Detector Developments for the European XFEL.

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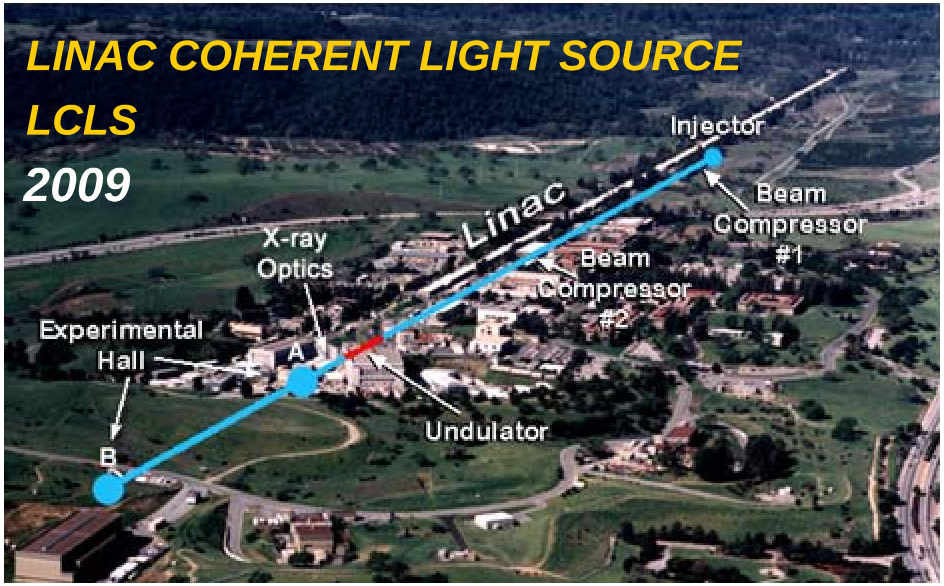
4th Detector Workshop of the Helmholtz Aliance; March 2011

HELMHOLTZ | ASSOCIATION

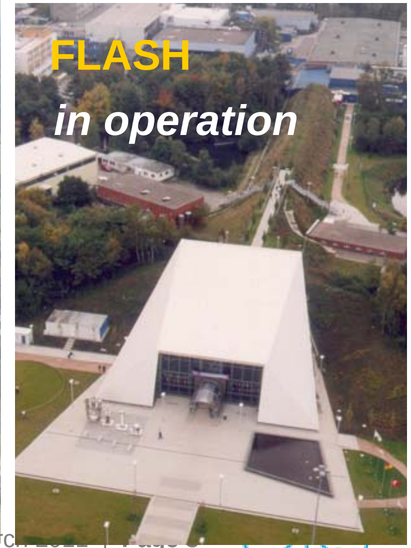
DESY

- **The FEL Detector Challenge**
- **The AGIPD project**
- **The DSSC project**
- **Summary / Conclusions**

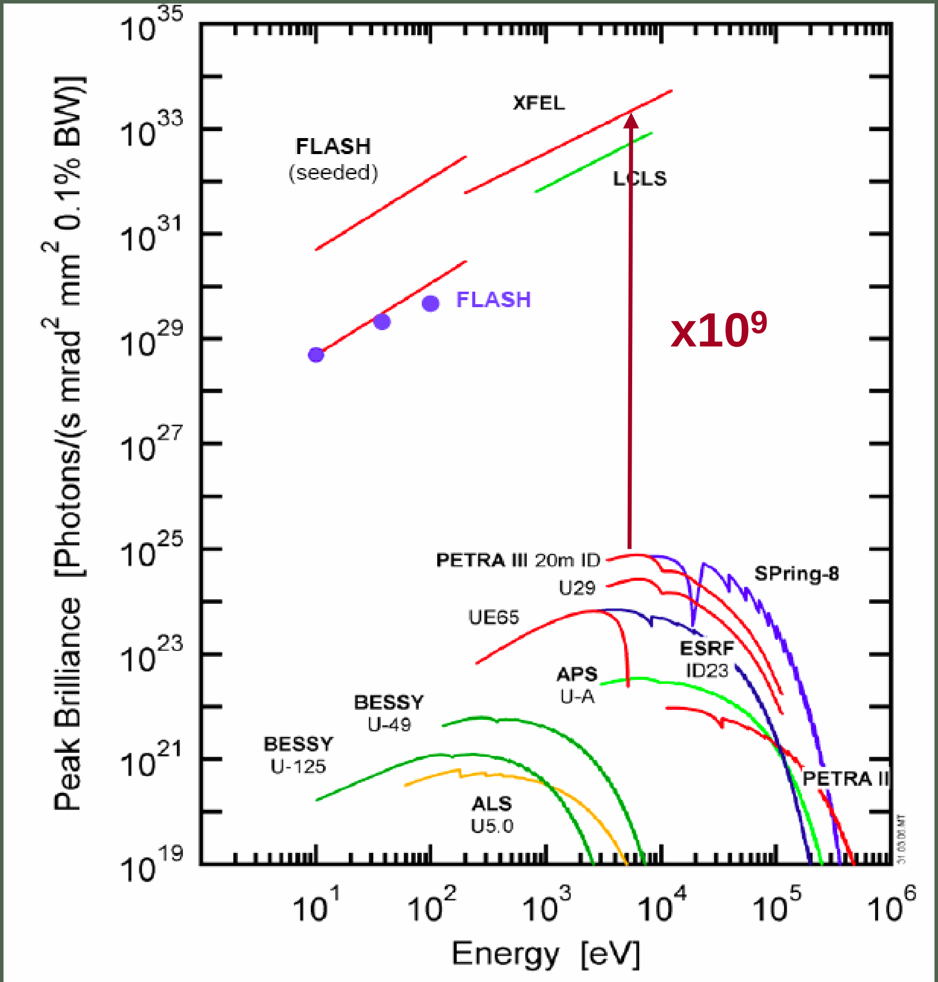
FEL Sources in the world



FLASH:	5 Hz, 10 Hz and 5 MHz
LCLS:	120 Hz
SCSS:	60 Hz
XFEL:	5 Hz, 10 Hz and 5 MHz

