STATUS REPORT ON THE SYNCHROTRON RADIATION RESEARCH CENTER

R.C. Sah, J.R. Chen, C.C. Kuo, and G.H. Luo
Synchrotron Radiation Research Center, No.1 R&D Road VI
Hsinchu Science-Based Industrial Park, Hsinchu, Taiwan, R.O.C

Abstract

The Taiwan Light Source (TLS) is a 1.5-GeV, third-generation light source located at the Synchrotron Radiation Research Center (SRRC). Since the commissioning of the TLS in 1993, it has been operated routinely for user experiments. At this time, the major emphases at SRRC are accelerator operations, accelerator improvements, insertion-device construction, photon-beamline construction, endstation construction, and the rapid expansion of the synchrotron radiation research program. The status of accelerator operations is discussed, as are the current status and future plans for facility upgrades.

1 INTRODUCTION

The Taiwan Light Source is a third-generation light source located at the Synchrotron Radiation Research Center in Hsinchu, Taiwan. SRRC is a research center with in-house research groups. The TLS was commissioned in 1993, and it has been operated routinely for user experiments since then[1].

2 ACCELERATOR OPERATIONS

2.1 Operating Mode

The Taiwan Light Source is normally run at a beam energy of 1.5 GeV. The beam lifetime is usually 9 hours or more, at a current of 200 mA. The emittance coupling is normally set at a few percent to increase the vertical beam size and the beam lifetime. Typical (1σ) beam sizes are 80 μm vertically and 300 μm horizontally. Except during scheduled shutdowns for machine maintenance and equipment installation, the light source is operated for users and for machine studies 6 days every week, 24 hours per day. The monthly beam availability normally exceeds 90%. During 1997, 117 proposals for experiments were allocated beam time. This number is projected to increase significantly in 1998.

2.2 Machine Reliability

Machine reliability is the first priority for the SRRC accelerator team. Therefore, an aggressive response is taken to all machine problems that are encountered. Several examples will be discussed below. Recently, the Light Source Division has been reorganized, in order to provide stronger technical support for machine operations. Although there has been and will continue to be a dedicated Operations Group, all the scientists in the Light Source Division will take on greater responsibilities for the routine operation and the upgrades of the Taiwan Light Source.

There is also an ongoing general program to improve reliability: lists of maintenance procedures are being written and will be carefully followed, accelerator subsystems are being upgraded for improved maintainability, and additional spare parts are being acquired as budgets permit.

2.3 Operational Problems

A discussion of several operational problems and the responses taken to these problems would be illustrative.

The TLS injector consists of a 50-MeV linac and a 1.3-GeV booster synchrotron. Some injector problems were encountered in 1996, and several days of user beam time were lost. The routine high-voltage conditioning of the electron gun and the linac could be accomplished only with considerable difficulty, and the booster-ring power supplies were subject to failures. The response taken to these problems was to integrate the injector maintenance effort with the storage-ring maintenance effort. As a result, a much larger group of staff members could contribute to the maintenance of the injector, and the result has been a significant improvement in the reliability of the injector.

Two serious radiofrequency (rf) problems were encountered in 1997. (1) It was found that large temperature variations of the rf cavities (up to several degrees C) caused unacceptable instability in the operation of the light source. The response was to repair and to upgrade the temperature control system for the rf-cavity cooling water, and the problem was solved. (2) A plastic insulator in an rf coaxial feedline melted and charred, and the RF2 cavity window was contaminated. The underlying problem was traced to the aging of the plastic. In response, many coaxial feedline parts were replaced with parts insulated with teflon, which has a higher melting point; and the feedline design was modified to minimize the exposure of the cavity window to any danger of contamination. Also, the cavity window was replaced. The general reliability of the rf system has much improved.

3 FAST BEAM INSTABILITIES

The transverse feedback system of the Taiwan Light Source is effective in suppressing transverse coupled-bunch oscillations of the electron beam.

However, longitudinal coupled-bunch instabilities are also observed during normal machine operations. For now, the most dangerous higher-order modes of the rf cavity are reduced or shifted away from beam modes, by using two tuners per cavity and by precisely controlling the cavity temperature. Future upgrades to the TLS are expected to reduce these longitudinal instabilities. A longitudinal feedback system (to be installed in July, 1998) is designed to damp these modes[2]. Also, a higher-harmonic passive (Landau) cavity will be installed late in 1998 to increase the beam lifetime. It will increase the spread in synchrotron frequencies and produce longitudinal Landau damping, so longitudinal instabilities will be further reduced.

