The Catalina Sky Survey

Current Operations and Future Capabilities

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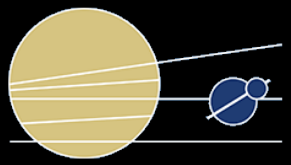

DEPARTMENT OF PLANETARY SCIENCES
Lunar and Planetary Laboratory

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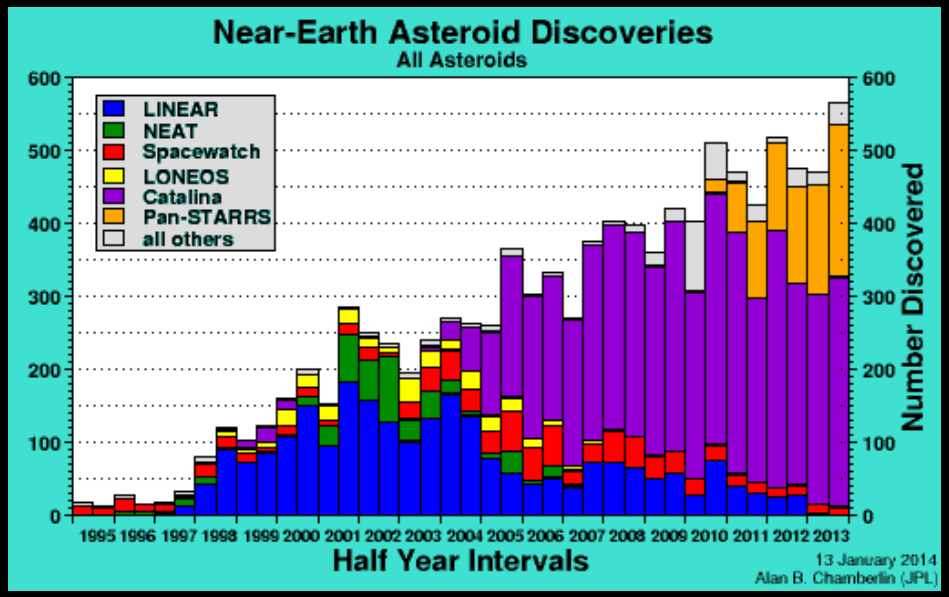
Catalina Sky Survey

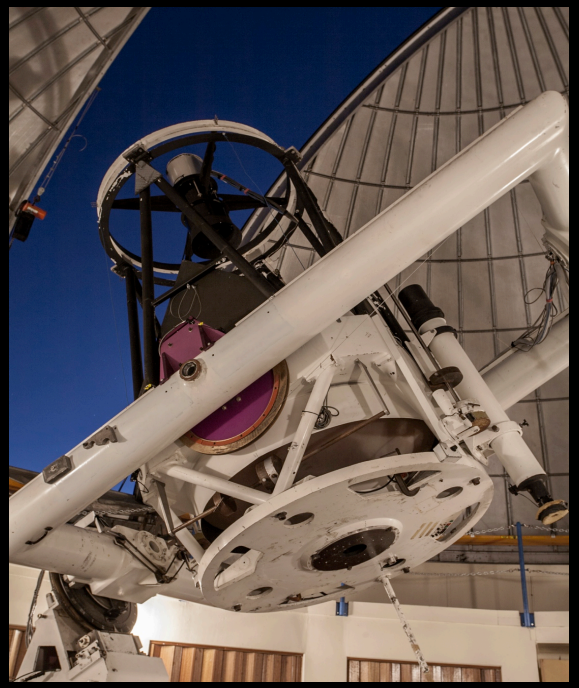
- Supported by NASA NEOO Program
- Based at the University of Arizona's Lunar and Planetary Laboratory in Tucson, Arizona
- Leader of the NEO discovery effort since 2004, responsible for ~65% of new discoveries (~46% of all NEO discoveries). Currently discovering NEOs at a rate of ~600/year.



