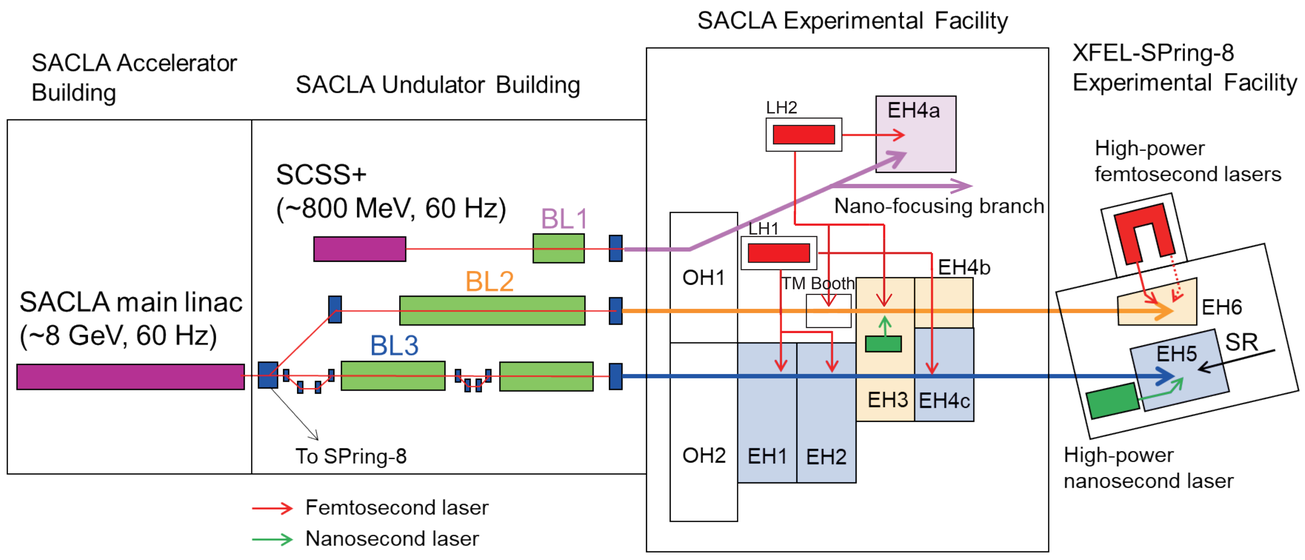
SACLA Users' Meeting 2025

Overview of SACLA Beamlines (BL1, 2, 3)

Taito Osaka, Gota Yamaguchi, Yuichi Inubushi, Tadashi Togashi
on behalf of SACLA beamline group

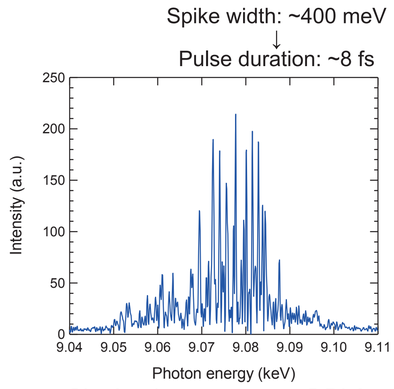
Schematic layout of SACLA beamlines



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		○	○	○



Single-shot spectrum @BL3

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

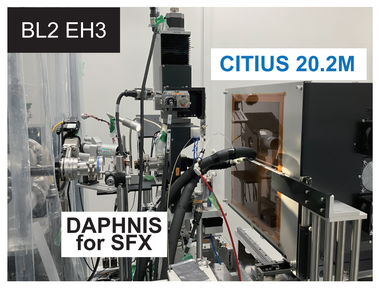
Major Updates

CITIUS 20.2M Commissioning Started

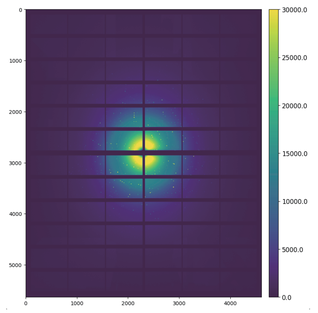
Commissioning of **CITIUS 20.2M** detector has been started in FY2024, targetting SFX experiments at EH3 of BL2.

→Poster #7

Commissioning & Pilot experiments: 2025A & 2025B
→B. Iversen' s talk
Opened for users: 2026A~ (?)



A photo of the setup



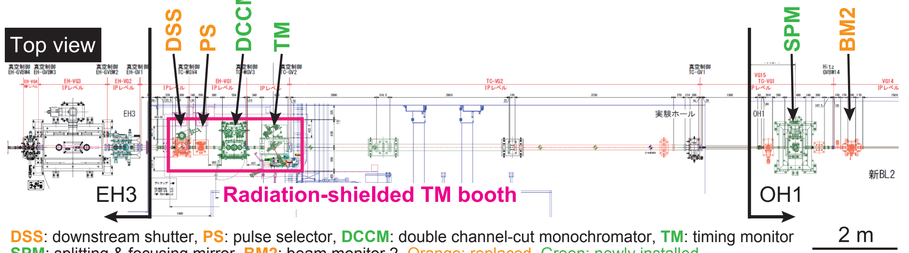
A diffraction pattern from lysozyme measured at EH3 of BL2

New TM Booth for P&P Experiments at BL2

A new **TM (timing monitor) booth** will be constructed at BL2, enabling fs-resolution pump–probe experiments at BL2 with

(1) non-destructive timing monitor w/ wavefront splitting & focusing mirror
(2) dobule channel-cut monochromator

Installation: 2025B, Commissioning & Pilot experiments: 2026A
Opened for users: 2026B~



DSS: downstream shutter, **PS**: pulse selector, **DCCM**: double channel-cut monochromator, **TM**: timing monitor
SPM: splitting & focusing mirror, **BM2**: beam monitor 2. Orange: replaced, Green: newly installed.

