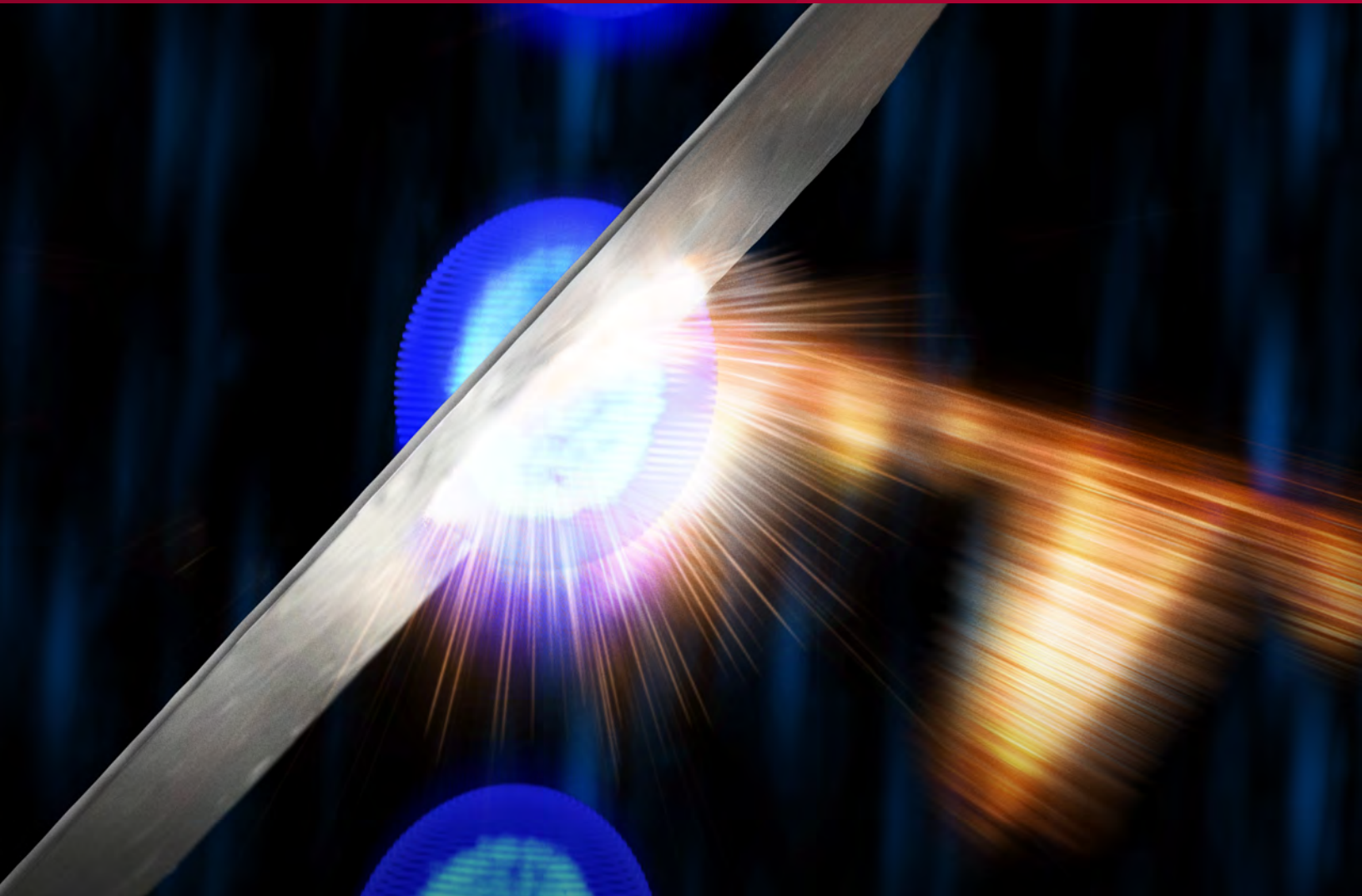


# SLAC Strategic Plan



November 2014

**SLAC** NATIONAL  
ACCELERATOR  
LABORATORY

# Contents

<b>Message from the Director</b>	<b>3</b>	Solve Energy Challenges	28
<b>Our Role as a DOE National Lab</b>	<b>4</b>	Batteries	29
<b>Our History</b>	<b>6</b>	Solar Energy	30
<b>Our Core Expertise</b>	<b>10</b>	Catalysis	31
Accelerators	12	Pursue a Frontier Program in Cosmology	32
Detectors	13	Dark Matter	33
X-rays	14	Dark Energy	34
Lasers	15	Cosmic Inflation	35
<b>Our Strategic Initiatives</b>	<b>16</b>	Particle Physics	36
Innovate and Operate Premier Accelerator-based Facilities	16	<b>Our Infrastructure and Operations Support Systems</b>	<b>38</b>
LCLS & LCLS-II	18	<b>Our Partners</b>	<b>40</b>
SSRL	20	<b>Our People</b>	<b>44</b>
FACET & FACET-II	21	<b>Our Values</b>	<b>46</b>
Ultrafast Electron Diffraction/Microscopy	22		
Identify and Pursue New Science Enabled by Our Facilities	23		
Materials Science	24		
Chemical Science	25		
Bioscience	26		
Matter in Extreme Conditions	27		

# Message from the Director

For more than 50 years, SLAC National Accelerator Laboratory has stood at the forefront of scientific discovery. What started as home to the world's longest particle accelerator, one of the largest scientific endeavors of its time, has over the years become the scene of transformative scientific research, where building blocks of matter have been discovered and life's fundamental processes studied and better understood.

SLAC has evolved many times throughout its history, forging new scientific paths. Today, we are a multipurpose national laboratory, leveraging our historical strength in particle physics and accelerator research to power discoveries across an even greater range of scientific disciplines. We operate the world's first hard X-ray free-electron laser, which generates light of unprecedented brilliance for capturing atomic-scale snapshots. We help companies use synchrotron radiation to design better pharmaceuticals, stronger materials and more efficient sources of energy. And we continue to build on our solid foundation in particle physics to peer into the farthest reaches of our universe, using ever more sophisticated tools and techniques.

As a Department of Energy (DOE) national laboratory, it is incumbent on us to develop and operate world-class facilities used by thousands of researchers each year. Our success also depends on a robust partnership

with Stanford University, which manages the Laboratory for the DOE and attracts some of the world's best scientists and most innovative research.

To make SLAC's next half century as successful as its first, we need a sound strategic plan. This plan will help guide our priorities for years to come, allowing us to invest in our people, our infrastructure and the tools we need to remain a major force for scientific advancement. It will guide us in choosing the right scientific boundaries to push while remaining good stewards of our resources. And it will ensure that all of us – our stakeholders, our employees and our partners – share a vision and a common understanding of where we are going as a laboratory.

In the coming years, SLAC will use its expertise in innovating and operating world-class facilities to advance research in areas such as ultrafast science and the study of matter under

extreme conditions; solve societal challenges in energy generation, transformation and use by working to improve batteries, catalysts and photovoltaic systems; and pursue a frontier program in cosmology that helps all of us better understand the invisible phenomena of dark matter, dark energy and inflation, the exponential expansion of the universe after the Big Bang.

When Wolfgang "Pief" Panofsky, the founding father of SLAC, was asked how long the laboratory could productively operate, he would answer, "Ten years, unless somebody produces a good idea." Fifty years later, SLAC has produced many good ideas that have changed the scientific landscape. I'm confident there are many more yet to come.

*Chi-Chang Kao*  
*Director, SLAC National Accelerator Laboratory*

# Our Role as a DOE National Lab

SLAC is one of 17 DOE national laboratories. Created during World War II, the national lab system has consistently carried out research and developed technologies in support of national priorities, from defending the nation against terrorism and other threats to finding sustainable sources of energy and keeping America competitive.

Ten of the national laboratories, including SLAC, are supported by the DOE Office of Science, which is the single largest supporter of basic research in the physical sciences in the United States. Together the Office of Science labs constitute the most comprehensive research system of its kind in the world.

They lead research in many fields, including high-energy and solid-state physics, large-scale scientific computing, nuclear medicine, plasma science and nanotechnology, and they specialize in pursuing important scientific questions that straddle the boundaries of traditional disciplines.

The Office of Science labs are also home to some of the world's largest, most sophisticated research facilities, of a scale no single company or university could afford to operate. Many of them are "user facilities" open to the broader research community, including three operated by SLAC:

- The Stanford Synchrotron Radiation Lightsource (SSRL), which produces bright X-ray light for probing matter at the atomic and molecular level, enabling advances in energy production, environmental cleanup, nanotechnology, new materials and medicine

- The Linac Coherent Light Source (LCLS) X-ray laser, which illuminates objects and processes at unprecedented speed and scale for research in physics, structural biology, energy science, chemistry and other fields
- The Facility for Advanced Accelerator Experimental Tests (FACET), which hosts experiments aimed at improving the power and efficiency of particle accelerators used in basic research, medicine, industry and other areas important to society

Thousands of researchers from universities, industry, research centers and other government agencies use these three SLAC facilities each year.

As a multipurpose national laboratory managed by Stanford for the Office of Science, SLAC supports the DOE mission, which is to ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions.

Within this mission, our aim is to leverage our intellectual capital, our relationship with Stanford and our location within Silicon Valley to:

- Innovate and operate world-leading accelerators, light sources and other tools for the use of scientists from around the world as well as from SLAC and Stanford;
- Deliver transformative chemical, materials and biological science enabled by our unique facilities;
- Find solutions for the nation's energy challenges; and
- Define and pursue a frontier program in cosmology.

As the institution that operates SLAC for the DOE, Stanford provides the Laboratory with important intellectual power for conducting scientific research and planning the next generation of facilities, and we coordinate our planning efforts with major Stanford initiatives.





U.S. DEPARTMENT OF  
**ENERGY**

**DOE (owner)**  
Conducts **OVERSIGHT**  
to ensure all work is done in  
accordance with the contract

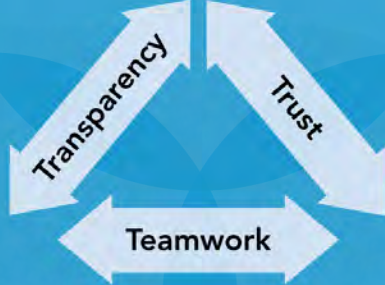
**SLAC**

**SLAC (laboratory)**  
Responsible for performing  
the work, and **ENSURING** safe,  
secure mission delivery



**Stanford**  
University

**Stanford (contractor)**  
Provides **ASSURANCE** that  
the lab is being managed  
and operated in accordance  
with the contract



# Our History

In 1962, in the rolling hills west of Stanford University, construction began on the longest and straightest structure in the world. The linear particle accelerator – first dubbed Project M and affectionately known as “the Monster” to the scientists who conjured it – would accelerate electrons to nearly the speed of light for groundbreaking experiments in creating, identifying and studying subatomic particles.

Stanford University leased the land to the federal government for the new Stanford Linear Accelerator Center and provided the brainpower for the project, setting the stage for a productive and unique scientific partnership that continues today, made possible by the sustained support and oversight of the DOE.

For nearly 40 years, the linear accelerator hosted pioneering experiments in particle physics, including research that led to three Nobel Prizes: the realization that protons in the atomic nucleus are composed of smaller entities called quarks; discovery of the J/psi particle, which implied the existence of the charm quark; and discovery of the tau lepton, the first of a new family of fundamental building blocks. In more recent years, the BaBar experiment offered important insights into the imbalance of matter and antimatter in the universe, providing experimental evidence that led to the award of the 2008 Nobel Prize in physics to the theorists who first explained

the source of this imbalance. These and other particle physics discoveries reshaped our understanding of matter and inspired whole new areas of science.

In the early 1970s, researchers realized that X-ray light released by electrons circling in an accelerator could be harnessed for exploring matter at an atomic scale. This early research blossomed into the facility now called the Stanford Synchrotron Radiation Lightsource (SSRL), which continues to produce both fundamental insights into the natural world and discoveries with practical applications. SSRL experiments helped determine the structure of an important biomolecule, RNA polymerase, leading to the 2006 Nobel Prize in chemistry, and also played a role in two more chemistry Nobels.

The past decade saw a new round of change, as SLAC deepened its ties with Stanford and evolved into a multipurpose laboratory with

strong programs in cosmology, chemistry, biology, materials science and energy research, as well as national user facilities that attract thousands of visiting scientists each year.

The lab now jointly operates three institutes and a research center with Stanford:

- Kavli Institute for Particle Astrophysics and Cosmology (KIPAC)
- Stanford Institute for Materials and Energy Sciences (SIMES)
- Stanford PULSE Institute
- SUNCAT Center for Interface Science and Catalysis

With the opening of LCLS, the world's first hard X-ray free-electron laser, in 2009, SLAC launched a new era in X-ray science, using incredibly fast, brilliant X-ray laser pulses to illuminate objects and processes at unprecedented speed and scale for research in physics,





STANFORD LANDS  
Area - 56,720.00 Study of Lands  
PROJECT 'M' LINEAR ELECTRON ACCELERATOR  
Construction - 1960-1966 Length - 3,200 feet Diameter - 300 feet



biology, energy science, chemistry and a host of other fields. That revolution will continue and intensify with the planned upgrade known as LCLS-II.

Today, the linear accelerator that first defined the lab and its mission serves as the backbone for LCLS and for FACET, an experimental test bed for designing the next generation of smaller, cheaper and more powerful particle accelerators.

While our last on-site particle physics experiment closed in 2008, we have broadened our mission to include particle astrophysics and cosmology, applying the resources of modern physics and our longstanding expertise in

building detectors and sensors to answer some of the biggest questions about the universe.

SLAC built and operates the main instrument for NASA's Fermi Gamma-ray Space Telescope, now in its sixth year in orbit. We actively participate in the ATLAS experiment at the Large Hadron Collider; in two underground experiments searching for dark matter, the Super Cryogenic Dark Matter Search (SuperCDMS) and LUX-ZEPLIN (LZ); and in the Enriched Xenon Observatory (EXO), which is looking for clues to the nature of the neutrino. We are also building the world's biggest digital camera for the nation's top priority ground-based astronomy project

for the coming decade, the Large Synoptic Survey Telescope (LSST), which is expected to provide important clues to the nature of dark matter and dark energy.

The lab's 50th anniversary celebration in 2012 was both a tribute to the momentous discoveries made possible by the minds and machines at SLAC and a look ahead at our continuing evolution. We fully expect our future growth into new frontiers of scientific research will keep the Laboratory at the forefront of discovery for decades to come.

**1960** **1965** **1970** **1975** **1980** **1985**

**1962** Contract signed

**1966** First beam in 2-mile accelerator

**1967** Friedman, Kendall, Taylor experiments in End Station A begin

**1968** 82-inch bubble chamber begins taking data

**1972** SPEAR collides first beams

**1973** SSRP established; first radiation experiments on SPEAR

**1974** J/psi particle discovered; SSRP begins operations at SPEAR

**1976** Tau lepton discovered; Richter shares Nobel for J/psi discovery

**1977** SSRP becomes SSRL

**1980** PEP stores first beam

**1984** SLAC named American Society of Mechanical Engineers landmark

**1988** Stanford Linear Collider collides first beams

**1990** Friedman, Kendall, Taylor receive Nobel for quark discovery; SPEAR becomes dedicated synchrotron for SSRL


**NATIONAL HISTORIC ENGINEERING LANDMARK**  
**THE STANFORD LINEAR ACCELERATOR CENTER**  
**1962**  
**STANFORD, CALIFORNIA**  
 THE STANFORD TWO-MILE ACCELERATOR, THE LONGEST IN THE WORLD, ACCELERATED ELECTRONS TO THE VERY HIGH ENERGIES NEEDED IN THE STUDY OF SUBATOMIC PARTICLES AND FORCE. EXPERIMENTS PERFORMED HERE HAVE SHOWN THAT THE FUNDAMENTALS OF THE UNIFIED THEORY OF ELEMENTARY PARTICLES COMPOSED OF FUNDAMENTAL PARTICLES AND FIELDS OF FORCE. THESE EXPERIMENTS HAVE UNCOVERED NEW FAMILIES OF PARTICLES AND DEMONSTRATED SUBTLE EFFECTS OF THE WEAK INTERACTIONS. THIS RESEARCH REQUIRES THE HIGHEST PRECISION IN THE LARGEST AND MOST COMPLEX OF INSTRUMENTS, SYSTEMS THAT ACCURATELY DEFINE, ACCELERATE AND STORE THE BEAMS OF PARTICLES AND IN THE DETECTOR THAT ANALYZES THE RESULTS OF THE PARTICLE INTERACTIONS. THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS-1984



# 50 Years of Discovery


## SLAC PROGRAM KEY


- FACET* – Facility for Advanced Accelerator Experimental Tests
- KIPAC* – Kavli Institute for Particle Astrophysics and Cosmology
- PEP* – Positron Electron Project
- PULSE* – Stanford PULSE Institute (formerly PULSE Institute for Ultrafast Energy Science)
- SIMES* – Stanford Institute for Materials and Energy Sciences
- SPEAR* – Stanford Positron Electron Accelerating Ring
- SSRP* – Stanford Synchrotron Radiation Project (now SSRL; see below)
- SSRL* – Stanford Synchrotron Radiation Lightsource
- SUNCAT* – SUNCAT Center for Interface Science and Catalysis

