U.S. Naval Observatory

Double Star Program :

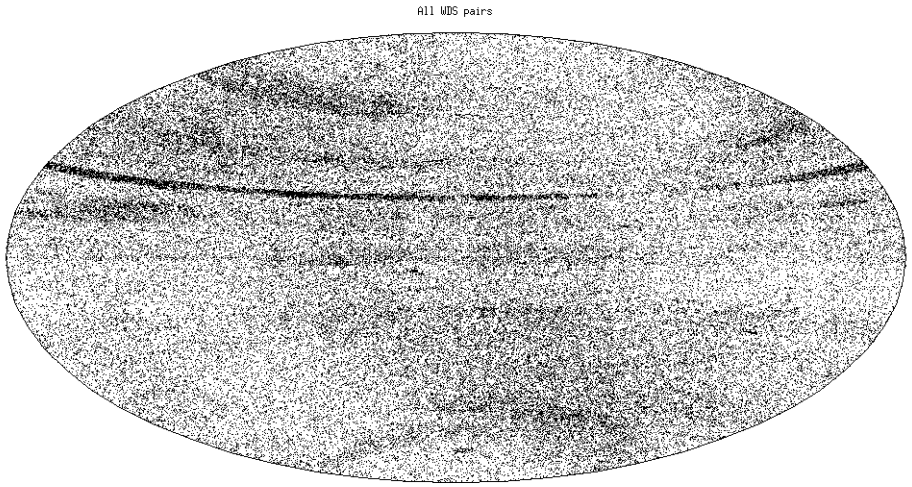
Observing at the USNO

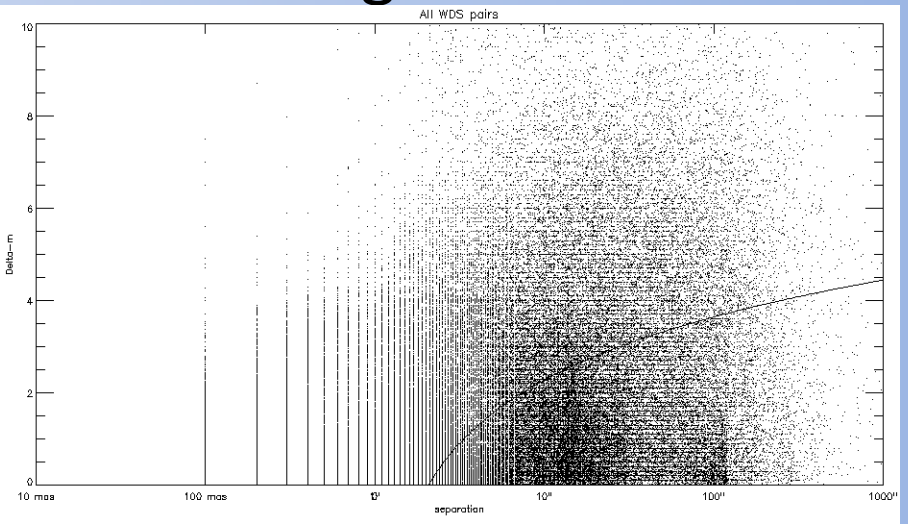
Observing Program

- One of the most significant differences between observing at other facilities and observing here is the need, or lack thereof, for an observing proposal.
- Prior to 1999 while under the supervision of Charles Worley the USNO double star program with the speckle camera concentrated on a small number of bright, close relatively fast moving pairs.
- In most cases these were over-observed and/or at a separation where they could (and were) being observed by others with access to larger telescopes.
- In 1999 a new classification of double star was defined as “neglected”. These neglected pairs would form the basis of the observing program from then to the present day.

All Pairs

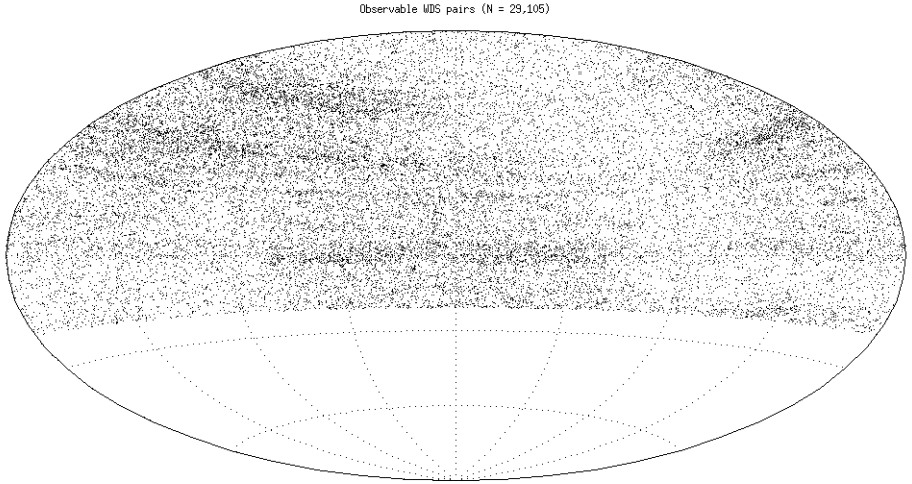
- All WDS pairs are plotted with the position on the sky and in a separation-magnitude plot.
- Although a plot of separation-Δm plot might be more useful.
- Graininess of ρ-Δm plots due to rounding in WDS.

