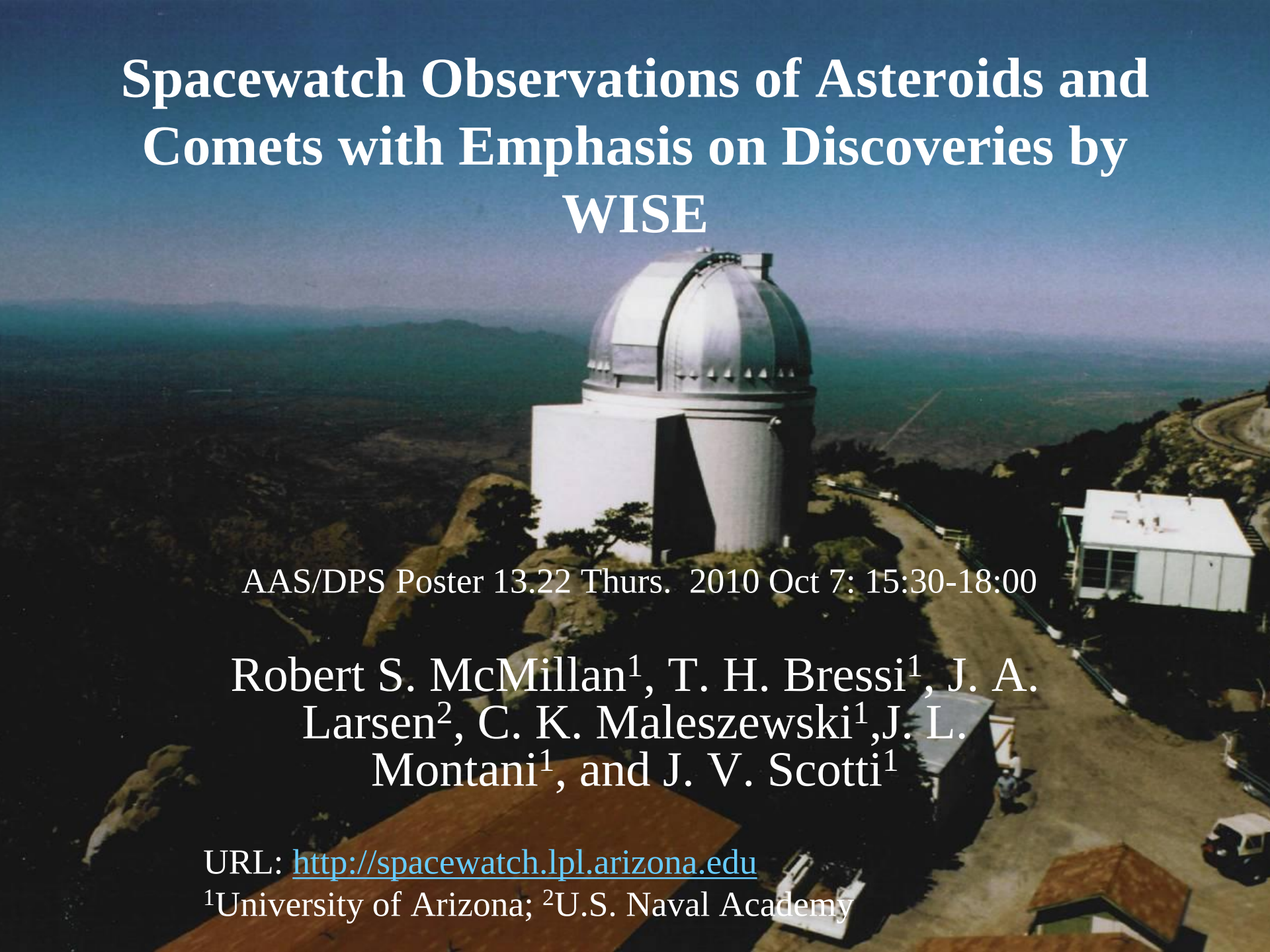
Spacewatch Observations of Asteroids and Comets with Emphasis on Discoveries by WISE



AAS/DPS Poster 13.22 Thurs. 2010 Oct 7: 15:30-18:00

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Abstract

- Targeted recoveries of objects discovered by WISE as well as those on impact risk pages, NEO Confirmation Page, PHAs, comets, etc.
- ~1900 tracklets of NEOs from Spacewatch each year.
- Recoveries of WISE discoveries preserve objects w/ long P_{syn} from loss.
- Photometry to determine albedo @ wavelength of peak of incident solar flux.
- Specialize in fainter objects to V=23.
- Examination for cometary features of objects w/ comet-like orbits & objects that WISE IR imagery showed as comets.

Why Targeted Followup is Needed

- Discovery arcs too short to define orbits.
- Objects can escape redetection by surveys:
  - Surveys busy covering other sky (revisits too infrequent).
  - Objects tend to get fainter after discovery.
- Followup observations need to outnumber discoveries 10-100.
- Sky density of detectable NEOs too sparse to rely on incidental redetections alone.

Why Followup is Needed (cont'd)

- 40% of PHAs observed on only 1 opposition.
- 18% of PHAs' arcs $<30^{d}$; 7 PHAs obs. $< 3^{d}$.
- 20% of potential close approaches will be by objects observed on only 1 opposition.
- $1/3^{rd}$ of $H \leq 22$ VI's on JPL risk page *are lost* and half of those were discovered within last 3 years.

