SACLA Beam Performance

Recent update on accelerator

The time-resolved operation of the SACLA linear accelerator as a ring injector, introduced in April 2021, has been on track and is running smoothly. The pulsed quadrupole magnet system introduced for SACLA's multi-beamline operations has also been used routinely, contributing significantly to ensuring XFEL performance and reducing the accelerator tuning time. Prior to the resumption of SPring-8-II operation in March 2029, another pulsed quadrupole magnet system was installed in the upstream bunch compressor section to enable pulse-by-pulse switching of bunch compression conditions during XFEL generation and beam injection into the ring. Parameter tuning will be performed using these systems in the next year and beyond.

In SACLA, the XFEL requirements for each experiment have become increasingly detailed and complex in recent years. Weekly accelerator tuning has become increasingly difficult to provide proper FEL characteristics for each of the three FEL beamlines. Although SACLA is already state-of-the-art in the implementation of ML-based accelerator tuning programs, further improvement of the accelerator tuning program that can more precisely meet users' requests for XFEL, while increasing the number of performance indicators that can be handled, including not only intensity but also spectra and laser profiles, is currently underway. We hope to report the results clearly in the next issue.

The basis for efficient tuning and stable XFEL generation is to stabilize the XFEL amplification over a long period. In the case of SACLA, it has long been known that the compensation of accelerator parameter drifts, which fix the multi-stage bunch compression system under constant conditions from upstream, is critically important. Recent efforts have resulted in a drift feedback system of the accelerator parameters shown in Fig. 1, which isolates the parameter variations of the multi-stage bunch compression system and applies

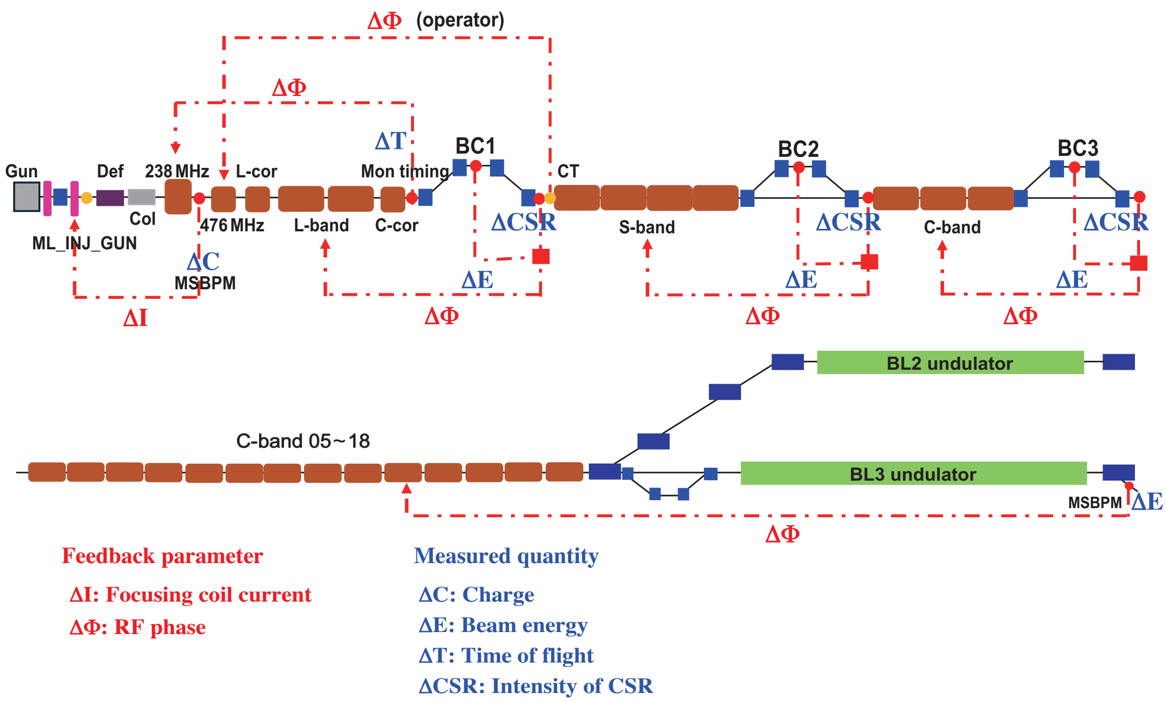

Fig. 1. Drift feedback system of accelerator parameters at the multi-stage bunch compression system at SACLA.

accurate feedback to the drift of each component, providing a stable XFEL for a long period of time. This feedback system contributed significantly to the stable operation of high-performance XFELs at SACLA.

To improve the reliability of the SACLA operation, the RF window system shown in Fig. 2 was installed step-by-step in the L-band, S-band, and C-band RF accelerator systems located upstream from the final bunch compressor, which had no spare RF system, to enable quick replacement in the case of klystron failure. The RF window system separates the vacuum between the directly connected klystron and accelerator tube, allowing the replacement of the klystron without releasing the vacuum of the accelerator tube. Three RF window systems were installed at by the end of 2023. The installation of the systems will continue with the aim of completing the modifications at the earliest.

The automatic recovery time from the RF system shutdown due to RF discharge or thyratron failure has been 30–50 s per event. To maximize the experimental efficiency, the shutdown time was reduced uniformly to 15 s. System modifications to enable a shorter recovery time from laser operation shutdown due to RF system down started in spring 2020, and all modifications of the RF acceleration systems were completed in the summer of 2023.

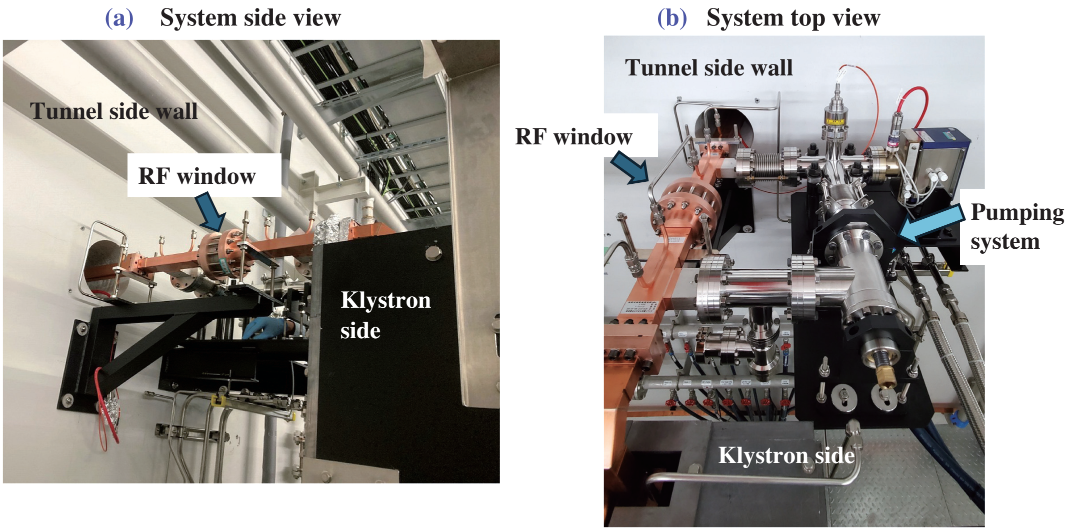

Fig. 2. RF window system installed at SACLA, **(a)** side view and **(b)** top view.

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