U.S. DEPARTMENT OF ENERGY | Office of Science

Program Highlights from the Office of Science

Nuclear Science Advisory Committee meeting

February 26, 2010

Dr. W. F. Brinkman
Director, Office of Science
U.S. Department of Energy
www.science.doe.gov

The Administration's S&T Priorities for the FY 2011 Budget

"When we fail to invest in research, we fail to invest in the future. Yet, since the peak of the space race in the 1960s, our national commitment to research and development has steadily fallen as a share of our national income. That's why I set a goal of putting a full 3 percent of our Gross Domestic Product, our national income, into research and development, surpassing the commitment we made when President Kennedy challenged this nation to send a man to the moon."

President Barack Obama
September 21, 2009

http://www.whitehouse.gov/the_press_office/Remarks-by-the-President-on-Innovation-and-Sustainable-Growth-at-Hudson-Valley-Community-College/

Office of Science (SC) FY 2011 Budget Request to Congress

(B/A in thousands)

	FY 2009		FY 2010	FY 2011		
	Current Base Approp.	Current Recovery Act	Current Approp.	Request to Congress	Request to Congress vs. FY 2010 Approp.	
Advanced Scientific Computing Research	358,772	161,795	394,000	426,000	+32,000	+8.1%
Basic Energy Sciences	1,535,765	555,406	1,636,500	1,835,000	+198,500	+12.1%
Biological & Environmental Research	585,176	165,653	604,182	626,900	+22,718	+3.8%
Fusion Energy Sciences	394,518	91,023	426,000	380,000	-46,000	-10.8%
High Energy Physics	775,868	232,390	810,483	829,000	+18,517	+2.3%
Nuclear Physics	500,307	154,800	535,000	562,000	+27,000	+5.0%
Workforce Development for Teachers & Scientists	13,583	12,500	20,678	35,600	+14,922	+72.2%
Science Laboratories Infrastructure	145,380	198,114	127,600	126,000	-1,600	-1.3%
Safeguards & Security	80,603	——	83,000	86,500	+3,500	+4.2%
Science Program Direction	186,695	5,600	189,377	214,437	+25,060	+13.2%
Small Business Innovation Research/Technology Transfer (SC)	104,905	18,719	——	——	——	——
Subtotal, Science	**4,681,572**	**1,596,000**	**4,826,820**	**5,121,437**	**+294,617**	**+6.1%**
Congressionally-directed projects	91,064	——	76,890	——	-76,890	-100.0%
Small Business Innovation Research/ Technology Transfer (DOE)	49,534	36,918	——	——	——	——
Use of prior year balances	-15,000	——	——	——	——	——
Total, Office of Science	**4,807,170**	**1,632,918**	**4,903,710**	**5,121,437**	**+217,727**	**+4.4%**

SC Supports Research at More than 300 Institutions Across the U.S.

The Office of Science supports:

- 27,000 Ph.D.s, graduate students, undergraduates, engineers, and technicians
- 26,000 users of open-access facilities
- 300 leading academic institutions
- 17 DOE laboratories

