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Spotlight on National Labs: Lawrence Livermore National Lab

American Nuclear Society Young Members Group Webinar

July 16, 2020

Lawrence Livermore National Laboratory

The Invention of the Modern, "Miniature" Nuclear Weapon

American Nuclear Society LLNL "spotlight" seminars

July 16, 2020

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Lawrence Livermore National Laboratory

LLNL-PRES-898447

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

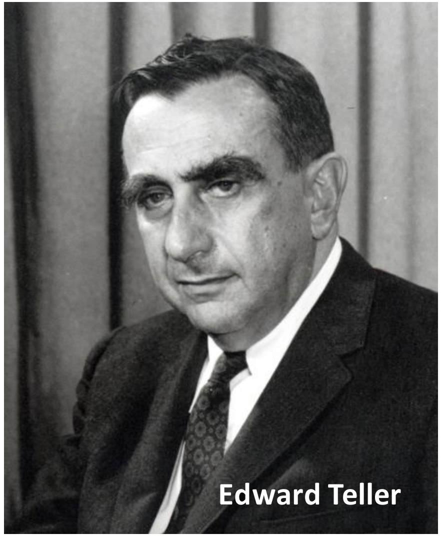
The modern nuclear weapon

- I will present the technical history of the type of weapon that is in the US stockpile today
- You can read all about what Los Alamos did in Rhodes' "The Making of the Atomic Bomb" history of the Manhattan Project and other histories of the atomic bomb
- You can read a description of the formation of Livermore in Rhodes' book "Dark Sun: The Making of the Hydrogen Bomb"
- I'm going to talk about something different, i.e. the ***modern, "miniature" H-bomb*** ***

This was done… at and by Livermore

* * * By "miniature", I mean nuclear weapons that fit in ICBMs, SLBMs, cruise missiles, etc.
i.e. – high yield, compact, light-weight nuclear warheads

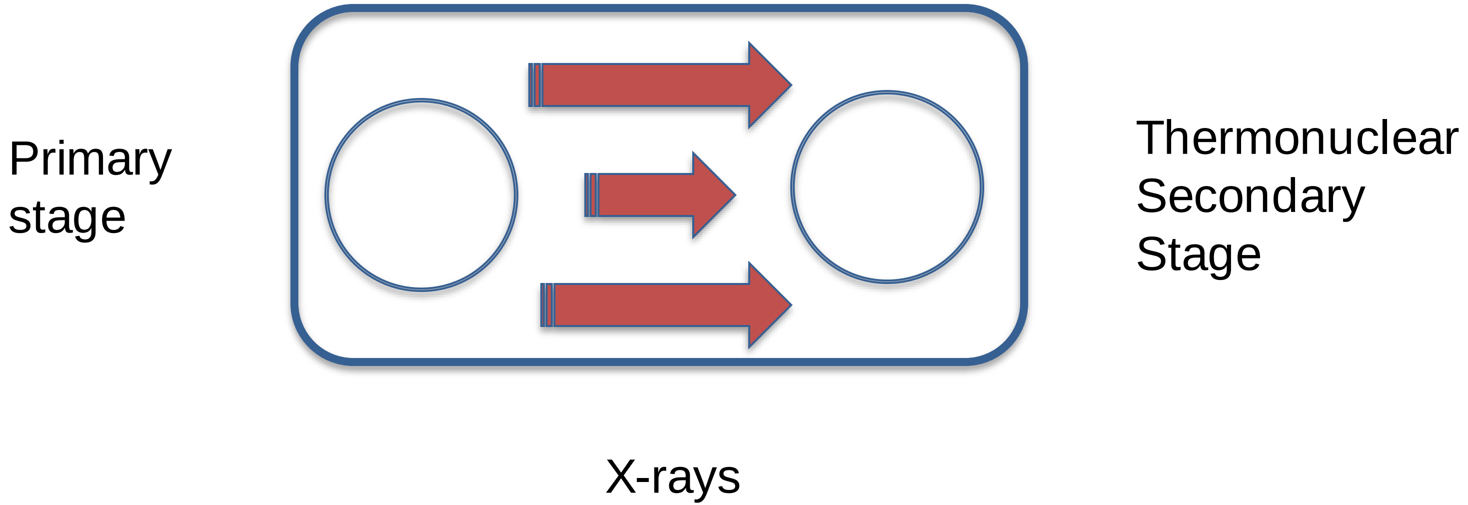
The modern nuclear weapon: step one – the H-bomb



- It all began March 1951 with E. Teller & S. Ulam's paper on coupling X-rays from an exploding A-bomb to ignite a much larger yield fusion second stage
- The key idea, i.e. radiation coupling, was Teller's. Ulam had a different approach that did not work as well. Seems Teller was generous in sharing credit
- Teller worked on fusion during WWII when everyone else was working on fission, e.g. – he proposed boosting in 1946

Teller's dispute over the H-bomb with those like Oppenheimer led Teller to leave the H-bomb project and campaign for a second Lab, i.e. – Livermore

Teller's idea for the hydrogen bomb



Los Alamos steps up to the challenge

Marshall Holloway, director of the Mike Shot, poses (center) in front of the device

- Ironically, the Russian '49 test (& the Fuchs Russian spy affair), Truman's direction to built it, and the formation of Livermore led Los Alamos to accelerate the H-bomb
- E. O. Lawrence opens Livermore on Sept 2, 1952 and Los Alamos tests the 1st thermonuclear (TN) explosive on Nov 1, 1952 using Teller's idea
- BTW/ it was neither a bomb nor a weapon, since it weighed more than 80 tons and required a separate refrigeration plant!

LLNL's 1st three tests (Ruth, Ray & Koon) *failed!*

Tower from the Ruth test. The explosion failed to demolish the tower - Los Alamos referred to it in DC as the invention of the "reusable test tower"!

- Lawrence directed that LLNL *could* do any weapons research deemed important, but *could not* do what LANL was doing
- Teller dominated Livermore's first efforts
- He went down paths for TN weapons different from the original Teller H-bomb idea done at LANL. They were failures
- Livermore failed, repeatedly, and there was a push to close the Lab (e.g. I. I. Rabi at Columbia U. was part of campaign to close LLNL, likely related to Oppenheimer/AEC hearings)

John Foster, Harold Brown and Herbert York's alternate ideas and technical genius saved Livermore and started the advance toward the modern, "miniature" TN explosive

The 1st Modern Nuke & LLNL's 1st successful nuclear test - TESLA

Weapon engineer eating lunch in a '55 Ford 2-door Ranch Wagon in Nevada

March 1, 1955

- **John Foster conceived an entirely new kind of atom bomb - primary. Harold Brown conceived an entirely new kind of H-bomb – secondary.**
- **Because Los Alamos was very busy, they could not lend Livermore the nuclear rated crane to lift devices atop the test tower. Foster improvised two-man rule suitcases to carry it to the tower top to stay on schedule. He made sure that there was a picture of the suitcases – LLNL invents the "suitcase nuke"**

The Navy goes nuclear (strategic): The 1956 Nobska Conference

- August 1956 Navy S&T conference at Woods Hole invited two staff from each of the nuclear Labs
  - Los Alamos sent Harold Agnew and Carson Mark
  - Livermore sent Edward Teller and Johnny Foster

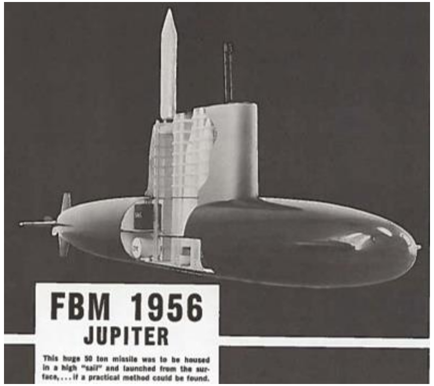
- The Navy planned giant submarines w/ 3 Jupiter missiles each w/ one nuclear warhead
  - Missiles are large – spanning from bottom of hull to top of the sail
  - Must surface to elevate, load liquid oxygen/fuel into each missile and launch
  - Plan to deploy in 1965 since big, special subs yet to be designed (no less built)

- Los Alamos says by '65, they'd double yield and cut weight to 1/3 – a 6-fold improvement

- Teller, knowing of Foster and Brown's work, does the arithmetic in his head and promises a 30-fold improvement – yet only one of the three new technologies had been tested!

The Navy picks Livermore

Polaris: Concept to deployment in four years



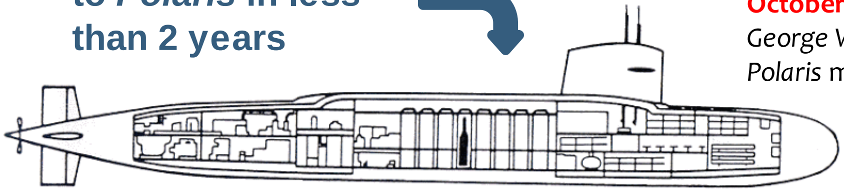
Summer 1956: Nobska conference

- Edward Teller proposes a radical, new warhead concept with 30 fold reduction in weight to yield
- Navy decides in 12/'56 on this basis to switch from *Jupiter* to *Polaris* missiles (<1/5 weight of Jupiter) thereby going from 3/4 liquid fuel missiles to 16 solid fuel missiles
- AEC/LLNL in parallel w/ Navy to design and produce radical, new warhead, *the W-47*

November 1957: Construction of #6 Skipjack class attack sub SSN589 *Scorpion* paused, conversion to #1 SSBN598 *George Washington* started January '58

- 133' long 16-missile section inserted behind sail

From *Jupiter IRBM* to *Polaris* in less than 2 years



October 1960: first Polaris SSBN 598 *George Washington* deploys with 16 *Polaris* missiles & *W-47* warheads

The acceleration slows for a time…

President Dwight Eisenhower

President Eisenhower then challenged things further by announcing the "Gentleman's Test Moratorium" with the USSR to start at end of Oct '58

While Foster's idea was thoroughly tested by then (and testing was essential to deployment), the Brown ideas had had only one test by Aug '58 and so could not be used until further testing was completed

Hence, the first sixteen W-47/Mk 0 warheads went to sea in Oct '60 aboard the SSBN George Washington with some old-style tech, ~ half the yield (only ~ 15-fold improvement over state-of-the-art 1955)

The Navy Was Still Satisfied

Thoughts on why the USSR broke out of the moratorium

- In the Fall of 1958, President Eisenhower and Premier Khrushchev agreed to a “gentleman’s” nuclear testing moratorium
  - The USSR may have agreed because they thought that they’d achieved nuclear parity with the US – both had deployed fission and thermonuclear weapons
  - A major issue in the 1960 US Presidential campaign was the “missile gap” – The US lagged the USSR in missile size – but this was a fake issue, US didn’t need large missiles Our TNs were small, the USSR’s TNs were huge and, therefore, so were their missiles
  - Polaris SSBN deploys in the Oct 1960 with megaton class TNs small enough to fit on a Polaris missile. The USSR noticed, eg - Oct’ 1960 CBS News Special “Year of the Polaris”*

* ”The whole point of the doomsday machine...is lost if you keep it a secret!” - Dr. Strangelove, 1964

The American nuclear advantage became starkly apparent during the Berlin Crisis of 1961

Counterforce survivability and assured retaliation

- **With Polaris submarines on station, Kennedy knew that US Counterforce would survive a massive, surprise nuclear strike with enough power to retaliate and destroy the Soviet Union**
  - **Kennedy faced down Khruschev's threat of massive land war in Europe over Berlin**
  - **Did the small thermonuclear warhead carried on Polaris make a difference in the Berlin crisis? Did it add backbone to Kennedy standing up to Khrushchev?**
  - **Kennedy's national security advisor, McGeorge Bundy, at the center of the crisis and who helped determine the response, said that it did**[1]

1 "It is true that many Americans throughout this crisis [Berlin] considered that the United States had superior nuclear forces, and that this superiority would help to make Khrushchev cautious. This belief may well have helped them to support positions about the American commitment to West Berlin that Khrushchev then found it imprudent to challenge. Thus, American superiority may in some degree have stiffened American determination. I believe that it did.

