Facility Report
Synchrotron SOLEIL

F. Orsini, for the Detectors Group

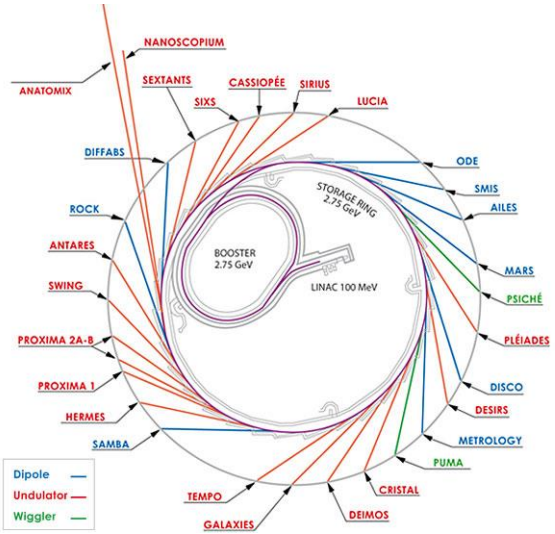
IFDEPS 21

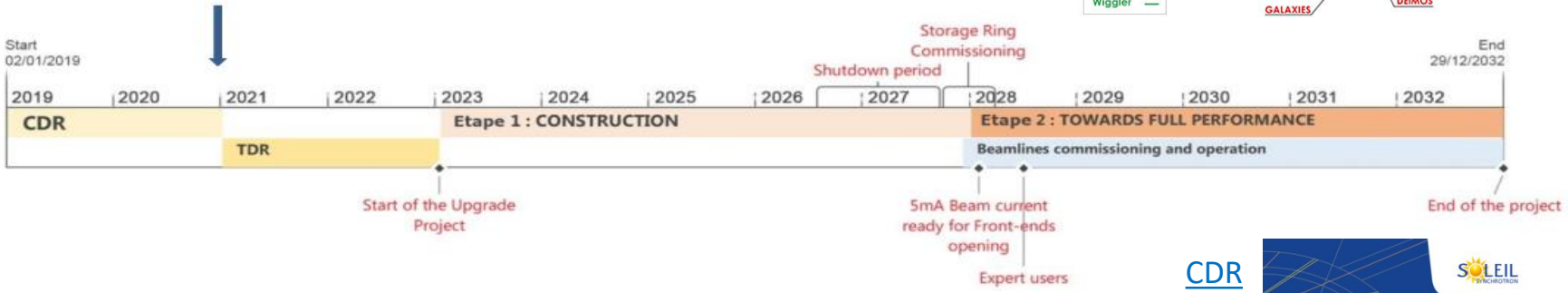
25 March 2021

Current context → SOLEIL Upgrade

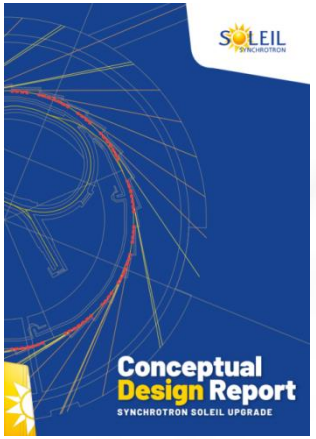
Ee=2.75 GeV / 354 m circumference /
500 mA in multibunch mode

First user operation in 2008
29 beamlines in operation





CDR



BEAMLINES

- More flux *(not all BL)*
- Smaller source
- More coherence
- Operando methods
- Multi-techniques

DETECTORS

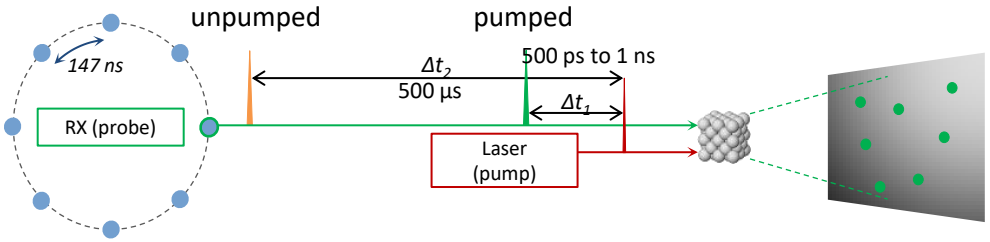
- Spatial resolution
- Detection efficiency
- Signal-to-noise ratio
- Readout speed
- Deadtime
- Data transfer