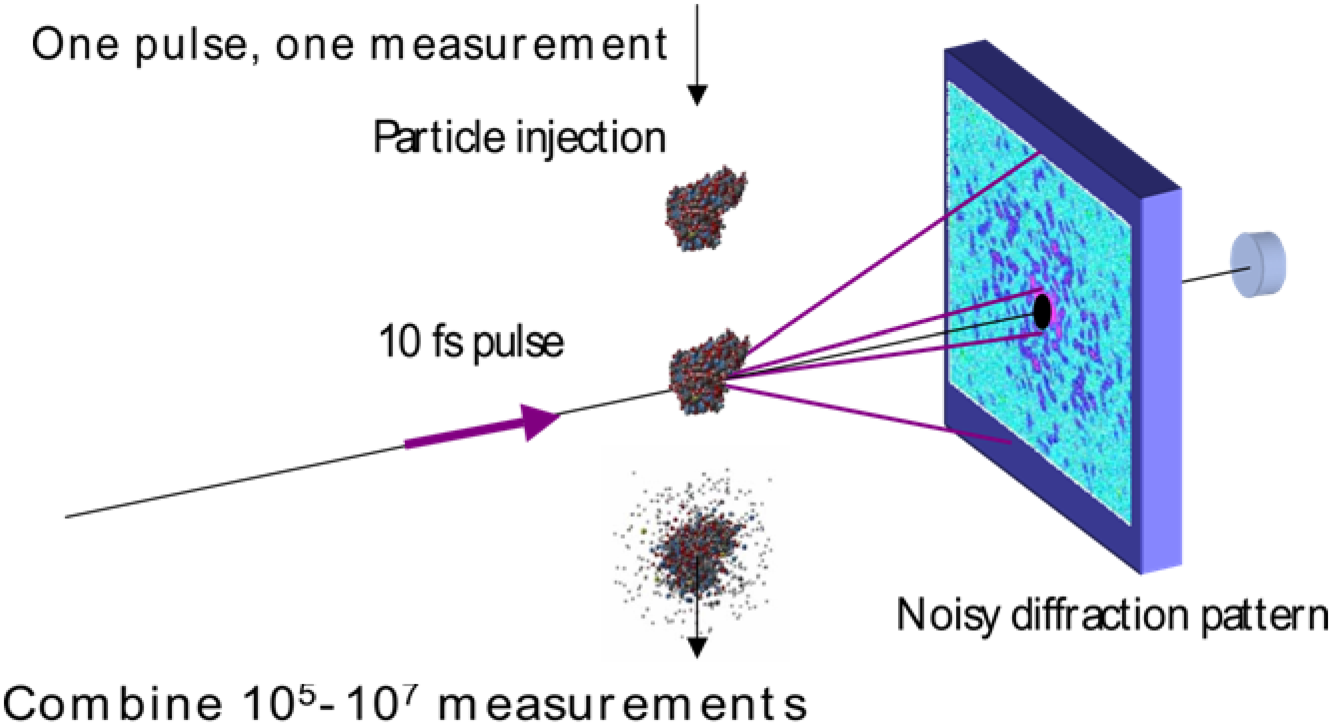


Challenge: Different Science

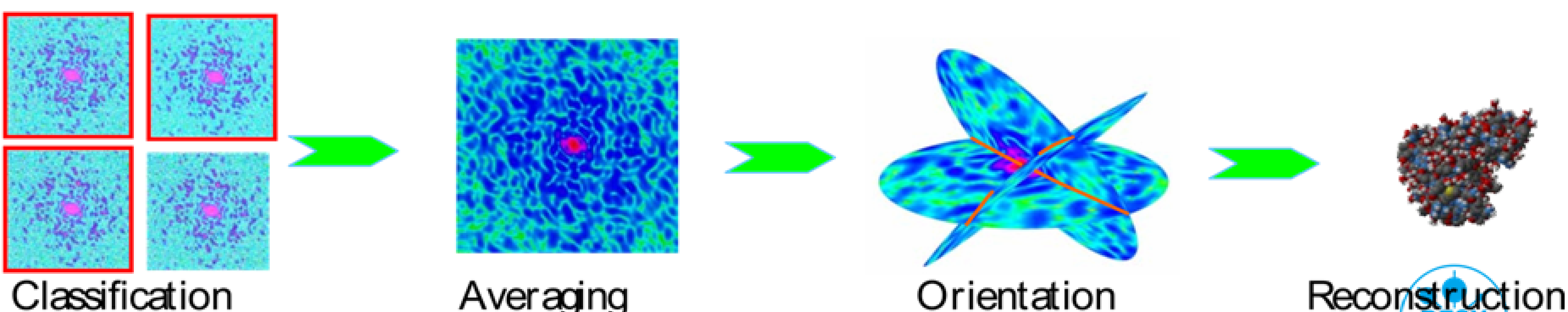


- Completely new science
- Fast science 100 fsec
- “Single shot” science

Single shot experiments

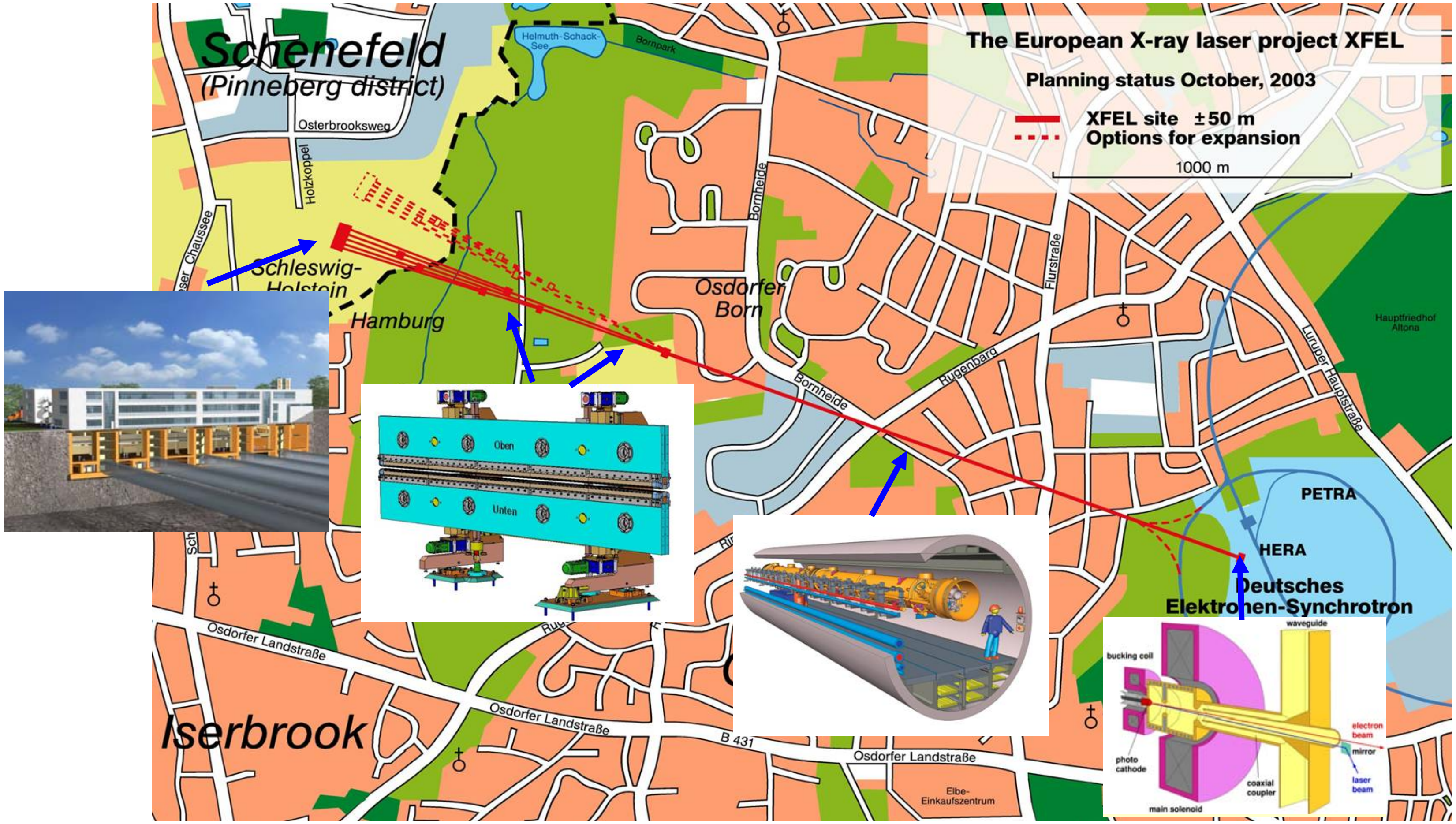


Solve the well known
Phase Problem



Overall layout of the European XFEL

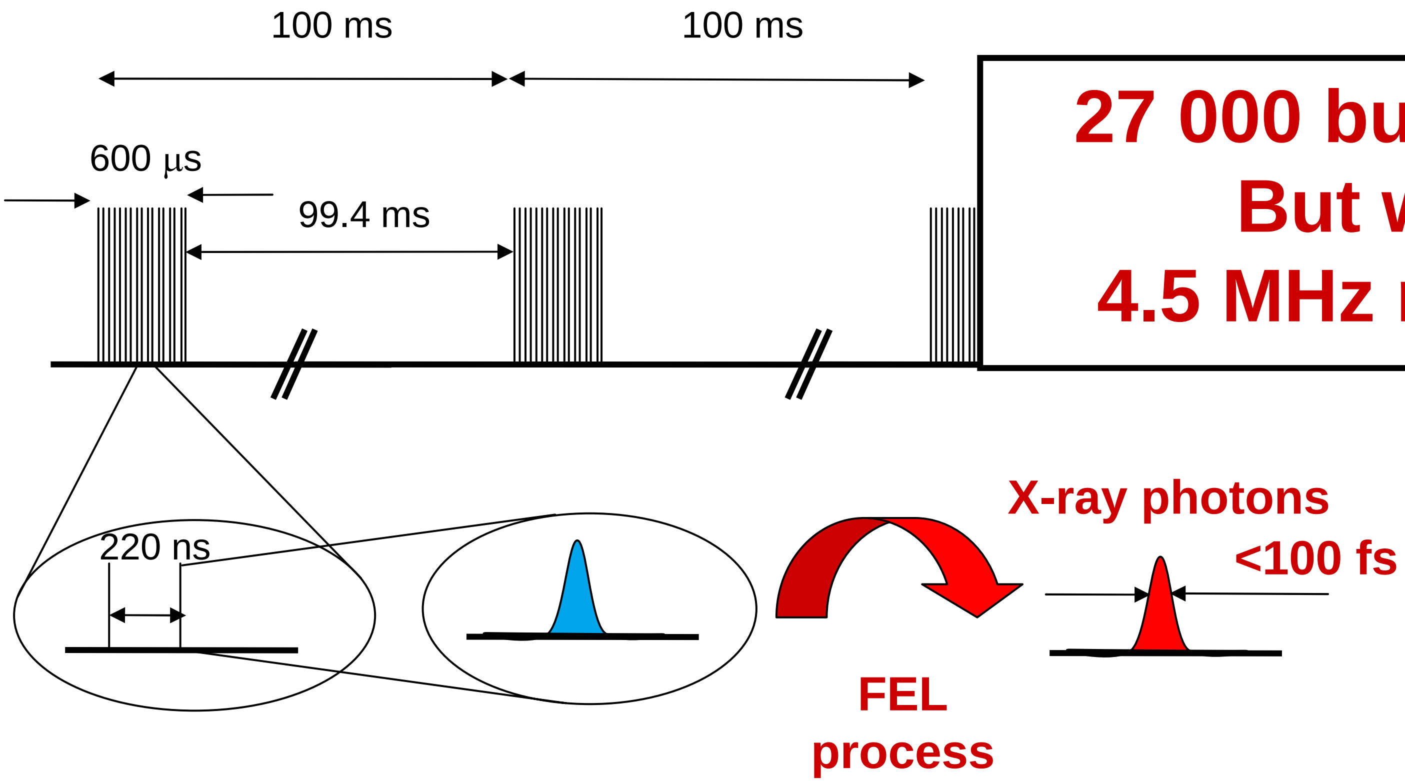
3.4km



XFEL experiment complex at Schenefeld site

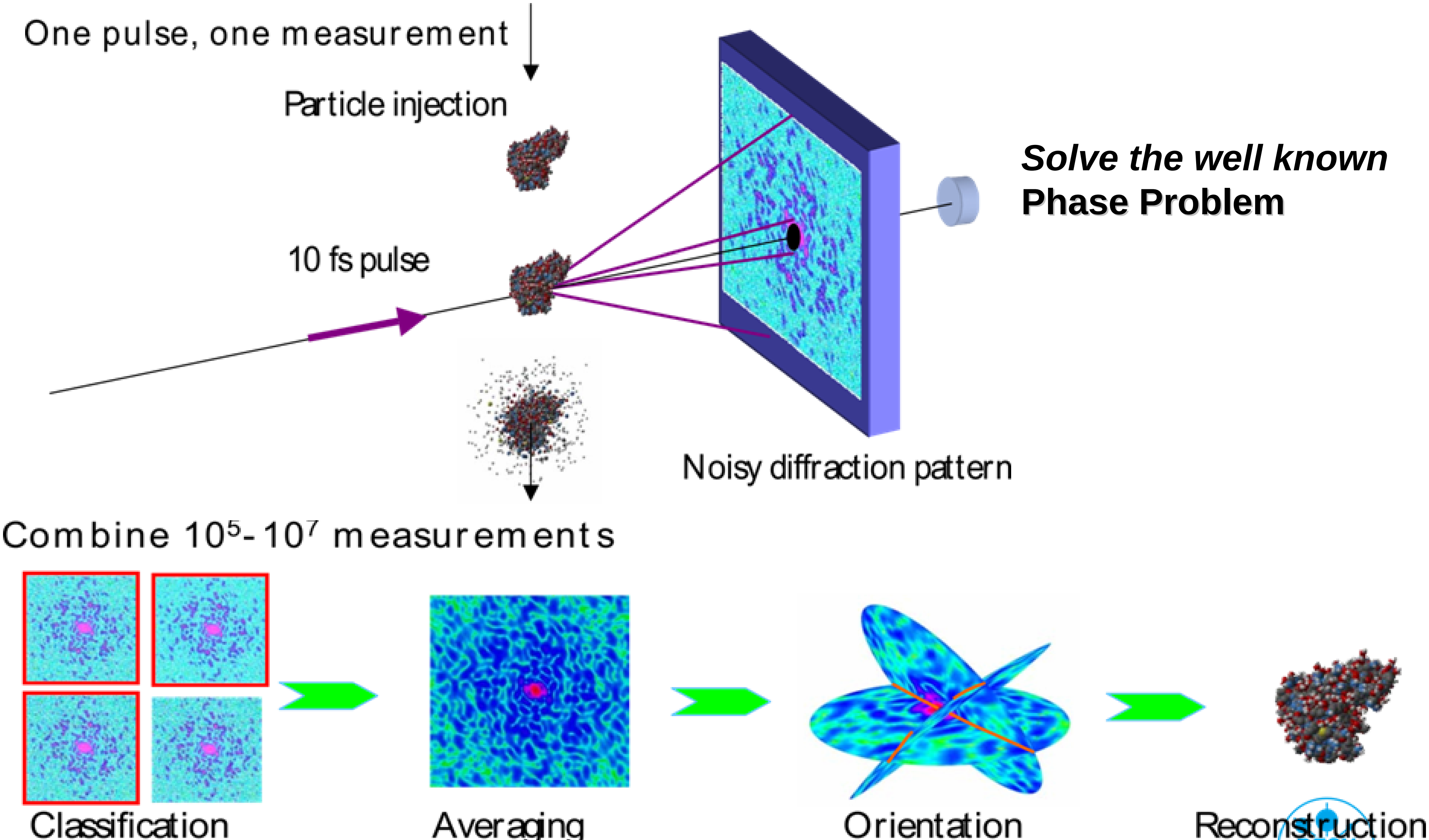
E-XFEL Challenge: Time structure = difference with “others”

Electron bunch trains; up to 2700 bunches in 600 μsec, repeated 10 times per second.
