

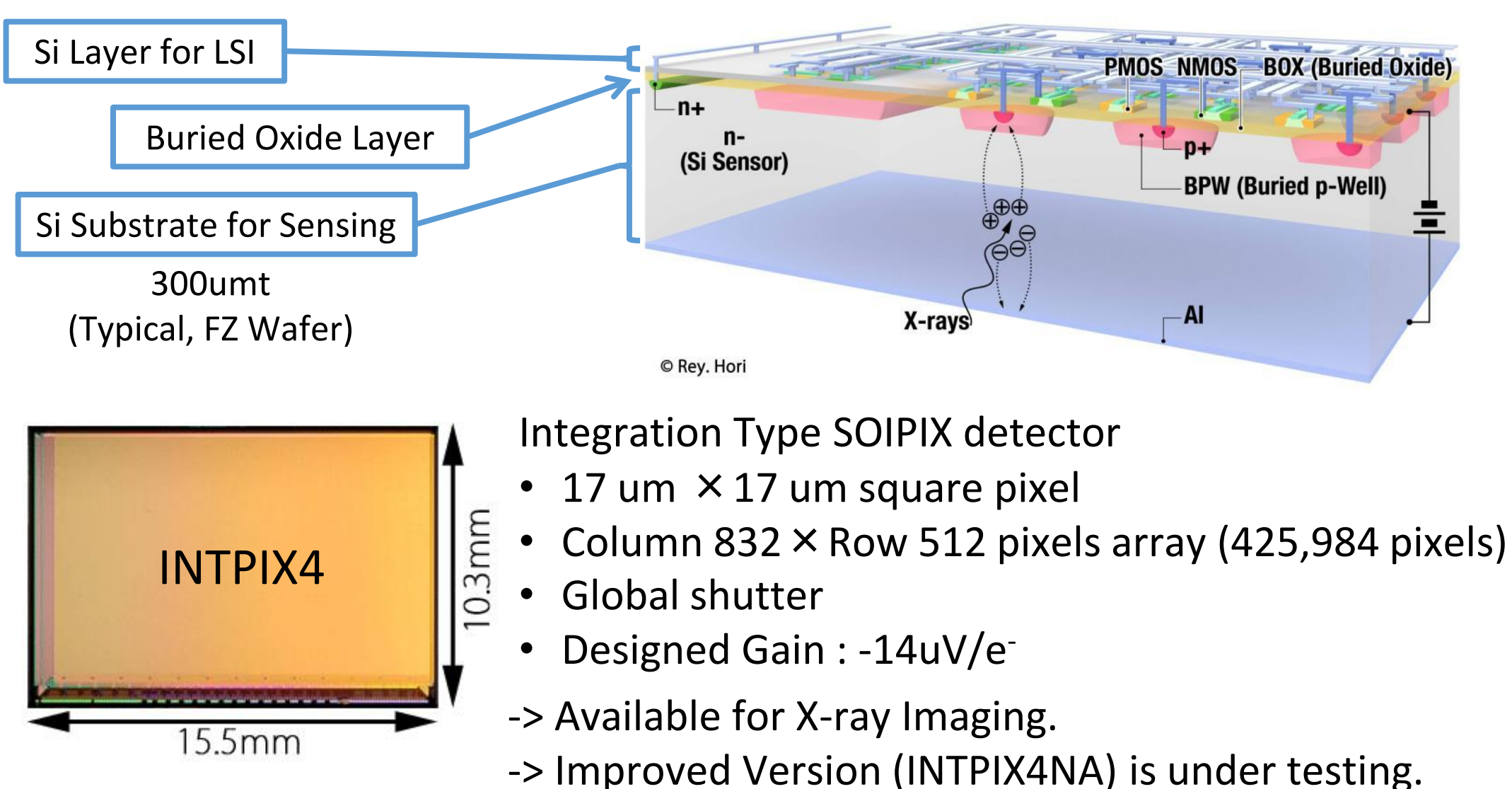
Development of new high speed data acquisition system prototype for SOI pixel detector using 10 Gb Ethernet SiTCP



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Introduction

SOI pixel detector (SOIPIX)



10Gb Ethernet SiTCP (SiTCP-XG)



SiTCP is a network processor IP (Intellectual Property) core that can be implemented in an FPGA.

