Operation and Recent Developments at the Siam Photon Source

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Introduction to the Siam Photon Source

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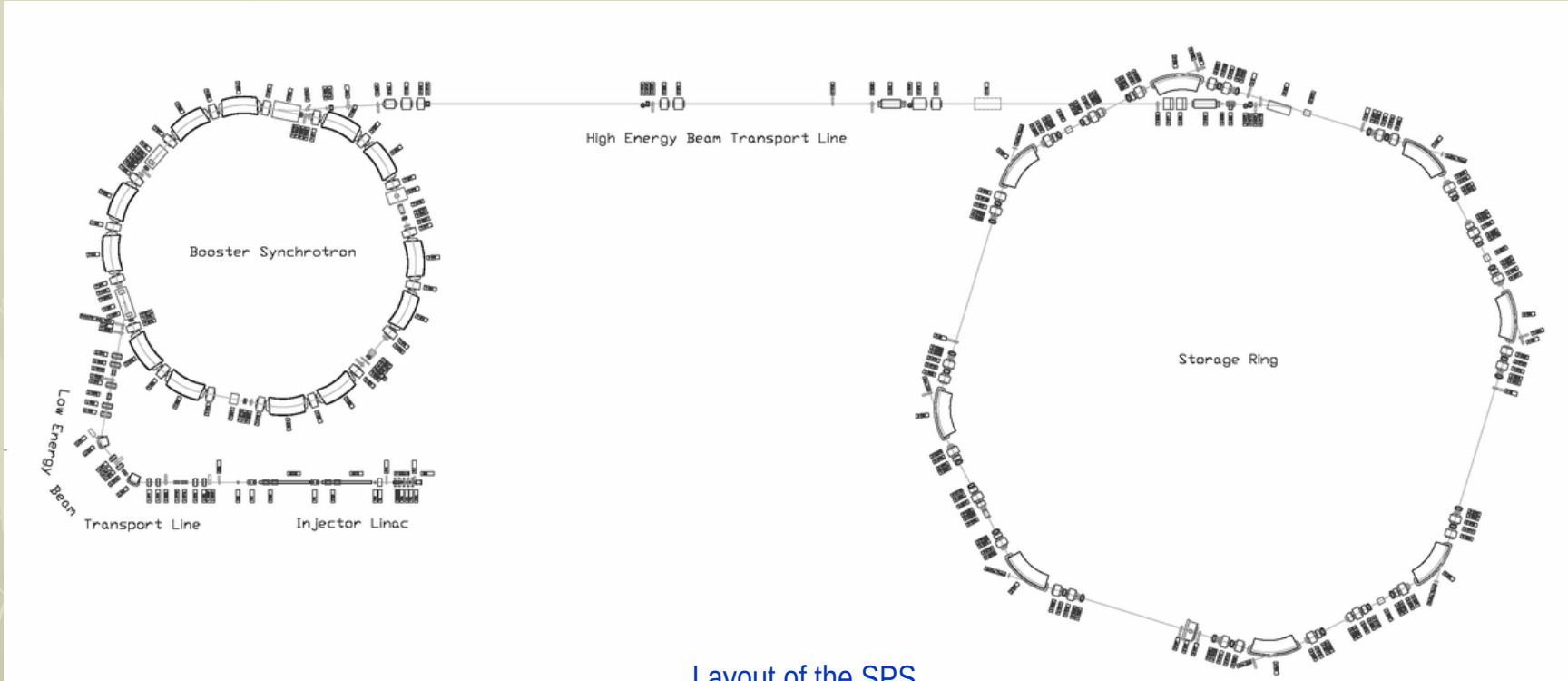
Siam Photon Source (SPS) is a dedicated 1.2-GeV synchrotron light source operated by the National Synchrotron Research Center (NSRC), and is located in Nakhon Ratchasima (~ 250 km northeast of Bangkok), Thailand.

Siam Photon Source (SPS)
Nakhon Ratchasima

SPS MACHINE SPECIFICATIONS	
Electron beam energy [GeV]	1.2
Beam current [mA]	100
Lattice	DBA
Superperiod	4
Horizontal emittance [nm·rad]	41
Coupling factor [%]	0.8
Circumference [m]	81.3
Number of straight sections	4
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]	100
RF power [kW]	10.5
Number of RF cavity	1
Energy loss per turn [keV]	65.94
Injection beam energy [GeV]	1.0
Number of beamlines	3

Introduction to the Siam Photon Source

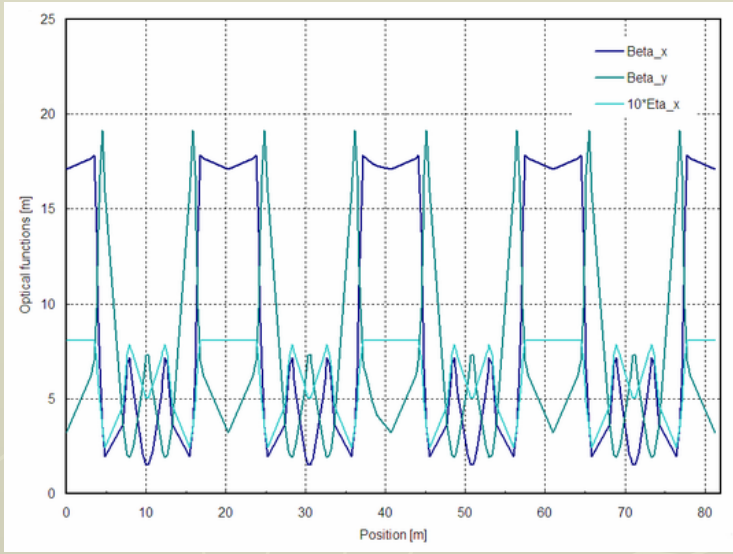
The beam is injected to the storage ring from a 1.0-GeV booster synchrotron, and then ramped up to 1.2 GeV in the storage ring. The NSRC has a plan to upgrade the energy of the booster synchrotron to 1.2 GeV for full energy injection and afterward top-up mode of operation.



