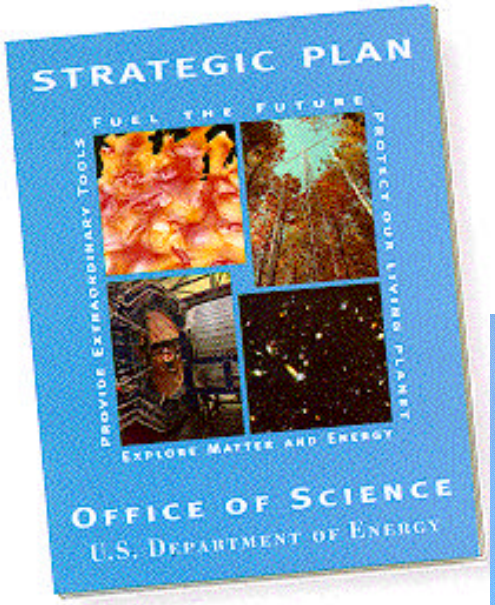
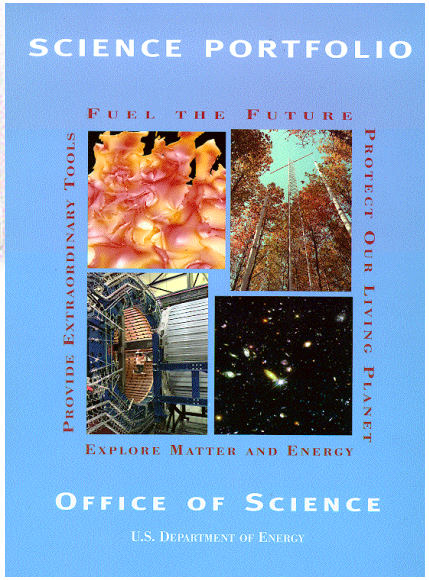


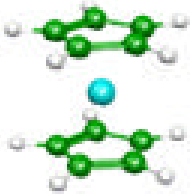

**THE MISSION OF THE OFFICE OF SCIENCE**

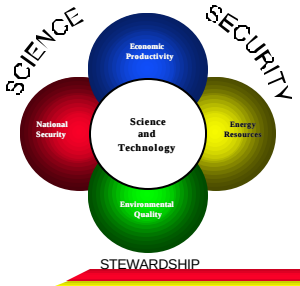
is to advance basic research and the instruments of science that are the foundations for DOE's applied missions, a base for U.S. technology innovation, and a source of remarkable insights into our physical and biological world and the nature of matter and energy.

# Planning in the DOE Office of Science

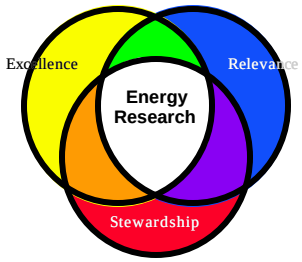
Bob Vallario
Office of Science
U.S. Department of Energy

*November 17, 1999*






# S&T Strategic Goals
# *Planning Background*




## DOE Plan '94 (Goals)

- Provide the science and technology core competencies that enable DOE's other business to succeed in their missions.
- Provide new insights into the nature of matter and energy, addressing challenging problems, and create a climate in which breakthroughs occur.
- Construct leading-edge experiments and user facilities on schedule, within budget, and in a safe and environmentally responsible manner.
- Add value to the U.S. economy through the application of new and improved technologies.
- Help provide a technically trained and diverse workforce for the Nation & enhance U.S. scientific literacy, especially in energy, and the environment, and the impact of science on the economy.

## ER Plan '95 (Goals)

- Advance sustainable energy production and use, economic growth, and a healthy citizenry through research and technology transfer, leading to new & improved technologies.
- Understand and anticipate environmental effects of energy production and use, and develop advanced products, processes and technologies to improve environmental quality.
- Provide new insights into the nature of energy and matter to better understand our natural world.
- Develop Fusion as a cost-effective, publicly acceptable energy technology for sustainable development
- Sustain scientific leadership and improve U.S. competitiveness by providing world class scientific facilities and DOE laboratories, with an adequate infrastructure.
- Advance the National Information Infrastructure by developing & demonstrating new information technologies for DOE applications.
- Ensure ER's programs are managed to increase quality, more efficiently use human and material resources, and sustain protection of the environment and the health and safety of workers and the public.
- Ensure that ER activities, results and benefits are widely known, valued and trusted.
- Increase the effectiveness of U.S. investments in research programs and facilities through interagency and international cooperation and collaboration.
- Strengthen the S&T capability and promote the diversity of the Nation's work force.

## DOE Plan '97 (Goal)

- Deliver the scientific understanding and technological innovations that are critical to the success of DOE's mission and the Nation's science Base.
- Objectives:
  - Develop the science that underlies DOE's long-term mission
  - Deliver leading-edge technologies that are critical to the DOE mission and the Nation.
  - Improve the management of DOE's research enterprise to enhance the delivery of leading-edge science and technology at reduced costs.
  - Assist in the government-wide effort to advance the Nation's science education and literacy.

