

Slow Global Orbit Feedback at Pohang Light Source (PLS)

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1

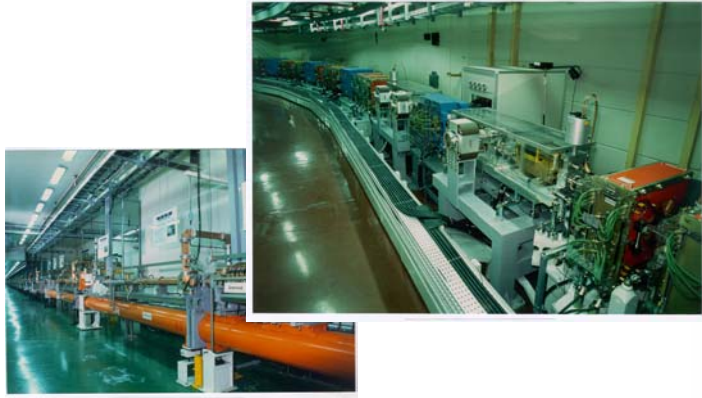


Brief History of PLS

1 Project started	Apr. 1	1988
1 Ground-breaking	Apr. 1	1991
1 2-GeV Linac commissioned	Jun. 30	1994
1 Storage ring commissioned	Dec. 24	1994
1 User's service started	Sept. 1	1995
1 Energy ramping to 2.5 GeV	Sept. 1	2000
1 2.5-GeV injection	Nov. 1	2002

2

2.5 GeV Linac / Storage Ring

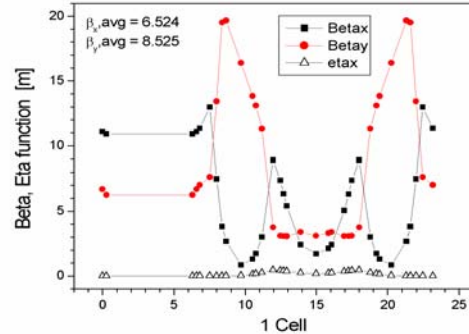


§ Beam Energy	2.5GeV
§ Beam Current	200mA
§ Lattice	TBA
§ Superperiods	12
§ Circumference	280 m
§ Emittance	18.9 nm-rad
§ Tune	14.28 / 8.18
§ RF Frequency	500 MHz
§ Energy spread	8.5×10^{-4}

PLS Orbit Stability Requirements

<1% x-y coupling>

	Beam Size		Orbit Stability	
	Horizontal	Vertical	Horizontal	Vertical
Bending Magnet	230 μm	24 μm	23 μm	2.4 μm
Insertion Devices	455 μm	35 μm	45 μm	3.5 μm



3

Orbit Feedback

q Slow global orbit feedback (SOFB)

Improvement of Power Supplies

§ V: 12 bit -> 20 bit resolution (22 ea)

New power supply with the **controller developed in BESSY II**

§ H: 12 bit -> 16 bit (22 ea)

modification of existing power supplies

Operational since October **2004**

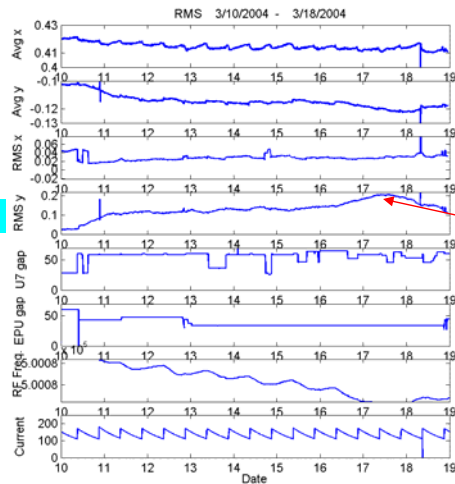
§ Feedback Speed: 4 sec

§ **SVD algorithm, MATLAB / EPICS**

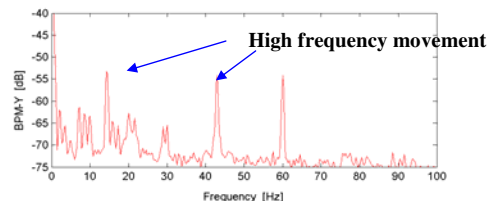
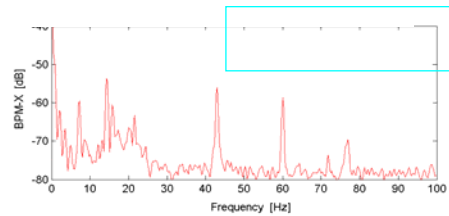
§ Feedforward correction for ID is under test

q Fast global orbit feedback (FOFB)

