JIVE at the DST

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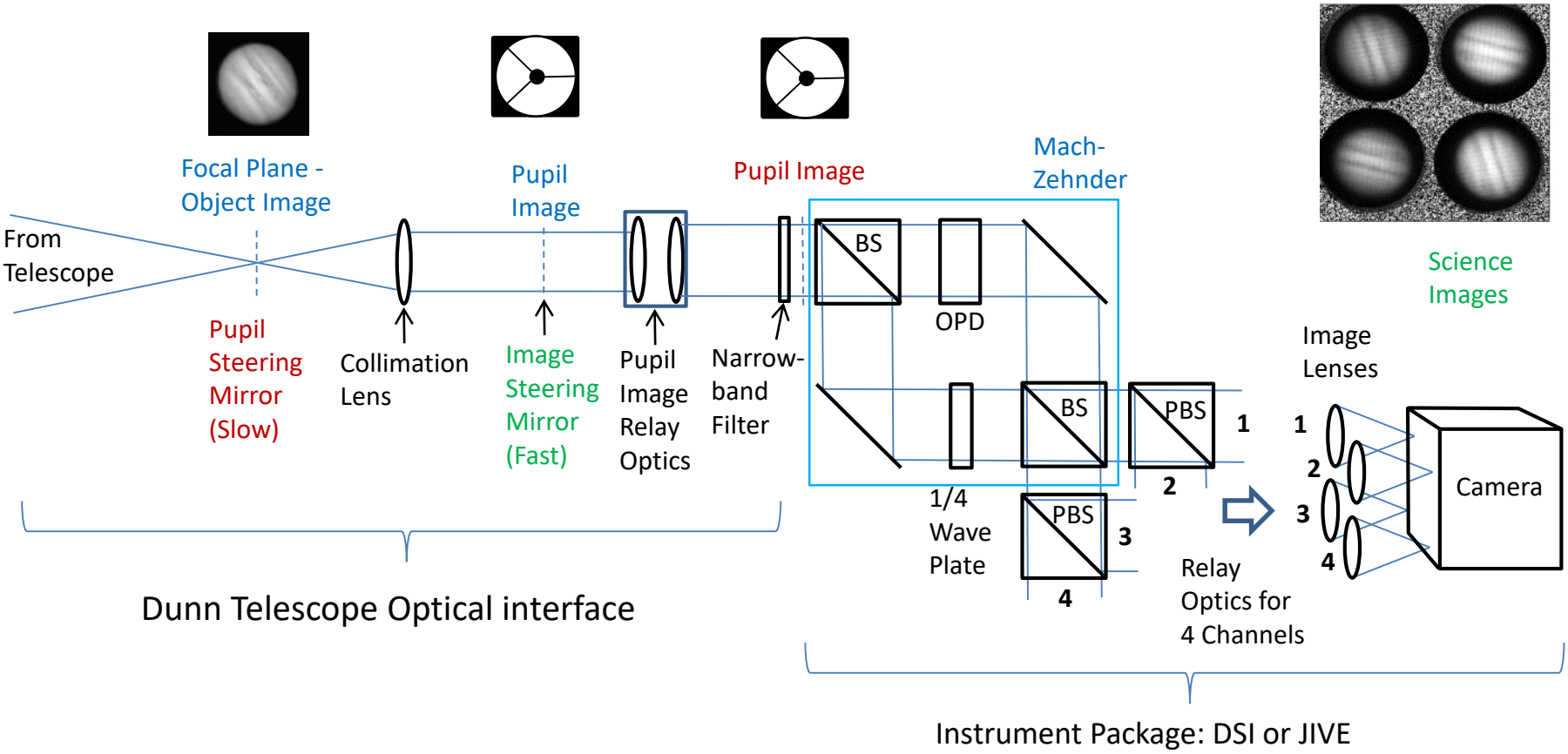
Topics

- Jive System Concept
- Interferometric Measurement Requirements
- Dunn Solar Telescope
- Night Guider (NMSU)
- Interface Optics (Observatoire de la Cote d'Azur (OCA))
- Status – photos data

JIVE Measurement Concept

- Record narrowband “sheared” images of Jupiter with interference fringes
- Doppler velocity components of Jupiter’s atmosphere are encoded in the fringe deformations



Interferometric Doppler Velocity Measurement

Modified Mach-Zehnder Interferometer:
Intensity at an image pixel is given by

$$I(\Delta) \approx I_0 \left\{ 1 + C(\Delta) \cos \left[2\pi\sigma_0 \Delta \left(1 + \frac{\delta v}{c} \right) + \varphi_0 \right] \right\}$$

where:

Δ - optical path difference (OPD) between interferometer legs

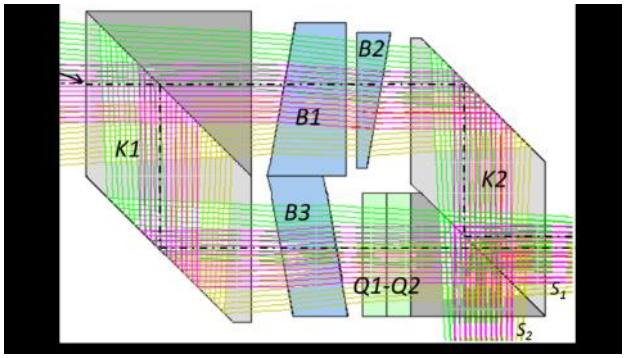
C – slowly varying fringe amplitude

σ_0 – fringe center wave number; depends on angle between legs

φ_0 – arbitrary phase shift

c – speed of light

δv – Doppler shift



Interferometer is extremely sensitive to temperature changes – OPD must be precise. Use thermal control and place in vacuum.

