POST-MORTEM ANALYSIS AT TLS

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Abstract

High availability and stability of the beam are important issues for the synchrotron light source. Analyzing of the post-mortem data is one of the most important approaches to identify the reason of beam trip. The post-mortem system has been developed at Taiwan light source (TLS) in 2008. This diagnostic data can provide useful information for troubleshooting and improve the beam reliability. The various diagnostic signals are read from hardware buffer and written to the file system by the post-mortem event trigger, which is generated by the signals of the beam trip detector, the superconducting RF system interlock and the superconducting insertion device interlock. In this report, we build an auto-analysis process to check whether a new trip event happened or not, promptly find out the unusual signals, and generate an analyzing result message. The detail will be discussed and summarized.

INTRODUCTION

The post-mortem diagnostic system can capture information while trip happened. Such kind of information will guide us to find out the drawback of the instrument and make the system better. This procedure is important for the synchrotron light source to enhance the stability and availability of the beam. In the new third generation synchrotron light source, the system is more complicated. We need more signals to completely identify the reason that cause the trip event. However, the number of the trip diagnostic signals is large and it is inefficient to check the unusual signals by the manpower. For this reason, we employ Matlab script to build an auto-analysis process. This process can wait as the new trip event was triggered; it takes out the abnormal signals and sorts them by the time sequence. Finally, a brief message will be created and sent to the related people as an E-mail that roughly describe the reason may cause this trip event. This method can promptly give us a direction to find out the machine error and improve the system stability.

POST-MORTEM DIAGNOSTIC TOOLS AND HARDWARE ARCHITECTURE

In order to identify the post-mortem event, it is necessary to bundle different time resolution scale signals to get the more messages. As shown in Table1 [1], we can classify the instrumentations in four different time resolution scales spanned from nanosecond to near second. For the RF bucket time scale (about nanosecond), oscilloscopes are used to observe fast event, such as pulse magnet waveforms, filling pattern etc. The bunch by bunch electronics (iGP) [2] are also used for the measurement of beam instability and the individual bunch tune etc. For the beam revolution time scale (about microsecond), the turn by turn BPM electronics (Libera Brilliance) [3] are employed to get the turn by turn beam position, intensity, and phase data. The buffer size in the BPM electronics can up to 256K samples and is dumped by the post-mortem trigger. For the slow data acquisition time scale (about hundreds of microsecond) the BPM electronics also support 10 kHz orbit stream data for global feedback and post-mortem analysis. A cPCI base 96 channels simultaneous sampling data acquisition (D-tAcq196) [4] with 16 bits resolution and up to 500 ksps sample rate is used for slow data capture such as beam current, injection trigger, the power intensity of bunch by bunch feedback RF power amplifier, SRF cavity transmission power, SRF interlock sum, and the interlocks of several insertion devices. Finally, the TLS has a 10 Hz logger with one week lifetime and a 10 seconds resolution archiver for permanent storage in the control system slow timing time scale (about hundred of millisecond).

Table1: Post-Mortem Diagnostic Tools

Time scales	Instrumentations	Diagnostic signals
~nsec	• oscilloscope • bunch by bunch electronics	• kicker waveform • beam instability • tune measurement
~400 nsec	• BPM electronics	• turn by turn beam position • turn by turn beam intensity
~ 100 μsec	• 10 kHz orbit recorder • cPCI Simultaneous digitizer	• 10 kHz orbit recorder • SRF cavity field and interlock sum • super conducting insertion device signals
~100 msec	• control system archiver	• 10 Hz control system signals

Figure1 shows the post-mortem hardware architecture. The post-mortem event is generated by the post-mortem trigger circuit, which has logic “OR” and combines with the input signals of the beam trip detector, SRF interlock sum and the interlocks of insertion devices. The beam trip detector is designed to produce the trigger signals as the beam current decreases more than 30% during 500 turns (the condition can be adjusted). When the post-mortem event happened, the post-mortem circuit

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sends the output triggers to dump the inner buffers of different diagnostic tools. These data will be transmitted to the data server and storage through the Ethernet.

