SAND2009-5000P

Science, Technology and Engineering Overview

Dr. Hamad & Dr. Radwan
National Research Center, Cairo, Egypt
July 9, 2009

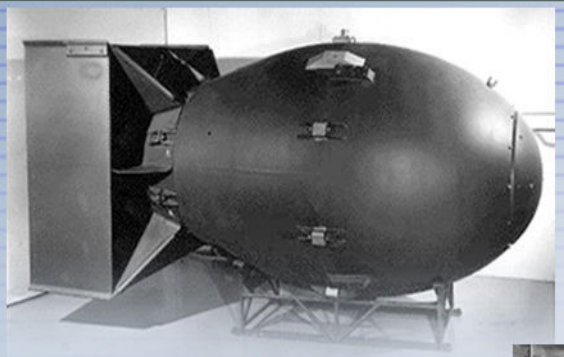
J. Charles Barbour
Deputy to the Vice President of
Science, Technology & Engineering

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories

Sandia has served the United States since 1949

"Exceptional service in the national interest"



THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

I am writing a similar note direct to Dr. O. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

Sandia National Laboratories

Sandia is a multi-program national laboratory with distributed facilities to meet national needs

Albuquerque, New Mexico

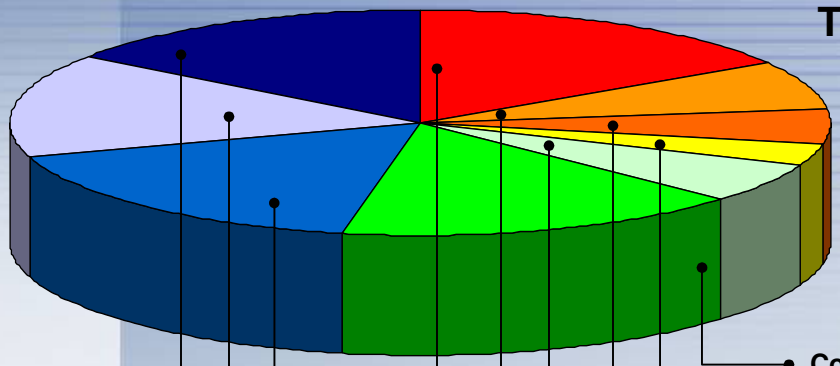
Livermore, California

Pantex, Texas

WIPP, New Mexico

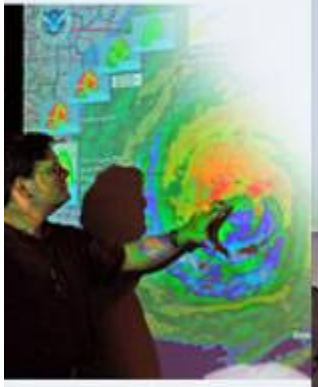
Sandia National Laboratories

We have 8,225 regular and 530 temporary employees, plus 1,170 contractors



Technical Staff (3,928) by Degree

- Computing 15%
- Math 2%
- Chemistry 4%
- Physics 6%
- Other Science 7%
- Other Fields 18%
- Electrical Engineering 17%
- Mechanical Engineering 16%
- Other Engineering 15%



FY09 Operating Revenue: $2,169M

Sandia National Laboratories

National Security Mission Space

Nuclear Weapons

One Management Unit

- Nuclear Weapons

Integrated Technologies and Systems

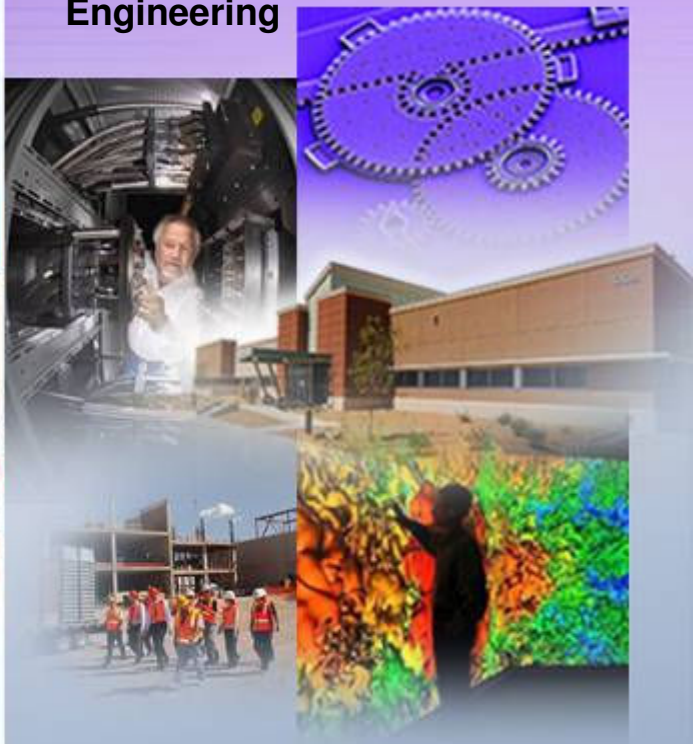
Three Management Units

- Defense Systems and Assessments
- Energy, Resources, and Nonproliferation
- Homeland Security and Defense

Laboratory Transformation

Two Management Units

- Integrated Enabling Services
- Science, Technology, and Engineering



Sandia National Laboratories

Science, Technology & Engineering at Sandia

Secure America's future through discovery and innovation at the interface of science and engineering

1. Nurture the Core

- Sandia's ST&E must be defining the cutting edge of science and engineering.
- Sandia must be attracting the best and brightest our country has to offer.

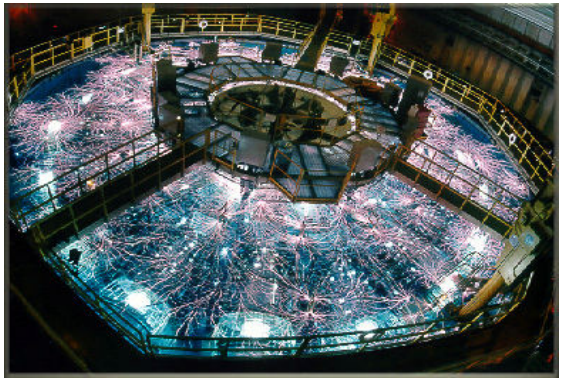
2. Enable the Missions

- Sandia's ST&E must be intimately and seamlessly connected to the missions.

Sandia National Laboratories

Sandia's strategic capabilities are underpinned by 6 research foundations

Strategic Capabilities

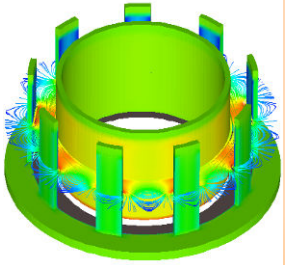


High Performance Computing & Simulation

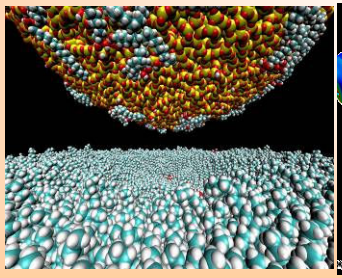
Nanotechnologies and Microsystems

Extreme Environments

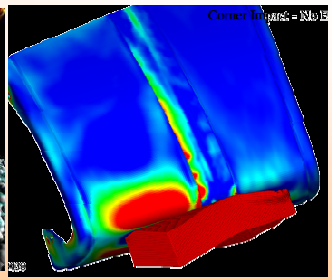
Computer Science



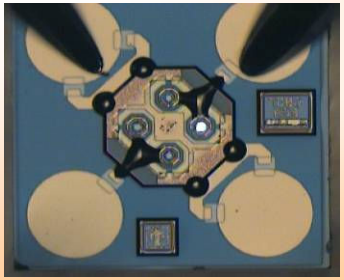
Materials



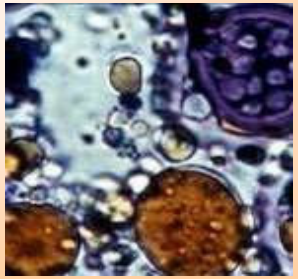
Engineering Sciences



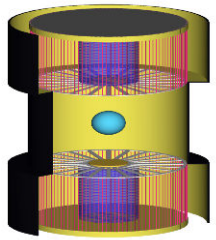
Micro Systems



Bioscience



Pulsed Power



Research Foundations

Metrics: Awards and Recognition

New Fellows

Gary Grest – Nat'l Acad. Eng.
James A. Miller – Nat'l Acad. Eng.
Mike Coltrin – AAAS
Jerry Simmons – AAAS
Jeff Tsao – AAAS
Jeff Brinker - MRS
Robert Hwang – American Phys. Soc.
Mike Dugger – Soc. Tribology & Lub. Engineers
Jerry Knorovsky – American Welding Soc.
Somuri Prasad – American Soc. of Materials, International

Recent Journal covers

Dec 2008 analysis lists Sandia as #1 worldwide in citations in energy research (1998-2008)

Individual Achievements

Wei Pan, Presidential Early Career Award for Scientists and Engineers

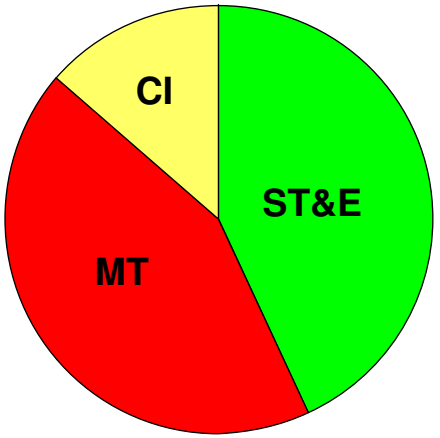
Burt Debusschere, Presidential Early Career Award for Scientists and Engineers

Patrick Hopkins, Truman fellow, Outstanding Young Engineering Graduate Award

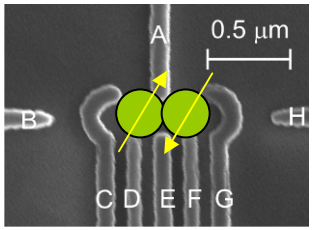
Laboratory Directed Research & Development (LDRD) is essential for the future of Sandia

LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

FY08 LDRD Budget
$151M

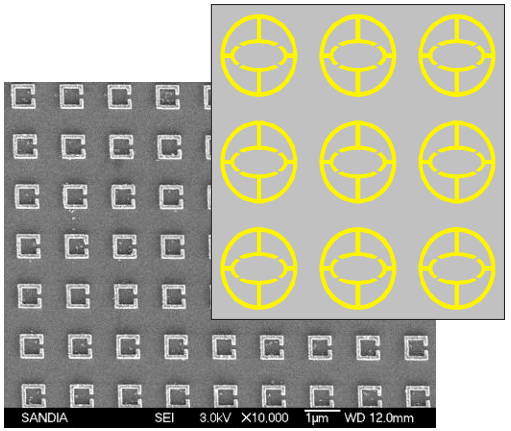


- Nurture core capabilities
- "Seed Corn" of the Labs' future mission technologies
- Allows us to anticipate and respond to national needs
- A mechanism for professional growth and development



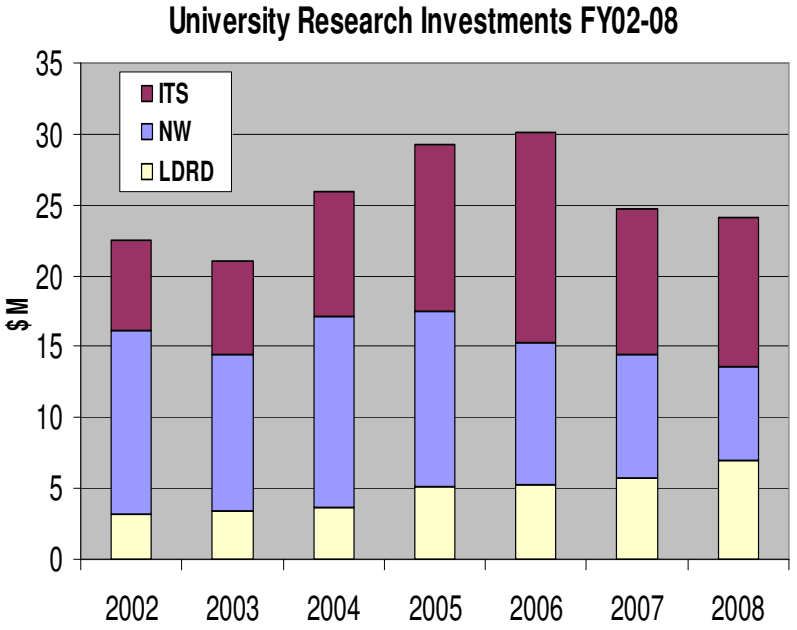
Physical Qubit & Native Gate Set

Metamaterials & Plasmonics

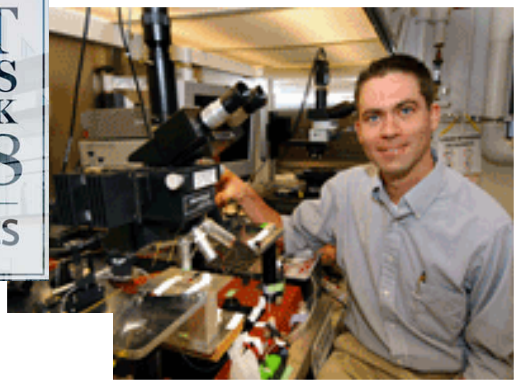


Sandia National Laboratories

Engagement with broader scientific community helps us maintain a vital workforce



TheScientist
BEST PLACES TO WORK 2008
POSTDOCS



Truman Fellows

Student Interns

Sandia National Laboratories

Discovery Science & Engineering Innovation Institutes accelerate innovation

LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

NATIONAL INSTITUTE FOR NANO ENGINEERING

A Sandia-University–Industry Consortium

- **Multi-disciplinary projects**
- **Future leaders development**
- **Value to the nation**

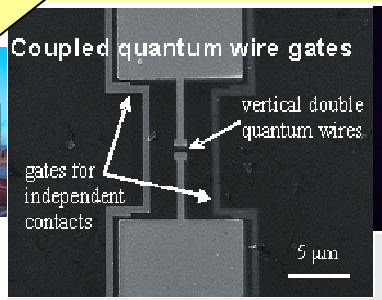
Students

Mentors

Facilities

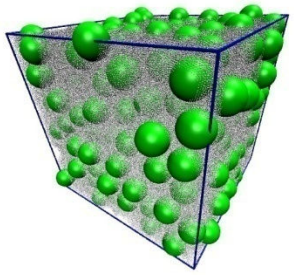
Technical Depth ***Leadership*** ***Teamwork*** ***Breadth***

Global Innovation Leaders

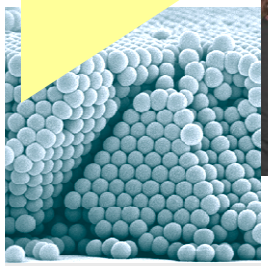


Next-generation Nanoelectronics

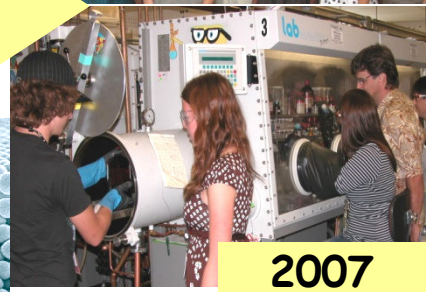
Nano for Energy



Computation & Modeling



Nano Materials

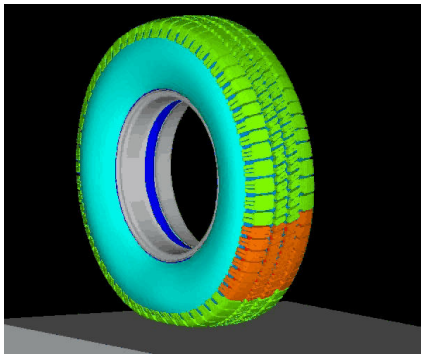


2007 NINE Summer Class

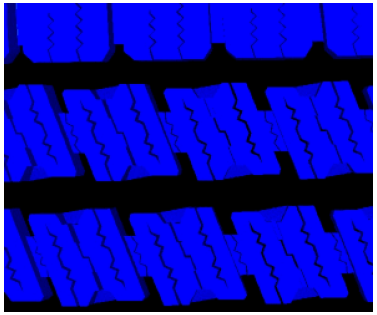
Sandia National Laboratories

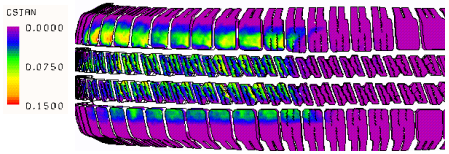
Industrial Partnerships provide strong value to Sandia

GOODYEAR



Assurance™ Featuring TripleTred Technology™





IBM

hp invent

P&G

LOCKHEED MARTIN

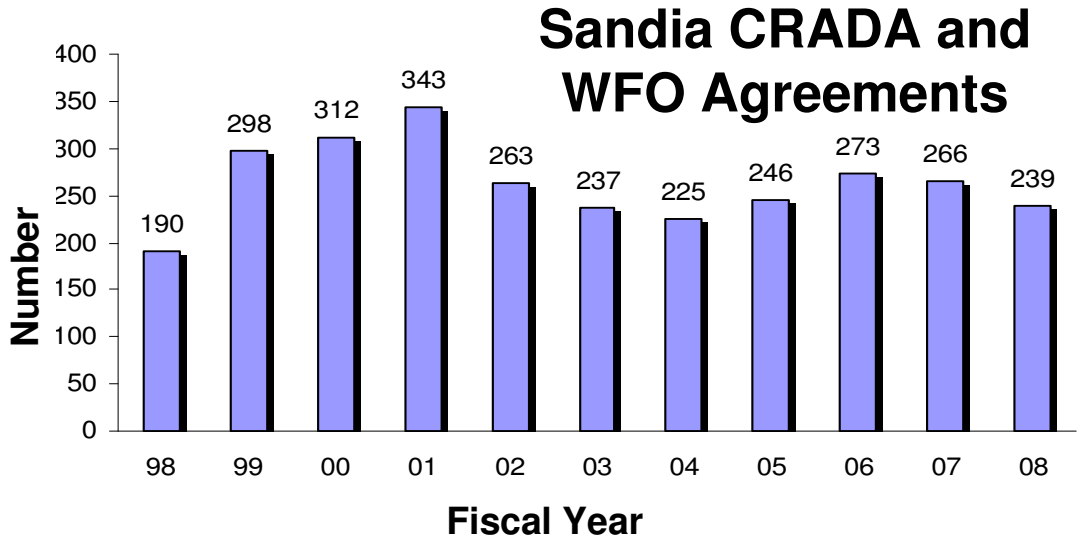
intel

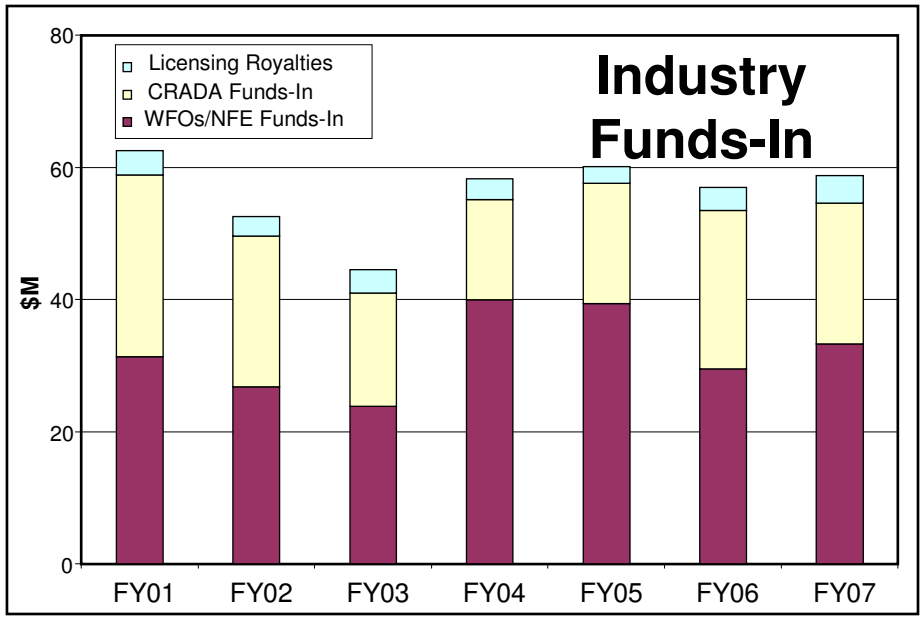
CORNING

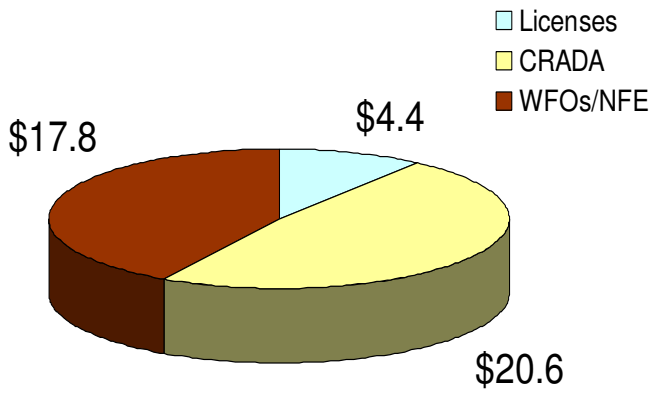
ExxonMobil
Taking on the world's toughest energy challenges.