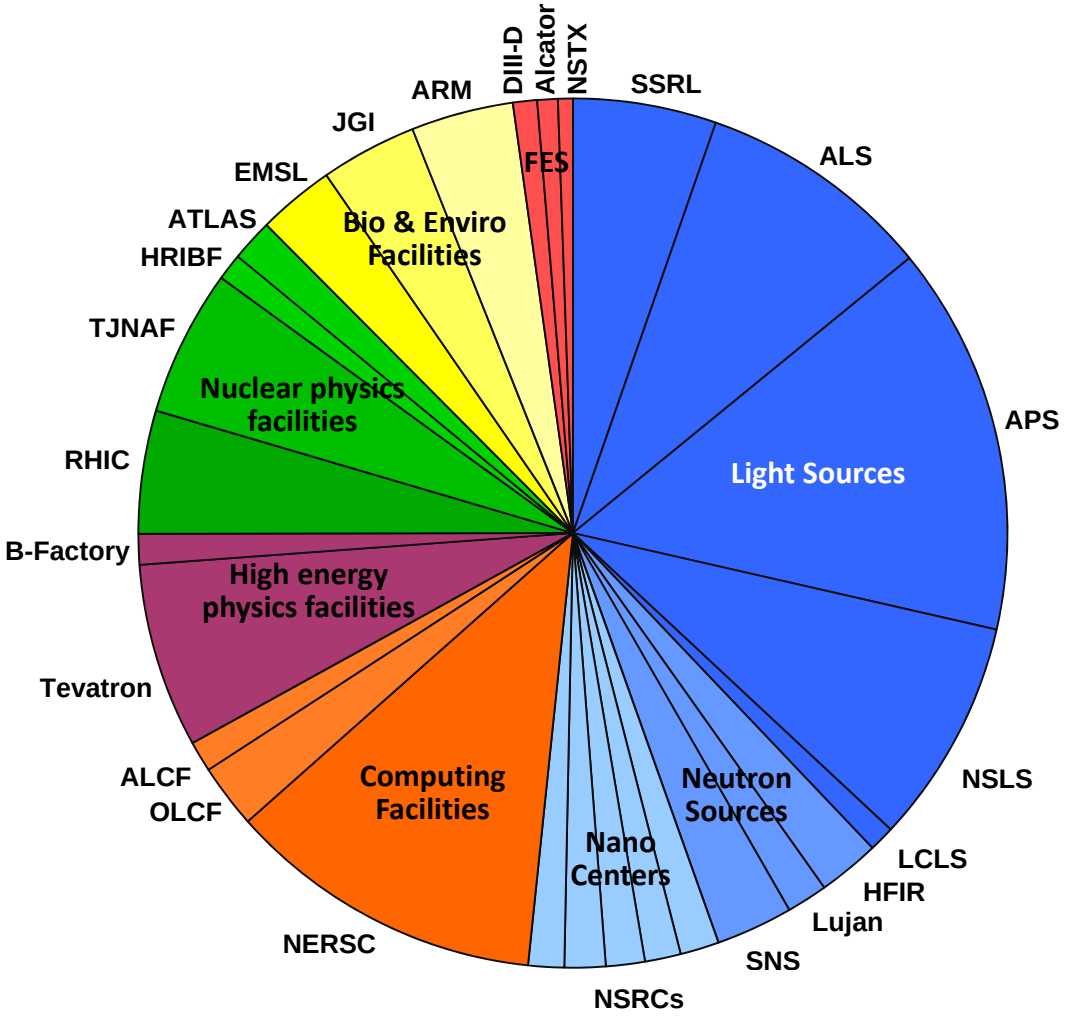
SC Supports World-Leading, Open Access Scientific User Facilities

User numbers continue to increase with more than 26,000 users expected in FY 2011

Numbers of Users at SC Facilities

	FY 2009	FY 2010 (Est)	FY 2011 (Est)
ASCR	3,696	3,850	4,025
BES	11,509	12,780	13,560
BER	2,716	2,690	2,690
FES	542	575	580
HEP	2,960	2,600	2,100
NP	3,170	3,260	3,300
Total	24,593	25,755	26,255

Breakdown of the expected users in FY 2011 by facility.



Office of Science FY 2011 Investment Highlights

The FY 2011 budget advances discovery science and invests in science for national needs in energy, climate, and the environment; national scientific user facilities; and education and workforce development.

Discovery science addressing national priorities

- Energy Innovation Hub for Batteries and Energy Storage (+$34,020K, BES)
- Enhanced activities in climate science and modeling (Regional and Global Climate Modeling, +$6,495K; Earth System Modeling, +$9,015K; Atmospheric System Research, +$1,944K; ARM Climate Research Facility, +$3,961K; BER)
- Individual investigator, small group, and Energy Frontier Research Centers (EFRCs) in areas complementing the initial suite of 46 EFRCs awarded in FY 2009 (+$66,246K, BES)
- Leadership Computing Facilities operations and preparation for next generation of computer acquisitions for S&T modeling and simulation ($34,832K, ASCR)
- Multiscale modeling of combustion and advanced engine systems (+$20,000K, BES)

Scientific user facilities—21st century tools of science, technology, and engineering

- Facility construction is fully funded; projects are meeting baselines
- 28 scientific user facilities will serve more than 26,000 users
- Several new projects and Major Items of Equipment are initiated in (e.g., the Long Baseline Neutrino Experiment, +$12,000K, HEP)

Education and workforce development

- Expansions of the SC Graduate Fellowship Program (+$10,000K, 170 new awards, WDTS) and the SC Early Career Research Program (+$16,000K, 60 new awards, funded in all of the SC research programs)

The Status of the DOE Energy Innovation Hubs

Three new Hubs are launched in FY 2010 with SC leading the Fuels from Sunlight Hub

Modeled after the Office of Science Bioenergy Research Centers, the Energy Innovation Hubs focus on critical energy technology challenges by building creative, highly-integrated research teams that can accomplish more, faster, than researchers working separately.

FY 2010 Hubs tackle three important energy challenges:

1. **Production of fuels directly from sunlight (SC)**
2. **Energy-efficient building systems design (EERE)**
3. **Modeling and simulation of advanced nuclear reactors (NE)**

The Fuels from Sunlight Hub will accelerate the development of a sustainable commercial process for the conversion of sunlight directly into energy-rich chemical fuels, likely mimicking photosynthesis, the method used by plants to convert sunlight, carbon dioxide, and water into sugar. In FY 2011, BES has budgeted $24,300K for the 2nd year of the Fuels from Sunlight Hub. The FOA was released on 12/22/2009, and proposals are due on 3/29/2010.

