

Balancing Basic and Applied Research

Netherlands National Academy of
Sciences

October 26, 2012

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



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Deputy Secretary
Daniel B. Poneman

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Agency – Energy
Eric Toone

Under Secretary for Nuclear
Security/Administrator for
National Nuclear Security
Administration
Thomas P. D’Agostino

Under Secretary
for Science

(Vacant)

Under Secretary
David Sandalow (A)

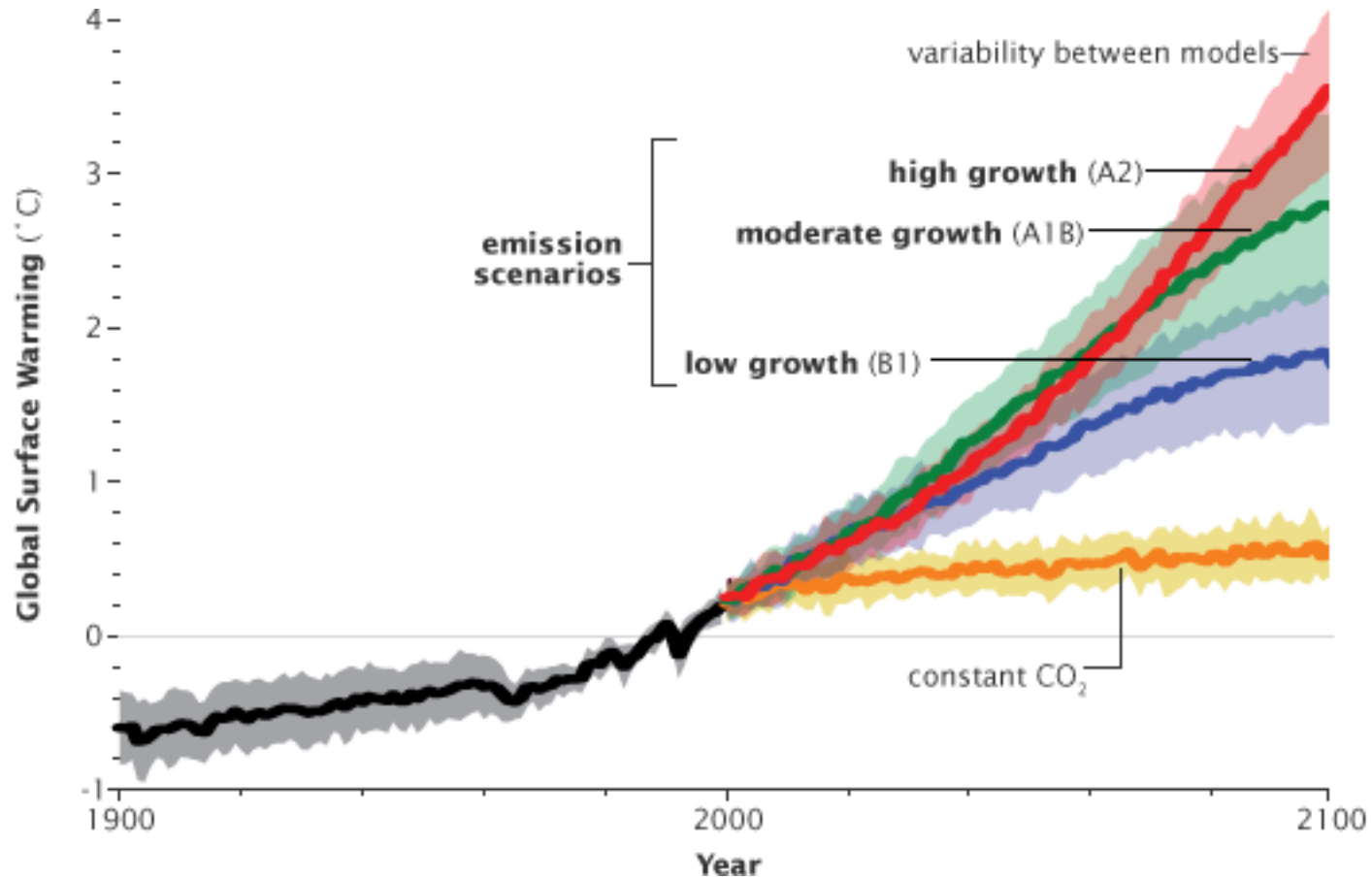
- Defense Nuclear Nonproliferation
- Defense Programs
- Naval Reactors
- Counter-terrorism
- Defense Nuclear Security
- Emergency Operations

Office of Science
Director - William Brinkman
Dep. Director for Science Programs - Patricia Dehmer