Under consideration

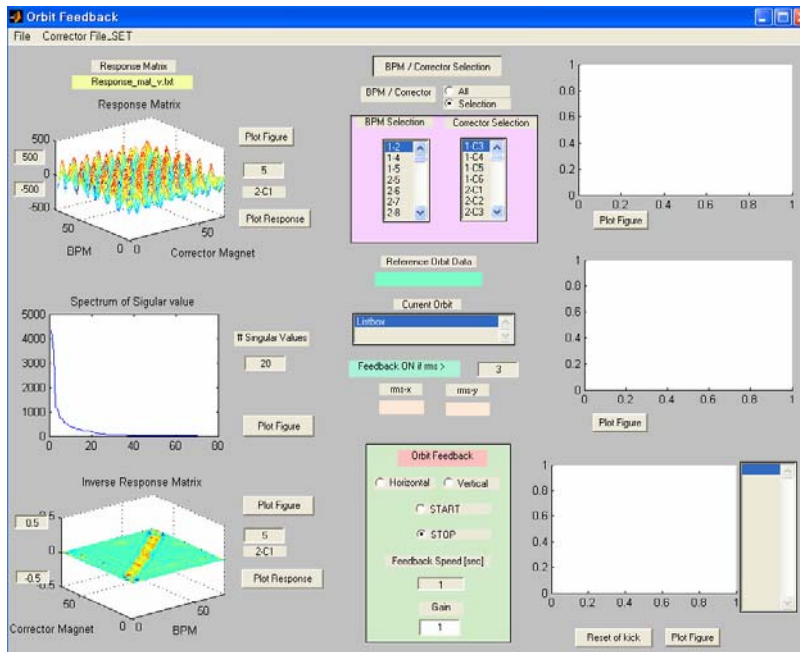


March 2004,
w/o SOFB
For 9 days



4

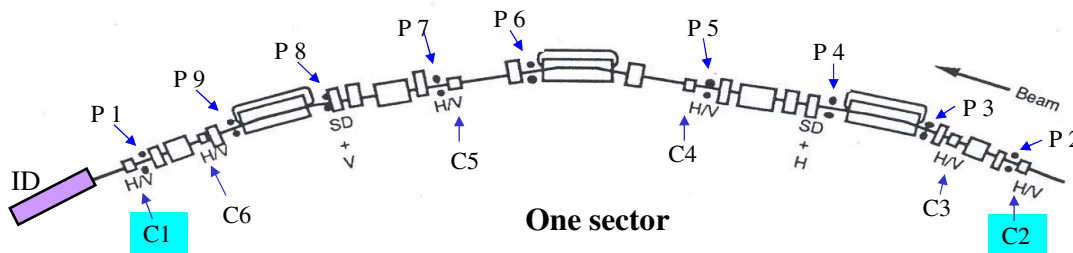
MATLAB GUI for Slow Global Orbit Feedback



- § The orbit feedback algorithm uses the SVD (singular value decomposition) method.
- § Use the Matlab Channel Access to EPICS IOC of BPMs and correctors
- § The GUI displays the response matrix, the spectrum of singular values, the real time orbit, and the correction kick.

5

Correctors and BPMs for SOFB



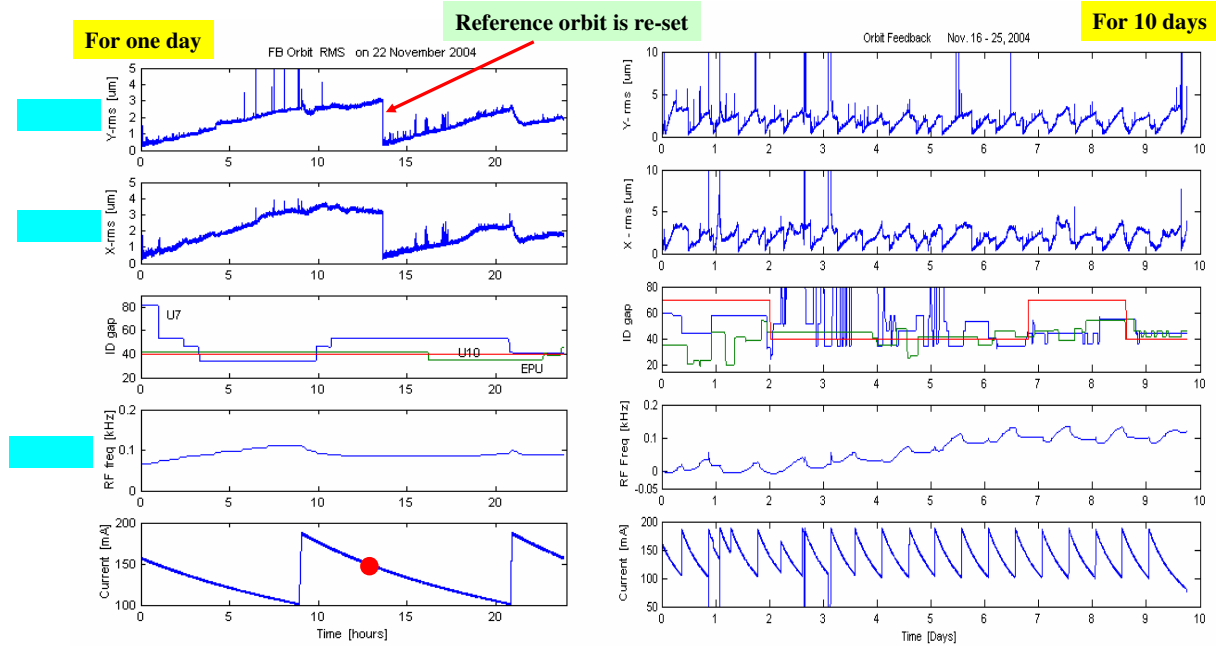
- 9 BPMs & 6 Correctors /sector Totally, 108 BPMs and 70 correctors in each plane
- BPM electronics: Bergoz MUX BPM
- Insertion Devices (6)
 - Undulator: U7, EPU6, U10, In-Vacuum Revolver (min. gap: 5 mm)
 - Multipole Wiggler: HFMX, HFMS

u **SOFB uses**

- 2 correctors (C1 & C2) / sector -> 22 correctors in each plane
- 6 BPMs / sector
- Current dependence table for BPM electronics

