STATUS OF THE LOS ALAMOS NEUTRON SCIENCE CENTER AND PLANS FOR THE FUTURE*

Paul W. Lisowski and Kevin W. Jones, Los Alamos National Laboratory,
Los Alamos, NM 87545, USA

Abstract

The Los Alamos Neutron Science Center (LANSCE) uses an 800-MeV linac to provide proton beams for a variety of basic and applied research applications. At present LANSCE has two facilities using the proton beam to make neutrons and one facility using it for radiography. Researchers at these areas require high availability, often at the highest possible beam current, in order to perform their work. Because the LANSCE linac has been operating for almost 30 years with a minimal maintenance budget, providing dependable operation with high beam availability (>85%) is a challenge. Nevertheless, during the past six-month operating period the entire facility attained 92% overall availability and served over 300 users. This paper describes the LANSCE facility and planned improvements with a focus on beam delivery requirements and factors that led to the unprecedented, increased level of beam availability.

1 INTRODUCTION

The Los Alamos Neutron Science Center (LANSCE), illustrated in Figure 1, is a unique multidisciplinary facility for science and technology. The core of the facility is an 800-MeV linear accelerator system that accelerates up to 100 kW of negative hydrogen ions with pulsed beam timing patterns suitable for a wide variety of experimental programs. Three experimental areas make up the user facility. At the Manuel Lujan Jr. Neutron Scattering Center (Lujan Center) sixteen flight paths utilize pulsed cold, thermal and epithermal neutrons produced at 20Hz by intense 0.13µs (FWHM) 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. It uses a bare tungsten target that serves six flight paths. The Proton Radiography Facility (pRad) provides a unique facility for the study of dynamic processes using the proton beam and a magnetic lens imaging system. To effectively support these diverse activities, LANSCE has recently implemented a more disciplined project management approach to both operations and maintenance that has resulted in improved operational performance and increased user satisfaction.

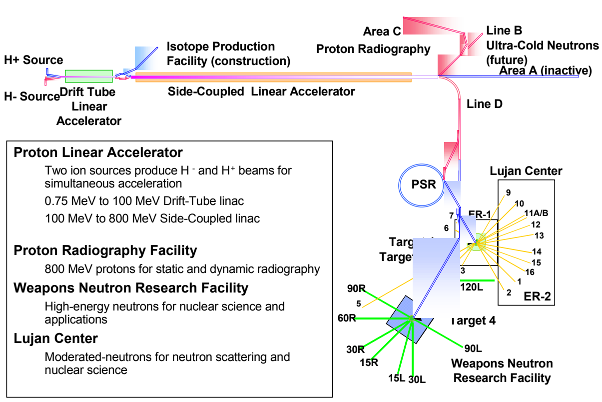

Figure 1 LANSCE User Facility and Additions

*Work supported by the U. S. Department of Energy under contract W-7405-ENG-36

2 THE LANSCE USER FACILITY

The Lujan Center serves both defense and academic research through a diverse set of instruments and specially equipped flight paths. There are 11 neutron scattering instruments capable of studying diverse material structures such as proteins, machinery components, powders, and single crystals using both elastic and inelastic techniques. A new inelastic scattering instrument is under construction and is scheduled for operation in 2003. Nuclear science at Lujan is supported by two flight paths. One is equipped with a 4π detector to measure low-energy neutron capture cross sections on unstable nuclei of interest to nuclear astrophysics. The other supports single-pulse neutron resonance spectroscopy. A new flight path for fundamental physics is also under construction and will support precision measurements of parity violation in the H(n,d)γ reaction.

Beam current to the Lujan target was limited in 2001 to 55 µA because of two mechanical failures in the Target-Moderator-Reflector System (TMRS) presented later in this paper.

Highlights for 2001 operation include:

- Commissioning of five scattering instruments (SMARTS, HIPPO, PROTEIN, PHAROS [rebuilt] and ASTERIX).
- Commissioning of one new nuclear physics instrument (DANCE).
- Development and implementation of a new generation of data acquisition and chopper control systems.
- Approval to conduct experiments with actinide materials.
- Neutron availability of 92% against schedule, and instrument availability of 95% against schedule.

- Visits by 270 users who performed 115 different experiments.

