Hearing on High Energy Physics, Nuclear Physics, and Isotopes

Energy Subcommittee on the House Science, Space, and Technology Committee
Date, Time: Wednesday, June 22, 2022, at 10 a.m. (ET)
Speaker: Jim Yeck
Delivery: Spoken in person (condensed); Written submitted 10 a.m. June 17 (full version)

Chairman Bowman, Ranking Member Weber, and members of the committee, thank you for the opportunity to appear before you today to discuss the Electron-Ion Collider, nuclear physics, and the management of big science projects. My name is Jim Yeck. I have had the honor of participating in and leading big science projects around the world, including the Relativistic Heavy Ion Collider (RHIC) and the National Synchrotron Light Source II at Brookhaven National Laboratory, the U.S. contribution to Europe's Large Hadron Collider (LHC), the IceCube Neutrino Observatory in Antarctica, and the European Spallation Source (ESS). I continue to serve on advisory and review committees for other big science projects, and I am a lecturer for the U.S. Department of Energy's Project Leadership Institute.

I am here today as Project Director for the Electron-Ion Collider, a nuclear physics research facility being built at Brookhaven Lab on Long Island in partnership with Thomas Jefferson National Accelerator Facility in Virginia and funded by the DOE Office of Science. I will share with you how the EIC will extend the frontiers of discovery in nuclear physics and lead to benefits for science and society. In combination with other Office of Science user facilities for nuclear physics research, the world-leading, one-of-a-kind EIC will maintain our nation's undisputed leadership and competitiveness in nuclear, accelerator, detector, and computing science — areas that are essential to economic advancement, national security, and technological development — for decades to come.

First, a few words about Brookhaven Lab.

Brookhaven is a multi-purpose DOE Office of Science Laboratory with about 2,700 staff, located on Long Island in New York. Our mission, in simple terms, is to carry out discovery science and related technology development to address national needs. We do that by building large facilities beyond the capabilities of universities and industry, and then making them available to scientists across the country and around the world.

One of those facilities is the Relativistic Heavy Ion Collider, or RHIC, which collides atomic nuclei at nearly the speed of light to recreate the conditions of the early universe, enabling some 1000 researchers from around the world to explore fundamental properties of the building blocks of matter. Since coming online in 2000, RHIC—the only operating particle collider in the U.S.— has enabled surprising discoveries and opened new areas of inquiry about nuclear matter—including discovering and characterizing a remarkable form of matter known as quark-gluon plasma and exploring the sources of proton spin. Over the next several years, RHIC will transition to the Electron-Ion Collider, the focus of my discussion today.

The EIC is a unique facility that will enable a new era of compelling science, expanding our knowledge of the inner workings of the atoms that make up nearly all visible matter in the universe. That's everything from galaxies and planets to the building we are in — and even you and me.

Today, all our technologies and much of our economy depend on what we learned in the last century about the atom — the positively charged nucleus and negatively charged electrons orbiting it. Those experiments revealed exquisite details of how electrons behave collectively, and ultimately led to the development of batteries, semiconductors, smart materials, all electronics, and more.

With an EIC, we will be able to look *inside* the nucleus to image its constituents, the quarks and gluons. The gluons are the particles that provide the "glue" that holds together the protons and neutrons of atomic nuclei while the quarks make up those particles. EIC experiments will reveal unprecedented insights into the collective behavior of gluons and the strong nuclear force — which creates the visible matter in the universe. We'll learn, for example, how the strong force drives interactions among completely massless gluons and nearly massless quarks to build up the mass, structure, and properties of visible matter.

Like the discoveries about the collective behavior of electrons in the last century, new discoveries about gluon interactions and the strong force will deepen our understanding of the world around us. And that understanding could potentially lead to the technologies of tomorrow.

This is a challenging field of science, with complex technological requirements. That's why it attracts the interest and efforts of thousands of the best and brightest scientists from around the world. Their contributions will extend the frontiers of discovery in nuclear physics while simultaneously sparking technological advances for science and society — in computing, electronics, energy, and medicine.

