New Opportunities with new Detectors

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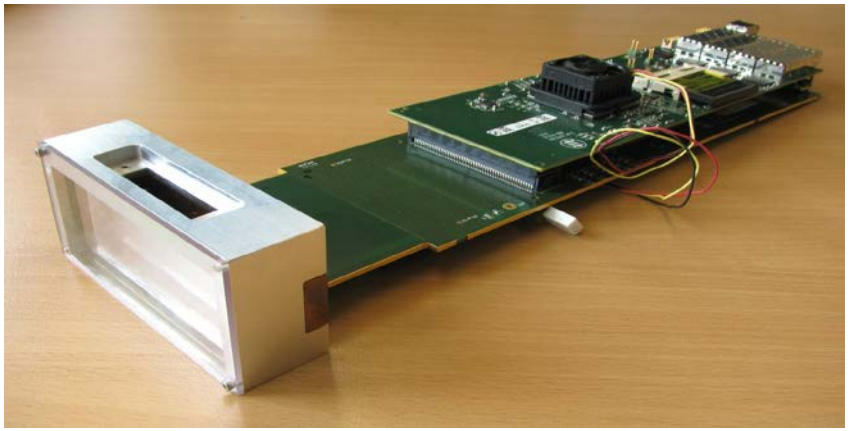
for the

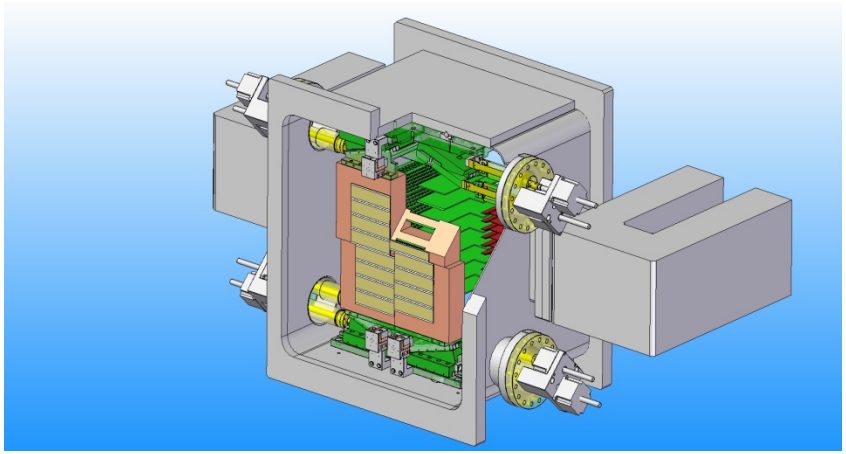
Photon-Science Detector Group

Two new systems under development

1. Large Area Medipix-Based Detector Array: LAMBDA

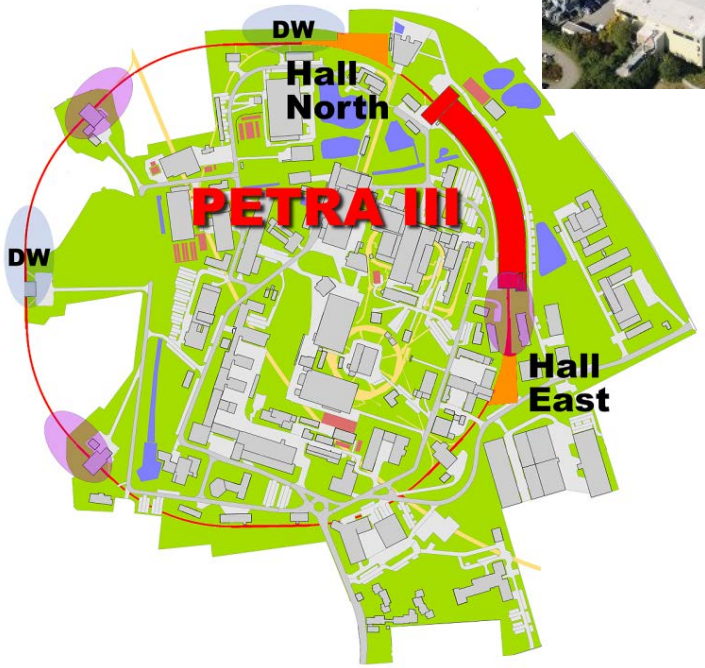


2. Adaptive Gain Integrating Pixel Detector: AGIPD

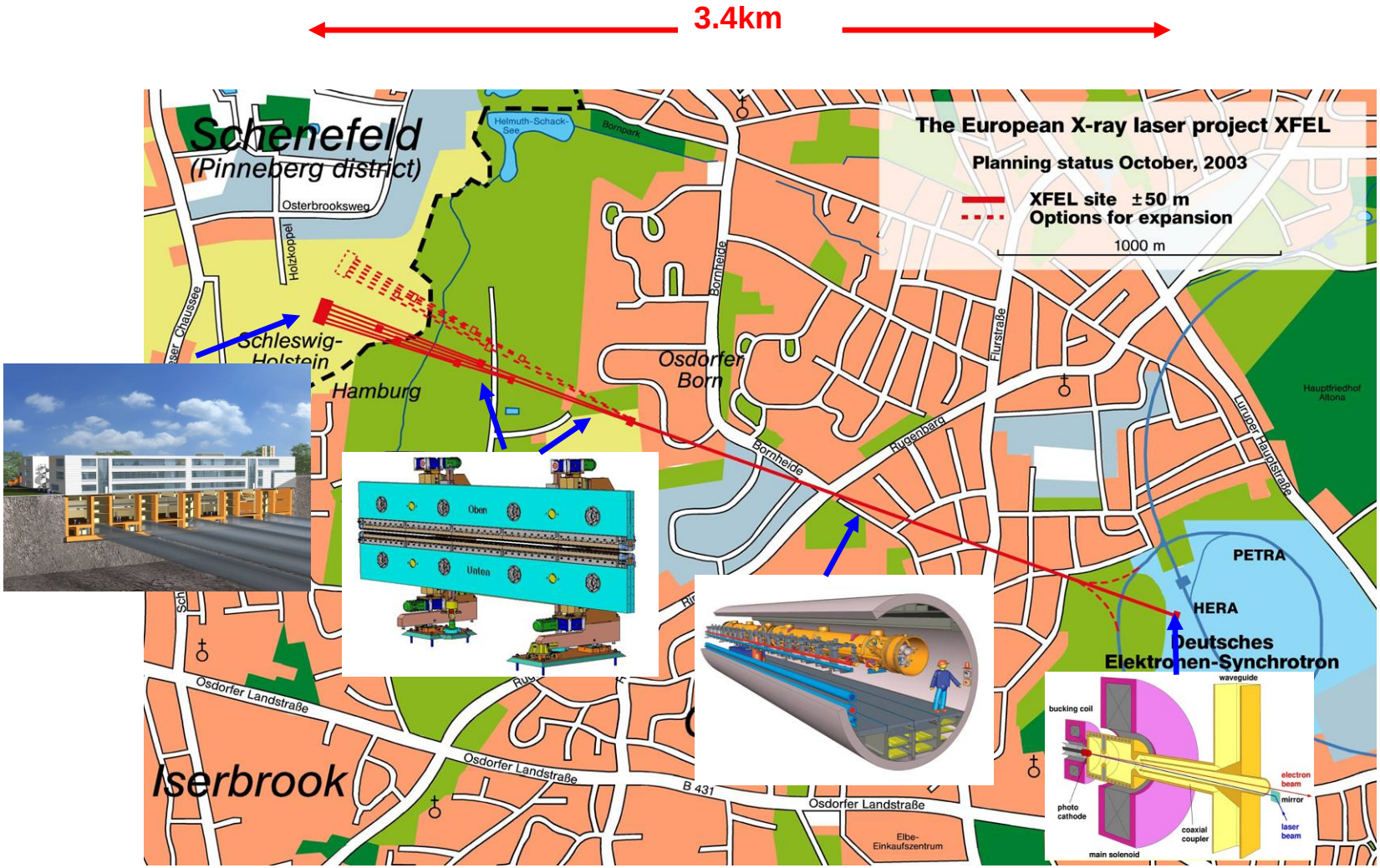


1. PETRA-III Storage ring X-ray source

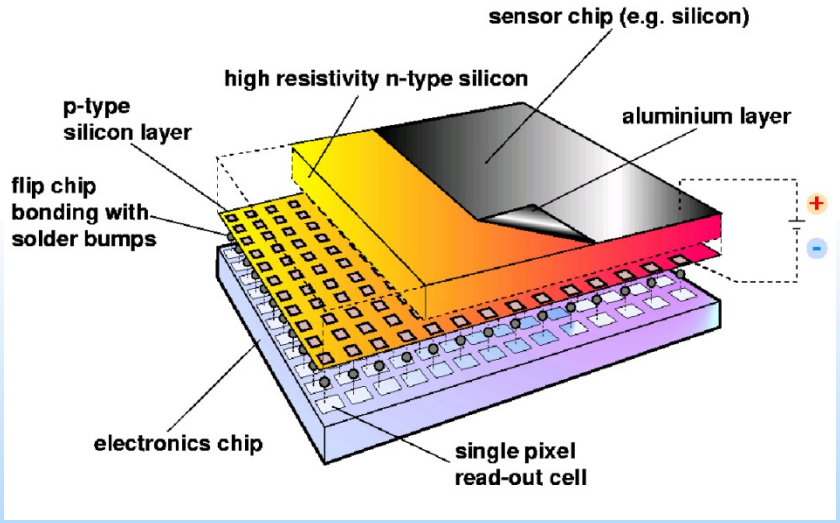
- 6 GeV source with low emittance (1 nmrad)
  - Nanofocusing, high-resolution, coherence…
  - Hard X-rays (>20 keV)
- 14 beamlines
- 2 extensions planned
  - Replacement for DORIS-III
  - 10 beamlines
  - Higher flux



