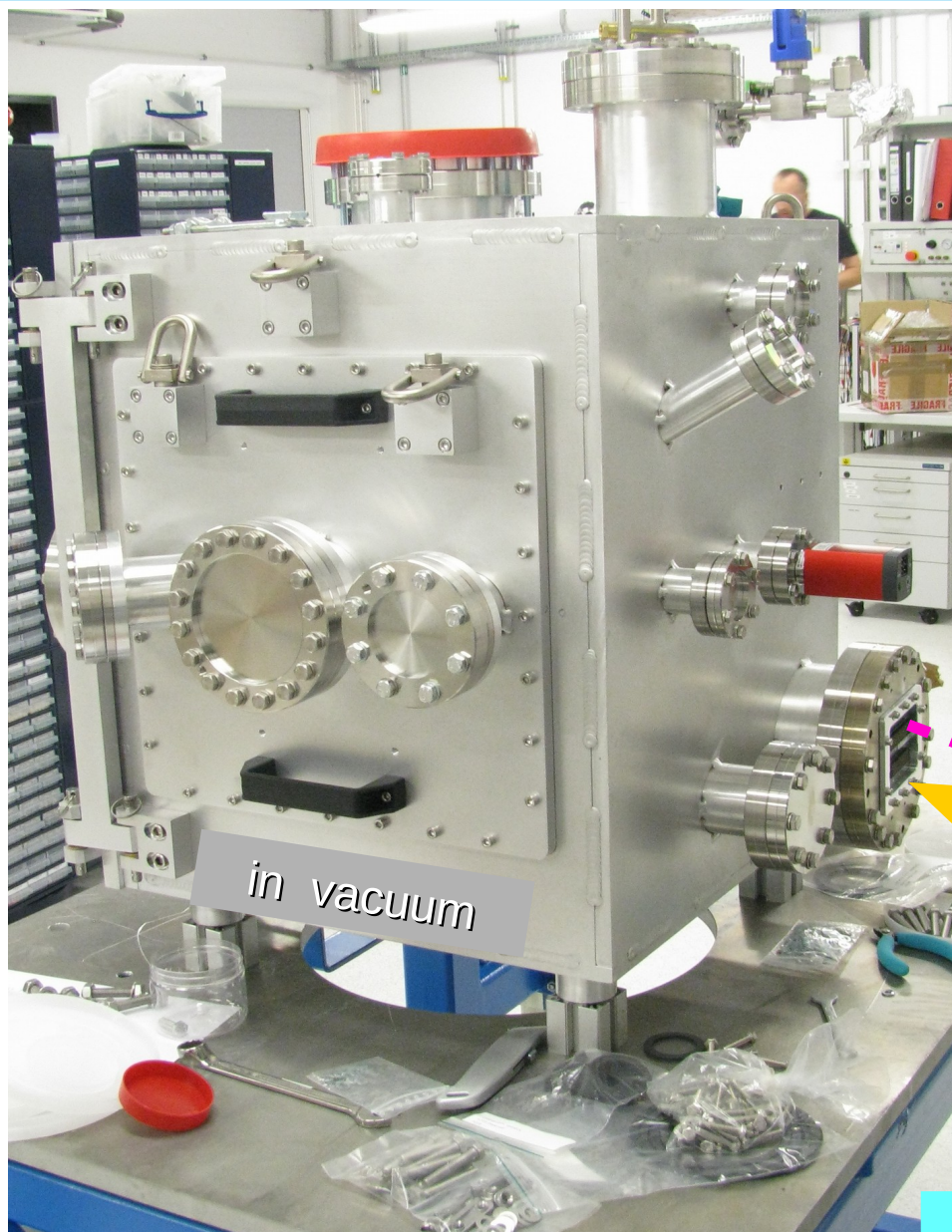


in air

The full PERCIVAL system (at a glance)



The full PERCIVAL system (at a glance)



in air

DAQ , IT, data structure

"because a detector does not end at its ethernet port"

