DEPARTMENT OF ENERGY
OFFICE OF SCIENCE

FY 2022 CONTINUATION OF SOLICITATION FOR THE OFFICE OF SCIENCE FINANCIAL ASSISTANCE PROGRAM

FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) NUMBER:
DE-FOA-0002562

FOA TYPE: Amendment 000001
CFDA NUMBER: 81.049

This amendment is being made to clarify instructions about how to identify individuals who should not serve as merit reviewers. See pages i., iii., and 75.

FOA Issue Date:	**September 30, 2021**
Submission Deadline for Pre-Applications:	**A Pre-Application is optional/encouraged**
Submission Deadline for Applications:	**Not Applicable** This Funding Opportunity Announcement (FOA) will remain open until September 30, 2022 or until replaced by a successor FOA. Applications may be submitted any time during that period.

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UPDATES AND REMINDERS

Recommendation

The Department of Energy (DOE) Office of Science (SC) encourages you to register in all systems as soon as possible. You are also encouraged to submit letters of intent (LOIs), pre-applications, and applications well before the deadline.

Current and Pending Support and Biographical Sketches

The instructions for the content of current and pending support and biographical sketches have changed. Please read the instructions carefully and follow them.

Individuals who Should not Serve as Merit Reviewers

Follow the updated instructions in Section VIII and consider the use of the template available at https://science.osti.gov/grants/Policy-and-Guidance/Agreement-Forms. Do not include this list as part of the biographical sketch.

Reporting and Administrative Requirements

DOE is implementing enhanced reporting requirements for applications and awards. Reporting and administrative requirements, including but not limited to those pertaining to other sources of support and potential conflicts of interest or commitment, are subject to change before the Federal award date. The terms and conditions of award will specify changed requirements: Applicants have the right to reject any proposed awards. Terms and conditions may be modified at the time of an award modification: Recipients have the right to reject such modifications and allow an award to expire.

Unique Entity Identifier (UEI)

The Federal Government is transitioning from the Data Universal Numbering System (DUNS), assigned by Dun and Bradstreet at https://fedgov.dnb.com/ to the UEI, assigned by the System for Award Management at https://www.sam.gov. Information systems including SAM.gov, Grants.gov and PAMS (https://pamspublic.science.energy.gov) are being updated: Please follow the on-screen instructions or contact each system's Help Desk for additional information. Detailed information about the transition is available at https://www.gsa.gov/about-us/organization/federal-acquisition-service/office-of-systems-management/integrated-award-environment-iae/iae-information-kit/unique-entity-identifier-update.

Acknowledgment of Federal Support

SC guidance about how its support should be acknowledged is published at https://science.osti.gov/funding-opportunities/acknowledgements/.

PUBLIC ACCESS

Awards made under this FOA are subject to DOE's Public Access Plan (https://www.energy.gov/downloads/doe-public-access-plan). Full-text version of scientific publications must be made publicly accessible at no charge to readers.

SC STATEMENT OF COMMITMENT

The DOE SC is fully and unconditionally committed to fostering safe, diverse, equitable, and inclusive work, research, and funding environments that value mutual respect and personal integrity. Discrimination and harassment undermine SC's ability to achieve its mission by reducing productivity, discouraging, or inhibiting talent retention and career advancement, and weakening the integrity of the SC enterprise overall. SC does not tolerate discrimination or harassment of any kind, including sexual or non-sexual harassment, bullying, intimidation, violence, threats of violence, retaliation, or other disruptive behavior in the federal workplace, including DOE field site offices, or at national laboratories, scientific user facilities, academic institutions, other institutions receiving SC funding, or other locations where activities funded by SC are carried out. All applicants and collaborators should familiarize themselves with the SC Statement of Commitment available at https://science.osti.gov/sc-2/Research-and-Conduct-Policies/Diversity-Equity-and-Inclusion/SC-Statement-of-Commitment.

UPDATING YOUR PAMS PROFILE

All applicants are encouraged to update their profiles in the PAMS website at https://pamspublic.science.energy.gov regularly, at least annually, to ensure SC has your most up to date information. The PAMS profile now requires that individuals provide responses to the demographic related fields. SC strongly encourages applicants and awardees, including Principal Investigators (PIs), Co-PIs, and other Key Personnel, to provide their demographic information. By providing your demographic information, you are assisting with SC's continued commitment to advancing diversity, equity, and inclusion in its business practices. Alternatively, for information you wish not to disclose, please select, "Do not wish to provide." Your individual demographic information will not be shared with peer reviewers and the information in your PAMS profile is protected by the requirements established in the Federal Privacy Act of 1974. Aggregate, anonymized demographic information may be shared with confidential review committees who are charged to evaluate the quality and efficacy of SC's business practices. For example, summary statistics of all applicants to or awardees selected from a particular SC FOA may be reviewed by a Committee of Visitors.

PDF GENERATION

The research narrative in an application must be one single machine readable PDF file that contains the DOE Title Page, project narrative, biographical sketch, current and pending support, bibliography and references cited, facilities and other resources, equipment, data management plan, and other attachments. This single PDF file may not be scanned from a printed document and must be attached in Field 8 on the Grants.gov form. You are strongly encouraged to submit the combined research narrative file through a "Print to PDF" or equivalent process to ensure

that all content is visible in one PDF file.

Checklist for Avoiding Common Errors:

Item	**Issue**
Page Limits	Strictly followed throughout application, including particular attention to: - Research Narrative - Appendix 2 Narrative, if any - Biographical sketches - Data Management Plan(s) (DMPs) - Letter(s) of Recommendation, if any
Personally Identifiable Information	None present in the application
Research Narrative	Composed of one PDF file including all appendices
List of Individuals who Should not Serve as Merit Reviewers	Provided as separate file in application
Project Summary / Abstract	Name(s) of applicant, Principal Investigator (PI)(s), PI's institutional affiliation(s), Co-Investigator(s), Co-Investigator's institutional affiliation(s)
DOE Title Page	Follow instructions closely
Budget	Use current negotiated indirect cost and fringe benefit rates
Budget Justification (attached to budget)	Justify all requested costs
Biographical Sketches	Follow page limits strictly
Current and Pending Support	Ensure complete listing of all activities, regardless of source of funding
Data Management Plans (DMP)	- If referring to an experiment's DMP, describe the relationship to the proposed research - Include a DMP even if no experimental data is expected

Section I – FUNDING OPPORTUNITY DESCRIPTION

GENERAL INQUIRIES ABOUT THIS FOA SHOULD BE DIRECTED TO:

Technical/Scientific Program Contact: Questions regarding the program technical requirements must be directed to the point of contact listed for each program area within this FOA.

STATUTORY AUTHORITY

Section 646 of Public Law 95-91, U.S. Department of Energy Organization Act
Section 901, et seq. of Public Law 109-58, Energy Policy Act of 2005

APPLICABLE REGULATIONS

Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards, codified at 2 CFR 200
U.S. Department of Energy Financial Assistance Rules, codified at 2 CFR 910
U.S. Department of Energy, Office of Science Financial Assistance Program Rule, codified at 10 CFR 605

SUMMARY

The Office of Science (SC) of the Department of Energy (DOE) hereby announces its continuing interest in receiving grant applications for support of work in the following program areas: Advanced Scientific Computing Research, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics, Nuclear Physics, Isotope R&D and Production, and Accelerator R&D and Production. On September 3, 1992, DOE published in the Federal Register the Office of Energy Research Financial Assistance Program (now called the Office of Science Financial Assistance Program), 10 CFR 605, as a Final Rule, which contained a solicitation for this program. Information about submission of applications, eligibility, limitations, evaluation and selection processes and other policies and procedures are specified in 10 CFR 605.

This FOA is our annual, broad, open solicitation that covers all research areas in SC and is open throughout the Fiscal Year. Any research within SC's Congressionally-authorized mission may be proposed under this FOA.

This FOA will remain open until September 30, 2022, 11:59 PM Eastern Time, or until it is succeeded by another issuance, whichever occurs first. This FOA succeeds DE-FOA-0002414, which was published October 1, 2020.

SUPPLEMENTARY INFORMATION

The SC mission is to deliver scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic and national security of the United

States. SC is the Nation's largest Federal sponsor of basic research in the physical sciences and the lead Federal agency supporting fundamental scientific research for our Nation's energy future.

SC accomplishes its mission and advances national goals by supporting:

- The frontiers of science—exploring nature's mysteries from the study of fundamental subatomic particles, atoms, and molecules that are the building blocks of the materials of our universe and everything in it to the DNA, proteins, and cells that are the building blocks of life. Each of the programs in SC supports research probing the most fundamental disciplinary questions.

- The 21st Century tools of science—providing the Nation's researchers with 28 state-of-the-art national scientific user facilities - the most advanced tools of modern science - propelling the U.S. to the forefront of science, technology development and deployment through innovation.

- Science for energy and the environment—paving the knowledge foundation to spur discoveries and innovations for advancing the Department's mission in energy and environment. SC supports a wide range of funding modalities from single principal investigators to large team-based activities to engage in fundamental research on energy production, conversion, storage, transmission, and use, and on our understanding of the earth systems.

SC manages its research portfolio through eight scientific program offices. The following program descriptions, websites, and technical points of contact are offered to provide more in-depth information on scientific and technical areas of interest to SC:

1. Advanced Scientific Computing Research (ASCR)
(a) Applied Mathematics
(b) Computer Science
(c) Computational Partnerships
(d) Advanced Computing Technologies

2. Basic Energy Sciences (BES)
(a) Materials Chemistry
(b) Biomolecular Materials
(c) Synthesis and Processing Science
(d) Experimental Condensed Matter Physics
(e) Theoretical Condensed Matter Physics
(f) Physical Behavior of Materials
(g) Mechanical Behavior and Radiation Effects
(h) X-ray Scattering
(i) Neutron Scattering
(j) Electron and Scanning Probe Microscopies
(k) Atomic, Molecular, and Optical Sciences

(l) Gas Phase Chemical Physics
(m) Computational and Theoretical Chemistry
(n) Condensed Phase and Interfacial Molecular Science
(o) Catalysis Science
(p) Separation Science
(q) Heavy Element Chemistry
(r) Geosciences
(s) Solar Photochemistry
(t) Photosynthetic Systems
(u) Physical Biosciences
(v) BES Accelerator and Detector Research

3. Biological and Environmental Research (BER)
(a) Biological Systems Science
(b) Earth and Environmental Systems Sciences

4. Fusion Energy Sciences (FES)
(a) Burning Plasma Science: Foundations—Advanced Tokamak
(b) Enabling Research and Development
(c) Burning Plasma Science: Foundations—Spherical Tokamak
(d) Burning Plasma Science: Foundations—Theory & Simulation
(e) Burning Plasma Science: Long Pulse—Tokamak
(f) Burning Plasma Science: Long Pulse—Stellarator
(g) Burning Plasma Science: Long Pulse—Materials
(h) Burning Plasma Science: Long Pulse—Fusion Nuclear Science
(i) Discovery Plasma Science: Plasma Science and Technology
(j) Discovery Plasma Science: Measurement Innovation
(k) Public-Private Partnerships in Fusion Energy Research

5. High Energy Physics (HEP)
(a) Experimental Research at the Energy Frontier in High Energy Physics
(b) Experimental Research at the Intensity Frontier in High Energy Physics
(c) Experimental Research at the Cosmic Frontier in High Energy Physics
(d) Theoretical Research in High Energy Physics
(e) Computational Research in High Energy Physics
(f) Accelerator Science and Technology Research and Development in High Energy Physics
(g) Detector Research and Development in High Energy Physics
(h) Quantum Information Science for High Energy Physics Research

6. Nuclear Physics (NP)
(a) Medium Energy Nuclear Physics
(b) Heavy Ion Nuclear Physics
(c) Nuclear Structure and Astrophysics
(d) Fundamental Symmetries
(e) Nuclear Theory
(f) Nuclear Data

(g) Nuclear Theory Computing
(h) Accelerator Research and Development for Current and Future Nuclear Physics Facilities
(i) NP Quantum Information Science (QIS)

7. Isotope R&D and Production (DOE IP)
(a) Radioisotope Production
(b) Isotope Processing and Purification
(c) Nuclear Chemistry and Radiochemical Separations
(d) Biological Tracers and Imaging
(e) Isotope Enrichment Technology

8. Accelerator R&D and Production (ARDAP)

1. Advanced Scientific Computing Research (ASCR)
Program Website: https://science.osti.gov/ascr

The Advanced Scientific Computing Research (ASCR) program's mission is to advance applied mathematics and computer science; deliver the most sophisticated computational scientific applications in partnership with disciplinary science; advance computing and networking capabilities; and develop future generations of computing hardware and software tools for science and engineering in partnership with the research community, including U.S. industry. The strategy to accomplish this has two thrusts: developing and maintaining world-class computing and network facilities for science; and advancing research in applied mathematics, computer science and advanced networking.

ASCR supports cross-disciplinary research in which other domains of scientific inquiry may provide the data to provide use-cases for computer scientists and applied mathematicians to devise generalized methods, models, algorithms and tools. ASCR's interest in these fields is not to solve the specific problems in other scientific domains but to use those challenges to advance the state of the art and increase knowledge in its fields of research.

The priority areas for ASCR include the following:

- Develop mathematical models, methods and algorithms to accurately describe and predict the behavior of complex systems involving processes that span vastly different time and/or length scales.
- Advance key areas of computer science that:
  - Enable the design and development of extreme scale computing systems and their effective use in the path to scientific discoveries; and
  - Transform extreme scale data from experiments and simulations into scientific insight.
- Advance key areas of computational science and discovery that support the missions of SC through mutually beneficial partnerships.
- Develop and deliver forefront computational, networking and collaboration tools and facilities that enable scientists worldwide to work together to extend the frontiers of science.

The computing resources and high-speed networks required to meet SC needs exceed the state-of- the-art by a significant margin. Furthermore, the system software, algorithms, software tools and libraries, programming models and the distributed software environments needed to accelerate scientific discovery through modeling and simulation are often beyond the realm of commercial interest. To establish and maintain DOE's modeling and simulation leadership in scientific areas that are important to its mission, ASCR operates Leadership Computing facilities, a high-performance production computing center, and a high-speed network, implementing a broad base research portfolio in applied mathematics, computer and network sciences, and computational science to solve complex problems on computational resources that are on a trajectory to reach exascale and beyond.

The ASCR subprograms and their objectives follow:

(a) Applied Mathematics

This subprogram supports basic research leading to fundamental mathematical advances and computational breakthroughs across DOE and SC missions. Important areas of basic research include: (1) novel deterministic or randomized numerical methods for the scalable solution of large-scale, linear and nonlinear systems of equations, including those solution methods that take into consideration the possibilities brought about by future HPC architectures; (2) optimization techniques and next-generation solvers; (3) numerical methods for modeling multiscale, multi-physics or multi-component continuous or discrete systems that span a wide range of time and length scales; (4) methods of simulation and analysis of systems that account for the uncertainties of the systems, or are inherently stochastic or uncertain; (5) innovative approaches for analyzing, extracting insight from, or reducing large-scale data sets; and (6) foundational research in Scientific Machine Learning (Scientific ML) and Artificial Intelligence (AI) as a cross-cutting area of interest for enabling greater adaptivity, automation, and predictive capabilities in scientific computing.

Submission of preliminary research descriptions (e.g., preproposals, pre-applications) is strongly encouraged. They will be reviewed for responsiveness of the proposed work to the research topics. Specifically excluded is research that primarily results in evolutionary improvements to the existing state of practice. You must send email to a Subprogram Contact for information regarding format and content.

Subprogram Contacts:

- William Spotz, William.Spotz@science.doe.gov
- Steven Lee, Steven.Lee@science.doe.gov

Website: https://science.osti.gov/ascr/Research/Applied-Mathematics

(b) Computer Science

The Computer Science research program supports research that enables computing and networking at extreme scales and the understanding of extreme scale, or complex data from both simulations and experiments. It aims to make high performance scientific computers and

networks highly productive and efficient to solve scientific challenges while attempting to reduce domain science application complexity as much as possible. The computer science program does this in the context of sharp increases in the heterogeneity and complexity of computing systems; the need to seamlessly and intelligently integrate simulation, data analysis, and other tasks into coherent and usable workflows; and the challenges posed by highly novel computing platforms such as neuromorphic systems.

Priority interests for the program include the following. Applications are not restricted to a single topic and may span several topics.

- **Data management, analysis, and visualization**:
  SC-supported researchers and facilities are generating large, complex, multi-modal data at unprecedented rates. There is a need for advanced visualizations and visual analytics tools for making sense of these data and making operational decisions. This program solicits research to develop techniques for deriving and visualizing insights from large scale and/or complex simulation, experimental, or observational data or combinations of these as relevant to SC and DOE priority applications: Visual analysis of high-dimensional data at scale, data from multiple sources and of varying types, attributes such as uncertainty, and data in the context of domain-specific knowledge; and Visual analytic approaches to understanding artificial intelligence/machine learning outcomes or the state and behavior of a supercomputing system at scale. This program also solicits techniques and tools for advancing findable, accessible, interoperable reusable (FAIR) data practices of management, archiving, curation, and/or reuse, of data generated by experimental, observational, and simulation relevant to SC mission areas. Additional areas of interest include combining of data streaming and cloud storage uses for SC infrastructure as well as visualization needs at the edge for SC experimental facilities.

- **In Situ Data Management (ISDM):**
  Scientific computing will increasingly incorporate a number of different tasks that need to be managed along with the main simulation or experimental tasks—for example, ensemble analysis, data-driven science, artificial intelligence, machine learning, surrogate modeling, and graph analytics. Many of these tasks will need to execute concurrently, that is, in situ, with simulations and experiments sharing the same computing resources.

  ISDM capabilities can enable scientific discovery from a broad range of data sources—i.e. HPC simulations, experiments, scientific instruments, and sensor networks—over a wide scale of computing platforms: leadership-class HPC, clusters, clouds, workstations, and embedded devices at the edge. ISDM capabilities can also manage large data volumes from computations and experiments to minimize data movement, save storage space, and boost resource efficiency—often while simultaneously increasing scientific precision.

  This program solicits research to advance ISDM capabilities to run on computing platforms at a variety of scales; to be automated and controllable; to be more interoperable and composable; and to use provenance and metadata for transparent results. This program also solicits co-designed research activities for ISDM as well as new in situ algorithms.

- **Storage Systems and I/O:**
  The success of the DOE computational, experimental, and observational sciences is inextricably tied to the usability, performance, and reliability of emerging storage systems and input/output (SSIO) technologies. SSIO technologies involve the organization, movement, placement, and efficient retrieval of data to enhance computation and discovery. This program solicits research to improve SSIO capabilities that enable science understandability and reproducibility; accelerate scientific discovery; enhance SSIO usability, performance, and resilience; and improve efficiency and integrity of data movement and storage. One particular focus of this program is to improve pipelines for analysis-centric, data intensive workflows on high performance computing (HPC) systems, and that use large-scale storage.

- **Programming Models, Environments, and Portability:**
  Innovative programming models for developing applications on next-generation platforms, exploiting unprecedented parallelism, heterogeneity of memory systems (e.g. Non-Uniform Memory Access [NUMA], non-coherent shared memory, high-bandwidth memory [HBM], scratchpads, and heterogeneity of processing (e.g., Graphics Processing Units [GPUs], Field-Programmable Gate Arrays [FPGAs], Coarse-Grained Reconfigurable Architectures [CGRAs], other types of accelerators, big-small cores, processing in memory, and near memory, etc.), with particular emphasis on making it easier to program at scale. Basic research on programming tools for all phases of the software-development cycle are relevant, including but not limited to, design, implementation, verification, optimization, and integration.. Particularly welcome are methods that infuse artificial intelligence/machine learning into the programming environment.

- **Operating and Runtime Systems:**
  System software that provides intelligent, adaptive resource management and support for highly-parallel software and workflow-management systems, and that facilitates effective and efficient use of heterogeneous computing technologies, including diverse execution models, processors, accelerators, memory, and storage systems. Target workloads include modeling and simulation, data analysis, and the processing of large-scale, streaming data from experiments.

- **Performance Portability and Co-design:**
  Methods that support performance portability, which provides the ability to efficiently use diverse kinds of hardware platforms with minimal changes to the application source code, and/or hardware/software co-design, which is a method for designing and/or adapting both hardware and software design as part of a holistic process. These methods include automated and semi-automated refinements from high-level specification of an application and/or hardware design to low-level code, optimized when compiled and/or, for software, at runtime, to different HPC platforms. The focus is on enabling performance portability of, and/or the design of future hardware for, applications developed for extreme-scale computing and beyond.

- **Distributed Scheduling and Resource Management:**
  As scientific-computing resources are being called upon to support a wide variety of

workloads, including those that tightly integrate large-scale and ensemble simulation and data-analysis workflows with experimental data collection and control, the algorithms and implementations matching computational requirements to resources need to scale to handle more tasks, more resources, and more-widely-distributed resources. Specifically sought are methods for decentralized, resilient, secure resource management, scheduling, and coupled data transfer across widely-distributed computing facilities; and modeling of such distributed systems.

This program also supports:

- **Participation in International Standardization:**
  Scientific computing relies on robust adoption of Voluntary Consensus Standards[1] (VCSs) that are applicable to state-of-the-art computing technologies. Notably, most applications running at the ASCR user facilities depend on some combination of standardized programming languages and application-programming interfaces (APIs), and DOE contributes to many of them, including, but not limited to, the Message Passing Interface (MPI), C, C++, Fortran, OpenMP, and SYCL. Moreover, standardization is an important enabler of knowledge transfer from research to industry. Similarly, the characterization of computing hardware relies on benchmarks established through a VCS process, and these benchmarks drive industry decisions affecting what capabilities ASCR user facilities can provide. Such benchmarks include, but are not limited to, SPEC CPU/ACCEL and MLPerf. VCSs and benchmarks relevant to data, artificial intelligence and machine learning, quantum computing, software, and hardware interfaces are all in scope.

  The development of standards relies on robust participation from a broad spectrum of stakeholders, and the program supports maintaining and broadening participation in standards development. Standards development benefits from the participation of laboratory and university researchers in addition to experts from businesses of all sizes. Funding may support training on standards development and leadership, travel to relevant meetings, the hosting of relevant meetings, the development of proposals for, and associated prototypes of, new standardized functionalities, and any Standards Development Activity[2]. Particularly welcome are activities supporting US leadership in standards development and activities including a specific focus on broadening participation from experts from traditionally underrepresented groups, academic institutions, small businesses, and others who may face higher participation barriers.

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1 Voluntary Consensus Standards are "Standards [that] are developed through a process that is open to participation by representatives of all interested parties, transparent, consensus-based, and subject to due process. These might be developed by governmental organization or private sector groups such as the American Society for Testing and Materials (ASTM) or the International Organization for Standardization (ISO)." See https://www.directives.doe.gov/terms_definitions/voluntary-consensus-standard; for additional discussion, see Office of Management and Budget Circular Number A-119, https://www.nist.gov/system/files/revised_circular_a-119_as_of_01-22-2016.pdf

2 Standards Development Activity is defined in 15 USC § 4301(a)(7). See https://www.govinfo.gov/app/details/USCODE-2015-title15/USCODE-2015-title15-chap69-sec4301/summary

- **Activities Supporting Career Development, and Broadening Participation, in Computer-Science Research:**
  Computer science research depends on a healthy, diverse community of computer-science researchers. Professional networking, mentorship, and associated training activities targeting students and early-career researchers support the health and diversity of the research community. Particularly welcome are activities including a specific focus on outreach to members of groups that are underrepresented in computer-science research.

Topics that are out of scope for Computer Science include:

- Applications that address topics not covered in the list of Computer Science Priority Interests, above, except with the specific encouragement of a Computer Science program manager in response to an emailed white paper;
- Applications with primary emphasis on resilient solvers, and/or new development of machine probabilistic methods and their mathematical formalisms;
- Applications aimed at advancing computer-supported collaboration, social computing, and generalized research in human-computer interaction;
- Discipline-specific data analytics and informatics without a clear articulation of how the research will generalize to other disciplines and/or advance computer science capabilities;
- Research focused on the World Wide Web, the dark web, and/or data about it;
- Research that is primarily to advance cloud computing, hand-held, portable, desktop, and/or embedded computing that is not applicable to ASCR-supported computational and data science environments; and
- Research and applications not motivated and justified in the context of current and future SC user facilities, especially those supported by ASCR (i.e., Argonne Leadership Computing Facility or ALCF, Oak Ridge Leadership Computing Facility or OLCF, and National Energy Research Scientific Computing Center or NERSC): https://science.osti.gov/ascr/Facilities.

Submission of preliminary research descriptions (e.g., pre-proposals, pre-applications) is strongly encouraged. They will be reviewed for responsiveness of the proposed work to the research topics. You must send email to a Subprogram Contact for information regarding format and content.

Subprogram Contacts:

- Margaret R. Lentz, Margaret.lentz@science.doe.gov, Data management, analysis and visualization; In-Situ Data Management (ISDM);
- Hal Finkel, Hal.Finkel@science.doe.gov, Storage Systems and I/O (SSIO); programming models, environments, and portability; operating and runtime systems; performance portability and co-design; distributed scheduling and resource management;
- Hal Finkel, Hal.Finkel@science.doe.gov, and Margaret Lentz, Margaret.Lentz@science.doe,gov, Participation in international standardization and activities supporting career development, and broadening participation, in computer-science research.

Website: https://science.osti.gov/ascr/Research/Computer-Science;
https://science.osti.gov/ascr/Community-Resources/Program-Documents

(c) Computational Partnerships

This subprogram supports computational research that will advance partnerships with SC, National Nuclear Security Administration (NNSA), other DOE programs, and the National Cancer Institute (NCI).

This includes research in pioneering science applications for the next generation of high-performance computing and research that incorporates and integrates applied mathematics, computer science, and computational sciences, to enable scientists to exploit effectively extreme scale computers in their pursuit of transformational scientific discovery through simulation and modeling.

For examples of SciDAC partnerships, refer to the website https://www.scidac.gov.

For examples of extreme scale computing systems, refer to the website: https://science.osti.gov/ascr/Facilities/Accessing-ASCR-Facilities

Additionally, this subprogram supports basic research to enable scientists to easily find and interact with unique scientific facilities and data, and to work with peers or facilities staff involved in a scientific discovery process. Research topics of interest include:

- Theories, algorithms, tools, and services needed to create diverse computing environments where multiple resources can be combined in unique ways to suit the needs of an individual science community,
- Mechanisms and theories to enable scientists to interact with their peers and technical staff that operate a distributed scientific facility,
- Tools and services needed to support physical experiments in testbeds and production networks, and
- Advanced modeling and simulation methods and capabilities that can accurately predict and reliably validate the suitability and performance characteristics of large globally distributed infrastructures and workflows.

This subprogram also provides graduate research training for the next generation of scientists.

Subprogram Contacts:

- Randall Laviolette, Randall.Laviolette@science.doe.gov, SciDAC Partnerships;
- Ceren Susut, Ceren.Susut-Bennett@science.doe.gov, SciDAC Institutes;
- Richard Carlson, Richard.Carlson@science.doe.gov, Partnerships that enable scientists to easily find and interact with unique scientific facilities; and
- Christine Chalk, Christine.Chalk@science.doe.gov, Graduate research training.

Website: https://science.osti.gov/ascr/Research/scidac

(d) Advanced Computing Technologies (ACT)

This activity supports quantum computing and networking efforts and Research and Evaluation Prototypes (REP). The Research and Evaluation Prototypes (REP) activity addresses the

challenges of next generation computing systems. By actively partnering with the research community, including industry and Federal agencies, on the development of technologies that enable next-generation machines, ASCR ensures that commercially available architectures serve the needs of the scientific community. The REP activity also prepares researchers to effectively use future generation of scientific computers, including novel technologies, and seeks to reduce risk for future major procurements.

Research topics currently of interest for ACT include:

- Research focused on information processing and computation systems for emerging computing technologies including hardware architectures, accelerators, development of programming environments, languages, libraries, compilers, simulators, and research and development on their algorithms for physical simulation;
- Cybersecurity for scientific computing integrity: research on security techniques appropriate for open scientific environments, with a focus on ensuring scientific integrity in the context of extreme scale high performance computing and other SC Scientific User facilities to deliver means that assure trustworthiness within open high-end networking and data centers;
- Machine Learning: Scalable software, methods, and techniques that ensure algorithm scalability to extreme scales and applications that are generalizable to scientific computing applications and operation of HPC systems.
- Neuromorphic Computing: Specific to HPC-enabled modeling and simulation of computing architecture at extreme scales for generalizable applications of the proposed approach.
- Advanced Wireless for Science focusing is on communications that cover higher frequencies, THz, of 5G+ or WiFi6+ and software defined capabilities. The expanding national rollout of advanced wireless networks is creating opportunities for scientific applications;
- Microelectronics for Scientific Computing: For continued advances in computing technologies, a fundamental rethinking is needed of the science behind computing processor synthesis, placement, architectures, and algorithms. No longer can the approach be modular and linear, as it has been in the past. Rather, these advances must be developed collectively, in a spirit of co-design, where each scientific discipline informs and engages the other to achieve orders of magnitude improvements in system-level performance.
- Research to evaluate the suitability of specific quantum computing hardware architectures for science applications, including resource estimates for quantum computing applications of interest to SC;
- Theoretical methods and software tools to:
    - Assess the performance of real-world quantum processors
    - Facilitate device-specific optimization of individual operations ranging from state-preparation and measurement through gate implementation and compilation
    - Suppress noise, mitigate crosstalk, control errors, and maintain optimally high-fidelity operations in the absence of formal error correction; and
- Adaptation of promising new quantum computing technologies for testbed use.

Proposed research should focus on applications of quantum computing relevant to the SC and on devices that are already available or that become available during the term of the award rather than large-scale, high-fidelity, fault-tolerant machines.

Topics that are out of scope include:

- Research that does not address the specific ACT topics described above;
- Development of quantum algorithms;
- Development of new candidate qubit systems or improvements to physical qubits;
- Development of integrated circuits for quantum computing;
- Quantum transduction;
- Quantum communication, networking, and key distribution;
- Cryptography and cryptanalysis;
- Error correction codes and implementation of error correction codes;
- Research solely relevant to large-scale, high-fidelity, fault-tolerant machines; and
- Projects that are duplicative of or competitive with industry.

Submission of preliminary research descriptions (e.g., pre-proposals, pre-applications) is strongly encouraged. They will be reviewed for responsiveness of the proposed work to the research topics. You must send email to a Subprogram Contact for information regarding format and content.

Subprogram Contacts:

- Robinson Pino, Robinson.Pino@science.doe.gov, microelectronics, neuromorphic and heterogeneous computing architectures, advanced wireless, machine learning, and cybersecurity; and
- Claire Cramer, Claire.Cramer@science.doe.gov, quantum computing research and evaluation prototypes.

Website: https://science.osti.gov/ascr/

2. Basic Energy Sciences (BES)
Program Website: https://science.osti.gov/bes/

The mission of the Basic Energy Sciences (BES) program is to support fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels. BES research provides the foundations to develop new energy technologies, to mitigate the environmental impacts of energy generation/use, and to support DOE missions in energy, environment, and national security. The portfolio supports work in the natural sciences by emphasizing fundamental research in materials sciences, chemistry, geosciences, and biosciences. BES-supported scientific user facilities provide specialized instrumentation and expertise that enable scientists to carry out experiments not possible at individual laboratories.

New research directions and priority opportunities are defined in BES workshop and roundtable reports. These are posted on the BES website at https://science.osti.gov/bes/Community-Resources/Reports.

Proposed research must be responsive to a supported topic in one of the core research areas listed below. Overarching research priorities for BES that are relevant to multiple core research areas are described in the bulleted list below. The individual program descriptions further define research directions relevant to these priorities.

- **Fundamental Science to Enable Clean Energy**: Research to provide understanding and scientific foundations for clean energy, including direct air capture of carbon dioxide; hydrogen production, storage, and use; solar energy conversion to electricity and fuels; and electrical and thermal energy storage.
- **Critical Materials/Minerals**: Research to understand the fundamental properties of rare earth and platinum group elements to improve separation and extraction processes and to enable discovery and design of alternates to critical materials that will reduce or eliminate their need.
- **Fundamental Science to Transform Low-Carbon Manufacturing**: Research to understand fundamental chemical and materials processes for low-carbon, circular, clean, and scalable synthesis and processing; to advance transformational operando characterization and multiscale models and tools; and to co-design materials, processes, and products for functionality and use. Includes polymer upcycling, research to provide the foundational knowledge for the selective deconstruction of the polymers that constitute plastics, followed by reassembly into high-value chemicals, fuels, or materials in a repeating cycle.
- **Artificial Intelligence and Machine Learning (AI/ML)**: Research to advance the approaches and use of data science and AI/ML to accelerate fundamental research for the discovery of new chemical mechanisms and material systems with exceptional properties and function, and to apply these techniques for effective user facility operations and interpretation of massive data sets.
- **Quantum Information Science (QIS)**: Research to advance understanding of quantum phenomena in systems that could be used for quantum information science, and the use of quantum computing in chemical and materials sciences research.

The BES divisions, program areas, and their objectives follow:

Materials Sciences and Engineering

The Materials Sciences and Engineering (MSE) Division supports fundamental experimental and theoretical research to provide the knowledge base for the discovery and design of new materials with novel structures, functions, and properties. This knowledge serves as a basis for the development of new materials for the efficient generation, storage, and use of energy and for mitigation of the environmental impacts of energy use. The MSE research portfolio consists of the research program areas listed below.

