CEBAF

Continuous Electron Beam Accelerator Facility

Jefferson Lab


More than 1,900 nuclear physicists from around the world come to Jefferson Lab to conduct and collaborate on research.

CEBAF opens up new avenues for exploration of the atom's nucleus.

CEBAF is Jefferson Lab's main research facility. The entire complex works like a giant microscope, except that unlike an ordinary microscope (which uses rays of light), CEBAF uses a highly focused beam of electrons. The facility's unprecedented electron beams and unique detector systems allow scientists to "see" things a million times smaller than an atom.

The accelerator is located in a tunnel about 25 feet below ground on the Yorktown Formation – the remains of an ancient seabed. The accelerator tunnel is shaped like an oval racetrack and is about 7/8 of a mile around. Inside the tunnel, the floor and ceilings are about 13.5 feet wide and the walls are about 10 feet high.

HOW CEBAF WORKS

CEBAF's electron beam originates in the injector, then zips into the underground racetrack-shaped accelerator at nearly the speed of light. Superconducting technology drives the electrons to energies up to 12 billion electron-volts (12 GeV).

The electron beam may be split for simultaneous use in experiments in the four experimental halls. Giant particle detectors record the interactions between the incoming beam and the quarks, protons and other particles inside the target nuclei. The data from these interactions are analyzed to reveal new information about the heart of matter.

CONDUCTING EXPERIMENTS

For experiments, the electron beam is created by shining laser light onto a postage-stamp-sized wafer made of gallium-arsenide. The laser energizes the electrons in the material, causing them to fly away from atoms.

This new beam consists of electrons grouped into a train of discrete bunches of about a million each. More than 80 percent of the electrons are typically polarized, or spinning the same way.

The electrons are then accelerated by riding energy waves down the center of the two linear accelerators in the straight sections of CEBAF. Accelerator components called cavities maintain the waves, which are similar to microwave energy, and impart this energy to the electrons.

The electrons may be circulated through the straight sections of the machine up to 5.5 times. Magnets in the accelerator's two arcs steer and focus the electron beams, keeping them on track to enter the next straight section.

Once they reach the desired energy, the electrons are directed to one of the lab's four experimental halls. CEBAF is capable of delivering beams of electrons for experiments into all four of its experimental halls simultaneously, at up to 11 GeV into Halls A, B and C, and up to 12 GeV into Hall D.

If CEBAF weren't superconducting, it would require three times the power to operate.

QUICK FACTS:

- Nearly 2,500 magnets of more than 81 different varieties focus and steer the electron beam. They range in size from a few inches to 4 meters and weigh as much as 5 tons.
- The electron beam can travel around the 7/8-mile racetrack-shaped accelerator five times in about 22 millionths of a second. At that speed, the electron beam could circle the Earth 7.5 times in one second.
- Approximately 16,500 gallons of the coldest liquid on earth – liquefied helium – chill components in CEBAF to just a few degrees above absolute zero for operations.
- The mass of an object increases as its relative speed increases. At 12 GeV, an electron's mass will increase by almost 23,500 times.

INTO THE HALLS

In Halls A, B and C, the electrons are typically smashed into the nuclei inside targets. A target can be a solid, liquid or gas composed of any element, such as hydrogen, helium or lead. Most of the electrons will pass through the target unperturbed, but some will collide with the protons, neutrons, quarks or other particles inside.

Beyond the targets lie sophisticated detector systems for capturing the outgoing electrons and other particles that may fly out of the target due to a collision. The detectors may measure the speed, direction and energy of particles and record the data for nuclear physicists to analyze.

For experiments conducted in Hall D, the beam of electrons is steered into a thin sliver of diamond about one-fifth the thickness of a human hair. Some of the electrons are diverted by the diamond's crystal structure, emitting photons that then zip the length of a football field into Hall D.

There, they pass through a hole about the size of a grain of rice that ensures that only perfectly aligned photons proceed toward the target. Just as in the other halls, sophisticated detector systems measure the particles that result from collisions of the beam with particles in the target.

