



Las Cumbres Observatory

Global Telescope Network

John Martinez, Project Manager

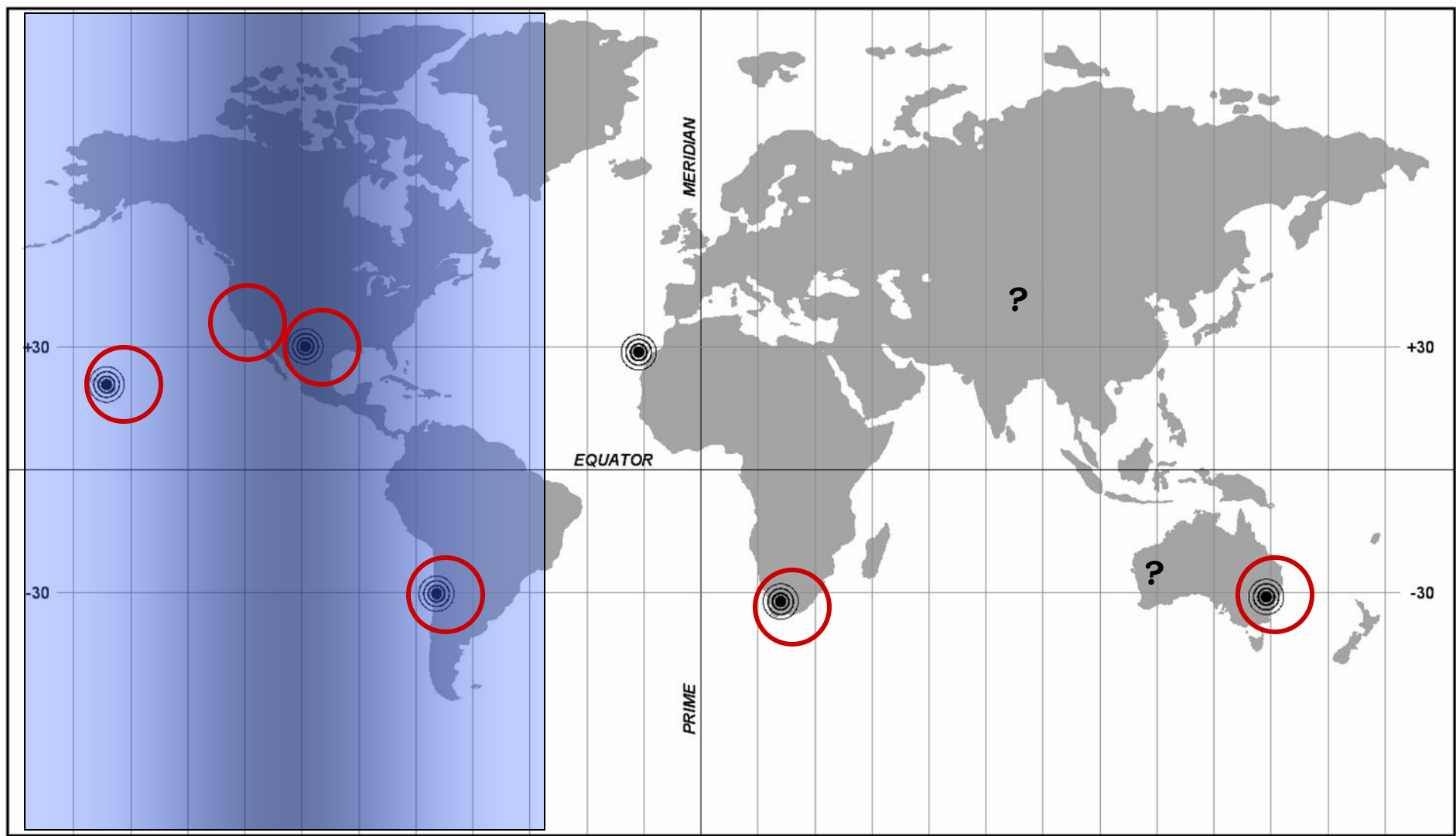


LCOGT: what we are...

- *A private, operating, non-profit foundation.*
- *35 employees with offices in the U.S. and the U.K.*
- *MEs, EEs, CEs, SEs, technicians, machinists, managers, administrators, and of course ASTRONOMERS!*

The LCOGT mission...

- *Build a durable scientific institution dedicated to the advancement of time-domain astrophysics:*
 - *Transiting exoplanets*
 - *Supernovae*
 - *NEOs*



LCOGT motto...

We'll

KEEP YOU IN THE DARK!

Engineer's motto...

