OPERATION EXPERIENCE AND PERFORMANCE STATISTICS OF TLS AT SRRC

G. H. Luo, J. Ching, M.J. Horng, C.C. Kuo, K.Y. Kuo,
T.H. Lee, J.A. Li, Y.K. Lin, R. Sah, W.D. Wey
SRRC, No. 1 R&D Road VI, Hsinchu, Taiwan, R.O.C.

Abstract

Taiwan Light Source (TLS) provides only three beam lines to synchrotron user at 1993 Light Source Dedication. The fast expansion of users' community pushes TLS to build more beam lines and install three insertion devices at straight sections. To fulfill the increasing beam time requests, SRRC enhances operation qualities by deploying full-time operation team, operating TLS around the clock, increasing the beam energy and stored beam current, installing active feedback system and putting extra tuner to detune the troublesome high-order-mode. The beam stability reaches 0.5% peak-to-peak variation and long term orbit drift maintain within 50 m. The competent engineers and well-trained technicians make the fine tune and upgrading projects carry out smoothly with minimized machine down time. Operation experience and statistic data will be provided.

1 INTRODUCTION

Taiwan Light Source (TLS) is the first third-generation dedicated light source in operation in Asia. The nominal beam energy is 1.3 GeV with beam current 200 mA and the expected beam lifetime is 6 hours. The strong coordination and engineering team makes the achievement exceed the design goal. The beam energy reached 1.5 GeV [1], which is limited by the saturation of dipole field in the ring, and the stored beam current exceed 240 mA with very high photon quality. The basic parameters of TLS is listed in Table 1. The fast expansion of user's community makes the beam time request growing faster than the beam line can provide.

2 BASIC PARAMETERS OF TLS

2.1 Storage Ring

TLS uses 1.3 GeV injector and transfer line to provide the injection electrons. The 1.3 GeV to 1.5 GeV energy ramping is performed at storage ring. Beam current top-up mode is adapted to reduce the injection time and keep the magnet field converged between the injection and operation lattice, 1.3 and 1.5 GeV respectively.

The beam parameters of low- and high-emittance lattices have been studied for different users' requirement in conjunction with the hardware reconfiguration, e.g. single cavity operation. Several operation lattices with different emittance and dispersion function coupled with ramping process also have been performed without beam loss [2], which provides a flexible operation mode.

Table 1. The Basic parameters of storage ring

Maximum energy	1.5 GeV
Multi-bunch beam current	240 mA
Beam lifetime (1.5GeV, 200mA)	> 9 hrs.
Lattice type	TBA
Natural horizontal beam emittance	19 nm-rad
Critical photon energy	2.14keV
Radio Frequency	499.654MHz

2.2 Beam Lines

Currently, there are eight operational beam lines which are listed in Table 2. Over one hundred proposals have been allocated for the beam time during 1997. The requests for the beam time are far beyond the capacity that beam line can provide. Hence, twelve beamlines are under construction. Six more beam lines are under designing or planing stage.

Table 2. Operational beam lines

Beam Line	Type	Energy (eV)	E/E
B-03B	1m-SNM	4-40	>5k
B-06A	6m-LSGM	15-200	>20k
B-11B	DCM	>1k	<7k
B-13B	white light	>1k	---
B-14B	white light	500-1k	---
B-15A	6m-HSGM	110-1.5k	>10k
B-15B	DCM	4k-12k	>5k
S-05B/W20	DCM	4k-15k	<7k

2.3 Insertion Devices

The installed insertion devices include 1.8 Tesla Wiggler, U5 undulator and a prototype EPU. An U9 undulator is going to be shipped to TLS at the end of 1998. An orbit tuning process for undulator dynamic-gap-variation is undergoing during the accelerator beam time. The rms orbit-distortion can reduce to less than 10 μm during the dynamic-gap-variation [3].

3 PERFORMANCE AND STATISTICS

The reliability and beam stability is the first priority for a dedicated synchrotron light source. We have experienced some short interruptions due to the water leakage of magnets, power supplies and beamlines; overheating of power supplies, septum and magnets; and trip-off of high-voltage components from RF transmitters. In some cases, the malfunction cause a longer shutdown of accelerator, e.g. vacuum leakage of a moving bellow, supporting dielectric burnout of high-power transmission-line due to aging, and short circuit of high-current septum, etc. The available ratio of TLS has been maintained around 90% since 1994.