**1990** 

**1991** SLAC hosts first website in North America


**1994** Final Focus Test Beam commissioned

**1995**  Perl receives Nobel for tau lepton discovery

**1995** 


**1996** Next Linear Collider Test Accelerator accelerates first beam

**1999** The PEP-II B factory's BaBar detector records first events

**2000** 

**2003** KIPAC established; SPEAR3 circulates first electrons

**2005** PULSE Institute established


**2006**  Kornberg awarded Nobel for RNA polymerase work done partly at SSRL

**2009** LCLS sees first light

**2010** SUNCAT established

**2011** First beam delivered to FACET

**2012** SLAC celebrates 50th anniversary

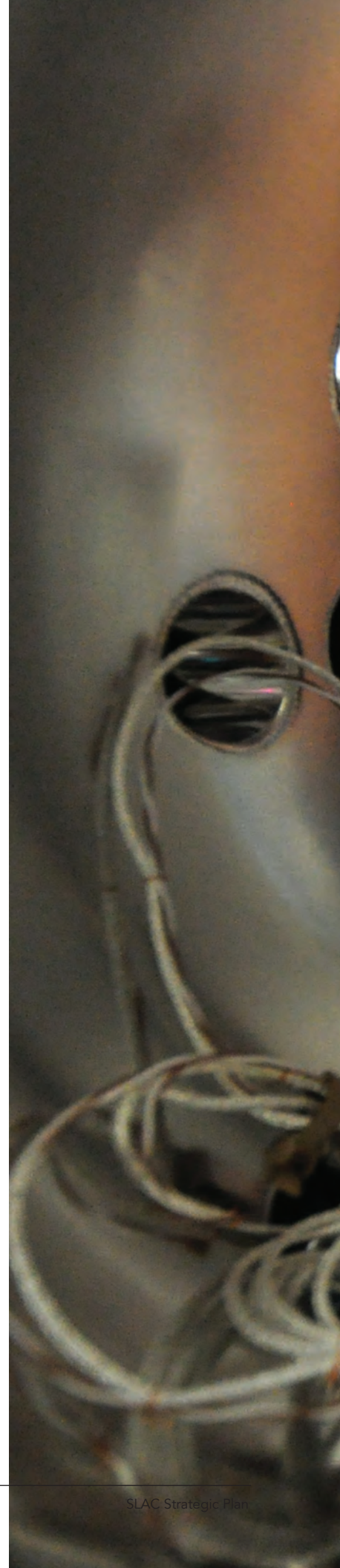
**2008**  BaBar CP violation results a key factor in Nambu and Kobayashi Nobel; Fermi space telescope begins mapping gamma-ray sky; SIMES (formerly XLAM) established

# Our Core Expertise

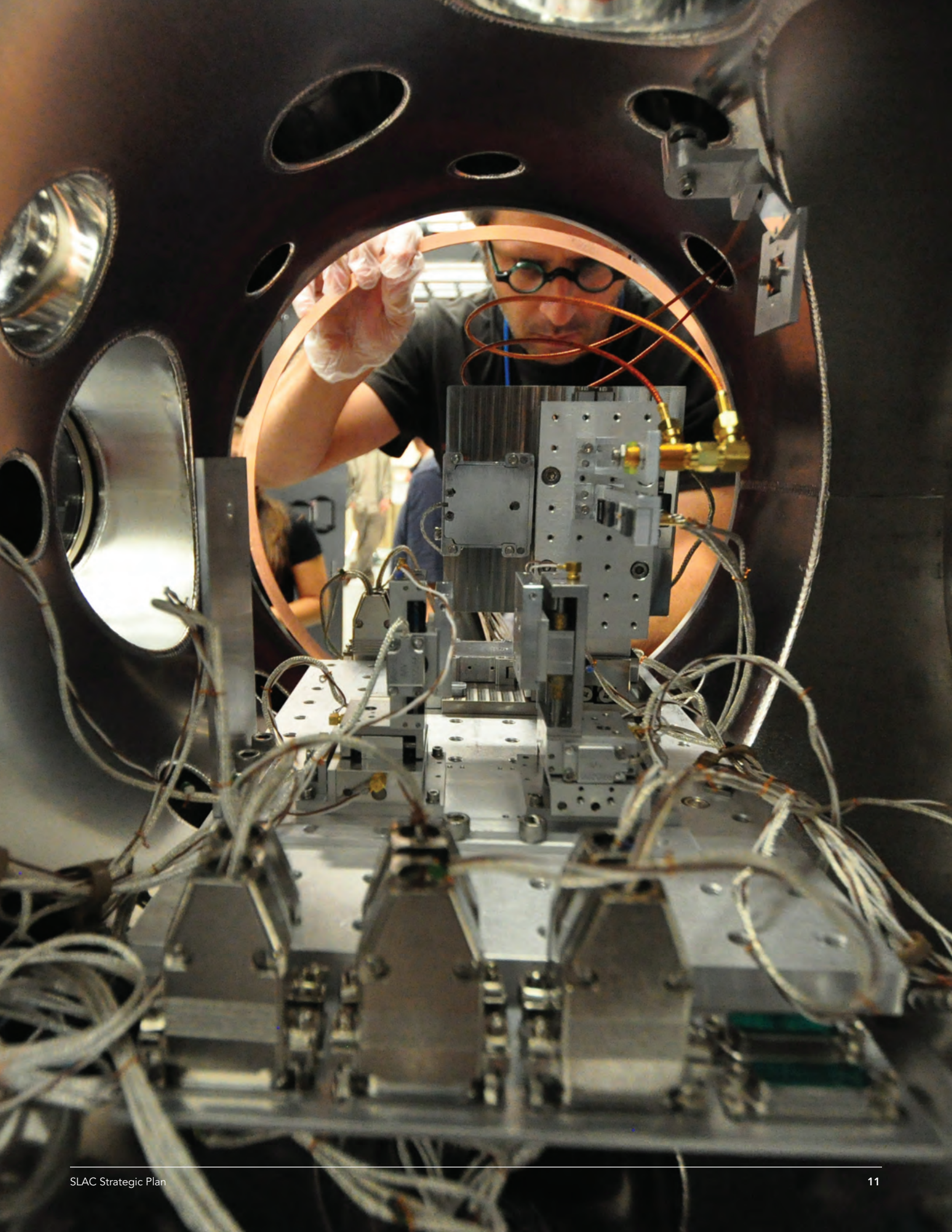
Our many years of experience in running large facilities, accelerating and detecting particles and producing bright beams of light for research allow us to make seminal advances in four core areas:

- Accelerators
- Detectors
- X-rays
- Lasers

Over the next decade, we will combine the skills of our highly qualified staff and our strong connection with Stanford to further strengthen these core competencies. This will enable us to do ever more advanced scientific research, carry out our strategic initiatives and those of the DOE, and support research by other government agencies, universities and industry.









## Core Expertise: Accelerators

Accelerating particles more efficiently and over much shorter distances would open new doors in many areas of science, medicine and industry. SLAC is a leader in exploring new methods of particle acceleration.

These studies build on our experience running the laboratory's 2-mile-long linear accelerator, SSRL, LCLS and FACET. They also take advantage of our unique combination of expertise in lasers, ultrafast timing and advanced acceleration techniques.

We're exploring four methods for creating compact sources of high-energy electrons with unprecedented brightness:

- Plasma wakefield acceleration, in which electrons "surf" on waves of plasma – a hot gas of charged particles – and gain very high energies in very short distances
- Dielectric wakefield acceleration, in which electrons gain energy by traveling through a dielectric material such as silica or diamond
- New approaches for using terahertz radiation – a relatively unexplored wavelength of light between microwaves and infrared – to accelerate particles in very short distances
- "Accelerator on a chip" technology that uses a laser to accelerate particles within a nanostructured glass chip

We hope to apply advanced acceleration concepts studied at FACET – and eventually its upgrade, FACET-II – to the design of compact accelerators, and demonstrate their capability and reliability for a wide range of applications in basic energy sciences and high-energy physics.

We are also developing new ways of operating today's accelerators that open up new areas of science. For instance, a technique known as "self-seeding" filters the LCLS X-ray laser beam to a single color, or wavelength, of light, giving researchers more control in studying and manipulating matter at the atomic level and delivering sharper images of materials, molecules and chemical reactions. Another LCLS technique produces two-color X-ray laser pulses – pairs of pulses in slightly different wavelengths, with finely adjustable intervals between them. This enables a wide range of new experiments, from imaging biological molecules to tracking changes in plasmas and atomic systems on a variety of timescales.

### ACCELERATOR ON A CHIP

In an advance that could dramatically shrink particle accelerators, researchers at SLAC used a laser to accelerate electrons at a rate 10 times higher than conventional technology in a nanostructured glass chip smaller than a grain of rice. At its full potential, this "accelerator on a chip" could match the accelerating technology of SLAC's 2-mile-long linear accelerator in just 100 feet. Although a number of challenges need to be overcome before this technology becomes practical for real-world use, it promises to substantially reduce the size and cost of future accelerators, enabling compact devices for security scanning, medical therapy and imaging, and research in biology and materials science.



## Core Expertise: Detectors

Detectors have been an important part of SLAC since its founding, helping scientists capture sprays of debris from particle collisions, identify particles raining in from space and analyze what happens when matter is bombarded with light. Detectors play a key role in SLAC science today, and many of the scientific challenges we face – at the lab and beyond – will require detectors that are orders of magnitude larger, faster and more sensitive.

In the coming years we will expand our detector capabilities, particularly to meet the needs of new scientific facilities. We will face transformative challenges and opportunities as we develop detectors to carry out very fast imaging at LCLS-II; track particles in the high-radiation environment of the ATLAS detector at the Large Hadron Collider; measure nuances of the cosmic microwave background radiation left over from the Big Bang; and develop new beamlines at SSRL (see page 20) and our proposed Ultrafast Electron Diffraction/Microscopy (UED/ UEM) facility (see page 22).

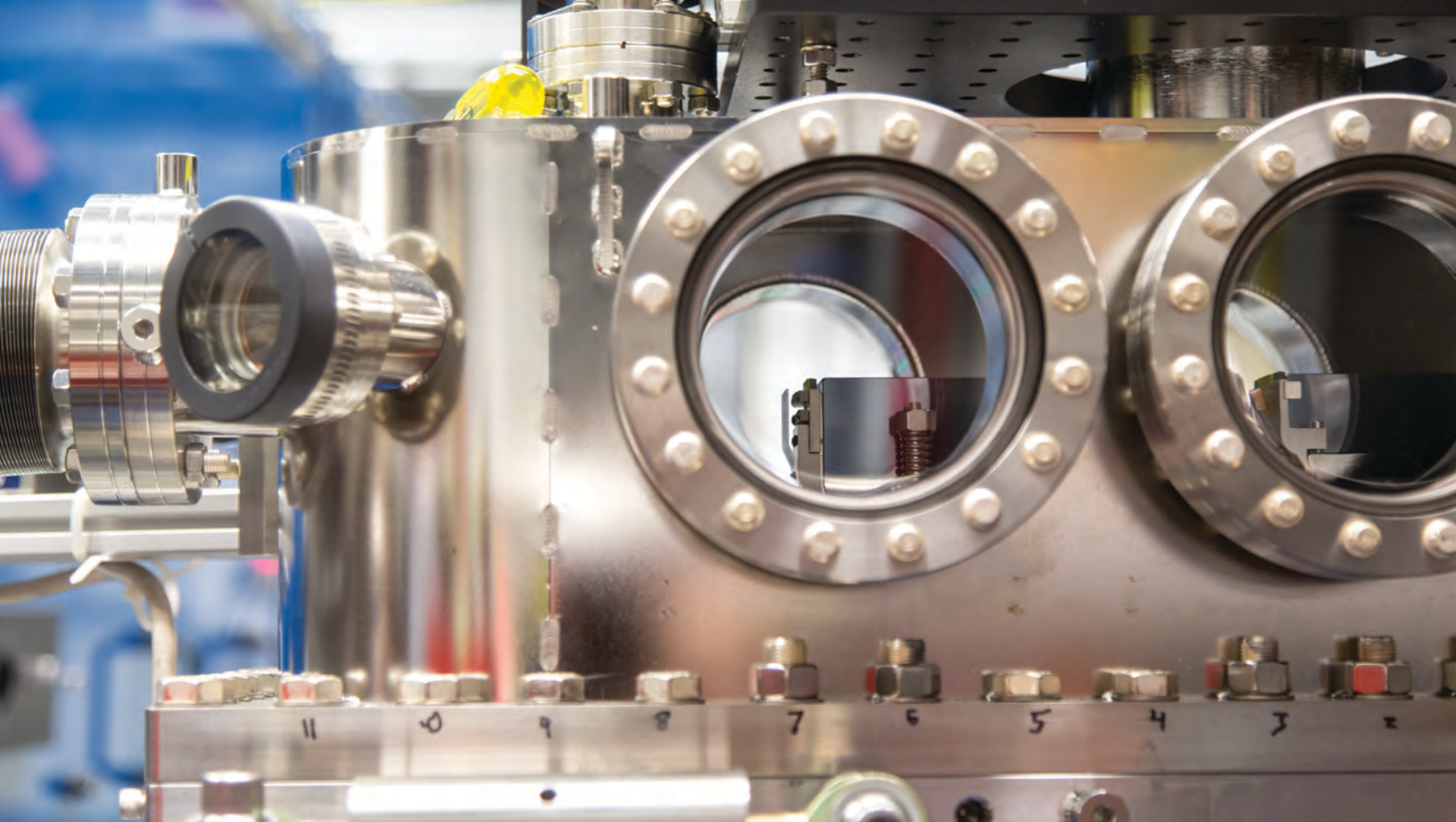
These diverse applications share much of the same technology base. This allows us to leverage detector-related resources across SLAC science areas, from photon science to particle physics. And by partnering with university groups and other laboratories within the DOE complex and beyond, we are able to share and leverage ideas, resources and advancements to strategically grow our detector program.



### DETECTING THE FAINTEST SIGNALS

SLAC plays an important role in developing detector technologies, including the Transition Edge Sensor (TES), an exquisitely precise thermometer for capturing some of the faintest signals detectable. The first version of TES was developed at Stanford; today, TES arrays are used to look for incoming particles of dark matter in the Cryogenic Dark Matter Search, explore the intricacies of the cosmic microwave background radiation in the BICEP experiments (see page 35), and – soon – precisely measure X-ray energies in experiments at SSRL and LCLS. The sensors are also used in the fields of nuclear non-proliferation, materials analysis and homeland defense.





## Core Expertise: X-rays

Electrons racing around a circular accelerator give off light in the form of X-rays. For years this was considered a nuisance, but in the early 1970s researchers at SLAC and elsewhere discovered how to harness this light into powerful beams for research in biology, chemistry and materials science. In 1974 SLAC became the first lab in the world to invite visiting scientists to use this synchrotron radiation for experiments, and in 2009 it took another big leap by opening the world's first hard X-ray free-electron laser, LCLS.

SLAC is still a leader in developing X-ray methods and instruments for answering our most challenging questions about the structure and behavior of matter on the atomic scale. SLAC's two X-ray light sources, SSRL and LCLS, as well as the future LCLS-II, afford opportunities to develop new methods and instruments for addressing these scientific challenges.

With its ultrabright and ultrafast pulses, LCLS allows revolutionary new insight into the inner workings of materials in ways that weren't previously possible. This requires a new and deeper understanding of both research techniques and the intricate interactions between X-rays and matter, to ensure that experiments are appropriately designed and the data fully understood. It also creates new challenges in developing X-ray optics, detectors, sample delivery systems and data acquisition and analysis tools.

Our focused X-ray science and technology program is also expanding the capabilities of SSRL, and finding ways that the two types of light sources – the synchrotron and the X-ray free-electron laser – can work together to address important research questions in the most efficient and effective manner. By coordinating our efforts and continually developing X-ray instrumentation and techniques, we can use SLAC's facilities to their fullest and gain new scientific insights.

### DIAMONDS SPLIT THE BEAM

Using very thin, perfect diamond crystals to select and divert particular wavelengths of X-ray light from the LCLS laser beam, scientists can now split the beam for use in two experiments simultaneously. This much-anticipated feat – the result of years of work by an international team led by SLAC scientists – is the first of its kind for a hard X-ray free-electron laser beam, and it has increased the research capacity of a facility where only one out of four research proposals can be accommodated. In the coming years, scientists hope to split the beam three ways for simultaneous use by three LCLS instruments and develop new pulse-forming schemes to make beam sharing even more efficient.

## Core Expertise: Lasers

Over the past decade, SLAC has developed an impressive array of more than two dozen laser systems. They provide a controlled source of energy that can be used to trigger specific changes in materials – lining up atoms, shocking and compressing matter or producing magnetic states, for instance – and measure those changes with great precision.

The buildup began during the development of the LCLS X-ray laser and continues today. Ultrafast lasers, whose light comes in pulses just trillionths of a second long, are now an essential part of LCLS operations, user experiments at LCLS, SSRL and FACET, numerous programs in accelerator, materials, chemical and high-energy-density science, and the development of free-electron lasers and novel acceleration techniques.

