

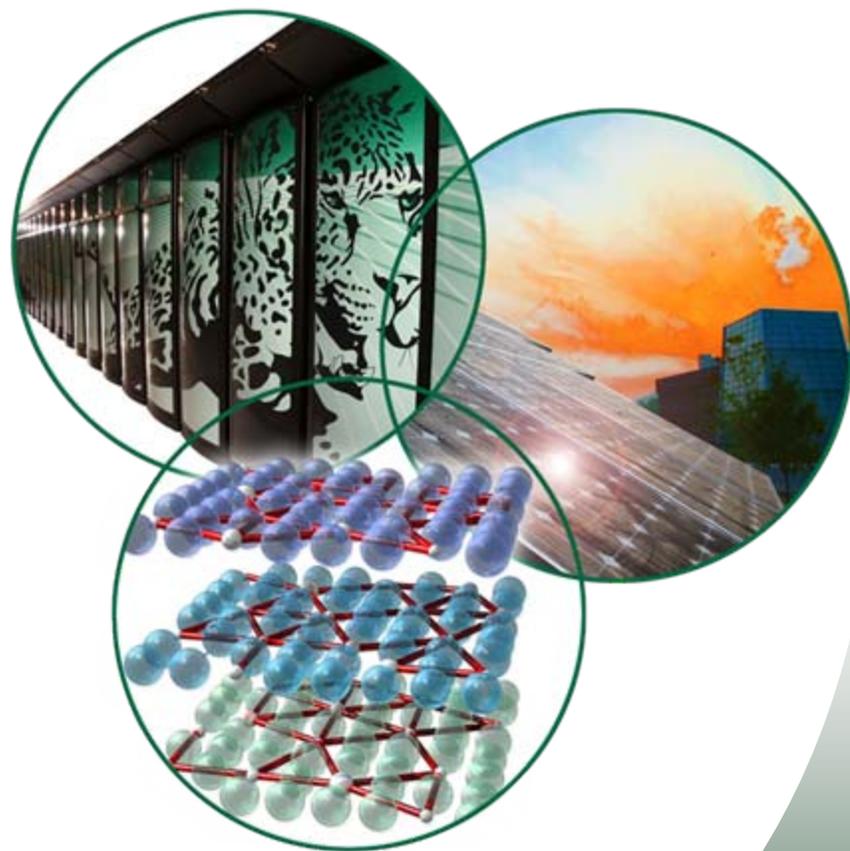
# ORNL: World Leadership in Scientific Discovery through Advanced Computing

Debbie McCoy

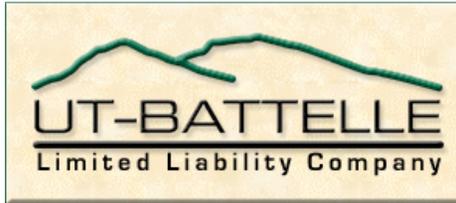
Research Alliance in  
Math and Science Program

Presented to  
Faculty / Mentor Workshop

January 21, 2009



# ORNL is managed and operated by UT-Battelle

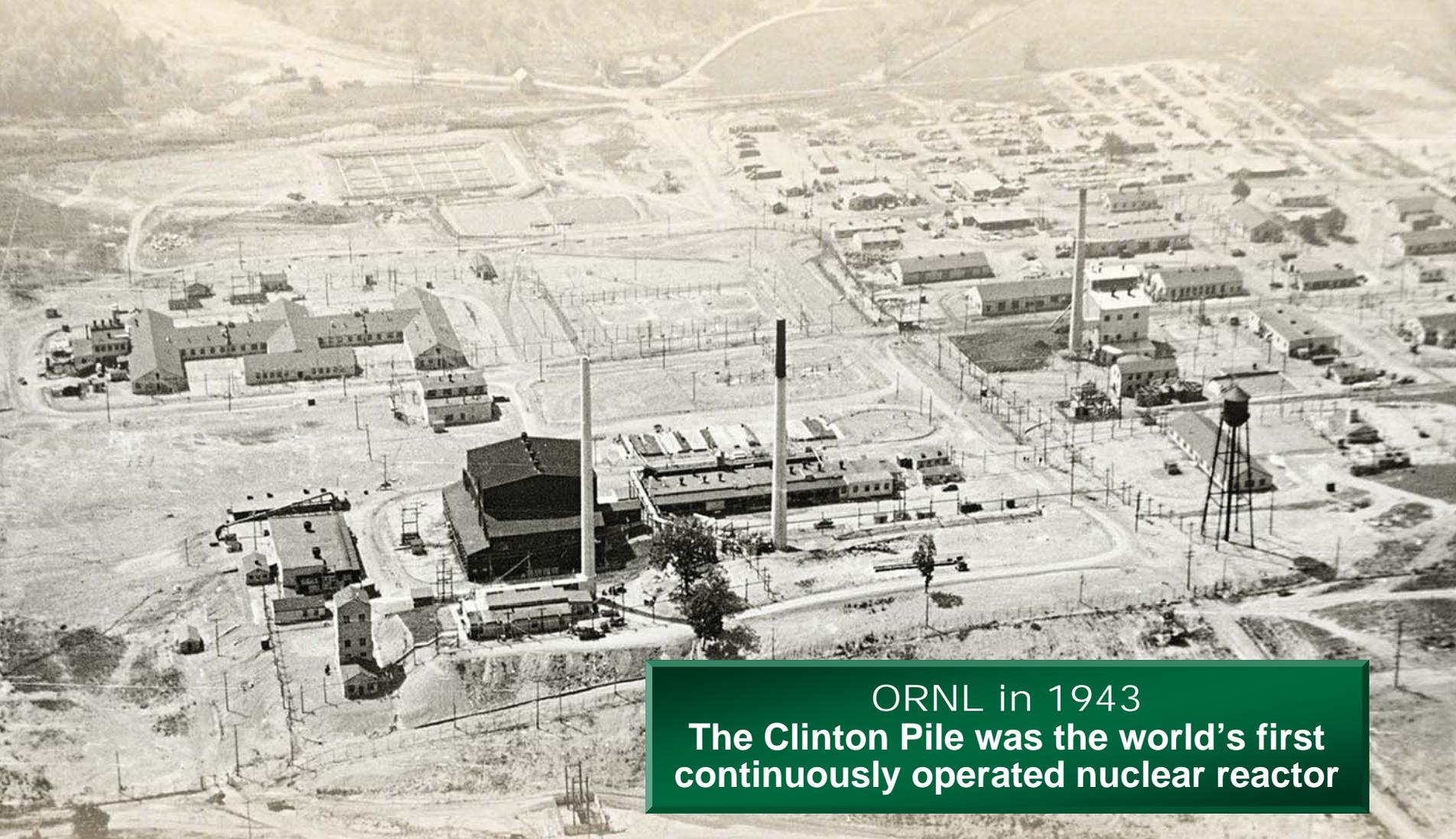


**The University of Tennessee  
Knoxville, Tennessee**



**Battelle  
Columbus, Ohio**

# Oak Ridge National Laboratory evolved from the Manhattan Project



ORNL in 1943  
The Clinton Pile was the world's first  
continuously operated nuclear reactor

# ORNL is DOE's largest multipurpose science and energy laboratory



- \$1 billion budget
- 4,100 employees
- 3,000 research guests annually
- Nation's largest unclassified scientific computing facility
- Nation's largest science facility: the \$1.4 billion Spallation Neutron Source
- Nation's largest concentration of open source materials research
- Nation's largest energy laboratory
- \$300 million modernization near completion



Building a  
research campus for  
the next generation  
of great science

# New ORNL east campus

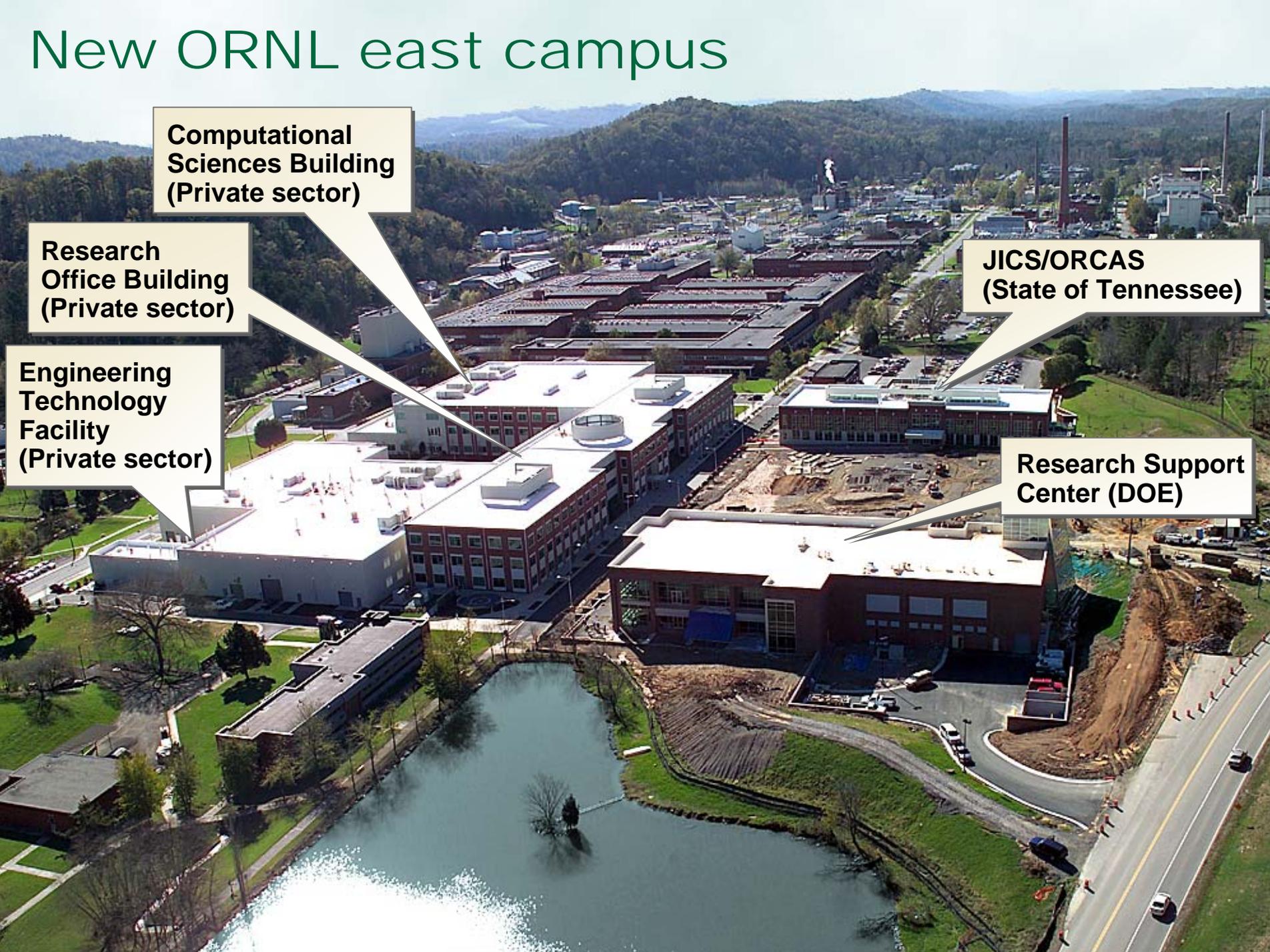
**Computational Sciences Building  
(Private sector)**

