Feedforward correction to injection bump error in the SPring-8

JASRI/SPring-8
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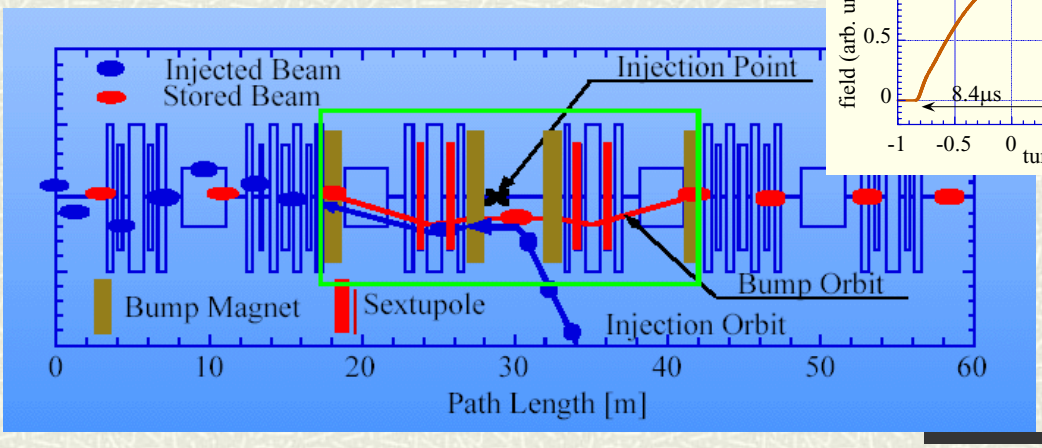
IWBS2004, 07 Dec. '04, Grindelwald, Switzerland

