An Update on the Installation of the AO on the Telescopes

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Overview

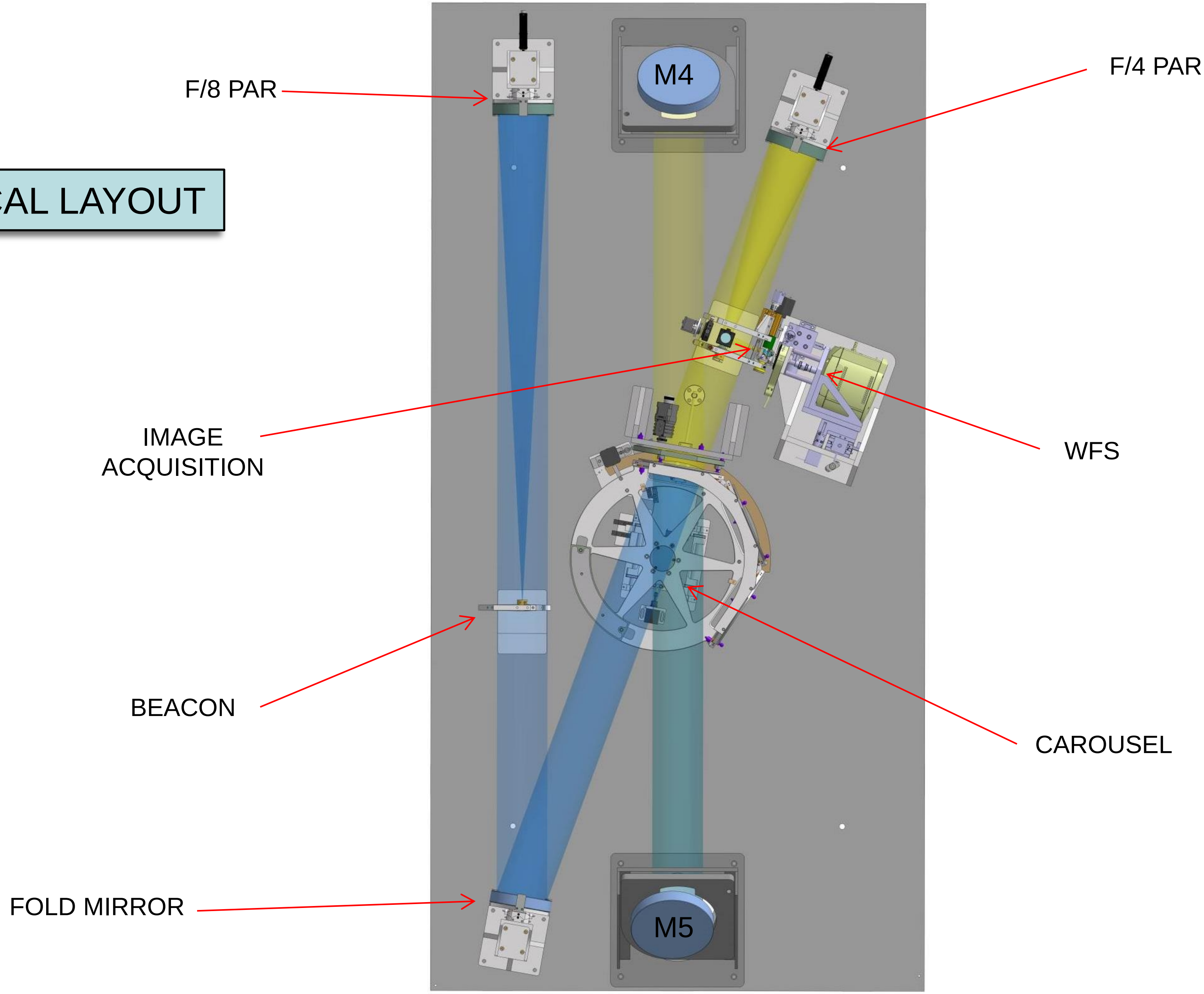
- Phase I

WFS on the telescopes
separate WFS and DM in the lab (LABAO)

- Phase II (unfunded)

