THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY

JEFFERSON LAB

Below: Magnets (red) focus electron beams as they speed to three experimental halls
Front Cover: JLab nuclear physicists discuss particle structure equations
Back Cover: A JLab scientist assembles an electron source for the Free-Electron Laser

ABOUT JEFFERSON LAB

Jefferson Lab is a world-leading laboratory funded by the U.S. Department of Energy's Office of Science. The lab is devoted to the study of the building blocks of matter that make up 98 percent of our visible universe. Scientists from across the nation and around the world use the lab's facilities to probe the nucleus of the atom.

WELCOME TO JEFFERSON LAB


Jefferson Lab's accelerator site

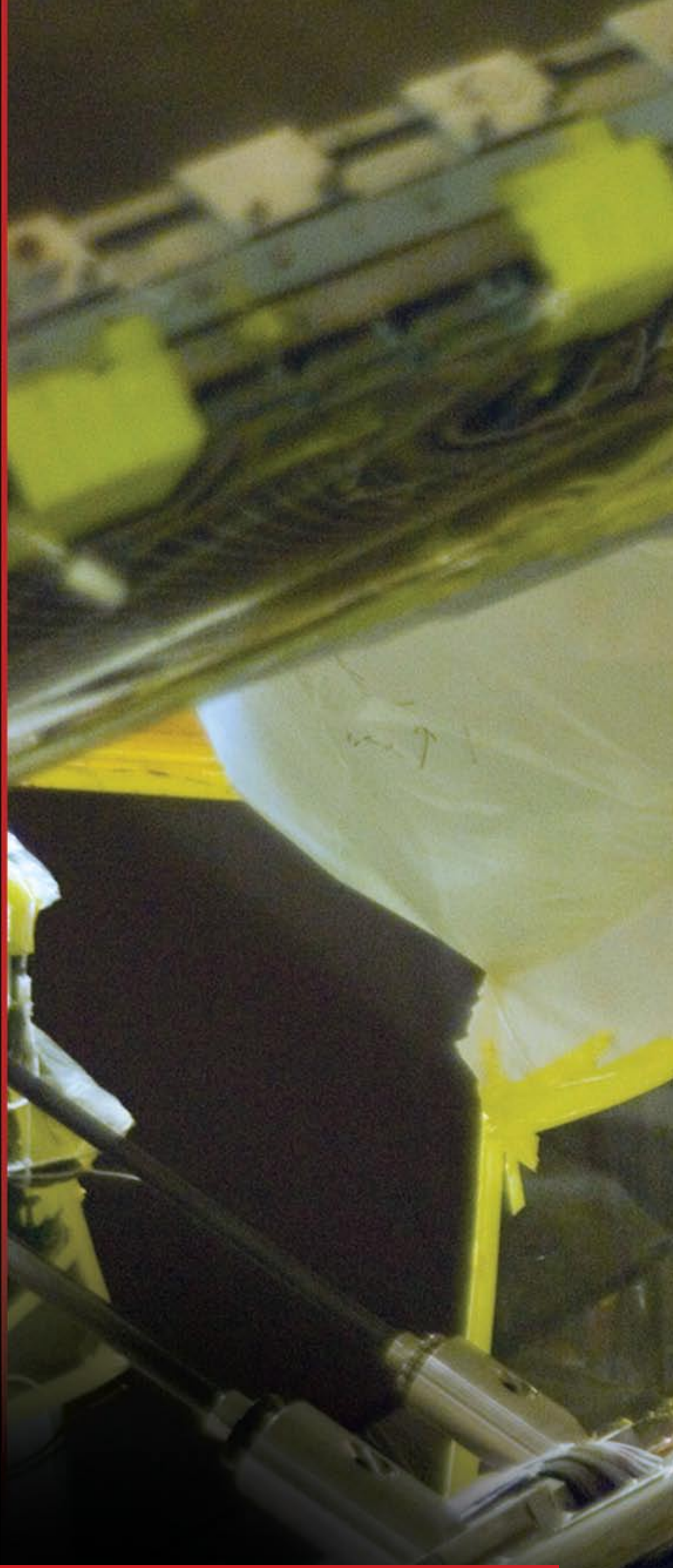
Have you ever looked up at the stars and wondered how they shine? Or looked out over the horizon and wondered how the Earth and everything on it is made? Perhaps you want to know how the planets, stars and galaxies in our vast universe were formed. These are just a few of the many questions that scientists are trying to answer. But while some scour the vastness of outer space and others plumb the depths of the Earth's oceans, physicists at the Thomas Jefferson National Accelerator Facility are exploring the innermost realm of matter – the nucleus of the atom. Their goal is to discover the origins of matter, improving our understanding of its building blocks and identifying the forces that transform it.

