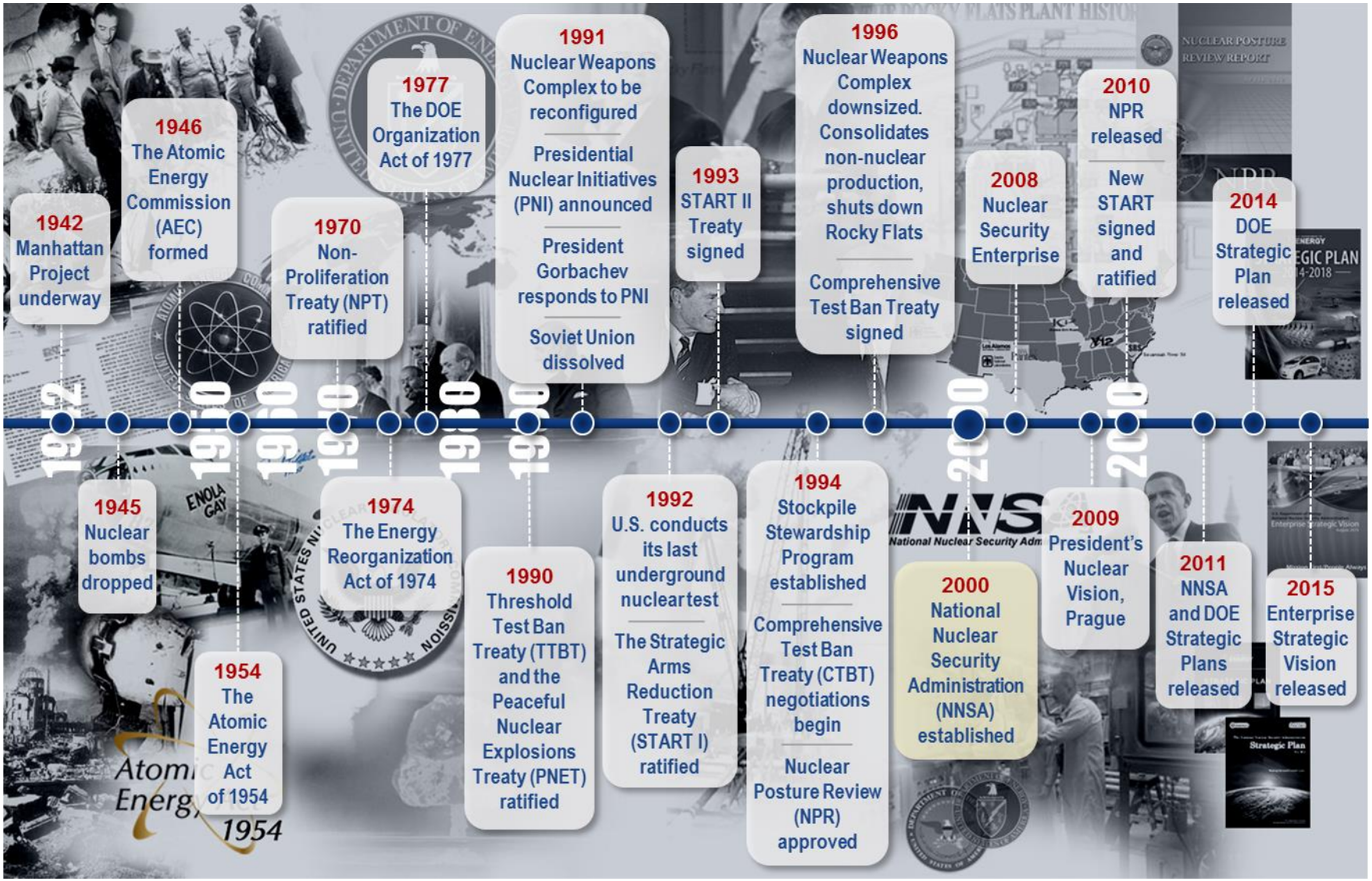
Bridging HED and Plasma Sciences to Stockpile Stewardship

Presented to:
Michigan Institute for Plasma Science and Engineering (MIPSE)
2017 Annual Symposium

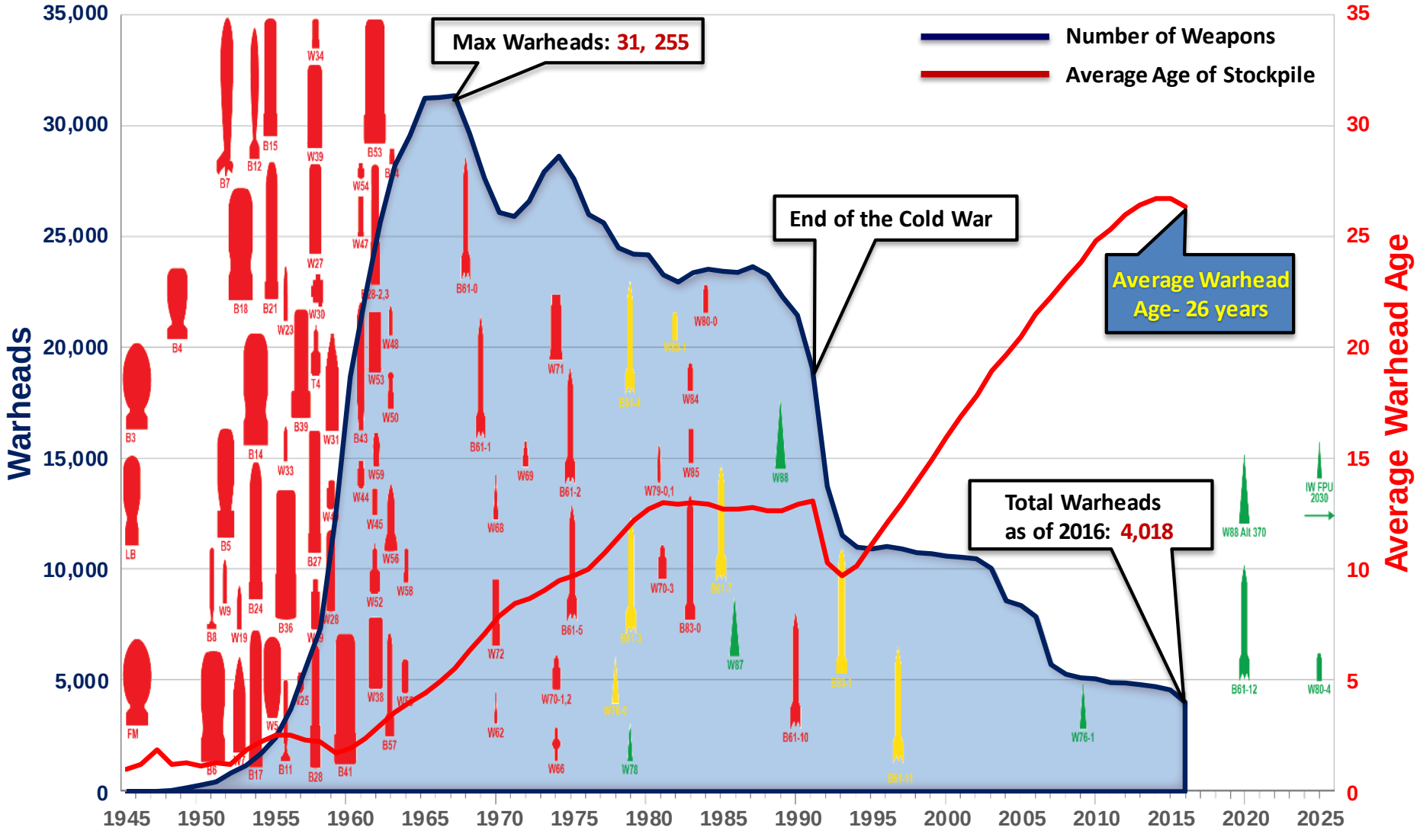
J. Tiberius Moran-Lopez
National Nuclear Security Administration (NNSA)
18 October 2017

History of the NNSA



U.S. Nuclear Weapons Stockpile, 1945-2016*

**Active and inactive warheads. Several thousand additional warheads are retired and awaiting dismantlement*



Weapons shown at date of stockpile entry: No longer in the stockpile | Being phased out | Future deterrent

Today's Nuclear Policy Direction

National Security Presidential Memorandum (NSPM) on Rebuilding the U.S. Armed Forces

The National Nuclear Security Administration's Missions

NA-10: Defense Programs

To sustain a safe, secure and effective nuclear deterrent through policy and the application of science, technology, engineering and manufacturing.

Nuclear Nonproliferation

To detect, secure, and dispose of dangerous nuclear and radiological material, and related weapons of mass destruction technology and expertise.

Naval Reactors

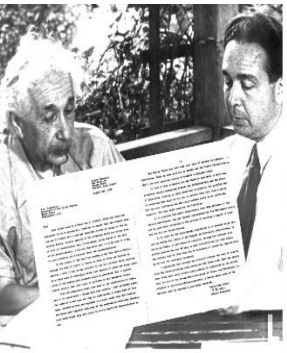
To provide militarily effective nuclear propulsion plants and ensures their safe, reliable and long-lived operation.

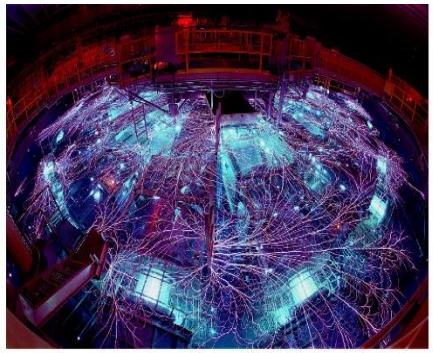
Defense Nuclear Security

To develop and implement security programs for NNSA including protection, control, and accountability of materials, and for the physical security of all facilities of the administration.

Emergency Operations

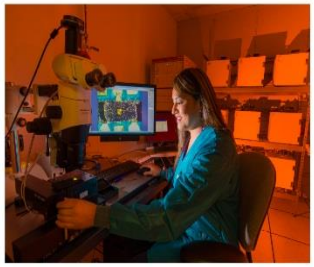
To provide radiological and nuclear emergency response and to provide security to the nation from the threat of nuclear terrorism.

