The Cal Poly 18

Approaching Operational Status

Portland VI Workshop

July 27, 2012

Richard Berry

Cal Poly 18: Capsule Description

- Economical research-grade telescope
  - 0.47-meter aperture, *f*/4.1 Newtonian
- Alt-azimuth configuration
  - Compact, symmetrical, inexpensive
  - Ever-changing drive rate in three axes
- Computer-controlled motors
  - Alt-az direct-drive: no gears, rapid response
  - Feedback from high-resolution encoders

Cal Poly 18: Timeline

- 2007: Portland I Conference.
  - Dave Rowe direct drive motor prototype.
  - Dan Gray demos “Lollipop” alt-az telescope.
- 2008: Cal Poly student assignment.
  - Design/construct fork and tube.
  - Debut at STAR Conf., San Luis Obispo.
- 2009: Cal Poly 18 moves to TMS.
- 2011: Press begins to make operational.
- 2012: Regular “engineering” operations begin.

The PDX I Meeting

Genet, Banich, Berry, Bartels, Gray, and “Lollipop”

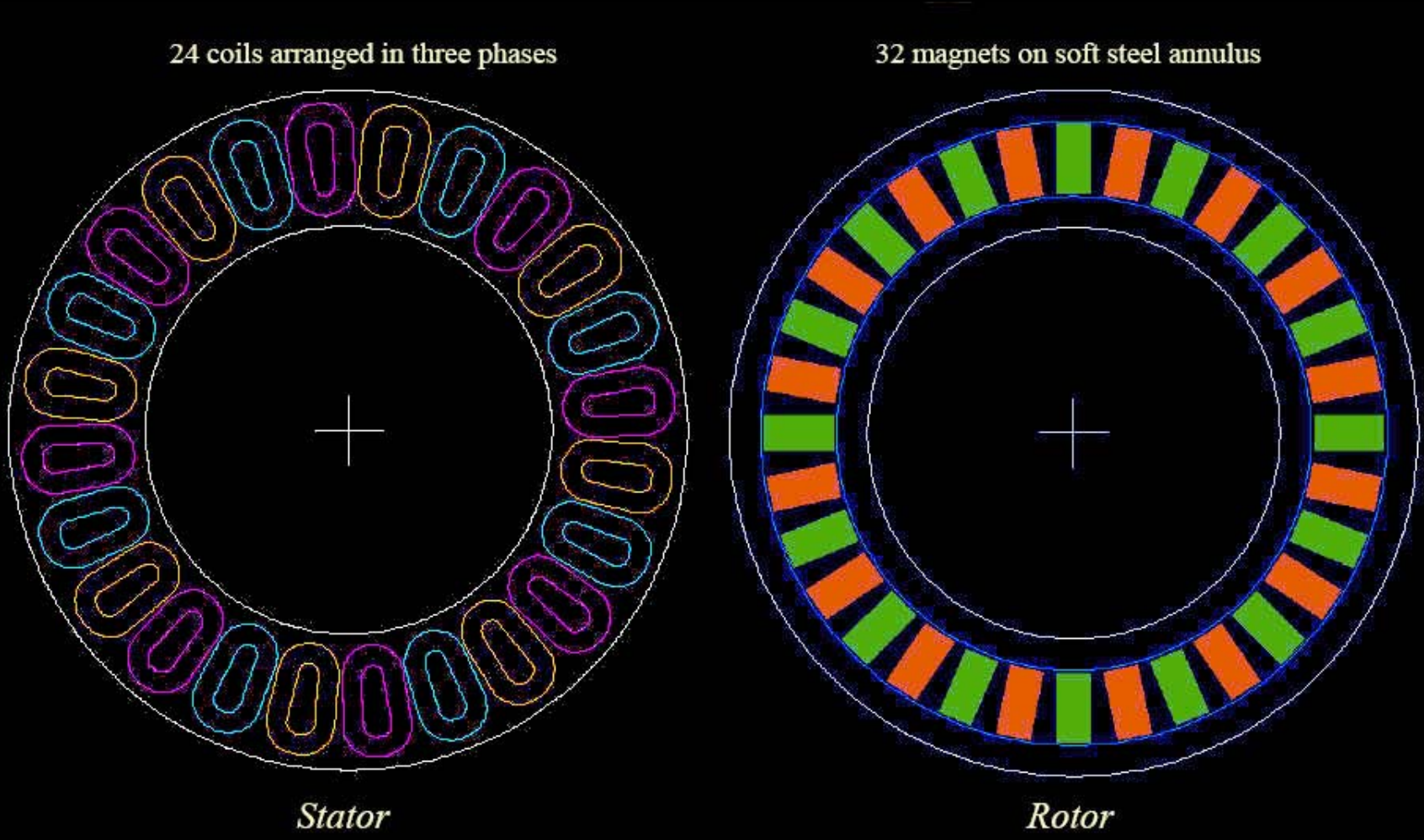
Prototype Direct-Drive Motor

The plywood prototype direct-drive motor

What Convinced Me…

5,000 Images of XX Cygni in four nights!

