



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

# DOE Office of Science

## Update and FY 2019 Budget

*Presented to the*

**Nuclear Sciences Advisory Committee**

by

**Steve Binkley**  
Deputy Director for Programs

Steve.Binkley@science.doe.gov

*November 2, 2018*

# Outline

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- Message from DOE leadership
- Appointee status
- FY 2019 budget



# Message from Secretary Perry

The President's Budget for FY 2019 requests \$30.6B for the Department of Energy (DOE) to advance U.S. national security and economic growth through transformative science and technology innovation that promotes affordable and reliable energy through market solutions and meets our nuclear security and environmental cleanup challenges.

## *The FY 2019 Budget provides:*

- \$15.1B to modernize and restore the nuclear security enterprise aligned with the Nuclear Posture Review (NPR) and National Security Strategy
- **\$6.585B to conduct cutting-edge, early-stage scientific research and development (R&D) and build state-of-the-art scientific tools and facilities to keep U.S. researchers at the forefront of scientific innovation, including achieving exascale computing in 2021**
- \$2.5B to promote America's energy dominance through technologies that will make our energy supply more affordable, reliable, and efficient
- \$6.6B to continue our commitment for the cleanup of sites resulting from five decades of nuclear weapons development and production and Government-sponsored nuclear energy research



# Message from the DOE Office of Science

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- Our job is to deliver the best science we can with the resources we are given by the President and Congress
- We pleased about the final passage of the Congressional Appropriation FY 2019
- As we proceed in the remainder of FY 2019, we remain focused on our priorities:
  - Deliver the best science we can with the resources we have
  - Continue the tradition of excellence in SC-funded university-based research, lab-based research, and operations of scientific facilities

# Appointee Status, continued



## Director, Office of Science Nominee Christopher Fall

- Nomination announced May 18, 2018
- Senate Hearing June 26, 2018, voted out of Committee July 24, 2018
- Awaiting final Senate Confirmation



# Director, Office of Science Nominee Christopher Fall

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Dr. Chris Fall presently is the Principal Deputy Director of the Advanced Research Projects Agency – Energy.

Dr. Fall served most recently for over six years with the Office of Naval Research, including as Innovation Fellow, as Director of the International Liaison Office, as Deputy Director of Research for STEM and Workforce, and finally as acting Chief Scientist. During this time, he also served for three years at the White House Office of Science and Technology Policy as Assistant Director for Defense Programs and then as acting Lead for the National Security and International Affairs Division.

Dr. Fall earned a B.S. in Mechanical Engineering and a Ph.D. in Neuroscience from the University of Virginia, as well as a master of business administration from the Kellogg School of Management. He was previously at the University of California at Davis, New York University, and the University of Illinois at Chicago.



DOE/CF-0144

# Department of Energy FY 2019 Congressional Budget Request



## Budget in Brief

February 2018

Office of Chief Financial Officer



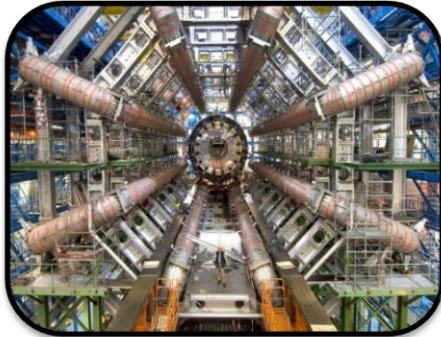
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# Office of Science at a Glance

**FY 2019 Enacted: \$6.585B**



Largest Supporter of Physical Sciences in the U.S.



Funding at >300 Institutions including all 17 DOE Labs



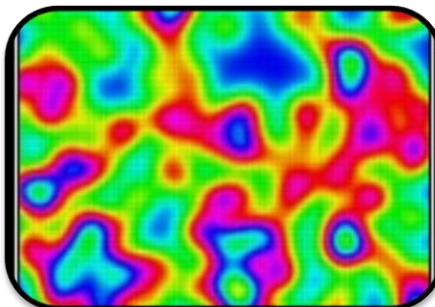
Over 22,000 Scientists Supported



Nearly 32,000 Users of 26 SC Scientific Facilities



~40% of Research to Universities



Research: 40%



Facility Operations: 39%,



Projects/Other: 21%,





# The Office of Science

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The DOE Office of Science (SC) has as its mission the delivery of 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 largest Federal supporter of basic research in the physical sciences in the United States. SC supports research at the frontiers of science—discovering nature’s mysteries, from the study of subatomic particles, atoms, and molecules that are the building blocks of the materials of our everyday world, to the DNA, proteins, and cells that are the building blocks of entire biological systems.**
- **SC also supports science for energy and the environment—advancing a clean energy agenda through fundamental research on energy production, conversion, storage, transmission, and use, and through advancing our understanding of the earth and its environment.**

The scale and complexity of the SC research portfolio provide a competitive advantage to the nation as multidisciplinary teams of scientists, using some of the most advanced scientific instruments in the world, are able to respond quickly to national priorities and evolving opportunities at the frontiers of science.

