

Stewardship Science Today

Office of Research, Development,
Test, and Evaluation (RDT&E)

VOLUME 2 | NUMBER 2 | JUNE 2020

Stewardship Science Today (SST) highlights the stewardship science and academic programs supported by the Department of Energy/National Nuclear Security Administration (DOE/NNSA). SST is published quarterly by the NNSA Office of Research, Development, Test, and Evaluation. Questions and comments regarding this publication should be directed to Terri Stone via email at terri.stone@nnsa.doe.gov.

TECHNICAL MANAGER

Dr. David Dombrowski**

MANAGING EDITOR

Terri Stone

PUBLICATION EDITOR & DESIGN

Millicent Mischo*



CALENDAR

7/12-16/2020 — Cancelled

Computational Science Graduate Fellowship (CSGF) Annual Meeting, Arlington, VA
<https://www.krellinst.org/csgf/conf>

8/18-21/2020

37th Hardened Electronics and Radiation Technology (HEART) Conference, Louisville, KY
<https://www.heartconferenceus.org>

9/14-18/2020

13th International Conference on High Energy Density Laboratory Astrophysics (HEDLA 2020), Lisbon Academy of Sciences, Lisbon, Portugal
<https://hedla.tecnico.ulisboa.pt/>

9/23-9/25/2020

Omega Laser Facility Users Group Workshop, Rochester, NY, <http://ouw.lle.rochester.edu/>
(Rescheduled from 4/29-5/1/2020)

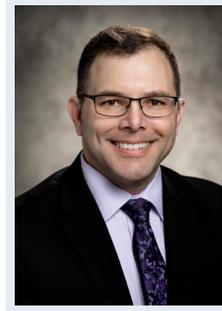
INSIDE

- 2 Measuring Current Delivered to an Inertial Confinement Fusion Target at Z with a State-of-the-Art, Line-Imaging Velocity Interferometer
- 3 The Light Source Strategy Workshop

*Contractor Support **National Laboratory Detailee

Welcome to this latest issue of *Stockpile Stewardship Today*. We are living in unprecedented times. We hope that you and your loved ones remain safe and that we all continue to work together to protect the welfare, safety, and health of each other. We are proud to be part of DOE/NNSA which not only is made up of state-of-the-art infrastructure and leading scientists, engineers, technicians, and administrators with key expertise but which also has been agile enough to mobilize these resources to contribute to the mitigation of the COVID-19 virus. Please read the article in this issue to learn how DOE/NNSA is contributing.

This issue also features some of the amazing scientific facilities in the Research, Development, Test, and Evaluation (RDT&E) portfolio. These include the Z pulsed power machine at Sandia National Laboratories which, among other work, is used for inertial confinement fusion (ICF) research. Featured in this issue are novel advances in diagnostics on Z that lead to better measurements and a better understanding of ICF target response. We highlight RDT&E's use of the national light source facilities



RDT&E's Mark Suriano, Deputy Assistant Deputy Administrator, has been chosen to be the NNSA representative for the New Strategic Arms Reduction Treaty (START) negotiations. We are honored to have him on our team and representing DOE/NNSA. Join us in congratulating Mark!

at Argonne National Laboratory, Brookhaven National Laboratory, and SLAC National Accelerator Laboratory for ground-breaking materials research that provide an exceptional opportunity to conduct experiments to resolve how microstructure impacts weapon performance.

We hope that you enjoy this issue. Stay safe, be well, and protect those around you.



Dr. Mark C. Anderson
Assistant Deputy Administrator
for Research, Development Test, and Evaluation

DOE/NNSA Contributions to Mitigate COVID-19 Impacts

by Sarah L. Nelson (National Nuclear Security Administration)

It is undeniable that our way of life has been altered due to the outbreak and spread of the 2019 coronavirus, also referred to as COVID-19. Schools have closed or moved online, shops are shuttered or with curbside-only service, social gatherings are prohibited, and businesses have been severely disrupted. We remind ourselves to not touch our faces, to use hand sanitizer, and to wear face masks to promote public health and prevent transmission of the virus prior to the development of a suitable vaccine. The development of a vaccine is a crucial component to saving lives worldwide, but there are many other research and development efforts under way to mitigate the impact of COVID-19 currently and into the future. These efforts span work to understand the spread of the virus, effective sterilization techniques, increasing the

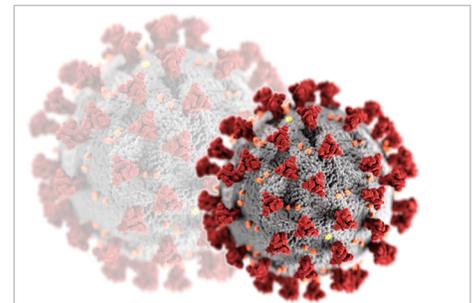


Photo courtesy of the Centers for Disease Control and Prevention

speed and accuracy of sample testing, drug development and distribution, and understanding how the disease spreads through a population. The U.S. Department of Energy (DOE) and its laboratories are proudly contributing to those efforts.