# A Guiding Perspective in SC's New Approach

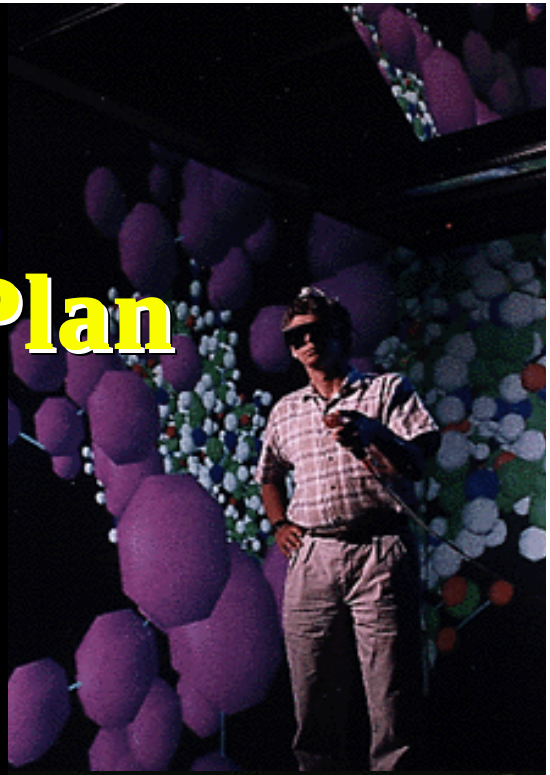
"Strategic planning isn't strategic thinking. One is analysis and the other is synthesis… Planners should make their contribution around the strategy-making process rather than inside it."

Henry Mintzberg
"The Fall and Rise of Strategic Planning"
Harvard Business Review

# A New Look at the Office of Science Present & Future

- Illustrate the Unique Role of SC Programs Within DOE Missions and the Federal Science Investment
- Develop a Shared Long-term Focus for SC Programs, Their Scientific Communities and Performers
- Position Our Current Scientific Program Content and Project Future Possibilities
- Provide a Framework for Cooperation & Risk Taking
- Inform and Inspire Our Sponsors and the General Public

# Office of Science Strategic Plan
## *Science for the Future*

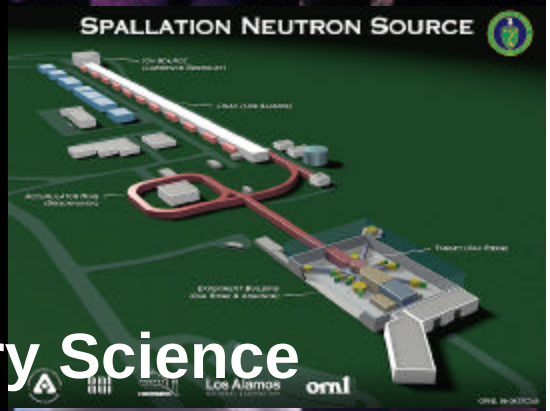


**Fuel the Future**
*Science for Clean and Affordable Energy*

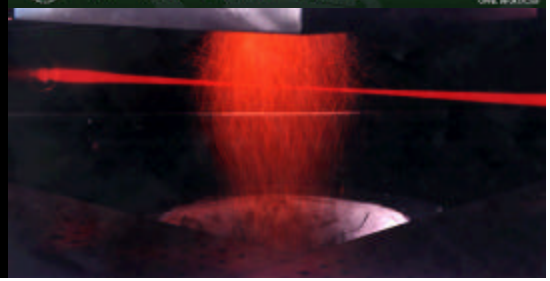
**Protect Our Living Planet**
*Energy Impacts on People and the Biosphere*