3.1 Availability of Storage Ring

Generally, TLS schedules a long shutdown period to perform major installations and upgrades each year. For every quarter, there is one-week shutdown to maintain the accelerator and conduct some minor repairs and replacements. Figure 1 shows the available ratio of TLS between Oct. 1993 and May 1998.

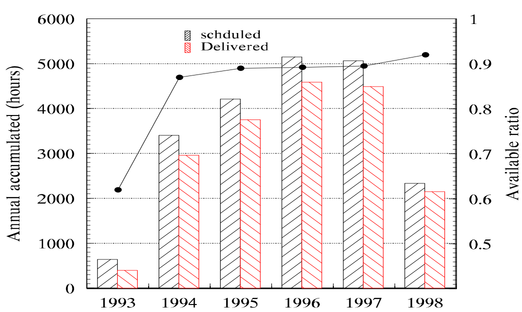

Figure 1. Statistics of TLS accelerator available ratio during 1993-1998.

3.2 Availability of Users' Shifts

The operational time slots are planned as 6 day a week and 24 hours per day. The availability of users' shifts between Jan. 1997 and May 1998 is shown in Fig. 2.

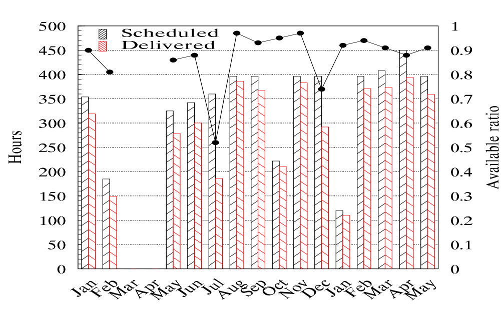

Figure 2. Availability of users' beam time during Jan. 1997- May 1998.

3.3 Weekly Report and Figure of Merit

Users' beam time is scheduled 108 hours per week. One of typical example of the weekly report is shown in Fig. 3, only a quarter of the whole graph is plotted [4]. Figure 3 indicates that the available ratio, scheduled time slot and Figure of Merit (FoM) for users' shift during the third week of May, 1998. The available ratio of accelerator reached 97.1%.

At SRRC, the FoM is defined as:

$$FoM = \left\{ \int I(t) \frac{w_\tau + 1}{[w_\tau + (\tau_1 t + \tau_0)/\tau(t)} \prod_i \frac{w_i + 1}{w_i + \sigma_i(t)/\sigma_{i0}} dt \right\} \Big/ \left[\int I_0 \tau_0^{1/\tau_1} / (\tau_1 t + \tau_0) \right]$$

where $I(t)$, (t) and $\sigma_i(t)$ are the beam current, lifetime and key parameters from archived data. The w_i is weighting factor for the corresponding indicators. The I_0 ,$_0$, $_1$ and σ_{i0} are the expected stored-current, lifetime, slope of the beam lifetime and the default value of the key indicators, respectively. Figure 3 indicates a low FoM value, 70.1%. Analyzed from archived data, the stored beam current is 180 mA which is lower than the specified beam current 240 mA. The beam size (1σ) in vertical direction is, 120 µm, larger than the nominal value, 90 µm [5].

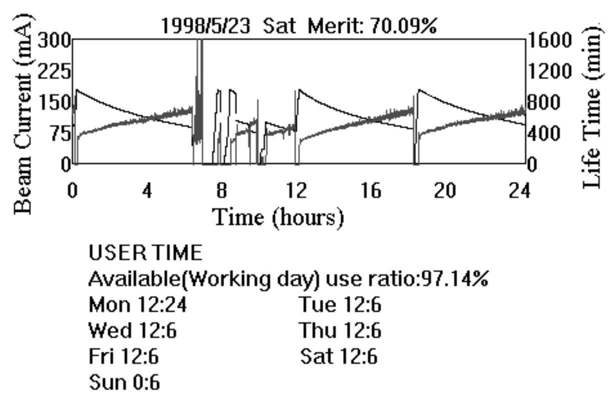

Figure 3. A quarter graph of weekly report of TLS operation where includes the FoM of storage ring.

