The DECam System: Technical Characteristics

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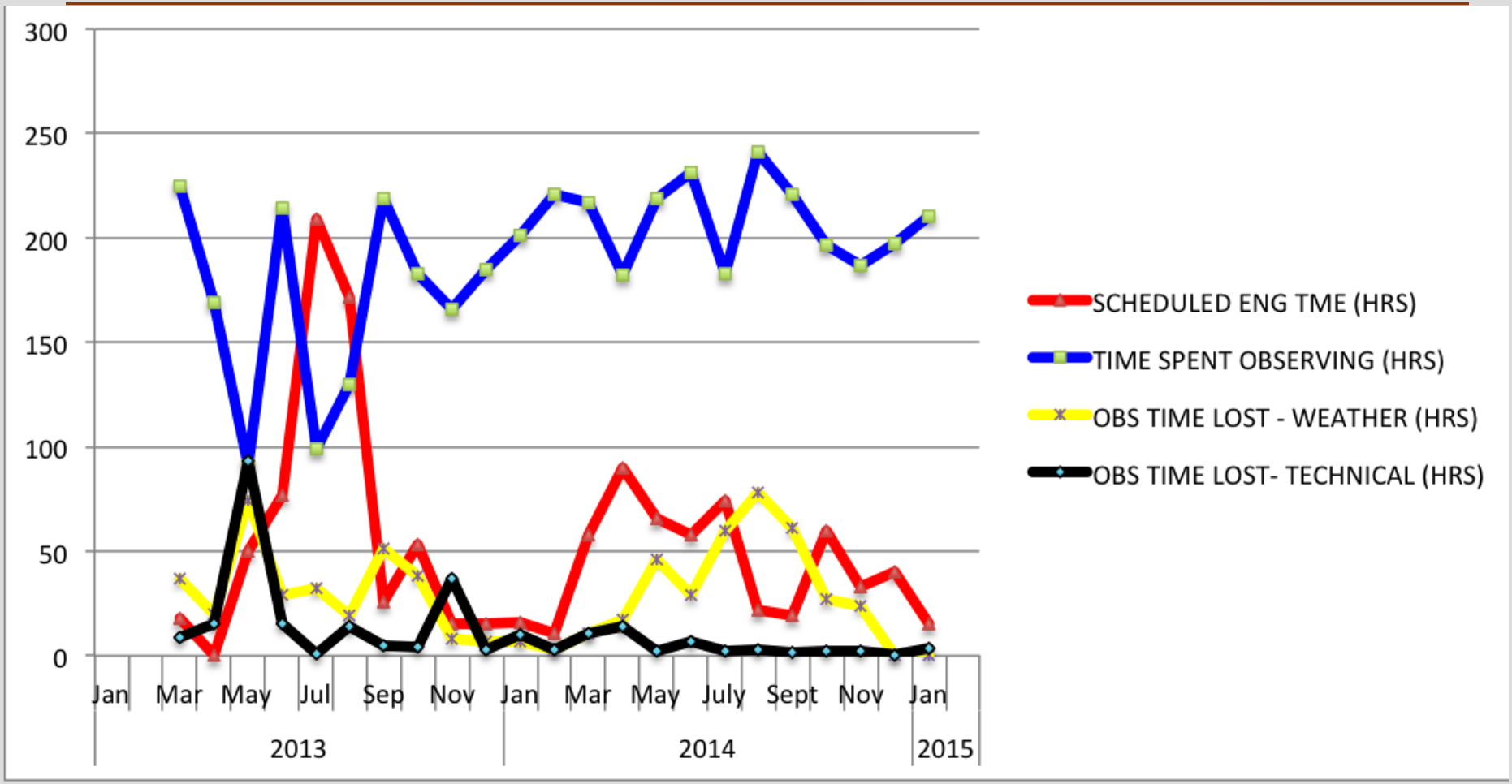
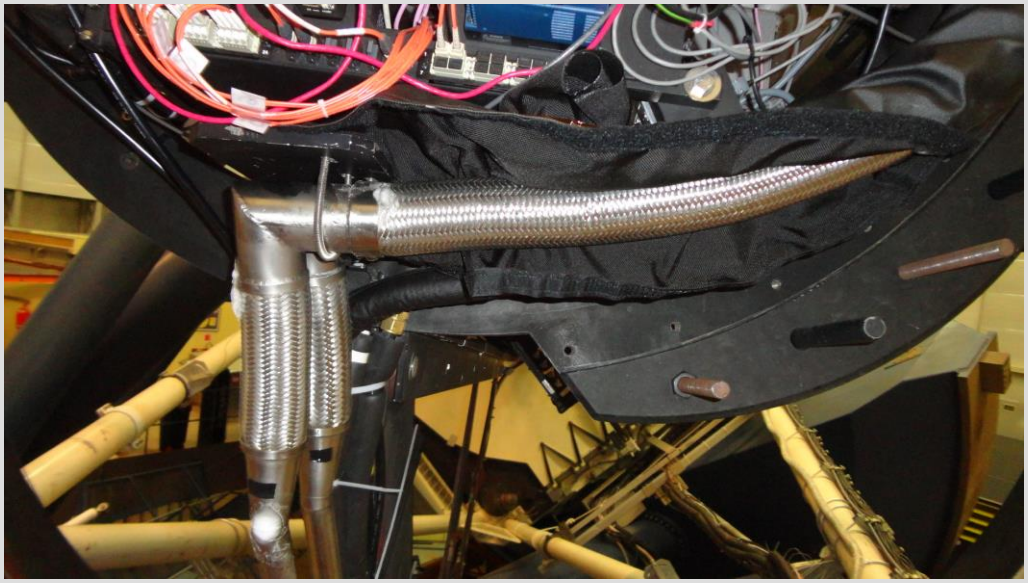
- Status & Statistics
- A selective look at some DECam & Blanco technical properties that influence DECam data quality, with emphasis on recent and planned improvements
  - CCDs
  - Optical Issues
  - Environment Control

Statistics



Status - Working well!

Issues and Activities - I



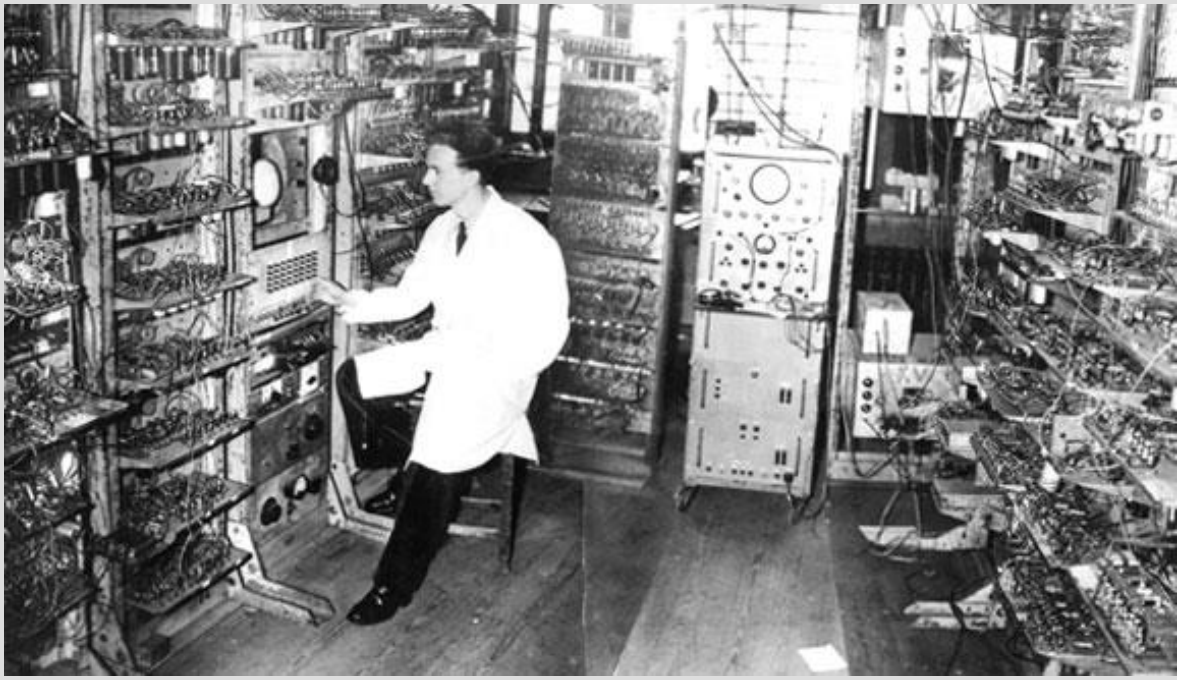
- The LN2 system has two thermal shorts in the supply and return lines as they enter the PF cage. The relevant line segments are being replaced in July 2015.

- The immersed LN2 pump needs replaced every 6-8 months, and that necessitates a warm-up. We'd like the pump to last at least a year.

Issues and Activities - II

- The SISPI data acquisition system (30 computers) is having hot spares built, and failure procedures defined (on-going). Now, some of the computers failing would take a significant time to recover.

