Real-time attenuation control system of incident beam using hybrid pixel detector with specific architecture

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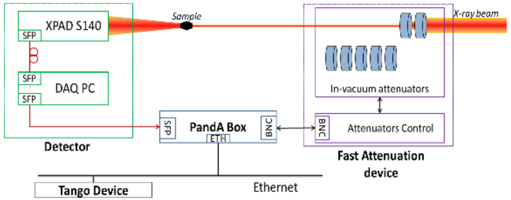
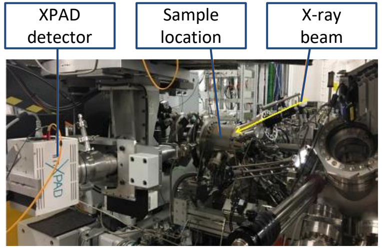
Motivation and operation principle

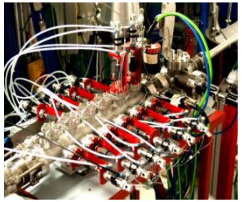
Development of a new real-time attenuation control system to adapt intensity of the incident beam accordingly to the used detectors and samples on SIXS beamline at Synchrotron SOLEIL

Global architecture of the attenuation control system with its main components

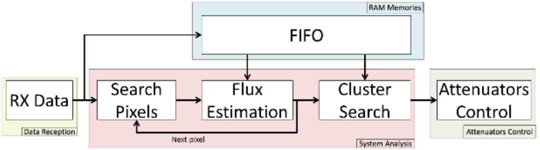


The SIXS beamline experimental station (left) and attenuation system (right)





Functional diagram



Data Reception

- data reception during image acquisition
- store data in FIFO memories

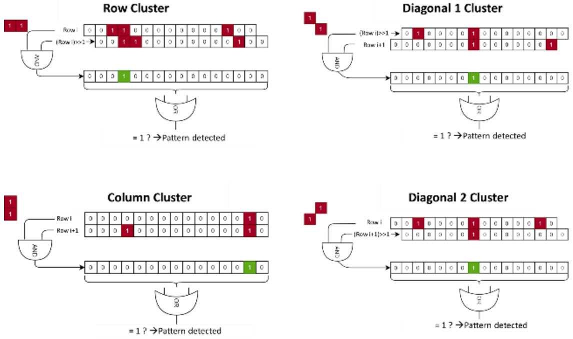
System Analysis

- estimate photons flux pixel by pixel
- flag pixels that exceed flux limits
- pixels clusters detection

Attenuators Control

- trigger attenuators insertion/extraction attenuators
- inhibit system while attenuators are changing

Pixels cluster detection



Performance

All processes, i.e. flux estimation for all pixels (140k) and cluster search are realized within 3 ms:

- flux estimation ≈ 2,1 ms
- Clusters search ≈ 0,7 ms

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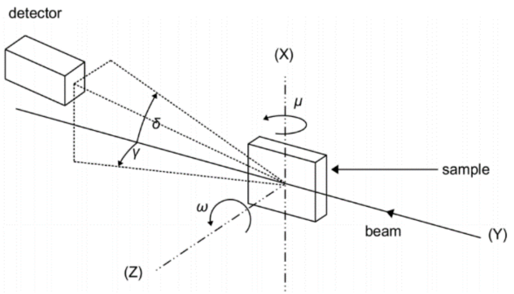
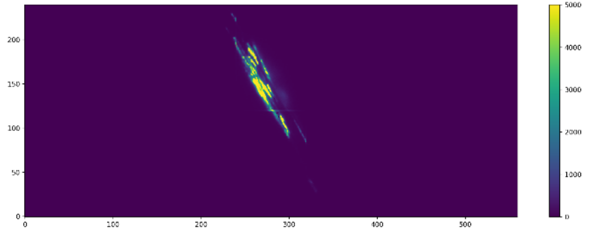
Beamline measurements

The experimental verification of the system functioning has been done on the SIXS beamline at Synchrotron SOLEIL.

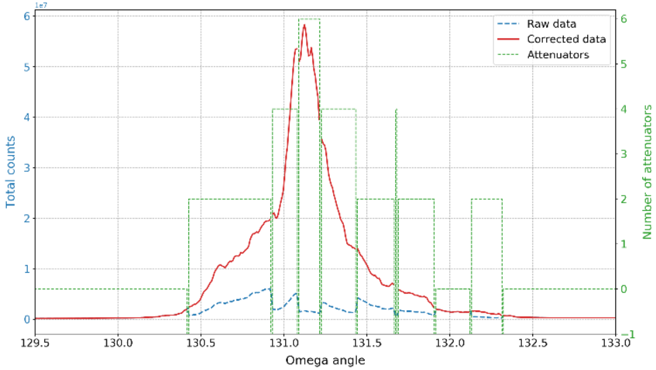
It consisted of measuring with the XPAD S140 detector a surface diffraction pattern from a sample. The schematic view of the experimental set-up is shown in the figure below. The measurements were performed at fixed incident angle μ (between the sample surface and the incident beam) while the sample angle, ω, was continuously rotated during the measurement.



Example diffraction image (Mo sample, 18 keV)



Raw and reconstructed total intensities (sum of all pixels)



The intensity correction is done based on the Beer-Lamber attenuation law:

$$S_{corr} = S_{raw}\, e^{\mu \cdot att}$$

Where S_{corr} is incident beam signal (corrected), S_{raw} is attenuated signal (raw detector data) and $\mu \cdot att$ is attenuation factor dependent of the filter material, thickness and energy

Conclusions

- The functioning of the system has been experimentally verified and validated
- The system is currently in the regular use on the beamline in user experiments
- The system is integrated with two different XPAD detectors (S70 and S140)

Planned upgrades

- Improvement of the system that will consist in permanent operation to protect against accidental exposure to the direct beam