U.S. DEPARTMENT OF ENERGY | Office of Science

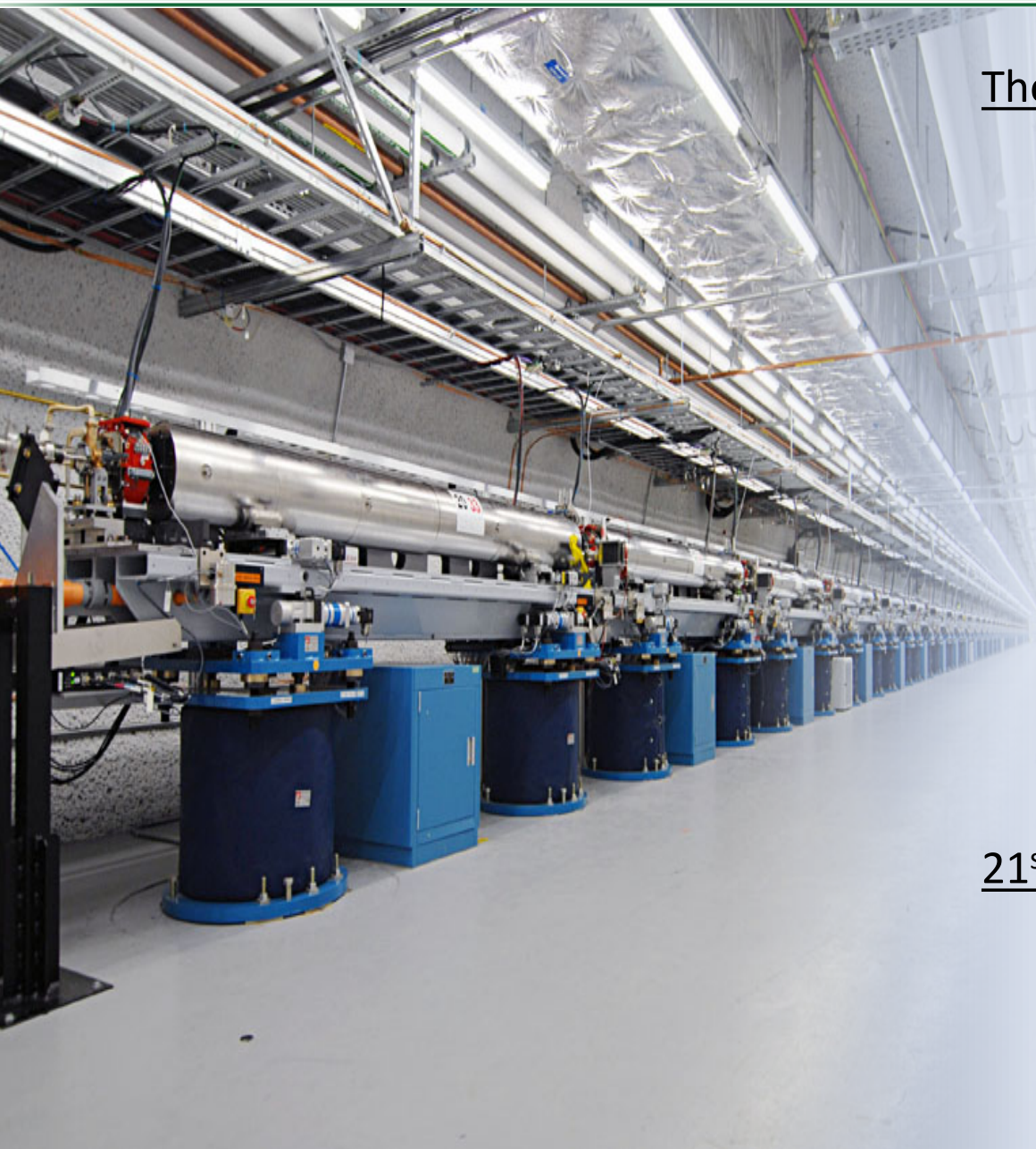
FY 2014 Budget Request to Congress for DOE's Office of Science

April 10, 2013

Dr. W. F. Brinkman
Director, Office of Science
www.science.energy.gov

Office of Science

Science to Meet the Nation's Challenges Today and into the 21st Century



The Frontiers of Science

- Supporting research that led to over 100 Nobel Prizes during the past 6 decades—more than 20 in the past 10 years
- Supporting 25,000 Ph.D. scientists, graduate students, undergraduates, engineers, and support staff at more than 300 institutions
- Providing 45% of Federal support of basic research in the physical and energy related sciences and key components of the Nation's basic research in biology and computing

21st Century Tools of Science

- Providing the world's largest collection of scientific user facilities to over 29,000 users each year

Science Underpins Our Energy Future

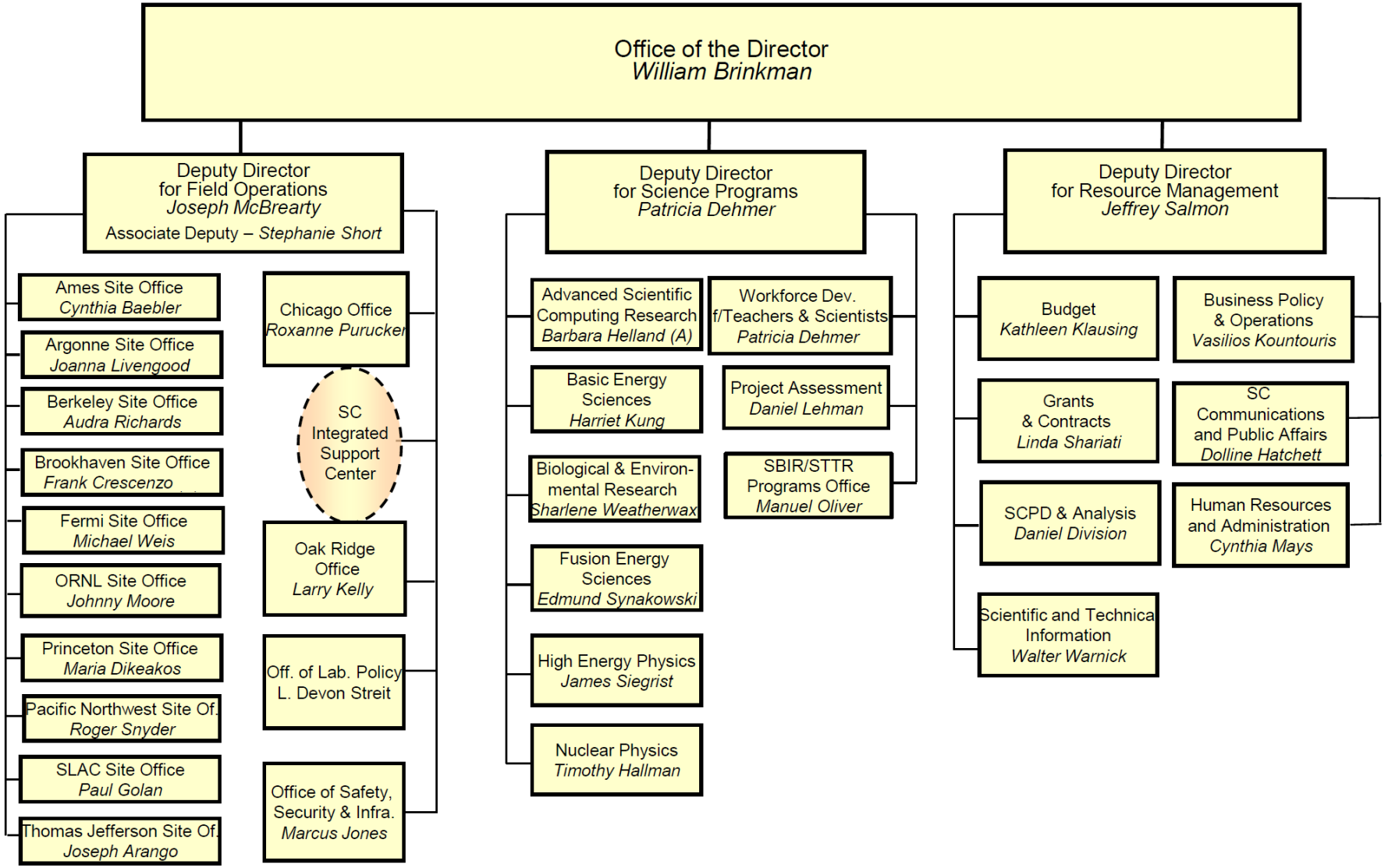
“We don’t stand still, we look forward. We invent. We build. We turn new ideas into new industries. We change the way we can live our lives here at home and around the world.”