I belabor this argument because it became an unexamined assumption about the Berlin crisis, both at the time and later, that in the successful defense of West Berlin, American strategic nuclear superiority was decisive. …In 1966, in one of the most thoughtful and illuminating of all early studies of the period, Arnold Horelick and Myron Rush – senior research associates at the Rand Corporation, a leading center of strategic study in Santa Monica – referred to the decisive role of American strategic superiority in Berlin at least eight times; they took that role so much for granted that they nowhere undertook to explain how it had worked, or why a simple awareness of nuclear risk would not explain Soviet behavior just as well." - **McGeorge Bundy**, Danger and Survival: Choices About the Bomb in the First Fifty Years, Random House, 1988, pp. 358-360.

Kennedy agreed and said so at Berkeley

- This is why, in March 1962, Kennedy came to the Lab in Berkeley to personally thank Livermore physicists for helping to avert thermonuclear war

- He set the stage himself when he offered his thanks to his weapons scientists before a crowd of 85,000 spectators

Note: Only one Los Alamos member in the party – Director Norris Bradbury at far left, and he's not smiling

The Russians broke out of the test moratorium in the Sept '61 with 135 nuclear tests in 15 months - a test every other day in '61, more than a test a week in '62. It appears they realized they did not have parity with US "miniature" TNs and needed to test a lot to catch up

The W-47 was just the beginning of technical innovation

- In the early 1960's, the USSR was developing Anti-Ballistic Missile (ABM) systems - an inexpensive ABM defeats a large, expensive ballistic missile

  An economic game that cannot be won

- The solution to ABM is MIRV. Many ABMs are needed to defeat one MIRV'ed missile with many nuclear warheads aboard

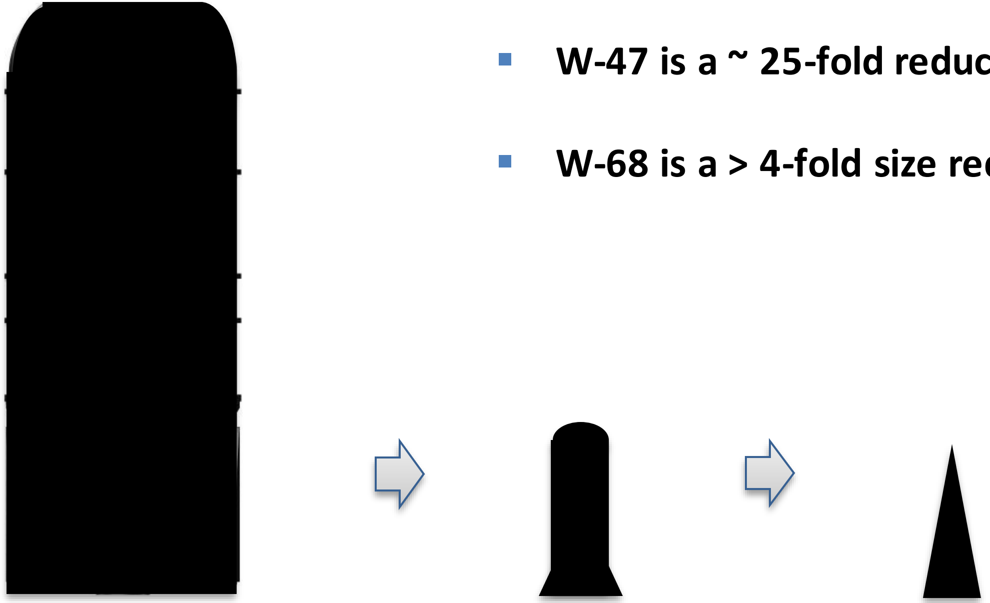
- LLNL stepped up to this challenge since it had the miniaturization tech needed. In '64, LLNL tested the technology that became the MIRV'd W-68 Poseidon warheads

This enabled another more than 4-fold size reduction and brought strategic re-entry vehicles to their zenith

* MIRV: Multiple Independently-targeted Re-Entry Vehicle

What did the reductions from B18 to W47 & W68 look like?

- **W-47 is a ~ 25-fold reduction from B-18**
- **W-68 is a > 4-fold size reduction from W-47**



B-18
Tested ‘53 – deployed ’55
State of the Art

W-47 Polaris
Tested ‘58 – deployed ‘60

W-68 Poseidon
Tested ’64 – deployed ‘70

Conclusion

- **From the '70's to '92, modern, "miniature" design was applied to the stockpile by both Labs**
- **This technology is used throughout our stockpile thus the stockpile is "miniature" and intrinsically safe throughout**
- **Since 1992, we no longer use the "cut and try" methods of nuclear testing to sustain our deterrent. The Stockpile Stewardship Program enables us to sustain the stockpile, and even design and build new nuclear weapons, without nuclear testing…**

…but that is a different talk…

Thank you

Bruce Goodwin
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Lawrence Livermore National Laboratory

Stockpile Stewardship in the LLNL Weapons Program

Presented to ANS

Cynthia K. Nitta
Associate Program Director,
Future Stockpile Transformation
Weapon Physics and Design, WCI

July 16, 2020

Lawrence Livermore National Laboratory

LLNL-PRES-811978

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Who am I? Why do I work on nuclear weapons? How did I get here?

Cynthia K. Nitta
APD Future Stockpile Transformation, WPD
WCI DESIGN PHYSICS DIVISION

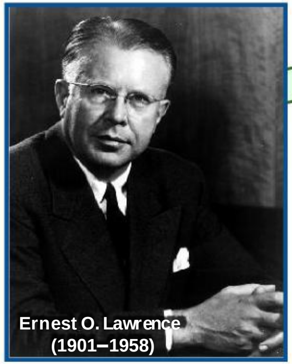
Princeton B.S.E. Chem. Eng.
M.I.T. M.S., Sc.D. Nuclear Eng.

Recruited to LLNL in 1986

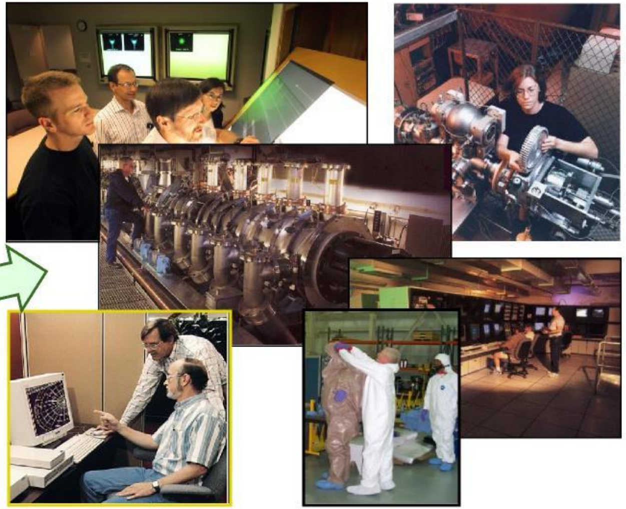
- **Design Physicist involved in nuclear testing**
- **Steward for several nuclear warheads and systems**
  - **Program manager for basic science support, materials, system development, oversight and peer review**
- **Line manager for weapons program – recruiting and hiring**
  - **Currently managing stockpile modernization programs and future system development**
  - **Teller Award – spent year at Georgetown learning about nuclear policy**
- **APS Panel on Public Affairs, National Security Panel**
  - **Past Board member, Treasurer for national Math Science Network (Expanding Your Horizons Conferences)**

Ernest O. Lawrence provided LLNL's guiding philosophy of innovation since its establishment in 1952

- Emphasized a multi-disciplinary team approach to big science
- Merged basic research with practical science and engineering
- A history of looking for new ideas to challenge old ones



LLNL's Legacy of Integration



LLNL has created many of the "modern" advances in nuclear weapons

1950s

Warhead for Polaris ballistic missile submarine

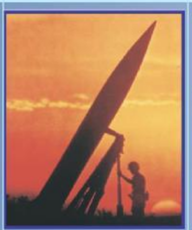
Demonstrated primary and secondary design concepts that form the basis for all current U.S. warheads

1960s

Small, high yield-to-weight warheads for MIRVed systems

Intrinsically one-point safe designs

1970s



First battlefield neutron bombs

First successful nuclear test with insensitive HE

ABM warhead development

1980s

MX basing studies

IHE warheads with modern safety features (e.g., fire-resistant pits)

1990s

Stockpile Stewardship concept developed by Labs/DOE

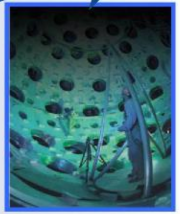
2000s

First 3-D full warhead calculations

Certification of W87 life extension without underground testing

Future

Meeting stockpile needs



NIF ignition and non-ignition experiments

ExaFLOPS computing

All-IHE designs

Low-SNM designs

Intrinsic surety

The Stockpile Stewardship Program: The nation's approach to ensuring confidence in the nuclear stockpile

Assessment and Certification
Ability to quantify with confidence the safety, reliability and effectiveness of the stockpile

Surveillance
Ability to accurately determine the state of health of the stockpile

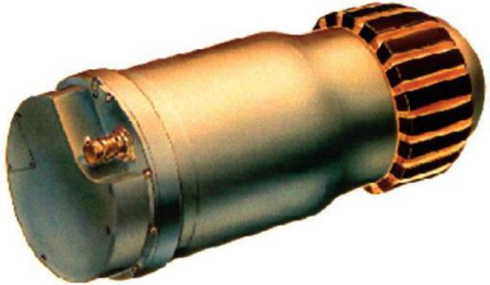
Design and Manufacturing
Ability to design, manufacture, and dismantle weapons, and store weapon components

Since 2017, in the Stockpile Responsiveness Program, we can develop our skills in the practice of weapon development from concept to prototype

We ensure that the US nuclear deterrent remains safe, secure, and effective in the absence of nuclear testing

The nuclear deterrent is a 'Triad'– Intercontinental and Submarine Launched Ballistic Missiles, Air-Carried Bombs and Cruise Missiles

LLNL has the lead responsibility for three weapon systems in the active nuclear stockpile

