NPOI Progress since SPIE 2008

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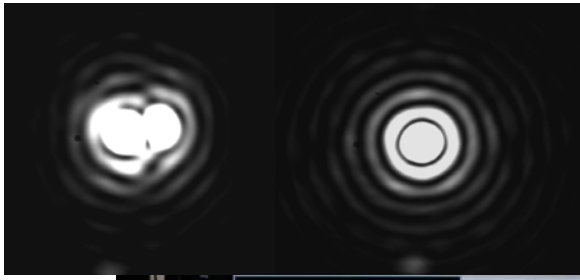
The "BASICS"

- NPOI is USNO/NRL collaboration, in association with Lowell Observatory
  - Lowell is science partner & contractor to USNO (infrastructure & ops)
- Astrometric array – perform very high precision astrometry of bright stars
- Compliments JMAPS, reducing major "problem stars" (binaries)
- Imaging array – test bed for synthetic aperture imaging

NPOI Progress since SPIE 2008

Current capabilities:



Overmon/Overcon GUIs

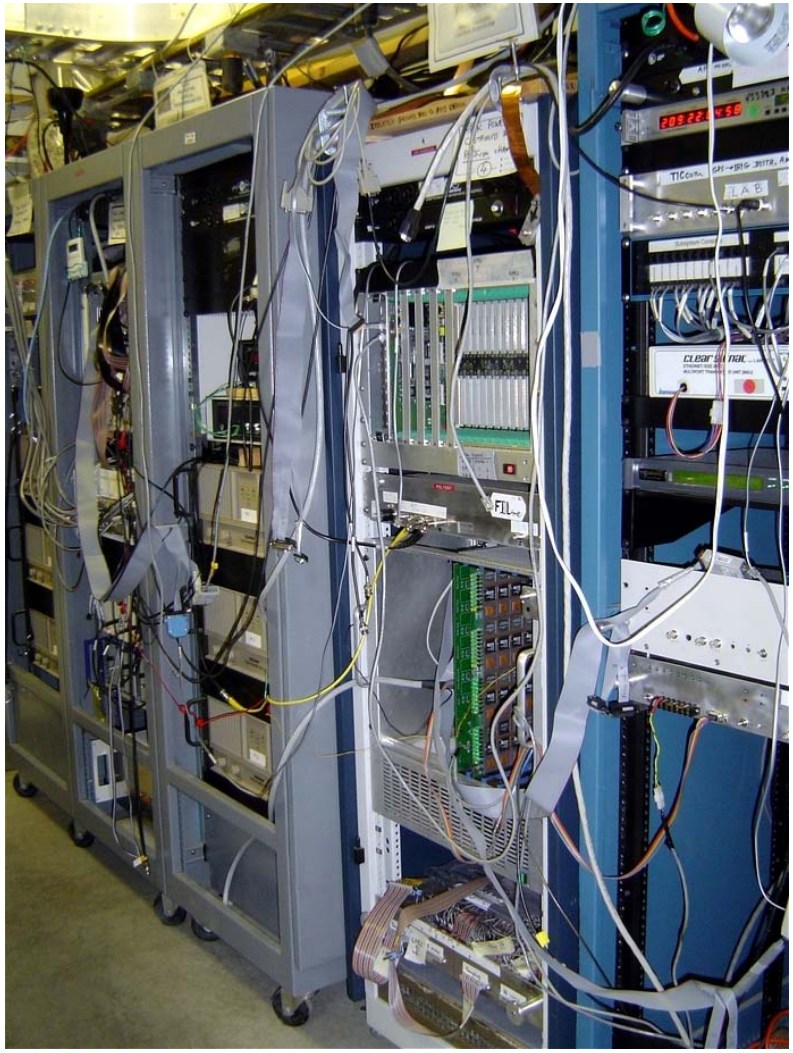
- With **new mirror coatings** & improved **beam overlap** control, fringe tracking at $m_v = 6.0$ now **routine**
- Improved wavefront quality (FDL optics) promises additional sensitivity.
- Above is before beam compressors or outrigger telescopes
- Operated by one observer, scheduled ~355 nights/year
- ~20K multi-baseline (30s) observations/year
  - In "imaging" mode, ~ **200 observations/night** (record 330)
  - Observations made on ~63% of nights
  - Nights lost: weather (32%) no observer (3%) equip./engineering (2%)

