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Title:	Enabling NNSA and DOE Missions: The Los Alamos Neutron Science Center National User Facility
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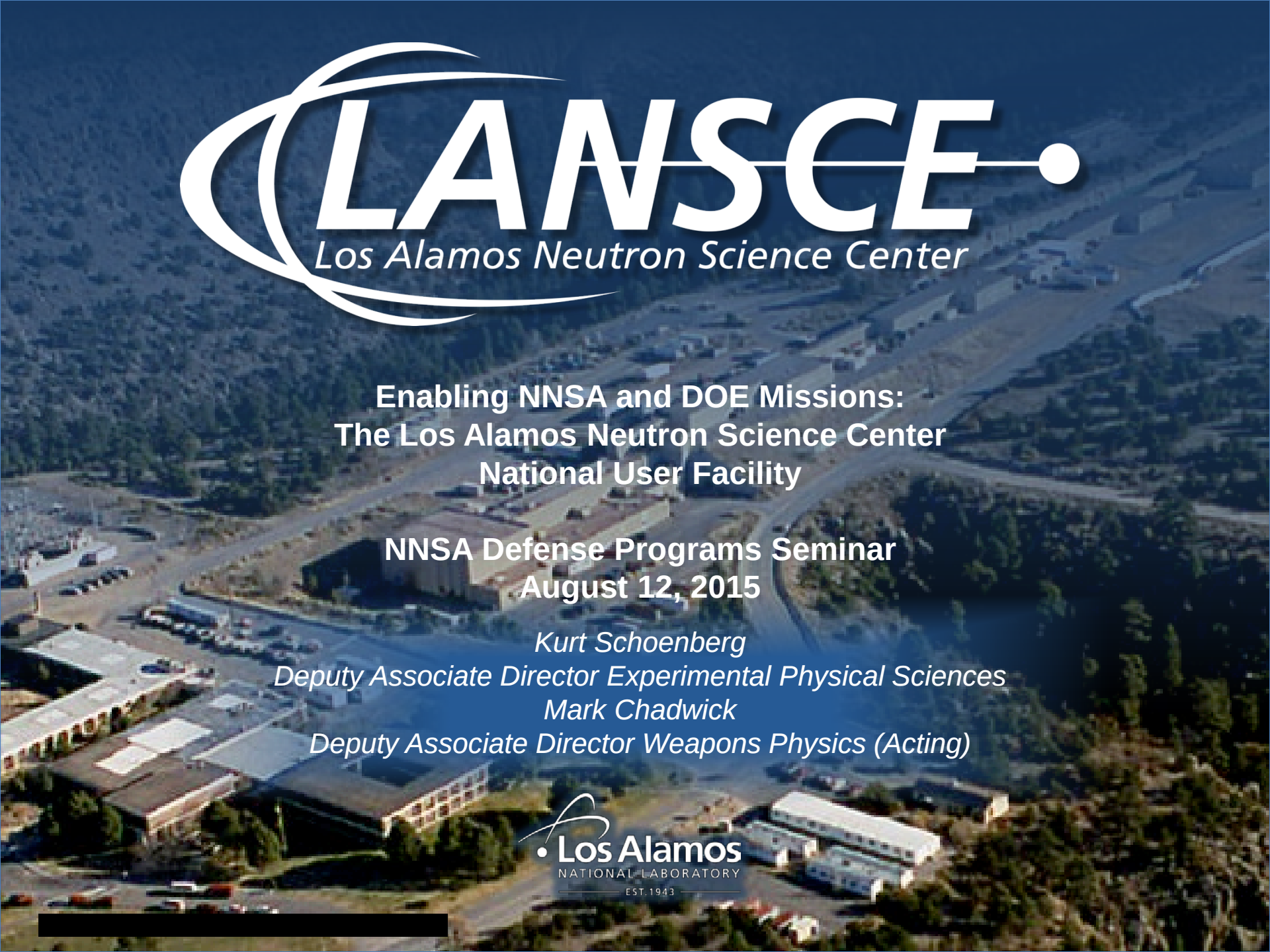

Enabling NNSA and DOE Missions: The Los Alamos Neutron Science Center National User Facility

NNSA Defense Programs Seminar
August 12, 2015

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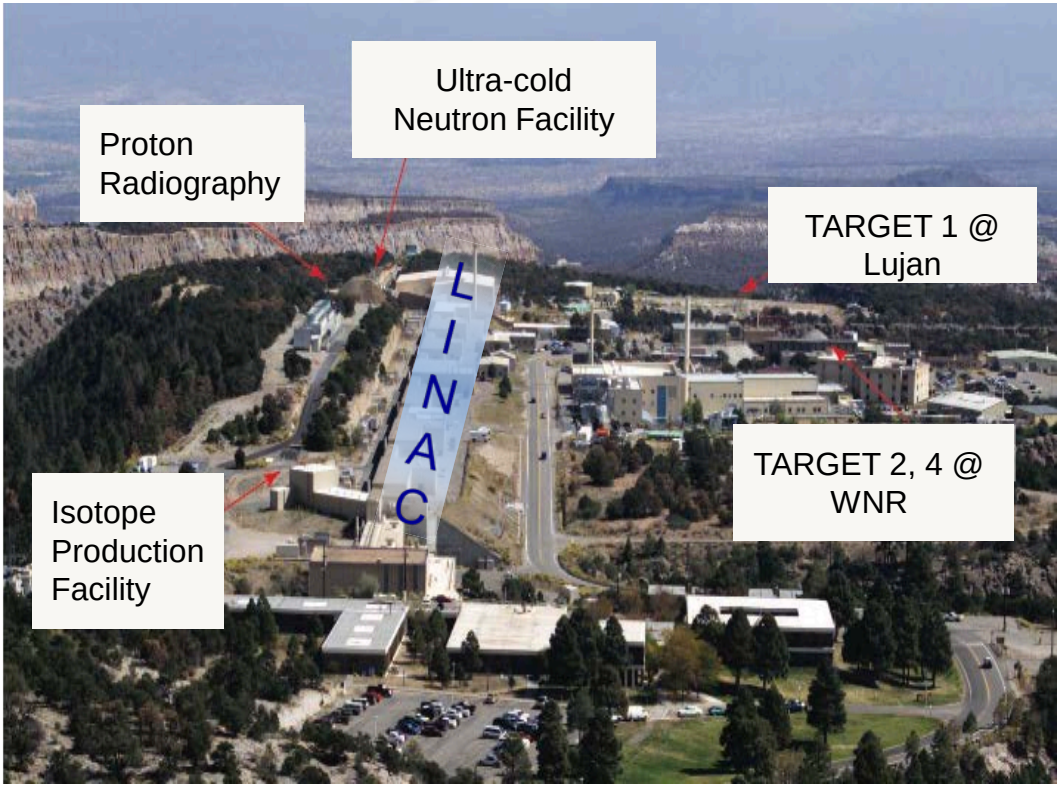
Los Alamos
NATIONAL LABORATORY
EST. 1943

Outline

- Facility description and recent user program highlights
- Operation performance
- LINAC Risk Mitigation update
- Future 5-year planning
- NNSA programmatic impacts: Mark Chadwick

The LANSCE LINAC drives six end-stations or targets for a broad spectrum of fundamental and applied programmatic and scientific research



Highly-flexible beam delivery to multiple facilities with 24-7 operation

Proton Radiography & Microscopy

- ***High explosives***
- ***Shock physics***
- ***Materials in extremes***
- ***Hydrodynamics***

Un-moderated neutron production (*T2 & T4 – WNR*)

- ***High energy nuclear physics (n,xn);(n,f)***
- ***Neutron radiography***
- ***Neutron and proton irradiation effects on materials and semiconductors***

Moderated neutron production (T1 @ Lujan Center)

- ***Low energy nuclear physics (n,γ)***
- ***Neutron scattering – material science***
- ***Neutron radiography***

