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Title: Weapons Engineering and Experiments (ADW) Capability Overview M, J, Q and W Divisions February 7, 2018

Author(s): Metcalf, Mary Melissa

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# **Weapons Engineering and Experiments (ADW)**

## **Capability Overview**

### **M, J, Q and W Divisions**

February 7, 2018

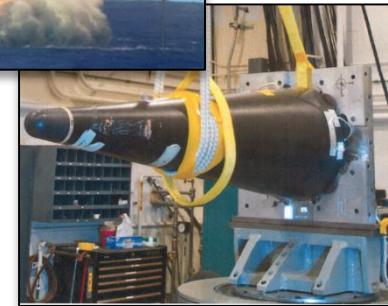
# ADW activities central to the National Stockpile Stewardship Mission

- Annual Weapon Assessments
  - Directors Annual Assessment letter
- Hardware realization of physics concepts and designs
  - LEPs and Alts
  - Concept and stockpile studies – interoperability, HE conversion
  - Systems Engineering and Requirements Management
  - Component Design and Development – GTS, detonators, surety
- Maintenance
  - Surveillance and Issue Response
  - Weapons Safety Assessment and Response
  - Support Production Plants
- Exploration and Validation Experiments
  - Large scale Hydro and Subcritical experiments
  - Smaller scale science- and issue- driven experiments
  - Explosive Science and R&D



# To sustain the stockpile requires a responsive, integrating, management capability

- LANL continues to successfully execute and deliver on multiple weapon program activities – many of which are being run in parallel
  - W76-1/Mk4A LEP
  - B61-12 LEP
  - W88 Alt 370
  - W88 CHE Refresh
  - Alt 940
  - W78 Lifetime Assessment and GTS improvements
  - Hydrodynamic testing
  - Nevada Sub-critical experiments
  - Significant Finding Investigation Resolution
  - Engineering Campaigns
  - Science Campaigns
  - Ongoing Stockpile Stewardship activities such as AAR, SAGSAT, Weapons Response, etc
- Coordinating activities across many capabilities and organizations



# Primary interface between the customers (NNSA and DoD) and LANL

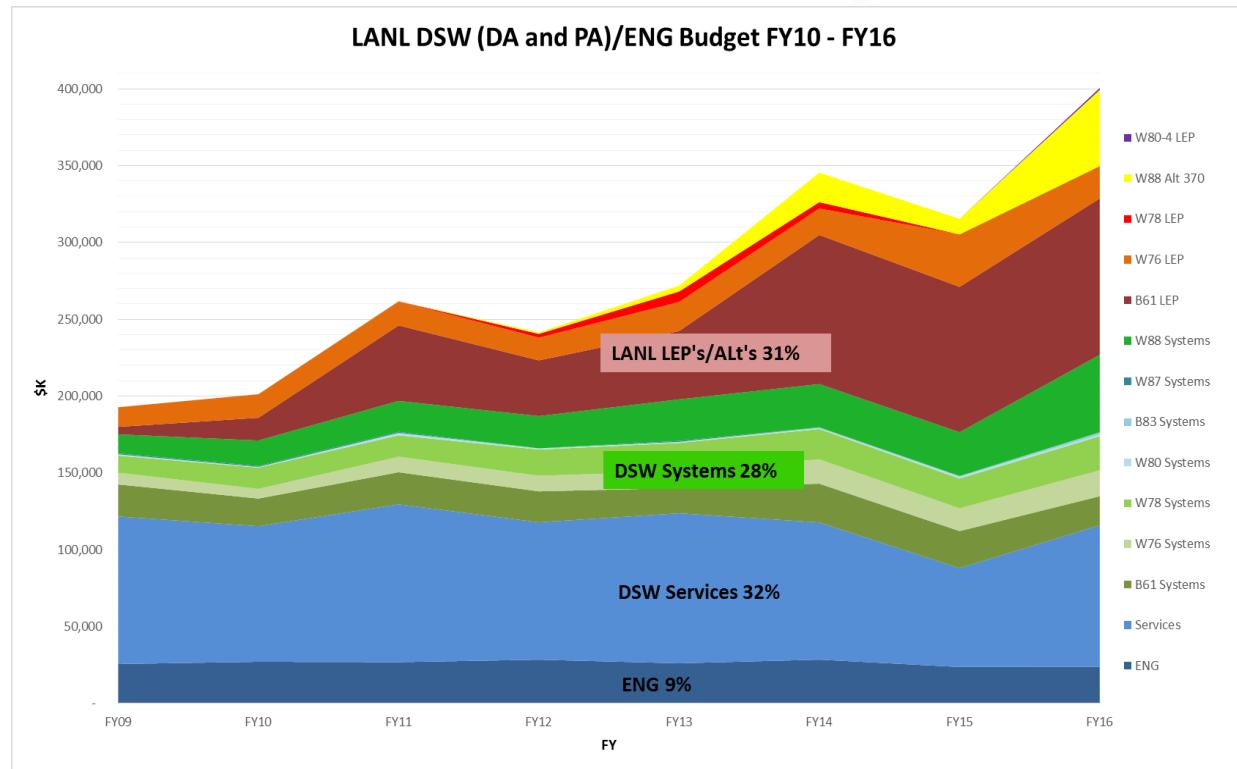
- Program Office responsibility for DSW, LEPs, and Engineering Campaign funding (~\$400M/yr)
- Interface to the Military Services through the Project Officers Groups (POGS)
- Interface to the NNSA through the Federal Program Managers, DSW, Engineering Campaigns
- Relies upon many technical capabilities drawn from across Laboratory to accomplish mission
  - PF Division, X Division, MST Division, AET Division, C Division, MPA Division ...



