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Milestones in Physics (30)

Update on the SLS 2.0 upgrade – Commissioning and First Results with Beam

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Figure 1. The renovated SLS building housing now SLS 2.0, showing the new aluminium roof fitted with solar panels.

A detailed and partly didactic report on the upgrade of the Swiss Light Source (SLS) at the Paul Scherrer Institute (PSI) to a diffraction-limited storage-ring was submitted in January 2024 (just as the original SLS was beginning to be replaced), and subsequently published in this journal in February 2024 [1]. In the intervening 19 months since submission, the storage ring has been entirely replaced and largely commissioned, while the first phase of beamlines are already hosting pilot users. This follow-up report describes activities during this period.

The old storage ring was dismantled and removed by the end of November 2023; installation of the new seven-bend-achromat design began immediately thereafter. The tunnel roof was closed towards the end of 2024 (Figure 1).

A summary of the timeline and most important milestones in the first seven months of 2025 is shown graphically in Figure 2. Commissioning began on 14th January 2025 after the 2024/2025 Christmas/New Year shutdown. It took three days to thread electrons around a full turn of the ring; two development-days later, the first stored beam (i.e., using the RF supply) was achieved. Thereafter, the ring was gradually conditioned at ever larger currents until the nominal current was obtained on 3rd March, 43 development days after commissioning start.

The beamline portfolio of all 18 user beamlines is shown graphically in Figure 3. All of the beamline frontends at SLS 2.0 have undergone or will undergo comprehensive updates, motivated by the increased power of the synchrotron beam, changing source points, new safety regulations, and enhanced beam properties. These new designs feature innovative and enhanced cooling systems to manage

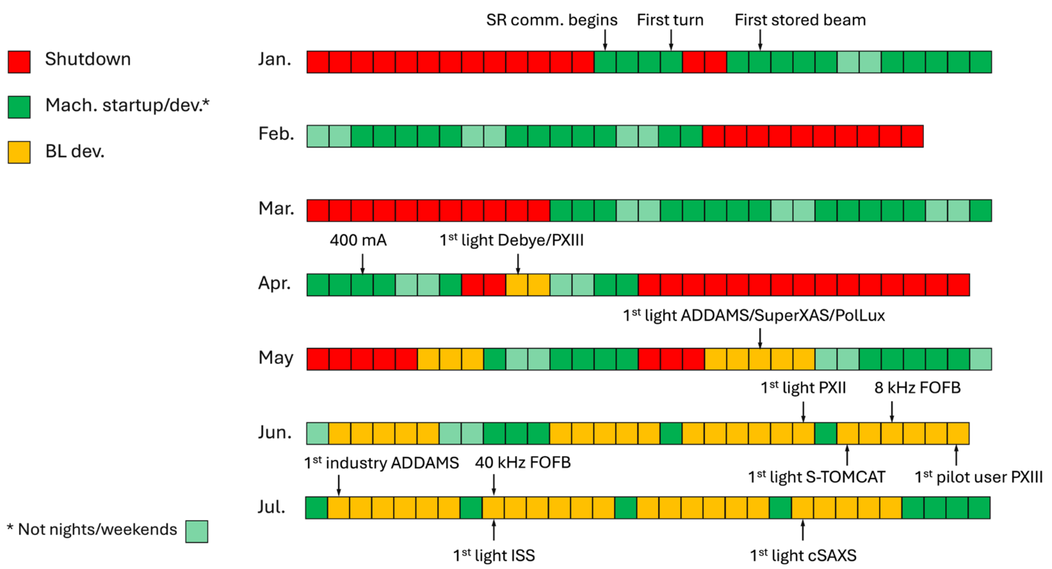


Figure 2. Timeline of the most important milestones in the commissioning of SLS 2 until end of July 2025. Note that from beginning of commissioning (14.01.2025) to attaining the nominal storage-ring current of 400 mA (03.04.2025) took 43 commissioning days, highlighted in green ( ). Weekends and night shifts were dedicated to vacuum conditioning (light green).

