Adventures on Science

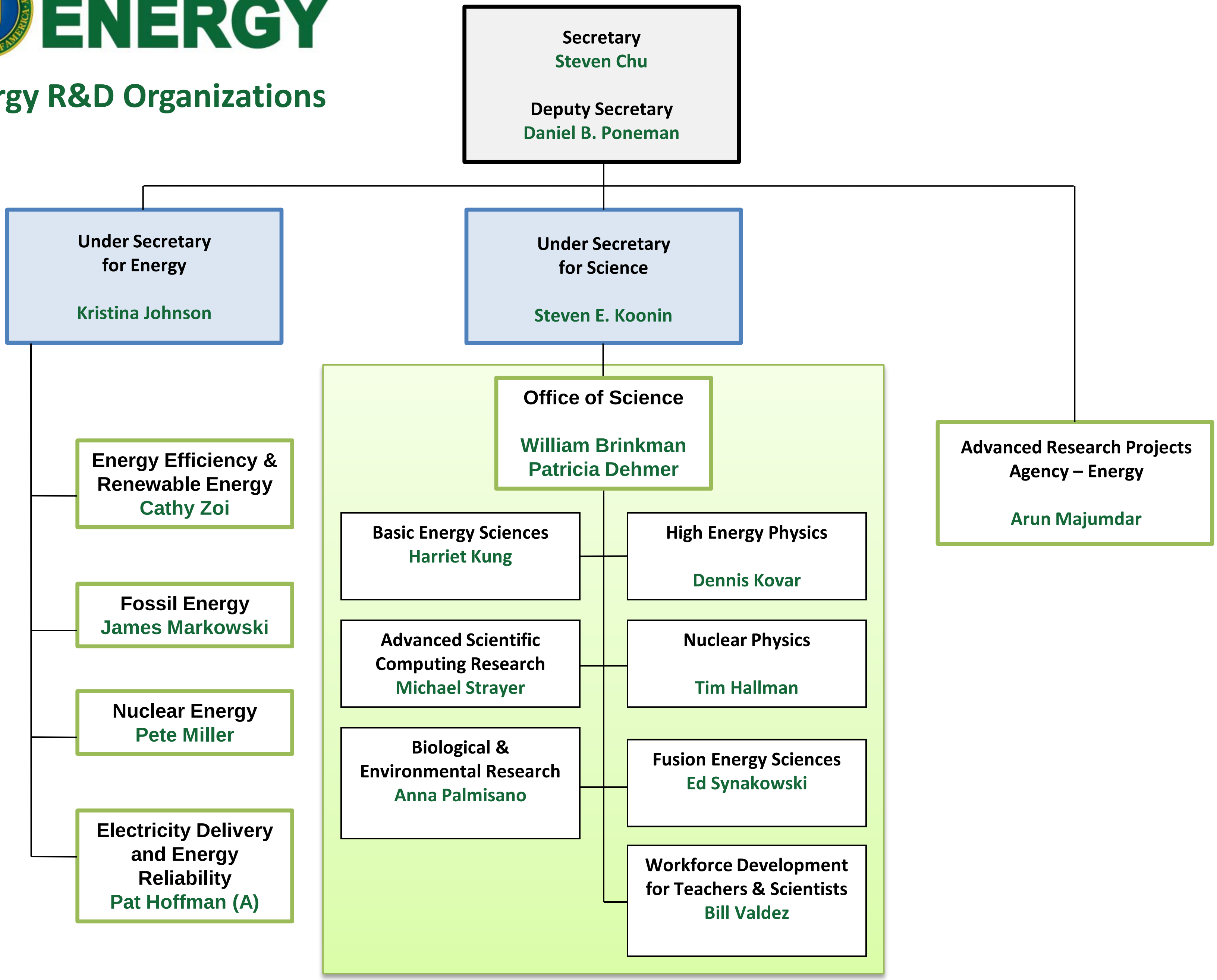
Bill Brinkman

Director, Office of Science

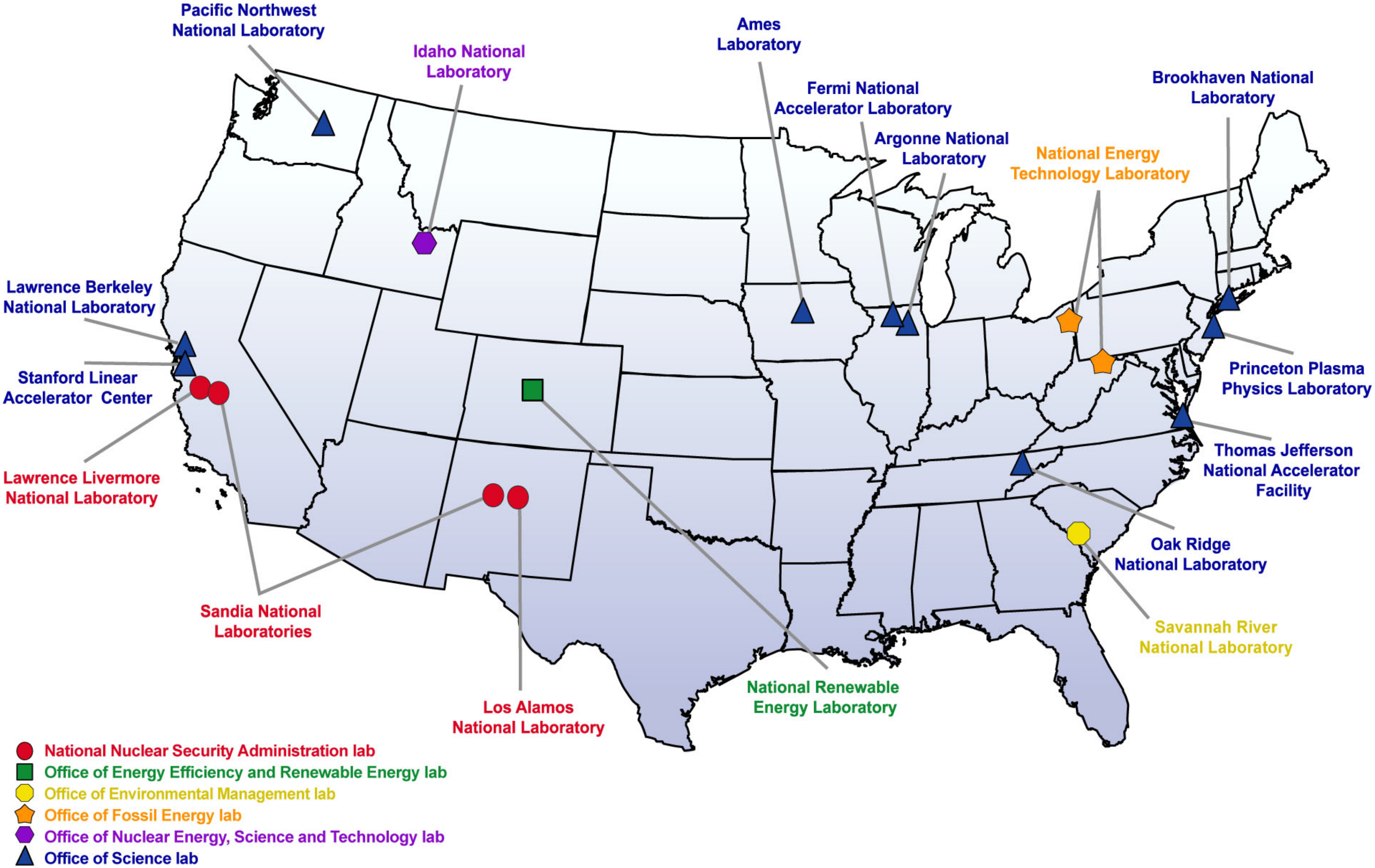
August 9, 2010

U.S. DEPARTMENT OF ENERGY

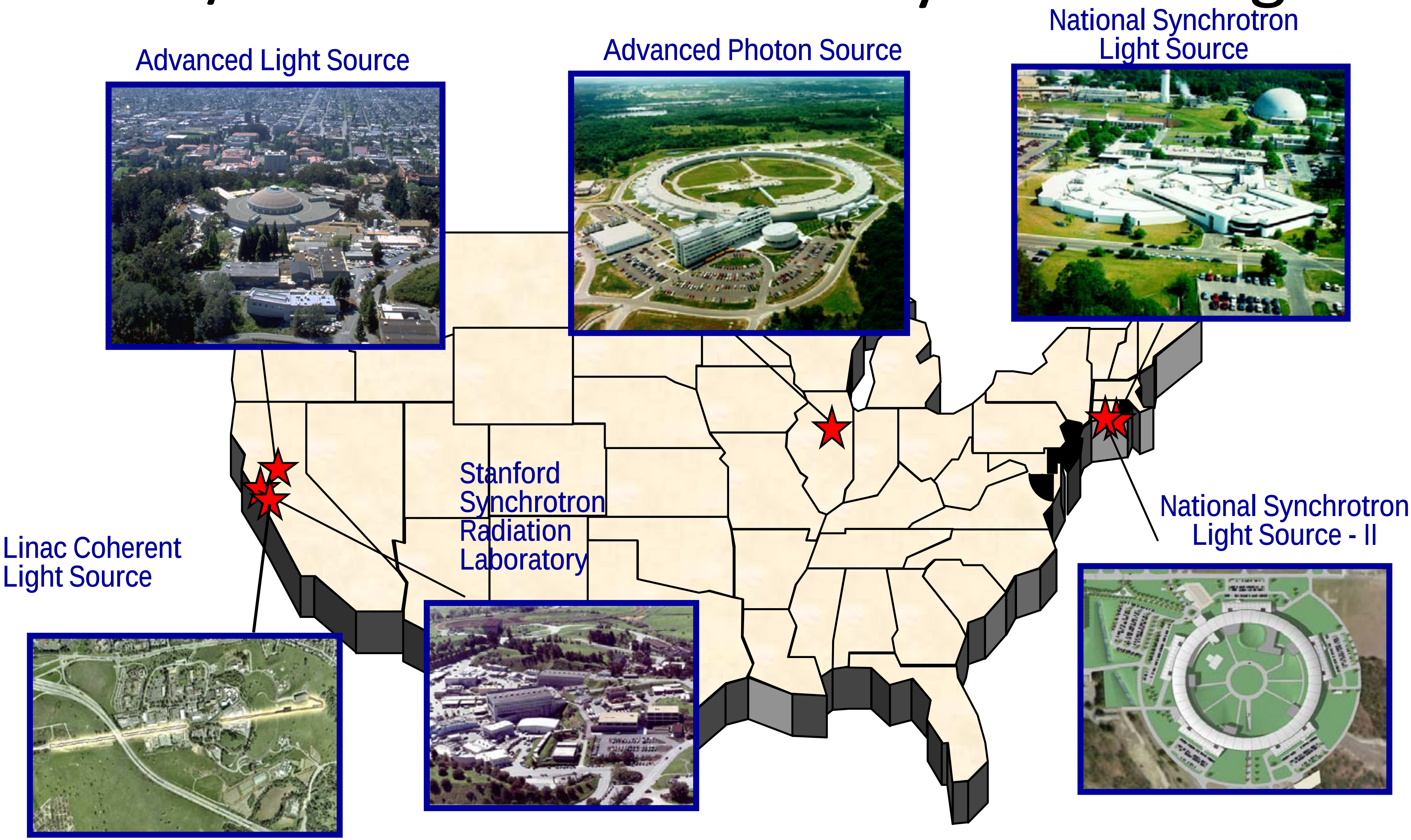
Energy R&D Organizations



DEPARTMENT OF ENERGY NATIONAL LABORATORIES

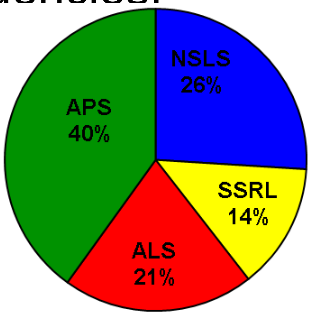


SC/BES Facilities for X-ray Scattering

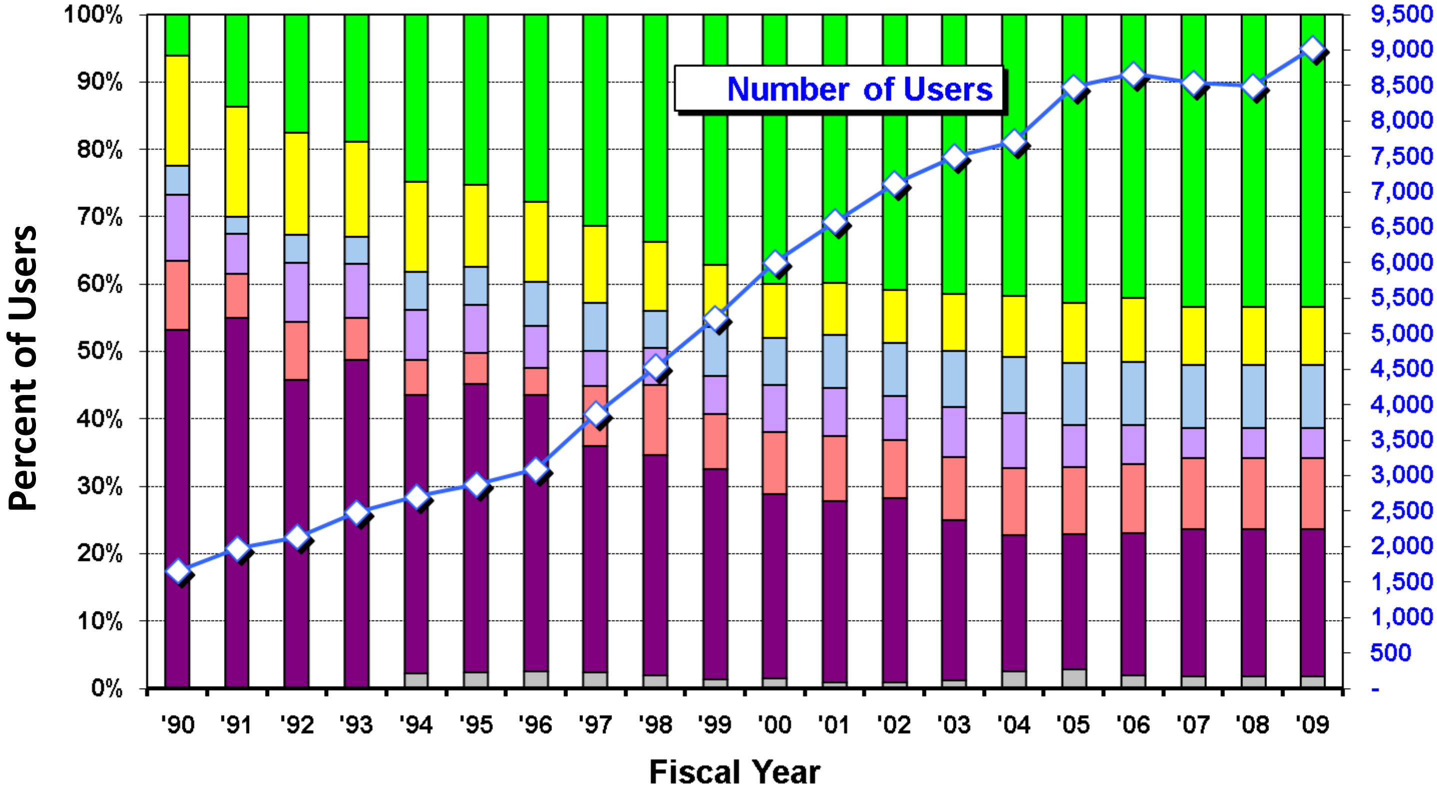


Number of Users by Discipline at SC/BES Light Sources

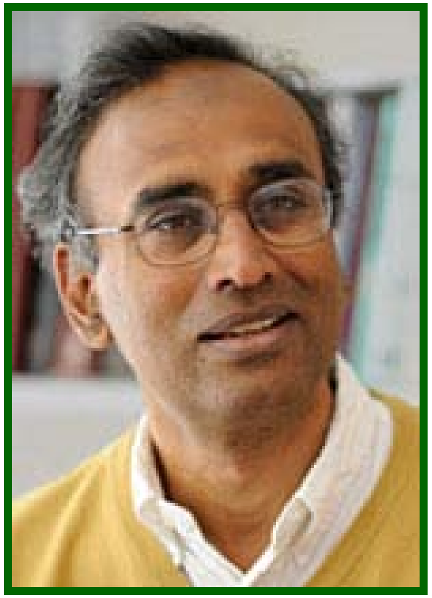
