CORRELATION STUDY BETWEEN BEAM BEHAVIOUR OBSERVED BY ELECTRON BPMS AND PHOTON MONITORS

K.H. Hu, C.H. Kuo, P.C. Chiu, Jenny Chen, C.Y. Wu, Y.S. Cheng, Y.T. Chang, K.T. Hsu
NSRRC, Hsinchu 30076, Taiwan

Abstract

Beam stability plays a crucial role for the operation of a synchrotron light source. To improve and to keep high beam quality, intensive correlation study program to investigate relationship between data taken by electron BPMs and photon monitors is on going. Modification of the data acquisition system to synchronize data capture is in proceed. Some current efforts and future plans are summarized.

INTRODUCTION

The TLS provides user services since October 1993. Several major and minor upgrades were done during last decade. SRF upgrade in late 2004 and top-up injection in late 2005 are two major activities to improve the light source performance drastically. There are many efforts to improve machine performance. To further explorer to reasons that caused beam quality imperfection, correlation analysis is performed to analysis various reasons which deteriorate beam quality. Follow up improvement are also under study.

CURRENT AVAILABLE TOOLS AND ITS FEATURES FOR THIS STUDY

New digital BPM system for TLS has been delivered recently. It could support functionalities of turn by turn beam position data, 10 kHz rate fast and 10Hz rate slow data acquisition. 10 kHz fast data transmission between Libera Brilliances [1] through Libera grouping mechanism also developed to acquire all BPM data for the fast orbit feedback system with low latency and jitter. New system equip with a dedicated diagnostic system which could record 8 sec orbit data simultaneously at 10 kHz rate with hardware and software trigger functionality. With aids of control system archiver, 10 kHz rate data capture system, turn by turn post-mortem buffer inside the Libera Brilliances, post-mortem data with 10 Hz, 10 kHz, 2.5 MHz rate are available. More integrated software tools and work will continue to develop for future operation.

The photon BPM (PBPM) is installed in the front end system to directly measure the synchrotron radiation photons without blanking-off the part of the photon beam that the beam line will accept. It operated in non-destructive way, and be capable to absorb the heat load on itself. The blade-type PBPM that measure the photons by photoemission method is promisingly useful to meet the requirement. In NSRRC, several 2-blades type PBPM that measures the vertical movement of the photon beam at bending magnet beamline has been successfully developed [2]. A positional resolution less than 1 μm was achieved. Existed data acquisition systems in independent of machine control system are involved for the PBPM with different groups. Integrated the PBPM system with the machine control system is on going to easy correlation analysis of various beam behaviours.

Photon beam intensity monitors (Io monitors) were deploying since very beginning of the TLS operation [3,4,5]. Three Io monitors are in service. Each Io monitor consists of vertical focusing mirror with demagnification factor of three, a precision 50 μm pinhole, a photodiode, and a high precision scanning stage to drive by linear piezo-actuator. A precision Io monitor system needed to indicate the Io fluctuation when the Io fluctuation is down to 0.1% at the photon beam line. The precision Io monitor system used an independent manipulator to isolate the mechanical vibrations from beam-line chamber. The thermal drift was reduced by a precision cooling water system and a precision air handling unit. A resolution 0.1 μm piezo-actuated flexible stage enhanced the scanning mechanism. Peaking the reading of Io monitor was done after every top-up injection. This precision Io monitor system was proved to be able to detect the Io fluctuation to less than 0.05%.

Since the PBPM system and Io photon system is independent from the machine control system due to historical reason. Collected data are asynchronous in nature. This makes study the real beam behaviour difficult slightly. To interpret some peculiar phenomenon, a prototype for PBPM and Io monitor integration is tested recently by PowerDNA [6]. The functional block diagram of the integrated system is shown in Fig. 1 [7]. The PBPM and Io data is acquire in 2 kHz rate and integrated with the existing electron BPM via reflective memory network. A dedicated diagnostics node can capture data in 10 kHz rate for all monitors. This wills easy the correlation analysis.

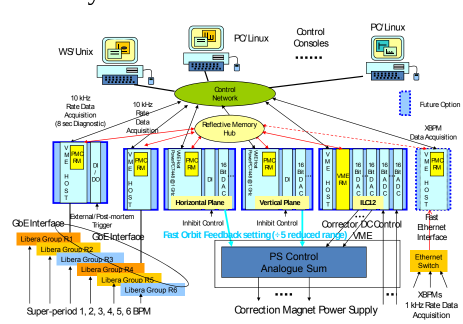

Figure 1: Data acquisition system which is in construction for the RF BPM, PBPM and Io monitors.