***Nothing happens
until
engineers build something!***

LCOGT telescopes

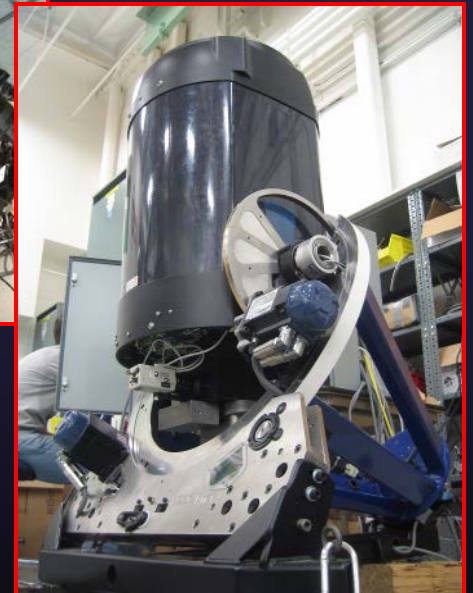
2.0m Telescope



1.0m Telescope



0.4m Telescope



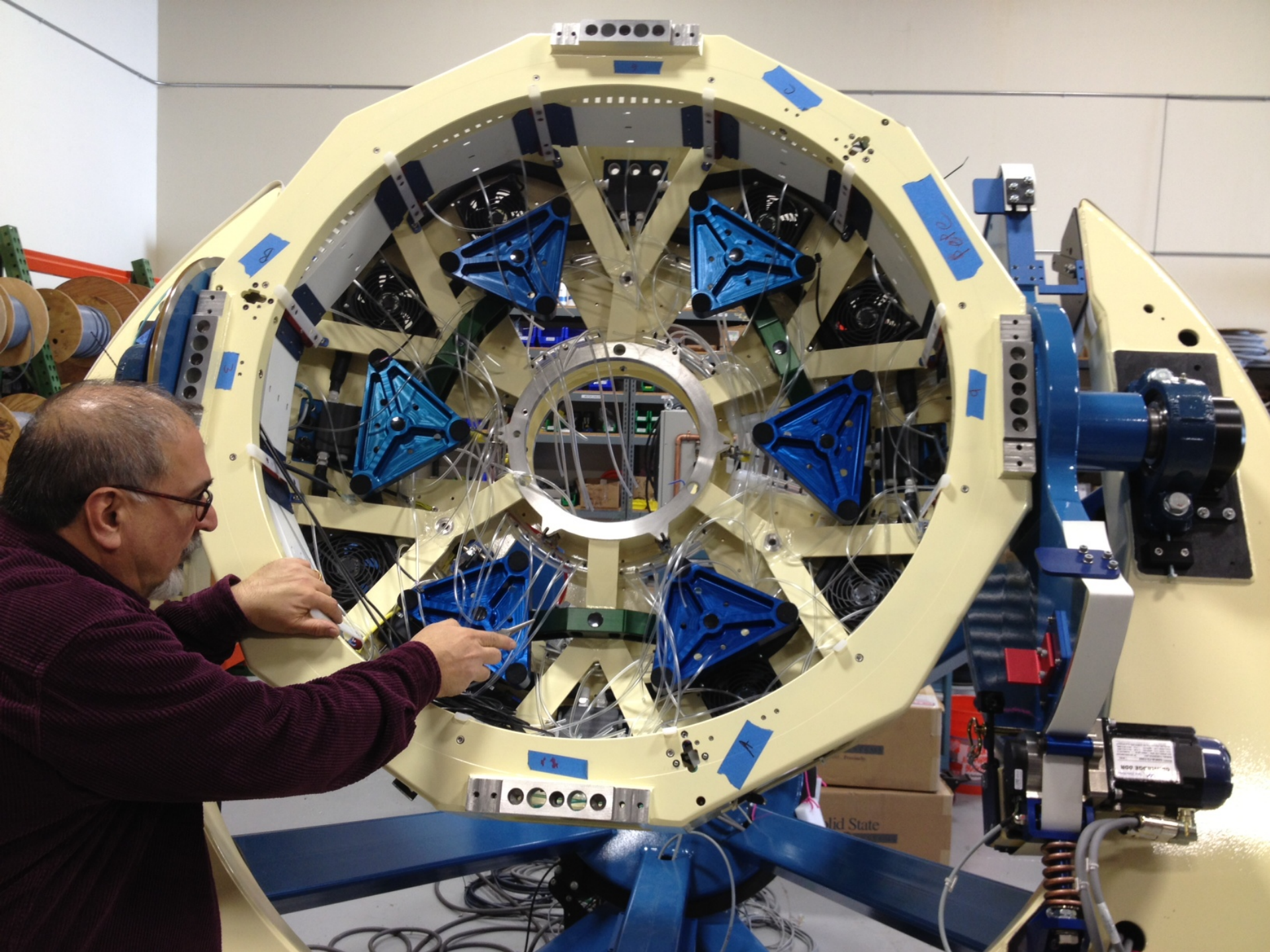
The engineering challenge

Design, build and deploy a globally distributed network of identical and highly calibrated photometric telescopes to many different countries:

Identical optical configurations, mount performance, control systems, detectors, and filters!









