

AO Overview

OA Meeting

2021-07-08

Jim Lyke

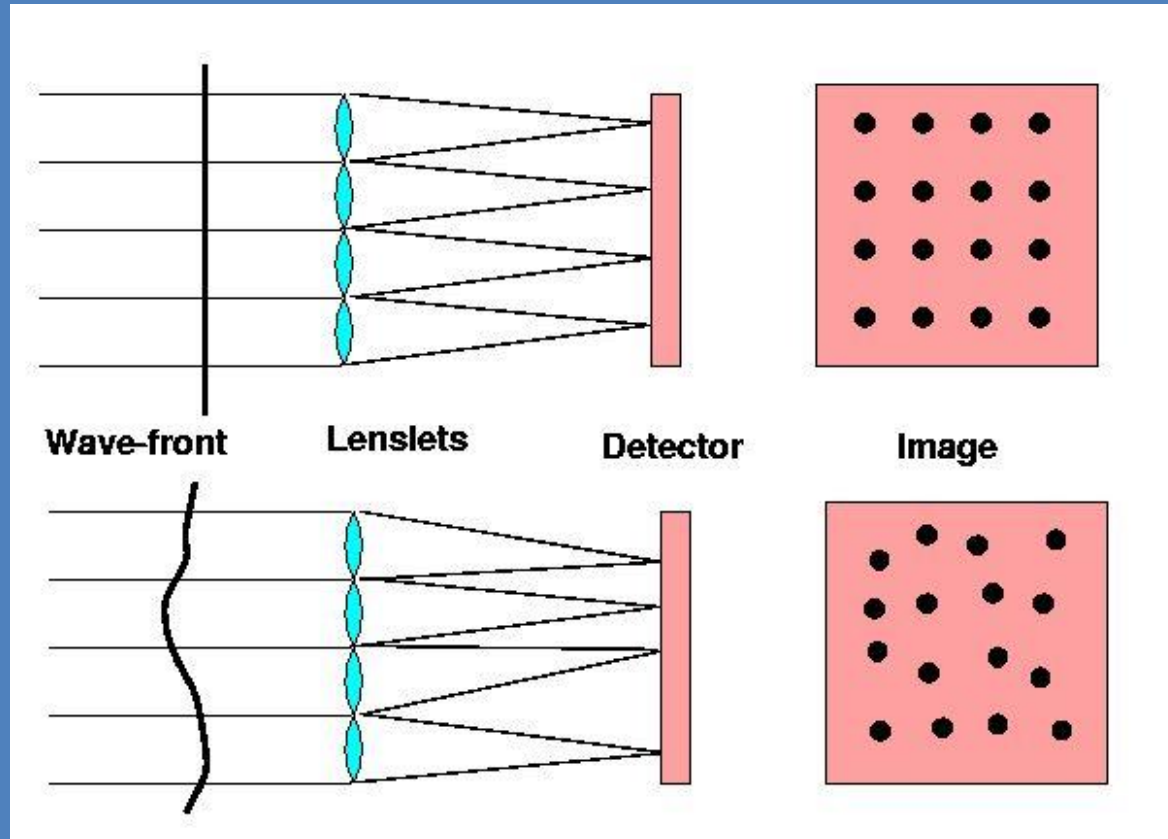
Functional AO

- The wavefront of light from astronomical objects is aberrated by the atmosphere
- Aberrations can be:
 - Measured → wavefront sensing
 - Described → Zernike polynomials
 - Removed → deformable mirror

Con conversationally, one can interchange “aberration” with “distortion”, but optically they have separate meanings.

Measure

- Shack-Hartmann Wavefront Sensor (SHWFS)

