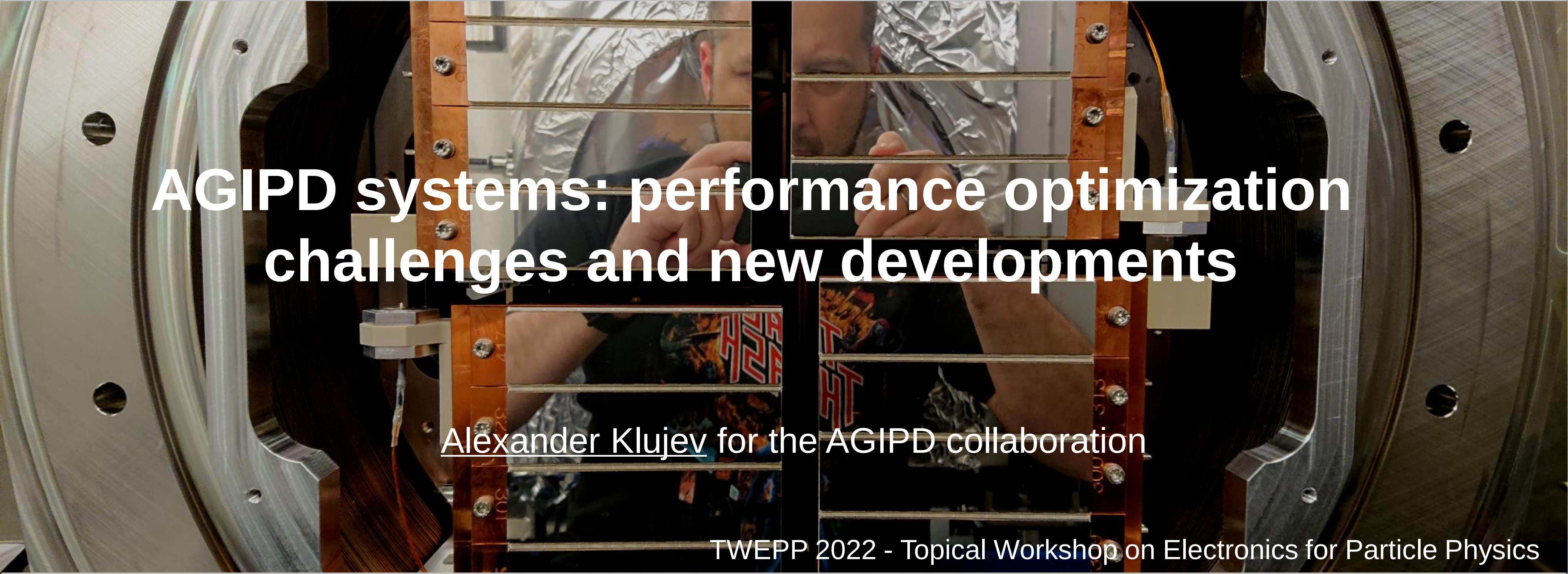
AGIPD



AGIPD systems: performance optimization challenges and new developments

Alexander Klujev for the AGIPD collaboration

TWEPP 2022 - Topical Workshop on Electronics for Particle Physics

UNIVERSITÄT BONN
DESY.
PAUL SCHERRER INSTITUT PSI
UHH Universität Hamburg DER FORSCHUNG | DER LEHRE | DER BILDUNG

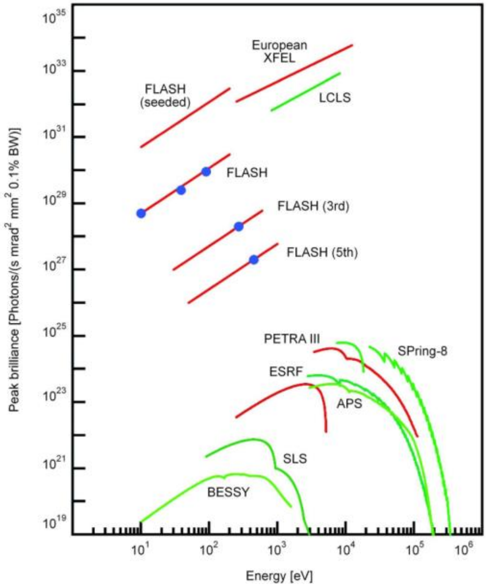
Outline

- The AGIPD detectors at the EuXFEL
- System problems and fixes
- 2nd generation systems
- Summary and outlook

Science at the EuXFEL

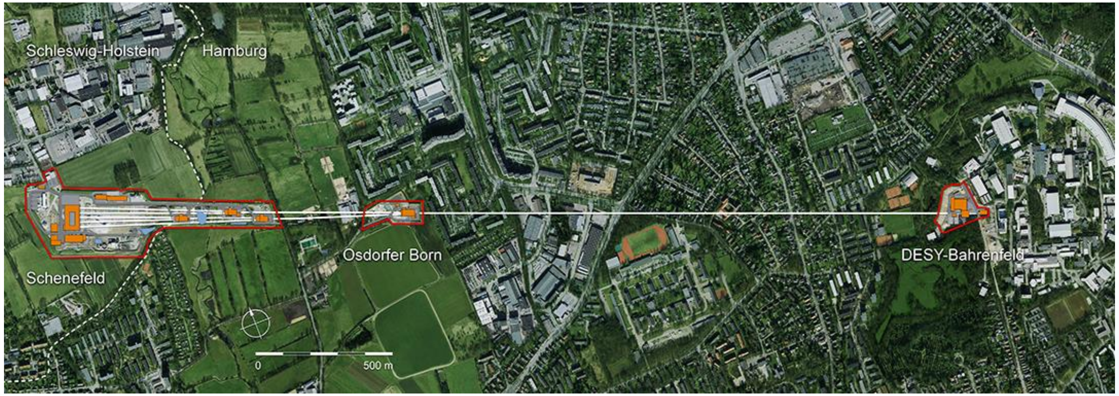
Main Features:

- High intensity pulses
- Very coherent bunches
- Fast imaging

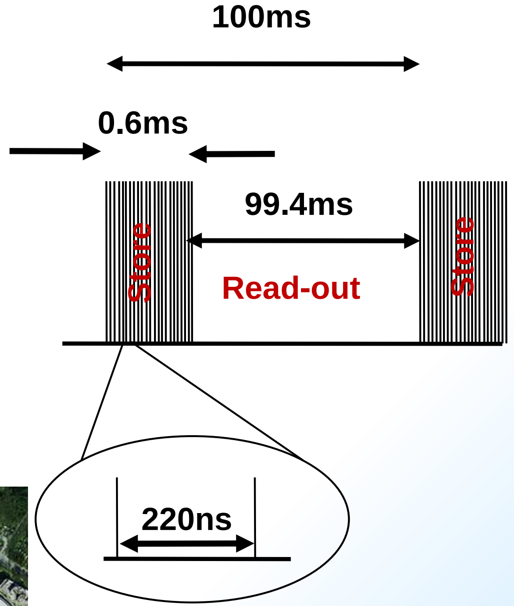


Scientific opportunities:

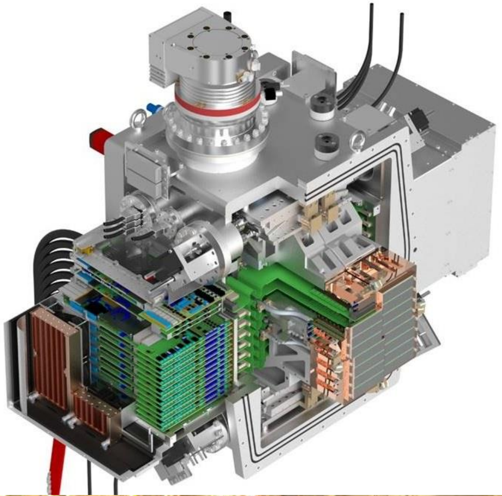
- Study of a very small objects
- (single (bio-)molecules)
- Imaging of non-regular structures
- (up to non-crystals)
- New material and fast processes
- studies