05-0101

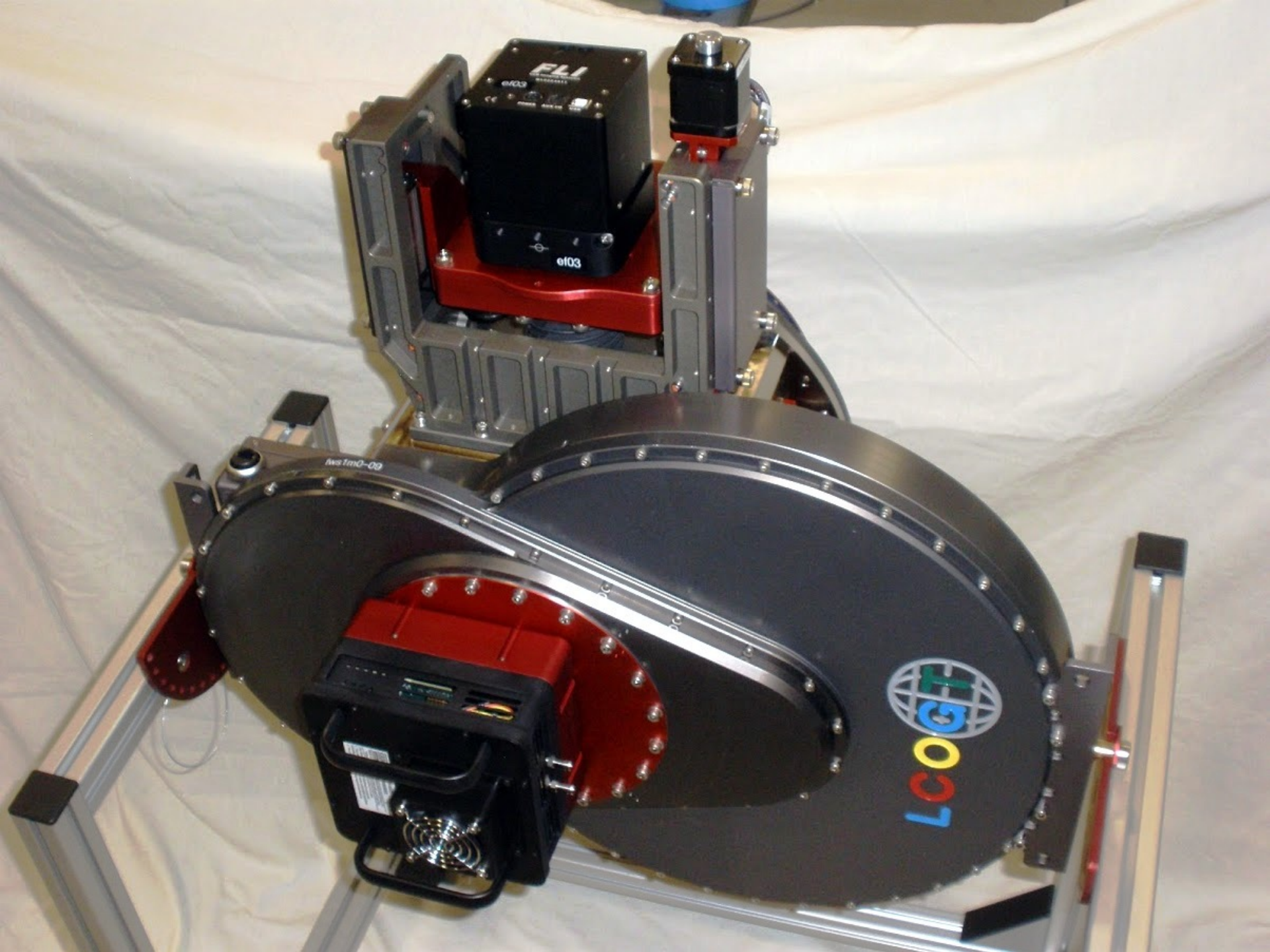


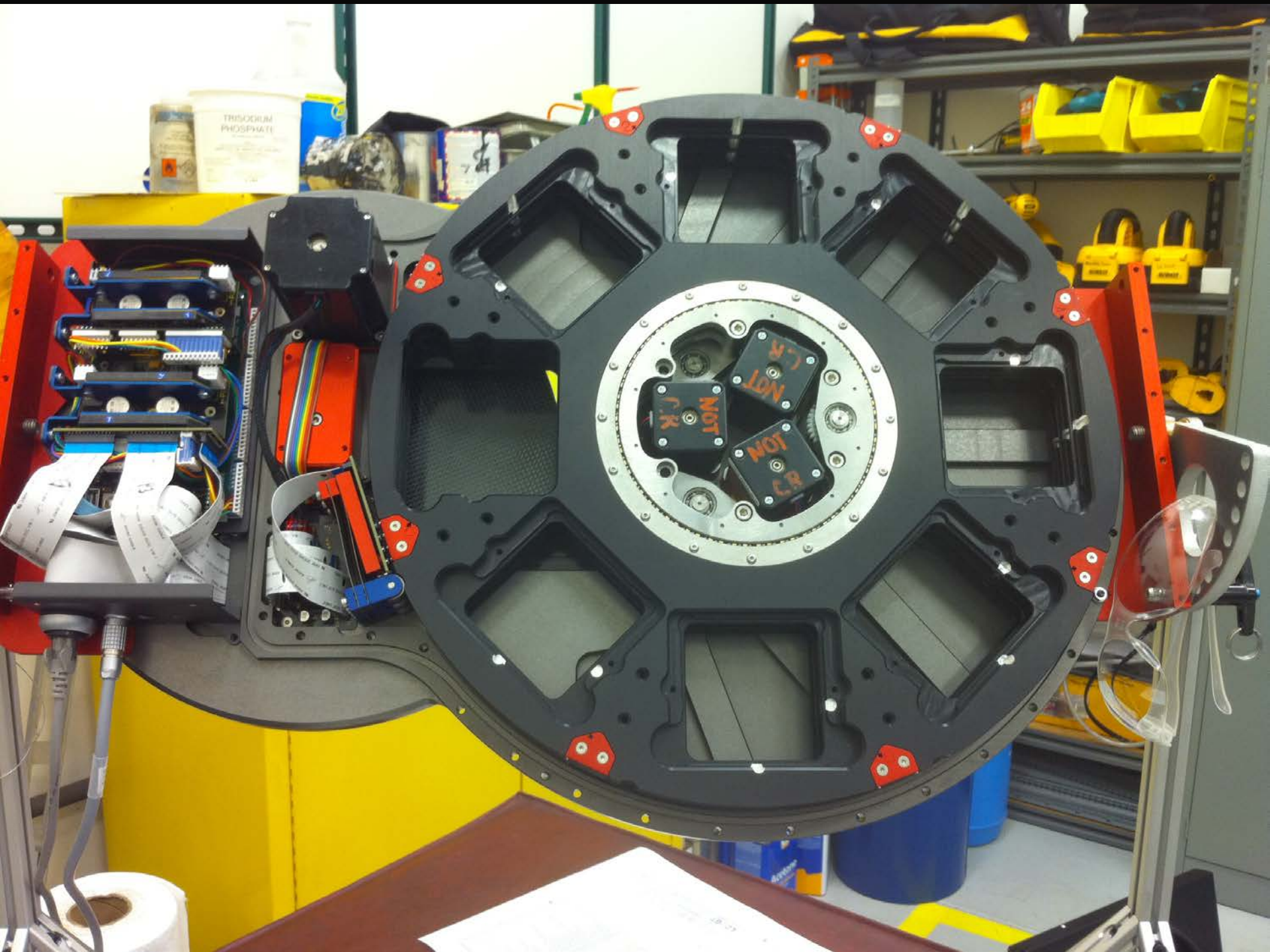












TRISODIUM PHOSPHATE

