OPERATION AND RECENT DEVELOPMENTS AT THE SIAM PHOTON SOURCE

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Abstract

The Siam Photon Source (SPS) is a dedicated synchrotron radiation facility located in Nakhon Ratchasima, Thailand. After successful commissioning and recent energy upgrade from 1.0 GeV to 1.2 GeV, the Siam Photon Source is currently well into user mode of operation. The light source is now providing routinely synchrotron radiation in the vacuum ultraviolet and soft x-ray spectral ranges to both internal and external researchers. In this report we describe the overview of the current machine performance including user availability, the progresses made recently, and the planned machine improvements, which emphasizes on improving beam stability and machine reliability. Plan to install two insertion devices, a permanent magnet planar undulator and a superconducting magnet wavelength shifter, is also discussed.

INTRODUCTION

The Siam Photon Source (SPS) is a synchrotron light source operated by the National Synchrotron Research Center (NSRC), and is located in Nakhon Ratchasima, Thailand. The accelerator complex consists of two 20-MeV injector linacs, a 1.0-GeV booster synchrotron, and an electron storage ring. The storage ring was originally designed to operate at 1.0 GeV and was later upgraded for 1.2-GeV operation in 2005 [1]. The lattice of the storage ring is a double bend achromat (DBA) lattice with four superperiods for a total of eight bending magnets. The ring is equipped with four straight sections for insertion devices. Currently the beam is injected to the storage ring at 1.0 GeV and then ramped up to 1.2 GeV. It is planned that the energy of the booster synchrotron will also be upgraded to 1.2 GeV for full energy injection and subsequently top-up mode of operation of the storage ring. Machine specifications of the SPS can be summarized as listed in Table 1. At present there are three photon beamlines in operation: a photoelectron spectroscopy (PES) beamline (BL-4) operated in the vacuum ultraviolet (VUV) spectral range, an x-ray lithography (XRL) beamline (BL-6), and an x-ray absorption fine-structure spectroscopy (XAFS) beamline (BL-8). All three are bending magnet beamlines.

Table 1: Summary of SPS machine specifications

Electron beam energy [GeV]	1.2
Beam current [mA]	120
Lattice	DBA
Superperiod	4
Horizontal emittance [nm·rad]	41
Coupling [%]	0.8
Circumference [m]	81.3
Number of straight sections	4 (7 m)
Betatron tunes ν_x, ν_y	4.75, 2.82
Synchrotron tune ν_s	2.33×10^{-3}
Natural chromaticities ξ_x, ξ_y	-9.40, -6.61
Momentum compaction	0.0170
RF frequency [MHz]	118
Harmonic number	32
RF voltage [kV]	120
RF power [kW]	14
Number of RF cavity	1
Energy loss per turn [keV]	65.94
Injection beam energy [GeV]	1.0
Number of beamlines	3

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OPERATION AND MACHINE PERFORMANCE

In the year 2006 the SPS has been operated in user mode of operation, providing routinely synchrotron radiation in the VUV and soft x-ray spectral ranges to users. The weekly operation schedule has been such that Monday morning was reserved for weekly preventive maintenance, while Monday afternoon and every other Tuesday were designated for machine study. The rest of the week until 2 PM Friday was scheduled for user experiments. Since the beam lifetime in the storage ring was still comparatively short, the beam was injected four times a day. The time it took for beam injection and energy ramping was approximately one hour for each round of injection. At the beginning of the year the beam lifetime was around 2.5 hours at 100 mA beam current. As time passed vacuum condition in the ring was improved by continual photodesorption, which in turn increased the beam lifetime. At the end of the year the beam lifetime increased to around 4 hours at 100 mA stored current, and was still increasing.

Table 2 shows the comparison between the scheduled beamtime and the beamtime actually delivered to the users in 2006. In total 1865 hours of user beamtime were scheduled and 1571 hours were actually delivered, resulting in the user beam availability of 84.25%. There were several machine problems which contributed to unscheduled downtime in 2006. It has been found that the main cause of the machine downtime was the electrical instability of the 22-kV electrical line supplying the SPS which led to numerous machine trips. This was even more prevalent during the rainy season. The problem is being addressed with the construction of a new electrical substation dedicated solely to the SPS. The construction was already finished and the station will be fully operational in 2007. Figure 2 shows the failure statistics in 2006, where the number outside the parentheses is the number of machine trips. The total number of machine trips occurred in 2006 was 117.