**Explore Matter and Energy**
*Building Blocks from Atoms to Life*

**Provide Extraordinary Tools for Extraordinary Science**
*National Assets for Multidisciplinary Research*




**Manage as Stewards of the Public Trust**
*Scientific and Operational Excellence*



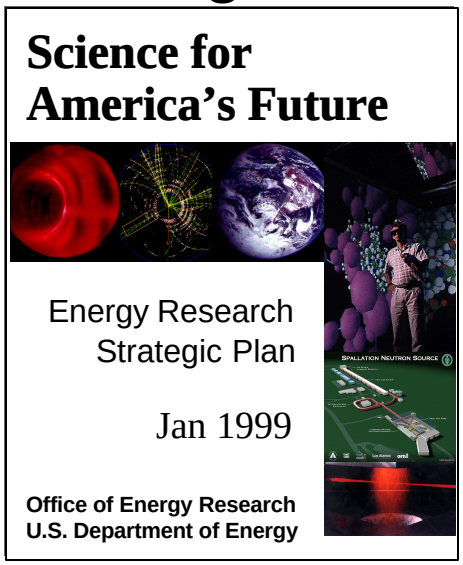
# Where We Go Next

*From the Second Science Strategic Planning Workshop - August 1998*

## Framework

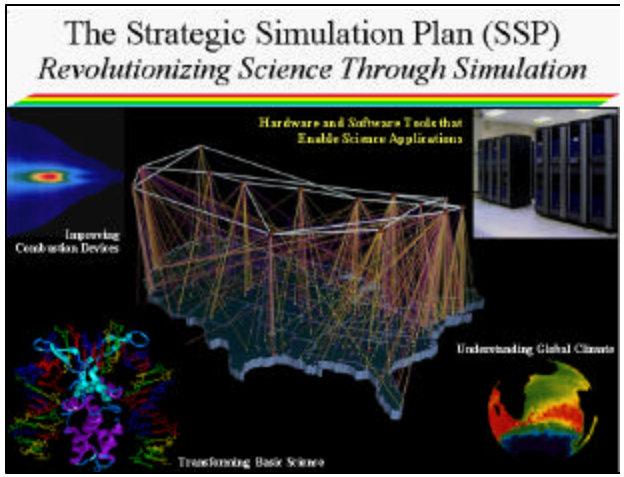
- Themes →
- Questions →
- Campaigns (Samples)

## Strategic Plan




- Science Goals
- Operational Goals
- Objectives
- Strategies
- Investigations (Samples)
- Success Measures

## Science Roadmaps




- Investigations, Priorities, Connections, Timeframes, Contingencies, and Uncertainties

# DOE Science Strategic Plan and R&D Portfolio Framework

*Office of Science Themes Development*

*Office of Science Strategic Plan*

## *Science Portfolio Framework*

### Fueling the Future
*Affordable Clean Energy*

- New Fuels
  - BES
  - BER
- Clean and Affordable Power
  - BES
  - FES
- Efficient Energy Use
  - BES

### Protecting Our Living Planet
*Energy Impacts*

- Source & Fate of Energy Byproducts
  - BES
  - BER
- Impacts on People & the Environment
  - BER
- Prevention & Protection
  - BES
  - BER

### Exploring Energy & Matter
*From Atoms to Life*

- Components of Matter
  - HEP
  - NP
  - BES
  - BER
- Origins & Fate of the Universe
  - HEP
  - NP
- Complex Systems
  - BES
  - BER
  - FES
  - CTR

### Extraordinary Tools for Extraordinary Science
*Facilities and Instrumentation*

- Instrumentation for the frontiers of science
  - ALL SC
- Scientific Simulation
  - ALL SC
- Institutional Capacity
  - ALL SC

### Enabling World Class Science
*Stewards of Public Trust*

- Excellence & Mission Relevance
  - ALL SC
- Protect Workers, Public & Environment
  - ALL SC
- Management Effectiveness & Efficiency
  - ALL SC

