A# Improved Ring Heater Testing

Design Development and Vacuum Verification

Helen Schwartz

10 December 2025

Need/Current Design- LIGO-D1001838

Increased laser power in the interferometer has side effects:

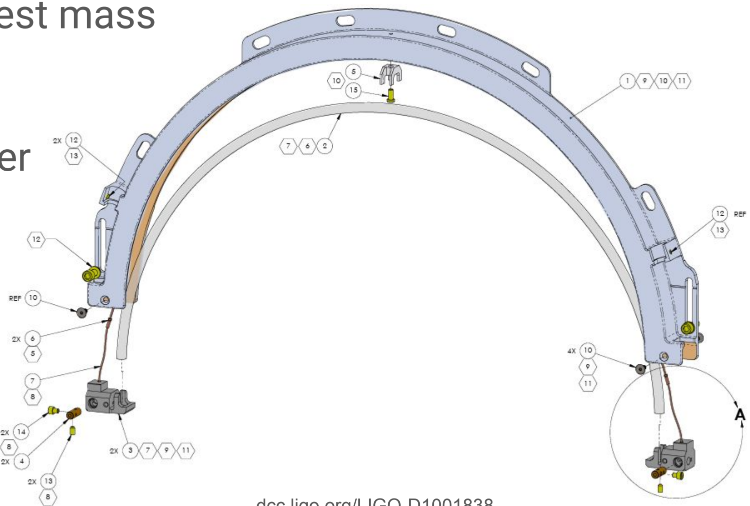
- ➢ Test masses will absorb some of the power
    - ○ Develop a thermal gradient
    - ○ Deforms and changes the spatial mode

Solution:

- ➢ Ring Heater creates uniformity of the thermal gradient with external heat to the test mass

Current design:

- ➢ aLIGO TCS Ring heater
    - ○ Glass rod
    - ○ NiCr Wire coils
- ➢ Issues with fragility and uniformity



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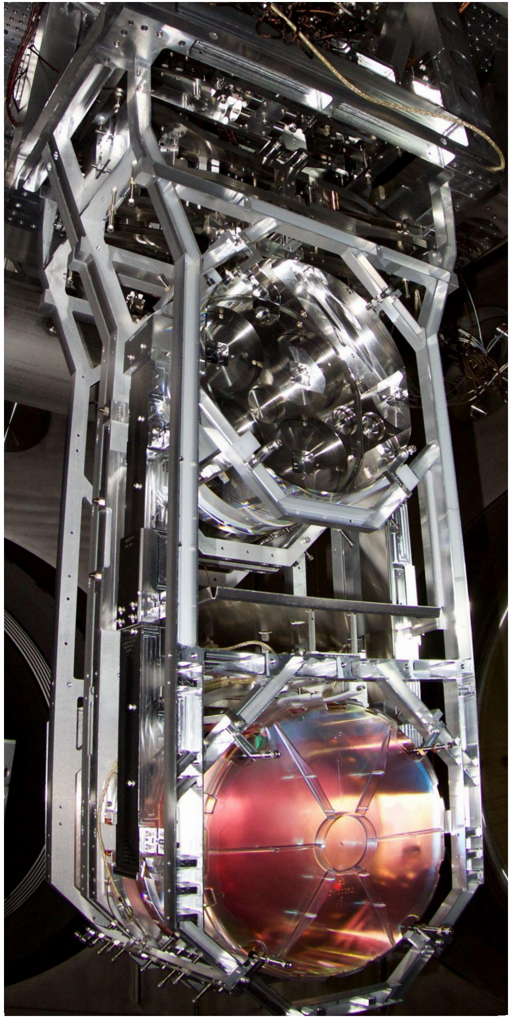

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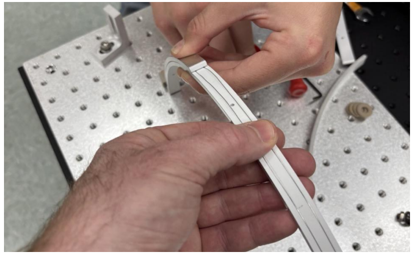
UF Ring Heater Design - LIGO-G1101169

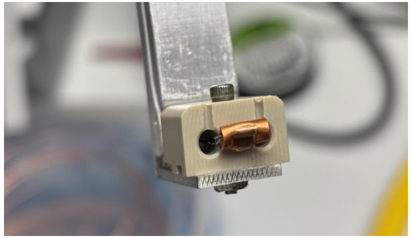
Two semi circle pieces make up the ring heater each containing:

