Electron Storage Ring
As a Single Shot Linac Beam Monitor

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NewSUBARU, LASTI,
University of Hyogo

SPring-8, JASRI
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SPring-8, JASRI
Top-Up Operation at NewSUBARU

1998 Continuous beam injection (every 20 seconds)
2003 Top-up injection (constant stored current)

2011 Top-up beam current 220mA → 250mA
2012 Top-up beam current 250mA → 300mA

SPring-8 Linac & NewSUBARU

Energy Compression System (ECS)

Electron Gun

SPring-8 Linac

Booster Synchrotron

Linac-NS BT
Fluctuation of Injection Efficiency

Injection Efficiency (%)

SPring-8 Linac

NewSUBARU

Linac-NS BT

0 20 40 (m)

number of shots

Injection Efficiency (%)
SR5 (Visible Light Monitor Line)
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Bunch Structure and Energy Profile

Dual Sweep Streak Camera Image

123 $\mu$s = 307 turns

ring rf phase
1.27 ns = 230°
Bunch Structure and Energy Profile

Dual Sweep Streak Camera Image

1.27 ns = 230°

Linac rf period

0.35 ns

Front

Middle

Rear

123 μs = 307 turns

Synchronous phase

Ring rf phase

1.27 ns = 230°
Bunch Structure and Energy Profile

Dual Sweep Streak Camera Image

123 μs = 307 turns

Front
Middle
Rear

linac rf period
0.35 ns

injection
Ts/4
bunch structure
energy profile

synchronous phase
ring rf phase
1.27 ns = 230°
Fluctuation of Longitudinal Beam Profiles

Shot-to-shot fluctuation of injection efficiency

A and B had worse efficiency
E and F had good efficiency
Fluctuation of Longitudinal Beam Profiles

50 µs

Front

Middle

Rear

Shot-to-shot fluctuation of bunch structure

Linac rf phase was locked to the ring rf phase
Pulse had two 2 bunches → Pulse width = 0.7 ns
Pulse gate had a timing jitter 0.2 - 0.3 ns?
(Grid voltage pulse of thermionic electron gun)
Fluctuation of Longitudinal Beam Profiles

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Pulse had two 2 bunches $\rightarrow$ Pulse width $= 0.7$ ns
Pulse gate had a timing jitter $0.2$ - $0.3$ns ?
(Grid voltage pulse of thermionic electron gun)
Fluctuation of Longitudinal Beam Profiles

The graph shows the energy profile of the middle bunch with contributions of the front and rear parts. The intensity is plotted against time (ns) and energy displacement (%). The color code for the contributions is as follows:

- Black: front
- Blue: middle
- Red: rear

The labels for the contributions are indicated in the graphs:

- Contribution of the front
- Contribution of the rear
- Energy profile (middle bunch)
Fluctuation of Longitudinal Beam Profiles

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SUMMARY
The injection efficiency had correlation with the bunch structure. As far as we see, the longitudinal acceptance was large enough.

EXPECTED IMPROVEMENTS
We started discussions for a stabilization of the gate timing. The linac energy was raised by 0.4% after the measurement. We are developing control system which enables independent energy tuning, one for the Booster and another for NewSUBARU.

THE NEXT IS
a single shot bunch-by-bunch transverse parameter measurement
Measurement of Vertical Parameters

Light Source Point

\[ \beta_x = 0.7 \text{ m} \]
\[ \beta_y = 17 \text{ m} \]
\[ \eta = 0.052 \text{ m} \]

\[ \Delta E/E = 0.5\% \]
\[ \rightarrow \Delta x = 0.26 \text{ mm} \]
\[ \text{HWHM}^2 = 25\pi \text{nm}^2 \]
\[ \rightarrow \text{FWHM} = 0.26 \text{mm} \]
Measurement of Vertical Parameters

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\[ \Rightarrow \text{FWHM} = 0.26 \, \text{mm} \]
Measurement of Vertical Parameters

Example of single shot data & its analysis

2.5 μs

Front Bunch
Middle Bunch
Rear Bunch
Measurement of Vertical Parameters

Example of single shot data & its analysis

2.5 μs

Front Bunch

Middle Bunch

Rear Bunch
Measurement of Vertical Parameters

Vertical profile
Fitting with Gaussian
Betatron Oscillation
Fitting with sinusoidal function

Measurement of Vertical Parameters

\[ y = A_0 + A_s \sin(2\pi\Delta\nu_y N) + A_c \cos(2\pi\Delta\nu_y N) \]
\[ \sigma^2 = B_0 + B_s \sin(4\pi\Delta\nu_y N) + B_c \cos(4\pi\Delta\nu_y N) \]
Measurement of Vertical Parameters

Reproduce ellipse at the injection point

Normalized phase space of vertical betatron oscillation
Measurement of 20 shots

Fluctuation of bunch charge
Fluctuation of Vertical Parameters

Measurement of 20 shots

Fluctuation of dipole oscillation; $A_c$ & $A_s$
Fluctuation of Vertical Parameters

Measurement of 20 shots

Fluctuation of quadrupole oscillation; $B_c$ & $B_s$
SUMMARY

The transverse (vertical) parameters had a dependence on the bunch structure.
Although we did not identify the source, It is possible that the horizontal has a similar dependence.

THE NEXT

The injection efficiency is less sensitive to the vertical parameter. This was the step for the measurement of more important horizontal parameters.
SUMMARY

We succeeded in the single shot measurement of the bunch-by-bunch ellipse of the vertical betatron oscillation.

However, there exist scope for improvements.

Our better understanding of the injection process and the linac beam parameters would provide an opportunity to solve problems of injection to NewSUBARU in a systematic way.