SLS: FIRST YEAR OF OPERATION

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The Swiss Light Source has successfully concluded the first year of operation. Light was delivered to the experiments at the first four beam lines for close to 4500 hours. User experience during this first year fully validated the concept of a medium energy (2.4 GeV) electron storage ring based source of synchrotron radiation with broad spectral coverage. Use of in-vacuum undulators with small gaps together with the 'top-up' injection provided for very stable sources of hard x-ray photons with energies well above 10 keV.

OVERVIEW

Year 2002 was the first full year of scheduled SLS operation for users. On the average, 75% of the running time light was delivered to the experiments at the first four SLS beam lines. The SLS performance was characterized by unprecedented long and short term source stability, in large part due to the 'top-up' injection used during the entire year.

OPERATION FOR USERS

Close to 4500 hours of beam was delivered to the users [1]. The machine was operated around the clock with scheduled shutdowns every few weeks, when new equipment had to be installed. About five days per month were dedicated to either machine studies or to the commissioning of the beam lines with beam. The number of shifts per month delivered to users in the course of this year is illustrated in Fig. 1.

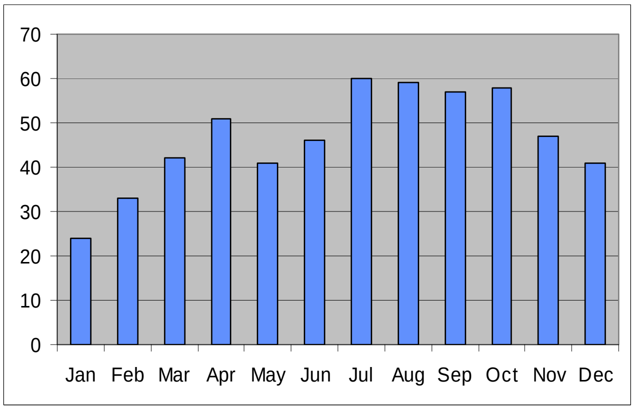

Fig. 1: Shifts per month delivered to the users

During all of these shifts the SLS was operated with 'top-up' or frequent injection. The stored beam current was kept constant at a given level (300 mA in the later part of the year). The injector chain would automatically be turned on as soon as the current fell 0.5 mA below the given level and within a few shots at 3 Hz repetition rate the 'top-up' would occur. It would take a few shots to compensate the current loss and the whole process would repeat itself every few minutes. Fig. 2 shows a day of operation with top-up injection at SLS superimposed onto a typical evolution of current vs. time at a light source using the normal injection mode.

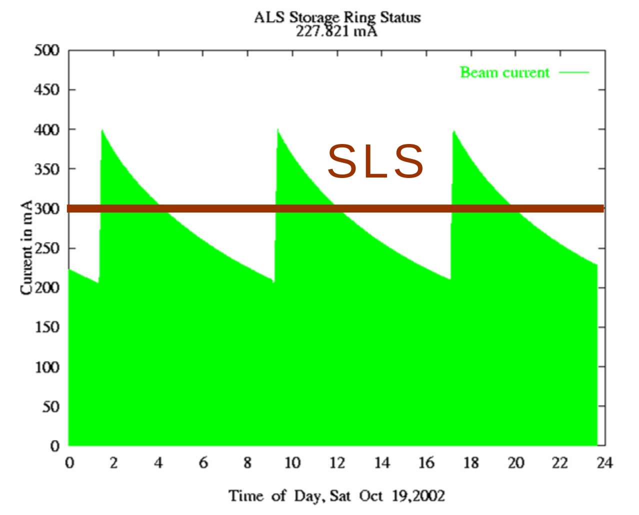

Fig. 2: Stored beam current at SLS is kept constant throughout the day to better than a percent with the 'top-up' injection. The normal injection mode is shown in the background.

STABLE OPERATION AT 400 mA

The recently commissioned passive superconducting 3rd harmonic RF cavity [2] in the SLS storage ring allowed us to operate the ring stably at the design current of 400 mA (cf. Fig. 3). Designed to decrease the electron charge density by lengthening the electron bunches in the storage ring, it provided the predicted bunch lengthening of up to a factor of three with associated lifetime improvement.

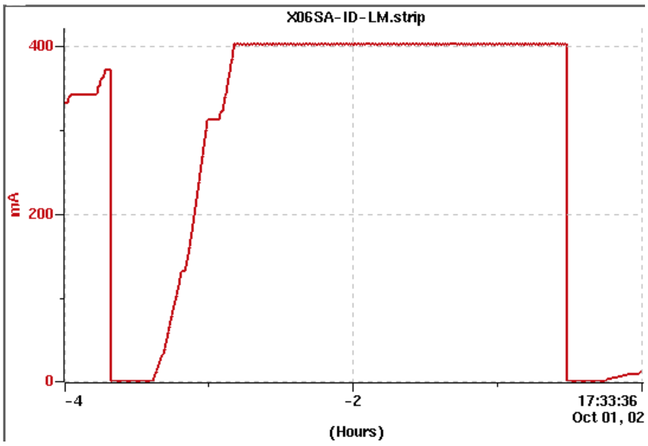

Fig. 3: First stable operation at 400 mA.