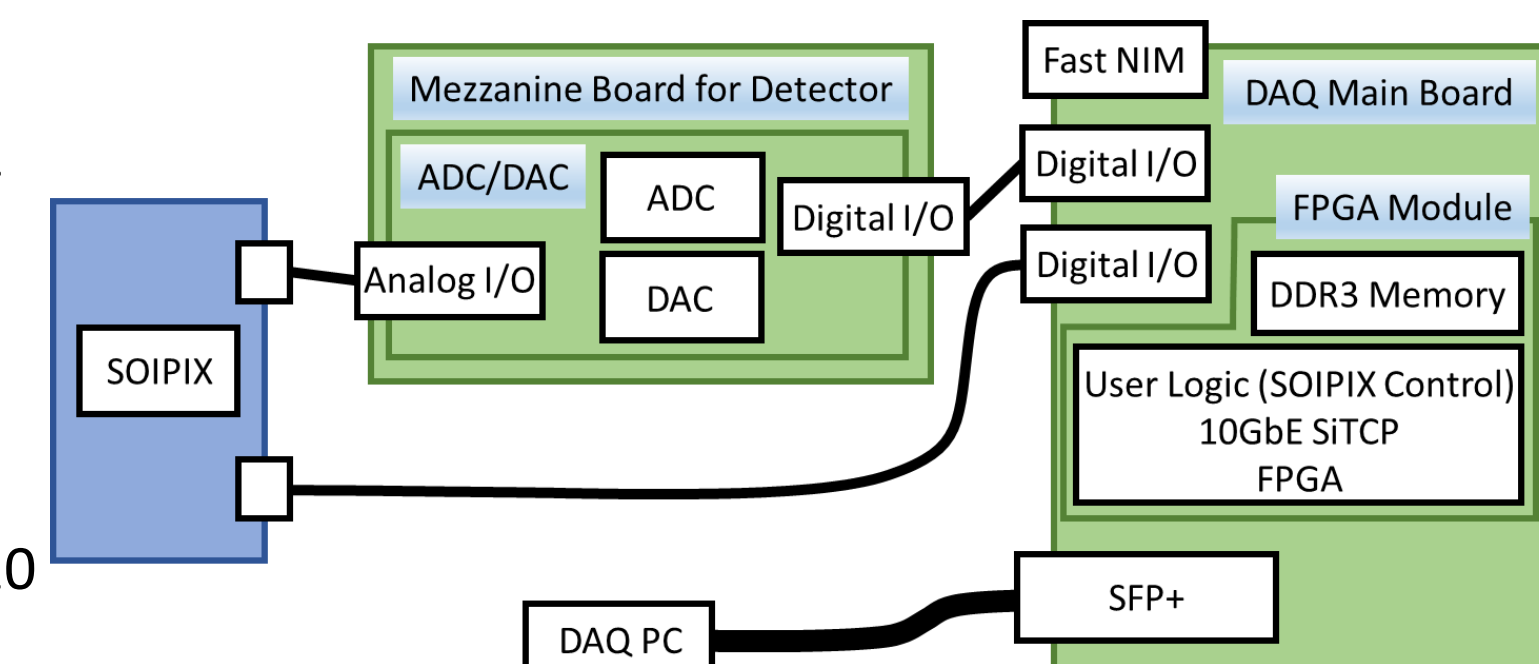
- Developed by Tomohisa Uchida (KEK ESYS), and currently developed and supported by Bee Beans Technologies.
- Small circuit size (~3000 Slice), simple FIFO like I/F, close to specification maximum transfer speed caused by Hardware-based implementation and easy to customize.
- Present system using 1GbE SiTCP, and it is not enough for advanced experiments. (high framerate, large area etc.)

-> **10Gb Ethernet SiTCP (SiTCP-XG) is upgrade version of SiTCP and strong solution for our readout system.**

