NPOI Update

1 March 2011

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U.S. Naval Observatory Flagstaff Station

NPOI Update

The "BASICS"

- NPOI = Navy Prototype Optical Interferometer
- NPOI is USNO/NRL collaboration, in association with Lowell Observatory
- Lowell is science partner & contractor to USNO (infrastructure & ops)
- Astrometric array – high accuracy catalog of bright stars (update Hipparcos)
- Imaging array – test bed for synthetic aperture imaging
- Funded by Oceanographer of the Navy and Office of Naval Research

NPOI Update

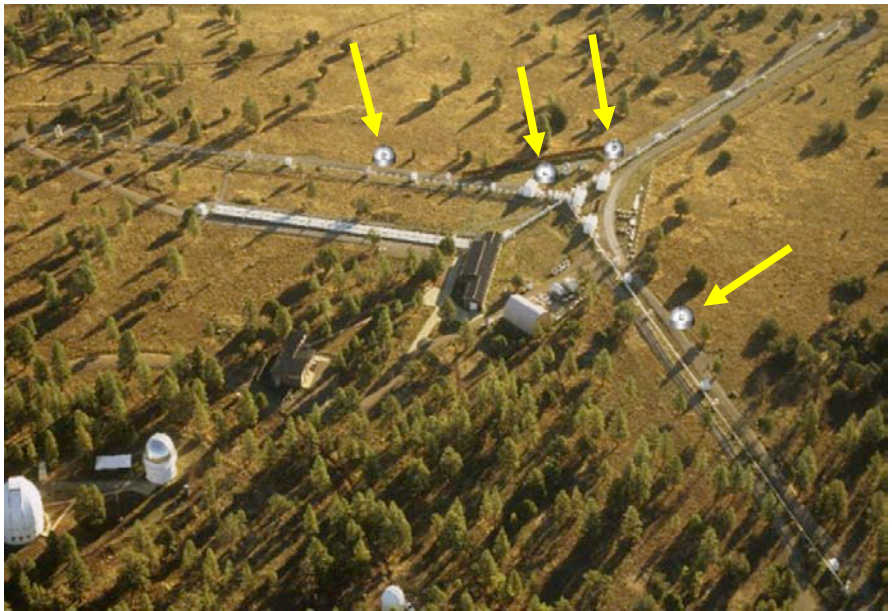
Current Capabilities:

- Simultaneous, group-delay fringe tracking on 1 to 6 baselines
- Bandpass 550-850nm in 16 channels (R ~ 30-50)
- Single-baseline fringe tracking to $m_v = 6.7$
- Multi-baseline fringe tracking w/closure phase to $m_v = 6.0$
- Operated by one observer, scheduled ~355 nights/year
  - e.g. calendar 2010:
    - »27,729 multi-baseline observations (30s fringe data each)
    - »Observations collected over 207 nights (57%)
    - »149 nights lost to weather (41%), 8 nights for holidays (2%)
    - »Only 1 full night (<<1%) lost to equipment problems

NPOI Update

Upgrades in Progress:

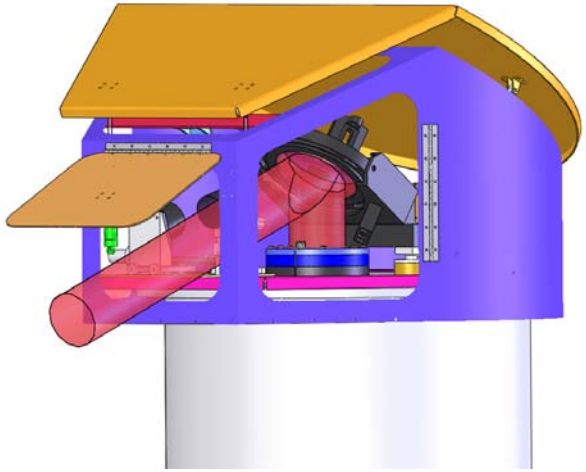
- **1.8 m telescopes:**
  - Undersecretary of Navy accepted gift of telescopes from CARA on 3 Nov 2010
  - No-cost contract for (eventual) transfer of 4th telescope from Australia in preparation
  - Contract for construction plans (civil, structural & electrical) in preparation (& funded)
  - Will specify dome vendor soon (March)
  - Lowell & consultant working with US Forest Service to determine permit requirements
  - Seeking funding (DARPA, USAF, others)