MSE Division Website: https://science.osti.gov/bes/mse

(a) Materials Chemistry

This program supports hypothesis-driven research on materials with a focus on the role of chemical reactivity, chemical transformation, and chemical dynamics on the material composition, structure, function, and lifetime across the range of length scales from atomic to mesoscopic. Discovery of the mechanistic detail for chemical synthesis, transformations and dynamics of materials, fundamental understanding of structure-property relationships of functional materials, and utilization of chemistry to control interfacial properties and interactions between materials are common themes.

Major scientific areas of interest include: (1) Fundamental aspects of chemical synthesis, including covalent and non-covalent assembly of materials; (2) Synthesis and characterization of new classes of materials including hierarchical materials or other innovative assemblies of matter with novel functionality; (3) Exploitation of extreme conditions, complex chemistries and molecules, or non-equilibrium conditions to accelerate new materials discovery; (4) Control of interphase chemistry and morphology; (5) Fundamental electrochemistry of solid-state materials; (6) Chemical dynamics and transformations of functional materials in operational environments; and (7) Development of new tools and techniques for the elucidation of chemical processes in materials, particularly *in situ* or *operando* studies of materials in energy-relevant applications.

Specific topics of interest are aligned with recent BES roundtable and workshop reports and include chemical "upcycling" of polymers, fundamental investigations of rare earth compounds and other critical materials, discovery of materials with the potential to enable the future development of advanced quantum information systems, and new approaches to materials discovery using data-driven science such as AI/ML, with emphasis on materials that underpin clean energy technologies and low-carbon manufacturing.

Research will not be supported if it is primarily aimed at optimization of properties of materials for applications, optimization of synthetic methods (including non-science-based scale-up research), device fabrication and testing, or synthesis of small molecules or nanoparticles. Applications focused on the elucidation of mechanisms of catalytic reactions, particularly with single-site or single-atom catalysts, will not be supported.

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Website: https://science.osti.gov/bes/mse/Research-Areas/Materials-Chemistry

(b) Biomolecular Materials

This activity supports fundamental materials science research for discovery, design and synthesis of functional materials and complex structures based on principles and concepts of biology. Biology provides a blueprint for organizing and manipulating matter, energy, entropy, and information across multiple length scales to build material systems that display complex yet well-coordinated collective behavior. The major programmatic direction is on the science-driven creation of materials and multiscale systems that exhibit well-coordinated functionality and information content approaching that of biological materials but capable of functioning under harsher, non-biological environments. This research activity seeks innovative fundamental science approaches for co-design and scalable synthesis of materials for clean energy and quantum information science that coherently and actively manage multiple complex and simultaneous functions and tolerate abuse. An area of emphasis will be activities to understand and control assembly mechanisms to seamlessly integrate capabilities developed for one length scale across multiple length scales as the material is constructed. Included is development of predictive models and AI/ML for data-driven science that accelerate materials discovery and support fundamental science to direct clean, energy efficient scalable synthesis with real-time

adaptive control.

Major scientific areas of interest are: self, directed, and dissipative assembly to form resilient materials with self-regulating capabilities such as reconfiguration of morphology and function, autonomous self-healing and growth processes, control of active matter, and non-equilibrium information and signaling processing; management of precise functional group positioning and component interactions across multiple time and length scales; and design and creation of next-generation materials that incorporate low-energy mechanisms for programmable selectivity and active management of energy and fluid transport.

The program will not support projects that do not have a clear focus on fundamental materials science or are aimed at optimization of materials properties for any applications, device fabrication, sensor development, tissue engineering, understanding of underlying biological synthetic or assembly processes, biological research, or biomedical research.

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Website: https://science.osti.gov/bes/mse/Research-Areas/Biomolecular-Materials

(c) Synthesis and Processing Science

This program supports research to understand the physical phenomena and unifying principles that underpin materials synthesis and processing for clean energy across multiple length scales. Some of these phenomena include diffusion, nucleation, and phase transitions and the role imperfections and interfaces play in the emergence of materials functionality. The emphasis is on hypothesis-based research that enables discovery of new materials, including quantum materials, with targeted composition, structure and function. New crystal growth methods and thin-film deposition techniques are needed to create complex materials, including new states of matter or discoveries under non-equilibrium conditions and through (multi-) scale and external interactions.

Applications that focus on creative coupling of physical synthesis/processing techniques with computational/theory approaches, including AI/ML for data-driven science, and/or real-time diagnostic tools and characterization techniques to provide information on the dynamic progression of structure and composition, and enable atomic level control during synthesis are encouraged. The program emphasizes innovative research to understand materials growth kinetics and mechanisms, especially as they relate to the science of advanced low-carbon manufacturing processes, organic and inorganic film deposition with controlled defects, and the organization of multifaceted mesoscopic hierarchical assemblies. An emerging area is research that examines how structure affects the electron/magnetic transport and how the transport influences structure. Novel hypothesis-based science for synthesis and processing approaches that will provide understanding for reductions or substitutions of rare earth and critical materials also is encouraged.

Projects aimed at controlling synthesis to direct optimization or engineering of properties will be de-emphasized. In addition, research will not be supported that focuses primarily on engineering

or optimization based on known processing or synthesis principles, device fabrication, or device development.

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Website: https://science.osti.gov/bes/mse/Research-Areas/Synthesis-and-Processing-Science

(d) Experimental Condensed Matter Physics

The Experimental Condensed Matter Physics program supports research that will advance our fundamental understanding of the relationships between intrinsic electronic structure and properties of complex materials. Research supported by the program focuses on systems whose behavior derives from strong electron correlation, competing or coherent quantum interactions, topology, and effects of interfaces, defects, spin-orbit coupling, and reduced dimensionality. Scientific themes include charge, spin, and orbit degrees of freedom that result in phenomena such as superconductivity, magnetism, and topological protection, and the interactions of these in bulk and reduced-dimensional systems. The program supports synthesis and characterization of new material systems required to explore the central scientific themes. This includes development of novel experimental techniques enabling such research.

Growth areas include emergent quantum phenomena in topological materials, low-dimensional materials, van der Waals materials, and materials with targeted clean energy-relevant and next-generation quantum information and microelectronics functionality. Of particular interest are phenomena associated with quantum phononic and magnonic transport; and moiré quantum matter beyond 2D.

Areas of decreasing emphasis include heavy fermion (non-topological) superconductivity and fractional quantum Hall physics. The program will not consider applications on cold atom physics, conventional superconductivity, bulk semiconductor physics (e.g., Si, GaAs), device development, and/or materials property optimization.

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Website: https://science.osti.gov/bes/mse/Research-Areas/Experimental-Condensed-Matter-Physics

(e) Theoretical Condensed Matter Physics

The Theoretical Condensed Matter Physics program supports research in quantum physics with an emphasis on quantum materials, materials discovery and design, out-of-equilibrium quantum dynamics, and fundamental research in materials related to energy technologies. Specific themes include strong electron correlations; quantum phases of matter, including topological states, magnetism, and superconductivity; multiferroic materials; and excited states phenomena and photon science. Research spans from purely analytical to computational with an emphasis on methods and technique development, as well as prediction and interpretation of novel quantum phenomena. This includes data-driven materials science, as well as high throughput

computations.

Growth areas focus on quantum materials and out-of-equilibrium quantum dynamics, including unpredicted, emergent materials behavior, and use of quantum computing or QIS approaches for condensed matter physics. Also highlighted is development and use of advanced computational tools for condensed matter physics and materials science, including data analytics, ML and AI.

Areas of decreasing emphasis include conventional superconductivity, quantum phase transitions, fractional quantum Hall effect, and wide bandgap semiconductors. Soft matter, polymers, glasses, granular materials, cold atoms, classical transport and classical molecular dynamics, and optimization of physical properties are not priorities.

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Website: https://science.osti.gov/bes/mse/Research-Areas/Theoretical-Condensed-Matter-Physics

(f) Physical Behavior of Materials

This program supports basic research to advance understanding of fundamental processes that take place in materials and in response to external stimuli, such as temperature, electromagnetic fields, chemical dopants and disorder, the proximity effects of surfaces and interfaces, and strain. The program emphasizes research on the structure-property relationships to physical behavior of materials, such as the relationship of atomic structure and crystal defects leading to semiconducting, superconducting, and magnetic properties, including novel diffusion and transport phenomena. The research should seek to understand how materials generate, transmit, and store clean energy. A detailed understanding of how a material's behavior can be influenced by the surroundings is critical to the understanding of photon generation and harvesting; spin, charge and heat transport; and novel magnetic and magnetocaloric materials.

The areas targeted for increased emphasis include materials research to support future microelectronics and light-matter interactions in the fields of excitonics, plasmonics, and the coherent interactions of quantum states in materials relevant for quantum information science (QIS). Growth areas include understanding of microscopic control in quantum materials, which ultimately fulfills the promise of materials-by-design in systems such as superconductors and quantum spin liquids, specifically with a focus to advance QIS.

Areas targeted for decreased emphasis in this program include conventional semiconductor physics, and research focused on theory and modeling of defects in crystals and their influence on the structural properties of materials (topics covered by the Mechanical Behavior and Radiation Effects program).

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Website: https://science.osti.gov/bes/mse/Research-Areas/Physical-Behavior-of-Materials

(g) Mechanical Behavior and Radiation Effects

This activity supports basic research to understand defects in materials and their effects on the properties such as strength, structure, deformation, and failure. Defect formation, growth, migration, and propagation are examined by coordinated experimental and modeling efforts over a wide range of spatial and temporal scales as well as a range of environments and stimuli. Topics include deformation of nanostructured materials, fundamentals of radiation damage, corrosion/stress-corrosion cracking in conjunction with radiation or stress, and research that would lead to microstructural design for tailored strength, radiation response, formability, and fracture resistance in energy-relevant materials. In addition to traditional structural materials, this program will also support research to understand deformation and failure mechanisms of other materials used in energy systems (e.g., polymers, membranes, coating materials, electrodes). Within these areas, research on topics such as driven systems, new materials and non-linear cooperative phenomena (multiple inputs, e.g. radiation + stress + corrosion) are of interest. There will be an increased emphasis in the program for research on understanding defect evolution in materials in radiation environments. Applicants are encouraged to consider the priority research directions in the reports from recent workshops including Basic Research Needs for Future Nuclear Energy (available on the BES web site). Of particular interest are applications that take advantage of advanced synthesis methods to create tailored structures in order to better isolate mechanisms, high-performance computing and data science techniques, and advanced characterization techniques such as neutron or x-ray scattering. These fundamental science efforts should impact clean energy topics in general, and may also impact advanced manufacturing and AI/ML.

Applications emphasizing high-strain-rate deformation or mechanics of materials (rather than materials science) will not be considered responsive.

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(h) X-Ray Scattering

This activity supports basic research on the fundamental interactions of photons with matter to achieve an understanding of atomic, electronic, and magnetic structures and excitations and their relationships to materials properties, including dynamics of quantum phenomena. The main emphasis is on x-ray scattering, spectroscopy, and imaging research, primarily at major BES-supported user facilities. Instrumentation development and experimental research in ultrafast materials science, across the full electromagnetic spectrum, is an integral part of the portfolio. This includes research aimed at manipulating and detecting ultrafast transient physical phenomena in materials, especially at excitation levels consistent with quantum coherence and controlled energy conversion and transport.

Advances in x-ray scattering and ultrafast sciences will continue to be driven by scientific opportunities presented by improved source performance and optimized instrumentation,

especially with the advent of improved synchrotron coherence and free electron laser sources. The x-ray scattering activity will expand current capabilities at the DOE facilities by providing support for independent external researchers who motivate and lead new instrumentation and technique development at those facilities. For example, research is sought that will take advantage of unprecedented levels of coherent brightness and of controlled timing structures at upgraded light source facilities. New investments in ultrafast science will emphasize development of novel ultrafast techniques and focus on research that uses radiation sources associated with BES facilities and beamlines. New pump schemes to manipulate dynamic states of quantum materials will be supported, especially those which can be adapted to XFEL and UED probe environments. Additionally, new approaches to improve the collection, processing and analysis of large data sets obtained with high repetition-rate pulsed sources or with fast multi-mega-pixel detector arrays are encouraged under the cross-cutting emerging domain of Data Sciences. Novel X-ray techniques are sought that enable detailed investigations of the fundamental dynamic mechanisms of clean energy conversion systems and their active material components.

The program will not support research considered "mature use" of existing x-ray or ultrafast techniques. Typically, the emphasis on new techniques enables new access to inhomogeneous and dynamic systems and therefore the program will de-emphasize steady-state research of bulk and equilibrium systems.

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Website: https://science.osti.gov/bes/mse/Research-Areas/X-Ray-Scattering

(i) Neutron Scattering

This activity supports basic research on the unique interactions of neutrons with matter to achieve a fundamental understanding of atomic, electronic, and magnetic structures and their relationship to macroscopic properties. This includes excitations of materials and the resulting dynamic behavior of materials. The program will develop novel approaches that exploit the unique aspects of neutron scattering to investigate emergent behavior in materials over a wide range of length and time scales. The program has a focus on transformative research that uniquely requires neutron scattering as a major tool. Investments from this program drive the concomitant advancement of neutron scattering techniques and capabilities for materials research. It will continue its stewardship in fostering growth of the U.S. neutron scattering community by developing innovative, time-of-flight neutron scattering instrumentation concepts and their effective utilization for materials research, primarily at the BES-supported user facilities.

Topics emphasized in FY 2022 are novel applications of the state-of-the-art neutron scattering techniques for fundamental research on materials that exhibit novel emergent phenomena or unique properties that could be impactful for clean energy technologies. It will support advancement of techniques for research on quantum and energy materials, collective behavior of multi-component systems, emergent phenomena at the interfaces, and design principles for polymer upcycling and polymer-based energy materials. Coupling among materials synthesis,

neutron scattering measurements, AI/ML and data science approaches, and theory and simulations is sought to provide a deeper understanding of materials structure and dynamics in equilibrium and non-equilibrium conditions.

The program will not support research considered "mature use" of neutron scattering techniques for materials research. It will de-emphasize applications with a focus on conventional and high-temperature superconductivity.

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Website: https://science.osti.gov/bes/mse/Research-Areas/Neutron-Scattering

(j) Electron and Scanning Probe Microscopies

This program supports basic research in materials sciences using advanced electron and scanning probe microscopy and related spectroscopy techniques to understand the atomic, electronic, and magnetic structures and properties of materials. This activity also supports the development of new instrumentation concepts and quantitative techniques to advance materials characterizations for energy applications. Supported advancements include ultrafast electron diffraction and imaging techniques. The goal is to develop a fundamental understanding of materials, including quantum phenomena, through advanced microscopy, spectroscopy, and the associated theoretical tools.

This activity emphasizes innovative research using electron and scanning probe microscopy techniques for groundbreaking science. These include understanding and controlling nano- or meso-scale inhomogeneity and investigations of the interplay among the quantum observables (e.g., charge, spin) that produce unique quantum effects. Research topics include imaging the functionality of materials and investigation of electronic structure, spin dynamics, magnetism, phase transitions, transport properties from atomistic to mesoscopic length scales, and data science methods in microscopy and data analysis, including machine learning and artificial intelligence. Progress in quantum research requires development of innovative techniques and probes that harness quantum behavior in their characterization schema, as well as the utilization of imaging and spectroscopic techniques for the understanding and control of quantum phenomena. Advanced *in situ* analysis capabilities for the study of time-dependent phenomena, including dynamics of quantum materials using ultrafast techniques, is also an area of interest in the program.

The program will not support research considered to be "mature use" of microscopy techniques or device development. Electron and scanning probe efforts, including technique development, that is proposed without associated scientific goals or is motivated primarily by support of other funded research will not be considered. Research focused on conventional superconductivity will be de-emphasized.

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Website: https://science.osti.gov/bes/mse/Research-Areas/Electron-and-Scanning-Probe-

Microscopies

Chemical Sciences, Geosciences, and Biosciences

The Chemical Sciences, Geosciences, and Biosciences (CSGB) Division supports experimental, theoretical, and computational research to provide fundamental understanding of chemical transformations and energy flow in systems relevant to DOE missions. This knowledge serves as a basis for the development of new processes for the generation, storage, and use of energy and for mitigation of the environmental impacts of energy use.

Five synergistic, fundamental research themes are at the intersection of multiple CSGB research focus areas: *Ultrafast Chemistry* develops and applies approaches to probe the dynamics of electrons that control chemical bonding and reactivity, to understand energy flow underlying energy conversions, and to elucidate structural dynamics in chemical transformations. *Chemistry at Complex Interfaces* addresses the challenge of uncovering emergent chemical phenomena at dynamic interfaces with structural and functional heterogeneity. *Charge Transport and Reactivity* elucidates the contributions of charge dynamics to energy flow and its coupling to reactions. *Reaction Pathways in Diverse Environments* discovers the influence of nonequilibrium, heterogeneous, nanoscale environments on complex reaction mechanisms. *Chemistry in Aqueous Environments* addresses the unique properties of water in extreme environments and the role aqueous systems play in energy and chemical conversions. Priority will be given to applications in the CSGB research focus areas listed below that address one or more of these synergistic research themes.

CSGB Division Website: https://science.osti.gov/bes/csgb/

(k) Atomic, Molecular, and Optical Sciences (AMOS)

The DOE AMOS program is focused on fundamental, hypothesis-driven research in ultrafast chemical sciences. The program supports basic experimental and theoretical research aimed at understanding the structural and dynamical properties of atomic and molecular systems. The research targets fundamental interactions of photons and electrons with atomic and molecular systems to characterize and control their behavior. The program aims to develop accurate quantum mechanical descriptions of ultrafast dynamical processes, such as charge migration and transfer, chemical bond breaking and forming, and interactions in strong fields, where electron-electron and electron-nuclei correlations are important. Topics of interest include the development and use of novel, ultrafast probes of matter; the interactions of atoms and molecules with intense electromagnetic fields; and control of quantum coherence/decoherence and entanglement in molecular systems.

The AMOS activity will continue to support science that advances DOE and BES mission priorities, including research that contributes to the BES priority on Clean Energy by developing a fundamental understanding of excitation dynamics and charge transfer relevant to the initial steps in clean solar energy conversion. The AMOS program will continue to have a prominent role at BES facilities in understanding and controlling the interaction of intense, ultrafast x-ray pulses with matter. Key targets for greater investment include attosecond science, ultrafast x-ray

science, and ultrafast electron diffraction from molecular systems. Closely related experimental and theoretical efforts are encouraged. The AMOS program will consider applications that contribute to the BES priority on Quantum Information Science by focusing on fundamental research aimed to advance understanding and control of quantum coherence/decoherence and entanglement in molecular systems. Projects involving technical development of sources or instrumentation must include a well-integrated scientific research focus.

The program emphasizes ultrafast, strong-field, short-wavelength science, and studies of correlated dynamics in atoms and molecules. Examples include ultrafast x-ray science at the Linac Coherent Light Source (LCLS-II) and the use of high-harmonic generation or its variants as soft x-ray sources for probing ultrafast dynamics. Applications of these light sources include ultrafast imaging of chemical reactions, diffraction and harmonic generation from aligned molecules, and inner-shell photoionization of atoms and molecules. The program encourages research exploiting next-generation capabilities of x-ray free electron lasers and modern data science approaches to provide new insights to electronic and molecular dynamics occurring on the attosecond-to-femtosecond time scale and to reveal key intermediate states in chemical reactions. Coherent control of nonlinear optical processes and tailoring of quantum mechanical wave functions with lasers will continue to be of interest, particularly in molecular systems. The program will continue to support the use of experimental and theoretical tools to advance the understanding of low-energy electron-molecule interactions in the gas and condensed phases.

The AMOS program **is not** accepting applications in the areas of plasma physics, nanoscience, bioscience, and science of ultracold systems.

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(l) Gas Phase Chemical Physics

This program supports research on fundamental gas-phase chemical processes that provide understanding and scientific foundations for clean energy. Research in this program explores chemical reactivity, kinetics, and dynamics in the gas phase at the level of electrons, atoms, molecules, and nanoparticles. A continuing goal of this program is to understand energy flow and reaction mechanisms in complex, nonequilibrium, gas-phase environments.

The major focus of research in this area is in five thrust areas (*Light-Matter Interactions, Chemical Reactivity, Gas-Particle Interconversion*, *Gas-Surface Chemical Physics* and *Ultrafast Imaging/Spectroscopy*). *Light-Matter Interactions* includes research in the development and application of novel tools, such as molecular spectroscopy, for probing the nuclear and electronic structure of gas-phase molecules to enable chemical and physical analysis of heterogeneous and dynamic gas-phase environments and to understand the dynamic behavior of isolated molecules, such as energy flow (e.g., relaxation of excited states), nuclear rearrangements, and loss of coherence and entanglement. Applications are encouraged that develop automated methods based on artificial intelligence and machine learning (AI/ML) methods to facilitate the analysis of complex molecular spectra or seek to improve the understanding of quantum phenomena in

systems that could be used for quantum information science. *Chemical Reactivity* comprises research in chemical kinetics and mechanisms, chemical dynamics, collisional energy transfer, and construction of, and calculations on, molecular potential energy surfaces to develop fundamental insight into energy flow and chemical reactions important in clean energy processes. Applications are encouraged that develop AI/ML methods for the construction of potential energy surfaces and optimization of chemical kinetic mechanisms. *Gas-Particle Interconversions* comprises research on the chemistry of small gas-phase particles, including their interactions with gas-phase molecules and dynamic evolution to understand the molecular mechanisms of formation, growth, and transformation (such as evaporation, phase transition, and reactive processing) of small particles. *Gas-Surface Chemical Physics* retains a strong emphasis on molecular-scale investigations of gas-phase chemical processes with the goal of gaining a better understanding of the cooperative effects of coupling gas-phase chemistry with surface chemistry. *Ultrafast Imaging/Spectroscopy* includes studies of the short timescale phenomena underlying photochemical and photophysical processes, such as photodissociation, isomerization, and nonadiabatic dynamics. Applications are encouraged that develop AI/ML methods for analyzing ultrafast images/spectra or to provide insight into chemical systems associated with clean energy.

Other areas of recent increased emphasis include benchmarking theoretical calculations via quantum state resolved experimental measurements of state-to-state chemical dynamics at conditions where quantum effects are significant, investigating the effect of non-thermal initial distributions on reaction dynamics, and understanding how complex reaction mechanisms transform over large temperature and pressure ranges. The Gas Phase Chemical Physics program does *not* support research in non-reacting fluid dynamics and spray dynamics, data-sharing software development, end-use combustion device development, and characterization or optimization of end-use combustion devices.

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(m) Computational and Theoretical Chemistry

The Computational and Theoretical Chemistry program (CTC) supports fundamental research for the development, improvement, and integration of new and existing theoretical and massively parallel computational or data-driven strategies that enable the accurate and efficient prediction or simulation of processes and mechanisms relevant to the BES mission. CTC research addresses systems, processes and mechanisms that are so complex that efficient computational implementation must be accomplished in concert with development of new theories and algorithms. Areas of interest include the development of (i) spatial and temporal multiscale methodologies that allow for time-dependent simulation of resonant, coherent and dissipative processes as well as rare events; (ii) capabilities for simulation of light-matter interactions, conversion of light to chemical energy or electricity, and the ability to model and control externally driven electronic and spin-dependent processes in real environments; and (iii) modular computational tools that enable or enhance interpretation and analysis of advanced experimental measurements, such as those acquired at DOE user facilities.

Applications to the CTC program must be tightly integrated with the research and goals of BES and provide theories and computational approaches to advance the fundamental science of at least one of the five overarching research priorities for BES in FY 2022 (see BES introduction). Efforts aimed at enhancing the accuracy, precision, applicability, and scalability of time-dependent quantum-mechanical simulation methods are encouraged. FY 2022 CTC research priorities include:

- Novel non-classical or non-perturbative theories and approaches for the predictive simulation and control of vibrationally-mediated chemical dynamics in non-equilibrium and/or field-driven complex open systems.

- Practical and hierarchical theories and methods for the high fidelity simulation of nonlocal chemical interactions and emergent phenomena occurring in complex molecular ensembles and environments, including stochastic and correlated quantum chemical approaches for the accurate simulation and prescriptive design of (i) emergent functionality, (ii) non-biological autocatalytic cooperative reaction networks, such as those leading to directed molecular assembly and/or replication processes, or (iii) correlated multi-electron and/or multi-photon governed chemical transformation and energy transduction processes.

CTC does not support projects based exclusively on (i) the "mature use" of presently available implementations of computational and theoretical chemistry methods and/or approaches, or (ii) the development of phenomenological models and empirical parameterization of models. Methods for, or applications to, systems that do not explicitly consider rearrangements of quantum-mechanical degrees of freedom are not supported.

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Website: https://science.osti.gov/bes/csgb/research-areas/computational-and-theoretical-chemistry/

(n) Condensed Phase and Interfacial Molecular Science (CPIMS)

The CPIMS program emphasizes basic research at the boundary of chemistry and physics, pursuing a molecular-level understanding of chemical and physical processes in liquids and at interfaces. With its foundation in chemical physics, the impact of this crosscutting program is far reaching, providing understanding and scientific foundations underpinning a variety of areas of importance to the DOE, including clean energy, catalytic and separation processes, energy storage, chemical synthesis and manufacturing, and microelectronics. The CPIMS program also supports efforts related to BES research priorities such as Artificial Intelligence, Machine Learning, and Quantum Information Science.

Experimental and theoretical investigations in the gas phase, condensed phase, and at interfaces aim at elucidating the molecular-scale chemical and physical properties and interactions that govern chemical reactivity, solute/solvent structure, and transport. Studies of reaction dynamics at well-characterized surfaces and clusters lead to the development of theories on the molecular origins of surface-mediated catalysis and heterogeneous chemistry. Studies of model condensed-

phase systems target first-principles understanding of molecular reactivity and dynamical processes in solution and at interfaces. Fundamental studies of reactive processes driven by radiolysis in condensed phases and at interfaces provide improved understanding of radiation-driven chemistry in nuclear fuel and waste environments. Investigations at model interfaces seek to understand processes underlying atomically precise synthesis, which could have an impact ranging from heterogeneous catalysis to future electronic devices. Basic research is also supported to develop new experimental and theoretical tools that push the horizon of spatial and temporal resolution needed to probe chemical behavior selectively at interfaces and in solution, enabling studies of composition, structure, bonding and reactivity at the molecular level. The transition from molecular-scale chemistry to collective phenomena in complex systems is also of interest, allowing knowledge gained at the molecular level to be exploited through the dynamics and kinetics of collective interactions. In this manner, the desired evolution is toward predictive capabilities that span the microscopic to mesoscale domains, enabling the computation of individual molecular interactions as well as their role in complex, collective behavior at continuum scales.

The CPIMS program has recently added research projects that (1) explore quantum entanglement to drive and sense reactions and reaction dynamics remotely in solution and at interfaces, including entanglement preservation at interfaces, (2) examine rare electrochemical events (such as nucleation and self-assembly) using machine learning and advanced sampling techniques of large data sets, (3) investigate the effect of the chemical environment on oxidation and spin states as well as the influence of native solvation environments on spin dynamics of solvated complexes, (4) study hydrogen bonding and solvation of ions in liquid electrolytes (including in conventional dipolar solvents, ionic liquids and deep eutectic solvents), (5) study manipulation of electrochemical reactivity on layered 2D materials by tuning the electronic structure via band structure manipulation and tunable electrostatic effects, (6) seek to demonstrate photoredox chemistry of excited polaritonic states along with studies of long-range energy and electron transport made possible by cavity polaritons, (7) seek an understanding of chemical bond dynamics in solution using mixed quantum/classical molecular dynamics simulations, and (8) study significantly enhanced molecular reactivity in microdroplets.

The CPIMS program does not fund research in continuum fluid mechanics or fluid dynamics, technological applications and device development, and research that is of principal importance to medical applications.

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Website: https://science.osti.gov/bes/csgb/Research-Areas/Condensed-Phase-and-Interfacial-Molecular-Sciences

(o) Catalysis Science

This program supports basic research pursuing novel catalyst design and quantum- and molecular-level control of chemical transformations relevant to the sustainable conversion of energy resources. Emphasis is on the understanding of reaction mechanisms, enabling precise identification and manipulation of catalytic active sites, their environments, and reaction

conditions for optimized efficiency and selectivity. Elucidation of *catalytic reaction mechanisms in diverse chemical environments* and *the structure-reactivity relationships of solid and molecular catalysts* comprises a central component of the program.

A long-term objective is to promote the convergence of heterogeneous, homogeneous, electro-, and bio-catalysis as a means to discover novel inorganic, organic, and hybrid catalysts that are selective for fuel and chemical production from both fossil and renewable feedstocks. Another enduring goal is to maximize the atom and energy efficiency of chemical transformations. Emerging activities in the area of clean energy and catalysis science underpinning sustainable chemical transformations are encouraged, including carbon-neutral hydrogen production and utilization, polymer upcycling, catalysis by Earth-abundant metals, and electro-driven processes. Specific focus areas are described below:

- Advanced concepts concerning catalyst design, including topics related with atomically precise synthesis, enabling, for instance: multi-functionality, confinement within porous materials, site cooperativity, nano- and single-atom stabilized structures, and manipulation of weak interactions;
- Electro-mediated catalytic approaches leading to sustainable manufacturing, such as low-temperature electrosynthesis, integrated separation-catalytic processes, or carbon-neutral transformations with the potential to impact fuel or large-scale chemical production;
- Strategies that explore catalysts and mechanisms associated with the direct catalytic transformations in multicomponent mixtures, multiple reactions, integrated processes, and circular processing, including upcycling of synthetic or natural polymers;
- Thermal or electro-catalysis mediated by earth-abundant metals or investigations related to transformations targeting the reduction or elimination of the use of platinum group elements;
- Development of novel time-resolved spectroscopic techniques and structural probes for in situ/operando characterization of catalytic processes, including *ultrafast* bond formation and transition state conversion, as well as slower ionic, or atomic, or molecular species rearrangements during reaction;
- Advanced theory, modeling, data-science, and machine-learning approaches to mechanism identification, catalyst discovery and development, and benchmarking of catalytic properties.

This program does not support: (1) the study of transformations appropriate for pharmaceutical applications; (2) non-catalytic stoichiometric reactions; (3) whole cell or organismal catalysis; (4) studies where the primary focus is photochemistry or photophysics; and (5) process or reactor design and optimization.

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(p) Separation Science

This program supports hypothesis-driven experimental and computational research to discover, understand, predict, and control de-mixing transitions, with the goal of enabling chemical

separation paradigms that may become the basis for solutions to the Nation's energy challenges – these include increasing the utilization of clean energy (renewable energy or fossil energy that is offset by negative-emissions approaches such as direct air capture with sequestration) as well as expanding the availability of critical elements while mitigating environmental impacts of removal and refinement from minerals or secondary waste. Basic research activity in these areas relies on understanding molecular interactions and energy exchanges that determine the efficiency of chemical separations. Advancing the understanding of basic chemical and physical principles at the atomic-, electronic-, molecular-, nano-, and meso-scales is essential.

Specifically, this program supports emerging fundamental scientific areas within separation science that are in a nascent stage. Selected topics of interest include:

- elucidating factors that cause a separation system to approach mass transfer limitation in the source phase;
- enabling and enhancing strategies for critical elements and materials recovery from natural and unconventional feedstocks, for water and environmental management of heavy elements and nuclear waste, and for carbon removal from low-concentration sources;
- understanding non-thermal mechanisms that have the potential to drive efficient and selective energy-relevant separations, such as electromagnetic, magneto-reactive, and other means to affect transport and bonding selectively;
- discovering and advancing strategies for removal of dilute constituents from a mixture, including but not limited to reactive separation approaches;
- generating specific and long-range interactions among trace constituents with the aim of promoting nucleation of a new phase that is enriched in the target species;
- discovering novel approaches for dehydration of heterogeneous systems without the application of heat;
- designing separation systems that have high selectivity, capacity, and throughput;
- understanding and controlling temporal changes that occur in separation systems.

The topics listed above are agnostic to the separation system and may include, for example, membranes, framework materials (e.g., metal-organic framework materials), zeolites, ionic liquids, and molecular complexes. Issues of selectivity, capacity, throughput, durability, and energy input are important for most separations, and should be of concern in separation science research, although they may not be the singular focus.

Based on programmatic priorities, this activity does not support the following areas: engineering design or scale-up, development of narrowly defined processes or devices, desalination, microfluidics, or sensors.

A recent National Academies study report, *A Research Agenda for Transforming Separation Science* (https://www.nap.edu/catalog/25421/a-research-agenda-for-transforming-separation-science) serves as reference for some of the basic science topics outlined above.

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(q) Heavy Element Chemistry

The Heavy Element Chemistry (HEC) program supports actinide and transactinide fundamental chemical research that underpins the DOE missions in energy, environment, and national security. Research performed in this program is essential to a clean-energy future, such as but not limited to, the fundamental research supporting carbon-free nuclear energy. The unique molecular bonding of these elements is explored using experiment and theory to elucidate electronic and molecular structure, reaction thermodynamics, as well as quantum phenomena, such as coherence and entanglement. Emphasis is placed on the chemical and physical properties of the transuranic elements to determine their bonding and reactivity, the fundamental transactinide chemical properties, and the overarching goal of resolving the *f*-electron challenge. The *f*-electron challenge refers to the inadequacy of current electronic structure methods to accurately describe the behavior of *f*-electrons, in particular strong correlation, spin-orbit coupling, multiplet complexity, and associated relativistic effects. Theoretical applications are considered that integrate closely with experimental research or otherwise demonstrate impact outside the theory community. The HEC program does not fund code development.

