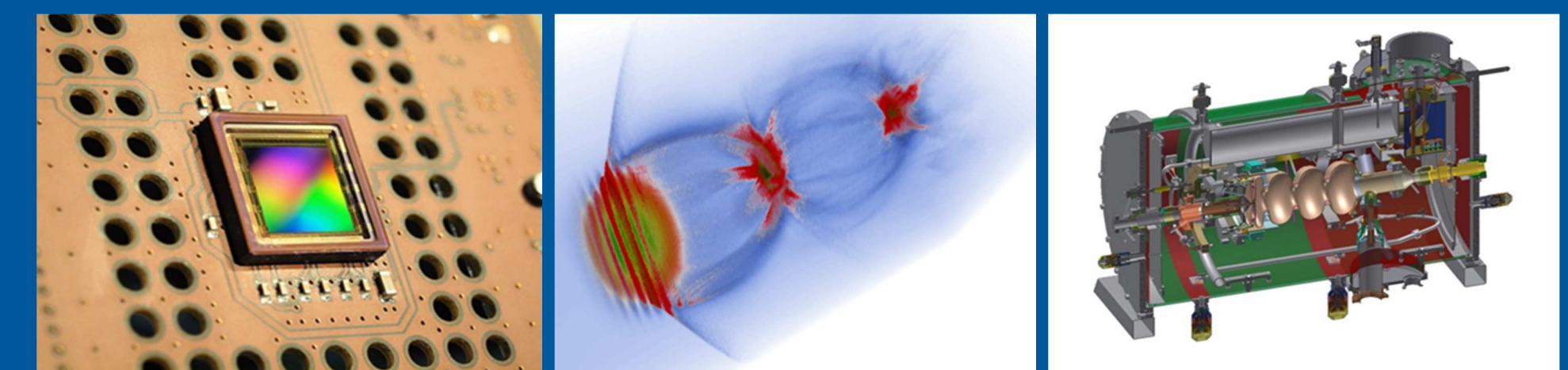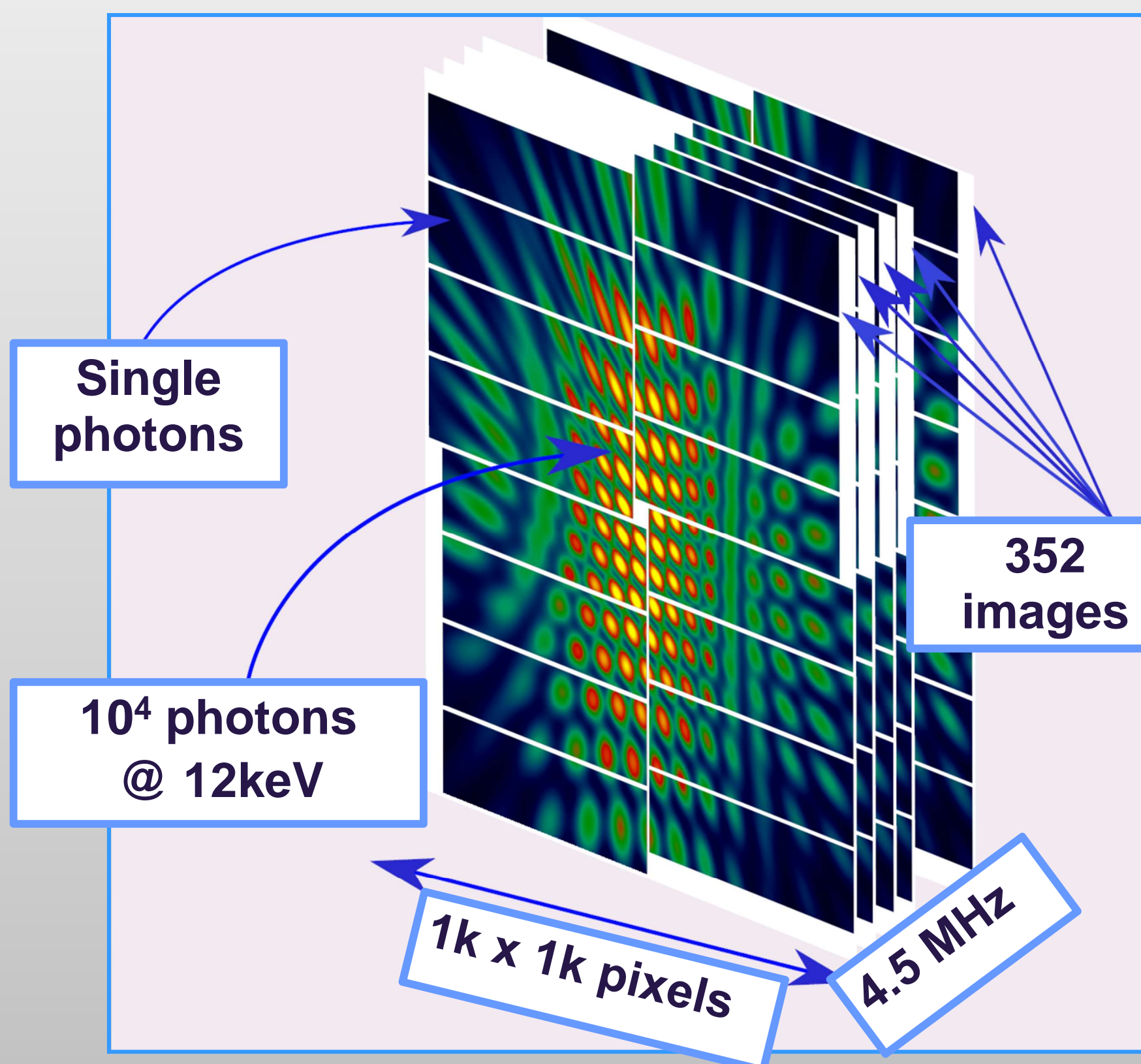# The Adaptive Gain Integrating Pixel Detector (AGIPD)

