MEASUREMENT OF THE FREQUENCY SPECTRUM ON THE BEAM PROFILE CONTROLLED BY RF KICKER

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Abstract

The frequency spectrum on the beam profile was measured at the compact superconducting storage ring of Ritsumeikan University. The radiation detector was used an avalanche photodiode module with a high frequency response of 1 GHz for the visible ray. Signals from the detector were transferred to a spectrum analyzer. The beam profile was magnified strongly by a conventional profile monitor system. We scanned the beam profile in vertical direction by shifting the detector. The distribution of peak intensity as a function of the position on beam profile was obtained.

INTRODUCTION

The world smallest electron storage ring AURORA with a super conducting magnet was developed by Sumitomo Heavy Industries [1]. Ritsumeikan University installed this storage ring in 1996. Since then, the SR center was utilized for synchrotron radiation researches [2]. There are 14 beamlines (XAFS, PES, Imaging and LIGA) and 2 beam-monitor-lines operated in the center. The number of registered users in last year was 405 in total, in which number of outside users was 149.

AURORA is the weak focusing type with the simplest lattice composed of a single bending magnet, which produces an exactly axial symmetric magnetic field with little error magnetic field. The vertical beam size was measured to use the SR-interferometer by Mitsuhashi et al in 1997 [3-4]. The result of the size to be 10.5 μm showed ability of the SR-interferometer. At the user operation, we controlled the vertical beam size to keep 130 μm by RFKO to extend beam lifetime [5-6]. We tried to measure the frequency spectrum on the beam profile to monitor any instability by RFKO.

Table 1 lists the parameters of the injector and the ring. Figure 1 shows the storage ring and beamlines in the experimental hall.

EXPERIMENTAL SETUP

Measurement system which was composed by the radiation detector (APDM: avalanche photodiode module, C5658 HAMAMATSU), spectrum analyzer (U3200 ADVANTEST) and PC was constructed behind the beam extraction port BL-9 and BL-16 at the atmosphere [7]. A thick beryllium flat mirror was set to reflect the primary ray by 90° to extract the visible component in the vacuum chamber. This visible ray through the optical glass window to divide the vacuum and atmosphere was reflected again by an aluminium mirror, and introduced into the measurement system.

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Table 1: Parameters of the Injector and Storage Ring

Injector parameters	
Energy	150 MeV
Repetition	3 Hz
Peak current	1 mA
Pulse width	2 μs

Storage ring parameters	
Energy	575 MeV
Stored current	300 mA
Circumference	3.14 m
Radius of curvature	0.5 m
Field strength	3.8 T
RF frequency	190.86 MHz
Number of cavities	1
Harmonic number	2
Critical energy of radiation	844 eV
Vertical beam size(σ)	0.0105 mm
Vertical beam size: user operation (σ)	0.13 mm
Horizontal beam size(σ)	1.1 mm
Beam lifetime	300 min

Figure 1: Photograph showing the storage ring and beamlines in the experimental hall.

The stored beam profile was magnified strongly by the conventional profile monitor using objective lens and magnifying lens. The radiation detector was scanned with using the micrometer on the beam profile in vertical direction. For the operating condition of the kicker for RFKO, the center of frequency was 57.6 MHz in agreement with vertical betatron frequency ($f_{\beta y}$), deviation of frequency modulation 200 kHz, sweep frequency 1, 3 or 10 kHz. Stored beam current was about 200 mA at every measurement.

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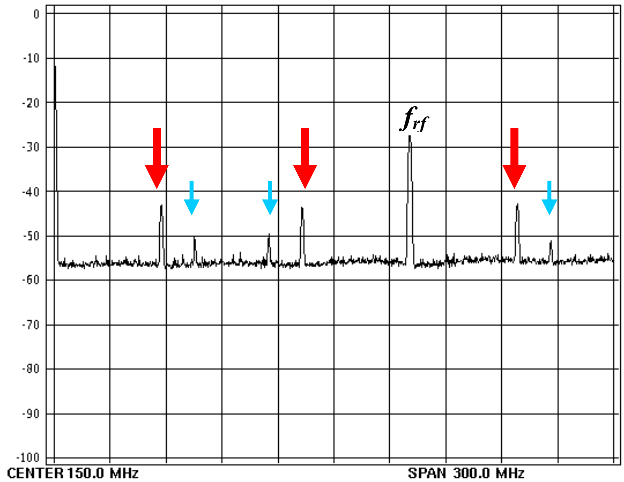

Figure 2: Frequency spectrum measured by APDM at BL-9. The center is 150 MHz, and the span 300 MHz. The unit of vertical axis is dBm.