4 STABILITY

Currently, the FoM calculation only includes beam lifetime, beam current and beam size. The beam stability and orbit-distortion, referenced to the golden-orbit, are the crucial indices to demanding users. These parameters will put into calculation after some hardware modification.

The beam stability was improved by the installation of RF second tuner and the enhancement of temperature control over the RF cavities. Ground vibration, induced by mechanical pump and the exhausting fan, was reduced to minimum by installed vibration absorber.

4.1 Orbit Stability

The temperature variation in the tunnel and the magnet chilling-water, which is affected by the weather and the cooling capacity, will cause a long term drift of the beam orbit [6]. We observed a large orbit swing, more than 150 μm, at the first session of users' shift immediately after accelerator startup. It was contributed to the working temperature swing of the dipole magnet. A better temperature control of chill water and tunnel temperature will improve the long-term orbit-drift. Figure 4 shows one of the best orbit stability, which was taken in the middle of users' sessions, without orbit feedback and among three consecutive users' shift.

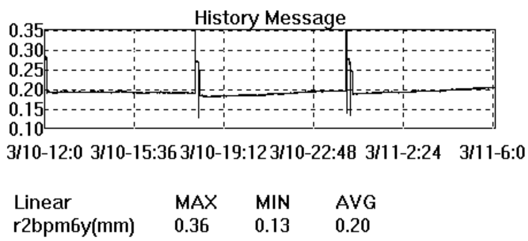

Figure 4. The orbit stability of the beam for three consecutive users' shifts. The beam orbit drift less than 20 μm.

4.2 Intensity Stability

Beam splitting and instability problems, which occurred at different current range, cause serious concern during normal operation. Installation of second tuner [7] and better temperature control of the cavities have been playing an important role in suppressing the high-order-mode in the RF cavities. The longitudinal-couple-bunch instability has been very effectively suppressed by an appropriate tuner position and working temperature of cavities. Figure 5 shows that the measured photo-current which is only function of stored beam current. The measured fluctuation of photo-current can maintain better than 0.2% [8].

4.3 Vacuum and Beam Stability

The interaction between bunched electron beam and heavy ions [9] also creates beam instability. For example, an over-baked of gate valve generated polymer which polluted the beam chamber. It took months of users' shift and using synchrotron light to cleanup adhesive polymer. The measured beam stability was worse than 3% during the period.

Installation of NEG pump around the ring and discontinuous the TMP operation reduced the base-pressure and eliminated the vibration source on the vacuum chamber. Actively sealing of leakage nearby flanges by vacuum experts further improved the vacuum pressure. The average base-pressure was reduced to 10^{-11} torr, which reduced the ion effects to minimum. The beam lifetime increased accordingly. The Monday effect [10] of beam lifetime was eliminated.

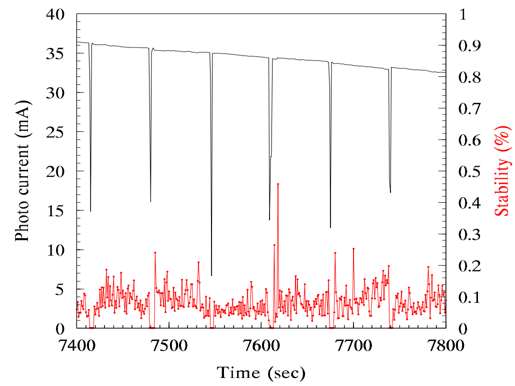

Figure 5. The I_0 is function of stored beam current only during the thermal equilibrium of focusing mirror. The measured $\Delta I/I_0$ is better than 0.2%.

5 CONCLUSION

The accelerator team at TLS continuously improve the machine performance and reliability. The beam stability is expected to be resolved by optimization and implementation of transverse and longitudinal feedback system. The stored beam lifetime will be significantly improved by the installation of high harmonic cavity this summer. Full energy injection upgrades the booster and transfer line which will eliminate the orbit drift during warm-up of magnets and make the operation simple.

6 REFERENCES

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