Isotope Production

- ***Nuclear medicine***
- ***National security isotopes***

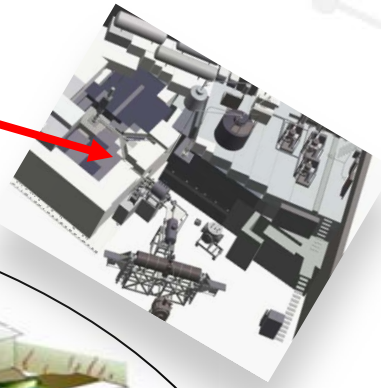
Ultra-cold neutron production

- ***Fundamental nuclear physics***

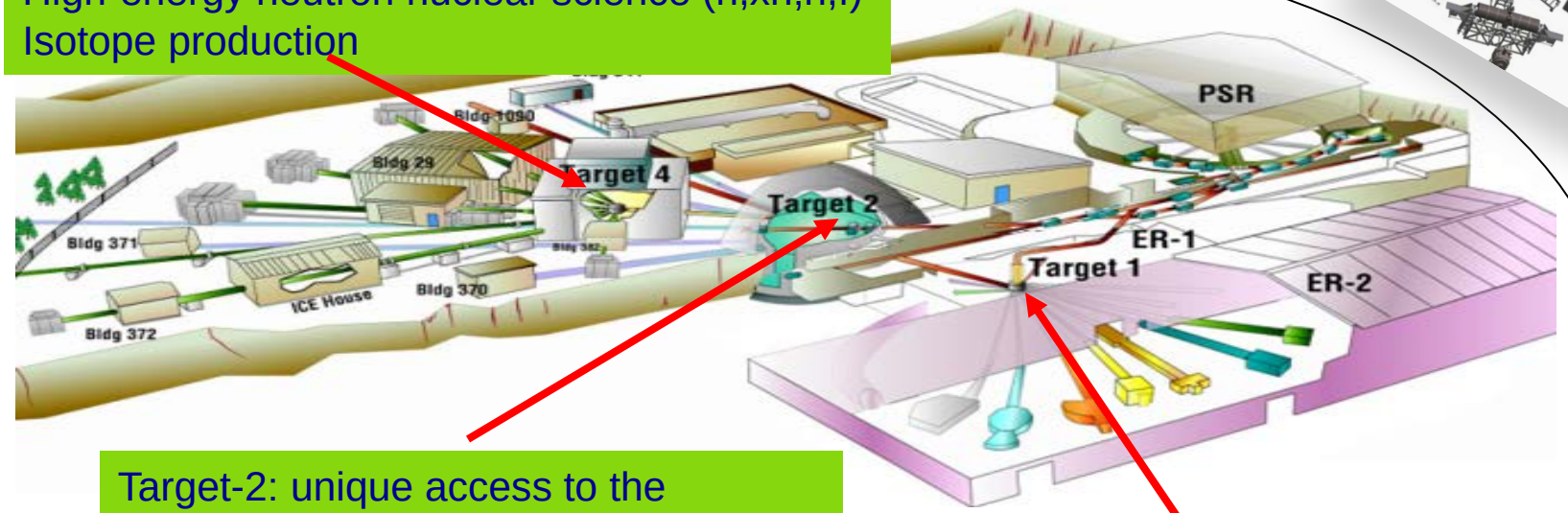
LANSCE Nuclear Science Research Capabilities employs 4 neutron spallation targets

IPF (isotope production)

UCN Target
neV neutron research



Target-4
High-energy neutron nuclear science (n,xn;n,f)
Isotope production



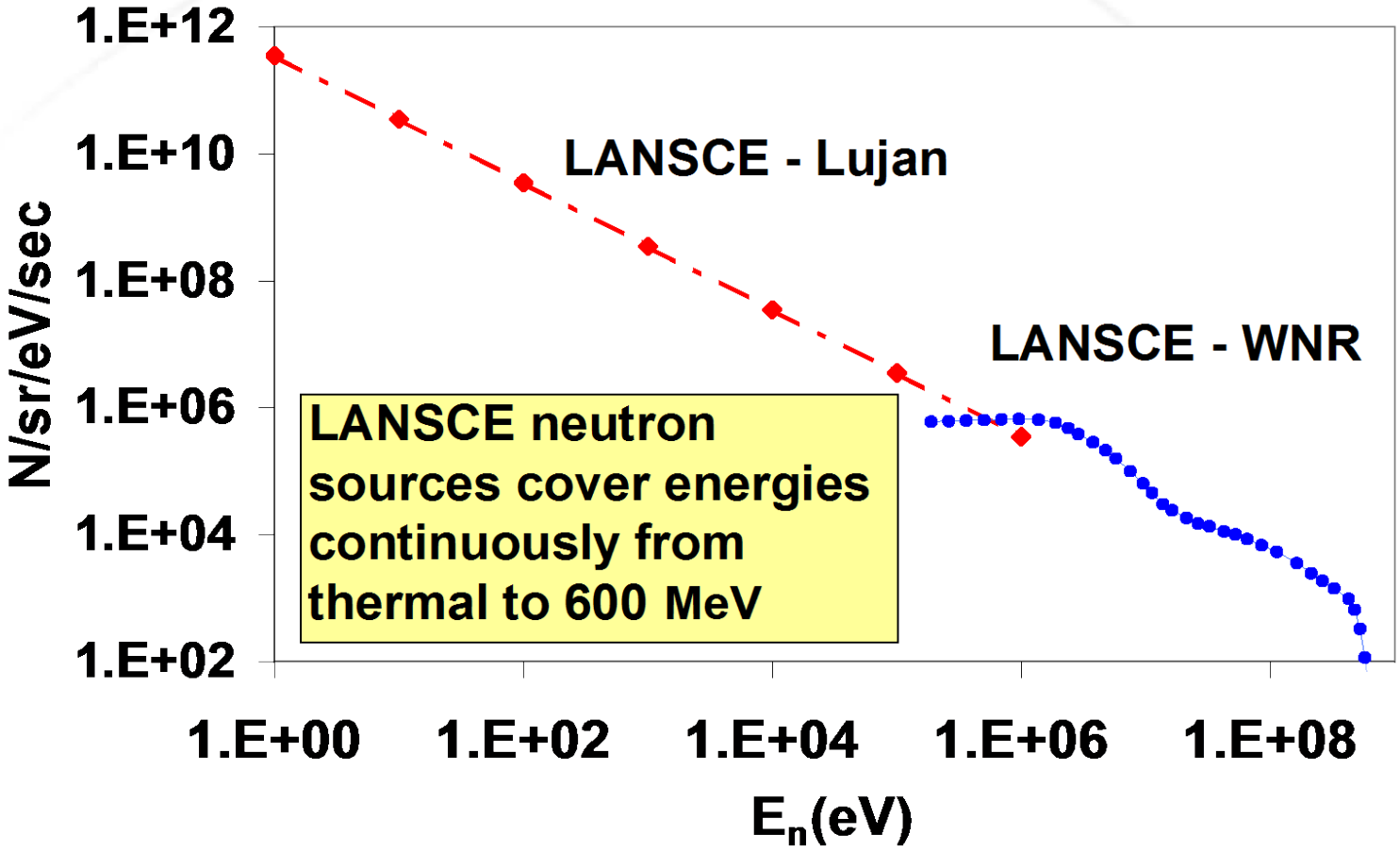
Target-2: unique access to the compressed or uncompressed 800 MeV proton beam

- Proton-induced reactions
- Single-pulse experiments
- Lead Slowing-Down Spectrometer
- High-energy Isotope production testing

Target 1: Lujan Center

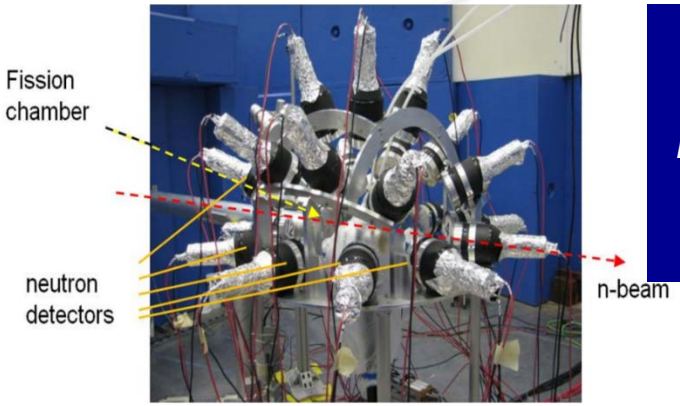
Low-energy neutron
Nuclear science (n,γ)

Only LANSCE has the spectral range to address the full suite of NNSA-DP research



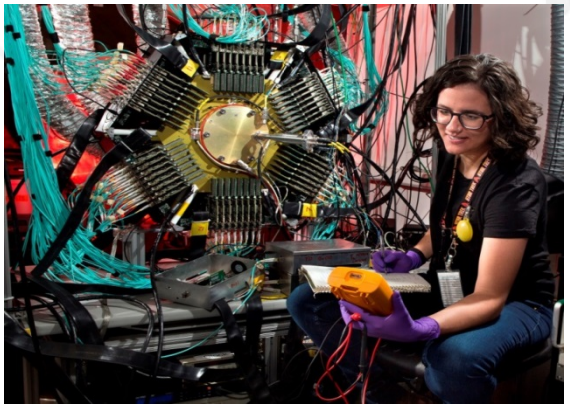
The un-moderated (high-energy) neutron sources at WNR directly inform NNSA programmatic milestones

Chi-Nu at the LANSCE (WNR)



Both Chi-Nu and TPC experiments need 120 Hz LINAC operation to meet programmatic milestones