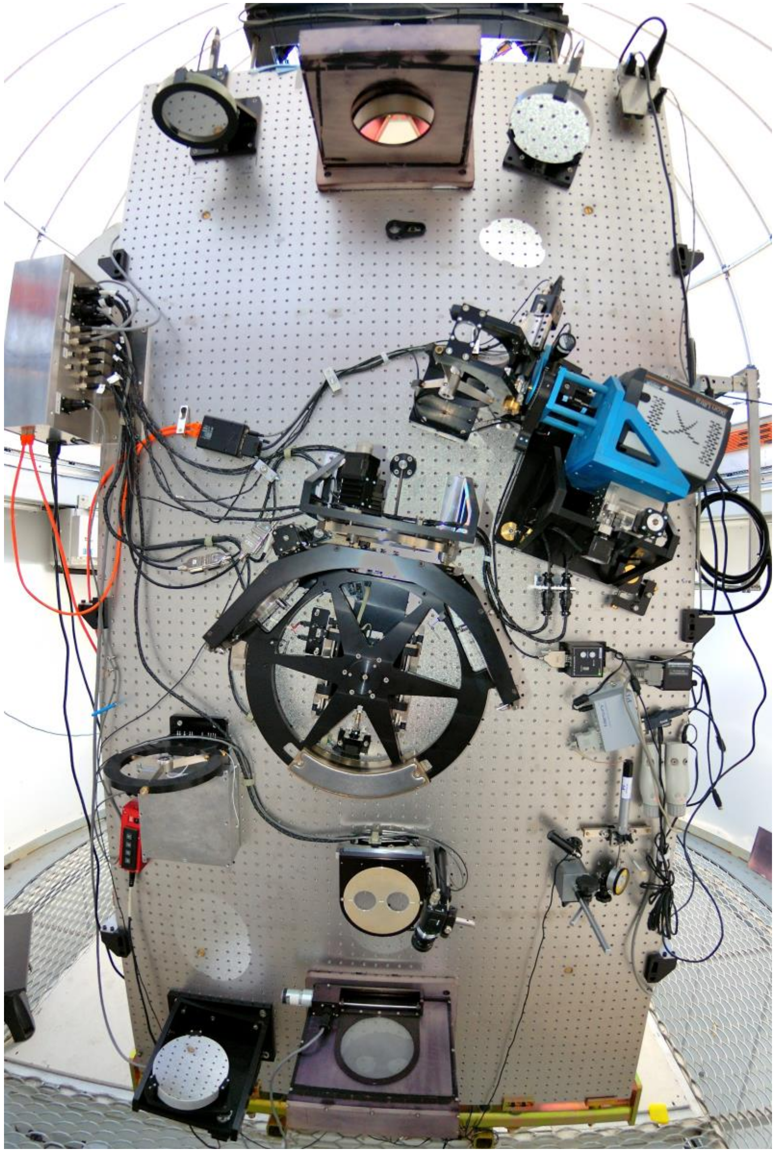
large DM replaces M4

OPTICAL LAYOUT

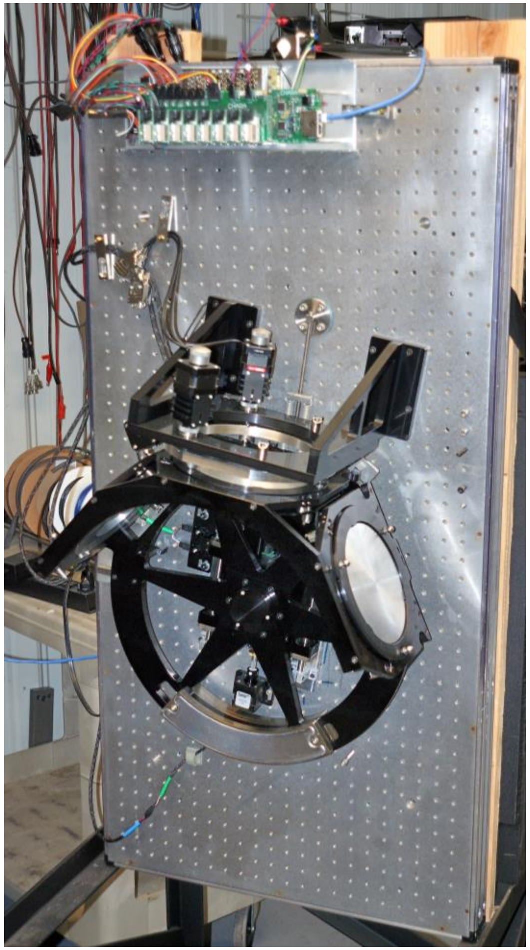


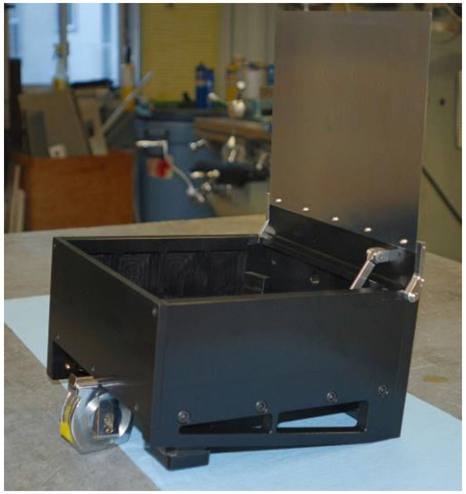
The breadboards have been installed in all six domes.

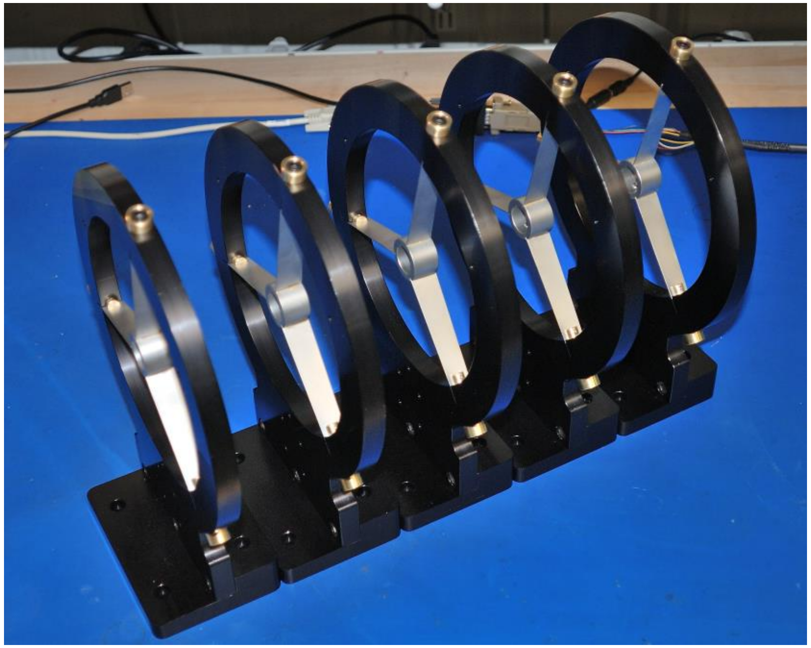
The old system have been reinstalled to keep the array operational while the rest of the hardware is being built.



