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Message from the Assistant Deputy Administrator for Research, Development, Test, and Evaluation, Dr. Kathleen Alexander

This holiday issue of the *Stockpile Stewardship Quarterly* describes the launching of a new experimental capability and captures some of the latest technology developments and experiments supporting stockpile stewardship today. A key element of the Office of Research, Development, Test, and Evaluation is to investigate the fundamental properties of materials. The Dynamic Materials Properties subprogram provides data and essential materials knowledge to address issues for the Annual Assessment of the stockpile, to evaluate and model the effects of the aging of materials, and to evaluate the effects of material replacement and pit reuse for Life Extension Program options. Dynamic materials experiments are conducted at a number of NNSA facilities. The picture to the right was taken at the dedication ceremony at the Dynamic Compression Sector. In this issue, we also discuss a modern pulsed power accelerator recently commissioned at Sandia National Laboratories—Thor.

Dynamic Compression Sector (DCS) Dedication Ceremony. Dr. Alexander participated in the DCS dedication ceremony held on August 4, 2016. Located at Argonne National Laboratory's Advanced Photon Source near Chicago, Illinois, DCS will help researchers understand material behavior at extreme conditions and short time scales in support of NNSA's national security mission and Stockpile Stewardship Program. The names of those pictured and more photos are provided on page 9.

Ignition remains a major goal for NNSA and DOE. The Ignition subprogram supports research activities to optimize prospects for achieving ignition at the National Ignition Facility (NIF), as well as development of and applications for robust ignition, advanced ignition, and burning plasma platforms. The article entitled "Low Gas-Fill Density Ignition Hohlraums on the National Ignition Facility" provides a history lesson on high and low gas-fill hohlraums and concludes with a discussion of future directions to design better hohlraums to contribute to our pursuit of ignition on NIF.

The "Source and Detector Development for Neutron-Diagnosed Subcritical Experiments" article highlights recent contributions from Laboratory Directed Research and Development and Site Directed Research and Development to develop novel capabilities that could have a large impact on stewardship.

The successes highlighted in this *Stockpile Stewardship Quarterly* would not be possible without our dedicated and skilled workforce. Key to our future workforce are our pipeline of students and postdoctoral scholars. We are proud that Dr. Mike Rosenberg received the 2016 Rosenbluth Doctoral Thesis Award in Plasma Physics. Also, don't forget to save the date for the Stewardship Science Academic Programs Annual Review Symposium that will be held April 12-13, 2017 in Naperville, Illinois.

I wish you all a safe and happy holiday season.

Inside

Comments
The *Stockpile Stewardship Quarterly* is produced by the U.S. Department of Energy/National Nuclear Security Administration (DOE/NNSA) Office of Research, Development, Test, and Evaluation. Questions and comments regarding this publication should be directed to Terri Stone at terri.stone@nnsa.doe.gov.
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Thor: A Modern Pulsed Power Accelerator for Material Science Application *by David Reisman (Sandia National Laboratories)*

One of the activities of scientific-based stockpile stewardship is to investigate the fundamental properties of materials. Specifically, this involves the development of models that describe how materials behave under extreme dynamic pressures. Of great interest is isentropic compression, which involves dynamically compressing materials to access low-temperature, high-pressure states of matter. By comparing data in this regime to material models, accurate equations of state can be developed.

The magnetically driven quasi-isentropic compression technique (ICE) was originally developed on the Z accelerator at Sandia National Laboratories. It has been used for over a decade for a variety of material studies. Currently Z can drive samples quasi-isentropically to pressures as high as 5 megabars.

ICE works by concentrating the large currents from a pulsed power generator, such as the Z machine, into a load. The high current densities in the load, which consists of electrodes, produce an associated magnetic field. This magnetic field in turn produces a magnetic pressure that compresses samples placed in the load. A smooth ramp pressure profile is a consequence of the current also having a continuous ramp shape in time. In fact, Z has the capability to "tailor" or shape in time, the current waveform through the individual triggering of 36 pulse-forming modules. For example, recent experiments on copper used a shaped 1.2 microsecond, 20 mega-ampere current pulse. This tailoring is required to produce pressure pulses that maintain quasi-isentropic, or shockless loading of samples.

In the ICE technique, sample response is measured with velocimetry techniques such as the velocity interferometer system for any reflector (VISAR) or photon Doppler velocimetry (PDV). Waveform analysis is then used to reconstruct the isentropic pressure-density, or stress-strain relation for the material. By comparing these relations to theory, accurate equations of state can be developed.

The success of Z and the ICE technique has motivated experimentalists to develop smaller machines that have greater shot throughput and are economical to operate. This is important as shots on Z are limited in number. Usually an experimentalist is only allotted a few shots a year.

