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INTRODUCTION

Thank you, Chairman Bowman, Ranking Member Weber, and distinguished members of the Committee. It is with great pleasure that I join you today to represent the Department of Energy (DOE or the Department) at this hearing on the Office of Science. As members of this committee know, the Office of Science's (SC) core mission is to deliver both the scientific discoveries and major scientific tools that will transform our understanding of nature and advance the energy, economic, and national security goals of the U.S. It is the largest Federal sponsor of basic research in the physical sciences and the lead in supporting fundamental scientific research for our energy future. Over decades, the investments and accomplishments in basic research and enabling research capabilities we've made have provided the foundation for countless new technologies that have benefited large and small businesses and launched new industries. These investments have contributed immensely to our Nation's economy, national security, and quality of life. SC continues this work today.

The core science programs in SC—Advanced Scientific Computing Research (ASCR), Biological and Environmental Research (BER), Basic Energy Sciences (BES), Fusion Energy Sciences (FES), High Energy Physics (HEP), and Nuclear Physics (NP)—along with the Offices of Isotope R&D and Production (DOE IP) and Accelerator R&D and Production (ARDAP) support research conducted at hundreds of universities and all 17 of DOE's National Laboratories, including the 10 for which SC has direct stewardship responsibility. SC supports different types of research programs—from single investigators and small teams to large, multi-disciplinary, multi-institutional collaborations. These programs probe fundamental questions to address nature's most compelling mysteries—from fundamental subatomic particles, atoms, and molecules that form the building blocks of our universe, to highly complex and dynamic systems, such as energy storage processes, microbial cells, and carbon cycling in the environment. The knowledge gleaned from this research provides the foundation for new discoveries and innovations that are essential to fulfilling the Department's missions.

Many of the transformative scientific discoveries made by our research community are enabled by our stewardship of 28 scientific user facilities, which are available to all researchers based on the scientific merit of their proposed research. These tools include the world's most powerful computers, brightest X-ray light sources, most intense neutron sources, fastest information network, and specialized capabilities, such as nanofabrication and multiple modes of imaging, within centers for nanoscience and bio-characterization. The Department continues to invest in the development of the next generation of scientific tools to maintain U.S. leadership in scientific discovery and technology development to support our Nation's economic competitiveness and national security.

Expanding Our Understanding of Matter, Energy, Space, and Time
SC-supported research in High Energy Physics (HEP) and Nuclear Physics (NP) expands our understanding of the universe, from the subatomic scale to the cosmic scale. Our investments ensure that the United States maintains its leading roles in these highly international efforts. Many of the groundbreaking discoveries enabled by the support provided by these programs and their predecessors at DOE—from the discovery of the top quark and the Higgs Boson to the discovery and characterization of the quark-gluon plasma to the recent measurements at the Muon g-2 experiment that call into question the standard model of physics—have been possible only due to the coordinated efforts of thousands of scientists in the U.S. and abroad working together at some of the most complex scientific instruments ever conceived and constructed. SC's support for research in fundamental physics requires the development of cutting-edge technologies, including those for accelerator science.

Half of the 28 current SC user facilities have a particle accelerator as a central component, providing particles and radiation of unmatched quality and facilitating research for thousands of researchers each year (almost 14,000 scientists in 2021). Keeping the accelerator-based SC facilities at the cutting edge requires continued, transformative advances in accelerator science and technology, as well as a workforce able to employ these tools to perform world-leading research. Developing new accelerator technologies for future generations of experimental facilities and supporting translation of these technologies into a broad range of applications that benefit society requires a coordinated effort across SC.

HIGH ENERGY PHYSICS

Program Intro
The HEP program's mission is to understand how the universe works at its most fundamental level by discovering the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time. U.S. investments in this area have been guided since 2014 by the report of the Particle Physics Project Prioritization Panel (P5), a multiyear scientific community effort coordinated by the High Energy Physics Advisory Panel (HEPAP) that identified five intertwined science drivers of particle physics with great promise for discovery. We pursue breakthroughs in these areas through a global program that

includes national and international partnerships that have enabled the U.S. to host world-leading facilities like the future Long Baseline Neutrino Facility and Deep Underground Neutrino Experiment (LBNF/DUNE), and for U.S. scientists to access the most advanced facilities located abroad.