**Research Office Building  
(Private sector)**

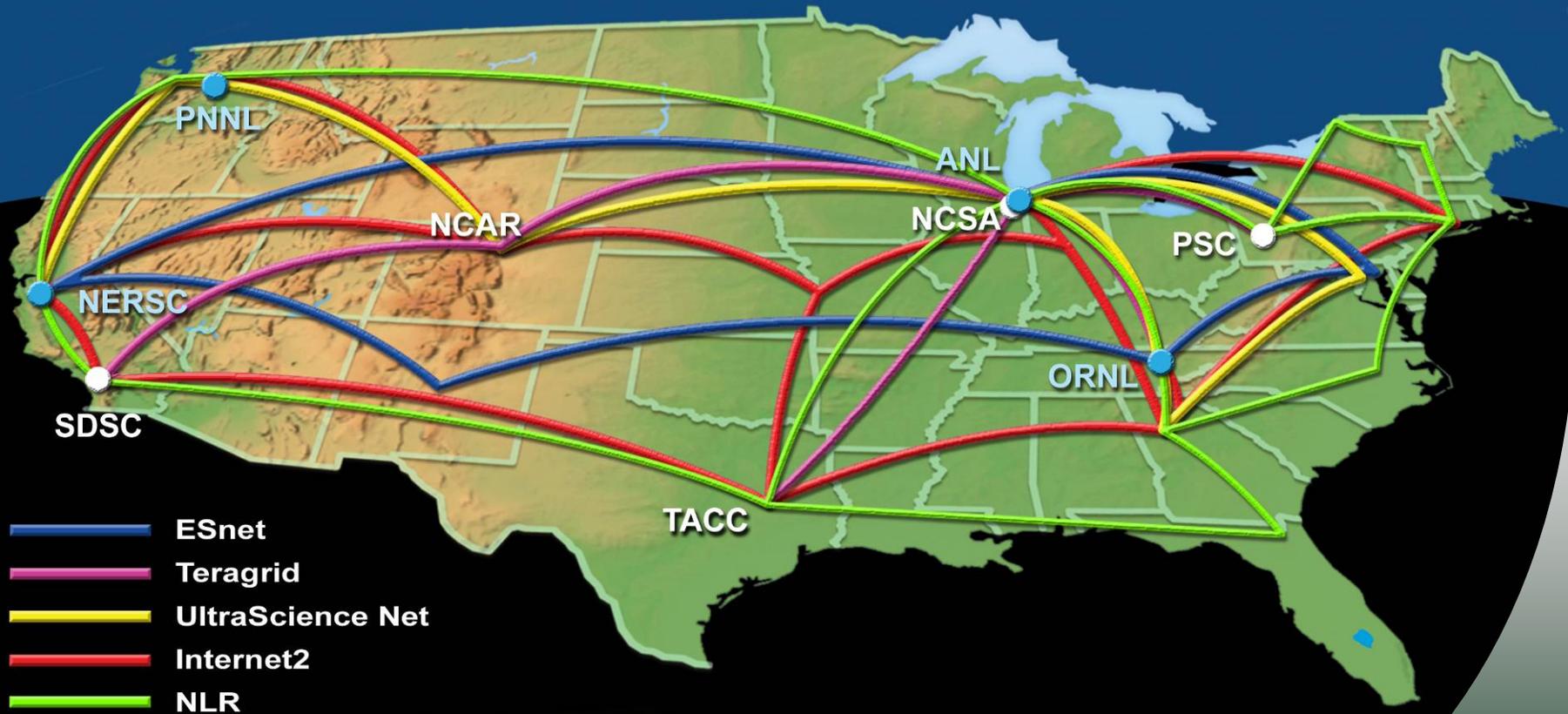
**JICS/ORCAS  
(State of Tennessee)**

**Engineering Technology Facility  
(Private sector)**

**Research Support Center (DOE)**



State-of-the-art owned network is directly connected to every major R&E network at multiple lambdas

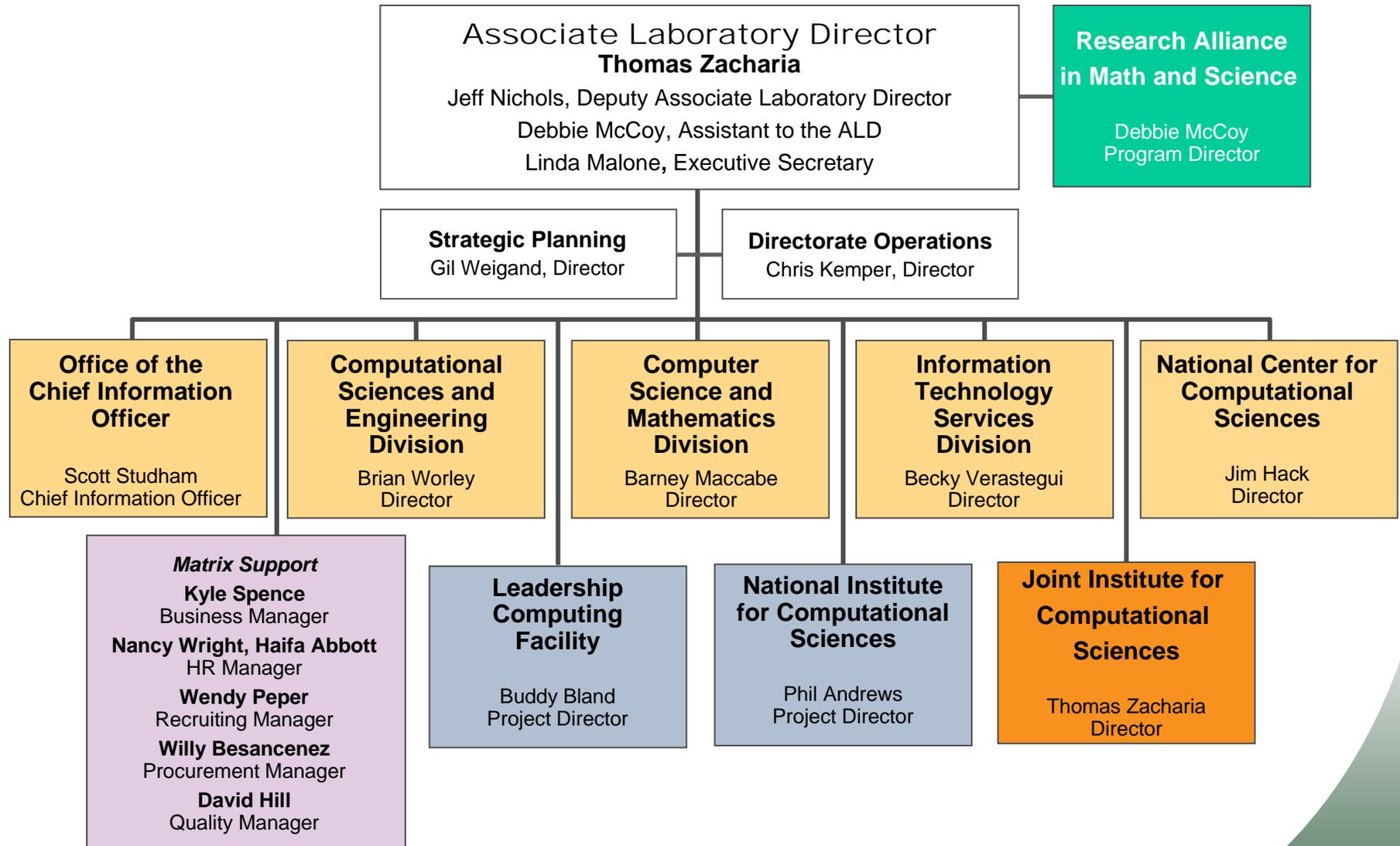


# Our vision for sustained leadership and scientific impact

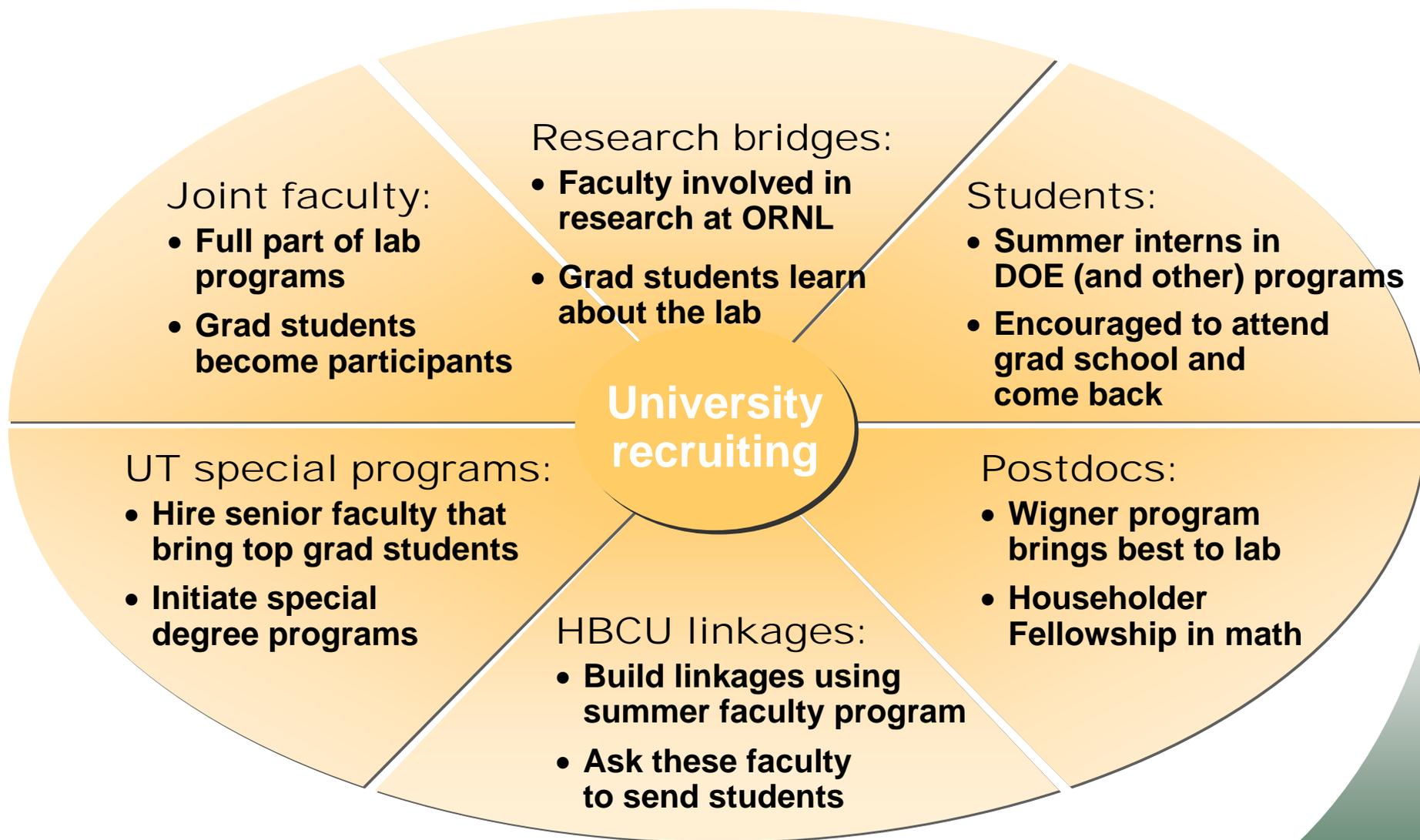
- Provide the world's most powerful open resources for capability computing and data analytics
- Follow a well-defined path for maintaining world leadership in these critical areas
- Attract the brightest talent and partnerships from all over the world
- Deliver cutting-edge science relevant to the missions of DOE and key federal and state agencies
- Invest in cross-cutting partnerships with industry
- Provide unique opportunity for innovation based on multi-agency collaboration
- Invest in education and training



