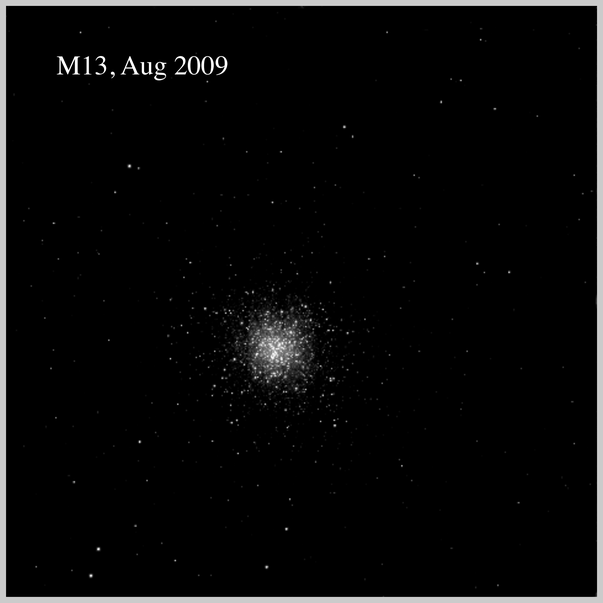
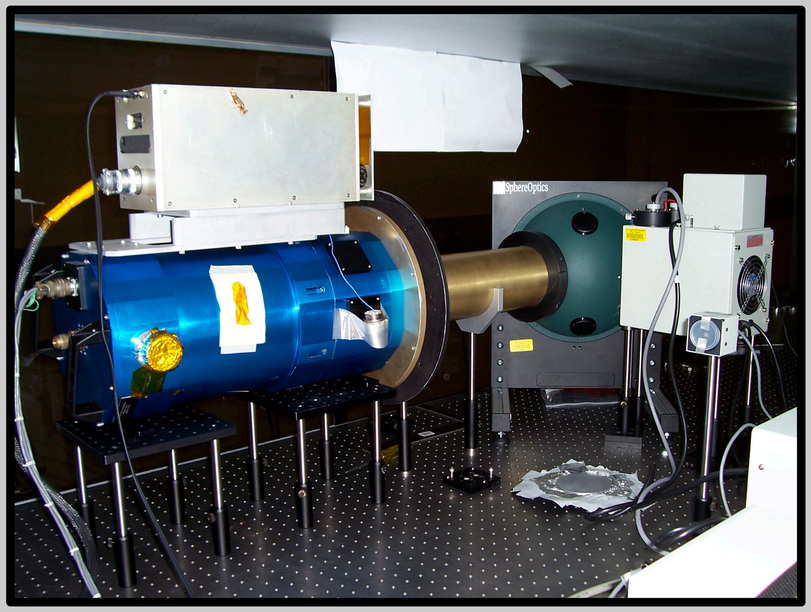
Latest Generation CMOS Hybrid Focal Planes: First Astrometric Results

R. P. Dudik, B. Dorland, D. Veillette
United States Naval Observatory

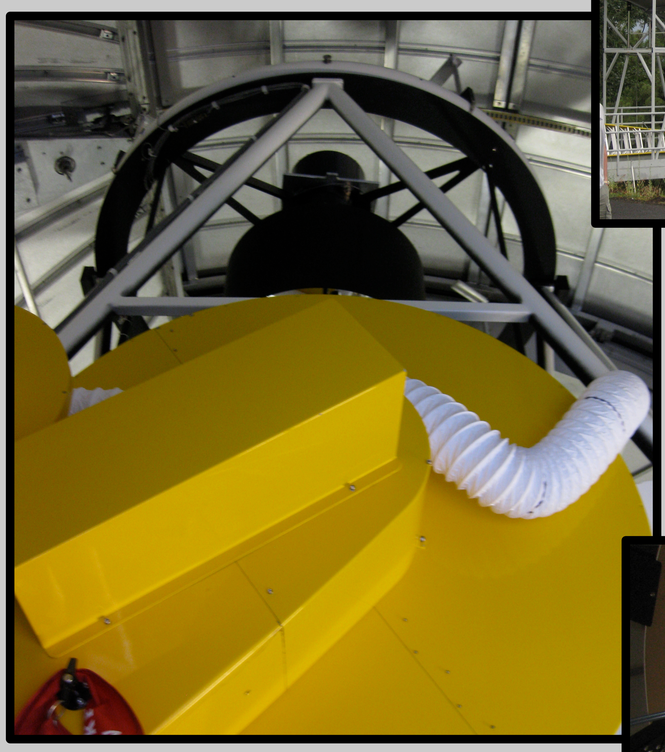
Abstract: We present the first ground-based astrometric testing results conducted using the second generation H4RG-10 A2 CMOS hybrid detectors. USNO is currently developing very large format CMOS hybrid focal plane technologies for use in astrometry and photometry. The results presented here are the latest in a series of calibration and astronomical tests that have been conducted for this purpose. Specifically we present the preliminary results of our astrometric analysis.





