Los Alamos NATIONAL LABORATORY

The Los Alamos Neutron Science Center (LANSCE): Status and plans

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Agenda

1. **The User Group Meeting**
2. The LANSCE facility
3. LANSCE missions
4. Responding to the challenges at LANSCE

LANSCE
Los Alamos Neutron Science Center

Welcome to the 2020/2021 LANSCE User Group Meeting!

Time (MST)	Presentation	Presenter	Format
08:00-08:50	Welcome and LANSCE Status and Plans	Mike Furlanetto	Livestreamed
08:50-09:20	LANSCE Modernization Project	Nathan Moody	Livestreamed
09:20-09:50	LANSCE Futures	Shea Mosby	Livestreamed
09:50-10:00	User Program Update	Nina Roelofs	Livestreamed
10:00-10:15	Break	n/a	
10:15-11:00	Panel Q&A	Stephen Milton (moderator)	Live

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3. LANSCE missions
4. Responding to the challenges at LANSCE

LANSCE
Los Alamos Neutron Science Center

LANSCE is a repurposed 800 MeV linear accelerator sending two beams (H^+ and H^-) to six areas

Operations began in 1972 as the Los Alamos Meson Physics Facility (LAMPF) for a twenty-year basic nuclear physics program

- Most powerful proton beam in the world (until the early 2000s)
- Beam delivery was flexible
- Defense applications began within a decade
- 50th anniversary in June 2022!

In the 1990s, the facility was renamed the Los Alamos Neutron Science Center and repurposed as a user facility for stockpile stewardship

- Data will be needed through 2050
- Significant sustainment investment in 2000s
- Ongoing – and increased – investment needed

View of the LANSCE accelerator complex from the west

LANSCE's unique flexibility allows it to serve a variety of missions

LANSCE's unique flexibility allows it to serve a variety of missions – and as a major recruiting center for LANL

Proton Radiography (pRad Facility)
- Dynamic radiography for defense programs and counterproliferation

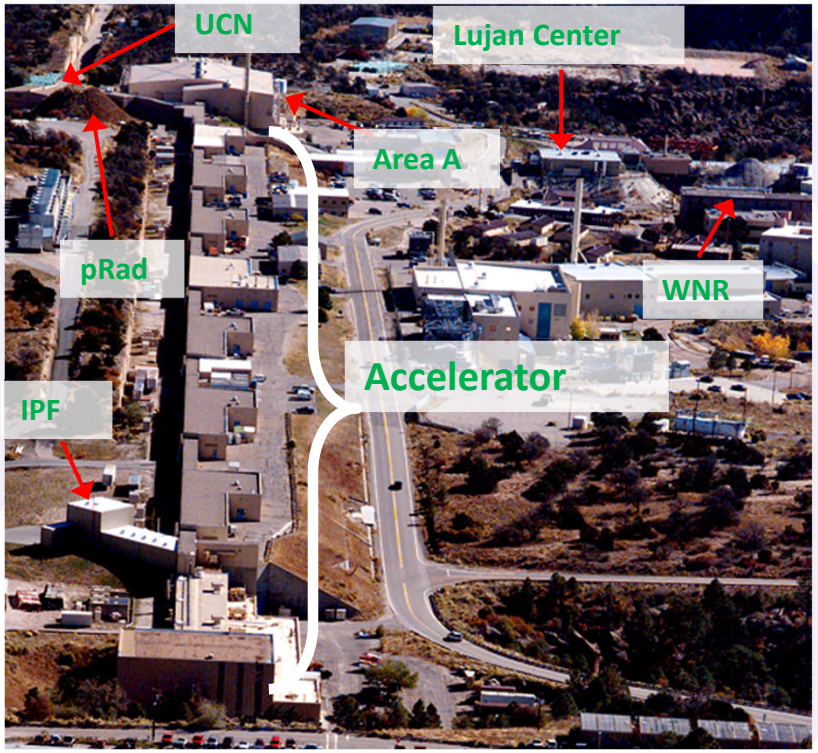
Lujan Neutron Scattering Center (Lujan Center)
- Neutron scattering and imaging for defense programs and nuclear energy
- Nuclear physics for defense programs

Weapons Neutron Research Facility (WNR)
- Nuclear physics for defense programs, counterproliferation, and criticality safety
- Electronics testing for industry and global security

Isotope Production Facility (IPF)
- Medical and other isotopes for the isotope program
- Short-lived isotopes for defense programs, non-/counterproliferation, and criticality safety

Ultra-Cold Neutron Facility (UCN)
- Unique probe for nuclear physics, possible future defense program uses

Area A
- *Future experimental possibilities*

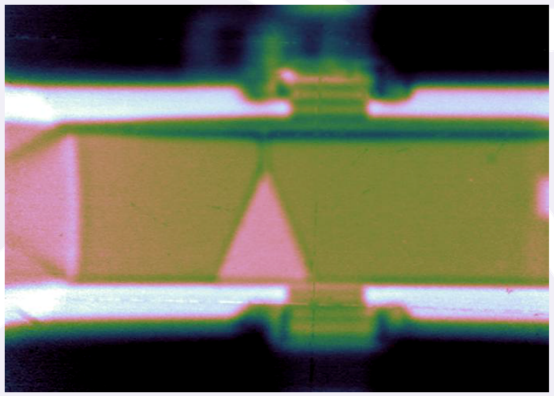


100-800 MeV proton energies
six target stations (three neutron spallation targets)
sixteen beam lines

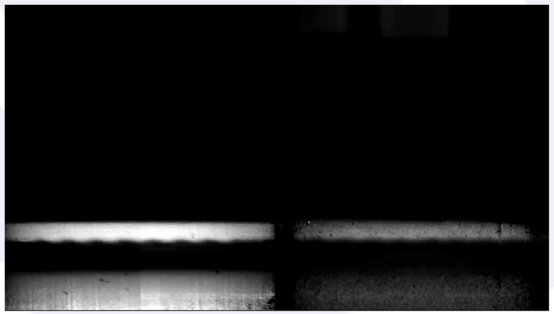
NNSA work
Other work

The pRad Facility provides a unique capability for dynamic radiography

- **pRad is able to take dynamic movies of shock and detonation events, with a unique ability to image high explosive detonation.** Data have been crucial to LEPs, ALTs, MODs, SFIs, and manufacturing
- pRad drivers include **high explosives (HE), a powder gun, and pulsed power**
- **Data acquired at pRad:**
  - Twenty-one radiographs of areal density
  - Up to sixteen channels of velocimetry
  - Multiple custom diagnostics, including visible imaging, x-rays, pins, etc.
- **Future plans include Pu@pRad experiments**
- **pRad is oversubscribed**, with most users granted less beam time than they request



