Observation of the injection beam behaviour at the Photon Factory storage ring

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Abstract

The beam behaviour injected from the linac was precisely observed with turn-by-turn using a fast beam position monitor system and a rf kicker system. A passage of the beam positions and the current was continuously measured until 800 turn after the injection with pulse-by-pulse for one second. We found that the capture efficiency of the ring was 30% through this measurement.

1 INTRODUCTION

The PF-ring is a 2.5 GeV dedicated light source, which has been stably operated for more than 17 years. The injector linac has enabled us to make a full energy injection. Since last December, the commissioning of KEKB, which is an asymmetric electron (8GeV) / positron (3.5GeV) collider for B-factory, was started. Therefore, the linac must supply three-mode beam to PF-ring and KEKB. For the PF-ring, the injection is once in a day, not so frequently. However, the time loss in the injection must be avoided as possible for KEKB. Therefore, we developed the observation system of the injection beam behaviour for smooth injection.

2 EXPERIMENT

The experiment was performed in user-operation mode of the PF-ring. The principal parameters are shown in Table 1. The single-bunch beam from the linac was employed with the repetition rate of 25 Hz. Since the injection rate during the measurement was about 0.5 mA/sec, each pulse current was about 0.02 mA.

Table 1: The principal parameters of the PF-ring

Beam Energy	E (GeV)	2.5
Circumference	C (m)	187
Harmonic number	h	312
RF frequency	f_{RF} (MHz)	500.1
Revolution period	τ_{rev} (nsec)	624
Betatron tune	ν_x, ν_y	9.60, 4.30
Synchrotron tune	ν_s	0.012
Emittance	ε_x, ε_y (nmrad)	36, 0.18
Beam size at β=5m	σ_x, σ_y (mm)	0.42, 0.03
Radiation damping time	τ_x, τ_y, τ_s (msec)	7.8, 7.8, 3.9
Energy spread	σ_ε	0.00078

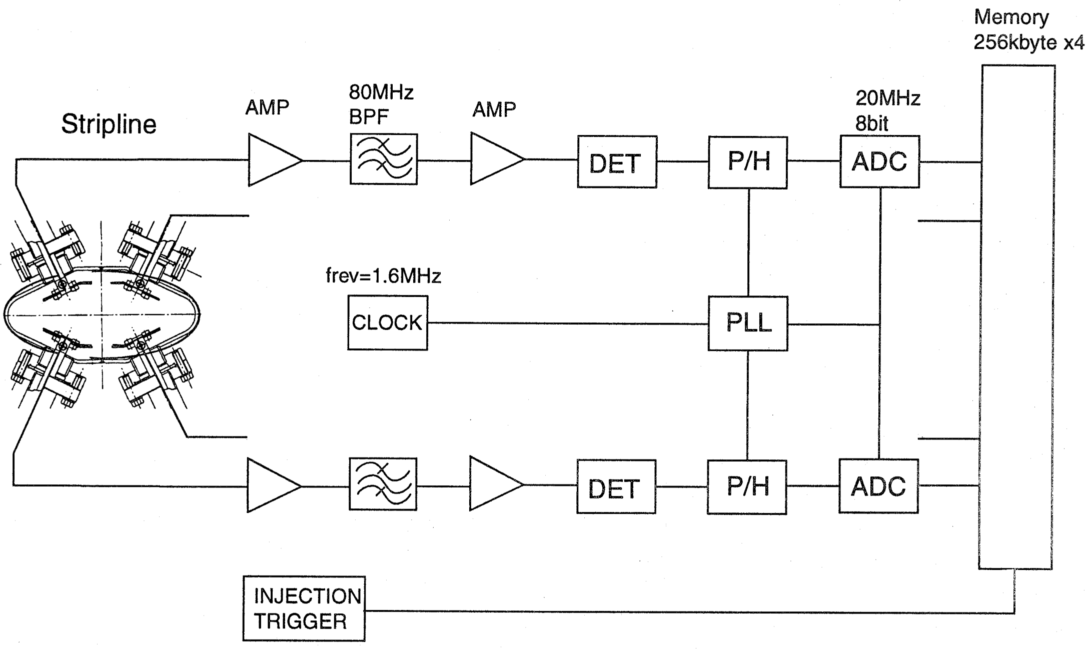

Fig. 1 The block diagram of the fast beam position monitor system.

