

The Bunch by Bunch Feedback System in J-PARC Main Ring

Y. Kurimoto*, M. Tobiyaama, Y. H. Chin, T. Obina and T. Toyama, KEK, Tsukuba, Ibaraki, Japan
Y. Shobuda, JAEA, Tokai, Ibaraki, Japan

1. Introduction

J-PARC Main Ring (MR)



Circumference	1568 m
Injection Energy	3 GeV
Extraction Energy	30 GeV
Repetition Period	3 sec
RF Frequency	1.67-1.72 MHz
Number of bunches	8
Synchrotron tune	0.0025-0.0001
Betatron tune	22.4, 20.75

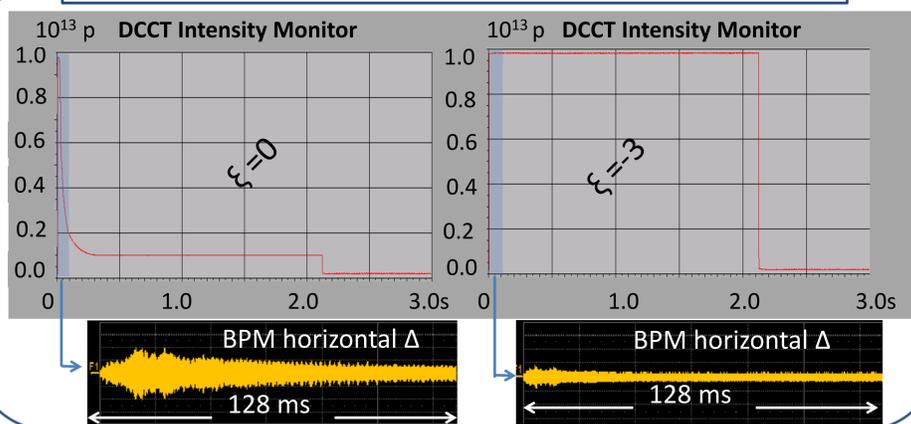
Beam intensity : 145 kW ($N_{ppb} = 10^{13}$)

Instability in MR

The impedance of the beams pipe and pulse magnets causes beam instability in high intensity beam.

With $\xi \geq 0$, the growth of the horizontal coherent oscillation is observed even at $N_{ppb} = 10^{12}$

Negative chromaticity damp the coherent oscillation



However, only negative chromaticity is not enough to achieve $N_{ppb} \geq 10^{13}$

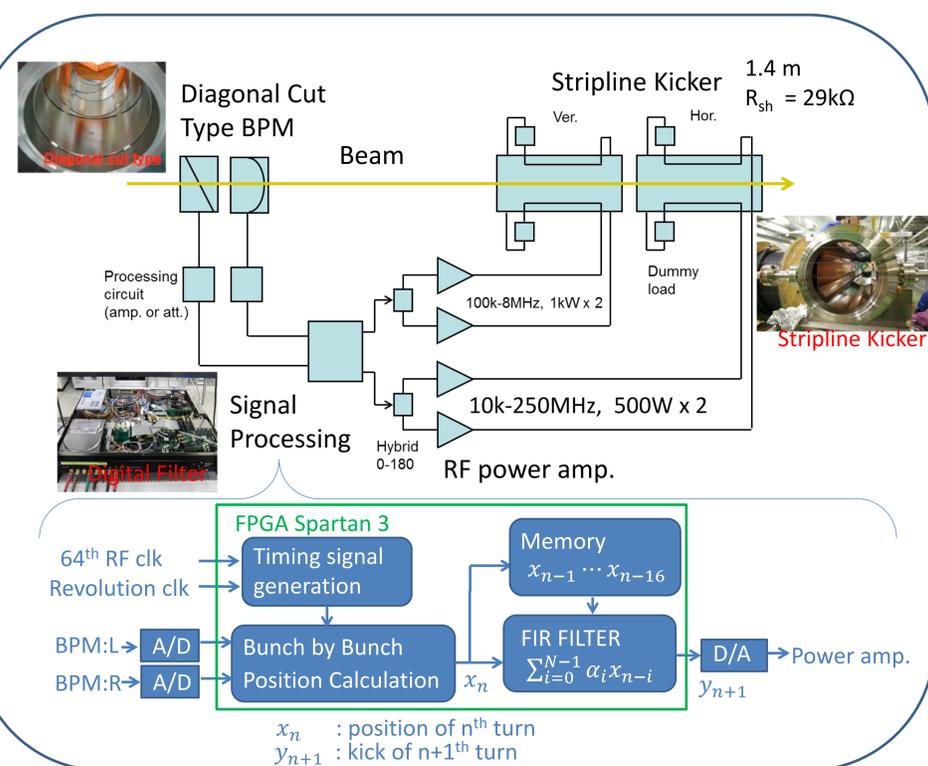
Issues for $N_{ppb} \geq 10^{13}$

The coherent oscillation by the residual field in the injection kickers is not damped fast enough even with $\xi = -6$.

We could not use the large negative ξ at the beginning of the acceleration (Tune spread & B ripple \rightarrow resonance ???).

