

COMMISSIONING STATUS OF THE H- ION SOURCE FOR THE LANSCE ACCELERATOR MODERNIZATION PROJECT*

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Abstract

The LANSCE Accelerator Modernization Project (LAMP) will replace the front-end of the existing LANSCE accelerator, from ion sources through the end of the 100 MeV drift-tube linac. LAMP requires higher peak H-beam currents, and longer lifetimes, than provided by the existing LANSCE H- ion sources. The project is currently constructing an SNS multicusp cesiated source design with an internal RF antenna. This paper discusses the H- source performance requirements for LAMP, and progress towards assembling, commissioning, and operating an SNS-type source at the LAMP RFQ Test Stand (RFQTS).

INTRODUCTION

The Los Alamos Meson Physics Facility (LAMPF) was originally commissioned in 1972 [1]. Now known as the Los Alamos Neutron Science Center (LANSCE), it is one of the oldest high-average-power accelerators in the United States [2]. LANSCE simultaneously produces high intensity H⁺ and H⁻ beams and delivers beam to six different end stations. Currently, Cockcroft-Walton generators are used to accelerate both ion species to 750 keV. Unfortunately, over recent years there has been a decrease in the reliability of the Cockcroft-Walton generators and the Low Energy Beam Transport (LEBT) regions. In addition, the filament based H- ion source used at LANSCE cannot produce sufficient peak current for users while also meeting ion source lifetime requirements. Two of the primary goals of the LANSCE Accelerator Modernization Project (LAMP) include replacing the Cockcroft-Walton generators with a dual-beam Radio-Frequency Quadrupole (RFQ) [2–4] and replacing the filament based H- ion source with an RF (2 and 13 MHz) based ion source heavily inspired by SNS. The RFQ Test Stand (RFQTS) was developed to demonstrate simultaneous dual-species propagation through an RFQ [3–5]. The test stand consists of a 35 keV H- beamline and H⁺ beamline which will merge and inject into an existing 750 keV RFQ. Note that these energies are different from the 65 keV LEBT and RFQ input energy and 2.1 MeV output energy planned for LAMP [6].

The H- beamline will utilize a multicusp, cesiated source design with an RF antenna, modeled after the H- source in use at SNS [7–9]. Initial assembly of the H- source for

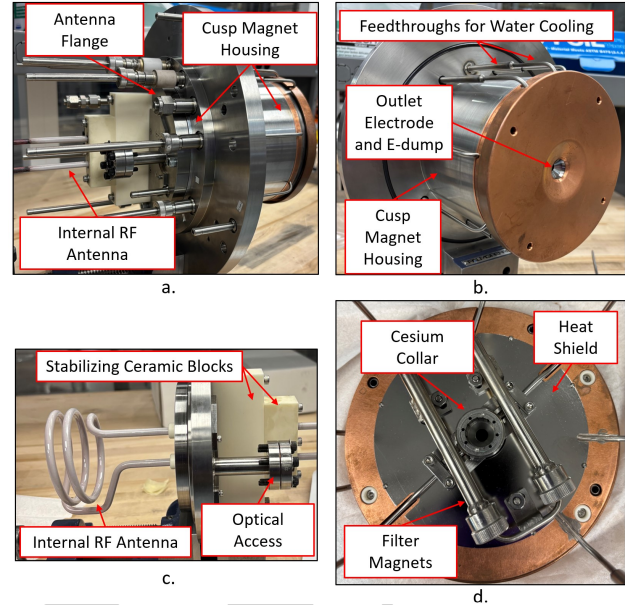


Figure 1: a.) Image of the fully assembled H- source. b.) Downstream view of the H- source showing the outlet electrode and e-dump. c.) Image of the fully assembled antenna flange. d.) Image of the components in the outlet electrode assembly.

the RFQTS was completed in late 2025. In this paper, we outline the building and commissioning process.

SOURCE DESIGN

The SNS internal RF antenna design was selected as the H- source for RFQTS due to its high peak current and long lifetime. This source can produce H- beams with a current of over 100 mA with a lifetime of over 4 months [10]. These current levels far exceed what can be extracted with the present injector at LANSCE (<20 mA) [11] and meet the needs of the LAMP project.

The source body can be separated into three primary parts: the back flange, which contains the plasma chamber and permanent magnets to confine it, the antenna flange, which couples the RF power to the gas to produce the plasma, and the outlet electrode, which contains the cesium converter, Pierce electrode, and electron dump. Each of these sections/parts contain various components critical to plasma formation and H- beam production. Fig. 1 shows various images of the source with relevant components labeled.

