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Inverse LGAD sensors for RIXS spectroscopy at the European XFEL

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The Spectroscopy and Coherent Scattering (SCS) instrument at the European XFEL is equipped with the Heisenberg-RIXS spectrometer (hRIXS), capable of performing resonant inelastic X-ray scattering (RIXS) measurements in the time domain, with time and energy resolution approaching the Heisenberg limit imposed by the uncertainty relations [1, 2]. The unique pulse delivery structure of the European XFEL allows for bursts of pulses within a bunch train to be delivered up to MHz rates, which is beyond the frame rate capability of most detectors. Combining this with the additional requirements of high spatial resolution and large sensitive area, finding a detector capable of fully exploiting the potential of the hRIXS spectrometer becomes a significant challenge. A detector sensitive to photon energies below 1 keV and simultaneously capable of resolving intra-train pulses would greatly benefit pump-probe laser experiments, by enabling the use of alternating pumped and unpumped pulses for more reliable data normalization.

In recent years, a collaboration between the Paul Scherrer Institute (PSI) and Fondazione Bruno Kessler (FBK) has materialized into the first prototypes of X-ray-sensitive inverse Low Gain Avalanche Diodes (iLGADs) sensors compatible with the readout chips of the widely adopted charge-integrating detectors developed by PSI, such as the JUNGFRAU [3, 4]. The JUNGFRAU 1.0 ASIC, which is already widely employed across several of the European XFEL experimental stations, is capable of storing up to 16 images in analogue memory cells, offering a maximum acquisition rate of ˜150 kHz in between readout cycles. Four ASICs each of 256×256 pixel with75 μm pitch have been bump-bonded to to an iLGAD sensor segmented into narrow rectangular pixels of 25x225 μm2, thus increasing spatial resolution along the energy dispersion axis.

This detector prototype has been extensively characterized and calibrated and its performance will be summarized here. Moreover, the main results of a recent beamtime with the hRIXS spectrometer will be presented highlighting the spatial resolution achieved using reference solid samples, and comparing it to the previously used commercial cameras. Finally, we present the RIXS spectra acquired at multi-kHz rates in combination with pump-probe laser excitation.

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