SC, through HEP, has played an important role in the collaboration between the U.S. and the European Organization for Nuclear Research (CERN) at the Large Hadron Collider (LHC), the world's largest and highest-energy particle collider. This collaboration continues with the High Luminosity upgrade of the LHC accelerator and two large detectors, which will increase the particle collision rate and increase the reach for discovering new physics. SC is leading in the development of LBNF/DUNE, our next big international mega-science project. When complete, this multi-location facility will be the centerpiece of a U.S.-hosted world-leading neutrino research program. It will use the world's most intense neutrino beam and large, sensitive underground detectors to reveal answers to fundamental mysteries of the universe.

Going forward, the scientific community is set to undertake the next iteration of the P5 process. When completed in 2023, the next strategic plan is expected to help HEP chart a course to support this scientific community through the rest of this decade and develop a high-level vision that enables the following decade of fundamental discoveries. The next iteration of the P5 process will include input from across the HEP community via an inclusive, community-led process, as well as the P5 panel itself, where particular attention will be paid not only to representing the full range of the community's science interests and aspirations, but also its rich diversity in terms of type and geography of institutions, and individual backgrounds and career stages. HEP plays a central role in this community, providing approximately 85% of U.S. particle physics funding, as well as supporting international collaborations.

Research Goals

HEP continually explores the primary structure of the universe—always pushing to higher energy collisions, more intense particle beams, and extremely low background environments in search of new and unexpected phenomena. In recent years, a significant focus of the field has been probing the known but most mysterious fundamental particles and forces in the Universe, such as the Higgs boson, discovered at the LHC in 2012. It is a particle unlike any other because it endows most other particles with mass through its interactions. A greater understanding of these interactions may finally help us unlock what lies beyond our current knowledge of particle physics. Conversely, neutrinos fill up the universe but are elusive because they glide through almost everything without interacting. Neutrinos may hold the key to why matter exists at all in the universe, as opposed to nothing. The LBNF/DUNE experiment will find the answer to this and other compelling questions.

Beyond the known particles lie the known unknowns: phenomena whose existence has been inferred from observations, but whose fundamental nature is still unclear. Two of the most important are appropriately referred to as "dark matter" and "dark energy," indicating how little we know about them. In short, dark matter holds the universe together via gravity but cannot be seen; it is thought to be due to exotic new kinds of particles yet to be discovered. Dark energy acts as a kind of anti-gravity, slowly pulling the universe apart over time. Physicists have no idea yet what causes that effect, but it is clearly seen in multiple types of observations. Exploration of the "dark sector" is one of the great challenges for particle physics in the 21st century and has inspired several new collaborative efforts between SC and other Federal agencies. For example, SC is working with the National Science Foundation on the Cryogenic Dark Matter Search experiment and the Vera C. Rubin Observatory, which will make precision measurements of the effects of dark energy. SC continues its long-standing collaboration with NASA on the Fermi Gamma Ray Space Telescope mission and the Alpha Magnetic Spectrometer experiment on the International Space Station, both of which provide important indirect constraints on dark matter, among other science goals.

While HEP provides insights about the universe that inspire awe and intellectual curiosity, it also leads to practical advances here on Earth. The best-known practical application to emerge from HEP is the World Wide Web, created by researchers at CERN who needed a simple, platform-independent way to share data between collaborators separated across time-zones. Less known but also broadly impactful is the significant role HEP played in developing the critical technology underlying modern Magnetic Resonance Imaging (MRI) systems. The superconducting material developed for high-field magnets in large particle accelerators—as well as the industrial-scale deployment of the magnets needed in those facilities—drove down the cost and drove up the performance of the technology, making modern high-resolution MRI an accessible and indispensable tool for medical diagnostics. Numerous other medical imaging technologies were derived from advanced sensors originally developed as particle physics detectors. More than 30,000 particle accelerators are in operation around the world, serving medicine, industry, energy, the environment, national security, and discovery science, with over 7,000 of them medical accelerators dedicated to the diagnosis and treatment of disease, including cancer. [1] As accelerator science and technology continue to advance, so too will their benefits to society.

