ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-TUPM087

TEST FACILITY SUPPORTING MODERNIZATION OF THE LANSCE FRONT END*

R. T. Thornton†, A. Alexander, M. S. Barrueta, K. Bishofberger, G. Dale, I. N. Draganic, T. W. Hall, E. Henestroza, J. T. M. Lyles, J. Medina, S. I. Sosa Guitron, J. Upadhyay, H. Xu, M. Zuboraj Los Alamos National Laboratory, Los Alamos, USA

Abstract

We present the latest developments of the test facility for the LANSCE Front-End Upgrade. The upgrade will significantly improve the operations and reliability of LANSCE, with upgrade options for future capability. This effort includes a highly diagnosed ion injector, low-energy beam characterizations, and RFQ analysis. Status of construction and upgrade plans of the test facility is presented.

INTRODUCTION

Modernization of LANSCE will improve performance and extend the life of the accelerator. If funded, the LANSCE Modernization Project (LAMP) mission is to modernize both the LANSCE front-end (up to 100 MeV) and the LANSCE proton storage ring (PSR), see Fig. 1.

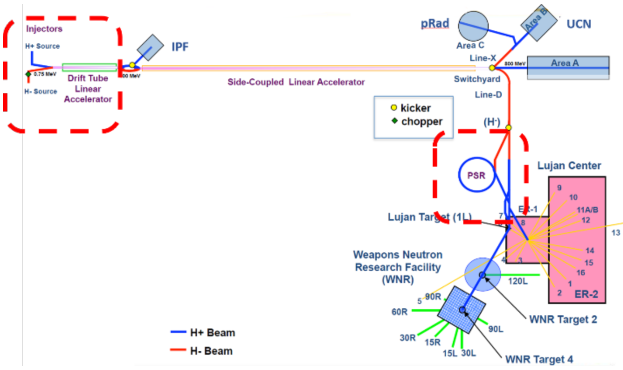

Figure 1: Schematic of the LANSCE accelerator complex. The red dashed boxes are what LAMP will replace.

LANSCE uses two Cockroft-Walton pre-accelerators to accelerate H+ and H- species to 750 keV. Two independent Low Energy Beam Transport (LEBT) beamlines steer and shape the beam for injection into the 100 MeV Alvarez Drift Tube Linac (DTL). After the DTL H+ is directed to an Isotope Production Facility (IPF) while H- is accelerated to 800 MeV through a Coupled Cavity Linac. H- is then transported to one of 4 user facilities: (i) Proton Radiography (pRAD), (ii) Ultra-Cold Neutron Facility (UCN), (iii) Manuel Lujan Neutron Scattering Center, and (iv) Weapons Neutron Research (WNR) facility. For the H- beam to be delivered to the spallation neutron target for the Lujan facility bunches must be accumulated using the PSR. The PSR takes the 625 µs linac macropulse and stacks the chopped microbunches into an intense 290 ns bunch that is extracted for the spallation target to produce neutrons.

LANSCE is unique in that it provides a different timing structure for each user facility as shown in Fig. 2, while running H- at 120 Hz and H+ at 100 Hz. The timing patterns are defined by a traveling wave chopper at the beginning of the H- 750 keV LEBT. The WNR beam structure is obtained by using a 16.66 MHz low frequency buncher prior to the 201.25 MHz main buncher in-order to combine five microbunches into one high intensity bunch. One challenge of LAMP will be to keep the same functionality that exists while improving beam performance.

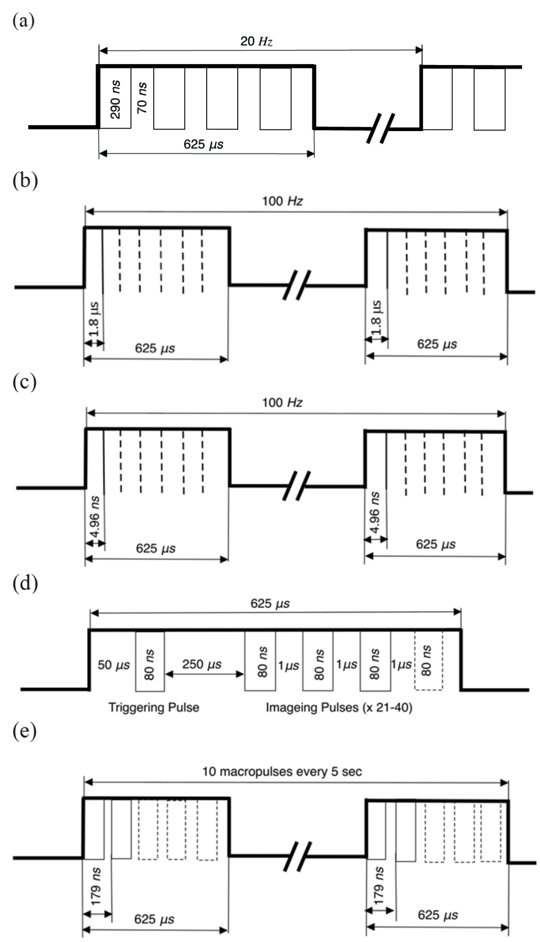

Figure 2: Various beam patterns for the user facilities: (a) Lujan, (b) WNR, (c) IPF, (d) pRAD, (e) UCN. Figure from [1].

