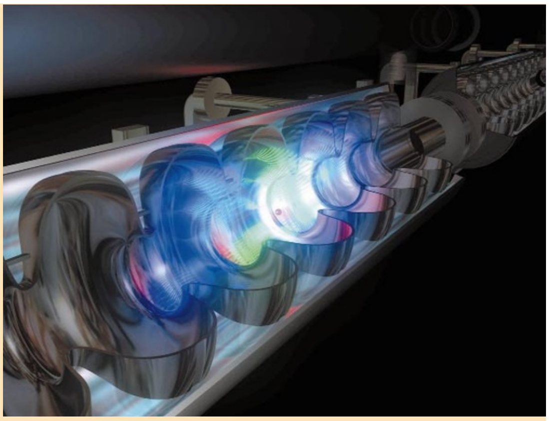
What is a synchrotron?



TESLA

Ironically, synchrotron radiation, although now greatly in demand, was a bane in the life of high-energy physicists working with particle accelerators. This is because the radiation represents a loss of energy.

In particle accelerators, charged particles travel millions of times round a doughnut-shaped ring containing a vacuum. Strategically placed magnets confine the particles to their circular path. The strength of the magnetic field must change as the particles accelerate, in order to keep them on course. Because this change must be synchronized with the energy gain associated with increasing the particles' speed, the radiation emitted acquired the name synchrotron radiation.

Particle accelerators are designed to compensate for the energy loss, but once scientists saw that synchrotron radiation might be useful, machines were built specifically to produce it — the 'second-generation' facilities. In these systems, the particle beams are confined in a 'storage ring' and siphoned off in a controlled manner along a beamline.

Instruments in the beamlines, such as monochromators, determine the frequencies available for a particular class of experiments — perhaps probing for fault lines or impurities in a material, or X-ray diffraction to determine a protein structure.

As accelerator physicists learned more about synchrotron radiation, they designed magnets engineered with precise proportions to increase the energy and brightness in a beam and so expand its potential range of applications. Instead of squeezing these 'insertion devices' into synchrotrons as an afterthought, 'third-generation' synchrotrons are specially designed with the devices in mind. One such facility, the Swiss Light Source, is scheduled to come online this August in Villigen, and Diamond and Soleil are planned for later this decade in Britain and France. **H. G.**

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joined Daresbury he knew nothing about the subject. Like Smith and others who join synchrotron facilities around the world, he learned to apply his knowledge of physics to the subject once he had got the job.

Typically, when scientists such as Lewis join national synchrotron facilities they become part of a team that deals with a class of experiments, such as protein crystallography. They are likely to be physicists, chemists or engineers by background. "Anything from 80% upwards of your time is supporting the users. You need to understand what they want to achieve and to liaise with them about what the equipment can do," Lewis says. "There is a real dearth of people who can fill this middle ground."

Beam-time shortage

Although the next generation of machines (see 'What is a synchrotron?', above) will mean there are more beamlines available, competition among users for beam time is, and will continue to be, acute, says Guy Le Lay, a professor at the University of Provence and member of the European Round Table for Synchrotrons and Free Electron Laser. "Obviously some competition — perhaps 150% over-subscription — is healthy," says Margaritondo, who chairs the round table, "but beamlines currently are between 200% and 300% oversubscribed and the situation for protein crystallography is even worse."

Given that opportunities are now opening up for biologists to learn about the proteins that the sequencing of the human genome tells them the body is producing, the pressure is not surprising and it will not ease up. But it is not only the biologists that are clamouring for time on synchrotron beamlines. The X-rays produced in synchrotron facilities are used by chemists, materials scientists and physicists alike.

Jörgen Albertsson, professor of inorganic chemistry at Chalmers University of Technology in Sweden, says that it can be hard to compete successfully against the protein crystallographers for beam time. Although the construction of Diamond and Soleil will ease this situation, users and providers of synchrotron radiation need to find ways to exploit both the second- and third-generation facilities more effectively.

In particular, the beamlines at these synchrotrons need better detectors, which offers fresh opportunities for beamline scientists and engineers. "In many cases it's not brightness that limits experiments, but how fast the detectors can record," says Lewis. Margaritondo agrees that there is a need for a major international push to develop better detectors.

But even as the third-generation facilities spring into operation around the world, the European Round Table for Synchrotron Radiation and Free Electron Laser is pondering the next step. There are two options: design a synchrotron at the limit of what physics allows or move to an alternative technology — free-electron lasers — that could surpass even the most advanced synchrotron.

One possibility could be for the European Synchrotron Research Facility based in Grenoble to develop the 'ultimate' synchrotron. Meanwhile, TESLA, a German proposal for a free-electron laser that can produce high-energy X-rays, would also be developed with international collaboration. "I sense a consensus developing that we should develop both," says Margaritondo.

So, whether as a user developing new techniques to exploit beamlines, as an accelerator physicist, beamline scientist or engineer, the job prospects at synchrotron facilities are bright for some time to come. And it is hard to imagine that in a decade or so any branch of science will not have some need of synchrotrons. ■

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Synchrotron radiation facilities
➧ **http://www.src.wisc.edu/links/sr_sources.html**
European Synchrotron Research Facility
➧ **http://www.esrf.fr**
European Round Table for Synchrotron Radiation and Free Electron Laser
➧ **http://www.elettra.trieste.it/sites/roundtable**

Automated for the people

Without new synchrotrons, US structural genomics may depend on automating existing facilities to meet its goals. But without an influx of interested physicists and engineers — and the funding to support them — speeding up the process of discerning a protein's three-dimensional structure may prove difficult.

The automated gene sequencer revolutionized genomics. But no single machine, by itself, will greatly speed up structural biology. Working out a protein's structure is a more complex process, with many more stages, says Peter Kuhn, assistant professor at the Stanford Synchrotron Radiation Laboratory.

The protein must be purified, crystallized, mounted in the beamline, probed by the light, then reconstructed by computer. Potential bottlenecks occur at every stage — and each stage may need different combinations of expertise to speed it up. For example, automating sample mounting in the beamline requires engineering skills, whereas finding and centring the sample within the beam needs computational skills.

Different US groups are working on separate stages of this problem. For example, Stanford is in the nascent stages of automating sample mounting. Once individual steps have been automated, systems engineers will need to evaluate how the entire process fits together, Kuhn says. **P. S.**

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