SACLA Users' Meeting 2022

Overview of SACLA Beamlines (BL1, 2, 3)

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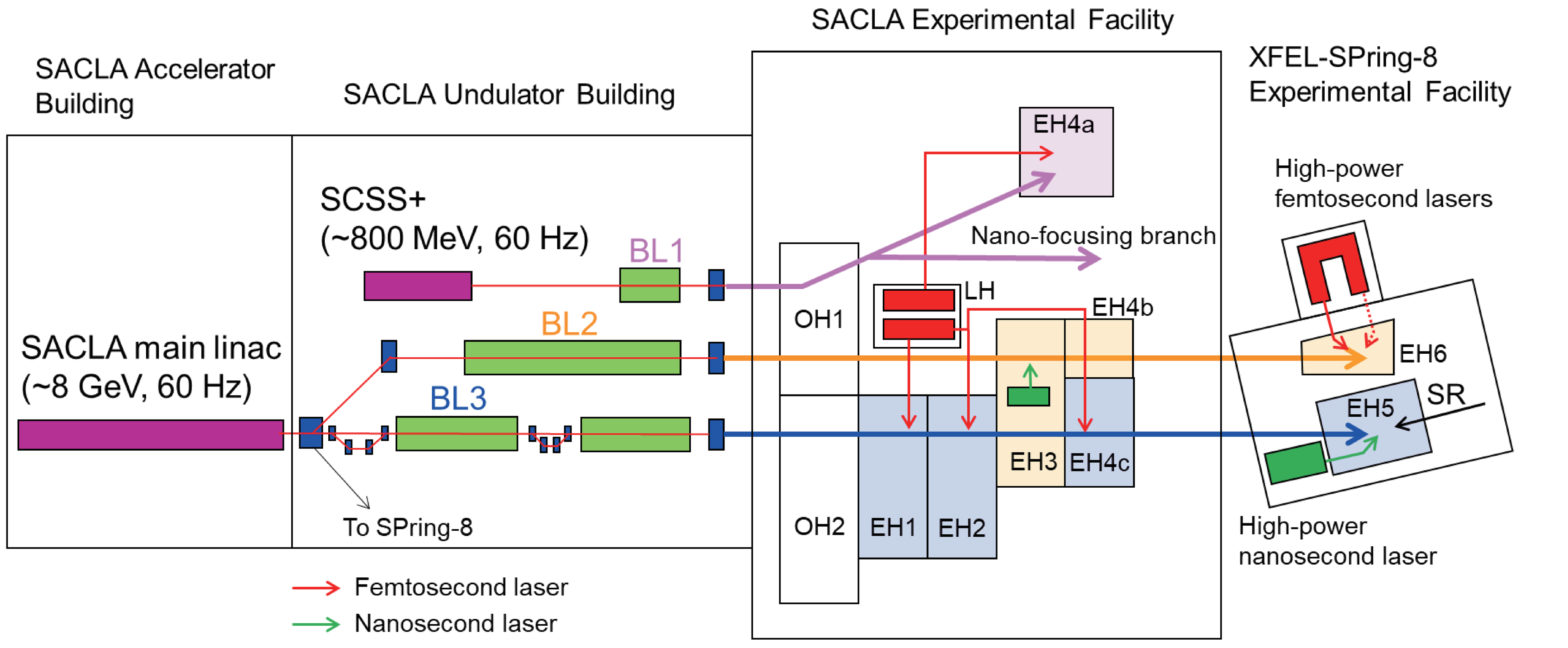
on behalf of SACLA beamline group