10GbE SiTCP Data acquisition system

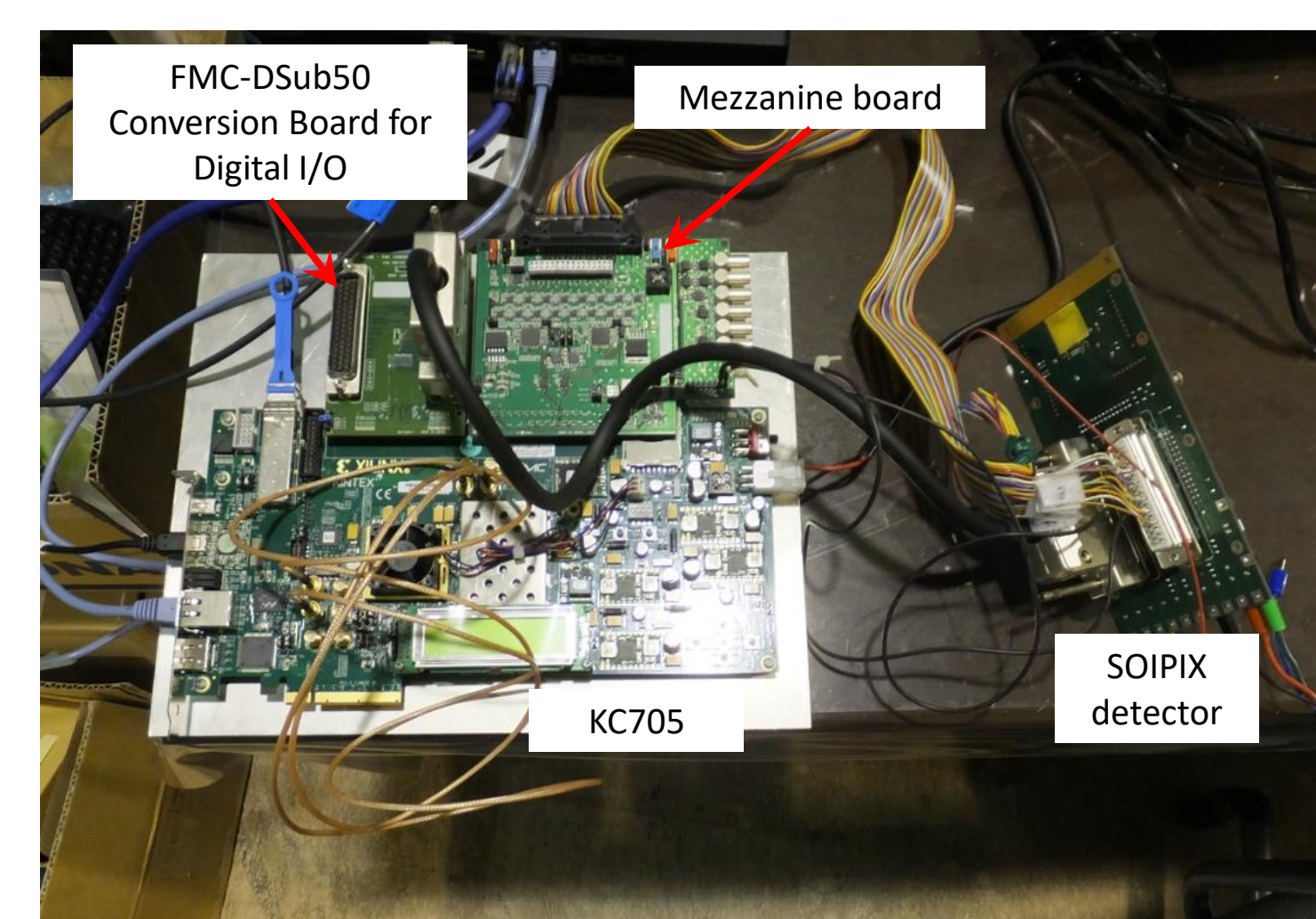
Plan of data acquisition system production board

- System boards consists of DAQ main board and Mezzanine board for detector's Analog signal processing.
- Mezzanine board has 16 channels 12-bit Analog-to-Digital Converter and 8 channels Digital-to-Analog Converter.
- DAQ main board has Digital I/O (MIL interface) for SOI pixel detector, Fast NIM interface for external trigger/synchronize control and SFP+ interface for 10 Gb Ethernet.
- Xilinx Kintex-7 FPGA and DDR3 memory were implemented on one ready-made module board and mounted on DAQ main board.
- 10GbE SiTCP was implemented to Kintex-7 FPGA, mixed implementation with SOIPIX control logic.



