Muons, Inc.

A novel injection-locked amplitude-modulated magnetron at 1497 MHz

(processes and product)

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Outline

- Muons, Inc.
  - A presentation of some history and commercialization program designs
- SBIR Program Status Year 2 including Year 3 plans and requirements

Muons, Inc.

- Rolland Johnson, President
- The company was founded in 2002 with gas filled cavity development and G4Beamline.
- The organization is “distributed”. We work from our home offices and local work spaces, and offices and work spaces at national labs.
- From 2002-2010 the primary focus was on Muon Collider Technology and related technologies
- From 2010-Present the focus has been on product development, commercialization, and ADSR (Accelerator Driven Sub-critical Reactor) Technology

Muons, Inc: a few of the projects

- Simulation programs (G4Beamline, MuSim), Gas Filled Cavities, Ion Sources, Magnet R&D, ADSR
- Magnetrons and RF Components
  - Building a 350 MHz magnetron for Niowave
    - The 350 has other applications in manufacturing processes that can benefit from microwave heating.
  - Developing and patenting magnetron operational techniques to further reduce the cost of high power pulsed magnetron systems
  - Lossy Ceramics for accelerators and other applications
  - AM modulation of magnetron with magnetic field… This SBIR

Muons, Inc. Commercialization Activities: Use of Lossy Dielectrics

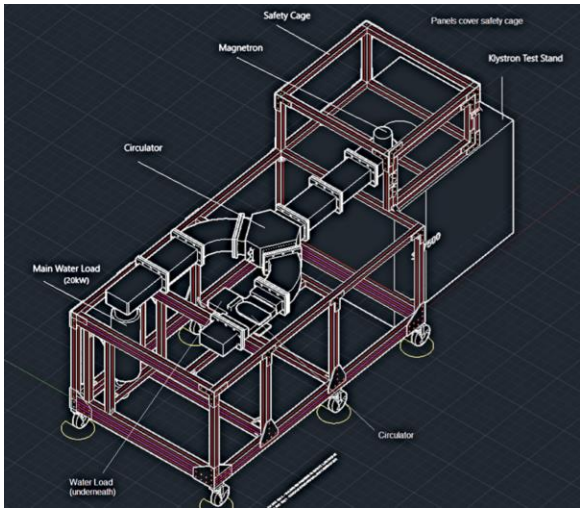
- Lossy Dielectrics Developed under DOE SBIR grant are proposed for use in hybrid microwave heating
  - The original material design was used for accelerator load material in the room temperature linac at SLAC.
  - The same material can be used for hybrid microwave heating, where heating occurs from thermal radiation and volumetric heating of a material. This allows for heating through regions where there is low dielectric loss in the material being sintered.
  - Our experiments and other researchers show greater than 1000C is achieved in less than 30 minutes in a commercial 2.45 GHz magnetron oven (with proper thermal insulation).

Injection-locked amplitude-modulated magnetron at 1497 MHz

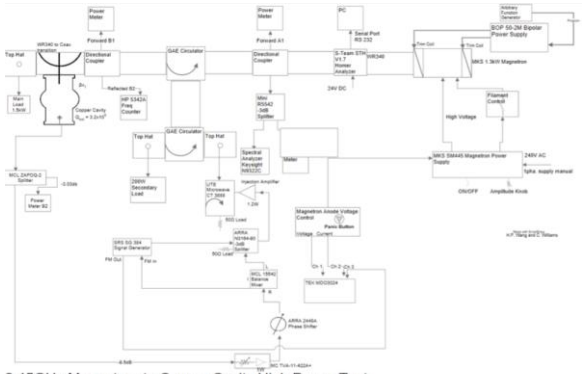
- Jefferson Lab is developing operational software, a test stand, and performing experiments with a “cooker magnetron” to evaluate electronics and trim coil + power supply requirements.
  - The match of the trim coil impedance and power supply impedance is being optimized for operation in the kHz region.
- Muons, Inc is building the 1497 MHz magnetron with a trim coil design that will be modified based upon Jefferson Lab experiments.
  - Anode fabrication is complete
  - All parts are complete and delivered.
  - Two magnetrons are about 2/3 complete with planned completion by the end of October.