THE CHALLENGE WE FACE

The research performed at Jefferson Lab continues a scientific exploration begun in antiquity. It was the Greek philosopher Democritus who proposed that matter could be cut into smaller and smaller pieces, until a piece was so small it could no longer be split. Scientists thought the atom was the smallest form of matter until J.J. Thompson discovered the electron – one of the building blocks of the atom. Since Thompson's discovery in 1897, we have learned that most of the matter on Earth is built of protons, neutrons and electrons. We also have discovered that protons and neutrons, known collectively as nucleons, account for more than 98 percent of the visible universe.

Scientists at Jefferson Lab are trying to learn how our universe is made by studying the structure of nucleons, how they merge to form the nucleus of the atom and what forces bind them together. They search for answers by probing inside protons and neutrons, which we now know are made up of quarks bound together by gluons. Quarks are the smallest bits of matter that, so far, cannot be split. Over the years, scientists have discovered six "flavors" of quarks: up, down, strange, charm, top and bottom. They also have learned that quarks are bound together by a fundamental force of nature known as the Strong Force. A unique characteristic of the Strong Force is that it does not decrease as two quarks are pulled apart.

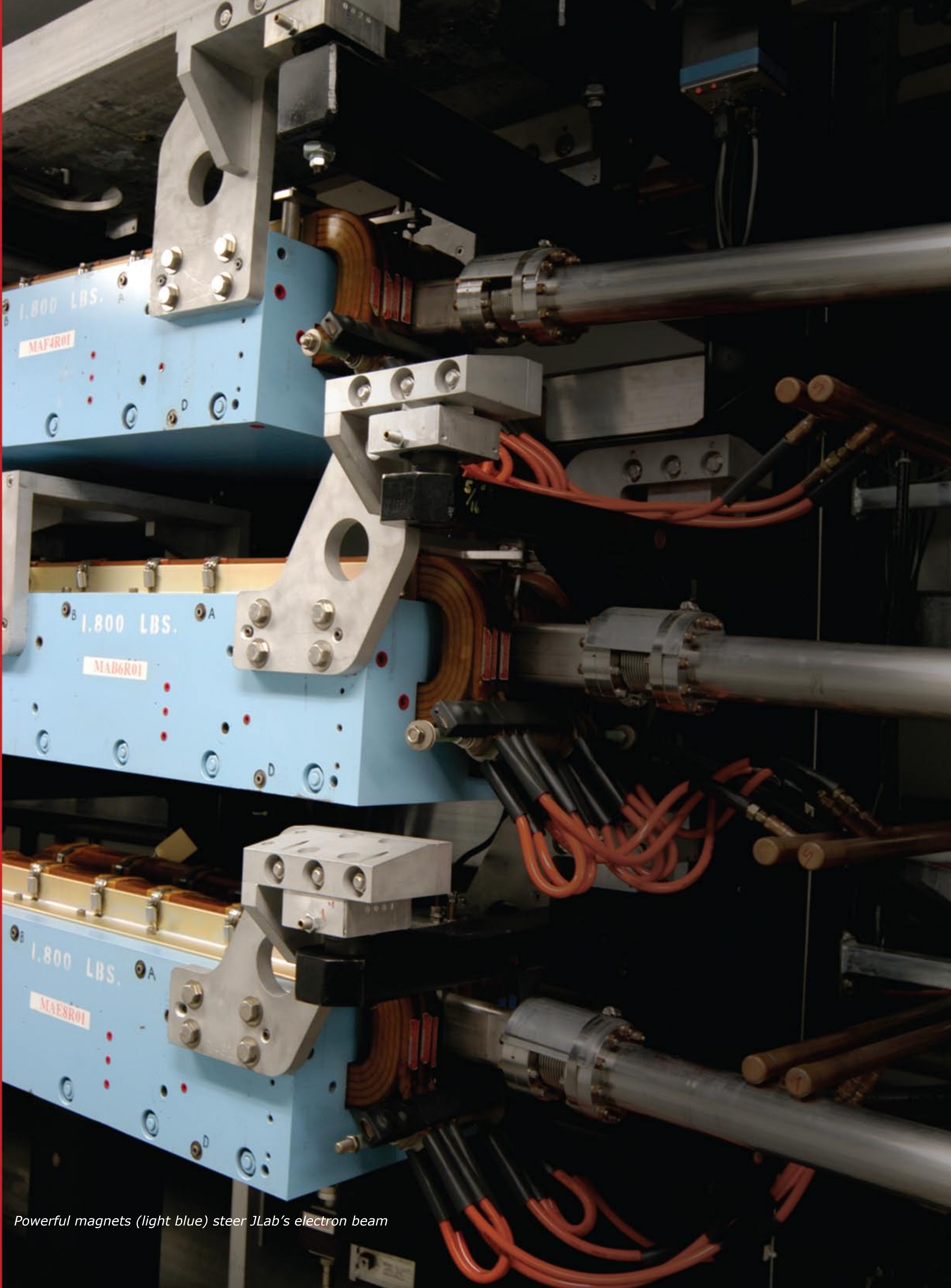
The nature of the Strong Force is such that a single quark has never been found alone, meaning that quarks are always found in clusters. A proton, for example, is built of three quarks – one down and two up quarks. Because individual quarks cannot be removed from their clusters, they are said to be "confined" in larger particles. It is this confinement that makes the study of quarks extremely difficult.