To give you some specific examples, the particle beam and detector technologies we are developing to explore the inner workings of atoms at the EIC could also lead to the next generation of:

- innovative accelerators for making and testing computer chips, killing cancer cells, and designing drugs, vaccines, and new materials for electronics;

Also:

- new isotopes for diagnosing and treating disease;
- detector technologies for medicine and national security;

- research relevant to protecting future astronauts and their electronics from harmful space radiation;
- and advances in exascale computing, data storage, distribution and data analysis that can be applied to modeling climate change, global pandemics, and even financial markets.

Planning for the EIC has been underway for more than two decades. The nuclear science community, through its most recent long-range planning activity, identified the EIC as the next major facility for the field. Then, through an extensive review process, the National Academies of Sciences, Engineering, and Medicine considered the scientific promise of the EIC and found it to be compelling and worthy of investment. These significant studies and assessments have laid the groundwork for moving ahead with the EIC with the backing of the entire nuclear science community.

The field of nuclear physics has a strong track record of delivering on the goals laid out through this careful planning process — and for bringing projects in within budget once they are launched. We also have a history of success in applying what we learn in ways that benefit society and our nation at large. We are the field that brought you nuclear medicine, medical imaging, particle accelerators for technology and cancer treatment. And from the EIC we anticipate unforeseen discoveries and applications as unimaginable as today's electronics industry was to the physicists of the early 20th Century.

Much of this success can be directly credited to the funding generously allocated by Congress to nuclear physics, including projects like the EIC. We are extremely grateful for that support — and that of the DOE Office of Science. We also understand the challenges that the country currently faces as Congress tries to decide how to best support our collective future. So I thank you again for the opportunity to share my views on what it takes for large science projects to succeed, along with some of the challenges we face when the budget profiles fall short of optimal. My goal is to find ways for us to work with all of you and with our valued partners at DOE to achieve our common goals.

Over the years, I have developed a list of key ingredients for the success of such big science projects. These include:

- Ensuring that the project remains a priority of the science community
- Securing funding commitments and establishing a strong role of the host funding agency and laboratory
- Appointing project leaders who enable the success of all stakeholders
- Encouraging collective ownership of problems and solutions
- Establishing realistic goals (in other words, valuing "experience over hope")
- Making the most of the available experience
- And sustaining the energy and enthusiasm of all stakeholders

To make the EIC a reality, we need all of these ingredients.

I am confident that we have the scientific and technical knowhow to build a world-class facility. We have an experienced project-management team that has successfully delivered complex facilities on time and within budgets. And we have a highly skilled workforce in place and very strong interest from the worldwide community of nuclear physicists eager to make use of the EIC. But I am concerned about current funding realities and their impacts.

Construction costs for the EIC are estimated in the range of $1.7–2.8 billion. That investment will create thousands of jobs in construction, materials, and manufacturing in New York State and beyond as we build the accelerator and detector components over the next 10-15 years — and hundreds of highly skilled, scientific, and technical jobs over the EIC's longer-term operational lifetime.

Part of the rationale for selecting Brookhaven Lab as the EIC site is to capitalize on more than $2 billion in investments in both unique infrastructure and the specialized workforce that built and currently operates the Relativistic Heavy Ion Collider (RHIC) — the facility that will provide essential accelerator systems as a backbone for the EIC. By adding new components for accelerating and storing electrons, cooling ions, and a range of other capabilities to this existing RHIC infrastructure, we will maximize the scientific impact of the new machine with significantly less investment than would have been required to build such a facility from a greenfield site.

Likewise, the team of scientific and technical experts currently operating RHIC are the result of more than 30 years of investment and specialized training. Their experience is essential for building the EIC, for growing our own diverse workforce, and attracting international partners. And because EIC is expected to operate well into the second half of this century, the handoff of knowledge between today's scientists, engineers, and technicians to the next generation will be critical.