2. The European XFEL X-ray source

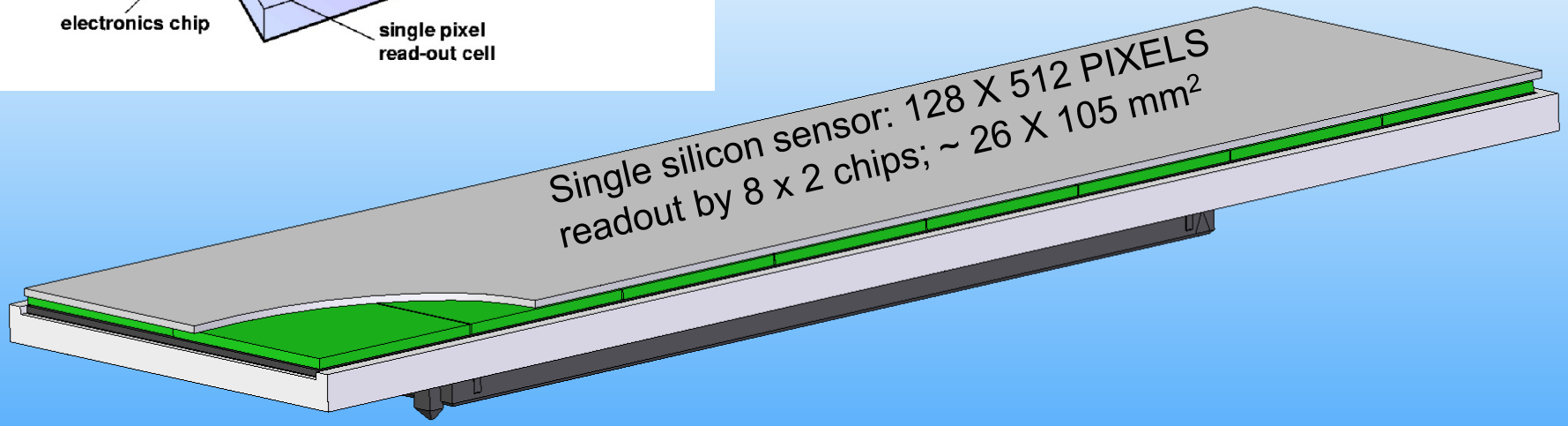


Hybrid Pixel Array Detectors



Pixellated Silicon Sensor:
absorbs photons and produces electrical signal

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

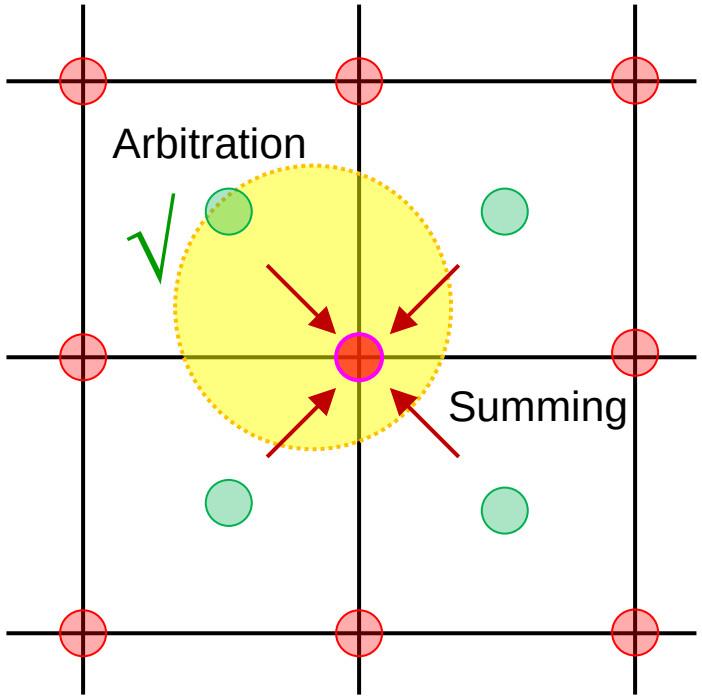


Chip carrier board to talk to and readout chips

The heart of LAMBDA: Medipix3 readout chip

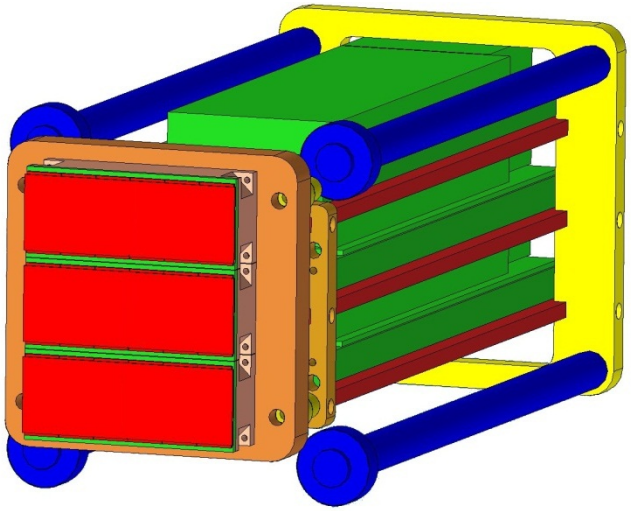
- CERN-led collaboration
- 256 by 256 array of 55µm pixels
- 2 counters / pixel for continuous read-write
  - 2000 fps at 12 bit depth
  - 6 (4) and 1 bit also possible
- Interpixel communication – avoids hit loss & double counting, better discrimination
- *Medipix3 "RX"*
  - First silicon assemblies received at CERN
  - CRW and interpixel communication fixed
  - Stability and pixel-to-pixel uniformity as designed

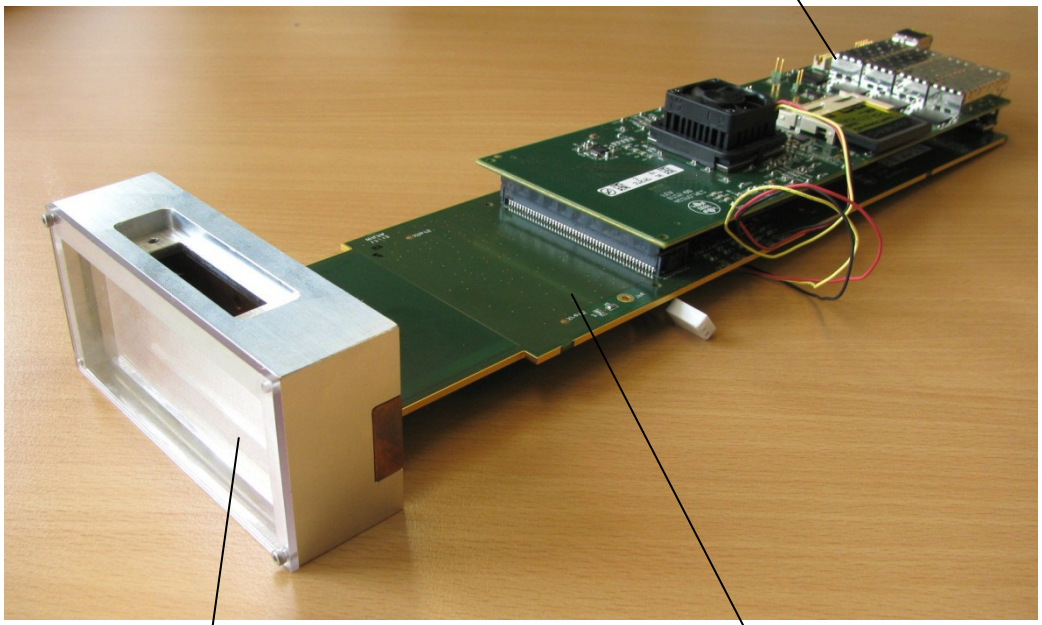
Medipix3 RX interpixel comm.



Large Area Medipix-Based Detector Array

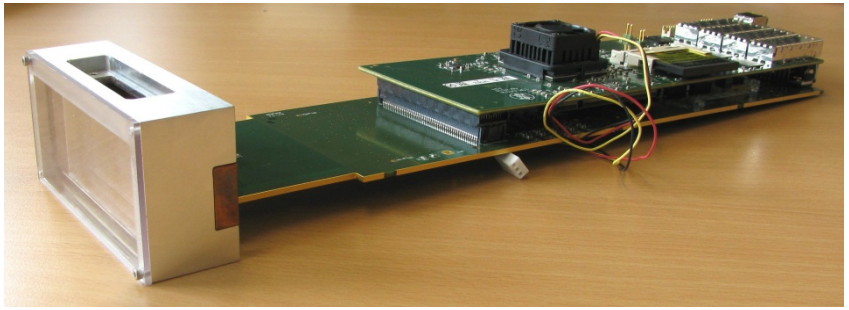
- Photon-counting detector
- Small pixel size (55µm)
- Large, tilable modules (1536 by 512 pixels)
- Fast readout (2 kHz+)
- High-Z compatible
  - inc. germanium cooling