Basic Energy Sciences Harriet Kung	High Energy Physics Jim Siegrist
Advanced Scientific Computing Research Daniel Hitchcock	Nuclear Physics Tim Hallman
Biological & Environmental Research Sharlene Weatherwax	Fusion Energy Sciences Ed Synakowski
SBIR/STTR Manny Oliver	Workforce Develop. for Teachers & Scientists Pat Dehmer (A)

- Energy Efficiency & Renewable Energy
Dave Danielson
- Fossil Energy
Chuck McConnell
- Nuclear Energy
Pete Lyons
- Electricity Delivery & Energy Reliability
Pat Hoffman

Global Average Temperature Projections



Adapted from Intergovernmental Panel on Climate Change Working Group I, 4th Assessment . NASA Earth Observatory

Actions taken by DOE in past three years

ARPA-E

Hubs

Energy Frontier Research Centers

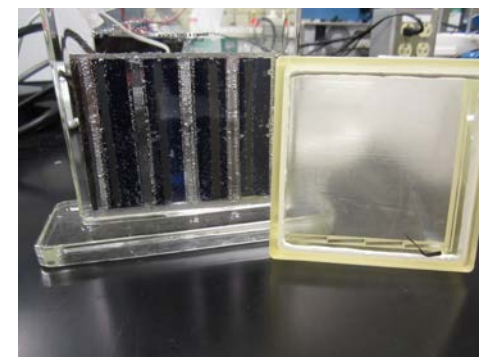
Biofuel Centers

Fuels from Sunlight Hub



JCAP South (Jorgensen Lab)

- High-throughput synthesis, analysis, and data mining to screen a million compounds per day for accelerated catalyst and light absorber discovery
- Prototype development through modeling, engineering analysis, and manufacture
- >20 publications, >120 technical presentations, and 10 invention disclosures

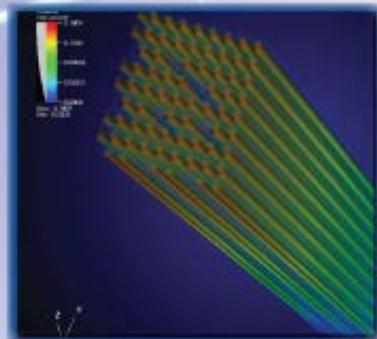


1st generation water splitting prototype



CASL expects selected analysis activities and decisions by nuclear power plant vendors and owners/operators supporting reactor operations such as core reload and new core design will be guided and informed by the CASL M&S technology and staff expertise. CASL technology is envisioned to become the leading nuclear energy industry M&S capability for supporting and furthering advanced nuclear steam supply system and nuclear fuel research, development, and deployment.

By making VERA available to the nuclear energy community, CASL's vision will demonstrate - through industry acceptance, adaption, and licensing - that its M&S technology proactively targets the right industry problems. CASL intends to address, key nuclear energy industry challenges to furthering power uprates, higher burnup, and/or lifetime extension while providing higher confidence in enhanced nuclear safety.



Simulated three-dimensional fission power distribution of a single 17x17 rod PWR fuel assembly



A partnership with unparalleled collective institutional knowledge, nuclear science and engineering talent, computational science leadership, and a record of LWR design and regulatory accomplishments!



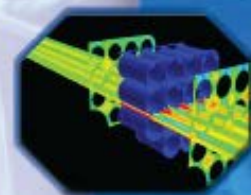
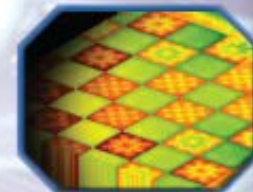
www.casl.gov
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 CASL Director
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 Oak Ridge, TN 37831-6003

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 E-mail: kothe@ornl.gov



Predicting the safe, reliable, and economically competitive performance of nuclear reactors, through comprehensive, science-based modeling and simulation technology