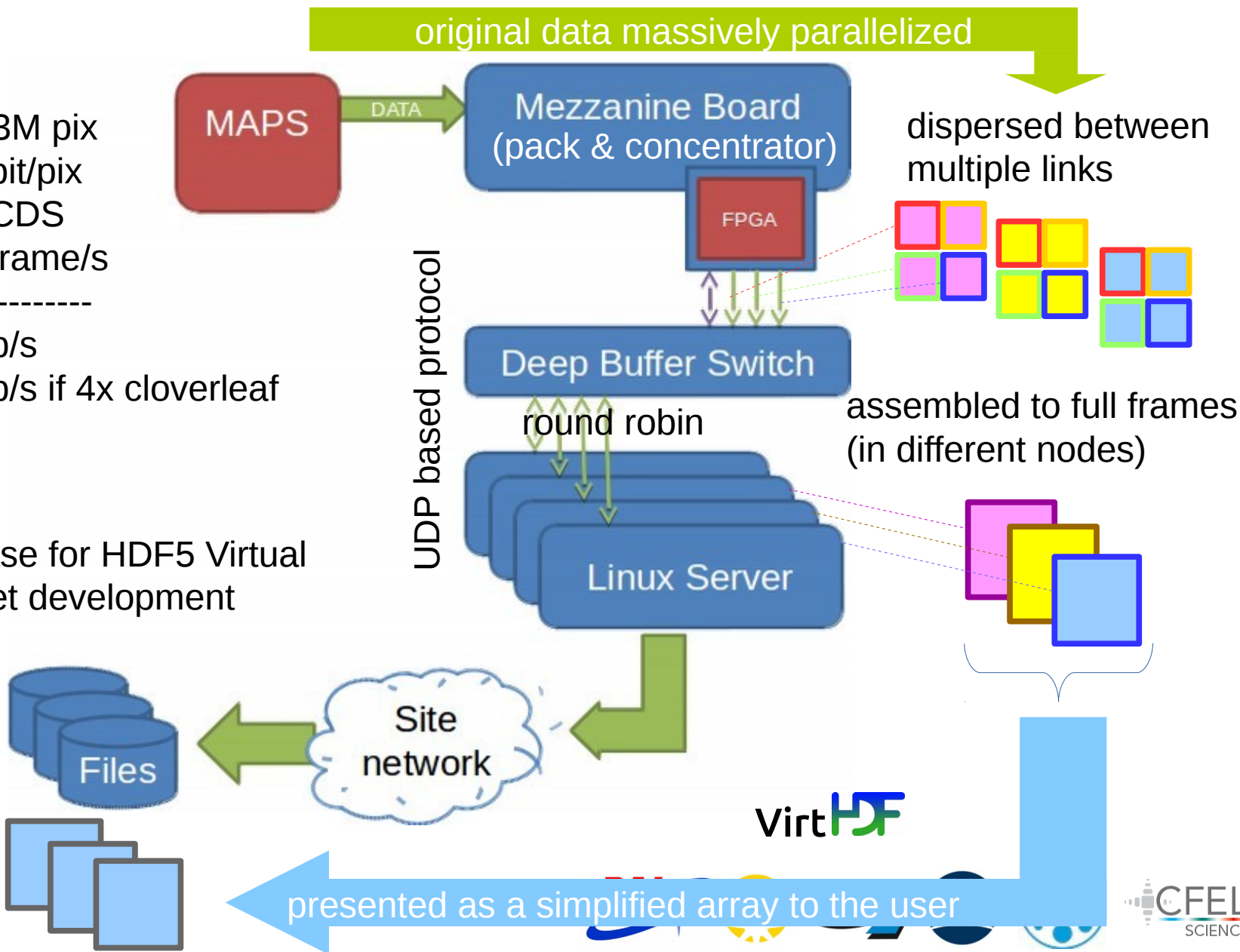


original data massively parallelized

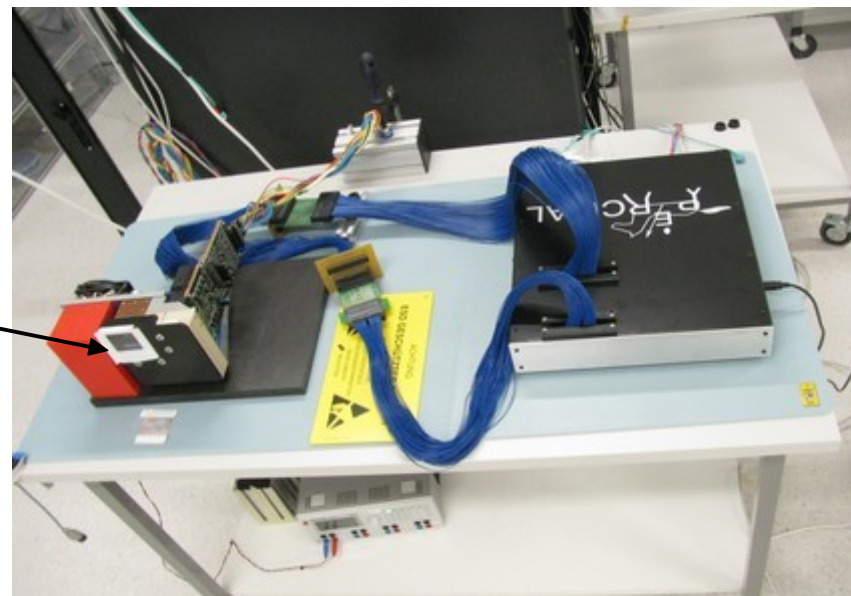
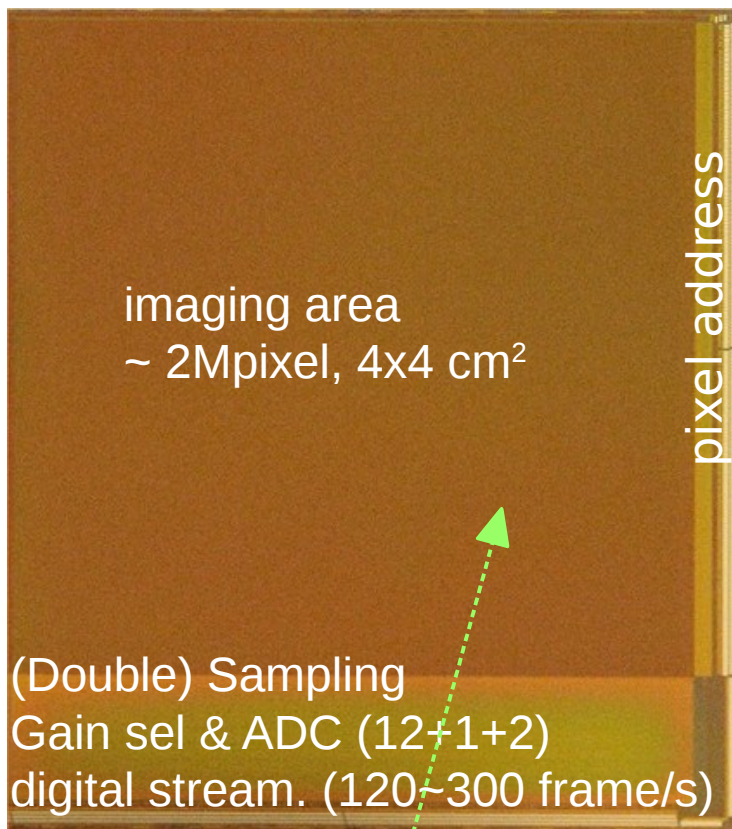
>2.13M pix
x 15 bit/pix
x 2 CDS
x300 frame/s

~20Gb/s
~80Gb/s if 4x cloverleaf

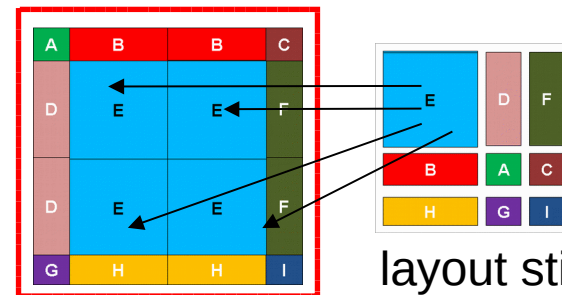
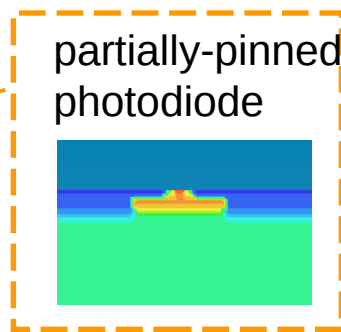
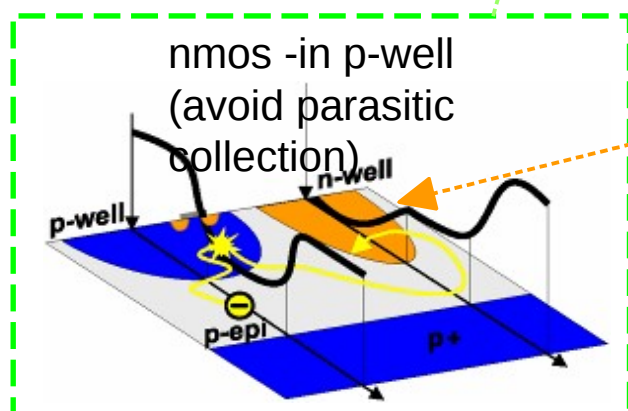
test case for HDF5 Virtual Dataset development



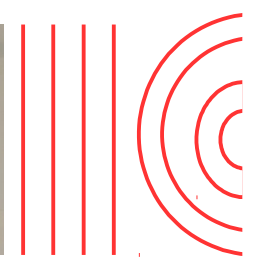
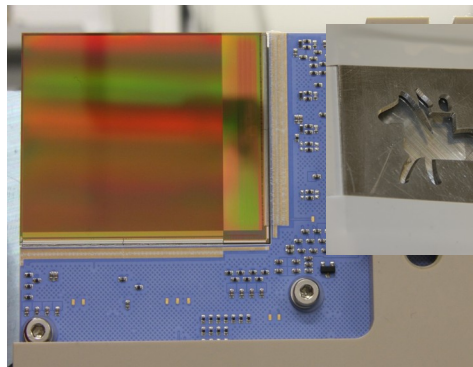
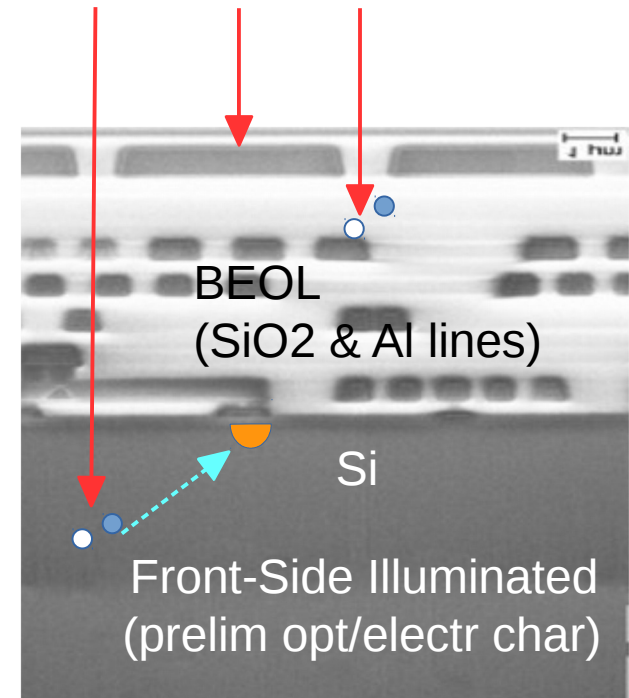
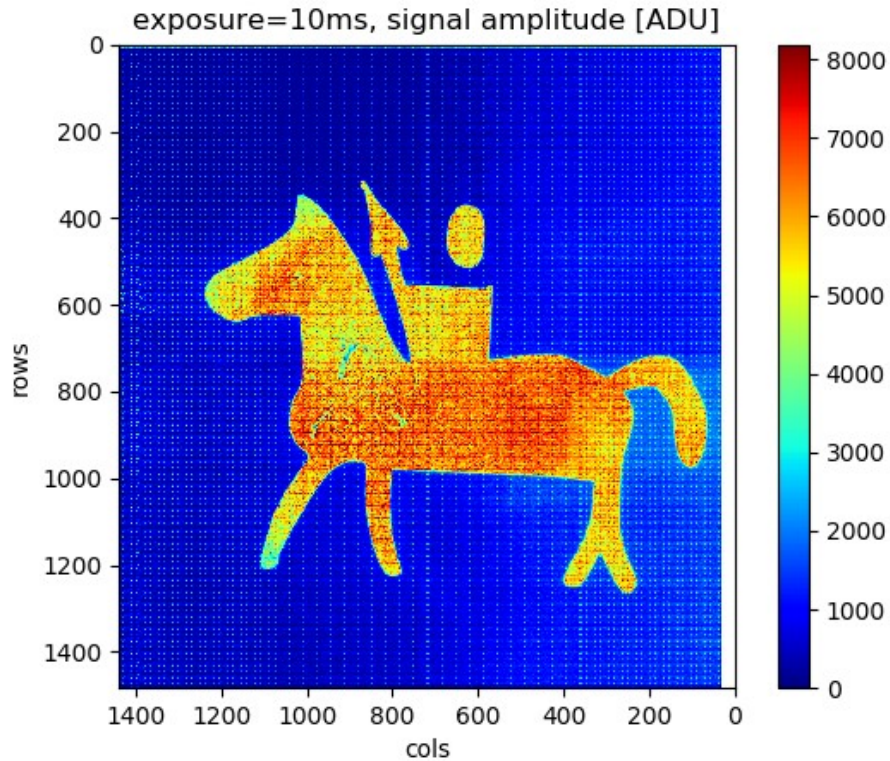
The PERCIVAL system core