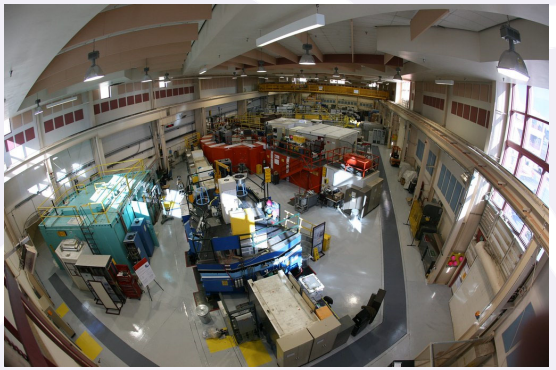
AWE experiment of a high explosive burn front past a plastic wedge



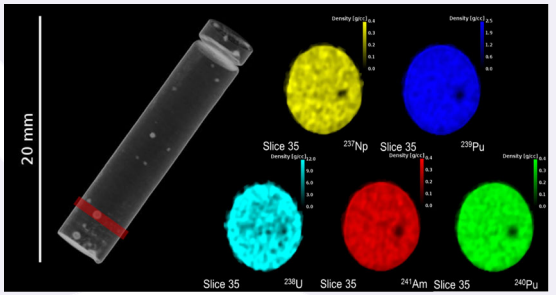
LANL experiment on material properties of copper

The Lujan Center characterizes NNSA materials for qualification

- Neutron scattering uses the **unique properties of neutrons** to provide **experimental microstructural characterization** used to **advance models for manufacturing and performance**
- **Unique mandate and ability to study classified, toxic, explosive, and/or radioactive materials under extreme conditions**
  - Weapon components
  - Nuclear fuels
- Recent highlights:
  - **Plutonium aging**
  - **Isotope-specific** imaging
  - Characterization of **additively manufactured LANL/LLNL/SNL/KCNSC components**
- **Beam time constraints mean that only ~2/3 of proposals receive time in a given run cycle**



Lujan Center experimental hall

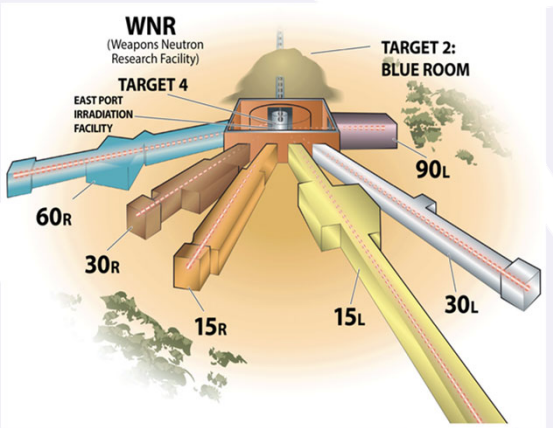


Nuclear fuel elemental distributions

Note that nuclear physics done in the Lujan Center is discussed below

The Weapons Neutron Research Facility is NNSA's center of excellence for nuclear physics

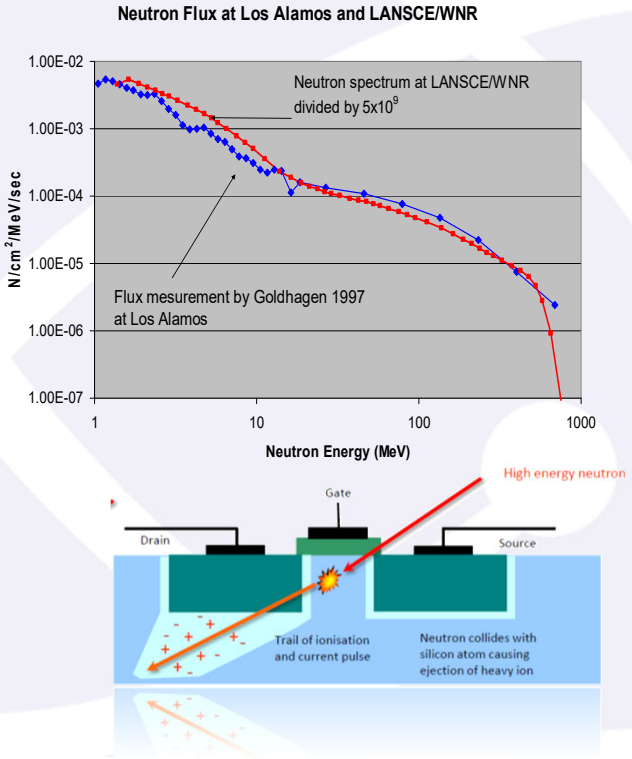
- The WNR Facility produces neutron beams for seven stations conducting a range of experiments **from fundamental measurements of the nuclear properties of materials to applied measurements acquiring radiographic and radiation effects data**
  - predicts the performance of **nuclear weapons primaries;** recent work made the **first credible uncertainty estimate of a key primary performance metric**
  - provides **technology validation** for high-performance computing systems, avionics components, space satellite sensing systems, and other systems
  - **radiography** complements x-rays and protons to image low-density, low-Z features obscured by high-density, high-Z material
- New Mark IV 1L target in 2022 will **increase flux for some nuclear physics experiments by 50-100x**
- **WNR is oversubscribed by 2-4x**



Neutron radiography enables imaging that is impossible with x-rays

Neutron radiation effects testing (at WNR) is critical for both defense and civilian applications

- **LANSCE is the best – and only U.S. - facility for electronics testing and certification**
  - Avionics, high-performance computing, self-driving vehicles, weapon components, and medical devices are studied
  - ISIS just opened ChipIR facility in the UK
  - ORNL is proposing a 3rd target station



