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LONG-TERM STABILITY OBSERVED BY ELECTRON BPM AND PHOTON BPM FOR TAIWAN PHOTON SOURCE

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Abstract

TPS is 3-GeV synchrotron light source which has opened for public users since September 2016 and now offers 400 mA top-up mode operation. The requirements of the long term orbit stability and orbit reproducibility after beam trip have been gradually more and more stringent and become a challenge from users' request. Furthermore, the thermal effect would be expected to be worsen after 500 mA top-up operation which should deteriorate the orbit drift. The report investigates the long-term orbit stability observed from electron BPM and X-ray BPM and also evaluates the possibility of the local XBPM feedback to improve photon beam stability.

INTRODUCTION

The TPS requires beam position stability of less than 10% of the beam size to provide advanced experimental capabilities at the 3rd generation light source. Therefore, FOFB and RF frequency compensation have been adopted to stabilize the electron orbit [1][2]. Besides, to monitor the position and stability of photon beams, two-blade type X-ray beam position monitors (XBPMs) are installed in beamline frontends and beamlines[3][4]. It is observed that the thermal effect would cause the mid-term orbit disturbance at the first 30 minutes after the beginning of beam stored and long-term slowly drift for the following 4~5 hours before it achieves the equilibrium, especially in the vertical plane. Besides, there are also obvious daily position change along with temperature variations and periodic 4-minutes variation consistent with injection cycle. Furthermore, insertion device (ID) gap/phase change is also significantly affect position stability where it is partly caused by deformation and resulted in BPM mechanics displacement and partly still due to thermal effect. The position drift/fluctuation seemed to be able to be controlled below several microns or even sub-micron in electron BPM. However, the errors would be amplified several times observed at the end of beamline XBPM. This report summarized the long-term orbit drift observed by electron BPM and photon XBPM. The preliminary local XBPM feedback test is also proposed to minimize the errors.

PHOTON BEAM POSITION MONITOR LAYOUT AND ELECTRONICS

There are seven beamline open to users in TPS now. For each beamline, there are different types of X-ray or photon beam position monitors are used to detect the synchrotron radiation. The blade-type X-ray BPMs (XBPM) [3] is standard equipment installed at each front-end; quadrant PIN photodiode BPMs (QBPMs) [4] are adopted by few experimental end station. The layout of front-end instrumentation is shown as Fig. 1. XBPM1 is completed calibration and observed reliable for a while. However, the calibration of XBPM2 is not yet completed and it was observed that the horizontal and vertical readings of XBPM2 had serious coupling. Therefore, only XBPM1 is presented and included for feedback in this report. About acquisition electronics, three types of electronics had been used and evaluated. The first one uses the FMB Oxford F-460 to convert current to voltage and read the voltage with a NI-9220. The second type of electronics is a home-made device with a 0.5 Hz update rate. The third type is the commercial product and now our majority: Libera Photon which could provide different data flow for different purpose of analysis, including 10/25 Hz streaming, 5 kHz/578kHz waveform with trigger as well as post-mortem functionalities.

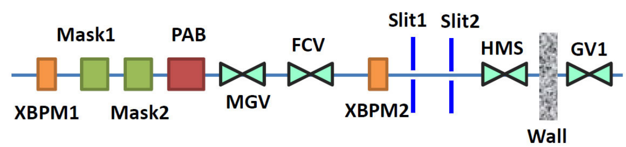

Figure1: Layout out of front-end instrumentation.