Prototype of data acquisition system

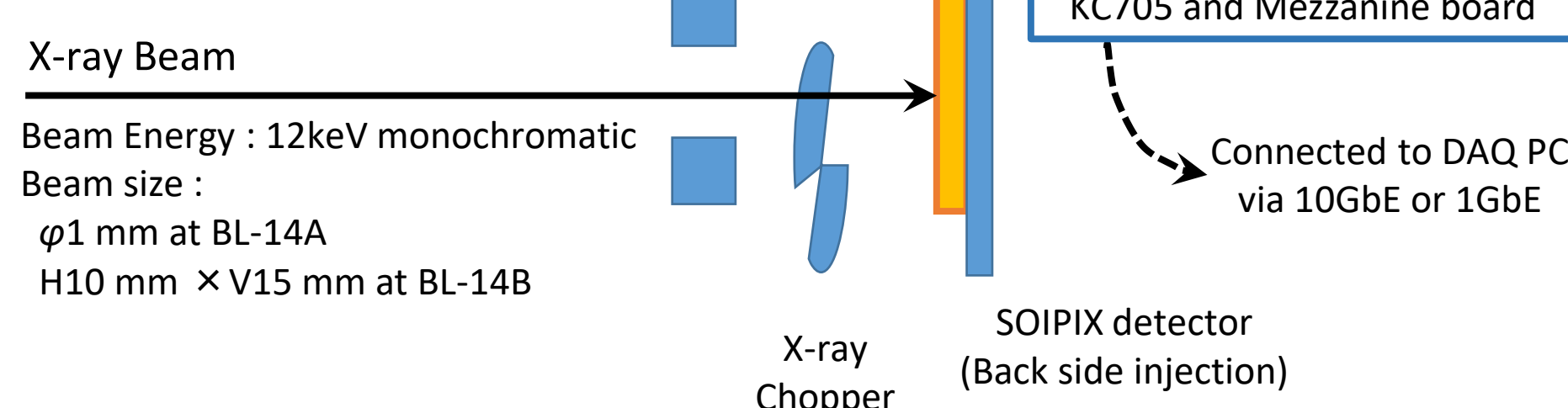
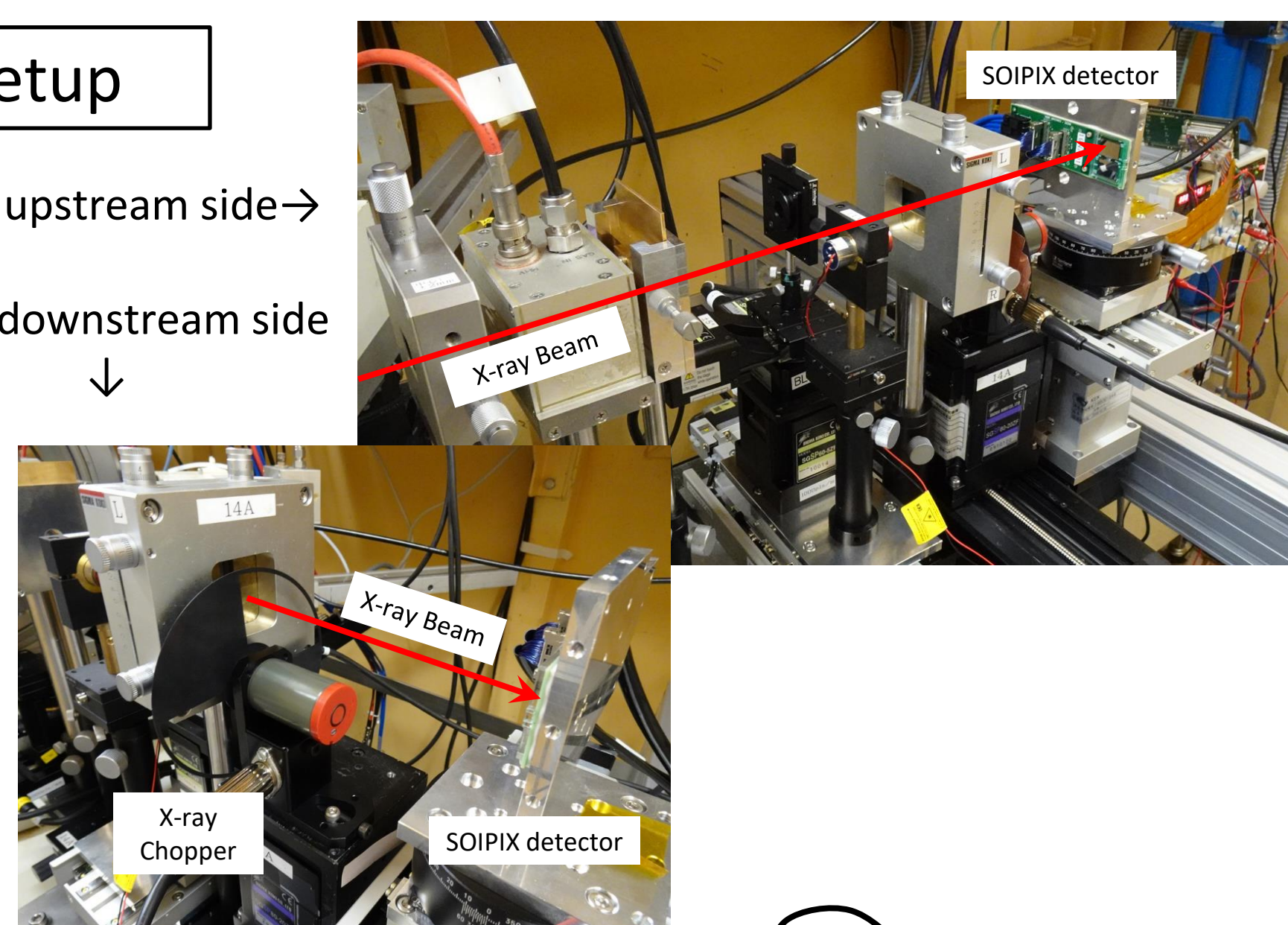
- KC705 commercial FPGA evaluation board was used as a substitute for the DAQ main board.
- Initial version of Mezzanine board was connected via FMC-LPC connector.
- Alpha release of 10GbE SiTCP was implemented to Kintex-7 FPGA on KC705, mixed implementation with SOIPIX control logic.
- Stable release of 1GbE SiTCP also available for comparison of the difference of performance.



Experimental results

Setup

From upstream side→
 From downstream side↓



Tests for prototype DAQ system were done at KEK Photon Factory BL-14A and BL-14B.