THOMAS JEFFERSON
NATIONAL ACCELERATOR FACILITY

12000 Jefferson Avenue, Suite 15,
Newport News, Virginia 23606
(757) 269-7100
jlabinfo@jlab.org • jlab.org

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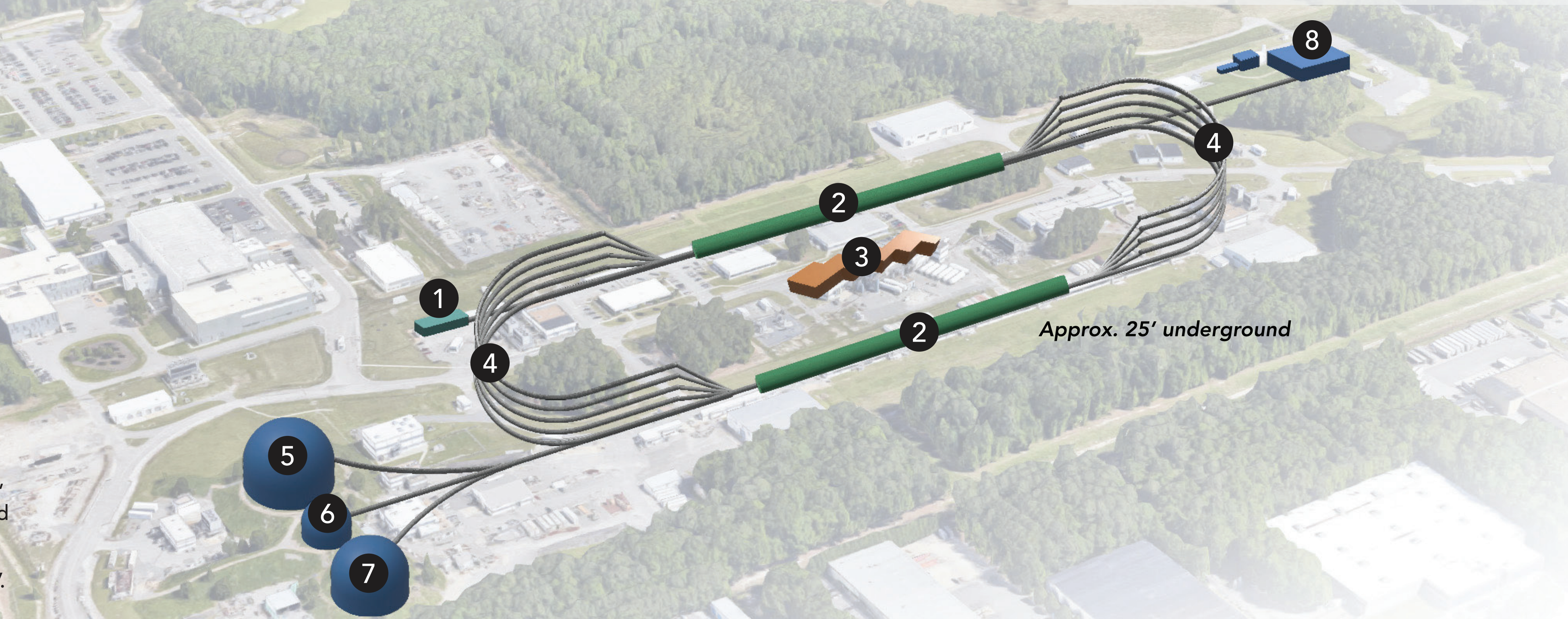
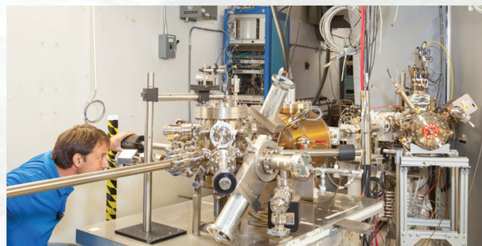
CEBAF AT JEFFERSON LAB

Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF) enables world-class fundamental research of the atom's nucleus. Like a giant microscope, it allows scientists to "see" things a million times smaller than an atom.

AT JEFFERSON LAB, NUCLEAR PHYSICISTS STUDY FOUR FUNDAMENTAL AREAS:

- Quark Confinement – Addressing one of the great mysteries of modern physics – why quarks exist only together and never alone.
- The Physics of Nuclei – Illuminating the role of quarks in the structure and properties of atomic nuclei, and how these quarks interact with a dense nuclear medium.
- Tests of the Standard Model – Studying the limits of the theory that describes fundamental subatomic particles and their interactions.
- The Fundamental Structures of Protons and Neutrons – Mapping in detail the distributions of quarks in space and momentum, culminating in a picture of the internal structures of protons and neutrons.





1 INJECTOR

The injector produces electron beams for experiments.

2 LINEAR ACCELERATOR

The straight portions of CEBAF, the linacs, each have 25 sections of accelerator called cryomodules. Electrons travel up to 5.5 passes through the linacs to reach 12 GeV.

8 EXPERIMENTAL HALL D

Hall D is configured with a superconducting solenoid magnet and associated detector systems that are used to study the strong force that binds quarks together.

3 CENTRAL HELIUM LIQUEFIER

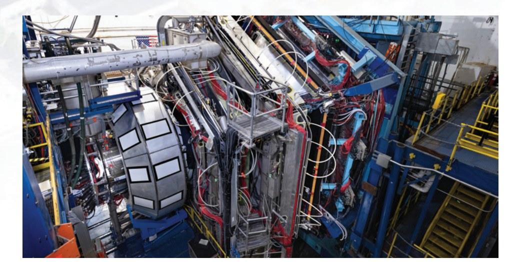
The Central Helium Liquefier keeps the accelerator cavities at -456 degrees Fahrenheit.

4 RECIRCULATION MAGNETS

Quadrupole and dipole magnets in the tunnel focus and steer the beam as it passes through each arc.

5 EXPERIMENTAL HALL A

The BigBite and Super BigBite spectrometers precisely measure the inner structure of nucleons. Hall A will also be used for the Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) experiment and a group of experiments using the Solenoidal Large Intensity Device (SoLID).



6 EXPERIMENTAL HALL B

The CEBAF Large Acceptance Spectrometer surrounds the target, permitting researchers to simultaneously measure many reactions over a broad range of angles.

7 EXPERIMENTAL HALL C

The Super High Momentum Spectrometer and High Momentum Spectrometer precisely measure the inner structure of protons and nuclei. Hall C is also used for experiments with the Neutral Particle Spectrometer and other unique, large-installation experiments.