The WNR facility addresses the needs of LANSCE users in the areas of basic and applied nuclear science. The white neutron source at WNR (Target 4) is the most intense source of high-energy (0.1 MeV - 760 MeV) neutrons worldwide and serves six flight paths. Experiments use sub-nanosecond proton pulses allowing neutron energy determination by time-of-flight. A 4π germanium detector array named GEANIE, jointly operated by Los Alamos and Livermore National Laboratories, is the premier instrument for neutron reactions through gamma-ray measurements. A second facility at WNR, Target 2, provides direct access to proton beams with energies up to 800 MeV for studies of proton-induced reactions as well as for target irradiations for materials testing. This target station is also equipped with five neutron flight paths.

Highlights for 2001 operation include:

- Completion of measurements of the $^{239}Pu(n,2n)^{238}Pu$ cross section using the GEANIE instrument
- Initiation of measurements of neutron-induced fission fragment yields using the Fission Induced Gamma Ray Observer (FIGARO) instrument
- Studies of high-explosive equation-of-state parameters using the Neutron Resonance Spectroscopy technique (NRS)
- Support for industry studies of single-event-upset sensitivity for the electronics and avionics industries
- Investigations of mercury target container lifetimes for Spallation Neutron Source Project
- Beam availability of 92% against scheduled operation.

The pRad facility provides a unique experimental capability for studies of dynamic processes. Multiple proton pulses, each with approximately 10^9 particles per pulse, temporally spaced at appropriate intervals, are transmitted through a dynamic object. The transmission and scattering characteristics of each pulse are imaged by a 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 support the study of material dynamics and failure mechanisms under shock conditions. The pRad program had 100% beam availability for dynamic experiments. In 2001, 36 dynamic experiments were performed, bringing the total to 114 experiments for which beam was delivered when requested. Refinement of the new and unique pRad technique is ongoing.

3 LANSCE OPERATIONS

The user facility operating period from July 1 through December 24, 2001, was the best on record for LANSCE for machine availability and overall beam delivery. We exceeded our expected availability of 75% by about 20%, with a record of 92% for the entire facility. The number of beam delivery hours to each of the user facility areas exceeded our goal by more than 30%, when taking into account our use and allocation of contingency. Our goal of reliable, predictable, safe operation was attained this year through dedication and hard work by the operations staff, timely institutional support for a few critical maintenance items, and the fact that only those components for which we had prudently prepared spares failed during the run.

A detailed 2001 outage was planned during the last quarter of 2000 to both coordinate and level personnel resources across the major tasks selected for the outage. This planning, together with execution by the LANSCE Operations Team, allowed facility turn-on to begin as scheduled on April 30, 2001. This was followed by scheduled user facility operations that began on July 1.

LANSCE management developed a detailed schedule for 2001 for user facility operations for proton radiography (pRad), Neutron Resonance Spectroscopy, and other irradiation activities that use the PSR beam at Target 2 at WNR. This scheduling was done in consultation with leaders of all key programs within the User Facility. A key element of this schedule was the definition and inclusion of blocks of time identified for "sole-use" activities. Sole-use activities are defined as any research and development use of the accelerator that precludes or interferes with beam delivery to the Lujan Center or with linac beam delivery to WNR. The scheduling of sole-use activities was done in accordance with a LANSCE Division Sole-Use Scheduling Policy that was approved and published on May 16, 2001.

Another important metric for LANSCE operations is the fraction of scheduled time lost for downtimes greater than 8 hours. Performance in prior years led management to establish a goal of less than 15% for this metric in 2001. The fraction of scheduled time lost for downtimes greater than 8 hours was 1.7% and 1.1% for the Lujan Center and WNR Target 4, respectively, which is substantially better than the goal. A comparative distribution of downtimes by major accelerator subsystems is given in Fig. 2.