Direct-Drive Configuration

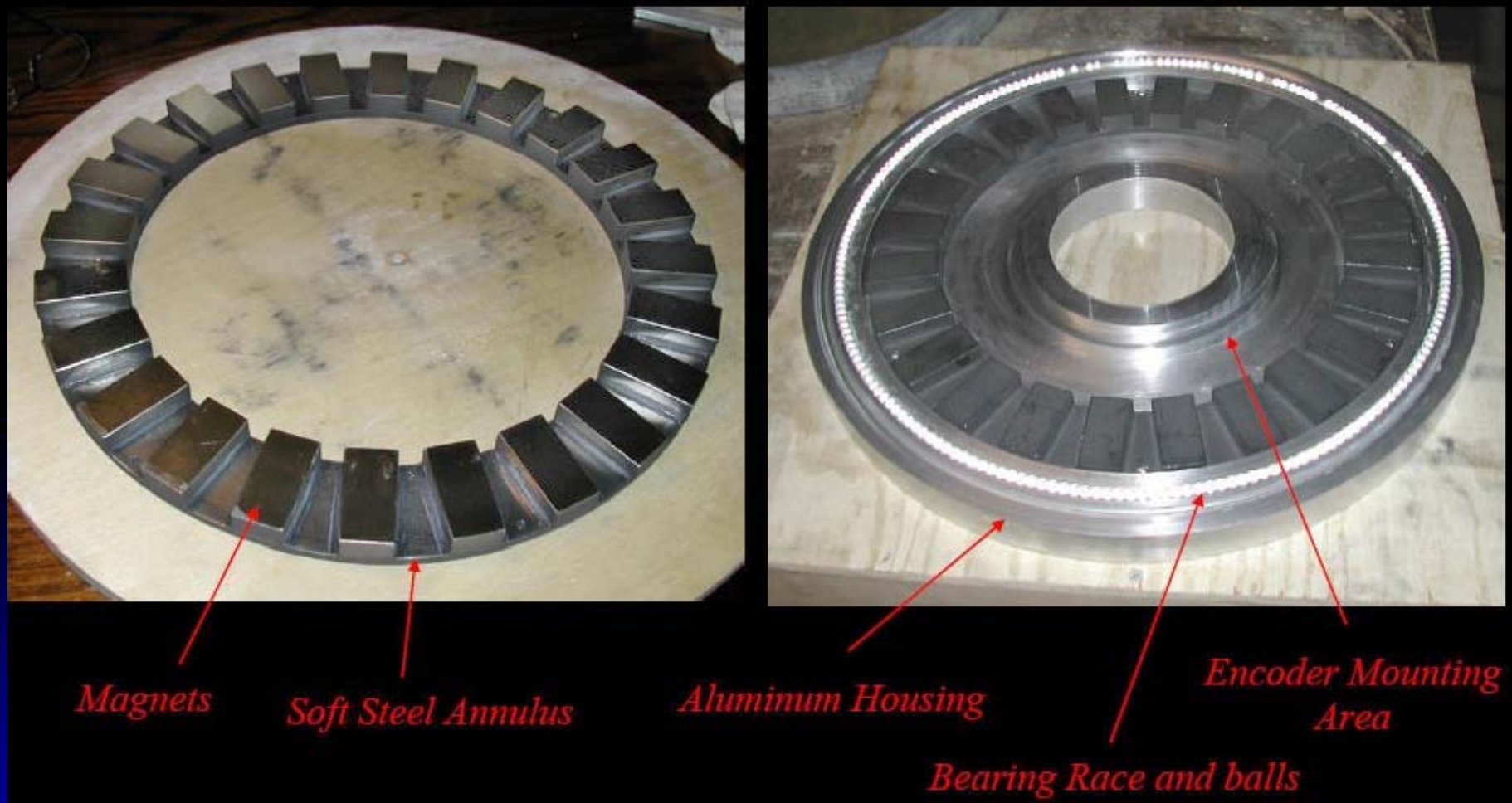


Credit: Dave Rowe

24 Handmade Coils

Credit: Dave Rowe

32 Rare-Earth Magnets

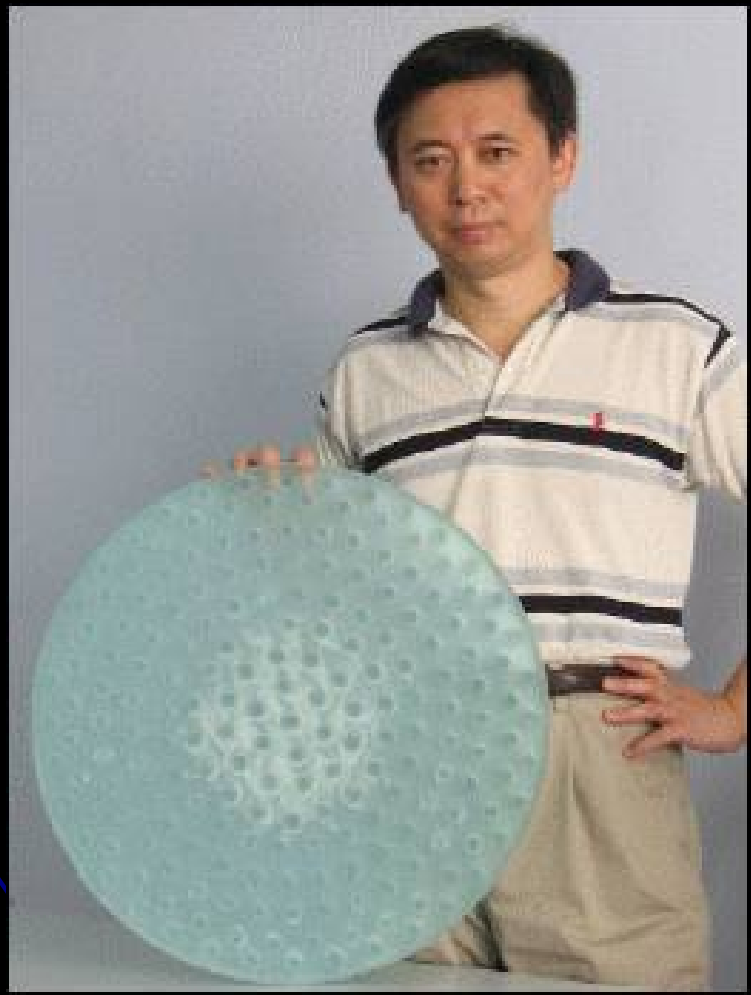


Credit: Dave Rowe

The Cal-Poly Design Team

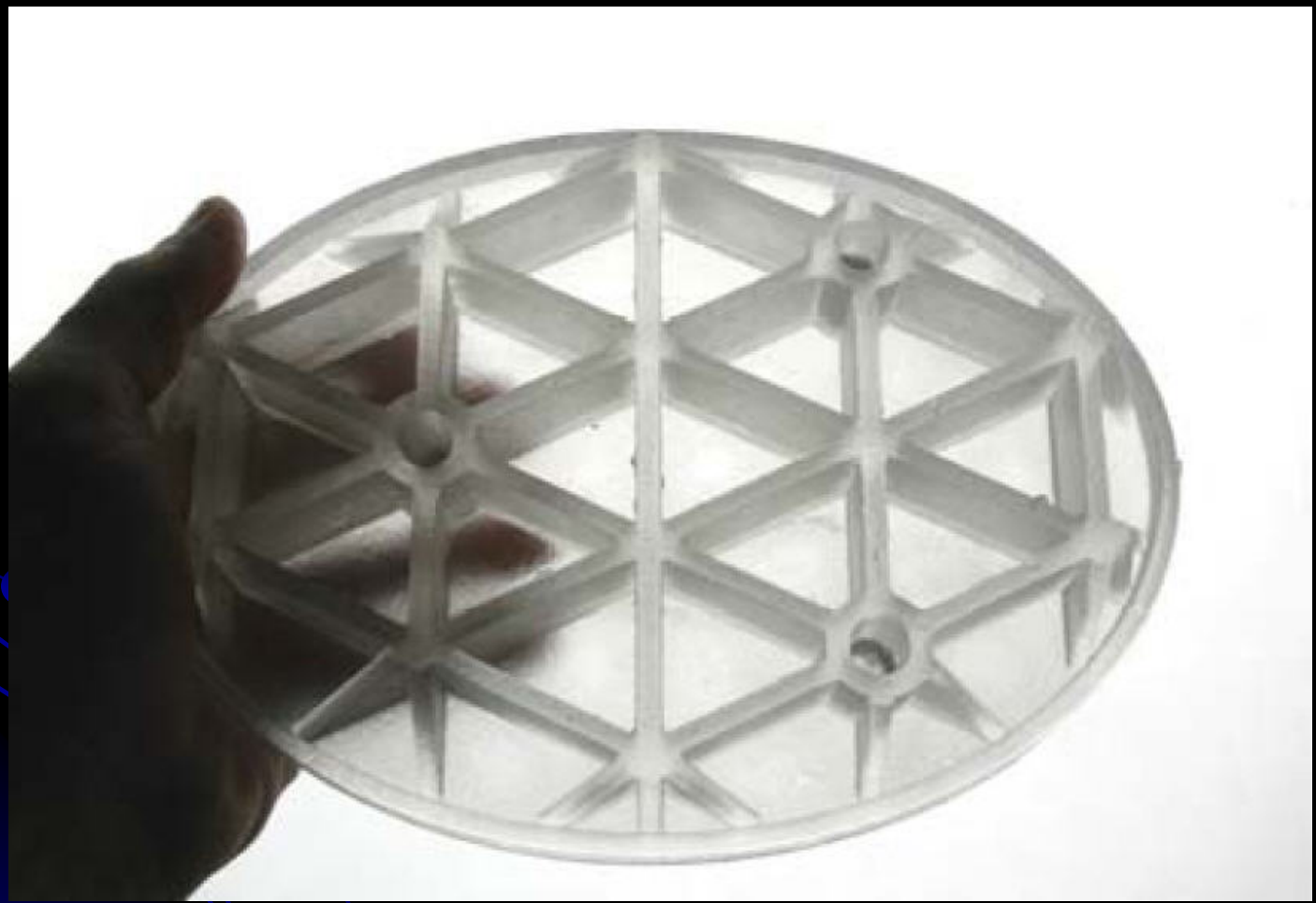
Matt Swanson, Josh Schmitt, Michelle Kirkup, and absent Wilson Chiu and John Ridgely, advisor, Dept. of Mechanical Engineering

Fused Sandwich Mirror



Tong Liu, Hubble Optics

Fused Borosilicate Secondary



2009 Status: Functioning Prototype

- Moved to TMS in Portland, OR.
- Azimuth base fabricated.
  - Six steel channel legs with adjustable feet.
- Altitude bearing/motor installed.
  - Axes not perpendicular, shimmed and epoxied.
- Mirror cell and secondary assembly completed.
- Slews/tracks under computer control both axes.
  - Slew rates to 30º/second; tracks at sidereal rate.
  - “Functional” as a telescope but untested.