2.1 Fast beam position monitor system

Figure 1 shows the block diagram of the fast beam position monitor system, which was developed for the non-linear beam dynamics studies [1]. Since the current of the injected beam was very low, the signals from four stripline electrodes were employed instead of the signals from the button-type electrodes. The signals were stretched through a band-pass filter and digitized with 20 MHz ADC after the detection and sample-hold. Then, data were sent to the memory, which has 256 kbyte/ channel, and then stored. If data were taken for 1024 turn (1 kbyte) to one pulse, the measurement can be maintained with pulse-by-pulse for ten seconds in the repetition rate of the 25 Hz.

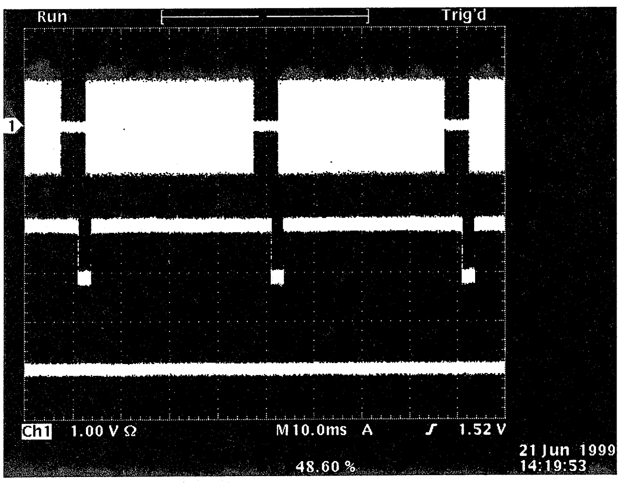

Fig.2 The timing signal of the rf kicker system. Upper part is an input signal for the rf kicker and middle part is the injection trigger signal.

2.2 RF kicker system

Figure 2 shows the timing signal of the rf kicker system, which was originally developed for the bunch-purification of the single-bunch operation. When the injected beam was stored repeatedly, the measurement was impossible because the signal became over voltage instantaneously. Thus, the rf kicker system was employed to sweep the stored beam to maintain the data taking. The rf kicker was active for 30 msec in the 25Hz repetition rate after data taking, and its frequency was set to be the vertical betatron side-band frequency.

3 RESULTS

The digitized raw data of one stripline electrode was shown in fig. 3. Data were taken for 1024 turn to each pulse, and the measurement was maintained for one second (25 pulses). Figures 4 shows the typical behaviour of the injected beam until 800 turn after the injection. The scale of the beam positions is arbitrary, and the current is normalized by the current of the first turn. The injected beam was gradually lost until 90 turn, and a rapid beam loss occurred between 90 and 120 turn. However, the survived beam was stored without loss after 120 turn. Figure 5 shows the typical passage of the current measured with pulse-by-pulse for one second. We found that the capture efficiency of the ring was 30% through this measurement.

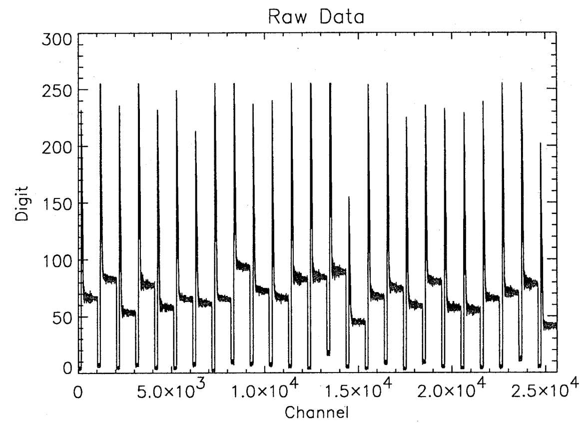

Fig. 3 The digitized raw data of one stripline electrode.

