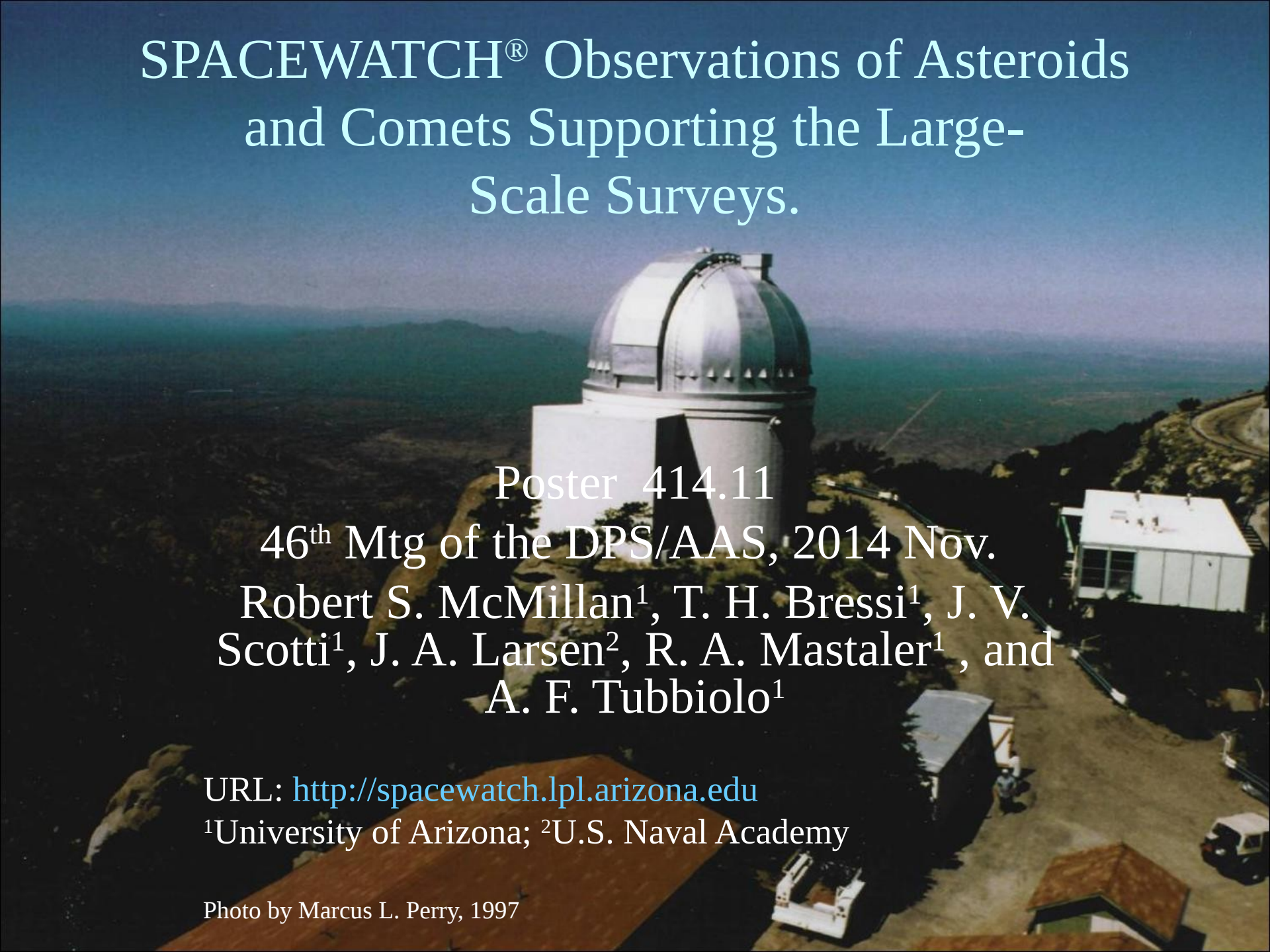
SPACEWATCH® Observations of Asteroids and Comets Supporting the Large-Scale Surveys.



Poster 414.11

46th Mtg of the DPS/AAS, 2014 Nov.

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URL: http://spacewatch.lpl.arizona.edu

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Photo by Marcus L. Perry, 1997

Summary

- Follow-up of "large" NEOs (H≤22) as they recede from Earth after discovery and become fainter, as well as VIs, PHAs, & NEOs observed by WISE.
- New, faster-reading CCD on 1.8-meter telescope.
- Observed at elongations as small as 46°.
- ~2800 tracklets of NEOs from Spacewatch accepted by MPC each year.
- Big, long archive from 0.9-m telescope to support precoveries.

