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Title: Associate Laboratory Directorate for Weapon Physics (ALDX)

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Intended for: Overview of ALDX for LANL postdocs

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Associate Laboratory Directorate for Weapon Physics (ALDX)



Kimberly Scott, ALDX

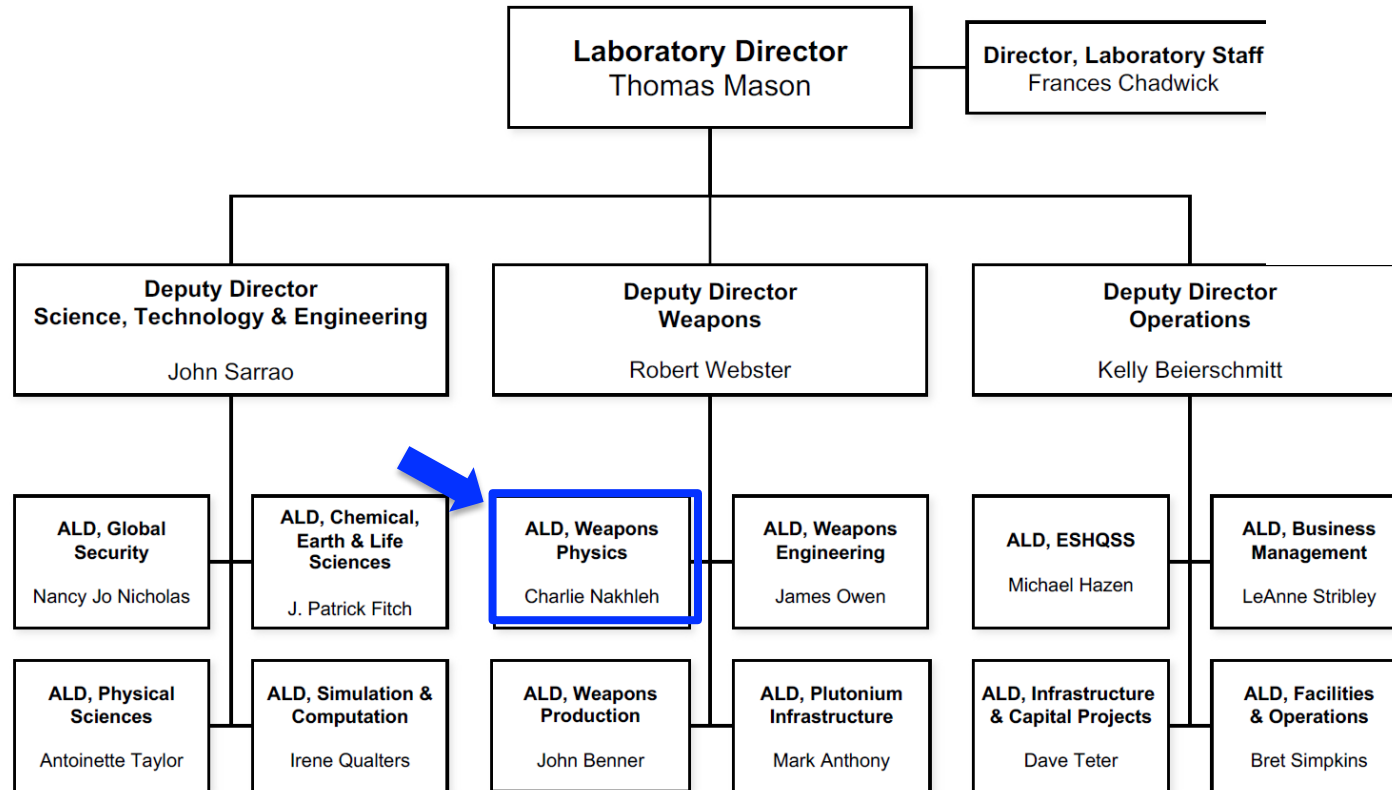
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Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

ALDX is one of seven technical Directorates at the Laboratory and resides within the Weapons Program

Los Alamos National Laboratory



X: A Reminder of the Directorate's History!

**X DIVISION
AT THIS NEW MEXICO
NATIONAL LAB
IS THE USA'S CENTER
FOR THE PHYSICS OF
NUCLEAR WEAPONS**

NEWS
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The Weapons Physics Directorate stewards a number of critical capabilities to meet its mission.

