LANSCE
Los Alamos Neutron Science Center

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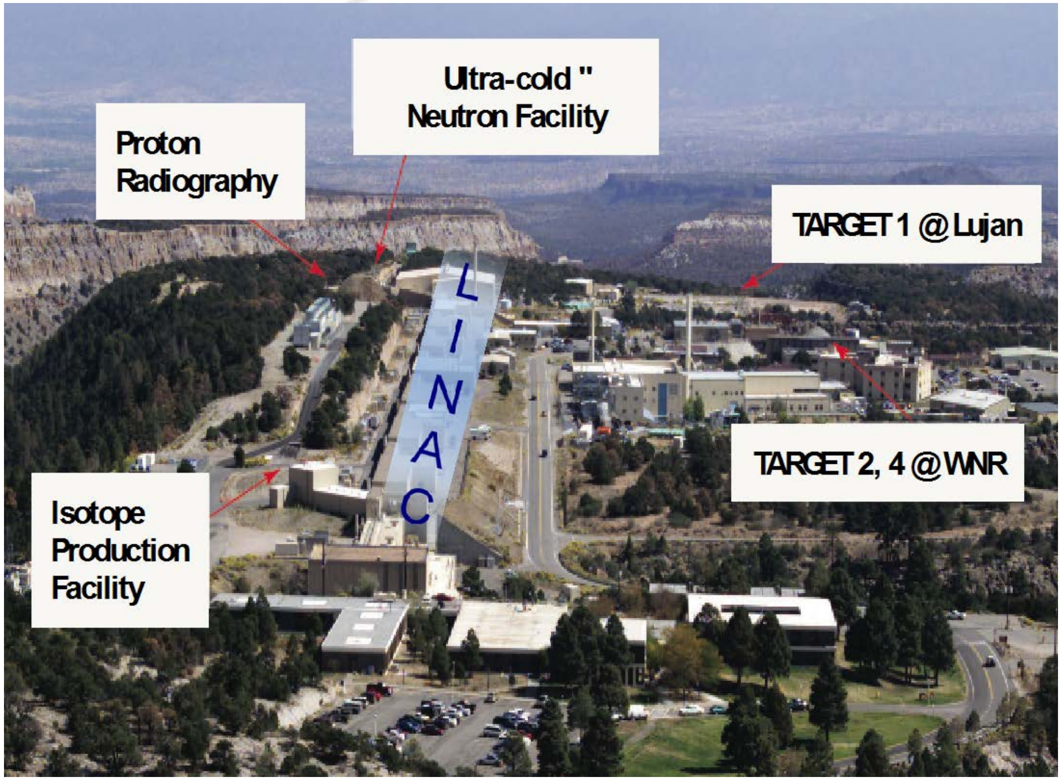
LA-UR-15-28475

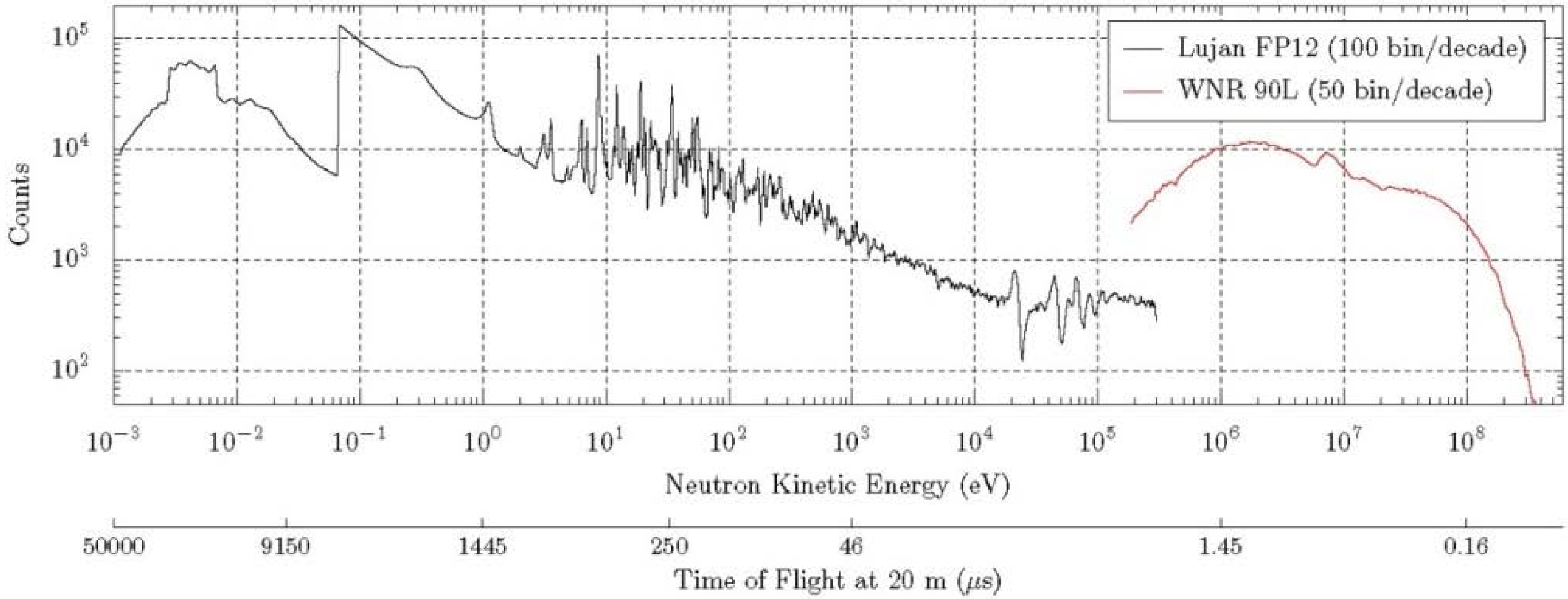
The LANSCE Facility



Six targets enable a broad range of programmatic and fundamental research

- Proton radiography
  - High explosives
  - Shock physics
  - Materials in extremes
- High-energy neutrons (WNR)
  - Nuclear physics (fission process)
  - Neutron radiography (high-energy)
  - Semiconductor
- Low-energy neutrons (Lujan Center)
  - Nuclear physics (fission process)
  - Material science
  - Neutron radiography (epithermal)
- Ultra-Cold Neutrons
  - Neutron lifetime
  - Beta-decay asymmetry parameters
  - Neutron electric dipole moment
- Isotope Production (IPF)
  - Largest source of Sr-82 for cardiac imaging (30,000 patients/month)
  - DOE NP funding $5.1M AIP

