Frequently Asked Questions on the Electron-Ion Collider and National Academies Report

What is an EIC?

An Electron-Ion Collider (EIC) would be a particle accelerator that collides electrons with atomic nuclei. It will produce snapshots of the internal structure of protons and nuclei—like a CT scanner for the atomic nucleus—to reveal unprecedented details of the arrangement and interactions of the quarks and gluons that make up the building blocks of nuclei.

Why do scientists want to build one?

Much of the technology we use today relies on what we learned about atoms in the last century, in particular the electromagnetic force between atomic nuclei and the electrons that orbit them. Advances in energy and medical isotopes came from understanding nuclear properties, while batteries, semiconductors, smart materials, and all electronics came from understanding the electronic structure of the atom. With an EIC we will look *inside* the nucleus to image gluons, particles that hold together the protons and neutrons of atomic nuclei with a force that is 100 times *stronger* than electromagnetism. What we learn about gluons and the "strong nuclear force" will deepen our understanding of the world around us, and could potentially power the technologies of tomorrow.

How will an EIC be different from earlier machines that explore the fundamental structure of matter?

The EIC would be the most advanced particle collider of its type ever built. The EIC will have collision rates 100-1,000 times higher than the only previous electron-proton collider; it will be able to collide electrons with large nuclei, not just protons; *and* it will be the world's first machine where both the proton and ion beams can be polarized, meaning the particles' spins can be aligned in a controllable way. The EIC's energy, high collision rates, and ability to collide electrons with large nuclei will enable explorations of a new form of matter in which gluons dominate. The polarization will allow scientists to solve longstanding questions about the origin of a proton's spin, a property that makes MRI scanning technology possible but is still not fully understood.

What do we hope to learn from an EIC?

- How do massless gluons produce more than 90 percent of the mass of visible matter in the universe?
- Whether densely packed gluons at high energies create what may be among the strongest force fields in nature, and why matter in this subatomic realm is stable.
- How quarks and gluons inside the proton combine their spins and motion to generate the overall spin carried by the proton.
- How quarks and gluons transform into the observed strongly interacting particles.

- Why quarks are never seen separately in nature.

What would an EIC cost to build and operate?
Construction and operating costs for an EIC have yet to be determined.

Who will pay for it? Will there be any international contributions?
This project would be funded primarily by the U.S. Department of Energy's Office of Science, Office of Nuclear Physics. International collaborations will be sought, potentially to contribute key technological components, "in-kind" contributions, and/or support for their researchers working on the project, among other possibilities. This is a work in progress.

Where would it be built?
DOE's Office of Nuclear Physics will make the decision about where an EIC would be built. Two DOE labs, Brookhaven National Laboratory in New York and Thomas Jefferson National Accelerator Facility in Virginia, are actively developing proposals and collaborating on research and development, as well as building the case for an EIC in the U.S.

When would it be built?
Once a site is chosen, the DOE Office of Nuclear Physics will also decide the schedule for construction as it considers other priority programs it supports and how they fit into future budgets.

What is the decision process going forward?
The project is expected to follow the typical DOE new construction project process. The first step would be for DOE to declare Critical Decision 0, Approve Mission Need. The project would then progress through the alternative selection, siting, cost, scope, and construction process.

Will it create jobs? How many?
Job impacts have yet to be determined.

Are other projects competing with it for funding?
The U.S. Nuclear Science Advisory Committee—a committee of experts that advises DOE and the National Science Foundation on their research programs in nuclear physics— recommends building an Electron-Ion Collider as the highest priority new facility for the field. The DOE Office of Nuclear Physics supports a range of research programs and will decide how an EIC fits within its current and projected future budgets.

What are an EIC's benefits to society?
Building an EIC will maintain and expand U.S. leadership in nuclear physics and accelerator science—fields of science that have impacts in health (diagnostic and therapeutic medical isotopes, accelerator advances for cancer treatment, and drug discoveries), national security (detector technologies for screening at borders,

nuclear security), energy (methods to make and study computer chips, batteries, and electronics), and the development of computational tools for managing all sorts of “big data” enterprises. The project will also serve as a training ground for hundreds and hundreds of students who will apply their expertise in a range of careers that fuel the economy, provide for security, and pave the way to a healthier, brighter future for all. The project will push the state-of-the-art in particle accelerator and detector technologies, two areas with wide-ranging economic and health impacts.

What kind of applications might come out of an EIC?

- innovative accelerators for making and testing computer chips, killing cancer cells, and designing drugs and new materials for electronics
- detector technologies for medicine and national security
- advances in computing and data analysis across science
- production of isotopes for diagnosing and treating disease
- unforeseen advances that stem from what we learn from this unprecedented exploration of the substructure of matter

Who will be involved in building the machine and the research done there?

A vibrant community of physicists, including an EIC User Group of more than 700 physicists from 29 countries around the world, is working to tackle the technological challenges of designing and building a U.S.-based EIC. If built, more than 1,000 scientists and engineers would work at an EIC.

Why did the National Academy of Sciences review the project?

DOE asked the National Academies of Sciences, Engineering, and Medicine to form a committee to carry out a thorough, independent assessment of the scientific justification for a U.S. domestic electron ion collider facility. In preparing its report, the committee was asked to address the role that such a facility would play in the future of nuclear science and the need for such an accelerator in the context of international efforts in this area.

Are any other countries planning to build an EIC?

Possible plans for electron-ion colliders are under discussion in China and Europe, but none of them could fully address the same scientific questions as the one proposed for construction in the U.S. and considered by the National Academy Panel.

How many detectors will there be at an EIC?

The design allows for the possibility of at least two detectors in the completed machine.

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