The NEID Precision Radial Velocity Spectrometer: Characterization and Operation of the NEID CCD Detectors

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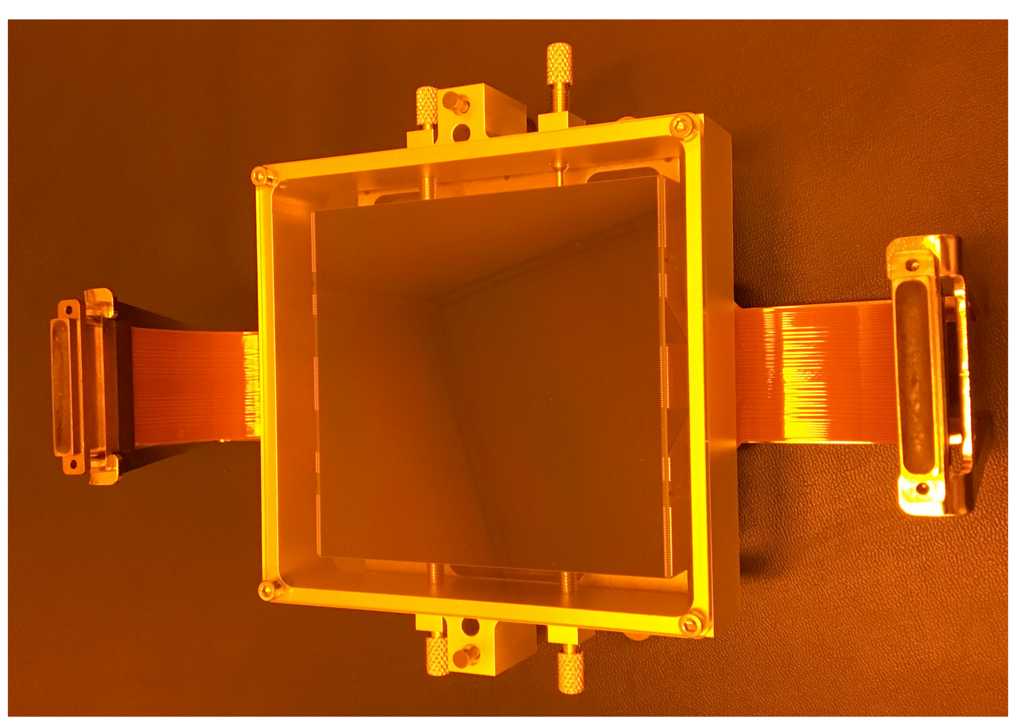
Introduction

NEID is a precision Doppler spectrometer in development for the WIYN 3.5-m telescope at Kitt Peak National Observatory as part of the NN-Explore Partnership. The wide spectral grasp of NEID (380-930 nm) requires a monolithic CCD detector having a large area, small pixels, and excellent quantum efficiency across the NEID band pass. NEID employs a single, deep depletion CCD290-99 device from e2v having 9Kx9K pixels with 10 micron pitch and Astro Multi-2 AR coating. We describe the operation of the CCD 290-99 device as well as the CCD testing and characterization efforts underway at the University of Pennsylvania.

CCD Operation

We operate the CCD290-99 using an Archon controller (STA, Inc.). We take advantage of the CCD dummy outputs to reject common-mode sources of noise across the 16 output channels. We do AC coupling and JFET buffering at the warm end of CCD flex cables, then convert the signal to a true differential output for transmission of the analog signal across ~1 m of cabling.