Producing 100 fsec X-ray pulses (up to 27 000 bunches per second).



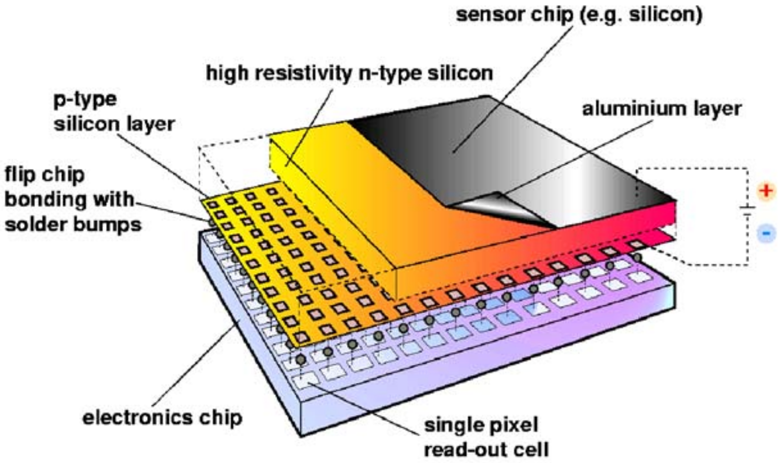
27 000 bunches/s
But with
4.5 MHz rep rate

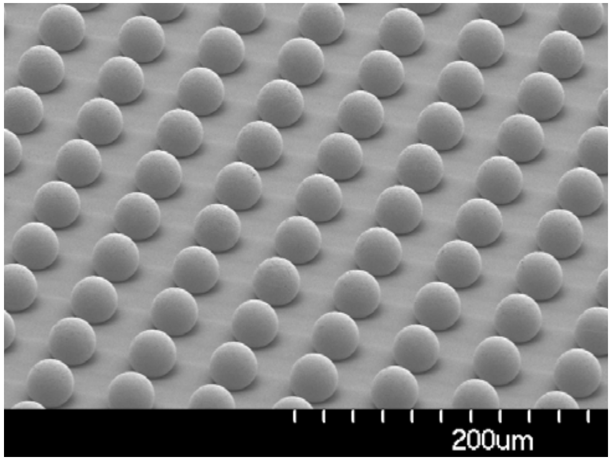
Single shot experiments

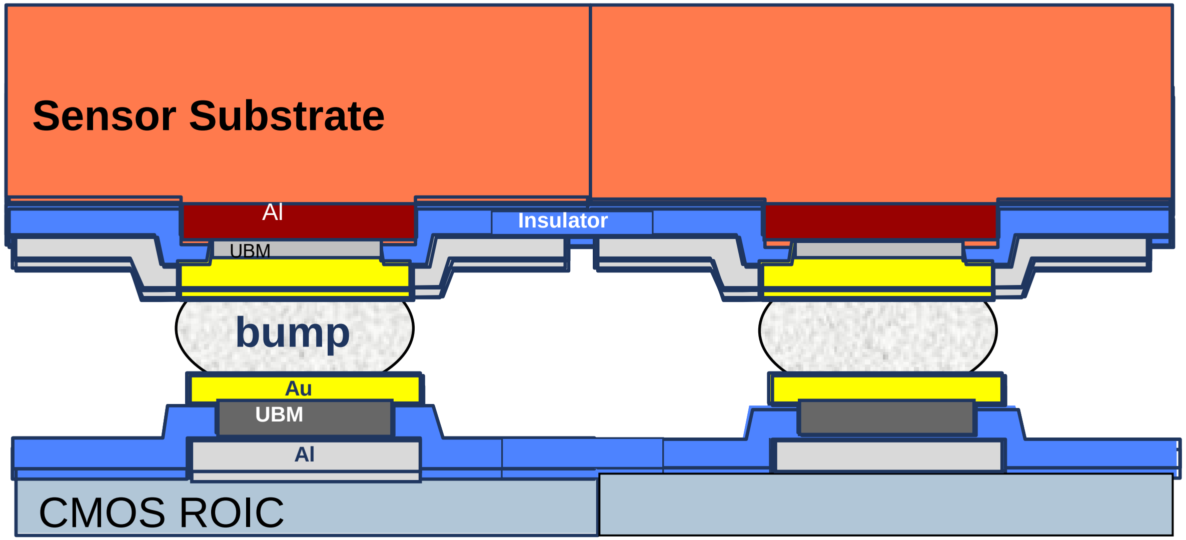


***Solve the well known* Phase Problem**

Hybrid Pixel Technology







The Adaptive Gain Integrating Pixel Detector (AGIPD) project

The Adaptive Gain Integrating Pixel Detector

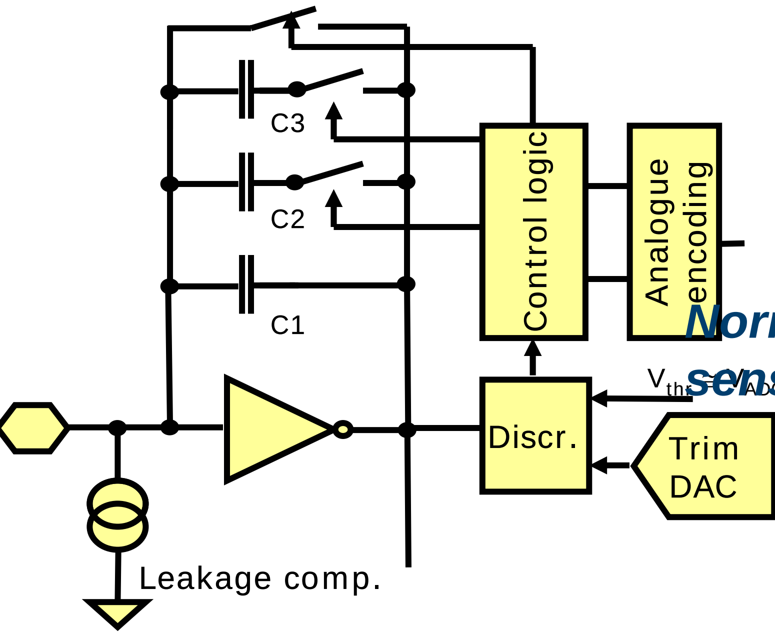
High dynamic range:

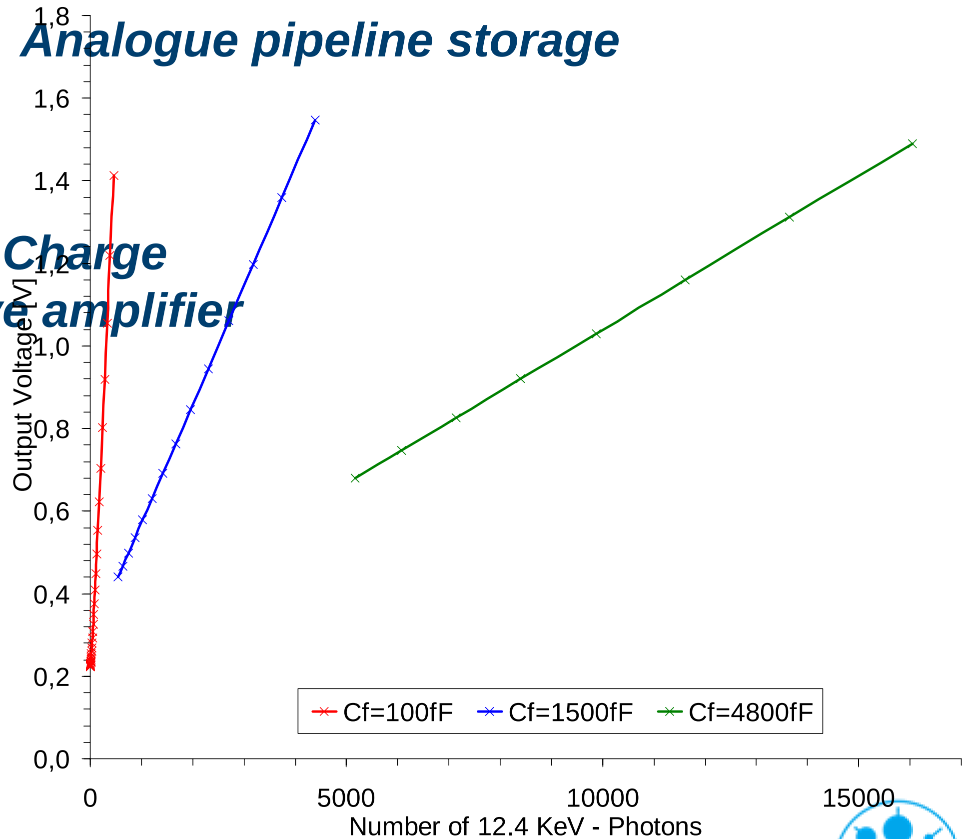
Dynamically gain switching system

Extremely fast readout (200ns):