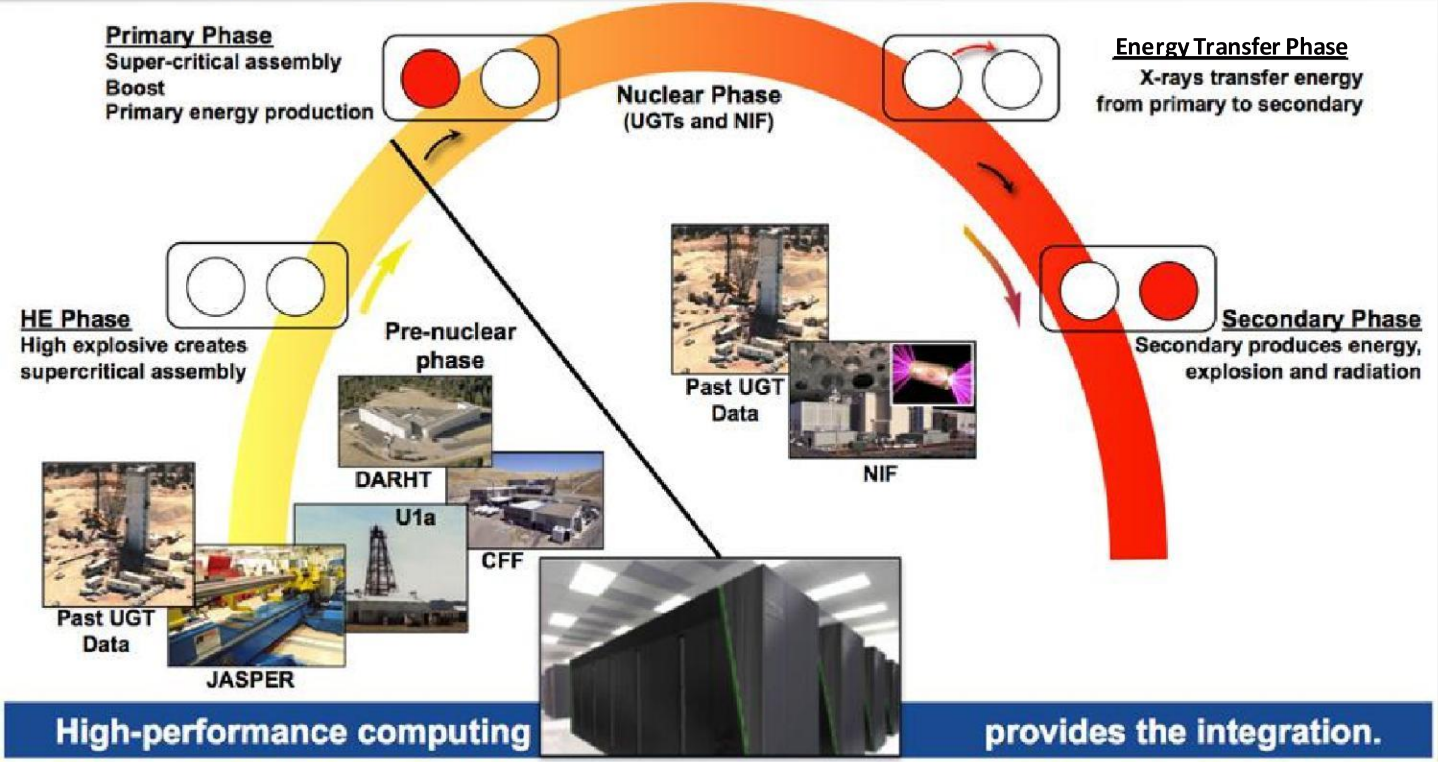


W80 Cruise Missile: Currently in a W80-4 Life Extension Program

B83 Gravity Bomb: Currently being evaluated for other missions

W87 ICBM Warhead: Currently in a W87-1 Life Extension Program

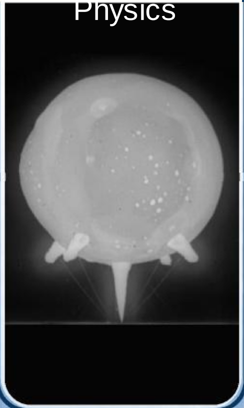
We are responsible for understanding the science underpinning all phases of nuclear performance



We leverage a wide range of expertise

- Actinide properties
- Astrophysics
- Atomic physics
- Thermonuclear physics
- Computational physics
- Diagnostic development
- Experimental design & execution
- Fluid dynamics & turbulence
- HED physics & experiments
- Materials in extreme conditions
- Nuclear explosives
- Plasma physics
- Radiation & particle transport
- Reactive flows & high explosives
- Uncertainty quantification (UQ)

Explosion Physics

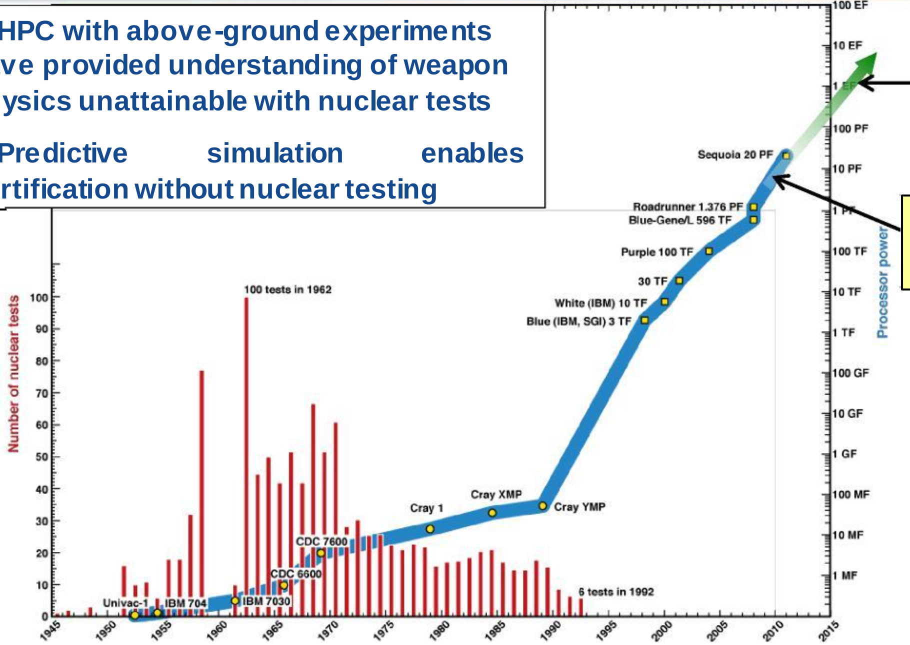


Inertial Fusion

Multiphysics Simulations

Simulation capability has increased dramatically under the SSP's HPC strategic partnership among NNSA, LLNL, and our vendors

- HPC with above-ground experiments have provided understanding of weapon physics unattainable with nuclear tests
- Predictive simulation enables certification without nuclear testing



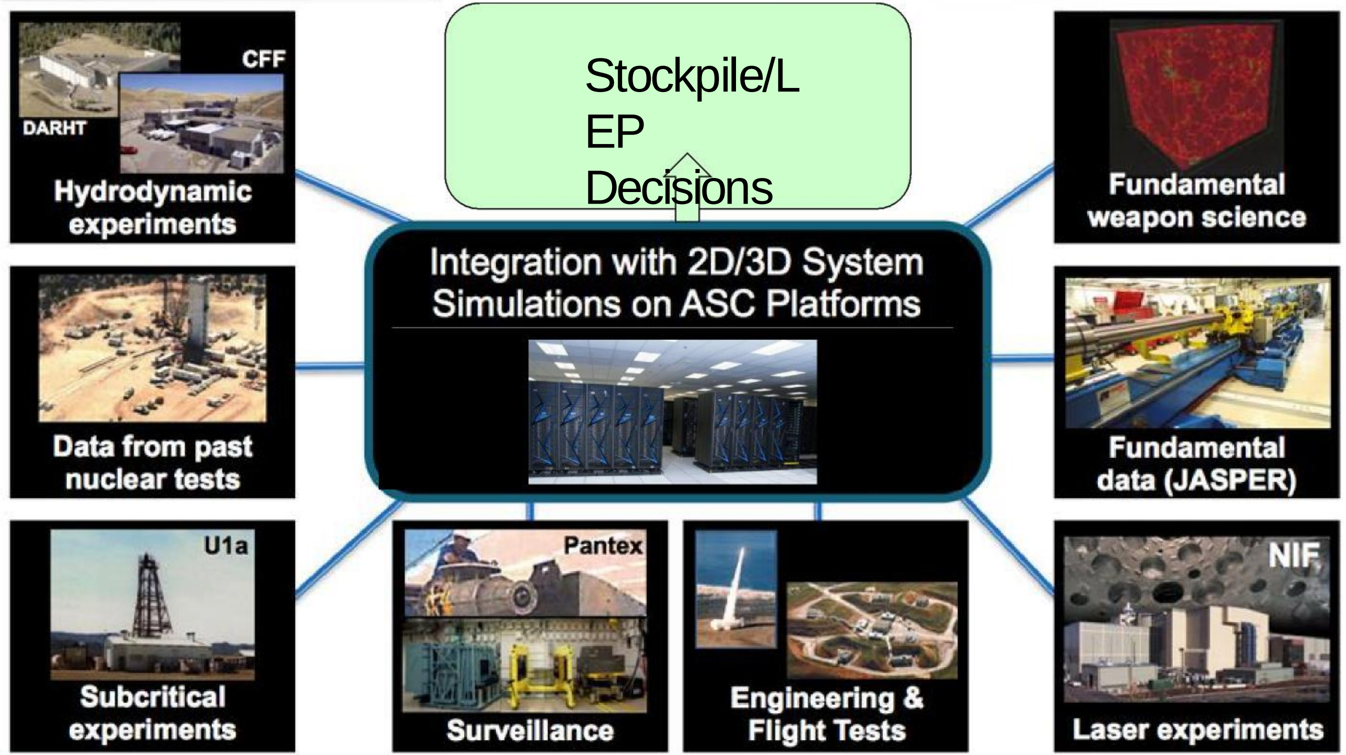
3D full system simulations with required fidelity and UQ – Sierra now at 125PF

2D full system simulations with required fidelity and UQ

- Represents a radical departure from previous production computers
  - 125 Pflops
  - Over 90% of the compute power is in the Graphics Processing Units (GPUs) rather than the traditional CPU

Exascale will make the next major contribution to our advancing predictive capability.

Stockpile decisions are informed by analysis integrating multiple data types, sophisticated design codes, unique facilities, and experienced staff



LLNL.gov

Simulation Capabilities at LLNL

American Nuclear Society, Young Members Group Webinar

July 16, 2020

Teresa Bailey
National Stockpile Programmatic Working Group Leader

LLNL-PRES 812391
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Who am I? How did I get here?