Monolithic Active Pixel Sensor
TowerJazz 0.18um CMOS technology,
over high-resistance thick epi

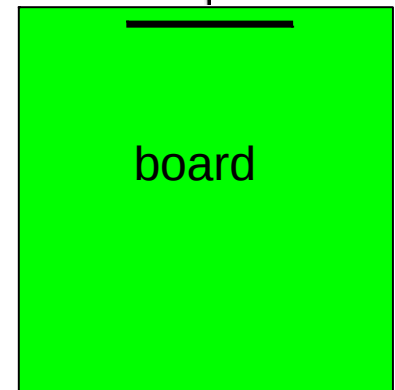
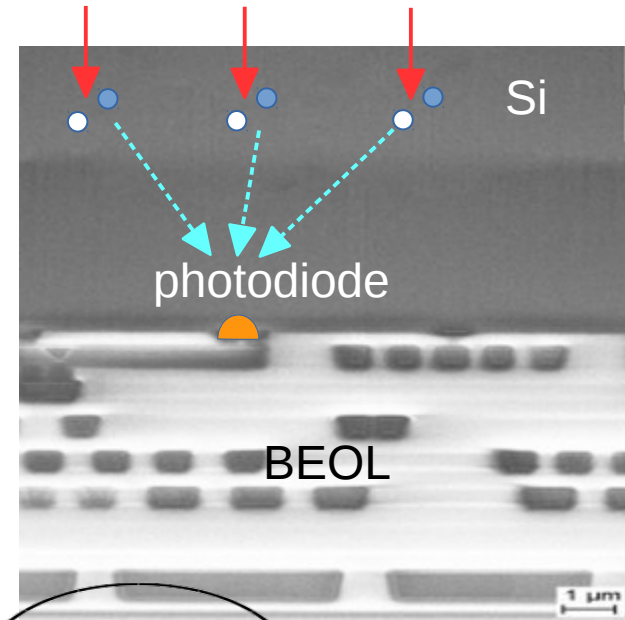
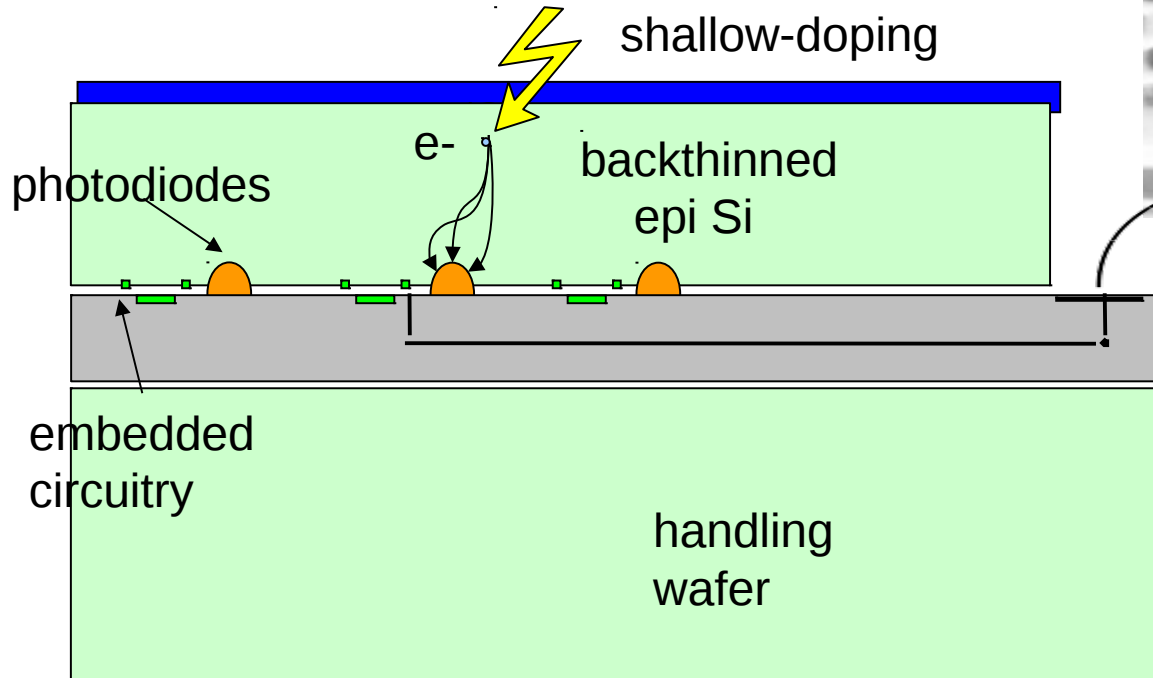


first images acquired (FSI)

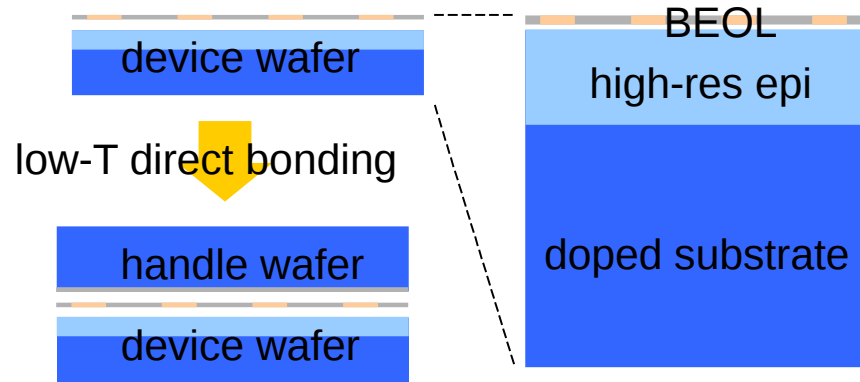
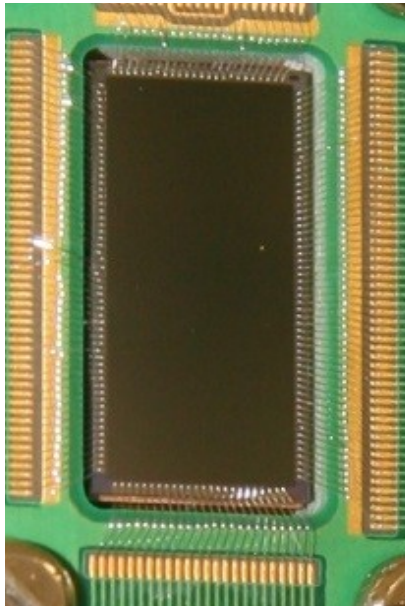