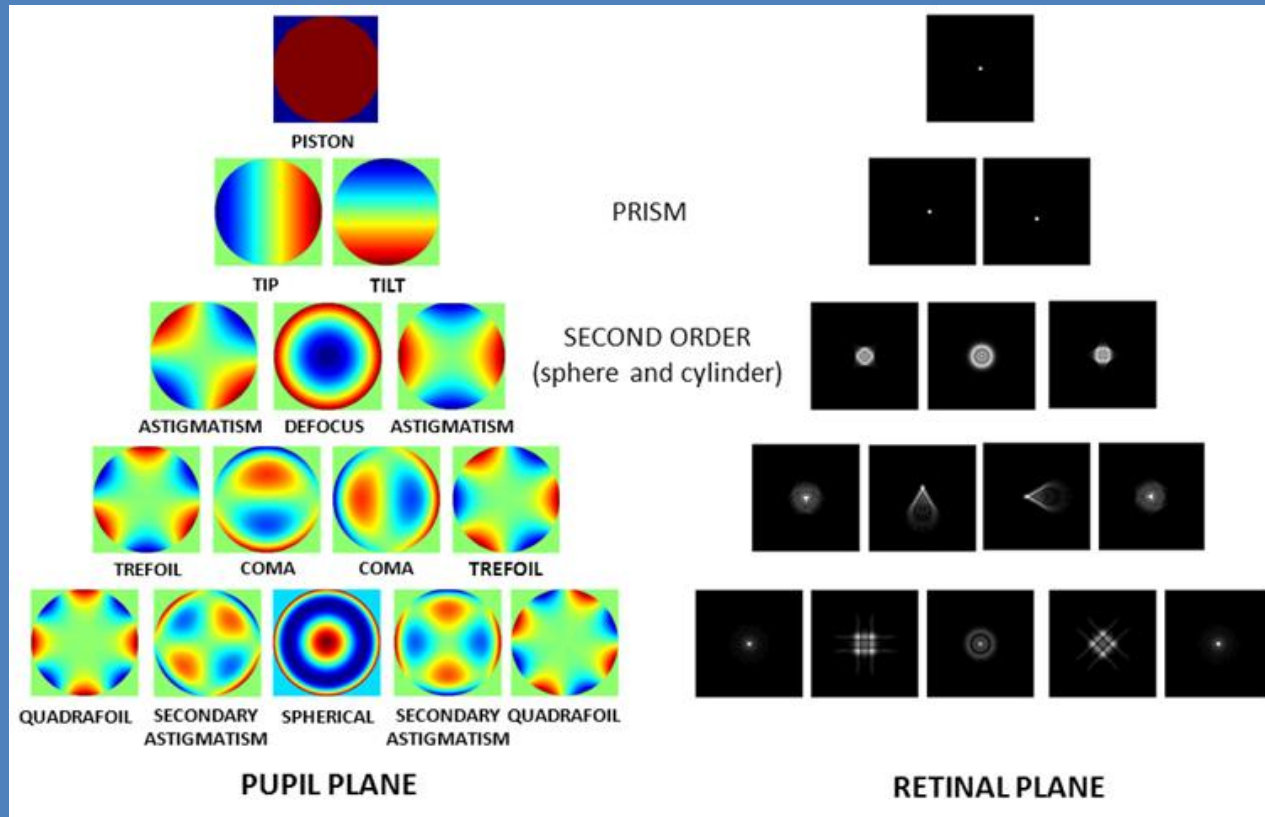


Wavefront sensor types

- 1. Shack-Hartmann – Uses centroids multiple pupil images to describe wavefront aberration*
- 2. Pyramid – A literal pyramid at the pupil plane splits the image of the pupil*
- 3. Curvature – early AO systems, fallen out of favor*

Describe

Order

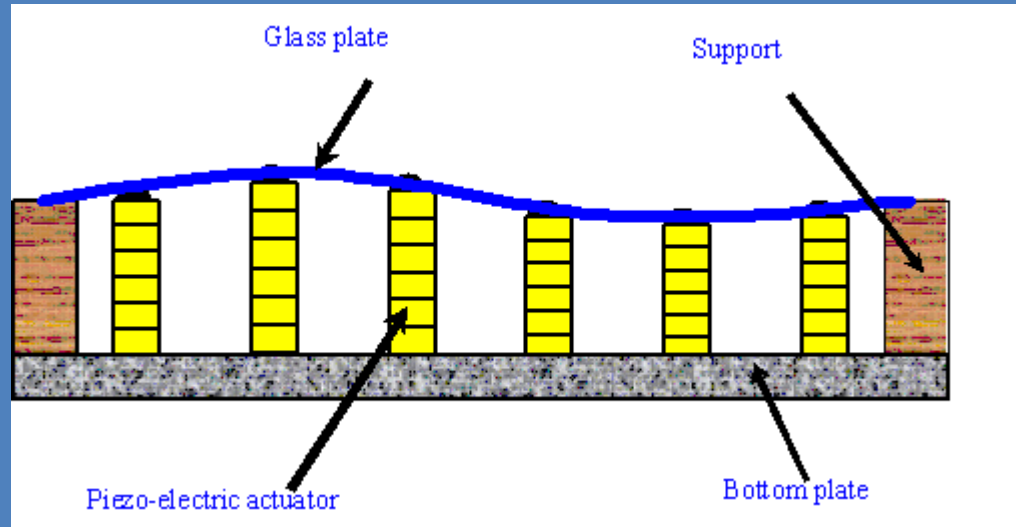


*Red = High, Blue = Low
Aberrations in the pupil plane can be described as a linear combination of Zernike polynomials*

*Retinal plane = focal plane
For opticians, the 2nd order is what we have in our eye glasses
Sphere = Defocus,
Cylinder = Astigmatism*

Remove

- Deformable Mirror



Current Keck DMs

- *Built by Xynetics*
- *349 actuators*
- *Sits very near pupil plane (image of the primary mirror)*
- *DM is oversized (~11.2 m equivalent) with respect to primary mirror*
 - *The hexagonal primary image rotates on the DM*

Keck AO Baseline

- On both K1 & K2:
 - Shack-Hartmann-based wavefront sensors
 - NGS
 - WFS measures TT and high-order
 - LGS
 - WFS -> LGS (high order only)
 - STRAP -> TT (tip-tilt only)
 - LBWFS -> TT (focus + higher orders)

