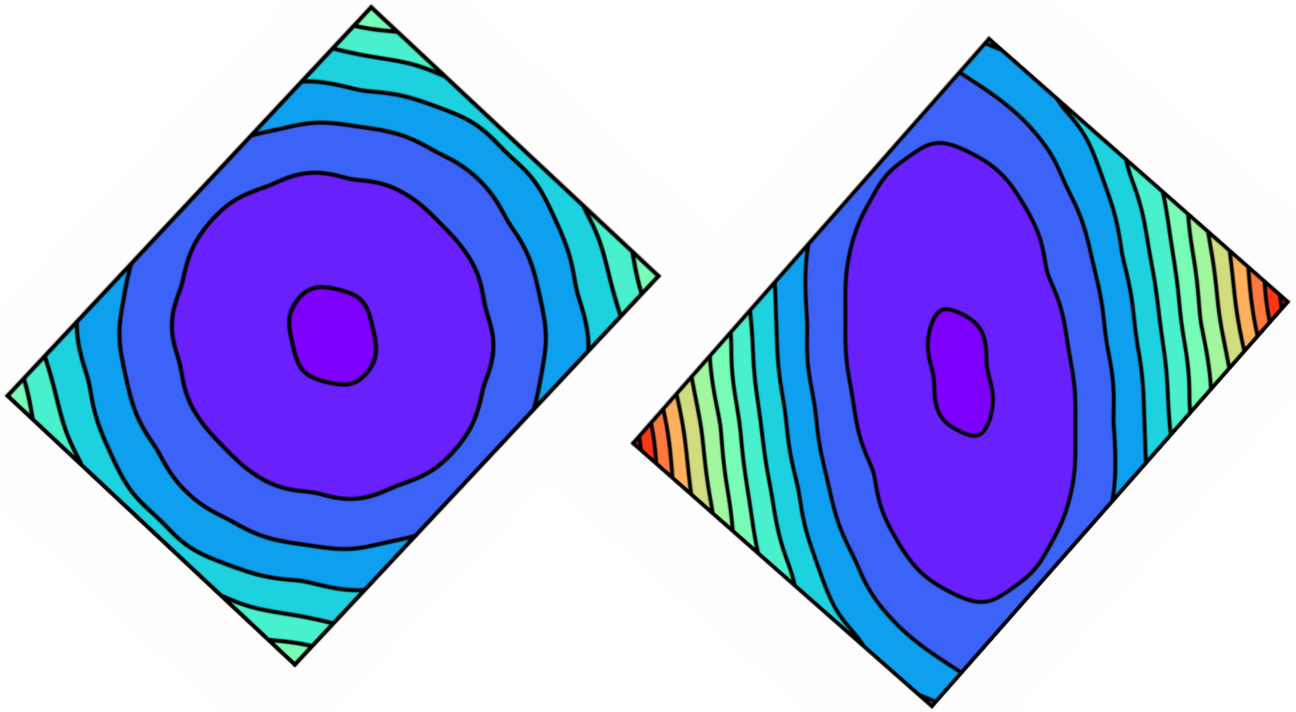
Actively Focused Lightweight Heliostats

Presentation for HelioCon 2023

Andrew Vagher, Roger Angel, Nick Didato, Matt Rademacher

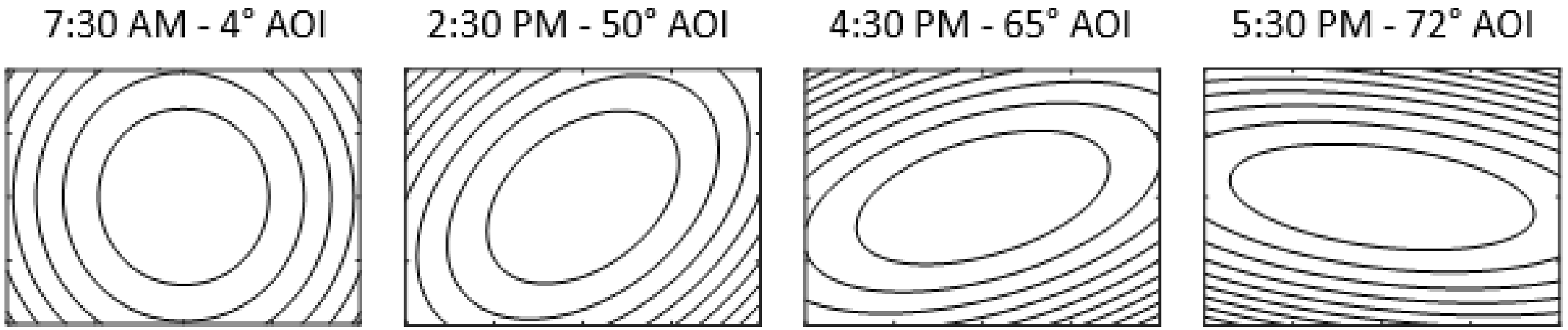
University of Arizona
Department of Astronomy and Wyant College of Optical Sciences



Normal incidence 60° incidence

To get the highest concentration, each heliostat in the field must focus the sunlight to a disc image

- Mirror shape must change from early morning to late afternoon, depending on angle of incidence (AOI)