BES provides complete support for the operations of the facilities as well as being the dominant supporter of light source research, including funds for beamlines, instruments, and PI support. Many other agencies, industries, and private sponsors provide support for instrumentat

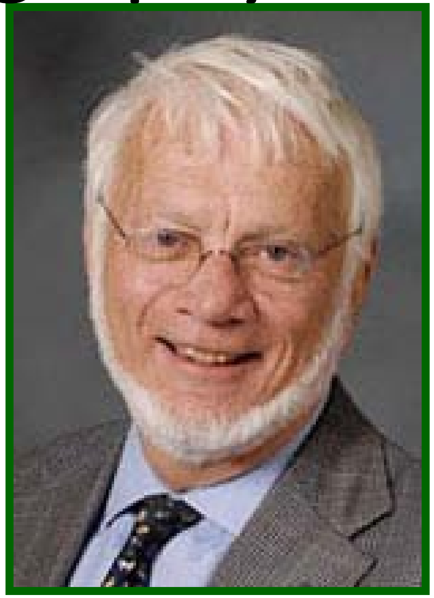


FY 2008



2009 Nobel Prize in Chemistry based on X-ray Crystallography



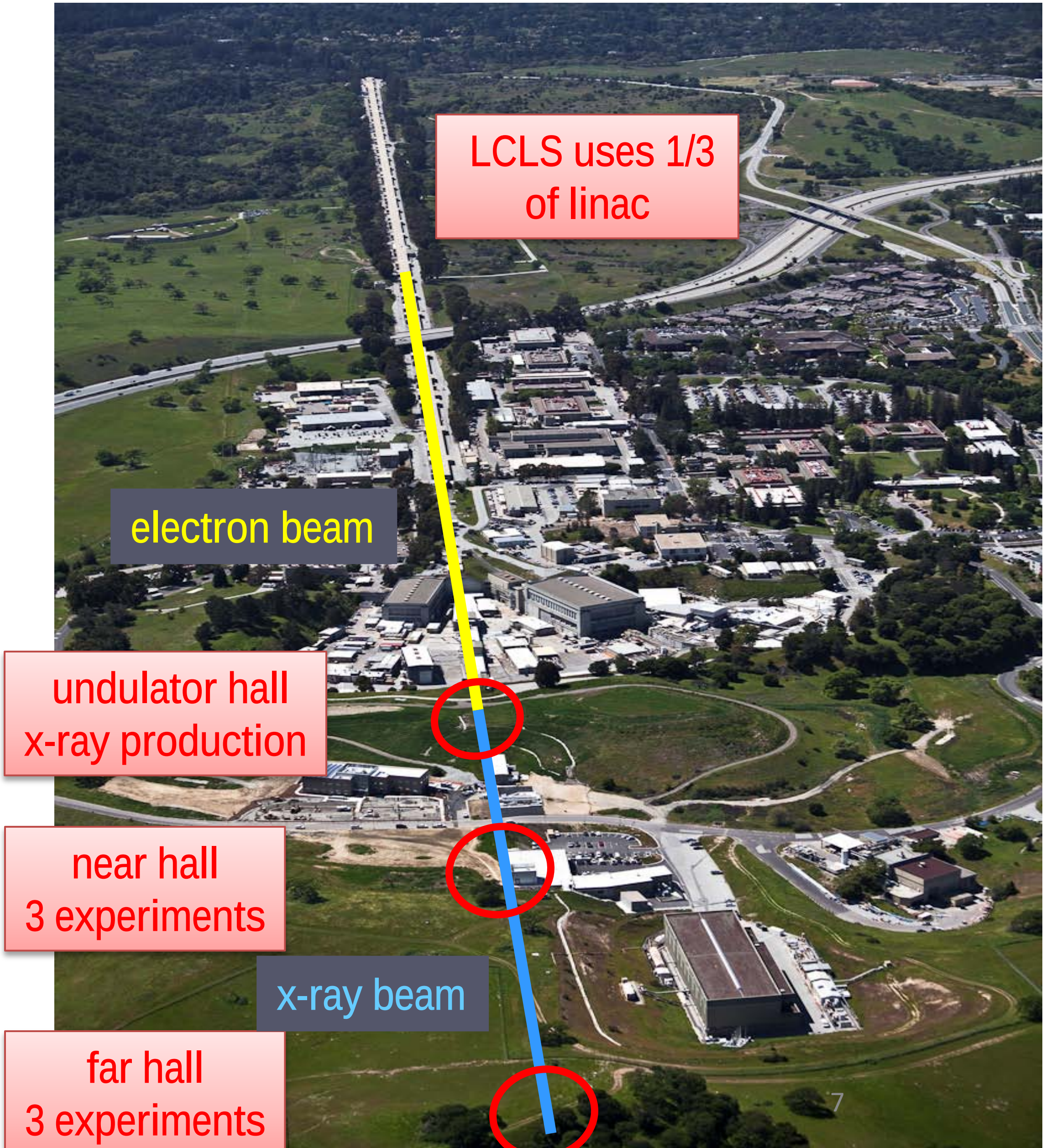


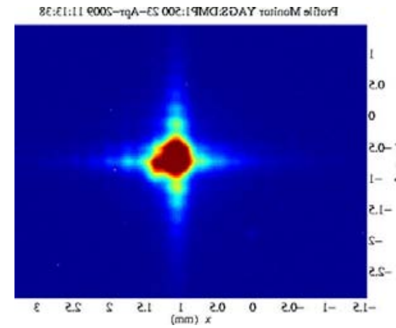
Venkatraman Ramakrishnan   Ada Yonath   Thomas Steitz

- Three molecular biologists who mapped the structure and inner workings of the ribosome — the cell's machinery for churning out proteins from the genetic code — have won the Nobel Prize in Chemistry in 2009.
- Venkatraman Ramakrishnan, who works at the Medical Research Council's Laboratory of Molecular Biology in Cambridge, UK; Ada Yonath of the Weizmann Institute of Science in Rehovot, Israel, and Thomas Steitz at Yale University in New Haven, Connecticut, share the prize equally.