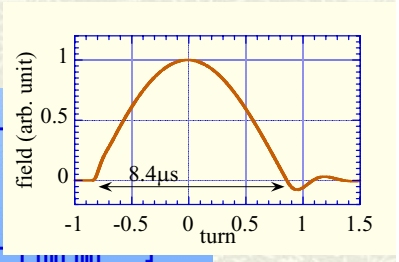
Motivation

- 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





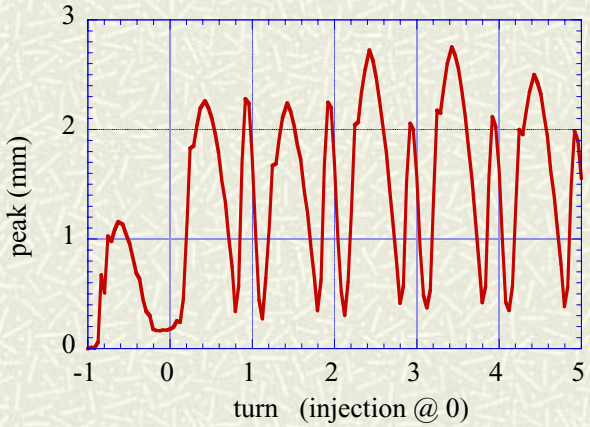
Status before improvement

- Bump is closed at its peak , but…

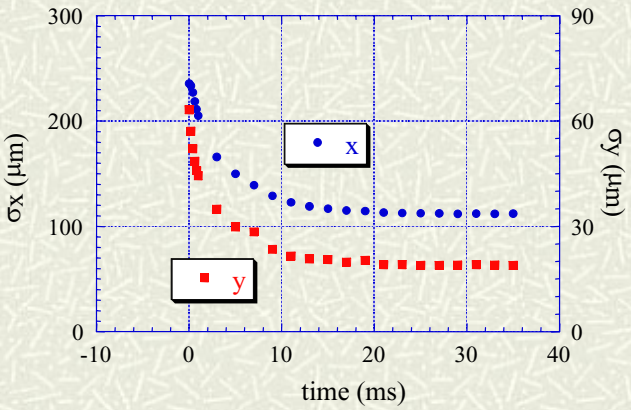
Measured horizontal amplitude

• beam is injected at peak of bump

•Strengths of bump magnets are adjusted to reduce horizontal oscillation at peak



Measured effective beam size



	σ_0	σ_{bump}
Horizontal	110um	213um
Vertical	20um	62um

$\sigma^2 = \sigma_0^2 + \sigma_{bump}^2$

strategy

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

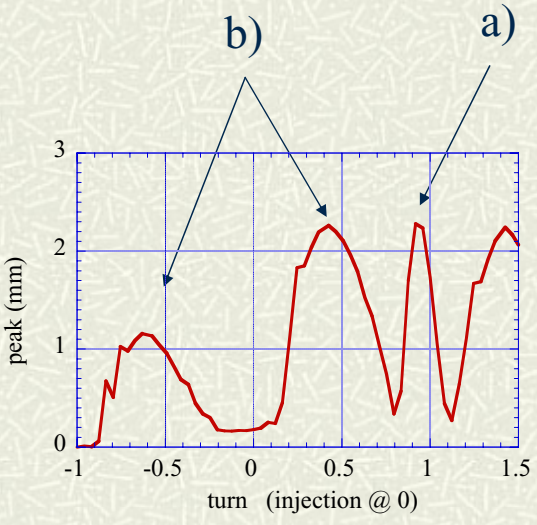
Error sources

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…

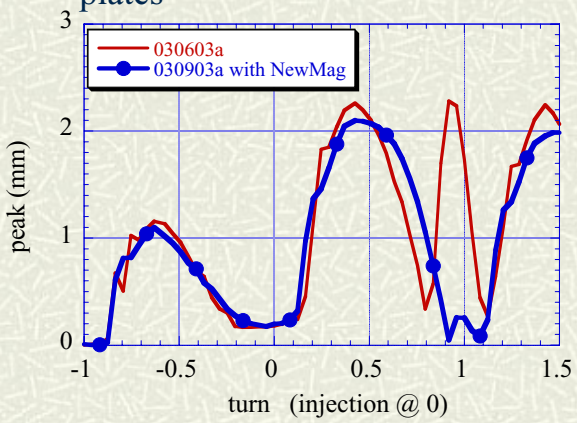


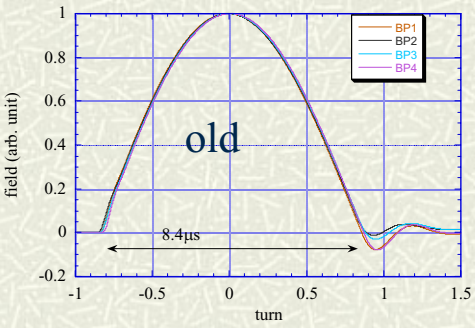
Error sources

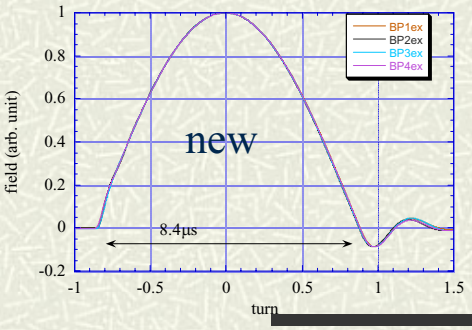
- Field similarity
  - Trigger timing and width adjustments
  - Difference in undershoot