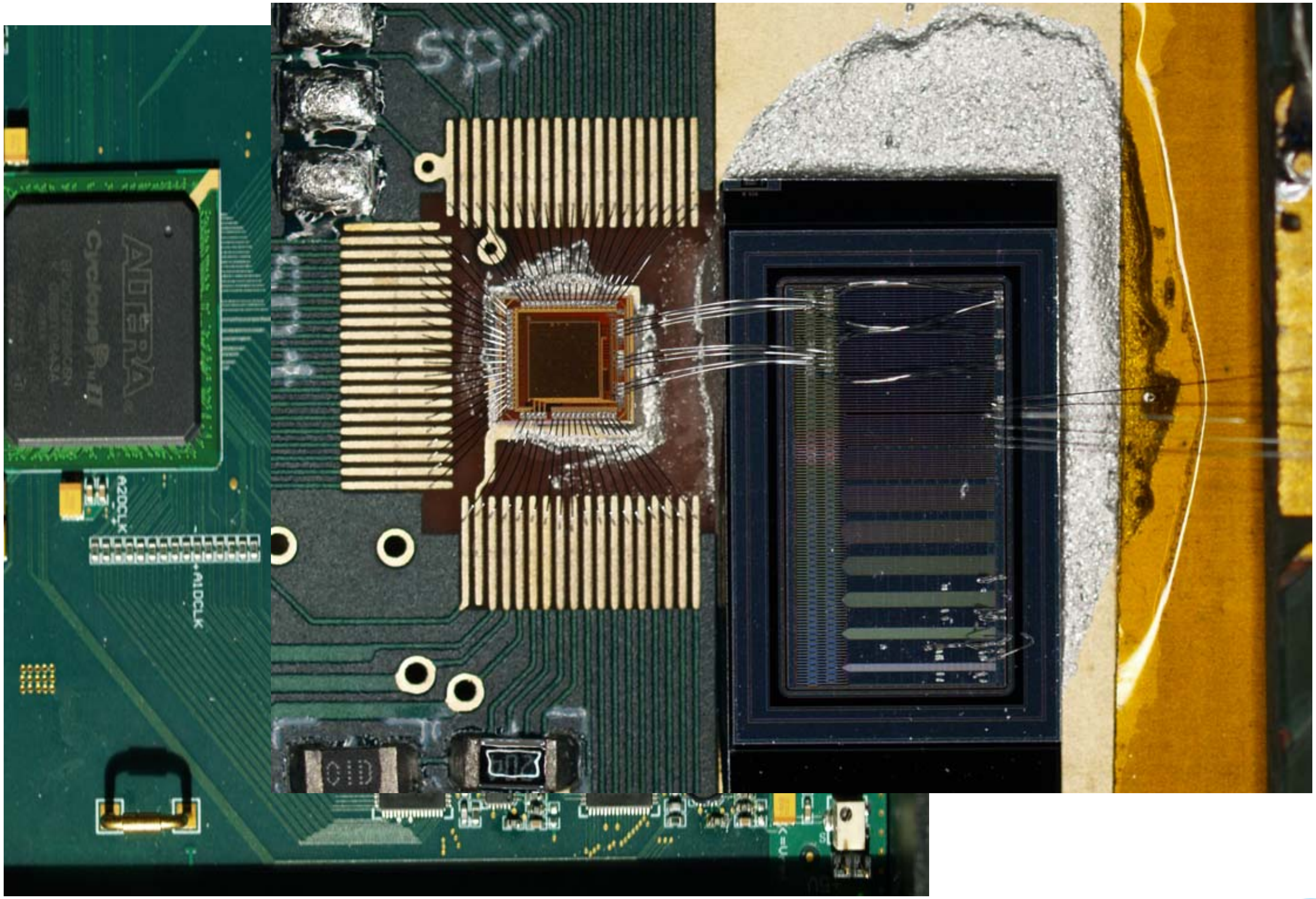
Analogue pipeline storage

Normal Charge sensitive amplifier

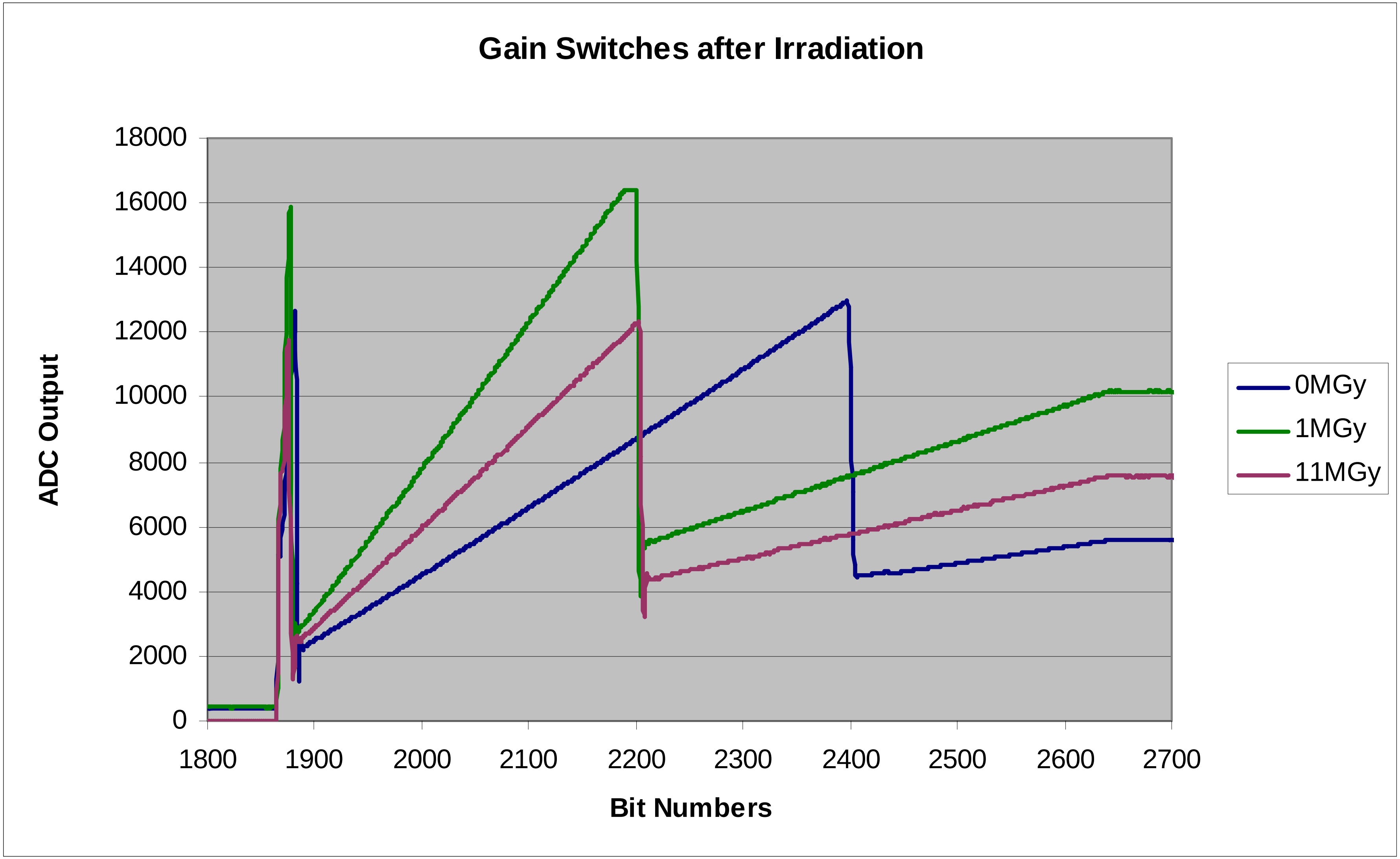




Overview of the chip test board



Dynamic Gain Switching works!