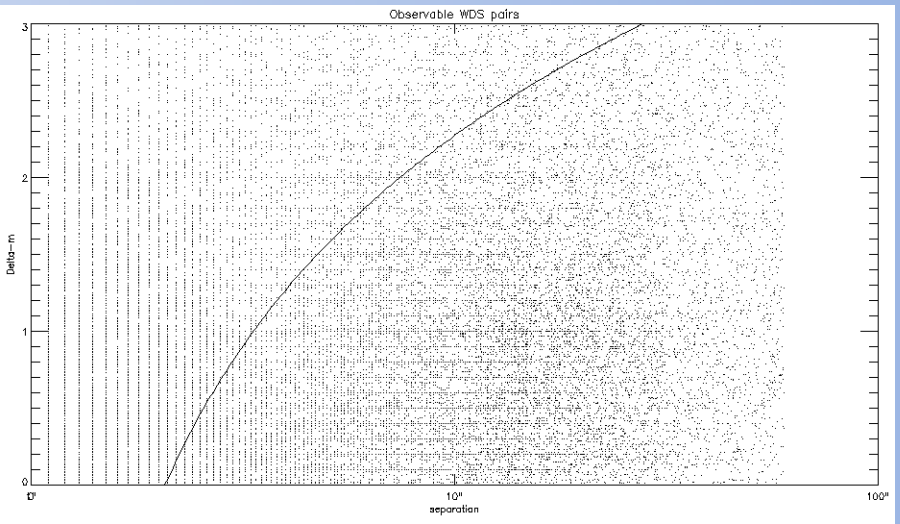




Observable Pairs

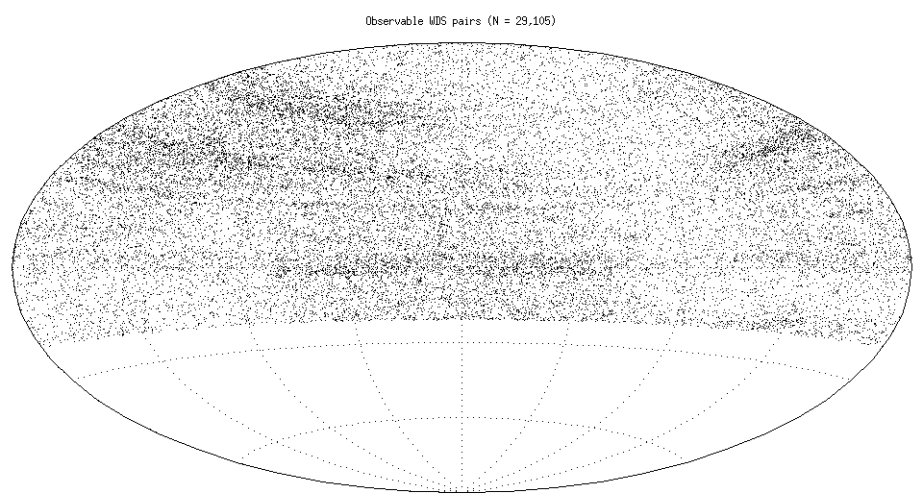
- Starting with the WDS as input, pairs appropriate for observing with the 26″ in Washington are plotted.
- Grossly, these are $\delta > -20$, $1'' < \rho < 60''$, $V_a < 12$, $V_b < 13$, $\Delta m < 3$ (new camera parameters)
- Rescaling ρ-Δm plot …

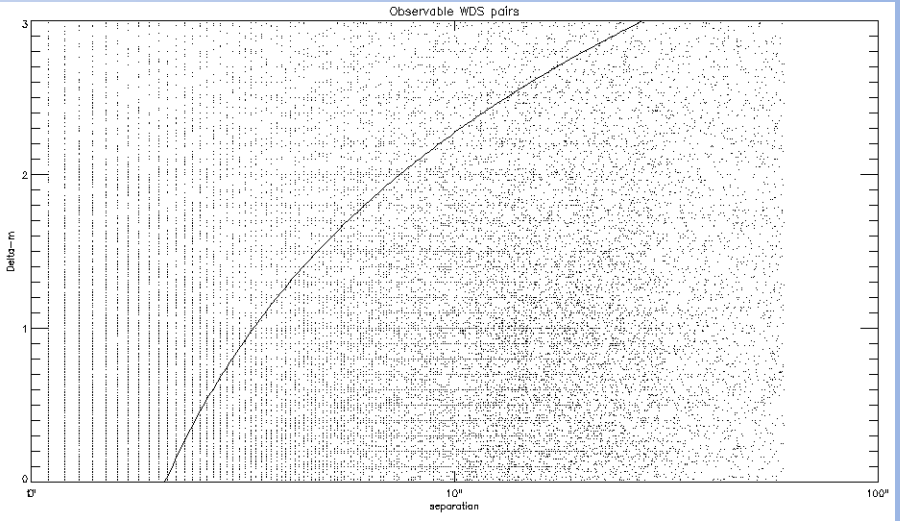




Neglected Pairs

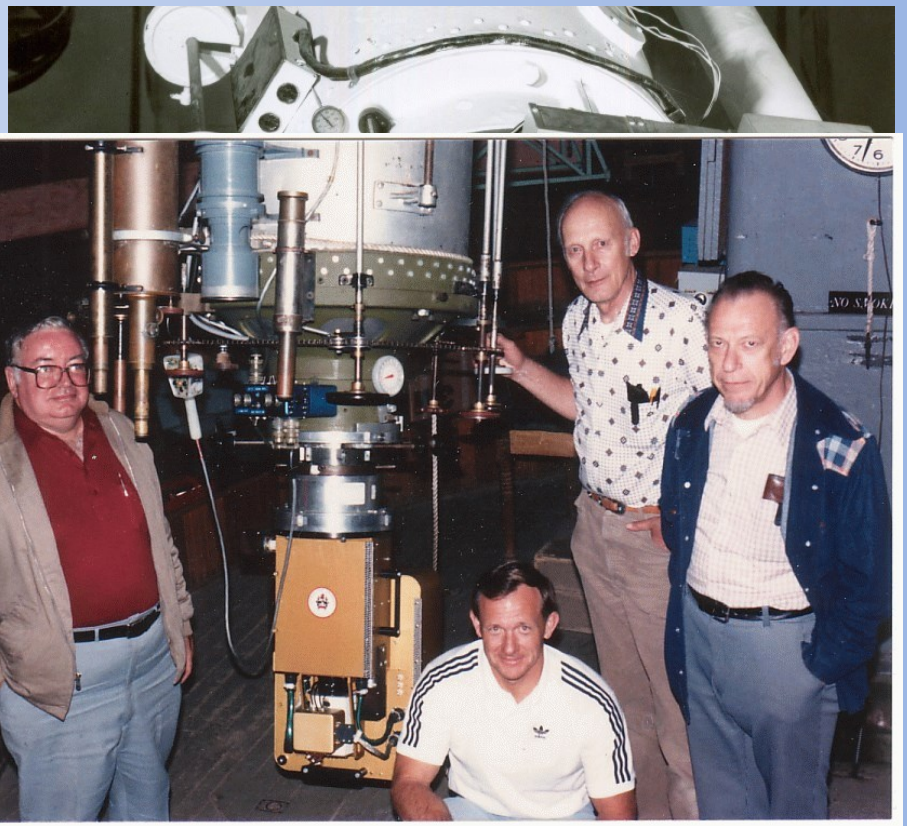
- Neglected doubles were defined to be pairs which are either unconfirmed or have not been observed in **N** years. This value of **N**, the observing cadence, is set at 10 years.





