Paul Scherrer Institute: Swiss Light Source & SwissFEL

- General Information: http://www.psi.ch/sls & http://www.psi.ch/swissfel

SLS key numbers user operation 2013
User operations: started from **2001**

User Operation	2013
Visitors (badge requests)	3616
Individual Users	1729
Experimental days	1961
Number of Experiments	1176
New Proposals	842
Number of Publications (in total)	582
High Impact Publications (≥ 7.1 (PRL))	160

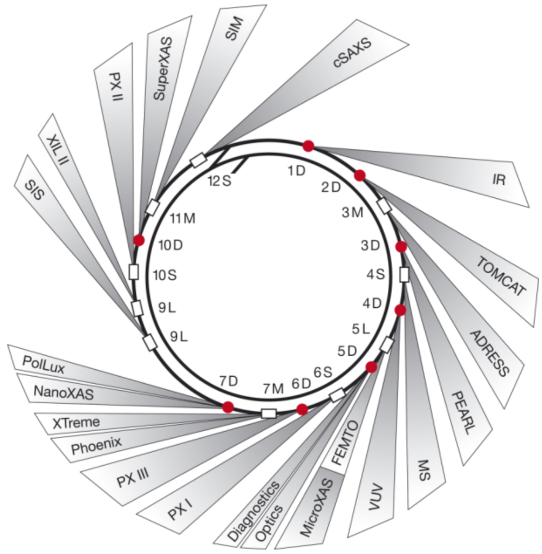
SLS-Accelerator: 2.4 GeV 400 mA Top-Up operations within 0.5 % current variation.

Total beamtime: 6888; 5'032 h user operation + 816 h beamline commissioning. Mean time between failure: 76 h (2013).

Synchrotron Radiation and Nanotechnology

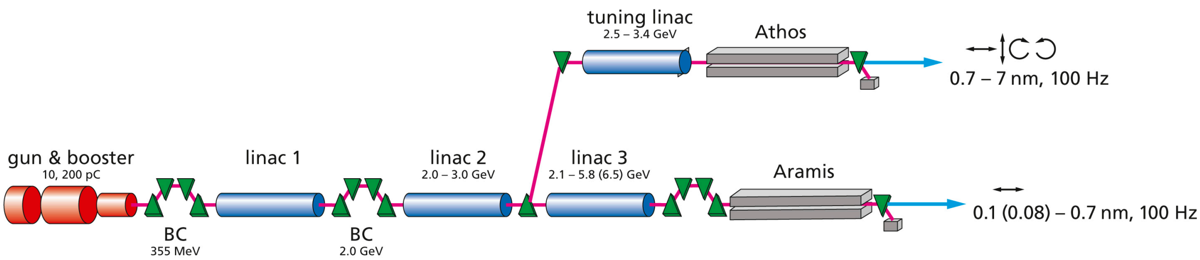
The Swiss Light Source (SLS) puts the old adage 'Seeing is believing' into practice. Being one of the world's most brilliant x-ray sources, the SLS enables researchers to investigate matter on a length scale of nanometers and time scales down to femtoseconds. Its facilities for X-ray diffraction, imaging and spectros-copy essentially attract researchers from all scientific disciplines. Having started operation in 2001 with four beamlines, SLS has now eighteen beamlines.

Beamline Map: 18 beamlines are in operation.



SwissFEL Facts and Figures

- **ARAMIS (phase I):** 1-7 Å hard X-ray SASE FEL, Seeded operation, In-vacuum , planar undulators with variable gap. User operation mid 2017.
- **ATHOS (phase II):** 7-70 Å soft X-ray FEL for SASE . Seeded operation . APPLE II undulators with variable gap and full polarization control.



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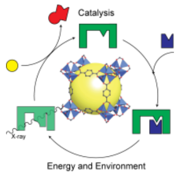
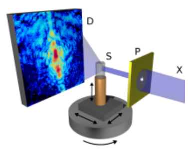
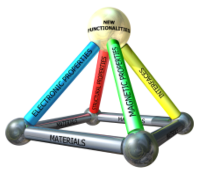
Current Activities

Swiss Light Source

The SYN-department comprises four laboratories. Three laboratories (LSK, LSB, LSC) are centered around the Swiss Light Source (SLS). The fourth is the Laboratory for Micro- und Nanotechnology (LMN).



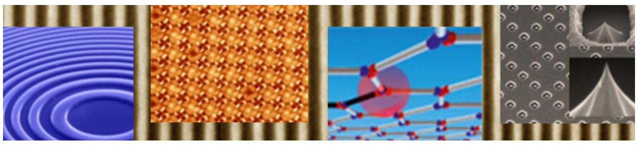




LSK: Two of the grand challenges of the 21st century are energy and sustainability. Within the LSK, we combine synthetic chemistry with development and application of new synchrotron-based characterization tools to contribute to solving these challenges.

LSB: In something as complex as a human being structures and processes occur on all length scales from macroscopic down to atomic dimensions. The SLS host a variety of techniques to address problems on different length scales.

LSC: Materials with new, functional properties are the scope of intense research, since they offer fascinating insights into fundamental interactions and hold promise for advanced technologies which is highly needed. The SLS host world-leading capability in advanced materials spectroscopy ranging from photoemission spectroscopy, over spectromicroscopy to different X-ray absorption, scattering and diffraction techniques. These techniques enable to provide the society with fundamental knowledge needed for the next generation technologies



LMN is dedicated to fundamental and applied research. We focus on outstanding nanoscience by exploiting the synergies between advanced micro/nanofabrication and PSI's large scale facilities, in particular the Swiss Light Source (SLS). We enable innovations in instrumentation (optics, detectors, diagnostics etc.) for large scale facilities by applying nanotechnology. A further focus is to provide advanced micro- and nanofabrication technologies to academic and industrial users, in particular in the area of polymer nanotechnology.