Why Targeted Followup is Needed

- Discovery arcs too short to define orbits:
  - Followup observation intervals need to be thousands of times longer than discoveries.
- Objects can escape redetection by surveys:
  - Surveys too busy covering other sky.
  - Objects tend to get fainter after discovery.
- Sky density of detectable NEOs is too sparse to rely on incidental redetections alone.

Why More Followup is Needed

- 1/3rd of PHAs observed on only 1 opposition.
- 1/6th of PHAs' arcs <30^{d}.
- ~Half of potential close approaches in the next 30 years will be by objects observed on only one opposition.
- 2/3^{rds} of H≤22 VI's on JPL risk page *are lost* and > half of those were discovered within the last 6 years by modern surveys.

How “lost” can they get?

- (719) Albert discovered visually in 1911.
- “Big” Amor asteroid, diameter ~2 km.
- Favorable (perihelic) apparitions 30 yrs apart.
- Missed in 1941 due to inattention.
- Missed in 1971 due to large uncertainty.
- MPC recognized (719) as a rediscovery by Spacewatch in 2000.

1979 XB: A “Big” Lost “VI”!

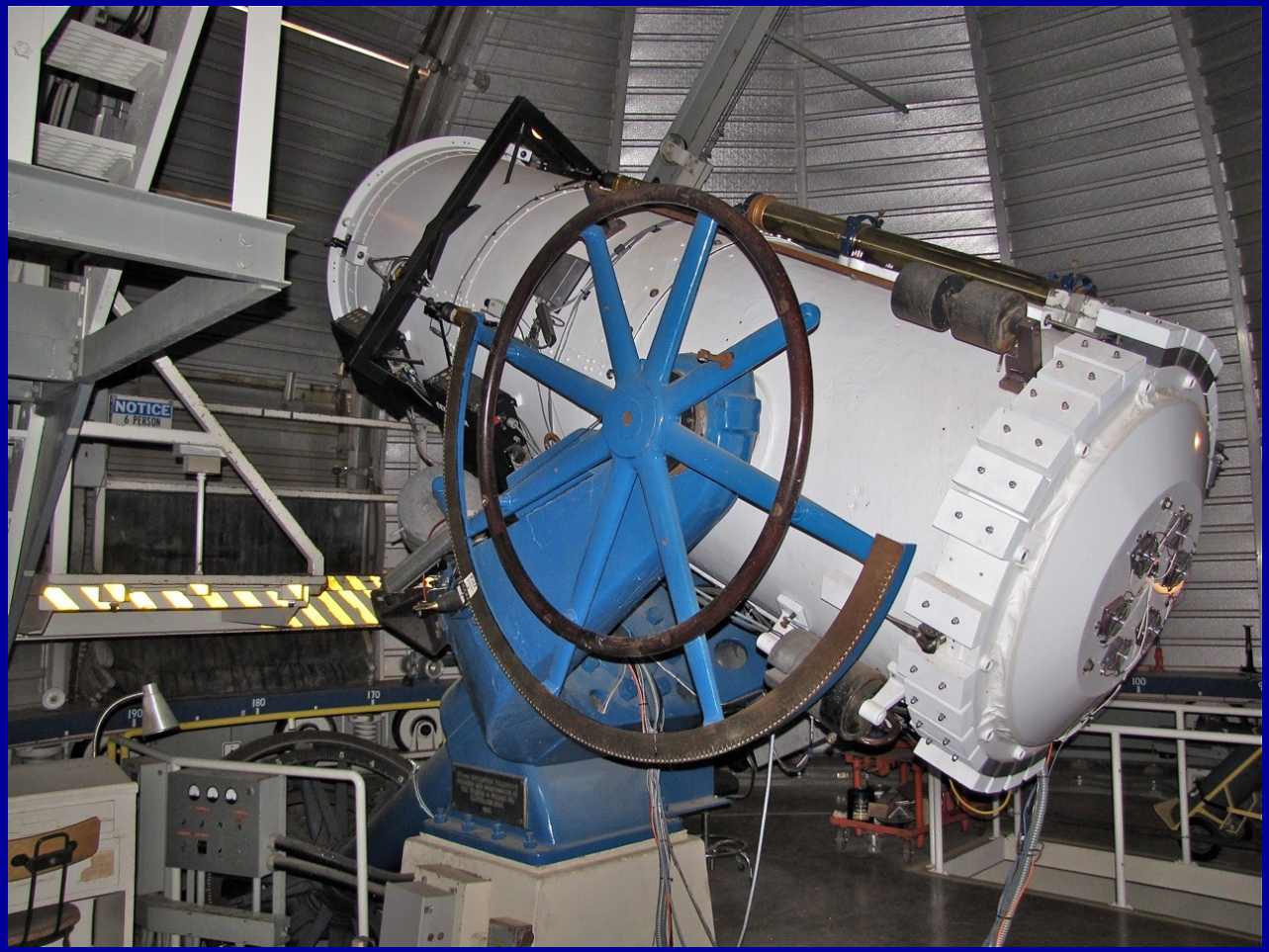
- 4-day observed arc in 1979 December.
- H ≈ 18.5 ↔ Diameter 370-1200 m.
- Synodic period ≈ 1.4y.
- Possible close encounters in 2056 & 2086.
- Not rediscovered in >3 decades of modern surveying.

