PALM-3000 Operations Manual (POM)

Version 1.1

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Revision Sheet

Revision No.	Date	Revision Description
0.1	02/06/12	First draft (RSB)
1.0	08/30/12	First committed release (RSB)
1.1	09/02/12	Several updates after lab and sky operation

Contents

Introduction

This document describes P3K operation procedures for system startup and common observing scenarios. Both lab and on-sky conditions are presented. Typical fault situations and their recovery strategies are addressed.

It is assumed that P3K is installed on either its cart or on the spit in the lab, or is mounted on the telescope. It is assumed that the instrument is fully cabled. It is assumed that the P3K racks are powered OFF before initiating the following steps. Palomar Observatory maintains the P3K installation and cabling documentation.

The *p3k-control* computer is the P3K operator's computer located on the rolling desk in either the lab or the data room. The *p3k-telem* computer is the main P3K computer and is located in the Palomar computer room.

P3K Startup Procedure

Palomar Chiller and Chiller Supervisor

The Palomar chiller and chiller supervisor system is responsible for delivering power to the P3K electronics racks (HODM1, HODM2, CASS1) when P3K is mounted on the telescope. Therefore, the chiller and chiller supervisor must be started and running normally before P3K can be powered up and started. The chiller supervisor control hardware runs on the CASS2 instrument rack.

- Power on the chiller:
    - o **Lab:** Outside the lab in the west corner of the room, push the green start button
    - o **Telescope:** In the coude room next to the data room (through the coude alley), start the chiller
    - o Ensure that the coolant level is above the intake filter in the reservoir (for both chillers). If more coolant is needed mix on a 1-1 ratio of de-ionized water and ??????
- Power on the CASS 2 instrument rack (where the supervisor control hardware is located)
- Open a firefox tab on the *p3k-control* computer (usually opened on Desktop #4)
- http://**chill200/default.html** (chill200 bookmark) to bring up the chiller supervisor
- Under "System Control" click the "Start Chiller" button
- Wait until "Cabinet Status" changes from "not powered" to "powered"

Leave the HODM racks powered OFF until P3K LODM Startup is complete. Palomar Observatory maintains the documentation for the chiller and the chiller supervisor.

P3K Software

To bring the HODM mirror up safely, the entire P3K system is brought up first with the HODM racks powered OFF. Now that the chiller system is running, turn power ON to **only** the CASS1 and CASS2 instrument racks.

- Open 2 terminal windows on the *p3k-control* computer (usually opened on Desktop #1)
    - o In terminal #1 (usually opened on the bottom-left of *p3k-control* Desktop #1)
        - ▪ **ssh –X p3k-telem**
        - ▪ (**dev** if running the development version)
        - ▪ **matlab**
    - o In terminal #2 (usually opened on the bottom, next to Terminal #1)
        - • **ssh –X p3k-telem**
        - • (**dev** if running the development version)
        - • **start_ao** (-debug and/or –tcs are options)
            - o When all of the computers and p3k components are communicating as expected, the system DEFAULT file is restored.
            - o Total startup takes ~ 15 seconds (60 seconds if CASS2 was power cycled)
            - o The blue terminal window displays status for the entire system

- On the *p3k-control* desktop in the right-hand monitor, click the green P3K GUI icon (or the red DEV GUI icon if running the development version)

- Acquire the white light
    - If there is no light in the HWFS GUI Camera display, look for the white light in the Acquisition Camera GUI (the white light is ON by default)
    - In the Acquisition Camera GUI, click the Camera ON radio button
    - In the Acquisition Camera GUI, click on the Motion Control tab
        - Under System click on the Stimulus radio button
        - Use the arrows to steer the white light under the target
        - For Stimulus the units are arcseconds (use 1-10" for coarse moves).
        - When the white light is under the target, you should start to see the light in the HWFS Camera GUI. Fine tune the motion further with smaller steps if necessary
    - Turn the Acquisition Camera OFF to save disk space, but leave the Acam GUI open for image motion access

- Take a HWFS background
    - In the HWFS Camera GUI, click on the HWFS Background tab, and then click Take Background

- Close the TTM loop
    - In the Main P3K Control GUI, click on the TTM button to close the TTM loop
    - If the white light remains in the HWFS GUI, go to the next section **Align field stop**
    - If the white light disappears, open the TTM loop by clicking the TTM button (it should turn grey)
        - In Terminal #2 set the TTM mirror back to zero
            - **ao move ttm_a 0**
            - **ao move ttm_b 0**
        - In the P3K Motor Control GUI select the Lenslet_Y and Offset radio buttons
        - In the P3K Motor Control GUI enter 30 units into the text entry field and click GO
        - Close the TTM loop again
        - If the white light remains in the HWFS GUI, go to the next section **Align Field Stop**
        - If the white light disappears again, open the TTM loop, and repeat the above steps (starting with setting the TTM back to zero)
        - Try +60 units of Lenslet_Y, and repeat. If that doesn't work, reset Lenslet_Y to where you started, and try -30 units (and then again with -60 if that fails)
        - If the above doesn't work, try the same steps with the Lenslet_X motor with Lenslet_Y back to 0

- Align field stop
    - Ensure the TTM loop is closed
    - In the P3K Motor Control GUI select the Lenslet_X and Offset radio buttons
    - In the P3K Motor Control GUI enter 20 units into the text entry field and click GO
    - Watch the image on the HWFS GUI as you move in steps of 20 units. Once the image starts to look "bad" on one side, stop and enter -20 into the P3K Motor Control GUI (see Figure #2 in the Align Field Stop section below). Click the GO button and count the number of steps until the other side of the image starts to look "bad". Typically 6-8 steps are required to span the full range.
    - Now again enter +20 units into the Motor Control GUI, but this time only click GO ½ of the steps you counted above. The image should now be nicely centered in X
    - Repeat the above procedure for the Lenslet_Y motor.
    - Note that the Lenslet_Y motion typically drifts more over time than the Lenslet_X motion

- Center the TTM to the middle of its range
    - With the TTM still closed, click on the Motion Control tab in the Acquisition Camera GUI
    - Click on the WFS radio button under System
    - In steps of arcseconds (typically 0.2), use the arrow buttons to steer TTM_A (red line on the Tip&Tilt Positions plot) and TTM_B (green line on the Tip&Tilt Positions plot) to within 0.1" of the zero line

- Check the LODM
    - In the HWFP Parameters GUI, check the LODM MAP radio button and select lodm_flatmap_tl

- A telescope flatmap should induce obvious changes across the entire pupil in the HWFS GUI display

