SACLA Users' Meeting 2024

Overview of SACLA Beamlines (BL1, 2, 3)

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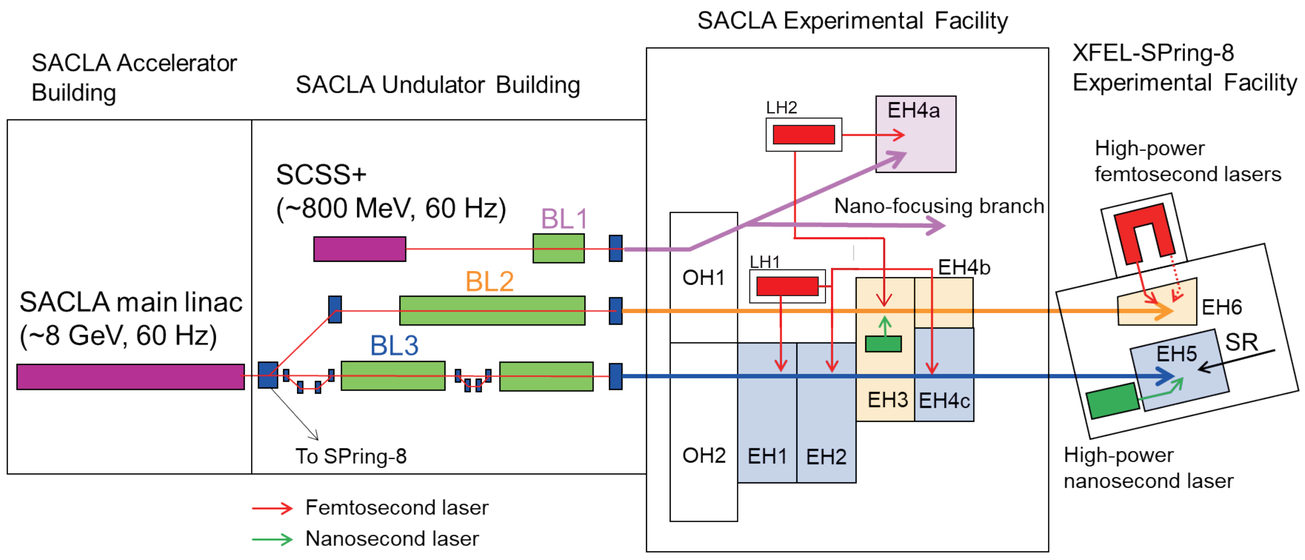
on behalf of SACLA beamline group

Schematic layout of SACLA beamlines

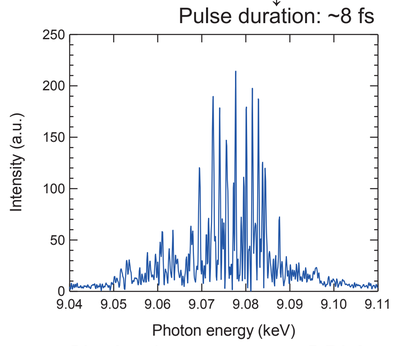


Three BLs are operated under different machine conditions (e^- beam energy, photon energy, etc.), simultaneously.
From the SACLA main linac, high-quality e^- bunches are delivered to the SPring-8 storage ring (1-2 shots/min in top-up mode).

Typical performance

		BL1 (SX)	BL2 (HX)	BL3 (HX)
Photon energy		40 ~ 150 eV	4 ~ 22 keV	4 ~ 22 keV
Pulse duration		~30 fs (fixed)	<10 fs (fixed)	<10 fs (fixed)
Pink beam	Bandwidth (ΔE/E)	~0.01	~3x10^{-3}	~3x10^{-3}
	Pulse energy	~90 μJ @100 eV	~500 μJ @10 keV	~700 μJ (up to 900 μJ) @10 keV
Monochromatic beam (Si 111 DCM/DCCM)	Bandwidth (ΔE/E)	-	1.3x10^{-4}	1.3x10^{-4}
	Pulse energy	-	~10 μJ @10 keV	~10–50 μJ @10 keV
Monochromatic beam (DCCM option)	Bandwidth (ΔE/E)	-	0.05–1.3×10^{-4} @10 keV (in air)	0.05–3.0x10^{-4} @10 keV
	Pulse energy	-	depends on b.w.	depends on b.w.
Repetition rate		60 Hz	30 / 60 Hz	30 / 60 Hz
Advanced operation modes		-	Two color (SASE+SASE w/o delay)	Two color (SASE+SASE / SASE+mono) Self-seeding / SDO
Tailor-made XFEL generation		○	○	○

