OVERVIEW OF THE LAMP CONCEPTUAL DESIGN*

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Abstract

The Los Alamos Neutron Science Center (LANSCE) Accelerator Modernization Project (LAMP) will replace the front-end of the aging LANSCE accelerator, specifically to maintain beam delivery to all user stations while improving beam availability and reliability. We present an overview of the LAMP beamline design, including beam physics results, design decisions, and key component capabilities.

PERFORMANCE SUMMARY

Los Alamos Neutron Science Center (LANSCE) is a production accelerator facility, providing both H+ and H– to multiple experimental facilities. Over its 54-year lifetime, reliability has degraded, such as the original Cockroft-Walton injectors and the drift-tube-linac (DTL) tanks.

The LANSCE Moderization Project, LAMP, is a major overhaul of the LANSCE front-end leveraging modern beamline technologies, with reliability and operability as the overarching goals. The project adopts established source technologies, radio-frequency quadrupole (RFQ) acceleration, robust beamline optics, and improved diagnostics [1].

This report summarizes the different beamline sections (‘subsystems’), including references to more detailed discussions. Table 1 captures a high-level view of simulation performance, demonstrating that they meet project requirements [2]. Table 1 lists three different beam ‘flavors’:

- H^+ (IPF): low charge for Isotope Production Facility;
- H^- (Lujan): medium charge mostly for Lujan Center;
- H^- (WNR): high charge for Weapons Research Center.

Other experimental facilities leverage the above flavors with unique timing requirements. For each of these flavors, Table 1 presents the maximum charge Q (in [nC]) per 4.96-nsec window exiting each subsystem. Below this charge is the microbunch’s rms normalized transverse emittance (in [µm]). Table 1 quantifies the losses and emittance growth from source to DTL exit in the current design (which has evolved and improved since prior reports [1, 3]).

The final column of Table 1 shows the beam-physics requirement of each flavor. These numbers reflect the amount and quality of each flavor to match current end-station operations. In each case, the LAMP simulations indicate superior charge and emittances. Simulations using lower currents (matching the required charge values exactly) shows even better transmission and emittance.

Table 1: Performance Parameters of Conceptual Design

Exit of:		Source	LEBT	RFQ	MEBT	DTL	Req
H^+ IPF	Q*	60	60	59	55	55	25
	ϵ^N_{rms}	0.031	0.039	0.18	0.21	0.29	0.93
H^- Lujan	Q	79	78	77	76	76	53
	ϵ^N_{rms}	0.14	0.24	0.30	0.36	0.44	0.93
H^- WNR	Q	273	254	220	214	213	128
	ϵ^N_{rms}	0.19	0.40	0.45	0.51	0.68	0.93

*units: Q=[nC]; ϵ^N=[µm]

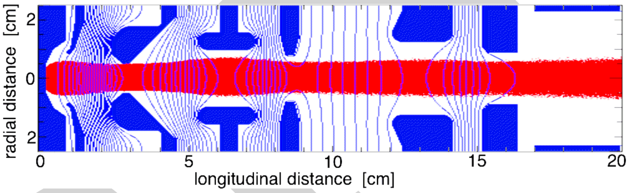

Figure 1: LAMP H^- source electrode geometry and WNR propagation. Lujan is notably different, utilizing different electrode voltages.

SOURCES

LAMP is studying modern source technologies, focusing specifically on technologies that have high reliability given LANSCE’s uniquely high 12% duty factor during operation [4]. For H^-, LAMP is considering modeling its source after SNS’s highly reliable multi-cusp approach. For H^+, both a duoplasmatron and ECR technologies are being investigated [5].

Independent of the technology, beam simulations launch a beam from a meniscus (using Warp and IBSimu). Figure 1 presents the design’s H^- injector, similar to SNS’s layout [6], including the high-current WNR beam profile. Lujan beam has different space charge, and thus utilizes different electrode voltages [7].

LOW-ENERGY BEAM TRANSPORT

LAMP’s low-energy beam transport (LEBT) is shown in Fig. 2 and discussed in detail elsewhere [7]. The LEBT transports and matches the beam from the sources through multiple choppers, merges the different flavors, enables diagnostics and safety systems, and matches into the RFQ. LAMP requires multiple species and multiple currents, which puts more constraints on the design.

