Defense Science *Quarterly*

News about the Science Campaign May 2008

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Chris Deeney, Director,
Office of Defense Science

Greetings from a newly reorganized NNSA!

As you know, the science campaign is always aiming towards the future and "Doing Tomorrow's Directed Stockpile Work Today" is the way we express that vision. This particular quarterly newsletter covers a number of activities critical to the future of Stockpile Stewardship: certification, capabilities and human capital. Robert Hanrahan's article discusses the new Advanced Certification (AC) activities in the science campaign. We had a very interesting workshop on AC in April, and we greatly appreciated the input we received from JASON and from Dr. Mullins at the Air Force. Key messages to us are "quality over process" in certification and "transparency." We will use the AC program to develop a future strategy and vision of certification and to create more transparency in our peer review processes. On a similar transparency note, the excellent high impact journal papers, summarized by Brad Wallin, demonstrate the quality of NNSA science to the world. Our university programs also contribute through their innovate research. A great example is Todd Ditmire and his team at the University of Texas at Austin. Congratulations on reaching a petawatt on their laser.

Certification and Assessments are the major product of the laboratories, but as we know these are built on foundational capabilities. In the article by Alan Wan and Warren Hsing, we see the significant advances that will be delivered to the complex by the National Ignition Facility (NIF). The Inertial Confinement Fusion Program has enabled high energy density physics experimental platforms for the last three decades culminating in NIF. The secondary and primary physics communities are eagerly awaiting access to the completed NIF to solve some critical and long-standing issues in the stockpile – gigabars, here we come.

Another important capability is "process aware" materials. We have spent a great deal of money throughout the complex on aging. In many cases, it has turned out that "aging" effects were actually caused by other processes like manufacturing steps in experimental hardware or irradiation during inspection. The science campaign is therefore championing that our material models should ultimately be process aware, that is, we can assess changes in performance based on changes in composition, structure, metallurgy, etc., caused by processes caused by aging or manufacturing. If we can couple such understanding with an ability to control processes, we can transform our manufacturing processes to achieve the desired performance. The paper on flame spray produced graded density impacts is a window to what that future would look like. In this case it produced an experimental capability but it is an easy jump to how such close coupling of science and production could impact TA55, Y12, Pantex, and Kansas City.

Unfortunately, it is not just our stockpile that is aging, so are we. Our Stewardship Science Academic Alliances Program is one of the vehicles we use to train and attract the future generation of stockpile scientists to our laboratories (70 to date). The recent symposium at the Carnegie Institution in Washington, DC, was a great success! We want to thank Administrator Tom D'Agostino, Deputy Administrator Bob Smolen and Chief Scientist Dave Crandall for attending and encouraging the next generation of scientists. We also want to thank Russ Hemley and Richard Meserve for allowing us the use of their superb facilities.

Finally, I want to congratulate LANL and their team members for excellent progress on DARHT. This project has met and exceeded its goals – well done! The DARHT team progress makes us all proud. The technical team is outstanding. I also wanted to thank the Federal staff: Kirk Levedahl and Ken Kellar for previous critical contributions; and Frank White and Shah Jaghoory for excellent federal leadership in bringing this project to the end game.

Advanced Certification by Robert Hanrahan, NNSA

The Consolidated Appropriations Act of 2008 (Public Law 110-161), created the Advanced Certification (AC) subprogram in the Science Campaign. The stated purpose of this new activity is to address issues raised in the summer 2007 JASON review of the Reliable Replacement Warhead (RRW), in the context of any stockpile strategy. In their review the JASON panel issued recommendations in four generic areas: development of quantitative measures and experiments applicable to certification without testing, improved understanding of materials compatibility and aging, understanding of proposed new manufacturing processes and their effect on certifiability, and increased transparency and consistency in peer review. These are applicable to any stockpile stewardship strategy.

AC will provide a broader framework and funding to address the JASON recommendations. This is particularly true in efforts such as adding quantitative rigor to metrics that define the relationship between different underground tests, the effect of manufacturing variables on performance, and enhancement of the peer review process.

Peer review is the area upon which the JASON panel placed the most emphasis and is a subject that the National Nuclear Security Administration (NNSA) has already been addressing through revision of the inter-laboratory peer review process. One recommendation of the JASON report is the "review" of the peer review process itself by an independent external group. To defend the scope of the new AC program, the Office of Defense Science has gathered input from the laboratories, JASON, and DoD representatives regarding lessons learned in the RRW review and warhead recent life extension and modification programs.

On February 27, 2008 NNSA submitted to Congress the first year financial plan for the new AC. In this document NNSA reported that AC would have a Campaign structure consisting of five major technical efforts (MTEs): Methodology, Near-Neighbor Definition, Manufacturing and Engineering Process Solutions, Advanced Surety Certification, and Failure Modes. These MTEs are supported by work across the current Science, Engineering, Advanced Simulation and Computing (ASC) Campaigns, and Directed Stockpile Work Research and Development. The MTEs are as follows:

(1) Methodology
Develop a strategy for certification and assessment of systems and components based on Quantification of Margins and Uncertainties, involving increased peer review and rigorous coupling of science and technology advances to define long term research needs for Advanced Certification.