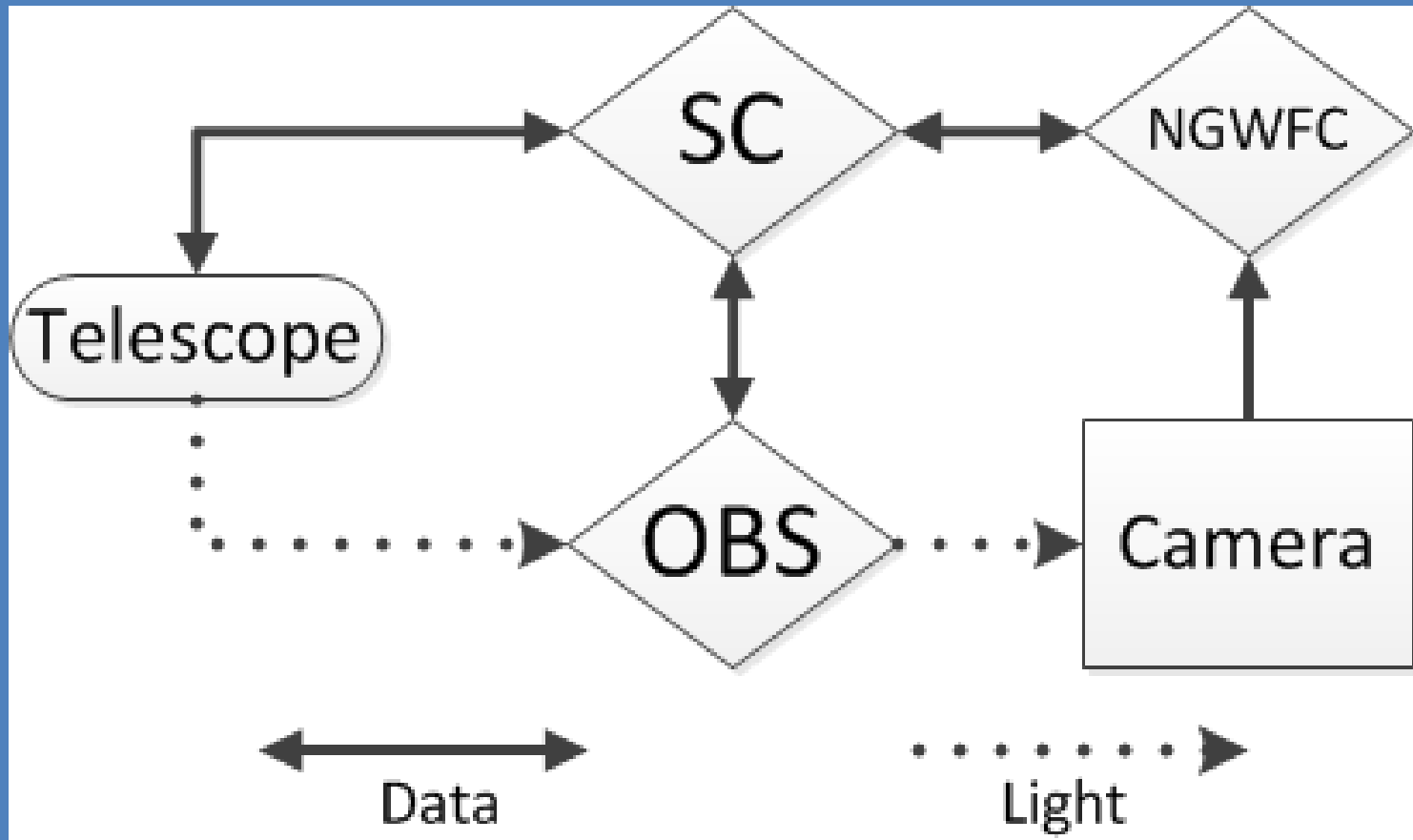
Computers + Function

- Unix
 - kNaoserver: GUIs, keyword services
- VxWorks
 - SC: Supervisory Controller
 - telescope communications
 - commands to stages
 - OBS: Optics Bench
 - optics stages motion control
 - NGWFC: Next-Gen (2006) WaveFront Controller
 - AKA Real-Time Controller (RTC)
 - calculator