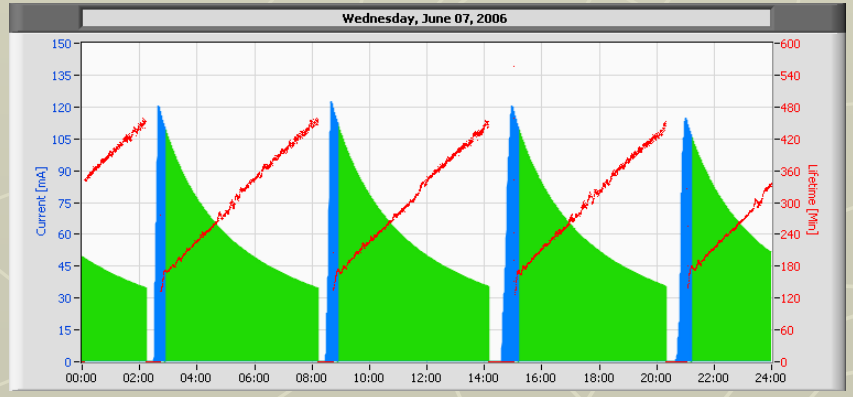
Layout of the SPS

Introduction to the Siam Photon Source

The lattice of the storage ring is a double-bend achromat (DBA) with 4 superperiods. There are 4 straight sections for insertion devices. Two IDs will be installed in the near future: a permanent magnet planar undulator and a 6.4T superconducting magnet wavelength shifter. A helium liquefier is now being installed to supply liquid helium to the WLS. The design emittance of the storage ring is 41 nm-rad.



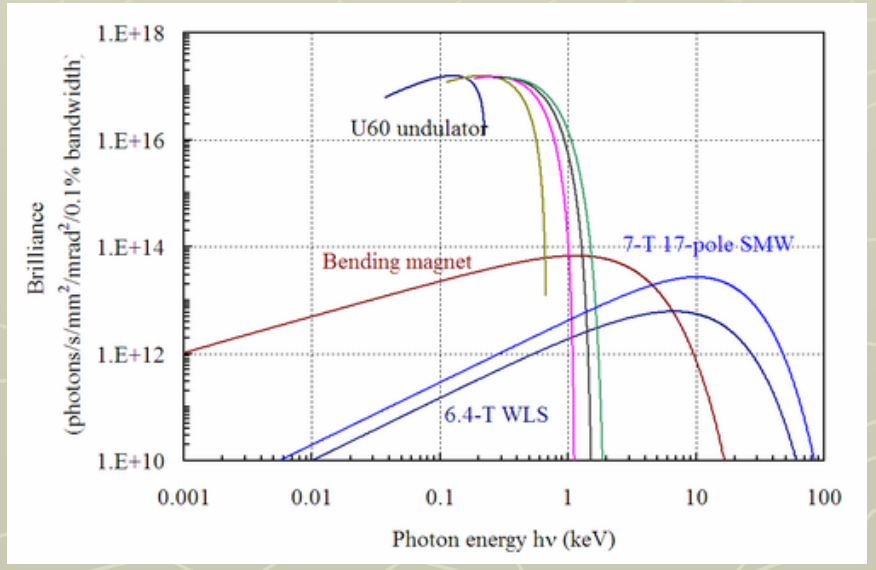
The beam is injected to the storage ring 4 times a day from Monday to Friday. Each round of injection and energy ramping takes less than an hour.



Introduction to the Siam Photon Source

The SPS is now operated in the user mode of operation, providing synchrotron light in the VUV and soft x-ray spectral regions to users. There are currently 3 beamlines in operation (All of them are bending magnet beamlines):

- **BL-4**: Photoelectron spectroscopy (PES) : 20 – 240 eV
- **BL-6**: X-ray lithography (XRL): 2 – 8 keV (white radiation)
- **BL-8**: X-ray absorption fine-structure spectroscopy (XAFS): 1.8 – 8 keV