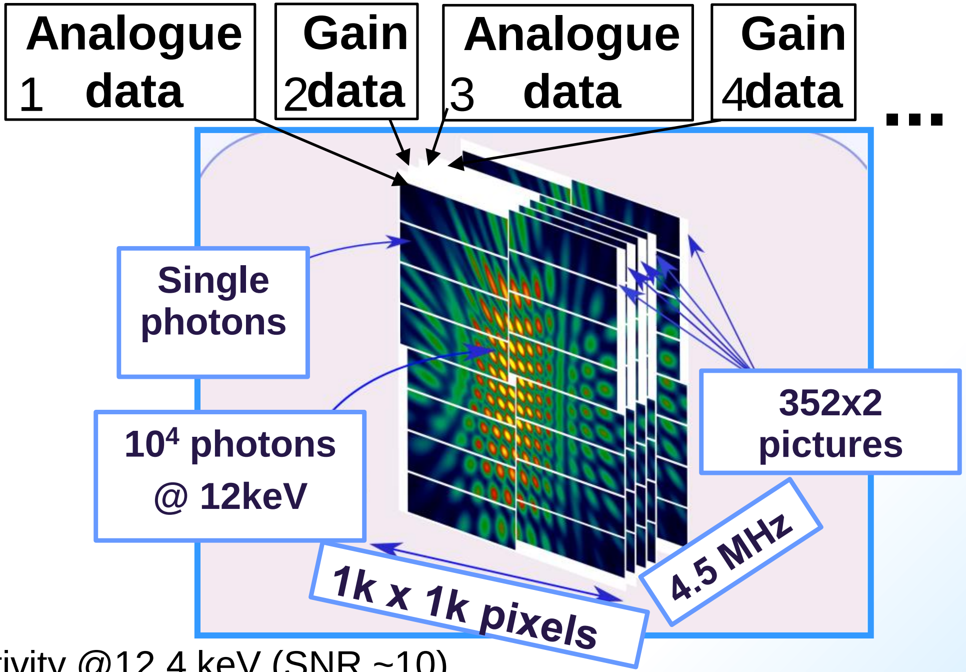
XFEL time structure

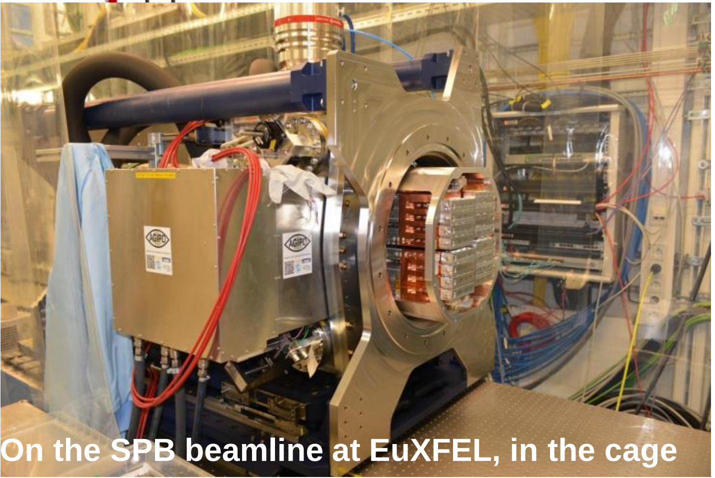


The AGIPD detectors at the EuXFEL



- **Adaptive Gain**
- **Integrating**
- **Pixel Detector**

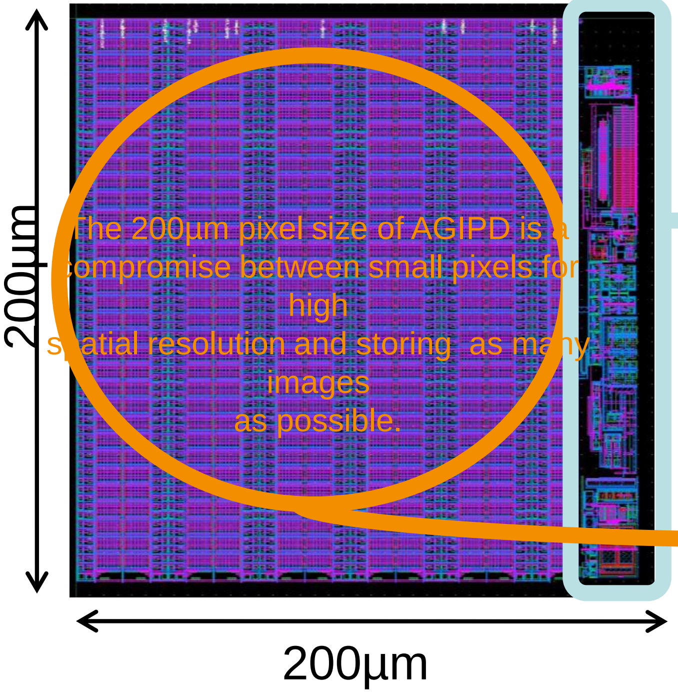


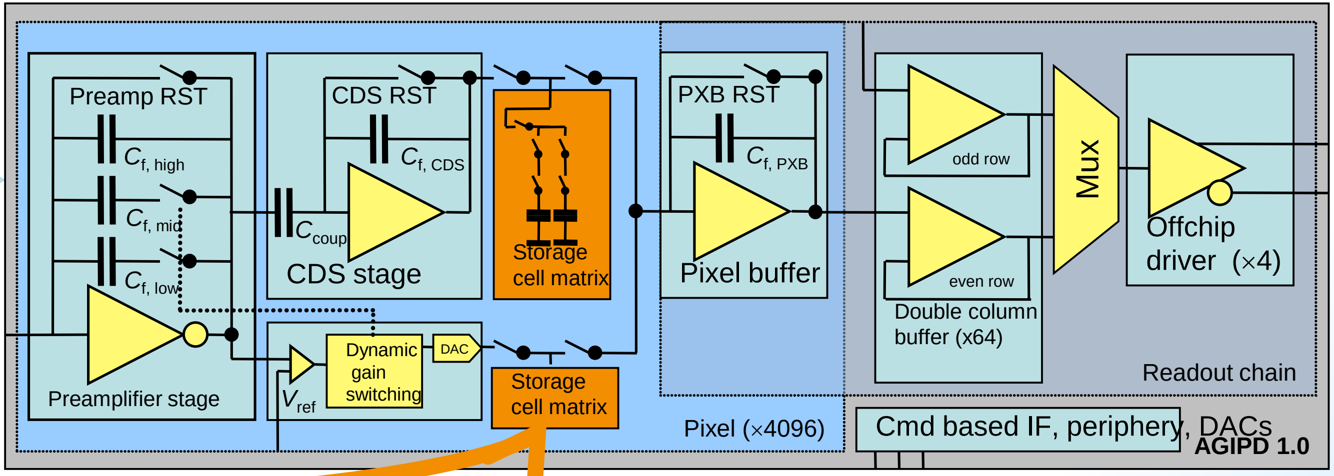

On the SPB beamline at EuXFEL, in the cage

Main features :

- Single photon sensitivity @12.4 keV (SNR ~10)
- High dynamic range (up to 10^4 12.4 keV photons)
- 4.5 MHz burst mode operation
- Lowest possible dead area
- Vacuum compatible
- Adjustable central beam-hole