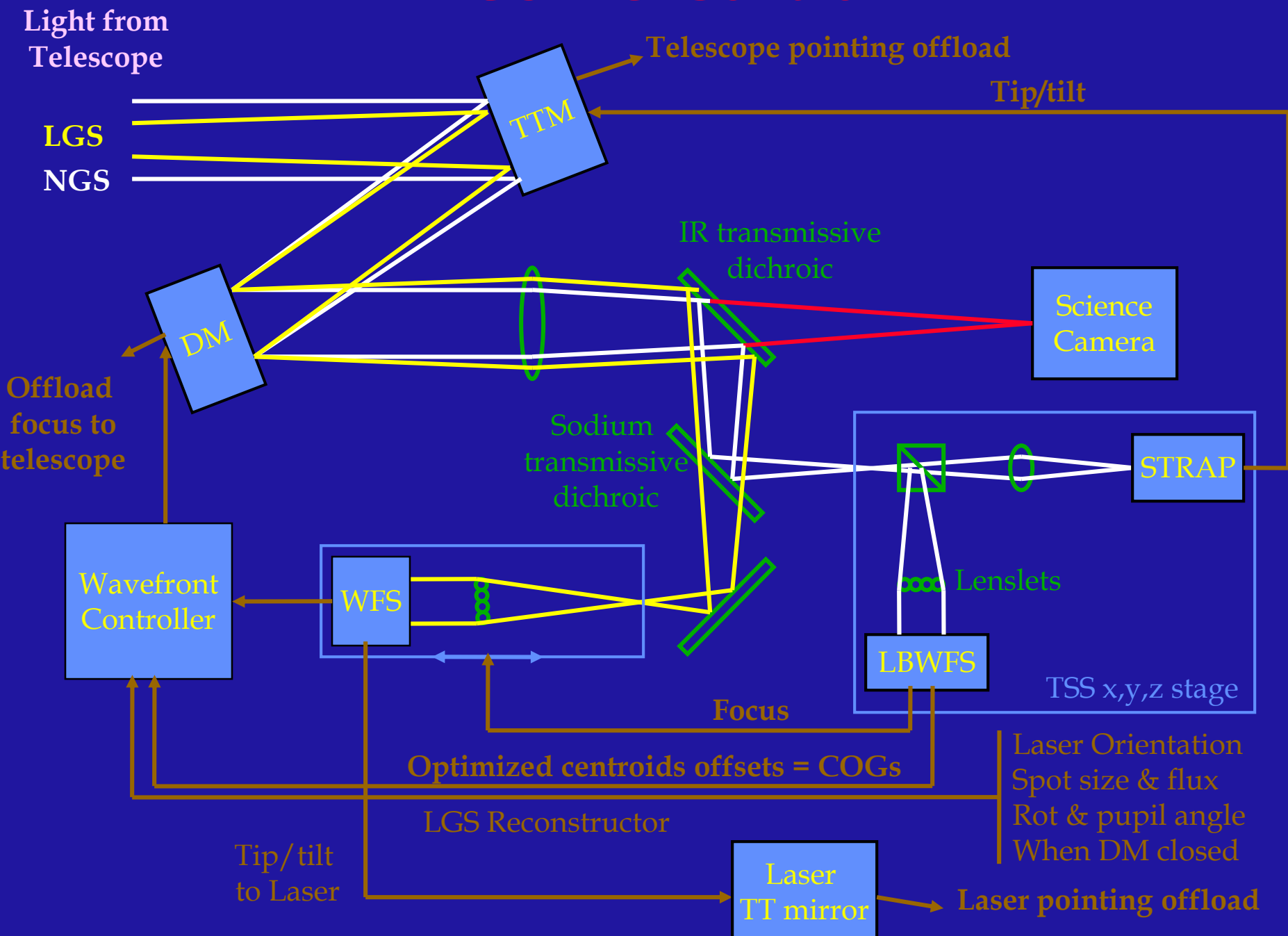
Upgrades are in progress

- *New kNaoservers*
- *SC as a softIOC*
- *RTC (+WFS) upgrades*

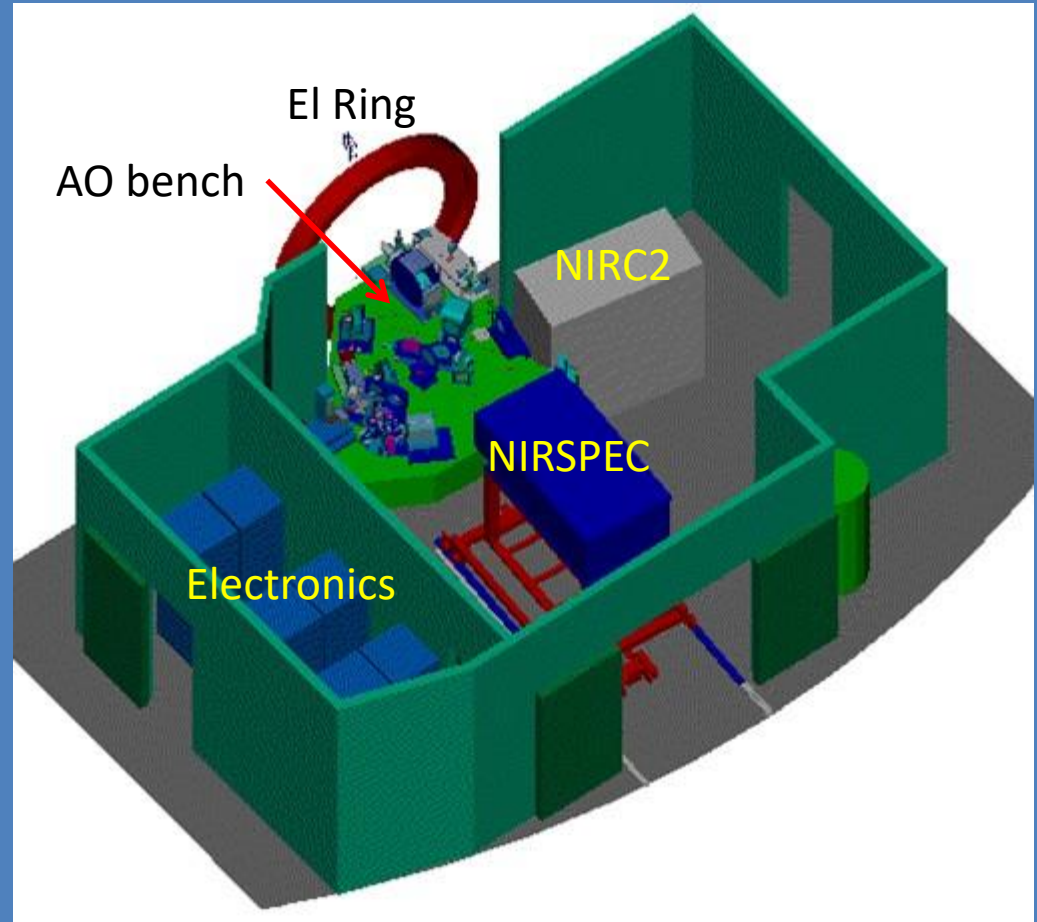
Simplified Control Flow



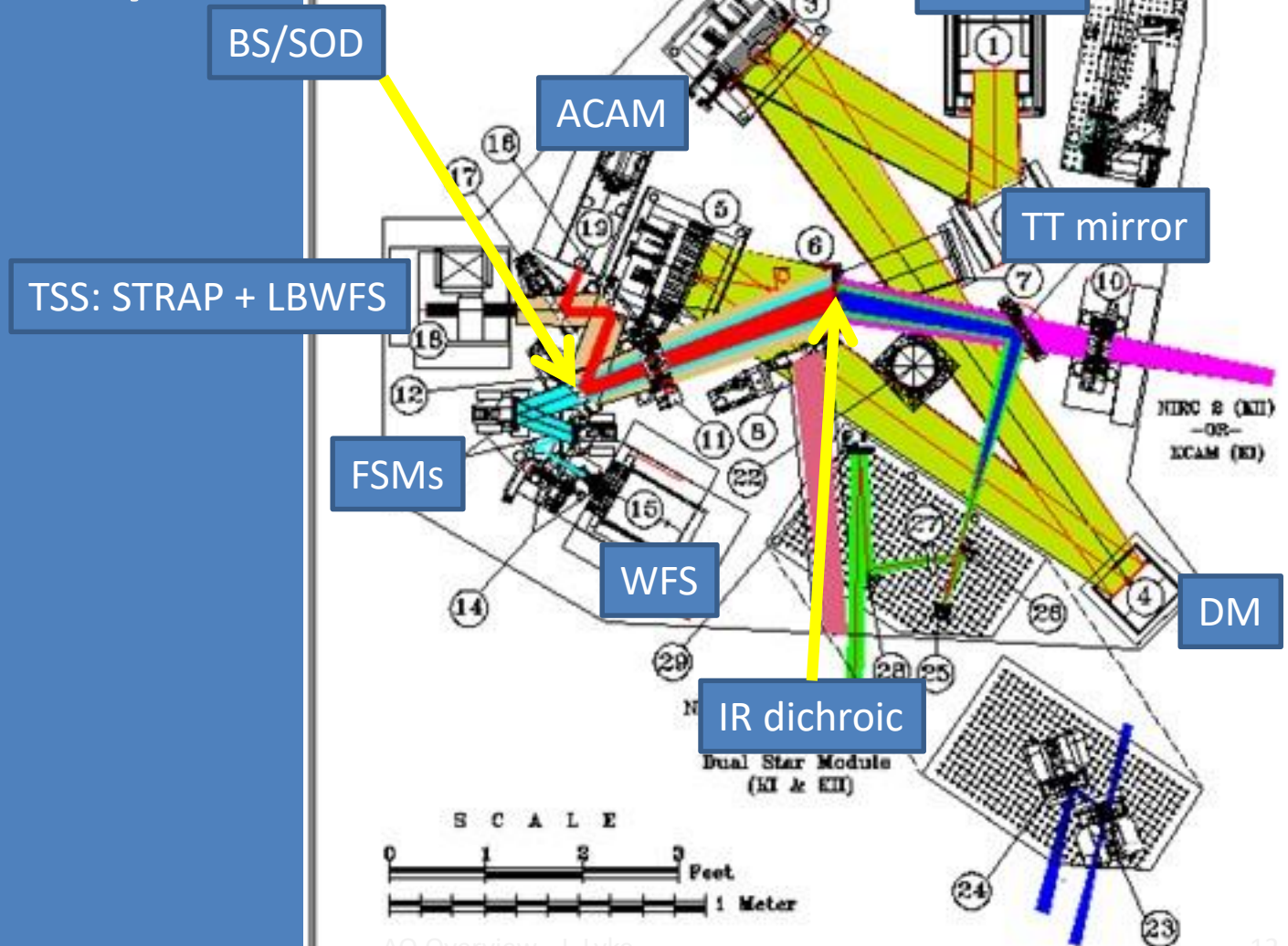
LGS AO Control



AO Enclosure



AO Bench (diagram)



Night Operations

The screenshot displays a comprehensive control interface for the Keck II telescope's adaptive optics system during night operations. The interface is divided into several functional areas:

- STRAP Status:** Shows target information (STRAP: OK, TSS: IMPUS) and seeing data (Rmag: 15.5, Avg: 15999; Cx: 0.066, Cy: 0.095).
- WFS Intensity - Keck II:** Displays WFS sensor data (A0: LGS, FSM: IMPUS) and a WFS image.
- MAORI: Keck 2:** Provides AO control parameters, including target (MAG: 7.670, -V MAG: 1.640), wavefront sensor (Frame rate: 1000, Intensity: 84), and loop status (TT, DM, Laser TT).
- LBWFS Img Acq v4.0:** Manages image acquisition (LBWFS cog file: zeros.cog) and processing (Level 00).
- Low-Bandwidth Manager v4.0:** Controls focus and cog, with a plot of Focus vs. Images.
- K2 CLS Sequencer:** Shows the current sequencer state (READY) and a sequence diagram with components like CLS, LSI, LSS, LEI, ENV, EZAR, ESTOP, and GWY.
- OA Permissive / Final Permissive:** Displays the status of various optical components (OA, LGS, Spotter, DCS, BT0, TBAD, etc.) and provides a 'RESET' button.
- LUI Version 2.1 - K2:** A summary panel at the bottom right showing key system parameters:

LASER Power: 0.0W Altitude: 87.41m	TIP/TILT Counts: 15.80K Rmag: 10.4	DM Fr Rate: 1000 Cnts: 84.4	LBWFS Rms WF: 300nm Defoc: 0.05mm	UTT/BM2 UTT Gain: 0.050 BM2 tracking: Off	TEL OFFLOAD Focus: -0.4mm TTO: open	TBAD Status: GRANT tUT: 22:33:09 UTC: 22:33:45.20
