

Top-up operation at SPring-8

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Top-up operation allows us, in principle, to create an ideal SR source, with both high stability and high brilliance. In this operation mode, beam losses are continuously compensated by injections occurring every few-minutes, leading to a nearly constant ring current, then a virtually infinite lifetime. The beam injections are practically invisible for users. Such operation enables users (1) a normalization-free scattering experiment and (2) long period and freely timed experiment without disturbance by beam injection with an extreme stability in the photon beam position and energy in the experimental hutch, without fluctuations due to the thermal changes of x-ray beam optics. Top-up operation is, therefore, regarded as an essential standard for brilliant SR sources, especially low energy sources where an electron-electron scattering is dominant in a beam lifetime. Here in SPring-8, since 1999 we have been improving the accelerator complex aiming at *perfect top-up operation*. The perfect operation demands not only steady stored current but also a stored beam oscillation-free and loss-free injection process and low impurity in a beam-filling pattern with isolated single-bunches. As a result of 6-years' R&D top-up operation has been started at SPring-8 since May 20, 2004 after users confirmed that the beam injections do not disturb any planned experiments. The user operation with the low emittance of 3nm.rad has been performed stably in the top-up operation mode.

A feature of the SPring-8 top-up operation

The SPring-8 top-up operation is characterized by a striking stability. This operation mode simultaneously provides (1) the current stability of 10^{-3} , (2) beam injection that is undetectable in any imaging experiment, (3) purity of a level of 10^8 for isolated single-bunches over the full user operation period, and (4) beam injection efficiency of 80~90% with the gaps of in-vacuum IDs fully closed. Besides, the several beam-filling patterns are available according to users' experimental demand.

Achieved merits of the top-up operation to SR experiments

Merits of the top-up operation were reported for various experiments, such as a diffraction, x-ray spectroscopy, nuclear resonant scattering, inelastic x-ray scattering and hard x-ray photoelectron spectroscopy. For example, the top-up operation allows us to measure very precise diffraction data of disordered materials up to high- Q . The accuracy of the calculated total structure factor $S(Q)$ and total correlation function $T(r)$ is then improved and this improvement is quite effective for the structural analysis of disordered materials.