# COMPENSATION OF BPM CHAMBER MOTION IN PLS ORBIT FEEDBACK SYSTEM*

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*Abstract*

The false BPM reading resulting from the BPM vacuum chamber motion due to thermal load change by synchrotron radiation is compensated by the real-time monitoring of the chamber position in the PLS orbit feedback system. The BPM chamber moves up to 20 $\mu$m during the beam refill and the chamber motion has a time constant of about one and half hour, which is related to thermal equilibrium of the vacuum chamber. To monitor the BPM chamber motion, LVDTs with 0.2 $\mu$m reading accuracy were installed on all BPM chambers, and the measured data are used in the orbit feedback every 1 minute. In this paper, we will describe how serious the BPM chamber motion are and how well it is compensated.

## INTRODUCTION

BPM that is an essential part of orbit feedback system is affected by the false measurement, which causes to move the beam in the wrong direction under the orbit feedback run so that the false BPM readings should be reduced or well compensated by appropriate methods.

The false reading of BPM comes from the BPM electronics' dependence on ambient temperature, beam current, bunch-fill pattern, and the BPM chamber motion [1] . Compensation of the BPM false reading is absolutely necessary in order to minimize the wrong motion of electron orbit by orbit feedback itself. The calibration data of current dependence of the BPM electronics is used to subtract the false values from the BPM readings in the orbit feedback. The vacuum chamber on which the button-type BPMs are mounted moves horizontally and vertically due to the change of synchrotron radiation heat load, which is also dependent on the electron orbit. In NSLS, the measured vertical motion of the vacuum chamber was less than 20 $\mu m$ and the horizontal motion less than 100 $\mu m$ [2]. The BPM electronics seems to be influenced by the ambient temperature in the control shed where it is located. The ambient temperature dependence of the BPM electronics is difficult to compensate by a kind of calibration table, thus should be minimized. One BPM electronics module shows the dependence on ambient temperature of 1.4 $\mu$m/ °C. Therefore, the ambient temperature in control shed should be well controlled below 0.5 °C.

PLS is a 3-rd generation light source where the electron beam is re-filled twice a day from the 2.5GeV electron linac. The magnet lattice is a triple bend achromat with 12 superperiods. Typically, the beam is refilled from 125 mA to 190 mA.

Figure 1 shows how big the vertical reading change of a BPM when the beam is re-filled. The values of reading changes are different for each BPM which seem to be dependent on the beam positions at each BPM.

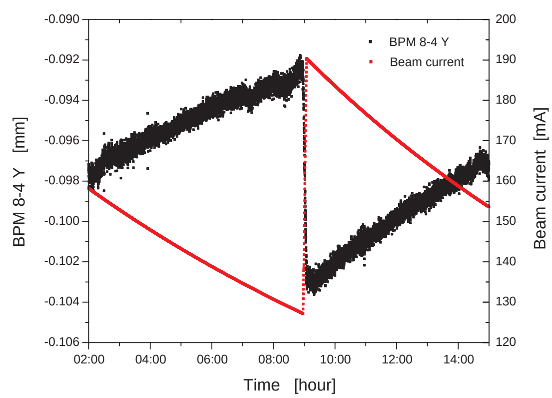


Figure 1: The vertical reading change of a BPM when the beam is re-filled. The red line represents the beam current.

Figure 2 shows the current change of one specific vertical corrector (4CV2) used in the orbit feedback for two days without the compensation of BPM electronics gain as

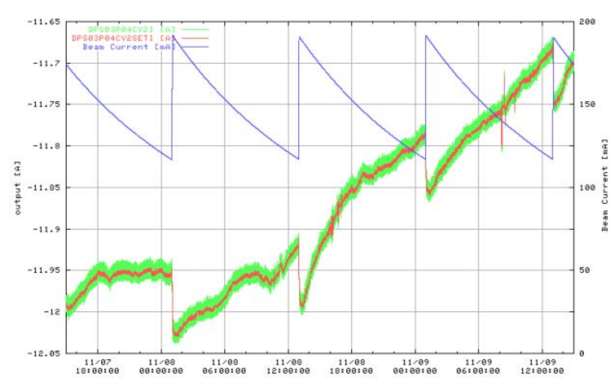

Figure 2: The current change of one specific vertical corrector (4CV2) used in the orbit feedback for two days without the compensation of BPM electronics gain. The blue line, the red line, and the green line represents the beam current, the set value of MPS, and the reading value of MPS, respectively.