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 ≈ 1.4^{y}.
- Possible close encounters in 2056 & 2086.
- Not rediscovered in >3 decades of modern surveying.

0.9-m Spacewatch Telescope

Hyperboloidal primary & refractive field corrector.

4-CCD Mosaic.

Bandpass ≈ 0.5-0.9 μm;

λeff ≈ 0.7 μm.

Began 2003 April.

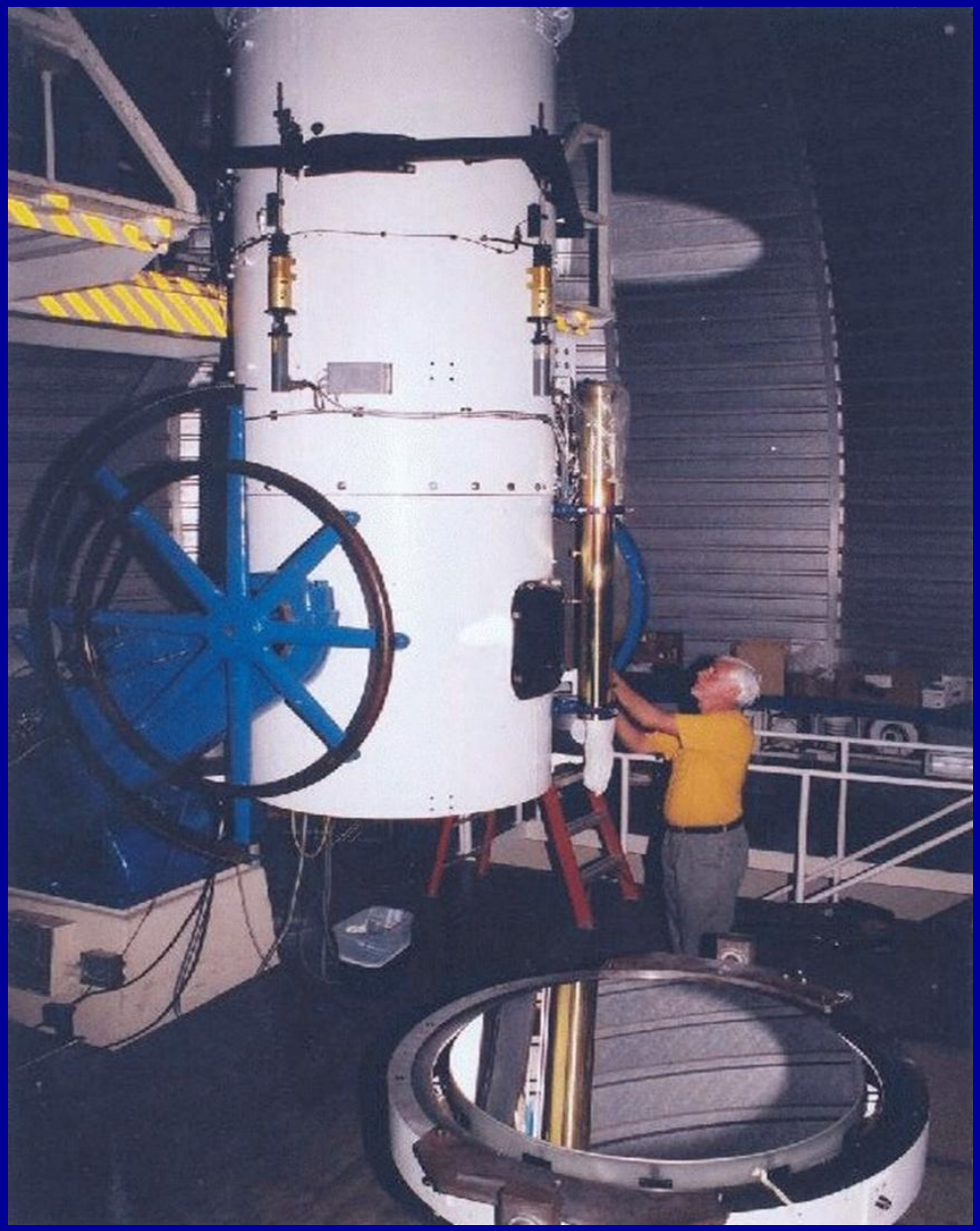
23 nights per lunation.

Automated in 2005 May.

Patterns near opposition, WISE regions, & low elongation in east in morning.

1400 deg^2 per lunation.

V mag limit ≈ 20.5-21.7 depending on conditions.



