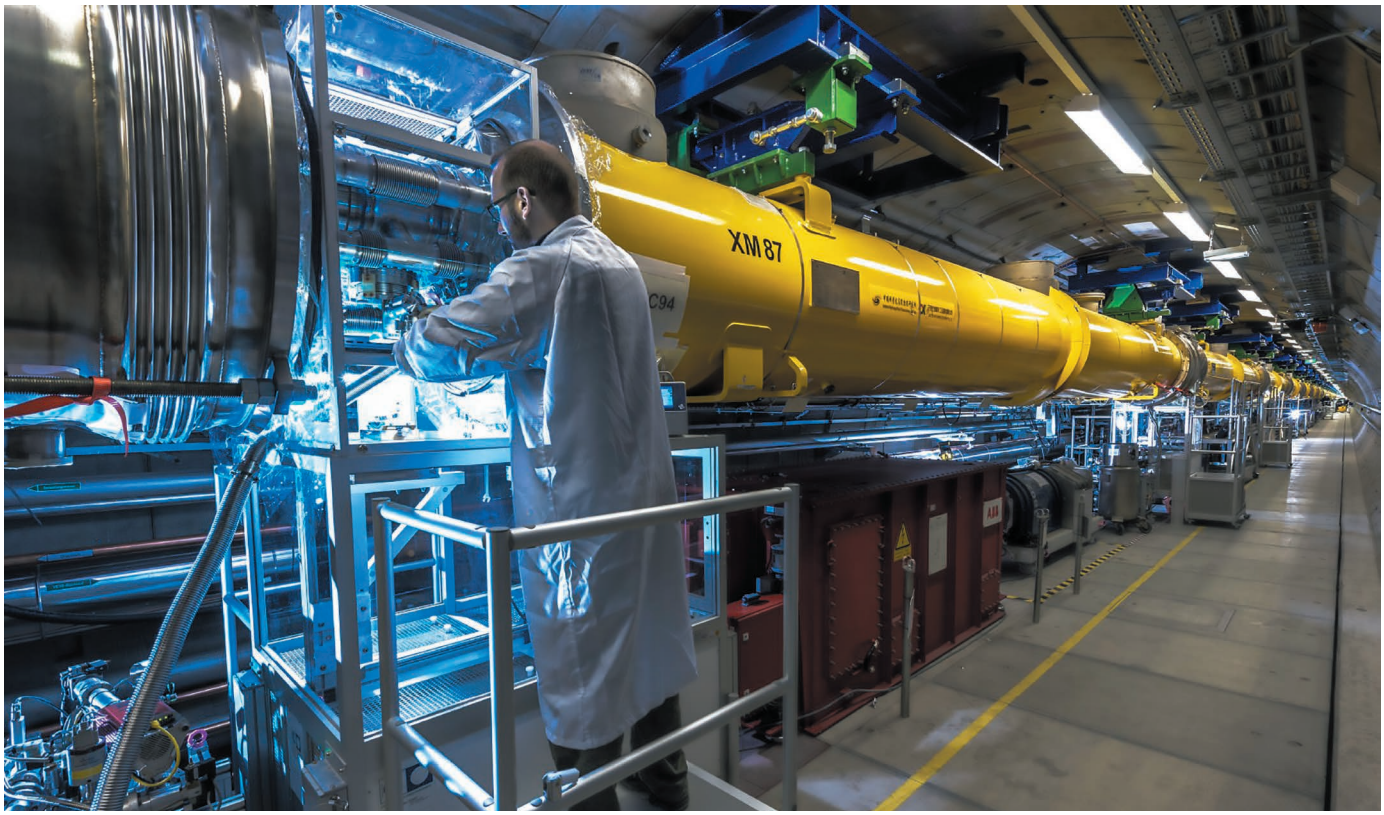
NEWS IN FOCUS

HEINER MÜLLER-ELSNER/EUROPEAN XFEL



Researchers will soon be able to use the European X-ray Free Electron Laser near Hamburg, Germany, to watch molecules in action.

PHYSICS

Europe's X-ray laser fires up

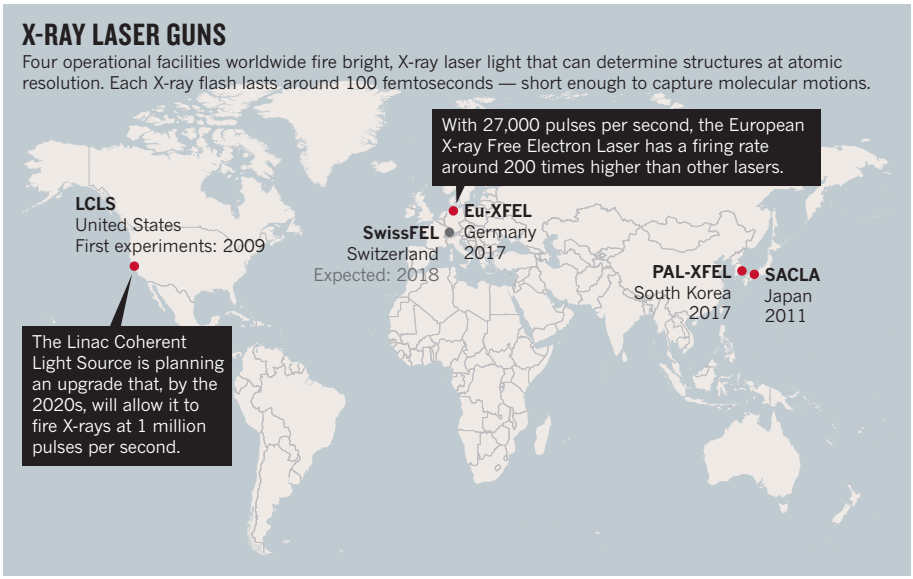
High-speed shooter will help scientists to make molecular movies.