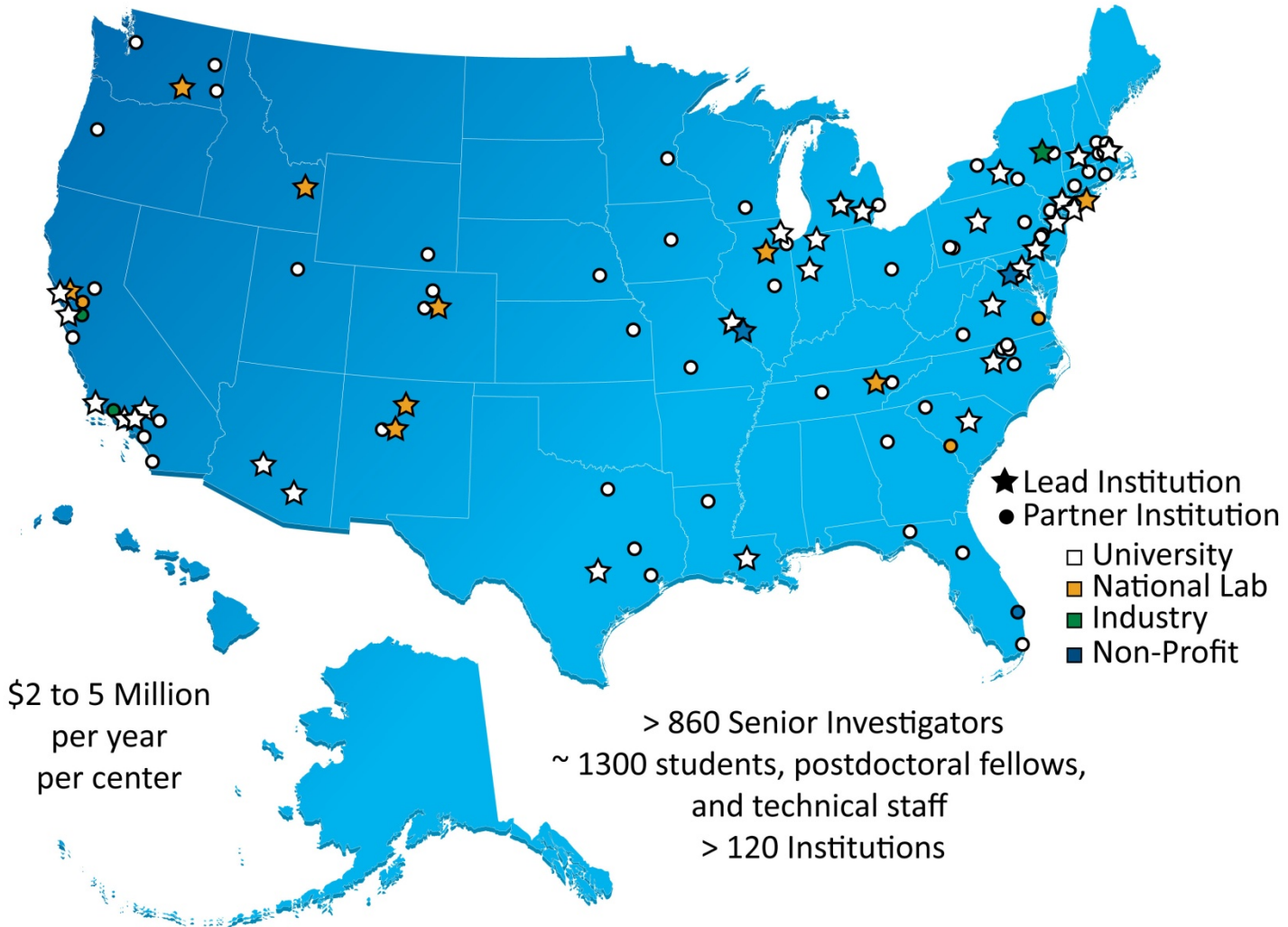
A DOE Energy Innovation Hub for Modeling and Simulation of Nuclear Reactors



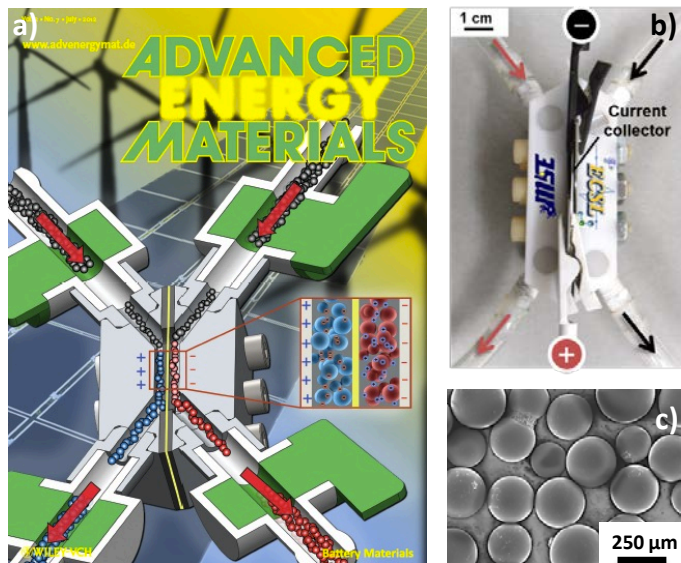
U.S. DEPARTMENT OF
ENERGY
 Nuclear Energy

Energy Frontier Research Centers

46 EFRCs in 35 States + D.C.



Scalable, High Power Charge Storage with Carbon Slurries



a: Schematic of a single-cell EFC – charged and discharged slurries are stored in separate containers which are scalable to the energy requirements of the system.

b: A charge/discharge EFC cell used for charging flowing slurry.

c: Capacitive slurry of microporous carbon beads in sodium sulfate and water.