**Focused on the national Nuclear Weapons mission**

# Weapon Program Activities

- LANL continues to successfully execute and deliver on multiple weapon program activities – many of which are being run in parallel
  - W76-1/Mk4A LEP
  - B61-12 LEP
  - W88 Alt 370
  - W88 CHE Refresh
  - Alt 940



Significant Growth over past five years

# A competent, sustainable workforce is essential to meet future programmatic deliverables

- Workforce Priorities
  - J, M, Q and W Divisions will all have significant attrition over next several years.
  - Q and W Division actively working significant staffing increase to support Programmatic increases
  - J Division anticipates growth to support ECSE
- Using all available recruiting and hiring vehicles
  - Directed transfers
  - Partnering with other divisions to take on unfunded staff with applicable expertise
  - UGS, GRA and Post Doc conversions
  - External and Student Hires

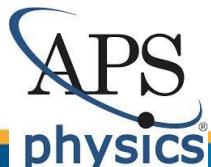
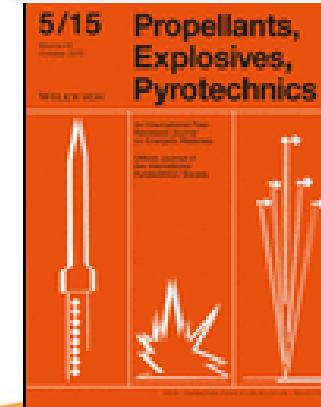
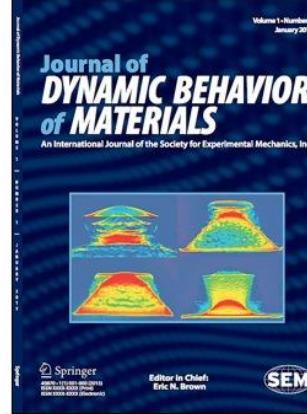




# Explosive Science and Shock Physics (M), Eric Brown

# M Division activities central to the National Science Based Stockpile Stewardship Mission

- David Chavez [2011 DOE Lawrence Awards]: For his discovery of new chemical synthetic schemes used to advance development of fundamentally novel, highly energetic, environmentally friendly (high-nitrogen) molecular materials important to national security missions.
- APS Fellows:
- Anderson, William [2012]: For significant contributions to the field of dynamic material properties research, and specifically for achieving a better understanding of the dynamic response of geophysical, planetary, and materials of importance to national security.
- Aslam, Tariq [2015]: For groundbreaking contributions to the computational physics of detonations and shock waves, including co-inventing the ghost fluid method, mapped weighted essentially non-oscillatory schemes, Runge-Kutta-Legendre time integration, and applications of level set methods.
- Dattelbaum, Dana [2014] : In recognition of her pioneering studies of dynamic properties and excited state behavior of materials using advanced diagnostics techniques and for her leadership and service to the Society and the Shock Physics community.
- Hixson, Robert S. [2006]: For sustained technical contributions towards dynamic properties measurements on materials of broad scientific importance and vital interest to national defense needs, and for leadership in the field of shock physics.
- Moore, David Steven [2004]: For breakthroughs in the use of nonlinear optical and ultrafast spectroscopies to understand the behavior of molecules under shock compression.
- Sheffield, Stephen A. [2005] : In recognition of his contributions to shockwave physics and in particular his development and implementation of the ORVIS interferometer for measuring kinetics and CJ parameters of detonating explosives and his studies of reactions in shocked liquid CS<sub>2</sub>.