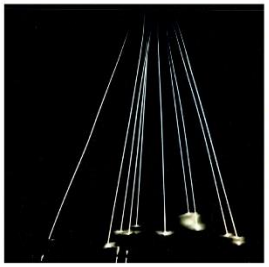
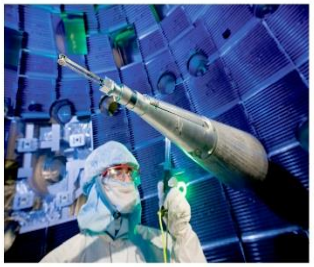




NNSA
National Nuclear Security Administration
DEFENSEPROGRAMS

WELCOME TO DEFENSE PROGRAMS





Office of the Deputy Administrator

Mission

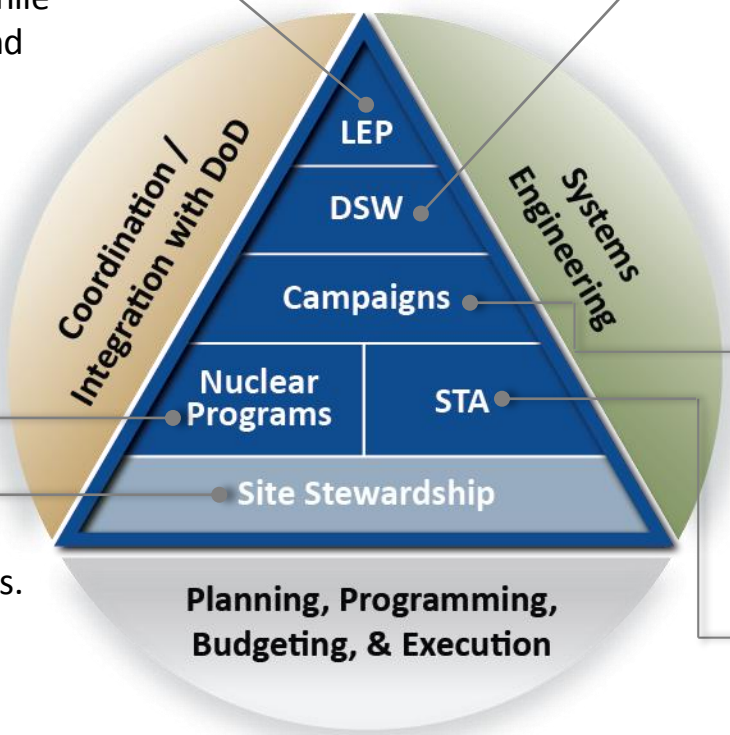
To maintain a safe, secure, and effective nuclear stockpile that will deter any adversary and guarantee the defense of the Nation and its allies.

Program Structure & Process Environment

Life Extension Program (LEP) prevents operational gaps while enhancing safety, security and use control.

Nuclear Programs provides strategic investments to modernize nuclear manufacturing capabilities.

Site Stewardship provides for field infrastructure and operations.



Directed Stockpile Work (DSW) provides the certification and stockpile production for DoD delivery.

Research, Development, Test Capabilities, and Evaluation (RDTE) provides tools and capabilities for stockpile assessment and certification, including the development of predicative capabilities

Secure Transportation Asset (STA) provides safely and secure shipment of nuclear weapons, weapons components, and special nuclear material.

Program Structure Process Environment

Nuclear Weapons Council
Shared Nuclear Deterrence Responsibilities

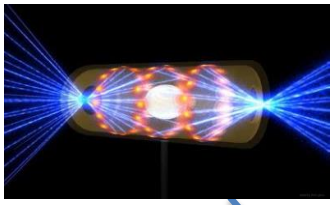
DOD

- Establish military requirements
- Design, develop, test, and produce delivery system
- Operate complete nuclear weapons system
- Secure and maintain nuclear weapons
- Train personnel and plan for employment

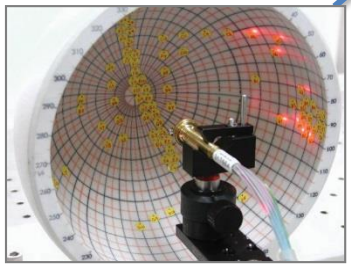
DOE

- Maintain safety, security, and effectiveness of the stockpile
- Research and develop nuclear weapon science, technology, and engineering
- Support stockpile levels
- Validate warhead safety and assess reliability
- Produce and manage nuclear materials

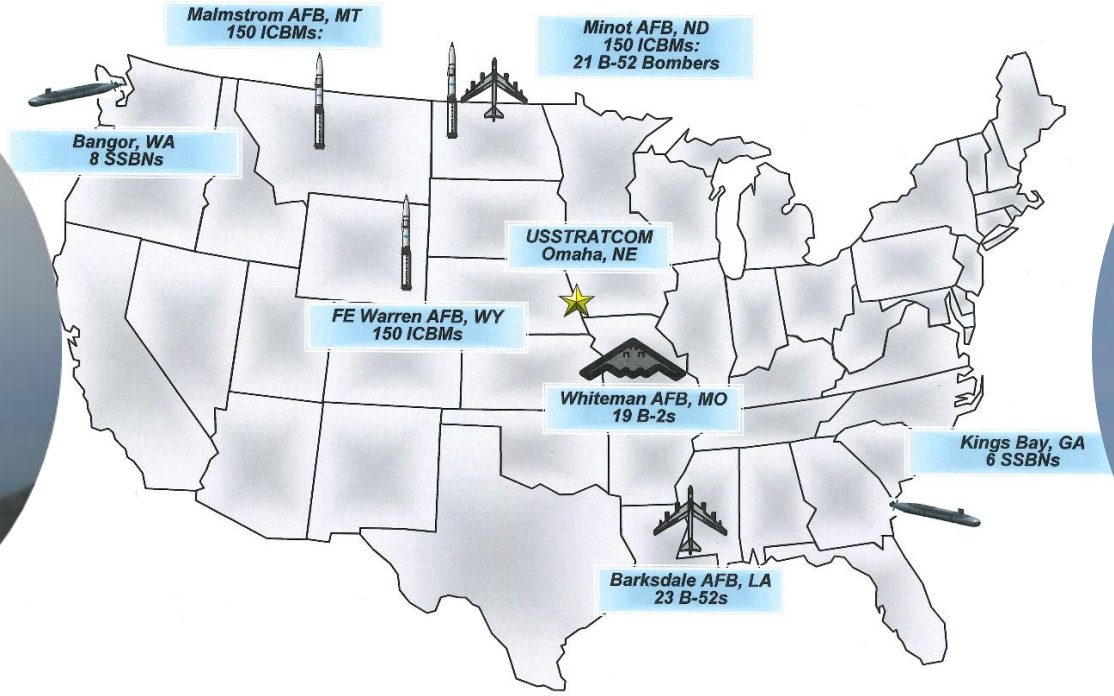
A Key Part of the Deterrent is a Responsive Nuclear Security Enterprise



Laboratory for Laser Energetics (LLE), Rochester, NY

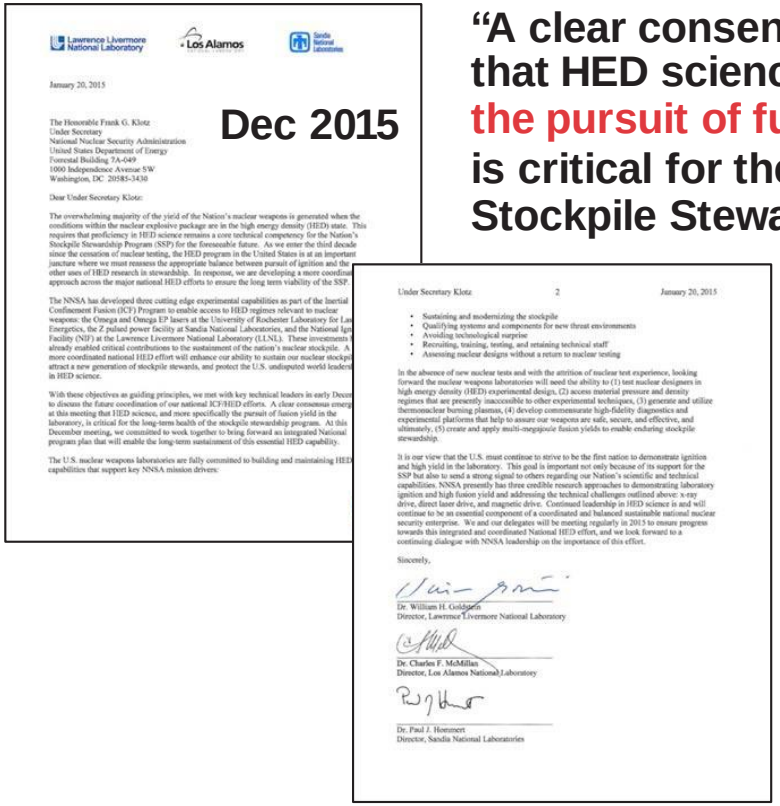


U.S. Nuclear Weapons and Delivery Platforms



How do HED, plasma, and fusion sciences impact the Stockpile Stewardship Program?

The NNSA Laboratory Directors' letter highlights importance of HED and plasma sciences to the SSP



Lawrence Livermore National Laboratory · Los Alamos · Sandia National Laboratories

January 20, 2015

The Honorable Frank G. Klotz
Under Secretary
National Nuclear Security Administration
United States Department of Energy
Forrestal Building 7A-049
1000 Independence Avenue SW
Washington, DC 20585-3430

Dear Under Secretary Klotz:

The overwhelming majority of the yield of the Nation's nuclear weapons is generated when the conditions within the nuclear explosive package are in the high energy density (HED) state. This requires that proficiency in HED science remains a core technical competency for the Nation's Stockpile Stewardship Program (SSP) for the foreseeable future. As we enter the third decade since the cessation of nuclear testing, the HED program in the United States is at an important juncture where we must reassess the appropriate balance between pursuit of ignition and the other uses of HED research in stewardship. In response, we are developing a more coordinated approach across the major national HED efforts to ensure the long term viability of the SSP.

The NNSA has developed three cutting edge experimental capabilities as part of the Inertial Confinement Fusion (ICF) Program to enable access to HED regimes relevant to nuclear weapons: the Omega and Omega EP lasers at the University of Rochester Laboratory for Laser Energetics, the Z pulsed power facility at Sandia National Laboratories, and the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL). These investments already enabled critical contributions to the sustainment of the nation's nuclear stockpile. A more coordinated national HED effort will enhance our ability to sustain our nuclear stockpile, attract a new generation of stockpile stewards, and protect the U.S. undisputed world leadership in HED science.