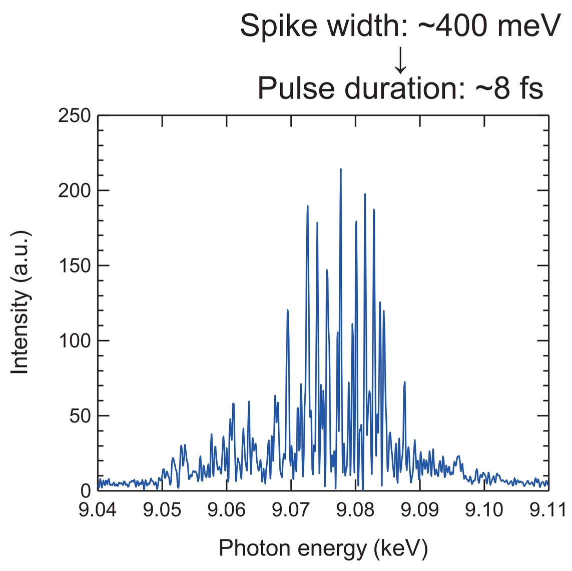
Schematic layout of SACLA beamlines



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 ~ 15 keV	4 ~ 20 keV
Pulse duration		~30 fs	<10 fs	<10 fs
Pulse energy	Bandwidth (ΔE/E)	~0.01	$\sim 5\times10^{-3}$	$\sim 5\times10^{-3}$
Pink beam	Pulse energy	~90 μJ @100 eV	~500 μJ @10 keV	~600 μJ @10 keV
	Photon number (photons/pulse)	$>5\times10^{12}$ @100 eV	$>3\times10^{11}$ @10 keV	$>3\times10^{11}$ @10 keV
	Peak power	>100 MW	>50 GW	>60 GW
Monochromatic beam	Bndwidth (ΔE/E)	-	1.3×10^{-4} (Si 111 DCM)	1.3×10^{-4} (Si 111 DCM)
Repetition rate		60 Hz	30 Hz	30 Hz



Single-shot spectrum @BL3

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

Guidance for remote experiments

http://sacla.xfel.jp/?p=14064&lang=en

1. In case users are able to come on-site

All users who come to SACLA should follow **the guideline "Prevention measures against COVID-19 at SPring-8/SACLA"**. To reduce the risk of COVID-19 infection, we strongly request users to minimize the number of on-site participants. The other group members should join in the experiment remotely by using tools below, for example.

- **Web conference tools**
  Remote communications using Zoom, Microsoft teams, Google Meet, etc.
- **Documents and data sharing**
  Access to Google Docs, Sheet, and Drive from operation consoles at experimental stations
  Experimental Data Transfer Service
- **Fast X server**[1)]
  Efficient remote data analysis using FastX for software on the SACLA High Performance Computing (HPC) system
- **Online storage server (Nextcloud)**[1)]

[1)] **Please contact the beamline staff well in advance if you like to use those tools.**

2. In case users are not able to come on-site

Experiments may be carried out by the facility staff even in case no users are able to be on-site. Please discuss the feasibility of mail-in-type experiments with the point of contact at SACLA. We anticipate carrying out such experiments on behalf of the users by using standard instruments of SACLA. Accordingly, some types of experiments or operations are impossible to conduct, for example (but not limited to):

- **Experiments using equipment owned by users.**
- **Experiments relying on unestablished methods or complex procedures.**
- **Sample preparation**
- **24-hour on-site operations**

The experimental plans should be finalized at least 6 weeks before the beamtime.
If you have to cancel your experiments, please inform the Users Office. This notification should be made at least one month before the beamtime.

3. Remote experiments (future plan)

We are developing a remote-operation system that allows users to control experimental instruments from outside. The beamline staff will work on-site to support remote experiments. First pilot experiments are expected to be carried out using high-power laser system in FY2021.

For users visiting from abroad

As of February 8, 2021, the Japanese government restricts the entry from abroad.
The latest information of entry restrictions can be found from the links on "**Prevention measures against COVID-19 at SPring-8/SACLA**".
Please note that visitors may be required a self-quarantine for a while even after the restrictions are lifted.