Speaking at the Advanced Photon Source at Argonne National Laboratory on March 15th, President Obama reiterated the importance of basic and applied science as he discussed new research and technology to reduce petroleum consumption by our cars and trucks.

Office of Science FY 2014 Budget Request to Congress

(B/A in thousands)

	FY 2012		FY 2013	FY 2014		
	Enacted Approp.	Current Approp.	Annualized CR (per budget)	FY 2014 President's Request	FY14 President's Request vs. FY12 Enacted Approp.	
Science						
Advanced Scientific Computing Research	440,868	428,304	443,566	465,593	+24,725	+5.6%
Basic Energy Sciences	1,688,093	1,644,767	1,698,424	1,862,411	+174,318	+10.3%
Biological and Environmental Research	609,557	592,433	613,287	625,347	+15,790	+2.6%
Fusion Energy Sciences	400,996	392,957	403,450	458,324	+57,328	+14.3%
High Energy Physics	790,860	770,533	795,701	776,521	-14,339	-1.8%
Nuclear Physics	547,387	534,642	550,737	569,938	+22,551	+4.1%
Workforce Development for Teachers and Scientists	18,500	18,500	18,613	16,500	-2,000	-10.8%
Science Laboratories Infrastructure	111,800	111,800	112,485	97,818	-13,982	-12.5%
Safeguards and Security	80,573	80,573	81,066	87,000	+6,427	+8.0%
Program Direction	185,000	185,000	186,132	193,300	+8,300	+4.5%
Small Business Innovation Research/Technology Transfer (SC)	———	114,125	———	———	———	———
Subtotal, Science	4,873,634	4,873,634	4,903,461	5,152,752	+279,118	+5.7%
Small Business Innovation Research/Technology Transfer (DOE)	———	61,346	———	———	———	———
Total, Science Appropriation	4,873,634	4,934,980	4,903,461	5,152,752	+279,118	+5.7%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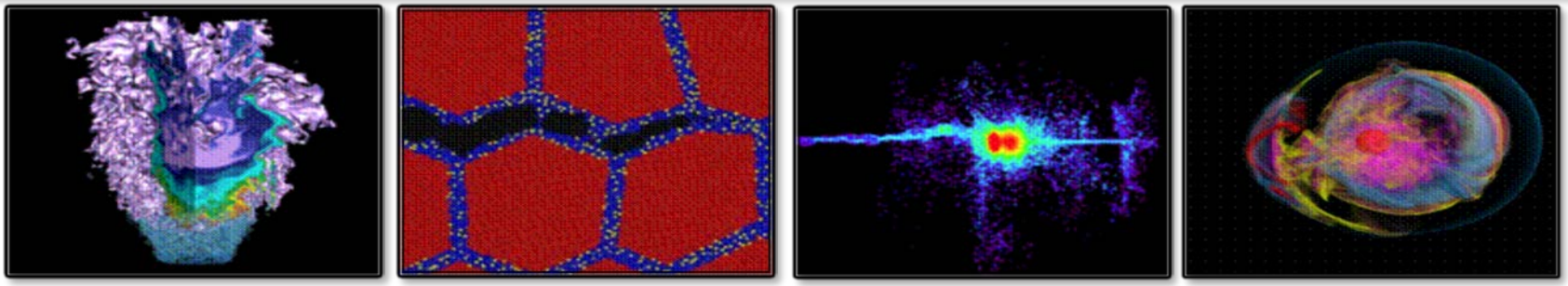
Advanced Scientific Computing Research

Delivering world leading computational and networking capabilities to extend the frontiers of science and technology

FY 2014 Budget Highlights:

- Research to address
  - Massive parallelism, power efficiency, and fault tolerance—the key challenges of exascale
  - Massive data (and its analyses) from modeling and from the scientific user facilities
- Co-design centers, which use scientific requirements to guide new computer architectures and system software and use technology capabilities to design algorithms and software
- Partnerships
  - Office of Science and DOE applied programs to accelerate implementation of high-performance computing tools
  - Research community and U.S. industries to increase adoption of high-performance computing to accelerate innovation
  - Research community, including U.S. computer vendors, to address critical challenges of power efficiency and resiliency on the path to exascale
- Facilities operation
  - Titan – the 27 petaflop computer at ORNL (#1 in Nov 2012 Top500 ranking)
  - MIRA – the 10 petaflop machine at ANL (#4 in Top500 ranking)
  - NERSC-7 at LBNL, doubling the capacity of production computing for DOE research community (install & operate)
  - ESnet – the100 gigabit/second network, interconnecting DOE laboratories and research sites

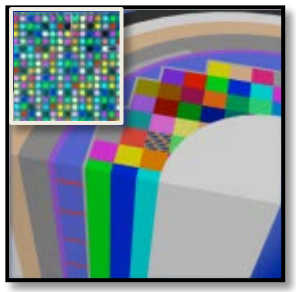


Leadership Computing Facilities

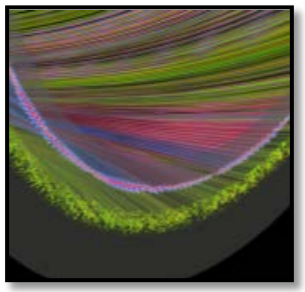
Oak Ridge Leadership Computing Facility

Argonne Leadership Computing Facility

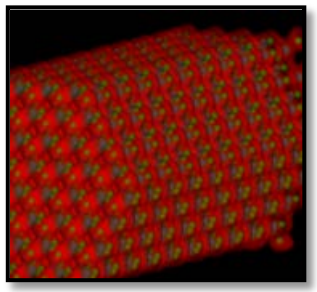
- The “Titan" at ORNL and the “Mira“ at ANL will provide ~5 billion processor hours in 2014.
- Demand for these machines has grown each year; acceptance rates are 33% of nonrenewal submittals and 100% of renewals.



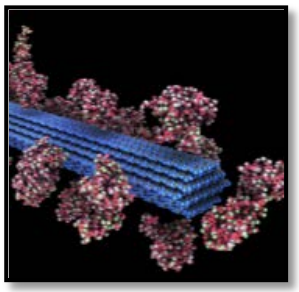
Nuclear Reactor Simulation



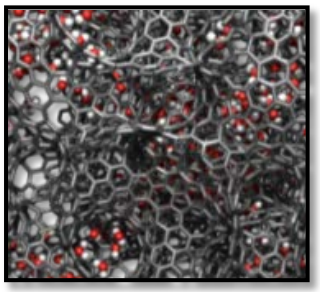
Fusion Plasmas



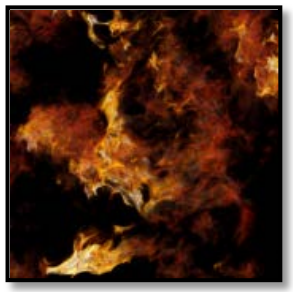
Nanoscale Science



Biofuels

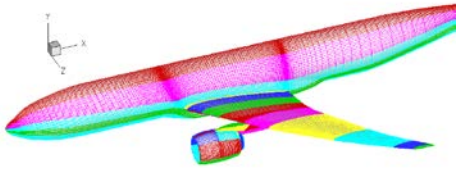


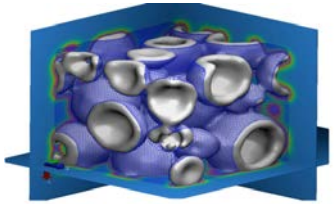
Energy Storage Materials



Turbulence

INCITE – Innovative and Novel Computational Impact on Theory and Experiment





An industry user determined the effects of unsteady flow interactions between blade rows on the efficiency of turbines.