2011 Status: Still a Prototype

- Minimum needed for science data collection:
  - Add limit/home switches.
  - Complete firmware/software.
  - Boards, wiring, Ethernet extender.
  - Replace unstable spider/upper end.
  - Optics: baffle, blacken, focus.
  - Design/build camera focuser/rotator.
  - Dedicated control computer.
  - CCD camera and filter wheel.
  - Site/shelter for dark-sky testing.
- Iterate until working:
  - Operate, evaluate, correct, repeat.

2012: Still Debugging

- Adequate for science data collection:
  - Has site/shelter suitable for dark-sky testing.
  - Powers up reliably.
  - Points reliably.
  - Pointing models work reliably.
  - Baffled against stray light.
- Identified and significant problems:
  - Poor quality star images (always ≥3.5 arcsec).
  - Software bug in camera rotation routines.
  - Unexpected focuser/rotator resets to zero.
  - Mirror may be moving in mirror cell.

April 2011

Testing in TMS Parking Lot

First Light

Cal Poly 18 First Light: TMS 2011-06-16

January 11, 2012: Everything Works!

Cal Poly 18 with temporary paper light shroud; cold, windy night

July 2012: Slewing Around

Video removed to reduce file size.

Settling After a Slew

- In the video, the Cal Poly “bounces”
  - Manual slew → no warning when to stop
  - Computer slew → decelerates to postion
- How fast does the Cal Poly settle?
  - Made video of star slewing into field
  - Star approaches, bounces once, settles
  - Settling time approximately 2 seconds

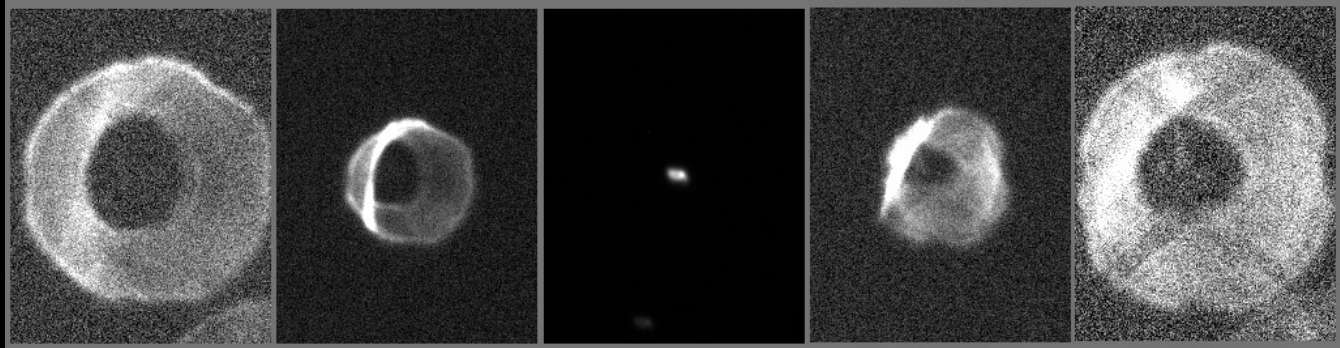
Settling After a Slew

Video removed to reduce file size.

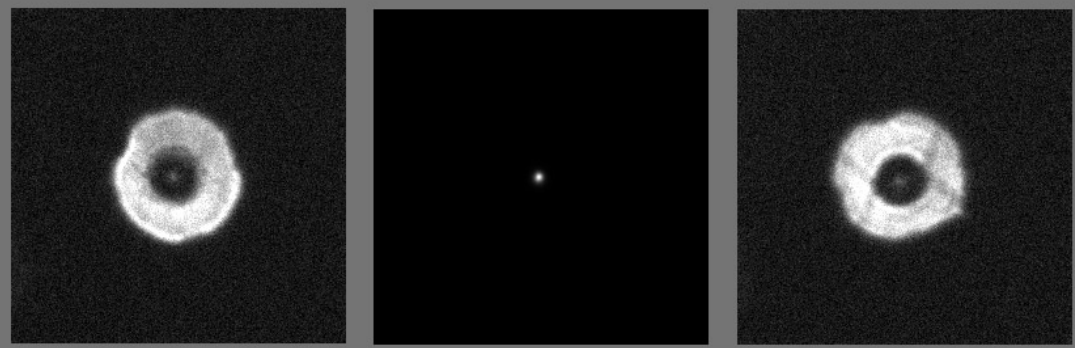
Mirror Image Problem

- Images never smaller than ~3.5 arcsec
  - With bad seeing, considerably larger
  - With bad tracking, considerably larger
  - With short exposures, always ≥3.5 arcsec
- Image quality worse when cooling
  - Afternoon ~22 C, midnight ~7 C
  - In-focus images show strong asymmetry
  - Mirror appears warped or deformed

