NEO Surveys

Don Yeomans
JPL/Caltech

With (considerable) help from Steve Larson, Grant Stokes, Ronak Shah and Richard Wainscoat
Catalina Sky Survey
Steve Larson (PI)
Eric Christensen (Co-I)
Southern hemisphere coverage
CSS telescopes are used full time for NEO survey

Coverage from the 2013 Jan. lunation
Catalina Schmidt – green
Uppsala Schmidt – blue
Mt. Lemmon 1.5m – yellow (along ecliptic)
Galactic plane (blank space) has too many stars to survey

CSS telescopes are dedicated and optimized for NEO search - not shared with other science experiments - for 24 nights per lunation per telescope.
Rapid response follow-up

Real-time identification of possible NEOs allow timely same-night follow-up to verify their reality and reduce the orbit uncertainty.

A refurbished 1-m telescope (silver dome at left) is sited near the 1.5-m survey telescope on Mt. Lemmon. A queue manager ensures optimal follow-up observations.
Experienced observers:

- Select coverage each night depending upon clouds and seeing
- Can adjust sequences as conditions change
- Validate the reality of candidate moving objects flagged by the software
- Can distinguish real objects only 1.5 sigma over background noise
- Schedule/carry out same-night follow-up
- Report obvious NEO candidates to MPC near real-time so others can observe
Future CSS improvements: larger fields/more coverage

Catalina Schmidt

- Current 0.7-m Schmidt
  - 8.2 deg.$^2$
  - 2.5 arcsec pixels

- Upgraded 0.7-m Schmidt
  - 19.4 deg.$^2$
  - 1.5 arcsec pixels

  Full moon to scale

Mt. Lemmon 1.5-m

- Current 1.5-m
  - 1.2 deg.$^2$
  - 1.0 arcsec pixels

- Upgraded 1.5-m
  - 5.0 deg.$^2$
  - 0.8 arcsec pixels

Software is being developed to ensure that observers can keep up with the increased data rate while maintaining faint threshold levels.
The amazing case of 2008 TC$_3$
Lincoln Near-Earth Asteroid Research Program

MIT Lincoln Laboratory
Grant Stokes, PI
Ronak Shah & Deborah Woods
Current Survey Method with LINEAR

- 20° lunar keep out
- During times when moon is up, observe as far north/south as possible in the opposite direction and away from sunrise/sunset in strips of constant declination
- During moonless periods, observe in strips of constant ecliptic latitude
- Spend most of the dark period scanning 15° of ecliptic plane
  - Observe opposition region twice/lunar dark period
LINEAR providing asteroid discoveries and tracking since March 1998
~250,000 discovered objects
462 Potentially Hazardous Asteroids
45% of all PHAs to date

Program improvements
Continue 1m survey
Deeper, greater area search with Space Surveillance Telescope
Incorporate new image processing
Improve existing association methods for challenging orbits
SST is an ideal asteroid hunter

Design combines rapid step-and-settle, significant aperture and wide field-of-view

3.5-m f/1 Mersenne-Schmidt Telescope
3°×2° Field-of-view
Mount achieves
Maximum rate of 4°/sec
0.5” class pointing

SST Facility at Atom Site, WSMR
SST Asteroid Discovery

• Performing simulations of small NEO detection with SST

• SST asteroid survey planning underway
  – ~20,000 sq. degrees per night using 5 revisits per field
  – Sensitivity to equivalent target sizes of ~200m at 1 AU
  – Complete sky coverage
The Pan-STARRS search for Near Earth Asteroids

Richard Wainscoat, Robert Jedicke, Larry Denneau, Peter Vereš, Bryce Bolin, Marco Micheli

University of Hawaii, Institute for Astronomy
The Pan-STARRS telescopes

- 1.8-meter diameter operational at Haleakala observatory in Maui (PS1). Second telescope (PS2) is being built.
- PS1 observations are designed for many different scientific goals, including the solar system, brown dwarfs, Galactic structure, supernovae and other transients, and cosmology.
- Nearly all PS1 observations allow them to be searched for Near Earth Objects.
- Astrometry from PS1 is excellent, and in most cases is better than 0.15 arcsec.
- Largest digital cameras in the world.
Gigapixel camera

- 1,382,400,000 px
- 7 square degree field-of-view
- Read time 12 sec
- Some CCDs are cosmetically poor
- 70% fill factor

Moon
November 3pi fields
October solar system fields
NEO Optimized survey

- We use a broad w-band filter to increase sensitivity
- Observing time increased to 11% in Nov. 2012
- Four 45 sec. exposures separated by 20 minutes in the opposition direction or 7 minutes in the low solar elongation sweet spot directions, using wide filter
- Opposition search has yielded 235 NEO discoveries, including 19 PHAs
- Sweet spot search has yielded 9 NEO discoveries, including 2 PHAs
- PS1 mostly dependent upon others for follow-up
Discovery rate

- PS1 discovers approximately 30 NEOs per month when the weather is good
- The median H magnitude for PS1 NEO discoveries so far in 2012 is 22.5
- Other NEO discoveries have median H=23.1
- Pan-STARRS is good at finding larger undiscovered NEOs that are distant and faint
- PS1 has discovered 10 NEOs this year with H<18.3
- Pan-STARRS has discovered 27 comets to date
Further into the future

- Pan-STARRS 2 on Haleakala
- Most of the funding needed is in hand, but not all
- Likely to work together with Pan-STARRS 1
- Better camera
- Higher fraction of dedicated NEO observing time in 2014