Optical Testbed and CMOS Camera Operation in a Vacuum Chamber

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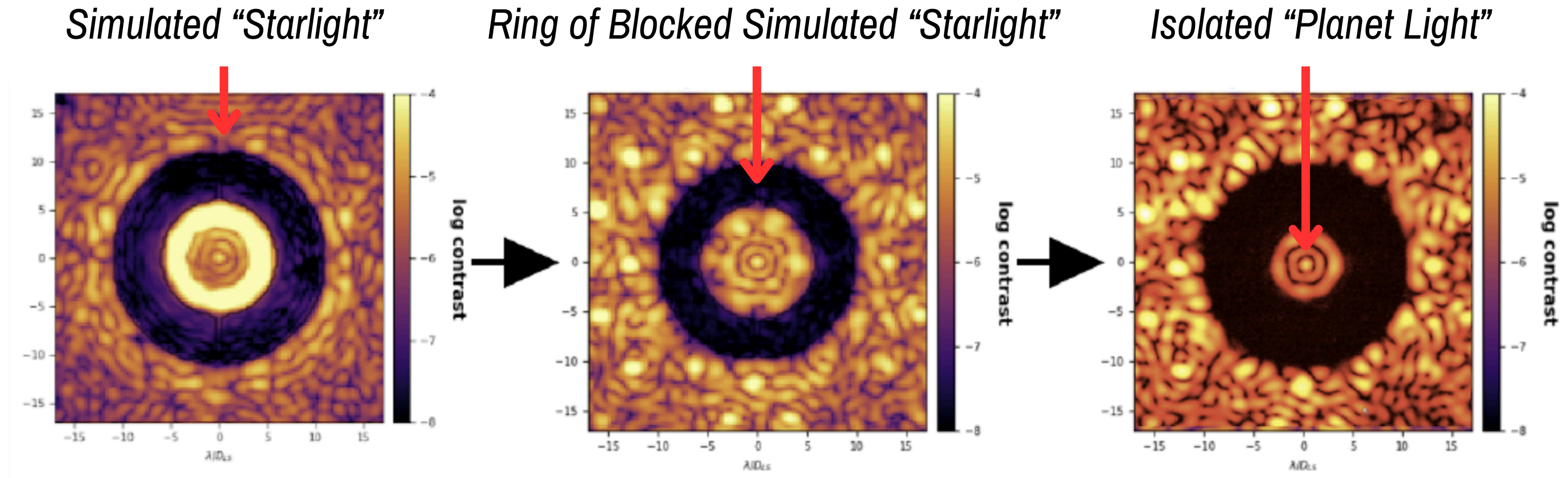
Background

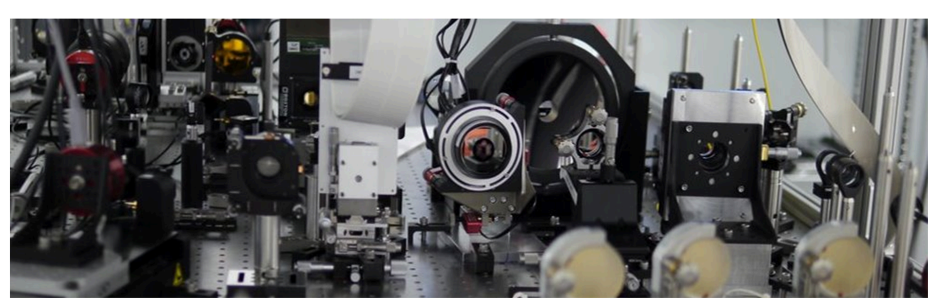
The Makidon Optics Lab at STScI works to advance high contrast imaging technology. By filtering starlight, it is possible to capture clearer images of exoplanets near stars, which is critical to the success of next-generation telescopes such as the Habitable Worlds Observatory.

Simulated "Starlight" — *Ring of Blocked Simulated "Starlight"* — *Isolated "Planet Light"*



Progress of image contrast over time where lower contrast = better results

The lab's primary testbed, the High-contrast Imager for Complex Aperture Telescopes (HiCAT), has reached limits in the level of contrast it can achieve due to vibration and effects from thermal expansion and contraction. To further high contrast imaging, further precision is necessary.



