Experimental platform for combinative use of XFEL and high pulse-energy laser

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Introduction

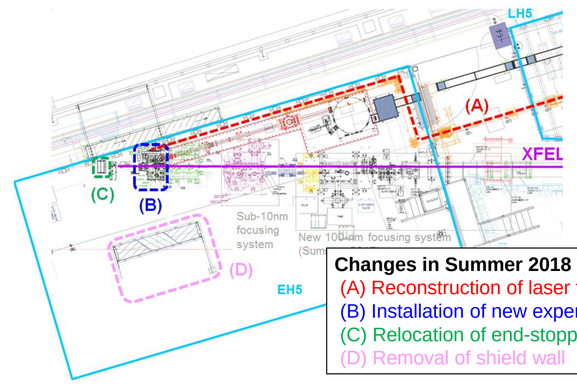
Background

- Development of experimental systems for HEDS applications has been led by Osaka University under the MEXT XFEL Program in FY2012-FY2016.
- A high pulse-energy laser (HAMAMATSU) was installed in 2015 and has been utilized for dynamical compression experiments.In 2018, the laser pulse energy is planed to increase from <20 J to ~100 J with 10 ns pulse duration at 532 nm wavelength.
- The present experimental system is compatible only up to ~10-J pulse energy (with 4 ns pulse duration) due to the limited sizes of optical components in the laser transport and the experimental chamber.
- In collaboration with Osaka University, SACLA started to upgrade the laser transport and the experimental chamber to accept higher pulse energy and enable advanced experiments

Objectives

- Enable XFEL experiments using the upgrade laser with the energy of ~100 J
- Develop user-friendly systems with standardized experimental procedures for inviting broader users in various disciplines and for improving experimental efficiency
- Exploit unique experimental capabilities

Current status of EH5
(September 2018)



Unique features

- Combination with the state-of-the-art K-B X-ray focusing system
  - Switchable between 1D-focusing (for diffraction) and 2D-focusing (for imaging, SAXS) modes
  - Tight focus down to 0.2 μm x 0.3 μm for imaging and local probe
- Fixed beam path of the laser to sample: from bottom to top
  - The angle between laser and X-rays is 90 degrees
  - This configuration is fixed due to the space constraint with the large sizes of optical components for laser
- Large flexibility of sample orientation to X-rays
  - The sample orientation can be changed while keeping VISAR/SOP diagnostic capabilities

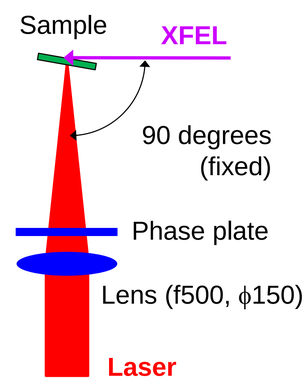
Beam parameters

XFEL

- SACLA BL3
- Focusing 2-D focus: 300 nm (V) x 200 nm (H) (min)
  1-D focus: 300 nm (min) x 500 μm
  Larger focal spot up to ~several μm is also available

LASER

- Parameters
  - Pulse energy: ~100 J (max)
  - Wavelength: 532 nm
  - Pulse duration: 3~10 ns (pulse shaping)
  - Repetition rate: 0.1 Hz
- Optical geometry
  - The laser beam is from the bottom to the top
  - The angle between laser and x-rays is fixed to 90 degrees
  - Lens: f = 500 mm
  - A phase plate will be installed to make a spot with a diameter of 200 μm (current design)

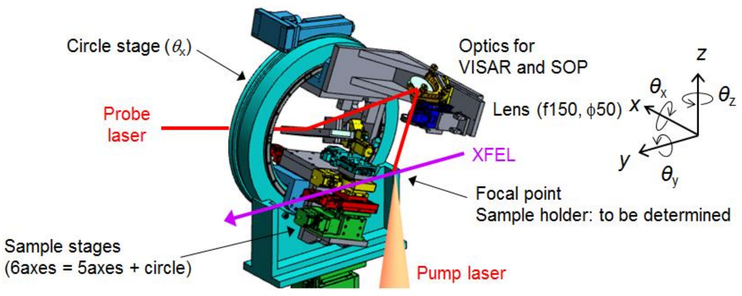


Configuration of sample stages and VISAR

Schematic

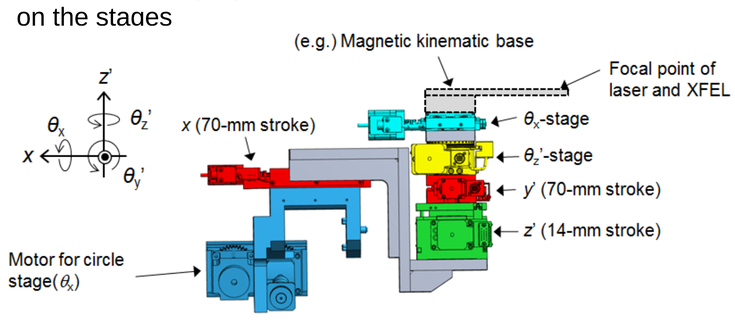
The sample stages and the VISAR stage are mounted on a single circle stage (θ_x)

- Rotation angles of sample and VISAR are independently controlled
- Typical experimental configurations: reflection and transmission geometries