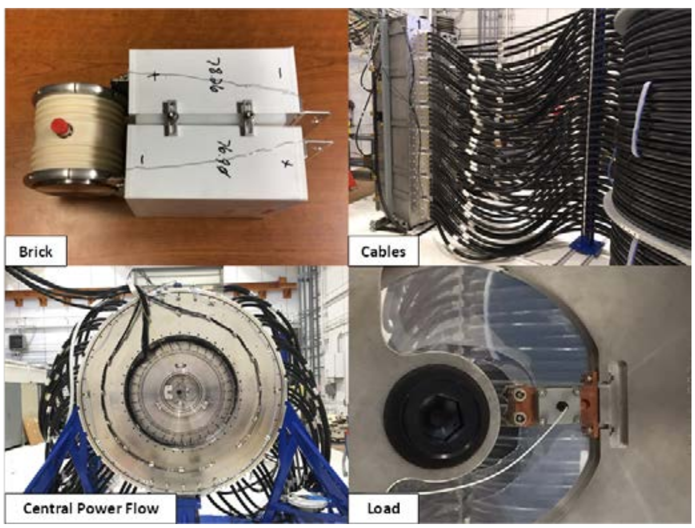

Figure 1. The elements of the Thor pulsed power generator, including bricks, coaxial cable connections that transport the current, central power flow which combines the current, and the load where dynamic compression experiments are performed.

To realize the benefits of an inexpensive ICE driver with a high-shot-rate capability, we have developed the Thor accelerator. Thor uses a novel "current adder" architecture, which involves combining currents to create the tailored current pulse. Thor consists of the following elements:

1. Up to 288 "bricks" which can be individually triggered. A brick is made of two capacitors connected in series to an electrically triggered switch.
2. Two hundred eighty-eight coaxial cables which are connected to the bricks. The bricks are decoupled from each other by the cable length, or electrical transit time. Also the cables are impedance matched to the bricks to efficiently deliver current.
3. A central power flow section which combines the current from the coaxial cables. This consists of a water-insulated line which transitions to a single plastic-insulated line.
4. A stripline load where current is concentrated from the plastic-insulated line. Here samples are placed and measurements are taken.

These elements of the Thor machine are shown in Figure 1.

Thor can deliver a precisely shaped current pulse with a peak value as high as 7 mega-amperes to a strip-line load. The peak magnetic pressure achieved within a 1-cm wide load is as high as 1 megabar. Although this is less than Z's 5-megabar capability, Thor does this with only 1/100th of Z's stored energy and with a small footprint that fits into a laboratory space. This is because the current-adder architecture uses electrical impedance matching of elements. This minimizes electrical reflections and increases the efficiency of power delivery to the load.

We have also developed an optimization process for producing tailored current pulses. This technique, which is unique to the current-adder architecture used by Thor, entirely avoids the iterative use of complex circuit models to converge to the desired electrical pulse. Essentially this involves using the brick currents as basis functions to build the desired current and magnetic drive pressure. This allows us to accurately determine the brick-triggering sequence necessary to generate a highly tailored current pulse time history for shockless loading of samples.

We have used this procedure for the Thor generator and developed designs for various materials of interest. This algebraic method produces trigger times corresponding to a precisely shaped pulse in approximately 30 seconds. This is an advance over present cut-and-try methods used on the Z accelerator that may take several days of performing circuit calculations and require actual experiments to get adequate results.

We have developed load designs that demonstrate the various aspects of the current-adder architecture as combined with the optimization technique. These include many materials of interest such as copper, aluminum, cerium, and tantalum. In Figure 2, we show the results of the optimizing procedure on a 1 megabar tantalum experiment. This specific design is intended to study the material strength of tantalum by loading the material, holding it at a near constant pressure, and releasing it.

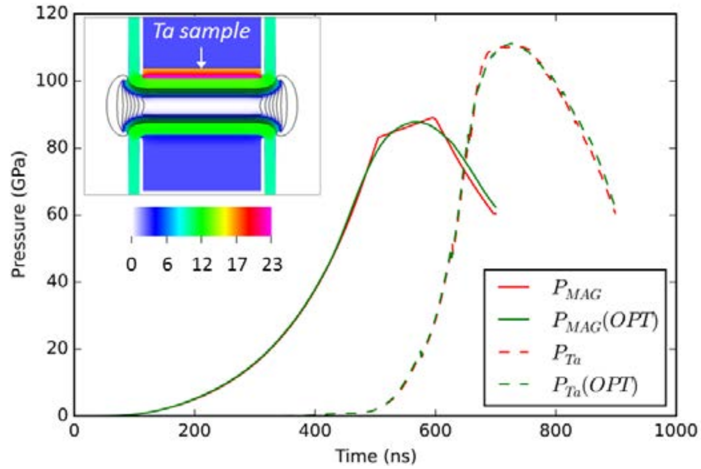

Figure 2. Design of a tantalum 1 Mbar (100 GPa) experiment using the current-adder optimization technique. Shown are the optimized drive pressures and material pressures in the sample (green) compared to their corresponding “desired” values (red). The inset shows density contours in the load at peak compression time.

