# NEWS IN FOCUS

**BIOMEDICINE** NIH considers rules to ramp up reproducibility **p.14**

**MICROBIOLOGY** Effort to catalogue bacteria loses its home **p.16**

**CLIMATE** Solid rock could be dustbin for Earth-warming $CO_2$ **p.18**

**ARCHAEOLOGY** How the dawn of dairying upended Europe **p.20**

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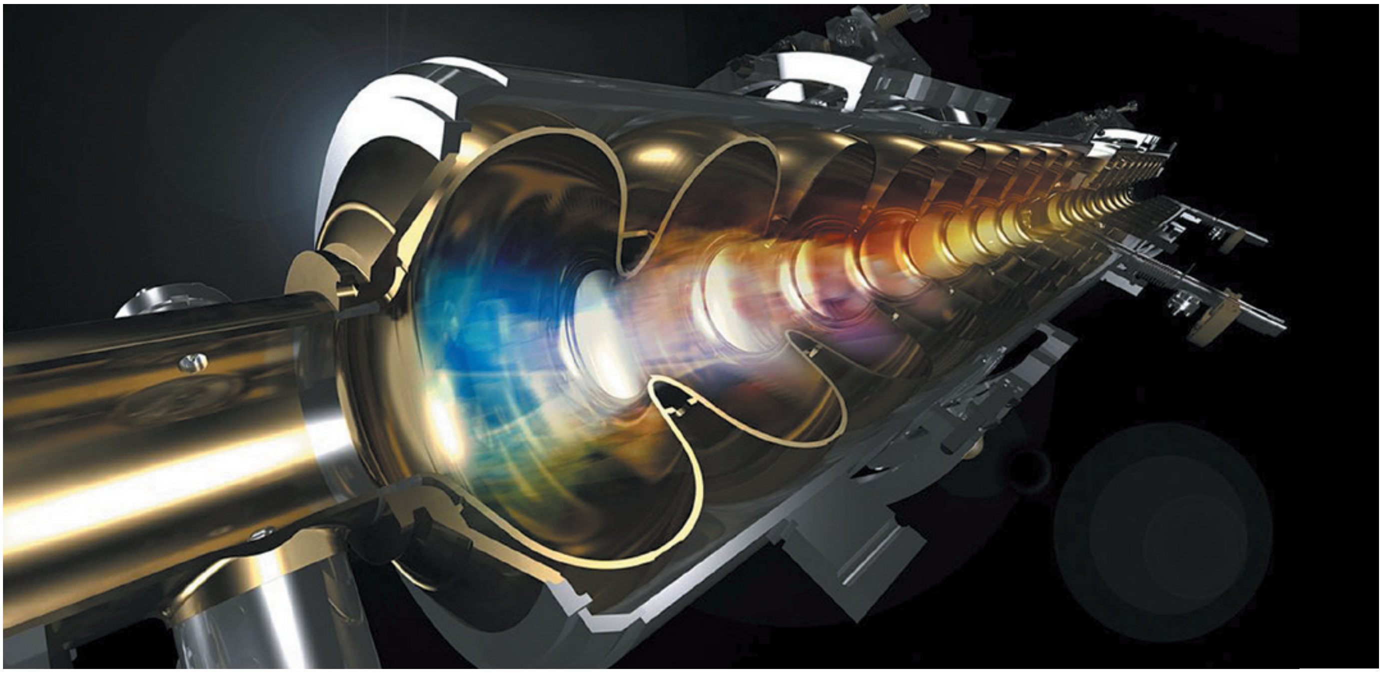

**Superconducting cavities in the Next Generation Light Source (artist's impression) would accelerate electrons and then extract laser-like X-ray light from them.**

PHYSICS

# Labs vie for X-ray source

*California facilities respond to US panel's call for a powerful free-electron laser.*

**BY EUGENIE SAMUEL REICH**

The competition to build the world's most powerful source of X-rays is becoming as intense as the light pulses it might one day emit, with two US Department of Energy (DOE) laboratories vying to host the proposed machine. The two California labs — the Lawrence Berkeley National Laboratory in Berkeley and the SLAC National Accelerator Laboratory in Menlo Park — each had hopes of getting its own project funded. But on 25 July, advisers to the DOE said that building just one, cutting-edge light source would be better.

"Instead of an argument, we'd like to have a unified proposal," says William Barletta, a physicist at the Massachusetts Institute of Technology in Cambridge who served on the DOE advisory committee, which met last week in Bethesda, Maryland, to put forward the light-source recommendations. "You want to make a revolutionary machine that really stands out."

X-ray light sources provide an imaging technology that serves a wide range of scientists, including biologists, chemists and materials scientists. The DOE has led the area in recent decades, building four powerful synchrotrons, which produce intense X-rays as electrons zip around circular paths. The department has also built a pioneering free-electron laser, which uses special undulator magnets to wiggle an electron beam so that it emits intense, laser-like pulses of X-ray light. A European collaboration is constructing a free-electron laser in Germany, and Sweden, Japan and Brazil are working on designs for synchrotrons that would compete with the US machines. In January, the DOE commissioned a review to try to sustain US leadership in the field.

The panel's resulting report throws down the gauntlet to light-source designers at the two competing labs to cooperate on a design for a single free-electron laser. In 2011, the Berkeley lab won initial approval from the DOE to begin work on a free-electron laser called the Next Generation Light Source (NGLS), whereas SLAC had hoped to upgrade its Linac Coherent Light Source (LCLS), the free-electron laser that it currently operates.