JLAB Projects

Test stand preparation

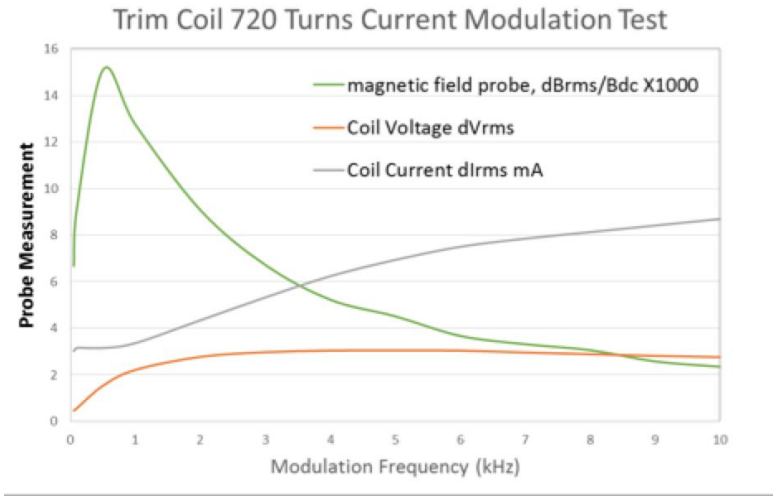


2.45 GHz magnetron to test software used in controlling the magnetic field of trim coil.

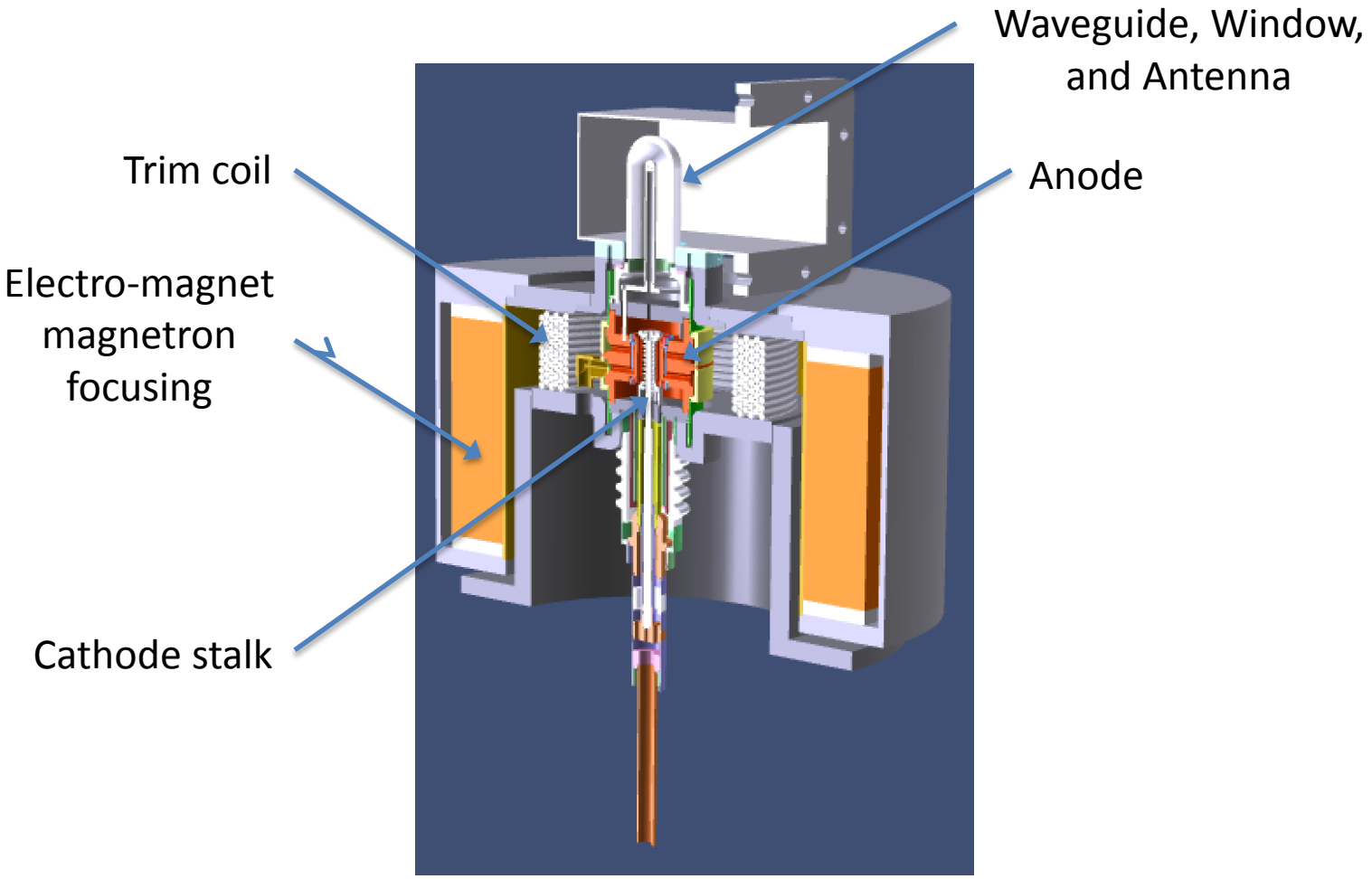


2.45GHz Magnetron to Copper Cavity High Power Test

Experiments with a trim coil of about 14 mH and a bi-polar power amplifier are underway. Initial results indicated the power supply was malfunctioning and is being returned for rework.



