OPERATIONAL STATUS OF THE TAIWAN LIGHT SOURCE

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Abstract

The Taiwan Light Source (TLS) is a third-generation synchrotron light source located at the Synchrotron Radiation Research Center (SRRC) in Taiwan. The TLS is now operating routinely for user experiments, and the highest priority is being given to insertion-device construction, photon-beamline construction, endstation construction, and the rapid expansion of the synchrotron-radiation research program. Many resources are also being devoted to improving accelerator operations, increasing machine reliability, and upgrading the accelerators. In order to increase machine reliability, SRRC is improving maintenance procedures, upgrading accelerator systems, and stocking spare parts. Many of the planned accelerator upgrades are intended to improve the stability of the stored electron beam: a longitudinal feedback system is under construction, orbit feedback systems have been developed, the RF system is being upgraded (better higher-order-mode performance), and the utilities are being improved.

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 has been operated routinely for user experiments since 1994[1].

2 ACCELERATOR PROGRAM

2.1 Program Goals

The goals of the SRRC accelerator program are to improve accelerator operations, to increase machine reliability, and to upgrade the accelerators. In order to increase machine reliability, SRRC is improving maintenance procedures, upgrading accelerator systems, and stocking spare parts. Many of the planned accelerator upgrades are intended to improve the stability of the stored electron beam: a longitudinal feedback system is under construction, a higher-harmonic passive (Landau) cavity is under construction, orbit feedback systems have been developed, the RF system is being upgraded (better higher-order-mode performance), and the utilities are being improved.

2.2 Operating Mode

The normal operating energy of the Taiwan Light Source is 1.51 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.

3 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. 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: system failures trigger formal investigations, lists of maintenance procedures are being prepared, accelerator subsystems are being upgraded for improved maintainability, and additional spare parts are being acquired as budgets permit.

4 ACCELERATOR UPGRADES

Many of the planned accelerator upgrades are intended to improve the stability of the stored electron beam. Among these upgrades are feedback systems to damp beam instabilities and to prevent orbit motion.

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.

4.1 Longitudinal Feedback System

A bunch-by-bunch longitudinal feedback system has been built and will be installed soon. The radiofrequency of the TLS is 500 MHz, and this is also the (very high) bunch-crossing rate. The difficult technical challenges of handling such a fast data stream have led to innovative solutions:

symbol 183 \f "Symbol" \s 10•} 500 Mbytes/sec fast digital signal processing
  electronics: commercially-available signal
   processing chips are used, as are specially-designed
   ADC/DEMUX and DAC/MUX circuits.
symbol 183 \f "Symbol" \s 10•} 1.0 - 1.25 GHz broadband RF system that kicks
  individual bunches every 2 nanoseconds.
symbol 183 \f "Symbol" \s 10•} A newly-invented longitudinal kicker that is efficient
  and fast. See Figure 1.

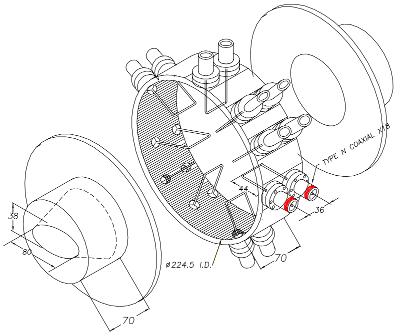

Figure 1. Kicker for Longitudinal Feedback System

4.2 Passive Landau Cavity

Decreasing the electron-bunch density is very desirable because it reduces Touschek scattering and increases beam lifetime. Increasing the transverse bunch size is not attractive, however, because it reduces photon-beam brilliance. One attractive solution is to use a higher-harmonic cavity to increase the bunch length and therefore to increase the beam lifetime (without reducing the photon-beam brilliance). A third-harmonic passive Landau cavity has been built and is being installed at this time. See Figure 2.

In a passive Landau cavity, the RF gap voltage is induced by the circulating bunched beam, so the performance of a passive cavity is current dependent. Calculations predict that, at a current of 200 mA, a doubling of the bunch length will occur. The amount of bunch lengthening is limited by (1) the available RF power from the main RF system, (2) the damping strength induced from the main RF cavities, and (3) the maximum 30 kW of allowed dissipated power on the cavity body.

