NEO Surveys

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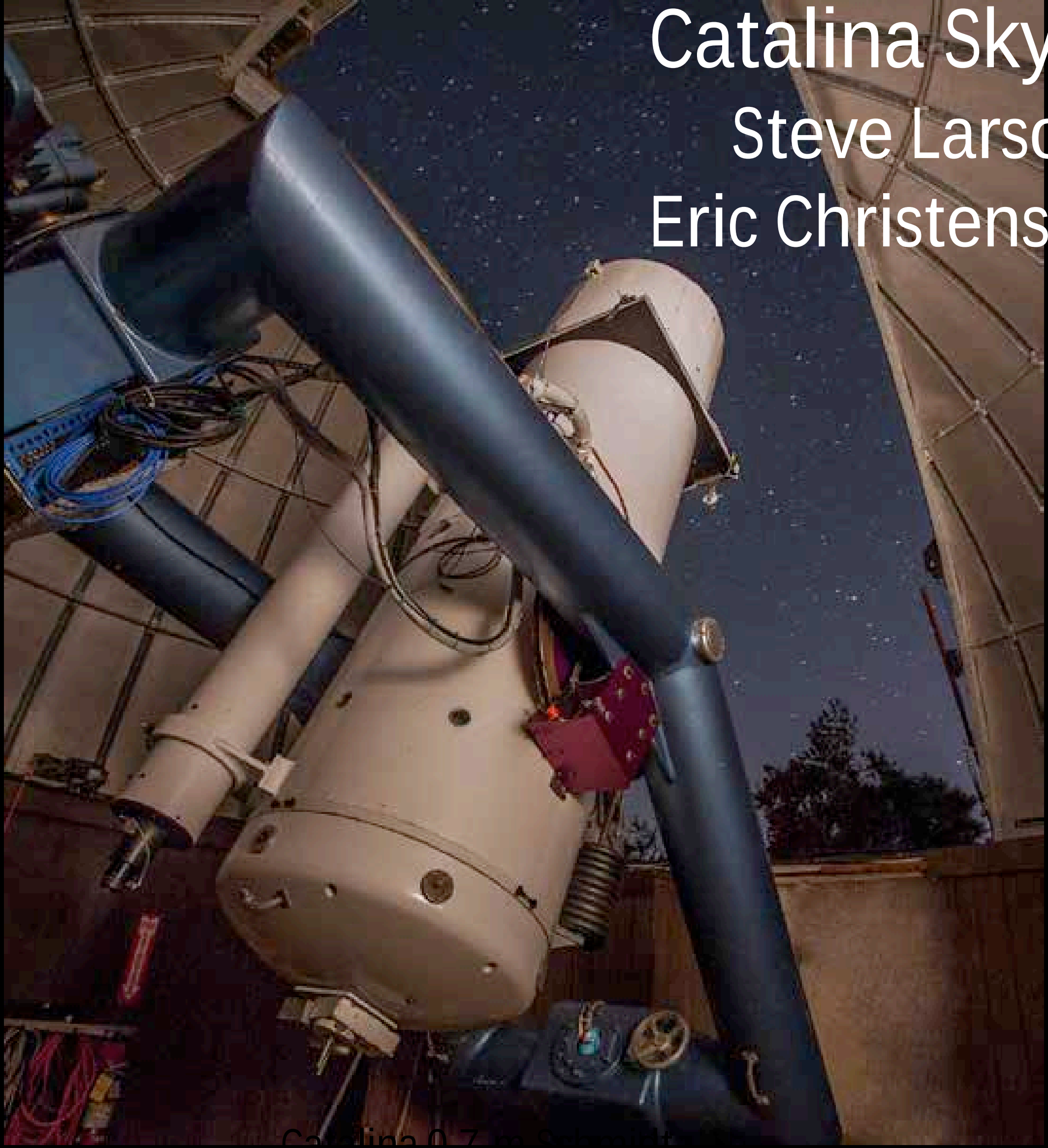
JPL/Caltech