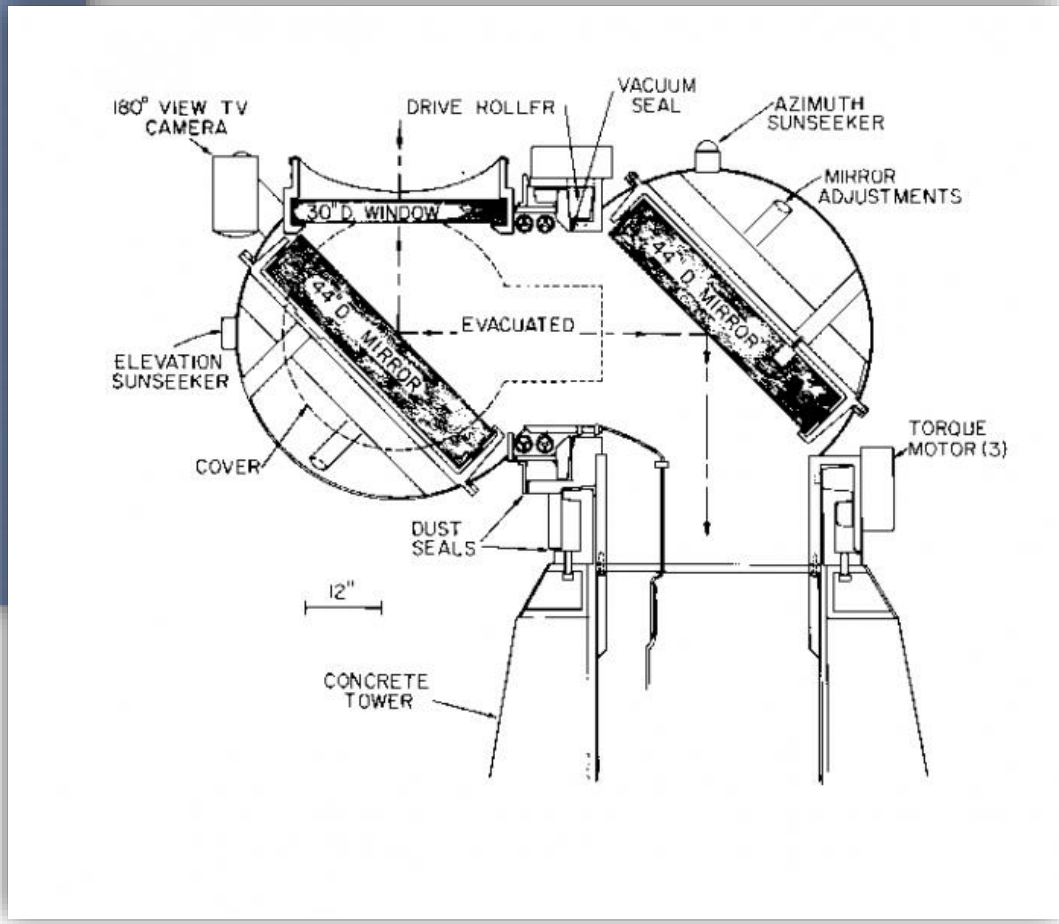
Determine δv at each image pixel by measuring phase shift using the four-bin measurement, in λ /4 steps, provided by interferometer

- Need "large" Δ ($\sim$ 5mm) for good detection sensitivity of δv …. OPD is a multiplier
- Need "narrowband" light ($\sim$ 1nm filter) to give larger C …. better fringe contrast

Richard B. Dunn Solar Telescope (DST) Selected for JIVE

- Environmentally stable lab for instrumentation
- Available optical port and tables
- Longer time periods for engineering and science observations
- 76 cm aperture provides sufficient signal for Jupiter

Turret pointing



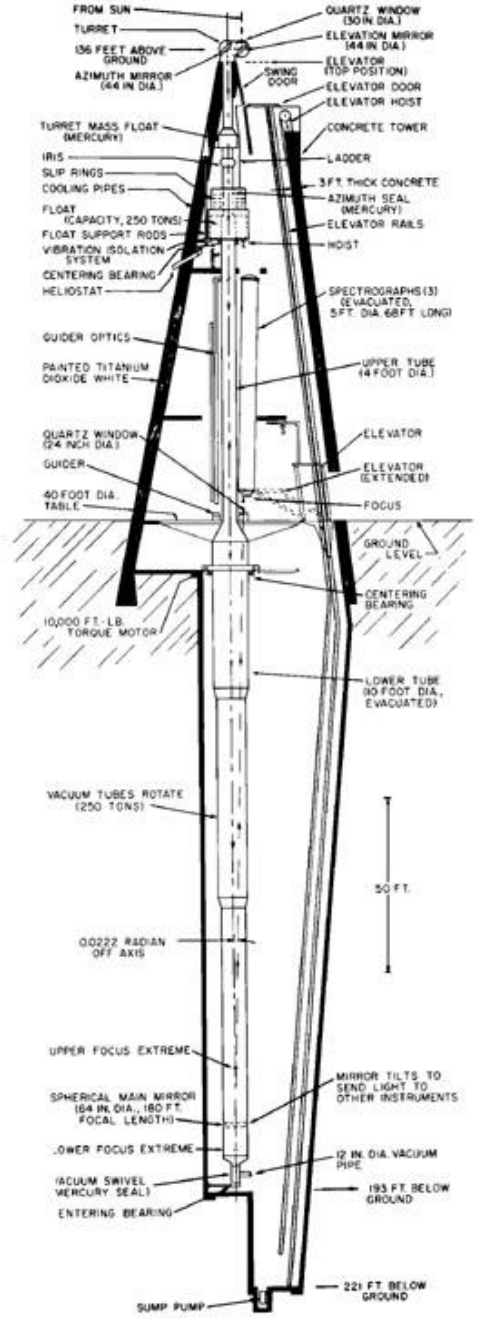
A long optical system …

Turret is 136 ft. above the ground.

