U.S. DEPARTMENT OF ENERGY | Office of Science

Update from the Office of Science

Fusion Power Associates

December 2, 2010

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

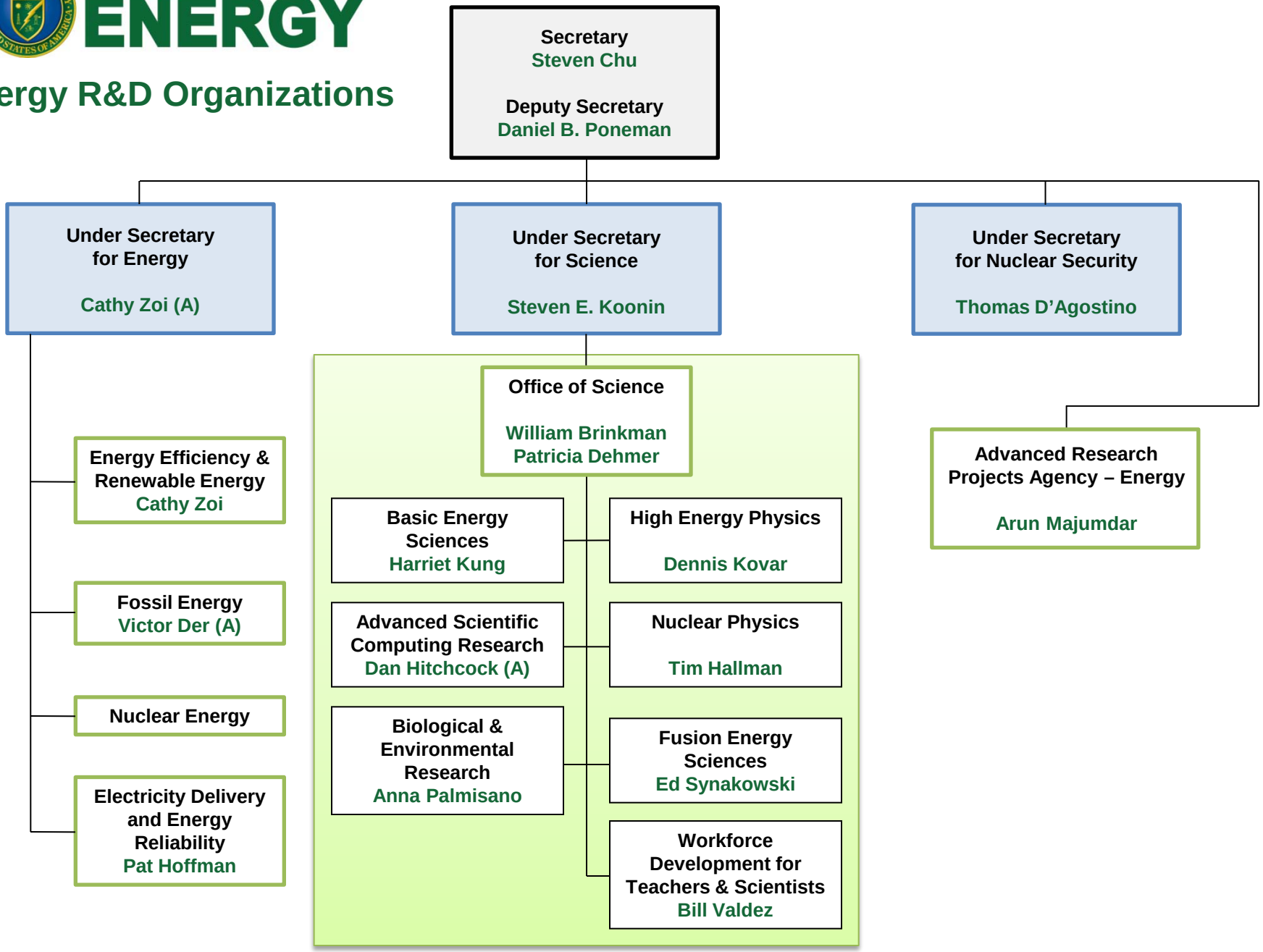
The Administration's S&T Priorities for the FY 2011 Budget

"We double the budget of key agencies, including the National Science Foundation, a primary source of funding for academic research, and the National Institute of Standards and Technology, which supports a wide range of pursuits – from improving health information technology to measuring carbon pollution, from testing "smart grid" designs to developing advanced manufacturing processes. And my budget doubles funding for the Department of Energy's Office of Science which builds and operates accelerators, colliders, supercomputers, high-energy light sources, and facilities for making nano-materials. Because we know that a nation's potential for scientific discovery is defined by the tools it makes available to its researchers."