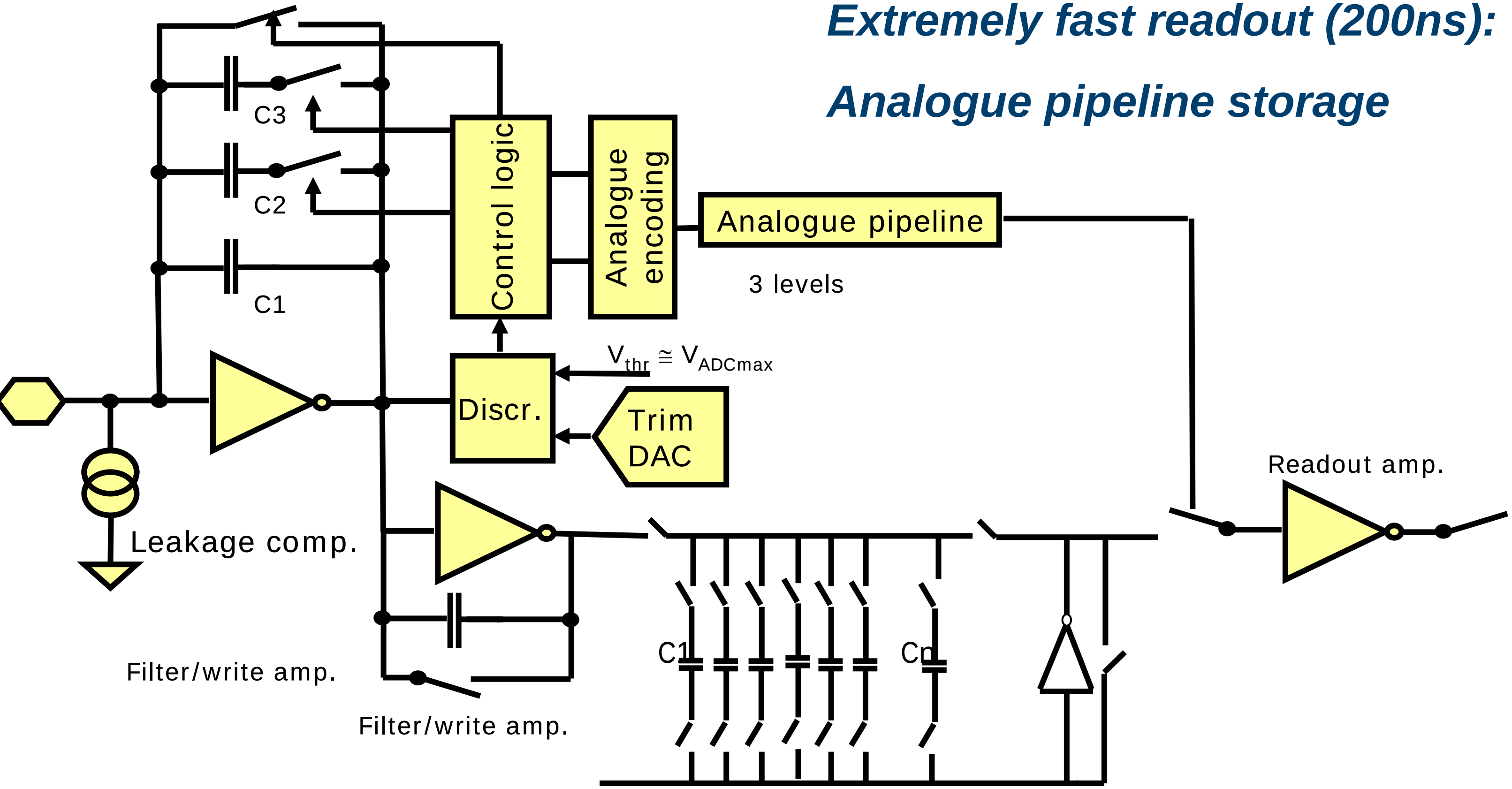
The Adaptive Gain Integrating Pixel Detector

High dynamic range:

Dynamically gain switching system

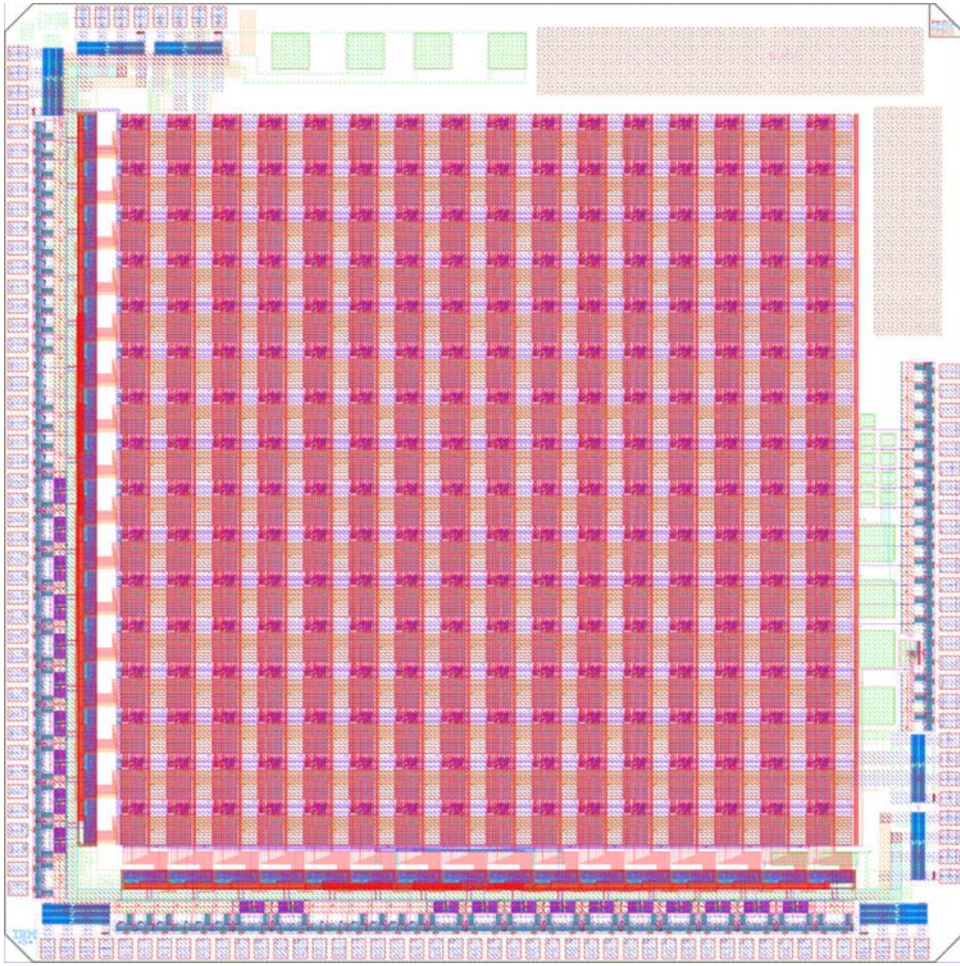
Extremely fast readout (200ns):