Mirror Image Problem

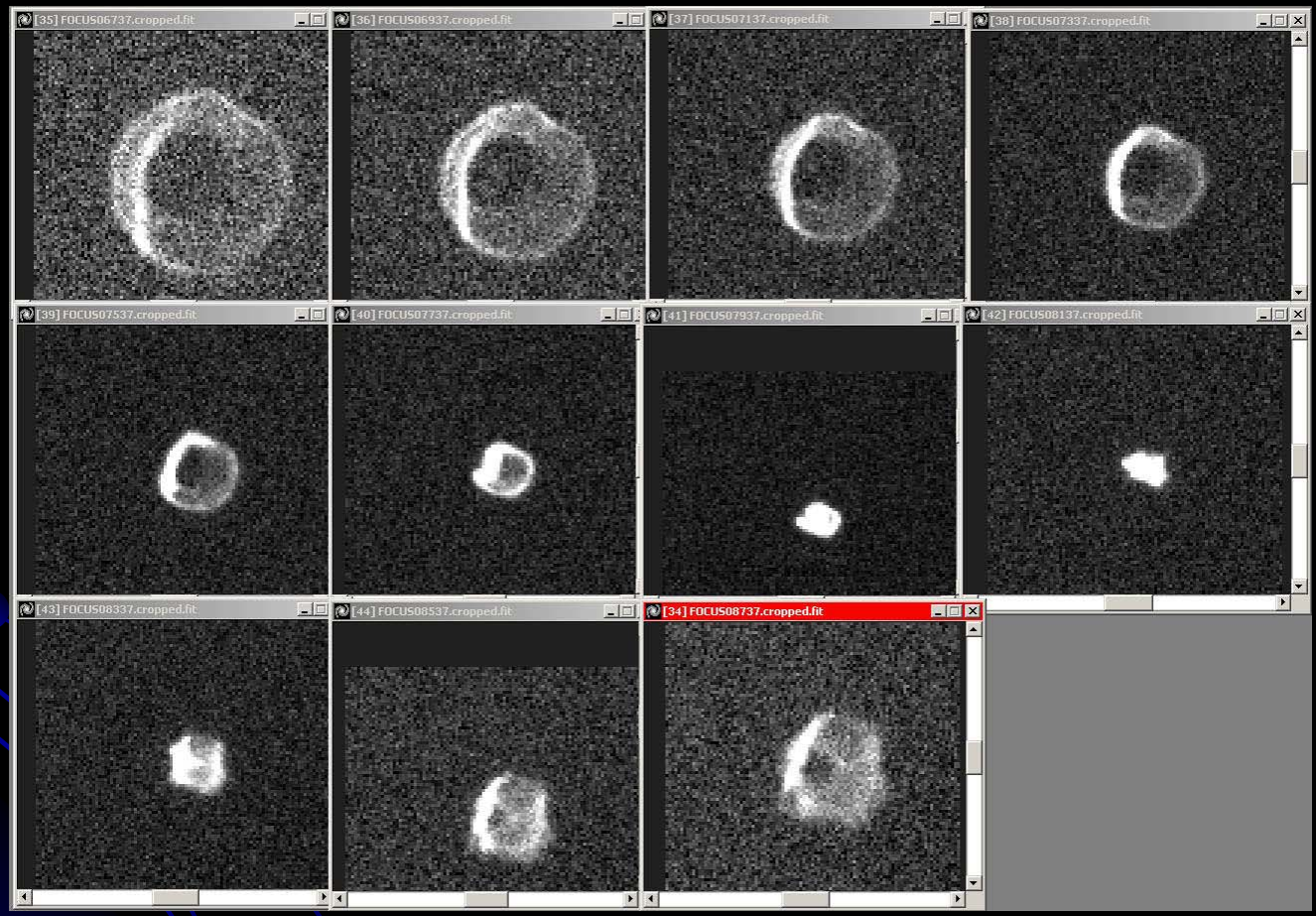


Through-Focus Star Images, Early Evening



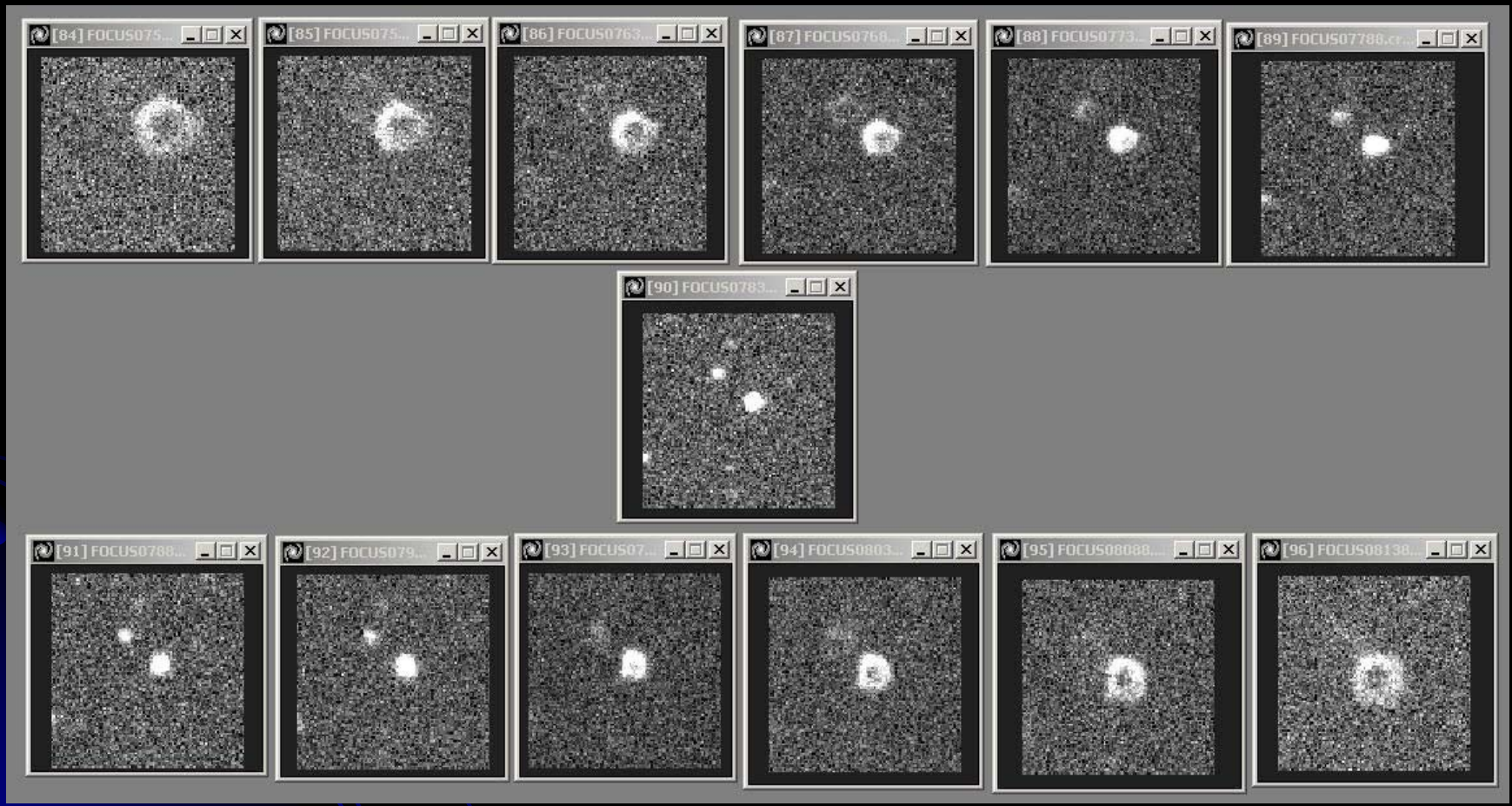
Through-Focus Star Images, 1:30 a.m.

Mirror Image Problem



Through-Focus Images as Mirror is Cooling

Mirror Image Problem



Through-Focus Images with Cooled Mirror

Testing the Primary Mirror

- Prime Focus in the Telescope
  - Standard configuration
  - Includes secondary aberrations
  - Minimal access to the mirror cell
- Foucault Test
  - Too much aberration to visualize deformation
- Optical Bench at Prime Focus
  - Artificial star at 120 feet (but spherical aberration)
  - Video camera at focus point
  - Long path at ground level
  - Easy access to mirror cell and mirror adjustments