Sandia National Laboratories

Technology Transfer: CRADA / WFO Agreements & Industry Funds-In







FY08 Total = $42.8M

Sandia National Laboratories

We use our Users Facilities extensively to engage researchers internationally

Center for Integrated Nanotechnologies (CINT):

- Provides access to tools and expertise for the research of nanoscience integration
- 162 user's projects in FY08
- Current number of users > 200
- 50% of the users are foreign nationals

Combustion Research Facility (CRF):

- Worldwide recognized R&D facility for combustion chemistry and turbulent flame research
- Develop applied science supporting industry

Computer Science Research Institute (CSRI):

- On-site joint research in computer science, computational science and mathematics
- 48% of visitors are foreign nationals

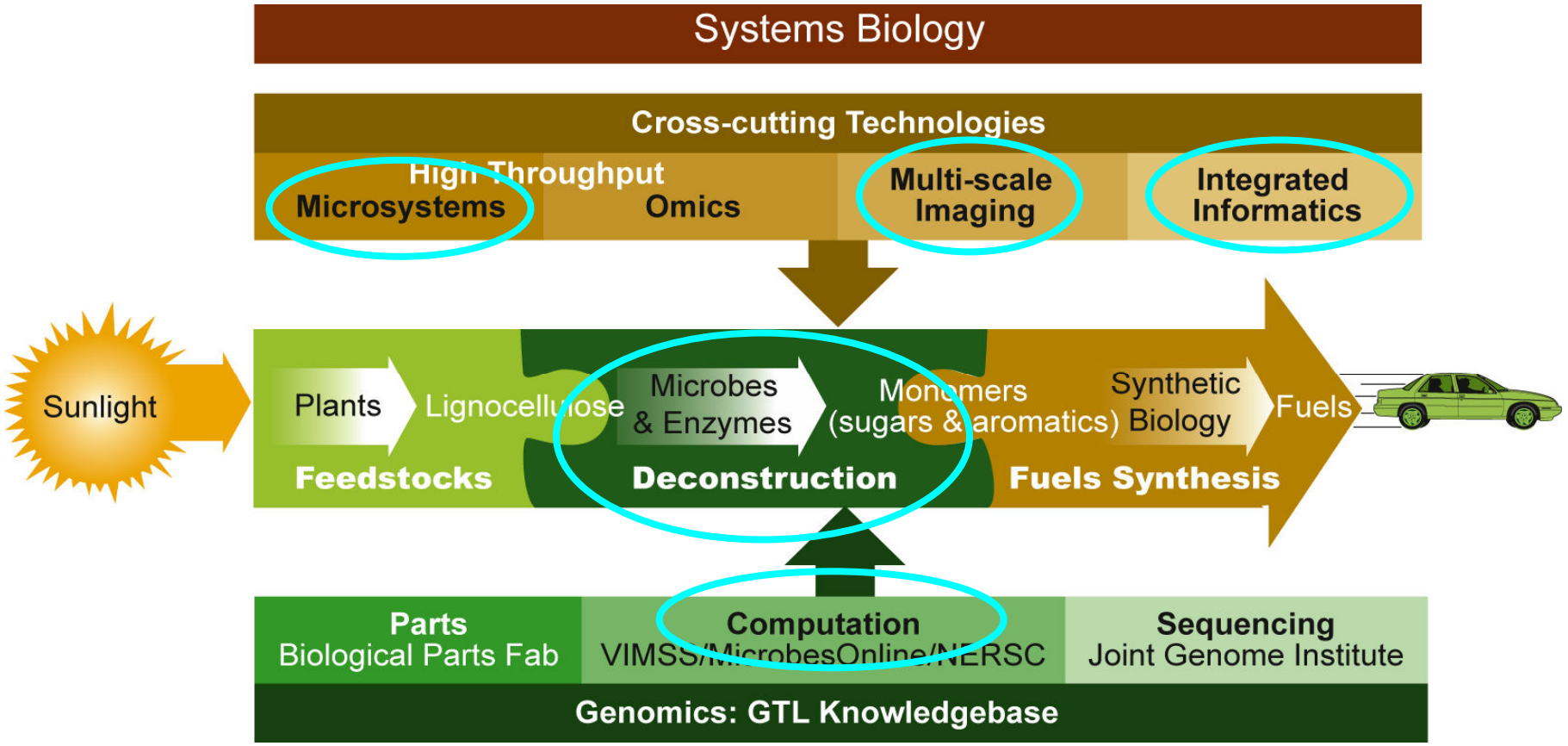
Sandia National Laboratories

Developing International Collaborations

- Carbon Capture and Storage
- Low-Carbon Technologies
- Photovoltaics
- Climate Change
- Smart Grid
- Nuclear Energy
- Energy Efficiency
- Renewable Technologies
- Energy and Water Relationships
- Nanoelectronics and Nanomaterials
- Computational Materials Sciences
- Basic Research

Sandia National Laboratories

Joint BioEnergy Institute (JBEI) leverages Sandia's key capabilities



DOE GENOMICS:GTL
SYSTEMS BIOLOGY FOR ENERGY AND ENVIRONMENT
OFFICE OF SCIENCE U.S. DEPARTMENT OF ENERGY

BERKELEY LAB

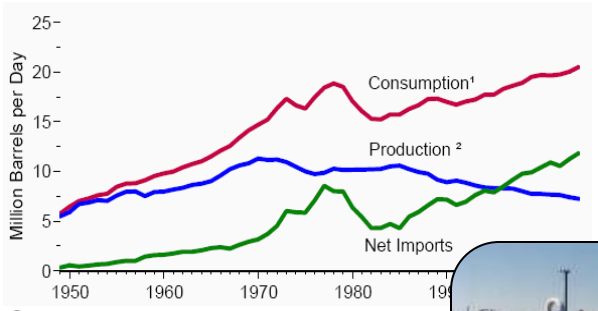
Sandia National Laboratories

UCDAVIS
UNIVERSITY OF CALIFORNIA

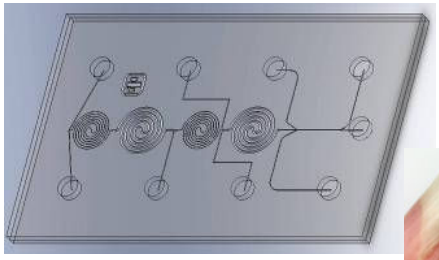
Sandia National Laboratories

Sandia's bioscience capabilities are aligned with two strategic mission thrusts

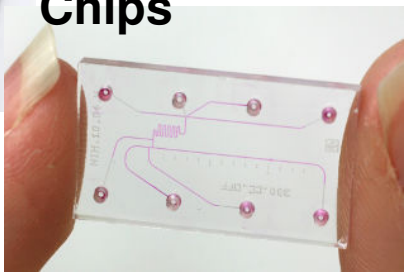
- **Biofuels:**
  - **Transportation BioFuels**
  - **Civilian & Military Use**
  - **Sustainable, coupled to co-products and carbon utilization**



- **Biosecurity:**
  - **Civilian & Military Biodefense**
  - **Emerging Infectious Diseases**



MISL Chips



Demonstrated a single-chip array for imaging & interrogating an individual cell, with time resolution of minutes

GNL GALVESTON NATIONAL LABORATORY

UTMB

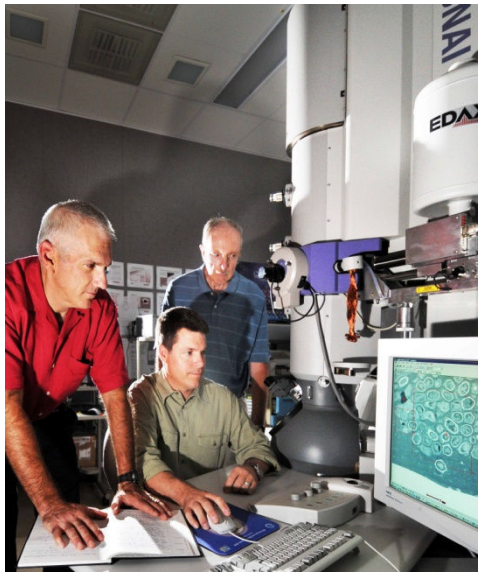
LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

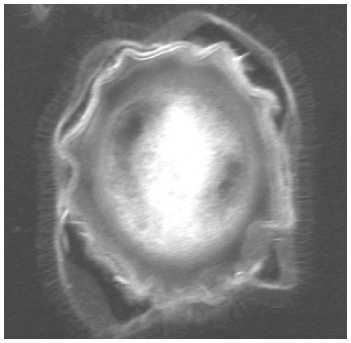
Sandia's advanced materials science analysis provided key evidence for anthrax analysis

- **Sandia worked secretly with the FBI since 2001 to resolve issues around the anthrax letters attack**

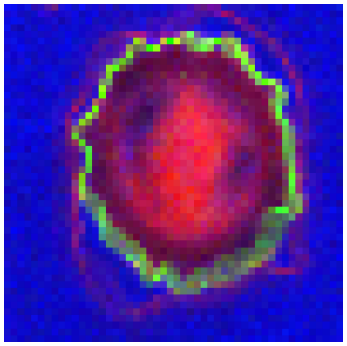
- **Results from S&T**
  - **Linked spore material in the *New York Post*, the Daschle and the Leahy letters to a single source**
  - **Anthrax was not weaponized**
  - **Not state-sponsored terrorism**