Current limitations
1) Ambient temperature fluctuations
2) Heat generation from electronics
3) Airflow Turbluence

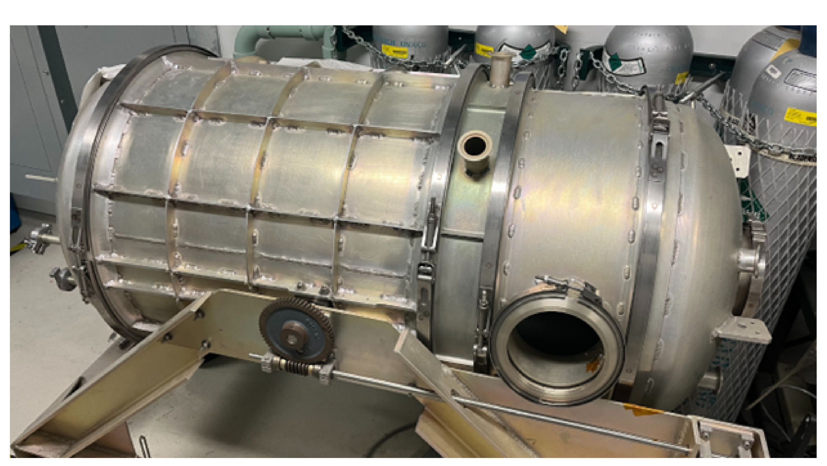
Photo of "High-contrast imager for Complex Aperture Telescopes" (HiCAT)

Achieving Further Precision: Testing in a Vacuum Environment

Testing in a vacuum mitigates many environmental factors which limit precision in high contrast imaging as it eliminates airflow turbulence, reduces ambient temperature fluctuations, and allows for better control over heat dissipation from electronics. ***The challenge?*** Electronics can no longer be cooled by air through convection and requires an alternate cooling method.

Project Objectives

STScI inherited a vacuum tank from NASA Goddard. The objective is to retrofit the vacuum tank with an optical table and modify/design a CMOS optics camera, equipped and ready for optics testing, to work in the vacuum for prolonged periods of time.