ORGANIZATIONS

X Theoretical Design Division

- Employs theoretical, numerical, and experimental tools and methods to understand nuclear weapon design, performance, safety, and nuclear threats.

X Computational Physics Division

- Develops, integrates, and delivers LANL's mission-critical modeling and simulation software.

Weapons Research Services Division

- Preserves and safeguards nuclear weapons knowledge for tomorrow's innovations.

PROGRAMS

Advanced Simulation and Computing Program

- Develops the tools to underpin the use of simulations with confidence in assessing the current and future stockpile.

Office of Experimental Sciences

- Develops and fields experiments that underpin our modeling capability.

Engineering and Technology Maturation

- Develops technologies, tools, and capabilities to promote future nuclear deterrence.

Budget of \$450M: 75% funding goes outside of ALDX; Supports work in 50% of LANL's Divisions

Our mission is to sustain the resilience of the US nuclear stockpile and help shape a globalized nuclear world.

1. Sustaining the stockpile

- How long can the current stockpile be sustained?
- What are its failure modes?
- What are options that can be developed and certified without the need for further nuclear testing?

2. Shaping a globalized nuclear world

- What are other countries pursuing regarding nuclear weapons?
- What are potential developments (avoidance of technological surprise)?
- What response options should the US have available?



The DARHT facility provides world-class radiography for non-nuclear tests. Experiments are fully contained to reduce environmental impacts.

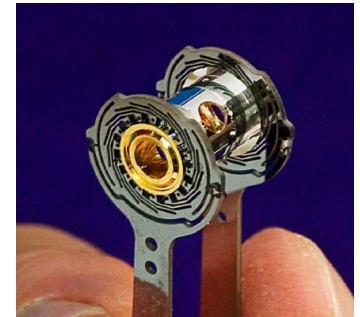


1. Sustaining the aging stockpile poses scientific challenges to assess and certify the stockpile without testing.

- **Since 1992, the US has not tested nuclear weapons. A sophisticated national program of stockpile stewardship has been developed over the past 30 years to underpin confidence in our nuclear deterrent.**
 - **Experiments:** Thousands of experiments are conducted annually to further our understanding of the science of nuclear weapons.
 - **Modeling and Simulation:** World-class computing hardware, software, and multi-physics codes are used to assess the current stockpile and design new weapons that may never be tested.
 - **Designer Judgement:** Experimental data is used to check judgement and train the next generation of designers.



Large bore powder gun – used to measure differences in performance of weapon materials of interest



High Energy Density experiments – can be used to investigate physics of interest

Why is maintaining the stockpile so challenging?

- Operating conditions of a nuclear weapon exist nowhere else and cannot be replicated in a lab setting.

- Temperatures $> 10^8$ K
- Material velocities $> 10^6$ m/s
- Pressures $> 10^7$ bar
- Time scales $< 10^{-8}$ s



- The problem requires multi-physics, often with non-linear interactions.

2. We are helping to solve major technical challenges in the nuclear global security regime.

- **We are advancing our capabilities for monitoring and countering foreign nuclear weapons programs.**
 - Avoid technological surprise by an adversary
 - Understand alternative methods for manufacturing weapon components
 - Explore production and detection of functional materials (supply chain)
 - Design innovative technologies for disabling nuclear devices
 - Research potential “game changers” for speeding up nuclear forensics



2. Geopolitical realities demand the Laboratory's excellence in providing solutions to national security problems.

- **The nuclear threats faced by the US are evolving rapidly.**
 - Russia
 - China
 - North Korea
 - Nuclear proliferation and nuclear development by non-peer states
- **Potential new offensive nuclear weapons**
 - New ICBMs
 - New air-and ground-launched cruise missiles
 - Hypersonic glide vehicles
 - Nuclear-powered cruise missiles
 - Unmanned aerial vehicles
- **Potential new anti-ballistic missiles**

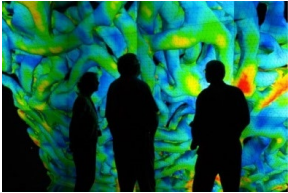


ALDX scientists rely on theory, experiment, & computation

Physics Models
 Numerical Methods
 Computer Science
 Software Development
 Model Validation
 Code & Solution Verification

$$G(\rho, T) = G_0(\rho) \left(1 - \alpha \frac{T}{T_m(\rho)} \right)$$

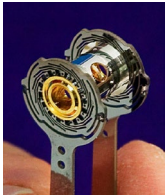
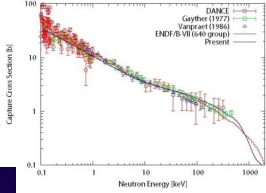
Theory



Computation



Experiment



Extreme material dynamics

High Performance Computing at Los Alamos opens the doors to many sophisticated modeling techniques.

