TLS Machine Status

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Machine Operation

In 2011, the impact of Taiwan Photon Source (TPS) civil construction on Taiwan Light Source (TLS) operation gradually reduced and ground vibration from the TPS civil construction caused TLS to have 6 trips.

The machine operation in year 2011 has delivered 5,580.7 user hours, which was 95.9% of the scheduled user time (5,818 hours). This availability is obviously lower than those of the past few years. The major event is that the klystron tube of linac modulator had reached its end of life time and, as a result, caused 128.3 hours of downtime in April. The accelerator reliability, measured by MTBF (mean time between failures) as 55.4 hours in 2011, is also less than that of the past few years. The statistics of machine operation from 2002 to 2011 is shown in Fig. 1. Table 1 is a summary of beam parameters of TLS storage ring.

Table 1: Beam parameters of storage ring.

Energy [GeV]	1.5
Number of buckets	200
Current [mA]	360
Bunch length [psec]	31
Horizontal emittance [nm-rad]	22
Vertical emittance [pm-rad]	88
Tunes ($\nu x/\nu y$)	7.302/4.17
Vertical (rms) orbit stability [um]	1
Coupling [%]	0.4
RF voltage [MV]	1.6
Lifetime [hour]	6

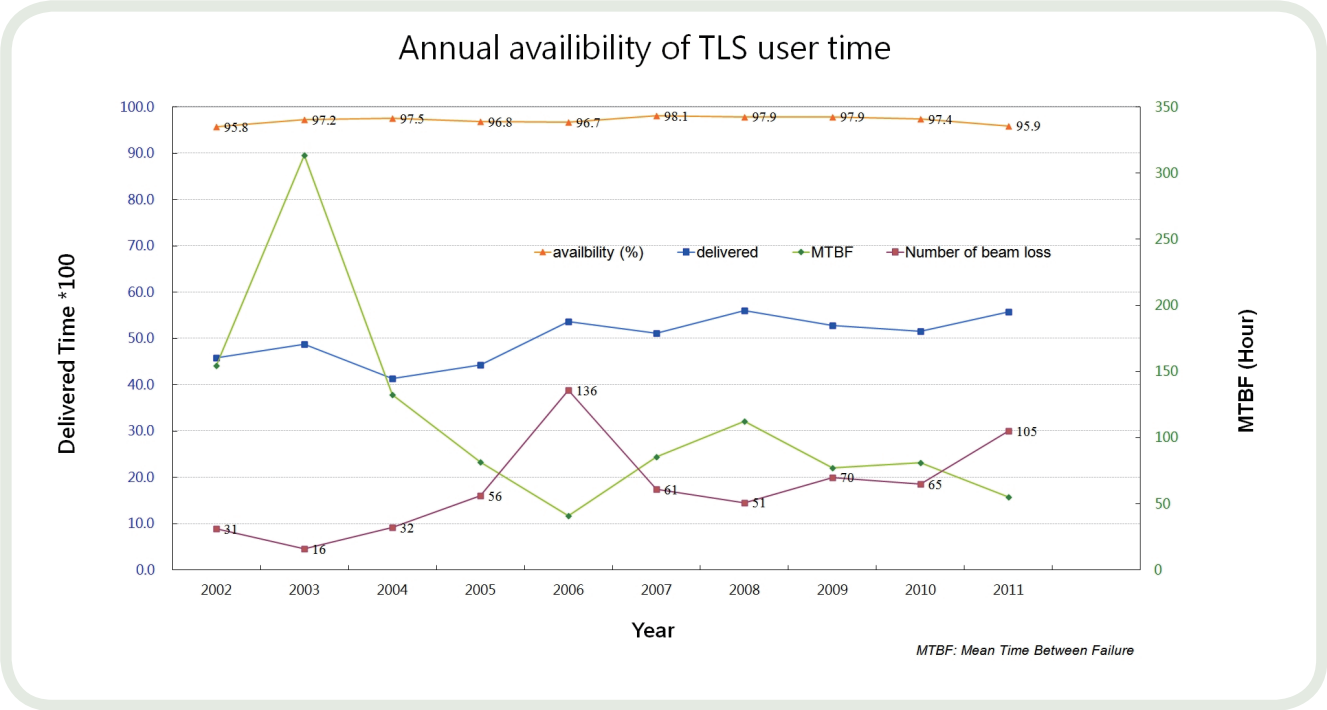

Fig. 1: The statistics of machine operation for last few years.

