SACLA: Present and Future

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Abstracts: *Present status of SACLA is introduced, with some retrospect and some foresight. SPring-8 site is heading to the future pulsed XFEL source as well as the future CW XFEL source.*

SACLA is the world's first compact X-ray free-electron laser using in-vacuum undulators and high-gradient C-band linac [1]. At the moment, SACLA is one of the only two operating hard X-ray free-electron lasers in the world next to the LCLS at SLAC in the US which is not compact. The R&D program toward a compact hard XFEL started in 2001 at the RIKEN Harima Institute, completed construction of prototype machine in 2005. Successful proof-of-principle operation of the SPring-8 Compact SASE Source concept leads to the launch of larger scale XFEL construction project, now known as SACLA, in 2006. The hardware construction was completed in 2011, and the first lasing at 10 keV was observed after three month commissioning. After a few months, the highest lasing energy reached 20 keV.

SACLA is designed to eventually have five FEL beamlines, as well as an electron beam transport to SPring-8 for the full-energy injection. User operation started in 2012 with two photon beamlines, one of which is an XFEL beamline and the other a lower-energy, short-pulse spontaneous beamline. SACLA's XFEL beam meets with SPring-8 SR beam in a newly constructed building where we can simultaneously irradiate a sample with both SACLA XFEL and SPring-8 SR. In collaboration with Osaka University, a suite of high-power lasers have been introduced in this building in order to expand the high-energy-density sciences.

The XFEL beamline was at first equipped with total 18 undulator units, each 5-m ling. One unit near the center was moved to the most downstream to make room for the self-seeding optics with a small electron-beam chicane. The test operation for self-seeding is continuing but not yet released for the user operation. The small chicane has been applied to make two-color, two-pulse operation with variable pulse separation time [2]. This two-color operation was used to demonstrate K-shell atomic laser with Cu [3] by tuning the first pulse just above the Cu K absorption edge and the second pulse to Cu Kα radiation.

In 2014 was completed the second XFEL beamline which enables us to make simultaneous operation of two XFEL lines even with different electron beam energies. The old prototype machine was relocated to the SACLA undulator hall and revitalized as a soft XFEL. A new initiative of smaller XFEL with laser plasma acceleration started. Another initiative is seeking the way to convert a 1 GeV storage ring to a CW EUV-FEL generating 13.5 nm. This would lead to the further step of converting SPring-8 to a CW XFEL machine.

[1] T. Ishikawa et al., Nature Photon. **6**, 540-544 (2012).

[2] T. Hara et al., Phys. Rev. ST-AB 16, 080701-1-5 (2013).

[3] H. Yoneda et al., Nature 524, 446-449 (2015).