OBSERVATION OF ORBIT STABILITY BY BPM AND XBPM

Position Drifts After Beam Restored

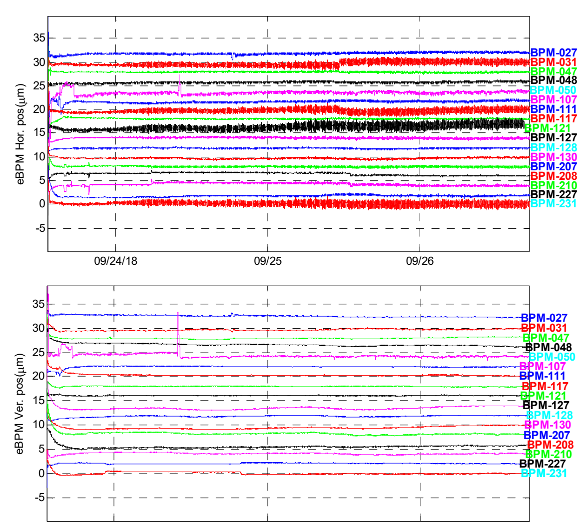

Figure 2: The upstream and downstream electron BPM reading nearby IDs for three days after beam restored.

It could be observed the upstream and downstream electron BPM nearby 7 IDs as Fig. 2 at first beginnings of beam stored, the position drift of some BPMs would be

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up to around 2~4 μm for the following 2~3 hours before it achieves an equilibrium as shown in the detail of Fig. 3 for the vertical plane. Then it could be remained below submicron. However, this 2~4 μm drift of the first 3 hours would be amplified in the beamline observed by front-end XBPM as Fig. 4 by 3~20 times. XBPM at the FE 41 even could up to 80 μm. This kind of drift is especially apparent in the vertical plane.

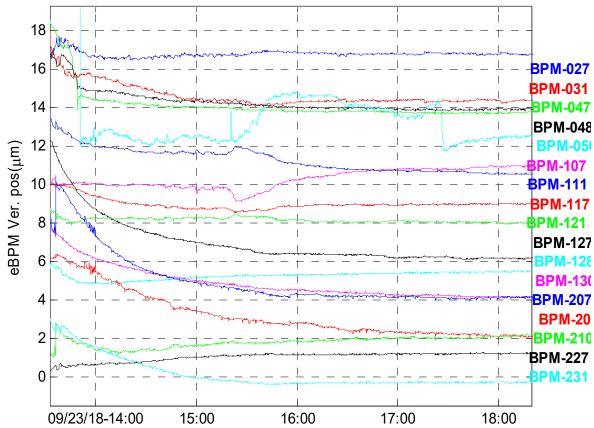

Figure 3: The vertical position change of BPM nearby IDs during the first 5 hours of beam stored.

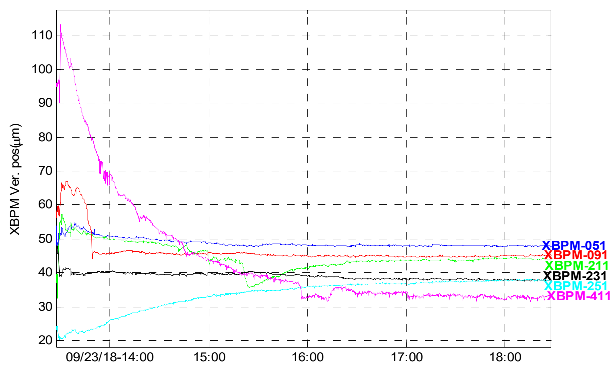

Figure 4: The vertical position change of XBPM during the first 5 hours of beam stored.

The patterns of these position distortions display quite similarly every time. But the range of the drift depends on different operational and environment condition. The major factor to affect the drift range is the time interval of the previous beam dump. Figure 5 shows the vertical position change of XBPM-41 on FE 41 and its adjacent upstream and downstream BPM during 2.5 hours from the beginnings of beam restored for Aug-21, Sep-10, Sep-23 this year. They are all operated on the standard User Mode. However, the amplitude of the XBPM and eBPM position drifts for Sep-23 (green line) is obvious 2-4 times larger than the other two. The cause is time interval (3 hours) between the beam stored is longer than the other two (0.5/1 hour). As beam dump is longer, the position drifts larger and it could take longer time to stabilize as well. Therefore, it is advised that the accelerator would be heated for a while before open to users. On the other hand, most of the beamlines actually also need to take a while for thermal equilibrium too. Besides, we'd make efforts to improve the machine reliability to decrease the accidental beam trip.