**ARTICLE**  
Received: 19th Oct 2013; Accepted: 27th Oct 2014; Published: 4 Dec 2014  
Ultrafast visualization of crystallization and grain growth in shock-compressed SiO<sub>2</sub>  
A.J. Gleason<sup>1</sup>, C.A. Boller<sup>1</sup>, H.L. Jia<sup>1</sup>, B. Nagel<sup>1</sup>, E. Galtier<sup>2</sup>, D. Mihailovic<sup>2</sup>, J. Hanevik<sup>2</sup>, R.G. Kneller<sup>2</sup>,  
J.H. Eppel<sup>2</sup>, D.E. Pinen<sup>2</sup>, G.W. Coyle<sup>2</sup>, R. Soderbom<sup>2</sup>, M. Yeung<sup>2</sup> & W.L. Marshall<sup>2</sup>

Pressure and temperature induced phase transitions have been studied for more than a century, but very little is known about the non-equilibrium processes by which these transitions occur. Here we report the first visualization of the crystallization and grain growth in shock-compressed silica at its Key Efficiency (KEO) pressure by the time-dependent atomic arrangements of the individual atoms. The visualization is obtained by using a high-resolution, fast-axes imaging system, enabling an approach to creating high-pressure shock-wave driven anisotropic grain growth. The visualization shows that the grain size increases with increasing pressure above 16 GPa if the nucleation of anisotropy appears to be kinetically limited to 16 GPa. The visualization also shows that the grain size increases with increasing pressure and that the growth mechanism is the same for all pressures. These are the first observations of crystalline grain growth in the shock between low- and high-pressure zones via XRD.

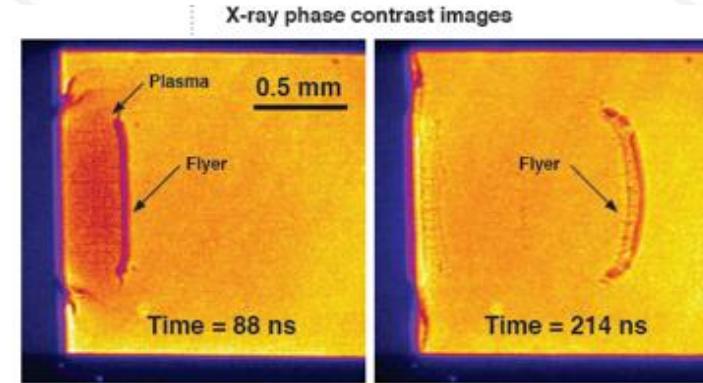
© 2014 Gleason et al. This article is published under the terms of the Creative Commons Attribution License. Use is permitted for non-commercial purposes, and a link to this article or journal is required for reuse.

# We maintain a full suite of test fire capabilities to meet our national security missions

Used for energetics and inerts R&D characterization, performance, safety, and application testing

Small- to large-scale characterization and test capabilities, e.g

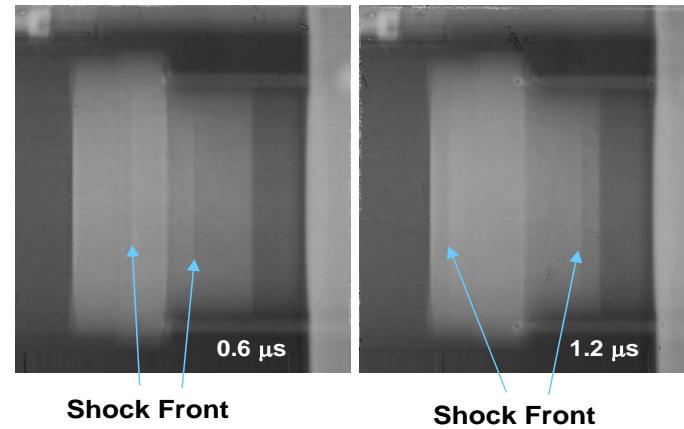
- Multiple Boom boxes
- 10 lb @ TA-40 Chamber 8
- 2000 lbs @ TA-39
- Collaborations at other facilities, including pRad at LANSCE, MEC at LCLS, and DC-CAT at APS



