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UPDATE ON THE STATUS OF THE LOS ALAMOS NEUTRON SCIENCE CENTER ACCELERATOR MODERNIZATION*

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Abstract

The Los Alamos Neutron Science Center (LANSCE) accelerator is a MW-class H-/H+ 800 MeV linear accelerator that serves five distinct user facilities that support Los Alamos National Laboratory (LANL) national security missions, commercial applications, and the Department of Energy Isotope Program (DOE IP). Now into its sixth decade of continuous operation, major accelerator systems are showing their age with decreased reliability and diminished vendor support due to equipment obsolescence. With plans to continue LANSCE operations for several more decades, LANL is exploring different avenues to modernize large portions of the accelerator. We will present the current status of those plans and an overview of supporting R&D.

THE LOS ALAMOS NEUTRON SCIENCE CENTER

In 1972 the Los Alamos Meson Physics Facility (LAMPF) began operations for a 20-year basic nuclear physics program. The most powerful proton beam in the world, until the early 2000s, LAMPF pioneered technologies such as the side coupled cavity linear accelerator and dual species acceleration. When its original mission ended, LAMPF was re-branded as the Los Alamos Neutron Science Center (LANSCE) and repurposed as a user facility for nuclear weapon stockpile stewardship, basic science, industry, and isotope production [1]. Highlighting the versatility of the machine, LANSCE currently supports five distinct user end stations (Fig. 1):

- Isotope Production Facility (IPF) – IPF produces medical and other isotopes for the DOE IP, short-lived isotopes for defense programs, counter and non-proliferation, and criticality safety studies
- Proton Radiography (pRad) [2] – pRad employs 800 MeV protons to do dynamic imaging of shock and detonation events.
- Ultra-Cold Neutron Facility (UCN) [3] – Unique probe for basic nuclear physics science.
- Lujan Neutron Scattering Center (Lujan Center) [4, 5] – Provides spallation neutrons for neutron scattering and imaging and provides neutrons for materials science.
- Weapons Neutron Research Facility (WNR) [5] – Enables nuclear physics for defense programs, counter-proliferation, and criticality safety. Serves as a user facility for electronics testing for industry and global security agencies.

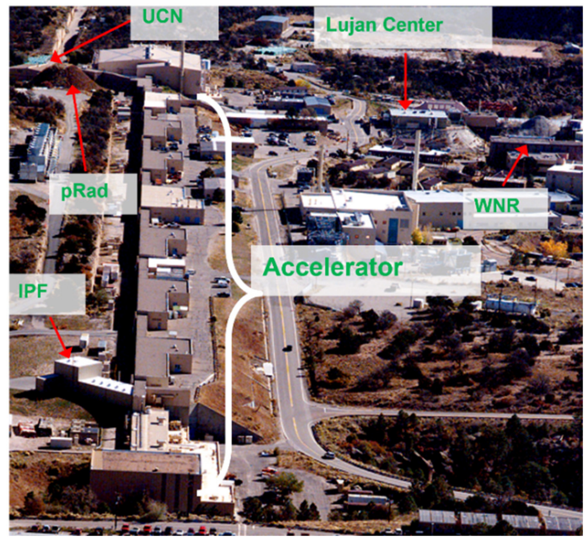

Figure 1: LANSCE [1].

LANSCE PRESENT STATUS AND FUTURE PLANS

LANSCE Present Status

In 2008 LANL embarked on an eight-year program to upgrade targeted LANSCE systems to both restored historical operating capability and to sustain future operation [6]. This involved an upgrade of the 201.25 MHz radiofrequency (RF) system that drives the LANSCE drift tube linear (DTL) accelerator, which accelerates the beam to 100 MeV, and procurement of 45 new 805 MHz klystrons from Communications and Power Industries to serve as spares for the 805 MHz High Power RF (HPRF) system, which powers the LANSCE coupled cavity linear (CCL) accelerator and boosts the beam energy from 100 MeV to 800 MeV. These new tubes are nominally identical to the original 1960s era design and were delivered by the end of 2014. The 201.25 MHz system upgrade was completed in 2016 [7].