With these objectives as guiding principles, we met with key technical leaders in early December to discuss the future coordination of our national ICF/HED efforts. A clear consensus emerged at this meeting that HED science, and more specifically the pursuit of fusion yield in the laboratory, is critical for the long-term health of the stockpile stewardship program. At this December meeting, we committed to work together to bring forward an integrated National program plan that will enable the long-term sustainment of this essential HED capability.

The U.S. nuclear weapons laboratories are fully committed to building and maintaining HED capabilities that support key NNSA mission drivers:

Dec 2015

Under Secretary Klotz 2 January 20, 2015

- Sustaining and modernizing the stockpile
- Qualifying systems and components for new threat environments
- Avoiding technological surprise
- Recruiting, training, testing, and retaining technical staff
- Assessing nuclear designs without a return to nuclear testing

In the absence of new nuclear tests and with the attrition of nuclear test experience, looking forward the nuclear weapons laboratories will need the ability to (1) test nuclear designers in high energy density (HED) experimental design, (2) access material pressure and density regimes that are presently inaccessible to other experimental techniques, (3) generate and utilize thermonuclear burning plasmas, (4) develop commensurate high-fidelity diagnostics and experimental platforms that help to assure our weapons are safe, secure, and effective, and ultimately, (5) create and apply multi-megajoule fusion yields to enable enduring stockpile stewardship.

It is our view that the U.S. must continue to strive to be the first nation to demonstrate ignition and high yield in the laboratory. This goal is important not only because of its support for the SSP but also to send a strong signal to others regarding our Nation's scientific and technical capabilities. NNSA presently has three credible research approaches to demonstrating laboratory ignition and high fusion yield and addressing the technical challenges outlined above: x-ray drive, direct laser drive, and magnetic drive. Continued leadership in HED science is and will continue to be an essential component of a coordinated and balanced sustainable national nuclear security enterprise. We and our delegates will be meeting regularly in 2015 to ensure progress towards this integrated and coordinated National HED effort, and we look forward to a continuing dialogue with NNSA leadership on the importance of this effort.

Sincerely,

Dr. William H. Goldstein
Director, Lawrence Livermore National Laboratory

Dr. Charles F. McMillan
Director, Los Alamos National Laboratory

Dr. Paul J. Hommert
Director, Sandia National Laboratories

"A clear consensus emerged at this meeting that HED science, and more specifically the pursuit of fusion yield in the laboratory, is critical for the long-term health of the Stockpile Stewardship Program"

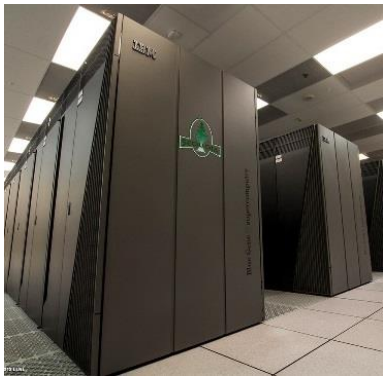
"NNSA presently has three credible research approaches to demonstrating laboratory ignition and high fusion yield"

"It is our view that the U.S. must continue to strive to be the first nation to demonstrate ignition and high yield in the laboratory"

The safety and reliability of the U.S. nuclear stockpile was once ensured by regular underground testing

The last U.S. nuclear test was conducted in 1992 (1054 total)

The stockpile was designed at the dawn of the supercomputer age



Today's challenge is to "replace empirical understanding derived from underground tests with ab initio application of the sciences":

Predictive Methods

- Simulations and numerical models
- High-performance computing
- Improved validation and verification

Experiments

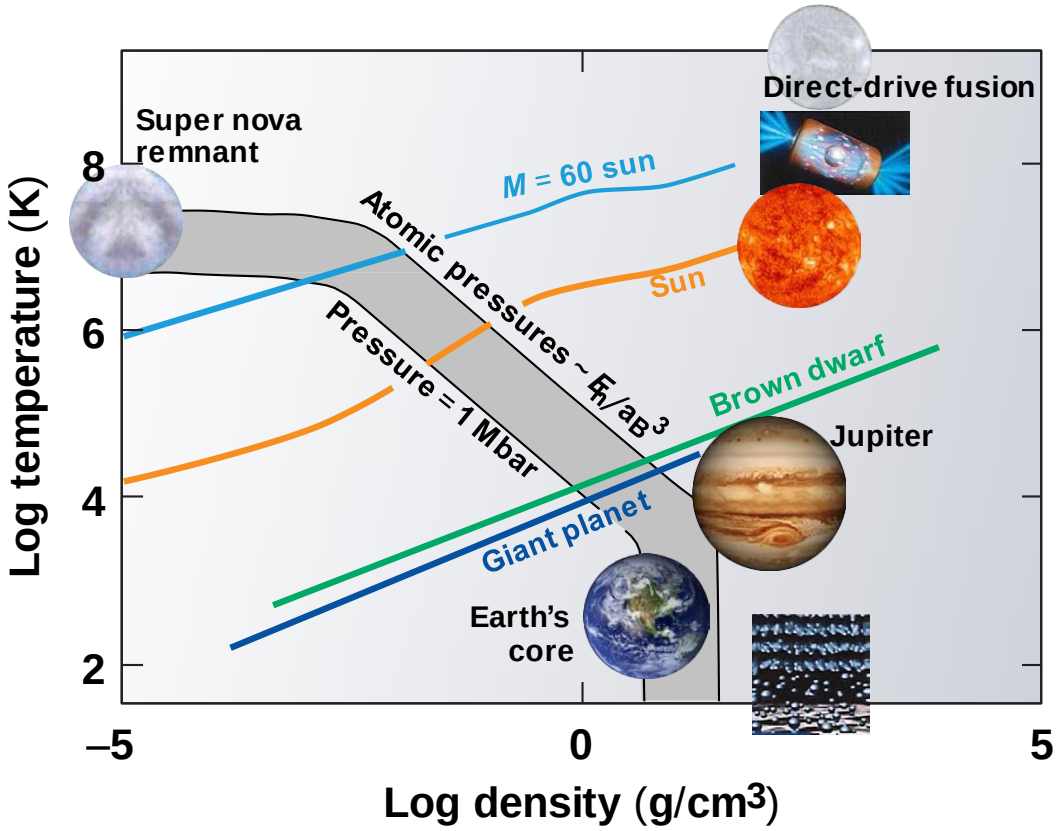
- Facilities: NIF, Omega, Z, DARHT
- State-of-the-art diagnostics and target engineering
- Infrastructure and facility operations

Theory

- Improved and representative physics models
- Multidisciplinary sciences
- Challenge current methods and introduce novel methods

Stewardship sciences require expertise across a broad spectrum of HED sciences

Stockpile Stewardship requires multidiscipline expertise and integration of broad areas of science and technology analogous to weapons design, engineering, and testing



Plasma physics
- laser interactions
- magnetic instabilities

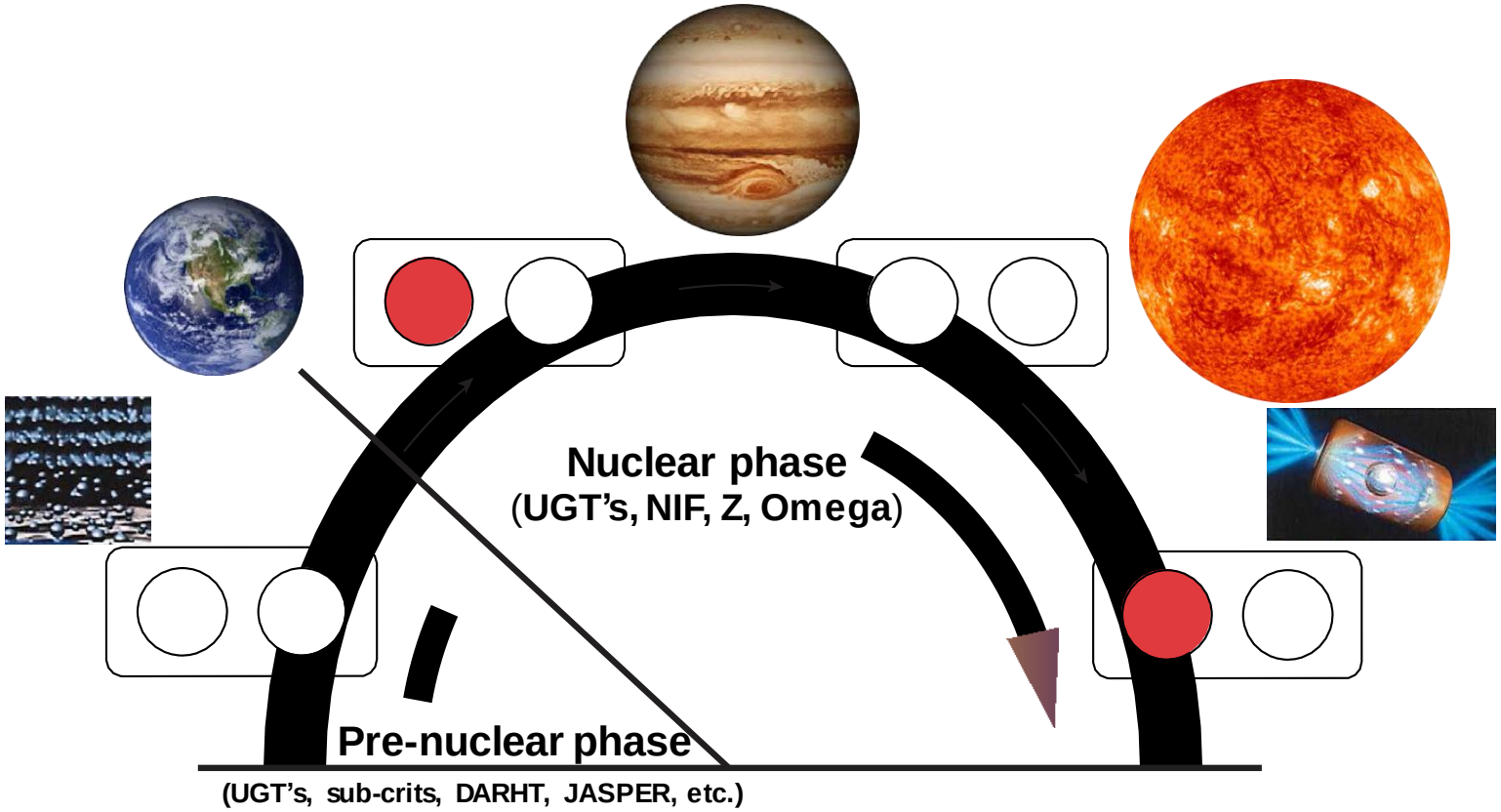
Nuclear sciences
- opacities

Radiation transport
- Rad-hydro

Hydrodynamics
- turbulence, mix
- viscosity

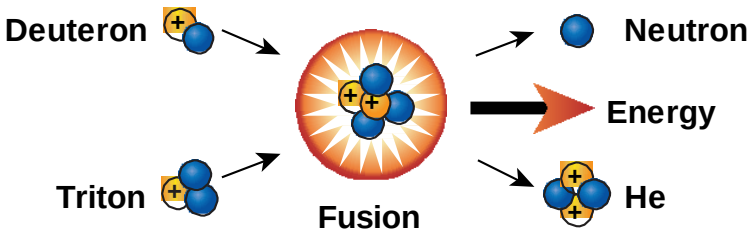
Material properties
- equations of state