The concepts behind Thor can also be extended to larger machines. Recently, we have developed conceptual designs for the megajoule-class Neptune machine. This machine consists of 600 8-stage brick units and is capable of delivering 31 mega-amperes to a physics load. Current is transported on water-insulated cables to a central power flow region, similar to Thor. We have developed various load designs for Neptune, including many capable of reproducing Z’s 5-megabar performance, with less than a quarter of Z's stored electrical energy. Furthermore, given this design, we were able to design shockless ramp-driven experiments of metals in the 10-megabar range of pressure.

Thor has recently been commissioned at Sandia National Laboratories. The current configuration, Thor-24, consists of 24 bricks. “First-light” experiments have been conducted at the 1-mega-ampere level. Each of the shots involved the complete experimental configuration of the facility. They also included a representative ICE stripline load, and all associated infrastructure necessary to support Thor shots. All data returned were consistent with circuit modeling, thus validating all major elements of the Thor design.

In the coming year, Thor-24 will perform experiments at 2 mega-amperes on copper strip-lines to fully validate the machine as an ICE driver. Also, Thor will be extended to Thor-48, a doubling of the energy delivery to the load. Experiments will be conducted at the 0.5-megabar level on materials of interest. Further expansion of the Thor generator is planned for the coming years, with the ultimate goal of 288 bricks driving samples at megabar pressures.

Historically, dynamic compression experiments like ICE have relied upon velocimetry diagnostics to provide insight into the behavior of materials under extreme conditions. However, one of the most fundamental properties of a solid is its crystallographic structure. X-ray diffraction data from dynamically compressed samples provide direct measurements of in-situ properties of materials. Therefore, combining magnetically-driven isentropic compression experiments with an x-ray diffraction capability would be a powerful capability for the dynamic materials community. This would enable the high-pressure phase diagram of materials, for instance, to be systematically mapped.

In the coming year, we will field an x-ray diffraction capability on the Thor machine. Using a compact x-ray source, we will study the phase transitions of zirconium under dynamic compression. This will be the first ever use of an in-situ x-ray diffraction diagnostic on a pulsed power generator. Later, this technique will be extended to study other materials with complex phase diagrams such as lithium and cerium.

The development of the "current-adder" pulsed power accelerator is a major advancement in the field of dynamical material studies. It will usher in an era of compact, economical machines with capabilities specifically tailored to performing dynamic materials experiments. This will also allow the development of powerful next-generation pulsed power accelerators that will play a key role in several DOE/NNSA missions. Ultimately, these accelerators will help the community perform experiments on materials of interest to stockpile stewardship.

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Low Gas-Fill Density Ignition Hohlraums on the National Ignition Facility *by Debra A. Callahan and the ICF Team (Lawrence Livermore National Laboratory)*

Introduction

In indirect drive ignition, the deuterium-tritium filled capsule (~ 1 mm radius) is placed inside a small (~ 1 cm long) gold cylinder called the hohlraum. The 192 laser beams on the National Ignition Facility (NIF) are focused through small holes in the ends of the hohlraum, "laser entrance holes" or (LEHs), and strike the inside of the hohlraum wall. The hohlraum wall surface is rapidly heated and becomes a plasma. The laser light is converted to x-rays that heat the outer surface of the capsule causing it to implode.

The main function of the hohlraum is to provide the time dependent x-ray drive required to compress and accelerate the capsule up to implosion velocities of 350-400 km/s. In addition, the hohlraum needs to drive the capsule in a symmetric fashion. Because the capsule compresses by a factor of 25-40x, any small imperfection in the drive symmetry is amplified and reduces the efficiency of the implosion in converting kinetic energy into internal energy. [1,2]

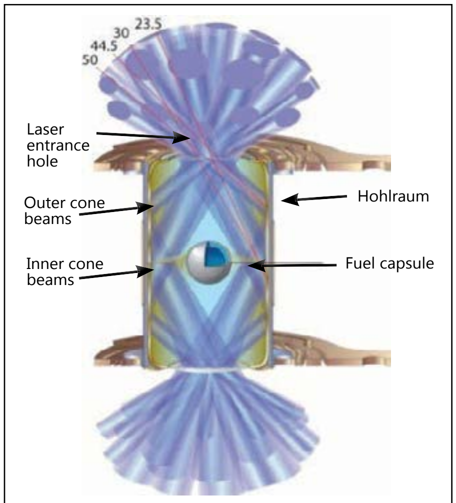

Figure 1. Schematic of a NIF ignition hohlraum. The fuel capsule is placed inside a gold (or other high Z) cylinder called the hohlraum. Laser beams enter the target at the ends of the cylinder through small "laser entrance holes" and strike the inside of the hohlraum to generate x-rays. The laser beams are arranged in two cones—an inner cone that is pointed toward the waist of the hohlraum and an outer cone that is pointed near the ends of the hohlraum. The two cones are independently controlled to help achieve a symmetric implosion.