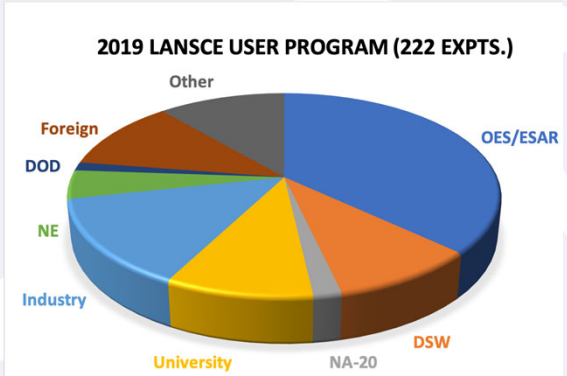
pRad, Lujan, and WNR constitute the NNSA LANSCE User Facility

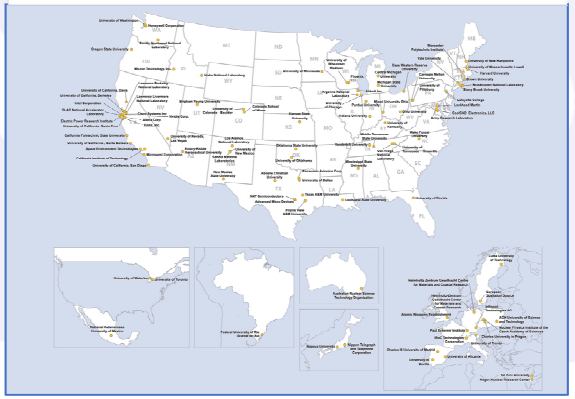
Proposal process:

- Proposals are solicited in January
- Each is reviewed for feasibility
- Feasible proposals go to review committees in February/March. Each proposal is evaluated for technical merit, relevance, and resource usage
- The committees send recommendations to the program in April. The program selects the final plan, with concurrence from line management and the LANSCE user facility director
- Experimental reviews before execution ensure safety, security, regulatory, and technical readiness
- Over the course of the June-December run cycle, programs adjust schedules to account for changes in beam delivery, sample availability, programmatic relevance, etc.

As a rule, ~80-85% of the experiments/beam time support mission deliverables and ~15-20% are reserved for experimental research and development. Non-NNSA experiments recover their full costs from the users

All experimental areas are ~2x oversubscribed

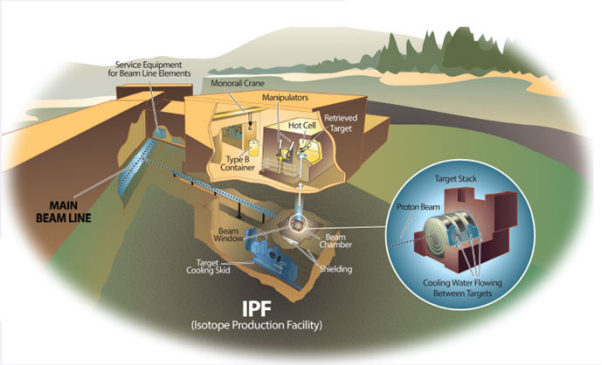


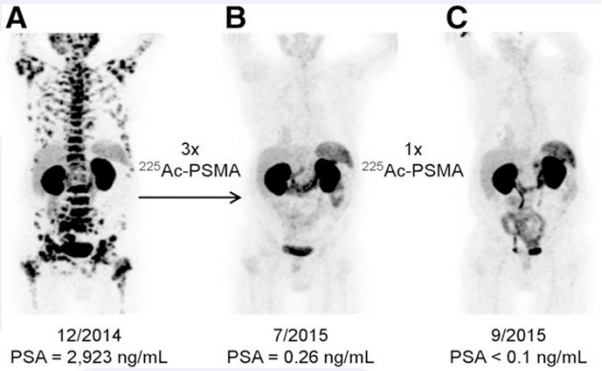


2019 run cycle: 591 users, 101 institutions, 16 countries

The Isotope Production Facility delivers time-sensitive medical isotopes for patients around the nation

- The Isotope Production Facility (IPF) is designed to produce **large quantities of isotopes for medical, industrial and research users**
  - The IPF does not compete with commercial suppliers, but instead uses its unique capabilities to supply isotopes that are more challenging to produce or for which market demand is still emerging
  - The IPF, along with the BLIP at BNL, ensures a steady supply of essential short-lived isotopes throughout the year
  - Isotopes for targeted alpha therapy (^{225}Ac) are future thrusts
  - Funded by the Isotope Program in the DOE Office of Science, which supports operations of the IPF beamline
- IPF has been producing **isotopes of interest to NA-11** for study at WNR – it has the unique capability to deliver the quantities and purities needed





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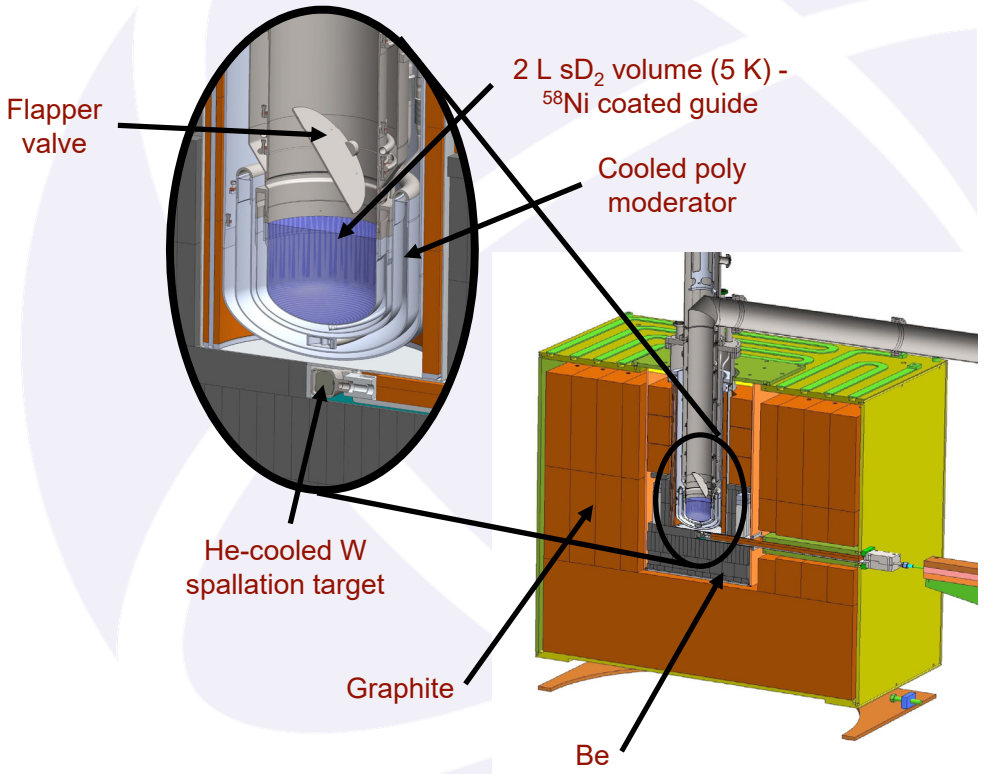
The Ultracold Neutron facility delivers nuclear data and potential applications