- Petascale supercomputers are critical to Los Alamos' national security mission.
- Trinity, our flagship HPC system, is one of the fastest supercomputers on Earth at ~41 petaflops.

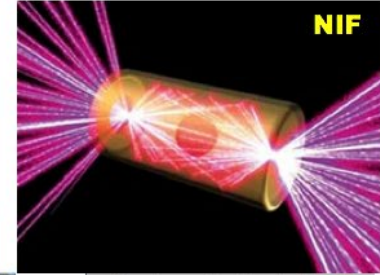


We use many experimental facilities to probe weapons physics

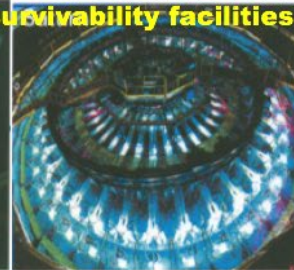
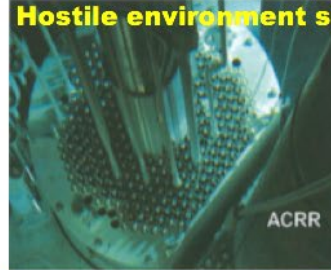


pRad, nuclear X-sections, material research

High-energy density (HED) physics experiments



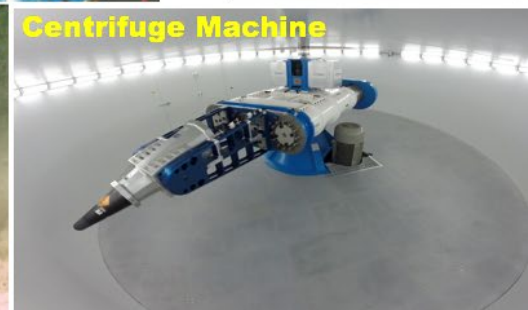
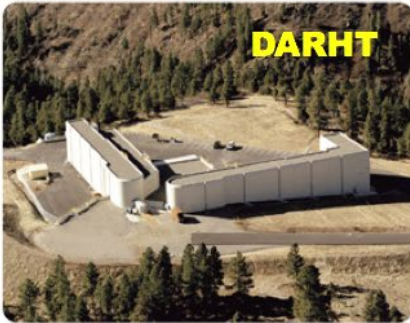
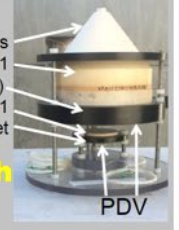
Hostile environment survivability facilities



Shot on the test stand

- P200 PW lens
- PBX 9501
- Ta flyer (1 mm)
- PBX 9501
- SS target

Bench top



In 2021, ALDX performed more than 1000 experiments

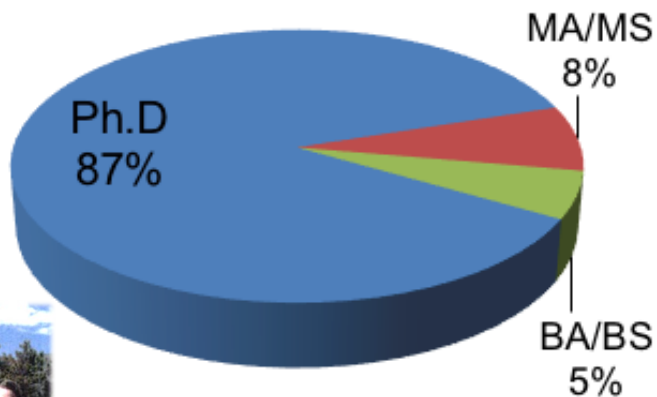
Expertise across many disciplines is crucial to the ALDX mission