NUCLEAR PHYSICS

Program Introduction

The NP program focuses on discovering, exploring, and understanding all forms of nuclear matter—including not only the familiar forms of matter we see around us, but also exotic forms that existed in the first moments of the universe and that may exist today inside neutron stars. The overarching goal of this program is to understand why matter takes on the specific forms observed in nature. The science supported by NP covers an extraordinary range in both time and scale: from probing quarks and gluons inside protons, to searching for the largest nuclei that can exist from microseconds after the Big Bang up to the present day. The community therefore requires access to a suite of accelerator facilities with unique, complementary capabilities. Currently, NP operates four national user facilities: the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab (BNL), the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF), the Argonne Tandem Linear Accelerator System (ATLAS), and the recently commissioned Facility for Rare Isotope Beams (FRIB) at Michigan State University. In the future, the Electron-Ion Collider (EIC), to be located at BNL, will provide the ability to "look inside" the proton and discover how the mass of

[1] The Accelerators for America's Future website has information about the broad range of applications of accelerator technology and links to workshops over the last more-than-a-decade sponsored by DOE. The website can be accessed at http://www.acceleratorsamerica.org/.

everyday objects is dynamically generated by the interaction of quark and gluon fields inside protons and neutrons. As noted by the National Academy of Sciences,[2] the EIC will also maintain U.S. leadership in accelerator science and technology of colliders. NP provides over 90 percent of the nuclear science research funding in the United States and supports U.S. participation in select international collaborations.

Research Goals

As documented in the National Research Council report, *Nuclear Physics: Exploring the Heart of Matter,*[3] NP research explores a broad range of epochs in the universe. RHIC recreates new forms of matter and phenomena that occurred in the extremely hot, dense environment that existed in the infant universe, including quark-gluon plasmas. CEBAF extracts information on quarks and gluons bound inside protons and neutrons that formed shortly after the universe began to cool. ATLAS "gently" accelerates nuclei to energies typical of nuclear reactions in the cosmos to further our understanding of the ongoing synthesis of heavy elements such as gold and platinum. FRIB, SC's newest scientific user facility located at Michigan State University, will afford access to eighty percent of all isotopes predicted to exist in nature and help to answer the long-standing "grand challenge" question of the ultimate limits of nuclear existence—extending our understanding of the extent to which neutrons can be added to elements before they become unstable—and the astrophysical sites and isotopic paths to heavy element production in the cosmos. All these experimental efforts, as well as the theoretical research that underpins them, is focused on understanding why matter takes on the specific forms observed in nature and how that knowledge can benefit society in the areas of energy, climate, commerce, medicine, and national security.

The future EIC will be a discovery machine for unlocking the secrets of the "glue" that binds the building blocks of visible matter in the universe. It will look inside the nucleus, and even inside its protons and neutrons. The EIC will be a particle accelerator that collides electrons with protons and nuclei to produce snapshots of those particles' internal structure. The electron beam will reveal the arrangement of the quarks and gluons that make up the protons and neutrons of nuclei. The force that holds quarks together, carried by the gluons, is the strongest force in nature. The EIC will allow us to study this "strong nuclear force" and the role of gluons in the matter within and all around us. While protons and neutrons make up the bulk of everything we see in the universe, their constituent quarks account for only a small fraction of their mass. That means gluons—massless particles that generate the glue-like force field of the strong nuclear force that holds quarks together—could account for more than 90 percent of the mass of visible matter in the universe, but the mechanism is unknown. The EIC will be a novel tool for exploring this inner microcosm dominated by gluons.

In addition to advancing scientific knowledge, pushing the boundaries of nuclear physics research facilities enables development of technologies that have near- and long-term benefits for society, even well outside of nuclear physics. The EIC currently beginning construction will be

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[2] National Academies of Sciences, Engineering, and Medicine 2018. An Assessment of U.S.-Based Electron-Ion Collider Science. Washington, DC: The National Academies Press. https://doi.org/10.17226/2517, p. 1.