- Calculated for representative heliostat due W of receiver at 20° elevation, equinox, 33° lat.
- Elliptical contours, angle rotates through the day

2020 field test with a 1.6 m^2 hexagonal heliostat

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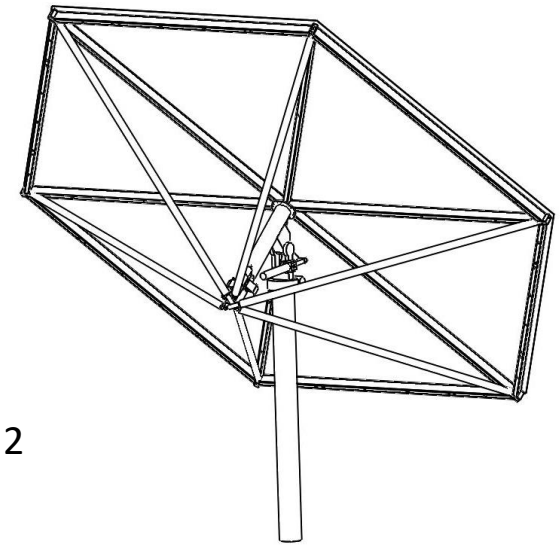
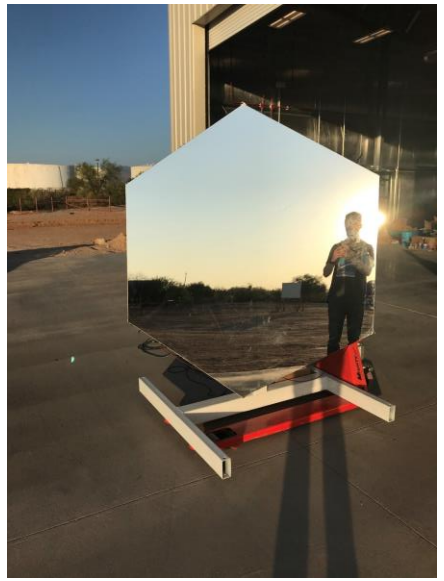
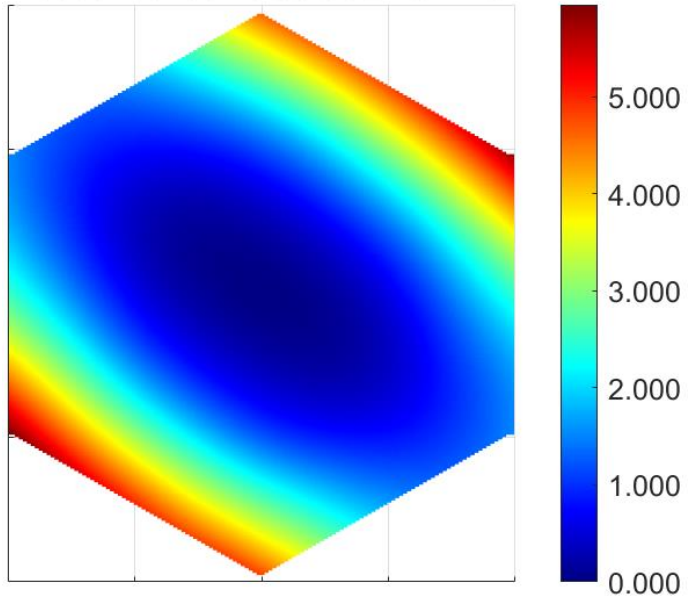
- One-piece mirror,
  - 3 mm thick glass
  - Area 1.58 m^2
- Alt-az mount
- 3 computer-controlled actuators to set shape