# Matching the Office of Science Strategic Plan and R&D Portfolio

| Goals | Fueling the Future | Protecting our Living Planet | Exploring Energy and Matter | Extraordinary Tools for Extraordinary Science |
|---|---|---|---|---|
| **Objectives** | • New fuels<br>• Clean & affordable power<br>• Efficient energy use | • Source & fate of energy byproducts<br>• Impacts on people & the environment<br>• Prevention & protection | • Components of matter<br>• Origins and fate of the Universe<br>• Complex systems | • Instrumentation for the frontiers of science<br>• Scientific simulation<br>• Institutional capacity |
| **Strategies** | – Solar energy conversion<br>– Plant & microbial research<br>– Geosciences<br>– Materials chemistry<br>– Plasma science & fusion research<br>– Condensed matter physics<br>– Metal & ceramic sciences<br>– Energy production, storage & transmission<br>– Combustion research<br>– Advanced materials<br>– Engineering sciences<br>– Catalysis & chemical transformations | – Sources & transport in the biosphere<br>– Chemical interactions & transformations<br>– Human health impacts & risks<br>– Ecosystem responses<br>– Regional & global consequences<br>– Pollution minimization<br>– Cleanup & remediation<br>– Carbon sequestration<br>– Health protection -- regulation & medicine | – Elementary particles and their interactions<br>– Nuclear matter & interactions<br>– Atoms and molecules<br>– Bio-molecular building blocks<br>– Beginning of the cosmos<br>– Creation of nuclei and matter<br>– Evolution of astrophysical structures<br>– Formation of life<br>– Collective phenomena<br>– Adaptive systems | – Accelerators for HENP<br>– Light sources & neutron beam facilities for natural & life sciences<br>– Plasma & fusion energy facilities<br>– Single-purpose & multi-disciplinary fac.<br>– BER facilities<br>– Computing & computational support Applications software<br>– Ultra high performance computational & communications facilities<br>– Computer science & enabling technologies<br>– National lab system<br>– Science education<br>– Broadening the scope of S&T performers |
| **Core Research Areas (CRAs)** | Materials Structure, Radiation Effects - Engineering and Neutron & X-Ray Scattering, Experimental Condensed Engineering Physics, Materials Chemistry, Experimental **93 Program Areas** Mechanical Behavior, Physical Behavior of Materials, Matter Physics, Theory & Simulations of Matter, Program to Stimulate Competitive Res, Photochem. & Radiation Research, Chemical Physics Research, Atomic, Molecular, & Optical Science, Catalysis & Chemical Transformations, Separations & Analysis, Heavy Element Chemistry, Chemical Energy & Chemical Engineering, Mechanical Systems, Systems Science, & Engineering Analysis, Geosciences, Energy Biosciences Neutron & Light Sources Facilities, CCTI, Structural Biology Research Facilities, Understanding & Predicting Protein Structure, High Through-put DNA Sequencing Resources & Tools for DNA Sequencing & Sequence Analysis, Radiopharmaceutical Development, Production DNA Sequencing Facility, Microbial Genomics, Analytical Chemistry Instrumentation,Health Risks from Low Dose Exposures, Advanced Medical Imaging, Understanding Gene Function, BNCT, Natural & Accelerated Bioremediation Research Program, Economics of Global Climate, EMSL, Ecological Processes, Climate Change Prediction Program, Cleanup Research, Carbon Cycle Research, Atmospheric Sciences, ARM research & Infrastructure, Focused Health Research, Applied Mathematics, Computer Science to Enable Scientific Computing, High Performance Computer Networks, Advanced Computing Software & Collaboratory Tools, Scientific Computing Application Testbeds, Advanced Computing & Communications Facility Operations, Laboratory Technology Research & Advanced Energy Projects, NSTX Facility Operations Physics Research, General Plasma Science, Fusion Physics Research & Facilities Ops on DIII-D, Plasma Theory & Computation, Inertial Fusion Energy Research Alcator C-Mod Facility Operations & Physics Research, Experimental Fusion Physics Support, Experimental Plasma Research, Advanced Fusion Design & Materials Research, Plasma & Fusion Technologies, CP Violation in B-Meson System & K-Meson System, Neutrino Mass, Missing Mass, Search for Higgs, Supersymmetry -Strong interactions & Particles, Electroweak Interactions, Hadron Spectroscopy, Spin Structure of Nucleons, Particle Astrophysics & Cosmology, High Energy Physics Theory, General Technology: Detector R&D, Accelerator R&D, Facility Operations: Fermilab, SLAC, AGS, Adv. Particle Accelerator Concepts Quark/Gluon Substructure of Nuclei - Medium Energy Nuclear Physics, Facility Ops. & Constr., Nuclear Structure/Dynamics-Phase Trans - Heavy Ion Nuclear Physics, Nuclear Structure & Astrophysics - Low Energy Nuclear Physics, Theoretical Nuclear Physics... | | | |

# Fueling the Future - Clean and Affordable Power

To understand the physical, material & chemical, processes for advanced power generation, storage & transmission

| Strategies | Strongly Supporting CRA's ($393.9M) | Moderately Supporting CRA's ($823.3M) |
|---|---|---|
| – Plasma science & fusion research<br>– Condensed matter physics<br>– Metal & ceramic sciences<br>– Energy production, storage & transmission, | – Advanced Computing and Communications Facility Operations<br>– Advanced Fusion Design<br>– Advanced Fusion Materials Research<br>– Alcator C-Mod Facility Operations<br>– Chemical Energy and Chemical Engineering<br>– Climate Change Technology Initiative<br>– DIII-D Facilities Operations<br>– Engineering Behavior<br>– Experimental Condensed Matter Physics<br>– Experimental Fusion Physics Support<br>– Experimental Plasma Research (Alternatives)<br>– Fusion Physics Research on Alcator C-Mod<br>– Fusion Physics Research on DIII-D<br>– Fusion Physics Research on NSTX<br>– Fusion Technologies<br>– Inertial Fusion Energy Research<br>– Mechanical Behavior and Radiation Effects<br>– NSTX Facility Operations<br>– Plasma Technologies<br>– Plasma Theory and Computation | – Advanced Computing Software and Collaboratory Tools<br>– Atomic, Molecular, and Optical Science<br>– Chemical Physics Research<br>– Cleanup Research<br>– Computer Science for Scientific Computing<br>– EPSCoR<br>– General Plasma Science<br>– General Purpose Plant & Equipment<br>– High Performance Computer Networks<br>– Laboratory Technology Research and Advanced Energy Projects<br>– Mechanical Systems, Systems Science, and Engineering Analysis<br>– Multiprogram Energy Lab Facilities Support<br>– Neutron and Light Sources Facilities<br>– Physical Behavior of Materials<br>– Science Education Support<br>– Small Business Innovation Research Program<br>– Small Business Technology Transfer Program<br>– Structure of Materials<br>– Theory & Simulation of Matter, Engineering Physics |