[3] National Research Council 2013. Nuclear Physics: Exploring the Heart of Matter. Washington, DC: The National Academies Press. https://doi.org/10.17226/13438.

the most advanced collider ever built, and even at this early stage promises multiple game changing technological advances. First among these is the ability to "cool" the forces that ordinarily diffuse the packets of closely packed charged particles in an accelerator beam and reduce the probability of the particles colliding as desired to provide new scientific insights. The development of so-called "strong cooling" technology for the EIC will allow it to have the highest collisions rate ("luminosity") possible and is also of central interest to any application requiring an extremely intense particle beam, such as materials testing and modification, production of X-rays for lithography, radiography, high-power microwave generation, or nuclear fusion.

The ability to develop, for the first time ever, a three-dimensional tomograph of the interior of the proton will require the development of innovative signal processing/noise reduction techniques as well as ultrafast on-the-fly data syncing and image reconstruction. These are technological advances with ready extension to imaging for other important applications in the physical sciences and medicine.

As the most challenging and complex particle collider ever built, the EIC will require full integration of innovative artificial intelligence, machine learning and advanced sensor technology, advancing the state-of-the-art for optimization of particle accelerator facility command and control as well as operational safety and efficiency—technological advances readily extensible to any complex electro-mechanical system.

ISOTOPE R&D AND PRODUCTION

Program Introduction:

The Department of Energy Isotope R&D and Production Program (DOE IP) supports world-leading research and development associated with creating novel and more efficient isotope production and processing techniques and has been at the forefront of the development and production of radioactive and stable isotopes that are used worldwide.[4] Isotopes are vital to ensuring the Nation's security and prosperity. They are enabling components in technologies used for numerous mission critical applications. Isotopes are used in, for example, the development and deployment of technologies for national security and defense, energy production, industrial manufacturing, medicine, quantum information, space exploration, and discovery science. DOE IP is uniquely responsible for producing critical radioactive and stable isotopes for the Nation that are either in short supply or not commercially available. For many isotopes, DOE IP is the only producer in the world.

DOE IP maintains robust partnerships with Federal and industrial stakeholders. This ensures its isotope production and R&D activities are focused on meeting the Nation's critical isotope needs. For example, DOE IP chairs an interagency group to ensure helium-3 availability for national security and cryogenics. DOE IP has recently established production capabilities for strontium-90, promethium-147, and other radioisotopes for nuclear batteries and long-lived radioisotope power sources for defense and space applications. Advanced stable isotope

[4] DOE IP was restructured to a stand-alone program within the Office of Science (SC) in 2020 after more than a decade as a subprogram within the SC Office of Nuclear Physics (NP). To assist DOE IP in planning for the future of the isotope research and production, SC is establishing a dedicated advisory committee for the program.

enrichment capabilities are being established to address demand in medicine, research, and quantum information science (QIS). DOE IP is working with advanced nuclear fission and fusion energy companies to establish the enriched stable isotope supply chains necessary for development, demonstration, and deployment projects. The DOE IP is collaborating with the National Cancer Institute (NCI) to accelerate the transition of promising medical isotopes, such as actinium-225, from the laboratory to clinical trials. DOE IP works closely with U.S. industry, providing isotopes that our foundational to a multitude of applications, such as californium-252 for oil/gas well logging, nickel-63 for explosives testing at airports, and barium-133 for industrial radiography. Overall, DOE IP has a profound impact on the Nation and contributes daily to its security and prosperity.

Research Goals:

The research portfolio of DOE IP is high impact, encompassing advanced targetry, radiochemistry, accelerator and reactor physics, engineering, robotics, and artificial intelligence. The two primary focus areas of the research program are 1) isotopes that can be transformative for cancer therapy, and 2) developing modern enrichment technology for stable isotopes.

A dramatic shift from chemotherapy, targeted alpha therapy (TAT) is an emerging cancer treatment that has shown stunning success in treating metastasized cancers.[5] For more than a decade, DOE IP has conducted research aimed at developing production and chemical separation techniques to increase availability of isotopes used in TAT in large enough quantities to support clinical trials and applications, in direct response to requests from the NIH and medical community. As a result, DOE IP leads globally in the provision of TAT isotopes and is currently supporting multiple clinical trials.