President Barack Obama
April 27, 2009

U.S. DEPARTMENT OF ENERGY

Energy R&D Organizations

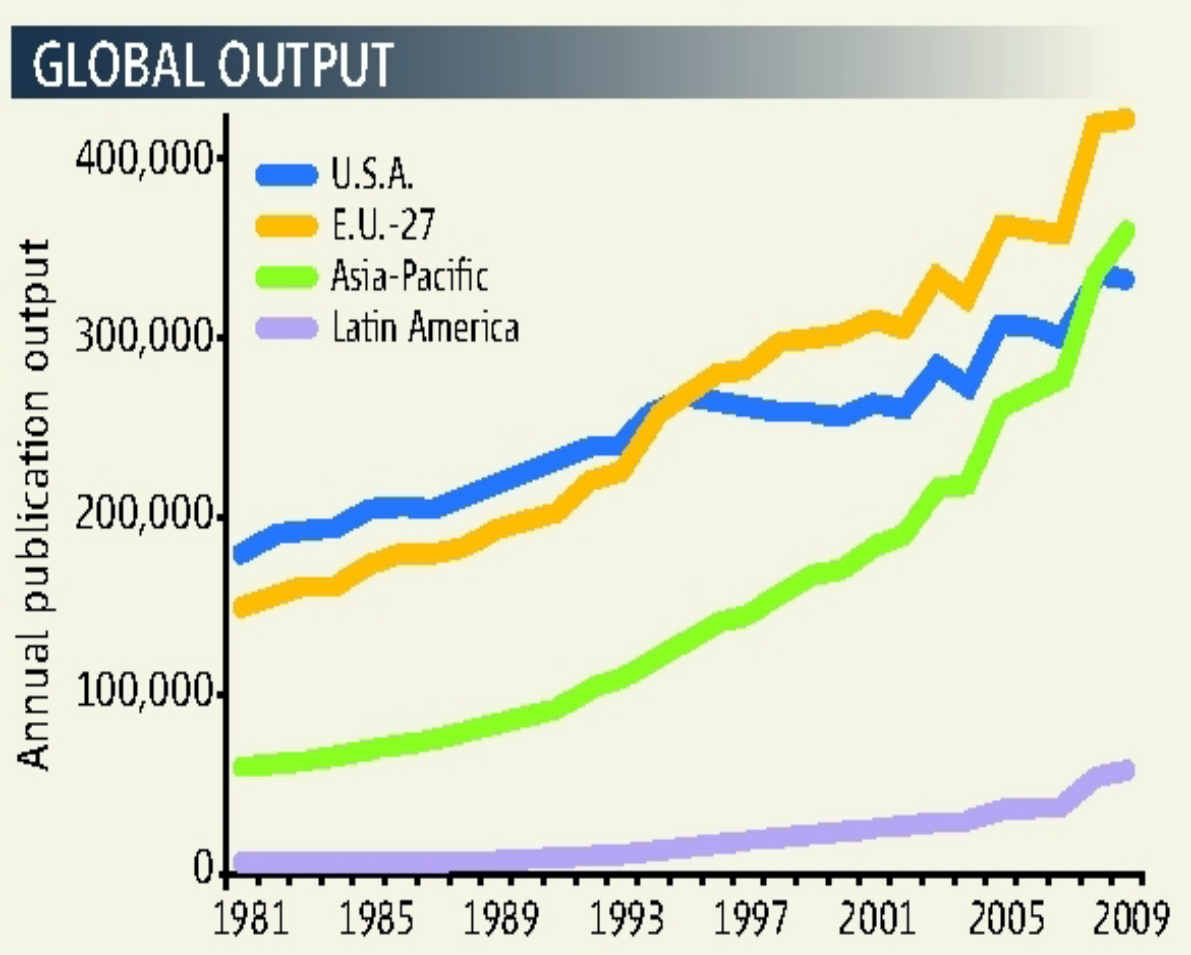


Status of FY 2011 Budget Request and Appropriations

(dollars in thousands)