NPOI Progress since SPIE 2008

Control system upgrades in progress:

- PC-based siderostat controllers (3 installed)
- New acquisition camera controllers
- Prototypes for control of vacuum feed system configuration & alignment, instrument covers
- Full remote control via GUIs

Redesign of the FDL Engine



Immediate redesign important!

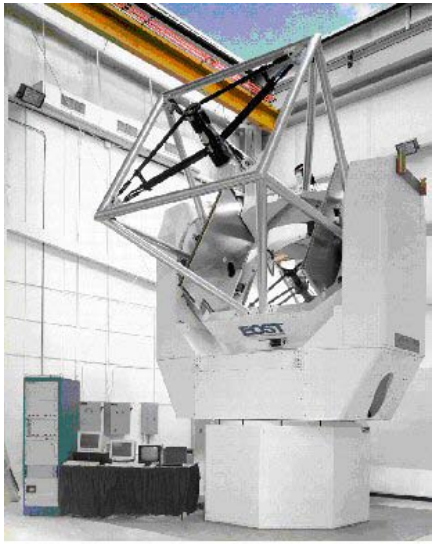
-Most components cannot be purchased anymore
-last spares already used
-'old' technology (we cannot program PLDs anymore)
-if FDL fails we cannot operate
-Fringe Engine needs to be redesigned next!