Material characterization analysts Joe Michael, Paul Kotula, and Ray Goehner



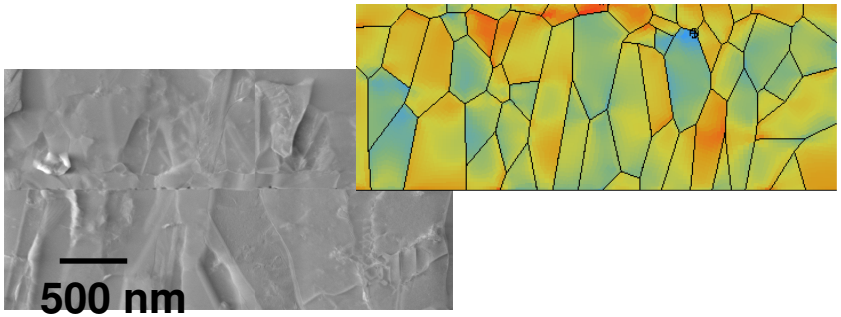
STEM image of *B. anthracis*



Spectral image of Si-O on the spore coat

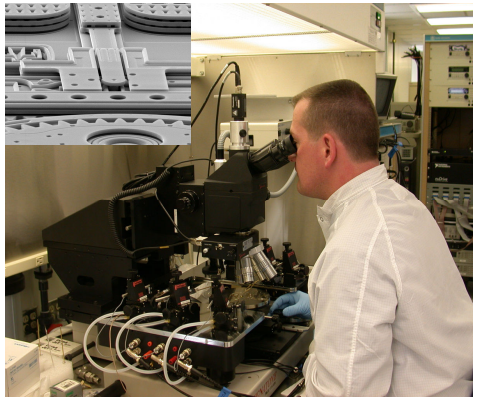
Sandia National Laboratories

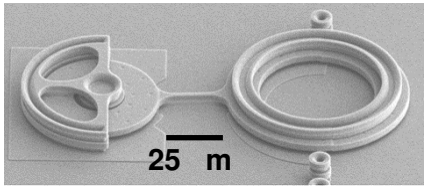
Our advanced materials science and engineering ensures robust microsystems

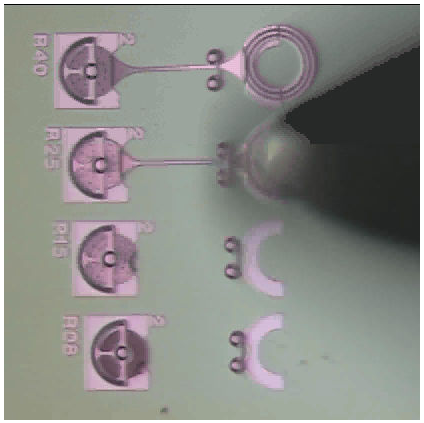


Microstructural Characterization

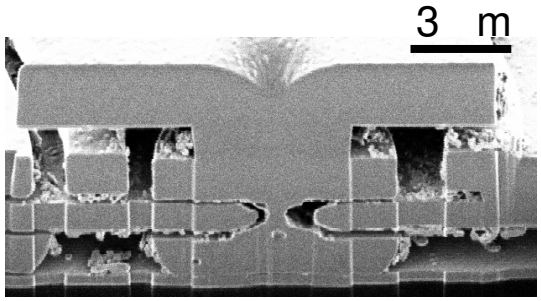
Micromechanical Testing



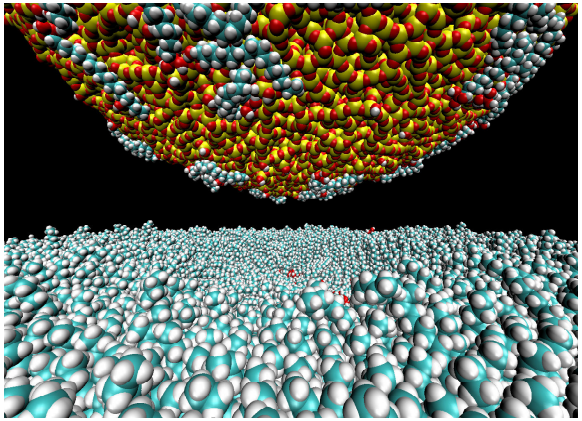




Fatigue & Reliability Study



607,000 cycles of rotation



High Performance Computing Enabled Performance Analyses on MEMS Coating

Micro- and nano- fabrication facilities

Microsystems & Engineering Sciences Applications

MESA: Production-scale Fab

Microelectronic Development Laboratory (MDL)

Compound Semiconductor Micro-Fab

- Trusted design & supply
- Rad-hard microelectronics
- MEMS & sensor systems

Center for Integrated Nanotechnologies (CINT)

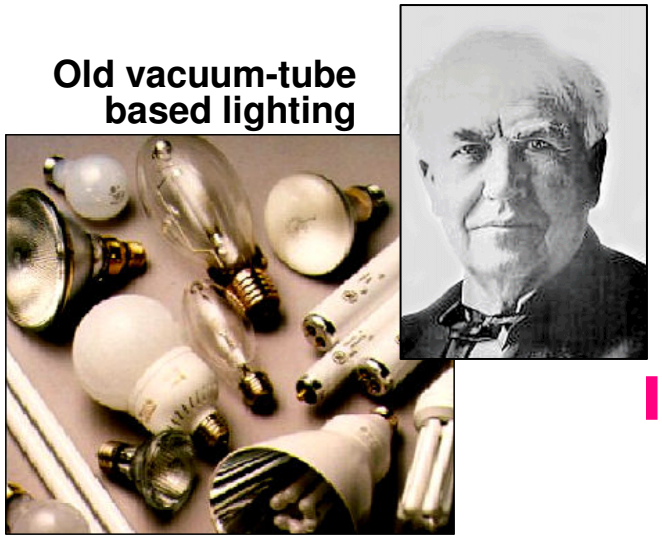
CINT: Rapid-turn R&D in nanodevices

A partnership between SNL & LANL

Sandia National Laboratories

Solid State Lighting (SSL) will change the way we light the world

Old vacuum-tube based lighting



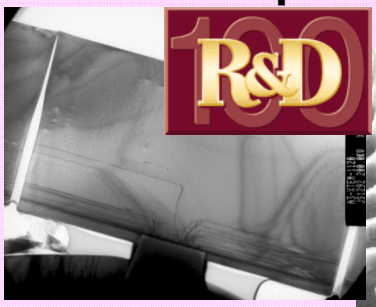
Lighting

SSL has the potential, by 2025, to:

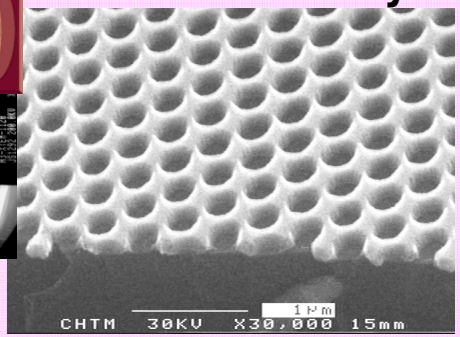
- Decrease electricity consumed by lighting by 70%
- Decrease total electricity consumption by 14%
- Reduce carbon emissions by >30 million tons

Successful R&D investments made Sandia the Lead Lab in US for SSL developments.

Cantilever Epitaxy



Photonic Crystal

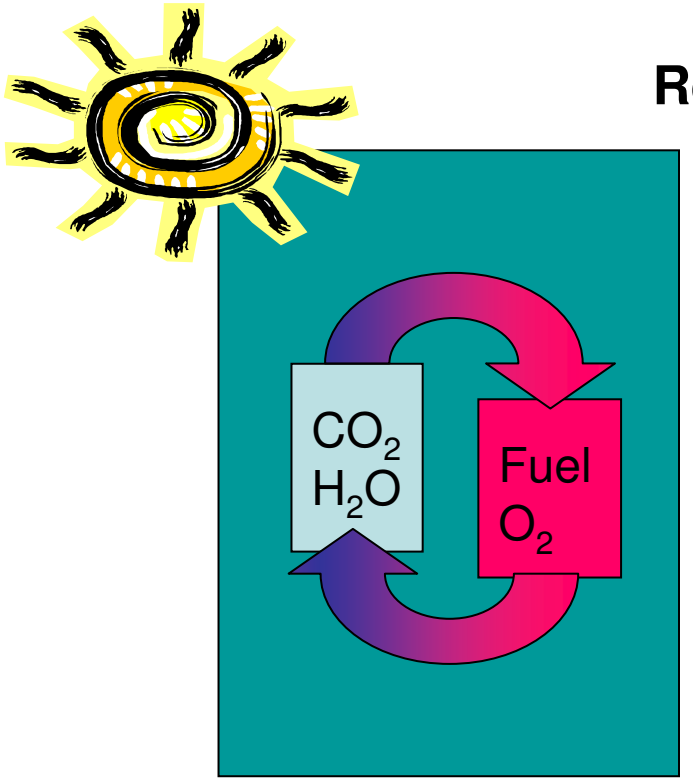


LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

Sandia energy research in the news

USA Today reports on LDRD Grand Challenge: Sunshine to Petrol



Recycling CO_2 into Fuel

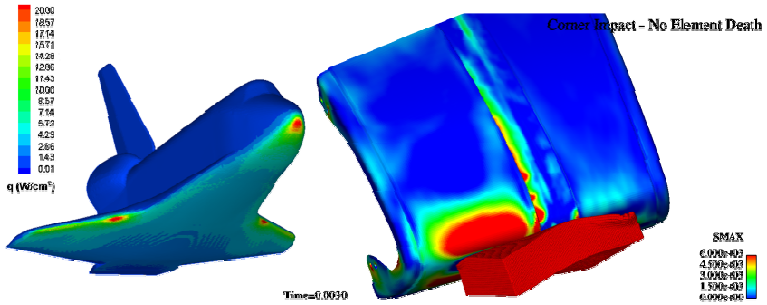
Concentrating solar system that supplies heat for reactor to turn carbon dioxide and water into fuel

$$\text{Sunlight} + CO_2 + H_2O \rightarrow \text{Fuel} + O_2$$

LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

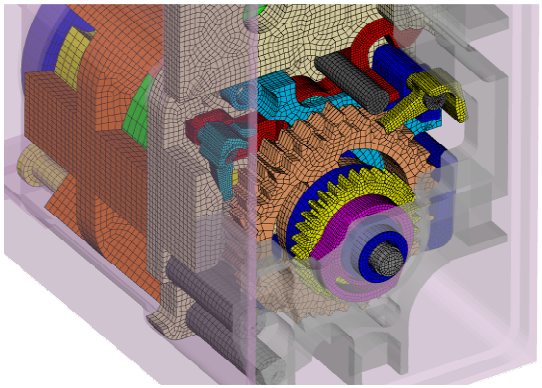
Sandia National Laboratories

Computing now enables unprecedented analysis and prediction for science and engineering