Horizontal plane: 16 bit resolution -> 0.06 μ rad/ 1 bit
 Vertical plane: 20 bit resolution -> 0.004 μ rad/ 1 bit

6



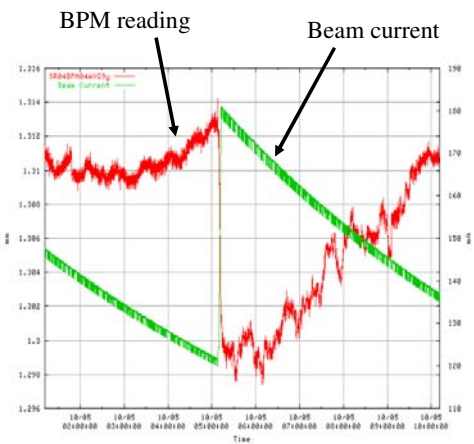
Reference orbit is re-set at 150 mA after refill.
 Current dependence data of BPM electronics is referenced to the BPM reading at 150mA

1. The number of correctors is not enough for correction
2. To effectively compensate the BPM electronics' current dependence

False BPM Reading

- BPM Reading
 - 1) Real Beam Position change
 - 2) BPM Electronics' dependence on Ambient temperature
 - 3) BPM Electronics' dependence on Beam current
 - 4) Chamber movement

2 μm



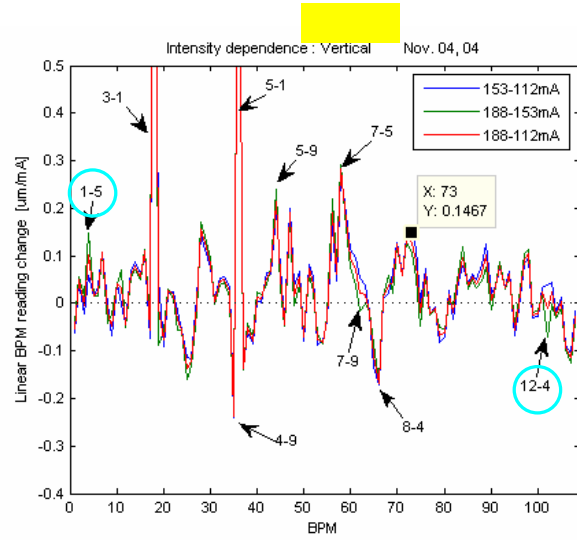
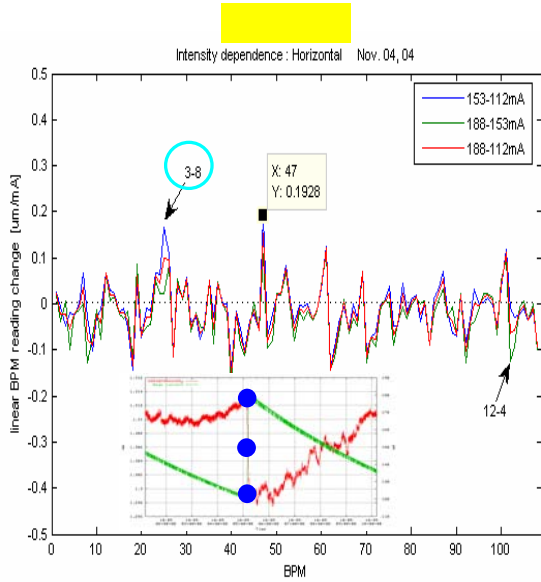
Current Dependence table is used to subtract the false value from the BPM reading for SOFB

But, chamber movement is not compensated.

- BPM electronics problem: Gain drifts and non-linearities

- u Compensation of false BPM reading is absolutely necessary in order to minimize the false motion by orbit feedback.
- u Ambient temperature dependence can not be compensated, thus should be minimized.

Beam Current Dependence of BPM electronics



BPM reading change between 120mA and 180mA

(not include the bad BPMs)