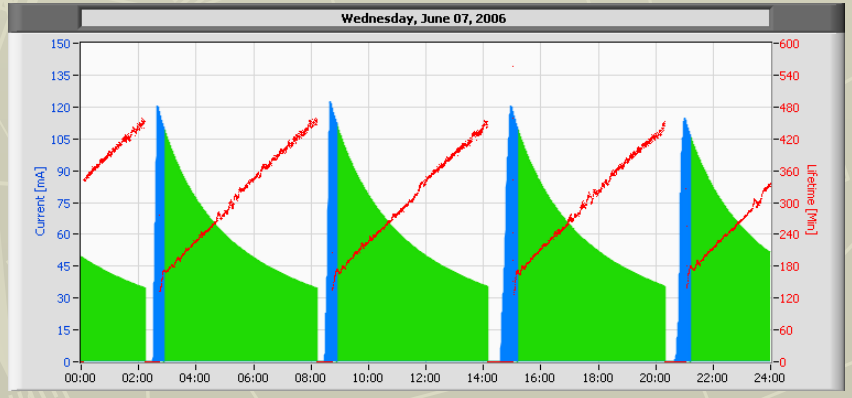


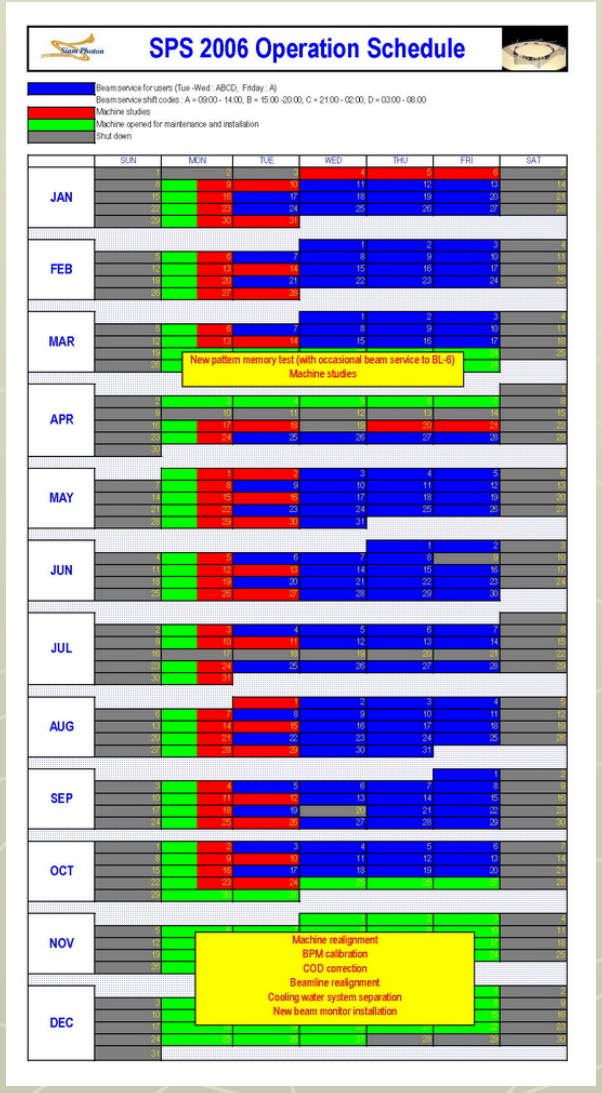
SPS spectrum
Including those of the planned U60 undulator and 6.4T superconducting WLS

Operation and machine performance in 2006

Machine operation schedule in 2006

The SPS weekly operation schedule in 2006 has been such that Monday morning is reserved for weekly preventive maintenance, while Monday afternoon and every other Tuesday are designated for machine study. The rest of the week until 2 PM Friday is 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 takes for beam injection and energy ramping was less than one hour for each round of injection.

