

THE ALARM AND DOWNTIME ANALYSIS DEVELOPMENT IN THE TLS

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Abstract

TLS (Taiwan light Source) is a 1.5 GeV synchrotron light source at NSRRC which has been operating for users more than twenty year. There are many toolkits that are delivered to find out downtime responsibility and processing solution. New alarm system with EPICS interface is also applied in these toolkits to keep from machine fail of user time in advance. These toolkits are tested and modified in the TLS and enhance beam availability. The relative operation experiences will be migrated to TPS (Taiwan photon source) in the future after long term operation and big data statistic. These analysis and implement results of system will be reported in this conference.

INTRODUCTION

TLS is a small, state-of-the-art and compact synchrotron radiation facility featuring with adapted energy for users. This machine are still operated and supported with high reliability and stability beam quality. For this operation request, alarm in advance and analysis after event must be quick and true to keep from problem in the next time. Amount of signals analysis and calculation are heavy duty. The beam trip analysis expert system is developed to scan signal automatically and find sub-system problem after event. Big data in the achieve database is accessed and analysed by this toolkit in each event. Following subsystem from beam trip event and statistics are to classify signal that is effective to reduce searching time and CPU loading.

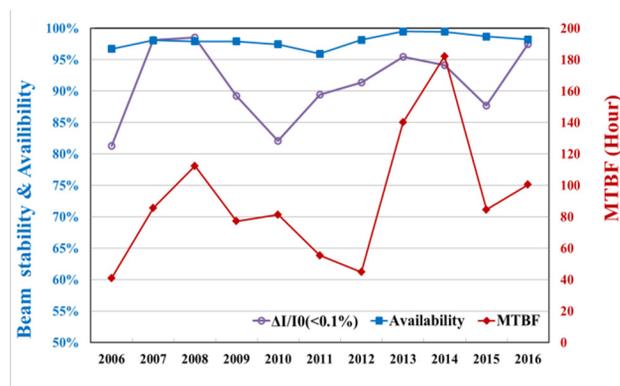


Figure 1: Annual operation statistic.

BEAM OPERATION STATISTIC

At a beginning of 200-mA top-up injection operations in October 2005 right after installation of the SRF module, TLS gradually raised the stored beam current to achieve 360 mA in 2010 and stayed there in the following

years as limited by the available RF powers. Meanwhile it is always aimed to improve the performance of facility as indicated by availability, mean time between failures (MTBF) and beam stability index. Availability is defined as the ratio of delivered user time to the scheduled user time; MTBF as the ratio of scheduled user time to number of faults; and beam stability index as the shot-to-shot photon intensity variation of the diagnostic beamline with a ratio better than 0.1%. Together with the scheduled user time and the operation mode, these performance indicators for TLS operation from 2003 to 2016 is shown in Fig. 1, are the related performance indicators since 2006 as the accelerator operation was stable.

Table 1: Monthly Beam Stability Index of TLS in the 2016

Month	< 0.1%	< 0.2%	Month	< 0.1%	< 0.2%
1	95.3%	99.9%	7	97.0%	99.9%
2	98.0%	99.9%	8	95.9%	99.8%
3	99.0%	99.9%	9	NA	NA
4	99.5%	99.9%	10	98.1%	99.8%
5	97.1%	100%	11	97.5%	99.8%
6	97.0%	99.9%	12	97.7%	99.8%

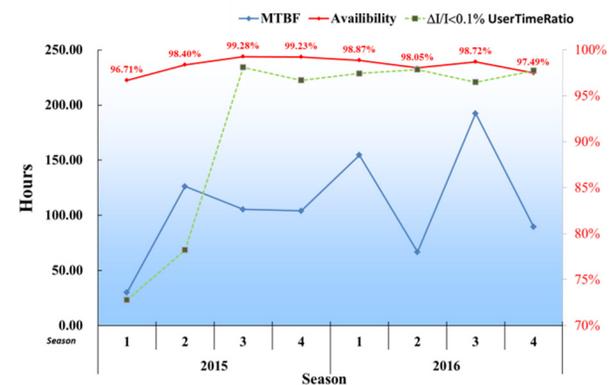


Figure 2: Season user time and beam performance indicators of TLS in 2016.