AGIPD ASIC



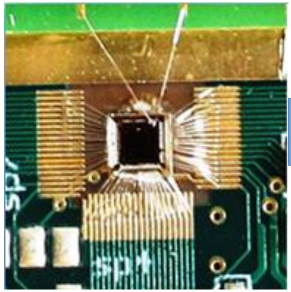


Pixel layout

Block diagram of the analogue readout chain

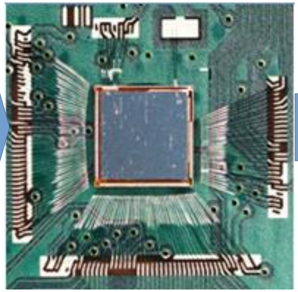
ASIC evolution

AGIPD 0.1 Jan. 2009



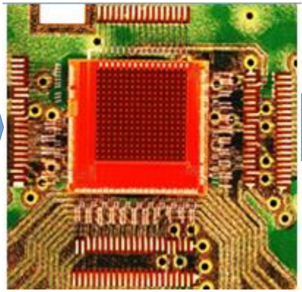
MPW

AGIPD 0.2 May 2009



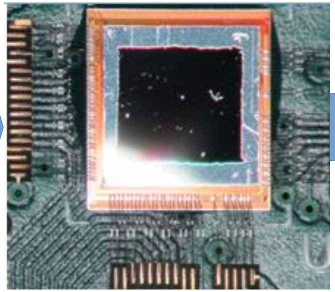
MPW

AGIPD 0.3 Nov. 2010



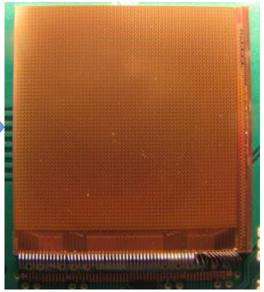
MPW

AGIPD 0.4 Nov. 2011



MPW

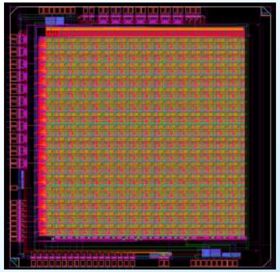
AGIPD 1.0 Apr. 2013



Engineering run

Bug fixes reported on TWEPP-2015

AGIPD 0.5 2016



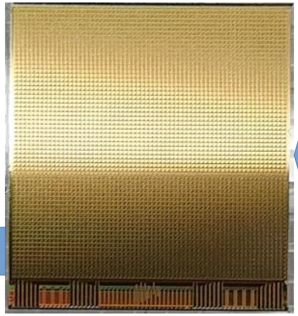
MPW

AGIPD 1.1 Nov. 2015

Engineering run

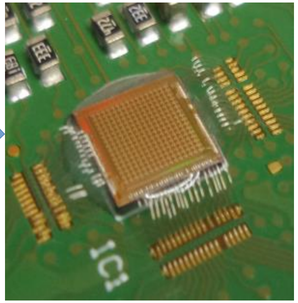
Bug fix reported on the next slide

AGIPD 1.2 Jan. 2019



Engineering run

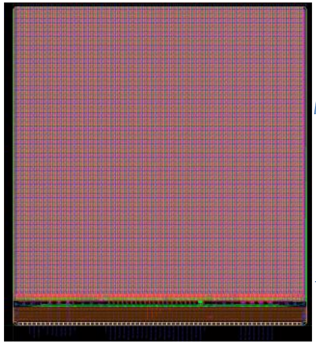
AGIPD 0.6 Nov. 2017



MPW

Progress reported later in this talk

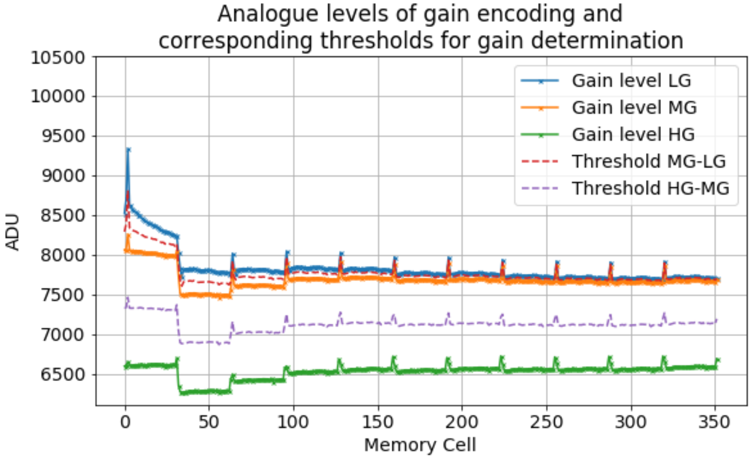
ecAGIPD (1.3) Apr. 2021

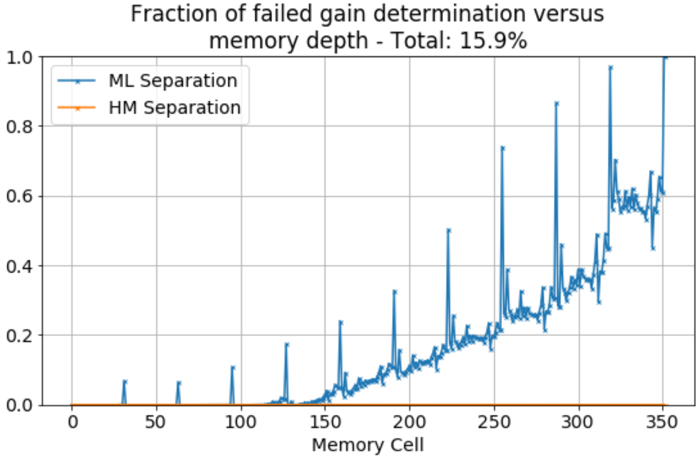


Engineering run

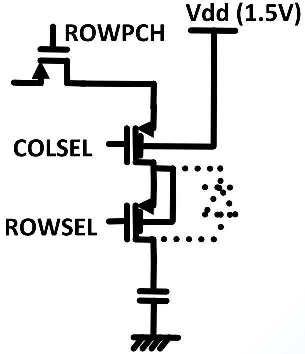
Gain encoding ambiguity

AGIPD 1.1

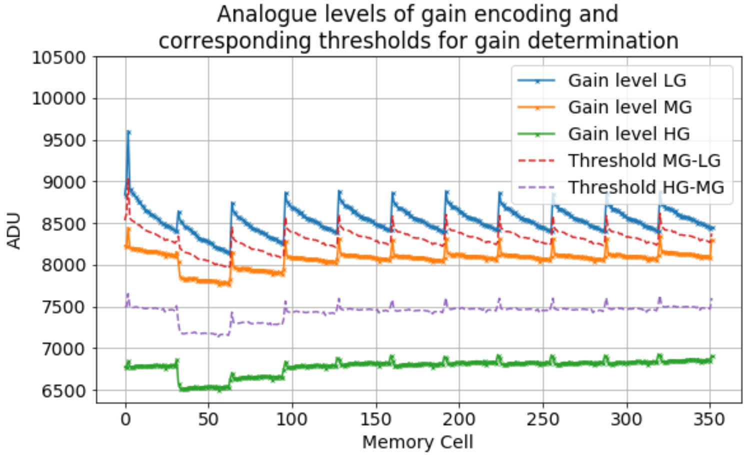


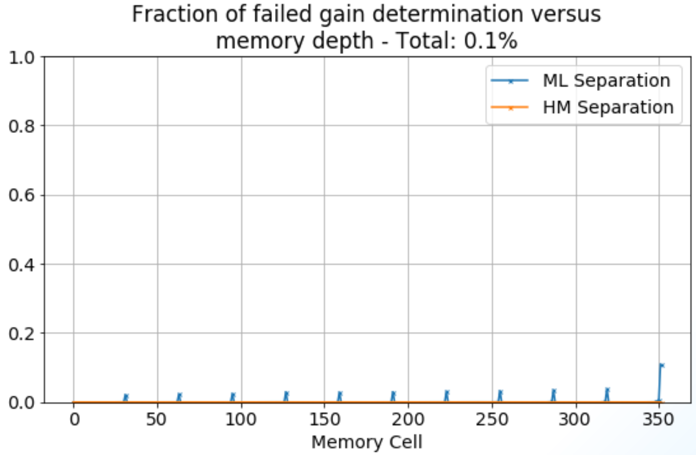


Memory cell of AGIPD 1.1
and all previous versions

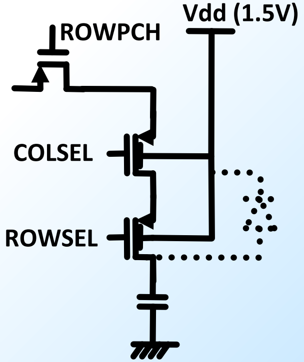


AGIPD 1.2





Memory cell of AGIPD 1.2,
AGIPD 0.6 and ecAGIPD (1.3)

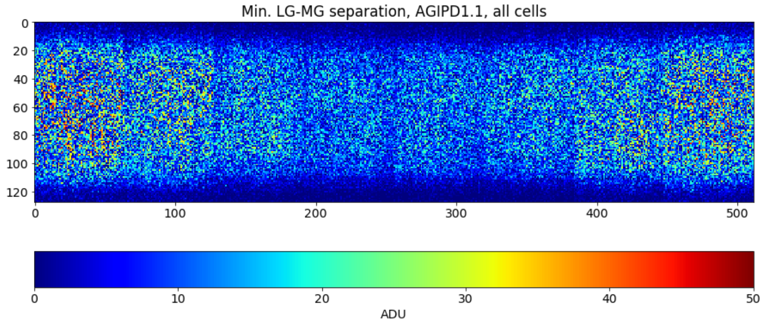


Gain encoding ambiguity

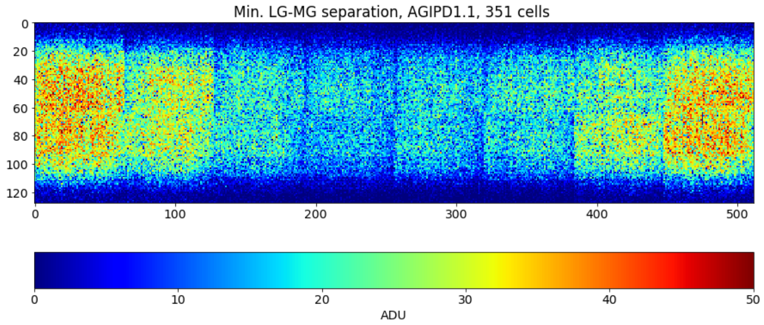
Temperature dependence and gain bit separation distribution over the tile