SLAC's world-class laser technology group develops novel laser sources and techniques that use a variety of wavelengths of light. Those wavelengths include deep ultraviolet, which approaches X-ray wavelengths;

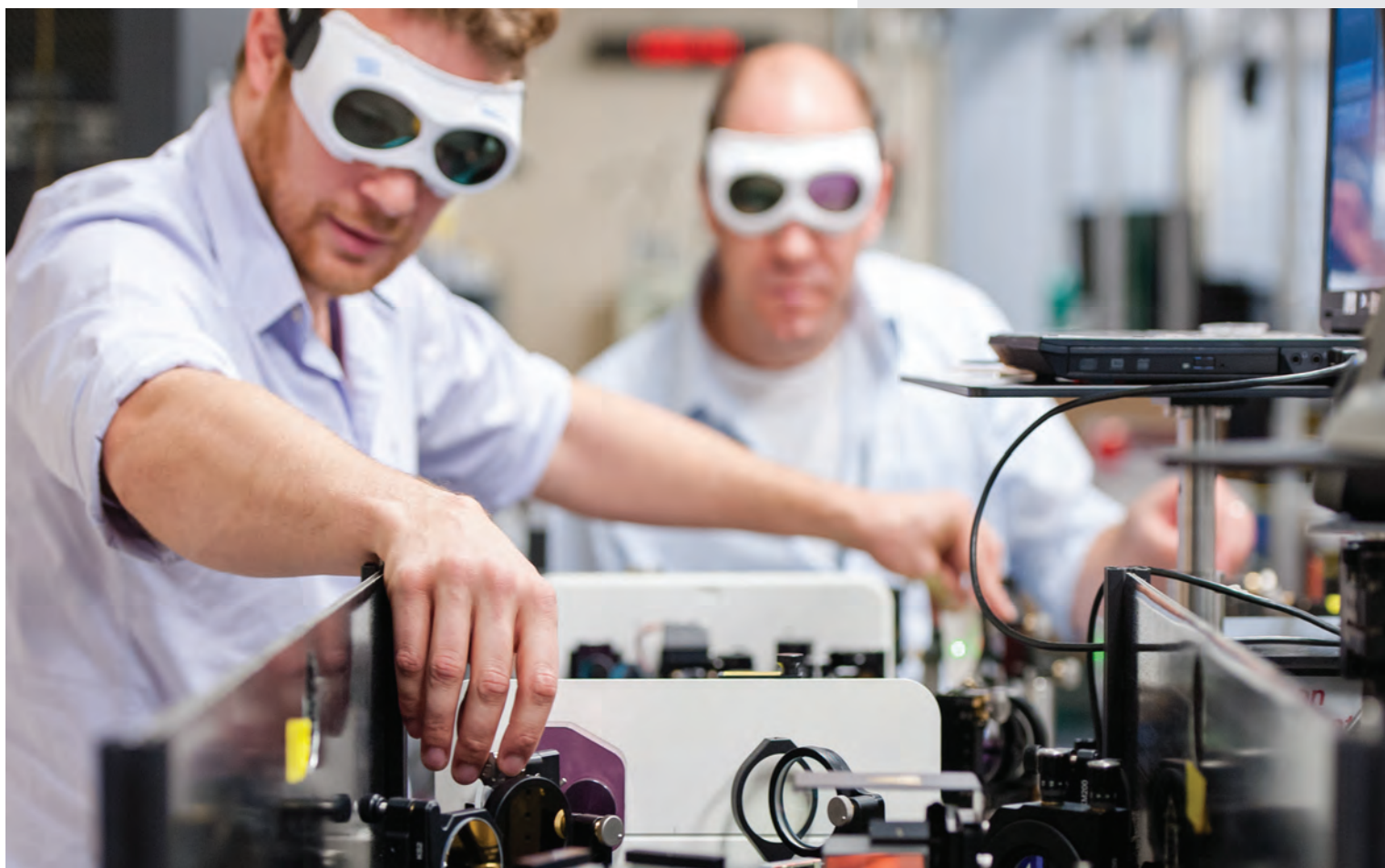
laser-driven terahertz radiation, which sits between microwave and infrared; and tunable mid-infrared radiation, midway between ultraviolet and terahertz.

We will also be developing lasers with extremely high peak power and ultrafast lasers with high repetition rates and high average power, used for experiments and beam conditioning at LCLS. A number of other laser sources are being developed to support advanced accelerator research and new programs in photon science.

In the coming years, we will expand our laser research and development while working more closely with laser groups at Stanford, in industry and within the wider research community. This will enhance the capabilities of our user facilities, enable new and broader multi-disciplinary scientific research and strengthen our ties to Stanford and to the Silicon Valley laser industry.

### EXPERIMENTING WITH LASER LIGHT

At LCLS, scientists conduct experiments on a wide variety of physical systems, from gases to matter in extreme conditions, which respond to specific wavelengths of laser light. SLAC offers laser light in nearly any wavelength, from deep ultraviolet to terahertz radiation, and about 75 percent of LCLS experiments take advantage of it. For example, in a typical “pump-probe” experiment, an optical laser produces a short-lived excited state in a material that is then probed with X-rays. By changing the amount of time between the arrival of the optical and X-ray laser beams, experimenters can map the response of the material as it passes through the excited state, which may last less than a trillionth of a second.





# Our Strategic Initiatives

SLAC makes scientific discoveries and develops scientific tools that transform our understanding of nature and help solve the nation's major scientific and technological challenges. The Laboratory's four major strategic initiatives, described in this section, build on our core expertise in accelerators, detectors, X-rays and lasers.

## Strategic Initiative: Innovate and Operate Premier Accelerator-based Facilities

Building on our long history of developing and delivering new accelerator technologies and facilities, SLAC has grown into the premier DOE accelerator laboratory.

We focus our efforts in four areas:

- LCLS and LCLS-II
- SSRL
- FACET and FACET-II
- Ultrafast Electron Diffraction/  
Microscopy (UED/UEM)

Next-generation plans will be further refined and proposals developed in close cooperation with DOE and other national laboratories.









## LCLS & LCLS-II

LCLS provides extremely high-energy X-ray laser pulses for scientific studies. With this intense X-ray light, approximately 600 scientists each year conduct groundbreaking experiments into the fundamental processes of chemistry, materials and energy science, biology and technology.

The unprecedented brightness of LCLS has enabled completely new areas of science, opening frontiers in imaging single nanoscale particles and in understanding chemistry on the natural timescales of reactions. These scientific advancements have garnered worldwide attention, and work has begun on a revolutionary new tool, LCLS-II. The new capabilities provided by LCLS-II's increased repetition rate and energy range will allow scientists to study how light triggers chemical reactions in gases and physical changes in materials. They will also allow study of

the high-resolution structure of matter under extreme conditions, such as high pressures and high temperatures.

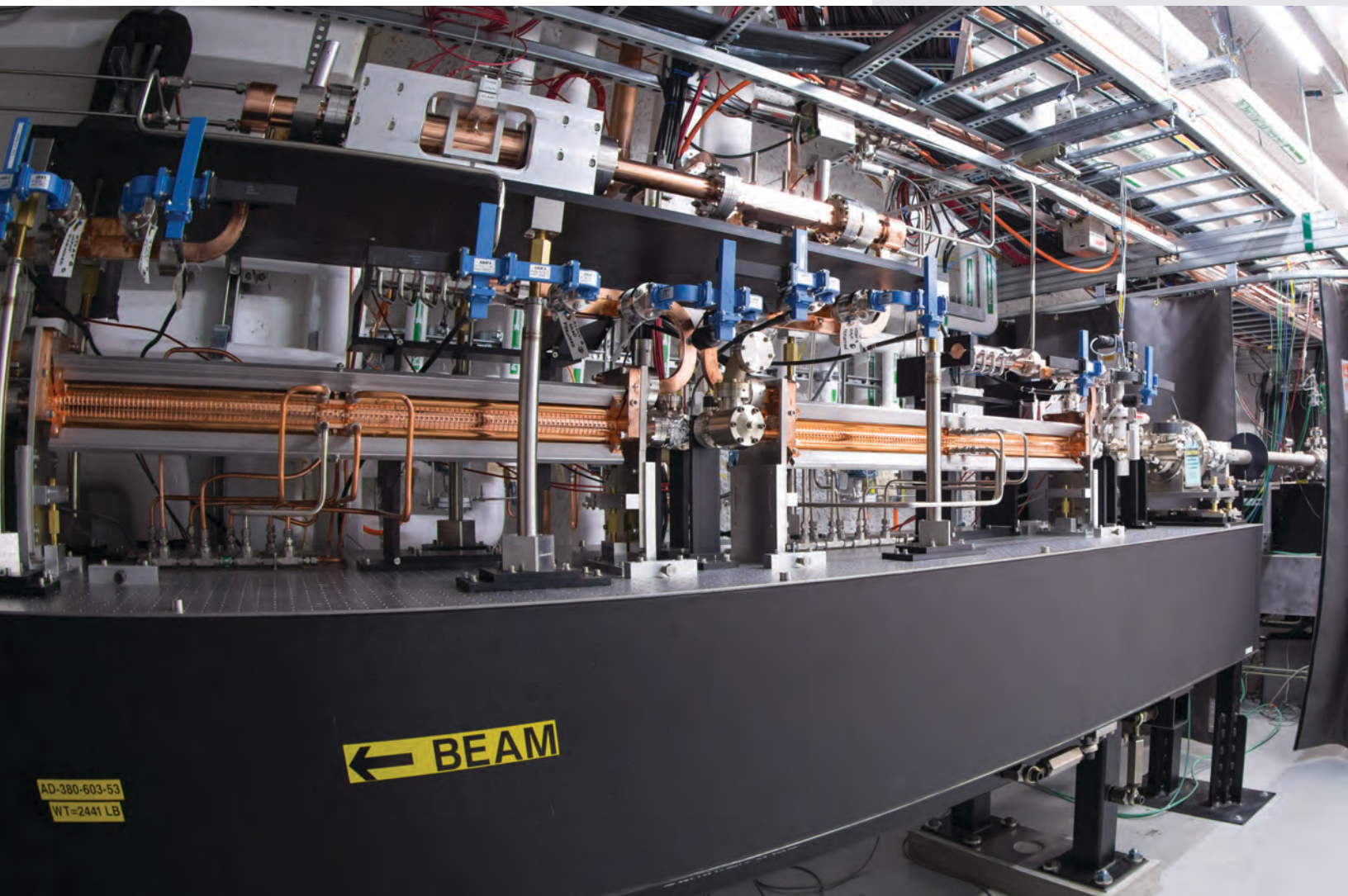
With LCLS-II, SLAC will continue to advance the frontiers of X-ray research, keeping the United States at the forefront of this very competitive international arena and supporting transformational science for the coming decade.

In addition to delivering the upgraded facility, SLAC will continue to pursue an integrated and focused R&D program to maximize the scientific impact of LCLS-II and to prepare for future facilities.

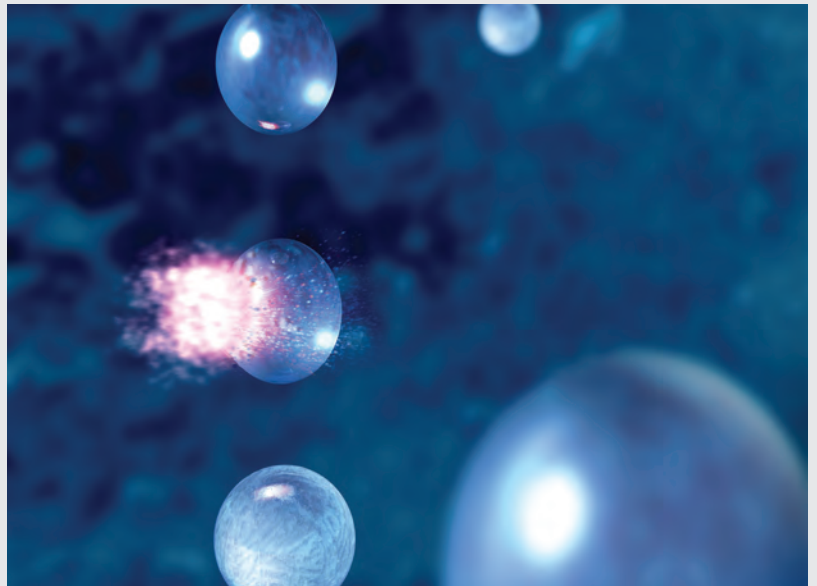
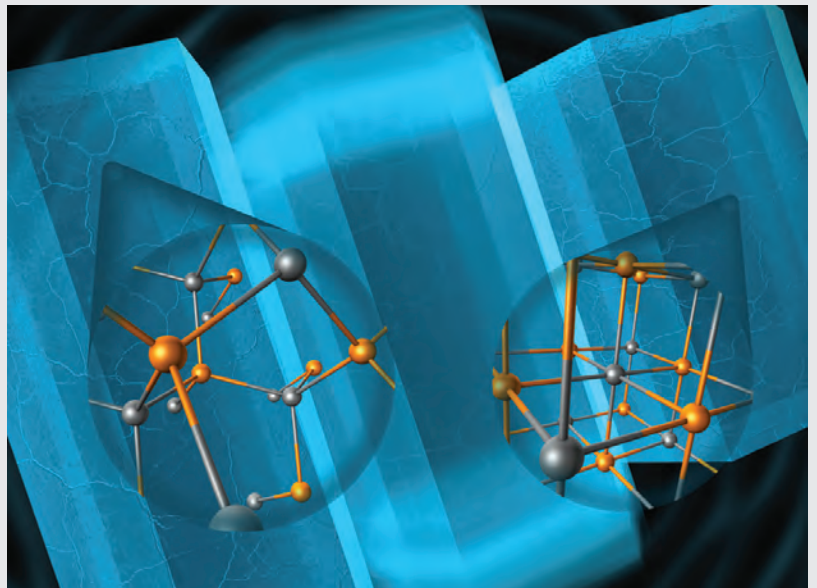
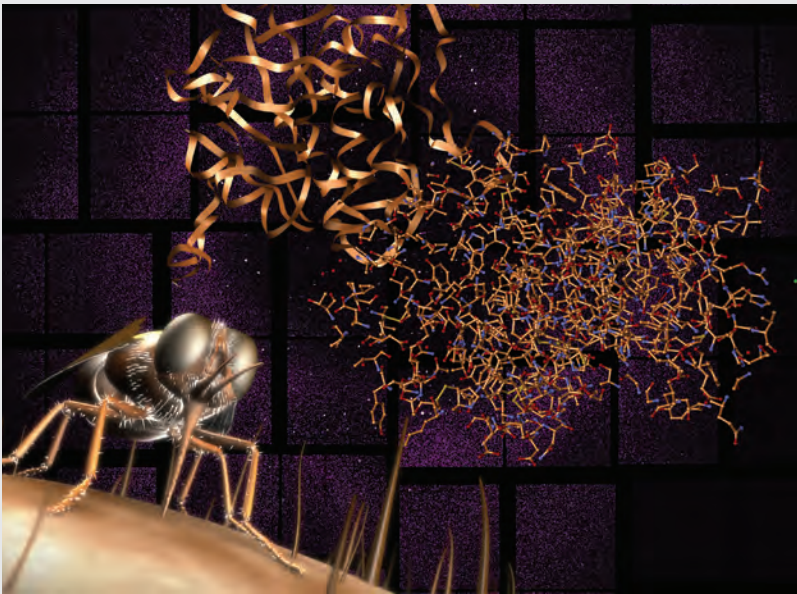
### EXTREMELY BRIGHT, EXTREMELY FAST

LCLS creates X-ray pulses a billion times brighter than previously available at synchrotrons. They are fired at a rate of about 100 pulses per second, each one lasting just quadrillionths of a second, too short a time for molecules to move much. These characteristics allow scientists to study important proteins at room temperature, in some cases even while they are active. Recently, scientists uncovered the 3-D molecular structure of an enzyme involved in the transmission of African sleeping sickness, and obtained live snapshots of the water-splitting reaction in photosynthesis.

The ultrabright X-ray pulses are also used to study matter in extreme conditions. For example, scientists were able to measure shock waves in metals heated to millions of degrees. At the other extreme, they got a first glimpse of the structure of supercooled water – water that remains liquid well below its normal freezing temperature – which had not been experimentally accessible before.







## SSRL

SSRL produces bright X-ray light for probing matter at the atomic and molecular level. More than 1,600 scientists from around the world use the facility each year for research that spurs advances in energy production, environmental cleanup, nanotechnology, new materials and medicine.

In the coming decade, through investments from DOE, Stanford and other sources, SSRL will develop new beamlines that keep it at the scientific forefront. The first three such beamlines will be equipped with instruments for advanced spectroscopy, which reveals a material's chemical environment; macromolecular crystallography, which allows high-resolution study of proteins, viruses and other biological samples; and metrology, which involves precise measurement. The new beamlines will help drive scientific innovation on new battery and solar cell materials, photosynthesis, drug discovery and catalysis, which promotes efficient chemical reactions.

