

LAT: A 9-MeV PROTOTYPE “FRONT-END” FOR THE LANSCE ACCELERATOR MODERNIZATION PROJECT

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Abstract

The LANSCE Accelerator Modernization Project (LAMP) is designing a modernized front-end, up to 100-MeV, for the LANSCE accelerator. The LAMP front-end will replace the two Cockcroft-Waltons injectors with a single Radiofrequency Quadrupole and replace the Drift Tube Linac (DTL) with a modernized version. As part of the Technical Readiness Evaluation there are Critical Technology Elements (CTEs) that need to be addressed for the project to achieve Critical Decision 3. To address these CTEs and as risk mitigation for an accelerator that is in current operation, we plan to assemble LAMP from ion sources through the first DTL Tank, approximately 9 MeV, in an adjacent facility. This paper discusses the current status and future work of this plan: LAT.

INTRODUCTION

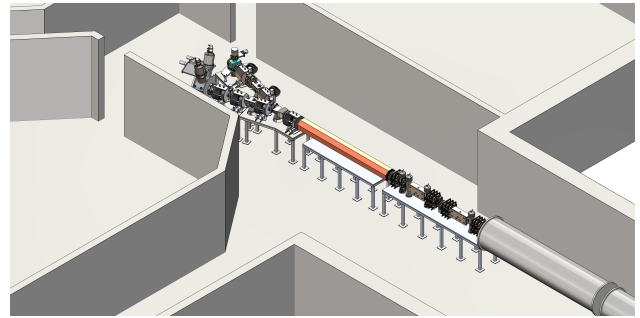
The LANSCE Accelerator Modernization Project (LAMP) is a major initiative managed by Triad National Security, LLC, for the U.S. Department of Energy’s National Nuclear Security Administration (NNSA). The project aims to modernize the front end of the LANSCE accelerator complex up to 100 MeV by replacing aging equipment with state-of-the-art components. Key upgrades include replacing two Cockcroft-Walton accelerators with a single modern Radiofrequency Quadrupole (RFQ) and replacing the aging the Drift Tube Linac (DTL).

A distinguishing feature of LANSCE is its capability to simultaneously accelerate and transport two oppositely-charged ion species while supporting five user facilities. Each user facility requires a different beam timing structure. These unique operational requirements present special technical challenges that must be addressed during the modernization effort. To validate critical design elements and reduce technical risk, the LAMP in ADEF Tunnel (LAT) prototype accelerator is being constructed in the Accelerator Development and Engineering Facility (ADEF) to serve as a 9 MeV full-scale prototype and testing platform.

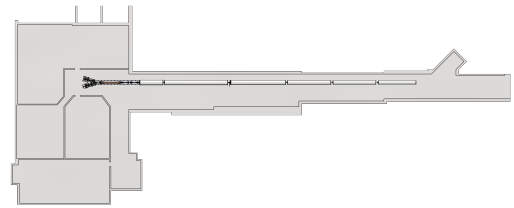
LAMP BASELINE DESIGN VERSION 2

The LAMP baseline design (version 2) [1–7], as seen in Fig. 1 encompasses a comprehensive front-end replacement that fits within the existing LANSCE infrastructure space constraints. The design leverages proven technologies

while incorporating innovations necessary for dual-species operation.



(a) LAMP “front-end” showing RFQ and first DTL cavity.



(b) Entire LAMP layout in the LANSCE tunnel.

Figure 1: LAMP baseline v2 front end (a) zoomed in and (b) layout through the DTL tanks in the LANSCE tunnel.

The design extracts the H^+ and H^- beams to 65 keV and merges them together in the Low Energy Beam Transport (LEBT) region before using a single RFQ to accelerate both beams to 2.1 MeV. The beams are then transported through a Medium Energy Beam Transport (MEBT) region before capture in the DTL which accelerates the beams to 100 MeV.

CRITICAL TECHNOLOGY ELEMENTS

Four Critical Technology Elements (CTEs) have been identified that require maturation from Technical Readiness Level (TRL)-5 to TRL-7 to ensure LAMP project success and meet Department of Energy requirements to achieve Critical Decision 3. These elements, MEBT chopper, simultaneous dual-beam acceleration of opposite charged beams in an RFQ, transport of dual beams through a single MEBT post RFQ, and pulsed focusing electrodes, address the unique operational requirements of LANSCE. The following is a summary of Ref. [8].

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CTE 1: Fast Chopper Systems

The LEBT and MEBT chopper systems must achieve: fast rise/fall times of 10 ns for the LEBT and 3 ns for the MEBT, low timing jitter of 1 ns, and reliable operation in dual-species mode. This CTE does not require dual-species testing and can potentially be demonstrated at existing DOE facilities with similar energy ranges, such as the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory.

CTE 2: Dual Species RFQ Acceleration

The RFQ must simultaneously accelerate two oppositely-charged ion species while maintaining beam quality and transmission efficiency. This represents a unique technical challenge not demonstrable in existing facilities at the required energy levels [9].

CTE 3: Dual Species MEBT Transport

Following RFQ acceleration, the MEBT must transport both species and properly match them into the first DTL tank. This includes: maintaining beam quality for both species, proper focusing and steering, integration with the fast chopper system, and efficient capture into the DTL that meets project requirements.