Idea of the USNO Speckle Camera

Following a successful observing run in 1980 on the Lowell 24″ with Otto Franz and the GSU speckle camera, Charles Worley began the process of securing a speckle camera for the USNO to transition the observing program from micrometry to speckle interferometry.

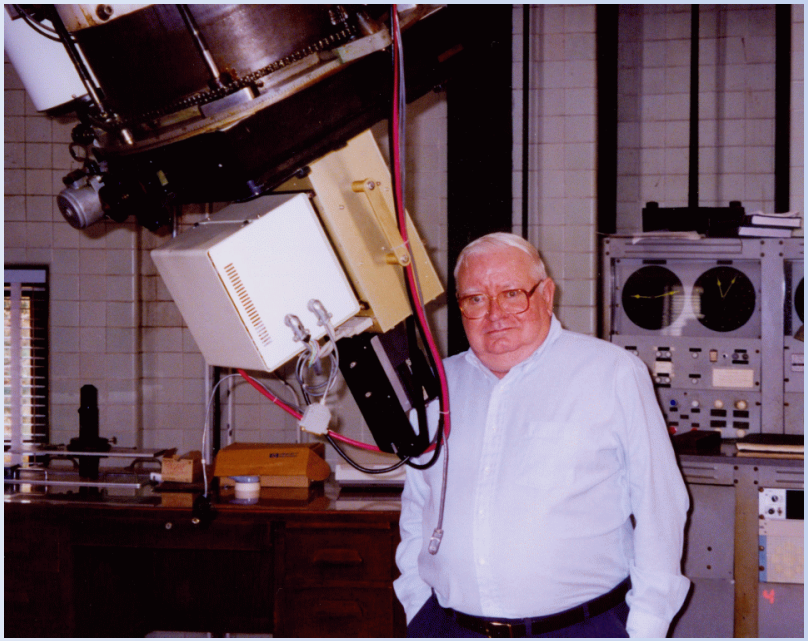


Acquisition of Speckle Camera

- The speckle camera, based on the GSU design of Bill Robinson, was built by Skip Andree (NOAO).
- It was installed in 1990 and the micrometer was retired.
- At right are the initial 26″ speckle observing team of Charles Worley, Geoff Douglass and Bob Hindsley as well as Bob Harrington.

Operation of Speckle Camera

- The initial team had an observer in the dome controlling the telescope.



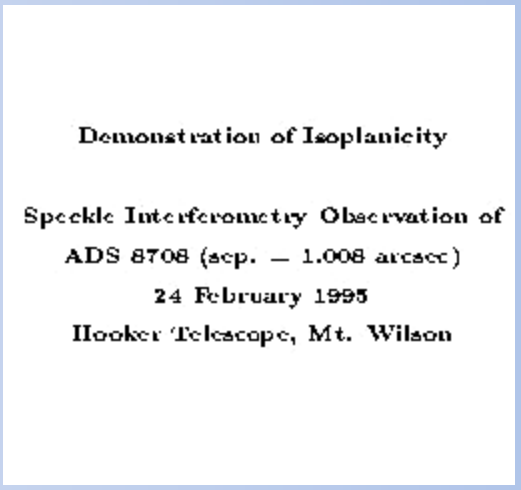
- Meanwhile a second member of the team controlled the data acquisition computer from one of the adjoining offices.

Operation of Speckle Camera II

Eventually this was replaced by a single operator in the dome controlling both the telescope and the speckle camera acquisition system.

Speckle Demo

- **STT 256 (discovered by Otto Struve, 1843)**
  - **sep = 1.008 arcsecs**
  - **V_A = 7.3**
  - **V_B = 7.6**

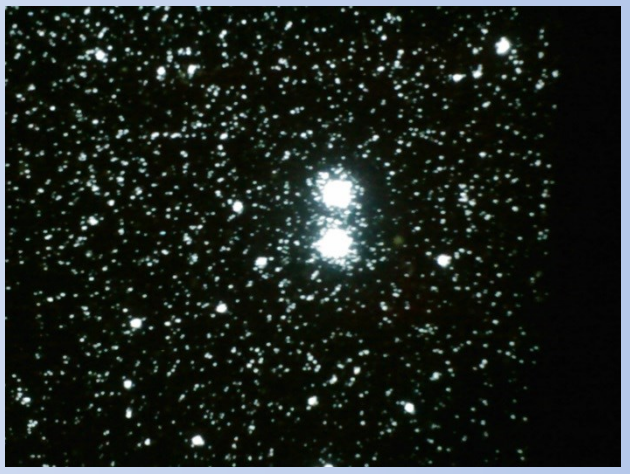


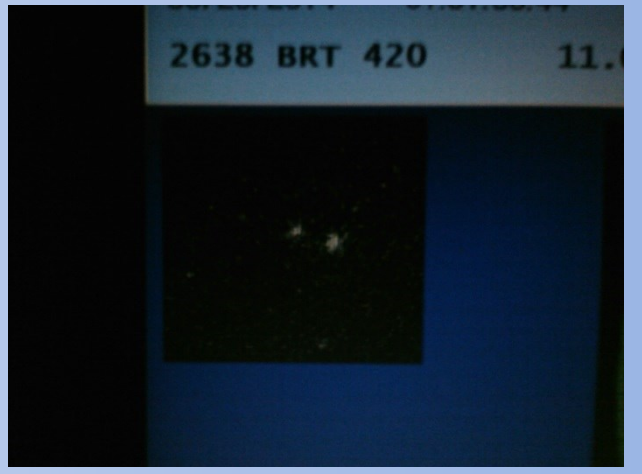
Demonstration of Isoplanicity

Speckle Interferometry Observation of
ADS 8708 (sep. = 1.008 arcsec)
24 February 1995
Hooker Telescope, Mt. Wilson

26″ Speckle Images

- STI 250, last measured in 1910. V_a = 11.4, V_b = 11.8, ρ = 10.8″
- STF1300, frequently observed calibration target. V_a = 9.5, V_b = 9.7, ρ = 5.0″
- BRT 420, last measured in 1893. V_a = 11.0, V_b = 11.1, ρ = 4.8″

