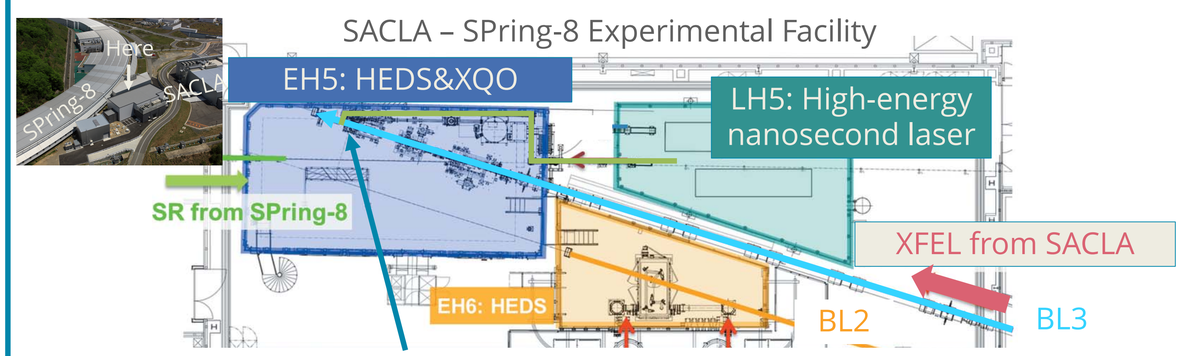
Experimental platform for high-power nanosecond laser with XFEL at SACLA

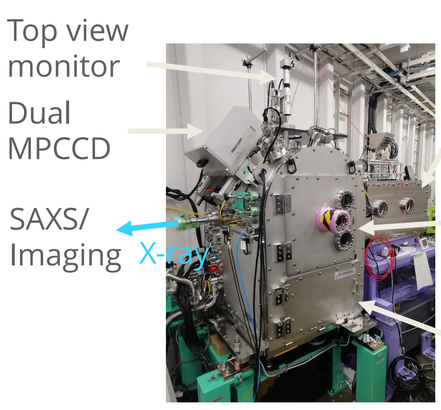
Kohei MIYANISHI (contact: miyanishi@spring8.or.jp), Keiichi SUEDA, Yuichi INUBUSHI, Toshinori YABUUCHI
SACLA

Summary

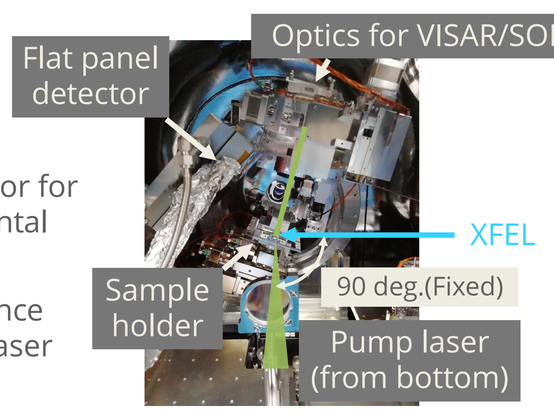
- The laser-driven dynamic compression pump and X-ray free-electron laser (XFEL) probe enables probing ultrafast lattice-level dynamical phenomena
- An experimental platform for combinative use of high-power nanosecond laser and XFEL designed for exploring dynamically compressed matters is available at SACLA [Y. Inubushi+, *Appl. Sci.* **10**, 2224 (2020)]
- The platform is compatible with X-ray diffraction (XRD), small-angle X-ray scattering (SAXS), and X-ray imaging measurements
- Focal spot smoothing system for high-power nanosecond laser is now open to users
- Variable and fixed attenuators for laser energy adjustment have been developed and are operational
- Improvements of usability, stability, and functionality of the platform are ongoing

Experimental platform





Interaction chamber



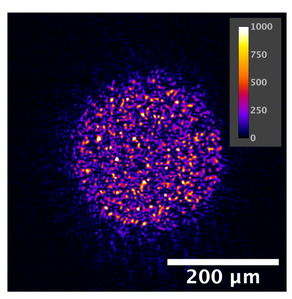
View from access door

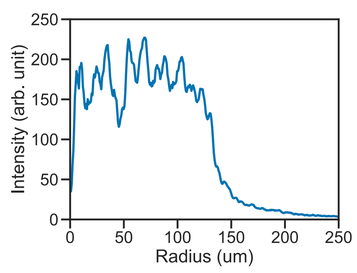
Beam parameters

High-power nanosecond laser	
Pulse Energy	> 15 J@5 ns on sample (current)
Spot size	150–250 μm (typical)
Wavelength	532 nm
Repetition Rate	0.1 Hz

Diffractive optical elements (DOEs) for focal spot smoothing are now open to users

- Flat top profiles with diameters of 150 and 250 μm are now available
- Spot monitoring system with spatial resolution of <2 μm has been developed
- Installation of DOEs for other spot sizes are planned



