DEVELOPMENT of a NEW DATA ACQUISITION SYSTEM for a PHOTON COUNTING DETECTOR PROTOTYPE at SOLEIL SYNCHROTRON

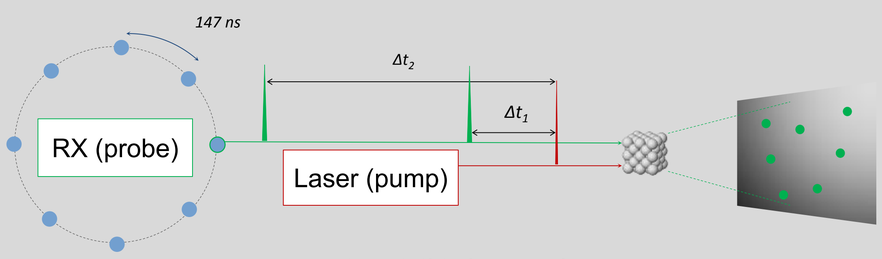
G. Thibaux*, Y.M. Abiven, D. Bachiller-Perea, J. Bisou, A. Dawiec, A. Jarnac, B. Kanoute, F. Langlois, C. Laulhe[1], C. Menneglier, A. Noureddine, F. Orsini, Y. Sergent, Synchrotron SOLEIL, Saint-Aubin, France

[1] also at Université Paris-Saclay, Saint-Aubin, France

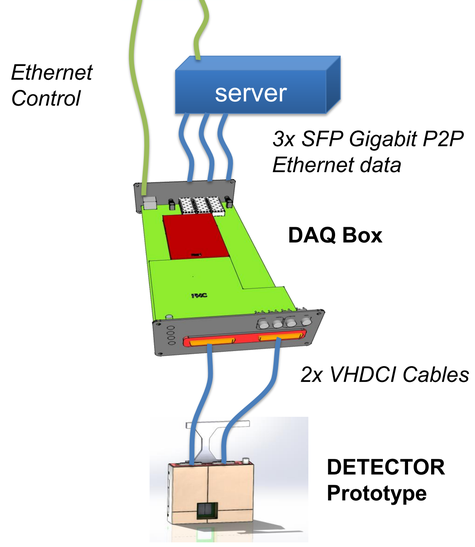
P. Grybos, A. Koziol, P. Maj, AGH University of Science and Technology, Krakow, Poland

Context

Time-resolved pump-probe experiments at SOLEIL Synchrotron



Laser pulses at half the frequency of X-ray beam pulses

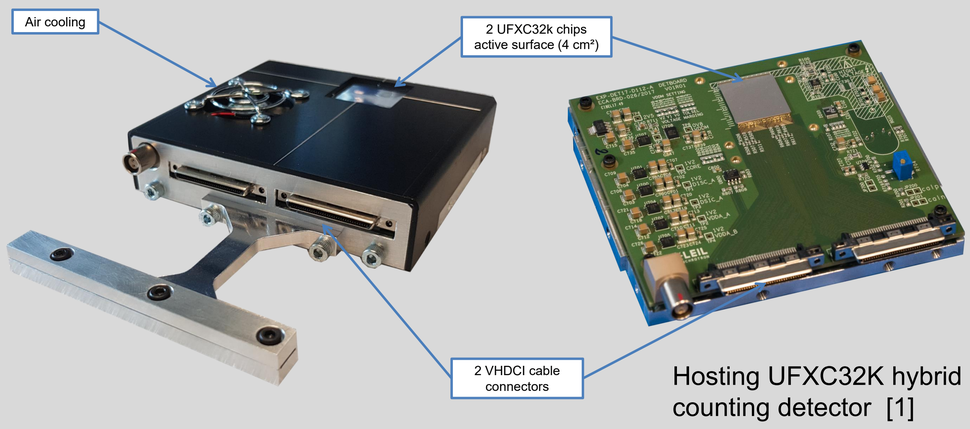


2-chip detector prototype characteristics

Pixel size	75 × 75 µm
Number of pixels	256 × 257 pixels (including one column of virtual pixels)
Active detection surface	2× 2 cm²
Inter chip gap	75 µm covered by larger sensor pixels (75 × 112.5 µm²)
In-pixel corrections	Offset (7 bit) and gain (4 bits)
Number of discriminators/pixel	2 thresholds (low, high)
Number of counter/pixels	2 of 14 bits
Camera framerate	20 kfps in 2-bit readout mode