- In FY 2008 this effort kicked off with a workshop including external participants.
- This effort will provide an annual assessment of the state of the enabling tools.
- In the long term this effort will define and refine requirements for life-cycle certifiability.
- Develop a plan to incorporate more probabilistic analysis as the models become more fundamentally physics based and take further advantage of the computational power provided by ASC.

(2) Near-Neighbor Definition
The focus of this effort is to understand the role of archival data from underground tests in the certification process. In particular this effort seeks to define metrics for comparison of tests and ensure that the long term use of Underground Test (UGT) data is rigorously evaluated. As more physics based models are implemented, data from additional historic UGTs will be able to be drawn into the certification process as "near neighbors."

(3) Manufacturing & Engineering Process Solutions
Conduct manufacturing and engineering process assessments and develop a rigorous connection between performance effects resulting from material, component or manufacturing changes. Certification solutions for variations in pit manufacturing techniques (including reuse). Develop options for alternate materials and processes to minimize the cost or use of expensive or hazardous materials. Analyze experimental data provided by the other stockpile stewardship activities to derive performance effects and uncertainties. Assess, as appropriate, the effect of changes of limited life components to maintain or improve yield margin.

(4) Advanced Surety Certification
This MTE is dedicated to the physical understanding and developing certification methodologies for new surety techniques and mechanisms. This MTE is expected to leverage the results from the related campaigns to validate these techniques and mechanisms.

(5) Failure Modes
Develop a comprehensive catalog of failure modes, thresholds and metrics.

a. Model primary and secondary failure modes.
b. Model engineering failures.
c. Determine the effects of certification of new or modified components and subsystems under STS conditions such as extremes in temperature or radiation exposure.
d. Design experiments to test failure modes.

Finally, a key issue for JASON was the perceived lack of a sufficiently rigorous and transparent peer review process. As a result there are numerous recommendations regarding peer review which are applicable not just to RRW but to the entirety of Defense Programs (DP) and

NNSA. For example, the response to the recommendation for additional rigor in peer review will not be limited to selected elements of weapons development activities, but will benefit all of DP.

Based on comments in the complete JASON RRW Report, as well as discussions with members of JASON, NNSA confirmed that this recommendation does not suggest that JASON be either the reviewing body for the certification process, or the body which determines efficacy of any future peer review process. JASON is not a peer review organization, but rather a broad ranging technical group serving the national security and intelligence communities.

Conceptually, NNSA is considering options such as an independent panel of experts to be assembled to act as both a review group for the planning and effectiveness of the peer review process. This group could evaluate the resolution process involving technical disagreements between the design and peer review teams, and provide written opinions to the laboratory directors and NNSA when needed. The structure of this group will be addressed in a future article.

Delivering High Energy Density Physics Data on the National Ignition Facility to Validate Predictive Physics Models by Alan S. Wan and Warren Hsing, LLNL

Introduction

The Stockpile Stewardship Program (SSP) is an integrated technical program for maintaining confidence in the assessment of the safety, security, reliability, and performance of the U.S. nuclear stockpile in an era without nuclear testing. A major objective of the SSP is to develop predictive capabilities based on advanced computational tools validated by relevant experimental data to assess and certify the stockpile.

As the computational and experimental capabilities continue to advance and mature, Lawrence Livermore (LLNL) and Los Alamos (LANL) National Laboratories are gaining insights into key physics issues left unresolved at the end of underground nuclear testing. The weapons laboratories are developing physics-based models to replace empirical models used in past and current assessment codes. The acquisition of weapon-physics-relevant data in the high energy density (HED) physics regime to validate these physics-based models is essential to the development of predictive capabilities for stockpile applications. The National Ignition Facility (NIF) will deliver unique capabilities to the complex by accessing regimes of interest for thermonuclear burn and enabling quantitative experiments to validate the codes and models of the nuclear phase of weapon operations. In addition, integrated experiments on NIF, incorporating a wide range of complex physics, will serve to develop and test the skills, knowledge, and abilities of the weapons program personnel.

NIF data requirements derive from the Predictive Capability Framework (PCF), a long-term science and technology roadmap that describes a timetable and capabilities needed to meet the needs of the SSP. The improvements in predictive capability will be applied to assessment of weapons for Life Extension Programs (LEPs) and Significant Finding Investigations and to deliver modern physics-based weapon performance baselines for the stockpile.