X-ray beam (12keV monochromatic) was injected from backside of SOIPIX detector and was intercepted by an X-ray chopper with a duty ratio of 50%. It is easy to determine if the DAQ system is transferring data correctly by looking at the X-ray profile being captured.

This prototype DAQ system was tested with below 3 conditions :

1. Take 100 fps X-ray movie (framerate was controlled by 100 Hz internal clock) with 1 GbE SiTCP and 10 GbE SiTCP to compare the difference of performance. (at BL-14A)
2. Take 350 fps X-ray movie (not controlled by internal clock) with 10 GbE SiTCP to determine the stability of transfer rate over than 1GbE speed. (at BL-14A)
3. Take 350 fps X-ray movie with larger field X-ray beam. (at BL-14B)

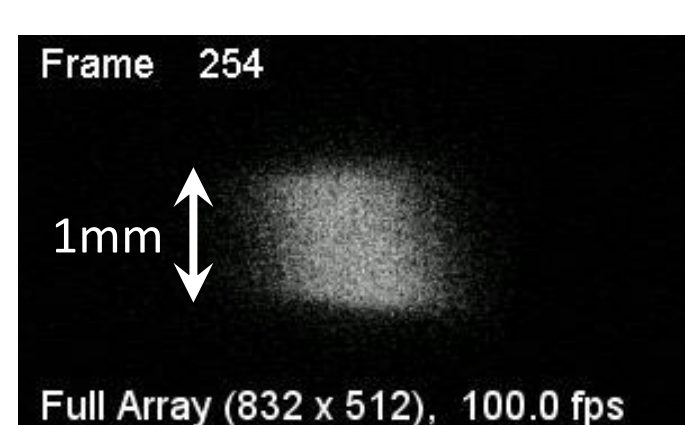
Conclusion

- SOI pixel detector's new DAQ system based on 10GbE SiTCP is now under developed.
- Prototype DAQ system was developed on KC705 FPGA board.
- Prototype system was tested with SOI pixel detector (INTPIX4NA) at KEK PhotonFactory BL-14A and BL-14B.
- 10GbE SiTCP result shows no fluctuation caused by instability of transfer rate in 682 Mbps average data traffic situation.
- 10GbE SiTCP shows stable framerate at 350 fps (average data traffic is 2.4 Gbps) .
- These results were the initial result of X-ray imaging data taken by 10GbE SiTCP.