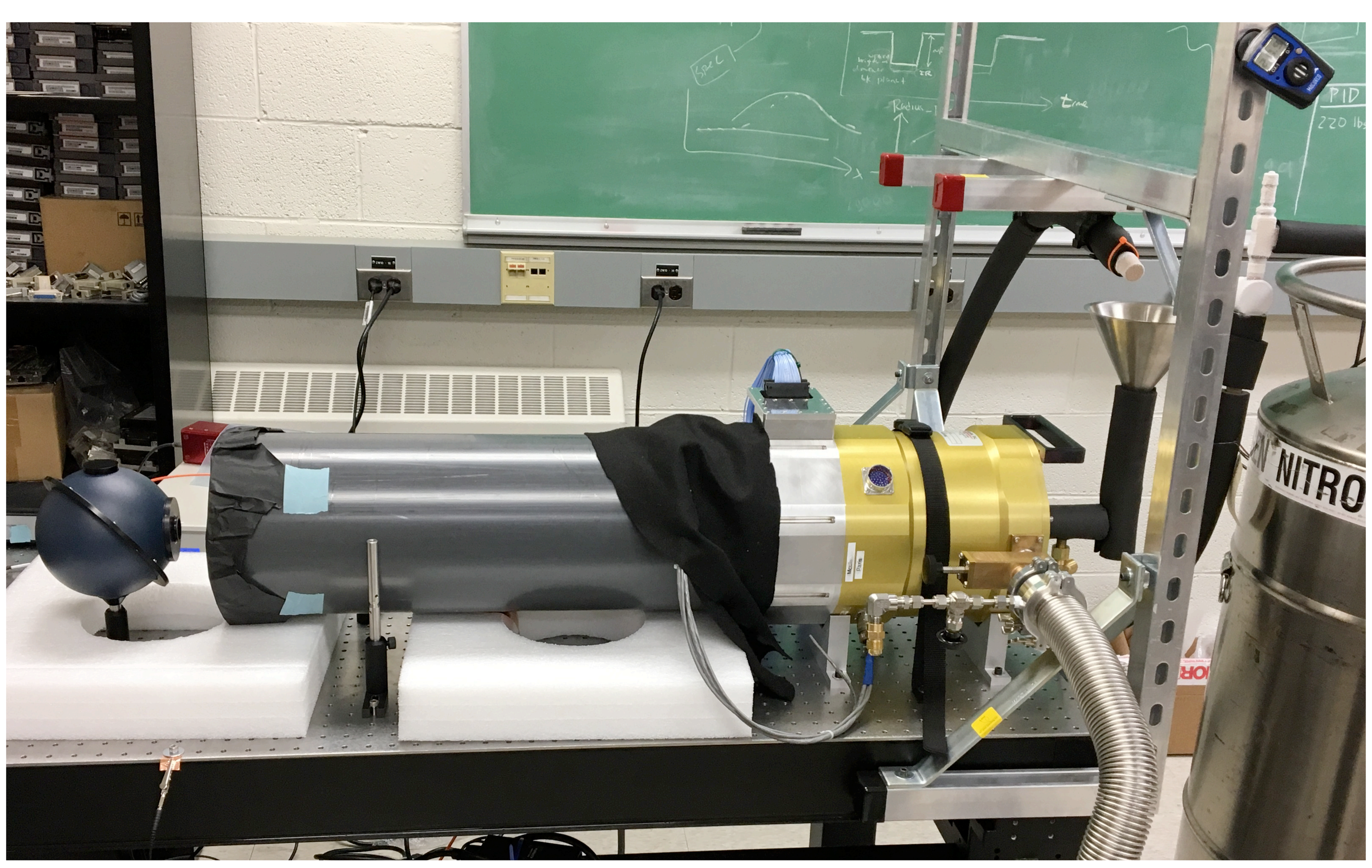
Archon Controller



A CCD290-99 in our custom handling jig. The CCDs are installed into our test Dewar within a Class 100 Cleanroom. The CCD is ~90 mm square.