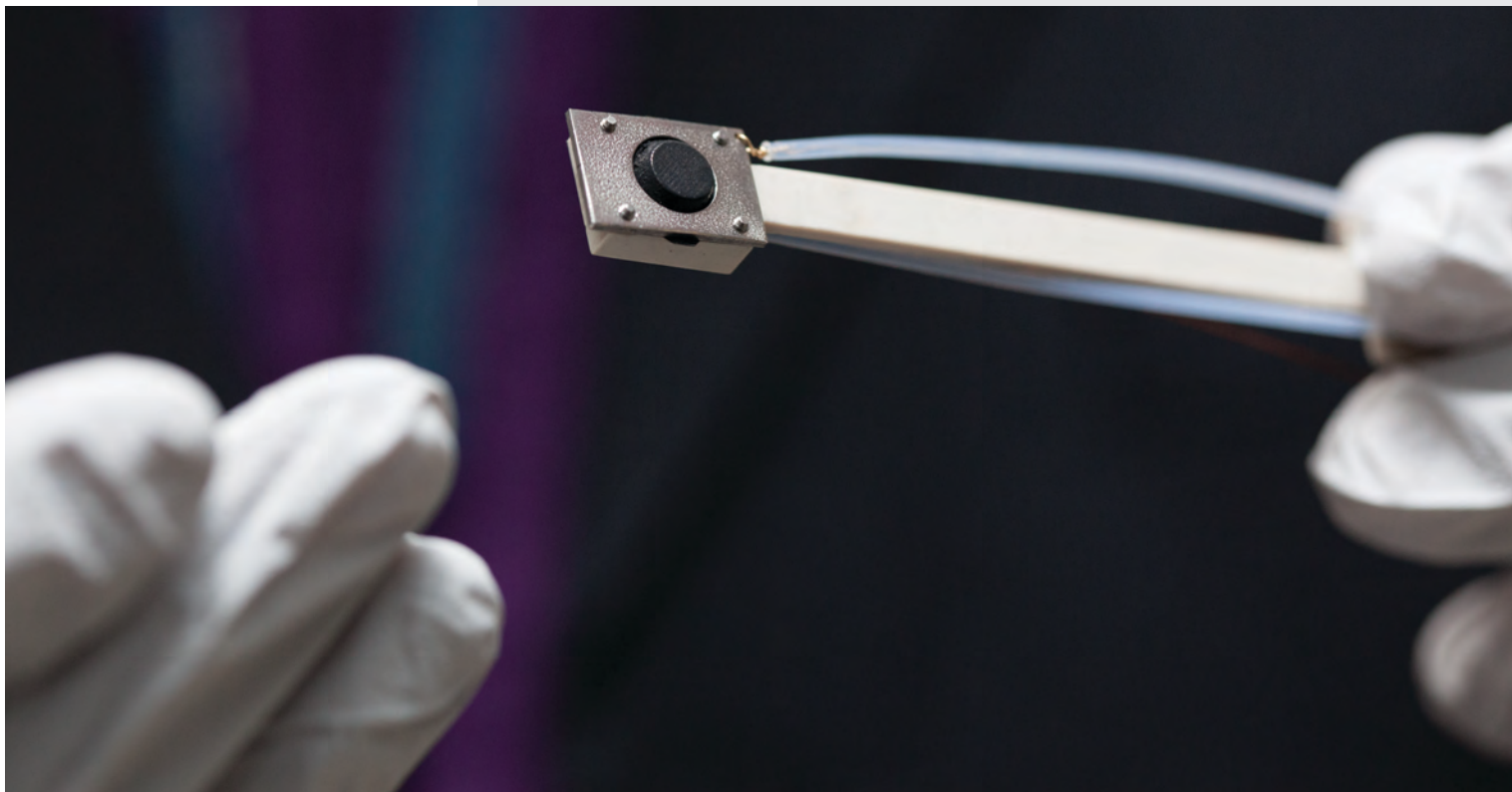
SSRL will also add advanced tools needed to realize the goal of "materials by design" in targeted areas, including catalysis, energy storage, solar energy and information

technology. These tools will also help scientists tease out the individual interactions that lead to the emergence of complex properties in systems such as high-temperature superconductors, cell biology and bioremediation.

SLAC leverages the synergy between SSRL and LCLS to maximize their impact on innovation and scientific discovery. This includes developing complementary techniques, sharing laboratory space and conducting studies at SSRL aimed at improving the underlying scientific understanding behind an experiment before deploying it at LCLS.

### FINE-TUNING FUEL CELLS

SSRL enables research that benefits every sector of the American economy. Recently, a team of researchers from SLAC's SUN-CAT center and the Technical University of Denmark developed materials for a new type of fuel cell that could eventually replace gasoline engines and the batteries found in small electronic devices. Unlike the prohibitively expensive platinum-rich fuel cells used today, these new cells use nanoparticles made of platinum and a cheaper element, yttrium. In tests at SSRL, the researchers discovered why the new material worked so well, offering insight needed to fine-tune its properties.





## FACET & FACET-II

Scientists from around the world come to FACET to conduct experiments aimed at improving the power and efficiency of particle accelerators used in basic research, medicine, industry and other areas important to society.

The facility's twin goals are to:

- Develop the capability to dramatically shrink the size and cost of particle accelerators by demonstrating plasma wakefield and dielectric wakefield acceleration (see page 12 and “Testing Future Accelerators” below) and

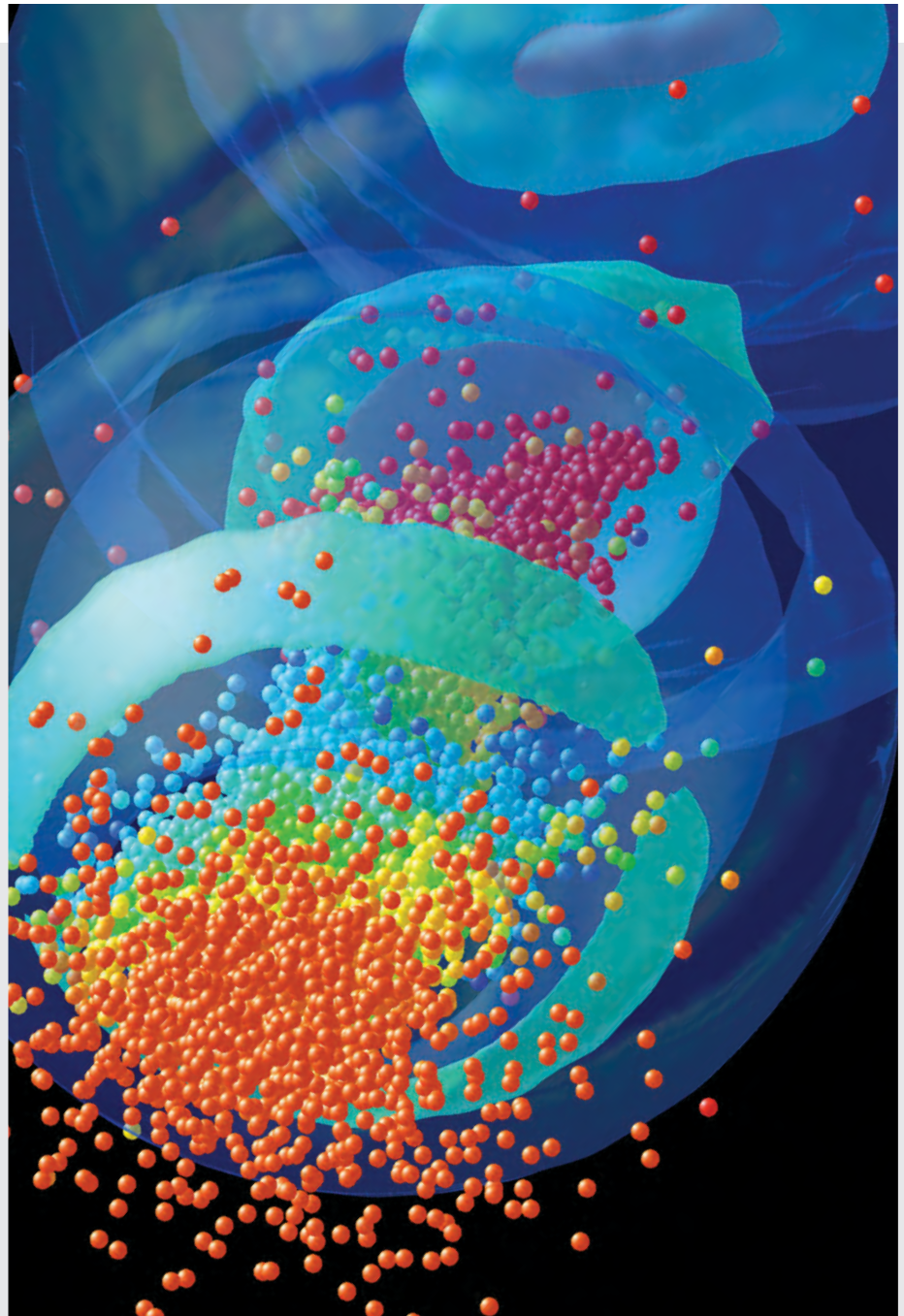
- Provide high-energy, high-density electron beams for experiments exploring areas such as the magnetic properties of materials, with applications in data storage, and high-energy sources of terahertz radiation, a relatively unexplored wavelength of light between microwaves and infrared that offers new applications in materials science and chemical imaging.

Once FACET closes to make way for LCLS-II, its proposed follow-on, FACET-II, will provide a major upgrade in capability with the potential for a broader research program.

FACET-II will expand the range of electron beam experiments possible at SLAC, enabling accelerator science vital to the future of high-energy physics, basic energy sciences and a wide variety of commercial applications.

### TESTING FUTURE ACCELERATORS

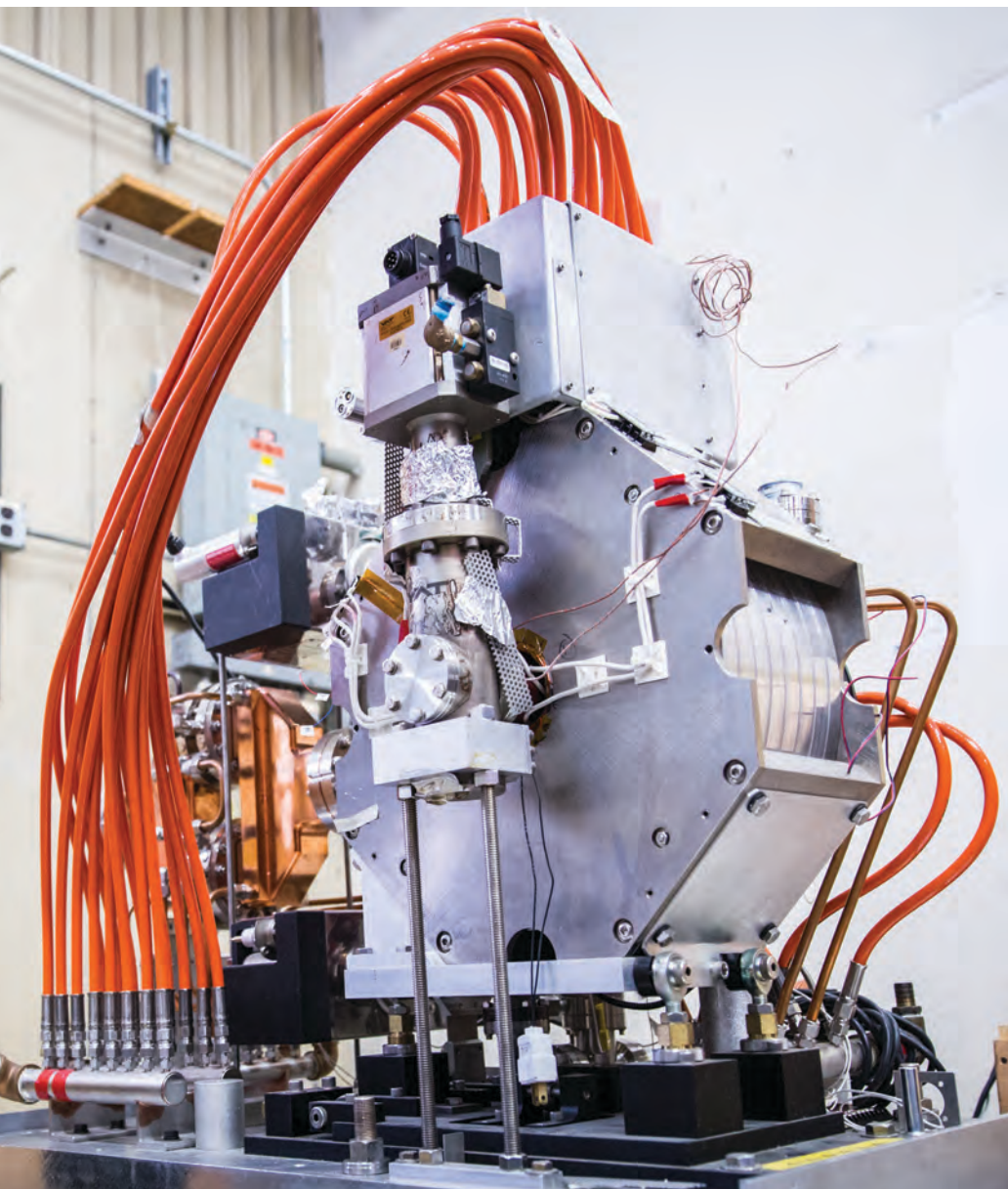
Many of the experiments undertaken at FACET seek to make accelerators smaller and more efficient using plasma wakefield or dielectric wakefield acceleration. These techniques accelerate particles to extremely high energies within a distance as much as 1,000 times shorter than SLAC's original 2-mile-long linear accelerator. In addition, FACET is a valuable tool for materials research, semiconductor research, chemical imaging and more. FACET's unique qualities also allow scientists to develop equally unique diagnostics, including non-invasive and inexpensive techniques for measuring the profiles of ultrashort bunches of electrons.



## Ultrafast Electron Diffraction/Microscopy (UED/UEM)

Electron microscopes have become essential tools in science, allowing researchers to see how atoms combine to make new and useful materials and molecules. Similarly, electron diffraction – a technique that sends electrons into a sample and measures how they scatter – reveals atomic structures. The ability to take ultrafast snapshots with high spatial resolution allows us to see not only how atoms combine, but also how they interact and rearrange.

With this in mind, SLAC has launched a new initiative to develop a UED/UEM facility. Leveraging the Laboratory's accelerator expertise, the facility will provide the world's leading ultrafast electron scattering instrumentation. SLAC's X-ray sources, SSRL and LCLS, interact primarily with the electrons within a material. The UED/UEM facility, on the other hand, will be highly sensitive to atomic nuclei. Together, these techniques will provide a more complete picture of ultrafast processes and highly complex systems.



### OVERCOMING SUN DAMAGE

One of the many questions a UED/UEM facility could help answer has to do with sun damage. Most chemical compounds break down in sunlight; that's why photographs fade over time and ropes left outside become brittle. Yet when mixed with a class of molecules called photo stabilizers, sensitive compounds are protected from damage. Previous research suggests that photo stabilizers absorb and then quickly release the sun's energy as heat – usually in less than 100 femtoseconds. X-ray studies cannot provide a complete picture of this process. But a UED/UEM facility could reveal exactly how photo stabilizers absorb and dissipate the sun's energy, knowledge that could help in creating products that resist damage from sunlight.



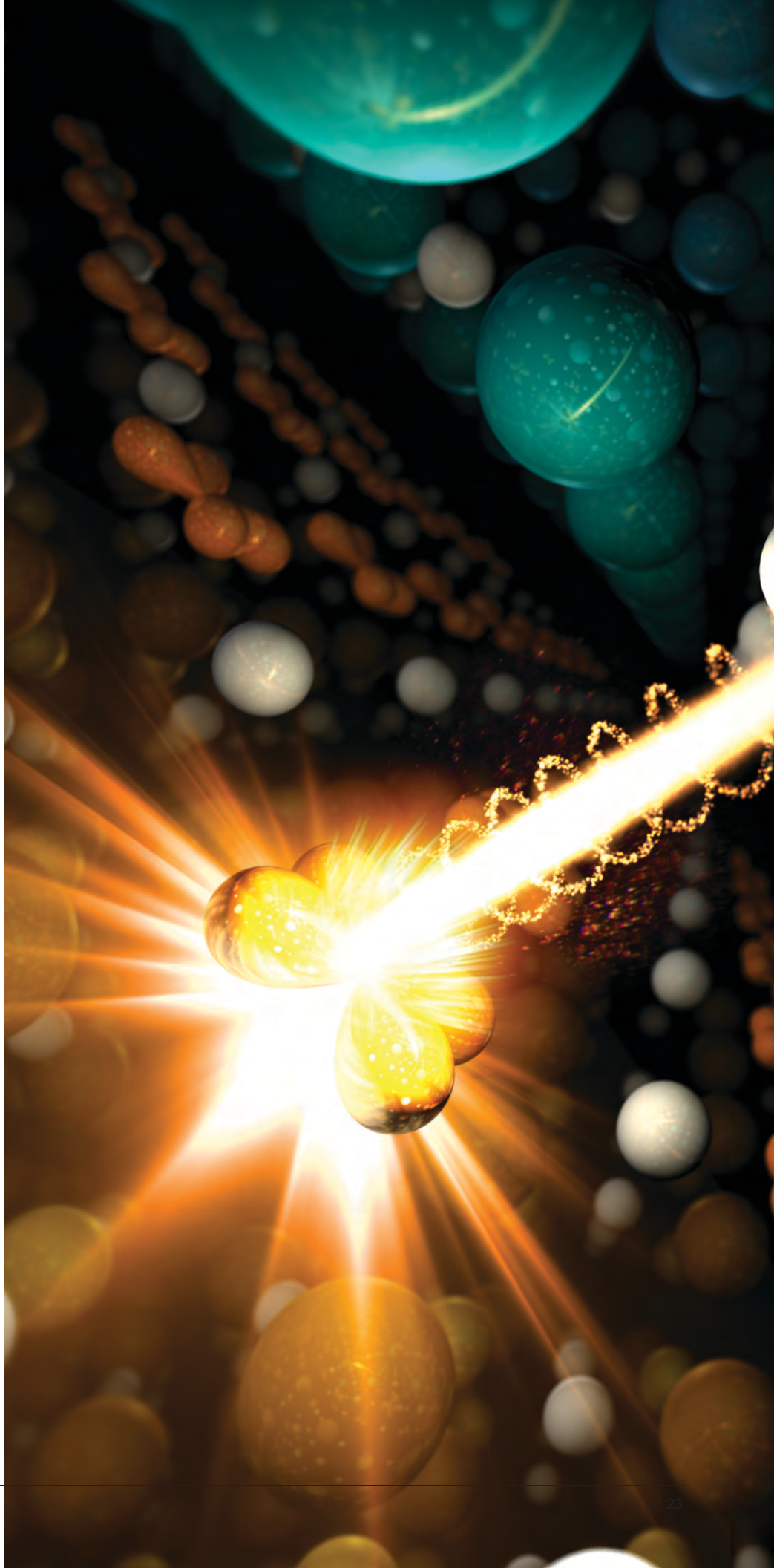
## Strategic Initiative: Identify and Pursue New Science Enabled by Our Facilities

SLAC recognizes that providing world-class research facilities is not enough. To ensure that the best science is carried out at our facilities and to maintain the high caliber of our staff, we must continually take a leadership role in identifying and pursuing new science.

