# New synchrotron radiation sources and the next-generation light sources

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Last December, the Swiss Light Source (SLS) at the Paul Scherrer Institute, located close to Zurich, became the latest third-generation synchrotron radiation source to come on-line (see Editorial, March 2001). Since its first stored beam (1.6 mA) on 19 December 2000, it has continued to make rapid progress towards user operation. In May 2001, a gap of 6.5 mm was achieved with an in-vacuum undulator and a beam of 70 mA, and in June the SLS achieved its designed beam current goal of 400 mA and attempted successfully its first top-up injection at 200 mA. In July, diffraction patterns from a protein crystal were recorded at a resolution of 1.15 Å using the in-vacuum undulator with a 10 mm gap and top-up injection mode at 200 mA. Three additional instruments have come on-line and, hence, within a year of first stored beam, scientific use has begun in earnest. This smooth and rapid progress with a new machine is testimony to the maturation of synchrotron radiation technology and close cooperation on the global scale in the synchrotron radiation community.

This summer, Australia became the latest country to decide to build its own national synchrotron facility, at Monash University in the State of Victoria. This A$157 million facility is expected to deliver a 3 GeV storage ring of diameter 57 m and a beam emittance of ~12 nm rad. The Canadian Light Source (CLS), approved in March 1999, took its step in commissioning its light source facility when its refurbished linear accelerator was successfully commissioned in September 2001. The CLS, a C$173 million project, will comprise of a 2.9 GeV booster synchrotron and a storage ring with a circumference of 170 m. Among the new projects, SOLEIL in France and DIAMOND in the UK are now beginning to concentrate on the first phase of their beamlines. While these new sources are emerging, there does not seem to be any shortage of demand from the existing communities and emerging areas. In the second half of the last decade, several third-generation sources emerged and at the time it was thought that the demand at older facilities would reduce, but this has proved not to be the case. A good example of this is in California where, in the presence of the ALS next door and the APS in Chicago, the Stanford Synchrotron Radiation Laboratory (SSRL) has undergone further expansion and found a significant niche in structural biology. With the progress made on further upgrades of SPEAR to SPEAR-III, the SSRL is likely to co-exist with its neighbours for the foreseeable future.

The quest for brilliance is going to continue beyond the third-generation low-emittance storage rings. Development in laser-driven photoinjectors and superconducting linac technology is opening up new and exciting possibilities. Cornell University, the home of one of the oldest synchrotron facilities, together with Jefferson Laboratory are looking at a new type of synchrotron radiation machine, called an energy recovery linac (ERL), based on a superconducting linac and a one- or multi-turn ring. This type of ring provides very low emittances in both the horizontal and the vertical planes. These, in combination with small-gap undulators up to 20–30 m in length, already realised at SPring-8, one of the most advanced third-generation rings, can produce ultra-brilliant X-ray beams with no limits on beam lifetime. In the UK, the concept of a low-energy source is taking shape along similar lines. The source, christened 4GLS (Fig. 1), is to cover the photon energy region below a few hundred eV and will deliver performance enhancements of orders of magnitude on all existing third-generation facilities. 4GLS proposes to utilize the ERL technology together with state-of-the-art undulator and free electron laser techniques to achieve this. The 4GLS design caters for up to ten bending-magnet user stations and seven undulator stations.

The other concept that is currently exciting the community is the development of linac-based free electron lasers. On 23 March 2001, DESY in Hamburg released the five-volume TESLA (TeV-energy superconducting linear accelerator) Technical Design Report, developed with the contribution of 1134 scientists from 36 countries. Even though the primary science driver for this project is high-energy physics, the project has offered the opportunity for an X-ray free electron laser (X-FEL). The TESLA test facility has already achieved lasing in the 800–1800 Å region. This concept was originally proposed at Stanford where use is made of the 15 GeV SLAC. The Linac Coherent Light Source, LCLS, envisages a single-pass X-FEL which is expected to operate in the 1–15 Å region. It is expected that the LCLS will be ready for commissioning in the second half of this decade. The SPring-8 team has proposed a compact SASE source, SCSS, where mini-gap undulators are combined with a high-gradient linac of moderate energy. The test facility has been funded from April 2002 where the linac energy will only be 1 GeV, but this, combined with a 3.7 mm-gap undulator, is expected to produce SASE FEL at ~30 Å.

It is clear that these next-generation sources will provide unprecedented scientific opportunities in the coming decades. The third-generation sources alongside the current operating sources will continue to be stretched by existing and emerging communities. The *Journal of Synchrotron Radiation* will continue to provide a rapid means of reporting scientific results obtained on these sources as well as ensuring high-quality publication of papers on developments in instrumentation and methods.

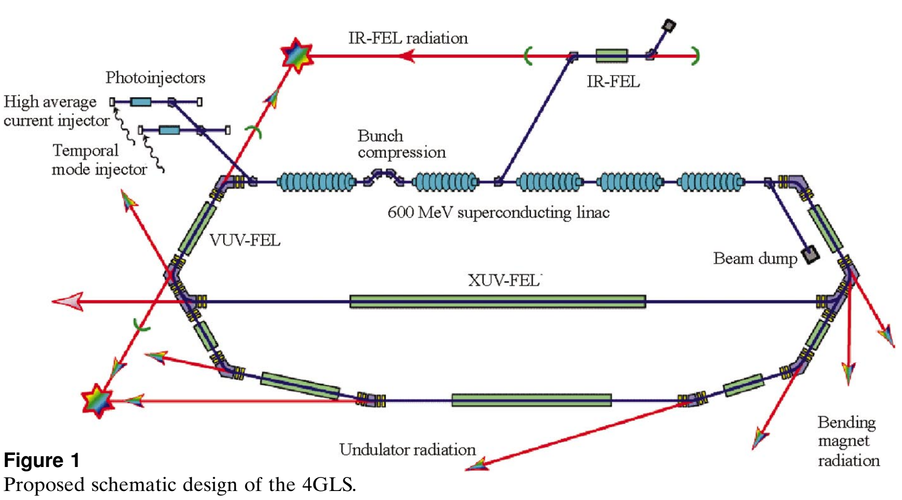


**Figure 1**
Proposed schematic design of the 4GLS.