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Title: The ASC Program at Los Alamos An introduction

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The ASC Program at Los Alamos

An introduction

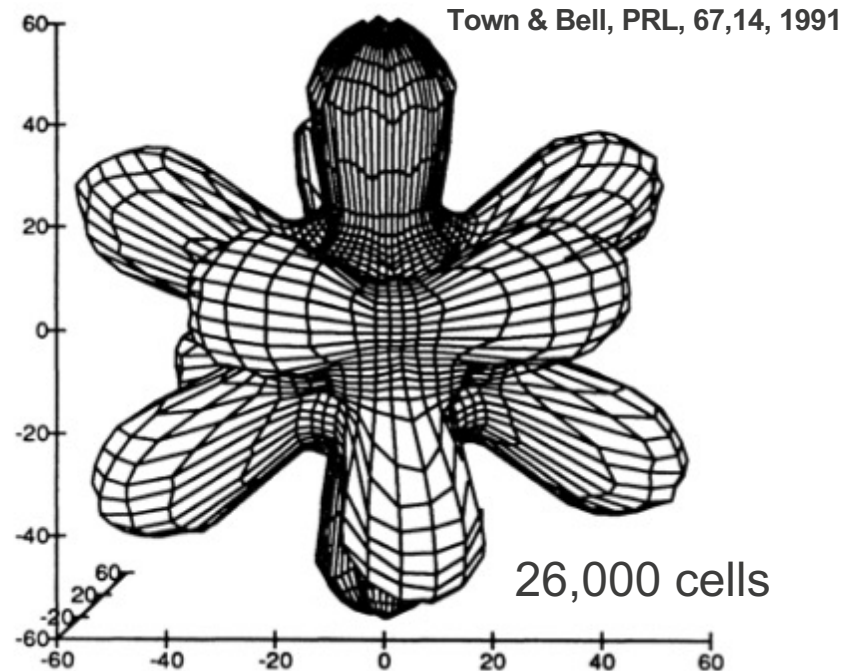


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At the beginning of Stockpile Stewardship there were stark gaps in our simulation capabilities

- Incomplete understanding of failure
 - Design “rules of thumb”
- Major deficiencies across the post-launch life of a weapon
 - Pre-boost implosion
 - One point safety
 - Boost
 - Energy coupling
 - Hostile survivability

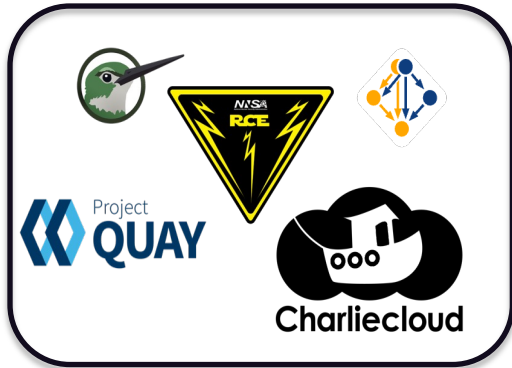
A State-of-the-art 1991 ICF Implosion Simulation
Heroic, but wrong



If they are remanufactured to the same specifications ... they will be as good as the day they were first made. This can be done any number of times and is the basis for my confidence in the future stockpile. – R. Garwin, Senate Testimony

Over the last 25 years ASC developed a broad set of computational capabilities for nuclear security