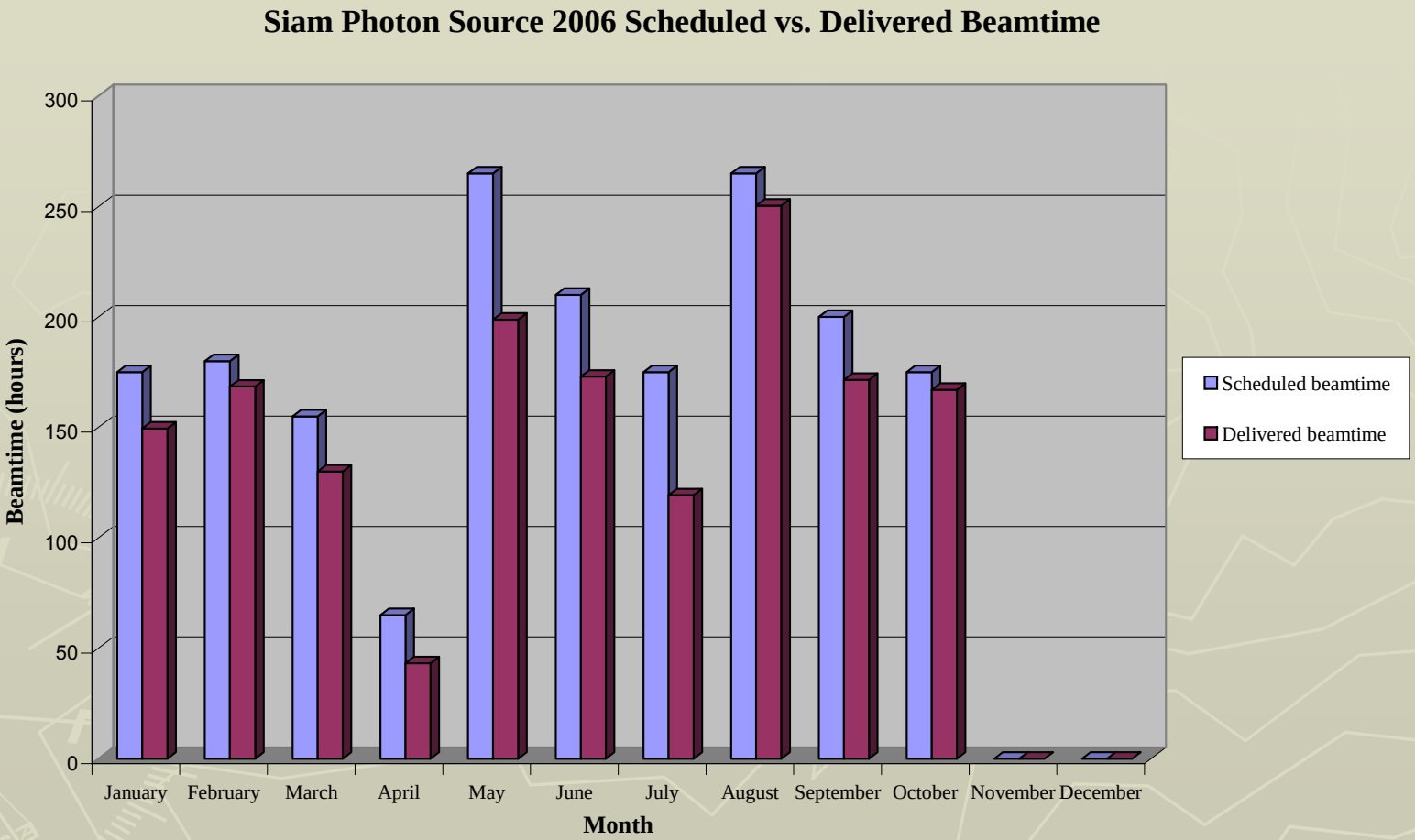




Scheduled vs. delivered beamtime in 2006

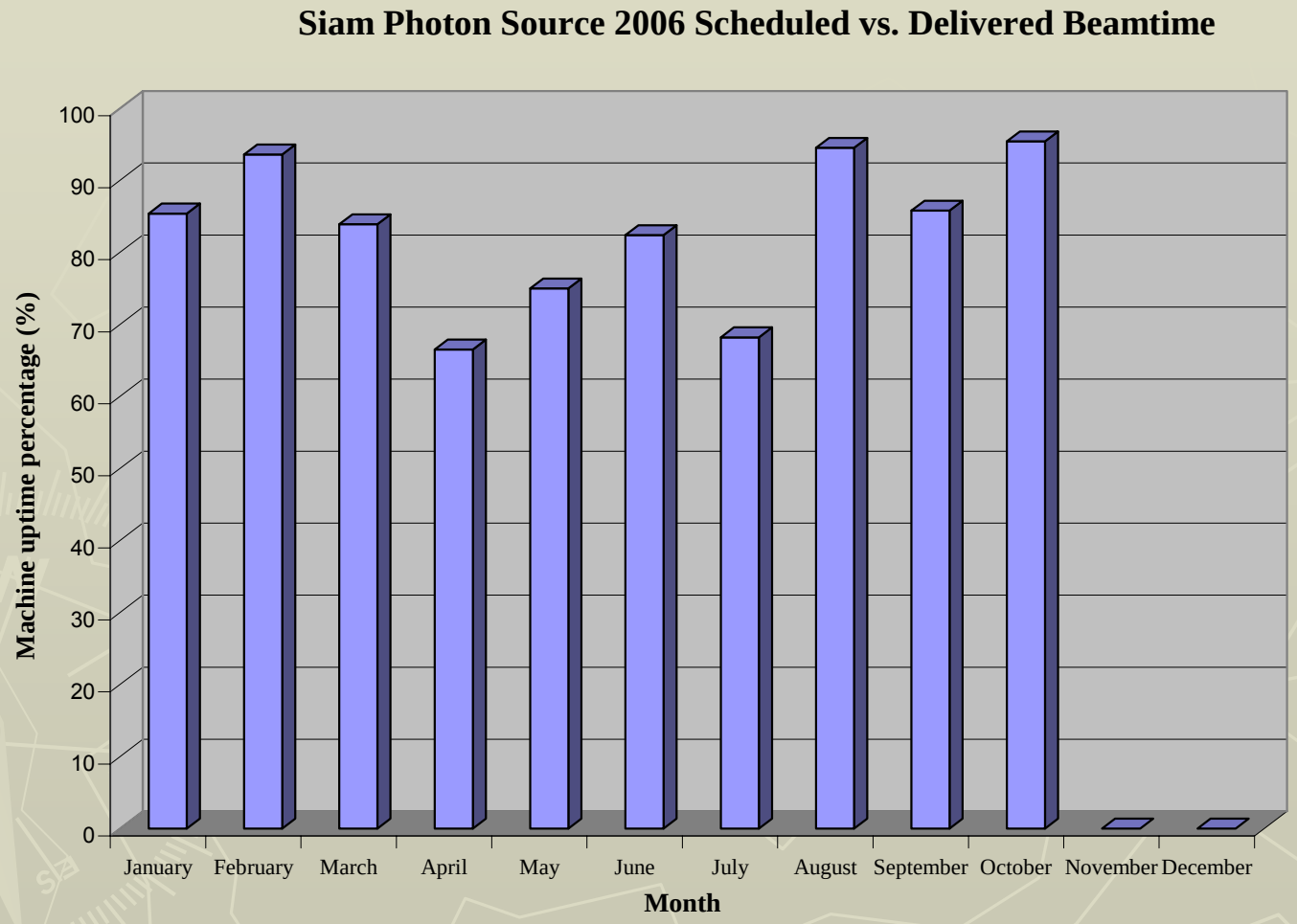
Month	Scheduled beamtime (hours)	Delivered beamtime (hours)	Percentage
January (January 2 – January 27)	175.0	149.5	85.4 %
February (January 30 – February 24)	180.0	168.5	93.6 %
March (February 27 – March 31)	155.0	130.0	83.9 %
April (April 3 – April 28)	65.0	43.2	66.5 %
May (May 1 – June 2)	265.0	198.8	75.0 %
June (June 5 – June 30)	210.0	173.0	82.4 %
July (July 3 – July 28)	175.0	119.3	68.2 %
August (July 31 – September 1)	265.0	250.4	94.5 %
September (September 4 – September 29)	200.0	171.5	85.8 %
October (October 2 – October 20)	175.0	167.0	95.4 %
November	Machine shutdown		
December			