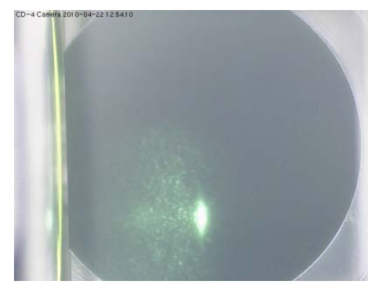
Linac Coherent Light Source or “LCLS” at SLAC

The World’s First X-ray Laser





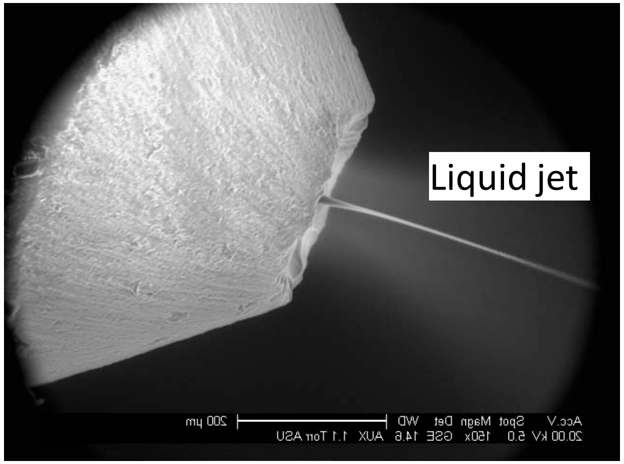
First X-rays:
~ 1 PM PDT
4/15/2009



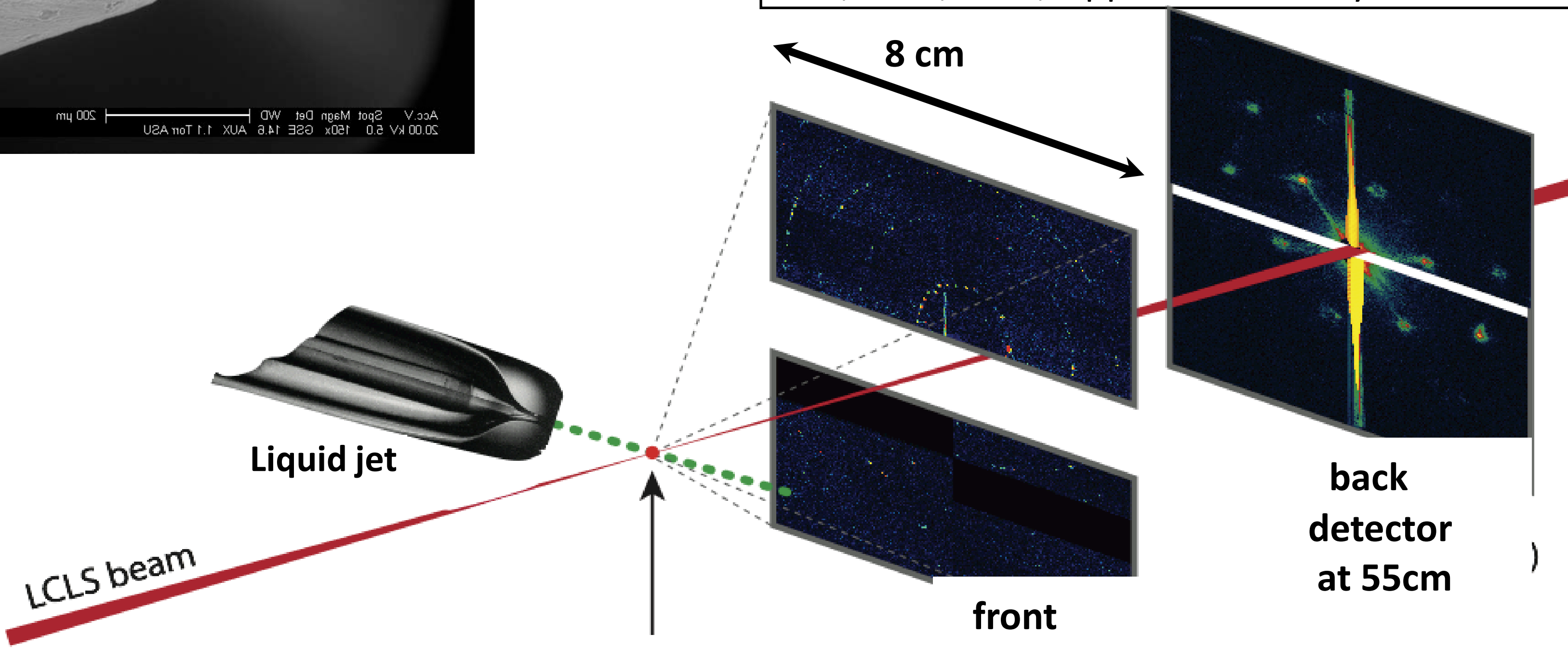
Detection of
X-ray at Far
Hall ~ 1 PM
PDT 4/22/2010

Early Studies at LCLS: Nanocrystals in Water Microjet

John Spence et al. ASU



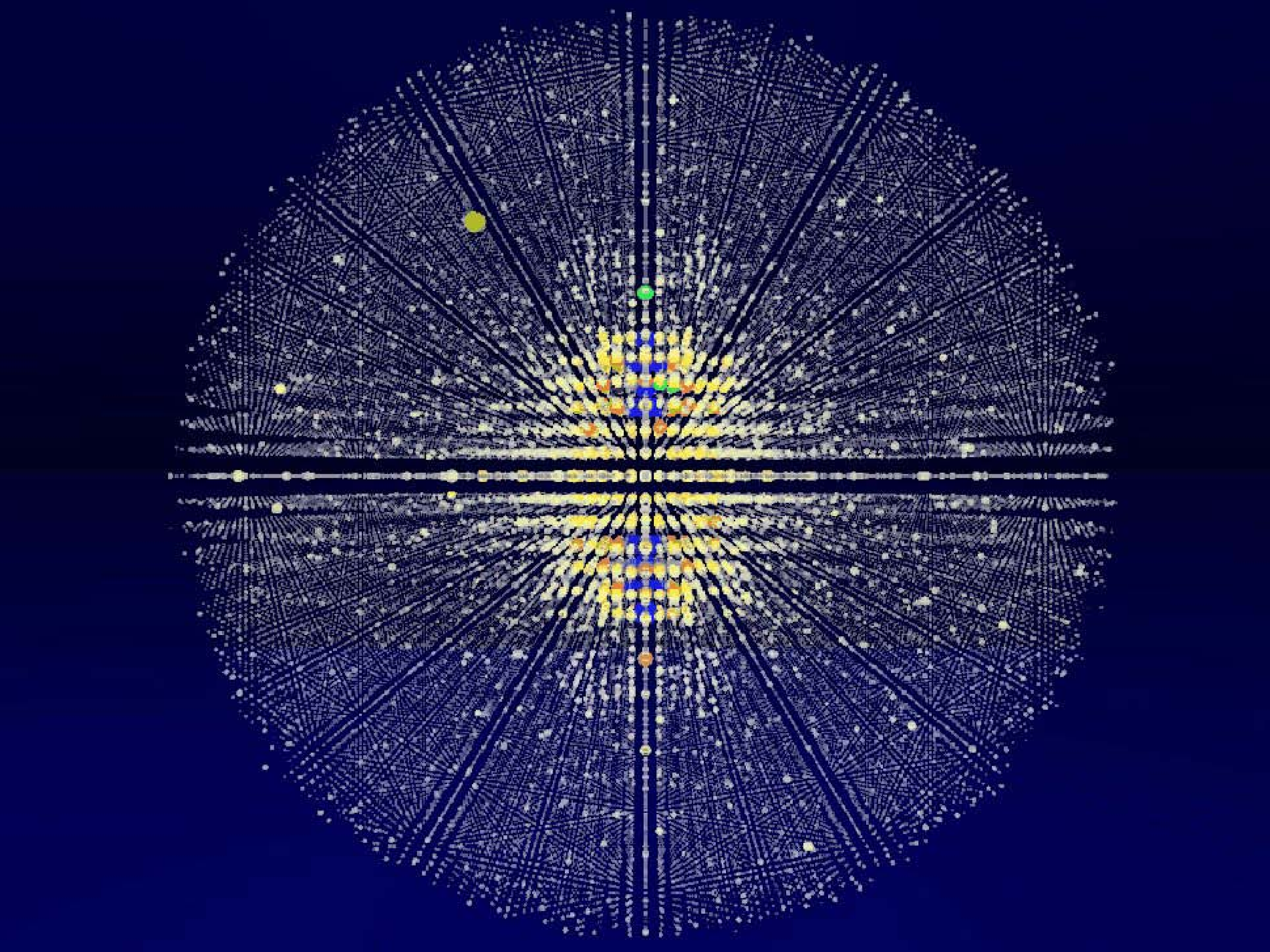
Spokesperson: **Henry Chapman** et al.
collaboration of
Center for Free Electron Laser Science DESY
Arizona State University, Max Planck CFEL ASG,
SLAC, LLNL, CBST, Uppsala University



