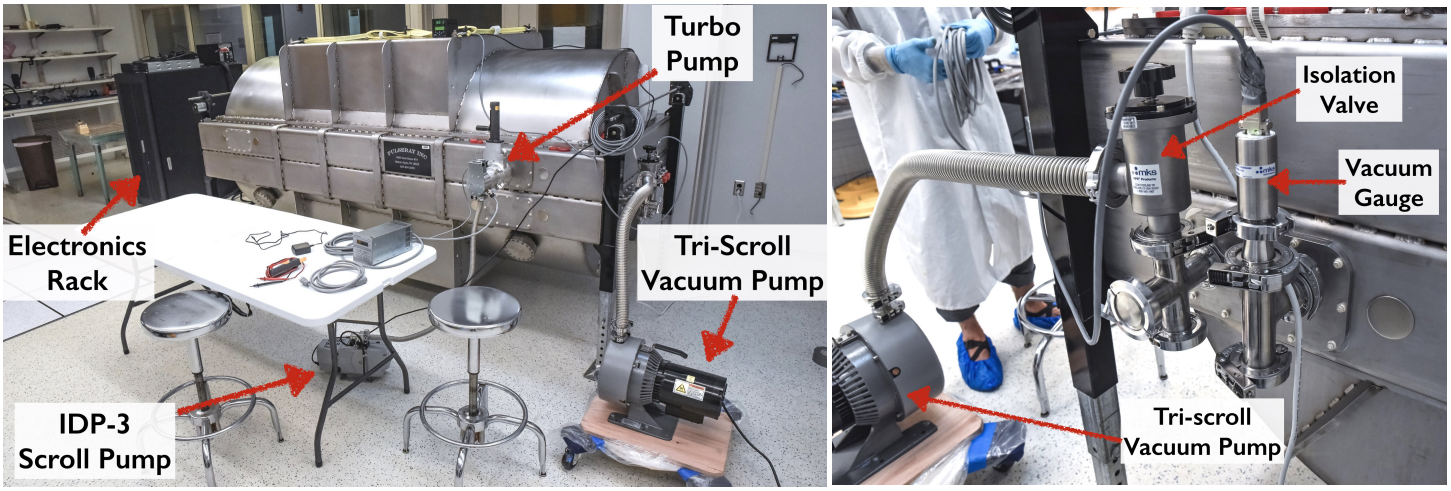
Initial rough vacuum quality of around 10^{-4} torr to 10^{-3} torr is achieved with a combination of vacuum pumps (see annotated photos in Figure 20). First, a large Tri-scroll pump from Agilent, is used to bring the pressure down to $0.1 - 1$ torr. From there a molecular turbo-pump (Turbo V 81-M from Agilent), and an accompanying dry-scroll pump (IDP-3 pump from Agilent) with a backing-isolation valve bring the pressure down further to 10^{-5} torr, a regime where the charcoal absorbers can take over, and bring the vacuum down to 10^{-7} torr level. Two sets of vacuum gauges are used to monitor the pressure in two independent ways: a HPT 200PB Digital Pirani Bayard-Alper gauge from Pfeiffer, and a 972B Dualmag Cold Cathode/Micropirani gauge from MKS. Both gauges can measure pressures from atmospheric pressure, down to 10^{-8} torr or better.



(a) (b)

Figure 20: Vacuum pumpdown setup during the initial HPF vacuum test at MRI, showing a) the large Tri-Scroll roughing pump, turbo pump, and accompanying IDP-3 scroll pump; b) a close up image of the vacuum ports on the West side of HPF cryostat, showing the MKS vacuum gauge, and Tri-scroll pump.

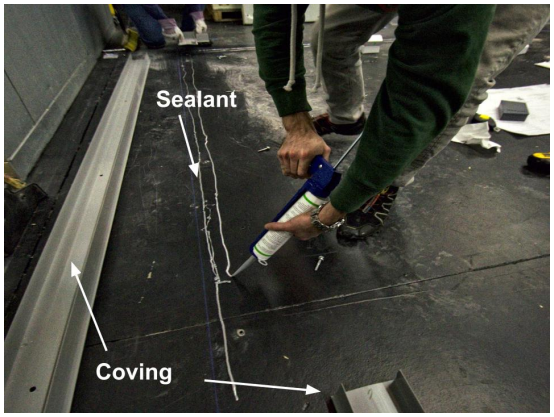
3.2.6 HPF Thermal Enclosure at the Hobby-Eberly Telescope (HET)

HPF will sit in a thermal walk-in closure from Bally Refrigerated Boxes Inc, located in the Hobby-Eberly Telescope (HET) Spectrograph Room. It will act as a passive buffer to smooth out any short-time high-frequency temperature variations. During installation of the enclosure in November 2014, a temperature monitoring system was also installed, to characterize the performance of the enclosure, and the HVAC system in the Spectrograph Room.

