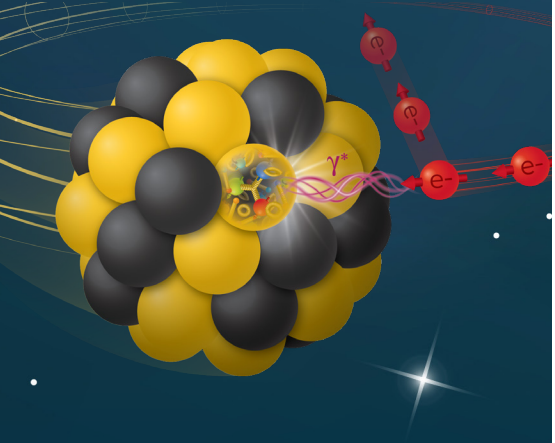
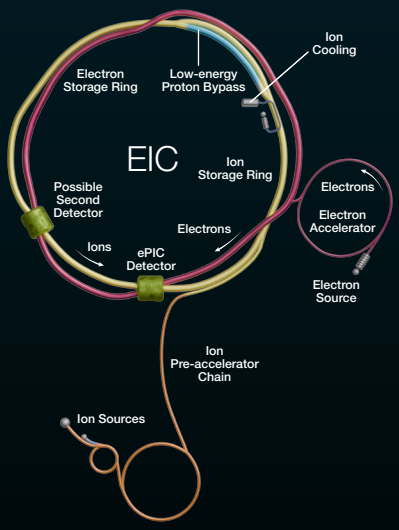


The world's most sophisticated collider

The EIC — a state-of-the-art, 2.4-mile-circumference accelerator complex being built at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory in partnership with DOE's Thomas Jefferson National Accelerator Facility — will be the only particle collider in the U.S. It will accelerate and collide beams of electrons with protons and nuclei. Unlike any collider that has ever existed before, both of the EIC's particle beams will be polarized, meaning their spins will be aligned in a controlled way to allow for precision measurements. A groundbreaking detector will act like a giant digital camera to capture thousands of collisions per second. Scientists will use this data to produce 3D snapshots of the never-before-seen internal structure of protons and nuclei.



03/2025

Science Overview

The Electron-Ion Collider

Unraveling the mysteries of the building blocks of matter and the strongest force in nature

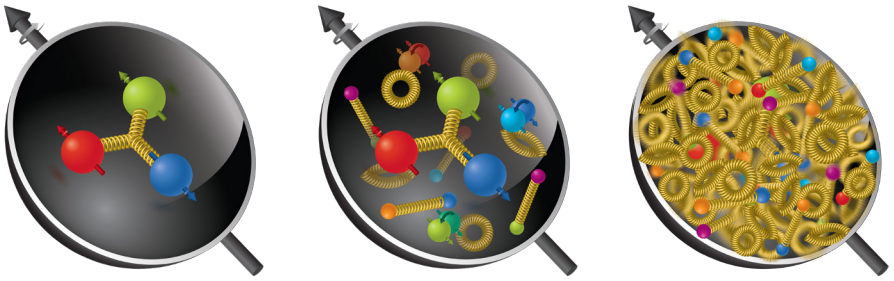
Major discovery potential

Scientists are building a new machine, an Electron-Ion Collider (EIC), to peer inside the nucleus of the atom and inside the individual protons and neutrons that make up the nucleus. This groundbreaking machine will spark a new wave of unimaginable discoveries, similar to the electronics revolution that gave us today's technologies and was driven by scientific discoveries about electrons and atoms over the last century.

Unique science

Visible matter — what we see in nature and throughout the universe, from plants and people to planets and stars — is made of atoms. Every atom contains a nucleus made of protons and neutrons that, in turn, are made of nearly massless quarks and completely massless gluons that bind them together.

We know this from five decades of research, including Nobel Prize-winning discoveries about the fundamental nature of matter. But our understanding of visible matter's innermost building blocks doesn't add up.



1980s | 1990s to 2000s | 2030s?

Compelling questions

The EIC will address longstanding questions about the building blocks of matter that underlie all of science. Scientists did not have the tools to answer them … until now.

How do subatomic building blocks with virtually no mass — quarks and gluons — interact to produce the mass of the proton and all we see in the universe?

What is the nature of the gluons that "glue" visible matter together, and how do they generate the strongest force in nature?

How does a proton's spin — a fundamental property used in medical imaging yet not fully understood — arise from its quarks and gluons?

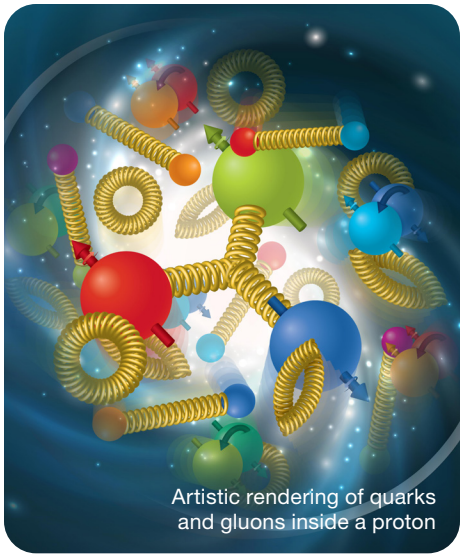
"The science questions that an EIC will answer are central to completing an understanding of atoms as well as being integral to the agenda of nuclear physics today … The science … is unique and world leading and will ensure global U.S. leadership in nuclear science, accelerator science, and the technology of colliders."