The mission was reaffirmed by the National Nuclear Security Administration (NNSA) High Energy Density Physics study in 2001[i] and the Defense Science Board Task force review of the Employment of the National Ignition Facility in 2004:[ii] "In order to be able to accurately model and develop validated predictive capabilities of weapon performance, it is essential to have a laboratory ability to study conditions of extreme temperature and pressure approaching those found in nuclear explosions. A key feature of NIF is the ability to place macroscopic volumes of matter under the relevant HED conditions that allow sufficiently precise measurements to distinguish between models and code simulations." Once the experimental capabilities are developed and qualified on NIF, the SSP will have a unique laboratory capability for studying a broad range of relevant phenomena ranging from material behavior of solids beyond 20 million atmospheres to the physics of burning deuterium-tritium plasmas to validate the models and codes used to assess and certify the stockpile.

NIF Experiments

NIF is a 192-beam laser facility located at LLNL. When complete in 2009, it will deliver about 1.8 MJ of 354 μm laser light into a 10-meter-diameter target chamber. When the laser beams are focused into a roughly mm scale gold cylinder (hohlraum), the laser light is converted into X-rays. A target package is typically placed inside or on the wall of the hohlraum, creating high energy density conditions. An important aspect of NIF is its ability to access a wide range of HED conditions to acquire data in different physics regimes of importance to weapon performance. Experiments on NIF provide key data for the first four major milestones of the PCF: Initial Conditions for Thermonuclear Performance, Initial Conditions for Weapon Implosion, Implosion Physics, and Thermonuclear Performance. These experiments include:

- Radiation transport - NIF can create a wide range of conditions to test radiation transport models.

- Plasma Material Properties - Opacity is the attenuation of light by a material as a function of the density and temperature of the material. The equation-of-state of a material describes the fundamental thermodynamical relationship between the materials density, pressure, and temperature.
- Materials Dynamics - This area includes material strength, equation-of-state, phase transitions, and melt.
- Complex Hydrodynamics - Hydrodynamic evolution of materials driven by pressure sources.
- Burn physics - Thermonuclear reactions in DT, including nuclear physics. The conditions of ignition create very hot dense radiative plasmas with high neutron flux.

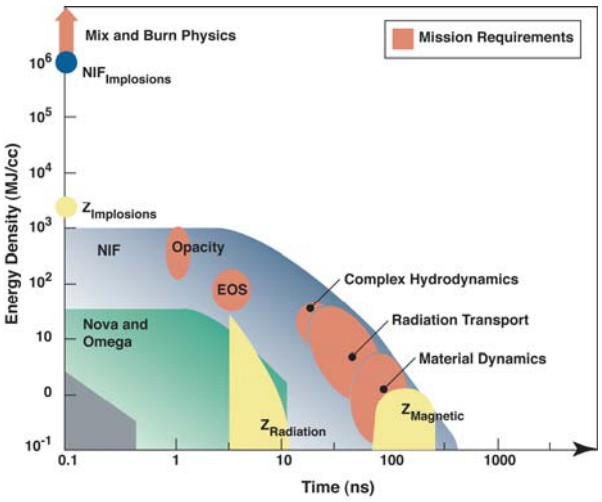

Figure 1. Regimes of energy density available on NIF

Figure 1 illustrates the regimes of energy density available on the NIF and the different physics areas they address. For each physics area, a specific experimental platform is required to be developed and commissioned. The experimental platform consists of the ensemble of capabilities required, including diagnostics, target fabrication, material properties of the targets, laser capabilities, and supporting facility capabilities. Once developed, the platform is applied to the particular physics area. Use of these platforms is wide ranging, including basic science.

Beginning next year, LLNL and LANL will start a series of experimental campaigns to acquire data on NIF to validate the models outlined in the PCF. The programmatic need for these experiments has been evaluated by a number of groups, including review committees for both LLNL and LANL, JASON, Predictive Science Panel, and at various multi-laboratory meetings such as JOWOGs and Nuclear Explosive Design Physics Conferences. Once the NIF Project comes to completion in 2009, NIF will be transitioned to a user facility where a formal peer review process will be established to review the proposed experiments.

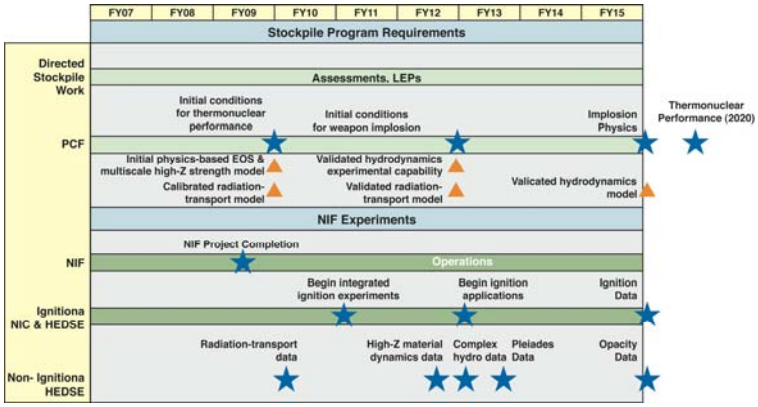

Figure 2. SSP Requirements and Campaigns of NIF Experiments

Figure 2 shows the current schedule of some high-level NNSA objectives. Additional experimental campaigns are planned longer-term to further address outstanding physics issues relevant for weapon assessment and certification.