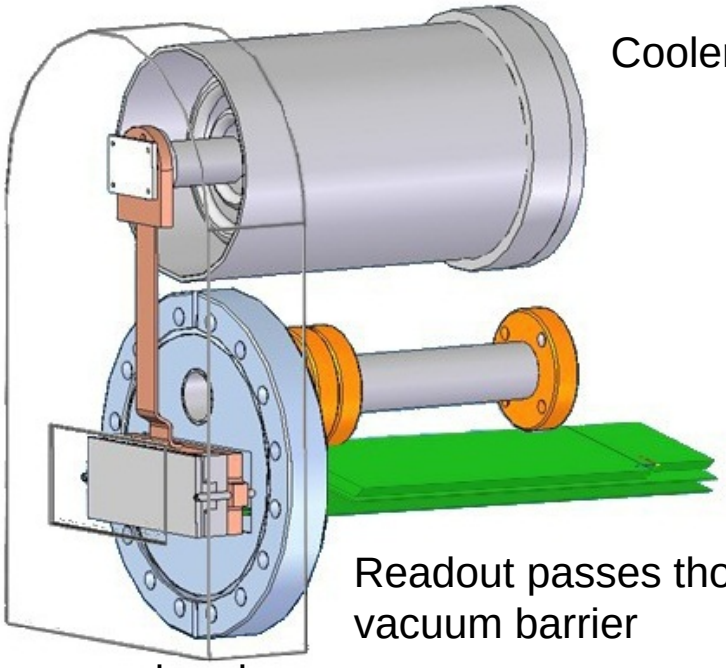




High-speed readout system

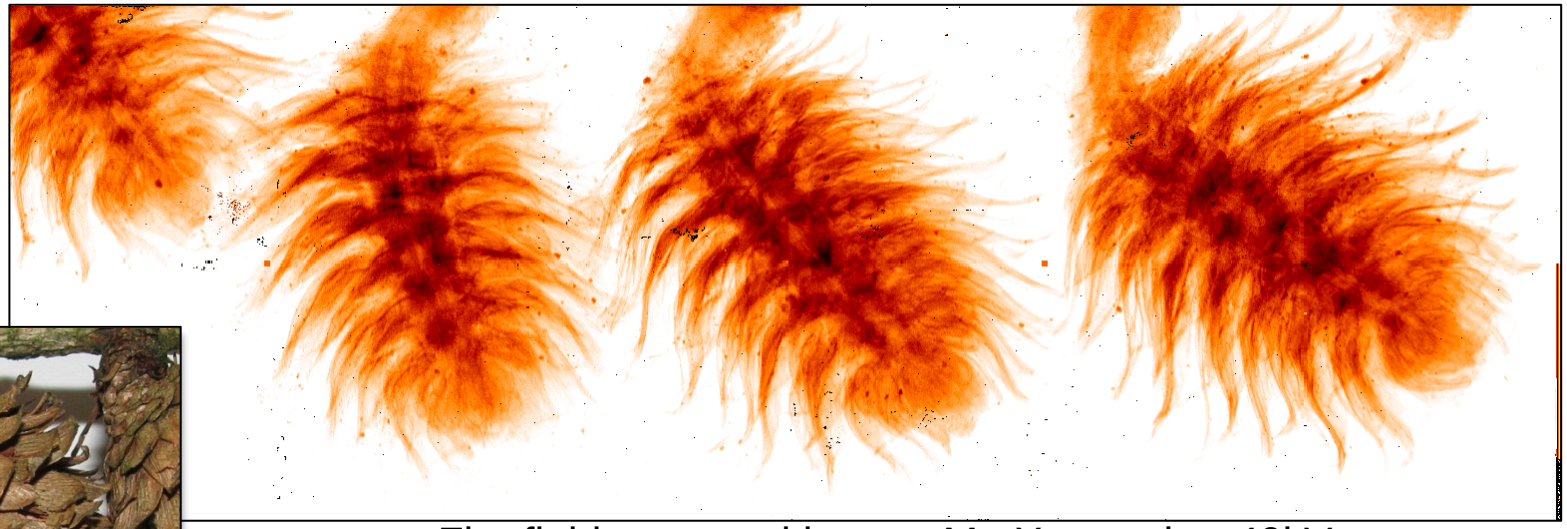
- Previously developed prototype system (USB2 readout only)
- High-speed readout with common DESY mezzanine card
  - Virtex-5 FPGA with PowerPC
  - 4 * 10 Gigabit Ethernet links
  - DDR2 RAM (8GB)
- “Signal distribution” board connects to det. head
  - Space for vacuum barrier with germanium detector
- Currently working on high-speed readout firmware





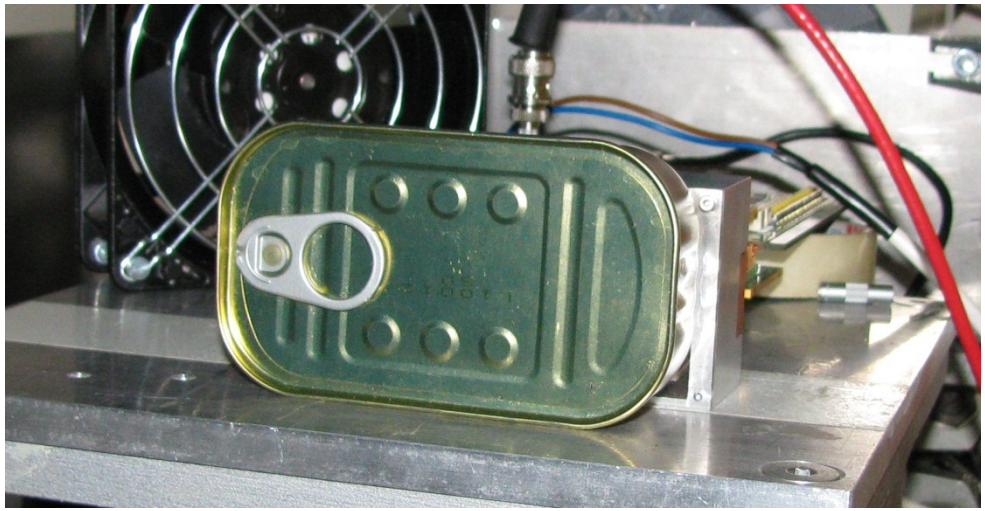
Test results with Si module

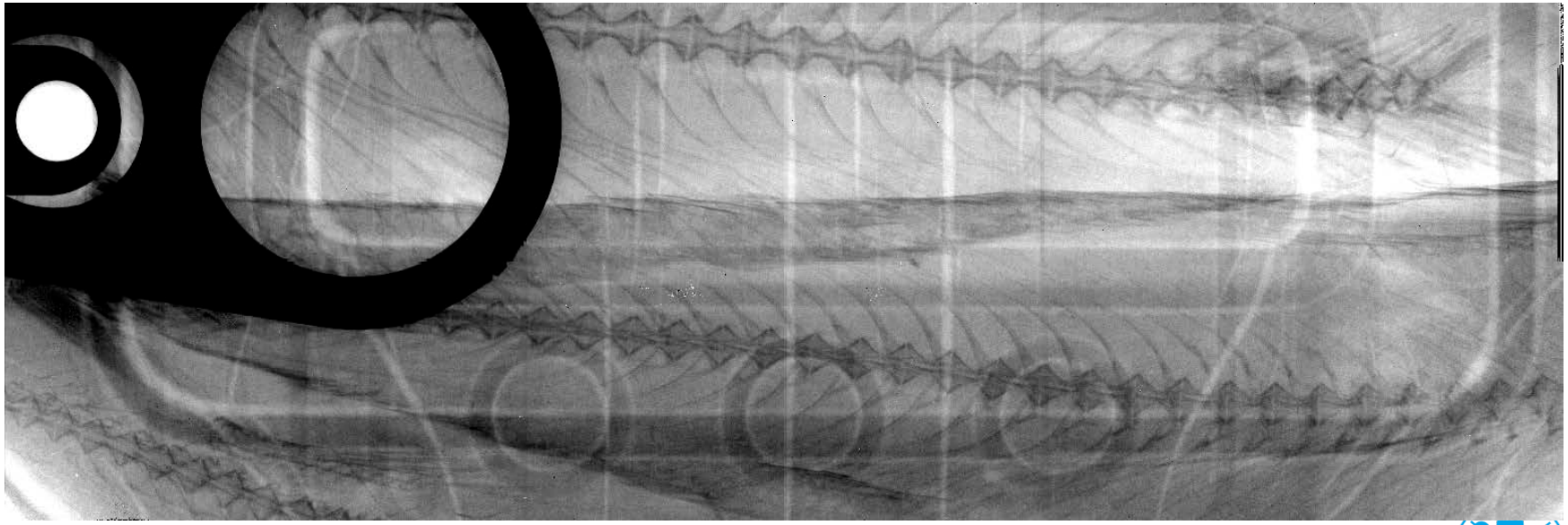
- First full Si module assembled (300µm sensor from Canberra)
  - Solder bonding at IZM
  - All 12 chips successfully bonded and functional
  - 1280 digitally bad pixels, 15 noisy, 700 insensitive – 0.25%