AGIPD1.1

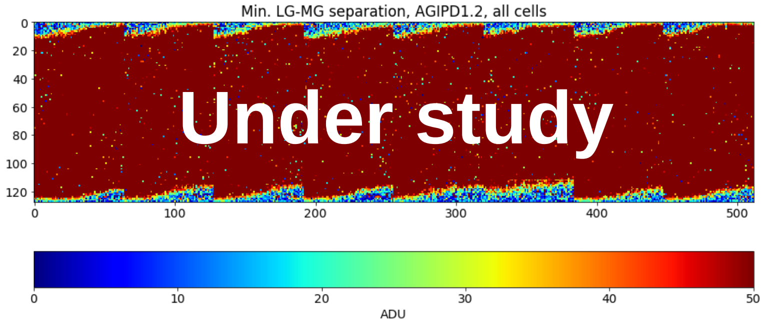
Cells [0..351]

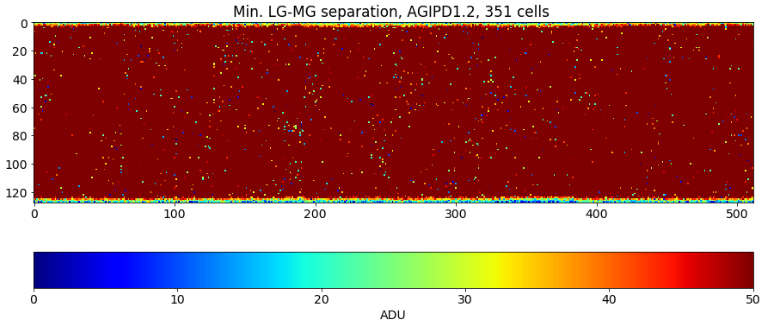


Cells [0..350]



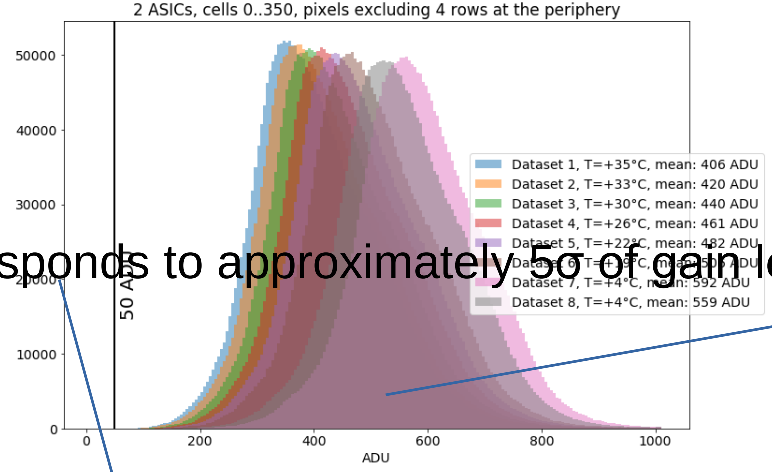
AGIPD1.2

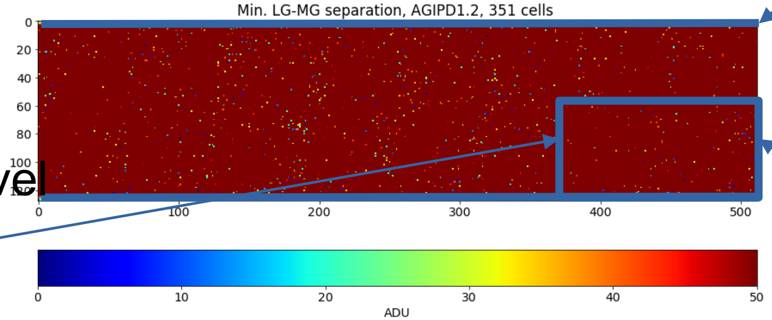




Gain encoding ambiguity

Temperature dependence and gain bit separation distribution over the tile



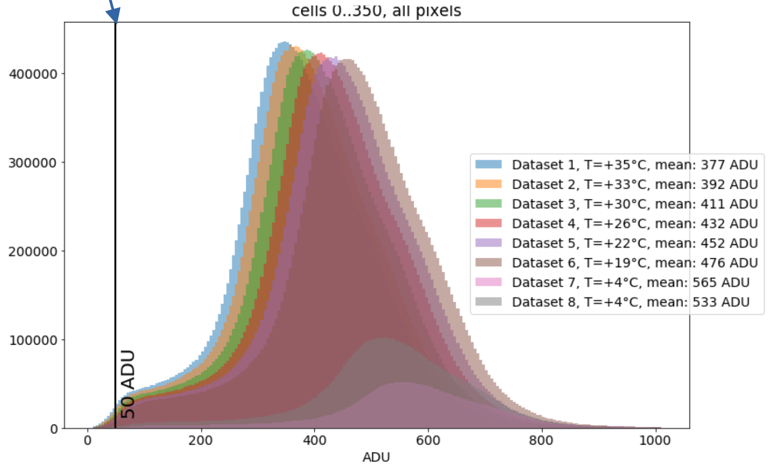


4 pixel rows

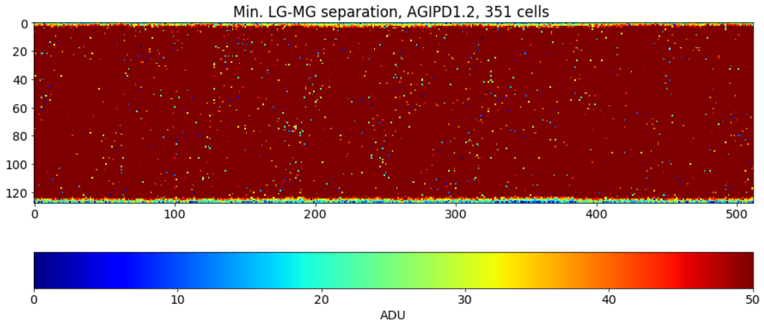
Only 2 ASICs

Cells [0..350]

corresponds to approximately 5σ of gain level noise



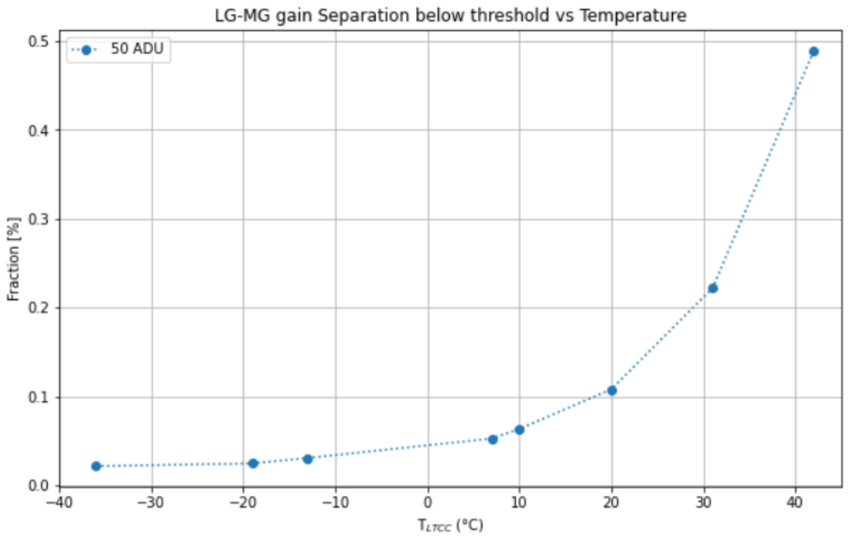
Cells [0..350]