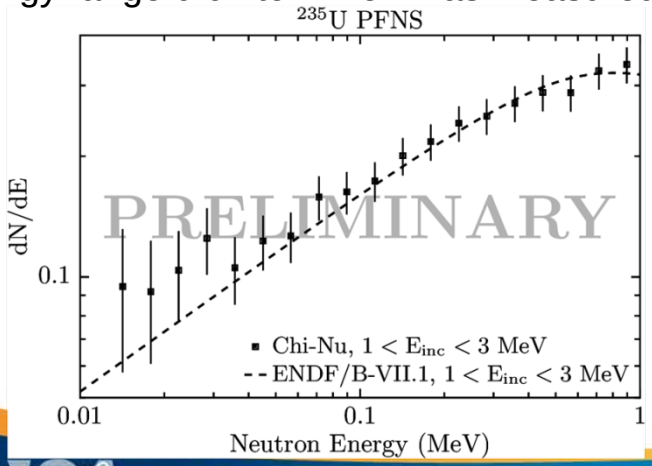
The TPC at the LANSCE (WNR)



Graduate student Verena Kleinrath

Goal: Precise measurement of ^{239}Pu and ^{235}U prompt fission neutron spectra in energy regions where the data are poorly known

2014 run cycle: The ^{235}U neutron spectrum in the energy range 0.01 to 1 MeV was measured



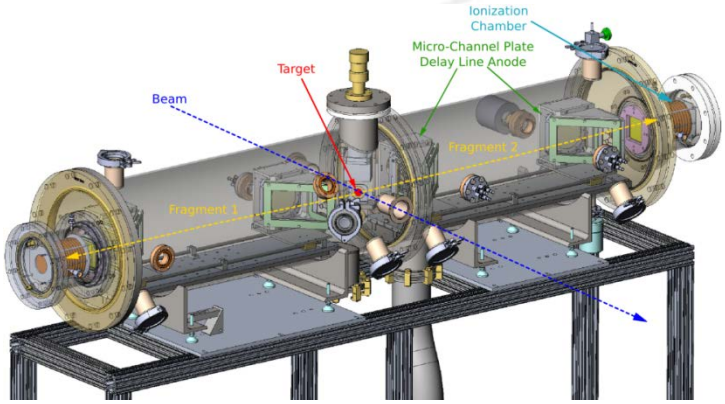
Goal: Measure the Pu-239 fission cross section with the unprecedented accuracy of 1%

2014 run cycle: Production data on Pu-239 as a ratio to U-235 was collected yielding a first, preliminary cross section

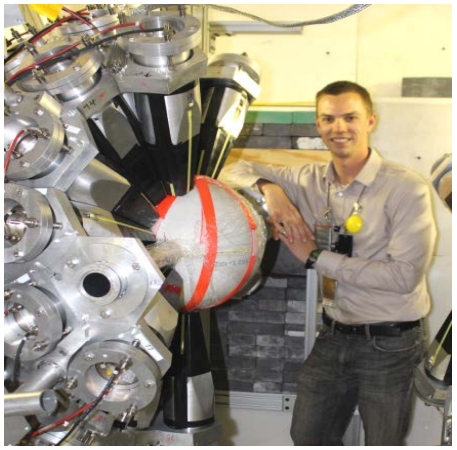
64 Nuclear Science proposals were completed in the 2014 run cycle – with a 2.6 oversubscription

The moderated neutron source at the Lujan Center is used to develop new techniques to improve weapons performance predictions

SPIDER at the LANSCE (LUJAN)



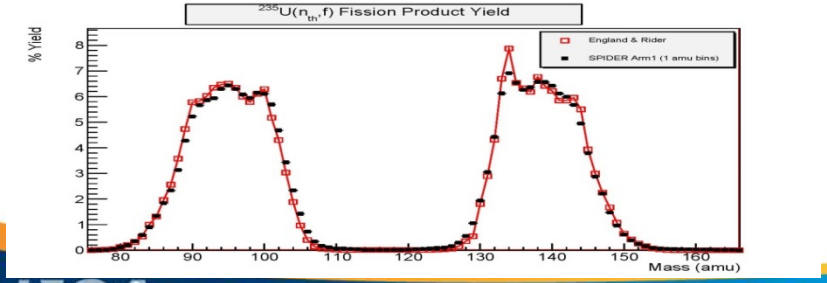
DANCE at the LANSCE (Lujan)



Goal: Measure the energy dependence of fission product yields (FPY)

Fission product yields are used to analyze nuclear test data, and help in evaluating weapons performance

2014 run cycle: Fission product yields in U-235 and Pu-239 were measured for thermal neutrons. Instrument performance was evaluated in a technical project review, and as a result the project received funding to build full system



Goal: measure properties of short-lived isomers in ^{236}U for NPF goals

2014 run cycle: New high-performance data acquisition and detectors installed to enable measuring actinide isomers in high-fluence environments in the important 1keV to 1Mev range

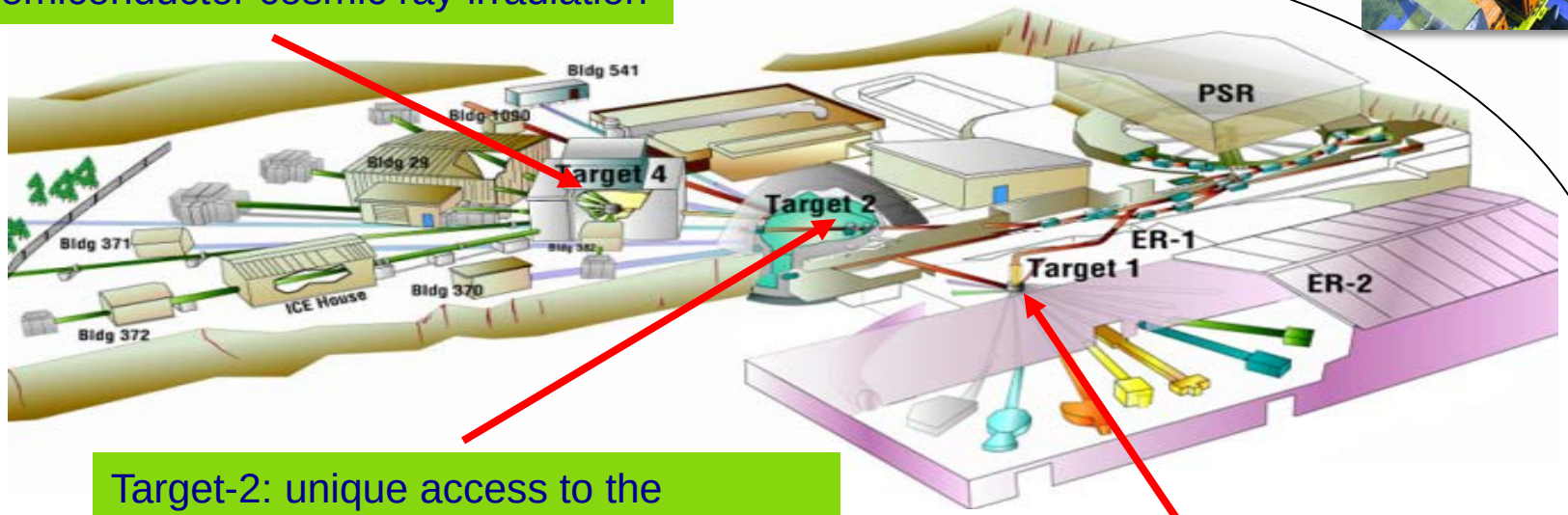
64 Nuclear Science proposals were completed in the 2014 run cycle – with a 2.9 over-subscription

LANSCE Materials Science Research uses protons and neutrons for irradiation, probes, and radiography

IPF (p,n irradiation)