0.9-m Telescope Modernized by Spacewatch in 2002

- Hyperboloidal primary & refractive field corrector.
- Mosaic of 4 CCDs.
- Bandpass ≈ 0.5-0.9 μm; λeff ≈ 0.7 μm.
- Began 2003 April; 24 nights per lunation.
- Automated in 2005 May.
- Patterns near opp'n, & low elongation in east.
- 1400 deg^2 per lunation; V mag ≈ 20.5-21.7.

0.9-m Telescope; Site Code 691

Photo by Roger Carpenter, 2012 Feb



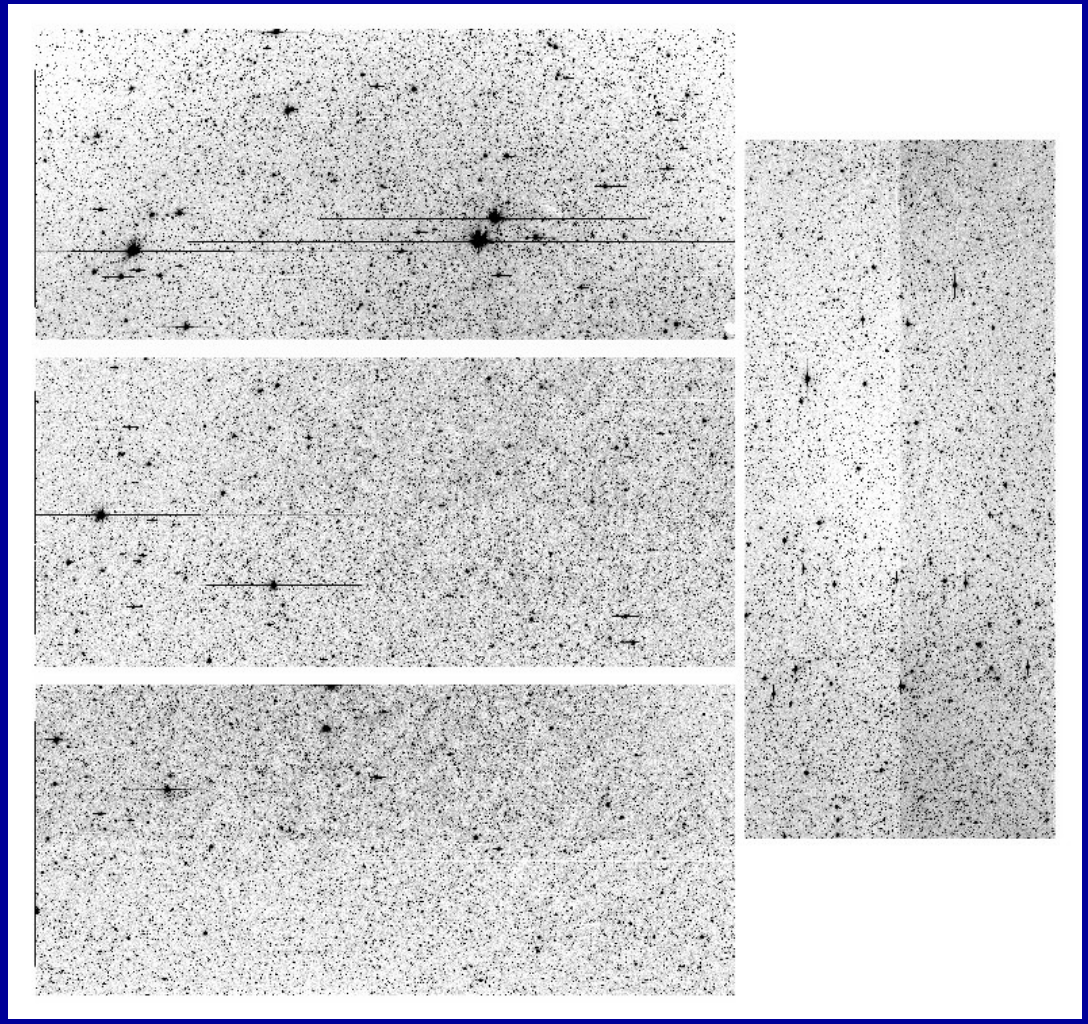
Spacewatch CCD Mosaic on 0.9-m telescope.