SwissFEL

ARAMIS scientific priorities

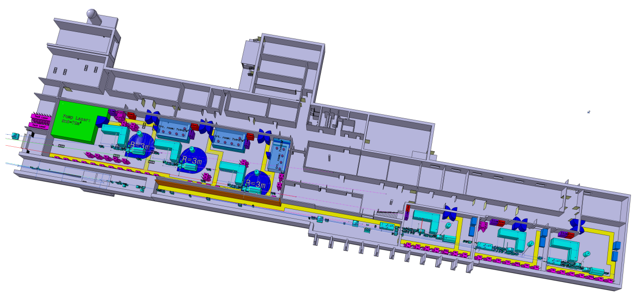
t-resolved chemistry:
charge-transfer reactions
catalytic rearrangements
photo-chemistry
liquid-jet injection and single-shot spectroscopy at **ESA**

t-resolved solid-state dynamics:
photo-induced phase transitions
ordering dynamics
coupled degrees of freedom
scattering from cryogenic thin films at **ESB**

membrane protein structure:
3D nano-crystal SFX in LCP at **ESA**
supported 2D crystallography at **ESC**

SwissFEL stresses:
potentially high-impact fields of local interest, for which the machine is competitive.

Technical considerations
100 Hz repetition rate: optimal for refreshed solid and liquid samples, LCP injection , large array detectors
10 fs time resolution, high-field THz pump:
ultrafast dynamics with pump-probe spectroscopy and scattering
3-7% broad bandwidth mode:
many reflections per shot in Laue crystallography
single-shot spectroscopy (L_2 and L_3 edges simultaneously)
2-5 keV:
strategic regime for catalysis



ATHOS Exp. surface:1 single hutch
ARAMIS Exp. surface: 3 separate hutches

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Future Perspective

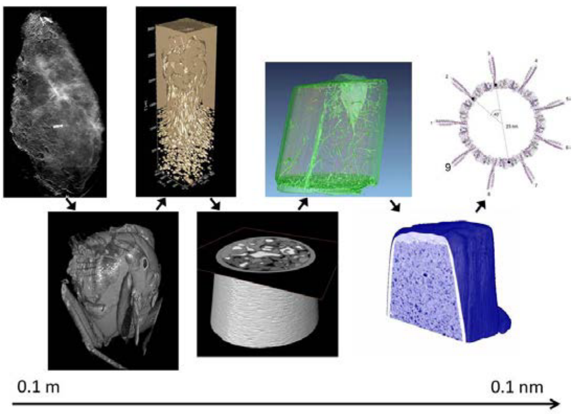
SLS has world-leading facilities for unraveling the structure of proteins, for in-depth 3D imaging of matter, and for investigating how the electrons of atoms and molecules keep matter together and render it properties such as magnetism and electron conduction at zero resistance ('superconductivity'). The beamlines for protein structure determination are intensively used by pharmaceutical companies in Switzerland and abroad. SLS is also leading in the development of pixelated X-ray detectors. The company DECTRIS has been spun off from these activities.

Of critical importance for the above studies is the brilliance of the X-ray source. Recent major developments in the technology of electron storage rings enable a great increase in the brilliance. Although SLS is already a brilliant X-ray source, it can be made even more brillant, namely by up to two orders of magnitude.

SLS 2.0

By 2021, the SLS will be twenty years old. Installation of an multi-bend achromat (MBA) lattice will bring it back at the forefront of international competition for another two decades. The high brilliance combined with high flux will enable much faster imaging of extended objects than before. 4D imaging on the time scale of milliseconds will be possible. This feature will be complementary to the much faster imaging times of smaller objects at SwissFEL. SLS 2.0 will enable us, for the first time, to bridge the so-called 'imaging gap' between the macroscopic world and the nano-world. The much smaller beam generated by SLS 2.0 will also bring significant improvements to the methods by which we determine the structure of certain classes of proteins. Also studies of electron bonding in matter will benefit greatly from the new properties of the facility. For the first time it will be possible to directly measure by resonant inelastic X-ray scattering the very small energy scales that determine the properties of correlated-electron materials, e.g., superconductors.

Bridging the length-scales between 0.1 m and 0.1nm (see below): (from left) Mammogram, fly in flight, volcanic process, hardened cement paste, lacuno-canalicular network in bones and piece of catalyst; (from right) molecular structure of centriole obtained by X-ray diffraction. At SLS 2.0, images will be taken 20 times faster and dynamic processes will be studied on shorter time scales.



ATHOS: Extending capabilities and doubling capacities for SwissFEL

Soft X-rays : strategic importance

- **Ultrafast Magnetization Dynamics**

  What is the temporal behavior in magnetic solids?

  What is the fate of the spin angular momentum in sub-ps laser-induced demagnetization?

- **Real-time chemistry and catalysis**

  What is the sequence of bond breaking and formation in a chemical process?

  Pump-probe spectroscopy at the C, N and O resonances maps the element-specific dynamics of energy and charge transfer.

- **Spectroscopy of Correlated Electron Materials**

  How do electron correlations generate novel states of matter?

  Time-resolved diffraction and imaging at spin- and orbital-sensitive transition-metal resonances follows the energy flow between coupled degrees of freedom.

- **Non-linear X-ray science**

  What new fundamental knowledge will arise from extending non-linear optics to X-ray / X-ray interactions in condensed matter?

  Stimulated Raman scattering promises a vast improvement in inelastic X-ray scattering efficiency.

Contact and Proposal Deadlines

Dept: synchrotron radiation and nanotechnology SYN

Prof. Dr. Gabriel Aeppli, gabriel.aeppli@psi.ch

Proposals: http://www.psi.ch/useroffice/