The role of 5*f* electrons in bond formation remains the fundamental topic in actinide chemistry and is an overarching emphasis for this program. Theory and experiment show that 5*f* orbitals participate significantly in molecular actinide compounds. Resolving the role of the *f*-electrons is one of the three grand challenges identified in the *Basic Research Needs for Advanced Nuclear Energy Systems (ANES)* report of the Basic Energy Sciences Workshop (2006) and echoed in the report from the Basic Energy Sciences Advisory Committee: *Science for Energy Technology: Strengthening the Link between Basic Research and Industry* (2010). The ANES report describes in depth specific challenges that continue to underlie contemporary actinide science, and the recent *Basic Research Needs for Future Nuclear Energy* report (2017) expands upon some of these chemical challenges, focusing on understanding and mastering the chemistry and reactivity of actinides in multi-component, multi-phase systems under extreme conditions. Catalytic reactivity involving actinides is of current interest to this program, if the project yields insight into *f*-electron behavior, and is not better aligned with the BES Catalysis Science program described in section (o). Exotic catalytic and redox behavior exhibited by actinides in extreme environments, such as the legacy nuclear waste tanks or molten salts, is also of particular interest to this program. Of particular interest as well is the exploitation of the unique electronic properties of the *f*-elements for quantum information science applications (e.g., actinide qubits or the synthesis and investigation of strongly correlated multidimensional lattices).

The inclusion of machine learning, artificial intelligence, and quantum computing methods are particularly desirable and aligned with current BES priorities. Also desirable and aligned with BES priorities are applications that provide understanding and scientific foundations for clean energy. Based on programmatic priorities, the HEC program does not fund research on: the processes affecting the transport of subsurface contaminants, the form and mobility of contaminants including wasteforms, projects focused on the use of heavy-element surrogates,

projects aimed at optimization of materials properties including radiation damage, device fabrication, data science efforts without chemical experimentation, or biological systems; these are all more appropriately supported through other DOE programs. The HEC program will consider applications to understand how the unique electronic structure of rare earth elements, including the role of *f*-electrons, determines the physical and chemical properties of molecules and materials, with the goal of accelerating their design to reduce or eliminate the use of critical elements. Research that is focused primarily on separations and does not address the unique properties of the heavy elements is better aligned with the BES Separation Science program, which is described in section (p). Applications should be hypothesis-based.

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(r) Geosciences

The Geosciences program supports basic experimental, theoretical, and computational research in geochemistry and geophysics. Geochemical research emphasizes fundamental understanding of the reaction mechanisms and rates associated with geochemical processes, focusing on molecular-mesoscale aspects of minerals and interfaces and on the molecular origins of critical element/isotope distributions and their influence on migration/separation/fractionation pathways in the earth, ranging from weathering environments to magmatic/hydrothermal systems. Geophysical research focuses on new approaches, particularly those based on new advances in data science, to understand subsurface processes, physico-chemical properties, and material response of fluid-rock systems.

In both geophysics and geochemistry, emphasis in the BES geosciences program is on pushing the boundaries of current measurement, modeling, and data analysis techniques and in connecting experiments, models, and data in novel and compelling ways to reveal underlying mechanisms.

Recent examples of projects in the program have focused on (1) understanding mechanisms of enhanced carbon mineralization, (2) molecular-level reading of the rock record preserved in shales and biogenic carbonates, (3) molecular speciation of REE in hydrothermal fluids, and (4) multiscale aspects of the structure and dynamics of fracture systems in field and laboratory environments, particularly as revealed by novel data science techniques applied to acoustic/seismic emissions.

Priority in BES funding is given to research that has multiple potential application areas with strong connections to subsurface clean energy storage or energy waste isolation. Projects focused on specific applications should contact the appropriate technology program.

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(s) Solar Photochemistry

This program supports fundamental, molecular-level research on solar energy capture and conversion in the condensed phase and at interfaces. Photochemical approaches may ultimately offer new routes for generating electricity or fuels from sunlight using closed, renewable, clean energy cycles. Advances in these areas will require a thorough understanding of elementary processes such as light absorption, charge separation, and charge transport within a number of chemical systems, including those with significant nanostructured composition.

Supported research areas include organic and inorganic photochemistry, light-driven electron and energy transfer in condensed phase and interfacial molecular systems, electrocatalysis and photocatalysis of solar fuels reactions, semiconductor photoelectrochemistry, light-driven generation or manipulation of quantum coherence and entanglement in molecular systems, and artificial assemblies that mimic natural photosynthetic systems. An enhanced theory and modeling effort is needed to improve current understanding of many photochemical phenomena.

To advance the science of light-driven fuels production, knowledge gained in photoinduced charge transfer needs to be applied in a meaningful way to activation of small molecules, including oxidation or reduction of H_2O as well as the reduction of CO_2 or N_2 to fuels. Considerable challenges remain in understanding degradation mechanisms to enhance photochemical durability, designing catalytic microenvironments that promote selective production of energy-rich solar fuels, exploiting direct coupling of light-driven phenomena and chemical processes to enhance performance, and tailoring interactions of complex phenomena to achieve integrated multicomponent assemblies for solar fuels production.

An additional regime of interest is the chemistry initiated through creation of excited states with ionizing radiation, as can be produced through electron pulse radiolysis, to investigate reaction dynamics, structure, and energetics of short-lived transient intermediates in the condensed phase, solutions, and interfaces.

The Solar Photochemistry program does not fund research on device development or optimization.

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(t) Photosynthetic Systems

This activity supports basic research on the capture and conversion of solar energy to chemically stored forms of energy in the photosynthetic systems of plants, algae, and photosynthetic microbes. Topics of study include, but are not limited to, light harvesting, quantum coherent energy transfers, proton and electron transport, reduction of carbon dioxide into organic compounds, and the self-assembly and self-repair of photosynthetic proteins, complexes and membranes. The goal of the program is to foster greater knowledge of the diverse photosynthetic

systems found in nature. These offer a natural library of self-assembling molecular structures that conduct unusually efficient transfers and conversions of energy, many with relevance to the development of clean energy technologies. Examples include capture of CO_2 by carboxylase enzymes and bicarbonate transporters, light-driven production of H_2 by hydrogenase enzymes, long-lived coherent energy transfers in photosystems, oxidation of water to get electrons for solar fuels, and the protein-protein interactions that drive self-assembly and self-repair of the complex molecular components of photosynthesis.

All submitted applications must clearly state how the knowledge gained from the proposed research is relevant to greater mechanistic understanding of the capture, conversion, and storage of energy in plants, algae, and photosynthetic bacteria. Photosynthetic Systems does not fund: 1) development or optimization of energy devices or processes; 2) development or optimization of microbial strains or plant varieties for biofuel or biomass production; 3) phenotype analyses that do not test specific hypotheses relevant to the program; 4) genomic, transcriptomic, or proteomic data acquisition that does not test specific hypotheses relevant to the program; and 5) projects that are primarily computational in nature.

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(u) Physical Biosciences

This program supports basic research that combines tools from the physical sciences with biochemical, chemical, and molecular biological approaches to further our understanding of the ways plants and non-medical microbes capture, convert, and store energy. Primary focus areas of the program include studies that will provide a better understanding of the structure/function, mechanistic, and electrochemical properties of enzymes that catalyze complex multielectron redox reactions (especially those involved in the interconversion of CO_2/CH_4, N_2/NH_3, and H^+/H_2); determine how the complex metallocofactors at the active sites of these enzymes are synthesized; and understand how the potential of these cofactors can be "tuned" using ligand coordination to reduce overpotential and better enable catalysis using earth-abundant metals. The program also funds studies on electron bifurcation, catalytic bias, proton and electron tunneling and other quantum phenomena in enzyme systems, and on the factors and critical components that direct and regulate the flow of electrons on larger spatial and temporal scales through energy-relevant metabolic pathways. Limited support is provided for basic research on the biosynthesis and structure of important electron stores in biological systems (such as plant cell walls, lipids, and terpenes), studies that provide insight into the assembly and maintenance of biological energy transduction systems, and research to understand the roles played by ion gradients in storing energy and driving transport processes. Please note that in the area of plant cell wall biosynthesis and structure, new projects will only be considered if they use biophysical methods to help us better understand complex polymer/polymer interactions that give rise to the mesoscale properties of these materials. A fundamental understanding of how these properties emerge from the underlying molecular phenomena could inspire new strategies for stabilizing, destabilizing, and/or converting synthetic polymers and plastics.

Projects funded by the program typically combine biochemistry, biophysics, molecular biology, computational chemistry, and other approaches to understand structural, functional, and mechanistic properties of enzymes, enzyme systems, and energy-relevant biological reactions. Combining approaches supports a multidimensional mechanistic understanding of these processes and identifies unique principles that can provide foundational knowledge for clean energy, for example, by providing a basis for the design and synthesis of highly selective and efficient bioinspired catalysts, enabling control of the flow of electrons in biological systems to achieve desired metabolic outcomes (e.g., enhanced lipid or terpene production), and guiding design of chemical pathways for direct air capture of carbon dioxide, hydrogen production and use, and solar energy conversion into fuels and other products..

All submitted applications must clearly state how the knowledge gained from the proposed research will further our fundamental understanding of the ways plants, algae, and non-medical microbes capture, convert, and/or store energy. Projects should ideally be hypothesis-driven. Physical Biosciences does not fund research in: 1) animal systems; 2) prokaryotic systems related to human/animal health or disease; 3) development or optimization of energy devices or processes; 4) development or optimization of microbial strains or plant varieties for biofuel/biomass production; 5) cell wall breakdown or deconstruction; 6) transcriptional or translational regulatory mechanisms or processes; 7) environmental remediation or identification of environmental hazards; 8) genomic or other "omic" data acquisition that does not test specific hypotheses relevant to the program; and 9) projects that are primarily computational in nature.

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Scientific User Facilities

The Scientific User Facilities (SUF) Division supports the research and development, planning, construction, and operation of scientific user facilities for a vast range of science spanning the fields of biology, chemistry, geoscience, material science, and the physical sciences using x-ray, neutron, and electron beam scattering as fundamental probes of matter. These facilities provide unique capabilities to the scientific community and are a critical component of maintaining U.S. leadership in this diverse range of scientific disciplines. The SUF Division also supports research activities leading to the improvement of today's facilities, and research that lays the foundation for the development of the next generation of facilities.

SUF Division Website: https://science.osti.gov/bes/suf/

(v) BES Accelerator and Detector Research

This program supports research that advances the instruments, techniques, and capabilities of the existing and/or future scientific user facilities. Research includes studies on creation, manipulation, and transport of ultrahigh brightness beams and modeling of beam dynamics. Research is supported that aims at developing techniques that will strongly benefit the next generation of accelerator-based particle sources including improved diagnostics.

Major areas of interest include: Development of innovative methods of beam acceleration, seeding, and beam manipulation techniques that enhance temporal control of x-ray free electron lasers (FELs), and that lead to higher peak and average brightness, enhanced energy stability, and reduction of temporal and intensity fluctuations. Advances in superconducting undulators with strong focusing and magnetic field tapering to maximize the electron energy conversion to x-rays and meet the challenges of Terawatt amplifiers for single particle imaging. Source-generated THz radiation models that will lead to advances in experimental sciences. Advances for tight control of beam losses that can address higher neutron-flux capabilities at the Spallation Neutron Source with high-intensity H^- currents. Applications of artificial intelligence and machine learning algorithms to improve performance optimization, recovery of fault conditions, and prognostics to anticipate problems.

Also of interest are detector developments that will allow efficient use of the high-intensity x-rays, electrons and neutrons produced by the new and upgraded sources. Advanced detectors require higher computational capabilities per pixel, improved readout rates, radiation hardness, better energy and temporal resolutions, and very large dynamic range. In addition, advanced x-ray and neutron optics developments are needed to respond to increasing demands for higher energy resolution, focusing, and preservation of coherence.

Research aimed at the optimization of materials properties for accelerator, detector, and optics components, and for device fabrication will be discouraged.

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3. Biological and Environmental Research (BER)
Program Website: https://science.osti.gov/ber

The mission of the Biological and Environmental Research (BER) program is to support transformative science and scientific user facilities to achieve a predictive understanding of complex biological, Earth, and environmental systems for energy and infrastructure security, independence, and prosperity.

The BER subprograms and their objectives follow:

(a) Biological Systems Science

Research is focused on using DOE's unique resources and facilities to achieve a predictive systems-level understanding of complex biological systems to advance DOE missions in energy and the environment. By integrating genome science with advanced computational and experimental approaches, the Division seeks to gain a predictive understanding of living systems, from microbes and microbial communities to plants and ecosystems. This foundational knowledge enables design and reengineering of microbes and plants underpinning a broad clean energy and bioeconomy portfolio, including improved biofuels, bioproducts and biomaterials,

improved carbon storage capabilities, and improved understanding of the biological cycling and transformation of nutrients, materials, and contaminants in the environment.

The major research objectives are to:

1. Determine the molecular and regulatory mechanisms governing genotype to phenotype translation needed to predictively understand genome-scale functional properties of microbes, plants, and microbiomes relevant to BER's research efforts; develop experimental "-omics" capabilities and enabling technologies needed to achieve a dynamic, system-level understanding of cellular and microbiome functions; and develop the knowledgebase, computational infrastructure, and modeling capabilities to advance predictive understanding and design of biological systems for a variety of bioenergy, environmental and synthetic biology applications underpinning a broader bioeconomy.
2. Develop the advanced characterization, measurement and imaging technologies to visualize the spatial and temporal relationships of key metabolic processes governing phenotypic expression in plants and microbes, information crucial for developing an understanding of the impact of various environmental and/or biosystems design impacts on whole cell or community function.

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(b) Earth and Environmental Systems Sciences

The Earth and Environmental Systems Sciences subprogram supports fundamental science and research capabilities that enable major scientific developments and enhanced predictability involving Earth system-relevant atmospheric, terrestrial, cryospheric, marine, and human system process and modeling research in support of DOE's mission goals for transformative science for energy and national security. This includes experimental and modeling research on components such as clouds, aerosols, precipitation, and turbulence interactions; experimental and modeling research involving terrestrial biogeochemistry, hydrology, and ecology; modeling of marine systems; evaluation of component interdependencies under a variety of forcing conditions; quantification of vulnerability and resilience of the full suite of energy and related infrastructures as well as disadvantaged communities to extreme events; and novel uncertainty quantification methodologies.

The major research objectives are to:

1. Understand the physics, chemistry, and dynamics governing clouds, aerosols, and precipitation interactions, with a goal to advance the predictive understanding of the Earth system;
2. Improve the understanding and representation of physical and hydro-biogeochemical processes that govern terrestrial surface and subsurface ecosystems, that in turn can be represented in system models to improve confidence in the models and their projections; and

3. Develop, evaluate and analyze complex models of Earth and environmental systems, in order to understand trends, variability, change, and patterns of extremes, including improved understanding of system component interactions and co-evolution of the systems.

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4. Fusion Energy Sciences (FES)
Program Website: https://science.osti.gov/fes/

The mission of the Fusion Energy Sciences (FES) program is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished through the study of plasma, the fourth state of matter, and how it interacts with its surroundings.

One of the next frontiers for the FES program is the study of the burning plasma state, in which the fusion process itself provides the dominant heat source for sustaining the plasma temperature (i.e., self-heating). Production of strongly self-heated fusion plasmas will allow the discovery and study of a number of new scientific phenomena. To achieve these research goals, FES invests in flexible U.S. experimental facilities of various scales, international partnerships leveraging U.S. expertise, large-scale numerical simulations based on experimentally validated theoretical models, development of advanced fusion-relevant materials, and invention of new measurement techniques. In addition, FES supports partnerships with the private fusion sector to accelerate progress toward the development of fusion energy.

In addition to its fusion energy mission, FES also supports discovery plasma science, which is focused on research at the frontiers of basic and low temperature plasma science and high-energy-density laboratory plasmas. Finally, FES invests in transformational technologies such as artificial intelligence and machine learning (AI/ML) and quantum information science (QIS), that have the potential to accelerate progress in several mission areas.

FES research is guided by the Long-Range Plan "Powering the Future: Fusion and Plasmas" developed by the Fusion Energy Sciences Advisory Committee (FESAC): https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf

Additional resources include:
- A series of community engagement workshops (https://science.osti.gov/fes/Community-Resources/Workshop-Reports),
- National Academies reports such as:
  - the 2018 report on a Strategic Plan for U.S. Burning Plasma Research
  - the 2018 report on Opportunities in Intense Ultrafast Lasers
  - the 2020 Decadal Assessment of Plasma Science report
  - the 2021 report on Bringing Fusion to the U.S. Grid

Specific information about FES program areas is as follows:

(a) Burning Plasma Science: Foundations—Advanced Tokamak

The Advanced Tokamak (AT) program area addresses gaps in the physics basis for the conventional tokamak approach to magnetic confinement fusion. The AT program develops methods that simultaneously obtain high plasma pressure, stationary plasma profiles, high plasma confinement, and adequate particle and power handling. The program includes research and facility operations on the DIII-D SC user facility at General Atomics in San Diego, CA, and small-scale advanced tokamak research conducted on university-scale devices. DIII-D is the largest magnetic fusion research experiment in the U.S. It can magnetically confine plasmas at temperatures relevant to burning plasma conditions. Its extensive set of advanced diagnostic systems and extraordinary flexibility to explore various operating regimes make it a world-leading tokamak research facility. Small-scale advanced tokamak research is complementary to the efforts at DIII-D and other user facilities, providing rapid and cost-effective development of new techniques, prototyping of new concepts, and detailed validation of theoretical models.

All new, renewal, and supplemental applications submitted for collaborative research as part of the DIII-D research program should be submitted to the Advanced Tokamak area of this Funding Opportunity Announcement (FOA). No separate DIII-D specific FOA will be issued in FY 2022. Research on DIII-D is carried out by an international research team, which includes scientific personnel from many of the leading U.S. fusion research institutions. Researchers from outside General Atomics are involved in nearly all areas of research on DIII-D. Potential domestic applicants are directed to DIII-D specific guidance available on the FES website: https://science.osti.gov/fes/Funding-Opportunities.

Applications focusing on the use of innovative or transformational approaches and technologies such as artificial intelligence / machine learning (AI/ML), advanced manufacturing, and engineered materials are also encouraged.

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(b) Enabling Research and Development

The realization of fusion energy and the advancement of plasma science requires advances in supporting technologies to achieve higher levels of performance and flexibility to explore new plasma regimes. The purpose of the Enabling Research and Development (R&D) program element is to develop these supporting technologies for deployment on existing and next-generation fusion research facilities. Research topics of interest include, but are not limited to:
- Magnet technologies, particularly those associated with High-Temperature Superconductors (HTS) and high-field magnets.
- Plasma heating and current drive systems.
- Plasma fueling and disruption mitigation systems.

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(c) Burning Plasma Science: Foundations—Spherical Tokamak

The Spherical Tokamak Research program seeks to utilize spherical tokamak research facilities with low aspect ratios to develop the physics knowledge needed to advance the FES energy mission. An improved understanding of the spherical tokamak magnetic confinement configuration is needed to establish the physics basis for next-step spherical tokamak facilities, broaden the scientific understanding of plasma confinement for ITER, and maintain U.S. world leadership in spherical tokamak research capabilities. Operation at higher magnetic field, reduced collisionality, and with controllable fully-non-inductive current-drive are necessary next steps for assessing the spherical tokamak as a potentially cost-effective path to fusion energy. The program includes major domestic (i.e., NSTX-U) and international facilities, as well as small scale facilities conducting high-risk high-reward research.

A variety of important research topics that broadly support the foundational science for burning plasmas are uniquely possible through the study of spherical tokamak plasmas. Specifically, spherical tokamaks have demonstrated much higher normalized plasma pressure than conventional aspect ratio tokamaks. Also, spherical tokamaks provide access to unique plasma turbulence, energetic particle instabilities, and edge plasma regimes.

Applications to this area must focus on experimental research and/or model validation pertaining to spherical tokamak plasmas. Applications addressing high impact studies involving low recycling walls, or non-inductive plasma startup are also encouraged.

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(d) Burning Plasma Science: Foundations—Theory & Simulation

This program area focuses on advancing the scientific understanding of the fundamental physical processes governing the behavior of magnetically confined plasmas. Specific areas of interest include:
- Macroscopic stability and dynamics of fusion plasmas, with a strong focus on the prediction, avoidance, control, and mitigation of deleterious or performance-limiting instabilities such as plasma disruptions;
- Understanding and control of the multiscale, collisional and turbulent physical mechanisms responsible for the loss of heat, momentum, and particles from the confining region;
- Interaction of externally launched radiofrequency waves designed to heat the plasma and drive current, with the background plasma and surrounding structures;
- Nonlinear interaction between background plasma, various instabilities, and energetic particle populations, including the alpha particles generated by the fusion reactions, and its impact on the confinement of these particles and the overall plasma performance; and,

- The effect of multiscale and multiphysics processes at the plasma boundary on the plasma performance and on the interaction and interface of the hot plasma boundary with the material walls.

The efforts supported by this program provide the foundations for whole-device modeling of fusion systems and range from analytical work to the development and application of advanced simulation codes capable of exploiting the potential of current and emerging high-performance computing systems. Research focused on transformative approaches such as fusion-relevant computing aspects of quantum information science (QIS) and AI/ML are also encouraged.

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(e) Burning Plasma Science: Long Pulse—Tokamak

This program area supports research conducted by U.S. teams on long pulse superconducting international tokamaks as well as on short pulse international tokamaks with unique capabilities not available in U.S. facilities, that are currently operating or will be operating in the near future. Supported teams build on the experience gained from U.S. fusion facilities to conduct research on international devices. This research will enable the exploration of plasma regimes that cannot be sustained for long duration on domestic machines, allowing the U.S. fusion program to gain the knowledge needed to control and sustain plasma discharges in future burning plasma devices such as ITER.

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(f) Burning Plasma Science: Long Pulse—Stellarator

This program area supports research on stellarators, which offer the promise of steady-state confinement regimes without transient events driven by net plasma current. The three-dimensional (3D) shaping of the plasma in a stellarator provides for a broader range in design flexibility than is achievable in a 2D system. This program element supports research conducted on U.S. stellarators that are focused on optimization of confinement through quasi-symmetric shaping of the toroidal magnetic field, and research by U.S. teams conducted on international facilities.

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(g) Burning Plasma Science: Long Pulse—Materials

A Fusion Pilot Plant (FPP) will produce heat, particle, and neutron fluxes that significantly

exceed those in present confinement facilities, and new approaches and materials need to be developed and engineered for the anticipated extreme reactor conditions. Those intense conditions affect all regions of the reactor in distinct ways, including the plasma-facing components (PFCs); structural, functional, magnet, and diagnostic materials; and ex-vessel components. In an FPP, high fluxes of 14 MeV neutrons produce damaging and poorly understood effects in materials. A scientific understanding of how the properties of materials evolve and degrade due to fusion neutron exposure is needed to safely predict the behavior of materials in future fusion reactors. Even those components not directly exposed to high fluxes from the plasma still experience a complex multifactor environment that includes high temperatures, tritium migration and trapping, material interfaces, and high stresses. This program element supports innovative research and development aimed at providing solutions to these challenges, targeting specifically:

- Development of plasma-facing materials and components.
- Development of advanced structural materials.
- Development of functional materials.
- Development of fusion focused theoretical and computational materials research techniques, including machine learning and artificial intelligence approaches.
- Development of advance and additive manufacturing techniques relevant to fusion applications.

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Website: https://science.osti.gov/fes/Research

(h) Burning Plasma Science: Long Pulse—Fusion Nuclear Science

Interlinked with a burning plasma and materials that can withstand fusion reactor conditions are all the key systems required to capture the power, breed fuel, and ensure the safe operation of the reactor. Before a device is constructed, materials and components must be qualified, and a system design must ensure the compatibility of all components. Just as the plasma and materials in a fusion reactor will need to advance beyond today's capabilities, the balance of plant equipment, remote handling, tritium breeding, and safety systems will also require significant advances. In particular, the closure of the fusion fuel cycle via successful breeding and extraction of tritium is seen as a critical issue for the deployment of a Fusion Pilot Plant (FPP). This program area supports innovative research and development aimed at providing solutions to these challenges, targeting specifically:

- Development of breeder blanket concepts and technologies.
- Development of tritium fuel cycle technologies.
- Development of heat extraction and balance of plant technologies.
- Development of integrated systems designs and associated tools.

Subprogram Contact:

- Guinevere Shaw, Guinevere.shaw@science.doe.gov

Website: https://science.osti.gov/fes/Research

(i) Discovery Plasma Science: Plasma Science and Technology

General plasma science supports research at the frontiers of basic and low temperature plasma science. Focus areas include: (1) dynamical processes in laboratory plasmas, magnetospheric, solar, and astrophysical plasmas, such as magnetic reconnection, particle energization, plasma dynamo, turbulence and transport, energetic particles, flows, collisional and collisionless shocks; (2) understanding the behavior of dusty plasmas, non-neutral, single-component matter and/or anti-matter plasmas, and ultra-cold neutral plasmas; and (3) understanding plasma processes and/or plasma chemistry in low temperature plasma, interfacial plasma, plasma-surface interaction, interaction of plasma with materials and/or biomaterials, microplasmas, the synthesis of nanomaterials, and low temperature plasma research relevant to microelectronics.

For more information, please see the report of the Panel on Frontiers of Plasma Science (https://science.osti.gov/-/media/fes/pdf/program-news/Frontiers_of_Plasma_Science_Final_Report.pdf)

Since many of the topics are included in the NSF/DOE joint program, applicants are strongly encouraged to submit their applications in response to the annual solicitation of the DOE/National Science Foundation Partnership in Basic Plasma Science and Engineering: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5602

Subprogram Contact:
- Nirmol Podder, Nirmol.Podder@science.doe.gov

Website: https://science.osti.gov/fes/Research

High Energy Density Laboratory Plasmas supports the study of ionized matter at extremely high density and temperature, specifically, when matter is heated and compressed to a point that the stored energy in the matter reaches approximately 100 billion Joules per cubic meter, corresponding to a pressure of approximately 1 million atmospheres. Systems in which free electrons play a significant role in the dynamics and for which the underlying assumptions and methods of traditional ideal-plasma theory and standard condensed matter theory do not apply (e.g., Warm Dense Matter at temperatures of a few electron volts) can have pressures as low as 0.1 Mbar and are also considered high-energy-density plasmas. Applications focused on HEDLP-relevant QIS research and on inertial fusion energy sciences are also encouraged.

Subprogram Contact:
- Kramer Akli, Kramer.Akli@science.doe.gov

Website: https://science.osti.gov/fes/Research

(j) Discovery Plasma Science: Measurement Innovation

This program element supports the development of innovative diagnostics to make detailed measurements of the behavior of plasmas. Advances in diagnostic systems with higher resolution, higher reliability, reduced complexity, or access to previously unmeasured parameters enable breakthroughs in scientific understanding, the linking of theory/computation with experiments, and active control of plasma properties to optimize device operation and plasma

performance in a variety of device configurations.

Subprogram Contact:
- Curt Bolton, curt.bolton@science.doe.gov

Website: https://science.osti.gov/fes/Research

(k) Innovation Network for Fusion Energy (INFUSE) Research Partnerships

The Innovation Network for Fusion Energy (INFUSE) program supports research partnerships with the emerging fusion private sector, with the goal of accelerating the development of fusion energy in the U.S. Applications under this topic are welcome from university or research institution-based scientists, seeking to collaborate with industrial partners in the INFUSE program. This topic seeks to advance our scientific understanding of fusion-related phenomena by fostering collaborations involving the expertise and unique resources available at DOE national laboratories and U.S. universities
Partnership awards made under the INFUSE program follow a unique application process, for which more information is available at the INFUSE webpage: https://infuse.ornl.gov/

Subprogram Contact:
- Daniel Clark, Daniel.Clark@science.doe.gov

Website: https://science.osti.gov/fes/Research

5. High Energy Physics (HEP)
Program Website: https://science.osti.gov/hep

Other Federal agencies and their FFRDCs may only submit applications as subawards under another organization's application to subject matters in High Energy Physics. Applications from other Federal agencies and their FFRDCs as a lead organization may not be submitted and are nonresponsive to these subjects.

The mission of the High Energy Physics (HEP) program 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.

The scientific objectives and priorities for the field recommended by the High Energy Physics Advisory Panel (HEPAP) are detailed in its recent long-range strategic plan, developed by the Particle Physics Project Prioritization Panel (P5) and available at:
https://science.osti.gov/~/media/hep/hepap/pdf/May-2014/FINAL_P5_Report_053014.pdf.

The HEP program focuses on three experimental scientific frontiers:

- *The Energy Frontier*, where powerful accelerators are used to create new particles, reveal their interactions, and investigate fundamental forces;
- *The Intensity Frontier*, where intense particle beams and highly sensitive detectors are used to pursue alternate pathways to investigate fundamental forces and particle interactions by studying events that occur rarely in nature, and to provide precision measurements of these

phenomena; and

- *The Cosmic Frontier*, where non-accelerator-based experiments observe the cosmos and detect cosmic particles, making measurements of natural phenomena that can provide information about the nature of cosmic acceleration, including dark energy and the cosmic microwave background; searching for dark matter particles; and studying properties of the universe that impact our understanding of matter and energy.

Together, these three interrelated and complementary discovery frontiers offer the opportunity to answer some of the most basic questions about the world around us. Also integral to the mission of HEP are the following cross-cutting research areas that enable new scientific opportunities by developing the necessary tools and methods for discoveries:

- *Theoretical Particle Physics*, where the vision and mathematical framework for understanding and extending the knowledge of particles, forces, space-time, and the universe are developed;
- *Computational High Energy Physics,* where computational tools, data management and analytics, and simulation techniques are developed for advancing the HEP mission;
- *Accelerator Science and Technology Research and Development*, where the technologies and basic science needed to design, build, and operate the accelerator facilities essential for making new discoveries are developed;
- *Detector Research and Development,* where the basic science and technologies needed to design and build the High Energy Physics detectors essential for making new discoveries are developed; and
- *Quantum Information Science for High Energy Physics Research,* is a new research area where innovative solutions to scientific discovery are developed through partnerships with the wider quantum information science community to advance the HEP science drivers, as identified by P5, the program mission of HEP, and the SC quantum information science initiative.

Applications in response to this FOA may propose activities *in support of* HEP research, which include, but are not limited to: conferences, experimental operations, or conceptual research and development (R&D), design, or fabrication *directed towards a specific project* within the HEP scientific program.

HEP invites teams of investigators from multiple institutions to submit applications in accordance with the mechanisms for "Multi-Institutional Teams" described at the end of this section. Such teams are particularly appropriate when the involvement of multiple institutions permits the formation of larger teams that can address larger questions of scientific inquiry.

Applicants addressing *specific HEP research or technology development* activities in one or more of these eight research areas (as in the examples given below, but excluding Computational Research in High Energy Physics and Quantum Information Science for High Energy Physics Research), are *strongly encouraged* to submit applications to either the annual HEP Comparative Review FOA and/or to the annual Early Career Research Program FOA, each available through https://www.grants.gov. Applications that are in direct support of HEP research activities in the eight areas may be submitted to this FOA, but will likely be assigned a lower programmatic

priority than those from the comparative review process. Prior to any submission to this FOA, applicants are *strongly encouraged* to contact the relevant HEP subprogram managers listed below to develop applications that address proper program goals.

Additional information about the HEP research areas described above, and in areas (a) through (h) below, may be found at https://science.osti.gov/hep/research/. Furthermore, applicants should pay particular attention to the following when preparing applications to be submitted to this FOA:

1. External peer reviewers will be explicitly requested to evaluate the applicant's proposed work in relation to the priorities established in the P5 strategic plan for HEP.
2. For applications where only a single investigator proposes work, the project narrative should not exceed ten (10) pages total when printed using standard letter-size (8.5 x 11 inch) paper with 1-inch margins (top, bottom, left, and right). The font must not be smaller than 11 point.
3. For applications where multiple investigators are proposing work, the project narrative should not exceed fifty (50) pages total, regardless of the number of investigators, when printed using standard letter-size (8.5 x 11 inch) paper with 1-inch margins (top, bottom, left, and right). The font must not be smaller than 11 point.
4. Applications addressing two or more HEP research areas, either across a) the different HEP subprograms listed below (e.g., activities on Energy Frontier, Cosmic Frontier, Intensity Frontier, and/or Detector R&D) or b) different research thrusts in a particular HEP subprogram (e.g., LSST, DESI, and/or LZ/LUX in the Cosmic Frontier), are accepted and reviewers will be requested to comment on each of the proposed activities and their impact.
5. Applications for support of *generic particle detector R&D* efforts should be directed to the Detector Research and Development research area described below. However, applicants proposing physics studies and pre-conceptual R&D efforts *directed towards a specific experiment* within an experimental frontier should submit their application to the relevant HEP scientific frontier research area.

(a) Experimental Research at the Energy Frontier in High Energy Physics

This research area seeks to support studies of fundamental particles and their interactions using proton-(anti)proton collisions at the highest possible energies. This is accomplished through direct detection of new phenomena or through sensitive measurements that probe the Standard Model and new physics beyond it. In particular, applications are sought for physics research utilizing data being collected at the Large Hadron Collider (LHC) by the ATLAS and CMS experiments. This research area also provides graduate and postdoctoral research training for the next generation of scientists, and equipment and computational support for physics research activities. Applications addressing physics studies and pre-conceptual R&D directed towards specific future Energy Frontier collider experiments are also accepted. Support for Heavy Ion Physics research is not provided under this research area.