Software Environments



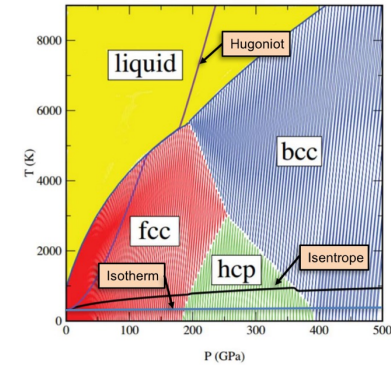
Computing Platforms



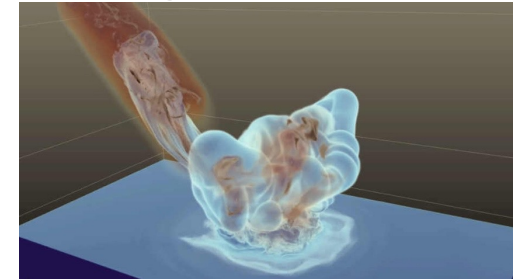
Facilities Operations & User Support



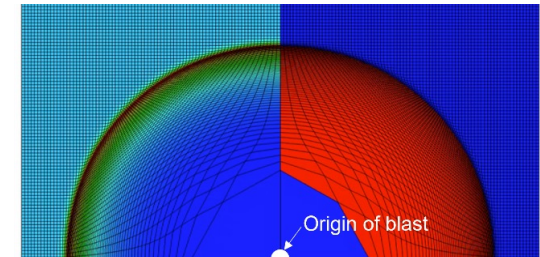
Physics & Engineering Models



Integrated Codes



Verification & Validation



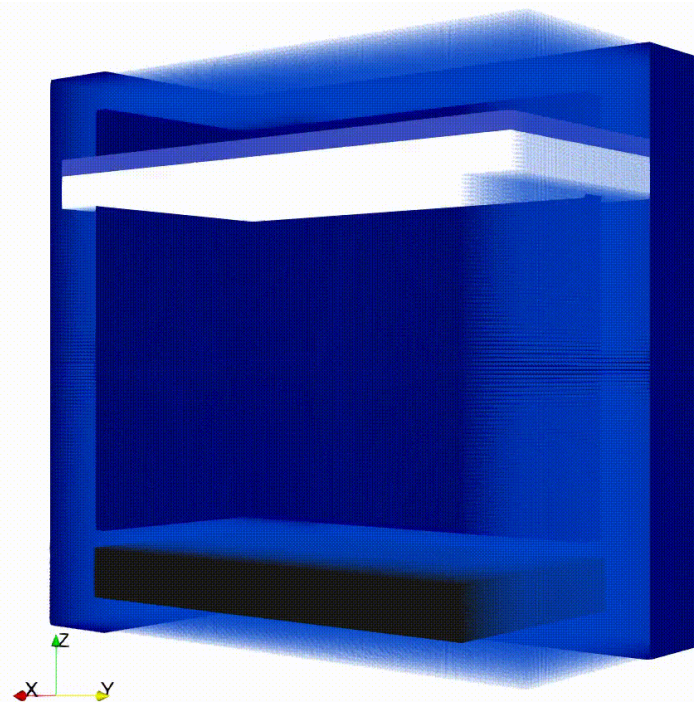
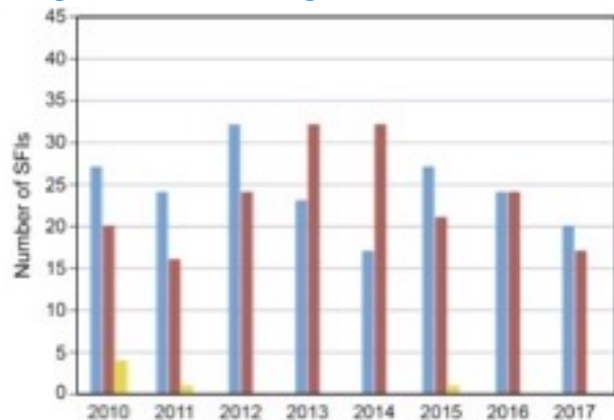
Computing

Defense Application Modeling

Through decades of work, the laboratories built simulation codes for underwriting performance

- Many of the historic gaps in our understanding have been resolved
- Although it is still a foundation, we are moving further from nuclear test data
 - Changes from legacy materials
 - Military requirements for the future
 - Aging and significant findings
- Nearly all performance questions are now answered with simulation
 - Safety
 - Normal and Hostile
 - Military effects

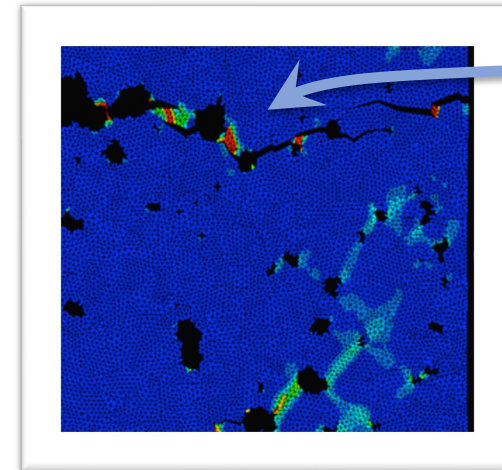
[100s of Significant Findings since the end of testing](#)



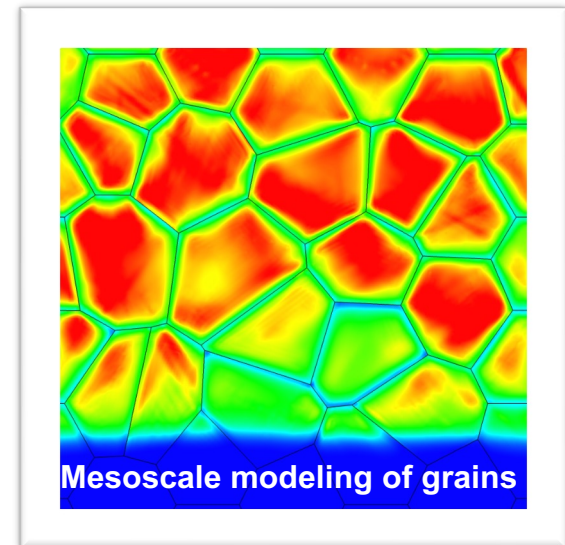
Aging and modernization are driving a more routine need for 3D simulation

Addressing security challenges has also depended on advances in fundamental models

- Aging has brought a steady drumbeat of changes
 - Metals corrode, metal coatings deteriorate
 - Material properties change with natural aging
- Modernization uses new materials and methods
 - Many legacy materials are no longer available (or wise).
 - New manufacturing methods lead to different material properties.
- New technologies and foreign advances are stretching US historic experience