Each experimental milestone represents the development and commissioning of an experimental platform in a specific physics area and the acquisition of first set of data from that platform.

Experimental platforms are being developed and commissioned using an Integrated Experimental Team (IET) approach. IETs are formed with memberships from across the complex with responsibility to plan, design, execute, and analyze the relevant experiments on NIF and supporting facilities. An IET has already formed with personnel from LLNL, LANL, the Atomic Weapons Establishment (AWE), National Security Technology LLC (NSTec), and General Atomics (GA) to develop and commission the first experimental platform for radiation transport.

The ability and readiness of each IET to meet the programmatic deliverables will be evaluated by a number of methods, including experimental readiness for the NIF, and technical peer reviews through external panels and inter-laboratory meetings and conferences. To coordinate the work and to provide a forum for technical exchange, periodic workshops will continue to be held. The 6th NIF/HED Workshop was held in October 17-19, 2007, with 150 registered participants from NNSA, LLNL, LANL, AWE, SNL, GA, NSTec, and LLE.

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[i] U.S. Department of Energy, High Energy Density Physics Study Report, National Nuclear Security Administration, U.S. Department of Energy, Washington, D.C., (April 6, 2001).

[ii] U.S. Department of Defense, Report of the Defense Science Board Task Force on the Employment of the National Ignition Facility, Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics U.S. Department of Defense, Washington, D.C. (October 2004).

Texas Petawatt Laser Achieves Power Milestone by Todd Ditmire

On March 31, 2008, the Texas Petawatt laser demonstrated over 1 petawatt of power. This makes this laser the first petawatt laser to be completed in the United States since the deactivation of the first Petawatt laser at Lawrence Livermore National Laboratory (LLNL) in 1999. At present, the Texas Petawatt is now the highest power operating laser in the world. The laser was constructed at the University of Texas by the Texas Center for High Intensity Laser Science, a National Nuclear Security Administration (NNSA) funded Stewardship Science Academic Alliances Center of Excellence.

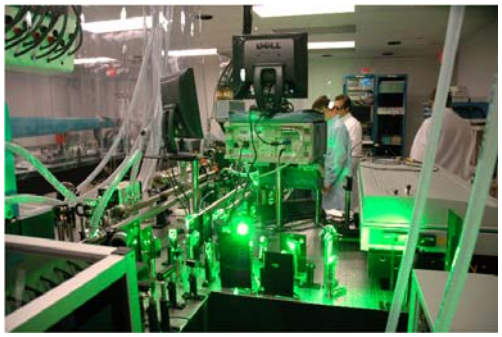
The Texas Petawatt laser achieved this power by amplifying a laser pulse to an energy of 190 J and compressing this energy to a pulse duration of under 170 fs (i.e. 0.00000000000017 seconds). At present, the Texas Petawatt is the only laser producing over a petawatt of power in the United States and only the second such laser constructed world-wide since the first petawatt laser was completed and deactivated at LLNL in the late 1990's. (The other such laser is the Vulcan laser at the Rutherford Appleton Laboratory in the United Kingdom). A petawatt is a quadrillion watts (10^{15} W) and is 2000 times the power output of the United States electrical grid.

The Texas Petawatt uses the same concept as the original Petawatt laser built on the NOVA laser at LLNL. It takes a short, low energy laser pulse, stretches it in time by a factor of about 10,000 and amplifies it. It then compresses the final amplified pulse back down to a duration near that of the initial laser pulse. This technique, known as chirped pulse amplification, is used in many of the world's highest power lasers, including the Titan laser at LLNL. In this approach, an ultrashort, low energy laser pulse is stretched in time so that its peak power is lowered and it is safe to amplify. Once amplified, the pulse is recompressed to its original duration to retrieve very high peak powers. While based on concepts similar to the initial Petawatt laser on NOVA, the Texas Petawatt uses a number of new technologies which allow it to compress its laser pulses to shorter time durations than the NOVA Petawatt, and, therefore, access petawatt powers without as high an energy as that first petawatt laser.

The Texas Petawatt was constructed in close collaboration with the NNSA laboratories, including LLNL and Sandia National Laboratories (SNL). For example, LLNL scientists from the National Ignition Facility (NIF) directorate have assisted the technical team from the University of Texas in the development of many of the key components of the laser such as the final amplifiers which are Nd:glass amplifiers from LLNL's NOVA laser, allocated to the University of Texas once NOVA was shut down. The large gratings needed to compress the Texas Petawatt pulse were also fabricated at LLNL, an optical capability unique to the Lab.