Spike width: ~400 meV
↓
Pulse duration: ~8 fs



Single-shot spectrum @BL3

Y. Inubushi *et al.*, *Phys. Rev. Lett.* **109**, 144801 (2012);
Appl. Sci. **7**, 584 (2017).

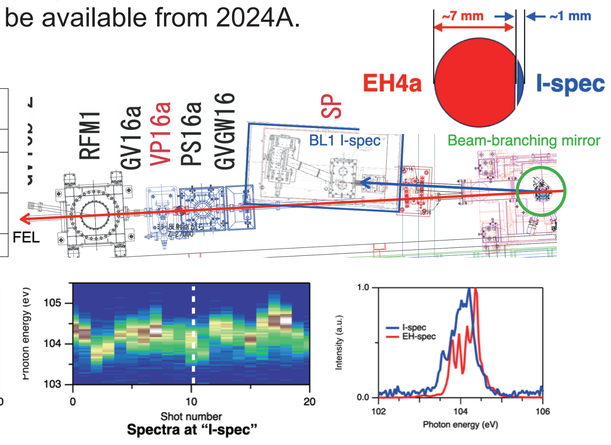
Major updates

'In-line' spectrometer at BL1

An in-line spectrometer (I-Spec) has been installed at BL1.
The new spectrometer will be available from 2024A.

Specifications

Beam branching method	Wavefront splitting (same as TM)
Grating	VLS (1200 mm^{-1})
Detector	MCP screen + VIS CCD
Photon energy range	1st: ~20 eV ~ >150 eV 3rd/5th: available
Calibration	Al L edge



Comparison of spectra measured at EH4a and by I-Spec.

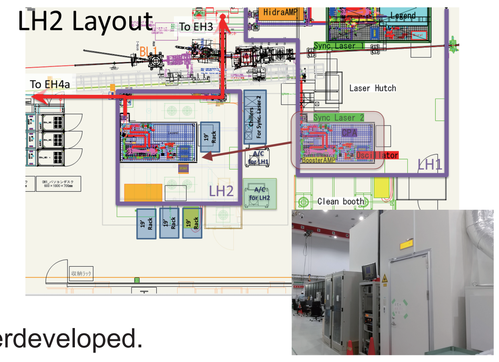
New Sync Laser Hutch 'LH2'

A new fs-laser hutch (LH2) has been constructed, and Sync Laser 2 has been relocated at LH2.

This upgrade enables:

(1) independent maintainance of Sync Laser 1 & 2

(2) the use of fs laser at EH3 (BL2) under limited conditions, e.g., only OPA (<1 mJ), no timing tool



A non-destructive timing tool is underdeveloped.

Experimental stations

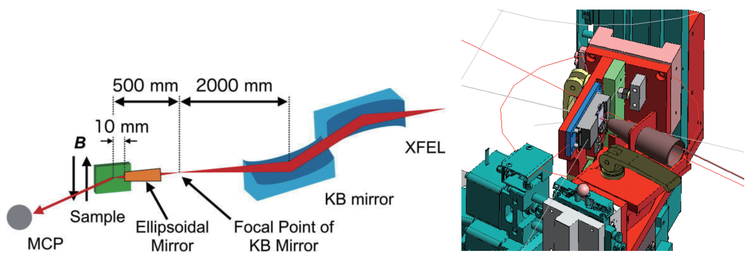
BL1

S. Owada *et al.*, *J. Synchrotron Rad.* **25**, 282 (2018).

EH4a

- **KB mirrors (~5 μm FWHM) + fs optical lasers (+ ellipsoidal / Wolter mirror(s) (sub μm))**

→ Mainly AMO, MAT & XNO experiments are carried out using a dedicated experimental chamber owned by users.