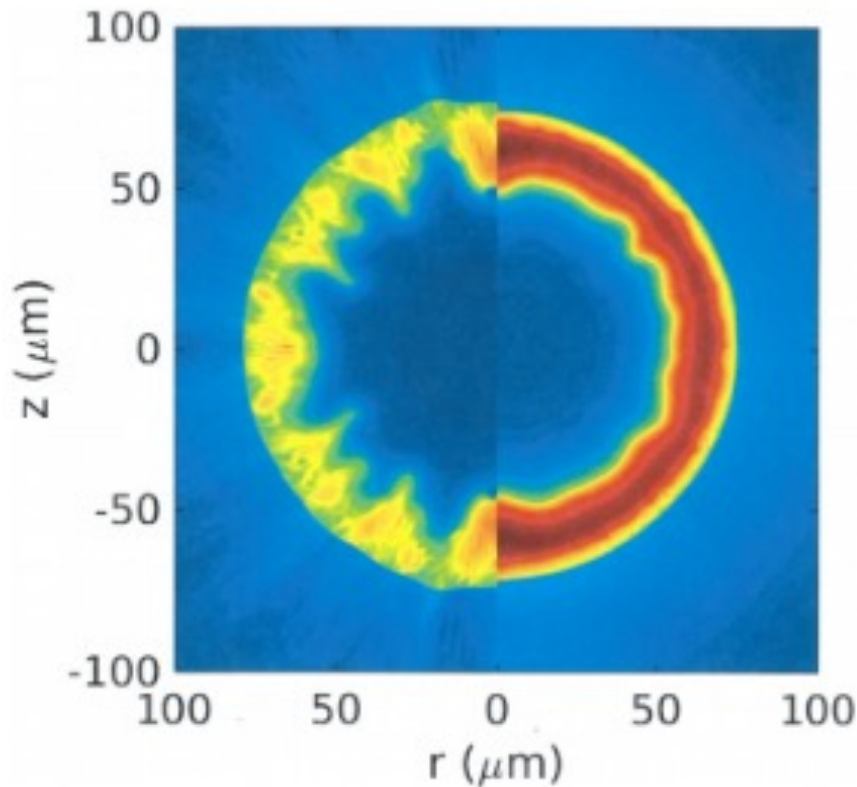


fracture

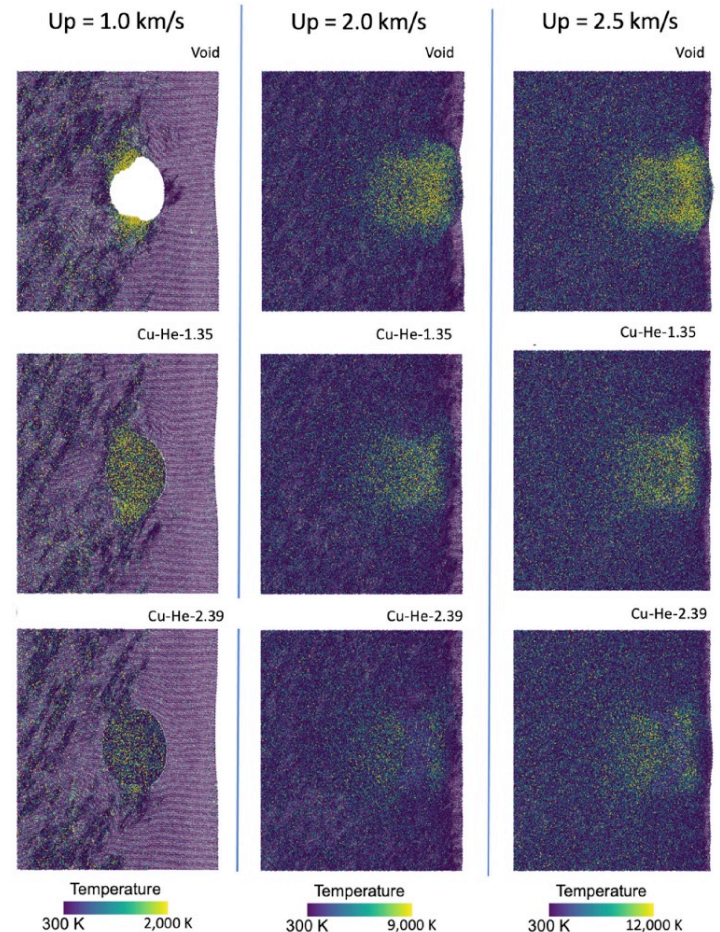


The computational resources in ASC have allowed world-class scientific discoveries for the deterrent

Influence of grain structure on ICF implosions

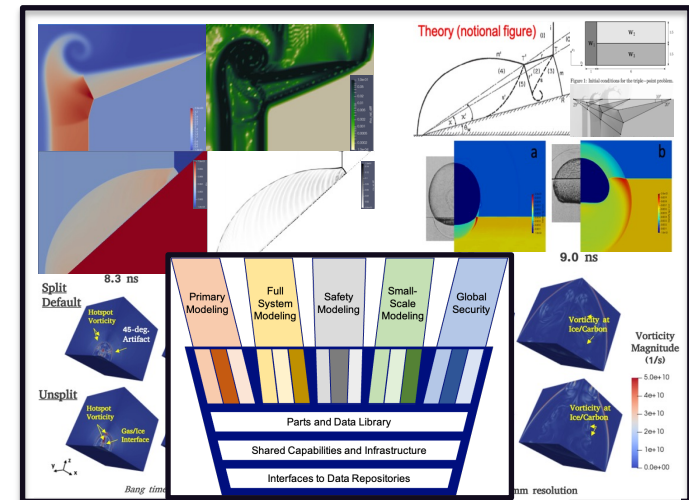
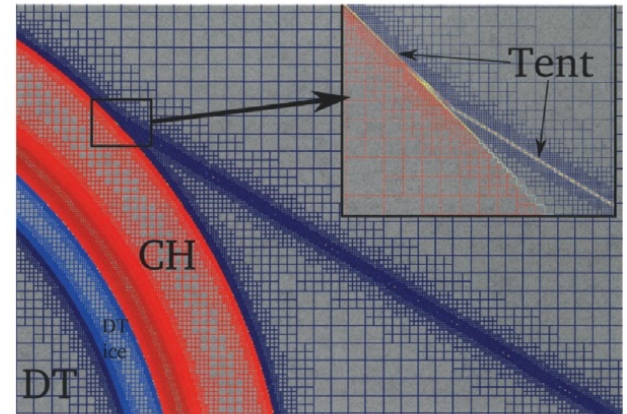