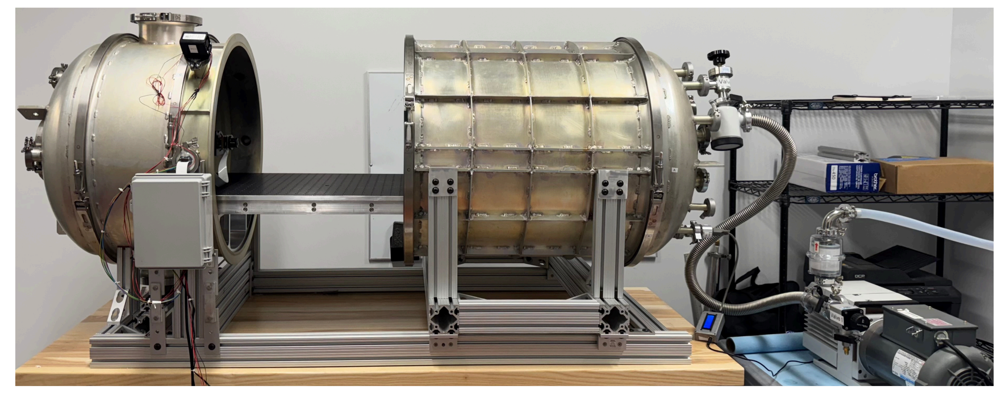


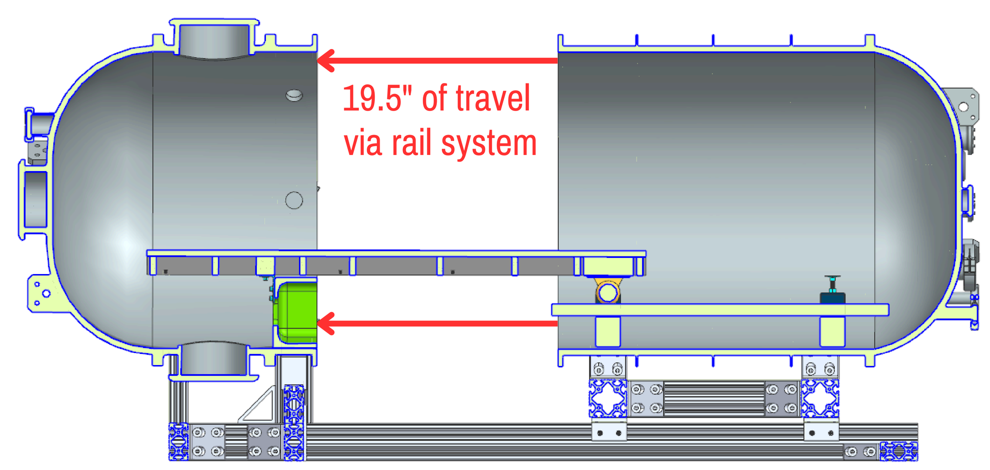
Vacuum Tank (Left), ZWO ASI533MC Pro USB3 CMOS Camera (Middle), Disassembled CMOS (Right)

Design Requirements

Ease of Use: Optical table must be easily accessible and operable by one adult human.
Vacuum Environment: Achieve internal pressure of <1Torr.
Imaging & Thermal Stability: Operate CMOS camera in vacuum for 3+ hours