Perspectives on Future NNSA Accelerator – Based Research

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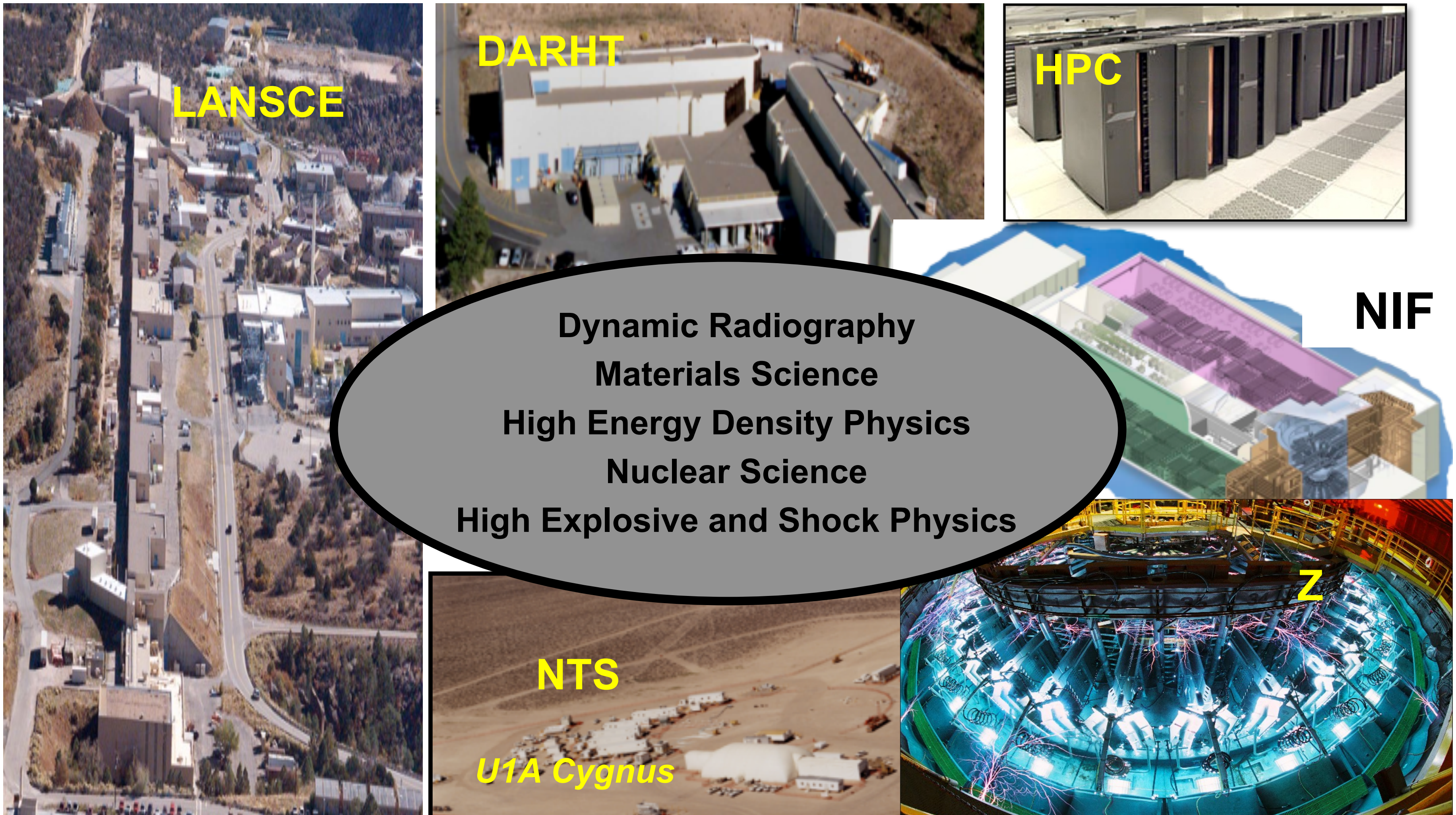
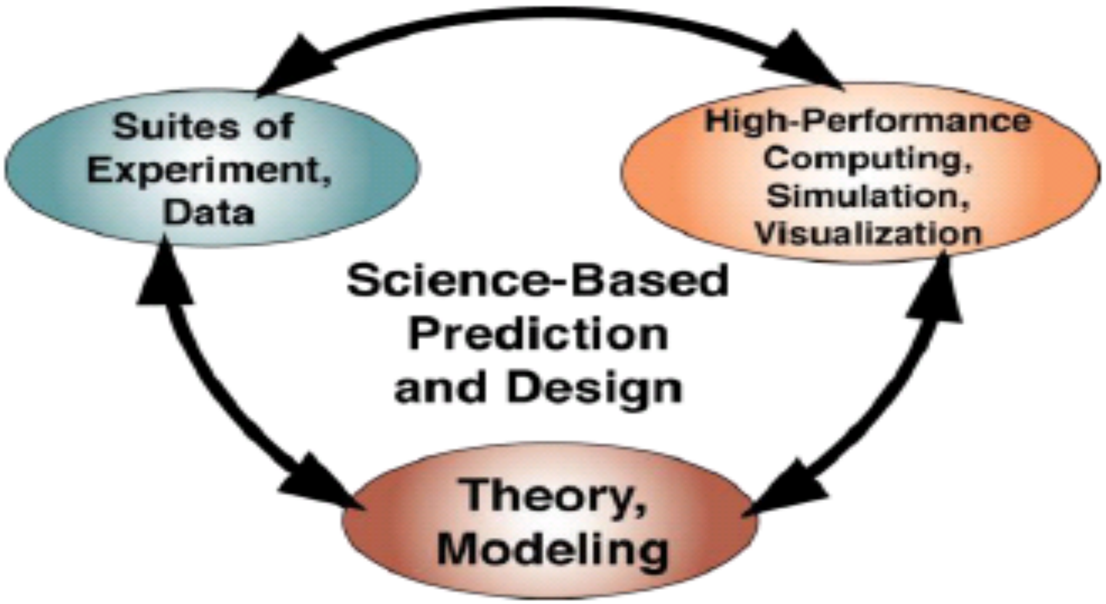
The NNSA uses major experimental and computational facilities for Stockpile Stewardship