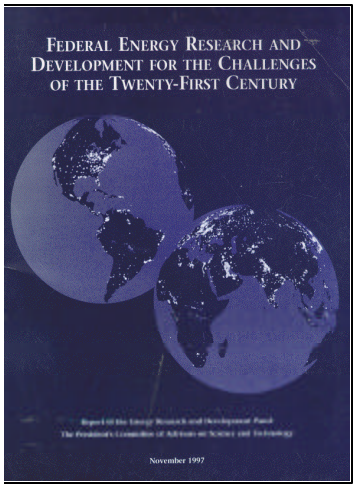
# Shaping a Fusion Science Roadmap

# Protecting our Living Planet - Prevention & Protection

*To create new scientific approaches to protect the biosphere from the effects of energy byproducts*

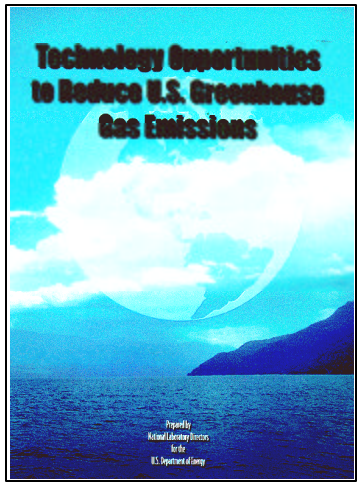
| Strategies | Strongly Supporting CRA's ($174.3M) | Moderately Supporting CRA's ($763.5M) |
|---|---|---|
| – Pollution minimization<br>– Cleanup & remediation<br>– Carbon sequestration<br>– Health protection -- regulation & medicine | – Advanced Medical Imaging<br>– Analytical Chemistry Instrumentation<br>– Boron Neutron Capture Therapy<br>– Cleanup Research<br>– Climate Change Technology Initiative (CCTI)<br>– Environmental and Molecular Sciences Laboratory (EMSL)<br>– Laboratory Technology Research and Advanced Energy Projects<br>– Microbial Genomics<br>– Natural and Accelerated Bioremediation Research Program<br>– Radiopharmaceutical Development<br>– Science Education Support<br>– Separations and Analysis | – Chemical Physics Research<br>– Energy Biosciences<br>– Experimental Program to Stimulate Competitive Research (EPSCoR)<br>– Focused Health Research<br>– General Purpose Plant & Equipment (GPP/GPE)<br>– Geosciences<br>– Health Risks from Low Dose Exposures<br>– Heavy Element Chemistry<br>– Multiprogram Energy Lab Facilities Support (MELFS)<br>– Neutron and Light Sources Facilities<br>– Small Business Innovation Research (SBIR) Program<br>– Small Business Technology Transfer (STTR) Program<br>– Structural Biology Research Facilities<br>– Understanding and Predicting Protein Structure<br>– Understanding Gene Function |

# Shaping the Carbon Sequestration Roadmap

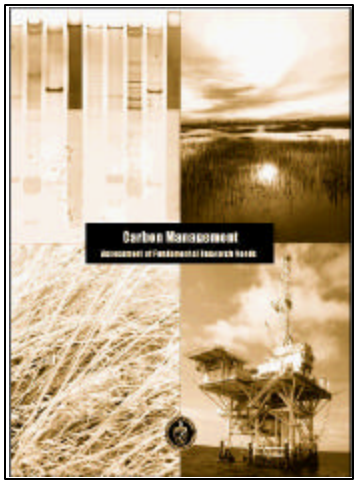



PCAST Study Fed. Energy R&D
*November 1997*

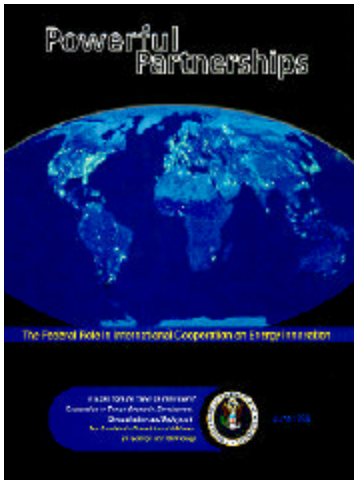
Carbon Sequestration Workshop
*September 1997*