BEAM BEHAVIOR DURING INJECTION ELEMENT ACTIVATED

The TLS operated in top-up injection mode since October 2005. Study about the relationship between the Io perturbation and the beam instability. Figure 2 show the Io monitor and PBPM reading during the case of open the transverse feedback system for 3 msec. However, due to large beam perturbation caused by the injection septum and kickers activated for up to 20 msec due to orbit excursion induced by the eddy current and large damped betatron oscillation within 5 msec, this period in injection cannot accept by the users and is gated out. There are many effects during instance of injection elements. To verify relationship between different monitors, several methods were adopted to change behaviours of the beam and make observation of various kinds of monitors. The eddy current induced by the leakage filed of the injection septum will cause orbit excursion up to 15 msec. Figure 3 show the Io monitor and PBPM reading, this is due to orbit excursion which confirm by the electron BPM data as shown in Fig. 4. The beam position move is due to eddy current induced stray file which affect the stored beam. While the Io reading is due to beam motion just after at the septum fired only. Figure 5 shows the R6BPM3 electron BPM and BL10 PBPM and BL10 Io monitor reading during the injection septum fired only. The PBPM and Io monitor data reading by PowerDNA seems a 15 msec delay, this is caused by the 30 taps FIR filter inside the ADC module which sampling at 2 kHz rate (0.5 msec sampling period). This is disadvantage for the data comparison, set up an integrated data acquisition system without this problem is in intensive study.

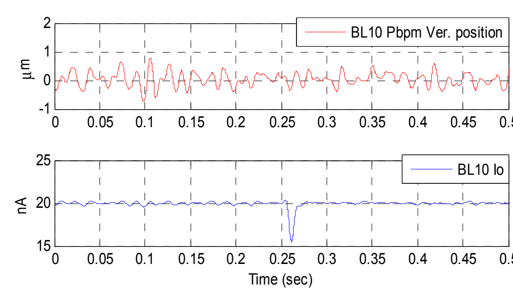

Figure 2: BL10 PBPM and BL10 Io monitor reading during the case of open the transverse feedback system for 3 msec.

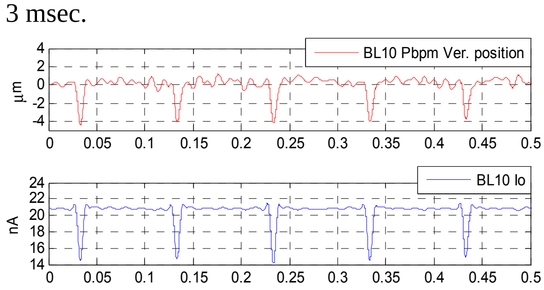

Figure 3: BL10 PBPM and BL10 Io monitor reading during the injection septum fired.

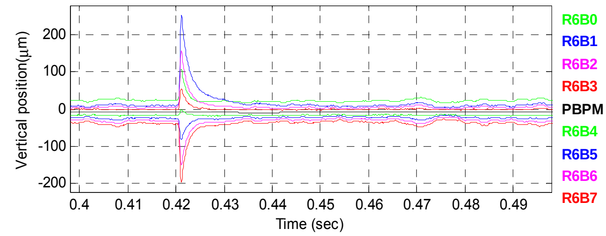

Figure 4: Data form electron BPM and PBPM shown the orbit excursion due to the eddy current induced by the leakage field of the injection septum fired.

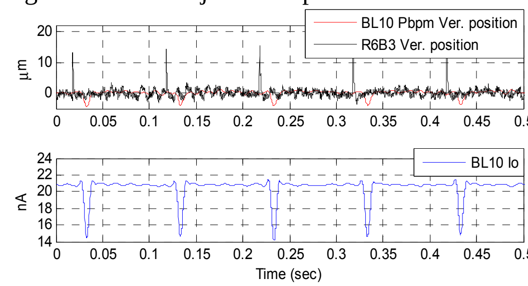

Figure 5: R6BPM3 electron BPM and BL10 PBPM and BL10 Io monitor reading during the injection septum fired.

There are two effects due to injection kickers, one is the local bump leakage which will excited damped betatron oscillation, the other is filed induced eddy current near the kickers will caused small orbit excursion. The eddy current induced by the leakage filed of the injection kickers will cause orbit excursion up to 5 msec as shown in Fig. 6. The beam position move is due to eddy current induced by stray of the kickers. The Io reading is due to beam blow up just after kicker fired instance before return to its normal state. Figure 7 shows data of R6BPM3 electron BPM and BL10 PBPM and BL10 Io monitor reading for the case of injection kickers fired.

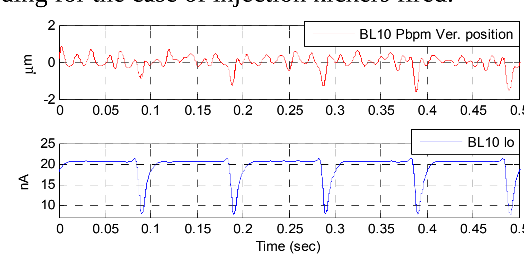

Figure 6: BL10 PBPM and BL10 Io monitor reading during the injection kickers fired only.

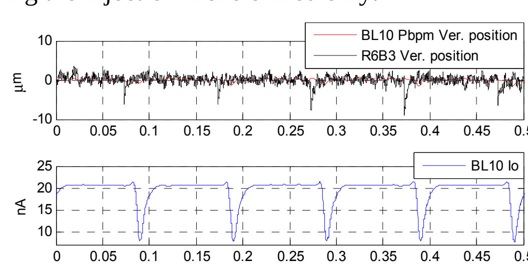

Figure 7: R6BPM3 electron BPM and BL10 PBPM and BL10 Io monitor reading during the injection kickers fired only.