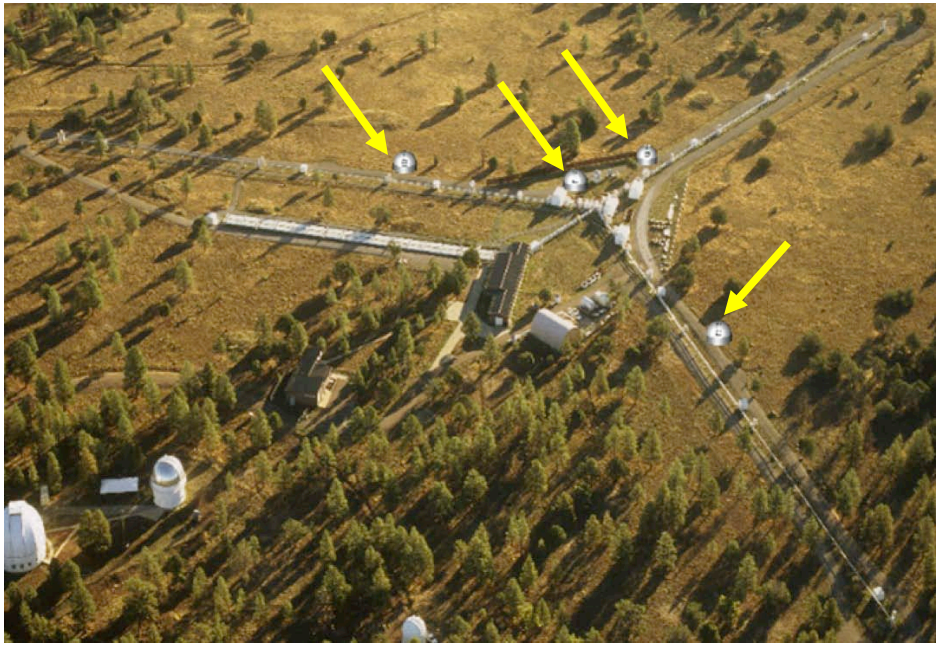
PC based FDL Engine

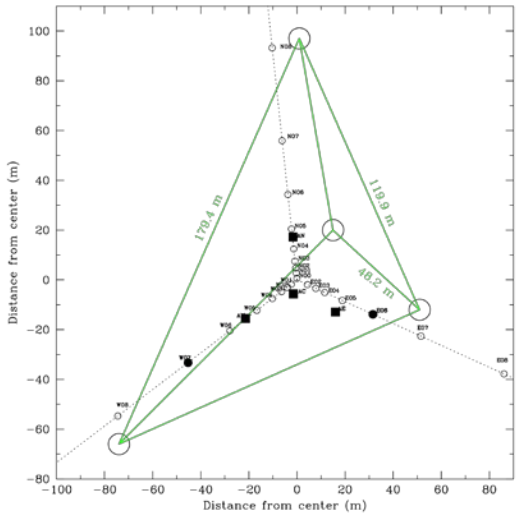
- based on real-time Linux
- >90% off-shelf components
- Built in "smart" diagnostics
- reliable and failsafe
- New metrology & fringe detection electronics

1.8 m Telescopes

- Four 1.8-m telescopes originally to be added by NASA to Keck Interferometer
- Adds capability for wide-angle astrometry & binary star studies on fainter sources (JMAPS support)
- Near IR capability for YSO & other studies/imaging

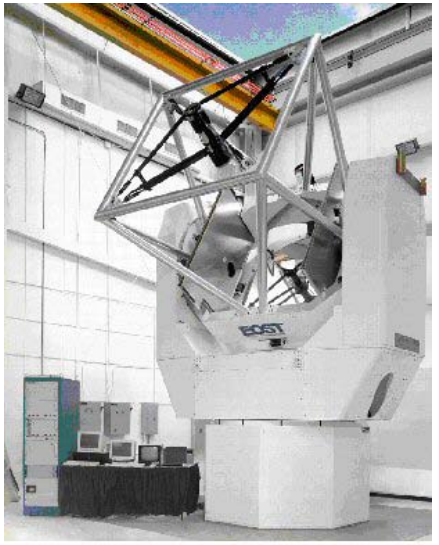


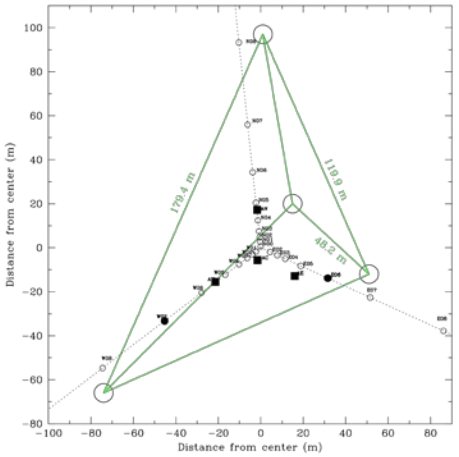




1.8 m Telescopes

- Present Status
  - Gift Letter from CARA
    - Four 1.8m telescopes
      - 3 in Tucson, 1 in Australia
    - Other items (domes, pipes, etc.) surplused
  - Letter approved at CNMOC, USFF & VCNO
    - Awaiting final acceptance by UNSECNAV
  - Preliminary site engineering studies completed
    - Standard domes, no dual-star feed
  - Preliminary discussions with USFS on permits
  - Seeking funding (DARPA, USAF, others)





Beam Combiner Upgrade

"Vision"

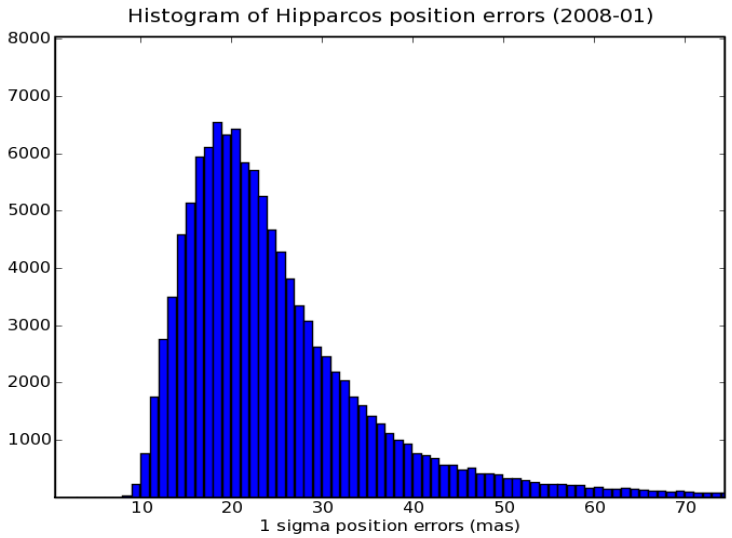
- NSF funded
  - PI: Matt Muterspaugh (Tennessee State Univ.)
- 6-beam, visible-light analog of MIRC
  - Spatial fringe modulation
- Development at TSU
  - Installation at NPOI ~ mid 2011

