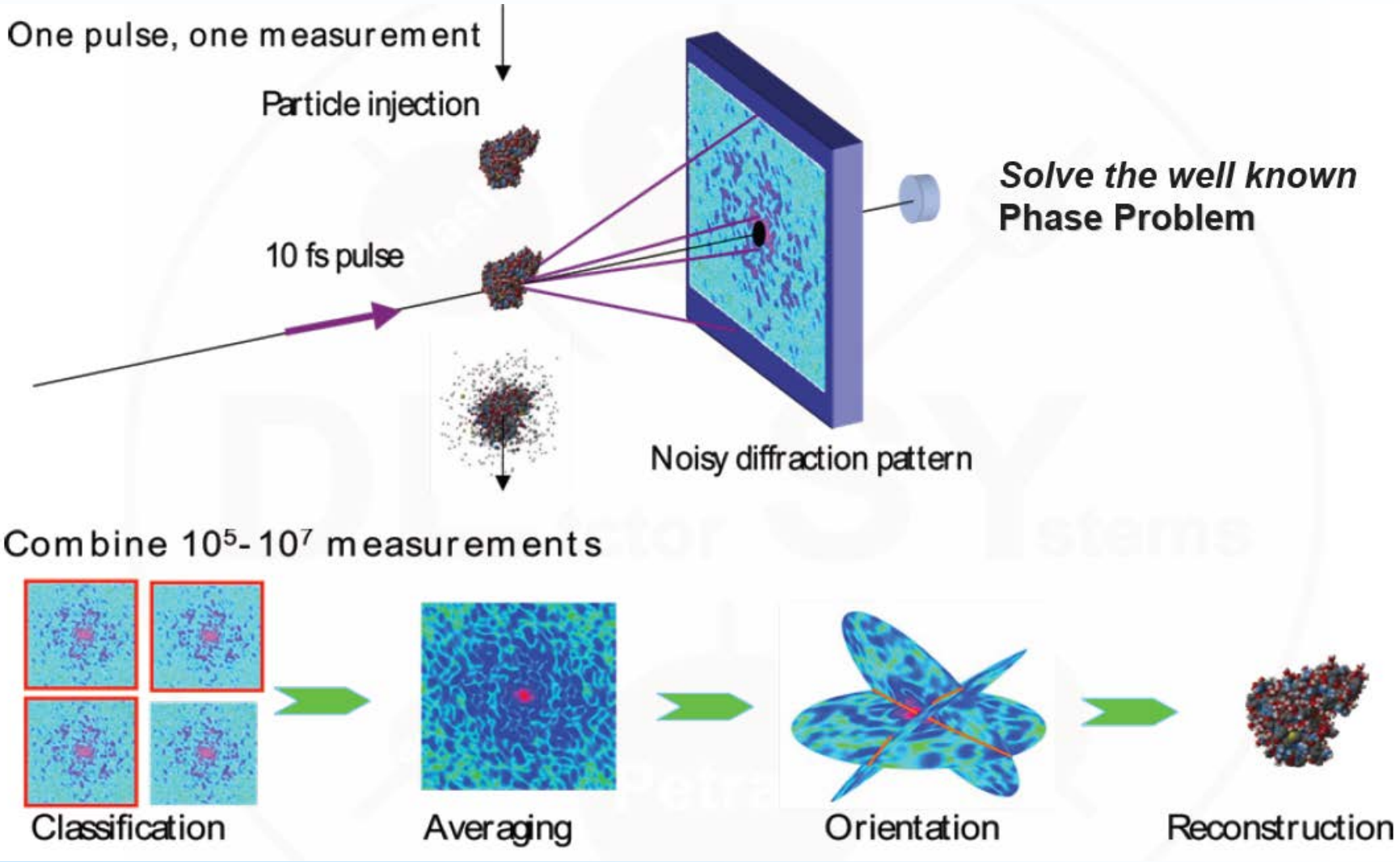
The Adaptive Gain Integrating Pixel Detector (AGIPD) Project

Heinz Graafsma, DESY

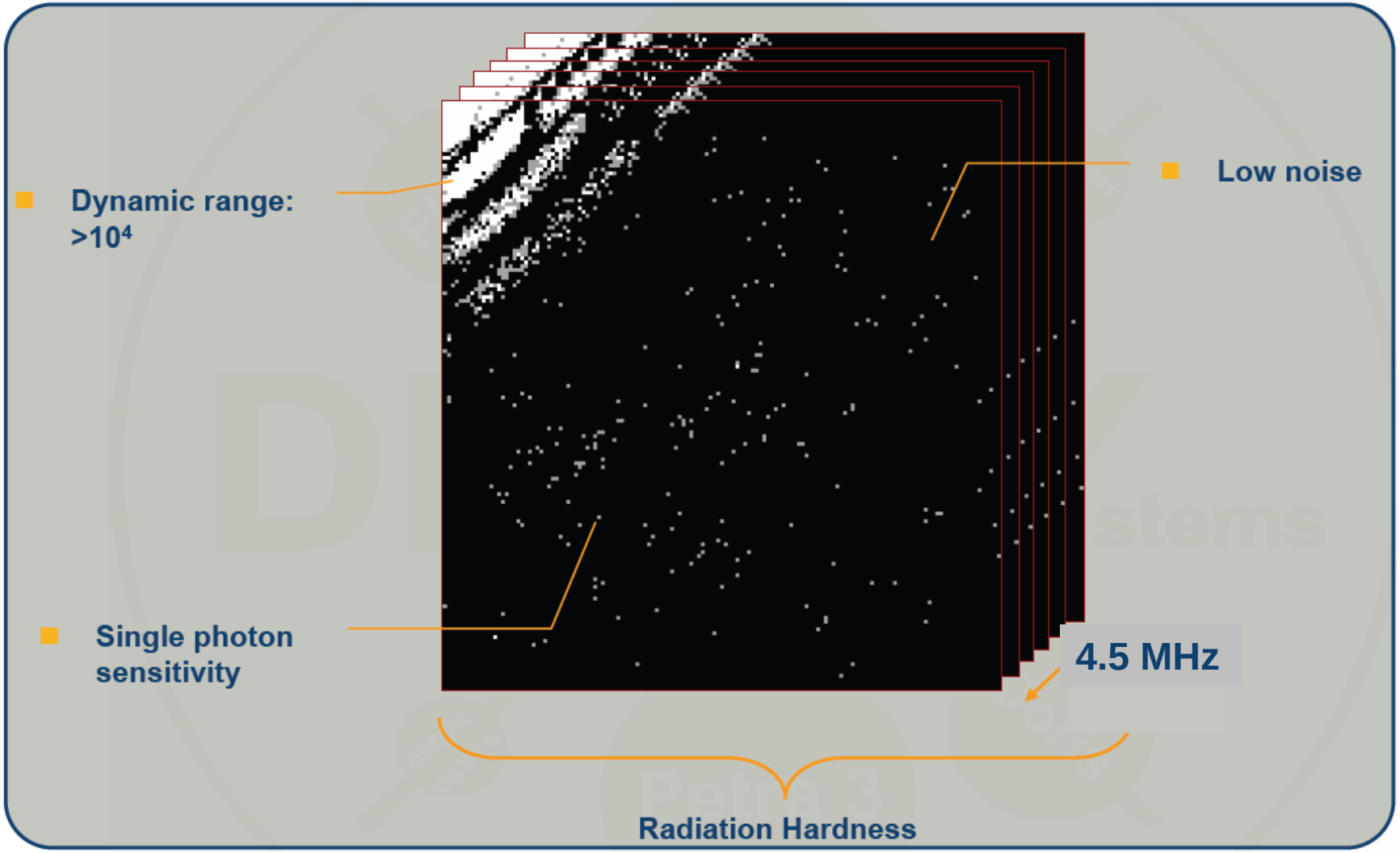
on behalf of the AGIPD-Consortium

What is the Goal ?