Flat-field corrected image, Mo X-ray tube, 40kV

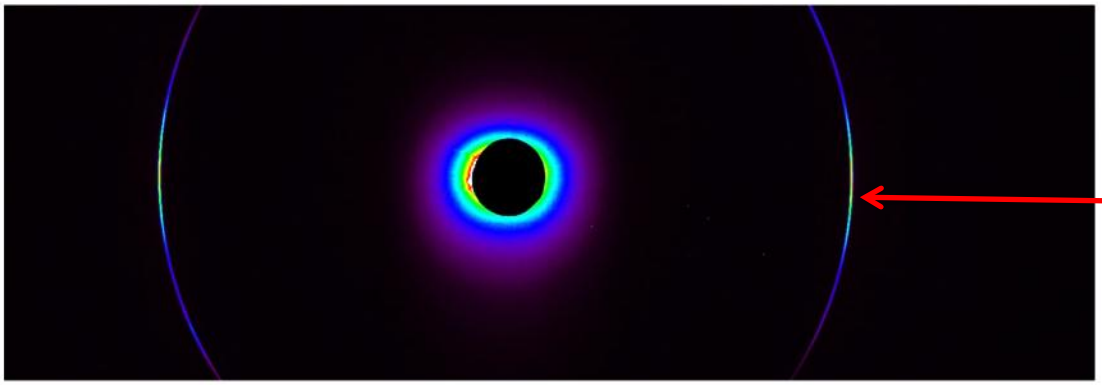
Test results with Si module

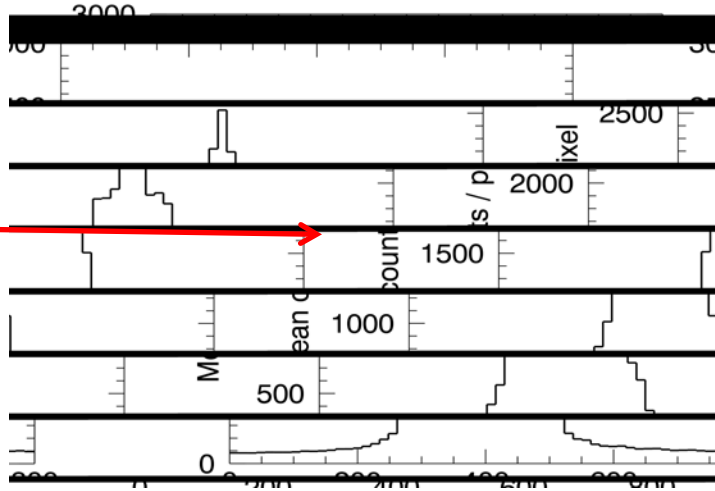




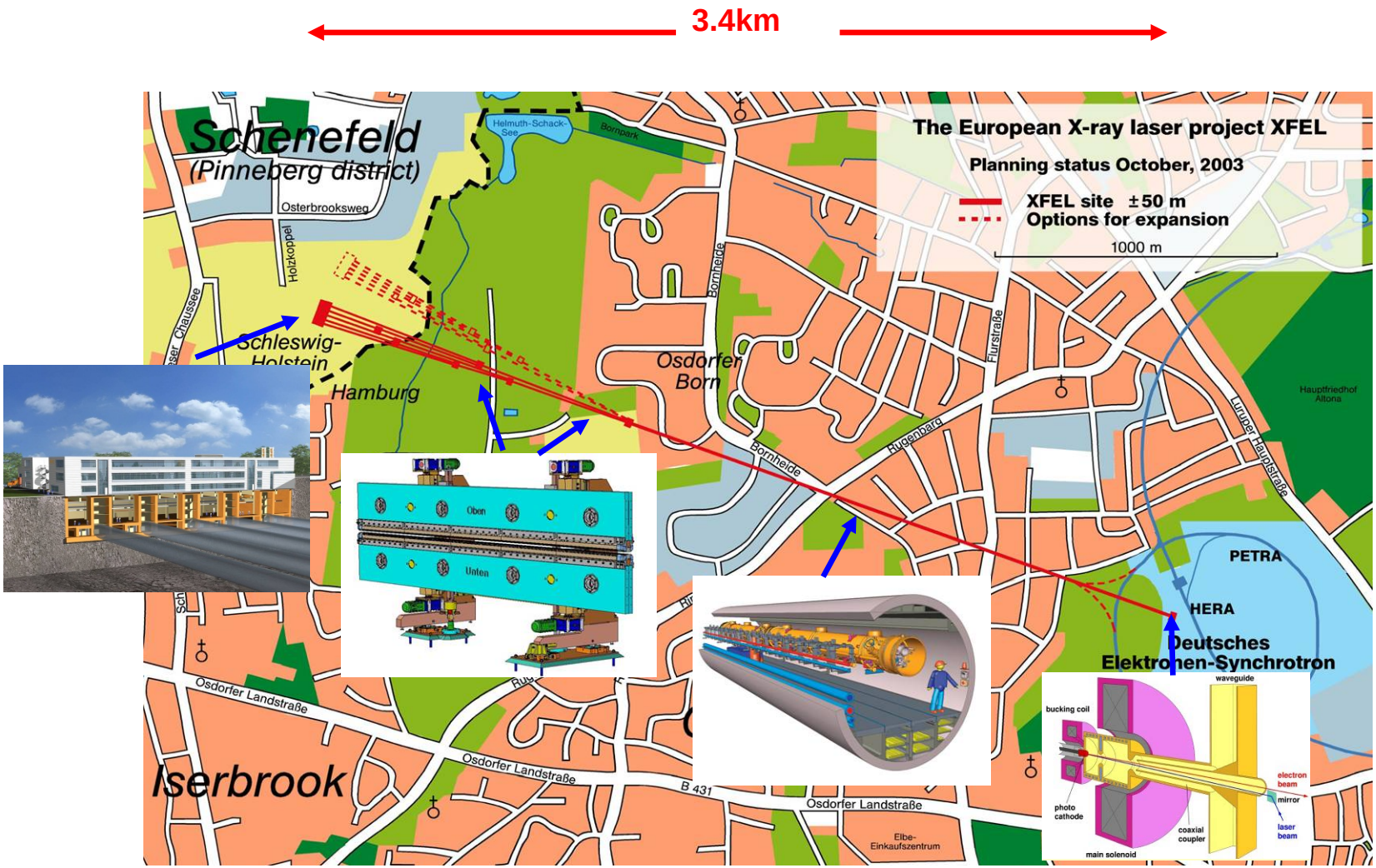
FS-DS: The LAMBDA pixel detector

- Diffraction from liquid crystal under strain (Rheo/SAXS setup at P10, Petra III)
  - First beamline experiment with LAMBDA detector
  - Pixel size enables line shape analysis

