SACLA
Beam Performance

In April 2015, SACLA launched routine user operations for two XFEL beamlines, BL2 and BL3. Later that year during the two-month summer shutdown, the large-scale transformation of BL1 from a short-pulsed spontaneous X-ray source to a new soft X-ray FEL source was completed and beam commissioning of BL1 is now underway. Figure 1 shows schematic drawings of the current SACLA facility. Substantial improvements to the tuning and preparation procedures have increased the total public user time available to about 4000 hours, corresponding to 60% of the total operations time. Further improvements are expected to increase availability to 70%. Machine enhancements enabled the generation of a laser peak intensity of 0.6 mJ/pulse at 10 keV and an average trip interval of 1 hour with a regular repetition rate of 30 Hz.

1) New BL2 beamline open for user experiments

The construction of BL2 was completed during the 2014 summer shutdown, with the first lasing obtained in October 2014. Subsequent beam tuning activities improved the efficiency, enabling an XFEL intensity greater than 100 μJ/pulse and the availability of BL2 for user experiments. User operations at BL2 began in April 2015 in a DC mode without pulse-by-pulse XFEL switching, where users can select either BL2 or BL3 according to the needs of their experiments.

In January 2015, testing began for multi-beamline operations combining pulse-by-pulse switching with time-interleaved multi-energy acceleration [1,2] in order to more fully utilize the capabilities of SACLA. In July 2015, stable lasing was successfully achieved using multi-beamline operations with pulse energies around 100–200 μJ, providing broad tunability of the laser wavelengths between the beamlines. This multi-beamline operation capability has been available for user experiments since autumn 2015. Figure 2 shows the stability of the laser pulse energies achieved at the two beamlines during multi-beamline operations.

Note that the peak current is currently limited to about 2 kA due to the CSR effects at the doglegged beam transport to BL2. Modifications of the beam transport, including the pulse-switching system, are under investigation, with a goal of achieving multi-beamline operations that provide a regular peak current greater than 10 kA.

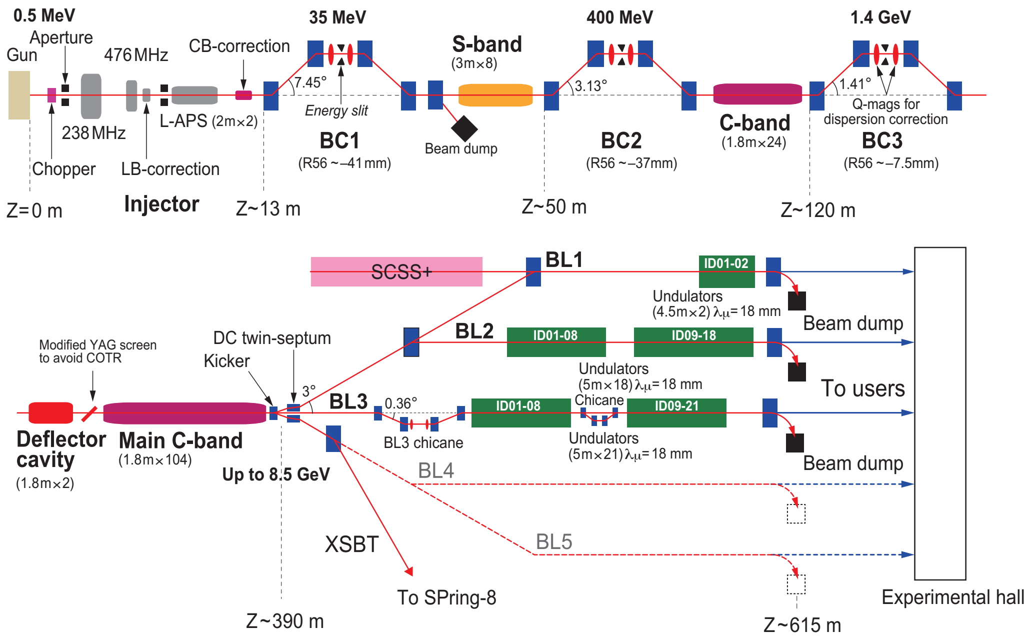

Fig. 1. Schematic drawings of the current SACLA facility. Two beamlines, BL2 and BL3, are now available for user experiments; a third beamline, BL1, that will provide a soft X-ray FEL is currently under commissioning.