Scheduled vs. delivered beamtime in 2006

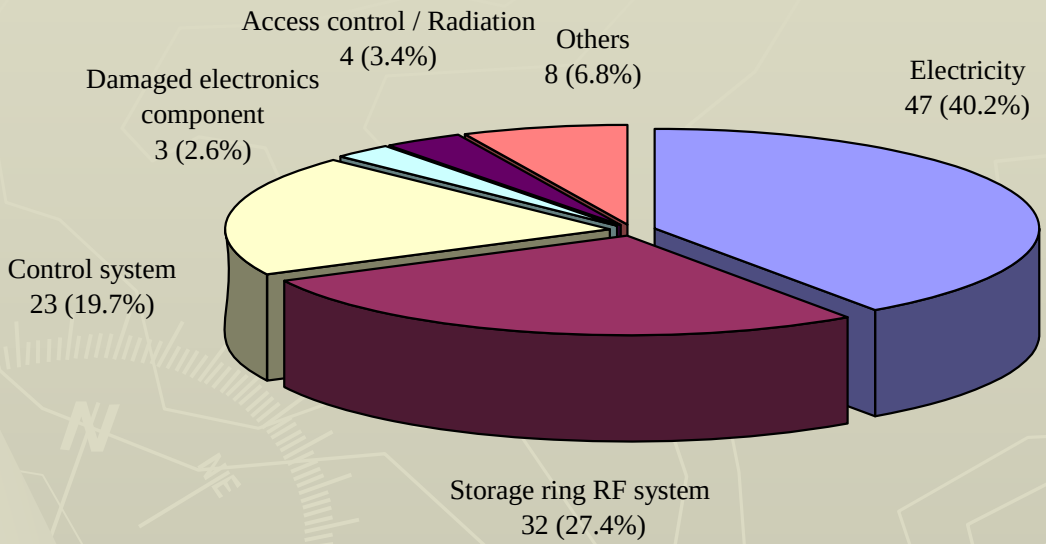


Total: Delivered 1571 hours out of the scheduled 1865 hours (84.25%).

Percentage of machine uptime



Failure statistics



Total number of machine trips in 2006: 117.

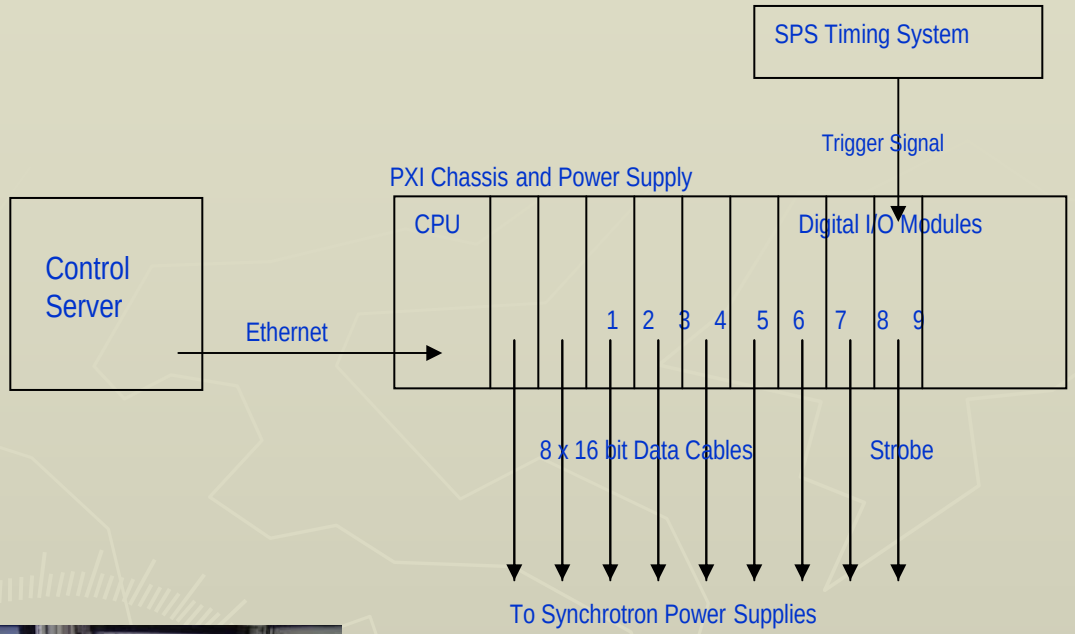
Instability of the electricity coming to the facility contributes most to the machine failure (40%).

This problem is being addressed by building our own electrical substation, which will be in full operation in 2007.

Subsystems of the storage ring RF (water cooling, power supply, etc.) also causes some problems (27%).