Teresa Bailey

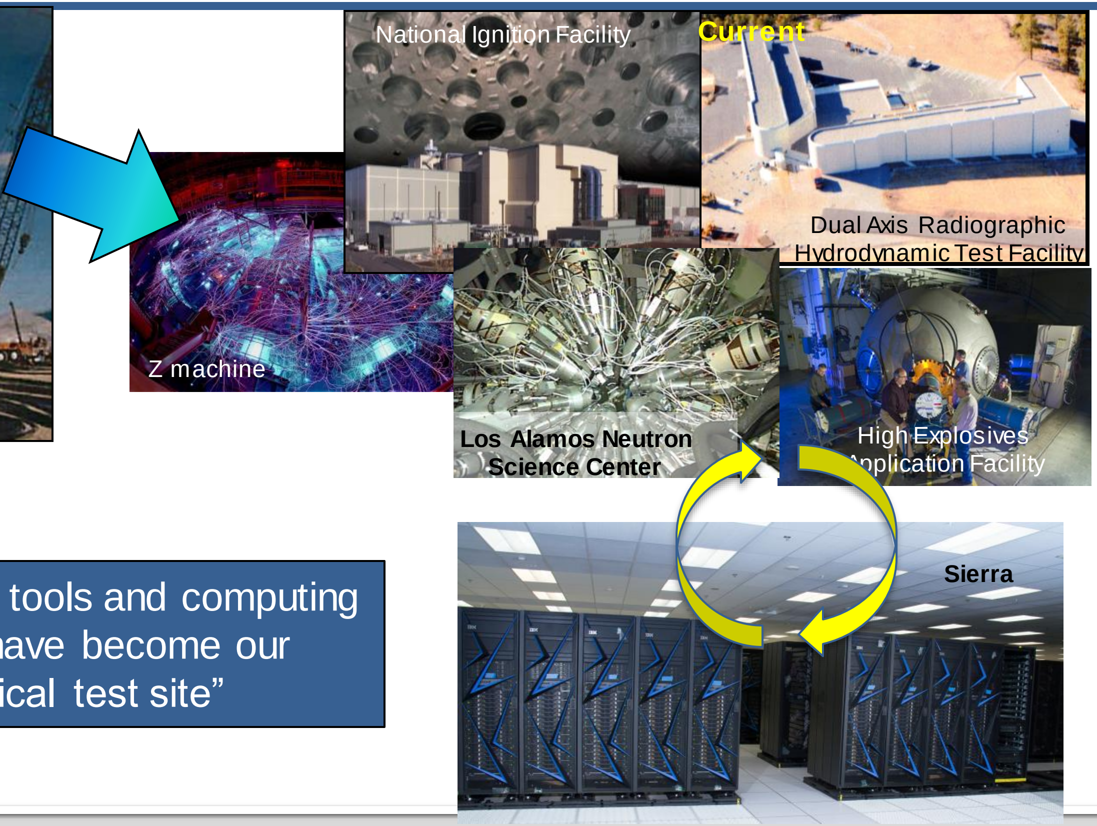
B.S. Nuclear Engineering
Oregon State University

M.S., Ph.D. Nuclear Engineering
Texas A&M University

First American Nuclear Society Event: 2002 Student Conference

- 2008: Started at LLNL as a code physicist working on neutron transport
  - Massively parallel algorithms
- 2015: Deterministic Transport Project Lead
  - Particle transport and thermal radiative transfer
- 2016: Nuclear Science Programmatic Working Group Leader
  - Nuclear Physics Experiments, Theory, Evaluation, Processing, V&V
- May 2020: National Stockpile Programmatic Working Group Leader
  - Physics assessment of the current US Stockpile

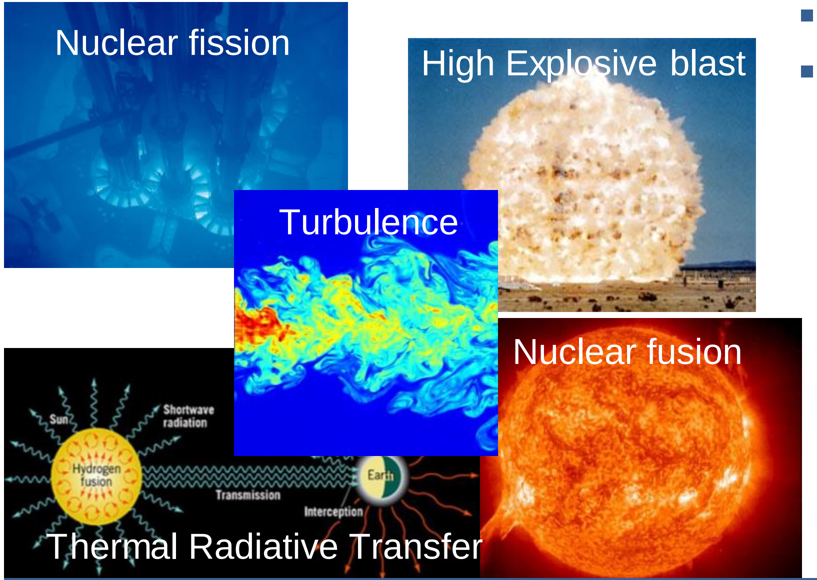
Simulation capabilities, coupled with non-nuclear experiments, have replaced underground tests



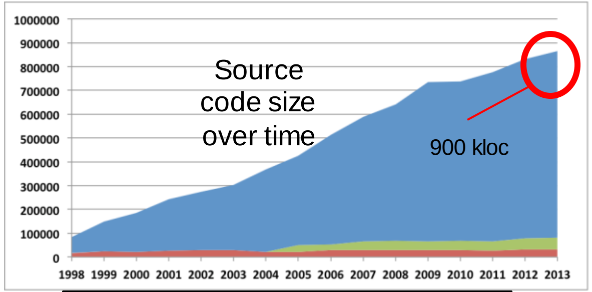
Our simulation tools and computing platforms have become our "numerical test site"

Our designers require complex, integrated, multi-physics capabilities utilizing advanced architectures

- Dozens of codes and models to cover the wide range of physics needed



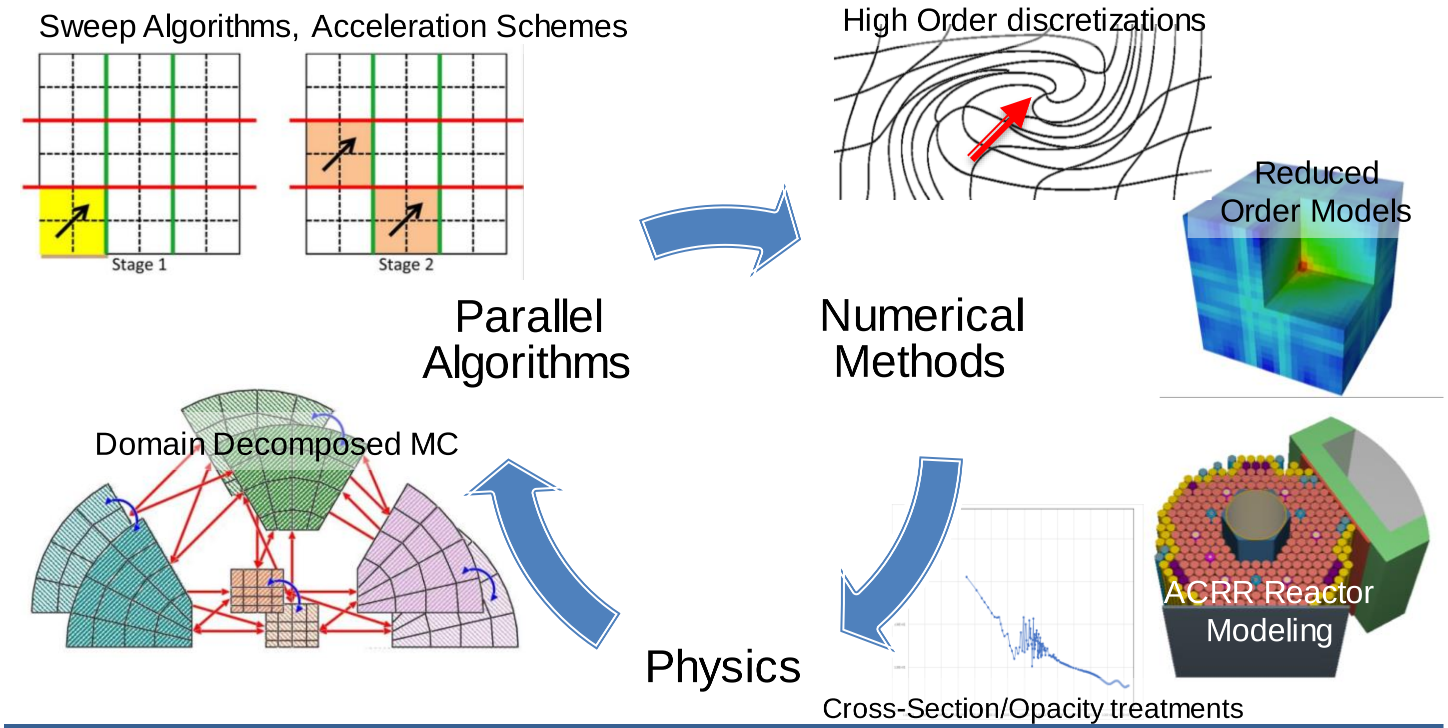
- Long life-time projects (15+ years)
- Multi-disciplinary teams
- Algorithms tuned for minimal turn-around time *based on today's hardware!*



Average of 60Kloc/year of additional code to support in a representative IC

Each of these phenomena, alone, are challenging to model. We often model them all simultaneously and tightly coupled.

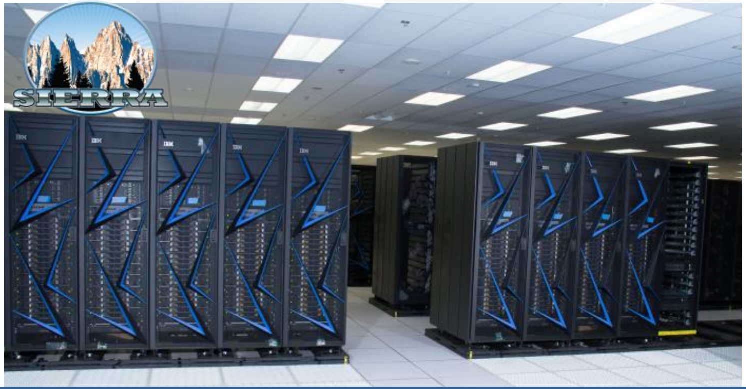
LLNL is at the forefront of computational transport R&D – Nuclear Engineers are key



We invest in Monte Carlo and Deterministic code efforts as peer capabilities

Sierra has transformed LLNL's capability; we are focused on exascale with El Capitan

- Represents a radical departure from previous production computers
  - 125 Pflops
  - Over 90% of the compute power is in the Graphics Processing Units (GPUs) rather than the traditional CPU



Examples of physics	Speed-up per node
3D Shaped Charge	9X
Neutron Criticality	1.2X (Monte Carlo) 15X (Deterministic)
Radiative Transfer	3X (Monte Carlo) 4X - 8X (Deterministic)
3D Primary model	11X

- More research on GPU algorithms is required
- Bigger calculations stress the architecture
  - Require new numerical methods
  - Enable more complex physics

Significant effort, along with close vendor collaboration, are showing big payoffs

Lawrence Livermore
National Laboratory

Nuclear data at LLNL

July 16, 2020

C.M. Mattoon
Nuclear Data and Theory group, PLS/NACS

LLNL-PRES-812331
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

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Nuclear data describes the structure and interactions of nuclei. A wide range of users depend on high-quality nuclear data for modeling, licensing, etc.