MODES OF OPERATION

Multi-bunch filling in the storage ring, with a gap of 90 out of the total of 480 buckets left unfilled was the only mode during the user operation. Top-up injection was used at all times.

During the machine development shifts we have successfully tried a “hybrid” filling mode, intended for the future time-resolved experiments. In this mode a single bunch with 3.5 mA was placed in the middle of the 90 bunch gap of the standard multi-bunch filling (cf. Fig. 4). The dead time of 90 ns on both sides of the single bunch that is available in this mode should be sufficient for initial tests of the time-resolved experiments that are scheduled for 2003.

Feasibility of SLS operation at higher energies was demonstrated in principle by storing 50 mA of current at the nominal energy of 2.4 GeV and successfully ramping it up to 2.7 GeV. The next step would be to establish the top-up operation at that energy and to demonstrate the possibility of quick energy change.

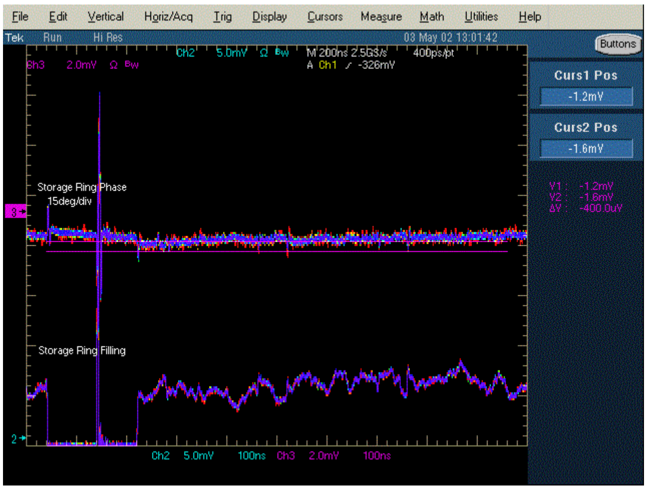

Fig. 4: Hybrid fill in the SLS storage ring. A single bunch with 3.5 mA is seen in the middle of the 90 bucket gap in the fill pattern of the SLS storage ring. The rest of the bunches were filled with about 0.5 mA.

SMALL GAP DEVICES

In order to provide competitive sources of high brightness hard x-rays from a medium energy ring, we have pursued aggressively the use of short period, small gap insertion devices. The U24 undulator used in the protein crystallography beam line was operated with a minimum gap of 6.5 mm. Given the positive experience with the present undulator (on loan from SPRing8, Japan), the second protein crystallography beam line will use a shorter period in-vacuum device U19 with a minimum gap of 5 mm.

However, the vertical acceptance in SLS is presently determined by the vacuum chamber of the material sciences beam line wiggler. It has 5 mm full inner height and is 2 m long and the vertical beta function at the centre is 0.9 m. This translates to a vertical acceptance of 3.1 mm·mrad.

It is planned to further reduce the vertical acceptance down to about 2 mm·mrad with the installation of the vacuum chamber for the modulator wiggler of the FEMTO beam line (laser slicing experiment).

FUTURE DEVELOPMENTS

A vigorous program of beam lines construction and commissioning is foreseen for the next few years at a rate of about 2 new beam lines per year.

The future machine developments at SLS include the introduction of three high peak magnetic field dipole magnets (so-called ‘super bends’) that will replace three of the present dipoles. The peak field of 3 Tesla is more than double that of the present magnetic field level. These dipole based sources will provide much higher photon energies and rather high brightness. The magnetic field profiles are shown in Fig. 5 for the normal SLS dipole magnet and for the SLS super bend.

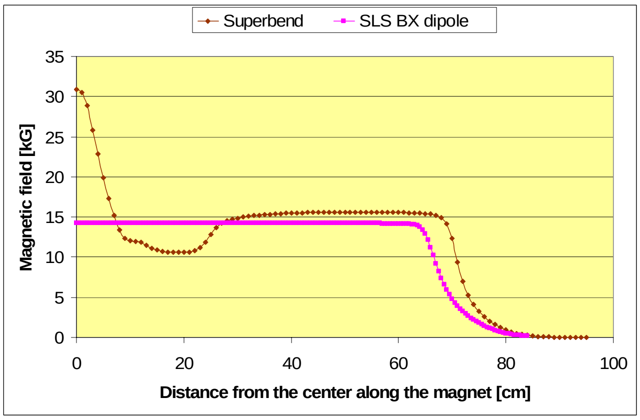

Fig. 5: Magnetic field profiles of the normal SLS dipole and the future super bend. The field is plotted as a function of position along the length of the magnet, starting in the centre.

The FEMTO project, designed to create femtosecond long x-ray pulses, is finishing the design stage and construction will start soon. Based on the electron beam slicing with a laser, a technique first introduced at the Advanced Light Source in Berkeley, it will produce very short pulses (~ 100 fs) of hard x-rays from an in-vacuum small gap undulator. Ring modifications needed for the implementation of the project are planned for the second part of 2003.

REFERENCES

[1] A.C. Mezger, A. Lüdeke, P.A. Schmelzbach, *Operation of the PSI Accelerator Facilities in 2002,* PSI Scientific Report 2002, VII.

[2] M. Pedrozzi et al., *Commissioning of the SLS third harmonic s.c. RF system* , PSI Scientific Report 2002, VI.