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Title:	Los Alamos National Laboratory Update
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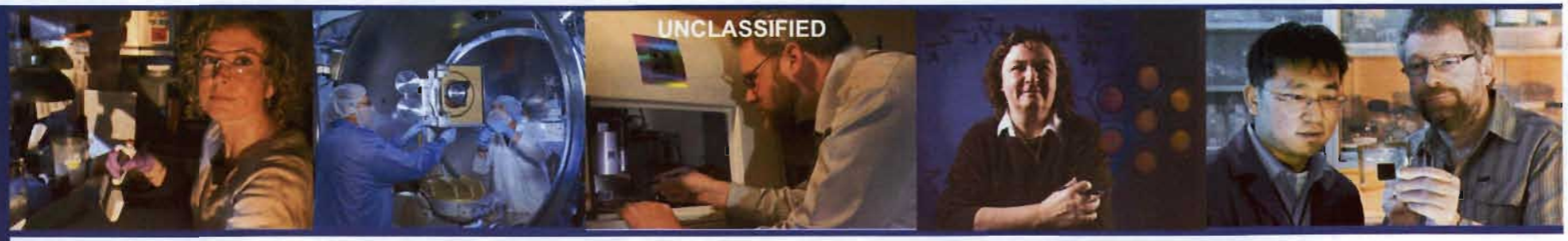
Intended for:	LANS/LLNS Science and Technology Committee Meeting Los Alamos, NM USA October 19, 2011

Form 836 (7/06)

Los Alamos National Laboratory Update

Alan R. Bishop, Janet A. Mercer-Smith, and Duncan W. McBranch

The Laboratory provides science solution to the mission areas of nuclear deterrence, global security, and energy security. The strength of LANL's science is at the core of the Laboratory. The Laboratory addresses important science questions for stockpile stewardship, global security, and energy security. The presentation will describe research and external scientific award highlights that have occurred during the last quarter.



Los Alamos National Laboratory

Los Alamos National Laboratory Update

Alan Bishop
Principal Associate Director for
Science, Technology, and Engineering

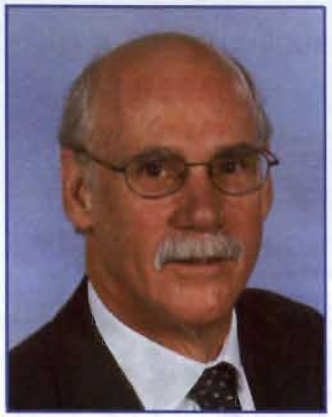
October 19, 2011

Los Alamos
NATIONAL LABORATORY
EST. 1943

Washington Update

- MaRIE

External awards recognize LANL researchers.



Robert Field

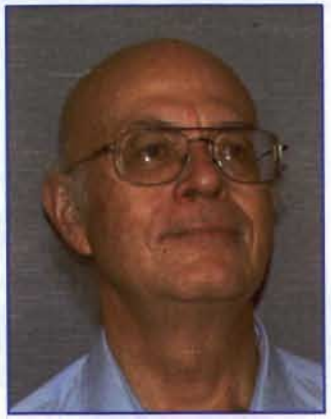
Deniece Korzekwa

Amit Misra

ASM International Fellows

Kimberly Thomas

American Chemical Society Fellow



Paul Burgardt

American Welding Society Fellow

Taylor Hood

Distinguished Scholars Award

Evgenya Simakov

Presidential Early Career Award for Scientists and Engineers

Nan Li

Acta Student Award
American Society of Metals

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Dr. Richard T. (Dick) Sayre, Scientist 6: A Game-changer for Los Alamos

- **Successful hire of a leading scientist, innovator, and entrepreneur.**
- **Internationally renowned biologist with funded programs in energy technology, public health and genomics.**
- **Research with a global impact; "One of five crop researchers who could change the world" (*Nature*, December 2008).**
- **Has led many multi-institutional international initiatives in bioenergy and biotechnology.**
- **Transformational for LANL: his extraordinary expertise and leadership will complement LANL's capabilities in computational and experimental science.**
- **Benefit to LANL, LANS, NNSA, and DOE to catalyze interdisciplinary research and enable new capability and technical infrastructure.**
- **Expected key contributions:**
  - Support Laboratory mission & programs
  - Attract & develop talent
  - Enable partnerships and technology transfer
  - Bring international recognition to the Laboratory

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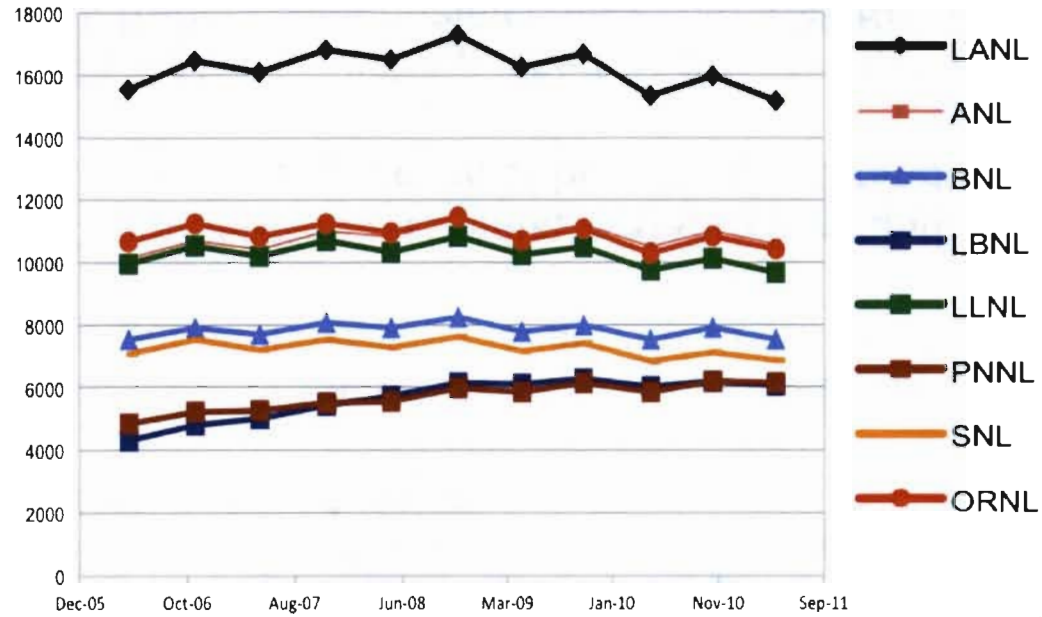
LANL adds Marie Curie Distinguished Postdoc Fellow.