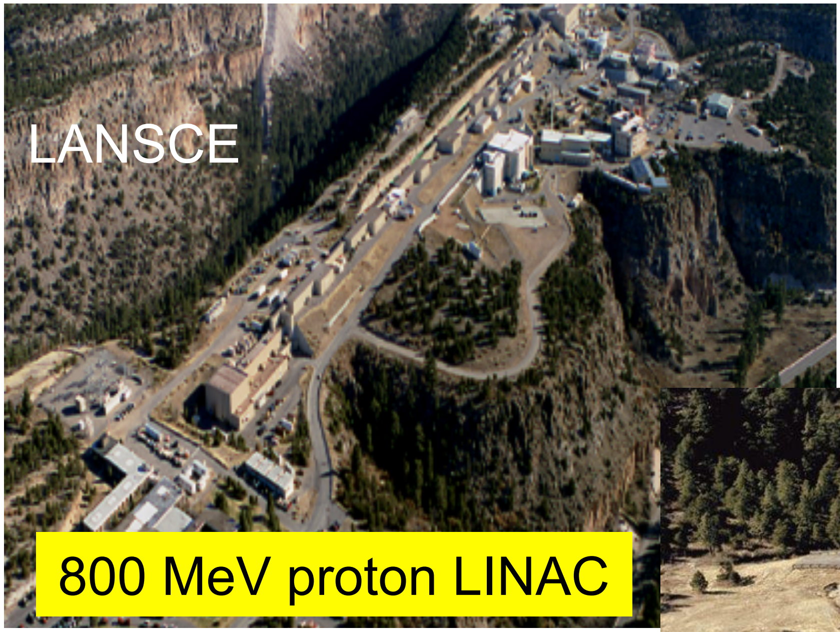


A strong coupling between Theory/Modeling, High Performance Computing and Experiment is a principal construct for NNSA programmatic research