Subprogram Contact:
- Abid Patwa, abid.patwa@science.doe.gov

Website: https://science.osti.gov/hep/research

(b) Experimental Research at the Intensity Frontier in High Energy Physics

This research area seeks to support precision studies that are sensitive to new physical processes at very high-energy scales, beyond what can be directly probed with energy frontier colliders, and that often require intense particle beams. This research area includes studies of the fundamental properties of neutrinos produced by a variety of sources, including accelerators and nuclear reactors; studies of rare processes or precision measurements probing new physics processes as described above with either high intensity stored beams or beams incident on fixed targets; and studies of high intensity electron-positron collisions. In addition, this research area includes searches for proton decay. Graduate and postdoctoral research training for the next generation of scientists, and equipment and computational support for physics research activities are also provided. Applications addressing physics studies and pre-conceptual R&D directed towards specific future Intensity Frontier experiments are also accepted. Support for the Large Hadron Collider beauty experiment (LHCb) research or studies of neutrinoless double beta decay is not provided under this research area.

Subprogram Contact:

- Brian Beckford, Brian.Beckford@science.doe.gov

Website: https://science.osti.gov/hep/research

(c) Experimental Research at the Cosmic Frontier in High Energy Physics

This research area seeks to support precision studies using observations of the cosmos and naturally occurring cosmic particles to understand the properties of fundamental particles and fields. Priorities include cosmic acceleration by studying the nature of dark energy and planning the next-generation ground-based cosmic microwave background experiment to explore the inflationary epoch, using direct-detection experiments to search for dark matter particles, and placing constraints on neutrino masses. Measurements using high-energy cosmic rays, gamma rays and other phenomena are included, but at a lower priority. Applications are sought for physics research efforts in support of current experiments in the Cosmic Frontier, as well as physics studies and pre-conceptual planning directed towards specific future experiments being considered for the program. This research area also provides graduate and postdoctoral research training for the next generation of scientists, and equipment and computational support for physics research activities.

Research efforts aimed at developing techniques or understanding experimental data within the context of theoretical models that are expressly for or as part of an experimental research collaboration are included in this area. General theoretical or computational research applications not specifically carried out as part of a particular Cosmic Frontier experimental collaboration should be directed to the Theoretical Research in High Energy Physics subprogram. Studies of gravitational physics (other than for cosmic acceleration), classical astrophysics phenomena, fundamental symmetries, or planning for future cosmic ray or gamma ray experiments are not included in this research area.

Subprogram Contact:

- Kathleen (Kathy) Turner, kathy.turner@science.doe.gov

Website: https://science.osti.gov/hep/research

(d) Theoretical Research in High Energy Physics

This research area seeks to support theoretical activities that provide the vision and the mathematical framework for understanding and extending our knowledge of particles, forces, space-time, and the universe. Theoretical research is essential to support current experiments at the Energy, Intensity and Cosmic Frontiers, to identify new directions for High Energy Physics and to provide a deeper understanding of nature. Topics studied in theoretical high energy physics research include but are not limited to: phenomenological studies that seek to interpret experimental data, suggest searches for new physics at existing facilities and develop a research program for future facilities; precision calculations of experimental observables to test our current theories at the level of quantum corrections; the development of new models of physical interactions to describe unexplained phenomena or to unify seemingly distinct concepts; progress in quantum field theory, quantum gravity and other possible frameworks to develop a deeper understanding of nature; and the development of analytical and numerical computational techniques to facilitate studies in these areas. This research area also provides graduate and postdoctoral research training for the next generation of scientists and the computational resources needed for theoretical calculations. Activities that rely on experimental data, performed expressly for or with an experimental research collaboration, are not included in this research area.

Subprogram Contact:
- William (Bill) Kilgore, william.kilgore@science.doe.gov

Website: https://science.osti.gov/hep/research

(e) Computational Research in High Energy Physics

This research area supports computational, data management, data analytic, and simulation techniques and tools that target the cross-cutting needs of HEP (i.e., those that are, or have the capability to be, broadly applicable). This subprogram also facilitates the effective use of DOE computing resources including, but not limited to, high-performance computing.

This subprogram does not support computing research and/or activities specific to individual projects or experiments in any of the other seven research and technology R&D subprograms described in this open solicitation. Support for specific operation efforts and/or hardware requests in each of the other subprograms are also outside the scope of this area. Applicants proposing such activities should submit their application to the relevant subprogram.

Subprogram Contact:
- Lali Chatterjee, lali.chatterjee@science.doe.gov

Website: https://science.osti.gov/hep/research

(f) Accelerator Science and Technology Research and Development in High Energy Physics

The Accelerator Science and Technology R&D subprogram develops the next generation of

particle accelerators and related technologies that are essential for discoveries in HEP. This research area supports world-leading research in the physics of particle beams, and long-range, early-stage exploratory research aimed at developing new concepts. This research area also provides graduate and postdoctoral research training, equipment for experiments and related computational efforts.

Topics studied in the Accelerator Science and Technology R&D subprogram include, but are not limited to: accelerator and beam physics, including analytic and computational techniques for modeling particle beams and simulation of accelerator systems; novel acceleration concepts; the science of high gradients in accelerating cavities and structures; high-power radio-frequency sources; high-power targets; high-brightness beam sources; and beam instrumentation. Also of interest are superconducting materials and conductor development; innovative magnet design and development of high-field superconducting magnets; as well as associated testing and cryogenic systems. R&D applications which are focused on accelerator uses outside of high-energy physics are now coordinated through the Accelerator Stewardship program under the Accelerator R&D and Production program.

Subprogram Contact:
- Lek (L. K.) Len, lk.len@science.doe.gov

Website: https://science.osti.gov/hep/research

(g) Detector Research and Development in High Energy Physics

The Detector R&D subprogram develops the next generation of instrumentation for HEP. It supports research leading to fundamental advances in the science of particle and radiation detection, and the development of new experimental techniques. This is typically long-term, "generic" R&D that is high-risk but has the potential for wide applicability and/or high impact. Applications should broadly align with the priority research directions identified in the report of the FY 2020 HEP Detector R&D Basic Research Needs study. Moreover, applications for "Blue-Sky" scientific research on innovative technologies not already in contention for implementation in future HEP projects are specifically encouraged.

Topics studied in the Detector R&D research area include but are not limited to: low-mass, high channel density charged particle tracking detectors; high resolution, fast-readout calorimeters and particle identification detectors; techniques for improving the radiation tolerance and fast-timing capabilities of particle detectors; detectors for photons from ultraviolet to infrared wavelengths; detectors for cosmic microwave background radiation; detectors and experimental techniques for ultralow-background experiments; and advanced electronics and data acquisition systems. Support for graduate and postdoctoral research training, engineering and other technical efforts, and equipment and computational efforts required for experimental detector R&D and fabrication *is* included in this research area.

Subprogram Contact:
- Helmut Marsiske, helmut.marsiske@science.doe.gov

Website: https://science.osti.gov/hep/research

(h) Quantum Information Science for High Energy Physics Research

This subprogram sponsors interdisciplinary research at the intersection of HEP and quantum information science (QIS) that advances the program mission of HEP, the science drivers identified by P5, as well as the SC and U.S. national initiatives in QIS. The subprogram supports interdisciplinary consortia engaged in foundational research connecting qubit systems and the cosmos, quantum sensors, computing and communications, QIS based small experiments, and applications of HEP technology to QIS advances

Subprogram Contact:
- Lali Chatterjee, Lali.Chatterjee@science.doe.gov

Website: https://science.osti.gov/hep/research

6. Nuclear Physics (NP)

Program Website: https://science.osti.gov/np/

The mission of the Nuclear Physics (NP) program is to discover, explore, and understand all forms of nuclear matter—not only the familiar forms of matter we see around us, but also exotic forms that existed in the first moments after the Big Bang and that may exist today inside neutron stars.

One of the enduring mysteries of the universe is the nature of matter—what are its basic constituents and how do they interact to form the properties we observe? The largest contribution by far to the mass of the matter we are familiar with comes from protons, neutrons, and heavier nuclei. Although the fundamental particles that compose nuclear matter—quarks and gluons—are themselves relatively well understood, exactly how they interact and combine to form the different types of matter observed in the universe today and during its evolution remains largely unknown.

The priority areas for NP include the following:

- How are the proton's mass and spin dynamically created in the interior of the proton?
- What are the properties of the novel quark-gluon plasma discovered at RHIC?
- What is the mechanism underlying the confinement of quarks and gluons?
- The search for new exotic particles and anomalous violations of nature's symmetries
- Understanding how nucleons—protons and neutrons—combine to form atomic nuclei and the limits of nuclear existence in nature.
- How have heavy nuclei have emerged since the origin of the universe and how are they still being made in the cosmos?
- Is the neutrino its own anti-particle? Do the neutron's properties point to new physics?
- The nature of the strong force in many-body systems
- Advanced Nuclear Data for Space, Energy, and Research.
- Searching for undiscovered forms of nuclear matter.
- Conceiving, constructing, and operating national scientific user facilities and developing novel detector and accelerator instrumentation

Within each of these priority areas, unique nuclear physics opportunities to advance or benefit from Artificial Intelligence or Machine Learning, and new developments in Microelectronics are also of NP programmatic interest. Applicants are encouraged to contact the relevant subprogram manager.

To carry out its mission and address these priorities, the NP program addresses three broad, yet tightly interrelated, scientific thrusts: Quantum Chromodynamics; Nuclei and Nuclear Astrophysics; and Fundamental Symmetries. NP supports basic research in seven subprograms areas: Medium Energy, Heavy Ion, Nuclear Structure and Astrophysics, Fundamental Symmetries, Nuclear Theory, Nuclear Data, and Nuclear Theory Computing (a through g). Additionally, NP supports Accelerator Research and Development for Current and Future Nuclear Physics Facilities (h), and R&D in Quantum Information Science (QIS) (i) which supports the QIS/QC initiative and Quantum Centers of SC and leverages opportunities for Nuclear Physics to benefit from advances in this topical area.

To advance knowledge in nuclear science and effectively train and mentor the next generation of nuclear scientists, NP places a high priority on supporting Principal Investigators who are active-career tenured or tenure-track faculty researchers.

The NP subprograms and their objectives follow:

(a) Medium Energy Nuclear Physics

The Medium Energy Nuclear Physics subprogram focuses primarily on understanding the structure of hadrons, how quarks move within a hadron and tests of the theory of the strong interaction known as Quantum Chromodynamics (QCD). According to QCD, all observed nuclear particles, collectively known as hadrons, arise from the strong interaction of quarks, antiquarks, and gluons. The protons and neutrons inside nuclei are the best-known examples of hadrons. QCD, although difficult to solve computationally, predicts which hadrons can exist in nature, and how they interact and decay. Specific questions addressed include: *What is the internal landscape of the protons and neutrons (collectively known as nucleons)? What does QCD predict for the properties of strongly interacting matter? What governs the transition of quarks and gluons into pions (hadronic subatomic particle) and nucleons? What is the role of gluons and gluon self-interactions in nucleons and nuclei?* The objectives of this subprogram are to develop a comprehensive picture of the spatial, momentum and angular momentum structure of the nucleon, elucidate quark confinement and hadron excitations, and understand the strong interaction in nuclei. Various experimental approaches are used to determine the distribution of "up", "down", and "strange" quarks, their antiquarks, and gluons within protons and neutrons, as well as clarifying the role of gluons in confining the quarks and antiquarks within hadrons. Polarized electron and proton beams are typically used to study the effects of the quark and gluon spins within nucleons, and the effect of the nuclear environment on the quarks and gluons. The subprogram also supports experimental searches for higher-mass "excited state" and exotic hadrons predicted by QCD, as well as studies of their production mechanisms and decay properties. In pursuing these topics, the Medium Energy subprogram supports experimental research at the subprogram's primary research facility, the Continuous Electron Beam

Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF), and at other facilities, including the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) and the High Intensity Gamma Source (HIGS) at the Triangle Universities Nuclear Laboratory (TUNL). Applications are sought for physics research efforts in support of current experiments in the Medium Energy program, as well as physics studies and pre-conceptual planning directed towards specific future experiments. Applications for instrumentation development for near-term experiments will also be considered. Also of interest are R&D on concepts and emerging technologies in Machine Learning and Artificial Intelligence that go beyond simple use cases for available software packages. Searches for Dark Matter and Dark Energy may receive low or no priority from this sub-program. You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Gulshan Rai, Gulshan.Rai@science.doe.gov

Website: https://science.osti.gov/np/research/

(b) Heavy Ion Nuclear Physics

The Heavy Ion Nuclear Physics subprogram focuses on studies of condensed quark-gluon matter at extremely high densities and temperatures characteristic of the infant Universe. The primary facilities in the world currently capable of exploring the properties nuclear matter in these conditions are the U.S. Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory and the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN). The goal is to explore and understand unique manifestations of QCD in this many-body environment and their influence on the Universe's evolution. Important avenues of investigation are directed at resolving properties of the quark-gluon plasma at different length scales and learning more about its physical characteristics including its temperature, the energy loss mechanism for quarks and gluons traversing the quark-gluon plasma, determining the speed of sound in the quark-gluon plasma, measuring the effect of the chiral magnetic force, understanding how quarks fragment and recombine to form hadronic matter (hadronization), and locating a possible critical point for the transition between the quark-gluon plasma and normal matter. The high baryon-density region of the phase diagram for nuclear matter also continues to be unexplored. Experimental research is carried out primarily using the RHIC facility and the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN). Early detector R&D activities supporting progress towards a future planned Electron-Ion Collider (EIC) and other opportunities will also be considered. You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Ken Hicks, Kenneth.hicks@science.doe.gov

Website: https://science.osti.gov/np/research/

Low Energy Nuclear Physics

The Low Energy subprogram has been separated into two distinct portfolios: that of Nuclear Structure and Astrophysics and Fundamental Symmetries.

(c) Nuclear Structure and Astrophysics

Nuclear Structure and Astrophysics addresses frontiers identified in the 2015 Long Range Plan for Nuclear Science: Nuclear Structure and Reactions, and Nuclear Astrophysics.

The atomic nucleus is at the core of all visible matter and comprises 99.9 % of its mass. Its relevance spans dimensions from the proton radius to objects as large as stars and covers the evolutionary history of the universe from fractions of a second after the Big Bang to today, 13.8 billion years later. The subfield of nuclear structure and reactions strives to measure, explain, and use nuclei to meet society's scientific interests and needs. The research addresses the underlying nature of atomic nuclei and the limits of their existence. It also aims to describe dynamical processes such as nuclear reactions and fission. The goal is to develop a predictive understanding of nuclei and their interactions grounded in fundamental QCD and electroweak theory; furthermore, this understanding must be based on experimental data from a wide variety of nuclei.

Nuclear astrophysics addresses the role of nuclear physics in our universe. As a field at the interface of astrophysics and nuclear physics, it is concerned with the impact of nuclear processes on the evolution of the universe, the role of nuclear structure in influencing the evolution of the cosmos, and the cosmogenic origin of elements that are the building blocks of life. It is a broad discipline that can identify new observational signatures probing our universe. Nuclear astrophysics can identify the conditions at the very core of stars and provide a record of the violent history of the universe.

Major goals of this subprogram are to develop a comprehensive description of nuclei across the entire nuclear chart including as-yet undiscovered superheavy nuclei, to utilize rare isotope beams to reveal new nuclear phenomena and structures unlike those that are derived from studies using stable ion beams, and to measure the cross sections of nuclear reactions that power stars and spectacular stellar explosions and are responsible for the synthesis of the elements. Experimental research is currently carried out using the Argonne Tandem Linac Accelerator System (ATLAS), a premier stable beam facility, as well as the Triangle Universities Nuclear Laboratory (TUNL), and the Texas A&M University Cyclotron Institute. Research and/or instrumentation development applications related to the Facility for Rare Isotope Beams (FRIB) scientific program will be considered. You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Sharon Stephenson, Sharon.Stephenson@science.doe.gov

Website: https://science.osti.gov/np/research/

(d) Fundamental Symmetries

This subprogram supports precision experiments to test the fundamental symmetries of nature and search for evidence of new forces or particles. Questions addressed in this frontier include: *What is the nature of neutrinos, what are their masses, and how have they shaped the evolution*

of the universe? Why is there now more matter than antimatter in the universe? What are the unseen forces that were present at the dawn of the universe but disappeared from view as the universe evolved? Specifically, the subprogram seeks to support: research to measure the neutrino mass and to determine if the neutrino is its own antiparticle; experiments with cold and ultra-cold neutrons to investigate the dominance of matter over antimatter in the universe, and to determine the lifetime of the neutron; experiments to illuminate the fundamental symmetries of nature through precise measurements of beta decay and searches for anomalous parity violation; research on other aspects of Fundamental Symmetries and Interactions involving nuclei. A major focus of this sub program is furthering progress towards a major priority of the 2015 Long Range Plan for Nuclear Physics, *Reaching for the Horizon*: the implementation of a ton-scale neutrino-less double beta decay experiment to determine whether the neutrino is its own anti-particle. You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Paul Sorensen, paul.sorensen@science.doe.gov

Website: https://science.osti.gov/np/research/

(e) Nuclear Theory

The Nuclear Theory subprogram provides the theoretical support needed to interpret the wide range of data obtained from the experimental nuclear science subprograms and to advance new ideas and hypotheses that identify potential areas for future experimental investigations. This subprogram addresses all of the field's scientific thrusts described in NSAC's long range plan, as well as the specific questions listed for the experimental subprograms above. Theoretical research on QCD (the fundamental theory of quarks and gluons) addresses the questions of how the properties of the nuclei, hadrons, and nuclear matter observed experimentally arise from this theory, how the phenomenon of quark confinement arises, and what phases of nuclear matter occur at high densities and temperatures. In Nuclei and Nuclear Astrophysics, theorists investigate a broad range of topics, including calculations of the properties of stable and unstable nuclear species, the limits of nuclear stability, the various types of nuclear transitions and decays, how nuclei arise from the forces between nucleons, and how nuclei are formed in cataclysmic astronomical events such as supernovae and neutron star mergers. In Fundamental Symmetries and Neutrinos, nucleons and nuclei are used to test the Standard Model, which describes the interactions of elementary particles at the most fundamental level. Theoretical research in this area is concerned with determining how various (beyond) Standard Model aspects can be explored through nuclear physics experiments, including the interactions of neutrinos, unusual nuclear transitions, rare decays, and high-precision studies of cold neutrons. You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Paul Sorensen, paul.sorensen@science.doe.gov

Website: https://science.osti.gov/np/research/

(f) Nuclear Data

The mission of the United States Nuclear Data Program (USNDP) is to provide current, accurate,

authoritative data for workers in pure and applied areas of nuclear science and engineering. This is accomplished primarily through the compilation, evaluation, dissemination, and archiving of extensive nuclear datasets. The USNDP also addresses gaps in the data, through targeted experimental studies and the use of theoretical models. A continuing interagency program of experiments led by NP continues to address critical gaps in nuclear data and modernization of nuclear data curation by incorporating new tools such as AI/ML. The USNDP involves the efforts of ~ 50 nuclear physicists at ~ 15 national labs, research centers, institutes and universities, and is an important resource for workers in a wide range of pure and applied topics in nuclear physics. Research opportunities in Nuclear Data include both experimental and theoretical work. You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Keith Jankowski, Keith.Jankowski@science.doe.gov

Website: https://science.osti.gov/np/research/

(g) Nuclear Theory Computing

Nuclear Theory Computing supports research in nuclear physics with "extreme" computational requirements, which has been enabled by the advent of high-performance computing (HPC). Funding for HPC-driven NP research is provided primarily through the programs Scientific Discovery through Advanced Computation (SciDAC) and the new Exascale Computing Project (ECP), through joint projects with the ASCR. NP SciDAC projects, which are five-year multisite collaborations on specific projects in computational nuclear physics, funded jointly by NP and ASCR, and closely aligned with the needs of the NP experimental program. These projects investigate 1) the properties of nuclei, using state-of-the-art models and numerical techniques; 2) the properties of strongly interacting particles (hadrons) composed of quarks and gluons, as predicted by the fundamental theory QCD; 3) the internal structure of nucleons and nuclei at sub-femtometer distance in terms of quarks and gluons; and 4) computational nuclear astrophysics, including the synthesis of the heavier elements in supernovae and neutron star mergers, and their observables effects. The two current NP ECP projects are addressing changes needed in computational NP practice in the Exascale Era, in the areas of 1) lattice QCD, and 2) nuclear astrophysics. Some computational resources needed for HPC research on NP problems are also provided by the National Energy Research Scientific Computing center (NERSC). You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Xiaofeng Guo, xiaofeng.guo@science.doe.gov

Website: https://science.osti.gov/np/research/

(h) Accelerator Research and Development for Current and Future Nuclear Physics Facilities

The Nuclear Physics program supports a broad range of activities aimed at research and development related to the science, engineering, and technology of heavy-ion, electron, and proton accelerators and associated systems. Areas of interest include R&D of technologies for

the Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC), with heavy ion and polarized proton beams; linear accelerators such as the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF); development of devices and/or methods that would be useful in the generation of intense rare isotope beams for the Facility for Rare Isotope Beams (FRIB) currently under construction at Michigan State University and in the generation of stable isotope beams at the Argonne National Laboratory's Argonne Tandem Linac Accelerator System (ATLAS), and R&D in accelerator science and technology in support of next generation Nuclear Physics accelerator facilities such as an electron-ion collider (EIC). Also of interests are R&D in emerging technologies in Machine Learning and Artificial Intelligence with focus on increasing cost savings and operational efficiencies of NP accelerator user facilities and their experimental programs. Research aimed at transformative advances in ion sources, superconducting radiofrequency, and beam cooling is encouraged. You must send e-mail to a Subprogram Contact for information regarding format and content.

Subprogram Contact:

- Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov

Website: https://science.osti.gov/np/research/

(i) NP Quantum Information Science (QIS)

Quantum Horizons: QIS Research and Innovation for Nuclear Science is an initiative to identify, prioritize, and coordinate emerging opportunities in both fundamental research and applied challenges at the interface of Nuclear Physics and Quantum Information Science and Technology (QIST). QIS is a rapidly developing interdisciplinary field and has been identified as an important cross-cutting topic and where continued leadership is critically important to our nation's national security and economic competitiveness. Emerging priority areas in QIS provide new opportunities to address challenges of enormous interest and complexity in NP.

NP's Quantum Horizons emphasizes the science-first approach and supports research that could, in the long-term, have a transformative impact on the NP mission area and/or advance QIS development enabled by NP-supported science, technologies, and laboratory infrastructure. Likewise, QIS technologies offer the ability to discover and probe the fundamental structure and behavior of Nature with unprecedented sensitivity and accuracy. Topics may include quantum computation, quantum simulations and simulators, quantum sensing, quantum-enhanced nuclear physics detectors, nuclear many-body problem, 'squeezed' quantum states, nuclear qubits, quantum entanglement, and implementation of NP theories on quantum hardware, as well as other novel areas of basic research and technologies.

This subprogram specifically encourages exploitation of the interdisciplinary nature of Quantum Computing and QIST to expand the frontiers of NP-supported research. Applications to this subprogram may be solicited through a separate Funding Opportunity Announcement. Prospective investigators are encouraged to contact the Subprogram Contact.
Subprogram Contact:

- Gulshan Rai, Gulshan.Rai@science.doe.gov

Website: https://science.osti.gov/np/Research/Quantum-Information-Science

7. Isotope R&D and Production (DOE IP)
Program Website: https://science.osti.gov/Isotope-Research-Development-and-Production

The mission of the Office of Isotope R&D and Production, commonly referred to as the DOE Isotope Program (DOE IP), is to produce and/or distribute radioactive and enriched stable isotopes that are in short supply or not produced in the U.S.; ensure national preparedness for critical isotope production and distribution by maintaining mission readiness of relevant national infrastructure and core competencies; conduct advanced R&D to develop innovative technology, advanced radiochemical separations and purifications, and unique and diverse core competencies to create or improve entirely novel isotope production and radiochemistry processing capability; and mitigate U.S. dependence on foreign supplies of isotopes by promoting robust domestic supply chains. The DOE IP relies on expertise across numerous technical disciplines to accomplish its mission, including nuclear and radiochemistry, nuclear physics, accelerator and reactor science, materials science and engineering, separations science, nuclear data, and others. The DOE IP utilizes national facilities and capabilities for the production and distribution of stable and radioactive isotopes to research and commercial entities. The scientific and technical staff involved in isotope production and the associated R&D efforts are also supported. Radioactive and enriched stable isotopes are made available using unique facilities stewarded by DOE IP at Brookhaven National Laboratory, Los Alamos National Laboratory, Argonne National Laboratory, and Oak Ridge National Laboratory. DOE IP also coordinates and supports isotope production at a suite of university, national laboratory, and other federal accelerator and reactor facilities throughout the Nation to promote a reliable, domestic supply of isotopes.

While not an exhaustive list, five broad topics of interest to the DOE IP R&D portfolio are listed below. The topics seek the development of advanced, cost-effective, and efficient technologies for producing, processing (including isotopic separations, and the development of biological tracers), extracting, recycling, and distributing isotopes in short supply. This includes technologies for production of radioisotopes using reactor and accelerator facilities and new technologies for enriching stable isotopes. It is also important to note that workforce development is viewed as an essential component of the Program's R&D portfolio. Excluded from this call are applications related to the production of Mo-99 and Pu-238, as these isotopes are under the purview of the National Nuclear Security Administration Office of Materials Management and Minimization and the DOE Office of Nuclear Energy, respectively. A primary document currently guiding DOE IP priorities is entitled "Meeting Isotope Needs and Capturing Opportunities for the Future: The 2015 Long Range Plan for the DOE-NP Isotope Program." This document may be accessed at: https://science.osti.gov/~/media/np/nsac/pdf/docs/2015/2015_NSACI_Report_to_NSAC_Final.pdf. Additional information about the Isotope Program may be found at: https://science.osti.gov/Isotope-Research-Development-and-Production. Furthermore, the DOE IP does NOT support investigations into the development of nuclear reactors for purposes outside the scope of the DOE IP priority areas described above.

(a) Radioisotope Production
Applications to this topic should be focused on novel or improved capabilities for inducing transmutation of atoms in targets to create radioisotopes. This includes aspects of targetry and

target fabrication. The development of innovative approaches to isotope production are of interest, including integration of artificial intelligence and machine learning techniques to model and predict the behavior of targets undergoing irradiation to optimize one or more parameters. Both accelerator- and reactor-based isotope production modalities are understood to require different considerations. Applications to this topic can address either or both production modalities. Robotics and advanced manufacturing techniques, as they apply to isotope production and processing, may also be proposed to this topic.
Subprogram Contact:

- Ethan Balkin, Ethan.Balkin@science.doe.gov

Website: https://science.osti.gov/Isotope-Research-Development-and-Production

(b) Isotope Processing and Purification

This topic includes, but is not limited to, the improvement and/or development of novel chemical and physical processes to recover and purify radioisotopes from activated targets. Development of automated production and processing techniques to enhance the efficiency and safety of radioisotope production (including uses of Artificial Intelligence or Machine Learning) would also be encouraged in this topic.

Subprogram Contact:

- Ethan Balkin, Ethan.Balkin@science.doe.gov

Website: https://science.osti.gov/Isotope-Research-Development-and-Production

(c) Nuclear Chemistry and Radiochemical Separations

Work in this topic might include recovery and purification of radioisotopes from legacy materials, facility components, used nuclear fuel, or waste streams of other processing efforts as well as from irradiated target material. Automation of production and processing techniques or facilities to enhance the efficiency and safety of radioisotope production (including uses of Artificial Intelligence or Machine Learning) would also be applicable here.

Subprogram Contact:

- Ethan Balkin, Ethan.Balkin@science.doe.gov

Website: https://science.osti.gov/Isotope-Research-Development-and-Production

(d) Biological Tracers and Imaging

Work in this topic should be focused on the development of isotopes and/or chemical constructs which have physical or chemical properties that make them particularly useful as biological tracers and/or imaging agents. Included in this topic are the synthesis and development of novel chelating agents or other ligands. Please note that the IP funds only basic science R&D. Studies investigating the applications of isotopes will not be considered for funding.

Subprogram Contact:

- Ethan Balkin, Ethan.Balkin@science.doe.gov

Website: https://science.osti.gov/Isotope-Research-Development-and-Production

(e) Isotopic Enrichment Technology
Applications to this topic should focus on the science and technology of separating isotopes of the same element from each other. Applications involving energy and feedstock efficient enrichment technologies are also acceptable. DOE IP is presently making significant investments in the establishment of a broad-scope stable isotope enrichment capability using gas centrifuge and electromagnetic ion separation (EMIS) technologies, as well as a modest radioisotope EMIS investment. Therefore, new applications aimed at stable and radioisotope enrichment should utilize technologies other than gas centrifuge and electromagnetic ion separation.
Subprogram Contact:

- April Gillens, April.Gillens@science.doe.gov

Website: https://science.osti.gov/Isotope-Research-Development-and-Production

Excluded from this call are applications related to the production of Mo-99, as this isotope is under the purview of the National Nuclear Security Administration Office of Materials Management and Minimization, and the production of Pu-238, as this isotope is under the purview of the Office of Nuclear Energy. A primary document currently guiding Isotope Program priorities is entitled "Meeting Isotope Needs and Capturing Opportunities for the Future: The 2015 Long Range Plan for the DOE-NP Isotope Program." This document may be accessed at https://science.osti.gov/~/media/np/nsac/pdf/docs/2015/2015_NSACI_Report_to_NSAC_Final.pdf. Additional information about the Isotope Program may be found at https://science.osti.gov/np/research/idpra/.

8. Accelerator R&D and Production (ARDAP)
Program Website: https://science.osti.gov/hep/Research/Accelerator-Stewardship

The Office of Accelerator R&D and Production's (ARDAP's) mission is to help coordinate Office of Science accelerator R&D, promote the development and deployment of accelerator technology, support workforce development and improve its diversity, and provide resources for accelerator design and engineering. Applicants addressing *cross-cutting accelerator research or technology development* activities in one or more of the following five research areas are *strongly encouraged* to submit applications to either the annual Research Opportunities in Accelerator Stewardship FOA and/or to the annual Early Career Research Program FOA, each available through https://www.grants.gov. Applications that are in direct support of ARDAP research activities may be submitted to this FOA but will likely be assigned a lower programmatic priority than those from the Accelerator Stewardship comparative review process. Prior to any submission to this FOA, applicants are *strongly encouraged* to contact the program manager listed below to develop applications that address the program's goals.

Topics funded through the ARDAP program include, but are not limited to:

1. Superconducting accelerator systems—both radiofrequency accelerators and high-field magnets—including research on superconducting materials, engineering, and cryogenic techniques.
2. Beam physics and high-fidelity computer modeling, together with better diagnostics and advanced control systems, including theory and simulation to accurately model the next generation of particle accelerators; better diagnostics, more sophisticated and automated

control systems; and advances in particle-collider-specific beam physics including final focusing and advanced cooling techniques.
3. Very high brightness and high current electron sources and in high intensity proton and ion sources and more robust megawatt-class targets for secondary beam production.
4. High average power radiofrequency and ultrafast laser sources, including improvements in power handling devices such as waveguide windows and couplers for radiofrequency systems, and high-power optics and coatings for laser systems.
5. High-risk high-reward advances in accelerator science and technology, including novel particle sources, advanced beam dynamics, new acceleration techniques, and next-generation materials.

Program Contact:
- Eric R. Colby, Eric.Colby@science.doe.gov

Website: https://science.osti.gov/

Open Science

SC is dedicated to promoting the values of openness in Federally supported scientific research, including, but not limited to, ensuring that research may be reproduced and that the results of Federally supported research are made available to other researchers. These objectives may be met through any number of mechanisms including, but not limited to, data access plans, data sharing agreements, the use of archives and repositories, and the use of various licensing schemes.

The use of the phrase "open-source" does not refer to any particular licensing arrangement, but is to be understood as encompassing any arrangement that furthers the objective of openness.

Multi-Institutional Teams

SC uses two different mechanisms to support teams of multiple institutions.

COLLABORATIVE APPLICATIONS

Teams of multiple institutions may submit collaborative applications. Each submitted application in such a team must indicate that it is part of a collaborative project/group. Every partner institution must submit an application through its own sponsored research office. Each multi-institutional team can have only one lead institution. Each application within the multi-institutional team, including the narrative, starting with the title page, and all required appendices and attachments, must be identical with the following exceptions:
- Each application must contain a correct SF-424 (R&R)[3] cover page for the submitting institution only.

3 The Standard Form 424 (SF-424) family of forms is used to apply for Federal financial assistance through https://www.Grants.gov. The Research and Related (R&R) set of forms is used by the Office of Science.

- Each application must contain a unique budget corresponding to the expenditures for that application's submitting institution only.
- Each application must contain a unique budget justification corresponding to the expenditures for that application's submitting institution only.

Our intent is to create from the various applications associated with a multi-institutional team one document for merit review that consists of the common, identical materials combined with a set of detailed budgets from the partner institutions. Thus, it is very important that every research narrative in the multi-institutional team be identical, while each team member must submit its own system-generated cover page, budget, and budget justification. Each team member's application must contain the same project title.

SUBAWARDS[4]

Multi-institutional teams may submit one application from a designated lead institution with all other team members proposed as subrecipients.