Astrometric Calibration Lab Setup: Dark current, Read noise and flat field calibration measurements were taken in the Astrometric Calibration Laboratory using the setup described above. The lab is equipped with an integrating sphere, a light source, and a monochrometer.

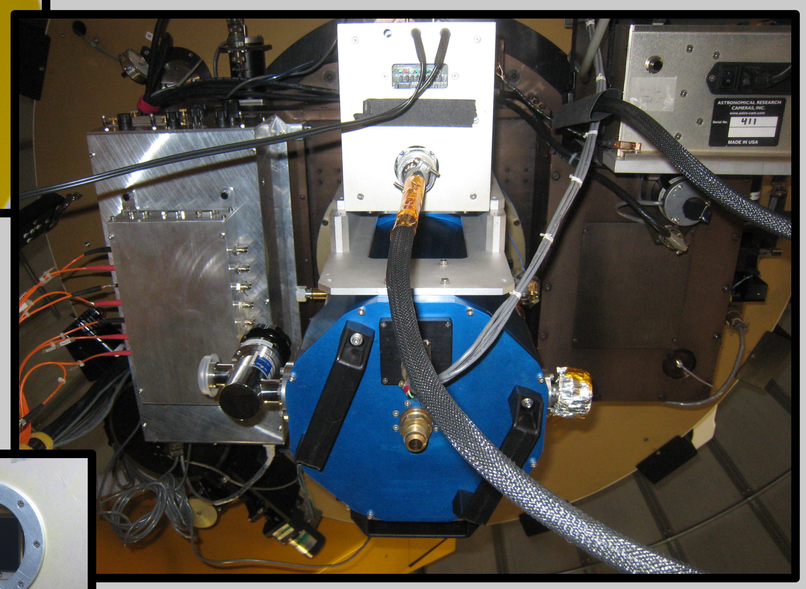
Telescope: A Teledyne H4RG-10 A2 detector and camera system was deployed to the Naval Observatory, Flagstaff Station (NOFS) in August 2009 and attached to the f/4.1, 1.3 meter telescope. Astrometric observations of NGC7092 and M13 and photometric observations of Landolt fields were taken over six nights. The seeing was no better than 2 arcseconds over the course of all six nights.



Astrometric Analysis Procedure: To minimize distortion effects from the 1.3 meter optics, images of each field were taken within an 1.5 hours of each other and the field center was translated no more than 10 pixels between images.

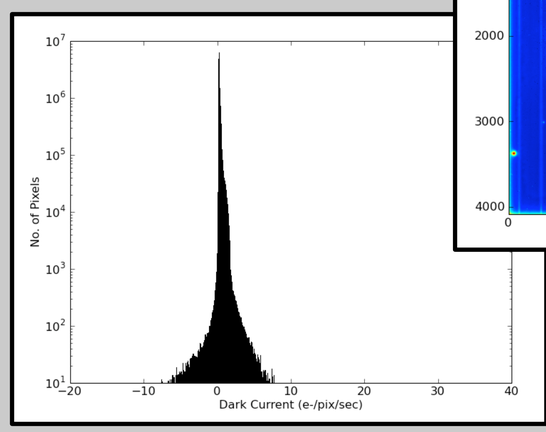
A reference image is chosen. All other images of the field were mapped to this reference image. The translations, angles, and plate scale differences were calculated for each translated image using an Affine transformation. The position offsets from the reference image for each star are then recorded. The standard deviation of the offsets for each star across all images represent the final astrometric error for each star.

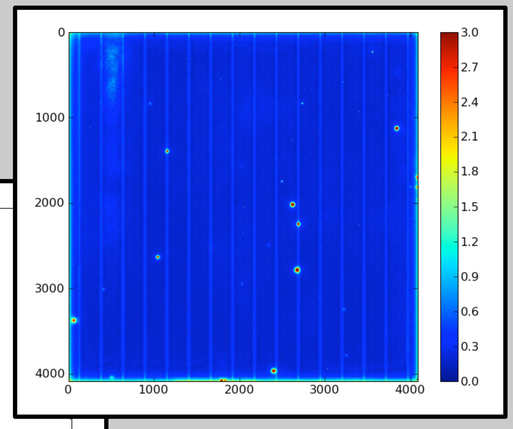
1.3 Meter Setup: The 1.3 meter is shown in the figure above. The image to the right shows the camera attached to the telescope. The dewar and detector are at the bottom in this image. The power supply box to the camera is at the top-right in the figure. A filter box with a standard astronomical filter set and spectrophotometric gratings is shown at the middle-right. The box on the left is the shutter electronics box.



H4RG-10 on the Telescope: The image to the right shows the H4RG in the dewar. The detector was operated at ~190K and all images were taken using the Cousins I-band filter (~700-900 nm). The 10μm, H4RG pixel corresponds to a 0.4 pixel subtense on the 1.3 meter.