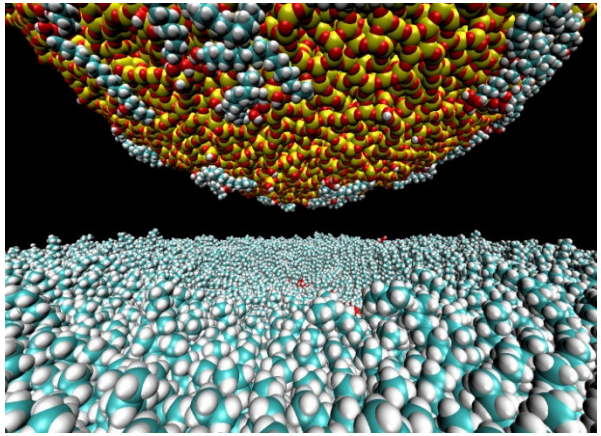


Columbia

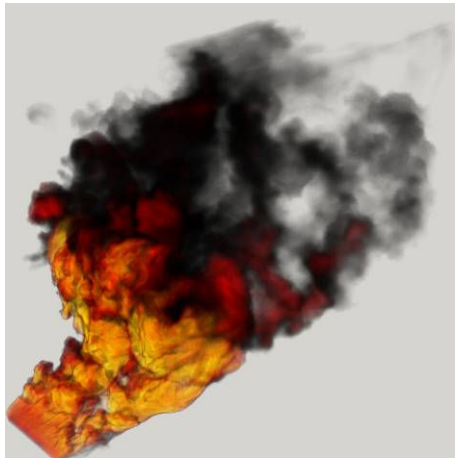
Industry



Safety & Security



Science

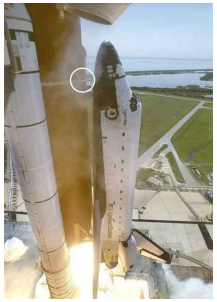
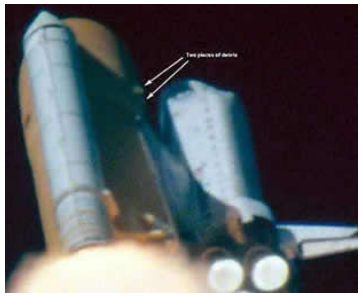
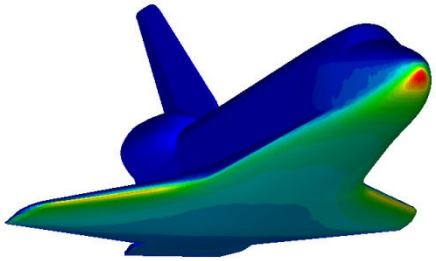


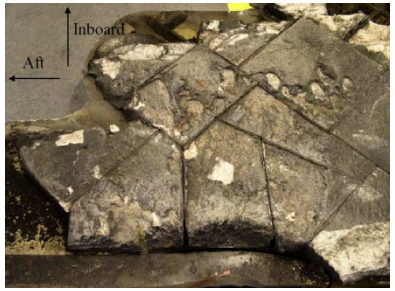
Extreme environments

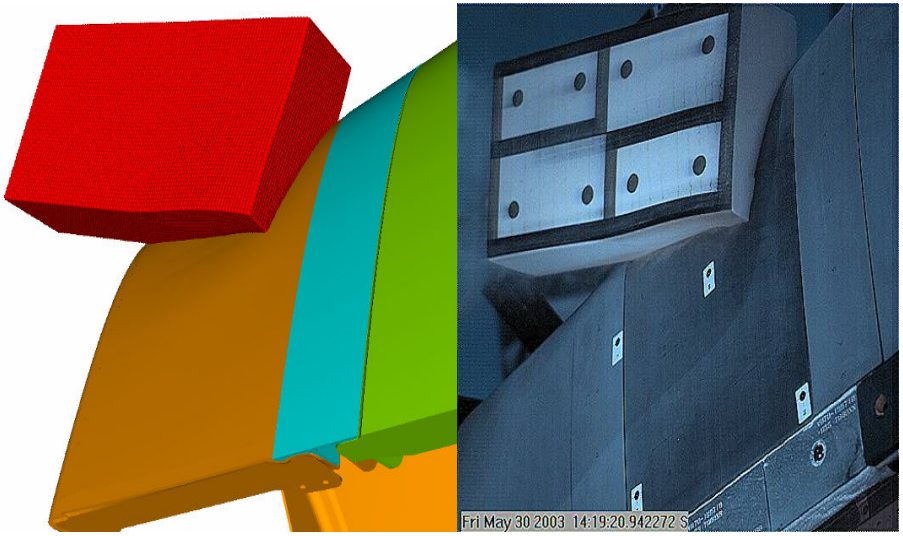
Sandia National Laboratories

Sandia's modeling & system-engineering expertise helped answer many critical questions