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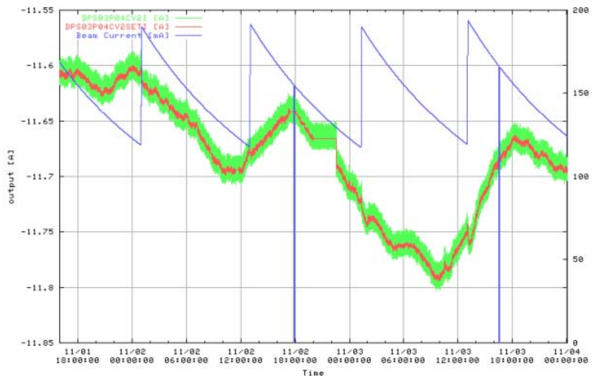

Figure 3: The current change of one specific vertical corrector (4CV2) used in the orbit feedback for two days with the compensation of BPM electronics gain.

a function of beam current. During the beam refills, corrector magnet current changes sharply, similar to the BPM reading change shown in Figure 1. It means there must be a mis-guidance of orbit due to false reading of BPM. On the other hand, in the case of applying the compensation (see Fig. 3), the corrector current does not show a rapid change just after the beam refill as the BPM reading does in Fig. 1, which means that the BPM electronics' current dependence is compensated well.

Even though the orbit stability is maintained below a few $\mu$m, we have observed the vertical position change of about 10 $\mu$m in a photon BPM at the beamlines after the current refill. We found that the BPM chamber motion is not negligible, which makes the correctors in the feedback be driven to the wrong direction.

## MEASUREMENT OF BPM CHAMBER MOTION

Figure 4 depicts the layout of PLS one cell. The number of BPM is 9 per cell and totally 108. Each cell has two sector vacuum chambers. The vacuum chamber on which the button-type BPMs are mounted is a 10-meter long, huge tank with many photon stops. BPM 4-2, 4-3, 4-4, 4-5 are mounted on sector chamber 1 and the others on sector chamber 2. In the figure PA and PB represent the photon stop. To measure the BPM chamber motion, linear voltage displacement transducers (LVDT) are installed on top of the BPM in the horizontal and vertical direction.

Figure 5 shows the measured vertical motion of the BPM vacuum chamber while the stored beam current changed for 36 hours. In the figure the beam was re-filled three times. The first and second refill is from 130 mA to 190 mA. The chamber near BPM 4-5 shows a biggest vertical position change of 10 $\mu m$ after the refill, the second largest one is BPM 5-1 with 7 $\mu m$, and the third one is BPM 4-9 with 2 $\mu m$. Others show a negligible change. It takes about one hour for the chamber motion to reach the peak. It turned out that the largest moving point is near the

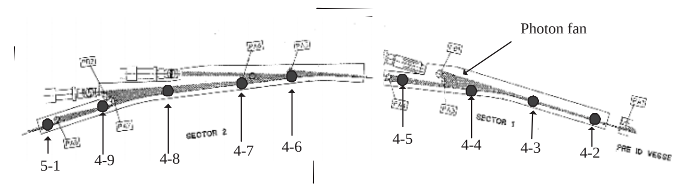


Figure 4: Two sector vacuum chambers in one cell. BPM 4-2, 4-3, 4-4, 4-5 are mounted on sector chamber 1 and the others on sector chamber 2. PA and PB represent photon stop. BPM naming convention is explained in Fig. 3.

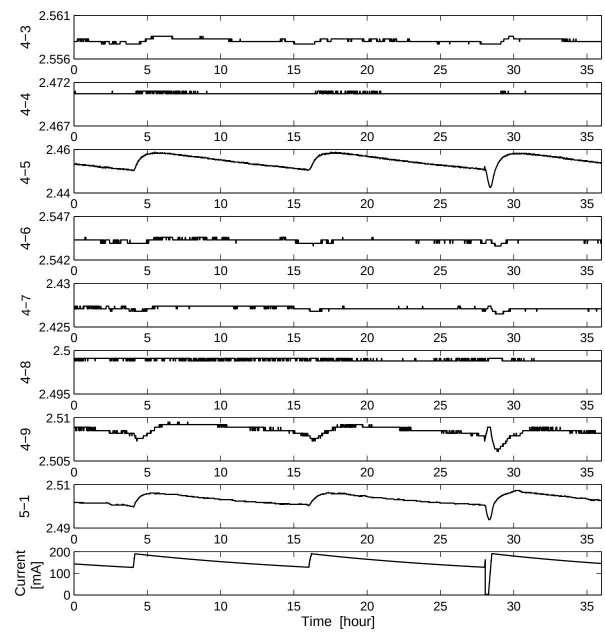


Figure 5: The measured vertical motion of vacuum chamber near BPM as the stored beam current changes for 36 hours. The vertical full scale in the graphs of BPM 4-5 and 5-1 is 20 $\mu m$, others 5 $\mu m$.

