SPring-8 Beam Performance

Recent update of accelerator operations

Most of the recent machine developments have the aim of maintaining stable and reliable accelerator operation. These developments are essential to provide stable light source performances for user experiments without significant machine operation problems. Simultaneously it is important to pursue these developments as a preparation for the future major upgrade currently being discussed. Three of these developments are presented as follows.

1) One of the key components of accelerators for stable beam operation is the so-called bunch-by-bunch feedback (BBF) system. The beam position monitor detects the offset of a passing beam position from an ideal orbit and the downstream kicker kicks it back by a closed loop feedback system. Without it, the spatial position and angle of synchrotron radiation in downstream X-ray optics could fluctuate turn by turn, increasing the effective radiation beam size integrated over the measurement time. Thus, the BBF system is kept operational during user operations so that an undesired beam oscillation excited by any kind of perturbation is damped before it has a significant effect on user experiments.

Nevertheless, beam instabilities in the vertical direction were intermittently observed, especially in a specific operation mode called the A-mode. This mode is also referred to as the 203-bunch mode as 203 out of 2436 buckets in the storage ring are supposed to be filled with electron beams with equal separation between them. However, in 2016 we had to make the decision to operate the A-mode with a 406-bunch mode from June 19 to July 2 and from September 15 to 24 due to the vertical instability, during which 406 buckets instead of 203 were filled with beams. After a detailed investigation, the internal electric circuit of the BBF system was revised (see Fig. 1 for the new digital feedback processor involving the revised internal electric circuit), and since then the vertical instability appears to have been suppressed. Thus, the next A-mode user operation from November 29 to December 11 was operated with the 203-bunch mode without notable instabilities. As the beam instability is one of the most important issues for stable and reliable accelerator operation, we will continue paying attention to this issue.

Fig. 1. New digital feedback processor for the BBF system.

There have been two further developments of the BBF system. First, the system has been reassembled and its sophistication has been increased so that accelerator operators can easily change the internal system settings by using a new GUI on the accelerator control computer. When the user operation is switched from a certain mode to another, for example, the operator simply needs to implement a single-click operation to adjust the BBF settings. This new feature is beneficial not only for quick operation but also for reliable management of the accelerators. Second, it has become possible to measure betatron tunes while the accelerator is being operated without noticeable perturbation for users. It is well known from beam dynamics that the betatron tunes have to be kept away from some harmful values to avoid instabilities originating from resonances. With the new capability, we are now able to measure betatron tunes anytime and adjust them if necessary. These two aspects were implemented by introducing a new digital feedback processor developed at SPring-8.

2) Some of the insertion devices at the SPring-8 storage ring generate a betatron coupling of the transverse motion, and consequently the vertical beam size increases. To correct the coupling, we installed skew quadrupole magnets for 12 insertion devices that have particularly large effects on the coupling. A GUI has been developed so that the excited coupling is now automatically corrected. This function has been applied in user operations since December 2016.

3) In the beamline BL43LXU, three short-period undulators are installed in tandem in a magnet-free long straight section. Since the photon beam axes of these undulators must be aligned with each other, the required stability and reproducibility of the electron beam orbit are severer than for the other beamlines, being less than 1 μrad in the vertical direction and 2 μrad in the horizontal direction. We hence carried out fine tunings of the strengths of correctors to make a closed local bump for orbit control as perfectly as possible and developed a single-click GUI to perform a quick orbit correction for three undulators at the same time in both the horizontal and vertical directions. From April 2017, this GUI will be used to quickly recover the change in the orbit caused by beam refilling and by some perturbations during user operation.

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