The Texas Petawatt will be used for fundamental experimental studies of high energy density plasmas. This includes making plasma states with temperatures exceeding those of fusion plasmas like those found in the sun or pressures exceeding a billion atmospheres. This will allow exploration of the properties of plasmas not usually accessible in university laboratories. The Texas Petawatt will also allow study of many astrophysical phenomena in miniature, such as the explosion of supernovae, the formation of galactic jets, or the properties of matter found in dense stars like a brown dwarf. Furthermore, the Texas Petawatt can be used to study aspects of the fast ignition approach to inertial confinement fusion. Much of this scientific program will be pursued in collaboration with staff from the NNSA labs including scientists from the LLNL NIF and Photon Science directorate, Physics and Advanced Technologies directorate, and the Chemistry and Materials Science directorate.

The primary mission of the Texas Petawatt will be to train students in the core areas of high energy density physics and ultimately prepare them for work on the large NNSA machines. As such, the Texas Petawatt serves as a smaller scale complement to the NNSA's suite of large scale HED machines such as the NIF at LLNL, Z at SNL and OMEGA at the University of Rochester's Laboratory for Laser Energetics.



The front end of the Texas Petawatt

The power amplifiers of the Texas Petawatt

Sandia Light Gas Gun Tests Demonstrate the Ability to Deliver an Engineered Shock Wave Using a Graded-Density Thermal Spray Coating

by Aaron Hall, Corbett Battaile, Ed Webb III, and Jack Wise, SNL

Light gas gun testing is used at Sandia National Laboratories to study high speed impact phenomena such as fundamental theories of fragmentation from warheads and armor, compressive properties of materials, and impact from orbital debris or meteorites. During a light gas gun test, a projectile or "flyer plate" impacts a target material at velocities as high as 13 km/sec. This impact event creates a controlled shock wave in the target material being studied. Monolithic flyer plates create shock waves that are step functions to interface velocity and pressure. Certain off-Hugoniot experiments require shock waves with ramped velocity and pressure responses. Creating these ramped shock waves requires flyer plates with varying material properties. Sandia's Thermal Spray Research Laboratory has teamed with Sandia's Computational Materials Science and Engineering group and Sandia's Dynamic Materials Properties group to demonstrate the ability to prepare graded-density flyer plates and to accurately predict the shock properties of these materials from knowledge of their microstructure.

Graded-density flyer plates are being prepared with an air plasma spray process. Air plasma spray is a thick film (> 100 μm) coating process comparable to spray painting with metals and ceramics. High temperature (> 1500°C) liquid droplets, approximately 25 μm in diameter, are sprayed onto a substrate where they solidify and form the desired coating. By injecting multiple feedstock into the air plasma spray system at different rates, well-controlled, graded-density, composite coatings can be obtained. Sandia's Thermal Spray Research Laboratory prepared flyer plates that are graded continuously from 100% copper to 100% aluminum (see Figure 1).

Cross-sectional micrographs of these flyer plates were used by Sandia's Computational Materials Science and Engineering group to create microstructurally accurate models of the graded-density materials. These models were use to predict the flyer plate response prior to conducting light gas gun testing.

Light gas gun testing of the flyer plates conducted by the Dynamic Materials Group not only demonstrated that the graded-density flyer plates produced linearly ramped shock waves but also that the predicted shock response was correct (see Figure 2). The model offers the ability to meet specific response requirements by predicting the necessary graded composition and structure.

Current work (Ref. 1) is focused on linking measurable characteristics of the air plasma spray process, such as particle temperature and velocity distributions, with the materials models that allow prediction of flyer plate properties. Atomistic models have been used to predict droplet solidification behavior during the air plasma spray process. This solidification information has been used in coating build-up models that allow prediction of coating microstructures and properties. Detailed materials models, linked with measurable process characteristics, will ultimately allow the preparation of graded-density flyer plates that deliver specific, pre-determined, shock wave profiles. All of the individual components for this vision have been demonstrated and are being integrated into a physics-based understanding of this very complex dynamic materials behavior.

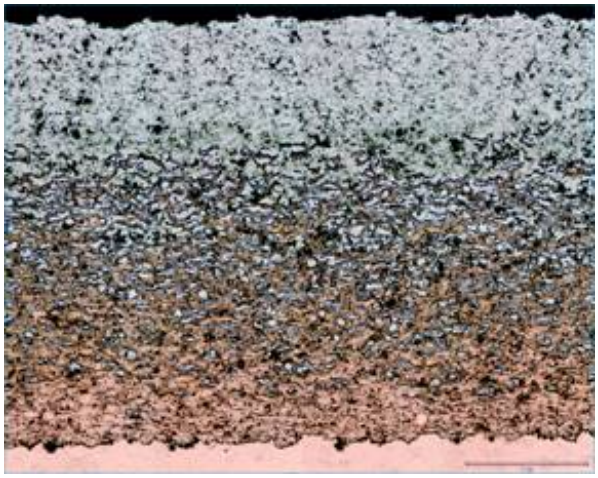


Figure 1. Cross section of copper (bottom) to aluminum (top) graded density flyer plate.