Fast gated hard X-ray imager

Hybrid pixels based on the UFXC ASIC (ASIC designed by AGH-FEE - Krakow)

First application: Time resolved studies

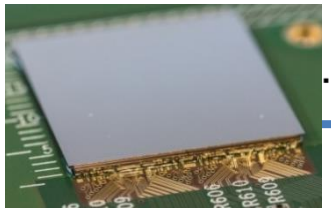
Pump and probe-probe experiment



Detector specifications

- Shutterless single bunch separation
  => gate min. counting time ≈100 ns
- Energy selection
  => two thresholds
- 5 kHz laser repetition rate (pump)
  => 20 kfps (1 trig laser = 4 images)
- Min. working energy 7 keV
  => min. threshold ≈3.5 keV
- Beamline integration
  => Tango controlled

IFDEPS 2018



2×2 cm²

Backup solution

10 kfps 1 chip

Adaptation board 2

20 kfps 2 chi

Adaptation board 1

FMC

Hardware adapted
FPGA embedded
TANGO ready

3 SFPs

2.5 Gb/s (SFPs)
Slow Control via ethernet

Server

Data processing, Storage and Control (Tango)

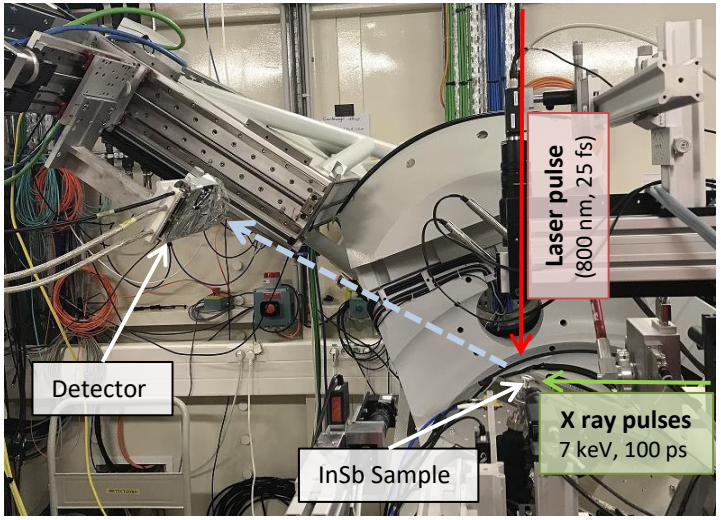
Synchronization
Trigger
2 Triggers

Lot of progress made since 2018

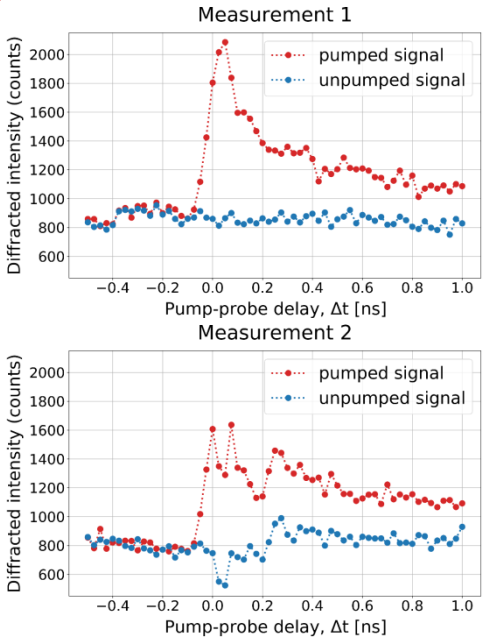
[A. Dawiec et al, AIP Conf Proc 2054 (2019)]

