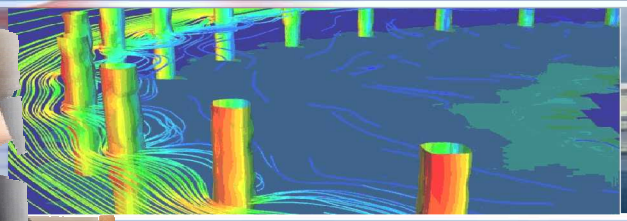
ENERGY, RESOURCES and NONPROLIFERATION

energy, water, and security . . . enabled by science & technology

SAND2010-1525P

March 17, 2010



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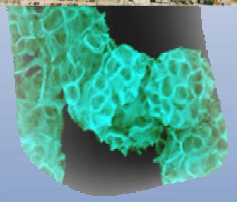
ERN Overview

Goodyear Tire and Rubber Company



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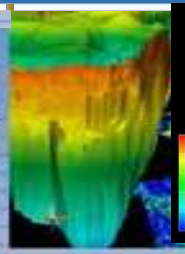
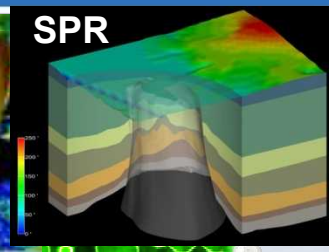
The DOE Laboratories Contribute to Securing America's Energy Future

Energy Supply and Efficiency, and Environmental Stewardship

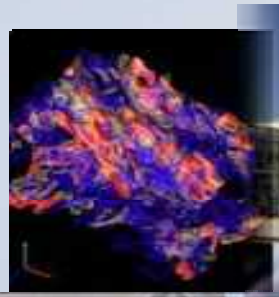



"Science Underpins and Enables Technology for Our Energy Missions"

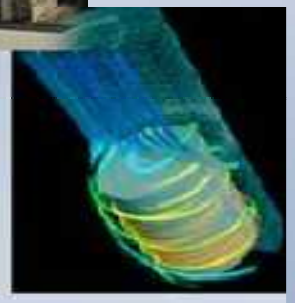




Safe, Secure, Reliable Energy and Water Supply and Infrastructure

Science and Technology







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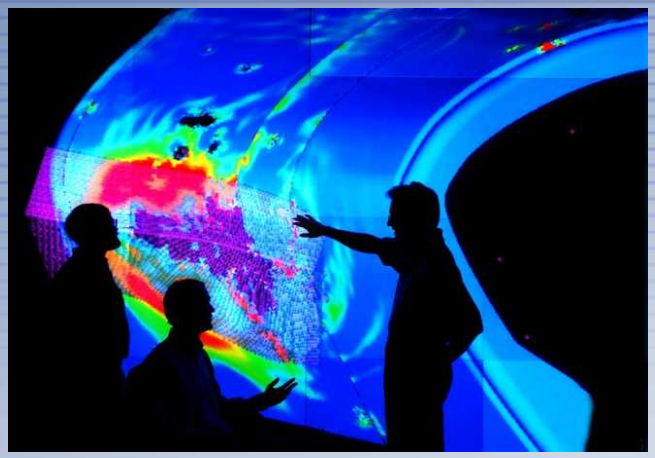
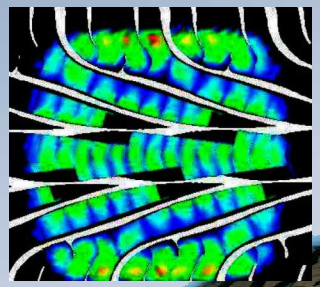
Coupling High-Performance Computing with Unique, Large-Scale Experimental Capabilities — POWERFUL!