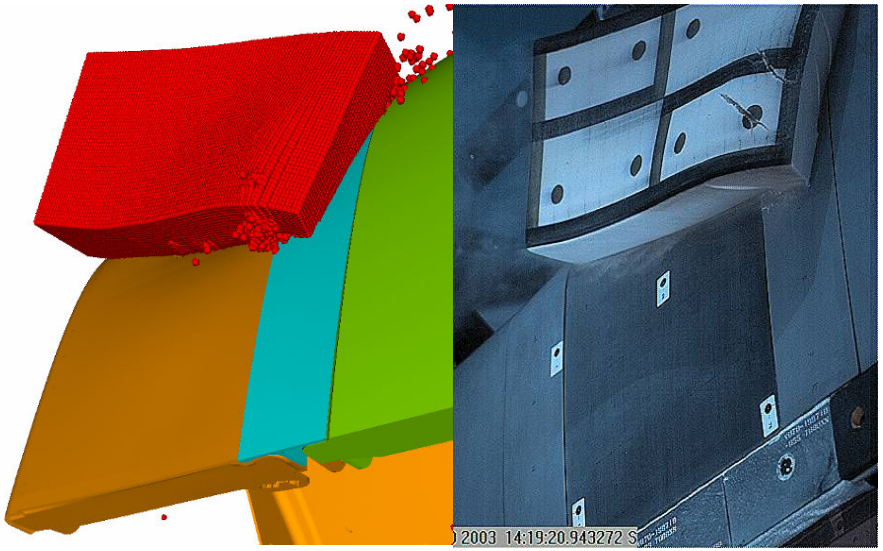
Study of the Columbia Accident



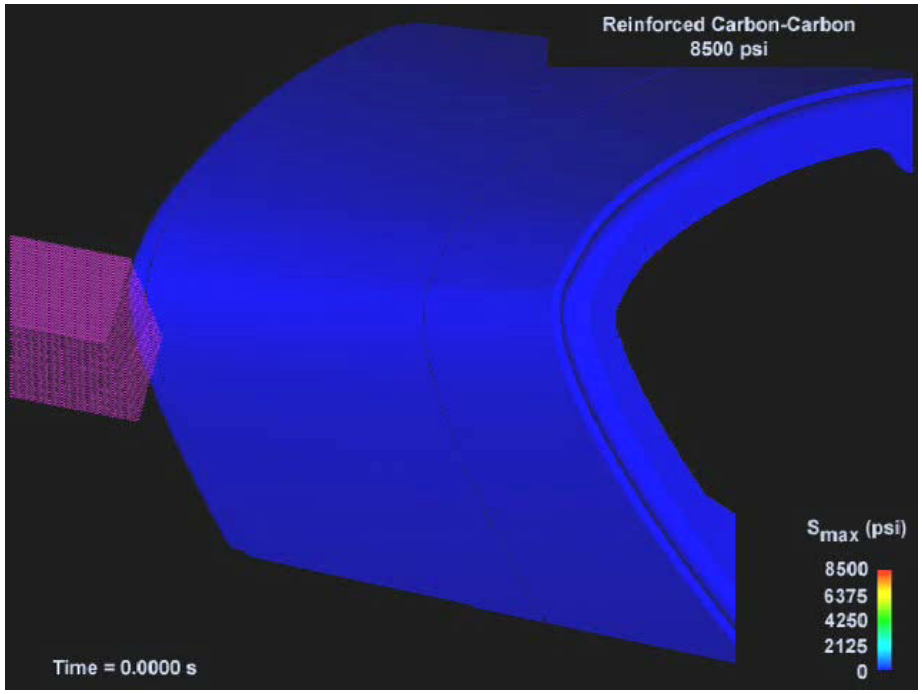


1.4 msec analysis of Panel 6

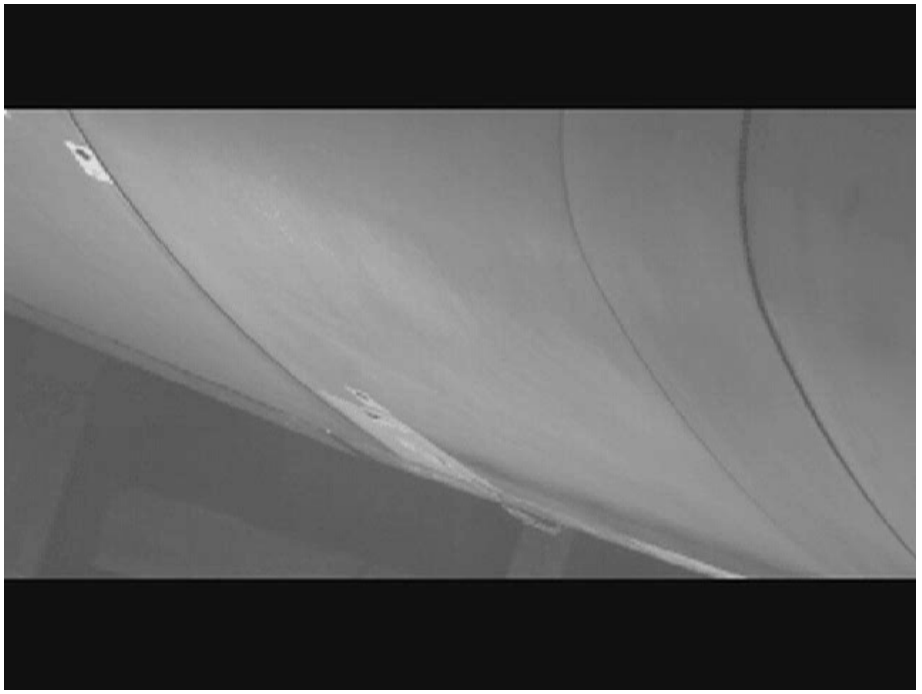


2.2 msec analysis of Panel 6

Study of the Columbia Accident



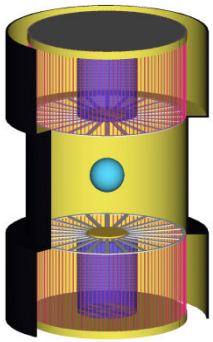
Sandia Simulation



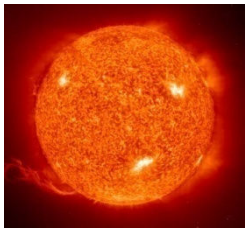
Physical Test

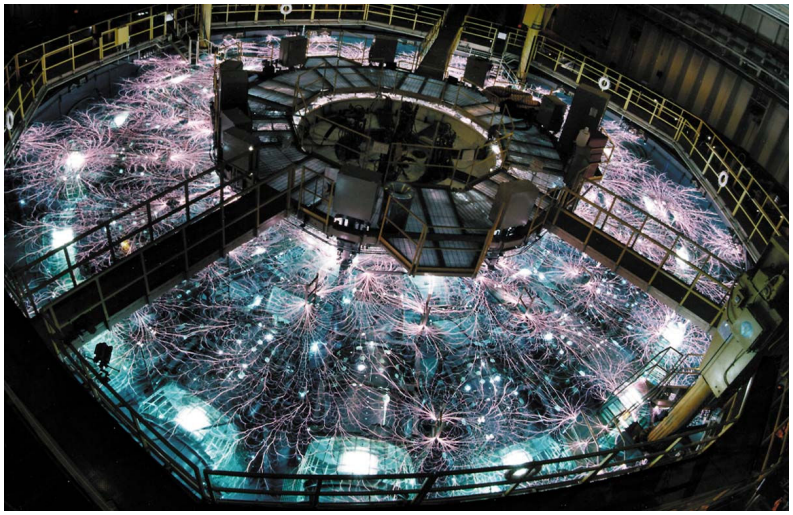
The Z Facility

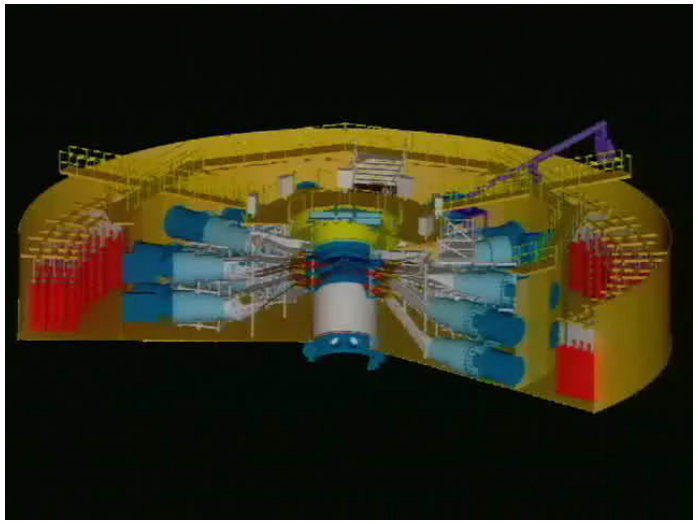
– The Most Powerful X-ray Source in the World –

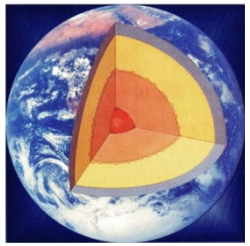


Concentrate electrical energy in *space* and *time* in order to create and understand high energy density environments









The Z facility provides extreme experimental environments:

- **Temperatures higher than *the center of the sun* (>10,000,000 K)**
- **Pressures higher than *the center of the earth* (>20,000,000 atm)**

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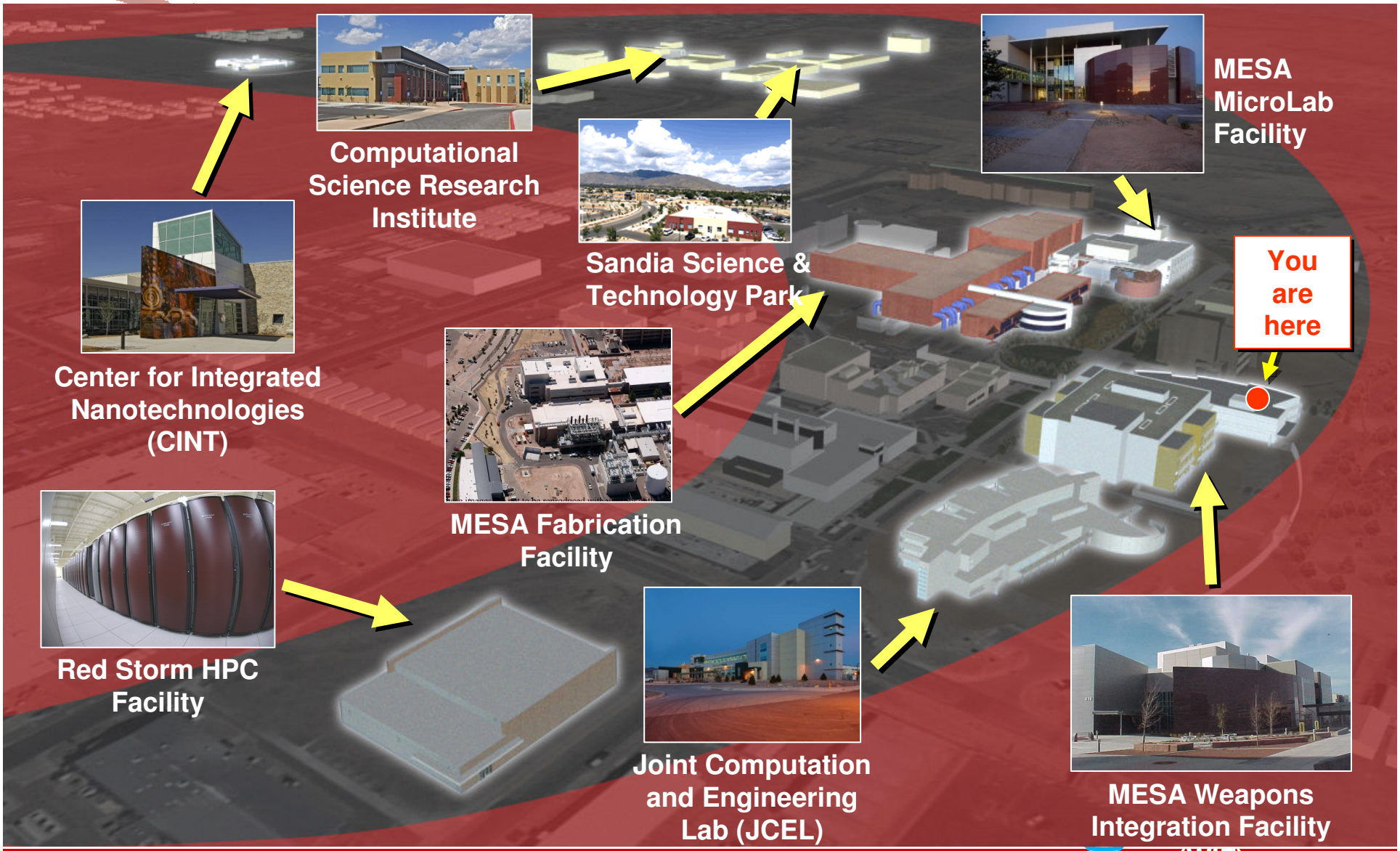
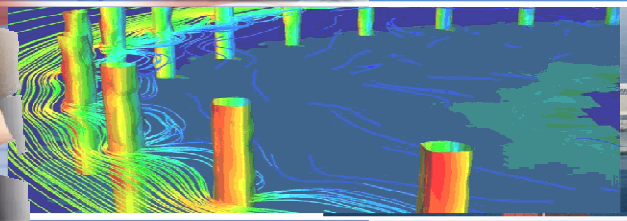
Sandia's Innovation Corridor opens Sandia to greater interactions



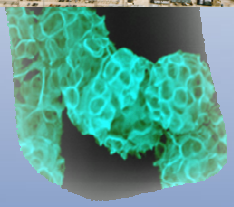
Energy Backups

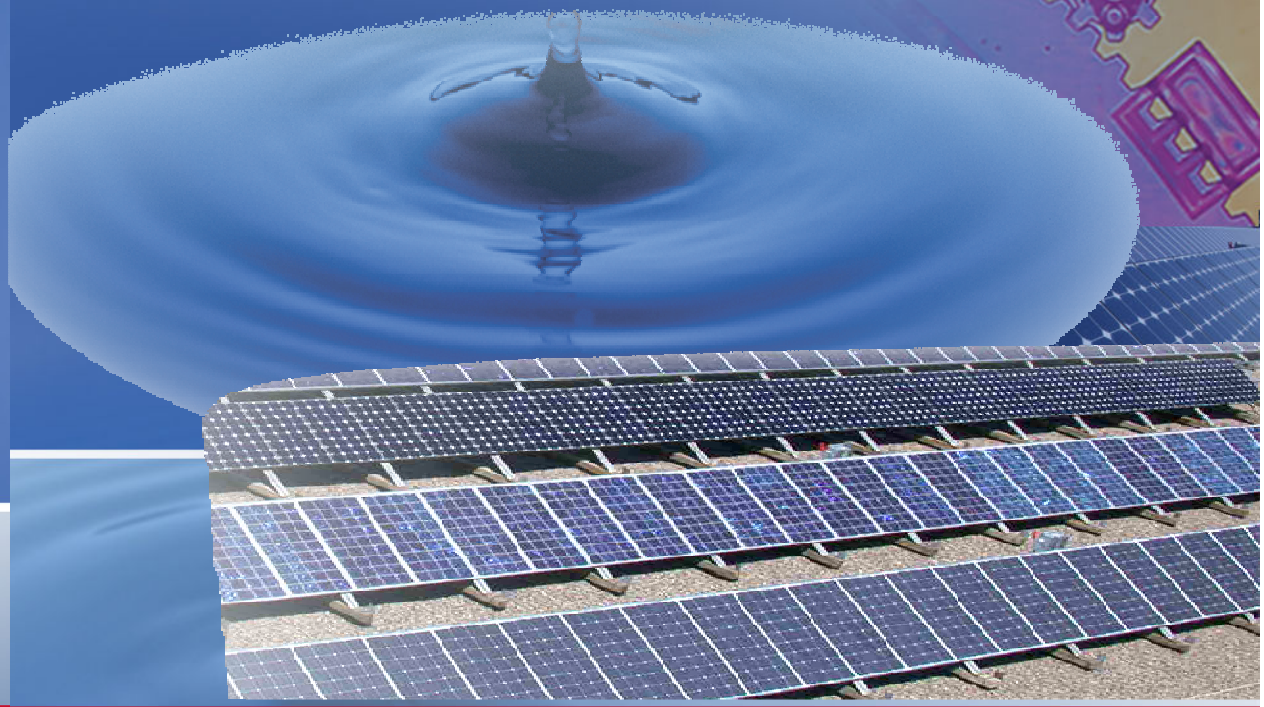
SANDIA NATIONAL LABORATORIES



March 13, 2008

Energy Program Overview





Driving the Future

"Creating competitive advantage for our mission areas . . ."