# Computing and Computational Sciences Directorate



# Each of our university partnerships relates to recruiting, although long term



# UT-ORNL joint institutes are points of intersection for university faculty

## Joint Institute for Computational Sciences



- **\$9M State-funded building, now in use**
- **Programs for students and postdocs**
- **Access to ORNL terascale computing capabilities**

## Joint Institute for Biological Sciences



- **\$8M State-funded building to be constructed in 2005**
- **Supports programs in genome science and systems biology**

## Joint Institute for Neutron Sciences



- **\$8M State-funded building planned**
- **Office and conference facility**
- **Workshops, visiting fellows, postdocs, students**

# Research Alliance in Math and Science

RAMS student orientation  
in JICS auditorium



- State-of-the-art distance learning
- Interactive seating
- Conference rooms
- Open meeting space
- Executive offices for distinguished scientists and directors
- Incubator suites for students and visiting staff



- **Opened 2005**
- **52,000 sq. ft.**

# Research Alliance in Math and Science

New state-of-the-art facilities

## Appointments

- Faculty
- Governor's chairs
- Joint faculty
- Postdoctoral
- Student

## Research

- Computer Science
- Computational Chemistry
- Computational Biology
- Computational Materials Science
- Networking
- Astrophysics
- Fusion
- Applied Math
- More . . .



# Research Alliance in Math and Science (RAMS) Program



**The Research Alliance in Math and Science program is designed to provide collaborative research experiences among faculty and students at colleges or universities and DOE national laboratory researchers. These experiences will improve the U.S. competitive research edge while encouraging and promoting Science, Mathematics, Engineering, and Technology (SMET) research throughout the academic year.**

# Research Alliance in Math and Science (RAMS) Program

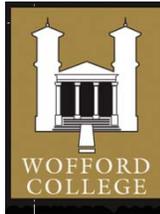
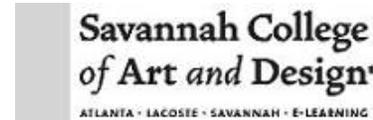


VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY



UNIVERSITY OF NOTRE DAME

JOHNS HOPKINS UNIVERSITY



# Research Alliance in Math and Science (RAMS) Program

Targets underrepresented students majoring in computer science, computational sciences, mathematics, engineering, technology



- 10 – 12 weeks (May/August)
- World-class research mentors
- Competitive stipend/housing allowance
- State-of-the-art distance learning
- Daily journal of activities and experiences
- Weekly technical seminars
- Skills-enhancing workshops
- Oral presentation of research results
- Project poster sessions
- Recognition banquet
- May arrange academic credit through college or university

# Research Alliance in Math and Science (RAMS) Program

Research opportunities in:



- Computer Science
- Algorithms and Theory
- Artificial Intelligence
- Communications and Networking
- Computational Biology
- Computer Architecture
- Data Management
- Distributed and Fault-Tolerant Computing
- Graphics and Visualization
- Human Computer Interaction
- Knowledge Discovery/Data Mining
- Mobile Computing
- Multimedia
- Natural Language Processing
- Operating Systems
- Performance Modeling and Analysis

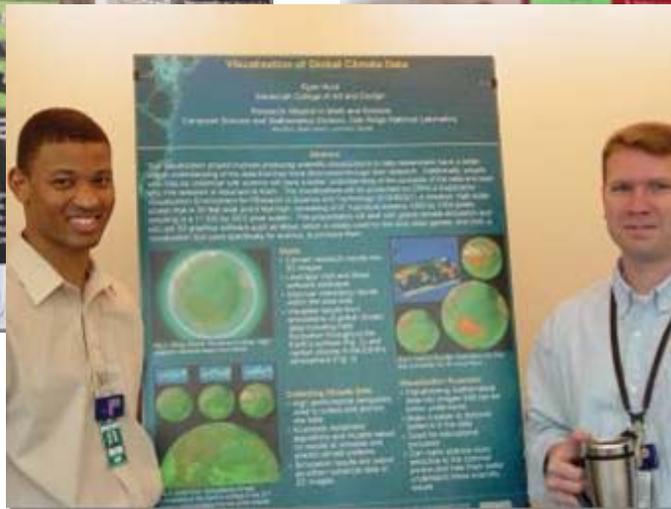
- Programming Languages and Software Engineering
- Security
- User Interface
  - Data Storage
  - Hardware Technologies
  - Mathematical Sciences
- Algorithms and Theory
- Dynamical Systems
- Knowledge Discovery and Data Mining
- Mathematical Modeling
- Numerical Methods
- Operations Research
- Probability and Statistics
- Risk Management
- Stochastic Optimization. . . more

**Summer student poster presentations in JICS lobby**  
Research Alliance in Math and Science Program  
[http://www.csm.ornl.gov/Internships/rams\\_06/posters.html](http://www.csm.ornl.gov/Internships/rams_06/posters.html)

# Research Alliance in Math and Science (RAMS) Program

Summer student opportunities:

Poster sessions



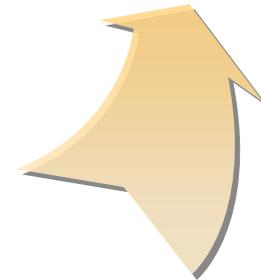
**Fortran for High Performance Computing taught by John Levesque**

# Research Alliance in Math and Science (RAMS) Program

Summer student opportunities:



**Tour \$1B Spallation Neutron Source**



# Research Alliance in Math and Science (RAMS) Program

Summer student opportunities:



Opportunities in visualization,  
applied mathematics, networking  
research, computer science,  
computational biology,  
computational chemistry,  
computational materials science

Tour **Exploratory Visualization Environment for Research in Science and Technology (EVEREST)**



# Research Alliance in Math and Science (RAMS) Program

Summer student opportunities:

National Center for  
Computational Sciences



# Research Alliance in Math and Science (RAMS) Program

Summer student opportunities:

High Temperature  
Materials Laboratory



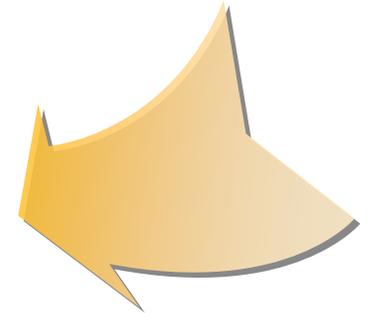
Biomedical engineering students examine ceramic replacement joints developed at ORNL's High Temperature Materials Laboratory

# Research Alliance in Math and Science (RAMS) Program

Summer student opportunities:



Tour  
High Flux Isotope  
Reactor facility



# Research Alliance in Math and Science (RAMS) Program



## Requirements:

- **Completed on-line application (website opens in January)**
- **Completed research proposal (students are encouraged to iterate research proposal with his/her faculty advisor)**
- **Two faculty recommendations completed online**
- **Official transcript**
- **Commitment for full participation**