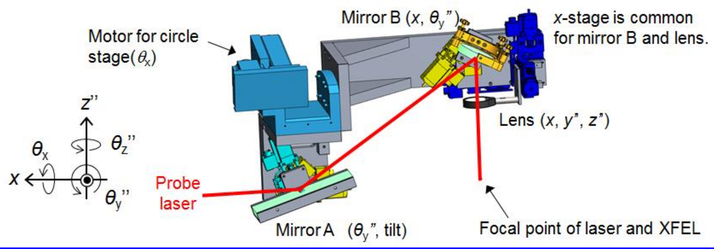
Sample stages

- The sample stages on the θ_x-circle has 5 axes (x, y', z', θ_y', θ_z'), so the sample can be aligned with the 6 axes stages in total
- Default sample holder on the stages will be designed by facility after this review
- Users can also prepare their own holders that can be mounted on the stages



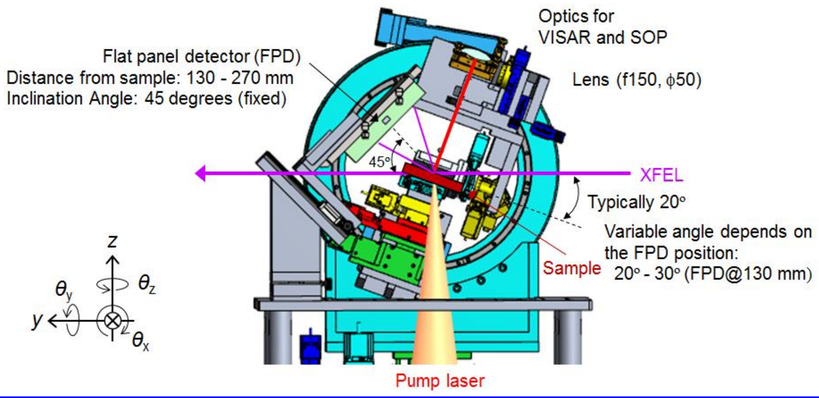
VISAR optics

- The probe beam to/from the final optics (mirror B and lens on the θ_x-circle) is reflected by the mirror A at the center of the θ_x-circle
- Since the mirror A is also mounted on the θ_x-circle with the final optics, the beam path of the probe laser before/after the θ_x-circle is unchanged even when the VISAR angle is changed
- A Dove prism is used for compensating image rotation on the streak camera
- Detailed specs of VISAR (resolution etc.) will be determined

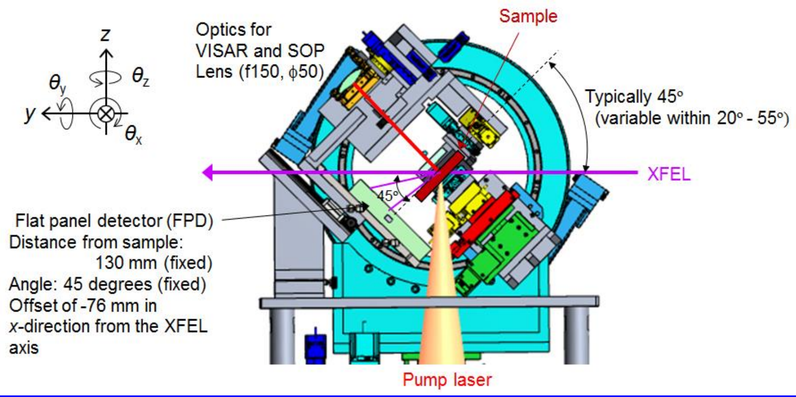


Experimental configuration for XRD

Reflection geometry



Transmission geometry

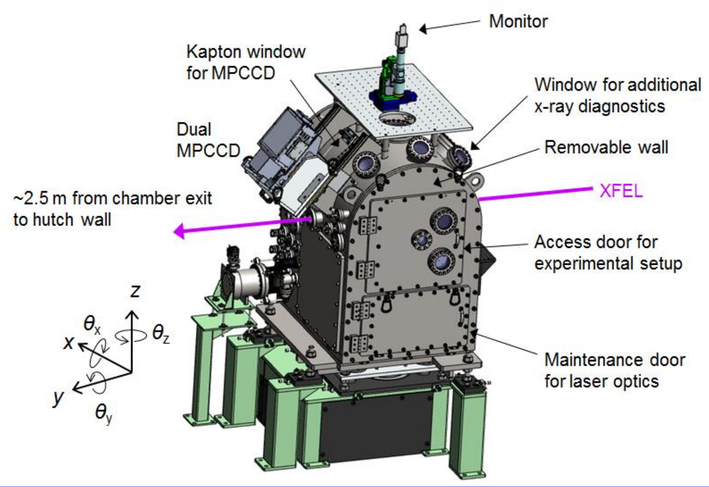


2D detectors

Main detector: Flat panel detector
High-resolution detector: Dual-MPCCD

	Flat panel detector (FPD)	Dual-MPCCD
Active area	204 x153 mm²	50 x 50 mm²
Pixel number	2064 x 1548	1024 x 1024
Pixel size	99 μm	50 μm
Synchronization	Synchronized by trigger system (start trigger)	Completely synchronized with SACLA system
DAQ	Local PC	SACLA storage system
Place	In vacuum	In air
Cooling	Water	Water

Experimental Chamber



Summary

Experimental platform for combinative use of XFEL and high pulse-energy laser is under development.

- Upgrade of the laser up to 100 J
- New experimental chamber
- New configurations of diagnostics

Commissioning will be performed from this Autumn.

User operation will start from early 2019.

We thank reviewers for useful discussion regarding the design of the experimental platform.