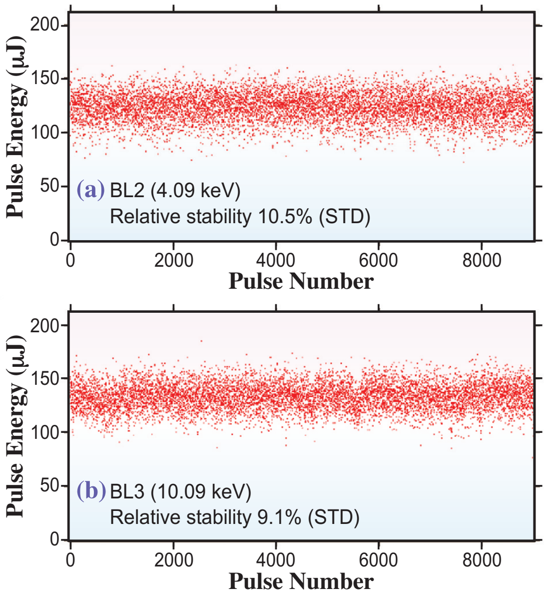

Fig. 2. Stability of the laser pulse energy for **(a)** BL2 and **(b)** BL3 during the multi-beamline operation. Each red dot represents the result for a single shot. The electron beam energies were 6.3 GeV for BL2 and 7.8 GeV for BL3. The undulator K-values were 2.85 for BL2 and 2.1 for BL3.

2) Successful upgrading of the existing beamline, BL1

Substantial renovation of BL1 was completed during the summer shutdown of 2015. Figure 3 shows the linear accelerator system dedicated to the BL1 beamline. This dedicated accelerator was constructed mainly by relocating the SCSS test accelerator [3] and adding two C-band acceleration units to the accelerator. Three in-vacuum undulators, each of which has a period of 18 mm, were installed in the BL1 beamline. The X-ray beamline components, including equipment at the frond-end and optical components in the optics hutch, were also greatly enhanced to accommodate a soft X-ray FEL.

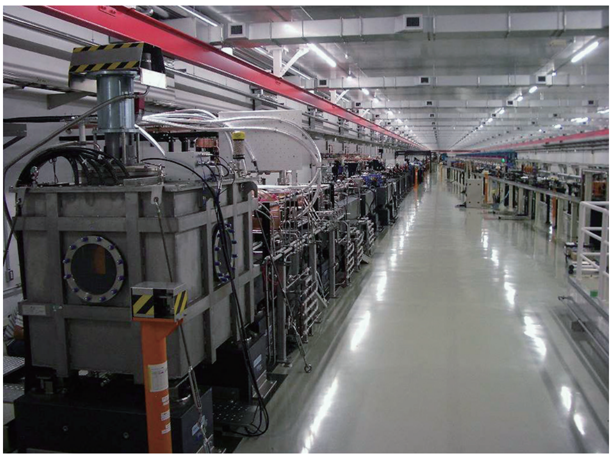

Fig. 3. Linear accelerator system dedicated to the BL1 beamline. This picture was taken from the electron gun side (i.e., the uppermost-stream side of BL1).

The two electron drivers, i.e., the dedicated accelerator and the SACLA linear accelerator, are switchable. The operation of BL1 is independent of that of SACLA when the dedicated accelerator is selected. Enabling this flexibility required modification to the beam transport channels and the safety and machine interlock systems.

Beam commissioning began on September 14, 2015, and the first lasing was obtained at a wavelength of 30 nm a few weeks later on October 7 [4]. The upgraded BL1 beamline passed its radiation inspection the following November. Beam tuning progressed well and the SASE pulse energy reached a few μJ by the end of 2015. Figure 4 shows the laser profile measured in the optics hutch. After additional beam tuning, user experiments at BL1 will commence in 2016.

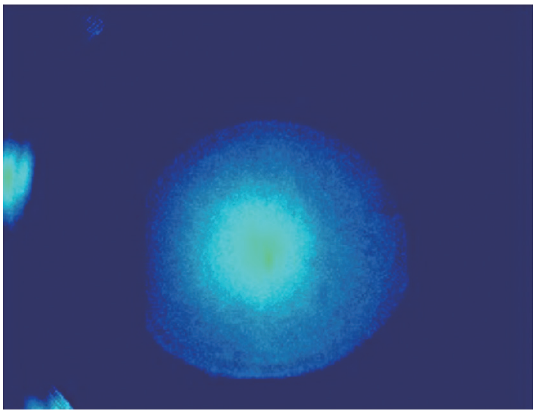

Fig. 4. Laser profile measured by the MCP (microchannel plate) in the BL1 optics hutch.

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References

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[3] T. Shintake *et al*.: Nature Photonics **2** (2008) 555.
[4] T. Sakurai *et al*.: Proc. 12th Annual Meeting of Particle Accelerator Society of Japan, Tsuruga, Japan (2015) 256.