## Contact:

**Debbie McCoy**

**Research Alliance in Math and Science (RAMS) Program**

**Oak Ridge National Laboratory**

**P.O. Box 2008**

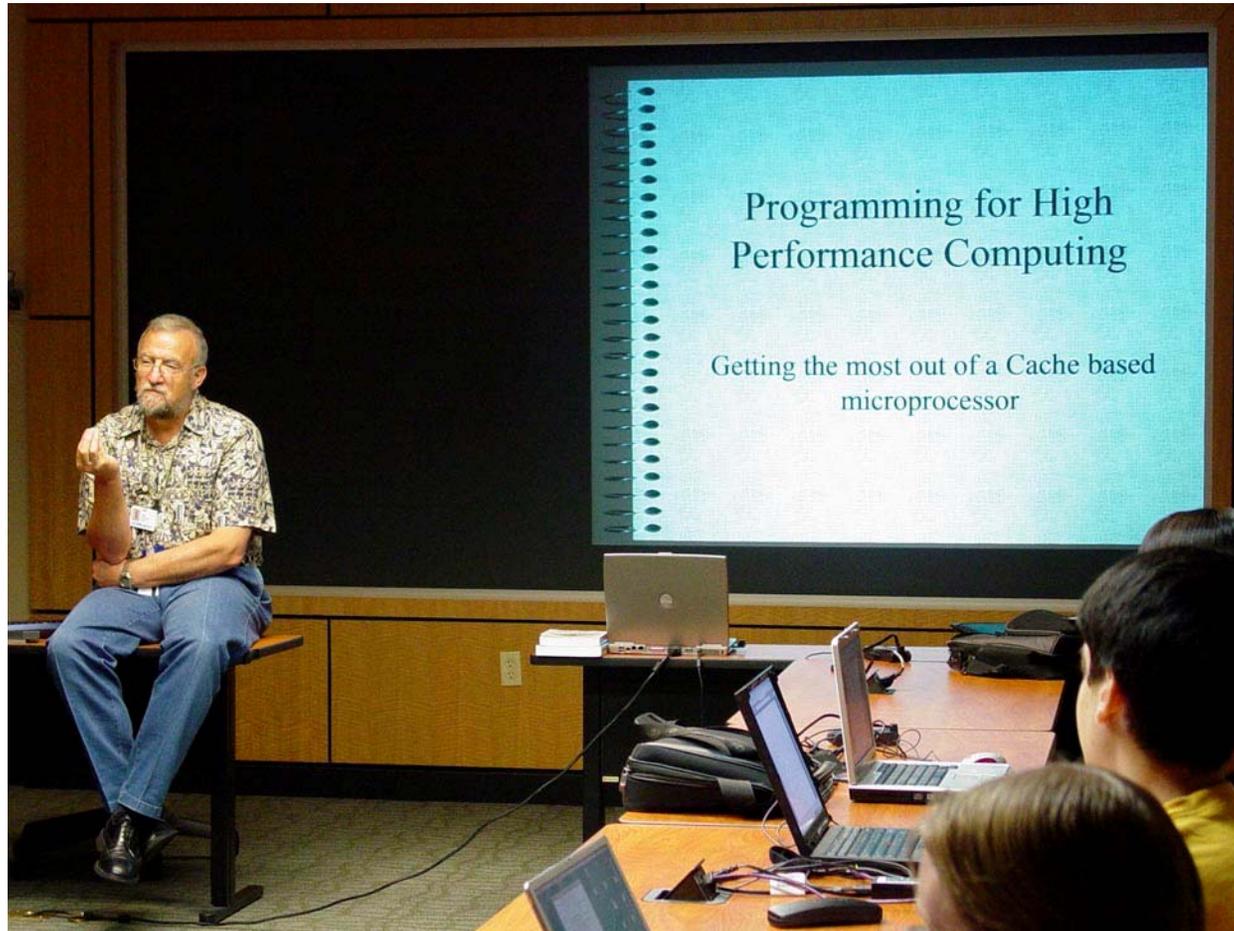
**Oak Ridge, TN 37831-6163**

**PHONE: (865) 574-6185**

**FAX: (865) 574-4839**

**Email: [mccoydd@ornl.gov](mailto:mccoydd@ornl.gov)**

# FORTRAN for high-performance computing



**Summer student opportunities**

**Research Alliance in Math and Science Program**

<http://computing.ornl.gov/Internships/RAMS.html>

# Poster workshop / poster session

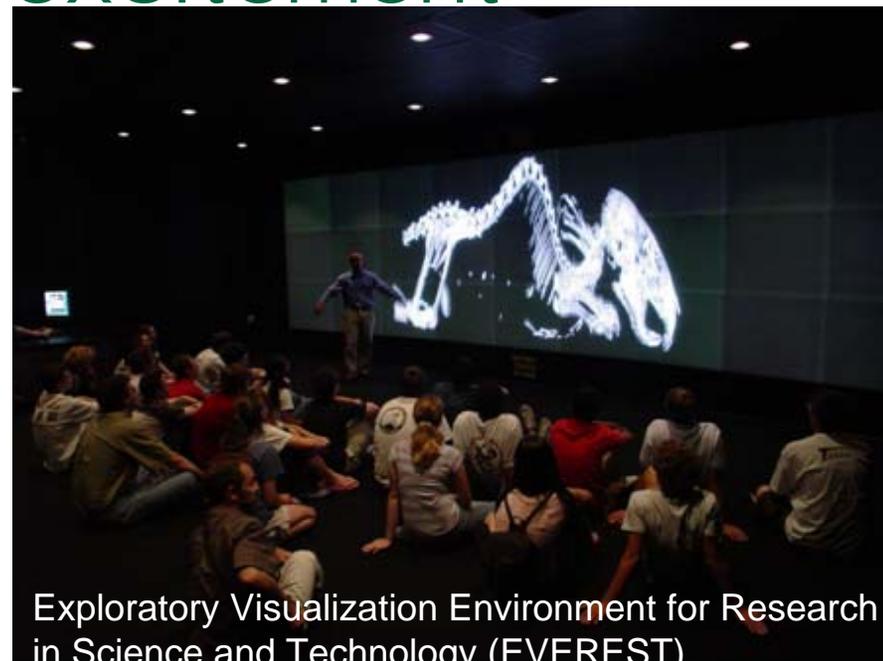


**Summer student poster presentations in JICS lobby**

**Research Alliance in Math and Science Program**

<http://www.csm.ornl.gov/Internships/RAMS.html>

# Students add to the excitement



Exploratory Visualization Environment for Research in Science and Technology (EVEREST)



**Paul Donnelly:** 2006 RAMS student - 2007 Co-Op employee



# Outstanding computational science and information technology opportunities

## Next generation of scientists:

- RAMS students
- Biomed engineering students
- JICS student appointments
- JICS postdoctoral appointments
- Joint faculty appointments
- RAMS mentor/faculty workshops
- UT Governor's School in Computer Science
- Wigner Fellowship
- Householder Fellowship

**Dr. Richard Tapia**  
2006 RAMS banquet  
keynote speaker



**ORNL Day of Science**



**Poster sessions**



**2006 RAMS students at SNS**



**Jennifer Ryan**  
Householder Fellow



**Alvaro Gonzalez**  
Wigner Fellow

## Requirements/Commitments

- On-line Application (includes research proposal, resume, transcript, and 2 faculty recommendations)
- Mentor collaboration
- Technical seminars
- Project web site
- Project abstract
- Project poster
- Oral presentation (PowerPoint)
- Research paper (technical review and document clearance)

## Internship Advantages

- Leading-edge research at DOE's largest multipurpose national laboratory
- World-class scientist mentors
- State-of-the-art computing facilities
- Generous stipend/housing allowance

## Research Opportunities

- Applied Mathematics
- Astrophysics
- Computer Science
- Computational Sciences (Biology, Chemistry, Climate, Fusion, Materials, etc)
- Distributed Computing
- High-Performance Network Research
- Intelligent Systems
- Nanoscale Science
- Visualization...and more

## Goals

### *Short Term:*

Increase the number of underrepresented minorities (African American, Hispanic American, Native American, and women) who pursue advanced degrees in Science, Technology, Engineering, and Mathematics (STEM)

### *Long term:*

Increase the number of underrepresented minorities with advanced degrees in STEM disciplines in the workforce

## Contact

Debbie McCoy  
Oak Ridge National  
Laboratory  
P. O. Box 2008  
Oak Ridge, TN 37831-6163  
[Mccoydd@ornl.gov](mailto:Mccoydd@ornl.gov)  
(865) 574-6185 voice  
(865) 574-4839 fax

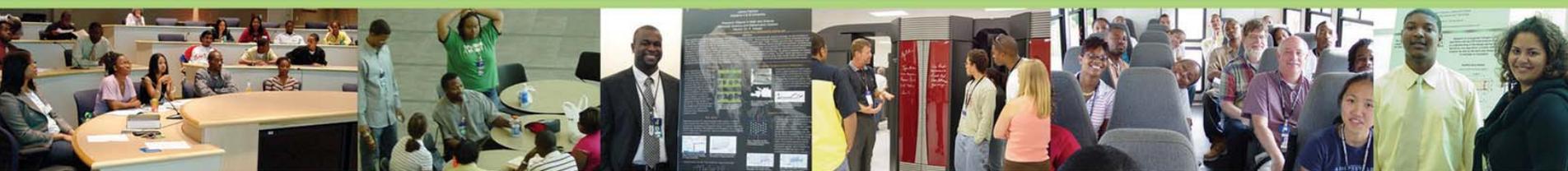
RESEARCH ALLIANCE  
IN MATH AND SCIENCE

<http://computing.ornl.gov/internships/rams/>



“The Research Alliance in Math and Science (RAMS) Program is based on the belief that national laboratories and universities, working hand in hand, offer the best opportunity to make a real impact on the quality of a diverse workforce.”

This program is sponsored by the Office of Advanced Scientific Computing Research, U.S. Department of Energy



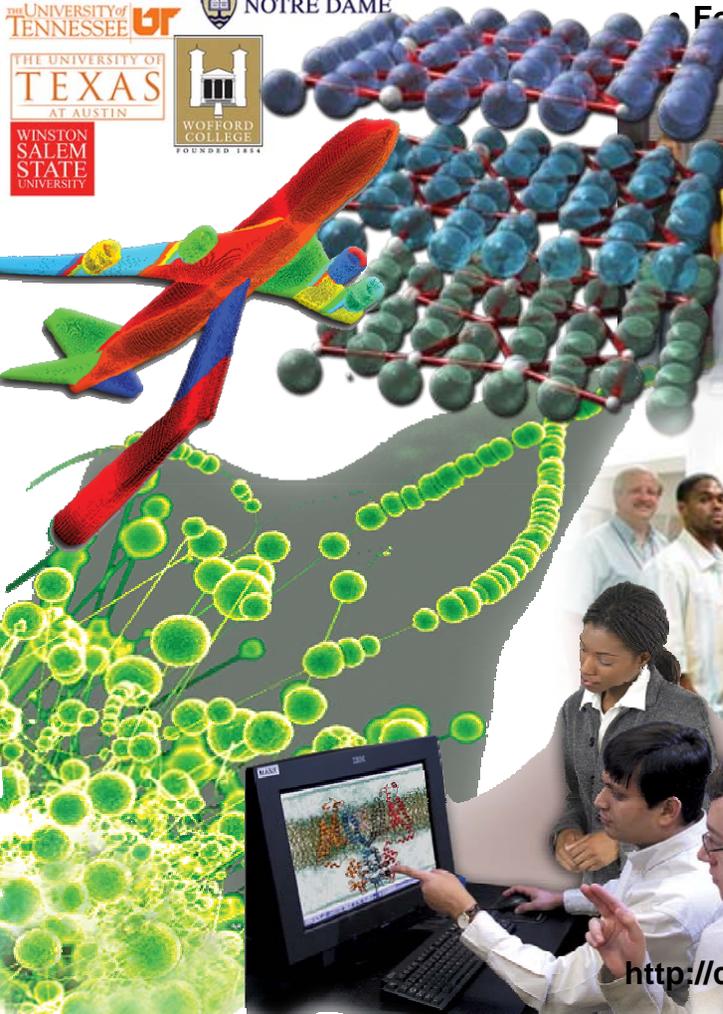
# Seminar Series Sampling

- Interdisciplinary Science at the Oak Ridge National Laboratory
- Professionalism and Ethics in Science
- From Micro Scale Mechanics to Molecular Scale Mechanics
- Toward a New Vision for Artificial Sight
- The virtual Human Project
- Forest Responses to a Changing Atmosphere

