Radial Velocity Technology Fusion: Combining Compact Adaptive Optics and Externally Dispersed Spectrographs

Principal Investigator: J. Kent Wallace, Optics Section (383)
Eugene Serabyn (326), Eric Cady (383), Luis Marchen (383)
Program: Strategic Initiative

Project Objective:

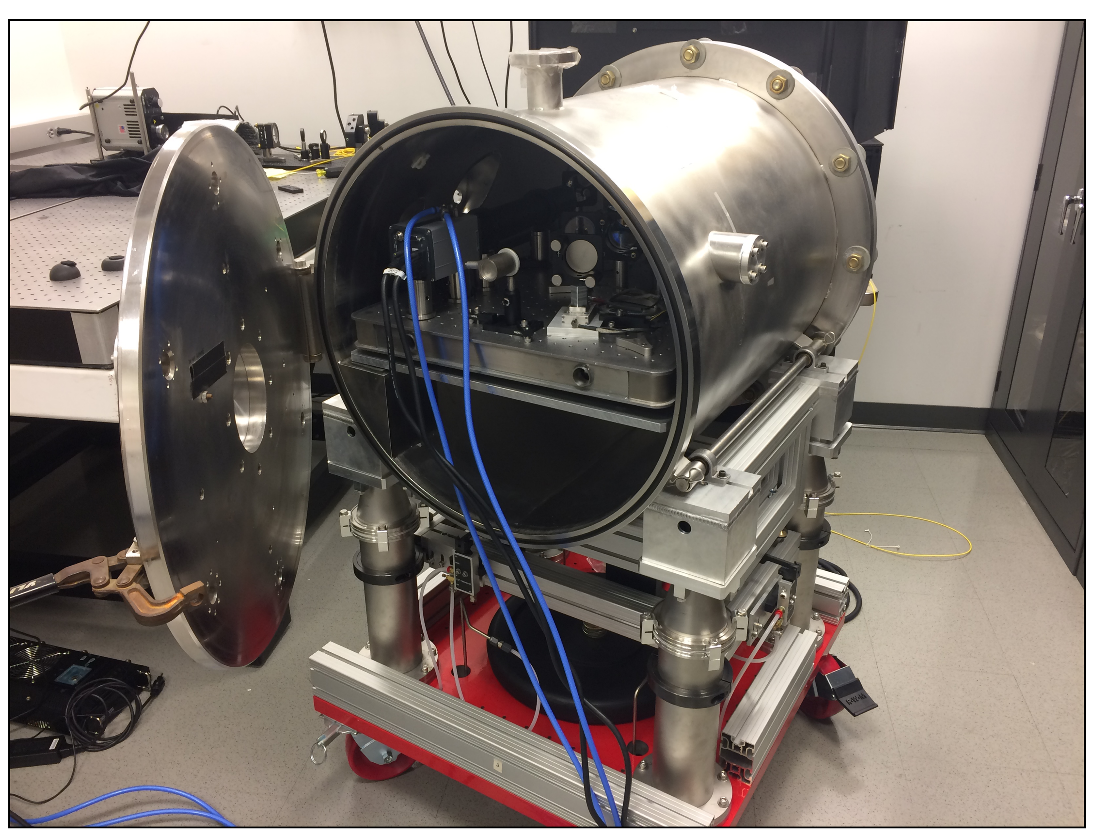
•Mature the precision single-mode fiber fed radial velocity instrument.

•Build and operate a compact adaptive optics system to couple light into a single mode fiber.

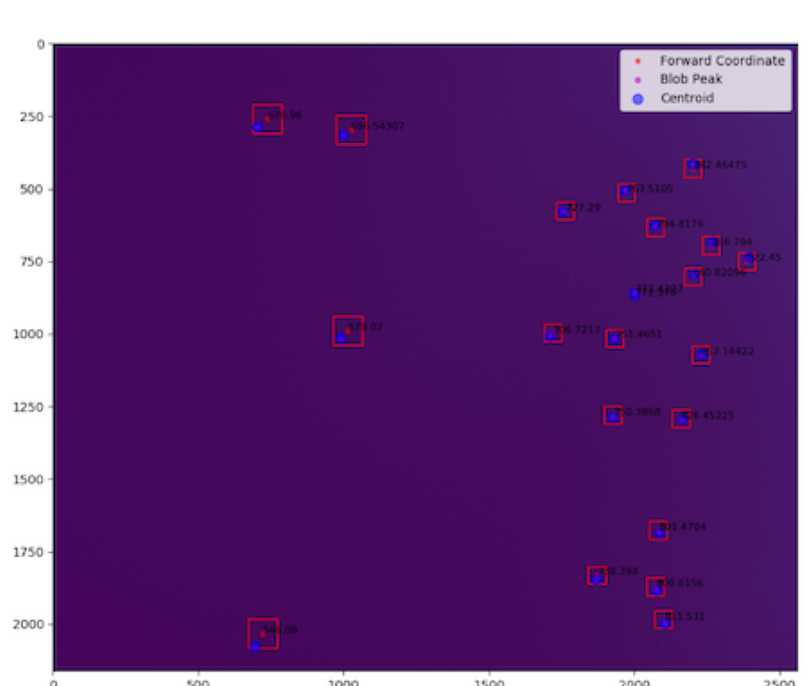
FY19 Results:

- **We successfully completed the wavelength calibration of the externally dispersed single-mode fed RV spectrograph.**
- **Designed the Pyramid Wavefront Sensor portion of the Compact AO instrument.**
- **Assembled, aligned and tested the Compact AO system**
- **Built up the realtime control software and hardware**
- **Integrated the realtime control computer with the key subsystem interfaces:**
  - **Deformable Mirror**
  - **Wavefront Sensor Camera**
  - **Tracking Camera**
  - **PZT Tip/tilt Stage**
- **Calibrated the Deformable Mirror influence functions**

Precision Radial Velocity



The VERVE Instrument is a single-mode fiber-fed externally dispersed echelle spectrograph. It covers the visible portion of the spectrum with a resolving power of ~ 20,000.



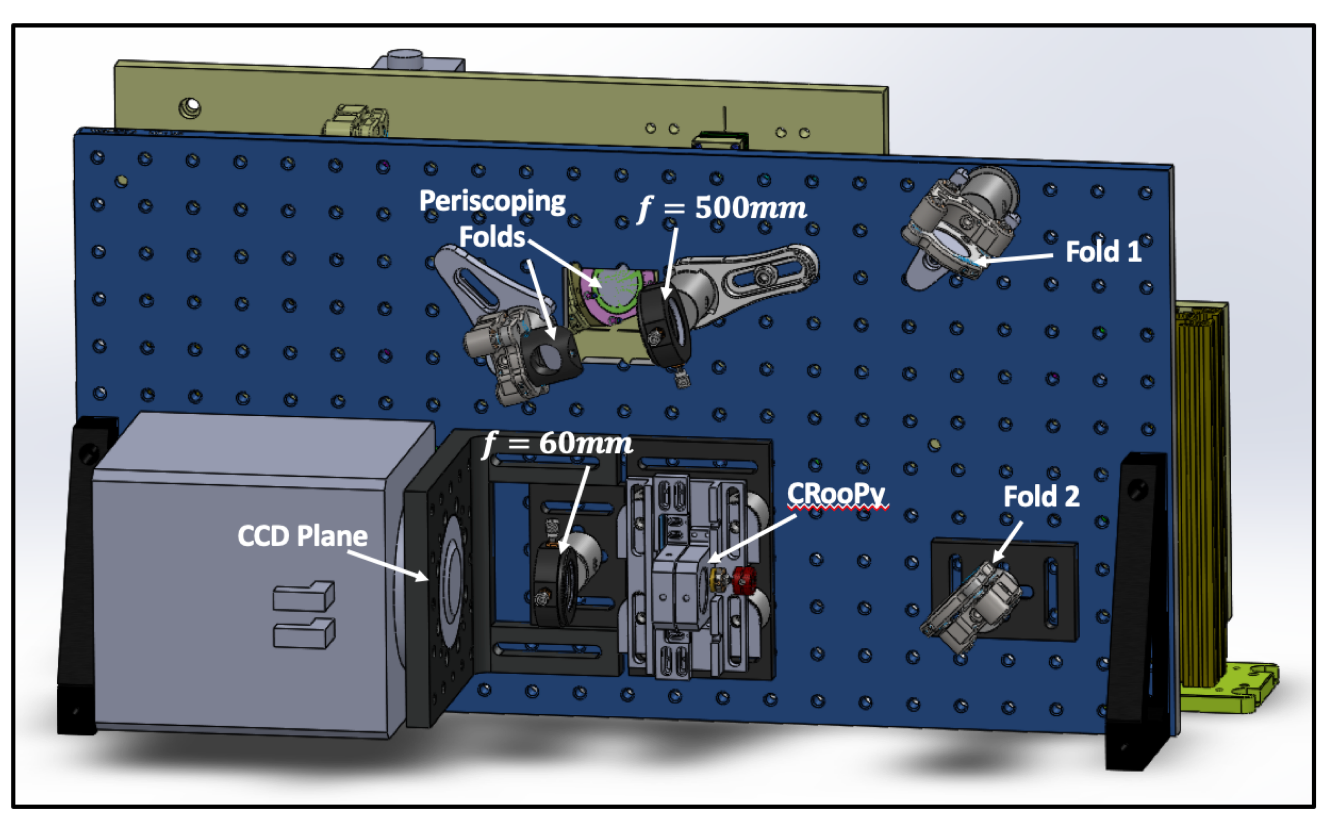
Spectral calibration of the instrument achieved wavelength calibration at the ~ 2 pixel level (0.1 nm) which is consistent with a 10cm s^{-1} detection limit.

