The LANSCE Facility

- 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

Six targets enable a broad range of programmatic and fundamental research
11 Orders of Magnitude in Neutron Energy: meV to 800 MeV
2014-2015 Run Cycle: pRAD

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

pRad performed 20 dynamic experiments in the run cycle

- HE Detonation 20%
- Material Strength 25%
- Material Damage 10%
- HE Initiation 20%
- CNI 10%
- DOD 15%
HE Burn Studies

Study the Propagation of Detonation and Shock waves through Inert Barriers

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
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

62 proposals run

- Academia: 60%
- Industry: 20%
- Government: 20%
2014-2015 Run Cycle: Nuclear Science (WNR and Lujan Center)

Chi-Nu
PFNS of $^{235}\text{U}$

$^{239}\text{Pu}$ 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

Measurements on predeformed U6Nb demonstrate that microstructure (and thus ductility) is recovered by a simple heat treatment to 800°C.
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
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 $880 \pm 1.1\text{s}$

Error of $\pm 4.2\text{ sec}$
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.
The pre-conceptual reference consists of a 12-GeV electron linac feeding a 42 keV XFEL. Located on 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.
"First Experiments" define mission-driven functional requirements and reveal facility performance gaps

<table>
<thead>
<tr>
<th>Mission Need</th>
<th>First Experiments</th>
<th>Functional Requirements</th>
<th>Performance Gaps</th>
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<tbody>
<tr>
<td>Dynamic Materials Performance</td>
<td>• Multiphase High Explosive Evolution</td>
<td>• Dynamic pressure: 4–200 GPa</td>
<td>Integrated Driver Suite</td>
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<td></td>
<td>• Dynamic Performance of Plutonium and Surrogate Metals and Alloys</td>
<td>• Strain rate: $10^{3} - 10^{7}$ s$^{-1}$</td>
<td>Repetitive 42-keV coherent x-ray source with $10^{10}$ photons in &lt; 1 ps focused to 1–100 mm</td>
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<td>• Turbulent Material Mixing in Variable Density Flows</td>
<td>• Stress loading &gt; 200 ns</td>
<td>Dynamic charged particle imaging with 12-GeV electrons and 0.8-GeV protons</td>
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<td>Process Aware Manufacturing</td>
<td>• Controlled Solidification and Phase Transformations</td>
<td>• HE &lt; 500g (&lt; 30g with SNM)</td>
<td>Synthesis, characterization, and processing with control of impurities and defects</td>
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<td>• Predicting Interfacial Microstructure and Strain Evolution</td>
<td>• Temperature rate $10^3$ °C/sec</td>
<td>Integrated co-design and data visualization</td>
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<td>• High Explosive Functionality by Design</td>
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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.