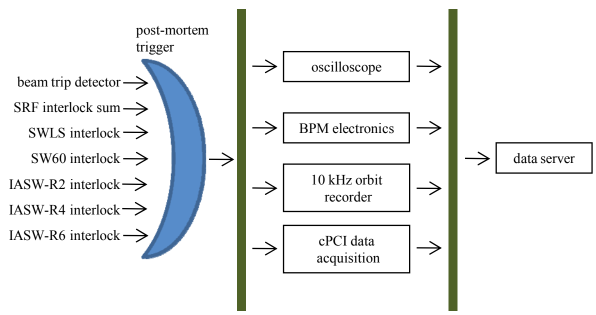

Figure1: Post-mortem hardware architecture

POST-MORTEM EVENT AUTO-ANALYSIS PROCESS

Figure2 shows the flow chart of the post-mortem event auto-analysis process. The data server will be checked by the Matlab script in every five minutes. Once the new data are found, the process will load the post-mortem data from the data server and checks all signals one by one to find out the abnormal signals, and then points out the timestamp where the error was occurred. According to these timestamps we can sort them by time and obtain the time sequence of this post-mortem event. Some diagrams about the abnormal signals will then be plotted and send to the related people together with a short description related to this event including the date, time, and the time sequence of abnormal signals to tell them the possible reason that may cause this event.

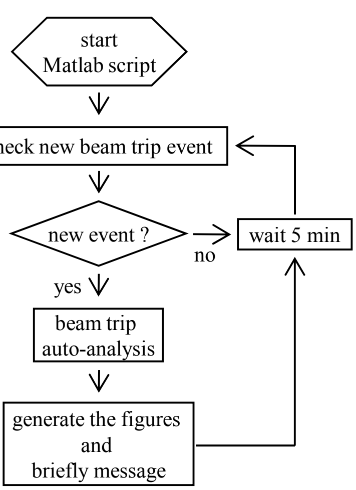

Figure2: Flow chart of post-mortem event auto-analysis Process.

RESULT EXAMPLES OF TRIP EVENTS

There are two post-mortem events in the machine maintenance time shown below as the examples. The red circles are marked on the signal plot point out the time stamps when the abnormal signals starting variation.

IASW-R4 Interlock Active

The event as shown in Figure3 is guided by the IASW-R4 (in-achromatic superconducting wiggler) interlock active and trip the power supply. It affects the horizontal orbit changed and is reflected by the correct power supply. The transverse instability is also excited, result the beam loss and IASW-R4 quench. Finally the SRF interlock is active to induce the orbit shrink effect before the beam died. The reason of the IASW-R4 interlock active can come from the 10Hz control system archive. It shows that the interlock active by the pressure of the gaseous Nitrogen is too high when the liquid Nitrogen is refilled. After increasing the threshold of the pressure meter, this trouble is solved.

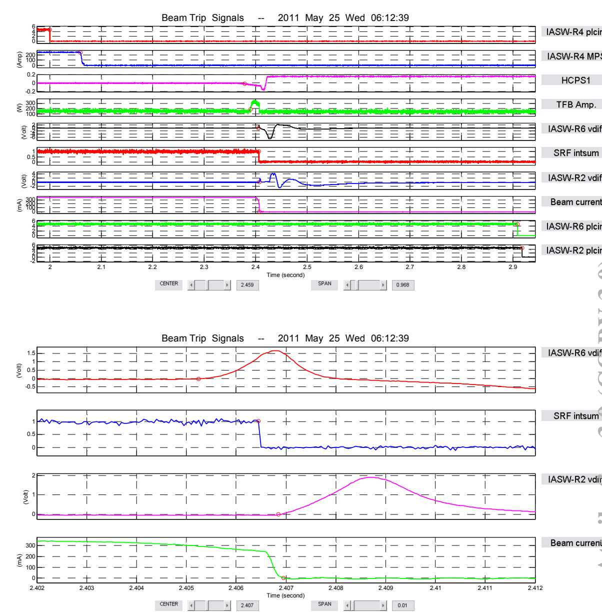

Figure3: The beam trip causes by IASW-R4 interlock active.

