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Title: OPERATIONAL STATUS AND LIFE EXTENSION PLANS FOR THE LOS ALAMOS NEUTRON SCIENCE CENTER (LANSCE)

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

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Abstract

The Los Alamos Neutron Science Center (LANSCE) accelerator and beam delivery complex generates the proton beams that serve three neutron production sources, a proton radiography facility and a medical and research isotope production facility. The recent operating history of the facility, including both achievements and challenges, will be reviewed. Plans for performance improvement will be discussed, together with the underlying drivers for the ongoing LANSCE Risk Mitigation project. The details of this latter project will also 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.

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 45 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 fundamental neutron nuclear physics 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.

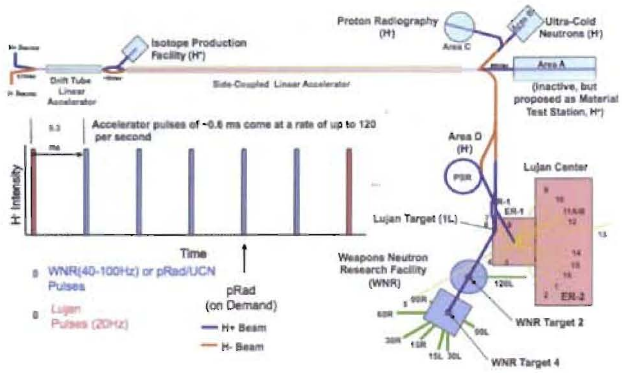

Figure 1: Schematic layout of the LANSCE User Facility

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 2009 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.

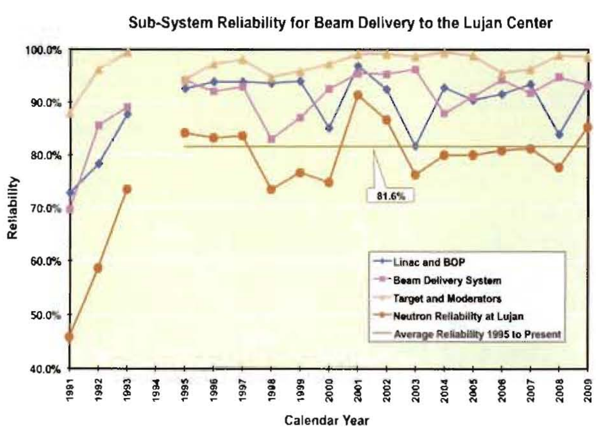

Figure 2: Sub-system reliability for beam delivery to the Lujan Center

These data illustrate that the 15-year average reliability from 1995 to 2007 is over 81% that is remarkable for a facility that is now in its 39th year of operation with much of the original equipment still in service.

Operating hours from 1989 to 2009 are illustrated in Figure 3.

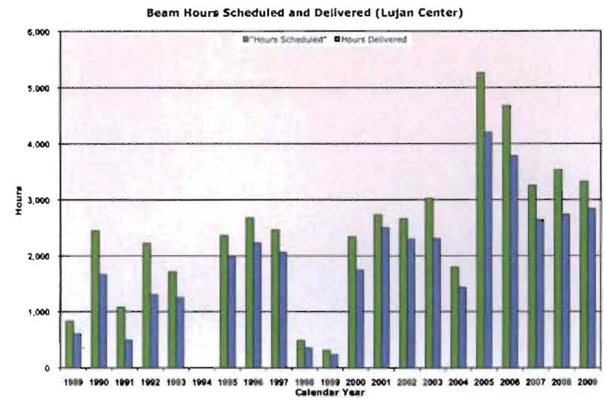

Figure 3: Operating hours for the Lujan Center illustrate recent stability at over 3,000 scheduled hours per year.

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 Risk Mitigation Project discussed below.

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 Risk Mitigation Project, and are shown in Figure 4.