Work was performed at Drexel University as part of the Fluid Interface Reactions, Structures and Transport Center (FIRST) EFC.

Presser, V. et al. *Advanced Energy Materials* 2012, **2**, 895-902.

Scientific Achievement

Discovered that carbon slurries can store electrical energy in electric double layers just like supercapacitors and that the electrochemical and flow properties of the slurries depend on particle concentration, particle size/shape, and carrier fluid viscosity.

Significance and Impact

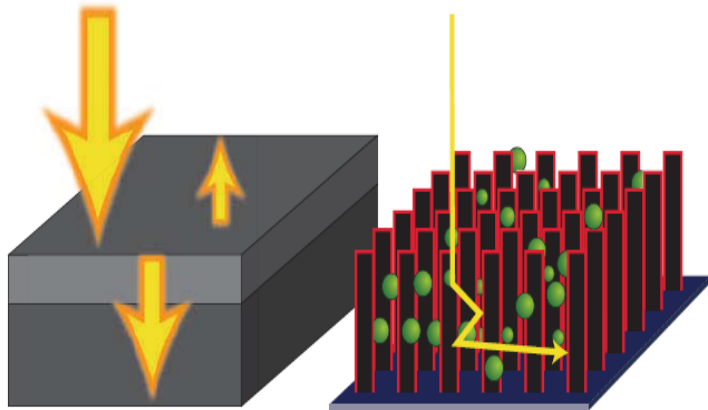
Capacitive carbon slurries can flow, enabling a new type of electrochemical storage device called the electrochemical flow capacitor (EFC), which combines the high power of supercapacitors with the scalable energy capacity of flow batteries.

Research Details

- Porous carbon particles with an organic or aqueous electrolyte are used as the flowable EFC electrode material.
- Carbide-derived carbon in aqueous electrolyte demonstrated the highest capacitance with 109 F/g at a rate of 2 mV/s.
- An EFC prototype that allows intermittent flow of a carbon slurry inside an electrochemical cell for charging/discharging was demonstrated (see figure).



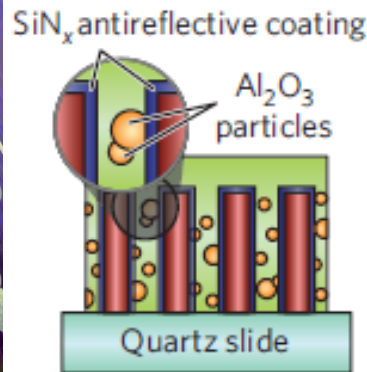
Materials by Design: Light absorption in wire arrays



Al_2O_3 nanoparticles reflect light towards Si wire arrays



Nature Materials, **9**, 239 (2010).



- Assembly on a reflective backing
 - Light absorbing nanowires surrounded by polymer that contains Al_2O_3 scattering particles
- Wire arrays can absorb just as much sunlight as a conventional PV cell, but with only 2% of the Si
 - Silicon wires fill as little as 2% of the cell's volume and absorb up to 85% of the sunlight
- More than 90% of the absorbed light generates electricity rather than heat
- Flexible arrays are inexpensive to make
- Impact from this work
 - 2010 Popular Mechanics Breakthrough Award
 - *Caelux* – a DOE-supported & venture-backed start-up company

Research supported by the Light-Material Interactions in Energy Conversion EFRC led by Caltech and featured as an SC [Story of Discovery & Innovation](#) on 7/7/2011.



The DOE/SC Labs Today – User Facilities



Berkeley, California
202 acres and 106 buildings
3,400 FTEs
1,084 students & postdocs
8,579 facility users

www.lbl.gov



Pacific Northwest
NATIONAL LABORATORY



Richland, Washington
600 acres and 101 buildings
4,180 FTEs
567 students & postdocs
2,414 facility users

www.pnnl.gov

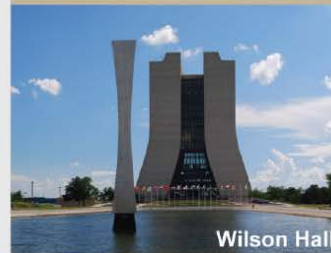


THE Ames Laboratory



Ames, Iowa
10 acres and 12 buildings
315 FTEs
210 students & postdocs

www.ameslab.gov



Wilson Hall

Batavia, Illinois
6,800 acres and 356 buildings
1,914 FTEs
1,090 students & postdocs
2,317 facility users