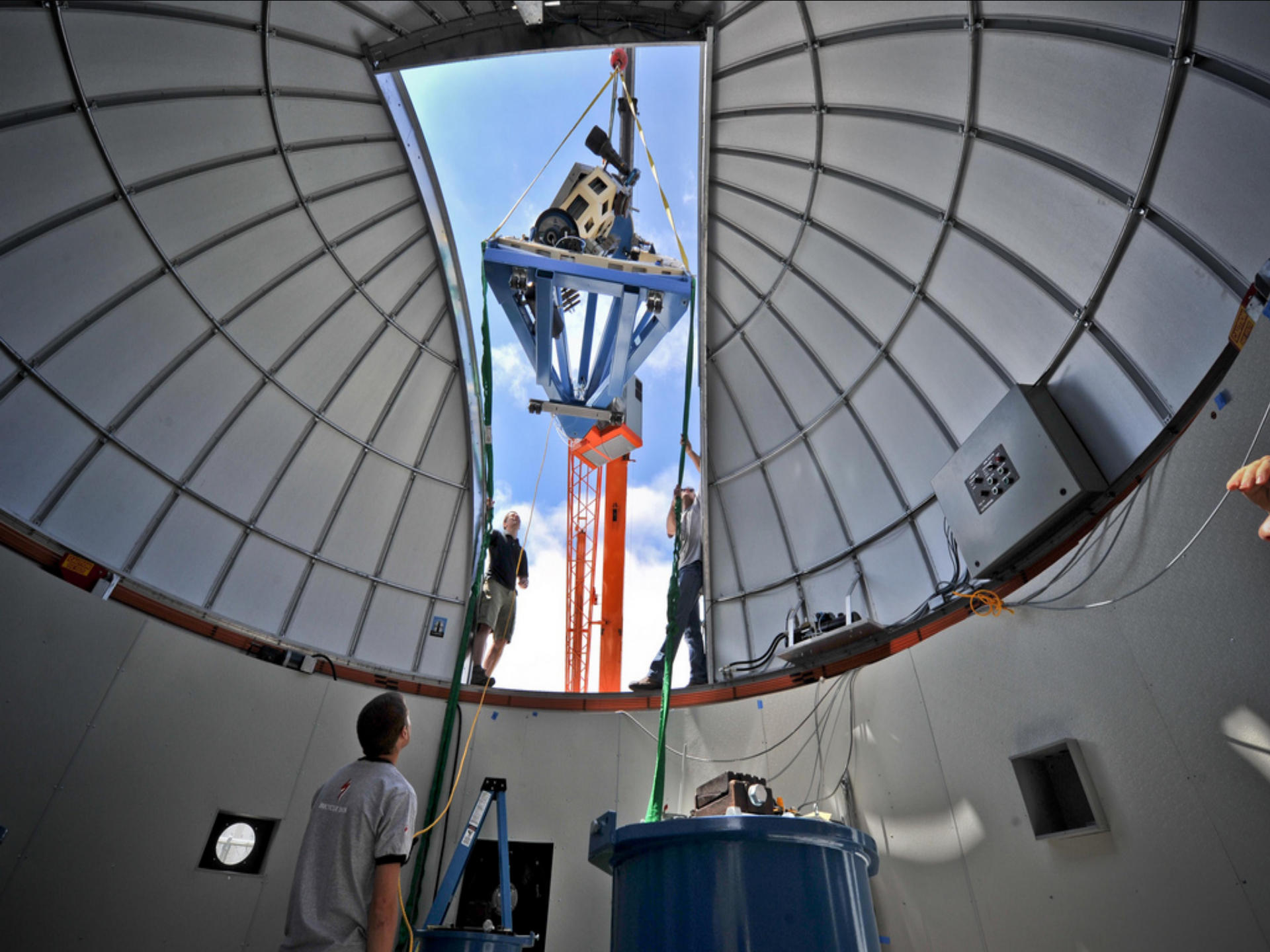
Technical drawing or schematic on a white sheet of paper.

Prototype and test!



