OPERATIONAL STATUS AND FUTURE PLANS FOR THE LOS ALAMOS NEUTRON SCIENCE CENTER (LANSCE)*

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Abstract

The Los Alamos Neutron Science Center (LANSCE) continues to be a signature experimental science facility at Los Alamos National Laboratory (LANL). The 800 MeV linear proton accelerator provides multiplexed beams to five unique target stations to produce medical radioisotopes, ultra-cold neutrons, thermal and high-energy neutrons for material and nuclear science, and to conduct proton radiography of dynamic events. Recent operating experience will be reviewed and the role of an enhanced LANSCE facility in LANL's new signature facility initiative, Matter and Radiation in Extremes (MaRIE) will be discussed.

INTRODUCTION

The Los Alamos Neutron Science Center (LANSCE) is a unique multidisciplinary facility for science and technology. The core of the facility is an 800-MeV linear accelerator system with demonstrated 1MW capability that presently accelerates up to 100kW of negative hydrogen ions with unique and highly variable timing patterns suitable for a wide variety of experimental programs. Five experimental areas form the core of the user facility. Four areas utilize the 800-MeV negative hydrogen ion beams directed by appropriate pulsed kicker systems: at the Manuel Lujan Jr. Neutron Scattering Center (Lujan Center) sixteen flight paths utilize pulsed thermal and epithermal neutrons produced at 20Hz by intense 0.29μs bursts of protons incident on a tungsten spallation target and moderated by water or liquid hydrogen; the Weapons Neutron Research Facility (WNR) provides the most intense source of high-energy neutrons in the world for neutron nuclear science and is an accepted world standard for irradiation of semiconductor electronics; the Proton Radiography Facility (pRAD) provides a unique facility for the study of shock-induced dynamic processes where shocks are driven by high explosives or projectiles; and the Ultra-Cold Neutron (UCN) facility uses a moderated solid deuterium target to generate intense pulses of ultra-cold neutrons for fundamental science research. The Isotope Production Facility (IPF) at 100 MeV utilizes a proton beam of up to 275 μA to produce proton-induced isotopes for medical imaging diagnostics and fundamental research. LANSCE continues a disciplined approach to both operations and maintenance that maintains operational performance and user satisfaction in a constrained funding environment.

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THE LANSCE USER FACILITY

The Lujan Center provides 11 neutron scattering instruments capable of studying materials structures of diverse items such as proteins, machinery components, powders, and single crystals using both elastic and inelastic techniques. Nuclear science is supported by three flight paths, one of which is equipped with a 4π detector used to measure thermal neutron capture cross sections on unstable nuclei. This suite of instruments applies and advances neutron scattering for both defense and academic research. Beam current to the Lujan target is nominally 100μA but can be as high as 125μA depending on ion source and accelerator optimization.

The WNR facility receives beam at 40-100Hz with a variable micro-pulse spacing (typically 1.8μs) to address the needs of LANSCE Users in the areas of basic and applied nuclear science. The pulse spacing permits resolution of frame overlap in the neutron spectra. This white neutron source (Target 4) is the most intense source of high-energy (<760 MeV) neutrons worldwide and is equipped with six flight paths that determine neutron energy using time-of-flight techniques. A key flight path used principally by industry users provides a neutron spectrum essentially identical to that of cosmic-ray neutrons to permit accelerated studies of single-event-upset sensitivity for the electronics and avionics industries. A related facility (Target 2) provides direct access to proton beams with energies up to 800 MeV for studies of proton-induced reactions and target irradiations for materials testing. This target station is also equipped with five neutron flight paths.

The pRAD facility provides a unique experimental technique for studies of dynamic processes. Up to 37 pulses of protons, each with approximately 10^9 particles per pulse, temporally spaced at appropriate intervals, are directed at a dynamic object. The scattering characteristics of each pulse are imaged by a collimator and magnetic lens system and recorded by a camera. This technique permits multi-frame radiographs of dynamic events driven by gas guns or high explosives. These radiographs permit the study of material dynamics and failure mechanisms under shock conditions.

The UCN facility accepts several full charge (~5μC) accelerator pulses separated by a period suitable for the moderation and bottling of the neutrons and compatible with average current limits, typically about 5-7 seconds. The ultra-cold neutrons are then directed through a guide to a decay volume where beta-decay parameters are measured.