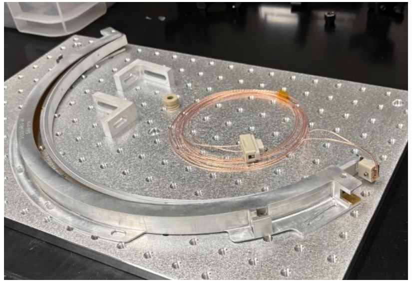
- ➢ One fire-sprayed alumina coated aluminum **inner shell** with two grooves on the top face
- ➢ Three fire-sprayed alumina coated aluminum **outer pieces** with two grooves on the lower face
- ➢ **NiCr wire** in the grooves routed to PEEK end connectors and crimped with copper conducting wire
- ➢ Aluminum shield prevents unwanted directional heat dissipation

Main issue: Alumina has not been used (in mass) in LIGO Vacuum Systems

- ➢ Outgassing of the coating could increase optical absorption







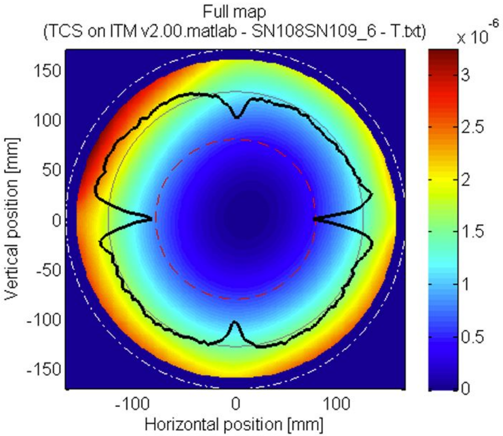
UF RH Prototype Results - LIGO-T1300756

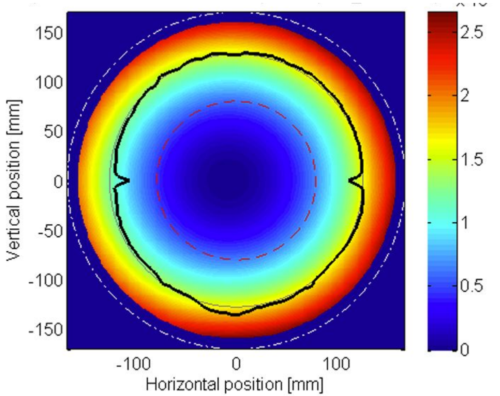
The current UF RH design solved many issues of the TCS model:

- ➢ Greater mechanical robustness
- ➢ Better production repeatability
- ➢ Much reduced sensitivity to handling
- ➢ Improved temperature uniformity

Top image: measured temperature profile of **aLIGO TCS** RH with about 5 W of electrical power per half-RH

Bottom image: measured temperature profile of the **UF** RH with about 5 W of electrical power per half-RH





dcc.ligo.org/LIGO-T1300756

CIT Vacuum Reliability Testing - LIGO-E2500134

Why:

➢ To test the robustness and potential outgassing/flaking of fire-sprayed alumina coating

Where:

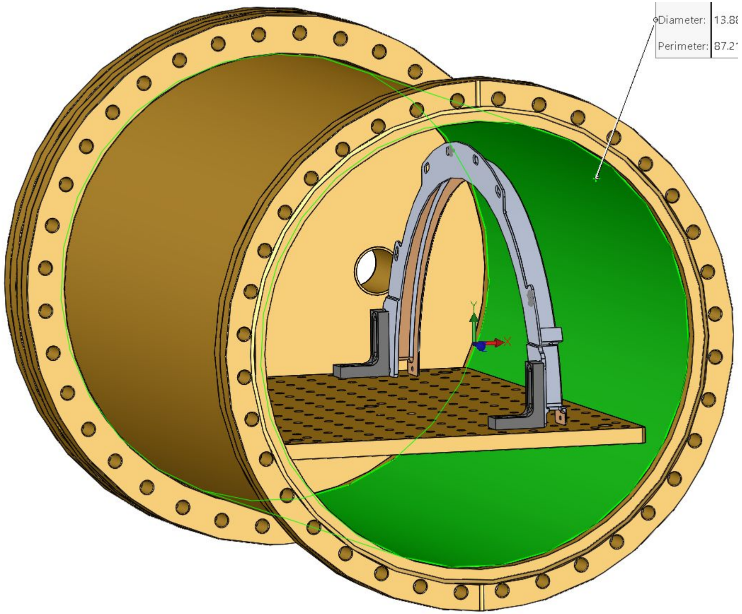
➢ VBOD, Clean & Bake Lab in the 40m Building of CIT