Movies of exploding bridge wire detonators



Ancho Canyon Point 88  
HE Pulsed Power Facility



# We investigate a wide range of shock and detonation physics problems

- Capabilities and expertise for SNM, inerts, and HE
- Supports designers' QMU requirements and predictive needs
  - Shock response:
    - Spall and strength
    - Shock initiation to detonation
    - EOS data
- Nuclear weapon HE requirements span a wide range of performance and safety issues from cradle-to-grave
- Proximity and access to LANL's diverse technical expertise has lead to significant innovations and broad range of applications



Gas Guns Capability  
1 to 8 km/s



# Explosives are central to LANL mission and National Security

- Current and Future stockpile: Assessment and certification, LEPs, aging, material replacement, IHE transition, enhanced surety
- Global threats: awareness, assessment, detection, disablement

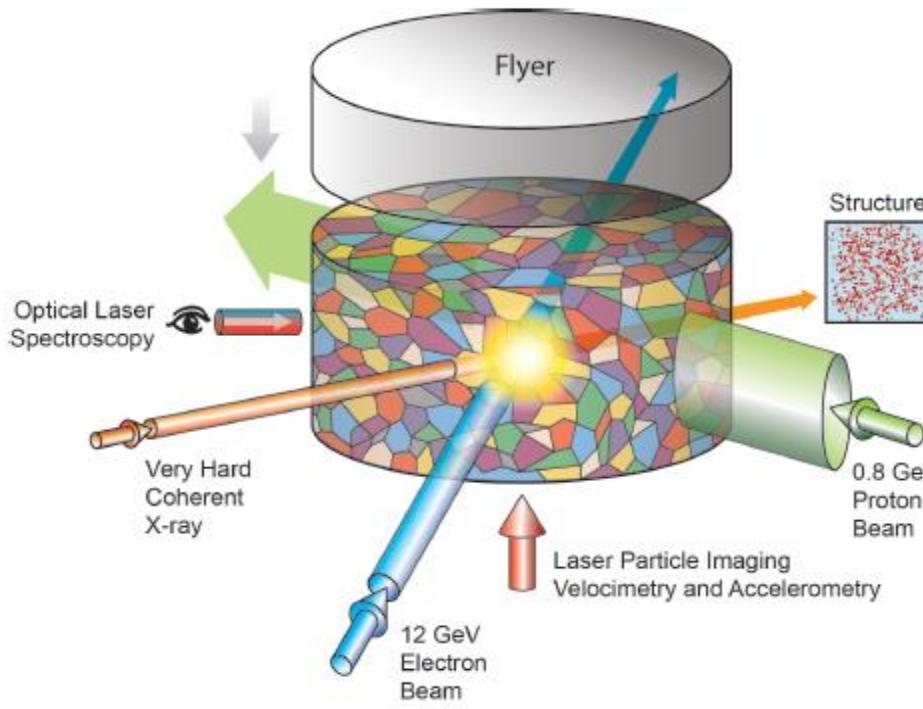
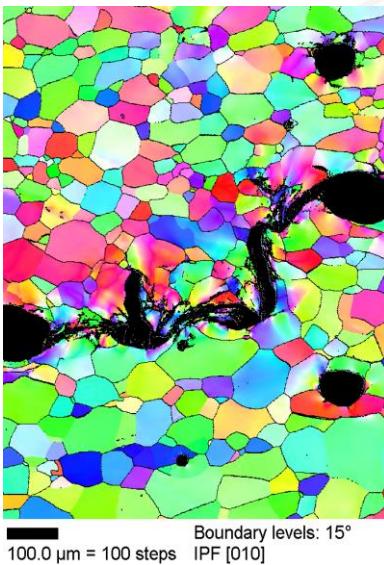


