



THE PALOMAR RADIAL VELOCITY INSTRUMENT

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SEPTEMBER 2019

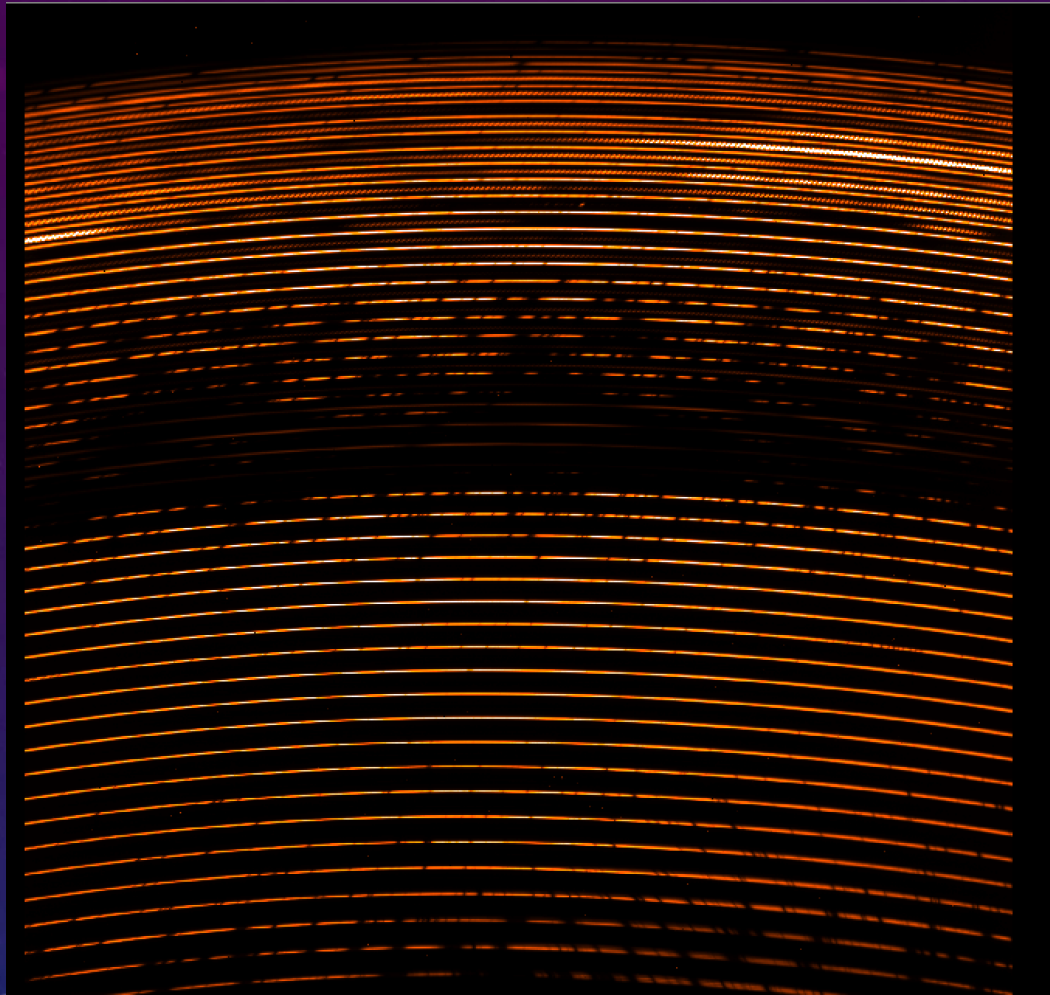
OVERVIEW

- The PALomar Radial Velocity Instrument (PARVI) is a AO-fed precision RV spectrograph operating with $R \sim 100,000$ spectral resolution between 1.2 and 1.8 μm .
- PARVI has three primary components:
 - The fiber coupling unit which couples the output of the P3K ExAO system into a single-mode fiber (SMF)
 - The fiber-fed diffraction-limited spectrograph
 - The Laser Frequency Comb (LFC) which (along with several gas cells) provides wavelength calibration
- PARVI was deployed at Palomar Observatory this summer, with commissioning runs in June and July.