*Leadership Computing Facility*



*Joint Institute for Computational Sciences (JICS) Distance Learning Center*



*Spallation Neutron Source (SNS)*



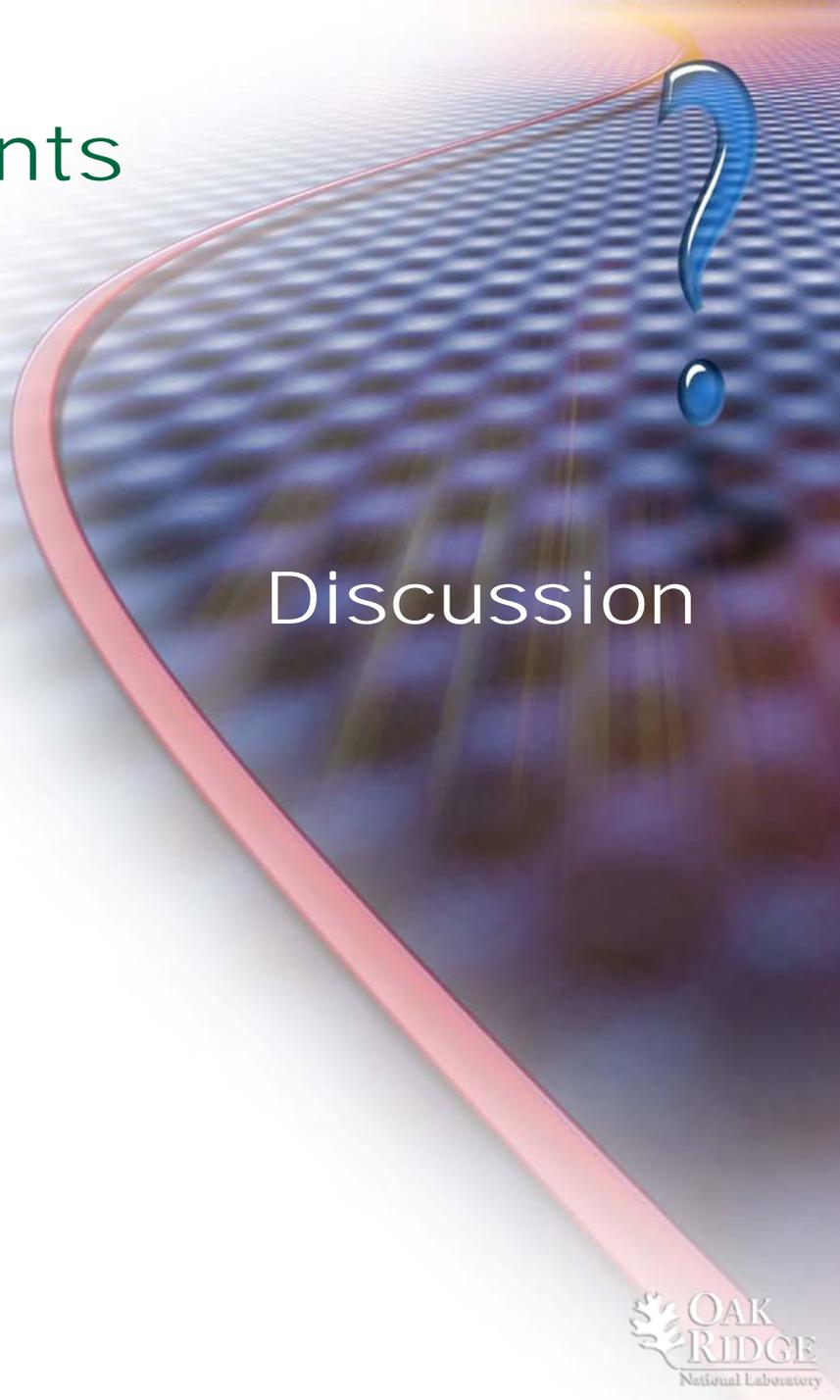
Visit this URL for more information, photos, and links:  
<http://computing.ornl.gov/internships/rams/>



*Exploratory Visualization Environment for Research Science Technology*

# Extraordinary opportunities for students in computing

<http://computing.ornl.gov/Internships/RAMS>



Discussion

# The best recruiting is by the students

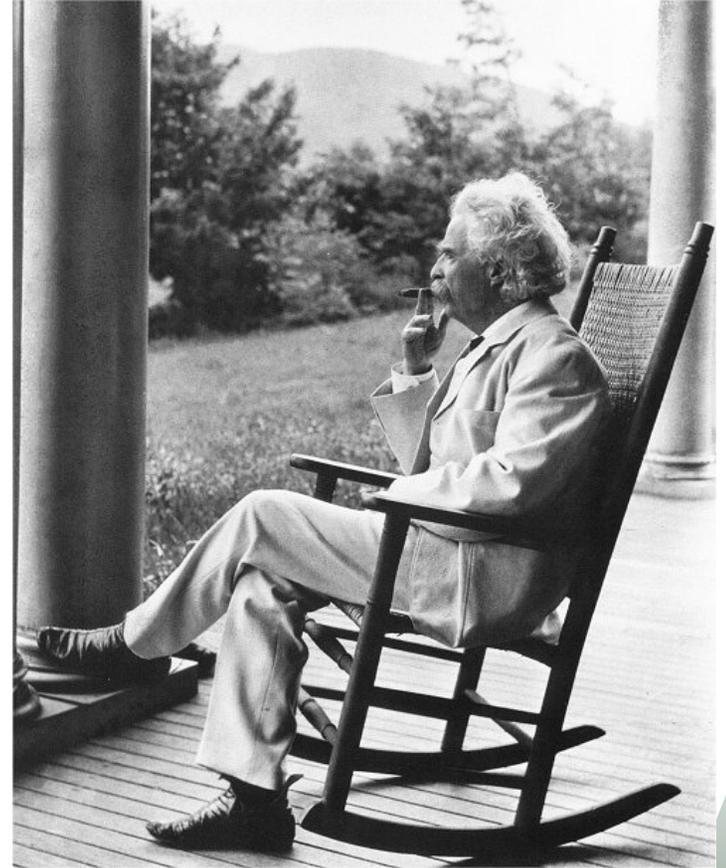


**Students are involved, excited,  
and motivated -- and tell others.**

# Explore, Dream, Discover

- **“Twenty years from now you will be more disappointed by the things that you didn't do than by the ones you did do. So throw off the bowlines. Sail away from the safe harbor. Catch the trade winds in your sails. Explore. Dream. Discover.”**

– Mark Twain





# DOE Leadership Computing Roadmap

**Mission:** Deploy and operate the computational resources required to tackle global challenges

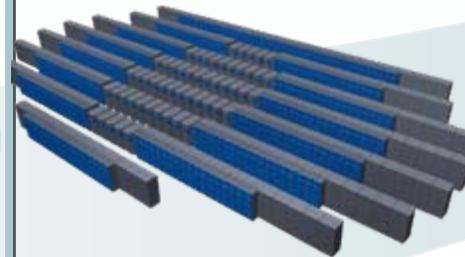
- Deliver transforming discoveries in materials, biology, climate, energy technologies, etc.
- Ability to investigate otherwise inaccessible systems, from supernovae to energy grid dynamics



Cray XT5: 1 PF  
10 PB Disk  
40 PB Archive

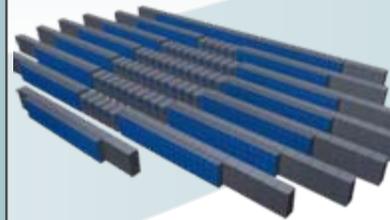
FY2009

35 Managed by UT-Battelle  
for the Department of Energy



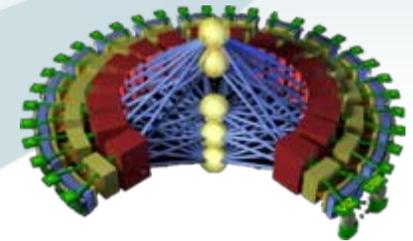
DARPA HPCS: 20 PF  
50 PB Disk  
200 PB Archive

FY2011



Follow on to DARPA  
HPCS: 100 PF  
150 PB Disk  
1 EB Archive

FY2015



Future system: 1 EF  
500 PB Disk  
10 EB Archive

FY2018

**Vision:** Maximize scientific productivity and progress on the largest scale computational problems

- Providing world-class computational resources and specialized services for the most computationally intensive problems
- Providing stable hardware/software paths increasing scale to maximize productivity and applications development

# DOE INCITE Program

- We provide leadership computing through DOE's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program
- Leading researchers from government, industry, and the academic world use our Cray leadership computers
  - In 2007, the Cray XT4 Jaguar and Cray X1E Phoenix systems provided >75% of the computing power allocated for the INCITE program
  - In 2008, these systems will provide 145 million processor hours to INCITE projects



	Projects	Hours
Total INCITE allocations	45	95 million
NCCS allocations	28	75 million

The Cray systems at ORNL will provide 145M processor hours to the INCITE Program in 2008

# With UT, we are NSF's National Institute for Computational Sciences for academia

- **1 PF system to the UT-ORNL Joint Institute for Computational Sciences**
  - Largest grant in UT history
  - Other partners: Texas Advanced Computing Center, National Center for Atmospheric Research, ORAU, and core universities
- **1 of up to 4 leading-edge computing systems planned to increase the availability of computing resources to U.S. researchers**
- **A new phase in our relationship with UT**
  - Engagement with the scientific community
  - Research, education, and training mission



# Blue Gene/P Comes to ORNL

- Oak Ridge National Laboratory and IBM have teamed up to bring the next generation of the IBM Blue Gene supercomputer, the Blue Gene/P, to ORNL
- The new system was accepted in late September and features 8,192 compute cores and is capable of more than 27 trillion calculations a second, or 27 teraflops

*“Selected chemistry and materials applications especially have shown strong performance on the Blue Gene. We look forward to seeing researchers produce cutting-edge science on this system.”*

**Thomas Zacharia, ORNL’s Associate Laboratory  
Director for Computing and Computational Sciences**



***Chemistry and materials applications show promise***

# ORNL Institutional Cluster

- **20+ TF clusters**
- **Combination of dual- and quad-core Xeon**
- **2300+ cores**
- **Capacity computing for ORNL staff**
- **Add new processors each year and remove oldest processors after 3 years**



# New Storage Device Online at the NCCS

## *More storage for data intensive applications*

- The NCCS recently received an upgrade to its High Performance Storage System (HPSS) with the addition of the Sun StorageTek SL8500 modular library system
- The HPSS helps researchers manage massive amounts of data necessary to tackle Grand Challenge Science
- HPSS is now able to store more overall data, giving one of the nation's top super-computing centers even more ammunition with which to tackle today's Grand Challenge Science



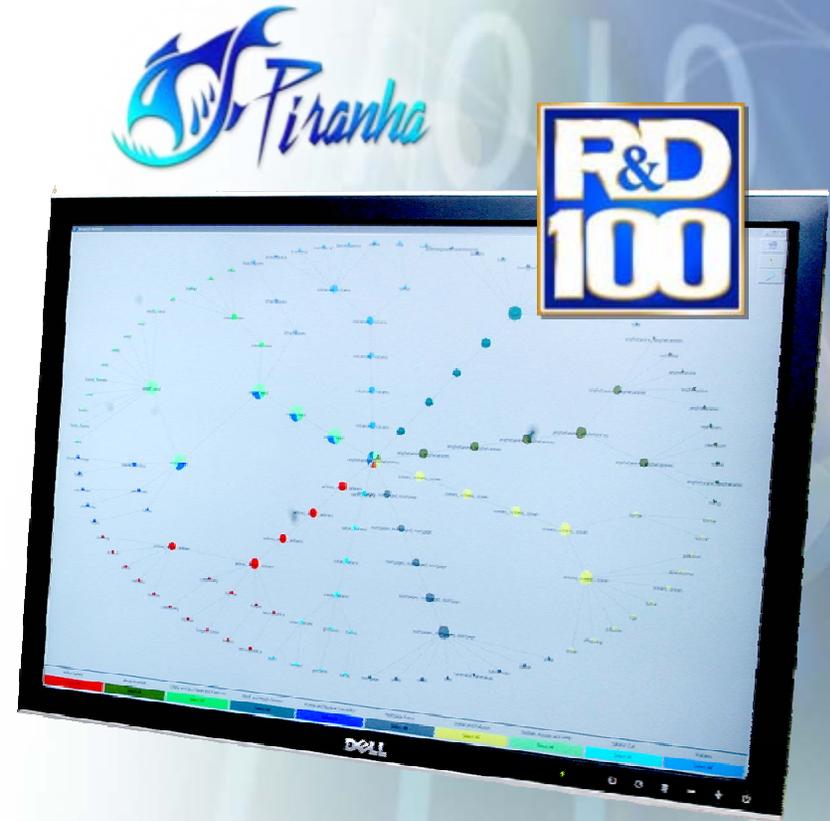
# We are leveraging expertise in knowledge discovery for national security

## KD Focus

- **Actionable insights from massive, dynamic, disparate data sources**
- **Ability to ask more complex questions and detect more complex processes using increasingly higher data resolution**