Four EEV Grade-1, back-illuminated, antireflection-coated CCDs of 4608x2048 pixels each.

37 million pixels.

1 arcsec per pixel.

2.9 deg^2 covered.



Archive from Mosaic on 0.9-m:

- Revisits @ 4^{d} intervals aid MBA linkages.
- ~20 TB in size.
- 11.5 yrs of uniformly conducted surveying.
- Incidental astrometry & precoveries of NEOs.
- V mag limit ~20-21.
- Coverage ~1400 deg^{2} per lunation (3 passes per pointing) mostly along ecliptic and low-elongation in the east.

Spacewatch 1.8-meter Telescope on Kitt Peak; Site code 291

New CCD in 2011 Oct:

FOV = 20′×20′.

Scale = 0.6 arcsec/pixel.

Bandpass ≈“V+R+I”.

Faster readout.

Limit V=23.

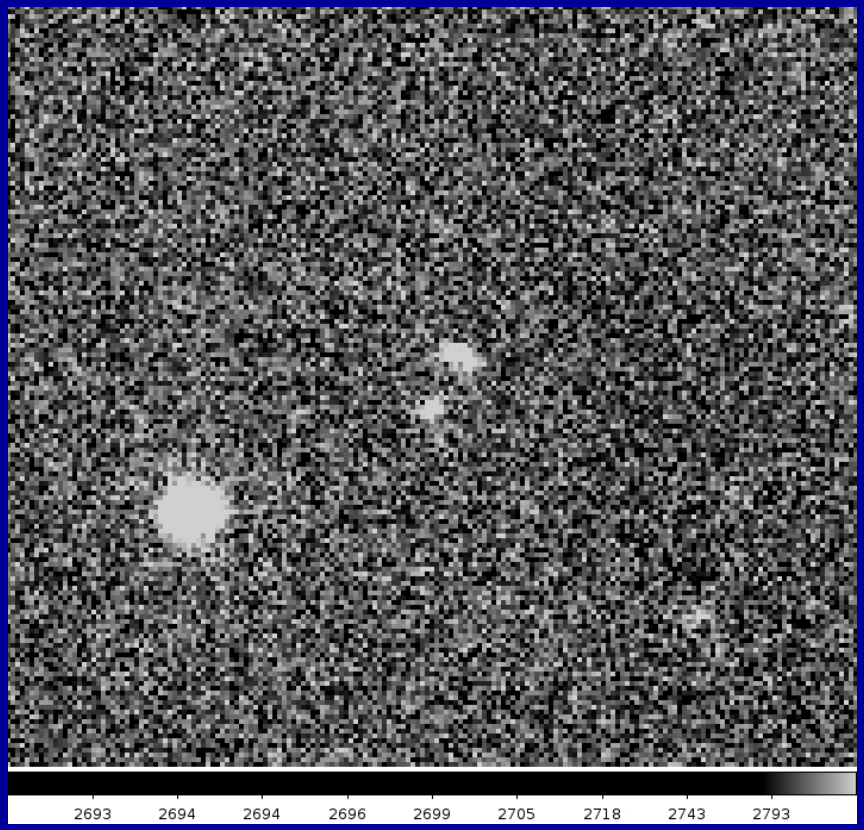
50% more obs per year.

Astrometric resids ≈**0.3 arcsec,** *vs.* 0.6 on NEOs with the old CCD.