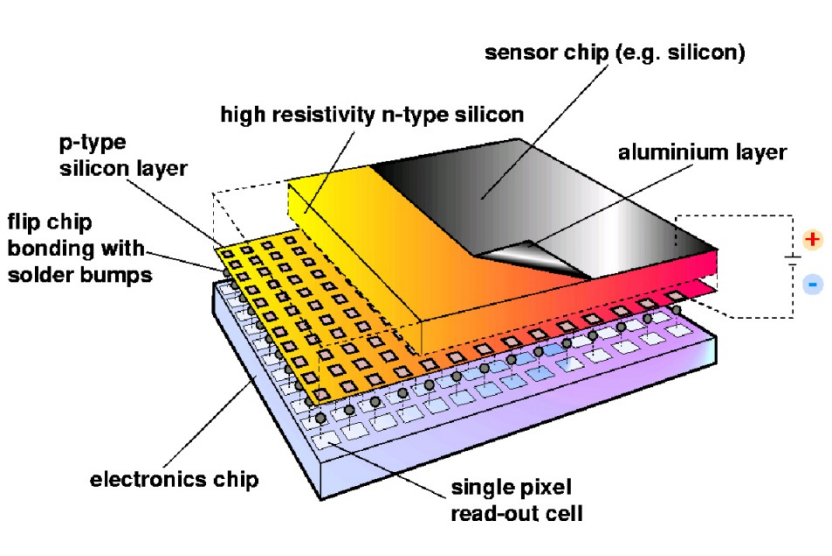


K. J. Gaffney and H. N. Chapman, *Science*
8 June 2007

What are the Challenges ?

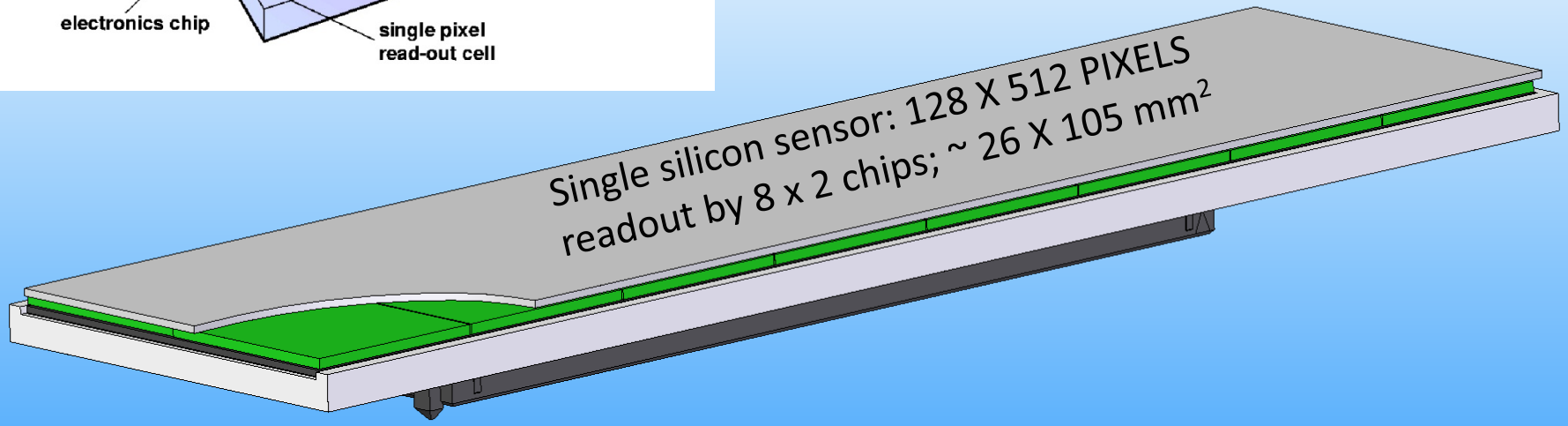


Hybrid Pixel Array Detectors



Pixellated Silicon Sensor:
absorbs photons and produces electrical signal

Pixellated readout chip (ASIC):
Processes signal produced in sensor and sends data out



Chip carrier board to talk to and readout chips

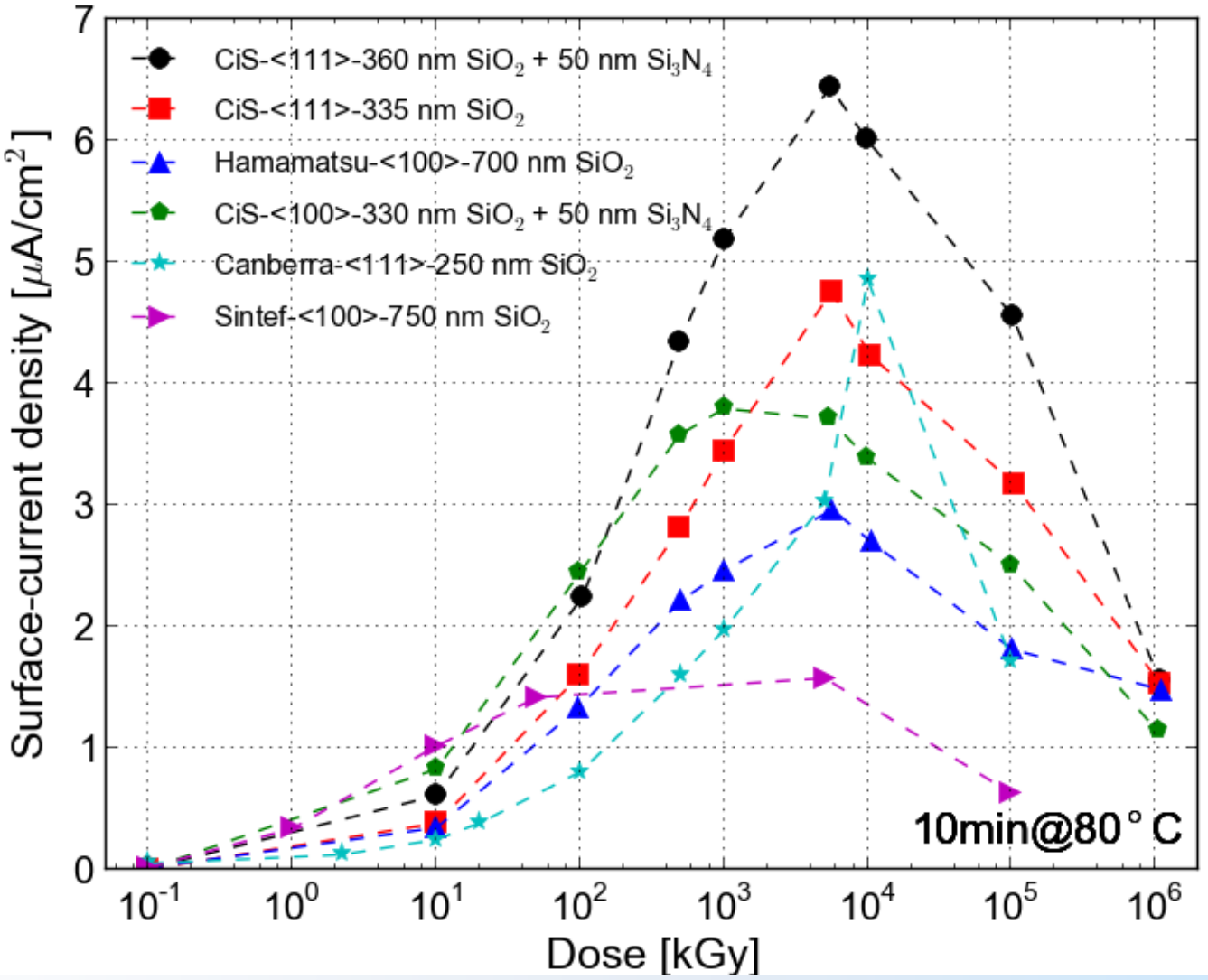
Radiation hardness sensor

- No bulk damage expected for 12 keV (<300 keV)
- Surface and interface damage:

➔

- Higher leakage current

Radiation hardness sensor



Radiation hardness sensor

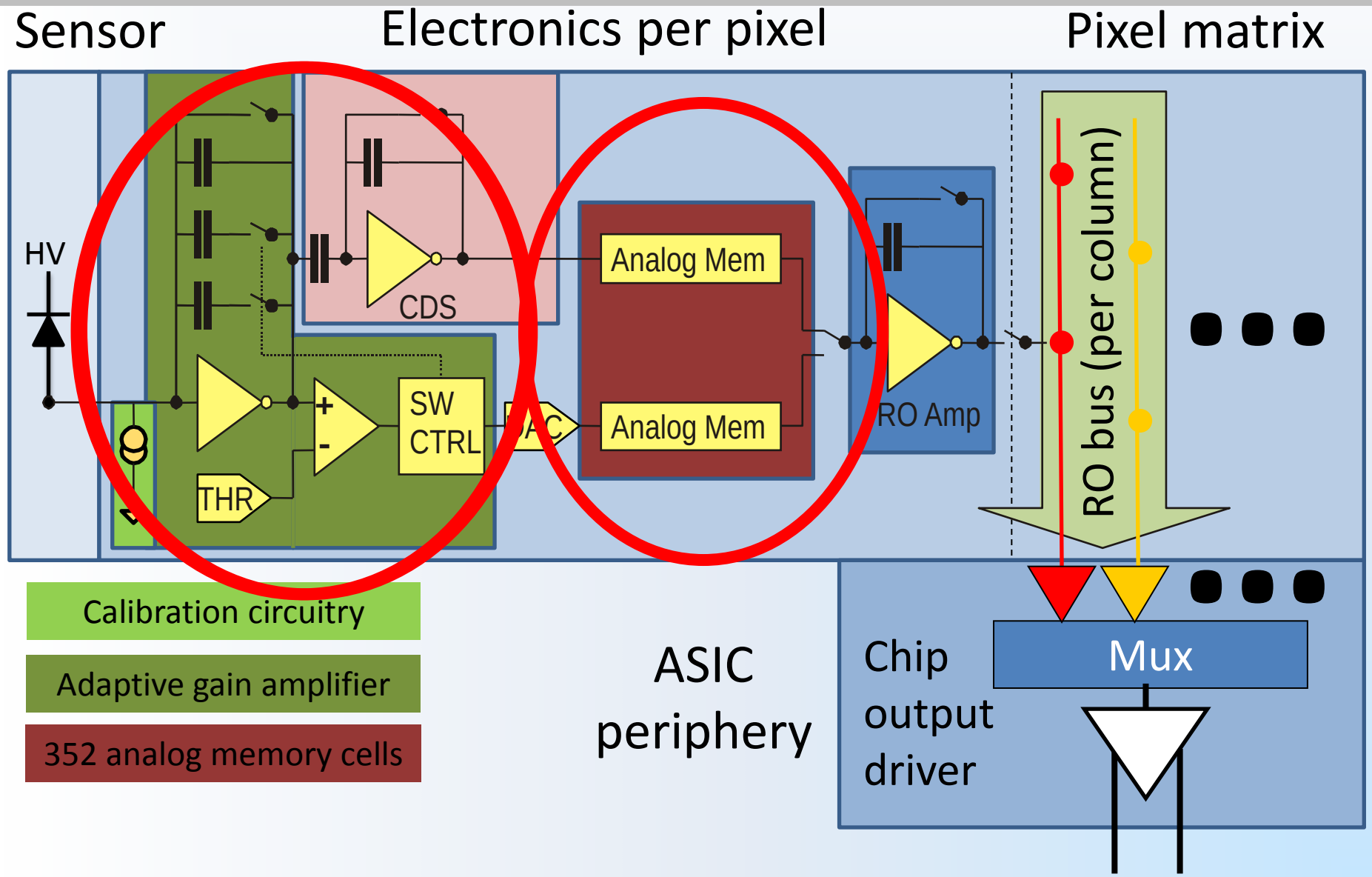
- No bulk damage expected for 12 keV (<300 keV)
- Surface and interface damage:

➔

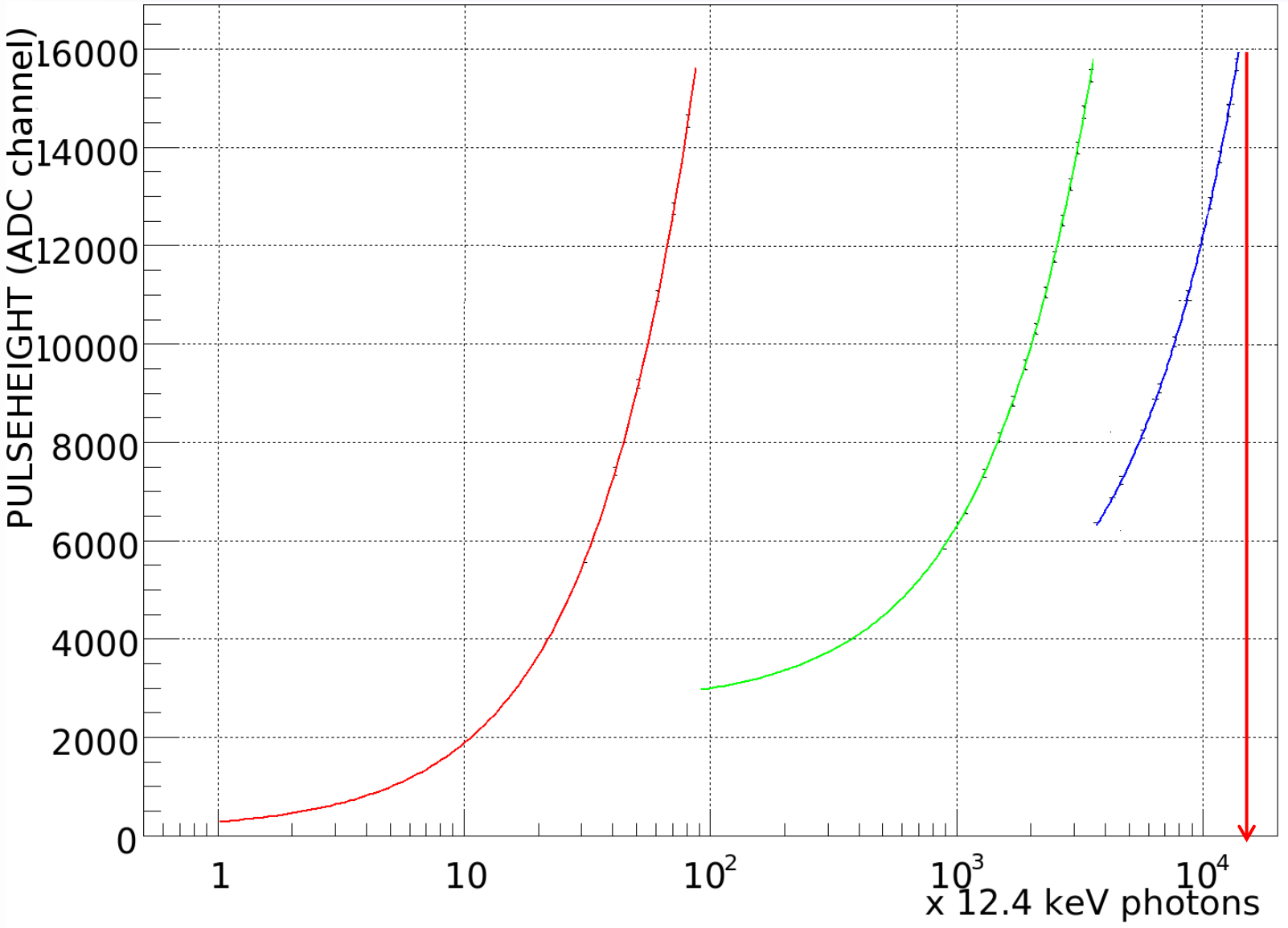
- Higher leakage current
- Higher depletion voltage
- Lower breakdown voltage
- Charge losses at interface
- Increased inter-pixel capacitance

Special high voltage design: withstands 10^{16} photons (= 1 GGy)