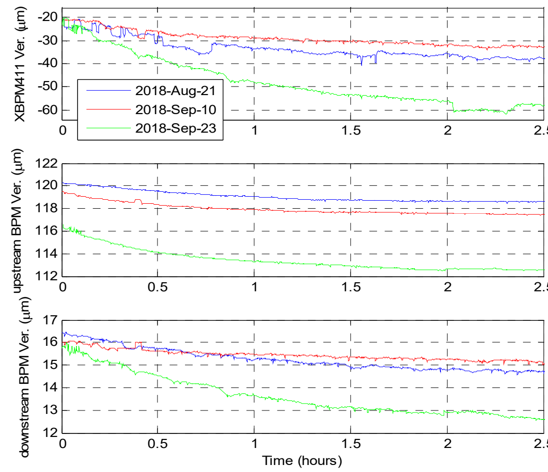

Figure 5: The vertical position change of XBPM-41 and the adjacent upstream and downstream BPM for 2.5 hours at initial beam stored.

Position Variation with Daily Change

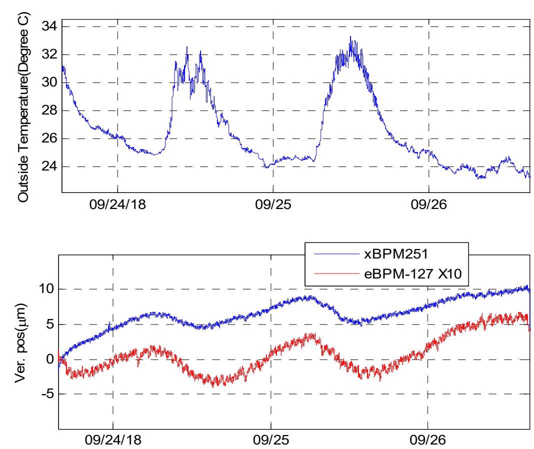

Figure 6: The upper plot is the temperature change for three days. The lower plot is the vertical position change of XBPM-251 and the adjacent upstream BPM.

It's also observed that there are some daily periodic variation for some eBPM and xBPM,. In FE-25, for example of the most visible case, the vertical position change of XBPM251 is highly correlated by it's upstream BPM, but amplified by a factor of ten as Fig. 6 shows. It could be inferred to be caused by daily temperature variation.

Position Fluctuation with Injection Cycle

Last, although in top-up mode, there is still effect appeared due to beam current change for some front-end XBPM. Figure 7(a) shows the vertical position of XBPM251 fluctuates around 5 um accompanying with beam current change during top-up while its upstream and

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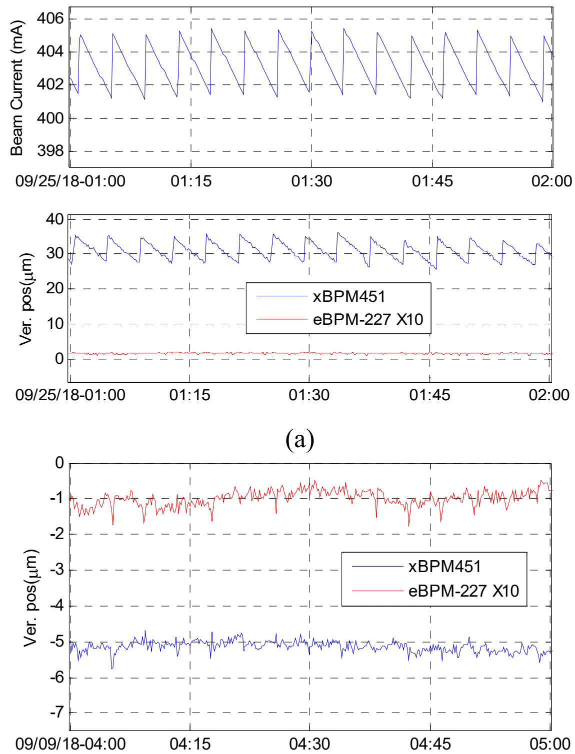
downstream BPM have no such variation. Furthermore, strangely, these phenomenon has not always existed. In Fig. 7(b), the same XBPM and eBPM, also in standard User Mode, had no such kind of behavior. The reason had not yet been clarified.