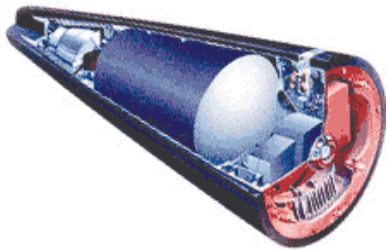
Planetary physics, stellar dynamics, and astrophysics share foundational sciences with nuclear weapon design and testing



HED yields, radiation transport, and plasma effects directly correlate to weapon physics

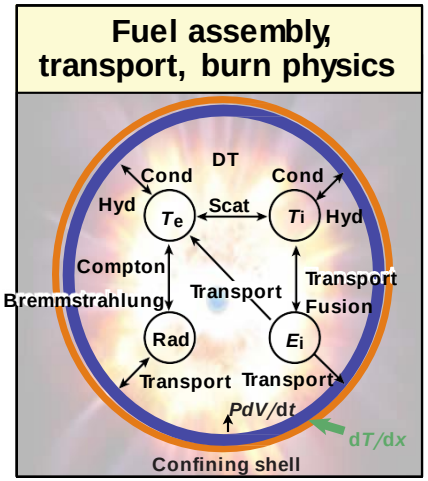
- Radiation effects on nuclear weapons components





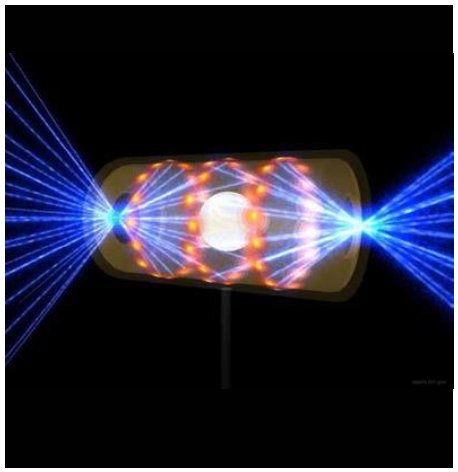
- Boost physics: understanding the behavior of materials at high-energy density in a fusion environment

- Greater than 99% of the nuclear yield occurs in the HED state



The NNSA supports a balanced approach to stewardship-centric ignition applications

Laser indirect drive

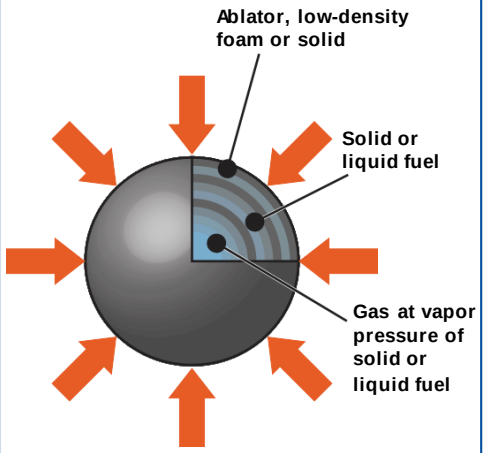


LLNL lead laboratory (LANL)

Facility

- NIF
  - OMEGA

Laser direct drive

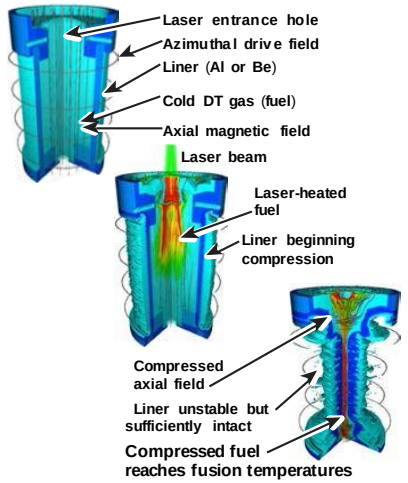


LLE lead laboratory (NRL)

Facility

- Omega
  - NIF
  - NIKE

Pulsed-power magnetized fusion



SNL lead laboratory (LANL, LLE)

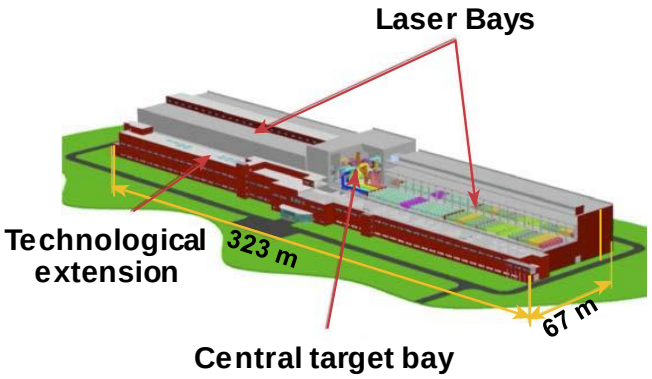
Facility

- Z
  - Omega
  - NIF

A balanced program is needed to address three approaches to evaluate their promise.

The international arena also demonstrates the importance of leadership in Stockpile Science

Russia: UFM Multi-MJ laser



30 September 2015

16 September 2016

China: SGIII (>120 kJ at 3 ns)

China plans for >1 MJ in 2020s

Russia's (Baikal) and China's (PJ5) also have aggressive programs in pulsed power

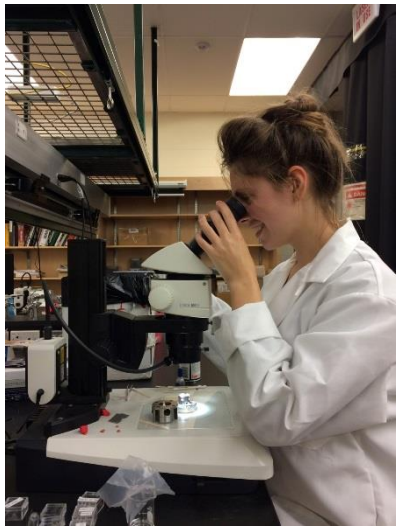
Stewardship Science Academic Programs (SSAP): Preparing Tomorrow's Leaders

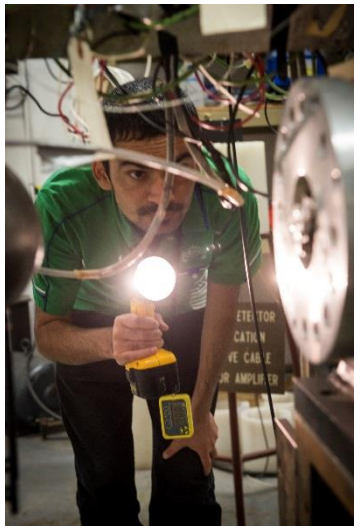
Academic Programs

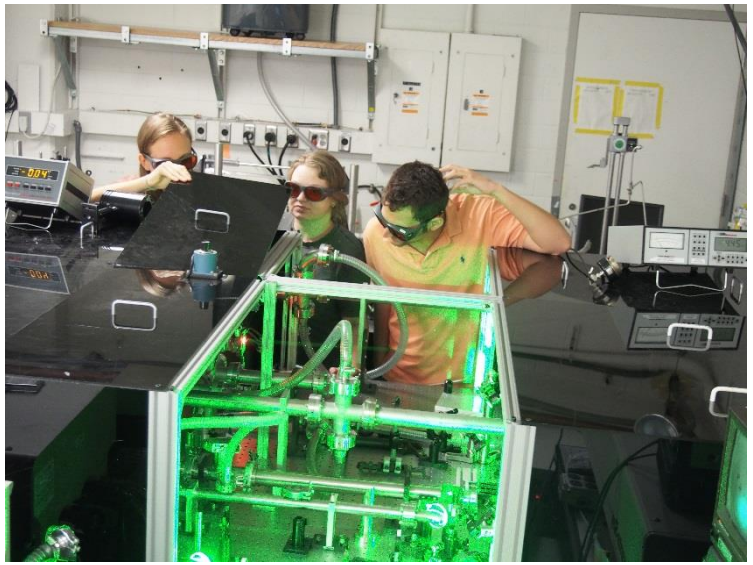
Providing research experience necessary to maintain a cadre of trained scientists to meet the nation's future in Stockpile Stewardship science and technology

- Stewardship Science Academic Alliances (SSAA)
  - 8 Centers of Excellence, 46 grants, 2 Cooperative Agreements
- High Energy Density Laboratory Plasmas (HEDLP)*
  - 10 grants
- National Laser Users' Facility (NLUF)
  - 13 grants
- Predictive Science Academic Alliance Program (PSAAP)
  - 6 Centers
- Minority Serving Institution Partnership Program
  - 6 grants
- Stewardship Science Graduate Fellowship
  - Separate program supporting ~22 students
- Computational Science Graduate Fellowship*
  - Separate program supporting ~ 70 students

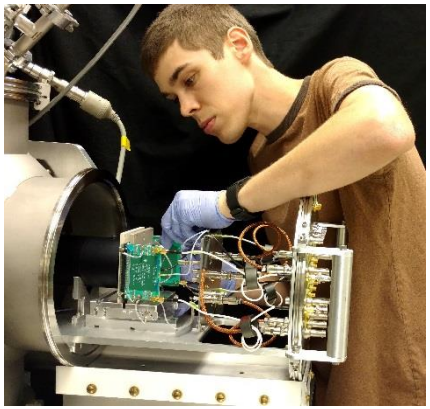
*Joint programs with DOE Office of Science