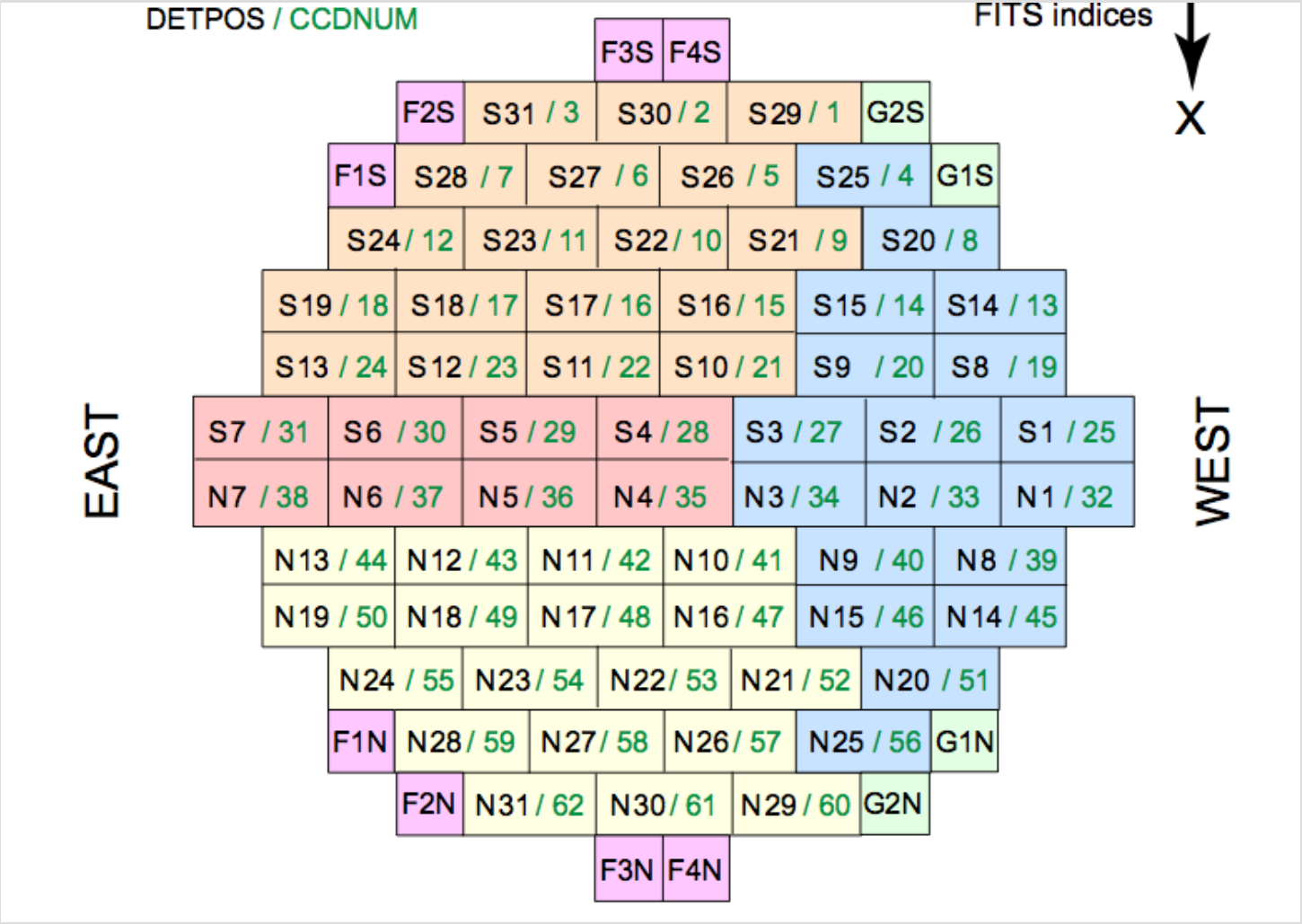
- We're working on the Active Optics systems and the Environment Control Systems (see later).



CCDs

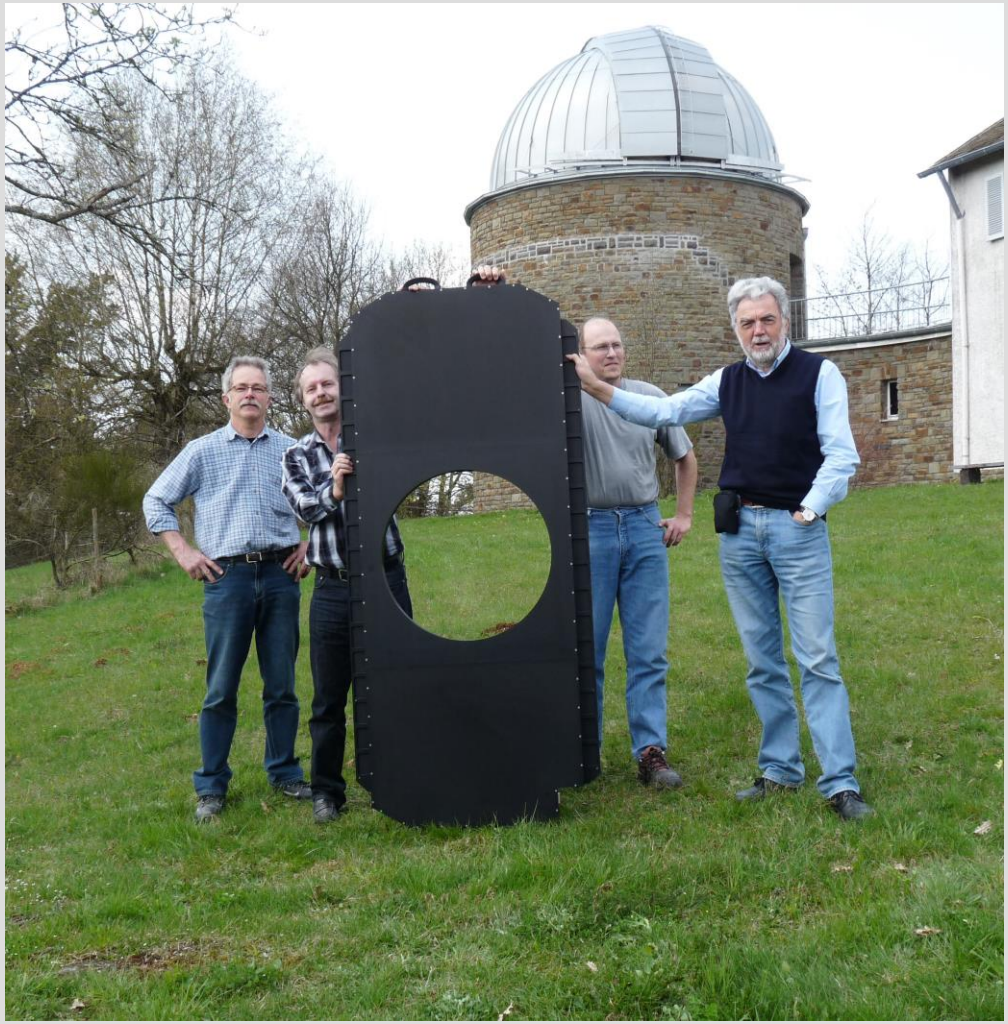
- Two failures
  - CCD # 61 (N30) very low full-well due to an over-illumination event in November 2011
  - CCD #2 (S30) on-chip or associated electronics failure, November 2012
- Poorly performing
  - CCD #31 (S7) A amplifier gain is unstable.
- Correctable properties
  - All display slight non-linearity at high counts
  - Some amplifiers are non-linear below ~1000 e-
- Interesting Properties
  - The 15 x 15 x 250 micron pixel shape introduces static (doping variations) and dynamic (charge repulsion) effects, affecting photometry and/or astrometry.