Fast gated hard X-ray imager

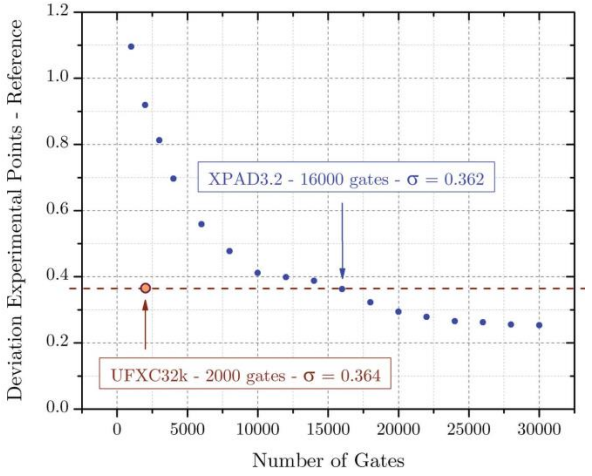
First pump-probe-probe tests on CRISTAL beamline in April 2019 *[D. Bachiller et al, JSR (2020), 27]*



Photoinduced strain in InSb sample (8-bunch mode 100 mA)



Deviation of experimental data from the 'theoretical' reference: in this example 8 times more gates were necessary for the XPAD detector



Key advantages of the detector

- Possibility to correct drifts of experimental conditions, and/or to follow unexpected evolution of sample (not possible with current detector)
- Less X-ray attenuation needed (factor 10), better statistics (at least 4 times more than current detector)
- (Better spatial resolution)

- ❑ 2_chip detector prototype tested with the **'First User'** experiment in November 2020
- ❑ 8_chip demonstrator design started (hybrids and DET_board produced, DAQ (FW) under development)

- ❑ Same chip integrated by RIGAKU (with seamless pixels array) tested at SOLEIL end of 2019 ⟶ *[Y. Nakaye et al, JSR (2021), 28]*

➡ *[A. Dawiec – Session 3 – 01 April 2021]*

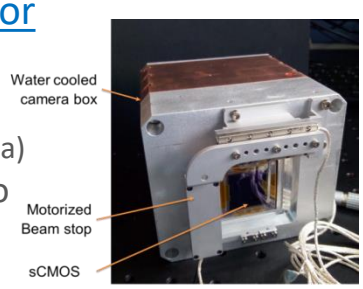
Fast Soft/Tender X-rays imager

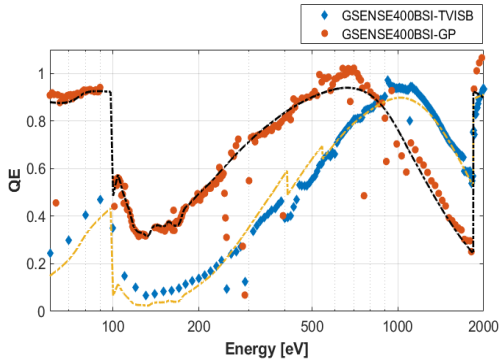
Back Side Illuminated Monolithic Active Pixel Sensor

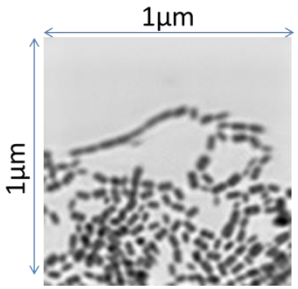
- Recent situation: lack of very performing 2D detectors in Soft X-rays domain
- Two approaches: a home-made adapted camera based on a performing commercial sCMOS sensor and a fast CMOS monolithic imager developed within a large collaboration of light sources

GSENSE(400BSI) sCMOS sensor

- **E_{range} = ~ 100 eV up to 2 keV**
- 4 MPix(~ 2.2 × 2.2 cm^2 sensitive area)
- Readout speed 24 Hz (HDR) up to 48 Hz (LG or HG)







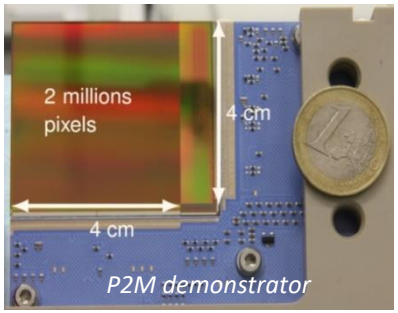
Ptychography reconst. of magnetosome (E=700 eV)

