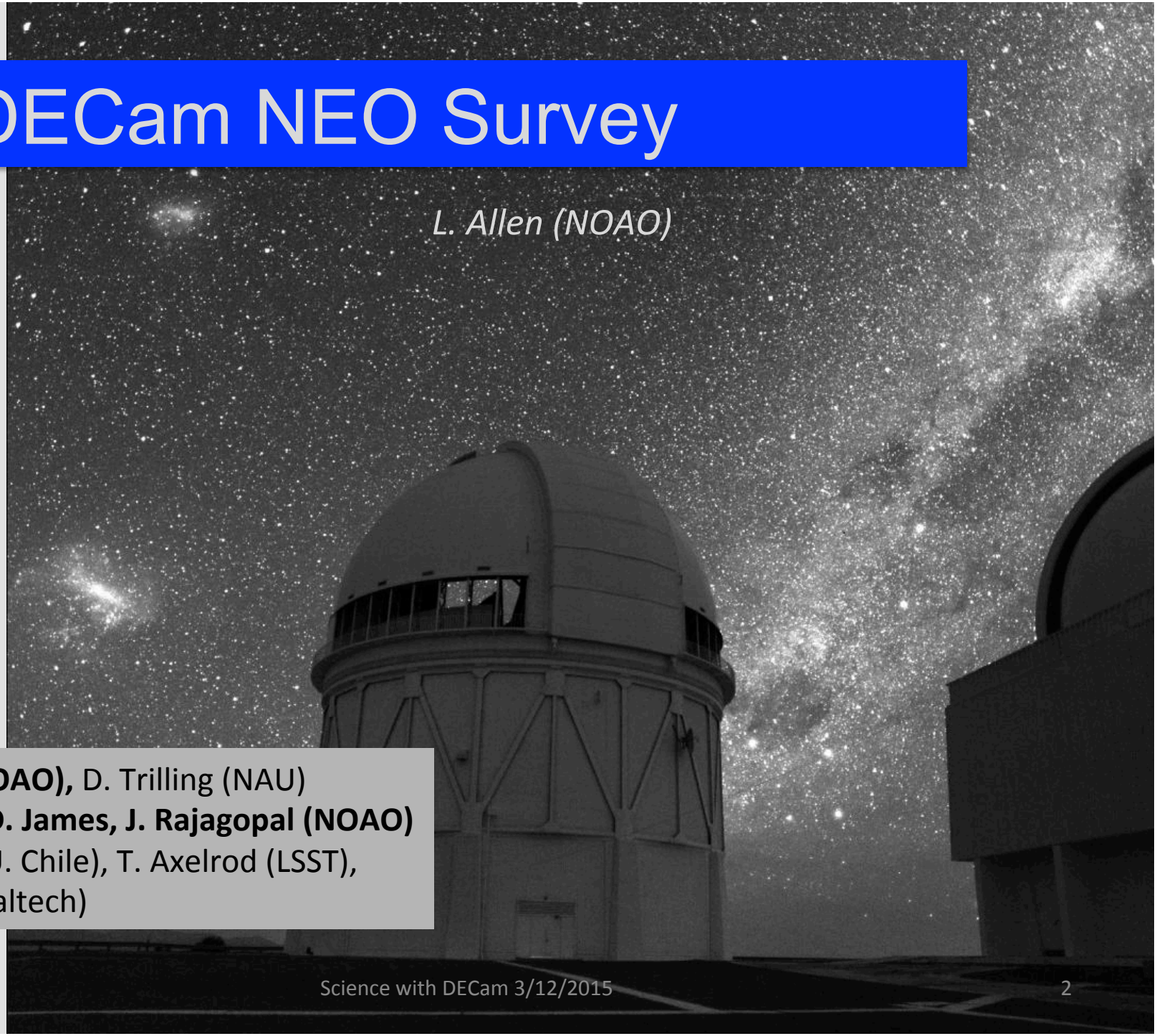
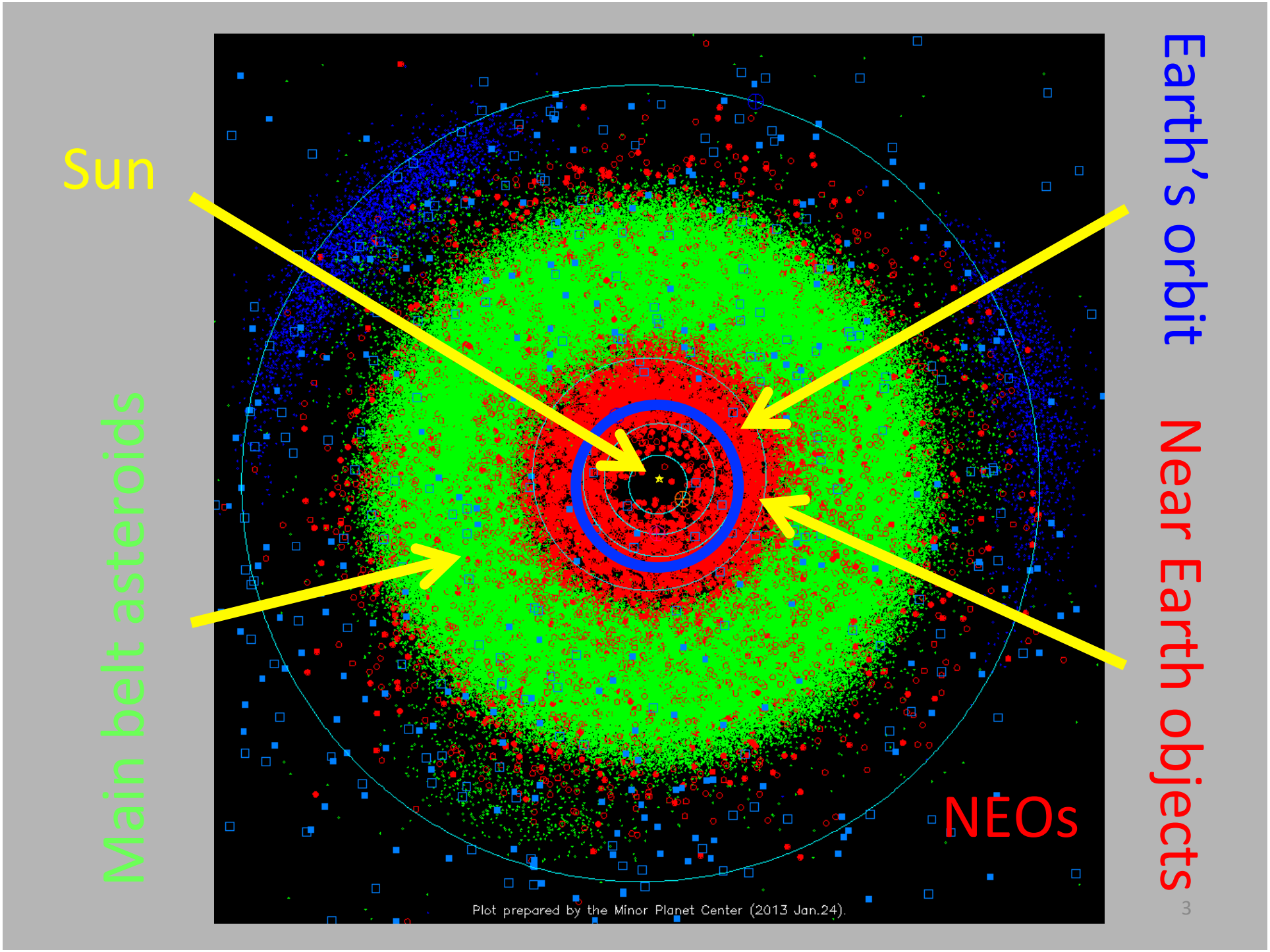
The DECam NEO Survey