SLAC is where new ideas in using free-electron laser tools to advance science are being developed. The whole world is watching – and working with us – as we lead research in this unexplored area.

The Laboratory focuses on four areas of science where these new capabilities will have the greatest impact:

- Materials science
- Chemical science
- Bioscience
- Matter in extreme conditions



## Materials Science

Understanding materials at the atomic level has helped build the advanced society we live in today – from our ubiquitous and sophisticated electronic devices to ultralight materials with unprecedented strength. Today, a revolution in scientific discovery and advanced technology is giving scientists important insights into how the collective behavior of individual atoms and electrons gives rise to “emergent” or “quantum” materials with remarkable properties. Their work has already led to five Nobel Prizes, and progress in the field remains breathtaking.

SLAC is a clear leader in this research, from the development of topological insulators – materials that conduct electricity with perfect efficiency, but only on their surfaces – to the discovery of exotic electronic and ionic

phenomena that emerge at the interface where two materials meet.

SLAC is tackling some of the most important questions in materials science: Can we develop materials that conduct electricity with 100 percent efficiency at room temperature? How do various magnetic and electronic states emerge and behave, and how can they be controlled to create more useful materials? We are also working to understand the interplay between spin, charge, orbital and lattice degrees of freedom. The resulting insights would give us a more comprehensive understanding of their properties and behavior.

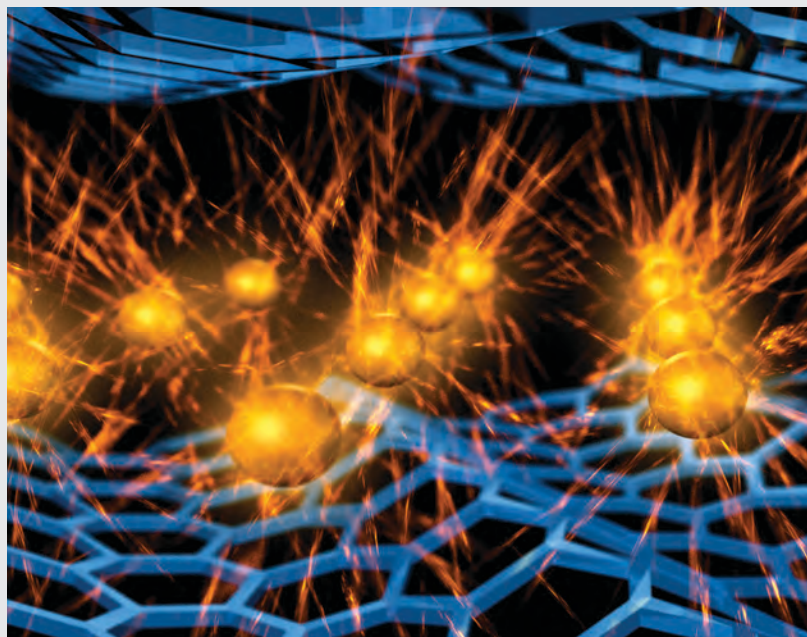
To study materials in exquisite detail, SLAC researchers synthesize them in the laboratory, study their properties with X-rays and other techniques and use theory and simulation to

understand and predict their behavior. These studies point a potential path to tailoring materials with new and improved properties for applications in energy storage and transmission, electronic circuits and other practical realms.

SLAC’s X-ray facilities play a critical role in this “materials by design” process. While macroscopic measurements reveal some properties of materials, truly deep insights usually, and sometimes only, come through combining theoretical insights with sophisticated experiments that examine materials at a very small scale. Experiments at SSRL and LCLS provide critical new information on novel materials and their behavior, anchoring materials science at SLAC.

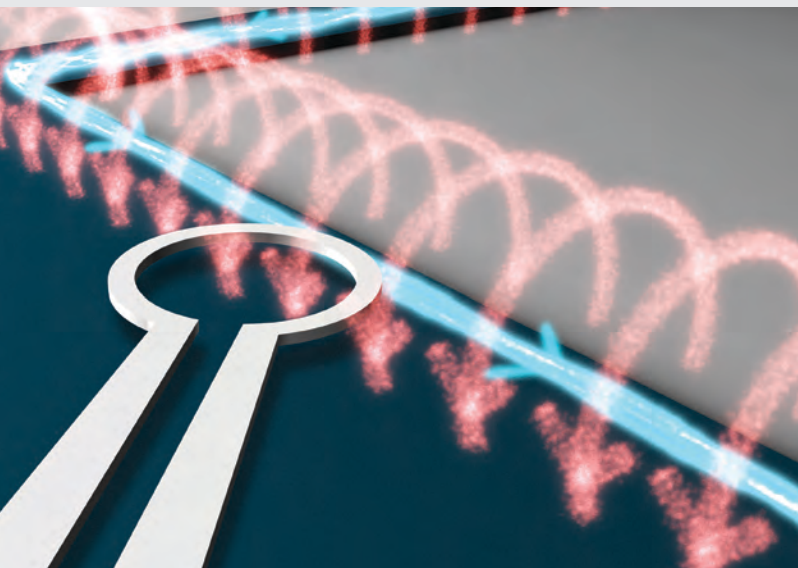
### TOMORROW’S ELECTRONIC DEVICES

SLAC and Stanford researchers are at the forefront of research into graphene, a material made up of a single layer of carbon atoms. The strength, flexibility, transparency and high electrical conductivity of graphene make it a potentially valuable material for the next generation of electronic devices. By tuning its properties, SLAC scientists seek to improve graphene’s already impressive capabilities. For example, if graphene can be made reliably superconducting, it could eventually enable ultrahigh-frequency analog transistors, nanoscale sensors and quantum computing devices. In addition to the Laboratory’s theoretical and experimental contributions, SLAC’s advanced capabilities for determining the properties of materials also play an important role in graphene research.

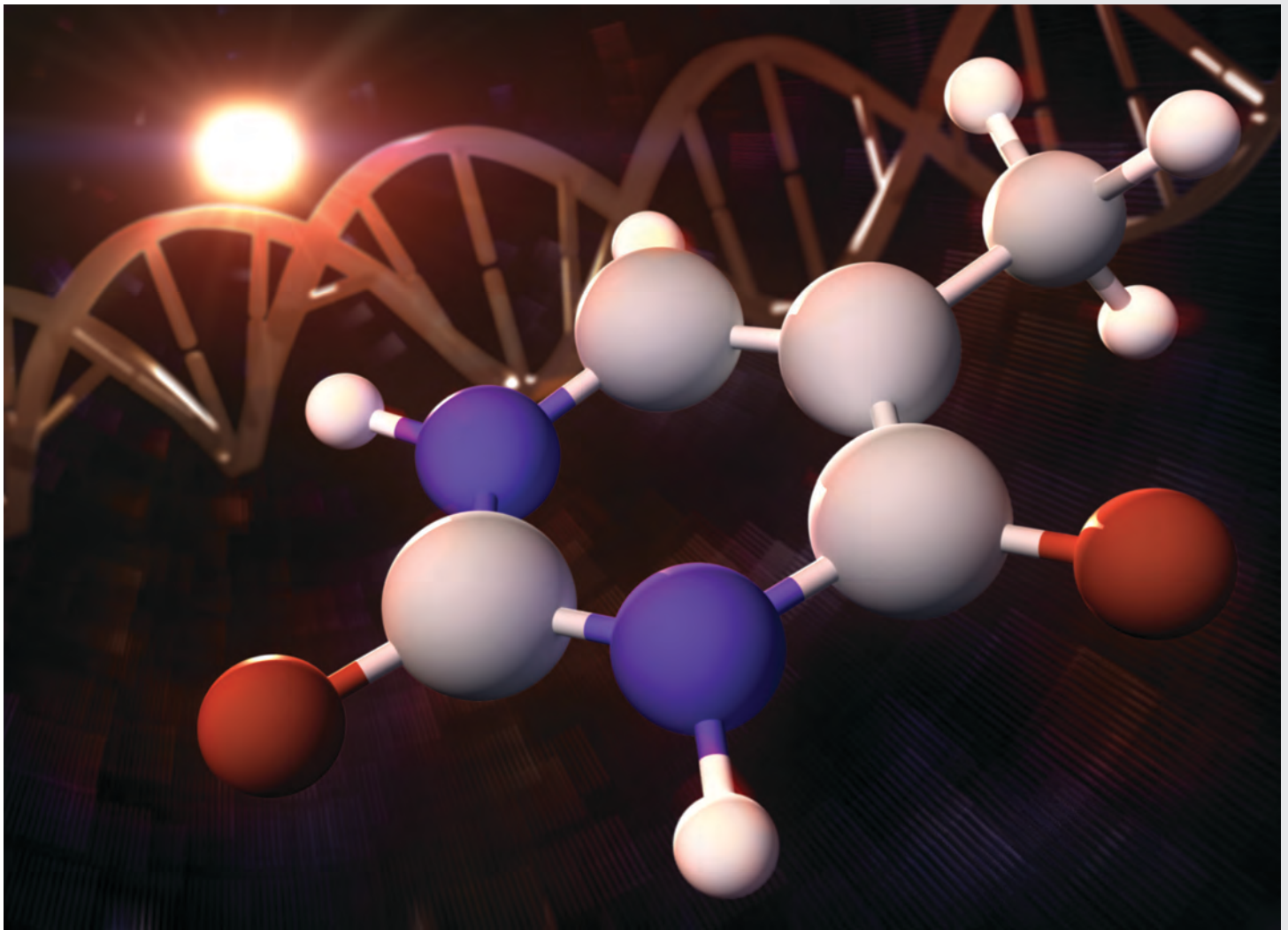


### A NEW TYPE OF CURRENT

Scientists at the joint SLAC-Stanford SIMES institute are leaders in the theory and design of topological insulators, materials that function as insulators on the inside but conduct electricity with 100 percent efficiency on their surface. SIMES researchers were the first to identify alloys that would behave as topological insulators – even at room temperature. They also play important roles in testing these materials to see exactly how they work. One of the most exciting topics in condensed-matter physics, topological insulators could be useful in spintronics, which would use the spins of electrons, rather than their charges, to carry current, as well as for studying exotic phenomena such as axions and magnetic monopoles.







## Chemical Science

Chemical science studies the structure, composition and properties of matter, as well as reactions that transform atoms, molecules and materials. The growing field of ultrafast science seeks to follow chemical reactions step by step, and the unique tools provided by LCLS and, in the future, LCLS-II, allow scientists to do just that with unprecedented resolution. To make the most of this compelling research opportunity, SLAC combines advanced ultrafast measurements and material synthesis with LCLS experiments. Theory also plays an important role, providing a solid framework for understanding experimental results and guiding future LCLS experiments.

Areas of exploration include understanding how nature converts energy from light into other useful forms of energy on femtosecond

timescales, and using very short pulses of high-energy X-rays to directly probe the processes that initiate and control catalytic reactions.

By combining X-ray pulses from LCLS with ultrafast electron diffraction from UED/UEM, researchers will also be able to separate complex chemical phenomena into distinct atomic and electronic motions. This will bring the level of experimental detail closer to equal footing with theory and simulation, greatly enhancing the interplay between theory and experiment.

### DNA AND ULTRAVIOLET LIGHT

The molecular building blocks that make up DNA absorb ultraviolet light so strongly that sunlight should deactivate them – yet it does not. Researchers at SLAC used LCLS to observe a single chemical bond within a DNA building block as it stretched and snapped back into place in just 200 quadrillionths of a second, dissipating energy and protecting the molecule from UV damage. The method used in this study may also enhance the value and impact of X-ray free-electron lasers for important problems in biology, chemistry and physics.

## Bioscience

Living systems operate on many scales of length and time: The trillionth-of-a-second transfer of electrons within a molecule during photosynthesis. The day-to-day functions of our body tissues and organs. The processes bacteria use to change carbon and nitrogen from the air into a chemical form that other living things can use, thus shaping whole ecosystems over thousands of years. To solve the most challenging problems in bioscience, scientists need to bring together multiple techniques for making observations and gaining insights over this wide range of scales.

LCLS has already demonstrated significant capabilities in studying nanocrystals and even viruses that are otherwise impossible to image. Among the most important targets of these studies are the membrane proteins, which sit in cell membranes and carry out many important functions. These proteins are the target of more than half of all new drugs in development, yet they are notoriously difficult to crystallize for studies of their structure,

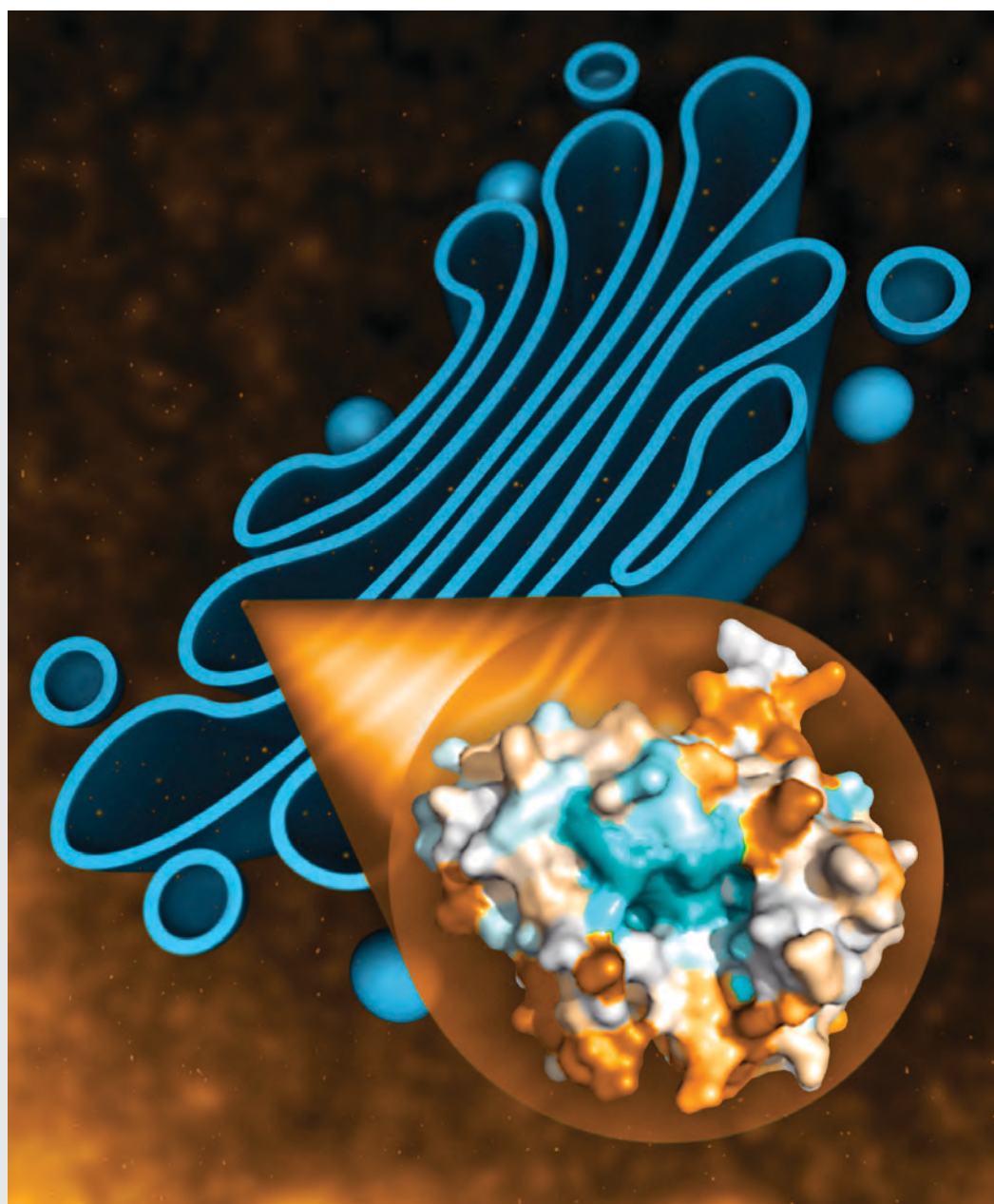
which are key to understanding how they function. The “diffract before destroy” technique pioneered at LCLS provides a potential way to obtain structures from smaller crystals while avoiding radiation damage that can occur with more traditional, synchrotron-based structural analysis.

SLAC will continue to improve these innovative techniques for examining the arrangement of atoms in crystallized proteins. The Laboratory also plans to build a suite of facilities and provide expert support for studying the structure and function of challenging biological targets, such as the ribosomes within cells where proteins are made, at room temperature and without radiation damage, thus preserving the sample’s natural state and environment.