The pre-conceptual design for LAMP [1] is to replace the two Cockroft-Walton pre-accelerators with a single radio

* Work supported by DOE-NNSA Office of Experimental Sciences, NA-113
† rtthorn@lanl.gov

ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-TUPM087

frequency quadrupole (RFQ) accelerator operating at 201.25 MHz. The H+ and H- will be extracted at 100 keV and then be simultaneously accelerated to 3 MeV in this novel RFQ. The four DTL tanks will be replaced with six shorter tanks, as shown in Fig. 3. The shorter tanks allow for better diagnostics, additional tuning parameters, and improved mode suppression due to their geometry.

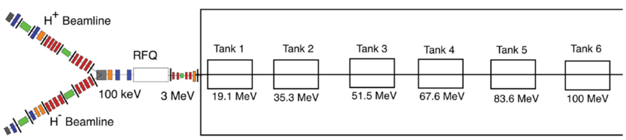

Figure 3: Layoutof the proposed LANSCE front-end [1].

A 4-rod 750 keV RFQ that was originally developed as a potential replacement for the H+ Cockroft-Walton pre-accelerator [2-4], will be used to experimentally validate simulations and test critical technical elements for LAMP. It is similar to the RFQ injector in operation at Fermilab. Although LAMP is proposing a 3 MeV RFQ, the 750 keV RFQ allows the project to demonstrate capability and build work force experience in advance. The experimental test

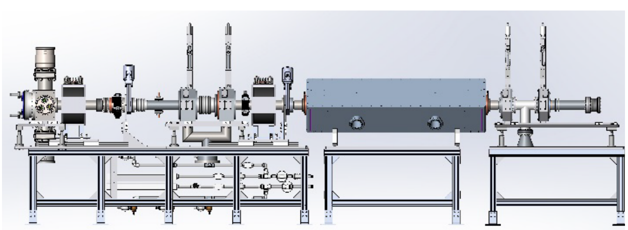

Figure 4: 750 keV RFQ Test Stand that was originally planned to replace the H+ injector and LEBT.

stand is shown in Fig. 4 and is currently under construction. Beam from the H+ Duo-plasmatron source will be extracted at 35 keV, focused by a solenoid before an emittance station, used to verify that the beam parameters are optimal for the RFQ. The beam will travel through another solenoid that will focus the beam into the RFQ. After the RFQ the 750 keV beam will be characterized.

PRESENT STATUS OF TEST STAND

Figure 5 shows the present state of the RFQ Test Stand. The source, extractor, and initial stages of the LEBT have been constructed. The RFQ is being conditioned using a high-power RF system capable of 170 kW peak and 20 kW average power. The LEBT will be extended after verification of the beam parameters coming from the source. A temporary emittance station will be installed (Fig. 6) for verification the beam parameters match the designed values for the RFQ. The RFQ has been conditioned up to 80 kW peak power, at 100 Hz repetition rate with a 1.2 ms RF pulse width. This is half of the necessary power for full conditioning. Cooling in the rod/post style RFQ must be carefully checked before going to full power.

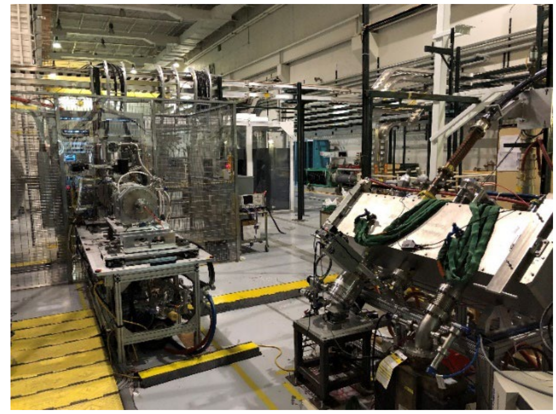

Figure 5: RFQ Test Stand shows the first stages of the LEBT on left and the RFQ separated on right,

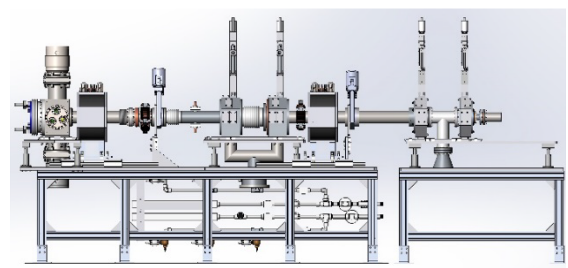

Figure 6: Beamline arranged to measure location and relative strengths of the solenoid fields before addition of the RFQ.

MODIFICATIONS FOR LAMP

Three critical tests are planned on the RFQTS for the LAMP project: (1) demonstration of "SNS-style" RF-driven H- source at higher duty factor and operating at much higher elevation than SNS, (2) simultaneous transport of H+ and H- through the RFQ, (3) simultaneous transport of bunched H- beam with high peak current with low H+ peak current. To accommodate these tests, the RFQTS will be reconfigured to combine the H+ LEBT with an H- LEBT at a bending magnet to send both beams simultaneously into the RFQ (as shown in Fig. 7).