## Targeted KD Research

- **High-speed analysis of text, video, audio, digital, and sensor data**
- **Geospatial science and technology**
- **Data-driven modeling and simulation to discover underlying social and physical processes**
- **Quantum information science**
- **Data quality, provenance, and security**
- **Hypothesis generation, deception detection, and threat anticipation**



We have a unique opportunity for advancing math and computer science critical to mission success through multi-agency partnership

- **We are establishing two national centers of excellence in HPC architecture and software**
  - **Funded by DOE and DOD**
  - **Major breakthrough in recognition of our capabilities**

### Institute for Advanced Architectures and Algorithms

- **Jointly funded by NNSA and SC in 2008 ~\$7.4M**
- **ORNL-Sandia partnership**

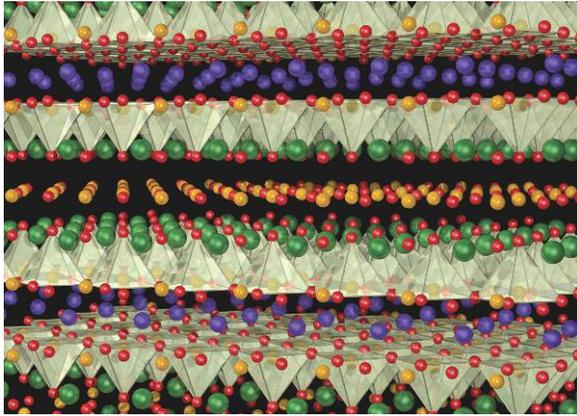


### Extreme Scale Software Development Center

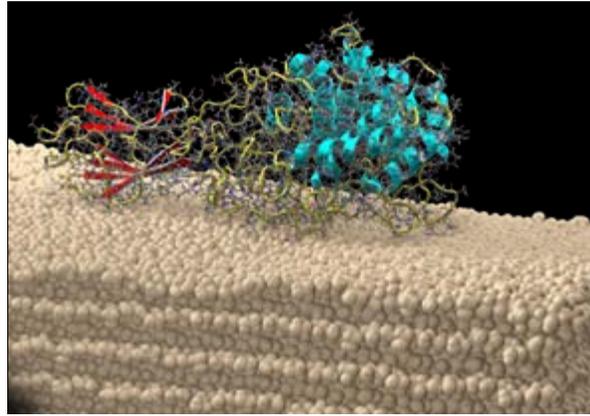
- **\$7M to \$15M in 2008**
- **Aligned with DOE-SC interests**



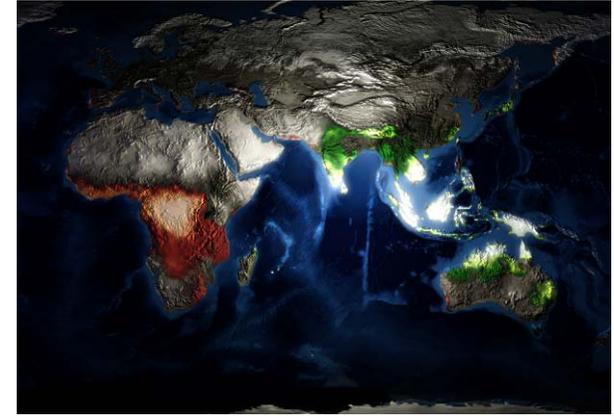
# We are advancing scientific discovery



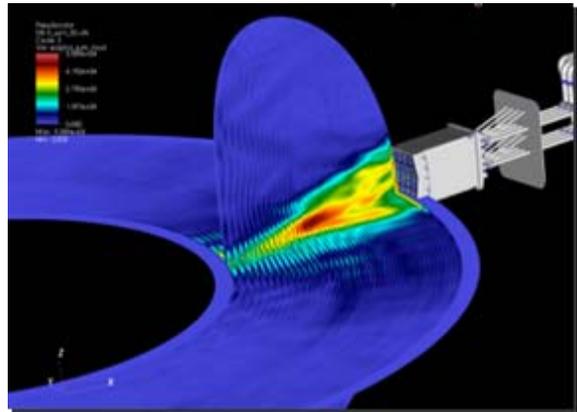
Resolved decades-long controversy about modeling physics of high-temperature superconducting cuprates



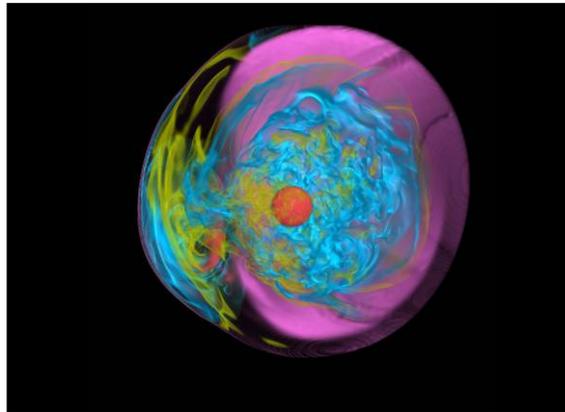
New insights into protein structure and function leading to better understanding of cellulose-to-ethanol conversion



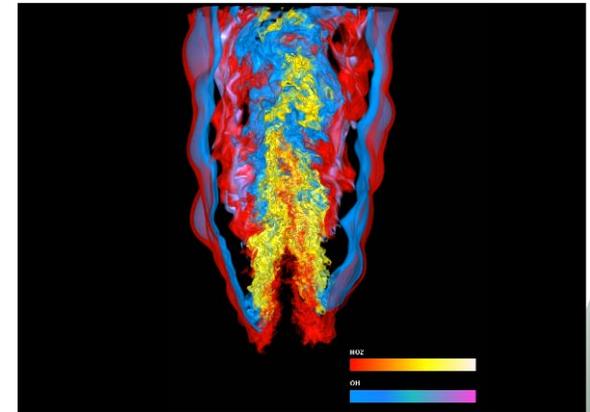
Addition of vegetation models in climate code for global, dynamic CO<sub>2</sub> exploration



First fully 3D plasma simulations shed new light on engineering superheated ionic gas in ITER



Fundamental instability of supernova shocks discovered directly through simulation



First 3-D simulation of flame that resolves chemical composition, temperature, and flow

# Upgrading 1PF Baker to 20 PF Cascade provides DOE with the best opportunity to deploy sustained petascale system

**Mission:** Deploy and operate the computational resources needed to tackle global challenges

- Climate change
- Terrestrial sequestration of carbon
- Sustainable nuclear energy
- Bio-fuels and bio-energy
- Clean and efficient combustion
- Energy, ecology and security

**Vision:** Maximize scientific productivity and progress on the largest scale computational problems

- Providing world class computational resources and specialized services for the most computationally intensive problems
- Providing a stable hardware/software path of increasing scale to maximize productive applications development



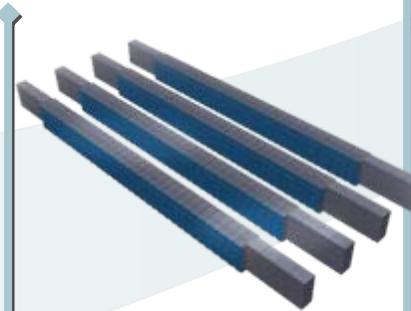
Cray XT4: 119 TF  
World's fastest  
open computer

FY2007



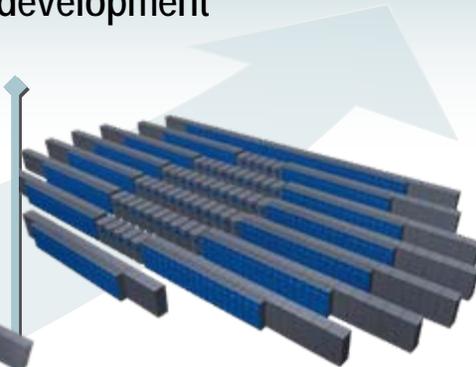
Cray XT4: 250+ TF  
AMD quad-core  
processor

FY2008



Cray XT5: 1 PF  
leadership class  
system for science  
AMD multi-core

FY2009



Cray Cascade: 20 PF  
leadership class  
sustained PF  
system for science  
AMD multi-core

FY2011

# Outstanding user services and support enabling breakthrough science

*"[On Jaguar,] we got 100-year runs in three days. This was a significant upgrade of how we do science with this model. 40 years per day was out of our dreams."*

Peter Gent of NCAR, Chairman of CCSM Scientific Steering Committee, during keynote at CCSM Workshop, June 19, 2007

*"[The NCCS has] been instrumental in being a bridge between our science and development teams and the computational resources."*

-Lawrence Buja, NCAR

*"[NCCS staff] serves as a crucial link for us in accessing these resources."*

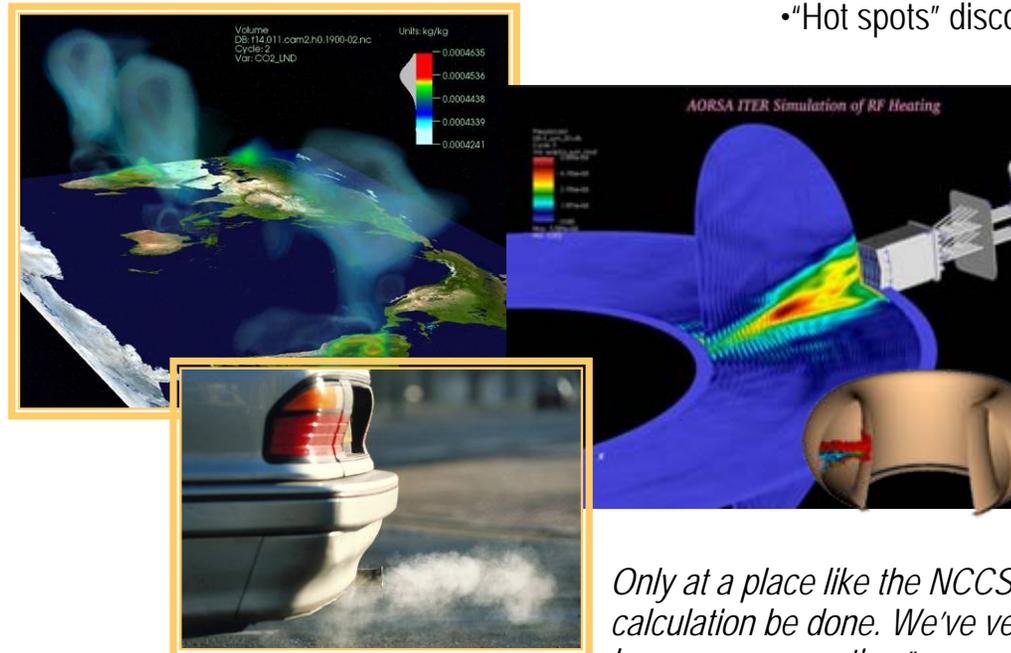
-W.W. Lee, PPPL

*"[They] really helped manage the code optimization."*

-John Drake, ORNL

*"...ORNL [staff] has been a crucial person in this effort, especially for code optimization."*

-Jeff Candy, General Atomics



First fully 3D simulations of plasma shed new light on the behavior of superheated ionic gas in the multibillion-dollar ITER reactor

- Demonstrated efficient plasma heating
- "Hot spots" discovered near antenna surface
- With NCCS help, code performance more than doubled in 2 months

*Only at a place like the NCCS can such an expensive calculation be done. We're very lucky that NCCS has been very supportive."* Jihui Yang, General Motors

General Motors researchers simulate materials that turn heat into electricity

# Joint Institute for Computational Sciences

**UT-ORNL Governor's Chairs**

The University of Tennessee is in partnership with the Oak Ridge National Laboratory is recruiting leading scientists to conduct research in the Joint Institute for Computational Sciences with access to some of the most advanced scientific and computational tools available. In addition to working in an exciting atmosphere of intellectual and academic freedom, you would be living in one of the most beautiful areas in the country with easy access to miles of inland waterways, pristine state and national parks, diverse cultural opportunities, and a unique mix of convenient urban and rural living settings.