The Era of High Gas-Fill Hohlraums

During the National Ignition Campaign[3] and the High Foot campaign[4-6] our focus was on ignition designs with a plastic (CH) ablator and a hohlraum with a relatively high hohlraum fill gas density (~ 1-1.6 mg/cc helium [He] fill). The purpose of the hohlraum fill gas is to "tamp" the inward motion of the laser-heated hohlraum wall during the 15-20-ns-long implosion time. The low atomic number gas (He, in this case) generates pressure to slow the expansion of the hohlraum wall, but is transparent to x-rays. Hohlraum wall material, which gets into the laser beam path, can stop the laser beam close to the laser entrance hole and spoil the hohlraum drive and symmetry.

NIF experiments showed that this hohlraum design was inefficient because the high hohlraum fill density resulted in strong laser plasma interactions (LPI). In particular, stimulated Raman scattering (SRS) caused a significant amount of laser energy to be backscattered out of the target. Measurements showed that about 15% of the laser energy was lost in this way—with most of it coming from the inner cone beams. These inner cone beams are pointed toward the hohlraum waist (see Figure 1) and are important for maintaining the required symmetric drive. To maintain symmetry with large inner beam backscatter we used another laser-plasma interaction process, cross beam energy transfer, to create a plasma grating inside the hohlraum and move laser energy from the outer cone beams to the inner cone beams inside the target.[7] Crossbeam energy transfer is done on NIF by setting the wavelength of the inner laser beams to be slightly different than the outer laser beams; this provided us with additional control over drive asymmetry even with backscatter. However, controlling and predicting the symmetry as a function of time during the entire pulse was challenging.

In addition to the measured laser plasma interactions, we found that the measured hohlraum drive was low compared to our radiation hydrodynamics calculations by an additional 15-25%.[8,9] This meant that the hohlraum was less efficient than predicted—we needed more laser energy to achieve a given drive and implosion velocity than we had assumed prior to the experiments. We were able to achieve the high velocity (~ 350 km/s) required for ignition but needed 1.8 MJ of laser energy to do so.[1,10-12] These experiments were a significant step toward ignition because they were the first to achieve fuel gain greater than one and a doubling in neutron yield due to heating from alpha particle deposition.[13,14] However, we have been unable to push to higher performance. Based on data and calculations, we believe our performance limit is being set primarily by hohlraum drive asymmetries.[1,2,15]

The Era of Low Gas-fill Hohlraums

We have begun to explore lower hohlraum gas-fills (≤ 0.6 mg/cc He fill) on NIF. The lower gas-fill designs have lower hohlraum plasma density and significantly reduced laser-plasma interactions. We find that for the same size hohlraum, the low fill hohlraums are ~20-25% more efficient at converting laser energy to x-rays than the high fill hohlraums.[16] In addition, we find that our calculations are much closer to the measured x-ray drives in these designs.[17,18]

The trade-off with the lower fill hohlraums is that the hohlraum wall expansion is only weakly tamped and moves significantly inward during the time of the laser pulse. We believe this leads to time-dependent changes in drive symmetry as the laser beam increasingly deposits more and more energy into the expanding hohlraum wall plasma.

One way to avoid these dynamic symmetry changes is to shorten the duration of the laser pulse. If we can arrange to have the laser pulse end before the hohlraum wall moves too much, we can achieve improved drive symmetry and symmetry control. The required length of the laser pulse is mainly determined by the time it takes for the first shock wave to traverse the

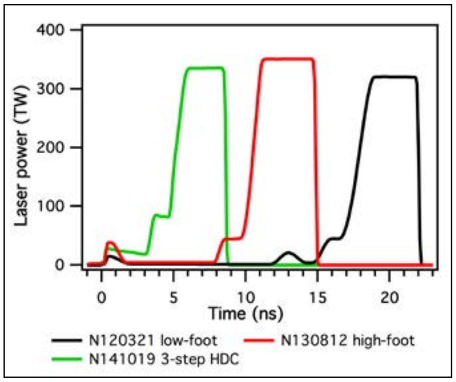

Figure 2. Low gasfill hohlraums are best suited to shorter laser pulses. For a plastic (CH) ablator, we have used pulses of 15-20 ns, shown in red and black. High density carbon (HDC), with its three times higher ablator density, is well suited to shorter pulses of ~ 7-8 ns as is shown in green.