pRad
Dynamic and extreme materials research

Target-4 (unmoderated neutrons)
Semiconductor cosmic ray irradiation



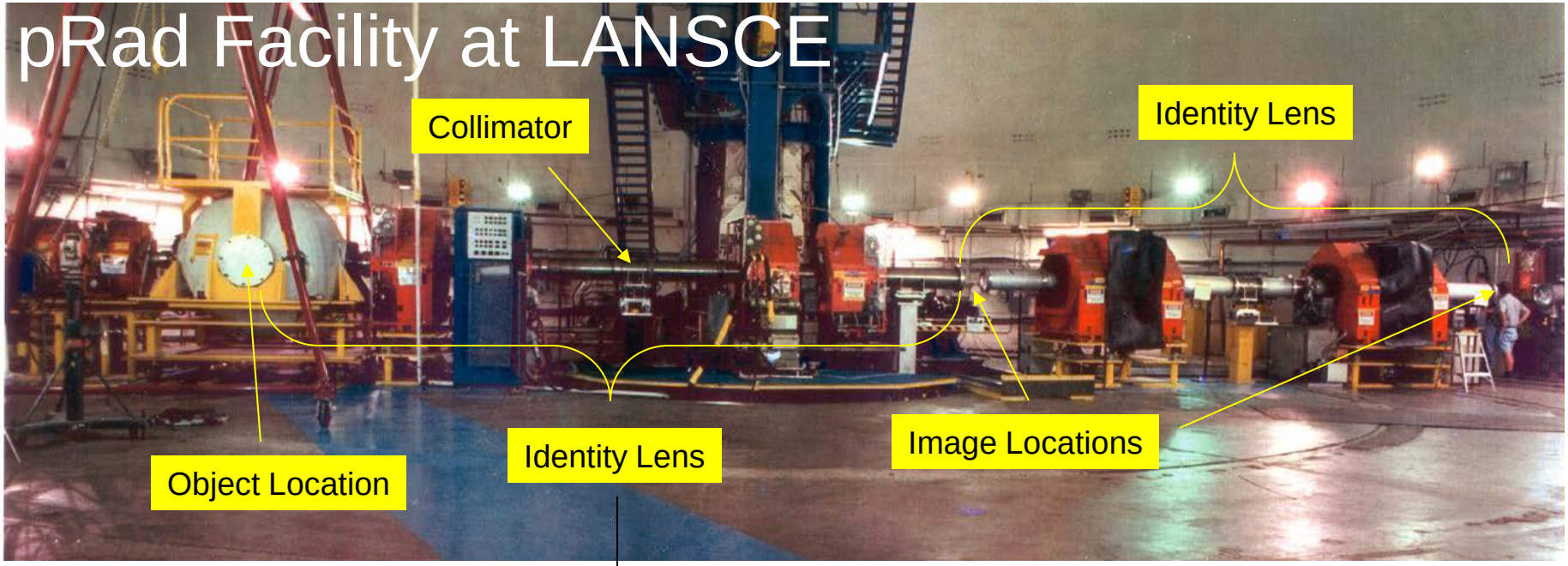
Target-2: unique access to the compressed or uncompressed 800 MeV proton beam

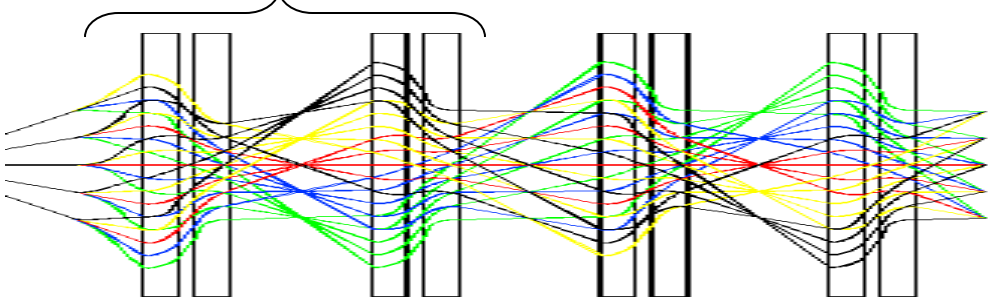
- (p,n) Material irradiation
- NRS dynamic materials

Lujan Center (moderated neutrons)

- Neutron scattering
- Neutron radiography

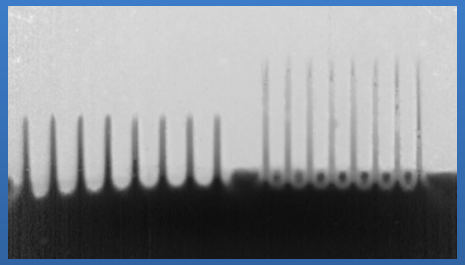
Proton microscopy (radiography) was developed at Los Alamos and has developed into an important and unique probe for dynamic materials research





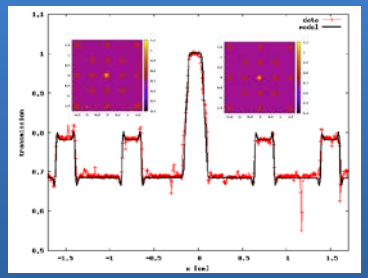
Proton Radiography continues to expand its role in stockpile stewardship through verification, calibration, and validation of physics-based models and codes

Ejecta



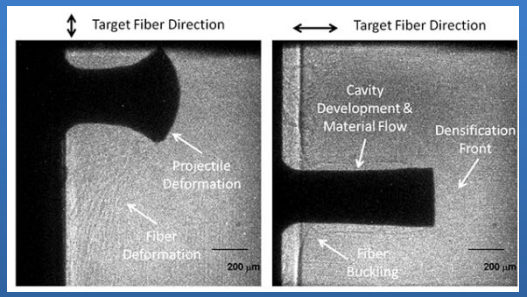
RMI-hydro codes

Radiograph interpretation



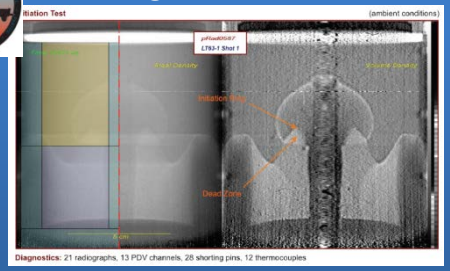
BIE analysis-Molli

Penetration mechanics



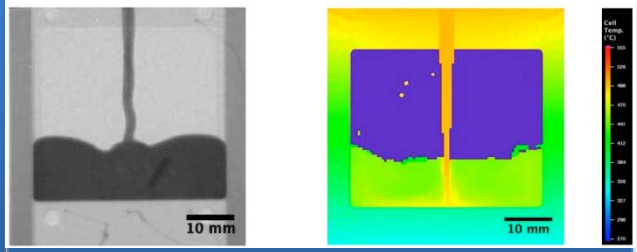
Supporting DOD

B61-12 LEP



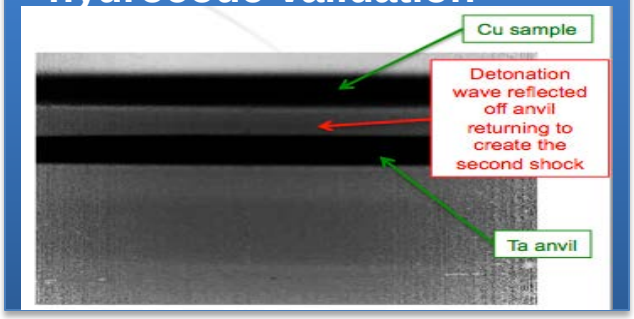
PBX 9502 initiation behavior

AM-Casting



TRUCHAS code

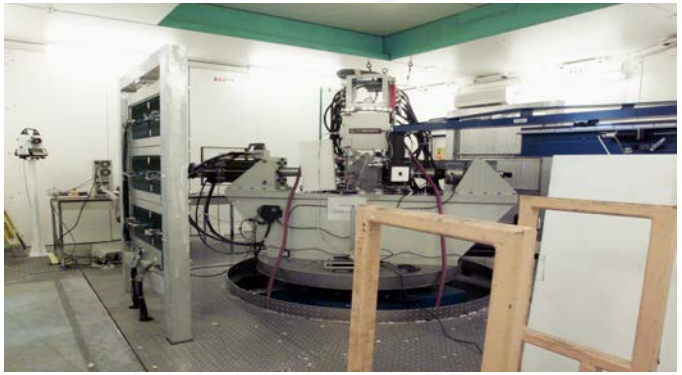
Red-Sage – Subcrit hydrocode validation



2014 run cycle was over-subscribed by 2.6

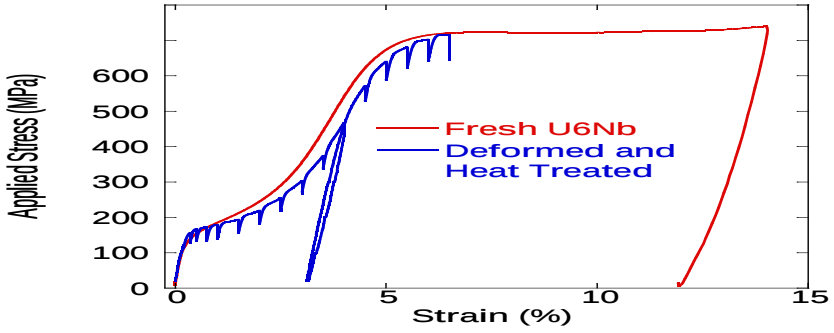
NNSA-focused materials researchers use the moderated neutron source at Lujan to develop new analysis techniques for stockpile materials

SMARTS at the LANSCE (LUJAN)



Goal: Lay scientific groundwork for re-use of existing U6Nb parts

2014 run cycle: Measurements **with LLNL** on pre-deformed U6Nb demonstrate that the microstructure (and thus ductility) is recovered by a simple heat treatment to 800C.