Analogue pipeline storage

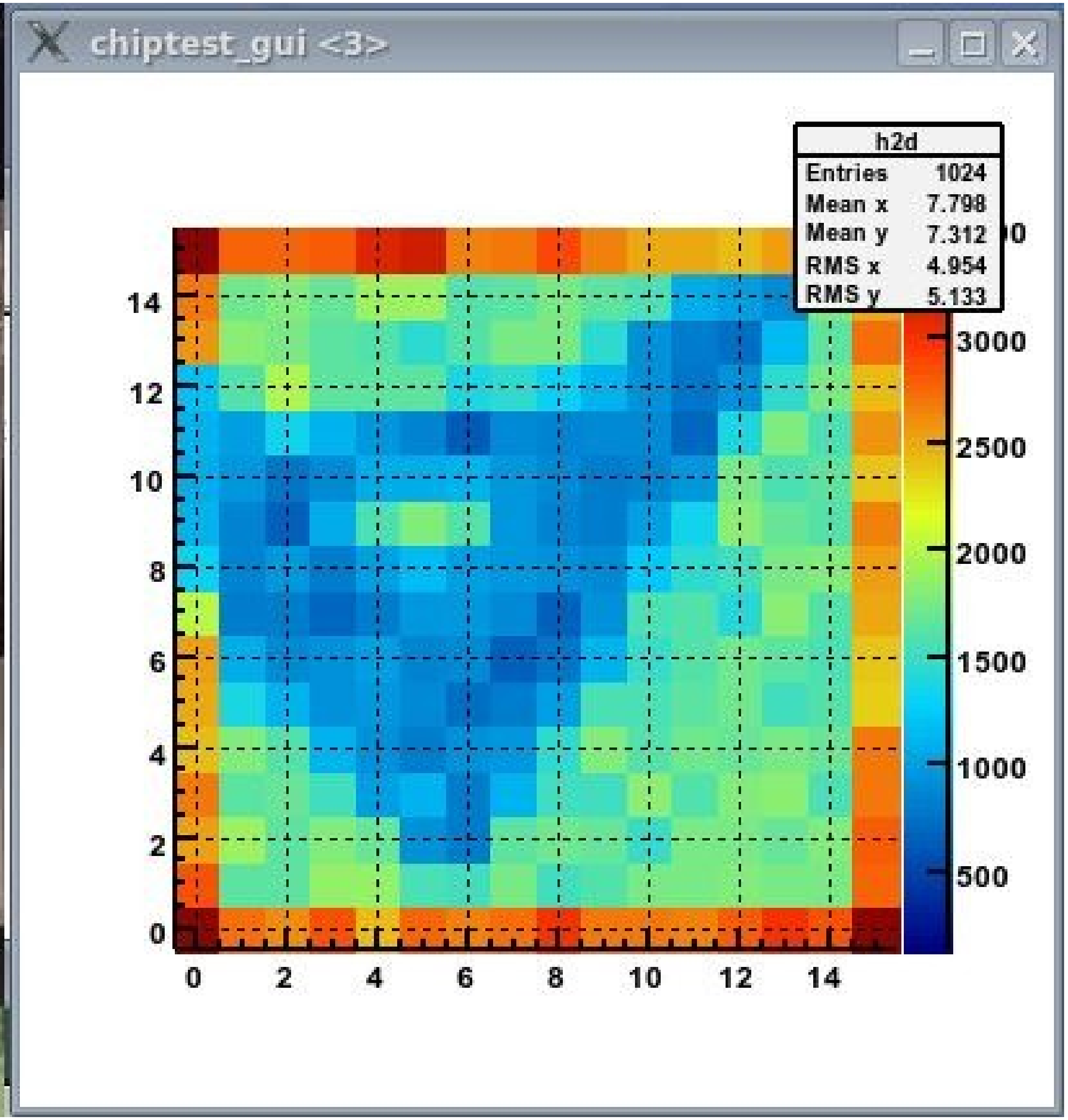


AGIPD02

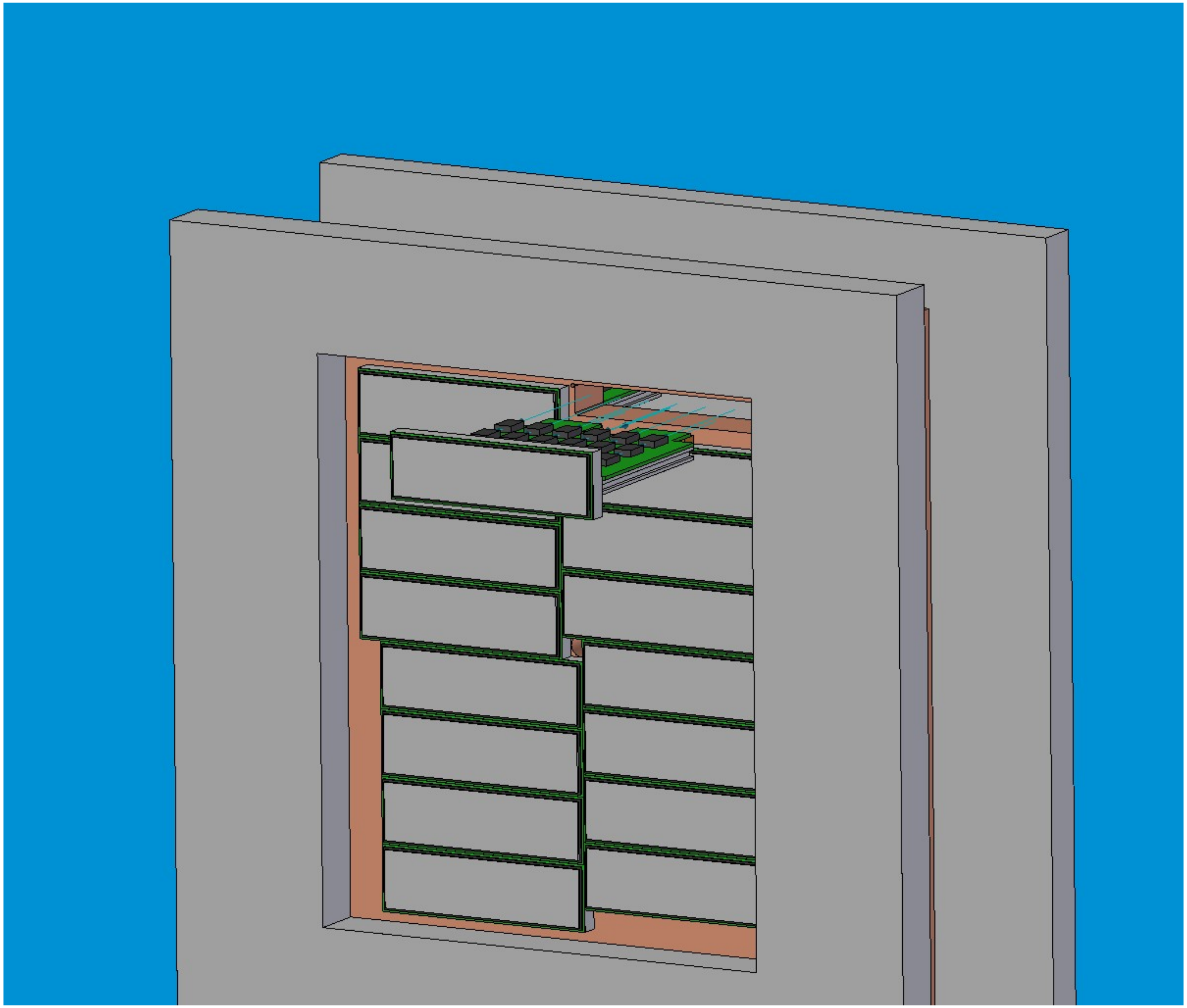
- 16 x 16 pixel prototype
- Adaptive gain
- Different flavors of storage
- 100 frames per pixel



First X-ray image taken with AGIPD02



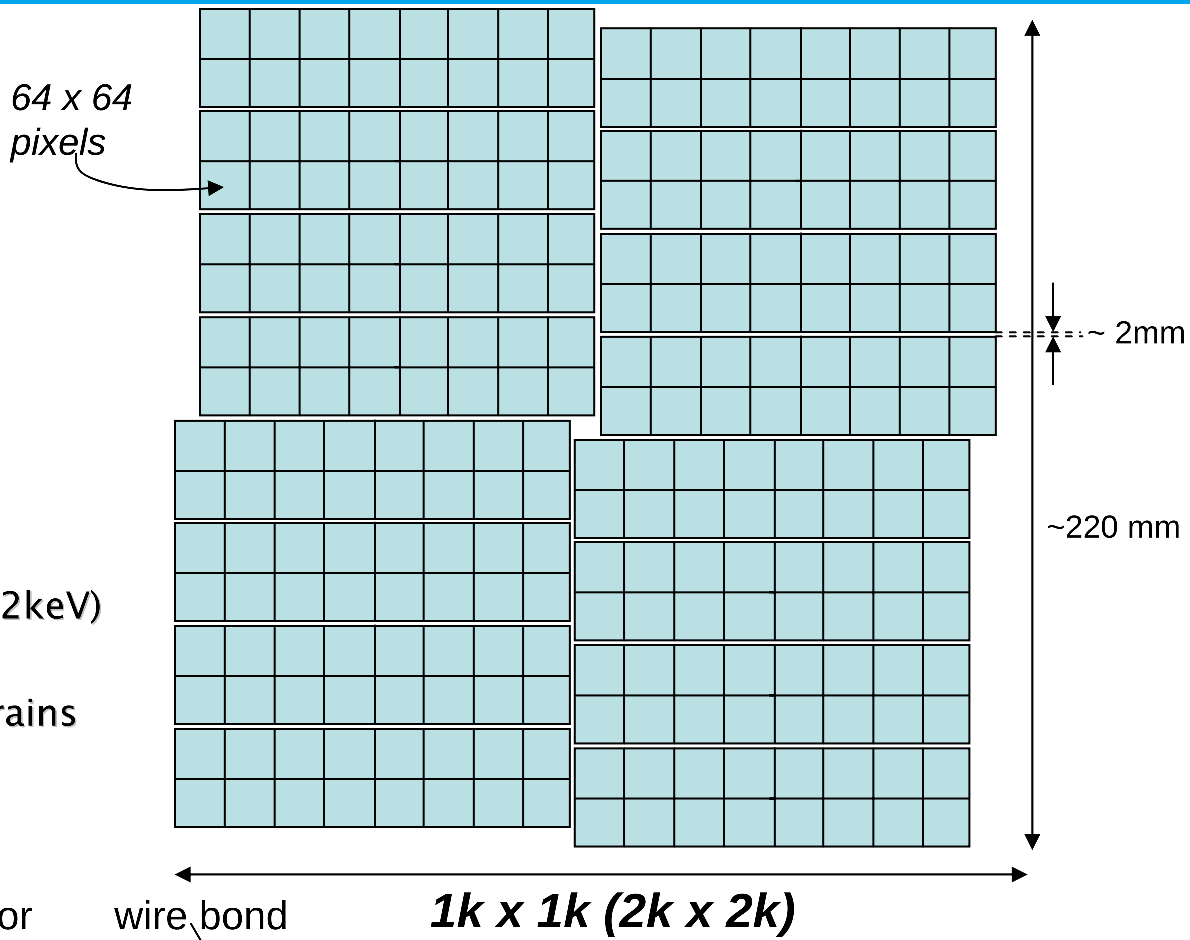
The 1k x 1k detector

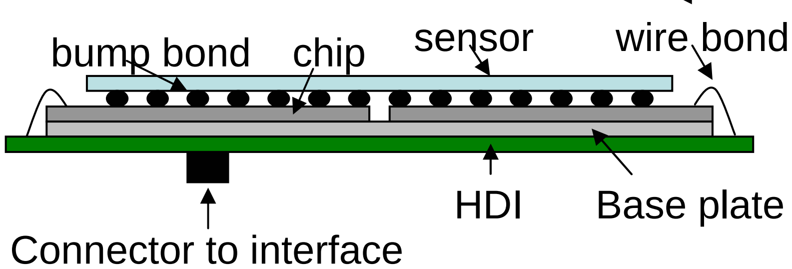


The Adaptive Gain Integrating Pixel Detector

<u>Basic parameters</u>

- 1 Megapixel detector (1k × 1k)
- 200μm × 200μm pixels
- Flat detector
- Sensor: Silicon 128 x 512 pixel tiles
- Single shot 2D-imaging
- 5MHz frame rate
- 2 × 10^4 photons dynamic range
- Adaptive gain switching
- Single photon sensitivity at 12keV
- Noise ≤200e (50 × 10^{-3} photons @ 12keV)
- Storage depth ≥200 images
- Analogue readout between bunch-trains





The Adaptive Gain Integrating Pixel Detector

> The AGIPD consortium:

PSI/SLS -Villingen: **chip design; interconnect and module assembly**

Universität Bonn: **chip design**

Universität Hamburg: **radiation damage tests, "charge explosion" studies; and sensor design**

DESY: **chip design, interface and control electronics, mechanics, cooling; overall coordination**

Some Facts

5 years development

~ 20 people

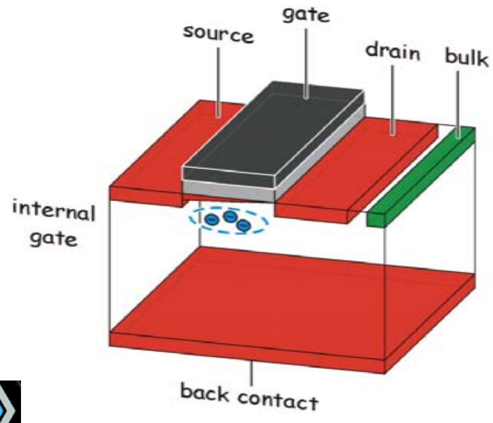
Some Milestones

First 16x16 pixels prototype	End 2010
Definition of final design	Summer 2011
Production, assembly and test	>2013