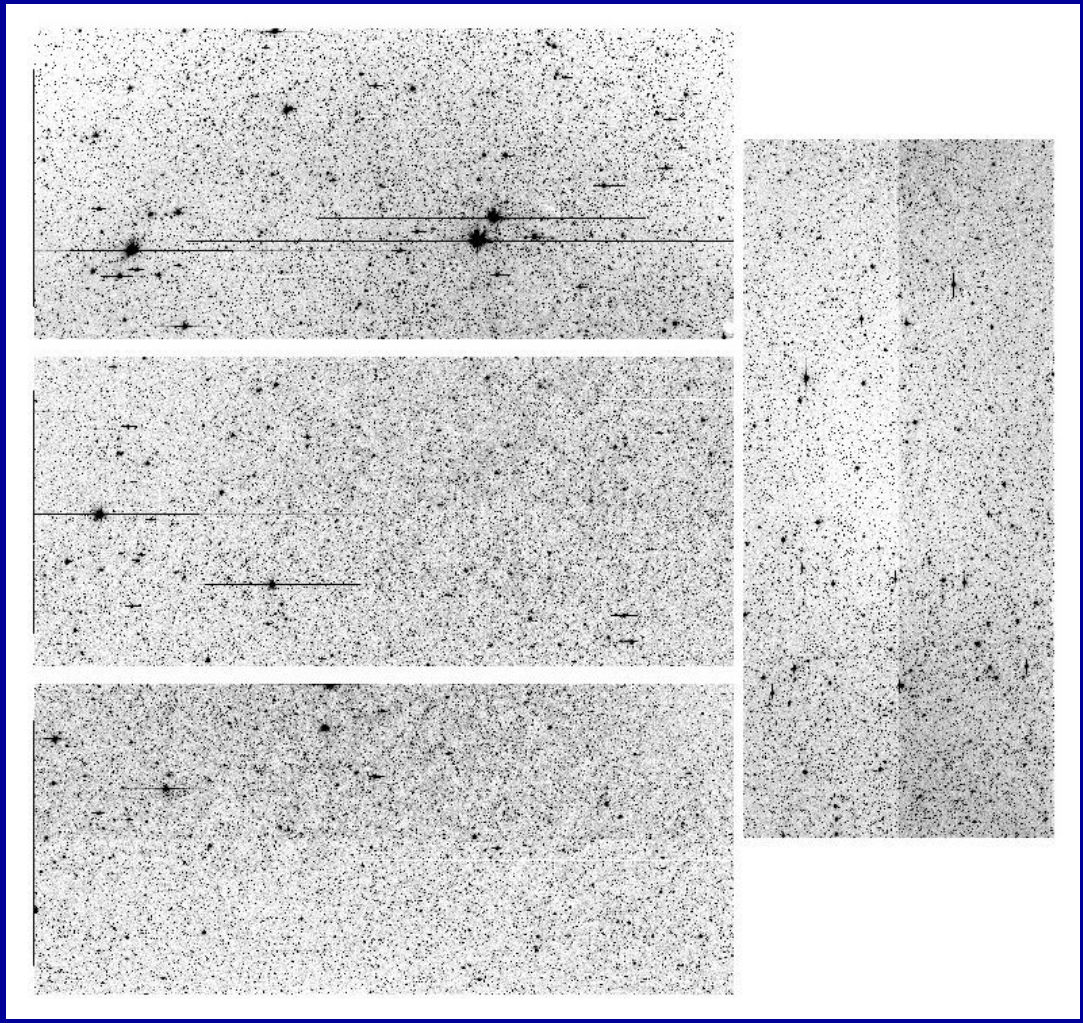
Spacewatch CCD Mosaic on 0.9-m telescope.

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.



Spacewatch 1.8-m Telescope: 0.6×0.6 deg FOV.

Same bandpass & scale as 0.9-meter.

Has reached V=23.3 by shift & stacking, typical $V_{lim} \approx 22.3$.

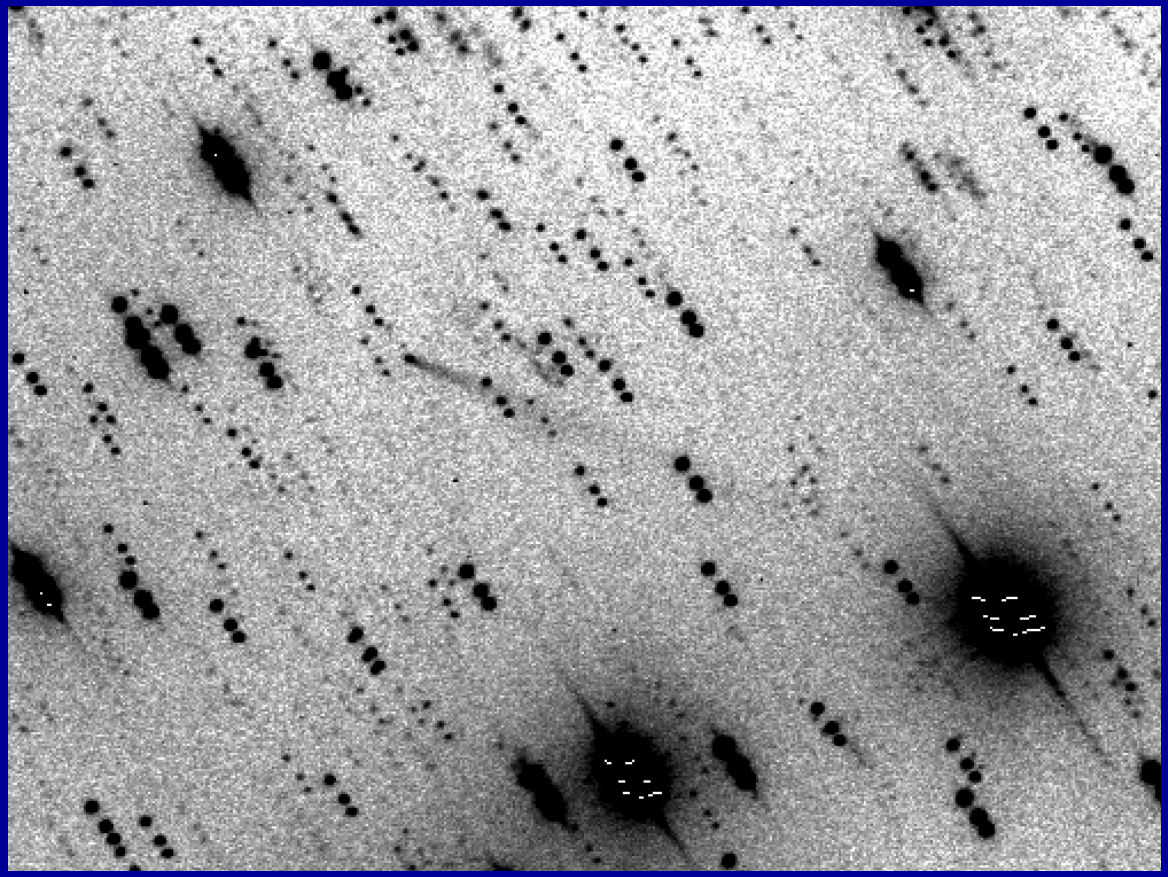
Mostly drift scanning for smoother background & responsivity.