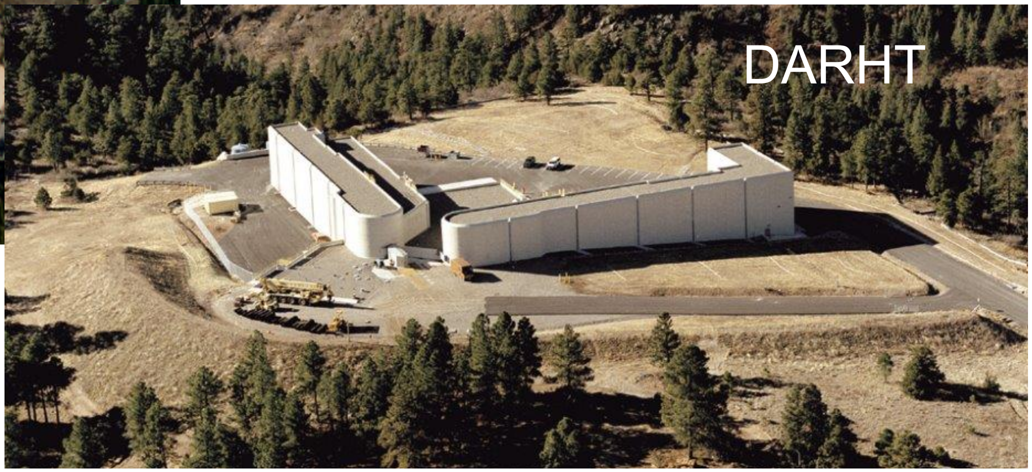


Effective "Science-based prediction and design" sets the requirements for the scientific disciplines and tools needed to achieve the predictive capability necessary for Stockpile Stewardship

At Los Alamos, LANSCE and DARHT are the two principal accelerator-based facilities



800 MeV proton LINAC



2 linear-induction electron beam accelerators with an included angle of 90°

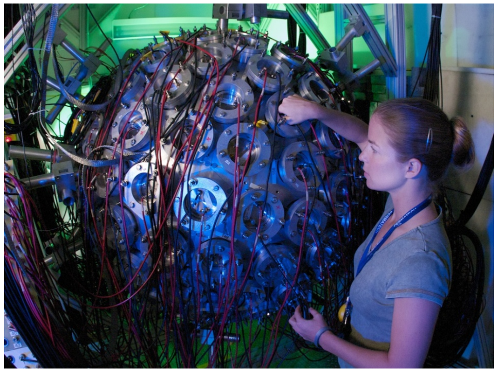
LANSCE

LANSCE is an accelerator-based research complex that provides unique capabilities for DOE and NNSA programs in neutron science

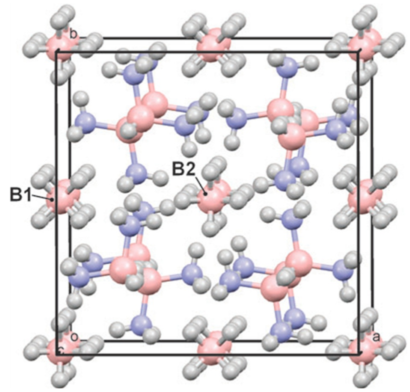
- **Lujan – Moderated Target**
  - Materials, bio-science, and nuclear physics
  - National security research
  - National user facility
- **WNR – Un-moderated Targets**
  - National security research
  - Nuclear physics
  - Neutron irradiation
- **Ultra Cold neutrons**
  - Fundamental Nuclear physics
- **Proton Radiography**
  - National security research
  - Dynamic materials science
  - Hydrodynamics
- **Isotope Production Facility**
  - Medical and research radioisotopes

24/7, highly flexible beam delivery, simultaneous to multiple experiments

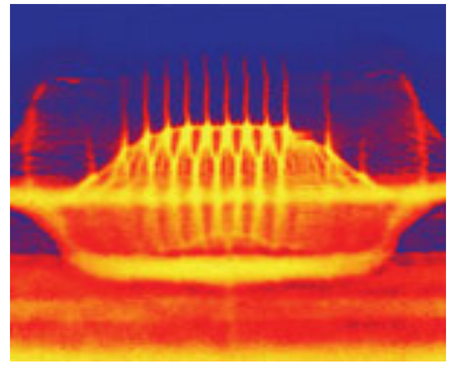
The breadth of LANSCE research reflects the specific demands of Stockpile Stewardship and the broader requirements for achieving scientific excellence.



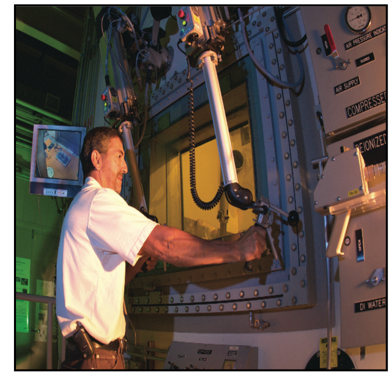
Nuclear Science and Technology



Materials Science

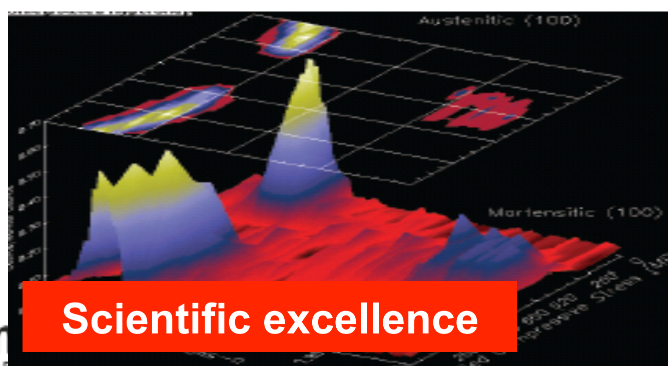


Materials in Extremes Research



Isotope Production

- Provide required research for Stockpile Stewardship and National Security
- Maintain and grow the excellence of the NNSA science base to ensure the quality of scientific and technical staff that ensures the stockpile is safe, secure, and effective