DECam focal plane

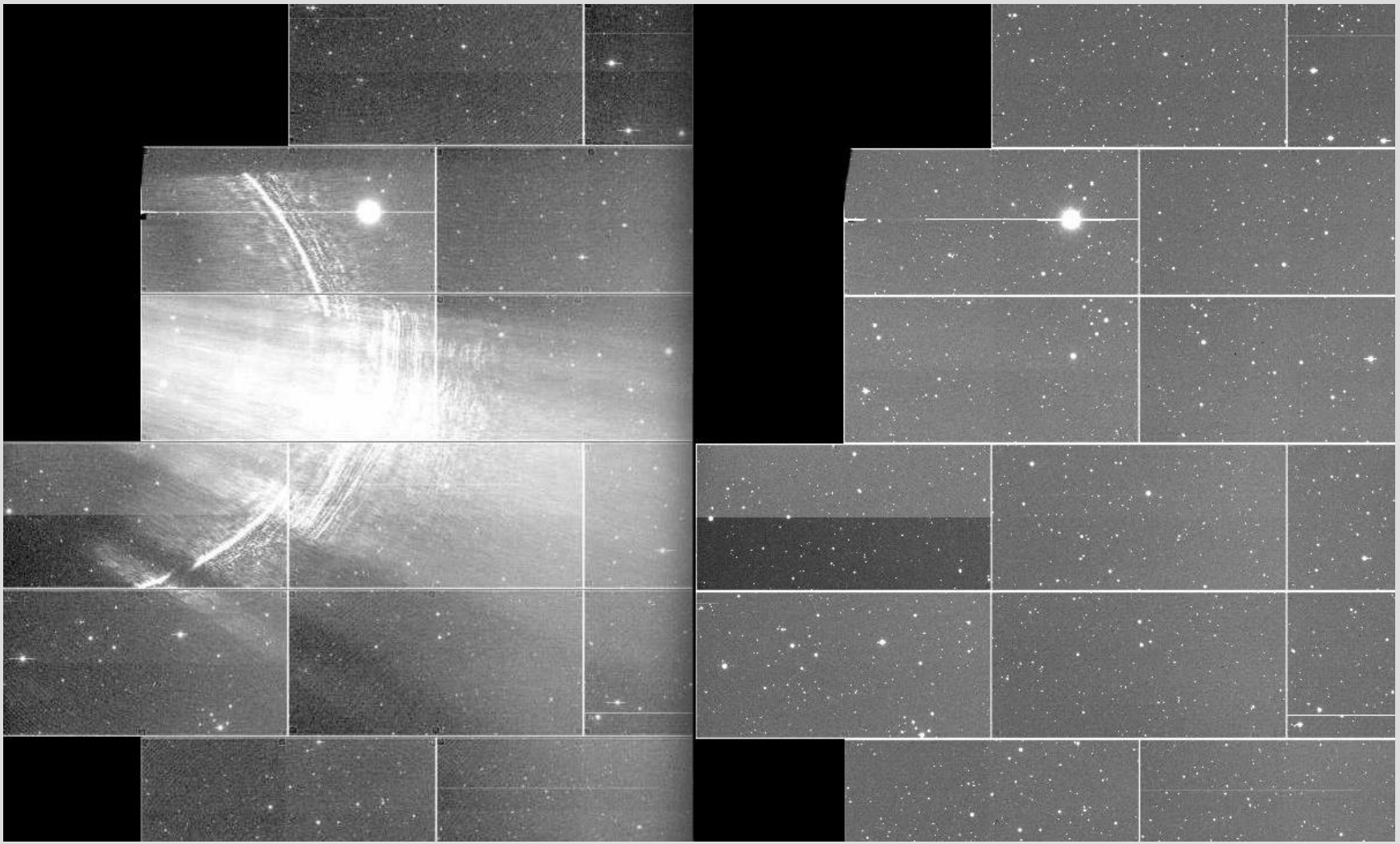


Optics – unwanted rays

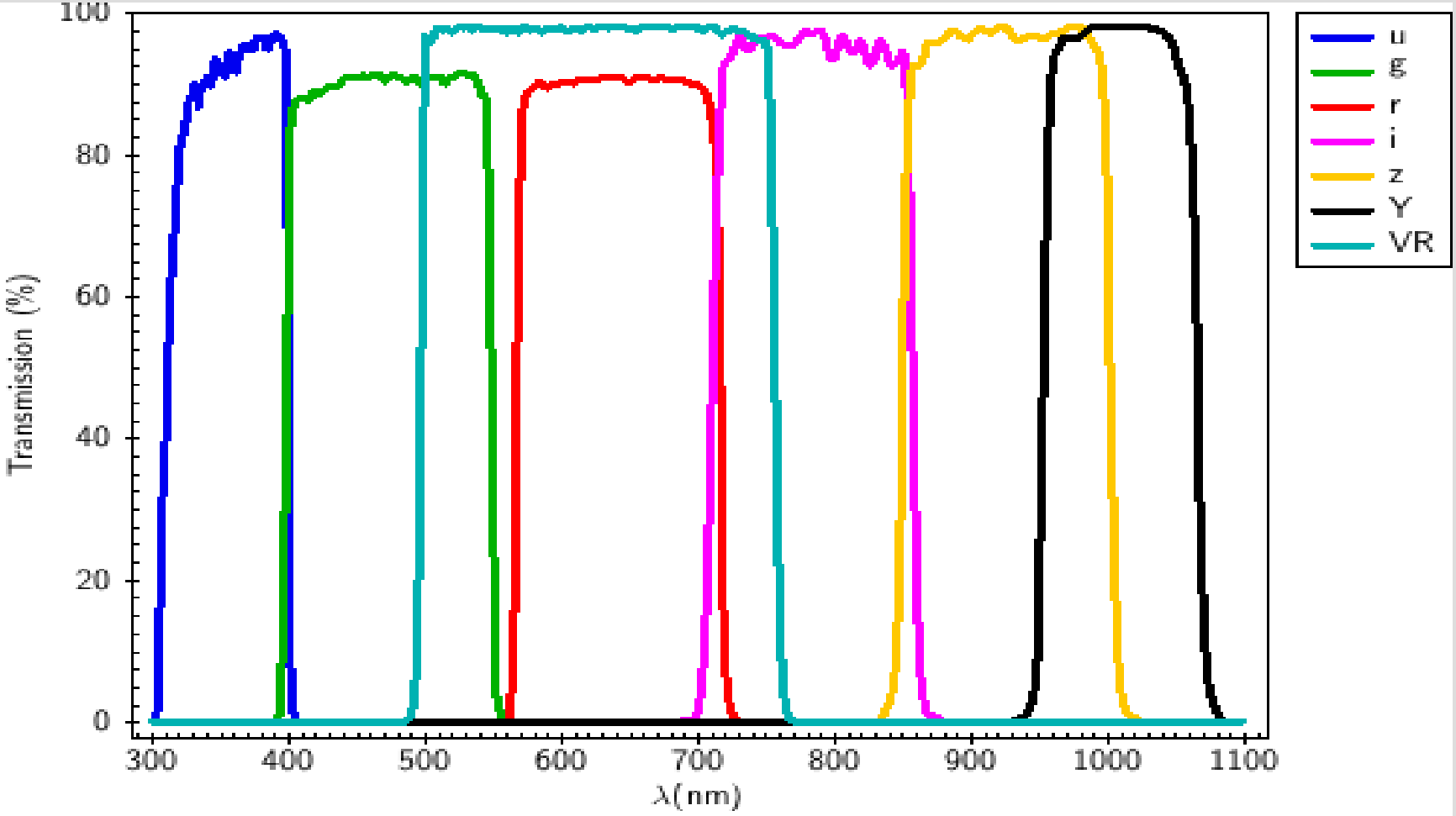
In March 2014 we masked the filter edges and painted the interior (glancing incidence) surfaces of the shutter and filter housing.



Before and after painting



Filters


Transmission (%)
100
80
60
40
20
0
300
400
500
600
700
800
900
1000
1100
λ(nm)
u
g
r
i
z
Y
VR

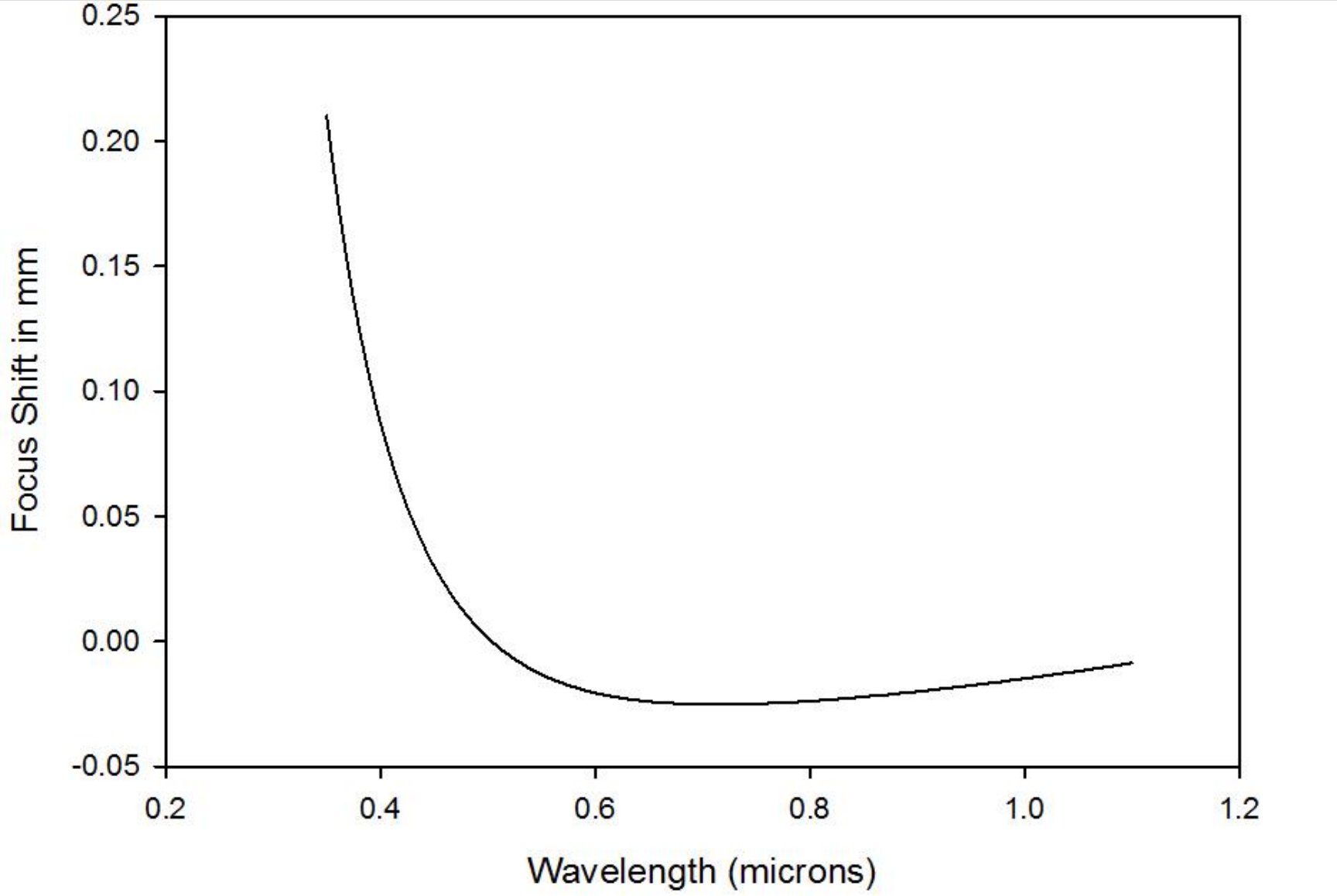
Optics - Differential Refraction

- The DECam optical corrector does not have an Atmospheric Dispersion Corrector.
- As a function of airmass, whisker introduced is