Studies of the beam instabilities have led to the observation of a current-independent instability of about 0.4% peak-to-peak. In response, a "Beam Stability Task Force" has been organized to study and to correct this problem. A number of possible noise sources have been studied: mechanical vibrations, magnet current ripple, stray magnetic fields, etc. It has been decided to replace a number of faulty bearings associated with the air-conditioning system fans.

4 SLOW BEAM DRIFT

Slow drifts of the electron beam orbit, up to 50 μm, have been observed in the TLS. It is difficult to identify the exact chain of causal events which lead to this orbit drift. However, it is believed that a large portion of these effects are caused by changes in the air temperature and in the cooling-water temperature. SRRC has therefore decided to undertake a major, multi-year program to improve the conventional utilities for the TLS. (Such upgrade programs have also been undertaken at other third-generation light sources.) Shortcomings in the SRRC air-conditioning system, in the cooling-water systems, and in the high-pressure air system will all be addressed. To be sure, these utility systems have operated continually for over five years, and some of the corrective measures are repairs of subsystems which have started to wear out. Also, the capacity of the conventional utilities need to be expanded to accommodate a growing research program.

Upgrades have already been made in the storage-ring tunnel air-conditioning system and in the cooling-water systems, and improved results can already be seen. It is anticipated that improvements to the performance of the utility systems will eventually reach a point of diminishing returns, at least in terms of reducing orbit drift. Therefore, the plan is to control the remaining beam drift by using orbit feedback systems. These feedback systems are under development.

5 MACHINE UPGRADES

5.1 Radiofrequency System Upgrade Program

The purpose of the rf-system upgrade program is to improve the beam stability by reducing or controlling the effects of rf-cavity higher-order modes (HOMs) on the beam stability. The first phase of these upgrades will run through FY2001. The present rf system, which uses DORIS cavities, will be improved by the addition of HOM damping and by improving the water-cooling system. If necessary, SRRC will undertake a second phase of upgrades by acquiring three quasi-HOM-free cavities. Two will be installed in the storage ring, and the third will be a spare to be kept in readiness on the test stand.

5.2 Other Major Upgrades

Other important upgrades include significantly increased laboratory and office space located at or near the light source building. Also, we plan control system upgrades, the integration of injection controls with storage-ring controls, and top-up injection mode studies. Lastly, a dedicated, fully-instrumented diagnostic beamline is being planned.

6 SYNCHROTRON RADIATION RESEARCH

There is currently a vigorous effort to build up the research program at SRRC. The major components of this effort are the construction of insertion devices, the construction of photon beamlines, the construction of experimental endstations, and the promotion of synchrotron-radiation research in Taiwan. Furthermore, negotiations are under way for SRRC to have a strong presence at SPring-8 in Japan. Taiwan researchers will then have ready access to high-performance x-ray beamlines, which will complement those available at the Taiwan Light Source.

6.1 Research Topics

Some of the major research topics at SRRC are the following:

- Surfaces and Interfaces
- Atomic and Molecular Sciences
- Materials Science

- Condensed Matter
- Methods and Instrumentation
- Industrial Applications

6.2 *Insertion Devices*

Many photon beamlines which originate from bending magnets are available at the TLS. In addition, there are four long straight sections in the magnet lattice which are available for the installation of insertion devices, the hallmark of third-generation light sources. The current and future insertion devices are listed in Table 1.

Table 1. Insertion Devices

Name	W20	U10	U5	U9	EPU5.6
Type	hybrid	hybrid	hybrid	hybrid	pure
λ[cm]	20	10	5	9	5.6
N	13	20	76	47	66
Gap min [mm]	22.5	24	18	18	18
$B_y(B_x)$ [T]	1.8	0.945	0.64	1.245	0.67(0.45)
E_{ph} [eV]	800-15k	5-100	60-1500	5-100	80-1400
Length [m]	3.04	2	3.9	4.5	3.9
Status.	oper.	oper.	oper. to be repl	oper.	const.
Installation	12/94	10/95	3/97	12/98	12/98

6.3 *Photon Beamlines*

A very aggressive program to build photon beamlines has been undertaken at SRRC. The number of operating beamlines has doubled in about two years, and it will nearly double again in a year or two. The operational beamlines and beamlines under construction are listed in Tables 2 and 3.