S2 board – Testbed



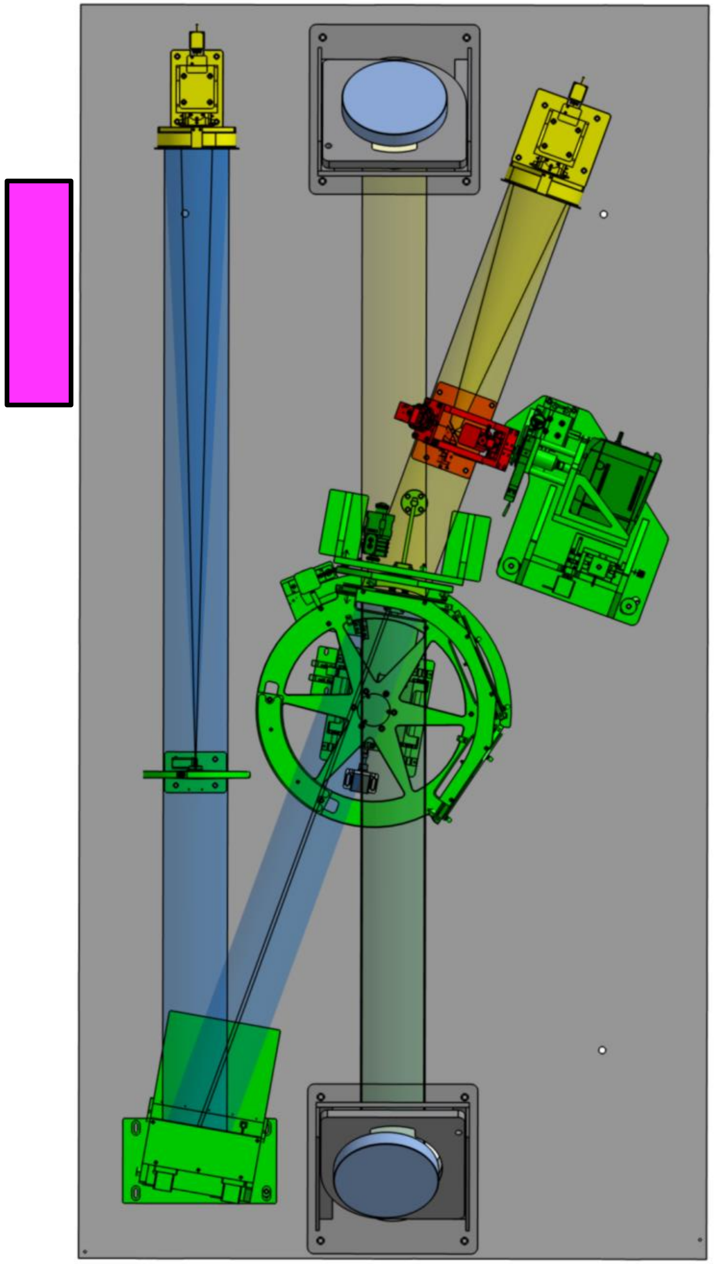




Mechanical parts are being manufactured in the GSU machine shop by

Peter G. Walker
Dwayne Torres
and
Samuel Mayberry

controller

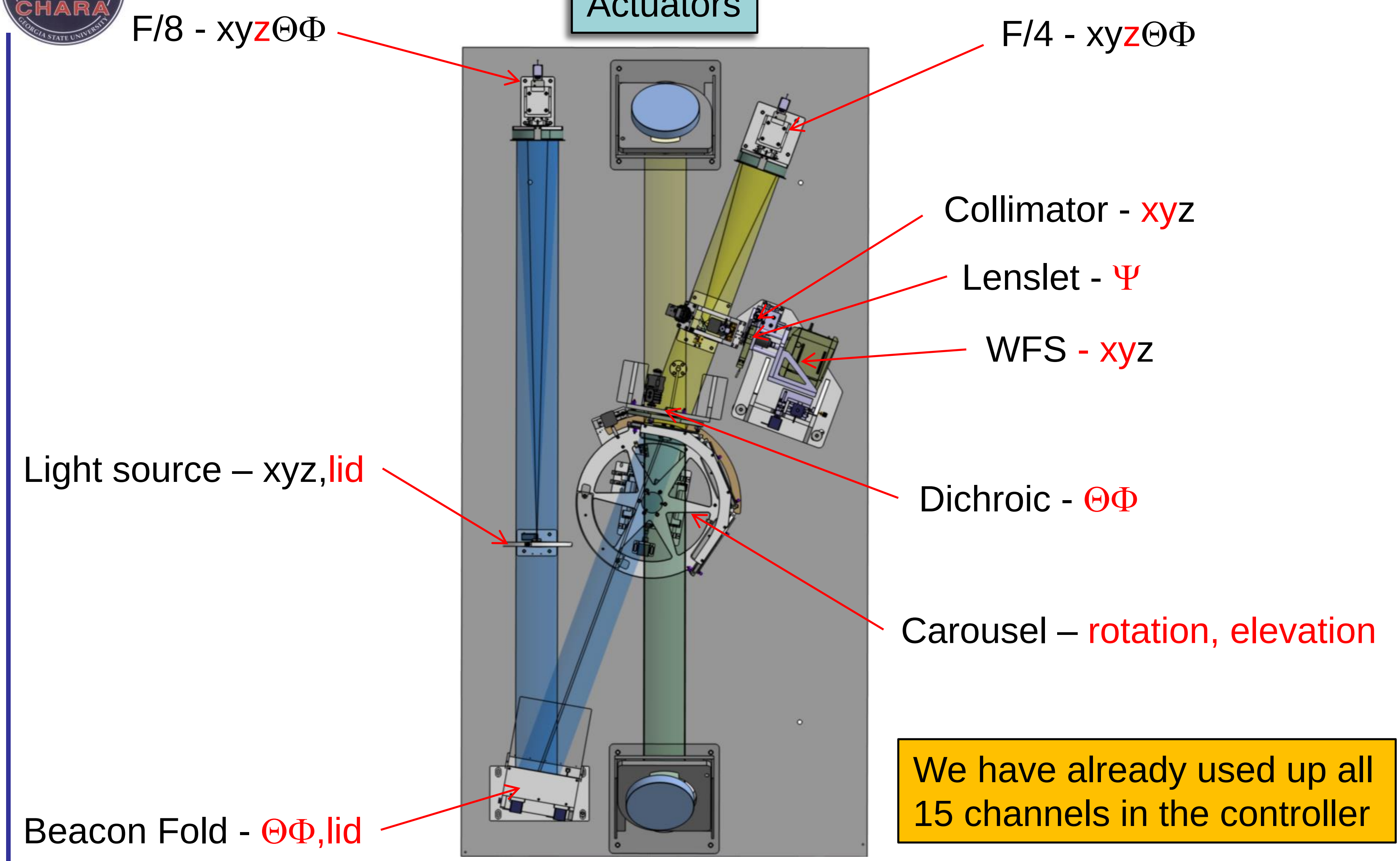


Green – ready to be installed

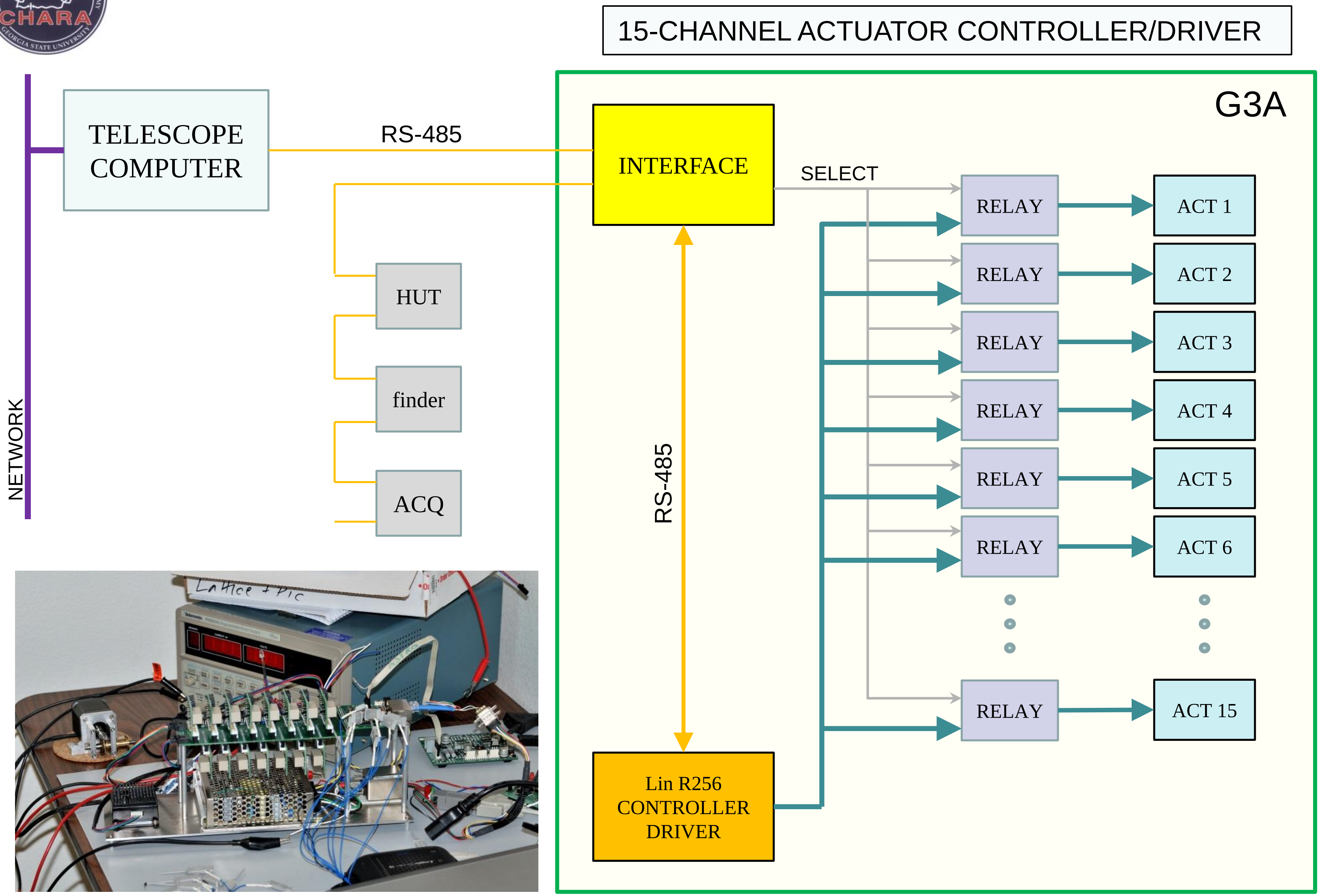
