Gemini North Infrared Detector Controller Upgrade Project

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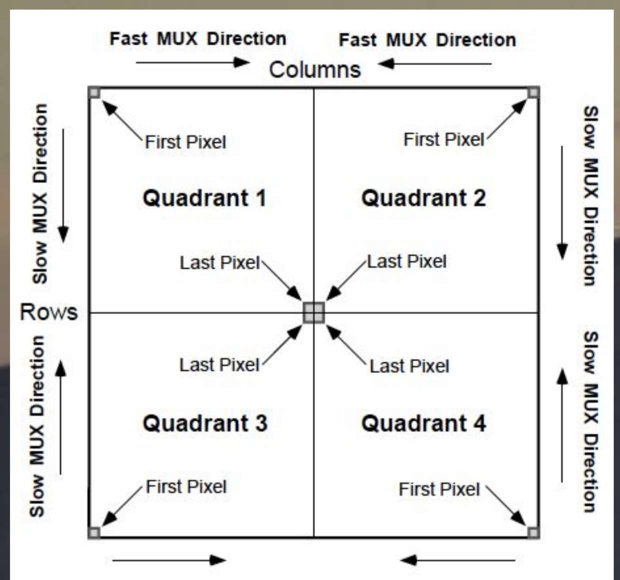
Abstract: The Gemini North Infrared Detector Controller (IRDC) Upgrade Project will replace the original Gemini NOAO IR Aladdin Array Controllers (GNAAC) still used with the Gemini NIR Spectrograph (GNIRS) and NIR Imager (NIRI) with Generation III ARC Controllers. The new detector controllers will provide **obsolescence mitigation**, offer the **potential for new functionality**, and **optimize efficiency** (first frame effect, readout noise, and fixed pattern noise). The data obtained with these controllers will be backwards compatible with the current Gemini IRAF package.

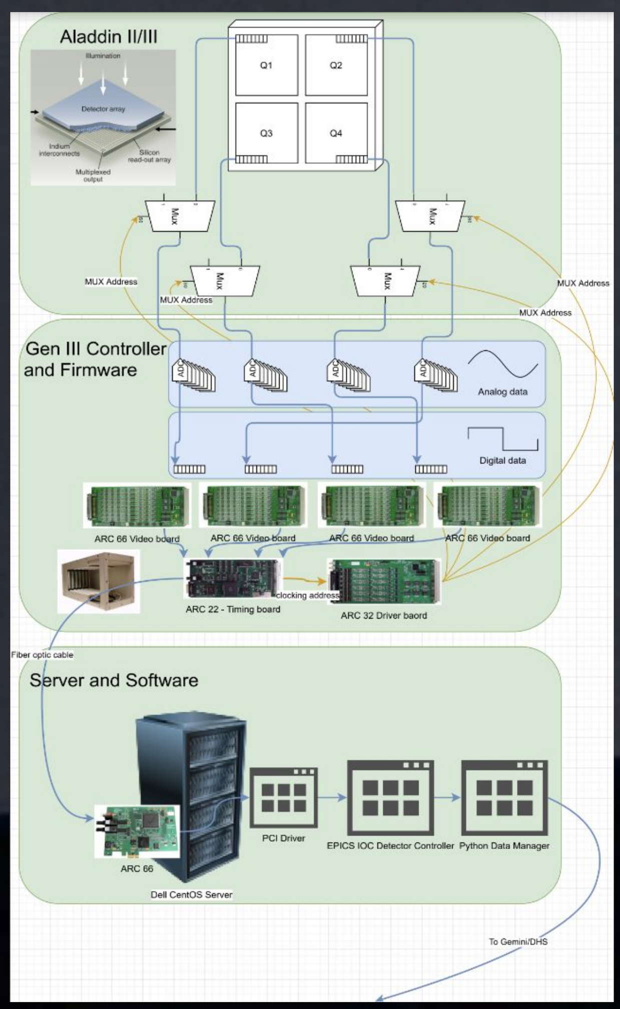
Results: The initial test results using the new ARC controller, at both the Hilo Base Facility (HBF) Detector Lab and installed on NIRI (while off the telescope) on Mauna Kea, are positive. The pattern noise seen in some NIRI and GNIRS data has not been seen with the new ARC controller. The read noise is currently higher than with GNAAC, but work is ongoing to reduce it by optimizing grounding and readout mode options (Fowler Sampling and digital averages). We are also exploring options to reduce the first-frame effect that is seen when changing the well depth and after sitting idle. Analysis of the temporal stability of the controller, gain, and well depth is ongoing.