- Named after the distinguished nuclear scientist and only person honored with two Nobel Prizes in different scientific categories (Physics and Chemistry).

- Provides the opportunity to collaborate with LANL scientists and engineers on staff-initiated research.
- Open to outstanding women scientists and engineers, of all nationalities, who are engaged in research aligned with the Lab's missions.
- Candidates must display extraordinary ability in scientific research and show clear and definite promise of becoming outstanding leaders in their research.
- Other LANL Distinguished Postdoctoral Fellowships include Richard P. Feynman, J. Robert Oppenheimer, and Frederick Reines.

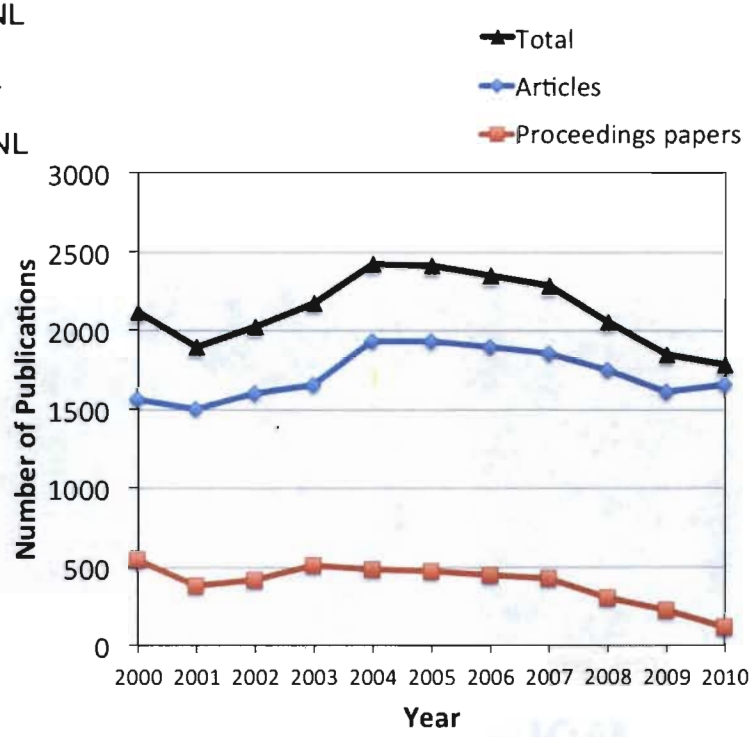
Publications reflect the quality of science.

Publication Comparison (moving 10 year sums): 2005-2010



LANL generated 2,079 peer-reviewed publications in FY11, the most since 2006.

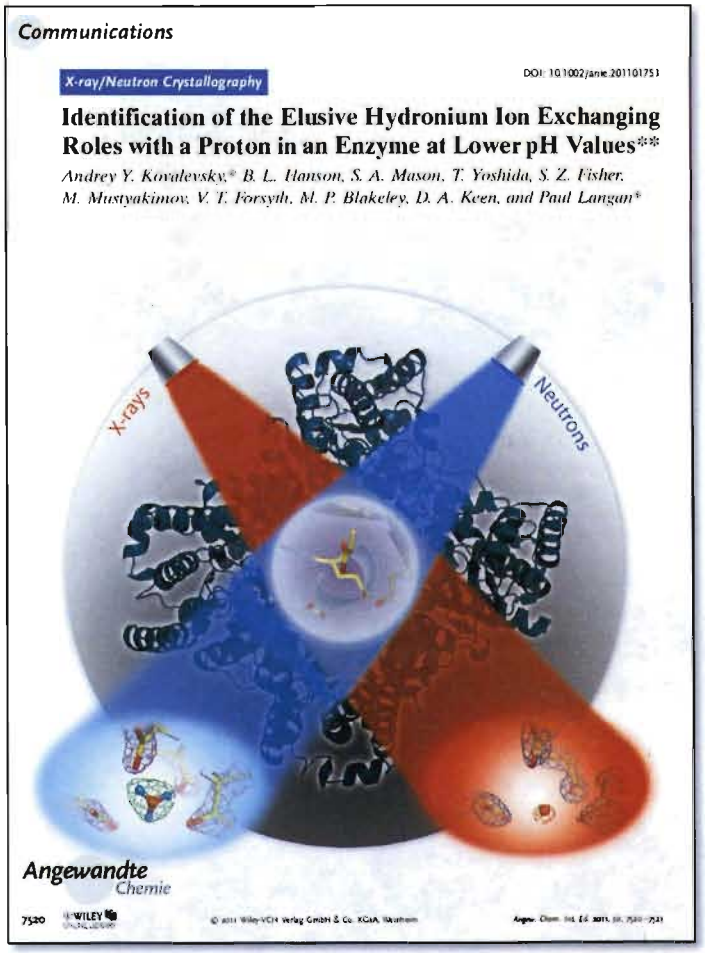
LANL ISI Publications 2000 - 2010



LANSCE reveals role of hydronium ion in biocatalysis.

- **LANSCE gave an unique view of the critical role that hydronium ion (water molecule bound to an additional hydrogen ion) plays in certain biological reactions (*Angewandte Chemie International Edition*).**
  - Enabled understanding of the role played by the elusive hydronium ion in the transfer of protons during enzyme-catalyzed reactions.

Insight could aid in treatment of peptic ulcers or acid reflux disease, or allow for more efficient conversion of woody waste into transportation fuels.



Hydronium ion is important in the catalytic mechanisms of enzymes.

Science achievements support the Lab's mission areas for national security science.

