Los Alamos National Laboratory (LANL) combines cutting-edge experimental and computational tools to meet the nation's national security needs. LANL's primary responsibility is to ensure the safety, security and reliability of the nation's nuclear deterrent. As part of the Science-Based Stockpile Stewardship program to meet this responsibility without nuclear testing, Los Alamos scientists and engineers acquire data and develop models to understand the performance and behavior of nuclear weapons in normal and abnormal environments. Beyond stockpile stewardship, LANL research contributes to broader national security needs in nuclear non-proliferation and counter-terrorism, energy and climate, and biodefense.

Los Alamos offers fellowship opportunities in the following research areas:

Pulsed power science and engineering

Los Alamos applies pulsed power technology across a broad range of topics, including complex hydrodynamics, material properties, plasma physics, high energy density physics, and accelerator technology. Each field of application brings unique challenges to its pulsed power drivers, requiring LANL pulsed power researchers to be creative and flexible. For instance, hydrodynamic and material properties applications demand a combination of high (multi-megampere) currents with high reliability and high precision electrical energy delivery. Plasma and high energy density physics topics typically require more modest energy and power delivery on faster timescales and at higher voltages, while accelerator-related applications need even faster energy delivery at even higher voltages, albeit at much lower currents.

Los Alamos programs in low impedance, very high current pulsed power span conventional and cutting-edge topics in traditional capacitive energy storage, switching, power conditioning and pulse shaping using capacitor banks, pulse lines, and cutting edge current multiplying transformer technologies. The Precision High Energy Liner Implosion Experiment (PHELIX) applies a mix of conventional and unconventional pulsed power technologies to provide unique drive conditions in portable packages for hydrodynamics and instability studies using the specialized imaging capability of proton radiography, and offers exciting research possibilities on a scale suitable for small team research. More unconventional research opportunities exist in the field of explosively drive flux compression pulse power, technology that makes hundreds of megampere currents available for unique experiments that have attracted world-wide interest and participation from researchers from many nations.

A new generation of engineers and physicists are being assembled to build an exciting careers in pulsed power engineering for both traditional approaches (discrete component, capacitive and inductive pulsed power for energy storage and delivery), and in development of unconventional pulsed power systems such as explosive flux compression systems. Diagnostic physicists and engineers have opportunities to explore some of the latest detector technology for hydrodynamics, shock-wave physics and material science in condensed matter environments that are unreachable using traditional drivers.

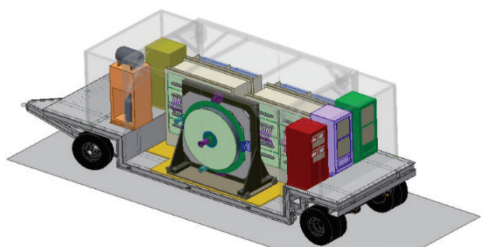

Figure 1: *The Precision High Energy Liner Implosion Experiment (PHELIX) driver for material science and complex hydrodynamic experiments.*

Radiation magneto-hydrodynamics/nuclear astrophysics/spectroscopy

LANL scientists are currently studying challenging problems in astrophysics and Inertial Confinement Fusion (ICF) where the formation of self-generated magnetic fields may play a critical role in imploding systems. ICF experiments use high-powered lasers to compress small capsules filled with the hydrogen isotopes deuterium and tritium to conditions at which thermonuclear burn could occur. Achieving such a goal comprises one of the scientific grand challenges of our time.

Los Alamos has several projects deigned to improve our understanding of magnetic fields generated from turbulent plasma flows with experiments on large laser facilities such as the National Ignition Facility and the Omega laser facility. The work supports developing improved models for our simulation codes to more accurately describe nature. One area of focus within this subject is improving our understanding of the conditions reached when the capsule implosion stagnates and fusion is initiated. Experiments show a discrepancy between measurements of the temperatures of the deuterium and tritium ions and our best models. One hypothesis to explain this discrepancy is that self-generated magnetic fields may inhibit cooling of the hot plasma by confining the charged particles. In addition to the generation of magnetic fields in ICF implosions, similar phenomena may be important in core-collapse supernovae. While most effort in this area of astrophysics focuses on the explosion phase, understanding the collapse may be essential in understanding the entire process. The use of high energy density facilities is one approach to providing direct experimental evidence to validate these astrophysical simulations.