Yellow – just about finished

Red – after yellows

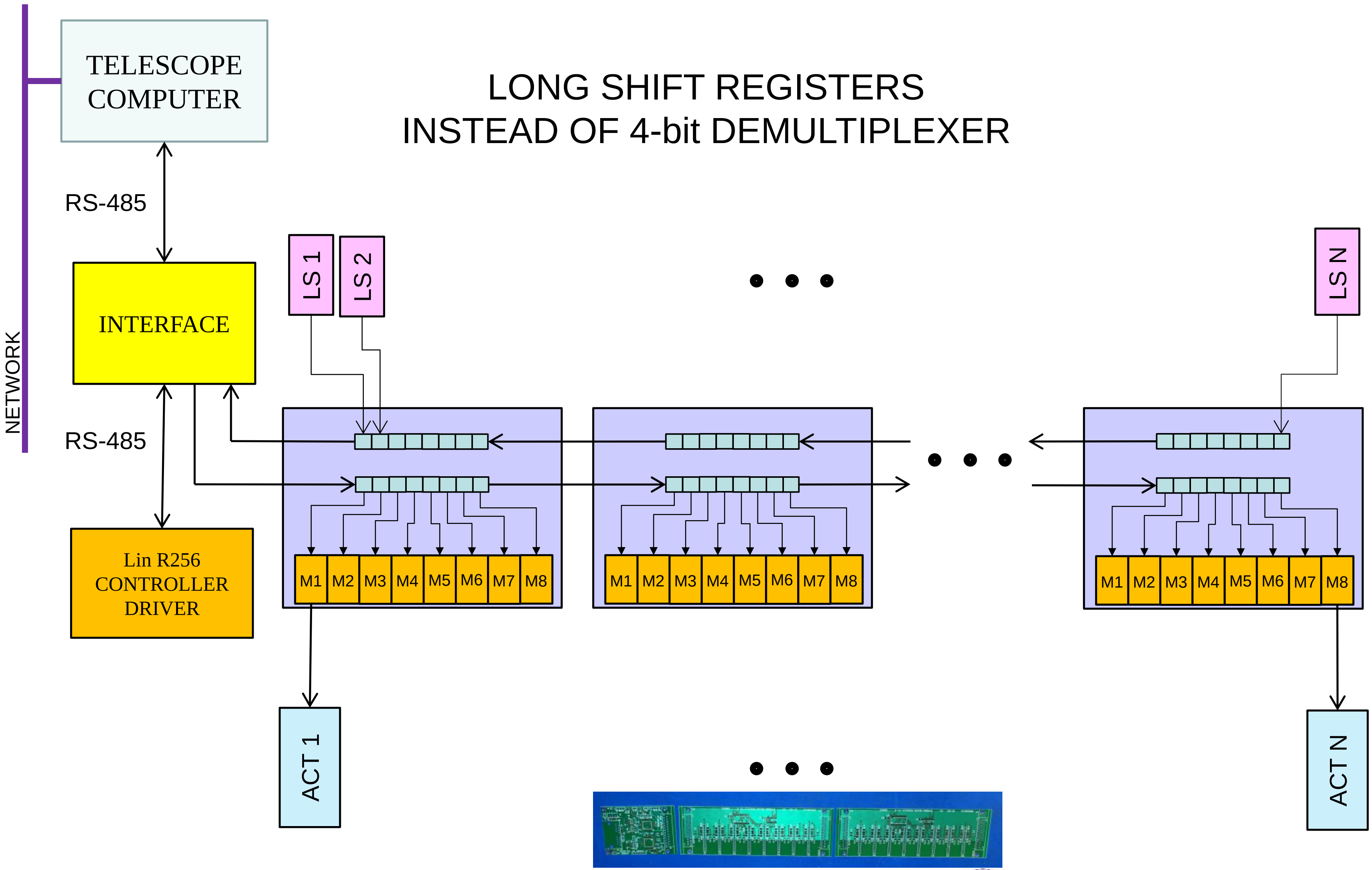
Actuators



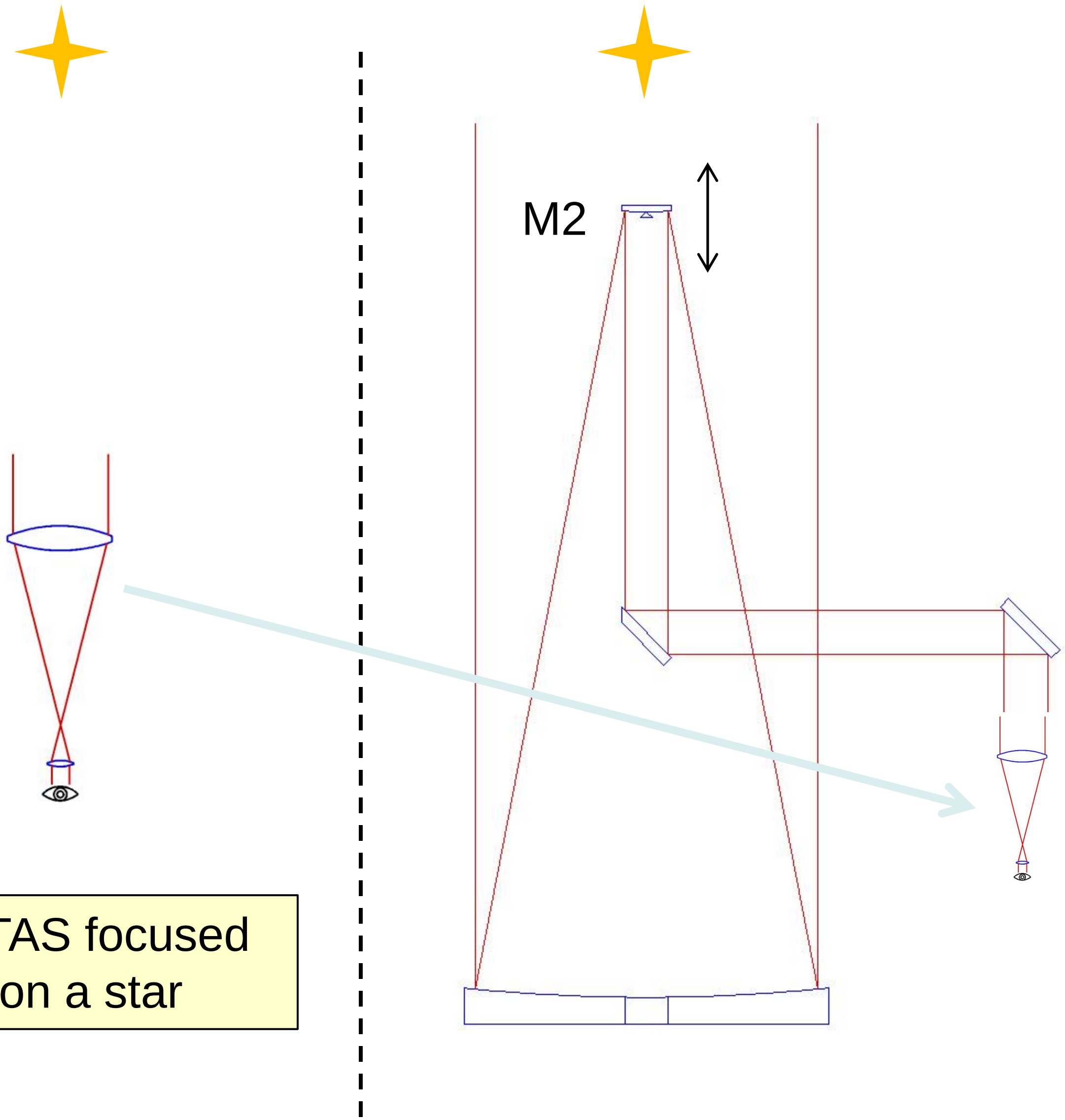
We have already used up all 15 channels in the controller


15-CHANNEL ACTUATOR CONTROLLER/DRIVER
G3A
NETWORK
TELESCOPE COMPUTER
RS-485
INTERFACE
SELECT
HUT
finder
ACQ
RS-485
RELAY
ACT 1
ACT 2
ACT 3
ACT 4
ACT 5
ACT 6
ACT 15
Lin R256 CONTROLLER DRIVER

MULTI-CHANNEL ACTUATOR CONTROLLER/DRIVER



Focusing the Telescope – The Past



1. TAS focused on a star

2. Telescope focused by translating M2

Focusing the Telescope – The Future

Using one of the WFS'.

WFS needs calibration.