Transverse Instability Growth

This event is governed by transverse instability grows up and induces the beam loss. The fast variance of the beam current leads the LLRF feedback system could not capture, hence the reflection power is too high to active the SRF interlock, which trips the input microwave power and protects the cavity. The cavity filed decays after the RF transmitter trip, the stored electrons will loss energy which result the orbit shrink and appear the dispersion pattern. This motion leads the electron beam to contract its closed orbit and hit on the vacuum chamber. The lost electrons may hit IASW-R2, IASW-R4 and IASW-R6; induce local heating of the superconducting coil which causes quench happened. While the interlocks of these three magnets are active to trip the power supply and protect the magnetic coil. The relative signals of this post-mortem event are shown below in Figure. 4.

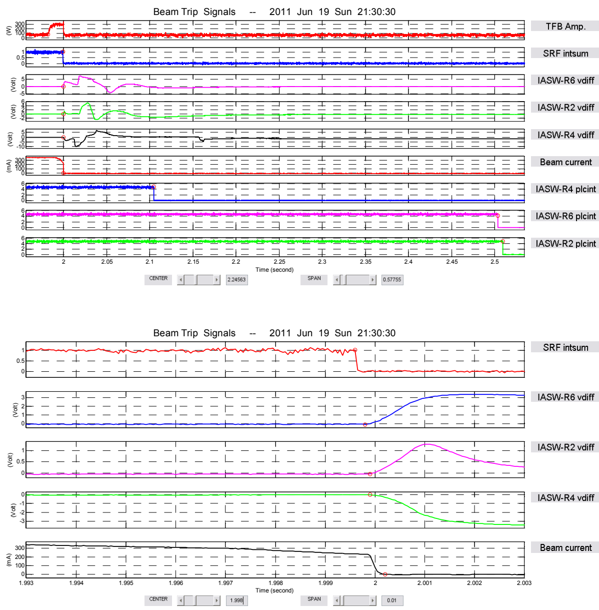

Figure 4: The beam trip causes by some instability growth.

FUTURE PLANS

Previous section shows some post-mortem events that governed by some kind of beam instability growth. However, the information is still not enough to dissect this instability. We should add the post-trigger function at the bunch by bunch electronics and integrate with the existing system better. Sometimes, these instability growth events relate to not only beam trip, but also partial beam loss. The available version of the beam trip detector could just trigger by the beam trip, and therefore designing another version of the beam trip detector for the partial beam loss detection is a valuable program. In some other case the trip event causes by the insertion device interlock active. But now we can just check the relative signals of the interlock inputs and find the clue from the 10Hz control system archiver. How to confirm the reason quickly and exactly why the interlock active is also important. It may need more information of signals or integrate the post-mortem system better.

SUMMARY

A post-mortem diagnostics system is available at TLS. It is a standard method to identify the drawback of the system, and help us to improve the availability and stability of the beam. This system includes several difference diagnostics tools which are employed in various time resolution scales. The post-mortem event is triggered by the beam trip detector, SRF interlock sum and the interlocks of the insertion devices. A post-mortem event auto-analysis process has been built, it can check whether a new event appears from data server, searches out the abnormal signals and their timestamp, finally gives us some practical information for the possible reason of this post-mortem event.

REFERENCES

[1] K. H. Hu, et al.,"Post-Mortem Diagnosic for the Taiwan Light Source", Proceedings of EPAC08, Genoa, Italy.
[2] iGP:http://dimtel.com/.
[3] Libera Brilliance: http://www.i-tech.si.
[4] cPCI digitizer: http://www.d-tacq.com.