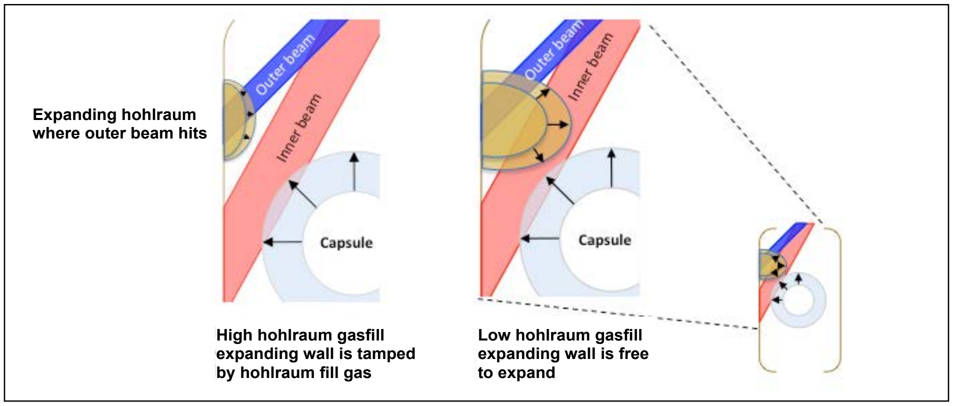

Figure 3. In the high gasfill hohlraum, the expanding hohlraum wall plasma is tamped by the hohlraum fill gas. In the low gasfill hohlraum, the wall is free to expand and can block the inner beam and prevent it from getting to the hohlraum waist. Because the low gasfill hohlraums are more efficient, the hohlraum can be made larger to combat that effect.

thickness of the capsule—this time is set by the strength of the first shock and the thickness of the capsule ablator. Moving to a higher density ablator, like high-density-carbon (HDC, or diamond), results in a thinner shell for the same mass. HDC has a density that is 3x higher than CH which results in a reduction in the pulse duration from ~15-20 ns to ~ 7-8 ns or less (see Figure 2).

A second method for improving control of asymmetry in low fill hohlraums is to increase the radius of the hohlraum. This allows the wall to expand more before it impedes the laser beam as is illustrated in Figure 3. The larger hohlraum requires more laser energy to achieve the same drive. As we said earlier, these low fill hohlraums are 20-25% more efficient than the high gasfill hohlraums so we can re-invest these savings to drive a larger hohlraum.

Conclusions and Future Directions

Experiments using lower fill hohlraums are showing improved symmetry and symmetry control for both HDC[16-20] and CH ablators.[21,22]

For the shorter pulse needed for HDC, the experiments have shown time dependent symmetry control. Future experiments will push this design by exploring how the hohlraum and capsule respond as the amount of laser energy is increased. We will also explore how the design performs as we make the capsule and hohlraum larger. Understanding how the design scales is a key part of understanding what it may take to get ignition on NIF.

In addition to these integrated performance experiments, we will be making detailed measurements of the hohlraum conditions (plasma temperature)[23] and measurements of how the inner beam propagates in these hohlraums. These detailed physics experiments will help us improve our modeling of the hohlraum—an improved hohlraum model will allow us to design better hohlraums in the future.

We will also be exploring advanced hohlraum concepts and geometries that may allow us to better control the hohlraum wall motion. One technique being pursued is to replace the solid material hohlraum wall with a low-density foam. The foam is expected to reduce the amount of wall motion because the wall starts out at lower density and pressure than a solid wall hohlraum. Experiments will test this hypothesis and quantify how the foam wall impacts the drive on the capsule. This is a challenge for target fabrication and requires close collaboration between target physics and target fabrication. If successful, it will open up new parts of parameter space for hohlraum design by allowing longer laser pulses and/or larger capsules in the same hohlraum.

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2016 Rosenbluth Doctoral Thesis Award in Plasma Physics

Dr. Mike Rosenberg, graduate of the Massachusetts Institute of Technology National Ignition Facility PhD Thesis Program (2014), received the 2016 Marshall N. Rosenbluth Outstanding Doctoral Thesis Award during the 2016 American Physical Society (APS) Division of Plasma Physics (DPP) Annual Meeting Banquet on November 2, 2016. His thesis, supervised by MIT High Energy Density Division Head Dr. Richard Petrasso, of the Plasma Science and Fusion Center, was entitled "Studies of Ion Kinetic Effects in Shock-Driven Inertial Confinement Fusion Implosions at OMEGA and the NIF and Magnetic Reconnections Using Laser-Produced Plasmas at OMEGA." This makes him the second ever PhD student, supported by DOE/NNSA, to receive the prestigious award. He received the prestigious award: "For first experimental demonstration of the importance of kinetic and multi-ion effects on fusion rates in a wide class of inertial confinement fusion implosions, and for use of proton diagnostics to unveil new features of magnetic reconnection in laser-generated plasmas."

Njema Frazier, Director (Acting) of NNSA's Office of Inertial Confinement Fusion, was on hand to congratulate Rosenberg on the Rosenbluth award.

Left to right: Mike Rosenberg's thesis advisor, Richard Petrasso, Rosenberg, and 2014 Rosenbluth awardee Mario Manuel.

APS DPP Chair David Meyerhofer congratulates Mike Rosenberg at Mike's reception.