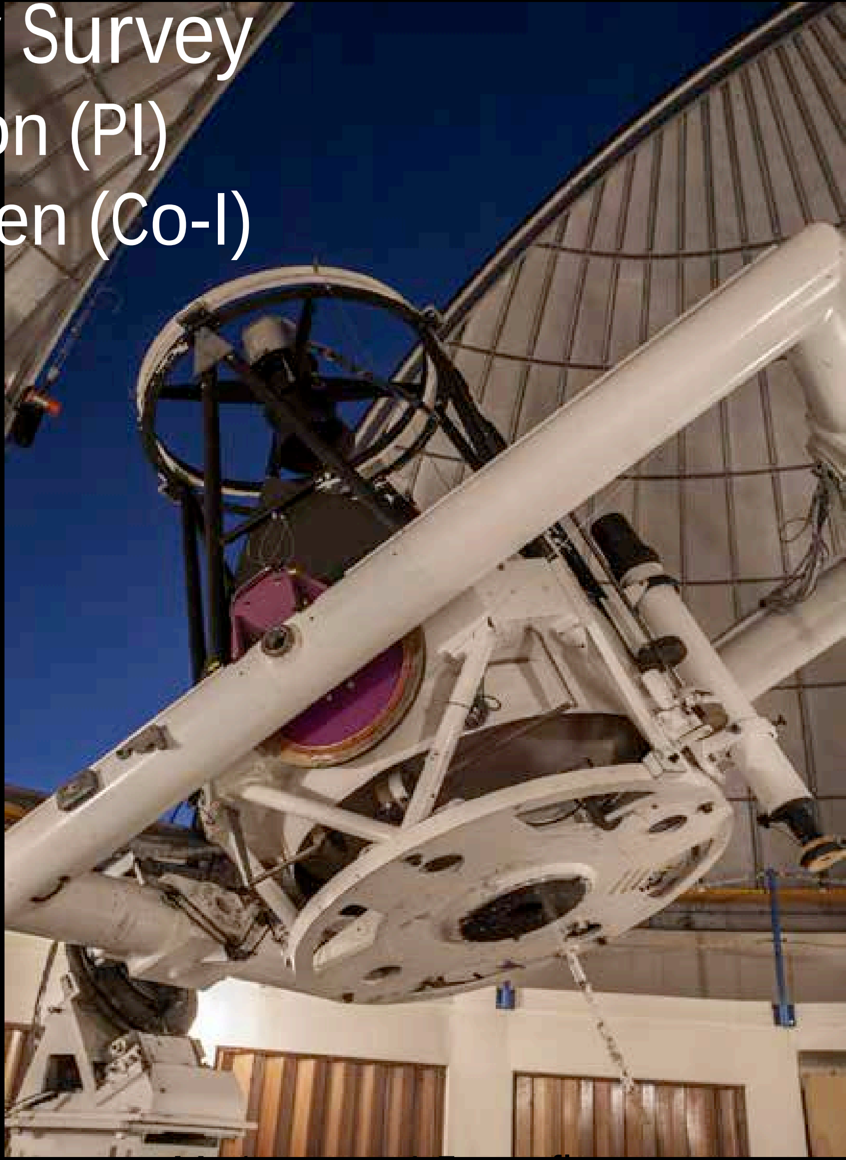
With (considerable) help from Steve Larson, Grant Stokes, Ronak Shah and Richard Wainscoat

Catalina Sky Survey

Steve Larson (PI)