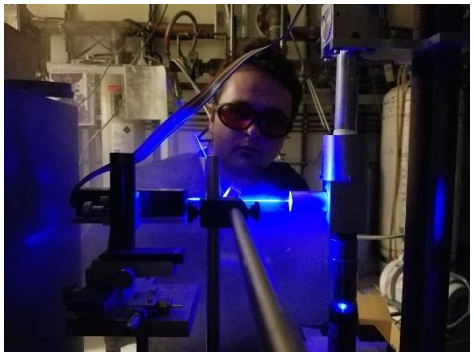




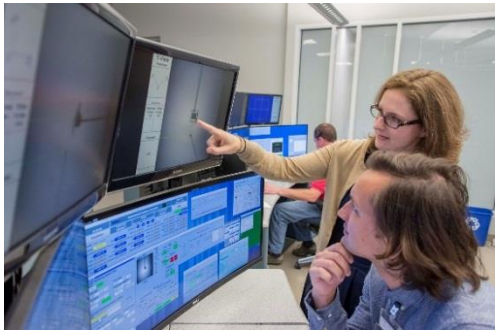


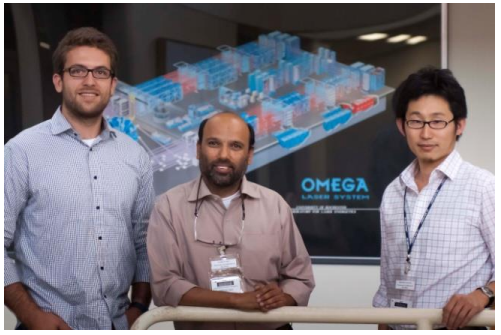
Academic Alliances Programs
Stewardship Science Academic Alliances (SSAA)





- Established in 2002 with primary focus on National Nuclear Security Enterprise mission
- 8 Centers of Excellence and 46 grants support hundreds of faculty, researchers, post-docs, graduate and undergraduate students
- Supports grants and cooperative agreements in areas vital to NNSA's mission
  - Materials under Extreme Conditions
  - High Energy Density Physics
  - Low Energy Nuclear Science
  - Radiochemistry





Academic Alliances and Programs: Recent Graduates

Four recent PhD graduates supported by the SSAP. Left to right: Hans Rinderknecht (LLNL), Dan Casey (LLNL), Alex Zylstra (LANL), and Mike Rosenberg (UR/LLE)

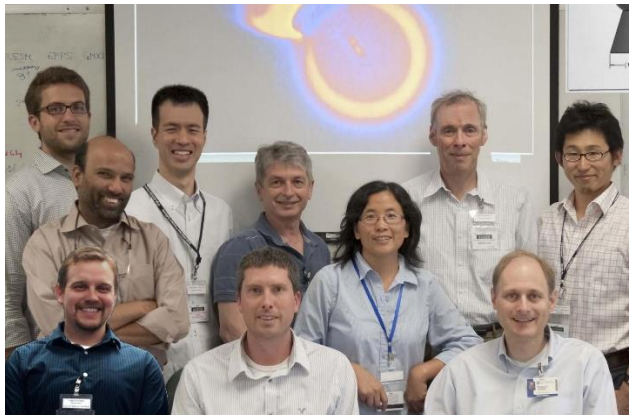
SSGF Alumni

Miguel Morales (LLNL)

Forrest Doss (LANL)

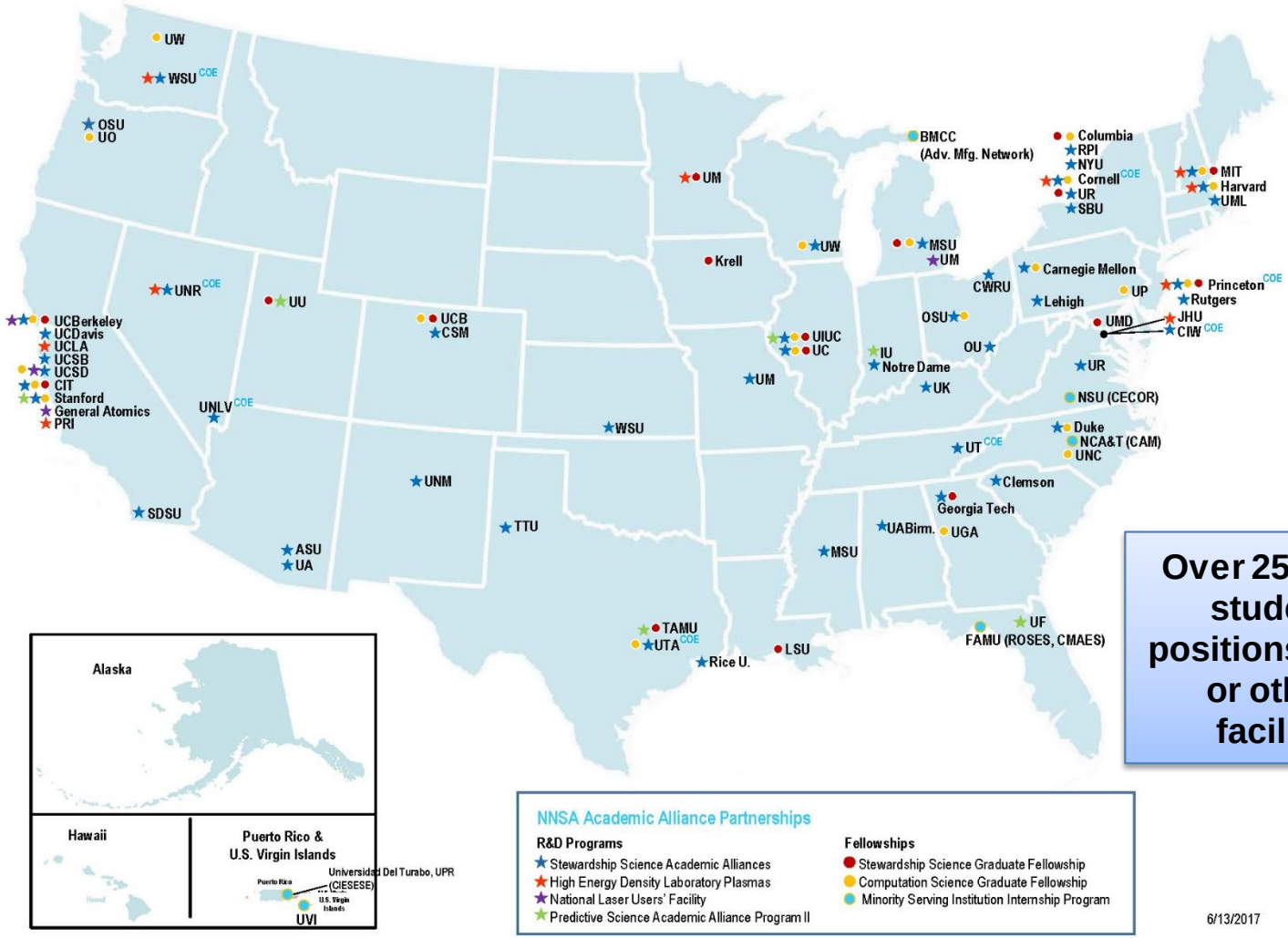
Laura Berzak Hopkins (LLNL)

UNLV students at the 2015 SSAP Symposium. Inset (left) Patricia Kalita PhD graduate now at SNL.



Graduates Charlie Jarrott (top left) and Chris McGuffey (bottom left) now at LLNL and UCSD

Award Map



Over 250 SSAP-supported students have taken positions at DOE/NNSA labs or other government facilities since 2002

Academic Alliances Programs
Fellowship Programs

Also a part of the SSAP are the Stewardship Science Graduate Fellowship (SSGF) Program and the Computational Science Graduate Fellowship (CSGF) Program, the latter jointly sponsored with the U.S. Department of Energy's (DOE's) Office of Science. These programs support PhD students in areas of interest to stockpile stewardship. They provide a yearly stipend, tuition, fees, and an academic allowance.

Approximately half of the 30 alumni from the SSGF program have gone on to careers at one of the national laboratories or other government agencies

Questions

Backup Slides

A Key Part of the Deterrent is a Responsive Nuclear Security Enterprise

Location: Livermore, CA
- **Weapon Design (Nuclear)**
- Design agency for the W80, W87, and B83
- **High explosive R&D** Center of Excellence

Location: Nevada
- Nuclear material and other **experiments**

Location: Los Alamos, NM
- **Weapon Design (Nuclear)**
- Design agency for the B61, W76, W78, and W88
- Pit production
- **Plutonium** sustainment

Location: Albuquerque, NM and Livermore, CA
- Systems engineering
- **Neutron generator** design and production
- **Weapon Design (Non-nuclear)**

Location: Amarillo, TX
- **Weapons assembly/ disassembly**
- **High explosive production** Center of Excellence