Back-Side Illuminated system

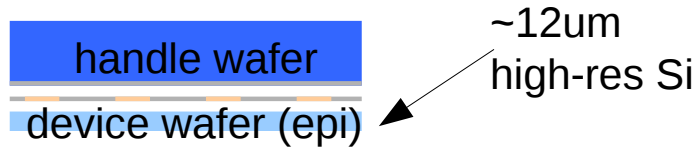
minimized entrance window
100% fill factor
suitable for low-E photons



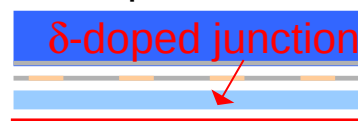
Back-Side processing



thinning (grind + CMP)



MBE growth of doped Si



shallow doping + laser annealing



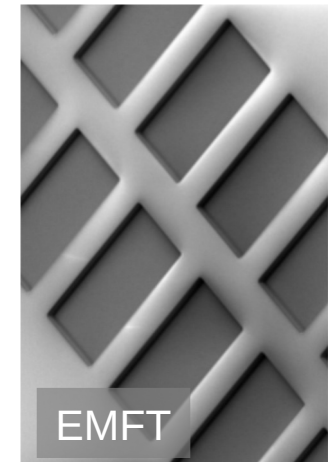
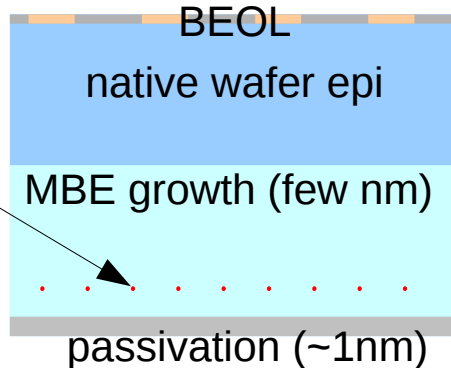
selective etching



selective etching

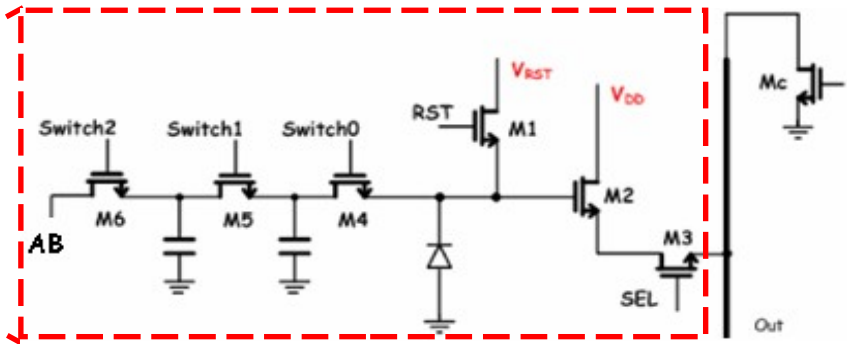
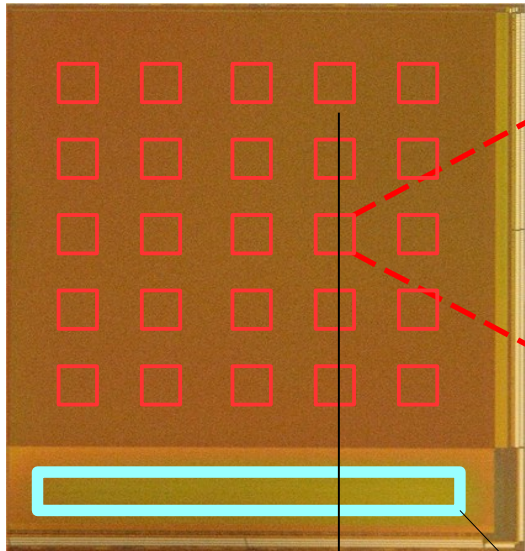
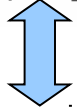


dopant defined down to single atomic layer
(Low Temperature) Molecular Beam Epitaxy



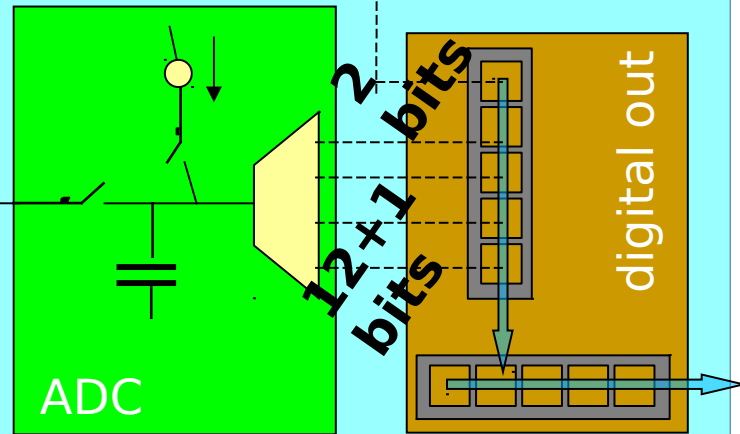
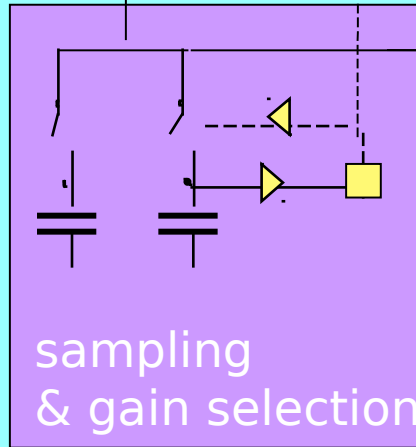
The PERCIVAL core

slow control PC



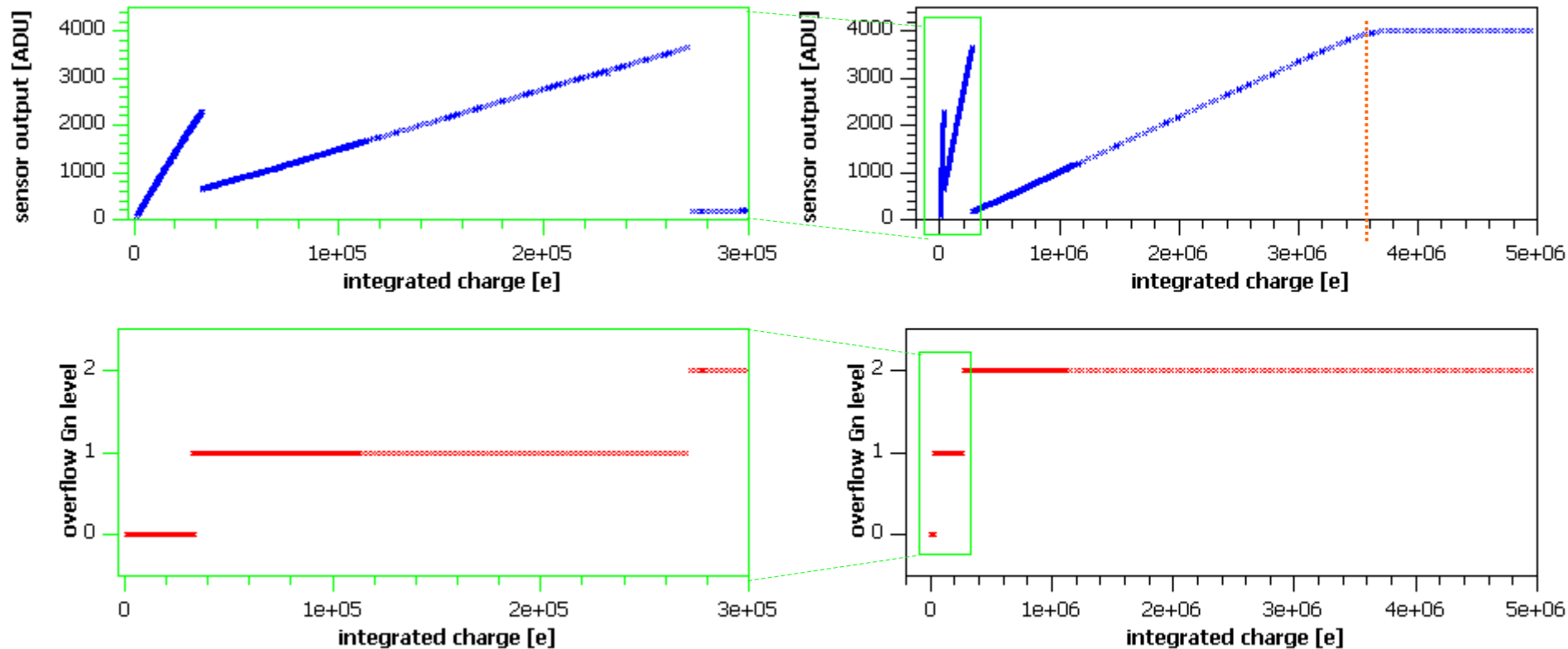
double sampling (of reset level & integrated signal)

data reduction: streams out only one [the most suitable] of the multiple reading of integrated signal (+2 sel. bits)