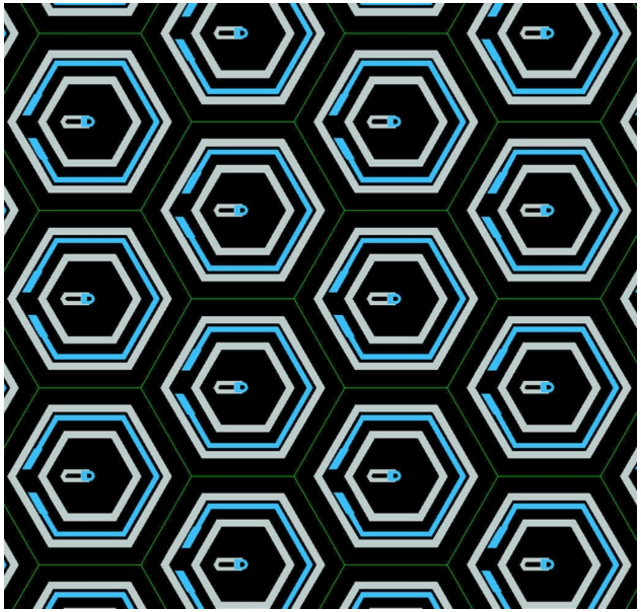
The DEPFET Sensor with Signal Compression (DSSC)

DSSC - DEPMOS Sensor with Signal Compression

- > DEPFET per pixel
- > Very low noise (good for soft X-rays)
- > non linear gain (good for dynamic range)
- > per pixel ADC
- > digital storage pipeline



- > **Hexagonal pixels 200μm pitch**



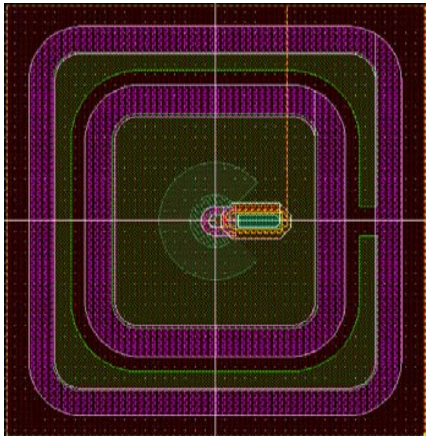
- combines DEPFET
- with small area drift detector (scaleable)

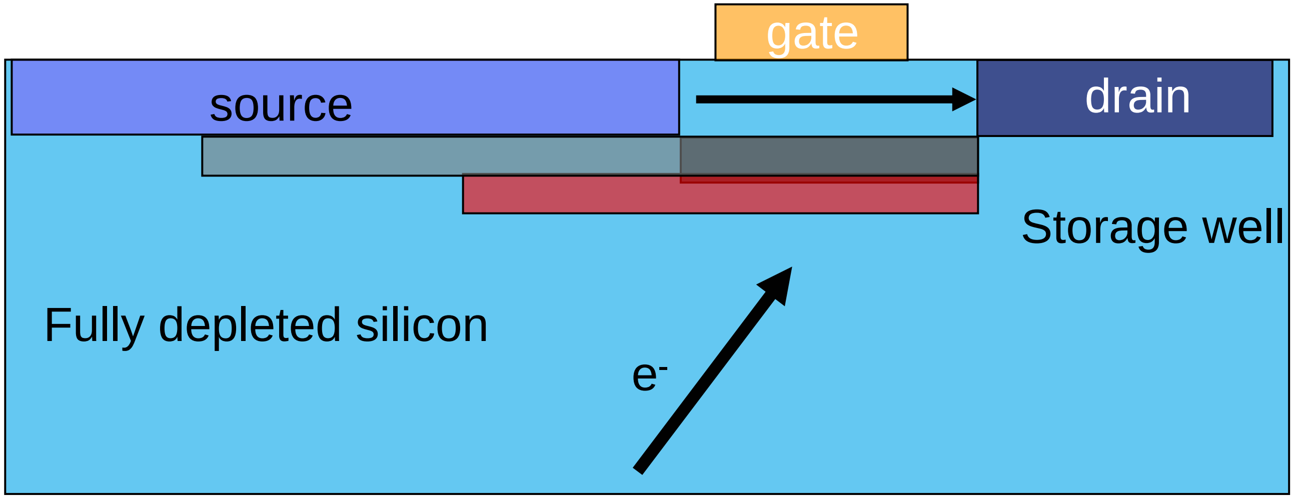
- > MPI-HLL, Munich
- > Universität Heidelberg
- > Universität Siegen
- > Politecnico di Milano
- > Università di Bergamo
- > DESY, Hamburg

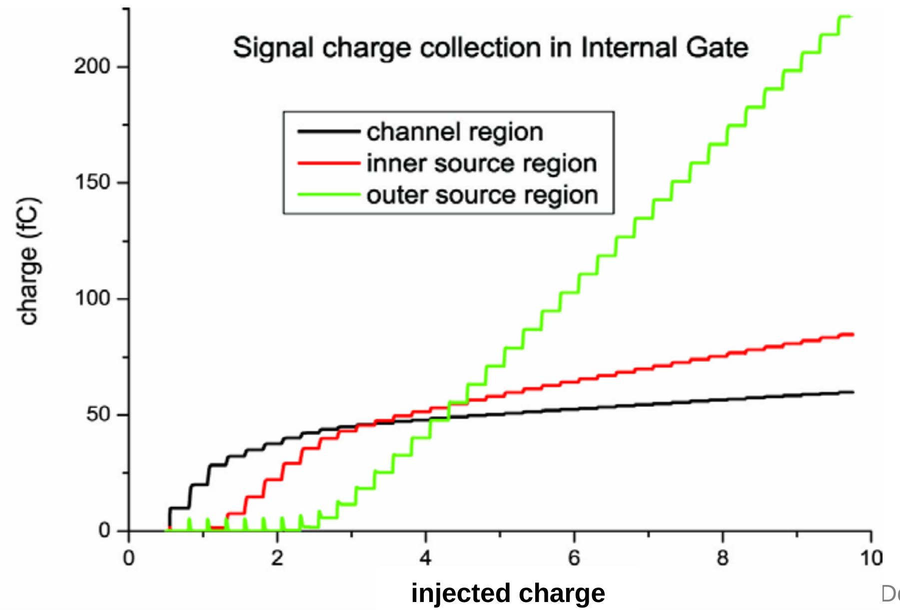
DEPMOS Sensor with Signal Compression

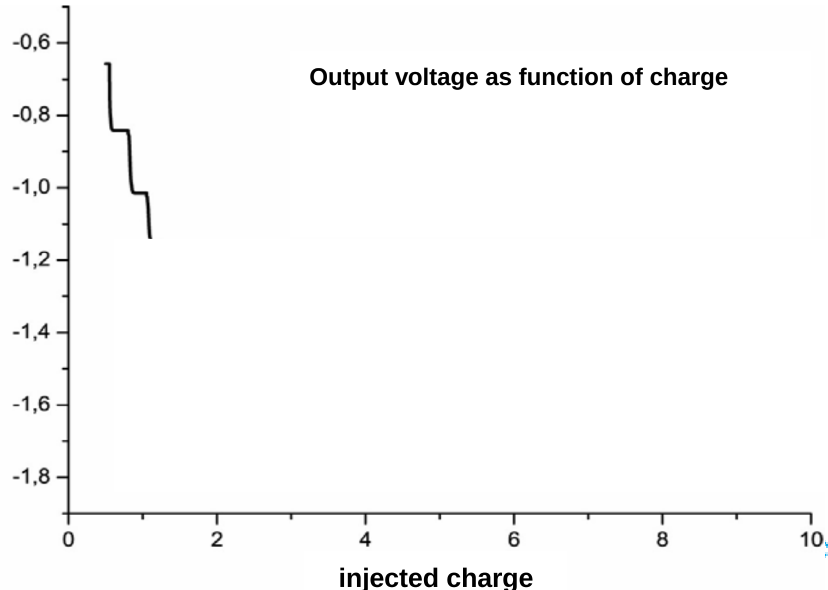
DEPFET: Electrons are collected in a storage well

⇒Influence current from source to drain



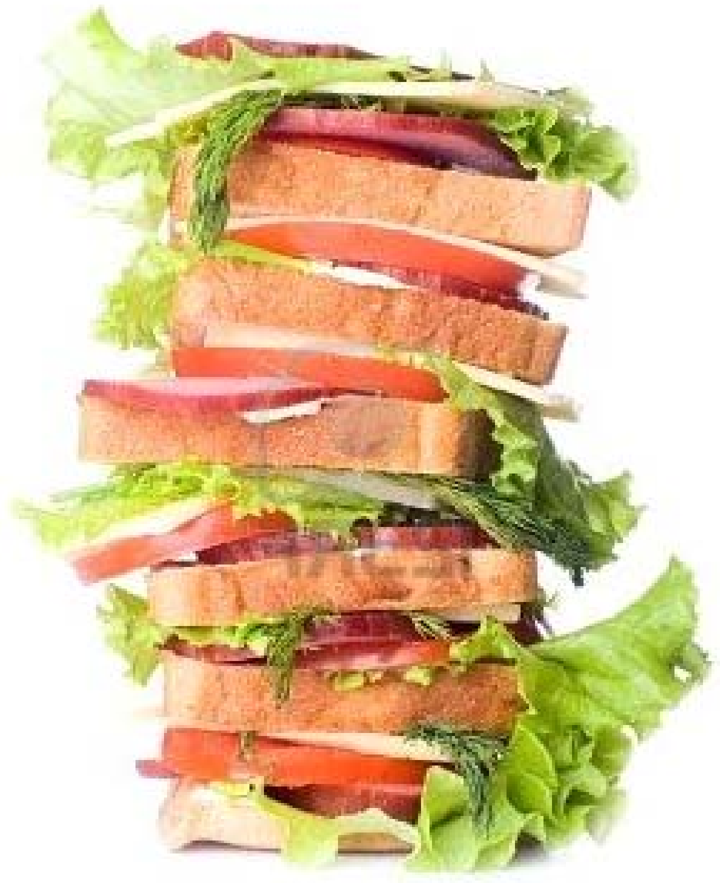






DSSC

why to go vertical



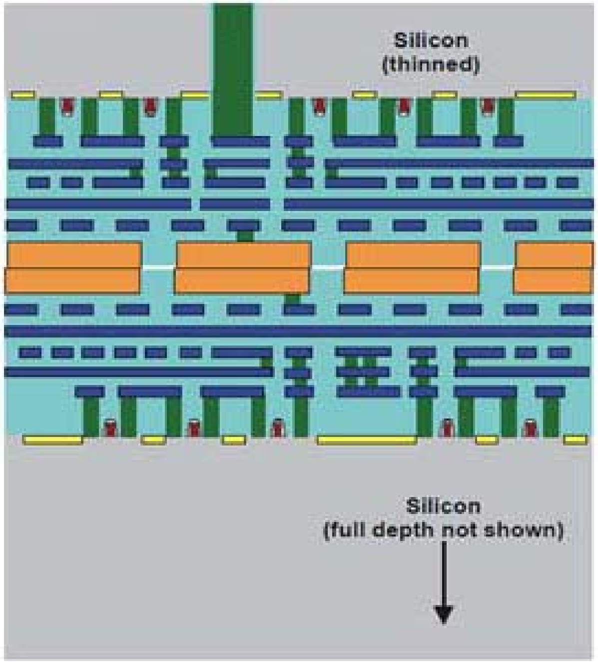
> Increased effective area
  - cheating on the area constraint

