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INJECTION LOCKED 1497 MHZ MAGNETRON*

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Abstract

Muons, Inc is building an amplitude modulated phase-locked magnetron to replace the klystrons in CEBAF. To do that requires changing the magnetic field at a rate that would induce eddy currents in the standard magnetron. We report on the status of the project to make a stainless steel anode with copper elements to minimize heating while the stainless steel reduces eddy current effects. The construction of the magnetron is two months from completion, while the test stand is ready for delivery of the magnetron.

INTRODUCTION

Muons, Inc is building a 13 kW 1497 MHz magnetron to replace the klystron in the CEBAF machine. The anode voltage of the magnetron and the beam voltage of the klystron are identical at 14kV. With the efficiency of the magnetron near 80% the anode current of the magnetron is expected to be about 1.16 amps compared to the klystron, which needs 1.76 amps. The filament power of the klystron is about 30 watts, while the filament power for the magnetron will be about 100 watts. With injection locking the magnetron will operate at around 20 db of gain compared to the klystron which operates at about 35 db of gain. It may be possible to improve the gain, but that depends on the prototype testing which will begin in approximately two months.

Modulation of the output power of the magnetron will be accomplished by changing the magnetic field in a trim coil that is approximately 10-20% of the operating magnetic field. This would produce eddy currents if the anode were made from copper but in this Phase II program; the anode is made from 314 Stainless Steel. The manufacturing process of explosion bonding copper onto the inside diameter of the stainless steel cylinder was accomplish and reported earlier [1]. A picture of the stainless steel anode is shown on in Figures 1 and 2 at different steps in the manufacturing processes.

STATUS OF THE PROJECT

Build Status

Brazing the stainless steel anode with copper tips has been completed. The anode is shown in Figure 1 before brazing the straps and other elements. The copper was explosion bonded onto the ID of a stainless steel cylinder, electrical discharge machined, final machined and copper plated. In Figure 2, the anode is shown having gone through three brazing operations. There has been some diffusion of the plating into the stainless steel as shown in Figure 2.

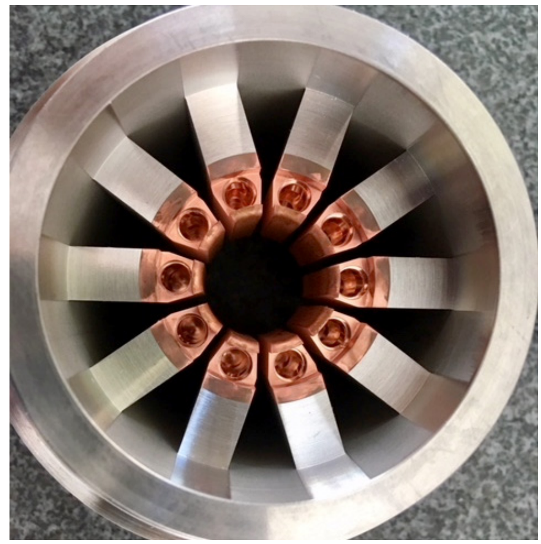

Figure 1: Stainless steel anode EDM'd and machined.

Heatwave, Inc is welding the Cathode Stalk, which contains the filament, in place. An example of these welds is shown in Figure 3. These welds include several critical steps in the assembly process: a) a nickel weld of the bot-

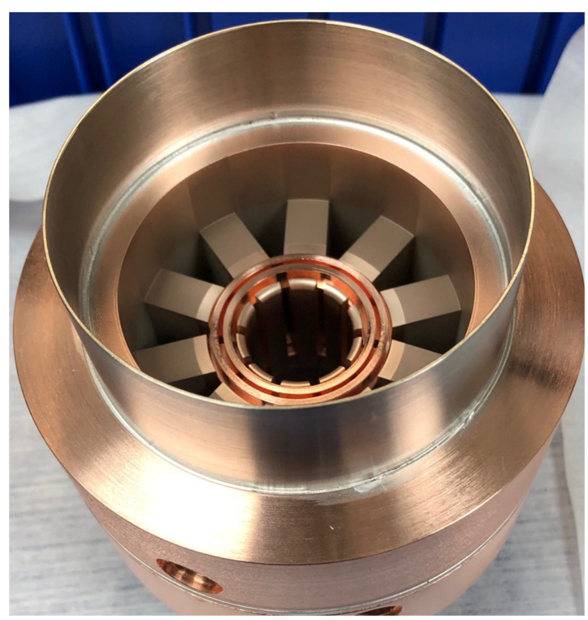

Figure 2: Copper plated stainless steel anode after three brazing cycles.