Multi-billion atom MD simulations for shocked materials



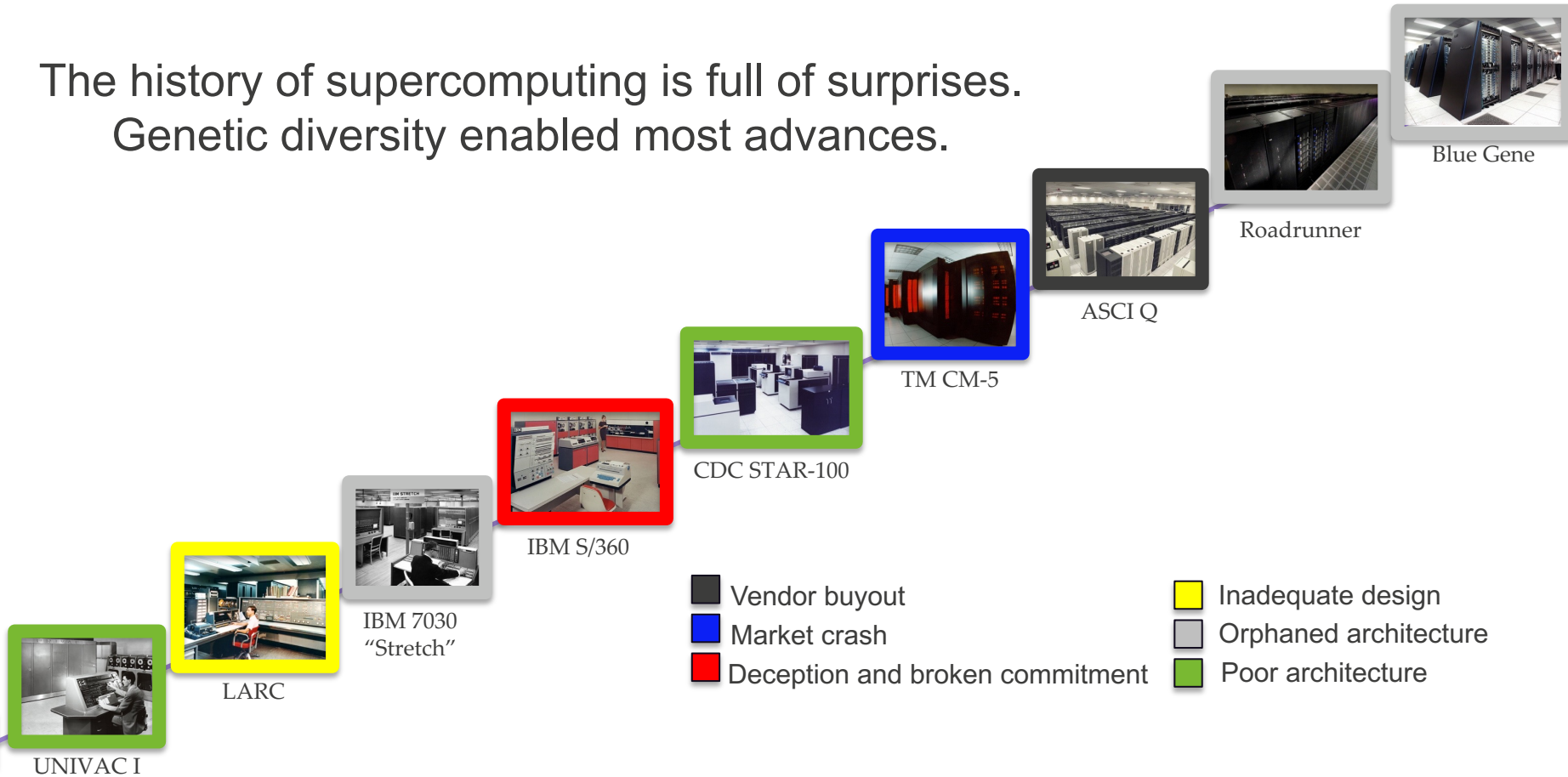
Verification and validation are paramount concerns

- Past mistakes have taught us to be cautious
 - Stockpile surprises
 - 3D features thought to be insignificant for ICF capsule modeling
- Test problem suites help identify where predictions can be trusted
 - Testing is continuous ... new capabilities are constantly being added
- Understanding the region of validity for complex simulations is an open question
 - Broad partnerships with academia are helping with this grand challenge



For 70 years the national laboratories have shaped computing technologies for complex systems

The history of supercomputing is full of surprises.
Genetic diversity enabled most advances.



ASC platforms are among the best in the world for our missions

- We have tailored our machines for simulating engineered systems
 - Our complex problems have very different needs than market trends
- Crossroads is a major advance, 5x better than Trinity for key simulations
 - High bandwidth memory, better chip technologies, intelligent storage
- Deep partnerships with industry on next-generation technologies
 - NVIDIA, Intel, HPE, SK
 - Focus on two root challenges: sparsity and branching



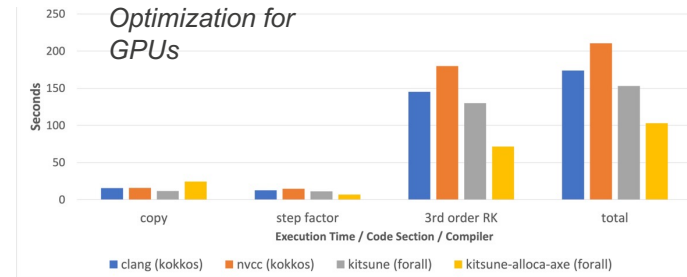
Leadership class computing is enabled with cutting edge computational systems and software environments