The IPF irradiates source materials to produce proton-induced isotopes for applications in medical diagnostic imaging and research. Most notable is the production of ^{82}Sr used for cardiac imaging, and other isotopes for the calibration of PET scanners. The operation of this facility is interleaved with others around the world to assure a constant supply of the necessary isotopes.

A schematic representation of the facility and its operating characteristics is given in Figure 1.

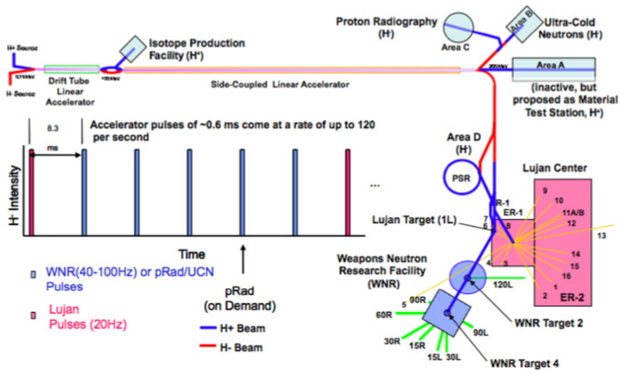

Figure 1: Schematic layout of the LANSCE User Facility

OPERATIONS PERFORMANCE

Integrated performance for the LANSCE User Facility has been remarkably consistent since the year 2000. This is best illustrated by reliability data for the Lujan Center from 1991 to 2007 as shown in Figure 2. This represents the most complex beam delivery system including the injectors and linac, the proton storage ring, and beam transport lines.

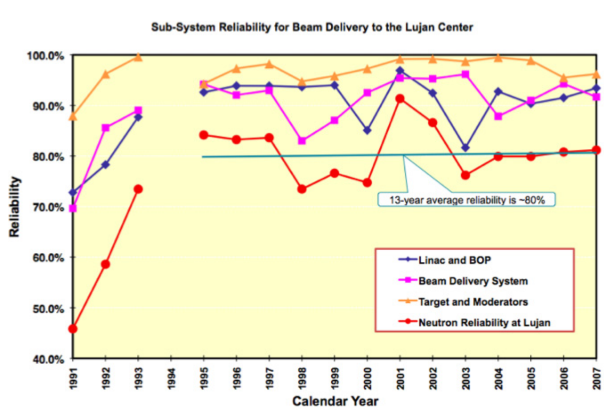

Figure 2: Sub-system reliability for beam delivery to the Lujan Center

These data illustrate that the 13-year average reliability from 1995 to 2007 is slightly over 80% which is remarkable for a facility that is now 36 years old with much of the original equipment still in service.

Operating hours from 1989 to 2007 are illustrated in Figure 3.

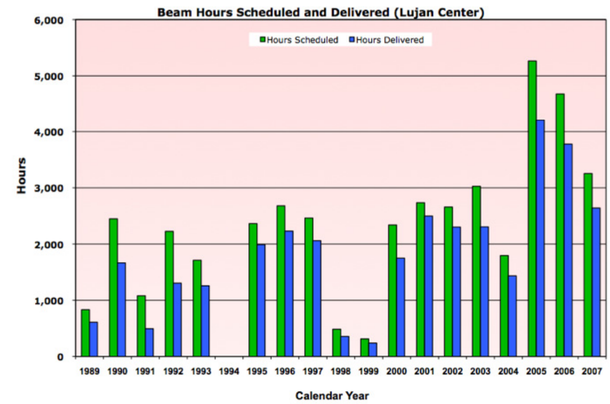

Figure 3: Operating hours for the Lujan Center illustrating recent gains.

Strong efforts have recently been made to increase the number of operating hours for the facility, but budget constraints coupled with increasing power costs dictate that future operating schedules be limited to 3,000 hours per calendar year. This operating scenario is consistent with that planned for the LANSCE Refurbishment Project discussed elsewhere at this conference [1].

Sub-system down time is recorded throughout each scheduled operating period with 1-minute resolution. Historical data allow for careful trending and allocation of scarce maintenance resources. These data have proved valuable in the definition of the scope of the LANSCE Refurbishment Project [1], and are shown in Figure 4.