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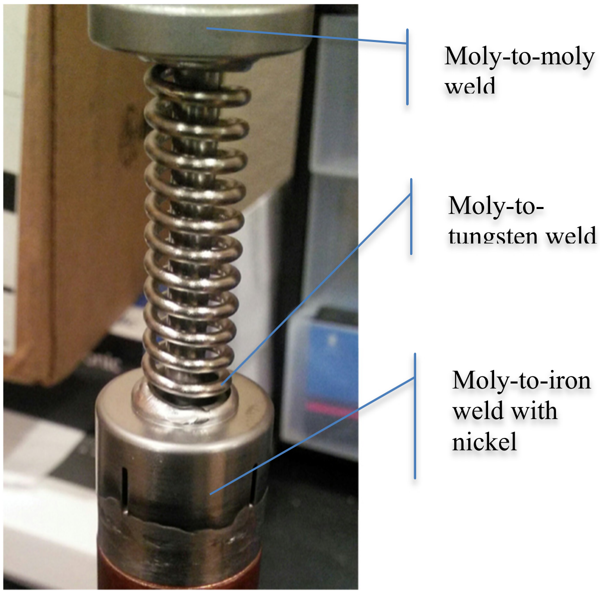

Figure 3: Example of filament welds for the Cathode Stalk of the magnetron.

tom moly filament hat to the iron polepiece in the stalk assembly, b) the weld of the moly top hat to the moly centering rod, c) welding the moly end hats to the tungsten filament. These three welds require precise fixturing and assembly techniques that are done by hand. After the welding is performed the complete stalk assembly is placed in a bell jar for processing. The processing steps are required to both check temperature and turn-to-turn sag, as well as clean the filaments from any material that was deposited during the welding processes.

FINAL ASSEMBLY STEPS

The final steps of assembly include brazing the antenna to the anode. This process includes a series of measurements to locate where on the vanes the antenna legs are connected before the brazing operation. Measurements are made of Qo and Qext in the clean room with several different lengths of antenna and dome window. The calculations are shown in Figure 4 and Figure 5. The measurements are shown in Figure 6. The discrepancy between calculations and measurements indicates the difficulty between the ideal parts and the physical parts, and the sensitivity of Qext to several dimensions in the output circuit. The full assembly used to measure Qext is shown in Figure 7.

Qo is the unloaded Q of the magnetron anode resonant structure and Qext is a measure of the coupling from the anode to the output. If Qext is too low, the magnetron will not oscillate, if the Qext is too high, the efficiency is low, and the anode will over heat.

Qext Measurements

The measurements of Qext will be completed next month. The best location of the existing parts provided a Qext of 163 with a Qo of 1010. These numbers are close, but the reduction of Qext into the range of 120-140 will be accomplished with a larger diameter antenna of the same height.

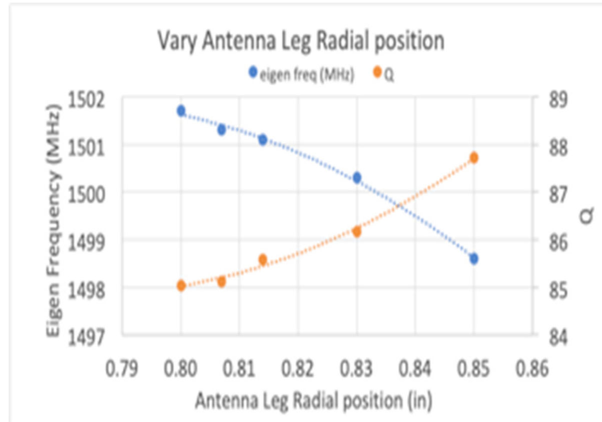

Figure 4: Calculations of Qext as a function of the radial location of the antenna legs on the vanes.

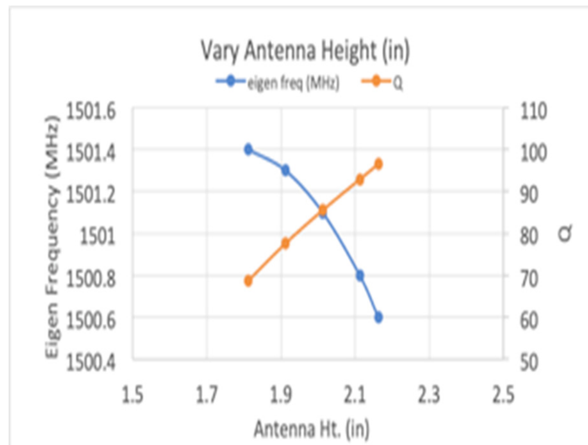

Figure 5: Calculations of Qext as a function of the length of the antenna.