RESULTS AND DISCUSSION

Figure 2 shows an example of the observed frequency spectrum. f_{rf} is the RF frequency of 190.9 MHz. Peak frequencies showed by bold-red arrows are given by $f_{\beta y}$ and $f_{rf} \pm f_{\beta y}$, and these intensities are almost same values at the each scanning position. Similarly, peak frequencies of blue arrows are 75.7 MHz and f_{rf} ±75.7 MHz. The frequency of 75.7 MHz doesn't agree with the horizontal betatron frequency ($f_{\beta x}$ = 76.1 MHz) but agree with the frequency given by $f_{rf} - 2f_{\beta y}$.

Figure 3 (A), (B) and (C) show measured peak intensities as a function of the vertical scanning position on the magnified beam profile for the sweep frequency of 1, 3 and 10 kHz, respectively. Distributions of plotted points for 190.9 MHz are consistent with the beam profile, and these intensities are in proportion to the stored beam current. On the distributions for 57.6 MHz, there are double peaks on both sides of the center of beam profile, and these intensities decrease dependent on the sweep frequency. This result suggests that the bunching beam size repeat increase because of the resonant oscillation using RFKO and decrease owing to the radiation dumping. This suggestion is consistent with that the dumping time constant of vertical betatron oscillation is 0.63 ms, and the tune spread is about 30 kHz and smaller than the deviation frequency of the modulation of RF kicker. We confirmed that the intensity of 57.6 MHz increased with every half of sweep time by using the real time spectrum analyzer (RSA230: SONY TEKTRONIX).

On the distributions for 75.7 MHz, there are single peaks at the center of beam profile. That tendency is obviously different by comparison with one for 57.6 MHz. The origin of 75.7 MHz isn't the vertical betatron oscillation, RF frequency or those sum peak effect. We guess that electrons kicked by RFKO oscillate in horizontal with the frequency of 75.5 MHz. The horizontal tune is 0.797 at the normal operation, and is 0.792 at the third order resonance given by $\nu_x + 2\nu_y = 2$.