at maximum capture rate (20fps) without exceeding the maximum temperature (50°C).
Mobility: Able to move CMOS camera to different locations on the table with ease.

Vacuum Chamber & Optical Table





Vacuum chamber in open position

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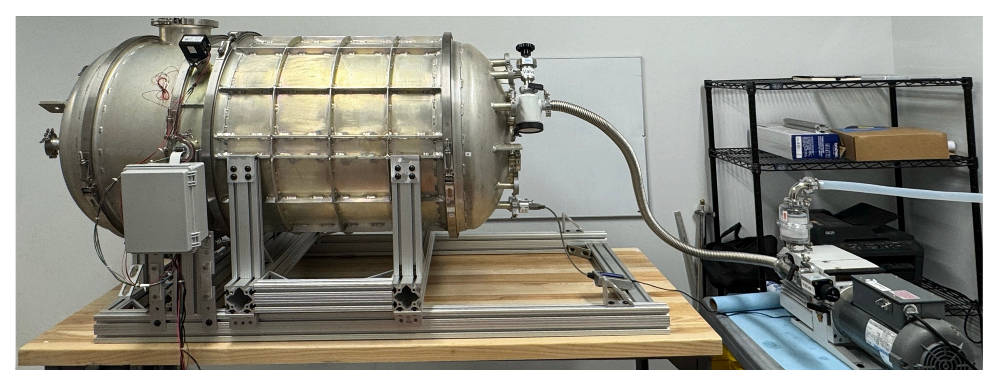
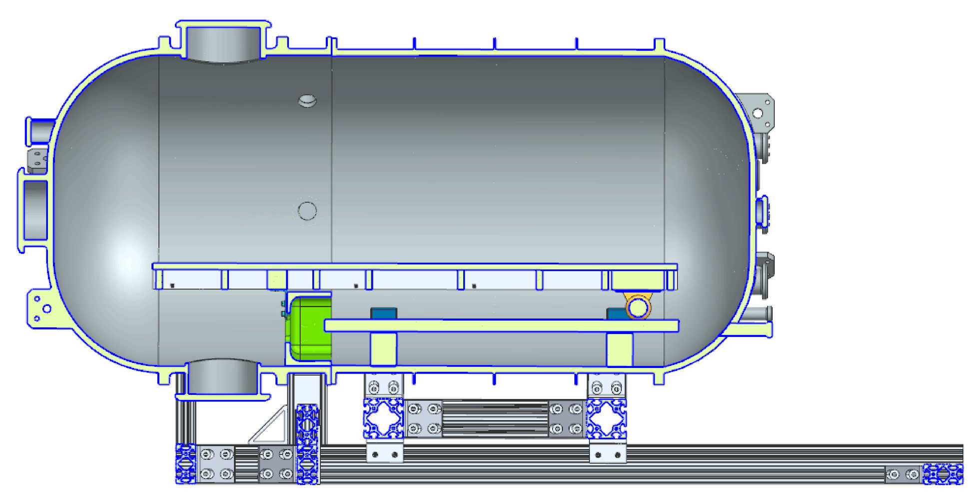
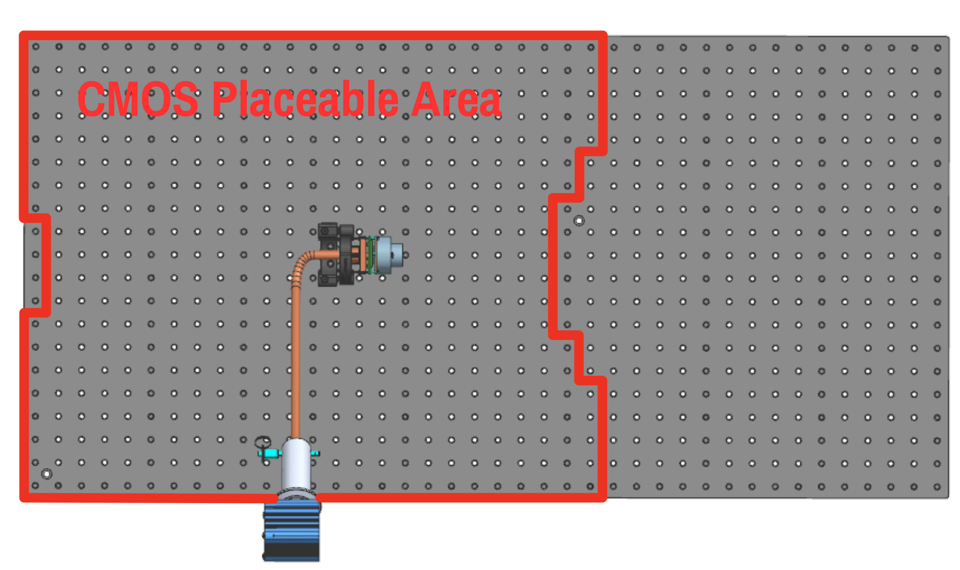




