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AN OVERVIEW OF THE LAMP FRONT-END UPGRADE AT LANSCE

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Abstract

The Los Alamos Neutron Science Center (LANSCE) is one of the oldest operating high-average-power accelerators in the United States, having recently celebrated its 50th anniversary of operation. LANSCE is comprised of an 800-MeV linac capable of concurrently accelerating both H+ and H- ions and can presently provide beam to six separate user stations. The LANSCE accelerator operates with much of its original equipment, including the Cockcroft-Walton injectors and drift-tube linac.

As part of the proposed LANSCE Modernization Project (LAMP), a refurbishment and upgrade effort would replace the initial portion of the LANSCE accelerator, from ion sources to the end of the 100-MeV drift-tube linac. This paper describes the overall approach taken to establish performance goals, downselect a preferred technology approach, and identify pathways towards implementation.

INTRODUCTION

The Los Alamos Neutron Science Center (LANSCE) is one of the oldest operating high-average-power accelerators in the United States. It was commissioned under its original name Los Alamos Meson Physics Facility (LAMPF) in 1972, based on technology developed in prior years [1]. LANSCE operates simultaneous H+ and H– acceleration, delivering beam in a myriad of formats to six end-user stations.

Figure 1 depicts one of two Cockroft-Walton high-voltage systems that launches the beams at 750 keV. While functional for since the beginning of LANSCE, the reliability of the Cockroft-Walton and low-energy transport sections has begun to decrease dramatically. Figure 2 presents recent beam-delivery hours per each run cycle, where the blue bars represent the scheduled or planned number of hours for each yearly run cycle, and the red bars represent the number of actual hours delivered. While the actual delivery is always less, the fraction of successfully delivered hours shows a surprising falloff.

The Los Alamos Modernization Project is a proposed effort to improve the functionality of the LANSCE injector and low-energy transport, together called the Front End. The overall goals of LAMP are:

- Better reliability,
- More delivered beam,
- Modern technology,
- Improved capabilities, and
- Reduced maintenance.

We are seeking to replace LANSCE's front end with a modern equivalent, mating to the beamline at 100 MeV.

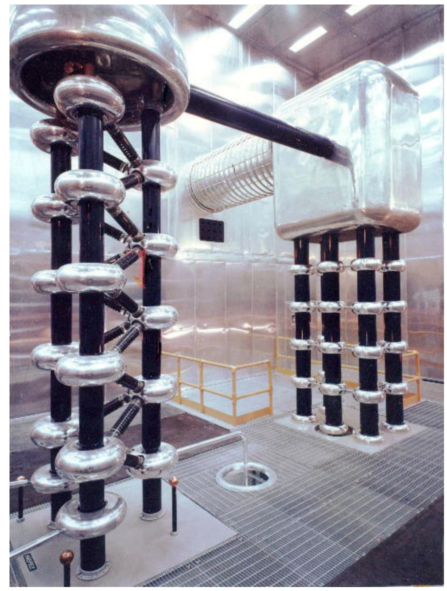

Figure 1: One of the Cockroft-Walton injectors.

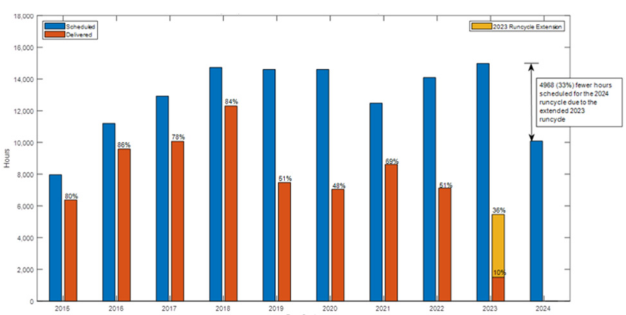

Figure 2: Schedules (blue) and delivered (red) beam time.

If approved, the more targeted LAMP deliverable is to provide a font-end that meets the following goals:

- Meet current LANSCE capability needs,
- Provide higher reliability and beam delivery to users, and
- Provide future upgrade opportunities to ensure LANSCE's utility for future decades.

Before official approval, LANL is performing scoping studies on various technological solutions that meet the above goals. Figure 3 illustrates a possible solution, leveraging modern source technology, simple low-energy beam transport (LEBT), robust radio-frequency quadrupole (RFQ) acceleration to about 3 MeV, and a compact medium-energy beam transport (MEBT) for matching into a modernized drift-tube linac (DTL) acceleration section.

Figure 3 shows these sections, with possible beamline components for manipulating the beams appropriately.