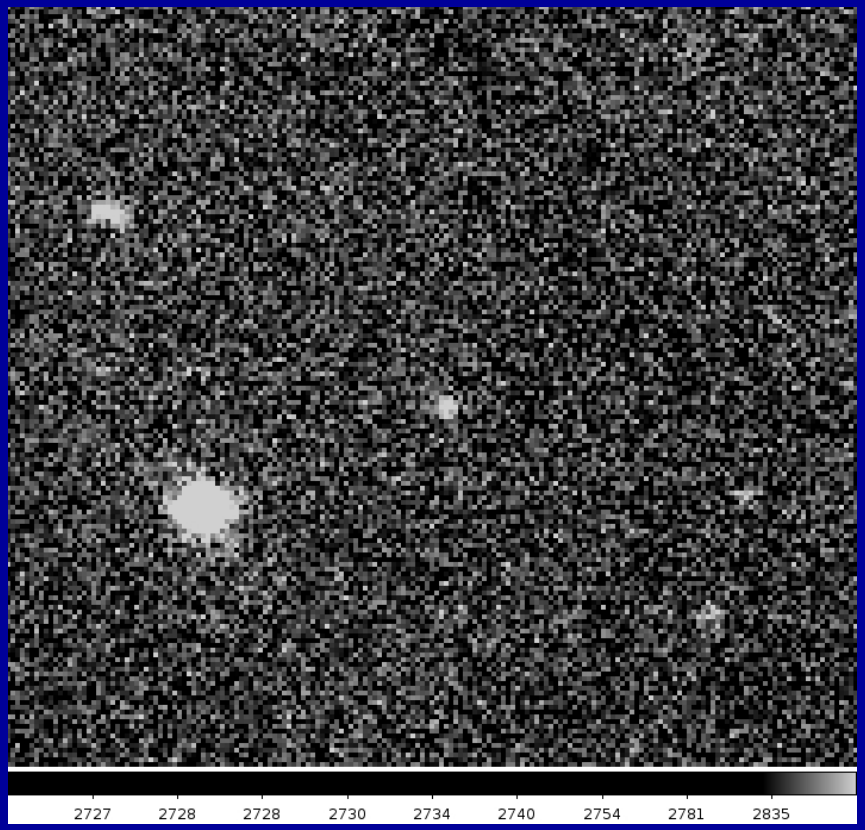
Photo by Roger Carpenter, 2012 Feb.

2014 SE145 on 2014 Sep 23, Spacewatch 1.8-m. R=18, 5 sec exp.

12:11:29 UT



12:12:21 UT



2014 SE 145: MPEC 2014-S75

Orbital elements: Earth MOID = 0.01 AU
 a=2.2 AU e=0.55 Incl=8 deg P=3.33 yr
AbsMag = 27.5V Orbital element Uncertainty U=6

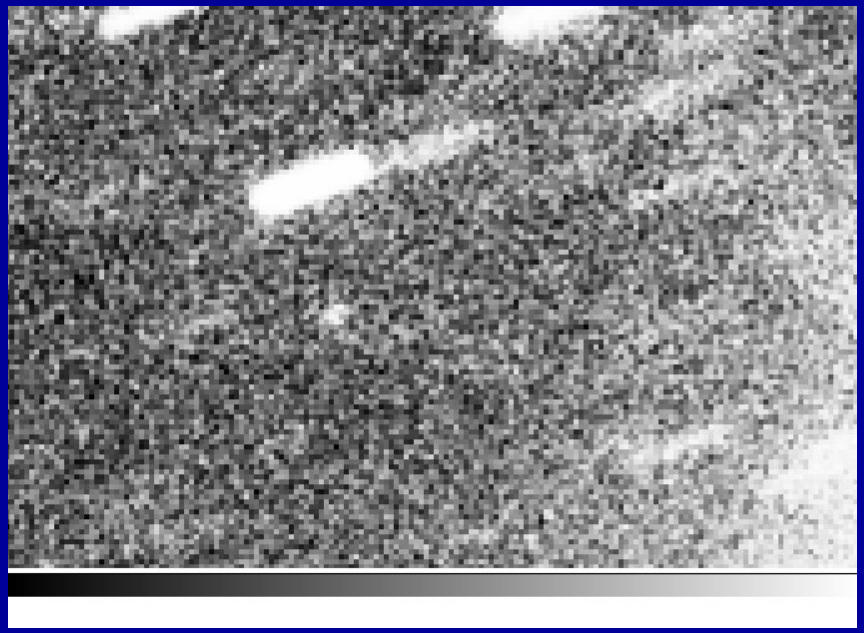
Residuals in seconds of arc

140923 I41(-12.4 +6.5) 140923 291 -0.2 +0.1 140924 474 -0.4 +0.3
140923 I41(-16.2 +6.4) 140924 104 0.0 -0.2 140924 474 -0.3 -0.2
140923 291 +0.1 -0.1 140924 104 +0.1 +0.1 140924 474 +0.5 -0.2
140923 291 0.0   0.0 140924 104 -0.2 +0.1 140924 474 +0.2 +0.1