The U.S. and Russia are the only two countries with expansive stable isotope inventories. Russia still produces enriched stable isotopes with electromagnetic-type devices and gas centrifuges. DOE IP has been re-establishing stable isotope enrichment production in the U.S. that has not existed since the 1990's to replenish dwindling inventories and alleviate dependence on Russia. DOE IP successfully developed novel electromagnetic isotope separation (EMIS) and modern gas centrifuge capabilities in 2017 and currently operates a small EMIS capability at ORNL. The Stable Isotope Production and Research Center (SIPRC), currently under construction, will include modern electromagnetic and gas centrifuge devices and dramatically increase our ability to perform multiple isotope production campaigns at large scale.[6] China is also developing significant stable isotope enrichment capabilities, moving quickly on multiple projects, including construction of a facility that seems similar in magnitude to SIPRC. The U.S. is third in stable isotope production capabilities, behind Russia and China. DOE IP is developing new enrichment capabilities using Atomic Vapor Laser Isotope Separation (AVLIS), to restore U.S. leadership

5 For a brief description of TAT, see https://joint-research-centre.ec.europa.eu/scientific-activities-z/medical-applications-radionuclides-and-targeted-alpha-therapy_en#:~:text=Targeted%20Alpha%20Therapy%20is%20based,are%20spread%20throughout%20the%20body. For review articles summarizing research on TAT, see https://link.springer.com/article/10.1007/s12210-020-00900-2, https://pubmed.ncbi.nlm.nih.gov/30326033/, or https://pubmed.ncbi.nlm.nih.gov/22143940/. . A teaching video for an IB Chemistry course can be found at https://www.youtube.com/watch?v=bH3plIzYLS8.
6 SIPRC is expected to begin operations in 2032.

and core competencies in multiple stable isotope enrichment capabilities. When implemented, the technique could provide large quantities of enriched isotopes needed for advanced, high-burnup nuclear fuels, improving operational reliability and reducing spent fuel generation. Other AVLIS enriched isotopes can support medical, scientific, and research purposes.

Impacts of Russian Invasion of Ukraine on Isotope Availability

The U.S. is dependent upon Russia for many critical isotope supply chains. Russia is the sole or primary source globally of many isotopes needed for medical, commercial, national security, and scientific applications. Current major projects supported by DOE IP, including SIPRC, were identified and initiated prior to Russia's invasion of Ukraine in part due to the recognition of the increased risk posed by reliance on a single country for critical isotopes.[7] Currently, DOE IP is actively working with Federal agencies and industry to identify and mitigate shortages in essential isotopes, within available funds; examples include helium-3 for cryogenics, carbon-14 for radio labeling of bio-chemical compounds for new drug development, cobalt-57 for Mossbauer Spectroscopy (heavily used in the study of nuclear structure in the physical sciences), and ytterbium-171 for quantum computing memory.

To entirely remove U.S. dependence on Russia in the long-term and meet growing U.S. radioisotope demand requires additional radiochemistry infrastructure through the completion of the Radioisotope Processing Facility (RPF) at Oak Ridge National Laboratory (ORNL) for reactor target processing. DOE IP is re-establishing stable isotope enrichment in the U.S. that has not existed since the 1990s. While currently Russia is the major commercial producer of stable isotopes world-wide, the SIPRC will provide the U.S. with large scale production capabilities of stable isotopes to rival those of Russia as well as the new Chinese facility under construction.

INFRASTRUCTURE

National Laboratory Infrastructure

The DOE mission is supported by the 17 DOE National Laboratories. SC supports research across the entire laboratory complex, with the largest share of contributions going to the 10 SC-stewarded National Laboratories. The expertise of the laboratory staff, and the research capabilities they help develop and operate, are invaluable assets that serve to advance the frontiers of fundamental scientific discovery, train the scientific and technical workforce in the U.S., and develop the tools and advanced instrumentation that keep our Nation at the forefront of innovation. The DOE National Laboratories are essential resources that the Nation turns to in time of emergencies. The optimal operation of this complex is indispensable to the country's leadership in science and technology development to ensure our energy, economic, and national security.