# The NEW Dynamic Equation of State (DEOS) Facility is crucial to the stockpile

- Currently planned and funded by RTBF Recapitalization (GPP)
- Gas gun tools and diagnostics are fundamental to modern and future stockpile They deliver high precision material compressibility data, or “equations of state” (EOS) used in all engineering, performance, and safety models
  - EOS and dynamic behavior of all inert, SNM, and explosive materials
  - EOS, dynamic, and initiation behavior of explosives
- These tools are utilized at historic levels to gather this data
- Current capabilities are housed in antiquated, substandard structures spread to the far boundaries of LANL
- Consolidation in modern facilities will
  - Enable operational efficiencies
  - Facilitate technical interaction
  - Maximize delivery of crucial data
  - Reduce operational costs
  - Reduce operational downtime



# The challenge is to observe the dynamic microstructure and phase evolution in materials down to the sub-granular level while connecting to the macroscale



**Requirements:**  
Sub-mm space resolution  
100's – 1000's-mm samples  
Sub-ns time resolution,  
~30 frames in  
1–10-ms duration

**The model:**  
Accurate sub-grain models of microstructure evolution coupled to molecular dynamics

## The goal

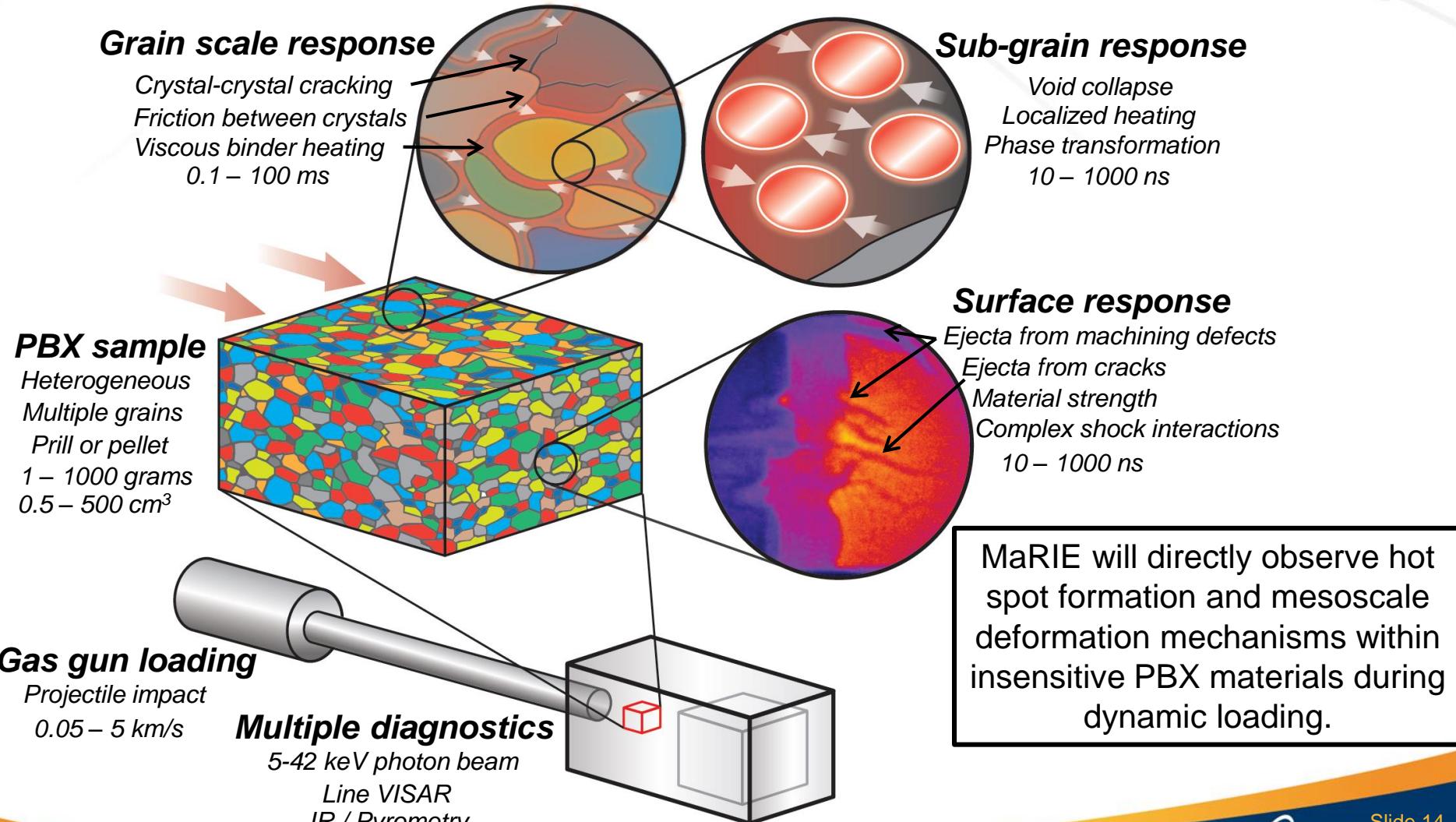
Predict dynamic microstructure and damage evolution