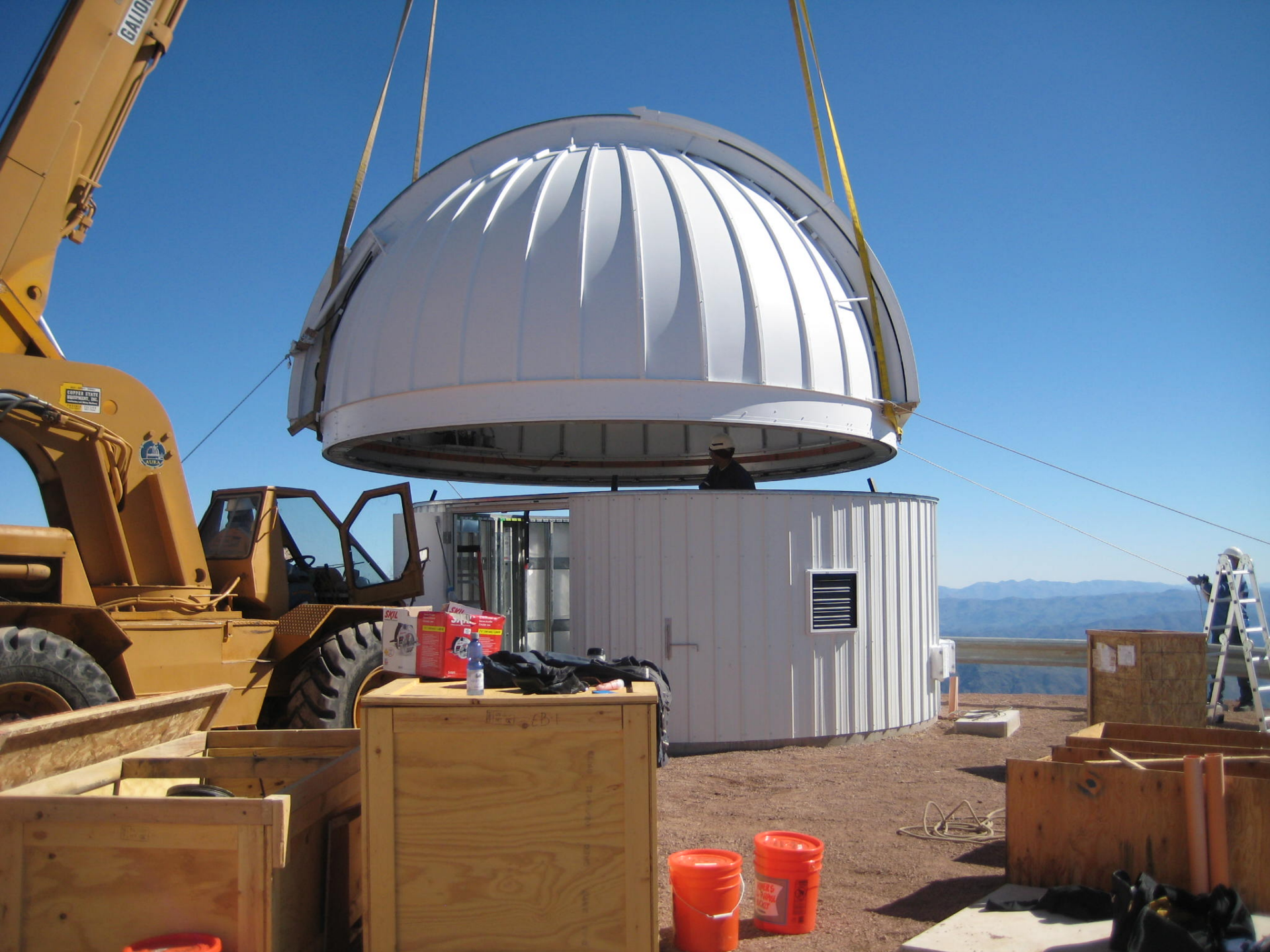
1-meter Install at Mcdonald





McD First Light- NGC 2903





CALIBER

COPPER STATE



SKYL

11-21-01 EB-1

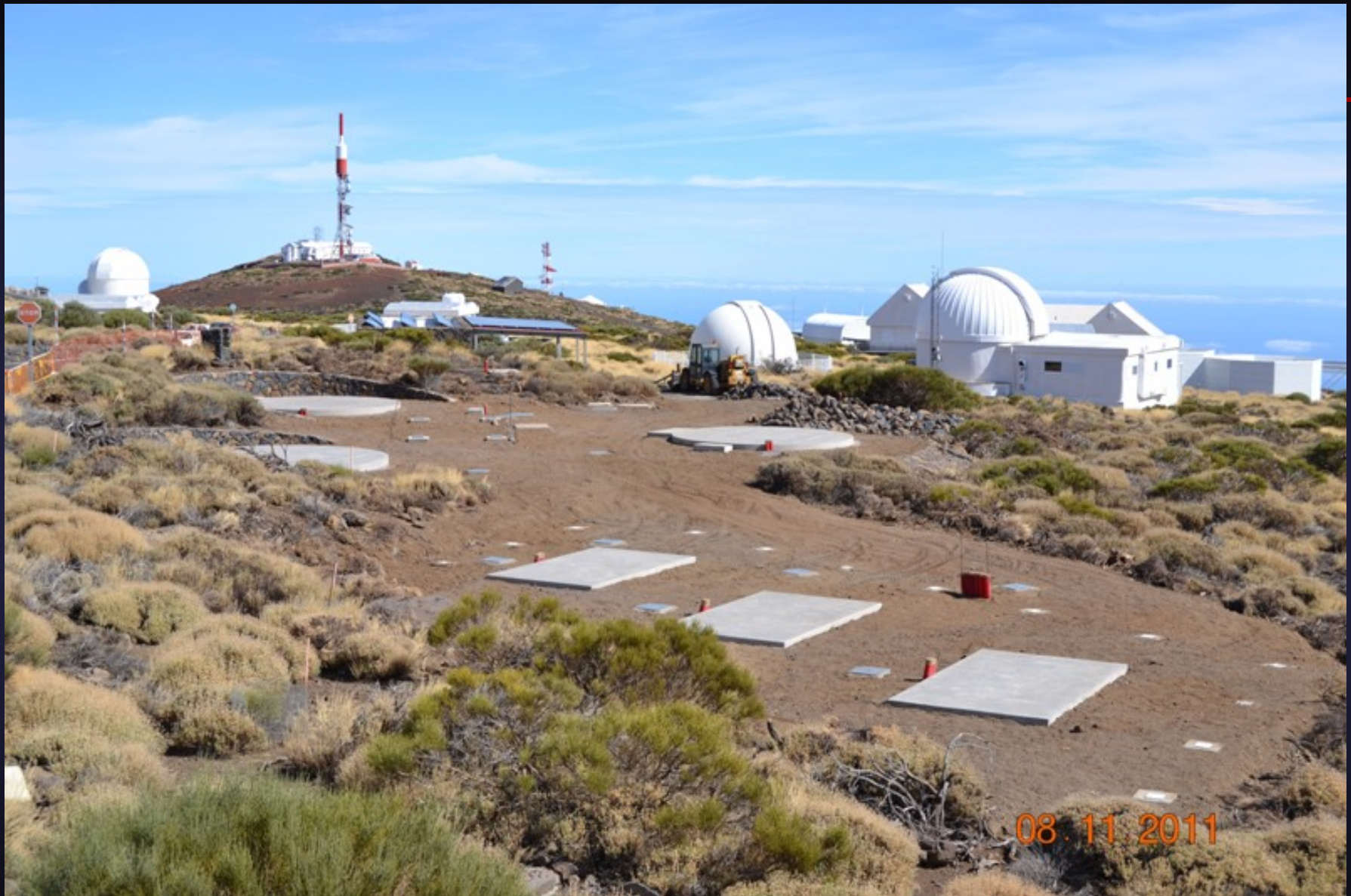
ORANGE BUCKETS







14/09/2012 12:40



08.11.2011

Andor Luca-R

on 0.4m telescopes

fov: $4.3^{\circ} \times 4.3^{\circ}$

max spacial resolution: $0.26''$

max cadence: 12.6hz full frame

66hz $30'' \times 30''$, 2x2 binning

limit (SNR=1) @15hz: mag **13**

LI: high resolution imaging planets

(for education),

spacially resolve bright stars

(e.g. for transiting systems)

HSP: occultation of bright stars



Andor iXon+ DU888

on 1.0m and 2.0m telescopes

fov: $2.9^{\circ} \times 2.9^{\circ}$ (1m) / $2.2^{\circ} \times 2.2^{\circ}$ (2m)

max spacial resolution: $0.18''$ (1m) / $0.13''$ (2m)

max cadence: 30hz $30'' \times 30''$, 2x2 binning

10hz full frame

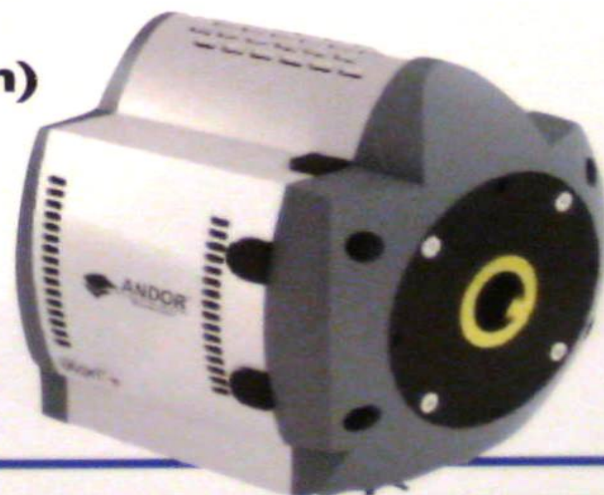
limit (SNR=1) @15hz: mag **19 (1m) / 22 (2m)**

LI: spacially resolve bright stars,

resolving extended sources (comets, light echoes)

microlensing: caustic resolution and deblending

HSP: occultations and compact binary eclipses



LUCKY IMAGING

increasing the spacial resolution

Lucky Imaging (LI) increases the spacial resolution of astronomical targets. In a sequence of high cadence ($>10\text{Hz}$) exposures we select the fraction (typically 1%) where the alignment of the atmospheric layers generated the sharpest images, closest to a diffraction limited image.

The selected images are aligned and stacked to obtain a "lucky" exposure (Law+ 2006 A&A 446,739).

LI tests have achieved resolutions of $\sim 0.6''$ at FTN (2m, Haleakala, HW).

LI allows blended targets to be resolved, which is particularly important to accurately characterize eclipsing and transiting systems

(e.g.: follow up of Kepler or Corot targets).