To access the Fuels from Sunlight FOA (reference number DE-FOA-0000214) go to:
https://www.fedconnect.net/FedConnect/PublicPages/PublicSearch/Public_Opportunities.aspx
and search for "Fuels from Sunlight" in the search box (note that the search flag should be set to "Title" or "Title/Description").

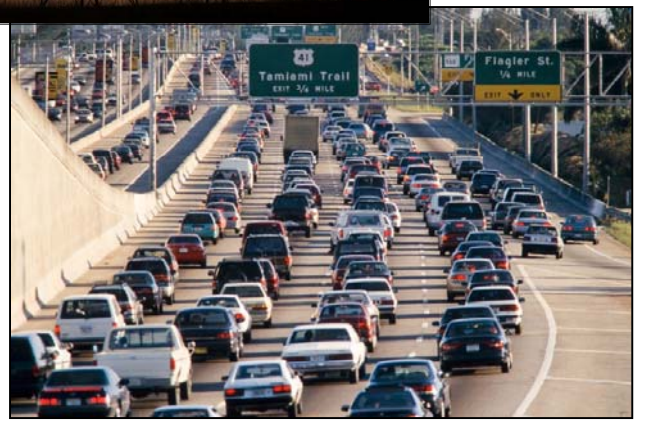
FY 2011 Energy Innovation Hub for Batteries and Energy Storage

Addressing science gaps for both grid and mobile energy storage applications

The Administration's Energy Plan has two goals that require improvements in the science and technology of energy storage:

- Solar and wind providing over 25% of electricity consumed in the U.S. by 2025
- 1 million all-electric/plug-in hybrid vehicles on the road by 2015

- Grid stability and distributed power require innovative energy storage devices
  - Grid integration of intermittent energy sources such as wind and solar
  - Storage of large amounts of power
  - Delivery of significant power rapidly
- Enabling widespread utilization of hybrid vehicles requires:
  - Substantially higher energy and power densities
  - Lower costs
  - Faster recharge times



Climate Science for a Sustainable Energy Future

Enhanced activities in climate research to improve our predictive capability

The demands on climate change modeling to inform policy and investment decisions are increasing. The current state of climate models is insufficient to predict with the detail and accuracy the future interactions between climate change and energy policy.

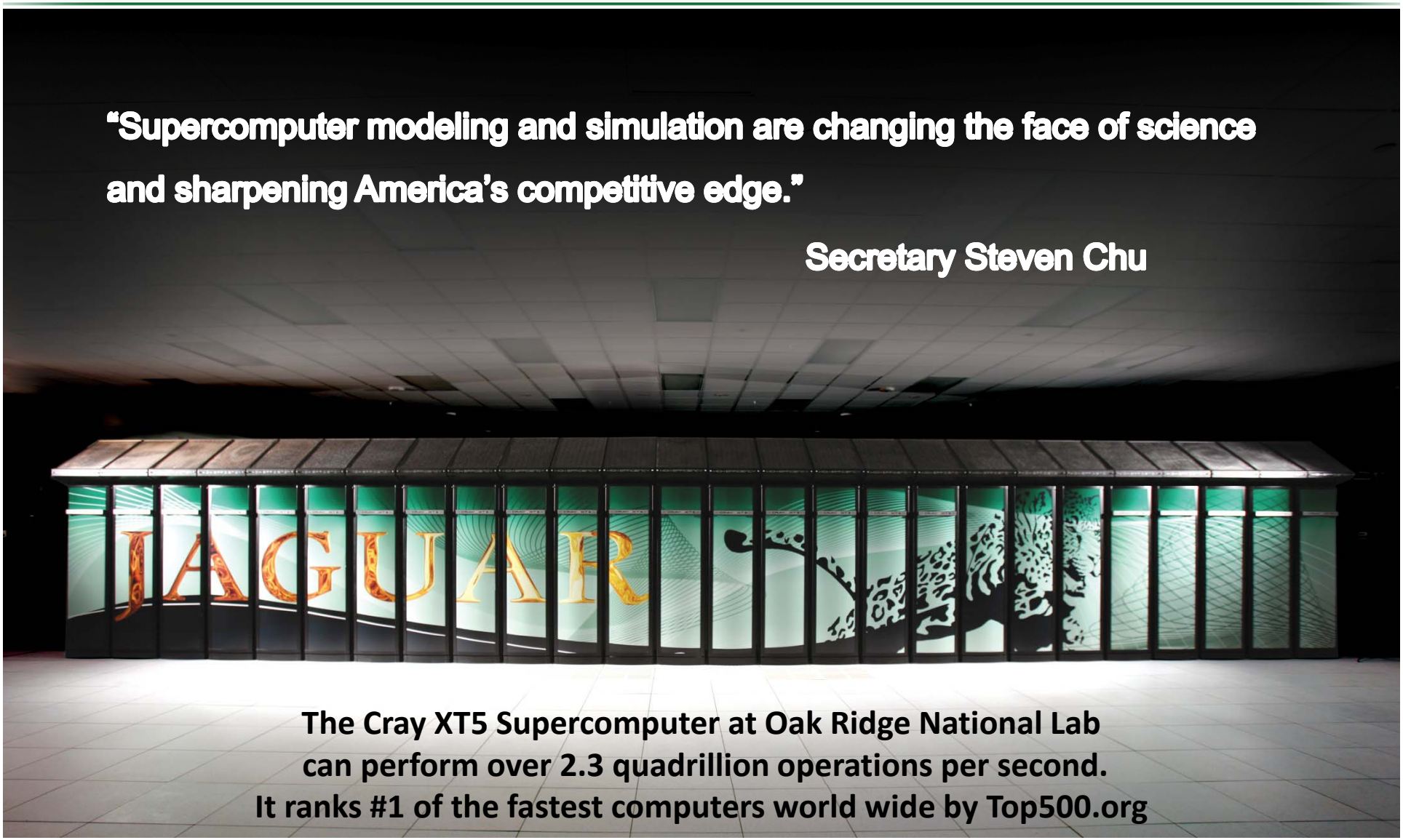
FY 2011 funding increases support in BER ($21,415K) for the development of a predictive capability that will rapidly incorporate new science into state-of-the-art climate models and that will improve uncertainty quantification.

