REAL-TIME BEAM LOSS MONITORING SYSTEM AND ITS APPLICATIONS IN SRRC

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Abstract

A new approach to measure and locate beam losses in the SRRC storage ring (Taiwan Light Source, TLS) by using semiconductor beam loss monitor (BLM) is presented in this report. Small size and low unit cost make it possible to be placed around the machine for amount of 50 in 120 meters storage ring. Beam loss counts is collected by multi-channel scalers on VME crate and is updated to database on workstation dynamically. Loss count information is updated into archive file for retrieval purpose. Two types of real-time display are supported by the graphical user interface on workstation: (1) Bar chart; (2) Loss counts display superimpose with storage ring layout. The first type is routinely used. The other type helps to identify beam loss with ease. During lattice change or operation of insertion devices, resonance lines crossing was observed by use of this beam loss monitoring system. Application to the tune space exploration indicates that this beam loss monitoring is a more efficient and sensitive devices in comparison with using beam size and beam lifetime estimation.

1. INTRODUCTION

With the information provided by the BLM placing around the ring, beam loss distribution pattern can then be directly monitored [1]. With the fast response nature provided by BLM, it is very helpful in studying the trapping phenomenon of dust or ions. The working principle of the BLM is described as follow. Two PIN-photodiodes mounted face-to-face can detect charged particles. It is becaused of the coincidence technique applied in the circuit, which makes it insensitive to synchrotron radiation. The BLMs produce voltage pulses when the active area of a PIN-diodes is struck by minimum ionizing particle (MIP), which causes a coincident. Installed BLM system distributes around 120 m TLS plays as a convenient and powerful diagnostic tool. Its real-time nature and integration with the control system making BLM system helpful for machine trouble shooting and routine operation.

2. TLS BEAM LOSS MONITORING SYSTEM

About 50 Bergoz's type BLMs have been installed around the storage ring in early of 1996 as shown in figure 1. The storage ring has six superperiods. Eight BLMs are installed per superperiod. Two additional BLMs are installed near by injection septum and scraper. This system has been operating for about one year. Beam loss counts are collected by multi-channel scalers on VME crate and updated to database on workstation dynamically. Time frame generator is planned to be included in the BLM upgrade version in order to provide useful information for studying dynamic phenomena. Loss counts is updated into archive file system for retrieval. Two types of real-time display mode are supported by the graphic user interface on workstation. The first type is a bar chart display which is routinely used by the operator and for radiation survey. The second type is a loss counts display superimpose with layout of the storage ring, as shown in figure 2, which helps to localize the beam loss spots.

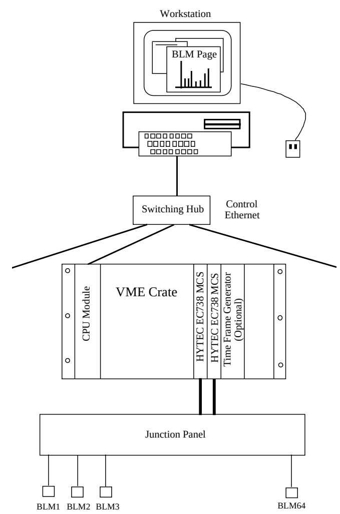


Figure 1. Functional block diagram of beam loss monitoring system

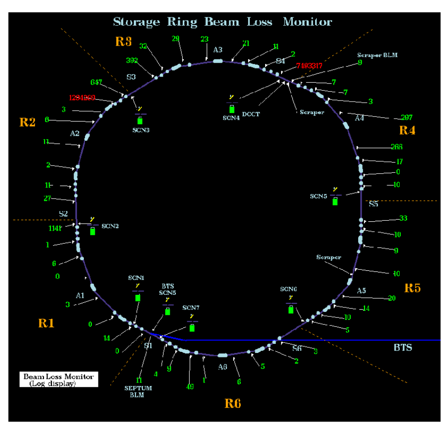


Figure 2. Loss counts display with the storage ring layout.