2014 SN1 (F51 disc., formerly a VI), diam=20-80 m, V=22.5, 0.7 arcsec/min.

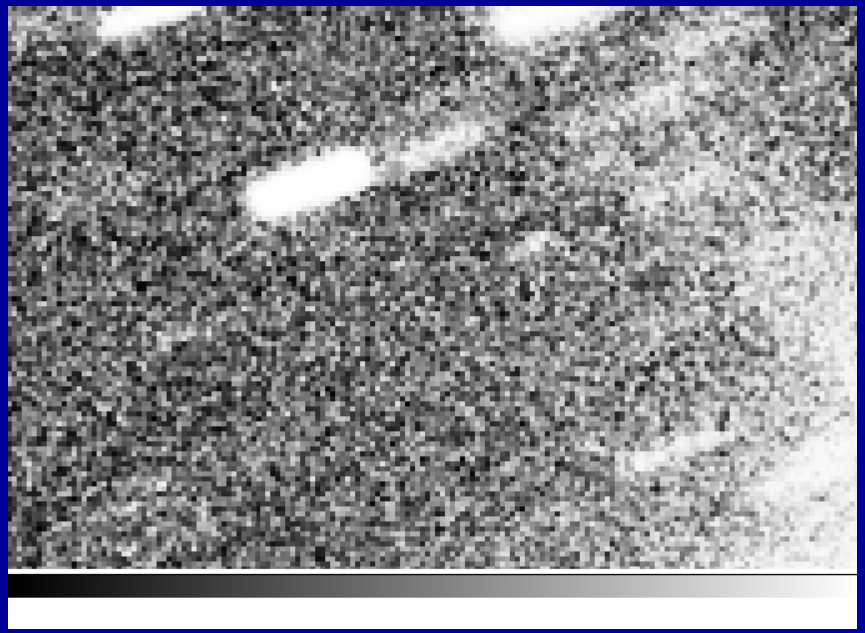
2014 Oct 1 04:29:04

14x120 sec stacked exp's.



2014 Oct 1 05:06:32

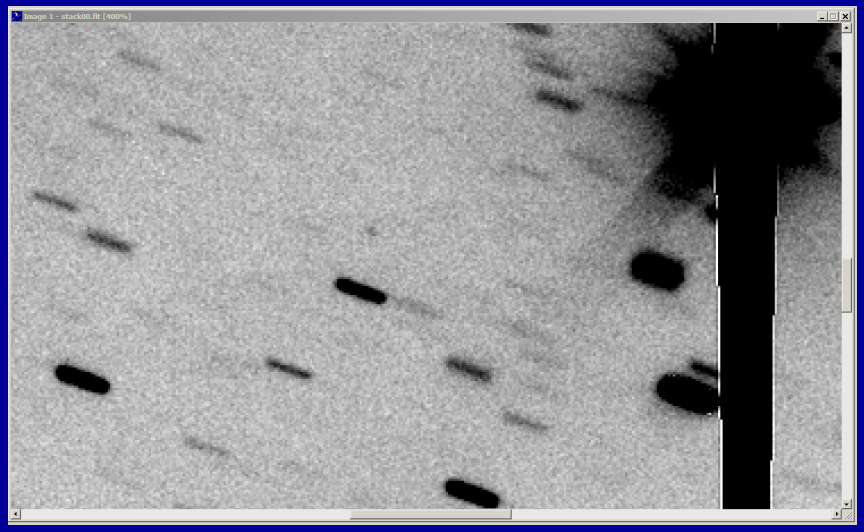
14x120 sec stacked exp's.



2014 SR261 (G96 discovery, VI), diam=7-30 m, V=22.5, 0.2 arcsec/min.

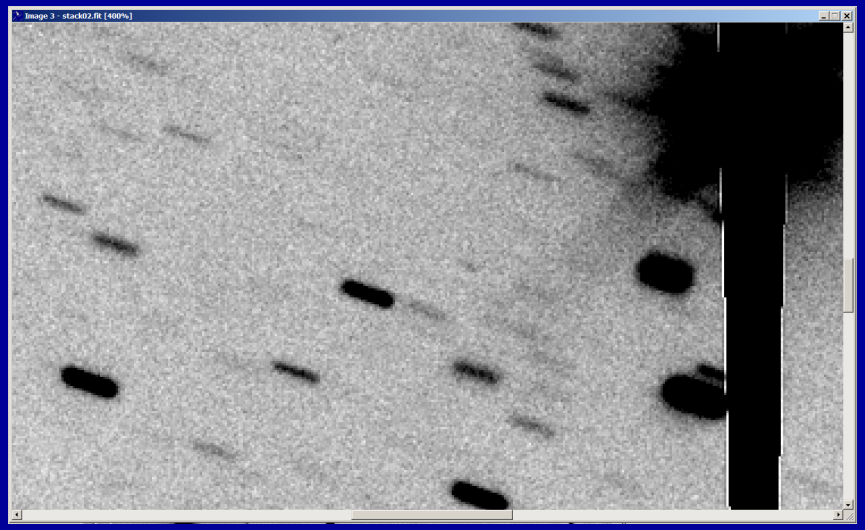
2014 Oct 1 07:55:00

14x120 sec stacked exp's.