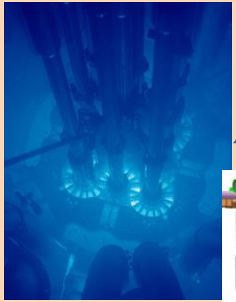
Experimental Nuclear Physics + Advances in Theory + Evaluator (compiles recommended best values)

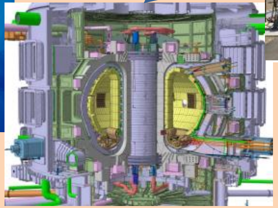
= "Evaluated" Nuclear Data Library

ENDF B-VIII.0

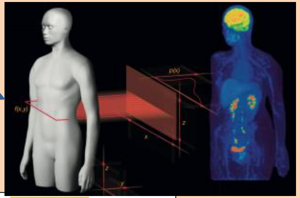
ENSDF: Evaluated Nuclear Structure Data File

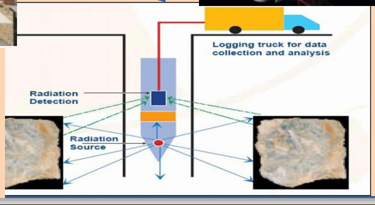
Processing + API





Transport applications

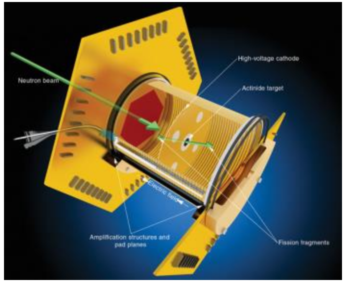




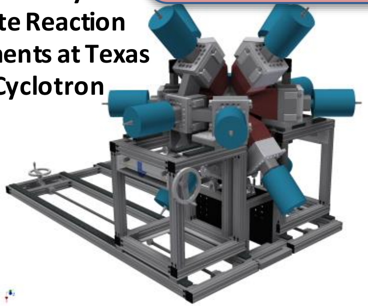
LLNL employs a diverse set of techniques to measure nuclear properties and reactions of interest, with experiments at facilities across the U.S.

Experimental Nuclear Physics

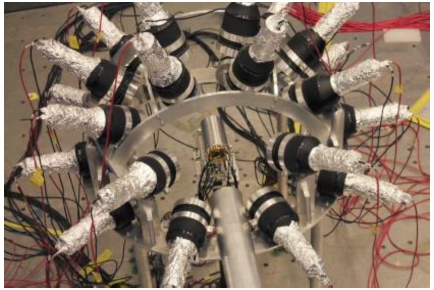
Fission-TPC at LANSCE



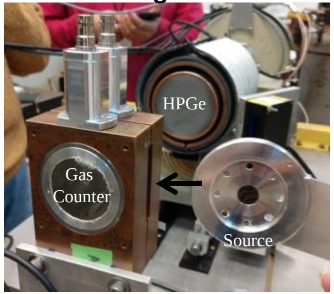
Hyperion Array for Surrogate Reaction measurements at Texas A&M Cyclotron



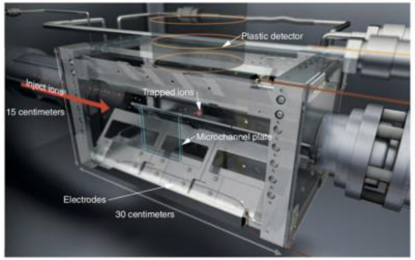
Prompt fission-neutrons with Chi-Nu at LANSCE



Fission product counting at LLNL

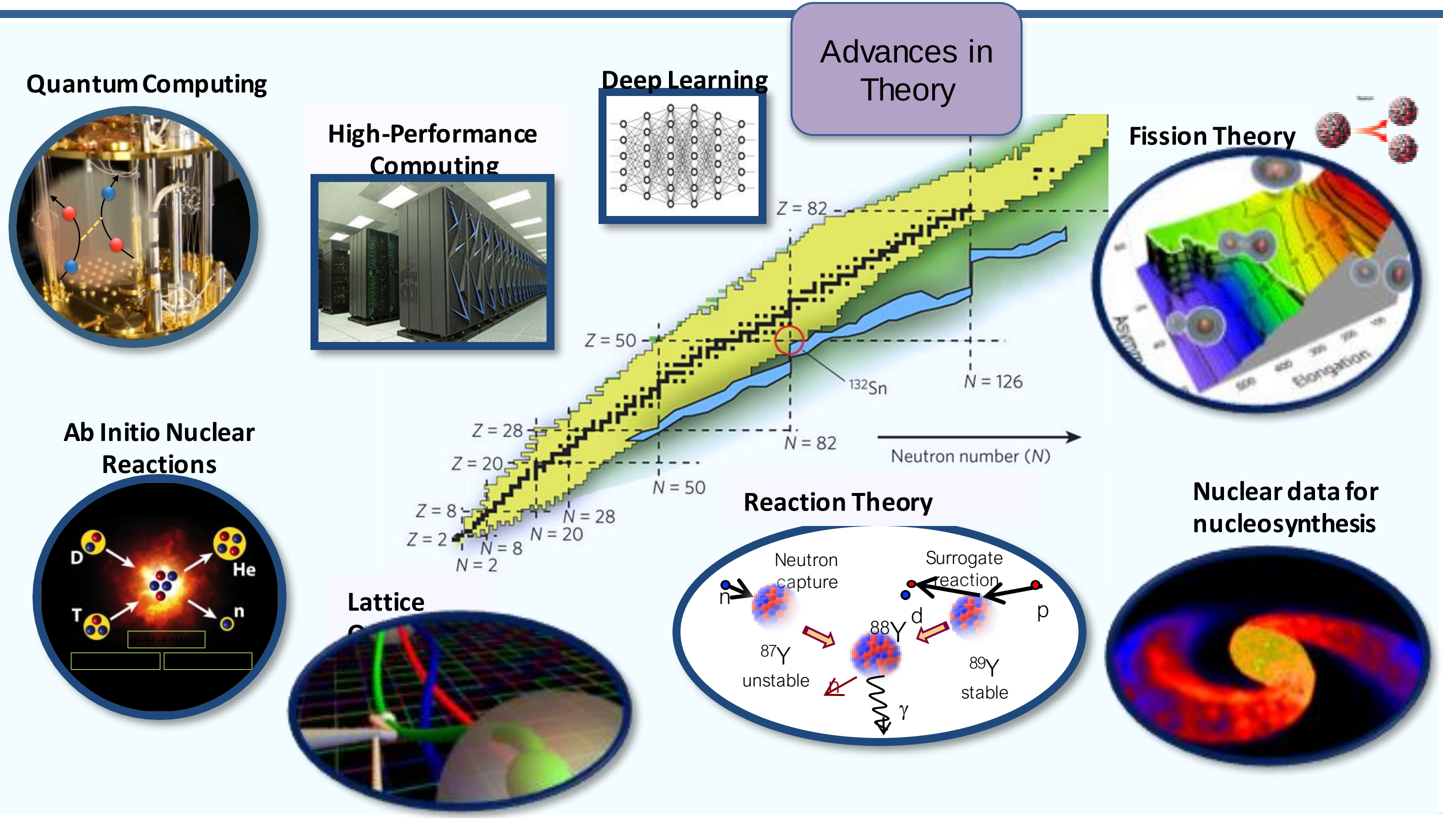


Ion trap at Argonne measures beta-delayed neutron emission from fission products



US Nuclear Facilities

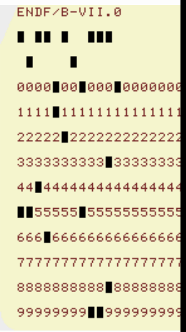
LLNL is at the forefront of developing theoretical, computational & machine learning methods for basic science & national security



LLNL is also leading an international effort to modernize how nuclear data are stored, processed and used in applications.

Evaluation, processing, API

- Replace old punch-card based formats with a new standard
  - Generalized Nuclear Database Structure (GNDS)
  - Compatible with hierarchical languages like XML, JSON, HDF5
  - Backwards-compatible with ENDF-6, but much more extensible




```xml
<?xml version="1.0" encoding="UTF-8"?>
<reactionSuite projectile="n" target="Fe54" evaluation="ENDF-VIII"
               format="1.9" projectileFrame="lab">
  ...
  <reactions>
    <reaction label="n + Fe54" ENDF_MT="2">
      <crossSection>
        <resonancesWithBackground label="eval"> ... </resonancesWithBackground>
        <XYs1d label="recon"> ... </XYs1d>
      </crossSection>
      <outputChannel genre="twoBody">
        <Q> ... </Q>
        <products>
          <product pid="n" label="n">
            <multiplicity> ... </multiplicity>
            <distribution> ... </distribution>
          <product pid="Fe54" label="Fe54"> ... </product>
        </products>
      </outputChannel>
    </reaction>
    <reaction label="n + (Fe54_e1 -> Fe54 + photon)" ENDF_MT="51"> ... </reaction>
    ...
  </reactions>
</reactionSuite>
```


- Update codes & infrastructure for generating evaluations, processing and accessing GNDS data.
  - Open-source codes FUDGE and GIDIplus both available at github.com/LLNL

“Nuclear data pipeline” moves data from fundamental science to applications. LLNL is working to improve all sections of the pipeline.