- Solar wind samples from Genesis mission give insight into the birth of the solar system (2 *Science* papers).
- First oxygen and nitrogen isotopic measurements of the Sun demonstrate that they are very different from the elemental stable isotope ratios on Earth.
- These isotopic measurements were the top priorities of NASA's Genesis mission, the first spacecraft to return from beyond the moon.
- LANL developed the Solar Wind Concentrator for Genesis to enhance the flow of solar wind onto a small collector target.

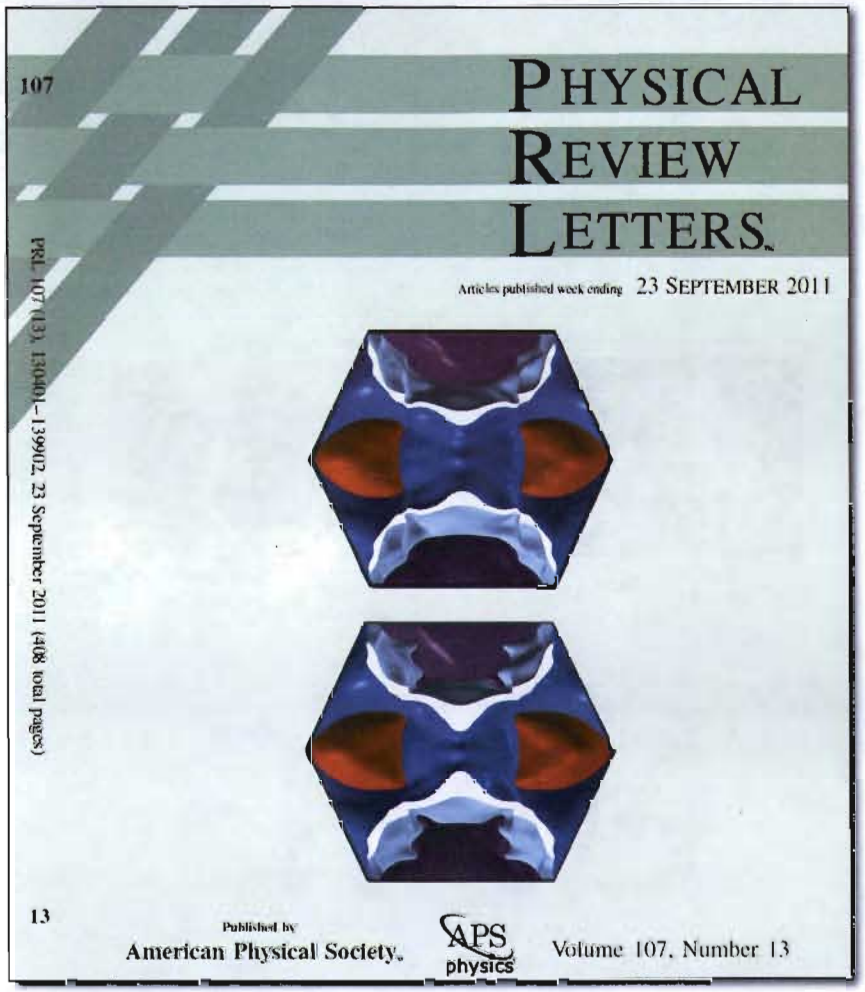
The Genesis Concentrator target after the crash of the sample return capsule

Research enhances the Lab's Global Security mission area and Science of Signatures science pillar.

Understanding the Complex Phase Diagram of Uranium

- **Experimental and theoretical investigation of the role of electron-phonon coupling in determining the low temperature phase diagram of uranium.**
  - Theoretical calculations show that the Fermi surface nesting is unchanged when pressure is applied.
  - Theoretical calculations estimate electron-phonon coupling and show that it correlates well with the charge-density- wave state.
  - Charge-density-wave state does not develop because the electron-phonon coupling is too weak to transmit the electronic information to the lattice.

Provides insight into the mechanisms that govern the interplay between charge-density-wave and superconductivity in alpha-uranium.



Cross section of the Fermi-surface topology for the alpha-uranium structure calculated at ambient pressure (top) and 20 Gpa (bottom)

Progress in ultra-low field MRI for whole body imaging.

- **Goal is a MRI system that is cost-effect, convenient, compact, and portable.**
- **Seek alternative to low temperature SQUIDs (superconducting quantum interference devices) in a special shielded room.**
  - Implementation of room temperature magnetometer eliminates need for cryogens, SQUIDs, and shielded room.
  - Increasing the frequency and the prepolarization field strength improves sensitivity by more than an order of magnitude.

Multi-channel system could enable large-size imaging of head, spine, or whole body.

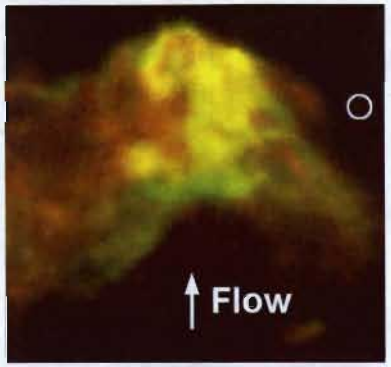
Experiments and simulations enable studies of protostellar jets.

- **LANL collaboration with Rice University, University of Rochester, AWE, and General Atomics uses simulations and small scale experiments to understand astrophysical phenomena (*Astrophysical Journal* 2011).**

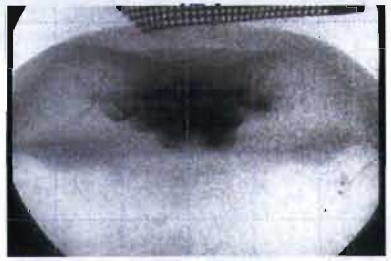
  – Herbig-Haro protostellar jets have been observed long enough by the Hubble Space Telescope to create "movies" of the evolution of these jets.

  – Experiments at the Omega Laser examine the dynamic behavior of plasma jets in a clumpy medium similar to the protostellar environment, but at a very different length scale.

  – LANL designed and analyzed the experiments using the Los Alamos Rage codes.