Stacking @ asteroid rate.

Spacewatch 1.8-meter telescope scans.

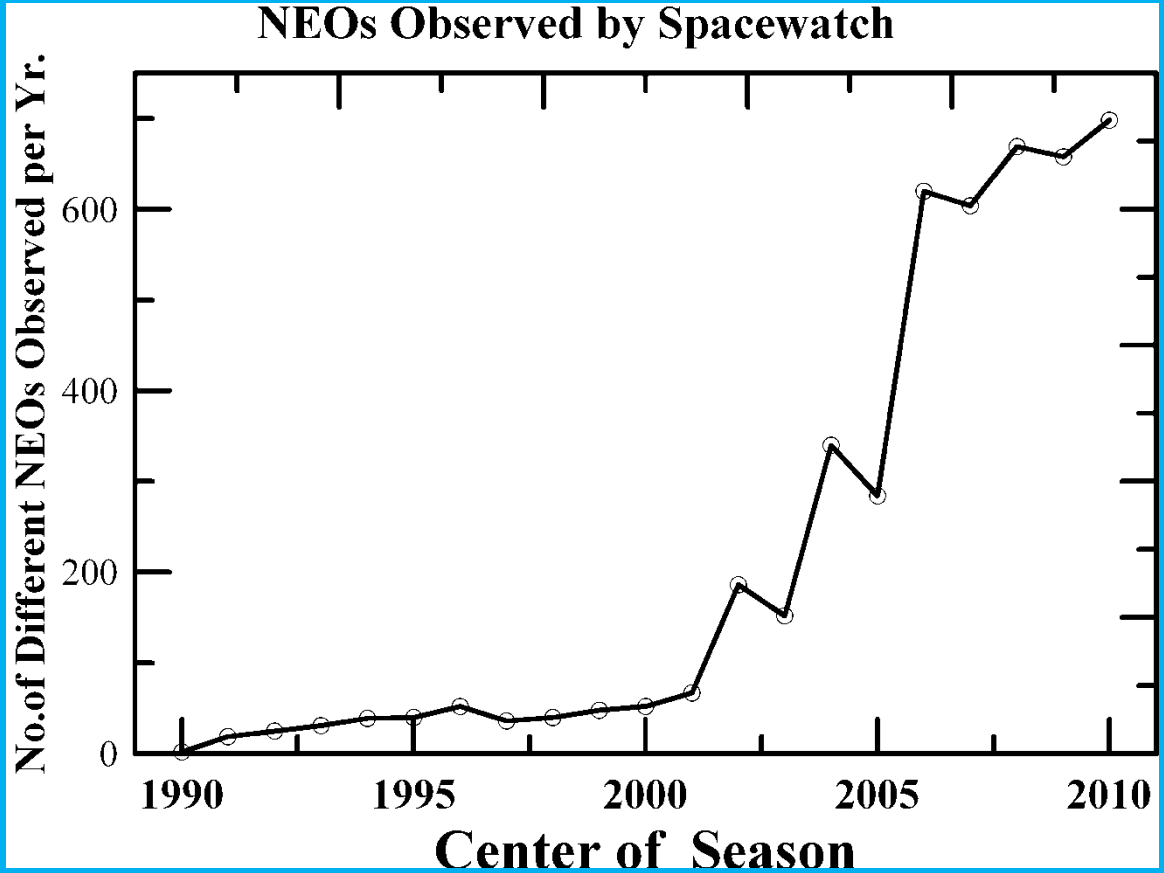
Spacewatch Followup of WISE-observed objects as of 2010 Sep 1

- 226 out of 324 NEOs observed by WISE.
- 54 out of 115 NEOs discovered by WISE.
  - V mags $\leq$ 22.9
- 10 out of 17 PHAs discovered by WISE.
- 9 out of 16 comets discovered by WISE.
  - T mags $\leq$ 22.1
- 19 out of 33 Centaurs, SDOs, & other irregular objects discovered by WISE.



Comet P/2002 LN13 = 2010 L2 (LINEAR) observed w/ Spacewatch 1.8-m on 2010 June 15.

Integration time in 3 co-added images = 418 sec. North up; East to left. Image size 23.5 12.6 arcmin. Tail ≥2.8 arcmin in p.a. 248 deg. Tmag=20.3. Discovered by LINEAR in 2002 as 2002 LN13. WISE discovered a tail on 2010 June 10 which was confirmed by these images.