OUR MISSION

Jefferson Lab's mission is to provide forefront scientific facilities, opportunities and leadership essential for discovering the fundamental nature of nuclear matter, to partner with industry to apply its advanced technologies, and to serve the nation and its communities through education and public outreach, all with uncompromising excellence in environmental protection, health and safety.

Experimental Hall B's one-of-a-kind detector dwarfs a JLab technician



Powerful magnets (light blue) steer JLab's electron beam

JLab staffers assemble a CEBAF electron source

WHAT WE DO

Scientists at Jefferson Lab use a sophisticated machine known as an accelerator to explore the nucleus of the atom. The accelerator works like a microscope. In a microscope, rays of light bounce off of a specimen, are collected by the lenses, and are magnified for the human eye to see. Instead of light, Jefferson Lab's accelerator uses electrons to reveal details too small for light to resolve. Electrons are directed into a target nucleus. The electrons bounce off of the nucleus, are collected by giant detectors, and are recorded.

Jefferson Lab's accelerator, known as the Continuous Electron Beam Accelerator Facility, or CEBAF, uses a highly focused beam of electrons. Shaped like a race track, the accelerator is 7/8-mile around and is located 25 feet underground. The maximum energy of the electron beam is 6 billion electron volts, or 6 GeV. The beam is delivered to one, two or all three of the lab's experimental facilities, which are named Hall A, Hall B and Hall C. In an experimental hall, the beam is aimed at a target, such as hydrogen, carbon or gold. As the beam smashes into the target, detectors collect and record information about the scattered particles. By studying the speed, direction and energy of the particles, scientists learn more about how the nucleus is put together.

LEADING THE WAY

Jefferson Lab provides far-reaching benefits for our nation by increasing our fundamental understanding of the world around us, by providing research opportunities for young scientists and engineers, developing technologies that advance science in other fields and strengthen our defense, providing spinoffs that enhance our quality of life, and increasing math and science understanding and performance among our young people.

