Jefferson Lab Fact Sheet - Open House 2016

What is Jefferson Lab?

Jefferson Lab is a U.S. Department of Energy national laboratory. Its primary mission is to conduct basic research that builds a comprehensive understanding of the atom's nucleus. Scientists from around the world use the laboratory's facilities to conduct their research. In addition, the laboratory also conducts applied research with industry and university partners through its nuclear imaging group. Jefferson Lab also provides a variety of teacher and student programs as it reaches out to help educate the next generation in science and technology.

Jefferson Lab's Mission

Jefferson Lab, a forefront U.S. Department of Energy nuclear physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community. Specifically, the laboratory's mission is to:

• deliver discovery-caliber research by exploring the atomic nucleus and its fundamental constituents, including precise tests of their interactions;

• apply advanced particle accelerator, detector and other technologies to develop new basic research capabilities and to address the challenges of modern society;

• advance knowledge of science and technology through education and public outreach, and;

• provide responsible and effective stewardship of resources.

What Makes Jefferson Lab Unique?

Superconducting electron-accelerating technology makes the laboratory unique. Researchers use Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF) - the first large-scale application of SRF - to conduct experiments. The accelerator provides high-energy electron beams for probing the sub-nuclear realm, revealing how quarks make up protons, neutrons, and the nucleus itself. Using this same superconducting electron-accelerating technology, Jefferson Lab staffers designed and constructed the Low Energy Recirculator Facility (formerly the Free-Electron Laser).

Jefferson Lab Facts

• Jefferson Lab is managed and operated by Jefferson Science Associates, LLC, a joint venture between Southeastern Universities Research Association, Inc., and PAE Applied Technologies under a contract with the U.S. Department of Energy.

• Jefferson Lab is an investment of the federal government, the Commonwealth of Virginia, the City of Newport News, foreign contributors and the U.S. nuclear physics research community. The laboratory's annual budget is about $150 million.

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• The 12 GeV Upgrade is a $338 million project that, in addition to doubling the maximum energy of the electron beams in Jefferson Lab's accelerator, also included the construction of a fourth experimental hall, upgrades to equipment in the existing halls and other upgrades and additions. The full project will be complete by Sept. 30, 2017.

• More than 700 people are employed at Jefferson Lab (April 2016).

• Approximately 1,500 scientists from around the world conduct experiments at Jefferson Lab. These scientists, called Users, come to the facility to perform experiments in the end stations (Halls A, B, C and D) and to conduct research with Jefferson Lab employees.

• The Jefferson Lab site is approximately 200 acres, which includes federal, state, and SURA land.

• Total original construction cost was $514.9M.
    • started construction in February 1987
    • started performing experiments in 1995

How Are Experiments Conducted with CEBAF?

The Continuous Electron Beam Accelerator Facility, CEBAF, acts like a giant microscope, providing an unprecedented view that enables scientists to "see" things a million times smaller than an atom. CEBAF does this by propelling an electron beam at nearly the speed of light. CEBAF is shaped like a racetrack and is located 25 feet below ground. The electron beam is generated in the injector. From there, it is propelled into the first of the two linear accelerators. The two linear accelerators are comprised of 25 cryomodules, which contain superconducting radiofrequency accelerator cavities. The cavities are made of a metal called niobium, which becomes superconducting – allowing energy to pass through with no resistance – at cryogenic temperatures. These cavities pass energy to the electrons, which start at one electron-volt and a may gain up to 11 billion electron-volts (11 GeV) before being sent into Halls A, B or C for experiments, or up to 12 GeV before being sent into the Hall D complex. Beam to Hall D is manipulated to generate photons before entering the hall. These electrons or photons are then directed into a target inside an experimental hall. A target can be a gas, a liquid or a solid substance. Common targets include hydrogen, helium, carbon and aluminum.