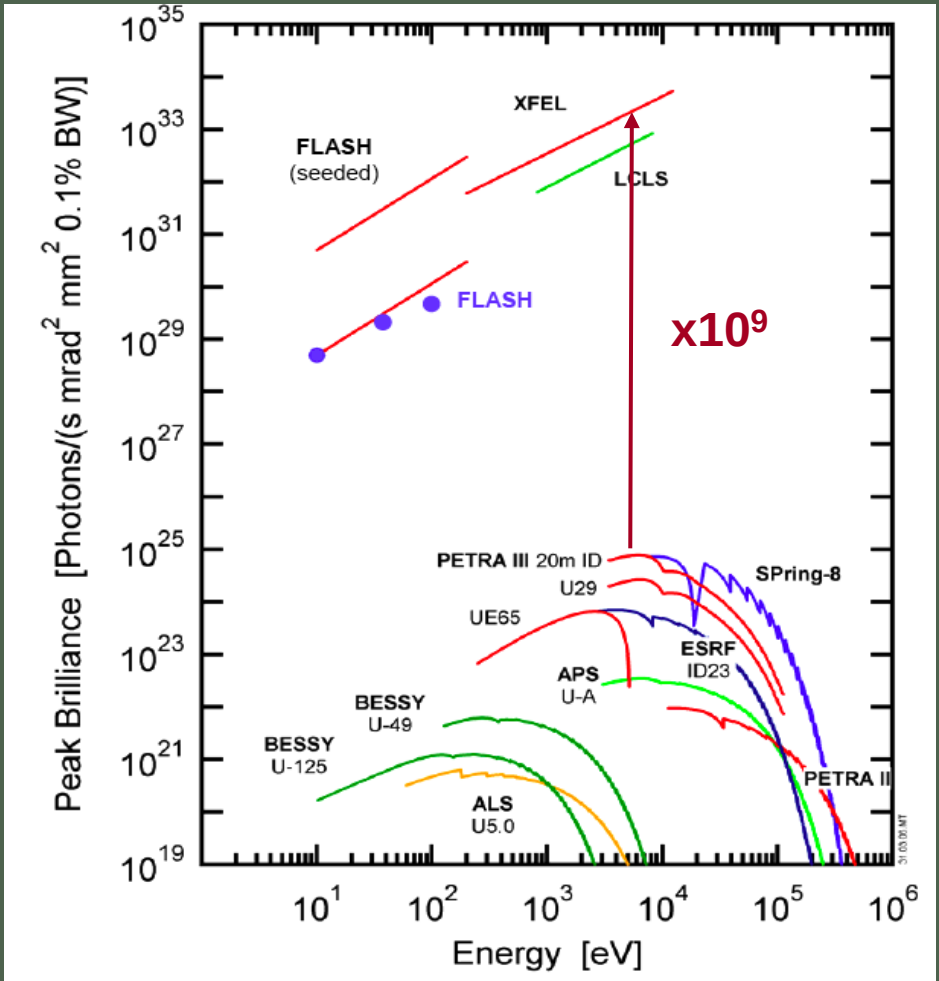




Overall layout of the European XFEL

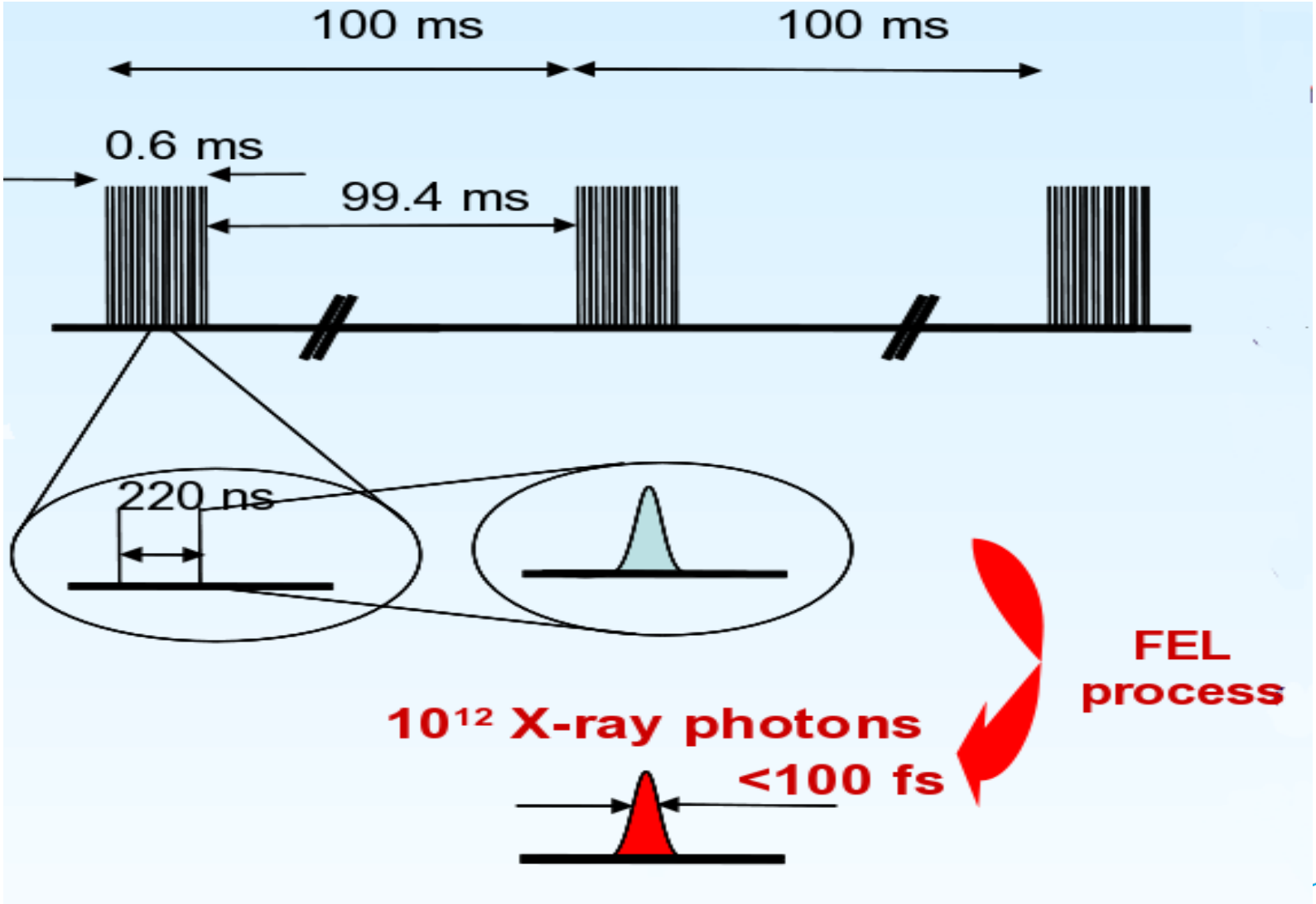


Challenge: Different Science

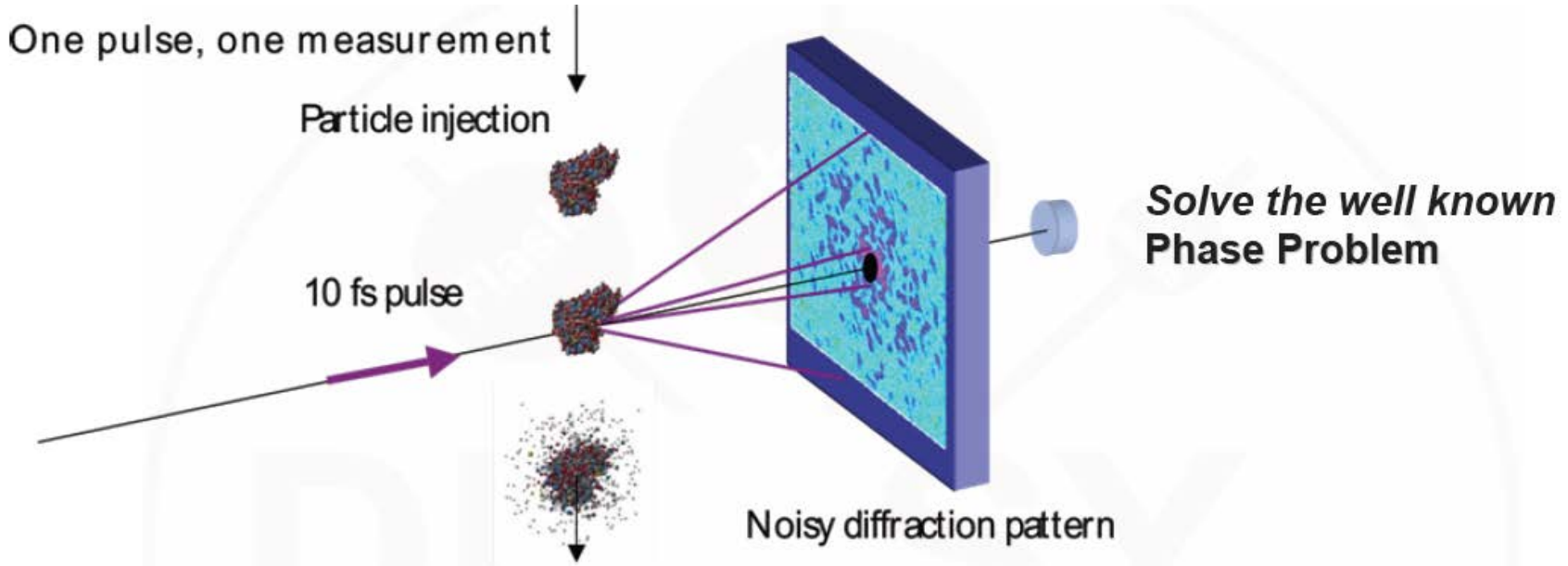


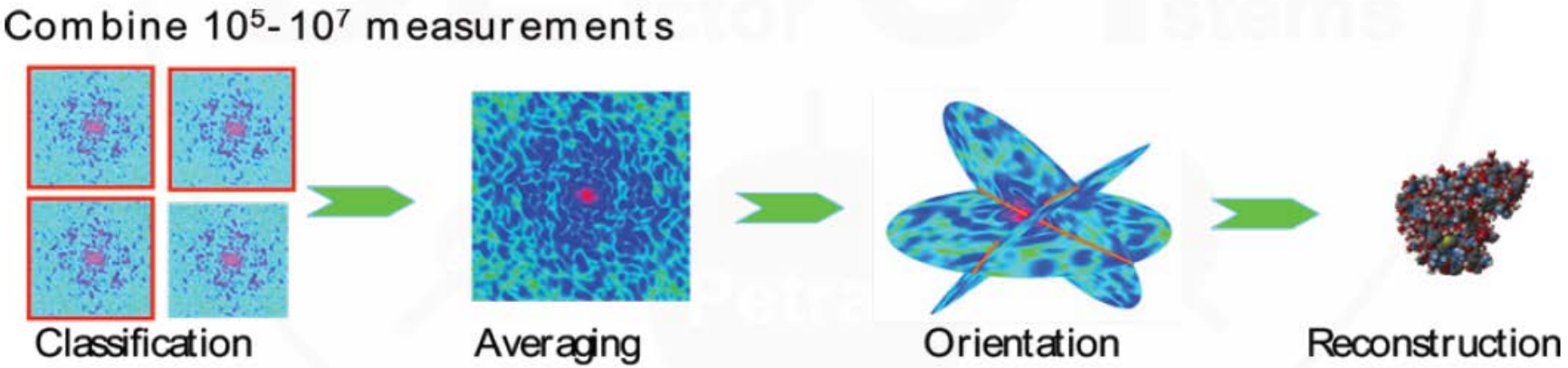
- Completely new science
- Fast science 100 fsec
- “Single shot” science

The European Free Electron Laser



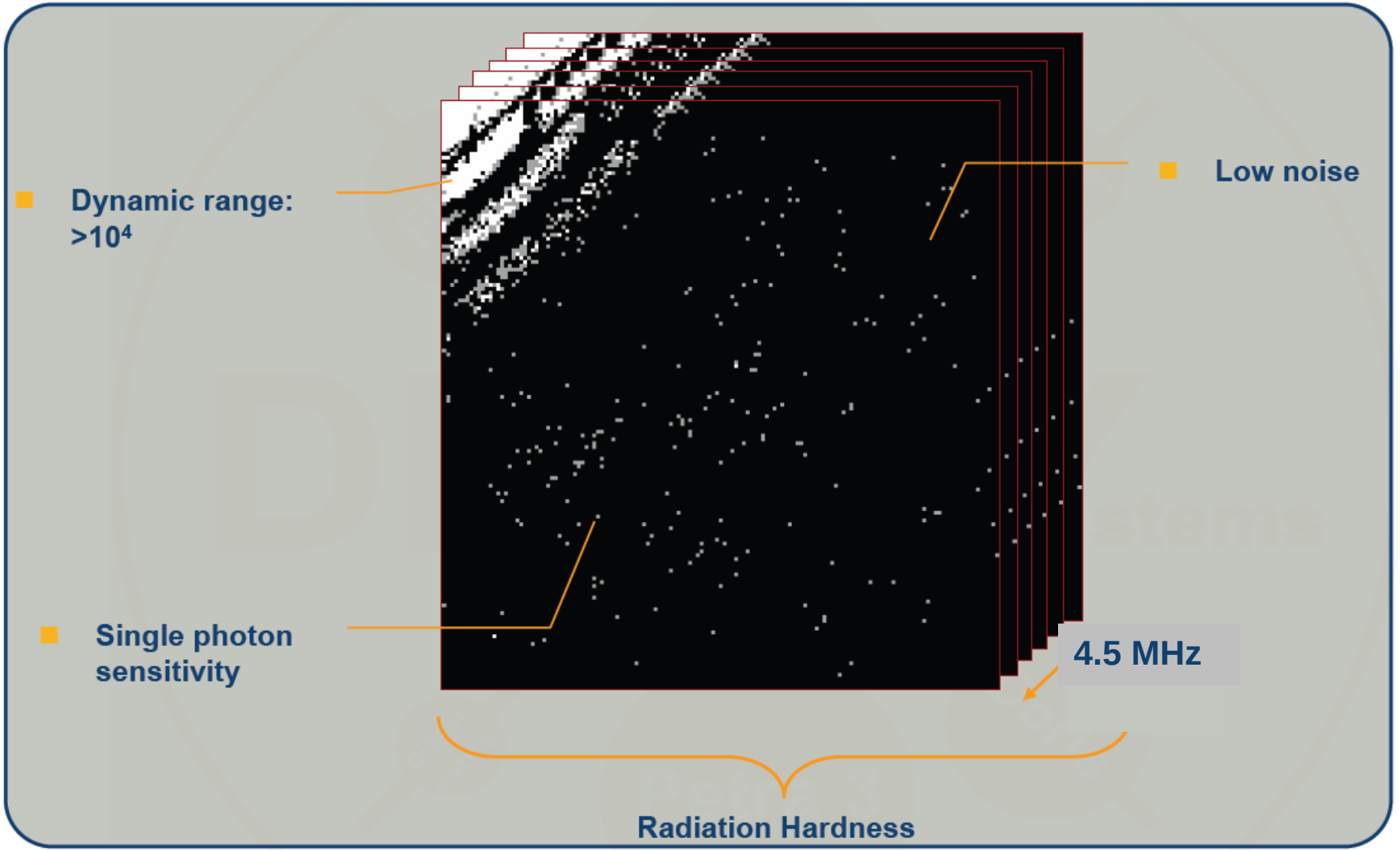
What is the Goal ?