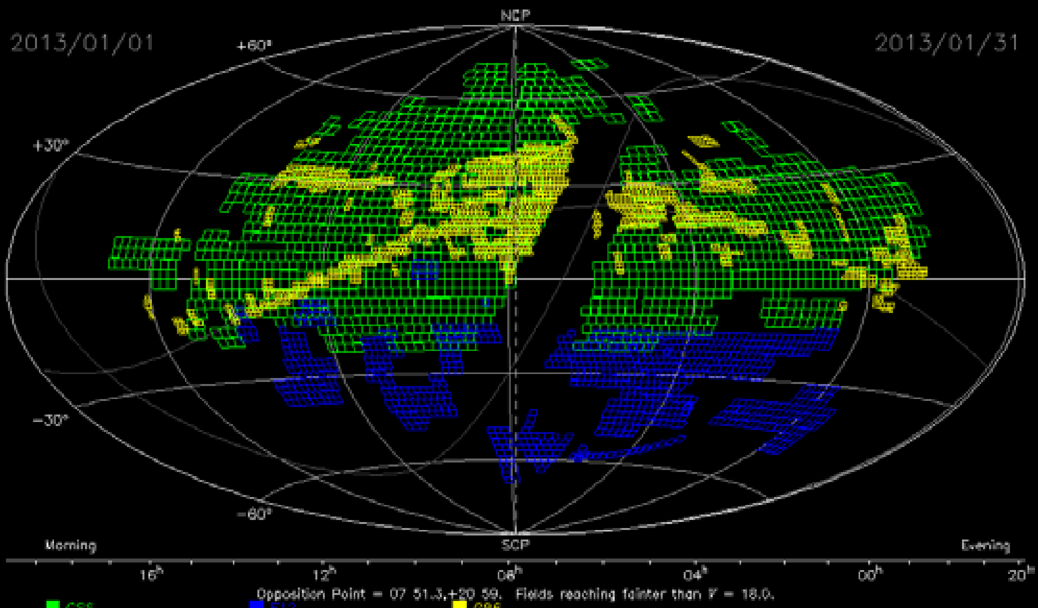
Eric Christensen (Co-I)





Southern hemisphere coverage
CSS telescopes are used full time for NEO survey

Uppsala 0.5 m Schmidt
Siding Spring Observatory
Australia



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

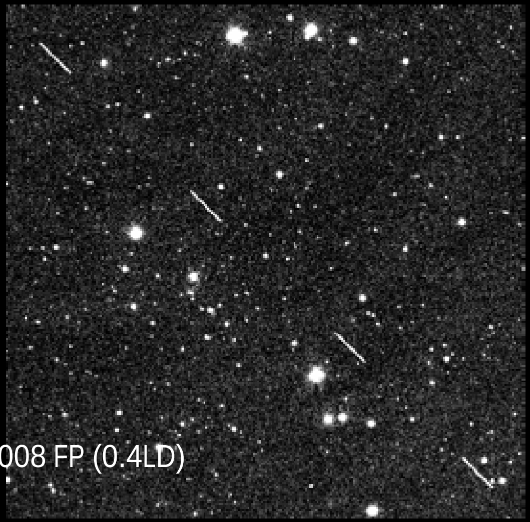
CSS telescopes are dedicated and optimized for NEO search - not shared with other science experiments - for 24 nights per lunation per telescope.

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.

The human factor: Real Time Response



2008 FP (0.4LD)

Experienced observers:

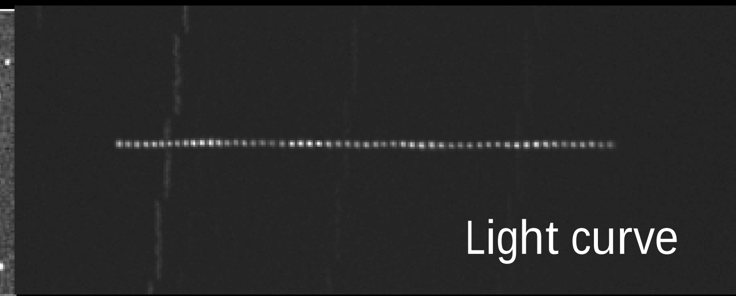
- Select coverage each night depending upon clouds and seeing
- Can adjust sequences as conditions change
- Validate the reality of candidate moving objects flagged by the software
- Can distinguish real objects only 1.5 sigma over background noise
- Schedule/carry out same-night follow-up
- Report obvious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