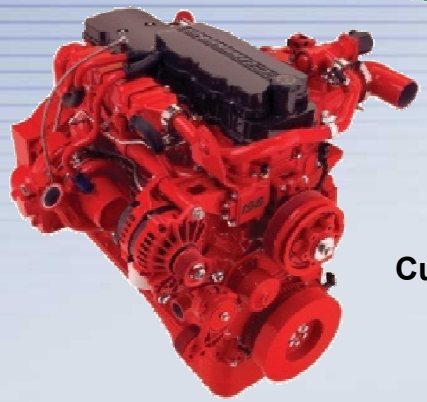
Space Shuttle Columbia
Accident Analysis



Goodyear

3-D CFD code with
spray model

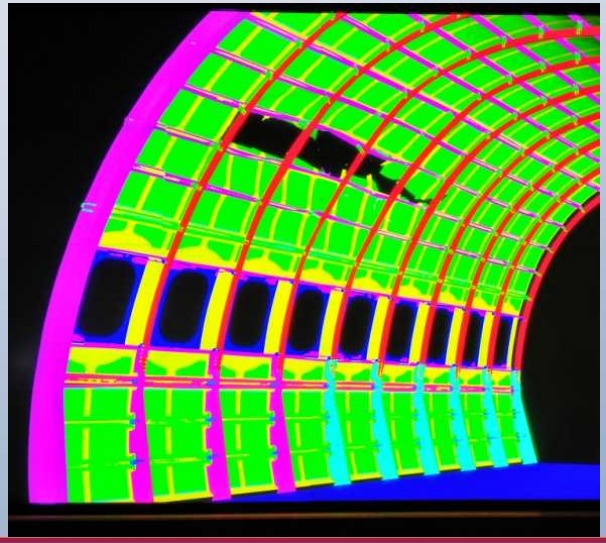
Soot Model



Local combustion
and NO_x model

Cummins Diesel

Aircraft
Fuselage
Modeling



Energy Security: Three Legged Stool

The National Security Agencies are Engaged

Environmental Stewardship

EPA, NOAA, NASA, CEQ

Economic Prosperity

DOC, Treasury, Fed. Res.

National Security

DHS, IC, DoD, DOE, DoS

Energy Enterprise
Supply → Use

DOE

Sandia has a trusted relationship with key players.

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Sandia is Currently Addressing Key Energy Security Challenges

- **Transportation Energy – Reduce Oil Dependence**
  - Combustion Research Facility – fuel and engine efficiency (DOE, University, Industry)
  - Joint BioEnergy Institute – cellulosic bio-fuels (DOE, University, Industry)
  - Sunshine to Petrol – solar energy to fuel conversion (LDRD)
- **Global Energy Infrastructure – Protect Against Disruption**
  - National Infrastructure Simulation and Analysis Center (DHS)
  - Liquefied natural gas safety and security (DOE, U.S. Coast Guard)
  - International energy infrastructure protection (Foreign Government, DoS)
  - Strategic petroleum reserve (DOE)

- **Nuclear Energy – Manage Waste and Reduce Proliferation**
  - Yucca Mountain / WIPP (DOE)
  - Waste packaging and transportation (DOE, Industry)
  - International non-proliferation programs (DOE, DoS, Foreign Government)
- **Next Generation Infrastructure – Deploy Low-Carbon Energy Sources**
  - Information and cyber security (DOE, DHS, Intelligence Community)
  - DoD base energy security assessments (DoD)
  - Mesa del Sol / Kirtland Air Force Base (DOE, DoD, Industry)

- **Climate Change – Mitigate and Adapt to Changes**
  - Carbon reutilization (LDRD)
  - Carbon capture, management, and sequestration (DOE)
  - Monitoring for treaty verification (DOE)

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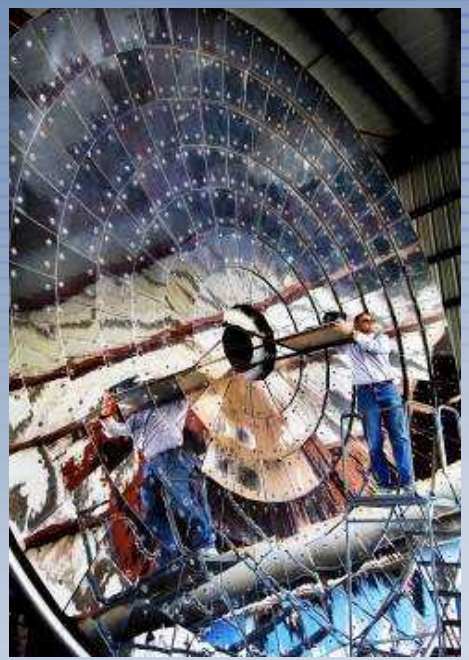
Sunshine to Petrol – "Creating Fuel from Sunlight"