- **World's most intense source** of ultracold neutrons, which flow like water, can be stored for minutes, and have unique interactions with materials
- **Most precise measurement** of neutron lifetime ever made is currently in press
- Studying potential applications to **fission fragment damage** and **material hydriding**



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LANSCE material and nuclear data are critical for stockpile assessment and certification

The LANSCE accelerator complex is a **unique NNSA resource** that acquires an enormous range of **physics and engineering data** required by the Los Alamos, Livermore, and Sandia weapons programs

- Authorization basis to **perform classified experiments with special nuclear material** using protons and neutrons
- **Unique capability to measure a breadth of nuclear data** needed for initial conditions for boost, neutron reactivity, radiochemical diagnostics, nuclear forensics, and criticality safety
- **Provides qualification and characterization** of new and aged materials, components, and high explosives **for Significant Finding Investigations (SFIs), Life Extension Programs (LEPs), Alterations**, and **Modifications**, as well as to qualify **new manufacturing methods**

Mission space available at various US accelerators

	LANSCE	Brookhaven	FermiLab	SNS
Proton Radiography	●	●	●	●
High Explosive Drive	●	●	●	●
Classified Experiments	●	●	●	●
Dynamic Plutonium Capability	●	●	●	●
Low-Energy Nuclear Physics	●	●	●	●
Isotope Production	●	●	●	●
Neutron Diffraction	●	●	●	●
Static Plutonium	●	●	●	●
Neutron Radiography	●	●	●	●
Energy-Resolved Tomography	●	●	●	●
Neutron Irradiation for Defense and Civilian Applications	●	●	●	●

LANSCE's experimental areas support all parts of NNSA's mission space … and demand is growing

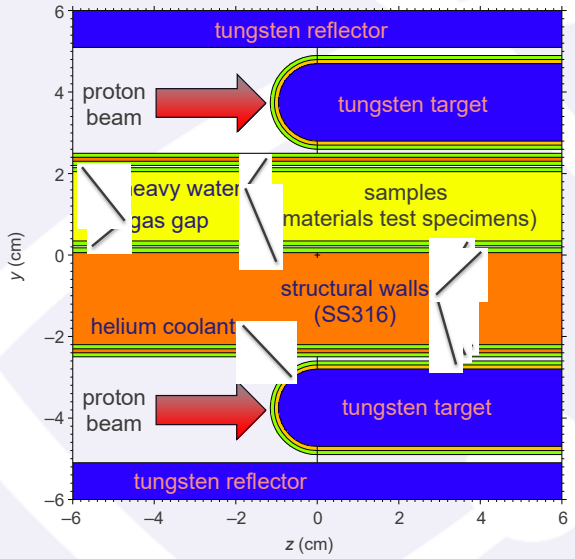
Mission/Area	Dynamic radiography (pRad)	Neutron scattering (Lujan)	Nuclear physics (Lujan/WNR)	Neutron radiography (Lujan/WNR)
Stockpile Sustainment	Significant findings; hydrodynamic experiment interpretation; *plutonium aging studies*	Plutonium aging studies; secondary and high explosive material properties	Underground nuclear test analysis; key nuclear data for neutron reactivity metrics	Component surveillance/ inspection
Future Deterrent	Explosive and subsystem characterization/ design (e.g., detonators); subcritical experiment interpretation; *safety/surety*	Advanced model development; scintillator development for hydrodynamic and subcritical experiments	2018 Level 1 pegpost; subcritical experiment interpretation	Advanced inspection technique development
Modern Materials and Manufacturing	**New explosive characterization**/formulation; *plutonium manufacturing*	Direct cast uranium; advanced manufacturing (*e.g.,* plutonium alloys and secondary components)	Criticality assessments for safety and efficiency; effects quantification	Component inspection
Threat Mitigation (NA-20/80)	**Render safe design; foreign materials**	**Scintillator and sensor development for nonproliferation**	**Nuclear data for foreign threats and nonproliferation; effects quantification**	***Foreign components***

Italics show planned future capabilities
Bold shows global security applications

Non-NNSA sponsors also foresee increasing needs

- **Fusion Energy Sciences:** LANSCE is one of the finalists for a Fusion Prototype Neutron Source (FPNS)*
- **Nuclear Energy:** increasing demand for characterization of fuels at Lujan and WNR
- **Isotope Program:** examining options for increased production and higher-power isotope sources*
- **National Science Foundation:** considering proposals for advanced UCN sources*
- **Irradiation:** industry requests for increased capacity and for a proton irradiation for space environments*