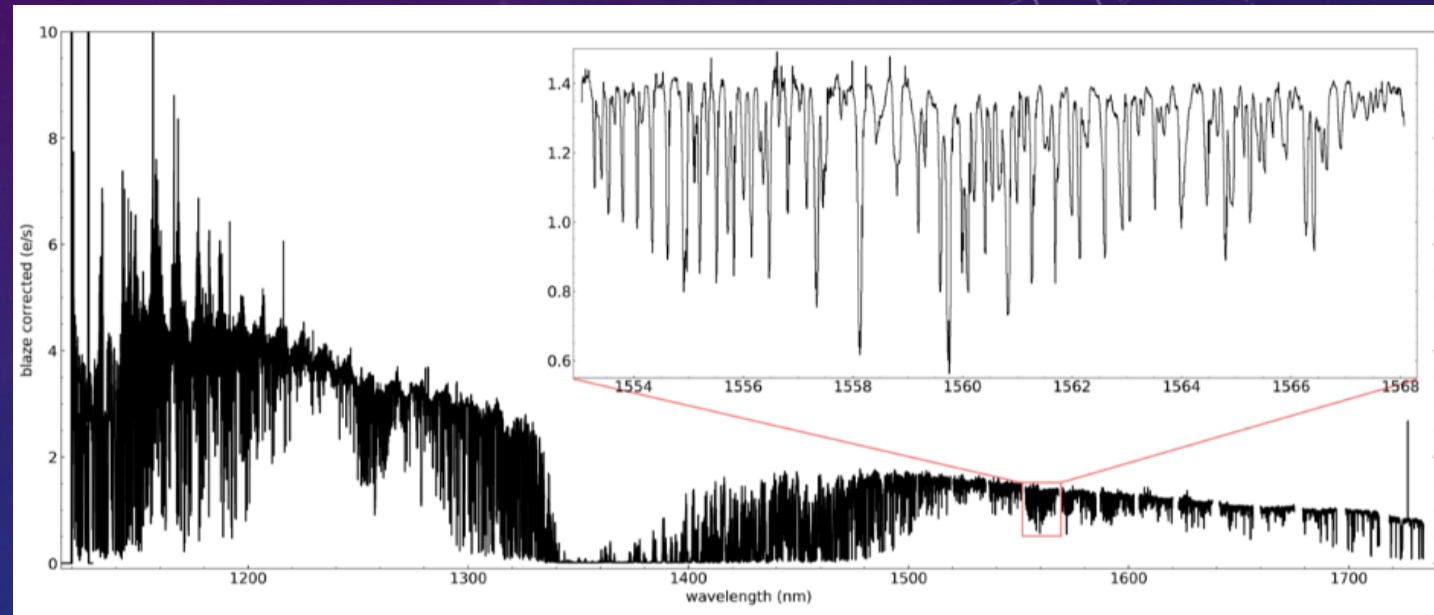
SCIENCE MOTIVATIONS

- Exoplanet Science
 - RV detection
 - Transit spectroscopy
 - Young stars
 - M-dwarfs
- Stellar Characterization
 - Characterizing sources of Astrophysical jitter
 - Brown dwarfs
- High-resolution near-IR spectroscopy

FIRST LIGHT ESCELLOGRAM AND SPECTRA FOR ARCTURUS (JUNE 14TH 2019)