www.fnal.gov



Advanced Photon Source

Argonne, Illinois
1,500 acres and 99 buildings
3,375 FTEs
1,147 students & postdocs
4,289 facility users

www.anl.gov



Menlo Park, California
426 acres and 142 buildings
1,681 FTEs
300 students & postdocs
3,384 facility users

www.slac.stanford.edu



Spallation Neutron Source

Oak Ridge, Tennessee
4,470 acres and 252 buildings
4,533 FTEs
1,753 students & postdocs
3,116 facility users

www.ornl.gov



Newport News, Virginia
169 acres and 63 buildings
769 FTEs
74 students & postdocs
1,376 facility users

www.jlab.org



NSTX Spherical Tokamak

Princeton, New Jersey
89 acres and 34 buildings
428 FTEs
66 students & postdocs
145 facility users

www.pppl.gov



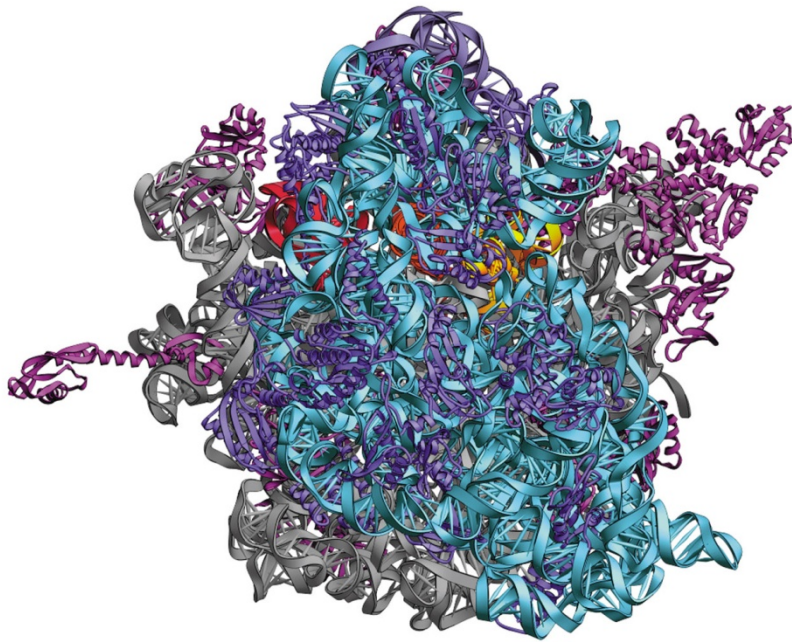
Relativistic Heavy Ion Collider

Upton, New York
5,320 acres and 331 buildings
2,990 FTEs
593 students & postdocs
4,253 facility users

www.bnl.gov

4 Nobel Prizes in 9 Years in Macromolecular Crystallography Using Synchrotron Light Sources

2009 Prize in Chemistry: Venkatraman Ramakrishnan, Thomas Steitz, and Ada Yonath) "for studies of the structure and function of the ribosome." *Used all 4 light sources.*



