Update on the NASA Goddard Astrophysics Division IR Detector Testbed

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Abstract

Teledyne's HgCdTe photodiode array detectors (specifically the H4RG) are current selections or front-runners as sensors for future missions in space and ground-based observatories. To calibrate these arrays to the precision needed for future science missions and increase their science capabilities, we need to understand these devices to unprecedented levels. To investigate these devices, we are building an IR detector test bed in the Astrophysics Divison at NASA Goddard. The test bed is intended to be an analog sandbox to assess the detailed performance of the H4RG, investigate the specific origins of electronic noise in the system, persistence, and other flux dependent nonlinearities. Mechanical components to hold and position the detector have been fabricated and assembled, a stable LED light source controller has been designed, and after some troubleshooting of the Leach controller system, we have room temperature array images. We are currently conditioning the testbed dewar by testing maximum vacuum attainable. The next steps are testing the cooling system of the dewar and testing our Leach system with repaired components that we discovered had failed.

We're building a test bed to operate an H4RG to examine the characteristics and develop a detailed physical model of these photodiode arrays and their response to light.

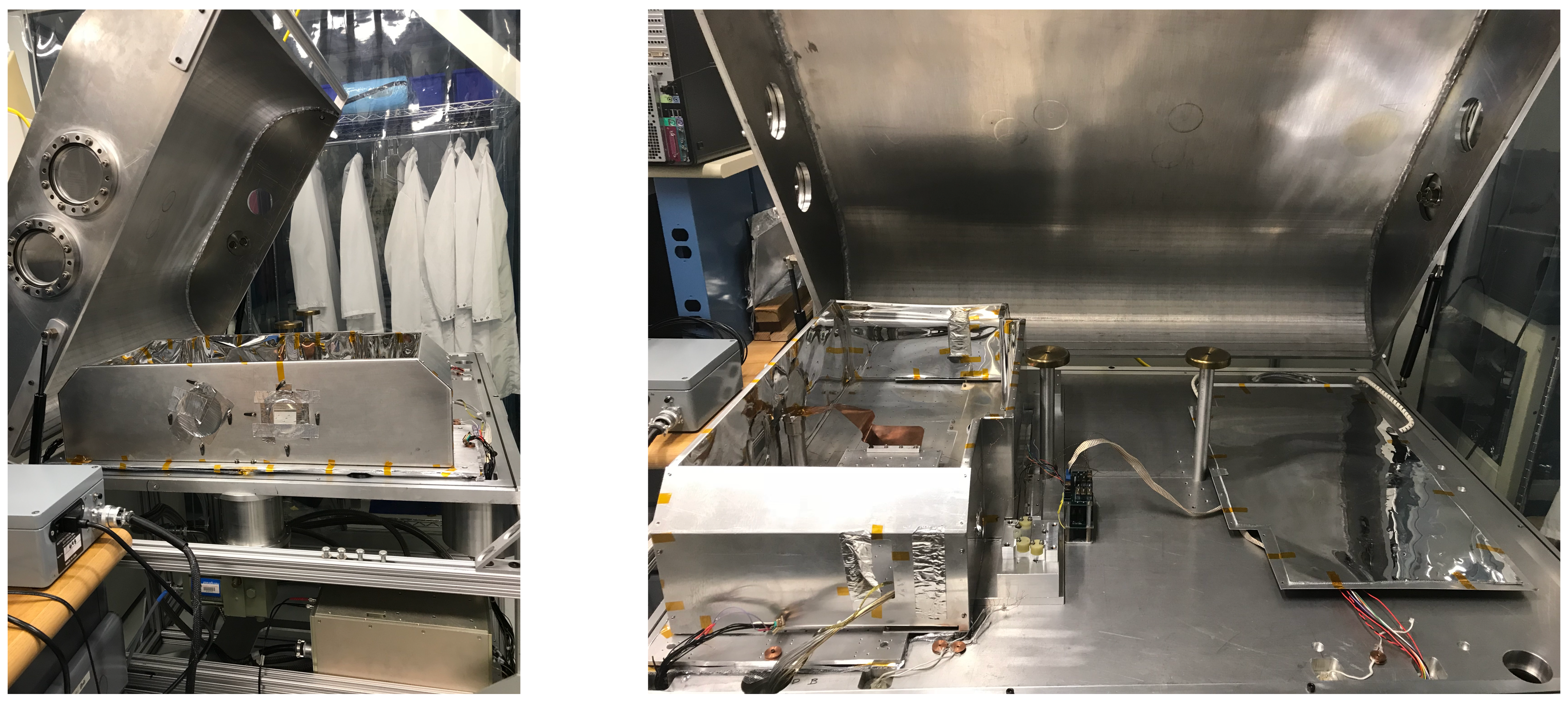

Figure 1 Images of the test dewar with the lid in the open position. The test dewar contains a smaller internal chamber seen on the near side of the dewar to which the cyrocooler's stages are coupled. Beneath the dewar the cryocooler (left) and Leach controller (right) are seen connected via their respective ports. The Leach's power supply is also seen in the foreground on the lab bench. The vacuum pump port is parallel and on the opposite side of the dewar from the Leach port.