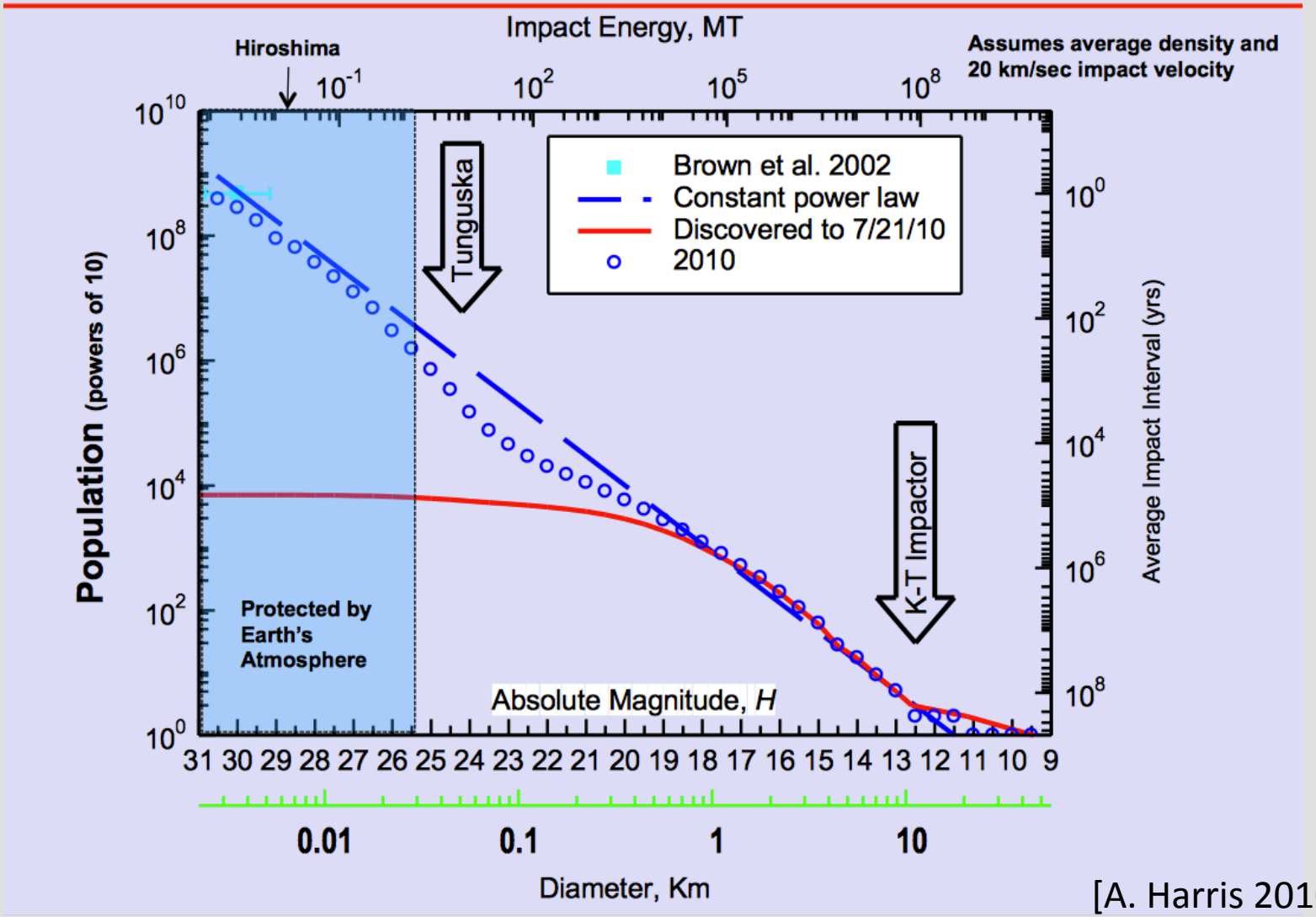


L. Allen (NOAO)

F. Valdes (NOAO), D. Trilling (NAU)
D. Herrera, D. James, J. Rajagopal (NOAO)
C. Fuentes (U. Chile), T. Axelrod (LSST),
M. Brown (Caltech)


Sun
Main belt asteroids
Earth's orbit
Near Earth objects
NEOs
Plot prepared by the Minor Planet Center (2013 Jan.24).

Population of NEOs by Size, Brightness, Impact Energy



[A. Harris 2010]

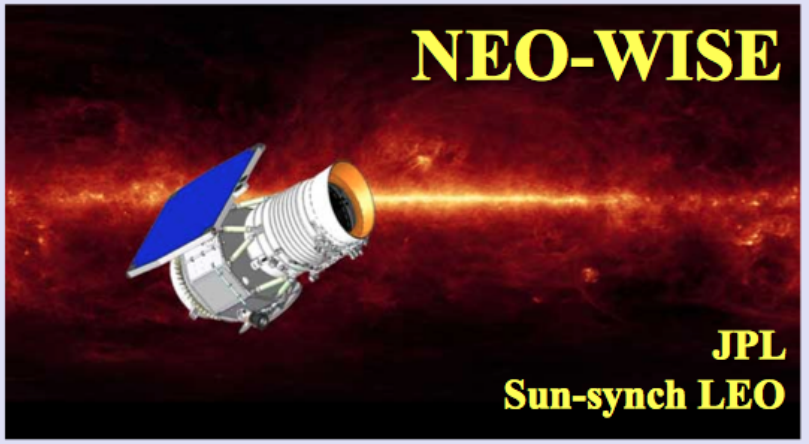
Major NASA-funded NEO Search Programs (current)

Minor Planet Center (MPC)
- IAU sanctioned
- Int'l observation database
- Initial orbit determination

www.cfa.harvard.edu/iau/mpc.html

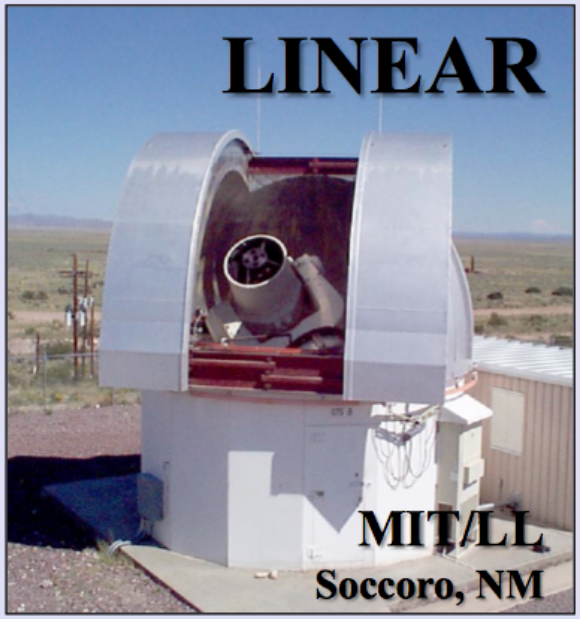
NEO Program Office @ JPL
- Program coordination
- Precision orbit determination
- Automated SENTRY