A fast high dynamic range camera for the European XFEL
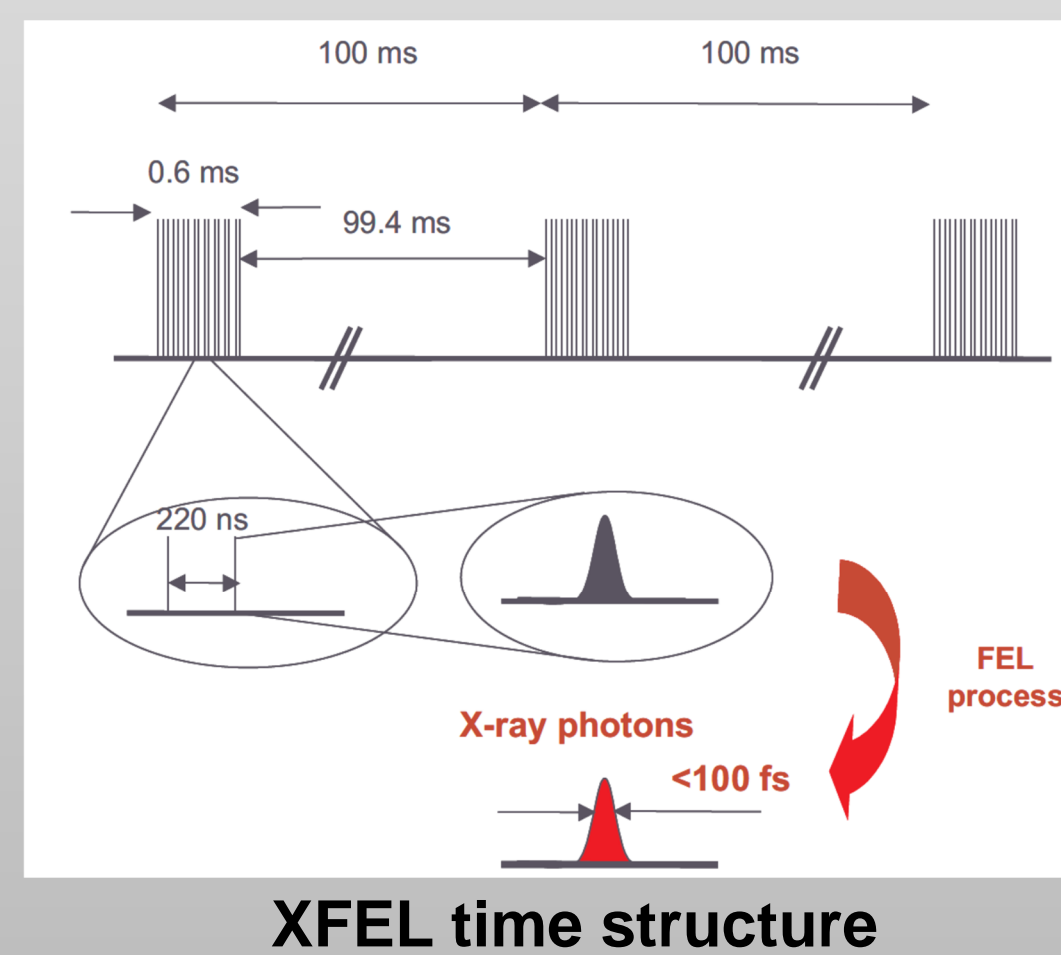
Julian Becker (DESY)