Mostly the operation performance of TLS in 2016 is better in comparison with 2015. On the basis of scheduled user time of 5526 hours, the delivered user beam time is 5427 hours to achieve an availability of 98.2%, while the MTBF and the beam stability index raises to 100.5 hours and 97.5%, respectively. Once an original component of old type aged to show bad performance, it was then upgraded to new model as possible. For example, the quadrupole power-supplies were all replacement with the new ones as the same

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model for TPS [1]. The beam performance was then gradually improved. Illustrated in Table 1 is the monthly beam stability index of TLS, pretty good all year long. The scheduled user time, beam availability, beam stability index of 0.1 %, and MTBF of each quarter in 2016 are shown together in Figure 2, obviously the accelerator performance is greatly improved since middle of 2015 and kept on going well in 2016.

Main Components Replacement and Improvement after Beam Trip Analysis.

Linac:

1. Replace the power-supply of modulator of Linac Klystron with new unit.

Power-supply of magnets:

1. Improve circuit performance on noise rejection of TLS kicker.
2. Implement the full-sine wave power-supply for the septum magnet.

Instruments and controls:

1. Power amplifier of vertical transverse feedback system is added with extra loop to enhance feedback power.
2. Upgrade the injection waveform display to EPICS control interfaces.

Lattice:

1. Minimize chromaticity of storage ring.

Environment Monitor:

1. Install Ethernet cameras inside the accelerator tunnel for remote monitoring and recording.

RF system:

1. Apply beam processing on SRF module by adjusting various tuning angles at high beam currents at scheduled shutdown period. This process highly raises reliability of SRF system as the vacuum burst event in SRF module being eliminated.

Downtime and Failure Analysis

In 2016, there are 55 beam trips with a recovery time of 1.8 hours in average for each trip event. Illustrated in table 2 are the major trip events: eleven beam trips are attributed to others, including partial beam loss, sag of electric power and earthquake; fifteen faults for power-supply problem, nine faults to magnet system, and six fails for injection system, includes wrong firing of kickers

Table 2 clearly shows some components of the subsystems, such as power-supply and injection system,

are approached the lifetime. This is what happens to all the subsystems of TLS after construction of nearly 3 decades. Some components are even not available anymore so that preparation works such as to modify the interface in advance at scheduled shut-down periods are critical to upgrade the old components with new models before failure.

The accumulated downtime of each subsystem is shown in the figure 3, with a total of 99.73 hours. Together with the trip events listed in Table 2, it is shown that some trip events resulted long downtime. For example, the single cryogenic event took about 6 hours to get system recovery. This tells the importance of high reliability on these critical subsystems.

Table 2: Summary of Major Trip Events in the 2016

Subsystem	Event	Trip #
Other	Partial beam loss without clear reason	6
Other	Sag of electric power	2
Other	Earthquake	3
Power-supply	Sextpole power-supply fail	3
Power-supply	Corrector power-supply fail	8
Injector	Wrong firing of kickers	5
Linac	Aged Klystron modulator power supply relay	1

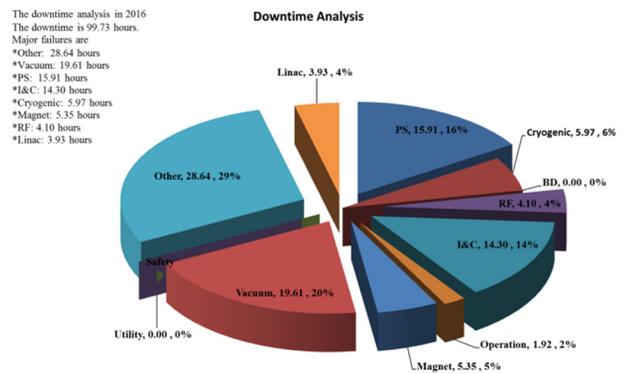


Figure 3: Downtime statistics of sub system in the 2016.