http://neo.jpl.nasa.gov/



Operations
Jan 2010
Feb 2011,
129 NEAs found

Reactivated
Sep 2013



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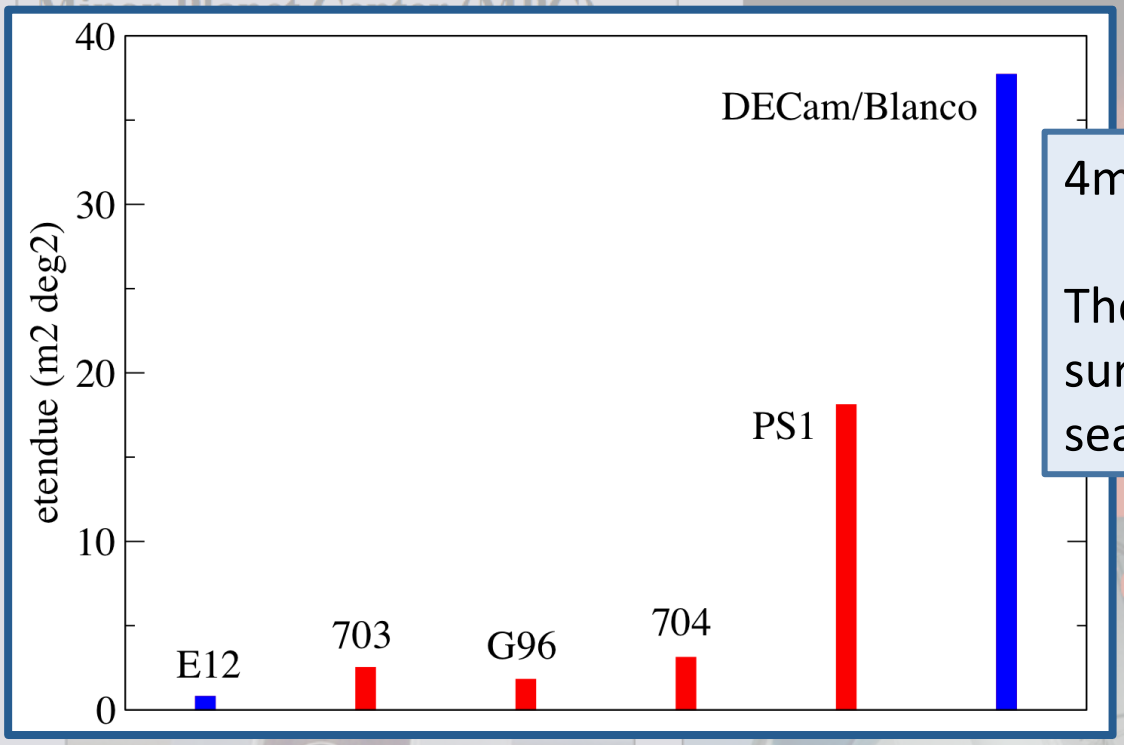
Major NASA-funded NEO Search Programs (current)



4m telescope + 3 square deg fov

The étendue of DECam+Blanco surpasses that of all existing NEO searches ➔ self follow-up.