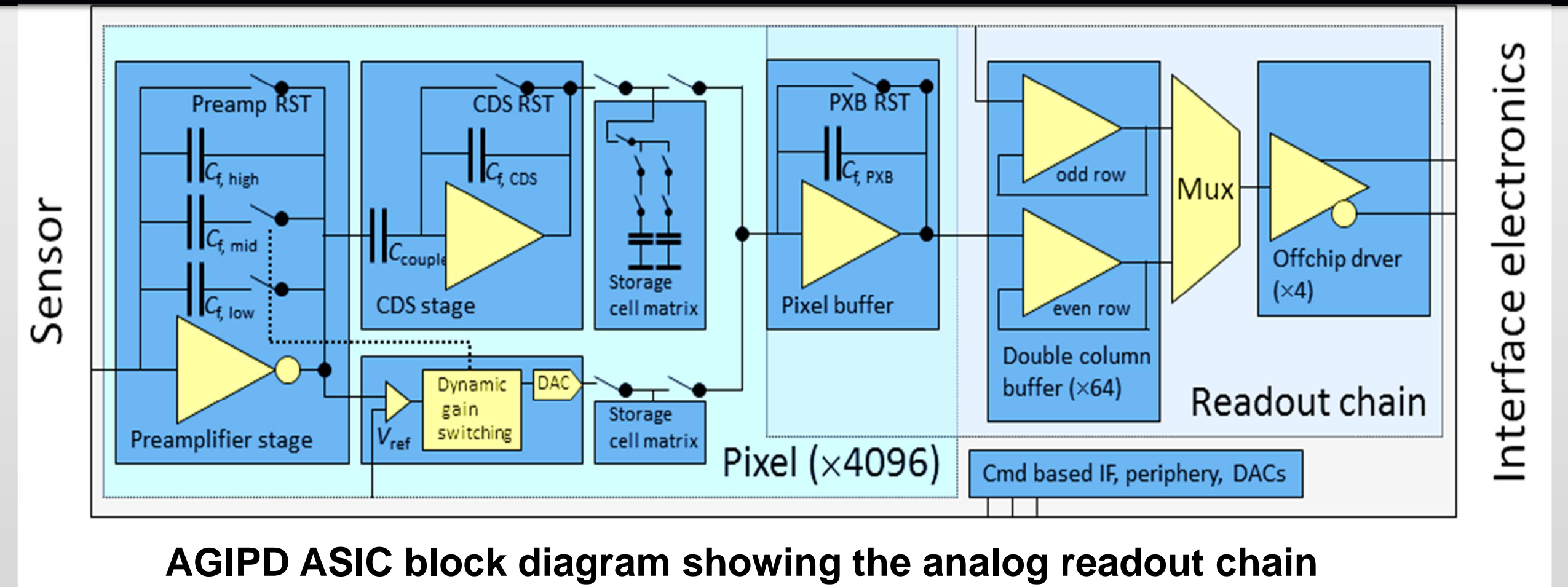## European XFEL detector requirements



*Detector features:*

- 500 µm thick silicon sensor for high quantum efficiency at 12 keV
- Radiation hard design
- 200 µm square pixels
- External veto capability
- Vacuum compatibility with hole