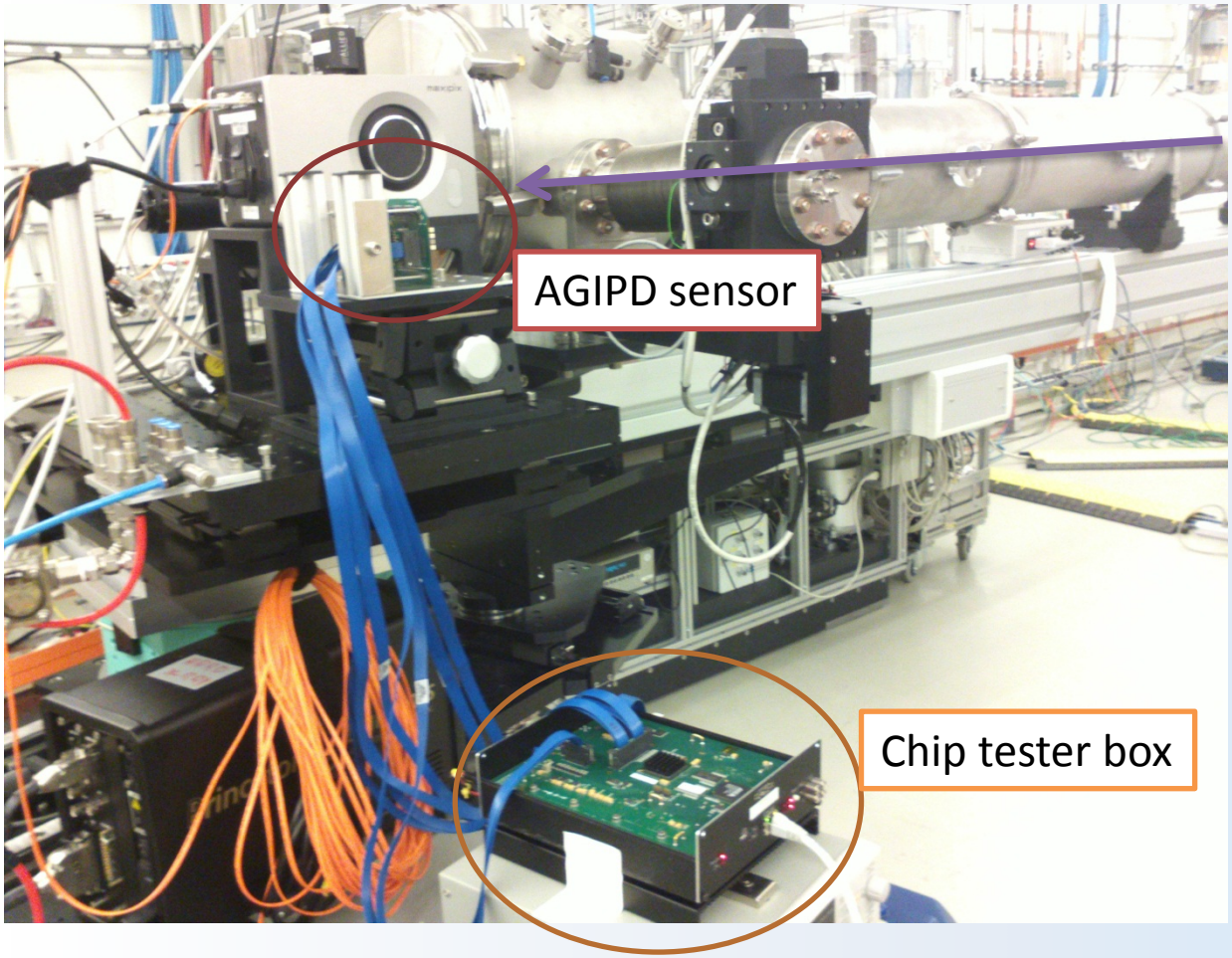
The AGIPD RO-Principle



Dynamic Range



At the P10 beamline

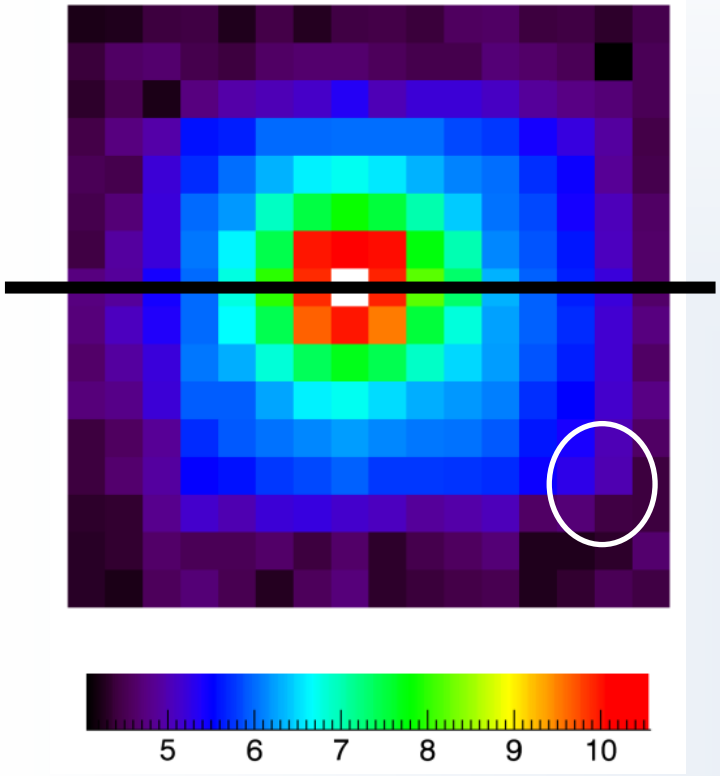


Beam direction
(coming from sample)

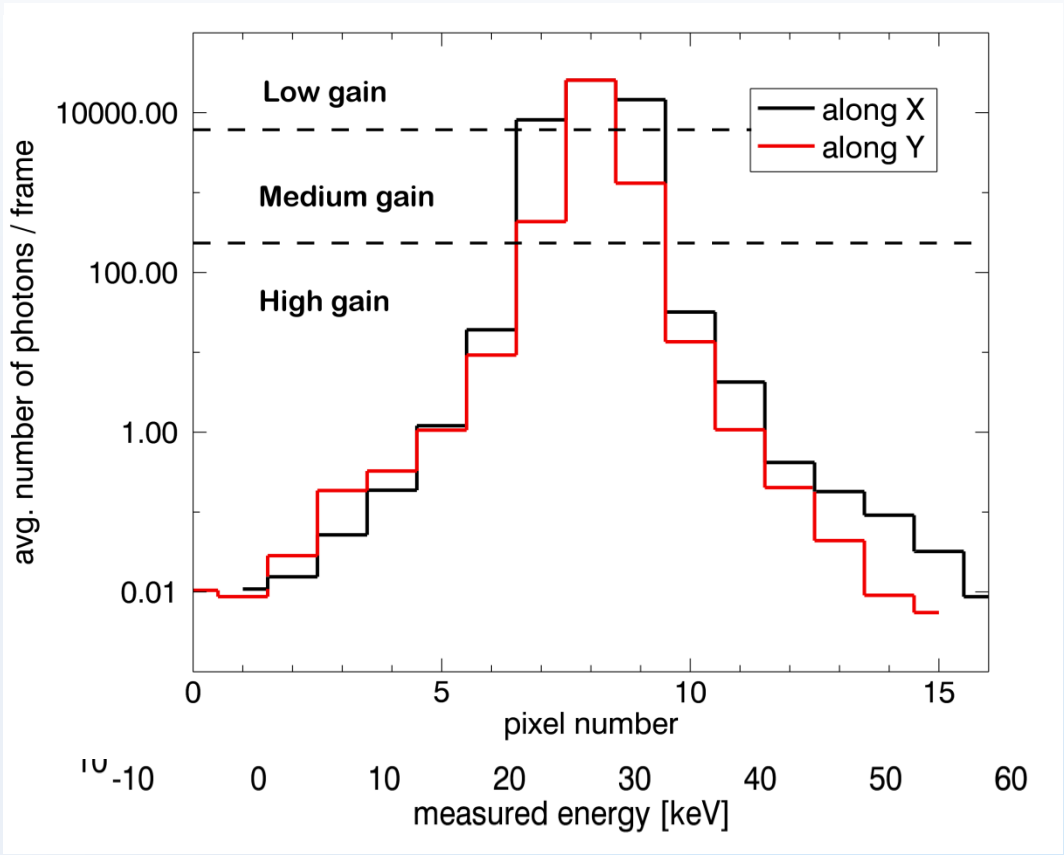
It took about 1 ½ hours to set up, after about 2 hours we saw the first image