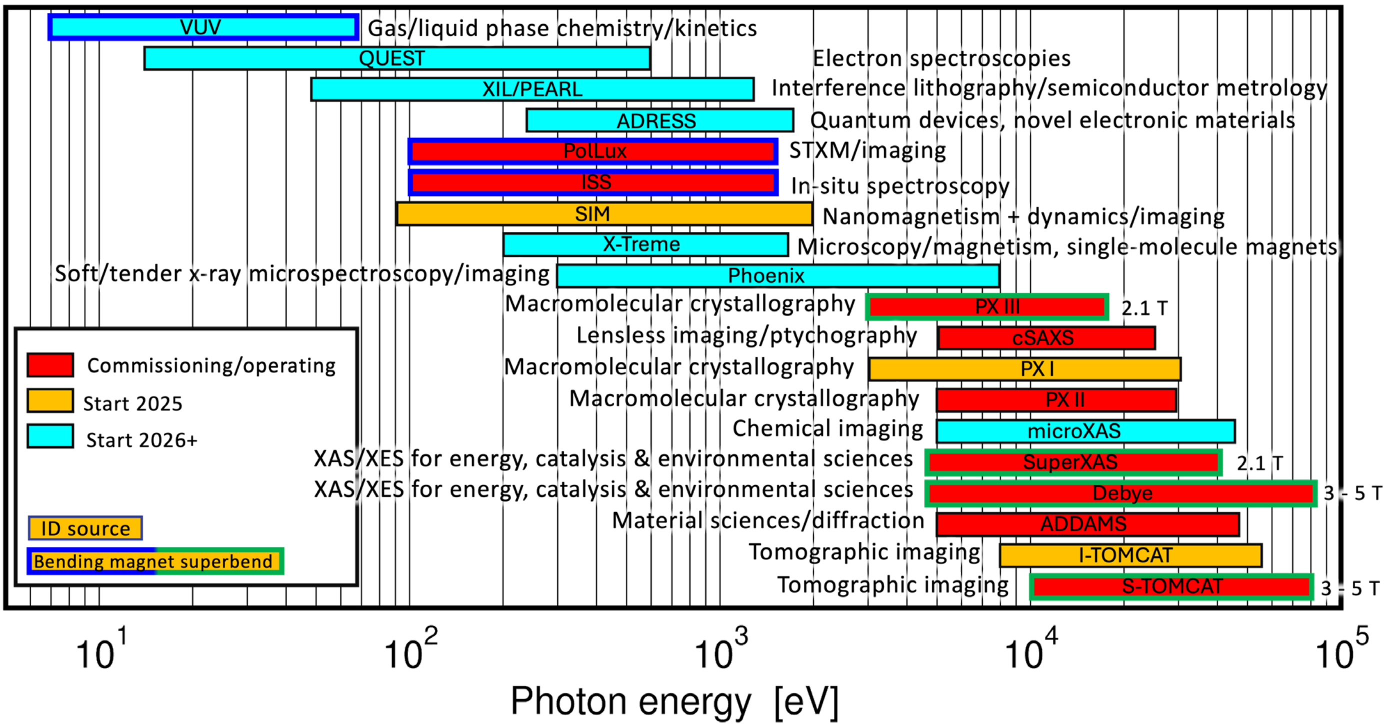


Figure 3. Beamline portfolio at SLS 2.0. The nine beamlines highlighted in red have, at the time of writing, taken first light and are either commissioning or hosting pilot users; beamlines in orange are expected to complete commissioning and take first users before the end of 2025; the remaining beamlines will begin commissioning, most starting in the second semester of 2026 after the second shutdown required to insert the superconducting superbends and the remaining insertion devices. Beamlines with undulator sources have thin black borders, while those with bending magnets (1.35 T) have thick dark blue borders, and the warm superbends (2.1 T) and cryocooled superconducting superbends (3 – 5 T) have thick green borders. Note that X-Treme and PHOENIX share beamtime on the same straight using the same insertion device.

the high-power load and meet new requirements such as mechanical stability and compact footprints dictated by the enhanced electron-beam properties, as described in detail elsewhere [2].