11 Orders of Magnitude in Neutron Energy: meV to 800 MeV



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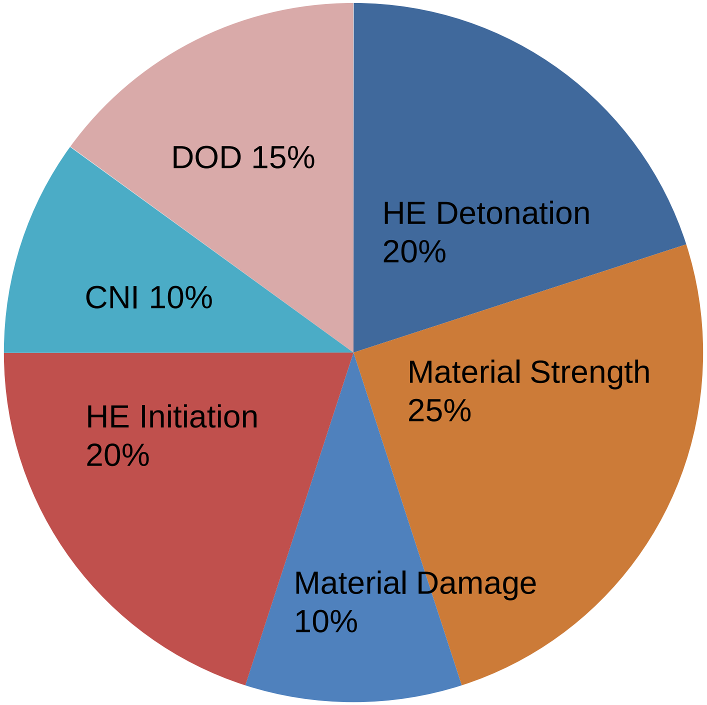
2014-2015 Run Cycle: pRAD

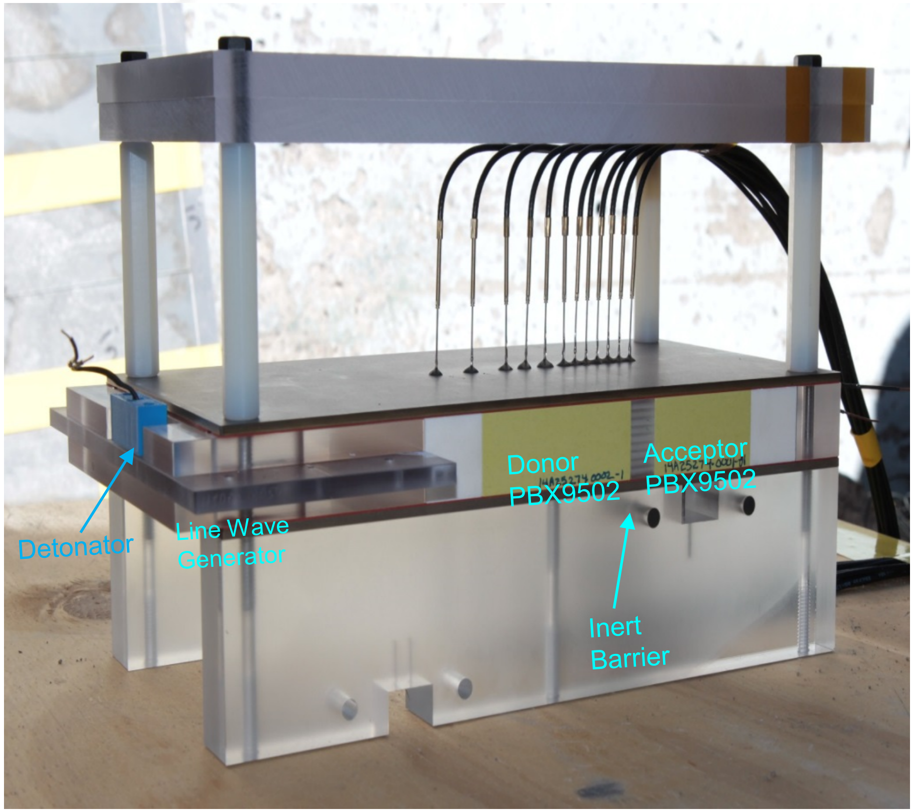
pRad performed 20 dynamic experiments in the run cycle



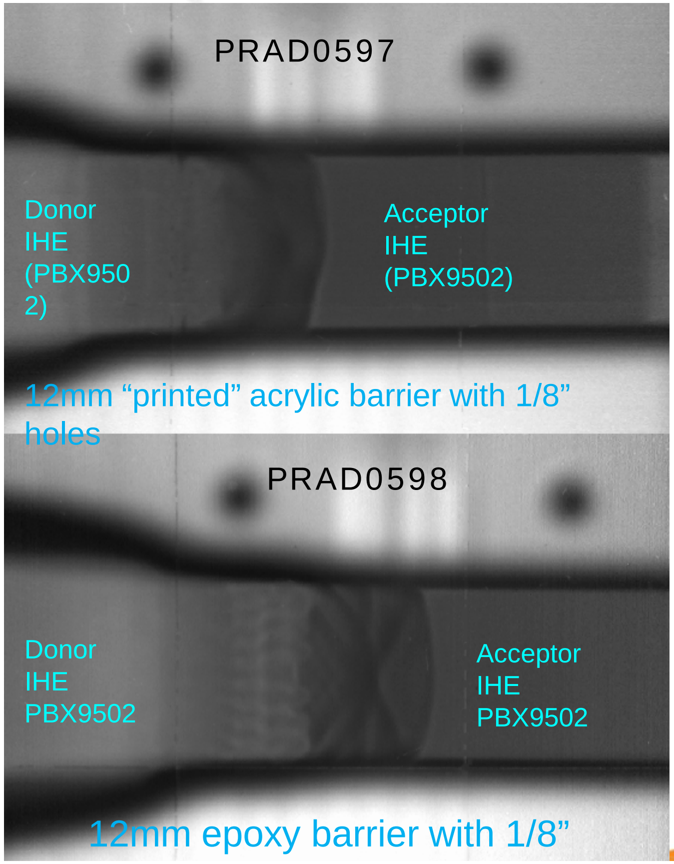
- B61-LEP: Understand performance of IHE
- Validation experiment for future subcritical experiment
- Focused physics experiments
  - Richtmyer-Meshkov Instabilities
  - High explosives studies
  - Solidification process