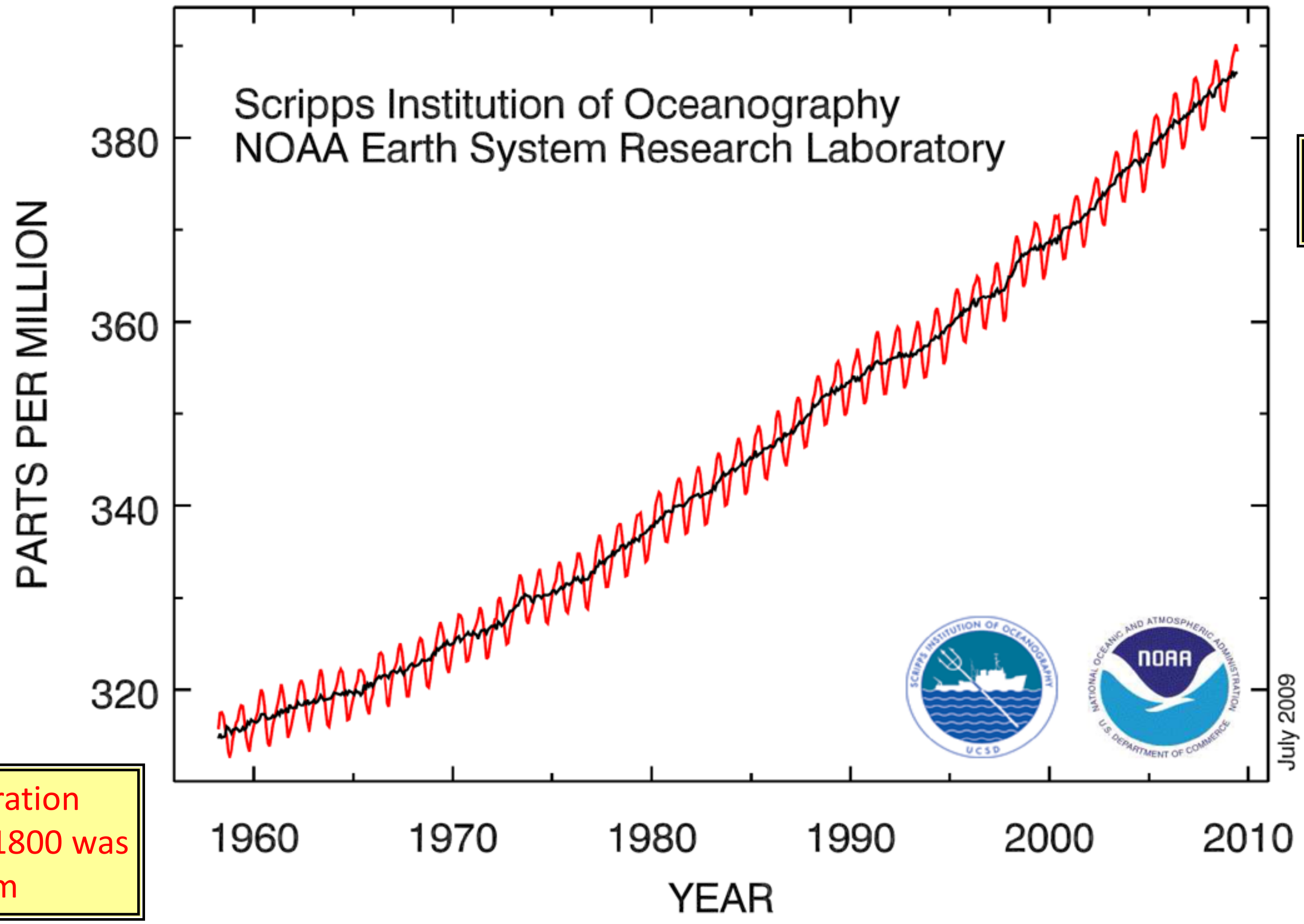
front detector at 7cm

1.8 keV
60 - 300 fs pulses
10^{13} photons / pulse

x-rays: 7 µm
liquid jet: 4 µm



Atmospheric CO_2 at Mauna Loa Observatory



Concentration now ~388 ppm

Concentration prior to 1800 was ~280 ppm

Greenland Ice Mass Loss
2002 to 2009

Increasing rates of ice mass loss from the Greenland and Antarctic ice sheets revealed by GRACE (Gravity Recovery and Climate Experiment) satellite:

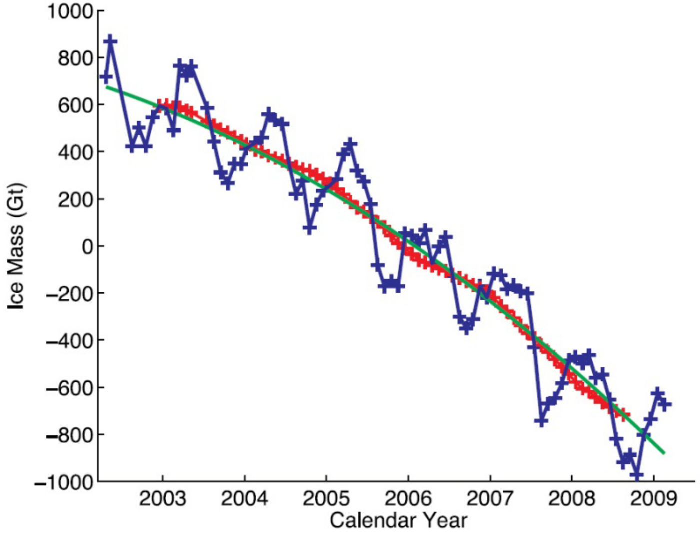
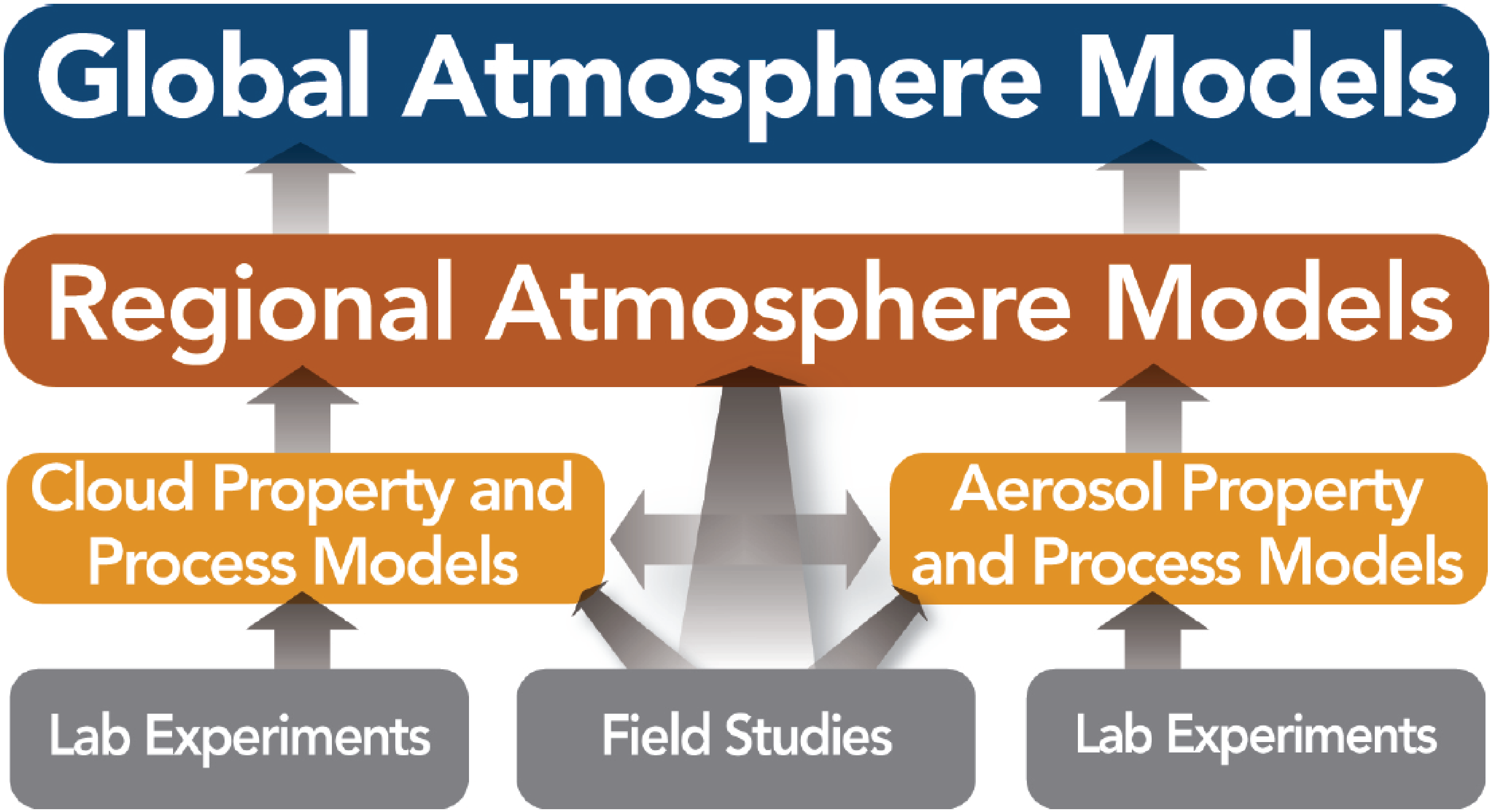