Hubble Telescope image of bow shock in Herbig-Haro



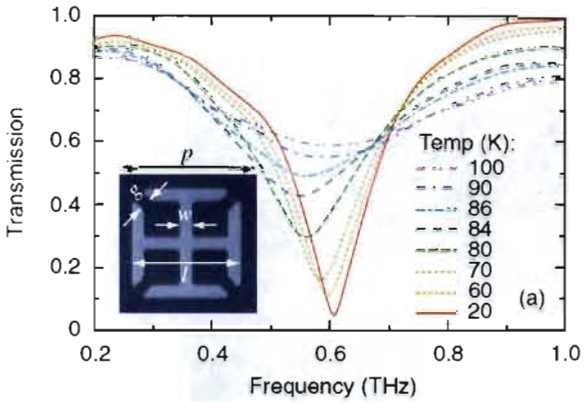
Radiograph from Omega laser experiment

Simulated radiograph of experiment

Research enhanced the Lab's Information Science and Technology for Integrative & Predictive Science pillar.

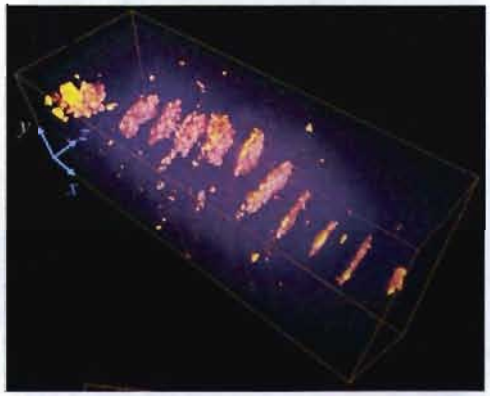
Advances in metamaterials support the Lab's mission areas for national security science.

- **Tuned the resonance in high temperature superconducting terahertz metamaterials (*Physical Review Letters*).**
  - Varying the temperature enables efficient switching and frequency tuning.
  - Numerical simulations reproduce the experiments.
  - Provides path to develop novel multifunctional metamaterials.



Combines superconductors and metamaterials for unique properties

- **Developed fast and inexpensive method to fabricate 3D metamaterial structures (*Review of Scientific Instruments*).**
  - Fabricated 3D periodic structure using high-frequency acoustic waves in a resonator cavity.
  - Acoustic waves direct nanoparticles toward the nodes of the standing wave field to form parallel periodic planes within a 3D matrix of epoxy.
  - The periodic pattern becomes permanent with cure of the epoxy.

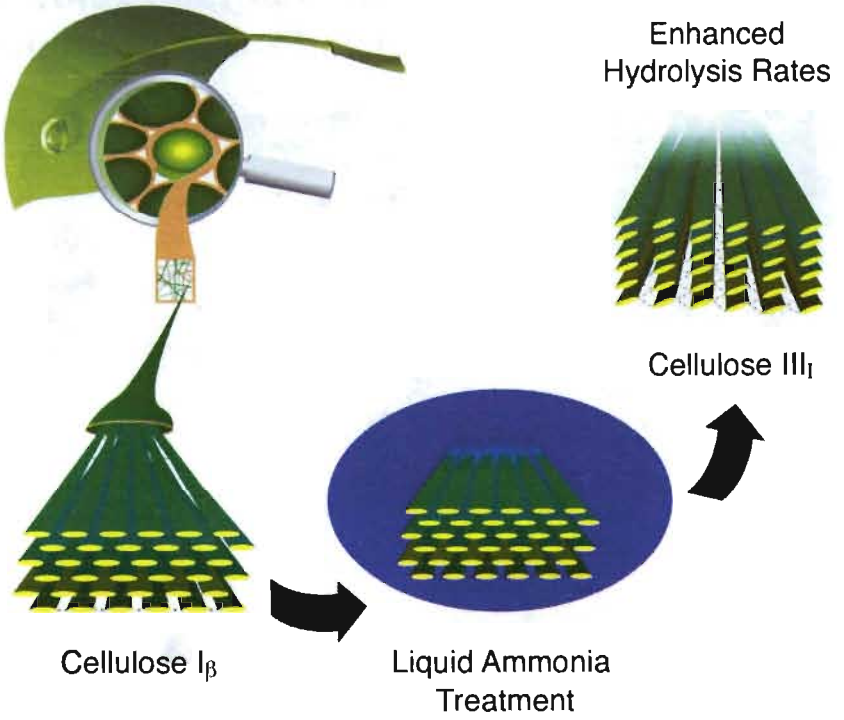


Nanocomposite metamaterial containing diamond nanoparticles

Enables materials design for specific properties.

Simulations and experiments guide biofuel treatment.

- **Discovered potential key to degrade biomass for biofuels *(Journal of the American Chemical Society*).**
  - Employed high performance simulations and experiments.
  - Molecular modeling showed how pretreatment decreases intrasheet hydrogen bond network of crystalline cellulose.
  - Pretreatment makes cellulose five times more digestible by enzymes that convert it to ethanol.



Pretreatment of biomass with ammonia

Provides potentially less costly and less energy intensive method that makes cellulose easier to degrade.

National High Magnetic Field Laboratory's Pulsed Field Facility (NHMFL-PFF) sets new world record.

- **World record: strongest magnetic field produced by a *nondestructive* magnet.**
- **Achieved a record field of 92.5 tesla on August 18, then surpassed their record with a 97.4-tesla field the next day.**
  - **Earth's magnetic field is 0.0004 tesla, a medical MRI scan has a magnetic field of 3 tesla.**
- **The Pulsed Magnet was engineered and built at LANL (AET, MST, MPA Divisions).**
- **NHMFL-PFF, a national user facility, now provides the unique capability for magnetic pulses of 95 tesla.**

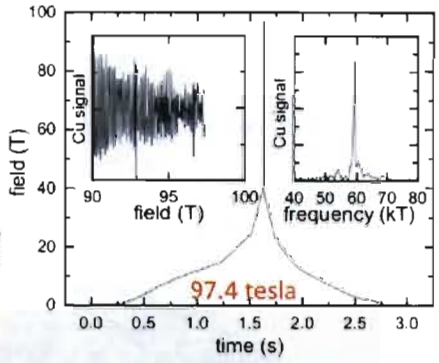
NATIONAL HIGH MAGNETIC FIELD LAB

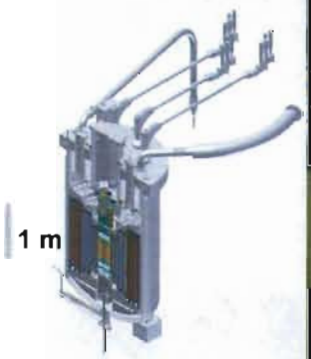
NSF

U.S. DEPARTMENT OF ENERGY Office of Science

Los Alamos

Confirmed 97.4 tesla via magneto quantum oscillations in polycrystalline copper.