ALARM TOOLKIT

The alarm toolkit is shown in the Fig. 4, is based on BEAST (Before the using of the Best Ever Alarm System Toolkit) [1, 2]. But data interface isn't EPICS in the TLS [3]. One soft IOC is used to bridge data from original control system of TLS to EPICS.

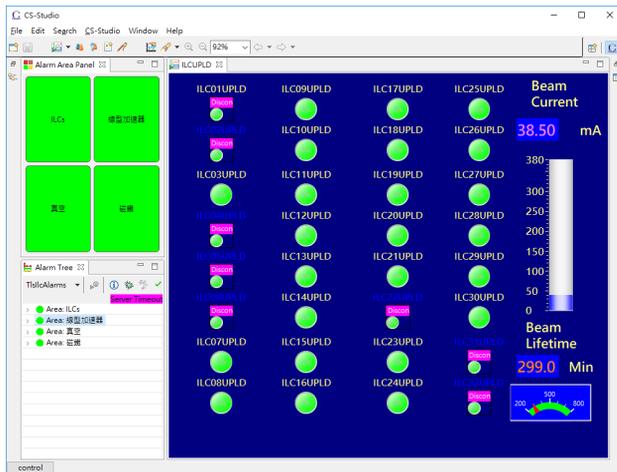


Figure 4: Alarm and notification system.

Alarm System with EPICS Interface

The EPICS control system have gradually been migrated to TLS in the recent year, the alarm system is developed and based in this interface. In the future, this system will be applied in the TPS. This alarm system of CSS support rich function that includes of alarm handle, acknowledge, event latch, email notification and audio announcement.

SMS Notification System



Figure 5: SMS automatic sending toolkit with EPICS.

The Short Message Service (SMS) information is still necessary to send to relative staffs from sub-system event. Especially, the WIFI of mobile phone is turned off. This toolkit GUI is developed by labview, is shown in the Fig. 5. It can be also compatible with EPICS and TLS original control system.

ANALYSIS TOOLKIT

After beam trip, reinject beam and resume machine isn't frequently the most important procedure. If the sub-system problems aren't found and solved, the beam trip will take place again very soon. Check all signals isn't

easy in this short time. Amount of signals will take time so much. Analysis toolkits will be helpful to find problem quickly. The toolkit GUI is shown in the Fig. 6. One of downtime events is recorded with 10Hz post-mortem mode. Several thousands of signals are recorded in the database. After toolkit processing, the signals number can be reduced to 21. It can help operator to find downtime event and reduce signal number. Checking 21 signals by operator can save much time that compares with all signals. In this case, it is injection problem and create super conductive magnet, RF cavity system problem. They are correctly searched from amount of signals and converged to twenty one signals.

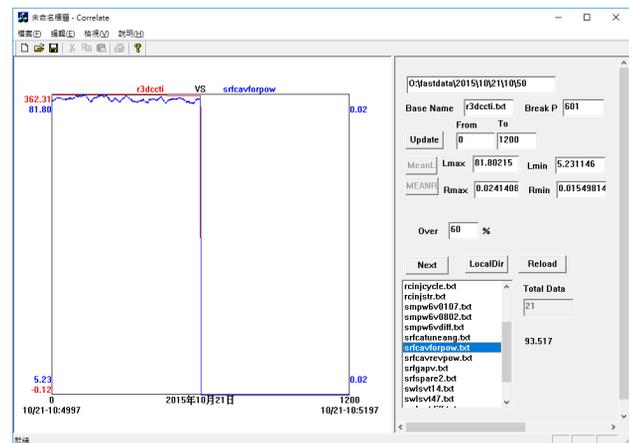


Figure 6: Downtime analysis toolkit.

SUMMARY

High reliability operation is very important to users in the modern light source. Various toolkit and diagnostic tools are used to check sub-system, look for problem between ten thousands signals and events in each downtime. In the future, this artificial intelligence (AI) toolkit and expert assistance (EA) system for downtime analysis will be developed continuously.

ACKNOWLEDGEMENT

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