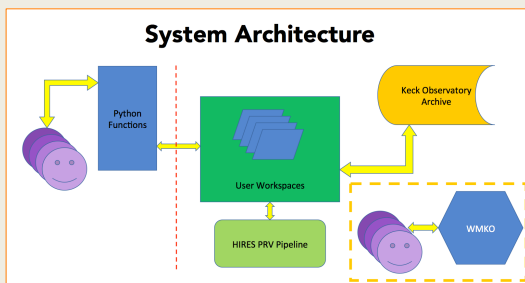# Breathing New Life Into An Old Pipeline:
Precision Radial Velocity Spectra of TESS Exoplanet Candidates
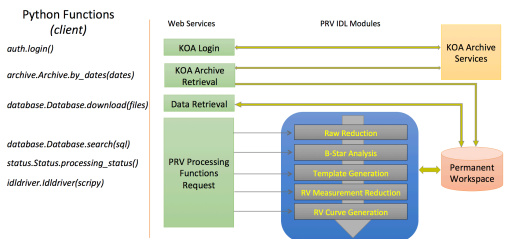
G. B. Berriman, **D. Ciardi**, **J. Good**, **B. J. Fulton**, **M. Kong** (Caltech/IPAC-NExScI), **H. Isaacson** (University of California, Berkeley), **J. Walawander** (W. M. Keck Observatory)
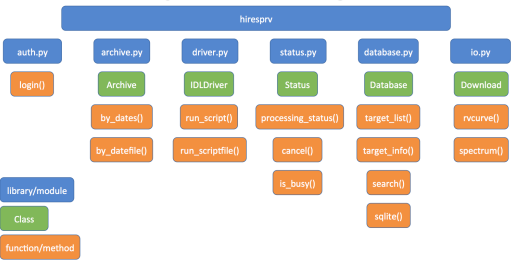
Pipeline Architecture

System Architecture

PRV Architecture: Python Functions and Web Services

Python API Design

A Modern Interface and System Architecture for a Long-lived Pipeline

A Public Precision Radial Velocity (PRV) Pipeline for the Keck Observatory

- There has been no public service for the reduction of Precision Radial Velocity (PRV) spectra acquired with the Keck/High Resolution Echelle Spectrograph (HIRES),which uses an iodine cell to derive a stable and accurate wavelength calibration.
- The IDL PRV pipeline, maintained by the California Planet Search (CPS), has enabled exoplanet discovery since 1995.
- CPS has generously made accessible all data products created by this pipeline as a public service, to enable mass determination of exoplanets expected to be discovered by the Transiting Exoplanet Sky Survey (TESS).
- *Available to Keck PIs in February 2019.*

Pipeline Will Remain Closed Source

- Requires IDL license.
- Results sensitive to IDL version and machine architecture.
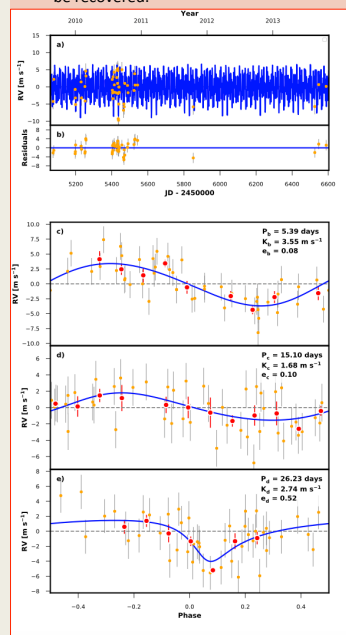- Too few resources to rewrite in Python and validate.

A Modern Interface and Operations Environment

- IDL code modified to operate on a dedicated server.
- Access to the pipeline is through Python client services, which logs on users via KOA-issued credentials, invokes data reduction, manages processing, and extracts PRVs.
- User data is stored in individual, permanent user workspaces.
- Reduction of one full night of data takes 5 to 7 hours.

Pipeline Performance: Velocity Precision
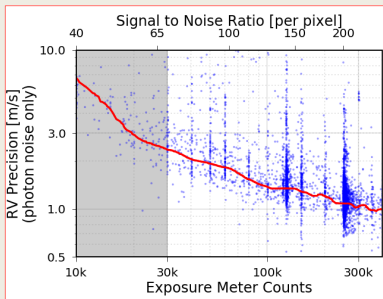
Photon-limited single measurement precision as a function of exposure meter setting and signal-to-noise ratio. The red line traces the lower 30th percentile of the individual measurements (blue points). Signal-to-noise ratios below 70 (gray shading) are not officially supported by the pipeline and may produce erratic results.

Pipeline Validation: Recovery of Three Exoplanets Orbiting HD 7924

HD 7924 has three exoplanets:
- Planet b published in 2009 with 7 years of data (198 RVs).
- Planets c & d published in 2016 with 18 years Keck + 1.5 years APF (907 RVs).
- With one year of RVs from the NExScI pipeline (167 RVs), the three planets can be recovered.

Planet	Fulton et al. (2015)	NExScI
a	K=3.6 m/s	K-3.55 m/s
b	K=2.3 m/s	K=1.7 m/s
c	K=1.7 m/s	K=2.7 m/s