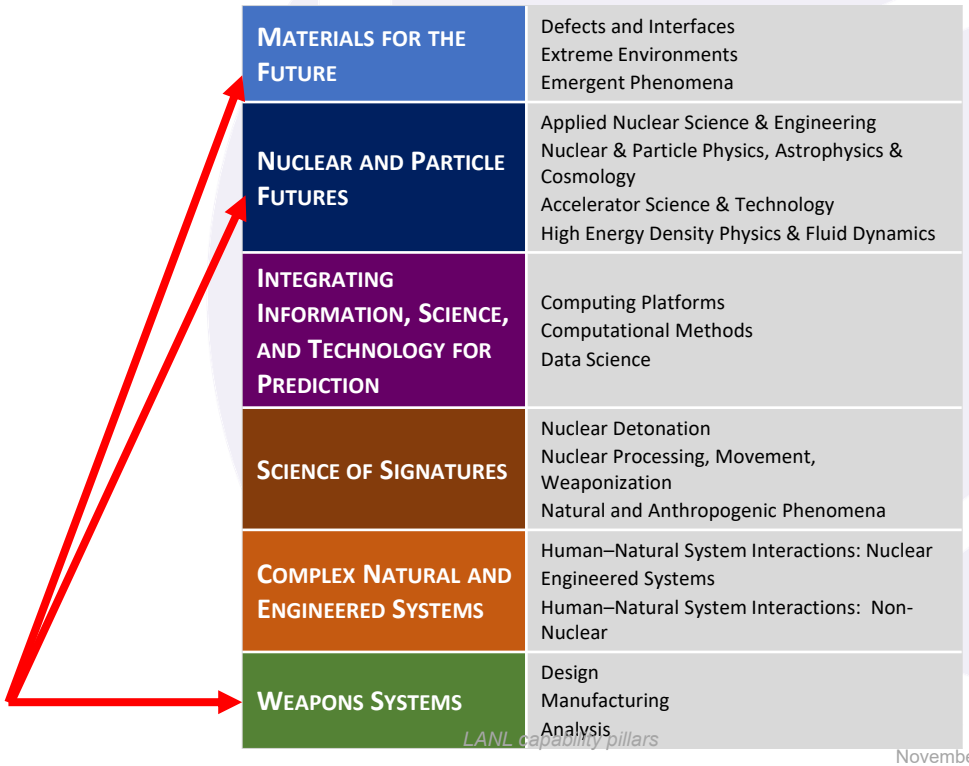
* possible options for Area A



Pre-conceptual design for LANSCE spallation target for FPNS

For LANL, LANSCE also provides crucial connections to the academic and industrial communities

- **User Program:** major source of graduate student and postdoctoral researcher recruiting
- **Rosen Scholar:** academic-in-residence program strengthens our scientific ties and reputation
- **Irradiation and Isotope Programs:** build ties to industry
- **Accelerator Operations (and futures):** ties to other accelerators and the academic community
- **Testbed** for diagnostics and experiments
- **LANSCE contributes strongly to three of LANL's capability pillars**



LANL capability pillars

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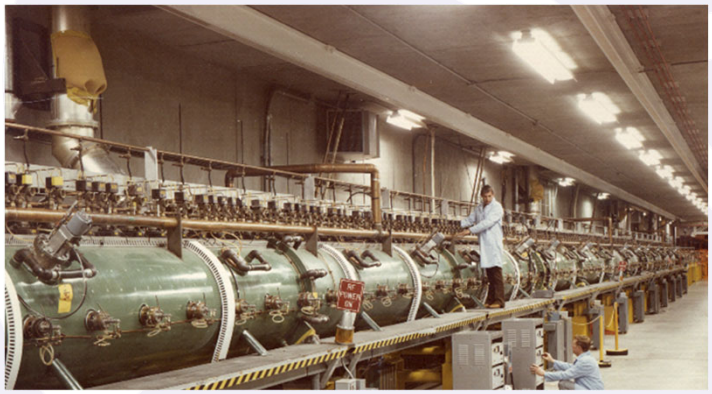
4. **Responding to the challenges at LANSCE**

LANSCE came online in 1972 and is decades beyond its design lifetime

- **Significant investments (~$115M) have been made** to sustain the accelerator over the last ~15 years; risk mitigation completed 2015
- **We are planning to extend LANSCE's lifetime – and improve its throughput - along three paths:**
  - **Ongoing investment in projects to upgrade utilities**, fire protection, controls, electronics, and targets, reversing deferred maintenance
  - **Asset management project** to improve reliability and efficiency of operations
  - **Capital investments** in front end (LAMP) and experimental areas (LANE)
- **These investments are urgently needed** to avoid the risk of catastrophic failure