- **Two Material Classes Demonstrated to Split Both CO_2 and H_2O**
- **Demonstrated Continuous, Fast, Repeated Cycles, Without Loss of Activity**
- **Counter-Rotating-Ring Receiver/Reactor/Recuperator**
  - Reliability science of materials

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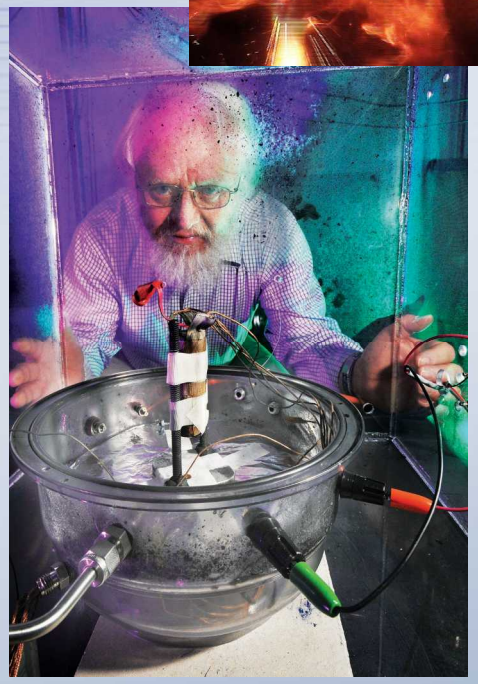
Sandia's Battery Abuse Testing Laboratory (BATLab)

"Where Batteries Go to Be Tortured"

- **BATLab's Goals**
  - Develop low-cost batteries for electric (EVs) and plug-in hybrid electric vehicles (PHEVs) that meet real-world requirements
  - Allow Sandia to offer valuable contributions to DOE's FreedomCAR effort
  - Make sure that battery "accidents" happen in the abuse-testing lab—not in your garage
- **Industry Transition to Lithium-Ion Technology**
  - 2–3 times the energy density of nickel-metal hydride batteries
  - 6 times the energy density of traditional lead-acid batteries
  - Smaller-scale lithium-ion applications (cell phones, laptop computers) have had problems
  - One bad EV or PHEV incident could spoil public opinion
- **Internationally Recognized Leader in Battery Testing**
  - Customers: NASA, U.S. military, and manufacturers such as UltraBattery, East Penn, LifeBatt, NorthStar, and Battery Energy
  - Testing virtually all battery technologies: valve-regulated lead-acid (VRLA), lithium-ion, nickel-metal hydride, and carbon-enhanced VLRA for applications ranging from large-scale grid storage to cell phones

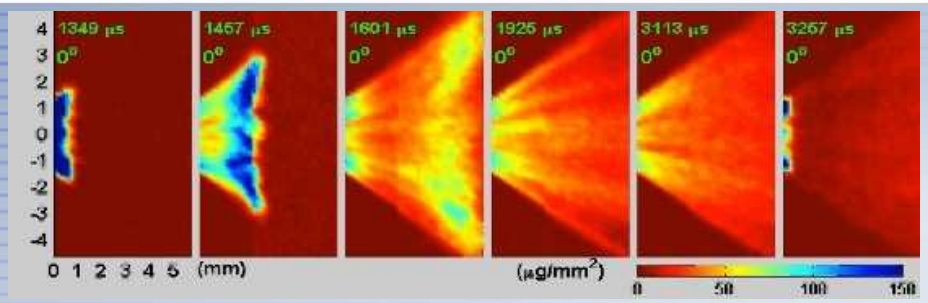


"They have made a significant contribution to automotive technology."
Menahem Anderman, President – Advanced Automotive Batteries

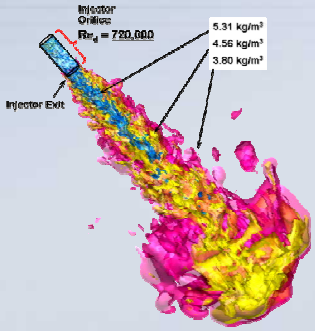
Addressing Combustion Science Challenges

