

## Keck Adaptive Optics Note 1538

### HAKA Nighttime Operations

A. Bouchez, E. Marin, C. Guthery, M. Cissé  
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## 1 Introduction

## 2 Starting Software Tools

On k2aoserver-new:2

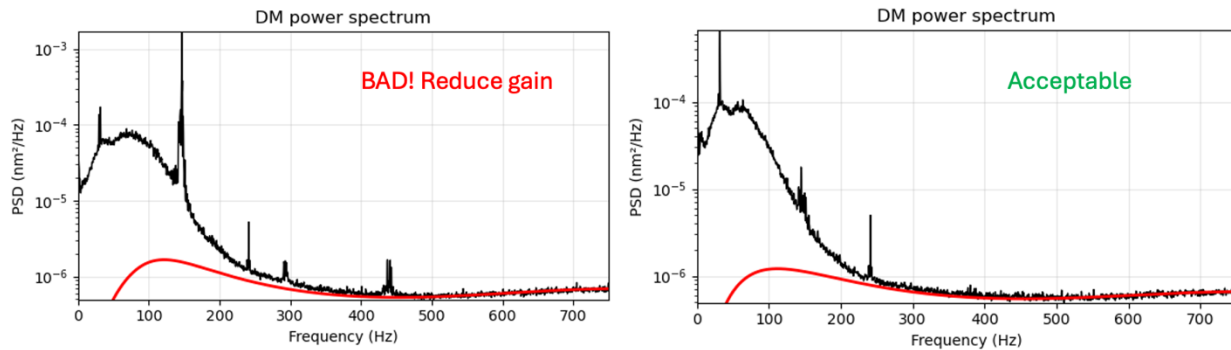
- Starting most GUIs from the background menu
  - NGS-AO Control > Start All NGS-AO Software or
  - LGS-AO Control > Start All LGS-AO Software
- Starting PyAO GUIs from the background menu
  - K2 AO Tools > PyAO > Start Control Main
  - K2 AO Tools > PyAO > Start Quicklook
  - K2 AO Tools > PyAO > Start Status Monitor
- Start reconstructor GUI (not yet part of Start All ... Software)
  - From the background menu open a k2obsao@k2aoserver-new terminal
  - IDL > recongui
- Start reconstructor process (not yet part of Start All ... Software)
  - From the background menu open a k2obsao@k2aoserver-new terminal
  - IDL > reconproc
- Start power spectral density (PSD) analysis tools
  - From the background menu open a k2obsao@k2aoserver-new terminal
  - cd into /home/k2obsao/mvandam/PYTHON
  - Run ipython
  - ipython > run analyze\_dtt (NGS TT PSD)
  - ipython > run analyze\_dm (DM PSD both NGS and LGS)
  - ipython > run analyze\_strap (LGS TT PSD)
    - Will not run until relevant loop is closed
- Start DM seeing Estimator (optional, useful)
  - From the background menu open a k2obsao@k2aoserver-new terminal
  - cd into /home/k2obsao/mvandam/ESTIMATESEEING
  - Run ipython
  - ipython > run atmogui
  - Leave all default parameters and click START

## 3 NGS AO Observing

- Run AO start-of-night script
  - Maori > Menu > Scripts > Start-of-night
    - Select NGS-AO mode; set right 2 displays for sound output
    - Note WPS is disabled and will alarm on alarm handler until disabled

- While slewing to target:
  - Setup Bench
    - Check that AOAcq shows correct target name, magnitude
    - Set desired pointing origin (eg. NIRC2)
    - Verify that Mode = NGSAO is selected
    - AOAcq > Setup Bench
    - If changing modes (eg. from LGSAO to NGSAO, or at start of night. This is temporary.)
      - In PyAO main GUI under RTC control tab set the mode one more time
- Setup NIRC2 (generally observer responsibility)
  - Set rotator mode, filter, pupil mask, subarray size, integration time, etc.
- Acquire star
  - AOAcq > Acquire Star
- Launch reconstructor computation (first target only; will be further automated)
  - In recongui, set smoothing parameter = 10, active subaps = 55
  - Set Mode -> Auto
    - Reconproc will now calculate and load a new reconstructor whenever the DM loop is closed and the pupil angle has changed by  $\geq 2$  degrees.
    - To disable reconproc, Ctrl-C in the window. Don't forget to restart it.
- Check WFS settings
  - Average WFS counts per subaperture should be between 200 (faint stars) and 5000 (bright stars).
  - Framerate should be as high as possible ( $\leq 1500$  Hz) while maintaining sufficient counts. The goal is to balance measurement error and latency error. The default settings should be appropriate if the sky is clear, but you may need to modify frame rate or EM gain in cloudy conditions or if the starlist magnitude is incorrect.
  - The OCAM2K camera will enter safe mode and set the EM gain to 1 if counts in any single pixel exceed 8000 counts in one frame. If OCAM is in safe mode (intensity display colored orange), either reduce the EM gain (for bright stars) or increase the frame rate and reset the EM gain (for faint stars). Take a new WFS background off-target and continue.
- Optimize control loop gains
  - The PSD tools enable the operator to monitor system performance and set optimal control loop gains. The AO system will not work well unless you do this! After acquisition, run analyze\_dtt and analyze\_dm. Each will display a plot of the residual wavefront error power spectrum and will give a recommended gain for that control loop.
  - If the recommended gain differs from the current gain by  $> 0.05$  and there are no strong resonances (see below), then follow the recommendation and update the control loop gain in the MAORI > AO Control tab.
  - The HAKA DM face sheet has strong mechanical resonances at 140-200 Hz at the locations of the 3 missing actuators. We are still developing control approaches to deal with this. For now, if you see strong resonances in the DM power spectrum (narrow

peaks more than 10x above the curve), then reduce the DM gain. The PSD on the left is bad – reduce the gain. The PSD on the right is acceptable.