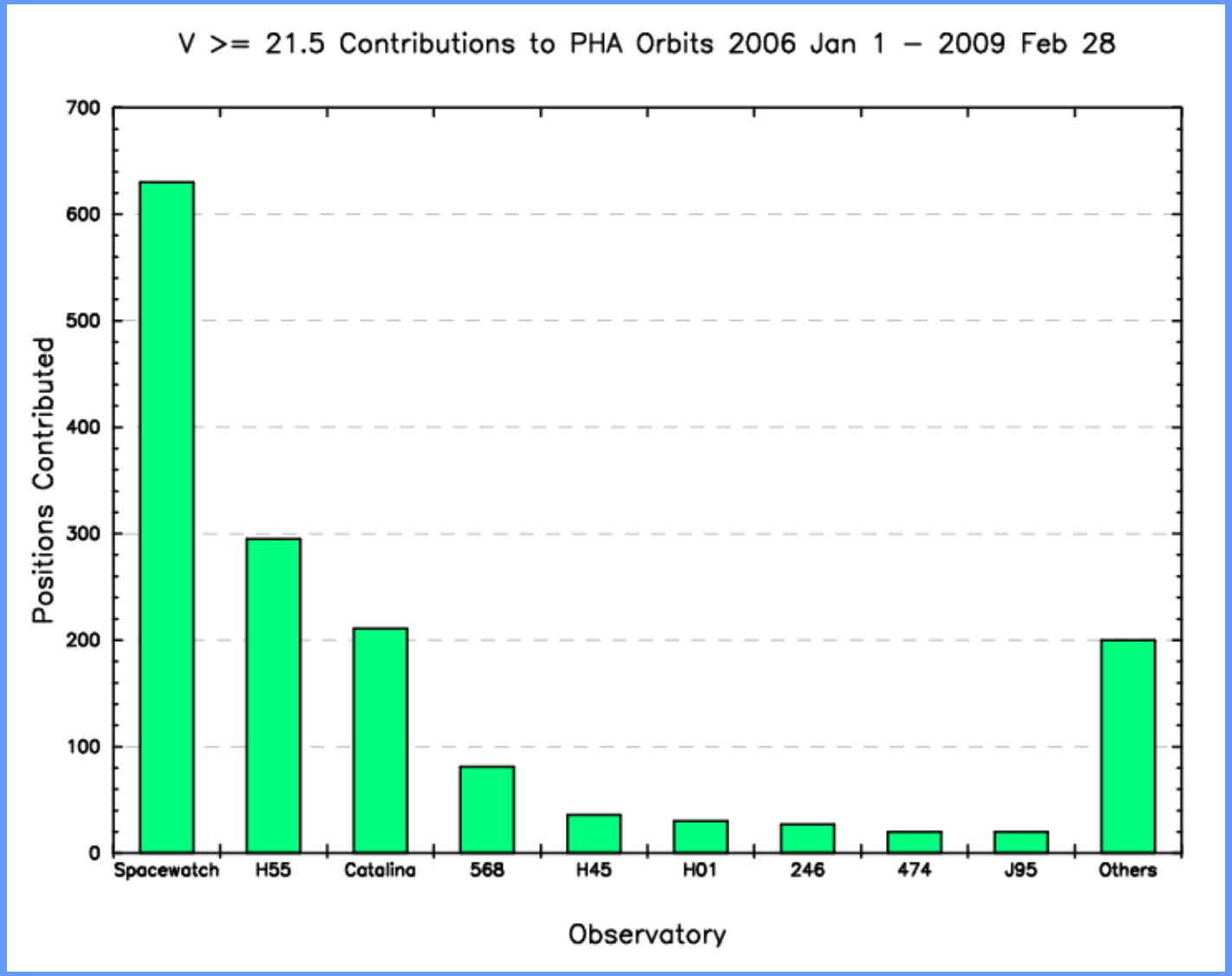
Number of NEOs Observed per Year

The effects of the introduction of the 1.8-meter telescope in 2001, the mosaic of CCDs on the 0.9-meter telescope in 2003, the automation of the 0.9-m in 2005, and recent software enhancements are evident.