Need additional method to damp the instability

2. Bunch by Bunch Feedback System

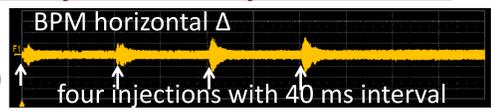


- ◆ 64th RF clk. ($1.7 \times 64 = 108.8$ MHz) is used for the signal processing.
- ◆ Betatron oscillation is extracted through the FIR filter.
- ◆ All protons in single bunch is kicked in same direction with same amount (Only one feedback value per single bunch)

3. Damping of Injection Error

Coherent Oscillation due to the residual field in the injection kickers

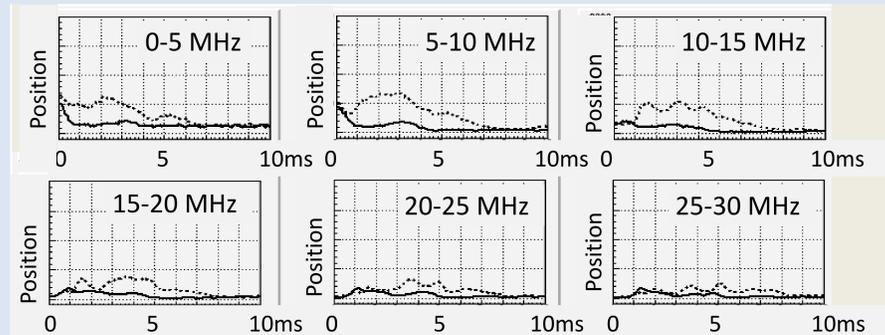
Beam Loss @ Injection ≥ 400 W (Collimator Limit)



- ◆ The coherent oscillation is excited at each injection timing
- ◆ Beam loss is coincident with the injection timing
- ◆ Negative chromaticity damping is not enough

Comparison between feedback on and off

Oscillation amplitude within 10 ms from the injection

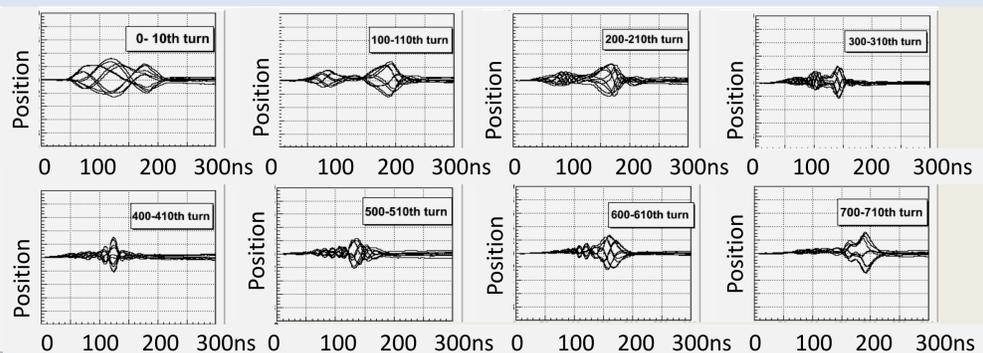


* Data is taken with stripline BPM
* Dotted line : Feedback Off Solid line : Feedback On

The feedback system damps the oscillation and reduce the injection beam loss by more than half

4. Internal Bunch Oscillation

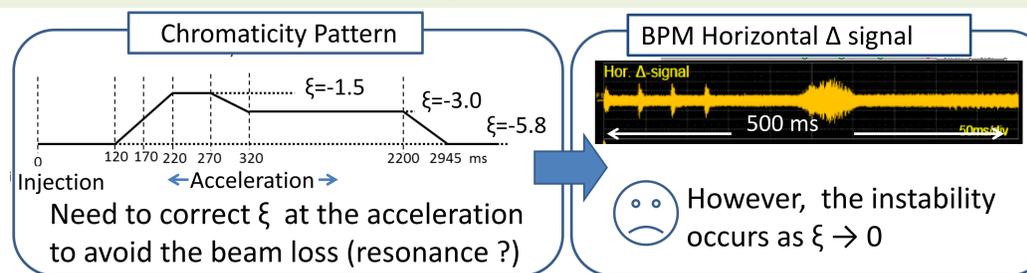
Horizontal position depending on longitudinal position in the single bunch



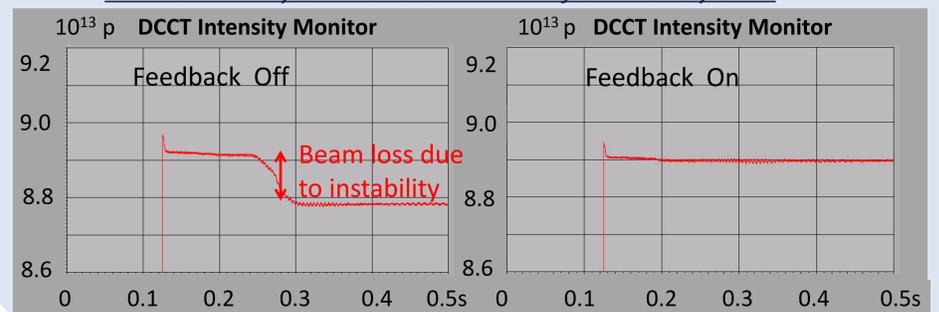
* Data is taken with stripline BPM
* 1000 turns from the injection with 100 turns interval

- ◆ Higher frequency mode appears and the oscillation is localized as time goes on
- ◆ The internal bunch feedback system may be needed to damp such oscillation although this is not severe at the current intensity

5. Instability at Acceleration



Beam intensity with or without the feedback system



The feedback system damps instability !

6. Summary

- ✓ J-PARC bunch by bunch feedback system damps the injection error and instability and reduces the beam loss in MR
- ✓ The system enables J-PARC MR to run the operation at 145 kW