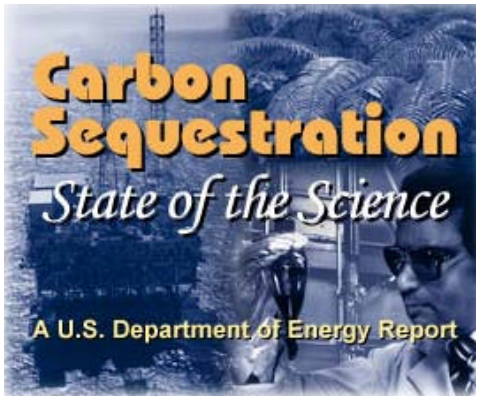

11 Lab Study
*April 1998*




Carbon Management Science *August 1997*




PCAST Study International Energy *June 1999*




DOE Roadmap for future R&D
*February 1999*

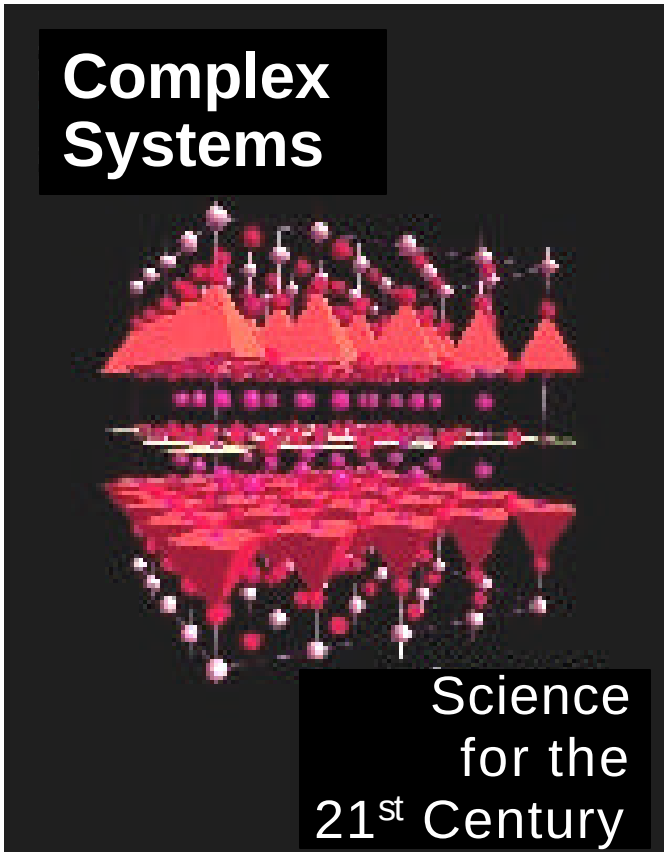
**U.S. Joint Global Oceans Flux Study**

# Exploring Energy and Matter - Complex Systems

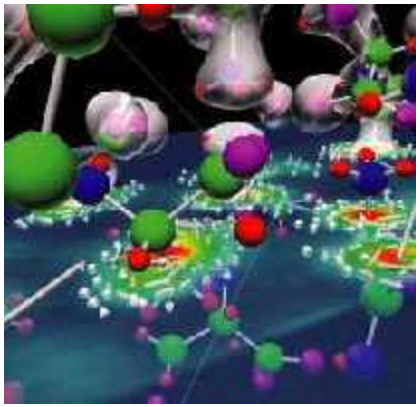
*To understand and control complex systems of matter, energy, and life*

| Strategies | Strongly Supporting CRA's ($1,091.8M) | Moderately Supporting CRA's ($381.5M) |
|---|---|---|
| – Collective phenomena<br>– Adaptive systems | – Advanced Computing & Communications Facility Operations<br>– Applied Mathematics<br>– Atomic, Molecular, & Optical Science<br>– Catalysis & Chemical Transformations<br>– Computer Science for Scientific Computing<br>– Energy Biosciences<br>– Experimental Condensed Matter Physics<br>– Fusion Physics Research on Alcator C-Mod, DIII-D, & NSTX<br>– General Plasma Science<br>– Geosciences<br>– High Performance Computer Networks<br>– High Throughput DNA Sequencing<br>– Materials Chemistry<br>– Mechanical Systems, Systems Science, and Engineering Analysis<br>– Neutron and Light Sources Facilities<br>– Neutron and X-Ray Scattering<br>– Photochemistry and Radiation Research<br>– Physical Behavior of Materials<br>– Plasma Theory and Computation<br>– Resources & Tools for DNA Sequencing and Sequence Analysis<br>– Scientific Computing Application Testbeds<br>– Separations and Analysis<br>– Structural Biology Research Facilities<br>– Structure of Materials<br>– Theory & Simulations of Matter, Engineering Physics<br>– Understanding and Predicting Protein Structure<br>– Understanding Gene Function | – Moderately Supportive RSPs (Combined Budget: $383.8 Million)<br>– Advanced Computing Software and Collaboratory Tools<br>– Advanced Medical Imaging<br>– Analytical Chemistry Instrumentation<br>– Chemical Energy and Chemical Engineering<br>– Chemical Physics Research<br>– Climate Change Technology Initiative (CCTI)<br>– Engineering Behavior<br>– Environmental & Molecular Sciences Laboratory<br>– Experimental Fusion Physics Support<br>– Experimental Plasma Research (Alternatives)<br>– General Purpose Plant & Equipment (GPP/GPE)<br>– General Technology: Accelerator R&D<br>– Health Risks from Low Dose Exposures<br>– Inertial Fusion Energy Research<br>– Mechanical Behavior and Radiation Effects<br>– Multiprogram Energy Lab Facilities Support (MELFS)<br>– Production DNA Sequencing Facility<br>– Radiopharmaceutical Development<br>– Science Education Support |

# Complex Systems
## *Science for the 21st Century*




- Collective Phenomena
- Materials by Design
- Functional Systems
- Nature's Mastery
- New Tools



Simulation , on a Cray T3E supercomputer, of the response of a crystal of glycine to the magnetic fiald applied during nuclear magnetic resonance spectroscopy studies.

