MAIN OPERATION IMPROVEMENTS ON TAIWAN LIGHT SOURCE

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Abstract

With the beam energy of 1.5 GeV, the storage ring of Taiwan Light Source (TLS) in National Synchrotron Radiation Research Center (NSRRC) has provided research service to users for more than twenty years. It takes a lot of efforts to keep this accelerator reliable and to improve its stability. NSRRC has finished the construction and commissioning of the new 3-GeV accelerator Taiwan Photon Source (TPS) which will be opened to users with limited beam lines in 2016. On the other hand, TLS has 25 beamlines and still serves users very well as being benefited by its mature operation skills and continuous efforts on maintenance and system improvement. Main challenges and corresponding solutions on TLS operation in these recent years t are presented herein, together with the statistics on operation performance.

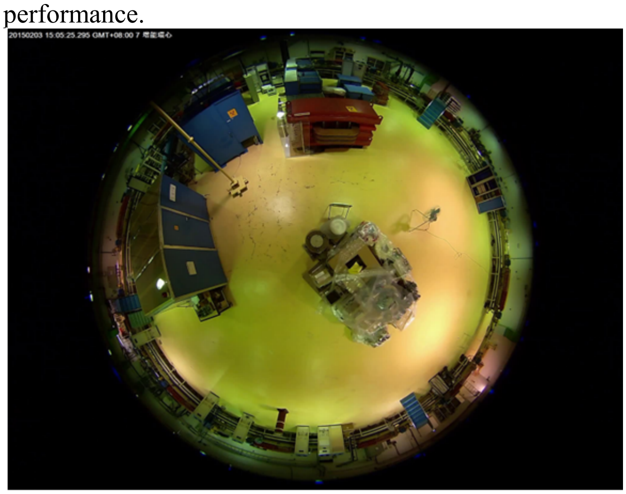

Figure 1: Topography of Booster.

INTRODUCTION

Taiwan Light Source (TLS) has been operation longer than two decades; its storage ring is 6-fold symmetry with 6-meter straight sections. So, that it takes more efforts on maintenance and harder to keep high availability and stability as before. There are many upgradation and substitution from sub-system of each group continuously. For example, power-supply promotion, digital environment camera built-up. The Ethernet camera with good image quality helps operator to check environment and equipment when entrance guard is started. Figure 1, show topography of booster when booster is operated. It still works excellently to deliver high-quality synchrotron light to users. Being a third-generation light source, insertion devices, top-up injection and high-order-mode free SRF module are standard equipment in this compact ring [1, 2].

THE STATISTICS OF MACHINE OPERATION

Taiwan Light Source started 200-mA top-up injection operations in October 2005 and, subsequently, raised the stored beam current to 300 mA; and then raised the beam current to 360 mA in 2010 and stayed there in the following years. Next it was 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-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 2002 to 2015 are summarized in Table 1.

Table 1: Summary of Performance Indicators for TLS Operation

Year	Schedule user time (hours)	Availability	MTBF (hours)	Operation mode	Beam stability $\Delta I/I0 < 0.1\%$
2002	4785	95.8%	154.4	Decay	47%
2003	5017	97.2%	313.6	Decay	86%
2004	4235	97.5%	132.3	Decay	85%
2005	4576	96.8%	81.7	Decay/ Top-up	76%
2006	5552	96.7%	40.8	Top-up	81.3%
2007	5219	98.1%	85.6	Top-up	98.1%
2008	5726	97.9%	112.3	Top-up	98.5%
2009	5402	97.9%	77.2	Top-up	89.2%
2010	5286	97.4%	81.3	Top-up	82.1%
2011	5818	95.9%	55.4	Top-up	89.4%
2012	5197	98.1%	44.8	Top-up	91.4%
2013	5178	99.5%	140	Top-up	95.5%
2014	5645	99.4%	182.1	Top-up	94.1%
2015	5327	98.7%	84.6	Top-up	87.7%

In 2015, the total delivered user time is 5256 hours, while the scheduled user beam time is 5327 hours, the beam availability is thus 98.7 %. Not only the beam availability, but also the MTBF of 84.6 hours and beam stability index of 87.7 % are all worse than the previous two years as the year-by-year summary shown in Figure 2. Majorly some old components aged or even failed in the first three operation months of 2015 and thus bothered the operation very much. They were then either replaced with spares or upgraded to new models so that the beam performance was gradually recovered. Illustrated in Table 2 is the monthly beam stability index and statistic percentage. The scheduled user time, beam availability, beam stability index of 0.1 %, and MTBF in each month

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of 2015 is shown in Figure 3. The machine beam performance at the last half year is obviously much better. After noise is isolated power-supply of quadpole (QPS) and new QPS is applied to TLS. The stability of beam is effective to improve. The QPS performance is show in the Fig. 4. The Fig. 5 shows beam stability improvement after QPS upgrade. The Fig. 6 shows new power-supply for quadpole magnet.