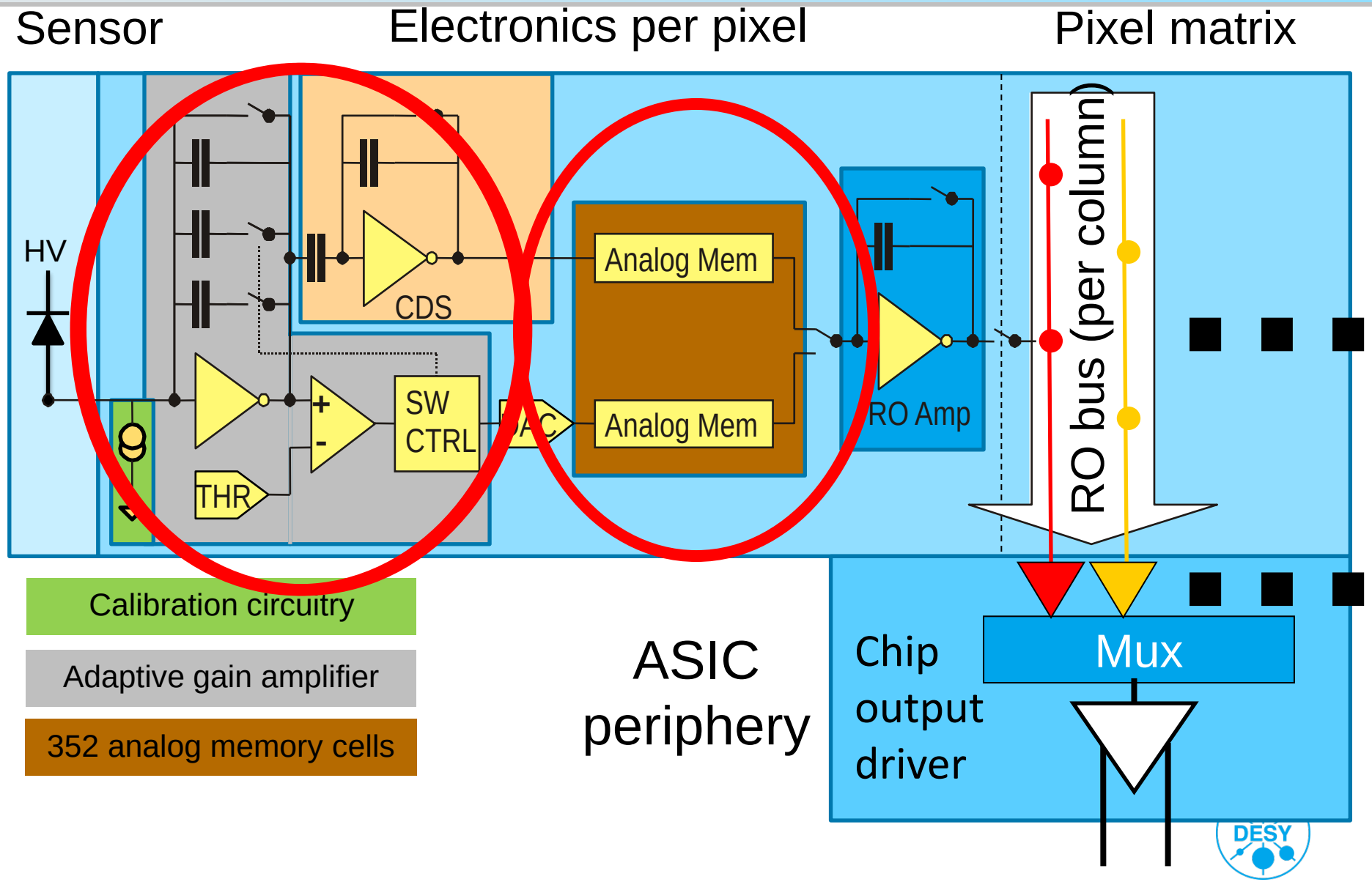


K. J. Gaffney and H. N. Chapman,
Science 8 June 2007

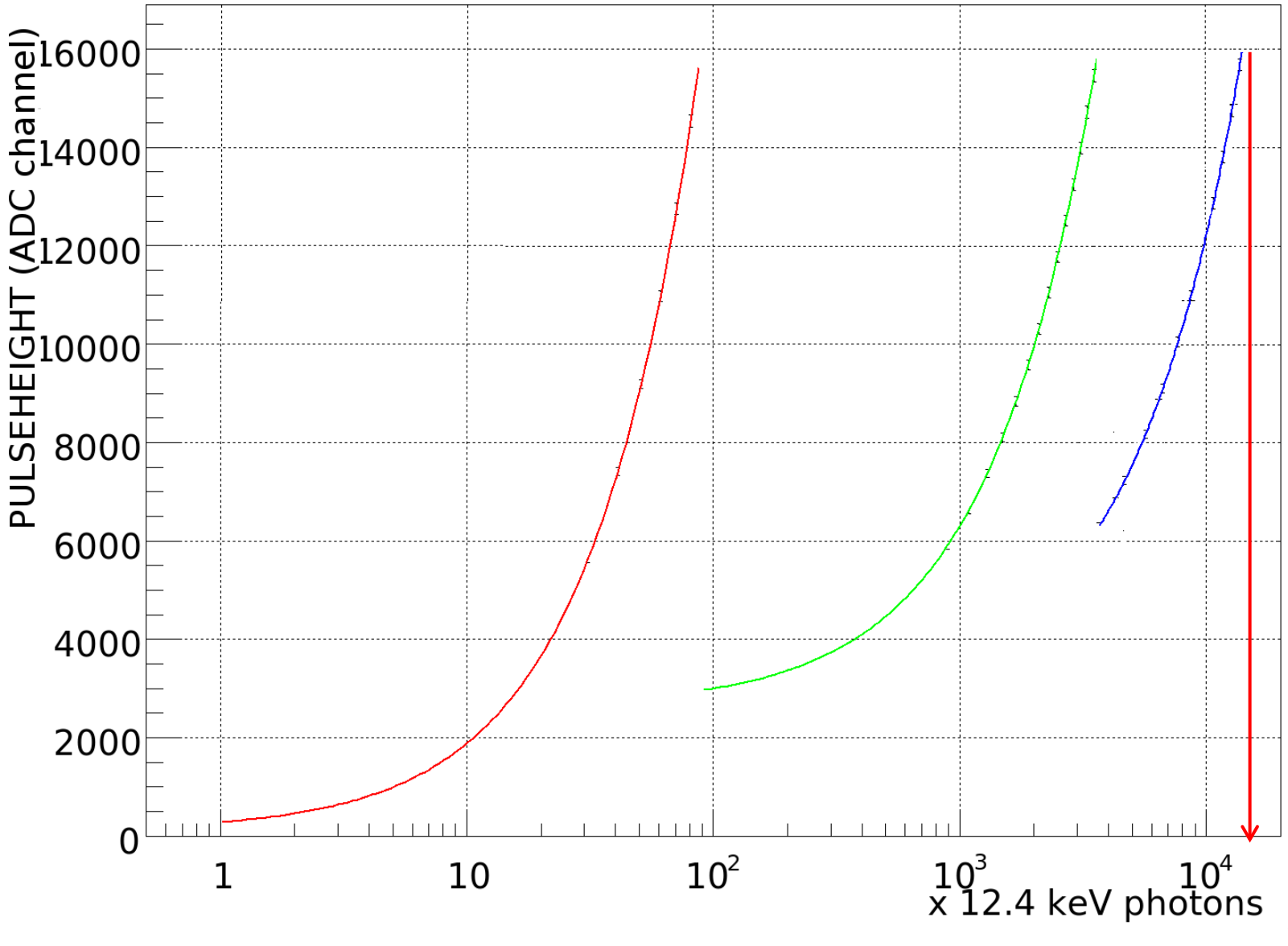
What are the Challenges ?