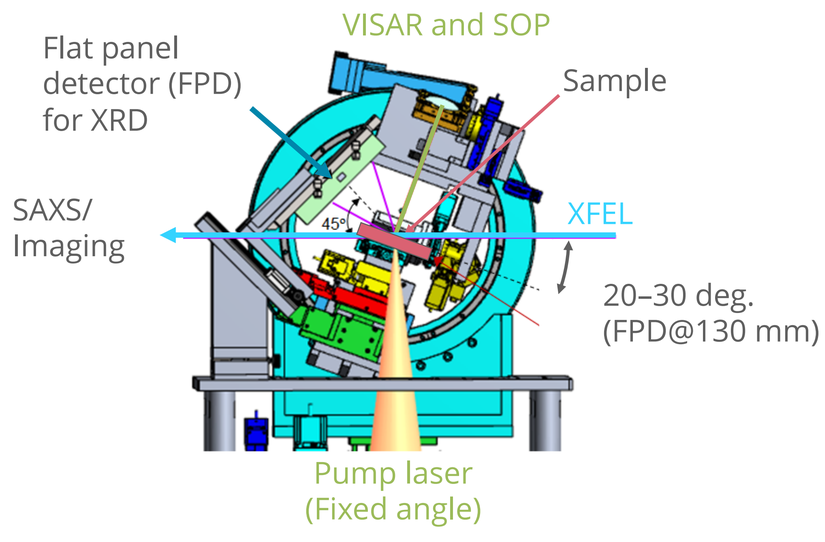


XFEL	
Beamline	BL3
Beam size	sub-μm to 10s um (KB mirror focusing) ~600 μm (Unfocused)

See poster "Overview of Beamlines (BL1,2,3)" for more details on XFEL characteristics

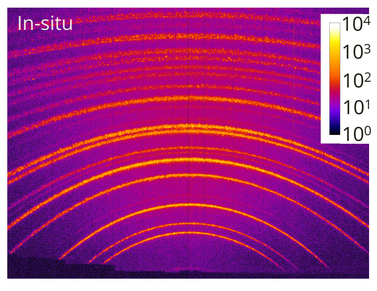
Experimental configuration

The platform is compatible with X-ray diffraction (XRD), small-angle X-ray scattering (SAXS), and X-ray imaging measurements along with velocity interferometry (VISAR) and optical pyrometry (SOP)

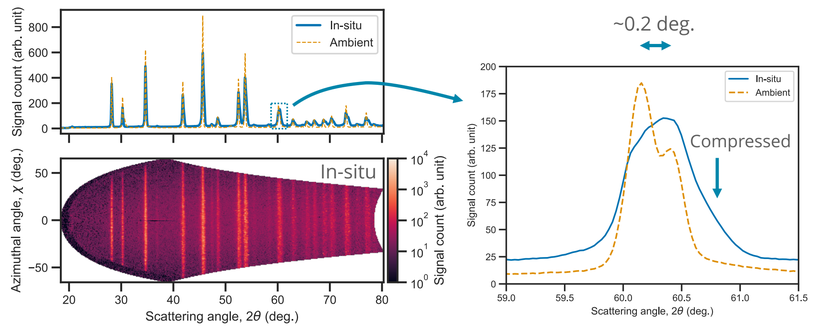


X-ray diffraction measurement

Large area flat panel detector (FPD) provides a wide angular range with a resolution of 0.1–0.2 degrees for X-ray diffraction measurement



XRD pattern of corundum

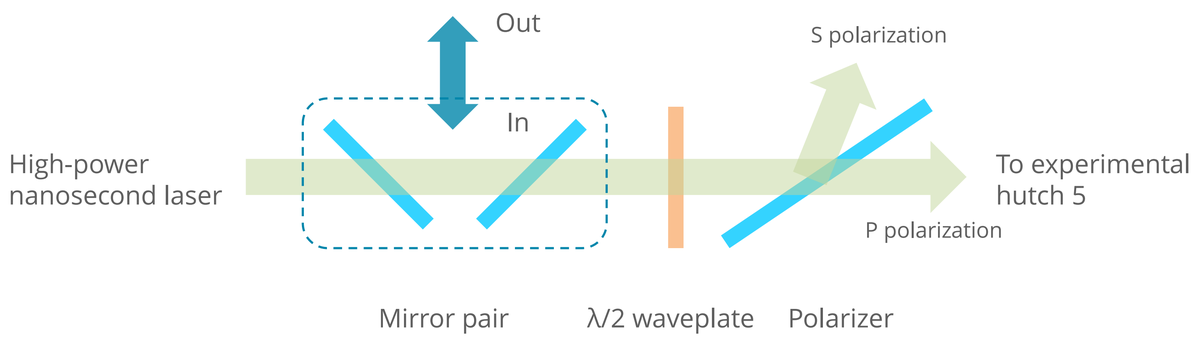


Flat panel detector

- Wide angular range
  - Scattering angle: 18–78 deg.
  - Azimuthal angle: +/- 60 deg.
- Resolution of 0.1–0.2 degrees in scattering angle
- Tested at laser energies of up to 60 J

Attenuators

Variable and fixed attenuators for laser energy adjustment are now in operation



Fixed attenuator

- Mirror pair attenuates laser energy for laser characterization, synchronization, and pointing with fully amplified pulse
- Optical density > 6

Variable attenuator

- Polarizer coupled with waveplate provides continuously-variable attenuation of laser energy for intensity scan
- Optical density < 1

Other improvements

Ongoing

- Development of user-friendly operation system
  - Operation system integration of the high-power laser and diagnostics for user experiments
  - Automated data acquisition system and efficient data sharing system for non-standard detectors of SACLA (flat panel detector, streak cameras, laser monitors)
- Development of electromagnetic pulses (EMP) resistant system
  - Protection of electronic equipment from EMP due to high-energy laser-matter interactions
- Improvements of energy stability and temporal waveform controllability of the laser system

Plan

- Developments of X-ray diagnostics (imaging, spectroscopy) for the platform

Acknowledgment

The high-power nanosecond laser system was deployed by Osaka University
Focal spot smoothing and monitoring system for the high-power nanosecond laser are developed under the SACLA Basic Development Program lead by N. Ozaki of Osaka University