The DOE National Laboratories were established from the 1940s to 1960s, with some approaching 80 years of service. The research facilities at these Laboratories—including general research laboratories, specialized research centers, accelerators, light sources, high-performance computers, and two nuclear reactors—are supported by general-purpose infrastructure and a vast network of utilities that form the backbone of each site. The 10 SC-stewarded laboratories alone

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7 DOE IP is the only Mission Essential Function in the Office of Science and continues to operate during times of national crisis, mitigating disruptions in isotope supply chains.

comprise an infrastructure portfolio worth nearly $22 billion, consisting of more than 1,600 buildings accounting for 24 million gross square feet, roads, utilities, and other supporting infrastructure assets on more than 18,000 acres of land. Today, nearly two-thirds of this support infrastructure, including utility systems, is rated as substandard or inadequate, with current deferred maintenance costs totaling $1 billion. This results in unplanned outages, costly repairs, elevated safety risks, and inefficiencies that impact our ability to maximize contributions to science and society. The Office of Science is pursuing a robust portfolio of maintenance and modernization construction projects across the 10 laboratories in our stewardship, which enable our continued innovation in the conduct of scientific discovery itself to address modern problems, including the application of AI and automation to scientific discovery.

Large-Scale Experimental Facilities

DOE's Office of Science stewards the construction and operation of some of the largest scale experimental facilities ever conceived to probe fundamental questions about the nature of matter, energy, and the cosmos. These powerful discovery tools have helped us unlock exciting insights into the universe that inspire scientists to continue asking new and ever more ambitious questions. It is part of SC's mission is to "deliver…the scientific tools to transform our understanding of nature…", in part because the scale of these projects is too vast to be pursued by smaller groups of researchers or by individual institutions (e.g., universities, private companies). Though realization of these discovery tools is challenging given their scope and ambition, SC has a demonstrated track record of working across constituencies to define these projects and bring them to fruition to meet the Department's science, energy, and security goals, in addition to the wider range of scientific and technical efforts pursued by other Government agencies and the private sector.

NP supports operations at multiple national accelerator user facilities, including the Relativistic Heavy Ion Collider (RHIC), the Continuous Electron Beam Accelerator Facility (CEBAF), the Argonne Tandem Linear Accelerator System (ATLAS), and the Facility for Rare Isotope Beams (FRIB). Completed earlier this year, FRIB is now beginning to deliver on its promise to afford access to eighty percent of all isotopes predicted to possibly exist in nature, including over 1,000 never produced on Earth. The operations of these facilities will be further enhanced by deployment of data analytics tools for autonomous decision making, currently under development through support from NP as well as parallel efforts being advanced across the SC programs. FRIB came in ahead of schedule and on-budget, serving as an exemplar of SC's project management approach and the value of the unique Cooperative Agreement with Michigan State University that was developed for the project.

Currently under construction, the Long Baseline Neutrino Facility/Deep Underground Network Experiment (LBNF/DUNE) aims to enable detection and study of one of nature's most abundant, yet elusive, particles by generating an intense beam of neutrinos, sending it underground for hundreds of miles, and measuring it using very massive detectors. These studies could advance understanding of fundamental science questions—such as, why the universe is comprised of matter instead of antimatter. The project is uniquely complex given both the scale and novelty of the detectors as well as the environment within which they will operate. This complexity made it difficult to advance the design of all parts of LBNF/DUNE simultaneously, so it has been split into subprojects to facilitate more nimble project management. DOE has continuously evaluated LBNF/DUNE and made adjustments to continue advancing it in a timely manner. The Department and its international partners have confidence that the current approach with sub-projects will provide stability going forward and will allow the project to meet its goals more quickly; this approach will be more thoroughly assessed this summer.

Isotope production and processing requires significant and varied infrastructure: nuclear reactors, particle accelerators, facilities to handle nuclear materials and waste, nuclear facilities for radiochemical processing and separations, and secure facilities for enrichment technology. DOE IP has maximized use of existing capabilities throughout the DOE/NNSA complex and university landscape, cost-effectively exploiting capabilities and recovering valuable isotopes from legacy wastes. However, new infrastructure investments are required to mitigate dependencies on foreign supplies of critical isotopes. In the coming years, DOE IP will be completing two projects—the Stable Isotope Production and Research Center (SIPRC) and Radioisotope Processing Facility (RPF), both at Oak Ridge National Laboratory—that will significantly expand on the program's existing laboratory and university-based capabilities in R&D and production of both stable and radioisotopes. SIPRC will provide the U.S. with the capability to enrich large-scale amounts of multiple stable isotopes simultaneously.[8] RPF will provide urgently needed radiochemical separation capabilities to meet the growing demand for radioisotopes.[9] In addition, DOE IP is reviewing the potential need and use of new facilities and will continue to support R&D at the Facility for Rare Isotope Beams (FRIB) to extract and process unreacted isotopes collected after experiments.