New and enhanced activities will emphasize:

- Research and atmospheric data collection for improving representation of the feedbacks produced by the indirect effect of aerosols
- Enhanced uncertainty quantification for climate model simulations and predictions
- Conversion of observational data sets into specialized, multi-variable data sets for Earth System Model testing and improvement.
- Model development testbeds in which model components can be rapidly prototyped and evaluated using integrated observational datasets; development of numerical methods to enable climate models to use future computer architectures
- Atmospheric System Research and operation of new ARM Climate Research Facility instruments to provide data for improving representation of clouds and aerosols in climate models

Leadership Computing Facilities

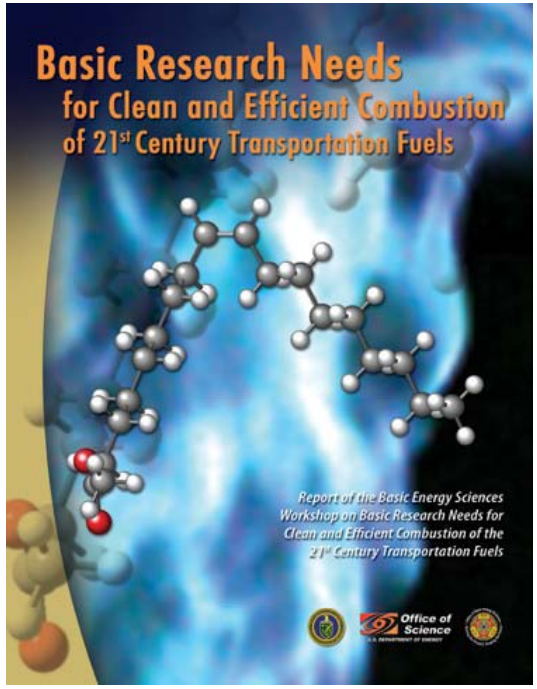
The Office of Science leads the World in supercomputing capabilities



Multi-scale Simulation of Internal Combustion Engines

A new initiative to develop the science base for computational design of advanced engines

Predictive simulation of combustion in an evolving fuel environment is essential for developing more efficient and cleaner engines.



The scientific community has provided a roadmap via:

- BES workshop: *Basic Research Needs for Clean and Efficient Combustion*, October 2006
- ASCR/BES workshop: *Discovery in Basic Energy Sciences: The Role of Computing at the Extreme Scale*, August 2009
- SC ongoing collaboration with EERE's Vehicle Technology Program

The new BES activity (+$20,000K) will provide:

- **Models that span vast scale ranges:** coupling of combustion chemistry with turbulent flow requiring simulation over 9 orders of magnitude in space and time.
- **Improved understanding of fundamental physical and chemical properties:** multi-phase fluid dynamics, thermodynamic properties, heat transfer, and chemical reactivity.
- **Engine simulation:** science-based predictive simulation and modeling design

Bioenergy Research Centers

The BRCs have pioneered new approaches to accelerate biofuels research

$75 million will support the fourth year of operations of the three BRCs

Joint BioEnergy Institute (JBEI)—research on model crops (*Arabidopsis* and rice) that can be transferred to bioenergy crops; lignin modification; synthetic biology approaches to fuels

- *Advanced biomass pretreatment using room temperature ionic liquids to remove lignin from plant cell walls improved biomass breakdown 5x.*
- *New cellulase enzyme more stable and active in ionic liquids at elevated temperatures and low pH.*