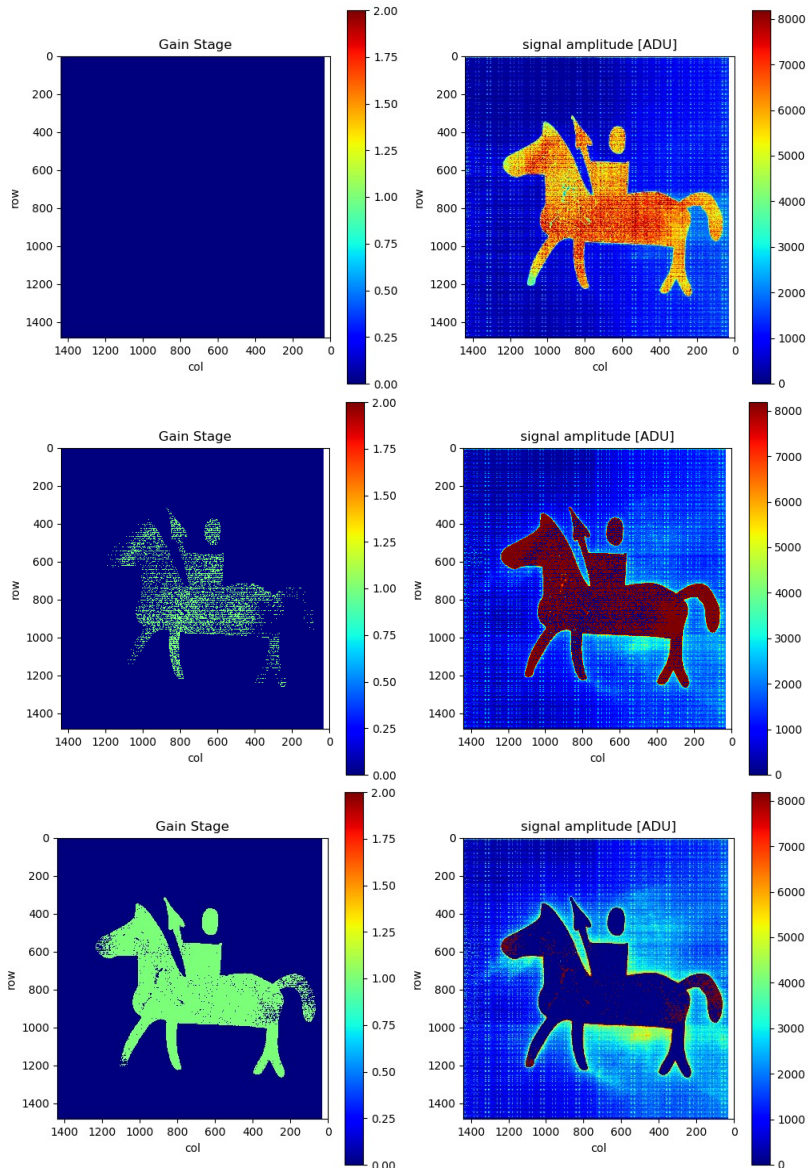
from ~10 up to 120~300(P2M goal) frame/s

Lateral-Overflow & dynamic range



dyn. range: 3.5Me ~ 50k photons @ 250eV

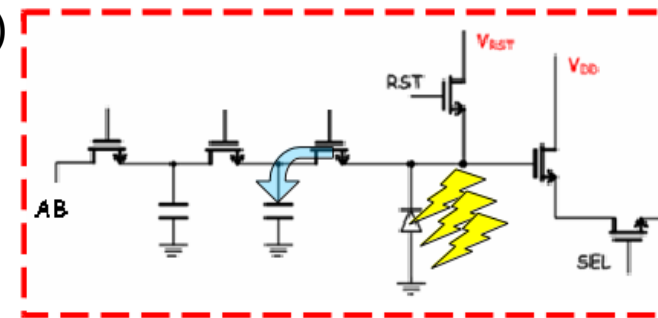
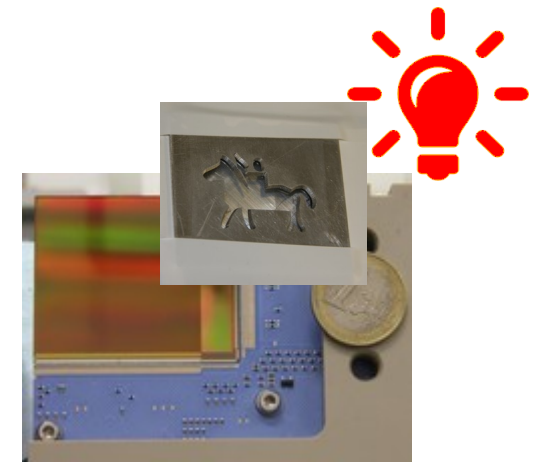
Lateral-Overflow



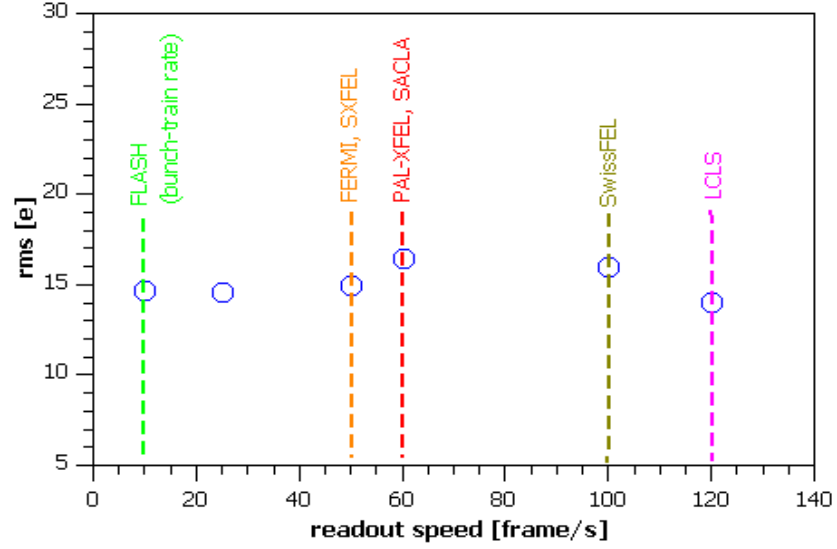
100 frame/s
(10ms int time)

33 frame/s
(30ms int time)