Vacuum chamber in closed position

Conclusions

- **Vacuum** Held pressure of <500mTorr
- **Thermal Stability** Reached steady-state of ~38°C and did not exceed maximum operating temperature over 3 hours
- **Ease of Use** Operable by one person
- **Mobility** Can be placed on 70% of the table



Imaging & Thermal Management System

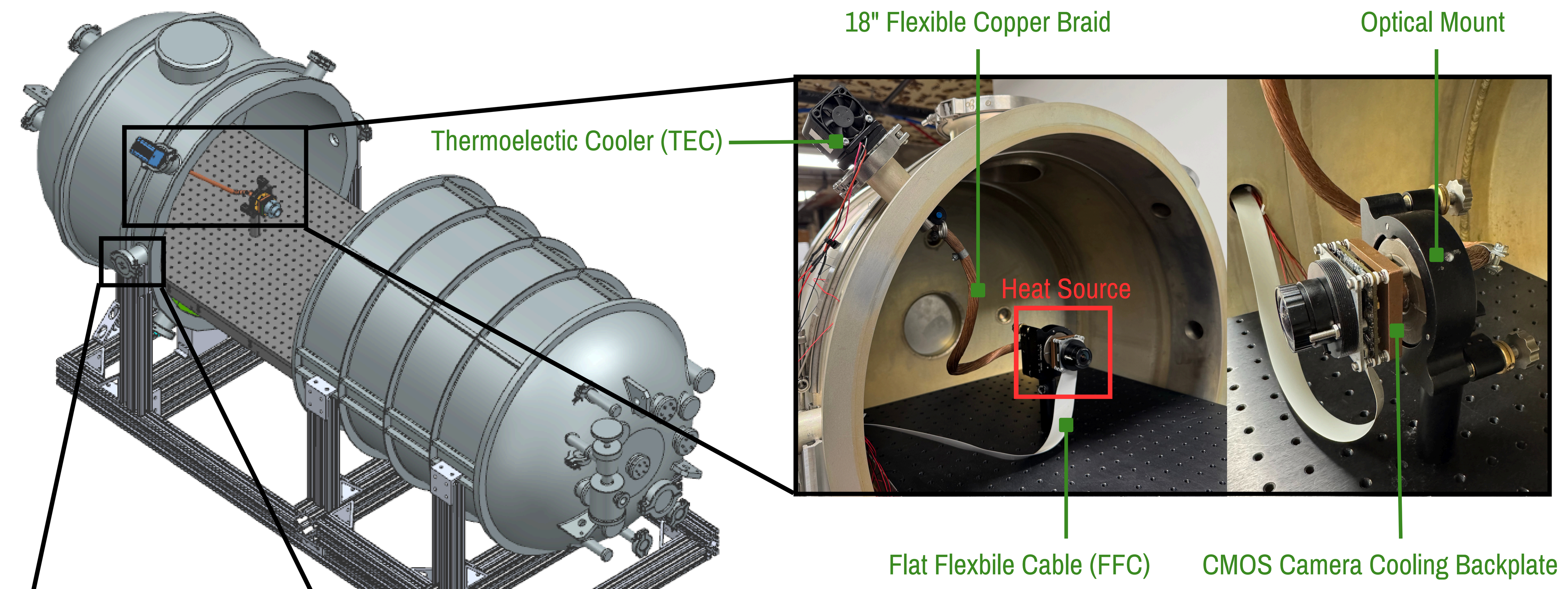
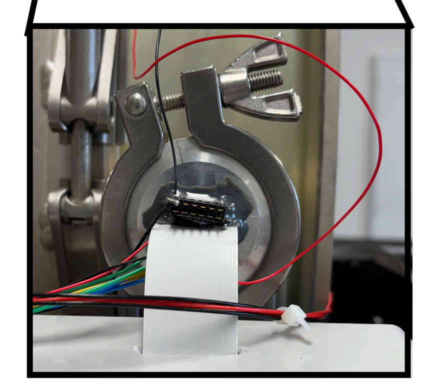
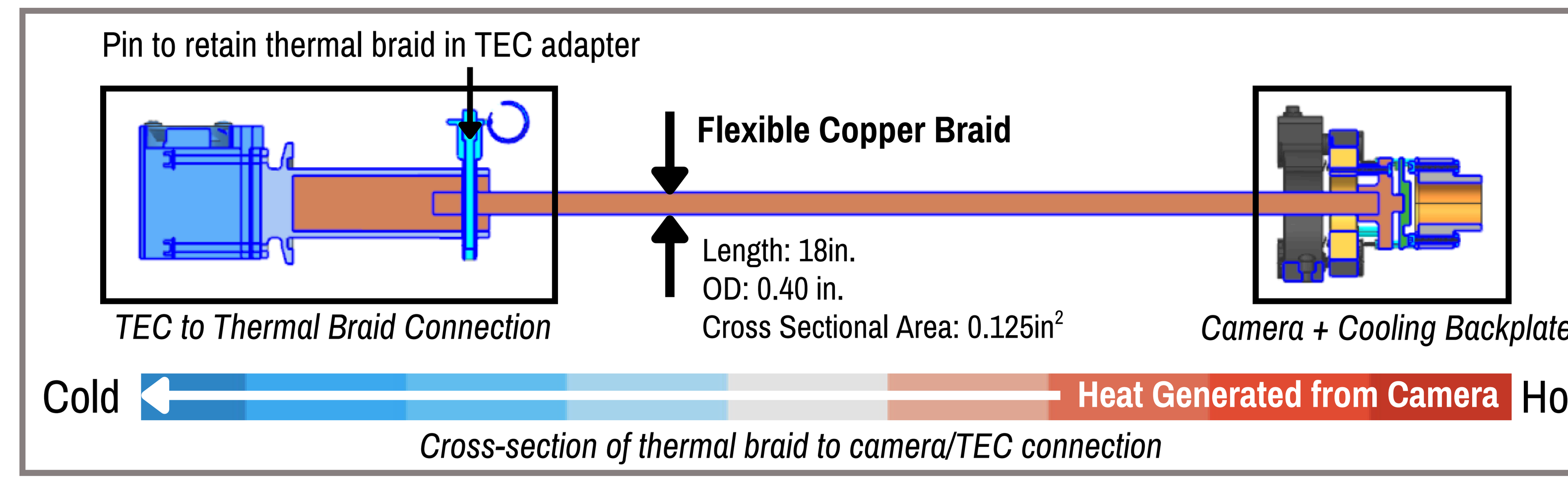