# Extraordinary Tools - Scientific Simulation

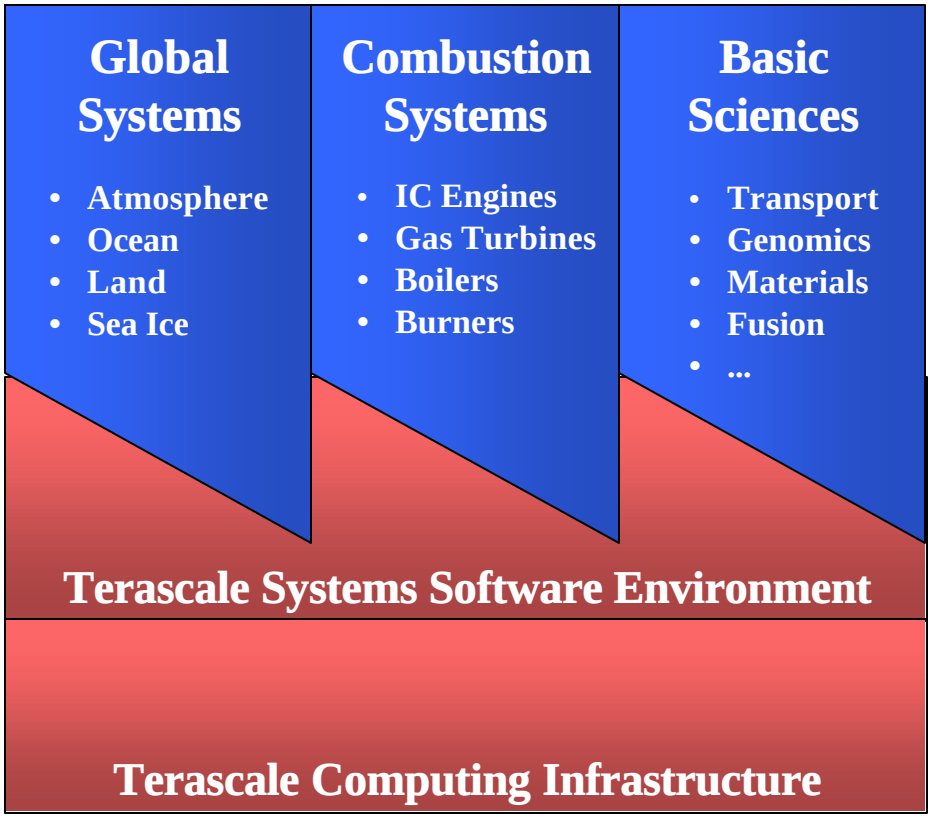
*To achieve computation and simulation as a critical tool in future scientific discovery*

| Strategies | Strongly Supporting CRA's ($811.0M) | Moderately Supporting CRA's ($1,175.1M) |
|---|---|---|
| – Applications software<br>– Ultra high performance computational & communications facilities<br>– Computer science & enabling technologies | – Advanced Computing & Communications Facility Operations<br>– Advanced Computing Software and Collaboratory Tools<br>– Applied Mathematics<br>– Chemical Physics Research<br>– Climate Change Prediction Program<br>– Environmental & Molecular Sciences Lab<br>– Facility Operations: AGS<br>– Facility Operations: Fermilab<br>– Facility Operations: SLAC<br>– General Technology: Accelerator R&D<br>– Geosciences<br>– High Energy Physics Theory<br>– High Performance Computer Networks<br>– High Throughput DNA Sequencing<br>– Mechanical Behavior & Radiation Effects<br>– Plasma Theory and Computation<br>– Production DNA Sequencing Facility<br>– Science Education Support<br>– Scientific Computing Application Testbeds<br>– Theory & Simulation of Matter, Engineering Physics<br>– Understanding and Predicting Protein Structure | – Adv. Particle Accelerator Concepts<br>– ARM Research & Infrastructure<br>– Atomic, Molecular, and Optical Science"<br>– Carbon Cycle Research<br>– Computer Science for Scientific Computing<br>– CP Violation - B& K Meson Systems<br>– Electroweak Interactions<br>– Energy Biosciences<br>– Engineering Behavior<br>– Experimental Condensed Matter Physics<br>– General Purpose Plant & Equipment (GPP/GPE)<br>– General Technology: Detector R&D<br>– Hadron Spectroscopy<br>– Materials &Heavy Element Chemistry<br>– Laboratory Tech. Research & Advanced Energy Projects<br>– Mechanical Systems Science, & Engineering Analysis<br>– Multiprogram Energy Lab Facilities Support<br>– Neutrino Mass and Mixing<br>– Neutron and Light Sources Facilities<br>– Neutron and X-Ray Scattering<br>– Particle Astrophysics & Cosmology<br>– Physical Behavior of Materials<br>– Search for Higgs & Supersymmetry<br>– Small Business Innovation Research Program<br>– Small Business Technology Transfer Program<br>– Spin Structure of Nucleons<br>– Strong Interactions, Supersymmetry & Particles<br>– Structure of Materials<br>– Theoretical Nuclear Physics |