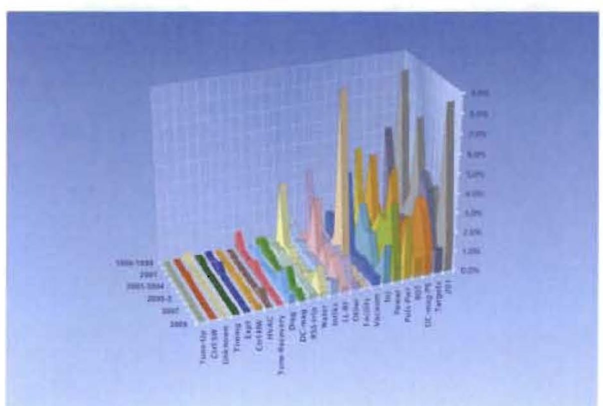

Figure 4: Historical sub-system down time for beam delivery to the Lujan Center

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

Table 1: 10-year average operating performance for the principal facilities at LANSCE

Facility	Reliability
Lujan Center	81.6%
WNR Target 4	84.9%
pRAD	89.3%
IPF	86.1%

THE LANSCE RISK MITIGATION PROJECT

Critical Decision 1 (CD-1) for the line item LANSCE Refurbishment Project (LANSCE-R) [1] was obtained in November 2009 with a planned investment of ~$150M (US). However the FY10 funding legislation for Los Alamos National Laboratory cancelled this line item project.

In its place the National Nuclear Security Administration (NNSA) has provided a firm commitment to proceed with both the scope of the original LANSCE-R project and additional scope to further mitigate risk to continued successful operation of the facility. The LANSCE Risk Mitigation Project (LRM) has received to date funding of $39.3M and the NNSA commitment is a total investment of $250M over 10 years, beginning in FY10.

The core elements of the first phase of the LRM project are those presented previously for the LANSCE-R project [1], but with schedule modifications to accommodate a more constant funding profile of ~$25M per year, and to emphasize early restoration of 120Hz operation for the LANSCE facility. This will be of significant benefit to the Weapons Neutron Research facility, increasing the available beam current to that facility by a factor of 2.5. The near-term focus is two-fold; establish a new vendor pipeline for 45 ~1.1MW peak power 805 MHz klystrons and develop and install new ~3.2MW peak power 201.25 MHz amplifier systems to replace the present systems that limit facility operation to 60Hz.

Installation of a modern high-bandwidth fiber-optic control system network is underway and will be complete by the end of the next scheduled facility maintenance outage in May 2011. This network will form the backbone of an upgrade to the LANSCE Control System that will begin with replacement of the present Master Timer system with a modern event-based system.

The electrical and mechanical design of new 201.25 MHz beam position and phase monitor (BPPM) diagnostics modeled on those developed for recent upgrade projects is complete, and fabrication is being pursued. A prototype device was successfully tested during 2010 turn-on as part of the present Delta-T system that is used to set machine energy.

Several new scope elements will be added to the LANSCE Risk Mitigation project. The most important of these is the replacement of the aging Cockcroft-Walton high-voltage injectors with 750-keV radio-frequency quadrupole (RFQ) injectors. Initial conceptual studies indicate that replacement of the H+ injector that provides beam for the Isotope Production Facility and the future Material Test Station is straightforward, but that replacement of the H- injector that serves all other experimental facilities may only be accomplished with two RFQs. This is because of the unique micro-pulse beam structure required by the WNR and proton radiography facilities that is not compatible with the more standard rf structure of the beams for the Lujan Center and the Ultra-Cold Neutron source.

A second enhancement under strong consideration is a set of modifications to the Proton Storage Ring (PSR) to enable "pulse-stacking" of WNR-like micropulses on selectable machine cycles; this capability would significantly enhance the low-energy neutron spectra in the 100 keV range at the WNR facility. Required modifications include ring rf bunching, extraction, and kicker systems necessary to direct such pulses "on demand" to the WNR facility rather than the Lujan Center.

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 ~$30M is planned for FY11-FY15.

The Los Alamos National Laboratory is developing conceptual plans for a new signature experimental facility, MaRIE discussed elsewhere at this conference [2].

Taken together, the LANSCE Risk Mitigation Project and the MaRIE initiative demonstrate a commitment to investment in the ongoing operation and improvement of the facility, and a resurgent interest in the spectrum of science accessible at LANSCE. These plans would assure continued facility operational and scientific vitality well beyond 2020.

REFERENCES

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

[2] R. Garnett and M. Gulley, "Matter-Radiation Interactions in Extremes," Linac10, Tsukuba, Japan, TUP038 (2010); http://www.JACoW.org.

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