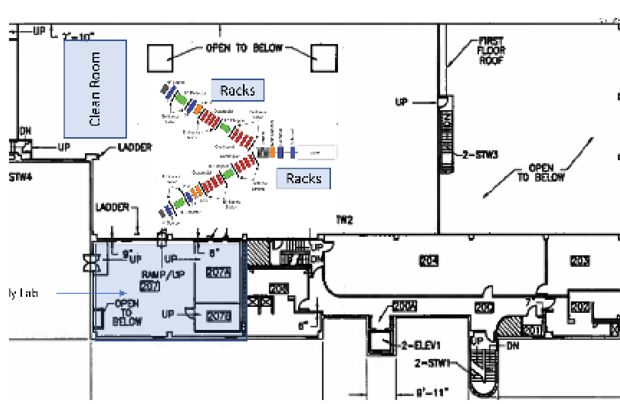

Figure 7: Layout of the final state for RFQ Test Stand.

ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-TUPM087

In the new configuration, the H+ LEBT before the bending magnetic will not change from what is shown in Fig. 6. The H- LEBT will include a chopper and a low frequency buncher in addition to what is included in the H+ LEBT. The chopper will generate the necessary beam pattern so the low frequency buncher can modify the beam current profile to allow merging of five microbunches into one intense bunch out of the RFQ. The combination of the chopper and the low frequency buncher will produce WNR-like beam on the RFQ Test Stand. The results from (2) and (3) will be used as verification of the simulation codes being used for the project [5].

The H- leg of the test stand will utilize a volume ion source with 2 MHz RF-excited plasma in a multi-cusp magnetic field. The H- source will have an electron filter while using a small amount of Cesium. The H- line will be extracted at 35 kV. This source is adopted from the SNS H- source to meet the required current increase needed by the user facilities. Reference [6] presents initial studies of running the SNS source up to 120 Hz – beyond the SNS normal operation of 60 Hz. An important demonstration will be the 120 Hz pulse rate at LANSCE's 2100 meter elevation above sea level, for an extended period of time. It will provide essential data about the lifetime of the source for the LAMP upgrade.

The 201.25 MHz RF power system for the RFQ test stand uses many of the same components that are used in the LANSCE DTL RF powerplant [7]. These include a 5 kW solid state amplifier driving a tetrode amplifier, with a circulator before the RFQ. Low level RF controls will use the digital I/Q-based design recently incorporated at LANSCE. The 2 MHz RF power system is a new solid-state amplifier with a HV isolation RF transformer to allow placement of the RF generator at ground potential. A third 13.56 MHz lower power generator provides a plasma ignition pre-pulse.

CONCLUSION

The RFQTS is being redesigned to test critical technical elements by verification of simulations for the proposed LAMP project. The H+ LEBT is presently being commissioned in stages while the H- LEBT is under design. Simultaneous acceleration of H+ and H- through the 750 keV RFQ is planned in FY25.

REFERENCES

[1] Y. K. Batygin, D. Gorelov, S. S. Kurennoy, J. W. Lewellen, N. A. Moody, and L. Rybarcyk, “Advancement of LANSCE Front End Accelerator Facility”, in *Proc. IPAC'21*, Campinas, Brazil, May 2021, pp. 1894-1896. doi:10.18429/JACoW-IPAC2021-TUPAB205

[2] S. S. Kurennoy, Y. K. Batygin, E. R. Olivas, and L. Rybarcyk, “Realistic Modeling of 4-Rod RFQs with CST Studio”, in *Proc. IPAC'14*, Dresden, Germany, Jun. 2014, pp. 3119-3121. doi:10.18429/JACoW-IPAC2014-THPRO098

[3] Y.K. Batygin *et al.*, "Design of low energy beam transport for new LANSCE Hþ injector," Nucl. Instrum. Methods Phys. Res., Sect. A, vol. 753, pp. 1-8, 2014. doi:10.1016/j.nima.2014.03.041

[4] R. W. Garnett *et al.*, “LANSCE H+ RFQ Status”, in *Proc. IPAC'15*, Richmond, VA, USA, May 2015, pp. 4073-4075. doi:10.18429/JACoW-IPAC2015-THPF148

[5] D. Dimitrov et al., "Modeling Codes Used for LAMP," Los Alamos National Lab. (LANL), Los Alamos, NM (United States), Rep. LA-UR-23-20148, 2023.

[6] M. P. Stockli, B. Han, M. Clemmer, et al., "Upgrading the LANSCE accelerator with a SNS RF-driven H- ion source," *Rev. Sci. Instrum.,* vol. 91, p. 013321, 2020. doi:10.1063/1.5129673

[7] J. T. M. Lyles *et al.*, “New Drift-Tube Linac RF Systems at LANSCE”, in *Proc. IPAC'18*, Vancouver, Canada, Apr.-May 2018, pp. 3680-3683.doi:10.18429/JACoW-IPAC2018-THPAL025