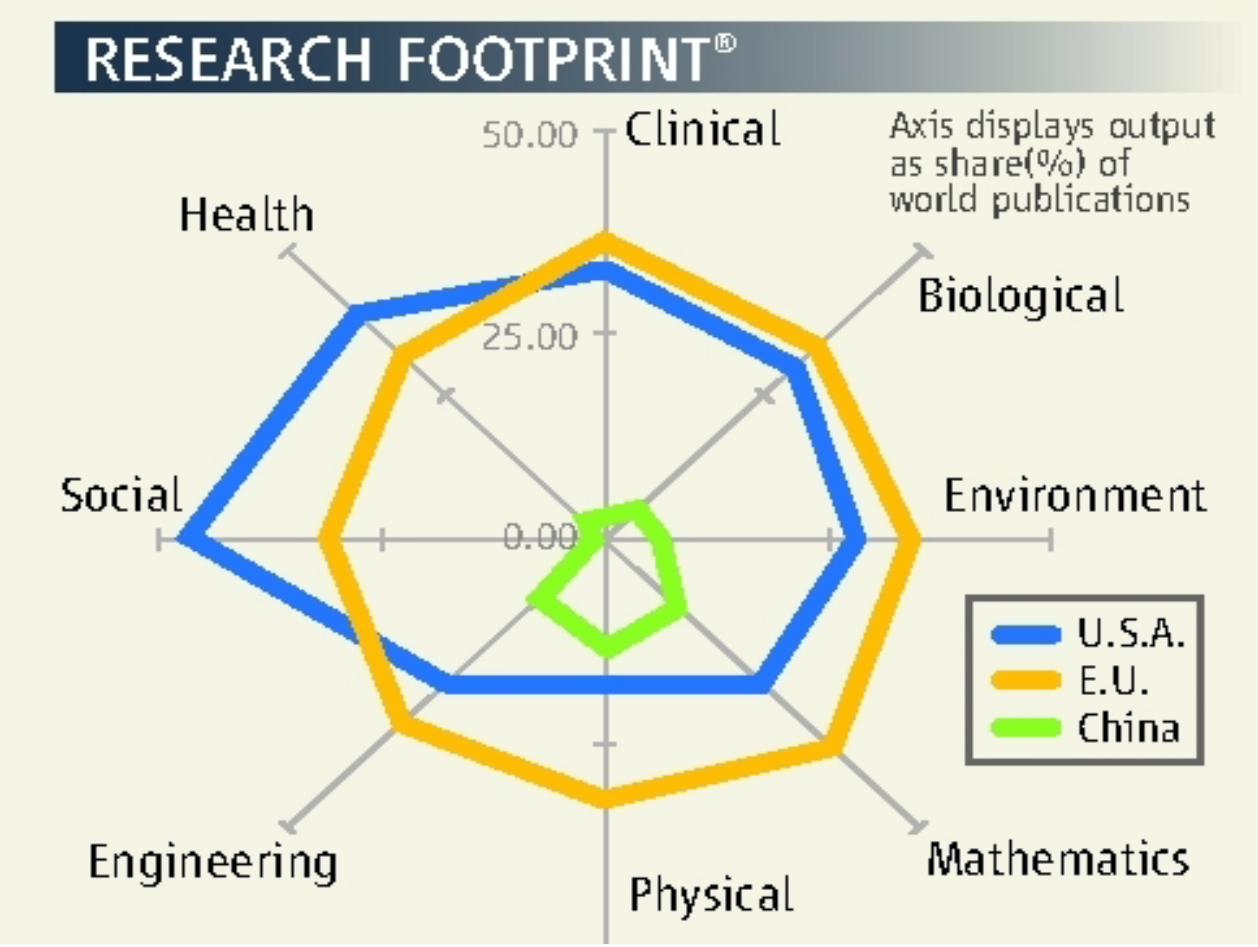
	FY 2010		FY 2011						
	Current Approp.	Total Recovery Act	FY 2011 Request to Congress	House Mark	House Mark vs. Request		Senate Mark	Senate Mark vs. Request	
Office of Science									
Advanced Scientific Computing Research	383,199	+161,795	426,000	424,800	-1,200	-0.3%	418,000	-8,000	-1.9%
Basic Energy Sciences	1,598,968	+555,406	1,835,000	1,670,618	-164,382	-9.0%	1,739,115	-95,885	-5.2%
Biological & Environmental Research	588,031	+165,653	626,900	613,617	-13,283	-2.1%	614,500	-12,400	-2.0%
Fusion Energy Systems	417,650	+91,023	380,000	380,000	——	——	384,000	+4,000	+1.1%
High Energy Physics	790,811	+232,390	829,000	816,500	-12,500	-1.5%	820,085	-8,915	-1.1%
Nuclear Physics	522,460	+154,800	562,000	552,500	-9,500	-1.7%	554,000	-8,000	-1.4%
Workforce Development for Teachers & Scientists	20,678	+12,500	35,600	22,678	-12,922	-36.3%	21,000	-14,600	-41.0%
Science Laboratories Infrastructure	127,600	+199,114	126,000	113,000	-13,000	-10.3%	126,000	——	——
Safeguards & Security	83,000	——	86,500	86,500	——	——	86,500	——	——
Science Program Direction	189,377	+4,600	214,437	201,437	-13,000	-6.1%	208,000	-6,437	-3.0%
Small Business Innovation Research/Tech.Transfer (SC)	107,352	+18,719	——	——	——	——	——	——	——
Subtotal, Science	4,829,126	+1,596,000	5,121,437	4,881,650	-239,787	-4.7%	4,971,200	-150,237	-2.9%
Earmarks	74,737	——	——	18,350	+18,350	——	40,800	+40,800	——
Small Business Innovation Research/Tech.Transfer (DOE)	60,177	+73,248	——	——	——	——	——	——	——
Subtotal, Science	4,964,040	+1,669,248	5,121,437	4,900,000	-221,437	-4.4%	5,012,000	-109,437	-2.1%
Use of PY Bal	-153	——	——	——	——	——	——	——	——
Total, Science	4,963,887	+1,669,248	5,121,437	4,900,000	-221,437	-4.3%	5,012,000	-109,437	-2.1%

U.S. is falling behind in Publications*



*Science **330**, 1032 (2010)

U.S. is falling behind in funding physical sciences*



*Science **330**, 1032 (2010)

Hub Initiatives in Office of Science

- Fuel from Sunlight
- Batteries and Storage Hub

Prospects for Solar Fuels Production

What We Can Do Today

$12/kg H_2 @ $3/pW PV
(BRN on SEU 2005)

PV cell
balance of system

current

electrolyzer

gas

fuel storage

H_2 compression

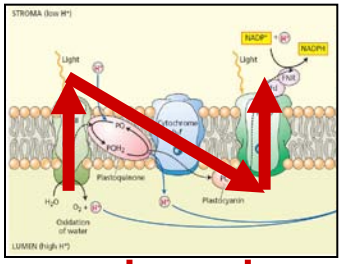
High capital costs

We do not know how to produce solar fuels in a cost effective manner.

Two Limits

Ultimate Goal

solar microcatalytic energy conversion



Low capital costs

liquid

fuel storage

gas

fuel storage

compression

Chemists do not yet know how to photoproduce O_2, H_2, reduce CO_2, or oxidize H_2O on the scale we need.