- Improvements in experimental methodology improve accuracy and precision of nuclear data
- Advances in theory complement experimental data, supporting better evaluations even for short-lived nuclides
- Flexible and extensible infrastructure for storing and using nuclear data helps LLNL respond faster to evolving needs of users

Nuclear fusion experiments at the National Ignition Facility

American Nuclear Society
Lawrence Livermore National Lab spotlight
July 16th, 2020

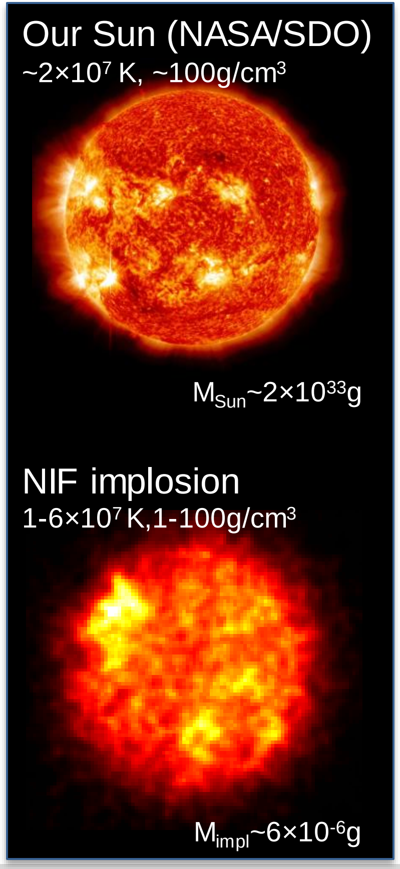
Dan Casey
Oh behalf of the NIF team

LLNL-PRES-812504
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344.
Lawrence Livermore National Security, LLC

Lawrence Livermore National Laboratory

Experiments at National Ignition Facility (NIF), the world's highest energy laser, create extreme high energy density conditions

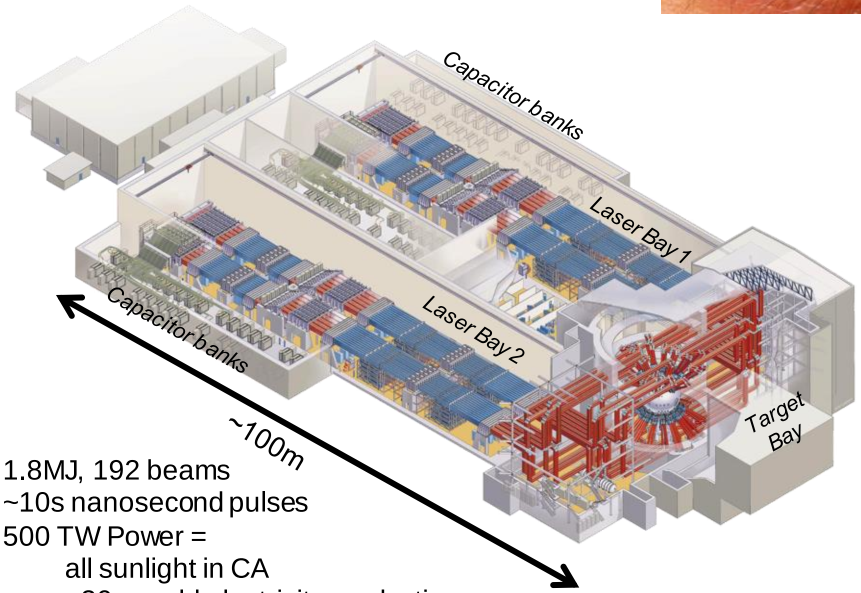
- NIF creates some of the most extreme conditions in the laboratory, with pressures, temperatures, and densities that exceed the center of the sun and neutron flux comparable to supernova.
- Experiments support a variety of the LLNL programs. Examples include extreme high energy density (HED) material science, radiation hydrodynamics, and the study of nuclear fusion via 'inertial confinement' fusion (ICF).
- Unique conditions have broad applicability for basic science. For example, nuclear astrophysics, studying nuclear processes at conditions that are directly comparable to how the elements are made in the universe.



The National Ignition Facility (NIF)
Livermore, CA (~35mi E of SF)

NIF is the world's largest laser

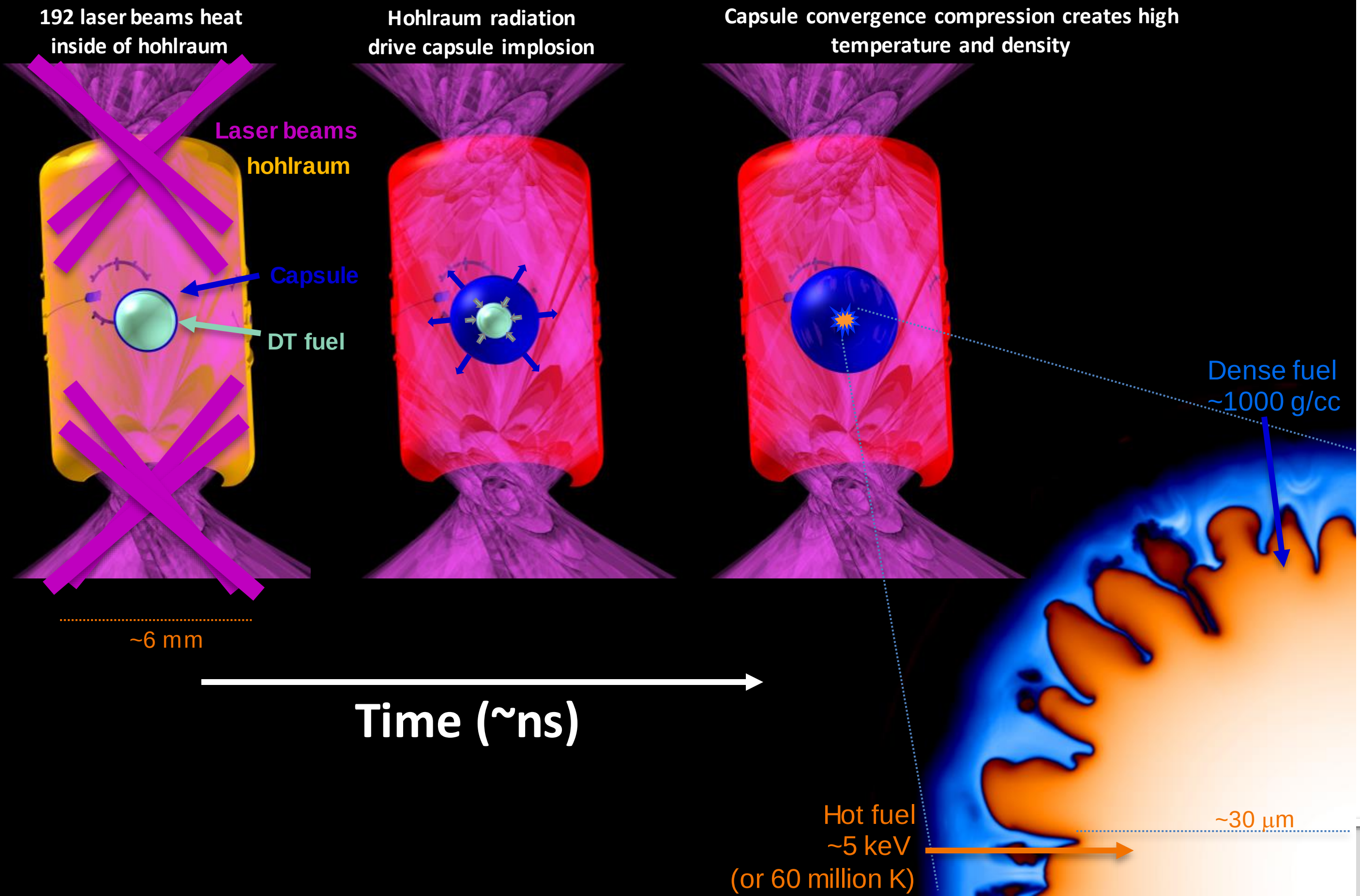
The NIF (schematics)



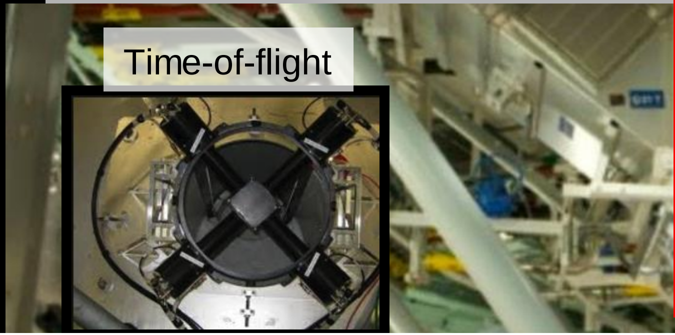
1.8MJ, 192 beams
~10s nanosecond pulses
500 TW Power =
all sunlight in CA
~30× world electricity production

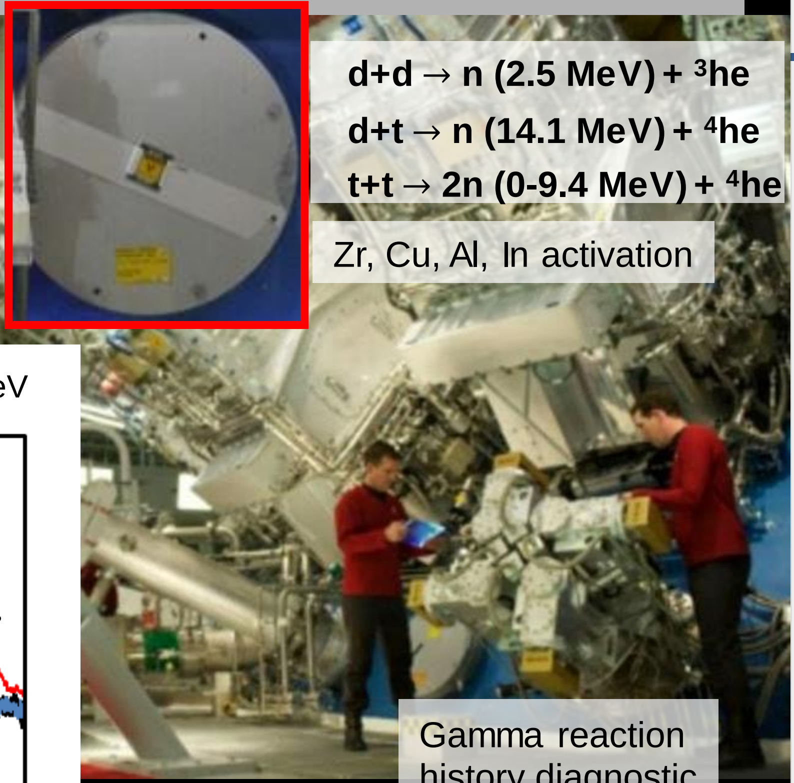
Fuel filled capsule

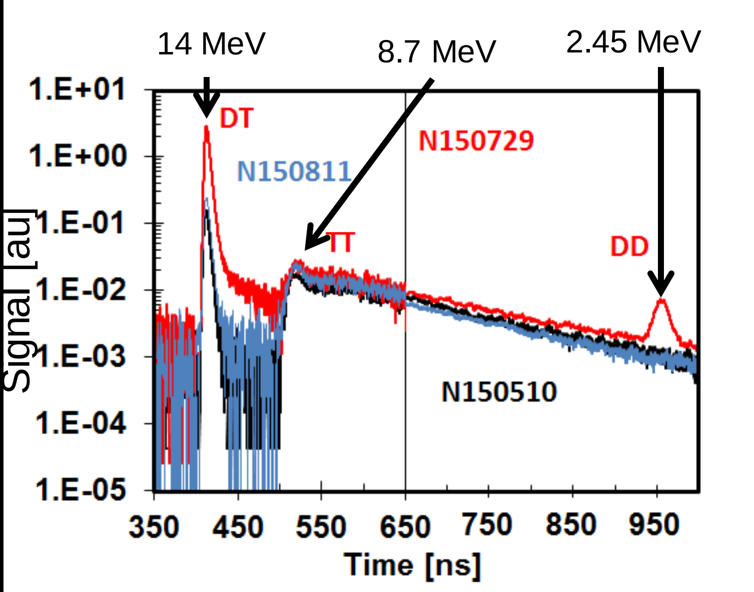
ICF works by converting laser energy into a high temperature D+T fuel hotspot confined by a dense D+T shell