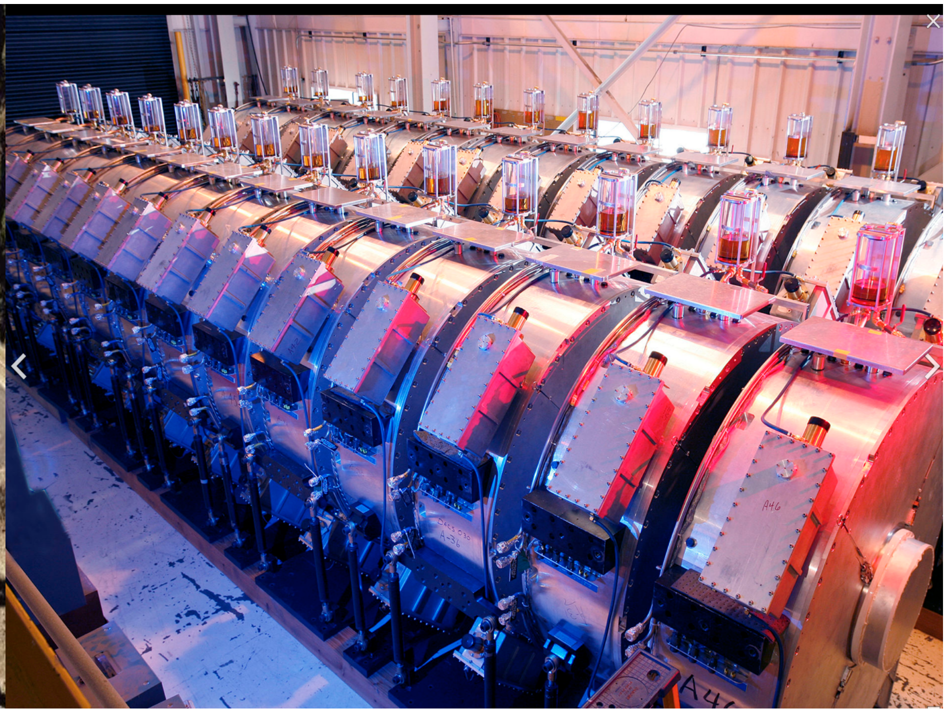
Scientific excellence

Recruiting Our Future Staff

DARHT

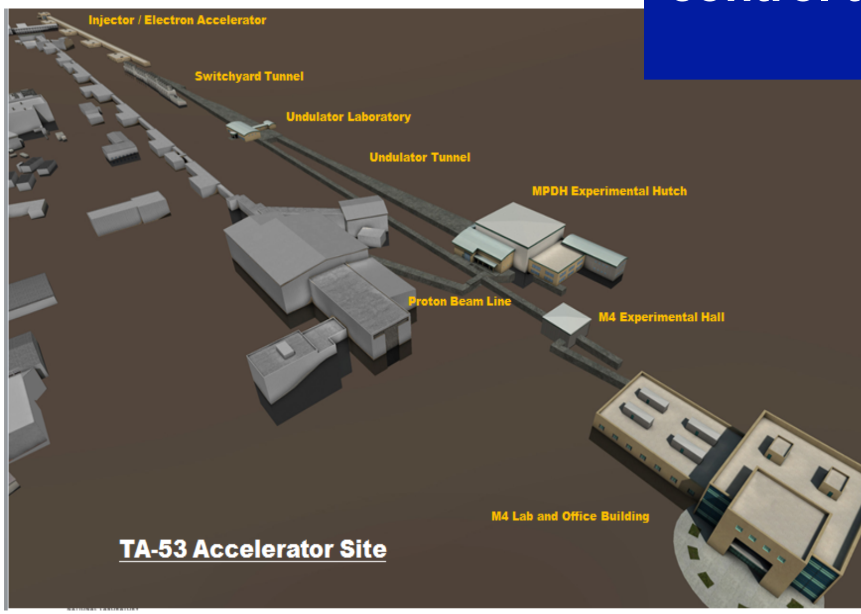
DARHT provides high-resolution radiographic capability to perform hydrodynamic tests and dynamic experiments in support of stockpile stewardship.