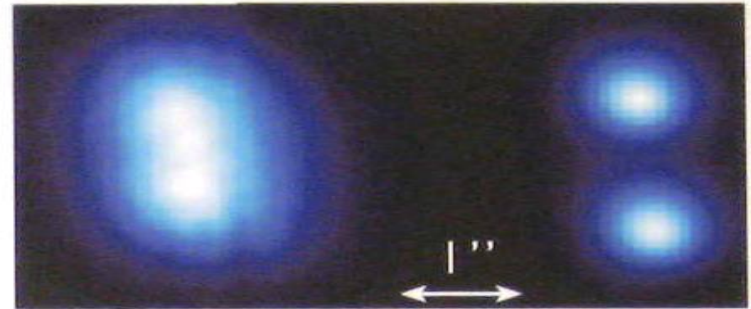
microlensing

LI will be used by the LCOGT ROBONET microlensing survey to resolve blends in the crowded bulge fields and characterize not only the target but its neighbors as well.

Once these instruments are fully commissioned, we will also use them for very high-cadence (up to $\sim 10\text{Hz}$) photometry during key times in the event lightcurves when they are changing most rapidly, e.g. during caustic crossings.

extended sources: comets and light echoes

Details of the structure of extended sources, such as nebulae, light echoes or comets, can be revealed by LI, or, wherever the surface brightness is low and the low duty cycle of LI prohibitive, by weighted tip-tilt stacking, where all images in a high cadence sequence are aligned and stacked with weights corresponding to their sharpness.



top: a close binary system

is deblended with LI.

(j2233-0936, R \sim 8, SDSS-r)

left: conventional image, 5 sec

right: LI, 5 sec stack, 10hz, 1% selection

bottom: comet 103P Hartley

near closest approach,

observed from FTN,

a Laplacian filter (edge detector)

has been applied to reveal structures in coma

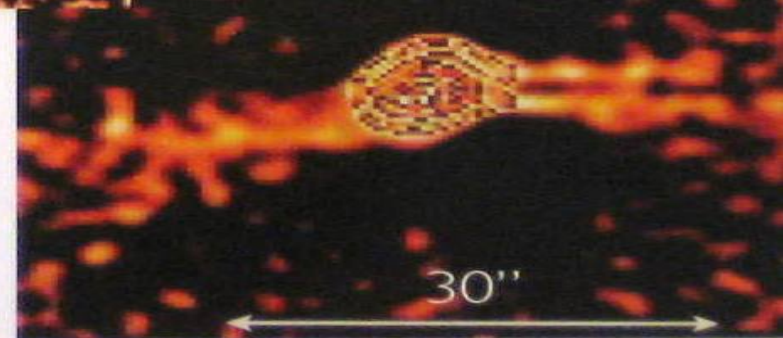
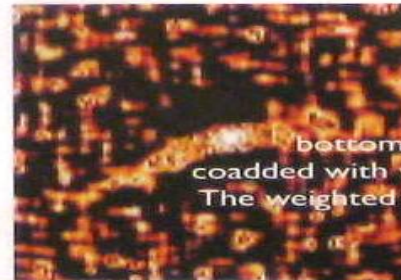
left: conventional image,

bottom: weighted stack (18000 sec) 10hz images

coadded with weights corresponding to their sharpness

The weighted stack reveals a split in the comet jets not

observed in conventional imaging



Snodgrass+, in preparation

HIGH SPEED PHOTOMETRY

occultations

FTN, one of our 2.0m telescopes, observed the predicted occultation of a magnitude $V=13.75$ star by KBO 55636 (2002 TX₃₀₀) on October 9 2009. The occultation was predicted by the MIT Planetary Astronomy Lab, lead by Prof. Elliot. The event was observed with an Andor Luca R camera, no filter, at 16 Hz cadence.

The FTN High Speed Photometry (HSP) data were paramount in the determination of the size of KBO 55636.

A null result from FTN for the Varuna, 02/2011 occultation is presented in poster 224.11 (Pasycoff+, tuesday May 24, 8:00 AM - 7:00 PM)

Occultations of large KBOs ($D>300\text{m}$) are now predictable to $\sim 20\text{-}100$ mas.

Working with occultation groups, predicted occultations observed from multiple sites provide:

- TNO sizes independent of albedo
- stellar atmosphere
- stellar angular sizes only with subsecond cadence
- limb darkening only with subsecond cadence
- detecting binary KBOs or binary background stars
- improved KBO orbits

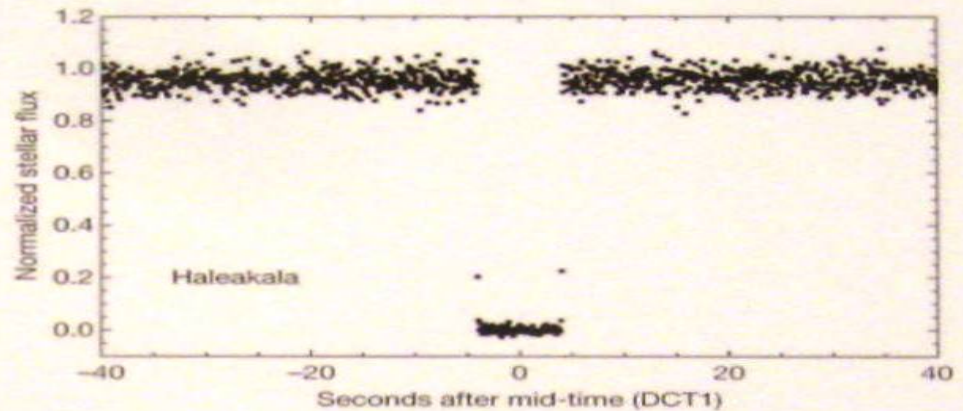
The full LCOGT network will enable multiple observation of an occultation from identical systems.