- Run Fast & Furious
  - This takes 3-10 min depending on star magnitude and will likely improve K Strehl by 5-10%. The correction is a function of pupil angle, so in PA mode the correction will rapidly go stale. In Vertical Angle mode the correction will last >1 hr, with some benefit provided all night.
  - F&F is now integrated into the PyAO Main Control GUI. However, the latest version is not yet released, and must be run on vm-aodev:20. Instructions for running F&F are provided here: [FandF Operation.docx](#)
  - If F&F was run and you would like to re-use the centroid offset (cog) file on the next target, run the following IDL command:
    - IDL > loadcog, 'FandF\_260530-054750.cog' (replace with last F&F cog name)
- Measure Strehl ratio
  - Measuring the Strehl ratio of an unsaturated star is the best measure of end-to-end AO performance.
    - From the background menu, NIRC2 Menu > Start Strehl Tool
    - Autofind = ON, Auto update image = ON
  - The expected K Strehl versus star magnitude in median conditions (0.6 arcsec DIMM seeing) is shown here: [link](#)
- End of night
  - Run Maori > Menu > Scripts > End-of-night

## 4 LGSAO Observing

- Run AO start-of-night script
  - Maori > Menu > Scripts > Start-of-night
    - Select LGS-AO mode; set right 2 displays for sound output
    - If starting with NGS checkout, select beamsplitter
    - Note WPS is disabled and will alarm on alarm handler until disabled
- Run laser start-of-night script (runs very fast, provides no feedback)
- NGS Checkout (see NGS AO Observing, above)
  - Slew to R=10 engineering star that will stay below EL=80 for ≥30 min
  - Set AOAcq NGS AO mode, PO=NIRC2
  - AOAcq > Setup Bench

- AOAcq > Acquire Star
  - Optimize control loop gains
  - Take an unsaturated NIRC2 image in BrG filter and measure Strehl. It should be 0.4-0.7 depending on seeing conditions.
- LGS Checkout towards R=10 star
  - ([https://www2.keck.hawaii.edu/inst/ao/nirc2\\_cls\\_checkout\\_new.html](https://www2.keck.hawaii.edu/inst/ao/nirc2_cls_checkout_new.html))
  - Set AOAcq LGSAO mode, PO=Opt Axis
  - AOAcq > Setup Bench
  - Acamtool > Cal Setup
    - Will prompt to note secondary position and refocus to Na layer.
  - Propagate laser
  - Center on WFS using Geevum (steer Rayleigh scatter *towards* pupil center)
  - Focus LGS (disable focus compensation, adjust lxf to minimize FWHM, "Set Base Focus", re-enable focus compensation)
  - Click "Update FWHM", "Fine" alignment (closes UTT and offload loops), and "Done" (sets reference pointing offset)
- LGSAO performance check on R=10 star
  - Set AOAcq LGSAO mode, PO=NIRC
  - AOAcq > Setup Bench
  - AOAcq > Acquire Star
  - Optimize control loops (see below)
  - Take unsaturated NIRC2 image (filt BrG, tint=0.2, coadd=10) and measure Strehl
- While slewing to each LGSAO target:
  - Setup Bench
    - Check that AOAcq shows correct target name, magnitude
    - Set desired pointing origin (eg. NIRC2)
    - Verify that Mode = LGSAO is selected
    - AOAcq > Setup Bench
      - Keep an eye on STRAP status in Maori > WFC. If faulted, try to STDBY and INIT.
    - If changing modes (eg. from LGSAO to NGS AO, or at start of night. This is temporary.)
      - In PyAO main GUI under RTC control tab set the mode one more time
- Setup NIRC2 (generally observer responsibility)
  - Set rotator mode, filter, pupil mask, subarray size, integration time, etc.
- Acquire star
  - AOAcq > Acquire Star
- Launch reconstructor computation (first target only)
  - Set smoothing parameter to 10
  - Set active subaps to 55
  - Once loops are closed, TRIGGER a new reconstructor
    - Check that it loads OK in reconproc window
  - Set Mode -> Auto

- It will now calculate and load a new reconstructor whenever the DM loop is closed and the pupil angle has changed by  $\geq 2$  degrees.

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## 5 Trouble-Shooting Guide

Notes from past nights of troubleshooting poor performance

- DM-loop Gain is unstable: (safest state is to set it to 0.25 or lower)
- WFS Intensity: If the average intensity is below 400 or the maximum is below 1000, increase the EM gain or framerate
- Reconstructor Pupil Mask: While in PA mode the reconstructor will recompute based on the pupil angle and take into account the overall illumination of the WFS. To check that the mask lines up open the DM loop and click "Recon. Mask is OFF" on the WFS intensity GUI to overlay the mask on the WFS intensity. With the mask applied you should still be able to see all of the pupil (minus some spots over the spiders/segment edges). If the mask cuts off the illuminated pupil, trigger a new reconstructor with the DM loop open.

Issues: 2026-05-31 UT:

- Start All NGS GUIs did not start MAORI
- Nighttime script noted that TRS timestamp not updating. Rebooting TRS from MAORI
- 19:40 TT loop unstable on first target. Reset mode, did not fix. Rebooting TT HVC from Maori. Then reset mode, load reconstructor, and flatten DM
  - 19:48 might be back. Came back with 304B.mr and DM not flat.
  - 19:50 definitely back.