- **The DARHT facility houses 2 linear-induction electron beam accelerator machines with an included angle of 90^{o}, which produce intense electron beams that are converted to x-ray pulses.**
- **The x-ray pulses are delivered to the R-312 firing site to radiograph high density materials during very short durations (e.g., 10 to 100 nanoseconds).**



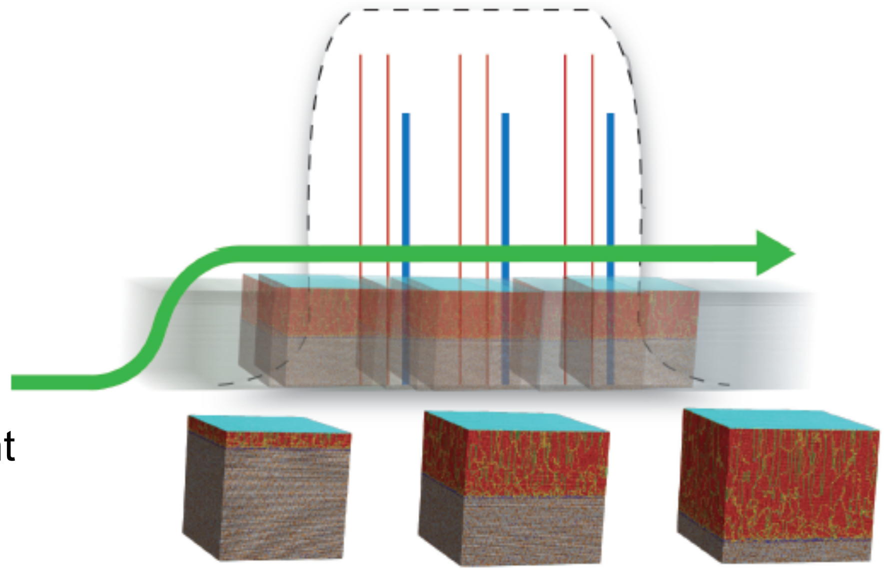
For the future, Los Alamos is pursuing the accelerator-based facility MaRIE (Materials-Radiation In Extremes)

MaRIE is the experimental facility needed to control the time-dependent properties of materials for national security missions.

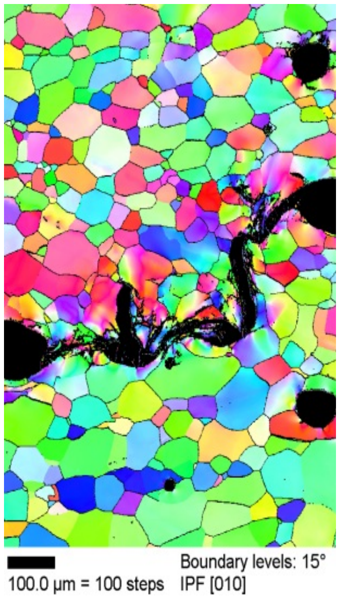


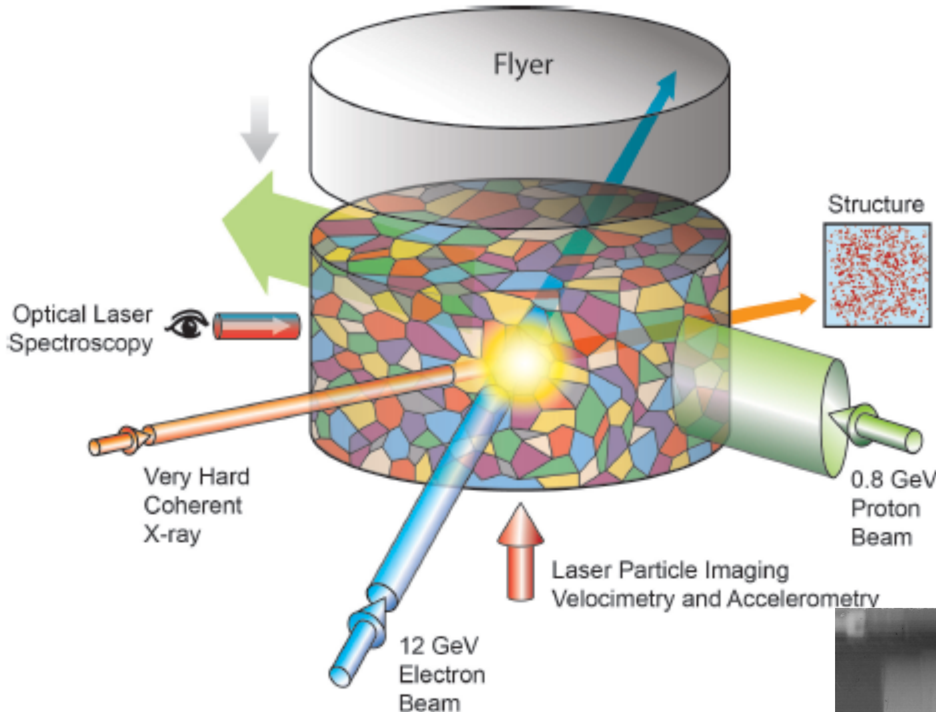
MaRIE 1.0 will provide a unique capability for simultaneous, multi-probe measurements of in situ transient phenomena in relevant dynamic extremes