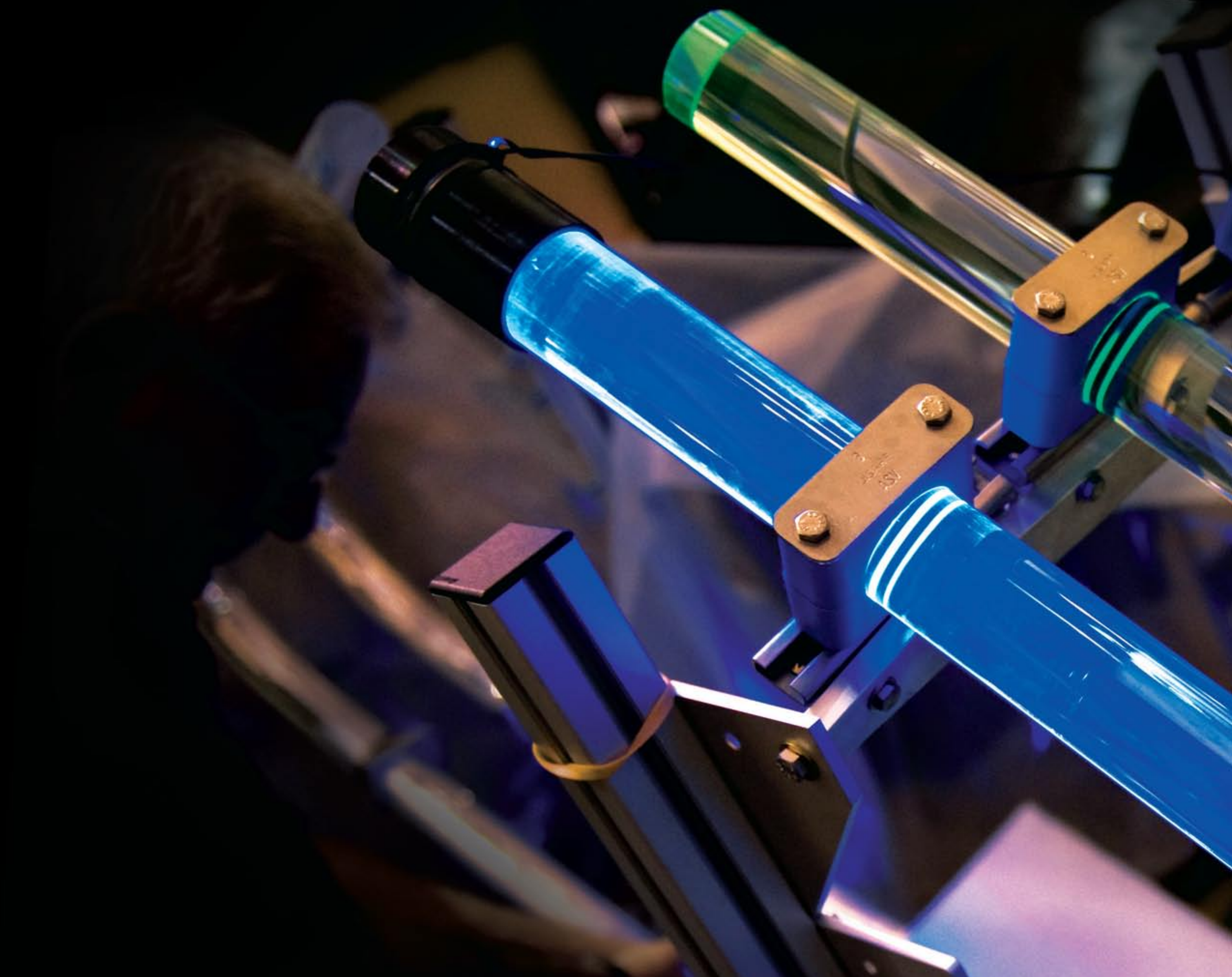
Preparing Hall B's detector for experiments

OUR SPONSORS

While primarily funded by the DOE, the lab also is supported by the Commonwealth of Virginia and the City of Newport News. The lab is managed and operated by Jefferson Science Associates, LLC, a joint venture of the Southeastern Universities Research Association and Computer Sciences Corp.

Experimental Hall A

Experimental Hall C



TECHNOLOGY FOR TODAY

Jefferson Lab is a world leader in superconducting radiofrequency accelerator technologies, recirculating and energy-recovering linear accelerators, cryogenics, detectors and high-performance computing. These core competencies make it possible for the lab to be a key contributor to major scientific research in the U.S. and abroad.

The lab's SRF expertise results from the processing and assembly of more than 500 SRF cavities and 65 cryomodules and more than a decade of operating two accelerators, which accounts for more than 35 percent of the world's integrated operational SRF experience. With this SRF expertise and substantial support from the U.S. Navy, Jefferson Lab designed, built and operates the world's first superconducting energy-recovering linear accelerator. This technology powers Jefferson Lab's record-setting free-electron laser, which provides intense, powerful beams of laser light that can be tuned to a precise color or wavelength. Jefferson Lab's FEL earned an R&D Magazine R&D 100 Award for being a technologically significant new product. The FEL is used to investigate new applications in materials science, electronics, photobiology, photochemistry and high-sensitivity spectroscopy by researchers worldwide.

In addition, the FEL serves as a test bed for SRF linear accelerator technologies, including new designs of SRF accelerator components, accelerator beam sources and energy-recovering linear accelerators. These advances allow FEL staff to provide the research, development and design expertise critical to the success of next-generation light sources for materials and biological research.

Jefferson Lab has made significant developments in cryogenics technologies, making it a recognized world leader in the field. The lab's cryogenics advancements, which have earned federal recognition, have resulted in substantial energy savings at Jefferson Lab and several other national research facilities. Processes and capabilities developed and refined at Jefferson Lab have been licensed by a commercial supplier for worldwide use to reduce energy consumption at existing and future cryogenic plants.

Jefferson Lab also has developed unique radiation detectors and spinoffs for medical purposes that are saving lives. The medical imaging group has been involved for several years in the development of high-resolution gamma and positron imagers for cancer detection and biomedical applications and also has developed novel X-ray imaging techniques.