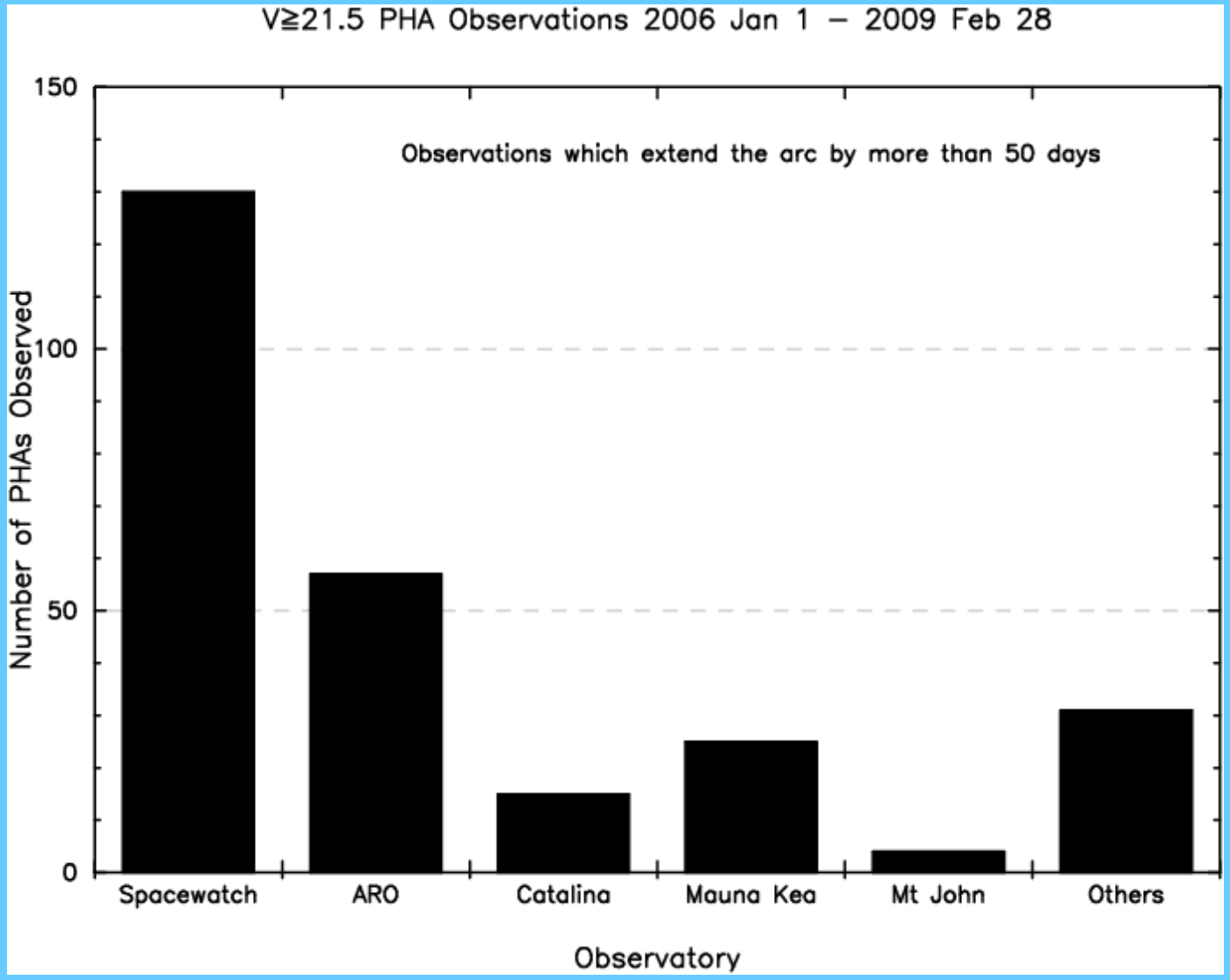
Numbers of Different PHAs Observed by Project 2003 Jan 1 - 2010 Aug 24:

- Spacewatch = COD 691 + COD 291 118
- Catalina = COD's 703, G96, E12, 693 & 413 113
- LINEAR = COD 704 90
- Holmes = COD's H21 + H55. 60
- Lowell = COD 699 (LONEOS) & 688 (1.8-m) 30
- NEAT (JPL) = COD's 644 + 675 + 566 + 608 26
- Faulkes = COD's F65 + E10 22
- Klet = COD's 046 & 246 19
- Mauna Kea = COD 568 19
- Mt. Hopkins/CfA = COD 696 19
- Mt. John, New Zealand = COD 474 18
- McDonald Obs. = COD 711 18