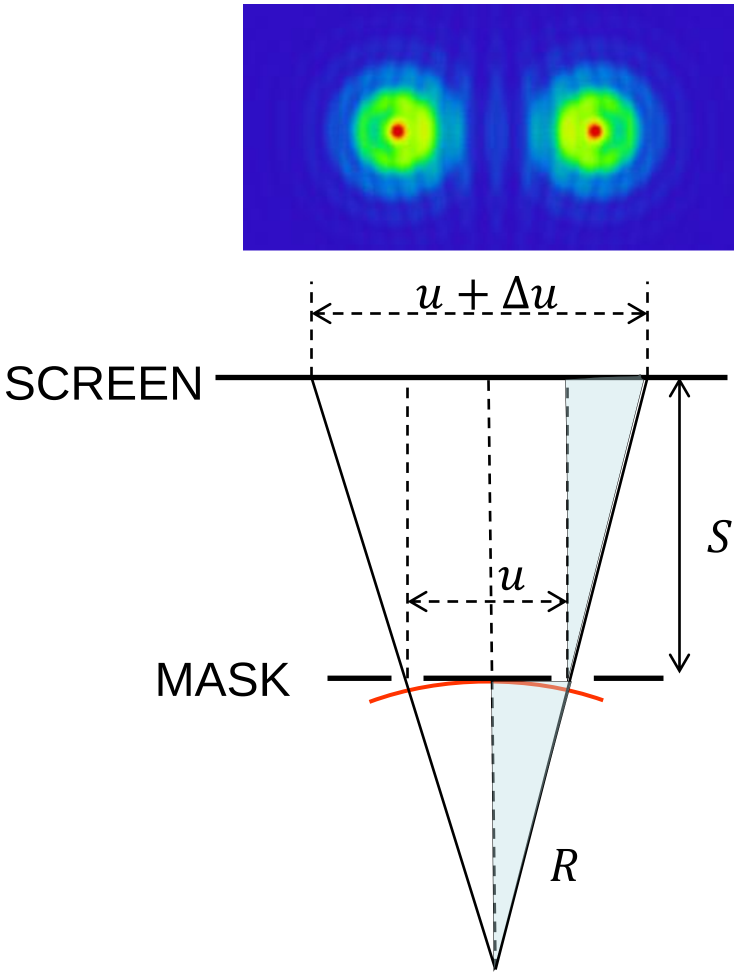
The beacon, after focusing, can provide a flat wavefront for the WFS'.

How to focus the beacon?

The simplest is putting a Hartmann mask above M5 and watching the diffraction spots in the lab. several hundred meters away.

A convergent beam puts the spots closer, a divergent beam farther than the distance between the holes.

Since this will likely be done regularly, we should do this preferably with a camera.



$$\frac{\Delta u}{S} \cong \frac{u}{R}$$

$$R \cong \frac{u}{\Delta u} S$$

$$P - V = R - \sqrt{R^2 - \frac{u^2}{4}} \cong \frac{u^2}{8R}$$

$$P - V = \frac{u\,\Delta u}{8\,S}$$

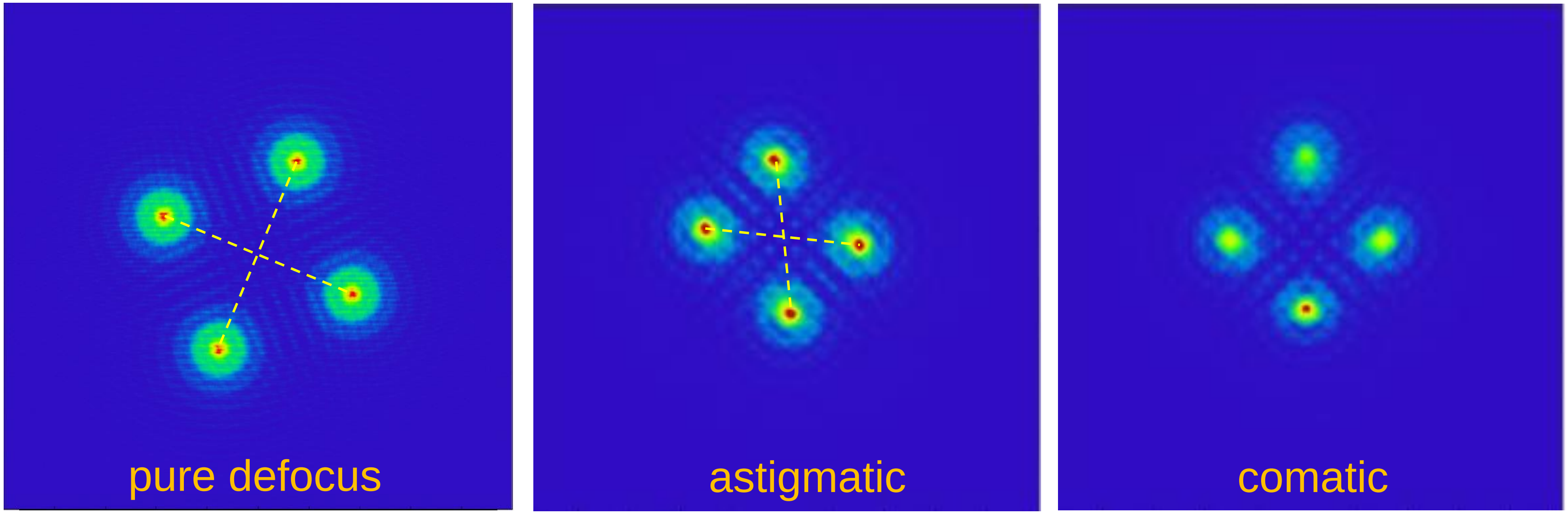
Example:

$u = 0.08\,m, \Delta u = 0.001 m$ and $S = 300\,m$

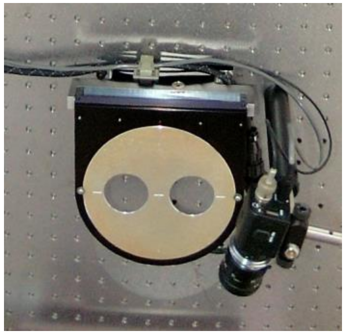
$P - V = 0.05\ waves$ at 600 nm

This is pretty good, but there may be other aberrations present in the beam.