Venkatraman
Ramakrishnan



Thomas
Steitz

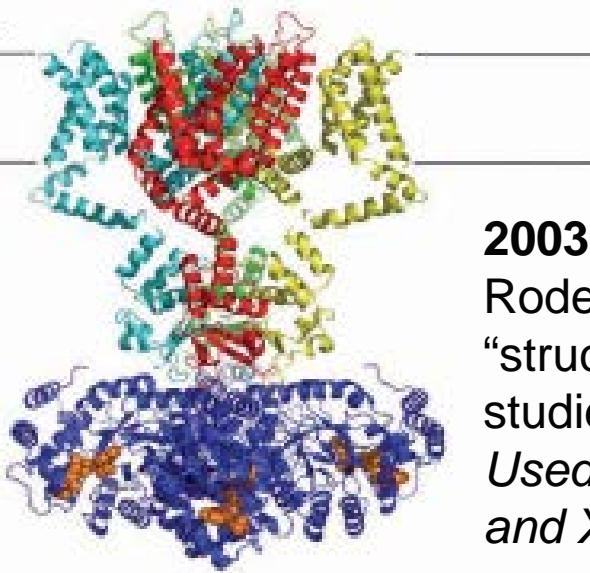


Ada
Yonath

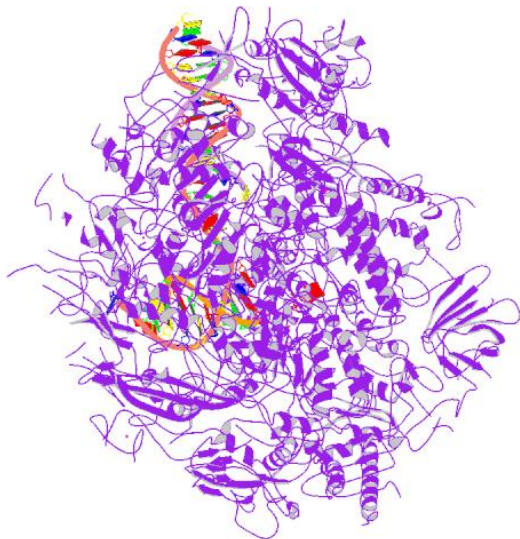
Extracellular

Membrane

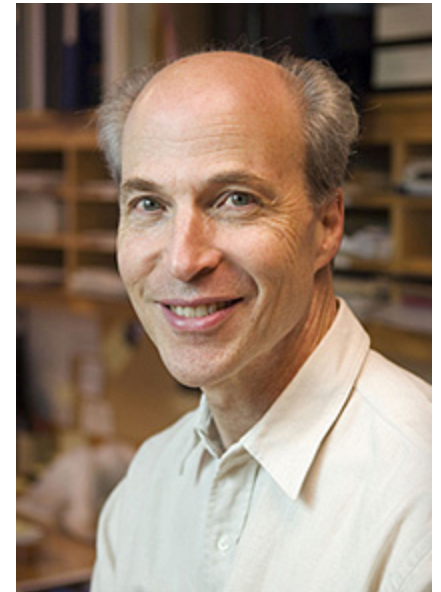
Intracellular



2003 Prize in Chemistry: Roderick MacKinnon for “structural and mechanistic studies of ion channels.” *Used NSLS beamlines X25 and X29.*



2006 Prize in Chemistry: Roger Kornberg “for his studies of the molecular basis of eukaryotic transcription.” *Used SSRL macromolecular crystallography beamlines.*



Important science advances are also occurring

Tremendous advances in Biology

Discovery of the Higgs particle

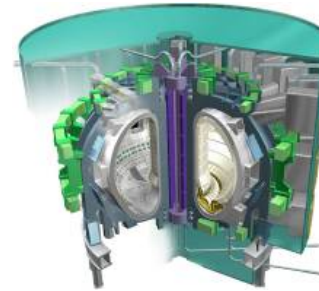
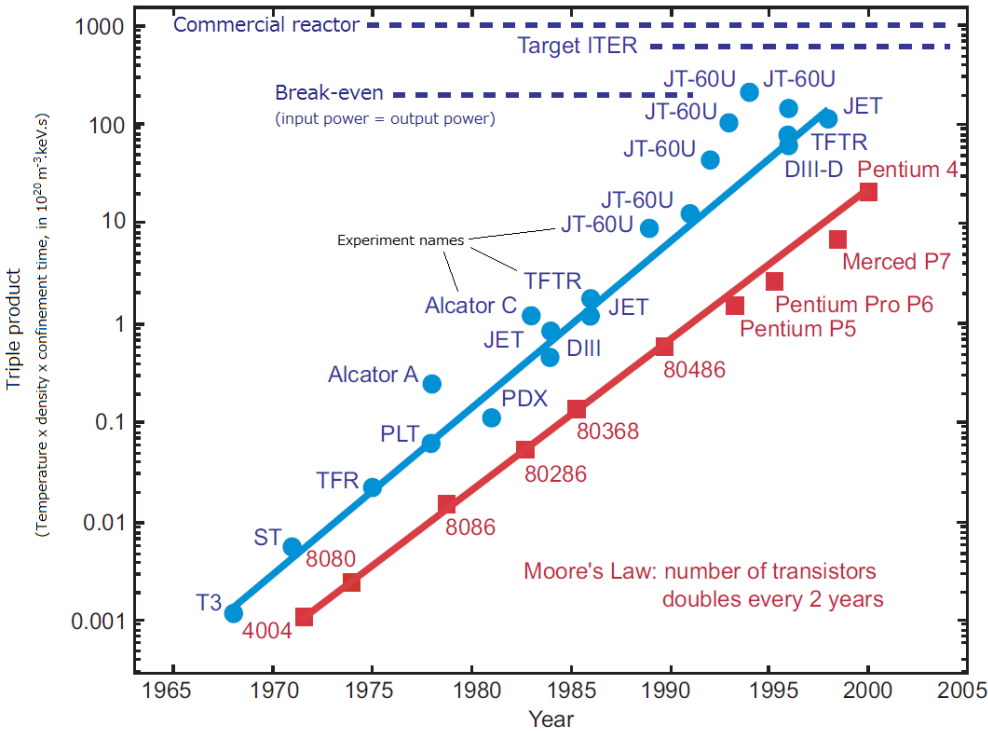
Measurement of important parameter
describing neutrinos

