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Low-energy X-ray detection with JUNGFRÄU

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The hybrid silicon pixel detector JUNGFRÄU has found widespread use at free-electron laser (FEL) and synchrotron facilities worldwide. Its charge-integrating architecture combines three dynamically switching gains per pixel and allows single photon resolution down to 1.5 keV while, simultaneously, providing a dynamic range of 10^4 photons at 12 keV. Although JUNGFRÄU initially targeted applications with hard X-rays between 2 keV and 16 keV, its low noise, high spatial resolution, fast readout, and high dynamic range make the detector an attractive choice for photon science at lower energies.

The first JUNGFRÄU system aiming at low-energy X-ray detection was installed at the Maloja end station of the Swiss free-electron laser (SwissFEL) in 2021. It combines an improved version of the JUNGFRÄU readout ASIC and sensors with thin entrance windows. The new ASIC (labelled JUNGFRÄU 1.1) reduces the noise of the detector to 34 electrons rms in high gain, and the sensors with thin entrance windows increase the quantum efficiency for low-energy photons. With these improvements, the system can detect single photons down to 800 eV.

In this contribution, we discuss the capabilities of JUNGFRÄU for low-energy X-ray detection based on the system at Maloja. We present recent measurement results and provide an outlook on ongoing improvements to the sensor design aiming to enable single photon resolution down to 250 eV.

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