Installing the HPF Enclosure A photo of the HET Spectrograph Room before installation of the enclosure is shown in Figure 21a. The panels are kept in place by plastic covings that were bolted to the floor with cement-anchors. The covings were insulated with sealant using a caulking-gun (on the coving-floor interface—see Figure 21b) to thermally seal the enclosure to the floor, increasing its overall thermal performance. Holes were drilled on the top

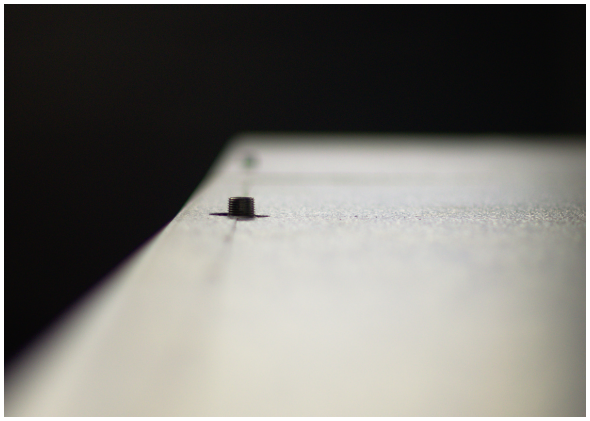
of the enclosure (see Figure 21d) to reach down to the electrical conduits that run through the enclosure. A time-lapse video of the enclosure installation can be found on YouTube[3].

(a) Before Installation



(b) Thermally sealing the coving

(c) After Installation



(d) Top panels: Electrical conduit pipe

Figure 21: **a) Before installation:** The *HRS enclosure* is the white box on the left, *the HPF Calibration enclosure* is the silver box in the middle, some of the enclosure panels can also be seen to the right. **b) Thermally sealing the coving:** The enclosure panels were kept in place by fitting them into covings that were thermally sealed with sealant to the Spectrograph Room floor. **c) After installation:** HPF will sit inside the enclosure inside a clean room which is yet to be installed. A 6 foot sliding door—big enough for HPF to get through—covers the opening. **d) Electrical conduits:** Holes were drilled from the top panels to reach the already installed electrical conduits that run through the enclosure.

Performance Figure 22 shows an annotated image of the temperature monitoring system. It monitors the temperature of six PT-100 sensors. The locations are shown in Figure 23, i.e. high and low a) inside the Spectrograph Room, b) inside the Calibration Enclosure, and c) inside the HPF enclosure.