DOE/National Nuclear Security Administration (NNSA) National Laboratories[5], other Federal agencies, and another Federal agency's FFRDCs[6], if participating in a team led by another institution, may be proposed as subrecipient.

Note that the value of any such proposed subaward may be removed from any such prime award: DOE may make separate awards to Federally affiliated institutions.

DISTINGUISHING BETWEEN COLLABORATIVE APPLICATIONS AND SUBAWARDS

The following points of advice to applicants may be helpful:

1. Both collaborative applications and proposed subawards are methods by which multiple institutions can work together to reach the scientific objectives described in this FOA. Choose the appropriate structure based on the nature of the scientific work being proposed. If multiple institutions will be functioning as a network of peer-level researchers, a collaborative structure would be more appropriate. If multiple institutions will be functioning with leadership and direction coming from one institution, a subaward arrangement would be more appropriate.
    a. Collaborative applications are assembled from multiple identical applications submitted by the proposing institution. Such applications may be submitted under this FOA in Grants.gov. The multiple applications will be assembled into one joint collaborative application, which will be merit-reviewed as one document, with recommendations to fund or decline the application made at the level of each independent application.

4 Subawards are made to subrecipients. Both terms are defined in 2 CFR 200.1 (https://www.ecfr.gov)
5 The phrase "National Laboratories" is used broadly to encompass DOE/NNSA laboratories and sites capable of performing the work described in this FOA and capable of receiving funds through the DOE Field Work System.
6 An authoritative list of all Federally Funded Research and Development Centers (FFRDCs) may be found at https://www.nsf.gov/statistics/ffrdclist/

b. Subawards exist when multiple institutions work together to submit one application with a designated prime awardee and multiple potential subrecipients.
c. DOE/NNSA National Laboratories, other Federal agencies, and another Federal agency's FFRDCs may be proposed as subrecipients, but the value of any such proposed subaward may be removed from any such prime award: DOE will often make separate awards to Federally affiliated institutions.

2. A well-thought-out research plan and its associated budget(s) should leave no confusion about which institution will do which parts of the research.

All entities submitting applications to this FOA must recognize the moral and legal obligations to comply with export controls and policies that limit the transfer of technologies with potential dual use. Applicants are reminded that international activities must comply with nonproliferation, sanction, and other protocols described at https://www.export.gov.

International activities related to special nuclear materials (SNM) are subject to additional requirements. Please see 10 CFR 810 for further information.

This FOA is to support scientific endeavors that could be described in scholarly publications. Do not submit applications containing restricted data or unclassified nuclear information as defined in the Atomic Energy Act of 1954, as amended, 42 USC 2011 et seq., 10 CFR 1017, 10 CFR 1045.

Section II – AWARD INFORMATION

A. TYPE OF AWARD INSTRUMENT

DOE anticipates awarding grants, cooperative agreements, and/or interagency agreements under this FOA.

DOE will consider funding multi-institution teams submitted as collaborative applications, in which each institution must submit its own application with an identical common research narrative, under this FOA. Multi-institutional teams may also apply using a prime and subaward model with one application submitted by the lead institution.

Statement of Substantial Involvement

Either a grant or cooperative agreement may be awarded under this FOA. If the award is a cooperative agreement, the DOE contract specialist/grants management specialist and DOE project officer will negotiate a Statement of Substantial Involvement prior to award.

B. ESTIMATED FUNDING

DOE anticipates that approximately $400 million in current and future fiscal year funds will be used to support awards under this FOA. The amount of funding allocated under this specific FOA will be decided based on a number of factors, including peer review, the number and contents of applications received, and the availability of appropriated funds.

DOE is under no obligation to pay for any costs associated with preparation or submission of applications. DOE reserves the right to fund, in whole or in part, any, all, or none of the applications submitted in response to this FOA.

C. MAXIMUM AND MINIMUM AWARD SIZE

The award size will depend on the number of meritorious applications and the availability of appropriated funds.

Ceiling

The largest award made under the Fiscal Year 2021 version of this FOA received no more than $5,000,000 in annual funding.

Floor

The smallest award made under the Fiscal Year 2021 version of this FOA received $5,000 in annual funding.

The ceiling and floor described in this FOA represent historical experience. Past practice is not an obligation to stay within the historic ceiling and floor for this FOA.

D. EXPECTED NUMBER OF AWARDS

The number of awards is subject to the availability of appropriated funds. Historically, applications that arrive in response to the FOA have resulted in 200 to 350 new awards per year.

The exact number of awards will depend on the number of meritorious applications and the availability of appropriated funds.

E. ANTICIPATED AWARD SIZE

The award size will depend on the number of meritorious applications and the availability of appropriated funds.

F. PERIOD OF PERFORMANCE

Awards are expected to be made for a project period of six months to five years as befitting the project, with the most common project period being three years in duration.

Continuation funding (funding for the second and subsequent budget periods) is contingent on: (1) availability of funds appropriated by Congress and future year budget authority; (2) progress towards meeting the objectives of the approved application; (3) submission of required reports; and (4) compliance with the terms and conditions of the award.

G. TYPE OF APPLICATION

DOE will accept new, renewal, and supplemental applications under this FOA. Information about how to distinguish between new and renewal applications is located in Section VIII.

Applications for supplemental funding to existing SC awards may be submitted under this FOA. Such applications compete for funding with all other applications submitted under this FOA. Applications for supplemental funding may be made in three broad types:

1. **Supplemental funding with no change in scope**. Such applications must indicate that they are being made to request additional funding without any change to the authorized scope of work. These applications will not require merit review and may be quite brief.
2. **Supplemental funding with a change in scope**. Such applications must indicate that they propose an additional scope of work from that authorized in the existing award. These applications are subject to merit review and must describe the proposed additional scope of work.
3. **Supplemental funding with additional time**. Regardless of the change in scope of work, a supplemental application may also indicate the need for additional time to achieve either the original or changed objectives.

Section III – ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

All types of applicants are eligible to apply, except nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995.

Federally affiliated[7] entities must adhere to the eligibility standards below:

1. DOE/NNSA National Laboratories

DOE/NNSA National Laboratories are not eligible to submit applications under this FOA but may be proposed as subrecipients under another organization's application. If recommended for funding as a proposed subrecipient, the value of the proposed subaward will be removed from the prime applicant's award and will be provided to the laboratory through the DOE Field-Work Proposal System and work will be conducted under the laboratory's contract with DOE. No administrative provisions of this FOA will apply to the laboratory or any laboratory subcontractor. Additional instructions for securing authorization from the cognizant Contracting Officer are found in Section VIII of this FOA.

2. Non-DOE/NNSA FFRDCs

Non-DOE/NNSA FFRDCs are eligible to submit applications (either as a lead organization or as a team member in a multi-institutional team) under this FOA and may be proposed as subrecipients under another organization's application unless otherwise indicated in Section III.D below. If recommended for funding as a lead applicant, funding will be provided through an interagency agreement to the FFRDC's sponsoring Federal Agency. If recommended for funding as a proposed subrecipient, the value of the proposed subaward may be removed from the prime applicant's award and may be provided through an interagency agreement to the FFRDC's sponsoring Federal Agency. Additional instructions for securing authorization from the cognizant Contracting Officer are found in Section VIII of this FOA.

3. Other Federal Agencies

Other Federal Agencies are eligible to submit applications (either as a lead organization or as a team member in a multi-institutional team) under this FOA and may be proposed as subrecipients under another organization's application unless otherwise indicated in Section III.D below. If recommended for funding as a lead applicant, funding will be provided through an interagency agreement. If recommended for funding as a proposed subrecipient, the value of the proposed subaward may be removed from the prime applicant's award and may be provided through an interagency agreement. Additional instructions for providing statutory authorization are found in Section VIII of this FOA.

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7 Institutions that are not DOE/NNSA National Laboratories, a non-DOE/NNSA FFRDC, or another Federal agency are not Federally affiliated, even if they receive Federal funds or perform work under a Federal award or contract.

Applicants that are not domestic organizations should be advised that:

- Individual applicants are unlikely to possess the skills, abilities, and resources to successfully accomplish the objectives of this FOA. Individual applicants are encouraged to address this concern in their applications and to demonstrate how they will accomplish the objectives of this FOA.
- Non-domestic applicants are advised that successful applications from non-domestic applicants include a detailed demonstration of how the applicant possesses skills, resources, and abilities that do not exist among potential domestic applicants.

B. COST SHARING

Cost sharing for basic and fundamental research is not required pursuant to an exclusion from the requirements of Section 988 of the Energy Policy Act of 2005.

C. ELIGIBLE INDIVIDUALS

Individuals with the skills, knowledge, and resources necessary to carry out the proposed research as a Principal Investigator (PI) are invited to work with their organizations to develop an application. Individuals from underrepresented groups as well as individuals with disabilities are always encouraged to apply.

D. OTHER ELIGIBILITY REQUIREMENTS

Additional Eligibility Requirements may be identified in the listing of topics in Section I of this FOA. In particular:

- For topics within High Energy Physics, other Federal agencies and their FFRDCs may not submit applications on their own behalf, though they may be proposed as subawards in another organization’s application.

Section IV – APPLICATION AND SUBMISSION INFORMATION

A. ADDRESS TO REQUEST APPLICATION PACKAGE

Application forms and instructions are available at Grants.gov. To access these materials, go to https://www.Grants.gov, select "Search Grants", and then enter the Catalog of Federal Domestic Assistance (CFDA) number (81.049) and/or the FOA number shown on the cover of this FOA. Select the "Apply" button to access the application package.

Applications submitted through www.FedConnect.net will not be accepted. Applications may not be submitted through PAMS at https://pamspublic.science.energy.gov.

B. LETTER OF INTENT (LOI) AND PRE-APPLICATION

1. Letter of Intent (LOI)

Not applicable.

2. Pre-application

PRE-APPLICATION DUE DATE

Pre-applications may be submitted at any time while this FOA is available.

A pre-application (also called a white paper) is recommended but optional. Before submitting a pre-application, read the information in Section I of this FOA carefully to make sure your idea is responsive and to select the topical subprogram most relevant to your idea.

You will be required to select a program manager when you submit your pre-application using the DOE SC Portfolio Analysis and Management System (PAMS) website. Choose the subprogram contact for the topical area most relevant to your idea from those listed in Section I of this FOA.

Feedback from DOE to the principal investigator is optional, but you are encouraged to use your submitted pre-application/white paper to initiate a discussion with the listed program manager about the appropriateness of the proposed research for this solicitation.

If a multi-institutional team is submitting collaborative applications, only the lead institution may submit a pre-application.

The pre-application attachment must include, at the top of the first page, the following information:

Title of Pre-application
Principal Investigator Name, Job Title
Institution
PI Phone Number, PI Email Address

This information must be followed by a clear and concise description of the objectives and technical approach of the proposed research. The pre-application may not exceed three pages, when printed using standard letter-size (8.5 inch x 11 inch) paper with 1-inch margins (top, bottom, left, and right). The font must not be smaller than 11 point. Figures and references, if included, must fit within the three-page limit.

In addition, the pre-application must include a listing of individuals who should not serve as merit reviewers of a subsequent application. Detailed instructions for how to craft such a listing are provided in Section VIII of this FOA. This listing will not count toward the pre-application's page limit. The list of individuals must be sent via email to the program manager selected as the recipient of your pre-application in PAMS.

The pre-application must be machine readable. Do not submit a scanned image of a printed document.

The absence of a pre-application will not negatively affect a thorough evaluation of a responsive application submitted in a timely fashion.

PRE-APPLICATION SUBMISSION

The pre-application must be submitted electronically through the DOE SC Portfolio Analysis and Management System (PAMS) website https://pamspublic.science.energy.gov/.

Applicants are strongly encouraged to inform their DOE Program Manager if teaming arrangements, proposed personnel, topics, or the anticipated title change between submitting the pre-application and when an application is submitted, to ensure that their application is properly linked to their pre-application and that reviewers are properly assigned to the application.

Detailed instructions about how to submit a pre-application are in Section VIII of this FOA.

C. GRANTS.GOV APPLICATION SUBMISSION AND RECEIPT PROCEDURES

Applications in response to this FOA must be submitted through Grants.gov. Detailed instructions for registering in and using Grants.gov are in Section VIII of this FOA.

D. CONTENT AND APPLICATION FORMS

1. SF-424 (R&R)

Complete this form first to populate data in other forms. Complete all the required fields in accordance with the pop-up instructions on the form. The list of certifications and assurances referenced in Field 17 is available on the DOE Financial Assistance Forms Page at https://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under Certifications and Assurances. Applicants are bound

by their representations and certifications in SAM.gov.

DUNS/UEI AND EIN NUMBERS (FIELDS 5 AND 6)

The DUNS/UEI and Employer Identification Number (EIN) fields on the SF-424 (R&R) form are used in PAMS to confirm the identity of the individual or organization submitting an application.

- Enter each number as a nine-digit number.
- Do not use hyphens or dashes.
- SC does not use the 12-digit EIN format required by some other agencies.
- SC does not use the DUNS+4 format.

TYPE OF APPLICATION (FIELD 8)

A **new** application is one in which DOE support for the proposed research is being requested for the first time. A **renewal** application requests additional funding for a period of time following a current award. If the application requests a significant change in the scope of work, please consult with the Program contact identified in this FOA to determine if the application should be considered new or a renewal.

SC does not make use of the Resubmission or Continuation options.

Applications for supplemental support of an existing award should be marked as "Revision."

Please answer "yes" to the question "Is this application being submitted to other agencies?" if substantially similar, identical, or closely related research objectives are being submitted to another Federal agency. Indicate the agency or agencies to which the similar objectives have been submitted.

2. Research and Related Other Project Information

Complete questions in fields 1 through 6 of the SF-424 Research and Related Other Project Information form.

Note regarding question 4.a. and 4.b.:

If any environmental impact, positive or negative, is anticipated, indicate "yes" in response to question 4.a., "potential impact – positive or negative - on the environment." Disclosure of the impact should be provided in response to question 4.b. First indicate whether the impact is positive or negative and then identify the area of concern (e.g., air, water, exposure to radiation, etc.). Should the applicant have any uncertainty, they should check "yes."

DOE understands the phrase in field 4.a., "potential impact … negative" to apply if the work described in the application could potentially have any of the impacts listed in (1) through (5) of 10 CFR 1021, Appendix B, Conditions that Are

Integral Elements of the Classes of Action in Appendix B. (https://www.ecfr.gov)

Additionally, for actions which could have any other adverse impacts to the environment or have any possibility for adverse impacts to human health (e.g., use of human subjects, Biosafety Level 3-4 laboratory construction/operation, manufacture or use of certain nanoscale materials which are known to impact human health, or any activities involving transuranic or high level radioactive waste, or use of or exposure to any radioactive materials beyond de minimis levels), applicants should indicate a "negative" impact on the environment.

Lastly, 1) if there would be extraordinary circumstances (i.e., scientific or public controversy) related to the significance of environmental effects (10 CFR 1021.410 (b)(2)), 2) if the work is connected to other actions with potentially significant impacts (10 CFR 1021.410 (b)(3), or 3) if the work is related to other nearby actions with the potential for cumulatively significant impacts (10 CFR 1021.410 (b)(3)), applicants should indicate a "negative" impact on the environment.

The bulk of your application will consist of files attached to the Research and Related Other Project Information form. The files must comply with the following instructions:

PROJECT SUMMARY/ABSTRACT (FIELD 7 ON THE FORM)

The project summary/abstract is a summary of the proposed activity suitable for distribution to the public and sufficient to permit potential reviewers to identify conflicts of interest. It must be a self-contained document. Provide the name of the applicant, the project title, the PI and the PI's institutional affiliation, any coinvestigators and their institutional affiliations, the objectives of the project, a description of the project, including methods to be employed, and the potential impact of the project (i.e., benefits, outcomes). A sample is provided below:

Project Title

A. Smith, Lead Institution (Principal Investigator)
A. Brown, Institution 2 (Co-Investigator)
A. Jones, Institution 3 (Co-Investigator)

Text of abstract

The project summary must not exceed one page when printed using standard letter-size (8.5 inch x 11 inch) paper with 1-inch margins (top, bottom, left and right) with font not smaller than 11 point. To attach a Project Summary/Abstract, click "Add Attachment."

If an application is recommended for award, the project summary will be used in preparing a public abstract about the award. Award abstracts and titles form a Government document that describes the project and justifies the expenditure of Federal funds in light of the DOE and SC mission statements at https://energy.gov/mission and https://science.osti.gov/about/.

- Do not include any proprietary or sensitive business information.
- DOE may use the abstract to prepare public reports about supported research.

DOE TITLE PAGE
(PART OF PROJECT NARRATIVE ATTACHED TO FIELD 8 ON THE FORM)

The application narrative must begin with a title page. The title page must include the following items:

- The project title:
- Applicant/Institution:
- Street Address/City/State/ZIP:
- Postal Address:
- Lead PI name, telephone number, email:
- Administrative Point of Contact name, telephone number, email:
- FOA Number: Include the FOA number printed on the cover of this FOA.
- DOE/SC Program Office:
- DOE/SC Program Office Technical Contact:
- DOE Award Number (if Renewal Application):
- PAMS Preproposal tracking number (if applicable):
- Research area or areas as identified in Section I of this FOA (if applicable) :

Important Instructions to the Sponsored Research Office of Submitting Institutions: SC requires that you create one single machine readable PDF file that contains the DOE Title Page, project narrative, biographical sketch, current and pending support, bibliography and references cited, facilities and other resources, equipment, data management plan, and other attachments. This single PDF file may not be scanned from a printed document and must be attached in Field 8 on the Grants.gov form. You are strongly encouraged to submit the combined research narrative file through a "Print to PDF" or equivalent process to ensure that all content is visible in the one PDF file. Do not attach any of the items listed in this paragraph separately in any other field in Grants.gov. If you do, these additional attachments will not become part of the application in PAMS.

TITLE PAGE SUPPLEMENT FOR COLLABORATIVE APPLICATIONS
(PART OF PROJECT NARRATIVE ATTACHED TO FIELD 8 ON THE FORM)

If a multi-institutional team is submitting collaborative applications, provide the following information on a separate page as a supplement to the title page. This page will not count toward the project narrative page limitation.

- List all institutions by name with each institution's PI on the same line.
- Indicate the lead PI who will be the point of contact and coordinator for the combined research activity.
- Provide a statement explaining the leadership structure of the team.
- Include a description of each institution's facilities, equipment, and resources that will be made available to the team.

- If applicable, explain how students and early-stage researchers will be trained and mentored by senior researchers.
- Include a table modeled on the following chart providing summary budget information from all institutions. Provide the total costs of the budget request in each year for each institution and totals for all rows and columns.

Collaborative Application Information								
	Names	**Institution**	**Year 1 Budget**	**Year 2 Budget**	**Year 3 Budget**	**Year 4 Budget**	**Year 5 Budget**	**Total Budget**
Lead PI								
Co-PI								
Co-PI								
Co-PI								

Example budget table ($ in thousands)

* Note that collaborating applications must be submitted separately.

PROJECT NARRATIVE (FIELD 8 ON THE FORM)

The project narrative consists of technical information, including charts, graphs, maps, photographs, and other pictorial presentations, when printed using standard letter-size (8.5 inch x 11 inch) paper with 1-inch margins (top, bottom, left, and right). The font must not be smaller than 11 point.

Do not include any websites (URLs) that provide supplementary or additional information that constitutes a part of the application. Merit reviewers are not required to access websites; however, Internet publications in a list of references will be treated identically to print publications. See Section VIII for instructions on how to mark proprietary application information. To attach a Project Narrative, click "Add Attachment."

The Project Narrative comprises the research plan for the project. It should contain enough background material in the Introduction, including a brief review of the relevant literature and any prior research in this area, to demonstrate sufficient knowledge of the state of the science. The major part of the narrative should be devoted to a description and justification of the proposed project, including details of the methods to be used. It should also include a timeline for the major activities of the proposed project, and should indicate which project personnel will be responsible for which activities. There should be no ambiguity about which personnel will perform particular parts of the project, and the time at which these activities will take place.

The following organization of the Project Narrative is suggested:

- **Background/Introduction**: Explanation of the importance and relevance of the proposed work as well as a review of the relevant literature.
- **Progress Report (for Renewal Applications Only):** The Project Narrative of a renewal

application must include a separate section that includes a description of results of the work accomplished during the current project period (since the last new or renewal award), an analysis of how the results relate to the activities proposed to be undertaken during the renewal period, and a description of any changes that affected the overall direction of the research being performed. Include an estimate of any remaining funds from the current project period at its anticipated end.

- **Project Objectives:** This section should provide a clear, concise statement of the specific objectives/aims of the proposed project.
- **Proposed Research and Methods**: Identify the hypotheses to be tested (if any) and details of the methods to be used including the integration of experiments with theoretical and computational research efforts.

The Project Narrative is considered the intellectual work of the proposed researchers. Concurrent submission of the same or substantially similar narratives attributed to different researchers may constitute academic dishonesty or research misconduct. Submission of a research narrative that is not the work of the proposed researchers, including machine-generated research narratives, may constitute academic dishonesty or research misconduct.

> **For Collaborative Applications Only**: Each institution in a multi-institutional team submitting collaborative applications must submit an identical common narrative, including all appendices. Collaborative applications will necessarily be longer than single-institution applications. The common narrative must identify which tasks and activities will be performed by which of the institutions in every budget period of the proposed project. The budget and the budget justification—which are unique to each institution—may refer to parts of the common narrative to further identify each institution's activities in the joint project. There should be no ambiguity about each institution's role and participation in the team.
>
> SC will use the multiple applications associated with a multi-institutional team to create one consolidated document for merit review that consists of the common, identical application materials combined with a set of detailed budgets from the partner institutions. It is very important that every application in the team be identical (including the title) with the exception of the budget and budget justification pages.

Do not attach any of the requested appendices described below as files for fields 9, 10, 11, and 12 in Grants.gov. Follow the below instructions to include the information as appendices in the single, bundled project narrative file.

APPENDIX 1: BIOGRAPHICAL SKETCH

Provide a biographical sketch for the PI and each senior/key person listed in Section A on the R&R Budget form.

- Provide the biographical sketch information as an appendix to your project narrative.
- Do not attach a separate file.

- The biographical information (curriculum vitae) for each person must not exceed two pages when printed on letter-size (8.5 inch x 11 inch) paper with 1-inch margins (top, bottom, left, and right) with font not smaller than 11 point

Detailed instructions may be found in Section VIII of this FOA.

> **WARNING**: These instructions have been significantly revised to require disclosure of a variety of potential conflicts of interest or commitment, including participation in foreign government-sponsored talent recruitment programs.
>
> The PI and each senior/key person at the prime applicant and any proposed subaward must provide a list of all sponsored activities, awards, and appointments, whether paid or unpaid; provided as a gift with terms or conditions or provided as a gift without terms or conditions; full-time, part-time, or voluntary; faculty, visiting, adjunct, or honorary; cash or in-kind; foreign or domestic; governmental or private-sector; directly supporting the individual's research or indirectly supporting the individual by supporting students, research staff, space, equipment, or other research expenses. All foreign government-sponsored talent recruitment programs must be identified in current and pending support.

APPENDIX 2: CURRENT AND PENDING SUPPORT

Provide a list of all current and pending support for the PI and senior/key personnel, including subrecipients, regardless of funding source. Provide the Current and Pending Support as an appendix to your project narrative. Concurrent submission of an application to other organizations for simultaneous consideration will not prejudice its review.

- Do not attach a separate file.

Detailed instructions may be found in Section VIII of this FOA.

APPENDIX 3: BIBLIOGRAPHY & REFERENCES CITED

Provide a bibliography of any references cited in the Project Narrative. Each reference must include the names of all authors (in the same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication. For research areas where there are routinely more than 10 coauthors of archival publications, you may use an abbreviated style such as the *Physical Review Letters* (PRL) convention for citations (listing only the first author). For example, your paper may be listed as, "A Really Important New Result," A. Aardvark et. al. (MONGO Collaboration), PRL 999. Include only bibliographic citations. Applicants should be especially careful to follow scholarly practices in providing citations for source materials relied upon when preparing any section of the application. Provide the Bibliography and References Cited information as an appendix to your project narrative.

- Do not attach a separate file.

APPENDIX 4: FACILITIES & OTHER RESOURCES

This information is used to assess the capability of the organizational resources, including

subrecipient resources, available to perform the effort proposed. Identify the facilities to be used (Laboratory, Animal, Computer, Office, Clinical and Other). If appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Describe only those resources that are directly applicable to the proposed work. Describe other resources available to the project (e.g., machine shop, electronic shop) and the extent to which they would be available to the project. For proposed investigations requiring access to experimental user facilities maintained by institutions other than the applicant, please provide a document from the facility manager confirming that the researchers will have access to the facility. Such documents, provided that they do not become letters of support or recommendation, may be printed on any letterhead. Please provide the Facility and Other Resource information as an appendix to your project narrative.

- Do not attach a separate file.

APPENDIX 5: EQUIPMENT

List major items of equipment already available for this project and, if appropriate identify location and pertinent capabilities. Provide the Equipment information as an appendix to your project narrative.

- Do not attach a separate file.

APPENDIX 6: DATA MANAGEMENT PLAN

Provide a Data Management Plan (DMP) as an appendix to the research narrative.

SC program offices may provide additional guidance, available through https://science.osti.gov/funding-opportunities/digital-data-management/. Compliance with a program office's additional guidance will not be considered during merit review and award selection.

DMPs are NOT required for conference or workshop applications.

DMPs are required for all New and Renewal applications submitted to this FOA.

- This appendix should not exceed a page limit of two pages including charts, graphs, maps, photographs, and other pictorial presentations, when printed using standard letter-size (8.5 inch x 11 inch) paper with 1-inch margins (top, bottom, left, and right)
- Do not attach a separate file.

The standard requirements for a DMP may be found in Section VIII of this FOA.

APPENDIX 7: OTHER ATTACHMENT

If you need to elaborate on your responses to questions 1-6 on the "Other Project Information" document, please provide the Other Attachment information as an appendix to your project narrative. Information not easily accessible to a reviewer may be included in this appendix, but do not use this appendix to circumvent the page limitations of the application. Reviewers are not

required to consider information in this appendix.

- Do not attach a separate file.

REMINDERS REGARDING ALL APPENDICES

- **Follow the above instructions to include the information as appendices to the project narrative file.**
- **Do not attach any files to fields 9, 10, 11, or 12.**

3. Research And Related Budget

Complete the Research and Related Budget form in accordance with the instructions on the form (Activate Help Mode to see instructions) and the following instructions. You must complete a separate budget for each year of support requested. The form will generate a cumulative budget for the total project period. You must complete all the mandatory information on the form before the NEXT PERIOD button is activated. You may request funds under any of the categories listed as long as the item and amount are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions in this FOA.

Additional information is found in Section VIII of this FOA.

BUDGET JUSTIFICATION (FIELD L ON THE FORM)

Provide a justification that explains all costs proposed in the budget. The following items of advice are offered to assist you in developing a justification.

- Organize the justification by listing items in the same order as presented on the budget.
- Ensure that the narrative matches the budget in dollar amounts and language.
- Explain the line items. If costs are estimated, provide a basis for the estimate. Explain if costs are based on prior experience of similar activities. If a cost is based on the product of two numbers (such as a number of items at a per-item price), ensure that your math is correct.
- If including an inflationary factor for future budget periods, explain the basis for the inflationary factor.

Provide any other information you wish to submit to justify your budget request. Including items in the budget justification is not considered a form of cost-sharing: Provide the details of all personnel (key or other) who will be working on the award, regardless of their source(s) of compensation. Explain their source(s) of compensation if it is not from this award. Include the indirect cost rate agreement as a part of the budget justification.

Attach a single budget justification file for the entire project period in field L. The file automatically carries over to each budget year.

Additional information is found in Section VIII of this FOA.

4. R&R Subaward Budget Attachment(s) Form

Budgets for Subawards: You must provide a separate R&R budget and budget justification for each subrecipient. Download the R&R Budget Attachment from the R&R SUBAWARD BUDGET ATTACHMENT(S) FORM and either email it to each subrecipient that is required to submit a separate budget or use the collaborative features of Workspace. After the subrecipient has either emailed its completed budget back to you or completed it within Workspace, attach it to one of the blocks provided on the form. Use up to 10 letters of the subrecipient's name (plus.pdf) as the file name (e.g., ucla.pdf or energyres.pdf). Filenames must not exceed 50 characters.

If the project involves more subrecipients than there are places in the SUBAWARD BUDGET ATTACHMENT(S) FORM, the additional subaward budgets may be saved as PDF files and appended to the Budget Justification attached to Field L.

Applicants should consult their local information technology ("IT") support resources for any necessary assistance in converting the forms downloaded from Grants.gov into plain PDF files that can be combined into one non-Portfolio PDF file (the Budget Justification).

Ensure that any files received from subrecipients are the PDF files extracted from the SUBAWARD BUDGET ATTACHMENT(S) FORM. Errors will be created if a subrecipient sends a prime applicant a budget form that was not extracted from the application package.

Note: If an application proposes subawards to a DOE/NNSA National Laboratory, a Federal agency, or another Federal agency's FFRDC, the value of such proposed subawards may be deducted from any resulting award: Those classes of organizations may be paid directly by SC. However, the details of such proposed budgets are an essential for understanding and analyzing the proposed research.

5. Project/Performance Site Location(s)

Indicate the primary site where the work will be performed. If a portion of the project will be performed at any other site(s), identify the site location(s) in the blocks provided.

Note that the Project/Performance Site Congressional District is entered in the format of the 2-digit state code followed by a dash and a 3-digit Congressional district code, for example VA-001. Hover over this field for additional instructions.

Use the Next Site button to expand the form to add additional Project/Performance Site Locations.

6. Disclosure of Lobbying Activities (SF-LLL)

If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the grant/cooperative agreement, you must complete and submit Standard Form

- LLL, "Disclosure Form to Report Lobbying."

7. Identification of Merit Reviewer Conflicts

Provide a list of individuals who should not serve as merit reviewers of this application, following the instructions in Section VIII of this FOA. Attach this information to Field 12 of the Research and Related Other Project Information Form.

8. Summary of Required Forms/Files

Your application must include the following items:

Name of Document	Format	Attach to
SF 424 (R&R)	Form	N/A
RESEARCH AND RELATED Other Project Information	Form	N/A
Project Summary/Abstract	PDF	Field 7
Project Narrative, including required appendices	PDF	Field 8
Identification of Merit Review Conflicts	File	Field 12
RESEARCH & RELATED BUDGET	Form	N/A
Budget Justification	PDF	Field L
R&R SUBAWARD BUDGET ATTACHMENT(S) FORM (if applicable)	Form	N/A
Subaward Budget Justification (if applicable)	PDF	Field L of the subaward budget
PROJECT/PERFORMANCE SITE LOCATION(S)	Form	N/A
SF-LLL Disclosure of Lobbying Activities, if applicable	Form	N/A

E. SUBMISSIONS FROM SUCCESSFUL APPLICANTS

If selected for award, DOE reserves the right to request additional or clarifying information for any reason deemed necessary, including, but not limited to:

- Indirect cost information
- Other budget information
- Name and phone number of the Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5)
- Representation of Limited Rights Data and Restricted Software, if applicable
- Commitment Letter from Third Parties Contributing to Cost Sharing, if applicable
- Environmental Information

Applicants that are not institutions of higher education, that request indirect costs, and that do not

already have an Indirect Cost Rate Agreement with their Cognizant Federal Agency or documentation of rates accepted for estimating purposes by DOE or another Federal agency, are advised to begin preparing an Indirect Cost Rate Proposal for submission, upon request, to the DOE contract specialist/grants management specialist who will evaluate your application if you are selected for award.

F. SUBMISSION DATES AND TIMES

1. Letter of Intent Due Date

Not applicable.

2. Pre-application Due Date

Optional, though recommended pre-applications may be submitted at any time while this FOA is available.

3. Application Due Date

This FOA will remain open until September 30, 2022, 11:59 PM Eastern Time, or until it is succeeded by another issuance, whichever occurs first. This FOA succeeds DE-FOA-0002414, which was published October 1, 2020.

Applications for conference or workshop support must be submitted at least six months before the meeting date and no later than April 1, 2022, to be considered for FY 2022 funding.

Renewal applications compete with all other applications and must be submitted through Grants.gov at least six months before the scheduled expiration of the current award's project period. Earlier submission is strongly encouraged to allow for timely processing.

Section V - APPLICATION REVIEW INFORMATION

A. CRITERIA

1. Initial Review Criteria

Prior to a comprehensive merit evaluation, DOE will perform an initial review in accordance with 10 CFR 605.10(b) to determine that (1) the applicant is eligible for the award; (2) the information required by the FOA has been submitted; (3) all mandatory requirements are satisfied; (4) the proposed project is responsive to the objectives of the FOA, and (5) the proposed project is not duplicative of programmatic work. Applications that fail to pass the initial review will not be forwarded for merit review and will be eliminated from further consideration.

2. Merit Review Criteria

Applications will be subjected to scientific merit review (peer review) and will be evaluated against the following criteria as found in 10 CFR 605.10 (d), the Office of Science Financial Assistance Program Rule.

- Scientific and/or Technical Merit of the Project;
- Appropriateness of the Proposed Method or Approach;
- Competency of Applicant's Personnel and Adequacy of Proposed Resources; and
- Reasonableness and Appropriateness of the Proposed Budget.