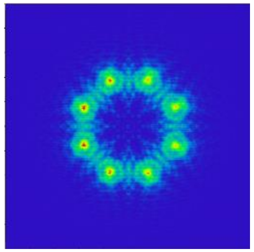
4-hole or rotating 2-hole mask

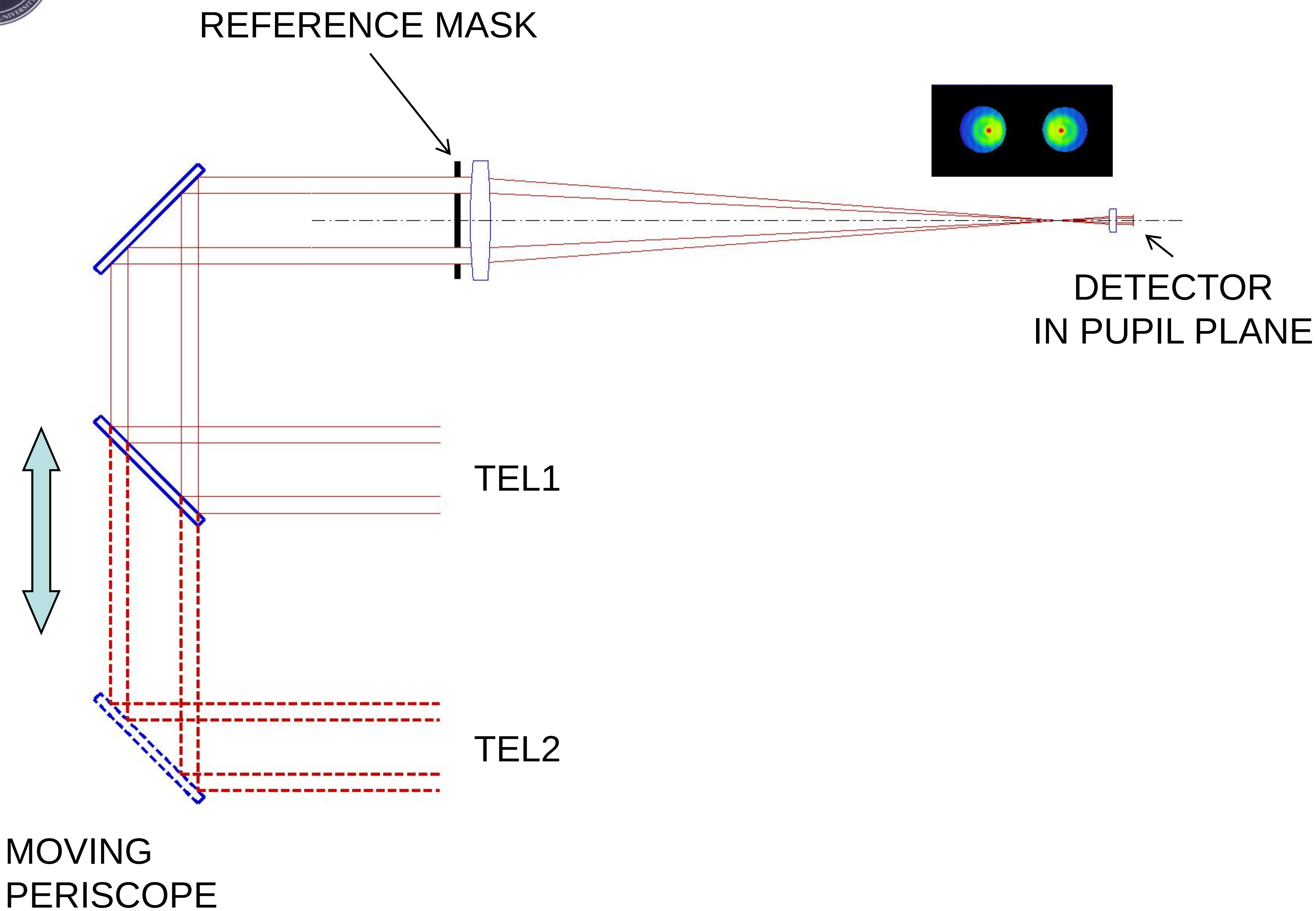


S2 has an actuated 2-hole mask which is used to focus the beacon beam toward the lab.



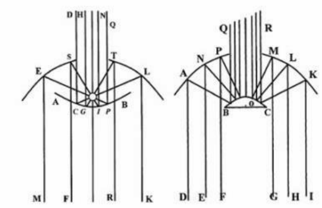
Too many holes makes it confusing




REFERENCE MASK
DETECTOR
IN PUPIL PLANE
TEL1
TEL2
MOVING
PERISCOPE

How sensitive the telescope etc. focus is to temperature

Mersenne 1636



The CHARA telescopes are 1:8 beam reducers with confocal paraboloids in Mersenne-Cassegrain arrangement.

If the foci are separated axially (despace), the output beam is no longer colli
If the separation is small, the wave front error is mostly defocus with a hint of spherical aberration.
The wave front error due to despace Δs can be estimated as

$$P - V = \frac{1}{8\,\lambda}\frac{\Delta s}{(F\#)^2}[waves]$$

$F\# = 2.5$ thus the sensitivity of the system to despace is $P - V = \frac{\Delta s}{50\,\lambda}\;[waves]$.

The secondary assembly is mounted in a frame that is “floating” on four 2.66 m long invar rods ($CTE = 1.2\;\times 10^{-6}\;K^{-1}$). The secondary assembly is made of mild steel. The geometry is such that thermal expansion/contraction of the invar rods is partially compensated by that of the steel mounting structure thereby keeping the distance between the M1 and M2 independent from temperature in the first order.
Despite of that, we see a seasonal change in telescope focus which can be easily corrected.
With a WFS installed at each telescope we will have a tighter control over focus in the future.

The primary and secondary are made of Astrosital and Zerodur, each has CTE an order of magnitude less than that of invar.