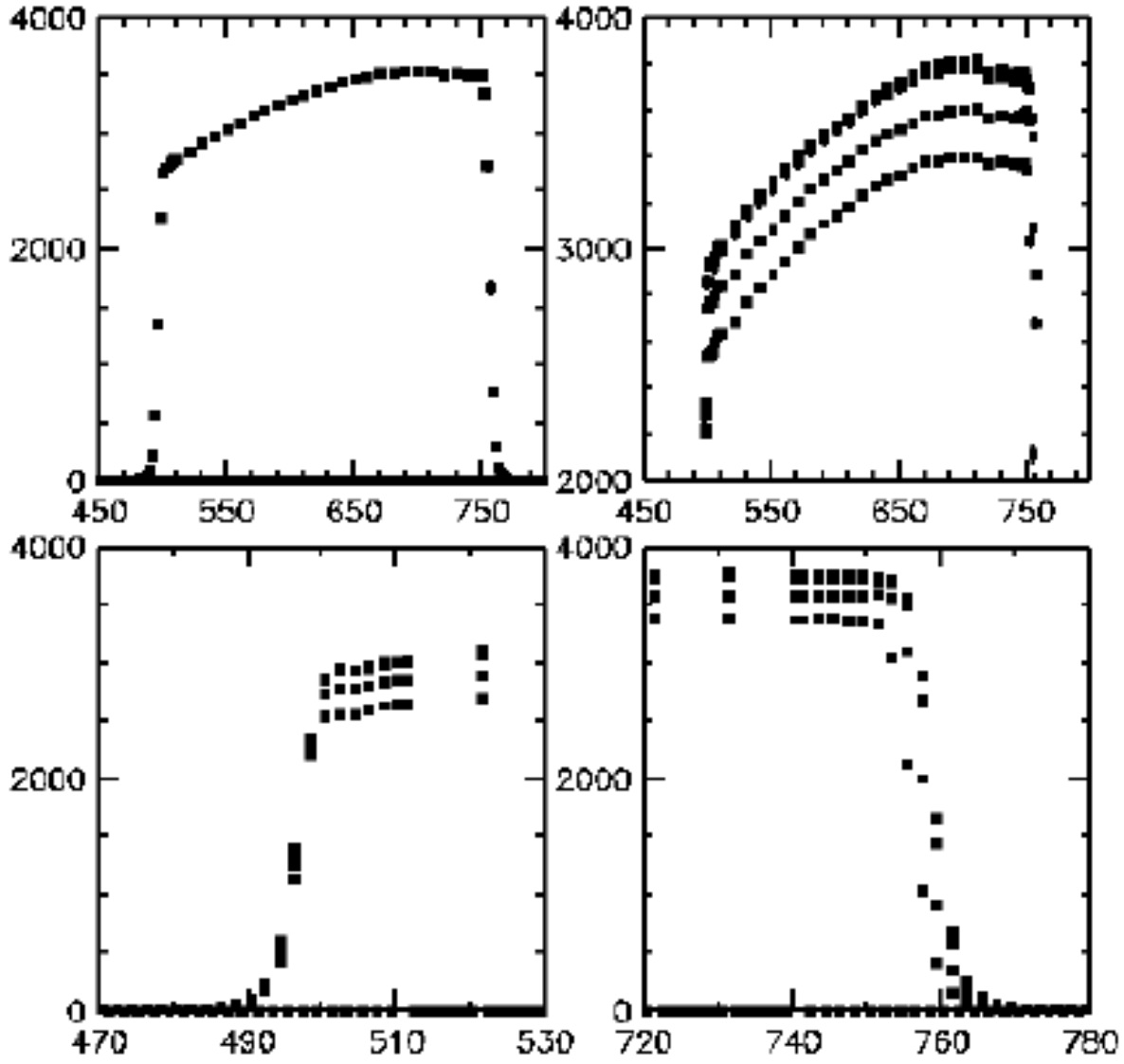
FILTER	AirMass = 1.8	Airmass = 1.3
u	0.85”	0.47”
g	1.24”	0.63”
r	0.51”	0.28”
VR	0.90”	0.50”
i	0.26”	0.15”
z	0.15”	0.08”
Y	0.07”	0.04”