Although this modest sustainment effort did in fact achieve its purpose, ensuring operation of LANSCE until 2020, it was not a long-term solution. LANL and the National Nuclear Security Agency (NNSA) have since realized that operation of LANSCE is needed until at least 2050. However, at 52 years of age modernization of the facility is now essential as reliability is now a major concern (Fig. 2). In 2019, for example, a crack developed in one of the four DTL tanks due to decades of thermal cycling. Fortunately, the location of the damage was accessible and was

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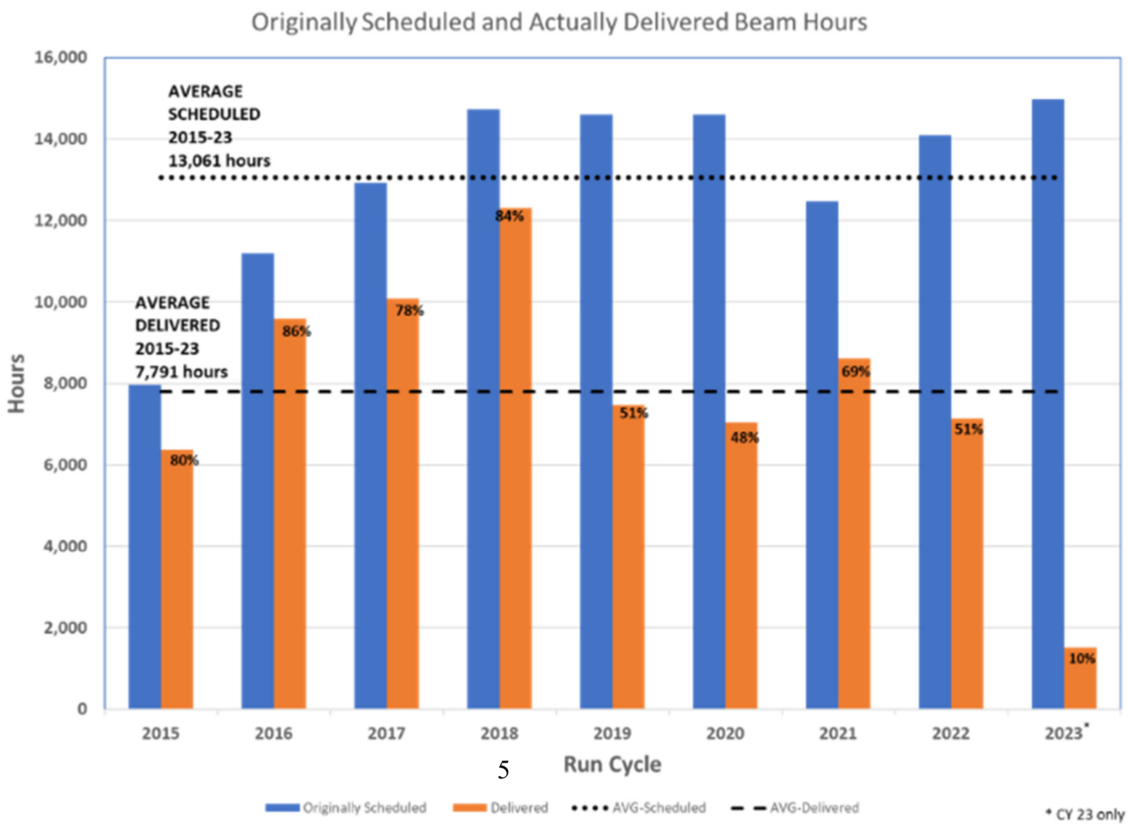

Figure 2: Delivered versus planned LANSCE beam hours showing a decrease in reliability.

repaired (Fig. 3). In 2023, the Cockcroft-Walton that provides 750 keV H+ to the accelerator was damaged. This halted proton production to the IPF for several months in 2023 and 2024 while repairs were made (Fig. 4). Recurring problems with the 805 MHz HPRF have also led to significant downtime, with repairs and replacement parts increasingly hard to come by as its subsystems fade into obsolescence. At the same time, the new 805 MHz klystrons procured as spares have proven to be much less robust than the originals they were meant to replace [8]. As a result, in 2024 we are limiting LANSCE to 100 MeV to preserve klystrons for 800 MeV operations required by high profile experiments occurring in 2025.

LANSCE Modernization Project (LAMP)

The most vulnerable section of the LANSCE accelerator is the front end that accelerates the proton beam up to 100 MeV. It consists of two Cockcroft-Walton based 750 keV injectors (one for H+ and one for H-) followed by four DTL tanks. In this region there exist several single point failure risks that would interrupt machine operation for many months or even years if repairs became necessary. To ensure reliable machine operations into the future, LANL has embarked on the LANSCE Modernization Project (LAMP) shown in Fig. 5. This is a multi-year effort to replace the ancient Cockcroft-Walton technology with a modern radio-frequency quadrupole (RFQ) based injector system and to upgrade the DTL accelerators. LAMP would also include a significant upgrade to diagnostics and instrumentation in this section of the accelerator. As of this writing, LANL is close to achieving CD-0 for the project with a tentative project completion date sometime in 2030.