Figure 1. Time series of ice mass changes for the Greenland ice sheet estimated from GRACE monthly mass solutions for the period from April 2002 to February 2009. Unfiltered data are blue crosses. Data filtered for the seasonal dependence using a 13-month window are shown as red crosses. The best-fitting quadratic trend is shown (green line). The GRACE data have been corrected for leakage and GIA.

I. Velicogna, *Geophysical Research Letters*, VOL. 36, L19503, 2009

- In Greenland, the mass loss increased from 137 Gt/yr in 2002–2003 to 286 Gt/yr in 2007–2009
- In Antarctica, the mass loss increased from 104 Gt/yr in 2002–2006 to 246 Gt/yr in 2006–2009

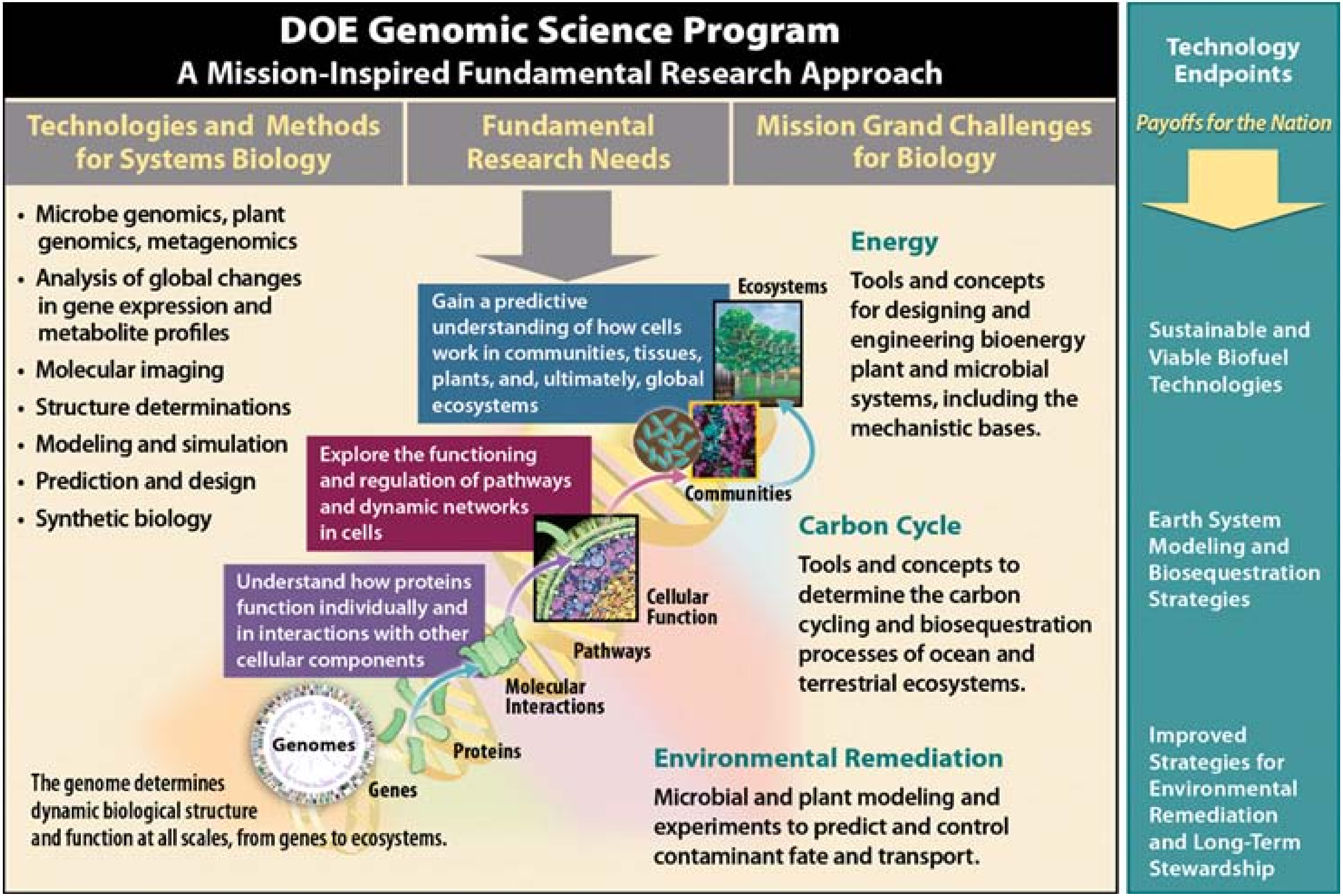
Reducing uncertainties in climate predictions
Atmospheric System Research



Terrestrial Ecosystem Research (Carbon Cycle)

- Advances the fundamental science concerning the effects of climate change on terrestrial ecosystems and the role of terrestrial ecosystems in global carbon cycling.

- Plans are proceeding for the next generation ecosystem experiment (arctic tundra warming) with infrastructure prototype development underway.