The DOE National Virtual Biotechnology Laboratory (NVBL) is a consortium of DOE national

(continued on page 4)

Measuring Current Delivered to an Inertial Confinement Fusion Target at Z with a State-of-the-Art, Line-Imaging Velocity Interferometer

by Clayton E. Myers, David E. Bliss, Mark H. Hess, and Michael C. Jones (Sandia National Laboratories), Philip S. Datte and Peter M. Celliers (Lawrence Livermore National Laboratory), and the Z Line VISAR Team

The Z pulsed power facility delivers >20 megaamperes of current in 100 nanoseconds to generate multi-megabar magnetic pressures that implode centimeter-scale inertial confinement fusion (ICF) targets such as the cylindrical liners used in Magnetized Liner Inertial Fusion (MagLIF) experiments.¹ One key to understanding the behavior of such targets is to measure the spatial distribution of the drive current with unprecedented accuracy. Obtaining these measurements in Z's harsh environment is challenging, however, because current losses in the power feed require us to measure the current as close to the target as possible.

Sandia National Laboratories (SNL) and Lawrence Livermore National Laboratory (LLNL) joined forces to employ a novel method to measure the current distribution. The most effective techniques in the load region of Z are velocimetry-based ones that measure the explosion of the metal return can surrounding the target. If the return can material and geometry are well characterized, the velocity history can be used to infer the current that is driving the explosion.² The Velocity Interferometer System for Any Reflector³ (VISAR) is a workhorse technique to measure such velocity histories. A laser beam bounces off the surface of a flyer plate and then interferes against itself to produce phase shifts proportional to the flyer velocity. Until now, we primarily have obtained VISAR data for ICF targets on Z with fiber-coupled point probes that measure zero-dimensional velocity histories with no spatial information. While this is sufficient to measure the current flowing along the side walls of the return can where the magnetic pressure is uniform, the technique fails closer to the target where

spatially varying magnetic pressures and velocities abound.

To resolve the current distribution spatially, we have developed a new imaging VISAR system in a multi-year SNL-LLNL collaboration.⁴ We refer to this as Z Line VISAR (ZLV), because it records a one-dimensional continuum of velocity histories along a line in space. ZLV uses an $f/2$ optic (Figure 1a) to focus a 532-nanometer laser onto a 4-mm region at the top of the return can (Figure 1b). The ZLV beam is transported ~50 meters to an isolated optics room where two streak cameras record radius-vs-time interferograms that are converted to velocity maps using established unfold techniques.⁵ The velocity map from a lossless commissioning experiment is shown in Figure 1c. As reported in Clayton Myers' invited talk at the 2019 IEEE Pulsed Power Plasma Science Conference, the measured velocities on our first attempt closely match the lossless simulation in Figure 1d, indicating ZLV works as designed. Our future experiments will include studies of the current delivered through a potentially-lossy transmission line designed to replicate

the conditions of a higher-current, next-generation pulsed power facility.

References

- ¹M.R. Gomez, S.A. Slutz et al., "Experimental Demonstration of Fusion-Relevant Conditions in Magnetized Liner Inertial Fusion," *Phys. Rev. Lett.* 113, 155003 (2014).
- ²A. Porwitzky, J. Brown, "Uncertainties in Cylindrical Anode Current Inferences on Pulsed Power Drivers," *Phys. Plasmas* 25, 063102 (2018).
- ³L.M. Barker, R.E. Hollenbach, "A Laser Interferometer for Measuring High Velocities of Any Reflecting Surface," *J. Appl. Phys.* 43, 4669-4675 (1972).
- ⁴P.S. Datte et al., "The Design of a Line Velocity Interferometer for Any Reflector for Inertial Confinement Experiments on the Z-Machine," *Rev. Sci. Instr.* 91, 043508 (2020).
- ⁵P.M. Celliers et al., "Line-imaging Velocimeter for Shock Diagnostics at the OMEGA Laser Facility," *Rev. Sci. Instr.* 75, 4916-4929 (2004).