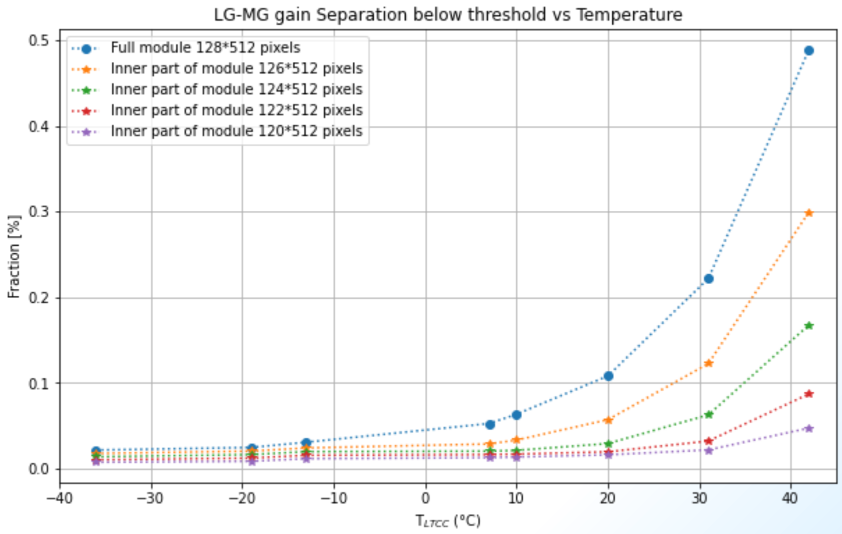


Gain encoding ambiguity

Temperature dependence and gain bit separation distribution over the tile

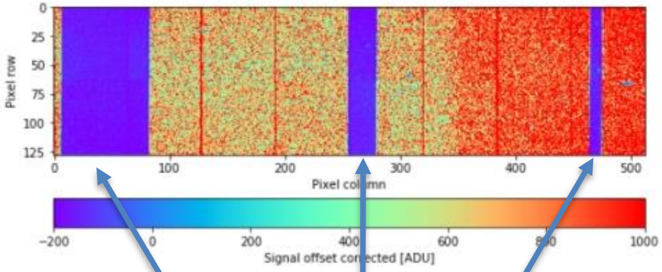
“Bad” pixels fraction



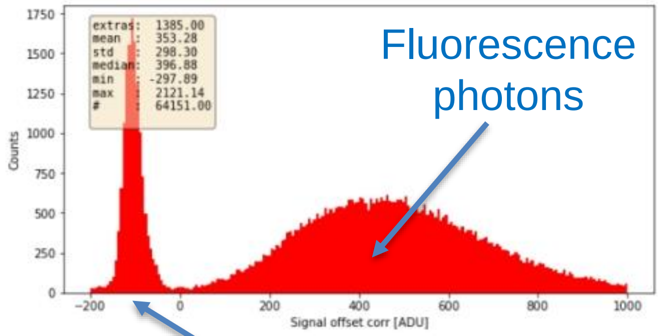


(Intensity-dependent) Baseline shift

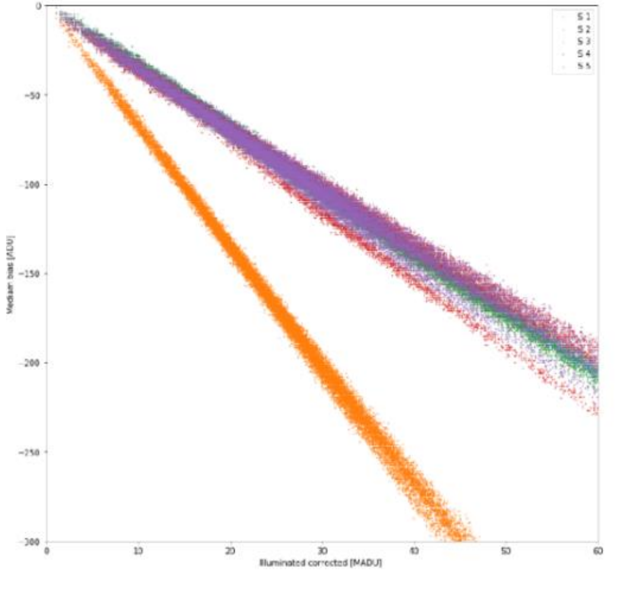
Example data: Cu-K$_\alpha$ flatfields



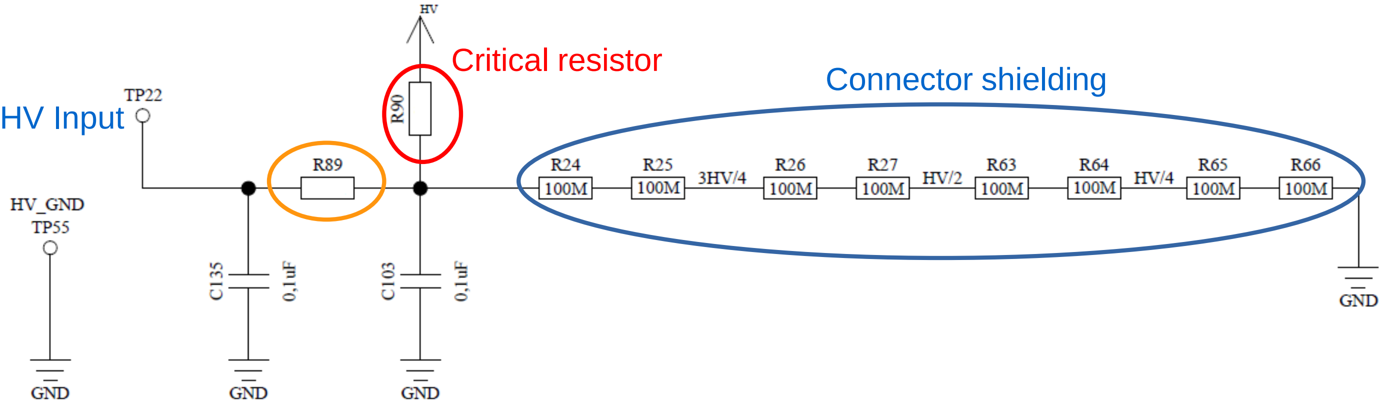
"Mask" stripes (SPB AGIPD1M)



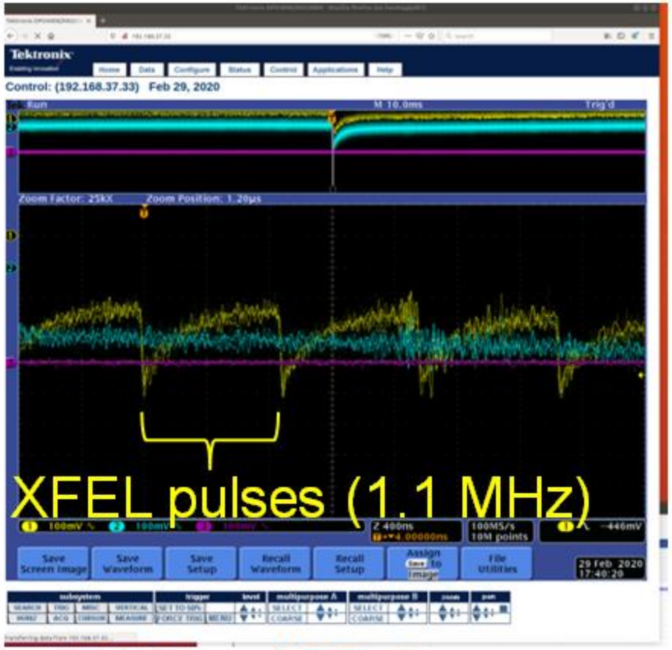
-100 ADU shift of zero-photon peak



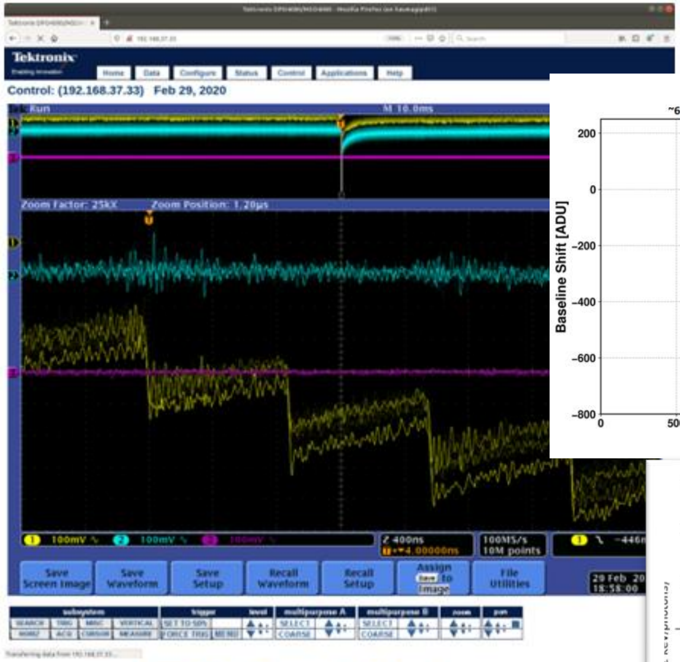
Baseline shift as a function of integrated intensity. Double size pixels are represented as orange points