— U.S. National Academy of Sciences

Brookhaven National Laboratory | Jefferson Lab | U.S. Department of Energy | Office of Science

Exploring mysteries of matter

The EIC will be the world's most versatile collider. Its unique capabilities will enable researchers to tackle a wide range of intriguing, unanswered scientific questions about the building blocks of matter. It will draw on decades of technical progress in collider science, including expertise gained from building and operating Brookhaven Lab's Relativistic Heavy Ion Collider (RHIC). Research at RHIC has revealed unprecedented discoveries about the nature of quarks and gluons as they existed in the early universe, before protons and neutrons ever formed. The EIC will delve deeper into quarks and gluons to explore their interactions and the force that holds together the visible matter that makes up our world today.



Artistic rendering of quarks and gluons inside a proton

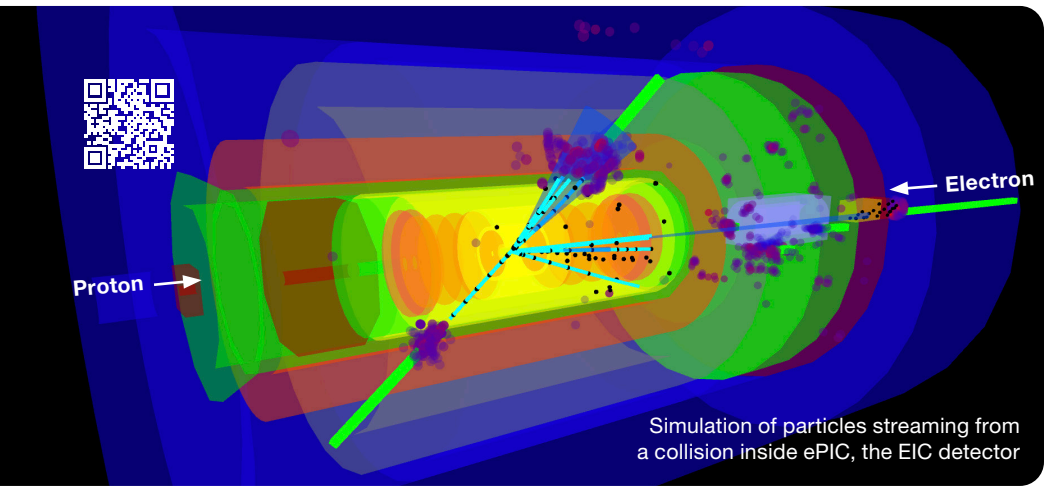
End-to-end AI technology

Artificial intelligence (AI) will be integrated into every aspect of the EIC, from the accelerator to detector to analysis. Specifically, AI-driven efficiencies will optimize accelerator collision rates, improve experimental design and decision-making to enhance detector performance, reduce operation and energy costs, and quickly transform high-quality data into groundbreaking discoveries.

U.S. leadership, global excitement for EIC experiments

A global community of more than 1,500 scientists is already engaged in developing the science program and experiments for the EIC.

- Members of this EIC user group come from nearly 300 institutions in 40 countries — including more than 80 U.S. universities.
- A subgroup of these scientists — including many from Brookhaven Lab, Jefferson Lab, six other DOE national laboratories, 19 U.S. universities, and institutions from 20 countries — is developing technologies needed to build the EIC.
- One scientific collaboration is already designing the EIC's first experiment, a house-sized detector that will capture particles streaming from collisions so scientists can transform data into discoveries.



Simulation of particles streaming from a collision inside ePIC, the EIC detector

"The EIC will elucidate the origin of visible matter in the universe and significantly advance accelerator technology."

— U.S. Nuclear Science Advisory Committee

Benefits of the EIC

Accelerator Applications

- Building the EIC is pushing the evolution of advanced accelerator technologies that could also impact the development of microelectronics, therapeutic drugs, batteries, and more.

Health & Medicine

- Running the EIC will enable the production of medical isotopes that play a crucial role in medical diagnosis and treatment.
- Developing advanced accelerator technologies could lead to new particle beam approaches for diagnosing and treating cancer.
- EIC detector technologies will help in the development of higher-resolution PET scans.

Artificial Intelligence & Computational Tools

- Approaches for analyzing EIC data may be applied to simulating climate change, tracking global pandemics, protecting national security, and other data-intensive challenges.

Energy & National Security

- Radiation-resistant materials and detector technologies developed for the EIC could be used in energy applications and for scanning and screening cargo at ports of entry.

Economic Engine

- By enabling discoveries and creating new technologies, the groundbreaking EIC will create high-paying jobs and high-tech advances for the future.
- Designing, constructing, and running the EIC will provide education and training opportunities for a future tech-savvy U.S. workforce and tech-based U.S. economy.