Find out more at <http://www.tennessee.edu/governorchairs/>

**Governor's Chairs in the UT-ORNL Joint Institute for Computational Sciences**

The State of Tennessee is recruiting 20 exceptionally accomplished researchers who will have joint appointments as tenured professors at the University of Tennessee (UT) and distinguished research staff of the Oak Ridge National Laboratory (ORNL). The Governor's Chair (GC) program seeks to utilize the development of leading edge research under the auspices of the joint institutes between UT and ORNL, Biological Sciences, Computational Sciences, Nuclear Sciences, and Advanced Materials Sciences. The GC appointments include an ongoing interdisciplinary research fund equal to twelve months salary.

The Joint Institute for Computational Sciences (JICS) will support both fundamental and applied research and teaching programs in computational sciences, computational mathematics, computer science, high performance computing, storage and networking, and cyber security.

UT and ORNL have strong research efforts in these areas: the research environment fosters cross-disciplinary, leading edge efforts that leverage special facilities in the physical and computational sciences. Major cross research facilities include the DOE Leadership Computing Facility (LCF), LCF is planning the acquisition and deployment of a 2017 high-performance computing (HPC) system by 2017 and a 2020/21 HPC system by 2020. It is expected that JICS will focus on applications and system software essential to optimal sustained performance of the HPC system to enable a range of computationally challenging and interdisciplinary research programs.

The UT-ORNL environment nurtures a rich interdisciplinary community of researchers with common interests and collaborative projects. The UT-ORNL research enterprise has more than \$2 billion in research in some of the world's most advanced research facilities.

There are immediate openings for Governor's Chairs in the following areas:

Science and engineering applications—Applications are sought from candidates interested in:

- Computational science of the petascale in the physical, biological, and environmental sciences

Computer science applications—Applications are sought from candidates interested in developing:

- Algorithms, methods, and libraries
- Computer-based, petascale program development and tools
- Systems software that scale to hundreds of processors
- Scalable systems for moving, storing, and analyzing data

Successful candidates will have an excellent record of scientific productivity and accomplishment, as exemplified, for example, in high-impact publications, scientific awards, or fellow status in scientific and engineering societies. Successful candidates will also have a demonstrated record of leading cross-institution teams of researchers and of developing successful interdisciplinary research programs.

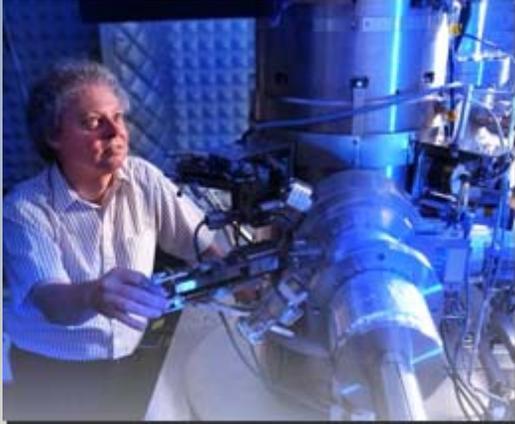
APPLICATORS: Applications should be submitted to the chair of interest and a curriculum vitae to: Thomas Zacharia, Chair, JICS-Governor's Chair Search Committee, Computing and Computational Sciences, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6100. Applications will commence on July 1, 2016, and will continue until the positions are filled. The University of Tennessee is an EEO/AAE/DFW/VV. The US Equal Opportunity Act (EO 12816) is in the process of its revision and employment programs and services.

Scientists and engineers at the Oak Ridge National Laboratory and the University of Tennessee conduct basic and applied research and development to create scientific knowledge and technological solutions that strengthens the nation's leadership in key areas of science, increase the availability of clean, abundant energy, reduce and protect the environment, and contribute to national security. UT and ORNL provide an environment that encourages collaborative research and development. UT-Battelle manages and operates ORNL under contract DE-AC05-00OR22710.

UT-BATTELLE THE UNIVERSITY OF TENNESSEE OAK RIDGE National Laboratory

# Building on nanoscale S&T to produce breakthrough innovations

## Advanced Microscopy Laboratory



- **World's highest resolution microscopes**
- **Direct images of single atoms**

## Center for Nanophase Materials Sciences



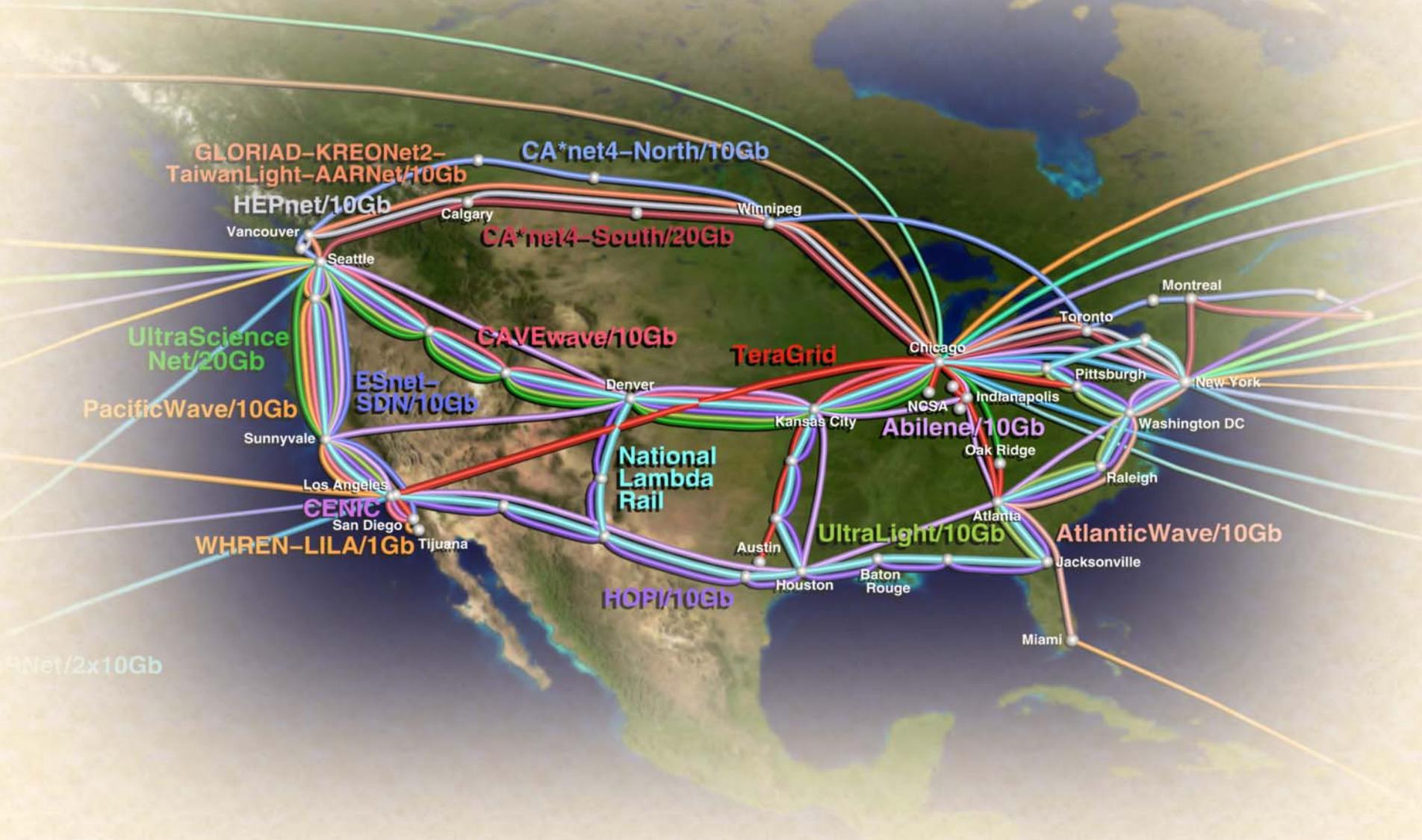
- **DOE's first nanoscale science research center**
- **Will use neutrons from SNS to study material properties**

## Joint Institute for Advanced Materials



- **To be constructed at UT's Knoxville campus**
- **Focus: Biomaterials, nanotechnology, and transportation systems**

# Joint Institute for Computational Sciences



# We apply our strengths in science and technology to six major missions

## Our intent:

- **Lead the world in the tools and research applications of neutron scattering**
- **Understand and control material properties at the nanoscale**
- **Deliver sustained world leadership in computational science and engineering at scale**
- **Create breakthroughs in energy technology**
- **Understand and apply protein and other biologically significant molecular interactions in microbial and plant cells and communities**
- **Apply our S&T base to deliver “first-of-a-kind” security technologies and implement arms control and nonproliferation programs**

# Studying materials with the world's best resources for neutron scattering

**The \$1.4 billion Spallation Neutron Source is now in operation**

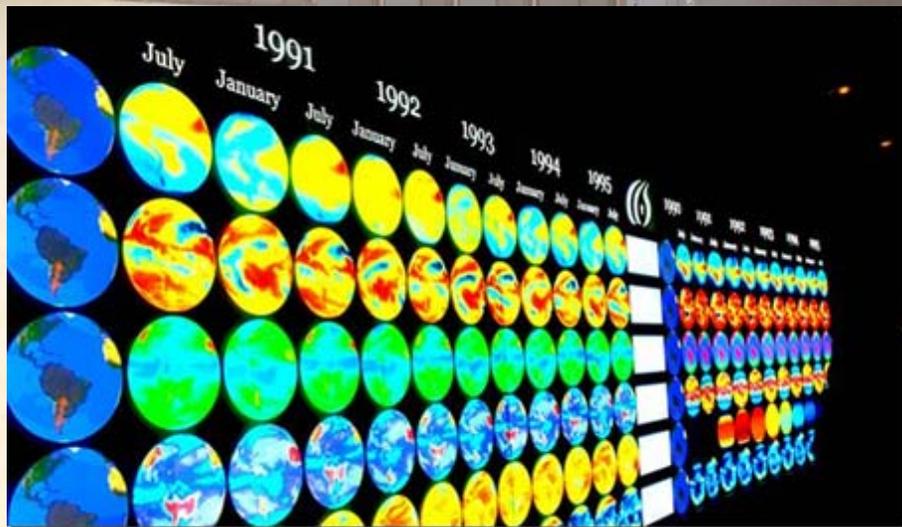
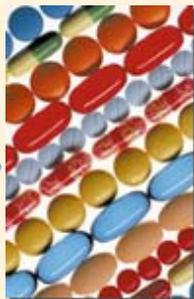
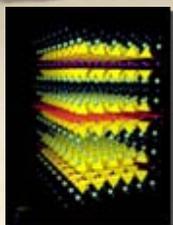
**DOE's first nanoscale science research center is producing exciting results**

