Center for Adaptive Optics
An NSF Science & Technology Center

The Lick Adaptive Optics System: Status and Lessons Learned

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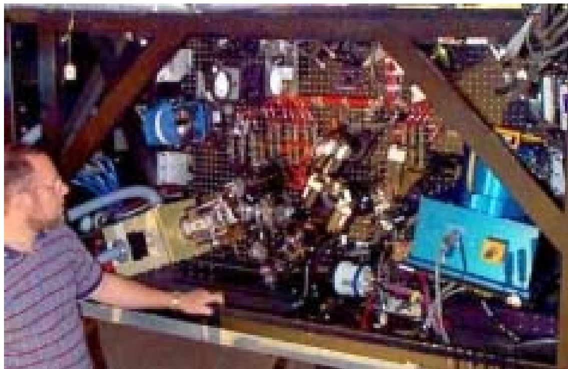
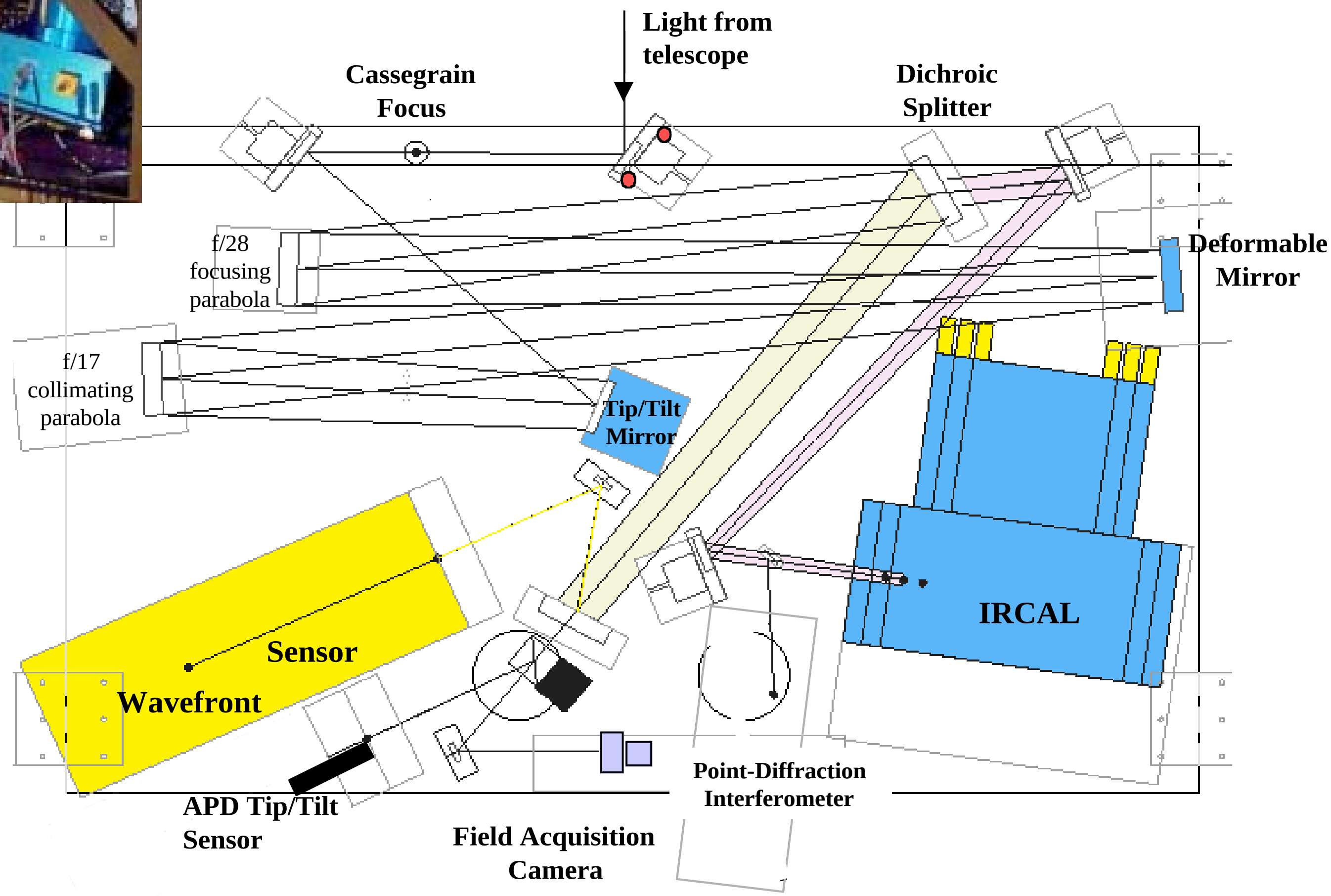
Laser Guide Star
Adaptive Optics Program