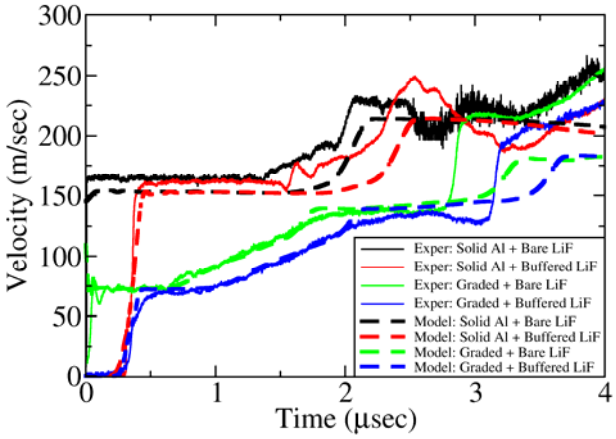


Figure 2. Light gas gun data showing linearly ramped shock waves for graded-density flyer plates (blue and green solid lines) as well as predicted shock response (blue and green dashed lines). Note: Red and black lines show a control experiment conducted with a monolithic flyer plate.

Ref. 1. A.C. Hall, et al., *Graded Coatings for Light Gas Gun Flyer Plate Applications*, Proceedings of the 2006 International Thermal Spray Conference, ASM International, Seattle, WA, May 15-18, 2006.

Annual Symposium of the Stewardship Science Academic Alliances Program

by Mike Kreisler, NNSA

The annual symposium of the Stewardship Science Academic Alliances (SSAA) program was held at the Carnegie Institution in Washington, DC, on February 26-28, 2008. This meeting brought together the faculty, post-docs and students working on all the SSAA projects as well as scientists from the National Nuclear Security Administration (NNSA) laboratories and NNSA officials. More than 240 individuals attended this lively three day meeting that featured 58 presentations and a well attended two day poster session. Senior NNSA officials attending this year included: Thomas D'Agostino, Under Secretary for Nuclear Security and NNSA Administrator; Robert Smolen, NNSA Deputy Administrator for Defense Programs; David Crandall, Chief Scientist for NNSA; Victor Reis, Senior Advisor to the Secretary; and Christopher Deeney, Director of the Office of Defense Science.

Tom D'Agostino with participants

The SSAA program was started in 2002 to:

1. Grow the U.S. scientific community, through the funding of research projects at universities, in areas of fundamental science and technology relevant to stockpile stewardship, with a focus on those areas that have not been traditionally supported by other federal agencies and for which there is a recruiting need within the NNSA laboratories complex;
2. Provide fundamental science information and develop advanced experimental measurement techniques in selected areas of physical sciences: condensed matter physics and materials science, hydrodynamics, plasma and high energy density physics, fluid dynamics, and low energy nuclear science;
3. Train scientists in specific areas of research relevant to stockpile stewardship;
4. Promote and sustain scientific interactions between the academic community and scientists at the NNSA laboratories through exchange of personnel;
5. Increase the availability of unique experimental facilities located at the NNSA laboratories to the academic community, particularly for collaborations in areas of relevance to stockpile stewardship; and
6. Develop and maintain a long-term recruiting pipeline to the NNSA laboratories by increasing the visibility of the NNSA scientific activities to the U.S. faculty and student communities.

David Hammer, Paul Drake, David Crandall

The SSAA program has been extremely successful in achieving these goals. More than 70 SSAA supported students have taken jobs at the NNSA laboratories since the start of the program, while over 1,300 peer-reviewed papers have been published from work supported by the SSAA effort since 2005. Participants in the SSAA program have received many prestigious awards and honors for their work.

Brad Wallin, Richard Meserve, Robert Smolen, Russ Hemley

The quality of all the presentations was extremely high. Excluding invited talks, several presentations in each session were selected as particularly interesting and worthy of mention. These 17 talks are (in order of their presentation):

Feb. 26 Morning session: Todd Ditmire, "The Texas Center for High Intensity Laser Science"; Dylan Spaulding, "New Frontiers in Planetary Science: Ultra-High Pressure Physics and Chemistry Using Laser-Driven Shocks"; and Nathaniel Fisch, "Fundamental Issues in the Interaction of Intense Lasers with Plasma"

Feb. 26 Afternoon session: Richard Petrasso, "Monoenergetic Proton Radiography of Electromagnetic Fields and Areal Density in Laser-Plasma-Interaction Experiments and in ICF Implosions"; Paul Drake, "Hydrodynamics and Radiation Hydrodynamics with Astrophysical Applications"; and James Stone, "Validation of Astrophysical Radiation Magnetohydrodynamic Codes"