- Power up the HODM
  - Switch HODM1 and HODM2 electronics racks (terminal servers take 30 seconds to come up)
  - In the MAIN gui push the HODM UP button (this procedure takes ~ 30 seconds to complete). The HODM light on the MAIN GUI will turn from red to green when the HODM is up and ready.
  - To ensure the HODM is up completely, in the HWFS Camera GUI DM Registration tab, click the Fine Pupil Test Pattern radio button and Apply.
    - You should see a regular poke pattern over the whole HODM mirror as in Figure #3 in the HODM Images section below
    - If you don't see a normal pattern, the HODM has not come up correctly and needs to be powered down. In the MAIN GUI push the HODM DOWN button.
    - Wait 60 seconds, power off HODM1 and HODM2 instrument racks, and try again
  - When the HODM appears correct, then P3K is now ready for normal operation

- Register the HODM to the HWFS
  - In the HWFS Camera GUI, click on the DM Registration tab, and then click RUN

- Make flatmaps (*if MGS is going to be run, then flatmaps are unnecessary*)
  - Generate a LODM flatmap on the white light
    - In the Flatmap GUI, check the LODM and Freeze HODM radio buttons
    - In the HWFP Parameters GUI, verify that the K1 and K4 gains are set to ensure a stable lock
      - Default values are K1=0.3 and K4=0.01
    - In the HWFP Parameters GUI, verify the centroid offset file
      - co_mgs is the default choice, and is likely to provide the best science image
      - co_zero may be used to ensure a clean p3k solution, but will not provide a sharp science image
    - To start with all LODM positions at mid range, check the CLEAR radio button; to start from the current LODM positions, leave the CLEAR radio button unchecked
    - To generate the LODM flatmap push the RUN button
    - To revert to the previous LODM flatmap (if you don't like the new map, for example), press the REVERT TO PREVIOUS button
    - To revert to a clean backup flatmap (useful for starting totally over), press the REVERT TO DEFAULT button. The backup flatmaps were made with co_zero centroid offsets
  - Generate a HODM flatmap on the white light
    - In the Flatmap GUI, check the HODM radio button
    - In the HWFP Parameters GUI, verify that the K0 and K3 gains are set to ensure a stable lock
      - Default values are K0=0.2 and K3=0.02
    - In the HWFP Parameters GUI, verify the centroid offset file
      - co_mgs is the default choice, and is likely to provide the best science image
      - **co_zero is *often* the best (stable) choice for HODM flatmaps**
    - To start with all HODM positions at mid range, check the CLEAR radio button; to start from the current HODM positions, leave the CLEAR radio button unchecked
    - To generate the HODM flatmap push the RUN button
    - To revert to the previous HODM flatmap (if you don't like the new map, for example), press the REVERT TO PREVIOUS button
    - To revert to a clean backup flatmap (useful for starting totally over), press the REVERT TO DEFAULT button. The backup flatmaps were made with co_zero centroid offsets

- P3K is now officially started and running
  - In the System Control GUI, save the current state of p3k to a filename of your choice, typically with a date and "wl" (for white light) in the string (ie: 20120822_wl)

P3K Alignment and Tuneup

When p3k is up and running, the science camera should be checked out. If the science camera connects to the p3k software interface, this connection should be verified. Palomar maintains separate documentation that describes p3k alignment and wavefront calibration procedures. The following items describe available p3k commands that may be useful for these actions.

Science Camera Checkout

- Update the science camera in the P3K software
    - On the MAIN GUI, select the current science instrument (Pharo is default)

- Center the white light on the science camera
    - In the Acquisition Camera GUI, click on the Motion Control tab
        - Under System click on the Science radio button
        - Use the arrows to steer the white light on the science camera
        - The units are arcseconds for science motion

P3K Pupil Alignment Procedure

- Align P3K to the science camera and to the telescope
    - See DM-Pharo Pupil Alignment document (2012-06-22)
    - http://www.oir.caltech.edu/twiki_oir/bin/view/Palomar/Palm3000/OperationsDocumentation

P3K Wavefront Calibration

- Tune-up the wavefront delivered to the science camera using one of two methods
    - Hand tuning
        - Close the TTM loop only
        - Have someone take science images, looking at the PSF of the white light source
        - In the matlab terminal window (terminal #1), type
            - >> tune_lodm(0,0,0,0,0,0,0,0);
            - This copies the current LODM flatmap into "lodm_tunemap" without making any changes
            - The available Zernike low order terms to change are
                - >> tune_lodm(focus,astig1,astig2,coma1,coma2,tri1,tri2,sphere);
                - ***Do not tune focus using this method***
        - Verify that the PSF looks the same in the science camera
        - In the matlab terminal window (terminal #1), type
            - >> tune_lodm(0,40,0,0,0,0,0,0);
            - This adds +40 nm of astigmatism to the surface of the LODM
        - Note the change in the PSF
        - In the matlab terminal window (terminal #1), type
            - >> tune_lodm(0,-40,0,0,0,0,0,0);
            - This adds -40 nm of astigmatism to the surface of the LODM
        - Note the change in the PSF
            - If the +40 and -40 PSF images look equally bad, set the first astigmatism value back to 0, and move on to the next astigmatism term like this
                - >> tune_lodm(0,0,40,0,0,0,0,0);
            - If the +40 and -40 PSF images are not equally bad, set the first astigmatism value to something between 0 and the value that produced the better image like this
                - >> tune_lodm(0,20,0,0,0,0,0,0);
                - Repeat on this term as necessary until satisfied that the balance is reached, and then move on to the next term like this
                - >> tune_lodm(0,25,40,0,0,0,0,0);

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- Iterate on each of the terms until satisfied that the wavefront errors are minimized to the point that the white light PSF is as good as possible. A typical final tuning solution may look like this
  - >> tune_lodm(0,25,-15,-5,0,3,0,5); when starting with something reasonably close
  - >> tune_lodm(0,85,-40,20,-5,3,0,15); when starting from co_zero centroid offsets
- Convert the LODM surface to centroid offsets
  - >> make_cents('co_<filename>');
- Make a new LODM flatmap using these centroid offsets (see the procedure above)

- MGS
  - A set of matlab scripts are available that will automatically command P3K and the Pharo science camera to take defocused images, and process these images to fine tune the wavefront for the Pharo detector.
  - See MGS Wavefront Tuning document (2012-08-22)
  - http://www.oir.caltech.edu/twiki_oir/bin/view/Palomar/Palm3000/OperationsDocumentation

- P3K is now ready to observe targets on-sky.