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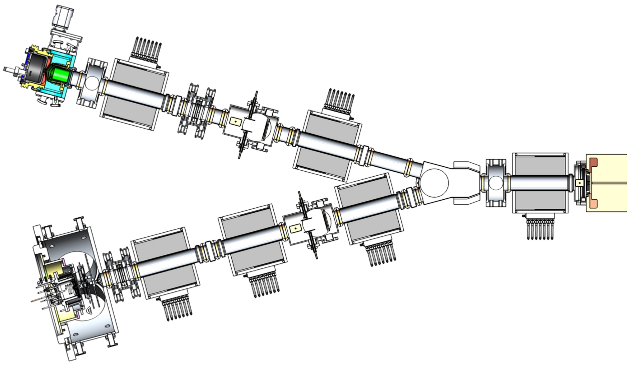

Figure 2: LAMP LEBT layout, showing sources, magnetic elements, choppers, and beam boxes that include diagnostics.

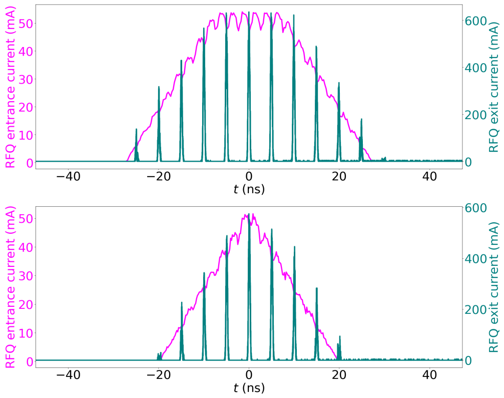

Figure 3: LAMP RFQ bunch capture, showing two optional LEBT ’chops’ (magenta) and the captured microbunches (green) at RFQ exit. The longer chop captures 219 nC, while the shorter captures 192 nC.

Simulation work utilized Trace2D/3D for initial setups, followed by Parmila, and Impact-T to track particles through beamline optics and apertures. Choppers were a key component of the design, as WNR requires single microbunches of high-charge H^-, and optimizing the chopping in LEBT versus MEBT requires various iterations.

The 65-keV LEBT enables easier matching into the RFQ, but critical focusing and diagnostics are housed in the space just before the RFQ entrance.

RADIO-FREQUENCY QUADRUPOLE

LAMP’s radio-frequency quadrupole (RFQ) accelerator is discussed in more detail in other reports [8]. LAMP’s RFQ design optimized between low and high charges, with an additional goal of minimizing longitudinal spreading. Specifically, the high-charge WNR bunches should be captured in their primary, ’main’ bucket as much as possible. Figure 3 shows the capture of two short bunch trains, indicating minimal longitudinal spreading.

The improved bunch capture was accomplished by adjusting the shaper-exit energy within the RFQ. This optimization was studied in detail in the Conceptual Design Report [1]. Careful simulations of the RFQ were performed using CST Particle Studio, including the separation of continuous H^+ and H^- beams.

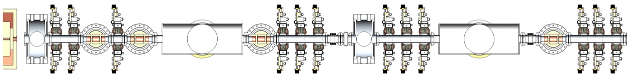

Figure 4: LAMP MEBT layout, presenting beam optics, choppers, rebunchers, and beam boxes where diagnostics will be included.

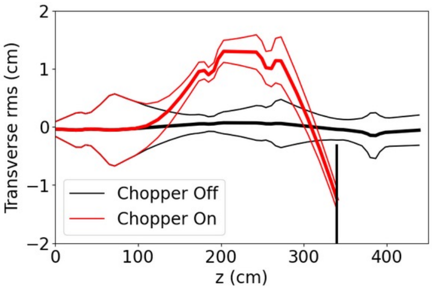

Figure 5: LAMP MEBT chopper performance. The black contours show the rms beam size of the beam passing along the MEBT, while the red show the same but for the beam deflected by two choppers. Separation is approximately 4σ when collected.

The input energy (65 keV) and output energy (2.1 MeV) are lower than prior design iterations [1]. These changes provide multiple advantages to the entire beamline. Significantly, the RFQ design is about 34% shorter and requires less than half the total power [9].

MEDIUM-ENERGY BEAM TRANSPORT

The medium-energy beam transport (MEBT) for LAMP is largely inspired by the MEBT currently operating at SNS. It is shown in Fig. 4 and detailed in other reports [7]. While Fig. 4 shows an accurate mechanical layout of most components, the design continues to evolve to ensure no mechanical interferences based on chopper dimensions.