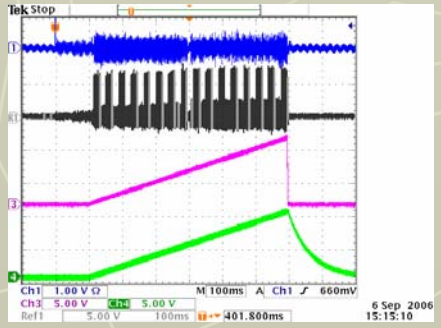
Recent developments

Implementing a new PXI-based pattern memory



Old Pattern Memory System

New Pattern Memory System



Old system: Proprietary system custom-made by Toshiba

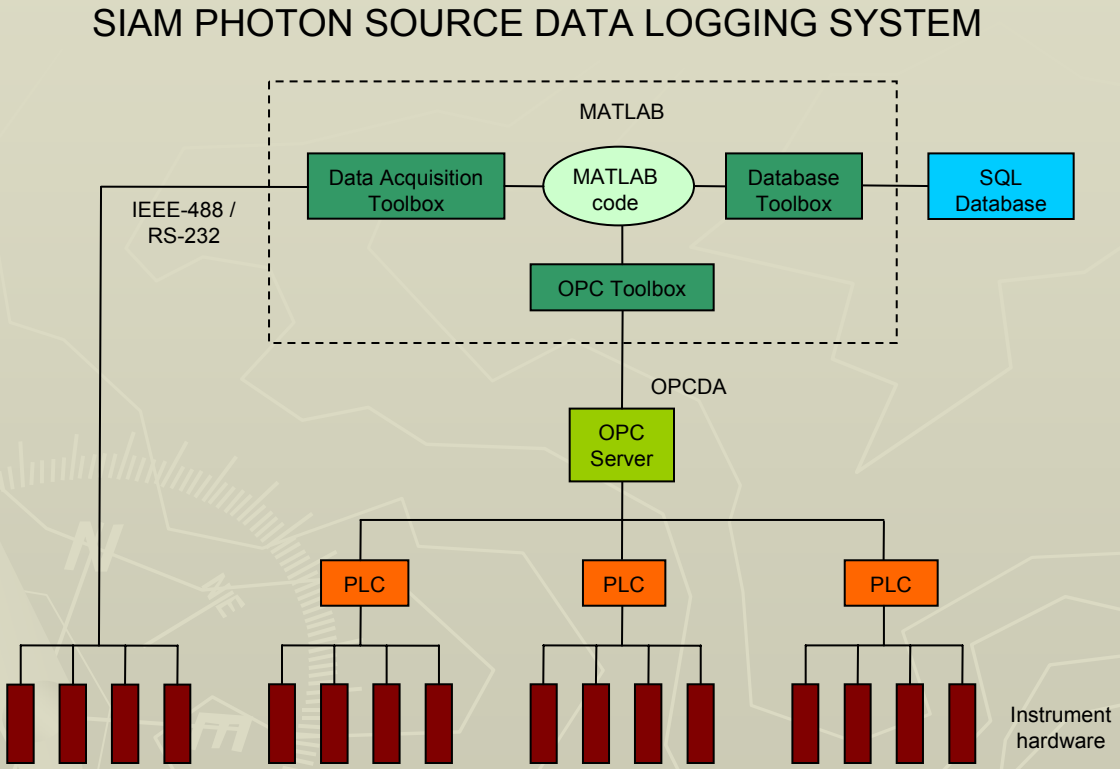
- Occasional failure
- Difficult for maintenance (lack of parts, circuit diagram)

New system: PXI bus-based digital I/O waveform generator

- Low cost
- Open standard
- Easy programming
- Off-the-shelf availability

G. Hoyes, *"A New, PXI Bus Based, Pattern Memory System for the Siam Photon Source"*, poster session.

Development of a new data logging system



Earlier data logging scheme: Simple Java applets.

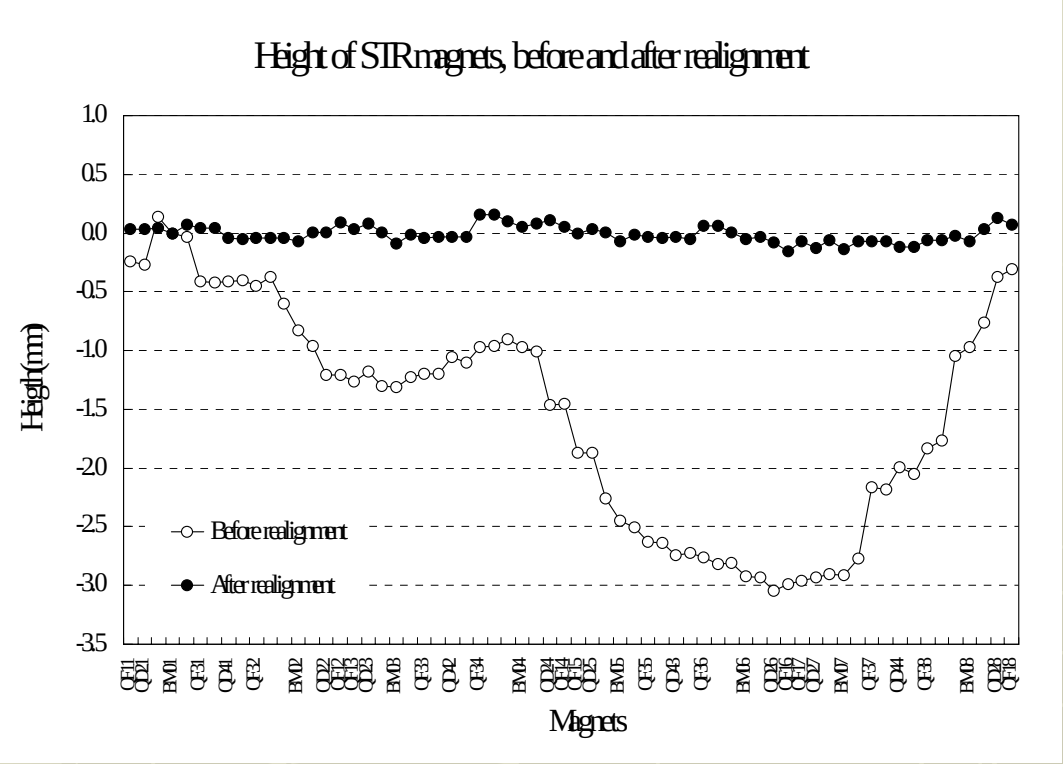
New MATLAB-based data logging and retrieval systems.

Suitable for the existing PLC (Programmable Logic Controller) –based control system.

Easy to incorporate into also MATLAB-based accelerator modeling tool Accelerator Toolbox (AT).

P. Klysubun and C. Netsai, *"Development of MATLAB-based Data Logging System at Siam Photon Source"*, Proceedings of EPAC 2006, Edinburgh, Scotland.