P3K On Sky Observing Procedures

First Setup Star

The Palomar night staff typically begins observing on the sky by acquiring and tuning on a bright 4th magnitude G star. The sky is usually dark enough to lock on a 4th magnitude star at civil twilight. Brighter stars may be observed in brighter sky conditions.

- Set the stimulus position to SKY
    - In the System Control GUI, choose the Stim_Select SKY selector

- Acquire a 4th magnitude G star near zenith
    - In the Acquisition Camera GUI, click the Camera ON radio button
    - Use the telescope hand paddle to steer the star behind the target
        - When the star is behind the target, you should start to see light in the HWFS Camera GUI. Continue until the pupil image in the HWFS GUI is nearly fully illuminated
    - Turn the Acquisition Camera OFF to save disk space

- Note the flux value in the blue flux stripchart
    - If the value is between 400 and 5000, leave the HWFS camera rate as is
    - If the value is less than 400, slow down the camera
        - In the HWFS Camera GUI, click on the Camera Control tab, select a lower rate on the HWFS_RATE selector, and then click RUN
    - If the value is greater than 5000, speed up the camera
        - In the HWFS Camera GUI, click on the Camera Control tab, select a higher rate on the HWFS_RATE selector, and then click RUN

- Set the Subap Minimum Flux value
    - Note the current flux value in the blue flux stripchart
        - In the HWFP Parameters GUI, change the Subap Min Flux value to 50% of the current flux

- Set the Pixel Gains
    - In the HWFP Parameters GUI, set the Pixel Gains to pix_gains_all

- Take a HWFS background
    - In the HWFS Camera GUI, click on the HWFS Background tab, and then click Take Background

- Register the HODM to the HWFS
    - In the HWFS Camera GUI, click on the DM Registration tab, and then click RUN

- Set the HWFP servo gains
    - In the HWFP Parameters GUI, set the servo gains to the following typical bright star values
        - K0=0.2, K1=0.6, K2=0.8, K3=0.02, K4=0.01

- Make a LODM flatmap
    - Generate a LODM flatmap on the star
        - In the Flatmap GUI, check the LODM and Freeze HODM radio buttons
        - In the HWFP Parameters GUI, verify that the K1 and K4 gains are set to ensure a stable lock
        - In the HWFP Parameters GUI, verify the centroid offset file
            - co_mgs is the default choice, and is likely to provide the best science image
            - Centroid offset files derived during the day for other science instruments may be used
        - To start with all LODM positions at mid range, check the CLEAR radio button; to start from the current LODM positions, leave the CLEAR radio button unchecked
        - To generate the LODM flatmap push the RUN button
        - To revert to the previous LODM flatmap (if you don't like the new map, for example), press the REVERT TO PREVIOUS button

- To revert to a clean backup flatmap (useful for starting totally over), press the REVERT TO DEFAULT button. The backup flatmaps were made with co_zero centroid offsets

- Generate a reconstructor at this telescope pointing
  - Ensure both the TTM and DM loops are closed
  - Ensure a stable lock by lowering the K0 and K1 gains by 0.1 to 0.2, raising the subap min flux value by 25%, and/or raising the K3 and K4 gains by 0.01 (to get a nice, clean pupil image)
  - In the matlab session running in terminal window #1
    - >> p3k_reconst
  - This script typically takes 3 minutes to complete. When it is done, a new reconstructor is created and loaded that is specifically measured for the current illumination pattern.
  - Reconstructor files are saved to the standard /p3k/tables/reconst/ location and are intended for reuse when observing again in the same region of the sky. The reconstructor naming convention is
    - <six digit date string>_<two digit index>_<method>_<HA#.#E|W>_<DEC+|-##>
    - example: 120719_01_wlsq_HA1.5W_DEC+33
  - Restore the servo gains and subap min flux if any were changed

- Close the loops and tune the image further, with feedback from the science instrument
  - In the MAIN GUI, click on the TTM and DM buttons to close the loops
  - Have the science operator take images, and report back the quality of the stellar PSF
  - Use Science Motion to steer the star on the science camera if necessary
  - Adjust the "power" of the centroid offsets
    - In the matlab session running in terminal #1
      - >> coTweak('co_file',num_subaps) where co_file is the current name of the centroid offset file and num_subaps is the observing mode (64, 32, 16, 8)
        - example: coTweak('co_mgs',64);
      - Change the value in the slider in steps of 20 until the best science image is observed (see coTweak Tool in the Appendix below)
      - Leave the current centroid offset file coTweak loaded while observing
      - If a new centroid offset file is loaded, close the coTweak Tool and restart it with the new centroid offset filename
  - Optimize the HWFP servo gains settings
    - Start by increasing the TTM gain (K2) in steps of 0.2. If the mirror starts ringing (evident in the TTM positions and residuals plots), decrease the TTM gain to 70% of the current value. The maximum TTM gain may be as high as 3.0, and is typically 1.0 to 2.0.
    - Increase the LO gain (K1) in steps of 0.1. When the LODM goes unstable (evident in the HWFS pixel display as a flickering checkerboard pattern), decrease the LODM gain to 70% of the current value. The maximum LODM gain may be as high as 1.2, and is typically 0.6 to 0.8.
    - Increase the HO gain (K0) in steps of 0.1. When the HODM goes unstable (evident in the HODM positions plot as strong saturation of red and blue), decrease the HODM gain to 70% of the current value. The maximum HODM gain may be as high as 1.0, and is typically 0.4 to 0.6.
    - In general, as the HWFS Camera rate is increased, the servo gains should be lowered, and as the rate is decreased, the servo gains should be raised
  - To optimize stability and performance, see the Stability Versus Performance section below

- P3K is now ready for science targets
  - Ask the telescope operator to "X" the telescope pointing
  - In the System Control GUI, save the current state of p3k to a filename of your choice

Bright Targets

Use the procedure described above to lock on target stars that are brighter than ~ 4th magnitude. In addition, the following notes may apply:

- If the flux from the star as noted in the blue flux strip chart is above 5000 at the fastest camera frame rate (2000 Hz), then change the HWFS camera gain
    - In the HWFS Camera GUI, click on the Camera Control tab, and select a higher Camera Gain value
    - Each incrementally higher gain value attenuates the signal by ~ 10 dB
    - New HWFS Backgrounds must be taken when the gain is changed

- In general, as the HWFS camera gain is increased, the HWFP servo gains should be decreased

Blue Stars

The HWFS camera suffers from a color dependence that induces focus into the wavefront correction. As a workaround until the problem is resolved, the following procedure must be used to correctly set the HWFS focus location to the proper position when observing blue stars. This procedure should also be used if the color of the star is unknown.

