SACLA Beam Performance

Since July 2016 [1], users have conducted experiments on BL1, which enables the simultaneous utilization of SXFEL and XFEL beamlines for different experiments. Despite a decrease in the total operation time for SACLA due to budgetary constraints, the total user time in FY2016 across user shifts at BL1 to BL3 is expected to exceed 4000 h, maintaining high laser availability with efficient multi-beamline operations. Through a high-power test for more than 1000 h, the first user experiment was implemented with a repetition rate of 60 Hz in autumn 2016, as shown in Fig. 1. A high XFEL repetition rate of 60 Hz will be fully available for user experiments in 2017.

In order to meet the increasing demand for XFEL utilization, pulse-by-pulse BL2/BL3 operation [2,3] has been offered since February 2016. However, the available peak power for the XFEL has been limited to around several GW due to degradation of the electron beam caused by strong CSR (coherent synchrotron radiation) through a dogleg composed of a bend and bend-back of 3 degrees. Since most experiments require a short pulse of less than 10 fs and a high laser pulse energy of several hundred μJ, enabling pulse-by-pulse BL2/BL3 operation with full laser performance is critical for further improving utilization efficiency. Therefore we investigated a new

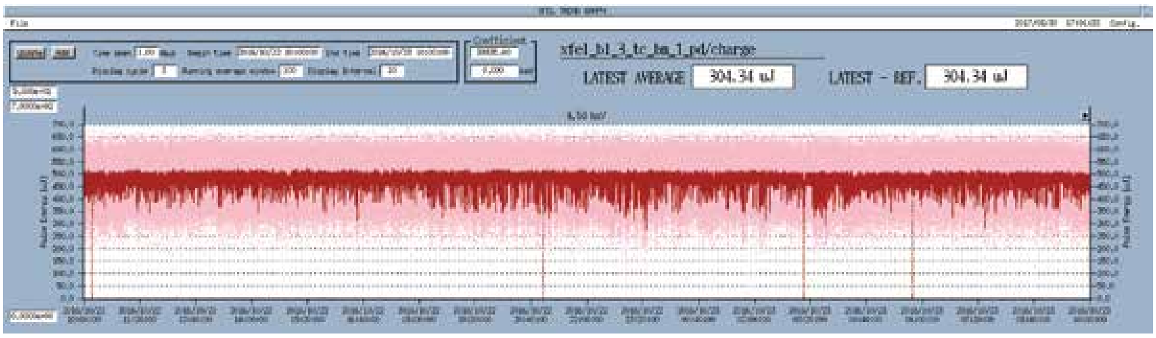

Fig. 1. Laser intensity trends for the first user experiment with a repetition rate of 60 Hz from October 22 to 23, 2016. The beamline is BL3 and the photon energy is 4.5 keV.

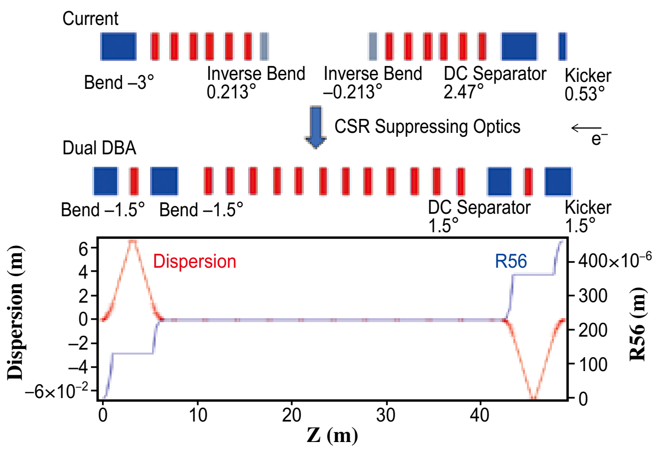

Fig. 2. Comparison of the previous dogleg configuration with the new dual DBA dogleg. The new design provides more symmetric optics for cancelling out perturbation effects caused by CSR compared with the current design. The lower figure shows the dispersion and R56 distributions over the new dogleg configuration.

beam-switching scheme to suppress the degradation caused by CSR and found that a dogleg based on a dual DBA (double bend achromat) with a matched phase advance of π (Fig. 2) could sufficiently reduce degradation [4]. The suppression mechanism is a result of the electron beam modulation occurring at the upstream DBA with a bend angle of +3 degrees being precisely canceled out at the downstream DBA with a bend angle of –3 degrees up to the second order of perturbation. This new scheme therefore allows us to generate XFEL with a high peak current of more than 10 kA, enabling both high laser peak power and high laser pulse energy. On the other hand, since this scheme requires a challenging 0.3 MW pulse power supply with extremely high stability (currently not commercially available), we have been working with Nichicon Corporation to develop a new power supply. Following the installation of the whole system (scheduled for winter 2016), the new beam switching system will be commissioned in February 2017.

During the summer shutdown of 2016, two C-band RF acceleration units were installed (Fig. 3) to increase the maximum electron beam energy for BL1 to 800 MeV. This energy upgrade widened the available photon energy range to 120 eV (sub-10-nm wavelength). Beam commissioning for the upgraded BL1 accelerator system started in autumn. By the end of November, a pulse energy of about 100 μJ had been obtained at a photon energy of 100 eV. The wider photon energy range will be fully available for user experiments at the BL1 beamline in 2017.

Fig. 3. BL1 to BL3 beamlines in the undulator hall taken from the experimental hall side (i.e., the downstream side) of BL1. The white circle indicates the newly installed C-band accelerator units in the BL1 accelerator.

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References

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