The test bed includes a 3 axis stage, a pair of integrating spheres to provide uniform Lambertian illumination, and optics to image a sub-pixel spot.

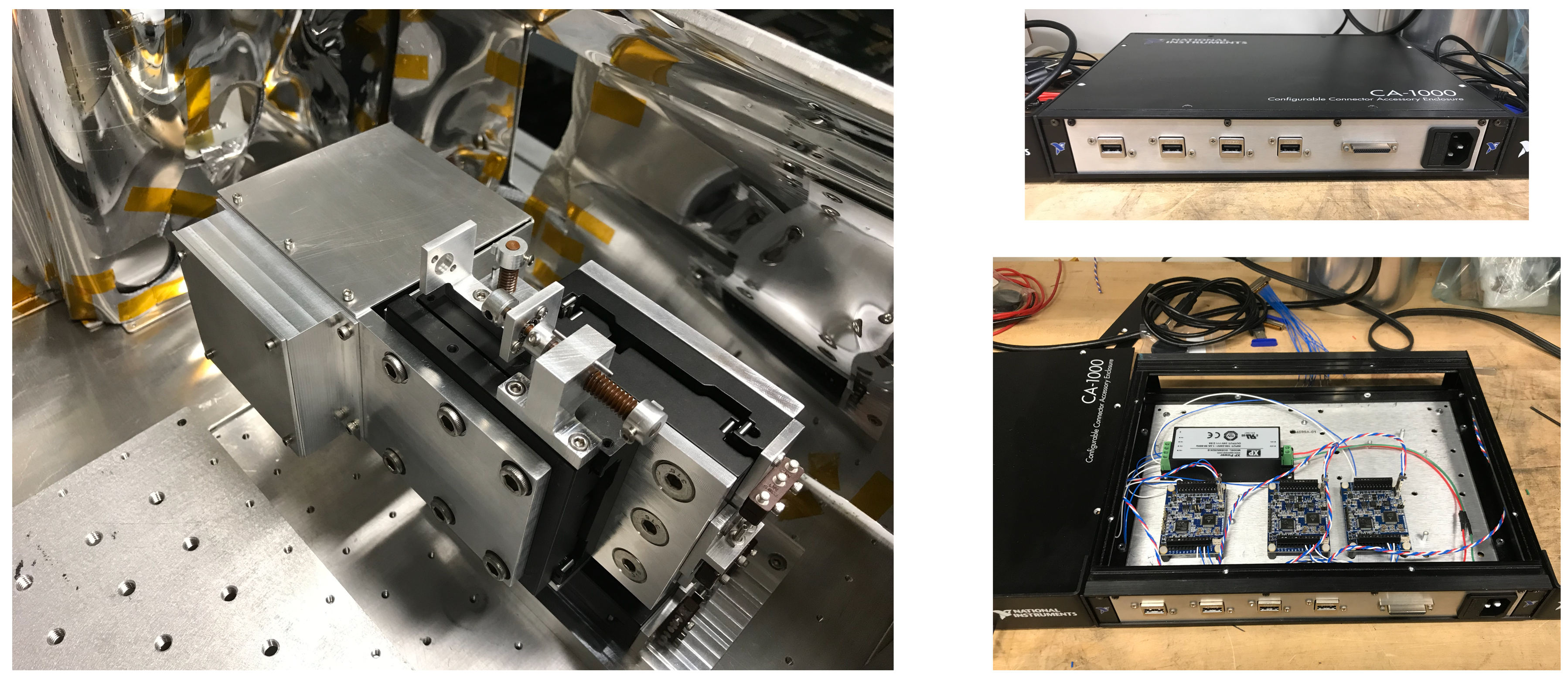

Figure 2 The internal chamber will house the detector on a 3 axis stage (left), a pair of integrating spheres to provide a uniform light source (Fig, 3), and additional optics to provide imaging of a sub-pixel spot on the detector plane or an image of the side port of the test dewar (not shown). Motor controllers (MCST 3601) integrated in the motor control box (right).