Topological insulators

Free Electron Lasers

Progress Toward ITER

Fusion: figure-of-merit (the 'triple product')
doubles every 1.8 years

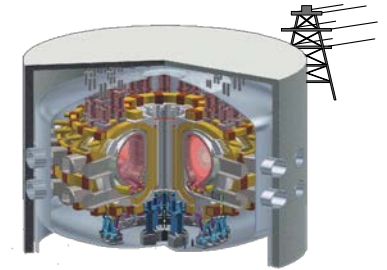


ITER

800 m^3

$\sim 500 \text{ MW}_{th}$

~ 2020



DEMO

$\sim 1000 - 3500 \text{ m}^3$

$\sim 2000 - 4000 \text{ MW}_{th}$

And beyond

Light Sources Contribute to U.S. Competitiveness

GE researchers used sophisticated scientific capabilities at the NSLS and APS to understand in detail the internal chemistry of an actual commercial battery while charging and discharging in real time. Additional studies of battery cross-sections helped GE engineers to further understand the system to achieve breakthroughs in energy density, charging power, and long cycle life. **Impact:** the new “Durathon™” sodium metal halide battery

Plexikon used unique and complementary capabilities at LCLS, APS, and ALS to determine the precise structure of a mutated protein involved in this deadliest form of skin cancer and potential drug candidates that could stop its spread. **Impact:** Successful clinical trials that the tests were halted so patients in the trial who were receiving other treatments could be moved to the new medicine.

SEMATECH Leadership capabilities at the ALS in extreme ultraviolet (EUV) lithography technology are critical for fabricating next generation of ultra-high-performance nanoscale semiconductor electronics and key to continued U.S. leadership in transistor density improvements. **Impact:** Capabilities used by SEMATECH and the entire semiconductor industry for advanced research in EUV lithography

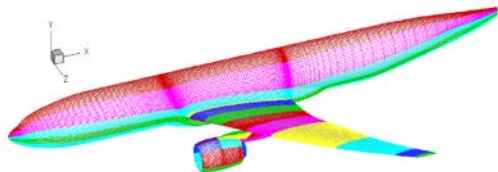
Lilly scientists use APS protein crystallography in the drug discovery process to help design their beta-secretase inhibitor as a treatment for Alzheimer’s disease. **Impact:** The drug is currently in Phase I clinical testing to determine its potential.



ASCR facilities Underpin Clean Energy R&D



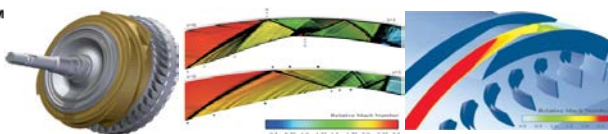
- Smart Truck Brands went from concept to design to manufacturer in 13 Months.
- Demonstrated fuel mileage improvements of 7% to 12% available 2011. Exceeds California CARB requirements.



- Boeing demonstrated the effectiveness and accuracy of high fidelity computational fluid dynamics simulation tools and then used them in designing their next generation of aircraft.
- Significantly reduced the need for costly physical prototyping and wind tunnel testing. Accelerated airplane design and lowered cost.



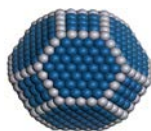
- GE determined the effects of unsteady flow interactions between blade rows on the efficiency of highly loaded turbines.
- Provided design engineers with the analytical tools to extract greater design efficiency and fuel savings.



- Ramgen used computational fluid dynamics with shock compression to expedite design-cycle analysis, and to make large stage configuration analyses possible.
- Advanced the development curve of the CO₂ compressor with next generation rotor now scheduled for testing in February 2012.



- Accelerate materials research by at least a year to help GM meet fuel economy and emissions standards.
- A prototype thermoelectric generator in a Chevy Suburban generated up to 5% improvement in fuel economy.