This work is supported by the Department of Energy/National Nuclear Security Administration under Awards DE-NA-0003525 and DE-AC52-07NA27344. ♦

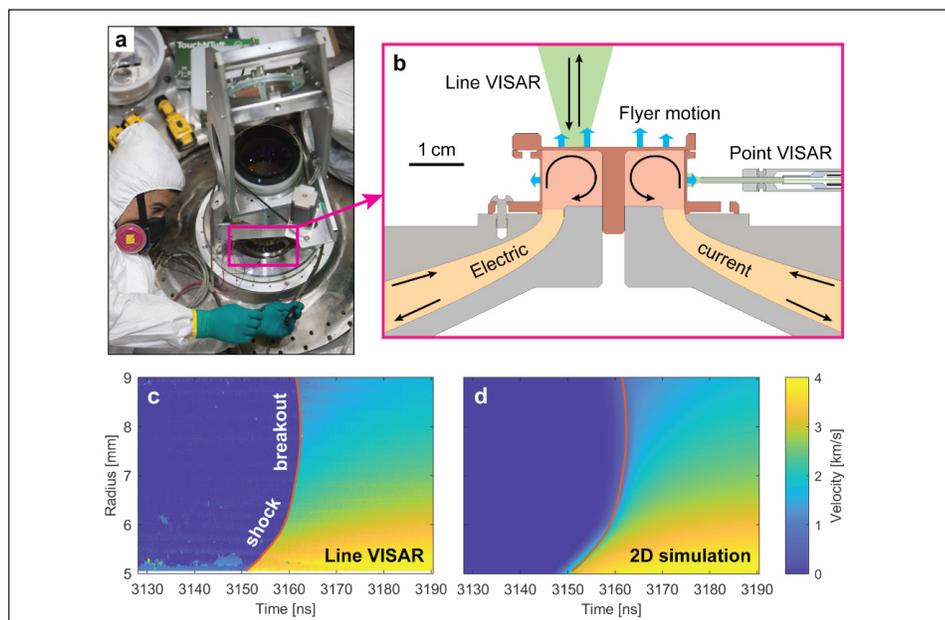


Figure 1. (a) Z Line VISAR $f/2$ optic installed on a lossless commissioning experiment. (b) Geometry of the commissioning experiment. Magnetic pressure in the load region (dark pink) causes the side walls and top plate of a copper return can to explode. A point VISAR probe measures the uniform radial expansion of the side walls, while the line VISAR system measures the non-uniform vertical expansion of the top plate. (c) Radius-vs-time velocity map of the measured motion of the top flyer plate. A shock breakout feature first appears at small radius where the velocities are highest. (d) A lossless 2D HYDRA simulation of the motion of the top flyer plate. The experimentally measured shock boundary is shown in red for comparison. The simulations agree with the data to $\pm 4\%$, indicating that the experiment is indeed lossless and that the Z Line VISAR system works as designed.

The Light Source Strategy Workshop

by Dayne E. Fratanduono (Lawrence Livermore National Laboratory) and D. Allen Dalton (National Nuclear Security Administration)

The NNSA recognizes the strategic importance of advanced light sources for a broad range of missions.

Advanced light sources provide a unique experimental capability that can interrogate the behavior of materials at length and timescales relevant to the nuclear explosive package. Currently, there is an unmet need to improve NNSA's ability to predict how changes to a material's microstructure (i.e., changes due to plutonium aging, changes in high explosive microstructure due to advanced manufacturing methods) impact performance in a weapons environment. Advanced light sources represent the ideal technique to probe the physics underlying material performance in these extreme conditions. This capability shortfall was recognized in the 2015 NNSA "Matter-Radiation Interactions in Extremes (MaRIE)" Mission Need Statement which recommended the development of a world class, NNSA-owned, advanced light source. Activities relating to the pursuit of this class of capability began in 2016 but were paused in the spring of 2019 to be consistent with federal guidance. In late 2019, NNSA's Office of Experimental Sciences (OES) recognized that alternative methods may be necessary to address this mission need.

Recently, the Office of Science (SC) within the Department of Energy (DOE) has recapitalized their existing light sources—Advanced Photon Source (APS), Linac Coherent Light Source (LCLS), and National Synchrotron Light Source II (NSLS-II)—to maintain their world-leading experimental capability (see Figure 1). These facilities are world leading with unique capabilities.