The RHIC program currently makes up approximately a quarter of Brookhaven Lab's workforce and its annual budget. Providing the funding needed now to initiate the EIC project and move it forward *while RHIC completes its scientific mission over the next three years* is essential to ensure a smooth transition from one facility to the next. Without the necessary funding, that smooth transition will be at risk, creating a potential gap between the conclusion of the RHIC science program and the timely development of the EIC. That gap would result in layoffs, including the very talented staff capable of operating these sophisticated machines and advancing the science of the EIC.

The EIC project is therefore dependent on several years of sustained and dedicated funding to support EIC construction and the transition of the highly trained workforce from RHIC to the EIC. This funding will ensure that the EIC project is advanced enough at the time of the completion of the RHIC science mission to keep the staff critical to implementing installation of new EIC components — and the eventual operation of the new facility. To date, however, funding has been well below the levels required for an optimally smooth transition, and below that required to execute the technically driven and most efficient construction schedule to keep the project on course and on budget.

A quick ramp up in EIC project funding while RHIC is still operating through FY2025 will allow the project to complete design work, start long lead procurements, and secure DOE CD-3 construction approval before the end of RHIC operations, and thereby maintain critical skilled workers for a smooth transition from RHIC to the EIC. Starting in FY2026, RHIC operations funds can be redirected to drive the EIC project to completion by the early 2030s.