HE Burn Studies

Study the Propagation of Detonation and Shock waves through Inert Barriers



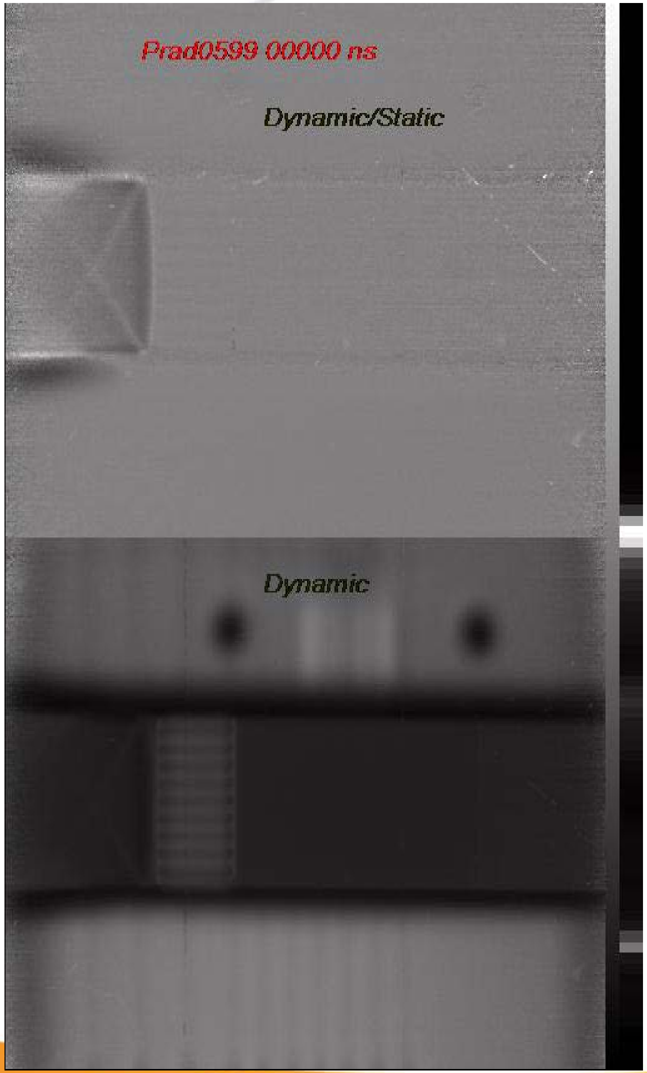
Shot Assembly



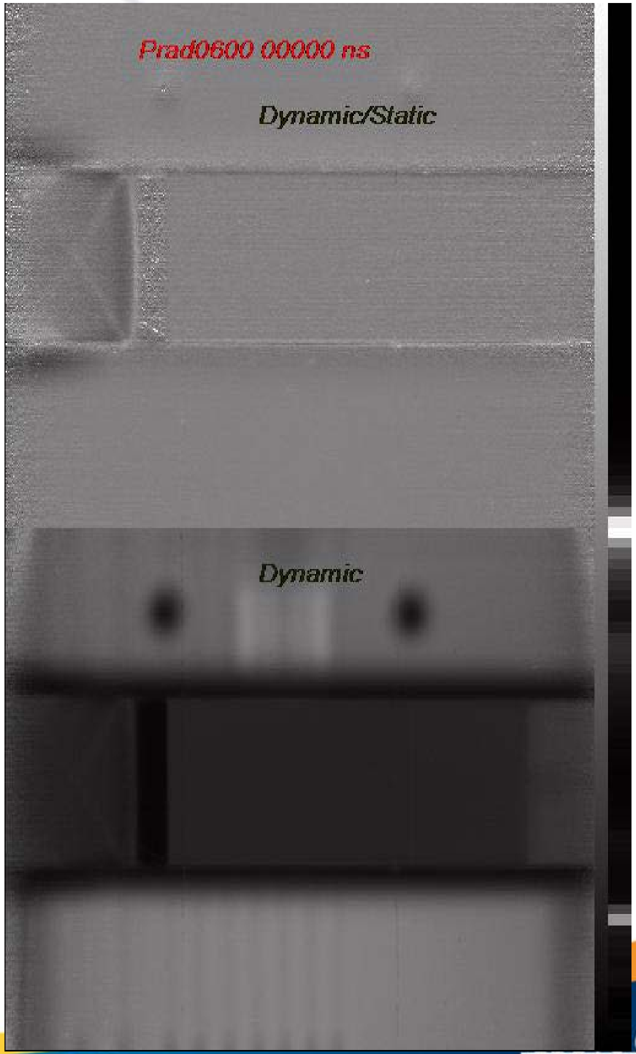
The structure of the shock waves in the detonation by products through an epoxy barrier and through a “printed” acrylic barrier appear quite different. The two barrier materials have identical dimensions and geometry and similar densities.