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Documentation

- The issue is NOT too little documentation
- Too much, too many places
- What works for you?

Tool Summaries?

LGS-AO: LOW BANDWIDTH WAVEFRONT SENSOR MANAGER (LBMngr)

The Low Bandwidth Wavefront Sensor (LBWFS) Manager (LBMngr) is a display tool for the AO operator to monitor and control how the LBWFS data are applied to the AO correction.

Overview

- Focus/COG control
- Plot of focus and RMS wavefront error
- Processed image display and calculated parameters
- Reconstructed wavefronts

[LBMngr](#)

Low-Bandwidth Manager v4.0

focus ctrl1 Reset gain: 1.00 ■

cog ctrl1 Reset gain: 0.50 ■

WFS: zeros.cog

GUI DESCRIPTION

FOCUS CONTROL

focus ctrl

- Radio button turns on/off LBWFS focus control.
- Color box on right hand side of GUI turns GREEN = on, or RED = off.

Reset

- Sets LBWFS focus control off
- Sets use COG to focus off
- Zeros the LBWFS focus contribution
- Set focus gain to max (currently 1.00)
- Set DM focus offload off

Cruise

- Update Na altitude
- Set focus gain to mid-range (currently 0.5)
- Set DM focus offload on
- Set DM focus offload timer to every 120 sec

gain:

- Editable box, values: 0.0-1.0.
- AOFCLBGN: How much of calculated focus correction is applied?

COG CONTROL

cog ctrl

- Radio button turns on/off LBWFS cog control.
- Color box on right hand side of GUI turns GREEN = on, or RED = off.

Reset

- Set update COG off
- Set use COG to focus off
- Set cog gain to mid-range (currently 0.5)
- Set leak to 0.95

Cruise

- Set cog gain to low-range (currently 0.3)
- Set leak to 0.95

gain:

- Editable box, values: 0.0-1.0.
- AOLBGAIN: How much of calculated cog correction is applied?