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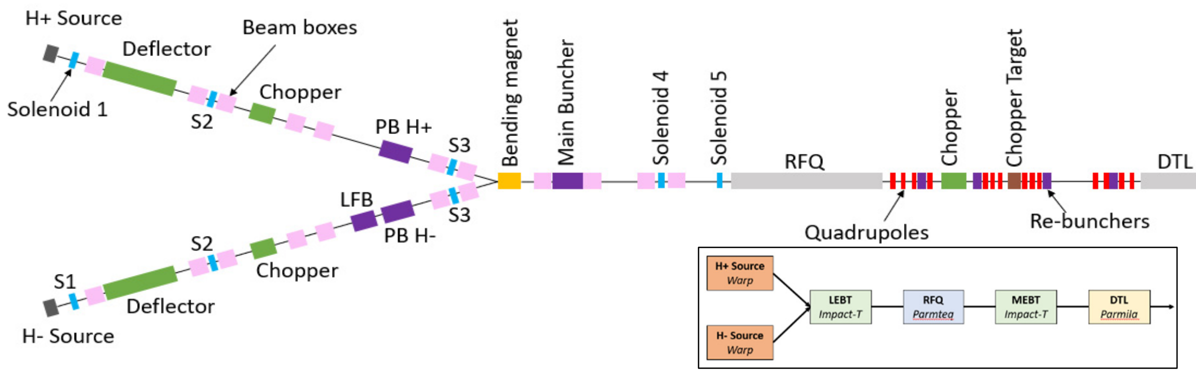

Figure 3: Notional design of the LAMP front end. Inset lists simulation codes being utilized.

Many of these components are more effective at beam waists, which then drives more optics, diagnostics, space charge, complexity, etc. Our optimization efforts try to weigh flexibility and capabilities versus simplification [2].

An initial study described what a LAMP front-end might look like [3] has been evolving over the duration of the ongoing studies. Currently, the simulation work is mostly using standard codes, as shown in the Fig. 3 insert. We translate particle distributions between Warp, Impact-T, Parmteq, and Parmila [4]. Components are commonly modeled in CST Studio, matching is being optimized in Trace-3D, and several other codes are used for verification and analysis.

ION SOURCES AND LEBT

Figure 4 presents simulation results from studies in developing high-current ion sources [2,4]. Similar electrode geometries are being studied in order to provide high-current H+ and H– beams with controlled beam size and emittance. To date, these simulations have focused on launching 35-mA beams from sources at 100 kV. Higher voltage reduces space charge effects, but increases challenges.

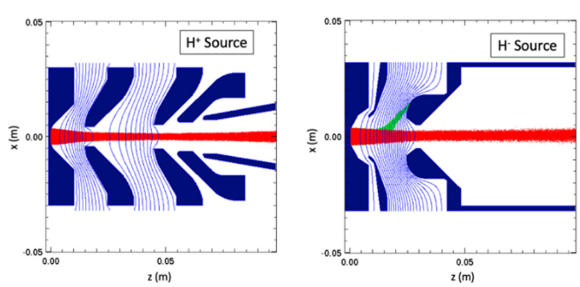

Figure 4: Simulation of H– (left) and H+ (right) sources.

The purpose of the LEBT is to match the beams into the RFQ, modeled in Fig. 5; however, we are interested in providing dedicated, modern diagnostics to monitor beam parameters. In addition, the beamline will likely provide fast-protection beam deflection, chop the beam to enable specifically tailored beam structures [3], and possibly be (partially or fully) bunched at 201.25 MHz.

WNR bunches require a significant amount of charge in a single 201.25-MHz bucket. We are exploring low-frequency bunching techniques to enable longitudinal bunching. Simulations in CST Studio support a device, similar to LANSCE's current low-frequency buncher, that velocity-modulates the 100-keV beam to provide significant charge enhancement within a single 201.25 RFQ bucket [5].

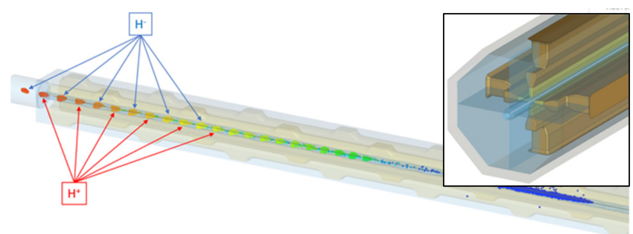

Figure 5: Simulated RFQ acceleration of two species simultaneously. Inset shows detailed end geometry.