MaRIE 1.0 multiplexes 42-keV x-ray photons (red), 12-GeV electrons (blue), and 0.8-GeV protons (green) during a single dynamic event



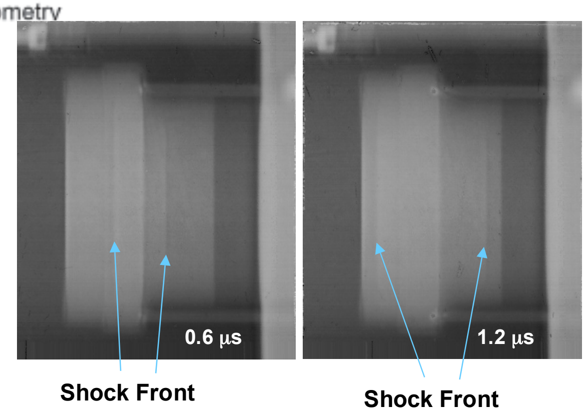
MaRIE's multiple probes will enable observation of the dynamic microstructure and phase evolution in actinides down to the sub-granular level while connecting to the macroscale or continuum





Sub-μm resolution
100's – 1000's μm samples
Sub-ns resolution,
~30 frames in
1 μs duration

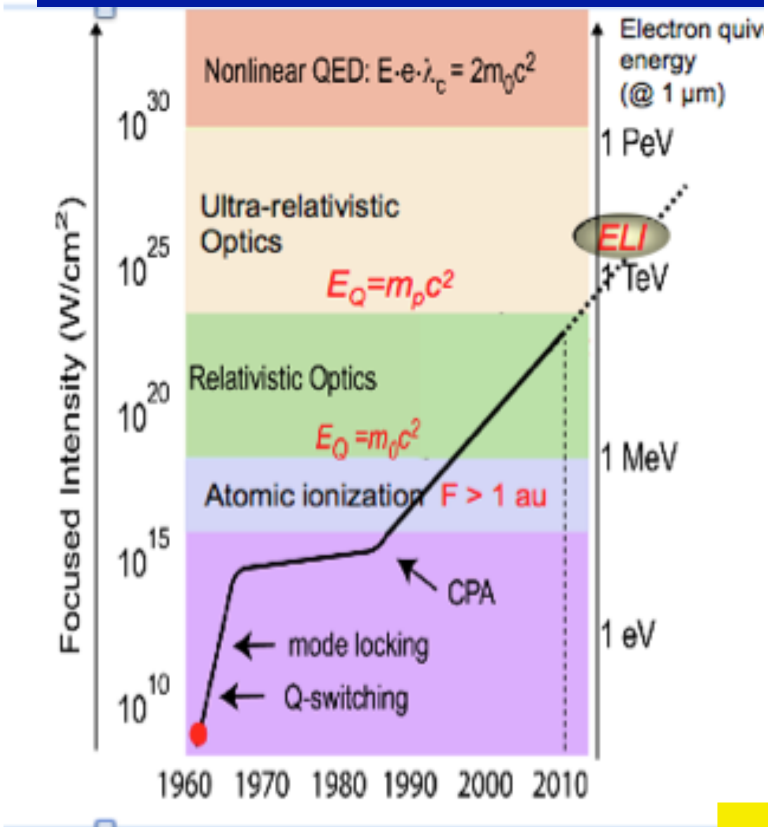
<u>The model:</u> Accurate sub-grain models of microstructure evolution coupled to molecular dynamics