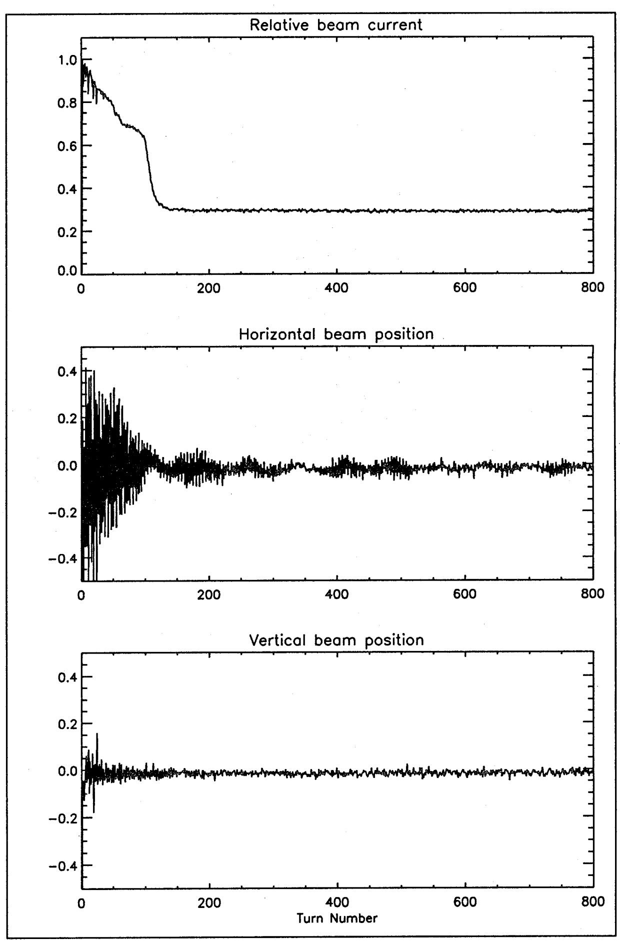

Fig. 4 The typical behaviour of the injected beam until 800 turn after the injection.

4 SUMMARY

The observation system of the injection beam behaviour was developed at the Photon Factory storage ring. We found the timing of the beam loss after injection. Then, the precise capture efficiency was estimated through the measurement. We are going to investigate the cause of the beam loss and try to increase the capture efficiency next run.

5 REFERENCES

[1] Y. Kobayashi et al., " Phase space monitor system at the Photon Factory storage ring", proc. of the 5th EPAC.

[2] T. Obina et al., "A New Purification Method for Single Bunch Operation at the Photon Factory Storage Ring", proc. of the 1999 PAC.

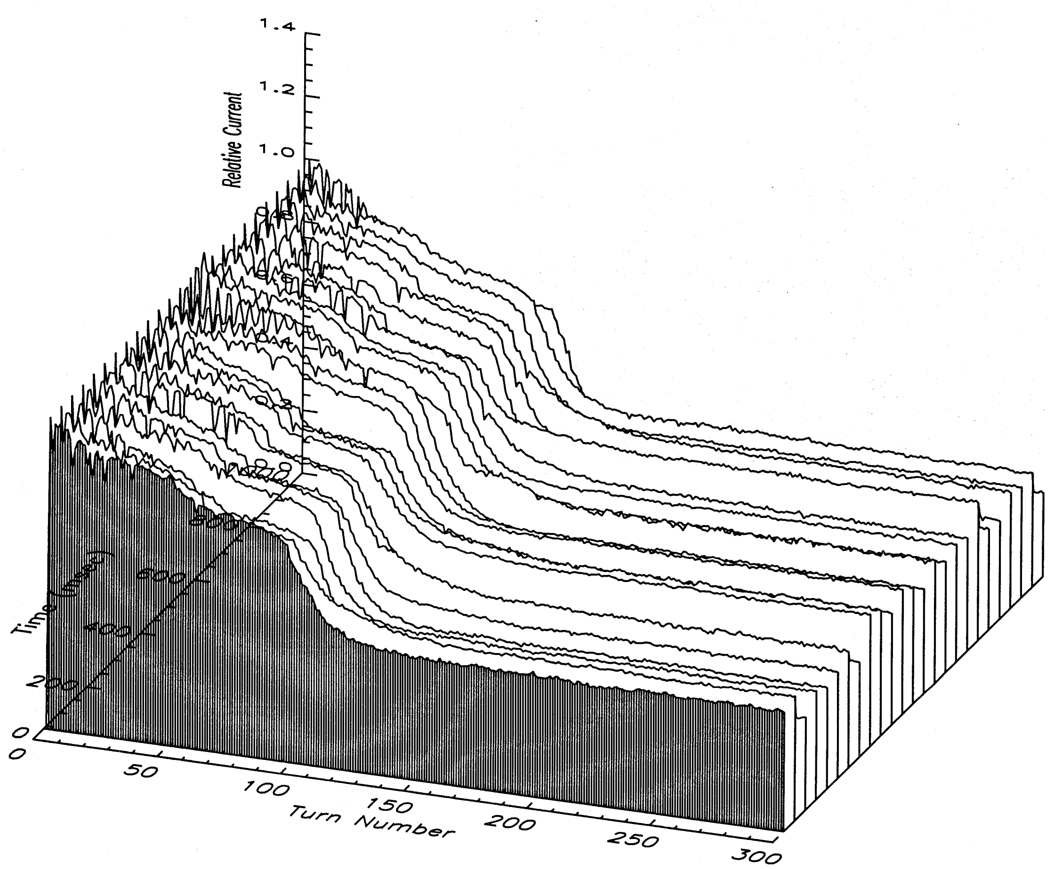

Fig. 5 The typical passage of the current measured with pulse-by-pulse for one second.