DOE Genomic Science Program
A Mission-Inspired Fundamental Research Approach
Technologies and Methods for Systems Biology
Fundamental Research Needs
Mission Grand Challenges for Biology
Technology Endpoints
Payoffs for the Nation
• Microbe genomics, plant genomics, metagenomics
• Analysis of global changes in gene expression and metabolite profiles
• Molecular imaging
• Structure determinations
• Modeling and simulation
• Prediction and design
• Synthetic biology
Gain a predictive understanding of how cells work in communities, tissues, plants, and, ultimately, global ecosystems
Explore the functioning and regulation of pathways and dynamic networks in cells
Understand how proteins function individually and in interactions with other cellular components
Ecosystems
Communities
Cellular Function
Pathways
Molecular Interactions
Proteins
Genomes
Genes
The genome determines dynamic biological structure and function at all scales, from genes to ecosystems.
Energy
Tools and concepts for designing and engineering bioenergy plant and microbial systems, including the mechanistic bases.
Carbon Cycle
Tools and concepts to determine the carbon cycling and biosequestration processes of ocean and terrestrial ecosystems.
Environmental Remediation
Microbial and plant modeling and experiments to predict and control contaminant fate and transport.
Sustainable and Viable Biofuel Technologies
Earth System Modeling and Biosequestration Strategies
Improved Strategies for Environmental Remediation and Long-Term Stewardship

DOE Bioenergy Research Centers

The DOE Bioenergy Research Centers

- New paradigm for research—single focus, multi-disciplinary, team-based transformational science
- BioEnergy Science Center (ORNL)
  - Multi-institutional partnership with strategic focus on overcoming biomass "recalcitrance" as route to cost-effective cellulosic biofuels
  - Goal of "Consolidated Bioprocessing" – one-microbe or microbial community approach going from plants to fuel
- Great Lakes Bioenergy Research Center (U. W.-Madison, Mich State U)
  - Goal of re-engineering plants to produce more starches and oils
  - Using HTP technologies to optimize chem/bio process for biomass deconstruction
  - Major research thrust on sustainability of biofuels
- Joint BioEnergy Institute (led by LBNL)
  - Experimenting with new pretreatment process using room temperature ionic liquids
  - Beyond cellulosic ethanol: re-engineering *E.coli* and yeast to produce hydrocarbons – goal of "green" gasoline, diesel, jet fuel

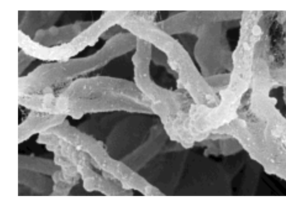
jbei Joint BioEnergy Institute

GREAT LAKES BIOENERGY RESEARCH CENTER

BESC BioEnergy Science Center

The DOE Joint Genome Institute

A User Resource for the Biological Sciences

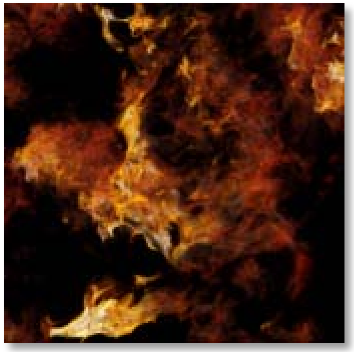


- Using high throughput tools, technologies and comparative analysis, the JGI serves as a discovery platform to understand the organization and function of complex genomes for bioenergy, carbon cycle, and bioremediation.
- Genome and metagenome expression and sequencing of microbes, plants, and other complex systems, such as microbial communities or the rhizosphere.
- Genome annotation, functional analysis and verification of genome-scale biological system models. Systems-level integration and validation of genomic data from multiple sequencing and functional analyses.
- Sequencing more than 4 Terabases per year (more than 1300 human genome equivalents)

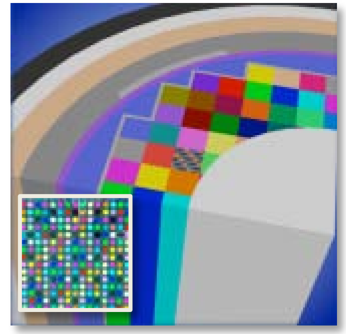
JGI
DOE JOINT GENOME INSTITUTE
US DEPARTMENT OF ENERGY
OFFICE OF SCIENCE

DOE Joint Genome Institute
Enabling Advances in Bioenergy & Environmental Research

Leadership Computing: Scientific Advances

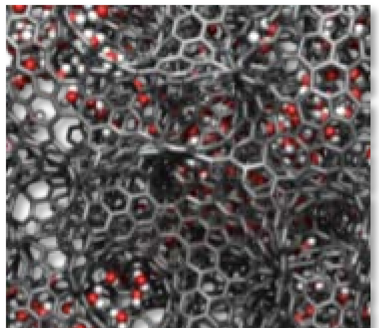


Turbulence
Understanding the statistical geometry of turbulent dispersion of pollutants in the environment.

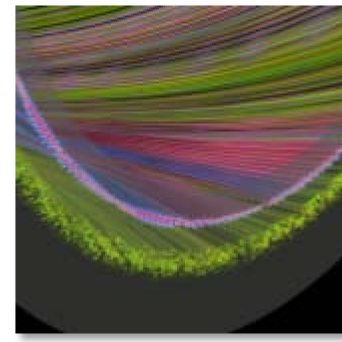


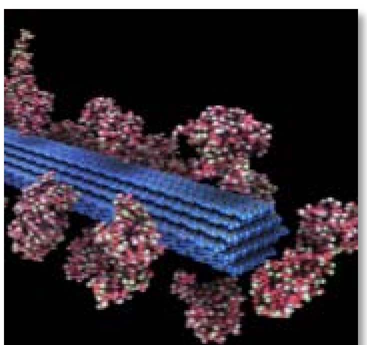
Nuclear Energy
High-fidelity predictive simulation tools for the design of next-generation nuclear reactors to safely increase operating margins.

Energy Storage
Understanding the storage and flow of energy in next-generation nanostructured carbon tube supercapacitors

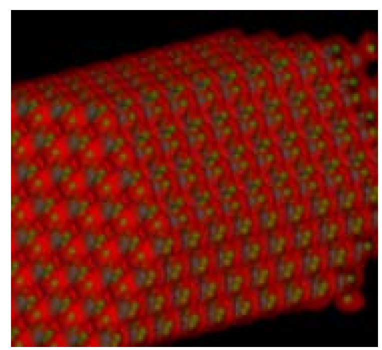


Fusion Energy
Substantial progress in the understanding of anomalous electron energy loss in the National Spherical Torus Experiment (NSTX).





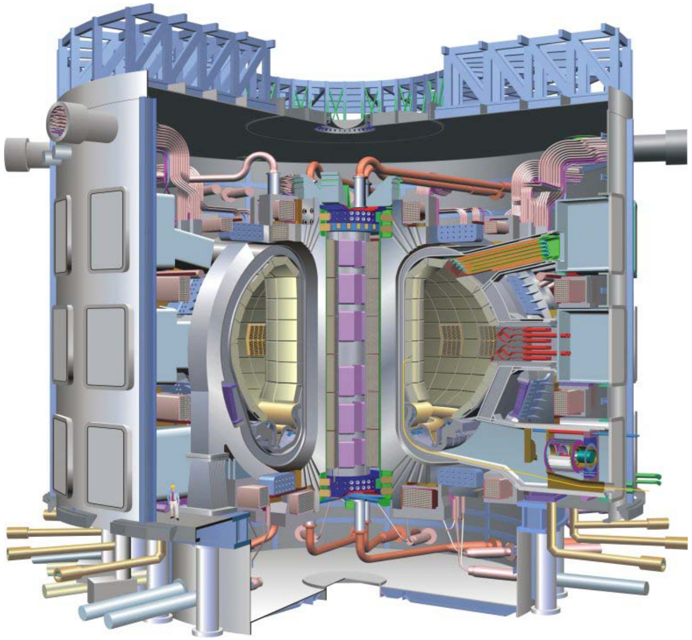
Biofuels
A comprehensive simulation model of lignocellulosic biomass to understand the bottleneck to sustainable and economical ethanol production.



Nano Science
Understanding the atomic and electronic properties of nanostructures in next-generation photovoltaic solar cell materials.