Table 2: Scheduled vs. delivered beamtime in 2006

Month	Scheduled beamtime (hours)	Delivered beamtime (hours)	Percentage (%)
January	175.0	149.5	85.4
February	180.0	168.5	93.6
March	155.0	130.0	83.9
April	65.0	43.2	66.5
May	265.0	198.8	75.0
June	210.0	173.0	82.4
July	175.0	119.3	68.2
August	265.0	250.4	94.5
September	200.0	171.5	85.8
October	175.0	167.0	95.4
November	Machine shutdown		
December			

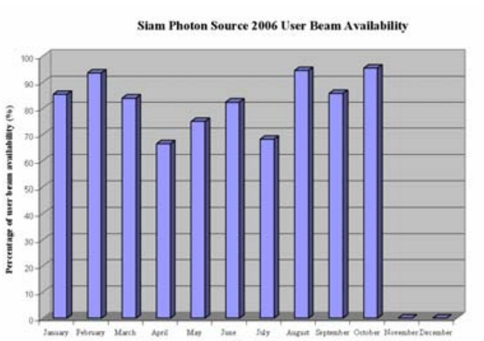

Figure 1: Percentage of the SPS 2006 user beam availability.

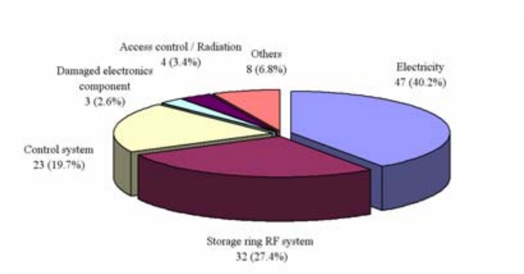

Figure 2: SPS 2006 machine failure statistics.

RECENT DEVELOPMENTS

In the first machine shutdown of 2006 the old and proprietary pattern memory system for the booster synchrotron was replaced with a new PXI-based digital I/O waveform generator [2]. The open PXI standard offers several advantages above the existing system. Most notably among them are improved reliability, easier programming, easier repair, and lower cost. The previous pattern memory system, custom-made by Toshiba, had occasionally experienced both software and hardware malfunctioning, which required system reset followed by pattern reloading and/or electronics board replacement altogether. Up to now the new PXI pattern memory has proved to be very stable and reliable.

A new data logging system for the SPS had also been developed [3]. The earlier data logging scheme was consisted of only simple Java applets that record the monitored data in a comma separated value (CSV) file format, without neither search nor retrieval capability. The new logging and retrieval systems were written entirely with MATLAB language and utilize MATLAB toolboxes, namely, the Open Process Control (OPC) Toolbox, the Data Acquisition Toolbox, and the Database Toolbox, to handle data communications and database interface, respectively. Since the MATLAB-based Accelerator Toolbox [4] is the most-used accelerator modelling tool at the SPS, the MATLAB-based retrieval module can be reused by accelerator physicists to easily import the logged data for accelerator optics studies.

During the second machine shutdown of 2006 at the end of the year the SPS storage ring was realigned. It had been found that before the realignment the ring was misaligned by as much as 3 mm in the vertical direction, which was primarily due to the effect of floor settlement. The situation was better in the horizontal plane, where the position of the magnets differed from the design values by less than 400 microns. However, the storage ring vacuum chambers were not aligned with the magnet centres. From the optical survey of the beam position monitors it was found that the position of the BPMs can be off by as much as 7 mm. The whole ring was then realigned. After the realignment the position of all the components were brought to within 200 microns with respect to the design values.

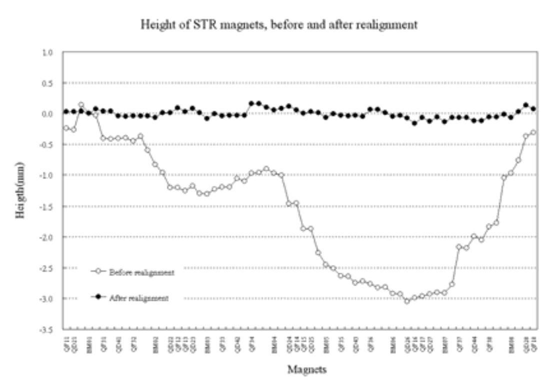

Figure 3: Height of SPS storage ring magnets, before and after the realignment.

After the realignment the SPS was successfully recommissioned. The first task carried out afterward was beam position monitor calibration, which was accomplished by using beam-based alignment [5] together with orbit response matrix measurement. After the BPMs were calibrated, closed orbit distortion (COD) correction was performed using Singular Value Decomposition (SVD) method. This was the first time the electron orbit in the SPS storage ring had been corrected.

The orbit rms errors were brought down from 3.13 mm. to 0.39 mm. in the horizontal direction and from 2.06 mm. to 0.85 mm. in the vertical direction [6].