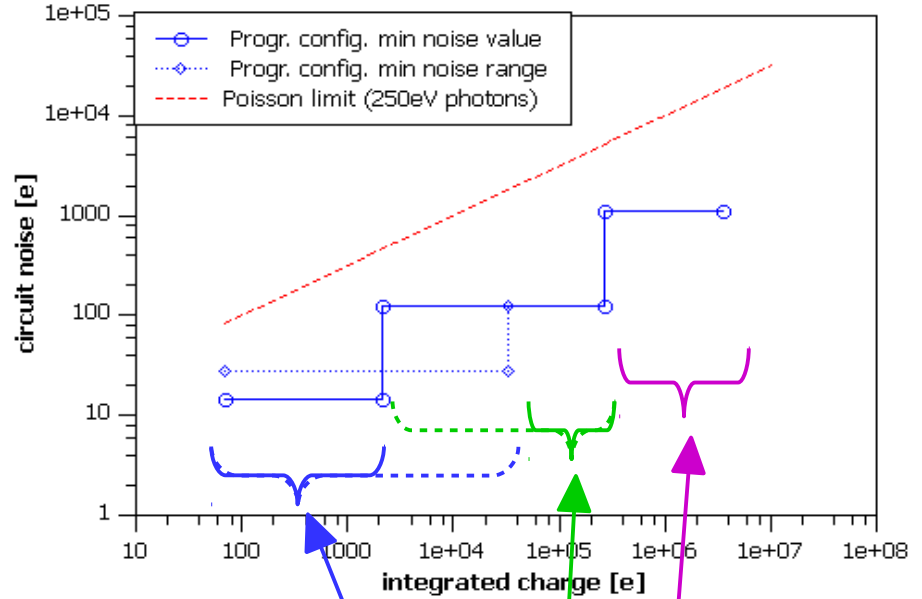
20 frame/s
(50ms int time)



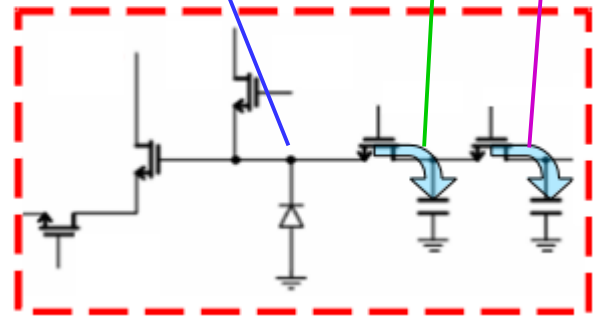
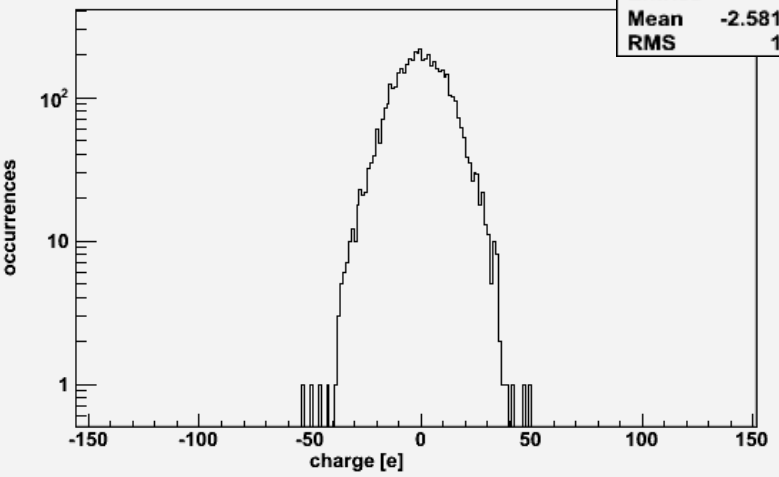
noise vs. readout speed
W08-03TS1.2PIX, T=-40°C



noise vs. overflow Gn level
W08-03TS1.2PIX, T=-40°C

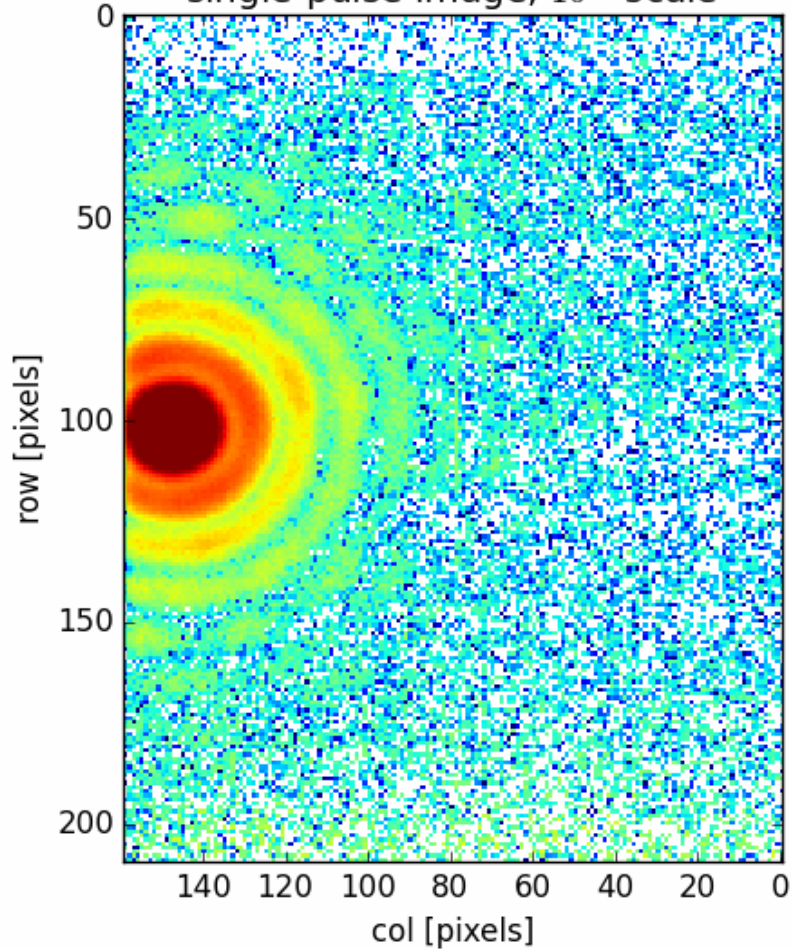


W08-03TS1.2PIX, Gn=0, PGA=6, pixel (120,70)