When:

➢ March 2025

How:

➢ Rapid and intense heat cycling, both manually and programmed, for long durations of time with serial inspections



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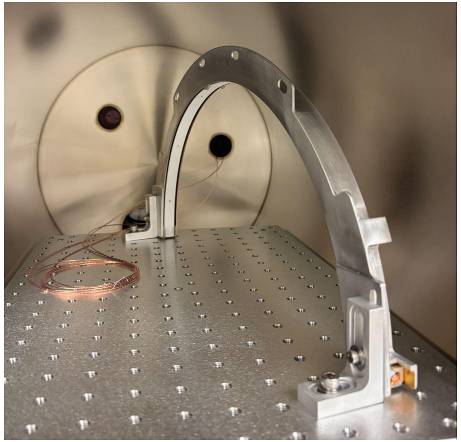
Theory/Testing - LIGO-E2500134

Alumina has about ¼ **the thermal expansion coefficient** of Aluminum

- 6.4µm/m-°C and 25.2µm/m-°C respectively
- Could result in **flaking off the alumina** under intense heating and cooling cycles
- Alumina may outgas unacceptable hydrocarbons onto optical coatings

Testing phases:

- Phase 1 (manual): 13V for 3½hr continuously followed by 13V in 30min increments for 7½hr
- Phase 2 (programmed): 13V for 1 week each of 1hr, 2hr, and 4hr increments
- RGA scans running the whole time & visual/wipe inspections conducted after each phase



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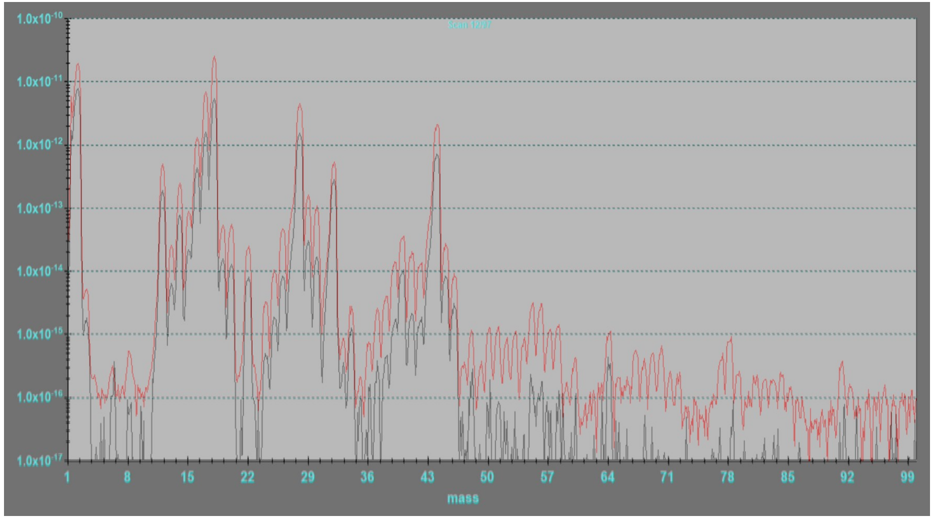
Results/Conclusion - LIGO-E2500134

After three manual trials and three programmed trials with RGA scans as well as two physical inspections, **no evidence of alumina flaking or excessive outgassing was detected.**

RGA Scans showed any increase in outgassing was within an acceptable range/can be partially attributed to noise (**Black=OFF**, **Red=ON**)



The only noticeable change was the resistance in the NiCr wire:

- ➢ Cold starting resistance: 16Ω
- ➢ Phase 1 hot resistance: 17.4Ω
- ➢ Cold ending resistance: 17.1Ω
    - ○ Suggests inelastic change in crystalline structure of NiCr under prolonged temperatures

Next Steps: Work with Don to develop a full size UF RH for implementation in the interferometer

Thank You for Your Time

Questions?

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