Great Lakes Bioenergy Research Center (GLBRC)—research on model plants and potential bioenergy plants; microbial biorefineries; sustainability of biofuel production

- *Improved screening of hydrolytic enzymes using gene expression approach coupled with enzyme screening and computational approaches – 100x more efficient than conventional methods*

BioEnergy Science Center (BESC)—research to overcome "recalcitrance" (resistance of plant fiber, or lignocellulose, to break down into sugars); gene discovery for recalcitrance; consolidated bioprocessing

- *New high throughput screening of chemical, structural, and genetic features of biomass – >100x faster than conventional methods.*
- *New imaging technologies to view cell wall at multiple scales to analyze recalcitrance*

The Genomic Revolution

Advances in DNA sequencing and analysis have revolutionized the study of biology

Sequencing the 3 billion base-pair human genome took 13 years and multiple national and international partners. Today the DOE Joint Genome Institute sequences over a trillion base pairs annually.

- DNA sequencing and analysis capabilities and the availability of genome data in the 1990s led to functional genomics, proteomics, metabolomics, systems biology, and synthetic biology.
- Genomic sequence information has dramatically increased our understanding of the biological processes of microbes and plants—knowledge that is being used to develop solutions for clean energy production, sequestration of atmospheric CO_2, and remediation of contaminated environments.
- Recent accomplishments:
  - **Sequencing the 1.1 billion base-pair soybean genome**—The largest plant project sequenced at JGI and the largest plant sequenced by the whole genome shotgun strategy, the soybean sequence will accelerate crop improvements for energy production and environmentally sustainable food and feed production for agriculture.
  - **DOE JGI publishes the Genomic Encyclopedia of Bacteria and Archaea**—The initial 56 microbial genomes sequenced resulted in the discovery of tens of thousands of genes that provide insights into natural environmental processes and advance biotechnology.
  - **Viable microbes in toxic subsurface environments—**Genetic techniques demonstrate that micoorganisms of the *Anaeromyxobacter* family, known to enzymatically reduce uranium to a less mobile form, can be detected in the most heavily contaminated environments and likely play a role in reducing the mobility of uranium in groundwater.

High Energy Density Laboratory Plasmas

Expanded research efforts in HEDLP will reveal new understanding of matter in extreme conditions

The emerging science of high energy density laboratory plasma (HEDLP) — the study of ionized matter at extremely high density and temperature — is enabling deeper understanding of extreme phenomena in a range of disciplines including fusion energy science, condensed matter physics, materials science, fluid dynamics, nuclear science, and astrophysics.

The increase in the FES High Energy Density Laboratory Plasma program (+$6,489K) will enable new research awards under the HEDLP joint program between FES and NNSA, which began in FY 2009.

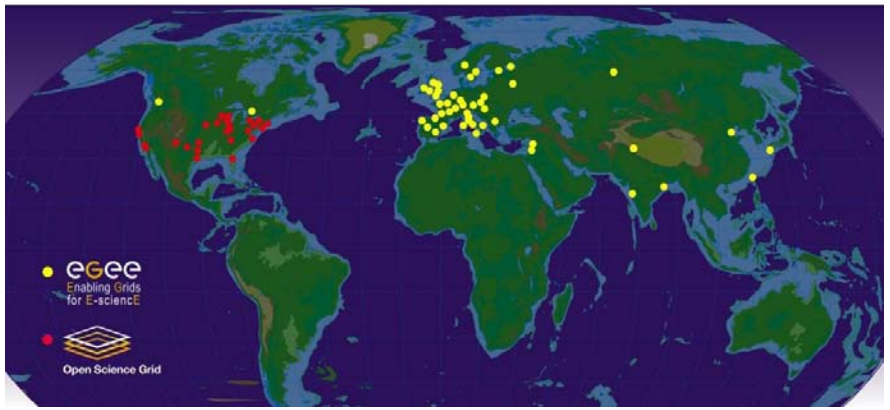
This research will leverage world-class FES and NNSA facilities to provide:

- information in assessing the viability of inertial fusion energy as a future energy source;
- first-of-kind laboratory studies of astrophysical phenomena that include testing of models used to infer the age of the universe; and
- opportunities for junior researchers to ensure continued excellence in scientific disciplines closely aligned with fusion energy science and stockpile stewardship.