  may be from eddy current at end plates

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

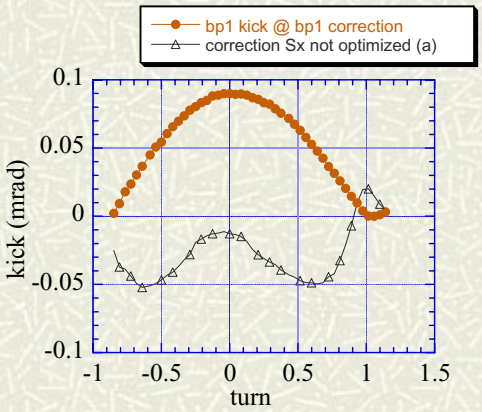


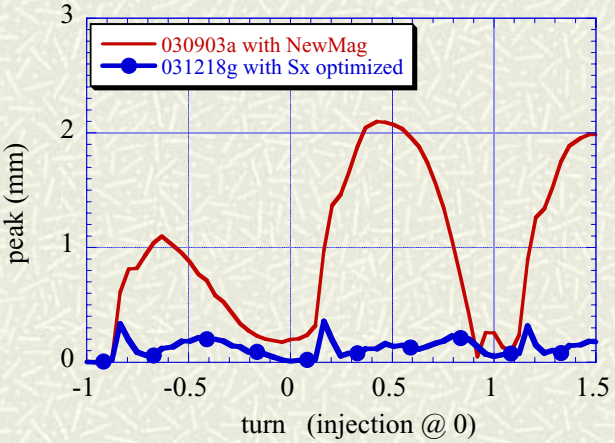




Error sources

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





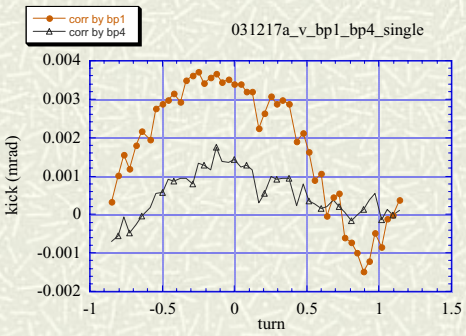
<---Drastically improved by adjusting strength ratio of two families

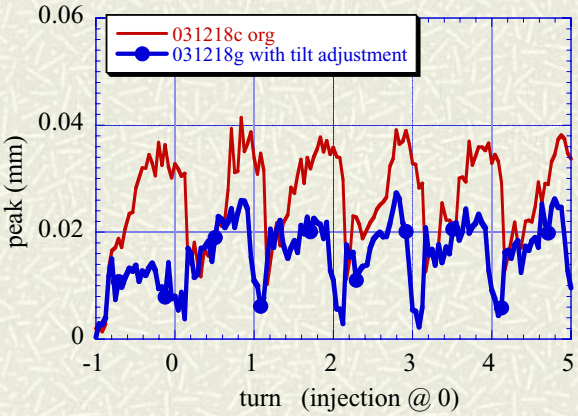
H. Tanaka et. al., to be published in NIM