- Provided engineers with the analytical tools to extract greater design efficiency and fuel savings.
- Results provided substantial ROI justification for user to purchase its own supercomputer

One company used computational fluid dynamics with shock compression to expedite design-cycle analysis.

- Accelerated the development of CO_2 compressor allowing transition from computer design to cutting a Titanium prototype in 2 months.

An airplane manufacturer demonstrated the effectiveness and accuracy of computational fluid dynamics simulation tools and used them in designing their next generation of aircraft.

- Significantly reduced need for prototyping and wind tunnel testing.

An automotive company accelerated materials research by at least a year to help meet fuel economy and emissions standards.

- A prototype thermoelectric generator in a SUV generated up to 5% improvement in fuel economy.

A consumer goods company was able to study the complex interactions of billions of atoms and create simulations to determine how tiny submicroscopic structures impact the characteristics of the ingredients in soaps, detergents, lotions and shampoos.

- Understanding these processes accelerates the development of many consumer goods, foods, and fire control materials.

A company designing after-market kits to improve the fuel efficiency for trucks went from concept to design to manufacturer in 18 months instead of 3 years.

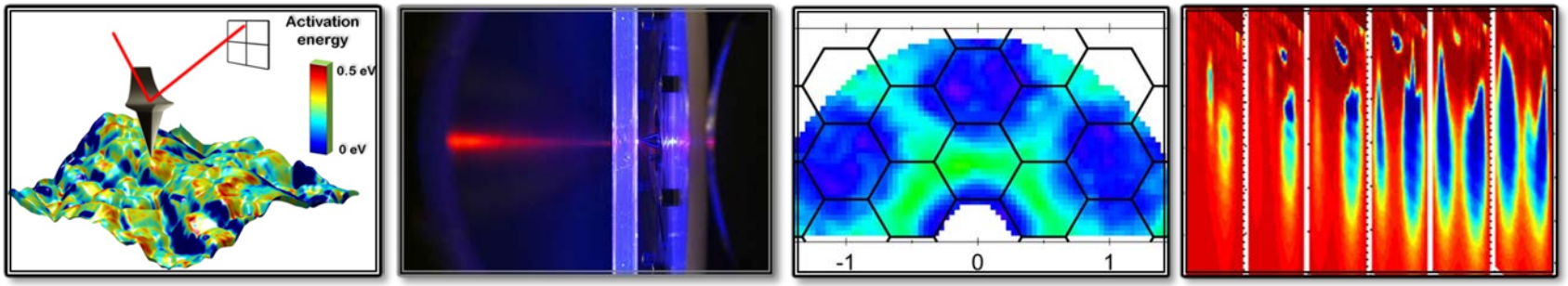
- Demonstrated fuel mileage improvements of 7% to 12% available 2011. Exceeds California CARB requirements.

Basic Energy Sciences

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

FY 2014 Budget Highlights:

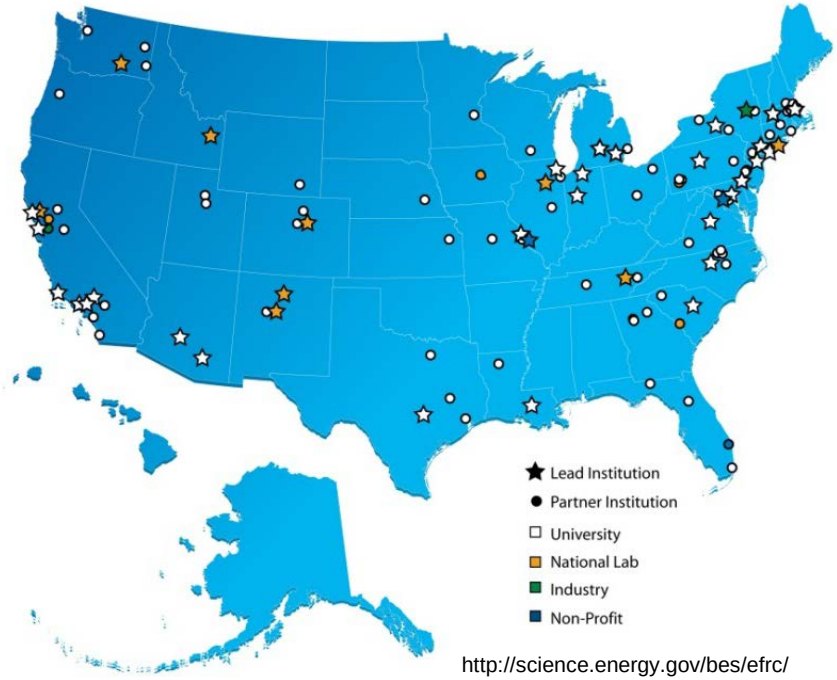
- Energy Frontier Research Centers (EFRCs) are recompeted (both existing and new awards)
- Energy Innovation Hubs
  - Fuels from Sunlight Hub: Joint Center for Artificial Photosynthesis (JCAP) will be in its fourth project year.
  - Batteries and Energy Storage: Joint Center for Energy Storage Research (JCESR) will be in its second year.
- Core research
  - Research, approximately flat at the FY 2012 level, increases work at the mesocale (2012 BESAC report *From Quanta to the Continuum: Opportunities for Mesoscale Science)*.
- Scientific user facilities are funded at optimum operations
- Construction projects
  - National Synchrotron Light Source-II
  - Linac Coherent Light Source-II
- Major Items of Equipment
  - Advanced Photon Source Upgrade
  - NSLS-II Experimental Tools



Energy Frontier Research Centers

Participants:

- **46** EFRCs in **35** States + Washington D.C.
- ~**850** senior investigators and ~**2,000** students, postdoctoral fellows, and technical staff at ~**115** institutions
- >**250** scientific advisory board members from **13** countries and >**40** companies



http://science.energy.gov/bes/efrc/

Progress to date (~3.5 years funding):

- >**3,400** peer-reviewed papers including >**110** publications in *Science* and *Nature*
- **18** PECASE and **11** DOE Early Career Awards
- >**200** patent/patent applications, plus an additional >**60** invention disclosures and at least **30** licenses
- At least **60** companies have benefited from EFRC research
- EFRC students and staff now work in: >**195** university faculty and staff positions; >**290** industrial positions; >**115** national labs, government, and non-profit positions

FY 2014 recompetition:

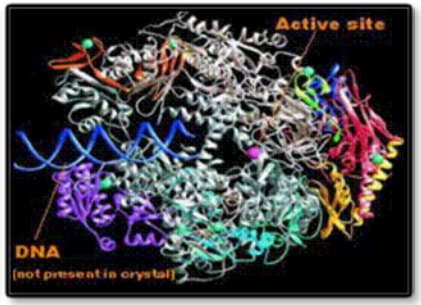
- Open competition for new and renewal EFRCs
- Annual funding continues at $100M/year; in addition, there is one-time funding of $68.7M to fully forward fund a number of EFRCs
- Selection based on peer review; for renewal proposals, review will consider of progress during the first 5 years

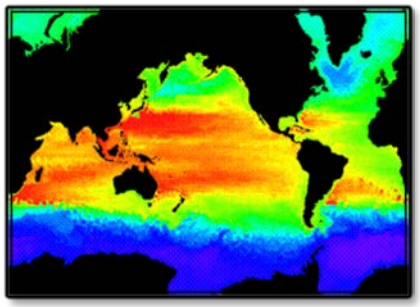
Biological and Environmental Research

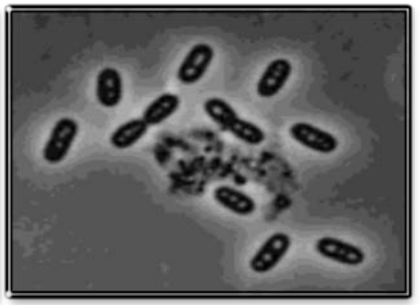
Understanding complex biological, climatic, and environmental systems across vast spatial and temporal scales

FY 2014 Budget Highlights:

- The 3 DOE Bioenergy Research Centers are fully funded.
- Core research in Biological Systems Science supports new opportunities:
  - Development of biosystem design tools for plant and microbial systems
  - Mesoscale to Molecules—the scaling of processes from the molecular to subcellular levels
- Radiological Sciences decreases—targeted investments are made to develop radiotracer imaging techniques for bioenergy-relevant and environmental processes; some projects are completed
- Atmospheric and Terrestrial Ecosystem Research focus on the Arctic and the Tropics
  - ARM mobile facilities and NGEE projects couple field experiments, observations, and modeling
- Climate Modeling advances science for high-resolution predictability, uncertainty characterization, and adaptive software to support new physics and compatibility with next-generation HPCs.
- Scientific user facilities are funded at optimal operations.