Current Research

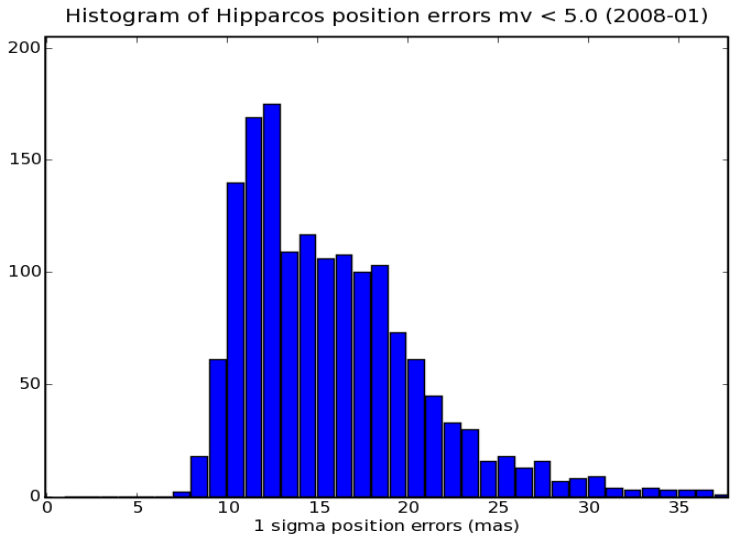
Wide-Angle Astrometry

- Astrometry needs to be referred to a common frame: International Celestial Reference Frame (ICRF)
  - Obtained by VLBI
  - Optical realization is defined to be the Hipparcos Catalog

- DoD requirement ≤ 16 mas accuracy in both RA & Dec
  - However: HIPPARCOS positions degraded (proper motions)