The beacon

The beacon paraboloid is made of borosilicate glass ($CTE_{glass} = 3.25 \times 10^{-6}\, K^{-1}$), the breadboard is SS430 ($CTE_{SS430} = 5.78 \times 10^{-6}\, K^{-1}$).

The breadboard expands/contract with temperature and so does the paraboloid. The distance between the fiber source and the mirror varies as

$$\Delta s = \left(CTE_{SS430} - CTE_{glass}\right) f\, \Delta T$$

or $\Delta s = 3.1 \mu m\, \Delta T[K]$ since $f = 1.22\, m$.

The effective $F\#$ of the beacon paraboloid is 9.6 thus the rate of defocus due to temperature changes seems like only about $0.007\, waves\, K^{-1}$.

The sensitivity of the beacon focus to temperature is $\cong 0.007\, waves\, K^{-1}$ at 600 nm.

WFS feed optics

The WFS is fed by a boresilicate $6\ in\ F/4$ paraboloid with an effective $F\#$ of 4.8 . The focus sensitivity is $\Delta s \cong 1.5\ \mu m\ \Delta T[K]$ and the corresponding defocus is $0.014\ waves\ K^{-1}$ at 600 nm.

The sensitivity of the WFS feed to temperature is $\cong 0.014\ waves\ K^{-1}$ at 600 nm.

Overall in the plane of the lenslet array

$$P - V = \frac{d^2 {f_p}^2}{8\ {f_2}^2 {f_c}^2} \Delta$$

$f_p -\ focal\ length\ of\ the\ F/4\ paraboloid = 609.6\ \mathrm{mm}$

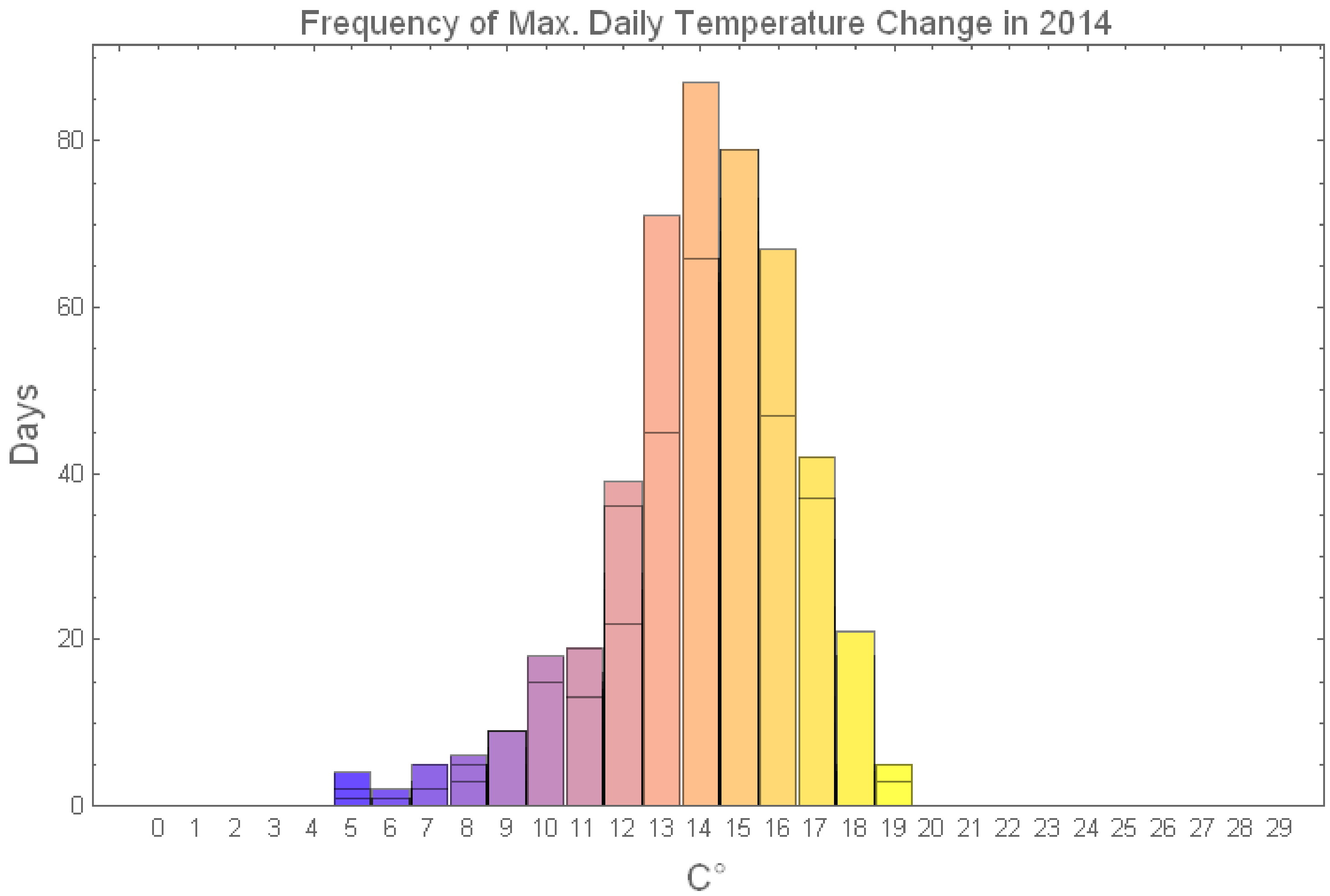
$f_2 -\ focal\ length\ of\ M2 = -312.5\ mm$

$f_c -\ focal\ length\ of\ the\ collimator = 9mm$

$d - beam\ diameter\ on\ lenslet\ array = 1.6\ mm$

$\Delta - axial\ displacement\ of\ M2 = 3.2\ \mu m\ K^{-1}$

$P - V = 0.084\ waves\ K^{-1}$ at 600 nm


Frequency of Max. Daily Temperature Change in 2014
Days
0
20
40
60
80
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
C°

Problem: The beacon focus changes a lot more than it should

$\Delta u \cong 1\ cm$ from one evening to the next noon. To produce this, the distance between the fiber and the beacon mirror had to change about $0.3\ mm$. A temperature rise of $97℃$ would be needed if this was purely due to temperature. We had a hot summer but not that hot.

There's clearly something else is going on.