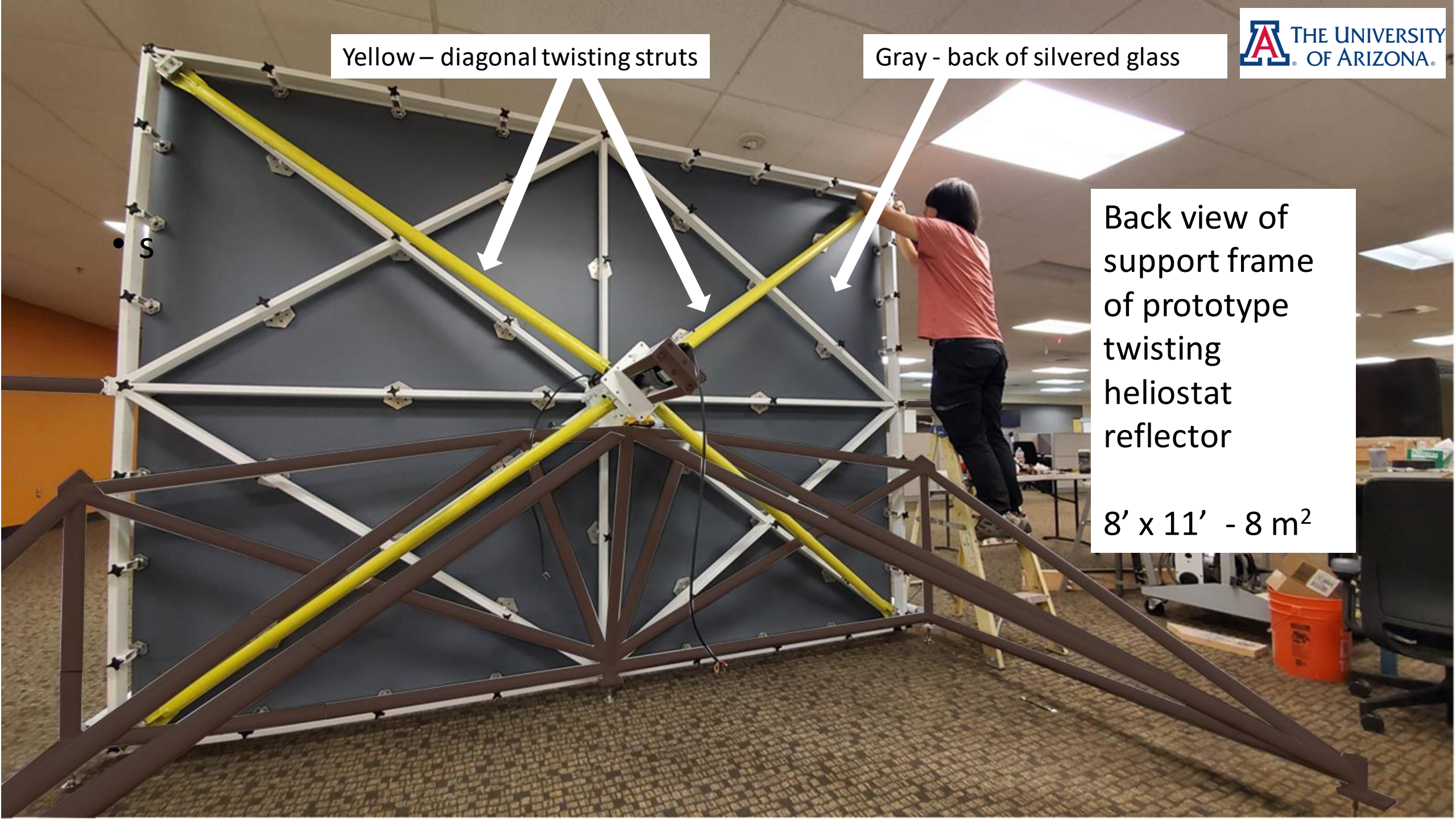




Solar disc image obtained at 2:30 pm, screen 40 m to the East, 62° AOI

2023 - now building new 8 m^2 twisting heliostat, funding from DOE SIPS and Heliocon

- Different elliptical contours generated by twisting a rectangular reflector surface
- Target–oriented dual axis mount
- Cross - axis sets the angle of incidence
- Cam drive from cross axis sets correct amount of twisting
  - no computer - controlled actuators