- 2 survey telescopes run by a staff of 8 (observers, software developers, engineering support, PI)

Current Facilities

Mt. Bigelow, AZ
0.7-m Schmidt
8.2 sq. deg. FOV
V_{lim} ~ 19.5
~250 NEOs/year



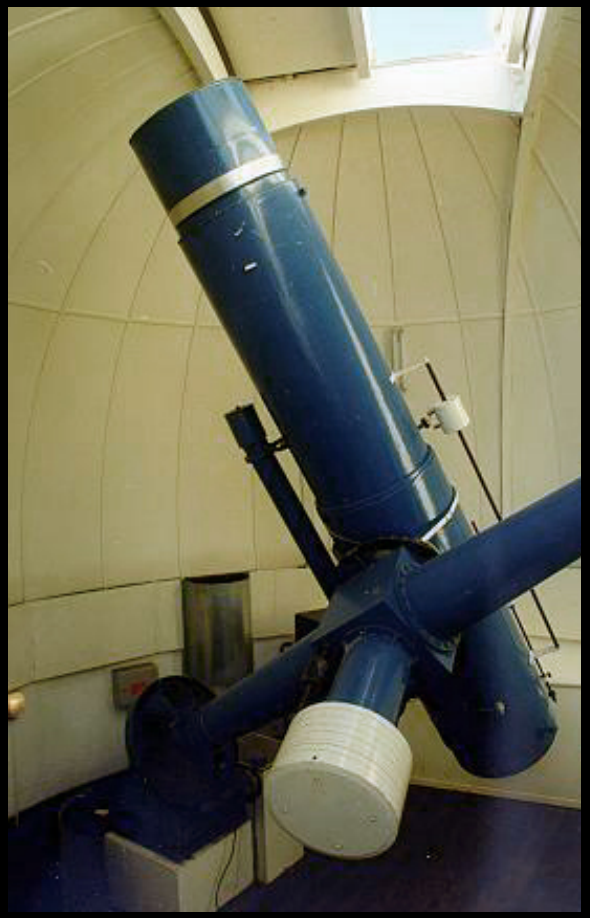
Mt. Lemmon, AZ
1.5-m reflector
1.2 sq. deg. FOV
V_{lim} ~ 21.3
~350 NEOs/year

Retired Facilities

Siding Spring Observatory, Australia
0.5-m Uppsala Schmidt
4.2 sq. deg. FOV
V_{lim} ~ 19.0
2004 – 2013
~50 NEOs/year

Was the only full-time NEO survey located in the Southern Hemisphere

Notable discoveries include Great Comet McNaught (C/2006 P1), rediscovery of Apophis