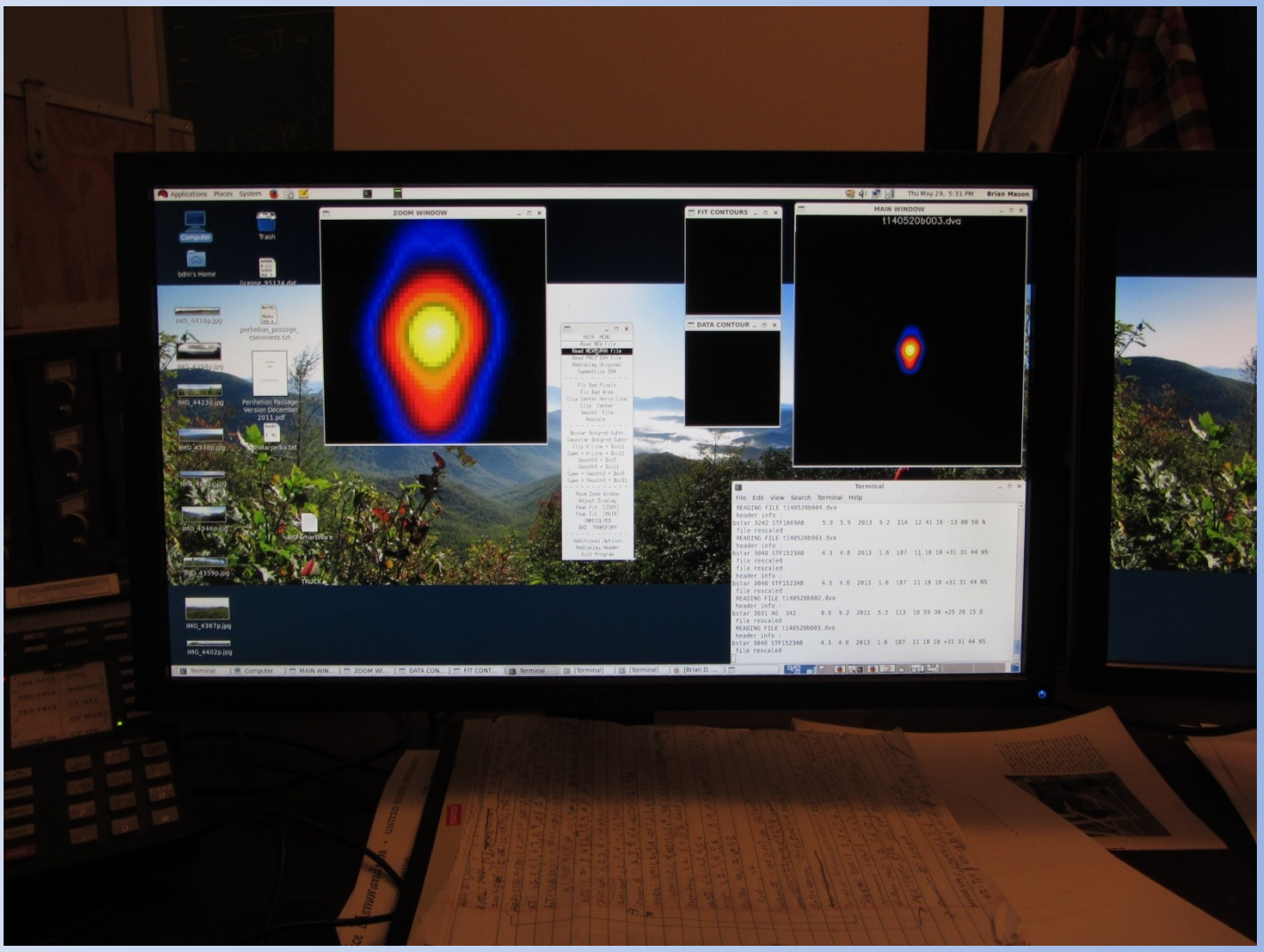




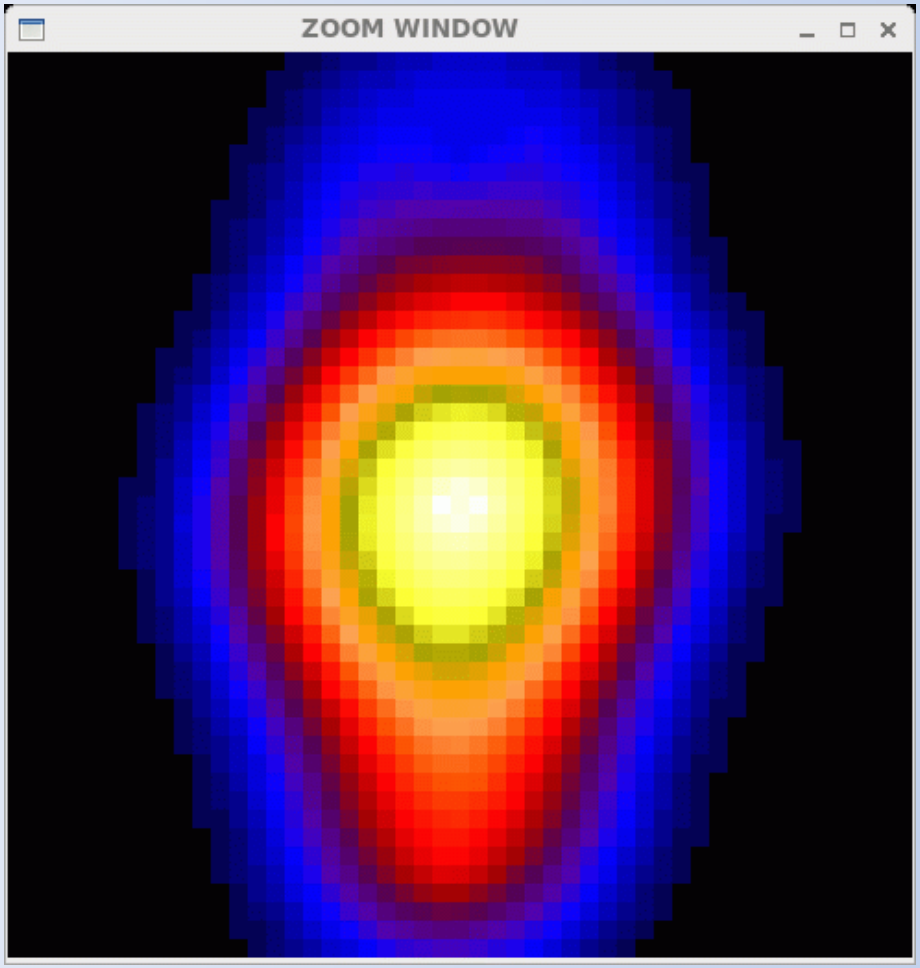
- Data are acquired by Gen IIIc – ICCD constructed by Syntronics (formerly Night Vision Systems) and fed into a Windows laptop with a frame grabber board.
- Using custom software written at USNO, data are thresholded and a “Directed Vector Autocorrelation” (DVA) file is written with a header giving observation parameters (object, time of observation, reduction mode, filter, etc.).