Emerging technologies

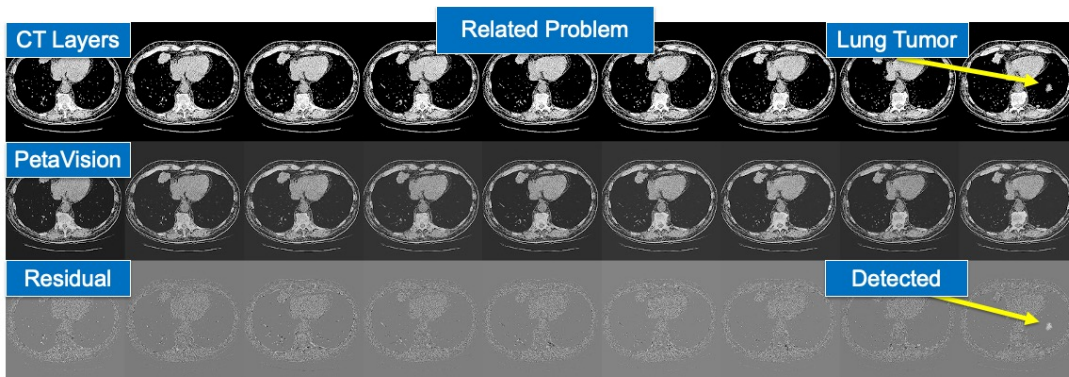


Darwin advanced technology testbed

Methods for exploiting new technology

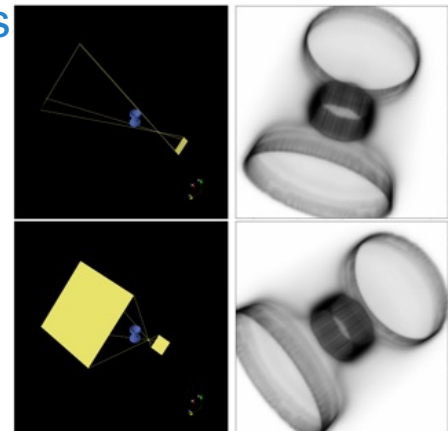


Advance capabilities like ML-assisted CT



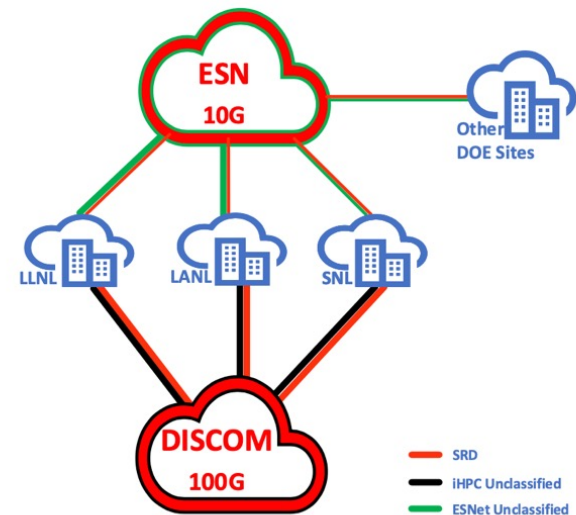
PetaVision being used to detect a lung tumor in a CT of a chest thorax

Inventing new data science capabilities



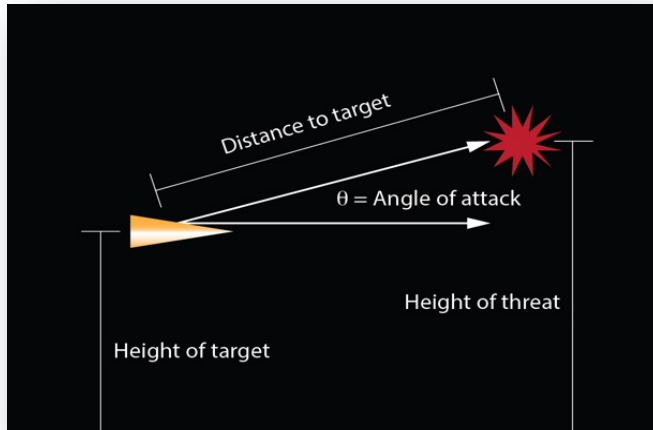
Infrastructure, operations, and user support are the foundation for leadership class machines

- First class facilities for our people and platforms
 - With SCC electrical upgrades we are ready for 2030
- Operational excellence
 - Nearly 100% recycled water
 - Outstanding record of uninterrupted machine availability
- User support of complex and diverse workflows
 - Towards seamless remote computing
 - New tools for data-centric computing

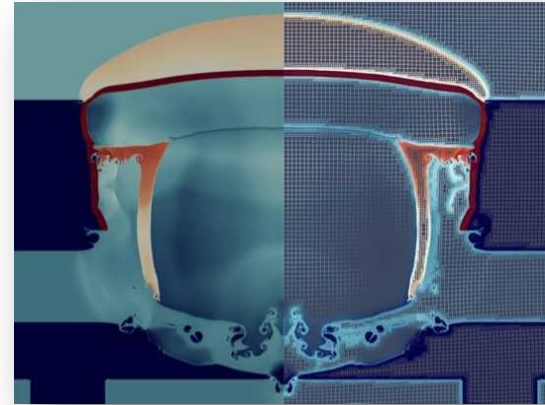


Steady advances in technology and simulation are allowing new types of contributions for the future