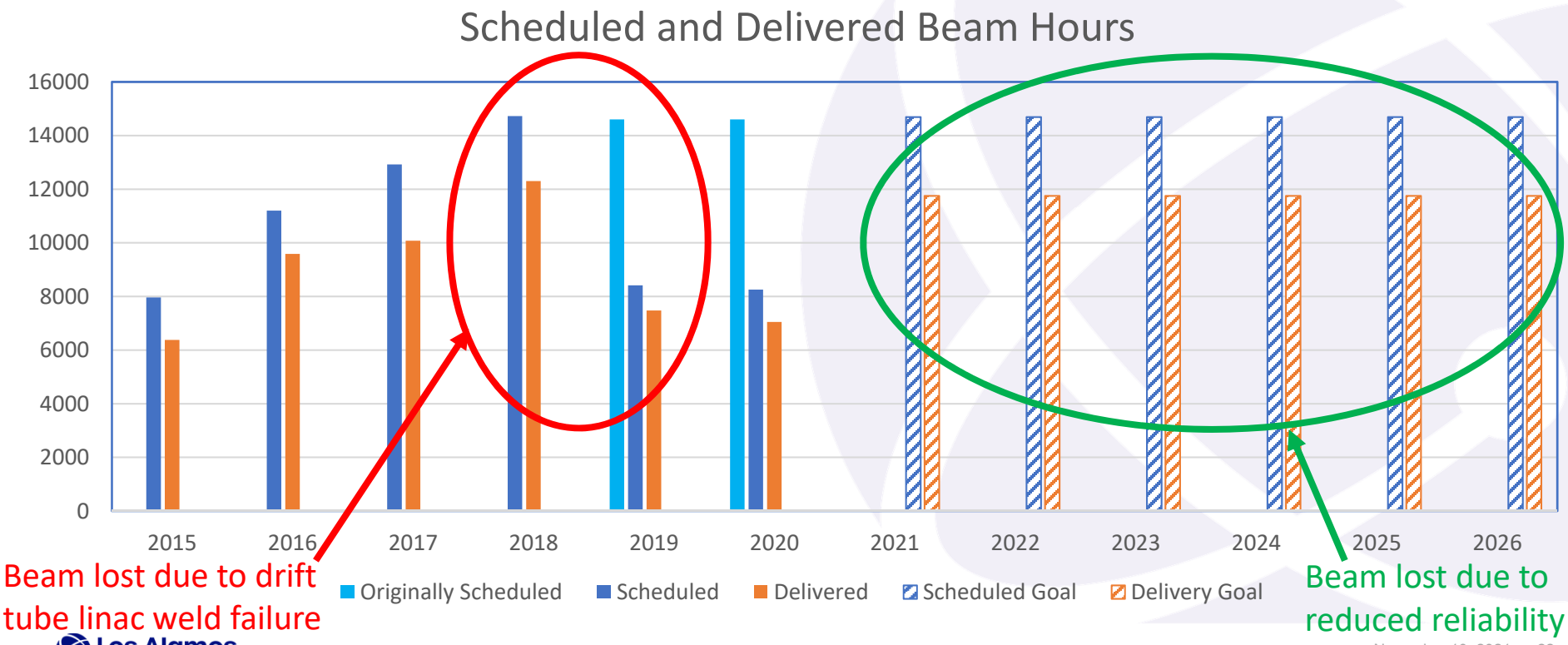
End-of-life drift tube linac



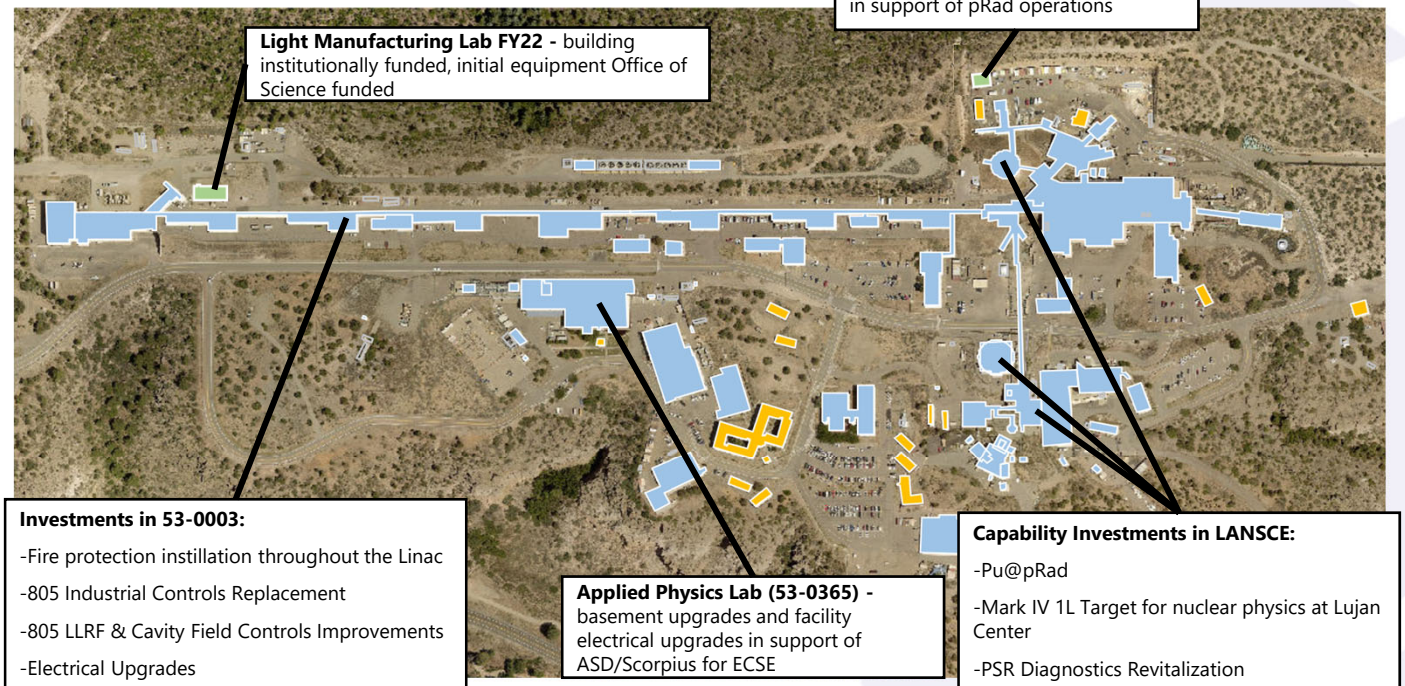
Old analog low-level radio frequency system still in use

Obsolete Cockcroft-Walton accelerators

Aging LANSCE infrastructure has been impacting beam delivery



NA-50, NA-194, and LANL have been actively investing in recapitalizations of LANSCE



pRad Storage FY21 - heated storage in support of pRad operations

Light Manufacturing Lab FY22 - building institutionally funded, initial equipment Office of Science funded

Investments in 53-0003:

-Fire protection instillation throughout the Linac

-805 Industrial Controls Replacement

-805 LLRF & Cavity Field Controls Improvements

-Electrical Upgrades

-Area A, B, & C HVAC Replacement and Upgrades

-Supply and Return Piping Replacement

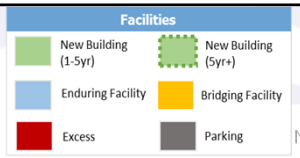
Applied Physics Lab (53-0365) - basement upgrades and facility electrical upgrades in support of ASD/Scorpius for ECSE

Capability Investments in LANSCE:

-Pu@pRad

-Mark IV 1L Target for nuclear physics at Lujan Center

-PSR Diagnostics Revitalization



The Asset Management pilot should systematize best practices in managing complex facilities

- The chemical and petrochemical industries have pioneered a body of knowledge in asset management (ISO 55000)
- DOE draft policy for real property
- SNS (ORNL) recently applied it to their accelerator
- We are rolling it out for LANSCE and SIGMA initially

Expected …

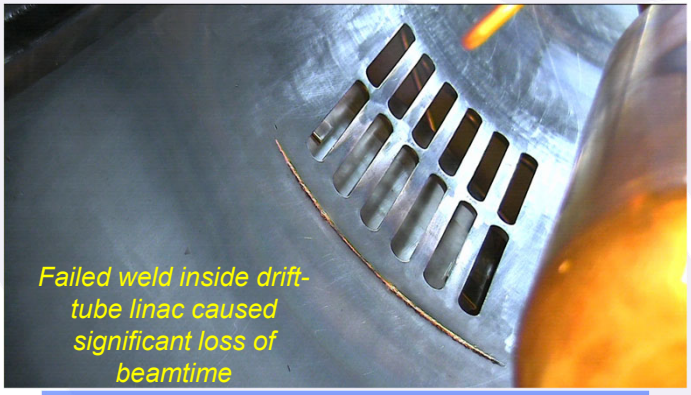
- Return on investment:
  10 times
- Reduction in maintenance costs:
  25% to 30%
- Elimination of breakdowns:
  70% to 75%
- Reduction in downtime:
  35% to 45%
- Increase in production:
  20% to 25%