Atomic physics and visible/UV/X-ray spectroscopy

Atomic physics and spectroscopy also play a critical role in the understanding and the diagnosis of physical systems ranging from materials on the surface of Mars, observational and theoretical astrophysics, and high energy density science. LANL owns a rich history of atomic physics research developing many basic spectroscopy tools and atomic physics models for a wide range of applications. For instance, in solar/stellar physics absorption spectroscopy can be used to determine the abundances of the elements in the outer region of the sun and stars and used in models to determine the radius of the radiation/convection zone boundary. However, these models disagree with helioseismology measurements of our own sun. One potential source of the discrepancy is the opacity for the various elements in particular of iron since it is the heaviest element found in stars. Recent measurements of the iron opacity at high temperatures (~2,000,000 K) on the Z-machine at Sandia National Laboratory disagree with our opacity models. These results along with improved measurements of other elements may explain the disagreement between the models and helioseismology measurements. LANL is leading an effort to make an independent measurement of the iron opacity using the National Ignition Facility as a high temperature driver. The results will crosscheck the Z work using a different experimental approach. The development of the platform for this measurement of the iron opacity will provide a unique tool for a broader range of opacity measurements of other materials under extreme conditions.

For research in high energy density physics, LANL utilizes our spectroscopy capabilities to address other interesting problems. Absorption spectroscopy measurements are used to measure supersonic radiation flow and transmission spectroscopy measurements provide a means to obtain the conditions inside capsule implosions for Inertial Confinement Fusion. These exciting areas of research support a wide range of applications over a wide range of material conditions.

Dynamic materials/shock physics

Many of the most challenging problems in stockpile stewardship revolve around the dynamic performance of materials under extreme conditions. Researchers at Los Alamos perform cutting-edge experiments to inform predictive models of material behavior under weapons-relevant conditions. Particular physics areas of emphasis include equations-of-state, reactive burn, strength models, damage models, and ejecta production. Because each of these behaviors depend on material phase and can be time-dependent, LANL is placing an increased focus on phase-aware models, detailed mechanistic insights, and kinetics. Each of these models is then applied to materials of stockpile interest, including ductile and brittle metals, polymers, foams, and high explosives.

Experimental facilities used in these studies range in scale from the benchtop through intermediate-scale gun and pulsed power facilities, to large integrated experiments using national assets like DARHT and the U1a Complex. Over the last several years, an increased focus has been coupling of high brilliance x-rays to dynamic experiments at U.S. light sources (such as the Advanced Photon Source at Argonne National Laboratory and the Linear Coherent Light Source at the Stanford Linear Accelerator Center). The experiments focus on discovery of new physics insights, provide parameters for models, and validation of those models. Because these models must be accurate (and physically realistic) over a range of scales – and because a broad set of models must work together in LANL's multiphysics codes to simulate the variety of physical phenomena present in complicated integrated experiments – successful model development demands a tight interplay between material science, computer science, and experimental data.

LANL's future thrusts in dynamic material science revolve around greater scientific understanding leading to greater control and prediction of performance. The future flagship MaRIE facility will provide unprecedented insight into the mesoscale physics that links microstructure to performance. A broad and deep LANL effort in additively manufactured metals, polymers, foams, and high explosives provides a potential avenue to improved performance for future applications.

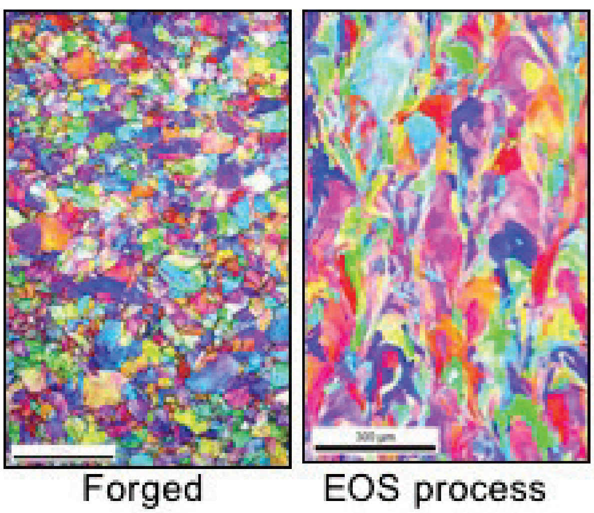

Figure 2: *Microstructures of 304L stainless steels made by traditional forged (left) and additively manufacturing (right) methods. The additively manufactured 304L stainless steel was made using a laser-powder bed ("EOS" technique. The microstructural differences result in different elastic limits and dynamic tensile strengths under dynamic loading.*

Energetic materials research has been foundational to the Laboratory's missions since the Manhattan project. As safety requirements evolve, the future stockpile demands a deeper, more fundamental understanding of insensitive high explosives, and the behavior of explosives under complex loading pathways. At the same time, stewardship of the existing stockpile continues to require a more complete picture of the behavior of conventional high explosive. Through LANL's partnerships with the Department of Defense (through the Joint Munitions Program) and the intelligence community, researchers have the opportunity to study and contribute to knowledge about an even broader set of explosives and other energetic materials.

