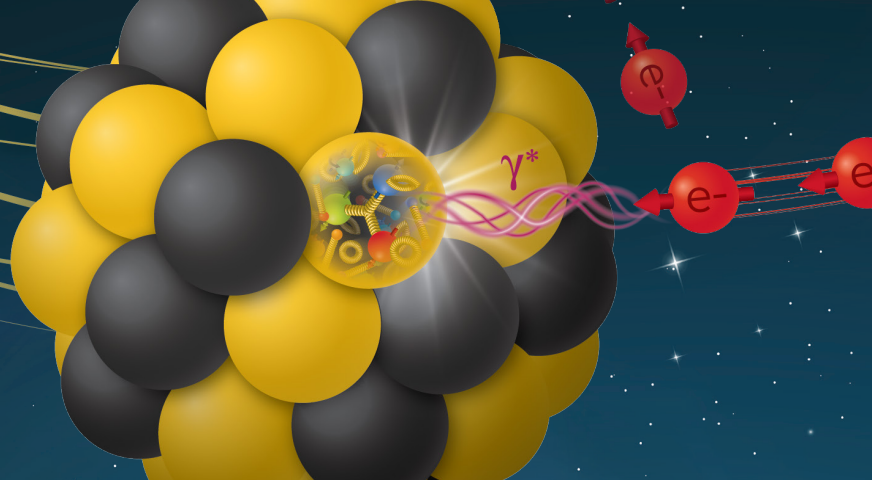
The Electron-Ion Collider (EIC)

Exploring the mysteries of the building blocks of matter



The Electron-Ion Collider (EIC), a powerful new facility to be built in the United States at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory in collaboration with DOE's Thomas Jefferson National Accelerator Facility, will directly explore the most fundamental building blocks of nearly all visible matter. Its focus is to reveal how these particles interact to build up the structure and properties of everything we see in the universe today, from stars to planets to people.

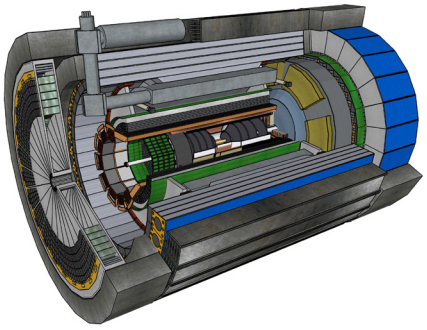
This exploration will provide insight into the workings of particles called gluons, which "glue" together quarks, the particles that make up protons and neutrons. For example, it will help explain how gluons contribute to the mass of visible matter and to "spin" —a property of fundamental particles that is used in medical imaging and quantum information science.

The EIC represents an opportunity for broad international communities of nuclear and accelerator physicists to collaborate on building this exciting new discovery machine. The project is attracting international partners who will contribute to accelerator and detector research and development, design, prototyping, nd construction. This sharing of expertise will advance the frontiers of accelerator and detector technologies, with possible applications in microelectronics, medicine, and other fields. The EIC will integrate Artificial Intelligence/ Machine Learning (AI/ML), from the accelerator to experiment to analysis, leading to applications essential to national competitiveness. AI-driven efficiency improvements will reduce operation and energy costs.

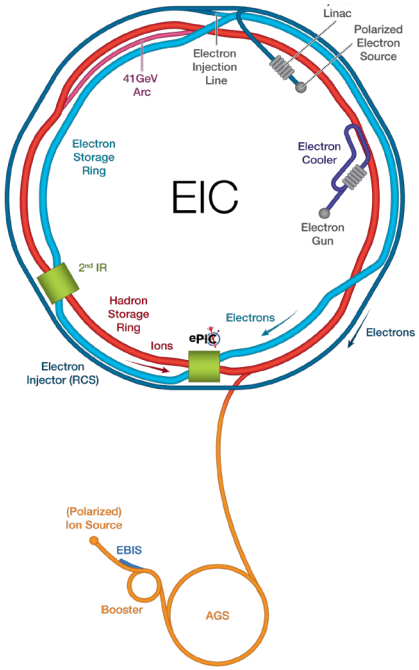
The U.S. Nuclear Science Advisory Committee recommends "the expeditious completion of the EIC as the highest priority for facility construction" in its 2023 Long Range Plan.