Evolution of an R&D project to Facility Instrument

Design considerations - initial engineering
Redesign of optical layout to remove non-common path powered optics
Reducing staff from a dozen engineers to one operator for NGS, two for
LGS (AO operator + Laser operator)
Documentation improvements
Remote control of motors (both laser and AO systems)
All staff in single room improving communication between
laser and AO staff
Improved laser safety systems and procedures
Software User Interface - addition of better motor & power control
WFS data analysis tools to evaluate performace quickly in
lab and on sky.

AO system optical bench layout





Calibration and Alignment

Calibration and Alignment

- Make sure TT mirror at center of travel before doing any other alignment (unfortunately our TT mirror drifts slowly over time when at 'center')
- Basic alignment still done manually, using fixed fiducial pinholes
- Use IR camera to set position of Cass focus point source fiber
- Pupil alignment into IR camera
- Calibrating out non-common path errors:
  - Point source in front of WFS, create new refcents
  - Point source at Cass focus then image sharpening to calibrate out other aberrations in the system
- Boresight WFS camera to IR camera
- LGS mode involves aligning into slow WFS and boresighting APD TT to WFS and IR Camera
- Internal alignment more critical on good to excellent seeing nights
- Proper AO loop gain more important then internal alignment for good performance on moderate seeing nights

Natural guidestar mode

NGS Operations

- Communication with Telescope and IR Camera for dithering scripts
- Flexure compensation done manually (adding Renishaw encoders to automate most - if not all - flexure compensation)
- WFS diagnostics & data:
  - evaluate atmospheric conditions - r0
  - look at power spectra to determine proper AO loop gain
  - Veran algorithms on the way for PSF determination
- Reduce AO loop gain for faint objects and slower frame rates - S/N issues
- Increase AO loop gain at large zenith distances because looking through more turbulence

Laser guide star mode

LGS Operations

- APD TT boresighting - flexure issues and only 2" field of view
- Laser flexure issues, aligning into WFS
- Rayleigh light gets into APD TT
- Star confusion on WFS for brighter stars (particularly during alignment)
- Moving WFS stage - heavy, needs counterweight. Really should use mirror trombone for focusing on laser.
- Focusing WFS on sodium layer using BWFS, requires bright star
- On sky image sharpening in development using BWFS
- Initial switchover from NGS to LGS takes at 30 to 90 minutes (typical is 1hr - though getting faster with experience)
  - Procedure has approx 60 steps to go from NGS to LGS science
- US Space Command and FAA considerations

Data acquisition techniques

Data Aquisition Techniques

NGS:

Set up on guide star first, then field steer off to science target

Take data with whatever dithering or nodding pattern required

Since don't yet have Veran (PSF estimation) algorithms working, some observers interleave observations of guide star with off axis science target to monitor changes in seeing.

New AO control computer allows simultaneous WFS data acquisition, so this may no longer be needed.

Move to PSF guide star of similar magnitude of science target guide star.

Field steer off to PSF star with similar position angle and distance as guide star-science target pair and take more data.

Some observers look at the PSF star before and after science observations

Data acquision LGS mode

LGS:

Mostly the same as NGS except addition flexure and APD FOV issues:

Set up on 9th mag star near (within 30 arcmin) of science target

Find boresight position of APD TT sensor and mark on guide TV

Boresight laser to WFS and APD

Close all loops (APD TT, uplink TT, and AO) and adjust WFS focus using BWFS measurement

Open loops and move to guide star, etc.

Laser guidestar mode: Issues

LGS issues:

- Especially sensitive to seeing conditions and atmospheric clarity
- Zenith distance makes a much larger impact on observations and observers typically realize
  - At larger zenith distance:
    - laser spot gets fainter because sodium layer farther away
    - rayleigh scatter gets brighter because looking through more atmosphere
    - spot gets bigger because of looking through more turbulence
- Not only do we have flexure between WFS and IR camera, but also flexure of the laser launch telescope
- Fast shutter gets stuck shut when looking south - must move telescope to ~ Dec +25 to open shutter
- Want high power and good beam shape. Typically we can get up to 13W with good beam quality. Have learned that beam quality is more important than beam power for good performance.