Future CSS improvements : larger fields/more coverage

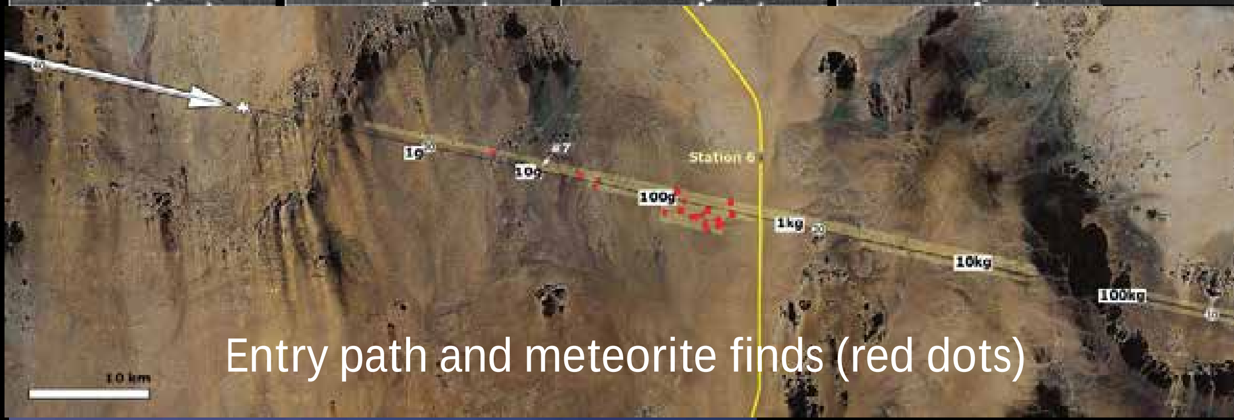
Software is being developed to ensure that observers can keep up with the increased data rate while maintaining faint threshold levels.

The amazing case of 2008 TC $_3$

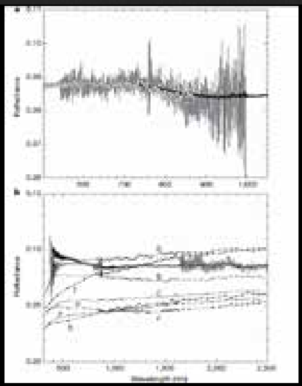
Discovery images



Light curve



Entry path and meteorite finds (red dots)