Benefits to NASA and JPL:

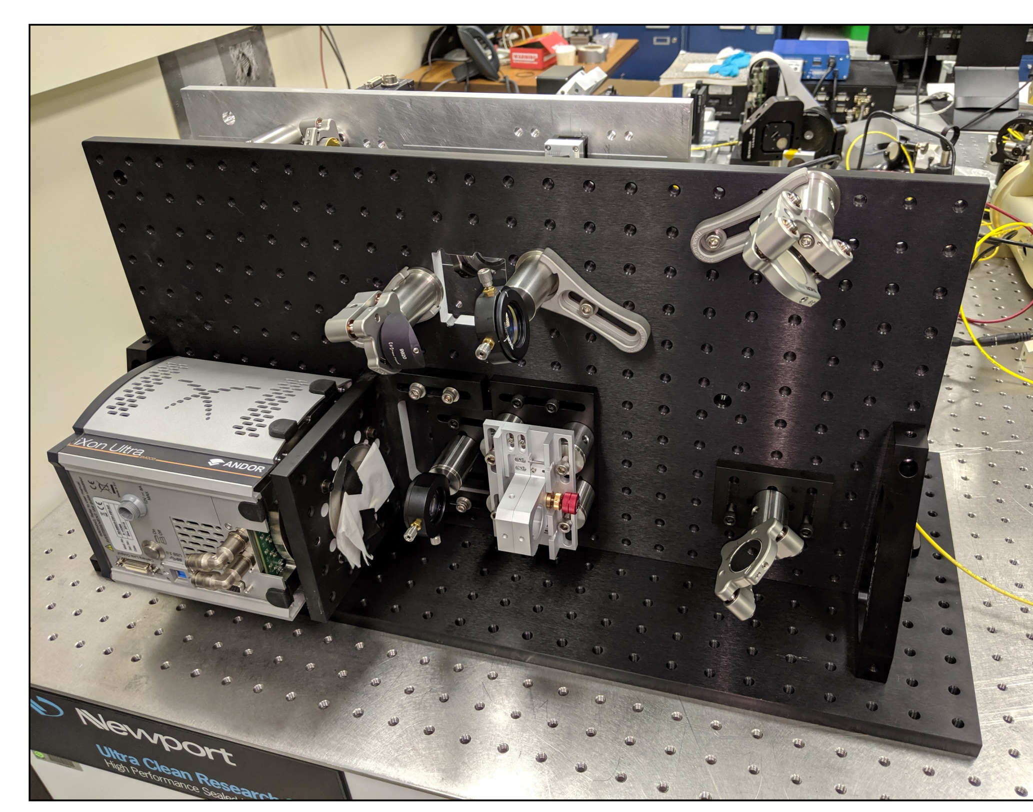
- Ground-based precision radial velocity measurements support NASA science mission objectives for: 1) target identification, 2) follow-up validation and characterization, and 3) mass and orbit determination.
- The need to complete the census of neighborhood stars down to Earth masses, along with follow-up of planetary candidates from NASA transit missions such as *Kepler* and *TESS*, are dramatically increasing the need for ultra-precise Doppler technology
- These NASA missions include Kepler, TESS, JWST, WFIRST, and future HABEX/LUVOIR missions