LAMP has adopted the 2.1-MeV beam energy to avoid radiation and activation concerns, and also to aid with the stringent goal of chopping any residual WNR satellite bunches. The dual-chopper scheme, designed into the SNS MEBT layout, provides significant separation of the unchopped and chopped beams, as shown in Fig. 5. By separating the beams by approximately 4σ, the dual-chopper system is able to eliminate a full-charge bunch to less than 1E–5 of the original.

The chopper is also required to turn off and on between two microbunches, separated by merely 4.96 nsec. LAMP is maturing the technology on a complete chopper subsystem (pulser, structure, and interconnects) that meets this fast risetime/falltime goal, along with flattop requirements appropriate for LAMP’s operation [10]. The structure itself is modeled after Fermilab’s very fast, low-dispersion design [11], and the MEBT layout is evolving along with this effort.

DRIFT-TUBE LINAC

The drift-tube linac (DTL) assumes a six-tank design very similar to other DTL systems, and is detailed in other

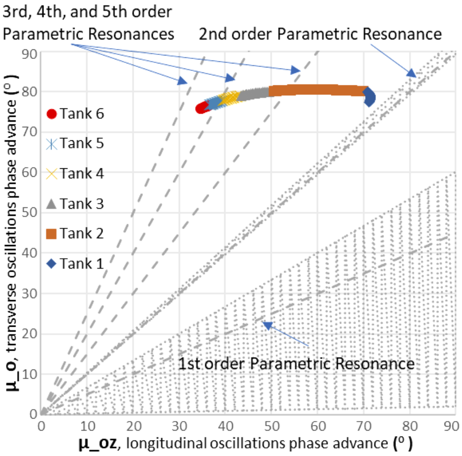

Figure 6: LAMP DTL-tank phase advance plot, compared to key parametric resonances. The design intentionally avoids key resonances, especially at low energy in Tank 1 (purple).

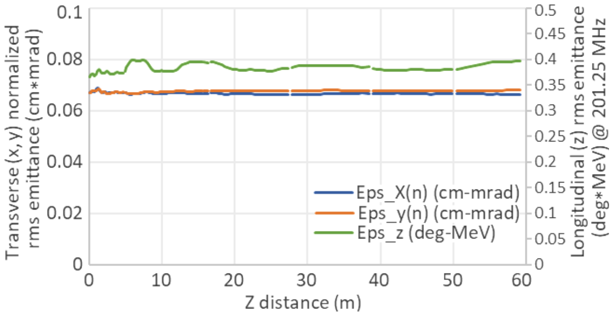

Figure 7: LAMP DTL emittance growth, showing horizontal (blue), vertical (orange), and longitudinal (green). All emittances are well-managed.

reports [12] Careful consideration of the design involves avoiding primary resonances, especially at low energy, as shown in Fig. 6. The field profiles and tank lengths have been adjusted to match the current RF infrastructure, as LAMP intends to leverage the current klystrons and diacrodes in operation at LANSCE.

The critical component of each subsystem is to minimize emittance growth and halo formation. The DTL changes required careful monitoring of emittance growth, as shown in Fig. 7. The emittances are well-managed, preserving the low levels that the RFQ and MEBT generated.

The LAMP design has expanded the distance between tanks, called inter-tank drifts (ITDs) to approximately $2\beta\lambda$, enabling more beam diagnostics and vacuum accessibility. Most of the DTL tube focusing will be based on permanent magnets to preserve a FODO lattice. However, using powered quadrupoles near each ITD allows to adjust the matching between tanks, where the lack of RF acceleration alters the ideal lattice focusing strengths.

FACILITIES AND DIAGNOSTICS

The current design fits well into the LANSCE building envelope, as shown in Fig. 8. Here, the sources, LEBT, RFQ, MEBT, and the beginning of the DTL are shown to scale with the facility walls. Additional infrastructure includes facility water, power, RF, HVAC, etc, which are all being assessed within the project.

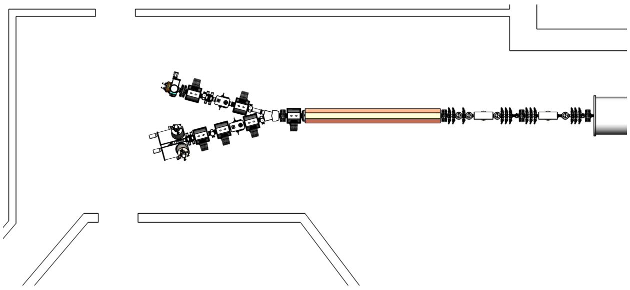

Figure 8: LAMP beamline shown to scale inside the LANSCE facility walls, indicating significant room for the beamline and additional infrastructure. High-speed diagnostics and controls can be located very close to the beamline.