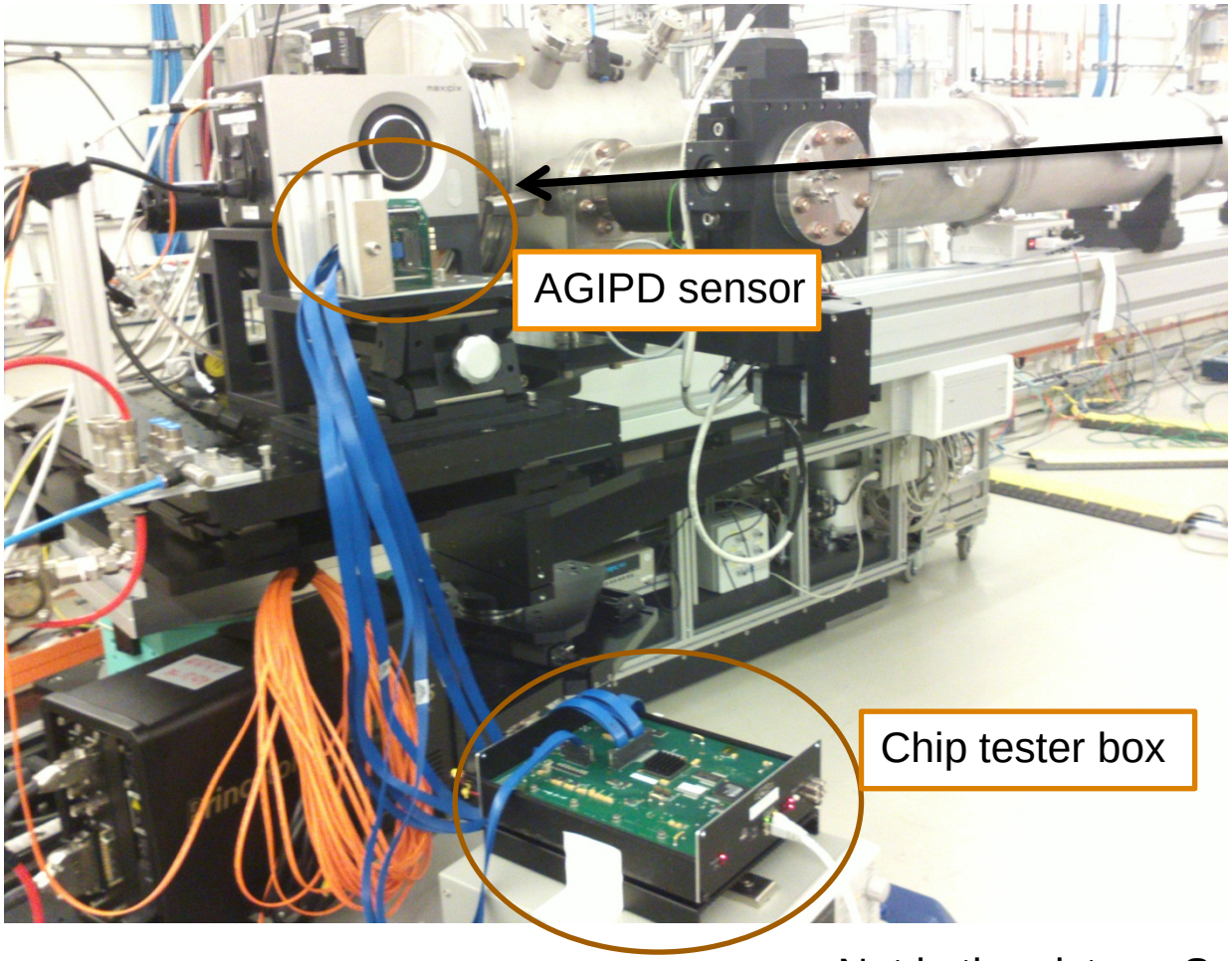
The AGIPD RO-Principle



Dynamic Range



At the P10 beamline

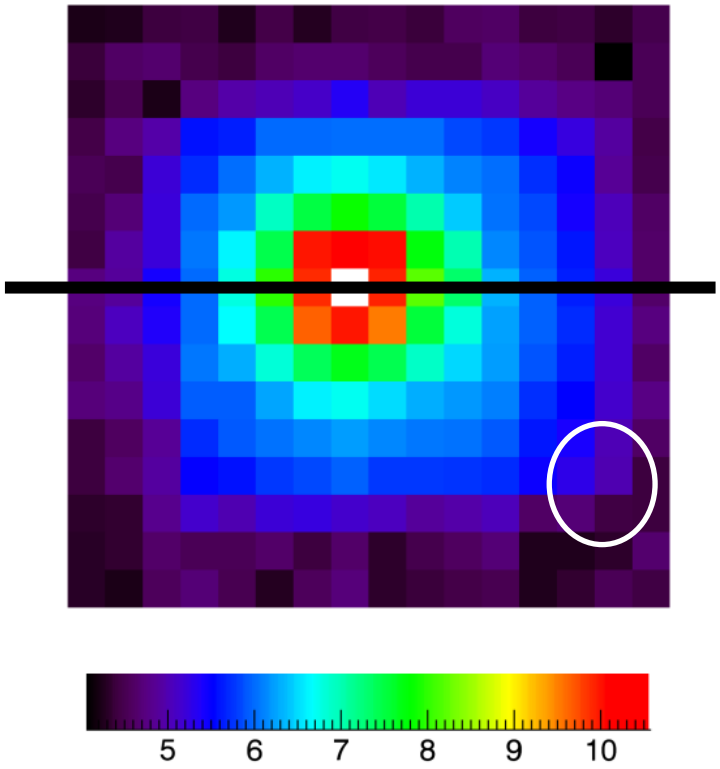


Beam direction
(coming from sample)

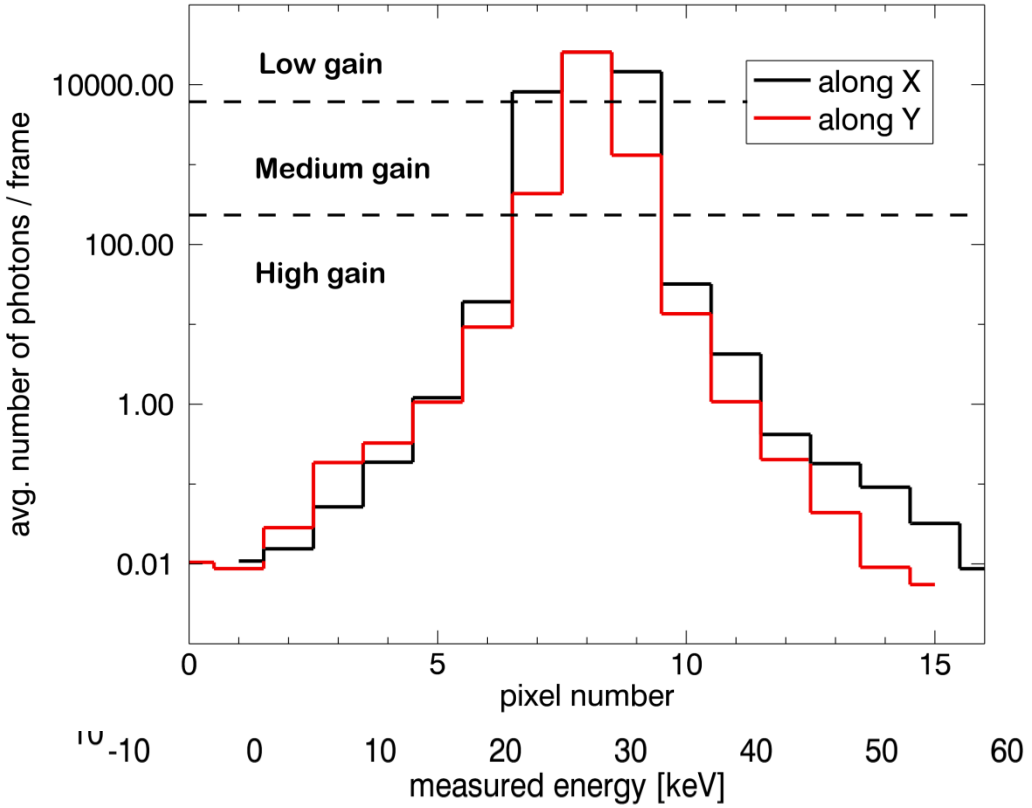
It took about 1 ½ hours to set up, after about 2 hours we saw the first image

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

Looking at the direct beam



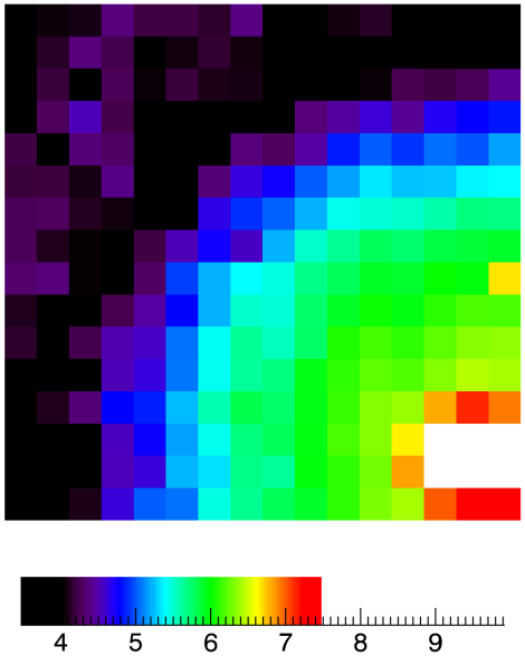
photons/second
Logarithmic color scale



Gain switching experimentally proven

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

SAXS patterns



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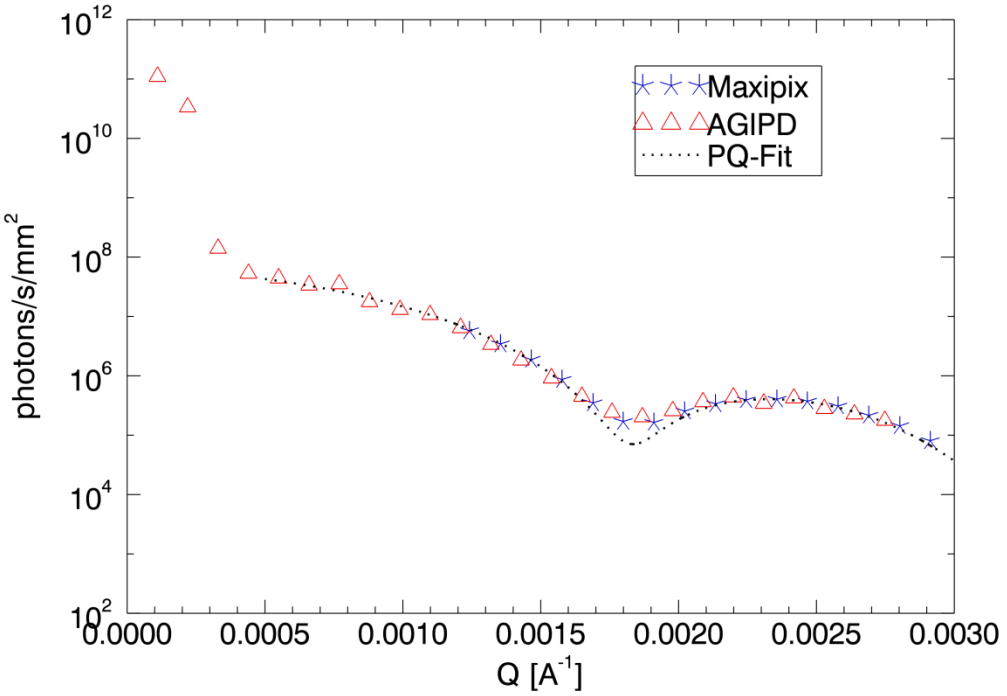
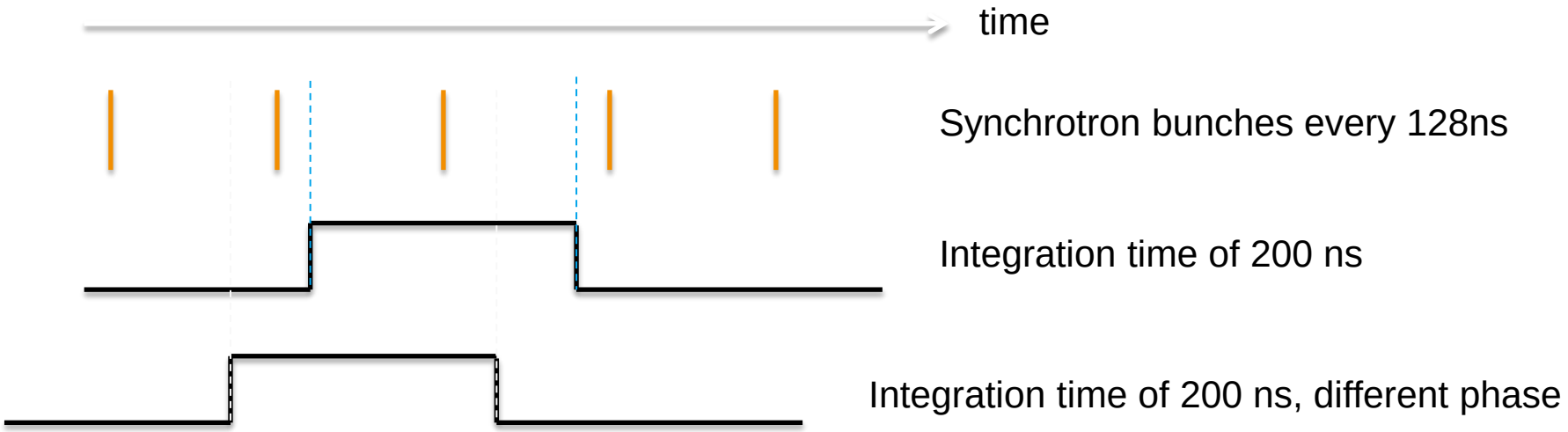