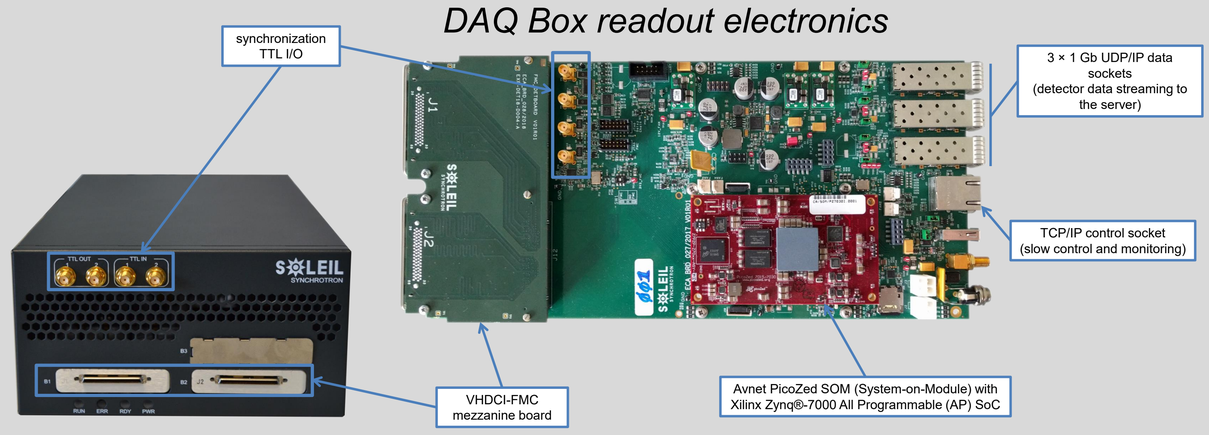
Hardware development from Sensor to readout electronic

Detector Prototype



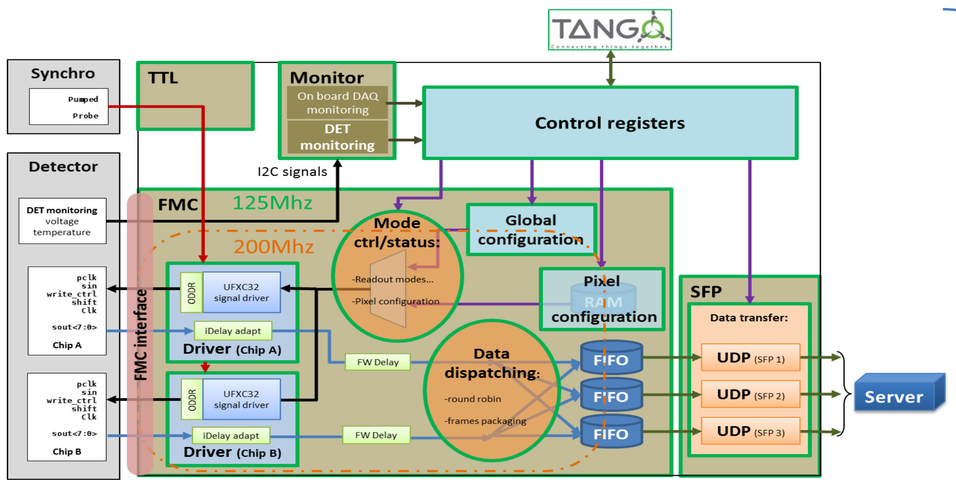
Hosting UFXC32K hybrid photon counting detector [1]

DAQ Box readout electronics



Electronics variant of PandABox [2]

Firmware & Software development



DAQ Firmware Architecture

FIRMWARE

Based on PandABlocks framework [3]

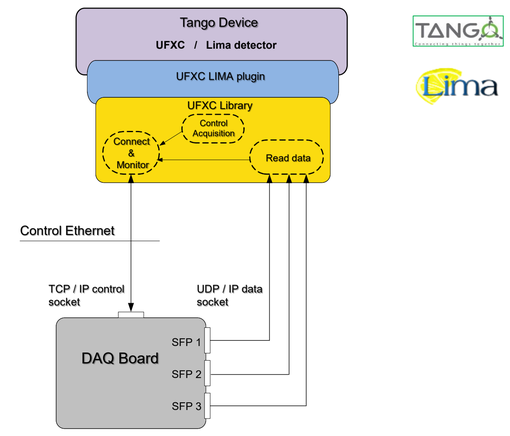
Specific IP developed to stream data over SFP.