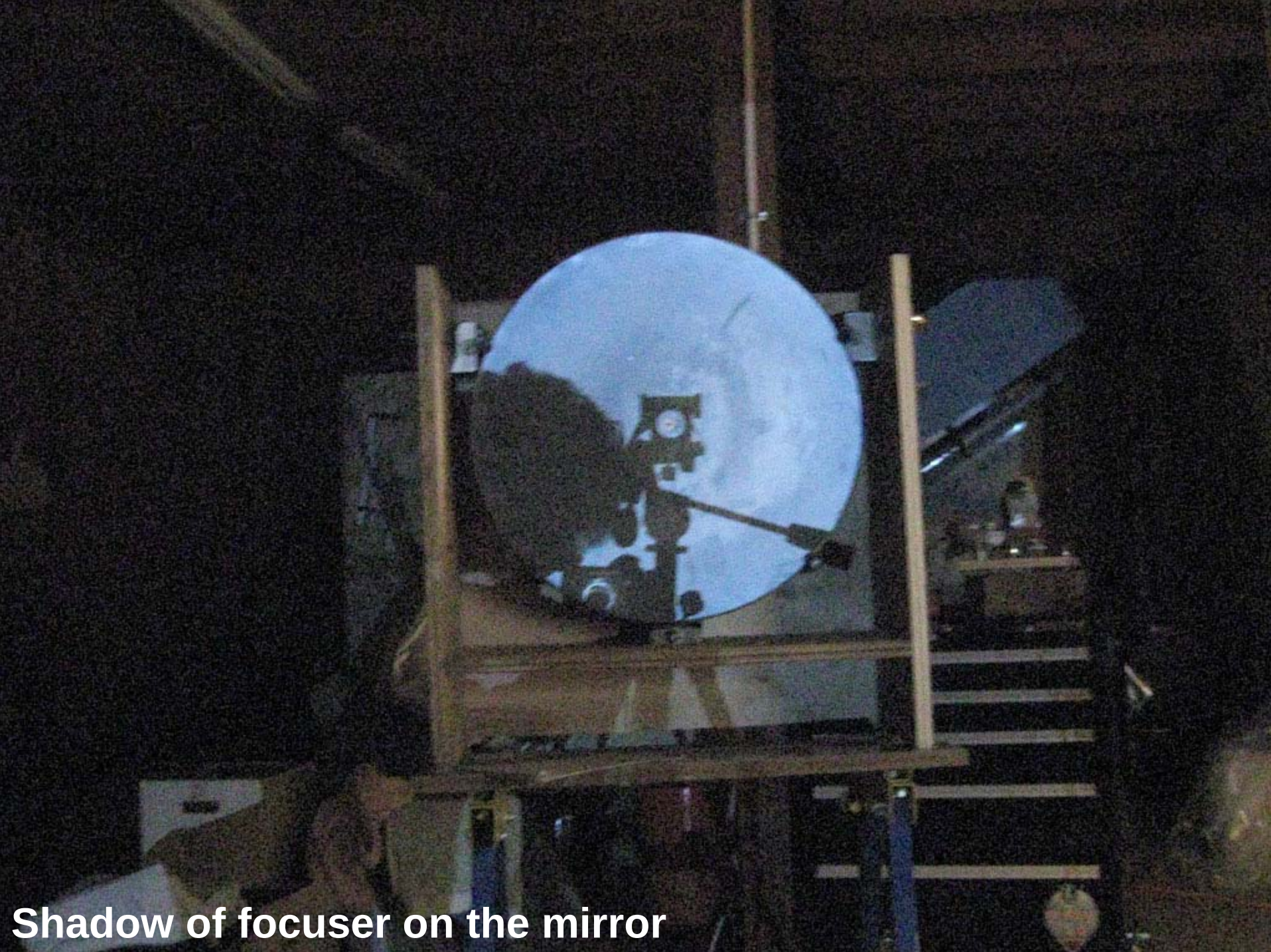
Star Image Video

Video removed to reduce file size.

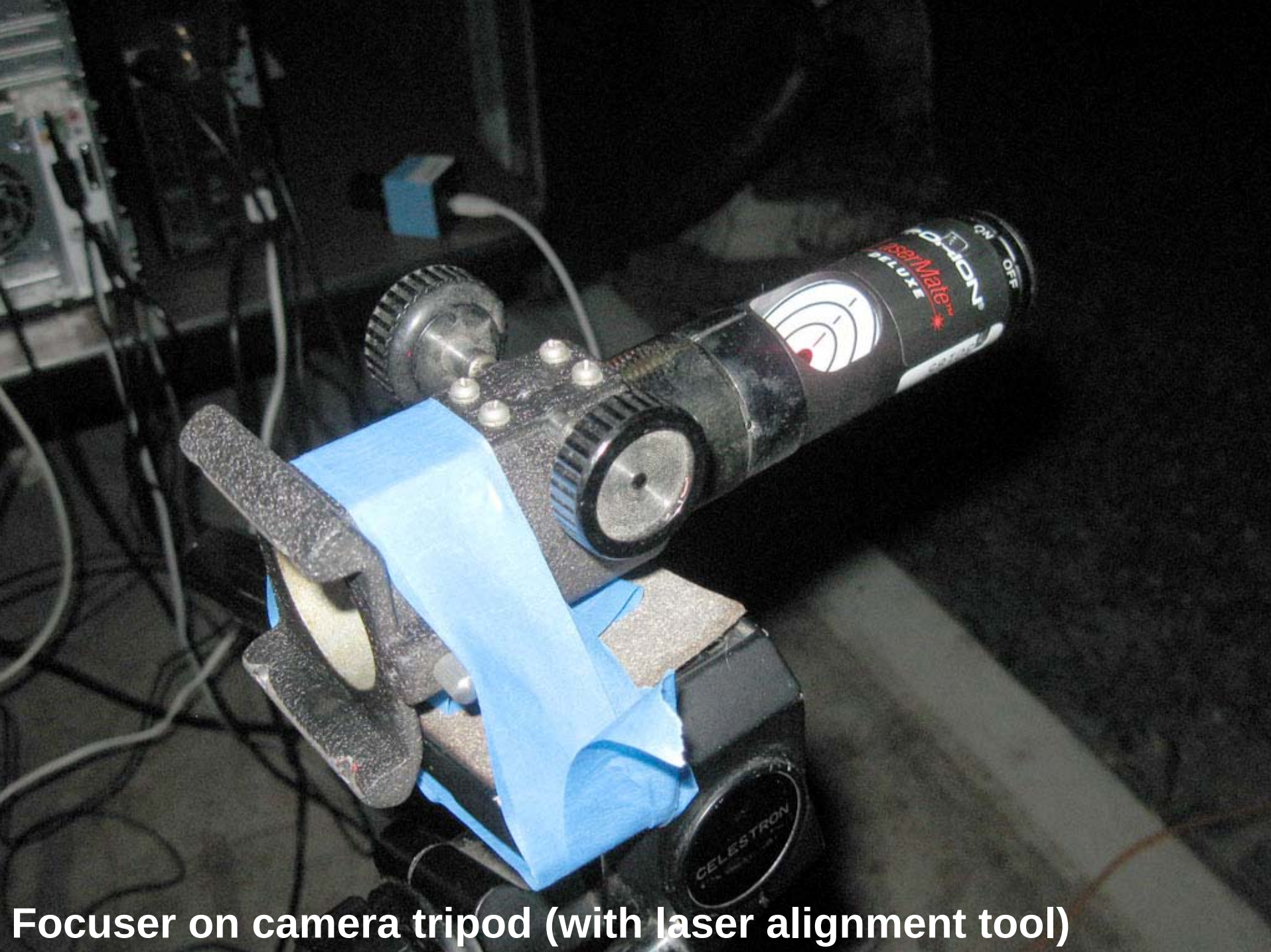
Cal Poly 18 Mirror Handling Fixture

Artificial Star

Artificial Star (very bright!)