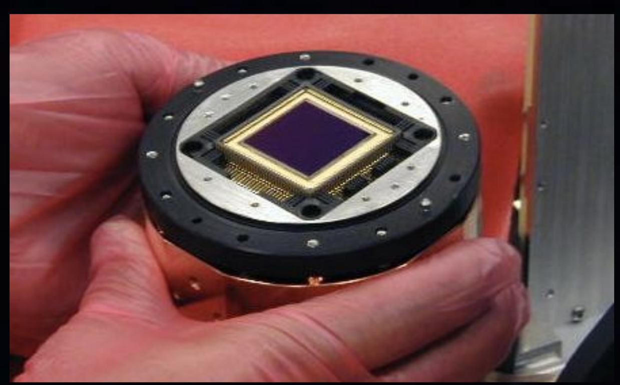
Detector Readout

Both GNIRS and NIRI are outfitted with 1024x1024 InSb arrays; NIRI has an ALADDIN II and GNIRS has an ALADDIN III. The ALADDIN arrays are read out in quadrants, and pixels from each quadrant are individually addressed using a multiplexer (MUX). The pixel values are read out 8 at a time simultaneously in each quadrant (32 pixels at a time) starting from the 8 pixels in the outermost corner and finishing with the 8 pixels in the center of the detector. The values are read as analog voltages which are then converted into a digital signal. This is done at the start and end of each exposure and the signal is the difference between the two.

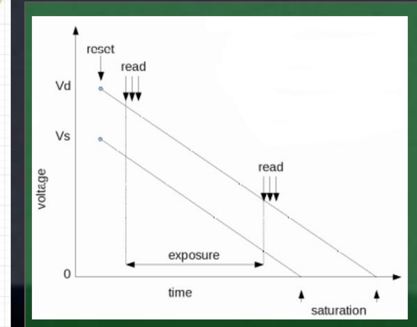
The ARC Controller will provide a system that we can support going into the future, and will allow us to address several GNAAC issues: first frame effect, read noise, and fixed pattern noise. We are experimenting with different techniques to reduce the first frame effect by changing well-depth, read mode, bias levels, and clocking. Work is also ongoing to reduce read noise with different sampling methods, namely Fowler Sampling (Low Noise Read Samples or LNRS), and Digital averages (NDAVGS). The fixed pattern noise will not be an issue with the ARC controller. We are also expecting less detector controller crashes with the new ARC controller; currently, if we are observing with GNIRS and/or NIRI, we expect at least one GNAAC crash per instrument per night.



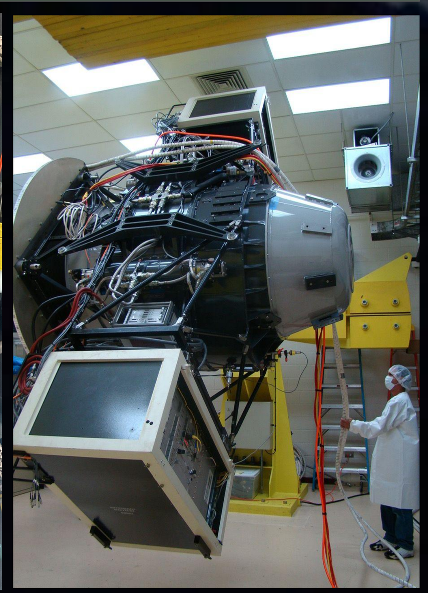
ARC data flow through the detector to the data handling software



NIRI's ALADDIN II Detector Array



Fowler Sampling: The figure on the left represents N=3 Fowler Samples (LNRS=3). The array is reset to the bias voltage (V_d or V_s), read out N_{Fowler} times, exposed, and then read out N_{Fowler} times. The signal is the average of the difference between the final and initial reads.