- Required 0.5 mrad precise tracking to be obtained by using
  - Commercial high resolution dual axis mount
  - Closed loop tracking camera


Yellow – diagonal twisting struts
Gray - back of silvered glass
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Back view of support frame of prototype twisting heliostat reflector
8’ x 11’ - 8 m2

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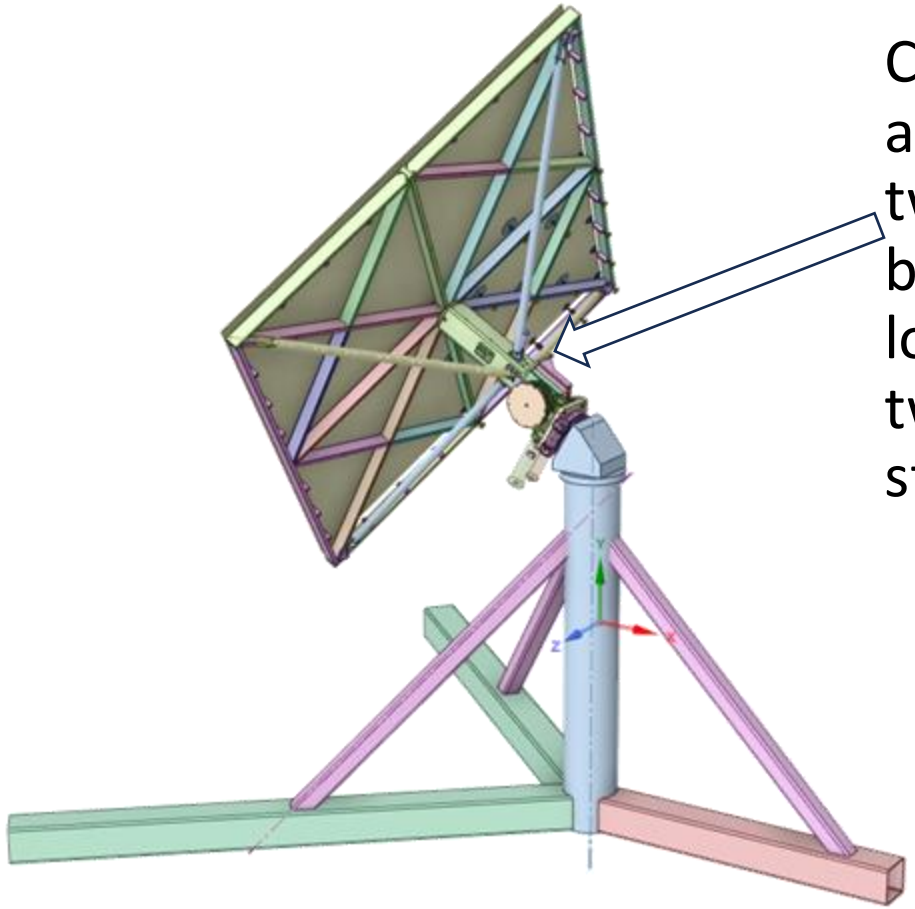
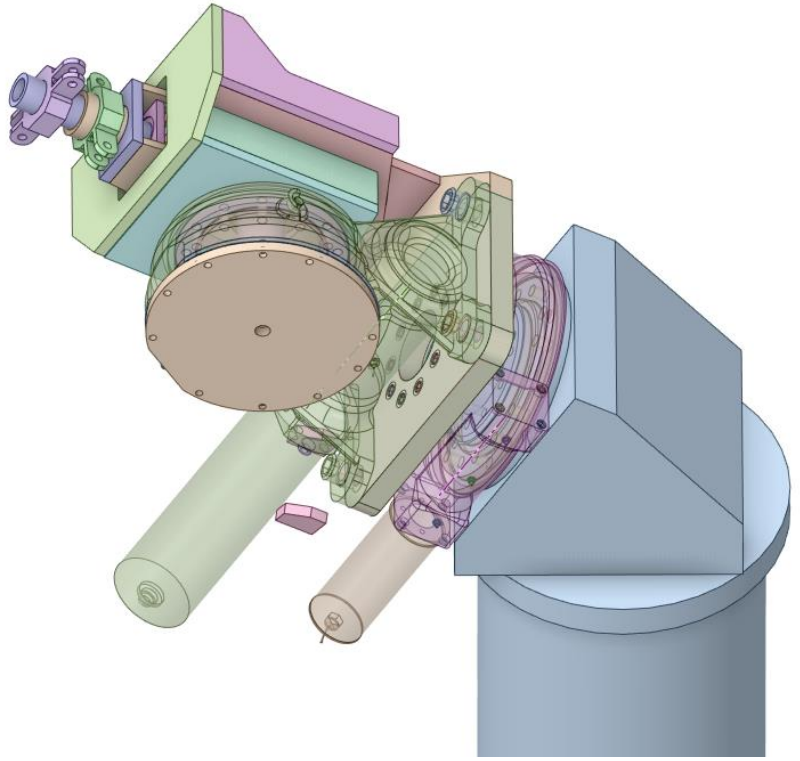
Target axis – cross axis drive