The DOE Bioenergy Research Centers

Fundamental science underpinning new biofuel technologies

Multidisciplinary fundamental science guided by milestones & deliverables, targeted to key areas needed to improve production of biofuels from renewable biomass.

- BioEnergy Science Center (Oak Ridge National Lab)
- Great Lakes Bioenergy Research Center (U. Wisc., Mich. State U.)
- Joint BioEnergy Institute (Lawrence Berkeley National Lab)

In 5 years of operations:

- 1,110 peer-reviewed publications
- Over 400 invention disclosures and/or patent applications

In FY 2014, the BRCs will target:

- Detailed characterization of selected candidate biofuel crops (switchgrass and poplar lines) with reduced recalcitrance properties.
- Improved lignin removal techniques producing a new product stream from pretreated biomass during biofuel production.
- Increased tolerance of biofuel-producing microorganisms to pretreatment processes.
- Optimized biosynthetic pathways in microbial hosts for conversion of cellulosic sugars to a variety of drop-in hydrocarbon fuel components.
- Incorporation of microbe-plant interactions and biogeochemical relationships into analyses of bioenergy crop sustainability on marginal lands.

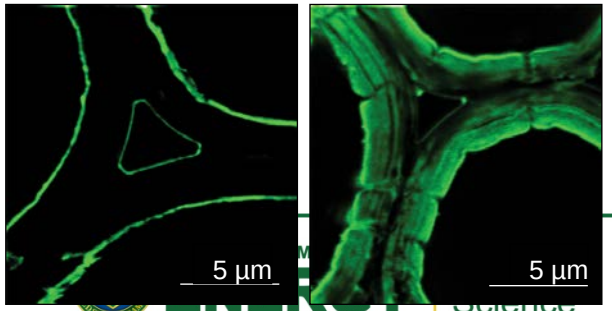
Development of Next-Generation Biofuels

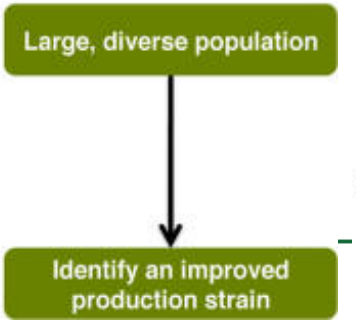
BESC BioEnergy Science Center

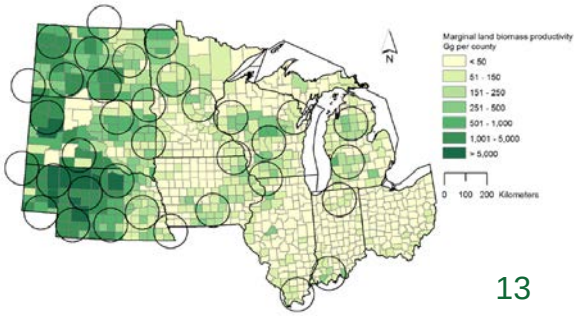
jbei Joint BioEnergy Institute

GREAT LAKES BIOENERGY RESEARCH CENTER

- Discovered a new type of lignin in plants extending the understanding of lignin biosynthesis and identifying new targets to alter lignin biosynthetic pathways for improved biomass digestibility.
- Developed new techniques to track, image and analyze the molecular-scale sites of cellulase attack on cellulose polymers in corn stover and other natural biomass samples.
- Developed new methods to track gene expression in biofuel-producing microbes on exposure to pretreatment chemicals and identify genetic targets to increase chemical tolerance in these organisms.
- New biosensor techniques to identify modified microorganisms capable of producing biofuel components at high concentrations.
- New NMR technique to analyze the lignin content in biomass samples as an important tool for bioenergy crop development
- Analyzed 20 years of data from 10 Midwest states to conclude that properly managed marginal lands could provide sufficient biomass to support a viable yet environmentally beneficial cellulosic biofuel production industry.





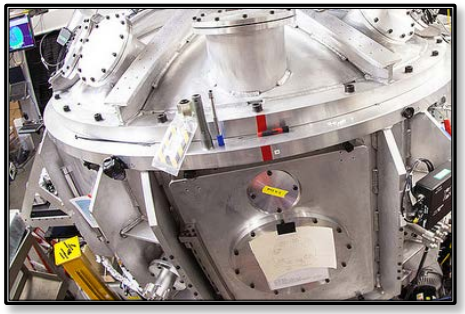
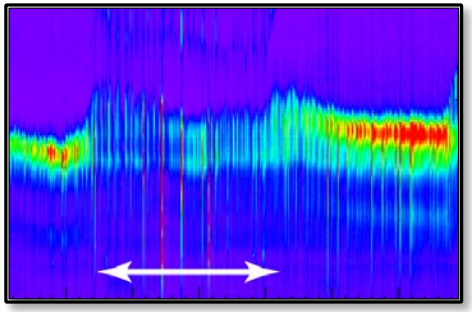
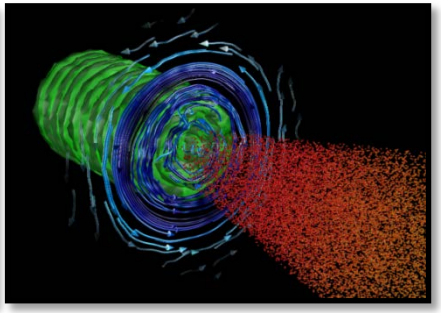
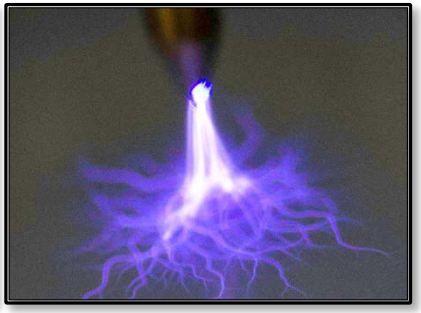


Fusion Energy Sciences

Understanding matter at very high temperatures and densities and building the scientific foundations for a fusion energy source

FY 2014 Budget Highlights:

- U.S. ITER Project funding is increased to $225M for long-lead procurements and fabrication as the ITER Project enters full construction phase.
- DIII-D run time is increased to 16 weeks.
- The NSTX Upgrade project at PPPL is fully funded.
- Core research continues to steward general plasma science in areas of low-temperature plasmas; international activities; and materials sciences.
- HEDLP activities focus on science at the new Matter in Extreme Conditions at the Linac Coherent Light Source at SLAC. Other programs are reduced; the joint program with NNSA is discontinued.
- The Massachusetts Institute of Technology Alcator C-Mod tokamak is terminated. Research and facility operations funding provided in FY 2013 will complete the safe shutdown of the facility.