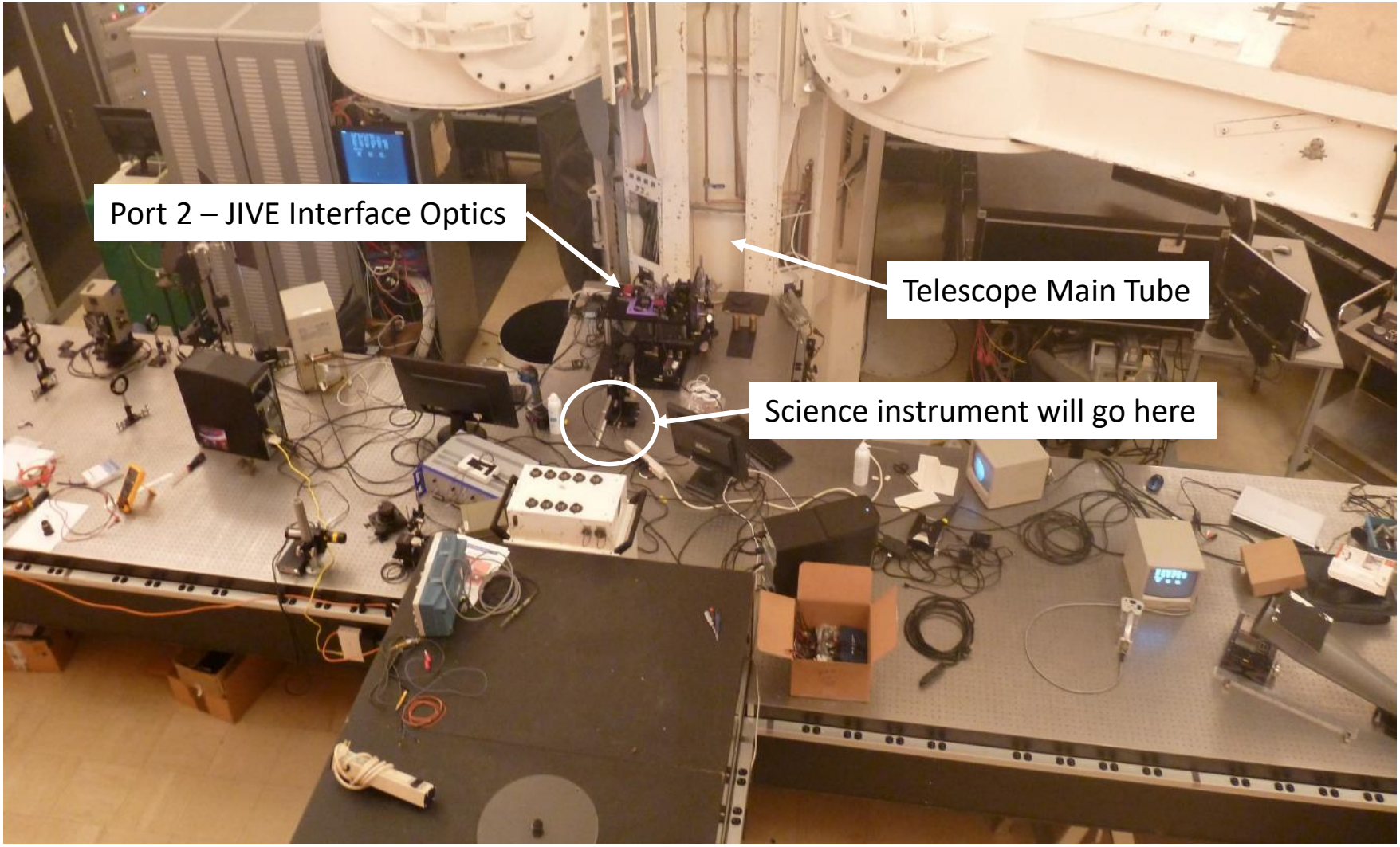
Primary mirror (long focal length of 54.86 m) sits 193 ft. below the ground.

Most of the optical path is in vacuum tube.

The optical train (250 tons) is suspended near the top of the tower and rotates on a mercury float bearing as the Sun moves (keeps the image from rotating)