During recent shutdown in February-March 1997, independent quadrupole power supplies, undulator U5, and undulator U10 prototype were installed to be incorporated with storage ring operation. Commissioning of these newly installed devices started in April. Loss counts at the early stage of the commissioning is shown in figure 3. The peaks at BPM index 10 and 17 are the BLMs situated just at downstream of U10P and U5 with narrow gap vacuum chambers of 18 mm. Peak near BLM index 20 is located at the downstream of scraper and RF cavities. Effort has been made to reduce the losses by changinf orbit around these region. And the BLM system has demostrated that is is a very handy tool in monitoring the orbit response in terms of localized beam loss radiation.

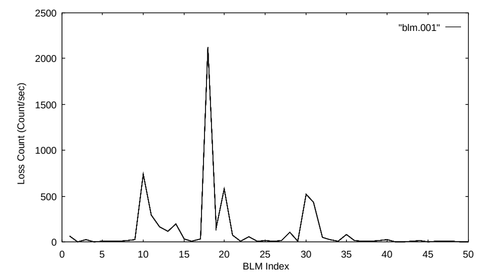


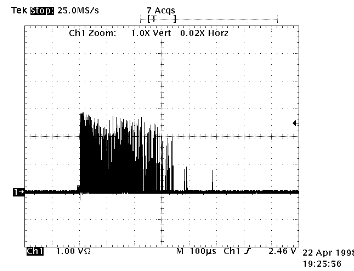
Figure 3. Beam loss distribution of first beam store on April 10, 1997 (beam current 16 mA). The ordinate shows the location of the monitor, and the abscissa shows the count rate.

3. BLM SYSTEM APPLICATIONS

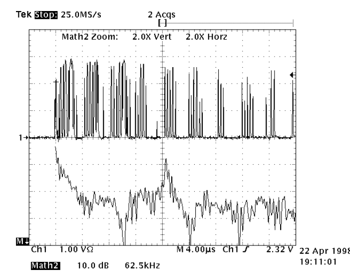
BLM system is used in routine operation as well as some particular purposed machine study. From the operation experience gained in the passed few years, its has shown that the BLM system plays an improtant role on various topics study. Details of a few BLMs related activities in SRRC are describe as follows:

3.1 Beam loss pattern during injection

High injection efficient is desired from the radiation safety as well as operation point of view. BLM system provides an alternate tool for injection study. Figure 4(a) shows a typical loss track at one of the BLM. Most of the losses occur within 500 μsec, i.e. about 1000 turns. Details from expanding in the time scale is goven in figure 4(b). The loss event has a somewhat periodic structure. It is easily identified that the frequency of the period is 260 kHz which corresponds to the vertical tune. The possible reasons of causing the lossed includes horizontal residual and leakage field of injection magnets, injected beam launching condition, coupling of the storage ring, and small vertical aperture chambers used for insertion devices. The results demostrated that BLM is very helpful for injection study to optimize the injection conditions. In this experiment, signal reading from some of the BLMs nearby injection kickers are interfered while injection kickers are firing. This problem is eliminated by gating technique. It is expected that after the grounding improvement is finished for the BLM system, the interference will be further suppressed.

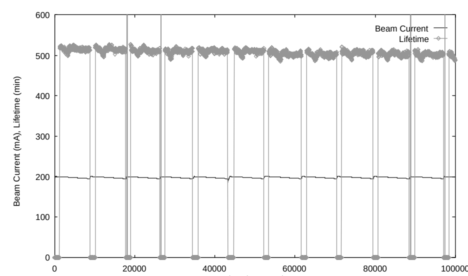


(a)

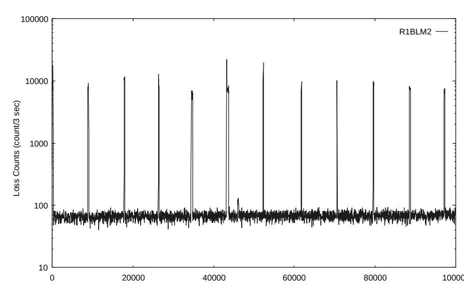


(b)

Figure 4. BLM applied in injection losses study, (a) Injection loss pattern; (b) tune observance by beam loss monitor.