HIPPO at the LANSCE (Lujan)

Goal: High pressure and temperature EOS of U6Nb

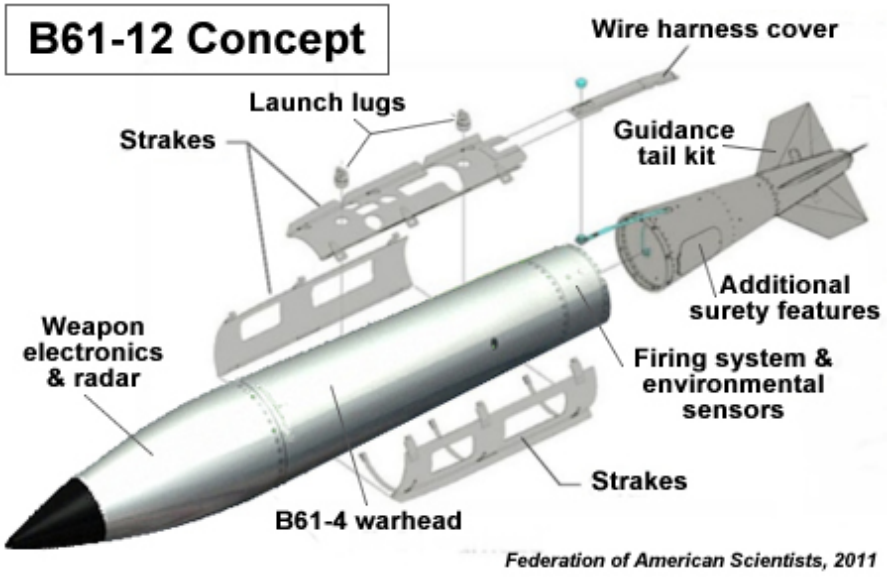
2014 run cycle:

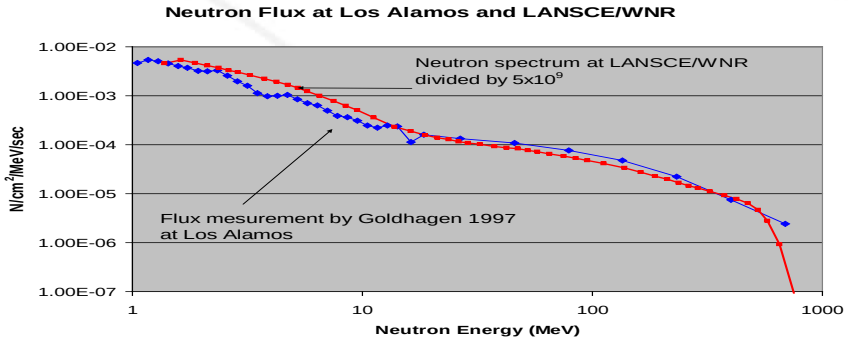
- Bulk modulus of U6Nb ~10% higher than uranium
- Phase stability depends on hydrostatic pressure.
- Nb stable in solution at lower temperature and increased pressure.

106 Material Science proposals were completed in the 2014 run cycle – with a 2.9 oversubscription

WNR produces an intense neutronic cosmic ray spectrum for testing electronics for single-event upset response

B61-mod12 Tail Kit Assembly Tests at WNR



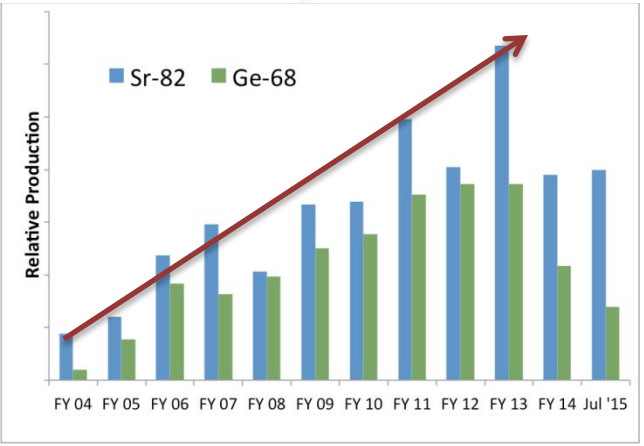


- All electronics/avionics suffer from neutron interactions which can cause failures
- WNR has a long history of performing critical testing for the avionics industry
- In the upcoming run cycle Boeing will test components of the B-61 tail kit guidance system in the WNR neutron beam
- 3 hours of beam will give the equivalent of 1 million hours of cosmic-ray bombardment

The Isotope Production Facility (IPF) is a National Resource

Meeting Domestic Need for Medical Isotopes

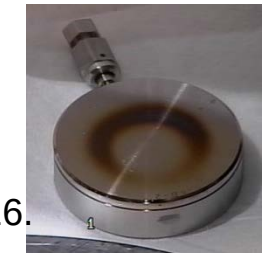
LANSCE production of Sr-82 for cardiac imaging impacts ~ 30,000 patients/ month.



LANL is the largest domestic supplier of ^{82}Sr

Demand continues to grow

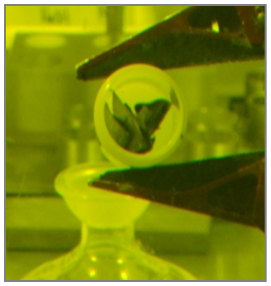
- Successful test of Rb metal targets in FY15 demonstrated a 1.4x increase in ^{82}Sr yield.
- Plan to implement at the end of FY16.



Goal: Continue to meet growing need for imaging isotopes; LRM will benefit reliability of supply

Cancer Therapy: Ac-225 Tri-lab Research Effort

- ^{225}Ac ($t_{1/2}$ 10 d) is a promising isotope for targeted alpha-based cancer therapy, but supply is limited.
- Conducted small-scale production irradiations at LANSCE.
- Will continue to increase production with improvements and evaluation of product and alternatives.



New radionuclides for therapy and imaging

- **^{119}Sb** is an Auger emitter ($t_{1/2}$ 38.5 h) of interest for therapy;
- **^{44}Ti** ($t_{1/2}$ 58.9 a) as a generator for the PET isotope ^{44}Sc ($t_{1/2}$ 3.92 h); produced record 5 mCi of ^{44}Ti in a single target

Goal: Build diverse portfolio of radionuclides for medical applications

LANL Isotope Program Future Directions

Isotopes For Medicine, Science and Industry

Nuclear Data & New Production Routes

- LANSCE is the only North American facility actively measuring charged particle excitation functions at proton energies from 60 – 800 MeV (IPF and WNR).
- Produce isotopes including ^{73}As for experiments at **Lujan Center.**
- Investigating production routes for radionuclides (*e.g.*, $^{236m/g}$Np, ^{236}Pu) needed as IDMS standards for national security.
- Anticipated new start to investigate ^{230}U production as a generator for alpha therapy isotopes.
- Exploring secondary neutron flux at the Isotope Production Facility (IPF) as a novel means of production of radionuclides and generation of nuclear data.

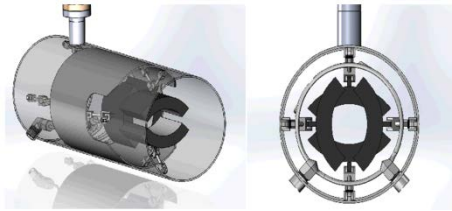
Goal: Provide needed data, evaluation and samples to address questions in the isotope production, national security and nuclear data communities

Accelerator Improvement Project

- The first DOE-SC AIP project at LANSCE in over 20 years was approved (8/3/15) to enhance the IPF beam transport system ($5.1M effort).
- Improved beam-target diagnostics will increase reliability and reduce risk to the facility.

Improved raster distributes beam energy over target

Novel adjustable collimator concept allows large aperture for production and small for R&D targets



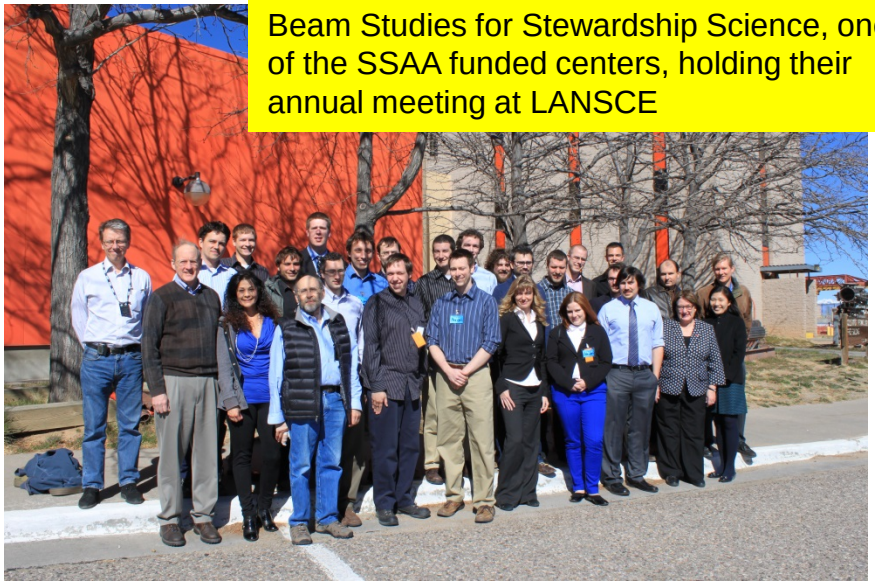
Goal: Reduced operational risk and major improvements to production and research capability at IPF