Single photons

$10^4$ photons @ 12keV

352 images

1k x 1k pixels    4.5 MHz

**XFEL time structure**

## ASIC design



**AGIPD ASIC block diagram showing the analog readout chain**
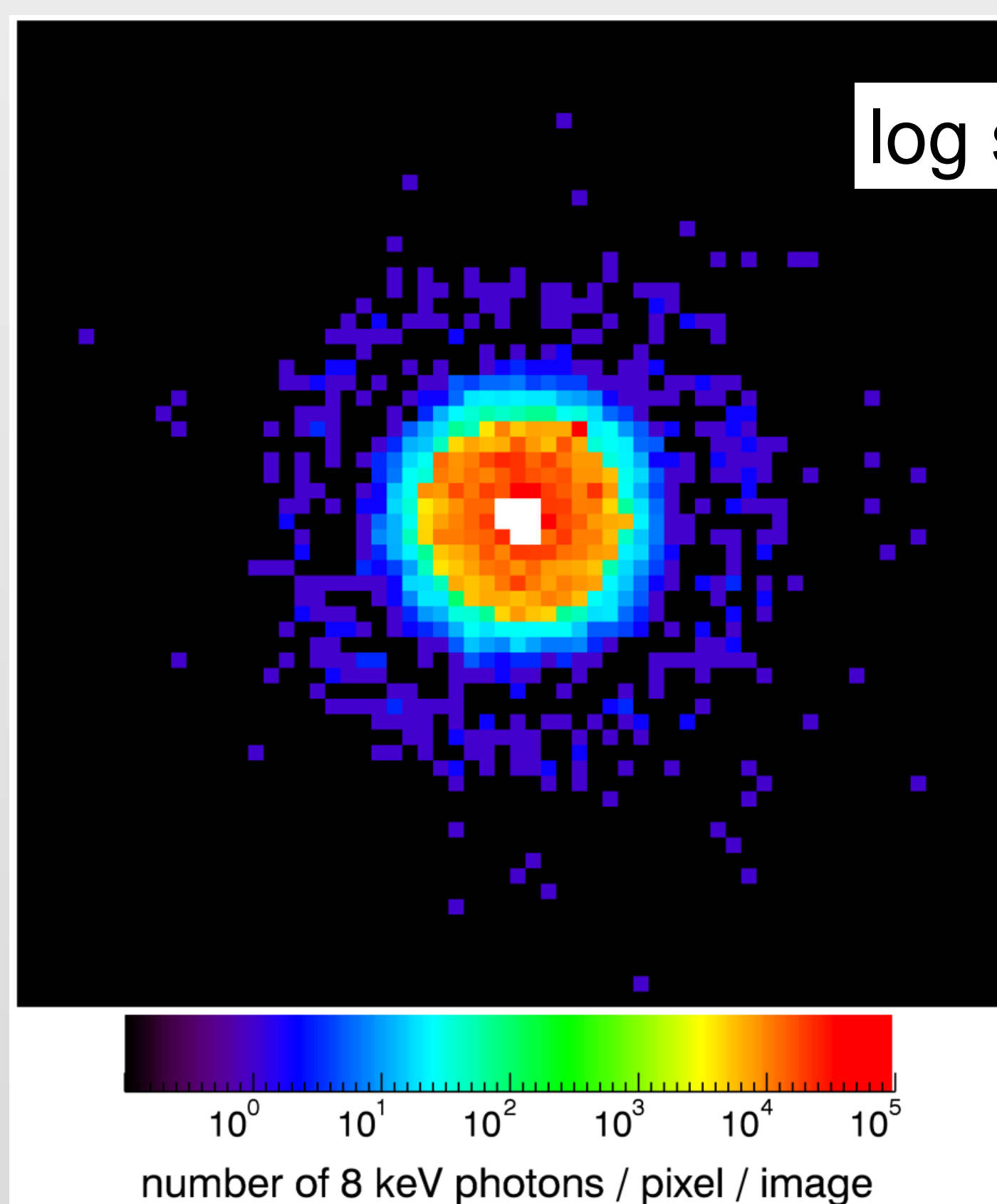
*Key features:*

- Preamplifier with adaptive gain to lower sensitivity and increase dynamic range once a threshold is crossed.
- Correlated Double Sampling (CDS) stage to remove reset noise and reduce low frequency noise.
- Analog memory (RAM) storing 352 images.
- Read out of stored signals in between the bunch trains