S. Owada *et al.*, *J. Synchrotron Rad.* **25**, 68 (2018);
J. Synchrotron Rad. **26**, 887 (2019).
Y. Kubota *et al.*, *Appl. Phys. Lett.* **117**, 042405 (2020).

→H. Motoyama' s talk

Nano-focusing branch

- **Two-stage focusing system (~20 nm FWHM)** *underdeveloped*

H. Motoyama, H. Mimura, *J. Phys. B Atom. Mol. Opt. Phys.* **48**, 234002 (2015).

BL2

EH3

- **KB mirrors (~1 μm FWHM) + ns or fs optical lasers**

→ Mainly Biology experiments (SFX etc.) are carried out using standard experimental platforms (DAPHNIS etc.)

K. Tono *et al.*, *J. Synchrotron Rad.* **22**, 532 (2015).

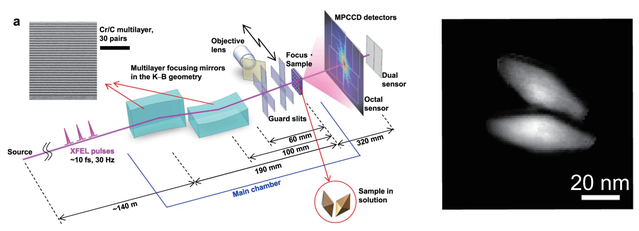
→S. Iwata' s talk

EH4b

- **Long sample(@EH3)-to-detector distance (<10 m)**

- **MAXIC-S (~100 nm FWHM @4 keV)**

→ Dedicated for CDI at 4 keV for biomolecules & nanoparticles



H. Yumoto *et al.*, *Nat. Commun.* **13**, 5300 (2022).

→A. Suzuki' s talk

EH6

- **CRLs (>2 μm FWHM) + High-power fs optical laser**

→ Dedicated for HED experiments

BL3

T. Ishikawa *et al.*, *J. Synchrotron Rad.* **26**, 333 (2019).
K. Tono *et al.*, *New J. Phys.* **12**, 083035 (2013).

EH2

- **CRLs (>2 μm FWHM) + fs optical lasers**

→ Mainly fs-P&P measurements in various fields are carried out using advanced P&P instruments (timing monitor, DCCM etc.).

T. Katayama *et al.*, *Struct. Dyn.* **3**, 034301 (2016);
J. Synchrotron Rad. **26**, 333 (2019).

EH4c

- **KB mirrors (~1 μm FWHM) + fs optical laser (λ = 800 nm)**

H. Yumoto *et al.*, *Nat. Photon.* **7**, 43 (2013).

→ Mainly XNO & HED experiments are carried out using advanced operation modes (two-color, self-seed, SDO etc).

- **Advanced KB mirrors (sub 10 nm)**

J. Yamada *et al.*, *Nat. Photon.* (2024). Accepted.

→J. Yamada' s talk

EH5

- **100exa KB mirrors (~100 nm FWHM)**

H. Yumoto *et al.*, *Appl. Sci.* **10**, 2611 (2020).

→ Mainly XNO experiments are carried out using ultimately intense (~10^{20} W/cm^2) XFELs.

→Z. Abhari' s talk

- **KB mirrors (>500 nm FWHM) + High-power nanosecond laser**

→ Dedicated for HED experiments using a standard platform.

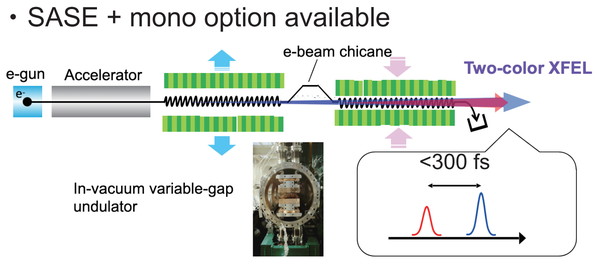
Y. Inubushi *et al.*, *Appl. Sci.* **10**, 2224 (2020).

