SPACEWATCH®

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SPACEWATCH® was founded in 1980 by Prof. Tom Gehrels and Dr. Robert S. McMillan at the University of Arizona Lunar and Planetary Laboratory (LPL) to explore the populations of small solar system bodies. Our main focus was to discover new objects, particularly near-Earth objects (NEOs).

From 2017 onward, we have focused primarily on astrometric follow-up of NEOs as the sole users of the Steward Observatory 0.9-m (observatory code 691) and LPL 1.8-m (observatory code 291) telescopes on Kitt Peak in Arizona. We also use the Steward Observatory 2.3-m Bok Telescope ~6 nights per lunation (^695).

In 2019, the Catalina Sky Survey and Spacewatch (SW) began the Bok NEO Survey (observatory code V00) to discover NEOs with the 2.3-m. This survey has already discovered the sixth most NEOs.

See the photo of the Kitt Peak summit at the right.

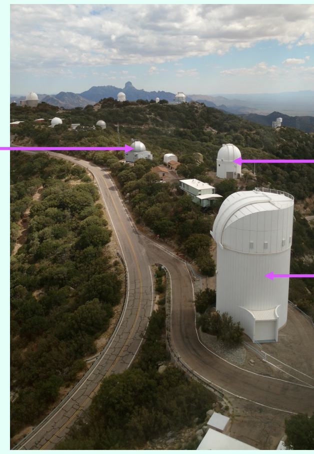


Photo: Melissa Brucker

Photo description: Image of the summit of Kitt Peak as seen from the KPNO Mayall 4-m. Pink arrow point to the telescopes we use. The large white telescope in the foreground is the Bok 2.3-m. The white 0.9-m is behind it and the silver 1.8-m is near the upper middle of the photograph. Trees cover most of the summit. A road is visible on the left side and the domes of more distant telescopes are seen in the upper background.

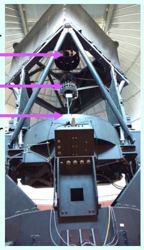
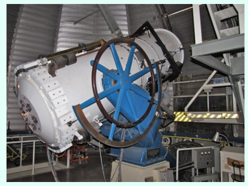
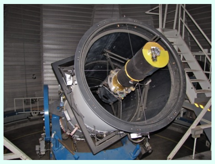


Photo: Melissa Brucker

Photo: Jim Scotti

Photo descriptions: LPL 1.8-m altitude-azimuth telescope.
Left from bottom to top: the mount, the cylindrical primary mirror cell, the electrically-cooled FLI camera and parallactic angle rotator surrounded by outer struts coming to a point in the middle near the top, black fabric making a square around the top shielding the secondary mirror from the wind. The closed metal dome is visible at the top.
Right: A side view of the 1.8-m with the dome shutter open. The black triangle attached to the telescope on the left is the shelf holding up the chiller for the camera.





Photos: Roger E. Carpenter, MD.

Photo descriptions: Steward Observatory 0.9-m/36": This 1921 Warner & Swasey telescope was moved from the University of Arizona campus to Kitt Peak in 1962.
Left: The white telescope tube pointed upward at an angle, mounted on a blue equatorial mount inside a metal dome.
Right: The Spacewatch mosaic camera and dewar pointing out of the front end of the telescope tube. The inside of the tube and most of the camera are covered in black material to reduce scattered light. The dewar for liquid nitrogen is the outermost part of the assembly.

NEO astrometry:
We prioritize our target selections from highest to lowest with virtual impactors (**VIs**) as our highest priority targets; then candidates for detection of the **Yarkovsky** Effect, Potentially Hazardous Asteroids (**PHAs**) that will come within 0.03 au of Earth within 40 years, objects on the **NEODyS** priority lists, potential targets of **radar**, NEOs observed by NEOWISE, NEOs listed on the **NHATS** webpage or requested via mailing lists, and **small** NEOs that will come within 0.03 au of Earth within 40 years. From February 1, 2025 through January 15, 2026, we made 5309 NEO measurements. See table 1 below.

Number of Unique NEAs Observed		
NEO 'flavor'	**SW only**	**SW + V00**
VIs	159	170
Yarkovsky	48	53
PHAs Close	61	72
NEODyS	1109	1406
Radar	55	64
NEOWISE	143	158
NHATS	327	378
Small Close	171	204

***Some NEOs are on more than one 'flavor' list**

Table 1: Number of unique NEOs detected between February 1, 2025 through January 15, 2026.

VI Targets of Opportunity:
We have a target-of-opportunity program to recover faint high priority VIs with larger telescopes, *e.g.*, Keck I, the MMT, the Blanco 4-m Telescope, and Gemini North and South. We measure VI astrometry to reduce uncertainty in VIs' heliocentric orbital elements to rule in or out possible impact(s).

We constructed the Priority Factor (PF) based on Marsden [1] and an urgency factor (UF) emphasizing the amount of time left before first possible impact.

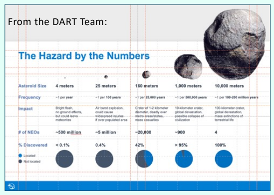
Equation 1: $PF = \log_{10}(PR * UF) = \log_{10}[\{(arclength/\tau)\}*\{(10+\log_{10}CIP)/(\tau/365.25)\}]$

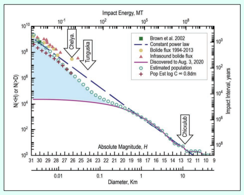
where *arclength* is the number of days that the previous observations span, τ is the time until first possible impact minus 1 year, and CIP is the cumulative impact probability.

We select a VI to be a ToO target if it has at least two of the following:
PF > -4, cumulative Palermo value > -5, cumulative impact probability > 10^{-5}, diameter > 140m

[1] Marsden B. G. *Impact Risk Communication Management (1998–2004): Has It Improved?,* in *Comet/Asteroid Impacts and Human Society,* Eds. P. T; Bobrowsky, H. Rickman, Springer-Verlag Berlin, 2007, Heidelberg; pages: 505-519.

No need for worry about potentially catastrophic impactors. Check out the graphics from the DART spacecraft team and the figure from Harris & Chodas 2021 [2].





Frequency of Impacts per NEA size. The horizontal axes are the NEA absolute magnitudes and diameter and the impact energy in megatons of TNT. The vertical axes are the cumulative number of NEAs and expected time intervals between impacts. Very large NEAs are rare and therefore so are impacts like Chicxulub. Very small NEAs are plentiful and so are their impacts.

[2] Harris, A. W. & Chodas, P. W. 2021. *Icarus*, **365**, 114452.

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The astronomical community is honored to have the opportunity to conduct astronomical research on Iolkam Du'ag (Kitt Peak) in Arizona. We recognize and acknowledge the very significant cultural role and reverence that this site has to the Tohono O'odham Nation.

University of Arizona Land Acknowledgement: We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.