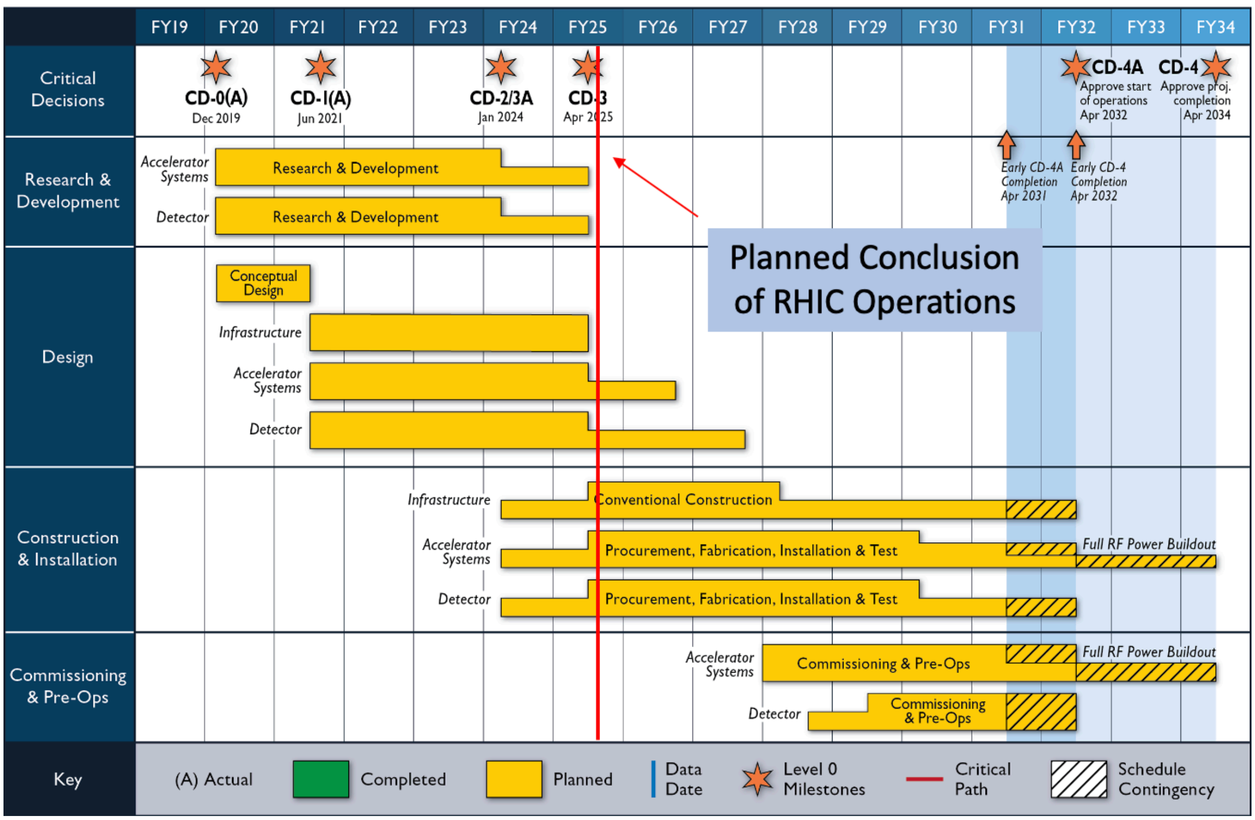

Figure 1. EIC Project Schedule

Significant funding constraints also affect the EIC project's ability to attract the next generation of physicists, technicians, and engineers, as well as international partners. If these future scientists and engineers don't bring their expertise to the U.S. and instead pursue projects in other nations, it will impact U.S. leadership and competitiveness in science and technology in general, and particularly in the critical fields of accelerator science and nuclear physics.

Currently, a robust EIC user community — about 1,300+ scientists from 250 institutions around the globe — has been helping to develop the EIC science program. These international collaborations of nuclear and accelerator physicists are developing advanced accelerator designs and sophisticated particle detector concepts to capture the data needed to turn EIC collisions into nuclear physics discoveries. Failure to adequately support the EIC project risks not just the international partnerships directly relevant to the EIC, but also international collaborators' confidence in U.S.-run projects in general, including DUNE, as well as the U.S. commitments made to overseas projects, such as at the Large Hadron Collider, which have been enormously beneficial to the advancement of U.S.-based scientists.

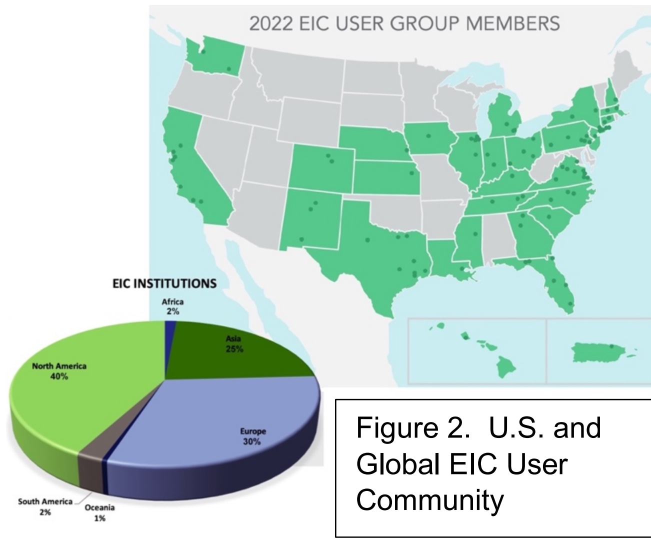

Figure 2. U.S. and Global EIC User Community

The accelerator complex at RHIC—and eventually the EIC—also supports DOE's Isotope Program and the NASA Space Radiation Laboratory. The Isotope Program produces key isotopes used to non-invasively image tumors in the body for diagnosis and monitoring of disease progression and response to treatment. One of the most promising is Actinium-225, which shows great promise in saving lives as an effective cancer treatment, even for cancers that have spread throughout the body. The NASA Space Radiation Lab uses the complex's particle beams to simulate cosmic radiation for experiments to better understand the risks astronauts would face on long-term missions, including journeys to Mars. The continuity of these activities also depends on the smooth transition from RHIC to the EIC.