Filippenko, 1982, PASP, 94, 715

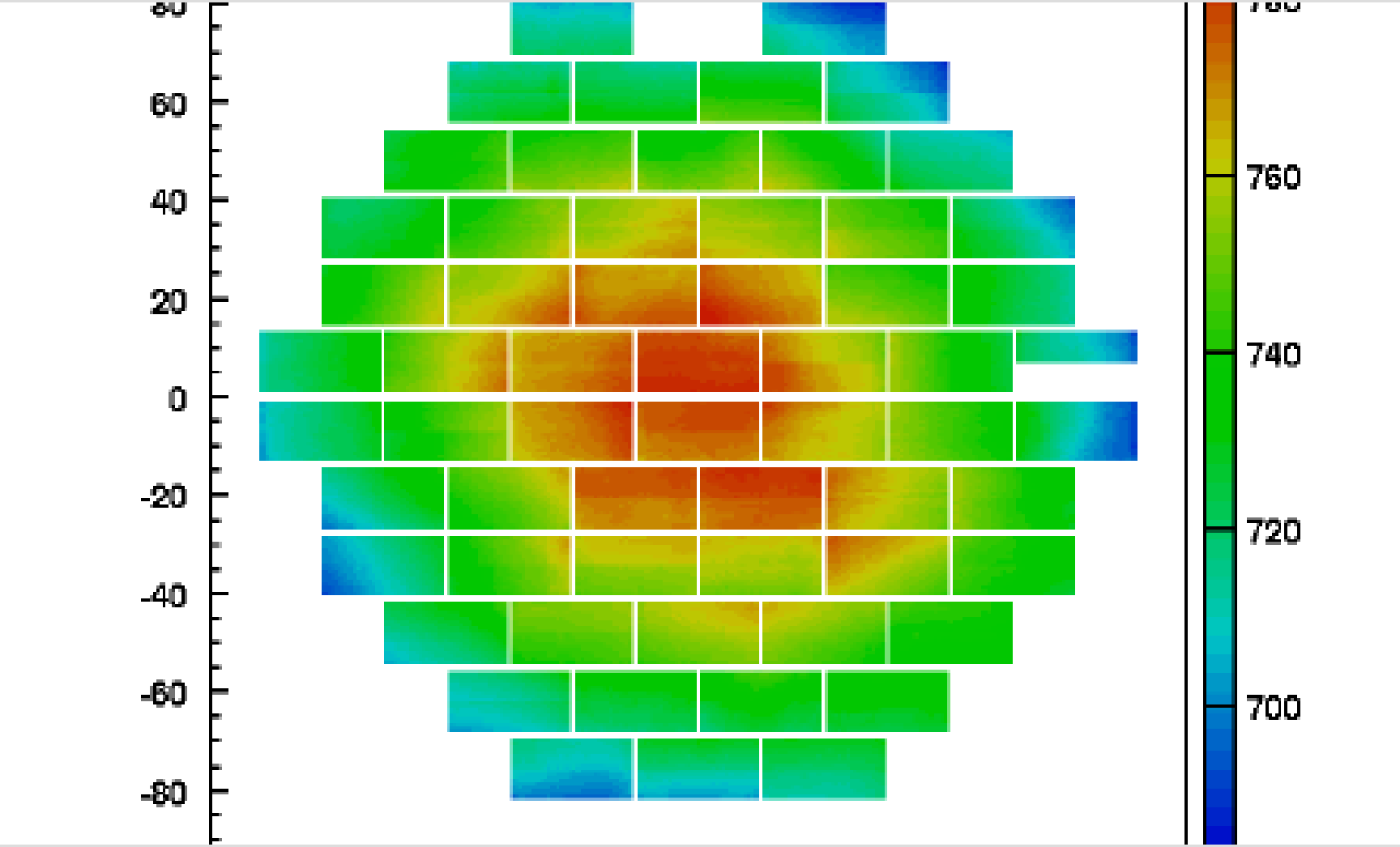
Focus shift with wavelength



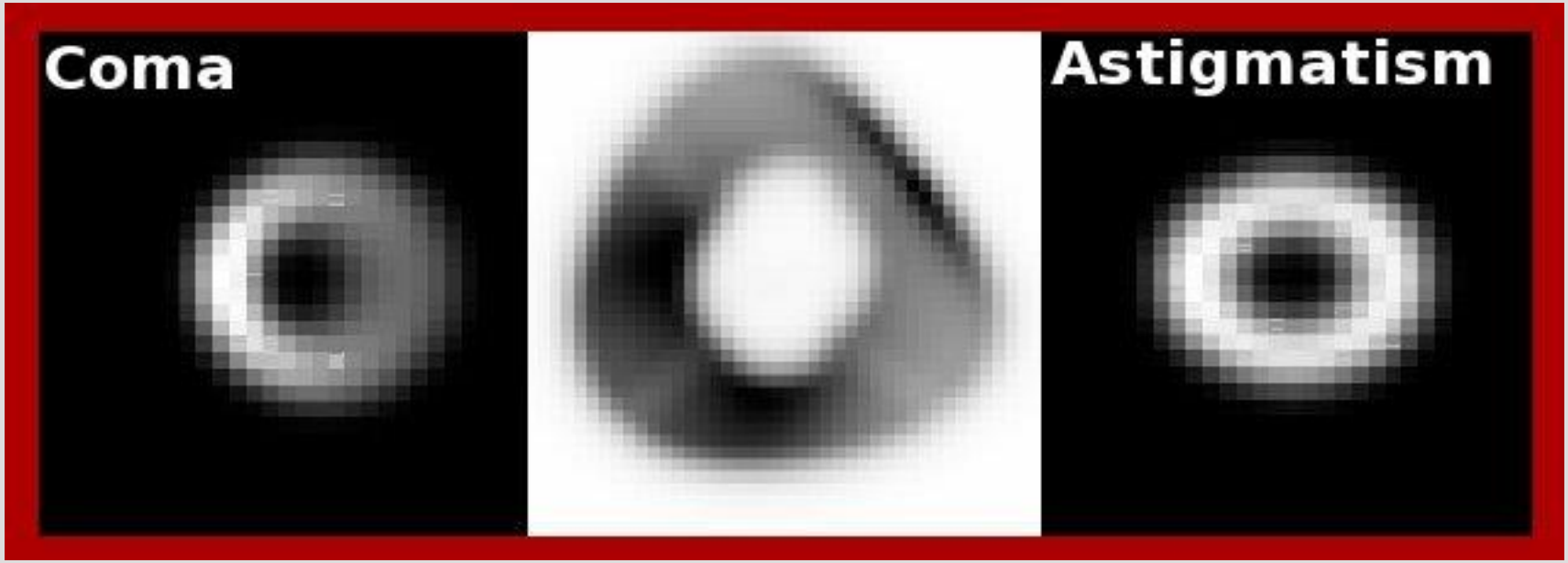
VR filter system spectral response



VR filter 600 nm response



Donuts…



Blanco-DECam Active Optics Systems

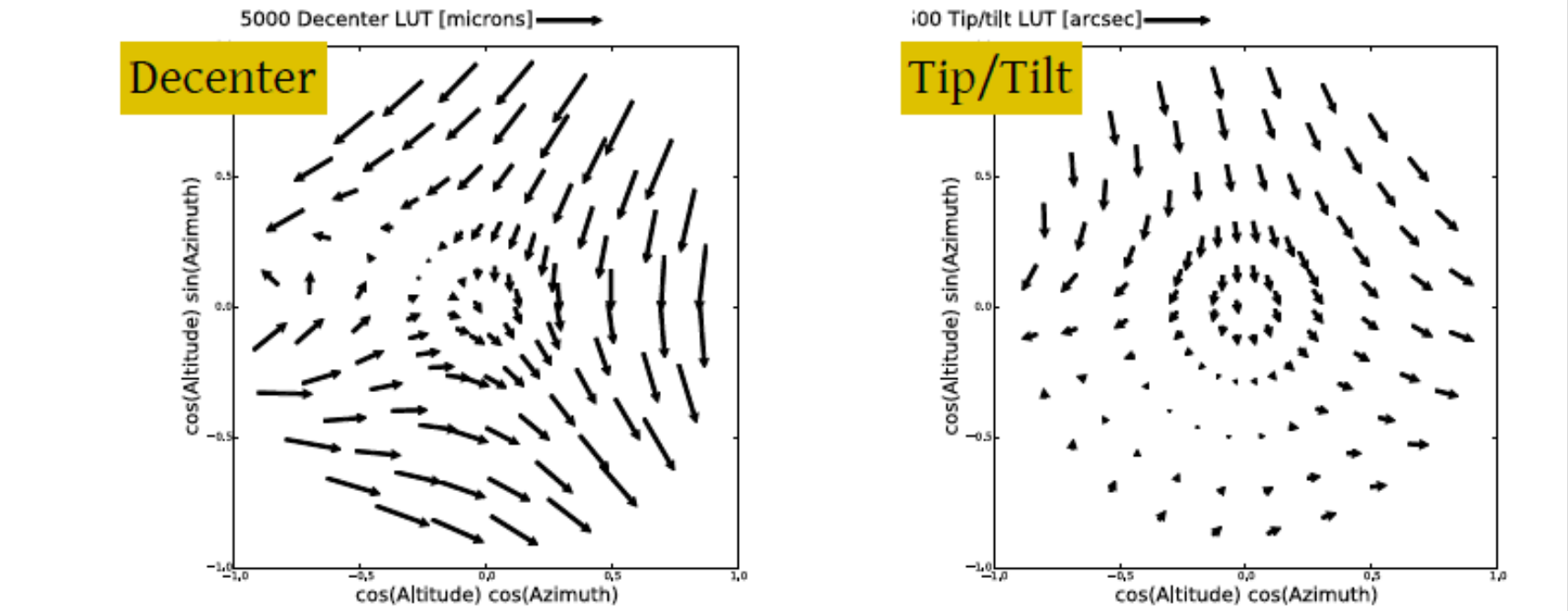
DECam:

- The position of the focal plane (focus, x and y displacements, x and y tilts) is driven by a hexapod
- A alt-azimuth look-up-table (LUT) provides the basic positioning
- There are 4 inside 4 outside focus (by 1.5 mm) wavefront-sensing 2Kx2K CCDs
  - Readout in 10s, analysis and derivation of corrections ready 10s later (5 computers)
- Control is applied before the shutter is opened for the next exposure – these are “tweaks”. Integrated tweaks are “trims”
  - Focus tweaks are almost (70%) applied in full. Other movements are highly damped.
  - Normally all five motions are adjusted (AOS-5 mode). It is possible to operate with only focus being adjusted (AOS-1 mode) for some special reason. (n.b. a displacement tweak of 200 microns corresponds to a shift of 3.6 arcsec).

Blanco-DECam Active Optics Systems

DECam, continued

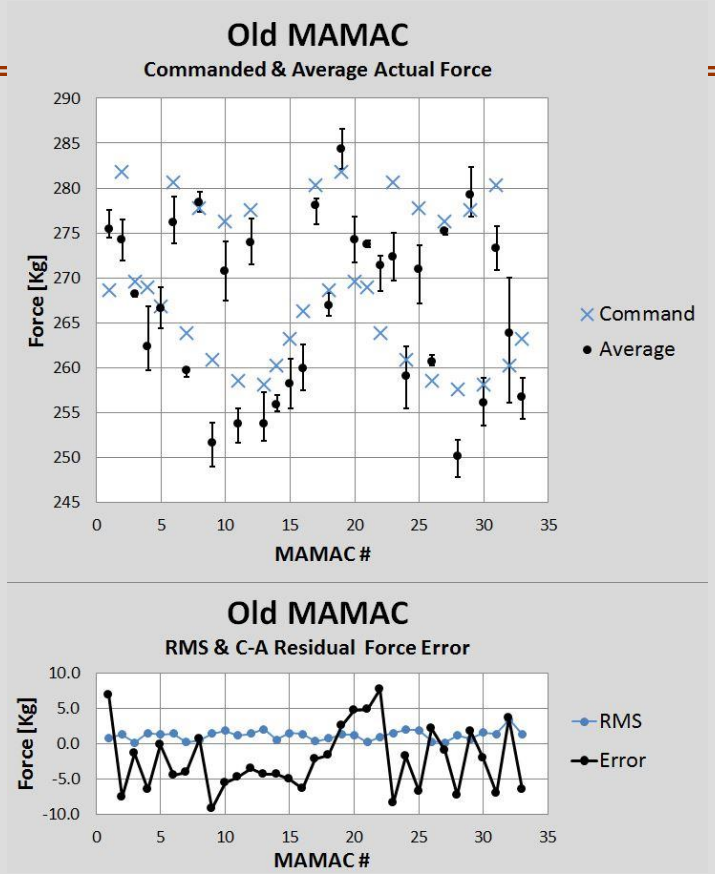
- The reference wavefront was updated October 21 2014
  - Expect 0.07 arcsec improvement in FWHM
- A revised Hexapod LUT was introduced on January 2 2015
  - Derived from a very large ensemble of images
  - Implies smaller hexapod adjustments after large slews

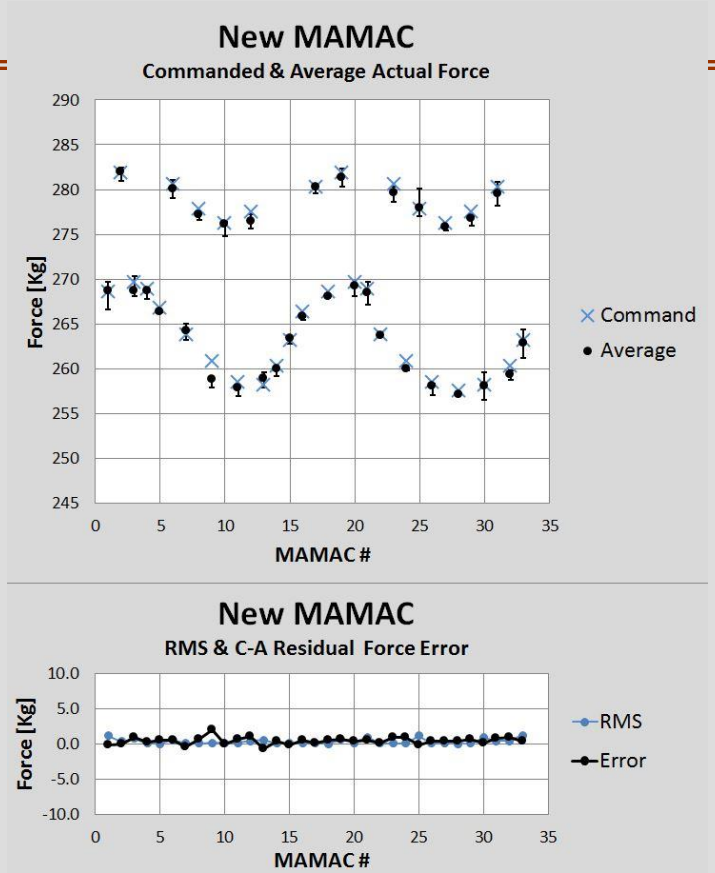


Blanco-DECam Active Optics Systems

- Primary Mirror
  - 33 pressure transducers, provide forces to counteract gravity (proporttional to cosine zenith-distance). The system resolution was recently improved with new hardware, factor 10 improvement In resoluion.
  - Introduce a “baseline” astingmatism and trefoil (revised)
  - Plus corrections from a LUT (under test)
  - Plus tweaks (to be tested, maybe not needed? Update frequency?)