Note that external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Both Federal and non-Federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

The questions below are provided to the merit reviewers to elaborate the criteria established by regulation:

SCIENTIFIC AND/OR TECHNICAL MERIT OF THE PROJECT

- What is the scientific innovation of the proposed research?
- What is the likelihood of achieving valuable results?
- How might the results of the proposed work impact the direction, progress, and thinking in relevant scientific fields of research?
- How does the proposed work compare with other efforts in its field, both in terms of scientific and/or technical merit and originality?
- Is the Data Management Plan suitable for the proposed research? To what extent does it support the validation of research results? To what extent will research products, including data, be made available and reusable to advance the field of research?

- For renewal applications only: Is the proposed work an appropriate outgrowth of, continuation to, or successor of the currently-supported research?

APPROPRIATENESS OF THE PROPOSED METHOD OR APPROACH

- How logical and feasible are the research approaches?
- Does the proposed research employ innovative concepts or methods?
- Are the conceptual framework, methods, and analyses well justified, adequately developed, and likely to lead to scientifically valid conclusions?
- Does the applicant recognize significant potential problems and consider alternative strategies?
- *For applications submitted to Fusion Energy Sciences, High Energy Physics, and Nuclear Physics:* Is the proposed research aligned with the published priorities in the program's strategic plan (i.e., 2021 FESAC Long-Range Plan, 2014 P5 strategic plan, and 2015 NSAC Long-Range Plan, respectively)?

COMPETENCY OF APPLICANT'S PERSONNEL AND ADEQUACY OF PROPOSED RESOURCES

- What is the past performance and potential of the research team?
- How well qualified is the research team to carry out the proposed research?
- Are the research environment and facilities adequate for performing the research, including any synergistic opportunities, institutional support, and/or infrastructure?
- Does the proposed work take advantage of unique facilities and capabilities?

REASONABLENESS AND APPROPRIATENESS OF THE PROPOSED BUDGET

- Are the proposed budget and staffing levels adequate to carry out the proposed research?
- Is the budget reasonable and appropriate for the scope?

B. REVIEW AND SELECTION PROCESS

Applications submitted to this FOA will be reviewed and considered for funding on a rolling basis. Applicants are cautioned that the Federal budget cycle may impact the availability of funds. Applications submitted in the latter half of the Federal fiscal year (April 1 – September 30) may be considered for funding in the next fiscal year.

1. Merit Review

Applications that pass the initial review will be subjected to a formal merit review and will be evaluated based on the criteria codified at 10 CFR 605.10(d) in accordance with the guidance provided in the "Office of Science Merit Review System for Financial Assistance," which is available at: https://science.osti.gov/grants/policy-and-guidance/merit-review-system/.

2. Program Policy Factors

The Selection Official may consider any of the following program policy factors in making the selection, listed in no order of significance:

- Availability of funds
- Relevance of the proposed activity to SC priorities
- Ensuring an appropriate balance of activities within SC programs
- Performance under current awards, if applicable
- Commitment to sharing the results and products of research
- Promoting principal investigators not previously supported by SC
- Promoting the diversity of supported investigators and researchers
- Promoting the diversity of institutions receiving awards
- Participation with multi-institutional teams in accordance with program priorities identified and incorporated in Section I of this FOA

3. Selection

The Selection Official will consider the findings of the merit review and may consider any of the Program Policy Factors described above.

4. Review of Risk

Pursuant to 2 CFR 200.206, DOE will conduct an additional review of the risk posed by applications submitted under this FOA. Such review of risk will include:

- Quality of the application,
- Reports and findings from audits performed under 2 CFR 200 or OMB Circular A-133, and
- Systems maintained under 2 CFR 180.

DOE may make use of other publicly available information and the history of an applicant's performance under DOE or other Federal agency awards.

Applicants with no prior performance of DOE awards may be asked to provide information about their financial stability and or their ability to comply with the management standards of 2 CFR 200.

5. Discussions and Award

The Government may enter into discussions with a selected applicant for any reason deemed necessary, including but not limited to the following: (1) the budget is not appropriate or reasonable for the requirement; (2) only a portion of the application is selected for award; (3) the Government needs additional information to determine that the recipient is capable of complying with the requirements in 2 CFR 200 as modified by 2 CFR 910 (DOE Financial Assistance Regulation); and/or (4) special terms and conditions are required. Failure to resolve satisfactorily the issues identified by the Government will preclude award to the applicant.

C. ANTICIPATED NOTICE OF SELECTION AND AWARD DATES

DOE anticipates making funding decisions within six months. The time interval begins on the date the application is received.

Section VI – AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. Notice of Selection

Selected Applicants Notification: DOE will notify applicants selected for award. This notice of selection is not an authorization to begin performance.

Non-selected Notification: Organizations whose applications have not been selected will be advised as promptly as possible. This notice will explain why the application was not selected.

2. Notice of Award

An Assistance Agreement issued by the DOE Contracting Officer is the authorizing award document. It normally includes, either as an attachment or by reference, the following items: (1) Special Terms and Conditions, (2) Intellectual Property Provisions, (3) Federal Assistance Reporting Checklist and Instructions, (4) Budget Pages, (5) The Research Terms and Conditions, available at https://www.nsf.gov/pubs/policydocs/rtc/rtcoverlay_march17.pdf, and DOE Agency Specific Requirements, available at https://www.nsf.gov/awards/managing/rtc.jsp, (6) Applicable program regulations, 10 CFR 605 at https://www.ecfr.gov/, (7) DOE Assistance Regulations, 2 CFR 200 as amended by 2 CFR 910 at https://www.ecfr.gov/, (8) Application/proposal as approved by DOE, (9) National Policy Assurances to Be Incorporated as Award Terms in effect on date of award at https://www.nsf.gov/awards/managing/rtc.jsp.

TERMS AND CONDITIONS

Sample DOE Special Terms and Conditions for Use in Most Grants and Cooperative Agreements are located at https://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under Award Terms.

The standard DOE financial assistance intellectual property provisions applicable to various types of recipients are located at:
https://energy.gov/gc/standard-intellectual-property-ip-provisions-financial-assistance-awards

NATIONAL POLICY ASSURANCES

The National Policy Assurances To Be Incorporated As Award Terms are located at https://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under Award Terms.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

The following additional policy provisions are applicable to this FOA. The full text of each provision is in Section VIII of this FOA and may be accessed by navigating to the hyperlinks below:

1. Evaluation and Administration by Non-Federal Personnel
2. Government Right to Reject or Negotiate
3. Intergovernmental Review
4. Modifications

Awards made under this FOA are subject to the following Administrative and National Policy Requirements. The full text of each provision is in Section VIII of this FOA and may be accessed by navigating to the hyperlinks below:
1. Administrative Requirements
2. Availability of Funds
3. Conference Spending (February 2015)
4. Commitment of Public Funds
5. Corporate Felony Conviction and Federal Tax Liability Representations (March 2014)
6. Environmental, Safety and Health (ES&H) Performance of Work at DOE Facilities

7. Federal, State, and Local Requirements
8. Funding Restrictions
9. National Environmental Policy Act (NEPA) Compliance
10. Nondisclosure and Confidentiality Agreements Representations (June 2015)
11. Notice Regarding Eligible/Ineligible Activities
12. Prohibition on Discrimination and Harassment
13. Prohibition on Lobbying Activity
14. Proprietary Application Information
15. Publications
16. Registration Requirements
17. Research Misconduct
18. Rights in Technical Data
19. Subaward and Executive Reporting
20. Title to Subject Inventions
21. U.S. Competitiveness

C. REPORTING

Reporting requirements are identified on the Federal Assistance Reporting Checklist, DOE F 4600.2, attached to the award agreement. The standard checklist is available at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under Award Forms: Individual awards may impose additional requirements.

D. REPORTING OF MATTERS RELATED TO RECIPIENT INTEGRITY AND PERFORMANCE (DECEMBER 2015)

DOE, prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold, is required to review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM

(currently FAPIIS) (see 41 USC 2313).

The applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM and comment on any information about itself that a Federal awarding agency previously entered and is currently in the designated integrity and performance system accessible through SAM.

DOE will consider any written comments by the applicant, in addition to the other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.206 Federal awarding agency review of risk posed by applicants.

Section VII - QUESTIONS/AGENCY CONTACTS

A. QUESTIONS

Questions relating to the Grants.gov registration process, system requirements, how an application form works, or the submittal process must be directed to Grants.gov at 1-800-518-4726 or support@Grants.gov. DOE cannot answer these questions. Please only contact the Grants.gov help desk for questions related to Grants.gov.

For help with PAMS, click the "External User Guide" link on the PAMS website, https://pamspublic.science.energy.gov/. You may also contact the PAMS Help Desk, which can be reached Monday through Friday, 9:00 AM – 5:30 PM Eastern Time. Telephone: (855) 818-1846 (toll free) or (301) 903-9610, Email: sc.pams-helpdesk@science.doe.gov. All submission and inquiries about this FOA should reference the FOA number on the cover of this Announcement. Please contact the PAMS help desk for technological issues with the PAMS system.

Questions regarding the specific program areas and technical requirements may be directed to the technical contacts listed for each program within the FOA or below. Please contact the program staff with all questions not directly related to the Grants.gov or PAMS systems.

B. AGENCY CONTACTS

Grants.gov Customer Support	800-518-4726 (toll-free) support@Grants.gov
PAMS Customer Support	855-818-1846 (toll-free) 301-903-9610 sc.pams-helpdesk@science.doe.gov
Program Manager Scientific Contact	Questions regarding the specific program areas/technical requirements should be directed to the point of contact listed for each program office within the FOA.

Section VIII – SUPPLEMENTARY MATERIAL

A. HOW-TO GUIDES

1. How to Distinguish Between a New and Renewal Application

New Application: An application must be submitted as "new" in the following circumstances:

- When applying for funding to create a new research award that has not previously received DOE funding, including any funding for the current year,
- When applying for funding to support continued research from the same applicant institution as the current grant but with a significant change in fundamental nature of the research, or
- When applying for funding to support continued research supported by an existing DOE award but at a new applicant institution.

Renewal Application: A renewal application is appropriate when funds are requested for an award that has no changes in the following items:

- The recipient/applicant institution,
- The award's senior leadership, and
- The fundamental nature of the award.

A change in an award's PI does not necessarily require submission as a new application: The change in personnel must be considered in light of other changes.

Renewal applications compete for funds with all other peer-reviewed applications and must be developed as fully as though the applicant were applying for the first time. Renewal applications must be submitted by the same sponsoring institution as that holding the current award for which renewal funding is requested, and the proposed research topic must be logical scientific extensions of the research that has been performed in the current award.

2. How Federally Affiliated Organizations May Participate and Be Funded

VALUE/FUNDING FOR DOE/NNSA NATIONAL LABORATORIES AND NON-DOE/NNSA FFRDCS

For grant awards, the value of, and funding for, a DOE/NNSA National Laboratory contractor, a non-DOE/NNSA Federally Funded Research and Development Center (FFRDC) contractor, or another Federal agency's portion of the work will not be included in the award to the successful applicant. DOE will fund a DOE/NNSA National Laboratory contractor through the DOE field work authorization system or other appropriate process and may fund non-DOE/NNSA FFRDC contractors and other Federal agencies through an interagency agreement in accordance with the Economy Act, 31 USC 1535, or other statutory authority.

RESPONSIBILITY

The successful prime applicant/awardee (lead organization) will be the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to, disputes and claims arising out of any agreement between the applicant and

any team member, and/or subrecipient.

If an award is made to a DOE/NNSA National Laboratory, all Disputes and Claims will be resolved in accordance with the terms and conditions of the DOE/NNSA National Laboratory's management and operating (M&O) contract, as applicable, in consultation between DOE and the prime awardee.

If an award is made to another Federal agency or its FFRDC contractor, all Disputes and Claims will be resolved in accordance with the terms and conditions of the interagency agreement in consultation between DOE and the prime awardee.

3. How Federally Affiliated Organizations May Apply

DOE/NNSA NATIONAL LABORATORIES

DOE/NNSA National Laboratories, if eligible either as a prime applicant or a proposed team member on another entity's application, should ensure that their cognizant DOE/NNSA Contracting Officer provides written authorization. This authorization should be submitted with the application as part of the Budget Justification for DOE/NNSA National Laboratory Contractor File. [This is not required for the National Energy Technology Laboratory because it is a Government Owned/Government Operated (GOGO).] **Please note that failure to provide this authorization may result in rejection of an application prior to merit review.** If a DOE/NNSA National Laboratory Contractor is selected for award, or proposed as a team member, the proposed work will be authorized under the DOE field work authorization system or other appropriate process and performed under the laboratory Contractor's M&O contract, as applicable. The following wording is acceptable for the authorization:

> "Authorization is granted for the _____ Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the laboratory and will not adversely impact execution of the DOE/NNSA assigned programs at the laboratory."

(end of acceptable authorization)

If required by the language in Section III, in addition to the cognizant DOE Contracting Officer, SC Laboratories[8] are required to provide written authorization from the Director of Laboratory Policy (SC-42) with the application in order to be eligible to apply for funding under this FOA.

The following wording is acceptable for the authorization:

> "Authorization is granted for the _____Laboratory to participate in the

8 SC Laboratories are Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Princeton Plasma Physics Laboratory, SLAC National Accelerator Laboratory, and Thomas Jefferson National Accelerator Facility.

proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the laboratory and will not adversely impact execution of the DOE assigned programs at the laboratory."

(end of acceptable authorization)

If a DOE/NNSA FFRDC is selected for award negotiation, the proposed work will be authorized under the DOE work authorization process and performed under the laboratory's Management and Operating (M&O) contract.

NON-DOE/NNSA FFRDCS

Non-DOE/NNSA FFRDCs, if eligible either as a prime applicant or a proposed team member on another entity's application, should follow the following guidelines:

The prime applicant must obtain written authorization for non-DOE/NNSA FFRDC participation. The cognizant Contracting Officer for the Federal agency sponsoring the FFRDC contractor must authorize in writing the participation of the FFRDC contractor on the proposed project and this authorization should be submitted with the application. The written authorization must also contain a determination that the use of a FFRDC contractor is consistent with the contractor's authority under its award and does not place the FFRDC contractor in direct competition with the private sector, in accordance with FAR Part 17.5. **Please note that failure to provide this authorization may result in rejection of an application prior to merit review.** The following wording is acceptable for the authorization:

"Authorization is granted for the _____ Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the laboratory and will not adversely impact execution of the (insert agency) assigned programs at the laboratory. This laboratory is authorized to perform the work proposed in the application submitted under DOE Funding Opportunity Announcement <<Include the FOA number on the cover page>> by the following statutory authority (insert statute name, citation, and section) ."

OTHER FEDERAL AGENCIES

Other Federal Agencies, if eligible either as a prime applicant or a proposed team member on another entity's application, must include in their budget justifications any specific statutory authorization (other than the Economy Act) that permits their receipt of an interagency agreement or that authorizes the payment of certain costs.

4. How Consortia May be Used

INCORPORATED CONSORTIA

Incorporated consortia, which may include domestic and/or foreign entities, are eligible to apply for funding as a prime recipient (lead organization) or subrecipient (team member).

Each incorporated consortium must have an internal governance structure and a written set of internal rules. Upon request, the consortium must provide a written description of its internal governance structure and its internal rules to the DOE Contracting Officer. There is no requirement that subawards be formalized into incorporated consortia.

UNINCORPORATED CONSORTIA

Unincorporated consortia (team arrangements), which may include domestic and foreign entities, must designate one member of the consortium to serve as the prime recipient/consortium representative (lead organization). There is no requirement that subawards be formalized into unincorporated consortia.

Upon request, unincorporated consortia must provide the DOE Contracting Officer with a collaboration agreement, commonly referred to as the articles of collaboration, which sets out the rights and responsibilities of each consortium member. This agreement binds the individual consortium members together and should discuss, among other things, the consortium's:

- Management structure;
- Method of making payments to consortium members;
- Means of ensuring and overseeing members' efforts on the project;
- Provisions for members' cost sharing contributions; and
- Provisions for ownership and rights in intellectual property developed previously or under the agreement.

Note that a consortium is applied for in one application and results in one award with subawards to consortia members. Multi-institutional teams may, if permitted under this FOA, submit collaborative applications with each institution submitting its own application with an identical research narrative, resulting in multiple awards to the collaborating institutions.

5. How to Submit Letters of Intent

Do not submit an LOI unless an FOA requires or allows their submission.

It is important that the LOI be a single file with extension .pdf, .docx, or .doc. The filename must not exceed 50 characters. The PI and anyone submitting on behalf of the PI must register for an account in PAMS before it will be possible to submit a LOI. **All PIs and those submitting LOIs on behalf of PIs are encouraged to establish PAMS accounts as soon as possible to avoid submission delays.**

You may use the Internet Explorer, Firefox, Google Chrome, or Safari browsers to access PAMS.

Submit Your Letter of Intent:

- Create your LOI outside the system and save it as a file with extension .docx, .doc, or .pdf. Make a note of the location of the file on your computer so you can browse for it later from within PAMS.

- Log into PAMS and click the Proposals tab. Click the "View / Respond to Funding Opportunity Announcements" link and find the current announcement in the list. Click the "Actions/Views" link in the Options column next to this announcement to obtain a dropdown menu. Select "Submit Letter of Intent" from the dropdown.
- On the Submit Letter of Intent page, select the institution from which you are submitting this LOI from the Institution dropdown. If you are associated with only one institution in the system, there will only be one institution in the dropdown.
- Note that you must select one and only one PI per LOI; to do so, click the "Select PI" button on the far right side of the screen. Find the appropriate PI from the list of all registered users from your institution returned by PAMS. (Hint: You may have to sort, filter, or search through the list if it has multiple pages.) Click the "Actions" link in the Options column next to the appropriate PI to obtain a dropdown menu. From the dropdown, choose "Select PI."
- If the PI for whom you are submitting does not appear on the list, it means he or she has not yet registered in PAMS. For your convenience, you may have PAMS send an email invitation to the PI to register in PAMS. To do so, click the "Invite PI" link at the top left of the "Select PI" screen. You can enter an optional personal message to the PI in the "Comments" box, and it will be included in the email sent by PAMS to the PI. You must wait until the PI registers before you can submit the LOI. Save the LOI for later work by clicking the "Save" button at the bottom of the screen. It will be stored in "My Letters of Intent" for later editing.
- Enter a title for your LOI.
- Select the appropriate technical contact from the Program Manager dropdown.
- To upload the LOI file into PAMS, click the "Attach File" button at the far right side of the screen. Click the "Browse" (or "Choose File" depending on your browser) button to search for your file. You may enter an optional description of the file you are attaching. Click the "Upload" button to upload the file.
- At the bottom of the screen, click the "Submit to DOE" button to save and submit the LOI to DOE.
- Upon submission, the PI will receive an email from the PAMS system <PAMS.Autoreply@science.doe.gov> acknowledging receipt of the LOI.

You are encouraged to register for an account in PAMS at least a week in advance of the LOI submission deadline so that there will be no delays with your submission.

> **WARNING**: The PAMS website at https://pamspublic.science.energy.gov/ will permit you to edit a previously submitted LOI in the time between your submission and the deadline. If you choose to edit, doing so will remove your previously submitted version from consideration. If you are still editing at the time of the deadline, you will not have a valid submission. Please pay attention to the deadline.

6. How to Submit a Pre-Application

Do not submit a pre-application unless an FOA requires or permits their submission.

It is important that the pre-application be a single file with extension .pdf, .docx, or .doc. The

filename must not exceed 50 characters. The PI and anyone submitting on behalf of the PI must register for an account in PAMS before it will be possible to submit a pre-application. All PIs and those submitting pre-applications on behalf of PIs are encouraged to establish PAMS accounts as soon as possible to avoid submission delays.

You may use the Internet Explorer, Firefox, Google Chrome, or Safari browsers to access PAMS.

Submit Your Pre-Application:

- Create your pre-application (called a preproposal in PAMS) outside the system and save it as a file with extension .docx, .doc, or .pdf. Make a note of the location of the file on your computer so you can browse for it later from within PAMS.
- Log into PAMS and click the Proposals tab. Click the "View / Respond to Funding Opportunity Announcements" link and find the current announcement in the list. Click the "Actions/Views" link in the Options column next to this announcement to obtain a dropdown menu. Select "Submit Preproposal" from the dropdown.
- On the Submit Preproposal page, select the institution from which you are submitting this preproposal from the Institution dropdown. If you are associated with only one institution in the system, there will only be one institution in the dropdown.
- Note that you must select one and only one PI per preproposal; to do so, click the "Select PI" button on the far right side of the screen. Find the appropriate PI from the list of all registered users from your institution returned by PAMS. (Hint: You may have to sort, filter, or search through the list if it has multiple pages.) Click the "Actions" link in the Options column next to the appropriate PI to obtain a dropdown menu. From the dropdown, choose "Select PI."
- If the PI for whom you are submitting does not appear on the list, it means he or she has not yet registered in PAMS. For your convenience, you may have PAMS send an email invitation to the PI to register in PAMS. To do so, click the "Invite PI" link at the top left of the "Select PI" screen. You can enter an optional personal message to the PI in the "Comments" box, and it will be included in the email sent by PAMS to the PI. You must wait until the PI registers before you can submit the preproposal. Save the preproposal for later work by clicking the "Save" button at the bottom of the screen. It will be stored in "My Preproposals" for later editing.
- Enter a title for your preproposal.
- Select the appropriate technical contact from the Program Manager dropdown.
- To upload the preproposal file into PAMS, click the "Attach File" button at the far right side of the screen. Click the "Browse" (or "Choose File" depending on your browser) button to search for your file. You may enter an optional description of the file you are attaching. Click the "Upload" button to upload the file.
- At the bottom of the screen, click the "Submit to DOE" button to save and submit the preproposal to DOE.
- Upon submission, the PI will receive an email from the PAMS system <PAMS.Autoreply@science.doe.gov> acknowledging receipt of the preproposal.

You are encouraged to register for an account in PAMS at least a week in advance of the preproposal submission deadline so that there will be no delays with your submission.

WARNING: The PAMS website at https://pamspublic.science.energy.gov will permit you to edit a previously submitted pre-application in the time between your submission and the deadline. If you choose to edit, doing so will remove your previously submitted version from consideration. If you are still editing at the time of the deadline, you will not have a valid submission. Please pay attention to the deadline.

7. How to Register and Submit an Application in Grants.gov

This section provides the application submission and receipt instructions for applications to SC. Please read the following instructions carefully and completely.

ELECTRONIC DELIVERY

SC is participating in the Grants.gov initiative to provide the grant community with a single site to find and apply for grant funding opportunities. SC requires applicants to submit their applications online through Grants.gov.

HOW TO REGISTER TO APPLY THROUGH GRANTS.GOV

a. Instructions: Read the instructions below about registering to apply for SC funds. Applicants should read the registration instructions carefully and prepare the information requested before beginning the registration process. Reviewing and assembling the required information before beginning the registration process will alleviate last-minute searches for required information.

Organizations must have a Data Universal Numbering System (DUNS) Number, active System for Award Management (SAM) registration, and Grants.gov account to apply for grants. If individual applicants are eligible to apply for this FOA, then you may begin with step 3, Create a Grants.gov Account, listed below.

Creating a Grants.gov account can be completed online in minutes, but DUNS and SAM registrations may take several weeks. Therefore, an organization's registration should be done in sufficient time to ensure it does not impact the entity's ability to meet required application submission deadlines.

Complete organization registration instructions can be found on Grants.gov here: https://www.Grants.gov/web/grants/applicants/organization-registration.html

1) *Obtain a DUNS Number*: All entities applying for funding, including renewal funding, must have a DUNS Number from Dun & Bradstreet (D&B). Applicants must enter the DUNS Number in the data entry field labeled "Organizational DUNS" on the SF-424 form. For more detailed instructions for obtaining a DUNS Number, refer to: https://www.Grants.gov/web/grants/applicants/organization-registration/step-1-obtain-duns-number.html

2) *Register with SAM*: All organizations applying online through Grants.gov must register with SAM at https://www.sam.gov. Failure to register with SAM will prevent your organization from applying through Grants.gov. SAM registration must be renewed annually. For more detailed instructions for registering with SAM, refer to: https://www.Grants.gov/web/grants/applicants/organization-registration/step-2-register-with-sam.html

3) *Create a Grants.gov Account*: The next step is to register an account with Grants.gov. Follow the on-screen instructions or refer to the detailed instructions here: https://www.Grants.gov/web/grants/applicants/registration.html

4) *Add a Profile to a Grants.gov Account*: A profile in Grants.gov corresponds to a single applicant organization the user represents (i.e., an applicant) or an individual applicant. If you work for or consult with multiple organizations and have a profile for each, you may log in to one Grants.gov account to access all of your grant applications. To add an organizational profile to your Grants.gov account, enter the DUNS Number for the organization in the DUNS field while adding a profile. For more detailed instructions about creating a profile on Grants.gov, refer to: https://www.Grants.gov/web/grants/applicants/registration/add-profile.html

5) *EBiz POC Authorized Profile Roles*: After you register with Grants.gov and create an Organization Applicant Profile, the organization applicant's request for Grants.gov roles and access is sent to the Electronic Business Point of Contact (EBiz POC). The EBiz POC will then log in to Grants.gov and authorize the appropriate roles, which may include the Authorized Organization Representative (AOR) role, thereby giving you permission to complete and submit applications on behalf of the organization. You will be able to submit your application online any time after you have been assigned the AOR role. For more detailed instructions about creating a profile on Grants.gov, refer to: https://www.Grants.gov/web/grants/applicants/registration/authorize-roles.html

6) *Track Role Status*: To track your role request, refer to: https://www.Grants.gov/web/grants/applicants/registration/track-role-status.html

b. *Electronic Signature*: When applications are submitted through Grants.gov, the name of the organization applicant with the AOR role that submitted the application is inserted into the signature line of the application, serving as the electronic signature. The EBiz POC **must** authorize people who are able to make legally binding commitments on behalf of the organization as a user with the AOR role; **this step is often missed and it is crucial for valid and timely submissions.**

HOW TO SUBMIT AN APPLICATION TO SC VIA GRANTS.GOV

Grants.gov applicants can apply online using Workspace. Workspace is a shared, online environment where members of a grant team may simultaneously access and edit different webforms within an application. For each FOA, you can create individual instances of a workspace.

Below is an overview of applying on Grants.gov. For access to complete instructions on how to apply for opportunities, refer to:
https://www.Grants.gov/web/grants/applicants/apply-for-grants.html

1) Create a Workspace: Creating a workspace allows you to complete it online and route it through your organization for review before submitting.

2) Complete a Workspace: Add participants to the workspace, complete all the required forms, and check for errors before submission.

a. Adobe Reader: If you decide not to apply by filling out webforms you can download individual PDF forms in Workspace so that they will appear similar to other Standard forms. The individual PDF forms can be downloaded and saved to your local device storage, network drive(s), or external drives, then accessed through Adobe Reader.

NOTE: Visit the Adobe Software Compatibility page on Grants.gov to download the appropriate version of the software at:
https://www.Grants.gov/web/grants/applicants/adobe-software-compatibility.html

b. Mandatory Fields in Forms: In the forms, you will note fields marked with an asterisk and a different background color. These fields are mandatory fields that must be completed to successfully submit your application.

c. Complete SF-424 Fields First: The forms are designed to fill in common required fields across other forms, such as the applicant name, address, and DUNS number. To trigger this feature, an applicant must complete the SF-424 information first. Once it is completed, the information will transfer to the other forms.

3) Submit a Workspace: An application may be submitted through workspace by clicking the Sign and Submit button on the Manage Workspace page, under the Forms tab. Grants.gov recommends submitting your application package *at least 24-48 hours prior to the close date* to provide you with time to correct any potential technical issues that may disrupt the application submission.

4) Track a Workspace: After successfully submitting a workspace package, a Grants.gov Tracking Number (GRANTXXXXXXXX) is automatically assigned to the package. The number will be listed on the Confirmation page that is generated after submission.

For additional training resources, including video tutorials, refer to:
https://www.Grants.gov/web/grants/applicants/applicant-training.html

Applicant Support: Grants.gov provides applicants 24/7 support via the toll-free number 1-800-518-4726 and email at support@Grants.gov. For questions related to the specific grant opportunity, contact the number listed in the application package of the grant you are applying for.

If you are experiencing difficulties with your submission, it is best to call the Grants.gov Support Center and get a ticket number. The Support Center ticket number will assist SC with tracking your issue and understanding background information on the issue.

Timely Receipt Requirements and Proof of Timely Submission

Proof of timely submission is automatically recorded by Grants.gov. An electronic date/time stamp is generated within the system when the application is successfully received by Grants.gov. The applicant AOR will receive an acknowledgement of receipt and a tracking number (GRANTXXXXXXXX) from Grants.gov with the successful transmission of their application. Applicant AORs will also receive the official date/time stamp and Grants.gov Tracking number in an email serving as proof of their timely submission.

When SC successfully retrieves the application from Grants.gov, and acknowledges the download of submissions, Grants.gov will provide an electronic acknowledgment of receipt of the application to the email address of the applicant with the AOR role. Again, proof of timely submission shall be the official date and time that Grants.gov receives your application. Applications received by Grants.gov after the established due date for the program will be considered late and may not be considered for funding by SC.

Applicants using slow internet, such as dial-up connections, should be aware that transmission can take some time before Grants.gov receives your application. Again, Grants.gov will provide either an error or a successfully received transmission in the form of an email sent to the applicant with the AOR role. The Grants.gov Support Center reports that some applicants end the transmission because they think that nothing is occurring during the transmission process. Please be patient and give the system time to process the application.

8. How to Prepare an Application

Application Preparation

You must submit the application through Grants.gov at https://www.Grants.gov/, using either the online webforms or downloaded forms. (Additional instructions are provided in 7., above.)

You are required to use the compatible version of Adobe Reader software to complete a Grants.gov Adobe application package. To ensure you have the Grants.gov compatible version of Adobe Reader, visit the software compatibility page at https://www.Grants.gov/web/grants/applicants/adobe-software-compatibility.html.

You must complete the mandatory forms and any applicable optional forms (e.g., Disclosure of Lobbying Activities (SF-LLL)) in accordance with the instructions on the forms and the additional instructions below.

Files that are attached to the forms must be PDF files unless otherwise specified in this FOA. Attached PDF files must be plain files consisting of text, numbers, and images without editable

fields, signatures, passwords, redactions, or other advanced features available in some PDF-compatible software. Do not use PDF portfolios or binders.

Please note the following restrictions that apply to the names of all files attached to your application:

- Please limit file names to 50 or fewer characters
- Do not attach any documents with the same name. All attachments must have a unique name.
- Please use only the following characters when naming your attachments: A-Z, a-z, 0-9, underscore, hyphen, space, period, parenthesis, curly braces, square brackets, ampersand, tilde, exclamation point, comma, semi colon, apostrophe, at sign, number sign, dollar sign, percent sign, plus sign, and equal sign. Attachments that do not follow this rule may cause the entire application to be rejected or cause issues during processing.

Renewal Applications

For renewal applications only, the PI is required to submit a Renewal Proposal Products section through the PAMS website at https://pamspublic.science.energy.gov. The PI must enter into PAMS each product created during the course of the previous project period. Types of products include publications, intellectual property, technologies or techniques, and other products such as databases or software. As soon as the renewal application is assigned to a DOE Program Manager, the PI will receive an automated email from PAMS (<PAMS.Autoreply@science.doe.gov>) instructing him or her to navigate to the PAMS Task tab to complete and submit the Renewal Proposal Products. The submitted product list will be sent for merit review as part of the application. The application will not be considered complete and cannot be sent for review until the product list has been submitted.

Resubmission of Applications

Applications submitted under this FOA may be withdrawn from consideration by using the PAMS website at https://pamspublic.science.energy.gov. Applications may be withdrawn at any time between when the applicant submits the application and when DOE makes the application available to merit reviewers. Such withdrawals take effect immediately and cannot be reversed. Please exercise due caution. After the application is made available to merit reviewers, the applicant may contact the DOE program office identified in this FOA to request that it be withdrawn.

After an application is withdrawn, it may be resubmitted, if this FOA is still open for the submission of applications. Such resubmissions will only count as one submission if this FOA restricts the number of applications from an applicant.

Note that there may be a delay between the application's submission in Grants.gov and when it is available to be withdrawn in PAMS. SC will usually consider the last submission, according to its Grants.gov timestamp, to be the intended version. Please consult with your program manager to resolve any confusion about which version of an application should be considered.

IMPROPER CONTENTS OF APPLICATIONS

Applications submitted under this FOA will be stored in controlled-access systems, but they may be made publicly available if an award is made. As such, it is critical that applicants follow these guidelines:

- Do not include information subject to any legal restriction on its open distribution, whether classified, export control, or unclassified controlled nuclear information.
- Do not include sensitive and protected personally identifiable information, including social security numbers, birthdates, citizenship, marital status, or home addresses. Pay particular attention to the content of biographical sketches and curriculum vitae.
- Do not include letters of support from Federal officials.
- Do not include letters of support on Federal letterhead. Letters that are not letters of support (such as letters confirming access to sites, facilities, equipment, or data; or letters from cognizant Contracting Officers) may be on Federal letterhead.
- Clearly mark all proprietary or trade-secret information.

CHANGE OF AWARDEE INSTITUTION

If an awardee chooses to relinquish an award made under this FOA to permit the transfer of the award to a new institution, the new institution must submit an application under the then-available SC "annual" or "open" FOA.

9. How to Prepare a Biographical Sketch

A biographical sketch is to provide information that can be used by reviewers to evaluate the PI's potential for leadership within the scientific community. Examples of information of interest are invited and/or public lectures, awards received, scientific program committees, conference or workshop organization, professional society activities, special international or industrial partnerships, reviewing or editorship activities, or other scientific leadership experiences.