## The first experiment

Multiple, simultaneous dynamic *in situ* diagnostics with resolution at the scale of nucleation sites (< 1 mm; ps – ns)

***MaRIE allows us to break apart the problem***

# MaRIE allows *in situ* study of hot spot formation and other microstructural phenomena





# **Weapons Stockpile Modernization (Q), Rob Bishop (acting)**

# **Weapon Systems Engineering (W), Patrick Garcia**

# Nuclear Weapon Mission

- **Core LANL Mission:** Ensure that LANL is a trusted Nuclear Design Agent with capabilities that support the National Deterrence Posture of the United States
- **Weapon Stockpile Modernization (Q Division)**
  - Focus on stockpile “modernization”
  - Weapon LEPs and ALTs
  - Development of new technologies and capabilities for the future stockpile
- **Weapon System Engineering Division (W Division):**
  - Focus on stockpile “sustainment”
  - Critical activities that sustain the stockpile at LANL and across the complex to assure the real-time safety, security and reliability
  - Division will continue to focus on capabilities that support the stockpile

# LANL is the design laboratory for the majority of the Nation's on-alert deterrent

- LANL has design and stockpile maintenance for four Nuclear Weapon Systems (W Division)

- B61-3,4,7,10,11, and 12
- W76-0/Mk4 and W76-1/Mk4A
- W78-0/Mk12a
- W88-0/Mk5



- Q Division is working on Life Extension Programs (LEP) for several weapon systems

- B61-12 LEP – currently in design and development
- Long Range Stand-off (LRSO) Cruise Missile Feasibility Evaluation (W80-4)

- W Division has Systems Engineering and Program Management responsibility for:

- B61-3,4,7,10,11, and 12
- W76-0/Mk4 and W76-1/Mk4A
- W78-0/Mk12a
- W88-0/Mk5



# Q and W Division are central to the National Nuclear Stockpile Stewardship Mission

- The Weapons Stockpile Modernization Division is focused on new technologies and capabilities for the future stockpile
  - Global Security
  - Lead Weaponization of Physics Designs
    - B61 Alt 357, B61-12 LEP, W76 LEP, W88 Alt 370
    - Concept development and stockpile studies
- The Weapon Engineering capability supporting the enduring stockpile and associated integrated experiments at LANL is organized predominately within the Weapon Systems Engineering Division
  - Annual Assessment (larger category of work)
  - Stockpile Maintenance
    - Surveillance and Production
    - Weapon Response
  - Experimental Projects and Programs
    - Small and Large-scale Hydrodynamic testing
    - Science Campaigns – Sub-critical (Gemini)
- The Weapons Program relies upon many other technical capabilities drawn from across Laboratory to accomplish mission
  - Many areas are significantly funded by weapons program through weapon engineering

# Systems Engineering Leadership and Program Management of LANL weapon systems in the current and future stockpile

- **Lead weaponization of physics designs**
  - Engineering design and development
    - B61-Alt 357, B61-12 LEP, W76 LEP, W88 Alt 370
  - Requirements Management including Interface control with other agencies
  - Qualification to MC and STS environments (testing and computational simulation)
  - Component design and development (GTS, detonators)
  - Nuclear safety, weapon response for Pantex
  - Surety assessments, design and development
  - Design Definition
- **Advanced concept development**
  - W78/W88-1 Phase 6.2/6.2A Ballistic Missile Warhead feasibility evaluation and cost study
  - Long Range Stand-Off Cruise Missile