Spray Dynamics

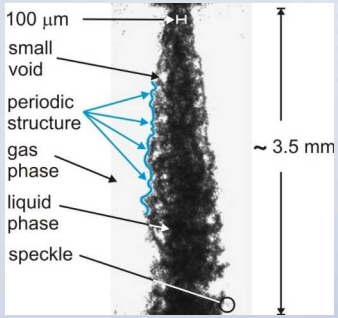
- Ballistic imaging
- X-radiography
  - Hard X-rays: phase-contrast imaging
  - Soft X-rays: chemistry effects
- Nozzle imaging
- High-pressure combustion
- High-fidelity modeling

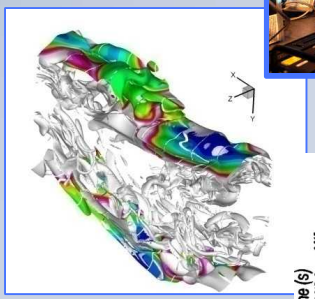


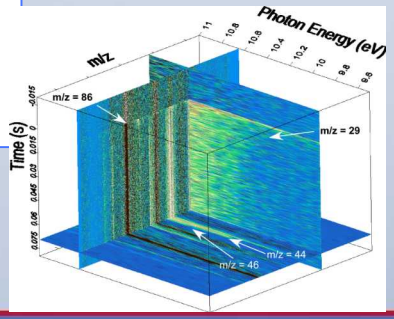
Hard X-ray imaging (Advanced Photon Source)



Femtosecond ballistic imaging







Fuel Chemistry

- Chemistry of combustion is complex: 1000s of reactions
  - pollutant formation, ignition chemistry
- Future combustion chemistry tools
  - fuel-adaptive mechanism predictor
  - rigorous, experimentally validated rate rules
  - automatic reduction and full uncertainty quantification

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Predictive Simulation of Combustion Engine Performance in an Evolving Fuel Environment

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It's all About People . . .

and We Have GREAT People!

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END

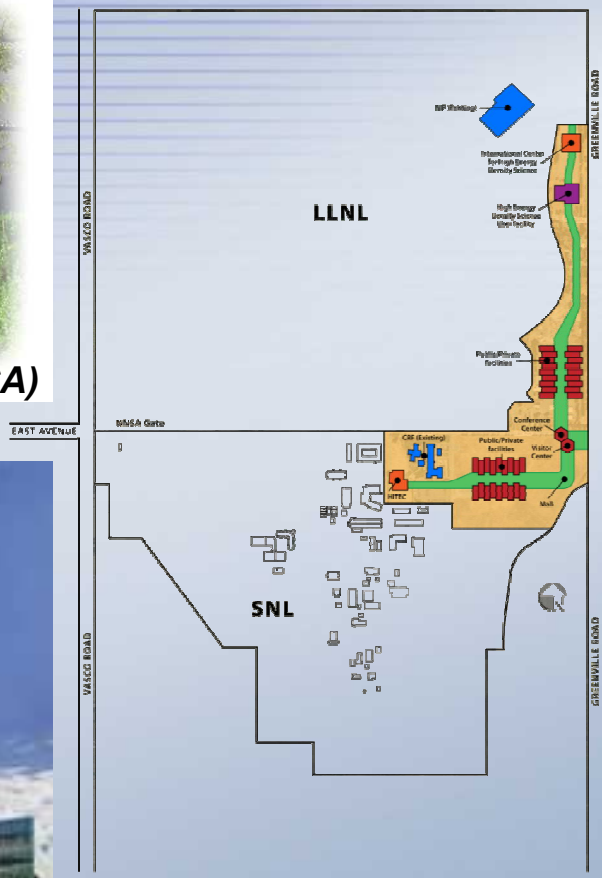
Backups

Sandia Centers of Innovation

Center for Integrated Nano Technologies (NM)

Combustion Research Facility (CA)

CA Open Campus



Microsystems and Engineering Sciences Applications Complex (NM)

Joint BioEnergy Institute (CA)