Primary Mirror Active Optics





The above applied forces should correct 300nm of astigmatism (the normal value at 3hrs over) corresponding to 0.1 arcsec of FWHM image broadening

- The new controllers have the resolution required to deliver this, the old controllers did not.

Pointing, Tracking, Guiding

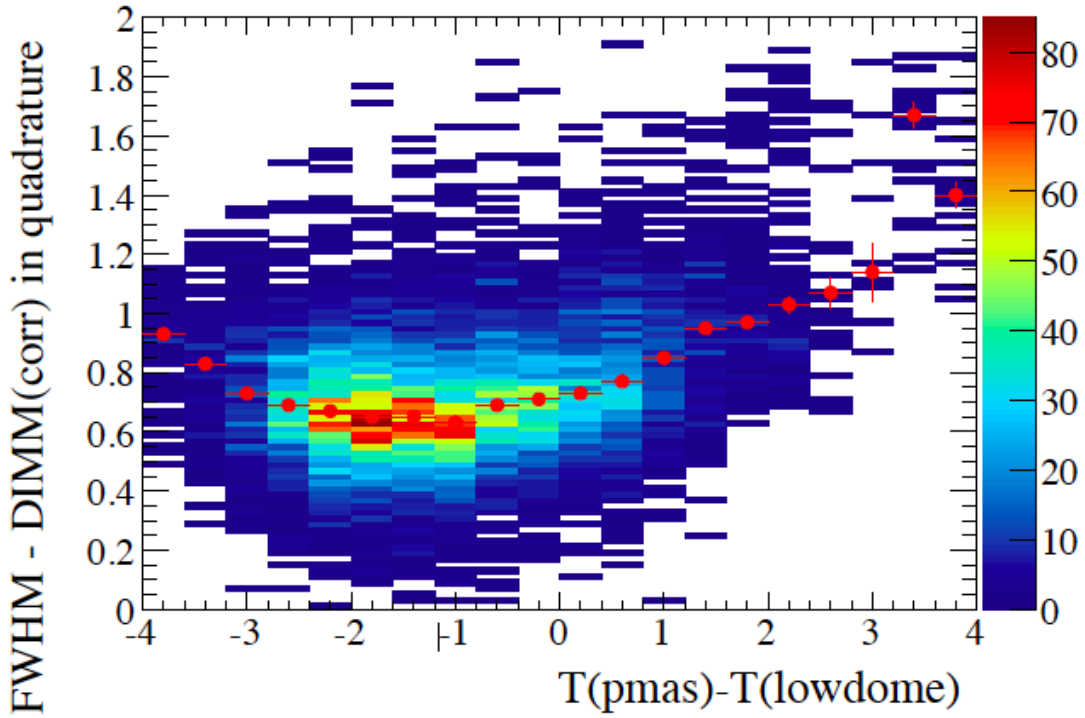
- Pointing rms is 7 arcsec
  - But hexapod tweaks can make this worse
  - The TCS does not know about hexapod “tweaks”. It could, but there would be an efficiency hit to compensate (another telescope offset)
  - If higher accuracy is needed, take a set-up exposure, run Kentools “center”, and do an offset (< 2 minutes)

- Tracking is excellent. Exposures < 30 sec do not use the guider

- Guiding is very stable
  - n.b. the input (1s rate) to the TCS is heavily damped (10% RA, 5% Dec)
  - There are some new knobs. You can change the exposure time from the nominal 600 ms. Longer for u band e.g 2400 ms, shorter for rich fields e.g. 100 ms.
  - Guiding in extremely rich fields is probably still an issue – the algorithmn fails to find an isolated guide star,

Environment Control

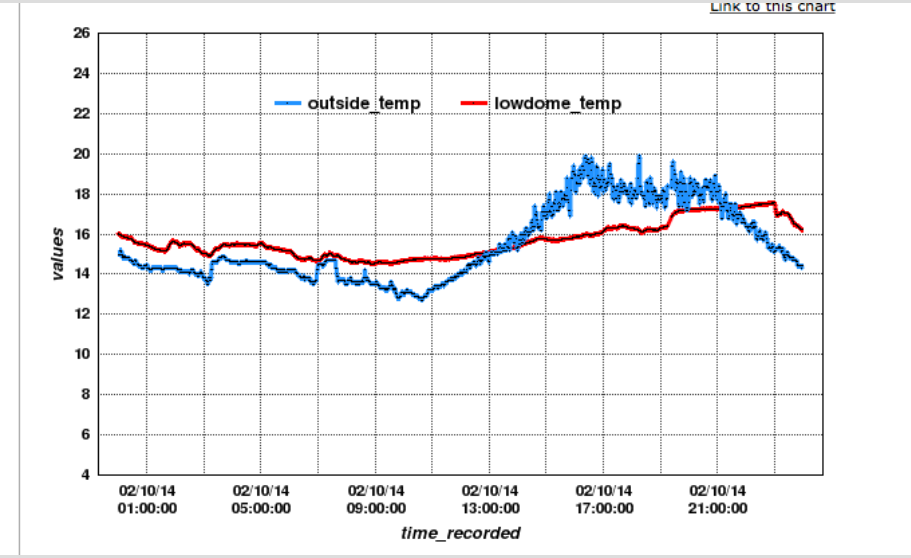
The critical issue is not to have turbulence in the first 15m of the light path – particularly right above the mirror (see Racine et al. 1991, PASP, 103, 1020)

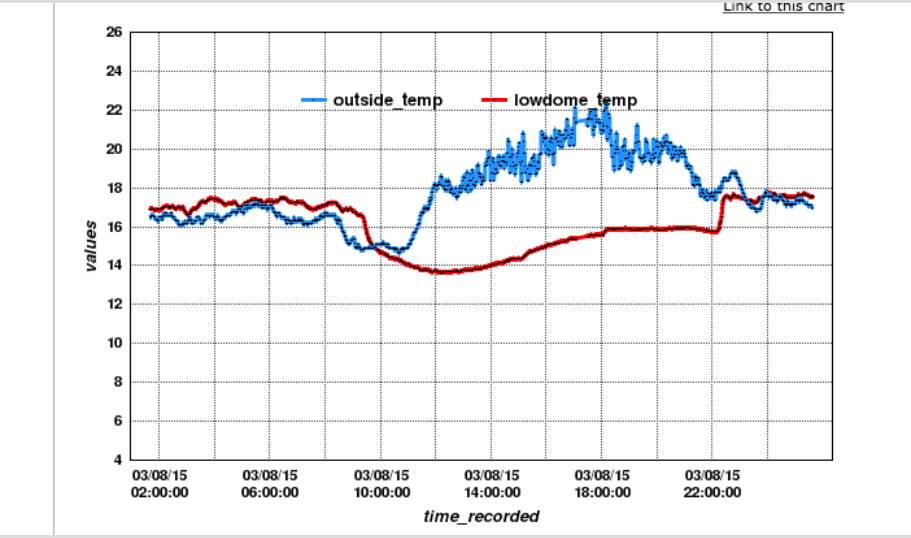


The plot shows the Image Quality with atmosphere outside the dome subtracted, as a function of the temperature difference between the mirror surface and the surrounding air