Spectrum in space, in lab

Dust train

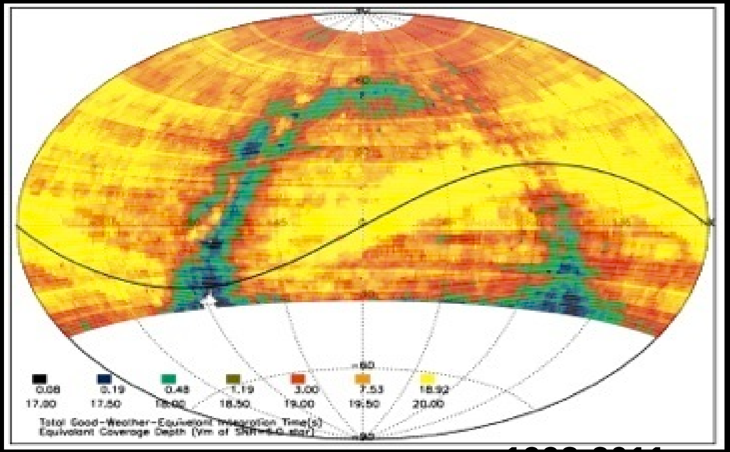
Almahata Sitta

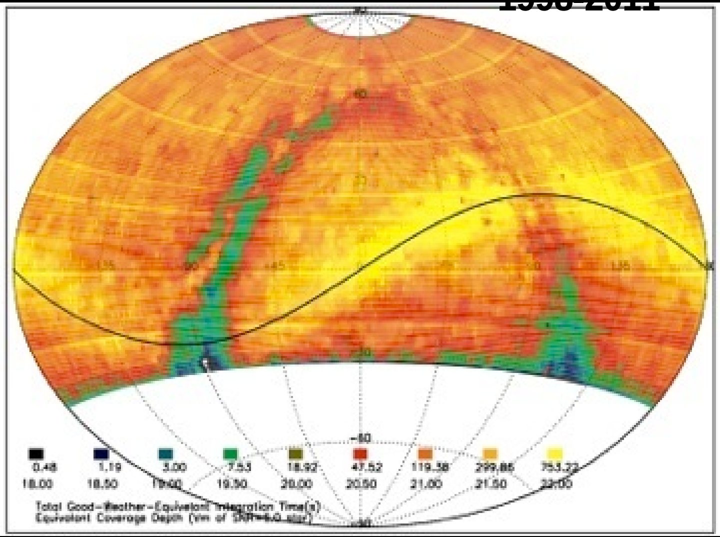
Lincoln Near-Earth Asteroid Research Program