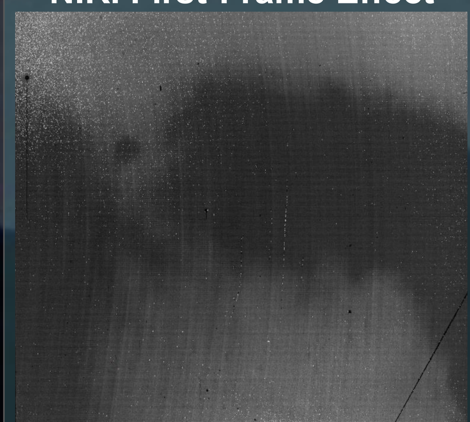


ARC controller (left), GNAAC pre-amp (right) GNAAC photos: ©John White

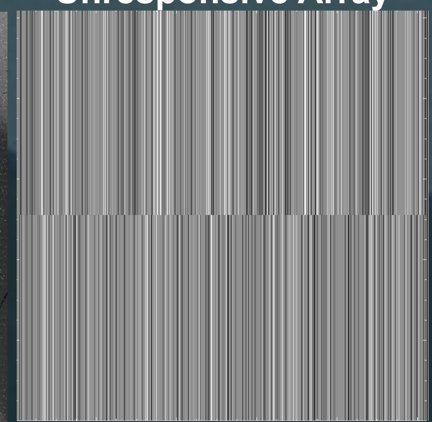
GNAAC crate (bottom), dewar (middle), components controller crate (top)

