Motivation

- In SR facilities, High brilliance of X-ray needs small electron-beam emittance
- This leads to short lifetime due to Touchesk effect
- Top-up operation (frequent beam injection with ID gap closed) is one solution to overcome short lifetime
- In this mode, the stored beam should be stable during beam injection
Beam injection

- Injection bump with 14mm height
- Four bump magnets are used with 8.4us half sine waveform

Status before improvement

- Bump is closed at its peak, but...

Measured horizontal amplitude
- beam is injected at peak of bump
- Strengths of bump magnets are adjusted to reduce horizontal oscillation at peak

Measured effective beam size

\[ \sigma^2 = \sigma_0^2 + \sigma_{bump}^2 \]

Horizontal: 110um, 213um
Vertical: 20um, 62um
strategy

- First: find out the error sources
- Second: suppress the error source
- Next: correction is made (feedforward)

Error sources

Horizontal errors

a) Errors in field similarity of four bump magnets

b) Nonlinearity of Sx in the bump orbit

c) Leakage field from septum magnets, charging current of bump PS, Eddy current induced at the vacuum chamber, and so on…
Error sources

**Field similarity**
- Trigger timing and width adjustments
- Difference in undershoot may be from eddy current at end plates

<--- New magnets with non-metallic end plates

\[ \text{Field (arb. unit)} \]

**Non-linearity effect**
- Four Sx magnets (two families) are included in the bump orbit

<--- Drastically improved by adjusting strength ratio of two families

\[ \text{kick (mrad)} \]

H. Tanaka et. al., to be published in NIM
**Error sources**

- **Vertical error**
  - Similar to half sine waveform
  - \( \approx \) tilt of pulse magnets

![Graph showing vertical error](graph.png)

Error kick corresponds to tilts of
BP1: \( 3.8 \text{urad}/2.27 \text{mrad}=1.7 \text{mrad} \)
BP4: \( 1.2 \text{urad}/2.32 \text{mrad}=0.5 \text{mrad} \)

**Corrector**

- **Further correction by feed forward using pulse corrector magnet**
- **Requirements**: complicated correction-waveform with fast rise time and high current
- **Use of Arbitrary Waveform Generator + amplifier**

Vertical correction
\(~1 \text{urad} \rightarrow ~5 \text{A}\)

Horizontal correction
\(~10 \text{urad} \rightarrow ~50 \text{A}\)

- Current amplifier
- Voltage amp + buffer amp
- Vertical corrector is installed at cell 2
- Two turn air-core coil + ceramics chamber
- Current amplifier
  - APEX microtech: PA05
  - 45V 30A 100V/us

Oscillation amplitude is reduced to ~ 1/4
- Horizontal corrector @ cell48
- Two single-turn coil with york voltage amp
  - Yokogawa
  - 10MHz 75V 2A
- Current Buffer amp for each coil
  - MOS FET source follower
  - Full bridge

Corrector (hor)

Oscillation amplitude was reduced to ~ 1/2
Bunch by bunch feedback

Transverse BBF reduces damping time

Summary
Horizontal and vertical oscillations were reduced to 1/10 and 1/5 from initial values
Effective beam size: before and after

No user uses mask signal up to now.

Users are enjoying perturbation free injection

There still remains oscillations

- Sharp peak @ starting part of bump wave

Further correction utilizing pickup of BBF to obtain error kick

- Strip line electrodes --> high resolution with fast response
- Known betatron phase between BBF pickup and corrector magnet
- Response function will be taken near future