(a) Beam current and lifetime for top-off mode test at 1.3 GeV



(b) Loss counts at R1BLM2

Figure 5. Beam losses observation for top-off mode test.

Top-off mode injection has been test in early 1996. Figure 5(a) shows beam current and lifetime during the test. Figure 5(b) shows the loss counts observed by R1BLM2. Loss peaks occur at the instant of injection. Discontinuity on lifetime display is due to the reasons that lifetime calculation is stop during injection and the data length for lifetime estimation needs aabout 3 minute to produce the fist lifetime data.

3.2 Beam losses during users shift

It has also been examined that BLM and vacuum gauges reading provide complementary information to identify and interpret many beam loss phenomena. Corrlation between archived BLMs data and other machine parameters is also important in understanding the dynamic mechanism of machine characteristics.

3.3 Resonance line crossing observation

Resonance line crossing is usually occurred while tuning lattice parameters, changinf of insertion devices, beam energy ramping, etc. Figure 6 shows the scenario of resonance line crossing during 1.8 Tesla wiggler gap change. The wiggler gap change form 22.5 mm to 23 mm, and then close back to 22.5 mm. The loss counts at downstream of wiggler and injection septum illustrated that strong loss peak, at wiggler gap near 50 mm, were due to resonance line crossing during wiggler gap change.

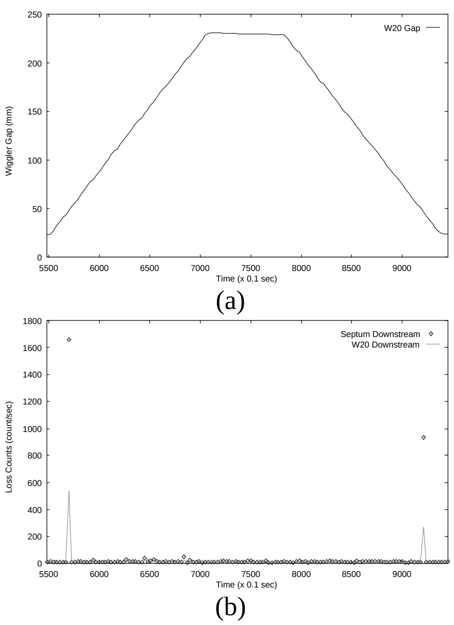


Figure 6. Resonance line crossing during W20 change gap. (a) Wiggler gap; (b) Loss count of BLM at downstream of septum and wiggler.

3.4 Tune mapping

Optimizing machine lattice requires systematic studing of its corresponding tune space [2,3]. Also, tune scan is also useful for studying insertion devices caused nonlinear resonance. Preliminary test result is shown in figure 7. The procedure is to reduce vertical aperture by scaper in association with the changing quadrupole strength of Q1 and Q2 for desired tune. Scan the various tunes and collect loss counts. The preliminary results are shown in figure 7. It is clearly shown that a tune trajectory crossing tune space, as shown in figure 7, corresponds to a third order resonance line.

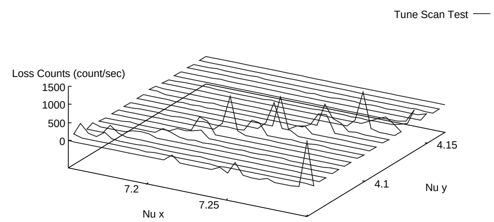


Figure 7. First tune scan test at Taiwan Light Source

3.5 Other applications and future plan

BLM is useful for studying the trapping phenomenon of micro-particles or ions. This study is in progress at TLS. Adding time frame generator will equip the scaler with capability to record dynamic loss for injection and tune scan study.

4. CLOSING REMARKS

BLM system provides an additional diagnostic tool which may help to locate problems in trouble shooting and finding possible reasons for poor beam lifetime in routine operation. BLMs system is also helpful in commissioning insertion devices.

5. ACKNOWLEDGMENTS

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