X - rms : 2.9 μm

Y - rms : 5.0 μm

Non-linearity of current dependence

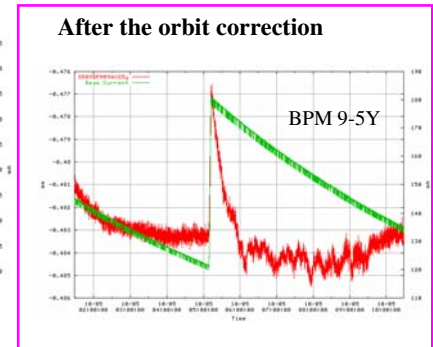
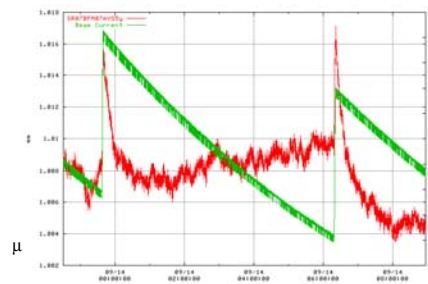
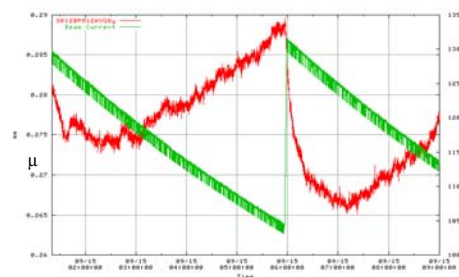
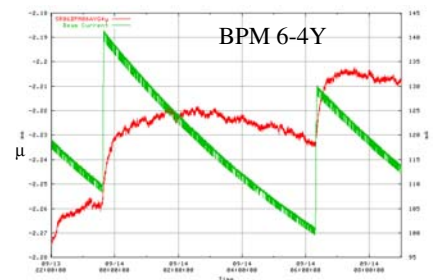
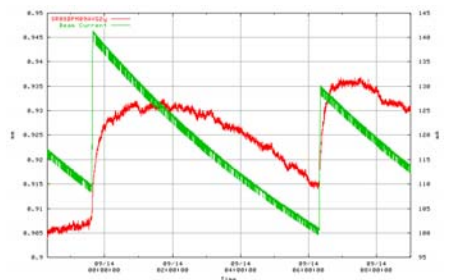
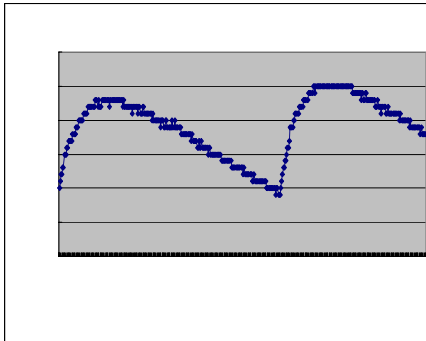
§ Different Change rate of current dependence

low current range: 153 – 112 mA (blue line)

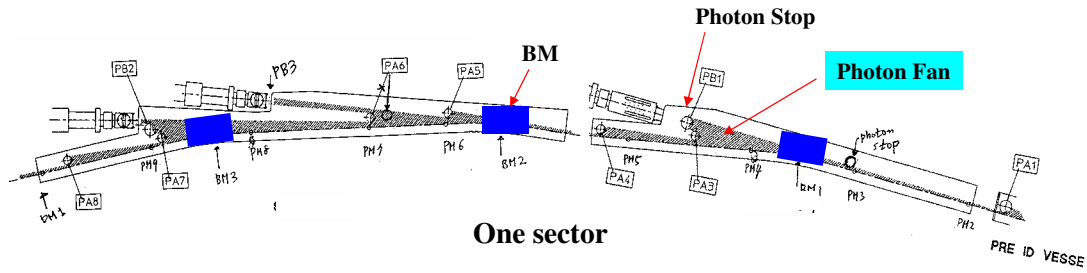
high current range: 188 – 153 mA (green line)

§ Current Dependence table for SOFB : red line (188-112mA)

Temperature of Vacuum Chamber in straight section (Sep. 14 – 15, 2004, **Bad Orbit condition**)



BPM Chamber Movement



vacuum chamber moves due to the change of synchrotron radiation heat load

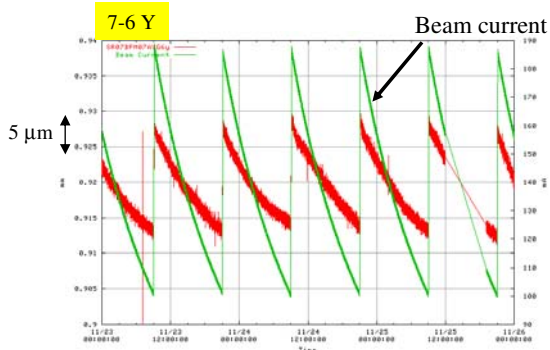
dependent on orbit

Look-up table is not easy to implement.

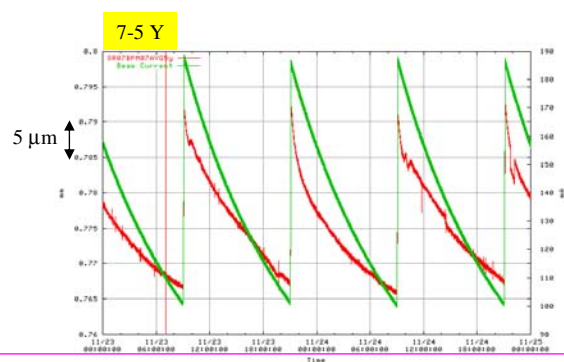
	2.0 GeV	2.5 GeV	2.5 GeV
	400 mA	200 mA	250 mA
Synchrotron radiation power	115 kW	128 kW	161 kW
Photon power / sector	9.6 kW	10.6 kW	13.4 kW