PRAD High Explosive Studies

14 mm epoxy barrier with 1.8 mm holes



5 mm Tantalum barrier



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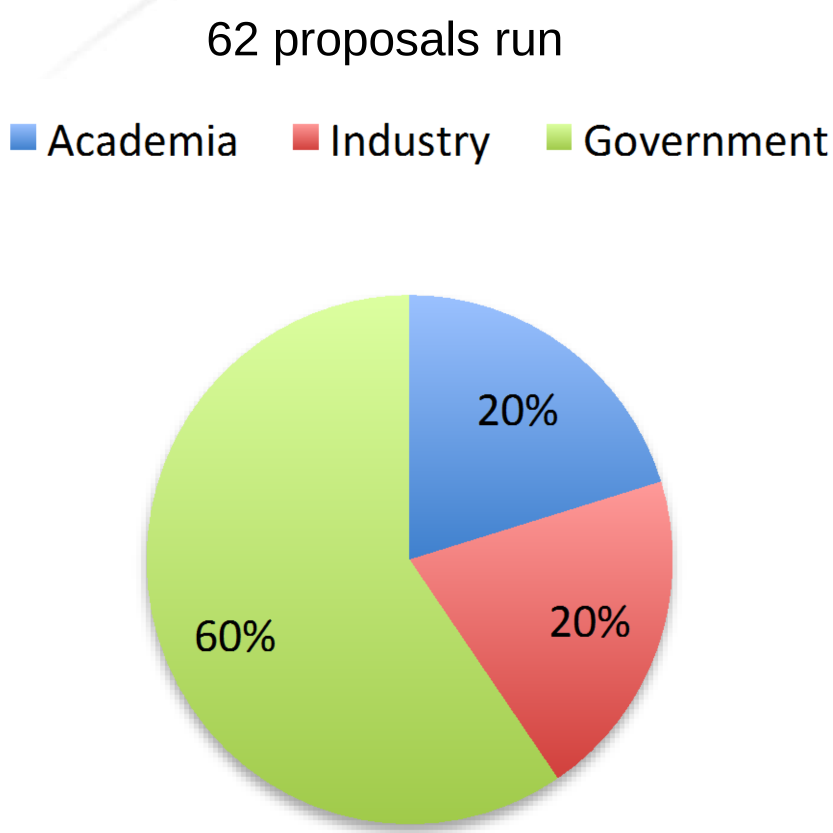
2014-2015 Run Cycle: Nuclear Science (WNR and Lujan Center)



- Return to 100 Hz operations (2.5x more neutrons)
- Chi-Nu: prompt fission neutron spectrum
- TPC: total fission cross section to 1%
- SPIDER: fission mass yields
- TKE: kinetic energy of fission products
- DANCE: isomers in 239Pu

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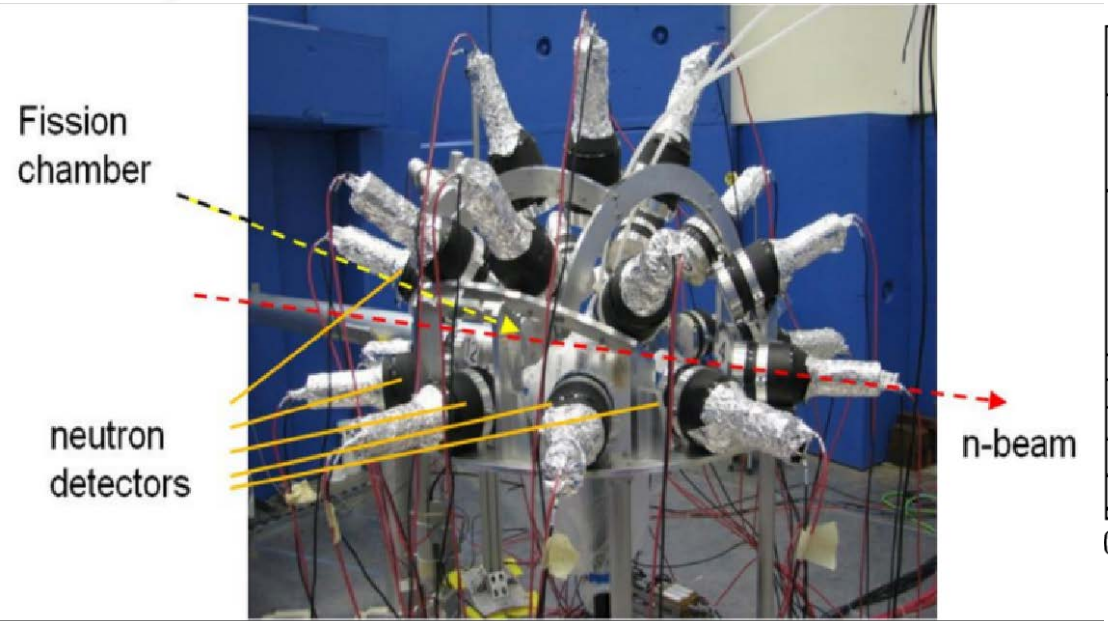
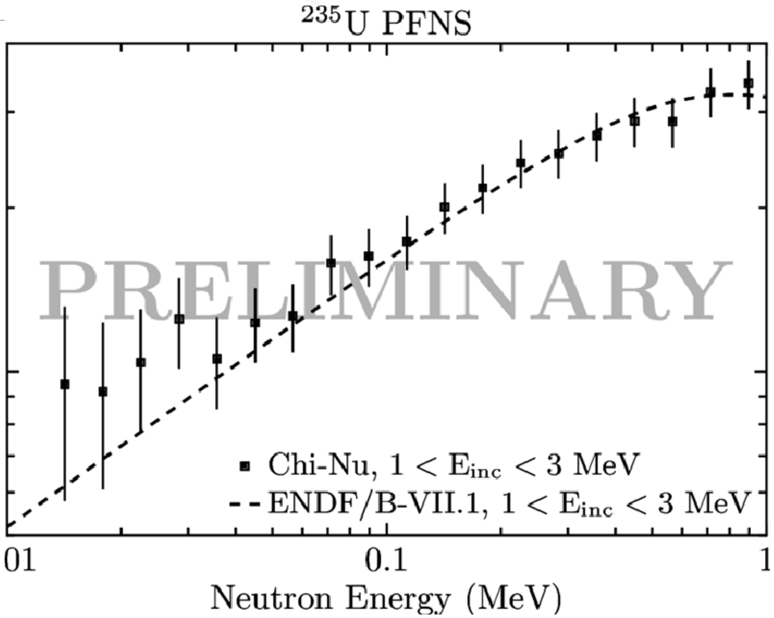
2014-2015 Run Cycle: Nuclear Science (WNR and Lujan Center)