Experimental stations

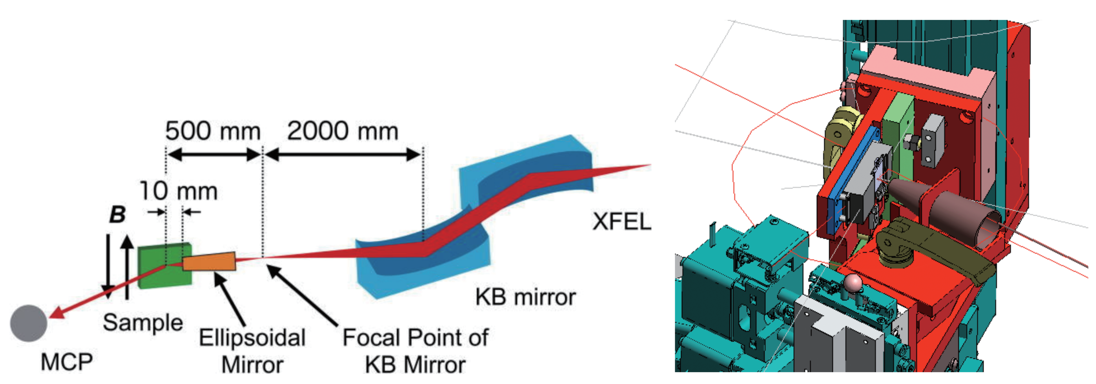
BL1

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

EH4a

- **KB mirrors (~5 μm FWHM) + Femtosecond lasers (+ ellipsoidal mirror (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) + Nanosecond optical lasers**

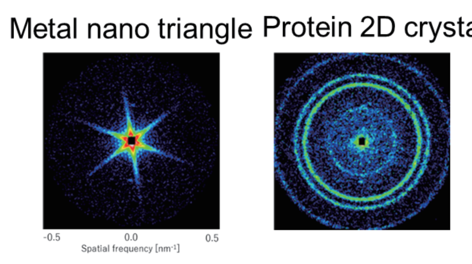
→ Mainly Biology experiments (SFX etc.) are carried out using standard experimental platforms (DAPHNIS etc.)

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

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



EH6

- **CRLs (>2 μm FWHM) + High-power femtosecond 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) + Femtosecond 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) + Femtosecond 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)** *underdeveloped*

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 ($\sim10^{20}$ W/cm^2) XFELs.

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

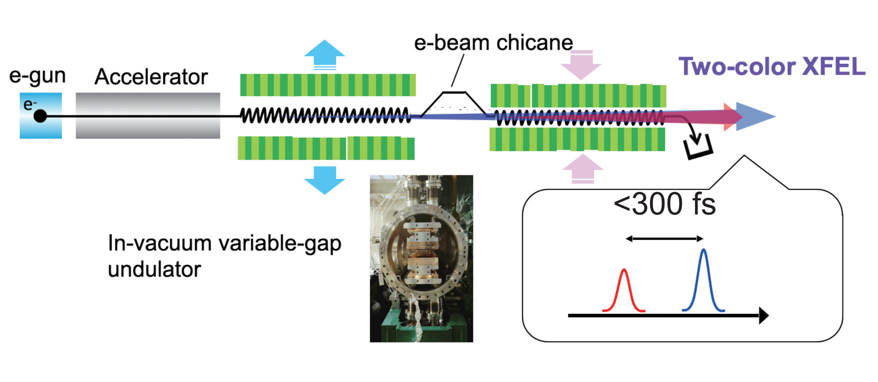
→ Dedicated for HED experiments using a standard platform.

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

Advanced capabilities at BL3

Two-color XFEL (+ time delay)

- Energy separation: <30%
- Delay time: <300 fs @8 GeV
- Pulse energy: ~200 μJ total (balanced case)