Avoiding surprise



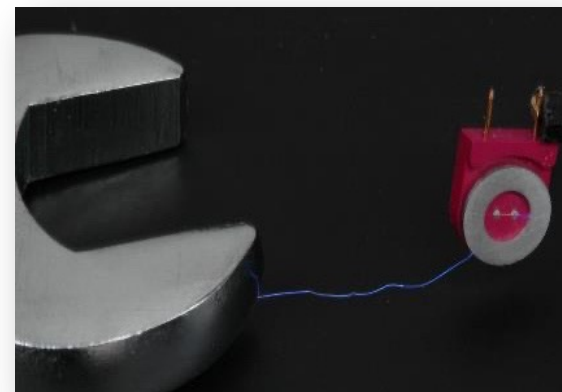
Accelerating Production



Assessing complex accidents



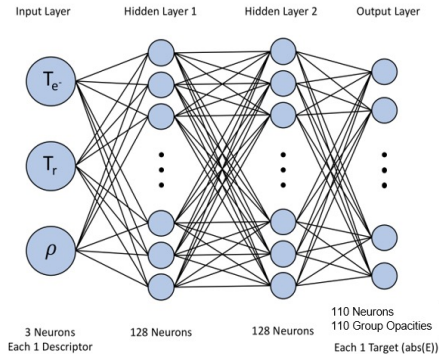
Improving plant operations



Machine learning is showing special promise for many of our needs

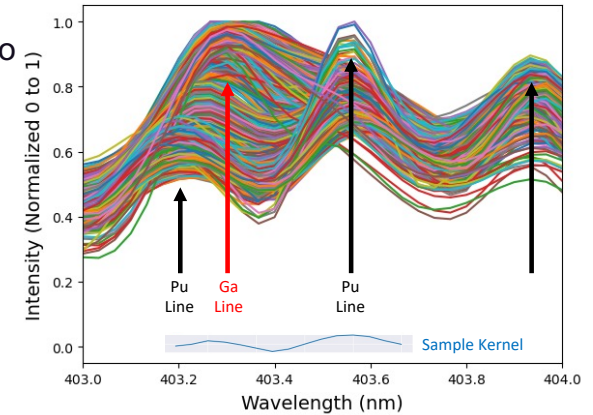
Improving Simulation

Reduced non-LTE opacity tables by 97%

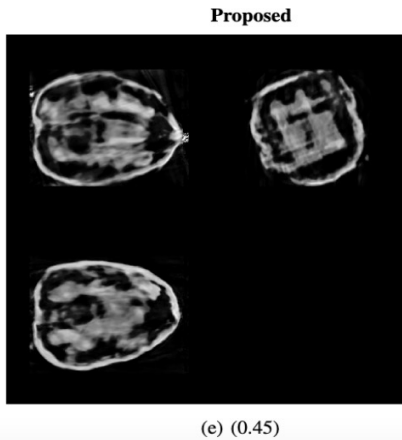


Strengthening Manufacturing

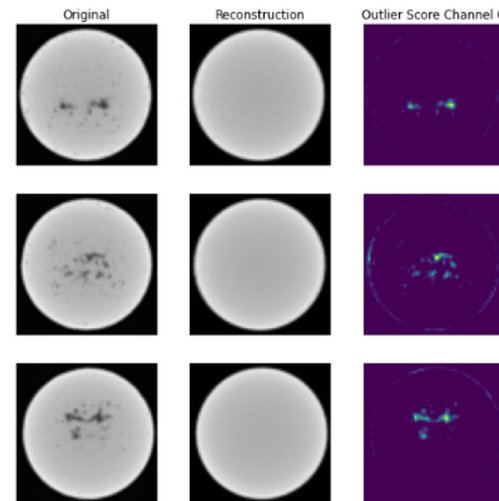
Learning LIBs spectra to possibly replace analytical chemistry.



Better use of Data



Generative adversarial network for reconstruction



Auto-encoders find defects in AM parts. (Partnership with Kansas City).

Backup Slides

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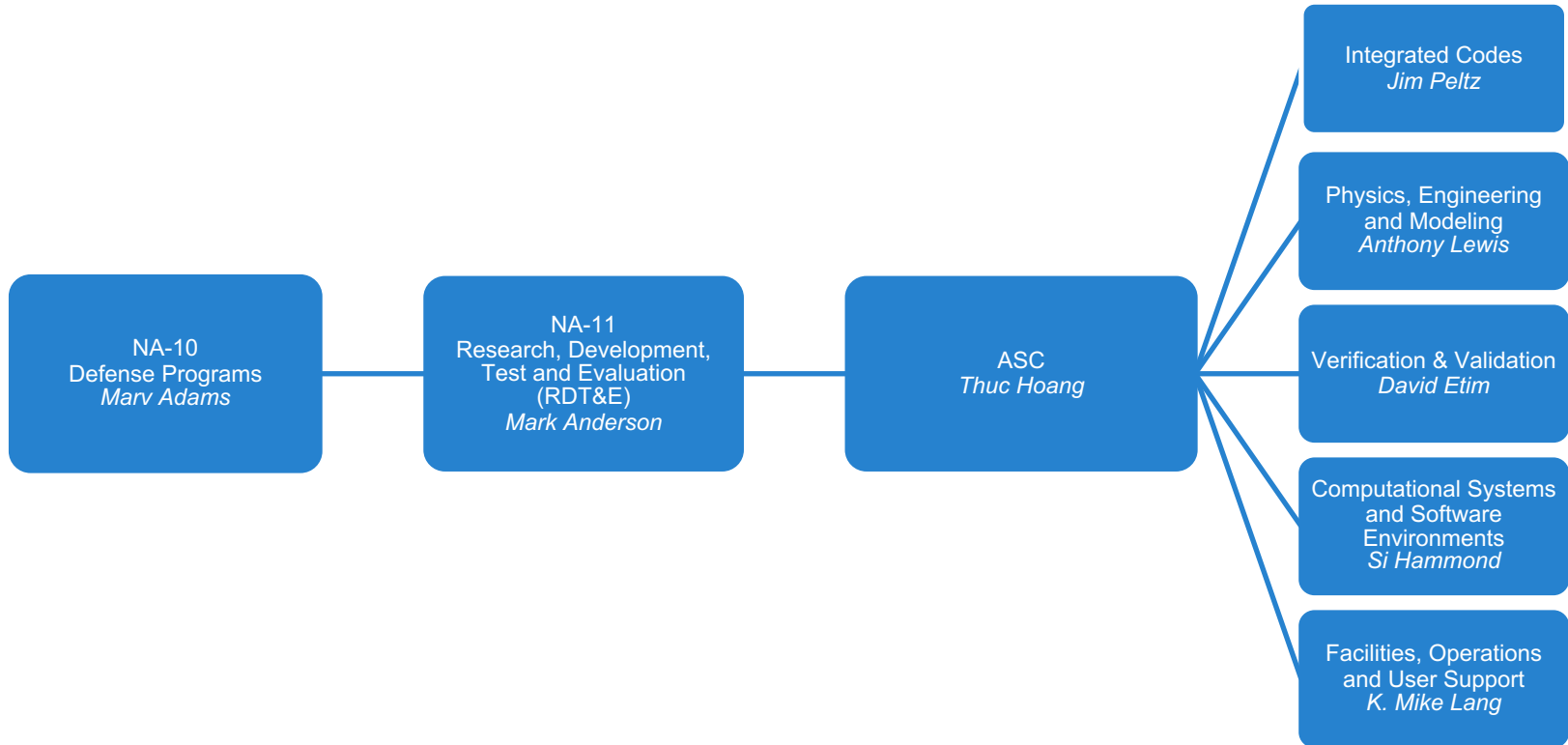
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Dave Bowman