# President Clinton's Information Technology for the 21st Century - *DOE Role: Scientific Simulation*

## Principal Objectives

- Revolutionize scientific research by the application of teraflop computational resources
- Understand, model and predict the effects on the Earth's global environment of atmospheric greenhouse gas emission, with an emphasis on carbon dioxide
- Understand, model and predict the behavior and properties of combustion processes and devices.
- Discover, develop, and deploy crosscutting computer science and applied mathematics



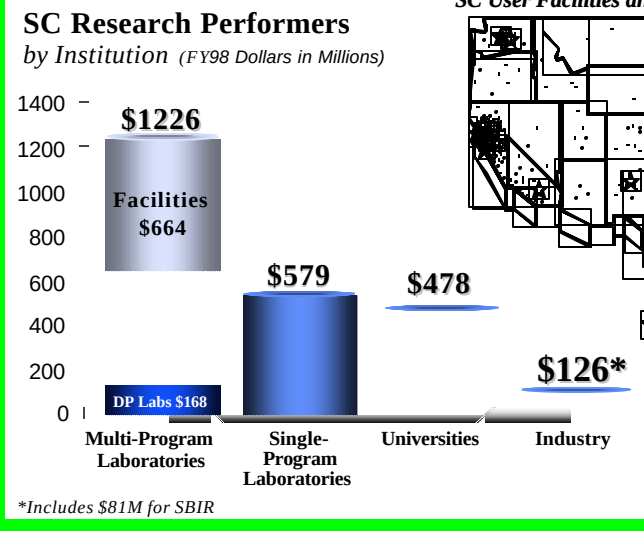

- Establish a national terascale (Capable of doing 1 trillion operations per second) distributed scientific simulation infrastructure

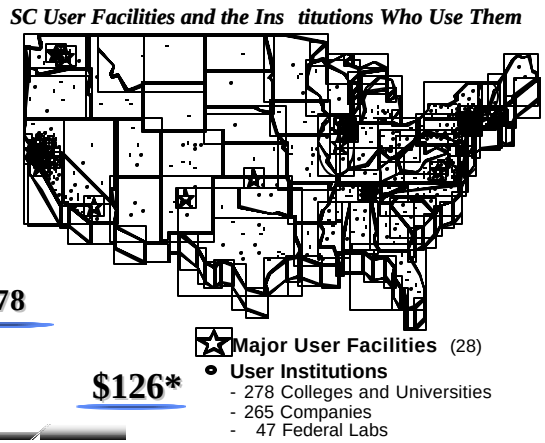
# DOE Office of Science

## *Pulling It All Together*

**Strategic Goals**

**Performers**




*Materials Structure, Radiation Effects - Engineering and Mechanical Behavior, Physical Behavior of Materials, Neutron & X-Ray Scattering, Experimental Condensed Matter Physics, Theory & Simulation of Matter, Engineering Physics, Materials Chemistry, Experimental Program to Stimulate Competitive R Photochem. & Radiation Research, Chemical Physics Research, Atomic, Molecular, & Optical Science, Ca & Chemical Transformations, Separations and Analysis, Heavy Element Chemistry, Chemical Energy & C Engineering, Mechanical Systems, Systems Science, & Engineering Analysis, Geosciences, Energy B Neutron and Light Sources Facilities, CCTI, Structural Biology Research Facilities, Understanding & Pred Structure alysis ceutical De ument from Low D cceler Research Program, Economics of Global Climate, EMSL, Ecological Processes, Climate Change Prediction Progra Carbon Cycle Research, Atmospheric Sciences, ARM research & Infrastructure, Focused Health Research, Applied M Science to Enable Scientific Computing, High Performance Computer Networks, Advanced Computing Software & Col Computing Application Testbeds, Advanced Computing & Communications Facility Operations, Laboratory Technology R Projects, NSTX Facility Operations & Physics Research, General Plasma Science, Fusion Physics Research & Facilities Computation, Inertial Fusion Energy Research, Alcator C-Mod Facility Operations & Physics Research, Experimental Fus Plasma Research, Advanced Fusion Design & Materials Research, Plasma & Fusion Technologies, CP Violation in B-Me*

**Disciplinary Stewardship**

# Conclusions

## Intent

- A process built around creative thinkers - RHIP not a factor!
- Broadly participatory - nearly 200 participants and many more reviewers
  - Scientists, technologists, futurists, policymakers, writers, others
- Crosscutting emphasis - eliminating stovepipes and discipline focus as constraints
- Evoking serious discussion on new future possibilities, and on how we might pursue them
- Clear separation of divergence and convergence phases of the process

## Practical Results

- New areas of science to pursue, new ways of thinking and of doing
- A common strategic framework - a consistent message
- Progress toward implementation: portfolio, roadmaps, budget/OMB