Feb. 27 Morning session: Malcolm Andrews, "Progress with Experiments and Our Understanding of Rayleigh-Taylor Driven Mixing"; and Ian Hall, "Experimental and Modeling Studies of Photoionized Plasmas"

Feb. 27 Afternoon session: George Crabtree, "Materials under Extreme Environments"; Russ Hemley, "Material Properties at Extreme Conditions"; and Richard Scalettar, "High Pressure Studies of Correlated Electron Systems: Experiment and Theory Structure and Thermodynamic Properties"

Feb. 28 Morning session: Ian Robertson, "An Experimental-Numerical Study of the Dynamic Response of Metals and Nanostructured Metallic Multilayers"; Roger Falcone, "Dynamics of Materials Under Extreme Conditions"; and Nigel Browning, "Enhanced Functionality for Materials Analysis in the Dynamic TEM"

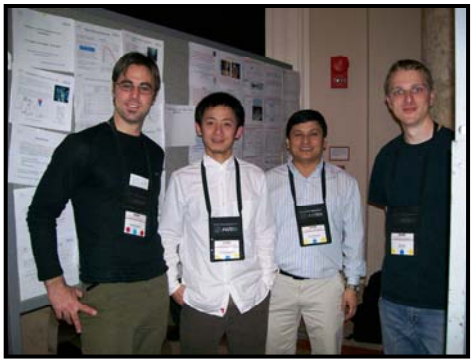
Feb. 28 Afternoon session: Jolie Cizewski, "New Results from Radioactive Ion Beam Studies for Stewardship Science"; Yaron Danon, "Measurements of Nanogram Quantities of Short-Lived Isotopes using a Lead Slowing Down Spectrometer"; and Anton Tonchev, "Neutron-Induced Reactions on Actinides using Pulsed and Monoenergetic Beams at Triangle Universities Nuclear Laboratory"

Chris Keane, Chris Deeney, Bedros Afeyan, Margaret Murane, Dave Hammer

This year's Symposium was noteworthy as it heralded the start of the Joint Program in High Energy Density Laboratory Plasmas (HEDLP). This Program is a collaboration between the Office of Fusion Energy Sciences in the DOE Office of Science and the Office of Defense Science in the NNSA. It is anticipated that there will be a joint solicitation for proposals combining HEDLP and SSAA in the near future.

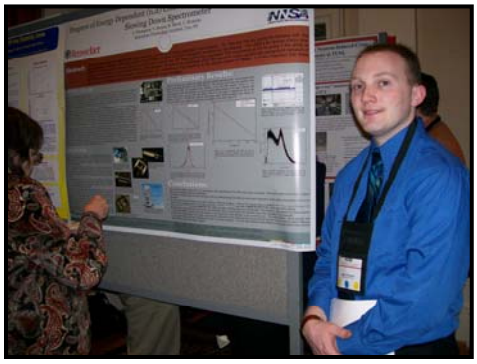
Participants at Poster Session

The Symposium was superbly organized by Brad Wallin of the Office of Defense Science. He was ably assisted by staff from ORISE - Tim Ledford, Marolyn Randolph, Linda Naney, Donna Nevels, Angela Kelly, Cynthia Bullock and several others.



Student Participants

Jolie Cizewski and Mike Kreisler



Student at Poster Session

For more information about the SSAA Program check out the Defense Science University Programs web site at http://www.nnsa.energy.gov/dsup.

Publication Highlights by Brad Wallin

In this section we highlight recent publications in high-impact scientific journals of research supported by the NNSA Science Campaigns.

"Hugoniot Data for Helium in the Ionization Regime," J. Eggert et. al., *Physical Review Letters*, 100, 124503 (2008)

The properties of dense Helium (He) at thermodynamic conditions between those of condensed matter and high-temperature plasmas are theoretically challenging, and to date the only He equation of state (EOS) data is Hugoniot data up to pressures of 56 GPa. The EOS currently used by the astrophysical community, SCVH, has been tuned to this data, and the theoretical methods used predict an increase in compressibility at the onset of ionization. To test these predictions, experiments in the 100 GPa regime are needed. In this paper, He samples statically precompressed by diamond anvil cells are then shock compressed to achieve pressures in excess of 100 GPa. Quartz was used as a reference material allowing a significant reduction in measurement uncertainties compared to previous studies. The new measurements confirm the increase in compressibility at the onset of ionization predicted by multiple theoretical techniques.