Not in the picture: Sample, Alexanders PC, people, …

Looking at the direct beam



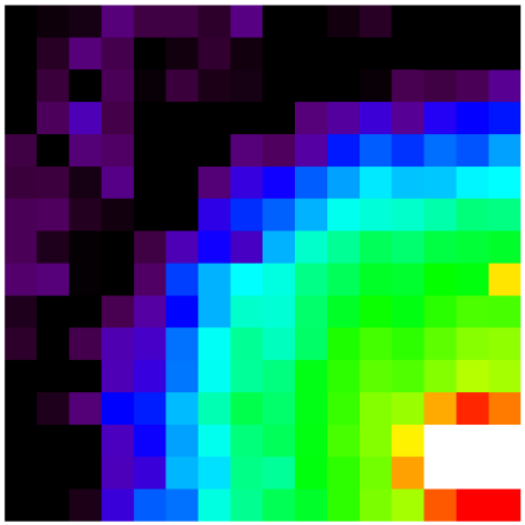
photons/second
Logarithmic color scale



Gain switching experimentally proven

- 10^4 photons / pulse
- Single photon sensitivity
- 4.5 MHz frame rate

Some XPCS measurements



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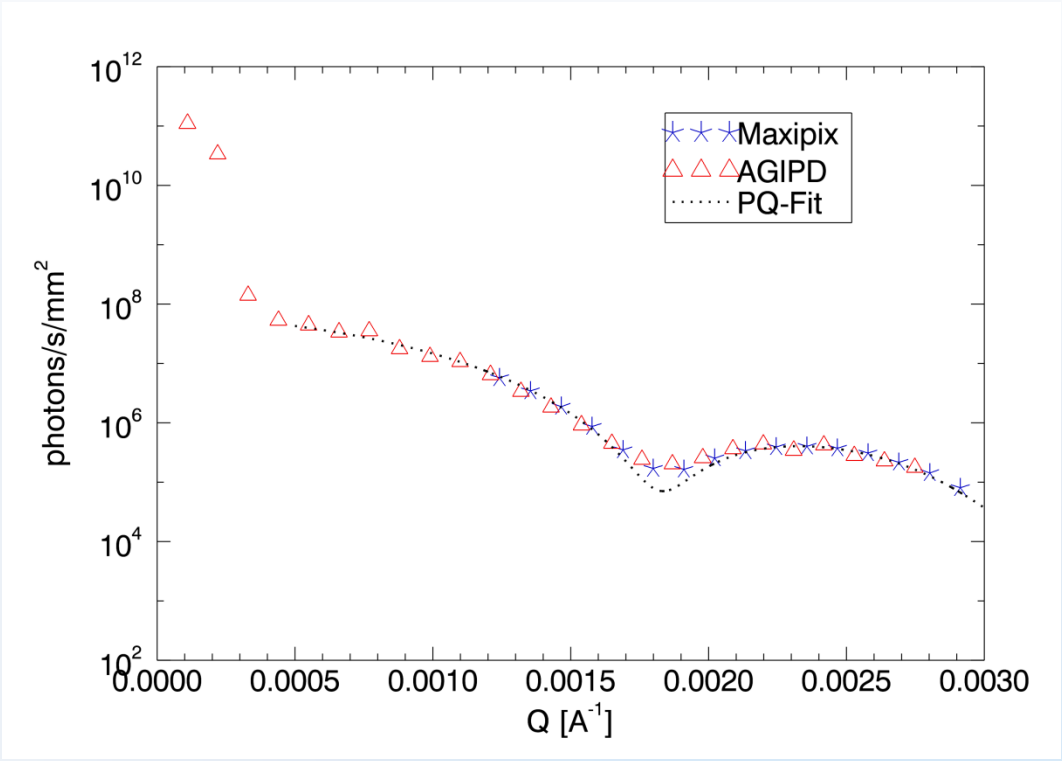
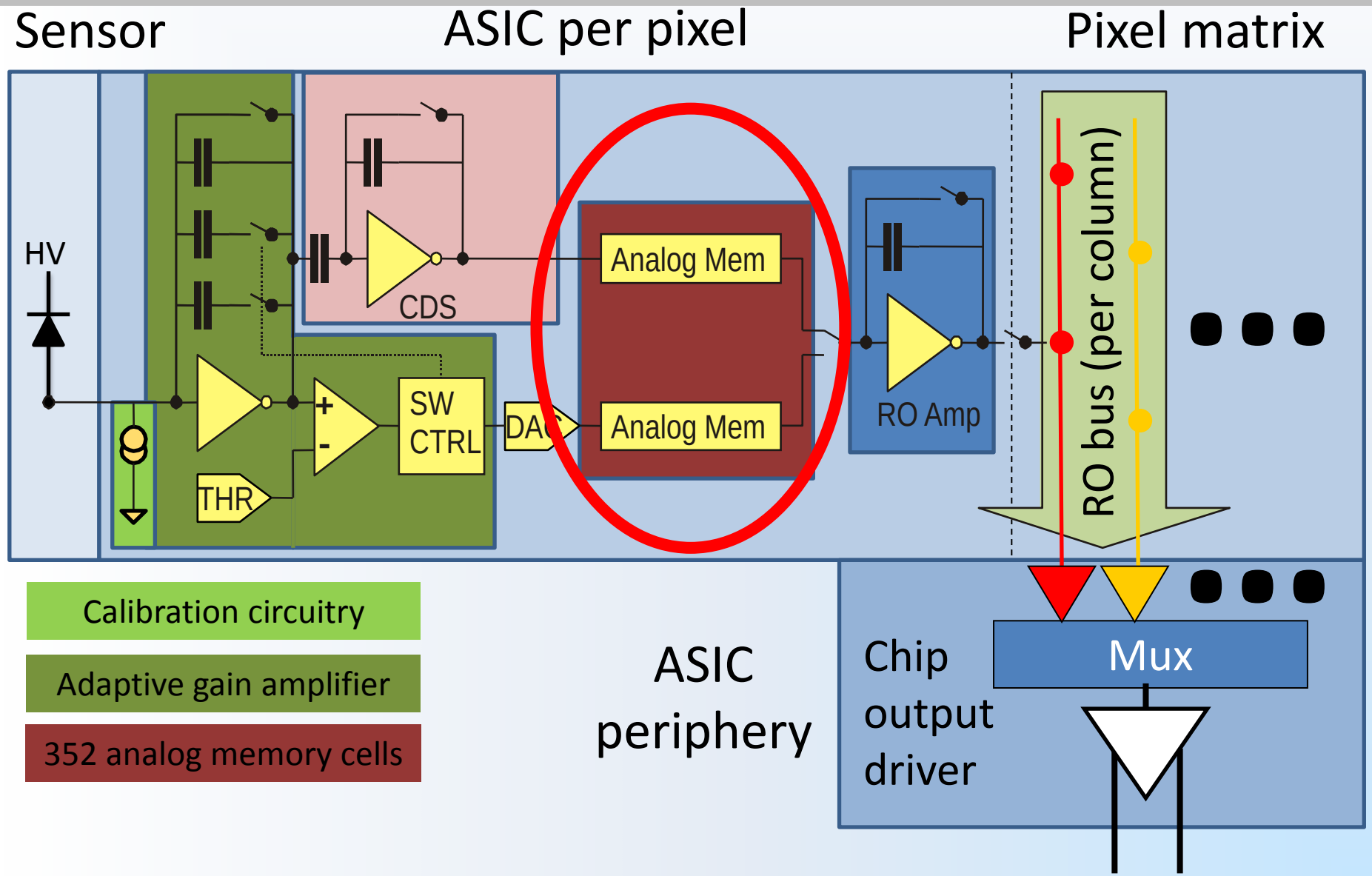