Location: Kansas City, MO
- **Nonnuclear** component manufacturing/ procurement

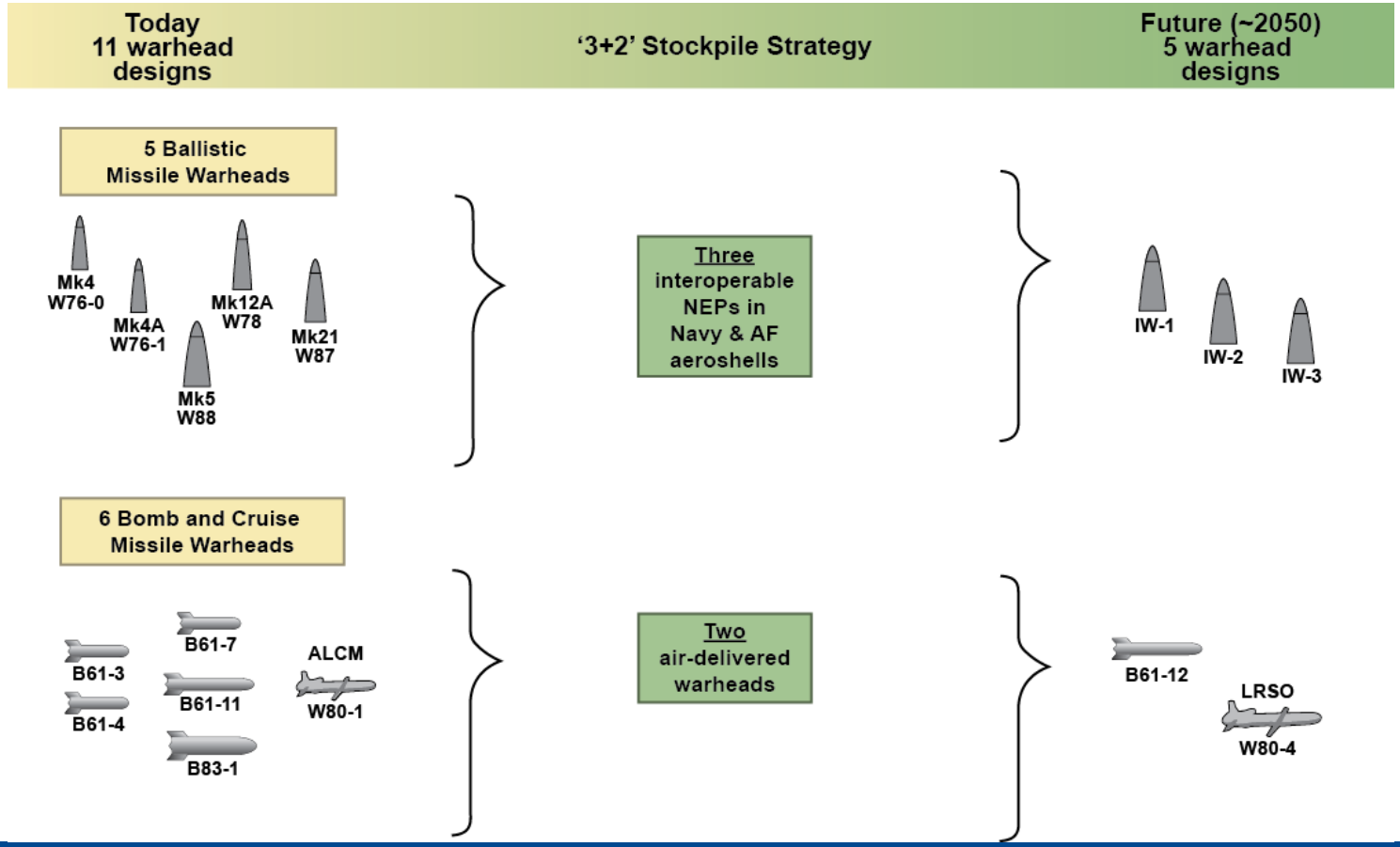
Location: Oak Ridge, TN
- **Uranium** component and sub-assembly production
- **Lithium** Processing

Location: Aiken, SC
- **Tritium** operations
- TPBAR extraction
- Reservoir change-out

Over 50% of NNSA Infrastructure is more than 40 Years Old

Policy to Action
The NWC's "3 + 2 Strategy"

- Enables a smaller stockpile while ensuring a responsive nuclear security enterprise.
- Incorporates improvements to stockpile safety, security, and use control.
- Supports New START Treaty and NATO nuclear commitments.



Life Extension Programs and Major Alterations

W76-1 LEP, Cost $3.6B, End Production FY 2019

- New Arming, Fuzing & Firing (AF&F) Assembly
- Refurbished Primary and Secondary
- Concurrent Limited-Life Component (LLC) Exchange (Gas Transfer Systems and Neutron Generators)

- ✓ Completed First Production Unit (FPU) in Sep 2008
- ✓ Completed Full Rate Production in Feb 2009
- ✓ Completed over 80% of production and 75% delivered as of June 2017

B61-12 LEP, Cost $8.3B, FPU March 2020

- Refurbished Primary and Secondary
- Redesigned Radar, Impact Sensors, Antennas
- Redesigned Firing Set
- LLC Exchange (Neutron Generator and Gas Transfer System)

- ✓ First development flight test in Jul 2015
- ✓ Completed System Baseline Design Review in Jan 2016
- ✓ Baseline Cost Report in May 2016
- ✓ Entered Production Engineering in Jun 2016

W88 Alt 370, Cost $2.6B, FPU December 2019

- New Arming, Fuzing & Firing (AF&F) Assembly
- Conventional High Explosive (CHE) Refresh
- New Lightning Arrestor Connector
- Concurrent Limited-Life Component Exchange

- ✓ Entered Development Engineering in Oct 2012
- ✓ CHE refresh decision at NWC in Nov 2014
- ✓ Integrated Baseline Review in Aug 2016
- ✓ Entered Production Engineering in Feb 2017

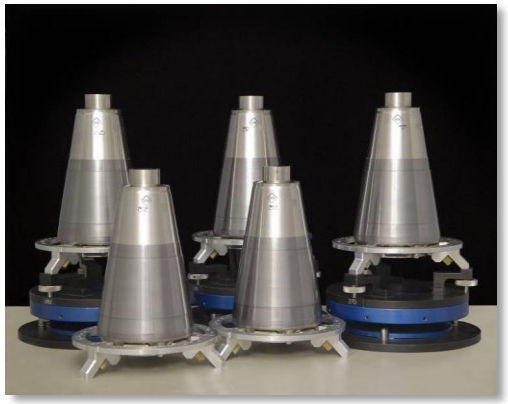
W80-4 LEP, Cost TBD, FPU FY 2025

- Primary refresh
- Non-nuclear component refurbishment
- Integration into the new Long Range Stand-off (LRSO) cruise missile
- Improvements in safety and security

- ✓ Began Concept Assessment in Jul 2014
- ✓ Began Feasibility Study & Option Down-select in Jul 2015
- Design Definition and Cost Study in 1Q FY 2018
- Development Engineering in 4Q FY 2018
- Production Engineering in FY 2022

Directed Stockpile Work

- Manage and direct all life-cycle activities and programs to provide a safe, secure, and reliable nuclear weapon stockpile
- Support strategic planning by providing direction for sustainment of the nuclear weapons stockpile, production infrastructure, and nuclear materials (plutonium, uranium, and tritium) availability, storage, and transportation
- Execute the nuclear weapons surveillance program
- Direct the DOE nuclear weapons surety program including safety, security, use control, and weapons quality
- Establish the framework and context of the nuclear weapon plutonium and uranium capabilities within the nuclear security enterprise
- Manage relationships with international agencies that have responsibilities that overlap with NNSA's mission



W76-1 LEP Arming Fuzing & Firing System

B61 at Pantex

Strategic Materials Programs

Plutonium

Maintain science associated with plutonium and build capabilities to resume production of war reserve (WR) pits.

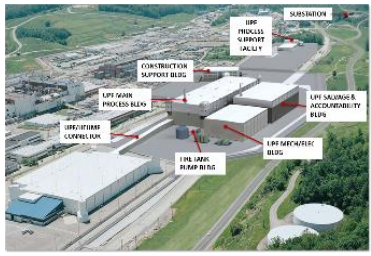
- Move operations from the CMR building into the Radiological Lab and Plutonium Facility.
- Reconfigure and equip facilities to prepare for production.
- Evaluate alternatives for additional capacity needed for WR pit production.

New Backfill Station Installation

Uranium

Sustain enriched uranium manufacturing capabilities.

- Develop new technologies that make uranium operations safer and more efficient, such as electro-refining and microwave casting.
- Deliver the Uranium Processing Facility (UPF) for $6.5B by 2025.
- Reduce nuclear materials in existing uranium facilities at Y-12 and cease operations in the old uranium building.



Uranium Processing Facility

Tritium

Provide tritium to meet long-term demand for limited life reservoir fills for delivery to the stockpile.

- Increase TVA reactor production capacity to meet inventory requirements in the mid-2020s.
- NNSA developing options for unobligated uranium enrichment for tritium production
- Manage technology, infrastructure, and commercial supply chain capabilities to sustain tritium production

Tritium Glovebox Work at Savannah River Site

Lithium

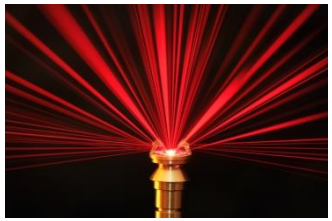
Provide lithium to meet demand for stockpile programs.

- Manage lithium supply, sustain infrastructure, and deploy technologies to meet production requirements through the 2020s.
- Plan for a new Lithium Production Capability to be operational in the mid 2020s.

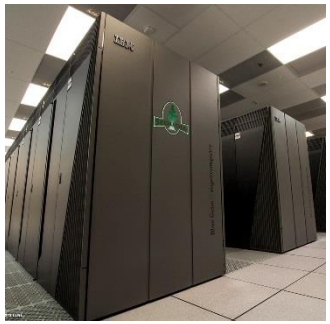
Lithium Production Infrastructure at Y-12

NNSA is adding rigor and discipline to Strategic Materials through dedicated Program Managers and new PM policies.

Research, Development, Test and Evaluation



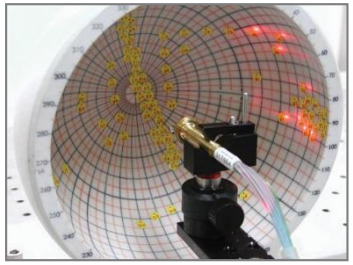
Science delivers weapons-relevant data, models, methods and capabilities that increase confidence in annual assessments and certification of refurbished weapons, explore future LEP options, and facilitate Significant Finding Investigations closure for Nuclear Explosives Package issues



Advanced Simulation and Computing delivers computer platforms and integrated codes with models and algorithms to facilitate assessment of weapon systems

Inertial Confinement Fusion delivers high energy density physics platforms to access extreme conditions essential to assessing weapons

Advanced Manufacturing Development delivers modern technologies necessary to enhance secure manufacturing capabilities and to provide timely support to critical needs of the stockpile



Engineering delivers technology solutions that facilitate surety, surveillance, survivability, and testing throughout the weapon lifecycle

These five capabilities provide the Nation's capability to underwrite the nuclear stockpile in the absence of underground nuclear explosive testing.