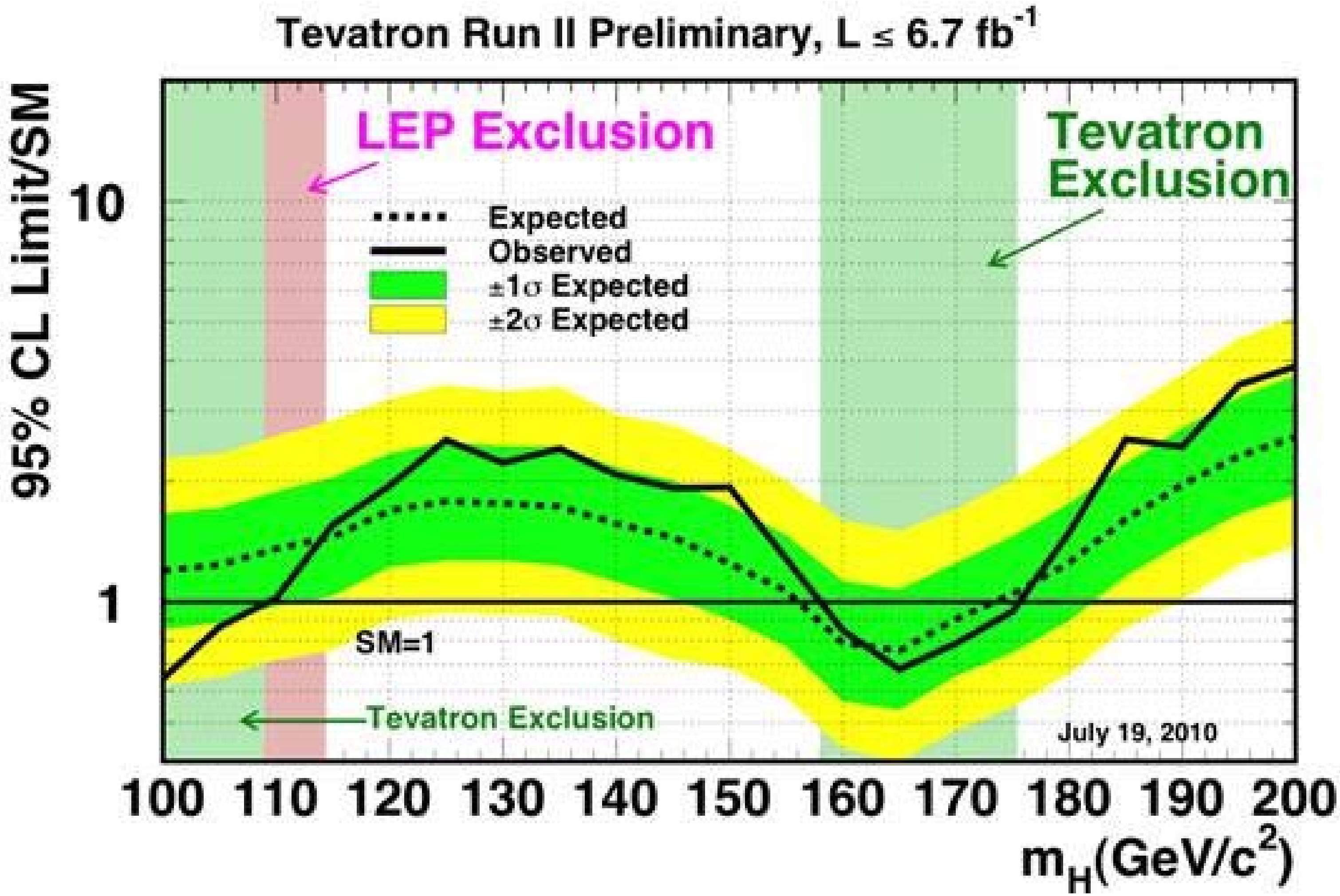
ITER

- 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 > 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

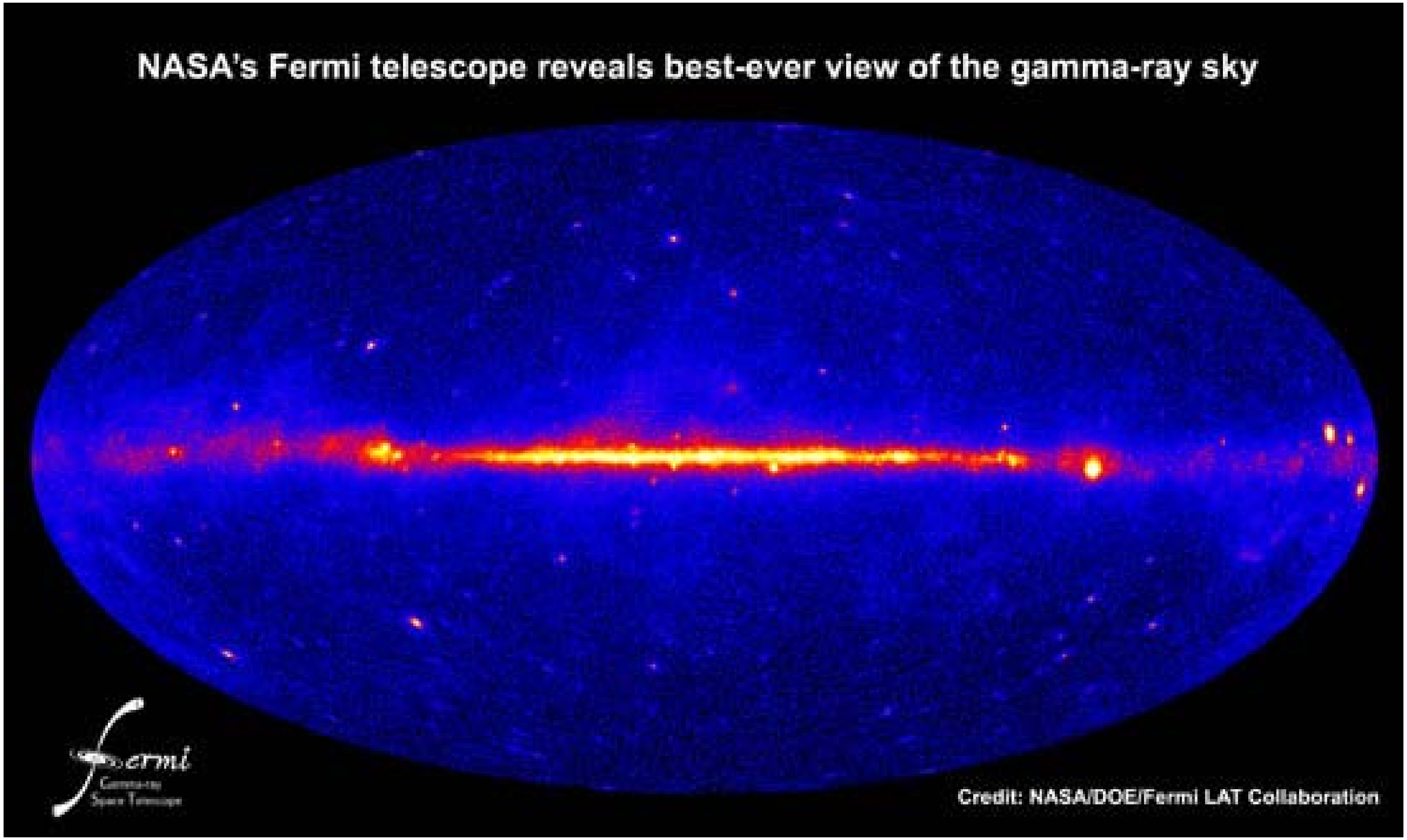


ITER Tokamak – Cross Sectional View

The search for the Higgs



Gamma ray view of the sky



Einstein said “The most incomprehensible thing about the world is that it is comprehensible”

This comprehensibility is true beauty of science, it is what we scientist most admire