Chi-Nu
PFNS of ^{235}U



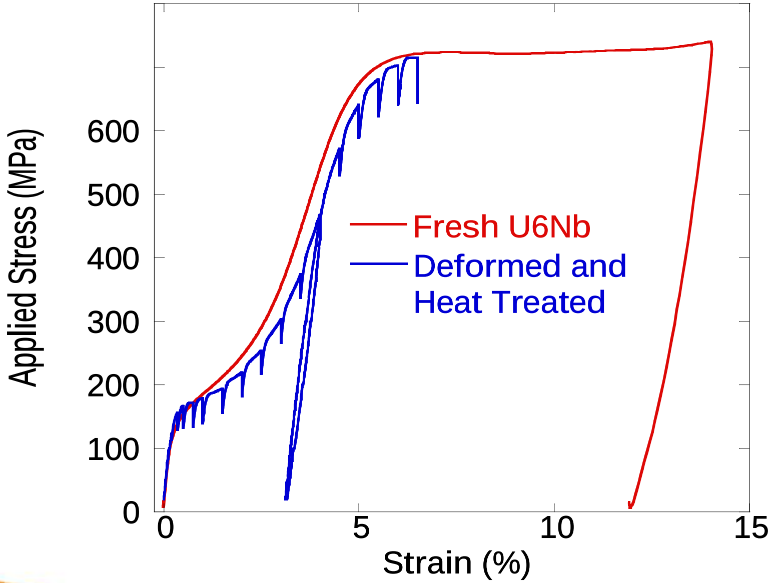


^{239}Pu data this run cycle

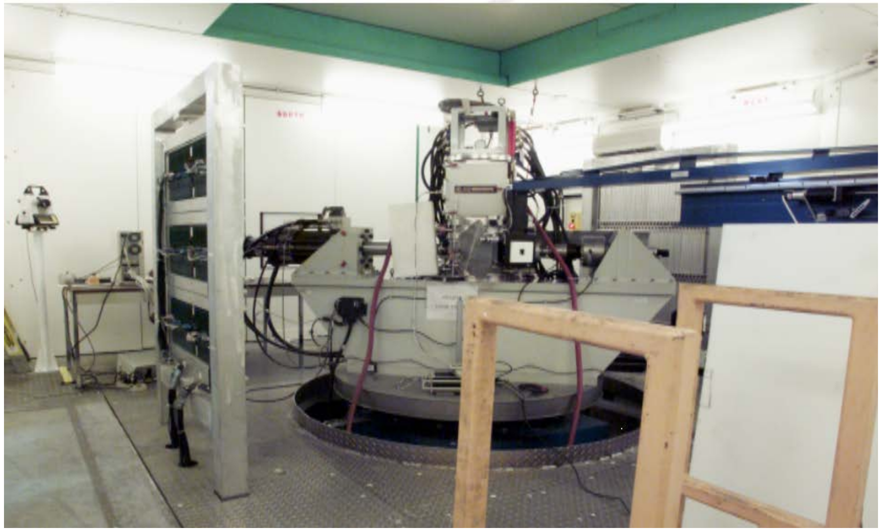
2014-2015 Run Cycle: Materials Science (Lujan Center)

- First run cycle after BES pullback
- Transition to programmatic work

Goal: lay scientific understanding for re-use of U6Nb parts



SMARTS



Measurements on predeformed U6Nb demonstrate that microstructure (and thus ductility) is recovered by a simple heat treatment to 800C.

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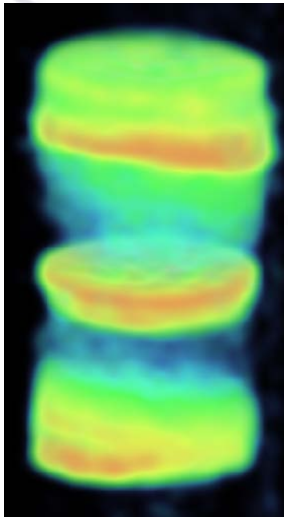
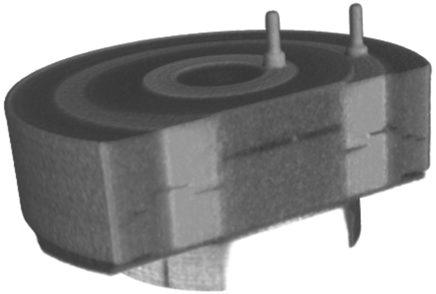
Neutron Radiography

- Low-energy neutron absorption spectroscopy
  - Isotopic imaging of fuel rods (NE)
- High-energy neutron radiography
  - Enhanced surveillance
  - Use energy resolved imaging to study performance of Livermore design for non-invasive surveillance



Density of Tungsten in UO_2 fuel rod

Radiography Phantom CT - 3D Rendering and slice



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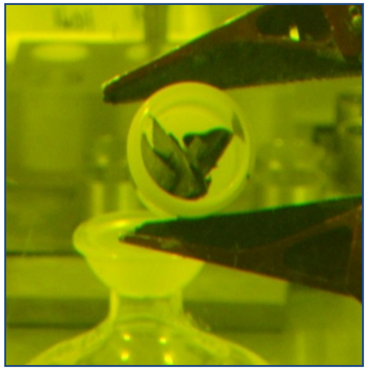
Medical Isotope Production at LANSCE

- LANL continues as the largest domestic supplier of Sr-82 for cardiac imaging (~ 30,000 patients/mo)
- Produce Ge-68 for cancer imaging, an emerging application for thousands of patients
- Completed FDA validation (irradiation and chemistry demonstration) of Rb metal targets for Sr-82, with an ~1.4 increase in yield
- >160 shipments this year to medical, industrial, and academic customers
- AIP approved to enhance the IPF beam transport system ($5.1M effort)