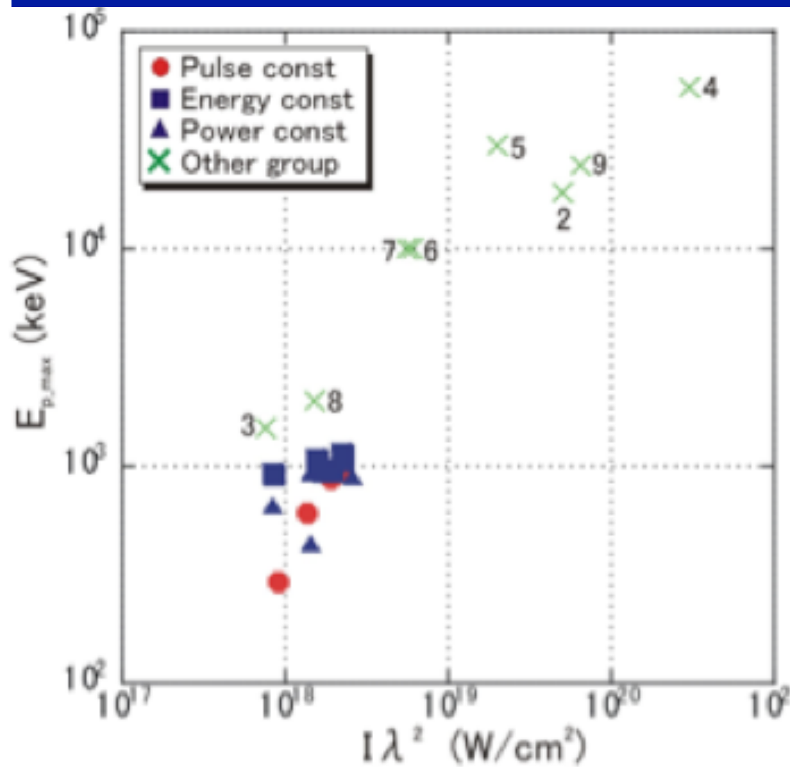
<u>The Goal:</u>
Predict shock-dynamic microstructure and damage evolution in Stockpile-relevant materials

Lasers will play an important role in the future of particle acceleration

Focused intensity is growing[1]



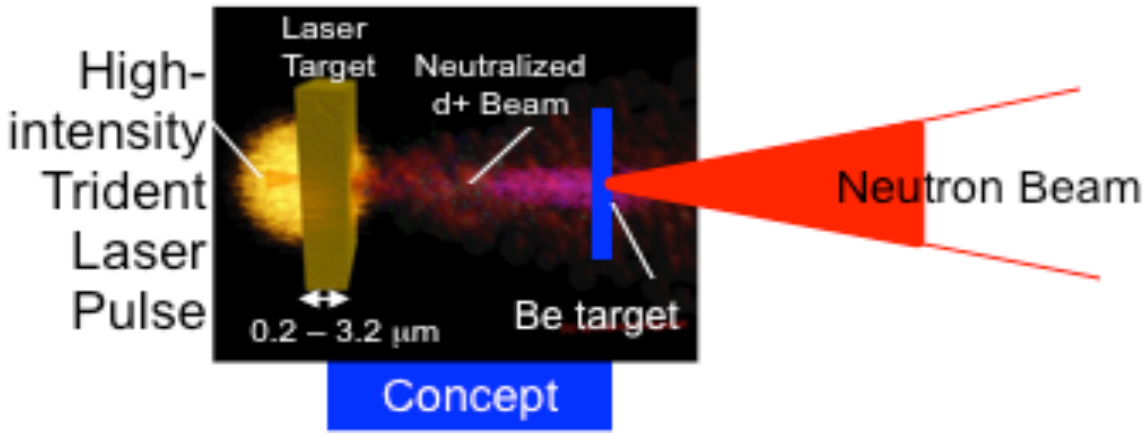
Proton energy scales with intensity[1]

