# MEASUREMENT OF THE BEAM SIZE DEPENDENT ON MODULATING FREQUENCY OF RFKO

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The vertical beam size of AURORA is controlled to keep 130 μm by RFKO (radio frequency knockout) to extend beam lifetime in normal user operation [1-3]. The frequency of RFKO is 57.6 MHz coincident with the vertical betatron frequency given by n-value. The actual betatron frequency shift and spread slightly to be affected by stored beam current, vacuum situation, and so on. This small changes lead to slow drifting and fluctuation of the beam size. Therefore, we appended the frequency modulation to RFKO. We measured the vertical beam size dependent on modulating frequency to check effective range of frequency modulation.

RFKO system was composed by a signal generator (KSG4310 KIKUSUI), an amplifier (A53-6702 THAMWAY), and an electrode on the beam orbit. The beam size monitor was constructed behind the beam extraction port BL-16 [4]. For the operating parameters of RFKO, the center of frequency was 57.6 MHz in agreement with vertical betatron frequency, peak frequency deviation 200 or 300 kHz, power of RFKO 0.1 or 0.2 W. Stored beam current was about 120 mA at each measurement. Figure 1 show measured beam size (full width at half maximum) in vertical as a function of modulating frequency. Observed results reflect the forced oscillation for RFKO and the damped one for synchrotron radiation. At lower modulating frequency, the radiation dumping is dominant. On the highest side of modulating frequency, beam instability or oscillation are shown for the peculiarity of frequency modulation.

Voltage $V_{fm}$ of RFKO with frequency modulation is given by

$$V_{fm}(t) = V_c \cos\left[ 2\pi f_c t + \frac{\Delta f}{f_m} \sin(2\pi f_m t) + \varphi \right] \tag{1}$$

where $f_c$ is center frequency, $\Delta f$ peak frequency deviation, $f_m$ modulating frequency, $\varphi$ initial phase and $V_c$ amplitude of RFKO. Using the Bessel function $J_n(\Delta f / f_m)$ in equation (1), we obtain

$$V_{fm}(t) = V_c \sum_n J_n\left(\frac{\Delta f}{f_m}\right)\cos[2\pi f_c t + 2\pi n f_m t + \varphi] \tag{2}$$

where

$$J_n(x) = \sum_{m=0}^{\infty} \frac{(-1)^m (x/2)^{2m+n}}{m!(m+n)!} \quad .$$

Figure 2 shows an example of frequency spectrum of RFKO with frequency modulation calculated by equation (2). Vertical axis indicate voltage of RFKO. Effective frequencies have discrete values per modulating frequency. The actual frequency spread of the betatron oscillation is about 20 kHz in AURORA. When the modulating frequency approaches the actual frequency spread, stored beam profile becomes unstable. We had employed the frequency of 3 kHz to modulating frequency, and confirmed stability of stored beam at every user operation in last fiscal year.

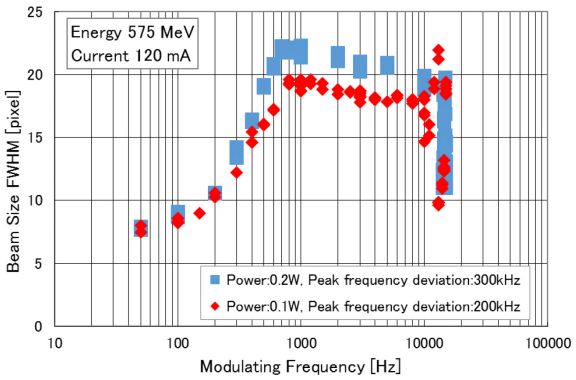


Figure 1. Measured beam size (FWHM) as a function of modulating frequency.

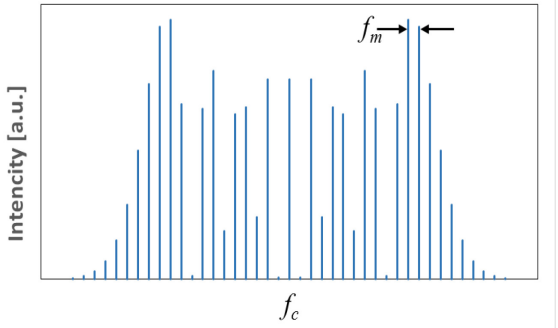


Figure 2. Calculated frequency spectrum. The modulating frequency is 15 kHz and the peak frequency deviation 200 kHz.

## References


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