Error sources

- Vertical error
  - Similar to half sine waveform

<-- tilt of pulse magnets





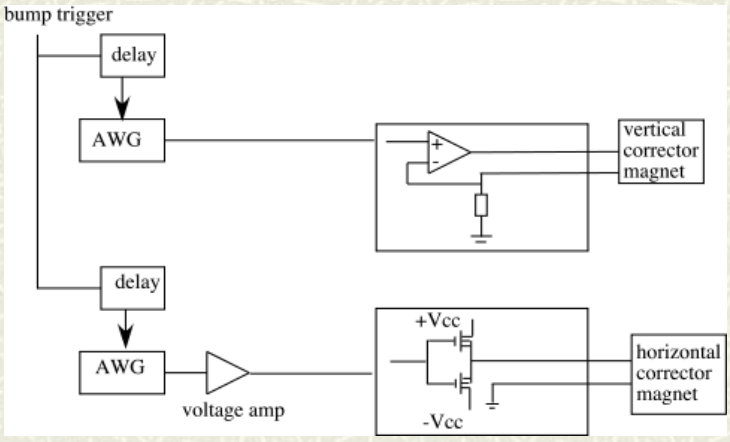
Error kick corresponds to tilts of

BP1 3.8urad/2.27mrad=1.7mrad

BP4 1.2urad/2.32mrad=0.5mrad

Corrector

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



Vertical correction

~1urad --> ~5A

current amplifier

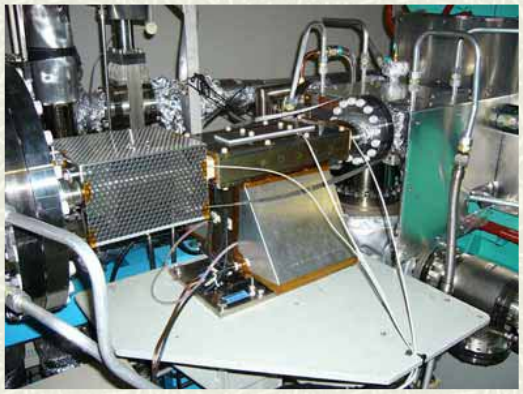
Horizontal correction

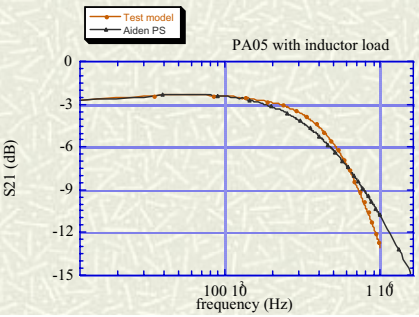
~10urad --> ~50A

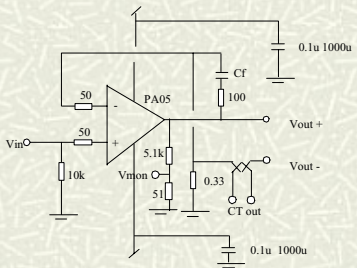
voltage amp + buffer amp

Corrector (ver)

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

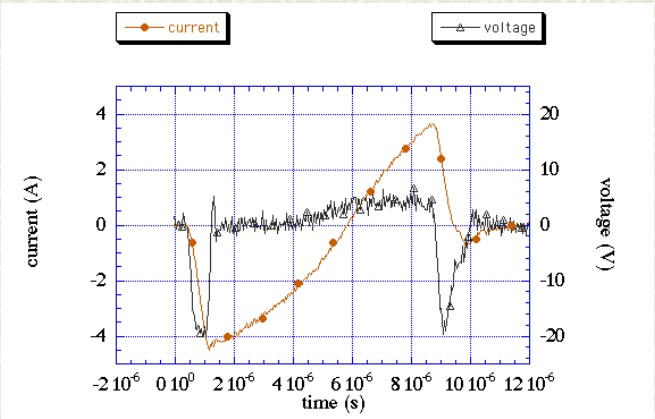


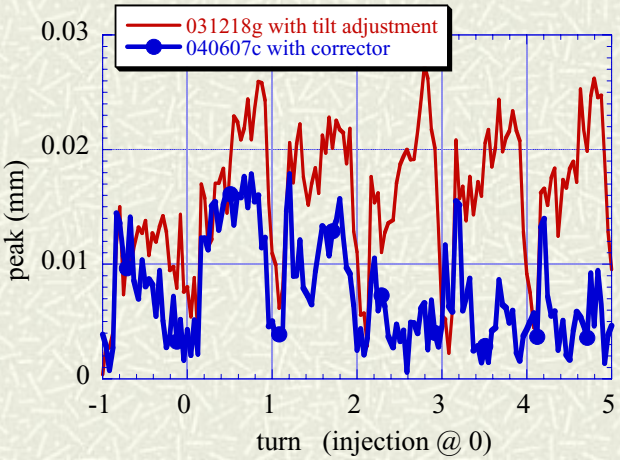




Corrector (ver)

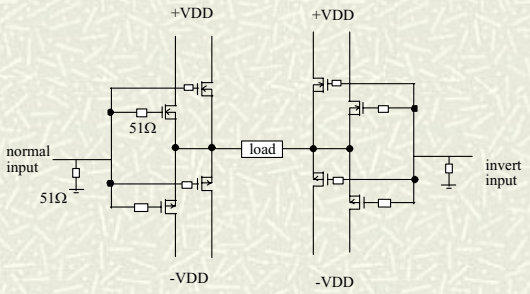
- Oscillation amplitude is reduced to ~ 1/4