These future capabilities will open a new chapter in investigating complex biological phenomena at many scales of length and time.

### DRUG DISCOVERY

Pharmaceutical companies use SLAC’s X-ray facilities to study the molecular structures of proteins and potential drugs and make discoveries that speed the development of new medications. Through work conducted in part at SSRL, scientists are studying a protein of the Ebola virus, searching for potential targets for developing drugs against the disease. Previous studies at SSRL and other facilities determined the structure of antibodies effective against bird flu (H5N1) and swine flu (H1N1), an important step toward vaccines. Researchers from Genentech have also used advanced tools at SSRL to help develop drugs for treatment of cancer, autoimmune disorders and other diseases. A similar approach was used by Plexikon to develop one of the most effective drugs for treating human melanoma.







### EXPLORING EXOTIC STATES

With its high peak brightness, short pulse duration and tunable energy, LCLS provides revolutionary capabilities for studying the fleeting behavior of matter in extreme conditions. The lasers at the Matter in Extreme Conditions experimental station can produce exotic states of matter ranging from warm dense matter to high-energy-density plasmas whose properties have been dramatically changed by high temperatures and densities. In a recent experiment, SLAC scientists took *in situ*, highly accurate measurements of the physical properties of high-density plasmas, revealing their precise density and temperature. Future experiments will examine instabilities in fusion plasmas, explore matter under the conditions found in planetary cores and pursue ways to accelerate particles in a much shorter distance.

### Matter in Extreme Conditions

SLAC's high-energy-density science program performs pioneering studies of matter under extreme conditions, such as the crushing pressures and multi-million-degree temperatures at the hearts of stars and planets. At LCLS's Matter in Extreme Conditions (MEC) experimental station, scientists create these exotic states with blasts of light from high-power optical lasers and probe their properties with the X-ray laser beam. This unique set of tools opens new ways to discover the properties of warm dense matter, in which atoms have had their electrons stripped away by heating or compression, and to study how high-intensity laser beams interact with dense, high-temperature plasmas.

Research now underway at MEC is exploring how to use lasers to accelerate electrons and

other particles, with the potential for developing unprecedented new sources of X-ray and particle beams. We are also planning to build a petawatt (quadrillion-watt) laser and use it, along with the LCLS X-ray laser, to create and measure the properties of matter under even more extreme conditions.

By building the world's most advanced high-energy-density instruments and partnering with the best experimentalists and theorists from Stanford and other institutions around the world, SLAC aims to tackle the grand challenges in high-energy-density science. Those challenges range from better understanding our universe to exploring the feasibility of inertial confinement fusion as a source of clean energy.



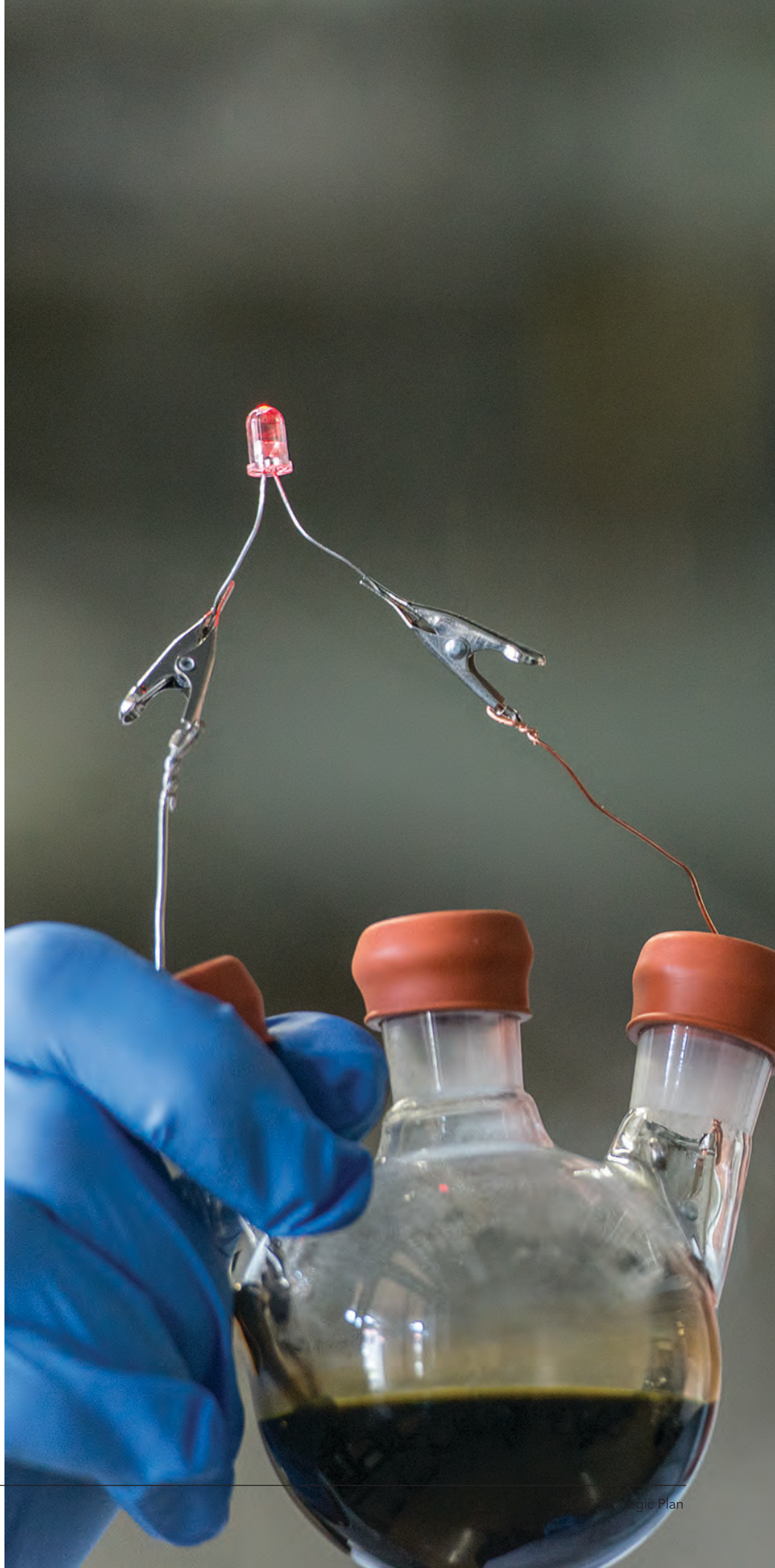
## Strategic Initiative: Solve Energy Challenges

With its strong base of fundamental knowledge in materials, chemical and biological science, SLAC is well positioned to solve important societal challenges regarding energy generation, use and efficiency. Our strategy is to identify the most important problems, develop improved scientific understanding in these areas, and then leverage our scientists and engineers and our unique facilities to apply that knowledge toward practical solutions.

The Laboratory currently focuses on three applied energy areas:

- Batteries
- Solar energy
- Catalysis

Many of these efforts are undertaken in collaboration with Stanford – in particular the Stanford School of Engineering, which has a strong tradition of applied research and entrepreneurship. Stanford also has a number of interdisciplinary research centers that focus on these challenges, including the Precourt Institute for Energy and the Global Climate and Energy Project, as well as strong links to industry. These connections, combined with the Laboratory's world-leading facilities and expertise, make SLAC and Stanford a powerful team.





## Batteries

SLAC's battery research aims to accelerate the translation of discoveries into real-world applications. Leveraging the Laboratory's partnership with Stanford, industry and other local institutions, SLAC will help enable the transition from fossil fuels to cleaner, renewable energy sources through dramatic improvements in rechargeable batteries. SLAC researchers are studying new battery chemistries and nanostructured materials that can extend power, capacity and lifetimes well beyond those of today's batteries. By peering inside batteries at SSRL, SLAC scientists can watch them operate, revealing the detailed physical and chemical changes that take place during charge and discharge. Understanding how batteries function – and what causes them to eventually fail – will help scientists design the next generation of battery technologies.

SLAC partners with national leaders in science and engineering from academia, industry and other national laboratories through the Joint Center for Energy Storage Research, led by Argonne National Laboratory. The goal of this DOE energy hub is to develop batteries with five times the energy storage capacity of today's best lithium-ion batteries at one-fifth the cost during the five-year lifespan of the research program. The lab also partners with Lawrence Berkeley National Laboratory and the California Clean Energy Fund through the CalCharge initiative to make it easier for battery companies to perform research at SLAC facilities, and thus help spur advanced energy storage manufacturing.

### POMEGRANATE INSPIRED

A team of researchers led by SLAC and Stanford scientists recently developed an electrode designed like a pomegranate – with silicon nanoparticles clustered like seeds in a tough carbon rind – that overcomes obstacles to using silicon for a new generation of lithium-ion batteries. Best of all, it operates at 97 percent capacity even after 1,000 cycles of charging and discharging, which puts it well within the desired range for commercial operation. The design is expected to enable smaller, lighter and more powerful batteries for products like cell phones, tablets and electric cars.



## Solar Energy

SLAC combines the capabilities of SSRL with targeted research to advance the development of photovoltaics, which turn sunlight into energy and play an important role in energy generation.

Many classes of materials have been studied for applications in solar cells, and the processing of these materials helps determine how well they work. For example, multi-component films based on cadmium, tellurium, selenium and zinc need to be heated and cooled in a particular way to maximize their light absorption and charge collection. To identify the best materials and the optimal way to make them, scientists study

fabrication processes while monitoring the material's structure with X-ray techniques at SSRL. Similarly, organic materials show great promise as photovoltaic materials, and have the potential for low cost and simple fabrication methods such as printing. Researchers at Stanford and SLAC have achieved dramatic improvements in performance through novel printing techniques.

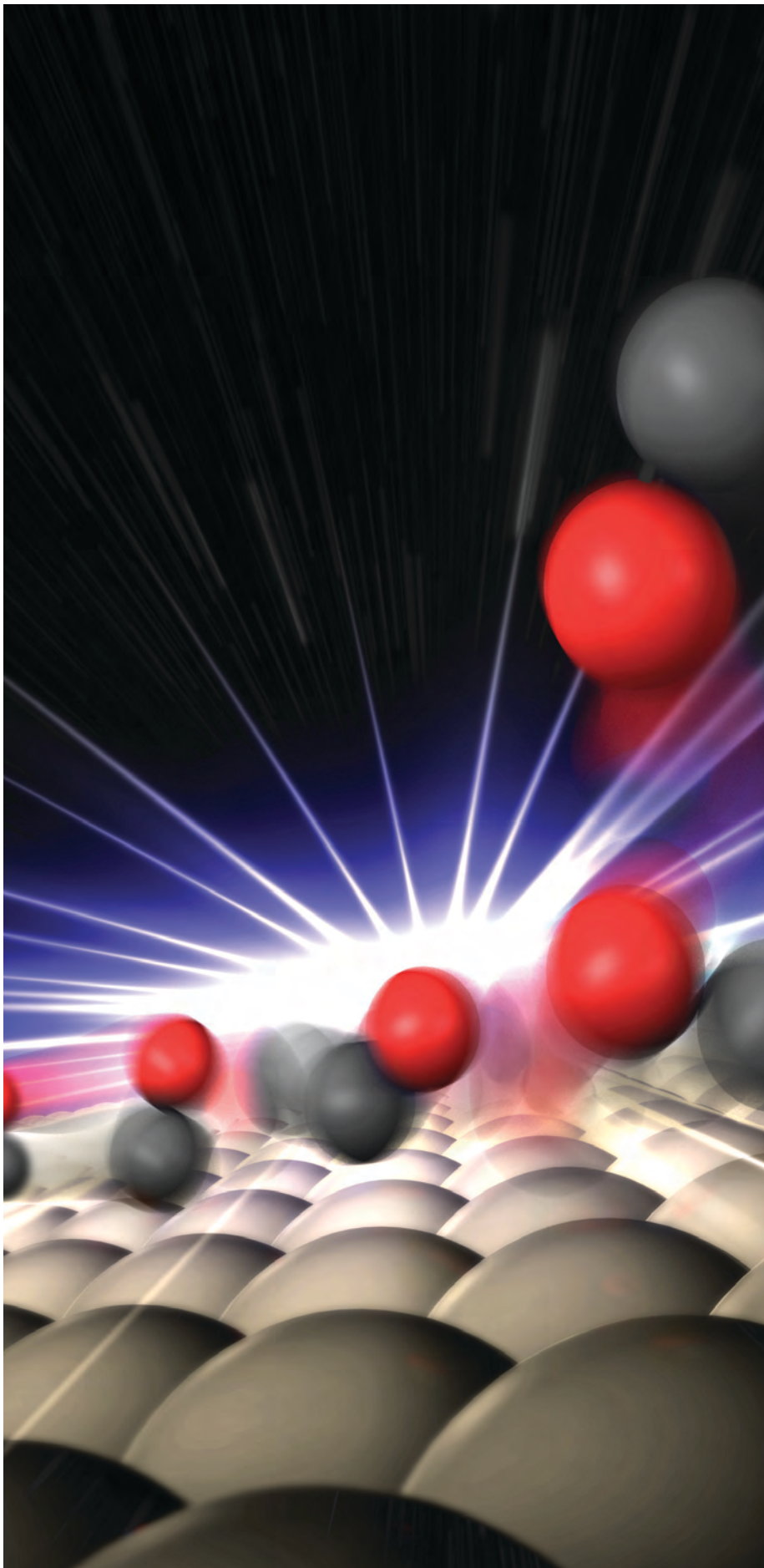
Through its targeted programs in solar materials processing, charge transfer studies, flexible materials and solar and thermionic emitters (see "Harvesting Light and Heat," right), SLAC aims to identify new photovoltaic materials and reduce the cost of manufacturing solar cells.

### HARVESTING LIGHT AND HEAT

Some solar devices harvest light from the sun; others harvest its heat. Doing both at once could nearly double the efficiency of photovoltaic devices. Researchers at SLAC and Stanford have invented a way to do that: photon enhanced thermionic emission (PETE). This process would convert waste heat from a particular type of utility-scale solar power plant – one that uses mirrors to focus and concentrate sunlight – directly into electricity, using a process called thermionic emission that "boils" electrons off the surface of a material to create electrical current. Any waste heat from the process could be used to generate even more electricity, reaching a theoretical total efficiency of more than 50 percent.







## Catalysis

Catalysts, which promote efficient chemical reactions, are omnipresent in modern life. They are used to create fuels, plastics and fertilizers and to reduce pollution. They also show promise for producing greener, more sustainable energy sources.

SLAC's catalysis initiative aims to develop the understanding of catalysis and other types of surface chemistry to the point where we can use them to design new catalysts. Major challenges that require new catalysts include artificial photosynthesis, chemical fuels, energy storage and sustainable chemical processes.

We undertake this mission by combining theoretical work, including simulation and modeling, with complementary experiments in catalyst synthesis, characterization and testing. SLAC's experimental activities will grow in the coming years, exploiting the unique possibilities provided by SSRL and LCLS. (See "Fine-tuning Fuel Cells," page 20.)

## Strategic Initiative: Pursue a Frontier Program in Cosmology

SLAC's strong scientific and technical workforce excels at using its unique combination of ground- and space-based experiments to explore the frontiers of particle physics and cosmology. The primary science drivers for the Laboratory's cosmology research are:

- Identifying the new physics of dark matter
- Testing the nature of dark energy
- Probing the physics of cosmic inflation

These are also major areas recommended by the high-energy physics community in the P5 (Particle Physics Project Prioritization Panel) report, which has laid out a strategic plan for future U.S. particle physics investments over the next 10 years.

Leveraging the highly successful KIPAC institute, we are well positioned to become DOE's premier laboratory for cosmology research. In addition, the Laboratory plays an important role in exploring the frontiers of particle physics.







## Dark Matter

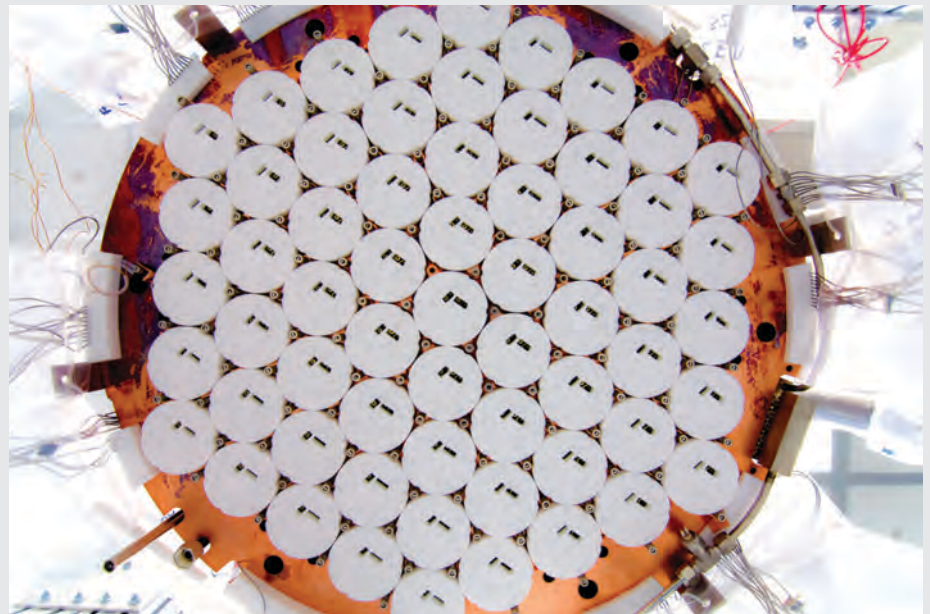
Dark matter, known to represent about 85 percent of the matter in the universe, has only ever been observed through its gravitational influence, and its interaction with ordinary matter is thought to be very weak.