Prototype Magnetron Assembly 1497 MHz



Muons, Inc. Commercialization Activities: Prototype Magnetron manufacturing

- In the beginning stages, the use of consultants were critical in evaluating processes, drawings, and designs. They then made recommendations about assembly and in-process test configurations and fixturing. They continue to assist at each assembly stage.
- The coordination of services to maintain a constant work flow was and is the most problematic since we do not own the means of production
  - This required the planning and execution at both a central facility as well as the "outsourcing" of processes not available at the central facility.
- The Development of the rework cycle was the next hurdle. What do we do when something goes wrong. The email systems was most critical when needing to consult with various groups: machine shop, central facility, consultants, and other support personnel.
  - This process was developed during the 350 magnetron build that is preceding the 1497 magnetron build.

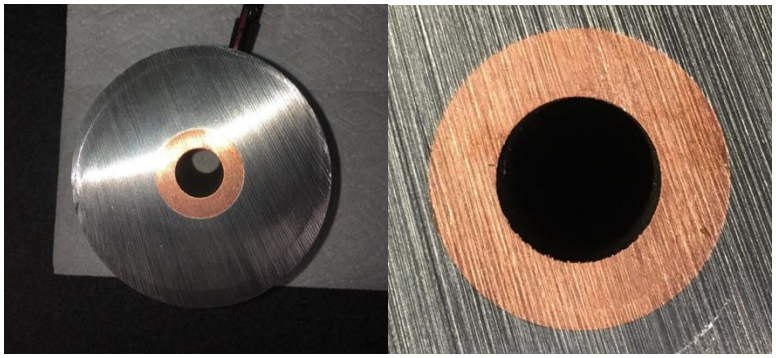
Muons, Inc.

Muons, Inc., Commercialization Activities: Prototype Magnetron Manufacturing

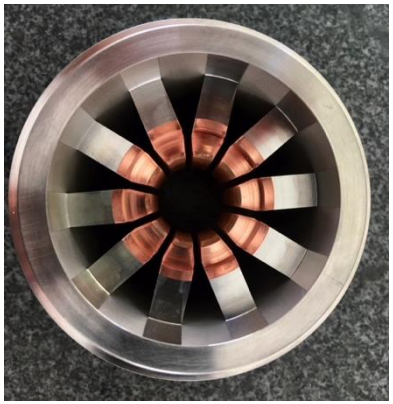
- Altair Technologies (http://www.altairusa.com/)
  - A “brazing house” with high temperature furnaces using various atmospheres used for the repair of medical accelerators and the making of other assemblies.
  - They are also expanding into other Silicon Valley markets that utilize high temperature processing.
  - Altair started as a way to outsource braze operations from an established microwave tube manufacturer: Varian Associates, now known as CPI.
  - They have all the processes needed to manufacture a magnetron: from brazing parts to final assemblies and bake out.
- Plating: Inta Technologies (http://www.intatech.com/)
- Ceramics: Coorstek (https://www.coorstek.com)
- Machine Shops
  - Grand Island Machining, Device Technologies, Electronic Carbide, B & H Grinding
- Explosion Bonding
  - High Energy Metals (http://highenergymetals.com)

Anode Construction

Explosion Bonding



Electrical Discharge Machining



Machine Shop

Plating → Altair for brazing

Examples of Brazed Assemblies for the 1497

Window braze fixturing, (needed some rework)

Brazed Window Assembly

Brazed pole piece assemblies

Sub-assembly of the cathode stalk.

Manufacturing Status of magnetron(s)

350 Magnetron was the “training” vehicle

Completed Brazes	15
Total Brazes per tube	20
Brazes to Complete	5
Percentage Brazing Completed	75%
Percent of Total Complete	86%

1497 Magnetron

Completed Brazes	8
Total Brazes per tube	19
Brazes to Complete	11
Percentage Brazing Completed	37%
Percent of Total Complete	63%

Phase IIB Framework

- Moving the prototype to production requires life testing the magnetron, stress testing of the prototype system and related technical decisions about specific design elements that move the system from prototype to production.
  - For example a design decision about the focusing of the commercial magnetron: Will it be a permanent magnet with trim coil?
  - Will the trim coil design need to be changed based on test results of the system.
- Stress testing of the system requires cycling the trim coil and power supply, cooling, full power cycling of the system, and optimization of system parameters.
- Other issues that may come up during system testing will need to be resolved.

Summary

- The program is on schedule to complete two prototype magnetrons by October-November. This will include a standard 1497 and one built for low eddy currents.
- System testing is planned for completion by the end of the no-cost extension.
- Additional funding will be required to ensure a commercially viable product.