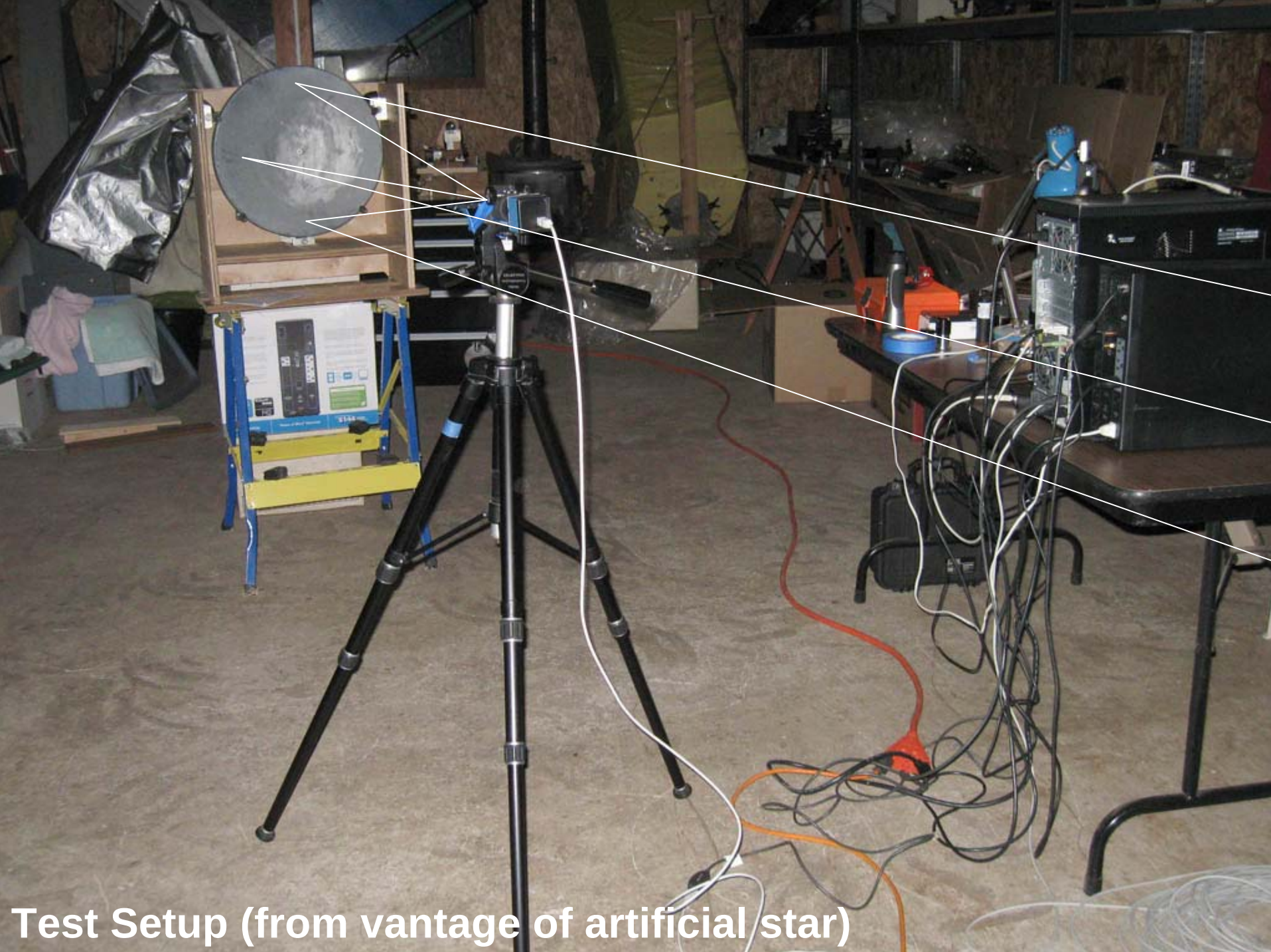


Shadow of focuser on the mirror



Focuser on camera tripod (with laser alignment tool)

Laser Beam aligned on the Mirror Spot



Test Setup (from vantage of artificial star)

Test Setup (flash photo)

Test Setup (ambient lighting)

Testing the Primary Mirror

Video removed to reduce file size.

Testing the Primary Mirror

- Fairly quick/easy to align optics
- No obvious asymmetric deformation
- Observer air currents cause problems
- Need to quantify scale and focus shift
- Still a “work-in-progress”
- Important: Primary may be okay….
- Important: So, test the secondary!

Cal Poly 18: Status

- Became “operational” December 2011.
- Able to operate “routinely” by April 2012.
- Attained performance level:
  - All-sky models to ≤10 arcsec r.m.s.
  - Acquires desired field/object reliably.
  - Tracks to ~0.5 arcsec for 15 minutes.
  - Resists reasonably large wind forces.
  - Focuser/rotator corrects field rotation.
- Much performance testing remains.

Thanks to…

- Russ Genet
- Dave Rowe
- Dan Gray
- Howard Banich
- John Ridgely
- John Keller
- Tong Lui
- Cary Chelborad
- Allan Keller
- Mel Bartels
- Greg Rohde
- Ed Harvey
- Billy Alberson
- Wilson Chiu
- Michelle Kirkup
- Drew Murphy
- Josh Schmitt
- Matt Swanson
- Rob Urban
- and many others.

Cal Poly Bulletins…

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