[3]Video link: https://www.youtube.com/watch?v=ZuZU4N9oSek

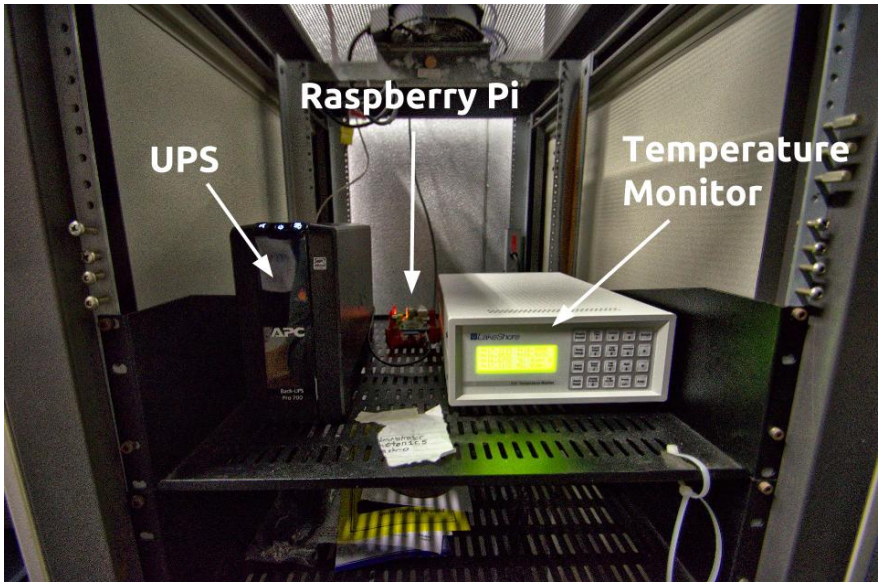


Figure 22: An annotated image of the temperature monitoring system at the HET Spectrograph Room, showing a) a UPS supplied by McDonald Observatory, b) Raspberry Pi control computer that logs the temperatures from c) the LakeShore temperature monitor, hooked up to the 6 PT-100 temperature sensors shown in Figure 23.

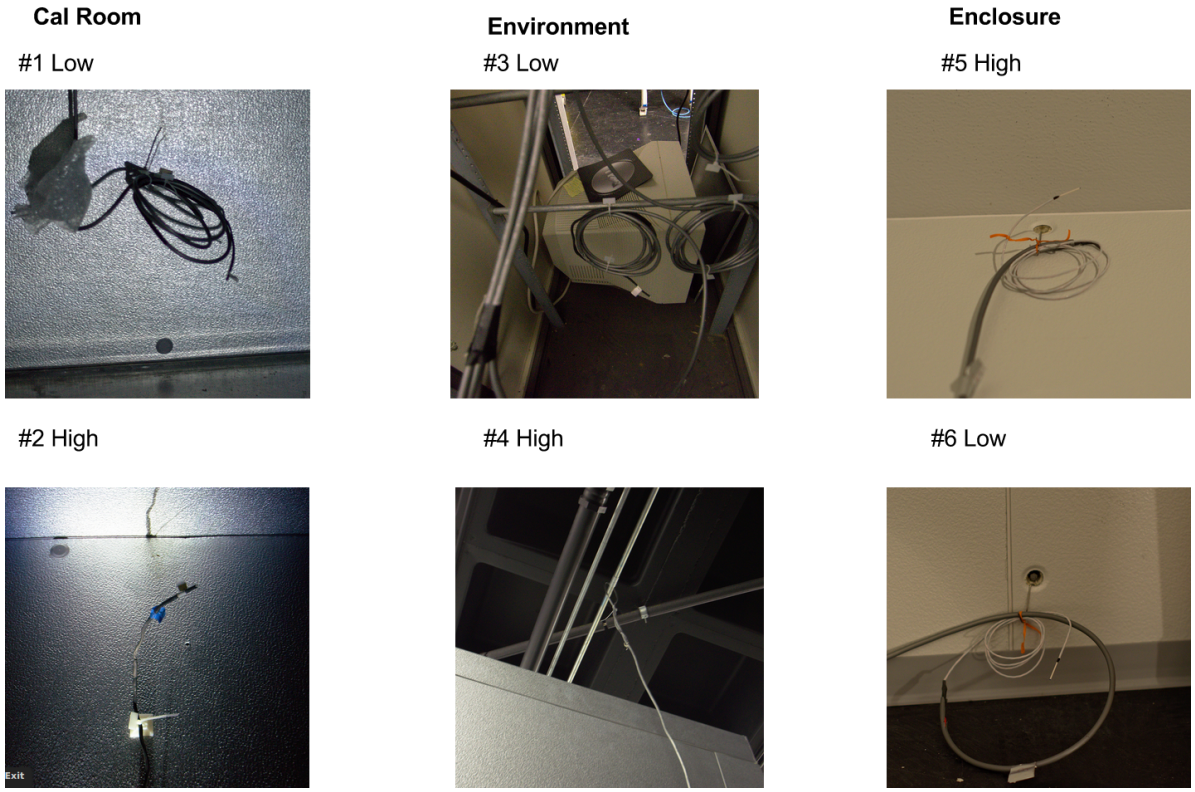


Figure 23: Locations of the 6 PT-100 temperature sensors placed high and low in: the HPF Calibration Enclosure (sensors #1, #2), outside environment (sensors #3, #4), and inside the HPF enclosure: (sensors #5, #6).