Beam diagnostics are a key element of LAMP modernization effort. Monitoring beam quality relates directly to facility reliability and beam availability. Being able to measure beam quality requires flavor-specific diagnostics, and thus high-bandwidth capabilities. LAMP is leveraging modern fast-digitization techniques to be able to observe flavor-specific beam parameters [13]. Noninvasive techniques will be employed when reasonable to provide during-production oversight and to enable future beam manipulation (such as machine learning and artificial intelligence or novel beam operations) [14, 15].

CONCLUSIONS

The LAMP project at LANL has created a self-consistent start-to-end conceptual design. This design continues to evolve, but specific technologies are being leveraged and developed to meet the project requirements. Each beamline subsystem (sources, LEBT, RFQ, MEBT, DTL) has been modeled and evaluated. Critically, realistic beam distributions have been generated at the source and pushed through the entire front end to demonstrate that the design is credible and valid. Adjustments are being made to resolve mechanical concerns and support specific component geometries (such as choppers and BPMs). In addition, the design nicely fits within LANSCE facilities and infrastructure requirements.

REFERENCES

[1] G. Dale *et al.*, "LANSCE Accelerator Modernization Project Conceptual Design Report", LANL, Los Alamos, USA, Rep. LAUR 25-31513, Nov. 2025. `doi:10.2172/3005578`

[2] J. Lewellen *et al.*, "Requirements evolution for the LANSCE Accelerator Modernization Project (LAMP)", presented at IPAC'26, Deauville, France, May 2026, paper WEP4329, this conference.

[3] K. Bishofberger *et al.*, "An overview of the LAMP front-end upgrade at LANSCE", in *Proc. IPAC'24*, Nashville, TN, USA, Jul. 2024, paper TUPS18. `doi:10.18429/JACoW-IPAC2024-TUPS18`

[4] A. Alexander *et al.*, “LAMP ion source commissioning and future plans”, presented at ICIS’25, Oxford, England, Sep. 2025.

[5] M. Howard *et al.*, “Commissioning status of the H$^-$ ion source for the LANSCE Accelerator Modernization Project”, presented at IPAC’26, Deauville, France, May 2026, paper THP4307, this conference.

[6] R. Keller, R. Thomae, and J. Reijonen, “Evolution of the LEBT layout for SNS”, in *Proc. LINAC’00*, Monterey, CA, USA, Aug. 2000, paper MOD19, pp. 253–255.

[7] S. Sosa Guitron *et al.*, “The LANSCE Accelerator Modernization Project front-end physics design and model”, presented at IPAC’26, Deauville, France, May 2026, paper WEP4332, this conference.

[8] H. Xu, “LAMP RFQ van tip macro-based 3D modeling”, LANL, Los Alamos, USA, Rep. LAUR 24-20338, Jan. 2024. doi:10.2172/2281497

[9] K. Bishofberger and H. Xu, “RFQ-structure power requirements: Analysis of two structure designs”, LANL, Los Alamos, USA, Rep. LAUR 26-23607, Mar. 2026.

[10] A. Chrysler *et al.*, “Preliminary investigation towards a pulse modulator for the LANSCE LAMP project”, *IEEE Pulsed Power Plasma Sci.*, pp. 1–2, Nov. 2025. doi:10.1109/ppps56198.2025.11248422

[11] G. Saewert *et al.*, “First performance results of the PIP2IT MEBT 200-ohm kicker prototype”, Fermilab, Batavia, IL, USA, Rep. Conf-18-144-AD, Apr. 2018. doi:10.48550/arXiv.1806.08750

[12] D. Gorelov *et al.*, “Recent developments in DTL design for LAMP project at LANL”, presented at IPAC’26, Deauville, France, May 2026, paper WEP4349, this conference.

[13] K. Bishofberger, “Extracting LANSCE macrobunch charge from WNR fast pickoff”, LANL, Los Alamos, NM, USA, Rep. LAUR 24-21226, Jan. 2024. doi:10.2172/2305297

[14] Y. Zhang *et al.*, “Capacitive beam position monitors for the low-β beam of the Chinese ADS proton linac”, *Chin. Phys. C*, vol. 40, p. 027003, 2016. doi:10.1088/1674-1137/40/2/027003

[15] C. Rohde and K. Bishofberger, “Building a MOPA aser for H$^-$ beam shaping”, presented at IPAC’26, Deauville, France, May 2026, paperl TUP7364, this conference.