# FY 2019 SC Budget Guidance

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**FY 2017 Enacted: \$5.391B**

**FY 2018 Enacted: \$6.260B**

**FY 2019 Enacted: \$6.585B**

## Priorities:

- Continue operations of the national laboratories
- Continue exascale computing research for delivery in FY 2021
- Expand quantum computing and quantum information science efforts
- Provide sufficient funding to ensure robust cybersecurity program
- Focus on cutting edge, early stage research and development
- Maintain interagency and international partnerships

# FY 2019 SC Budget (House-Senate Conference)

(Dollars in Thousands)

	FY 2017			FY 2018		FY 2019			Conference
	President's Request	Enacted Approp.	Current Approp.	President's Request	Enacted Approp.	President's Request	House Mark	Senate Mark	
ASCR	663,180	647,000	626,559	722,010	810,000	899,010	914,500	980,000	935,500
BES	1,936,730	1,871,500	1,812,113	1,554,500	2,090,000	1,850,000	2,129,233	2,193,400	2,166,000
BER	661,920	612,000	588,826	348,950	673,000	500,000	673,000	715,000	705,000
FES	398,178	380,000	368,119	309,940	532,111	340,000	590,000	425,000	564,000
HEP	817,997	825,000	802,849	672,700	908,000	770,000	1,004,510	1,010,000	980,000
NP	635,658	622,000	604,473	502,700	684,000	600,000	690,000	710,000	690,000
WDTS	20,925	19,500	19,500	14,000	19,500	19,000	19,500	24,500	22,500
SLI	130,000	130,000	130,000	76,200	257,292	126,852	290,147	302,100	232,890
S&S	103,000	103,000	103,000	103,000	103,000	106,110	106,110	106,000	106,110
PD	204,481	182,000	182,000	168,516	183,000	180,000	183,000	184,000	183,000
SBIR/STTR (SC)	...	...	154,561	...	...	...	...	...	...
Total Budget Authority and Obligations, Office of Science	5,572,069	5,392,000	5,392,000	4,472,516	6,259,903	5,390,972	6,600,000	6,650,000	6,585,000
SBIR/STTR (DOE)	...	...	90,813	...	...	...	...	...	...
Rescission of Prior Year Balances	...	-1,028	-1,028	...	...	...	...	...	...
Total, Office of Science	5,572,069	5,390,972	5,481,785	4,472,516	6,259,903	5,390,972	6,600,000	6,650,000	6,585,000



# SC Research Programs

FY 2017 Enacted, FY 2018 Enacted, FY 2019 Enacted

## **Advanced Scientific Computing Research** *(ASCR: FY 2017 \$647M; FY 2018 \$810M; FY 2019 \$936M)*

- Advances applied mathematics, computer science, and computational research to discover, develop, and deploy computational and networking capabilities to analyze, model, simulate, and predict complex phenomena important to the U.S.
- Builds and operates some of the fastest computers in the world for open science. Leads the U.S. effort to develop the next generation of computing tools (exascale).

## **Basic Energy Sciences** *(BES: FY 2017 \$1,872M; FY 2018 \$2,090M; FY 2019 \$2,166M)*

- Advances fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels to provide foundations for new energy technologies. Supports a large portfolio of core research in chemical sciences, geosciences, biosciences, and materials sciences and engineering to advance DOE priorities.
- Constructs and supports scientific user facilities that enable atomic-level visualization and characterization of materials from many scientific fields, including chemistry, physics, geology, materials science, environmental science, and biology.

## **Biological and Environmental Research** *(BER: FY 2017 \$612M; FY 2018 \$673M; FY 2019 \$705M)*

- Advances fundamental research to achieve a predictive understanding of complex biological, earth and environmental systems for energy and infrastructure security, independence, and prosperity.
- Supports core research in genomic sciences of plants and microbes, research to understand atmospheric and earth system processes and to understand the dynamic physical, biogeochemical, microbial, and plant processes and interactions.



# SC Research Programs

FY 2017 Enacted, FY 2018 Enacted, FY 2019 Enacted

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## **Fusion Energy Sciences** *(FES: FY 2017 \$380M; FY 2018 \$532M; FY 2019 \$564M)*

- Advances the theoretical and experimental understanding of matter at high temperatures and density, including magnetic confinement science, fusion materials, and discovery plasma science.