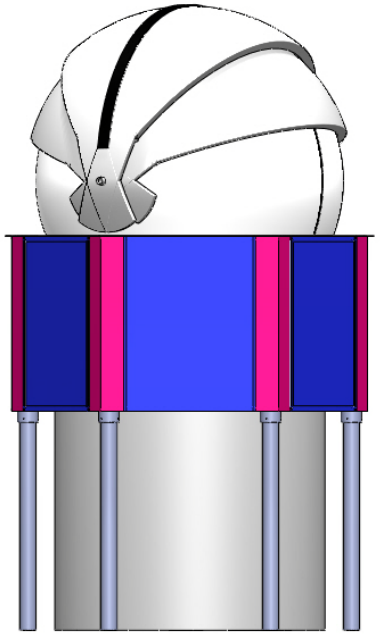
NPOI Update

Upgrades in Progress (2):

- New enclosures for star acquisition & tip-tilt optics under construction
  - All 6 imaging stations, install & commission May-Sept 2011



- New dome under design for last 3 imaging siderostats
  - Baselines to 437m, install 2012
  - Dome & frame can be lifted together for move to another station.



NPOI Update

Upgrades in Progress (3):

- Long Delay Line (LDL) “pop-up” mirrors installed at all 36 stations (up to 440m delay)

- Currently assembling prototype of new “periscope” assembly (interface to LDLs)

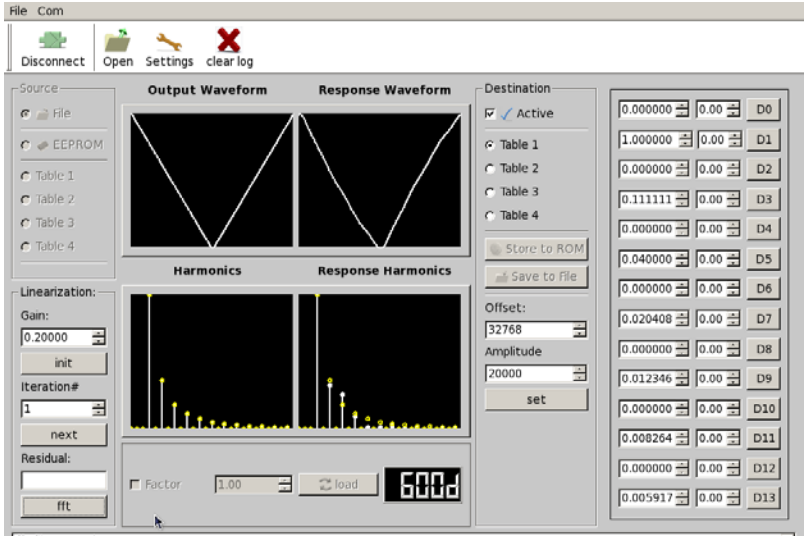
- Prototype controller boards completed
  - Require programming and GUI interface
  - Testing w/periscope ~ Jan 2012

NPOI Update

Upgrades in Progress (4):

- PC-based Fast Delay Line (FDL) Engine (mid 2012):
  - Based on real-time Linux, 90% off-shelf components
  - New 2MHz metrology detection & (delay dither) piezo electronics:
    - » achieves 800 samples / 2ms FDL piezo stroke
    - » allows highly accurate calibration of piezo response
    - » reduces cross-talk in multi-baseline observations

- New stellar fringe engine Implementation
  - » will allow increased bandpass (450-850nm, 32 channels)
  - » will allow use of all beam combiner outputs



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Upgrades in Progress (5):

- Realigning optics of FDL carts w/Zygo interferometer (finish mid-2011)
  - increase limiting m_v ~ 0.75 mag.