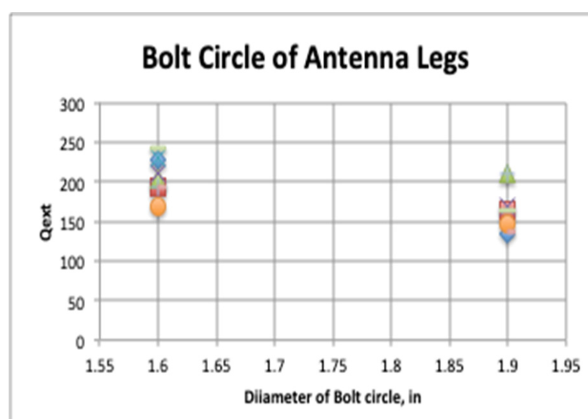

Figure 6: Measurements of Qext as a function of the location of the antenna legs on the vanes.

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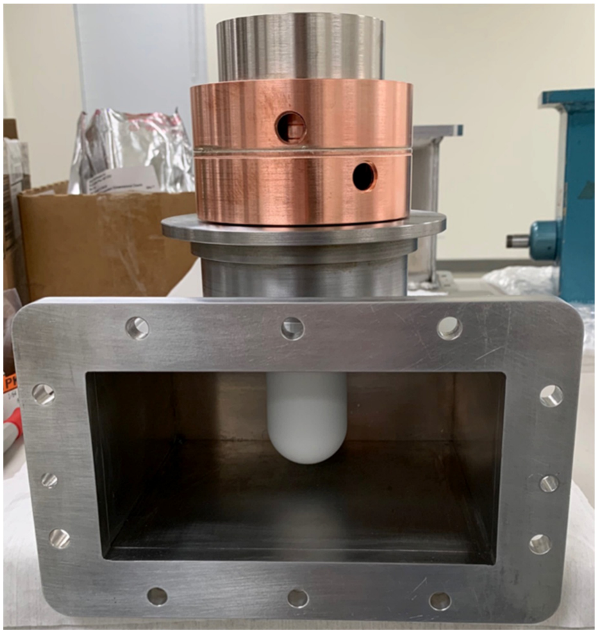

Figure 7: The assembly of parts used for the Qext measurements.

Magnet Construction

The final details of the magnet construction was completed with thermal measurements of the focussing magnet. The original magnet was found to have a water leak, so a new magnet was constructed with an extra turn of cooling coils to maintain an optimum temperature.

The trim coil, which is located as shown in Figure 8, is currently under construction. It will be completed in the next month.

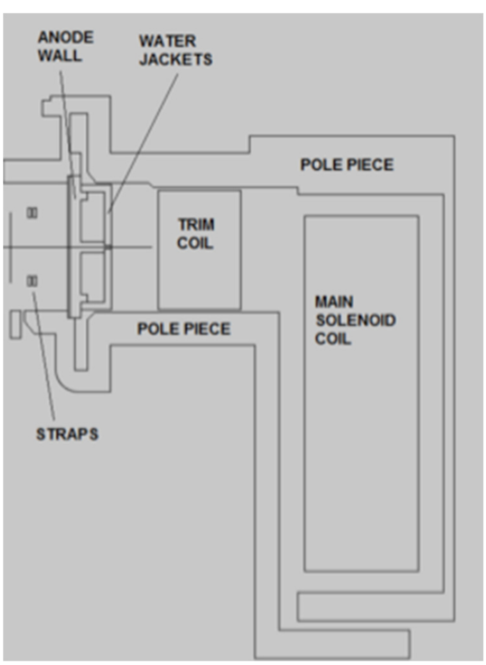

Figure 8: Location of the trim coil with respect to the main coil.

Test Stand

The test stand is being built at JLAB with a configuration as shown in Figure 9. Low level tests have been completed on the system [2].

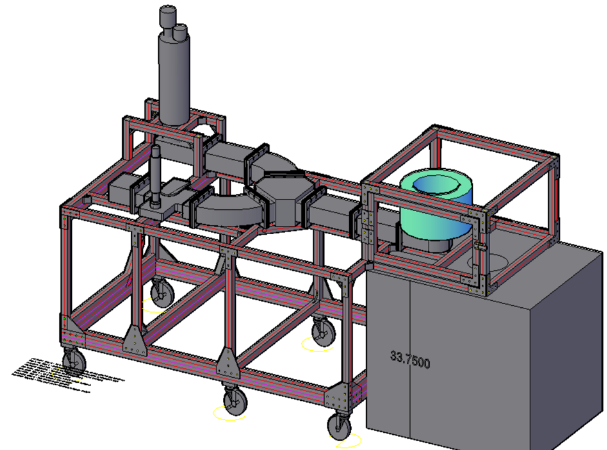

Figure 9: Test stand configuration at JLAB

CONCLUSION

The analysis of the design was completed and presented at IPAC2017[1]. This status report reflects the work down in the preceding two years.

The program for building the magnetron and amplitude modulation is nearly complete for testing at the facilities at JLAB.

ACKNOWLEDGMENTS

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