**AGIPD1.0 single chip assembly**

## Beamline tests

### Single shot        ### Average of 8500 shots

log scale



number of 8 keV photons / pixel / image

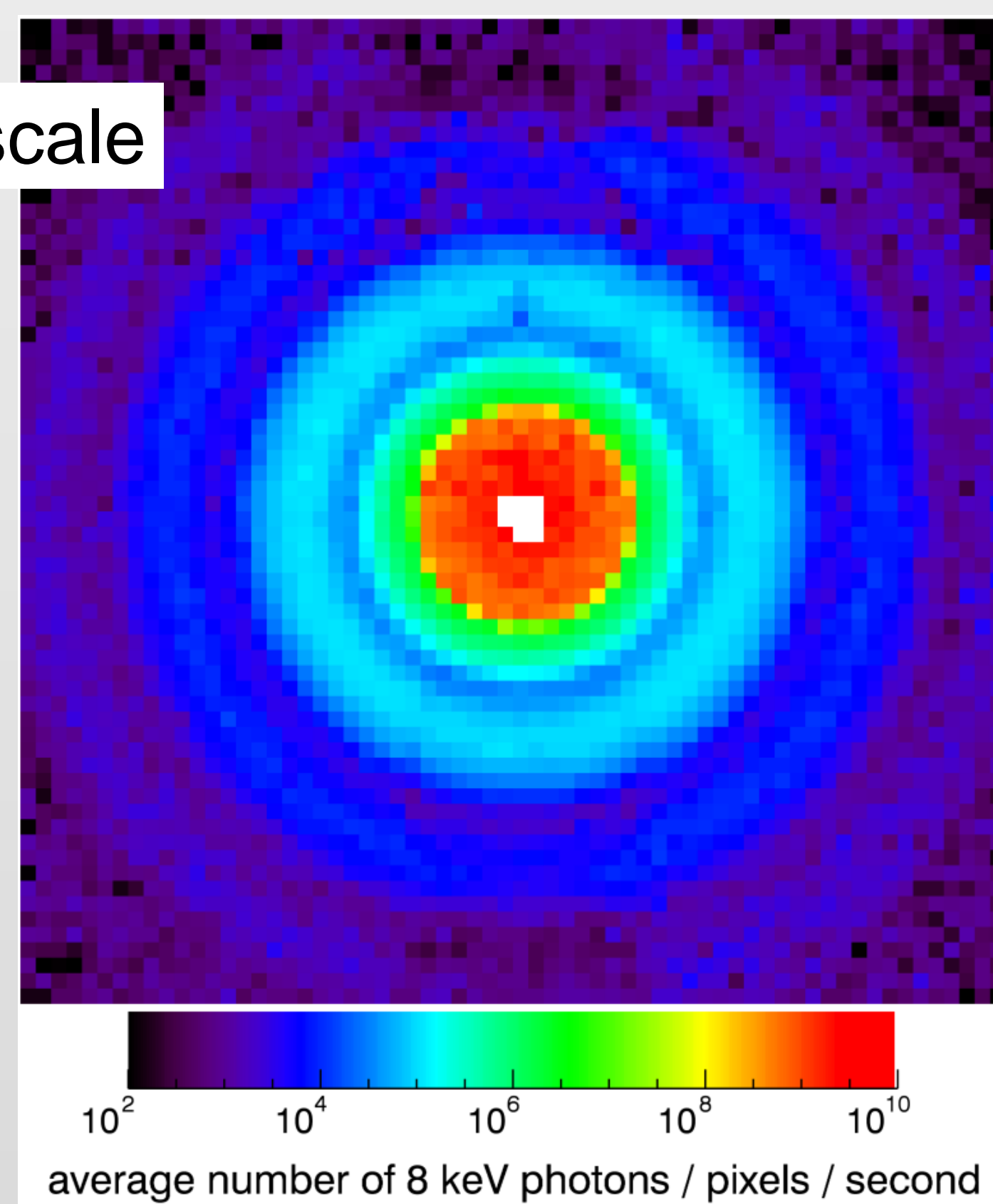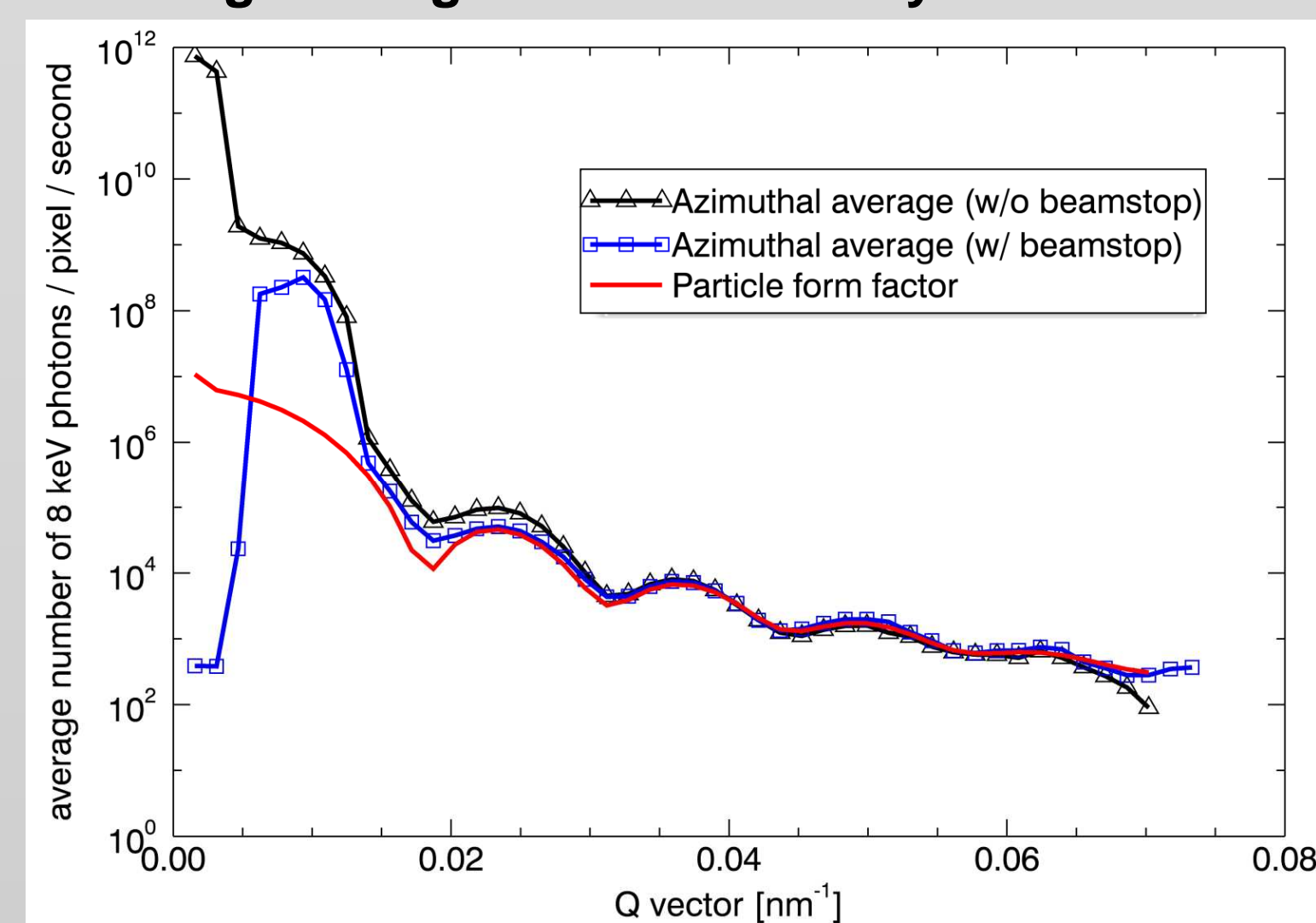