Experimental platform using high-energy nanosecond laser with XFEL at SACLA

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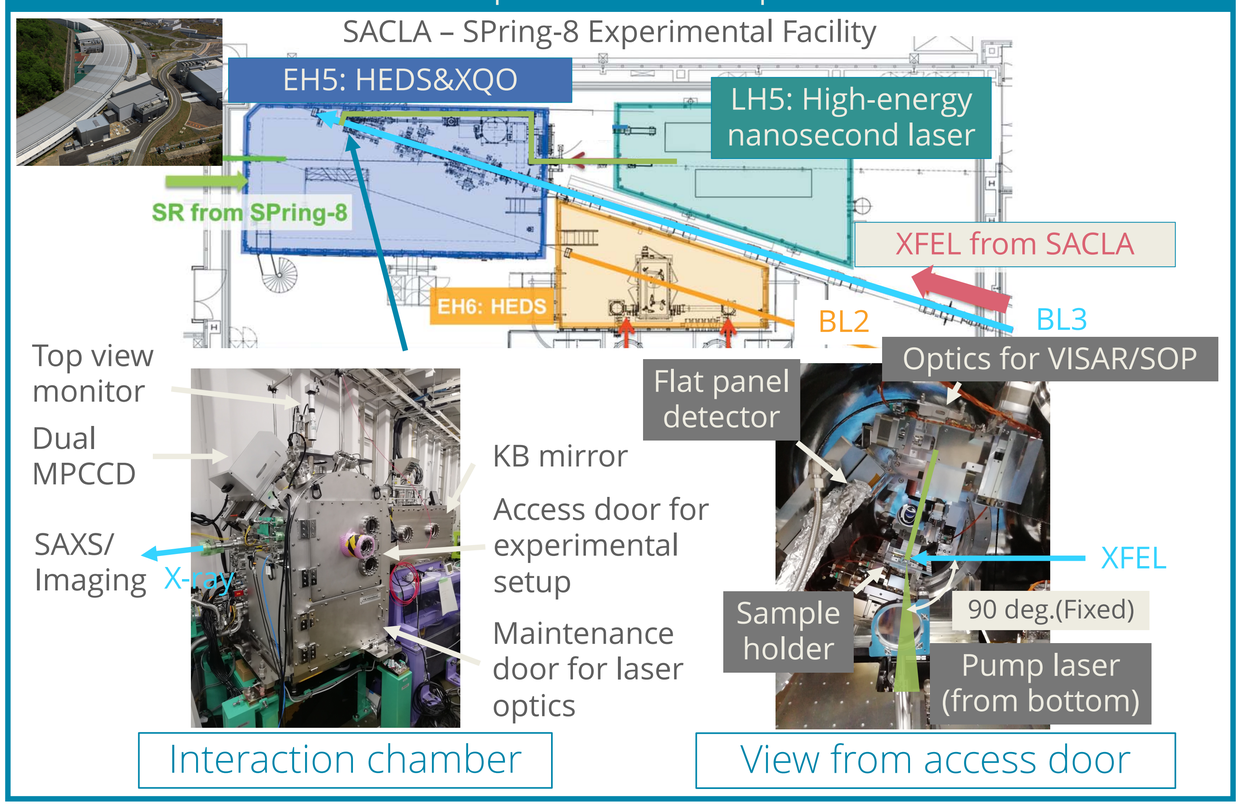
Summary

- We have developed a new experimental platform for combinative use of XFEL and high-energy nanosecond laser, designed for high energy density science (HEDS) applications
- The platform is compatible with XRD, SAXS, and imaging measurements
- Users' experiments have been carried out in 2018B and 2019A with energies of up to 50 J
- Next steps are the followings;
  - Improvements in the focus profile of the laser system
  - Development of electromagnetic pulse resistant system
  - Development of user-friendly operation scheme
  - Improvements of energy stability and temporal waveform controllability of the laser system

A new experimental platform



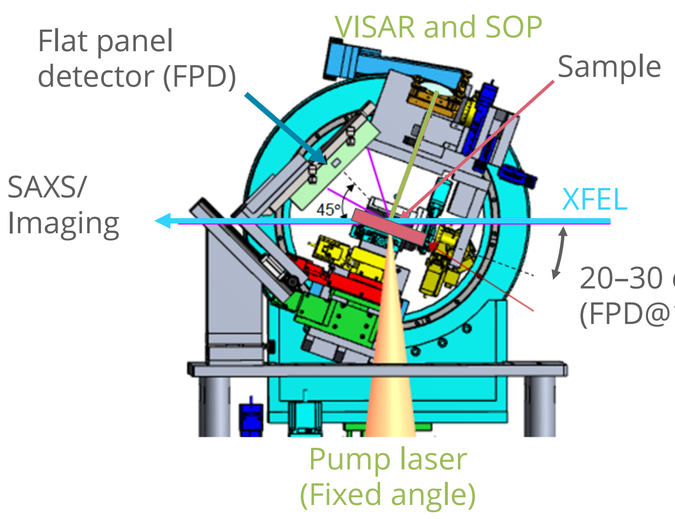
Beam parameters

Optical Laser Status	Operational (recently upgraded)
Pulse Energy (current)	> 50 J@10 ns
Wavelength	532 nm
Repetition Rate	0.1 Hz