- "Vision" beam combiner:
  - NSF funded, PI: Matt Muterspaugh (Tennessee State Univ.)
  - 6-beam, visible-light analog of MIRC
  - test fiber inputs at NPOI in March
  - complete installation in late 2011

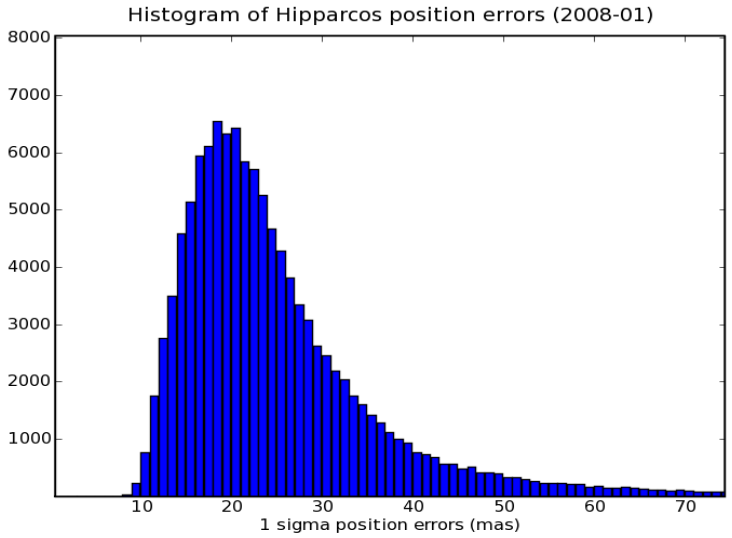
Current Research

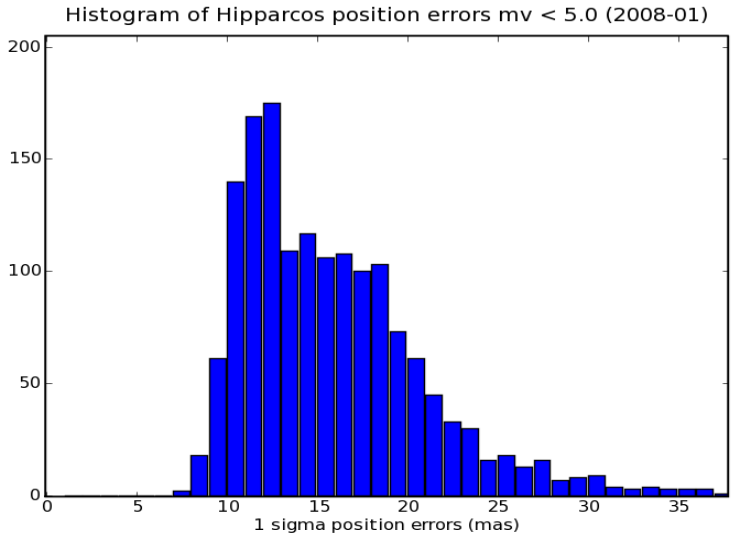
NPOI Update

USNO – NPOI Astrometric Catalog (UNAC):

- 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)

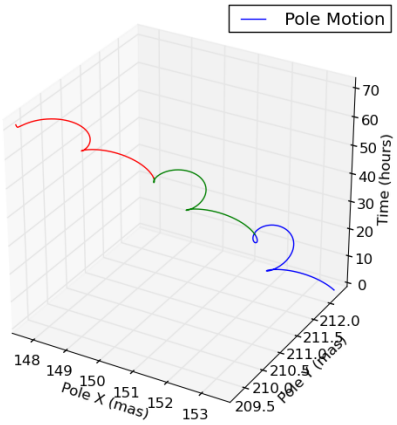


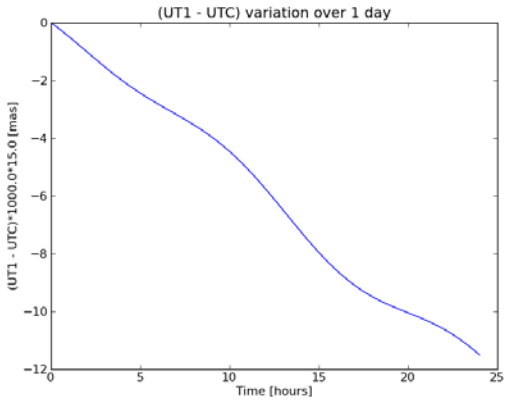


NPOI Update

UNAC (2):

- At present, have 116 stars that show astrometric precisions < 16 mas.
- To evaluate accuracy, will soon run all data through an improved data processing pipeline, that includes the following:
  - Incorporates the recently released NOVAS 3.0 that has several improvements that, at the levels important for UNAC, significantly affect the accuracy of calculations of *absolute* (not differential) stellar apparent positions.
  - A more robust method that ensures that we only use data (in a per baseline manner) recorded during the time that the fringe tracker was truly locked on the fringe.
  - Add full, simultaneous solutions that use all baselines present.

