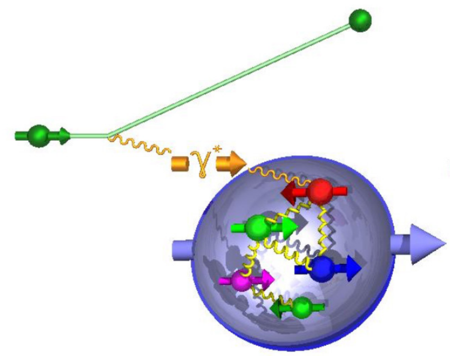
Consensus Study Report

July 2018

HIGHLIGHTS

An Assessment of U.S.-Based Electron-Ion Collider Science

At the request of the U.S. Department of Energy, the National Academies of Sciences, Engineering, and Medicine assessed the science case for a U.S.-based electron-ion collider (EIC). The committee evaluated the scientific benefits of constructing an EIC in the U.S. and identified the broader impacts it would have on the nuclear and physical sciences as well as on U.S. science leadership in the global context. ***An EIC, as envisioned in this report, would be a unique facility in the world that would boost the U.S. STEM workforce and help maintain U.S. scientific leadership in nuclear physics.***



A scattered electron probes the inner workings of a nucleon. SOURCE: U. Elschenbroich (HERMES)

UNDERSTANDING THE NATURE OF MATTER IN THE UNIVERSE

A central goal of modern nuclear physics, which concerns itself with atomic nuclei and their constituents and interactions, is to understand the structure of the proton and neutron directly from the dynamics of their constituent parts (quarks) and the particles (gluons) binding them together. Protons and neutrons are complex, interacting many-body systems, and this complexity gives rise to profound questions about the nature of ordinary matter. Electrons can be used to cleanly probe atomic nuclei down to the smallest components because they do not have an internal structure and behave as point-like particles in a collider environment.

ANSWERING FUNDAMENTAL QUESTIONS

An EIC—with its exceptionally powerful probing capability—would uniquely address profound, fundamental questions about nucleons (neutrons and protons) and their assembly into nuclei of atoms, such as:

(1) How does the mass of the nucleon arise?
(2) How does the spin of the nucleon arise?
(3) What are the emergent properties of dense systems of gluons?

These high-priority science questions can be answered by an EIC that has sufficiently high luminosity and variable center-of-mass energy. Answers to these questions will have implications across many fields.

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A UNIQUE FACILITY TO REINFORCE U.S. LEADERSHIP IN NUCLEAR PHYSICS AND ACCELERATOR SCIENCES

An EIC as envisioned by this report would be a unique facility in the world. Its high luminosity would push the frontiers of accelerator science and technology. The innovations required to design, construct, and support an EIC will help the United States maintain international leadership in nuclear physics, accelerator science, and related fields. Building an EIC would also help boost the U.S. STEM workforce by attracting outstanding graduate students, more than half of whom will likely go on to jobs in industry or in DOE laboratories if recent history is a guide.

LOWERING RISK AND MEETING DESIGN CHALLENGES

Taking advantage of existing resources and expertise would make the development of an EIC cost effective and could potentially reduce risk. Both Brookhaven National Laboratory (BNL) and the Jefferson National Accelerator Facility (JLab) have proposed concepts for an EIC utilizing existing infrastructure and accelerator experience. However, neither existing design can fully deliver on the three driving science questions above. The current accelerator R&D program supported by the Department of Energy will therefore continue to be crucial to address outstanding design issues. The DOE will also need a robust theory program to tackle the scientific challenges that would unfold from an EIC.

PLANNING FOR THE FUTURE

A high luminosity Electron-ion Collider (EIC) is the highest priority for new facility construction, according to the U. S. nuclear science community's 2015 Long Range Plan. This plan is thorough and thoughtful in its planning for the future, taking into account both science priorities and budgetary realities.

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This Consensus Study Report Highlights was prepared by the Board on Physics and Astronomy (BPA) based on the report *An Assessment of U.S.-Based Electron-Ion Collider Science* (2018). The study was sponsored by the Department of Energy. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of the sponsors. Download the report at **nap.edu**.

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