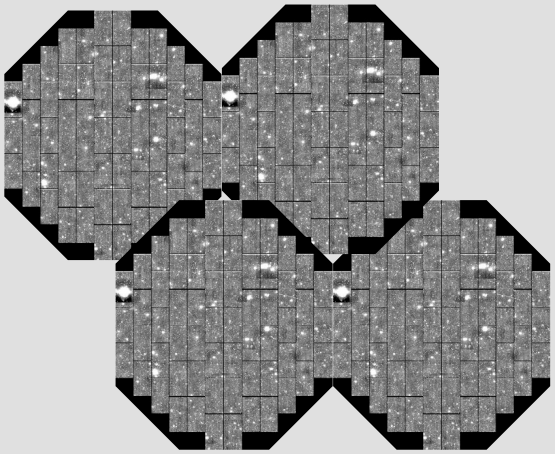
NEO-WISE

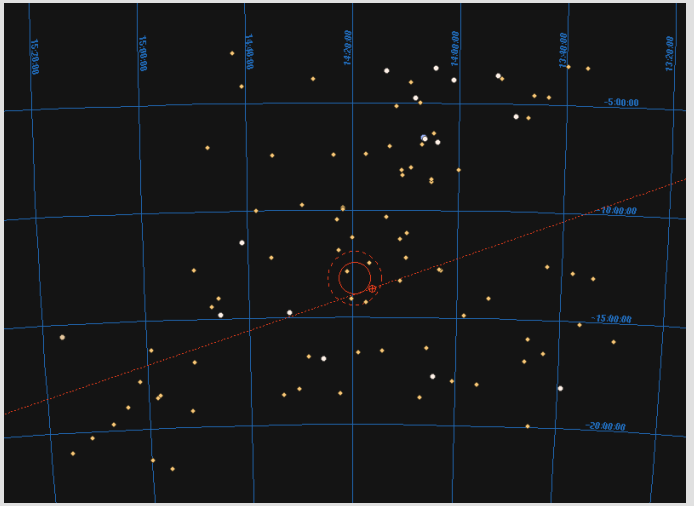
Operations
Jan 2010
Feb 2011

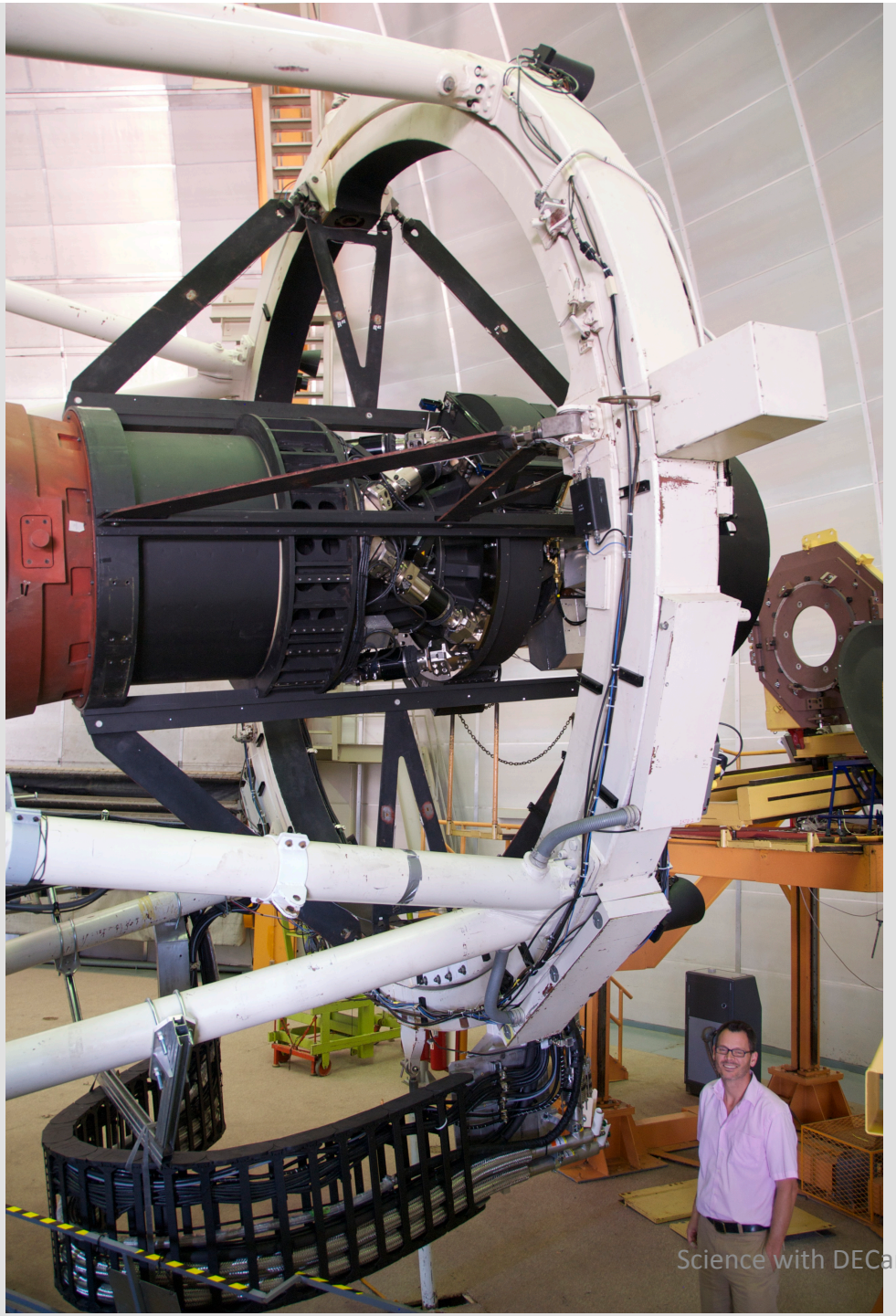
11

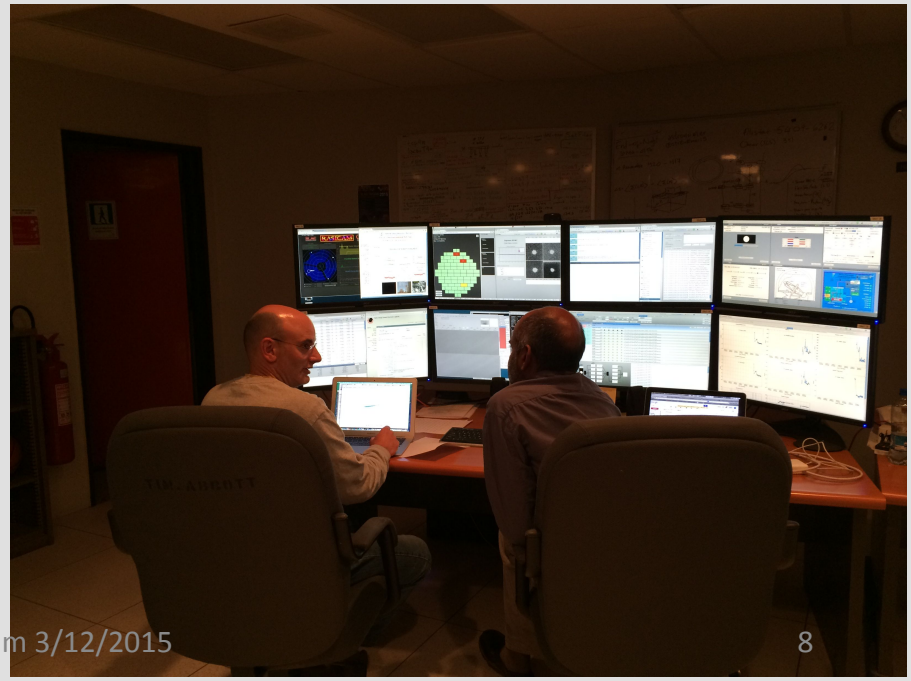
Survey Observing

- DECam: 60 2Kx4K CCDs with 2.7 sq. deg. field
- 30 nights over 3 semesters
- Covers 320 sq. deg. in ~525 exposures per full night
- 40 sec. exposures in VR filter (~23 mag)
- 5 exposures per field with 5 min. cadence
- repeat fields a 2nd and 3rd night