## **High Energy Physics** *(HEP: FY 2017 \$825M; FY 2018 \$908M; FY 2019 \$980M)*

- Advances understanding of the basic constituents of matter, deeper symmetries in the laws of nature at high energies, and mysterious phenomena that are commonplace in the universe, such as dark energy and dark matter.

## **Nuclear Physics** *(NP: FY 2017 \$622M; FY 2018 \$684M; FY 2019 \$690M)*

- Advances experimental and theoretical research to discover, explore, and understand all forms of nuclear matter.
- Supports DOE's Isotopes Development and Production for Research and Applications subprogram for production of stable and radioactive research isotopes.

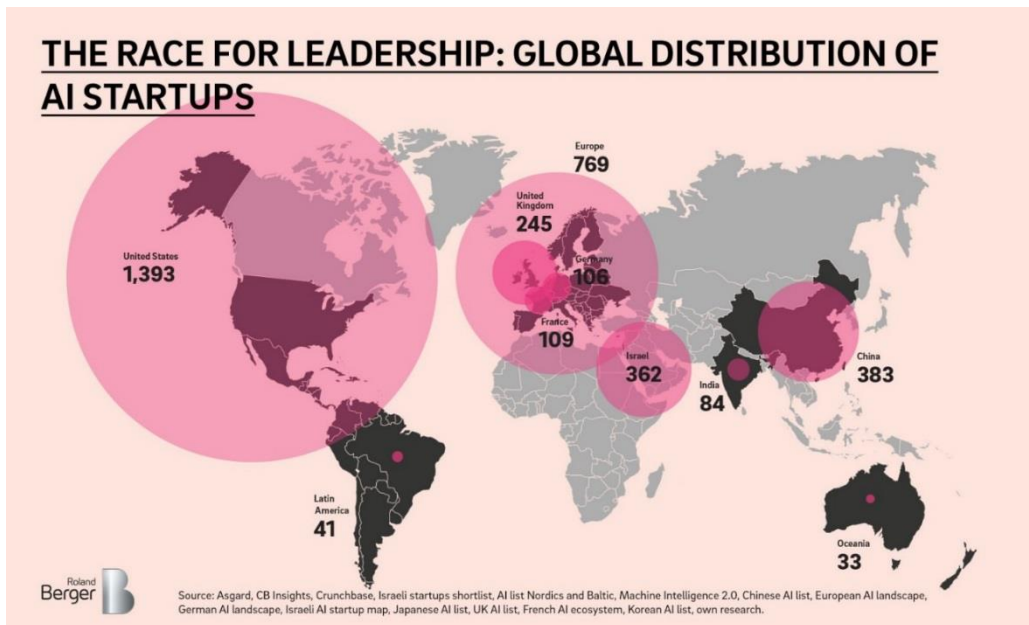
## **Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR)**

*(SBIR 3.20%; STTR 0.45%)*

- SC manages the competitive SBIR/STTR Programs for DOE (except ARPA-E), competing the 3.65% of DOE's appropriated R&D to small businesses, in collaboration with the DOE science and technology offices.



# Artificial Intelligence – Race for Global Leadership



**Foundational technology that is disrupting the current landscape and will lead to decades of innovation**



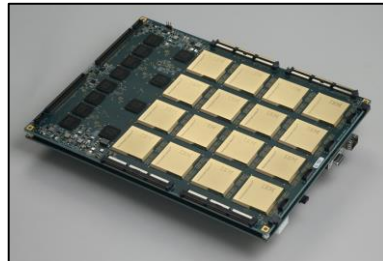


# Artificial Intelligence

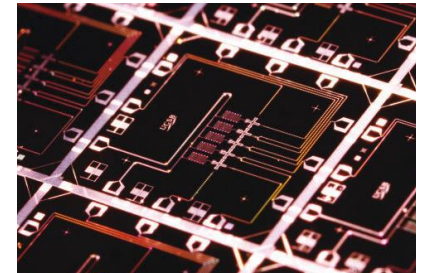
- Spans sensors, learning, deciding, autonomy and human interface, mission support
- Not High Performance Computing (HPC);
- AI platforms use less space and energy
- Lives in data
- Applied at source of data creation
- Transforming hardware landscape
- Surface questions and proposes models from data
- Beyond Von Neumann architectures and Moore's Law to the next-gen computing technologies