"Shock, Release and Taylor Impact of the Semicrystalline Thermoplastic Polytetrafluoroethylene," N.K. Bourne, E.N. Brown, J.C.F. Millett, and G.T. Gray III, *Journal of Applied Physics*, 103, 074902 (2008)

The high strain-rate response of polymers is a subject that has gathered interest over recent years due to their increasing engineering importance, particularly in load bearing applications subject to extremes of pressure and strain-rate. A polymer of particular interest is polytetrafluoroethylene (PTFE) due to its high temperature stability and melting point, excellent chemical resistance, and low coefficient of friction. The majority of the work to date on the pressure-temperature phase diagram of PTFE has been performed statically. Here, two specific sets of experiments interrogate the effect of dynamic, high-pressure loading in the regime of the phase II to phase III pressure-induced crystalline phase transition in PTFE: gas-gun driven plate and Taylor impact experiments. An elevated release wave speed shows evidence of a pressure-induced phase change at a stress commensurate with that observed statically. Convergence between analytic derivations of release wave speed and the data requires the phase II to phase III transition to occur. The Taylor impact experiments show a rapid transition from ductile to brittle behavior observed that occurs at a pressure consistent with this phase transition.

"Effect of Initial Properties on the Flow Strength of Aluminum During Quasi-Isentropic Compression," J. R. Asay, T. Ao, J.-P. Davis, C. Hall, T. J. Vogler, and G. T. Gray III, *Journal of Applied Physics*, 103, 083514 (2008)

Ramp loading techniques offer a method for obtaining strength information at high pressure and low temperature. The most common ramp loading techniques, such as the use of graded density impactors, do not produce a loading profile sufficiently smooth for some applications such as detecting phase transitions. This limitation has been overcome by the development of magnetic loading techniques, which can produce smooth compression to pressures of several hundred gigapascals on time-scales of a few hundred nanoseconds. In this study, several different compositions of polycrystalline aluminum and 6061 aluminum alloy were magnetically loaded to study the effect of initial material properties on compressive strength at high pressure. The results show that the change in flow strength for quasi-isentropic loading is insensitive to initial metallurgical properties such as grain size, texture, impurities, initial precipitate size and distribution. The results also show that compressive strength values obtained at comparable stress levels are similar for shock and quasi-isentropic loadings and suggest that similar deformation mechanisms are responsible for the observed strength behavior in both cases.

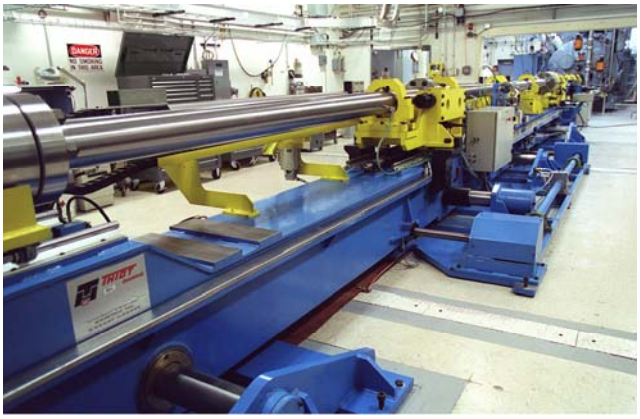
"Radiating Shock Measurements in the Z-Pinch Dynamic Hohlraum," G.A. Rochau et al., *Physical Review Letters*, 100, 125004 (2008)

The Z-pinch dynamic hohlraum (ZPDH) has demonstrated the capability to deliver > 40 kJ of absorbed x-ray energy to an inertial confinement fusion capsule. The ZPDH is formed when an annular tungsten Z-pinch plasma is accelerated onto a low-density foam converter. Radiation from the shocked converter is trapped by the tungsten thereby creating a hohlraum. Using space-resolved Si tracer spectroscopy, the time-dependent electron temperature and density of the shocked plasma have been measured for the first time. The shock density increases from 15 mg/cc to 35 mg/cc and the electron temperature decreases from 400 eV to 300 eV. The shocked plasma x-ray emission delivers > 180 kJ to the hohlraum. The current simulations of the ZPDH predict reasonable shock densities, but overpredict the shock pressure.

Highlights and Awards

Getting the Job Done from Nevada

The Joint Actinide Shock Physics Experimental Research (JASPER) project successfully conducted the first special nuclear material (SNM) experiment since February 21, 2007. Within one year of the NNSA Nevada Site Office (NSO) direction to stand-down SNM operations, pending implementation of the Justification of Continued Operations as a Hazard Category 3 Nuclear Facility, the project team was able to bring JASPER back online, execute this experiment using SNM, and retrieve 100% of the data. Lawrence Livermore National Laboratory's Bruce Goodwin (Principal Associate Director, Weapons and Complex Integration) was ecstatic for the extraordinary efforts of the JASPER project team.



The Joint Actinide Shock Physics Experimental Research (JASPER) Project

Awards

Jay Norman retired from NNSA after 50 years of service to the Nation. He was honored by Secretary Bodman and received the Secretary's Exceptional Service Award. Best wishes for your future in Oklahoma and thank you, Jay, for your inspiration to so may in the Stockpile Stewardship Program.

Comments

Questions or comments regarding the *Defense Science Quarterly* should be directed to Terri Batuyong (Terri.Batuyong@nnsa.doe.gov).