- ◆ LCLS creates unique light that can see details down to the size of atoms and processes that occur in less than one tenth of a trillionth of a second.
- ◆ APS provides the nation's highest-brightness, hard x-rays that can penetrate deeply into materials for



Figure 1: NNSA light source workshop considered investments at APS, LCLS, and NSLS-II, world leading Office of Science light source facilities.

real-time studies of the internal structure and the chemical state in actual environments.

- ◆ NSLS-II is the nation's brightest synchrotron over a wide spectral range (from the far infrared to the hard x-ray) offering world-leading spatial and energy resolution.

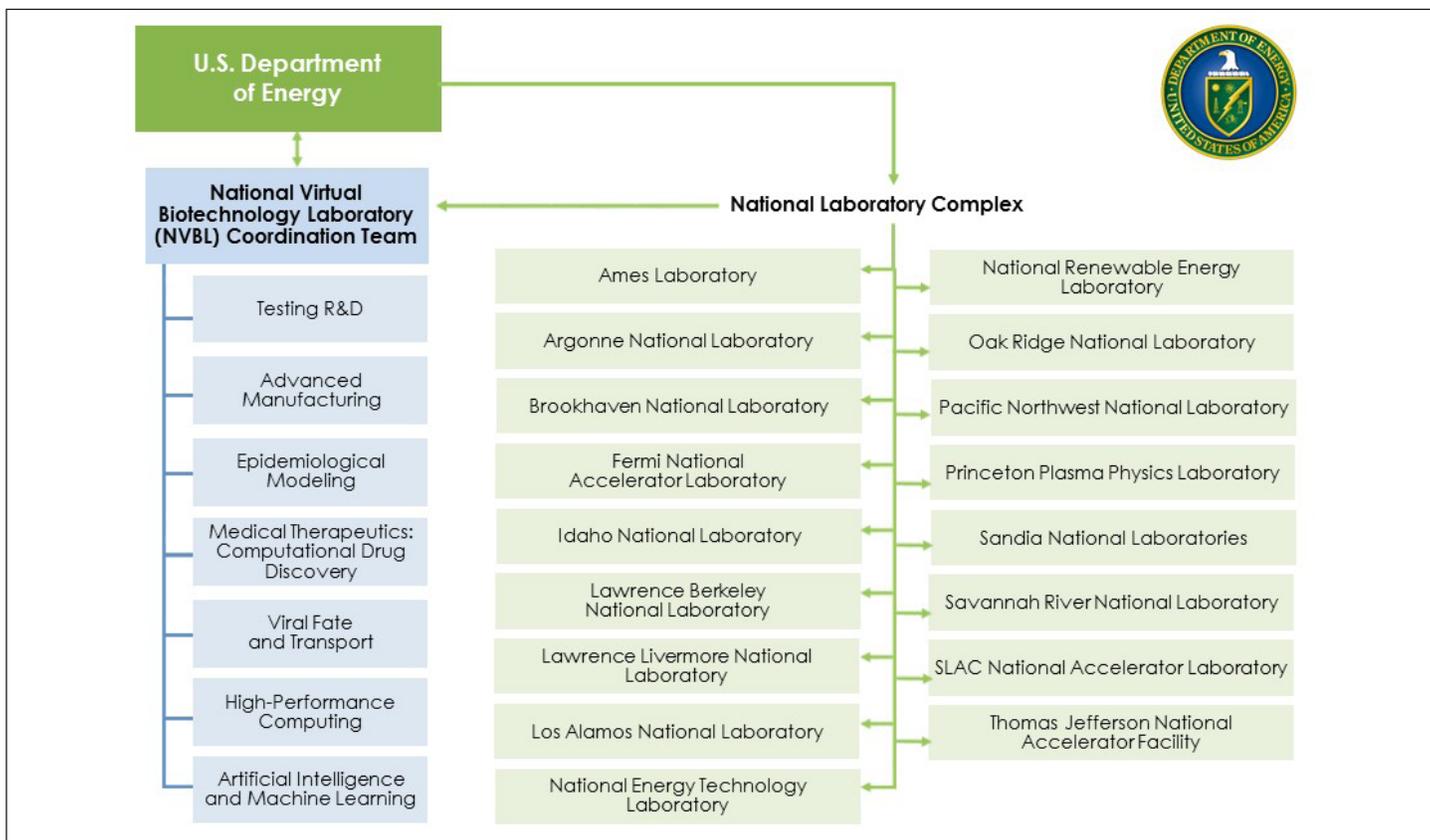
As a result, OES issued a memo in September 2019 requesting that Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Sandia National Laboratories (SNL) explore concepts to better utilize the world-class SC capabilities to enhance NNSA programmatic efforts and to address portions of the 2015 mission need.