GNAAC issues to investigate and improve with the new ARC Controller

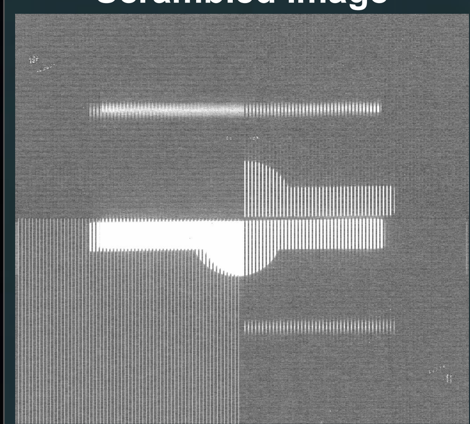
NIRI First-Frame Effect



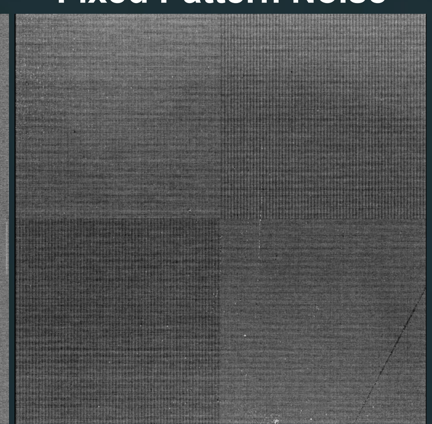
Unresponsive Array



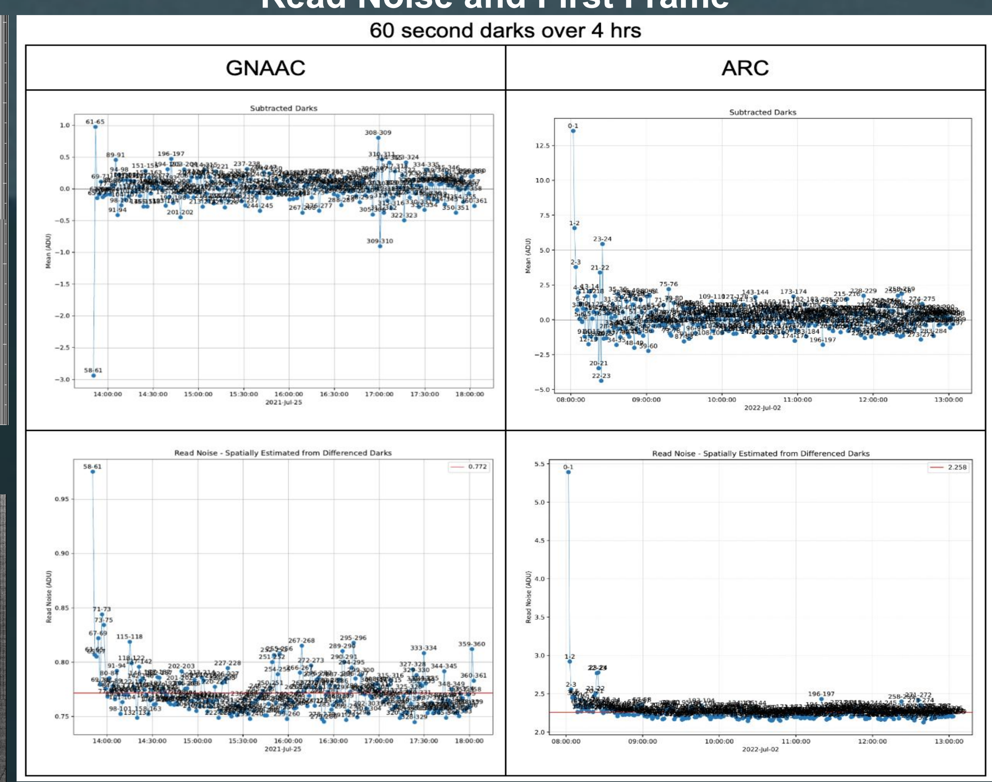
Scrambled Image



Fixed Pattern Noise

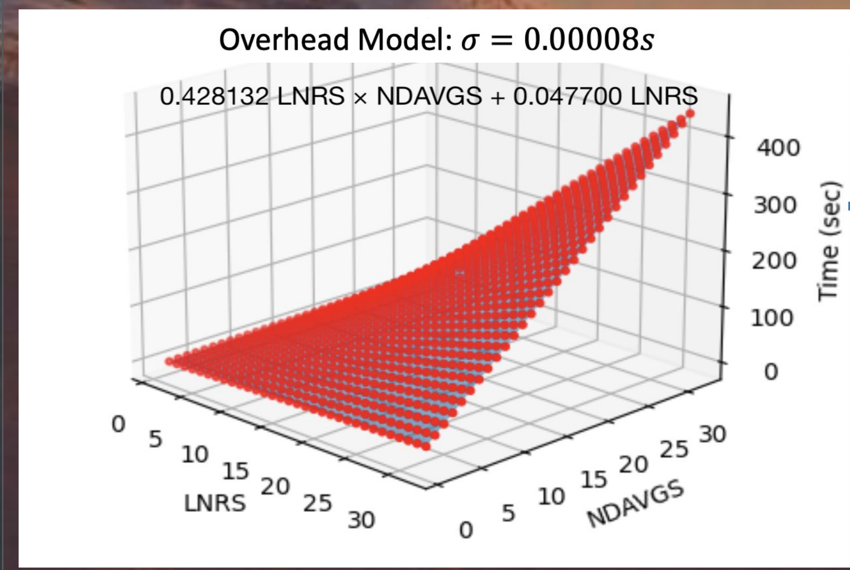


Read Noise and First Frame

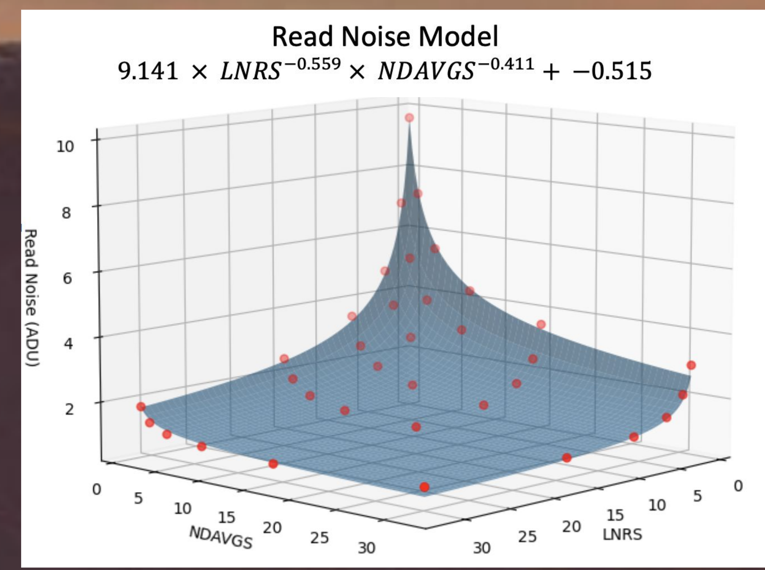


60 darks taken over 4 hrs with GNAAC (left) and ARC (right). Results