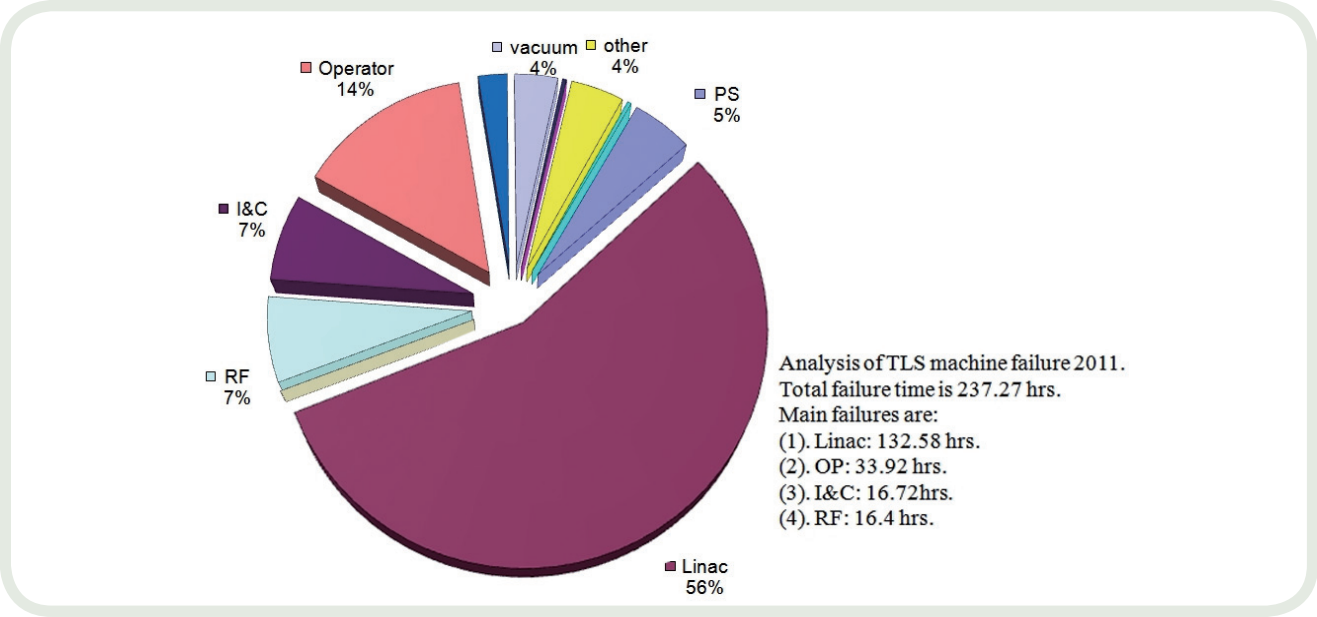

Fig. 2: The statistics of subsystem failures.

Downtime and Failure Analysis

In 2011, a major event and other 105 faults contributed to the total downtime of 237.3 hours, of which 109 hours were resulted from the latter, significantly more than the average fault (62 times) that occurred during 2007-2010. The statistics of failures and the subsystems responsible for the events are shown in Fig. 2.

Two constraints limit the operation current of storage ring to 360 mA. One is that the RF power delivered from the 100 kW klystron has been reached 85 kW level. The other is that inefficient kicker strength of transverse bunch-by-bunch feedback system was implemented to suppress strongly collective beam instabilities for daily user operation. A serious partial beam loss occurred when the feedback efficiency was reduced for some situations, and subsequently SRF interlock was triggered, resulting in 27 faults attributed to the operation group. This kind of faults has been dramatically increasing since the stored beam current was raised from 300 mA to 360 in December 2009. Several efforts have been taken to sustain the stable performance of bunch-by-bunch transverse feedback system, which includes another feedback loop, tune feedback.