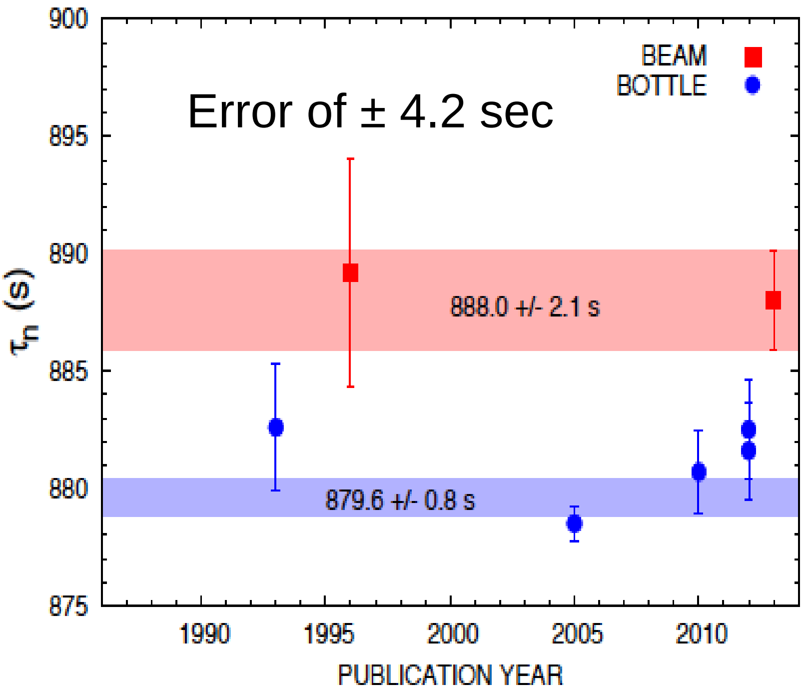


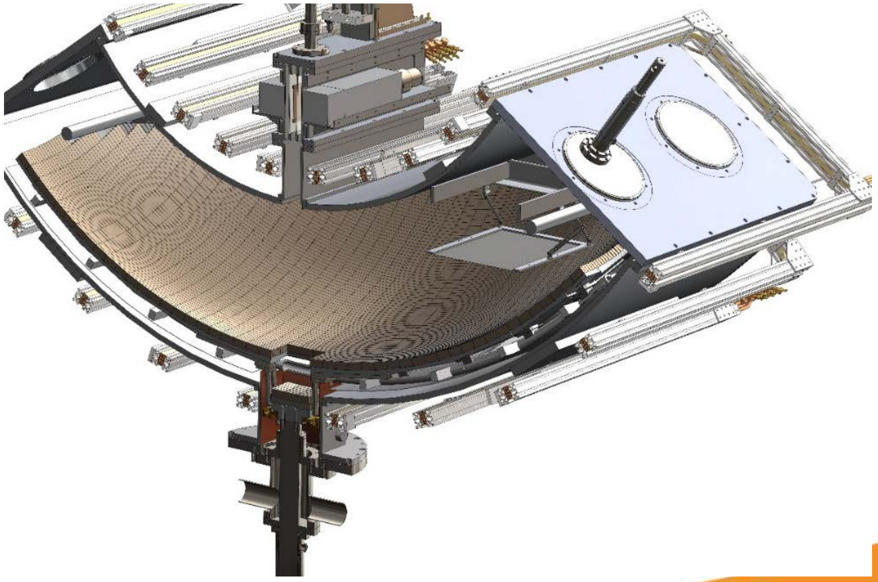
Small scale demonstration of isotopes for cancer therapy including actinium-225 (the most promising isotope for targeted alpha therapy,) antimony-119 (auger electrons) and rhenium-186g (beta therapy)

Ultra-Cold Neutrons

- First (preliminary) neutron lifetime measurement using LANL designed magneto-gravitational trap

Consistent with PDG value 880 ± 1.1s





IED

2015-2016 Run Cycle

- LANSCE continues to attract high quality proposals and is again oversubscribed for beam time
- ~200 proposals submitted for beam time at pRAD, WNR, and Lujan Center
- We continue to provide valuable data to the Science Campaigns and the DSW program
- We continue to attract strong fundamental science proposals

LANSCE Outlook

- LANSCE now has a stable funding model for the next 5 years
- The budget will enable 24/7 operations, replacement of the final high-power amplifier, and investments necessary to ensure long-term reliability
- Lujan Center plans:
  - Run 3 material science flight paths: SMARTS, HIPPO, and ASTERIX
  - Run 3 nuclear physics flight paths: DANCE, FP-5, and FP-12
- Operate LANSCE into the MaRIE era

Matter-Radiation Interactions in Extremes: MaRIE

- Future stockpile stewardship needs will require the ability to predict the performance of new materials in extreme environments in the absence of nuclear testing
- Understanding the behavior of materials at the meso-scale is needed to predict performance
  - Need to observe the dynamic evolution of polycrystalline materials at the granular and sub-granular level
- With MaRIE we will be able to create a material and probe its response in extreme environments with multiple probes: x-rays, protons, electrons, and optical photons
- Goal is to enable the creation of new materials with controlled functionality.
- Intimately coupled with Exa-scale computing

What is MaRIE?

- MaRIE 1.0 will provide the world's highest energy (42-keV) **XFEL** with GHz (few pulses) repetition;
- A **Making, Measuring, and Modeling Materials (M4) Facility** for materials synthesis and characterization with high-performance computational co-design focused on the mesoscale; and
- A **Multi-Probe Diagnostic Hall (MPDH)** coupling hard, coherent, brilliant x-ray photons with charged particle radiographic tools in time-dependent extremes.

MaRIE facility definition derives from "First Experiments" functional requirements and identified performance gaps.