Finally, the lab's High Performance Computing group is conducting research and development in parallel cluster computing, parallel job scheduling and high-performance messaging software to support a national effort in simulations of Quantum Chromodynamics, the fundamental theory believed to describe the Strong Force.

Light guides for a 12 GeV Upgrade detector

RESEARCH FOR TOMORROW

It’s difficult to say what future discoveries will be made in nuclear physics. But Jefferson Lab is poised to continue its tradition of leading the field in nuclear physics research as it prepares to upgrade its facilities and double the energy of its accelerator to 12 billion electron volts, or 12 GeV.

The 12 GeV Upgrade will allow the lab to pursue its mission with even greater precision and reach, opening critical new directions for cutting-edge research in nuclear physics. The upgrade will be optimized to study the forces between quarks (the basic building blocks of the universe), how they are formed, how they interact and the forces that mediate these interactions.

WHEN IT ALL BEGAN

A proposal to create Jefferson Lab was first made in 1976. Seven years later, the Department of Energy selected a proposal by the Southeastern Universities Research Association to construct, manage and operate a new national research facility. In 1984, a site was selected in Newport News, Virginia. Construction started in 1987 and the first experiment began in 1995. Jefferson Lab was first known as the Continuous Electron Beam Accelerator Facility. The lab’s name was changed to the Thomas Jefferson National Accelerator Facility in 1996.

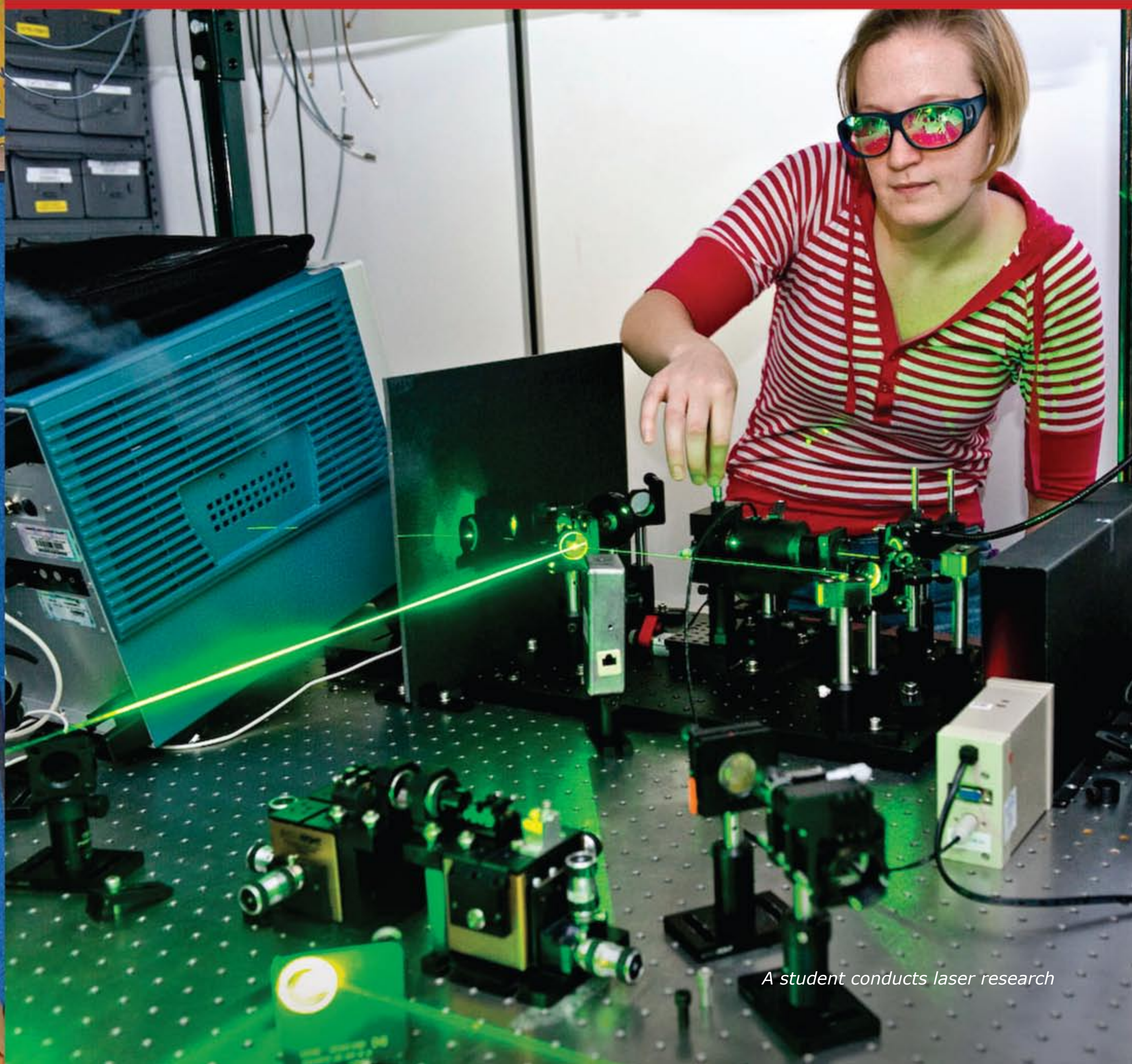
Making adjustments to a JLab accelerator component