Yet every indication suggests that the next generation of experiments has a good chance of finally identifying dark matter particles. SLAC is deeply involved with two recently selected next-generation experiments: the Super Cryogenic Dark Matter Search (SuperCDMS), which will search for dark matter candidates with low masses, and the LUX-ZEPLIN (LZ) experiment, which will

provide the world's best sensitivity to candidate particles with higher masses.

In addition, the Laboratory led the design, development, construction and operation of the state-of-the-art Large Area Telescope, which launched in June 2008 onboard the Fermi Gamma-ray Space Telescope and now searches for indirect evidence of dark matter produced when a subatomic particle collides with its antiparticle and they annihilate, releasing energy.

Overall, we are well positioned to be a leader in dark matter discovery, opening up a profound new area of research for the coming decades.



### HUNTING UNDERGROUND

Dark matter is five times more prevalent than ordinary matter and seems to exist in clumps around the universe, forming a kind of scaffolding on which visible matter coalesces into galaxies. While the nature of dark matter is unknown, physicists have suggested that it, like visible matter, is made up of particles. Both SuperCDMS and LUX-ZEPLIN (LZ) will look for a type of dark matter particle known as the WIMP, or weakly interacting massive particle, from thousands of feet below ground inside former mines, where there's very little background noise that could mimic the weak signal of a passing WIMP. SuperCDMS will specialize in looking for relatively light WIMPs, while LZ is capable of identifying WIMPs with a wide range of masses, including those much heavier than any particle the Large Hadron Collider at CERN could produce.



## Dark Energy

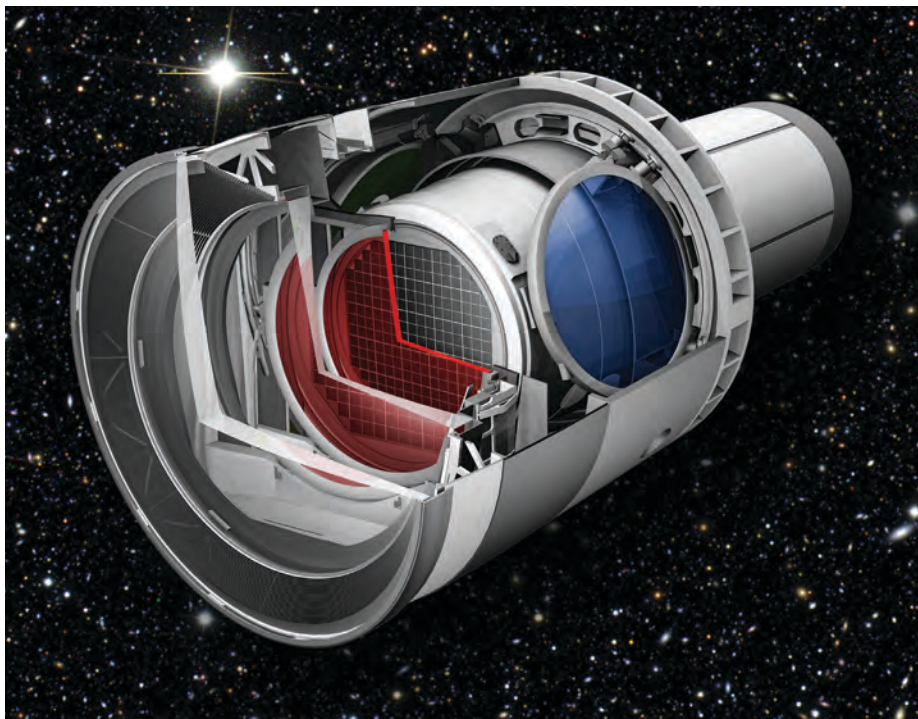
Dark energy drives the ever-increasing expansion rate of the universe, yet scientists do not yet have a compelling physics explanation for this force. The Large Synoptic Survey Telescope is designed to increase our understanding of dark energy with precision measurements of the universe's rate of expansion over time. Through its role in leading the construction of the LSST camera, in supporting analysis preparations and computational needs of the LSST Dark Energy Science Collaboration, and in attracting world-class scientific talent through KIPAC, SLAC strives to be a go-to center for dark energy research in the 2020s and beyond.

SLAC plans to enhance the science coming out of LSST by hosting a user center to increase the data analysis capabilities of dark energy researchers, and thus the scientific return of LSST. The proposed Dark Energy User Center (DEUCe) would provide scientific support staff with strong computational science skills, expertise in LSST simulation and data reduction tools, and expertise in high-performance computing. The center would also provide access to SLAC-hosted midrange computing capabilities – which are required to develop algorithms and analyses for reprocessing LSST survey data – as well as supercomputer and grid computing capabilities hosted elsewhere.

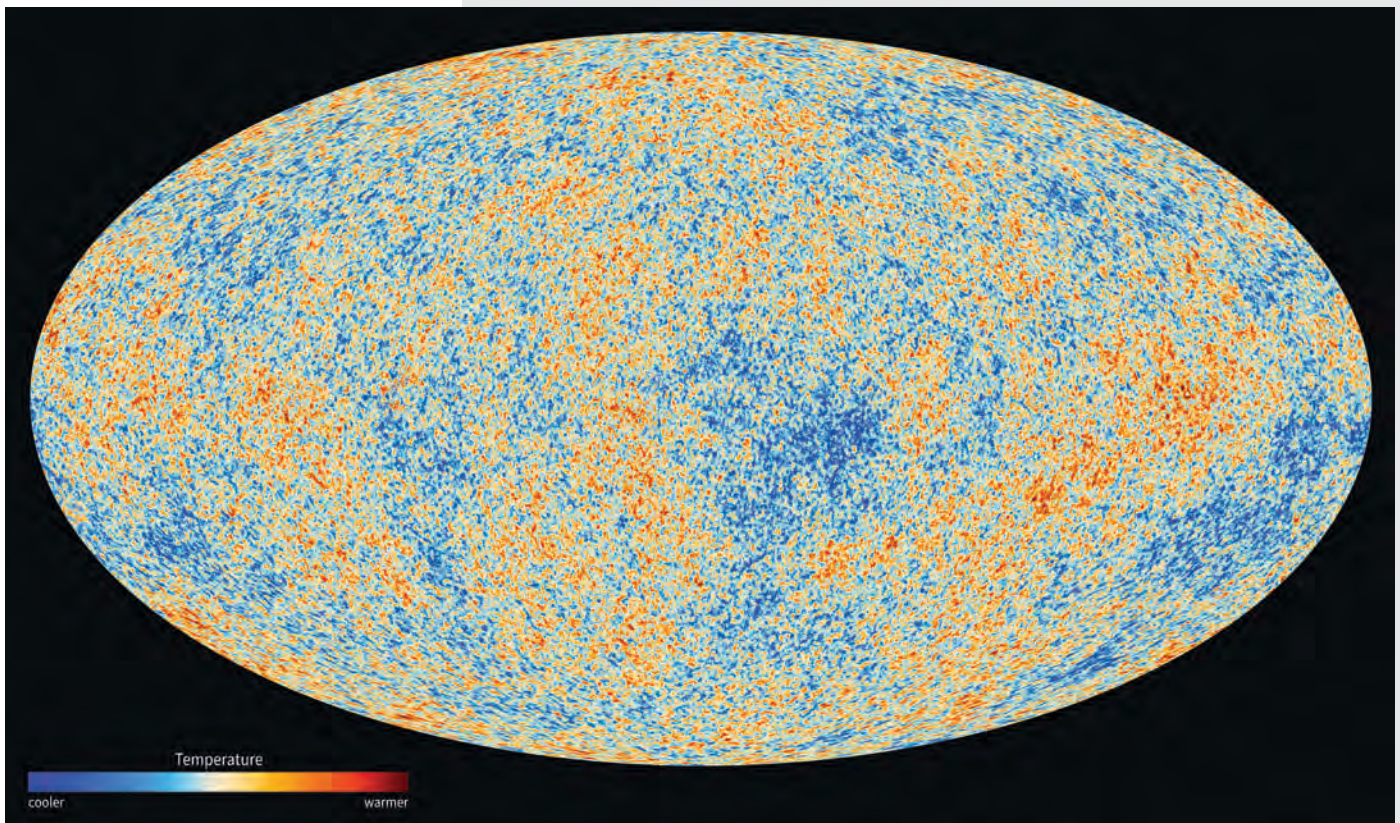
### THE BIG PICTURE

Dark energy is the name given to the force that's causing the expansion of the universe to speed up. However, we know very little about dark energy. It's everywhere, like gravity, but its force repels rather than attracts. Discovering the nature of dark energy is one of the biggest quests in astrophysics today; future insights into dark energy will likely lead to other advances, including a better understanding of the birth of the universe and its ultimate fate.

Over its 10 years of operation the LSST will create an unprecedented public archive of data – about 6 million gigabytes per year, the equivalent of shooting roughly 800,000 images with a regular 8-megapixel digital camera every night. Through DEUCe, SLAC could support the computational burden for dark energy analysis, enhancing the science to come out of both the LSST collaboration and the broader community of scientists, in the United States and worldwide, who will engage in dark energy research with LSST. SLAC's unique combination of critical mass and deep expertise in LSST science, simulations, analysis and computing makes the Laboratory an ideal location for this highly needed resource.







ESA and the Planck Collaboration

## Cosmic Inflation

In its earliest moments, the universe expanded with unmatched speed, smoothing the geometry of space and time. However, the physics of this inflation, at extreme energy scales, lies well beyond the reach of terrestrial accelerators.

SLAC intends to be a leader in developing a new round of experiments to better study the swirling pattern that inflation imprinted on the surface of the cosmic microwave background, which is the thermal radiation left over from the Big Bang. We will start by extending the measurements made with the Background Imaging of Cosmic Extragalactic Polarization (BICEP) series of instruments – which, if the BICEP2 result is confirmed, have discovered evidence of cosmic inflation, the rapid expansion of the infant universe in its first trillionth of a trillionth of a trillionth of a second. This will eventually lead to constructing a major next-stage experiment to measure the properties of inflation and constrain competing theories with high precision. These roles couple SLAC’s extensive expertise in instrument development with the problem of developing the efficient, low-cost, mass-producible microwave detectors required for large-scale cosmic microwave background experiments.

### THE EARLY UNIVERSE

In its first moments, the universe underwent an explosive expansion, stripping away nearly all non-uniformities. In that instant, the universe doubled in size more than 60 times, growing from a size smaller than a proton to a vastness that defies comprehension. This explosion quickly ran out of energy, causing it to slow to the lazy pace of expansion seen today. What drove inflation, and how exactly did physics work in those first hot, dense moments? These questions have yet to be answered.

The light from the earliest moments of the universe carries with it the imprint of conditions just after the Big Bang, conditions that defined the large-scale structure of the present-day universe. Scientists at SLAC made key contributions to the 2014 BICEP2 discovery of a hidden pattern in this early light. While confirmation is still needed, this pattern appears to offer the first direct evidence for cosmic inflation, the period when the infant universe expanded with mind-boggling speed. Over the next 10 years, SLAC will remain an important part of the BICEP collaboration as it builds BICEP3 and follow-on systems that will discover even more about the early universe.



Steffen Richter, Harvard University



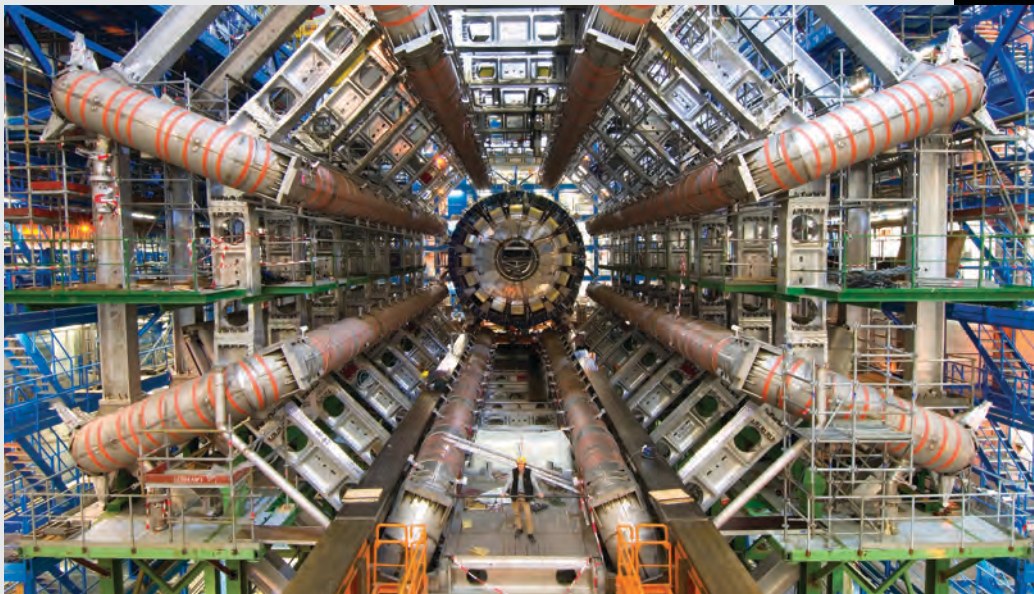
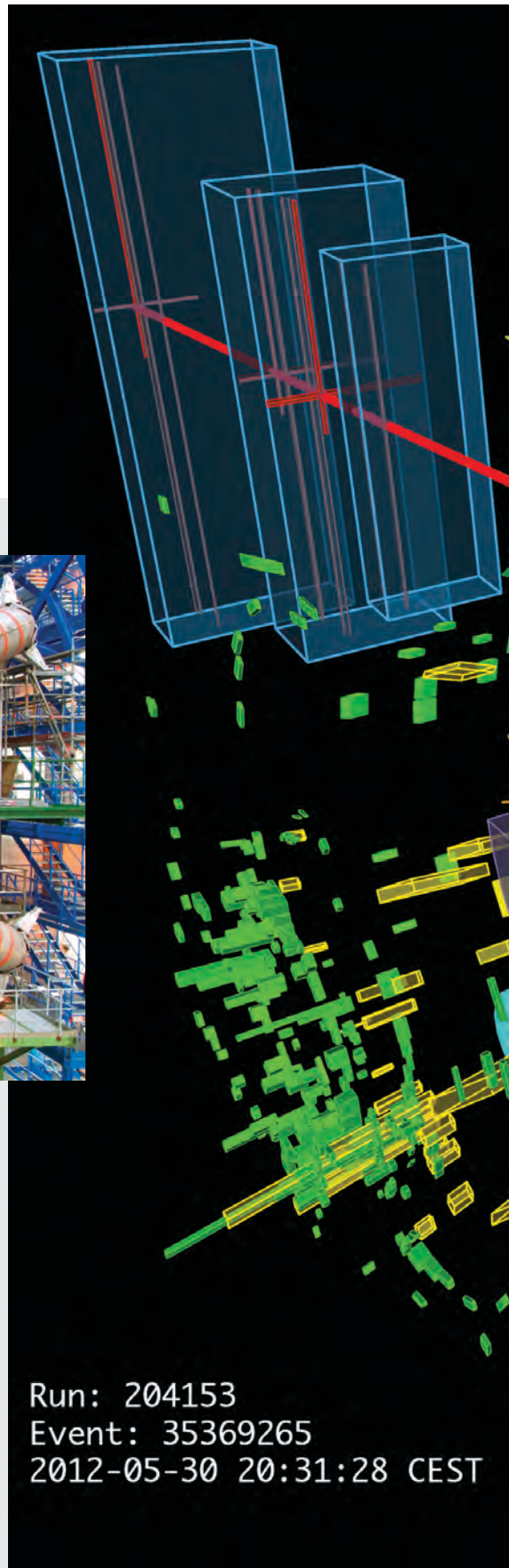
## Particle Physics

SLAC will continue to play an important role in several endeavors at the frontiers of high-energy physics.

The ATLAS experiment at the Large Hadron Collider observes collisions of very high energy particles. The debris from these collisions may help elucidate the properties of the newly discovered Higgs boson, which is connected to the field that imbues matter with mass, and could also yield evidence for supersymmetry, which predicts that each known particle has an as-yet-undiscovered partner particle and helps explain why particles have mass. SLAC will maintain its significant role in ATLAS pixel systems, data acquisition and trigger systems, simulations and operations, as well as in R&D for

the ATLAS upgrade. We will also remain a leading contributor to detector R&D for the International Linear Collider, a next-generation particle collider.

SLAC will also continue in its role as an important member of the Enriched Xenon Observatory (EXO), which seeks to explain mysterious properties of a particle called the neutrino, and will increase its involvement in the Long-Baseline Neutrino Facility, which will further explore the properties of neutrinos and eventually search for an explanation of why the universe contains more matter than antimatter, a situation known as charge-parity violation.