Novel Memory  
Architectures



Neuromorphic  
Systems



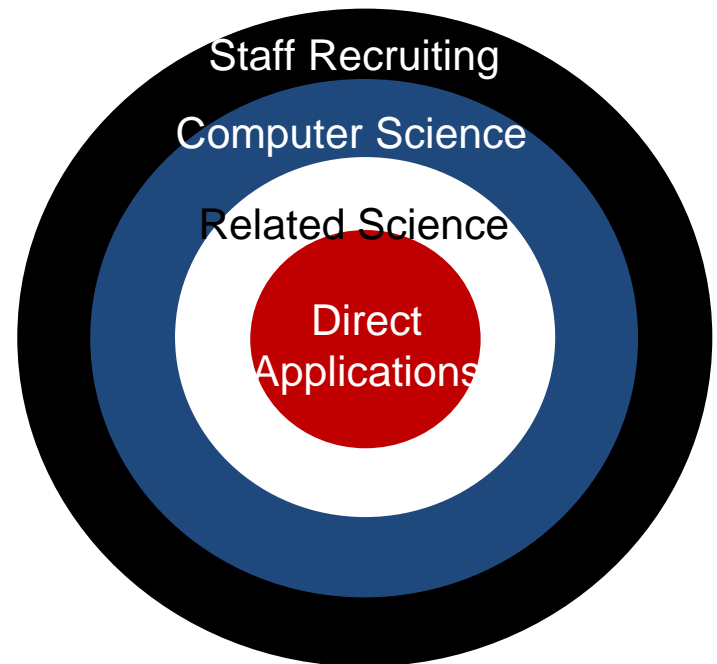
Quantum Information  
Systems

**Computing landscape will continue to evolve  
US must develop and capitalize on future technologies**



# Application of AI Research in DOE

- Artificial Intelligence concepts shift in scientific high-performance computing
- AI applicable to energy, science, national security realms
- AI concepts are an integral part of early Exascale systems
  - Direct applications
    - Data driven modeling
    - Multi-scale modeling
    - Rethinking algorithms
    - Concept space exploration
    - Mesh management
  - Science applications
    - Data analysis
    - Feature extraction
    - Uncertainty quantification
  - Computer science applications
    - Problem partitioning
    - Job scheduling
    - Adaptive refinement
  - Staff recruiting



# U.S. Artificial Intelligence (AI) Priorities

- **Using AI for government services:**
  - Executive departments and agencies are to apply AI to improve government services
- **Removing barriers to AI innovation:**
  - Facilitate creation of new American industries by removing regulatory barriers to deployment of AI-powered technologies
- **Achieving strategic military advantage:**
  - Administration's National Security Strategy recognizes need to lead in AI
- **Supporting Research & Development (R&D):**
  - Prioritized funding for fundamental AI research and computing infrastructure, machine learning, and autonomous systems



EXECUTIVE OFFICE OF THE PRESIDENT  
WASHINGTON, D.C.



July 31, 2018

M-18-22

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: MICK MULVANEY   
DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET

MICHAEL KRATSIOS   
DEPUTY ASSISTANT TO THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SUBJECT: FY 2020 Administration Research and Development Budget Priorities

The United States is a nation of thinkers, inventors, and entrepreneurs. Empowered by free-market capitalism and driven by bold ideas, Americans created an ecosystem of innovation that is the envy of the world, advancing science and technology and making the Nation prosperous and strong. America brought the miracle of electric light to people's homes, placed millennia of knowledge in people's pockets, and put men on the Moon and brought them safely back to Earth.

## American Leadership in Artificial Intelligence, Quantum Information Sciences, and Strategic Computing

Continued leadership in AI, quantum information science (QIS), and strategic computing is critically important to our national security and economic competitiveness. Advances in these areas promise opportunities for major scientific breakthroughs and are quickly transforming American life and industry. Agencies should invest in fundamental and applied AI research, including machine learning, autonomous systems, and applications at the human-technology frontier. Agencies should prioritize QIS R&D, which will build the technical and scientific base necessary to explore the next generation of QIS theory, devices, and applications. Agencies should prioritize investment in research and infrastructure to maintain U.S. leadership in strategic computing, from edge devices to high-performance computing, that accelerates delivery of low-power, high performance devices; supports a national high-performance computing ecosystem; and explores novel pathways to advance computing in a post-Moore's Law era.



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# In Conclusion ...

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- **In the immediate future:**
  - Keep producing great science!
  - Continue the traditions of excellence in SC-supported research and operations of our scientific facilities
  
- **In the coming weeks and months:**
  - The FY 2019 budget was enacted and in place on October 1
  - We are executing the FY 2019 budget



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# Questions?



