Improving Experimental Variation in Optical Testing Enclosure

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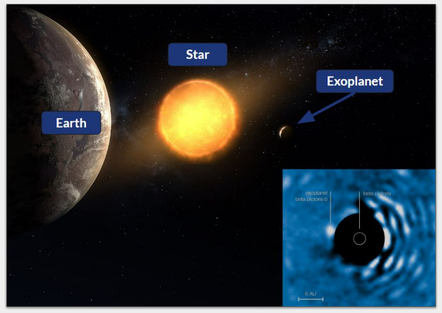
Introduction

The goal of NASA's future Habitable World Observatory is to find earth-like exoplanets with space telescopes. However, a nearby star's light can outshine the exoplanet making the exoplanet hard to see. Therefore, a star's light must be masked.

STScI has created HiCAT (High-contrast imager for Complex Aperture Telescopes) to mask a star's light.

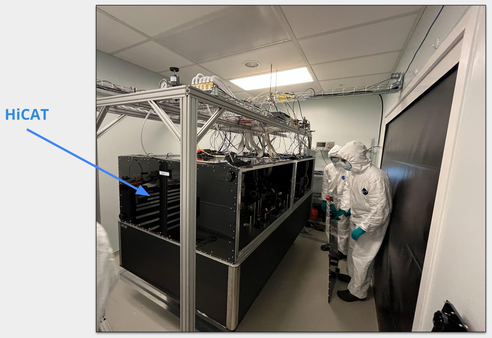
HiCAT uses a laser to simulate incoming starlight. This laser must be extremely stable, but testing conditions (humidity, turbulence, vibration) create undesirable laser beam propagation.



Project Goals

1. Identify & reduce vibration sources causing experimental error
2. Closed-loop-controlled humidity environment
3. Redesign top panel & cable paths to decrease airflow out of enclosure
4. Install a sub-enclosure to isolate the laser path from turbulence

Overview



Our project mainly focused on vibration reduction in HiCAT, where we found the source of vibration and determined how to best reduce it.

We implemented a valve system to control the injection of dry air, which reduces humidity. The most expensive hardware can only operate at low humidity. In addition, hygroscopic components introduce drifts in the beam path, hence the need for a closed-loop-controlled humidity regulation system.

We designed and installed now top panels to improve air leakage and cable management.

We built a sub-enclosure inside HiCAT to isolate important pathways from external turbulence.

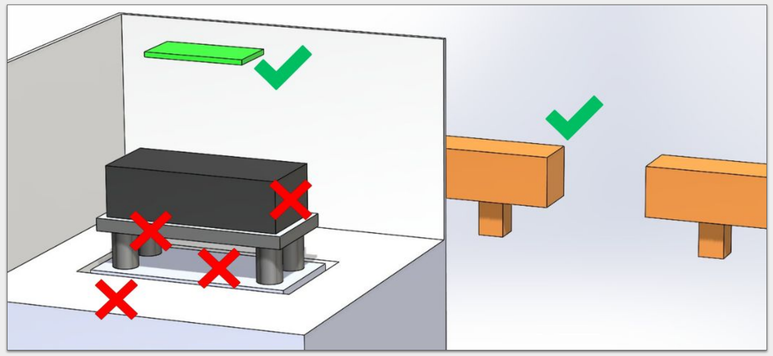
HiCAT is located in a cleanroom, meaning our solutions had to be compatible with the extremely clean conditions the room requires.

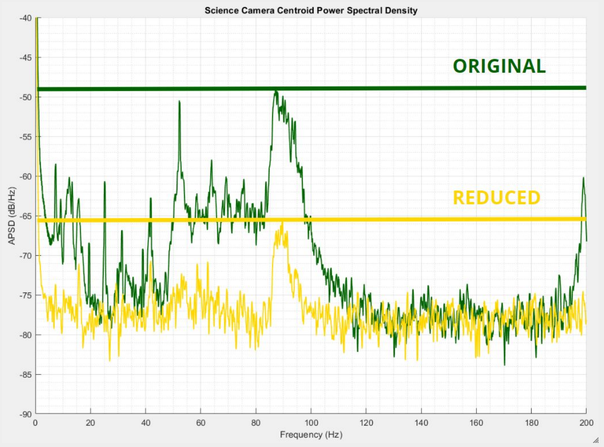
Vibration Source

A contributor to instability in HiCAT is vibration. Our main task was to find the source of the vibration.

Our initial tests focused on mechanical vibrations coming from the floor, table, or HiCAT enclosure itself. None of these were found to be the source.

In later tests, we found that vibrations were acoustically driven by the fan units above the enclosure and HVAC units external to the HiCAT cleanroom (green and orange below). To reduce their effect on experimental variation, we simply turn them off for the duration of the experiment.





Above: vibration reduction from HVACs being turned off

Valve

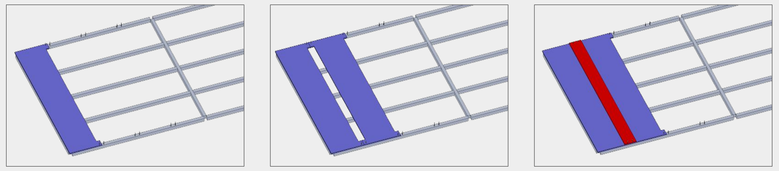
To control humidity, we made an automated valve system to constantly inject a controlled stream of cool and dry air into HiCAT.

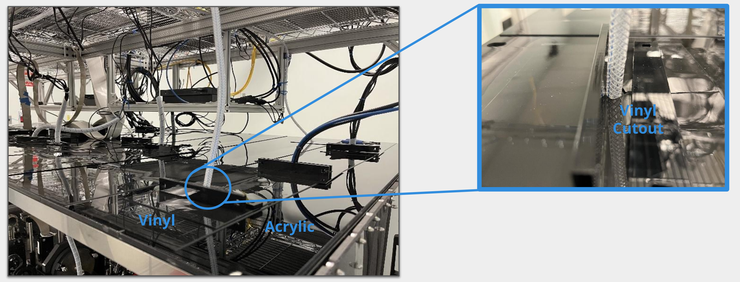
It also features a manual bypass that allows the user to flush the system and control the injection of dry air by hand.

Top Panel

In order to reduce air turbulence within HiCAT and decrease the amount of humid air entering HiCAT, the panels must seal the top of HiCAT including the electrical cables that pass through to power the optical equipment inside HiCAT. This was done via acrylic I-beam shaped panels and vinyl for sealing.

1. Place panel (blue) on HiCAT
2. Place 2nd panel (blue) on HiCAT
3. Lay vinyl (red) between panels





Sub-Enclosure

We initially designed some enclosures using 8020 and acrylic, but found that they would be too complex to remove, and didn't fit between the optical equipment.

The bent and rolled sheet metal panels did a much better job of addressing the objectives, and the THORlabs panels were powdercoated and cleaned to ensure clean room compatibility.