LANL's 1.43 GW generator safely delivers a 600 MJ electrical pulse, a key capability giving the US a lead in high magnetic field generation capability.

Provides an unprecedented tool to study fundamental properties of materials and understand the physics of structurally complex systems at a quantum level.

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Science and Energy Achievements

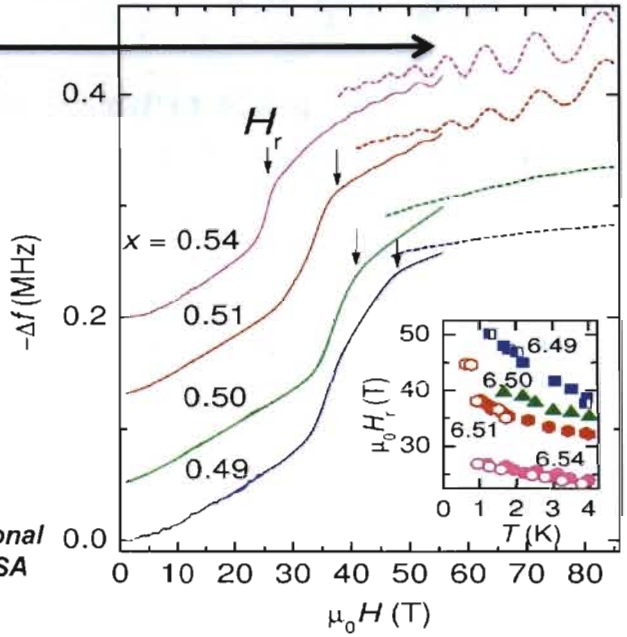
National High Magnetic Field Laboratory's Pulsed Field Facility (NHMFL-PFF) explores material in extremes.

New states of matter revealed in Ultra-High Magnetic Fields

- Magneto-quantum oscillations reveal the Fermi surface of materials.
- Each color represents a separate doping of a High T_c superconductor.

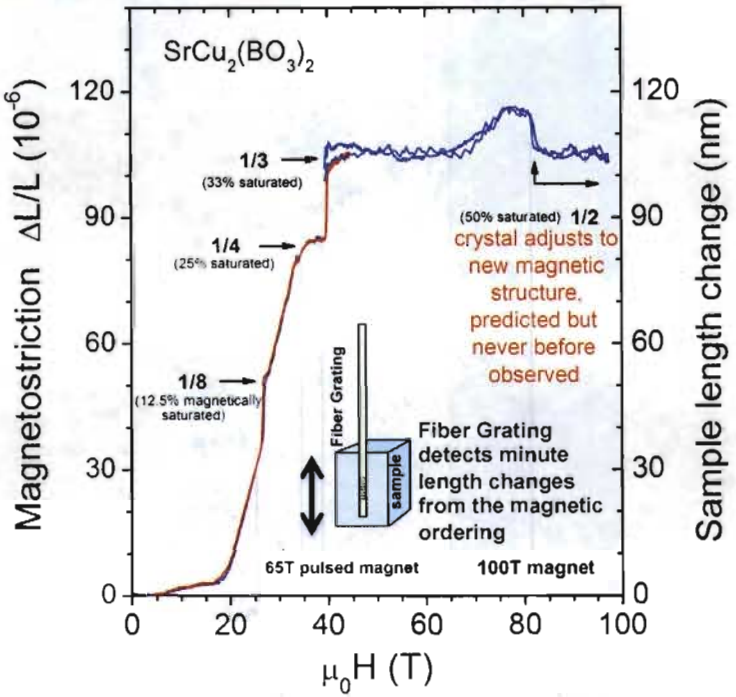
NATIONAL HIGH MAGNETIC FIELD LAB

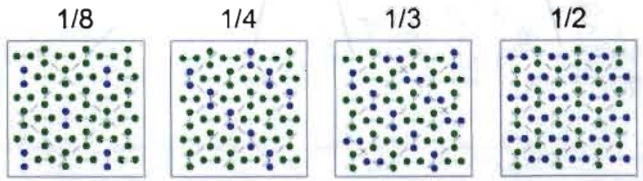
Proceedings of the National Academy of Sciences USA



- Very high magnetic fields are essential to reveal a material's quantum energy states, which yield electronic structure and electron mass.
- Inset shows the temperature dependence of the quantum oscillations (each point represents a distinct magnetic field pulse.)

- Developed optical technique to sense the "magnetostriction" of a magnetic material.





Multiple Magnetic States are driven by magnetic field

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Industrial partnerships enable the Lab's mission areas for national security science.

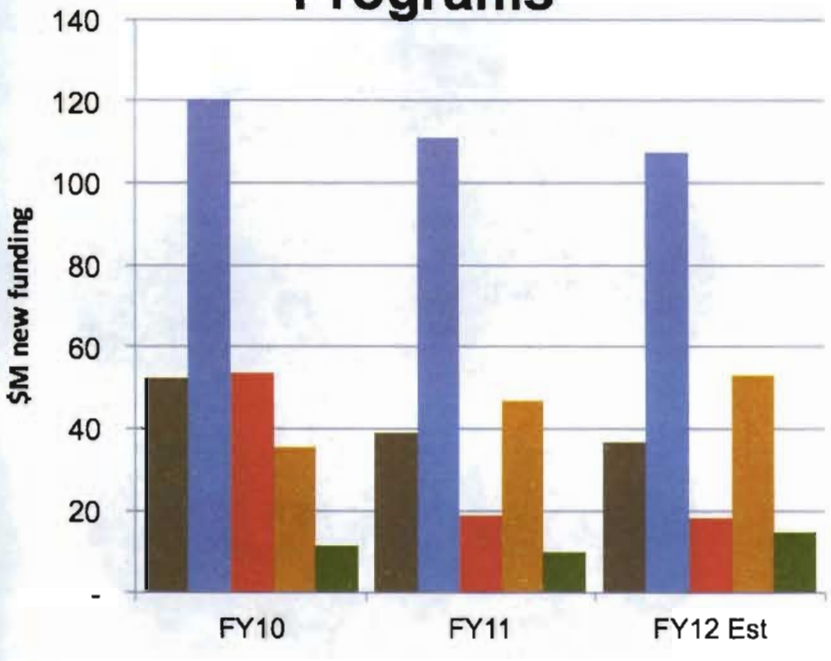
- **LANL and Raytheon received a patent for the Multimodal Radiation Imager.**
  - Combines two gamma-ray imaging techniques to detect radiological materials.
  - Sensitive detection is needed for accidental release or nonproliferation.
  - Imager can scan a given area from up to 100 meters away while driving