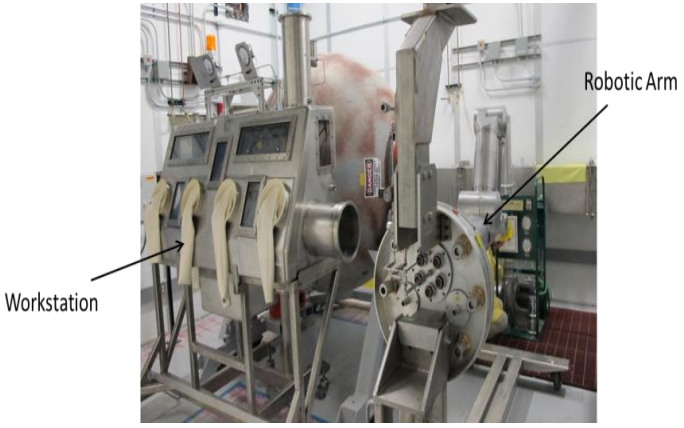
Infrastructure and Operations

- Manage projects and major acquisition programs for modernization of science and manufacturing capabilities
- Manage General Plant Project level construction projects (<$10M)
- Manage strategy development and execution for enhanced manufacturing
- Allocate resources, apply appropriated funding, formulate budgets, and perform budget execution oversight for major modernization projects
- Develops and executes strategies for maintenance of key strategic nuclear materials like tritium, lithium, enriched uranium, and plutonium

Aerial View – Highly Enriched Uranium Materials Facility 3

Y-12 Production Microwave

Radiological Laboratory Utility Office Building



LANL Confinement Vessel Disposition

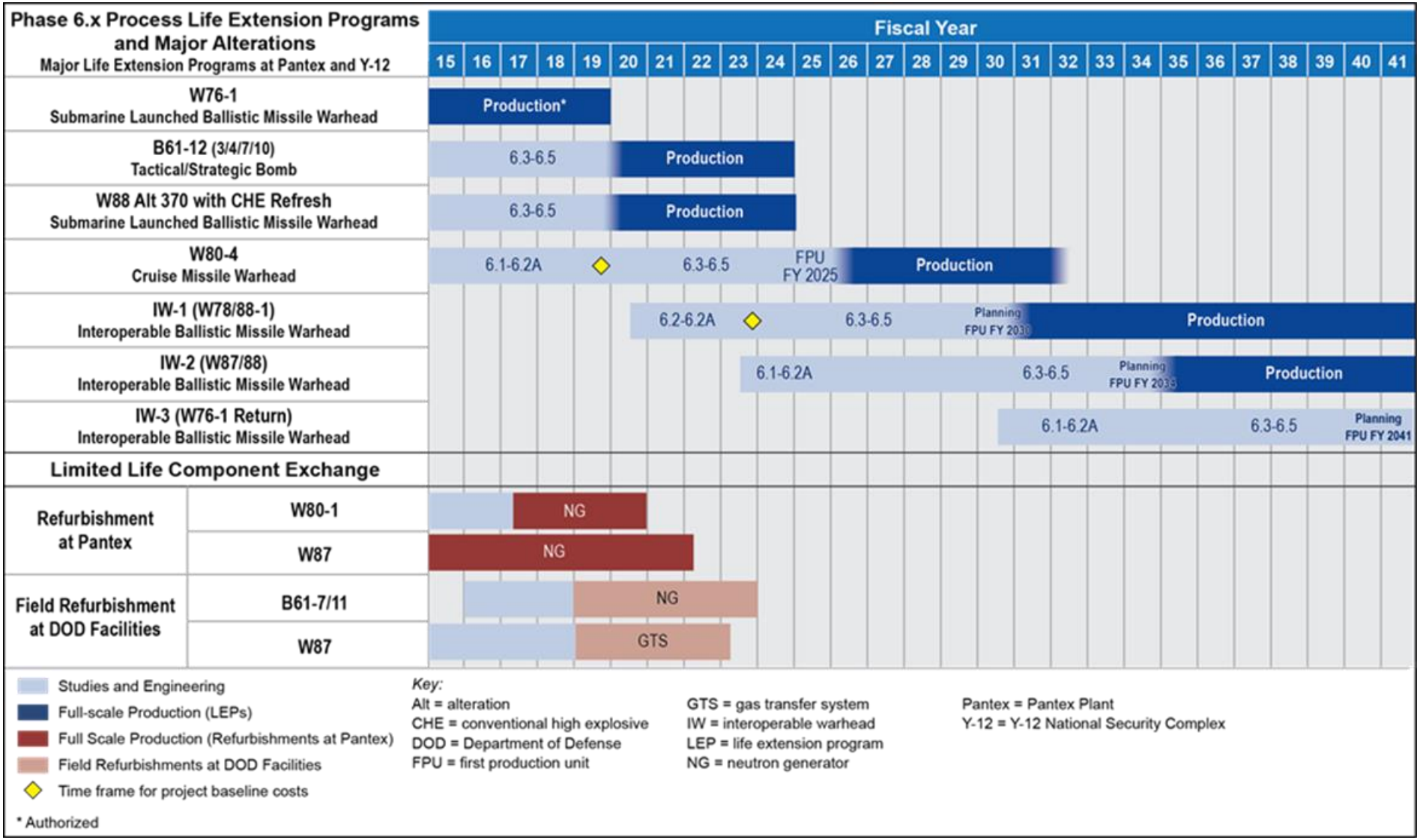
Secure Transportation

- Safely and securely ship nuclear weapons, weapons components, and special nuclear material
- Defend, recapture, and recover nuclear materials in case of an attack
- Ensure convoy safety and security
- Support increasing shipments demand needed to meet dismantlement and maintenance schedules

Escort Vehicle (EVHC)

Federal Agents

Life Extension Programs Schedule



Nuclear Security Enterprise: Design and Experimental Agencies

Los Alamos National Laboratory

Los Alamos, NM

- 7,574 M&O Employees
- 77 Federal Employees
- Nuclear design/ physics lab
- Pit production
- Pu sustainment
- Design agency for the B61, W76, W78, and W88

Los Alamos NATIONAL LABORATORY

Lawrence Livermore National Laboratory

Livermore, CA

- 5,196 M&O Employees
- 74 Federal Employees
- Nuclear design/ physics lab
- High explosive R&D Center of Excellence
- Design agency for the W80, W87, and B83

Lawrence Livermore National Laboratory

Sandia National Laboratories

Albuquerque, NM and Livermore, CA

- 11,358 M&O Employees
- 84 Federal Employees
- Systems engineering
- Neutron generator design and production
- Non-nuclear component design

Sandia National Laboratories

Nevada National Security Site

Nevada

- 2,426 M&O Employees
- 76 Federal Employees
- Experimental site
- "Subcritical" nuclear material experiments

NEVADA NATIONAL NNSS SECURITY SITE

Nuclear Security Enterprise: Production Agencies

Pantex Plant

Amarillo, TX

- 3,246 M&O Employees
- 61 Federal Employees
- Weapons assembly/ disassembly
- High explosive production Center of Excellence

Y-12 National Security Complex

Oak Ridge, TN

- 4,501 M&O Employees
- 65 Federal Employees
- Uranium component and sub-assembly production
- Uranium Center of Excellence

Kansas City National Security Campus

Kansas City, MO

- 2,574 M&O Employees
- 38 Federal Employees
- Nonnuclear component manufacturing/ procurement

Savannah River Site

Aiken, SC

- 1,641 M&O Employees
- 25 Federal Employees
- Tritium operations
- TPBAR extraction
- Reservoir change-out

Managed under the NNSA Production Office (NPO)

Major FOAs:

- **SSAA, HEDLP, NLUF**
  - **Main Objectives:** Develop and maintain a long-term recruiting pipeline supporting the DOE/NNSA laboratories by training and educating the next generation of scientists in fundamental research of relevance to stockpile stewardship goals, and to provide access to facilities for hands on training.
  - **Strategic Goal:** "Strengthen key science, technology, and engineering capabilities and modernize the national security infrastructure." Sponsoring research programs at universities and student internships at DOE labs to secure a pipeline of national security professionals is critical to ensuring the intellectual vitality of the national security technical enterprise and a key component of meeting this DOE strategic objective.
  - **Vehicle:** Financial assistance is the appropriate vehicle for this as the primary purpose of the award is to support or stimulate a public purpose, rather than to procure goods and services for the government.
  - **Focus Areas:**
    - SSAA: properties of materials under extreme conditions and/or hydrodynamics (condensed matter physics and materials science, and fluid dynamics); low energy nuclear science; and radiochemistry. Centers include high energy density physics as well.
    - HEDLP: HED Hydrodynamics; Radiation-Dominated Dynamics and Material Properties; Magnetized HED Plasma Physics; Nonlinear Optics of Plasmas and Laser-Plasma Interactions; Relativistic HED Plasmas and Intense Beam Physics; Warm Dense Matter; High-Z, Multiply Ionized HED Atomic Physics; Diagnostics for HED Laboratory Plasmas
    - NLUF:
  - **Metrics to Measure Success:** Accomplishment of Milestones

Major FOAs

- **PSAAP**
  - **Main Objective:** Support fundamental science at U.S. Universities in the emerging field of predictive science. Predictive Science is development and application of verified and validated computational simulations, in a high-performance computing (HPC) environment, to predict properties and dynamics of complex systems, with quantified uncertainty.
  - **Strategic Goal:** To engage the U.S. academic community in advancing the field of predictive science and science-based modeling and simulation technologies.
  - **Vehicle:** Financial assistance is the appropriate vehicle for this as the primary purpose of the award is to support or stimulate a public purpose, rather than to procure goods and services for the government.
  - **Focus Areas:** These Cooperative Agreements are either a Multidisciplinary Simulation Center (MSC) or a Single-Discipline Center (SDC) that work toward solving a problem that advances basic science/engineering and Verification & Validation (V&V)/Uncertainty Quantification (UQ), and contribute toward achieving effective exascale computing, to demonstrate predictive science in an HPC environment.
  - **Metrics to Measure Success:** Accomplishment of Milestones

Major FOAs

- **MSIPP**
  - FY 2018 will be the first FOA issued for this program. In the past the awards have been noncompetitive.
  - **Main Objective:** To build a sustainable pipeline between DOE labs, plants and sites and talent from the nation's Minority Serving Institutions (MSIs) in STEM disciplines.
  - **Strategic Goal:** "Strengthen key science, technology, and engineering capabilities and modernize the national security infrastructure." Sponsoring research programs at universities to secure a pipeline of national security professionals is critical to ensuring the intellectual vitality of the national security technical enterprise and a key component of meeting this DOE strategic objective.
  - **Vehicle:** Financial assistance is the appropriate vehicle for this as the primary purpose of the award is to support or stimulate a public purpose, rather than to procure goods and services for the government.
  - **Focus Areas:** Increasing the STEM/Research capacity and infrastructure at the MSI level; providing students with a access to world-class resources and research opportunities; pipeline to DOE/NNSA sites.
  - **Metrics to Measure Success:** Accomplishment of Milestones

Note: The Minority Serving Institutions Partnership Program (MSIPP) is a stand alone program managed by NNSA's Office of Learning and Career Management (NA-MB-40) and is not a part of the Stewardship Science Academic Alliances (SSAA) Program. In FY 2016 Congress combined the funding for the SSAA Program and the MSIPP program into the *Academic Alliances and Partnerships* budget line.