SOFTWARE

DAQ electronic connected to TANGO.

UFXC Detector integrated into Tango/Lima [4] libraries.

Data Acquisition carried out over UDP/TCP frame through PtP connection to the server.

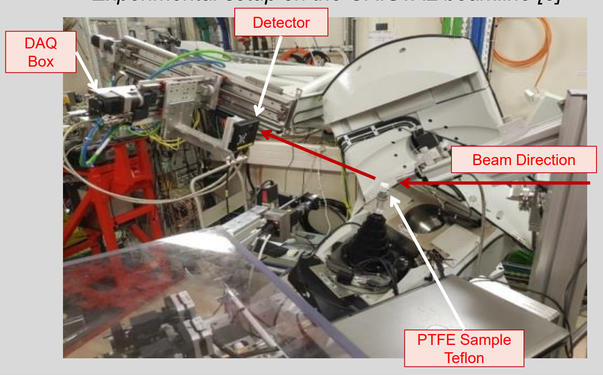


Tango/Lima UFXC Libraries Structure

February 2019 First CRISTAL Beamline Experiment

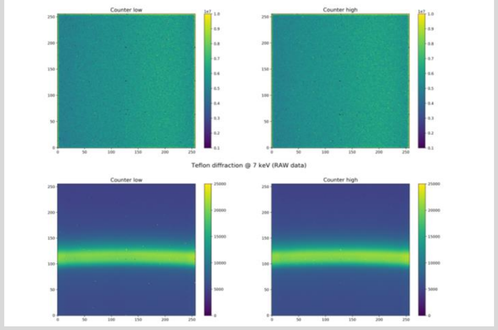
Detector head & DAQ electronics installation on the diffractometer. A reference experiment was performed with acquisition of diffraction rings from a PTFE sample. This sample was already studied with other X-ray hybrid pixel detectors.

Experimental setup on the CRISTAL beamline [5]



The images of the two counters (high and low) acquired during the tests contains:

- Flat field exposure, used to locate bad pixels and the detector pixels uniformity response. For the constitution of the detector pixel calibration file (pixel gain, offset …).
- PTFE diffraction rings are well reproducible.



Images of Flat field (top) and PTFE diffraction rings (bottom)

CONCLUSION

- **2 Full detector systems already validated with All Hardware, Firmware and Software.**
- **New requirement identified for with different sensor geometry of 1 x 4cm².**
- **Improvement identified for a new acquisition mode with 28 bits per pixel in order to extend exposure time at high beam fluxes without saturating pixel counter dynamics.**
- **Full system validated during experiments on CRISTAL beamline at SOLEIL.**

This present development is part of a longer term detector program at SOLEIL. Next step consists to develop a 8 modules demonstrator based on the same ASIC.

[1] P. Grybos *et al.*, "32k Channel Readout IC for Single Photon Counting Pixel Detectors with 75 µm Pitch, Dead Time of 85 ns, 9 e− rms Offset Spread and 2% rms Gain Spread," IEEE Transactions on Nuclear Science, vol. 63, no. 2, pp. 1155-1164, 2016.
[2] S. Zhang *et al.*, "PandABox: A Multipurpose Platform for Multi-technique Scanning and Feedback Applications", in *Proc. ICALEPCS'17*, Barcelona, Spain, Oct. 2017, pp. 143-150.
[3] G. B. Christian *et al.*, "PandABlocks - a Flexible Framework for Zynq7000-Based SoC Configuration", presented at the ICALEPCS'19, New York, NY, USA, Oct. 2019, paper TUAPP05.
[4] LImA : Library for Image Acquisition, https://lima1.readthedocs.io/en/latest/
[5] Cristal Beamline, https://www.synchrotron-soleil.fr/en/beamlines/cristal

* gauthier.thibaux@synchrotron-soleil.fr