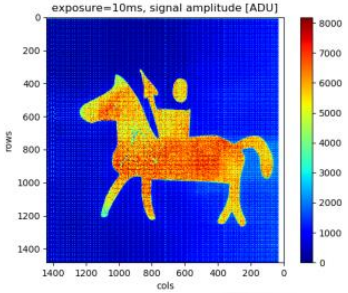
- 1 adapted camera in production in 1 beamline (end of 2020), another beamline will be equipped in 2021
- Concept transferred to AXIS Photonics company

[K. Desjardins et al, JSR (2020), 27]

PERCIVAL: P2M sensor

- **E_{range} = ~ 100 eV up to 2 keV**
- 2 MPix (~ 4 × 4 cm^2 sensitive area)
- Auto-adaptive gain
- Readout speed 82 Hz (design limit: 300 Hz)





- SOLEIL participated in the data analysis framework
- BSI sensor is operational and under tests at DESY

[A. Marras et al, JSR (2021), 28]

➡ *[C. Wunderer – Session 7 – 08 April 2021]*

High counting rate fluorescence detector

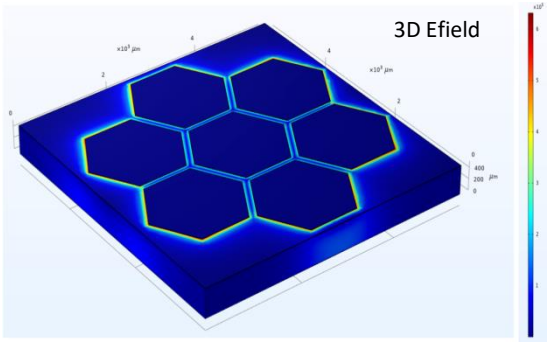
Multi-Element Germanium detector

- Current situation: slow evolution of very performing germanium detectors in the past 10 years
- SOLEIL joint DIAMOND's R&D effort on multi-element Ge spectroscopy grade detector systems for XAS applications

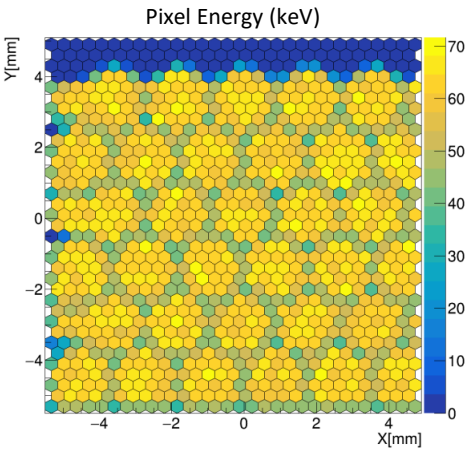
Requirements for the detector + electronics

- Energy range: 5-100 keV
- **Highest counting rate** with moderate dead time
- Energy resolution ex: < 200 eV @ 5.9 keV @2Mcps
- Peak to Background ratio > 500
- No degradation of performances in time
- Robustness and reliability of all channels

Detector with hexagonal pixels
(1.8 mm side)



Detector response
with E=70 keV (no collimator)



First prototype with 19 pixels is under realization

- Simulations: pixels configuration comparison is in progress
- New Ge sensor realized (will be delivered soon at DIAMOND)
- New carrier board under tests

[N. Tartoni – Facility Report – 25 March 2021]

'High throughput X-ray Spectroscopy Detector System' = EU Project LEAPS-INNOV (WP2)