Leverages intellectual property and industry partners for mission delivery and capability enhancement.

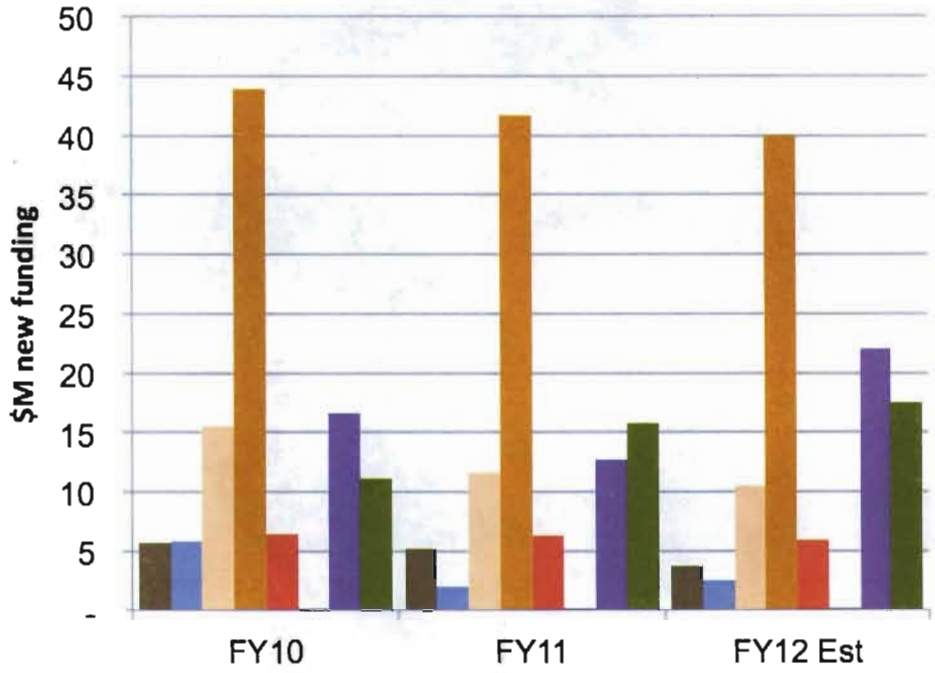
Live testing shows path of the truck, test source locations, and images of the sources.