Upcoming Facilities

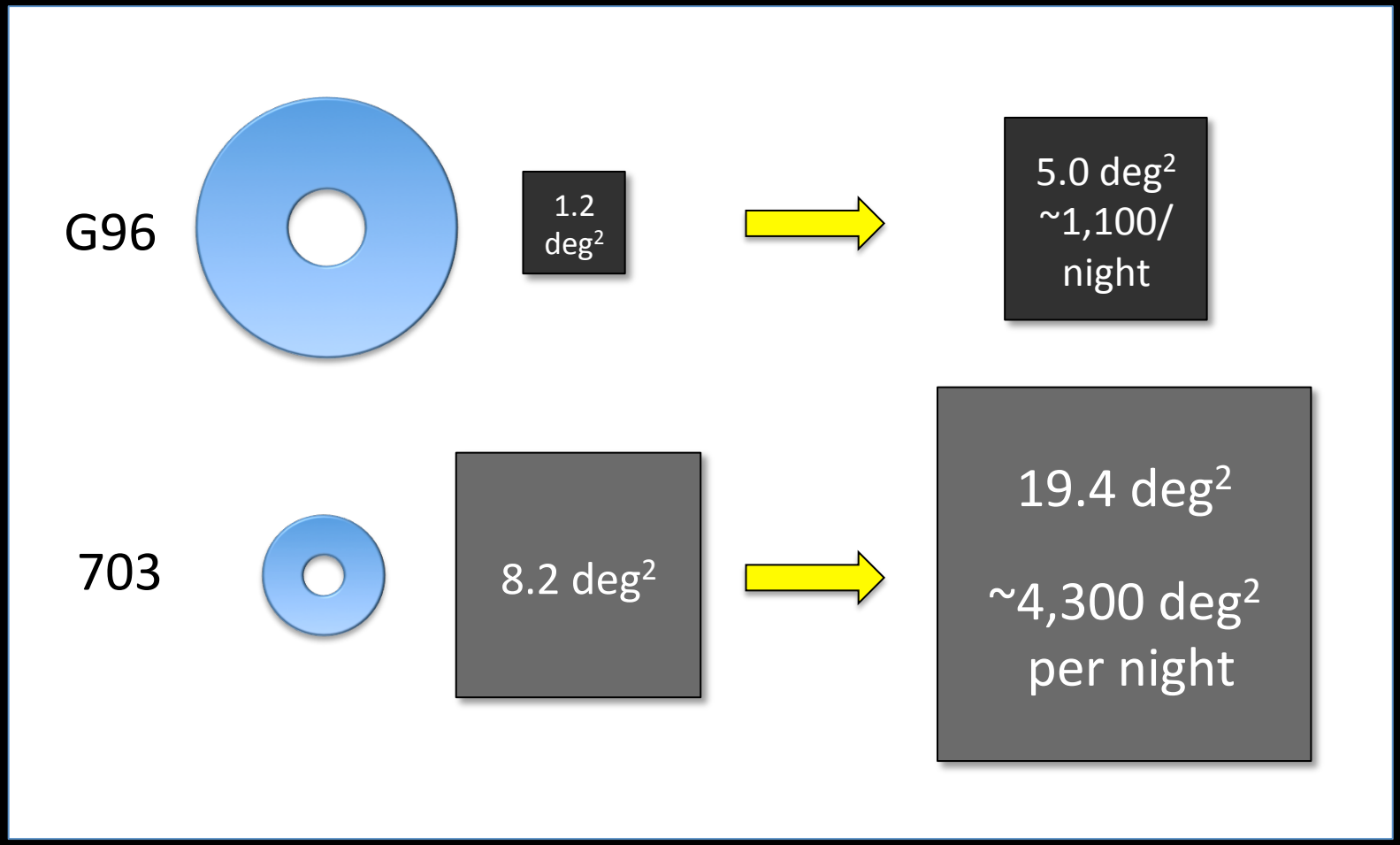
Mt. Lemmon, AZ
1.0-m reflector
0.3 sq. deg. FOV
1.0 arcsec/pixel

Operational 2014 – currently in commissioning

Will be primarily used for confirmation and follow-up of newly-discovered NEOs

Will remove follow-up burden from CSS survey telescopes, increasing available survey time by 10-20%