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# Backup Slides





# Priorities for FY 2019

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- **Focus on cutting edge, early stage research and development; achieve 40% funding for research**
  - SC is the largest Federal supporter of basic research in the physical sciences in the United States. SC supports research at the frontiers of science—discovering nature’s mysteries, from the study of subatomic particles, atoms, and molecules that are the building blocks of the materials of our everyday world, to the DNA, proteins, and cells that are the building blocks of entire biological systems.
  - SC also supports science for energy and the environment—mitigating the environmental impacts of energy use through fundamental research on energy production, conversion, storage, transmission, and use, and through advancing our understanding of the earth and its environment.
- **Maintain investment in Exascale Computing to achieve exascale-capable computer in 2021**
- **Continue operations of the national laboratories**
  - SC oversees the operation of 10 DOE national laboratories. SC conducts a formal laboratory strategic planning process annually with its labs to understand future directions, immediate and long-range challenges, and resource needs.
  - SC also conducts an annual evaluation of the scientific, technological, managerial, and operational performance of the M&O contractors of its laboratories.
  - In addition, SC funds mission-ready infrastructure and investments that foster safe and environmentally responsible operations at the labs.
- **Maintain all on-going projects and start new construction projects**
  - New Construction Projects: Advanced Light Source Upgrade (ALS-U) at Lawrence Berkeley National Laboratory and Linac Coherent Light Source-II High Energy (LCLS-II-HE) project at SLAC National Accelerator Laboratory in Basic Energy Sciences and Energy Sciences Capability at Pacific Northwest National Laboratory in Science Laboratories Infrastructure.

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# FY 2019 Program Summaries



# DOE's Office of Science: World Leading Science

To Meet the Nation's Challenges Today and into the 21<sup>st</sup> Century

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## ▪ Advancing the frontiers of science

- Providing over 45% of Federal support in the physical sciences
- Supporting over 22,000 Ph.D.s, graduate students, undergraduates, engineers, and support staff at more than 300 universities and at all 17 DOE laboratories

## ▪ Advancing DOE missions

- Supporting specialized centers for energy and environmental research including 36 Energy Frontier Research Centers and 4 Bioenergy Research Centers for the study of cellulosic biofuels

## ▪ Serving the Nation's scientists

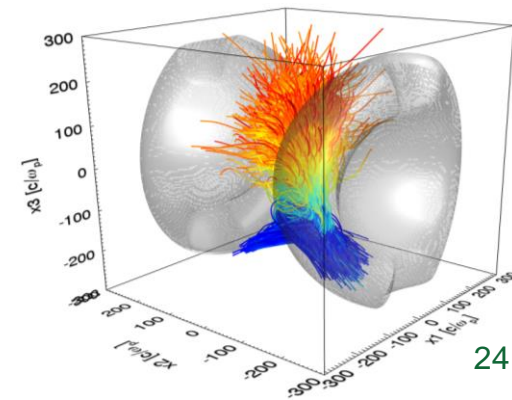
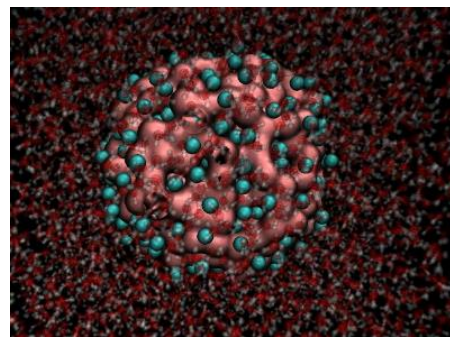
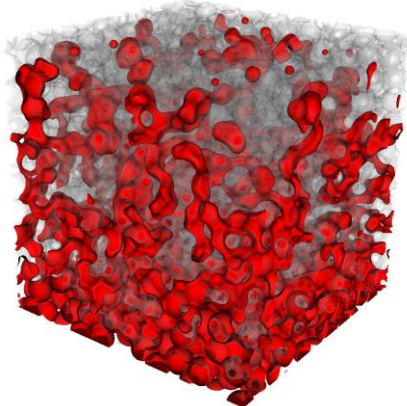
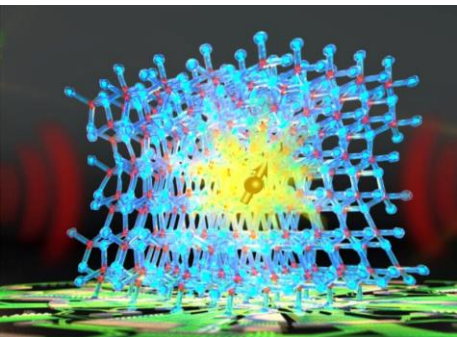
- Providing world-leading scientific user facilities to nearly 32,000 users per year



# Advanced Scientific Computing Research

Computational and networking capabilities to extend the frontiers of science and technology