Award of the “Fuel From Sunlight” Hub

- Winning team led by Cal Tech and LBNL
- Other institutions involved:
  - SLAC National Accelerator Laboratory
  - Stanford University
  - UC Berkeley
  - UC Santa Barbara
  - UC Irvine
  - UC San Diego
- Professor Nate Lewis leader
- Looking for a factor of 10 over nature
- Strong push to integrate processes to form a complete system

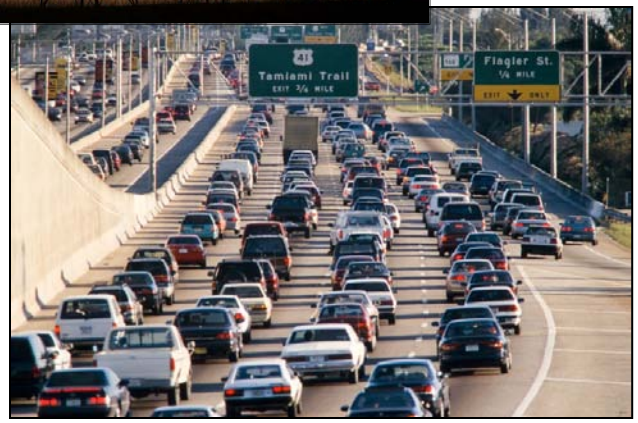
FY 2011 Energy Innovation Hub for Batteries and Energy Storage

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



World's Most Powerful Computers for Open Science

#1 Now #2

#9

WORLD'S FASTEST OPEN SCIENCE SUPERCOMPUTER

ALCF

ARGONNE LEADERSHIP COMPUTING FACILITY

JUNE 2008 • SOURCE: 31ST TOP500

#17

NERSC

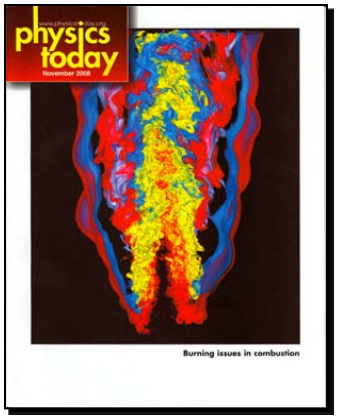
Rankings from June, 2010 Top 500 Supercomputing List

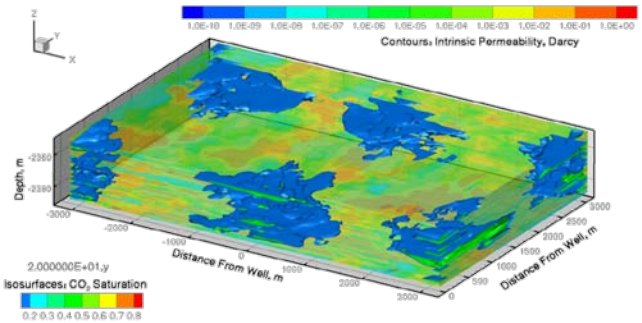
Exascale Initiative

The Goal: *"Provide the United States with the next generation of extreme scale computing capability to solve problems of National importance in Energy, the Environment, National Security, and Science"*

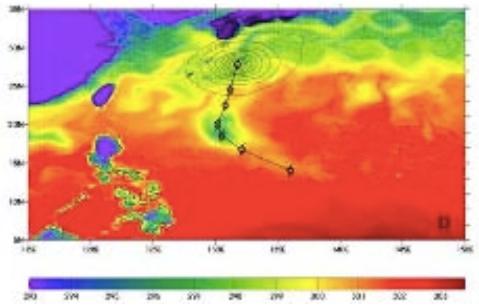
Why do Exascale?

- **Environment**
- **Energy**
- **National Security**
- **Science and Innovation**
- **American Competitiveness**





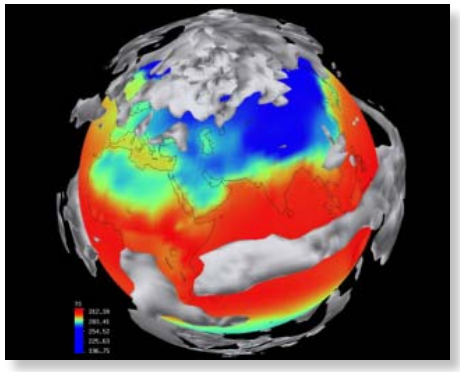
Geologic sequestration

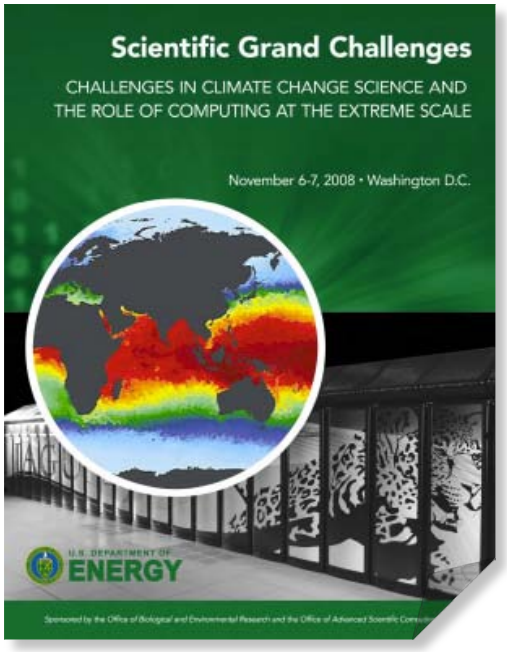


Massive Earth System Model ensembles
(e.g. decadal forecasts, extreme weather)