> better I/O connections
  - shorter, faster, and more of them

> integration of different technologies
  - select the most suitable tech to do each thing

going vertical: a simple AGIPD evolution hypothesis

- Chartered-Tezzaron technology
- CMOS Low Power, 130 nm , 1.5 V
- available for MPW through MOSIS

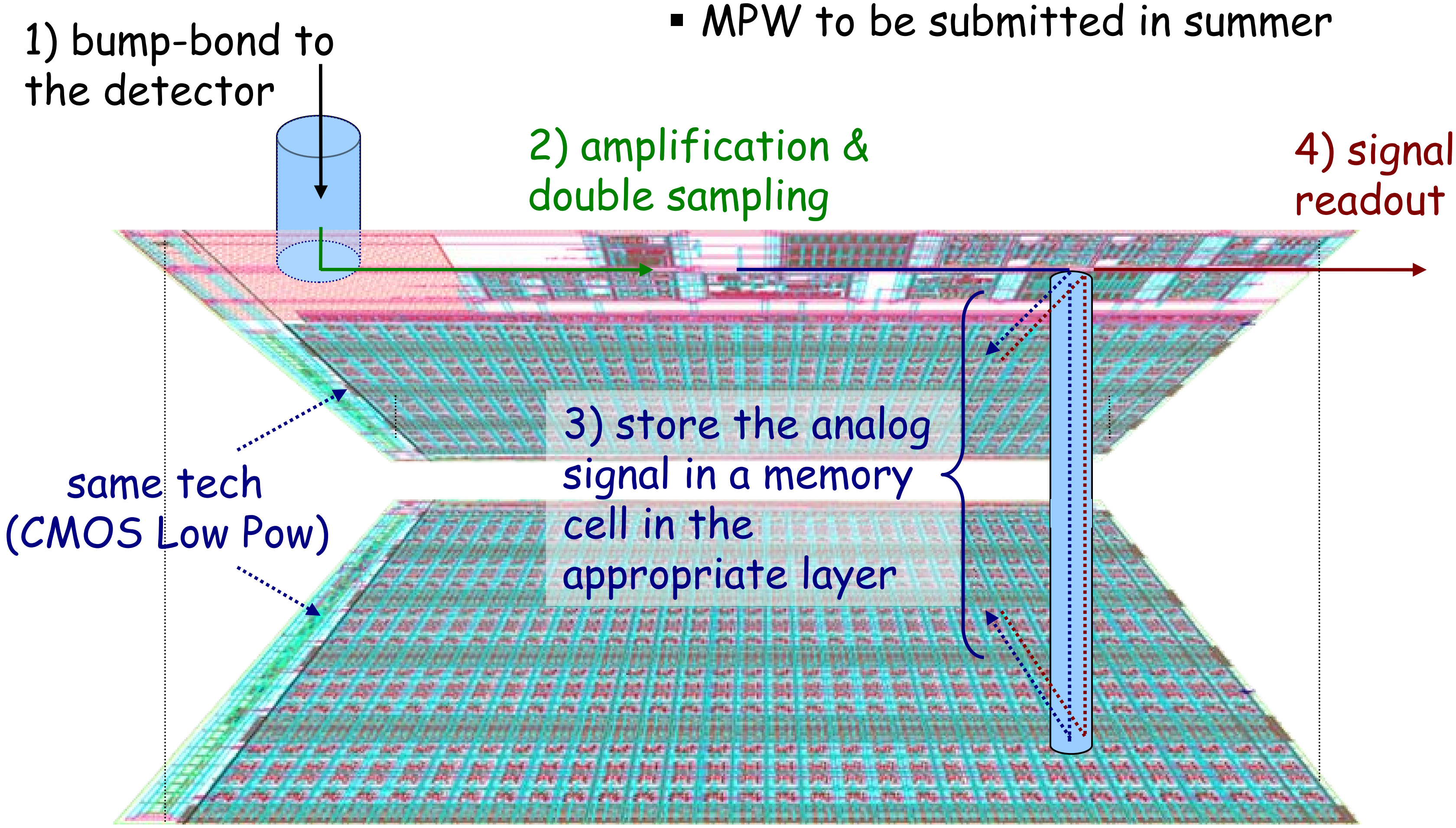


other hypothesis

- Ziptronix (3D bonding only)
- Fraunhofer (TSV only)
- IMEC (developing)
- AMS (developed but not commercially available yet)
- IBM (TSV not insulated yet)
- 3D Package (Amkor, Tessera)

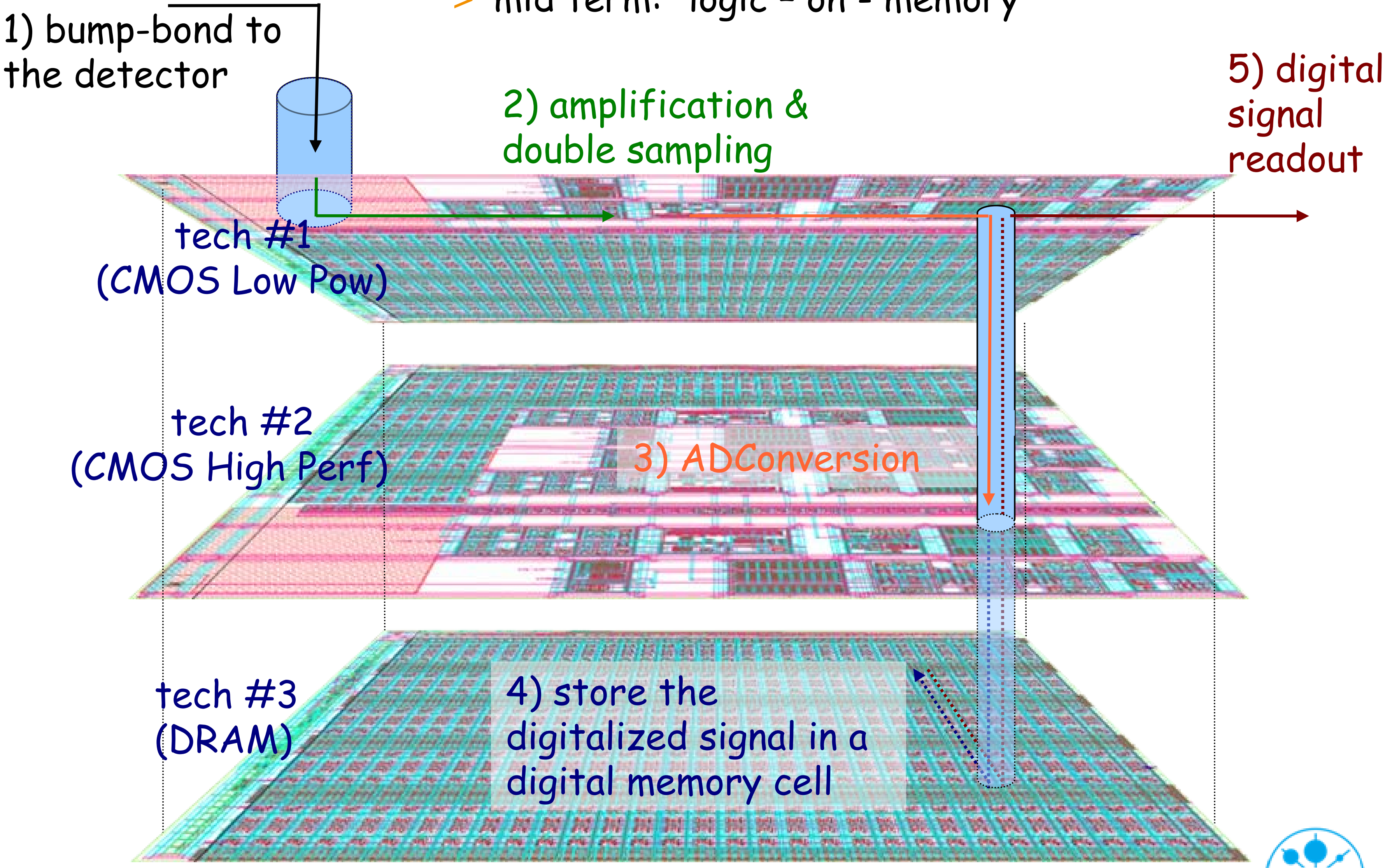
going vertical: a simple AGIPD evolution hypothesis

- near future: "logic – on – logic"
  - MPW to be submitted in summer



going vertical: a simple AGIPD evolution hypothesis

> mid term: "logic – on - memory"



Summary

- FELs need conceptually new detectors: fast, low noise, large dynamic range
- Dedicated detector developments for Photon Science (Europe, Japan and USA)
- Detectors will be decisive for the success of the European XFEL (bunch train structure).
- Photon Science possibly driving force for new detector develpments, but synergy with HEP essential.