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**





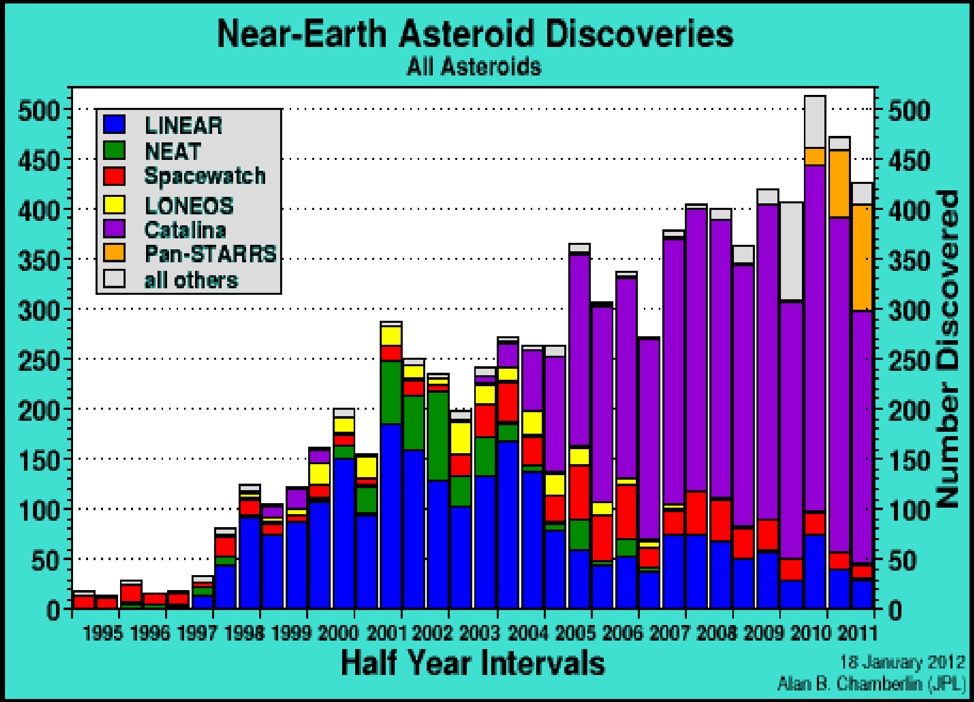
Overview

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

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

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

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

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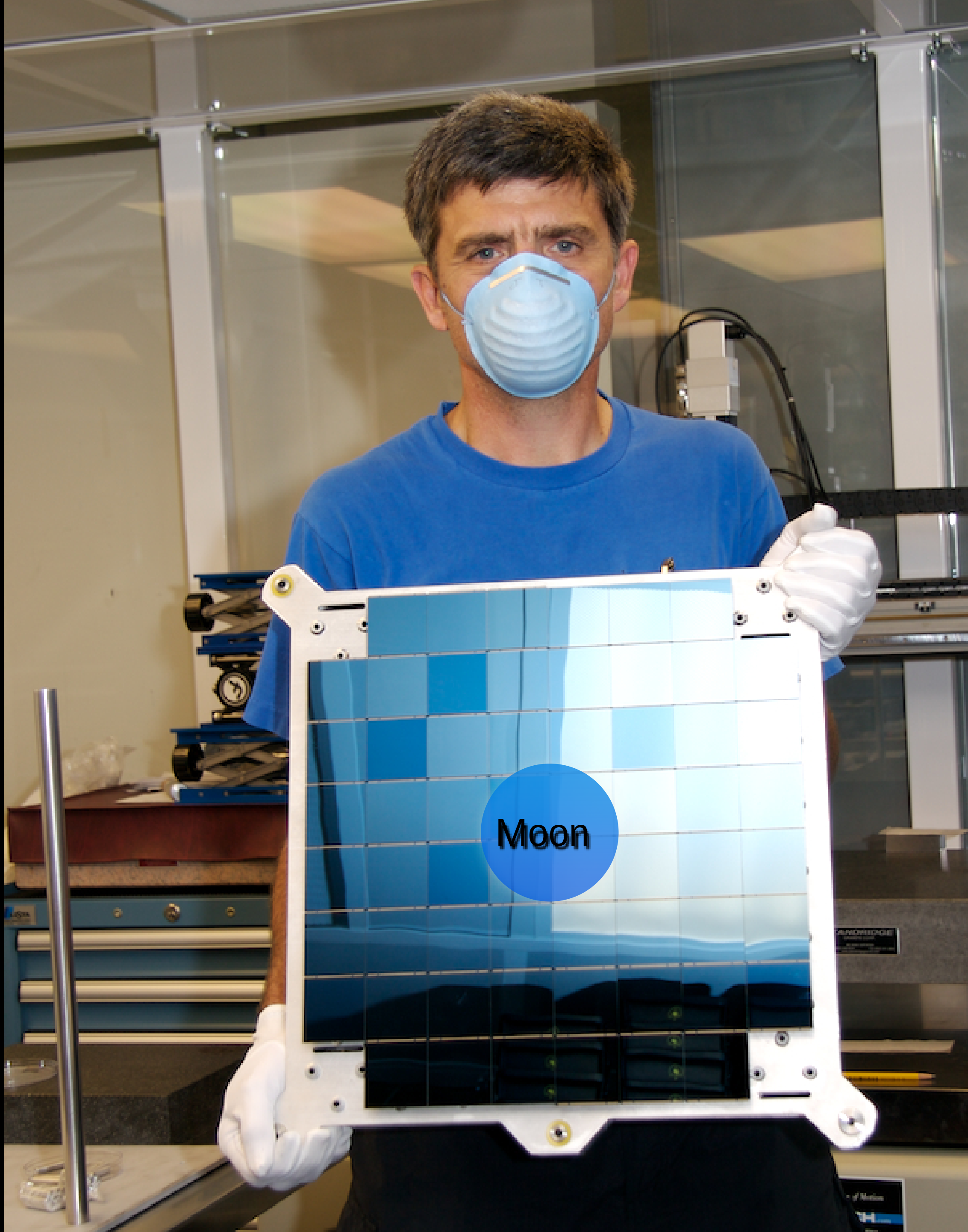
University of Hawaii, Institute for Astronomy