- Acquire and tune the star normally
- Just before starting science, monitor a series of science images while offsetting the wfs_z motor in steps of +/- 500 as you would in a standard focus loop (by eye)
- Leave the wfs_z motor at the position that creates the best science PSF image

Faint Targets

Use the procedure described above to lock on target stars that are fainter than ~ 8th magnitude. In addition, the following notes may apply:

- ***Acquire and tune on a nearby bright star to register the HODM, make a flatmap, and generate a reconstructor before acquiring the faint target***
- The acquisition camera integration time may be increased to up to 10 seconds in order to see faint targets
- If the flux from the star as noted in the blue flux strip chart is below ~ 200 counts, then lower the HWFS camera frame rate until at least 200 counts is observed on the faint star
- In general, as the HWFS camera rate is lowered, the HWFP servo gains should be increased

Extended Targets

Use the procedure described above to lock on extended targets. In addition, the following notes may apply:

- This section will be filled in as experience is obtained (spatial filter, table settings)

Stability Versus Performance

There are several options available to the p3k operator that may improve closed loop stability at the expense of performance, or alternatively improve closed loop performance at the expense of stability. Until system tools are developed to optimize these options, it is up to the operator to find the balance between the two.

- To increase stability
    - Raise the Subap Minimum Flux value to 75% of the current subaperture flux (as opposed to 50%)
    - Decrease the K0 and/or the K1 servo gains
        - The K0, K1, and K2 servo gains scale linearly
    - Increase the K3 and/or the K4 leaky servo gains

- The K3 and K4 servo leaky gains do not scale linearly
- A value of 1.0 for the HODM (K3) and the LODM (K4) drives these mirrors to their respective flatmaps. A value of 0.0 leaves the mirrors unprotected from the leaky correction term, and is unstable. A value 0f 0.01 to 0.02 is the default for setup and good seeing. A value of 0.03 results in a strong flatmap term applied which is good for poor seeing. Values greater than 0.03 result in a very strong static flatmap term with little correction of the atmosphere

- To increase performance
  - Lower the Subap Minimum Flux value to 20% of the current subaperture flux
  - Increase the K0, K1, and K2 servo gains
  - Decrease the K3 and K4 leaky servo gains

- When all else fails
  - Try a different reconstructor file
  - Retune the centroid offsets with coTweak
  - Reregister the HODM with DM Registration
  - Take a new HWFS Bakground
  - Lower the K0 and/or the K1 servo gains
  - Make a new LODM telescope flatmap

P3K Shutdown Procedure

HODM Shutdown

The HODM *must* be powered down before shutting down the p3k software if you're leaving the system unattended for any length of time. The HODM does not need to be powered down if you're simply restarting the software.

- In the MAIN gui push the HODM DOWN button

- Wait 2 minutes to let the HODM voltages drain completely before powering off the HODM1 and HODM2 instrument racks

System Shutdown

- In Terminal #2
    - **stop_ao**

- Turn power off to the CASS1 instrument rack

- In the Chiller Supervisor GUI click the ***Running / Stop*** button, then click the ***Stop*** button

- If you are returning to operate P3K within 24 hours, leave the CASS2 instrument rack powered ON. Otherwise, power it off

- Power off the chiller:
    - **Lab:** Outside the lab in the west corner of the room, push the red stop button
    - **Telescope:** In the coude room next to the data room (through the coude alley), stop the chiller

Appendix

Typical Fault Conditions

- **Database Failure**
  - On the MAIN GUI, if the DB State light is red, then the database is corrupted
  - If the system appears hung, or sluggish, then the database may be corrupted
  - To clear the database
    - In terminal #2, stop the p3k software by typing **stop ao**
    - In terminal #2, type **rmdb**
    - In terminal #2, start the software by typing **start ao**
   - Continue with the system startup procedure as described above

- **HODM Failure**
  - On the MAIN GUI, if the HODM State light is red, then the hodm is powered off
  - To recover, in the MAIN gui push the HODM UP button. The HODM light on the MAIN GUI should turn from red to green when the HODM is up and ready
  - To ensure the hodm is up completely, in the HWFS GUI DM Registration tab, click the Fine Alignment Map radio button and Apply
    - You should see a regular poke pattern over the whole HODM mirror as in Figure #3
    - If you don't see a normal pattern, the HODM has not come up correctly and needs to be powered down. In the MAIN GUI push the HODM DOWN button.
    - Wait 60 seconds, power off HODM1 and HODM2 instrument racks, and try again
  - When the HODM appears correct, then P3K is now ready for normal operation

- **HWFS Camera Issues**
  - If the image in the HWFS Camera GUI turns completely black in columns 3-8 (the entire right side of the CCD), then the camera gain needs to be cycled
    - On the HWFS Camera GUI in the Camera Control tab Manual Controls box, change the Camera Gain from 0 to 1, and then change it back
    - Push the Sync HWFP button
  - If the image in the HWFS Camera GUI freezes completely and does not come back
    - Close the GUI entirely, and then restart the GUI
  - If the image in the HWFS Camera GUI remains frozen, power cycle the HWFS controller
    - In terminal #2, type **stop_ao**
    - Toggle the power on the HWFS controller on the CASS1 instrument rack
    - In terminal #2, type **start_ao** and follow the startup procedures as described above

- **Data Freeze**
  - If the pixel data and plots freeze for an extended period of time, close the MAIN GUI (which closes the entire GUI), and restart the GUI

- **When All Else Fails**
  - Stop the software with **stop_ao**
  - Remove the database files with **rmdb**
  - Restart the software
  - Redo the above, this time power cycling the instrument racks
  - Call an expert (Kevin Melvin Rykoski)