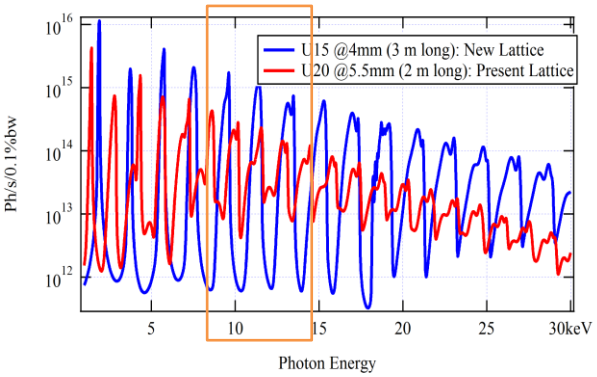
Ultra Fast Energy Resolved Imager

Photon Counting Detector – Hybrid pixels

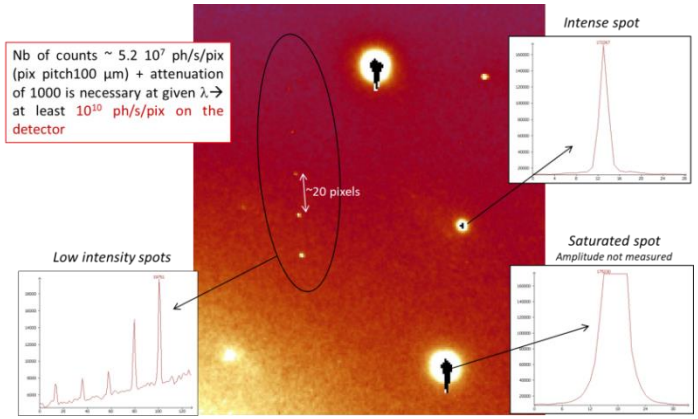
Health
Advanced Materials
Pink beam

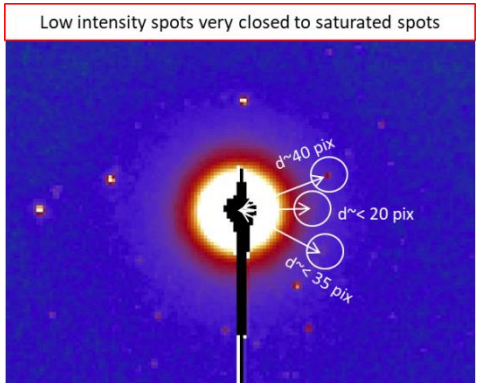
- Objective: perform 'Pseudo' Laue diffraction with multi pink beam
  - A factor of over 1000 in acquisition speed maybe expected, compared to current performances
  - Capability of simultaneous measurements of continuous photon fluxes at different energies

Example of photon flux expected at the ondulator output

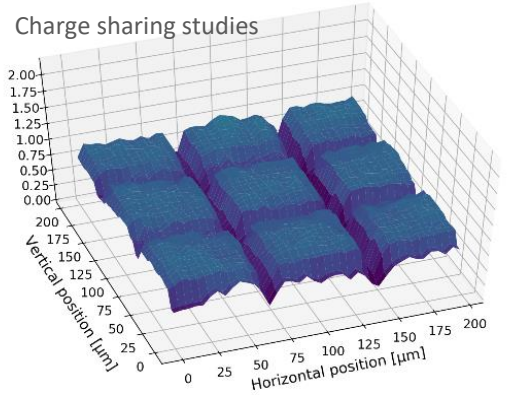


Example of diffraction spots received by the detector (CRISTAL, metallo-organic sample)





Charge sharing studies

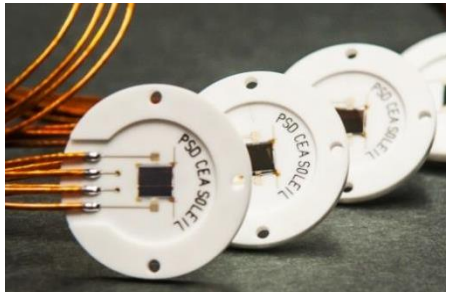


- Few challenges for the ASIC: r/o speed, charge sharing, E_{resol}
- Specifications in discussion with AGH-FEE for feasibility
- Prototyping phase should start this year

Other detectors activities

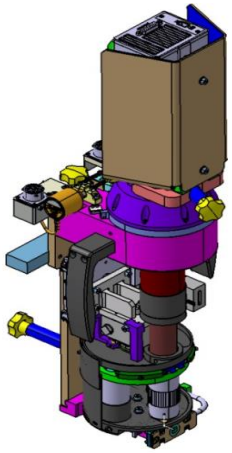
XBPM

(CVD Diamond XBPM, etc)