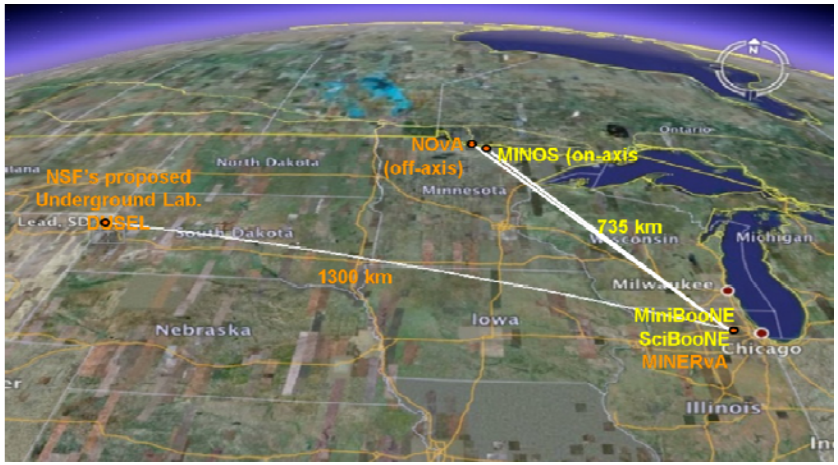
The U.S. High Energy Physics Program

The U.S. is uniquely positioned for a world-leading program in neutrino physics

The U.S. is a critical and strategic partner in global scientific collaborations that push the boundaries of High Energy Physics. The U.S. has developed components for the Large Hadron Collider at CERN and hosts centers for data analysis.



Network sites of the Open Science Grid and Enabling Grids for E-sciencE used for transmitting experimental data from the LHC to scientists worldwide.



The NuMI beamline provides the world's most intense neutrino beam for the MINOS experiment and proposed NOvA and LBNE experiments

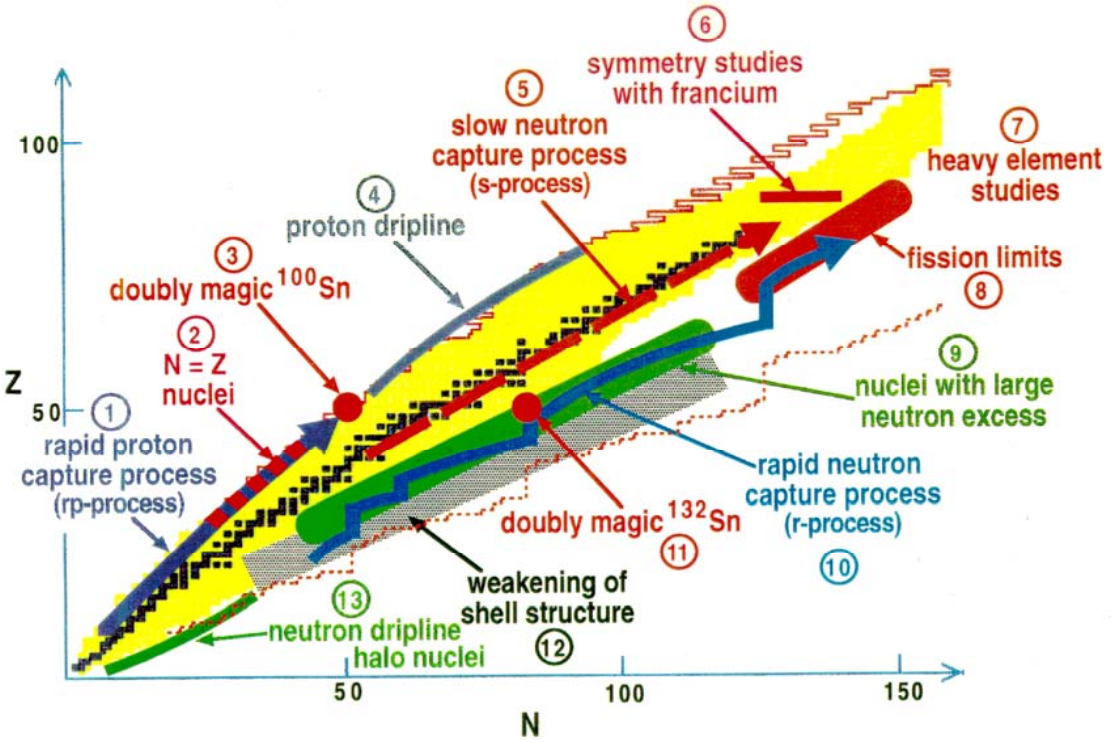
At home, HEP builds on its investments in tools and facilities to capture the unique opportunities of neutrino science. These opportunities are fundamental to the science of particle physics.

At the heart of the DOE HEP program is the *NuMI beamline* at Fermilab, the world's most intense neutrino source, which serves MINERvA and MINOS and will support NOvA and the proposed LBNE (+$12,000K, HEP, initiated in FY 2011).

The DOE Nuclear Physics Program

Charting new directions at the frontiers of nuclear science

The U.S. is a leader in studying the compelling questions of nuclear science, advancing our knowledge of the world, and leading to applications in energy research, medicine, national security, and isotopes for a wide variety of purposes.