P3K-CONTROL Left Monitor
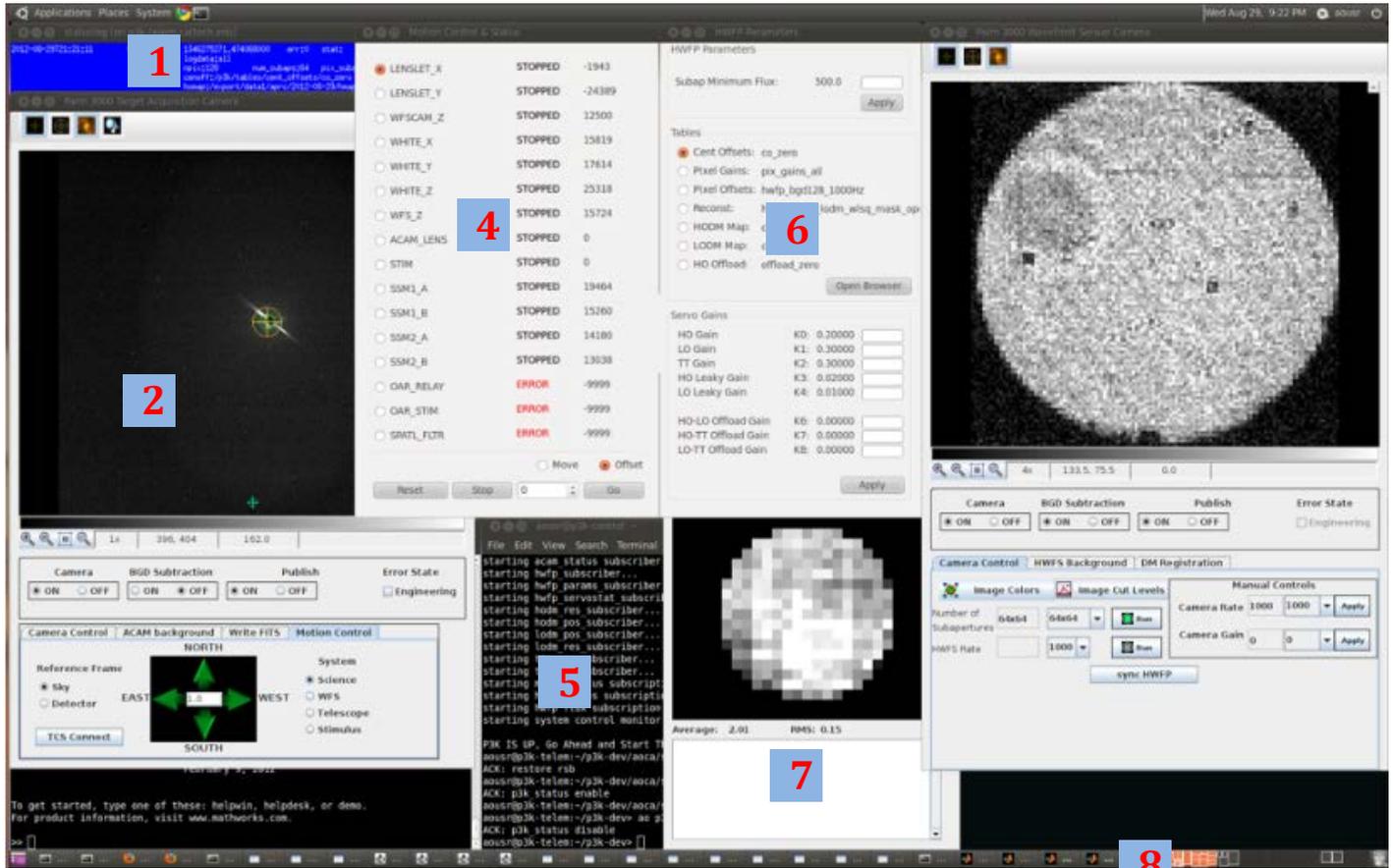
1	Statusmon (Blue Window)	
2	Acquisition Camera / Motion Control GUI	
3	Terminal window #1 (matlab)	
4	Motor Control GUI	
5	Terminal window #2 (p3k commands)	
6	HWFP Parameters GUI	
7	Flatmap GUI	
8	HWFS Camera GUI (Camera Control / HWFS Background / DM Reg)	

P3K-CONTROL Right Monitor
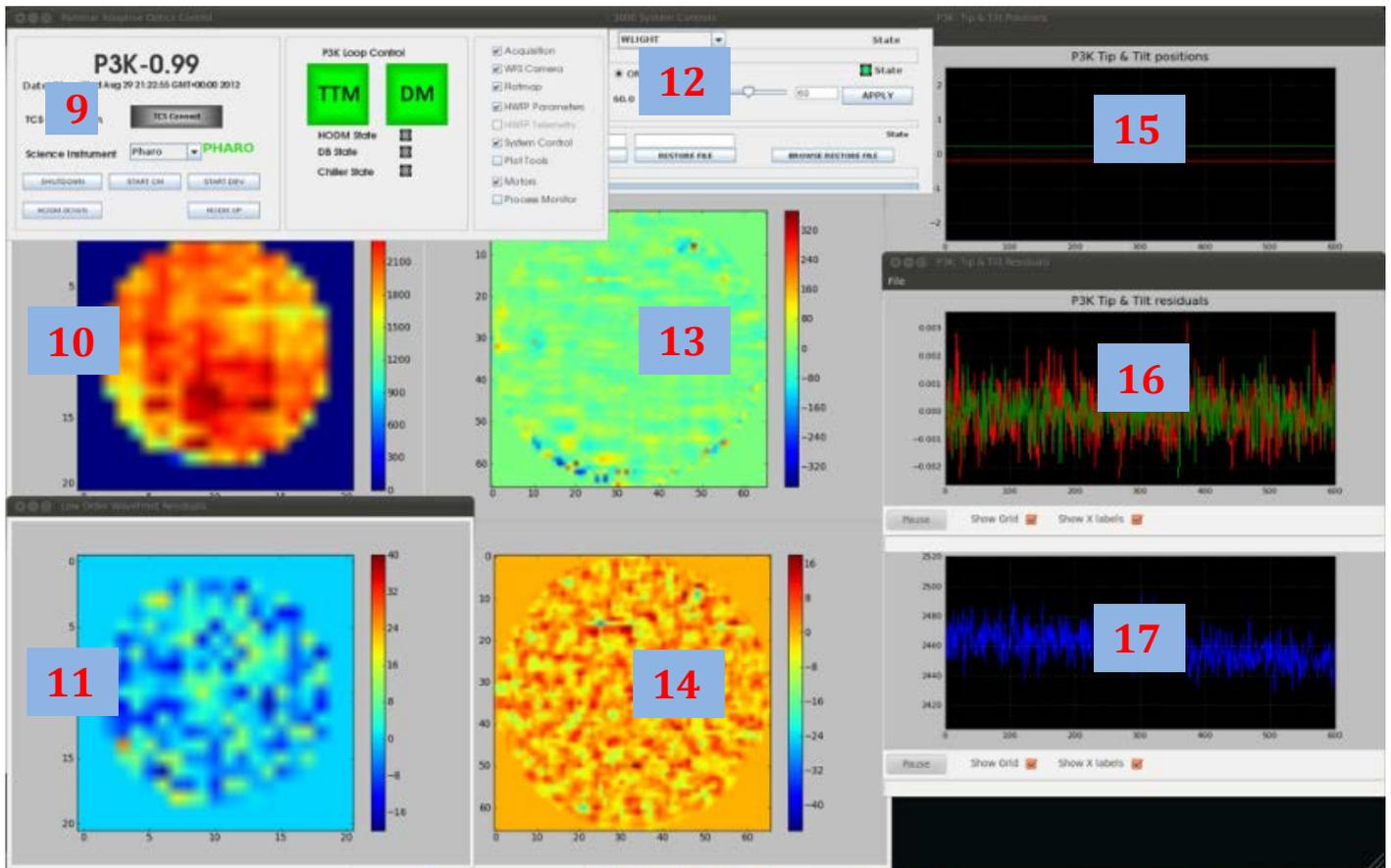
9	P3K MAIN GUI
10	LODM Positions Plot
11	LODM Residuals Plot
12	System Control GUI
13	HODM Positions Plot
14	HODM Residuals Plot
15	TTM Positions Plot
16	TTM Residuals Plot
17	Subaperture Flux Plot