ITER Construction Site Shows Significant Advances

U.S. Provides Hardware for the Tokamak Core

ORNL
100% Central Solenoid Windings

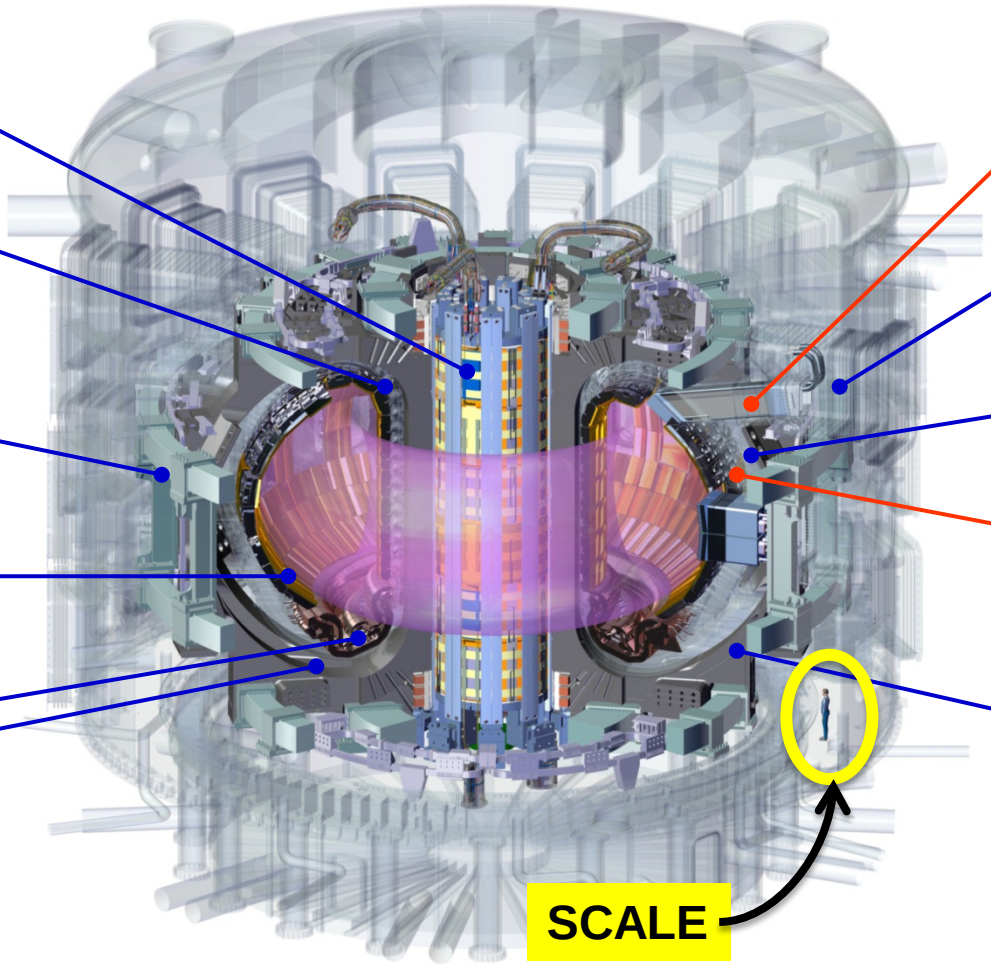
ORNL
8% of Toroidal Field Conductor

ORNL
100% Pellet Injector
100% Disruption Mitigation

ORNL
Blanket/Shield
(design only)

ORNL
100% Tokamak Cooling Water System

PPPL
75% Steady State Electrical Network



PPPL
14% of Port-based Diagnostics

ORNL
88% Ion Cyclotron Transmission Lines

ORNL
88% Electron Cyclotron Transmission Lines

PPPL
In-Vessel Coils
(prelim. design only)

ORNL
100% Roughing Pumps, Vacuum Standard Components

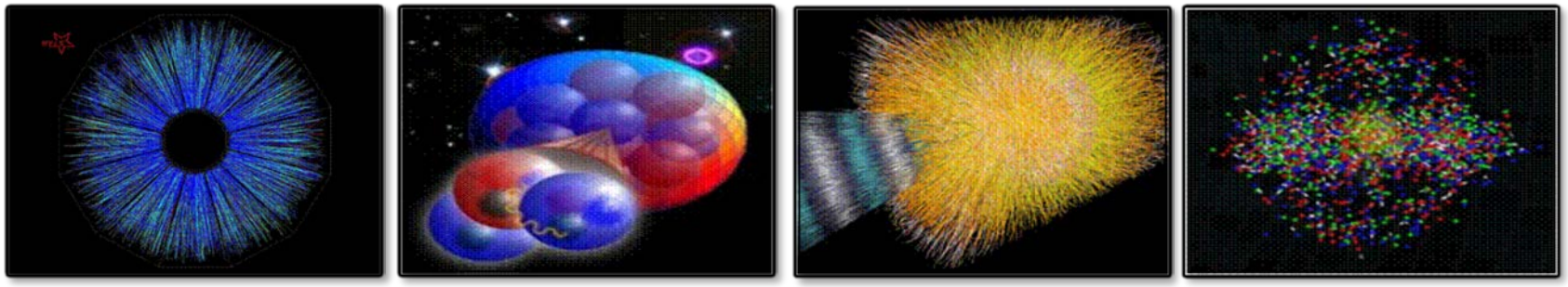
SRNL
100% Tokamak Exhaust Processing System

Nuclear Physics

Discovering, exploring, and understanding all forms of nuclear matter

FY 2014 Budget Highlights:

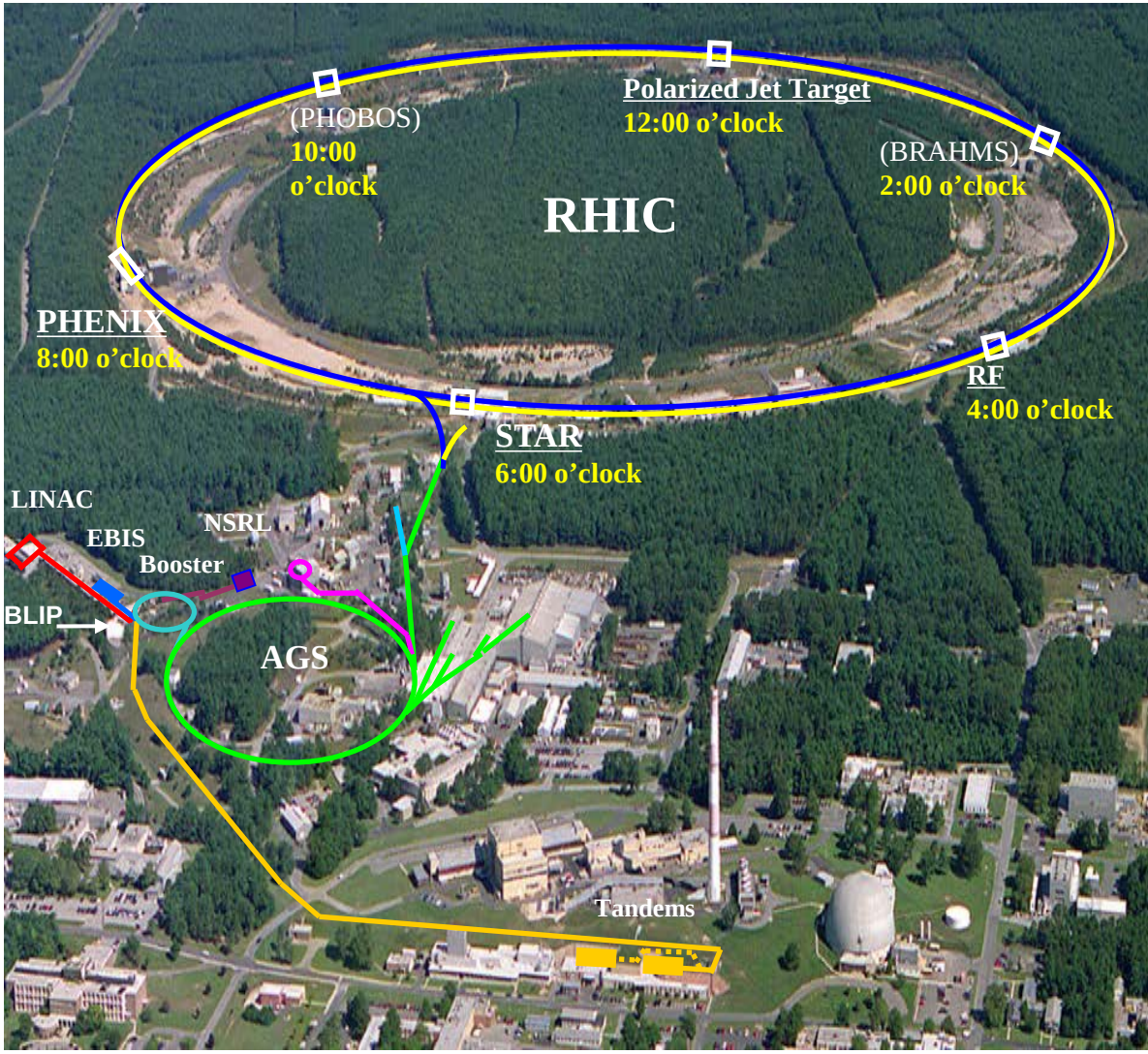
- Research at RHIC capitalizes on the10-fold enhancement in luminosity to investigate the properties of a new perfect Quark-Gluon liquid.
- Construction continues on the 12 GeV CEBAF Upgrade to study the quark structure of nucleons and nuclei.
- Construction is supported for the Facility for Rare Isotope Beams to study nuclear structure and nuclear astrophysics.
- ATLAS beams using the new Californium Rare Isotope Breeder (CARIBU) upgrade enable the study of nuclear structure and the origin of the elements in the cosmos.
- Research, development, and production of stable and radioactive isotopes is provided for science, medicine, industry, and national security.
- Research funding continues at the FY 2012 level.