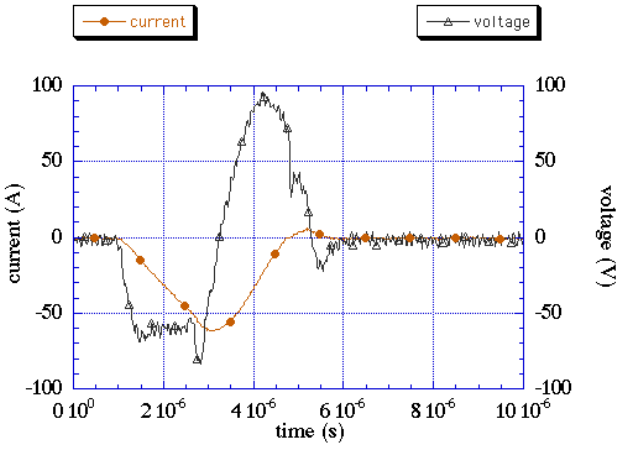
Corrector (hor)

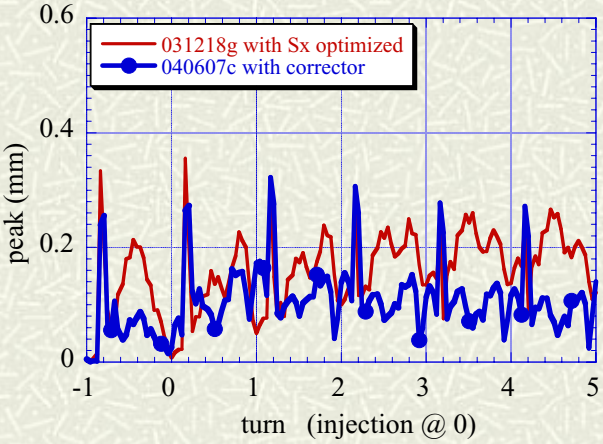
- Horizontal corrector @ cell48
- Two single-turn coil with york
- Voltage amp
  - Yokogawa
  - 10MHz 75V 2A
- Current Buffer amp for each coil
  - MOS FET source follower
  - Full bridge



Corrector (hor)