# Support to experimental programs that underpin advancements in weapon scientific knowledge

- **Subcritical tests at U1a (underground test facility)**
  - Engineering design, fabrication and assembly of Gemini experiments (dynamic plutonium experiments)
- **Integrated Hydrodynamic tests at Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility and Lawrence Livermore National Laboratory (LLNL)**
  - Hydro device assembly engineering
  - Fielding of the devices at DARHT
  - Integration of advanced diagnostics – Photon Doppler Velocimetry (PDV)
- **pRad experiments at Los Alamos Neutron Science Center (LANSCE)**
- **Containment and confinement vessel engineering**
- **Planning and program management**
- **Design and analysis of Large Bore Powder Gun**

**Engineering of both small high-precision, high-fidelity systems and large scale systems are required to support experimental activities**

# Stockpile Maintenance and Weapon Systems Quality

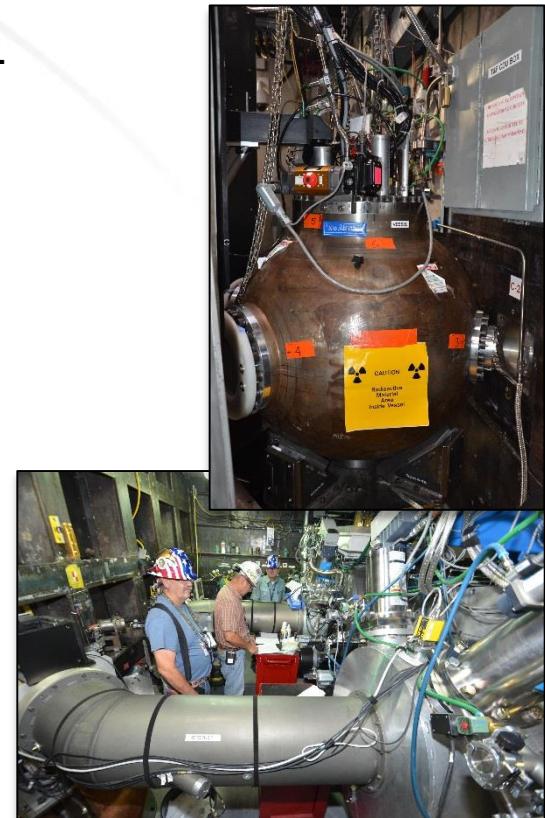
- **Design Agency responsibility**
  - Production plant interfaces
  - Configuration management of design definition
- **Weapon Systems Engineering and Experimental Quality**
  - QC-1 compliant engineering processes
  - Production Plant Qualification Engineering (QE) activities
  - Overall W Division quality program requirements and standards
- **Surveillance**
  - Continuous evaluation of weapon system health
  - Deployment of new technologies to better evaluate warhead (WH) health
- **Dismantlement**
  - Safe and secure dismantlement of retired nuclear weapon assets



# Integrated Weapons Experiments (J), Chuck Mielke

# Experiments advance understanding of weapons performance

- Integrated Hydrodynamic tests at DARHT and LLNL
  - Hydro device assembly engineering
  - Fielding of test devices at DARHT
  - Integration of advanced diagnostics - MPDV
- Subcritical tests at U1a in Nevada at NNS
- pRAD experiments at LANSCE
- Small scale explosive testing
- Containment and confinement vessel engineering
- Design and analysis of testing platforms
- All of these activities are formally planned and managed



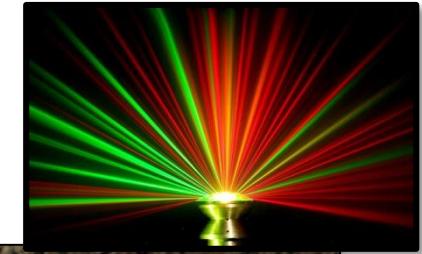
# DARHT world class imaging supporting the national security missions of LANL

- World class X-ray radiography for non-nuclear tests
- Axis 1 single image
- Axis 2 four images
- Experiments fully contained to reduce environmental impacts and increase shot rate



# The weapons program has set a goal to consistently execute 10 hydrotests at DARHT each year

- Execution of 10 hydrotests per year requires a well integrated program
  - Involves close coordination between X, J, M, Q and W Divisions
  - Development of an integrated experiment design process that ensures the test device meets physics design requirements
- Significant progress in fabrication and assembly of hardware
  - Investments in prototype fabrication, PF Division
- Improvements in design and engineering have saved significant time and money
  - Transition from pins to “universal” off-the-shelf MPDV
  - Reduced design timeline and a focus on design manufacturability
- Multiyear Plan for DARHT equipment and people