- UT studies of nickel and platinum are demonstrating that the less expensive nickel can be used as a catalyst to produce hydrogen. 16

SLAC National Accelerator Laboratory
Menlo Park, California

Pacific Northwest National Laboratory
Richland, Washington

Idaho National Laboratory
Idaho Falls, Idaho

National Renewable Energy Laboratory
Golden, Colorado

Ames Laboratory
Ames, Iowa

Argonne National Laboratory
Argonne, Illinois

Fermi National Accelerator Laboratory
Batavia, Illinois

Brookhaven National Laboratory
Upton, New York

National Energy Technology Laboratory
Morgantown, West Virginia
Pittsburgh, Pennsylvania

Sandia National Laboratories
Livermore, California
Albuquerque, New Mexico

Lawrence Livermore National Laboratory
Livermore, California

Lawrence Berkeley National Laboratory
Berkeley, California

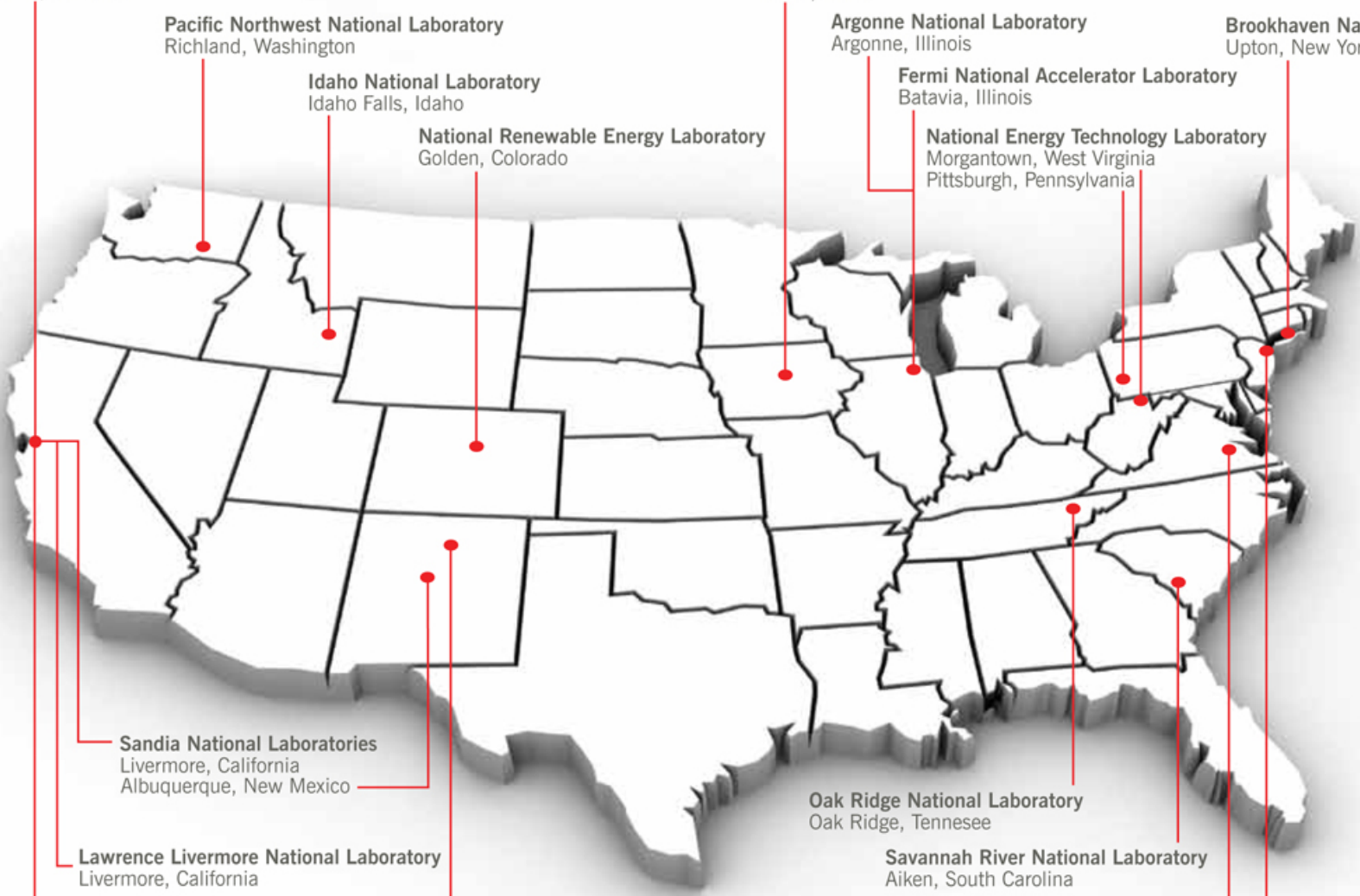
Los Alamos National Laboratory
Los Alamos, New Mexico

Oak Ridge National Laboratory
Oak Ridge, Tennessee

Savannah River National Laboratory
Aiken, South Carolina

Thomas Jefferson National Accelerator Facility
Newport News, Virginia

Princeton Plasma Physics Laboratory
Princeton, New Jersey



Difficult balancing act between basic and application driven research

Must maintain strong basic research but it must move with the times

Must also respond to the opportunities of applied research given the advances in knowledge and the society needs.

Requires Judgment