Field Stop Alignment

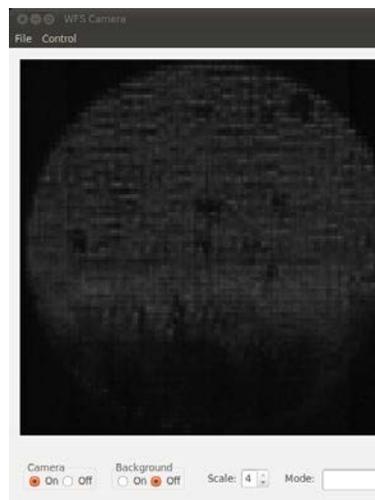
Figure 1a: TTM loop must be CLOSED

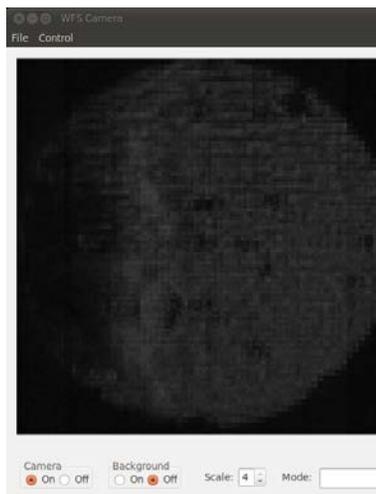**Figure 2b: Lenslet_Y Motor +30 Units**
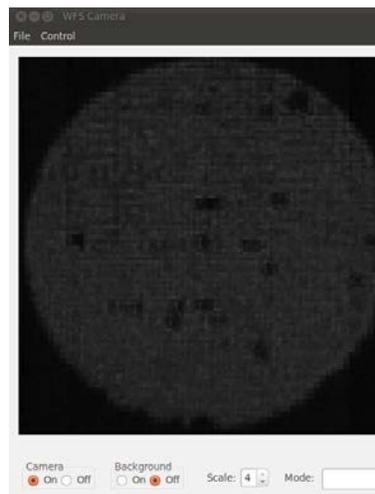