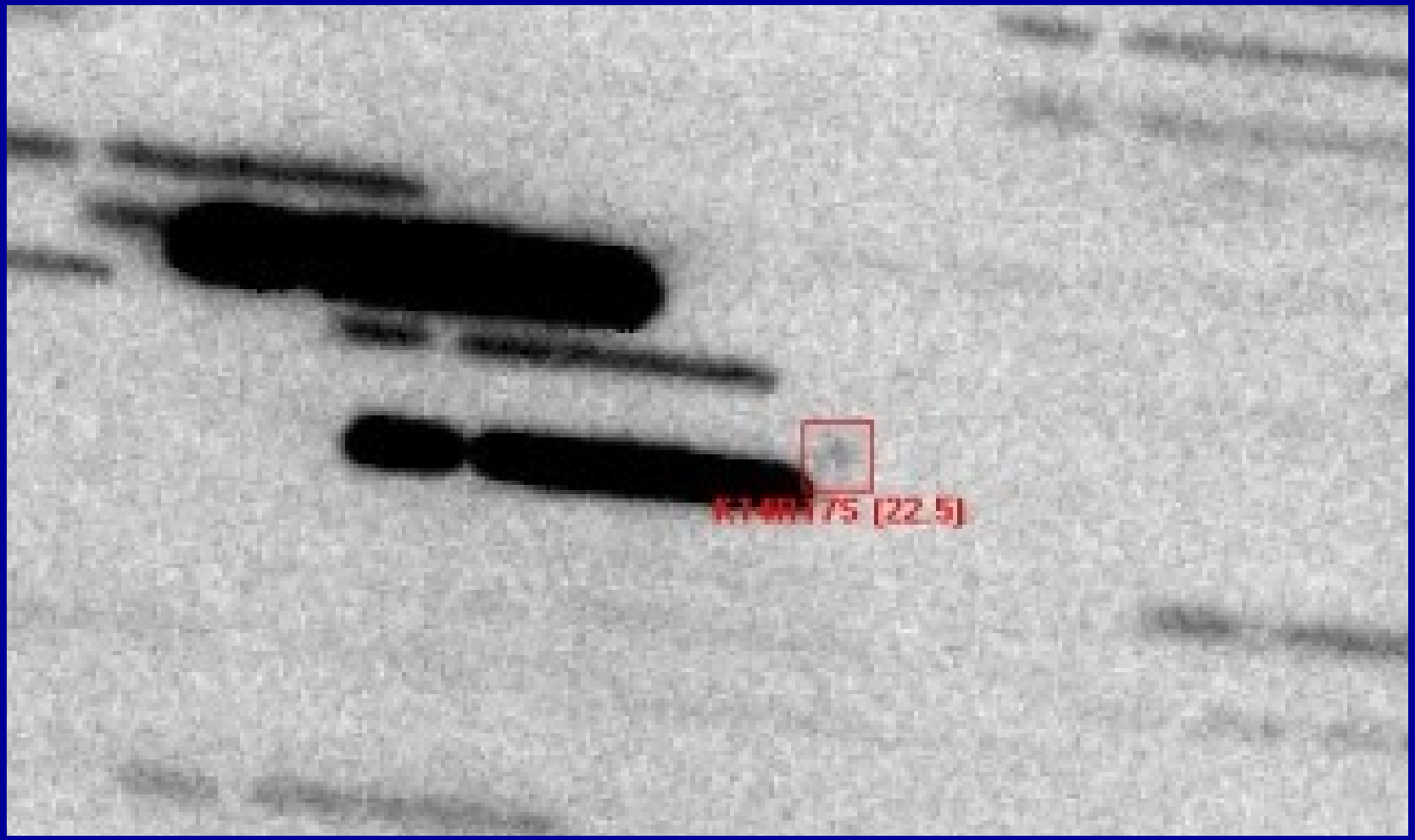


2014 Oct 1 08:32:28

14x120 sec stacked exp's.



2014 RS17: Former VI, disc COD 703, R=22.5, diam=40-150 m, 0.6 arcsec/min, 2014 Oct 1 06:00:34. 18 stacked exp’s @120 sec.