Experimental stations

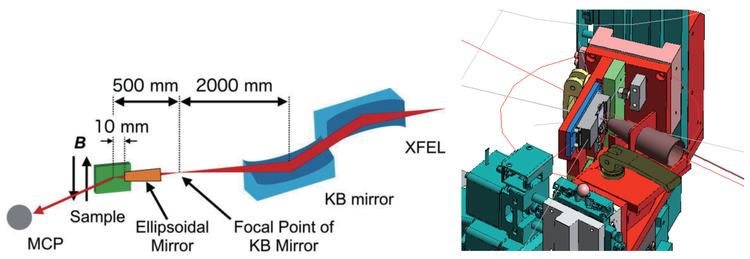
BL1

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).

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.)

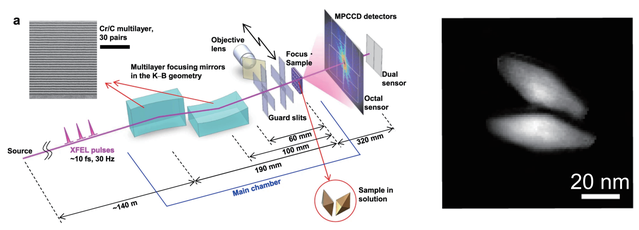
K. Tono *et al.*, *J. Synchrotron Rad.* **22**, 532 (2015).
→E. Nango' s talk

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).

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.* **18**, 685 (2024).

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.

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

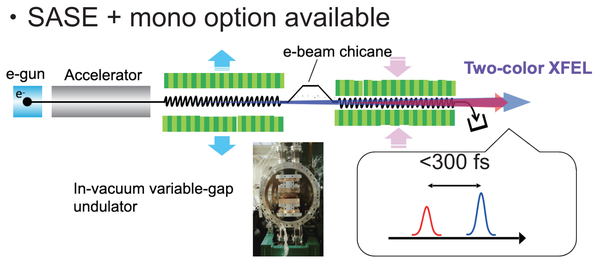
→ Dedicated for HED experiments using a standard platform.

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

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

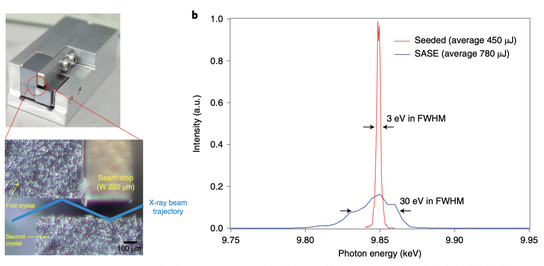


T. Hara *et al.*, *Nat. Commun* **4**, 2919 (2013).
H. Yoneda *et al.*, *Nature* **524**, 446 (2015).
I. Inoue *et al.*, *Phys. Rev. Lett.* **126**, 117403 (2021).
M. D. Doyle *et al.*, *Optica* **10**, 513 (2023).

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

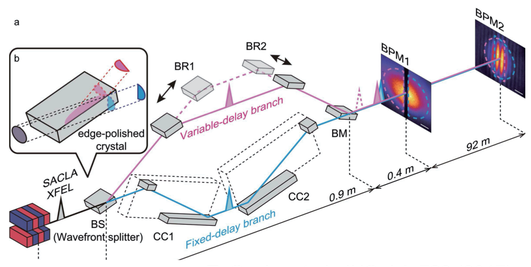


I. Inoue *et al.*, *Nat. Photon* **13**, 319 (2019).
T. Osaka *et al.*, *J. Synchrotron Rad.* **26**, 1496 (2019).
S. Matsumura *et al.*, *Opt. Express* **28**, 25706 (2020).
I. Inoue *et al.*, *Phys. Rev. Lett.* **127**, 163903 (2021).

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)

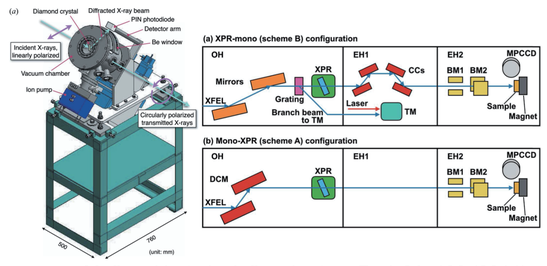


T. Osaka *et al.*, *IUCrJ* **4**, 728 (2017).
Y. Shinohara *et al.*, *Nat. Commun.* **11**, 6213 (2020).
T. Osaka *et al.*, *Phys. Rev. Research* **4**, L012035 (2022).

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