Breakthrough ST&E Capabilities

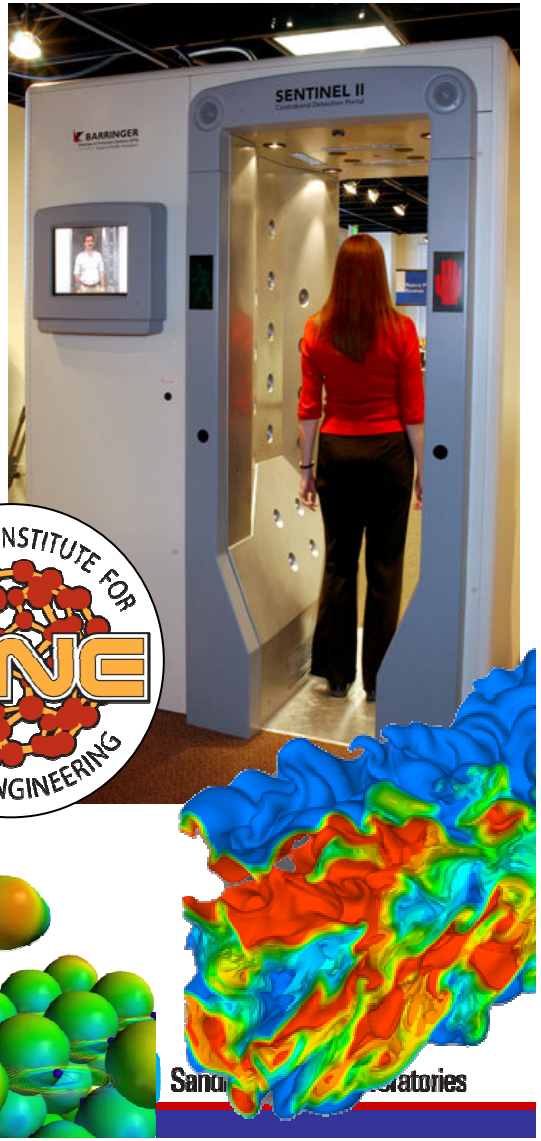
- Engage in Major Science challenges
- Office of Science Programs
- Develop strategic partnerships
- Open up User Facilities

Systems Modeling and Analysis

- Development of new, differentiating capabilities
- Capabilities in science and social regimes
- Inform policy debate and strategic direction

Intrinsic Security Systems

- Building Intrinsic Security into system solutions for our customer (physical – information – operations)
- Cost-effective risk management for increasing and evolving threats



Objective of the Fuel and Water Systems Line of Business

Provide systems perspective and critical technological solutions for fuel and water that help assure:

Secure and sustainable supply;

Safe and resilient delivery infrastructure; and

Clean and efficient use of resources.

- Safe
- Secure
- Reliable
- Sustainable
- Cost Effective
- Integrated System

Solar Technology

Technologies:

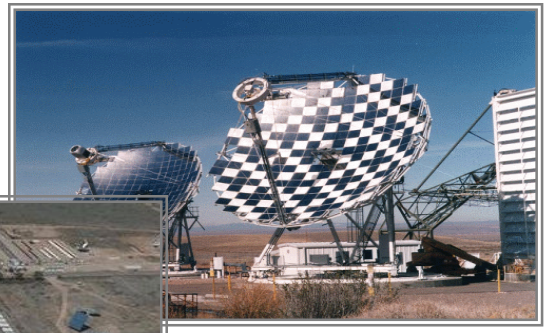
Photovoltaics

- Modules/arrays
- Inverters
- Systems

Concentrating Solar Power

- National Solar Thermal Test Facility (Tower)
- Troughs
- Dishes

Solar Hot Water



Activities:

Advanced R&D

- New systems integrations
- Hydrogen production
- New “smarts”: controls, communications, power conversion

Modeling – performance prediction

Reliability engineering

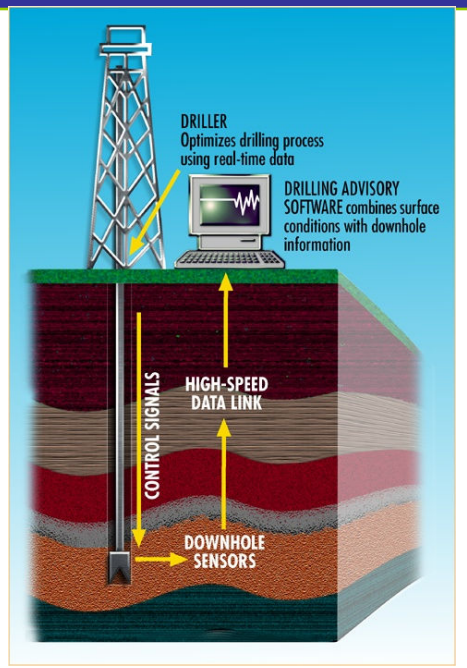
Evaluations/characterizations of new components/products

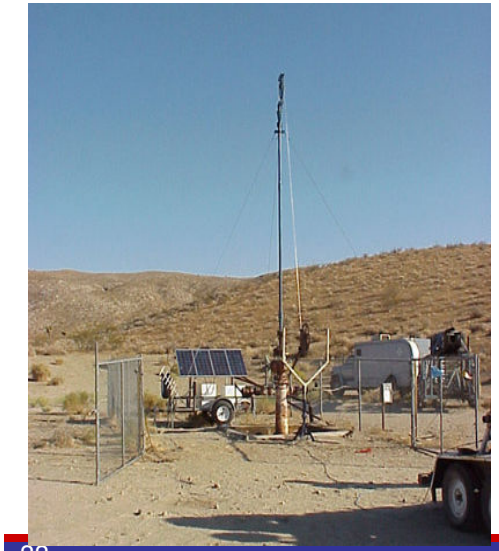
Barrier removal: codes, standards, certification, design assistance, technical support

National Nuclear Security Administration

Geothermal Research
Drilling and Monitoring in Harsh Environments

- Geothermal Well Construction
  - High-Temperature Electronics
  - Diagnostics-While-Drilling
  - Rock Reduction Technologies
  - Wellbore Integrity and Lost Circulation
  - Drilling Dynamics Modeling and Simulation
  - Vibration Mitigation





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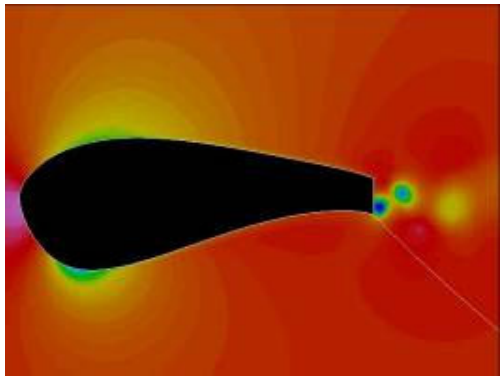
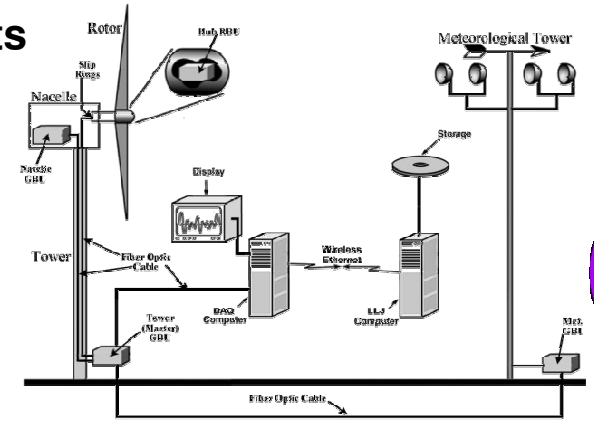
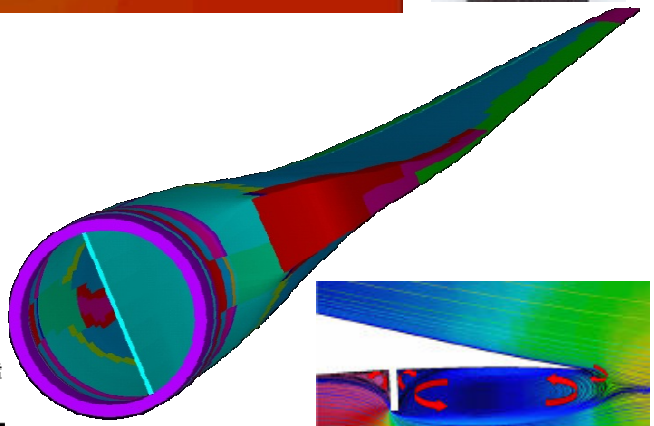
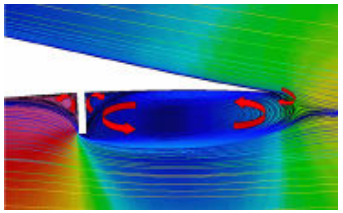
Wind Energy Technology