SC requires the use of the format approved by the National Science Foundation (NSF), which may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at https://nsf.gov/bfa/dias/policy/nsfapprovedformats/biosketch.pdf. The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats.

The biographical information (curriculum vitae) must include the following items within its page limit:

- **Education and Training**: Undergraduate, graduate, and postdoctoral training, provide institution, major/area, degree, and year.
- **Research and Professional Experience**: Beginning with the current position, list professional/academic positions in chronological order with a brief description. List all current academic, professional or institutional appointments, foreign or domestic, at the applicant institution or elsewhere, whether or not remuneration is received, and, whether full-time, part-time, or voluntary.

- **Publications**: Provide a list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically. Patents, copyrights, and software systems developed may be provided in addition to or substituted for publications. An abbreviated style such as the Physical Review Letters (PRL) convention for citations (list only the first author) may be used for publications with more than 10 authors.
- **Synergistic Activities**: List no more than five professional and scholarly activities related to the effort proposed.

Requested information may be appended to a biographical sketch, whether produced from a fillable PDF or in SciENcv.

Do not attach a listing of individuals who should not be used as merit reviewers: This information is no longer collected as part of a biographical sketch.

Personally Identifiable Information: Do not include sensitive and protected personally identifiable information including social security numbers, birthdates, citizenship, marital status, or home addresses. Do not include information that a merit reviewer should not make use of.

10. How to Prepare a List of Individuals Who Should Not Serve as Reviewers

To assist in identifying individuals who should not serve as merit reviews, provide the following information for each and every senior/key person who is planned to be or is identified in Section A of the R&R Budget for the applicant and any proposed subrecipients:

- Advisees (graduate students or postdocs) of the senior/key person
- Advisors of the senior/key person while a graduate student or a postdoc
- Close associates of the senior/key person over the past 48 months
- Co-authors of the senior/key person over the past 48 months
- Co-editors of the senior/key person over the past 48 months
- Co-investigators of the senior/key person over the past 48 months
- Collaborators of the senior/key person over the past 48 months

Do not identify any personnel at the applicant institution or any proposed subrecipient or team institution: Those personnel are prohibited from serving as merit reviewers.

Large collaborations of 10 or more researchers do not require that all collaborators be identified: rather, only list the researchers with whom the senior/key person actually collaborated.

For all identified individuals, provide the following information:

- The senior/key person to whom the individual was an advisee, advisor, close associate, co-author, co-editor, co-investigator, or collaborator, identified by first name and last name
- The individual's first (given) name
- The individual's last (family) name
- The individual's Open Researcher and Contributor ID (ORCiD), if known

- The individual's institutional affiliation spelling out acronyms (For joint appointments, separate each institution with a slash ("/"). Do not list departmental affiliations.)
- The reason for listing the individual (advisee, advisor, close associate, co-author, co-editor, co-investigator, collaborator)
- The year when the individual last was a close associate, co-author, co-editor, co-investigator, or collaborator

You may also provide a list of all senior/key personnel who is planned to be or is identified in Section A of the R&R Budget for the applicant and any proposed subrecipients.

The lists do not need to be sorted in any method.

The lists must be submitted in tabular format, preferably as Microsoft Excel (.xls or .xlsx) files.

For your convenience, a template is available at https://science.osti.gov/grants/Policy-and-Guidance/Agreement-Forms. The template may also be posted with this FOA in Grants.gov.

11. How to Prepare Current and Pending Support

> **WARNING**: These instructions have been significantly revised to require disclosure of a variety of potential conflicts of interest or commitment, including participation in foreign government-sponsored talent recruitment programs.

Current and Pending support is intended to allow the identification of potential duplication, overcommitment, potential conflicts of interest or commitment, and all other sources of support. The PI and each senior/key person at the prime applicant and any proposed subaward must provide a list of all sponsored activities, awards, and appointments, whether paid or unpaid; provided as a gift with terms or conditions or provided as a gift without terms or conditions; full-time, part-time, or voluntary; faculty, visiting, adjunct, or honorary; cash or in-kind; foreign or domestic; governmental or private-sector; directly supporting the individual's research or indirectly supporting the individual by supporting students, research staff, space, equipment, or other research expenses. All foreign government-sponsored talent recruitment programs must be identified in current and pending support.

SC requires the use of the format approved by the National Science Foundation (NSF), which may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at https://www.nsf.gov/bfa/dias/policy/nsfapprovedformats/cps.pdf. The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats.

For every activity, list the following items:

- The sponsor of the activity or the source of funding
- The award or other identifying number

- The title of the award or activity. If the title of the award or activity is not descriptive, add a brief description of the research being performed that would identify any overlaps or synergies with the proposed research.
- The total cost or value of the award or activity, including direct and indirect costs. For pending proposals, provide the total amount of requested funding.
- The award period (start date – end date).
- The person-months of effort per year being dedicated to the award or activity

If required to identify overlap, duplication of effort, or synergistic efforts, append a description of the other award or activity to the current and pending support.

Requested information may be appended to current and pending support, whether produced from a fillable PDF or in SciENcv.

Details of any obligations, contractual or otherwise, to any program, entity, or organization sponsored by a foreign government must be provided on request to either the applicant institution or DOE.

12. How to Prepare a Data Management Plan

In general, a DMP should address the following requirements:

1. DMPs should describe whether and how data generated in the course of the proposed research will be shared and preserved. If the plan is not to share and/or preserve certain data, then the plan must explain the basis of the decision (for example, cost/benefit considerations, other parameters of feasibility, scientific appropriateness, or limitations discussed in #4). At a minimum, DMPs must describe how data sharing and preservation will enable validation of results, or how results could be validated if data are not shared or preserved.
2. DMPs should provide a plan for making all research data displayed in publications resulting from the proposed research open, machine readable, and digitally accessible to the public at the time of publication. This includes data that are displayed in charts, figures, images, etc. In addition, the underlying digital research data used to generate the displayed data should be made as accessible as possible to the public in accordance with the principles stated in the Office of Science Statement on Digital Data Management (https://science.osti.gov/funding-opportunities/digital-data-management. This requirement could be met by including the data as supplementary information to the published article, or through other means. The published article should indicate how these data can be accessed.
3. DMPs should consult and reference available information about data management resources to be used in the course of the proposed research. In particular, DMPs that explicitly or implicitly commit data management resources at a facility beyond what is conventionally made available to approved users should be accompanied by written approval from that facility. In determining the resources available for data management at Office of Science User Facilities, researchers should consult the published description of data management resources and practices at that facility and reference it in the DMP. Information about other Office of Science facilities can be found at https://science.osti.gov/user-facilities/.
4. DMPs must protect confidentiality, personal privacy, Personally Identifiable Information, and U.S. national, homeland, and economic security; recognize proprietary interests, business

confidential information, and intellectual property rights; avoid significant negative impact on innovation, and U.S. competitiveness; and otherwise be consistent with all applicable laws, and regulations. There is no requirement to share proprietary data.

DMPs will be reviewed as part of the overall SC research proposal merit review process. Applicants are encouraged to consult the SC website for further information and suggestions for how to structure a DMP: https://science.osti.gov/funding-opportunities/digital-data-management

13. How to Prepare a Research and Related Budget and Justification

The following advice will improve the accuracy of your budget request:

- Funds requested for personnel (senior, key, and other) must be justified as the product of their effort on the project and their institutional base salary.
- Funds requested for fringe benefits must be calculated as the product of the requested salary and, if present, the negotiated fringe benefit rate contained in an institution's negotiated indirect cost rate agreement.
- Funds requested for indirect costs must be calculated using the correct indirect cost base and the negotiated indirect cost rate.
- You are encouraged to include the rate agreement used in preparing a budget as a part of the budget justification.
- Do not prepare a budget justification using the expired DOE form F4260.1.

If you are proposing indirect costs and do not already have an Indirect Cost Rate Agreement with your Cognizant Federal Agency or documentation of rates accepted for estimating purposes by DOE or another Federal agency, it is recommended that you begin preparing an Indirect Cost Rate Proposal to be submitted, upon request, to the DOE contract specialist/grants management specialist who will evaluate your application if you are selected for award.

For your convenience in preparing an Indirect Cost Rate proposal, a link to applicant resources, including indirect rate model templates, has been provided below: https://science.osti.gov/sbir/applicant-resources/grant-application/.

Budget Fields

Section A Senior/Key Person	For each Senior/Key Person, enter the requested information. List personnel, base salary, the number of months that person will be allocated to the project, requested salary, fringe benefits, and the total funds requested for each person. The requested salary must be the product of the base salary and the effort. Include a written narrative in the budget justification that justifies the need for requested personnel. Within the justification, explain the fringe benefit rate used if it is not the standard faculty rate.
Section B Other Personnel	List personnel, the number of months that person will be allocated to the project, requested salary fringe benefits, and the total funds requested for each person. Include a written narrative in the budget justification that fully justifies

	the need for requested personnel. Within the justification, provide the number of positions being filled in each category of other personnel.
Section C Equipment	For the purpose of this budget, equipment is designated as an item of property that has an acquisition cost of $5,000 or more and an expected service life of more than one year, unless a different threshold is specified in a negotiated Facilities and Administrative Cost Rate. (Note that this designation applies for proposal budgeting only and differs from the DOE definition of capital equipment.) List **each** item of equipment separately and justify each in the budget justification section. Do not aggregate items of equipment. Allowable items ordinarily will be limited to research equipment and apparatus not already available for the conduct of the work. General-purpose office equipment is not eligible for support unless primarily or exclusively used in the actual conduct of scientific research.
Section D Travel	For purposes of this section only, travel to Canada or to Mexico is considered domestic travel. In the budget justification, list each trip's destination, dates, estimated costs including transportation and subsistence, number of staff traveling, the purpose of the travel, and how it relates to the project. Indicate the basis for the cost estimate (quotes from vendors or suppliers, past experience of similar items, or some other basis). To qualify for support, attendance at meetings or conferences must enhance the investigator's capability to perform the research, plan extensions of it, or disseminate its results. Domestic travel is to be justified separately from foreign travel. Within the budget justification, detail the number of personnel planning to travel and the estimated per-traveler cost for each trip.
Section E Participant/Trainee Support Costs	If applicable, submit training support costs. Educational projects that intend to support trainees (precollege, college, graduate and post graduate) must list each trainee cost that includes stipend levels and amounts, cost of tuition for each trainee, cost of any travel (provide the same information as needed under the regular travel category), and costs for any related training expenses. Participant costs are those costs associated with conferences, workshops, symposia or institutes and breakout items should indicate the number of participants, cost for each participant, purpose of the conference, dates and places of meetings and any related administrative expenses. Indicate the basis for the cost estimate (quotes from vendors or suppliers, past experience of similar items, or some other basis).
Section F Other Direct Costs	• **Materials and Supplies:** Enter total funds requested for materials and supplies in the appropriate fields. In the budget justification, indicate general categories such as glassware, and chemicals, including an amount for each category (items not identified under "Equipment"). Categories less than $1,000 are not required to be itemized. Indicate the basis for the cost estimate (quotes from vendors or suppliers, past experience of similar items, or some other basis).

	• **Publication Costs:** Enter the total publication funds requested. The proposal budget may request funds for the costs of documenting, preparing, publishing or otherwise making available to others the findings and products of the work conducted under the award. In the budget justification, include supporting information. Indicate the basis for the cost estimate (quotes from vendors or suppliers, past experience of similar items, or some other basis). • **Consultant Services:** Enter total funds requested for all consultant services. In the budget justification, identify each consultant, the services he/she will perform, total number of days, travel costs, and total estimated costs. Indicate the basis for the cost estimate (quotes from vendors or suppliers, past experience of similar items, or some other basis). • **ADP/Computer Services:** Enter total funds requested for ADP/Computer Services. Cloud computing costs must be included under this item. The cost of computer services, including computer-based retrieval of scientific, technical and education information may be requested. In the budget justification, include the established computer service rates at the proposing organization if applicable. Indicate the basis for the cost estimate (quotes from vendors or suppliers, past experience of similar items, or some other basis). • **Subawards/Consortium/Contractual Costs:** Enter total costs for all subawards/consortium organizations and other contractual costs proposed for the project. In the budget justification, justify the details. • **Equipment or Facility Rental/User Fees:** Enter total funds requested for Equipment or Facility Rental/User Fees. In the budget justification, identify each rental/user fee and justify. Indicate the basis for the cost estimate (quotes from vendors or suppliers, past experience of similar items, or some other basis). • **Alterations and Renovations:** Enter total funds requested for Alterations and Renovations. In the budget justification, itemize by category and justify the costs of alterations and renovations, including repairs, painting, removal, or installation of partitions, shielding, or air conditioning. Where applicable, provide the square footage and costs. • **Other:** Add text to describe any other Direct Costs not requested above. Enter costs associated with "Other" item(s). Use the budget justification to further itemize and justify.
Section G Direct Costs	This represents Total Direct Costs (Sections A through F)
Section H Other Indirect Costs	Enter the Indirect Cost information, including the rates and bases being used, for each field. Only four general categories of indirect costs are

	allowed/requested on this form, so please consolidate if needed. Include the cognizant Federal agency and contact information if using a negotiated rate agreement. Within the budget justification, explain the use of multiple rates, if multiple rates are used.
Section I Total Direct and Indirect Costs	This is the total of Sections G and H

14. How to Register in PAMS

After you submit your application through Grants.gov, the application will automatically transfer into the Portfolio Analysis and Management System (PAMS) for processing by the DOE SC. Many functions for grants and cooperative agreements can be done in PAMS, which is available at https://pamspublic.science.energy.gov.

You will want to "register to" your application: a process of linking yourself to the application after it has been submitted through Grants.gov and processed by DOE.

You must register in PAMS to submit a pre-application or a LOI.

You may use the Internet Explorer, Firefox, Google Chrome, or Safari browsers to access PAMS.

Notifications sent from the PAMS system will come from the PAMS email address <PAMS.Autoreply@science.doe.gov>. Please make sure your email server/software allows delivery of emails from the PAMS email address to yours.

Registering to PAMS is a two-step process; once you create an individual account, you must associate yourself with ("register to") your institution. Detailed steps are listed below.

CREATE PAMS ACCOUNT:

To register, click the "Create New PAMS Account" link on the website https://pamspublic.science.energy.gov/.

- Click the "No, I have never had an account" link and then the "Create Account" button.
- You will be prompted to enter your name and email address, create a username and password, and select a security question and answer. Once you have done this, click the "Save and Continue" button.
- On the next page, enter the required information (at least one phone number and your mailing address) and any optional information you wish to provide (e.g., FAX number, website, mailstop code, additional email addresses or phone numbers, Division/Department). Click the "Create Account" button.
- Read the user agreement and click the "Accept" button to indicate that you understand your responsibilities and agree to comply with the rules of behavior for PAMS.

- PAMS will take you to the "Having Trouble Logging In?" page. (If you have been an SC merit reviewer or if you have previously submitted an application, you may already be linked to an institution in PAMS. If this happens, you will be taken to the PAMS home page.)

REGISTER TO YOUR INSTITUTION:

- Click the link labeled "Option 2: I know my institution and I am here to register to the institution." (Note: If you previously created a PAMS account but did not register to an institution at that time, you must click the Institutions tab and click the "Register to Institution" link.)
- PAMS will take you to the "Register to Institution" page.
- Type a word or phrase from your institution name in the field labeled, "Institution Name like," choose the radio button next to the item that best describes your role in the system, and click the "Search" button. A "like" search in PAMS returns results that contain the word or phrase you enter; you do not need to enter the exact name of the institution, but you should enter a word or phrase contained within the institution name. (If your institution has a frequently used acronym, such as ANL for Argonne National Laboratory or UCLA for the Regents of the University of California, Los Angeles, you may find it easiest to search for the acronym under "Institution Name like." Many institutions with acronyms are listed in PAMS with their acronyms in parentheses after their names.)
- Find your institution in the list that is returned by the search and click the "Actions" link in the Options column next to the institution name to obtain a dropdown list. Select "Add me to this institution" from the dropdown. PAMS will take you to the "Institutions – List" page.
- If you do not see your institution in the initial search results, you can search again by clicking the "Cancel" button, clicking the Option 2 link, and repeating the search.
- If, after searching, you think your institution is not currently in the database, click the "Cannot Find My Institution" button and enter the requested institution information into PAMS. Click the "Create Institution" button. PAMS will add the institution to the system, associate your profile with the new institution, and return you to the "Institutions – List" page when you are finished.

For help with PAMS, click the "External User Guide" link on the PAMS website, https://pamspublic.science.energy.gov/. You may also contact the PAMS Help Desk, which can be reached Monday through Friday, 9AM – 5:30 PM Eastern Time. Telephone: (855) 818-1846 (toll free) or (301) 903-9610, email: sc.pams-helpdesk@science.doe.gov. All submission and inquiries about this FOA should reference the FOA number printed on the cover page.

15. How to View Applications in PAMS

Each Grants.gov application submitted to the DOE SC automatically transfers into PAMS and is subsequently assigned to a program manager. At the time of program manager assignment, the three people listed on the SF-424 (R&R) cover page will receive an email with the subject line, "Receipt of Proposal 0000xxxxxx by the DOE Office of Science." These three people are the PI (Block 14), Authorized Representative (Block 19), and Point of Contact (Block 5). In PAMS notation, applications are known as proposals, the PI is known as the PI, the Authorized Representative is known as the Sponsored Research Officer/Business Officer/Administrative

Officer (SRO/BO/AO), and the Point of Contact is known as the POC.

There will be a period of time between the application's receipt at Grants.gov and its assignment to a DOE SC program manager. Program managers are typically assigned two weeks after applications are due at Grants.gov: please refrain from attempting to view the proposal in PAMS until you receive an email providing the assignment of a program manager.

Once the email is sent, the PI, SRO/BO/PO, and POC will each be able to view the submitted proposal in PAMS. Viewing the proposal is optional.

You may use the Internet Explorer, Firefox, Google Chrome, or Safari browsers to access PAMS.

Following are two sets of instructions for viewing the submitted proposal, one for individuals who already have PAMS accounts and one for those who do not.

If you already have a PAMS account, follow these instructions:

1. Log in to PAMS at https://pamspublic.science.energy.gov/.
2. Click the "Proposals" tab and click "Access Previously Submitted Grants.gov Proposal."
3. Enter the following information:
   - Proposal ID: Enter the ten-digit PAMS proposal ID, including the leading zeros (e.g., 00002xxxxx). Do not use the Grants.gov proposal number. Use the PAMS number previously sent to you in the email with subject line, "Receipt of Proposal …".
   - Email (as entered in Grants.gov application): Enter your email address as it appears on the SF424(R&R) Cover Page.
   - Choose Role: Select the radio button in front of the role corresponding to the SF-424 (R&R) cover page. If your name appears in block 19 of the SF-424 (R&R) cover page as the authorizing representative, select "SRO/BO/AO (Sponsored Research Officer/Business Officer/Administrative Officer)." If your name appears in block 14 of the SF424 R&R cover page as the PI, select "Principal Investigator (PI)." If your name appears in block 5 of the SF424 R&R as the point of contact, select "Other (POC)."
4. Click the "Save and Continue" button. You will be taken to your "My Proposals" page. The Grants.gov proposal will now appear in your list of proposals. Click the "Actions/Views" link in the options column next to this proposal to obtain a dropdown list. Select "Proposal" from the dropdown to see the proposal. Note that the steps above will work only for proposals submitted to the DOE SC since May 2012.

If you do not already have a PAMS account, follow these instructions:

1. To register, click the "Create New PAMS Account" link on the website https://pamspublic.science.energy.gov/.
2. Click the "No, I have never had an account" link and then the "Create Account" button.
3. You will be prompted to enter your name and email address, create a username and password, and select a security question and answer. Once you have done this, click the "Save and Continue" button.
4. On the next page, enter the required information (at least one phone number and your mailing address) and any optional information you wish to provide (e.g., FAX number, website,

mailstop code, additional email addresses or phone numbers, Division/Department). Click the "Create Account" button.

5. Read the user agreement and click the "Accept" button to indicate that you understand your responsibilities and agree to comply with the rules of behavior for PAMS.
6. You will be taken to the Register to Institution page. Select the link labeled, "Option 1: My institution has submitted a proposal in Grants.gov. I am here to register as an SRO, PI, or POC (Sponsored Research Officer, Principal Investigator, or Point of Contact)."
7. Enter the following information:
   - Proposal ID: Enter the ten-digit PAMS proposal ID, including the leading zeros (e.g., 00002xxxxx). Do not use the Grants.gov proposal number. Use the PAMS number previously sent to you in the email with subject line, "Receipt of Proposal …".
   - Email (as entered in Grants.gov proposal): Enter your email address as it appears on the SF424(R&R) Cover Page.
   - Choose Role: Select the radio button in front of the role corresponding to the SF-424 (R&R) cover page. If your name appears in block 19 of the SF-424 (R&R) cover page as the authorizing representative, select "SRO/BO/AO (Sponsored Research Officer/Business Officer/Administrative Officer)." If your name appears in block 14 of the SF424 R&R cover page as the PI, select "Principal Investigator (PI)." If your name appears in block 5 of the SF424 R&R as the point of contact, select "Other (POC)."
8. Click the "Save and Continue" button. You will be taken to your "My Proposals" page. The Grants.gov proposal will now appear in your list of proposals. Click the "Actions/Views" link in the options column next to this proposal to obtain a dropdown list. Select "Proposal" from the dropdown to see the proposal.

If you were listed as the PI on a prior submission but you have not previously created an account, you may already be listed in PAMS. If this is the case, you will be taken to the PAMS home page after agreeing to the Rules of Behavior. If that happens, follow the instructions listed above under "If you already have a PAMS account…" to access your Grants.gov proposal.

16. How to Register in Other Systems Before Submitting an Application

SYSTEMS TO REGISTER IN

Applicants must complete a series of registrations and enrollments to submit applications in response to this FOA. Applicants not currently registered with SAM and Grants.gov should allow **at least four weeks** to complete these requirements.

You should start the process as soon as possible.

You may not be able to use your preferred Internet browser: Each system has its own requirements.

Applicants must obtain a DUNS number at https://fedgov.dnb.com/webform.

Applicants must register with SAM at https://www.sam.gov/. More information about SAM registration for applicants is found at

https://www.sam.gov/SAM/transcript/Quick_Guide_for_Grants_Registrations.pdf. SAM maintains a complete user guide at https://www.sam.gov/SAM/transcript/SAM_Non_Federal_User_Guide.pdf.

Applicants must provide a Taxpayer Identification Number (TIN) to complete their registration in www.SAM.gov. An applicant's TIN is an EIN assigned by the Internal Revenue Service (IRS). In limited circumstances, a Social Security Number (SSN) assigned by the Social Security Administration (SSA) may be used as a TIN. You may obtain an EIN from the IRS at https://www.irs.gov/businesses/small-businesses-self-employed/apply-for-an-employer-identification-number-ein-online.

Do not use a SSN as a TIN.
Obtain a TIN from the IRS using the website listed above.

Applicants must register with FedConnect at www.FedConnect.net. The full, binding version of assistance agreements will be posted to FedConnect.

Recipients must register with the Federal Funding Accountability and Transparency Act Subaward Reporting System at https://www.fsrs.gov. This registration must be completed before an award may be made: you are advised to register while preparing your application.

Registering in Grants.gov

Applicants must register with Grants.gov, following the instructions at https://www.Grants.gov/web/grants/applicants/registration.html and described above.

Where to Submit an Application

You must submit the application through Grants.gov at www.Grants.gov, using either the online webforms or downloaded forms, or a system-to-system service

Submit electronic applications through the "Apply for Grants" function at www.Grants.gov. If you have problems completing the registration process or submitting your application, call Grants.gov at 1-800-518-4726 or send an email to support@Grants.gov.

Please ensure that you have read the applicable instructions, guides, help notices, frequently asked questions, and other forms of technical support on Grants.gov.

DOE SC Portfolio Analysis and Management System (PAMS)

Applicants must register in the Portfolio Analysis and Management System (PAMS) to submit letters of intent and pre-applications, to view merit reviewer comments, or to take a number of post-award actions.

B. POLICY PROVISIONS

1. Evaluation and Administration by Non-Federal Personnel

In conducting the merit review evaluation, the Government may seek the advice of qualified non-Federal personnel as reviewers. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The applicant, by submitting its application, consents to the use of non-Federal reviewers/administrators. Non-Federal reviewers must sign a conflict of interest agreement and a certificate of confidentiality prior to reviewing an application. Non-Federal personnel conducting administrative activities must sign a non-disclosure agreement.

2. Government Right to Reject or Negotiate

DOE reserves the right, without qualification, to reject any or all applications received in response to this FOA and to select any application, in whole or in part, as a basis for negotiation and/or award.

3. Intergovernmental Review

This program is not subject to Executive Order 12372 Intergovernmental Review of Federal Programs.

4. Modifications

Notices of any modifications to this FOA will be posted on Grants.gov and the FedConnect portal. You can receive an email when a modification or an FOA message is posted by registering with FedConnect as an interested party for this FOA. It is recommended that you register as soon after release of the FOA as possible to ensure you receive timely notice of any modifications or other FOAs. More information is available at www.FedConnect.net.

C. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

1. Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR 200 as modified by 2 CFR 910 (DOE Financial Assistance Regulations).

2. Availability of Funds

Funds are not presently available for this award. The Government's obligation under this award is contingent upon the availability of appropriated funds from which payment for award purposes can be made. No legal liability on the part of the Government for any payment may arise until funds are made available to the DOE Contracting Officer for this award and until the awardee receives notice of such availability, to be confirmed in writing by the DOE Contracting Officer.

3. Conference Spending (February 2015)

The recipient shall not expend any funds on a conference not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded that would defray the cost to the United States Government of a conference held by any Executive branch department, agency, board, commission, or office for which the cost to the United States Government would otherwise exceed $20,000, thereby circumventing the required notification by the head of any such Executive Branch department, agency, board, commission, or office to the Inspector General (or senior ethics official for any entity without an Inspector General), of the date, location, and number of employees attending such conference.

4. Commitment of Public Funds

(a) A DOE financial assistance award is valid only if it is in writing and is signed, either in writing or electronically, by a DOE Contracting Officer.

(b) Recipients are free to accept or reject the award. A request to draw down DOE funds constitutes the Recipient's acceptance of the terms and conditions of this Award.

5. Corporate Felony Conviction and Federal Tax Liability Representations (March 2014)

In submitting an application in response to this FOA the Applicant represents that:

- It is **not** a corporation that has been convicted of a felony criminal violation under any Federal law within the preceding 24 months,
- It is **not** a corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

For purposes of these representations the following definitions apply:

- A Corporation includes any entity that has filed articles of incorporation in any of the 50 states, the District of Columbia, or the various territories of the United States [but not foreign corporations]. It includes both for-profit and non-profit organizations.

6. Environmental, Safety and Health (ES&H) Performance of Work at DOE Facilities

With respect to the performance of any portion of the work under this award which is performed at a DOE-owned or controlled site, the recipient agrees to comply with all state and Federal ES&H regulations, and with all other ES&H requirements of the operator of such site.

Prior to the performance on any work at a DOE-Owned or controlled site, the recipient shall contact the site facility manager for information on DOE and site specific ES&H requirements.

The recipient shall apply this provision to all subrecipients at any tier.

7. Federal, State, and Local Requirements

With respect to the performance of any portion of the work under this award, the recipient agrees to comply with all applicable local, state, and Federal ES&H regulations. The recipient shall apply this provision to all sub awardees at any tier.

8. Funding Restrictions

Funding for all awards and future budget periods are contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority.

Cost Principles: Costs must be allowable, allocable, and reasonable in accordance with the applicable Federal cost principles referenced in 2 CFR 200 as modified by 2 CFR 910 (DOE Financial Assistance Regulation).

Pre-award Costs: Recipients may charge to an award resulting from this FOA pre-award costs that were incurred within the ninety (90) calendar day period immediately preceding the effective date of the award, if the costs are allowable in accordance with the applicable Federal cost principles referenced in 2 CFR 200 as modified by 2 CFR 910 (DOE Financial Assistance Regulation). Recipients must obtain the prior approval of the DOE Contracting Officer for any pre-award costs that are for periods greater than this 90 day calendar period.

Pre-award costs are incurred at the applicant's risk. DOE is under no obligation to reimburse such costs if for any reason the applicant does not receive an award or if the award is made for a lesser amount than the applicant expected.

9. National Environmental Policy Act (NEPA) Compliance

If question 4.a. on the "Research and Related Other Project Information" document indicates "potential impact on the environment", or if DOE's own review indicates it, DOE may ask the applicant to provide additional information on those impacts in order to prepare an environmental critique/synopsis per 10 CFR 1021.216. Note that this pre-award environmental critique/synopsis process would be separate from the preparation of a NEPA document such as an environmental impact statement (EIS) or an environmental assessment (EA). If DOE determines the latter documentation is necessary, this process would need to be completed, funded by and with the participation of the awardee, prior to them taking any action on the proposed project that could have adverse environmental effects or that could limit the choice of reasonable alternatives. Note that in most cases, even when "Potential Impact to the Environment" is checked "Yes," preparation of such NEPA documents is rarely necessary, but DOE has the expectation that the Applicant will disclose the potential, which would serve to initiate dialog with DOE if necessary. The inability to satisfy the NEPA requirements after an award would result in cancellation of the award.

10. Nondisclosure and Confidentiality Agreements Representations (June 2015)

In submitting an application in response to this FOA the Applicant represents that:
(1) It **does not and will not** require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contactors from lawfully reporting waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.
(2) It **does not and will not** use any Federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:

a. *''These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this agreement and are controlling.''*

b. The limitation above shall not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

c. Notwithstanding provision listed in paragraph (a), a nondisclosure or confidentiality policy form or agreement that is to be executed by a person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States Government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not disclose any classified information received in the course of such activity unless specifically authorized to do so by the United States Government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosures to Congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

11. Notice Regarding Eligible/Ineligible Activities

Eligible activities under this program include those which describe and promote the understanding of scientific and technical aspects of specific energy technologies, but not those which encourage or support political activities such as the collection and dissemination of information related to potential, planned, or pending legislation.

12. Prohibition on Discrimination and Harassment

All people conducting, supporting, or participating in scientific research under this award must be able to do so on the basis of their abilities and without any unnecessary barriers. Recipients of awards resulting from this FOA are prohibited from engaging in discrimination on any basis

prohibited by law, including harassment (sexual or non-sexual) as contained in 10 CFR 1040, 1041, and 1042.

Recipients may contact the DOE's Office of Civil Rights for technical assistance in meeting their institutional requirements under these regulations, including assistance in addressing complaints of discrimination or harassment (https://www.energy.gov/diversity/title-ix). The United States Equal Employment Opportunity Commission also makes a number of resources available at https://www.eeoc.gov/eeoc/publications/index.cfm to ensure that employees may perform their work without hindrance. Graduate students and post-doctoral researchers are understood to have a dual role as both trainees and employees, in accordance with 2 CFR 200.400 (f).

13. Prohibition on Lobbying Activity

By accepting funds under this award, you agree that none of the funds obligated on the award shall be expended, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 USC 1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

14. Proprietary Application Information

Patentable ideas, trade secrets, proprietary or confidential commercial or financial information, disclosure of which may harm the applicant, should be included in an application only when such information is necessary to convey an understanding of the proposed project. The use and disclosure of such data may be restricted, provided the applicant includes the following legend on the first page of any document included in the application that contains such proprietary information and specifies the pages of the document which are to be restricted:

"The data contained in pages _____ of this document have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award. This restriction does not limit the government's right to use or disclose data obtained without restriction from any source, including the applicant."

To protect such data, each line or paragraph on the pages containing such data must be specifically identified and marked with a legend similar to the following:

"The following contains proprietary information that (name of applicant) requests not be released to persons outside the Government, except for purposes of review and evaluation."

15. Publications

The recipient is expected to publish or otherwise make publicly available the results of the work conducted under any award resulting from this FOA. Publications and other methods of public

communication describing any work based on or developed under an award resulting from this FOA must contain an acknowledgment of SC support. The format for such acknowledgments is provided at https://science.osti.gov/funding-opportunities/acknowledgements/. The author's copy of any peer-reviewed manuscript accepted for publication must be announced to DOE's Office of Scientific and Technical Information (OSTI) and made publicly available in accordance with the instructions contained in the Reporting Requirements Checklist incorporated in all Assistance Agreements.

16. Registration Requirements

Additional administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR 25 (See: www.eCFR.gov). Prime awardees must keep their data in SAM current at www.SAM.gov. Subrecipients at all tiers must obtain DUNS numbers and provide the DUNS to the prime awardee before the subaward can be issued.

17. Research Misconduct

Scientific discoveries can only take place when scientific research is conducted in a fair, transparent, and honestly reported manner. Any form of dishonesty—whether plagiarism, falsifying results, or misrepresenting conditions—makes it impossible to advance our understanding of the physical universe.

Recipients are "responsible for maintaining the integrity of research of any kind under an award from DOE including the prevention, detection, and remediation of research misconduct, and the conduct of inquiries, investigations, and adjudication of allegations of research misconduct," and conducting appropriate administrative processes in response to allegations of research misconduct in accordance with 2 CFR 910.132. Allegations of any misconduct under an award resulting from this FOA must be reported to the appropriate institutional officials in accordance with institutional policies against misconduct. Additional information on DOE research misconduct policies can be found at: https://science.osti.gov/grants/Policy-and-Guidance/Research-Misconduct.