Cam on cross axis drive sets twisted shape by raising and lowering the two diagonal strut nodes



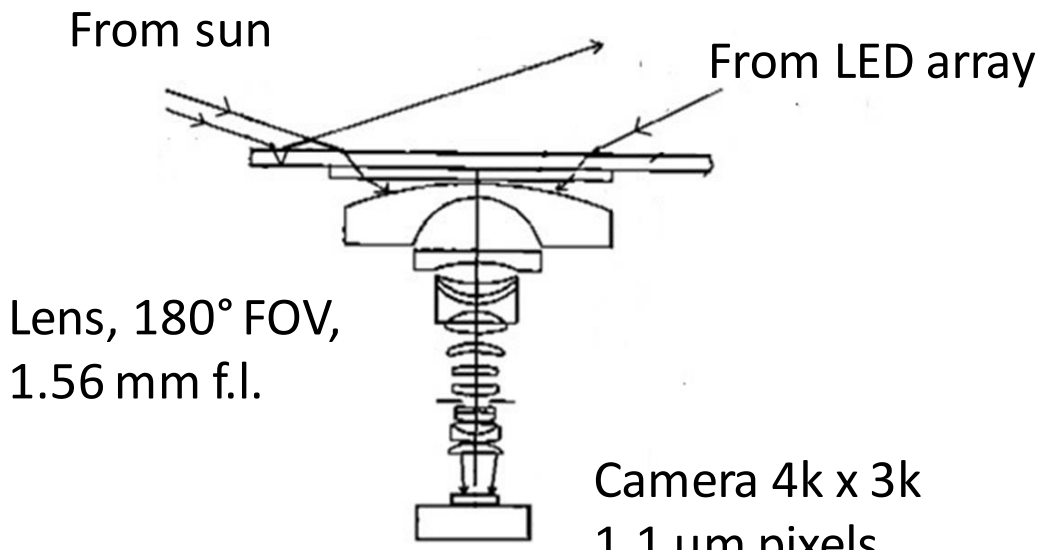
Portable prototype to be tested first at U Arizona, then at Sandia NSTTF (Randy Brost)