Change of BPM Reading in SOFB

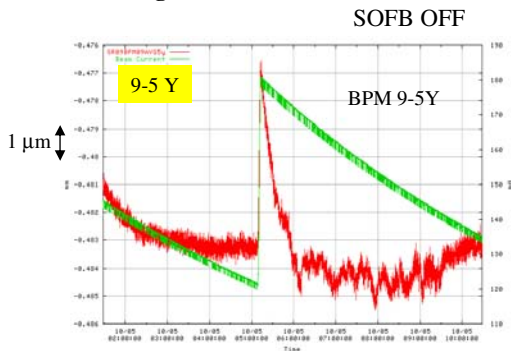
BPM with a negligible chamber movement



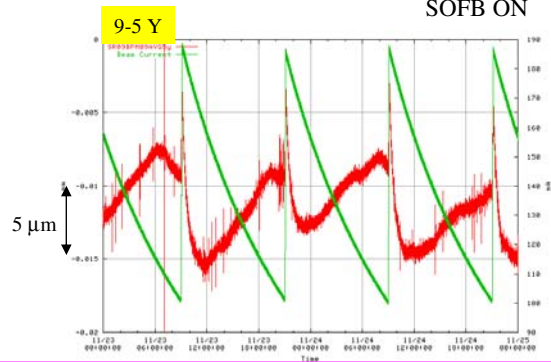
BPM with a small chamber movement



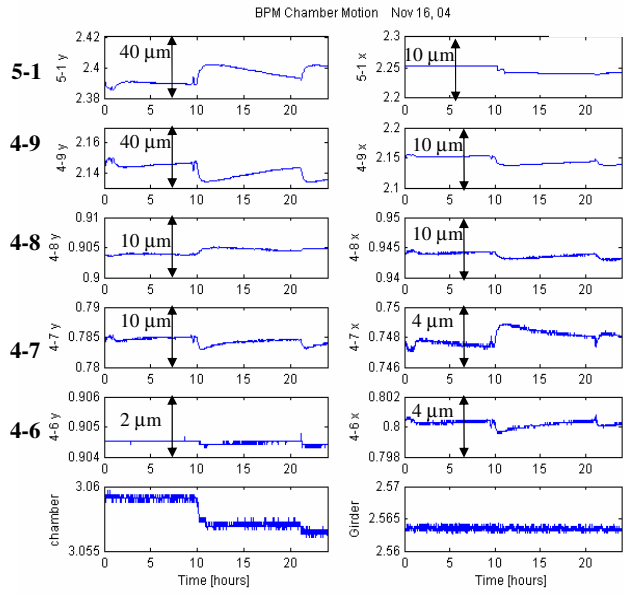
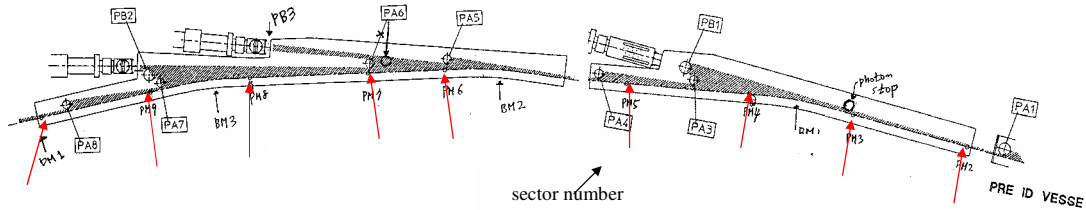
BPM with a large chamber movement



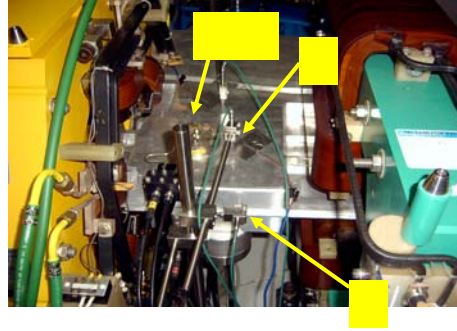
SOFB ON



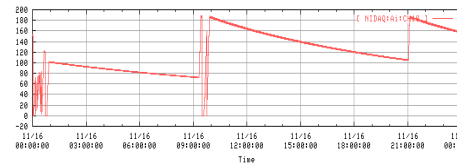
Measurement of BPM Chamber Movement



Digital Position sensor (accuracy: < 100 nm)