(Intensity-dependent) Baseline shift

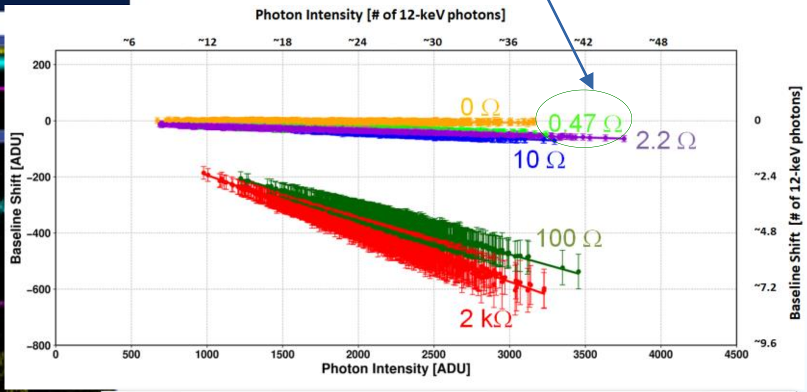


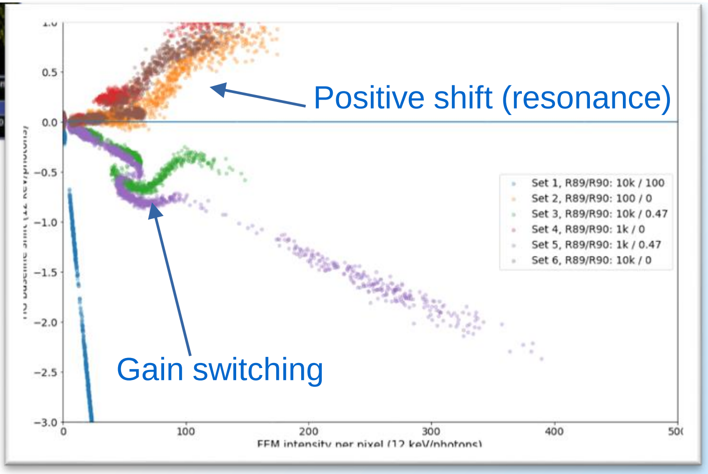
R90 = 100 Ω



R90 = 2kΩ

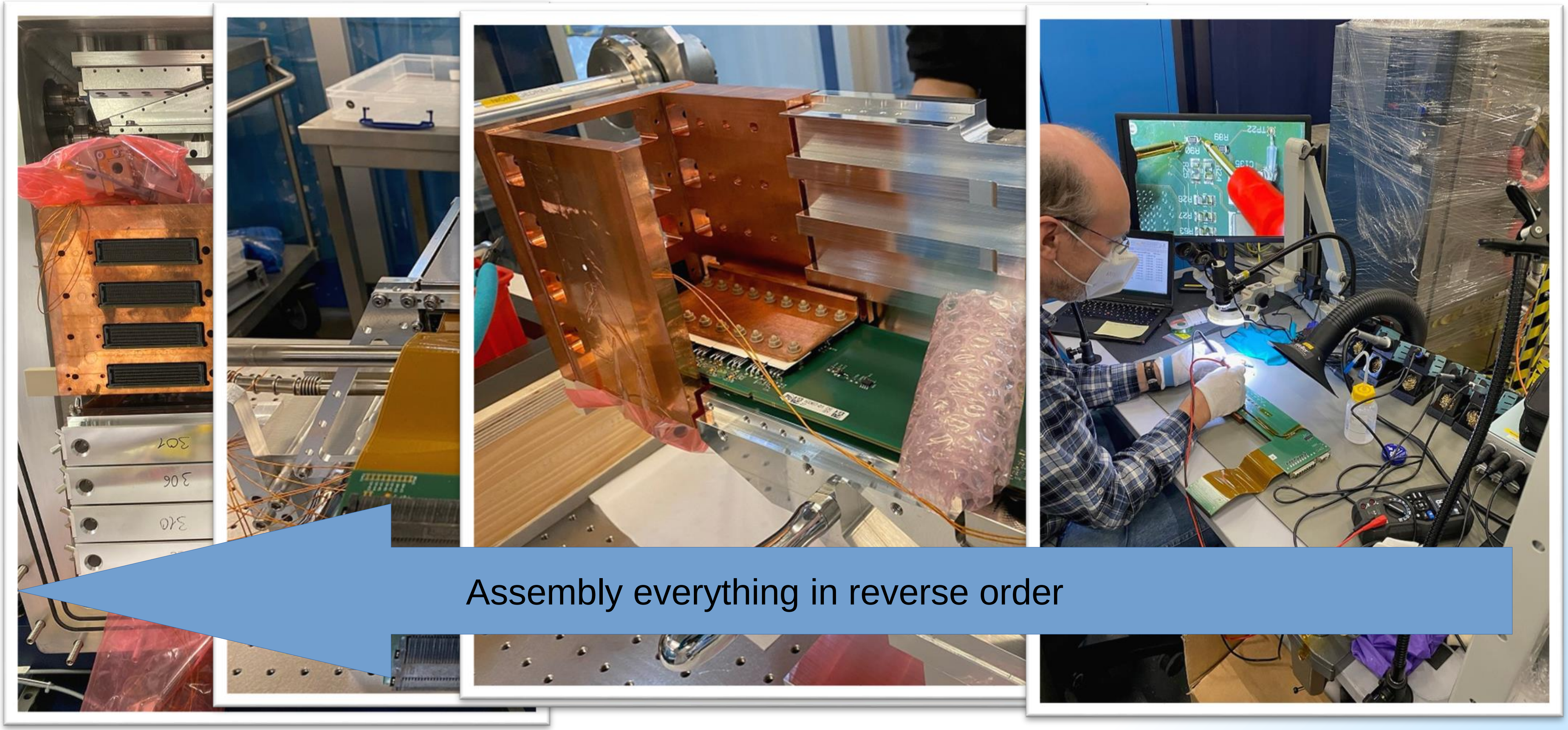
R90 value decision





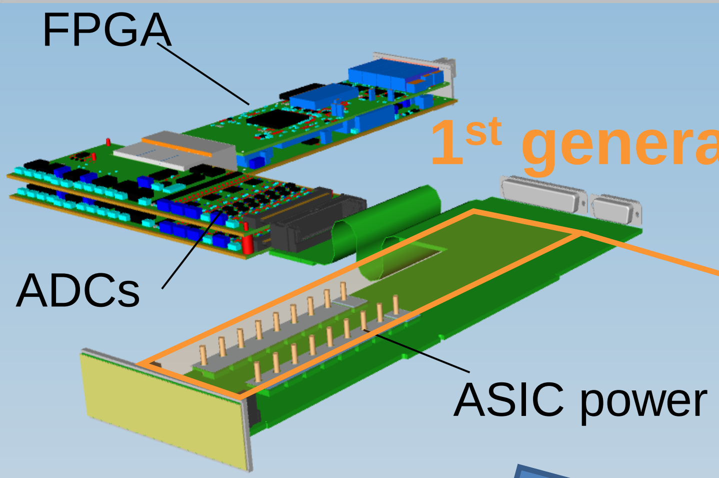
Experimental verification

(Intensity-dependent) Baseline shift



Assembly everything in reverse order

2nd Generation systems

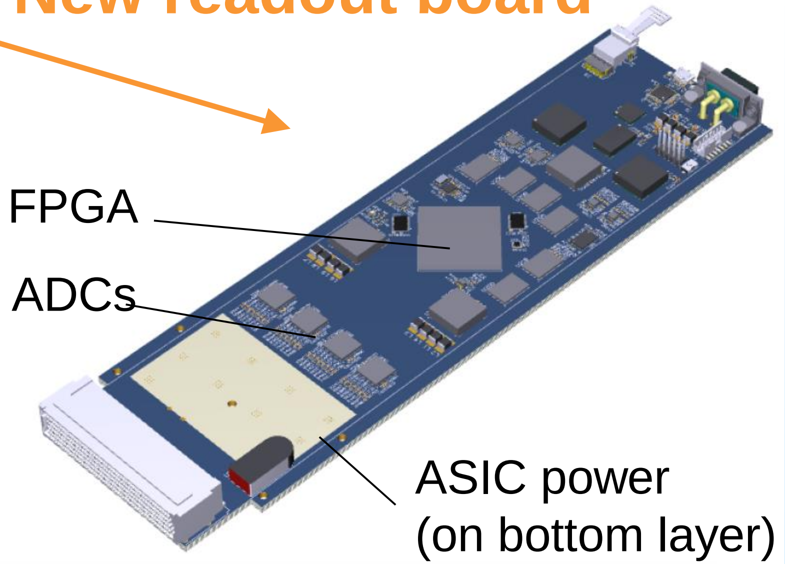