The Future: Exascale Computing and Climate Modeling

- Exascale computing will enable:
  - Simulation of clouds over their natural range of scales for global climate
  - Modeling fully turbulent exchange of heat and gases between the atmosphere and ocean
  - Robust climate models for early warning, adaptation, and mitigation
  - Higher resolution





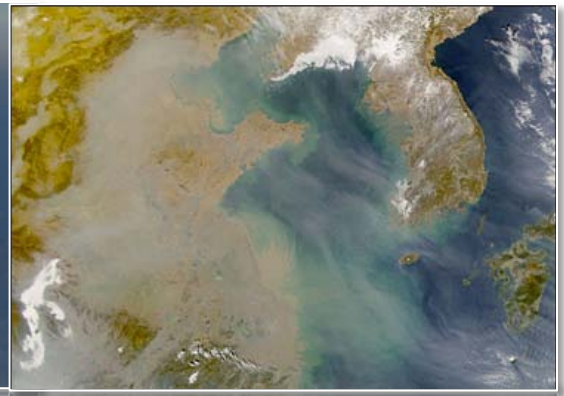
"Challenges in Climate Change Science and the Role of Computing at the Extreme Scale." DOE BER and ASCR, 2009.

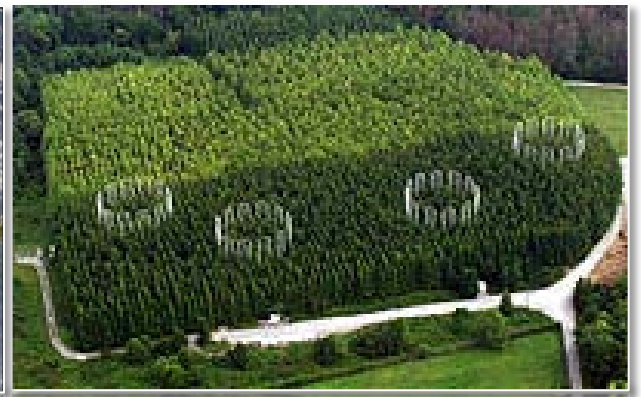
What are the major knowledge gaps in climate models?

Representation of **clouds** in climate models

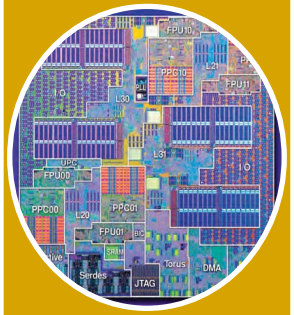
Direct and indirect effects of **aerosols** on climate

Interactions of the **carbon cycle** and climate





Exascale Initiative Major Components



Platform R&D

2 Vendor Tracks

- Power
- Integration
- Risk Mitigation

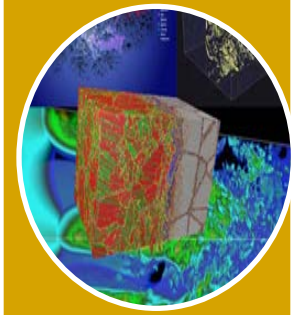
Critical Technologies

(everyone benefits)

- Memory
- Nonvolatile storage
- Optics

Software and Environments

- Operating environment
- Systems Software
- System reliability
- Programming model



Co-design

- Physics Models
- Applied Math
- Performance models
- Simulators
- Applications integration with vendors