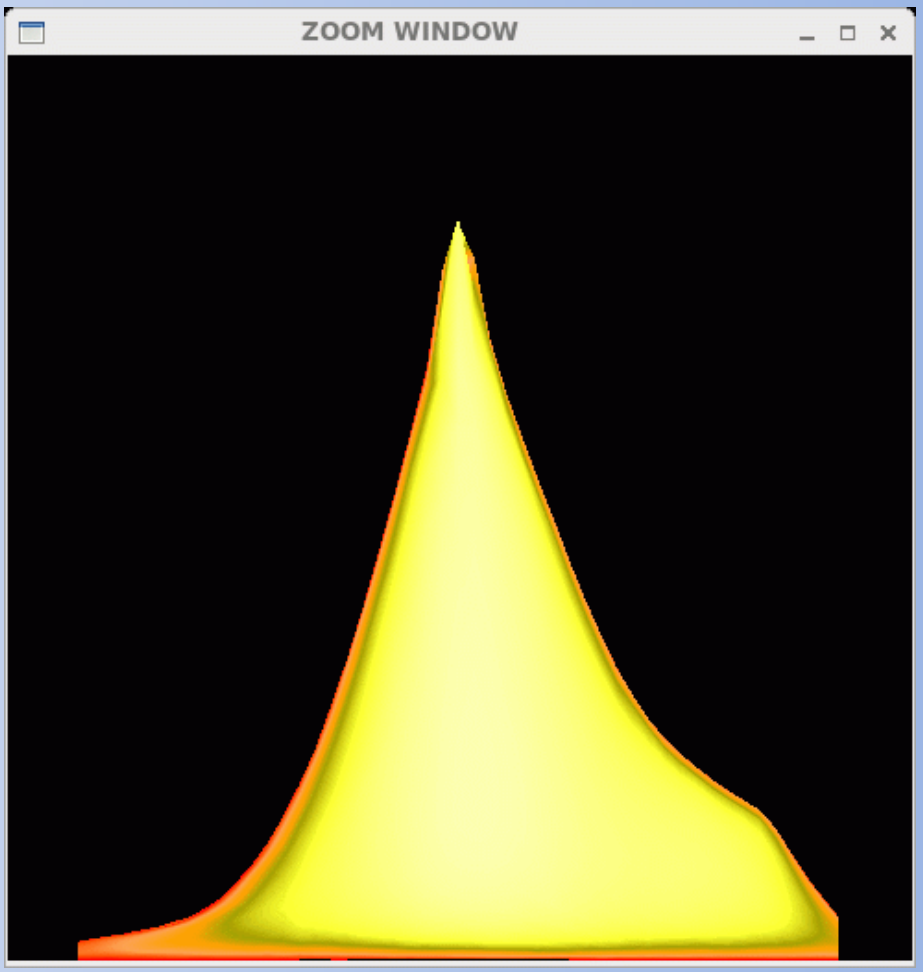
Reduction of DVAs

Using custom software written at USNO, individual DVAs are then manually analyzed.