Size

Advantages

- Short analogue signal path
- Local DC/DC -> less power cables
- Control and DAQ completely based on optical data transmission

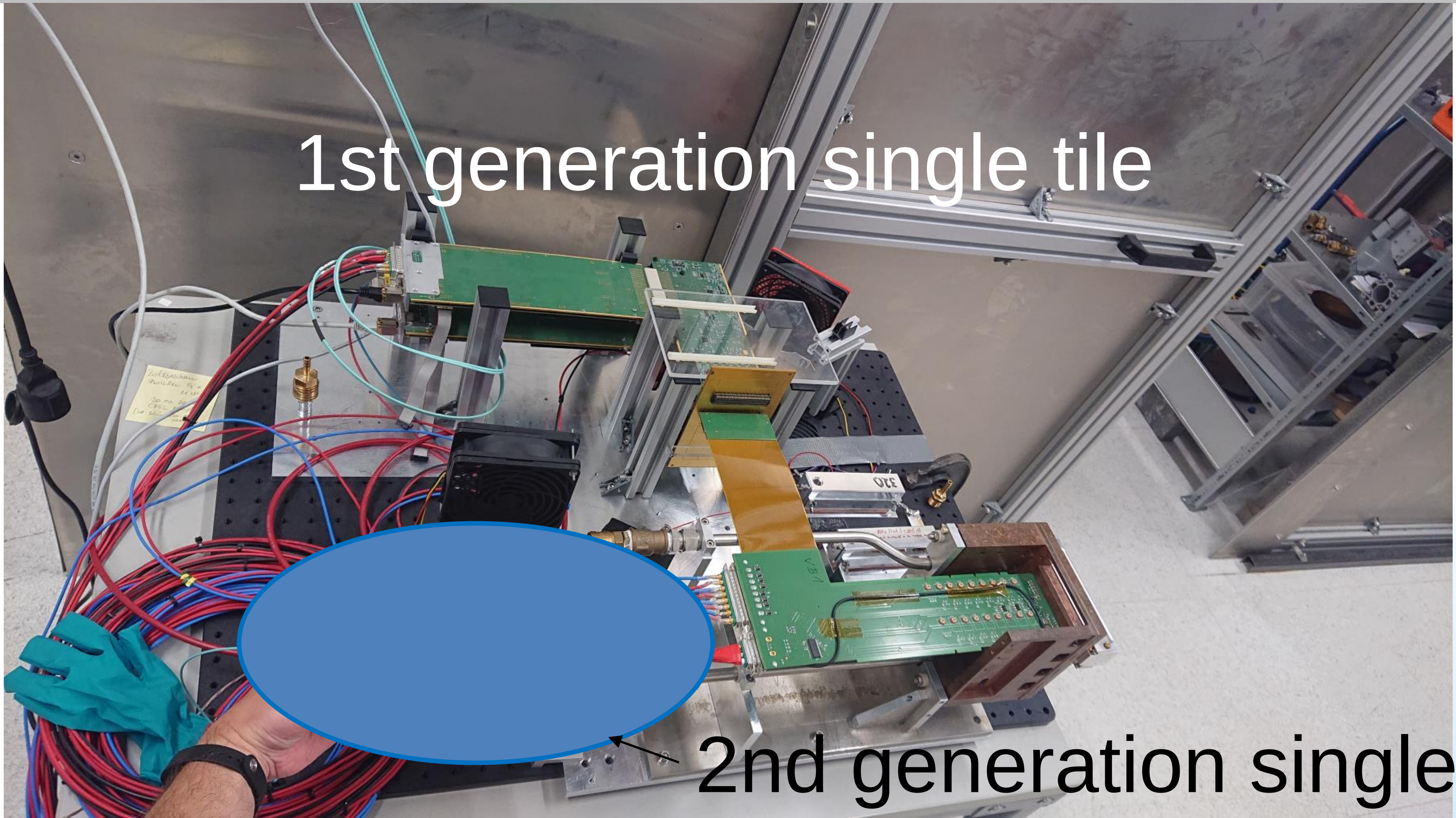
New readout board



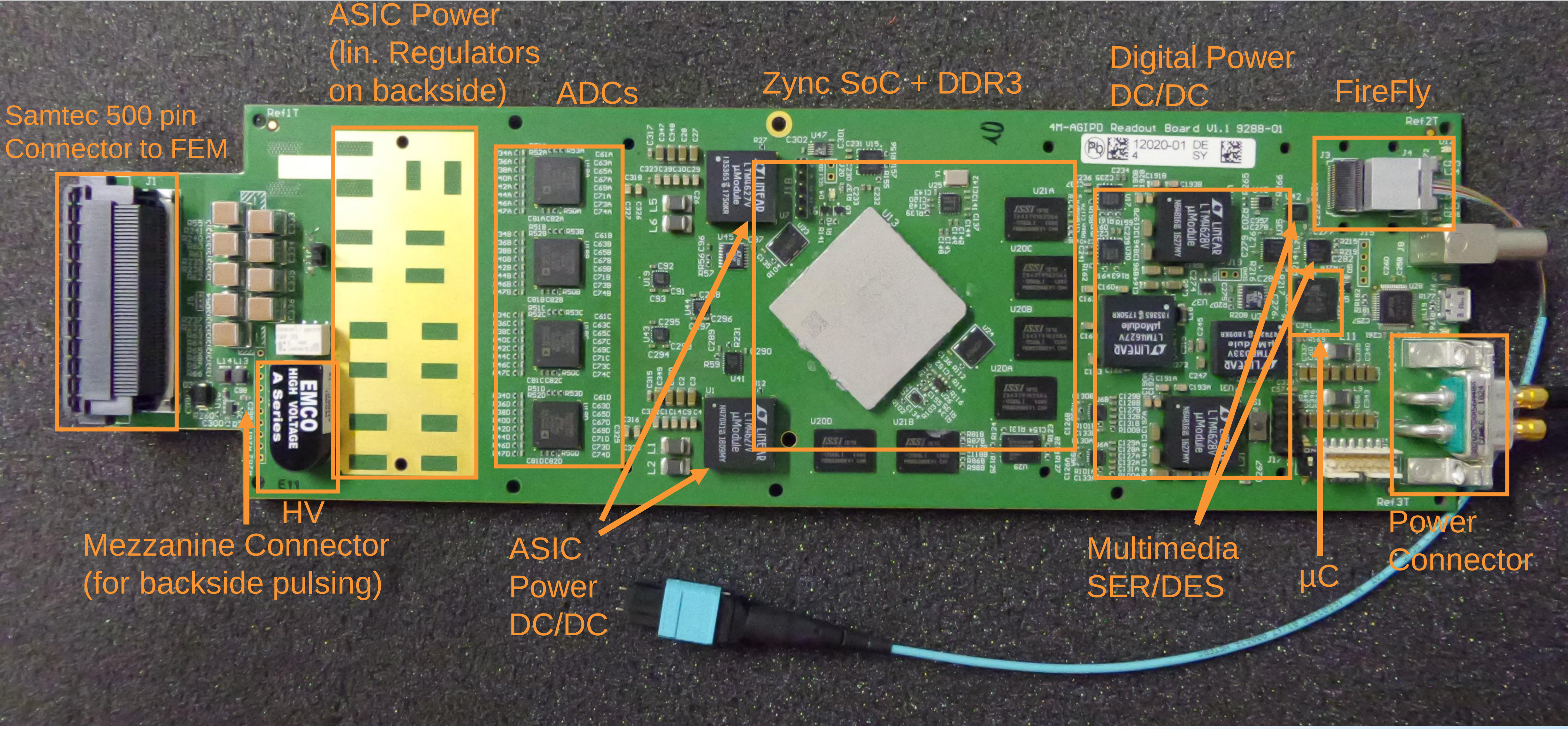
Challenges

- Complete redesign of the boards
  - Readout board in vacuum
  - Receiver board outside vacuum
- Cooling of readout board in vacuum