In response to this request, the tri-labs (LANL, LLNL and SNL) hosted a workshop at LANL in February 2020 to identify concepts for intermediate-scale investments (up to \$100M) at existing SC light sources to advance the NNSA program of record. Expertise from the DOE enterprise (Academic Partners, APS, LANL, LCLS, the University of Rochester Laboratory for Laser Energetics, LLNL, NNSA, SC, and SNL) and contributions from external NNSA stakeholders were significant

in informing the tri-lab thinking on potential options. The workshop focused on proposed investments that would provide materials structure-property-performance data and improve the fundamental understanding of the underlying phenomena connecting mesoscale features to dynamic performance in support of current stockpile missions.

Three concepts emerged from the tri-lab workshop that would advance the NNSA's existing program of record and mission needs. The three complementary proposals targeted investments at the APS, LCLS, and NSLS-II, optimizing the x-ray characteristics of each facility's different science needs. The workshop attendees proposed constructing a new Defense Materials Science Sector (DMSS) hutch at the APS, partnering with the Fusion Energy Sciences (FES) office within SC to enhance the ongoing upgrade at the Matter in Extreme Conditions (MEC) end station at LCLS, and partnering with NSLS-II and Idaho National Laboratory to design and construct a specialized radiological material dynamics (RMD) beamline for work on materials in radiation environments. These proposed investments would support the qualification of classified components and study the physics of larger quantities of high explosives (DMSS, APS), generate the necessary conditions to study meso-scale science under dynamic compression (MEC, LCLS) and diagnose at-scale manufacturing processes supporting production science (RMD, NSLS-II). These near-term investments aim to influence the program of record today and to build a strategic long-term partnership with SC. NNSA representatives attended the February workshop, reviewed the final report, and have stated that they recognize the exciting scientific and mission opportunities made possible utilizing x-ray light sources. NNSA will continue to explore opportunities to leverage investments while balancing existing fiscal constraints and programmatic priorities.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. ◆



laboratories, each with core capabilities relevant to the threats posed by COVID-19. The NVBL is taking advantage of DOE expertise and user facilities, including light and neutron sources, nanoscale science centers, sequencing and bio-characterization facilities, and high performance computer facilities, to address key challenges in responding to the COVID-19 threat. Examples include developing innovations in testing capabilities, identifying new targets for medical therapeutics, providing epidemiological and logistical support, and addressing supply chain bottlenecks by harnessing extensive additive manufacturing capabilities. The NVBL collaborates extensively with researchers, both in academia and the private sector. In addition, the DOE user facilities are available to users in all sectors of the research community.

Some examples of efforts under way by the NVBL are:

- ◆ Working with the U.S. Food and Drug Administration, Centers for Disease Control and Prevention, and Department of Defense representatives of the Diagnostics Task Force, the NVBL is providing experimental evidence to help inform national guidance on testing. Milestones include
 - a) comparison of four different viral transport media and storage of nasal swab samples at different temperatures that may influence storage and shipping guidance
 - and b) side-by-side comparisons of RNA extraction efficiency for kits from different manufacturers have been completed and are being considered by the FDA.
- ◆ Utilizing COVID-19 incidence and response data at county scale, NVBL is developing near-term (7-14 days) and longer-term (weeks to months) forecast capabilities for disease transmission, stress on public health infrastructure resources, and economic outlook for the nation. These capabilities are being matured with detailed data from the City of Chicago and the State of New Mexico that will be generalized for other geographic regions.
- ◆ SNL developed pathogen management kits that can be attached to respiratory machines and that use ultraviolet light to disable COVID-19 and other pathogens before a patient's exhaled breath is circulated back into the room.
- ◆ Researchers have used Argonne National Laboratories' Advanced Photon Source to characterize a dozen proteins—potential targets for medicines and countermeasures—from COVID-19, including a critical protein that lets the virus hide from the immune system.
- ◆ Additional cabinets and computer nodes were purchased to support ongoing COVID-19-related research that is relying heavily on Artificial Intelligence, Machine Learning, and Deep Learning.

For more information, please visit:

<https://science.osti.gov/nvbl>

<https://covid19-hpc-consortium.org/> ◆