Figure 8 show the Io monitor and PBPM reading, this is due to orbit excursion which confirm by the electron BPM data as shown in Fig. 9. The beam position move is due to eddy current induced stray file which affect the stored beam. While the Io reading is due to beam motion just after at the septum and kickers fired. Figure 10 shows the R6BPM3 electron BPM and BL10 PBPM and BL10 Io monitor reading during the injection septum and kickers fired.

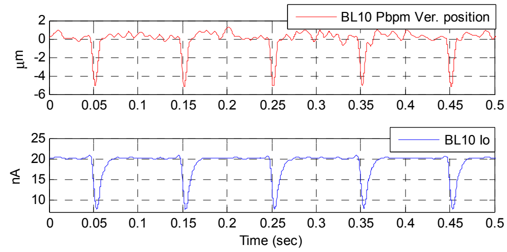

Figure 8: BL10 PBPM and BL10 Io monitor reading during the injection septum and kicker fired.

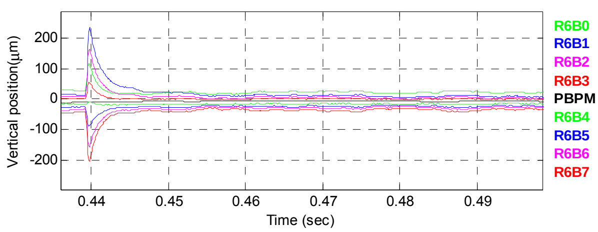

Figure 9: Data form electron BPM and PBPM shown the orbit excursion due to the eddy current induced by the leakage field of the injection septum and kickers fired.

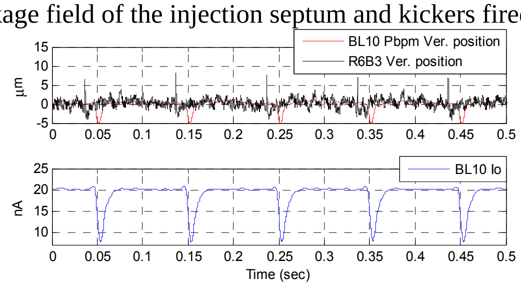

Figure 10: R6BPM3 electron BPM and BL10 PBPM and BL10 Io monitor reading during the injection septum and kicker fired.

EFFECTIVENESS TEST OF THE GLOBAL ORBIT FEEDBACK SYSTEM TO THE Io MONITOR READING

The photon beam intensity variation (ΔIo/Io) is used to define quality of the photon beam for the TLS since very beginning. Value for user service should keeps ΔIo/Io value to less than 0.1 % or even better. Figure 11 (a) shown the relation between EPU phase, orbit feedback status. ΔIo/Io monitor reading during EPU5.6 phase change between adjunct of injections every 60 seconds is shown in Fig. 11 (b). The orbit feedback system help to keep ΔIo/Io to less than 0.1% when the feedback "ON". However, large ΔIo/Io happened when the feedback is "OFF". The photon beam intensity Io 10 sec data is show as Fig. 11 (c).

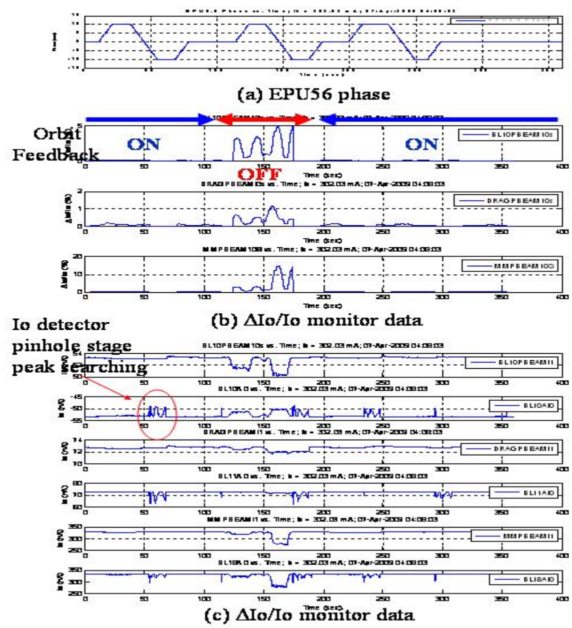

Figure 11: Relationship between EPU5.6 phase, ΔIo/Io monitor reading, and Io monitor reading. The top-up injection happened every 60 seconds. (a) Phase of the EPU5.7; (b) BL10, dragon and MM photon beam ΔIo/Io monitor reading; (c) Io monitors data.

SUMMARY

Preliminary correlation study between electron BPMs and photon monitors are underway. Investigate observed phenomenon and try to improve beam quality further is the driven force to do this study. Upgrade the data acquisition system to synchronize the acquired data for analysis is on going. Compare data of the different monitors and to verify relationship between spike happened at ΔIo/Io data and the electron beam behaviours is the first step. Dig out the reasons of spike happened and eliminate these spike is the current efforts.

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