DST Lab

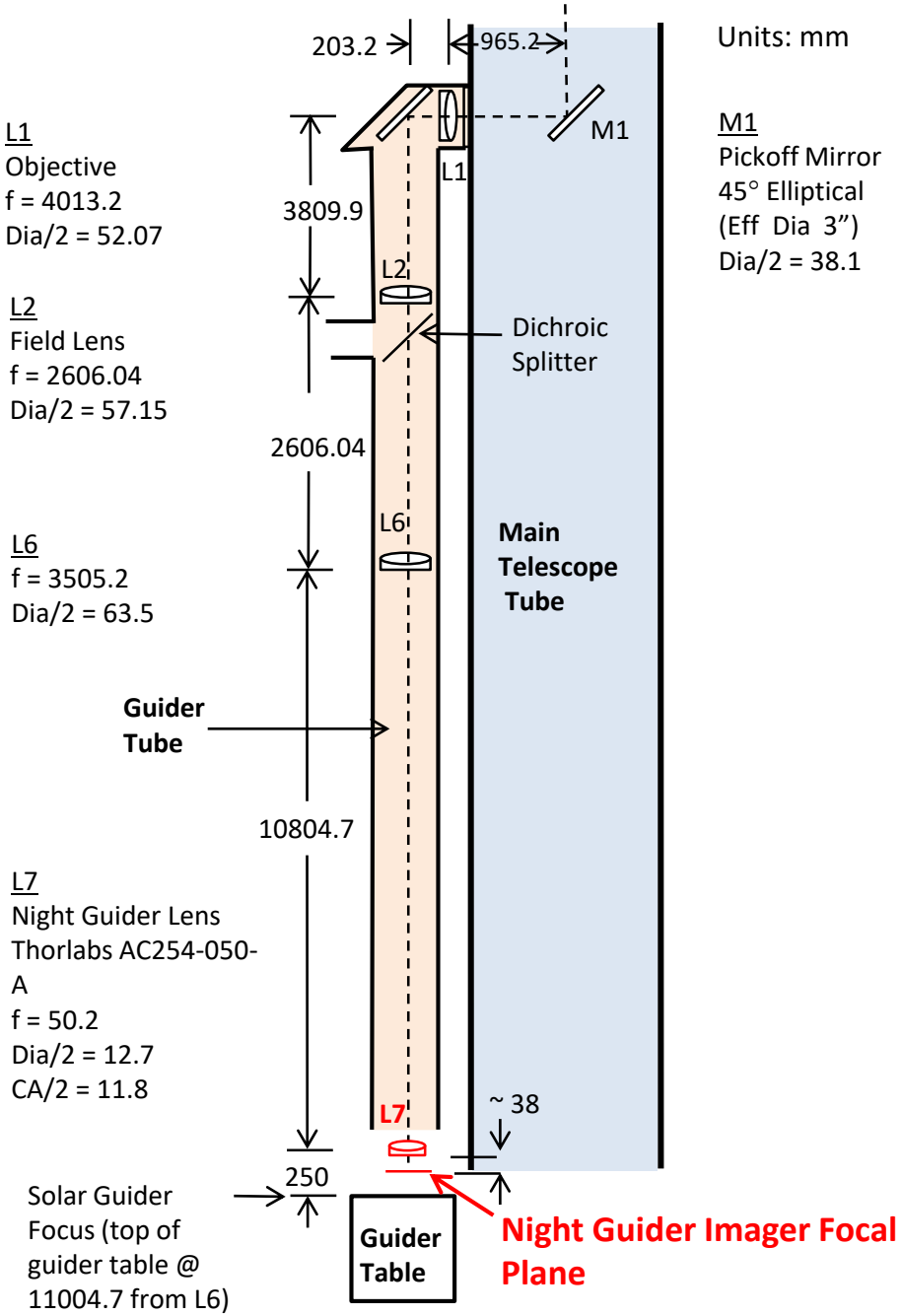

Port 2 – JIVE Interface Optics
Telescope Main Tube
Science instrument will go here

JIVE Engineering Tasks with Dunn Solar Telescope

- Develop night guider for Jupiter
  - Dunn ephemeris guiding is stable, but drift can be a few arcsec/min
  - Need to correct for drift to stay within dynamic range of fast steering mirror [specification: $< \pm 10$ arcsec on sky]
- Stabilize pupil at entrance to JIVE interferometer
  - Interferometer response is not spatially uniform – entering light bundle needs to be stable
- Stabilize image at science camera
  - Image motion smears velocity measurement and spatial features

Guider Approach

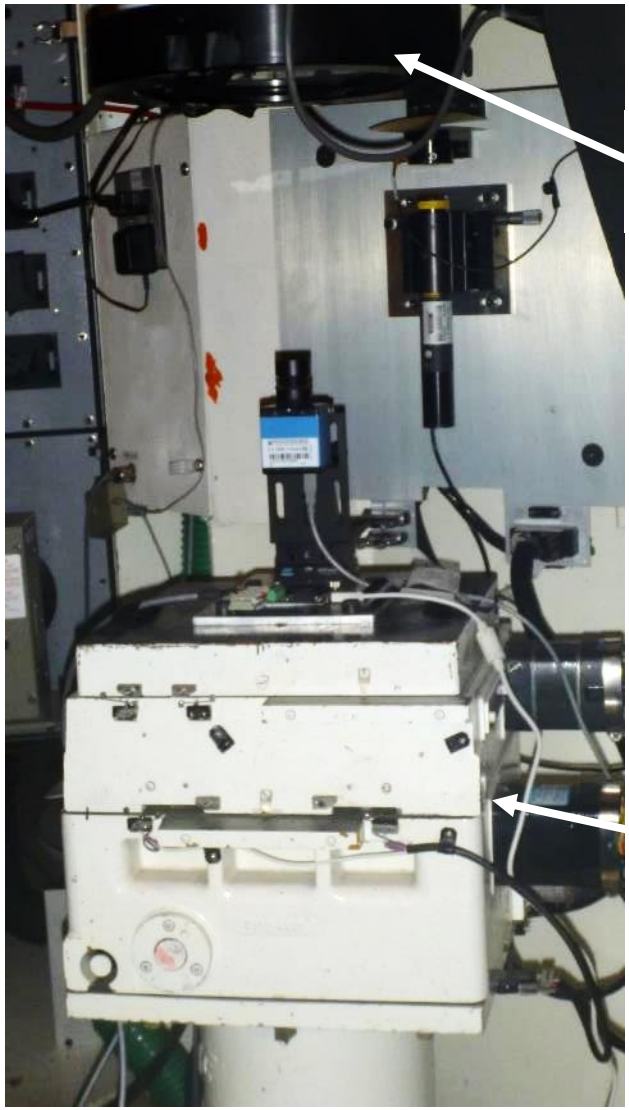
- Use the guider tube (pickoff from main tube) that is used for solar guiding
- Replace solar quadcell system on guider table with CCD camera/lens
- Drive telescope position from camera video with control loop