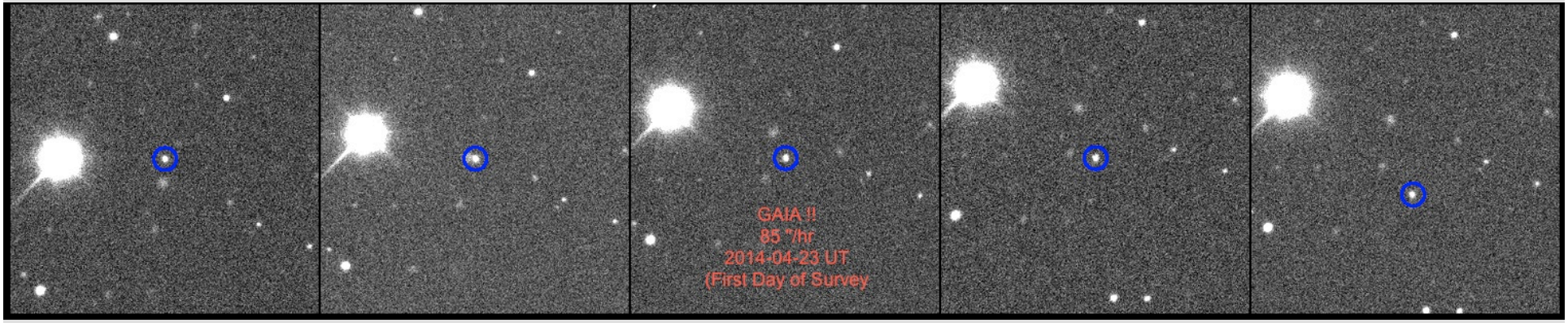






Data Handling

- 1.2 Gb/exp, 525 exp/night, 0.62 Tb/night
- Transported to Tucson by DTS within minutes
- Calibrated with the NOAO Community Pipeline (CP)
- Tracklets found with the CP Moving Object Detections System
- Review results and report to Minor Planet Center (MPC)