(b)

Figure 7: (a) The upper plot is the beam current. Beam injects every four minutes. The lower plot is the vertical position change of XBPM-451 and the adjacent upstream BPM on Sep.25 2018. (b) Data on Sep.09 2018

PRELIMINARY TEST OF LOCAL XBPM FEEDBACK

To further improve XBPM position stability, the local feedback to use XBPM is considered and proposed. Although the XBPM position is quite depended on ID gap/phase, the gap/phase has been not moving too often for most beamlines of TPS in practice. Therefore, the preliminary tests for XBPM local feedback is ongoing. Figure 8 shows the results of the experiments for FE21. It was 100 mA top-up mode. The upper plot is XBPM vertical position; the lower is its upperstream and downstream BPM. Feedback started at beginning and stopped at 16:20. The position fluctuation due to beam current change looked improve efficiently by feedback. Figure 9 shows the other FE09 case for applying XPM local feedback. It seemed the position drift improved somewhat as well. However, the reliability of XBPM is still an issue. Besides, sometimes FOFB and XBPM local feedback would be interfered with each others which would results the correction of corrector accumulated rapidly to saturation or even worsen, deteriorate the drift.

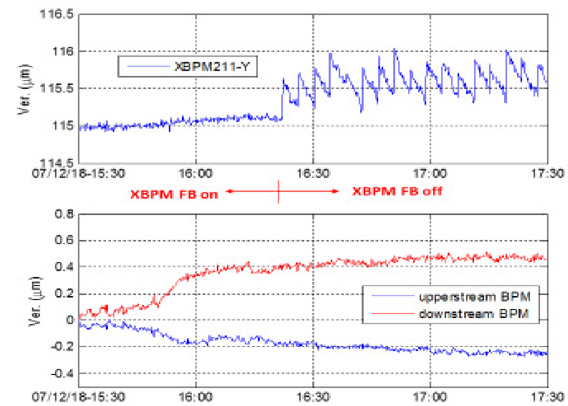


Figure 8: Local XBPM vertical feedback for FE21. Feedback stopped at 16:20. 100 mA at top-up mode.

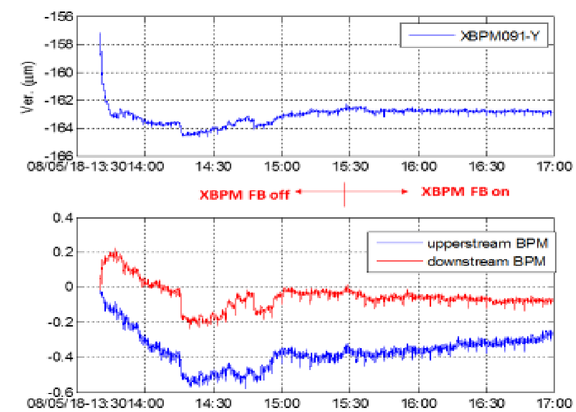


Figure 9: Local XBPM vertical feedback for FE09. Feedback started at 15:30. 300 mA top-up mode.

CONCLUSION

The long-term position stability observed from electron BPM and XBPM is presented. Three types of orbit variation are summarized. The major concern from users is the orbit drift would remain 1~3 hours at different ranges for different beamline after beam dump and restored. As beam dump longer, the drift become larger and longer. Therefore, the local XBPM feedback is tested to improve the drift. The result is promising while there are still some practical issues required to be resolved.

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