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Teresa Robbins

Sandia Field Office
(NA-SN)
Daryl Hauck

DECEMBER 6, 2022

The ASC program within NNSA Defense Programs



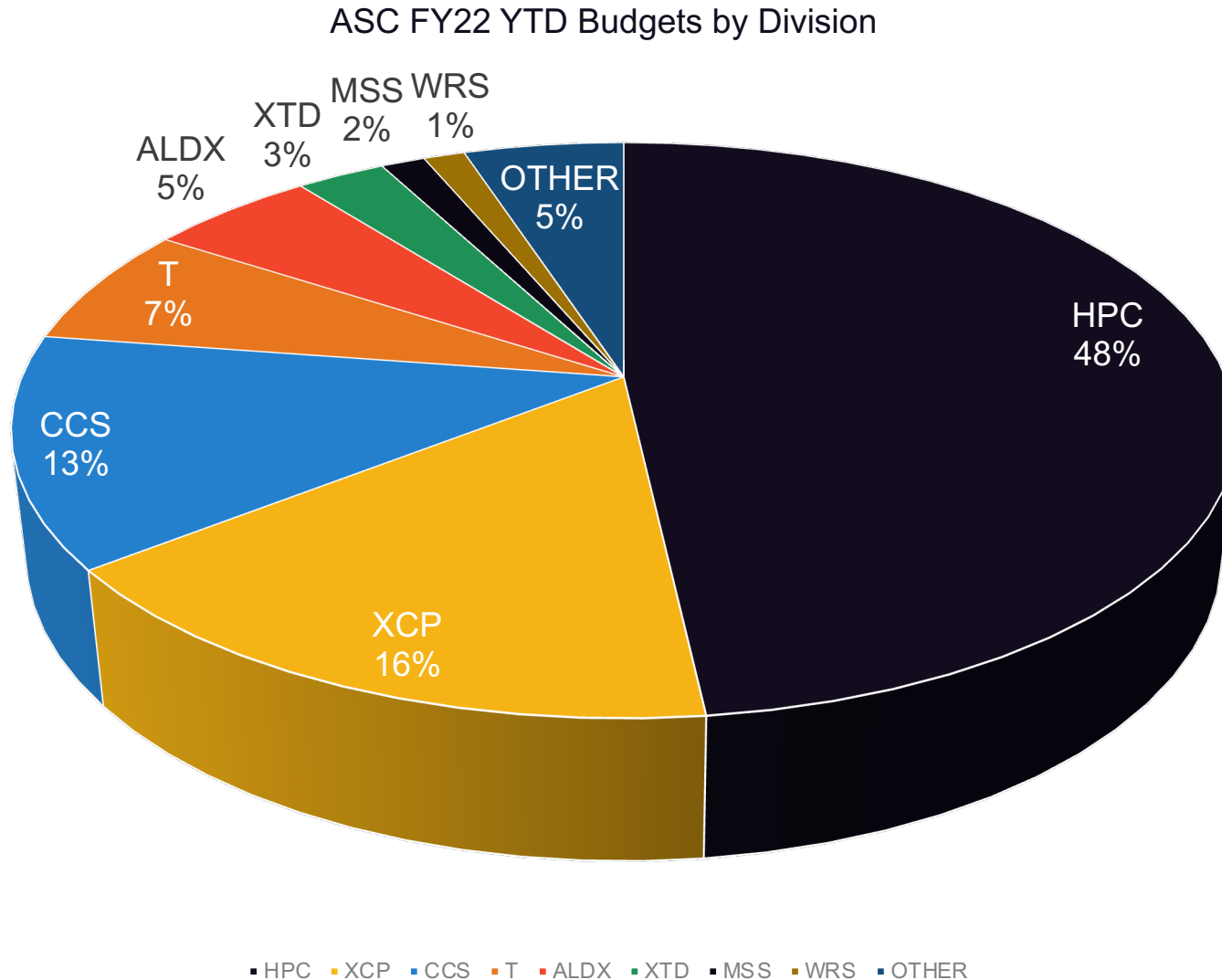
The Advanced Simulation and Computing program