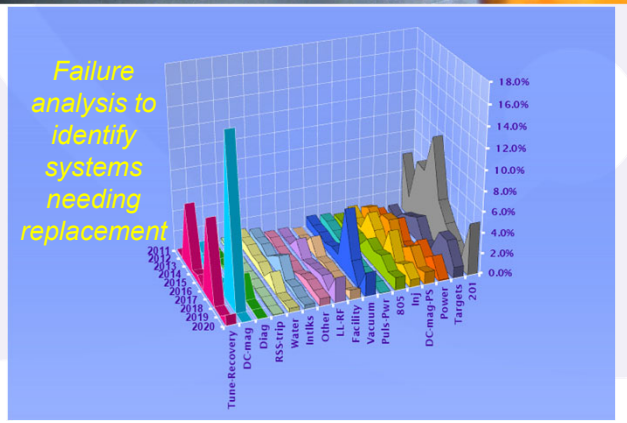
Source: DOE Operations & Maintenance Best Practices Guide, Pacific Northwest National Laboratory for the Federal Energy Management Program, U.S. Department of Energy, August, 2010

The LANSCE Modernization Project (LAMP) is a critical upgrade required to ensure LANSCE readiness and reliability

The timeline for LAMP is driven by four factors:

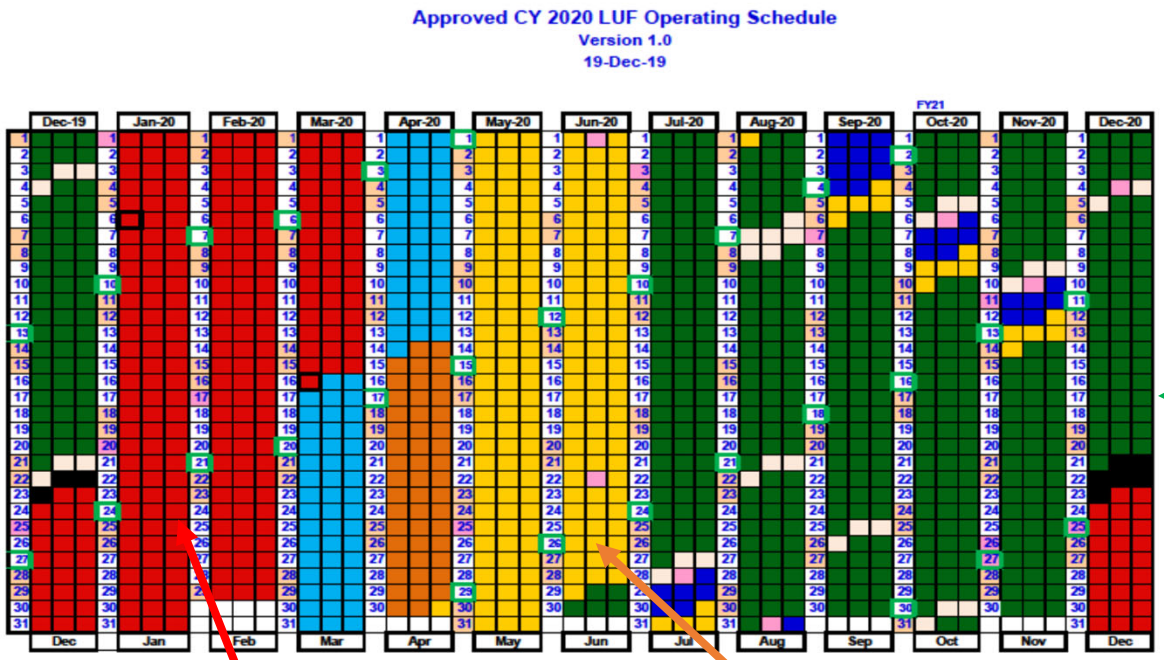
- Data from LANSCE will be required to support assessment and certification at least **through 2050**
- We have already started to experience **end-of-life failures** that have reduced beam availability
- We have developed a **high-TRL pre-conceptual upgrade design** which would take ~7 years (~FY23-FY29) to complete. It would replace everything from the ion sources through the drift-tube linacs. The emphasis will be on increased reliability and maintainability, though the potential peak beam current will also increase
- We are investigating alternatives involving multiple projects to allow **more options** for completion of this work, albeit at the cost of increased duration and/or cost and decreased capability





Current LANSCE beam availability lags significantly behind both its need and its peers

