Implementation and testing of a hybrid fast/slow readout mode for the H2RG detectors in SCALES

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SCALES Project Goals

The upcoming SCALES (Slicer Combined with Array of Lenslets for Exoplanet Spectroscopy) instrument for W.M. Keck Observatory will enable new coronagraphic imaging and low-/mid-resolution IFS observations over the wavelength range from 2-5 microns. SCALES is optimized for exoplanet science and will enable new insights into colder and older exoplanet systems than are currently characterizable[1]. At the heart of the instrument are two HgCdTe Teledyne Imaging H2RG detectors, hardwired for slow mode operation (~100kHz pixel clock rate) with a fixed 4-channel readout. However, in ground-based operation at these wavelengths, such slow operation will accumulate a significant infrared background flux and reduce data quality.

To enable high quality observations without premature saturation on sky background, we operate the detectors using a Teledyne Imaging SIDECAR ASIC followed by an AstroBlank/Markury Scientific MACIE controller card, which allows the detector to be read out at faster pixel clock rates. This, in combination with the slow-mode H2RG, is what we characterize as hybrid fast-slow readout, enabling readout speeds at least 50 times greater than possible in slow-mode.

We implement hybrid fast/slow readout for H2RG detectors to improve frame rates to avoid sky saturation during ground-based IR observations.

Test Plan & Next Steps

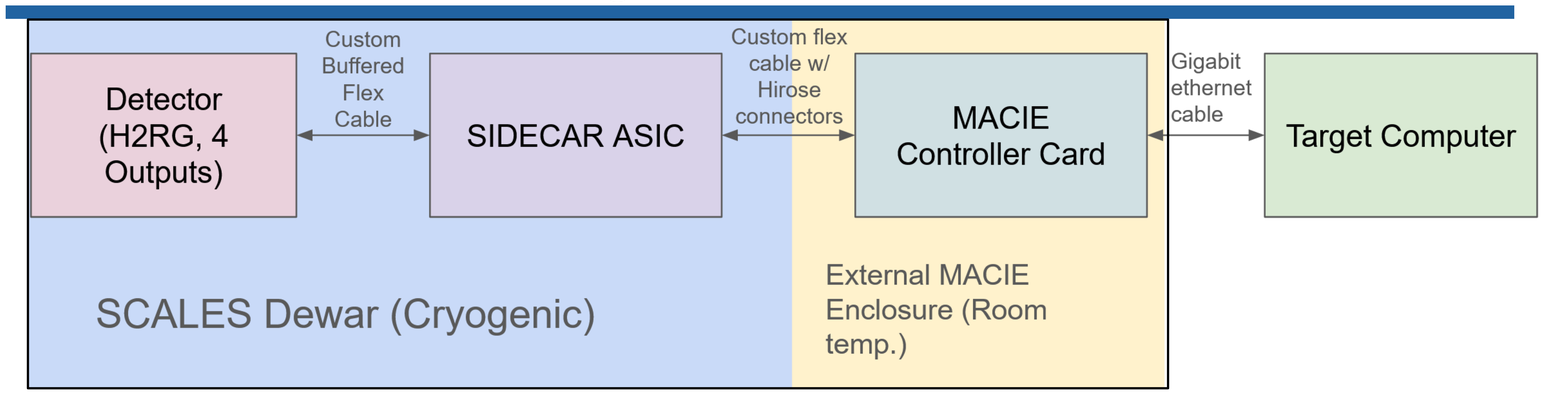
In the coming months, we will perform multiple tests to validate the performance of the detector head subsystems. We plan to perform a minimum of three cryogenic cooling tests in the UCLA IR Lab dewar in the coming weeks.