The back flange houses 20 NdFeB cusp magnets, each with $B_R = 13500$ Gauss, that create the magnetic field which contains the plasma generated by the internal RF antenna.

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This flange also contains several feedthroughs for the water and air cooling lines on the outlet electrode assembly. Both the antenna flange and outlet electrode assembly mount onto this flange, as shown in Fig. 1a and b.

The antenna flange, as shown in Fig. 1c, holds the internal RF antenna, and hydrogen gas feedthrough. An optical port enables plasma emission and absorption spectroscopy. Ten permanent magnets (not pictured) further contain the plasma and reduce electron back-bombardment. The internal RF antenna generates the plasma and is composed of copper tubing bent into a helical shape and coated with 500 - 700 μm of porcelain enamel for increased lifetime [12, 13].

The outlet electrode assembly and E-dump, shown in Fig. 1b and d, consists of several components critical to H- ion beam formation. The cesium collar has multiple cut-outs in which cesium chromate cartridges are placed. These cartridges are then heated by the plasma and release elemental cesium that is deposited onto the molybdenum converter underneath. The cesiated converter increases the H- yield through negative ion conversion on its surface [14]. The filter magnets keep high energy electrons away from the converter region to reduce H- ion stripping and increase yield. The Hallbach array (not pictured) deflects co-extracted electrons to the cooled e-dump while the H- ions are directed through both the Pierce and e-dump apertures. (see Fig. 1b).

VACUUM TESTING

Assembly of the H- source was completed in June 2025. However, when the source was initially placed under vacuum, the vacuum pressure stalled at 3.0×10^{-1} Torr, indicating a large vacuum leak. Extensive leak checking was performed. A custom flange (see Fig. 2a) was designed and manufactured in-house which allowed for the cusp magnet wells in the back flange to be accessible while the source was under vacuum, as the wells themselves should not be under vacuum. With this flange, we could test each well individually with helium and ethanol. When ethanol was sprayed into the magnet wells near the tapped holes on the back of the source body (see Fig. 2b), the vacuum pressure quickly spiked, indicating a large leak in that area.

The tapped holes were identified as the primary cause and were rewelded to eliminate any leak paths. Once this joint was repaired, vacuum pressure easily reached 1.0×10^{-7} Torr and below. No additional leaks were found and vacuum testing concluded in March, 2026.

MATCHING NETWORK

The ion source uses 2 RF sources at different frequencies: a 13.56 MHz source that provides CW "starter" plasma and a 2 MHz mode which provides a high-power, pulsed plasma that is used to produce the H- ion source beam. The 13.56 MHz CW plasma reduces the gas pressure and power required to produce the pulsed beam. Efficient power transfer to the plasma requires a matching network between the RF source and the antenna. A separate matching network is used for the 13 MHz and 2 MHz RF sources. The differences are

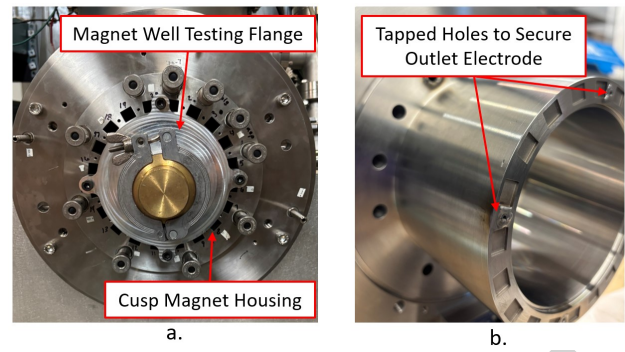


Figure 2: a.) Image of the testing configuration for leak checking the individual magnet wells. b.) Image of the tapped holes and seal between the magnet back plate and the magnet housing.

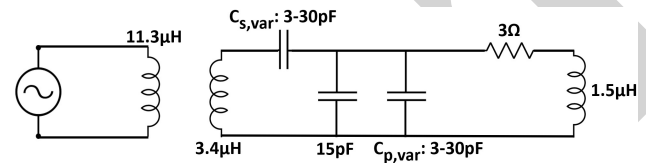


Figure 3: Circuit diagram for the 13.56 MHz matching network.

mostly due to the different plasma impedance at 13 MHz and 2 MHz. The pulsed plasma is always matched when it is on, while the 13 MHz RF source is only matched when only the 13 MHz RF source is on (e.g. the 13 MHz source is unmatched while the 2 MHz source is on) [15]. This simplifies the matching network design. The matching network floats at the same potential as the ion source, and thus must be isolated from the RF sources, which are at ground.