18. Rights in Technical Data

Normally, the government has unlimited rights in technical data created under a DOE agreement, including the right to distribute to the public. Delivery or third party licensing of proprietary software or data developed solely at private expense ("Limited Rights Data") will not normally be required except as specifically negotiated in a particular agreement to satisfy DOE's own needs or to insure the commercialization of technology developed under a DOE agreement.

If software is specified for delivery to DOE, or if other special circumstances exist, e.g., DOE specifying "open-source" treatment of software, then the DOE Contracting Officer, after negotiation with the recipient, may include in the award special provisions requiring the recipient to obtain written approval of the DOE Contracting Officer prior to asserting copyright in the software, modifying the retained Government license, and/or otherwise altering the copyright provisions.

19. Subaward and Executive Reporting

Additional administrative requirements necessary for DOE grants and cooperative agreements to comply with the Federal Funding and Transparency Act of 2006 (FFATA) are contained in 2 CFR 170. (See: www.eCFR.gov). Prime awardees must register with the new FSRS database at https://www.fsrs.gov and report the required data on their first tier subrecipients. Prime awardees must report the executive compensation for their own executives as part of their registration profile in SAM.

20. Title to Subject Inventions

- **Determination of Exceptional Circumstances (DEC)**: DOE has issued the DEC entitled, DETERMINATION OF EXCEPTIONAL CIRCUMSTANCES (DEC) UNDER THE BAYH-DOLE ACT TO FURTHER PROMOTE DOMESTIC MANUFACTURE OF DOE SCIENCE AND ENERGY TECHNOLOGIES.In accordance with this DEC, all awards, including sub-awards, under this FOA shall include the U.S. Competitiveness Provision below. A copy of the DEC can be found at https://www.energy.gov/gc/determination-exceptional-circumstances-decs.
- Pursuant to 37 CFR § 401.4, any nonprofit organization or small business firm as defined by 35 U.S.C. 201 affected by any DEC has the right to appeal it by providing written notice to DOE within 30 working days from the time it receives a copy of the determination.
- DOE may require additional submissions or requirements as authorized by any applicable DEC.
- **DEC**: DOE has issued the DEC entitled, "DETERMINATION OF EXCEPTIONAL CIRCUMSTANCES UNDER THE BAYH-DOLE ACT FOR QUANTUM INFORMATION SCIENCE TECHNOLOGIES", dated August 28, 2020, pursuant to 37 CFR 401.3(a)(2), which applies to agreements issued under this FOA requiring each applicant to agree to a U.S. Competitiveness Provision. DOE has determined that exceptional circumstances exist that warrant the modification of the standard patent rights clause for small businesses and non-profit awardees under the Bayh-Dole Act, 35 U.S.C. 200 et seq., to the extent necessary to ensure that DOE "obtains sufficient rights in the federally supported inventions to meet the needs of [DOE]" and "to promote the commercialization and public availability of inventions made in the United States by United States industry and labor" and/or further promote other purposes of the Bayh-Dole Act. 35 U.S.C. § 200. In accordance with this DEC, all awards, including sub-awards, under this FOA shall include the U.S. Competitiveness Provision above. A copy of the DEC can be found at https://www.energy.gov/gc/determination-exceptional-circumstances-decs.

Ownership of subject inventions is governed pursuant to the authorities listed below:

- **Nonprofit organizations or small business firms**: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), nonprofit organizations or small business firms as defined by 35 U.S.C. 201 may elect to retain title to their subject inventions subject to the above identified U.S. Competitiveness Provision.
- **All other parties**: The federal Non-Nuclear Energy Act of 1974, 42. U.S.C. 5908, provides that the government obtains title to new inventions unless a waiver is granted (see below).
- **Patent Waiver**: Applicants may request a waiver of all or any part of the rights of the United

States in inventions conceived or first actually reduced to practice in performance of an agreement as a result of this FOA, in advance of or within 30 days after the effective date of the award. Even if such advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver of the rights of the United States in identified inventions, i.e., individual inventions conceived or first actually reduced to practice in performance of the award. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784. For more information, see https://energy.gov/gc/services/technology-transfer-and-procurement/office-assistant-general-counsel-technology-transf-1 . Nonprofit organizations and small business firms do not need a patent waiver in order to retain title to their subject inventions (see above).

Class Patent Waiver: DOE has issued Class Patent Waiver No. W(C) 2020-001 of Patent Rights Related to Quantum Information Science and its Technology Applications that applies to this FOA for any domestic large business that is a recipient, or subrecipient at any tier to this FOA and is providing at least 20% cost share. Under this Class Patent Waiver, domestic large businesses may elect title to their subject inventions similar to the right provided to the domestic small businesses, educational institutions, and nonprofits by law. In order to avail itself of the class patent waiver, a domestic large business must agree that any products embodying or produced through the use of a subject invention first created or reduced to practice under this program will be substantially manufactured in the United States. Entities not eligible under the Class Patent Waiver are still able to petition DOE for rights under an Advanced or Identified Patent Waiver as described above.

Nonprofit organizations and small business firms do not need a patent waiver in order to retain title to their subject inventions (see above).

21. U.S. Competitiveness

A primary objective of DOE's multi-billion dollar research, development and demonstration investments is to cultivate new research and development ecosystems, manufacturing capabilities, and supply chains for and by U.S. industry and labor. Therefore, in exchange for receiving taxpayer dollars to support an applicant's project, the applicant must agree to the following U.S. Competitiveness Provision as part of an award under this FOA.

U.S. Competitiveness

The Recipient agrees that any products embodying any subject invention or produced through the use of any subject invention will be manufactured substantially in the United States unless the Recipient can show to the satisfaction of DOE that it is not commercially feasible. In the event DOE agrees to foreign manufacture, there will be a requirement that the Government's support of the technology be recognized in some appropriate manner, e.g., alternative binding commitments to provide an overall net benefit to the U.S. economy. The Recipient agrees that it will not license, assign or otherwise transfer any subject invention to any entity, at any tier, unless that entity agrees to these same requirements. Should the Recipient or other such entity receiving rights in the invention(s): (1) undergo a change in ownership amounting to a controlling interest,

or (2) sell, assign, or otherwise transfer title or exclusive rights in the invention(s), then the assignment, license, or other transfer of rights in the subject invention(s) is/are suspended until approved in writing by DOE. The Recipient and any successor assignee will convey to DOE, upon written request from DOE, title to any subject invention, upon a breach of this paragraph. The Recipient will include this paragraph in all subawards/contracts, regardless of tier, for experimental, developmental or research work.

Please note that a subject invention is any invention conceived or first actually reduced in performance of work under an award. An invention is any invention or discovery which is or may be patentable. The recipient includes any awardee, recipient, sub-awardee, or sub-recipient.

As noted in the U.S. Competitiveness Provision, if an entity cannot meet the requirements of the U.S. Competitiveness Provision, the entity may request a modification or waiver of the U.S. Competitiveness Provision. For example, the entity may propose modifying the language of the U.S. Competitiveness Provision in order to change the scope of the requirements or to provide more specifics on the application of the requirements for a particular technology. As another example, the entity may request that the U.S. Competitiveness Provision be waived in lieu of a net benefits statement or U.S. manufacturing plan. The statement or plan would contain specific and enforceable commitments that would be beneficial to the U.S. economy and competitiveness. Examples of such commitments could include manufacturing specific products in the U.S., making a specific investment in a new or existing U.S. manufacturing facility, keeping certain activities based in the U.S. or supporting a certain number of jobs in the U.S. related to the technology. DOE may, in its sole discretion, determine that the proposed modification or waiver promotes commercialization and provides sufficient U.S. economic benefits, and grant the request. If granted, DOE will modify the award terms and conditions for the requesting entity accordingly.

The U.S. Competitiveness Provision is implemented by DOE pursuant to a Determination of Exceptional Circumstances (DEC) under the Bayh-Dole Act and DOE Patent Waivers.

D. REFERENCE MATERIAL

Glossary of Useful Grants and Cooperative Agreement terms

Acquisition cost	*Acquisition cost* means the cost of the asset including the cost to ready the asset for its intended use. Acquisition cost for equipment, for example, means the net invoice price of the equipment, including the cost of any modifications, attachments, accessories, or auxiliary apparatus necessary to make it usable for the purpose for which it is acquired. Acquisition costs for software includes those development costs capitalized in accordance with generally accepted accounting principles (GAAP). Ancillary charges, such as taxes, duty, protective in transit insurance, freight, and installation may be included in or excluded from the acquisition cost in accordance with the non-Federal entity's regular accounting practices.
Administrative requirements	*Administrative requirement*s means the general business management practices that are common to the administration of all grants, such as financial accountability, reporting, equipment management, and retention of records.
Advance payment	*Advance payment* means a payment that a Federal awarding agency or pass-through entity makes by any appropriate payment mechanism, including a predetermined payment schedule, before the non-Federal entity disburses the funds for program purposes.
Allocation	*Allocation* means the process of assigning a cost, or a group of costs, to one or more cost objective(s), in reasonable proportion to the benefit provided or other equitable relationship. The process may entail assigning a cost(s) directly to a final cost objective or through one or more intermediate cost objectives.
Allocability	*Allocability* means the principle which requires that an expense or service charged must directly benefit and be necessary for the performance of the project; when multiple projects are benefited reasonable proportions must be able to be assigned. See 2 CFR 200.405.
Allowable cost	*Allowable cost* means a cost incurred by a recipient that is: (1) reasonable for the performance of the award; (2) allocable; (3) in conformance with any limitations or exclusions set forth in the Federal cost principles applicable to the organization incurring the cost or in the award documents as to the type or amount of cost; (4) consistent with regulations, policies, and procedures of the recipient that are applied uniformly to both federally supported and other activities of the organization; (5) accorded consistent treatment as a direct or indirect cost; (6) determined in accordance with generally accepted accounting principles; and (7) not included as a cost in any other federally supported award (unless specifically authorized by statute). See 2 CFR 200.403.
Application	*Application* means a request for financial support of a project or activity submitted to DOE on specified forms and in accordance with DOE instructions. Also known as a proposal.
Appropriation Act	*Appropriation act* means the statute that provides the authority for Federal agencies to incur obligations to and make payments out of the U.S. treasury for specified purposes.
Approved budget	The approved budget for the Federal award summarizes the financial aspects of the project or program as approved during the Federal award process. It may include either the Federal and non-Federal share or only the Federal share, depending upon Federal awarding agency requirements. It must be related to performance for program evaluation purposes whenever appropriate. See 2 CFR 200.308(a).
Assurance	*Assurance* means a certification by an applicant, normally included with the application or State plan, indicating that the entity is in compliance with, or that it will abide by, a particular requirement if awarded a Federal grant.

Authorized organizational representative	*Authorized organizational representative* means the individual, named by the applicant organization, who is authorized to act for the applicant and to assume the obligations imposed by the Federal laws, regulations, requirements, and conditions that apply to grant applications or grant awards.
Award	*Award* means the provision of funds by DOE, based on an approved application and budget or progress report, to an organizational entity or an individual to carry out a project or activity.
Award documents	*Award documents* means the entirety of the documents describing the legal relationship between DOE and an awardee or recipient. The award documents include an Assistance Agreement and other documents which may be incorporated by reference or as attachments to the Assistance Agreement. The award documents are the official, legally binding document, signed (or the electronic equivalent of signature) by a Contracting Officer that: • notifies the recipient of the award of a grant; • contains or references all the terms and conditions of the grant and Federal funding limits and obligations; and, • provides the documentary basis for recording the obligation of Federal funds in the DOE accounting system.
Bayh-Dole Act	*Bayh-Dole Act* means a law which encourages universities and researchers to develop their inventions into marketable products; formal citation is Section 6 of the Patent and Trademark Amendment of 1980, Pub. L 96-517 as amended.
Budget	*Budget* means the financial plan for the project or program that the Federal awarding agency or pass-through entity approves during the Federal award process or in subsequent amendments to the Federal award. It may include the Federal and non-Federal share or only the Federal share, as determined by the Federal awarding agency or pass-through entity.
Budget period	*Budget period* means the intervals of time (usually 12 months each) into which a project period is divided for budgetary and funding purposes.
Business officer	*Business officer* means the financial official of the grantee who has primary fiscal responsibility for the grant. Also known as authorized organizational representative.
Capital assets	*Capital assets* means tangible or intangible assets used in operations having a useful life of more than one year which are capitalized in accordance with GAAP. Capital assets include: (a) Land, buildings (facilities), equipment, and intellectual property (including software) whether acquired by purchase, construction, manufacture, lease-purchase, exchange, or through capital leases; and (b) Additions, improvements, modifications, replacements, rearrangements, reinstallations, renovations, or alterations to capital assets that materially increase their value or useful life (not ordinary repairs and maintenance).
Carryover	*Carryover* means unobligated Federal funds remaining at the end of any budget period that may be carried forward to another budget period to cover allowable costs of that budget period (whether as an offset or additional authorization). Obligated, but unliquidated, funds are not considered carryover.
Change in scope	*Change in scope* means an activity whereby the objectives or specific aims identified in the approved grant application are significantly changed by the grantee after award. Contracting Officer prior approval is required for a change in scope to be allowable under an award.
Closeout	*Closeout* means the process by which a Federal awarding agency determines that all applicable administrative actions and all required work under an award have been completed by the grantee and the Federal awarding agency.
Competitive segment	*Competitive segment* means the initial project period recommended for support or each extension of a project period resulting from a renewal award.

Conference (domestic or international)	*Conference (domestic or international)* means a symposium, seminar, workshop, or any other organized and formal meeting, whether conducted face-to-face or via the Internet, where individuals assemble (or meet virtually) to exchange information and views or explore or clarify a defined subject, problem, or area of knowledge, whether or not a published report results from such meeting.
Consortium or sub-award agreement	*Consortium or sub-award agreement* means a formalized agreement whereby a research project is carried out by the grantee and one or more other organizations that are separate legal entities. Under the agreement, the grantee must perform a substantive role in the conduct of the planned research and not merely serve as a conduit of funds to another party or parties. These agreements typically involve a specific level of effort from the consortium organization's PD/PI and a categorical breakdown of costs, such as personnel, supplies, and other allowable expenses, including F&A costs. The relationship between the recipient and the collaborating organizations is considered a sub-award relationship.
Consultant	*Consultant* means an individual who provides professional advice or services for a fee, but not as an employee of the engaging party. To prevent apparent or actual conflicts of interest, grantees and consultants must establish written guidelines indicating the conditions of payment of consulting fees. Consultants also include firms that provide professional advice or services. See 2 CFR 200.459.
Continuation application/award	*Continuation application/award* means a financial assistance request (in the form of an application or progress report) or resulting award for a subsequent budget period within a previously approved project period for which a recipient does not have to compete with other applicants.
Contract	*Contract* means a legal instrument by which a non-Federal entity purchases property or services needed to carry out the project or program under a Federal award. The term as used in this part does not include a legal instrument, even if the non-Federal entity considers it a contract, when the substance of the transaction meets the definition of a Federal award or sub-award (see 2 CFR 200.1 Subaward).
Contractor	*Contractor* means an entity that receives a contract as defined in 2 CFR 200.1 Contract.
Contracting (or Grants) Officer	*Contracting (or Grants) Officer* means a DOE official responsible for the business management aspects of grants and cooperative agreements, including review, negotiation, award, and administration, and for the interpretation of grants administration policies and provisions. COs and GOs are delegated the authority to obligate DOE to the expenditure of funds and permit changes to approved projects on behalf of DOE.
Contracting (or Grants Management) specialist	*Contracting (or Grants Management) specialist* means a DOE staff member who works with a Contracting or Grants Officer and is assigned the day-to-day management of a portfolio of grants and/or cooperative agreements. These activities include, but are not limited to, evaluating grant applications for administrative content and compliance with statutes, regulations, and guidelines; negotiating grants; providing consultation and technical assistance to grantees; and administering grants after award.
Cooperative agreement	*Cooperative agreement* means a type of financial assistance used when there will be substantial Federal scientific or programmatic involvement. Substantial involvement means that, after award, scientific or program staff will assist, guide, coordinate, or participate in project activities.
Cost principles	*Cost principles* means the government-wide principles, 2 CFR 200 Subpart E (or, in the case of commercial organizations, the Federal Acquisition Regulation [48 CFR 31], or, in the case of hospitals, see Appendix IX to Part 200—Hospital Cost Principles, Appendix E, "Principles For Determining

	Costs Applicable to Research and Development Under Grants and Contracts with Hospitals"), on allowability and unallowability of costs under federally sponsored agreements.
Cost sharing or matching	*Cost sharing or matching* means the portion of project costs not paid by Federal funds (unless otherwise authorized by Federal statute). See also 2 CFR 200.306 Cost sharing or matching.
Deadline	*Deadline* means the published date and/or time that a grant application is to be submitted to the funding agency.
Debarment and suspension	*Debarment and suspension* means the actions taken by a debarring official in accordance with OMB guidance at 2 CFR 180, "Non-procurement Debarment and Suspension," to exclude a person or organization from participating in grants and other non-procurement awards government-wide. If debarred or suspended, the person or organization may not receive financial assistance (under a grant, cooperative agreement, or sub-award, or contract under a grant) for a specified period of time. Debarments and suspensions carried out pursuant to 2 CFR 376 are distinct from post-award suspension action by an awarding agency. See 2 CFR 901 for DOE implementation.
Direct costs	*Direct costs* means costs that can be identified specifically with a particular sponsored project, an instructional activity, or any other institutional activity, or that can be directly assigned to such activities relatively easily with a high degree of accuracy. See 2 CFR 200.413.
Disallowed costs	*Disallowed costs* means those charges to a Federal award that the Federal awarding agency or pass-through entity determines to be unallowable, in accordance with the applicable Federal statutes, regulations, or the terms and conditions of the Federal award.
Domestic organization	*Domestic organization* means a public (including a State or other governmental agency) or private non-profit or for-profit organization that is located in the United States or its territories, is subject to U.S. laws, and assumes legal and financial accountability for awarded funds and for the performance of the grant-supported activities.
DUNS number	*DUNS number* means a nine-digit number established and assigned by Dun and Bradstreet to uniquely identify a business entity.
Effort	*Effort* means the amount of time, usually expressed as a percentage of the total, which a faculty member or other employee spends on a sponsored project. No one is allowed to spend more than 100% total commitment on all academic activities, including grant-sponsored research, university-sponsored research, teaching, administration, advising and other contracted duties. Effort is indicated on the budget in units of person-months.
Equipment	*Equipment* means tangible personal property (including information technology systems) having a useful life of more than one year and a per-unit acquisition cost which equals or exceeds the lesser of the capitalization level established by the non-Federal entity for financial statement purposes, or $5,000. See also 2 CFR 200.1 Capital assets, Computing devices, General purpose equipment, Information technology systems, Special purpose equipment, and Supplies.
Expanded authorities	*Expanded authorities* means authorization to grantees under certain research grant mechanisms which waives the requirement for prior agency approval for specified actions related to awards. Example: 90-day pre-award spending authority, no cost extensions for up to one additional year, and automatic carryover of unobligated funds from one budget period to the next. The expanded authorities are now contained in the standard terms and conditions for most research grants.
Expiration date	*Expiration date* means generally, the date signifying the end of the current project period, after which the grantee is not authorized to obligate grant funds.

Facilities and administrative costs	*Facilities and administrative costs* means costs that are incurred by a grantee for common or joint objectives and that, therefore, cannot be identified specifically with a particular project or program. These costs also are known as indirect costs.
Federal financial report	*Federal financial report* means submitted on Standard Form (SF) 425, to indicate the status of awarded funds for the period covered. Frequency of reporting is specified in the Reporting Checklist provided as part of the award documents.
Financial assistance	*Financial assistance* means transfer by DOE of money or property to an eligible entity to support or stimulate a public purpose authorized by statute.
Financial status report	*Financial status report* means see Federal Financial Report.
Foreign travel	*Foreign travel* is meant to include travel outside of North America (Canada, Mexico, and the United States) and U.S. territories and possessions (Guam, American Samoa, Puerto Rico, the U.S. Virgin Islands. A trip is considered foreign travel for all legs of the itinerary if the traveler does not return to his or her post prior to departure for a foreign destination. Costs for foreign travel may be restricted by the language of a Funding Opportunity Announcement.
Funding opportunity announcement (FOA)	*Funding opportunity announcement (FOA)* means a publicly available document by which a Federal Agency makes known its intentions to award discretionary grants or cooperative agreements, usually as a result of competition for funds. Funding opportunity announcements may be known as program announcements, requests for applications, notices of funding availability, solicitations, or other names depending on the Agency and type of program. Funding opportunity announcements can be found at www.Grants.gov. An FOA may also be known as a solicitation.
Grant agreement	*Grant agreement* means a legal instrument of financial assistance between a Federal awarding agency or pass-through entity and a non-Federal entity that, consistent with 31 USC 6302, 6304: (a) Is used to enter into a relationship the principal purpose of which is to transfer anything of value from the Federal awarding agency or pass-through entity to the non-Federal entity to carry out a public purpose authorized by a law of the United States (see 31 USC 6101(3)); and not to acquire property or services for the Federal awarding agency or pass-through entity's direct benefit or use; (b) Is distinguished from a cooperative agreement in that it does not provide for substantial involvement between the Federal awarding agency or pass-through entity and the non-Federal entity in carrying out the activity contemplated by the Federal award. (c) Does not include an agreement that provides only: (1) Direct United States Government cash assistance to an individual; (2) A subsidy; (3) A loan; (4) A loan guarantee; or (5) Insurance.
Grant-supported project or activity	*Grant-supported project or activity* means those activities specified or described in a grant application or in a subsequent submission that are approved by DOE for funding, regardless of whether Federal funding constitutes all or only a portion of the financial support necessary to carry them out.
Grantee	*Grantee* means the organization or individual awarded a grant or cooperative agreement by DOE that is responsible and accountable for the use of the funds provided and for the performance of the grant-supported project or activity. The grantee is the entire legal entity even if a particular component is designated in award documents. The grantee is legally responsible and accountable to DOE for the performance and financial aspects of the grant-

	supported project or activity. Also known as awardee or recipient.
Grants.gov	*Grants.gov* (https://www.Grants.gov/) has been designated by the Office of Management and Budget as the single access point for all grant programs offered by 26 Federal grant-making agencies. It provides a single interface for agencies to announce their grant opportunities and for all applicants to find and apply for those opportunities.
Indirect costs (facilities & administrative)	*Indirect (F&A) costs* means those costs incurred for a common or joint purpose benefitting more than one cost objective, and not readily assignable to the cost objectives specifically benefitted, without effort disproportionate to the results achieved. To facilitate equitable distribution of indirect expenses to the cost objectives served, it may be necessary to establish a number of pools of indirect (F&A) costs. Indirect (F&A) cost pools must be distributed to benefitted cost objectives on bases that will produce an equitable result in consideration of relative benefits derived.
Institutional base salary	*Institutional base salary* means the annual compensation paid by an organization for an employee's appointment, whether that individual's time is spent on research, teaching, patient care, or other activities. Base salary excludes any income that an individual may be permitted to earn outside of duties for the applicant/grantee organization. Base salary may not be increased as a result of replacing organizational salary funds with grant funds.
Matching or cost sharing	*Matching or cost sharing* means the value of third-party in-kind contributions and the portion of the costs of a federally assisted project or program not borne by the Federal government. Matching or cost sharing may be required by statute or program regulation. Costs used to satisfy matching or cost-sharing requirements are subject to the same policies governing allowability as other costs under the approved budget.
Merit (or peer) review	*Merit (or peer) review* means the process that involves the consistent application of standards and procedures that produce fair, equitable, and objective examinations of applications based on an evaluation of scientific or technical merit or other relevant aspects of the application. The review is performed by experts (reviewers) in the field of endeavor for which support is requested. Merit review is intended to provide guidance and to the DOE individuals responsible for making award decisions.
Monitoring	*Monitoring* means a process whereby the programmatic and business management performance aspects of a grant are assessed by reviewing information gathered from various required reports, audits, site visits, and other sources.
NEPA	NEPA means the National Environmental Policy Act (NEPA), Public Law 91-190, as amended. NEPA requires Federal agencies to assess the environmental effects of proposed major Federal actions prior to making decisions.
No-cost extension	*No-cost extension* means an extension of time to a project period and/or budget period to complete the work of the grant under that period, without additional Federal funds or competition.
Non-Federal share	*Non-Federal share* means when cost sharing or matching is required as a condition of an award, the portion of allowable project/program costs not borne by the Federal government.
Obligations	*Obligations* when used in connection with a non-Federal entity's utilization of funds under a Federal award, *obligations* means orders placed for property and services, contracts and sub-awards made, and similar transactions during a given period that require payment by the non-Federal entity during the same or a future period.
OMB circulars	*OMB circulars* means government-wide guidance issued to Heads of Federal agencies by the Director of the Office of Management and Budget.
Other significant contributors	Other significant contributors means individuals who have committed to contribute to the scientific development or execution of the project, but are not

	committing any specified measurable effort (i.e., person months) to the project. These individuals are typically presented at "effort of zero person months" or "as needed." Individuals with measurable effort may not be listed as Other Significant Contributors (OSCs). Consultants should be included if they meet this definition.
Program participant	*Program participants* are the recipients of service or training provided at a workshop, conference, seminar, symposium or other short-term instructional or information-sharing activity funded by an external grant or award, or the training beneficiaries of the project or program funded by an external grant or award. A participant is not involved in providing any deliverable to the grantee or a third party or would not be terminated or replaced for failure to perform.
Participant support costs	*Participant support costs* means direct costs for items such as stipends or subsistence allowances, travel allowances, and registration fees paid to or on behalf of participants or trainees (but not employees) in connection with conferences, or training projects.
Person months	*Person months* is the metric for expressing the effort (amount of time) PD/PI(s), faculty and other senior/key personnel devote to a specific project. The effort is based on the type of appointment of the individual with the organization; e.g., calendar year, academic year, and/or summer term; and the organization's definition of such. For instance, some institutions define the academic year as a 9-month appointment while others define it as a 10-month appointment.
Pre-application or pre-proposal	*Pre-application or pre-proposal* means a brief outline or narrative of proposed work and sometimes budget, for informal review by a sponsor to determine whether an application should be submitted. Three predominant reasons for requiring submission of a preliminary pre-application are: • Reduce the applicant's unnecessary effort in proposal preparation when the chance of success is very small. This is particularly true of exploratory initiatives where the community senses that a major new direction is being identified, or competitions that will result in a small number of actual awards. • Increase the overall quality of the submission. • Distill the number of applications that will be submitted to the agency and the number of anticipated reviewers needed to review.
Pre-award costs	*Pre-award costs* means any cost incurred prior to the beginning date of the project period or the initial budget period of a competitive segment (under a multi-year award), in anticipation of the award and at the applicant's own risk, for otherwise allowable costs.
Prior approval	*Prior approval* means written approval from the designated Contracting Officer.
Program Director/ Principal Investigator	*Program Director/ Principal Investigator* means the individual(s) designated by the applicant organization to have the appropriate level of authority and responsibility to direct the project or program to be supported by the award. The applicant organization may designate multiple individuals as program directors/principal investigators (PD/PIs) who share the authority and responsibility for leading and directing the project, intellectually and logistically. When multiple PD/PIs are named, each is responsible and accountable to the applicant organization, or as appropriate, to a collaborating organization for the proper conduct of the project or program including the submission of all required reports. The presence of more than one PD/PI on an application or award diminishes neither the responsibility nor the accountability of any individual PD/PI.
Program income	*Program income* means gross income earned by the non-Federal entity that is directly generated by a supported activity or earned as a result of the Federal award during the period of performance except as provided in 2 CFR 200.307

	paragraph (f). (See 2 CFR 200.1 Period of performance.) Program income includes but is not limited to income from fees for services performed, the use or rental or real or personal property acquired under Federal awards, the sale of commodities or items fabricated under a Federal award, license fees and royalties on patents and copyrights, and principal and interest on loans made with Federal award funds. Interest earned on advances of Federal funds is not program income. Except as otherwise provided in Federal statutes, regulations, or the terms and conditions of the Federal award, program income does not include rebates, credits, discounts, and interest earned on any of them. See also 2 CFR 200.407 Prior written approval (prior approval). See also 35 USC 200-212 "Disposition of Rights in Educational Awards" for inventions made under Federal awards.
Program Manager	*Program Manager* means the DOE official responsible for the programmatic, scientific, and/or technical aspects of a grant. The same role is filled by Program Directors, Program Officers, or Project Directors at other Federal agencies.
Progress report	*Progress report* means periodic, frequently annual, report submitted by the grantee and used by DOE to assess progress and to determine whether to provide funding for the budget period subsequent to that covered by the report.
Project/performance site	*Project/ performance site* means location(s) of where the work described in the research plan will be conducted.
Project period	*Project period* means the total time for which Federal support of a project has been programmatically approved as shown in the award documents; however, it does not constitute a commitment by the Federal government to fund the entire period. The total award period comprises the initial competitive segment, any subsequent competitive segments resulting from a renewal award(s), and extensions.
Proposal	See application.
Re-budgeting	*Re-budgeting* means reallocation of funds available for spending between approved budget categories to allow best use of funds to accomplish the project goals.
Recipient	*Recipient* means the organizational entity or individual receiving a grant or cooperative agreement.
Renewal application	*Renewal application* means an application requesting additional funding for a period subsequent to that provided by a current award. Renewal applications compete for funds with all other peer reviewed applications and must be developed as fully as though the applicant is applying for the first time.
Research	*Research* is defined as a systematic study directed toward fuller scientific knowledge or understanding of the subject studied. See 2 CFR 200.1 Research and Development (R&D).
Research misconduct	Research misconduct means fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results, but does not include honest error or differences of opinion. See 10 CFR 733.
SAM.gov	*SAM.gov* is the System for Award Management (SAM) a consolidated service that includes Entity Registration, Assistance Listings, and other services for making, managing, and receiving Federal awards.
Scope of work	*Scope of work* means the aims, objectives, and purposes of a grant; as well as the methodology, approach, analyses, or other activities; and the tools, technologies, and timeframes needed to meet the grant's objectives. This includes the research or training plan included with the original grant application, along with any approved modifications.
Senior/Key Personnel	*Senior/Key personnel* means the PD/PI and other individuals who contribute to the scientific development or execution of a project in a substantive, measurable way, whether or not they receive salaries or compensation under the grant. Typically, these individuals have doctoral or other professional

	degrees, although individuals at the masters or baccalaureate level may be considered senior/key personnel if their involvement meets this definition. Consultants and those with a postdoctoral role also may be considered senior/key personnel if they meet this definition. "Zero percent" effort or "as needed" is not an acceptable level of involvement for Senior/Key Personnel.
Significant re-budgeting	*Significant re-budgeting* means a threshold that is reached when expenditures in a single direct cost budget category deviate (increase or decrease) from the categorical commitment level established for the budget period by more than 25 percent of the total costs awarded. Significant re-budgeting is one indicator of change in scope.
Small business concern	*Small business concern* means a business that meets the regulatory and size requirements established by the SBA at 13 CFR 121.
Solicitation	See Funding Opportunity Announcement.
Subaward	*Subaward* means a legal instrument by which a recipient provides funds (or property in lieu of funds) to an eligible subrecipient (or a lower-tier transaction) to perform a substantive portion of the grant-supported program or project. The term includes such financial assistance when provided by any legal agreement (even if the agreement is called a contract) but does not include any form of assistance which is excluded from the definition of a grant, including the recipient's procurement of property or services needed to carry out the project or program. The term includes consortium agreements.
Subrecipient	*Subrecipient* means a non-Federal entity that receives a subaward from a pass-through entity to carry out part of a Federal program; but does not include an individual that is a beneficiary of such program. A sub-recipient may also be a recipient of other Federal awards directly from a Federal awarding agency.
Supplement	*Supplement* means a request for an increase in support during a current budget period for expansion of the project's scope or to meet increased costs unforeseen at the time of the new or renewal application. A supplement may increase support for future years in addition to the current year. Supplements require applications and are subject to administrative and merit review.
Terms and conditions of award	*Terms and conditions of award* means all legal requirements imposed on a grant by DOE, whether based on statute, regulation, policy, or other document referenced in the grant award, or specified by the grant award document itself. The award documents may include both standard and special conditions that are considered necessary to attain the grant's objectives, facilitate post-award administration of the grant, conserve grant funds, or otherwise protect the Federal government's interests.
Unallowable costs	*Unallowable costs* means costs that cannot be charged, directly or indirectly, to Federal awards because the costs are prohibited by law, regulation (including applicable cost principles), or the terms and conditions of award. Costs that are not allowable, allocable, or reasonable are unallowable.
Unliquidated obligation	*Unliquidated obligations* means, for financial reports prepared on a cash basis, obligations incurred by the non-Federal entity that have not been paid (liquidated). For reports prepared on an accrual expenditure basis, these are obligations incurred by the non-Federal entity for which an expenditure has not been recorded.
Unobligated balance	*Unobligated balance* means the amount of funds under a Federal award that the non-Federal entity has not obligated. The amount is computed by subtracting the cumulative amount of the non-Federal entity's unliquidated obligations and expenditures of funds under the Federal award from the cumulative amount of the funds that the Federal awarding agency or pass-through entity authorized the non-Federal entity to obligate.

Validate	In the context of the data management plan requirements, *validate* means to support, corroborate, verify, or otherwise determine the legitimacy of the research findings. Validation of research findings could be accomplished by reproducing the original experiment or analyses, comparing and contrasting the results against those of a new experiment or analyses, or by some other means.