show the first frame effect and the read noise is still higher with the ARC controller. Work is ongoing to reduce the noise.

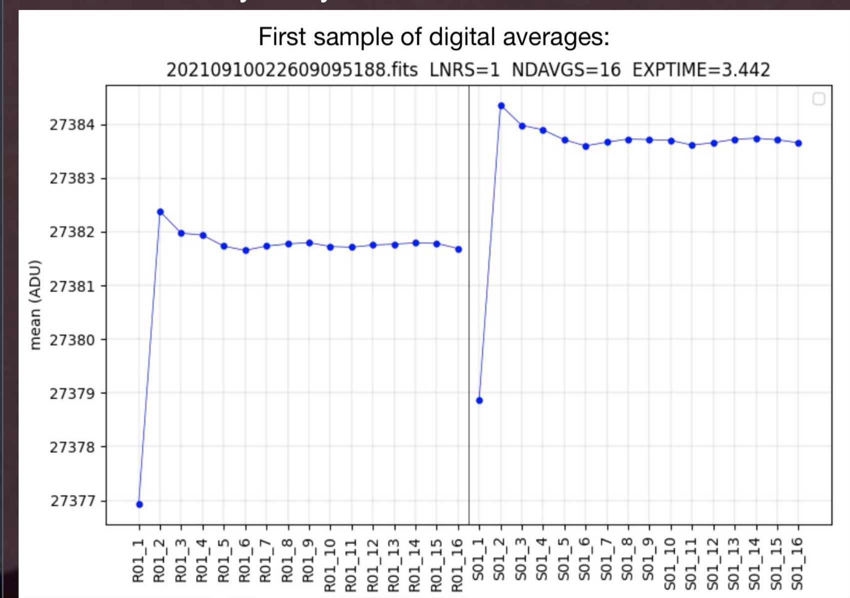
Data taken with the ARC Controller in the lab and at the summit



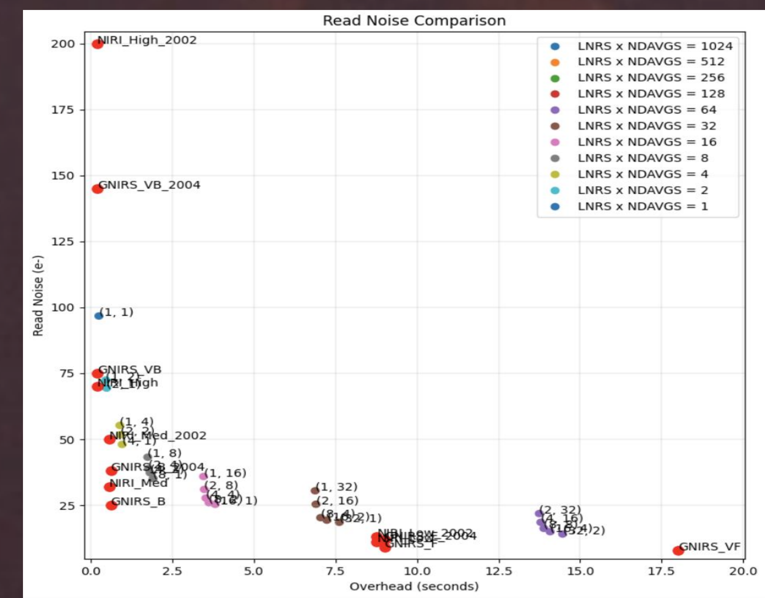
Work at the HBF Detector Lab has been done to improve the precision of the timestamps. The overhead is calculated using these timestamps written in the FITS headers at every array readout.