A circuit diagram created in LTspice® [16] for the 13.56 MHz matching network is shown in Fig. 3. The network consists of a ferrite core transformer with an 8:4 turn ratio, two variable capacitors (one in series, $C_{s,var}$, and one in parallel, $C_{p,var}$), a fixed capacitor, and inductors and resistors to simulate the inductance/resistance of the antenna during plasma formation. The matching is confirmed by looking at the impedance of the network, shown in Fig. 4, which peaks at 13.56 MHz.

The current prototype of the matching network, coined "Gen 2", utilizes small scale components, a VNA, and the transformer which will be used in the final design. The Gen 2 prototype is shown in Fig. 5a. With the VNA, we confirmed that the system is matched at 13.56 MHz with a high signal, as shown in Fig. 5b.

For the final 13.56 MHz matching network, we will use larger variable capacitors which range from 3-30 pF. The network requires RF shielding and a custom enclosure that is currently in development. Once the enclosure is assembled, we will connect to the source using inductive coils that clip directly onto the antenna.

The 2 MHz matching network requires much larger components and a custom, water-cooled, 7:1 transformer due to the higher power. The fabrication of the 2 MHz matching network is also in progress.

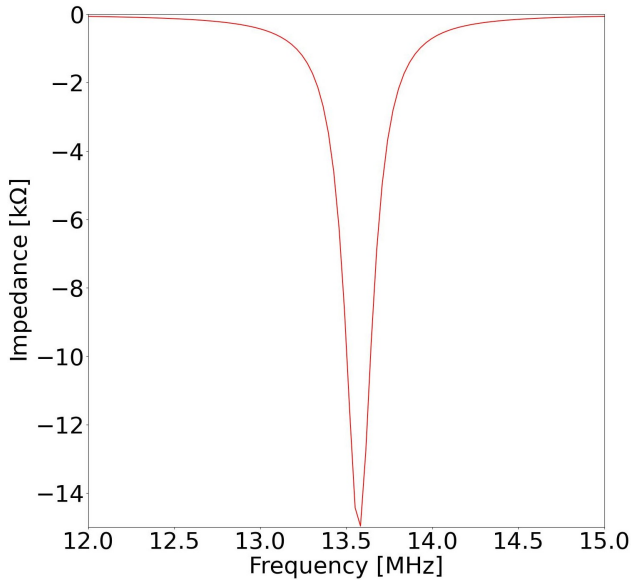
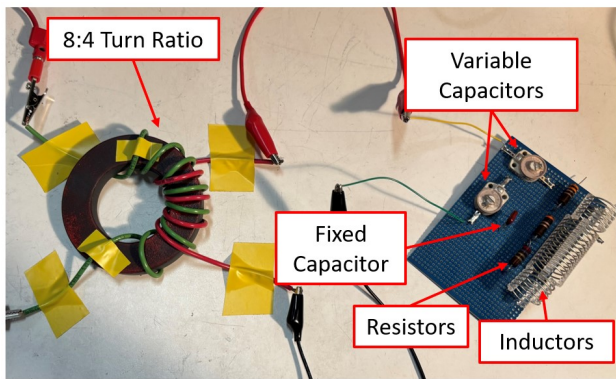
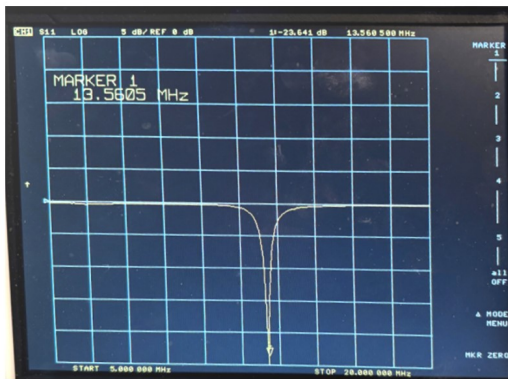


Figure 4: Impedance plot of the LTspice® [16] simulation for the 13.56 MHz matching network.



a.



b.

Figure 5: a.) "Gen 2" matching network prototype. b.) VNA results for the Gen 2 prototype.

CONCLUSIONS AND NEXT STEPS

A SNS style H- source is being commissioned for use on the RFQTS as part of the LAMP project. The source was assembled on-site at LANL with support from ORNL. After undergoing extensive vacuum testing, the source is ready to begin generating low-power plasma upon completion of the matching network. We are also designing and building the enclosures required to operate the pulsed high power 2 MHz source required for beam extraction.

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