Scientific quality data obtained
- Complete system proven to work
- Calibration proven to be adequate

XPCS with missing synchronization



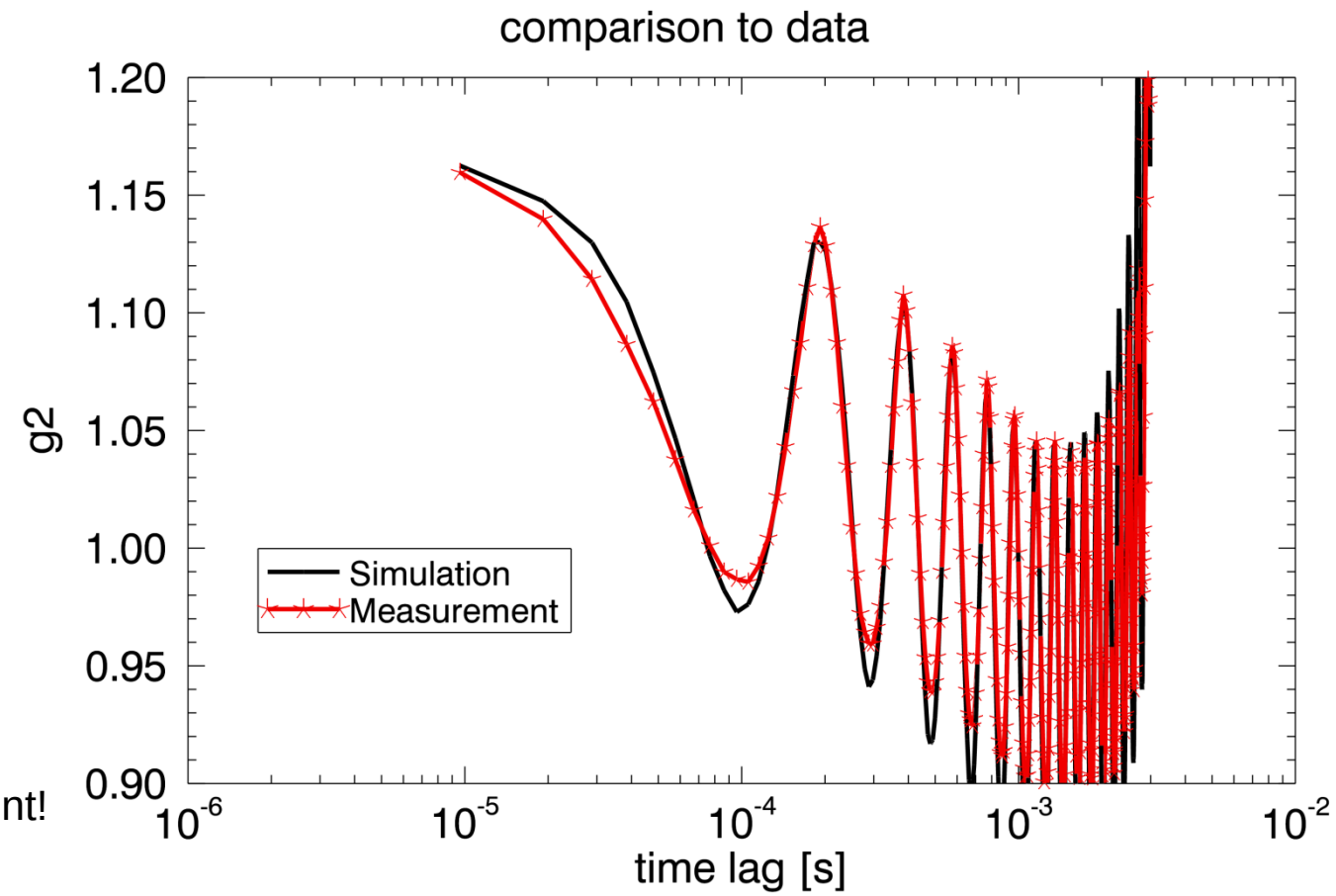
Oscillations of ‘apparent’ Intensity with $I_{max} = 2 * I_{min}$

(as already seen in imaging data)

XPCS data evaluation

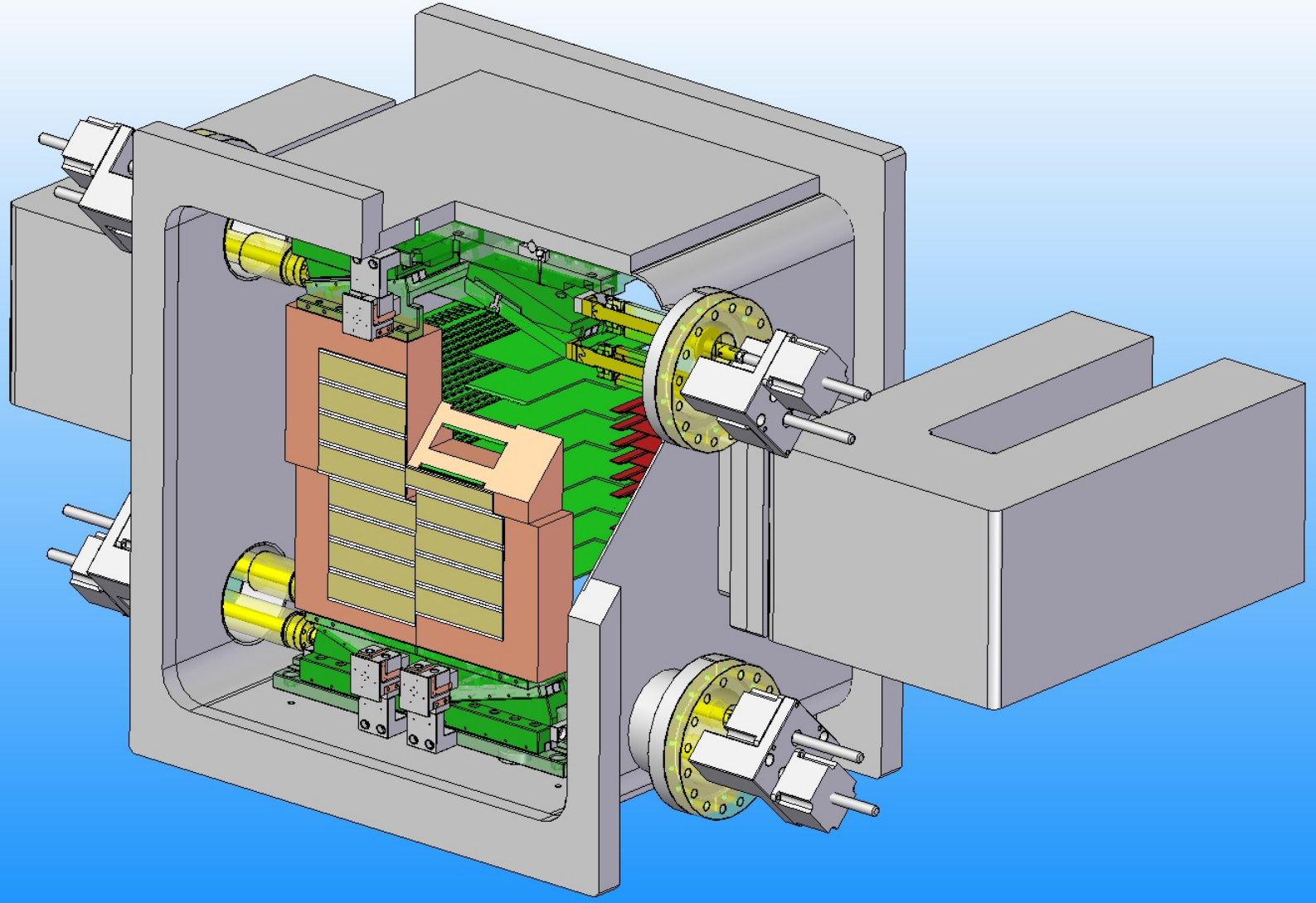
Some minor differences in decorrelation time and contrast
-> initial guess not perfect

Oscillations well reproduced
-> Alias effect of bunch structure plausible



All in all, very good agreement!

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

Summary

Two new detectors:

1. LAMBDA:
   - 55 micron pixels; >1000 frames/sec (1 msec);
   - Available June 2013
2. AGIPD:
   - 200 micron pixel; 5.4 M frames/sec (220 nsec)
   - Available mid 2014 (single modules)