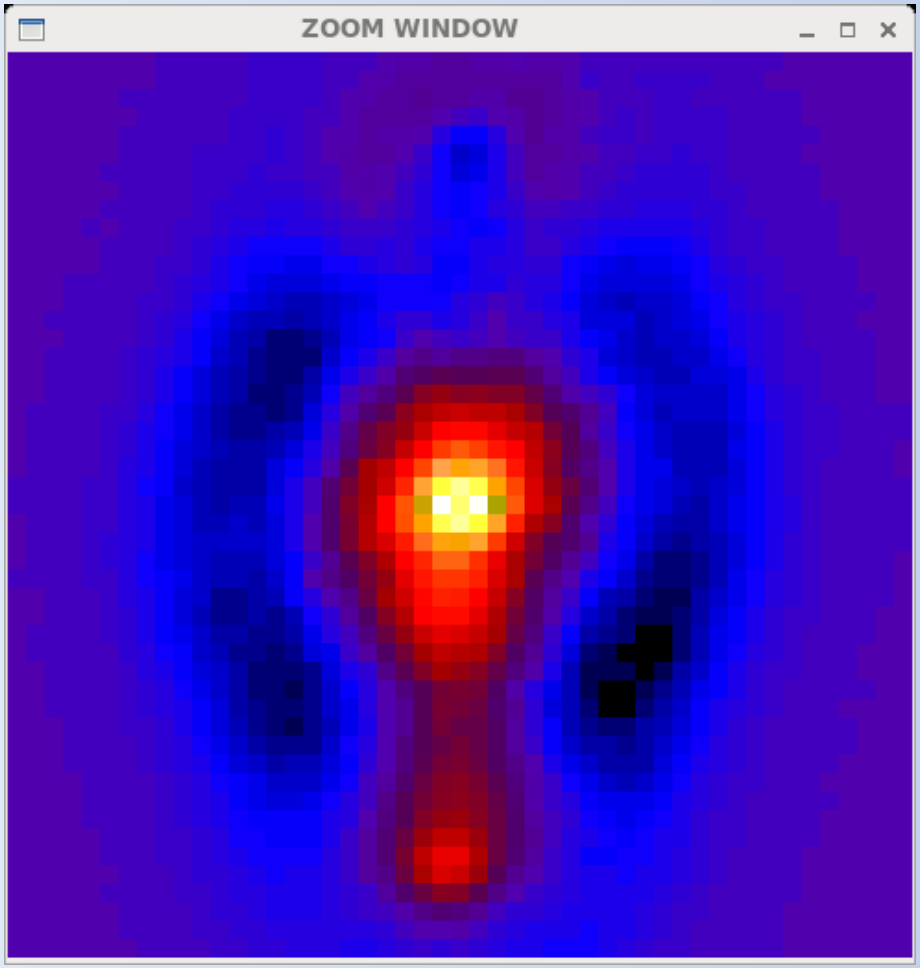


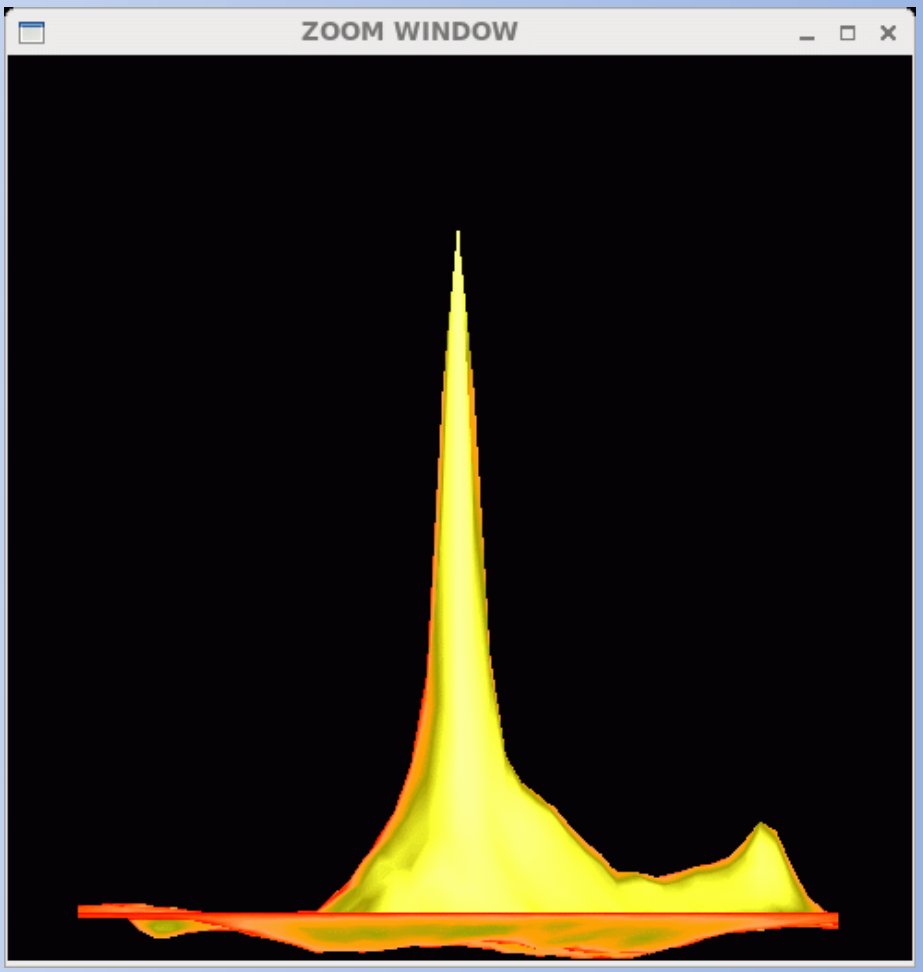
Zoom window





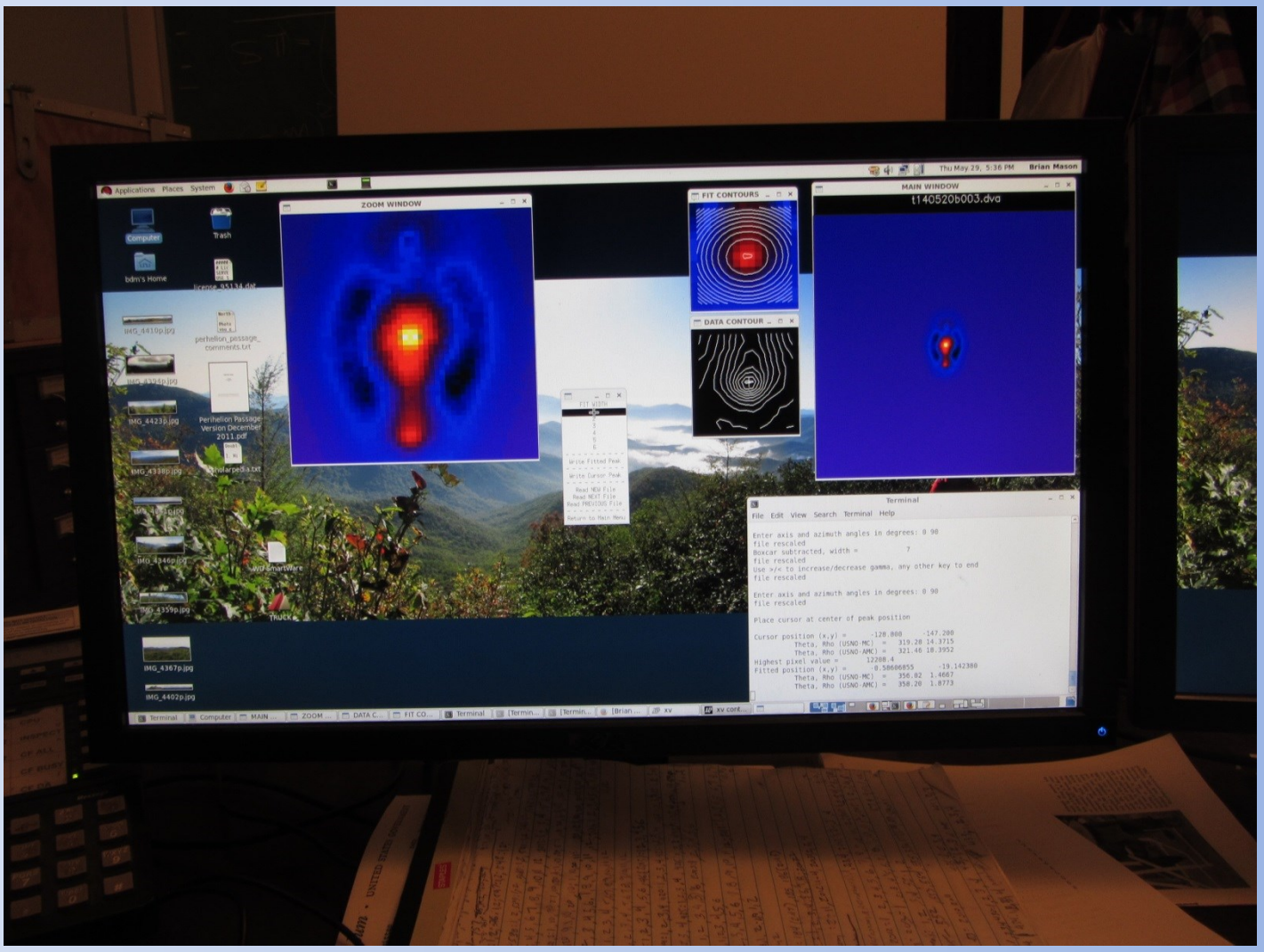
Following Boxcar of DVA





Reduction of DVAs

The output is written to a “peak” file which has X and Y offsets to the position of the secondary relative to the primary as well as information about the observation (object, Besselian observation date, filter, objective, etc.).