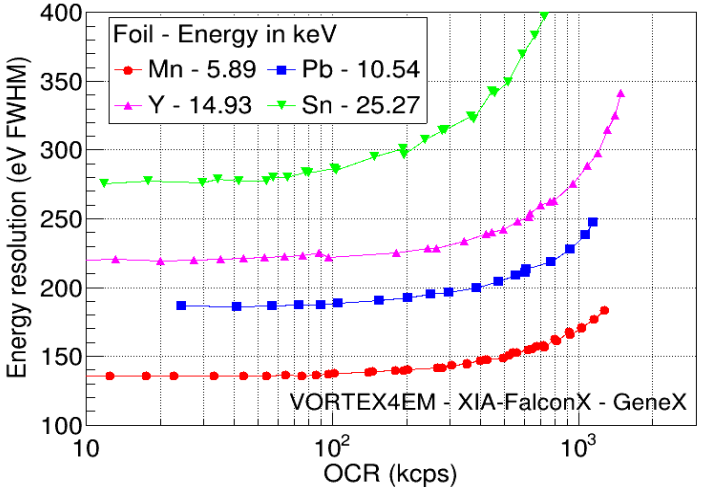
X-ray camera systems

(design, assembly, tests)

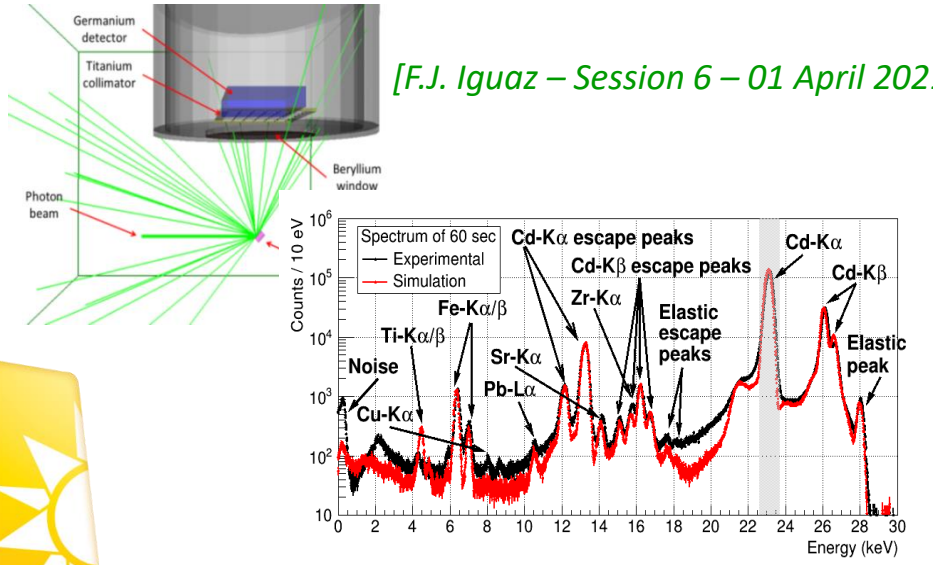


Digital Electronic characterization

(FALCONX, XSPRESS3(4), DANTE)



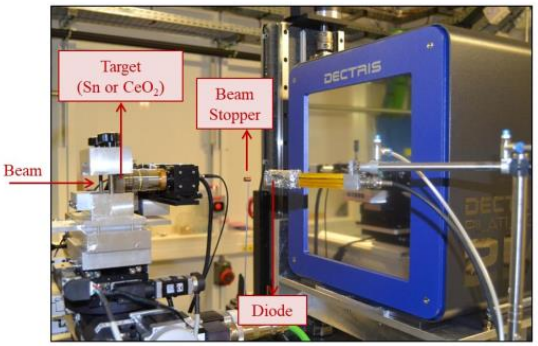
Detectors Simulations

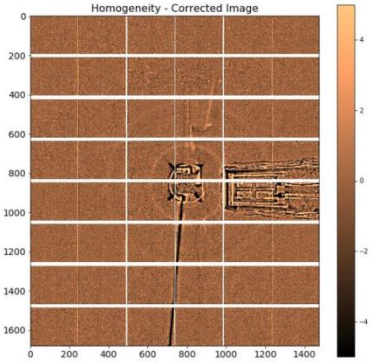


[F.J. Iguaz – Session 6 – 01 April 2021]

Commercial detectors acceptance tests

Ex: PILATUS 2M CdTe





Thank you for your attention

Detectors Group

A. Dawiec, K. Desjardins, B. Kanoute, FJ. Iguaz, C. Menneglier, F. Orsini

(Non permanent) C. Bacchi, EH. Ait Mansour, E. Sacchetti, T. Saleem