BY PHILIP BALL

Scientists who make movies of molecules in motion have a new high-speed camera to shoot with. The €1.2-billion (US$1.4-billion) European X-ray Free Electron Laser (XFEL) will start running its first experiments in September near Hamburg, Germany.

The European XFEL fires powerful X-rays in bursts of a few hundred femtoseconds: so short that, like strobe lights, they can capture snapshots of jittery molecules frozen in time, and with a wavelength small enough to provide pictures at atomic resolution. The Hamburg machine is one of a few such X-ray lasers worldwide, but boasts a unique rapid-fire feature: it can rattle off 27,000 pulses every second, a firing rate more than 200 times greater than the next-fastest facility, the $420-million Linac Coherent Light Source (LCLS) at the SLAC National Accelerator Laboratory in Menlo Park, California. "It's such a different beast to anything else on the planet that it really feels like going into uncharted territory," says Arwen Pearson, a biochemist at the Centre for Free-Electron Laser Science in Hamburg.

In a single second, scientists should be able to collect more than 3,000 good-quality X-ray pictures, compared with 100 or so at other facilities, says Adrian Mancuso, a project scientist at the European XFEL's experimental stations in Schenefeld, near Hamburg. "Having lots of data matters, and the European XFEL will deliver it in truckloads," says Abbas Ourmazd, a physicist at the University of Wisconsin–Milwaukee. The European machine — paid for by 12 countries — should relieve some of the pressure on older XFELs in the United States and Japan (see 'X-ray laser guns'), which are heavily oversubscribed by scientists keen to capture atomic-scale images of their samples. Another XFEL opened to users in Pohang, South Korea, in June, and a machine in Villigen, Switzerland, is due to start experiments in 2018.



SOURCE: EUROPEAN XFEL

At the Hamburg XFEL, bunches of electrons are first accelerated down a 1.7-kilometre-long tunnel. Magnets then bend the electrons' path into wiggling slalom tracks, causing them to emit bunches of high-energy X-rays as they curve. The bright X-ray pulses are so intense that they destroy the samples they hit — but not before enough photons have been scattered to reveal the sample's atomic structure.

X-RAY MOVIES

In structure-determination experiments using conventional X-ray sources, molecules must be packed into crystals to scatter enough photons to deduce their structure. But the X-rays from XFELs are so bright that researchers can gather diffraction patterns from crystals just a few nanometres in size, or even from non-crystalline clusters of molecules. This means that XFELs can study proteins that are hard to crystallize. And researchers can create movies of enzymes, viruses or catalysts in action by building up thousands of different snapshots of the same system taken at different timepoints — often by passing a jet of molecules in solution past an X-ray beam.

In 2015, for example, scientists using the LCLS reported eight snapshots of myoglobin, a muscle protein that binds oxygen, at a resolution of 0.18 nanometres. The images were taken a few picoseconds after a flash of light dislodged a molecule of carbon monoxide from its binding position on the protein (T. R. M. Barends *et al. Science* **350,** 445–450; 2015). On 14 August, Ourmazd and his colleagues reported using X-ray scattering from single viruses at the LCLS to create a 3D movie at 9-nm resolution. It shows the motions of a virus as it reorganizes its genome so that the genetic material can squeeze through a tubular molecular structure — a process that occurs when the virus infects a cell (A. Hosseinizadeh *et al. Nature Methods* http://dx.doi.org/10.1038/nmeth.4395; 2017).

Work such as this depends on gathering many snapshots of identical particles in different conformational states to build up a composite picture of a particle's range of motion, explains physicist John Spence at Arizona State University in Tempe. He says that the European XFEL's high pulse rate will make this process much quicker — so structural data could be accumulated for much smaller individual particles. One of the European facility's most important milestones will be proving that diffraction patterns can indeed be collected from single particles at very high rates, says Mancuso. Because an intense X-ray burst obliterates each particle it hits in a passing spray or jet, it can be a challenge to ensure that the destroyed sample does not impede capture of the next shot. "We won't know that until we try," he says.

Hamburg's facility also has a larger capacity than its competitors: unlike other XFELs, it has three separate undulators to create simultaneous X-ray beams, with the 27,000 pulses per second distributed among them. But the European XFEL will reign for only a limited time: SLAC this year began construction of a $1-billion project to create an even brighter laser beam that, by the early 2020s, will fire up to 1 million pulses each second. ■

Additional reporting by Mark Zastrow

GLOBAL WARMING

Legal threat raises stakes on climate forecasts

Australian lawsuit shows the difficulty of turning global-warming data into useful advice.

BY NICKY PHILLIPS

In a world-first case, an Australian court will next month begin hearing from shareholders who have sued a bank for failing to disclose its vulnerability to climate change.

The case highlights the fact that financial institutions around the world have been slow to acknowledge the risk that climate change poses to investments in infrastructure, agriculture and property. But researchers say the lawsuit also shows that Australia and many other countries are currently unable to forecast the financial risks of climate change.

Shareholders Guy and Kim Abrahams filed the lawsuit on 8 August against the Commonwealth Bank of Australia, saying that the institution's 2016 directors' report did not adequately inform investors of climate-change risks. Their suit also seeks an injunction to stop the bank from making the same omissions in future annual reports.

Climate scientist Andy Pitman at the Centre of Excellence for Climate System Science in Sydney, Australia, says that researchers have been warning companies and governments for years about the need to invest in climate modelling and the related field of climate services, which provides forecasts and other information to public and private users. He says that it would take substantial investment and five to ten years of work for his team to provide banks with the climate information they need.