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The Status of the Swiss Light Source (SLS)

Christoph Quitmann (SLS-Project Paul-Scherrer-Institut*)

On December 15th the Swiss Light Source (SLS) produced a stored beam for the first time (**Fig. 1**). This marks one of the last milestones on the way to a new 3rd generation synchrotron under construction at the Paul-Scherrer Institute in Switzerland.

Up to now researchers in Switzerland, active in the field of synchrotron radiation, had to rely on synchrotrons abroad. After a concentrated effort to obtain the funding and after a construction period of only 3 years, they are now eagerly awaiting user operation of the SLS.

The design of the SLS had to fulfill many contradicting requirements. It should provide hard X-rays for the large communities of protein crystallography and materials science, while also serving the many surface scientists with UV and VUV-photons, and most of all this had to be realized with a limited budget of 159 million Swiss Franks (ca. 1 billion ¥). This lead to a novel layout[1] (**Fig. 2**).

Synchrotron radiation is produced by a 2.4 GeV storage ring of 288 m circumference having 12 straight sections (3×11 m, 3×7 m, 6×4 m). With a natural emittance of 4.5 nm radian and a design current of 400 mA the brightness delivered by undulators will exceed 10^{19} photons/s/0.1% BW/mm^2/mrad^2/400 mA. This is comparable to values achieved by other machines like SPring8. Providing such high brightness for undulator beamlines covering photon energy ranges from 10 eV up to 17.5 keV is only possible by fully relying on state of the art insertion devices[2].

The acceleration system consists of a conventional 100 MeV LINAC followed by a booster with an innovative design. The booster is located in the same tunnel as the storage ring and with a circumference of 270 m it is almost as large as the storage ring. The large circumference allows the use of small combined function magnets and results in a low emittance beam which facilitates top-up injection. Most of all it substantially reduced the cost.

The LINAC, purchased as a turn-key device from ACCEL Instruments GmbH, and the booster have already been commissioned successfully. The booster routinely accelerates an electron beam of 1 nC charge. The 3 Hz cycle starts with the injection at 100 MeV and after 160 ms the beam is extracted at 2.4 GeV (**Fig. 3**). The typical acceleration efficiency is 88%.

In the first phase 4 beamlines are being built. A materials science beamline will enable computed micro-tomography and powder diffraction. A special endstation will allow surface diffraction while growing materials using an insitu chamber. This beamline uses a commercial hybrid wiggler spanning an energy range from 5 to 40 keV.

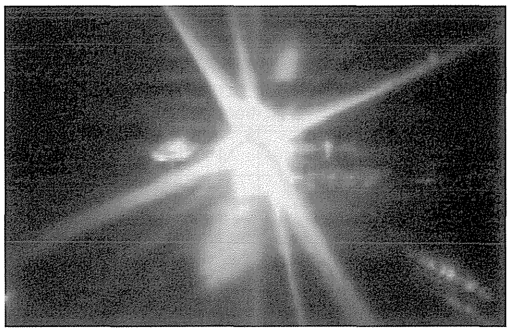

Figure 1. Image from a synchrotron radiation monitor showing the first stored beam on December 15th after only 4 days of commissioning. The beam parameters are 2.4 GeV beam energy, 3 mA current, and a lifetime of approx. 10 minutes. After 4 days, the lifetime increased to 8 hours at the same current.

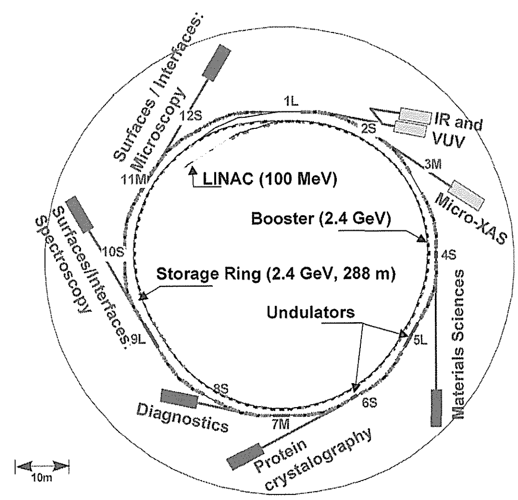

Figure 2. Schematic layout of the SLS showing linac, full size booster, storage ring, and the beamlines. Four undulator beamlines plus a diagnostic beamline are under construction, two more (shown hatched) are under design.