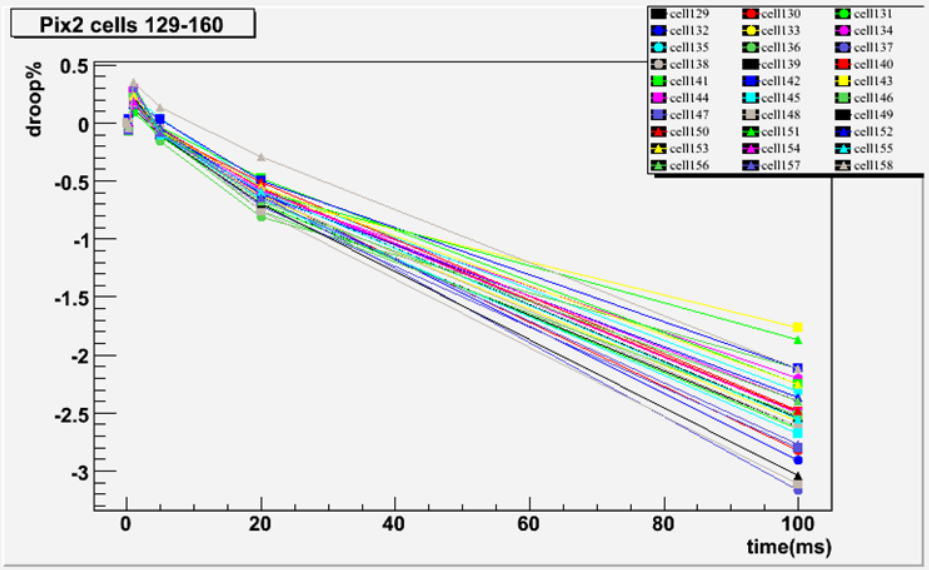
Scientific quality data obtained

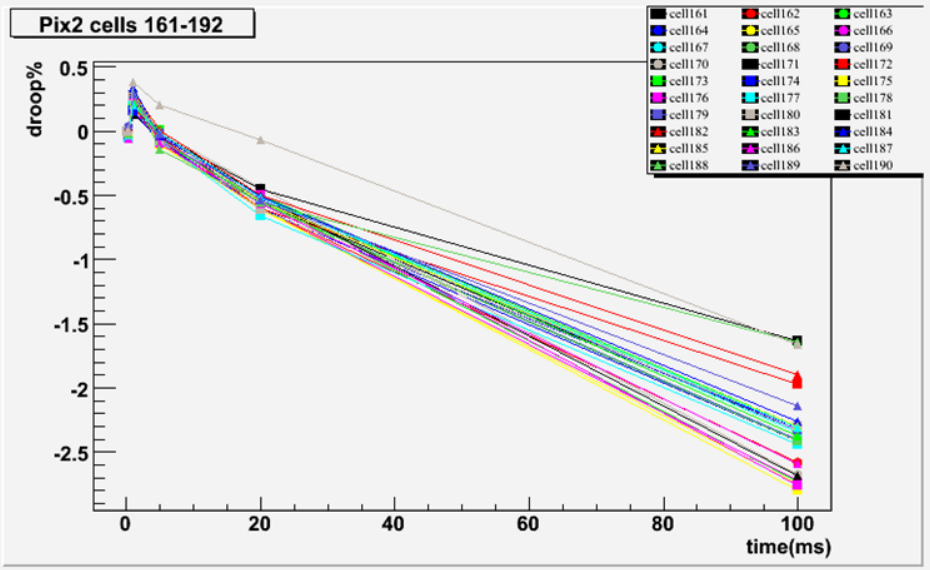
- Complete system proven to work
- Calibration proven to be adequate