- Oscillation amplitude was reduced to ~ 1/2

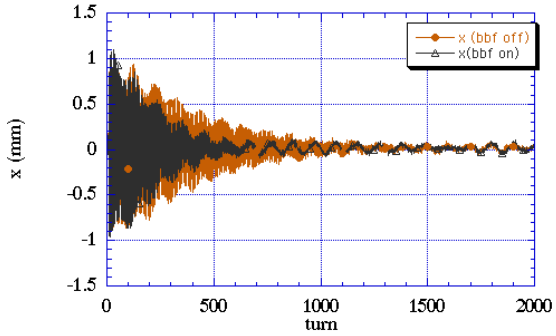


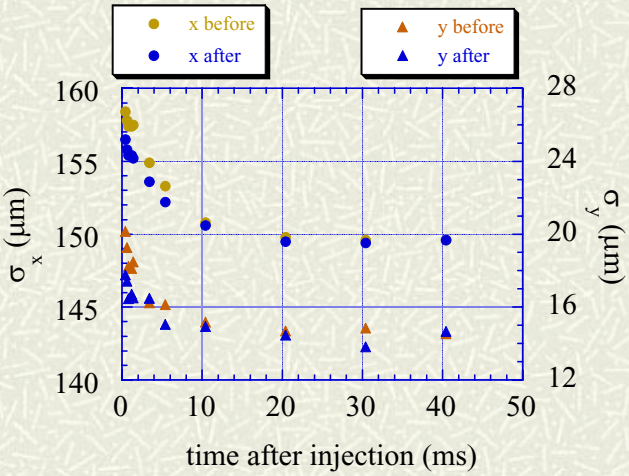


Bunch by bunch feedback

- Transverse BBF reduces damping time

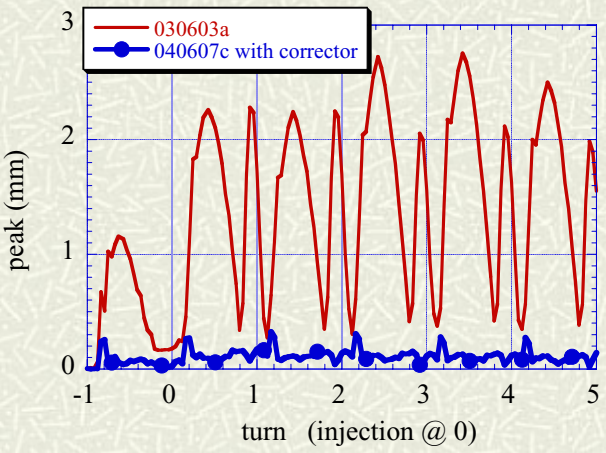
T. Nakamura, et. al., proc. of EPAC04 (2004) p.2646

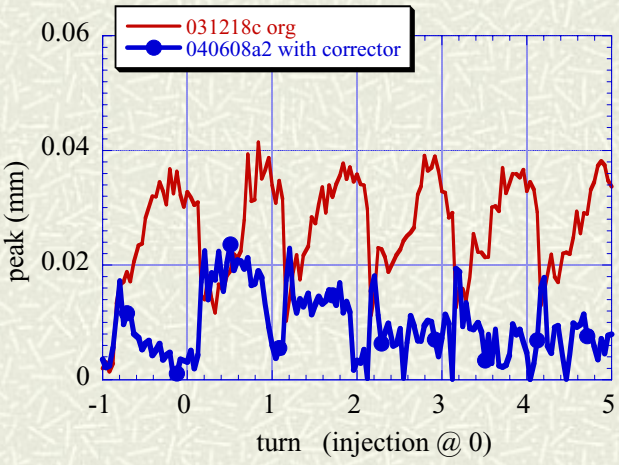




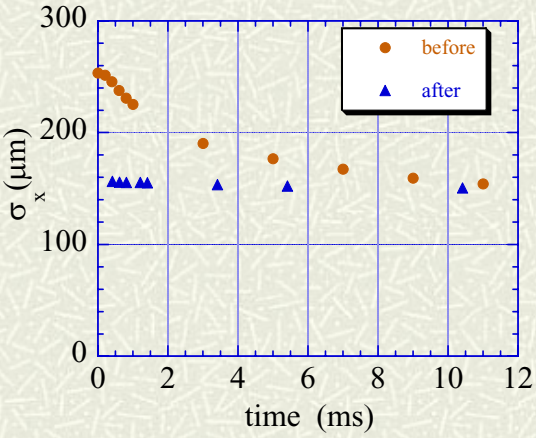
Summary

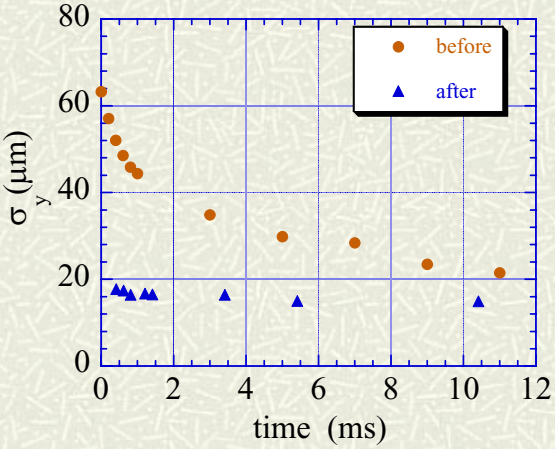
- Horizontal and vertical oscillations were reduced to 1/10 and 1/5 from initial values





- 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