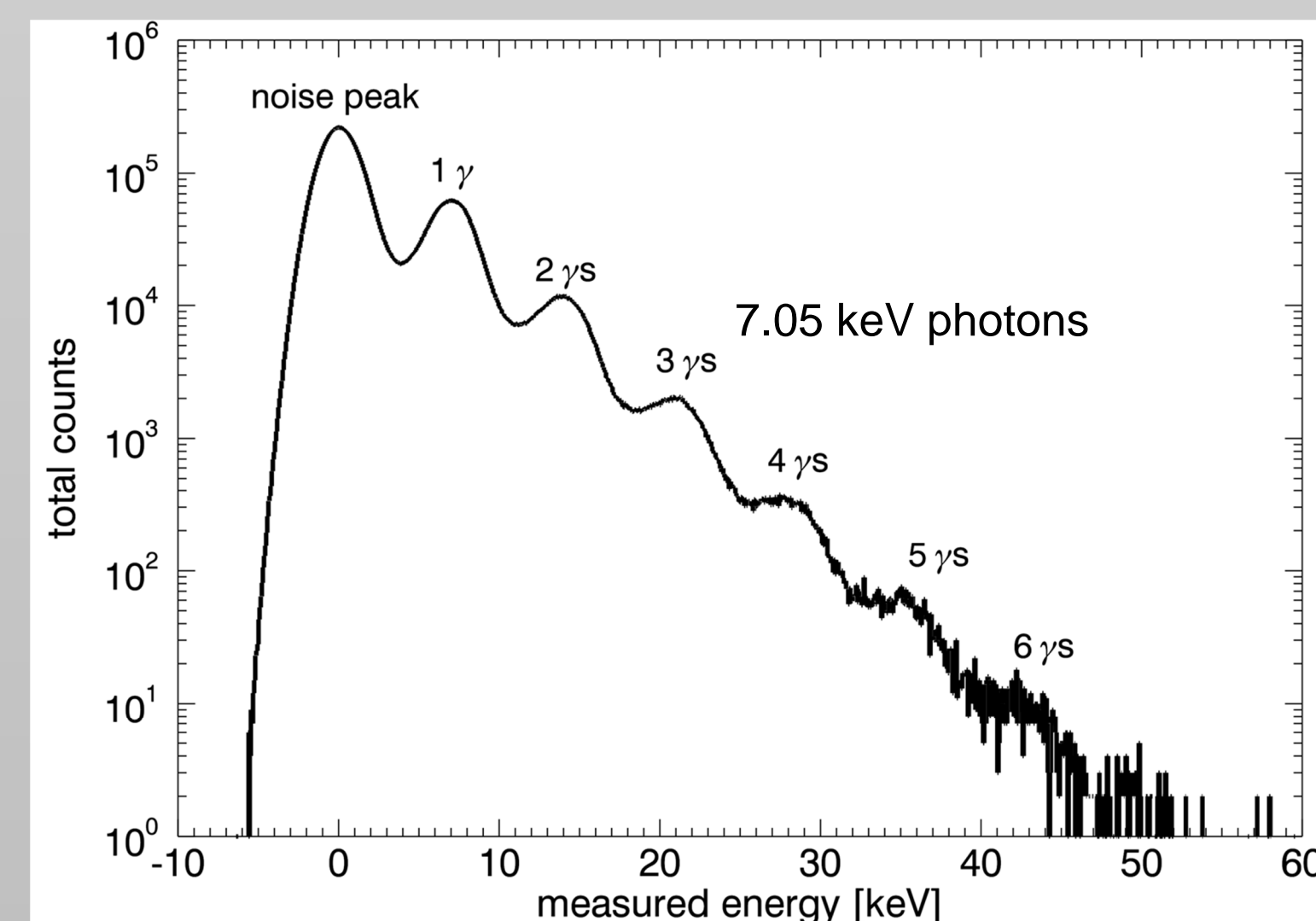average number of 8 keV photons / pixels / second