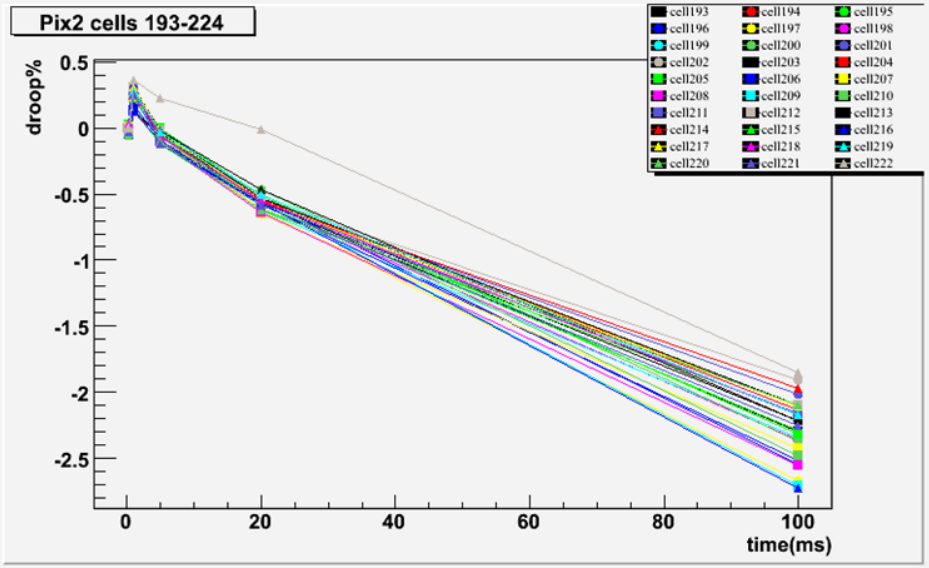
The Analogue Storage

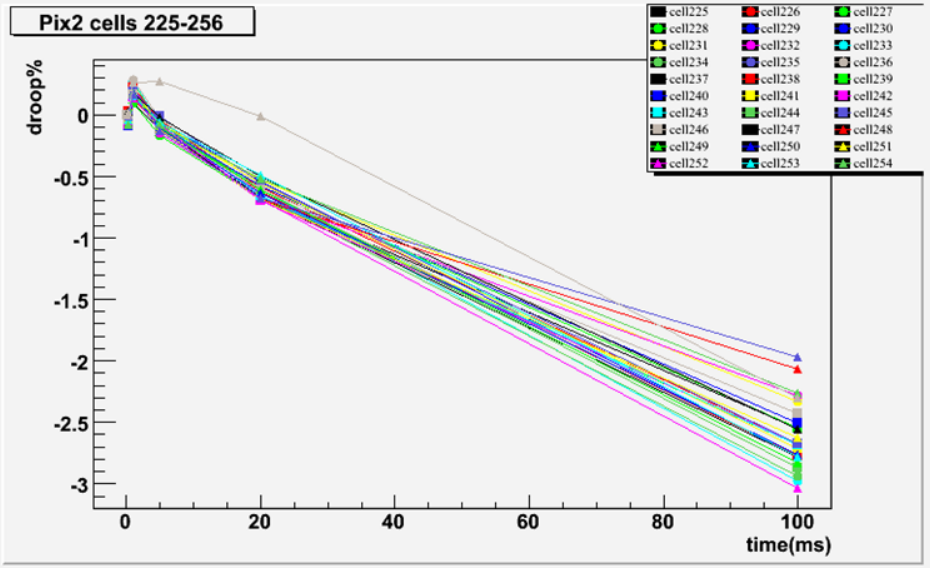


Droop curve: Pix 2 cell 128-256

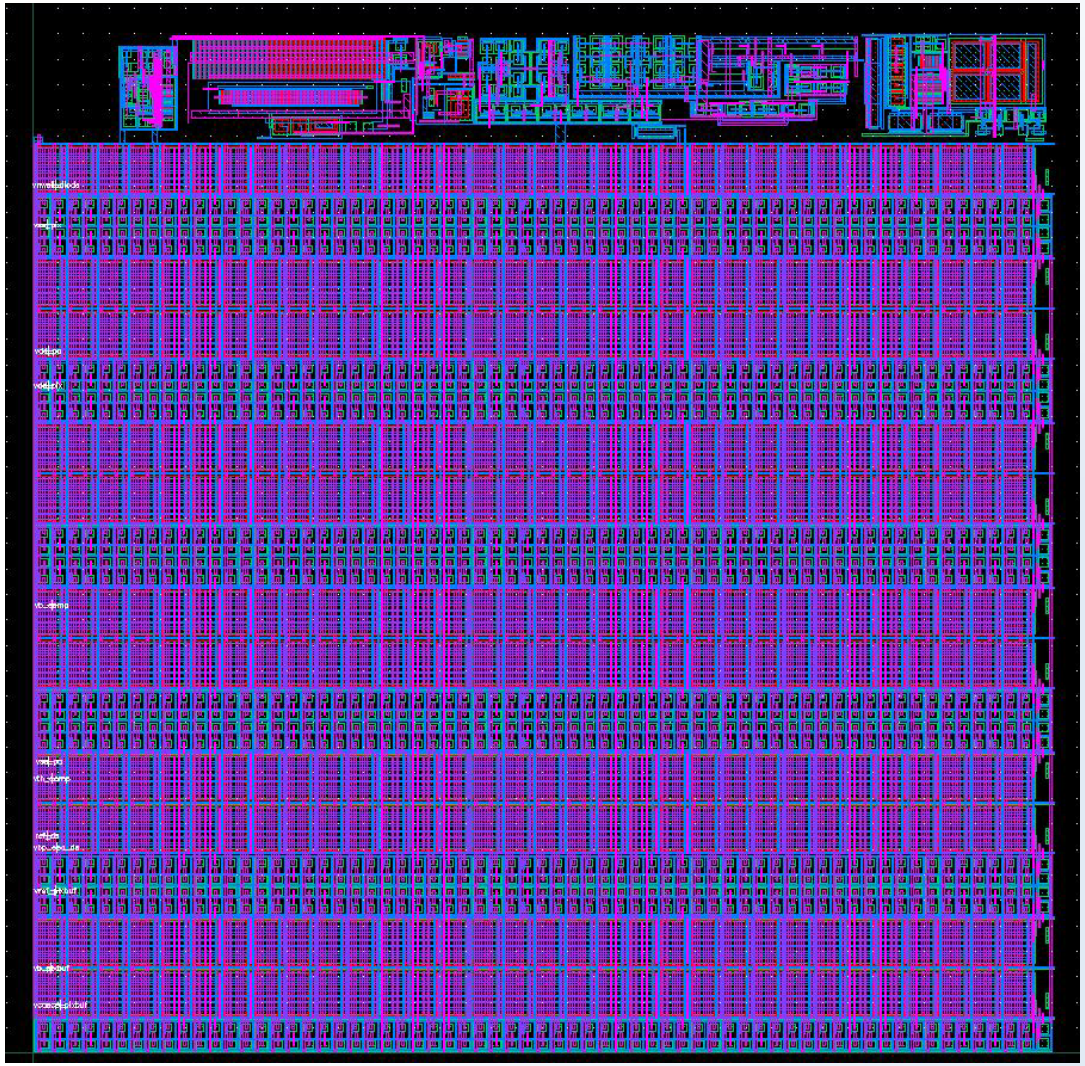






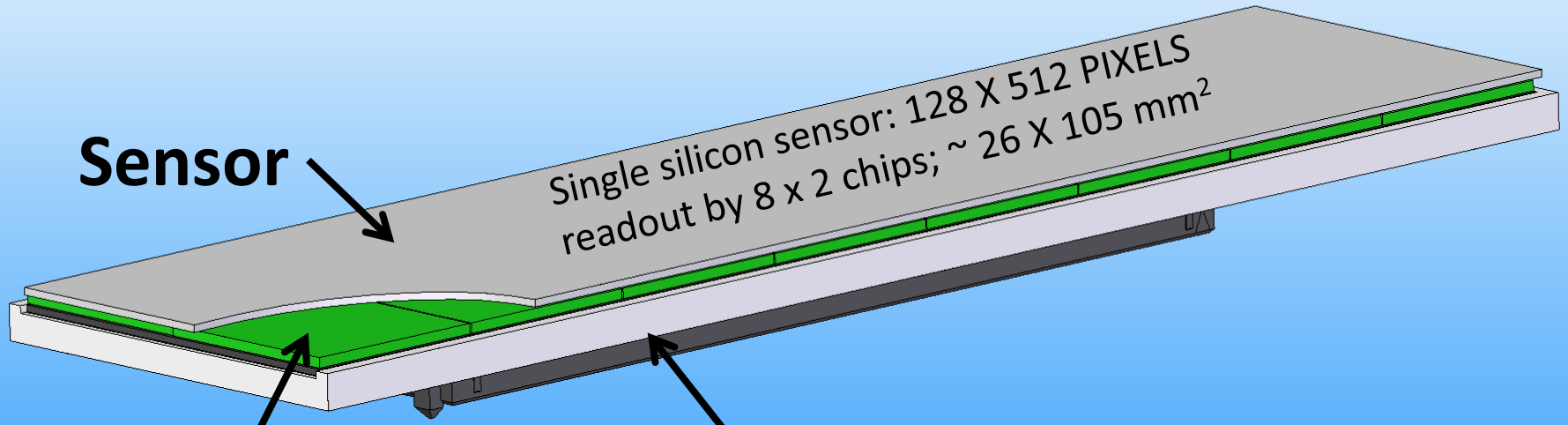


AGIPD 1.0 Pixel electronics

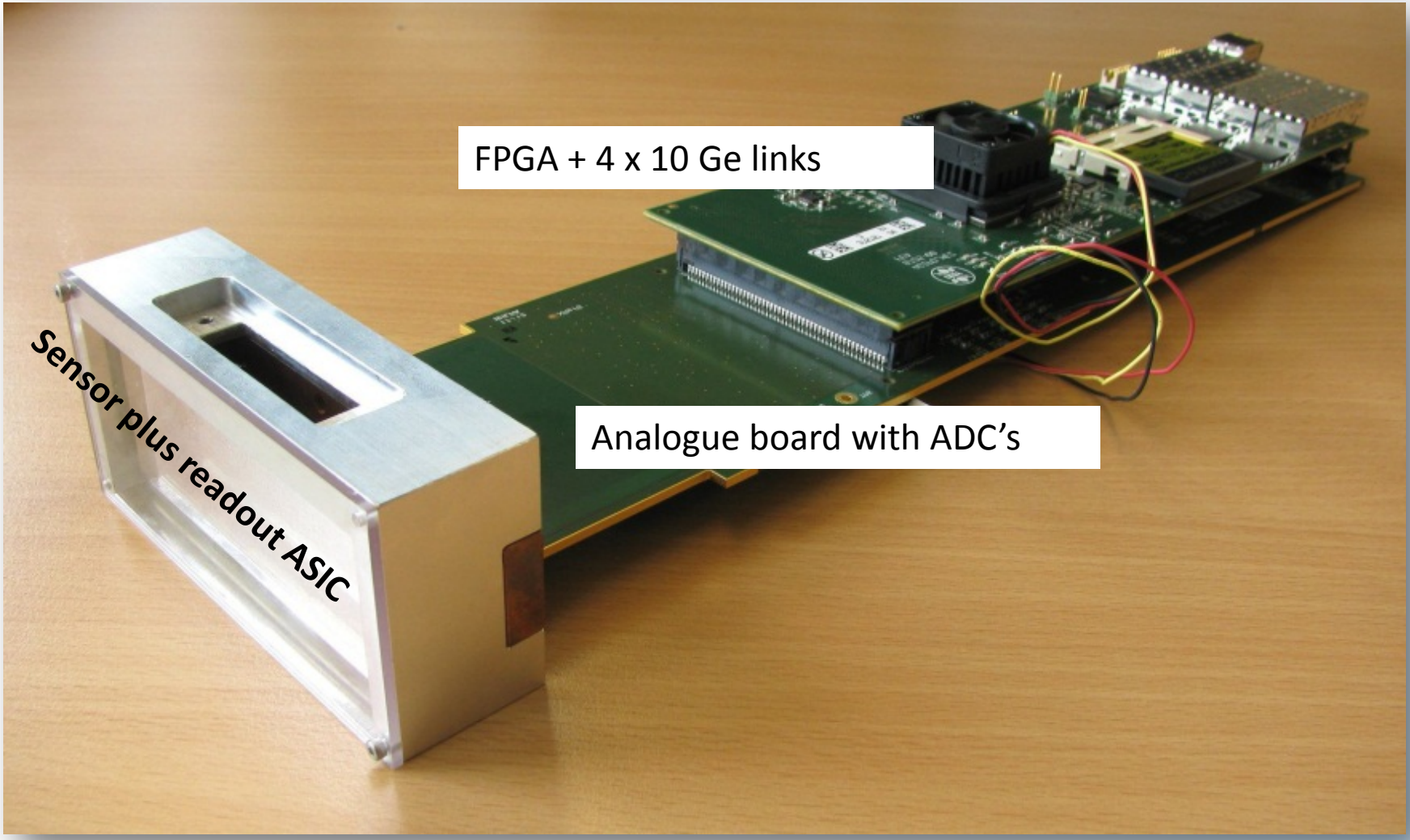


- 200 x 200 micron^2 pixels
- 352 storage cells + veto possibilities.
- Minumum signal (noise) = 330 electrons = 0.1 photon of 12 keV
- Maximum signal = 33 10^6 electrons = 10^4 photons of 12 keV
- 4.5 MHz frame rate
- 64 x 64 pixels per ASIC
- 2 x 8 ASICs per module (128x512 pixels, no dead area)
- 4 modules per quadrant