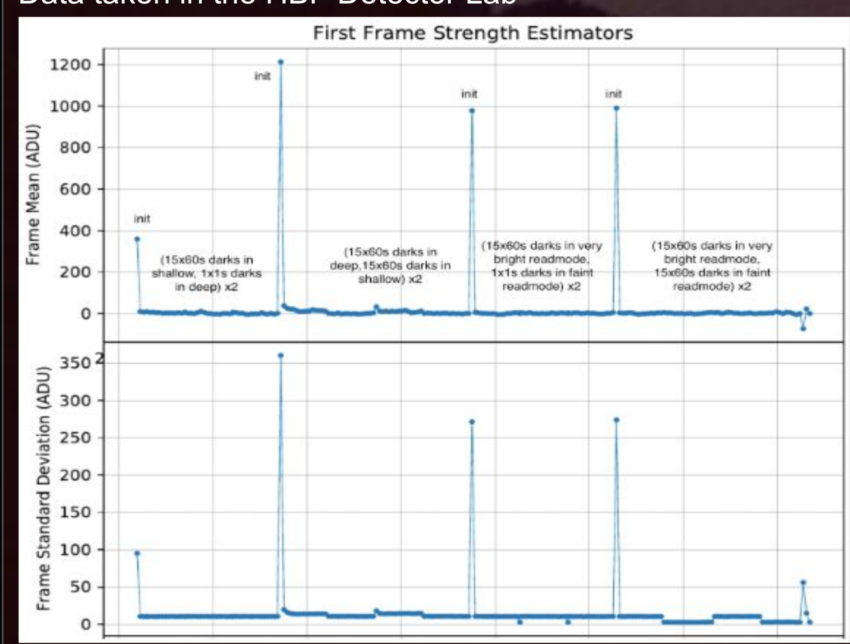
Data taken at the summit after powering down GNAAC. The read noise model is calculated in two ways: spatial variation of differenced darks and the temporal variation of the sequence of darks.



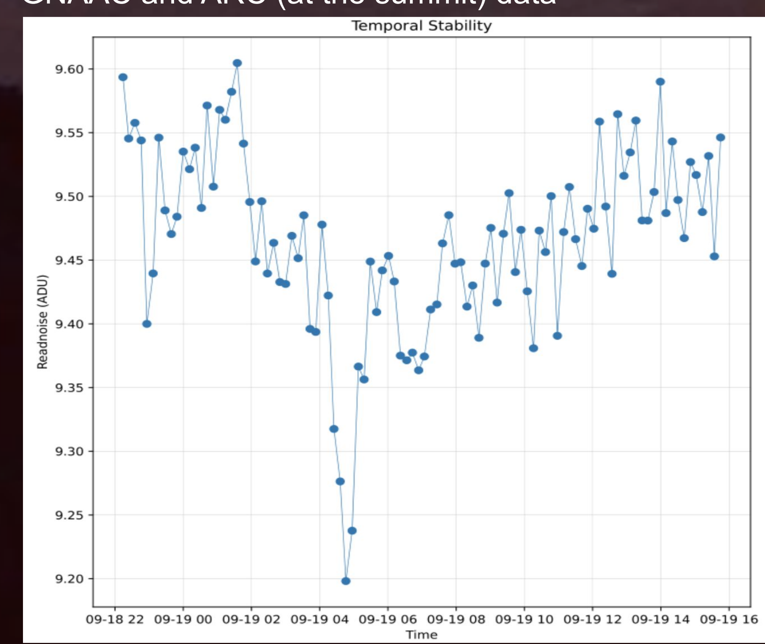
Data taken in the HBF Detector Lab



GNAAC and ARC (at the summit) data



First frame after after changing bias levels & read modes and running an ALADDIN II containing an init, at the summit



Data taken at the summit with LNRS=1 and NDAVGS=1 over ~18 hrs

Next Steps: GNIRS + ARC on-sky Commissioning in 22B