Observations of PHAs, by Observatory

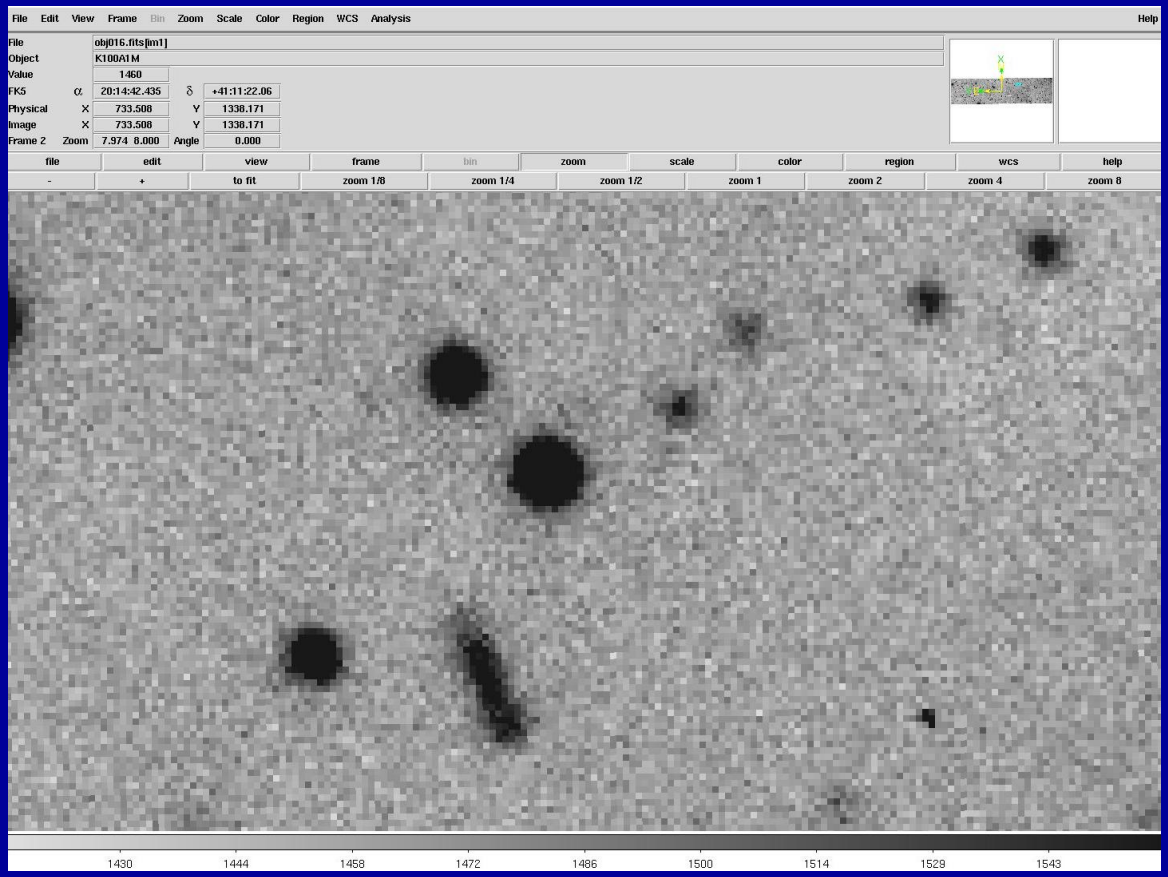


>50^{d} arc-lengthening PHA Followup



Using Bigger Telescopes

- Target-of-Opportunity Mode → V=24.
  - KPNO 4-meter MOSAIC camera, FOV 35 35 .
  - WIYN 3.5-meter MiniMo camera, FOV 9 9 .
  - CTIO 4-meter Mosaic camera, FOV 35 35 .
- Steward 2.3-m 90Prime camera, FOV ~1 deg^2.

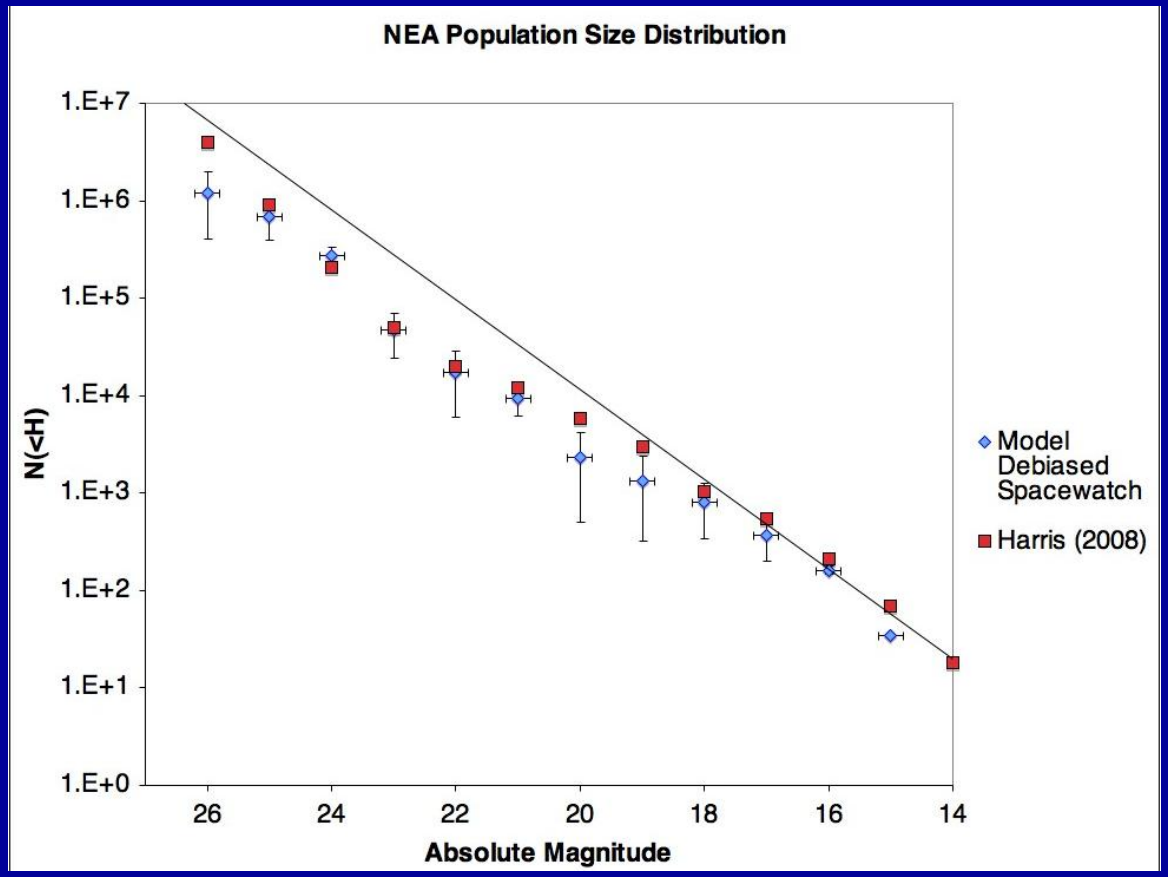


Minor Planet 2010 OM101 observed with the WIYN 3.5-m f/6.3 telescope on 2010 Sep 9 UT.