The upcoming Electron Ion Collider (EIC) will extend the conventional facilities and technical infrastructure initially constructed for the Relativistic Heavy Ion Collider. Beyond the partnership between Brookhaven National Laboratory and the Thomas Jefferson National Accelerator Facility, the EIC is being constructed with participation by multiple DOE labs including Argonne, Lawrence Berkeley, Los Alamos, Lawrence Livermore, and Oak Ridge National Laboratories.[10] The EIC is intended to be a scientific asset for the world, and international collaboration with Italy, France, the U.K., Canada, Japan, Poland, and the Czech Republic is actively being pursued. Other countries have expressed interest as well.

These major infrastructure investments and feats of scientific inquiry are aimed at harnessing efforts from broad swaths the HEP, NP, and IP communities. Input regarding the needs for these sorts of facilities is derived from our strategically assembled advisory committees and planning processes to ensure that investment dollars are enabling extensive and impactful research portfolios as we continue to build our understanding of the universe.

Science Laboratories Infrastructure (SLI)

[8] The Stable Isotope Production and Research Center (SIPRC) achieved CD-1 in 2021 and its completion has been delayed to at least 2032, due to constrained funding.
[9] RPF achieved CD-0 in 2021, but constrained funding has pushed completion to at least 2032.
[10] The project received CD-1 in June of 2021. Operation of the EIC is envisioned to begin early in the early 2030s, subject to annual appropriations.

The Science Laboratories Infrastructure (SLI) program enables scientific and technical innovation at the SC-stewarded laboratories by funding and sustaining general purpose infrastructure. Though these investments are not directed to specific program areas or projects, it is important to note that they enable an expansive portfolio of experiments, including the large-scale experiments. Since 2006 and with the support of Congress, the SLI program has invested over $1.2 billion to support general purpose buildings and utilities in line-item construction, general plant, and focused utility projects that have successfully provided modern, reliable, and mission-ready facilities and infrastructure to support the SC mission now and into the future. The Department's continued emphasis on addressing core infrastructure issues across the DOE laboratory complex will enhance the ability of these laboratories to continue delivering scientific and technical leadership for the next 80 years and beyond.

WORKFORCE DEVELOPMENT

SC and all its programs are committed to training a highly skilled research workforce drawing from the best minds across the full spectrum of backgrounds and cultures within the Nation, in alignment with the Biden administration's priorities emphasizing diversity, equity, and inclusion in STEM fields. SC workforce development initiatives support undergraduates, graduate students, and postdoctoral researchers through research and development awards at universities and at the DOE national laboratories as well as educational and training programs to promote science and energy literacy.

Many of the future STEM professionals trained by SC are in the crucial areas of high energy and nuclear physics and isotope production. For example, DOE NP operates a traineeship opportunity for undergraduate students to help ensure the future U.S. nuclear science workforce remains the most competent and capable resource of its kind in the world, while DOE IP trains students and postdoctoral researchers to address the high demand for all core competencies in isotope research and production. The DOE IP traineeship program, in which Texas A&M is the lead institution partnering with 13 other academic sites and 3 DOE/NNSA National Laboratories, was designed to link academic institutions, particularly minority serving institutions (MSIs), with active programs and researchers involved in isotope production and processing, enabling students to participate in activities at a minimum of two different isotope production sites.

The Reaching a New Scientific and Energy Workforce (RENEW) program aims to build foundations for SC research at institutions historically underrepresented in the SC research portfolio. RENEW leverages SC's unique national laboratories, user facilities, and other research infrastructures to provide training opportunities for undergraduate and graduate students, postdoctoral researchers, and faculty at academic institutions not currently well represented in the U.S. science and technology ecosystem. The hands-on experiences gained through the RENEW initiative will open new career avenues for the participants, forming a nucleus for a future pool of talented young scientists, engineers, and technicians with the critical skills and expertise needed for the full breadth of SC research activities. HEP and IP have issued new funding opportunity announcements (FOAs) through the RENEW program, while NP is using RENEW funding to expand its current undergraduate program with an emphasis on engaging institutions and communities historically underrepresented in nuclear physics research.