Compact Adaptive Optics

- Opto/mech Hardware

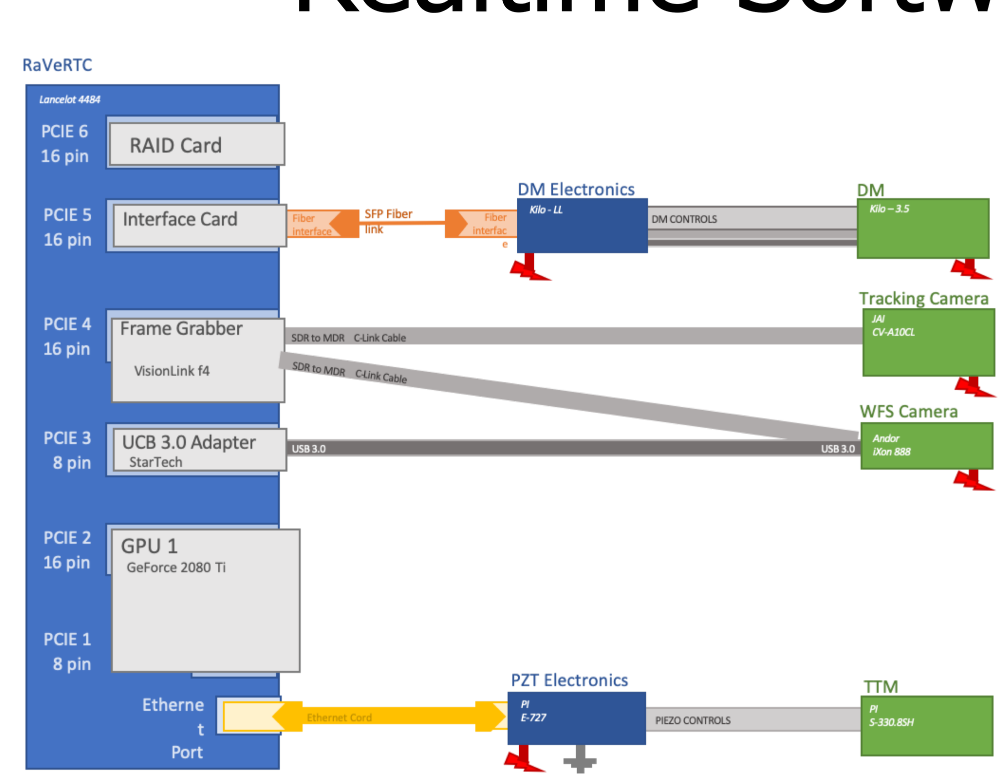


The wavefront sensor arm of the Compact AO system used a transmissive pyramid wavefront sensor. This wavefront sensor arm enhanced the nominal DM relay design from the Keck Planet Imager and Characterizer (KPIC).

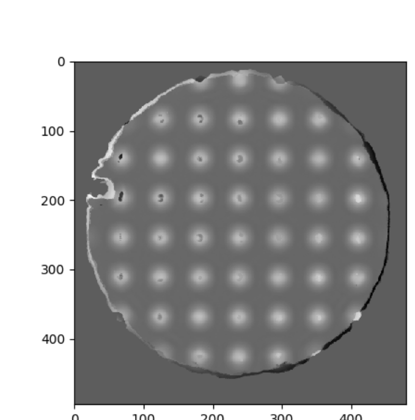


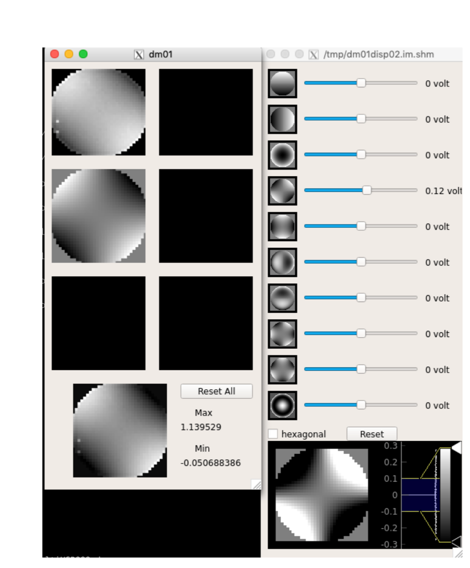
The final, fully assembled hardware is shown in this figure. The plate closest in the image shows the pyramid wavefront sensor. The hidden vertical plate has the optical relay with the deformable mirror and fiber injection optics.

- Realtime Software/Instrument Control



Hardware architecture for the realtime control system. The key subsystems are: deformable mirror, pyramid wavefront sensor, tracking camera, and fast steering mirror.





The software interface to the DM is via a GUI that controlled the mirror shape via low-order Zernike polynomials. The response of the actuators was measured via a square poke pattern for all of the mirror actuators.

Publications: None.

PI/Task Mgr. Contact Information: J. Kent Wallace
Email: James.K.Wallace@jpl.nasa.gov

Poster No.:RPC-107