Figure 2c: Lenslet_X Motor -40 Units
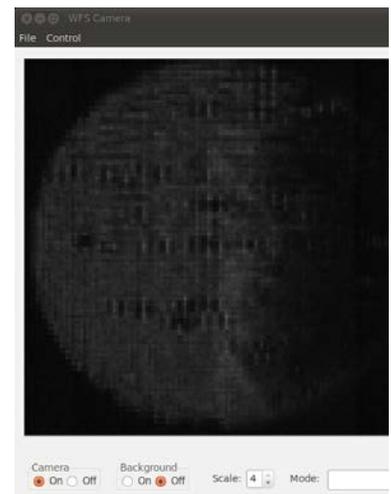

Figure 2d: Field Stop Aligned
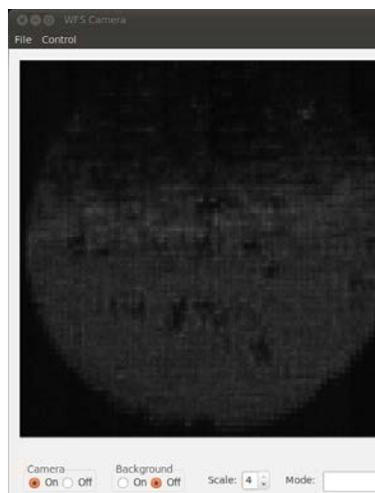

Figure 2e: Lenslet_X Motor +40 Units
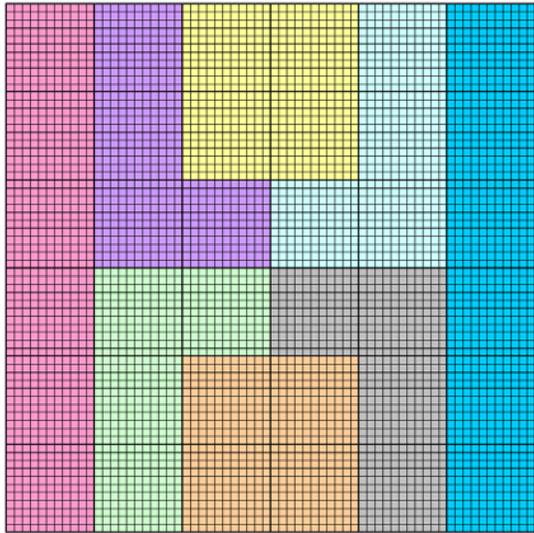

Figure 2f: Lenslet_Y Motor -30 Units

HODM Images

Figure 3a: HODM schematic showing each actuator, module, and region controlled by 1 of the 8 control driver electronics (arranged here by color)
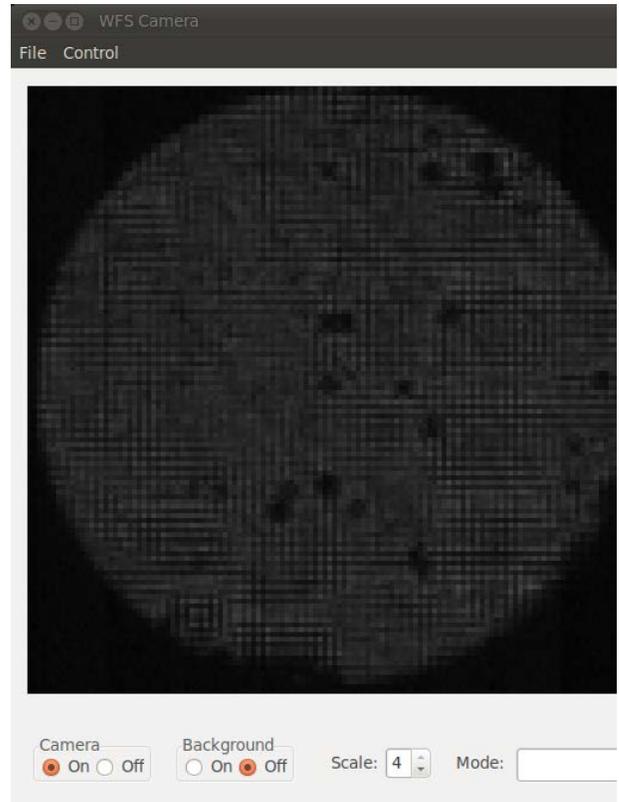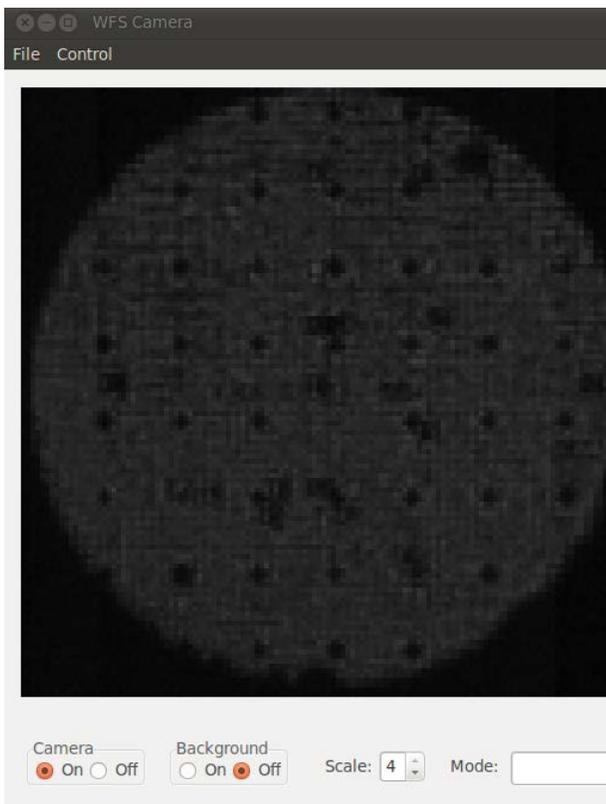

Figure 2b: HODM unpowered

Figure 3c: HODM powered with pokes (hodm_reg_pattern)
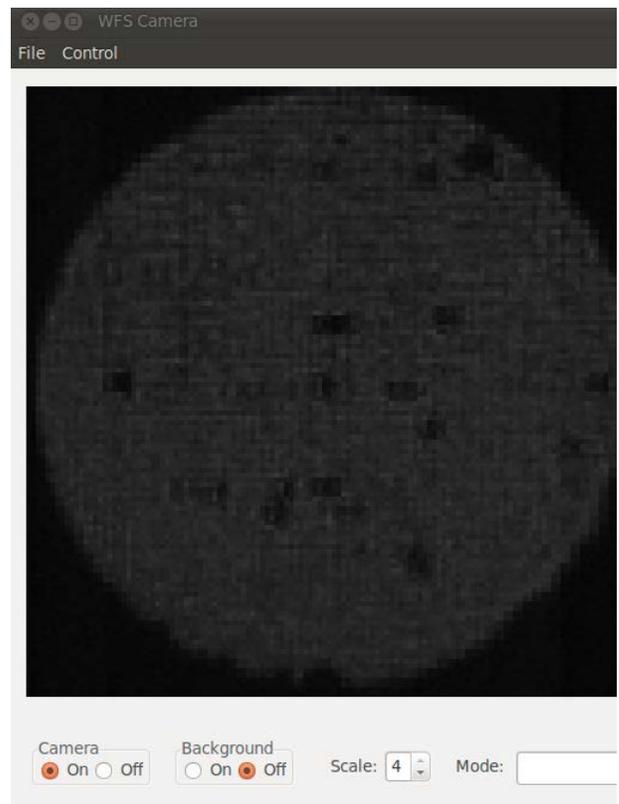

Figure 3d: HODM powered up and smooth

P3K Cross Mounts

The P3K GUI running on the p3k-control computer expects the cross-mount from p3k-control to p3k-telem to exist across the /p3k partition. To ensure this cross-mount is maintained when computers are rebooted, the following commands are executed at the end of a reboot:

p3k-telem /etc/rc.local
- /usr/sbin/exportfs -a
- ssh aousr@p3k-control 'sudo umount -f /p3k'
- ssh aousr@p3k-control 'sudo mount 198.202.125.206:/p3k /p3k'

p3k-control /etc/rc.local
- /bin/mount 198.202.125.206:/p3k /p3k

To manually refresh the cross-mount, an icon on the p3k-control desktop (Remount_p3k) is linked to a script that executes the command p3k-control:/usr/local/bin/remount_p3k.


Humidity Sensor

The HODM needs to be maintained at all times to a constant humidity (33% relative) to stabilize the surface features. Sensors are attached to the HODM and the surrounding area to monitor temperature and relative humidity. To access these values

- Open a firefox window on the *p3k-control* computer (usually opened on Desktop #4)
- http://198.202.125.234 (P3K HODM bookmark)
- Click Chart
- On the selector above the graph select Draw Both
  - The leftmost temperature value (red) is ambient air in the bench
  - The rightmost temperature value (pink) is coupled to the HODM
  - The leftmost relative humidity value (light blue) is ambient air
  - The rightmost relative humidity value (dark blue) is coupled to the HODM
- Small packs containing a substance that controls the humidity are placed in an enclosure in the HODM to maintain the relative humidity as close to 33% as possible. If the humidity reading of the HODM sensor (dark blue) is higher than this, then the packs need to be swapped out (consult an expert!!)