The Pan-STARRS telescopes

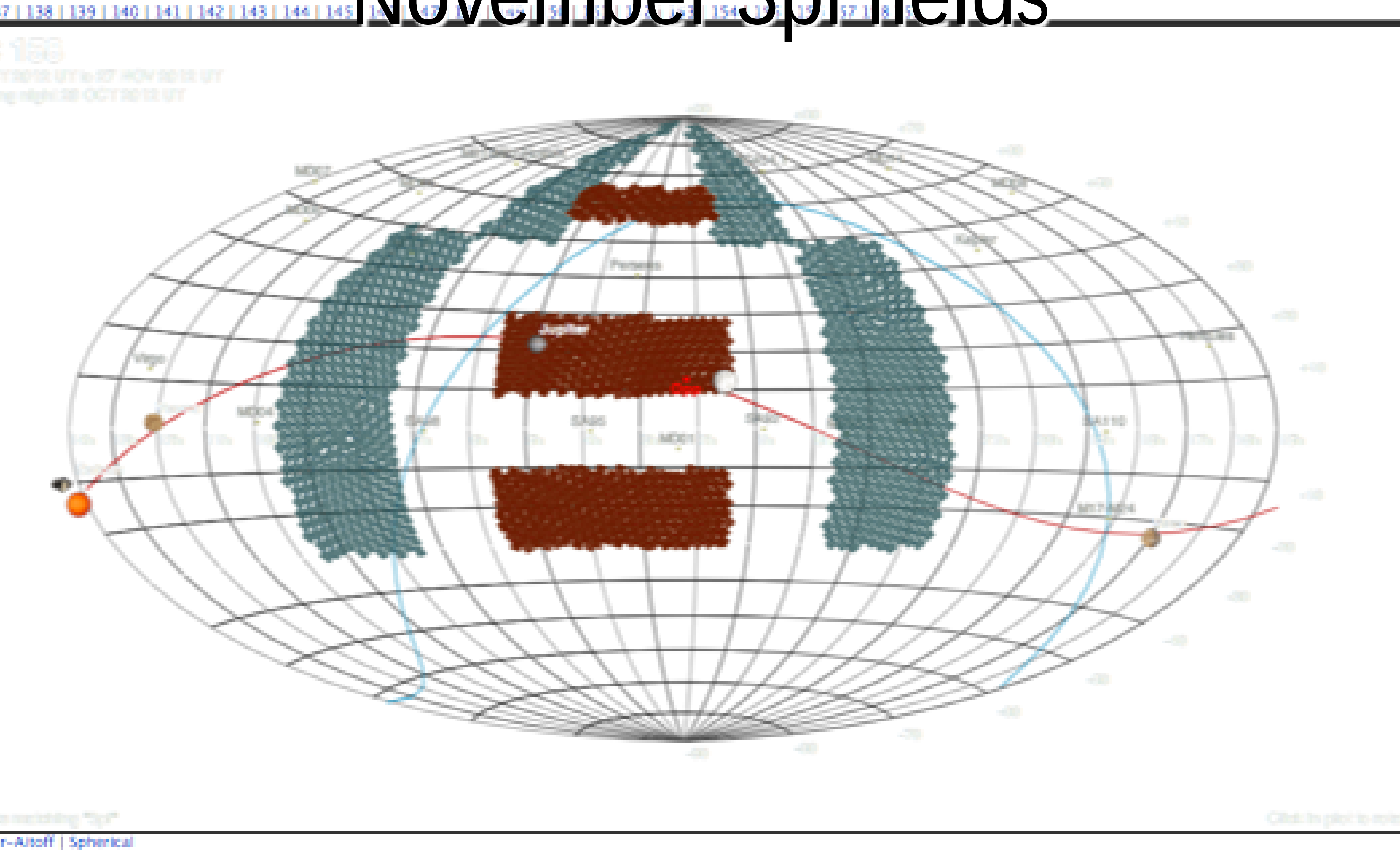
- 1.8-meter diameter operational at Haleakala observatory in Maui (PS1). Second telescope (PS2) is being built
- PS1 observations are designed for many different scientific goals, including the solar system, brown dwarfs, Galactic structure, supernovae and other transients, and cosmology
- Nearly all 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

