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Monte Carlo Simulations for XIDER, a Novel Digital Integration X-ray Detector for the Next Generation of Synchrotron Radiation Sources

This work presents the first simulation results of the incremental digital integration readout, a charge-integrating front-end scheme with in-pixel digitisation and accumulation. This novel readout concept [1] is at the core of the XIDER project, which aims at building 2D pixelated X-ray detectors optimised for high energy scattering and diffraction applications for the next generation of synchrotron radiation storage rings. These new photon sources such as the ESRF Extremely Brilliant Source (EBS), the first fourth-generation high-energy synchrotron facility worldwide, will provide new research opportunities but at the same time, will require very demanding new X-ray instrumentation. For this purpose, the digital integration readout and the XIDER detector will open the possibility of high-duty-cycle operation under very high photon fluxes enabling fast frame-rate and high dynamic range with single-photon sensitivity in the 40 100 keV energy range. The readout method will allow for noise-free effective X-ray detection, but also a high level of versatility to suit a wide range of synchrotron radiation experiments.
The digital integration concept is currently under thorough investigation to evaluate the impact of main critical design parameters in order to identify the weaknesses and strengths of the readout scheme and consequently to propose refinements in the final implementation. Simulations are performed with a dedicated Monte Carlo simulation tool, DECIMO [2], a modular Python package designed to recreate in an easy-to-use way the complete detection chain of X-ray detectors for synchrotron radiation experiments, including the XIDER project.
In addition to presenting simulation results for this novel readout scheme, this work underlines the potential of the approach and some of its limitations.

[1] P. Fajardo et al., 2020 JINST 15 C01040
[2] T. Johng-ay et al., 2016 IEEE Nuclear Science Symposium (NSS/MIC/RTSD), pp. 1-7

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