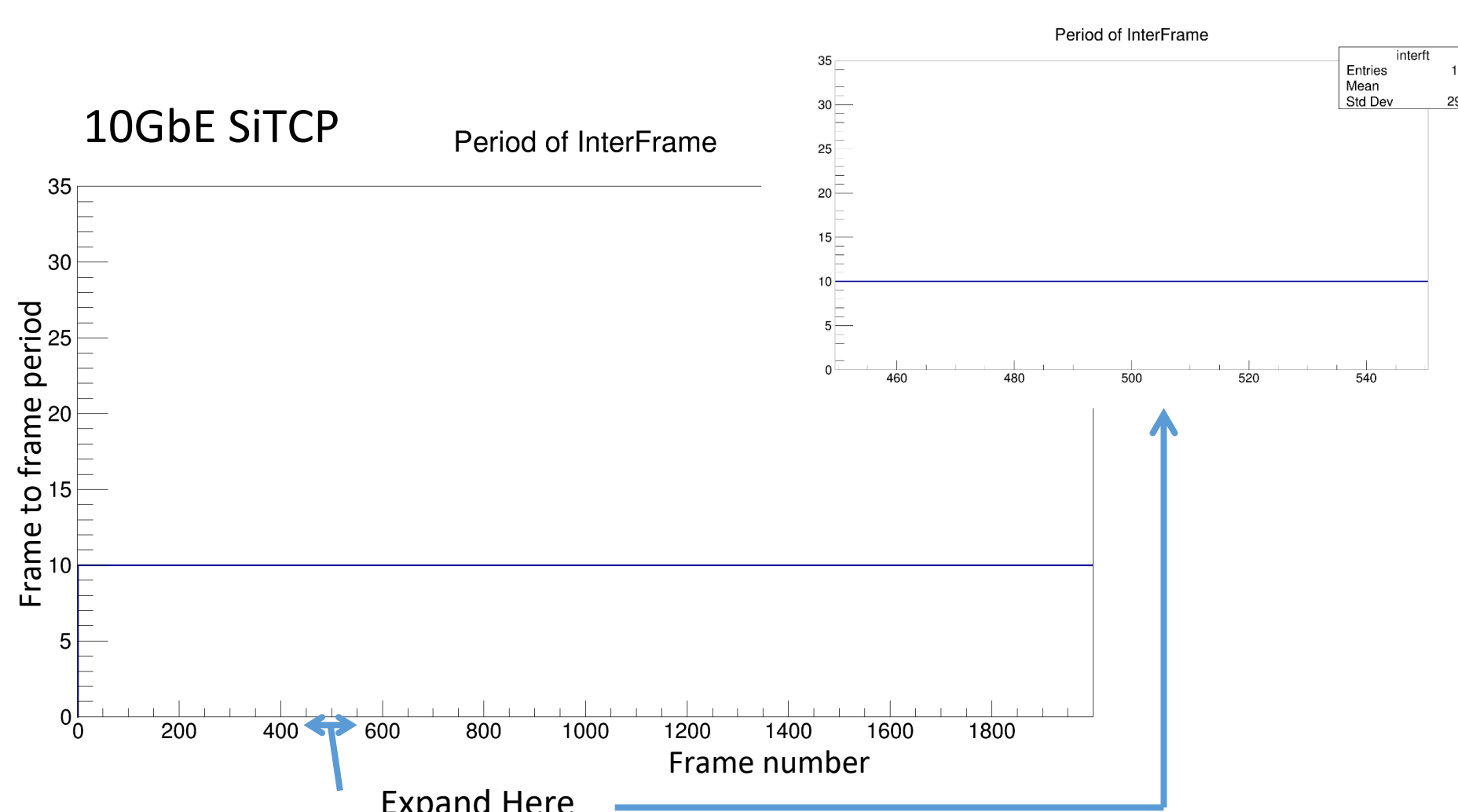
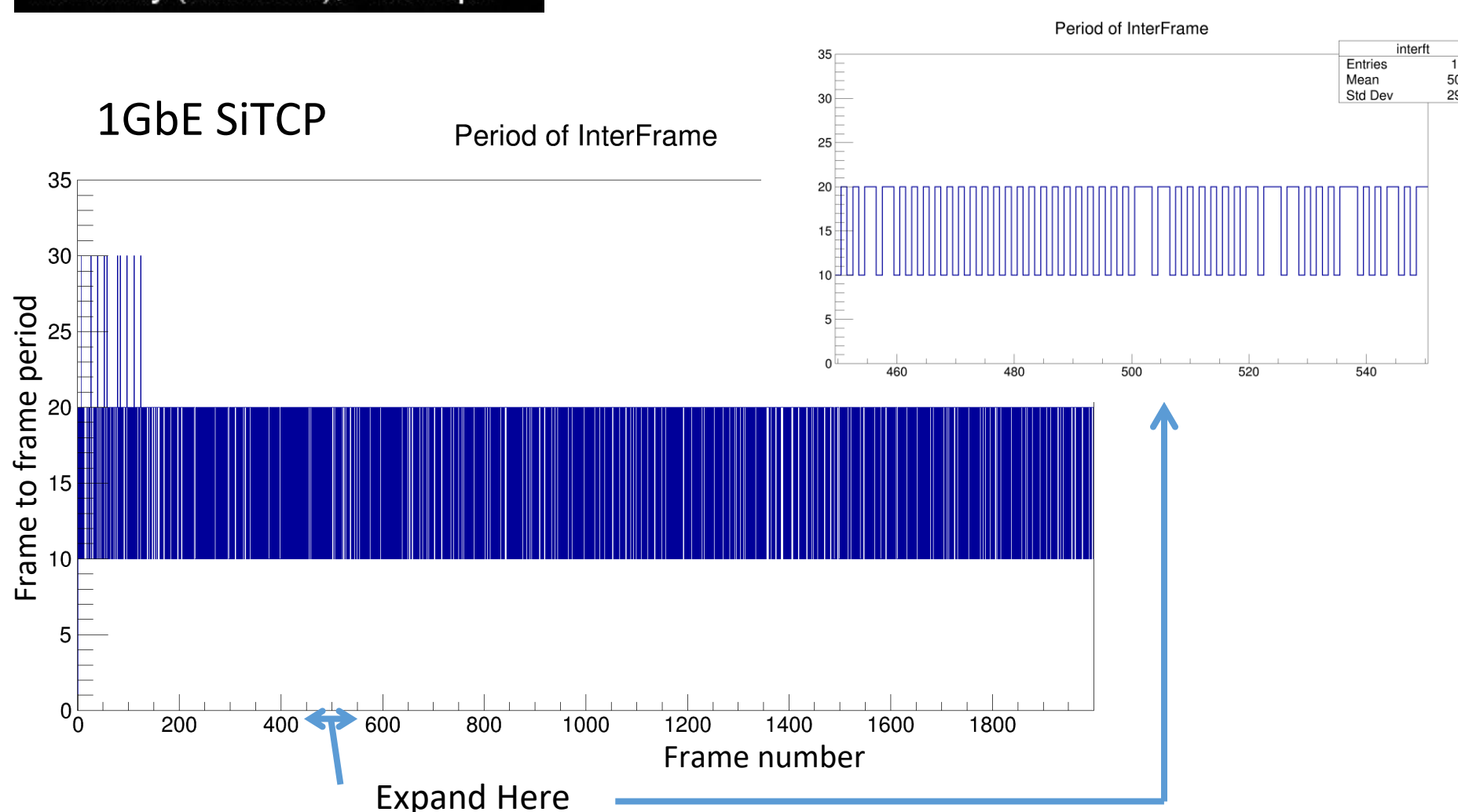
Results

Condition of Test 1.