Research at the Relativistic Heavy Ion Collider

RHIC discovered a new state of matter—a perfect quark-gluon liquid. The RHIC science campaigns planned in the next 3-5 years will:

- determine, with precision, the properties of this perfect liquid;
- search for new discoveries such as the postulated Critical Point in the phase diagram of QCD;
- explore the gluon and sea quark contributions to the spin of the proton using RHIC, the only collider with polarized beams; and
- explore and develop intellectual connections and broader impacts to other subfields.

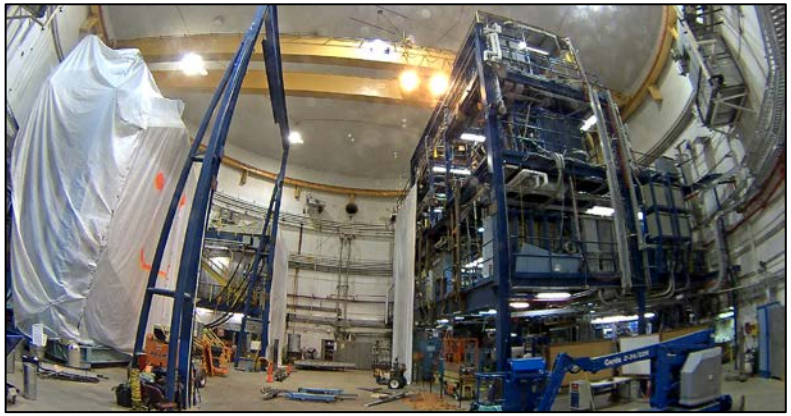


The 12 GeV CEBAF Upgrade at TJNAF is 75% Complete

The 12 GeV CEBAF Upgrade will enable:

- The search for exotic new quark anti-quark particles to advance our understanding of the strong force
- Evidence of new physics from sensitive searches for violations of nature's fundamental symmetries
- A detailed microscopic understanding of the internal structure of the proton, including the origin of its spin, and how this structure is modified when the proton is inside a nucleus
- An SC construction project management review is scheduled for May, which should enable a rebaselining of the project.

The Forward Calorimeter (FCAL) being assembled in the newly constructed Experimental Hall D.



Experimental Hall B readied for construction of the 12 GeV CEBAF Large Acceptance Spectrometer (CLAS12)

Facility for Rare Isotope Beams

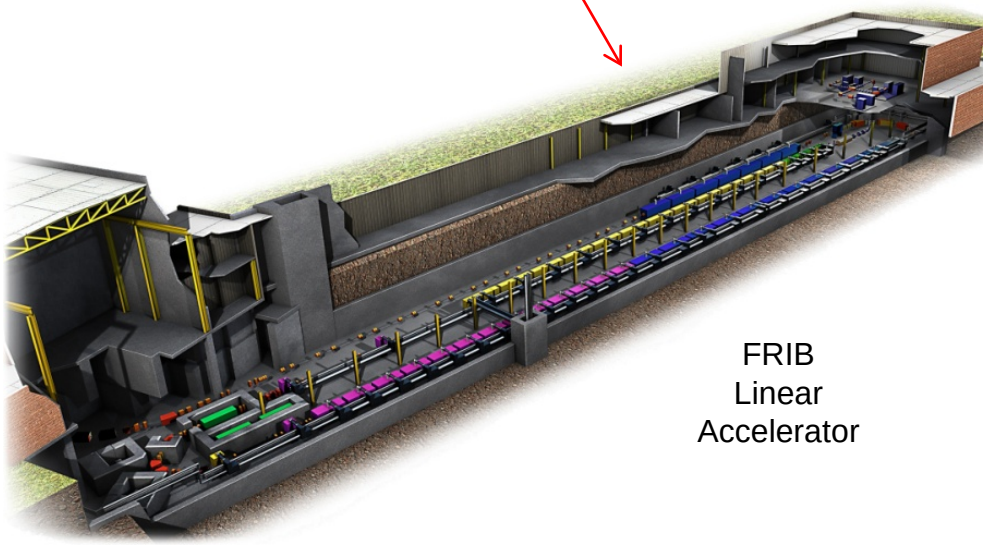
FRIB will increase the number of isotopes with known properties from ~2,000 observed over the last century to ~5,000 and will provide world-leading capabilities for research on:

Nuclear Structure
- The ultimate limits of existence for nuclei
- Nuclei which have neutron skins
- The synthesis of super heavy elements

Nuclear Astrophysics
- The origin of the heavy elements and explosive nucleo-synthesis
- Composition of neutron star crusts

Fundamental Symmetries
- Tests of fundamental symmetries, Atomic EDMs, Weak Charge

An SC construction project management review is scheduled for early June, which enables CD-2/CD-3A cost and schedule baselining/long-lead procurement and excavation soon thereafter.



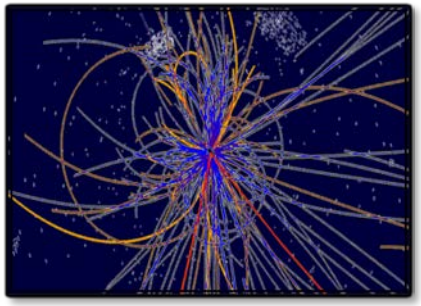
FRIB
Linear
Accelerator

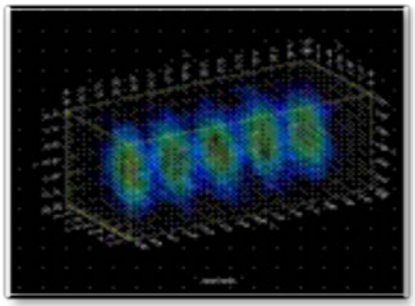
High Energy Physics

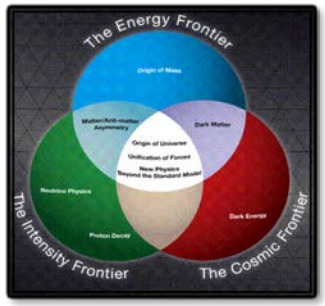
Understanding how the universe works at its most fundamental level

FY 2014 Budget Highlights:

- Energy Frontier:
  - Exploit the LHC, including measurements to address whether the recently discovered particle is consistent with a Standard Model Higgs boson.
- Intensity Frontier:
  - Neutrino physics: The NOvA project will be in full operation in 2014
  - Rare processes: The Muon to Electron Conversion Experiment (Mu2e) experiment, now under construction, will search for the conversion of a muon to an electron in the field of a nucleus, expected to be a very rare event.
- Cosmic Frontier: Dark matter and dark energy experiments (with NSF):
  - R&D for next-gen experiments designed to directly detect dark matter particles using underground detectors
  - Large Synoptic Survey Telescope for studies of dark energy using ground-based telescope facility
- Accelerator stewardship: New subprogram focuses on fundamental physics of charged particle beams and on accelerator technology with broad applications.
- Facility operations/construction:
  - Full support of existing facilities and the Mu2e construction project.
  - The accelerator complex at Fermilab shut down in April 2012 for a year-long upgrade to enhance the beam power from approximately 400 to 700 kW for the NOvA experiment.