Workforce development by these SC programs benefits society not just through advancing research into fundamental questions about the universe, but also by providing career pathways beyond the physics research community. It is estimated that more than two-thirds of people trained in particle physicists and over half of those trained in nuclear physics find their way to diverse sectors of the economy, including energy, information technology, medical physics and imaging, nuclear medicine, electronics, communications, space exploration, national security, and finance. For example, scientists trained in high energy and nuclear physics have pioneered methods in meteorology to measure raindrop sizes with optical sensors. Others are working to develop technologies essential for the realization of a long-distance quantum network. And many of the top financial analysts developed their modeling skills while being trained in particle physics. Wherever the workforce requires highly developed analytical and technical skills, the ability to work in large teams on complex, often globally distributed projects, and the ability to think creatively to solve unique problems, you will find people trained by HEP, NP, and DOE IP workforce development programs.

CONGRESSIONAL GUIDANCE

SC welcomes the opportunity to work with Congress and our communities to plan and direct the activities of programs in high energy and nuclear physics and isotope research moving forward. We continue to adhere to a structured planning process for developing our world-leading portfolios that treats researchers as valued partners. The Particle Physics Project Prioritization Panel (P5) Strategic Planning process, coordinated by the High Energy Physics Advisory Panel (HEPAP), plays a crucial role in setting priorities for particle physics. The joint DOE/NSF Nuclear Science Advisory Committee (NSAC) provides guidance for nuclear physics and periodically pursues a long-range planning activity to identify the most compelling science questions in the field and guide major programmatic decisions, including next-generation facilities. Going forward, we are pursuing establishing an advisory committee dedicated to isotope R&D and Production, replacing the isotope subcommittee of NSAC. The National Academy of Sciences contributes regular Decadal Surveys on Astronomy and Astrophysics. SC incorporates advising from the research communities through these mechanisms into broader strategic planning and communicates with OMB and OSTP to cooperatively develop budget requests. It is by following this process that SC can be confident that information we provide to Congress accurately reflects the consensus priorities of the relevant research communities and the executive branch of the Federal Government. SC welcomes Congressional guidance and oversight in developing program directions, ensuring necessary authorizations, and determining appropriate funding levels to achieve mission goals.

CONCLUSION

Chairman Bowman, Ranking Member Weber, and members of the Committee, thank you again for the opportunity to speak with you about our High Energy and Nuclear Physics programs, the importance of isotopes and the work of our Isotope R&D and Production program to meet national needs, and our efforts on ensuring reliable infrastructure and the skilled workforce to enable both missions. Within the Federal Government's research enterprise, SC's core competence is in large scale, multi-institutional, multi-disciplinary science, which takes many forms—large research centers and national laboratories, user facilities, and hosting international mega-science projects such as LBNF/DUNE. To do “big science” well, SC researches and develops the science and technology needed for building the large experimental facilities where future research will be done—cutting-edge particle accelerators, isotope harvesting facilities, exascale supercomputers running artificial intelligence algorithms, and so on. In this way, SC is a force multiplier accelerating scientific advances in multiple fields. SC also serves as the Federal Government’s science and technology research service and research laboratories. At the aptly named DOE National Laboratories, staff conduct research not just to meet DOE’s mission, but also on behalf of other Federal agencies, as well as state and local governments, and even in partnership with industry to serve the public good. SC’s 28 user facilities are where researchers in government, academia, and industry employ world-leading experimental tools to do research at scales that cannot be supported by individual institutions such as universities or corporate laboratories.

Perhaps in no other fields are these massive scales and futuristic technologies as necessary as in High Energy and Nuclear Physics and Isotope R&D and Production. To answer extreme questions about the smallest-scale structures of the universe and its earliest moments requires extreme technologies and engineering, such as the most powerful and highest luminosity particle accelerators and fastest supercomputers. With support for infrastructure and continuing programs for developing a diverse and highly skilled workforce, SC will continue to provide insights into the fundamental nature of the universe and deliver the isotopes and technologies to meet the Nation’s needs.