WFS: File name of fast wavefront sensor COG

? Choose another COG file to load

Plot: Focus (m) and RMS WF (nm) vs Images. Focus ranges from 0.0 to 0.4 m, RMS WF from 0 to 300 nm. Images range from 0 to 10.

Image Display: img0024.fits, ExpT(s) 1.0, Na: 88000, defoc: 0.49, WFO: -0.1, Go, l1bfoc: -11.6. FWHM 0.40, MedPk 19633, UTC 01:20:55.73, SNR 35.3. Rec. wf from LB cents, Rec. wf from COG.

Troubleshooting Guides?

AO Troubleshooting
Last updated on 04-09-2019 16:15:12

WWW Search Optics pages

- **AO Performance**
 - [User Guide for Optimization Tool \(also named bandwidth widget\)](#)
 - [Checklist for bad AO performance](#)
 - [How do I measure the seeing](#)
 - [Seeing is either large or very fast, what should I do?](#)
 - [The seeing is OK but LGS AO Performance is NOT, TT gain is very low \(less than 0.1\)](#)
 - [Checking the WFS centroid origin calibrations](#)
 - [Stars appear elongated, what should I do?](#)
 - [The Guide Star is a 2"-5" binary \(NGS only\)](#)
- **Telescope/AO interactions**
 - [AO/DCS communications: general](#)
 - [Dither failure: light lost on WFS:](#)
 - [Dither failure 2: light lost on WFS:](#)
 - [NEEDS UPDATE: Generalized offset/dither problem in NGS and LGS](#)
 - [Dither failure: timeouts in AO/DCS handshake](#)
 - [About "Restart AO/DCS communications":](#)
 - [How do I check the TT offloading parameters](#)
 - [SKY/AO conflict for non-sidereal \(planetary\) targets](#)
- **AO Operations**
 - [How to set the WFS parameters manually?](#)
 - [How to insert/remove a neutral density filter \(WND\)](#)
 - [Why is the PSF observation so important to AO observers?](#)
 - [How much should you care about the B-V magnitude](#)
 - [No sounds???](#)
 - [Poor Correction on Extended Objects](#)
 - [Acquisition tool \(AOAcq\) pointing origin \(PO\) mismatch](#)
- **LGS AO Operations**
 - [What are the main differences between LGS AO and NGS AO](#)
 - [Where are the LTCS pages?](#)
 - [NGS and LGS operations procedures](#)
 - [Laser Manual Acquisition](#)
 - [Acquisition when background is uneven \(e.g., M31\)](#)
 - [Laser spot not detected on ACAM image, M3 misaligned.](#)
 - [Noise on the LBWFS](#)
 - [Cannot measure the unstacked LGS spot size on ACAM](#)
 - [Express LGS AO Checkout](#)
 - [Checking STRAP](#)
 - [TSS: DAR and TSS FOCUS control in LGS mode](#)
 - [LGS AO VNC session Xserver seems dead](#)
 - [LGS AO VNC Norse Viking Attack](#)
 - [Cannot take LBWFS images](#)

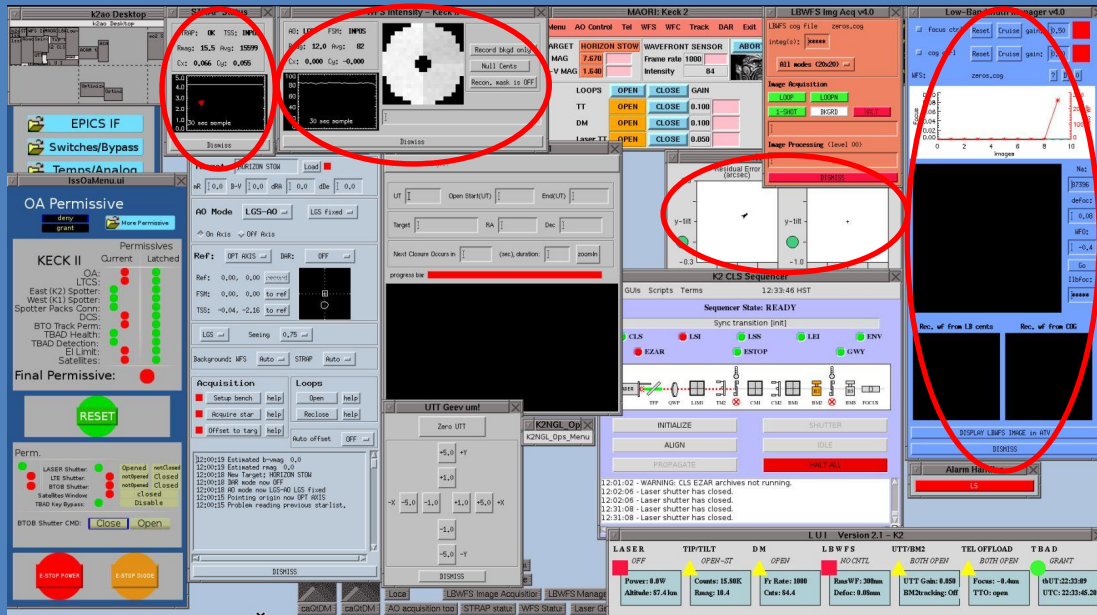
[AO Troubleshooting](#)

Night Operations

The screenshot displays a complex astronomical control interface with several windows and panels. Red circles highlight specific areas:

- STRAP Status:** Shows STRAP: OK, TSS: IMPIS, Rmag: 15.5, Avg: 15999, Cx: 0.066, Cy: 0.065.
- WFS Intensity - Keck II:** Shows AO: LGS, FSM: IMPIS, Rmag: 12.0, Avg: 82, Cx: 0.000, Cy: -0.000, and a WFS intensity plot.
- MAORI: Keck 2:** Shows AO Control, WFS, WFC, Track, DAR, and Exit menus. Includes parameters like HORIZON STOW, WAVEFRONT SENSOR, and ABOR.
- LBWFS Img Acq v4.0:** Shows LBWFS cog file, zeros.cog, and Image Acquisition controls.
- Low-Bandwidth Manager v4.0:** Shows focus ctrl, Reset, Cruise gain, and cog ctrl.
- OA Permissive:** Shows KECK II status with Current and Latched indicators for various systems like OA, LTCS, and Spotter Packs.
- Final Permissive:** Shows a large green RESET button.
- Perms:** Shows status for LASER Shutter, LIE Shutter, BT08 Shutter, and Satellites Window.
- UTT Gev um!:** Shows Zero UTT and coordinate adjustments (+5.0, +1.0, -1.0, -5.0).
- K2 CLS Sequencer:** Shows Sequencer State: READY and various control buttons like INITIALIZE, ALIGN, PROPAGATE, and HALT ALL.
- Log:** Shows a list of warnings and events, including "WARNING: CLS EZAR archives not running" and "Laser shutter has closed".
- LUI Version 2.1 - K2:** Shows overall system status for LASER, TIP/TILT, DM, LBWFS, UTT/BM2, TEL OFFLOAD, and T B A D.

Night Operations Notes

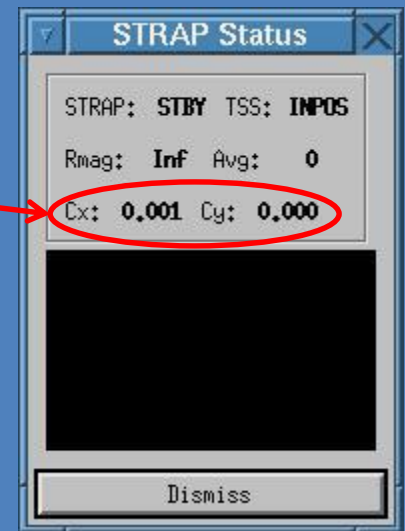
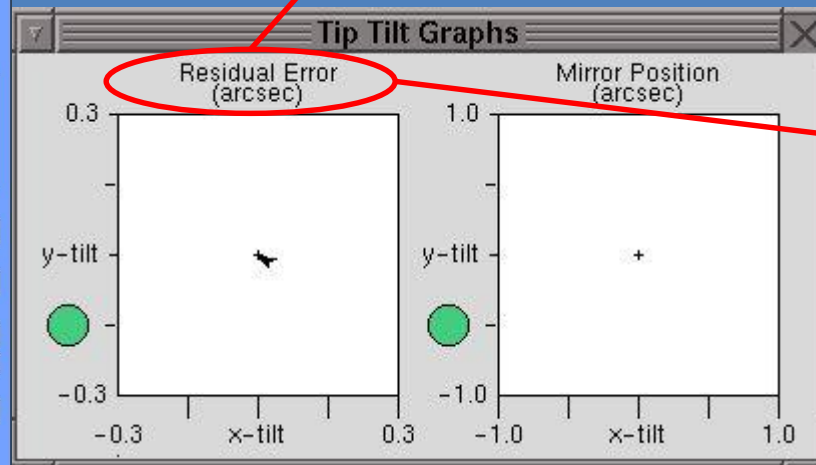
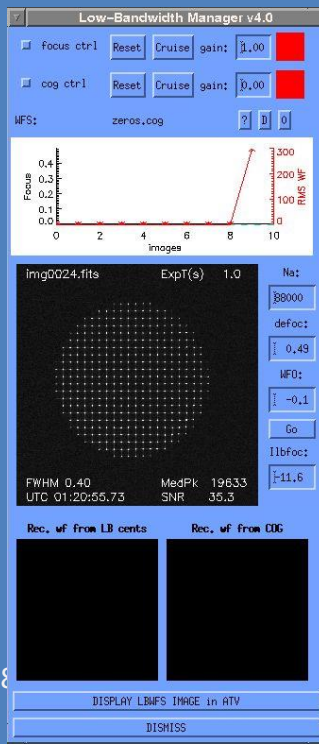
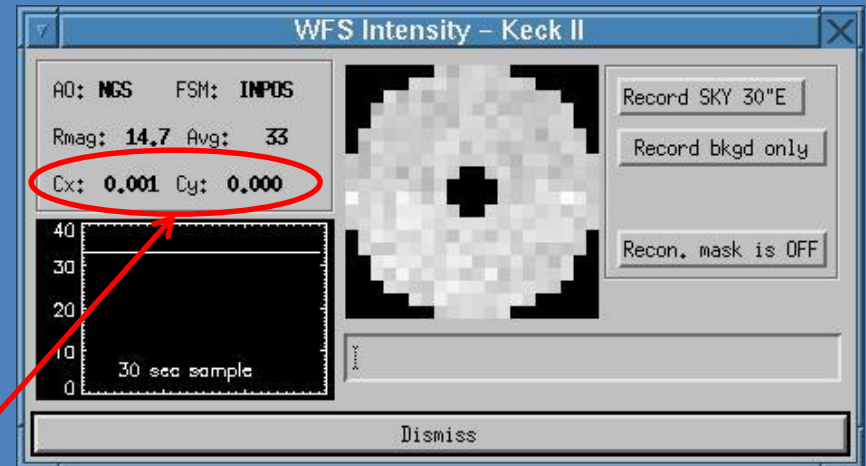


The red circles denote what I watch during the night.