Table 2. Operational Photon Beamlines

Beamline	Monochr. Type	Energy [eV]	E/ΔE	Description
B-03A	--	vis. light	--	(Beam size and stability diagnostics)
B-03B	1m-SNM	4-40	>5k	(Spectroscopy, PI, PES, ARPES, PAS)
B-06A	6m-LSGM	15-200	>20k	(Spectroscopy, PES, ARPES, XPS, PAS)
B-06C	white light	>1000	--	(Beam stability diagnostics)
B-11B	DCM	1k-9k	up to 7k	(Spectr., NEXAFS, EXAFS, diffr., reflec.)
B-13B	White light	>1000	--	(Micromachining)
B-14B	White light	500-1000	--	(X-ray lithography)
B-15A	6m-HSGM	110-1500	>10k	(Spectroscopy, PES, XPS, SX-MCD, XAS)
B-15B	DCM	4k-12k	>5k	(NEXAFS, EXAFS, instrum. testing)
S-05B/W20	DCM	4k-15k	up to 7k	(Scattering, diffraction)

Table 3. Photon Beamlines (Under Construction)

Beamline	Monochr. Type	Energy [eV]	E/ΔE	Description
B-01B	ERG	20-1200	up to 3k	(Spectroscopy)
B-02(h-f)	6m-CGM	4-40	>20k	(Spectroscopy, PES, ARPES, PAS)
B-06B	White light	<1000	--	(Pho. ass. CVD)
B-08A/ EPBM	6m-SGM	20-1200	>10k	(Spectroscopy, PES, XPS, XAS, MCD)
B-09A(w-r)	6m-SGM	10-1500	>10k	(Spectroscopy, PES, ARPES, XAS, MCD)
B-13A	White light	<1000	--	(Diagnostic)
S02/EPU	6m-SGM	60-1500	>10k	(Magnet. mat.)
S03B/U5	6m-SGM	60-1500	>10k	(Spectromicroscopy, PES, XPS, XAS)
S-05A/W20	BTCM	4k-15k	1000	(Diffraction, scattering)
S-05C/W20	DCM	4k-15k	up to 7k	(Spectroscopy, NEXAFS, EXAFS, diffr.)
S-06A/U9	gas filter	4-500	50	(PI, chemical dynamics)
S-06B/U9	6m-CGM	4-100	up to 60k	(Atomic molecular, condensed matter)

7 MANAGEMENT ISSUES

A number of management issues have been addressed at SRRC in the past two years. Most importantly, a new top-management team (including the new Director, Dr. C.T. Chen) has been put into place to provide leadership for the laboratory.

Secondly, as was discussed earlier, the Light Source Division was reorganized in order to strengthen machine operations. In addition, the maintenance of the injector was integrated with the maintenance of the storage ring.

Thirdly, contacts with the world-wide accelerator community were greatly increased, because the physical location of SRRC tends to lead to an undesirable isolation of the staff. One strategy which has proved to be particularly effective has been to invite accelerator scientists to visit SRRC, typically for one-week periods. The number of visitors has averaged about one per month.

Lastly, SRRC wishes to improve the professional training of its staff, so a regional accelerator school at SRRC is being organized for August, 1998. The lectures will be conducted in Chinese.

8 CONCLUSION

The basic mission of SRRC is to build and to operate a synchrotron-radiation research center. The accelerator team's role is to provide the best possible source of synchrotron light.

- Our first priority is reliable machine operations.
- Our second priority is beam stability and improved machine performance.
- Organizational improvements will increase our operating efficiency.

Aggressive plans to achieve these goals have been put into operation, and improvements can already be seen.

9 REFERENCES

[1] "Performance of the TLS at SRRC." Y.C. Liu, et al., EPAC 96, p.700-702, 1996.

[2] "Longitudinal Damper for SRRC/TLS Storage," W. K. Lau, et al., EPAC 96, p. 1926-1928, 1996