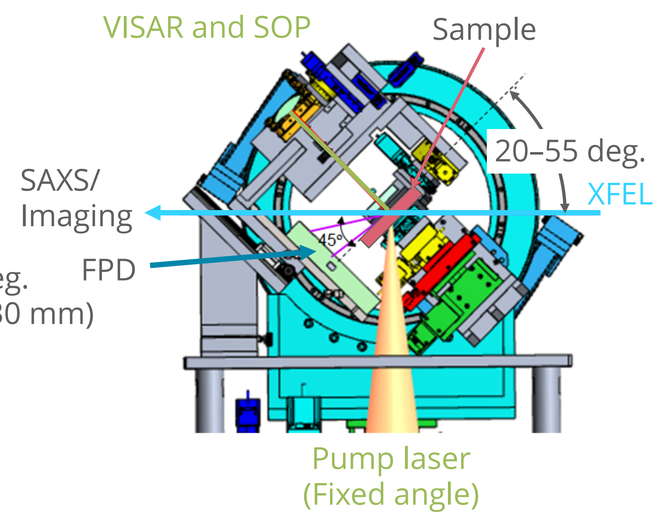
XFEL Status	Operational
Photon Energy	4 – 20 keV
Band Width, ΔE/E	~5 × 10^{-3} (pink beam) ~1 × 10^{-4} (monochromatic beam)
Pulse Energy	~ 600 μJ @10 keV
Pulse Duration	< 10 fs
Repetition Rate	30 Hz
Focusing Optics	KB Mirrors for Focus (down to sub-um)
Advanced Operation	Self-Seeding, Split-and-Delay Optics, Two Colors

Experimental configurations

Reflection geometry

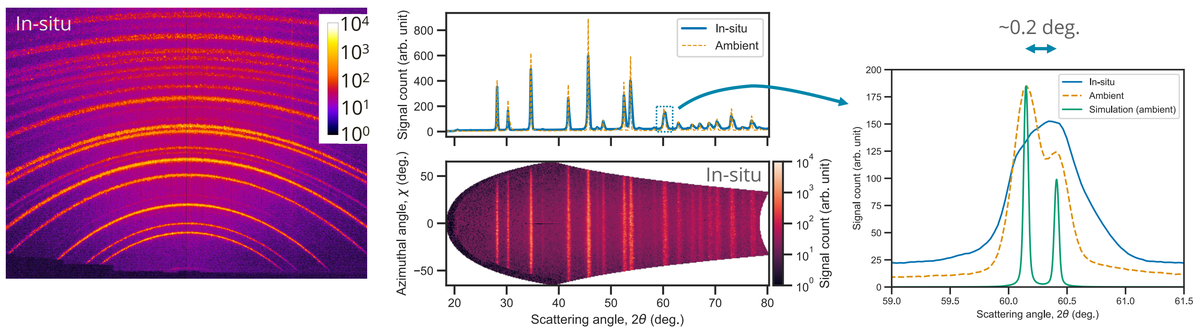


Transmission geometry

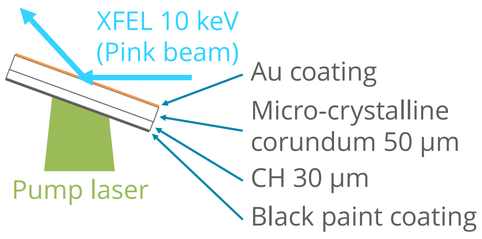


2D detectors	Flat panel detector	Dual-MPCCD
Active area	204 × 153 mm^2	50 × 50 mm^2
Pixel number	2064 × 1548	1024 × 1024
Pixel size	99 um	50 um
Distance from sample	130–270 mm (reflection) 130 mm (transmission)	~630 mm
Inclination angle	45 deg.	40 deg.
2θ	18–78 deg. (FPD@130 mm)	20–50 deg. (sliding detector position)
Synchronization	Synchronized by trigger system (start trigger)	Completely synchronized with SACLA system
DAQ	Local PC (current)	SACLA storage system
Place	In vacuum	In air
Cooling	Water	Water

Flat panel detector



FPD@130 mm



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

Next steps

- Improvements in the focus profile of the laser system
  - Diffractive optical elements (flat-top profile with D=150 μm and 250 μm)
  - Focus monitor system with high resolution (< 2 um)

  1st delivery of phase plate is scheduled in early 2020 under the SACLA Basic Development Program (PI: N. Ozaki of Osaka University).
  The system is planned to be available for users' experiments after mid-2020.
- Development of electromagnetic pulses (EMP) resistant system
  - Protection of electronic equipment from EMP due to high-energy laser-matter interactions
  - EMP monitoring system

  We have experienced malfunctions of stages and CCD cameras on >50 J shots in the first experiments after the upgrade.
- Development of user-friendly operation scheme
  - Operation system integration of optical laser and diagnostics for user experiments
- Improvements of energy stability and temporal waveform controllability of the laser system

Acknowledgment

This development was performed in collaboration with Osaka University (Profs. N. Ozaki and R. Kodama).
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