LANSCE is an important portal for national and international collaboration and recruitment

Example: Stockpile Stewardship Academic Alliance (SSAA)

- The SSAA program funds academic research in the areas of materials under extreme conditions, low-energy nuclear science, radiochemistry, and high-energy density physics
- Six experimental campaigns, funded by the SSAA program, ran in the 2014 LANSCE run cycle
- Experiments are planned to continue in the 2015 run cycle, and one additional SSAA-funded collaboration has requested beam time

36 academic institutions utilized Lujan and WNR during the FY 14 run cycle



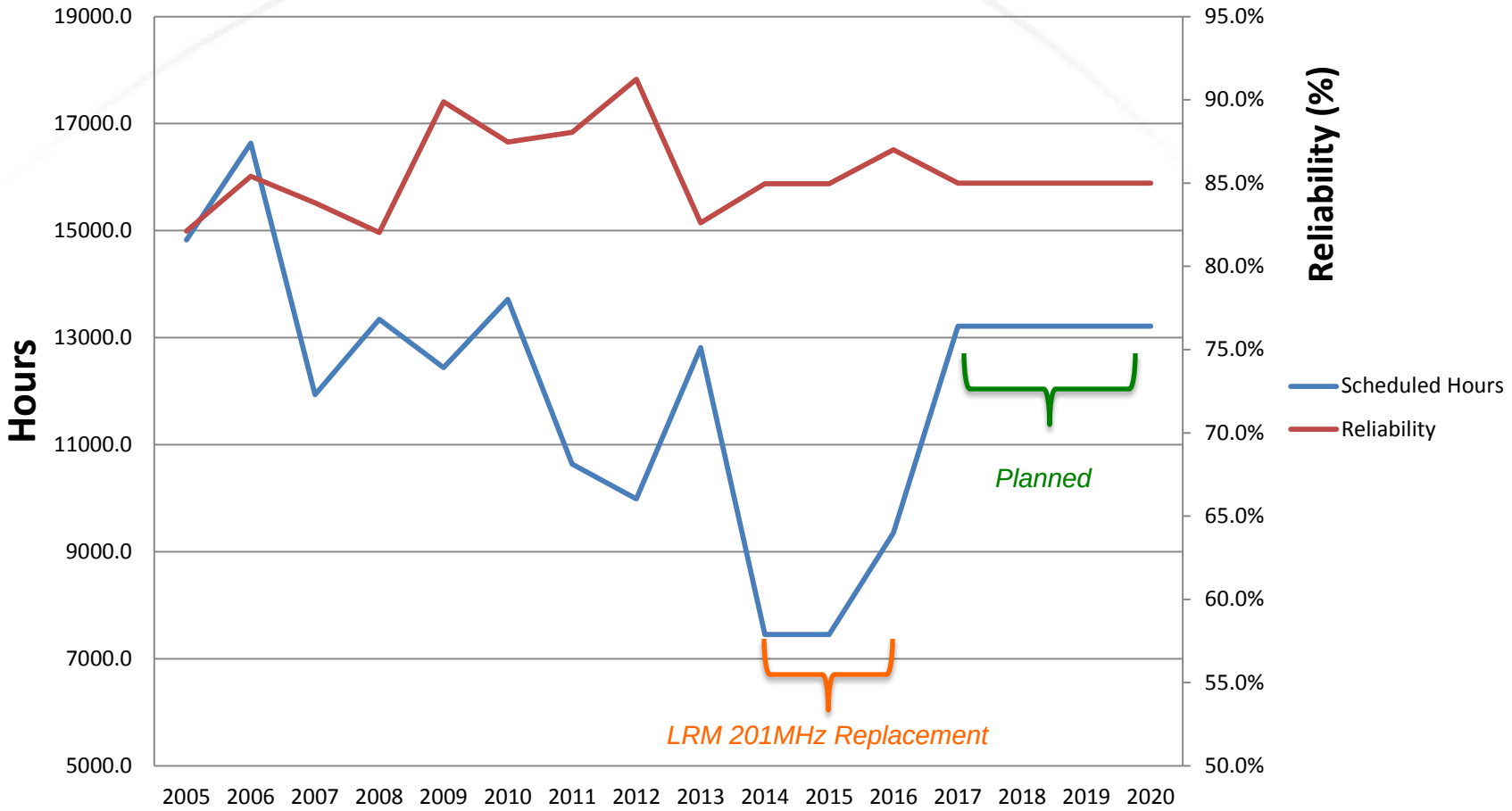
The Center of Excellence for Radioactive Ion Beam Studies for Stewardship Science, one of the SSAA funded centers, holding their annual meeting at LANSCE

Brett Manning, then a SSAA funded student, discussing his research with Eric Brown, the P-23 group leader.

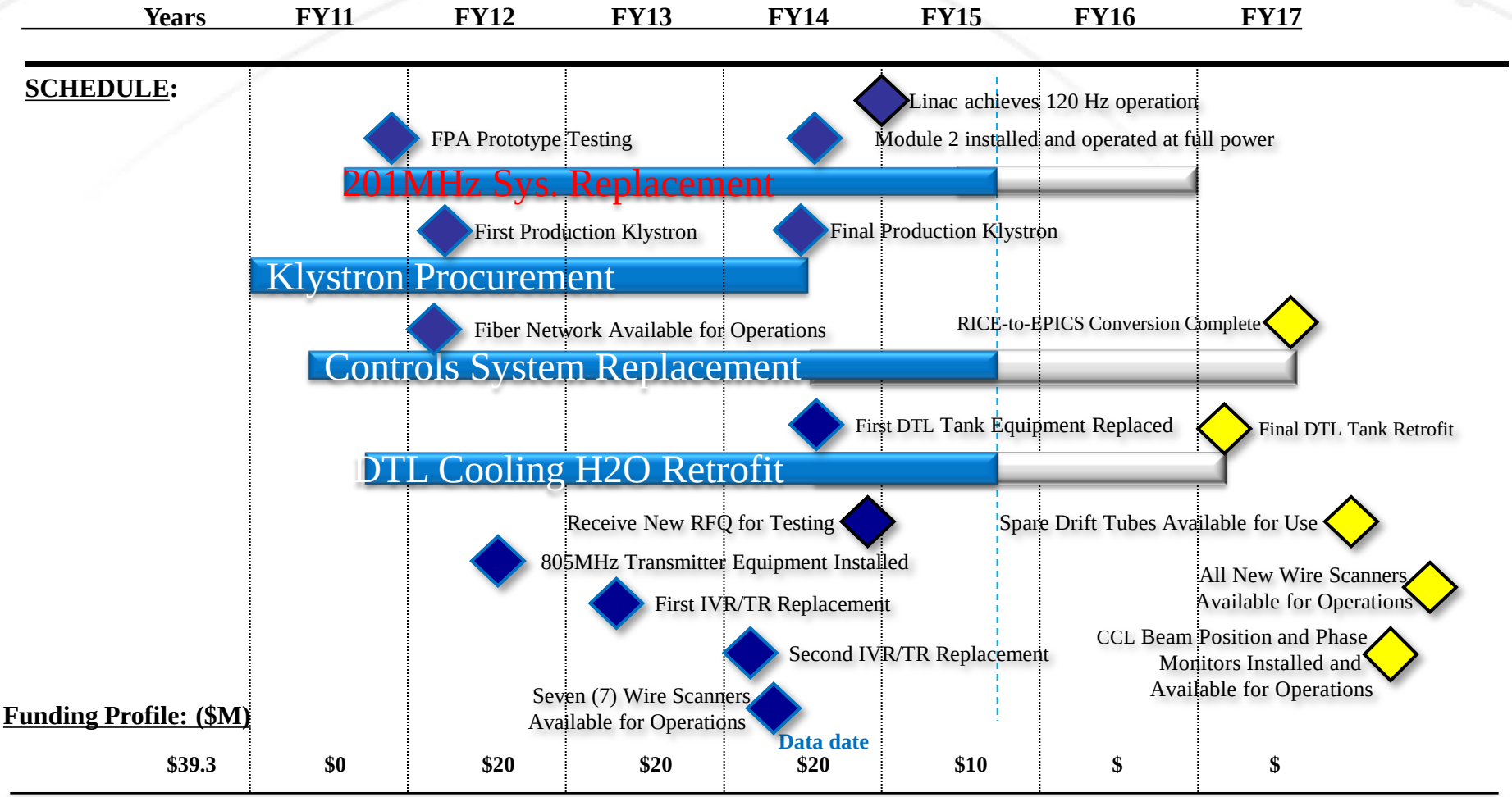
Outline

- Facility description and recent user program highlights
- **Operation performance**
- **Linac Risk Mitigation update**
- Future 5-year planning
- NNSA programmatic impacts: Mark Chadwick