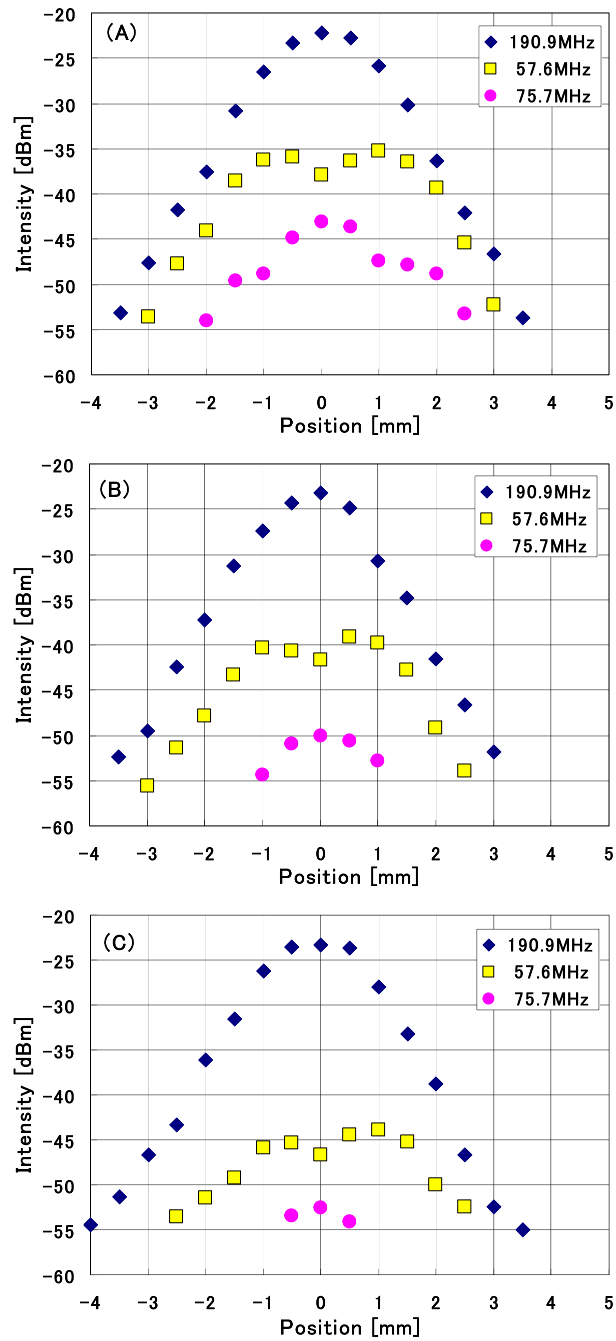

Figure 3: Observed peak intensity as a function of scanning position. (A), (B) and (C) show results for 1 kHz, 3 kHz and 10 kHz of the sweep frequency of the modulation, respectively. Diamonds show the results for 190.9 MHz of peak frequency, squares for 57.6 MHz and circles for 75.7 MHz, respectively.

Hence, ν_x is horizontal tune, ν_y vertical tune: $\nu_y = f_{\beta y} / f_{rev}$, and f_{rev} revolution frequency: 95.4 MHz. We think the horizontal oscillations are induced by RFKO using vertical betatron frequency duo to the effect of third order resonance. Figure 4 shows the generation of resonant oscillation and dumping of frequency of 75.7 MHz

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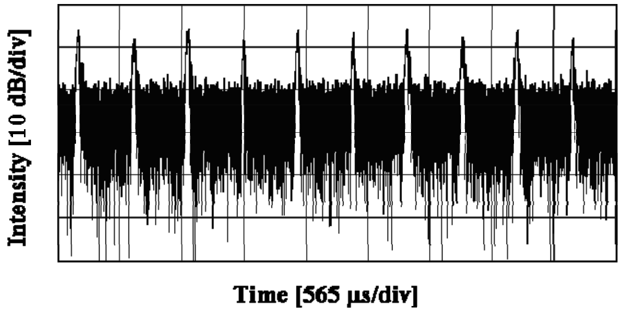

Figure 4: Time dependent change of peak intensity for 75.7 MHz measured by APDM (R263VF MATSUSADA) at BL-16. Sweep time is 1.0 ms.

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REFERENCES

[1] N. Takahashi, Nucl. Instrum. Methods Phys. Res. A 24/25, 425 (1987).

[2] H. Iwasaki, Y. Nakayama, K. Ozutsumi, Y. Yamamoto, Y. Tokunaga, H. Saisho, T. Matsubara, and S. Ikeda, J. Synchrotron Radiation **5**, 1162 (1998).

[3] T. Mitsuhashi, H. Iwasaki, Y. Yamamoto, T. Nakayama, and D. Amano, Proceedings of the Eleventh Symposium on Accelerator Science and Technology, 1997, pp. 441-443.

[4] Y. Yamamoto, I. Sakai, T. Mitsuhashi, D. Amano and H. Iwasaki, Nucl. Instrum. Methods Phys. Res. A 467-468, 921 (2001).

[5] I. Sakai, Y. Yamamoto, T. Mitsuhashi, D. Amano and H. Iwasaki, Rev. Sci. Instrum, 71, 1264 (2000).

[6] I. Sakai, Y. Yamamoto, T. Mitsuhashi, D. Amano and H. Iwasaki, Nucl. Instrum. Methods Phys. Res. A 480**,** 373 (2002).

[7] Y. Yamamoto, T. Hori, I. Sakai, K. Yadomi, and I. Iwasaki, Nucl. Instrum. Methods Phys. Res. A 533, 505 (2004).

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