CCD Characterization

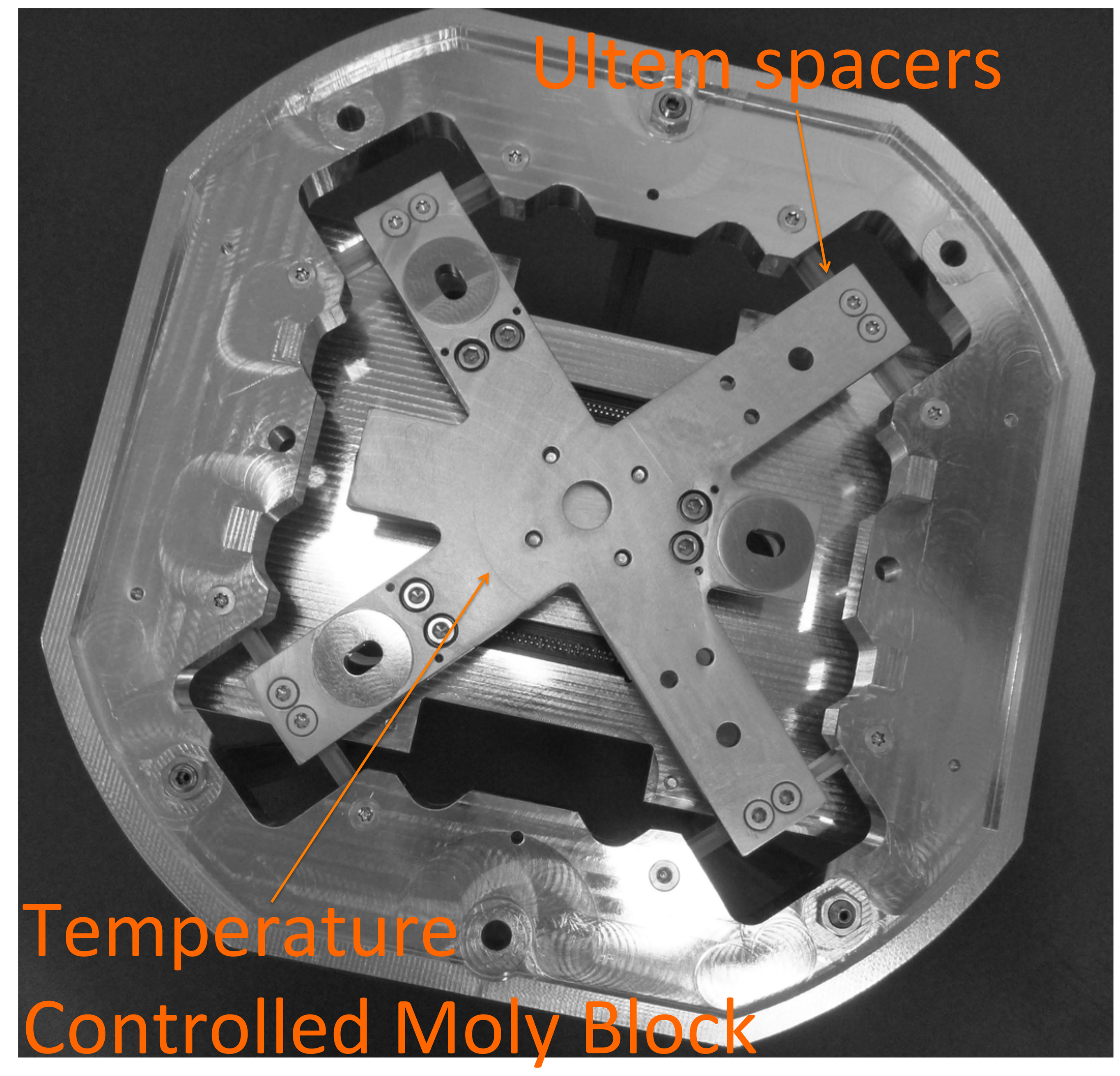
With a variety of light sources, lasers, and projection optics we characterize the CCD performance, including: dark current, linearity, read noise, cross talk, PRNU, CTI, as well as temporal variations in CCD power dissipation.



The CCD characterization lab. The CCD is cooled to -100C in an LN2 Dewar with an auto-fill system. A wide range of light sources can be projected from approximately 1m away.