Upcoming Cooldown Tests

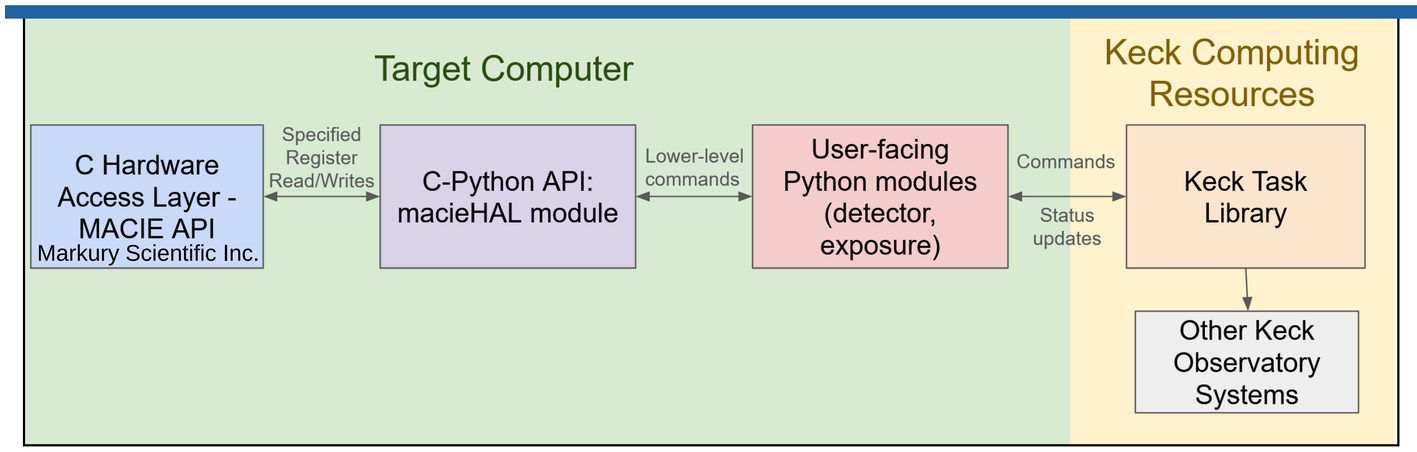
1. Validation of thermal control, using only mechanical parts (no detectors)
2. Operation of both detectors in a dark, light-tight environment
3. Validation of detector light sensitivity with illumination

In both cooldowns 2 and 3, we will measure the statistical properties of the detectors, as well as their persistence, non-linearity, and photon-electron conversion gain. The maximum frame rate will be determined by varying the clock rate during testing in cooldowns 2 and 3 and analyzing the statistical properties of the resultant data.

Detector Hardware Design

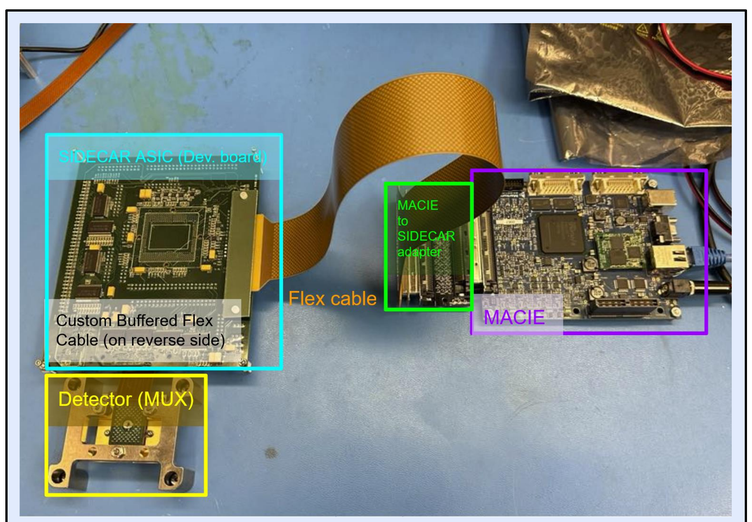


Controller Software Design



Implementation Status

At present, the C-Python module and the user-facing Python modules are complete and undergoing testing. Integration with the Keck Task Library is ongoing and expected to be completed well in advance of SCALES commissioning. Our current tests are performed using a MUX in place of the H2RG detector, while the detector support and handling hardware is in production and post-production validation. At present we have demonstrated readouts at with pixel clock rates up to 30MHz, but data quality will need to be validated with the photosensitive H2RG detectors. Integration of the H2RG detectors will be taking place during Summer 2024.



Room-temperature testing setup in UCLA IR Lab

Questions? Email pbenac@g.ucla.edu

REFERENCES

1. Skemer, A. J., et al. 2022, *Design of SCALES: a 2-5 micron coronagraphic integral field spectrograph for Keck Observatory.* SPIE Proceedings, Ground-based and Airborne Instrumentation for Astronomy IX.