Most of the hard-x-ray beamlines have benefitted from a significant optics upgrade program [3]. Monochromators and mirrors have been redesigned with the reduced horizontal breadth of the photon beam at SLS 2.0 in mind. New crystal and multilayer monochromators scatter and disperse the incident radiation in the horizontal plane; the minor loss in intensity due to polarization factors is more than offset by the benefit of the superior stability of horizontal rotational movements, thus also allowing compact and stable designs. Horizontally deflecting and focusing mirrors are also significantly shorter and thereby gain in stability.

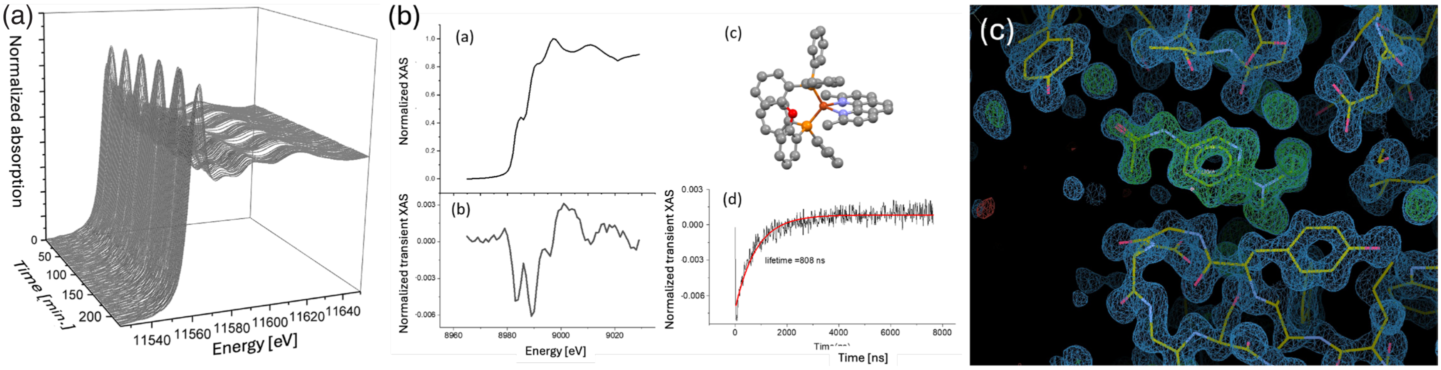
The unexpectedly rapid machine commissioning allowed the first bending-magnet beamlines, Debye and PXIII, to open their shutters on 10th April. Over the following eight weeks (despite this including a three-week shutdown), seven further beamlines, ADDAMS, SuperXAS, PolLux, PXII, S-TOMCAT, ISS, and cSAXS saw "first light" [5–7]. Of these, ADDAMS, PXII, and cSAXS are hard-x-ray insertion-device beamlines. A gallery of first results emerging from a selection of the above beamlines is shown in Figure 4. Three further beamlines, the new I-TOMCAT ID-based tomography beamline, PXI, the cutting-edge macromolecular crystallography beamline, and SIM, the soft x-ray imaging beamline (i.e., the orange beamlines in Figure 3), will all get first light by the end of 2025.

Five of these so-called "Phase-1 beamlines" (ADDAMS, Debye, PolLux, PXIII, and SuperXAS) have advanced sufficiently that a limited call for experiment proposals was announced on 14.07.2025 for beamtime in November and December 2025. By the submission deadline on 20.08.2025, 58 proposals had been submitted and then sent to the Proposal Review Committee. Regular PRC-based proposals are planned for Phase-1 beamlines from Summer 2026.