**The upgraded High Flux Isotope Reactor offers complementary capabilities**

**The UT-ORNL Joint Institute for Neutron Sciences provides a user gateway for SNS and HFIR**



# Applying the nation's fastest scientific computers to challenging problems

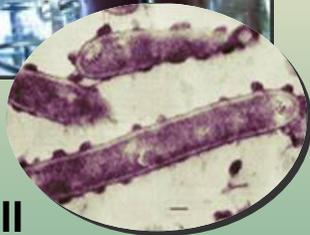


# Transforming the new biology into bioenergy

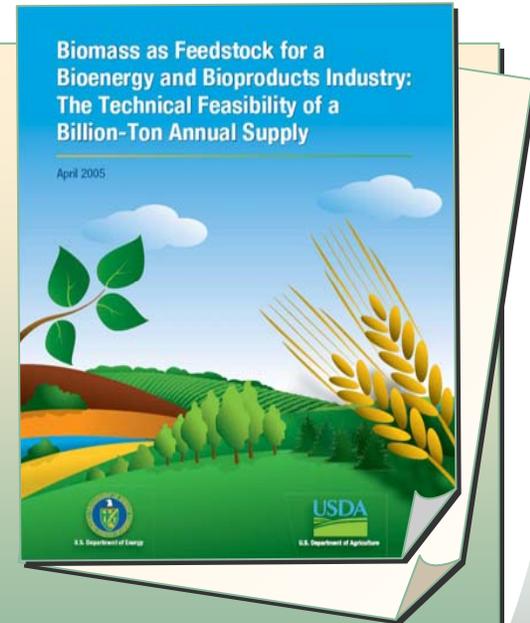
**Integrating our programs in genetics, biotechnology, process chemistry, and engineering to deliver biofuels**



***Clostridium thermocellum* breaks down cell walls to enable ethanol production from cellulose**

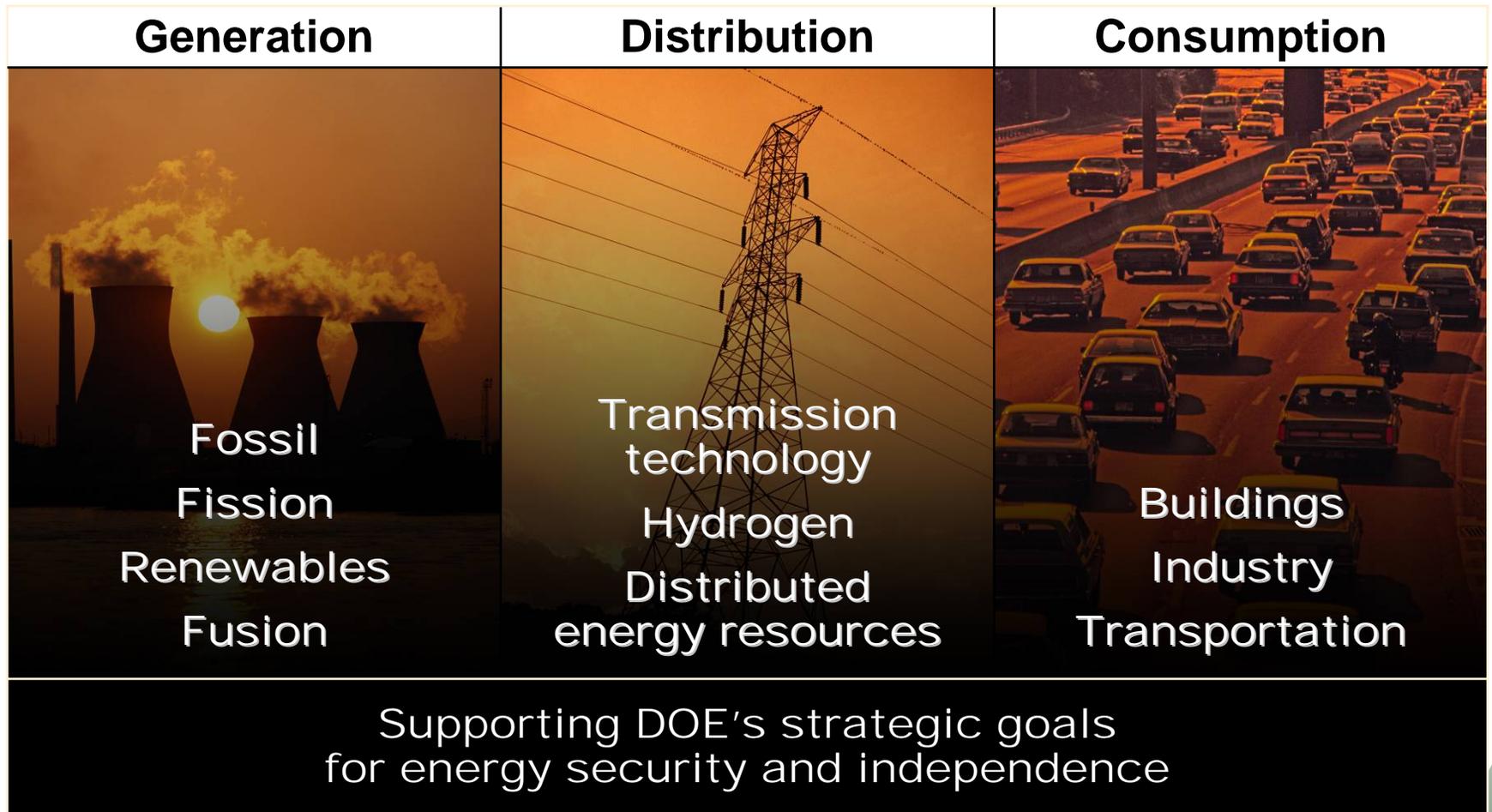


**Sequencing of poplar genome will lead to trees that produce more biomass for conversion into fuel**



**Biofuels can displace 30% of imported oil**

# Addressing the energy challenges of the present . . . and the future



# Applying our S&T resources to national and homeland security

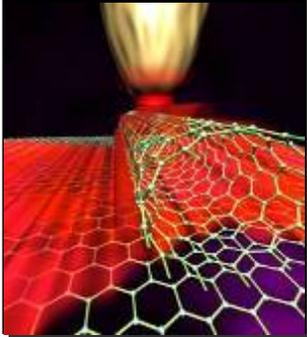
- **Detecting, preventing, and reversing the proliferation of weapons of mass destruction**
- **Deploying integrated systems for incident awareness, detection, and response**
- **Providing technology for detecting explosives at the part-per-trillion level**
- **Delivering enhanced protection and new capabilities to first responders and warfighters**



# DOE established Leadership Computing Facility based on peer-reviewed proposal

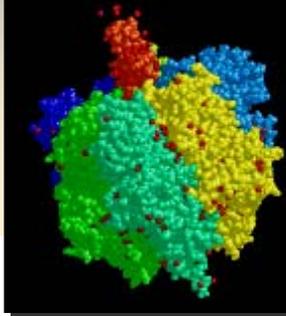
Office of Science research priorities

Manipulating  
the Nanoworld



Computational  
design of  
innovative  
nanomaterials

Taming the  
Microbial  
World



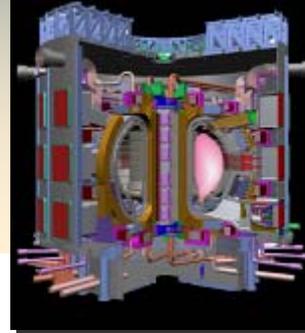
Predictive  
understanding  
of microbial  
molecular and  
cellular systems

Environment  
and  
Health



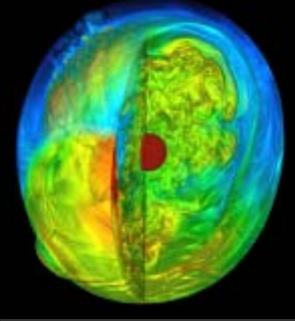
Full carbon  
cycle in climate  
prediction,  
IPCC

ITER for  
Fusion  
Energy



Simulation of  
burning plasma,  
Fusion  
Simulation Project

Search  
for the  
Beginning



Terascale  
Supernovae  
Simulation

**Theory, Mathematics, Computer Science**

**National Leadership-Class Computing Facility for Science**

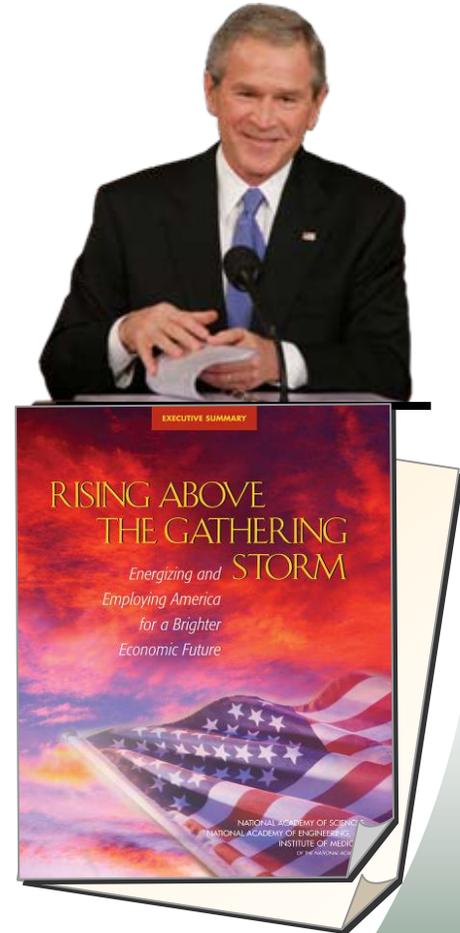
# American Competitiveness Initiative

In the President's State of the Union Address on January 31, 2006, President Bush stated,

*"I propose to double the federal commitment to the most critical basic research programs in the physical sciences over the next ten years. This funding will support the work of America's most creative minds as they explore promising areas such as nanotechnology, supercomputing, and alternative energy sources."*

*Secretary Bodman, Ibid.*

*"Developing revolutionary, science-driven technology is at the heart of the Department of Energy's mission. To ensure that America remains at the forefront in an increasingly competitive world, our Department is pursuing transformational new technologies in the cutting-edge scientific fields of the 21<sup>st</sup> century – areas like nanotechnology, material science, biotechnology, and high-speed computing."*



# ORNL's programs depend on close university partnerships

**Our long relationship with the University of Tennessee has been expanded to include other key universities**



**The UT-Battelle partnership explicitly includes other academic institutions**

**Oak Ridge Associated Universities**



**Seven "core university" partners:  
Duke, Florida State, Georgia Tech,  
North Carolina State, Vanderbilt,  
Virginia, Virginia Tech**



**New relationships with minority educational institutions**