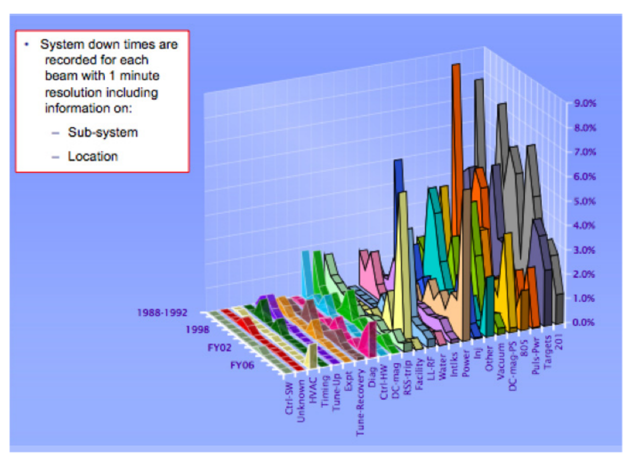

Figure 4: Historical sub-system down time for beam delivery to the Lujan Center

Average operating performance over recent years for the principal facilities at LANSCE is summarized in Table 1.

Table 1: Recent average operating performance for the principal facilities at LANSCE

Facility	Reliability
Lujan Center	81.6%
WNR Target 4	84.7%
pRAD	89.5%
IPF	83.7%

FUTURE PLANS

Substantial effort has been invested in the LANSCE Refurbishment Project (LANSCE-R) that is discussed elsewhere at this conference [1]. The National Nuclear Security Administration (NNSA) investment in LANSCE-R is planned to be ~$150M (US).

Another core element of facility refurbishment is replacement of electrical, water, and HVAC utilities in the linac service building. This has been done for one of the eight sectors of the accelerator, Sector B. This replacement project for the remaining 7 sectors and budgeted at $22M is planned for FY09-FY12.

Two partner organizations also plan significant investment in the facility. The DOE Office of Science/Basic Energy Sciences plans to enhance the materials science instrument suite at the Lujan Center to emphasize utilization of cold neutrons and improve compatibility with the Spallation Neutron Source at Oak Ridge National Laboratory. This will also involve a new design of the moderator suite for the target-moderator-reflector system that serves the Lujan Center. This work is underway.

The DOE Office of Nuclear Energy plans to install a Material Test Station (MTS) in the decommissioned high-power beam end-station, Area A, which in the past housed the pion and muon production targets and experimental stations for the original LAMPF nuclear physics program. Site preparation in Area A has begun and the shielding doors surrounding the production targets have successfully been opened after 15 years. The MTS will provide a target facility capable of accepting at least 800kW of proton beam power to irradiate fast-fission spectrum fuel elements for material science studies, and will be designed to accept beam powers of up to 3.6MW. The planned budget for this facility is ~$75M with construction scheduled from FY10-FY12.

Several other facility enhancements proposed by work-for-others programs are being considered. A proton interrogation test facility for remote cargo interrogation is in the conceptual design phase. This initiative would utilize single micro-pulses accelerated to 1GeV in a high-gradient superconducting afterburner accelerator for delivery down a 600m external flight path to examine prototypical cargo containers for materials of interest. This project is one of several projects at the conceptual design phase using accelerated particle beams aimed at improving national security. Other projects underway at Los Alamos also consider the use of muon beams for this purpose.

The Proton Storage Ring (PSR) beam may be utilized in different ways. Recent successful development activities have focused on modifications to the PSR to allow accumulation of stacked micro-pulses rather than the 290ns pulse intended for the Lujan Center. These stacked micropulses would be delivered to WNR Target 4 and would enhance the neutron spectrum from the white source in a region of significant interest to the neutron science program. A second concept would extract high-charge (~10μC) pulses from the PSR and deliver them to a new low-enriched sub-critical assembly where the proton burst would drive the assembly to generate a substantial neutron burst, essentially emulating a short-pulse critical assembly. This facility could replace the Short Pulse Reactor facility at Sandia National Laboratory that had been used to study neutron-induced radiation effects on materials and electronics. The estimated cost of such a facility, which is in the conceptual design stage, is ~$70M.

The Los Alamos National Laboratory is developing conceptual plans for a new signature experimental facility, MaRIE. LANSCE will form the foundation for this new facility. Plans include an increase in power capacity for the present linac from 1MW to 1.8-3.6MW for enhanced operation of the MTS. Plans also include a 35GeV high-gradient electron linac and FEL facility that will produce radiation of ~50keV for enhanced material science capabilities.

The LANSCE User Facility is the subject of resurgent interest in the spectrum of science accessible at the facility, and the future is bright.

REFERENCES

[1] J. Erickson, K. Jones and M. Strevell, "Status of the LANSCE Refurbishment Project," Linac08, Victoria, BC, MOP014 (2008); http://www.JACoW.org.