State-of-the-art detector technologies

Scientists will track particles produced by the colliding beams using a complex detector. This detector will act like a giant microscope to give insight into the properties of visible matter. Technologies required to enable discoveries at the EIC include:



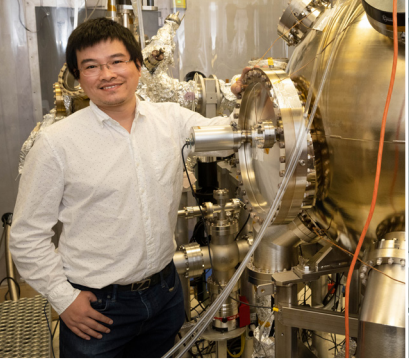
- High-precision tracking systems for reconstructing the trajectories of charged particles
- High-resolution systems for measuring the energies of particles
- Components for precision particle identification
- Efficient data acquisition systems incorporating AI/ML
- Advances in software and computing for analyzing data



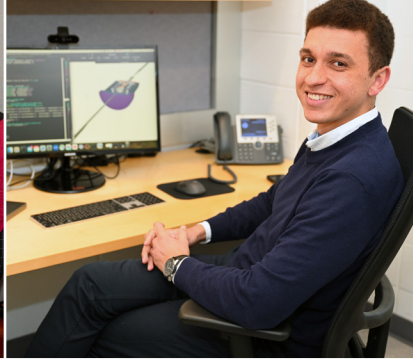
An exciting new discovery machine

The EIC will make use of key infrastructure from Brookhaven's existing Relativistic Heavy Ion Collider and add sophisticated electron accelerator components. One ring will store an intense beam of polarized electrons (where the particles' spins are oriented in a controlled way), while the other stores a counter-rotating high-energy beam of polarized protons or ions (nuclei of atoms). Scientists will steer and focus the electron and ion beams into collisions at very high rates at points where the two rings intersect, and they'll collect data using detectors that surround these interaction regions. The collider will feature specialized state-of-the-art technologies:

- Sources for producing ions and electrons
- Vacuum and cryogenics systems
- Superconducting radio-frequency cavities for accelerating ions/electrons and superconducting magnets for steering and focusing beams
- Instrumentation for measuring and correcting beam properties
- Spin rotator devices for maintaining particle spin direction
- Advanced systems for keeping particles in beams tightly packed to maximize collision rates







Vibrant national and international community

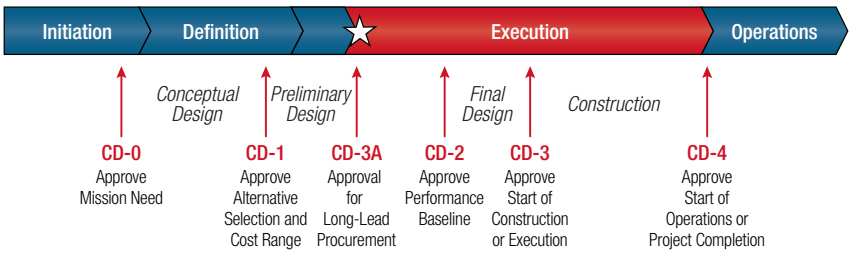
The growing EIC Users Group—currently 1,500+ physicists from 291 scientific institutions in 40 countries around the world, and growing—has been extremely active in developing the science case for the EIC as well as plans for the accelerator and detector(s). While the project scope includes funding for one detector, this international community has presented a compelling case for a second detector to take full advantage of the EIC's planned capabilities. The EIC community of experimental nuclear physicists, accelerator scientists, theorists, and many others is working to develop partnerships and a path for realizing the full scientific potential of this unique machine.

In 2023, the EIC Accelerator Collaboration was established, creating opportunities for a worldwide accelerator collaboration. Nationally, at least nine national labs and 99 U.S. universities and institutions will participate in the EIC.

The EIC will maintain U.S. leadership at the frontiers of nuclear physics and accelerator science technology.

Building a diverse and tech-savvy workforce

The EIC Project is jointly managed by Brookhaven National Laboratory and Thomas Jefferson National Accelerator Facility. It has passed the first two of five DOE "critical decision" (CD) milestones and is in the design phase (☆). Maintaining this progress is essential to attracting and retaining the highly skilled workforce needed to build and operate such a state-of-the-art facility and provide additional job opportunities for construction workers, equipment makers and material suppliers, technicians, engineers, scientists, and early career professionals, as well as economic opportunities for local, state, and national businesses and Minority and Women-Owned Business Enterprises. Construction is expected to start around 2024, with operations beginning in the early 2030s, followed by 20+ years of scientific impact and opportunities for innovation and improvement that do not exist today.



Benefits beyond physics

As the only collider planned to be constructed anywhere in the world in the next decade, the EIC will significantly advance accelerator and particle detector technology with potential benefits for many other fields important for economic development and improving quality of life:

- New medical isotopes and particle beam approaches for diagnosing and treating cancer
- Artificial intelligence and other computational tools for simulating climate change, tracking global pandemics, and protecting national security
- Accelerator advances for making and testing computer chips, studying proteins and therapeutic drugs, designing better batteries, and more
- Development of radiation-resistant materials for energy applications
- Hundreds of highly skilled jobs and training for a future tech-savvy workforce

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