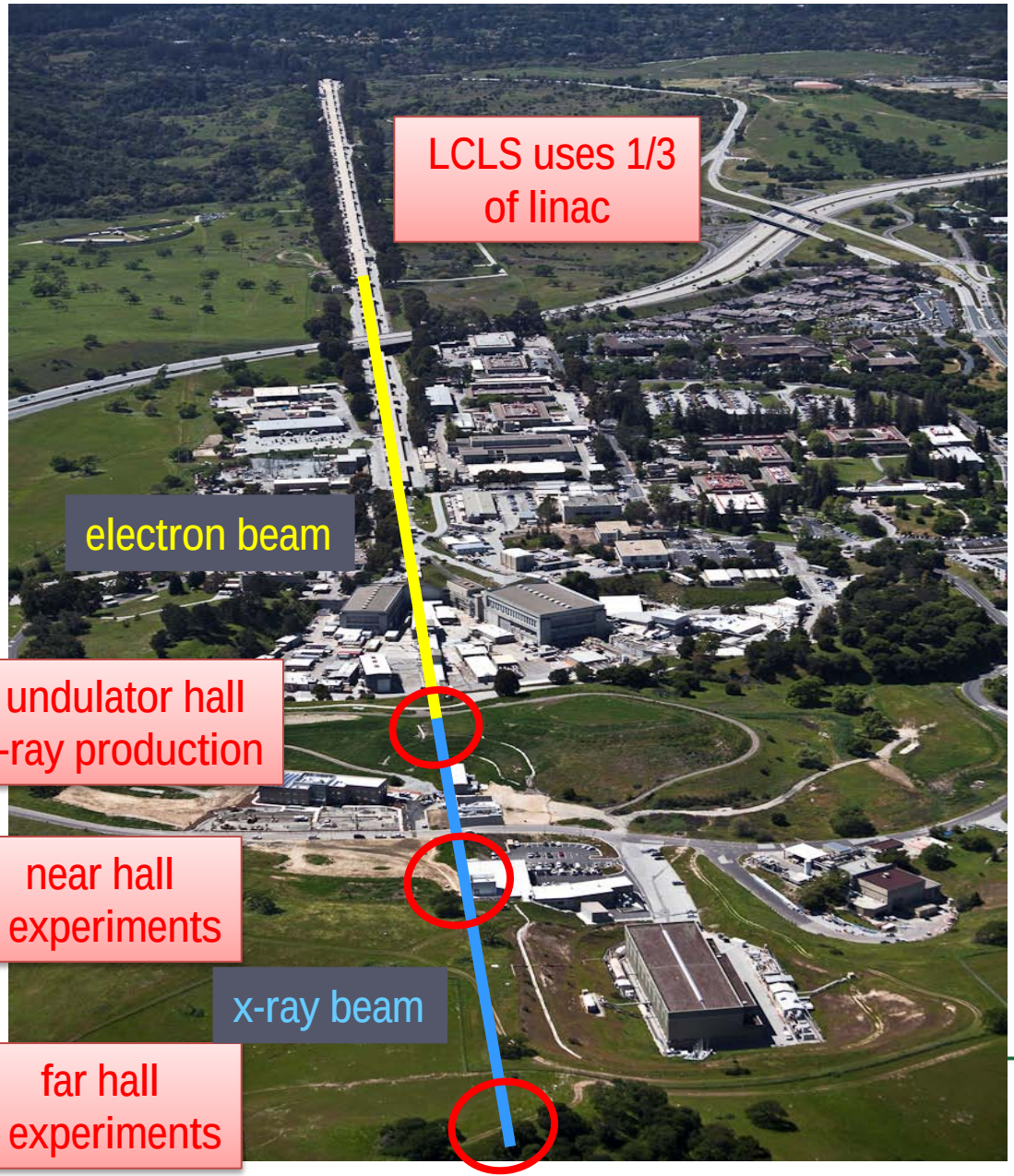
Platforms

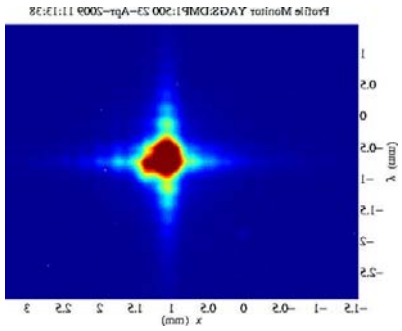
- Early prototypes to ensure component integration and usefulness
- Risk mitigation for vendors – Non recoverable engineering cost

Exascale Initiative

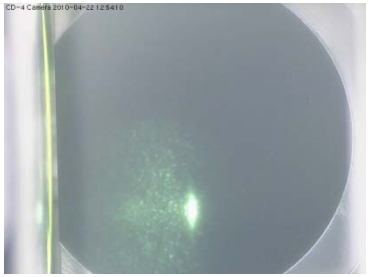
Linac Coherent Light Source or "LCLS" at SLAC