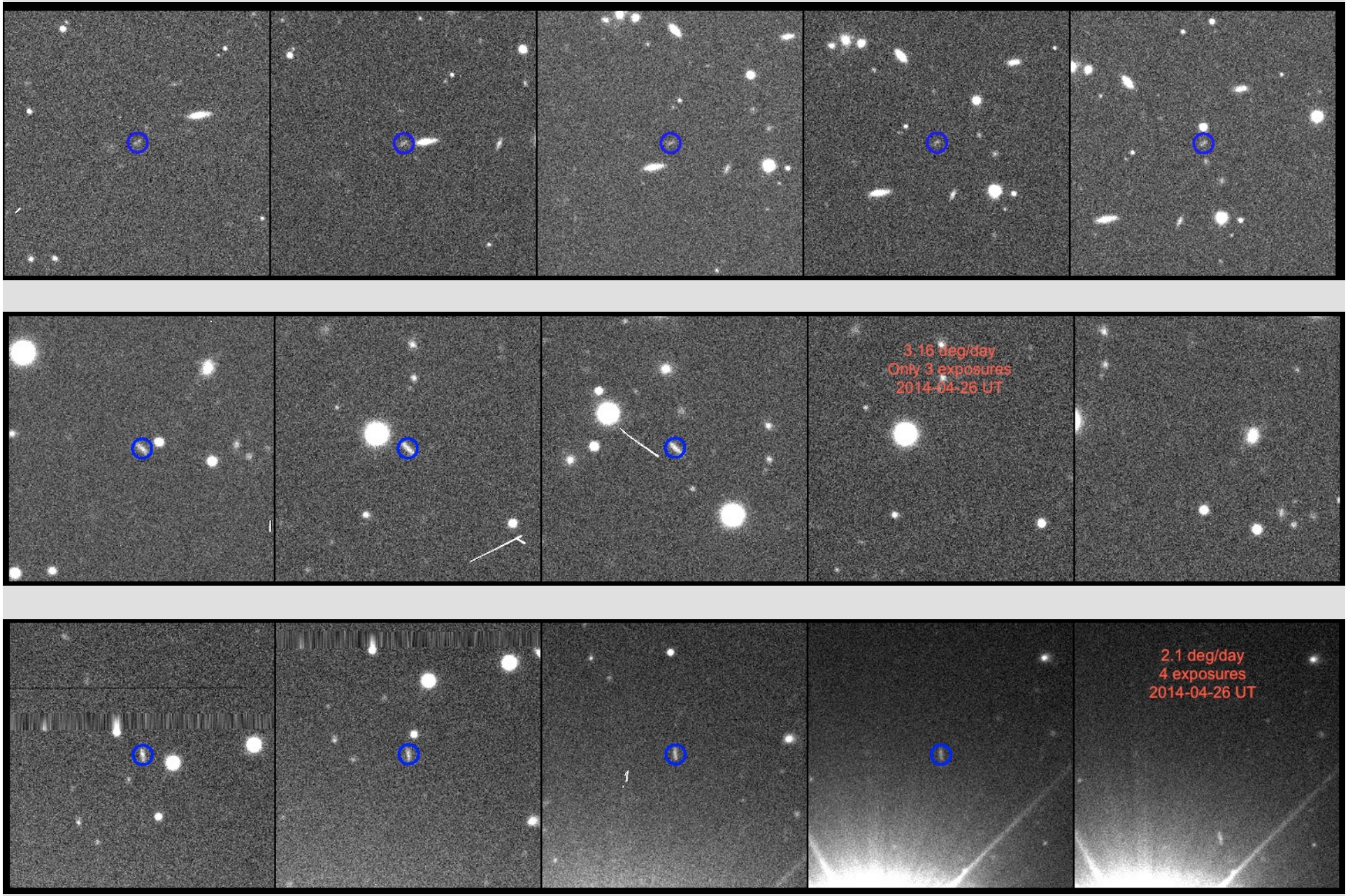
Moving Object Detections

(See poster by Valdes)

- Add synthetic asteroids at variety of rates, mags, PAs
- Make median stack for each pointing
- Catalog sources in difference images (exposure - median)
  - Pre-filter for common sources of contamination
  - Form pairs within the range of desired motions; require similarity (mag, shape, …)
  - Extend motion calculated from pairs to position at a common epoch
  - Cluster positions to identify tracklet
  - Filter based on moving object signature to eliminate non-physical groupings

Identifying NEOs

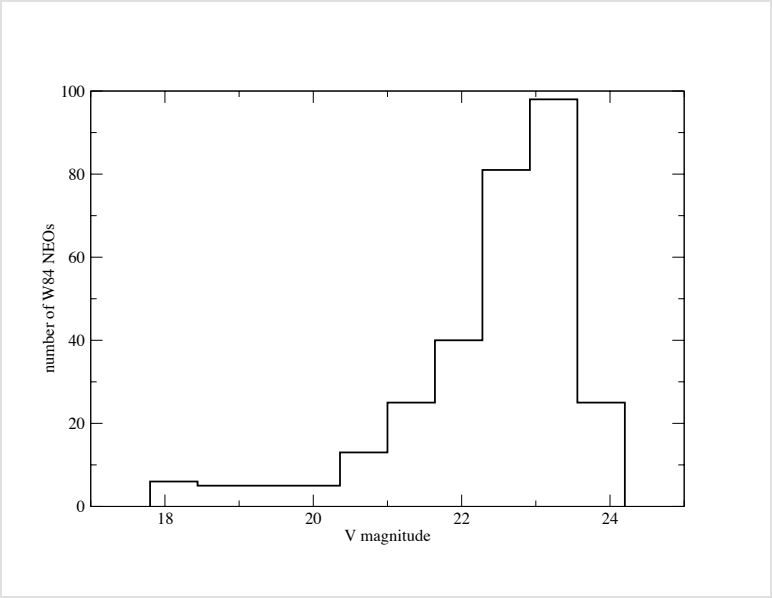
- Create cutouts
- Use MPC **`digest2`** program to make subset of detections of interest (NEO's, Trojans, Centaurs and unusual motions)
- Visually review the subset to eliminate remaining contamination
  - Virtually all 4 & 5 exposure detections are real
  - ~2% of 3 exposure detections are real (work continues to eliminate contamination automatically)
- Report to MPC
- MPC provides linkages and enables follow-up by community


3.16 deg/day
Only 3 exposures
2014-04-26 UT
2.1 deg/day
4 exposures
2014-04-26 UT

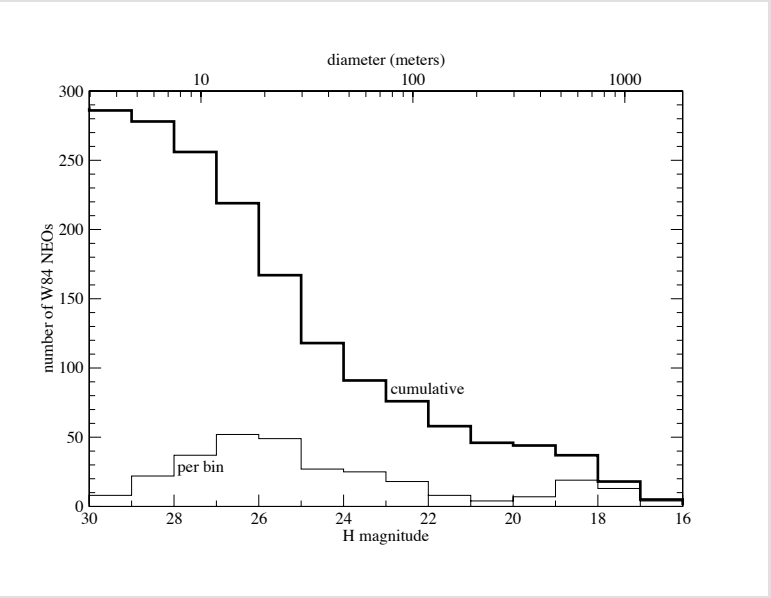
Results (from first 10 of 30 nights)