We took certain maintenance actions during the 2001 outage in an attempt to address significant causes of downtime in 2000. A newly designed and installed air-

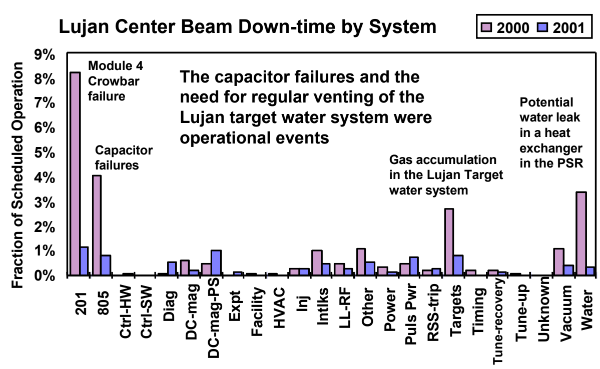

Figure 2 Subsystem Downtimes for 2000 and 2001

eliminator system for the TMRS target water system eliminated the necessity for daily beam-off periods of approximately 20 minutes to vent dissolved gases that accumulate in this water system during beam operation.

In 2000 capacitor failures were a significant source of accelerator downtime. Maintenance personnel carefully evaluated the condition of capacitors used to stabilize the klystron voltages in the accelerator rf power systems. They removed weak units, andorganized older capacitors into similar groupings. The result of these actions was only a single capacitor failure during the entire 2001 operating period. This represents a significant step forward from the problems experienced during the preceding year. We also developed a conservative schedule of accelerator duty-factor changes to avoid stressing the rf systems based on lessons learned in 2000.

4 THE REVITALIZATION OF LANSCE

Many components of the LANSCE accelerator and beam delivery complex are now 30 years old. Significant enhancements have been made to the facility during its lifetime, but many operational risks resulting from aging systems remain to be addressed.

There have been several recent upgrades that together comprise a foundation for what is anticipated to be an aggressive revitalization of the facility. A new radioactive liquid wastewater treatment plant is operational. This plant, which replaced a conventional lined earthen evaporation pond, accepts radioactive wastewater from activated target cooling systems and treats this effluent in accordance with United States and Department of Energy environmental requirements. Three old cooling towers, built with arsenic-treated lumber, have been replaced by two modern, efficient towers with enhanced cooling capacity. These newer towers have improved operational efficiency and eliminate a substantial number of environmental concerns.

During the 2001 operating period, the Lujan TMRS was limited to 55 µA by two concerns. One of these was a probable internal weld failure leading to reduced the cooling margin in an upper tungsten neutron production target. The second was due to reduced thermal contact with cooling loops cast inside a lower lead reflector. Both of these problems were corrected during the 2002 outage with redesign, fabrication, and installation of a new TMRS at Lujan. This system is now successfully operating at 100 µA.

Looking to the future, we have had remarkable performance of the 805-MHz klystrons at LANSCE. Many of the 44 klystrons now have operational lifetimes in excess of 100,000 hours. A program to replace these klystrons, together with the attendant high-voltage systems, is being pursued. It is likely that the technology developed at Los Alamos for the SNS project will be adapted for this application. Also, the 201.25 MHz triode final power amplifiers will be replaced by a diacrode system that is currently being engineered. A comprehensive plan that addresses these and many other upgrade project that enhance operational reliability is being developed.

5 LANSCE PLANS SEVERAL CAPABILITY IMPROVEMENTS

An intense source of ultra cold neutrons (UCN), based on a tungsten target surrounded by solid deuterium moderators, has demonstrated a density that has the potential to be significantly higher than that of the ILL facility in France. This new capability now under construction will significantly enhance the fundamental neutron science capabilities at LANSCE.

A beam kicker system will be installed in the beam switchyard in early 2003. This system will permit delivery of single accelerator macropulses “on demand” to the pRad facility. The kicker system will result in an immediate increase of 20% in beam that can be scheduled for the Lujan Center and WNR, as well as increase the time available for pRad and UCN by a factor of 5.

A new medical Isotope Production Facility (IPF) will become operational in 2003. This facility will take H^+ beam at 100 MeV and direct it to a production target. The isotopes produced will be used to produce research pharmaceuticals for disease treatment and also for development of medical diagnostic techniques.

6 CONCLUSION

LANSCE is a unique multidisciplinary facility serving a wide range of users. Unlike other neutron sources, the many operational modes of the proton beam require increased maintenance and schedule management in order to be successful. Over the past two years the facility has focused on improved operational availability and now routinely meets our goal for predictable, reliable operation. Over the next five years, Los Alamos plans a program of revitalization of key parts of the facility in order to maintain and increase the productivity of LANSCE.