Improvement in the beam lifetime by means of an rf phase modulation at the Photon Factory storage ring

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Summary

In the 2.5-GeV Photon Factory storage ring at KEK, we have found that the beam lifetime can be improved by modulating the phase of an rf accelerating voltage at the frequency of two times the synchrotron oscillation frequency. By applying this phase modulation with a peak-to-peak amplitude of 3.2 degrees, the beam lifetime could be improved, typically, from 22 to 36 hours under the beam current of about 360 mA. At the same time, longitudinal coupled bunch instability could be considerably suppressed. The improvement in the beam lifetime can be explained as the improved Touschek lifetime which is caused by a quadrupole-mode longitudinal oscillation of the stored bunches.
1. rf-phase modulation

Very simple equipment. Only a function generator and a phase shifter!!
2. Effect of rf-phase modulation

Improvement of beam lifetime.
Suppression of the longitudinal coupled-bunch instability.

Modulation OFF

Modulation ON

Center Frequency  1GHz
Span               1GHz
3. Stable quadrupole oscillation

Motion of bunches  (streak camera)

Modulation OFF

Modulation ON
Suppression of the coupled-bunch instability is not known clearly.