Source and Detector Development for Neutron-Diagnosed Subcritical Experiments *by J. Tinsley (National Security Technologies, LLC [NSTec]) V.W. Yuan and A. DeYoung (Los Alamos National Laboratory), and L. Veeser (NSTec)*

A central mission of the Stockpile Stewardship Program is to predict, detect, and evaluate potential problems of the Nation's aging and changing stockpile. Laboratory Directed Research and Development (LDRD) at Los Alamos National Laboratory (LANL) and Site Directed Research and Development (SDRD) at National Security Technologies, LLC (NSTec) contribute to this mission by developing new capabilities that might offer higher performance, lower cost, and improved safety and security options to the Nuclear Weapons Complex. An issue of late concerns whether defects in aging plutonium indirectly and adversely affect neutron reactivity in a fissioning system. The Neutron-Diagnosed Subcritical Experiment (NDSE) proposes to quantify the neutron multiplication in a subcritical assembly by measuring the signal decay following an initial flash of neutrons from a fast, high-intensity source. This multiplication is the fundamental mechanism generating energy in nuclear weapons.

NSTec has built a Dense Plasma Focus (DPF) machine that produces neutrons by means of electromagnetic acceleration that heats and compresses a volume of deuterium and/or tritium gas in a z-pinch to a pressure and density sufficient to induce fusion. The version adopted for the NDSE experiments, which was developed by NSTec several years ago and supported in part by the SDRD program (see the *Stockpile Stewardship Quarterly,* Vol. 4, No. 3, September 2014) produces 14-MeV neutrons from a mixture of deuterium and tritium. Using LDRD funding, LANL is researching novel detectors for the characterization of the neutron source and demonstrating this technology with proof-of-concept NDSE experiments at the Nevada National Security Site (NNSS). The flux of detected particles mandates the replacement of traditional particle-counting techniques with current-mode detection, a concept used previously in nuclear testing. To meet that challenge, we are studying new materials, both scintillators and Čerenkov media, to achieve a signal with large dynamic range, few-nanosecond-scale prompt time response, and reduced delayed-light afterglow which contributes background to the decaying fission signal.

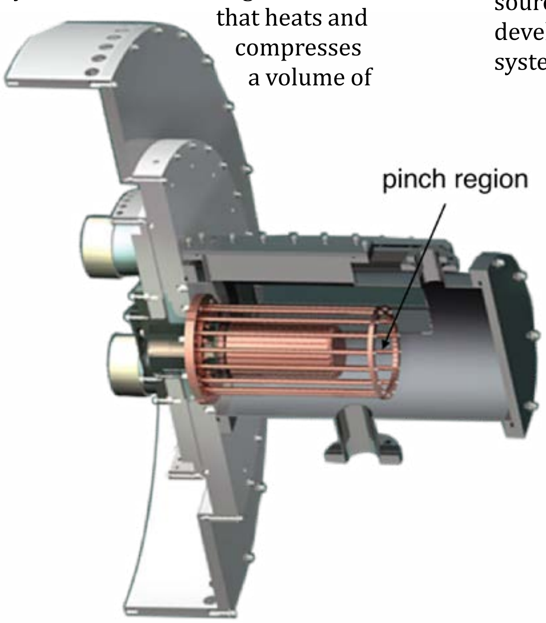
Pulsed Neutron Source

The DPF was identified as the leading candidate for the neutron irradiation source for NDSE; however, further development was necessary to ready this system for underground experiments.

The NDSE program will require a neutron source whose time signature is as short as is practical to accurately measure the time profile of reaction products. Some of the research goals are to maximize the neutron yield (5×10^{12} at present); minimize pulse width; eliminate or minimize additional pinches that may form during a given discharge; and ensure maximum repeatability. A great deal of effort has gone into the elimination of multiple pinches, which generate neutrons outside the main pulse. These form in the space between the tip of the inner electrode and the end of the chamber (see Figure 1). By using a reentrant tube to limit the volume in which pinches can form, we have eliminated all but one secondary pinch, whose magnitude can be minimized by adjusting the distance between the inner electrode and the wall of the reentrant tube.

Gamma Detectors

In NDSEs, the reactivity of a package containing fissile material can be determined from the decay rate of fission gamma particles emitted from the package after the initial neutron flash. The escaping gamma flux is a measure of the temporal neutron population, whose decay is a function of the system's reactivity. To allow an