Key:
Maintenance
Startup
Experimental operations



Beam reliability only 60-85%; industry standard 90+%

Long maintenance period determined by work required and obsolete designs

Startup ~6 weeks; other accelerators ≤ 2 weeks

Planned enhancements could lead to ~2x as much beamtime by 2035

Key:
Maintenance
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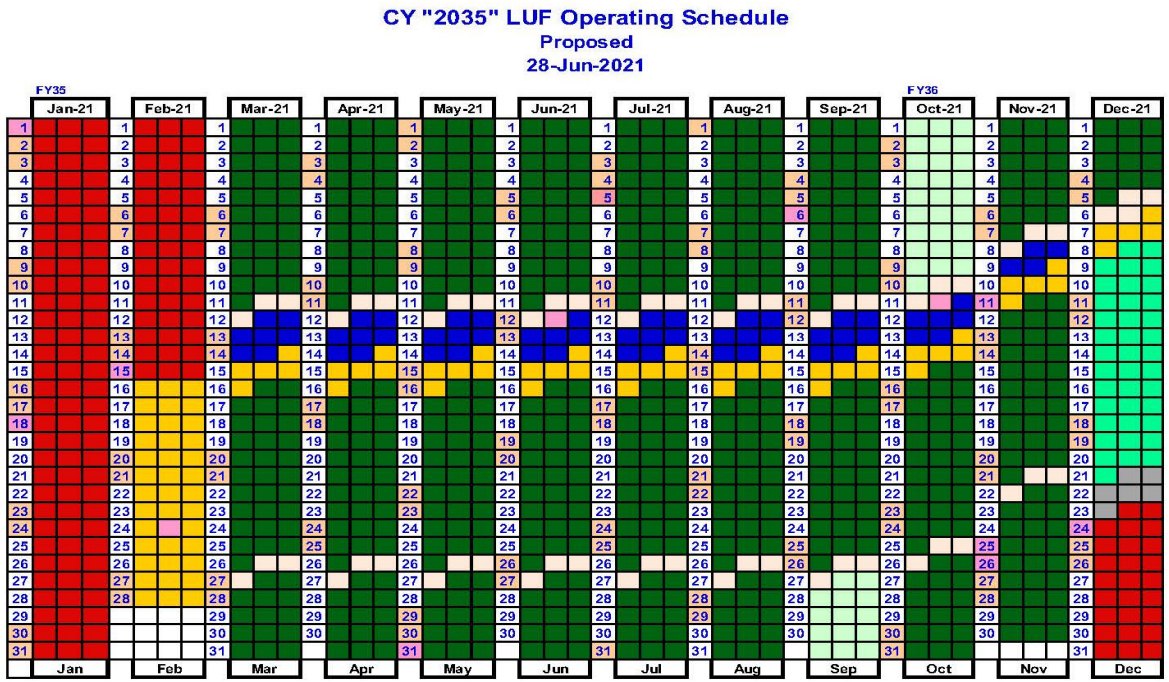
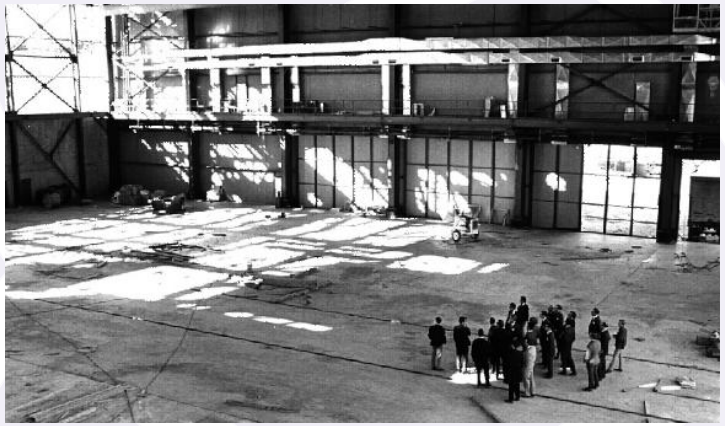
Experimental operations



Modest investments in experimental areas can deliver even more impactful data [LANSCE Enhancements (LANE) and beyond]

- Area A provides a **high-quality experimental facility**
- To deliver the **data needed to support advanced assessments needed in the 2030s**, we are examining options for Area A, including restoring (high-power) H^+ transport. Its existing infrastructure enables the installation of several new capabilities relatively easily. **Options include:**
  - Increased energy and/or multiple-probe pRad
  - Revolutionary nuclear physics
  - Fusion material studies (for FES)
  - Enhanced effects characterization (for NNSA, global security, and industry)
  - World-leading ultracold neutrons (for NSF/DOE-NP)
  - Higher energy isotope production (for NNSA and DOE-IP)
- LANSCE has held a series of workshops – with participation from all the current experimental areas, plus possible future users - to select and refine the most feasible and valuable options

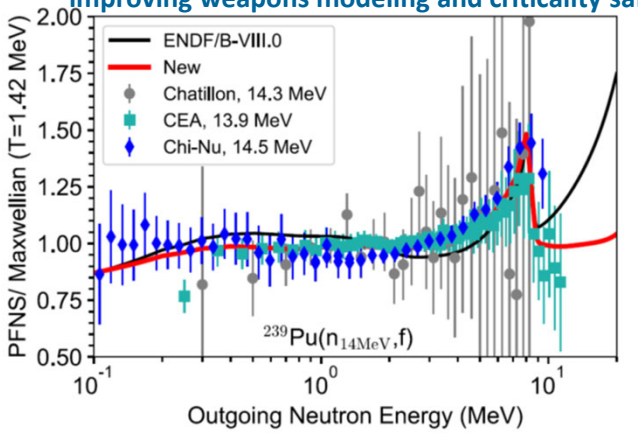


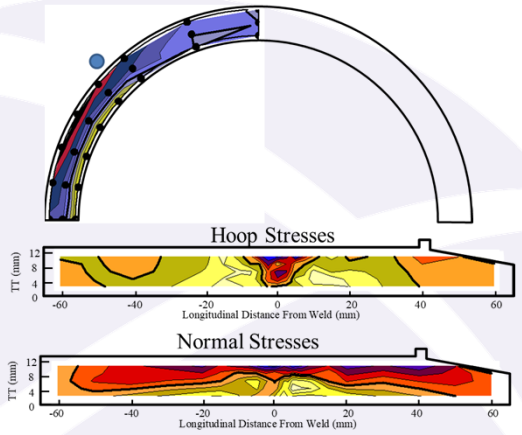
Area A is almost ready for the installation of beam equipment – in 1970 and now

Key Takeaways

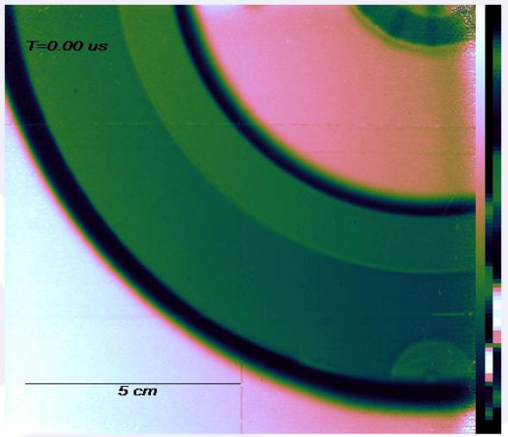
- LANSCE protons and neutrons will be needed through 2050
- To extend the lifetime of LANSCE, increase its reliability, and maximize its throughput, we are pursuing capital improvements, asset management enhancements, and ongoing recapitalization. In parallel, we are exploring options for redeveloping unused experimental areas in order to deliver data for the future
- The User Program remains a vital part of LANSCE's future. Thank you for your continued support!

Advanced nuclear physics measurements at WNR improving weapons modeling and criticality safety





Hydro components characterized at the Lujan Center before the dynamic experiment



pRad Halfpipe experiment to characterize high explosives