LANSCE has achieved excellent operational reliability for all facilities over the past decade with a return to full production in CY17

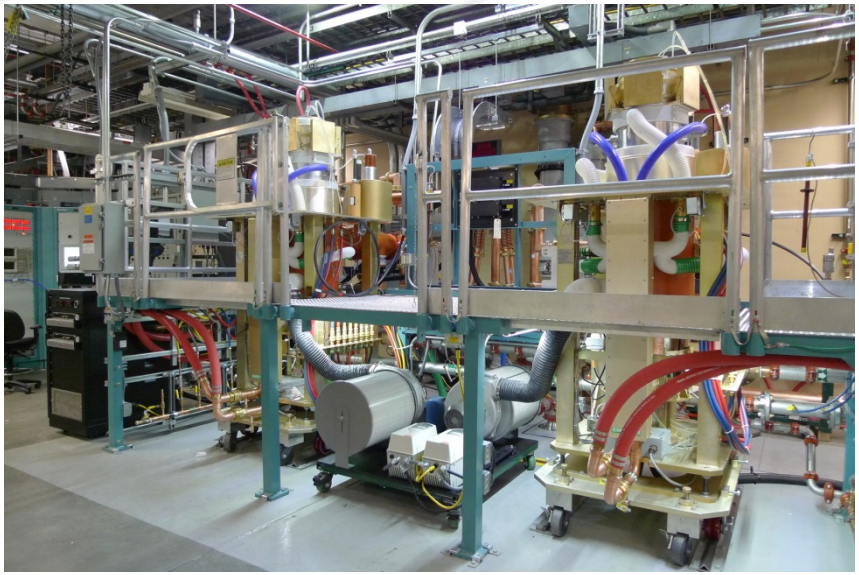


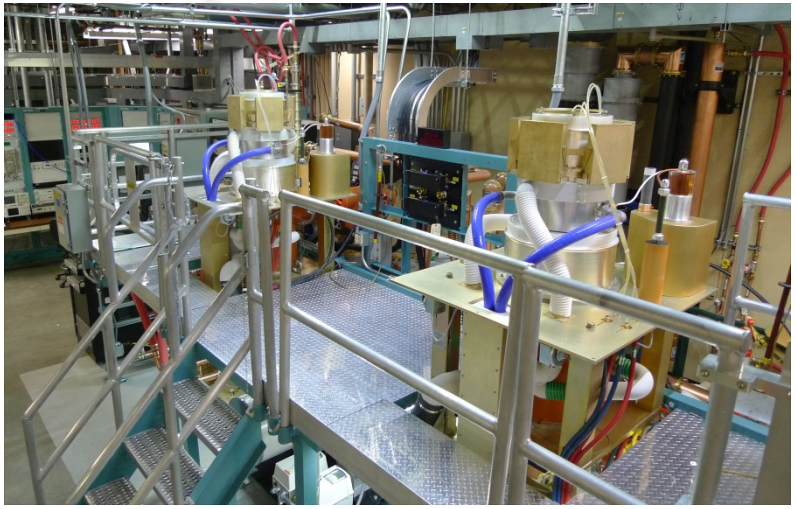
Linac Risk Mitigation activities have completed major milestones on the road to sustainable operations



LINAC returned to 120 Hz operation during FY15 run

High Power Amplifier Installed in Module 2 enabled regaining design performance at 120 Hz in FY14

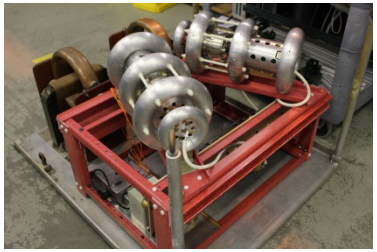




Module 2 High Power 201.25 MHz amplifier

In addition to the 201 MHz RF success, a wide variety of new LRM-funded systems has operated successfully in the FY14 run cycle

New Klystrons



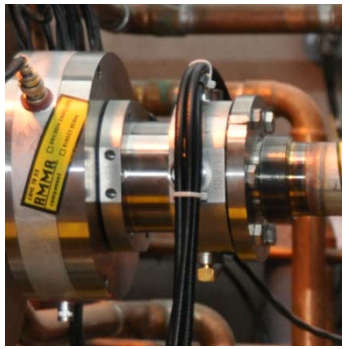
New Modulators

New DTL water Instrumentation and piping

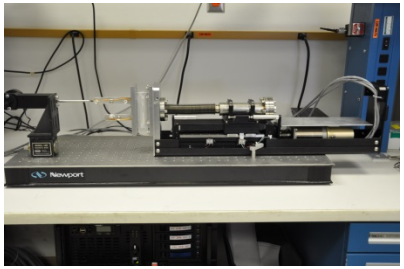
New DTL pumps and control valves

Refurbished Transformer Rectifiers

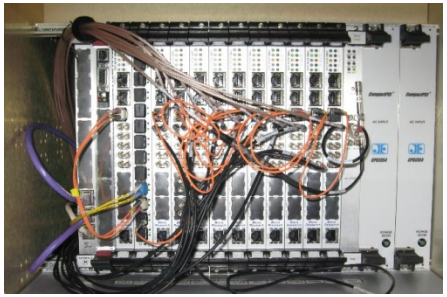
New Industrial Controls



Beam Position and Phase Measurement Sensor



Wire Scanner Actuator



Master Pattern Generator for New Timing System

Refurbished Inductrol Voltage Regulators

The second High Power 201.25 MHz Power amplifier was installed in FY 2015 and will allow sustainable operation at 120 Hz

Module 4 High Power Amplifier

Outline

- Facility description and recent user program highlights
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- **Future 5-year planning**
- NNSA programmatic impacts: Mark Chadwick

Long-term LANSCE run schedule shows a return to full 7-month production in CY 2017

~CY Operational Hours Available	FY	~FY Operational Hours Available
3744	FY 2012	3696
3624	FY2013	3696
3624	FY2014	2256
1968	FY2015	1752
1992	FY2016	2784
2232	FY2017	3600
3720	FY2018	3744
3720	FY2019	3744
3720	FY20120	3744

Programmatic and scientific demand for LANSCE nuclear research in FY16 remains high and oversubscribed

- The 2015 LANSCE nuclear science call accepted proposals for 11 flight paths
  - 80 proposals were received
  - 1441 days were requested across the available flight paths
  - 743 days of beam time have been scheduled for the upcoming run cycle
  - A diverse set of proposals were received; the most oversubscribed is a general-use flight path, 4FP60R
- Many of the proposals support Primary Assessment Technologies (Science Campaign 1) and Industry users
  - The Chi-Nu and TPC projects funded by C1 will need essentially all beam time on two flight paths to meet their FY2016 milestones
  - Another thrust area is radiography; the number of proposals has been growing over the last few years
  - The interest from industry users to characterize radiation effects at LANSCE-WNR continues to be strong

Programmatic and scientific demand for LANSCE material science research in FY16 remains high and oversubscribed

- The 2015 LANSCE material science call accepted proposals for 3 beamlines
  - Even with the reduced number of material beamlines there is significant interest from internal and external users to perform experiments at Lujan Center
  - Total number of proposals received: 100
  - Days requested: 571
  - Available: 240
  - All three flight paths are heavily oversubscribed
- The majority of proposals are supporting the Science Campaigns, but there are also several requests from other institutions
  - About half of the proposals funded by NNSA
  - Another major thrust area is nuclear energy: 11 proposals funded entirely or in part by DOE-NE were received