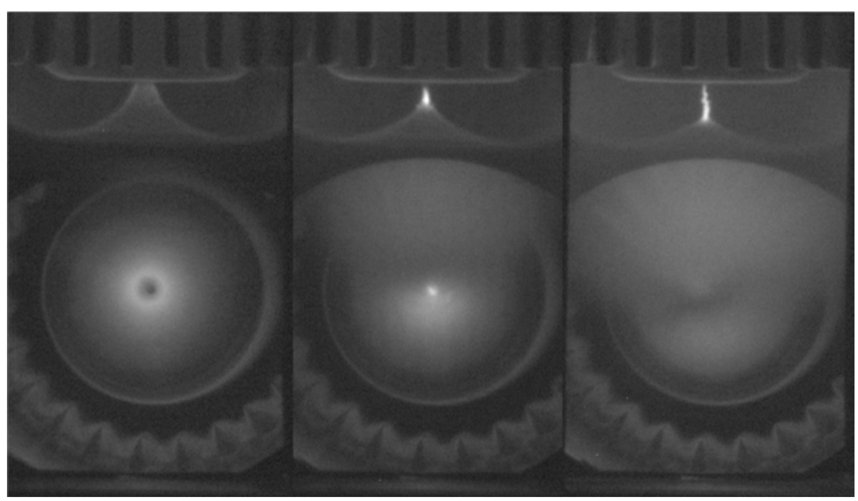


Figure 1. Detail of the DPF head showing the pinch region inside the gas-filled chamber. A typical pinch formation sequence is shown in the photo to the right. The top shows the radial view with the pinch forming and the bottom shows the on axis inward compression. (Exposures are approximately 5 ns duration with 25 ns between frames. The pinch shown in third frame is roughly 20 mm in length.)

accurate measurement of the gamma flux, the source must not produce late-time neutrons and the detectors must be almost completely free from afterglow. To provide adequate time-of-flight separation between this gamma signal and the neutrons that follow, the flight path must be > ~15 m. Since the number of gammas emerging from the system after the neutron flash is relatively small, as is the solid angle coverage at 15 m, our detector system must be intrinsically efficient in detecting gamma radiation and reasonably large in size. This necessarily implies a direct trade-off between neutron source strength and detector array size.

Our current baseline detector uses a liquid scintillator medium that meets requirements for NDSEs. Based on the "Liquid A" scintillator (previously developed by EG&G/Santa Barbara Operations and LANL in the 1980s, which had the smallest afterglow tail of any scintillator), a new formulation was created with a higher flashpoint required for underground safety at the NNSS U1a Complex. The decay time for this liquid scintillator, known as Liquid VI, is 1.2 ns, well-matched to NDSE requirements, and the afterglow is very similar to that of Liquid A. Although Liquid VI is slightly brighter than Liquid A, this increase in light does not contribute significantly to the statistical uncertainty of the signal. It is important to note that the afterglow, if accurately characterized, can be deconvolved to reveal the underlying gamma signal. A set of proof-of-concept experiments using boron and uranium targets are presently underway and yielding results proving the viability for future NDSE applications.

Figure 2 shows a prototype NDSE detector using a 38 cm × 38 cm area scintillator and a photomultiplier tube (PMT). We estimate that NDSE will require 50 to 100 such detectors, which seems large, but not impossible to engineer if the cost of the material can be kept modest.

A second option we have investigated would use the Čerenkov medium as the radiation-to-light converter in our detector array rather than a conventional scintillator; this option would provide sub-nanosecond decay time and the absence of the afterglow characteristic of scintillators. While Čerenkov media are relatively insensitive to nonrelativistic neutrons, and so may provide better discrimination against certain backgrounds in NDSEs, we have found that they have some sensitivity to 14 MeV neutrons. Furthermore Čerenkov media produce significantly less light per incident gamma. Consequently, Čerenkov detectors would require a substantially greater number of PMTs (~600 for a 3 × 3 m detector), making them cost prohibitive for LDRD experiments.

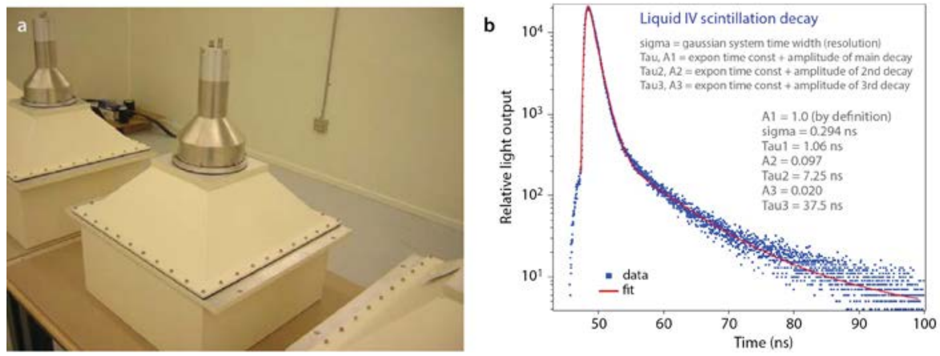


Figure 2. A novel super-fast liquid scintillator was developed by Eljen and NSTec for the gamma detector. (a) The detector housing and PMT as built by Eljen, and (b) the measured time response of the scintillator.