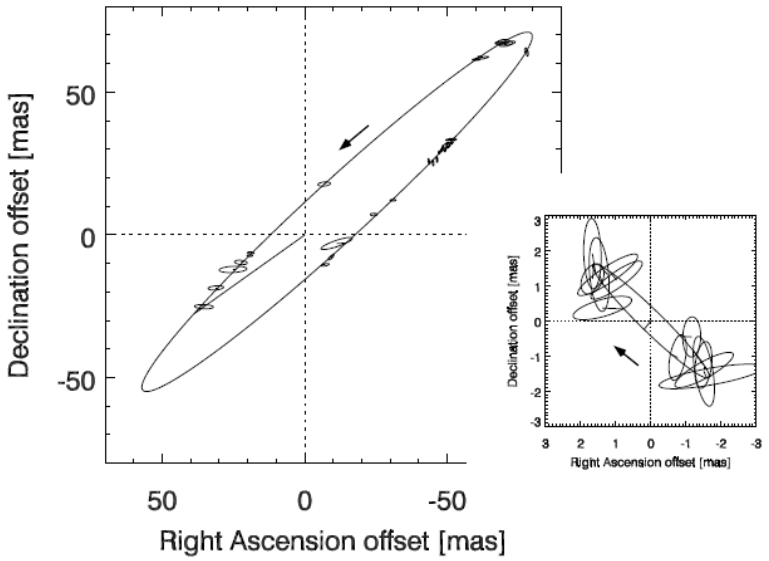




NPOI Update

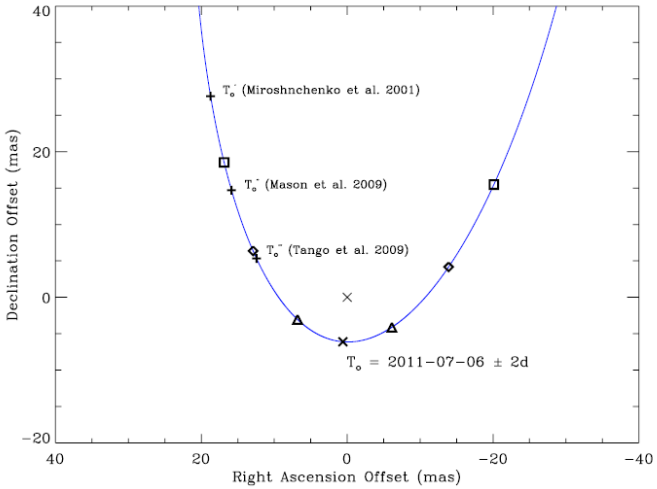
Binary Stars:

- NPOI improving orbits of radio star systems for possible use in UNAC frame tie to ICRF:
  - orbits of all 3 Algol components & PA ambiguity of C-component solved
  - 5 other radio binaries mv ≤ 6.5 under observation



Zavala et al. 2010, ApJL, 715, L44

- Be star disks & binaries
  - δ Sco: date of periastron passage revised to UT2011 Jul 6±2d



Tycner et al. 2011, ApJ, 729, L5

NPOI Update

Binary Stars(2):

- NPOI supports USNO-DC (Brian Mason) by routinely observing speckle binaries:

  ~ 12 systems to improve speckle orbits (especially near periastron)

- Numerous observation requests fulfilled for NPOI collaboration:

  - Lisa Prato (Lowell): faint (V ≤ 6.7) Pop II binaries

  - Jenny Patience (U. Exeter): B-star multiplicity survey

  - Zavala (USNO) & Prato: O-star masses

  - Otto Franz (Lowell), Henrique Schmitt (NRL) & Zavala: various faint binaries

  - Christian Hummel (ESO): triple systems

NPOI Update

K III & Exoplanet Host Stars

Baines et al.

Interferometric diameters (NPOI, CHARA) compared to photometric diameters (Kervella (B–V) vs. log θ_{LD} relation)