The NNSA Science Campaign needs in FY16 – FY20 are well defined for Proton Radiography, WNR, and the Lujan Center

pRad

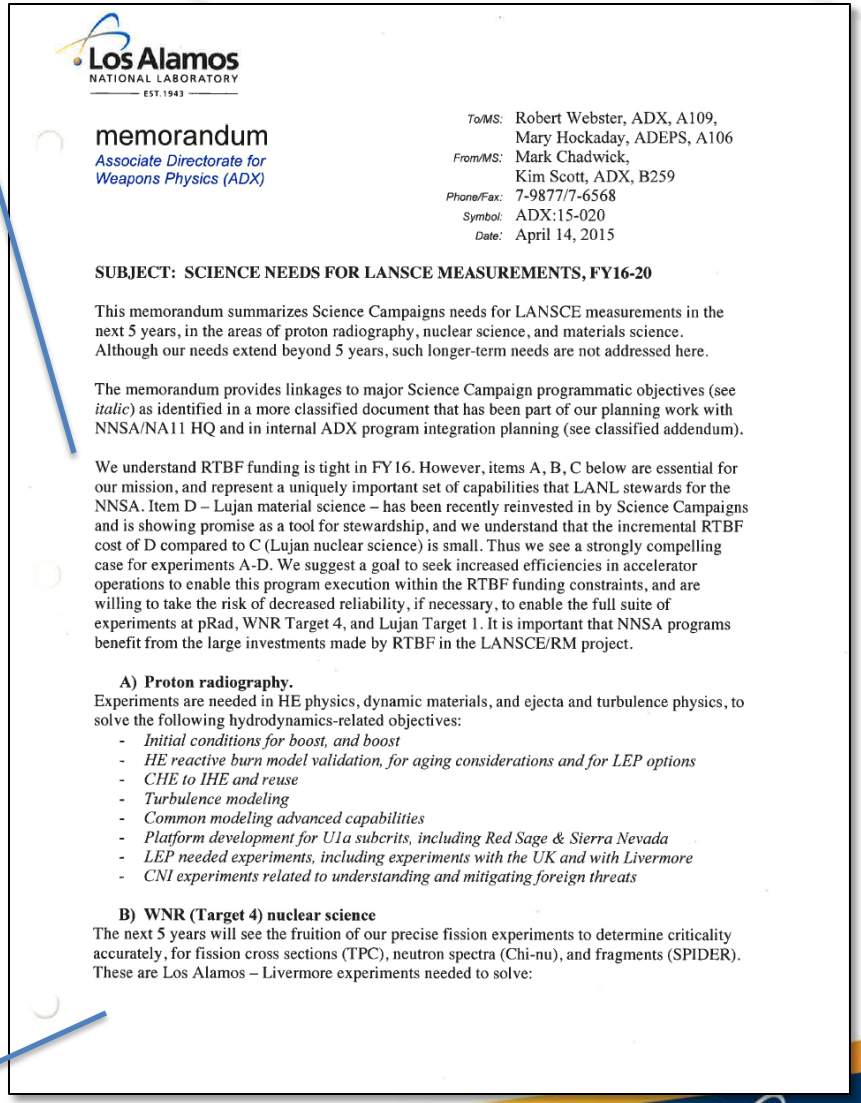
- *Initial conditions for boost and boost*
- *HE reactive burn model validation*
- *CHE to IHE and reuse*
- *LEP needed experiments*
- *Experiments with UK and LLNL*
- *Platform development for U1A subcrits ..*

WNR

- *Precise criticality for boost and Ics*
- *NDSE nuclear science support and n-rad option*
- *Outputs and effects*
- *Diagnostics of fission yields*
- *N-Rad (advanced surveillence)*
- *Forensics / CNI capture diagnostics*

Lujan

- *NDSE for modeling fission g-ray outputs, fission product isomer background characterization*
- *Radchem cross sections*
- *Late-time yield diagnostics and forensics*
- *Characterization of AM*
- *Pu multi-phase EOS upgrades*
- *Material properties for assuring performance in relevant environments*
- *HE reactive burn model development*



Los Alamos NATIONAL LABORATORY EST. 1943

memorandum

Associate Directorate for Weapons Physics (ADX)

To/MS: Robert Webster, ADX, A109, Mary Hockaday, ADEPS, A106
From/MS: Mark Chadwick, Kim Scott, ADX, B259
Phone/Fax: 7-9877/7-6568
Symbol: ADX:15-020
Date: April 14, 2015

SUBJECT: SCIENCE NEEDS FOR LANSCE MEASUREMENTS, FY16-20

This memorandum summarizes Science Campaigns needs for LANSCE measurements in the next 5 years, in the areas of proton radiography, nuclear science, and materials science. Although our needs extend beyond 5 years, such longer-term needs are not addressed here.

The memorandum provides linkages to major Science Campaign programmatic objectives (see *italic*) as identified in a more classified document that has been part of our planning work with NNSA/NA11 HQ and in internal ADX program integration planning (see classified addendum).

We understand RTBF funding is tight in FY16. However, items A, B, C below are essential for our mission, and represent a uniquely important set of capabilities that LANL stewards for the NNSA. Item D – Lujan material science – has been recently reinvested in by Science Campaigns and is showing promise as a tool for stewardship, and we understand that the incremental RTBF cost of D compared to C (Lujan nuclear science) is small. Thus we see a strongly compelling case for experiments A-D. We suggest a goal to seek increased efficiencies in accelerator operations to enable this program execution within the RTBF funding constraints, and are willing to take the risk of decreased reliability, if necessary, to enable the full suite of experiments at pRad, WNR Target 4, and Lujan Target 1. It is important that NNSA programs benefit from the large investments made by RTBF in the LANSCE/RM project.

A) Proton radiography.
Experiments are needed in HE physics, dynamic materials, and ejecta and turbulence physics, to solve the following hydrodynamics-related objectives:

- *Initial conditions for boost, and boost*
- *HE reactive burn model validation, for aging considerations and for LEP options*
- *CHE to IHE and reuse*
- *Turbulence modeling*
- *Common modeling advanced capabilities*
- *Platform development for U1a subcrits, including Red Sage & Sierra Nevada*
- *LEP needed experiments, including experiments with the UK and with Livermore*
- *CNI experiments related to understanding and mitigating foreign threats*

B) WNR (Target 4) nuclear science
The next 5 years will see the fruition of our precise fission experiments to determine criticality accurately, for fission cross sections (TPC), neutron spectra (Chi-nu), and fragments (SPIDER). These are Los Alamos – Livermore experiments needed to solve:

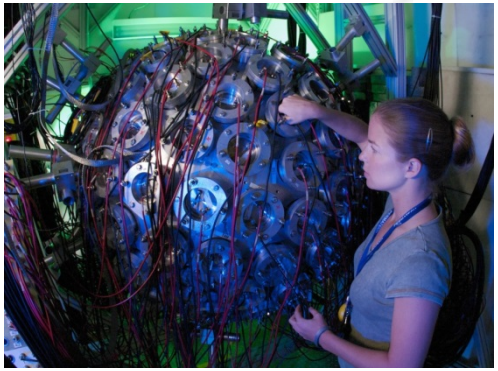
We developed a "FYNSP FY16-FY20" operations plan, with defined decision points, consistent with programmatic deliverables and MaRIE CD-0 schedule

- Drives linac at 120 Hz with beam delivery to the present 6 targets.
- Meets Nuclear Science deliverables to Science Campaigns and DSW at pRad, WNR and Lujan
- Maximizes scientific and programmatic output for LANSCE facilities. .

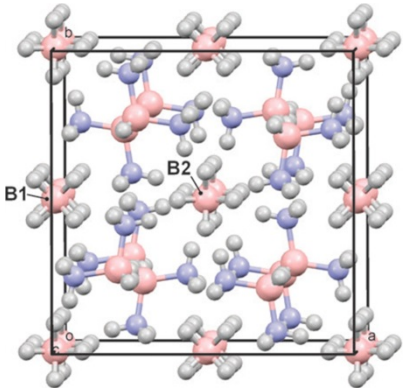
- Continues critical investments in Linac infrastructure to maintain facility research availability and to prepare the proton Linac for MaRIE.
  - *201MHz power amplifier work is completed in FY16 (Module 3)*
  - *Includes sustainability investments in Linac and conventional facilities, including critical spares*
- Maintains accelerator operations expertise and infrastructure until needed for MaRIE construction (CD-3 activities in FY21)

Our vision: Operating LANSCE as a "designated national user facility" will optimize its scientific and programmatic value as we segue the scientific user community to MaRIE

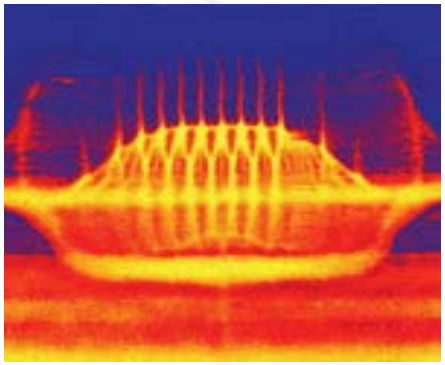
As we look toward MaRIE, LANSCE will continue to evolve capabilities to meet the specific demands of National Security and the broader requirements for achieving scientific excellence.



Nuclear Science and Technology



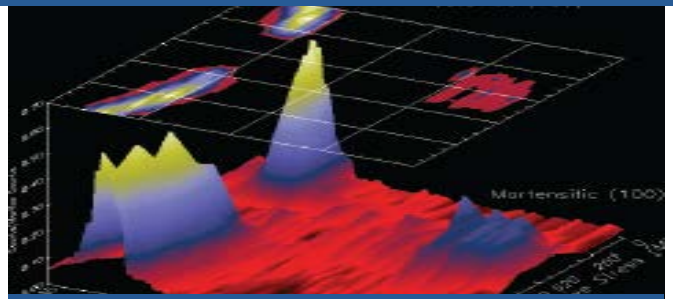
Materials Science



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

Outline

- Facility description and recent user program highlights
- Operation performance
- Linac Risk Mitigation update
- Future 5-year planning
- **NNSA programmatic impacts: Mark Chadwick**