2nd Generation systems



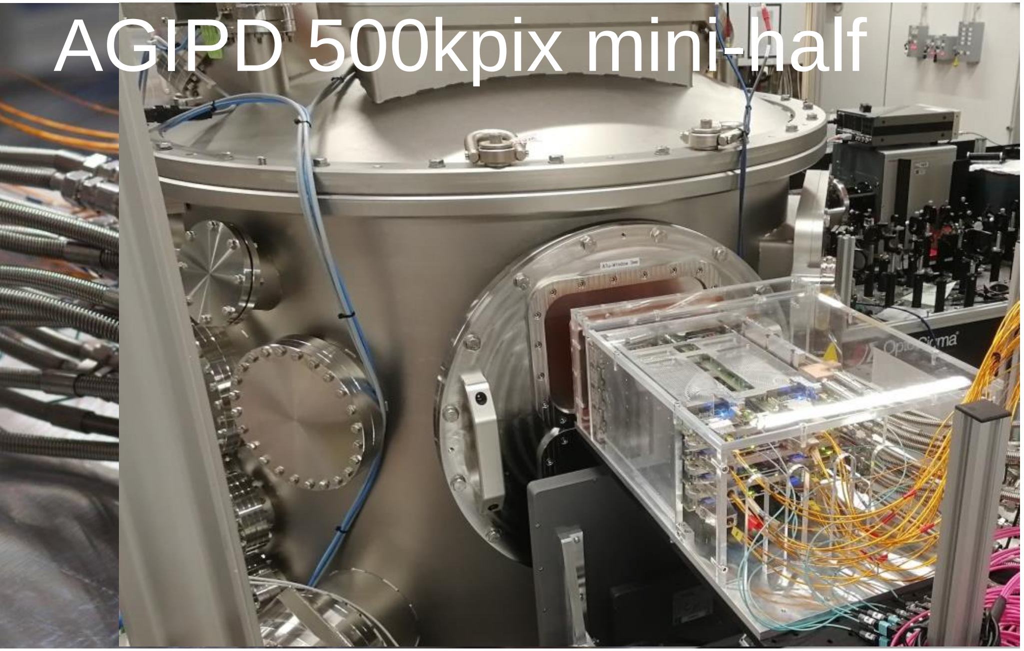
2nd Generation systems



2nd Generation systems

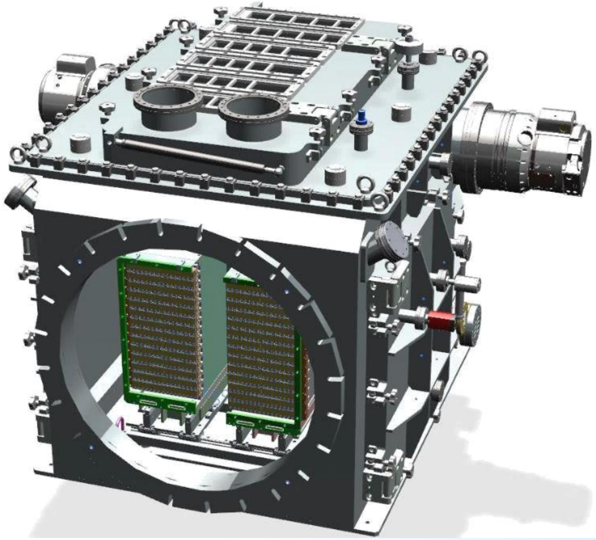
- 2 x 8 Front-End-Modules, arranged in
  - 2 x 4 Double-Modules
- Two halves
  - 2 x 8 FEMs each

(ecAGIPD used in final detector)



AGIPD 1M Detector for HiBEF

- 4 x 14 Front-End-Modules, arranged in
  - 2 x 14 Double-Modules
- Two halves
  - 2 x 14 FEMs each
  - Independent in-vacuum x-motion



AGIPD 4M for SFX instrument

Summary and outlook

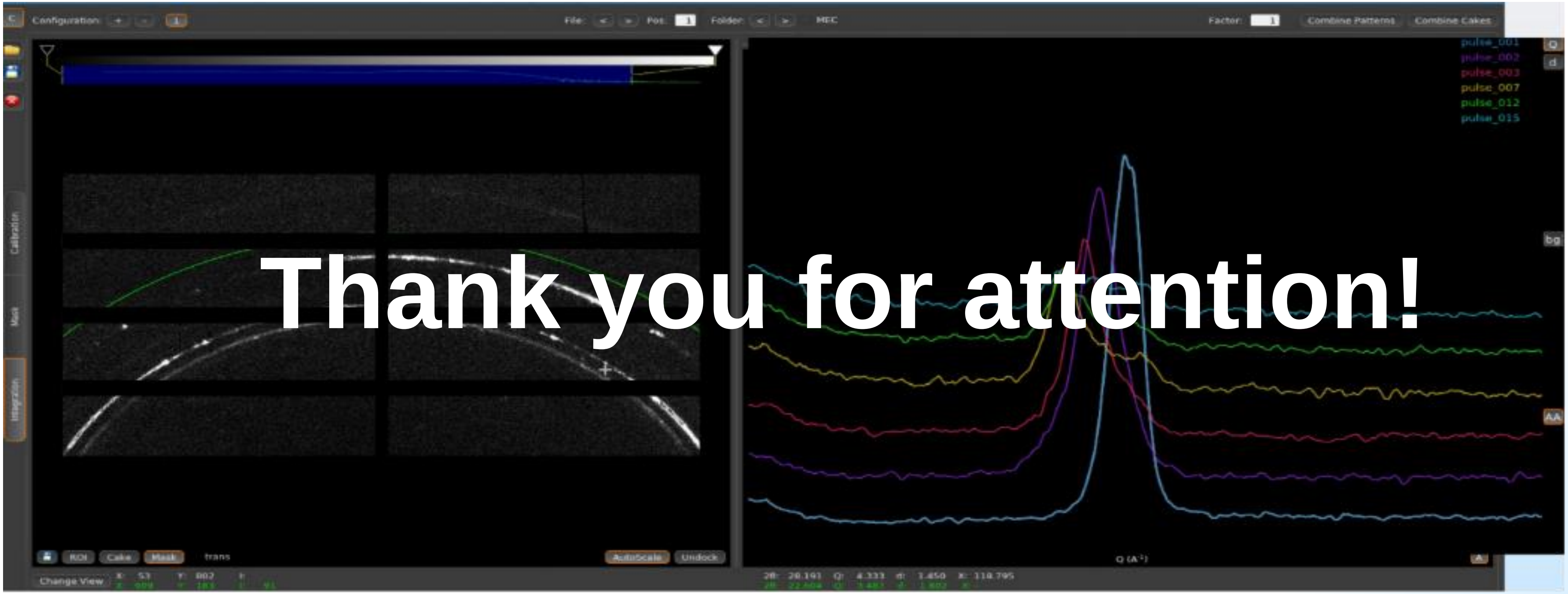
- AGIPD 1.2 ASIC is a validated solution against the gain bit ambiguity and new front-end modules are in production

- Major intervention is done on the AGIPD system at the SPB instrument in order to eliminate the baseline shift effect

- 1st generation systems hardware was upgraded

- 2nd generation systems are in production and already showed the potential of the scientific use

Summary and outlook



Thank you for attention!

Experiment Nov 2020: Single-train MHz-pulse-resolved diffraction data from X-ray (and laser-) heated Platinum in diamond-anvil cells, intra-train thermal peak shift and melting