A second two-month machine shutdown is planned for the beginning of 2026 to install most of the remaining sources (both superconducting superbends and insertion devices) and complete the installation of the frontends. By the end of 2026, all remaining "Phase-2 beamlines" will be back in full user operation, with the exception of ADRESS and QUEST, which require more time to build and install their novel 4-m knot undulators (UE36kn and UE90kn devices, respectively), and microXAS, which is relocating from Straight 5 to Straight 8 and will thus start commissioning only towards the end of 2026. The operating Phase-2 beamlines expect to take regular users at the start of 2027.

The roof of the SLS has been replaced with an aluminium construction, on top of which solar panels are integrated over approximately half the roof area (Figure 1). This provides an energy production of some 900 MWh per year. This, along with the replacement of electromagnets of the old lattice with permanent magnets in SLS 2.0, the use of solid state RF power amplifiers instead of klystrons, and power-efficient new cooling infrastructure, means that the total yearly net power consumption of the facility, including beamlines and infrastructure, drops from approximately 23 GWh to 15 GWh.

The SLS 2.0 upgrade was officially inaugurated on 21st August 2025. The ceremony was attended by many Swiss



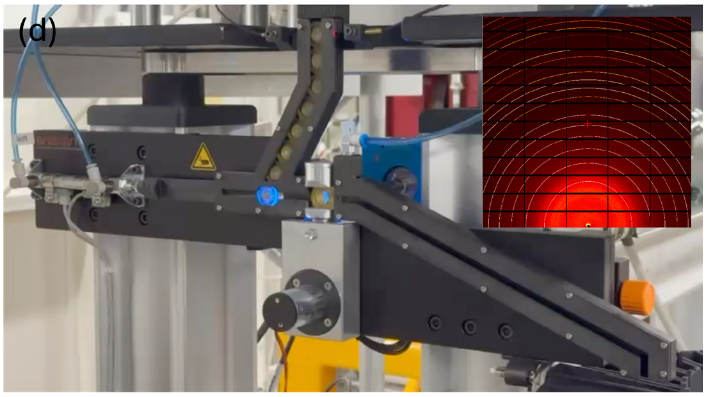


Figure 4. A gallery of initial results from the first phase of beamlines to come back online.
(a) Pt L_3-edge spectra recorded every 0.5 s at the new Debye beamline during hydrogen cycling of a novel fuel cell at high current densities, simulating true device operation of > 2 A/cm^2. Courtesy Adam Clark and Maarten Nachtegaal.
(b) Transient Cu K-edge spectra recorded at SuperXAS associated with a 355-nm, 10-ps-laser-induced excited triplet state of a possible Cu-luminophore complex for OLED applications. Courtesy Grigory Smolentsev, Olga Safonova, and Maarten Nachtegaal.
(c) Electron-density distribution derived from diffraction data recorded at PXIII of a pyridine–piperidine derivative attached to endothiapepsin. Courtesy Olga Tarkhanova, ChemSpace, and the SLS MX group.
(d) Detail of the automated setup for high-throughput powder diffraction measurements at ADDAMS [4]. Samples in pucks (lit blue in this image) are fed into the x-ray beam and a powder diffraction pattern, such as shown in the inset, is recorded. In the run performed in early July 2025, 3020 samples were measured in five hours (ca. 6 s/sample). Courtesy Nicola Casati, ADDAMS beamline, ANAXAM, and DeterMin.

luminaries and both Swiss and international scientists, including Federal Councillor Guy Parmelin, head of the Department of Economic Affairs, Education and Research; and Martina Bircher, member of the cantonal government and Head of the Department of Education, Culture and Sport of Canton Aargau (see Figure 5 & 6).

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Figure 5. The SLS 2.0 inaugurational party (from left to right): Professor Christian Rüegg, Director of PSI; Federal Councillor Guy Parmelin; Aargau cantonal council member Martina Bircher; and Upgrade project lead Dr. Hans Braun.

Figure 6. Members of the SLS 2.0 management board (from left to right): Markus Jörg, Alun Ashton, Hans Braun, Romain Ganter, Phil Willmott, Jörg Raabe, Shawn Bell, Frithjof Nolting. Absent: Roland Kobler and former member Terry Garvey.