Coherent THz radiation at NewSUBARU

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Abstract

NewSUBARU is a 1.5 GeV synchrotron radiation ring at the SPring-8 site. Laboratory of Advanced Science and Technology for Industry (LASTI) at the University of Hyogo is in charge of its operation, collaborating with SPring-8. The beam is injected from the SPring-8 linac with 1.0 GeV of electron energy. Three types of CSR (coherent synchrotron radiation) from three types of electron beam were detected in the storage ring, NewSUBARU.

One was quasi-dc CSR (in other wards, steady state CSR) from a low-current, short-bunched beam, which is used for application experiment at BESSY-II. The ring was operated in a quasi-isochronous mode (with a low momentum compaction factor), in which it a short-bunched beam can be stored stationary. At NewSUBARU a quasi-dc CSR was obtained at low current of 1 pC/bunch and short bunch length of 3.4 ps FWHM. In this state, the longitudinal coherent oscillation amplitude depended on the stored beam current probably because of a burst of CSR by a longitudinal instability. Burst CSR could produce a sudden energy loss and excite a coherent synchrotron oscillation. Fig. 1 shows the FFT power spectrum of the pulsed CSR signal. This quasi-isochronous operation requires delicate tuning and high stability of the storage ring.

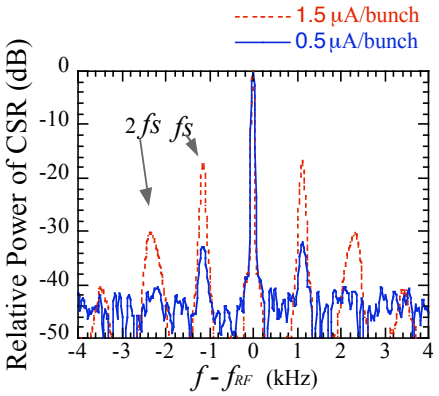

Fig. 1. Beam current dependence of the power spectrum of CSR signal. The main peak (rf frequency f_{RF}) is normalized to 0dB.

The second type was a radiation pulse following injection. A short-bunch linac beam, with a base width of 20 ps and a charge of 50 pC/bunch, emitted short-pulse CSR in the storage ring. It was almost impossible to store short and high-charged electron bunch in a storage ring but the production of short and intense bunch at a linac is not difficult. When the short bunch is injected into an ideal isochronous ring, the time structure of the bunch is frozen and it emits short-pulsed radiation for every turn. It would supply a strong coherent radiation pulse train in THz region for beam lines in the storage ring. This plan will be presented in the other presentation titled "Bunch compression at the SPring-8 linac for successive generation of THz pulse train in the isochronous ring" at the workshop.

The third type was a radiation burst from a high-density, single-bunch beam. Although its radiation power is extremely high and easy to be obtained in any electron storage ring, this type is not used for experiments. This is because the source of the CSR burst is a fine time structure in the bunch due to longitudinal beam instabilities, and is not stable. However, it could be used for some kind of application experiments with an appropriate time averaging. We investigated the time structure of the CSR burst using Schottky diode detector, which had a high time resolution. When we took an averaging period of 10ms (=25250 revolutions), the fluctuation of the integrated power was about 10% (standard deviation). In this time range, the relative fluctuation decreases with the period length faster than the square root scaling law as shown in Fig. 2. It is thought that the CSR burst can be obtained in most storage rings. This type does not require fine and delicate machine tuning as the quasi-isochronous operation does. However for a user operation, two accelerator techniques, an accurate bucket selection in the injection process, and the top-up operation are required. These two techniques are not common at the existing storage rings but coming to be a standard of new rings.

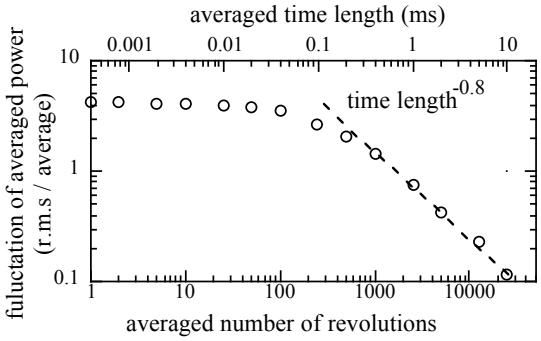

Fig. 2. Fluctuation of time-averaged power of CSR burst. The broken line is a guide which shows the dependence of period$^{-0.8}$.