Plot by Aaron Roodman

Dome air conditioning



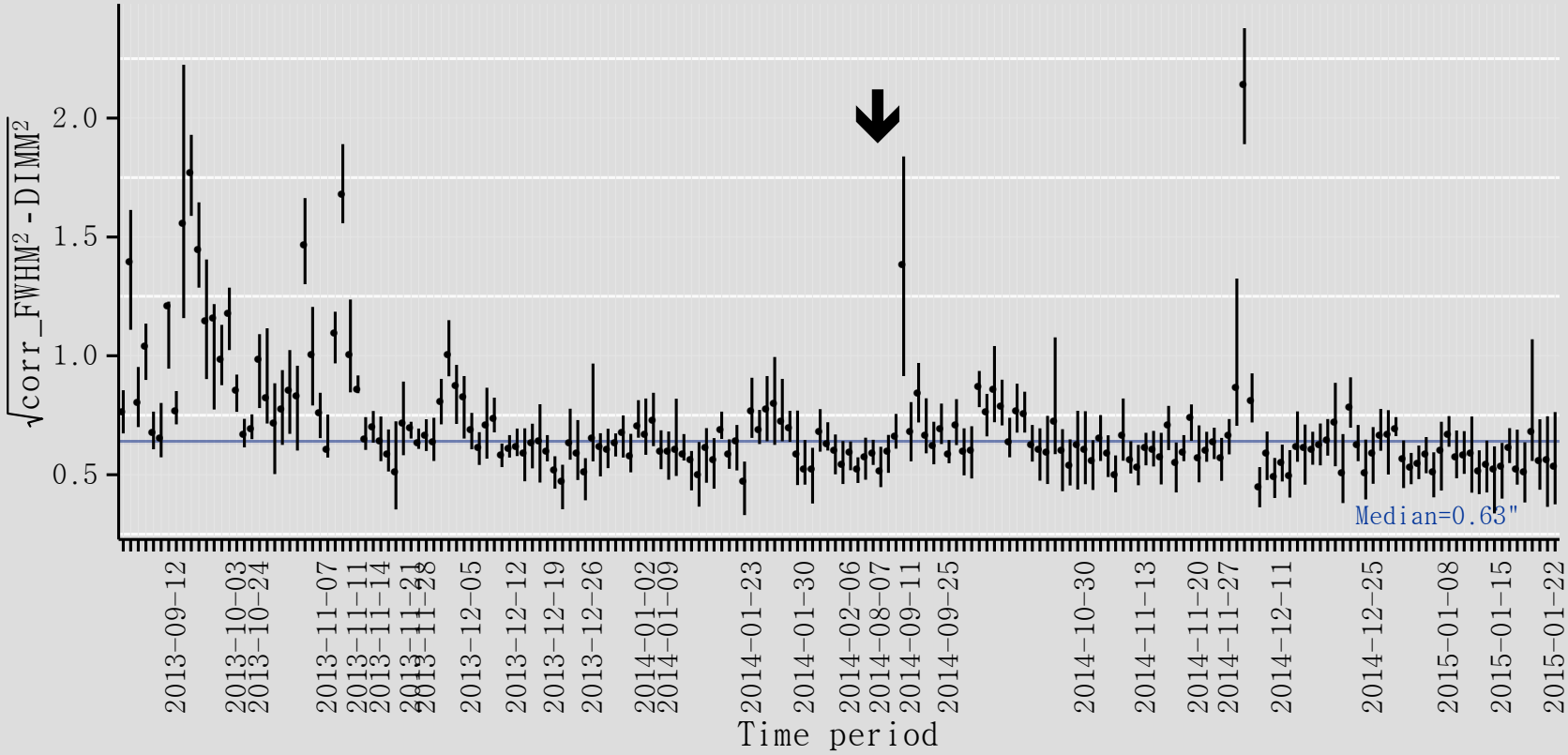


- New glycol plumbing from 2 x 40T Trane chillers outside the dome
- 2 new 10T air handling units in the dome
- Improved telemetry and control
- Adjust the glycol temp. depending on the season (to come)

The goal is to keep the mirror surface 0 to 2C cooler than the ambient temperatures at night.

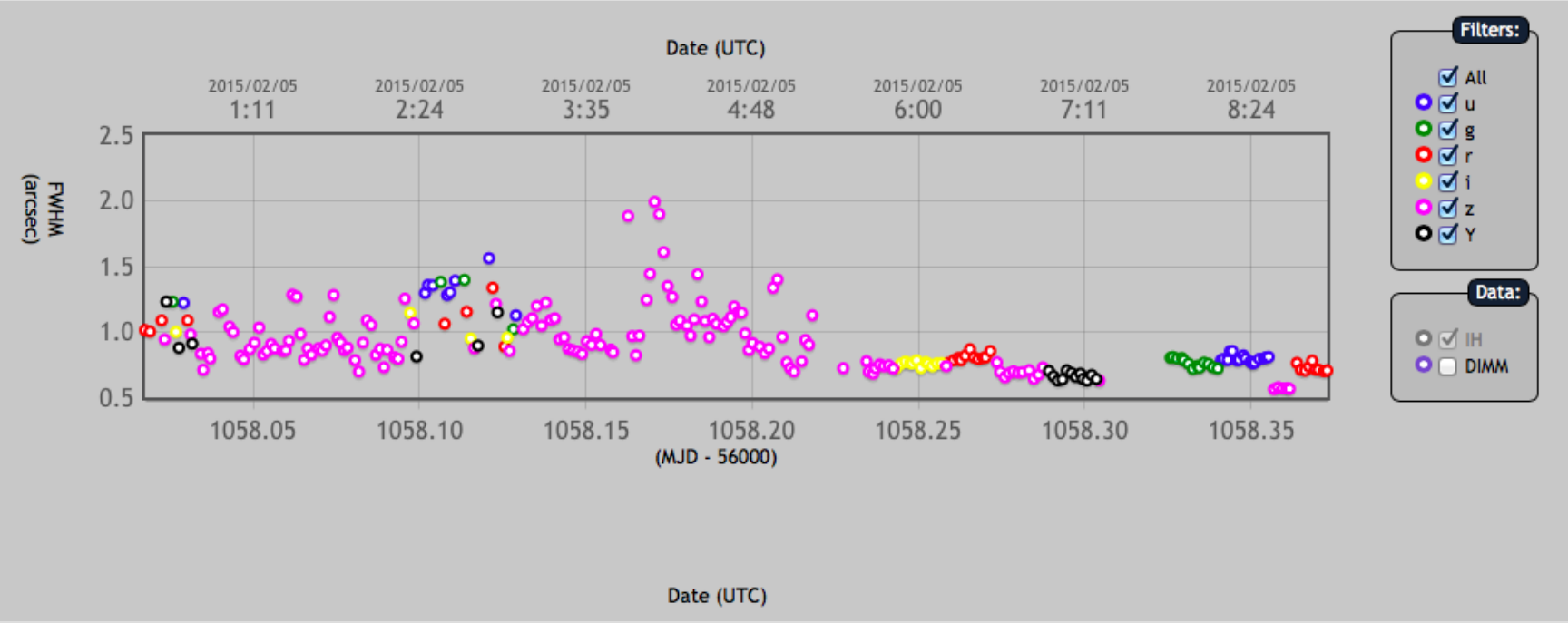
But: the thermal inertia of the 50cm thick, 15T primary mirror will always limit what we can do.

DECam Image Quality, atmosphere removed



The plot shows measured image quality less the DIMM, on a night by night basis, for DES Year 1 and most of Year 2. (Thanks to Eric Nielsen)

Sometimes the Magic Works



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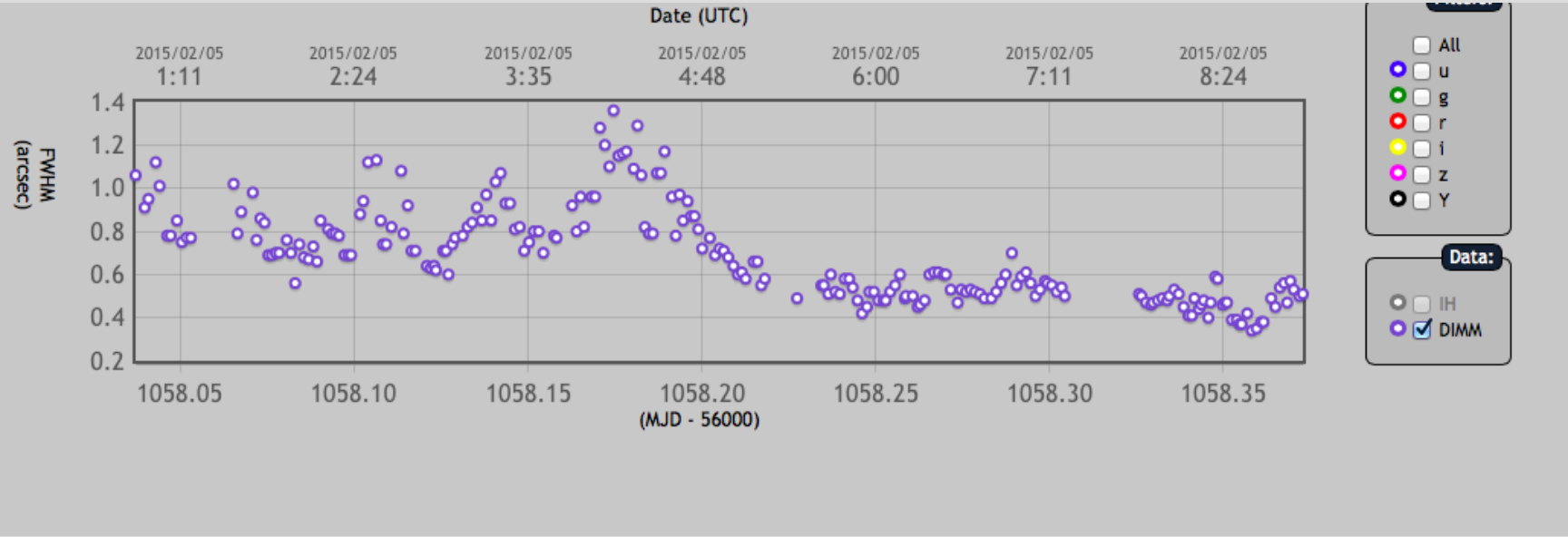

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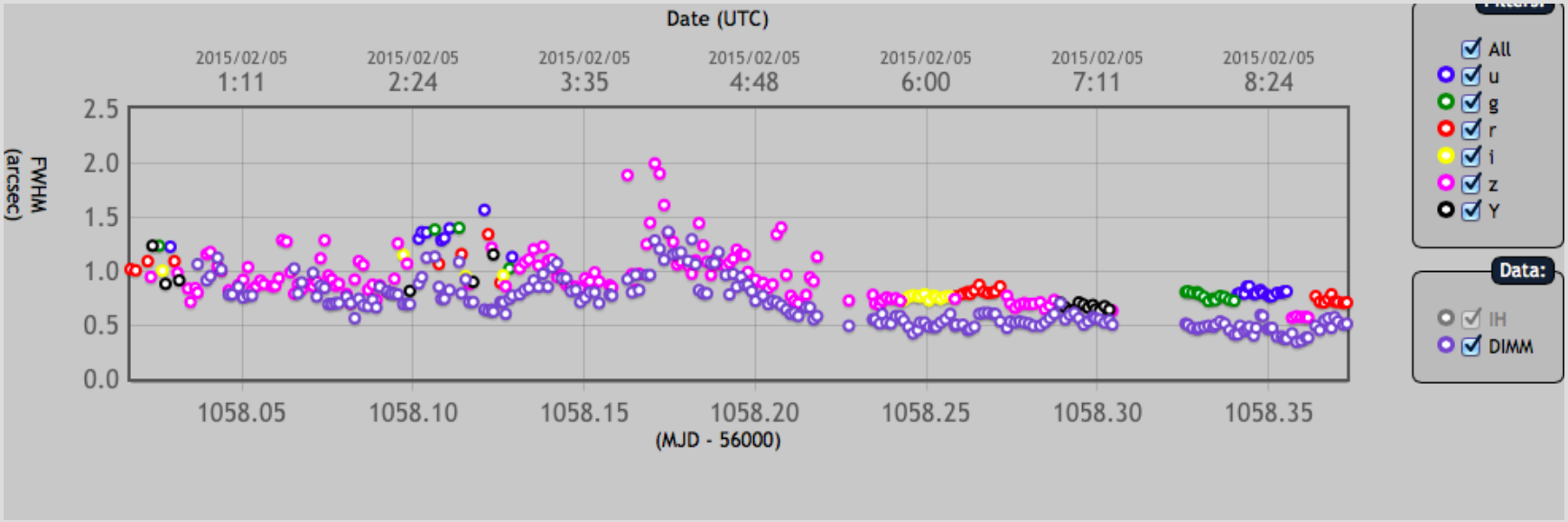


Is there more to gain?