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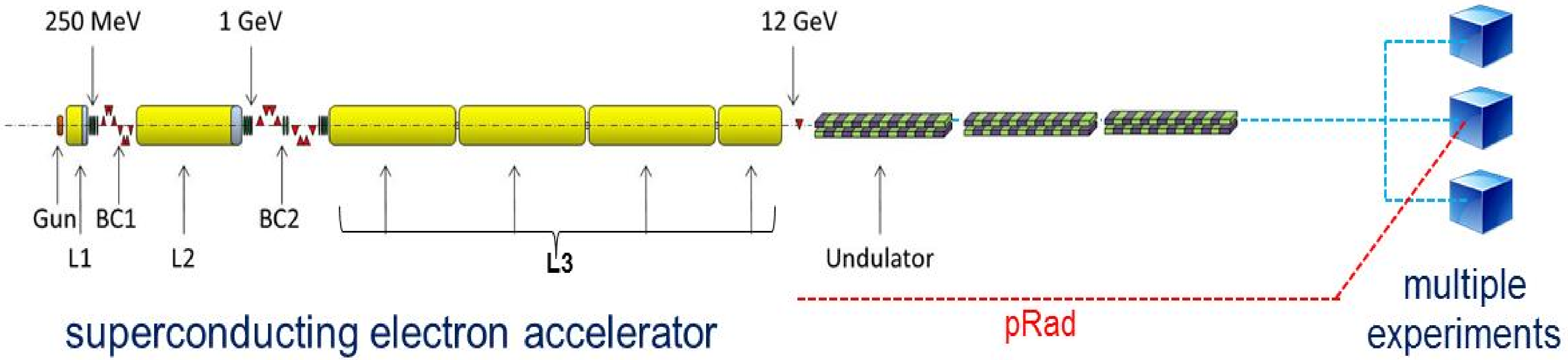
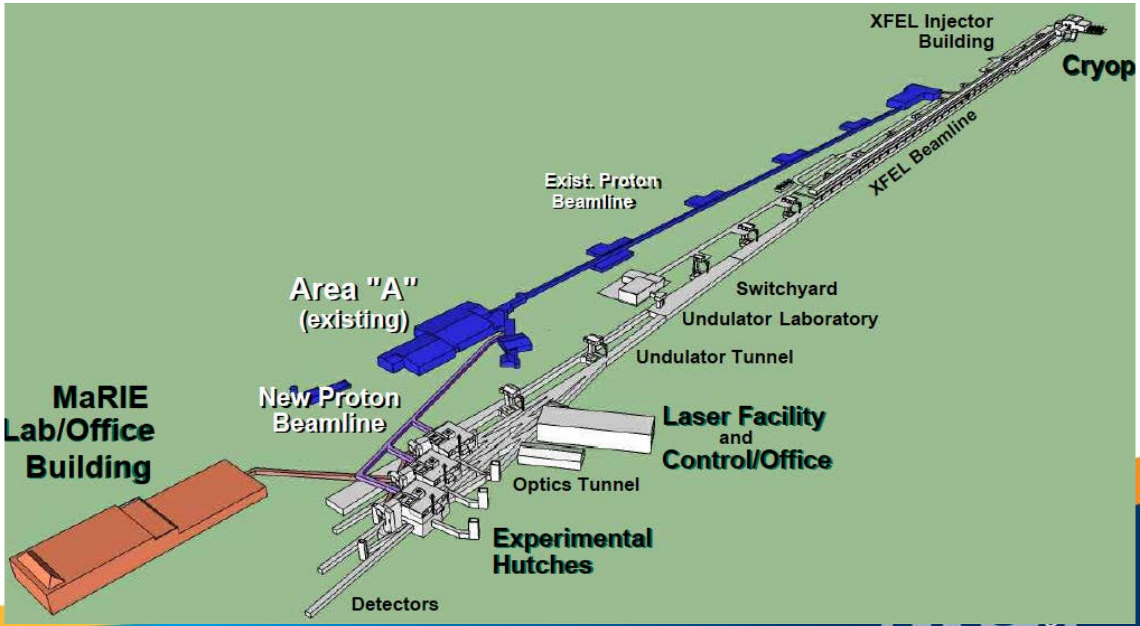
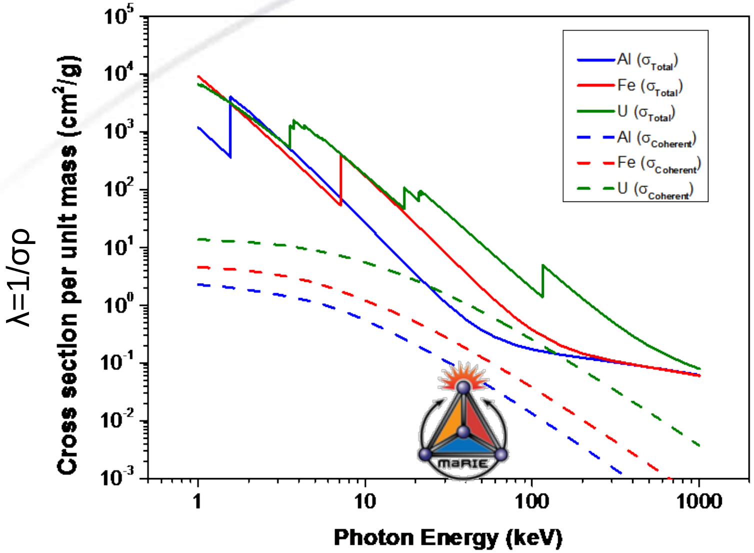
MaRIE Pre-Conceptual Design

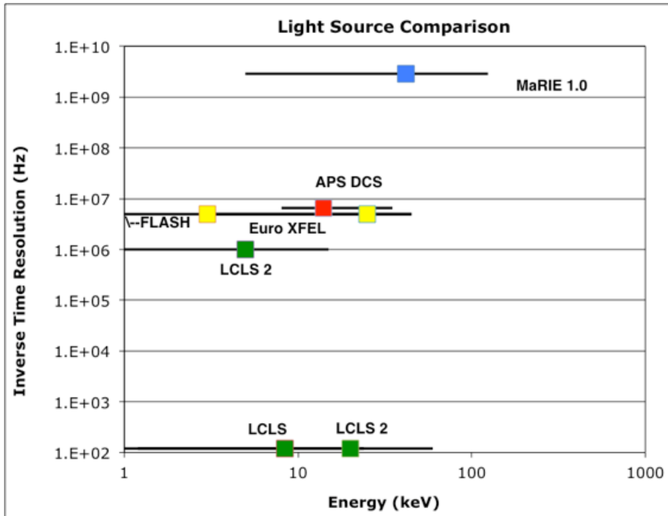


The pre-conceptual reference consists of a 12-GeV electron linac feeding a 42 keV XFEL. Located on the the LANSCE mesa it can leverage the capabilities of the existing proton/neutron facilities.