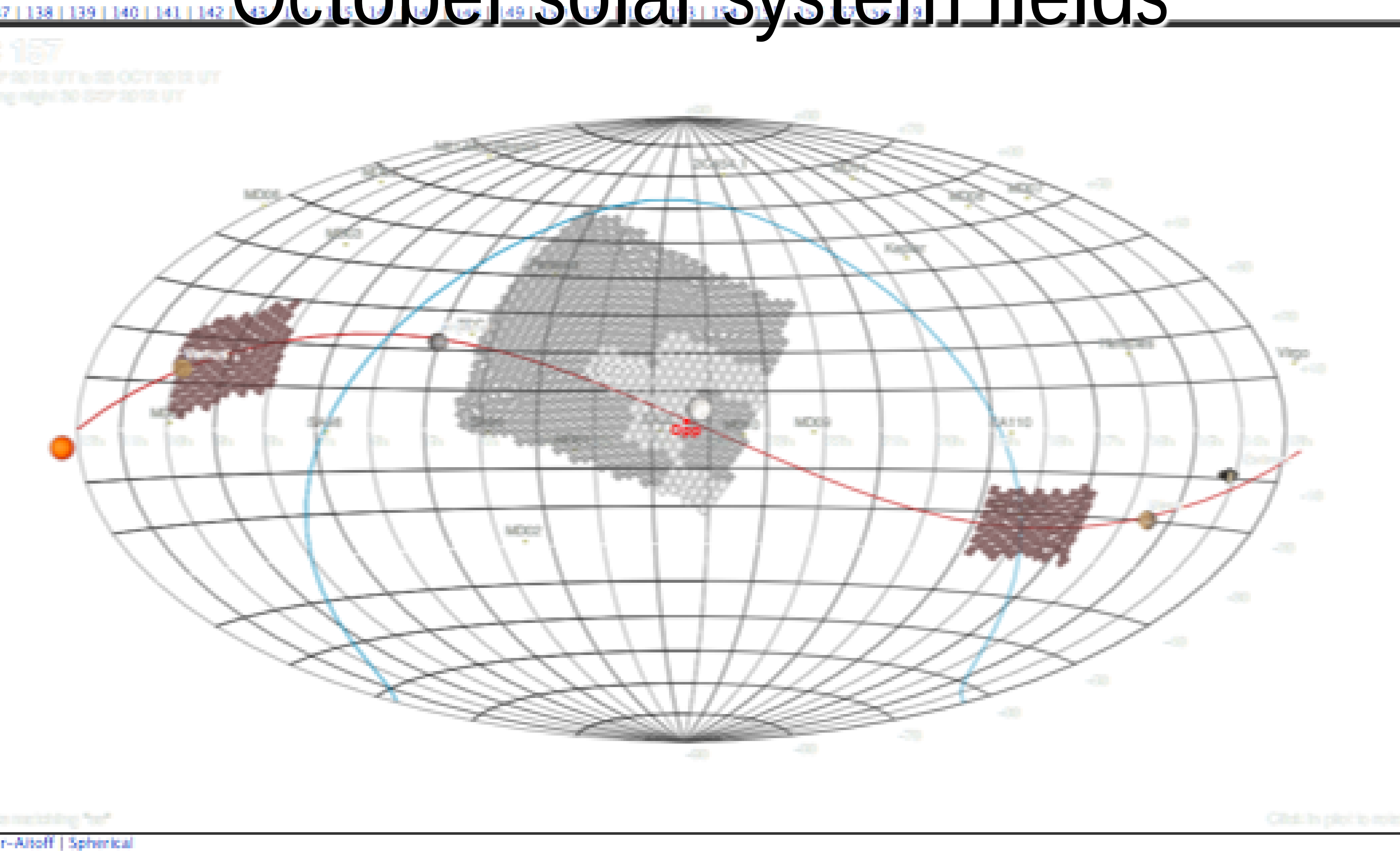
- 1,382,400,000 px
- 7 square degree field-of-view
- Read time 12 sec
- Some CCDs are cosmetically poor
  - 70% fill factor



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