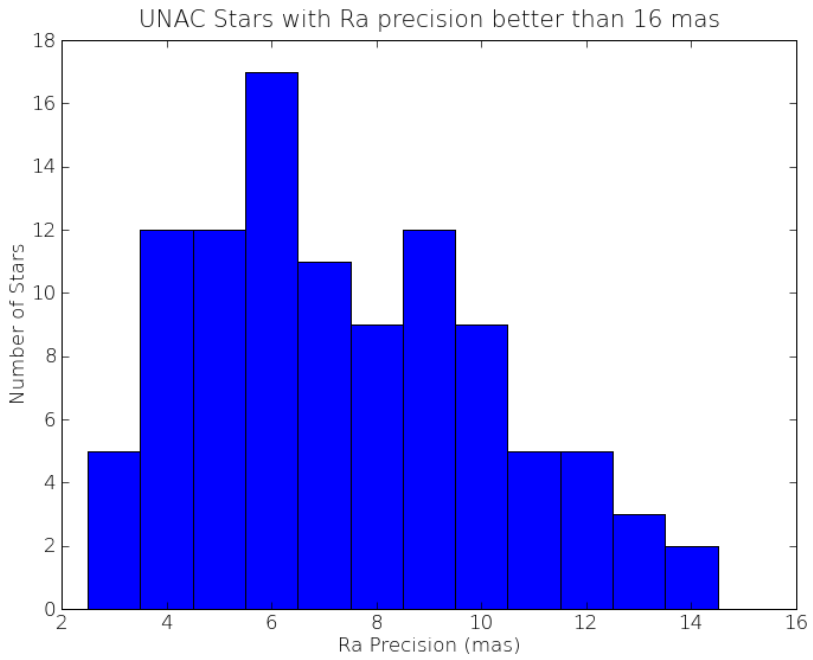


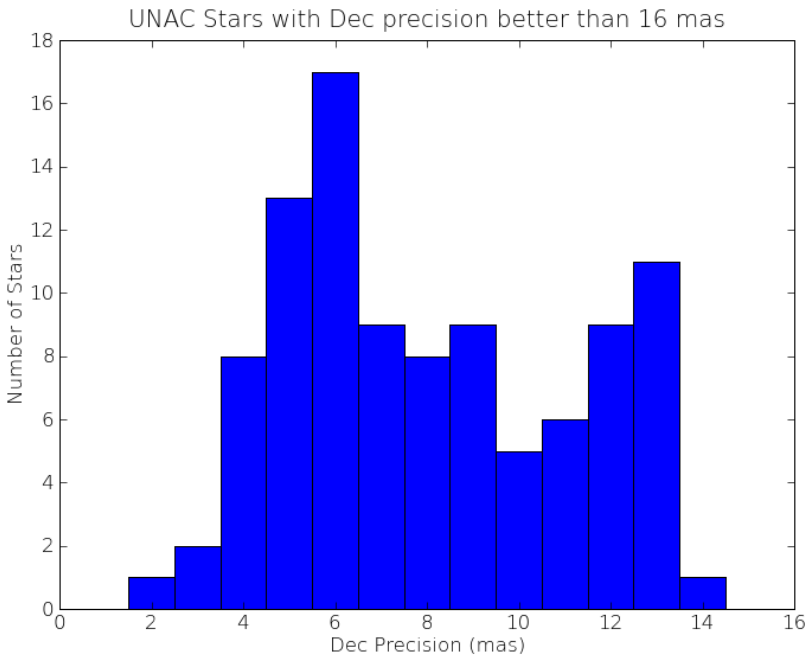
Hipparcos Position Errors: 2008.0



m_v <5.0 Position Errors: 2008.0

USNO-NPOI Astrometric Catalog (UNAC)





- UNAC now contains 115 stars with RA & Dec precisions < 16 mas
  - Median: 7.2 mas RA, 8.1 mas Dec

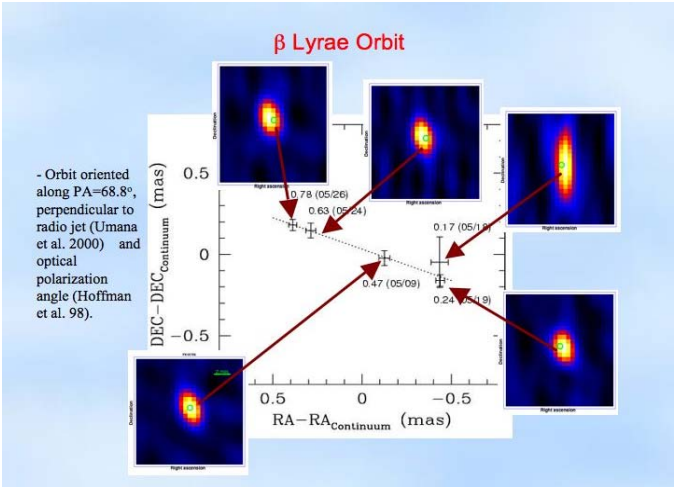
- Evaluating accuracy via comparison to other catalogs, NOFS observations