We've designed a driver using a PyBoard running Micropython to control a high precision light source for the integrating sphere system.

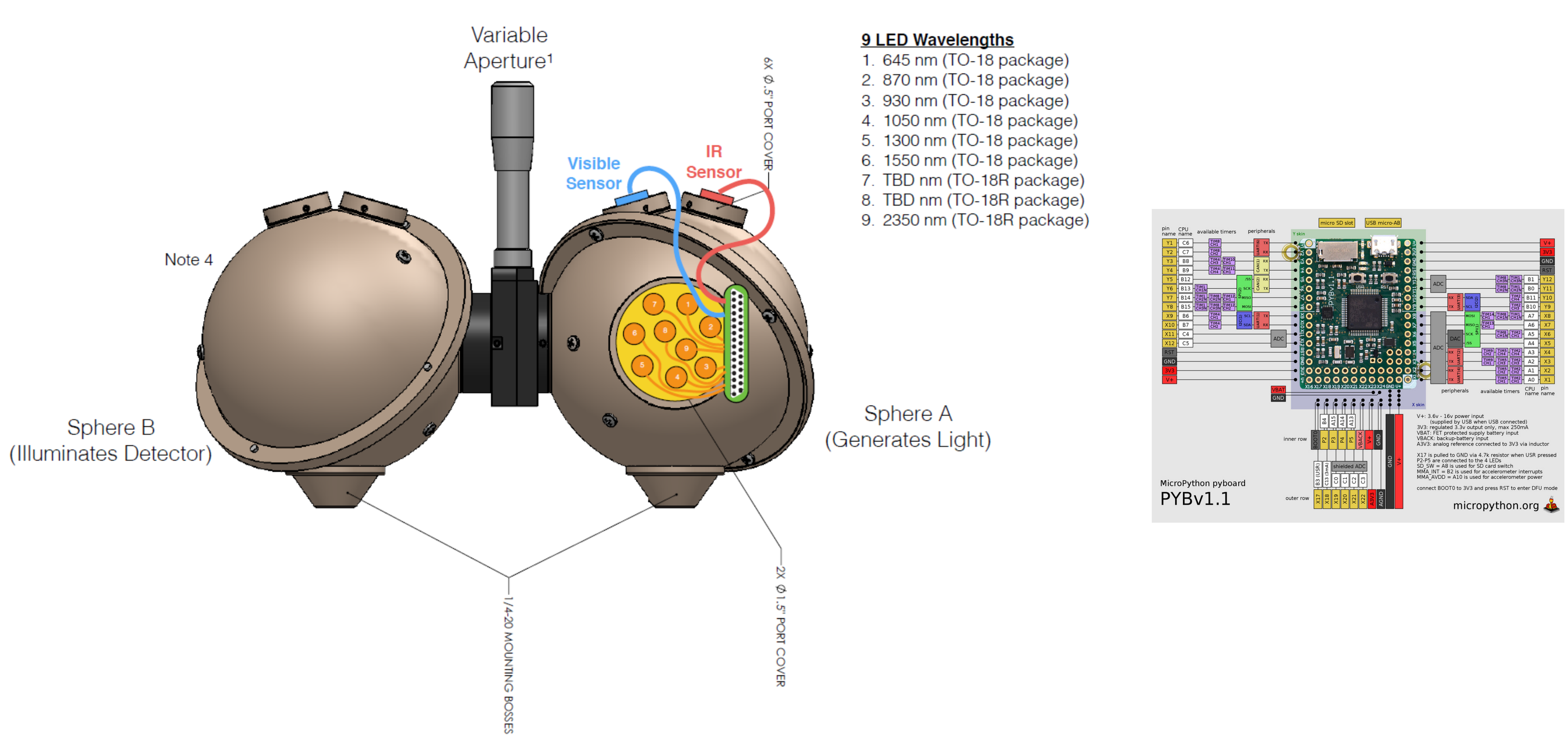

Figure 3 CAD model of the integrating spheres and planned LED and sensor placement (left). A pyBoard running Micropython (right) will be used with a designed LED driver and control circuit board (not shown) to provide stable illumination from the pair of integrating spheres.

Room temperature operation of a H4RG array was successful after switching power supplies, replacing a failed timing card, and removing 2 damaged video cards.