- Consider only objects designated by MPC as NEOs
  - Derived orbit gives distance & V → H (asteroid absolute magnitude)
  - Assume albedo (0.2) gives H → diameter
  - >1300 NEOs observed, 97 new NEOs discovered
    - (18%, 57% of all NEO observations, discoveries in same time period)

Number of detected NEOs vs. V mag

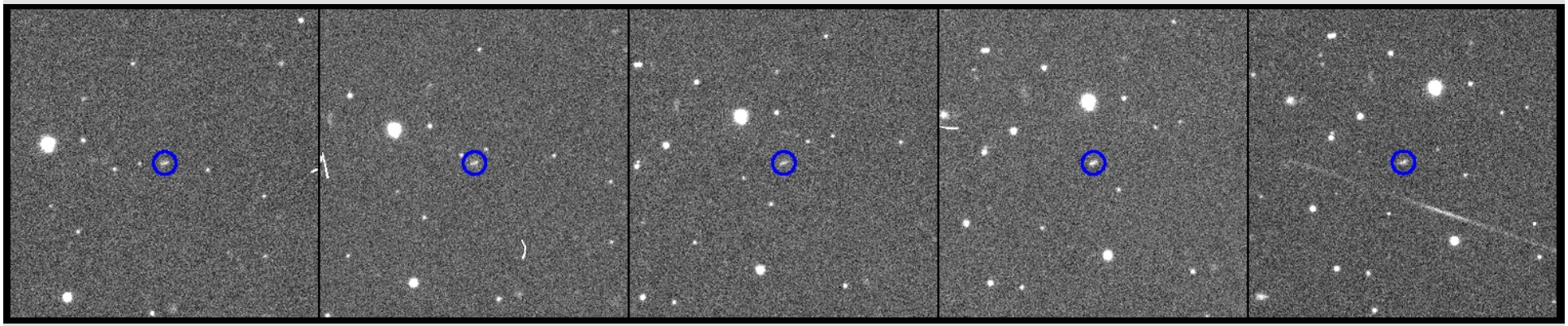


Number of detected NEOs vs. diameter



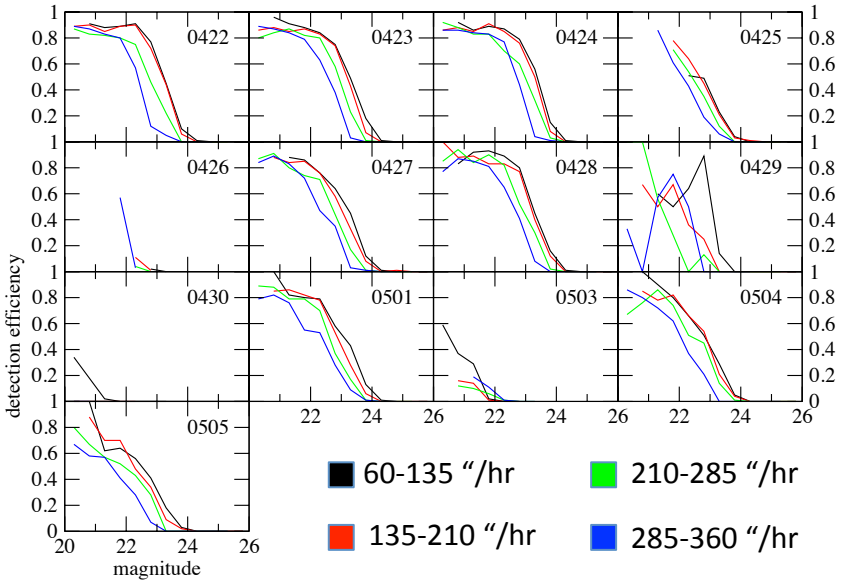
Computing Detection Probabilities

- Add simulated asteroids to data (~100/exposure)
  - Use each exposure's image quality
  - Skew distributions to provide sampling at all magnitudes and NEO rates
- Process observations with added asteroids with CP and MODS
- Match added asteroids to detected tracklets
- Compute probability as fraction of detections / total added



Detection efficiency

- Calculated for each night
  - Depends strongly on seeing, so some nights better than others
- Calculated for a range of rates of motion
  - Smearing of signal lowers surface brightness



Efficiency functions for all nights of April/May 2014 observing run, based on the injection and recovery of many thousands of synthetic objects.

Summary / Future

- Completed first third of survey time
  - CP+MODS proven
  - Synthetic NEO injection & recovery key to debiasing
  - First measured sized distribution to 10's of meters
- 20 more observing nights over next 2 years
  - Refine distribution, reduce uncertainties
- Deal with false positives in 3/5 detections
- Submit observations of Main Belt Asteroids to MPC
- Mine data for other transient phenomena
- Use survey as pathfinder to LSST NEO search