- **The Relativistic Heavy Ion Collider (RHIC)** is the only dedicated machine in the world colliding heavy ions at near light speed.
- **The Continuous Electron Beam Accelerator Facility (CEBAF)** is the world's most powerful probe for studying the nucleus of the atom.
- Investments in **Radioactive Ion Beam** experiments and capabilities (such as the **Facility for Rare Isotope Beams—FRIB**), probe the properties of rare nuclear isotopes to better understand the origin of the elements and fundamental symmetries of nature

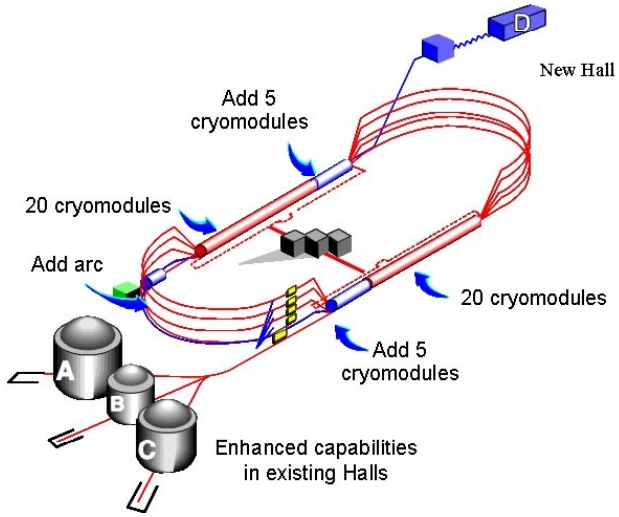
The DOE Nuclear Physics Program

New science follows the completion of the 12 GeV Upgrade at TJNAF

With the completion of the 12 GeV Upgrade, researchers will address:

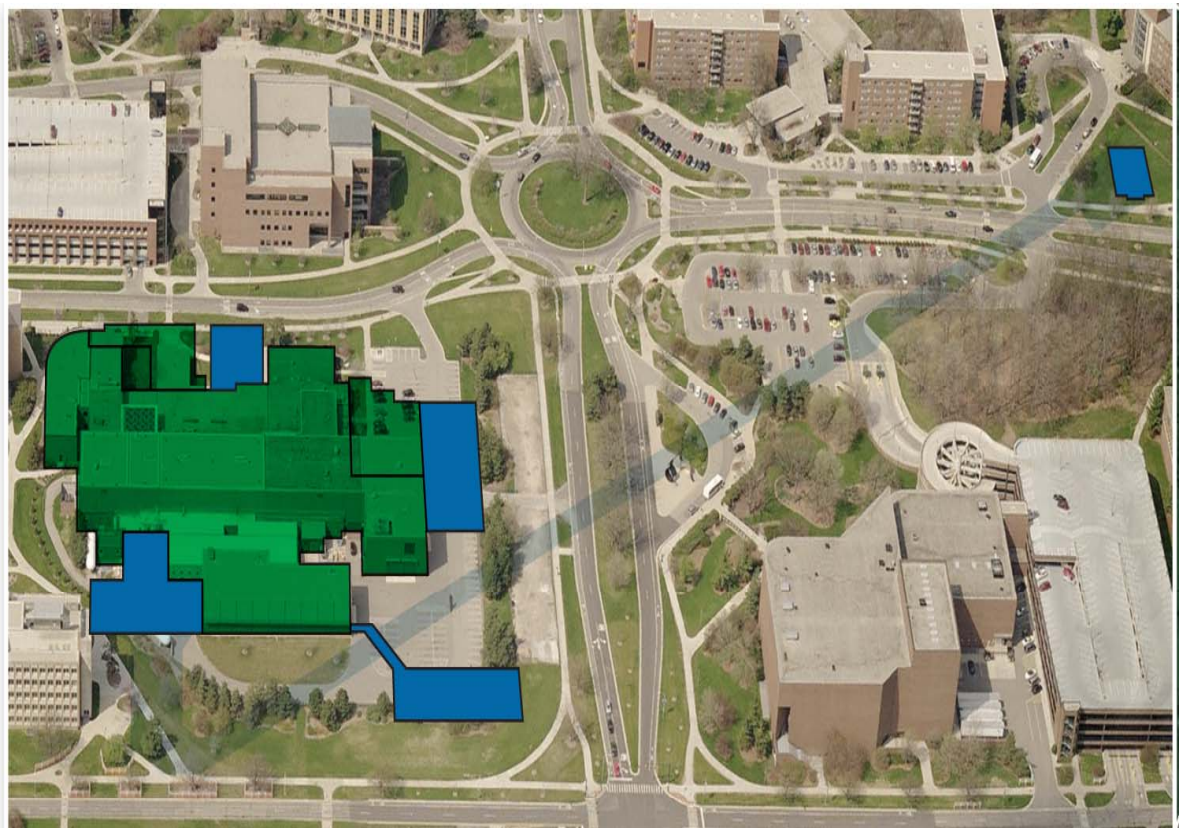
- The search for exotic mesons—a quark and an anti-quark held together by gluons, but unlike conventional mesons, the gluons are excited
- Physics beyond the Standard Model via high precision studies of parity violation
- The spin and flavor dependence of valence parton distributions—the heart of the proton, where its quantum numbers are determined
- The structure of atomic nuclei, exploring how the valence quark structure is modified in a dense nuclear medium
- Nuclear tomography to discover and explore the three-dimensional structure of the nucleon