Commercial dual axis PE7 drive

Stiffness measured in lab

Closed loop tracking to be used to get accurate (0.5 mrad) orientation

- Fish-eye camera will view both sun and LED array source near the receiver in a single exposure

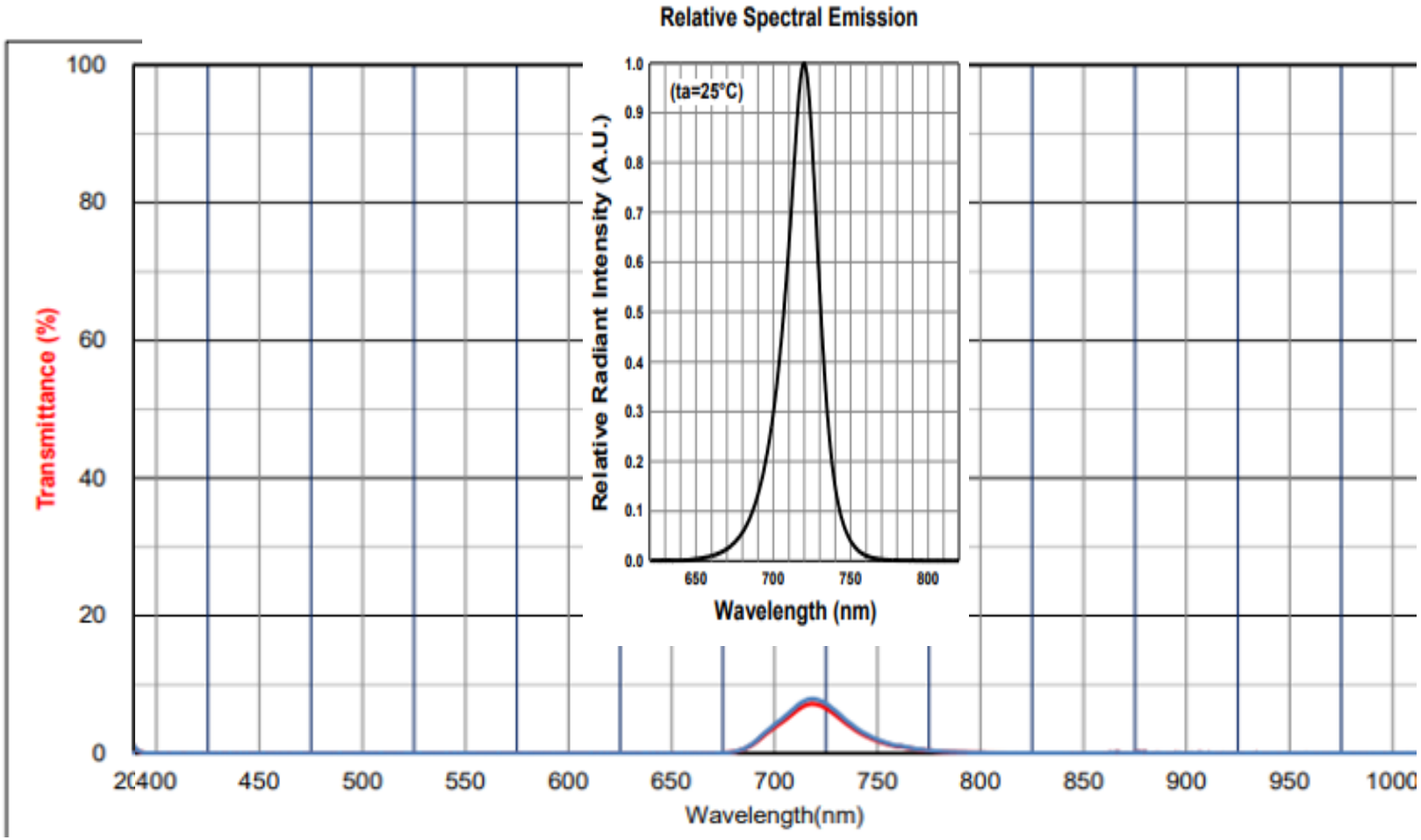


Fish-eye camera attached to center of twisting reflector

Silver removed over 3” hole for camera to look through

LED Source

- Will use an array of bright LEDs that emit at 720 nm
  - Hoya U340A glass filter has a passband over the same wavelength
  - Flashing the LED for 100 µsec at low duty cycle allows for higher brightness