Nuclear diagnostics (e.g. activation, track, time-of-flight, Cherenkov) provide many of the key observables in experiments at NIF



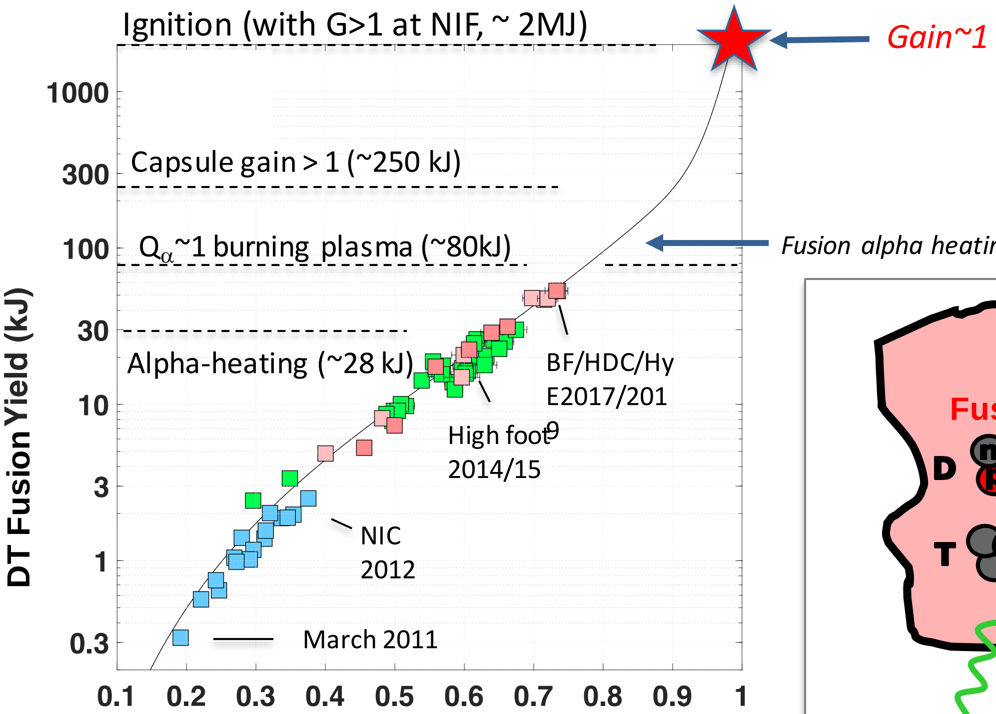




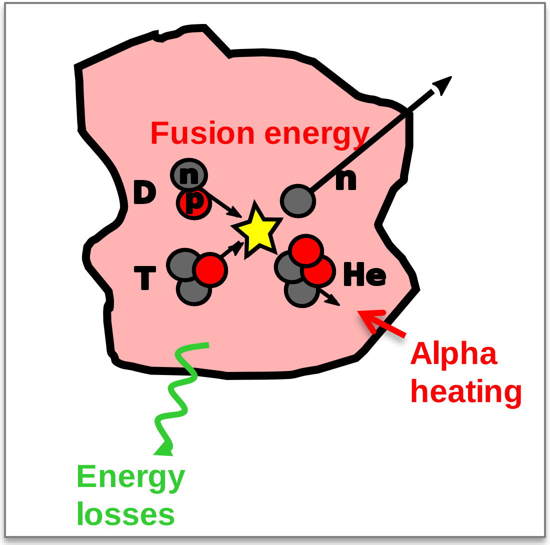
d+t → γ (17 MeV) + ⁵he

Star Trek: Into Darkness (2013)
Courtesy Warner Brothers / Star Trek

Recent ICF experiments on NIF have generated significant fusion self-heating, and are just shy of a 'burning plasma'

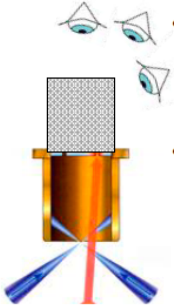


Fraction of **Pressure x Confinement time** needed to ignite – exact location of ignition is not known precisely

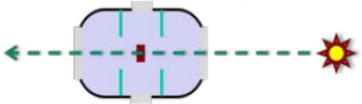


High energy density (HED) experiments can be divided into four major thrust areas

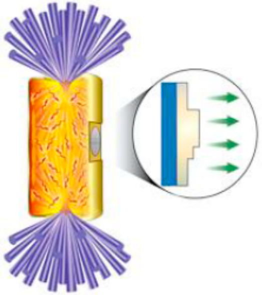
Radiation Transport & Opacity



- Radiation transport thru media: spectra, temperature, space, time and mix evolution
- Opacity: calibrated broad band time-gated spectra

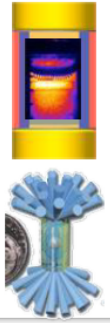


High Pressure Materials



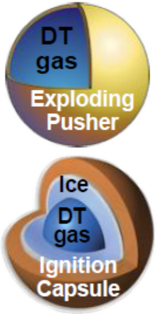
- Phase structure and kinetics
- High photon energy radiography
- High accuracy 1D/2D VISAR
- Conductivity
- Temperature

Hydrodynamics & Rad Hydro

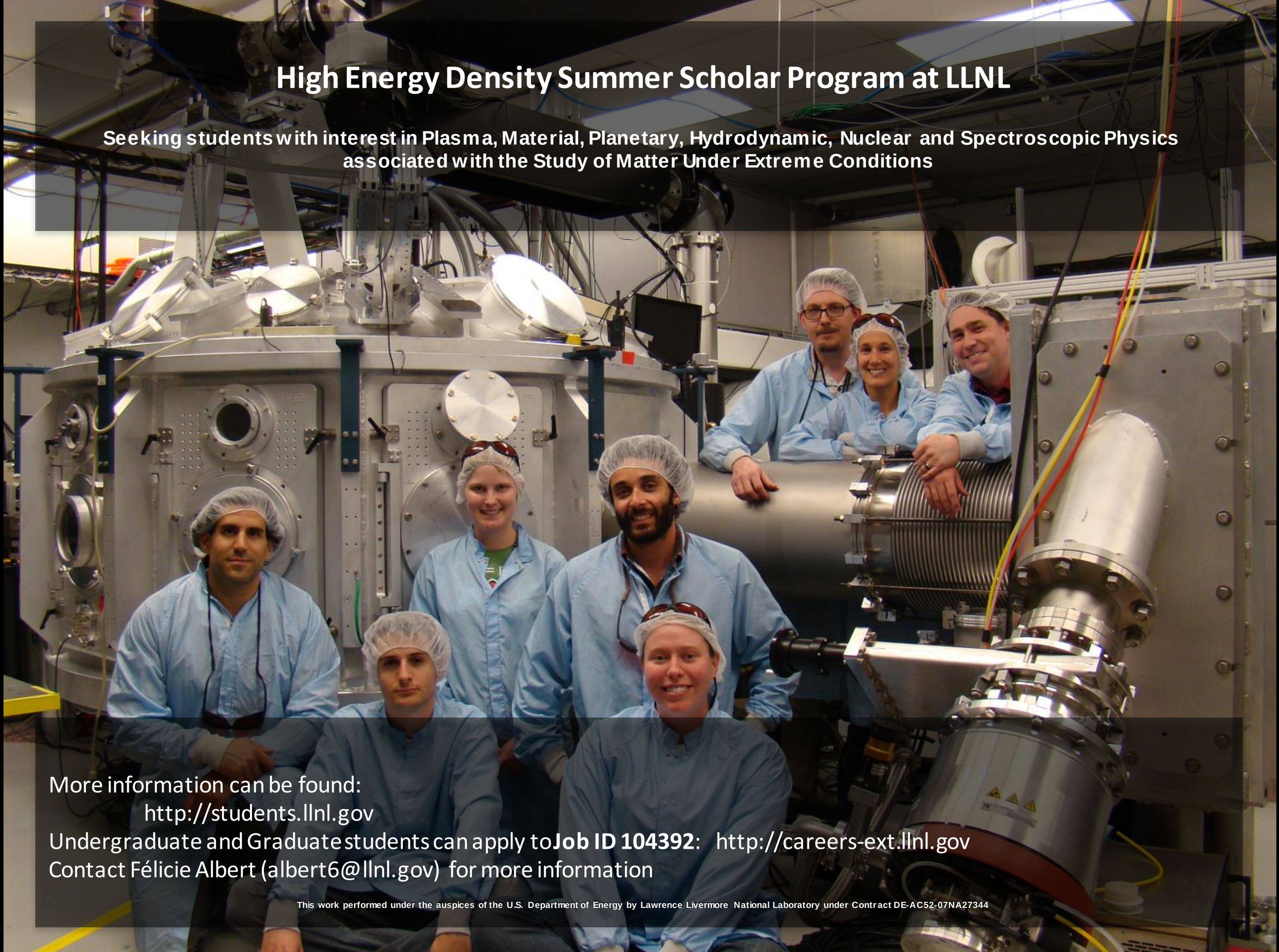


- Planar mix: transition to turbulence - interspecies concentration vs space, time, mode structure from nonlinear to diffusion, PIV
- Convergent hydro: multi-image, multi LOS, time resolved, energy selective gamma

Ignition Applications and Burn



- Forensics: fission yields of short lived isotopes - rapid extraction
- Nuclear excited state measurements
- (n,γ) cross sections
- n effects



High Energy Density Summer Scholar Program at LLNL

Seeking students with interest in Plasma, Material, Planetary, Hydrodynamic, Nuclear and Spectroscopic Physics associated with the Study of Matter Under Extreme Conditions

More information can be found:

http://students.llnl.gov

Undergraduate and Graduate students can apply to **Job ID 104392**: http://careers-ext.llnl.gov

Contact Félicie Albert (albert6@llnl.gov) for more information

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

High Energy Density Science Postdoctoral Fellowship

Seeking candidates with interest in experimental and theoretical Plasma, Material, Planetary, Hydrodynamic, and Nuclear Physics associated with the Study of Matter Under Extreme Conditions

ANS Young Members Group

@YoungMembersGroup
@ans_ymg
americannuclear

Upcoming Events:

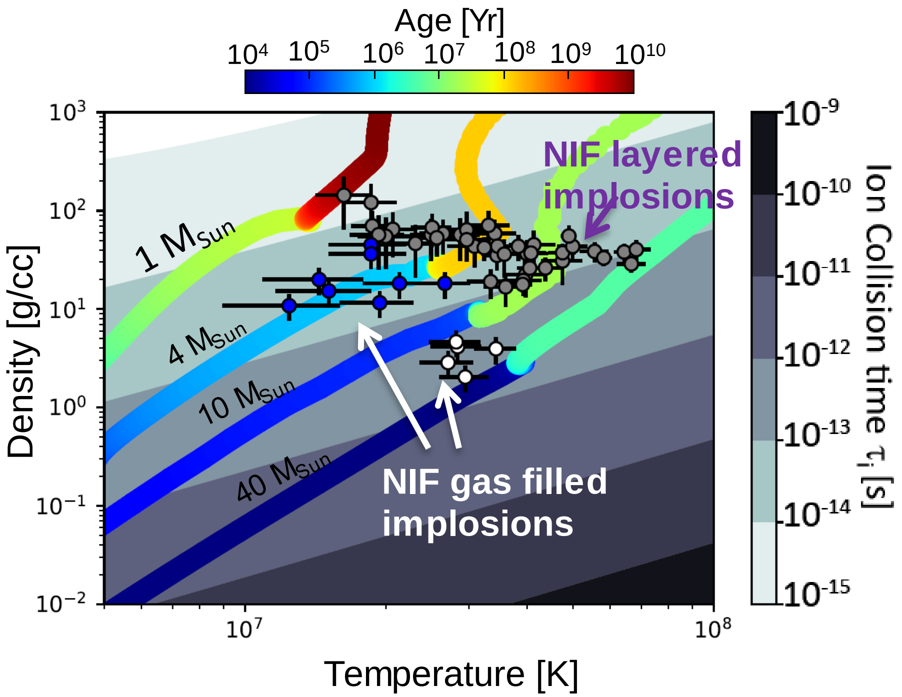
- July 21: Virtual Trivia (ANS Members Only)
- August 12: Spotlight on National Labs: Oak Ridge National Lab

Learn more and register at ans.org

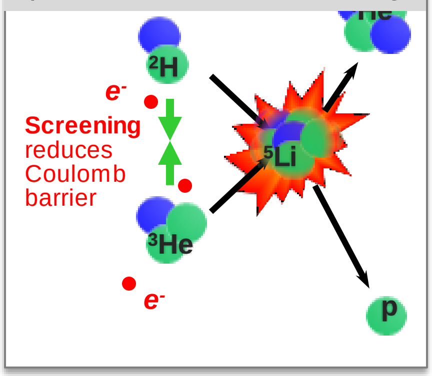
EXTRA Slides

Lawrence Livermore National Laboratory

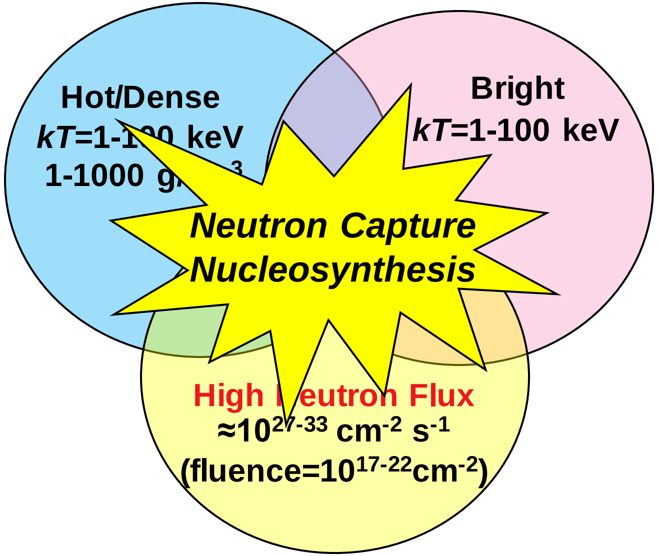
NIF reaches similar density and temperatures to that of large stars

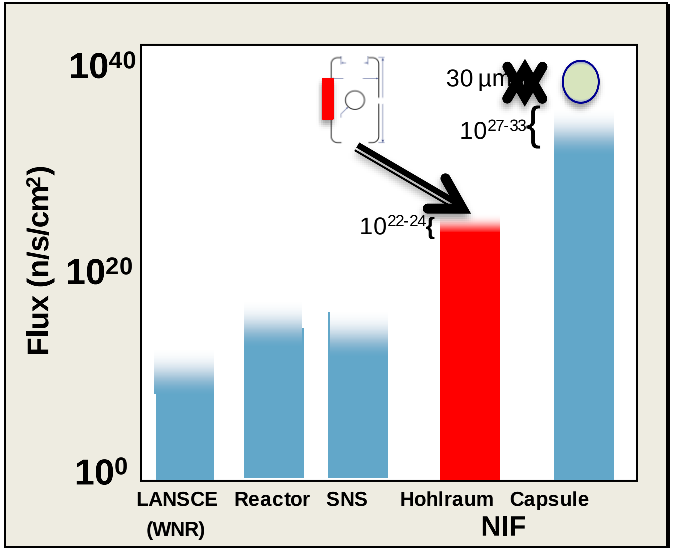


Stellar conditions matter for processes like e-screening



NIF allows studies of nuclear physics *in a plasma environment similar to astrophysical settings*





We have results from *two different diagnostics* showing that neutron capture experiments can be done at NIF right now

Opportunities at LLNL

Presented to the ANS YMG

16 July 2020

Paul L. Miller, PhD

Deputy Division Leader Design Physics Division Weapons and Complex Integration Lawrence Livermore National Laboratory

LLNL-PRES- 812414

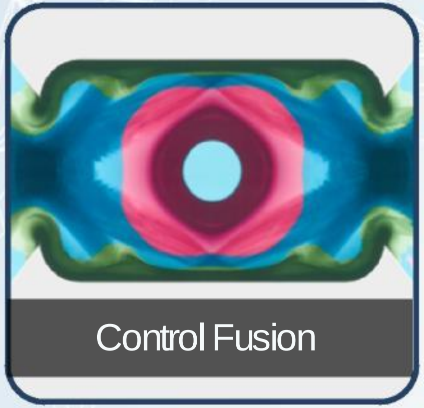
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

•LLNL hires nuclear engineers

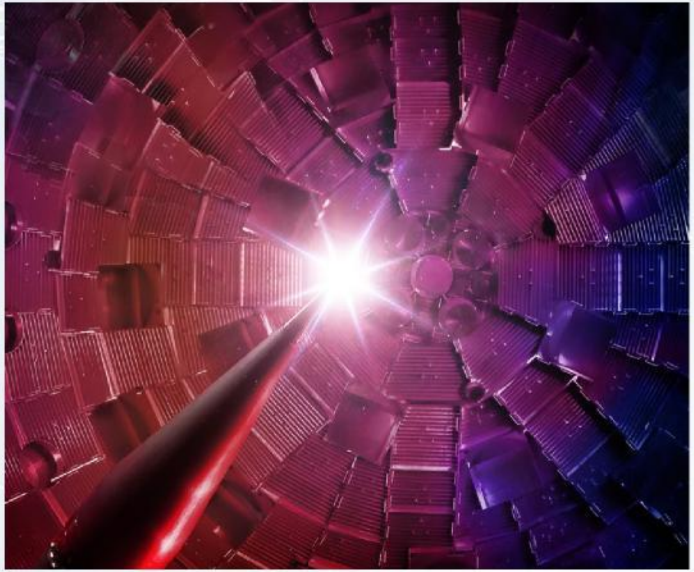
- About 32 people work at LLNL as SE15s (Nuclear Engineer)
- Roughly another 100 people with Nuclear Engineering degrees work in a wide range of areas, throughout all the major programs at LLNL
- These numbers don't include nuclear physicists and related fields

Three things I hear employees say they value about working at LLNL

We bring experts from different fields work together to answer questions and solve complex problems of national importance



We bring to bear cutting-edge facilities and capabilities to take on the most challenging problems



Sierra computer

#3 on 125 petaFLOPS
Top 500 List peak

(20-exaFLOPS El Capitan planned)

National Ignition Facility

192
laser beams

2.15 MJ
to target

We are highly rated as a place to work, largely on account of our people

glassdoor

2020 BEST PLACES TO WORK

6

To top it all off, Livermore sits in the heart of Northern California

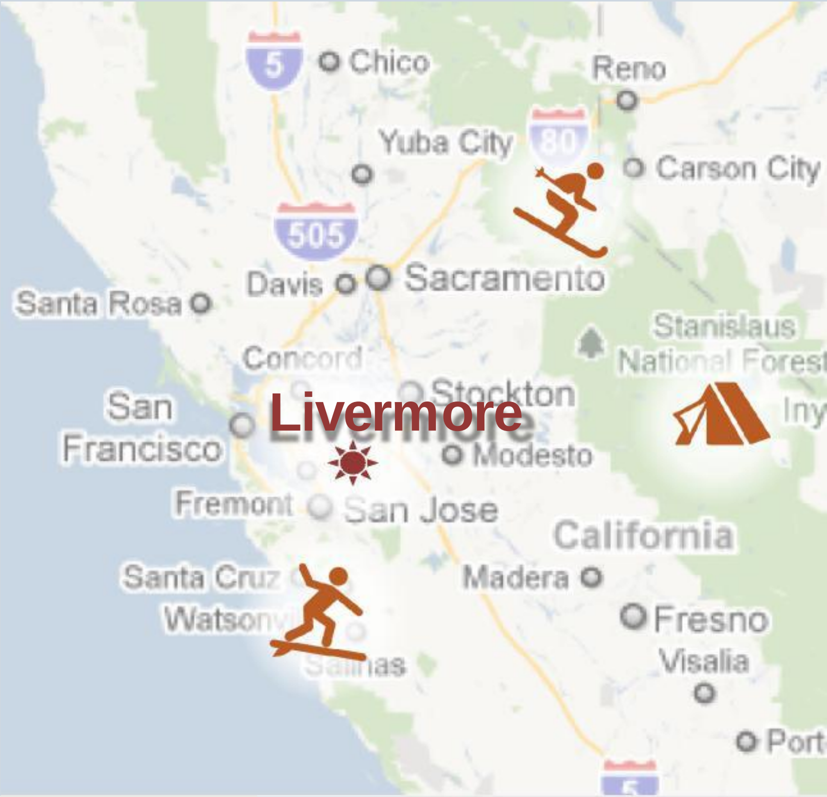
Beautiful Weather

Over 50 Wineries

Vibrant Downtown

Livermore at a glance

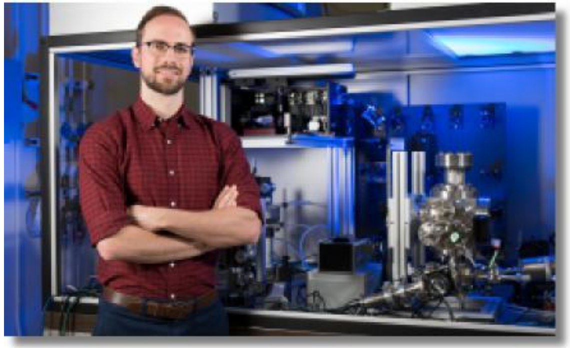
- Mediterranean climate
- Bay Area metropolitan area
- Wide range of outdoor activities



Let’s say you are interested, what next?

Research opportunities include:

- informal collaborations
- formal collaborations
- in-residence graduate study
- and more . . .



Employment opportunities include:

- summer internships
- graduate-student fellowships
- postdoctoral fellowships
- career positions

For more information, check out our website, LLNL.gov

our jobs page, careers.LLNL.gov,

and the annual report, annual.LLNL.gov

LLNL.gov