Major Non-Competitive: Fellowships

- **SSGF and CSGF**
  - **Main Objectives:** Develop and maintain a long-term recruiting pipeline supporting the DOE/NNSA laboratories by training and educating the next generation of scientists in fundamental research of relevance to stockpile stewardship goals.
  - **Strategic Goal:** "Strengthen key science, technology, and engineering capabilities and modernize the national security infrastructure." Sponsoring Fellowships to secure a pipeline of national security professionals is critical to ensuring the intellectual vitality of the national security technical enterprise and a key component of meeting this DOE strategic objective.
  - **Vehicle:** Financial assistance is the appropriate vehicle for this as the primary purpose of the award is to support or stimulate a public purpose, rather than to procure goods and services for the government.
  - **Focus Areas:**
    - SSGF: properties of materials under extreme conditions and/or hydrodynamics (condensed matter physics and materials science, and fluid dynamics); low energy nuclear science; and high energy density physics.
    - New traineeship aspect
    - CSGF: fields of study that utilize high performance computing to solve complex problems in science and engineering.
  - **Metrics to Measure Success:** completion of fellowship, hires to labs and academia.

Approximately half of the 30 alumni from the SSGF program have gone on to careers at one of the national laboratories or other government agencies

Major Non-Competitive: Cooperative Agreements

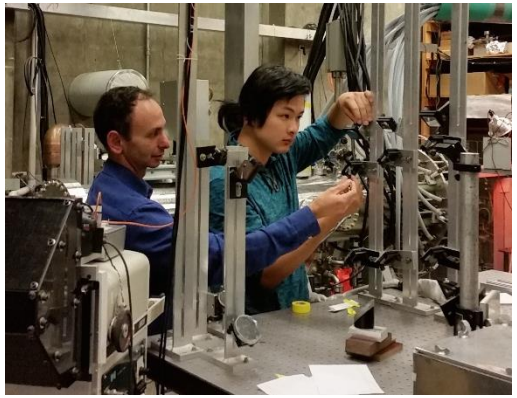
- **Dynamic Compression Sector (DCS)** – cooperative agreement with Washington State University
  - Focus Area: DCS at the Advanced Photon Source, has a focus on time-resolved X-ray diffraction and imaging measurements in materials subjected to dynamic compression.
- **High Pressure Collaborative Access Team (HPCAT)** – cooperative agreement with Carnegie Institute of Washington
  - Focus Area: HPCAT at the Advanced Photon Source, has a focus on advancing fundamental knowledge of the behavior of materials central to the NNSA science mission in a broad range of environments, such as pressure, temperature, radiation, and deviatoric stress, including both static and dynamic phenomena.
- Main Objectives: Develop and maintain a long-term recruiting pipeline supporting the DOE/NNSA laboratories by training and educating the next generation of scientists in fundamental research of relevance to stockpile stewardship goals, and to provide access to facilities for hands on training.
- Strategic Goal: "Strengthen key science, technology, and engineering capabilities and modernize the national security infrastructure."
- Vehicle: Financial assistance is the appropriate vehicle for this as the primary purpose of the award is to support or stimulate a public purpose, rather than to procure goods and services for the government.
- Metrics to Measure Success: Accomplishment of Milestones

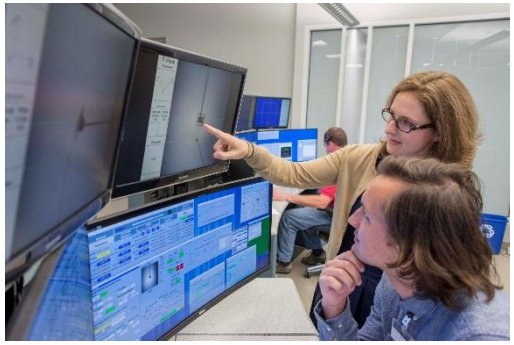
Major Non-Competitive: Cooperative Agreements

University of Rochester Laboratory for Laser Energetics (UR-LLE)

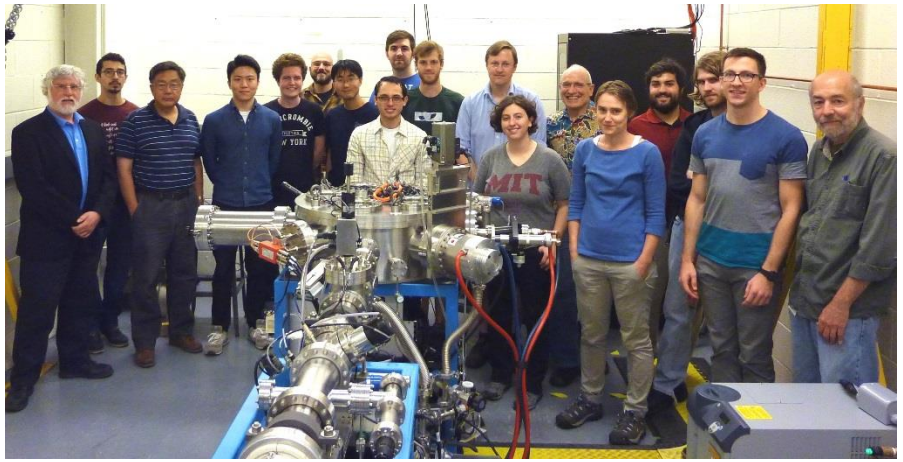
- Main Objectives: Develop and maintain a long-term recruiting pipeline supporting the DOE/NNSA laboratories by training and educating the next generation of scientists in fundamental research of relevance to stockpile stewardship goals, and to provide access to facilities for hands on training.
- Strategic Goal: "Strengthen key science, technology, and engineering capabilities and modernize the national security infrastructure."
- Vehicle: Financial assistance is the appropriate vehicle for this as the primary purpose of the award is to support or stimulate a public purpose, rather than to procure goods and services for the government.
- Metrics: Accomplishment of Milestones

Academic Alliances Programs
High Energy Density Laboratory Plasmas

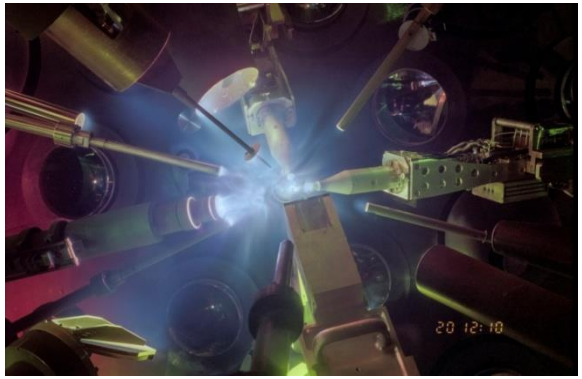




- The Interagency Task Force on HEDP charted a path to coordinate HEDP research across the government
- In response, NNSA and Office of Science established a joint program in high energy density laboratory plasmas in 2008 to steward effectively the emerging HEDP field within DOE
- Some of the areas of interest include high energy density hydrodynamics, radiation-dominated hydrodynamics and material properties, nonlinear optics of plasmas and laser-plasma interactions, and warm dense matter
- Currently there are 10 NNSA funded grants



Academic Alliances Programs
National Laser Users' Facility

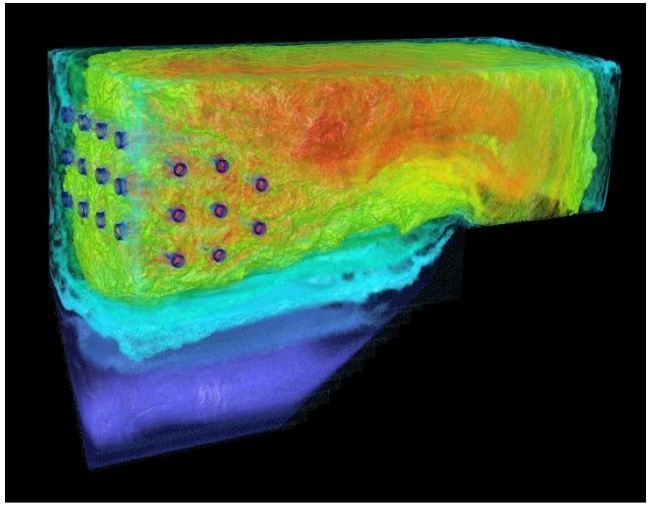


- NLUF program was established in 1979 for the primary purpose of providing facility time for university- and business-led high energy density experiments on the Omega Laser Facility
- Currently, approximately 15% of the Omega Facility time is devoted to NLUF
- The objective of the National Laser Users' Facility is to make one of NNSA's major high energy density facilities, Omega, accessible to a broad community of academic and industrial research interests, for use:
  - As a tool for conducting basic research experiments in both low and high energy density physics and laser-matter interactions; and
  - In providing research experience necessary to maintain a cadre of trained scientists to meet the nation's future needs in these areas of science and technology.
- Currently there are 13 NNSA funded grants

Academic Alliances Programs
Minority Serving Institutions Partnership Program

- The MSIPP was initiated through eight non-competitive grants totaling $4M that were awarded in FY12 to encourage establishment of Minority Serving Institutions (MSI) and Lab/Plant collaborations to foster the growth of consortia components that include pipeline and curriculum development, research and student internships.
- MSIPP was designed to build a sustainable pipeline between DOE's sites and laboratories and Minority Servicing Intuitions in the science, technology, engineering and mathematics (STEM) disciplines and bring a heightened awareness of NNSA plants and laboratories to MSIs. The partnerships also provides STEM students with the cutting edge resources and technology housed at DOE facilities, ultimately increasing STEM student retention.
- Currently the MSIPP supports six consortium-based teams consisting of participants from select Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), Hispanic Serving Institutions (HSIs), as well as NNSA production facilities and laboratories.

Academic Alliances Programs
Predictive Science Academic Alliance Program



Volume rendered image of the new design of an oxy-coal boiler for high efficiency, low-cost carbon capture. The simulation was performed using CCMSC tools running on Vulcan from LLNL. The visualization was performed using volume-rendering tools developed by the CCMSC visualization team and running in VisIt from LLNL

- The Predictive Science Academic Alliance Program (PSAAP) was established in 2008. PSAAP II began with six, 5-year awards granted in FY14
- The PSAAP II Centers will develop science/engineering models and software for large-scale simulations, and methods in emerging disciplines of verification and validation (V&V) and uncertainty quantification (UQ); computer science research will also focus on resolving issues on the path to exascale computing.
- All NNSA-funded students and post docs work at a NNSA laboratory for a ten-week summer assignment
- The Centers are reviewed annually by teams composed of two researchers from each of the DP Labs
- To date, the Centers have supported more than 175 students, 18 of which have been hired by the national laboratories