The unique breadth of this research at Los Alamos – from chemical synthesis and characterization, through formulation, process development, pressing, and machining, to small- to large-scale performance testing – allows researchers to engage in the full range of energetic material research. A unique capability to additively-manufacture explosives is pushing the limits of our understanding of the structure-to-performance relationships in these uniquely challenging materials.

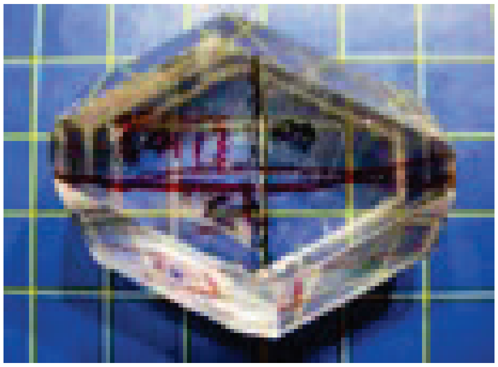

Figure 3: *(Left) A single crystal of high explosives on a 1 cm grid. Single crystal explosive samples are studied using traditional optical diagnostics and emerging x-ray diffraction probes to understand plastic deformation mechanisms under shock compression. (Right) David Chavez of the Explosives Synthesis and Formulation group synthesizes new target energetic molecules that exhibit reduced sensitivity.*

Accelerator design

Los Alamos offers theory, design, and experimental opportunities in all aspects of both pulsed high-current electron beam technology for accelerators used for x-radiography applications and low-current electron beam technology for radio-frequency accelerators and advanced Free Electron Lasers (FEL). Penetrating imaging of dynamic, dense objects requires intense pulses of high energy (>10 MeV) bremsstrahlung x-rays created by focusing kiloampere electron beam pulses to very small spot sizes. Material science applications require radiation sources with flexible temporal and spectral characteristics (for which the FEL is the leading candidate) for use as probes in multi-scale material experiments with material scales ranging from atomic to macro-scale as part the LANL Material and Radiation in Extremes (MaRIE) initiative.

LANL programs in radiography offer exciting opportunities for research, engineering, modeling, and diagnostics at the existing Dual-Axis Radiographic Hydrotest Facility (DARHT) 1 and DARHT 2 linear induction accelerator facilities, and a challenging family of opportunities in working with the team developing a new multi-pulse, high current radiographic accelerator called Scorpius. Opportunities in RF accelerator engineering and technology are available at the Los Alamos Neutron Science Center accelerators and in the rapidly evolving MaRIE program.

These twin broad areas of application invite a new generation of engineers and physicists to build rewarding careers in pulsed power engineering for both traditional (pulse line and discrete-component pulsed power) and power electronic (solid-state) pulsed power drivers for linear induction accelerators. Candidates interested in plasma and electron-beam physics can explore the many challenging physics issues associated with high precision multi-pulse accelerator design including beam stability, breakdown, surface plasmas, complex magnetic geometries (for both accelerator guide and wiggler field structures), and electromagnetics. Diagnostic physicists and engineers have opportunities to explore the latest (and yet to be invented) detector technology for electron beam experiments, and for the imaging, optics, recording and data transfer aspects of advanced radiography. Measurement of the spectral, temporal and special parameters of the x-ray pulsed used for radiography constitute yet another diagnostic challenge as are advanced neutron detectors.

__Figure 4:__ *The Dual-Axis Radiographic Hydrotest Facility (DARHT) uses two linear induction electron accelerators to provide dynamic radiographs of imploding systems.*

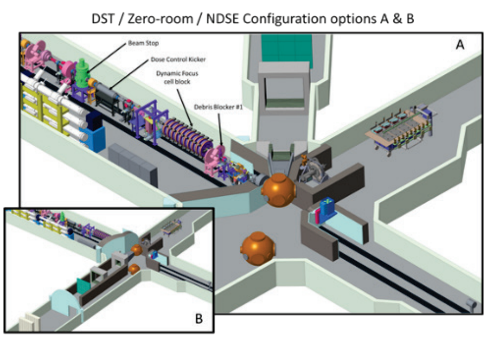

__Figure 5:__ *The planned Enhanced Capabilities for Subcritical Experiments facility will include a multi-pulse linear induction accelerator for dynamic radiography of imploding plutonium systems. LANL is leading the design of the accelerator.*

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