CCD Mount

The CCD, which is a SiC package, is attached to a temperature controlled Molybdenum cold block. The cold block is fixed to a mounting ring using specially designed Ultem 1000 spacers, which provide robust thermal and mechanical isolation for the CCD.



Dither Clocking

The CCD is the major transient heat source inside NEID. Both the CCD parallel and serial registers are clocked during idle. During integration, we use the four CCD phases to "dither" the parallel clocks while the serial registers are also clocked, reducing transient heat output.

HIGH=11V LOW=0V

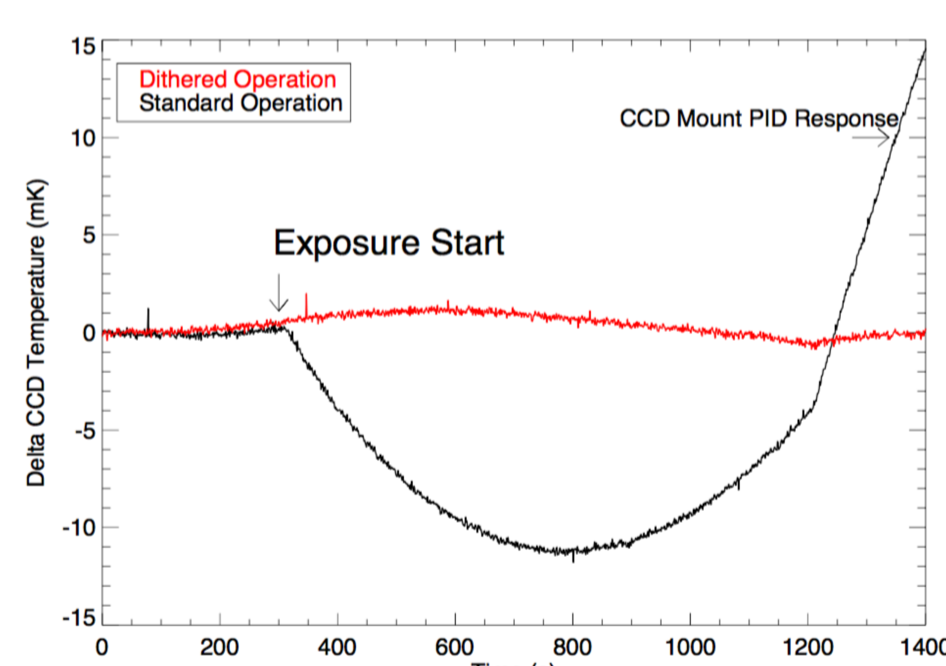
Step	Phase 1	Phase 2	Phase 3	Phase 4
	Parallel gates			
1	LOW	HIGH	HIGH	LOW
3 ms → 2	HIGH	HIGH	HIGH	LOW
3	HIGH	HIGH	LOW	LOW
4	HIGH	HIGH	HIGH	LOW
5	LOW	HIGH	HIGH	LOW
6	HIGH	HIGH	HIGH	LOW
7	HIGH	HIGH	LOW	LOW
8	HIGH	HIGH	HIGH	LOW
9	LOW	HIGH	HIGH	LOW

Time →

The "dither" clocking scheme takes advantage of the four CCD phases to exercise the parallel clocks during integration without moving charge between pixels.

CCD Heat Generation

We monitor temperature variations of the detector during operation with an RTD attached directly to the SiC CCD package. With the parallel clocks idle during integration, the CCD package temperature drops by 10-15 mK, while the dither mode reduces the amplitude of the thermal transient to the 1 mK level.



Temperature variations of the CCD package during integration and readout are significantly smaller using the "dither" clocking scheme. Preliminary investigations indicate that the "dither" operation has little impact on MTF, clock induced charge, or well depth.

For more information see: Papers 10702- 226, 241, 226, 257, 39; Halverson et al. (2016), Schwab et al. (2016); website: http://neid.psu.edu/