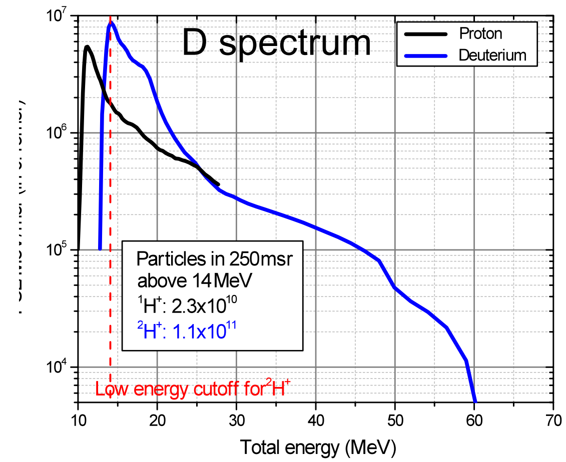


For a 10 kJ 100 PW laser one can expect 3×10^{13} protons >500MeV

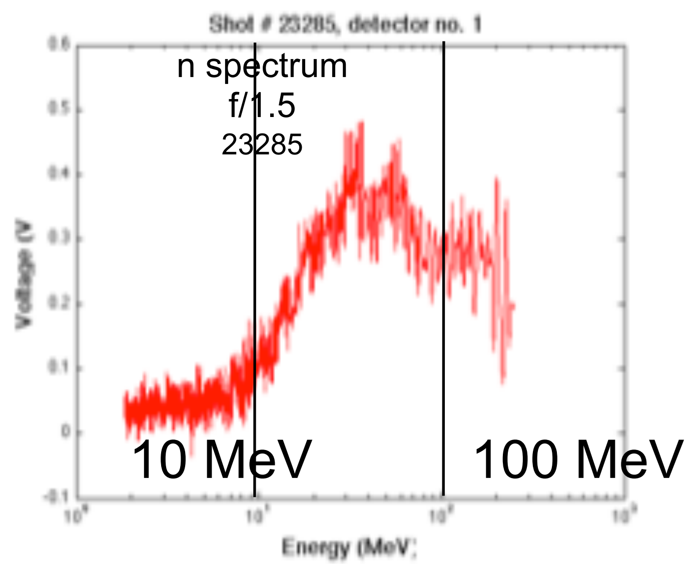
REFERENCE:
1. M Roth, TUD Darmstadt, IZEST, 2013

Example: Record neutron production with Los Alamos Trident laser-produced deuterium beam





- Driven by D beam made with BOA[1] mechanism
- Neutron source ~ ns, forward-directed (~ 0.25 – 1 Steradian)
- At 1.2×10^{21} W/cm^2 : ~ 10^{10} neutrons with forward fluence of ~ 5×10^9 n/sterradian



*M. Roth et al., PRL **110**, 044802 (2013)

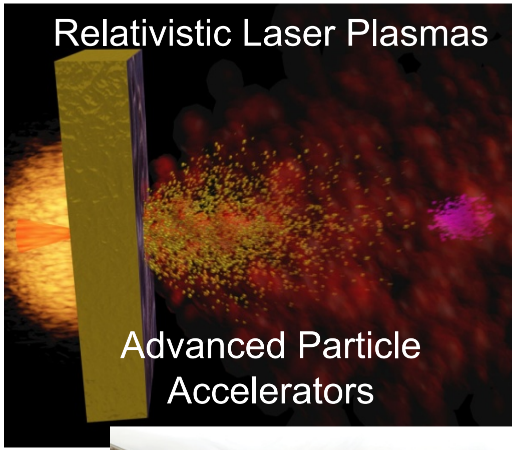
A 10 kJ High Energy Short Pulse laser is estimated to yield close to a 10^{14} neutron beam per shot and maybe 10^{15} in real spallation mode in < 1 ns

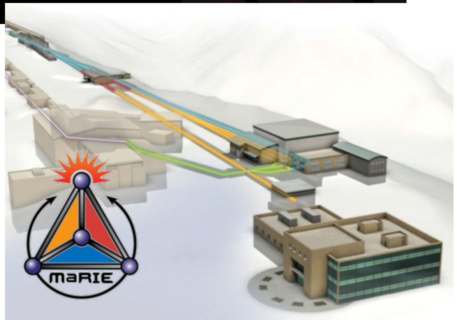
UNCLASSIFIED

Example: Emerging and unconventional opportunities in High Energy Density science rely on the nexus of accelerators and lasers

- Evolution of existing technologies:
  - ➢ Using accelerators to produce matter in extreme conditions
  - ➢Using laser-produced intense ion beams to make and probe matter under extreme conditions

- Co location of evolving technologies - examples
  - ➢ Co-location of HED laser facility at the SLAC FEL
  - ➢ HIBEF (Helmholtz International Beamline for Extreme Fields) Laser at the European EXFEL (DESY)
  - ➢ Co- location of a high-energy Petawatt laser with the heavy ion accelerator at the Facility for Antiproto Research (FAIR) Darmstadt
  - ➢ Concept MaRIE at Los Alamos





FAIR Facility for Antiproton and Ion Research in Europe GmbH

HZDR

CONCLUSIONS

- Accelerators play a major role in NNSA facilities for Stockpile Stewardship research
- Evolution of accelerator science and technology will continue to enable attaining the predictive capability necessary for Stockpile Stewardship
- Laser acceleration of particles is a rapidly evolving science with large implications for future fundamental and applied research