High-e outer solar system object (trail) discovered Jul 28 by WISE showed no coma in 0.7 arcsec seeing while near perihelion. Observers A. L. Henry, M. A. Malkan, G. Will; Measurers A. Mendez, J. A. Larsen.

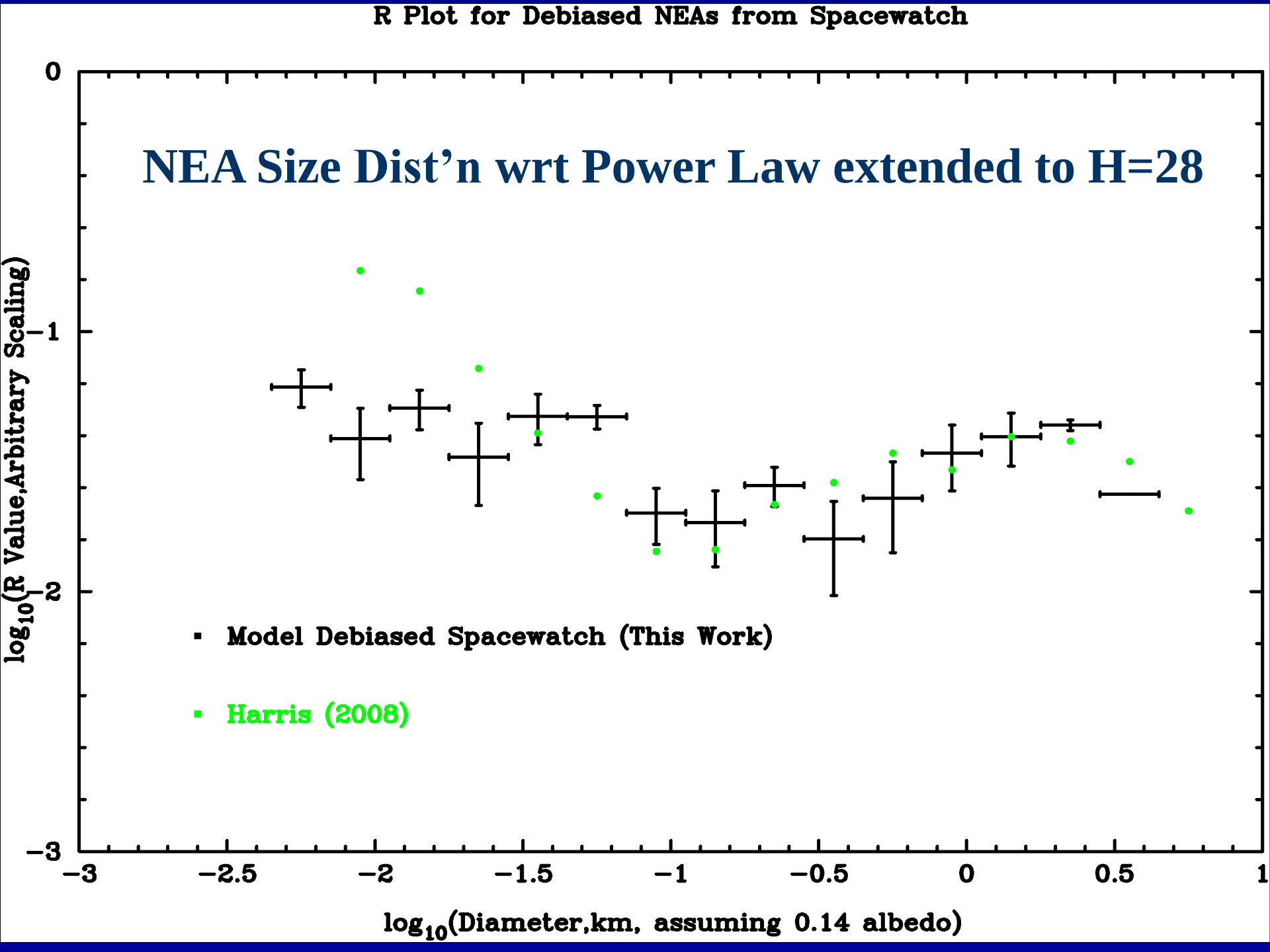
Distribution of Absolute Magnitudes of Small NEOs

- Spacewatch 0.9-m mosaic survey 2003-2010.
- Detections of known + previously unknown NEOs.
- De-biased for sky coverage & efficiency.
- Extended knowledge of dist'n to H≈ 28.
- Compare w/ dist'n of small craters on Moon.



Cumulative Absolute Magnitude of NEOs

Determined by de-biasing detections of NEOs with Spacewatch 0.9-m telescope and 2.9 deg^2 mosaic that surveyed the ecliptic from 2003 Apr -2010 June.


R Plot for Debiased NEAs from Spacewatch
NEA Size Dist'n wrt Power Law extended to H=28
log10(R Value,Arbitrary Scaling)
log10(Diameter,km, assuming 0.14 albedo)
0
−1
−2
−3
−3
−2.5
−2
−1.5
−1
−0.5
0
0.5
1
Model Debiased Spacewatch (This Work)
Harris (2008)

Acknowledgements

- The Spacewatch Team.
- The NEOWISE Team led by A. K. Mainzer.
- The IAU's Minor Planet Center listings.
- NASA's NEOO & PAST Programs.
- The Brinson Foundation, the estates of R. L. Waland and R. S. Vail, & other private donors.