coTweak Tool

- Slider = 100 is no change to the starting centroid offsets
- Slider < 100 is percentage multiplier to reduce the power of the starting centroid offsets
  - example : co_mgs * 0.80 = coTweak
- Slider > 100 is percentage multiplier to increase the power of the starting centroid offsets
  - example : co_mgs * 1.05 = coTweak
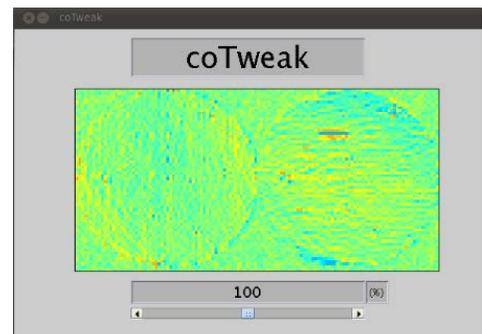
P3K Quick Start

1. Power up the chiller

2. Start the chiller supervisor
   - Firefox: (chill200 bookmark), START

3. Start the p3k software
   - In terminal #2, **dev**
   - In terminal #2, **start_ao –tcs**

4. Start the GUI by clicking the red DEV GUI icon on the right p3k-control desktop

5. Use the Acquisition Camera GUI to move the target into the HWFS Camera

6. If on a star; Set the HWFS Camera rate to optimize the subap flux

7. If on a star; Set the Subap Minimum Flux value to 50% of the subap flux value from the blue strip chart

8. Take a HWFS Background

9. Close the TTM Loop

10. Align the field stop

11. Power up the HODM
    - Ensure the HODM is up by loading the FINE pupil test pattern

12. Register the HODM to the HWFS with DM Registration

13. If on a star; Run the p3k_wfsz matlab script to optimize the wfs_z focus position

14. Make flatmaps (or run MGS if starting during the day)

15. If on a star; optimize the centroid offset with coTweak

16. If on a star; optimize the servo gains

17. If on a star; generate a new reconstructor with the matlab script p3k_reconst

P3K Command List

start_ao {-tcs | -tcssim | -debug | -noaoca | -noaodd | -nohwfp | -nogui | -help}

stop_ao

==
PRIMITIVE COMMANDS   <required>   {optional}
==

```
ao hwfp
        rate
        calc            = on | off
        ttm             = on | off
        dm              = on | off
        K(0:8)          = 0.0 : 1.0
        log_data        = all | none | pixels | flux | centroids | offload |
                           hodmres | hodmpos | lodmres | lodmpos | ttmres | ttmpos
        log_interval    = 1 : 500
        ttm_move_a      = <float>
        ttm_move_b      = <float>
        ttm_offset_a    = <float>
        ttm_offset_b    = <float>
        table           = pix_offsets | pix_gains | cent_offsets | reconst |
                           hodm_map | lodm_map | ho_offload | hodm_pos | lodm_pos

ao hwfs
        rate            = 30 : 2000
        bin             = 0 | 1
        gain            = 0 | 1 | 2 | 3

ao acam
        on | off
        int_time        = 0.125 : 10
        bgd             = on | off
        window          = 0 | 1 | 2 | 3 | 4

    [0 = full1x1, 1 = full2x2, 2 = full4x4, 3 = acq4x4, 4 = pupil2x2]

ao motor
        id              = motorid
        pos             = <float>
        off             = <float>

        [motorid = lenslet_x | lenslet_y | wfscam_z | ssm1_a | ssm2_ | ssm1_b |
                    ssm2_b | white_x | white_y | white_z | wfs_z | acam_lens |
                    spatial_filter | stim | oar_relay | oar_stim]

ao wlight
        on | off
        pwr             = 0.0 : 100

ao hodm
        up | down
```

```
================================================================================
AUTOMATION COMMANDS      <required>      {optional}
================================================================================


ao hwfs_align
        8 | 16 | 32 | 64

ao hwfs_rate
        30 : 2000

ao stim_select
        wlight | sky

ao acam_select
        image | pupil

ao acam_bgd
        run
        ra                = <float>
        dec               = <float>
        nframes           = 1 : 60

ao hwfp_bgd
        run
        ra                = <float>
        dec               = <float>
        time_avg          = 0.1 : 60.0

ao ttm_offload
        enable | disable
        gain              = 0.0 : 1.0
        time_avg          = 0.1 : 30.0
        thresh            = 0.001 : 2.0

ao foc_offload
        enable | disable
        gain              = 0.0 : 1.0
        time_avg          = 0.1 : 30.0
        thresh            = 0.001 : 2.0

ao dm_reg
        run
        coarse | fine | both
        cthresh           = 0.001 : 10.0
        fthresh           = 0.001 : 10.0
        counter           = 1 : 10
        time_avg          = 1 : 30

ao flatmap
        run
        hodm | lodm
        {nohodm | nolodm}
        clear             = 0 : 1
        iterate           = 1 : 10
        time_avg          = 1.0 : 60.0
        {freeze}
```

ao write_fits
        {filename}

ao save
        <filename>

ao restore
        <filename>

ao move
        motorid | ttm_a | ttm_b <float>

ao offset
        motorid | image_x | image_y | pupil_x | pupil_y | ttm_a | ttm_b <float>

ao home
        motorid

ao log_rate
        1 : hwfs.rate

ao sci_inst
        pharo | p1640 | swift | tmas | fibernuller

ao sci_motion
        n | s | e | w | u | d | l | r <float>
        radec <ra_float> <dec_float>
        no_ssm

ao p3k_status
        enable | disable

==
MISCELLANEOUS COMMANDS
==

ao tcs
        <tcs command>

ao tcscom

ao pharo
        <pharo command>

ao cancel
        <automation | all>

ao shutdown

dbtime

dbget   <dataid> -start <start> -stop <stop>
        start|stop = yyyymmddThhmmss or sssssssss or last (both must be last)
        {-o <filename>}
        {-a}
        {-l}
        {-h, --help}

```
===============================================================================
Matlab scripts that will work with this release:
===============================================================================


streambin.m          stream data in from database
                     pix=streambin('hwfp_pix128','20100527T123816','20100527T123826')

readbin.m            read in binary telem file from dbget
                     pix=readbin('hwfp_pix128.dat','hwfp_pix128')

readcsv.m            read in csv telem file from dbget
                     pix=readcsv('hwfp_pix128.csv','hwfp_pix128')

readstat.m           read in command or status file from dbget
                     hwfp=readstat('/p3k/DBGET/hwfp_stat.dat','hwfp_stat')

make_cents.m         make_cents('co_test')

p3k_reconst.m        make a p3k reconstructor using pixel illumination
                     p3k_reconst(64)
```

Science Instrument Volume

FM 2

FM 1

TTM

DM 3388

SSM 1

FM 3

FM 4

DM 241

OAP 1

WFS & ACam

SSM 2

OAP 2