**Image of a colloidal sample, left single image, right time average. Zero photons are encoded as black. Each image contains pixels in all three gain stages simultaneously**



- Azimuthal average (w/o beamstop)
- Azimuthal average (w/ beamstop)
- Particle form factor

**Azimuthal average of the above. Excess of photons from direct beam and halo**



- AGIPD1.0 tested at PETRA III
- Sufficiently radiation hard to be used at synchrotrons without beam stop
- Dynamic range from single photons to more than $10^4$ 12 keV photons per pixel per image
- Ability to detect single photons demonstrated for 7.05 keV photons
- Possibility of imaging individual photon pulses of PETRA III in 40 bunch mode (5.2 MHz pulse frequency)
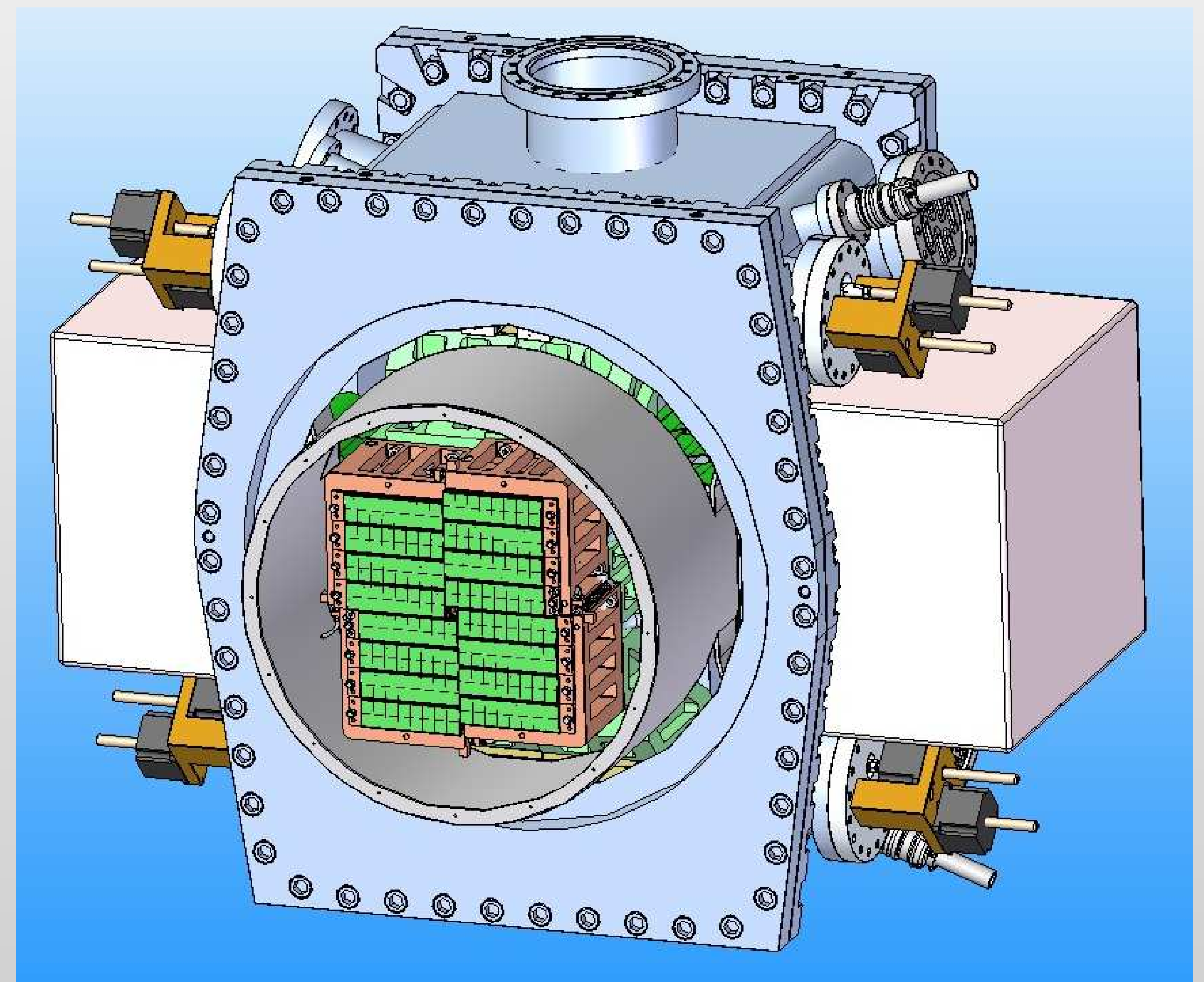
noise peak

$1\gamma$

$2\gamma$s

$3\gamma$s

7.05 keV photons

$4\gamma$s

$5\gamma$s

$6\gamma$s

**Single pixel data. Mean intensity of 0.3 photons per 200 ns (image) => 1.5 Mcps/pixel => 37.5 Mcps/mm², 320 electrons rms noise**

## Detector layout and mechanics



**Mechanical layout of an AGIPD 1M detector. Image plane will stick out of the detector vacuum vessel, indicated by the gray cylinder protruding from the light blue vacuum tank.**

- AGIPD 1M will be used at the SPB and MID beamlines of the European XFEL
- 4 independently movable quadrants
- Arbitrary hole sizes up to (25 mm)²
- Sticking out of vessel
- External electronics in adjoining environments (left and right boxes).

- Each module (green rectangle) is basically an independent detector unit
- A module consists of 2 x 8 ASICs, bump bonded to the monolithic pixelated silicon sensor.
- Modules can be replaced from the front without dismantling the detector

## Summary

- Pixelsize (200 µm)²
- 500 µm sensor thickness
- Single photon sensitivity
- Dynamic range >$10^4$ 12 keV photons
- Memory for 352 images

- Veto and trigger capabilities
- Imaging at 5.2 MHz possible
- Single modules available mid 2014
- 1M system available early 2015

The project is a collaboration with PSI, Uni-HH and Uni-Bonn

DESY · JÜLICH FORSCHUNGSZENTRUM · HI Jena Helmholtz Institute Jena · HIM Helmholtz Institute Mainz · HZB Helmholtz Zentrum Berlin · HZDR · KIT Karlsruhe Institute of Technology · GSI

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