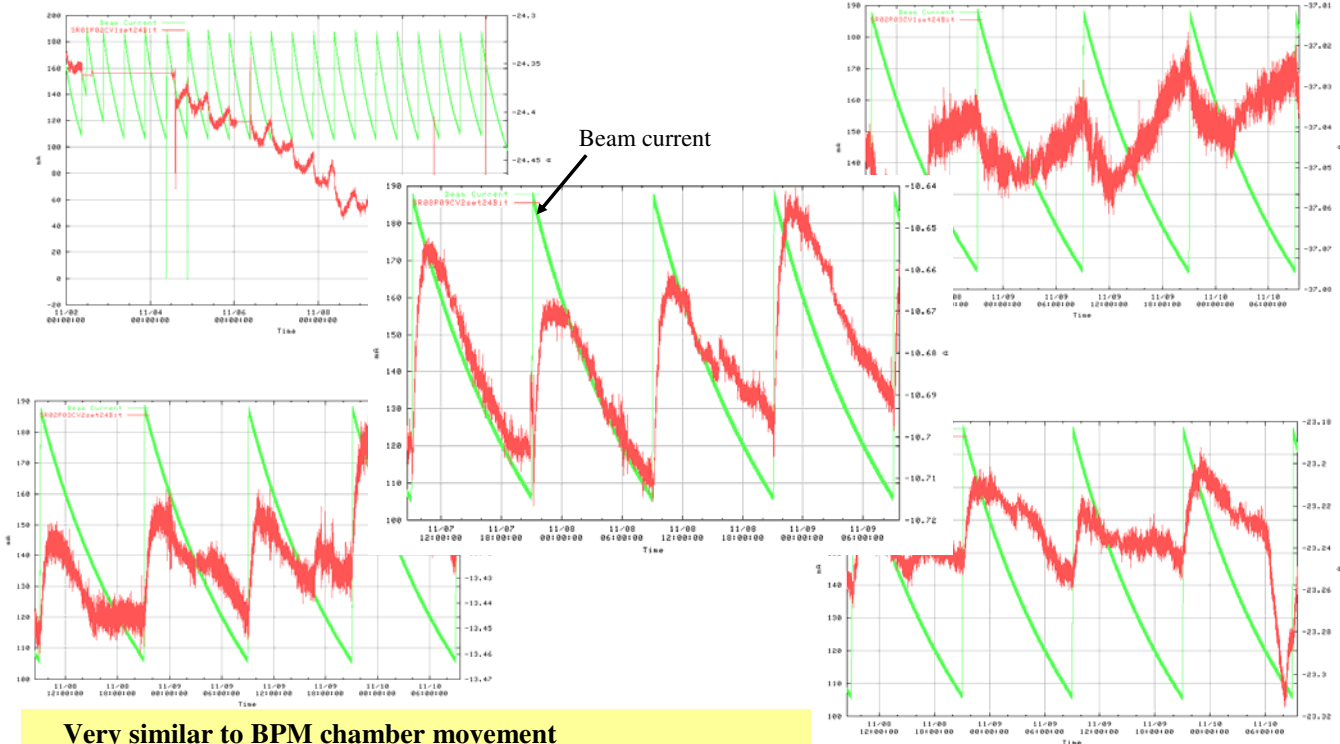


Beam Current @ 2.5 GeV



13

Variations of Corrector Currents in SOFB

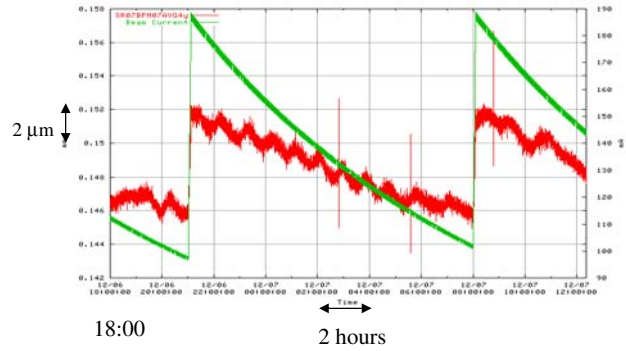
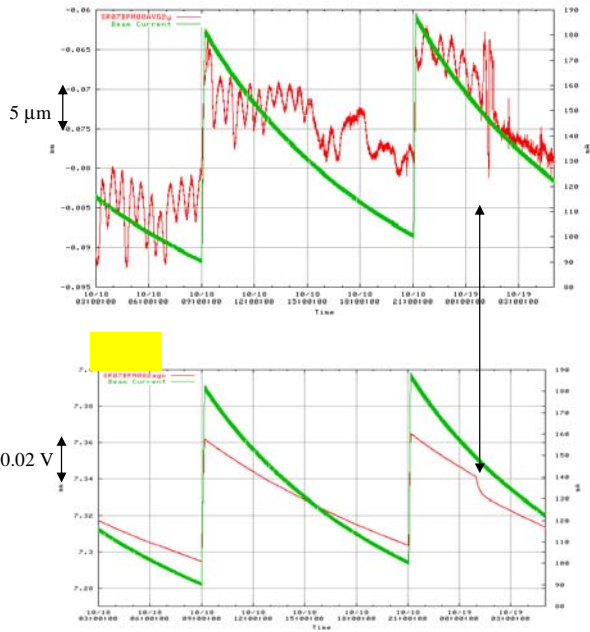


Very similar to BPM chamber movement
 BPM electronics' current dependence looks compensated well.

14

Ambient Temperature Dependence of BPM Electronics

BPM reading oscillation)



18:00

Dec. 6

The same oscillation was observed in the ambient air temperature in the control shed where the BPM electronics is.

BPM electronics Must be influenced by the ambient temperature.

One BPM electronics module shows

Dependence on Ambient temperature : $1.4 \mu\text{m} / ^\circ\text{C}$

Ambient temperature in control shed should be well controlled.

15

BPM's intensity Dependence limits the SOFB performance.

Solution is TOP-UP!