NPOI Binary Star Capabilities

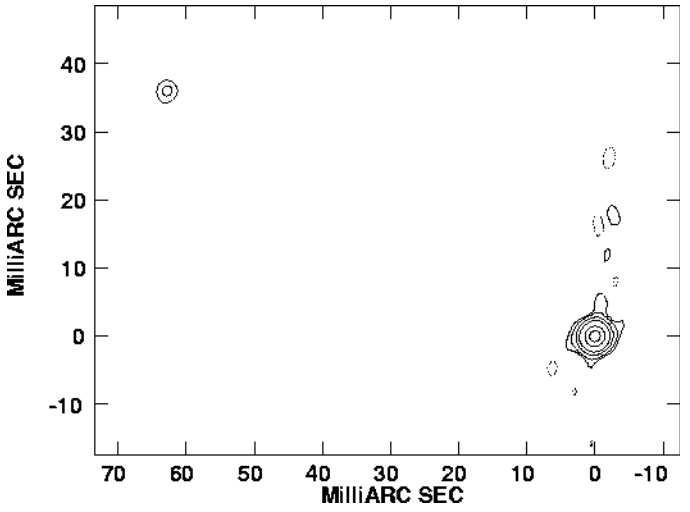
- Limiting Δm = 3.0 (V^2 data) for separations 3 – 300 mas (from known binaries)

- Binaries observed at angular separations <1 mas (β Lyr) to 700 mas (HD76943)

Schmitt et al. 2009, ApJ, 691, 984

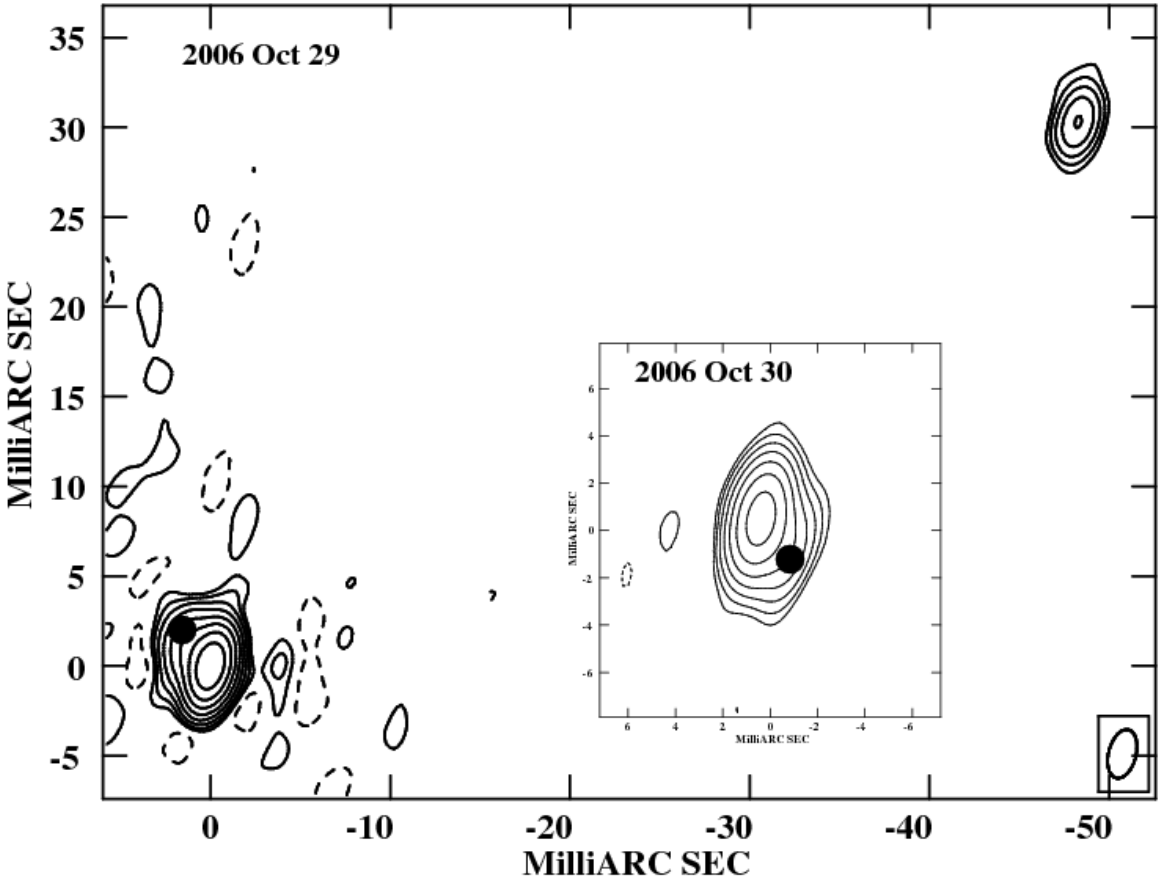


- *Binary detection possible in as few as 1-2 scans*
  - Example: 15 Mon (V = 4.7; Δm = 1.6)
  - Image from <u>one</u> 32 second scan!