Science and Energy Programs: FY10-12

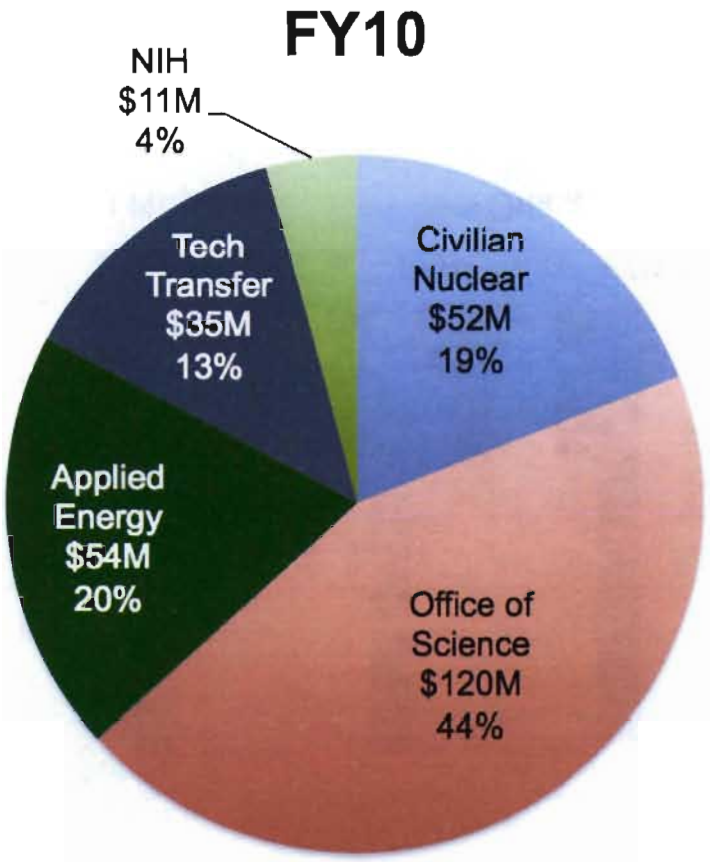
Science & Energy Programs

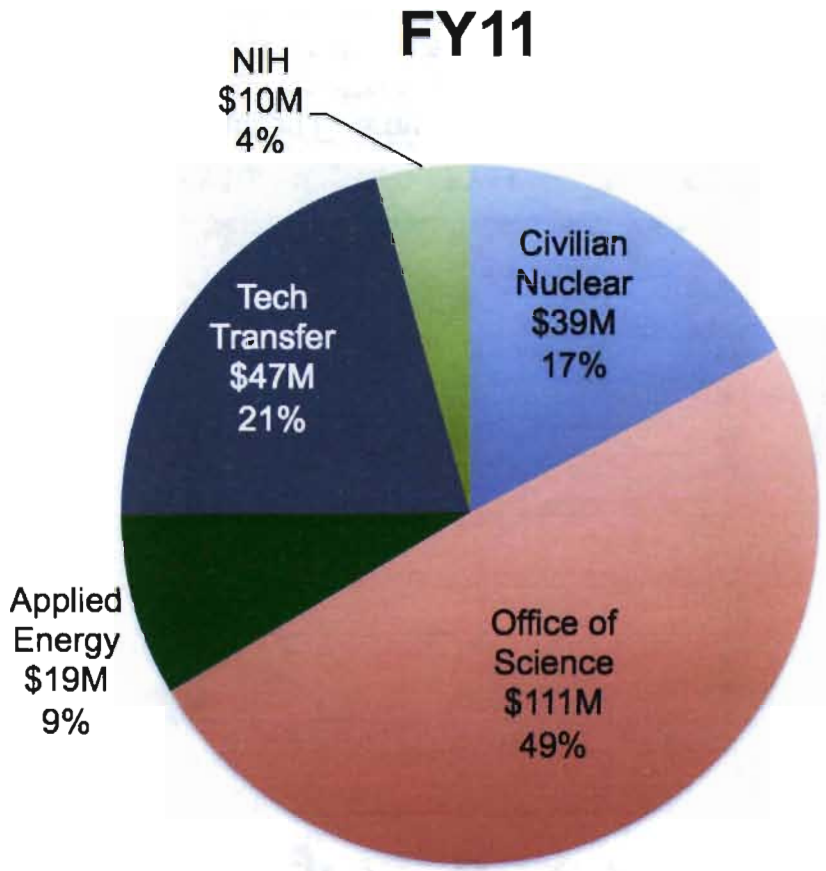


Office of Science Program Detail



Science and Energy Program Funding: FY10-11



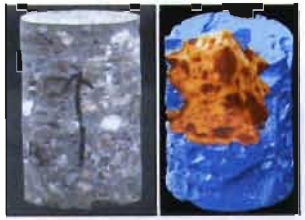


Equipment Obtained during FY 2011

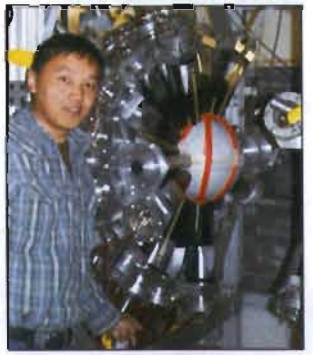
- 700 MHz Nuclear Magnetic Resonance - ($1,718 K)
- High resolution, high transmission secondary ion mass spectrometer (SIMS) - ($1,300 K)
- Spectral Signature Experimental Laboratory ($596 K)
- Neutron computed tomography instrument - ($533 K)
- Protein crystallography X-ray unit - ($499 K)
- Spectrometer for Materials Research at Temperature and Stress (SMARTS)/HIPPO quenching furnace capability - ($300 K)
- High resolution gamma detector in Detector for Advanced Neutron Capture Experiments (DANCE) - ($270 K)

Mass spectrometer

Growth chamber



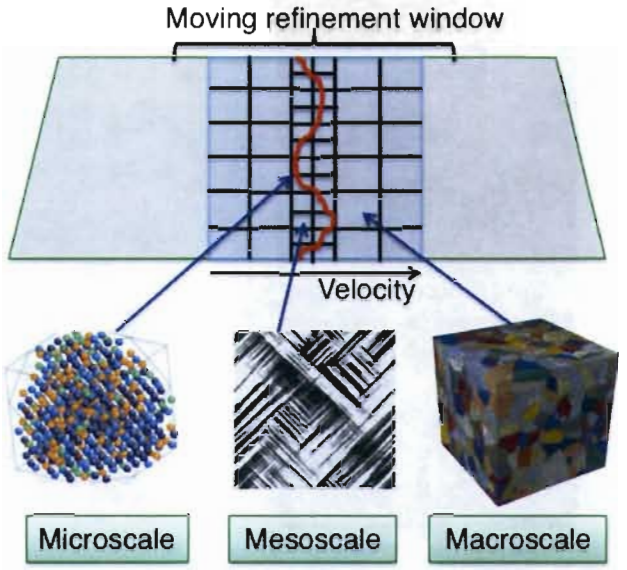
Neutron tomography



DANCE

LANL leads the Exascale Co-Design Center for Materials in Extreme Environments (ExMatEx) and partners in others.

- Co-design is a new paradigm in which the exascale hardware, system software, and application codes are concurrently designed to create the exascale simulation environment.
- The goal is to achieve more realistic large scale simulations of materials in extreme mechanical and radiation environments.
- A predictive understanding of the response of materials to extreme conditions underpins DOE and NNSA missions and Laboratory programs.



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Sandia National Laboratories

OAK RIDGE National Laboratory

ExMatEx

Massachusetts Institute of Technology

CALIFORNIA INSTITUTE OF TECHNOLOGY 1891

PRINCETON UNIVERSITY

Lawrence Livermore National Laboratory

CRAY THE SUPERCOMPUTER COMPANY

intel

STANFORD UNIVERSITY

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MaRIE External Advisory Board met in August, 2011

[Present: J. Hemminger (Chair), C. Baker, M. Cappiello, P. Fleury, R. Hemley, W. Herrmannsfeldt, A. Kerman, C. Mailhiot, T. Mason, R. Selden, J. Birely (ex-officio)]

- **Have we articulated an acquisition strategy for MaRIE that is complete and compelling? Is our status with partnering appropriate for MaRIE's level of development?**

"The strong focus on the NA-10 call-for-proposals for long-range experimental facilities is appropriate and responsive. This is a key and unprecedented opportunity that must be seized vigorously. The acquisition strategy, including any options for a phased build, needs to remain flexible."

"We have seen much more substance in partnering activities. Interactions with the other labs is much more advanced than we have seen in the past and this will be critical for the future development of the MaRIE program. "

- **Consistent with an NNSA-centric acquisition, are the weapons mission drivers sufficiently compelling to justify the mission need for a $1B class facility and to intrigue and engage the broader scientific community?**

"The classified presentations had a significant degree of coherence and uniformity in the message they delivered....The presenters clearly identified the types of issues that arise in the stockpile (e.g., aging, and refurbishment). There is a growing recognition in the weapons program that a long-term experimentally-validated predictive capability will require a facility such as MaRIE."