BUT, Decided not to use it until

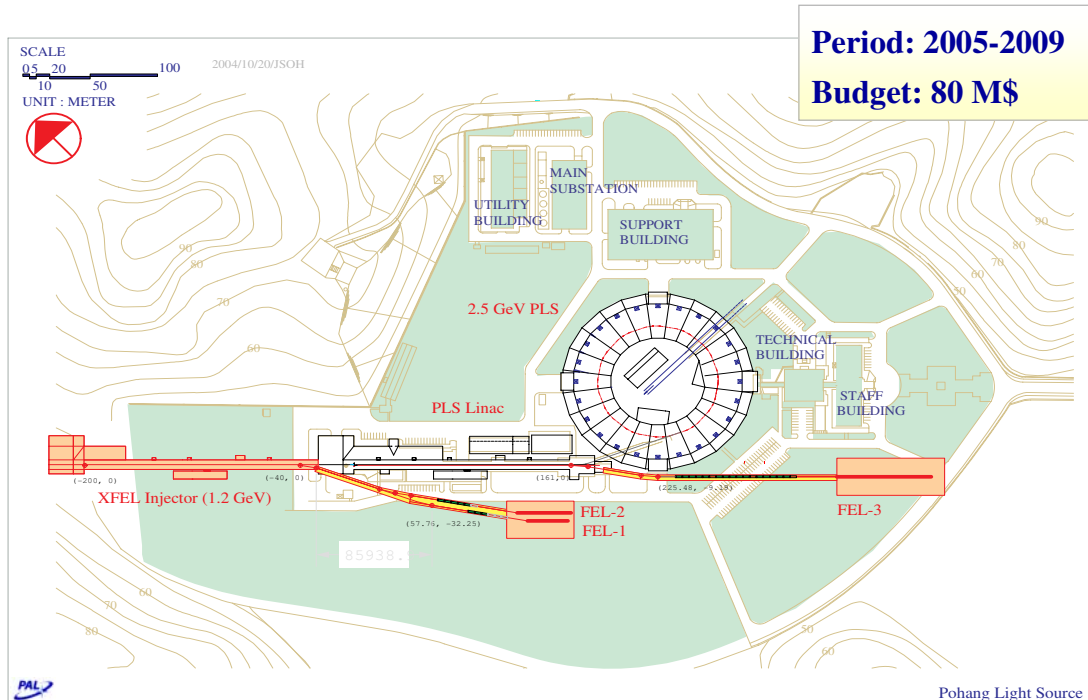
Because

1. For Linac, Injection efficiency is not so good compared to Booster.

Synchronization of RF between SR and Linac is required.

2. We will start SASE-FEL project in 2005.

No. 1 Priority of Linac is changed...



17

How to Compensate Chamber Motion in SOFB

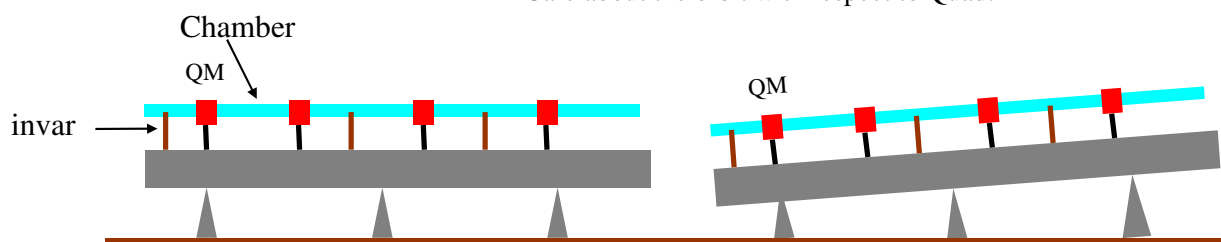
Real-time measurement of BPM Chamber Motion for all BPMs (108 ea) by Digital position sensor or LVDT (**Budget allocated in 2005**)

Chamber position is monitored with respect to Girder, which is equivalent to Quad because Girder is very rigid.

EPICS Database

Compensate the chamber motion from BPM reading in SOFB (data refresh time : 1-3 minutes)

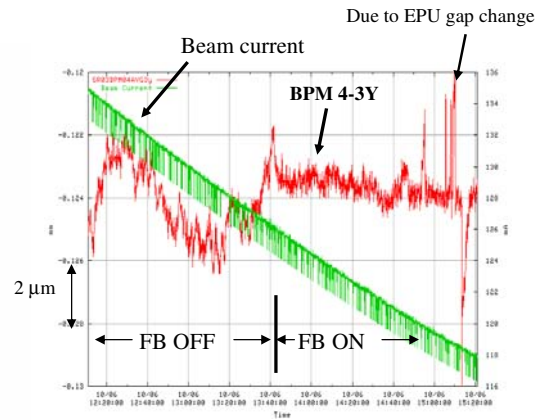
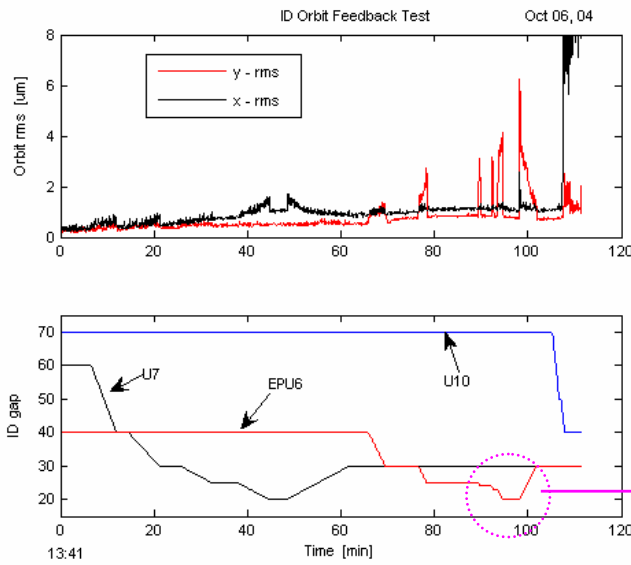
- ∨ Neglect the Girder motion with respect to ground, and the Girder to Girder differences
- ∨ Quad does not move as the Beam loading changes.
- ∨ Care about the orbit with respect to Quad.