The World's First X-ray Laser





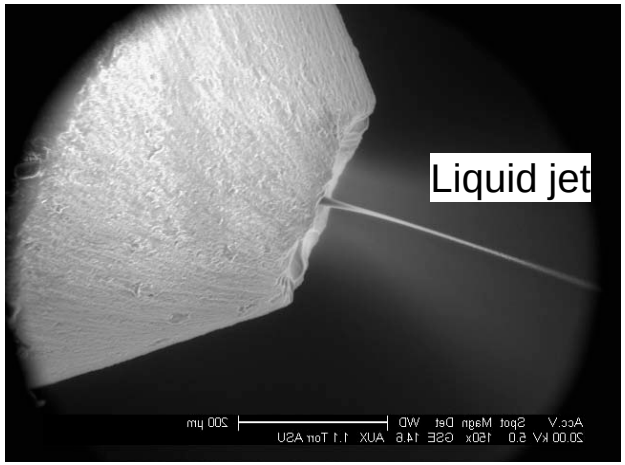
First X-rays: ~ 1 PM PDT 4/15/2009



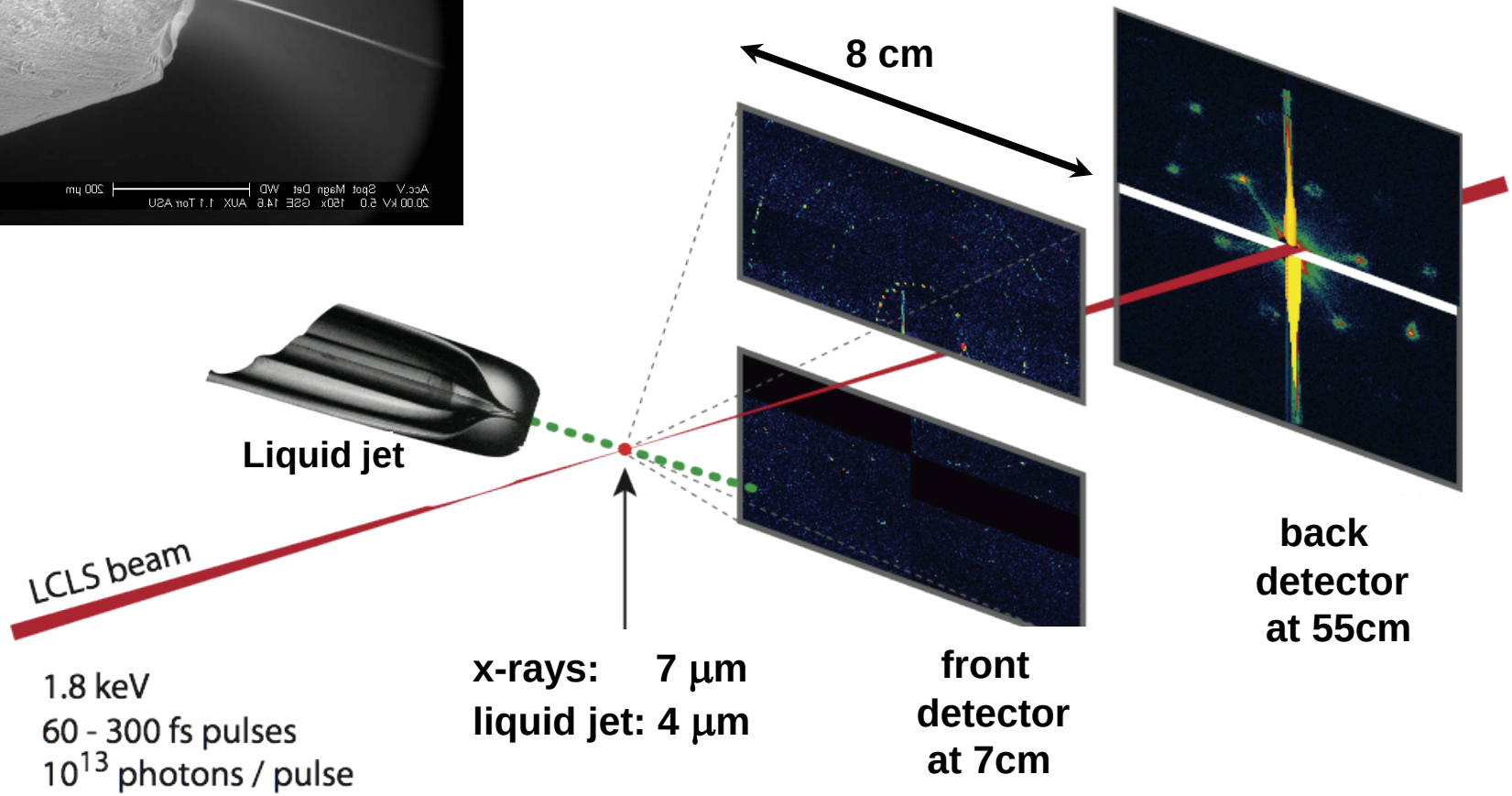
Detection of X-ray at Far Hall ~ 1 PM PDT 4/22/2010

Early Studies at LCLS: Nanocrystals in Water Microjet

John Spence et al. ASU

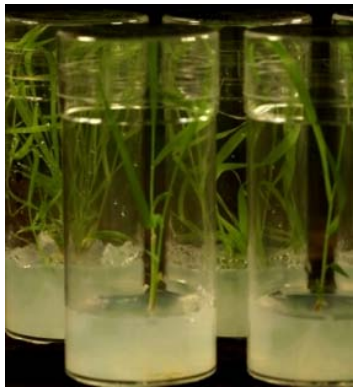


Spokesperson: **Henry Chapman** et al.
collaboration of
Center for Free Electron Laser Science DESY
Arizona State University, Max Planck CFEL
ASG, SLAC, LLNL, CBST, Uppsala University

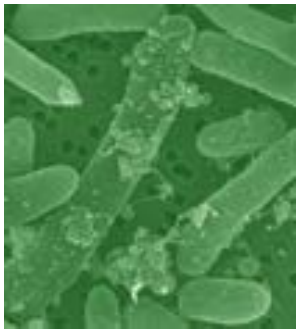


Bioenergy Research Centers: Recent Highlights

- Identification of key lignin biosynthesis genes in switchgrass, providing potential targets for improving switchgrass as a bioenergy crop.



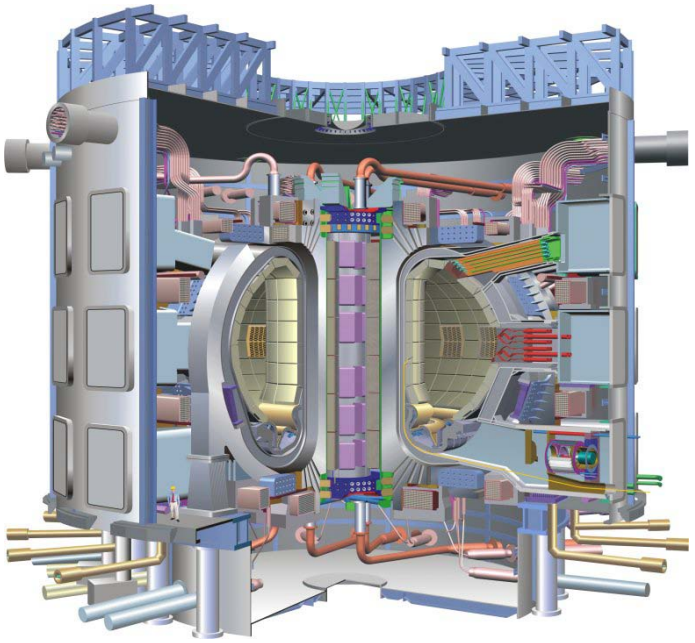
- Used synthetic biology toolkit to construct the first microbes to produce an advanced biofuel directly from biomass.



