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JungfrauJoch: A System for 2 kHz Framerate Data Acquisition with Large Format Detector and Data Processing at 4th-Generation Synchrotrons and X-ray Free Electron Laser Facilities

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The ongoing 4th-generation synchrotron source upgrades and new constructions around the world will provide a higher brilliance, enabling scientists to investigate the dynamics of biological structures at shorter timescales and with higher throughput than ever before. Large-area photon counting and integrating detectors with fast framing capabilities and large dynamic range have become a vital tool for cutting-edge synchrotron and XFEL science¹. The exponential increase of generated data, shown in Figure 1 (A), requires efficient methods to manage data online and offline^{2,3}. At PSI, we developed a single standard-sized server, called JungfrauJoch (Figure 1 (B))⁴, that is capable of handling 40 GB/s data stream and carrying out initial data analysis (spot finding, indexing, azimuthal integration, etc.) from a 9 Mpixel detector at 2 kHz⁵. After successful demonstrations of this powerful server with the new PSI JUNGFRAU 9M detector at the PXI beamline at the SLS, we now aim to push forward and show the potential of JungfrauJoch at other sources and with different applications. This drive is especially relevant, given the current upgrade of the SLS to SLS 2.0 – a 4th-generation light source.

To evaluate the compatibility and capability of JungfrauJoch, we present the process of integrating the JungfrauJoch system in a 4th-generation light source (MicroMAX, MAX IV) and an X-ray free-electron laser (XFEL) facility (Cristallina, SwissFEL) along with demonstrations of time-resolved serial crystallography experiments. As we investigate and optimize additional functionalities and gain more experience with integrating JungfrauJoch into different workflows and infrastructures, JungfrauJoch could be a broadly applicable solution for more types of detectors, more beamlines, and more techniques at both Synchrotrons and XFEL facilities.

1. F. Leonarski, S. Redford, A. Mozzanica, et al., Nat. Methods, 15, 799–804 (2018).
2. F. Leonarski, A. Mozzanica, M. Brückner, et al., Struct. Dyn., 7, 014305 (2020).
3. M. Galchenkova, A. Tolstikova, B. Kloppe, et al., IUCrJ, 11, 190–201 (2024).
4. F. Leonarski, M. Brückner, C. Lopez-Cuenca, et al., J. Synchrotron Rad., 30, 227–234 (2023).
5. F. Leonarski, J. Nan, Z. Matěj, et al., IUCrJ, 10, 729–737 (2023).

Figure 1. (A) Rapid growth of data rates over the past and predicted into the future after the SLS 2.0 upgrade. (B) JungfrauJoch data flow.

I plan to submit also conference proceedings

No

Primary authors: DUAN, Jiaxin (PSI); LEONARSKI, Filip (Paul Scherrer Institute)

Co-authors: GRIMM, Sascha (DECTRIS); NAN, Jie (MAX IV Laboratory); MATEJ, Zdenek (MAX IV Laboratory, Lund University); URSBY, Thomas (MAX IV Laboratory, Lund University); AURELIUS, Oskar (MAX IV Laboratory); BEALE, John (Paul-Scherrer-Institut); Dr AUGUSTIN, Sven (Paul-Scherrer-Institut); Dr MOZZANICA,

Aldo (Paul Scherrer Institut); LOPEZ-CUENCA, Carlos (Paul Scherrer Institut); STADLER, Hans-Christian (Paul Scherrer Institut); BRÜCKNER, Martin (Paul-Scherrer-Institut); WANG, Meitian (Paul Scherrer Institut)

Presenter: DUAN, Jiaxin (PSI)

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