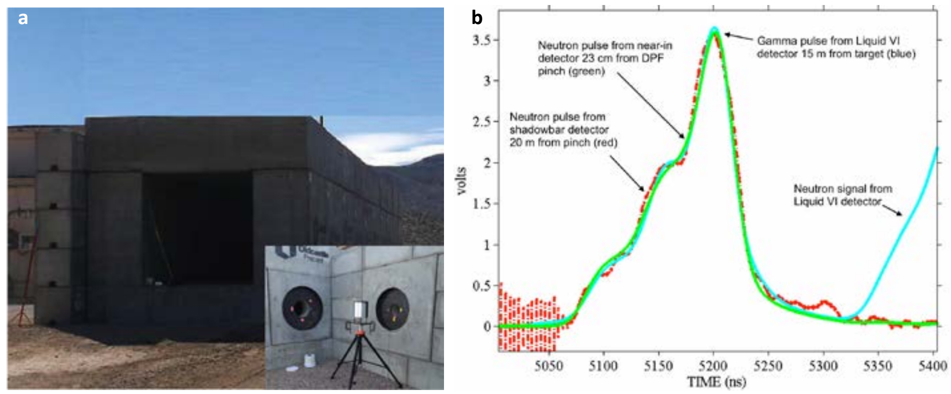


Figure 3. An NDSE proof-of-concept experiment was performed at the NNSS using novel detector technology developed by the LANL LDRD program. (a) Line-of-sight (LOS) shielding for the gamma detector with inset of a target at the intersection of the gamma detector LOS and the DPF with collimators composed of layers of steel and polyethylene in a double cone configuration; (b) agreement between three sets of unfolded DPF data taken by the near-in, shadowbar, and Liquid VI gamma detectors.

We are also looking at a BaF_2 crystal as our secondary detector design. Although it would be as costly as the Čerenkov (would also require > 600 photodetectors), its response is higher than the Čerenkov model. We are presently testing a sample detector.

Neutron Detectors

When performing the NDSE proof-of-concept experiments, it is necessary to measure the neutron source term to properly account for it in the analysis. The difficulty of measuring neutrons is exacerbated by the fact that they readily scatter from any available surface and they frequently create high-energy gammas in the process.

One technique that is compatible with the required high bandwidth is shadowbar background subtraction, whereby two identical detectors comprising a fast plastic scintillator + PMT are fielded, with and without a shadowbar. By subtracting the shadowbar detector signal from the foreground detector signal we derive a high-fidelity measurement of the DPF neutron pulse. Another diagnostic is a 'near-in' detector to measure the DPF pulse shape. The EJ-232 scintillator from Eljen, placed ~23 cm from the pinch, allows real-time pulse-shape measurement without time-of-flight spreading issues. A second, near-identical near-in detector was fielded with filters to detect the ultraviolet component of a BaF_2 scintillator. This detector corroborated the results from the EJ-232.

Prior to performing the first proof-of-principle static experiment with a boron target, we studied the DPF output using a graphite target near the source. A detector at 15 m observed the 4.4 MeV gamma signal resulting from 14 MeV neutron inelastic scattering from the graphite. This provides a useful 'background scatter' determination in that any deviation between this signal and the other measured DPF neutron pulse signals indicates that there is unwanted scatter in the line-of-site (LOS) tunnel between the source and assembly (see Figure 3). These measurements are in excellent agreement, showing that the detectors are making consistently good measurements of the neutron pulse and that the shielding and collimators are blocking unwanted background at the 0.5% level.

Summary

The present DT DPF appears capable of future application on static NDSE measurements. Using detectors that have been developed for this program, we find that the backgrounds in the LOS tunnel are < 0.5%, a critical aspect for obtaining high-accuracy gamma decay measurements. The primary gamma detector system has demonstrated more than sufficient sensitivity for these measurements. Recent substantive results from the proof-of-concept experiments using boron targets show that we can recover the negative alpha to well beyond the required accuracy.

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Highlights

NIF Holhraum Represents Livermorium in Life-Size Periodic Table

The Katholieke Universiteit Leuven (KU Leuven) has created a life sized representation of the Periodic Table of the Elements (www.mtm.kuleuven.be/mendeleev). Each cubicle in this display contains a sample of the element or some artifacts that represent the element or the Laboratories that made the discovery. KU Leuven requested some artifacts that represented Lawrence Livermore National Laboratory in recognition of the element Livermorium. LLNL is donating an excess laser Hohlraum to be displayed in the Livermorium cubical as one of the most recognizable artifacts from Lawrence Livermore National Laboratory.

Dynamic Compression Sector Dedication Ceremony, August 4, 2016

Congressman Bill Foster (center) examining an impactor, held by Paulo Rigg (WSU) used on the two-stage launcher in the DCS Impact Facilities. They are flanked by Yogendra Gupta (WSU) and Peter Littlewood (ANL).

Kevin D'Amico, ANL, (Far Right) describing the Forward Optics Enclosure (Station A) for the DCS.

Group involved in the VIP Tour with Congressman Bill Foster (tan suit).

Kathleen Alexander making remarks during the ceremony luncheon.

On the Cover: Front row: Yogi Gupta (WSU), Chris Keane (WSU), Kathleen Alexander (NNSA), Peter Littlewood (ANL), Stephen Streiffer (ANL), Thomas Russell, (Army). Back Row: Daryll DeWald (WSU), Doug Ray (PNNL) , Ralph Schneider (NNSA), Glenn Fox (LLNL), Keith LeChien (NNSA), Phillip Perconti (Army), Alan Bishop (LANL), and Matthew Tirrell (ANL).