- The instrument floor is ~ 0.47 arcsec (CCD diffusion, DECam optics, primary mirror)

- Getting the environment right is tricky, and there is only so much we can do

- But, is there still some more in the image quality? Maybe another 0.1 arcsec?

Wind effects

- Telescope tracking degrades when the telescope points into the wind, even under moderate wind speeds.

- A 2.2Hz oscillation was observed in the instrument using an accelerometer, producing an rms jitter of ~6μm. This was not transmitted to the telescope mount.

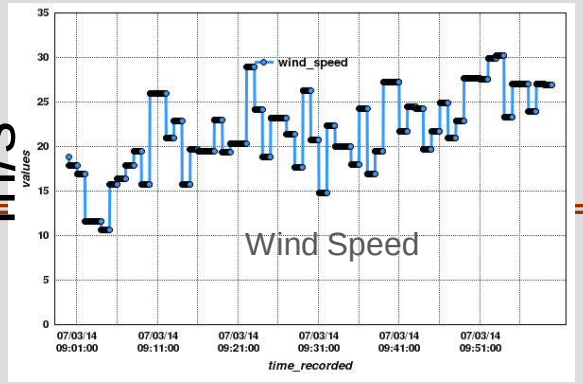
- The telescope tracking jitter is the result of the position servo response to a broadband disturbance, consistent with high wind pressure on the structure.

- The image quality degradation appears to be mostly due to the telescope tracking jitter, as the measured motions on the top assembly due to wind are small.

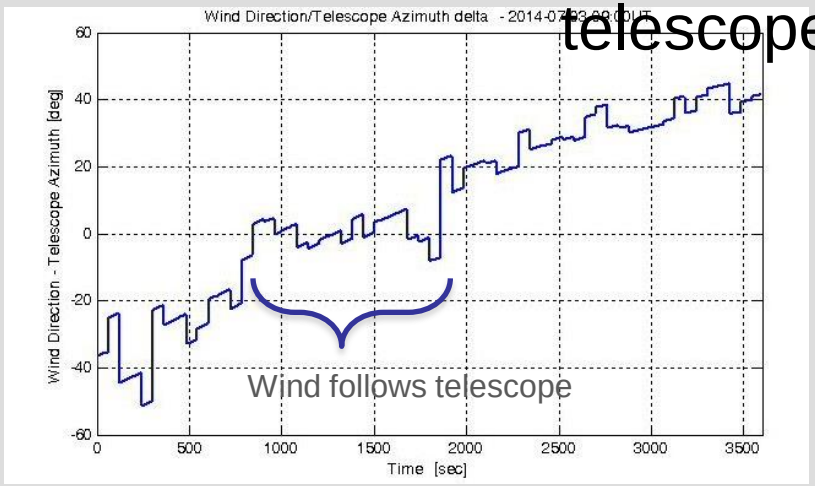
- Amelioration: raise the wind curtain. Close the side doors.
- We are augmenting the TCS display to show a real-time measure of telescope jitter. This should allow the telescope operators and observers to make informed judgments of the appropriate response to windy conditions. (It should make a good seismometer as well)

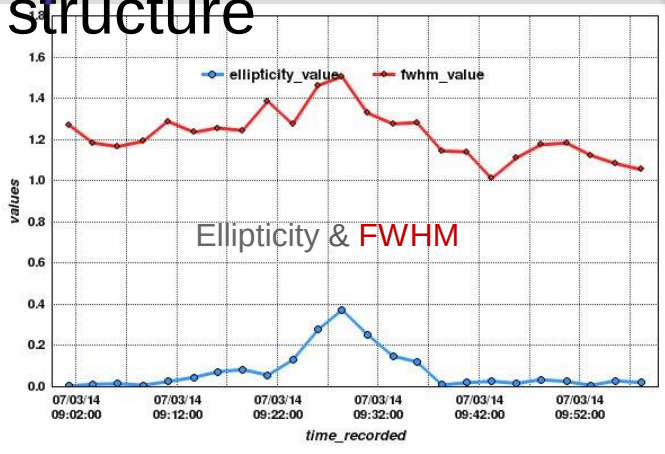
Wind effects

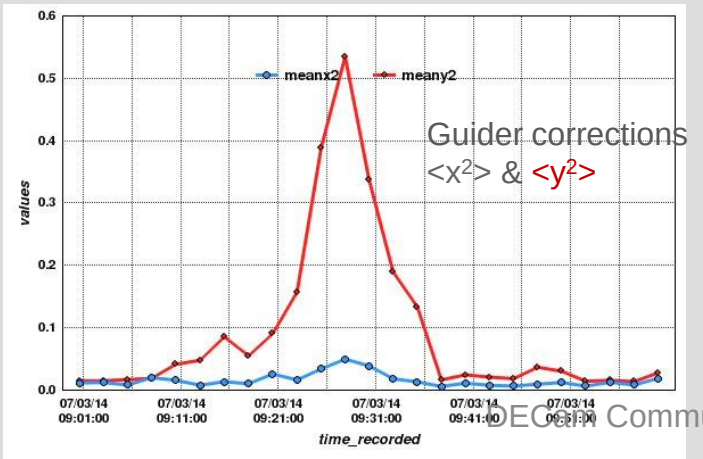
Michael Warner

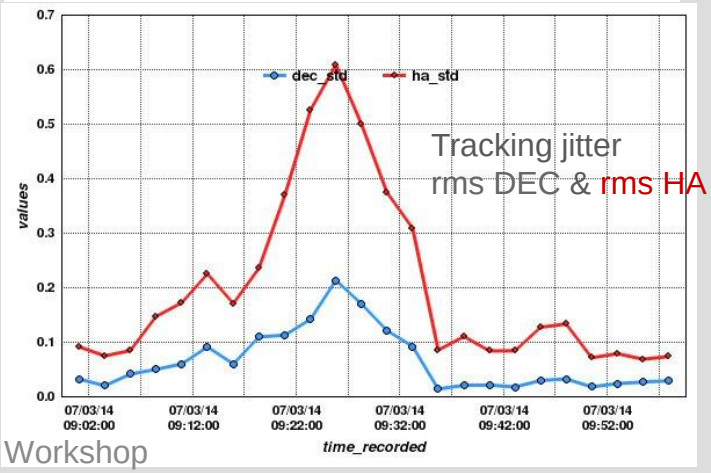


Facing the telescope into the wind can produce considerable image degradation through buffeting of the telescope structure





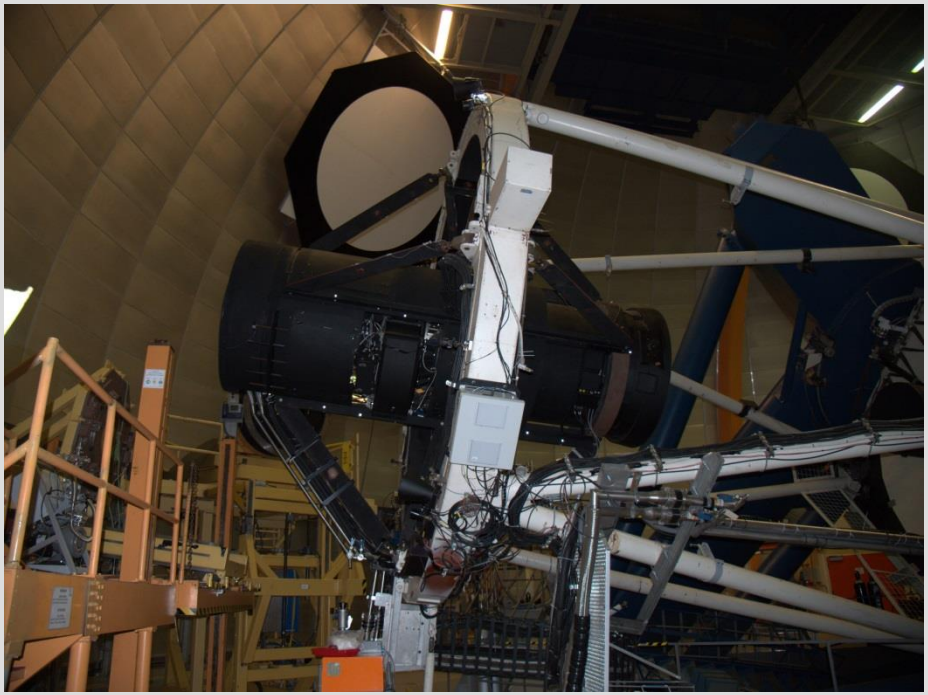




Future work

- Backup Computers

- Environment Control System tuning
- Active optics tuning
- Dome
  - Windscreen camera
  - Shutter drive
  - Reduction gears & motors
  - Reflective coating



- Mirror lift upgrade
- Aluminizing chamber upgrade
  - Next recoat expected 2016

- Big procedure preparation
  - Replacing CCDs
  - Hexapod failure

The End