

JUNGFRAU Prototypes with iLGAD Sensors for Soft X-ray RIXS

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The recent development of inverse Low Gain Avalanche Diode (iLGAD) sensors with optimized thin entrance windows has made hybrid pixel detectors available for applications with soft X-rays. One promising use case is Resonant Inelastic X-ray Scattering (RIXS), which requires high statistics and multidimensional scans while being inherently photon-starved. The multi-kHz image rates and large area coverage of hybrid pixel detectors would substantially improve RIXS efficiency and throughput compared to existing detectors.

We have developed multiple detector prototypes combining iLGAD sensors fabricated by Fondazione Bruno Kessler with different versions of the charge-integrating JUNGFRAU readout ASIC. These include various single-chip ($2 \times 2 \text{ cm}^2$) and four-chip ($4 \times 4 \text{ cm}^2$) systems, featuring rectangular pixels (with $225 \times 25 \text{ }\mu\text{m}^2$, $300 \times 18.75 \text{ }\mu\text{m}^2$, or $375 \times 15 \text{ }\mu\text{m}^2$ pixel dimensions) that fit to the native JUNGFRAU pixel matrix ($75 \times 75 \text{ }\mu\text{m}^2$). This design enables one-dimensional position interpolation via charge sharing, crucial for enhancing spatial resolution and, consequently, RIXS energy resolution.

The prototypes have undergone extensive characterization in the lab and at the Pollux beamline of the Swiss Light Source, with larger systems tested at RIXS spectrometers at SwissFEL and European XFEL. This contribution summarizes the results collected to date, discussing noise performance, device uniformity, pixel yield, stability, and interpolation effectiveness, comparing rectangular-pixel and regular square-pixel designs. Additionally, we will introduce prototypes with a modified version of the JUNGFRAU ASIC, aimed at further reducing electronic noise and thereby extending single photon resolution to lower X-ray energies.