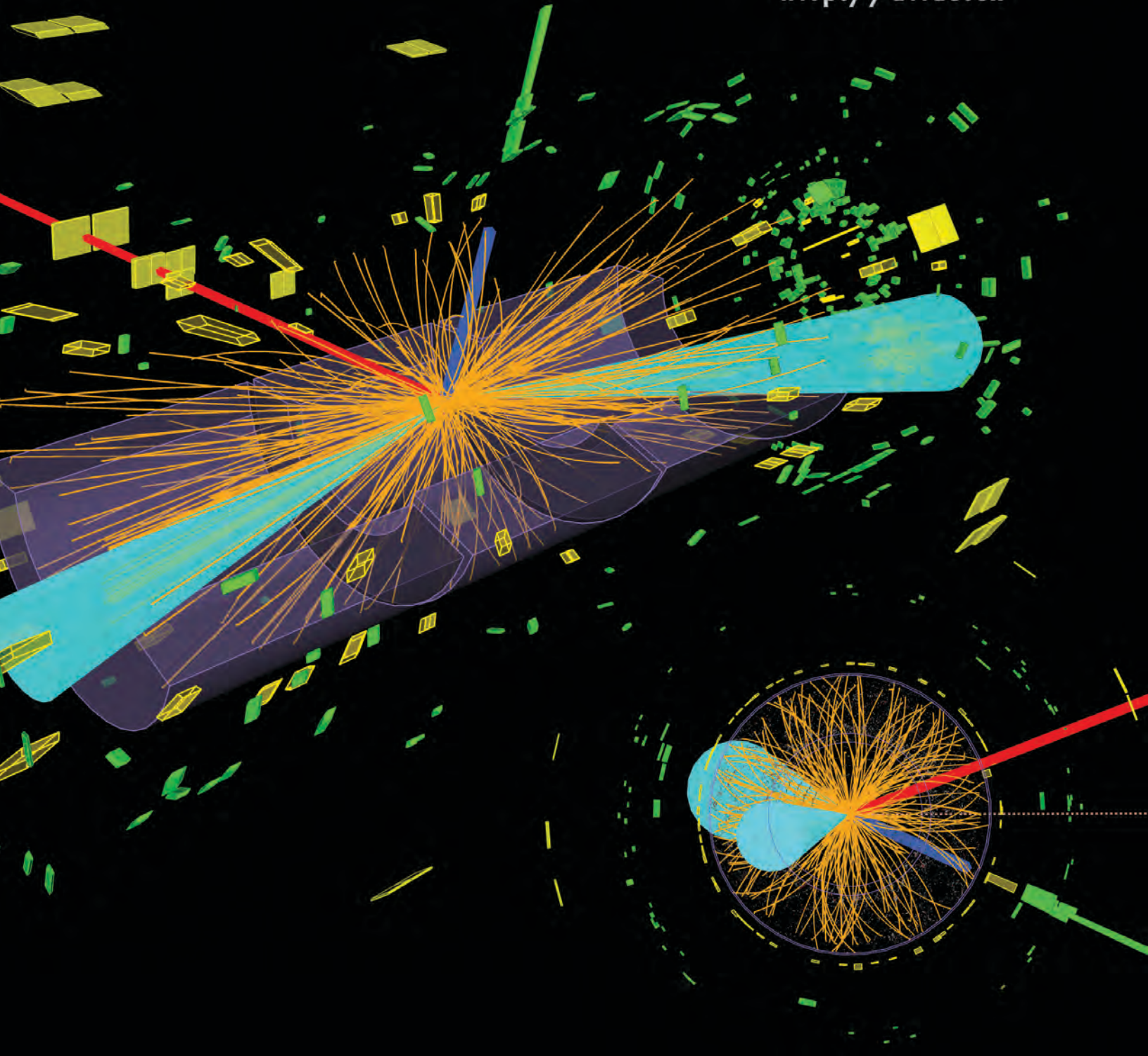
ATLAS Experiment © 2014 CERN

### HIGH-ENERGY DISCOVERIES

Continuing SLAC's long tradition in high-energy physics, ATLAS is a top priority of the Laboratory's work in particle physics. We have more than a dozen scientists dedicated to data analysis, and also maintain a strong team of professionals and engineers with computing and detector expertise that supports the Laboratory's experimental involvement. The SLAC ATLAS team played a vital role in the process that led to the discovery of the Higgs boson, and will continue to contribute important expertise and analysis in the Large Hadron Collider's second run beginning in 2015.

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# Our Infrastructure and Operations Support Systems

As the Laboratory invests in new research facilities and the science they will enable, we are also revitalizing the facilities, infrastructure and operational support systems needed to support this growth.

These much-needed infrastructure improvements will modernize space for both lab staff and users. The largest of these projects is the 2015 completion of the Science and User Support Building, which replaces the Laboratory's 50-year-old auditorium, visitor center and cafeteria. Located at SLAC's entrance, the 63,000-square-foot building will bring together many of the administrative functions that support facility users, visitors and laboratory staff, and provides a state-of-the-art conference center and auditorium, as well as a cafeteria and visitor center.

We also plan to add a significant amount of laboratory space in the coming years to support SLAC's initiatives in chemical, materials and biological sciences and energy research. This new laboratory space will provide a large and necessary increase in capacity as we implement this strategic plan.

We are making a substantial investment in a new Enterprise Resource Planning system for financial, human resources and procurement management. The upgraded system will reduce transaction costs and offer improved controls, more consistent processes and increased efficiency and reliability.

Over the next decade, we will also upgrade our aging information technology and server infrastructure by replacing servers, cables, network switches and other equipment, and by improving capabilities such as Internet bandwidth. With cybersecurity continuing to pose serious economic and national security challenges, we are also investing in our cyber infrastructure to ensure our mission needs are met and the personal information entrusted to the Laboratory is protected.

We are also working to improve the reliability of accelerator components, electrical power distribution and cooling water systems, thereby increasing efficiency and minimizing long-term operational costs.

Through these and future investments, we will make sure our operations are effective and efficient so we can attain our science goals in a manner that is protective of the environment and is safe for our employees and neighbors.









# Our Partners

SLAC can't undertake all of its innovative, far-reaching research alone. By partnering with other laboratories, universities, institutes and companies, we can better solve society's major scientific and technical challenges.

## User Community

SLAC's scientific users are critical to the Laboratory's success, driving scientific discoveries and contributing to the lab's technological advancements. Nearly 4,500 users from all over the world each year visit the lab to conduct experiments at LCLS, SSRL and FACET or collaborate remotely on key scientific programs, such as research with Fermi space telescope's main instrument, the CDMS dark matter experiment and continuing analysis of data from the BaBar experiment. In addition, many students launch their research careers at the Laboratory.

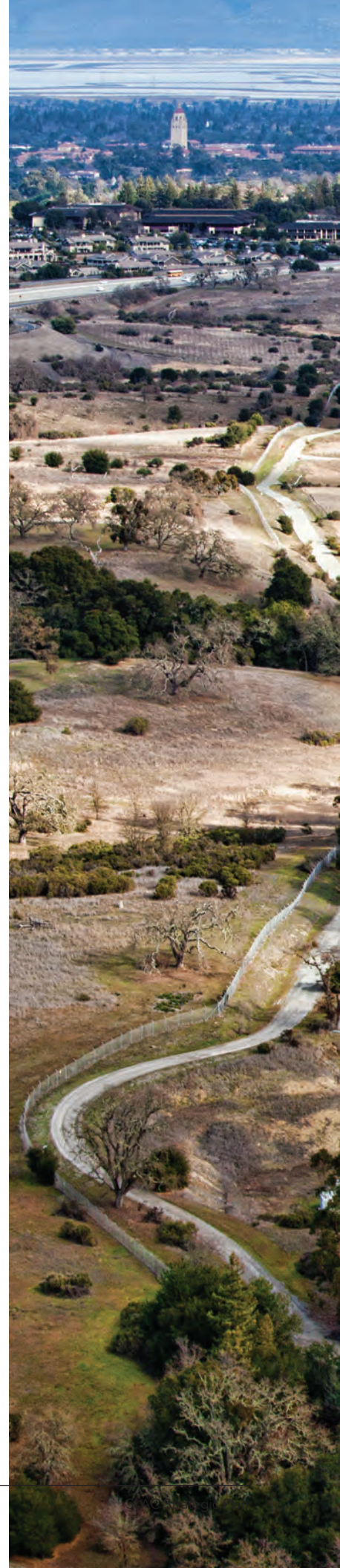
## National Laboratories

SLAC also collaborates with other DOE national laboratories. Each laboratory brings unique expertise to the table; collaborating allows us to leverage that expertise to address scientific challenges. Examples include SLAC's partnership with other

national labs on the design and construction of new facilities, including the Fermi space telescope and LSST; and the Laboratory's LCLS-II project, which involves a significant degree of collaboration with Argonne National Laboratory, Cornell University, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory and Thomas Jefferson National Laboratory.

## National and International Research Institutions

This type of collaborative research relationship extends to other universities and institutes as well. Since our founding, SLAC has fostered collaborations with national and international partners, including long-standing relationships with CERN in Switzerland, DESY in Germany and KEK in Japan. SLAC also participates in many of the new DOE collaboration models, including the Energy Storage Hub, and supports the work of many Energy Frontier Research Centers.









## Industry

While fundamental science is a key focus at SLAC, those basic discoveries can lead to innovative applications of interest to industry. SLAC's X-ray facilities are used by pharmaceutical companies to determine protein structures as part of drug design. They also help measure the properties of catalysts for more efficient chemical processes and new materials for batteries and solar cells, helping to advance renewable energy generation. In addition, accelerator technology developed at SLAC has spurred the recent creation of start-up companies, and accelerator components developed here are being manufactured by industry. We continue to develop and expand our relationships to better bridge the gap between scientific discoveries and their practical applications.

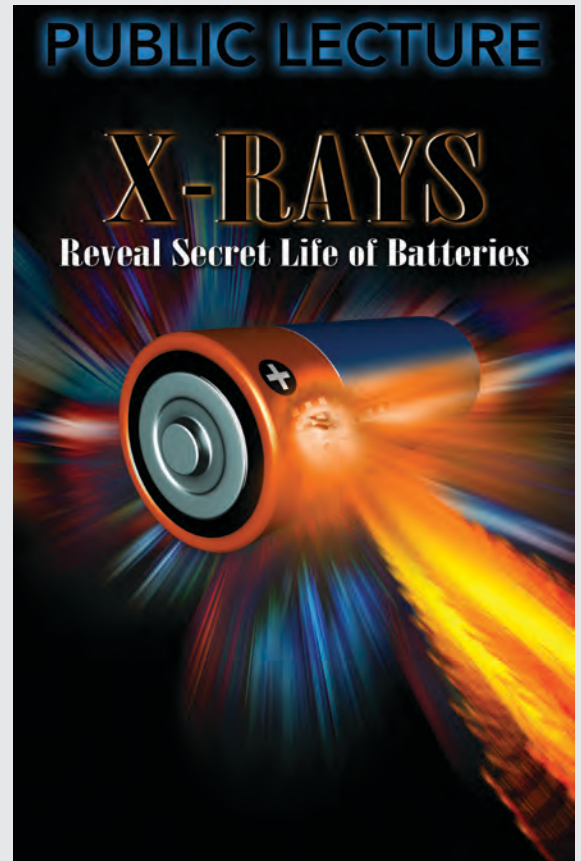


## Federal Agencies

In addition to the DOE, SLAC also receives important support from a variety of other federal agencies, including the National Institutes of Health, the National Science Foundation, the Department of Defense and NASA.







#### COMMUNITY TIES

Situated among Silicon Valley's small businesses, technology companies, research institutions, venture capital firms and residential communities, SLAC is committed to being an engaged neighbor and partner. Laboratory employees collaborate with local researchers from both industry and academia, and regularly interact with the community through public meetings, educational initiatives and presentations, helping promote awareness of the Laboratory's scientific capabilities and discoveries. In addition, SLAC welcomes the community to visit the lab for public lectures, symposia and other activities.



# Our People

What started as a group of 200 people, all focused on a single project – to build and operate the world’s longest linear accelerator – has grown over the last 50 years into a large and diverse workforce that performs and supports cutting-edge research across a variety of disciplines. Our 1,600 employees include scientists, engineers, technicians and specialists in a wide range of operational support areas, from human resources and business services to facilities, security and maintenance, all working together in a collaborative environment.

SLAC employs the best and brightest minds in their fields, and every member of our staff, working individually and in teams, makes important contributions to our success. By tapping into the interest and motivation of our employees and offering guidance and opportunities for development, we seek to provide an enriching work environment.

As Stanford employees, SLAC staff members have the opportunity to partner with other world-class talent at one of the world’s best universities and can also take advantage of the many educational and social opportunities that Stanford offers.

Attracting and retaining a talented workforce is key to carrying out SLAC’s strategic objectives. Workforce planning – the process of understanding and developing the necessary skill sets to ensure SLAC’s ongoing success – is an important part of the Laboratory’s long-term plan.

Specifically, SLAC’s workforce planning focuses on answering these three questions:

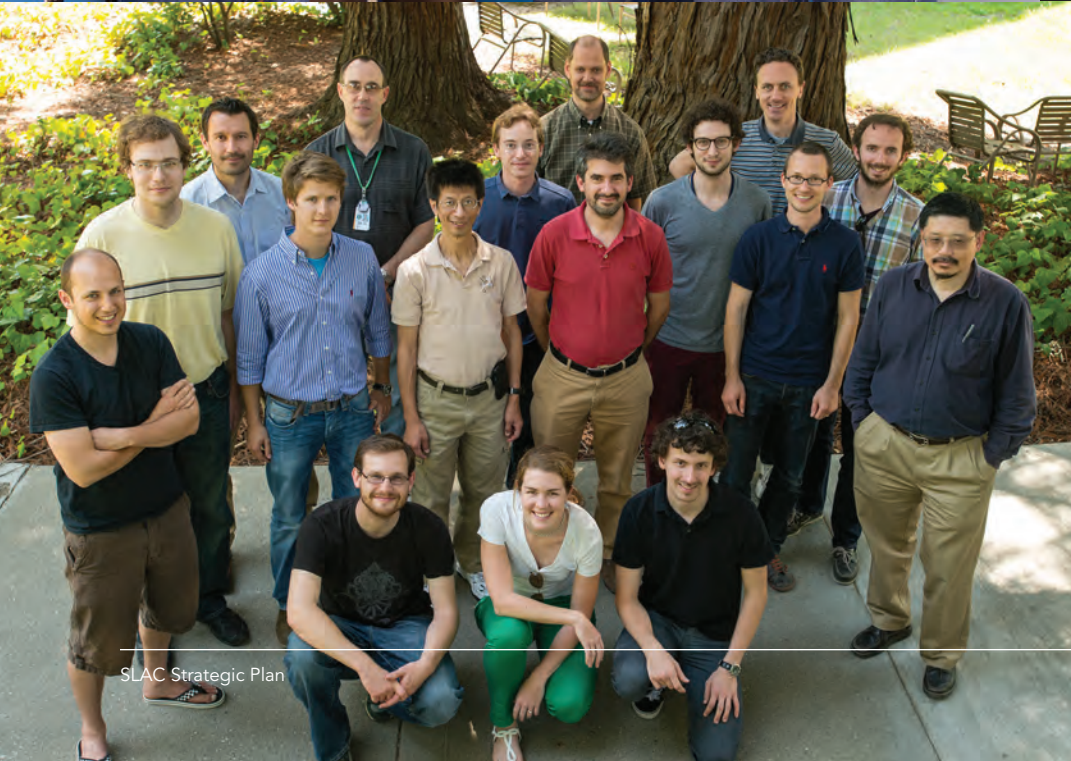
**Who will lead?** Where will we find the next generation of leaders to run our laboratories and lead key functions? How do we support the development of those ready to take the next career step in the short term? We define leadership competencies and use them as benchmarks to assess leadership potential and performance, while developing leadership talent by tailoring individual development plans. This ensures that qualified leaders are ready when needed across the lab and provides planned internal growth and promotional opportunities.

**Who will innovate, design, create and discover?** Where will we find the next generation of scientific thought leaders to lead research and design efforts in our strategic mission areas – not just for SLAC, but for the entire scientific community? To keep our research and engineering capabilities strong, we develop the technical skills of our talented staff through research and mentoring. This nurtures visionaries who can foster new lines of research, shape our scientific and creative communities, bring in new revenue streams and collaborate with their peers to take advantage of growth opportunities.

**What are the skills and abilities needed to achieve the objectives of our strategic plan?** What are the critical, hard-to-find-or-replace core competencies and skills we must have in place? SLAC is redefining its performance management process to more accurately assess employee performance and compare our current capabilities with the needs of the lab. This updated process will allow us to more thoughtfully plan the development of internal talent, while understanding the availability of critical skills outside of SLAC will help us carefully plan the acquisition of new talent.

Expanding our workforce planning practices will ensure we have the right leaders, scientists, engineers and operations talent in place when we need them. Such plans also include building a thriving, diverse population that brings in new thinking and perspectives, enhancing our collective knowledge. A renewed focus on diversity and inclusion will further enhance SLAC’s focus on its people in the years to come.







# Our Values

As we pursue our scientific goals, we are committed to upholding these values:

## **Excellence**

We achieve outstanding results without compromising the safety, well-being or security of personnel, visitors or the environment.

## **Integrity**

We are accountable for our actions and for the culture of our laboratory. We are honest and transparent in our conduct and communication.

## **Creativity**

We encourage each other to be creative and courageous in exploring new ideas and overcoming challenges, whether in our research or operations.

## **Collaboration**

We are committed to the collective success of SLAC. We celebrate our individual strengths and talents, while acknowledging that we achieve more by working together.

## **Respect**

We value the respectful treatment of every individual and embrace the diversity of thought, experience and culture they bring to the Laboratory.





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