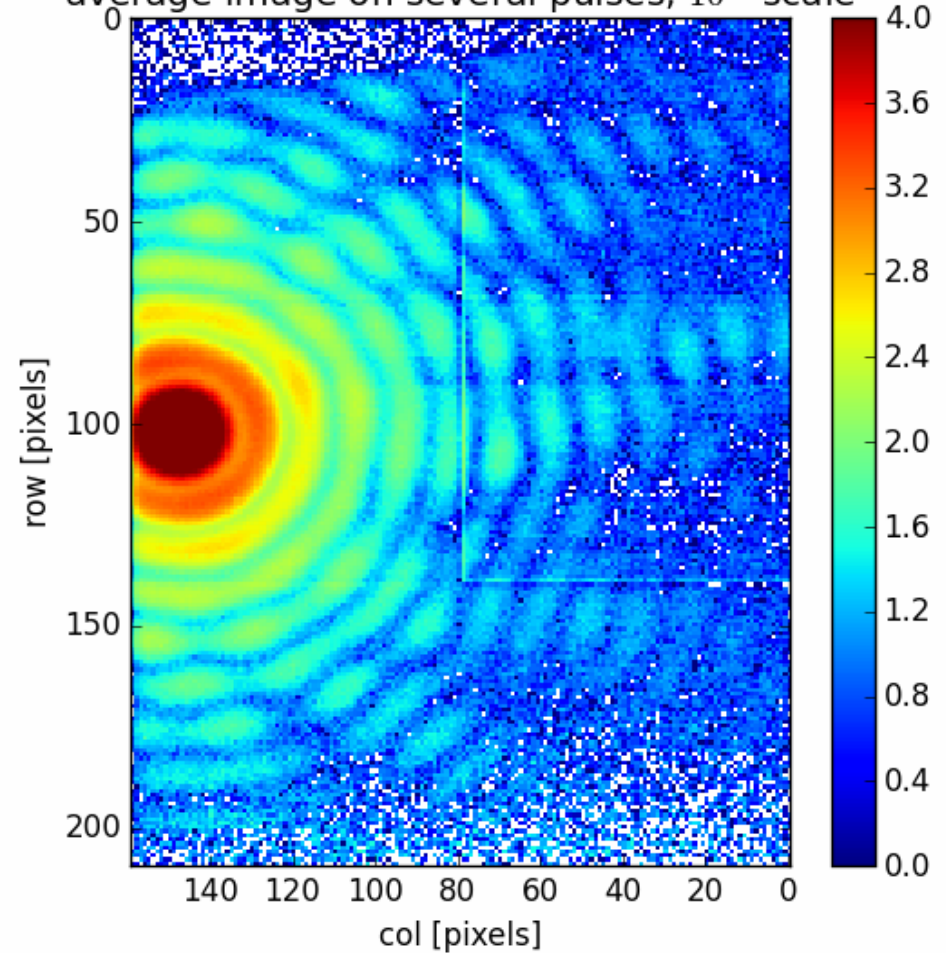


1-shot operation

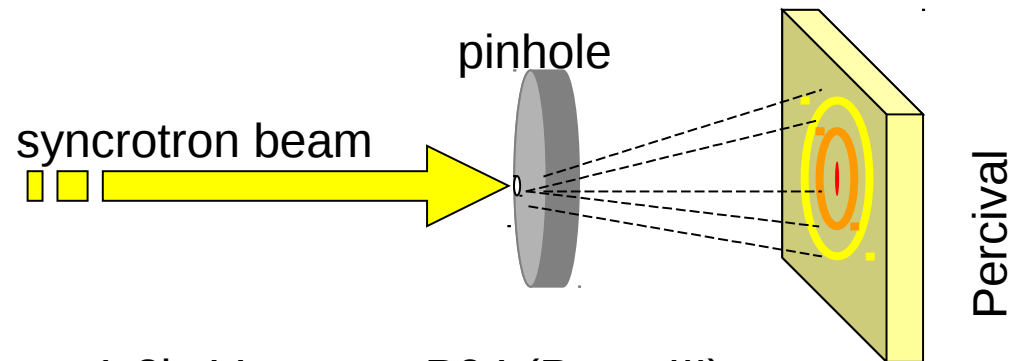
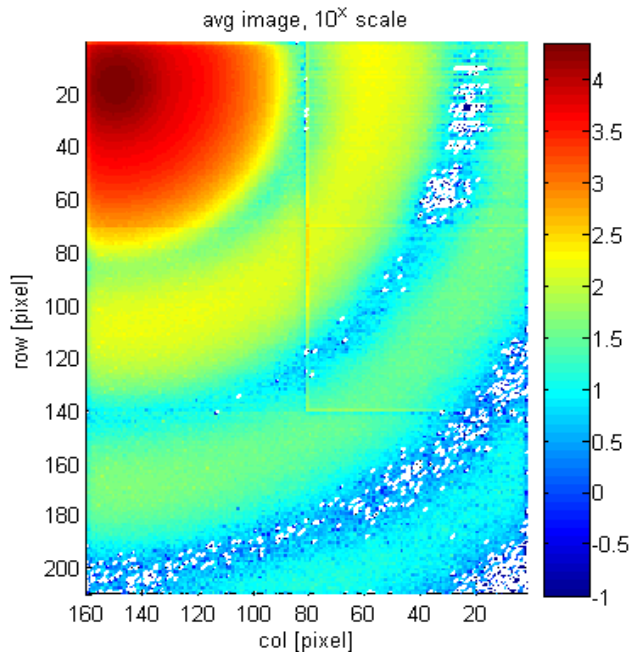
single-pulse image, 10^x scale



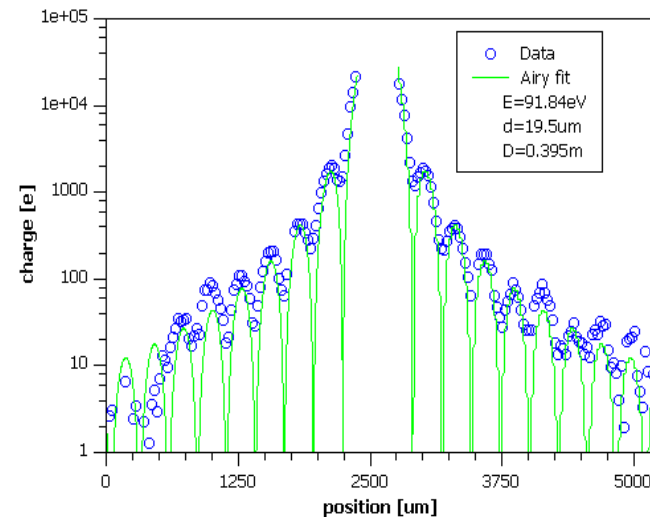
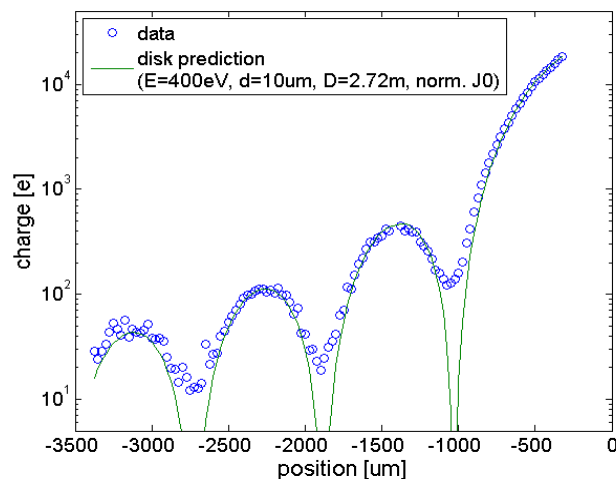
average image on several pulses, 10^x scale



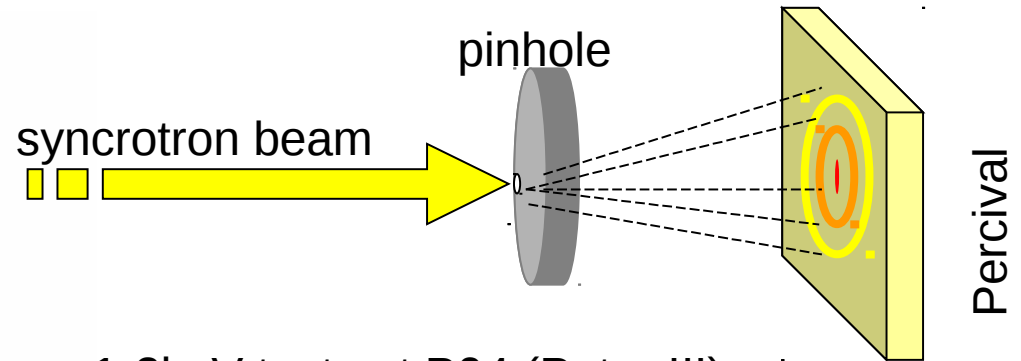
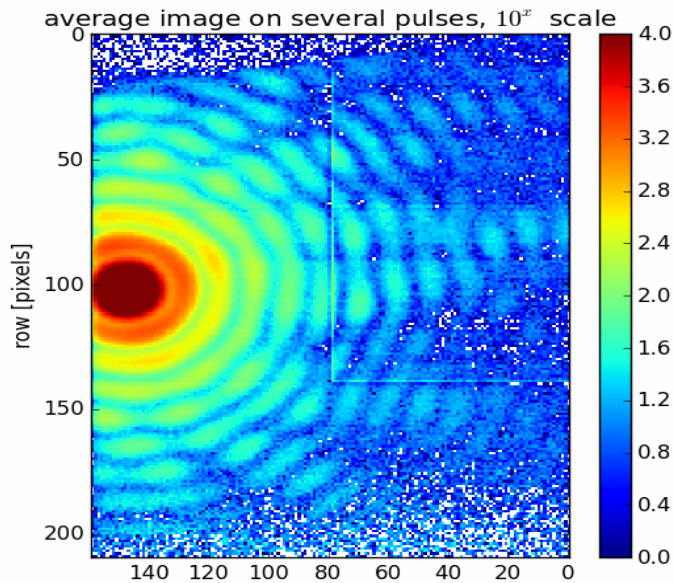
Low-Energy photon detection