→N. Ozaki' s talk

Advanced capabilities at BL3

Two-color XFEL (+ time delay)

- Eenergy separation: <30%
- Delay time: <300 fs @8 GeV
- Pulse energy: ~200 μJ total (balanced case)
- SASE + mono option available

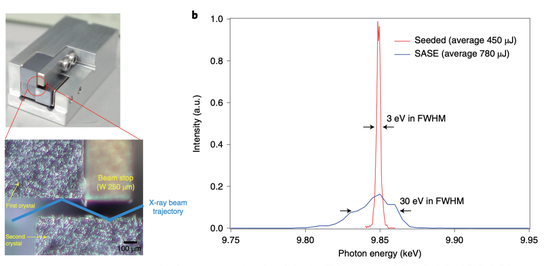


T. Hara *et al.*, *Nat. Commun* **4**, 2919 (2013).
H. Yoneda *et al.*, *Nature* **524**, 446 (2015).
I. Inoue *et al.*, *Phys. Rev. Lett.* **126**, 117403 (2021).
M. D. Doyle *et al.*, *Optica* **10**, 513 (2023).

XFEL-pump–XFEL probe

Reflection self-seeded XFEL

- Bandwidth Δ*E*/*E*: ~3x10^{-4}
- Photon energy: 8 ~ 12 keV
- Pulse energy: ~200 μJ w/o DCM

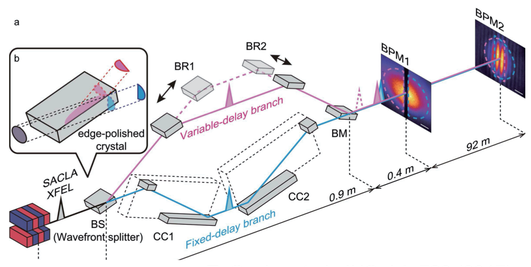


I. Inoue *et al.*, *Nat. Photon* **13**, 319 (2019).
T. Osaka *et al.*, *J. Synchrotron Rad.* **26**, 1496 (2019).
S. Matsumura *et al.*, *Opt. Express* **28**, 25706 (2020).
I. Inoue *et al.*, *Phys. Rev. Lett.* **127**, 163903 (2021).

X-ray nonlinear spectroscopy

Split-and-Delay Optics (SDO)

- Delay time: <200 ps @10 keV
- Photon energy: 5 ~ 15 keV
- Pulse energy: ~4 μJ total (self-seeded)

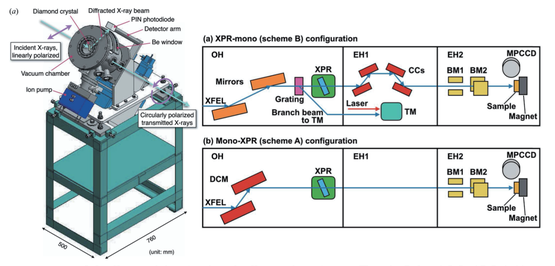


T. Osaka *et al.*, *IUCrJ* **4**, 728 (2017).
Y. Shinohara *et al.*, *Nat. Commun.* **11**, 6213 (2020).
T. Osaka *et al.*, *Phys. Rev. Research* **4**, L012035 (2022).

Studies of spontaneous fluctuation

Phase retarder (+ timing monitor)

- Photon energy: 5 ~ 16 keV
- Degree of polarization: circular ~97%
  vertical ~67%



M. Suzuki *et al.*, *J. Synchrotron Rad.* **21**, 466 (2014).
Y. Kubota *et al.*, *J. Synchrotron Rad.* **26**, 1139 (2019).
K. Yamamoto *et al.*, *New J. Phys.* **21**, 123010 (2019).

TR studies of magnetism