Night guider photos

Camera/lens

A/D Board to drive telescope

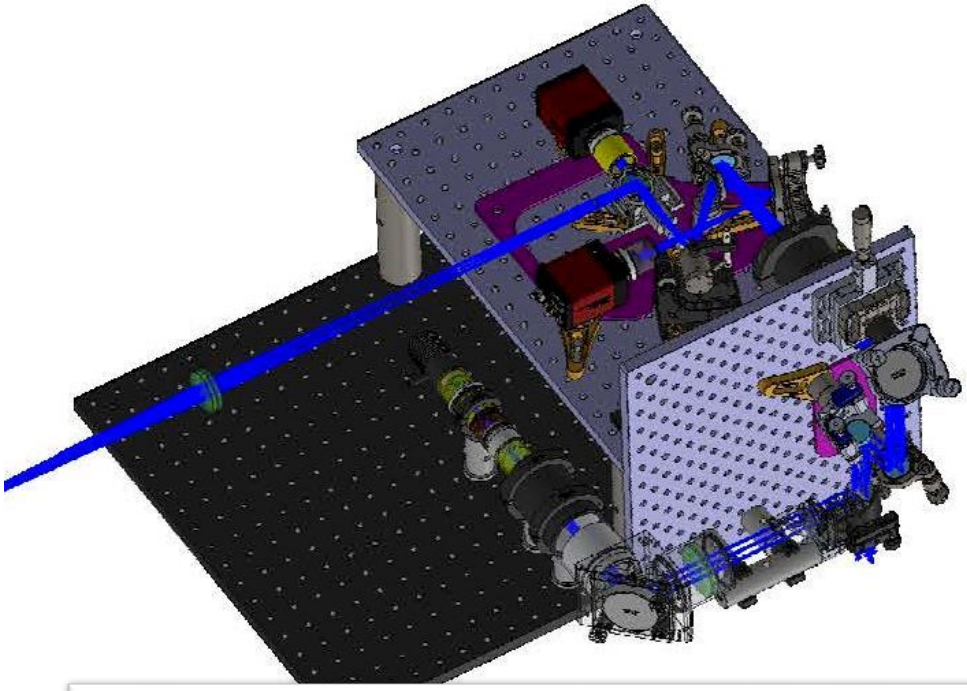


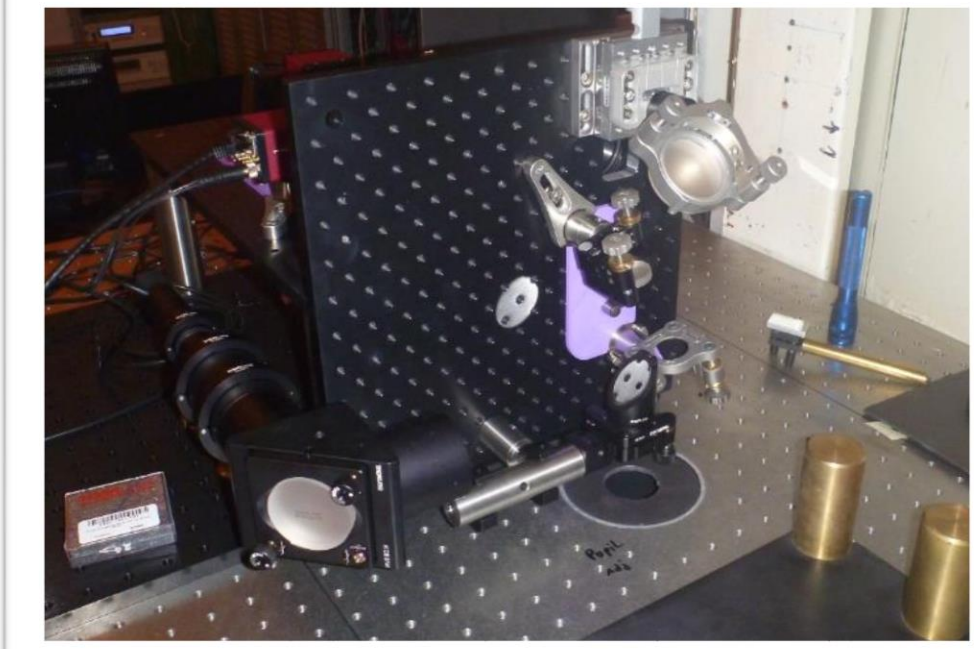
Guide Tube

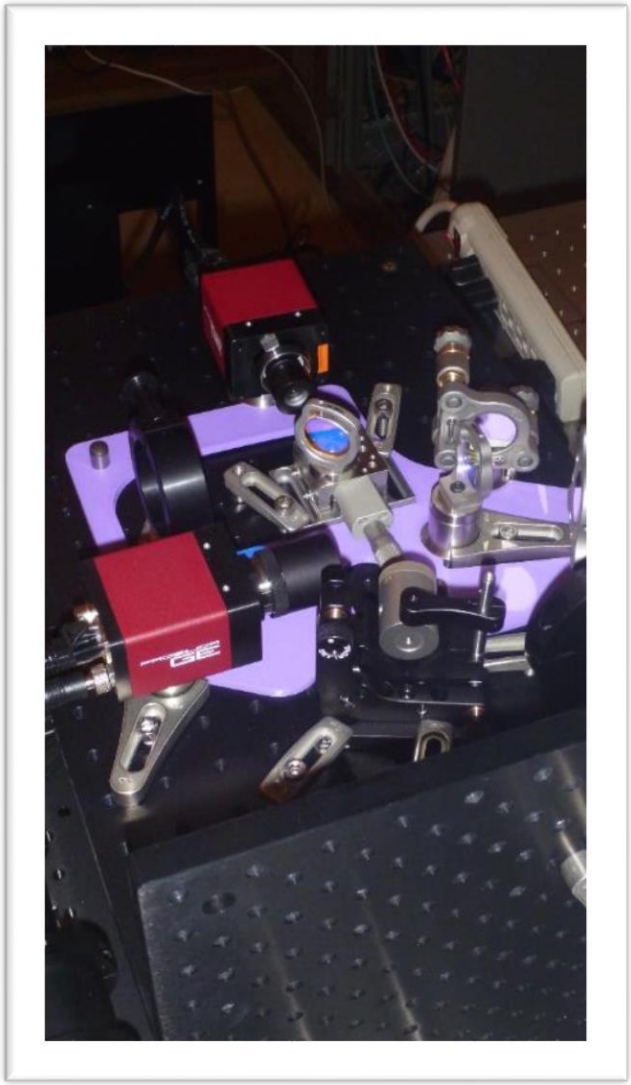
Guide Table

Telescope Interface Optics

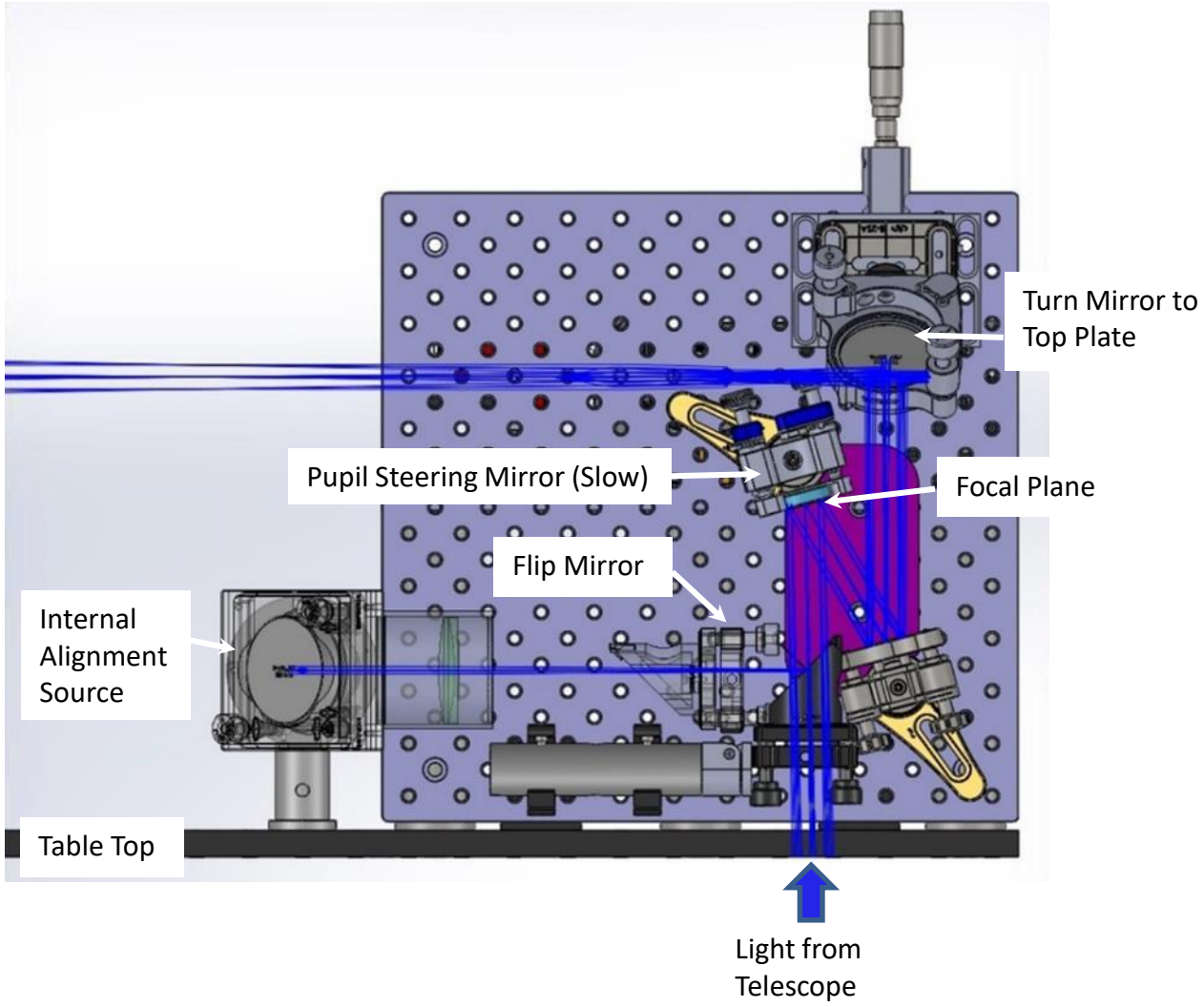
By Observatoire de la Cote d'Azur



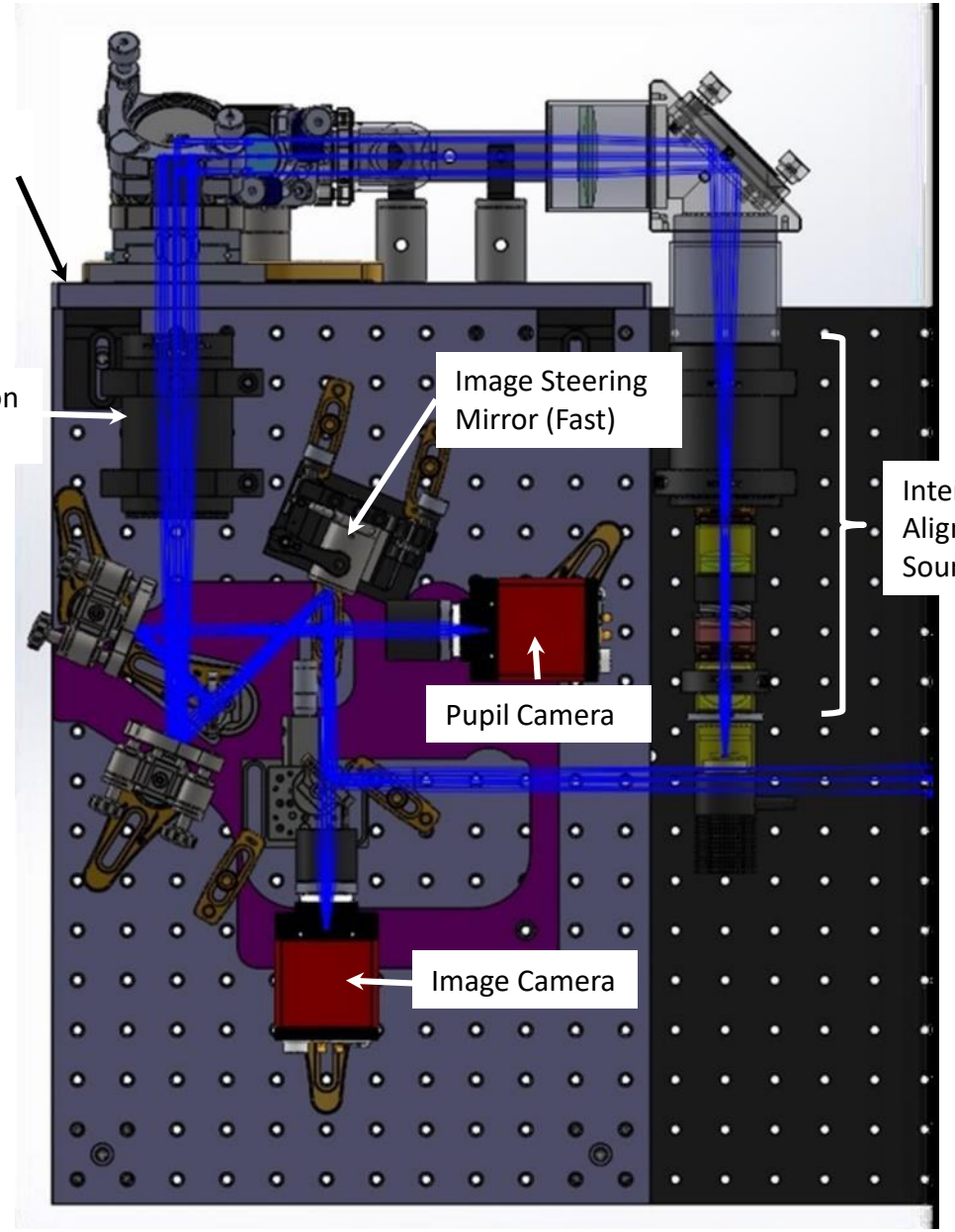




Dunn Interface Optics - Vertical Plate

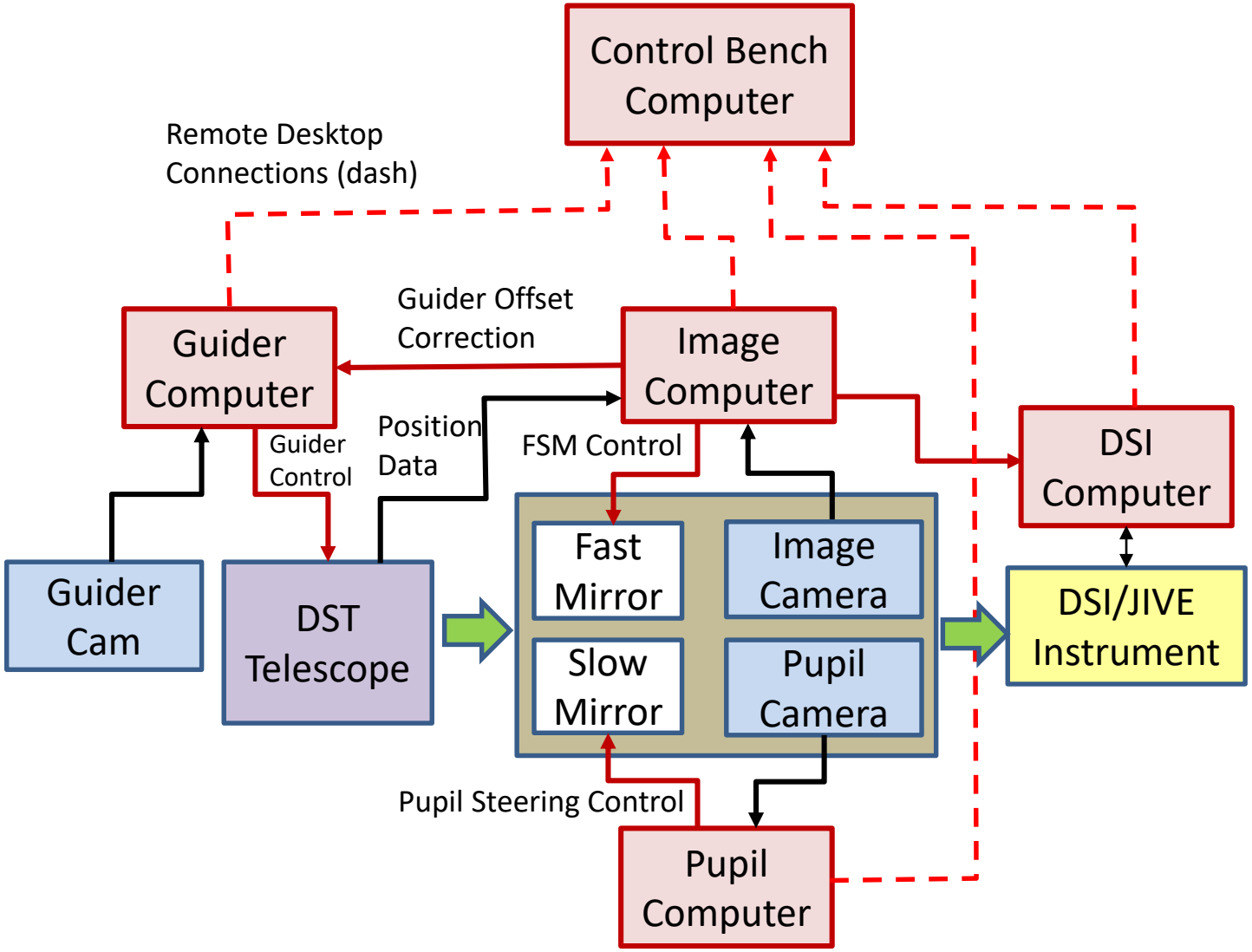


Dunn Interface Optics – Top (Horizontal) Plate



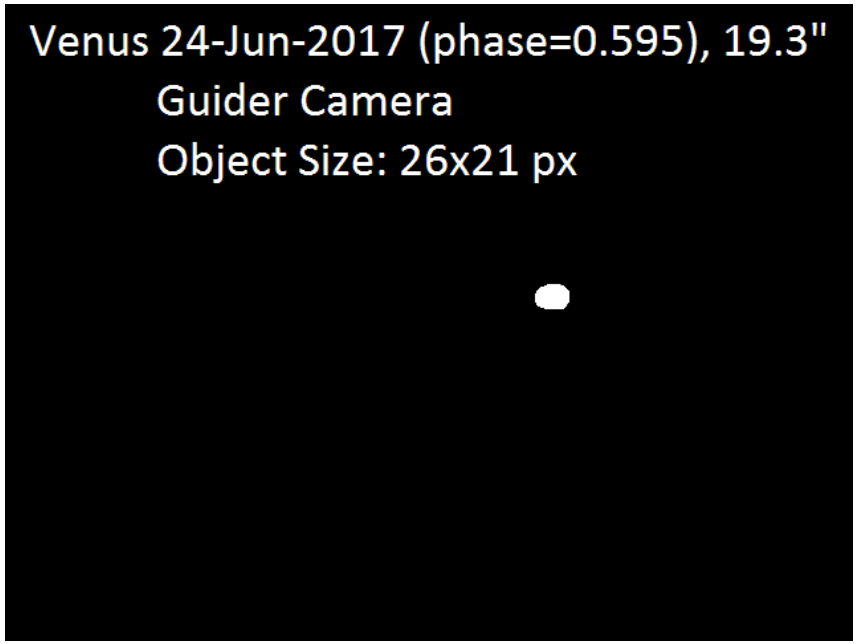