Provides the simulation tools to enable the nation's nuclear deterrence

Principles

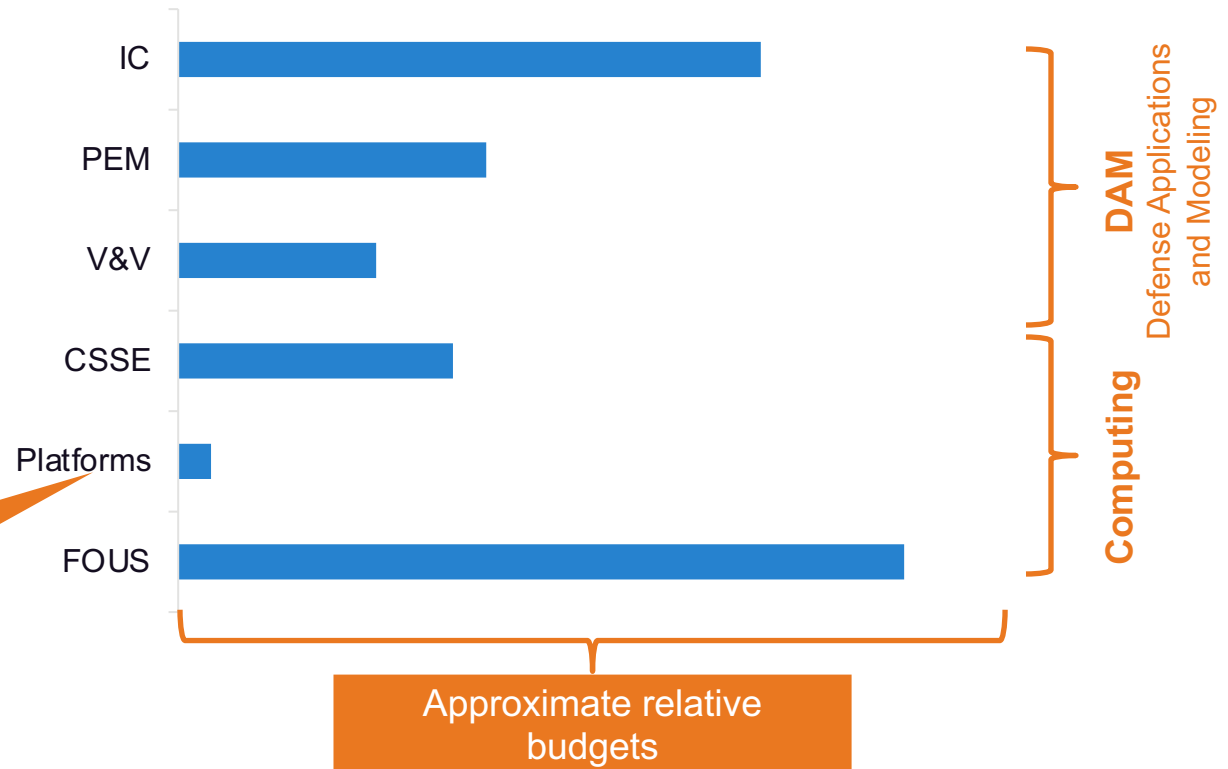
- The ASC Program is responsible for providing future stockpile-related simulation and computing capabilities.
- Requirements from Direct Stockpile Work, Life Extension Programs (LEPs), Science and Engineering programs, Nuclear Counterterrorism, and other related national programs drive the ASC Program and its associated budgets.
- The ASC Program is defined by a single work breakdown structure that is incorporated into the DOE Budget and Reporting Codes (B&R) system.
- The ASC Program is a Federally managed and coordinated program, with primary responsibility for execution assigned to the NNSA national security laboratories.
- Efficient management requires coordination and collaboration with other government agencies, particularly those with high performance computing (HPC) programs.
- Periodic reviews of the technical and administrative activities hold the participants accountable for their part of the ASC Program.

The breadth of ASC contributions can be seen in the broad cross section of contributors across DDW and DDSTE



ASC Program Structure

- Five sub-programs nationally
- At LANL, CSSE is further partitioned as
 - CSSE
 - Platforms



Contracts and budget for major acquisitions flow through here

Approximate relative budgets

Defense Applications and Modeling (DAM) sub-programs

Descriptions paraphrased from ASC 2015 Business Plan

IC: Integrated Codes

- Culmination of the software development efforts of the program
- Provide the simulation capability for the Stockpile Stewardship Program (SSP) and underpin a credible nuclear deterrence
- Meet Directed Stockpile Work (DSW) requirements, including Significant Finding Inquiries (SFIs) and Life Extension Programs (LEPs)

PEM: Physics and Engineering Models

- Provide the models and databases that are implemented in the integrated codes
- Connection to the Science Programs, which carry out the experimental portion of the SSP

V&V: Verification and Validation

- Ensure a pedigreed scientific basis of the modeling and simulation program
- Verification that models are correctly implemented in the integrated codes
- Validation (e.g., via comparison with experiment) that the codes are a representation of physical reality at the required fidelity in the regime of interest

Computing sub-programs

Descriptions paraphrased from ASC 2015 Business Plan

FOUS: Facility Operations and User Support

- The support infrastructure for program's high-performance computing (HPC)
- Provide space, power, cooling and systems monitoring for HPC compute and storage
- User support for HPC
- Coordinate with national and institutional facility strategic planning

CSSE: Computational Systems and Software Environments

- Provide the computational infrastructure to support the integrated codes
- Integrate SW and HW products into an ecosystem of workflow processes, support tools, storage systems, and communication devices
- Understanding and planning to meet future computational needs of the program

Platforms (LANL only, broken out from CSSE)

- Platform acquisition, and contract management
- Vendor relationships
- Coordinate with national and institutional platform strategic planning