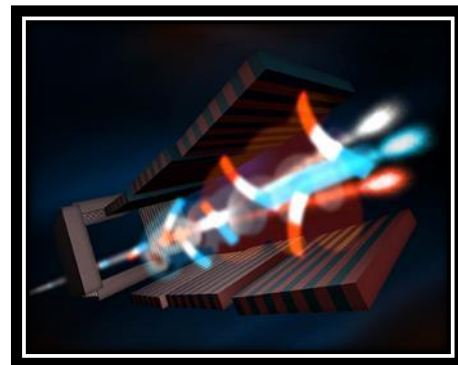
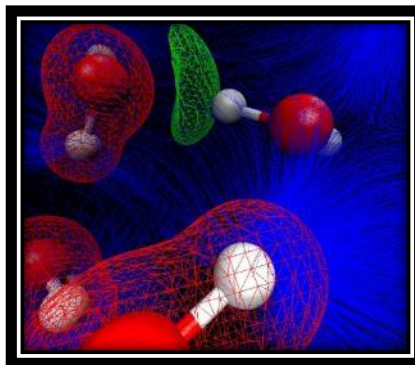
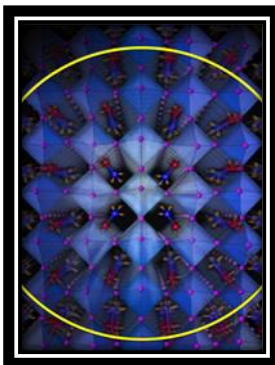
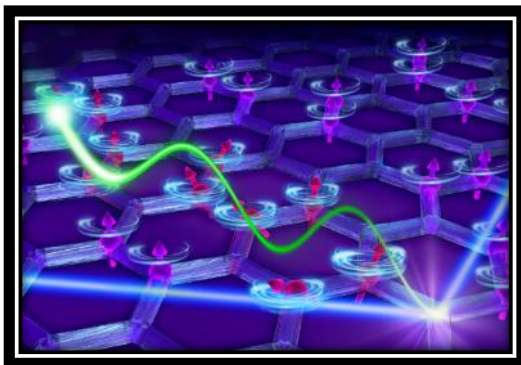
- **Exascale Computing Initiative (ECI) and Exascale Computing Project (ECP).** The ECI activity is a joint ASCR/NNSA partnership to undertake, through ECP, the application, software and hardware R&D necessary to develop an exascale ecosystem and through the facilities, deploy at least one exascale-capable computer ( $10^{18}$  operations per second) in 2021.
- **Facilities** operate optimally and with >90% availability; deployment of 200 petaflop upgrade at OLCF, continue operations and maintenance while supporting upgrades at NERSC and Esnet, and through ECI, continue site preparations and non recurring engineering investments at ALCF and OLCF for deployment of a second exascale system in the 2021-2022 timeframe.
- **SciDAC partnerships and institutes**, selected in FY 2017, continue activities that span basic science priorities.
- **Applied Mathematics research** addresses challenges of increasing complexity and improving the rigor and reliability of machine learning techniques; **Computer Science research** and **Research and Evaluation Partnerships** explore future computing technologies, including quantum testbeds and networks.
- Maintain support for the **Computational Sciences Graduate Fellowship**.



# Basic Energy Sciences

Understanding, predicting, and controlling matter and energy at the electronic, atomic, and molecular levels

- The BES FY 2019 Request of **\$1,850M** focuses resources toward the highest priorities in fundamental research, in operation and maintenance of scientific user facilities, and in facility upgrades.
- The highest priorities in core research are quantum information science (QIS), ultrafast science, and computational materials and chemical sciences as part of the Exascale Computing Initiative (ECI), as well as materials and chemistry for future nuclear energy. Other research priorities include catalysis science, synthesis, instrumentation science, materials and chemical research related to interdependent energy-water issues, and next-generation electrical energy storage.
- Funding is requested for continued support of the **Energy Frontier Research Centers**, two BES-supported **Energy Innovation Hubs** (Batteries and Energy Storage and Fuels from Sunlight), and the DOE **Established Program to Stimulate Competitive Research**.
- The **BES user facilities** continue operations at 95% of optimum: five x-ray light sources, two neutron scattering sources, and five research centers for nanoscale science.
- No funding is requested for **Long Term Surveillance and Maintenance** or for the disposition of unused equipment for the **Lujan Neutron Scattering Center**.
- To maintain international competitiveness of our facilities, the **Linac Coherent Light Source-II (LCLS-II)** project is fully funded for its last year and the **Advanced Photon Source Upgrade (APS-U)** project continues. The Request also includes funds to initiate the **Advanced Light Source Upgrade (ALS-U)** project at Lawrence Berkeley National Laboratory and the **Linac Coherent Light Source-II High Energy (LCLS-II-HE)** project at SLAC National Accelerator Laboratory.