First light Eschellogram for Arcturus



Extracted spectra for Arcturus

CURRENT STATUS

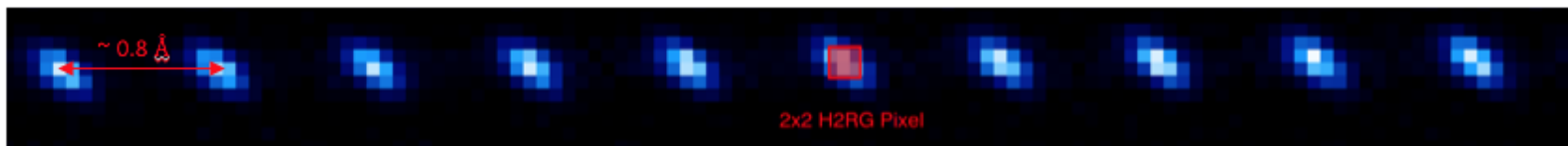
- PARVI has been installed at Palomar Observatory and has moved to the commissioning phase.
 - We have demonstrated successful operation of all three major components of the system on-sky.
- Total throughput on-sky is $\sim 0.25\%$ for point sources ($\sim 2.5\%$ for extended sources).
 - Currently only $\sim 10\%$ of the light is coupling into the SMF, believed to be due to static wavefront error in the fiber coupling bench.
 - We expect throughput to increase by a factor of x3-10 after planned upgrades in the coming months
- The data reduction pipeline and system control software are currently in development.

PLANNED UPGRADES

- The fiber coupling bench will be realigned with minor upgrades to relax constraints on the beam input.
 - ADC prisms have been designed and will be manufactured, installed, and calibrated in the upcoming year.
 - The current doublet lenses used for collimation and fiber coupling will be replaced with OAPs to remove chromatic effects and reduce static wavefront error.
 - The operation of the CRED2 guide loop will be improved to allow better tracking on faint sources.
 - Our CRED2 is being repaired by FirstLight to resolve a condensation issue
- The spectrograph will be opened in the coming months for upgrades
 - The current engineering-grade grating will be replaced with the final science grating, significantly improving efficiency.
 - The fiber collimator mount is being replaced with an Invar design to reduce errors in the fiber position after cool down.
 - Baffling will be improved to reduce the background in the cryostat.
- The LFC will be upgraded to provide better stability and improve spectral flattening.

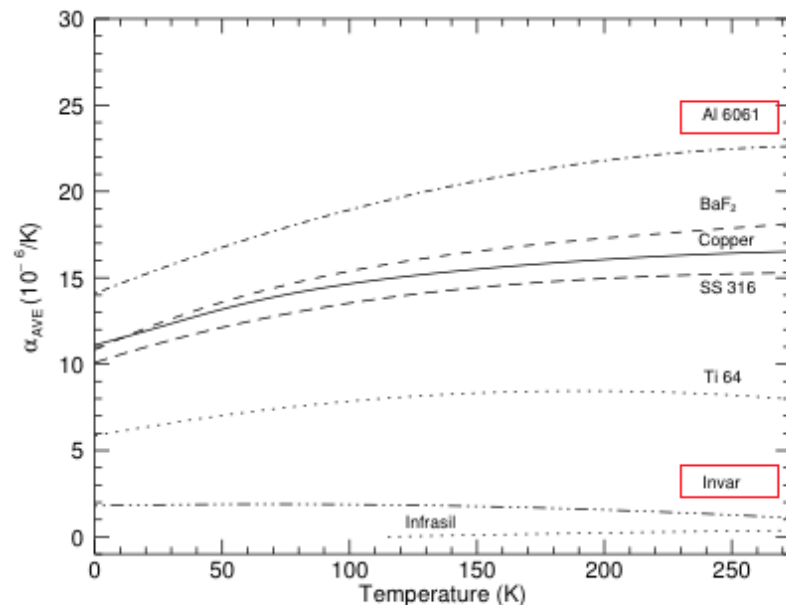
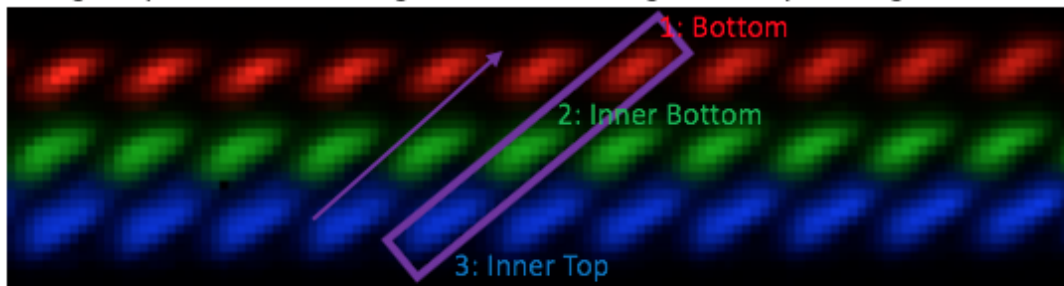
Warm PSF Image Quality on CRED detector