JLab's education programs challenge and entertain

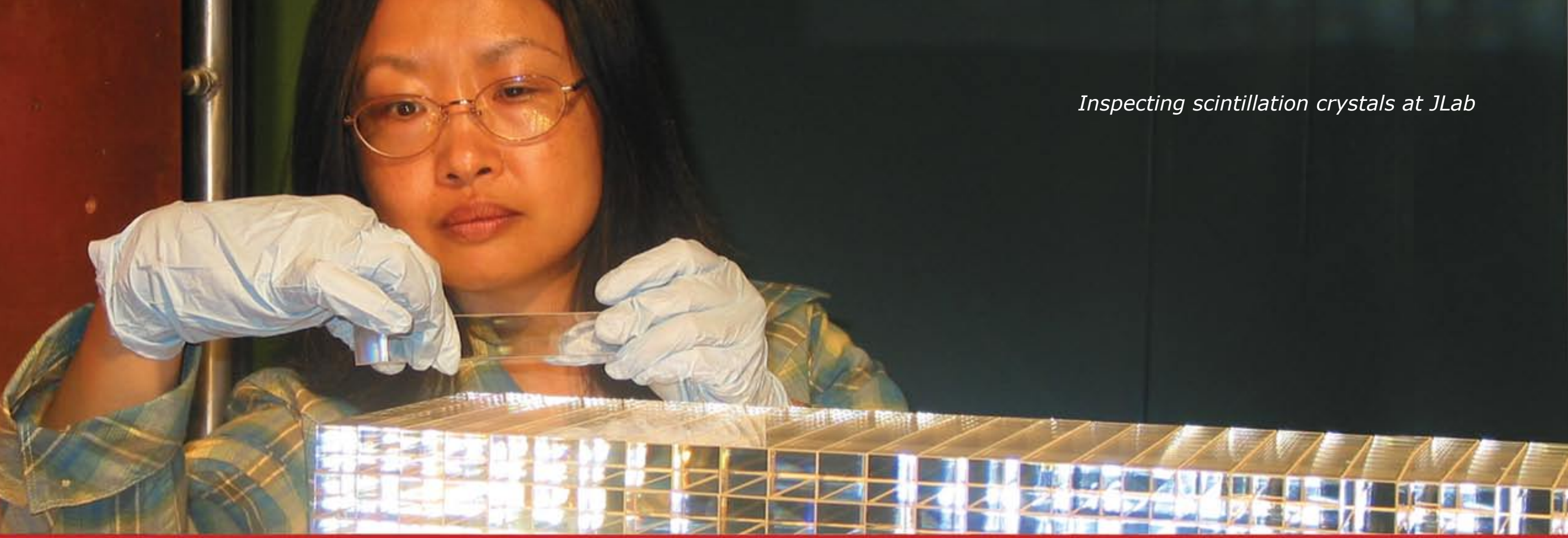
PAYING FORWARD

The lab actively engages the next generation in science through educational programs and internships. The lab hosts thousands of students and their teachers each year, and one-third of all nuclear physics Ph.D.s awarded in the United States are now based on research conducted at Jefferson Lab.

One of the most successful education initiatives at Jefferson Lab is the Becoming Enthusiastic About Math and Science program, which targets middle-school children. During the academic year, more than 1,000 students and their teachers come to Jefferson Lab, where they are immersed in lab-related science and math events and activities conducted with the help of volunteer scientists, engineers and technicians. BEAMS participants are among the more than 12,000 students and 750 teachers who annually participate in the lab's educational programs.