Photo of CMOS Camera & Thermal Management System



Electrical Passthrough

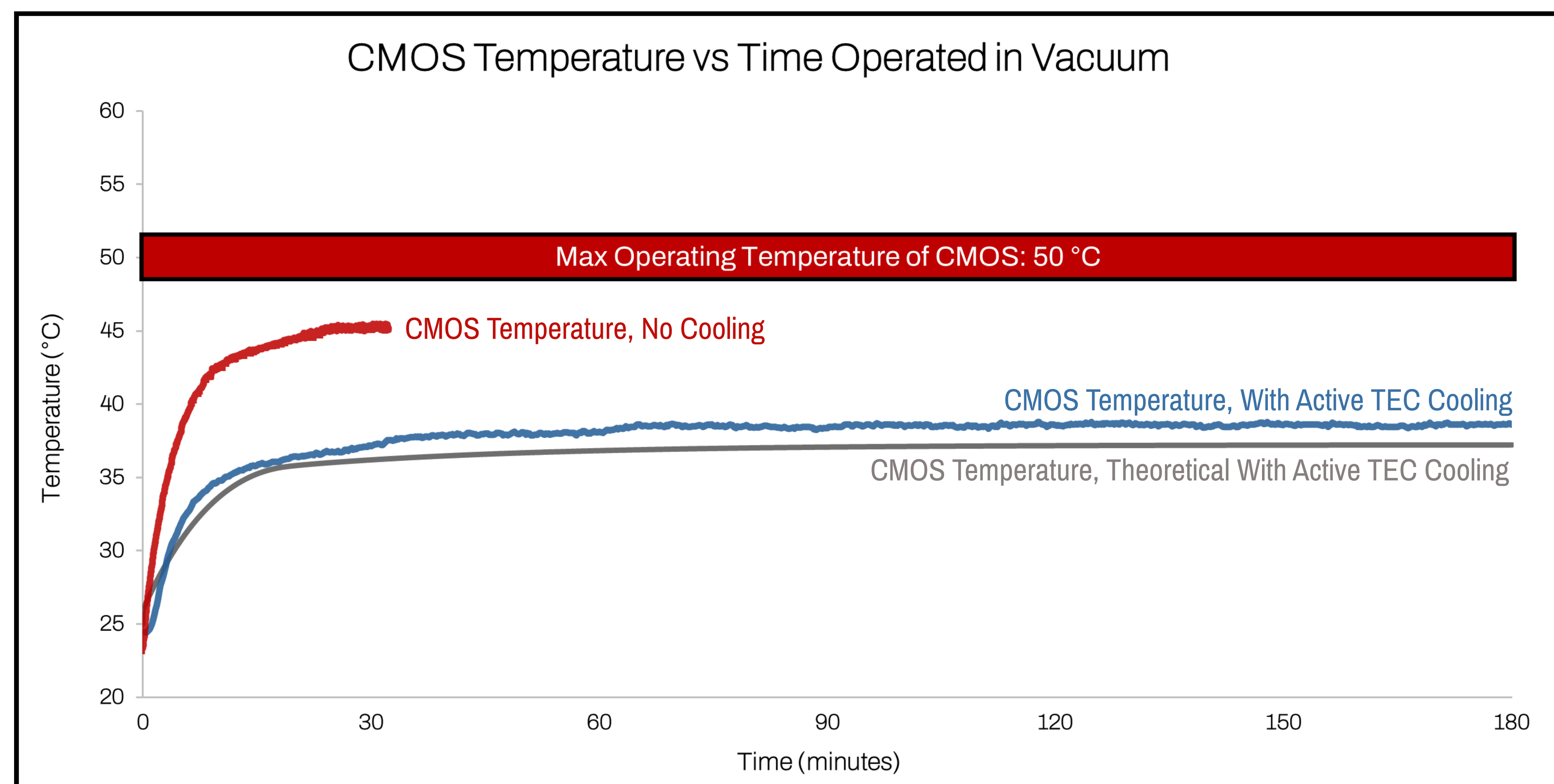


Cross-section of thermal braid to camera/TEC connection

Thermal Performance: Testing

To test the performance of the thermal management system, the CMOS camera was run continuously for 3 hours at its maximum capture rate of 20fps in the vacuum chamber whilst under a maintained internal pressure of less than 500mTorr.

Live image of CMOS camera in operation (Left)



Acknowledgements

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