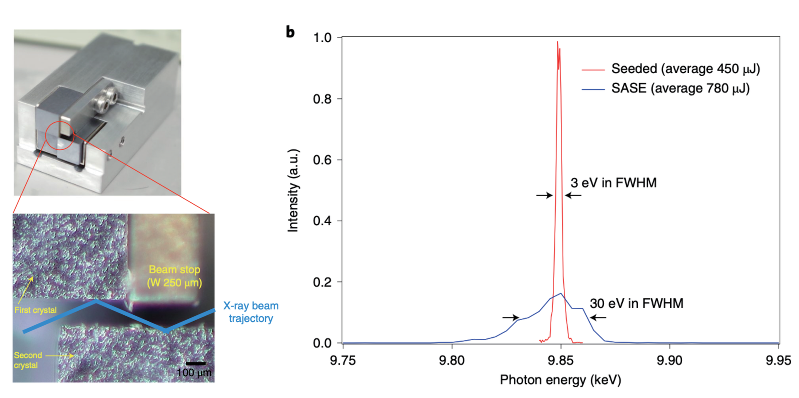


T. Hara *et al.*, *Nat. Commun* **4**, 2919 (2013).
H. Yoneda *et al.*, *Nature* **524**, 446 (2015).
I. Inoue *et al.*, *Proc. Natl. Acad. Sci. USA* **113**, 1492 (2016).

XFEL-pump–XFEL probe

Reflection self-seeded XFEL

- Bandwidth $\Delta E/E$: $\sim3\times10^{-4}$
- Photon energy: 8 ~ 12 keV
- Pulse energy: ~200 μJ w/o DCM

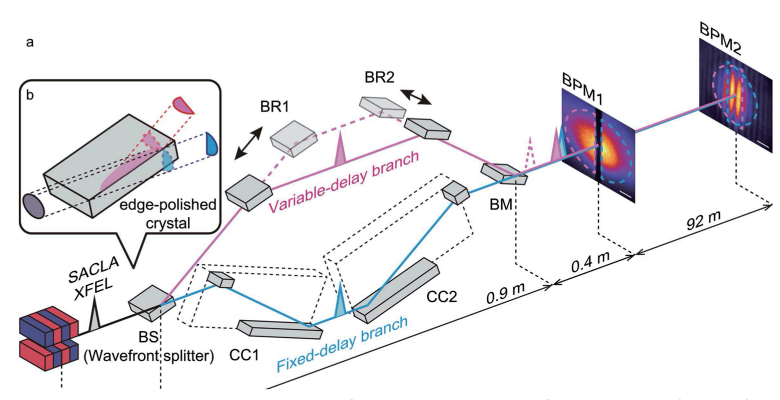


I. Inoue *et al.*, *Nat. Photon* **13**, 319 (2019).
T. Osaka *et al.*, *J. Synchrotron Rad.* **26**, 1496 (2019).
S. Matsumura *et al.*, *Opt. Express* **28**, 25706 (2020).

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)

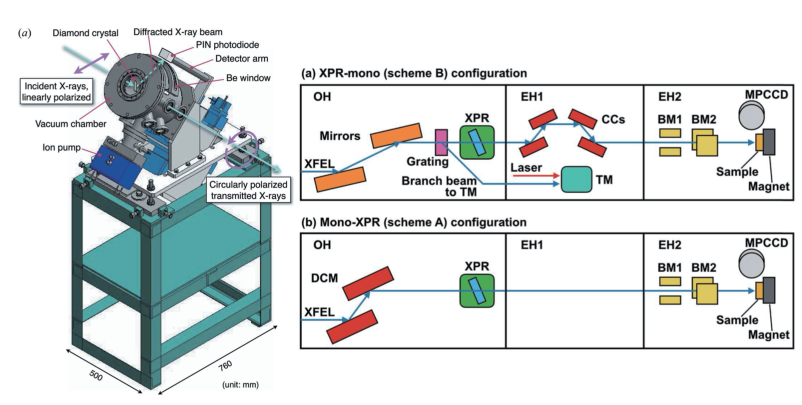


T. Osaka *et al.*, *IUCrJ* **4**, 728 (2017).
T. Hirano *et al.*, *J. Synchrotron Rad.* **25**, 20 (2018).
Y. Shinohara *et al.*, *Nat. Commun.* **11**, 6213 (2020).

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