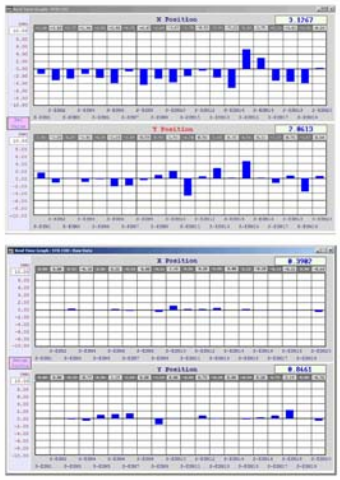

Figure 4: SPS uncorrected orbit (top) compared to the corrected orbit (bottom).

Currently a new beam profile monitoring system is being installed at the bending magnet 2. The previously employed monitoring system, which consisted of only a simple telescopic imaging optics, at the bending magnet 6 (BM6) was removed because of the plan to modify the beamline BL-6 for soft x-ray lithographic research and microstructure fabrication by LiGA technique [7]. The plan for the new beam profile monitor includes x-ray pinhole imaging employing a YAG crystal, x and y interferometers, and an optical beam profiler in the visible region. During the second machine shutdown in 2006 most of the components of this new system had been installed, and it is expected that the system will be fully functioning before the second quarter of 2007.

INSERTION DEVICES

Two insertion devices, a permanent magnet planar undulator (U60) and a 6.4T superconducting magnet wavelength shifter (WLS), will be installed in the SPS storage ring in the next two years. The U60 undulator, which has 41 magnetic periods with period length equal to 60 mm, will be installed in 2007. It will provide more intense synchrotron radiation with photon energy tunable from 30 to 900 eV to the users. At present the magnetic measurements of the magnet are being carried out [8].

For the installation of the WLS in 2008, matching calculations had been performed. It was found that the perturbations introduced by the WLS on the SPS storage ring optics can be corrected by adjusting three pairs of quadrupole magnets adjacent to the WLS. Three quadrupole magnet power supplies had been procured. Two superconducting magnet power supplies and a quench detector had been purchased from Danfysik A/S in 2006. A helium liquefying system for supplying liquid helium to the WLS had been purchased from Air Liquide and is now being installed. The installation is expected to be completed in July 2007, when the system will be commissioned. Currently the WLS cryostat is being modified to accommodate all the instrumentation and sensors. Vacuum chambers both downstream and upstream of the WLS including heat absorbers had been designed and analyzed for heat load tolerance using FEA software. Due to limited space the details of this preparation will be presented elsewhere [9].

SUMMARY

After successful commissioning and energy upgrade of the storage ring from 1.0-GeV to 1.2-GeV operation, the Siam Photon Source is now operated in the user mode of operation. There are currently three photon beamlines. The SPS operation still requires energy ramping in the storage ring; however, energy upgrade of the booster synchrotron is planned. In 2006 user beam availability in 2006 was around 84%, where the main problem was the electricity coming to the facility. A new electrical substation was already built and will be fully operational in 2007. Several machine improvements were carried out with further machine enhancements already planned. The main goal is to improve the machine reliability and beam stability. Two insertion devices, a permanent magnet undulator, and a 6.4T superconducting WLS, will be installed to increase the flux and energy range of the generated synchrotron radiation to the users.

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REFERENCES

[1] S. Rugmai et al., "Energy Upgrade of the Siam Photon Source", AIP Proceedings 879 (2007) 58.

[2] G. Hoyes, “A New, PXI Bus Based, Pattern Memory System for the Siam Photon Source”, these proceedings.

[3] P. Klysubun and C. Netsai, “Development of MATLAB-based Data Logging System at the Siam Photon Source”, EPAC’06, Edinburgh, June 2006, p. 3098.

[4] A. Terebilo, “Accelerator Toolbox for MATLAB”, SLAC-PUB-8732 (2001).

[5] G. Portmann et al., “Automated Beam Based Alignment of the ALS Quadrupoles”, PAC’95, Dallas, May 1995, p. 2693.

[6] S. Rugmai et al., “Beam Based Alignment and COD Correction for the Siam Photon Source”, these proceedings.

[7] P. Klysubun et al., “Soft X-ray Lithography Beamline at the Siam Photon Laboratory”, AIP Proceedings 879 (2007) 1490.

[8] S. Rugmai et al., “Soft X-ray Undulator for the Siam Photon Source”, AIP Proceedings 879 (2007) 335.

[9] P. Klysubun et al., “A 6.4 T Superconducting Wavelength Shifter for the Generation of Hard X-rays at the Siam Photon Source”, to be published.