Measured FWHM is 2.2 pix (spectral) and 2.6 pix (spatial) (pix = 18 μm)



Cold PSF Image Quality on H2RG detector

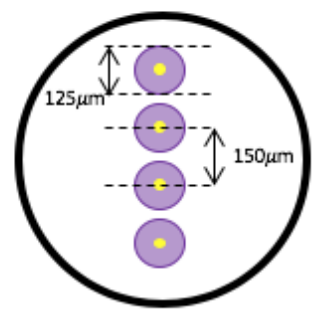
Measured FWHM is 2.7 pix (spectral) and 4.4 pix (spatial) in bottom fiber. Cold image quality depends on fibers position along the pseudo-slit meaning aberration is being caused by mis-alignment of fiber to collimator.



Aluminum (CTE = 18 ppm/K) \rightarrow Invar (CTE = 2 ppm/K)
 Predicted fiber displacement wrt OAP when going from 293K to 80K

- De-focus = 364 μm \rightarrow 40 μm
- Up/Down = 65 μm \rightarrow 7 μm
- Left/Right = 167 μm \rightarrow 18 μm

Fiber Array Layout



Object Plane

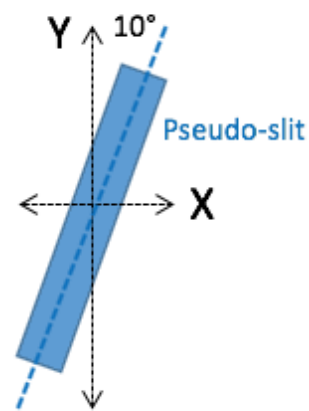
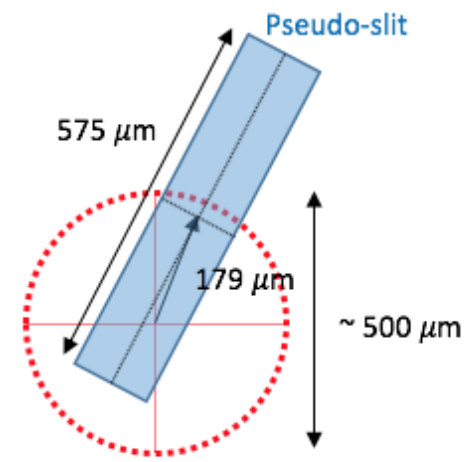
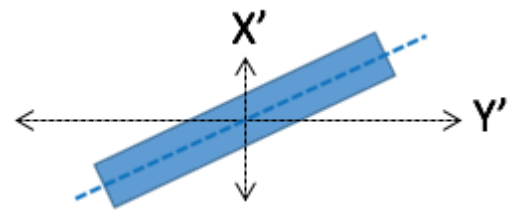
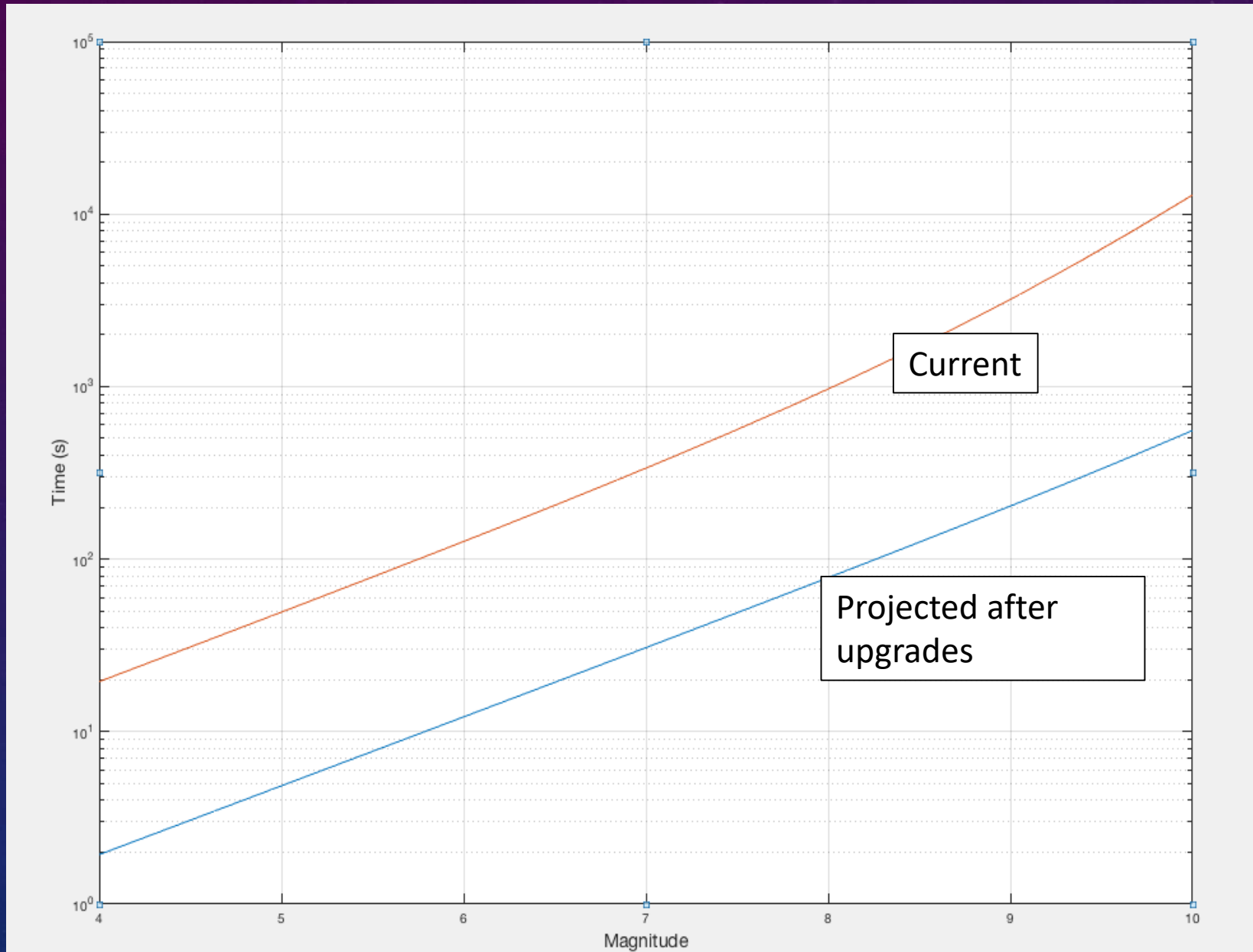


Image Plane



Collimator F/4 FOV
 (area that gives > 90% Strehl)

MEASUREMENT TIME FOR SNR 40 VS TARGET MAGNITUDE



CONCLUSIONS



- PARVI is a precision RV spectrograph currently being commissioned at Palomar Observatory operating in the J and H bands.
- The system uses a fiber-fed diffraction-limited design with an ultimate goal of ~ 30 cm/s RV sensitivity.
 - We estimate the current precision to be ~ 1 m/s (due to residual temperature drifts)
- After upgrades in the coming months the instrument will be back on sky in November, taking advantage of the upgraded P3K AO system.
- We have 6 remaining nights scheduled in 2019, 3 in January 2020, and are proposing for 16 more in 2020A.

PARVI is not being offered in general call for 2020A. However, if folks are interested in proposing for targets we will observe them on a shared risk basis during the 8+8 nights that we will request from JPL and Caltech.