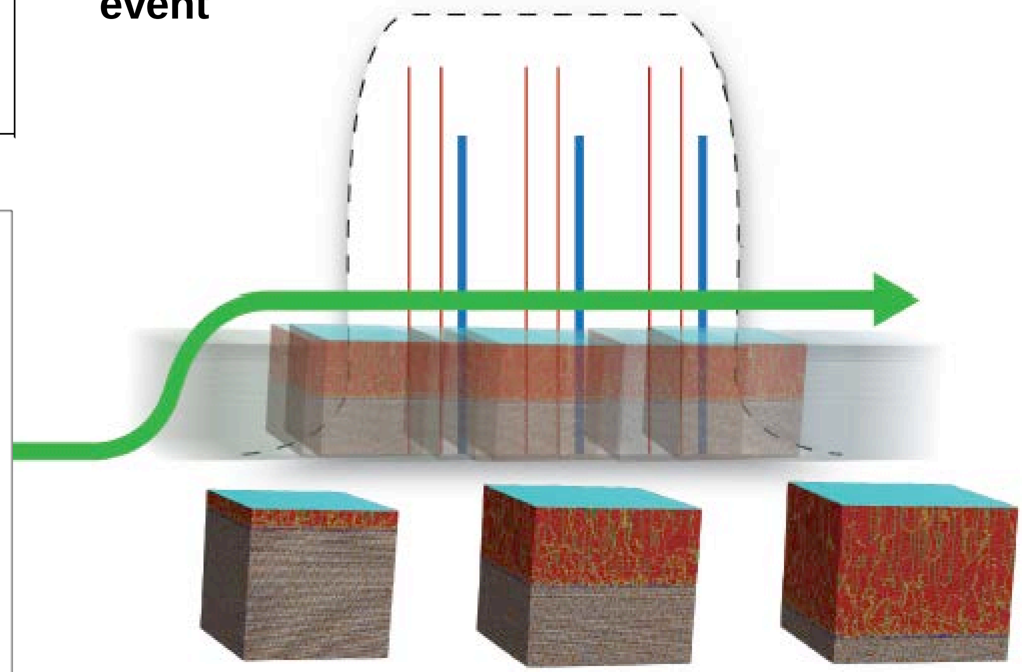
To Time Resolve at the Mesoscale Requires: X-rays (High Energy, Coherent, Brilliant, High Repetition-Rate) and Multiple Probes at Multiple Scales





The MaRIE 1.0 XFEL is harder and higher repetition rate than peer photon sources

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



Goals of LUG-2015 Workshop

- This meeting is about you the Users of LANSCE
- What capabilities do you need over the next 5 years?
- Are there other flight paths and/or probes that are needed?
- Discuss a possible SSAA Center of Excellence for Materials Science based on research at LANSCE.
- NNSA is expected to issue a call in Spring/Summer of 2016 with funding in 2017.

Backup

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"First Experiments" define mission-driven functional requirements and reveal facility performance gaps

Mission Need	First Experiments	Functional Requirements	Performance Gaps
	Dynamic Materials Performance • Multiphase High Explosive Evolution • Dynamic Performance of Plutonium and Surrogate Metals and Alloys • Turbulent Material Mixing in Variable Density Flows **Process Aware Manufacturing** • Controlled Solidification and Phase Transformations • Predicting Interfacial Microstructure and Strain Evolution • High Explosive Functionality by Design	**Environments** • Dynamic pressure: 4–200 GPa • Strain rate: 10^{3}–10^{7} s^{-1} • Stress loading > 200 ns • HE < 500g (< 30g with SNM) • Temperature rate 10^{5} °C/sec **Transient Multi-frame Measurements** **Imaging** • 0.1–1 µm, < 0.3 ns res over 0.1–1 mm • 0.1–1 nm, < 1 µs res over 10 µm • 1% density accuracy **Diffraction** • Defects: 1 nm res over 10 µm • Phase: 1–2 µm res over 100 µm • Lattice Strain: 10^{-5}–10^{-3} over 10's of µm **Thermo-Physical** • Temperature: 10 µm and 10–100 ns res • Chemistry 1 µm; < 100 fs **Synthesis with *in situ* Characterization** • Single crystals and 2D interfaces • Tailored microstructures with control of grain size, phase, and composition • HE and actinides, metal alloys • Real-time feedback during processing	**Integrated Driver Suite** **Repetitive 42-keV coherent x-ray source with 10^{10} photons in < 1ps focused to 1–100 mm** **Dynamic charged particle imaging with 12-GeV electrons and 0.8-GeV protons** **Synthesis, characterization, and processing with control of impurities and defects** **Integrated co-design and data visualization**

Stockpile Stewardship Academic Alliance: Program Objectives

- Support the U.S. scientific community by funding research projects at universities that conduct fundamental science and technology research that is of relevance to Stockpile Stewardship, namely; materials under extreme conditions, low-energy nuclear science, high-energy density physics, and radiochemistry
- Provide opportunities for intellectual challenge and collaboration by promoting scientific interactions between the academic community and scientists at the DOE/NNSA laboratories
- Develop and maintain a long-term recruiting pipeline to the DOE/NNSA laboratories by increasing the visibility of the DOE/NNSA scientific activities to U.S. academic communities