When the beam strikes the target, most of the electrons or photons fly through without interacting and are stopped in a collector called a "beam dump." The electrons and photons that interact with the target may do so by interacting with the protons and neutrons inside nuclei or even with the quarks and gluons that make up protons and neutrons. These interactions may alter the electrons and photons that caused them, or they may knock protons, neutrons or quarks out of the target, or they could also cause the production of entirely new particles. The products of the interactions are collected and recorded in giant detectors, and that data is studied to learn about the constituents of matter.

Why Name The Lab After Thomas Jefferson?

• Thomas Jefferson was a promoter of science and technology and displayed an avid scientific curiosity through his recordings of facts concerning such things as crop growth, planting trees and making bricks.

• Authored an encyclopedia titled Notes on the State of Virginia, which cataloged data on flora and fauna, rivers, ports, climates, weights and measures, boundaries and populations.

• Wrote what is considered by many to be the first scientific paper published with government support: a report on methods for distilling fresh water from salt water.

• Jefferson presented a formal paleontology paper to the American Philosophical Society and later became that society's president.

• As president, Jefferson supported and commissioned a methodical exploration of the nation's frontier with the Lewis and Clark expedition, stating the expedition was meant to extend for citizens "the boundaries of science, and to present to their knowledge that vast and fertile country."

What We Study

Nuclear Physicists come to Jefferson Lab to use the CEBAF accelerator to study the protons and neutrons in the nucleus and the quarks and gluons that make up protons and neutrons. Future research goals include:

• Study the mechanism that confines quarks and seek an answer to one of the great mysteries of physics: Why is one quark never found alone?

• Research the fundamental structure of neutrons and protons.

• Seek an answer to how protons and neutrons bind together to form the nucleus.

• Study the limits of the Standard Model, the theory that describes the fundamental particles and their interactions.

The Low Energy Recirculator Facility

Jefferson Lab’s Low Energy Recirculator Facility, formerly known as the Free-Electron Laser, was developed using the lab’s expertise in superconducting radiofrequency (SRF) accelerators. As an FEL, the facility was the world’s highest-power tunable infrared laser and also provided ultraviolet laser light, including vacuum ultraviolet light, and Terahertz light. Currently, the lab is using the term Low Energy Recirculator Facility, or LERF, to refer to this facility, as future missions with potentially broader scope are under development.

Many of the future uses envisioned for the LERF use its underlying Energy Recovery Linac (ERL) design. The present range of discussion includes future nuclear physics experiments, characterization of materials using low-energy positrons, and R&D on production of medical isotopes. There is also substantial potential for facilitation of commercial development of free-electron laser technology, and Jefferson Lab is pursuing this option, as well. The lab is developing a plan for future utilization of this facility in a manner that is of maximum benefit to the mission of the laboratory and of the nation.

New and Upgraded Facilities for the 12 GeV Upgrade

• A new experimental facility (Hall D) and accompanying workspace and control room totaling 10,000 square feet was added, contributing to a total of 28,000 new square feet for the entire Hall D Complex.

• The accelerator tunnel was extended by 250 feet.

• Ten new cryomodules (or accelerating units) were added to the accelerator linacs, bringing the total to 50 cryomodules. The advanced design of the new modules allow researchers to double the electron beam's maximum energy from 6 GeV to 12 GeV.

• An additional arc of magnets was installed to transport the 12 GeV electron beam to the new experiment facility (Hall D), expanding the existing 5-pass machine to a 5.5-pass machine.

• Physical additions to the refrigeration plant or Central Helium Liquefier (CHL) and other accelerator facilities totaling 8,400 square feet and doubling the refrigeration plant's capacity.

• Utility upgrades include water, sewer, electrical, cryogenics distribution and telecommunications.

• New or upgraded equipment was installed in the experimental halls, including a nearly 100-ton and a ~1,000-ton "spectrometer" system consisting of massive magnets and detectors necessary for analyzing particle trajectories, momenta and energy after the electron beam collides with the target particles.

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