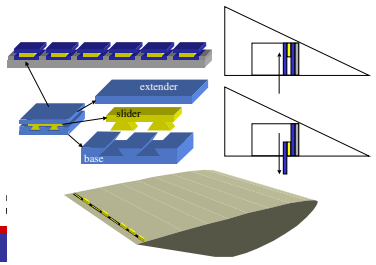
- **Blade Technology**
  - **Materials and Manufacturing**
  - **Structural, Aerodynamic, and Full System Modeling**
  - **Lab - Field Testing and Data Acquisition**
  - **Sensors and Structural Health Monitoring**
  - **Advanced Blade Concepts**
- **System Reliability**
  - **Industry Data Collection**
  - **Improve reliability of the existing technology and future designs**





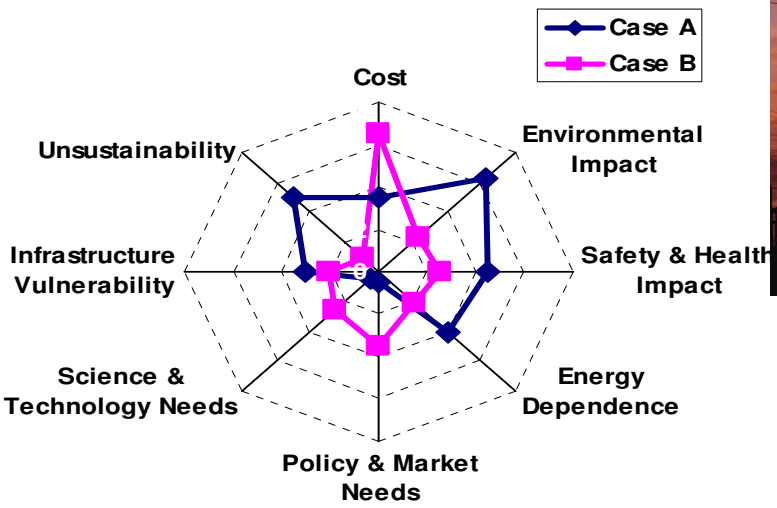






Energy Systems Analysis

- **Competencies:**
  - **Power grid (generation, transmission, distribution) operations, modeling**
  - **Energy transport security (pipelines, power grid, marine, railways)**
  - **SCADA and control systems analysis and security**
  - **Energy system vulnerability, safety, and risk assessment**
  - **Energy system modeling and simulation**
  - **Energy systems analysis**
  - **Energy-Water Nexus issues**



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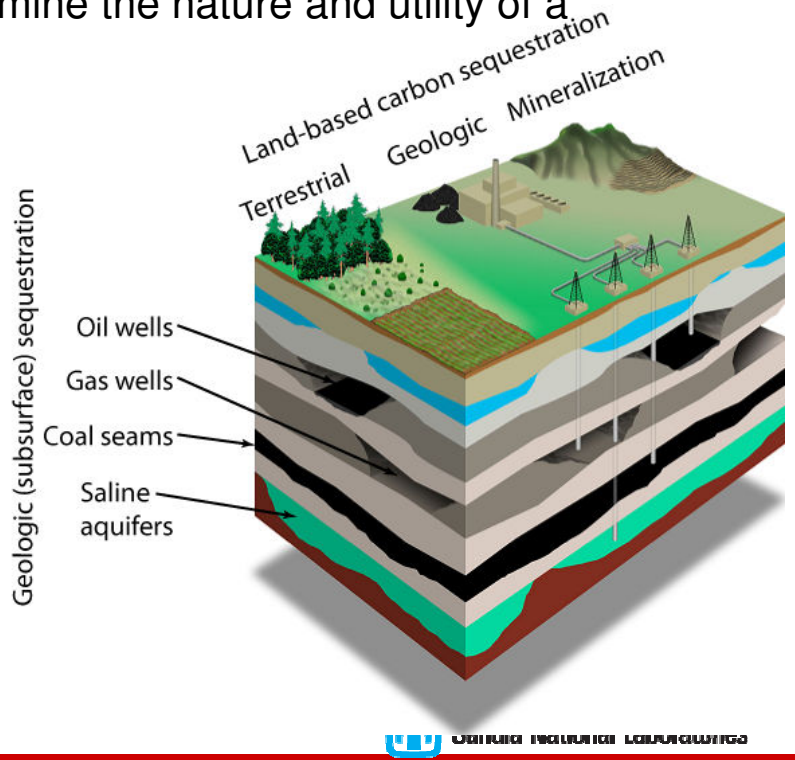
Carbon Sequestration

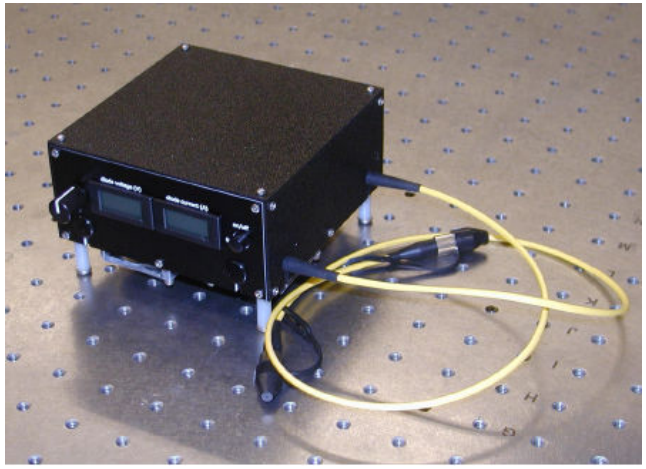
Sandia National Laboratories is

- Developing hybrid membranes to selectively trap CO_2 from power-plant waste streams/flue gasses
- Trying to mimic earth CO_2 capture processes as an engineered system (i.e., increase the speed and efficiency of the reactions).
- Developing a computational code that helps determine the nature and utility of a potential sequestration site.
- Characterizing the geology (knowing whether the subsurface pocket will securely hold the sequestered CO_2),
- Developing persistent monitoring of sequestration sites using seismic methods, and
- Geomodeling the fate (flow rates and direction) of injected CO_2

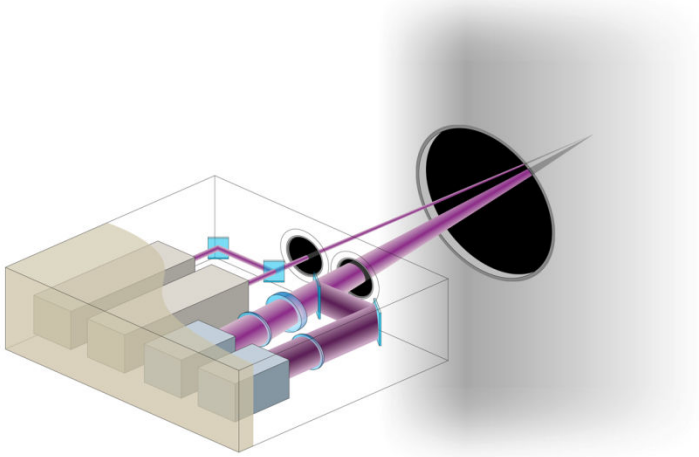


Pollution-Control Technologies

- Ongoing project supported by FE/NETL Advanced Research program
  - Need for on-line system to differentiate elemental mercury (Hg) from oxidized mercury in flue gas



- Utilize our unique strengths in laser diagnostics and fiber laser sources to develop new Hg detection techniques
  - Resonance fluorescence for Hg^0
  - Photofragment fluorescence for HgCl



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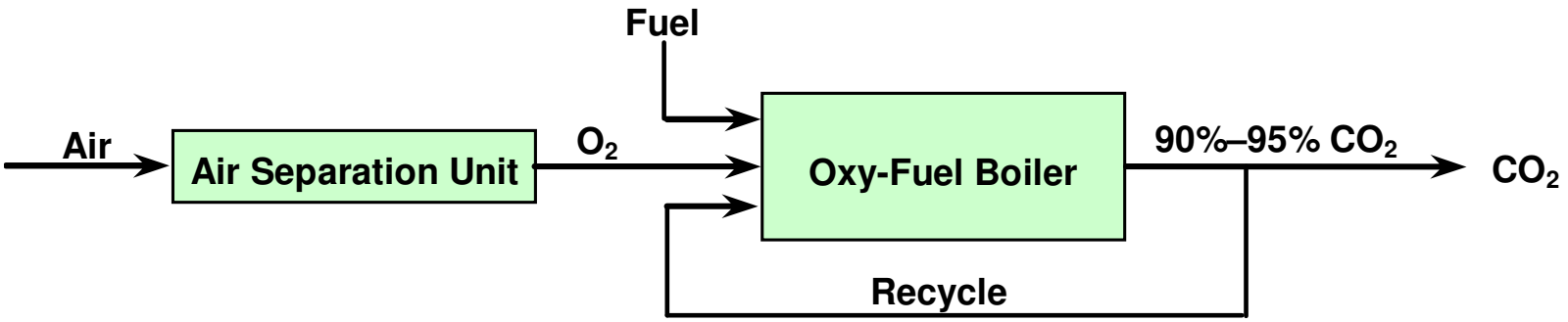
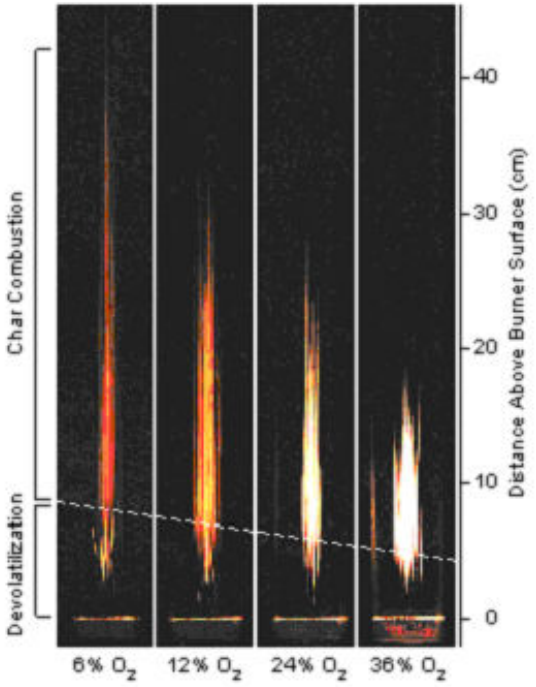
New Coal Combustion Techniques



- Ongoing FE/NETL Advanced Research program
- Promising technology for coal power with CO_2 sequestration
  - retrofittable, zero-emission
- Need to better understand coal ignition, char combustion rates, and NO_x formation under these conditions
- Utilize expertise in laser/optical diagnostics and chemical kinetic modeling



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