SPring-8 Beam Performance

Recent update on accelerators

The user time operation of SPring-8 with full-energy direct beam injection from the linear accelerator of SACLA to the SPring-8 storage ring started in 2020. Some user experiments require the ratio of the number of electrons in the satellite bunches to that in the main bunch, that is the bunch purity, to be as small as 10^{-8} or less. Here, we define the main bunches as those that are expected to fill specific RF buckets in the filling patterns for the operation modes. In the traditional SPring-8 operation with beam injection from the booster synchrotron, undesired electrons in the satellite bunches are removed using the RF knock-out system in the booster synchrotron to deliver storage ring users high-purity isolated bunches. However, once we started the beam injection from the SACLA linac, it was no longer possible to remove the undesired electrons in the booster. Experiments of beam injection from SACLA have revealed that unwilling electrons can be injected into several RF buckets coming after the main bunches. That will not be tolerated in some user experiments such as nuclear resonant scattering experiments.

We have developed a bunch cleaner system to remove spurious satellite bunches inside the storage ring. As long as spurious bunch cleaning is carried out in a storage ring, it is crucial not to disturb the main bunches in the several filling patterns for the user operation modes. The bunch cleaner system developed is composed of a signal-generating digital processor, amplifiers, and a stripline kicker. The digital processor generates a time-gated signal to kick out spurious bunches. The output signal of the processor is amplified and fed to a stripline kicker so as to kick the spurious bunches vertically. The stripline kicker is installed in cell 30 of the storage ring. The signal fed to the kicker is modulated at a frequency equal to the product of a fractional vertical betatron tune and the revolution frequency of the ring. The spurious bunches are resonantly excited to oscillate, and they are lost at a beam scraper in cell 48, limiting the vertical aperture of the ring.

The performance of the bunch cleaner of the storage ring is shown in Fig. 1 by an example of the bunch purity history during the user time. The filling pattern is the H mode, which includes one isolated bunch, and the bunch purities of the 12 satellite bunches after the main bunch are also illustrated. The beam refill on 9 February at 10 a.m. and the following continuous top-up operation were carried out with beam injection from SACLA. In the SACLA linac, the spurious bunch sweeping system is available to eliminate impure electrons that appear out as satellite bunches in the storage ring. The bunch sweeping system was in operation and the impure electrons were being substantially eliminated in the SACLA linac. Undesired electrons were nonetheless accumulated in the storage ring through the top-up injection from SACLA and significantly detected as satellite bunches in certain RF buckets after the main bunch. The operation of the bunch cleaner in the storage ring started on 12 February at 4 p.m., and it was activated once every eight hours aiming at clearing the fourth and the following RF buckets after the main bunch. After starting the operation of the bunch cleaner in the storage ring, the targeted spurious bunches were successfully cleared and an ultimate bunch purity better than 10^{-10} was realized, except for the first two satellite bunches behind the main bunch.

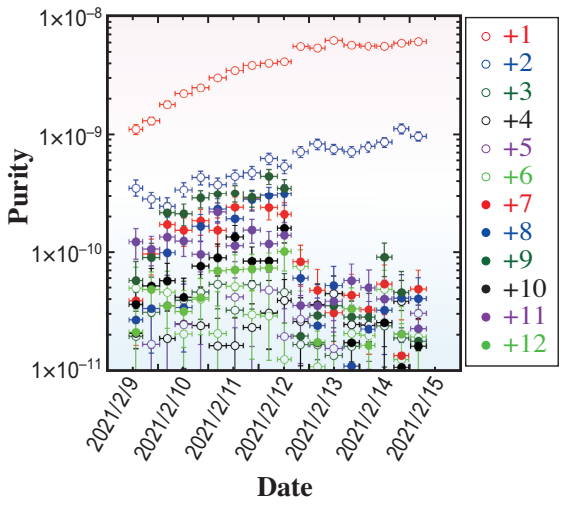

Fig. 1. Example of bunch purity history during the user time with injection from SACLA. The bunch purities of the 12 satellite bunches after the main bunch are illustrated for the H mode. The beam was refilled on February 9 at 10 a.m. followed by continuous top-up injections. The operation of the bunch cleaner started on February 12 at 4 p.m., and it was activated once every eight hours.

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