Managers at the labs had said that there was room for two complementary machines. The NGLS would produce lower-energy, 'soft' X-rays — ideal for imaging biological matter, chemical reactions and electron movement in the outer shells of atoms. Its particular strength would be a high repetition rate for its X-ray pulses, which would enable multiple snapshots of electron motion and the creation of 'molecular movies' of chemical processes. By contrast, the LCLS upgrade would extend ▶

**SHINING LIGHTS**

Individually, proposals for the Linac Coherent Light Source (LCLS) and the Next Generation Light Source (NGLS) do not meet the specifications called for by a panel that advises the US Department of Energy.

| Proposed project | Repetition rate | Upper energy limit |
|---|---|---|
| LCLS upgrade | 1 kHz | 25,000 eV |
| NGLS | 1,000 kHz | 720 eV |
| Panel recommendation | 100 kHz | 5,000 eV |

Kilohertz (kHz); electronvolts (eV)

the machine's capability to produce higher-energy, 'hard' X-rays, which could image the arrangement of atoms and penetrate deep into heavier elements. But its intense pulses would come at a lower repetition rate, ruling out movies of dynamic processes.

Both approaches would be likely to attract users. Lou DiMauro, an atomic physicist at Ohio State University in Columbus, is keen to run 'pump-probe' experiments, in which an initial X-ray pulse is used to excite an atom, and the next pulse is used to probe the atom's state. The closely spaced pulses of the NGLS design would be ideal for that. But Phil Bucksbaum, an atomic physicist at Stanford University in California, who uses the SLAC light source, says that the NGLS would not be able to probe heavier elements because it operates at too low an energy compared with an upgraded LCLS.

The DOE advisory group found that the broadest science case could be met by a single facility that combines the strengths of both the NGLS and the LCLS (see 'Shining lights'). The committee's recommendations will help the energy department to respond to members of the US Congress who have asked for a more compelling case for a future free-electron laser. Building two, smaller, less-capable machines "is not the best science per dollar", says Barletta.

In response to the panel's recommendation, the Berkeley lab and SLAC have been scrambling to extend the reach of their proposals, and jockeying to be the front-runner to host a single site. Paul Alivisatos, director of the Berkeley lab, says that the NGLS design had an upper energy limit of 720 electronvolts (eV) to keep project costs below US$700 million. Increasing the budget to $1.2 billion would allow the electron-beam accelerator to be lengthened and would boost the upper energy limit to 3,000 eV, not far from the advisory panel's desired level of 5,000 eV. "It's a straightforward extension of our proposal," he says.

*"You want to make a revolutionary machine that really stands out."*

Uwe Bergmann, associate director of the LCLS, says that an upgrade to his machine could get it to a repetition rate of 10 kilohertz (kHz), but the current proposal boosts it to only 1 kHz. To get near the panel's recommendation of 100 kHz, he acknowledges that his facility would need to replace its accelerator with a superconducting one — a key feature of the Berkeley lab's proposal. But ultimately, he says, the idea of upgrading an existing machine may be more realistic in a cost-constrained environment than the advisory panel's ambitious vision. "A committee suggests something — but the committee doesn't foot the bill."

The tight fiscal climate has exacerbated competition between the two proposals, says accelerator physicist Michael Borland of Argonne National Laboratory in Illinois. "There is limited funding, and government agencies need to decide which machine to build first," he says. But he sees at least one way to combine the two projects: the electron source and superconducting linear accelerator from the NGLS proposal could be put in the existing LCLS tunnel to take advantage of its undulator magnets. "This seems to make more sense than starting from scratch with a higher-energy NGLS."

For users, a new plan cannot come too soon, says Thomas Russell, a polymer scientist at the University of Massachusetts Amherst. Russell wants to use a fast-repeating X-ray source to watch the crystallization of photoactive materials used in solar cells. The current LCLS is not fast enough to make the movies he wants, and moreover, as the premier free-electron laser in the United States, the LCLS turns away four scientists for every one that is granted time. He has visited all four of the US X-ray synchrotrons, but the diffuse nature of their light would make it impossible for him to understand his crystal structures. "You reach a certain limit and you just can't do the experiment you want to do," he says. "The light sources that exist just don't provide enough oomph." ■

BIOMEDICINE

# NIH mulls rules for validating key results

*US biomedical agency could enlist independent labs for verification.*

BY MEREDITH WADMAN

In biomedical science, at least one thing is apparently reproducible: a steady stream of studies that show the irreproducibility of many important experiments.

In a 2011 internal survey, pharmaceutical firm Bayer HealthCare of Leverkusen, Germany, was unable to validate the relevant preclinical research for almost two-thirds of 67 in-house projects. Then, in 2012, scientists at Amgen, a drug company based in Thousand Oaks, California, reported their failure to replicate 89% of the findings from 53 landmark cancer papers. And in a study published in May, more than half of the respondents to a survey at the MD Anderson Cancer Center in Houston, Texas, reported failing at least once in attempts at reproducing published data (see 'Make believe').

The growing problem is threatening the reputation of the US National Institutes of Health (NIH) based in Bethesda, Maryland, which funds many of the studies in question. Senior NIH officials are now considering adding requirements to grant applications to make experimental validations routine for certain types of science, such as the foundational work that leads to costly clinical trials. As the NIH pursues such top-down changes, one company is taking a bottom-up approach, targeting scientists directly to see if they are willing to verify their experiments.

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There is the looming