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High-Speed X-ray Imaging Detectors for Storage Rings: Statistical performance requirements and the solution implemented to CITIUS

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Recent developments in the accelerator technologies for large storage rings and novel X-ray optics enabled the delivery of 100-1000 times brighter X-rays onto the sample. X-ray imaging detectors are required to improve their performance to take the potential of these new sources fully. At the SPring-8 facility, we started the development of the X-ray imaging detector CITIUS for such purposes. CITIUS has integrating-type pixels with a square shape of 72.6 x 72.6 μm2, and a silicon sensor thickness of 650 μm. The thick sensor will be advantageous as the new sources are brighter for higher photon energies. However, such a combination of pixel size and the sensor thickness exhibits a non-negligible effect of charge sharing [1]. In the conceptual design, we found a non-linear jump in the effective detector efficiency when we accumulate a significant number of frames with simple threshold analysis.
The jump appears at a count rate of about one photon/pixel/frame; it corresponds to 17.4 kcps/pixel in the standard 17.4 kfps operation of CITIUS, a critical intensity region for many applications. We identified that the jump arises because the thresholding rejects a portion of the signal charge hidden in the readout noise. We found two efficient algorithms to correct these artifacts, namely, T2C and 2x2 sum. These also provide a high compression ratio while preserving statistical information. In the presentation, we report an overview of the CITIUS project, emphasizing these algorithms. Their predicted performance and the implementation of T2C into the CITIUS data-acquisition systems will also be presented.

1) K. Nakajima, et.al., Nucl. Instrum. Methods Phys. Res. Sect. A 1003 (2021) 165303.

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