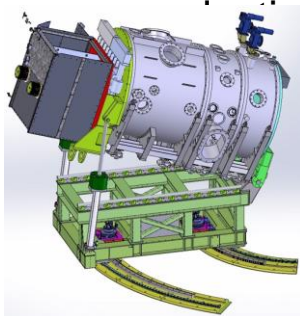




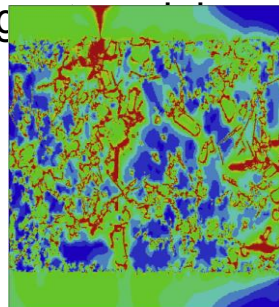
# Fusion Energy Sciences

Matter at very high temperatures and densities and the scientific foundations for fusion

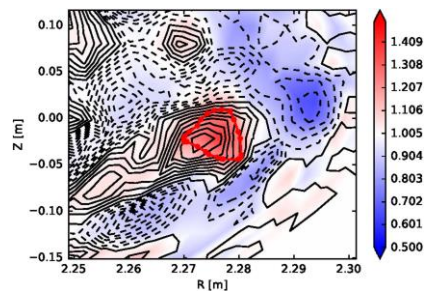
- DIII-D emphasizes completion of facility improvements begun in FY 2018, followed by 12 weeks of research operation on high-priority topics identified by community research needs workshops.
- NSTX-U focuses on high-priority activities to implement repairs and corrective actions required to obtain robust, reliable research operations.
- Scientific Discovery through Advanced Computing research continues to emphasize whole-device modeling.
- Support maintained for U.S. research involvement on international facilities with unique capabilities, such as EAST (China), KSTAR (Korea), W7-X (Germany), and JET (U.K.).
- Materials and Fusion Nuclear Science research focuses on high-priority research, including the Materials Plasma Exposure eXperiment (MPEX) MIE project.
- HEDLP research is focused on the MEC instrument at LCLS.
- General Plasma Science activities focus on the intermediate-scale plasma science collaborative user facilities, including the partnership with NSF.
- The U.S. Contribution to the ITER project focuses on the highest-priority First Plasma hardware components, including the continued fabrication of the central solenoid



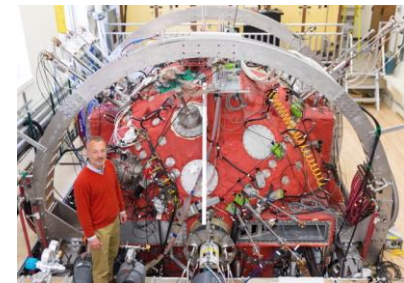
Modified bi-directional off-axis neutral beam for heating and current drive in DIII-D



Predicted material damage and fracture development in dual-phase Ti<sub>3</sub>SiC<sub>2</sub>/SiC joints



Simulation of density and potential fluctuation "bubbles" at the edge of magnetically confined plasmas



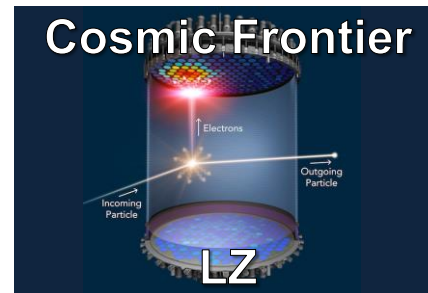
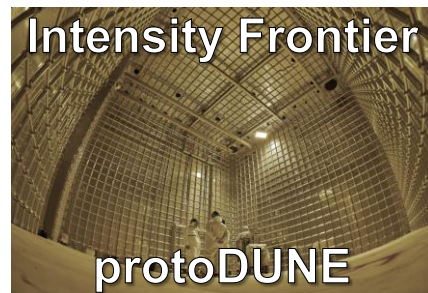
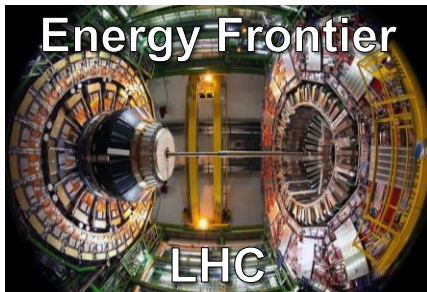
New WiPL intermediate-scale experimental facility for general plasma science



# High Energy Physics

## Understanding how the universe works at its most fundamental level

- FY 2019 Request is guided by priorities of Administration, SC, and P5 report
  - “Building for Discovery” by supporting the highest priority P5 projects to enable the future program
  - Research support advances P5 science drivers and world-leading, long-term R&D in Advanced Technology, Accelerator Stewardship, and Quantum Information Science
  - Operations support enables world-class research at HEP User Facilities
- Energy Frontier: Actively engage in successful LHC program and HL-LHC upgrades
  - The High-Luminosity Large Hadron Collider (HL-LHC) ATLAS & CMS detector upgrades (new MIE starts) and the HL-LHC Accelerator Upgrade Project are together considered one of P5’s highest priority large projects
  - The U.S. will continue to play a leadership role in LHC discoveries by remaining actively engaged in analysis of world’s highest energy particle collider data
- Intensity Frontier: Support establishing a U.S.-hosted world-leading neutrino program
  - LBNF/DUNE is P5’s highest priority U.S.-hosted large project and FY 2019 investments in far-site civil construction are crucial to enable scheduled delivery of contributions from international partners
  - Support Short-Baseline Neutrino (SBN) program at Fermilab, DUNE prototype R&D efforts at CERN, and continued funding for PIP-II project to upgrade the Fermilab Accelerator Complex
- Cosmic Frontier: Advance our understanding of dark matter and dark energy
  - P5 recommended complementary suite of projects to search for dark matter candidates and study dark energy; request supports full planned profile for LZ, SuperCDMS-SNOLAB, and DESI