805 MHz High-Power RF System Upgrade

The next most vulnerable portion of LANSCE is the 805 MHz HPRF system [6], which consists of 44 1960s era 1.25 MW klystrons and an obsolete high voltage power system. Movement is afoot to embark on a ten-year upgrade of this system following one of two paths. The first, and baseline option, would be to replace the existing HPRF with modern vacuum tube technology based on what is used at the Spallation Neutron Source (SNS) [9] or the European Spallation Source (ESS) [10].

The second option would be to leapfrog klystron technology and develop an HPRF system based on solid-state amplifiers (SSAs). SSA powered RF systems are becoming increasingly attractive for accelerator facilities [11]. At LANL we have begun a small project to assess the possibility of developing an SSA (Fig. 6) based HPRF system capable of driving the LANSCE CCL.

CONCLUSION

Now in its sixth decade of operation, the LANSCE accelerator has been remarkably productive. LANL has identified the need to extend its life and is embarking on modernization efforts to ensure it continues as a workhorse user facility for decades to come.

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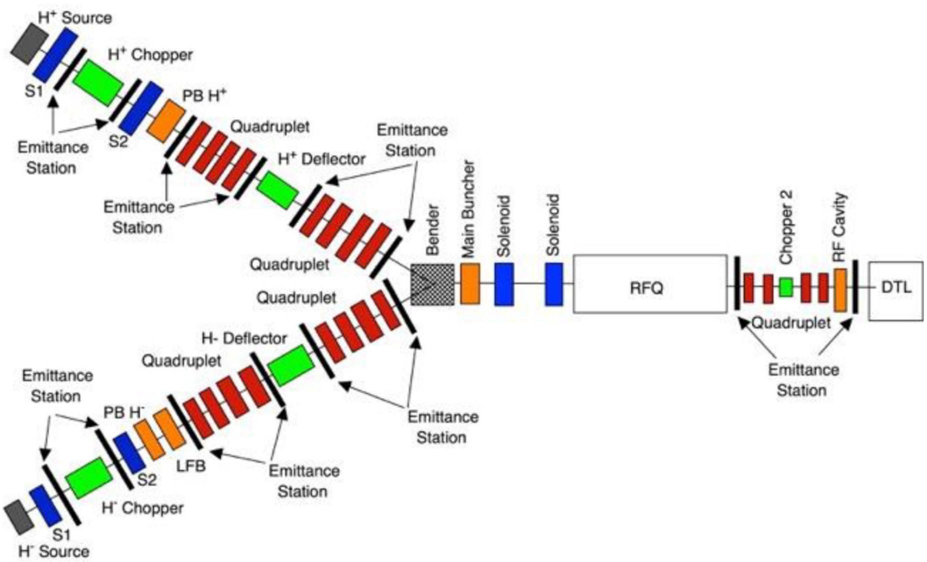

Figure 5: LANSCE Modernization Project will replace the low energy (up to 100 MeV) front end of LANSCE with modern accelerator systems.

Figure 3: LANSCE DTL repair. Crack shown in left image. Welding repair in in right image.

Figure 4: Repair of H+ Cockcroft-Walton accelerator column 2023 - 2024.

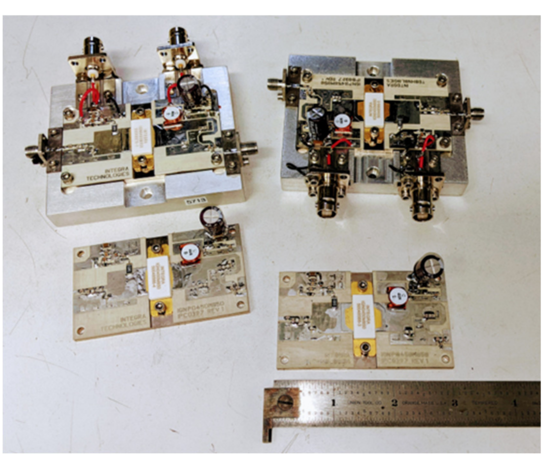

Figure 6: High power (~3 kW) GaN SSA from Integra Technologies.

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