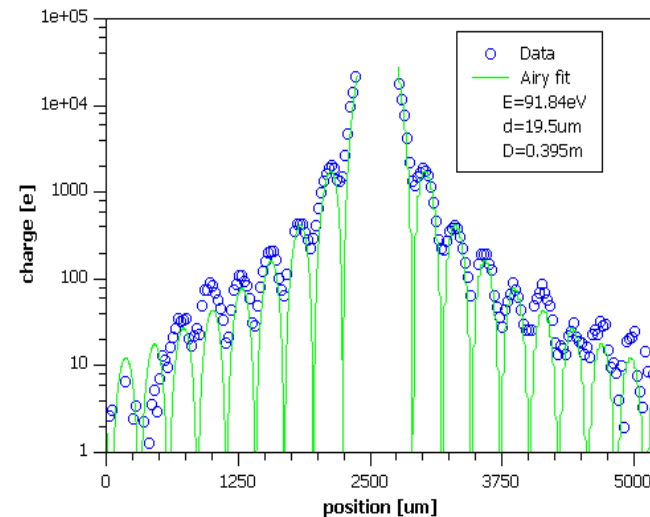
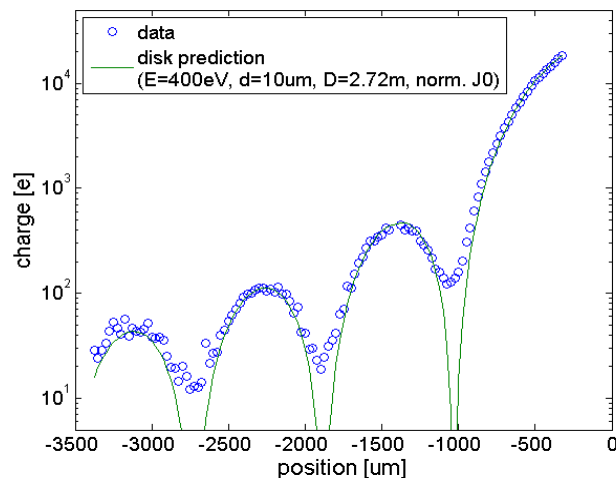
1-2keV tests at P04 (Petra III)
400eV tests at I10 (DLS)
100-300eV tests at Twinmic, Cipo (Elettra)
91.84eV at FLASH



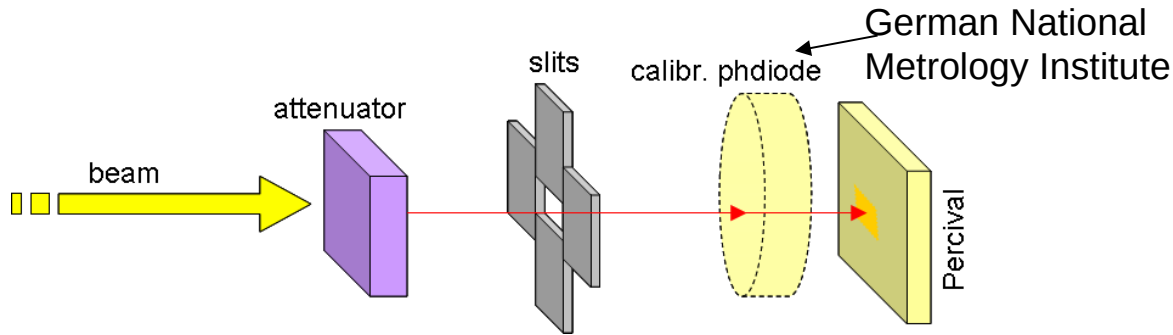
Low-Energy photon detection



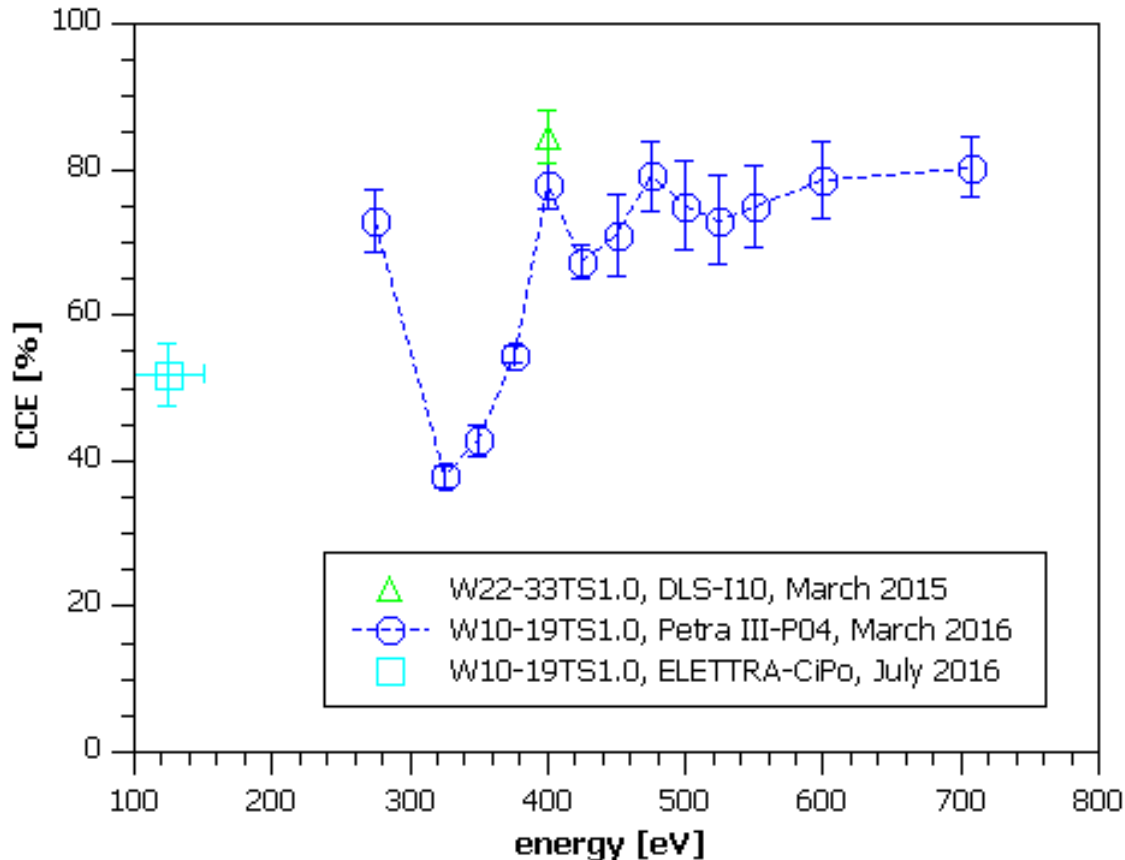
1-2keV tests at P04 (Petra III)
400eV tests at I10 (DLS)
100-300eV tests at Twinmic, Cipo (Elettra)
91.84eV at FLASH



Charge Collection Efficiency



measurement at
I10 beamline (DLS)
Cipo beamline (ELETTRA)
P04/09 beamline (Petra III)
PTB beamline (BESSY)



P.E.R.C.I.V.A.L.

(Pixellated Energy-Resolving Cmos Imager Versatile And Large)

tests on prototypes





- ✓ Lateral Overflow
- ✓ low noise (~15e)
- ✓ high dynamic range (3.5Me – 50k ph.)
- ✓ up to 120 frame/s
 - ✓ compatible most FEL
- ✓ tested 92eV-2KeV

P2M


- 2M pixels (27um pixel pitch)
- ~4×4cm² sensible area
- no gaps, 2-side buttable
- prelim electrical and optical tests
- tested up to 100frame/s (expected: ~300 frame/s)
- FSI under test
- BSI post-process in progress





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M. Zimmer



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L. Stebel, G. Pinaroli



A. Greer, U. Pedersen, N.
Tartoni



H. Hyun, K. Kim, S. Rah

Beamline(s) support:

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Seltmann, J. Viefhaus

Twinmic, Cipo (Elettra): A. Gianoncelli
N. Zema, S. Rinaldi, D. Catone

I10 (DLS): P. Steadman, M. Sussmuth

BL2 (FLASH): S. Toleikis, S. Duesterer

PTB (in BESSY II ring): C. Laubis

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