18

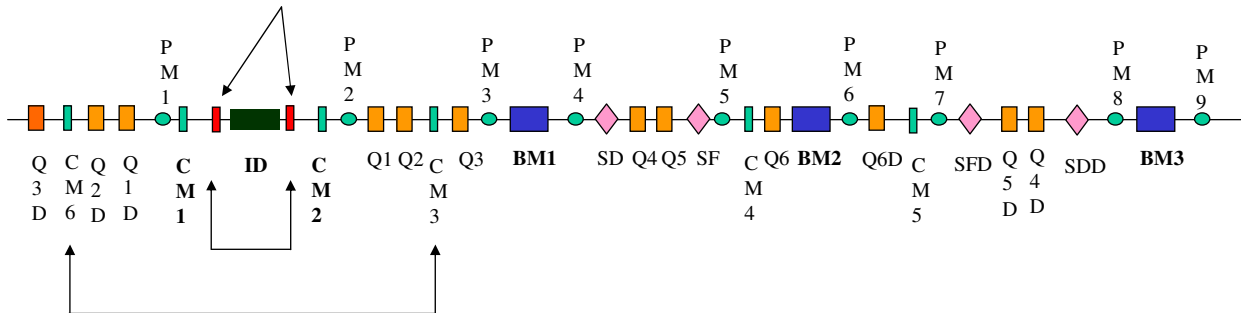


SOFB for Insertion Device



- Vertical orbit changes up to 6 μm in rms when the EPU gap is moving between 20 and 25 mm.
- Feedforward correction is required.

H: 16-bit correctors
V: 20-bit correctors



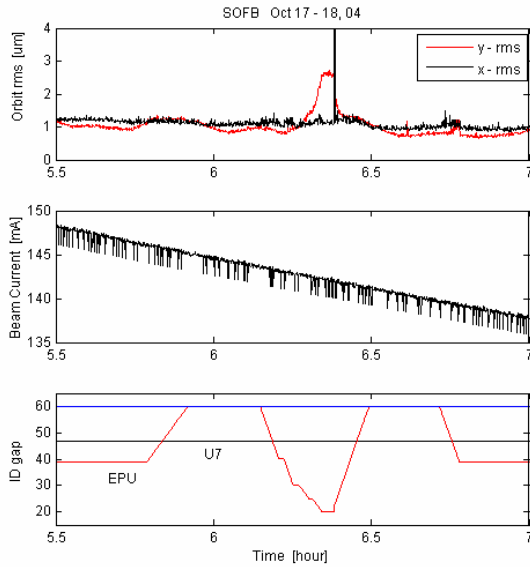
correctors: 1CM6 and 2CM3 just done for test

New correctors for Feedforward ready for test

- speed: 10 Hz

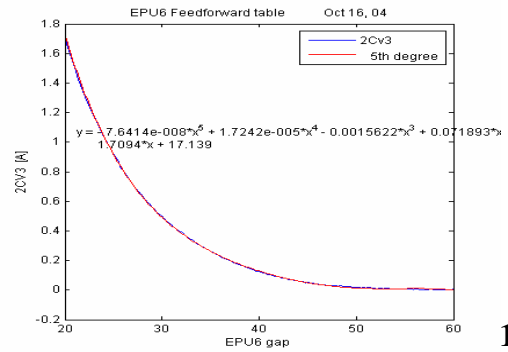
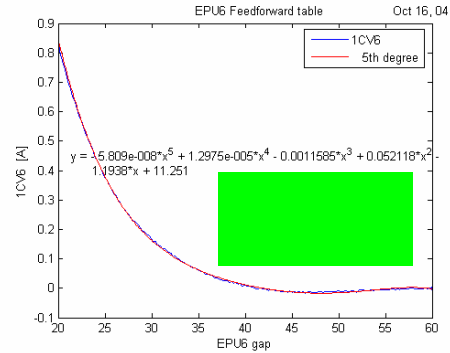
EPU6 Feed-forward Correction

Vertical correctors: 1CM6 and 2CM3



Feedforward speed: 10 Hz

Feedforward table



1

Summary

- 1 Achieved orbit stability by SOFB
 - short term (1 hour) : $< 1 \mu\text{m}$
 - long term (12 hours) : $< 3 \mu\text{m}$
- 1 BPM Chamber movement due to Synchrotron Radiation heating mainly limits the SOFB performance.

Improvement Plan of SOFB in 2005

- 1 Real-time measurement of BPM Chamber Motion for all BPMs (108 ea)
- 1 Reduction of BPM Noise
 - Feedback speed : 4 sec 2 sec
- 1 70 correctors in vertical plane 20-bit resolution