  - Expect to see the LED and the sun together in a single exposure



Finite element analysis of wind load mispointing

Wind speed (mph)	Elevation (degrees)	Pointing error (mrad)
11	10	0.16
11	30	0.27
11	60	0.22
11	90	0.04
27	10	0.87
27	30	1.51
27	60	1.33
27	90	0.24

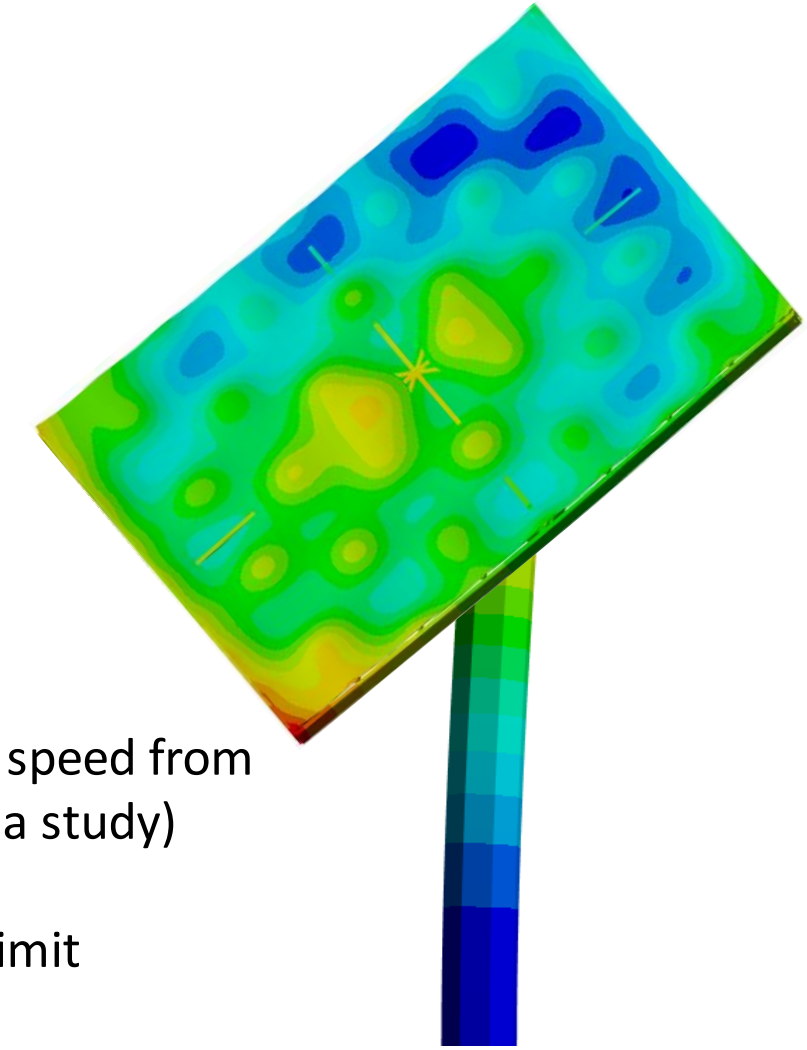
Includes measured stiffness of PE7 bearing

Lowest resonant frequency: 5.5 Hz

11 mph most common speed from Lee Ranch study (Sandia study)

27 mph – operational limit

Closed loop pointing control at 1 Hz will reduce the error
- to be studied



Deformation under 11 mph headwind