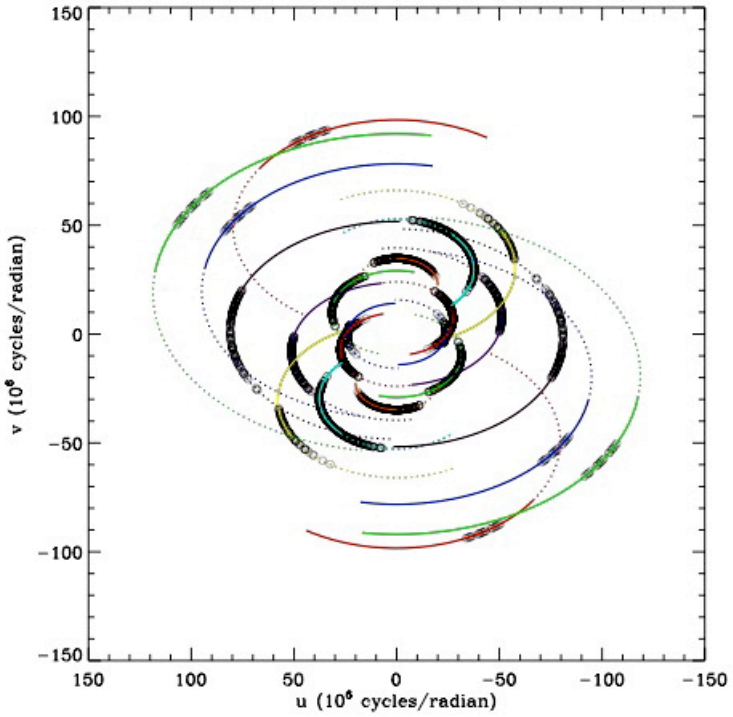
Hierarchical Triple systems

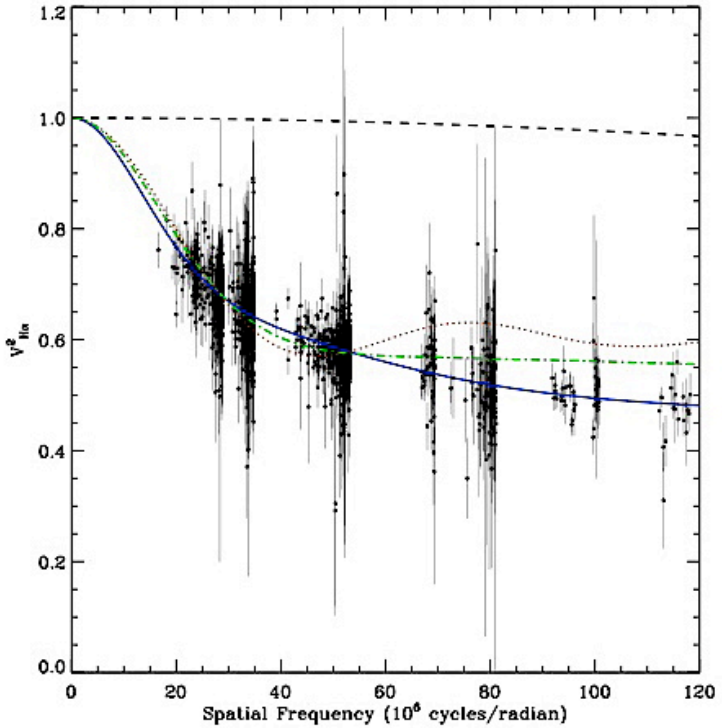
- Example: Algol (Zavala et al. 2009, ApJL, in press)
  - Simultaneous NPOI & radio (VLBI) mas-resolution images
  - Absolute astrometry via image registration ("B" is radio source)
  - Resolved all 3 optical components (orbital elements, Δm's, masses)