Storage ring realignment (Oct-Nov 2006)

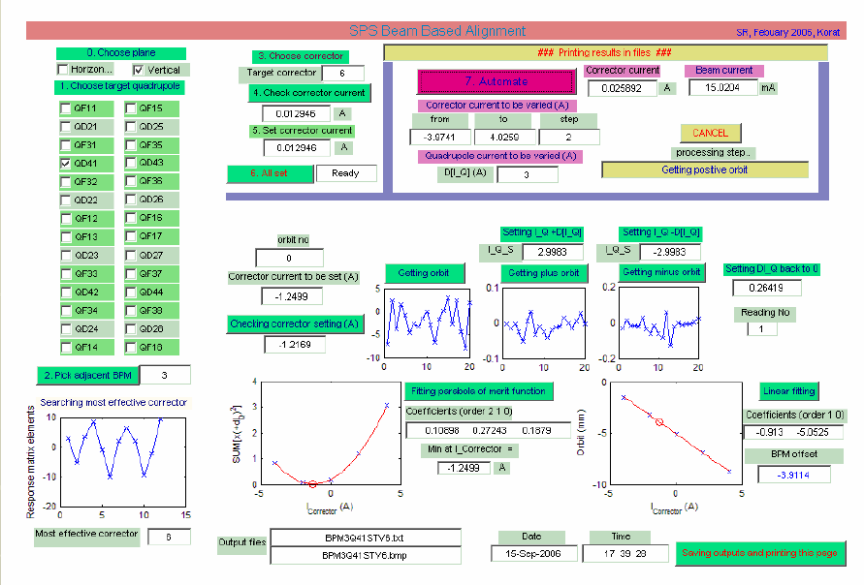


From optical survey it had been found that the SPS storage ring was misaligned by as much as 3 mm in the vertical direction primarily due to the effect of floor settlement.

The ring vacuum chambers were not aligned with the magnet centers.

The whole ring was realigned. Position of all the components were brought to within +/- 200 microns with respect to the design values.

Beam position monitor calibration (Dec 2006)



SPS beam-based alignment program

S. Rugmai, C. Kwankasem, and P. Klysubun, *"Beam Based Alignment and COD Correction for the Siam Photon Source"*, poster session.

There are 20 Bergoz 4-button BPMs in the SPS storage ring. They were not properly calibrated previous to the installation and commissioning of the SPS storage ring.

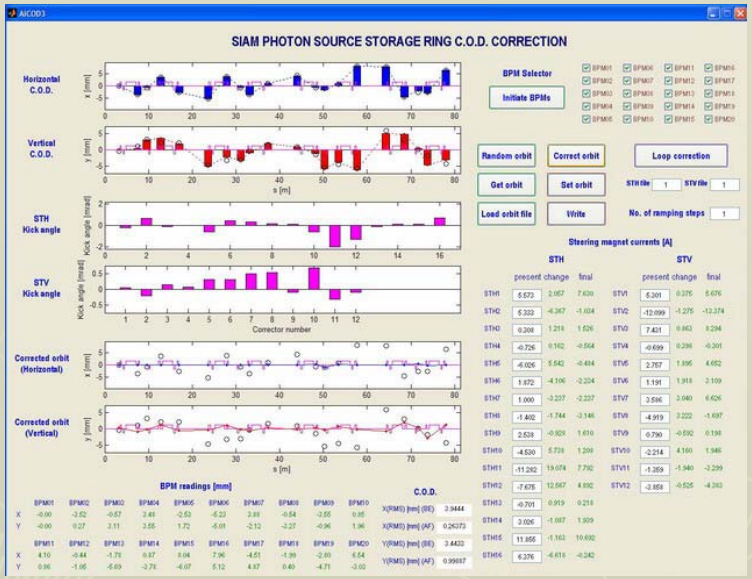
Calibration methods:

Scaling factor: comparison between model and measured orbit response matrices.

Offsets: beam-based calibration.

All 20 BPMs are now calibrated to a certain degree. (This is due to the fact that precise magnet characteristics and accurate model of the SPS storage ring are not yet obtained.)

Closed orbit distortion correction (Dec 2006)



SPS storage ring COD correction program

After the BPM system was calibrated, COD correction was performed using Singular Value Decomposition (SVD) method. COD correction program for the SPS storage ring was written with MATLAB. The connection to the PLC are done with the MATLAB OPC Toolbox.

Uncorrected and corrected orbits

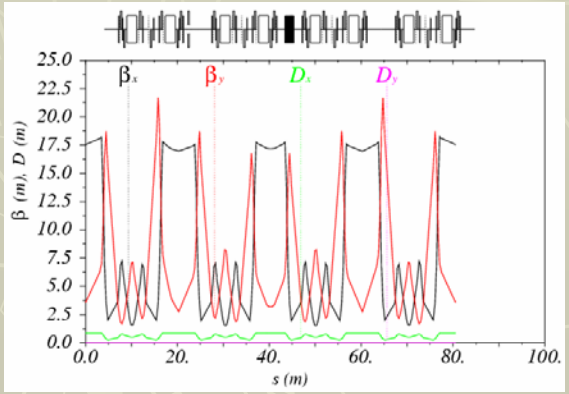
The orbit rms errors were brought down from 3.13 mm. to 0.34 mm. in the horizontal direction and from 2.06 mm. to 0.90 mm. in the vertical direction.

Insertion devices

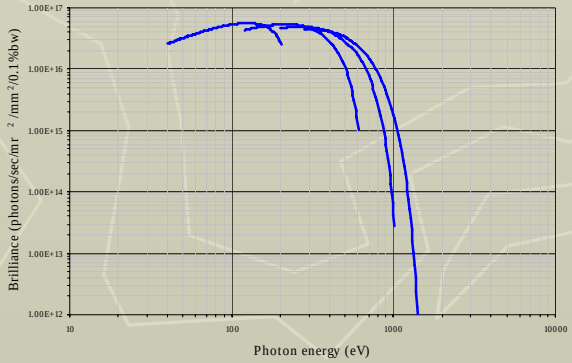
U60 planar undulator

U60 undulator

Magnetic measurement



Effect on SPS optics



U60 spectrum

U60 PPM planar undulator

- Period length: 60 mm
- No. of periods: 41
- Peak field at minimum gap: 0.54 T
- Max. deflection parameter (K): 3.05
- Tunable photon energy: 30 - 900 eV
- Maker: Danfysik

To be installed in 2007 after the magnetic measurements are completed.