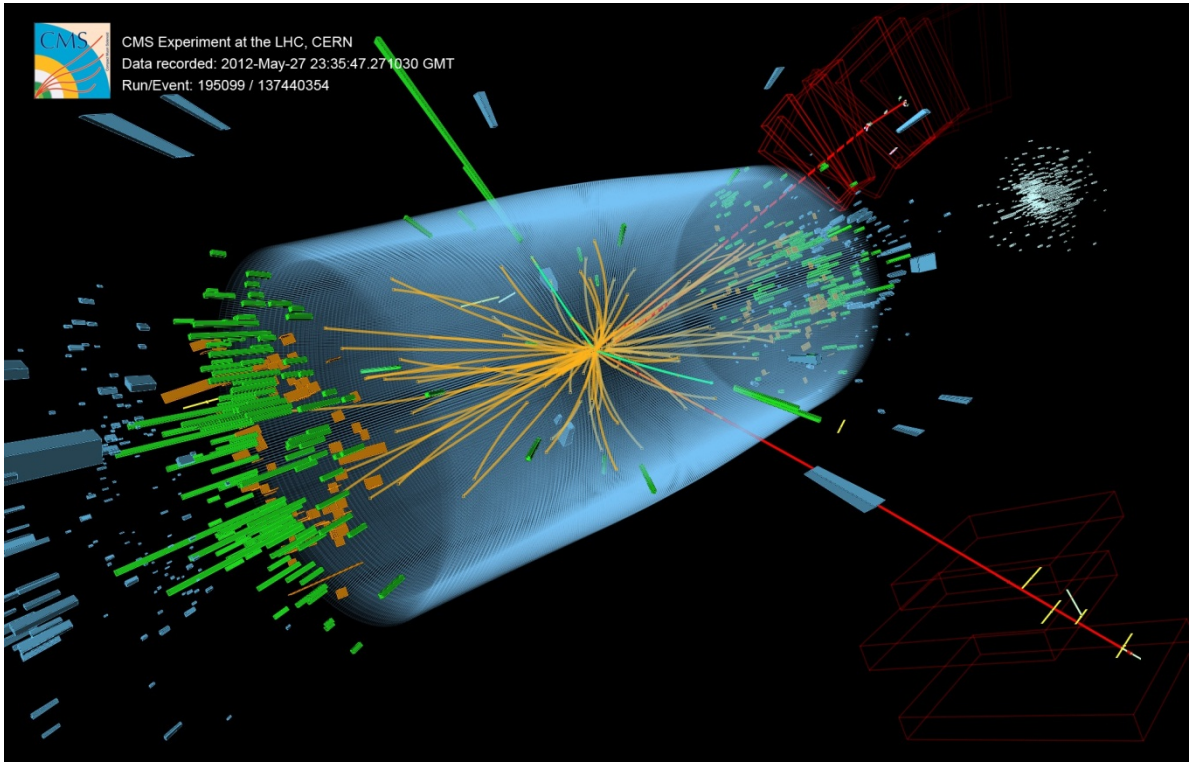




Recent and Forthcoming Planning Activities

- HEPAP facilities Prioritization
  - Rate current and proposed HEP facilities on scientific impact and technical readiness to proceed to construction as input to a 10-yr SC-wide facilities plan
- DPF community-wide planning (“Snowmass”) process that will conclude this summer
  - Focuses on physics opportunities
  - Informed by and coordinated with European and Japanese HEP planning
- Prioritization process (a.k.a. “P5”)
  - HEPAP, through the P5 subpanel and with well-defined guidance, will identify compelling HEP science opportunities, over an approximately 20 year time frame using input from the above
  - Large panel, with opportunities for community input, will update the strategic plan and priorities for U.S. HEP

The Discovery of the Higgs Boson

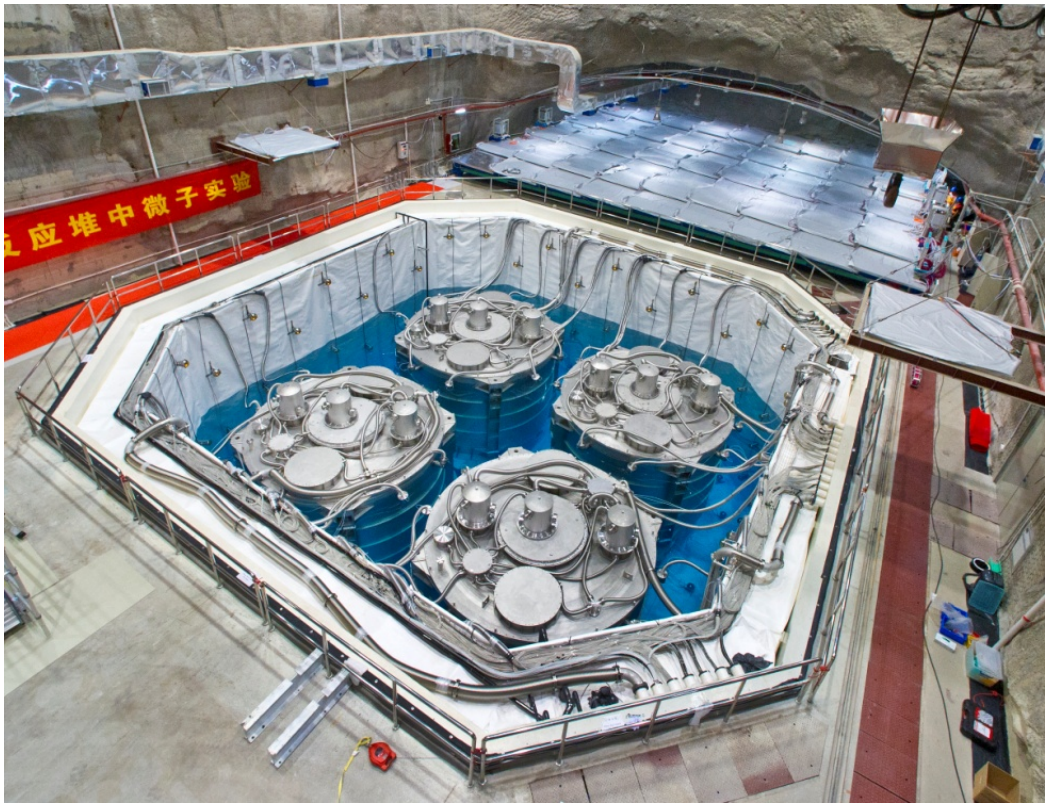


Event from the CMS detector at the LHC that is consistent with a Higgs Boson decay.

The experiments at the Large Hadron Collider (LHC) have produced a flood of results, including the discovery of a new fundamental particle observed at about 125 GeV. This new particle is compatible, including recent measurements of its spin and parity, with being the long-sought Standard Model Higgs boson. U.S. physicists make up about one quarter of each of the two scientific teams, and play critical leadership roles in all aspects of the experiment.

Daya Bay Experiment—first definitive measurement of the remaining unknown neutrino mixing angle

In China, the Reactor Neutrino Experiment collaboration led by U.S. and Chinese physicists reported a measurement of the mixing angle responsible for changing muon neutrinos to electron neutrinos. This result means that in the current neutrino oscillation model, the possibility of matter-antimatter asymmetry, and a hierarchy of neutrino masses, can be definitively tested with new experiments.