Thirty-two faults attributed to RF group and 11 faults were due to the large vibration of SRF cavity induced by sudden expansion of Helium gas during LHe refill of the downstream superconducting wiggler. This problem has been solved by increasing the frequency of refilling process. Ten faults were due to a fast change of tuner phase. A laser position tracking system has been implemented to find out the cause of this problem. Table 2 gives detailed causes about the failures and the action items. The operational performance of TLS is shown in Table 3.

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Table 2: Subsystem failure analysis.

Linac	Time/Hour	Cause/Action item
Aging klystron	128.3	Replaced the klystron.
Kicker misfired	2	The charging voltage of the kicker power supplies is applied only at a few seconds, and more filters are implemented in kicker 2.
Waveform shift	1	The parameters of thyratron are fine tuned.
Operation		
Chamber outgas	2	The SRF vacuum interlock was triggered by poor vacuum nearby the RBT area.
Poor feedback efficiency of TFB system.	28	Poor vacuum increased the growth rate of instability, then caused the partial beam loss during injection period. It could be solved by temporarily reducing the operating current.

I&C		
Malfunction of global orbit feedback	2	The SRF interlock was active by large change of electron beam orbit.
Malfunction of U90 controller	13.8	The machine statue was switched to beam adjustment due to reset of the U90 controller after occurrence of the hang event.
RF		
Cavity vibration	12	The SRF interlock was triggered by cavity vibration, which was caused by the sudden expansion effect during LHe refilling period of the downstream SW6.
Tuner phase	10	The SRF interlock was active by a fast change of tuner phase.
Transmitter	4	This includes water flow rate interlock, reflection power interlock of circulator, Iacc interlock.
Unstable LLRF	2	The SRF interlock was active by an unknown unstable LLRF.
Poor vacuum	2	The SRF vacuum interlock was active by FBT cold cathode gauge.
Oscillation	2	The SRF interlock was active by an unknown oscillation.
Other		
TPS civil construction	6	The SRF interlock was triggered by cavity vibration, which was caused by the TPS civil construction.
Earthquake	5	The SRF interlock was triggered by cavity vibration, which was caused by earthquake.
Voltage sag	1	The stored beam was lost due to a voltage sag event of Tai-power.
Magnet		
R4IASW	5	The SRF interlock was triggered by partial beam loss event that was caused by trip of R4IASW. The quench interlock of R4IASW was active by improper setting of LN2 pressure.
SW6/R4IASW	4	The SRF interlock was triggered by partial beam loss event that caused by trip of SW6/R4IASW. The quench interlock of SW6/R4IASW was active by the sudden expansion of LHe refill. It was caused by the change of the poor vacuum condition of the LHe feed pipe after maintenance.
PS		
Fault	8	This includes dipole power supply failure (2), water flow meter fault of power supply (2), SWLS power supply failure (4).

Table 3: Operational performance of TLS.

Year	Annual schedule user time (hour)	Up time	MTBF (hour)	Operation mode	Beam stability $\Delta I/I0<0.1\%$
2002	4,785	95.8%	154.4	Decay	47%
2003	5,017	97.2%	313.6	Decay	86%
2004	4,235	97.5%	132.3	Decay	85%
2005	4,576	96.8%	81.7	Decay/Top-up	76%
2006	5,552	96.7%	40.8	Top-up	81.3%
2007	5,219	98.1%	85.6	Top-up	39.9%
2008	5,726	97.9%	112.3	Top-up	95.7%
2009	5,402	97.9%	77.2	Top-up	89.2%
2010	5,286	97.4%	81.3	Top-up	82.1%
2011	5,818	95.9%	55.4	Top-up	89.4%