JIVE System- Signals

4 cameras, 5 computers, 2 steering mirrors, & 1 telescope

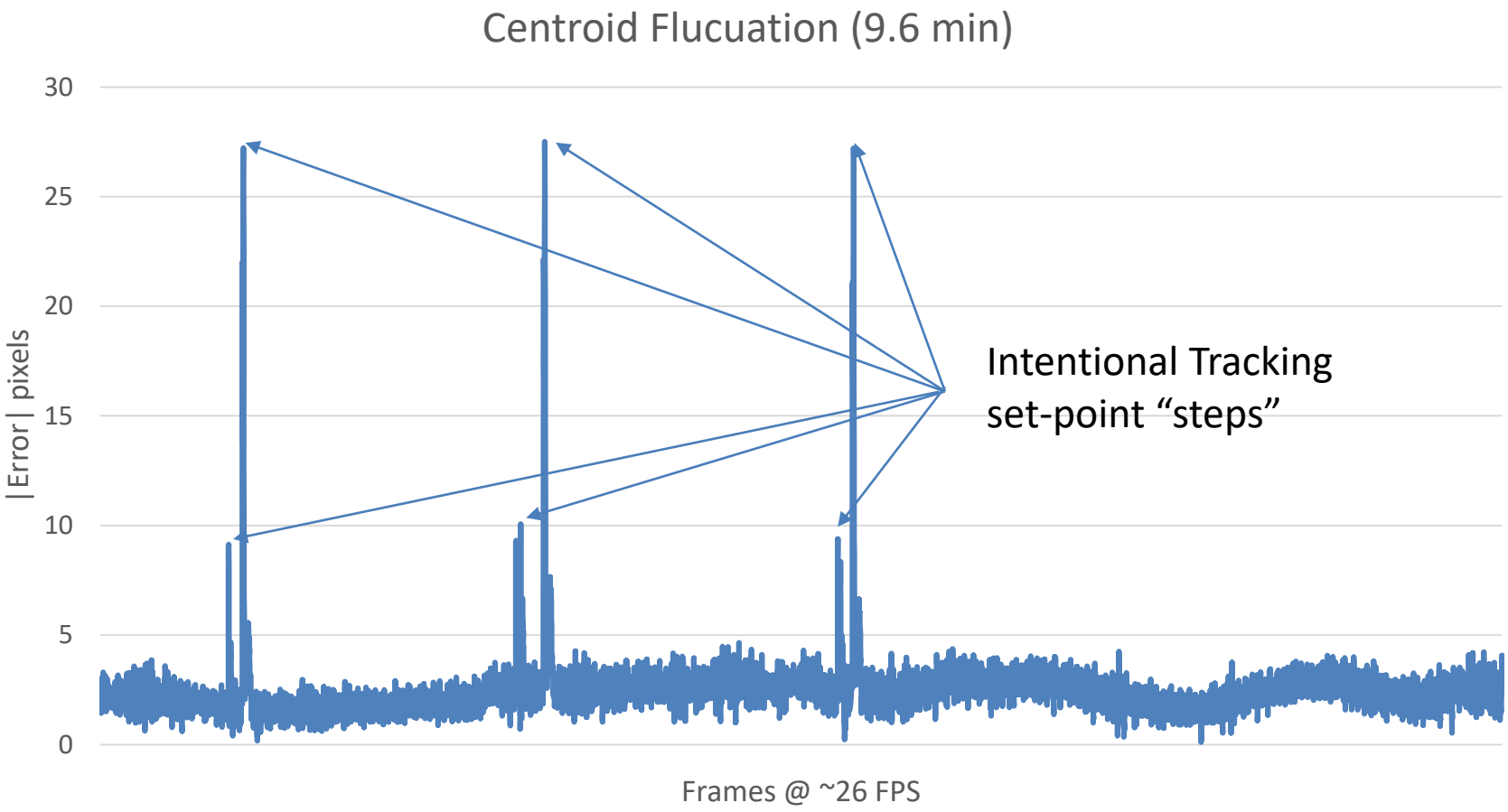


Guider Status

- Concept implemented
  - Successful test on June 23, 2017 with Vega, Venus (Jupiter had set)
  - Stability with good sky conditions, appears to be considerably better than ± 10" -- need to look at data
- Hardware is complete – except for a few tweaks
  - Switch to permanent computer
  - Replace electronics board terminal block with standard connector (e.g. D9)