DIR McMillan reiterated his commitment to MaRIE and his focus on the NA-10 facility call.

NNSA has launched a "New Facilities Committee" emulating Orbach 2003 SC Facility Plan.

MEMORANDUM FOR PAUL HOMMERT
PRESIDENT AND LABORATORIES DIRECTOR
SANDIA NATIONAL LABORATORIES

CHARLES MCMILLAN
DIRECTOR, LOS ALAMOS NATIONAL LABORATORY

GEORGE MILLER
DIRECTOR, LAWRENCE LIVERMORE NATIONAL LABORATORY

FROM: DONALD L. COOK
DEPUTY ADMINISTRATOR
FOR DEFENSE PROGRAMS

SUBJECT: Planning for Future NNSA Experimental Facilities

ISSUE: Request that the laboratories follow the process developed by the "New Facilities Committee" (members nominated by the laboratory directors) for creating a long-term strategy for future experimental facilities.

New Facilities Committee

Jason Pruet, NNSA
Melissa Marggraff, LLNL
Julia Phillips, SNL
John Sarrao, LANL

Meetings

LLNL, 6/28; DC, 7/14

Output

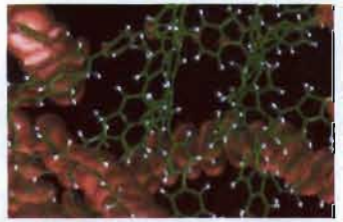
Define values, criteria, proposal content, review process
(NOT to perform actual review)

Call issued Sept. 16, 2011

Proposals due Feb. 15, 2012

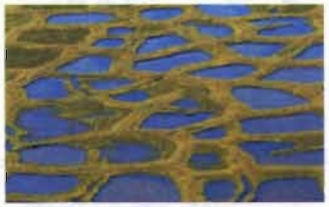
New LDRD DR Projects Beginning in FY 12

- Organic Electronic Materials: Designing and Creating Functional Interfaces
- Energy Storage
- Dynamic Earthquake Triggering, Granular Physics and Earthquake Forecasting
- Genetically Encoded Materials: Libraries of Stimuli-responsive Polymers
- TeV Jets: Nature's Particle Accelerators
- Integrated Modeling of Perturbations in Atmospheres for Conjunction Tracking
- Hydrodynamical Mix Studies at the National Ignition Facility (U)
- Advancing the Fundamental Understanding of Fission (U)
- Predicting Climate Impacts and Feedbacks in the Terrestrial Arctic
- Physics Beyond the Standard Model with the Long-Baseline Neutrino Experiment
- Hierarchical Sparse Models for Robust Analysis of Video Data
- Elucidating Humankind's Evolving Environment
- Plutonium-242: A National Resource for the Fundamental Understanding of 5f Electrons
- Modern Challenges in Actinide Science
- Quantum Science: From Information to Materials

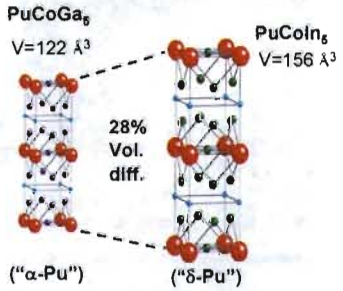


Organic Electronic Materials

TeV jets



Predicting Climate Impacts in the Arctic



Plutonium-242

Future of Science

Premier National Security Science Lab: US needs now more than ever

- **Accelerating discovery to innovation for technology delivery**

- **Interdisciplinary science of systems at scale:** ***From Understanding to Prediction***

ExMatEx

CMIME
Center for Materials at Irradiation and Mechanical Extremes

- **Sustaining the environment for success:**
  - Excellent people
  - Exciting scientific challenges
  - Unique facilities/infrastructure

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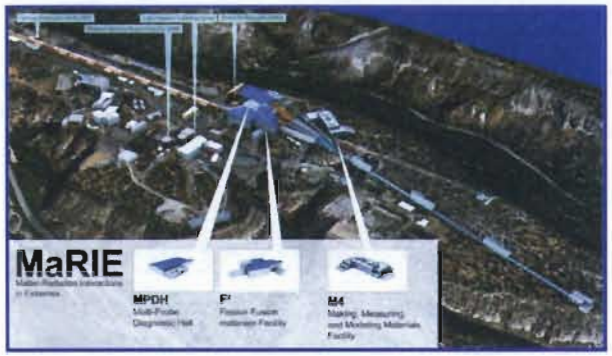
Backup Slides

Backup Slides

Optimizing Excellence and Impact in Science, Technology, and Engineering

Workforce



Facilities

R&D Equipment

- People: Managing a technical workforce for science & engineering excellence
- Delivering mission impact: Indicators of success
- Investing in the future: FY12 and beyond

Biofuel research advances with algae on several fronts.

- **First pilot-scale demonstration of oil and gas "produced water" to grow algae for biofuels**
  - Oil and gas production in the US bring about 800 billion gallons of saline "produced water" to the surface annually.
  - This impure water could be used to grow algae for biofuels.
  - Working with industrial partners on water quality for cultivation.
- **Developed an efficient, innovative process to convert algae-derived oils to hydrocarbons for fuel.**
  - The carboxylic acid groups from fatty acid oils and makes a hydrocarbon that can easily be reformed to fuels.
- **Optimized a LANL-developed process to harvest biofuel from algae.**
  - LANL process is based on the R&D Award-winning Ultrasonic Algal Biofuel Harvester.
- **Developed world's first genetically engineered "magnetic" algae.**
  - Expressed gene from magnetotatic bacteria in green algae to create magnetic nanoparticles, enabling separation of the algae with a permanent magnet.

Algae grows in mixed media with produced water.

A dilute "pond" solution of algae before treatment (left tube) and after treatment (right tube).

WNR Project Update

- Demolition and pit excavation complete 08/12/11
- Additional earthwork and excavation required due to poor soil conditions; some delays due to thunderstorms and poor drainage
- Structural steel delivery and concrete placement scheduled for week of 09/26/11
- Current EAC with known trends accounted for = $2.11M
- Current funding available = $2.4M
- Working with sub-contractor to pull schedule in as much as possible