Characterisation of iLGAD sensors on a JUNGFRAU detector in burst mode operation

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Hybrid-pixel detectors bump-bonded to silicon sensors are widely adopted for X-ray detection. However, their performance deteriorates in the soft X-ray regime due to reduced quantum efficiency and signal-to-noise ratio degradation. Recent advancements in X-ray detectors for photon science applications involve hybrid detector assemblies equipped with Inverted Low Gain Avalanche Diodes (iLGADs), featuring a high electric field layer where avalanche multiplication of charges (electrons and/or holes) can take place.

Charge-integrating JUNGFRAU detectors, developed by the Paul Scherrer Institute (PSI) originally for hard X-rays, are now deployed across various synchrotron and FEL facilities. New prototypes of these detectors incorporate iLGAD sensors, expanding the scope of their application to scientific cases in the soft X-ray regime. One promising application is the Heisenberg Resonant Inelastic X-ray Scattering (hRIXS) spectrometer of the Spectroscopy and Coherent Scattering (SCS) instrument at the European XFEL, which aims to explore the limits of energy and temporal resolution for time-resolved RIXS, and for which low noise, high spatial resolution, and high frame rates are the most stringent requirements.

The pixels of the JUNGFRAU 1.0 chips contain 16 memory cells capable of storing the detected analog signal in between readout cycles, allowing for the acquisition of up to 16 images at a frame rate greater than 100 kHz (burst mode operation). Additionally, the rectangular segmentation of the iLGAD sensors consisting of 25x225 μm^2 pixels allows for high spatial resolution in the energy dispersion dimension, which can be further enhanced by taking advantage of the charge sharing across pixels applying interpolation methods. This makes a JUNGFRAU detector with an iLGAD sensor an attractive option to use in the hRIXS spectrometer, allowing to resolve not only individual trains (bunches of X-ray pulses at MHz rate that arrive at 10Hz) but also individual pulses. This would bring substantial improvements over the currently implemented commercial cameras with much slower readout speed, namely allowing for train-to-train jitter correction, improving time resolution, and for alternated pumped and unpumped pulses, improving normalization.

To investigate the viability of this detector for the hRIXS spectrometer, a characterization of two iLGAD sensors was conducted at the European XFEL using PulXar, a pulsed X-ray generator featuring an electron gun of tunable energy and intensity, and a variety of selectable targets and filters. In this work we will discuss the results of this characterization, particularly focusing on noise, signal uniformity across memory cells and subpixel resolution achieved by clustering and interpolation methods. Additionally, an overview of first measurements carried out with the hRIXS spectrometer will be presented.