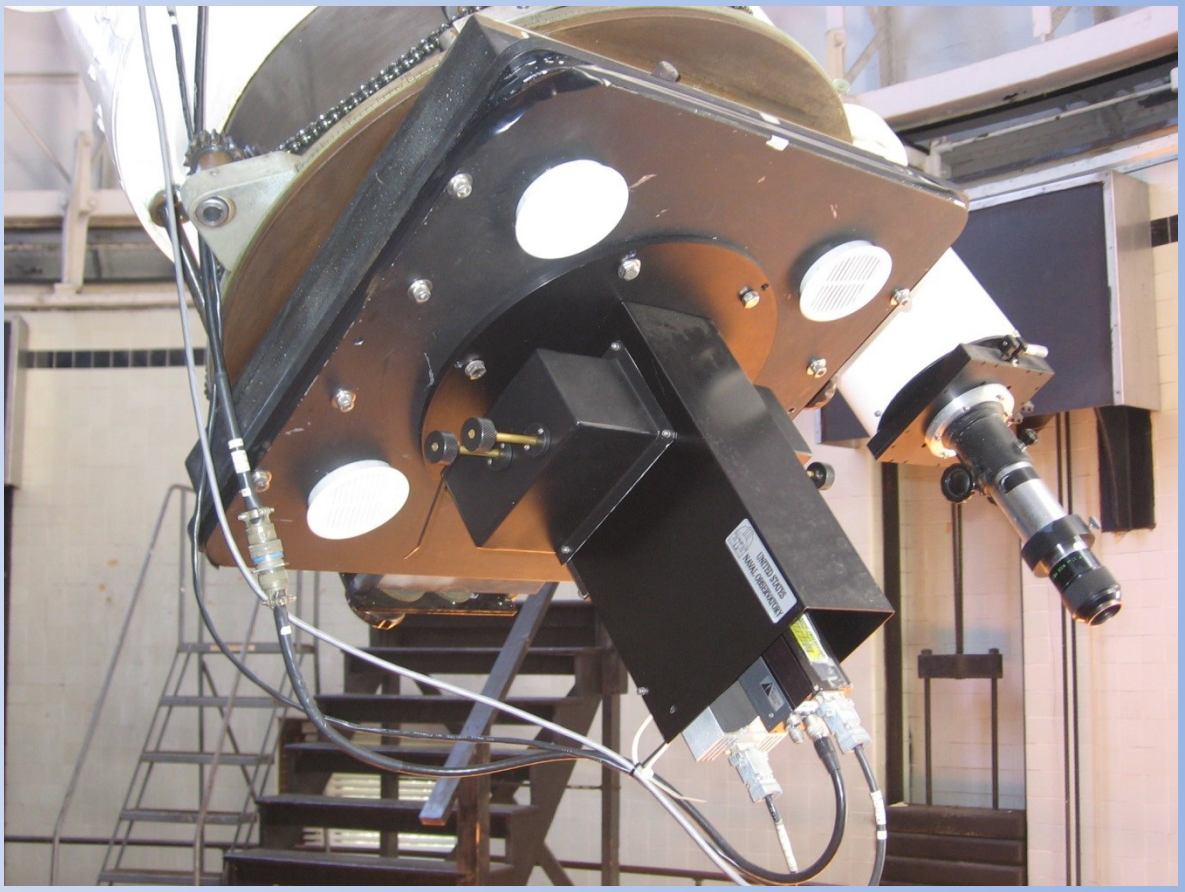
Calibration of Data

Calibration is extremely important!

- Calibration can be accomplished with many (two dozen plus or more) well-defined orbits or linear fits.
- Another and more fundamental approach is through the use of slit-mask observations of single stars.

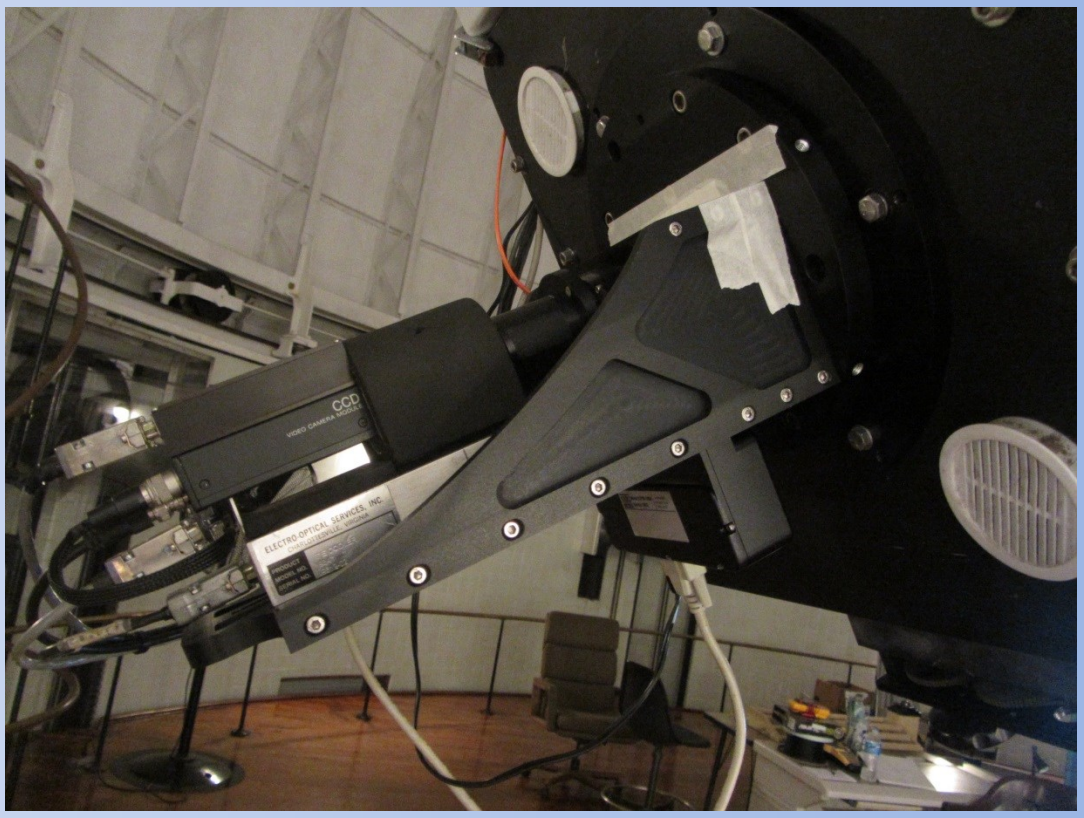
Secondary Camera

- In mid 2006 the USNO instrument shop constructed a secondary camera for use when the primary camera was at remote observatories.
- The secondary camera had a simpler set of optics (filters and objectives) controlled with manual spindles.
- While the secondary camera lacked some of the optical precision associated with the primary camera, such as Risley prisms to correct for atmospheric dispersion, it remained perfectly adequate for wider pairs. The lower limit on separation was set at approximately 5*x* the resolution limit of the telescope.