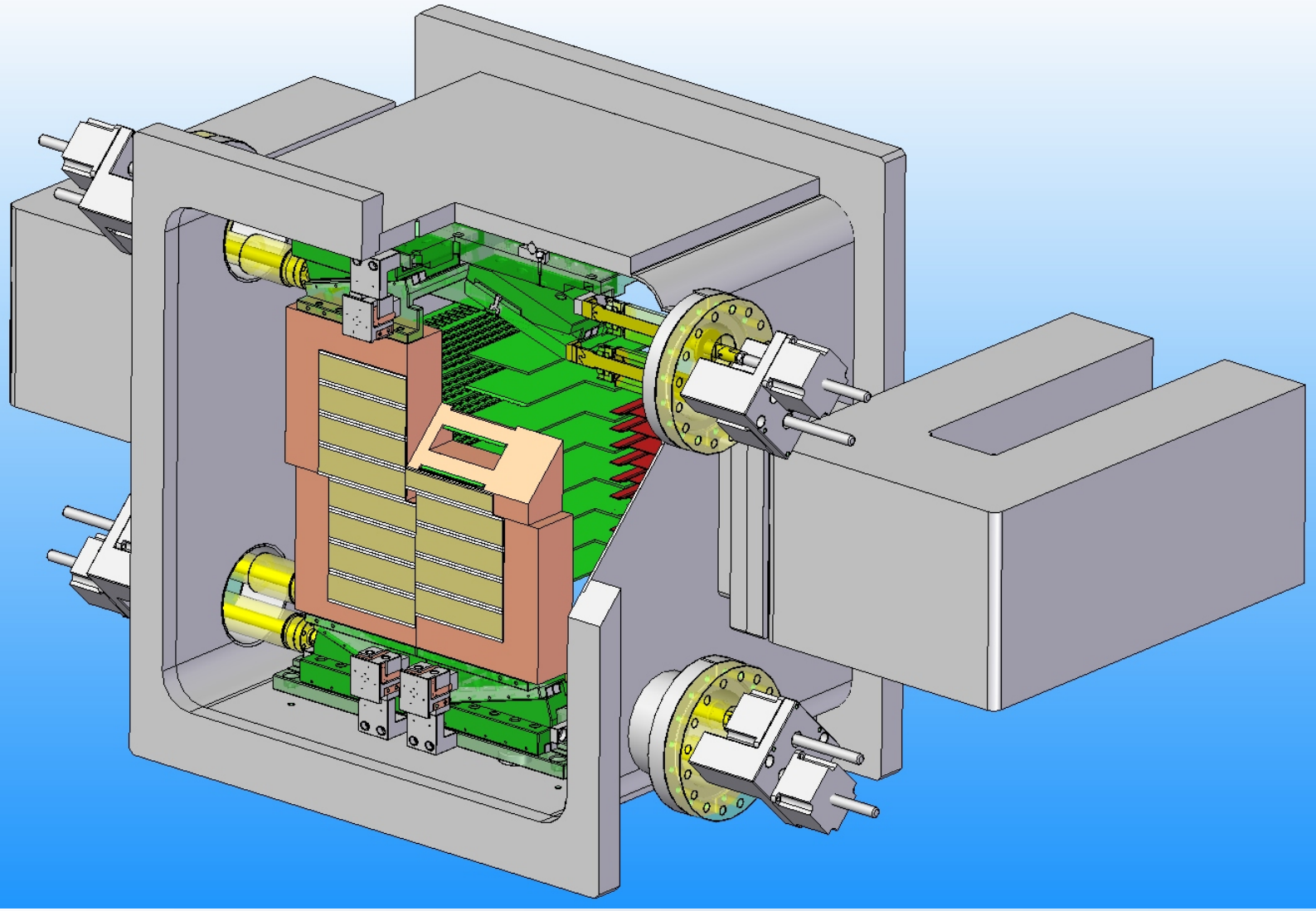
The front-end



The module building block



General Mechanics Concept



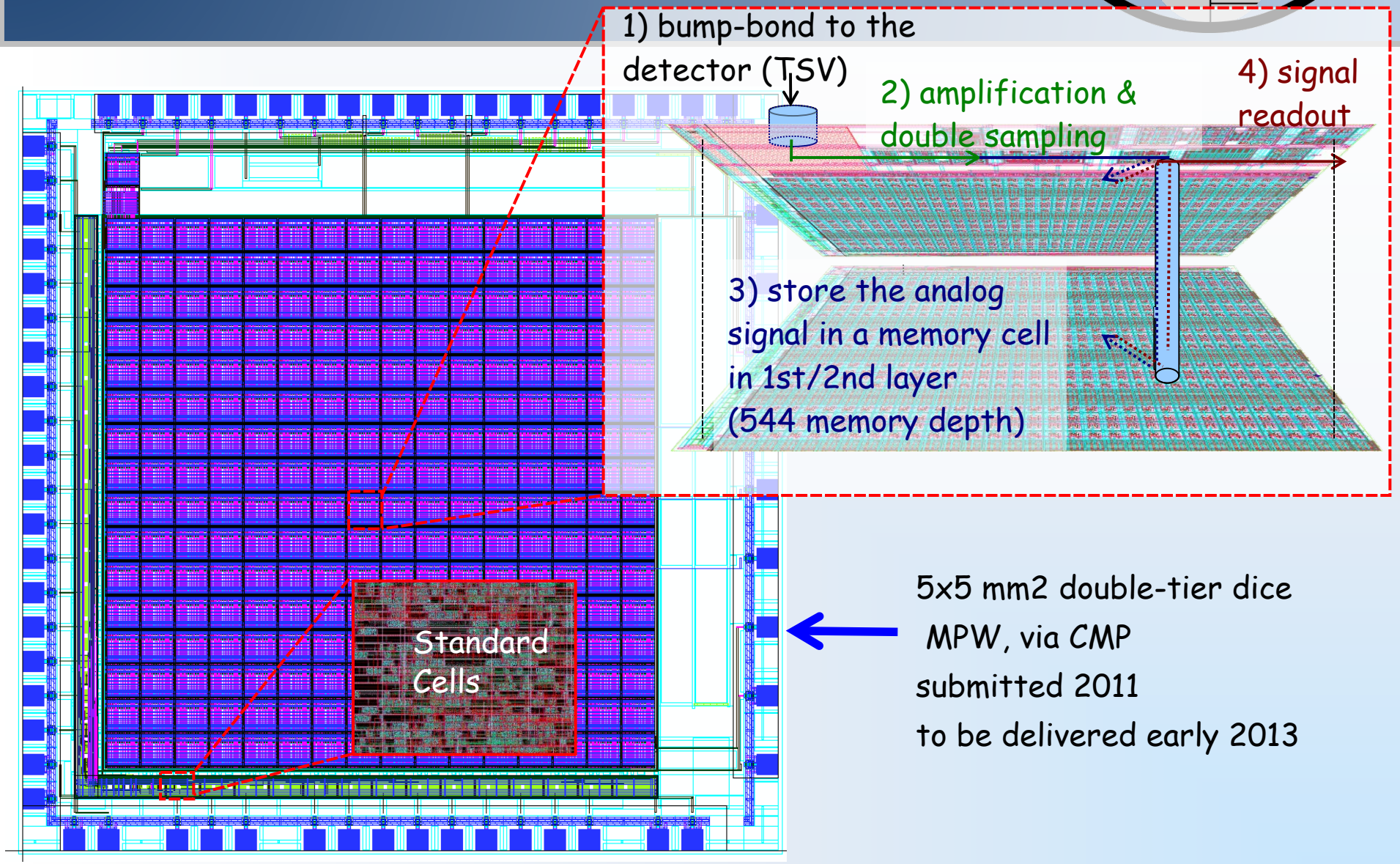
Planning

- Sensors are ordered: delivery Jan. 2013
- AGIPD 1.0 in final stage of design: submission coming weeks
- Interface boards designed and ordered
- Single chip assemblies: summer 2013
- First modules (8x2 chips): beginning 2014
- 1k x 1k system(s) beginning 2015

What could be next? AGIPD2?

- Smaller pixels with
  - Reduced dynamic range (no gain switching);
  - Reduced number of frames?
- New Technologies including:
  - 3D CMOS: second layer (more functionality)

3D-CMOS



5x5 mm2 double-tier dice
MPW, via CMP
submitted 2011
to be delivered early 2013

What could be next? AGIPD2?

- Smaller pixels with
  - Reduced dynamic range (no gain switching);
  - Reduced number of frames?
- New Technologies including:
  - 3D CMOS: second layer (more functionality)
  - 65 nm CMOS technology (more functionality)
  - 3D CMOS + 65 nm CMOS

Who are the People ?

DESY

Julian Becker

Laura Bianco

Peter Goettlicher

Heinz Graafsma

Helmut Hirsemann

Stefanie Jack

Alexandre Klyuev

Sabine Lange

Alessandro Marras

Bjoern Nilsson

Seungyu Rah

Igor Shevyakov

Segrej Smoljanin

Ulrich Trunk

Manfred Zimmer

PSI

Roberto Dinapoli

Doninic Greiffenberg

Beat Henrich

Aldo Mozzanica

Xintian Shi

Bernd Schmitt

Uni-HH

Eckhard Fretwurst

Robert Klanner

Joern Schwandt

Jiaguo Zhang

Uni-Bonn

Markus Gronewald

Hans Krueger

E-XFEL

Jolanta Sztuk-Dambietz