Figure 24 summarizes the results from the temperature monitoring from November 2014, to July 2015. We see that the HPF enclosure effectively buffers out high-frequency temperature changes in the Spectrograph Room due to HVAC cycling. However, we do observe long-term trends that print through the enclosure. These are the trends HPF will see. We have been in contact with the HET Observatory Staff about this issue. They are currently working on modifying the HVAC controlling system, in hopes of gaining better control of the long term temperature swings. We will continue to monitor the progress.

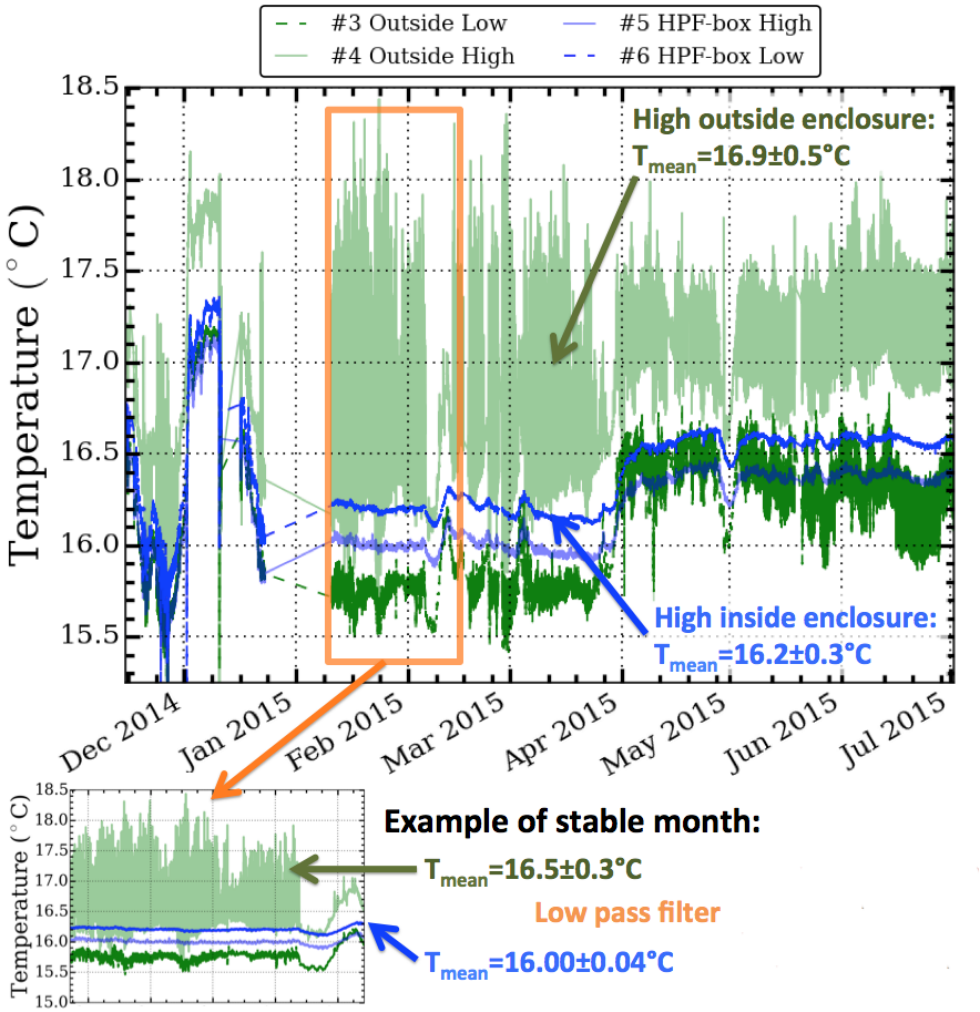


Figure 24: The upper graph shows the temperature vs time from November 2014 to July 2015, for sensors #3, and #4, (green) low and high outside the HPF enclosure, and for sensors #5, and #6 (blue) high and low inside the HPF enclosure. We see that the enclosure works as an effective buffer for HVAC cycling inside the Spectrograph Room, especially when a temperature-quiet month (lower inset graph) is considered. The temperature data for the Calibration Enclosure was not plotted for clarity.