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# The NEID Precision Radial Velocity Spectrometer: Laboratory AI&V and Commissioning Update

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## Abstract

NEID is a precision Doppler spectrometer being built to provide an instrumental radial velocity stability of 30 cm/s. The instrument is supported by NASA and the NSF through the NN-Explore program, and has a primary science objective to discover and characterize terrestrial mass exoplanets around nearby stars, and support space based exoplanet missions such as TESS and JWST. During the first half of 2019, NEID is undergoing Alignment, Integration, and Verification. In mid-to-late summer, NEID will be shipped to Kitt Peak National Observatory to be commissioned at the 3.5 m WIYN telescope. The spectrometer will be available to the exoplanet community in late 2019 to begin science operations. I will provide an update regarding the instrument status, and describe the commissioning efforts underway.

## 1. Introduction

NEID is an ultra-stabilized, high-resolution, fiber-fed, spectrometer being built by a multi-institutional team for the 3.5 m WIYN telescope at Kitt Peak National Observatory. The instrument's primary science objective is to discover and characterize terrestrial mass exoplanets, including follow-up of planets discovered by TESS and other spacecraft missions. NEID will be sensitive to terrestrial mass planets in the habitable-zones of late G through M type stars (Figure 1). Achieving this requires a multi-faceted approach that combines ultra-stable instrumentation, a significantly improved understanding of the stellar radial velocity signal and intrinsic stellar variability, and large numbers of observations distributed optimally in time following guidelines refined over the past 25 years of RV exoplanet discovery.

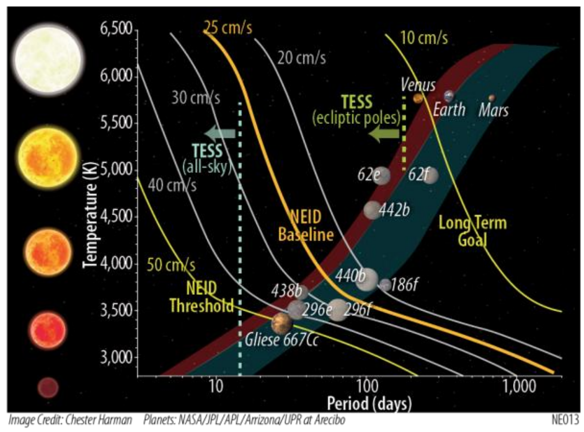


**Figure 1 NEID RV precision will be sufficient to confirm Earth-mass candidates discovered by TESS and to discover terrestrial planets in the habitable zones of low-mass stars. Colored swaths show the conservative (blue) and optimistic (red+blue) habitable zone, where water can exist on the surface.**

## 2. Instrument Design

NEID uses a single-arm white pupil echelle optical design to produce R~100,000 spectra covering the complete wavelength range from 380 – 930 nm on a single 9k x 9k CCD [3]. The optical bench and optics are stabilized with a temperature control system that achieves sub-mK stability, and are surrounded by a vacuum chamber that maintains 10^-7 Torr pressure or better [2]. The extreme stability minimizes drift in the optics and optomechanical systems. Light is transferred from the telescope to the spectrometer via a newly developed, sophisticated port system on the WIYN upper bent cassegrain position [1], which feeds an optical fiber feed that combines circular and octagonal fibers with a ball-lens double scrambler and a mechanical agitator. The fiber feed is designed to minimize the impact of illumination variations induced at the port, and scramble modes transmitted by the fiber, in order to provide a stable spectrometer line spread function. Wavelength calibration is provided by a Laser Frequency Comb, backed up by a stabilized Etalon and a system of Hollow-Cathode Lamps. A low resolution spectrometer is integrated into the spectrograph to provide real-time exposure information and chromatic exposure time centroids. A data reduction pipeline that builds upon algorithms developed over decades of precision RV spectroscopy will automatically transform raw images and telemetry into RVs and other high-level data products, which will be served to users and the community through a NExScI portal.

## 3. AI&V and Commissioning

NEID was aligned in the integration laboratory at Penn State University in State College, PA in January 2019. Throughout the spring, a variety of integration tasks were completed, and as of May 2019 the instrument was entering into the final set of in-lab verification runs. The final of these runs will take place during the early summer, and will provide a many week long demonstration of the intrinsic instrument stability, while also serving to debug and improve the robustness of the instrument control system and the data reduction pipelines. While this run is underway, the telescope port will be commissioned at the WIYN. NEID will ship to WIYN in late summer and begin a six month long commissioning exercise. The first three months of commissioning will focus on integrating the instrument into the WIYN environment, integrating the instrument with the port, demonstrating on-sky target acquisition, and exercising the data pipeline. During the second three months of commissioning, NEID will be opened to a shared risk science period that will exercise the newly developed queue operating mode while allowing the exoplanet community to immediately exploit NEID’s capabilities.

## 4. Conclusions

NEID will provide the exoplanet community with a state of the art Doppler measurement facility, just in time to exploit TESS northern hemisphere observations. The spectrometer will carry out an initial 5-year observing program at WIYN that includes a combination of programs including a zero-proprietary period, high cadence, quiet star program, a GTO program to search for habitable zone Earths, and a variety of GO programs contributed by the community through the NOAO time allocation process. These observations will be competitive with other world class Doppler facilities, and guarantee that the next half-decade of exoplanet astronomy is truly groundbreaking.

## Acknowledgements

NEID is supported by the NN-EXPLORE program, a joint endeavor between NASA and the NSF to provide the exoplanet community with extreme ground-based Doppler radial velocity (RV) measurement capability.

## References

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