The protein crystallography beamline will have two diffractometers allowing to study either large unit cells structures or micro-crystals, respectively. For this beamline an in-vacu-

* Paul Scherrer Institut, CH-5232 Villigen-PSI, Switzerland
TEL: +41-56-310-4560 FAX: +41-56-310-3151 E-mail: christoph.quitmann@psi.ch

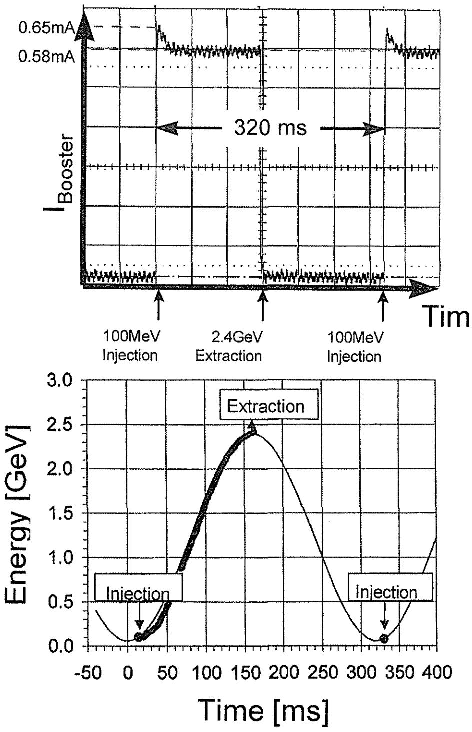

Figure 3. Acceleration cycle of the booster showing a full energy cycle (bottom) and the current in the booster during the full cycle (top).

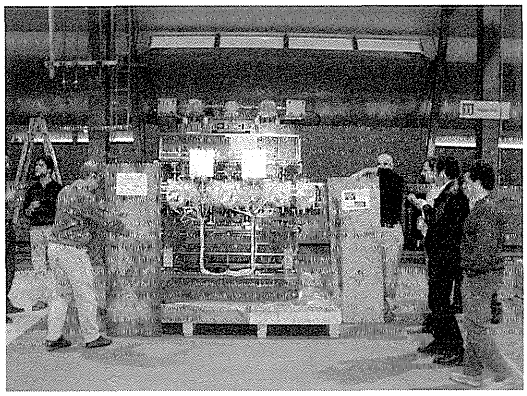

Figure 4. SLS staff celebrating the arrival of the SPring-8 in-vacuum undulator for operation at the SLS storage ring, a joint SPring-8/SLS project.

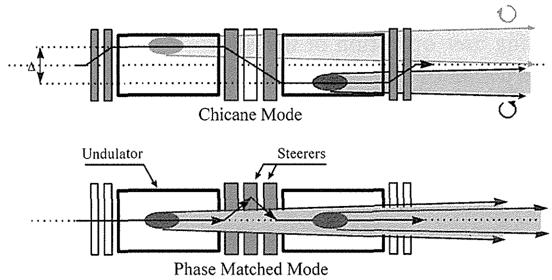

Figure 5. Schematic top view showing the helicity switching. Two undulators are located in line. The electron beam can be offset ($\Delta \sim 1$ mm) using steerer magnets (top). This produces two separate horizontally displaced light sources. If no helicity switching is needed, the steerer magnets phase match the two undulators, thus maximizing the brightness (bottom).

um undulator was given to the SLS as a loan by Dr. Kitamura of SPring-8 (**Fig. 4**). It was optimized and adopted to the special needs at SLS in a close collaboration and arrived in November 2000. Currently it is being prepared for installation.

Two beamlines will serve the surface science community. The first is dedicated to spectroscopy[3]. It combines a pair of electromagnetic helical undulators with a high resolution monochromator and a high resolution photoelectron spectrometer. To allow spectroscopy down to $h\nu = 10$ eV despite of the high ring energy (2.4 GeV), two new features are included. The undulator uses an amplitude modulated quasi-periodic electro-magnet[2] and the monochromator can be used in either a grazing incidence or a normal incidence geometry.

The second surface science beamline will focus on microscopy[4]. Light will also be provided by a pair of helical undulators, which are built in collaboration with BESSY. The endstation uses a commercial photoemission electron microscope (PEEM). To enable studies of time resolved magnetic phenomena, both surface science beamlines will use a novel scheme allowing rapid helicity switching[4].

A pair of helical undulators can produce photon beams of opposite helicity (**Fig. 5**). To separate these two sources a chicane can be introduced into the electron orbit using electromagnetic steerers. On the optical elements the two photon beams overlap because of the finite photon beam divergence. Only at the horizontal focus are they separated and here a mechanical chopper is used to block one of the beams. A refocus mirror then images both beams onto the sample. This novel design will allow rapid helicity switching with minimum disturbance to the storage ring and to other beamlines.

At present the storage ring is being commissioned and beamlines are being build up. In a next step, starting in April 2001, the insertion devices will be installed. It is expected that the first light will be available at the endstations in August 2001. From 2002 on, a new 3rd generation synchrotron will be available to researchers from Switzerland and from abroad, allowing to perform state of the art research using synchrotron radiation.

References

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3) U. Flechsig et al.: Proceedings of SRI 2000, Nucl. Instr. Meth. A in press.
4) C. Quitmann et al.: Proceedings of 2nd LEEM/PEEM Workshop, Paris, 26–28th September 2000, Surface Science in press.