A student conducts laser research

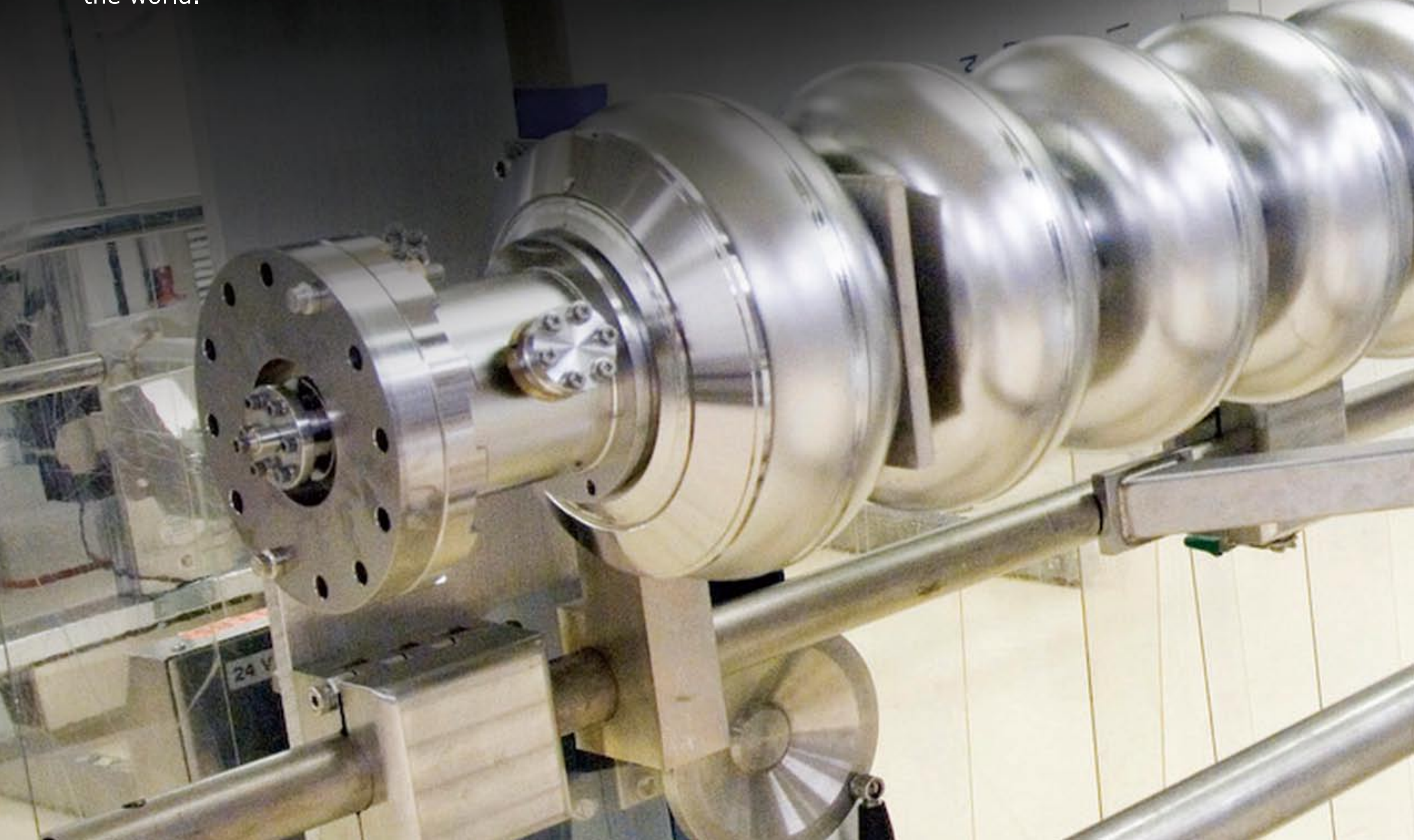


Inspecting scintillation crystals at JLab

PACKING A PUNCH

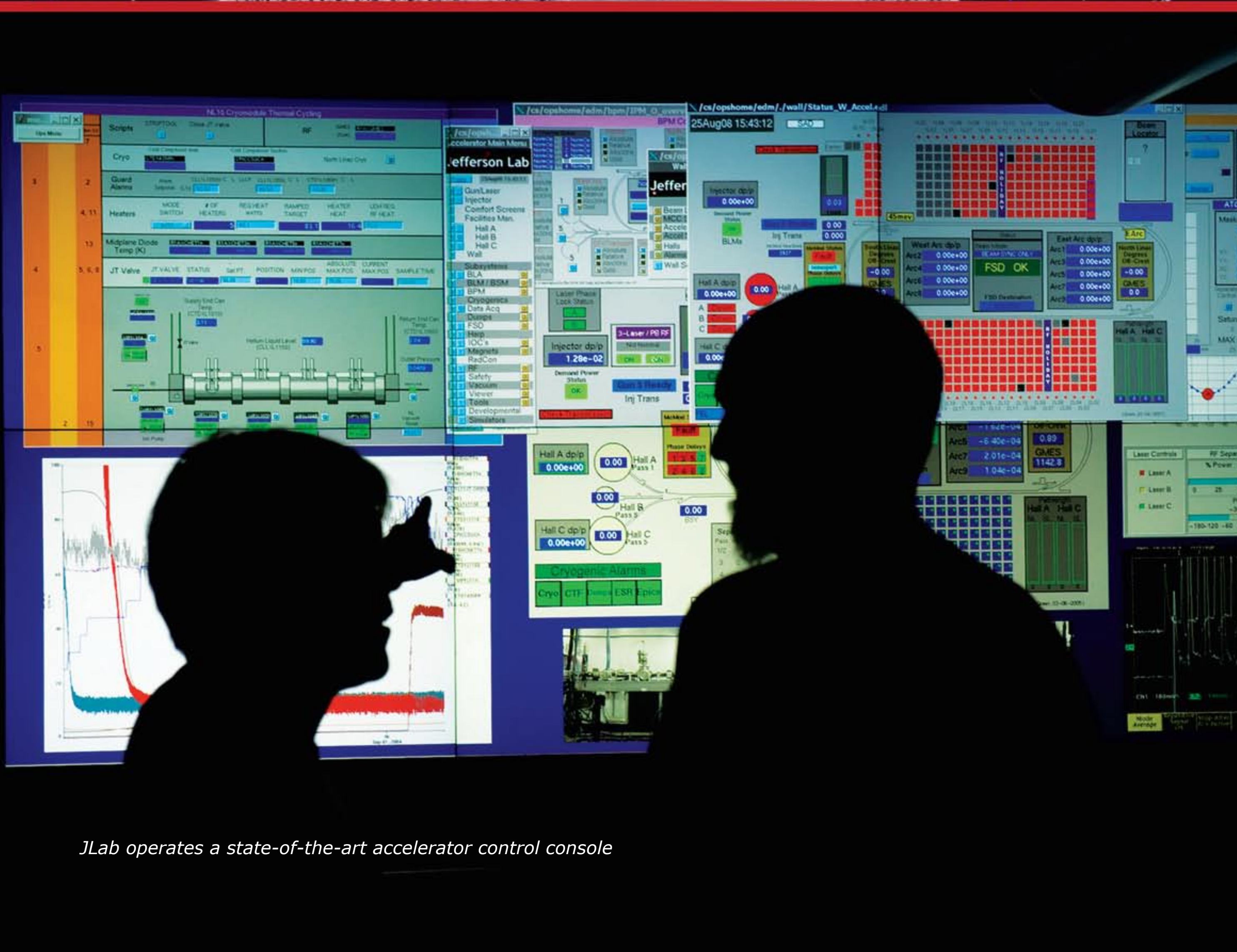
Jefferson Lab ranks among the top 30 employers in the Hampton Roads region. The lab employs about 650 people, most with advanced college degrees and specialized skills, and has a total annual budget of roughly $100 million. Jefferson Lab is open to scientists from around the world and supports a user community of 1,200 scientists who conduct basic and applied research at the lab. This is the largest community of scientific users at any nuclear physics lab in the world.

Jefferson Lab's science programs have a significant impact on the local, state and national economies. The lab generates an estimated $132 million income in the Hampton Roads area, while creating 1,607 jobs. Statewide it's estimated that the lab generates $151 million income and more than 1,700 jobs. Nationwide, the lab is estimated to produce $318 million income and nearly 2,700 jobs, according to a recent study.



JLab is a world leader in accelerator component R&D

Supercomputers speed data analysis at JLab



JLab operates a state-of-the-art accelerator control console

Rows of magnets in a JLab accelerator arc

VISITING THE LAB

Jefferson Lab holds an open house every other year, opening many of its unique work and research areas to the general public. Hundreds of Jefferson Lab scientists, engineers and technologists participate so they can talk directly to the public about their work and the latest research developments underway at the lab.

Group tours of Jefferson Lab and its facilities are available. In addition, scientists affiliated with Jefferson Lab, as well as lab experts in other fields, are available for public speaking. To arrange a tour or inquire about a speaker, contact the Public Affairs Department at 757-269-7689 for more information.

For more information about Jefferson Lab, its research and its programs, visit our website at www.jlab.org.

Thomas Jefferson National Accelerator Facility (Jefferson Lab) is
managed by Jefferson Science Associates, LLC for
the United States Department of Energy's Office of Science

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