Observations of the June multiple eclipse of the Pluto system are planned in concert with the SWRI occultation group from FTN (Haleakala, HI, USA) and FTS (Siding Spring, BC, Australia).

compact systems eclipses and transits

EMCCDs (electron multiplying charge couple devices) can achieve high precision, high cadence astronomical observations (Harpsoe+ 2011 A&A, submitted).

All-sky surveys such as PTF are discovering compact binary systems with eclipse durations of minutes (e.g. WD-WD binaries, Steinhardt+ 2010). Fast photometry (few seconds to few hertz) allows the characterization of the ingress and egress in such rapidly rotating systems.



Elliot+., *Nature* 465, 897–900 (June 2010)

2-meter telescope:

F/10 Ritchey-Chretien, Alt-Az

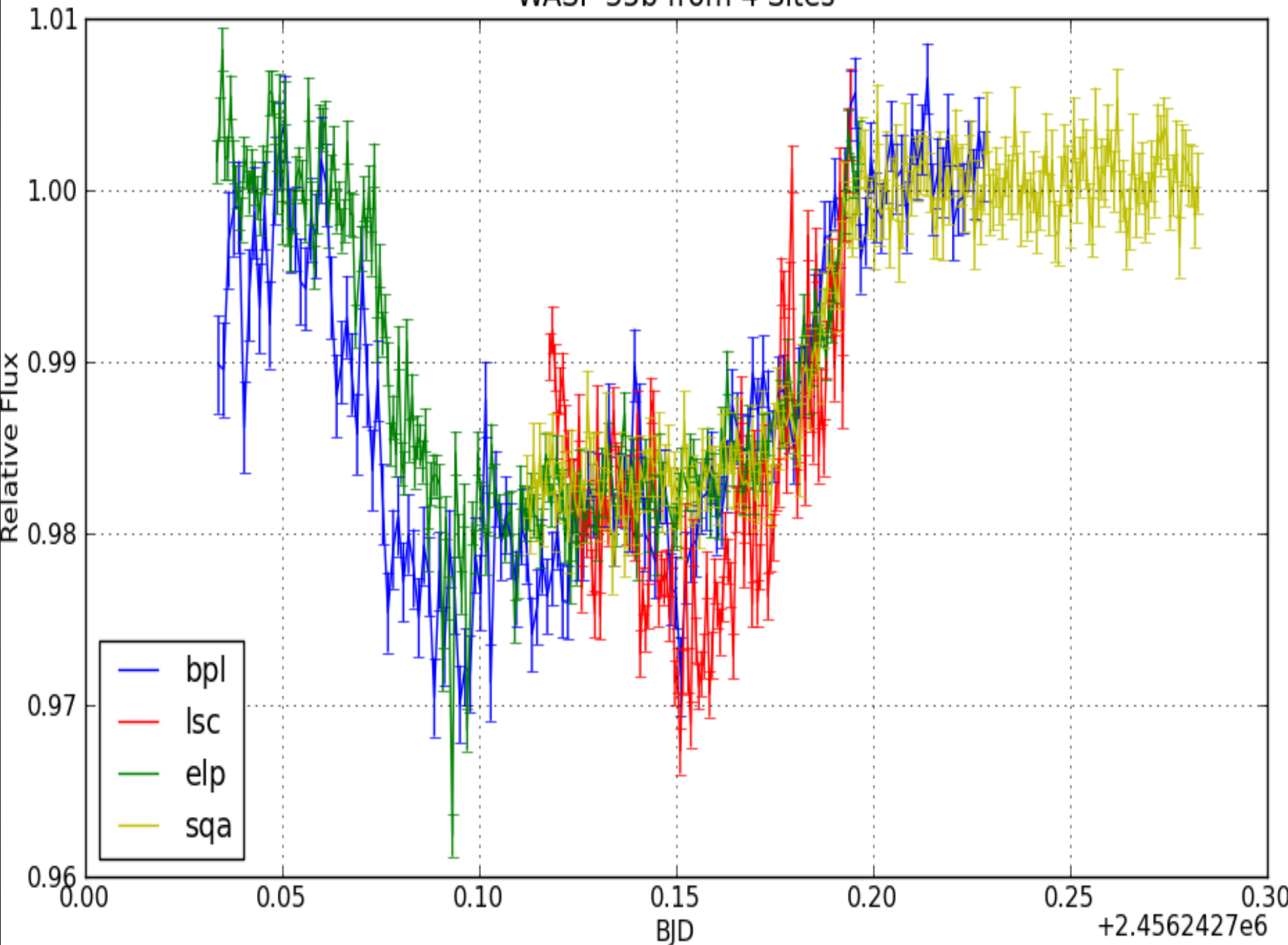
- *Corrected focal plane: 250mm*

Instrumentation:

- *Andor Luca "R" EMCCD, 1kx1kx8, 13 fps, 3.5 arcmin FoV, 0.2 arcsec/pixel.*
- *Andor iXon EMCCD 1kx1kx13, 9 to 4200 fps, 2.3 arcmin FoV, 0.13 arcsec/pixel.*
- *Filter sets: Bessel, Sloan, PanStarrs.*



WASP-35b from 4 Sites



Imagery...



Thank You!