- High explosives
 - Detonation characteristics
 - Energetics and equation of state
- Material properties
 - Equation of state
 - Strength and damage
- Hydrodynamics
 - Material deformation, fracture, spall, and ejecta
 - Elastic and plastic flow and friction
 - Laminar to turbulent fluid flow
 - Material mixing and morphology
- Radiation transport
 - Transport methods
 - Opacities
 - Atomic physics
- Nuclear physics
 - Cross sections
 - Reaction rates
 - Energetics
- Thermonuclear physics
 - Plasma physics
 - Reaction rates
 - Charged particle transport

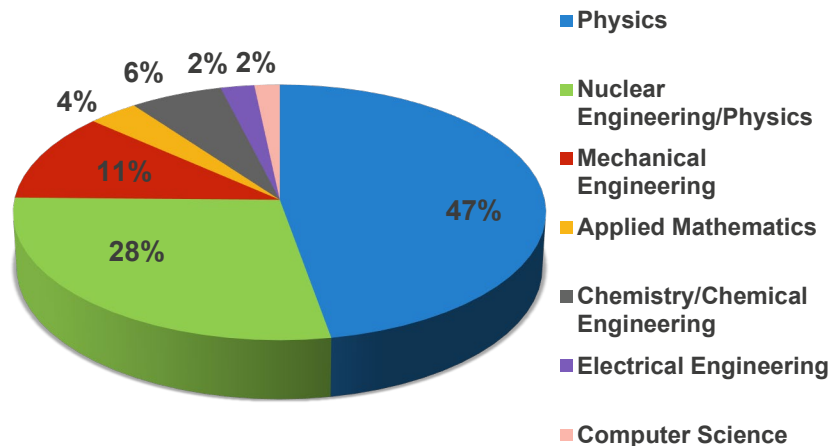
ALDX multi-physics codes model a wide range of relevant physics.

The diverse skill set required to execute ALDX's mission has benefited greatly from the Postdoc program

Highest Degree of our Technical Staff



ALDX PhDs by Discipline



50% of ALDX scientist hires are postdocs from outside the Directorate

Questions?

Feel free to contact me at kscott@lanl.gov.

LANL job board:

- Go to <https://lanl.jobs>
- In the Job Title box, either type in the technical area of interest (physics, chemistry, etc) or select a department (XTD, XCP, etc)
- Postdoc and Scientist 1, 2, and 3 jobs are currently posted

Los Alamos National Laboratory is a national security science resource for the Nation.

- **Established in 1943 as part of the Manhattan Project**
 - Designed, tested, and delivered to the Army Air Corps two weapons that helped end World War II, Little Boy and Fat Man
- **To date, Los Alamos has designed and certified 46 of the 63 nuclear weapons systems put into the US stockpile.**
- **Today's stockpile consists of seven types of weapons.**
 - W76* and W88* are carried on Trident submarines
 - W78* and W87 are carried on ICBMs
 - B61*, B83, and W80* are carried on aircraft
- **Annually, Los Alamos, Sandia, and Lawrence Livermore Labs are legally obligated to report to the President on the state and health of the deterrent.**



** Designed by LANL*

LANL stewards much of the U.S. nuclear stockpile. One of our greatest challenges is mission execution without nuclear testing.

- We are the design agency for 4 of the 7 weapons systems in the U.S. stockpile.
- We are responsible for the safety (accidental detonation), surety (prevention against unauthorized use), and reliability (intentional use) of these systems.



W78 land-based warhead



B61 aircraft-carried bomb



W88 & W76 sub-launched warheads

Robust student and postdoc programs are vital to the ALDX's early-career pipeline.

- **Conversion of postdocs to technical staff is our most highly utilized early career pipeline.**
- **ALDX hosts a post-graduate 3-year classified program called TITANS (Theoretical Institute for Thermonuclear and Nuclear Science). TITANS provides academic-style training in physics, engineering, nuclear science, chemistry, material science, and other areas of relevance to weapons science.**

What to know if you are interested in a career path at Los Alamos

- **Working as a scientist at a national lab offers a lot of flexibility!**
 - Can choose to move around the lab from division to division, changing technical areas.
 - Can choose to stay in one division and focus on one technical specialty for a career.

- **Example: My career path**
 - PhD in computational astrophysics
 - 2 Postdocs (LANL for 1 year)
 - LANL staff on multiple projects for two years
 - Evolved to part-time technical work and part-time project leadership for about 5 years
 - Management (line & program) for 15 years