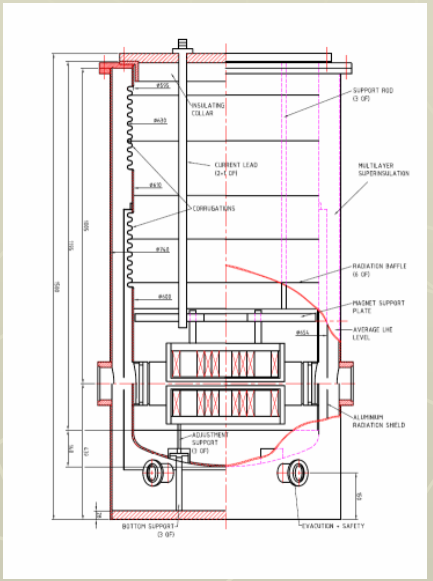
6.4T Superconducting wavelength shifter

A 6.4 T superconducting wavelength shifter was donated to NSRC by MAX-LAB in 2004/2005.

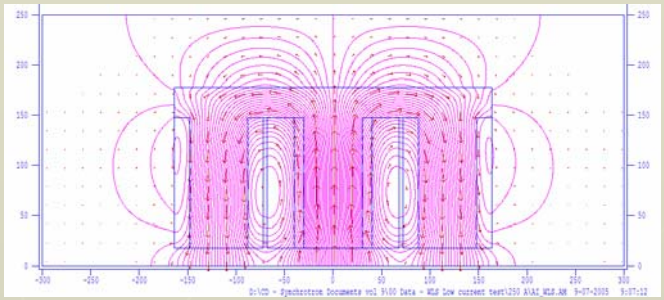
- Not a closed system
- No sensors

Components to be added/modified

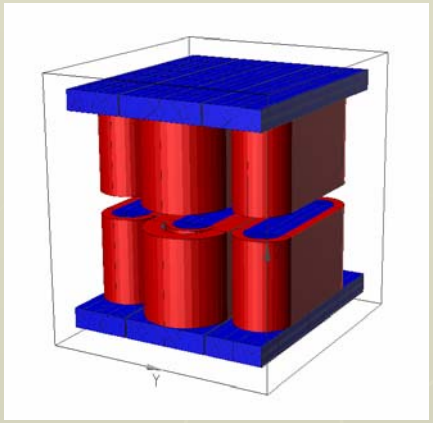
- Cryogenic Hall probes
- Liquid helium filling:
  - LHe level sensor & auto-fill system
- Temperature sensors
- Helium vapor-cooled current leads
- Safety equipments:
  - pressure relief valve & rupture disc
- He gas return port
- Cryostat cover

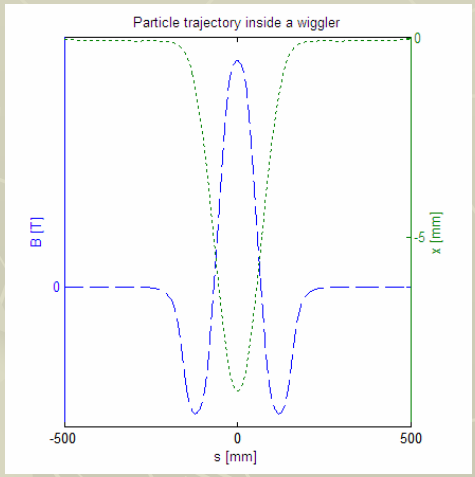


6.4T Superconducting wavelength shifter



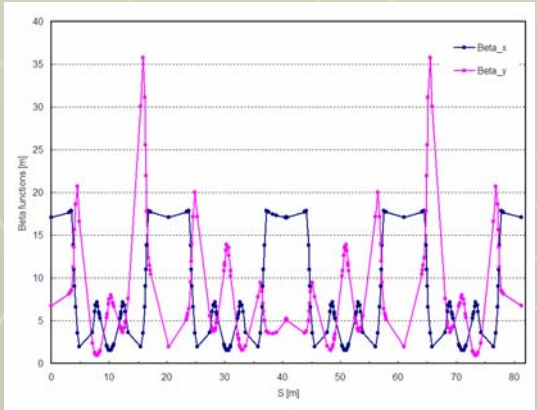
WLS magnetic simulation with Poisson and Radia





Maximum orbit displacement: **7.4 mm**

Maximum angular deviation: **72 mrad**



Effect on SPS optics (before ID matching)

WLS hard-edge model

Main pole

Magnet length l: 112.34 mm

Peak field B_p: 6.36 T

Bending radius ρ: 0.80 m

Bending angle θ: 0.14 rad

Side pole

Magnet length l: 96.96 mm

Peak field B_p: -3.69 T

Bending radius ρ: -1.38 m

Bending angle θ: -0.07 rad

To be installed in 2008 after the completion of the helium liquefier system.

Summary

- After successful commissioning and energy upgrade of the storage ring from 1.0 to 1.2 GeV operation, the Siam Photon Source is now in the user mode of operation. There are currently 3 bending magnet beamlines in operation.
- The operation of the SPS still requires energy ramping in the storage ring. Energy upgrade of the booster synchrotron was already planned for full energy injection and subsequently top-up mode of operation.
- User beam availability in 2006 was at 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 planned. The main goal is to improve machine reliability and beam stability.
- Two insertion devices will be installed: a permanent magnet planar undulator (U60) in 2007, and a 6.4T superconducting magnet wavelength shifter in 2008, to increase the flux and energy range of the generated synchrotron radiation to users.