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Commissioning and operation of the JUNGFRAU detector at the European XFEL: status and prospects

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The JUNGFRAU detector is a now established hybrid pixel detector developed at Paul Scherrer Institute (PSI), featuring 75 μm pixel pitch with a charge integrating architecture¹ designed for FEL applications². Thanks to its dynamic gain switching mechanism it provides an extensive dynamic range up to $\sim 10^4$ photons/pixel at 12 keV³. With an average noise of ~ 80 ENC rms for 10 μs integration time, it offers single photon resolution above ~ 1 keV. An array of 16 memory cells per pixel makes it possible to store images at a repetition rate greater than 200 kfps, which allows the detector to partially exploit the EuXFEL time structure. The combination of these features makes the JUNGFRAU detector a promising candidate for several scientific instruments at the EuXFEL facility. The small pixel pitch grants enhanced spatial resolution in comparison to other high speed imaging detectors available at EuXFEL, which is of great advantage for Small Angle X-ray Scattering (SAXS) experiments like the ones performed at the High Energy Density (HED) instrument or for all spectroscopy applications. The Femtosecond X-ray Experiment (FXE) instrument exploits this feature, together with the compact dimensions of a single JUNGFRAU module, to setup a versatile single shot spectrometer mounted on a robotic arm. The combination of a large dynamic range and modular structure of the detector is fundamental for a large area camera for diffraction experiments, like the ones performed at the Single Particles, Clusters, and Biomolecules & Serial Femtosecond Crystallography (SPB/SFX) instrument. On the other hand, the excellent signal-to-noise ratio in the 3–16 keV range is fundamental for experiments performed in the single-photon regime, like the X-ray Photon Correlation Spectroscopy (XPCS) and Coherent X-ray Diffraction Imaging (CXDI) which are the goals of the Materials Imaging and Dynamics (MID) instrument. We will present the status of commissioning of the JUNGFRAU detector at the EuXFEL in general terms and with focus on details specific for individual scientific experiments at EuXFEL. Even though the full implementation of the 16-memory cell operation mode of the detector currently is at an advanced experimental stage, particular focus will be given to the status of its implementation, its integration at the facility and results of the first tests.

¹ “The JUNGFRAU Detector for Applications at Synchrotron Light Sources and XFELs”, Mozzanica A. et al., SYNCHROTRON RADIATION NEWS 31, 16 (2018)

² “Operation and performance of the JUNGFRAU photon detector during first FEL and synchrotron experiments”, Redford S. et al, JOURNAL OF INSTRUMENTATION 13, C11006 (2018)

³ “First full dynamic range calibration of the JUNGFRAU photon detector”, Redford S. et al, JOURNAL OF INSTRUMENTATION 13, C01027 (2018)

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