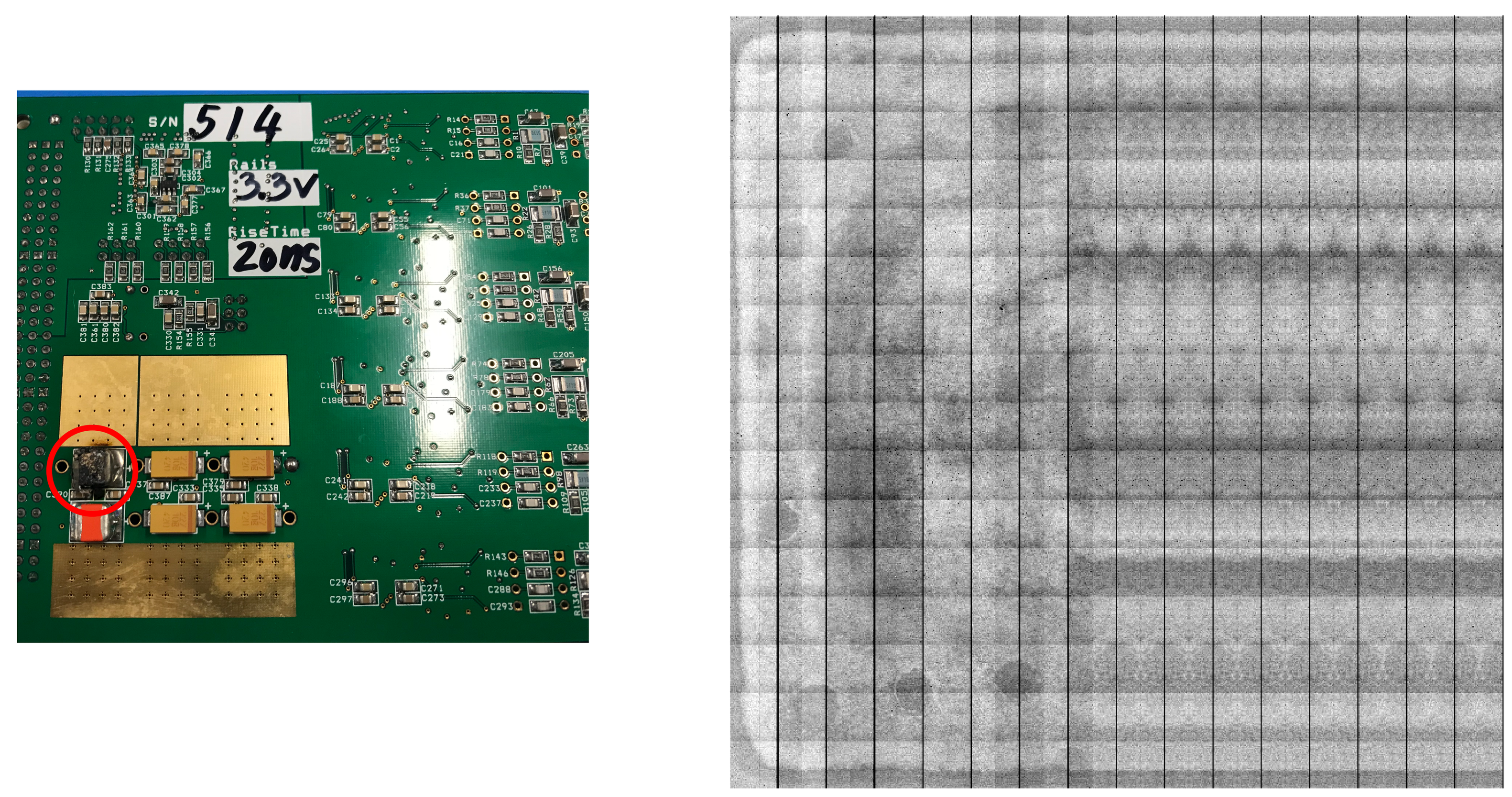

Figure 4 After reconnecting the H4RG using new controller software, images appeared dominated by Leach output noise. We soon discovered a blown capacitor on the timing card (left). Images still seemed dominated by Leach output noise, so we checked the power supply whose 5V source was unstable. Funky images persisted even with a replaced timing card, new power supply, and new Leach box. We finally tracked the anomalous images down to 2 malfunctioning video cards that are shipped out for repair. Removing the malfunctioning cards, we did recover an image of half an H4RG at room temperature (right). NOTE the signals in the last two outputs with detector signals are duplicated in the remaining output columns without cards to read back the array.

Once repaired cards are returned, we'll retest full array readout at room temperature. In the mean time in preparation for cryogenic operation, we are pumping the dewar down to measure maximum vacuum attainable. Next steps are testing minimum temperature of the cryocooler system and installing the detector in the dewar.