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Characterization of the IBEX ASIC for Electron Detection

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Hybrid Photon Counting (HPC) detectors revolutionized measurement methods and data collection strategies at synchrotron facilities and laboratories over the last 10 years thanks to key features such as the absence of readout noise, high photon flux capability, high dynamic range and high frame-rate. Similar advantages are expected to be directly transposed to the field of electron detection, e.g. in the context of Transmission Electron Microscopy (TEM). The high dynamic range and the fast read-out are of great advantages for in-situ Electron Microscopy and Materials Science techniques where the typical solid-state sample or nanostructure can tolerate high electron flux. In electron diffraction experiments is then possible to get an accurate count rate from both the un-scattered beam and the weaker Bragg spots without damaging the detector. Low noise and single electron counting capability, on the other hand, are extremely beneficial in the field of life science where sample damage requires the accurate detection of weak signals.
In order to assess the electron detection performance of a hybrid pixel counting detector, we characterize an EIGER 1M detector in a TEM microscope. The detector is based on the IBEX ASIC and the sensor material is silicon, 450 µm thick, with a pixel size of 75 µm. The calibration is performed with X-rays in the range 8-75 keV and the explored electron energies are in the range 20-300 keV
Images taken with a high statistic flat-field illumination show a high count homogeneity with sigma of about one percent. The electron energy spectra show one main peak at the electron energy down to energies of 30 keV. The average cluster size (event multiplicity) increases for higher energies and for lower threshold energies. The measured multiplicity reaches a value of 3.5 at 300 keV at a threshold energy of 20 keV.
The imaging properties are evaluated at different beam energies and thresholds through the Modulation Transfer Function (MTF) and Detective Quantum Efficiency (DQE) and compared with simulations.
The IBEX retrigger technology, originally developed to cope with the very intense X-ray beams available at modern synchrotrons, also allows for very high count rates (up to 10 Mcts/pixel/s) in the case of electron counting. Moreover, long-term exposure at high fluxes up to $2.6 \cdot 10^6$ electrons/pixel/s over a spot of about 8000 pixels has a stable behavior. A very high level of radiation tolerance is measured with 300keV electron beam: no count variation on a flat-field image is observed after 10min of irradiation at fluxes of about $250 \cdot 10^6$ electrons/pixel/s.
For the correct interpretation of our first experimental results, experimental data are complemented by Monte Carlo simulations based on FLUKA –a multi-particle transport simulation tool developed at CERN. In the contribution, we present the simulation workflow and illustrate how the comparison between measurements and simulations yields a very high degree of consistency.
Based on these first encouraging results, we prove the suitability of the IBEX (Bochenek et al., 2018) Hybrid Pixel Counting technology for electron detection and we believe that it has the potential to be the next successful paradigm for many applications in the field of electron microscopy, such as small molecule electron crystallography (Grüne et al., 2018; Heidler et al., 2019).

M. Bochenek, S. Bottinelli , Ch. Broennimann, P. Livi, T. Loeliger, V. Radicci, R. Schnyder, P.Zambon. IBEX: Versatile Readout ASIC With Spectral Imaging Capability and High Count Rate Capability. IEEE Transactions on Nuclear Science (Volume: 65 , Issue: 6 , June 2018)
Grüne, T., Wennmacher, J. T. C., Zaubitzer, C., Holstein, J. J., Heidler, J., Fecteau-Lefebvre, A., De Carlo, S., Müller, E., Goldie, K. N., Regeni, I. et al. (2018). Rapid structure determination of microcrystalline molecular compounds using electron diffraction. Angew. Chem. Int. Ed. 57, 16313-16317.
Heidler, J., Pantelic, R., Wennmacher, J.T.C., Zaubitzer, C., Fecteau-Lefebvre, A., Goldie, K.N., Mueller, E., Holstein, J.J., van Genderen, E., De Carlo, S. et al. (2019). Design guidelines for an electron diffractometer for

structural chemistry and structural biology. Acta Cryst. D75, https://doi.org/10.1107/S2059798319003942.

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