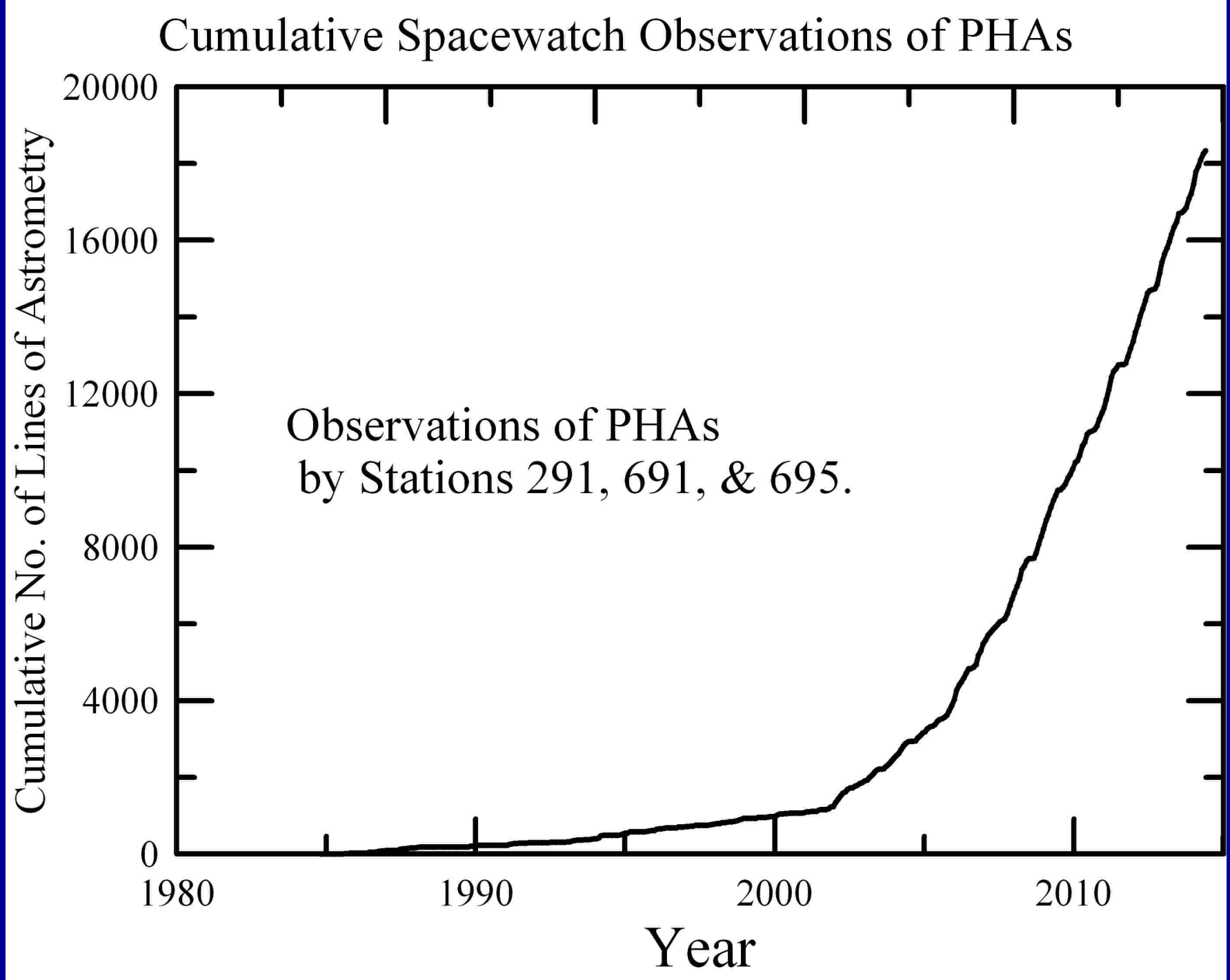


Recent Spacewatch Results

- Annual average of 8,492 lines of astrometry of 1,018 different NEOs including 177 different PHAs /yr.
- Contributed to the removal of half of the objects that were retired from JPL's impact risk list.
- Per year we observe…
  - about 35 radar targets,
  - 50 NEOs that were measured by NEOWISE, and
  - 100 potential rendezvous destinations.

Spacewatch Contributions

- Between 2011 Oct 16 & 2014 Sep 25 Spacewatch observed:
  - 50% of all NEOs observed in that time.
  - 54% of all PHAs observed in that time.
- Leading station in followup of provisionally designated PHAs while faint (V≥ 22); contributing 41% of all such observations.


Cumulative Spacewatch Observations of PHAs
Cumulative No. of Lines of Astrometry
20000
16000
12000
8000
4000
0
Observations of PHAs
by Stations 291, 691, & 695.
1980
1990
2000
2010
Year

Needs of Followup Campaign (besides money).

- Get longer arcs during discovery apparitions:
  - Require longer arcs for posting on NEO CP.
  - Keep provisional desigs. on the NEO CP.
  - Help us get more time on larger telescopes.
- More focused selections of targets in MPC's NEA Observation Planner:
  - NEOWISE, NHATS, Radar, comet candidates.

Acknowledgements

- NASA’s NEO Observation Program.
- The IAU’s Minor Planet Center.
- JPL’s NEOWISE Team led by A. K. Mainzer.
- JPL’s NEO Office.
- The U. S. Naval Academy.
- The estates of R. L. Waland and R. S. Vail.
- Other private donors.