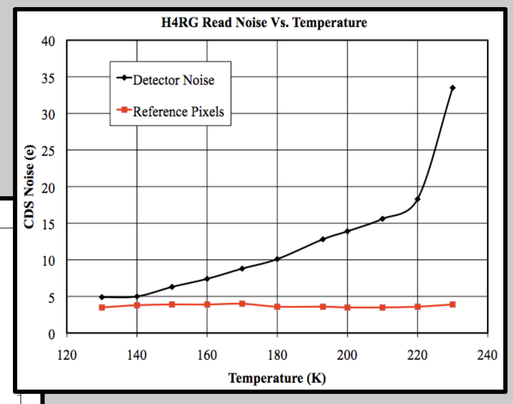
Clipped Dark Current Map: The map on the right is clipped so that pixels with dark current greater than 3 e/s/pix are set to 3 e/s/pix. At 190K, the dark current for the majority of the 4k X 4k array is well below 1 e/s/pix

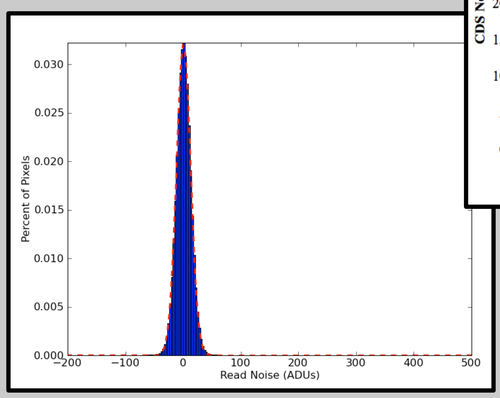




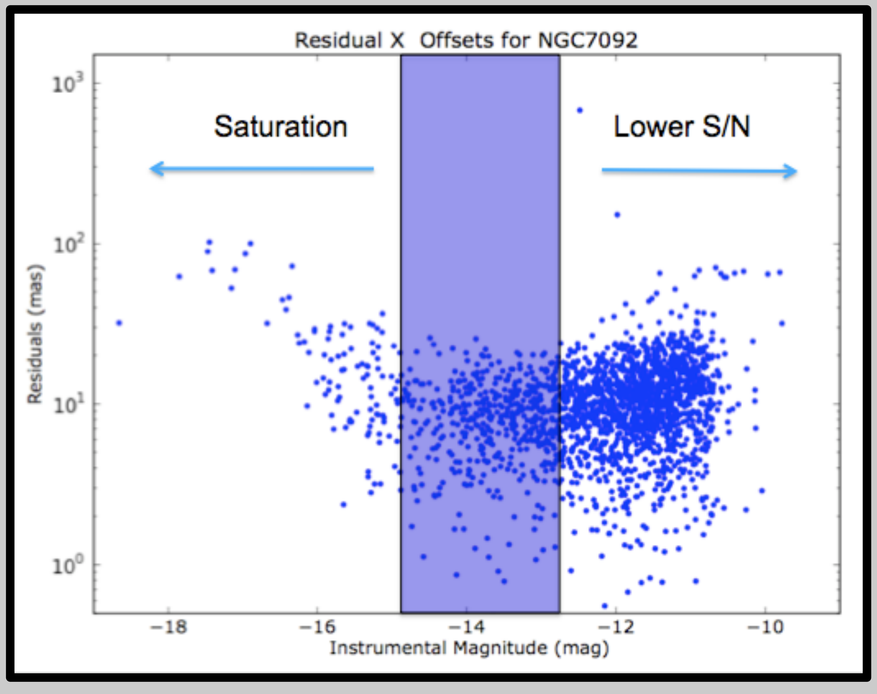
Dark Current Distribution at 190K: The dark current distribution at 190K is roughly Gaussian. The mean dark current at 190K for this SCA is ~0.35 e/s/pix with ~18% of pixels having dark current values 3 sigma greater than the mean.

Read Noise as a Function of Temperature: Read noise measurements were taken form temperatures 130-230K. We find an nearly linear trend in read noise as a function of temperature which is not replicated in the reference pixels. This implies that the detector layers is contributing excess noise to the measurement.





Read Noise Distribution at 190K: Read noise measurements were calculated by fitting a Gaussian function to 45, 1 second CDS frames and taking the average sigma over all 45 frames. Such a fit is shown in the 190K distribution shown right. The read noise at 190K is roughly 12 electrons.



Astrometric Results: Initial astrometric results showed errors no lower than 25—30 mas. This is significantly higher than the expected ~8-10 mas expected from uncorrected atmospheric and telescope effects. After exclusion of the lower 20% of the detector, the results shown above were obtained. An astrometric "sweet spot" is shown between instrumental magnitudes -15 and -13 with astrometric precision in the 8—9 mas range, consistent with atmospheric noise (Zacharias 1996). This sets an upper limit of approximately 1/70th of a pixel for the level of astrometric precision supported by the H4RG-10 A2 generation of detectors.