CTE 4: Fast Pulsed Electrodes

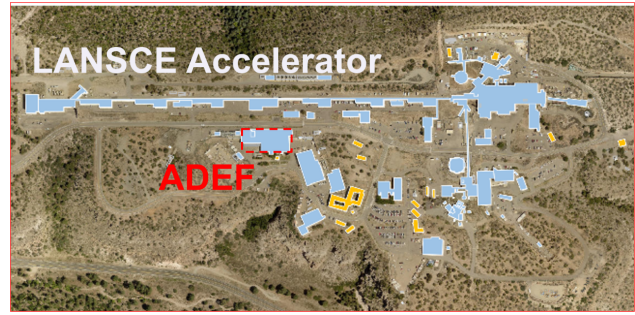
The source extractor chamber requires fast-pulsed electrodes capable of: rapid switching at 120 Hz to focus different beam currents, minimal beam disruption, and long-term reliability under operational conditions. This pulsed operation is required because beam delivery to the WNR facility requires 55 mA of source current, while all other H⁻ user facilities typically require about 16 mA source currents.

LAT DESCRIPTION

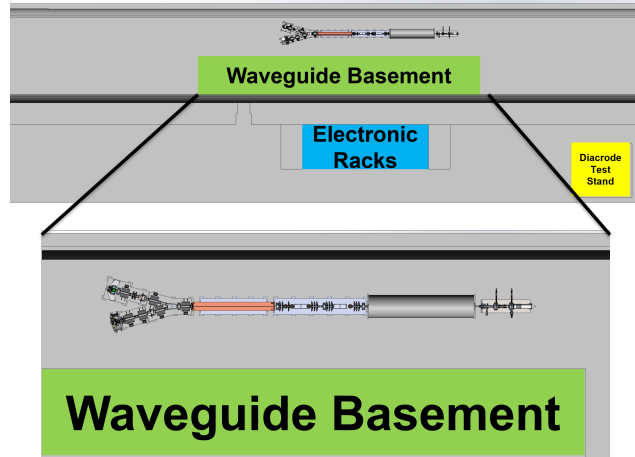
The unique requirement for simultaneous dual-species acceleration and MEBT transportation means no existing DOE facility can provide the complete testing environment needed for CTE maturation. Therefore, a full-scale LAMP prototype called LAT is being constructed at LANL. A small-scale prototype test stand is currently in operation, RFQTS, see Refs. [10, 11].

LAT is being installed in the ADEF tunnel, see Fig. 2. Key advantages of the ADEF location include:

- **Existing Infrastructure:** Shielded tunnel with appropriate radiation protection
- **RF Systems:** High-power 201 MHz system already available [12]
- **Cooling Systems:** Resonance control cooling infrastructure in place
- **Support Facilities:** Adequate rack space and waveguide basement to reuse for coaxial transmission lines



(a) Areal view of the LANSCE Complex with the Accelerator Design and Engineering Facility location highlighted relative to the LANSCE accelerator.



(b) LAMP layout in the ADEF tunnel.

Figure 2: LAT (a) location within the LANSCE complex, and (b) location within the ADEF tunnel.

- **Safety Systems:** Personnel access controls already implemented

The LAT design maintains the existing test facility footprint, utilizing current waveguide basement infrastructure, electronic rack spaces, and supporting systems. This approach minimizes facility modifications while achieving substantial performance improvements.

The LAT will construct through the first DTL tank with an output energy of about 9 MeV, providing a complete “front-end” system for comprehensive testing and validation.

Instrumentation and Control Development

In addition to the design of the LAT beamline, there are various obsolete supporting components and systems in service at LANSCE that need design and development. Included on that list is modern master timing, high-speed data acquisition, and digital low-level RF systems. Requirements for these systems include: provide precise timing control for dual-species operation, enable fast time-resolved measurements, and support beam “flavor” discrimination between species for diagnostics and control of the high-power RF.

PROJECT TIMELINE AND MILESTONES

LAT follows an ambitious but achievable schedule through fiscal year 2030 as shown in Table 1.

Table 1: Timeline for LAT Milestones

Milestone	Year
Long-lead procurement activities begin	June 2026
ADEF tunnel prep	Jan–Dec 2027
Ion source installation and testing	July–Dec 2027
RFQ and DTL conditioning and acceptance testing.	April–Dec 2028
RFQ installation into beamline and dual-beam testing through RFQ.	July 2028 – June 2029
MEBT installation and dual-species matching into DTL, including chopper integration.	April 2029 – March 2030
Pre-commissioning activities commence, preparing for final installation.	March 2030

Following successful completion of pre-commissioning activities, LAT will be disassembled and installed in the LANSCE front-end during the scheduled LAMP installation period. This approach ensures that all critical technologies have been thoroughly validated, and that the beamline meets project requirements through the first DTL tank, before installation in the operational facility, significantly reducing implementation/commissioning risk and downtime for the LANSCE facility users.

CONCLUSION

LAT represents a critical step in the successful modernization of the LANSCE accelerator. By providing a full-scale prototype environment, LAT enables demonstration of critical technical elements to TRL-7, validation of dual-species acceleration and transport, pre-commissioning activities that reduce installation risk, and training and procedure development before operational deployment.

The project is on track to meet its ambitious timeline, with systematic progression through design, construction, testing, and validation phases. Leveraging existing ADEF infrastructure while developing new capabilities positions LAMP for successful implementation.

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