Bunch compression at the SPring-8 linac for successive generation of THz pulse train in the isochronous ring

T. Asaka, H. Dewa, H. Hanaki, Y. Hisaoka*, T. Kobayashi, T. Matsubara*, T. Mitsui*, A. Mizuno, Y. Shoji*, S. Suzuki, T. Taniuchi, H. Tomizawa, and K. Yanagida

SPring-8, JASRI, Sayo-cho, Sayo-gun, 679-5198, Japan

**NewSUBARU, LASTI, University of Hyogo, Kamigori-cho, Ako-gun, 678-1205, Japan*

Abstract

We have already demonstrated our idea of circulating a short and intense bunch in a synchrotron radiation ring. The idea is based on the understanding that it is almost impossible to store short and high-charged electron bunch in a storage ring but it is not difficult to produce that kind of bunch at a linac. When the short bunch is produced at a linac and 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.

In our previous work [1] we compressed the bunch of the SPring-8 linac to a few picoseconds (r.m.s.) by means of an energy compression system and a beam transport line from the linac to NewSUBARU. The bunch charge was about 0.02 nC. The NewSUBARU storage ring was set at quasi-isochronous condition and the bunch circulated for about 50 turns after injection while maintaining the short bunch length. A strong coherent radiation was observed using a Shottkey diode detector, which was sensitive to 0.1 - 0.14 THz radiation. Fig. 1 shows the turn-by-turn radiation power after injection in the storage ring. The radiation power at the initial turn was raised by the bunch compression. This high power radiation lasted longer by setting the ring quasi-isochronous. At the present, the imperfection of the isochronous condition produces the increase of bunch length and the reduction of coherent radiation power.

Our plan for the next few years, which is not yet approved, is to install the photo-cathode electron gun developed at SPring-8. According to the expected beam parameters listed in Table 1, the beam would be shorter and stronger with the smaller energy spread. Consequently it would supply more lasting shorter pulses in the ring. The smaller energy spread is important not only because this parameter is a trade-off of the bunch compression, but also that the small energy spread reduces the bunch elongation due to the higher order momentum compaction factor. Many improvements of the linac since 1998 for stability and reliability were also essential for this research.

Our method is partly very similar to ERL (Energy Recovery Linac). There is no stationary state in the ring or bending arc, therefore its performance as a light source strongly depends on the initial beam. Performance of the electron gun is essential. The quasi-isochronous ring as a circulator can be a model of a bending arc of ERL. Many circulations in the ring would enhance problems, which would occur in ERL arc.

We hope that this new beam handling would bring us new understandings on beam physics. What we would see is a transient process starts from a short pulsed intense beam. We can observe energy spreading by instabilities or CSR in time domain. The turn-by-turn time structure of a bunch will be measured using a streak camera and a beam profile by a fast gated ICCD camera. The diode detector in THz region is a diagnostic on fine time structure in a bunch.

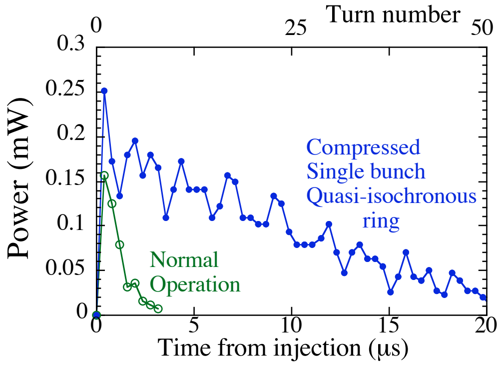

Fig. 1. The turn-by-turn coherent radiation power after injection. The line with open circles shows the power obtained with the parameters of normal operation, where there were three bunches in a pulse. The line with filled circles shows the power obtained from one compressed bunch in the quasi-isochronous ring. The bunch charge was about 0.02 nC/bunch in both cases.

Table 1. Beam parameters at 1.0 GeV with the present thermionic electron gun and the expected parameters with the new photo-cathode electron gun.

	Present	Next
Electron Gun	Thermionic	Photo-Cathode
Energy Spread	(+/-) 0.5%	(+/-) 0.1%
Bunch Length	2.2 ps	< 1 ps
Bunch Charge	< 0.1 nC	> 1 nC