Daya Bay Far Detector Hall with 4 neutrino detectors

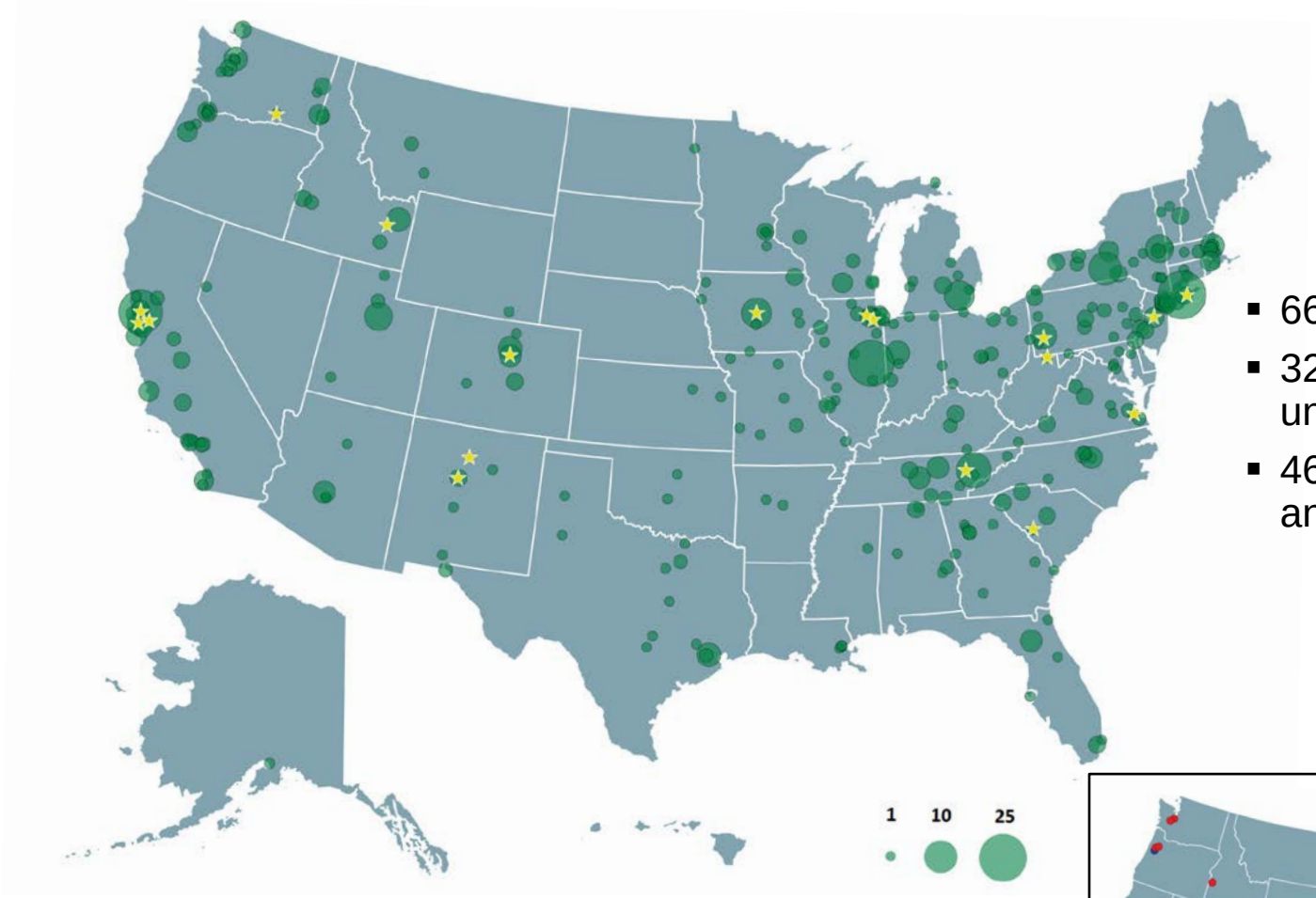
Workforce Development for Teachers and Scientists

Ensuring a pipeline of STEM workers to support the DOE mission, administer its programs, and conduct its research.

FY 2014 Budget Highlights:

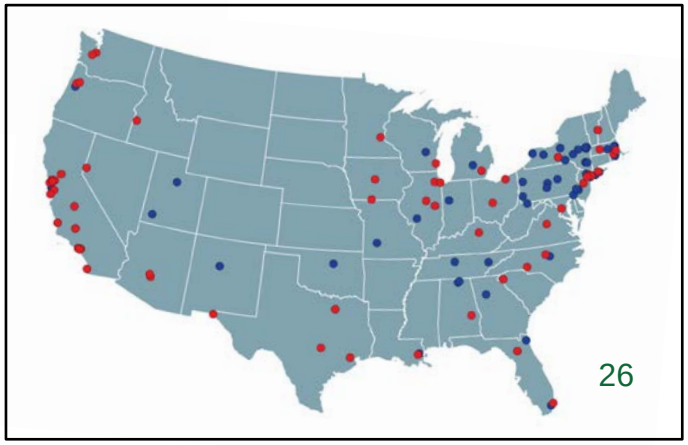
- Activities at the DOE laboratories: WDTS will support ~1,000 individuals in FY 2014
  - Highest priority is to execute well these undergraduate-student, graduate-student, and visiting-faculty internships and research programs at the DOE labs.
  - FY 2013 is the beta-test year for new on-line application systems, which also collect and archive deliverables and other participant data for program evaluation. In FY 2014, the systems will be refined and extended to other activities.
  - A 4thQ FY 2012 Reverse Site Visit of the Lab Education Directors (LEDs) identified best practices and opportunities for improvement. In FY 2014, the LEDs will complete the task of identifying the core requirements that serve as the standard for managing WDTS laboratory programs across the complex.
- Albert Einstein Distinguished Educator Fellowship
  - 4 Fellows in Hill offices, 2 Fellows in WDTS each year. We work to optimize the match of skills, proclivities, and professional development goals of the Fellows with the needs of Hill and WDTS programs.
- National Science Bowl
  - More than 20,000 students, coaches, and volunteers participate in the regional and final competitions each year; WDTS brings the regional winners, the top 4% of the teams, to Washington, D.C. for the final competitions.
- Program assessment
  - Reverse Site Visit (RSV) and FY 2014 Committee of Visitors (COV)

2012 SULI Participant Undergraduate Institutions



- 665 students
- 321 colleges/ universities
- 46 states, Puerto Rico and U.S. Virgin Islands

Inset at right shows home institutions of students who interned at two of the DOE labs: Lawrence Berkeley National Lab (red dots) and Brookhaven National Lab (blue dots)



Science Laboratory Infrastructure

Supporting infrastructure and fostering safe and environmentally responsible operations at the Office of Science laboratories

FY 2014 Highlights:

- Continuation of funding for the design and construction of the Science and User Support Building at SLAC
- Two utility projects, one each at TJNAF and FNAL, are poised to start as soon as funding is available

Recent and Near-Term Accomplishments:

- The new areas of the Technology and Engineering Development Facility at TJNAF completed in March 2012
- The Interdisciplinary Science Building at BNL scheduled for CD-4 in April 2013
- The Research Support Building at SLAC scheduled to complete construction in 4Q FY 2013
- The Energy Sciences Building at ANL scheduled to complete construction in 4Q FY 2013

Safeguards and Security

Supporting appropriate levels of protection against unauthorized access, theft, or destruction of DOE assets and hostile acts

FY 2014 Budget Highlights:

- Maintains consistent security levels at SC sites.
- Supports progress of the SC Baseline Level of Protection through technologies in lieu of staff to perform automated access control and security monitoring services.
- Supports infrastructure investments in access control systems and Homeland Security Presidential Directive-12 (HSPD-12) requirements,
- Supports cyber security enhancements to ensure labs are properly protected against emerging threats and persistent attacks against IT systems.
- Supports the new Protective Forces Contract at ORNL and for the additional protection needed to secure the Category 1 Special Nuclear Material at ORNL's Building 3019.

Safeguards and Security Improvements

- Nuclear security is a high priority for SC, particularly for the Category I Building 3019 at Oak Ridge National Laboratory and our other nuclear facilities.
- SC along with the Department is looking at all of our security operations and oversight functions to identify and fully implement needed upgrades.
- SC has implemented a comprehensive plan to improve security operations and Federal oversight at our facilities.
  - New security Proforce contract for Oak Ridge was competed and awarded.
  - Shared services from the DOE Y-12 facility are obtained through a formal Memorandum of Understanding, e.g., Central Training Academy support.

Program Direction

Supporting a Federal workforce to oversee Office of Science investments in world-leading scientific research

FY 2014 Budget Highlights:

- 1,010 FTEs
  - Manage science programs, facilities, and projects; support operations associated with portfolio management; administer President's Council of Advisors on Science and Technology (PCAST)
  - Hiring is restricted to essential backfills, critical succession planning requirements, and a very few targeted new recruitments.
- SC Information Technology Modernization Plan (ITMP)
  - Consolidate three data centers into one; consolidate IT support service contracts; improve cyber security; provide new technologies to enhance collaboration and mobile computing
- Federal travel for essential scientific program oversight and mandatory site visits for health and safety inspection. Also supports required travel for PCAST activities.