1. STRAP status – do we have the TT star?
2. WFS intensity – do we have the laser?
3. TT Graphs
 1. Are the balls green?
 2. Are the arrows mostly in the center?
 3. If not green and/or not in the center, you may have lost the star
4. LBMngr
 1. Is the wavefront error (WFE, red) graph stable and a reasonable value (<200-300 nm)
 2. Is the focus error (black) graph stable and a reasonable value (absolute < 0.5 mm)
 3. Does the LBWFS image look like a regular hexagon? If not, there is something wrong

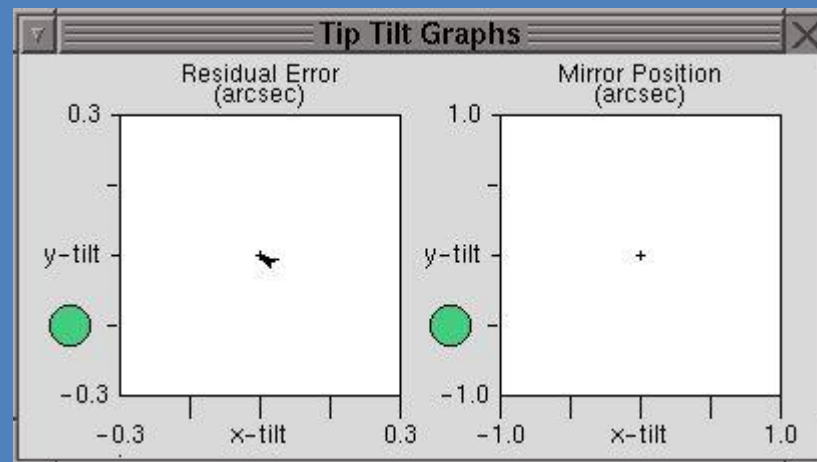
Ops & Troubleshooting

- Where is the light?
 - Stages: FSM, TSS, AFM
 - Tel: PO's/Offsets/Focus
 - Laser/LTCS/SpaceCom
 - Tip-Tilt/LBWFS



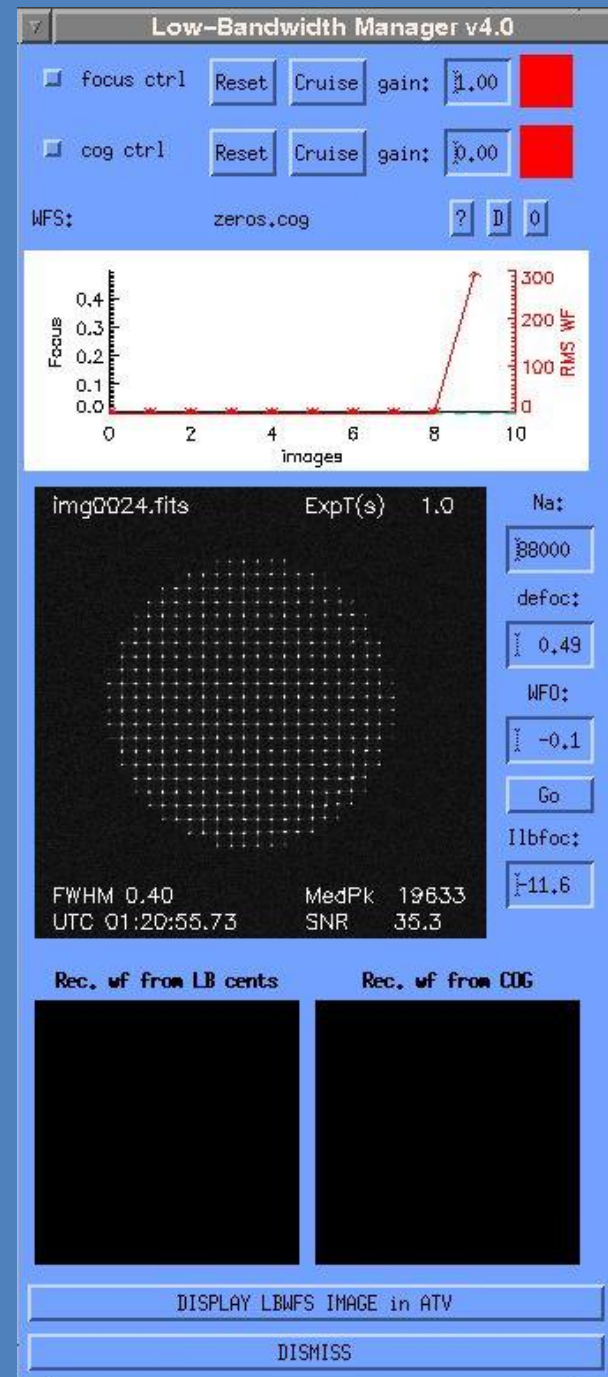
TT Graphs

- No mirror position? => reboot WFC
- Mirror wandering? =>
 1. Bad/fast seeing
 2. Low TT gain
 3. cycle TT offloading
 4. reboot SC



LBWFS

- Want
 - Regular Hex pattern
 - Flat-ish plots
 - $\text{Abs}(\text{Focus}) < 0.5 \text{ mm}$
 - $\text{RMS WF} < 200 \text{ nm}$
 - *Some nights we don't get there*
- Watch for
 - Tel focus runaway
 - Vignetting
 - Non-regular Hex pattern



Troubleshooting Hammers

Poor Correction

1. NGS: New background
2. LGS: Check LBWFS
3. Restore an old COG
4. Reacquire
5. Reboot WFC + Reacquire
6. Check correction on brighter star
7. Verify ACS snap
 1. Use PCS snap
8. Re-calibrate (30-60 min)

Offset Issues

1. Reset AO/DCS
2. Reset AO/DCS + Reacquire
3. Re-run Nighttime script + Reacquire
4. Reboot SC + Reacquire
 1. LGS needs LBWFS recovery
5. Reboot WFC + Reacquire
6. Another rotator?

What's New?

K1

- TRICK
 - Near-IR TT sensor
- TOPTICA laser
- KAPA
 - New RTC
 - New WFS
 - Laser tomography

K2

- Pyramid WFS
 - Different method than SH
 - Works in IR
- KPIC
 - Fiber-injection (NS feed)
- RTC upgrade
 - RTC + WFS