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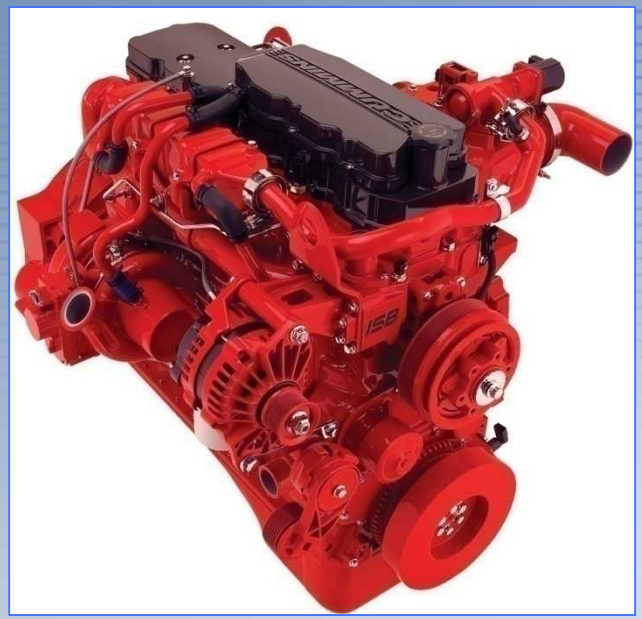
Predictive Simulation Based on Deep Scientific Understanding Is Required to Meet the Goals



Cummins achieved a milestone in engine design by bringing a diesel engine, the 2007 ISB 6.7 liter, to market solely with computer modeling and analysis tools. The only testing was after-the-fact to confirm performance. Cummins achieved a reduction in development time and cost (estimated to be about 10 to 15% for this first effort). As important, they realized a more robust design, improved mileage, and met all environmental and customer constraints.

Goodyear's Assurance® Triple Tred all-weather tire was its first product designed using predictive modeling simulation tools developed in conjunction with Sandia National Laboratories. This tire and the subsequent products utilizing advanced modeling capabilities resulted in a factor of three reduction in product development time and led to record profits for Goodyear.

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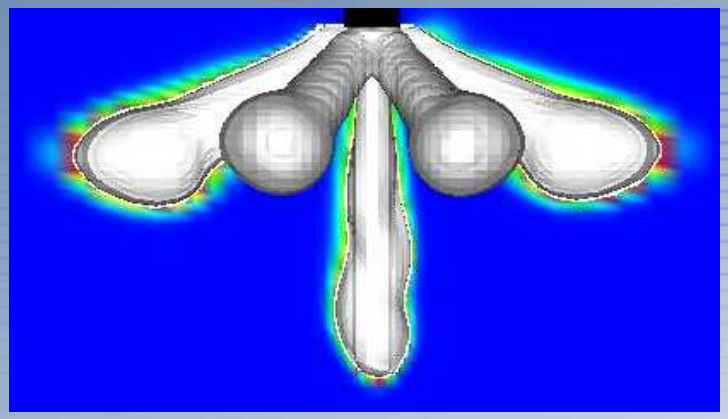
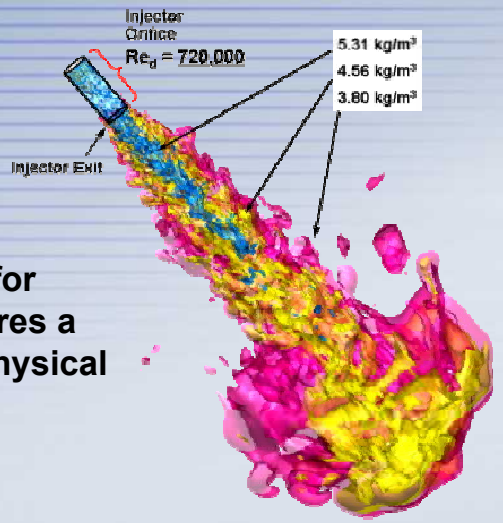
Evolving Predictive Simulation for Product Engineering



Reynolds-averaged Navier-Stokes calculation for fuel injector captures mean behavior



Large Eddy Simulation calculation for fuel injector captures a greater range of physical scales

Current Computational Fluid Dynamics (CFD) tools

- Reynolds-averaged Navier-Stokes
- Calculate mean effects of turbulence
- Turbulent combustion submodels calibrated over narrow range
- ***Direct Numerical Simulation and Large Eddy Simulation for science calculations at standard pressures***

Future CFD tools

- Improved math models for more accurate Reynolds-averaged Navier-Stokes simulations
- Large Eddy Simulation with detailed chemistry, complex geometry, high pressures, and multiphase transport as we achieve exascale computing
- Direct Numerical Simulation for submodel development
- **Alternative fuel combustion models**

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