- Characterized soil microbial community structure to understand impacts of biomass crop growth on marginal lands

ITER

- ITER (Latin for “the way”) is a first of a kind major international research collaboration on fusion energy.
- U.S. is a 9.09% partner.
- ITER Goals
  - Designed to produce 500 MW of fusion power ($Q \geq 10$) for at least 300-500 seconds
  - *Burning plasma* dynamics and control
    - U.S. emphasizes the value of ITER, its flexibility, and its diagnostics as a scientific instrument: develop a predictive capability of the burning plasma state
  - Will optimize physics and integrate many of key technologies needed for future fusion power plants
- The *Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project*, entered into force in October 2007 for a period of 35 years.



ITER Tokamak – Cross Sectional View

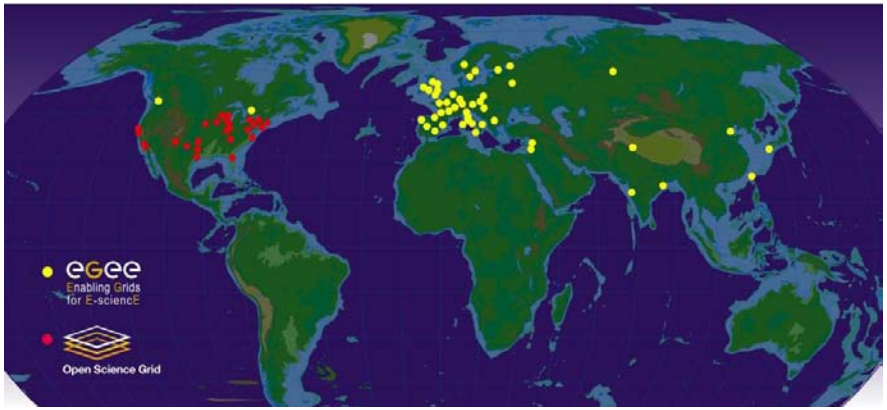
ITER Status

- Over the past year a scope, schedule and cost analysis has been completed.
- The EU and Japan agreed that if the EU gained approval for the additional funding they required to allow them to commit to the overall ITER project cost and schedule, the Japanese would agree to a change in the DG position. SC led effort in brokering this agreement and in helping the EU find ways to accelerate their schedule
- Dr. Osama Motojima (Japan) is the new DG. He led highly successful LHD stellarator construction and research institution in Japan.
- EU funding outlook now positive even amidst overall EU financial chaos. Their delegation is optimistic that EU is poised to commit € 6.6 B.
  - Represents a €600M decrease over the previous estimated costs.
  - Cost management imperative for all parties. US ITER Project Office (ORNL) undergone Lehman Reviews of project operations (February and July; favorable).
- Acceptance of ITER cost, schedule, and baseline, and leadership change occurred in late July Extraordinary Council meeting.

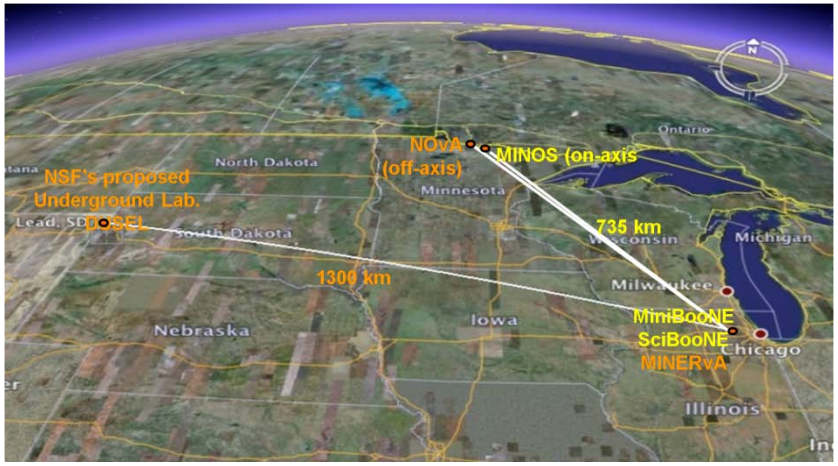
The U.S. High Energy Physics Program

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 world's most intense neutrino source at Fermilab, which serves MINERvA and MINOS and will support NOvA and the proposed LBNE (+$12,000K, HEP, initiated in FY 2011).

Accelerator Technology – Is it good enough?

- Long term waste storage needs dominated by actinides
- Fast Spectrum Reactors can burn actinides but require chemical processing
- Accelerator Driven Systems could allow the reduction of the actinides and burning of the spent fuel without chemical processing

Question: can accelerators be built with ~50MW of power in the beam and can associated targets be constructed

SBIR and STTR

- Continuous need for enhancing small businesses
- DOE-wide SBIR and STTR programs are managed by SC
- It is not a small program ~$150M/yr
- Steps are being taken to strengthen program

→ **Moved up to report to Deputy Director in SC**
→ **Enhancing office to make it more effective**
→ **Strengthening involvement of DOE executive management**

http://www.science.doe.gov/sbir/

DOE Office of Science Graduate Fellowships

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

$10 million is needed to FY 2011 to fund 150 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 and to couple the fellows into the Departments research

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:

- 150 awards were announced this summer using 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