downstream end of the vacuum chamber in the direction of BPM, BPM 4-5 and 5-1, as expected. The chamber motion pattern looks very repetitive until the third refill when the beam was OFF for about 15 minutes and then refilled from zero current to 190 mA. During the beam-loss time the chamber motion became unstable, and a rapid drop of up to 10 $\mu m$ occurred.

## COMPENSATION OF BPM CHAMBER MOTION

It is practically impossible to use a kind of look-up table for compensation of chamber motion because the chamber motion is very non-linear and becomes uncertain if the ther-



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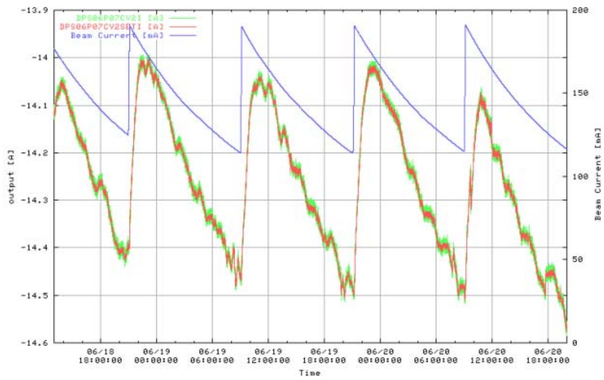

Figure 6: The current change of one specific vertical corrector (7CV2) used in the orbit feedback for two days without the compensation of BPM chamber motion. The definitions of colored lines are the same as in Figure.

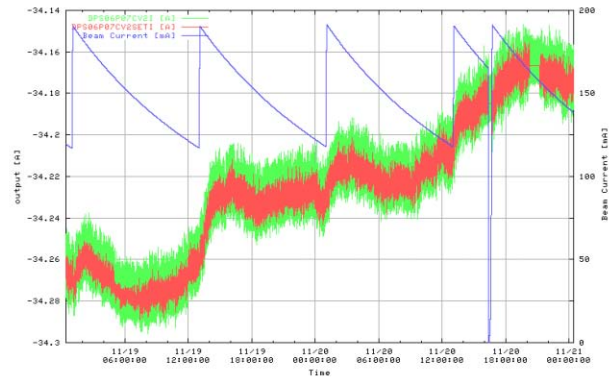

Figure 7: The current change of one specific vertical corrector (7CV2) used in the orbit feedback for two days with the compensation of BPM chamber motion.

mal equilibrium of the vacuum chamber is broken by the rapid change of thermal load like beam loss as seen in Fig. 5. In order to compensate the chamber motion, real-time measurement of the BPM chamber motion for all BPMs (108 ea) by LVDT was completed in 2006. The LVDT sensor is mounted on a 0.5-m long invar support which is fixed on the girder. The chamber position will be monitored with respect to the girder on which the quadrupole magnets are also supported. The BPM chamber position data are recorded in a database with the data refresh time of 1-3 minutes. In the orbit feedback the data will be updated to compensate the chamber motion from the BPM reading.

Figure 6 shows the current change of one specific vertical corrector used in the orbit feedback for two days without the compensation of BPM chamber motion. It looks very similar to the BPM chamber motion with the same time constant described in Fig. 5. The corrector current rises slowly after the beam refill is done as the vacuum chamber position does.

On the other hand, in the case of applying the compensation of BPM chamber motion, the corrector magnet current does not follow the beam current change markedly during beam refills as shown in Fig. 7, which means that the BPM chamber motion is compensated well in the orbit feedback.

## SUMMARY

BPM chamber motion, one of the sources of BPM false reading, could be well compensated by real-time measurement of the BPM chamber motion for all BPMs (108 ea) with LVDT attached onto BPM chamber. Applying the compensation scheme showed a good improvement in orbit feedback performance.

## REFERENCES

[1] H. S. Kang, et al., Proceedings of the 2005 Particle Accelerator Conf., knoxville, USA, p. 847.

[2] J. Safranek, et al., Proceedings of the 1995 Particle Accelerator Conf., 1995.