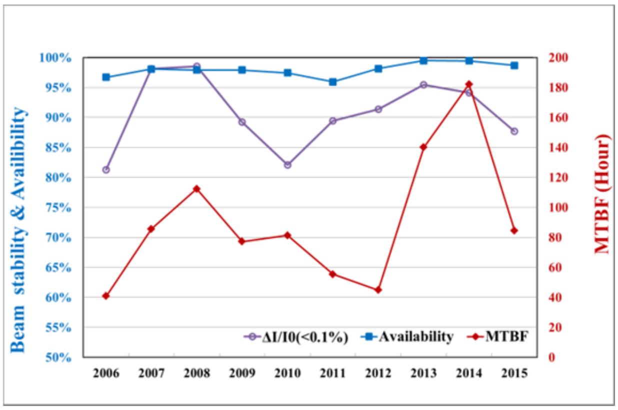

Figure 2: Summary of the beam stability index of 0.1 %, beam availability, and MTBF from 2006 to 2015.

Table 2: Monthly beam stability index of TLS. The power supplies of three quadpole families were attached to a power regulator in July and thus improved the beam stability

Month	< 0.2%	< 0.1%	Month	< 0.2%	< 0.1%
1			7	99.1 %	98.6 %
2	90.2 %	75.1 %	8	99.2 %	98.5 %
3	93.8 %	70.5 %	9	99.6 %	97.2 %
4	97.4 %	67.7 %	10	99.6 %	97.7 %
5	97.9 %	82.6 %	11	99.8 %	97.9 %
6	97.9 %	84.4 %	12	99.9 %	94.5 %

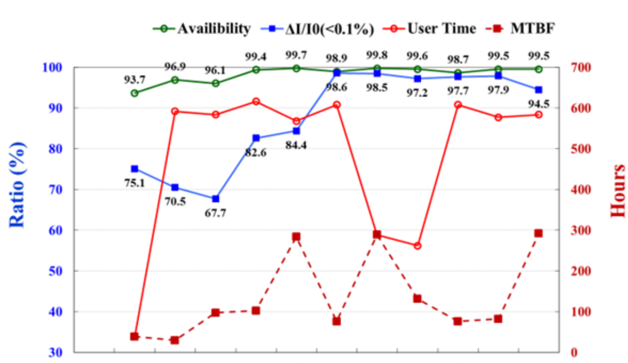

Figure 3: Monthly user time and beam performance indicators of TLS in 2015.

MAIN COMPONENTS REPLACEMENT AND IMPROVEMENT

To summary some components upgrading:

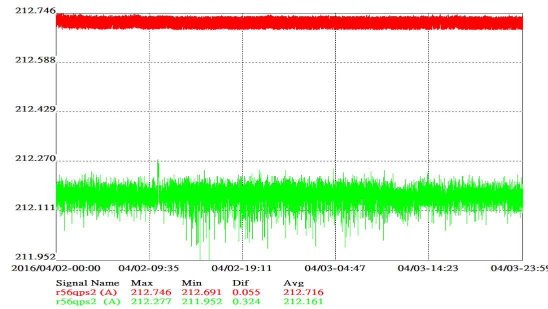

Figure 4: Powersupply of quadpole reading, red line is new model, green line is old type QPS in the early half of 2015.

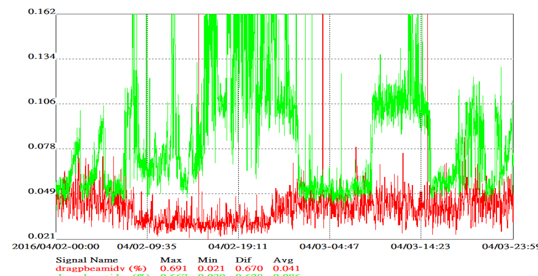

Figure 5: ΔI/I of beamline stability, red line is after QPS upgrade, green line is poor stability with old type QPS.