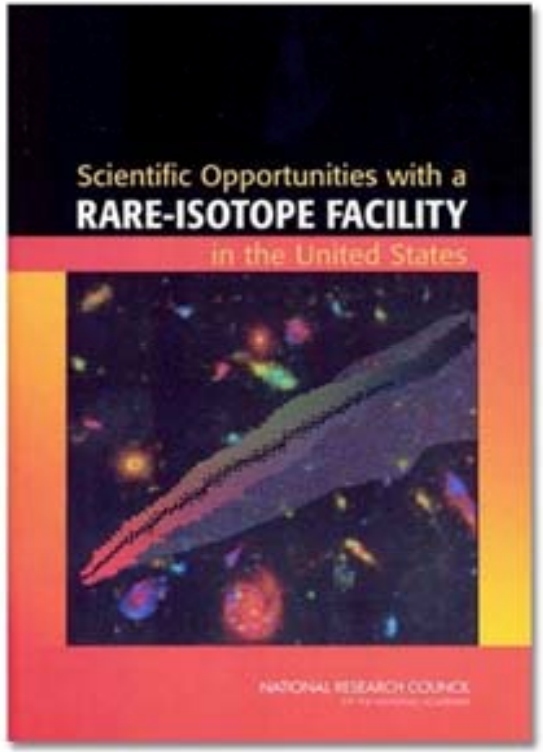
Pouring the foundation for the Hall D complex.



The DOE Nuclear Physics Program

New capability at FRIB will sustain core competency in nuclear structure & astrophysics





- Cooperative Agreement between DOE and Michigan State University signed in June, 2009
- DOE investment of up to $550M and $94.5M cost share from MSU

Office of Science Early Career Research Program

Investment in FY 2011 will bring 60 new scientists into the program

$16 million will be available in FY 2011 to fund about 60 additional Early Career Research Program awards at universities and DOE national laboratories.

Purpose: To support individual research programs of outstanding scientists early in their careers and to stimulate research careers in the disciplines supported by the Office of Science

Eligibility: Within 10 years of receiving a Ph.D., either untenured academic assistant professors on the tenure track or full-time DOE national lab employees

Award Size:

- University grants $150,000 per year for 5 years to cover summer salary and expenses
- National lab awards $500,000 per year for five years to cover full salary and expenses

FY 2010 Results:

- 69 awards funded via the American Recovery and Reinvestment Act
- 1,750 proposals peer reviewed to select the awardees
- 47 university grants and 22 DOE national laboratory awards
- Awardees are from 44 separate institutions in 20 states

FY 2011 Application Process:

- Funding Opportunity Announcement issued in Spring 2010
- Awards made in the Second Quarter of 2011

http://www.science.doe.gov/SC-2/early_career.htm

DOE Office of Science Graduate Fellowships

The FY 2011 request doubles the number of graduate fellowships in basic science

$10 million will be available in FY 2011 to fund about 170 additional fellowships

Purpose: To educate and train a skilled scientific and technical workforce in order to stay at the forefront of science and innovation and to meet our energy and environmental challenges

Eligibility:

- Candidates must be U.S. citizens and a senior undergraduate or first or second year graduate student to apply
- Candidates must be pursuing advanced degrees in areas of physics, chemistry, mathematics, biology, computational sciences, areas of climate and environmental sciences important to the Office of Science and DOE mission

Award Size:

- The three-year fellowship award, totaling $50,500 annually, provides support towards tuition, a stipend for living expenses, and support for expenses such as travel to conferences and to DOE user facilities.

FY 2010 Results:

- 160 awards will be made this Spring with FY 2010 and American Recovery and Reinvestment Act funds.

FY 2011 Application Process:

- Funding Opportunity Announcement issued in Fall 2010
- Awards made in March 2011

Future Outlook

The 2011 Congressional Request allows for:

- Continued support of discovery science and advances in technology
- New opportunities for ground breaking research
- Increased support for training and advancement of the next generation of scientists
- Construction of next generation research tools and facilities

The FY 2011 Request is a challenge for NP – there is substantial growth – somewhat in competition with other Presidential initiatives

Strong support by the research community is essential

Office of Science may be faced with constrained budgets in the outyears

- President Obama has frozen discretionary spending but remains committed to doubling the budget for science
- Large U.S. international commitments will put pressure on Office of Science budgets
- Tight budgets for all programs are a real possibility; operating a large number of user facilities will be challenging
- As in the past, the Office of Science will work closely with the nuclear science community to insure high priority, compelling research continues to be accomplished