Hα-observations of P Cygni

- Hα flux from wind structure has profile unlike Be-star disks (non-Gaussian)
- Hα-emitting wind structure stable to 10% (2005-2008)

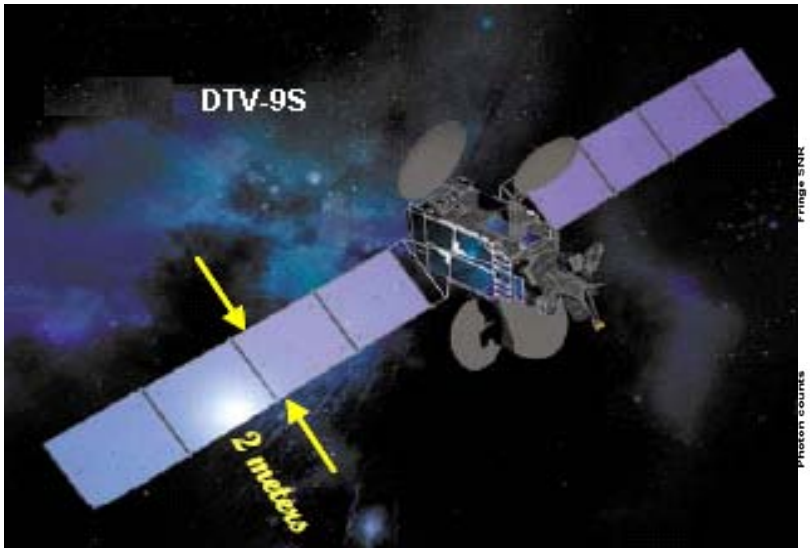


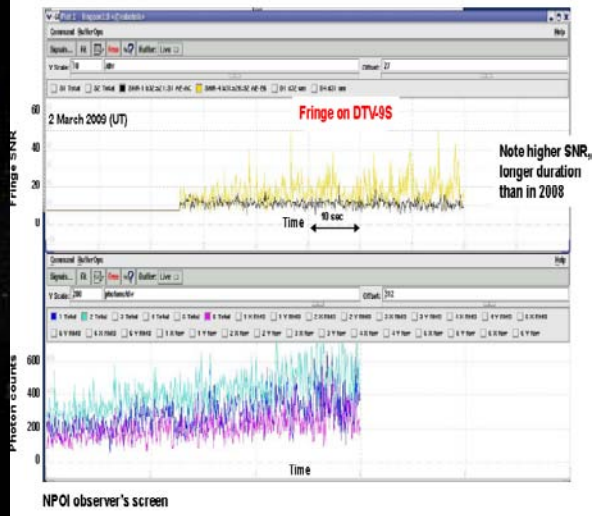


Balan et al. 2010, AJ, in press

GEOsatellite observations

- 1st-ever fringe tracking on geosynchronous satellite “glints” in 2008 & 2009
- Observations of DirecTV-9s modeled
  - 2-component model (71% of flux unresolved, rest resolved ~26 mas)





NPOI observer's screen

Armstrong et al. 2009, Proc. Adv. Maui Optical and Space Surveillance Technologies Conf., Wailea, HI.
Vrba et al. 2009, ibid.

NPOI Progress since SPIE 2008

Other projects:

- Combining coherent averaging, phase referencing, self-calibration
  - ***ζ Dra (Δm = 3 binary):*** *Coherent averaging applied (SPIE paper)*
  - ***η Vir (triple system):*** *Imaging with baseline phases à la β Lyrae (SPIE)*
  - ***Solar analogs:*** *Preliminary results on precise diameter measurements*

- Exoplanet host stars: Diameters, evolutionary status