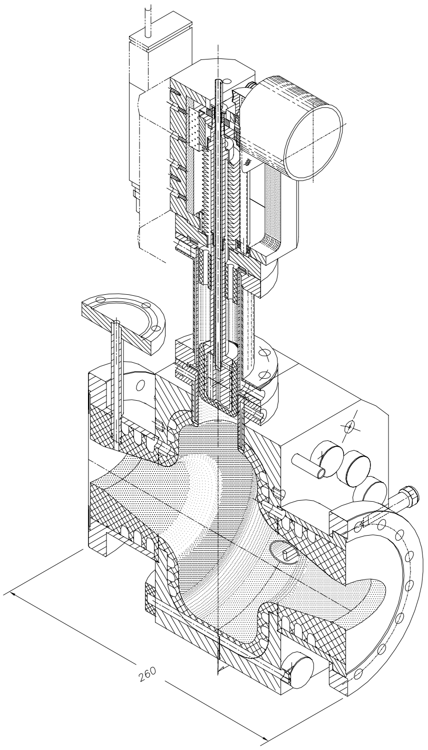

Figure 2. Higher-harmonic Cavity

The passive Landau cavity will increase the spread in synchrotron frequencies and produce longitudinal Landau damping. Therefore, longitudinal instabilities will be further reduced.

4.3 Sources of Noise

Studies of the electron-beam instabilities have led to the observation of a current-independent instability which is sometimes as large as 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. These studies show that faulty bearings associated with the air-conditioning-system fans are important sources of noise, so these bearings will be replaced.

4.4 Orbit Feedback

Providing a stable beam is a crucial requirement for a synchrotron light source. Motions of the electron-beam orbit make it difficult and sometimes impossible to carry out high-quality experiments. In the TLS, orbit motions with time scales from milliseconds to days have been observed. Therefore, several feedback systems have been developed to suppress these motions. First of all, a Digital Global Feedback System has been developed at SRRC and is undergoing operational tests during user beam time. Also, a Local Feedback System has been developed to work in conjunction with the global system. Lastly, a Slow Orbit Feedback System has been built to provide beam stability at frequencies much less than 1 Hertz. These feedback systems are undergoing beam testing, in order to work out the optimal operational modes.

4.5 Utilities Upgrades

Slow drifts of the electron beam orbit, up to 50 symbol 109 \f "Symbol" \s 10µm, 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. Shortcomings in the SRRC air-conditioning system, in the cooling-water systems, and in the high-pressure air system will all be addressed. 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 the orbit-feedback systems discussed earlier.

4.6 Damping of Higher Order Modes

The transverse and longitudinal feedback systems are designed to suppress the coupled-bunch instabilities of the stored electron beam. An alternative approach for reducing these instabilities is to damp the higher-order modes (HOMs) of the radiofrequency (rf) system, since these modes drive the beam instabilities in the first place. Consequently, a development program to reduce these HOMs has been initiated. Silicon-carbide absorbers will be installed in the beam pipes adjacent to the rf cavities. Should it prove necessary, major rf-system upgrades will be undertaken, including the installation of quasi-HOM-free cavities.

4.7 Full-energy Injection

The TLS was designed to provide 1.3-GeV (full-energy) injection of a 1.3-GeV electron storage ring. Now that the storage ring operates at an energy of 1.51 GeV, however, the beam must be injected and stored at 1.3 GeV, and then ramped to the final operating energy. Normally, this procedure is quick and easy. When there are storage-ring operational problems, however, the energy ramping of the storage ring can present problems. Therefore, a plan is being developed to increase the energy of the injector to 1.51 GeV. Providing full-energy injection will also permit the TLS injection system to operate in a top-off mode.

4.8 Other 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 and the integration of injection controls with storage-ring controls. Lastly, a dedicated, fully-instrumented diagnostic beamline is being planned.

5 STAFF TRAINING

Contacts with the world-wide accelerator community have been greatly increased, because the physical location of SRRC tends to lead to an undesirable isolation of the staff. One successful strategy has been to invite accelerator scientists to visit SRRC, typically for one-week periods. The number of visitors has averaged about one per month.

SRRC wishes to improve the professional training of its staff, so a regional accelerator school at SRRC is being organized. The OCPA '98 Accelerator School is scheduled for August, 1998. The lectures will be conducted in Chinese.

6 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. Therefore, the highest priorities are reliable machine operations, beam stability, and improved machine performance. Aggressive plans to achieve these goals have been put into operation, and improvements can already be seen.

7 REFERENCE

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