Exposure time : 200 us/frames , Analog output settling wait time : 240 ns/pix
 Frame to frame period (Starting edge-to-edge) : 10 ms (Triggered by 100 Hz clock) , Average data traffic : 682 Mbps
 (If one frame's data transfer wasn't completed in 10 ms, next frame's period will extended to 20 ms or 30 ms.)



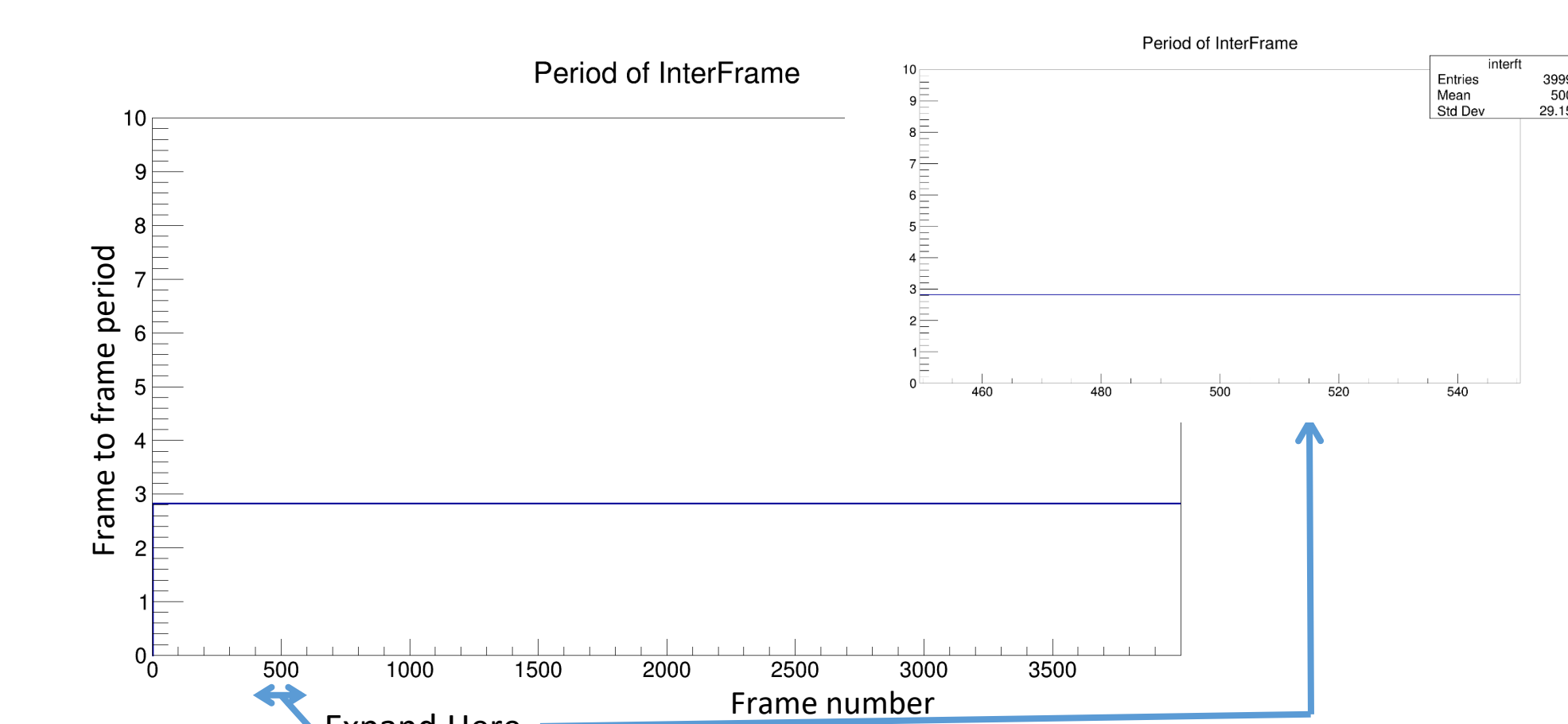
X-ray profile taken by 10GbE SiTCP DAQ system at BL-14A. (Cropped around beam profile)



10GbE SiTCP result shows no fluctuation caused by instability of transfer rate.

Condition of Test 2.