Finally, a word about the educational impact of the EIC on our nation's young people, who represent our future. Brookhaven Lab takes great pride in its internship programs, including having attained a 50/50 gender diversity mix and drawing nearly 40 percent of our student class from underrepresented populations. These programs are developing the diverse workforce of the future. As the only particle collider of its kind in the world, the EIC will be a unique resource for driving that progression, providing educational opportunities for the next generation of engineers, technicians, and physicists needed to address a wide range of our nation's scientific and technological challenges. For example, students across the U.S. and around the world collaborating on EIC detector design will gain valuable hands-on experience designing, testing, and constructing sophisticated electronic components — and invaluable insight into large-scale science collaboration and the international nature of physics research. These skilled workers may apply their expertise directly in the fields of accelerator and nuclear science, or across a wide range of disciplines where such skills are needed in jobs across the economy.

I hope this testimony has convinced you of the enormous value an investment in the Electron-Ion Collider will deliver to our nation — in terms of ground-breaking science, technological advances, opportunities for education and workforce development, and U.S. leadership in critical areas for decades to come, and that significant increases in project funding are needed now.

Thank you for your time today.

I'm happy to take any questions.

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About Brookhaven National Laboratory

At Brookhaven, we focus on several different areas of science:

Nuclear and particle physics — research aimed at gaining a deeper understanding of matter, energy, space, and time. In nuclear physics, we operate the Relativistic Heavy Ion Collider, or RHIC, serving about 1000 users. The accelerator complex at RHIC also supports the production of critical medical isotopes and research into the effects of space radiation as noted above. And we also play a leading role in global particle physics experiments that push the limits of precision and expand our understanding of the cosmos, including the ATLAS experiment at the LHC and the Rubin Observatory.

Energy and climate science — leveraging our capabilities in advanced materials, catalysis, bioenergy, environmental systems, and climate science to put the U.S. on a path to a net-zero economy. These programs and others are supported by several DOE Office of Science user facilities, including the National Synchrotron Light Source II, the Center for Functional Nanomaterials, and the Atmospheric Radiation Measurement research facility — collectively serving thousands of users.

Advanced computer science, applied math, data science, and computational science — developing the infrastructure and algorithms to transform scientific discovery at Brookhaven's facilities and enhance its science programs.

Advanced and emerging technologies — leveraging strengths in instrumentation, magnets, accelerators, and laser science and technology

Applications — applying the results of Brookhaven's discovery science and technology to address emerging opportunities, including clean energy solutions, isotopes, national security solutions, and national emergencies.

About Thomas Jefferson National Accelerator Facility

Thomas Jefferson National Accelerator Facility (Jefferson Lab) is a U.S. Department of Energy Office of Science national laboratory. Scientists worldwide utilize the lab's unique particle accelerator, known as the Continuous Electron Beam Accelerator Facility (CEBAF), to probe the most basic building blocks of matter - helping us to better understand these particles and the forces that bind them - and ultimately our world.

In addition, the lab capitalizes on its unique technologies and expertise to perform advanced computing and applied research with industry and university partners, and provides programs designed to help educate the next generation in science and technology.

Managing and operating the lab for DOE is Jefferson Science Associates, LLC. JSA is a limited liability company created by Southeastern Universities Research Association.

Mr. Jim Yeck is the Associate Laboratory Director and the Project Director for the Electron-Ion Collider at Brookhaven National Laboratory. He has over 30 years of project director and project manager experience including recently serving as the Director General of the European Spallation Source from 2013-2016. He successfully led projects in both federal and contractor roles such as the DOE Project Manager for the Relativistic Heavy Ion Collider and the US contribution to the Large Hadron Collider, Project Director for the construction of the IceCube Neutrino Observatory, and NSLS-II Deputy Project Manager. Mr. Yeck is a member and serves as chair of numerous advisory committees for large projects supported by DOE, NSF, and international funding agencies and is a regular lecturer for the DOE Project Leadership since its inception in 2017. His academic training includes studies at University of Illinois (B.S. 1982), Northwestern (M.S. 1988), and the University of Pennsylvania.