RFQ, MEBT, AND DTL

Figure 6 shows a possible MEBT beamline, modeled similarly to SNS's MEBT. The design is meant to provide matching from the RFQ into the DTL, while preserving the 201.25-MHz bunching and offer space for beam diagnostics. Future effort will analyze alternative designs with less complexity. An additional, focused effort is on fast MEBT chopper options to provide LANSE pulse structure [6,7].

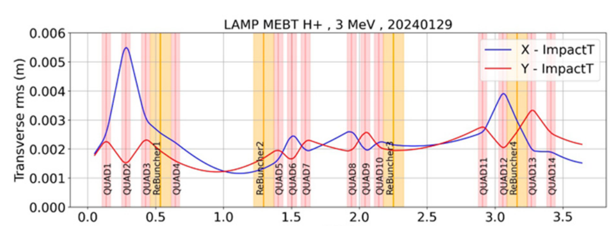

Figure 6: Beam envelope through MEBT channel.

The DTL is also being studied. Current work has focused on capturing beam efficiently by the first module, matching into subsequent modules, and providing space for diagnostics. Simulation work takes into account peak RF power levels, phase-control strategies, and real-estate constraints [8].

PROJECT TIMELINE AND CONCLUSIONS

Figure 7 illustrates a notional timeline for the proposed LAMP project. This timeline assumes achieving CD-0 in

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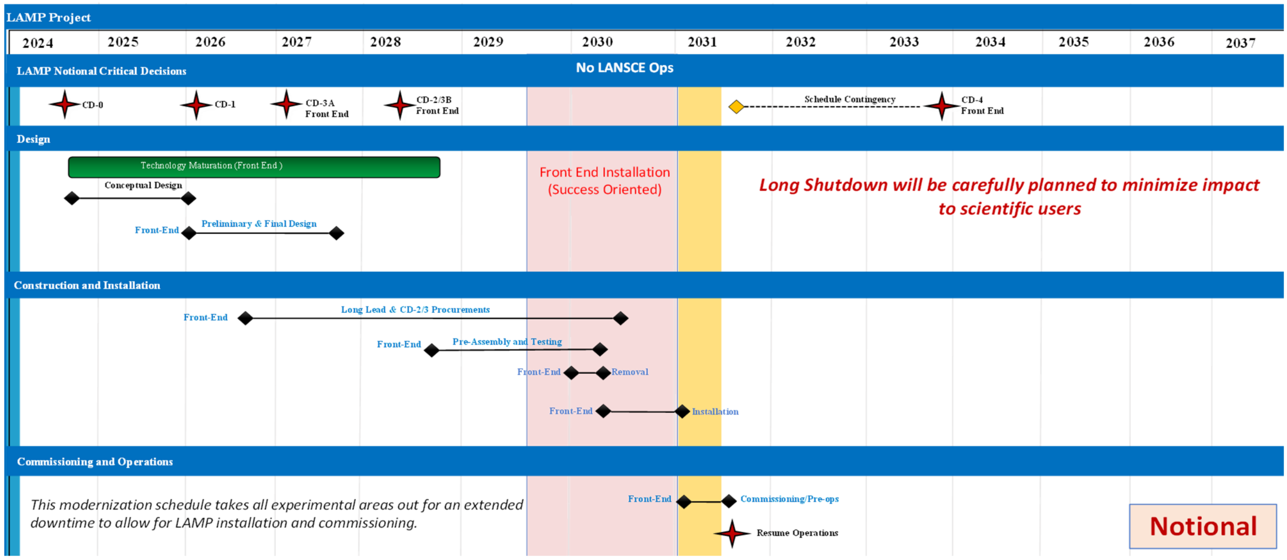

Figure 7: Notional timeline for the LAMP project.

mid-2024 and an optimistic work schedule. The project is leveraging active laboratory testing and development with a recently commissioned 35-keV H+ test stand [9], a planned H– test stand [10], and a short RFQ (Fig. 8) that recently achieved our desired peak power [11].

Figure 8: RFQ under test at the RFQ Test Stand.

Thanks to the anticipated LAMP project, a significant amount of experimental work is needed. Demonstrating simultaneous H+ and H– acceleration through an RFQ will be a significant near-term achievement. Within the LAMP project itself, other demonstrations will be necessary to prove technology or verify specifications. The front-end itself is planned to be built in its entirety (using one DTL module) at LANL and tested in full operational mode. Only then, LANSCE will be shut down for a front-end replacement with the newly confirmed LAMP upgrade. In parallel with this experimental work, simulation validation and code development will increase as well.

LANL has a multitude of national security missions that require accelerator capabilities. LAMP is one project that feeds on this growing capability.

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