- Software – core functions complete; working on robustness:
  - Frame processing in poorer conditions
  - Occasional unexplained skips
  - More diagnostic data under different conditions
- Need to implement communications with interface optics image camera
  - Remove residual boresight drifts (slow drift over the night between guider and image camera)

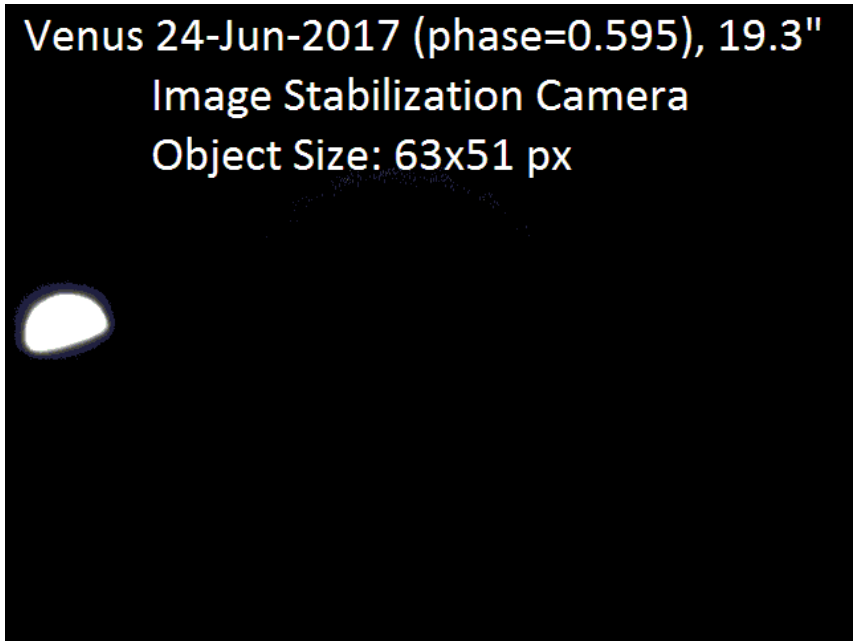


Guider Tracking 24-Jun-2017



Interface Optics Status

- Interface optics installed 25 Feb. – 1 Mar. 2017 at the Dunn by Observatoire de la Cote d'Azur (OCA - Julien and Yves)
  - Alignment of both pupil and image stabilization paths accomplished – no issues
  - Ghost image in pupil path to be removed with filter
- Communications established with telescope to be able to log pointing positions
- Image stabilization system needs to be inserted
- Pupil stabilization system needs to be inserted



JIVE Instrument Status

- Will use DSI (first version) initially
- Hope to collect science data on Venus this fall
- Switch to JIVE instrument perhaps in spring 2018