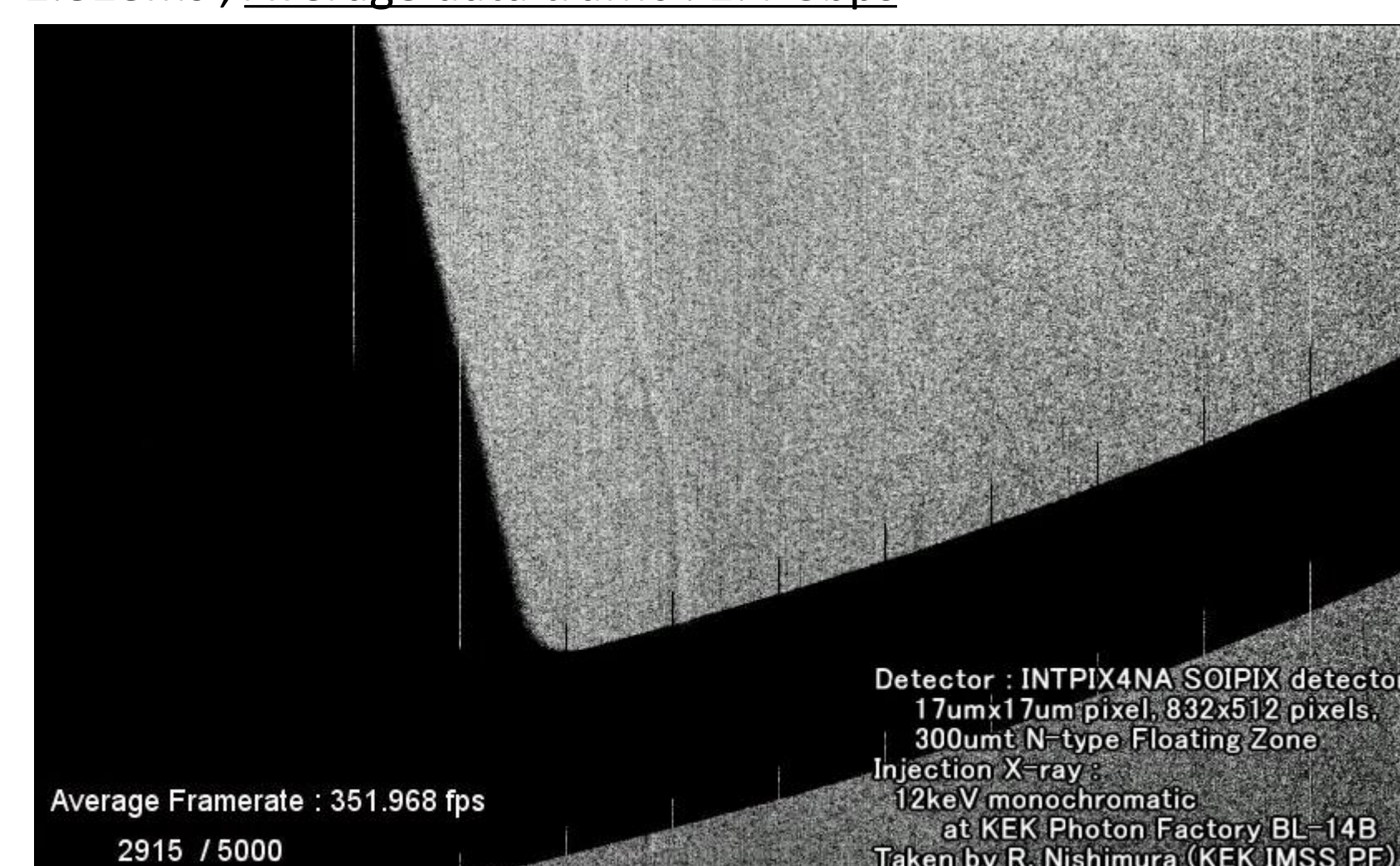
Exposure time : 200 us/frames , Analog output settling wait time : 80ns/pix
 Frame to frame period (Starting edge-to-edge) : 2.828ms , Average data traffic : 2.4 Gbps
 (If one frame's data transfer wasn't completed in 2.828 ms, next frame's period will shows longer time)



10GbE SiTCP shows stable framerate even in higher(>1GbE) transfer rate condition.

Condition of Test 3.

Exposure time : 200 us/frames , Analog output settling wait time : 80ns/pix
 Frame to frame period (Starting edge-to-edge) : 2.828ms , Average data traffic : 2.4 Gbps



You can see the movie data from below link or right QR code.
 (Dropbox link valid until 2021/05/31.)
https://www.dropbox.com/s/9fhv06qofwnqkx1/201122-25_BL-14B_I4NA_XG_350fps_Run00003.mp4



10GbE SiTCP was advanced to Beta release and now you can try!
 Go to https://github.com/BeeBeansTechnologies/SiTCPXG_Netlist_for_Kintex7 or Scan right QR code.