Figure 6: New QPS.

Linac:

1. Cathode and thyrotron tube are replaced with new components.
2. Circuit performance for noise rejection of TL kicker is improved.

Power supplies of magnets:

1. Some crates for correctors' power supplies are replaced with new one.
2. Quadpole power supplies (QPS) of family 1, 2 and 3 are upgraded to new model.

Instruments and controls:

1. Power amplifier of transverse feedback system is refreshed to new model.
2. Control interfaces of QPSs are updated.
3. FPGA based global orbit feedback system.

The orbit feedback system (OFB) is very important to control orbit. New FPGA based platform of OFB is also tesing in 2015. In the same time, corrector power-supply controller interface (CPSC) is applied in this new system. The platform is shown in the Figure 7 [3, 4].

Figure 7: Orbit feedback system platform.

The new feedback platform is based on libera Brilliance+ that is micro-TCA liked system with difference kinds of digital bus. The GDX (Gigabit data exchange) module includes of Xilinx Spartan-6 FPGA for FA data grouping and OFB computation. It was contracted to D-TACQ. This module will convert dgital data to 16bit analog output from AURORA rocket I/O receiving. The CPSC module supports fast settings from orbit feedback system and sum with slow setting channel from ILC.

The CPSC include of 32 channels analog output, offers substantial performance improvement on RTM-AO16. For AO, here is a FIFO driven AWG function, capable of operating continuously up to 1MHz. Fig. 8 is frontend and backend of CPSC.

(a)

(b)

Figure 8: (a) CPSCI AO32 frontend. (b) CPSCI AO32 backend. 32 channels AO is extend to 64 channels AO by RTM-AO16 bus.

Table 3: Summary of Major Trip Events

Subsystem	Event	Beam trip
Other	Partial beam loss without clear reason	19
Other	Sag of electric power	4
Other	Earthquake	2
Other	Multi-events in the same time	2
Linac	Wrong firing of kickers	9
Linac	Aged thyrotron tube and cathode	4
I&C	Transverse and Longitudinal feedback	5

DOWNTIME AND FAILURE ANALYSIS

Downtime of each subsystem is shown in Figure 9. With a comparison to the trip events listed in Table 3, it is shown some subsystem has low trip rate but long recovery time. For example, there were only two trips on the super-conductivity magnets, but it took nine hours downtime. Another one is the power-supply system to take fifteen hours downtime at four trips.

In 2014, TLS was suffered very much on the 20-Hz vibration during refilling period of the liquid helium to the superconducting wiggler SW6 to perturb or even trip the SRF system. This is temporarily solved by modifying the control algorithm of RF tuner as applying a stepping frequency below 20 Hz on the tuner motor. In 2015, the SRF module was processed with various tuning angles at high beam currents before TLS was opened to users. This completely solved the gas loading problem on the SRF cavity and thus the 20-Hz perturbation is no more a problem to TLS operation.

CONCLUSION

There are many subsystems are gradually modified and implemented in the 2015. New model QPS includes of rich diagnostic function with better performance. The difference of QPS is very small in each other that can reduce parameter adjustment and operation duty. The new FPGA based orbit feedback system with individual PID control rule shall be adaptive with various type correctors. Diagnostic functions of BPM by using 10 kHz rate are useful to analysis instability. The post mortem utility can identify fail components and analysis accident responsibility of subsystem. That is useful to improve reliability of machine. Every effort can make high availability and stability for users.

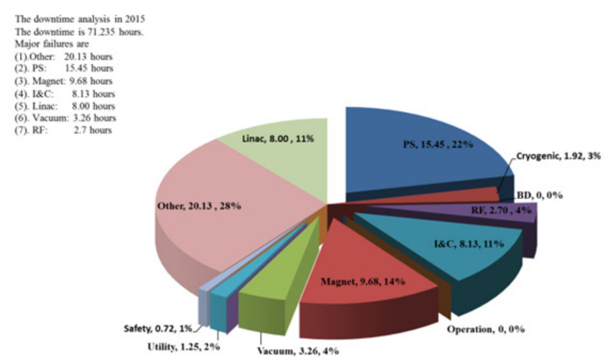

Figure 9: Downtime of each subsystem in 2015.

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