New Camera Design

- Based in part on an optical design provided by Andrei Tokovinin (CTIO) a new speckle camera was constructed in 2013-4.
- Constructed with lenses rather than microscope objectives, the smaller number of optical surfaces improves the faintness limit by 1-2 magnitudes.
- ICCD, filter and lens changing will be done by fiber optic control from outside the dome floor.
- For further details of other 26″ upgrade features see tour and talk from USNO instrument shop.

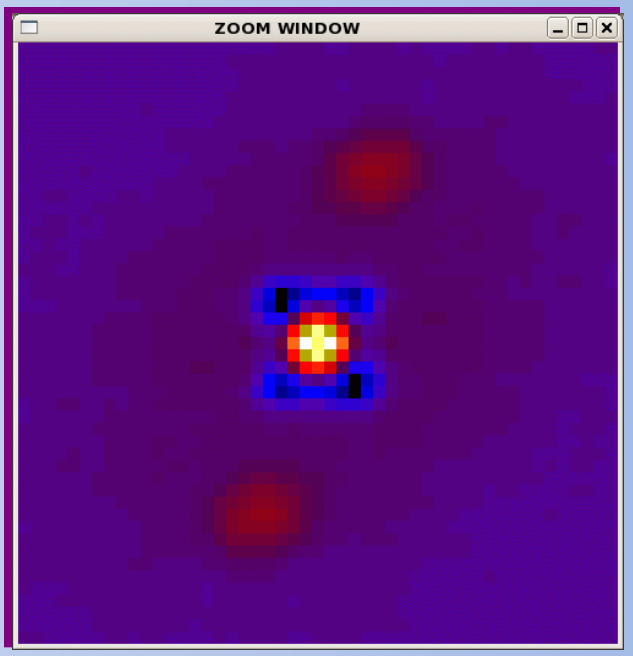


Additional Observing Targets

While the primary 26″ observing program is of neglected pairs additional targets are observed:

- scale and orientation calibration pairs,
- Special requests for which this telescope is adequate (e.g., long period spectroscopic binaries),
- pairs with multiple orbits in the “Sixth Catalog of Orbits of Visual Binary Stars,”
- bright pairs suitable for navigation and on the “Astronomical Almanac” or “Observer’s Handbook” bright doubles lists,
- pairs whose possible co-planarity under investigation,
- pairs which are potentially unstable according to the “Harrington Criteria,” (1975BAAS….7.476H) and
- pairs which are fast moving (δPA >5° or $\delta\rho$>0.1").

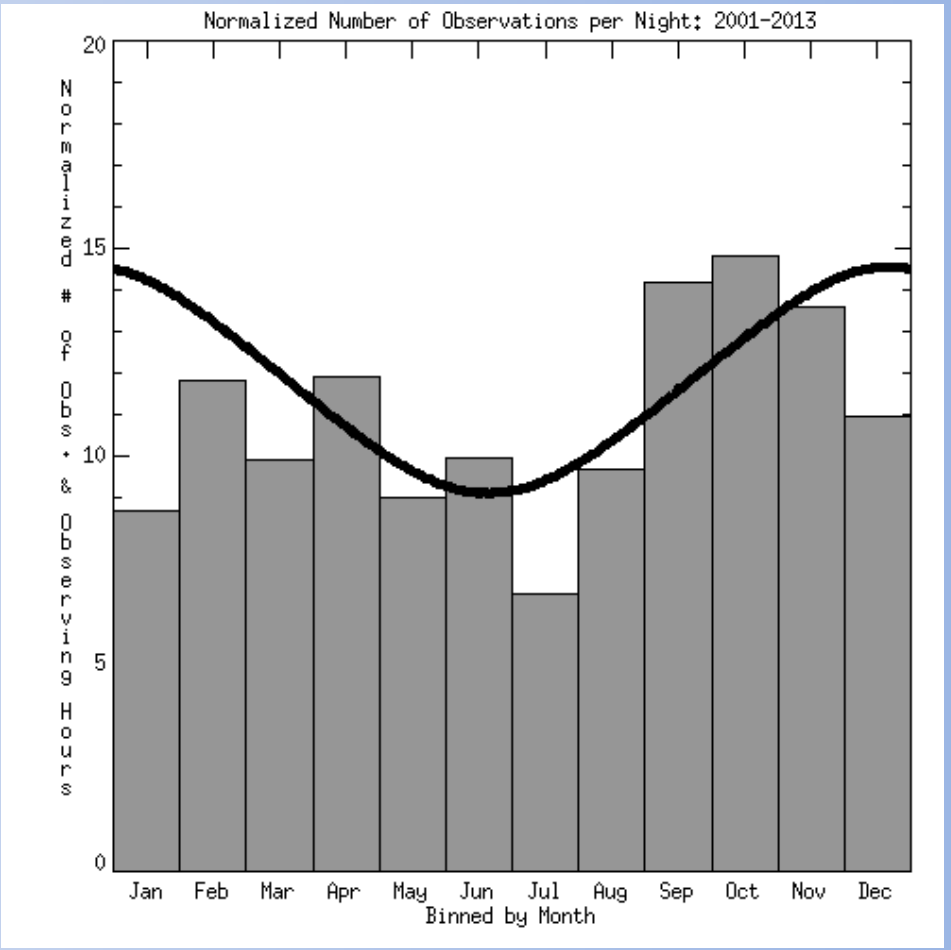
- Observations of η CrB



- 26” observations 1999-2009

USNO as an observing site

- While the USNO is a bright site, we can see as faint as V = 13 through the finder and acquire data for reduction.
- The magnitude limit is seasonally limited being only about V = 11 mid-summer due primarily to haze.
- Seeing can be adequate to quite good in spring and autumn approaching an arcsecond.
- At right are the number of dark hours and the number of observations per night (normalized). Above the black curve are periods of typically good observing conditions and vice versa.



Long time commitment for long period binaries