SACLA
Beam Performance

SACLA maintained smooth operations throughout 2013. Annual public user time increased 10% following advances in optimization of the tuning and preparation procedures. Significant improvements in laser performance produced gains both in intensity and repetition rate.

1) Intensity enhancement

Figure 1 shows the progress of laser intensity since the first lasing. The laser pulse energy, which was around 300 μJ at the end of 2012, increased to 400 μJ before the summer shutdown and up to about 500 μJ in autumn 2013 due to diligent tuning efforts. Since then, a highly intense laser with pulse energy around 500 μJ has been routinely available for user experiments as shown in Fig. 2. The measured gain curve shows that this greater intensity comes from the enhanced amplification in the latter half of the undulator beamline. The performance likely results from the following cause. By optimizing the parameters in the multi-stage bunch compressor, a second broader peak is formed in addition to the main sharp peak in the beam current profile. The sharp peak with a high current quickly initiates the lasing and soon reaches the state of power saturation. The broader peak with a low current slowly starts lasing and contributes to increasing amplification in the second half of the undulator beamline.

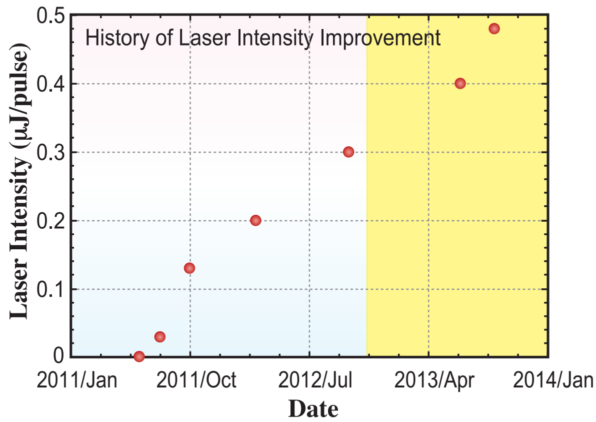

Fig. 1. Progress of SASE XFEL laser intensity from the first lasing in June 2011. The yellow area shows the part of 2013.

2) Beam repetition rate increase

Figure 3 shows the change in repetition rate during 2013. The repetition rate began at 10 pps at the beginning of 2013 and increased to 30 pps by the middle of November. To reduce the RF trip rate, we made two improvements. The first was reducing the rate of electric discharge in the RF structures by RF conditioning. The second was modifying the interlock of the Thyratron (High voltage switch) so as to ignore

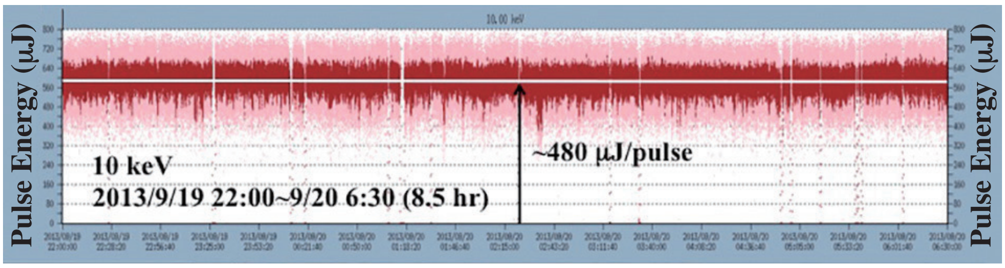

Fig. 2. XFEL intensity variation during the user experiment at a photon energy of 10 keV.

a single misfire in the first minute. This interlock modification was performed by proving the reliability through operation testing. The interlock modification is effective for improving laser availability, however, a misfire of the Thyratron causes a large wavelength shift and produces a single unavailable shot for experiments requiring great precision. We therefore provided users with an error flag indicating the unavailable shot so that these shots could be ignored in later analyses.

3) Successful beam commissioning of XSBT (XFEL to Synchrotron Beam Transport)

Following preparation activities, beam tuning began in the first week of September to transport the electron beam from SACLA to the dump of the booster synchrotron. The tuning was successfully completed by injecting the sharp beam to the dump without significant beam losses. The facility passed inspection in the second week of September. The XSBT line is now available for transporting the beam from SACLA to the storage ring.

4) Accelerator operation upgrade

SACLA has the capacity to install up to five XFELs. Currently, two beamlines, BL1 (broad band) and BL3 (SASE), are in operation and the second SASE beamline, BL2 is under construction and targeting completion in the summer of 2014. In order to effectively utilize the multi-SASE beamlines after introducing a pulse-by-pulse switching system,

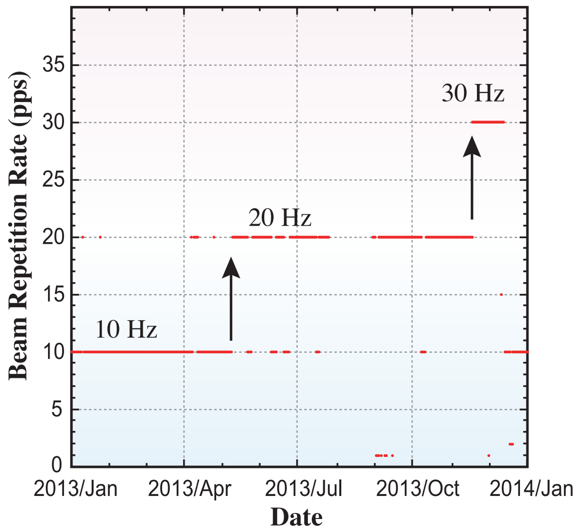

Fig. 3. History of the repetition rate change in 2013.

SACLA must change the laser wavelength for every beamline where different experiments are planned. Since the required wavelength range is much larger than that produced by adjusting the K-values of the undulator, we have developed a special operation scheme named TIME (Time Interleaved MultiEnergy acceleration) [1] that can change beam energy widely and stably using the pulse-by-pulse technique. We have already performed a proof-of-concept experiment at SACLA and proven that the scheme has sufficient stability and a changeable energy range. Figure 4 shows a schematic illustration of the TIME scheme.

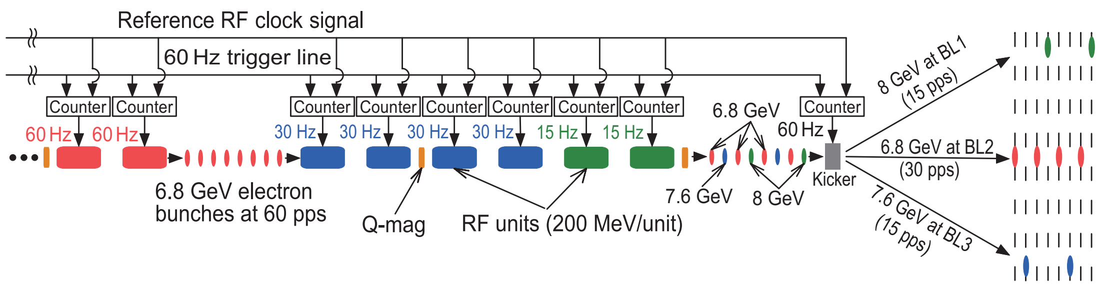

Fig. 4. Schematic illustration of the TIME operation [1].

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Reference

[1] T. Hara *et al*.: PRSTAB **16** (2013) 080701.