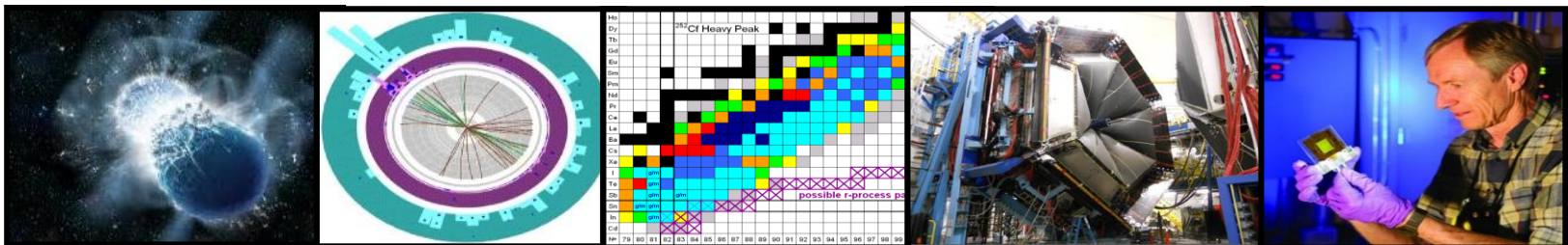


	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

# Nuclear Physics

## Discovering, exploring, and understanding all forms of nuclear matter

- Funding for research focuses resources on the highest priority nuclear science research in relativistic nuclear collisions, hadron physics, nuclear structure and nuclear astrophysics, and fundamental symmetries.
- Operations at RHIC are supported for 19 weeks in FY 2019 to search for a critical point in the phase diagram of nuclear matter. The sPHENIX MIE is initiated within current RHIC funding levels for precision, high rate particle jets studies.
- The 12 GeV CEBAF Upgrade, completed in FY 2017, continues its scientific program with a 19 week run in FY 2019 promising new discoveries and an improved understanding of quark confinement.
- Funding for ATLAS supports 34 weeks of operations, to provide high-quality beams of all the stable elements up to uranium, as well as selected beams of short-lived nuclei for nuclear structure and astrophysics experiments.
- Construction continues on the Facility for Rare Isotope Beams. The Gamma-Ray Energy Tracking Array (GRETA) MIE is continued to exploit the scientific potential of FRIB.
- A Nuclear Physics Quantum Information Science (QIS) effort is initiated to support NP experiments and modeling, as well as the production of critical isotopes for quantum computing.
- Increased funding for the Isotope Program supports the Stable Isotope Production Facility (SIPF) MIE to produce kilogram quantities of enriched stable isotopes, mission readiness of radioisotope production facilities, and the initiation of a university production network for short-lived isotopes and QIS.





# FY 2019 President's Request User Facilities

Number of  
User Facilities  
**26**



SNS



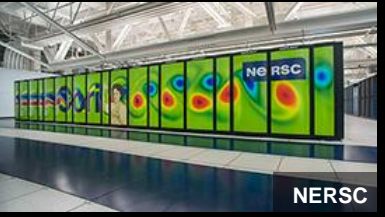
HFIR



OLCF



ALCF



NERSC



ESnet



ALS



APS



LCLS



NSLS-II



SSRL



CFN



CINT



CNM



CNMS



TMF



EMSL



ARM



JGI



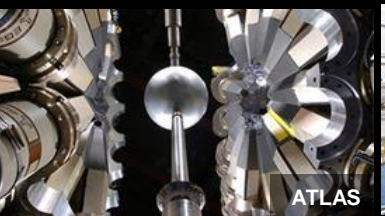
DI-II-D



NSTX-U



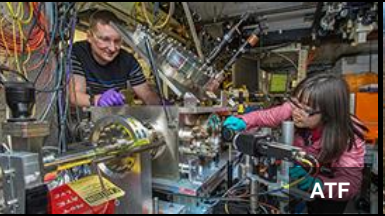
RHIC



ATLAS



CEBAF



ATF



Fermilab AC