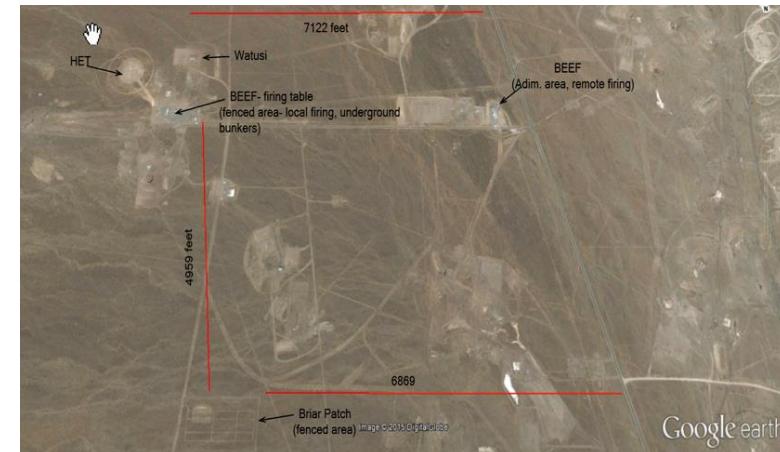
# Robust HE Fabrication Capabilities

- Primary Goal: Support all LANL experimental needs with HE & Mock HE pressing, fabrication/machining, and inspection as needed to complete small scale HE experiments, integrated experiments, hydros, sub-critical experiments and joint test assemblies.
- Core Capabilities
  - Pressing, Cutting/Sawing, Machining, Inspection
- Typical Products
  - Plane wave lenses, line-wave generators, bulk pressings, mock pressings
  - Machined components
  - Component radiography, density measurement & dimensional inspection



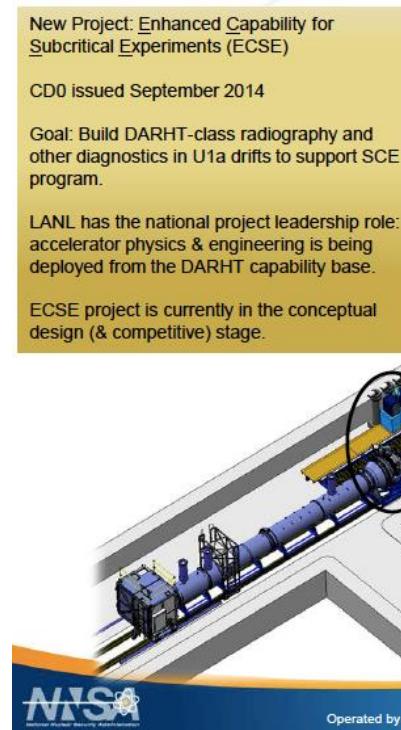
# NNSS as a venue for LANL Outdoor Explosives Operations

- J-div & JLON white paper, Aug 2015
  - NNSS SWEIS, on-the-ground facts
- Proposal: Develop and implement processes by FY17 to sustainably and cost-effectively campaign 10-20 shots/year at NNSS
- Shot scope:
  - GS and other non-WP (e.g. HELIOS)
  - Dismantlement/Disposition shots
  - Hard-to-confine DU-bearing shots
  - SCE vessel operations (proof testing and clean-out)
- Implementation
  - BEEF w/LANL secondary REOP and NSTec site stewards using their RTBF
  - Develop paperwork in FY16, execute HELIOS shots FY17
  - Campaign mode, portable instrument trailers or BEEF bunker
  - Organization details (J-3, J-EI, J-LON)



# ECSE radiography machine development

- New project office in J-div to manage tri-lab effort
  - \$17M FY16, \$5M @ LANL
  - Acting assignments for 6-months, then consider project viability
- International collaboration initiated
- Immediate need to identify lab space for tech. development & test-stands
  - RSL needed for DARHT
  - R-185: \$2.5M needed in FY16



# A competent, sustainable workforce is essential to meet future programmatic deliverables

- Workforce Priorities
  - J, M, Q and W Divisions will all have significant attrition over next several years.
  - Q and W Division are actively working significant staffing increase to support Programmatic increases
  - J Division anticipates growth to support ECSE
- Using all available recruiting and hiring vehicles
  - Directed transfers
  - Partnering with other divisions to take on unfunded staff with applicable expertise
  - UGS, GRA and Post Doc conversions
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