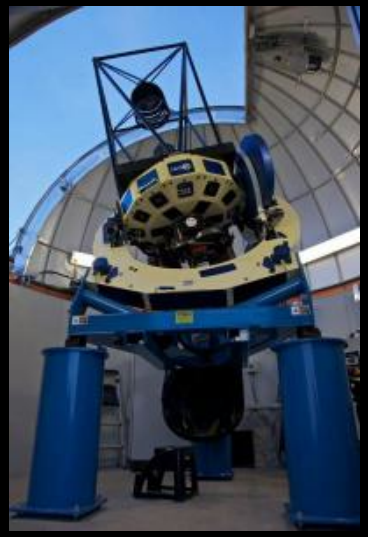
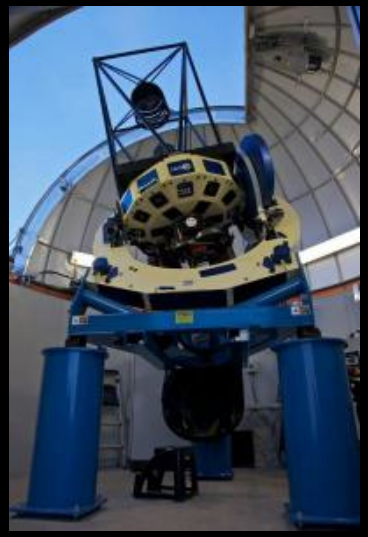
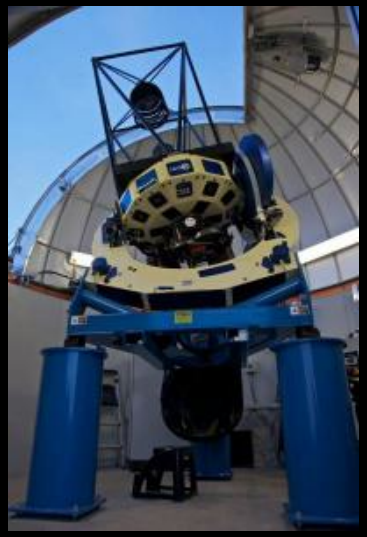
Increased FOV for both CSS survey telescopes



New 10k x 10k cameras will increase the FOV of both survey telescopes by factors of 4x and 2.4x. Discovery rate expected to increase by ~2-3x

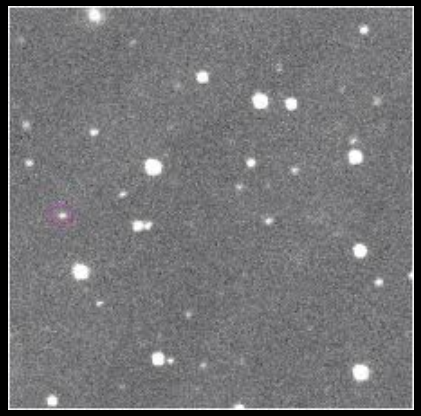
Proposed Facilities

- CLASS: the Catalina LCOGT Asteroid Southern Survey
- 3 x 1.0-m telescopes, 25 sq. deg FOV equivalent
- Flexible operation – can survey separately or together
- ~5800 sq. deg. coverage per night to V~20.4, or ~2000 sq. deg. to V~21.6 (assuming 4 visits)
- To be located on Cerro Tololo, Chile

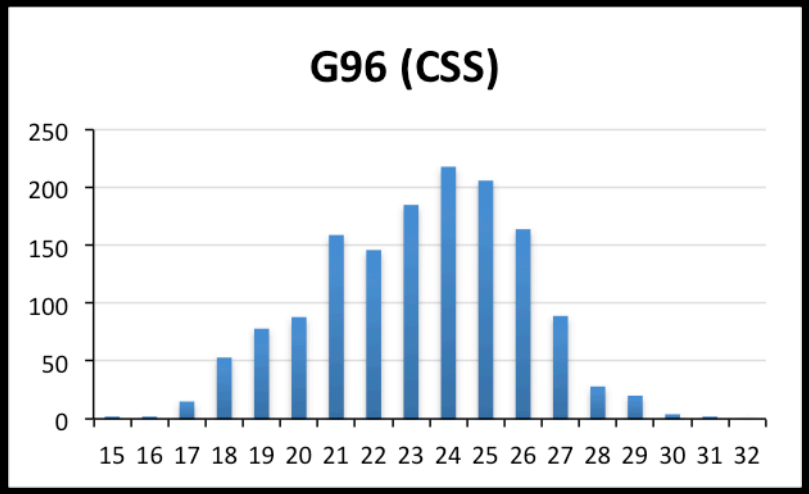
Notable CSS capabilities

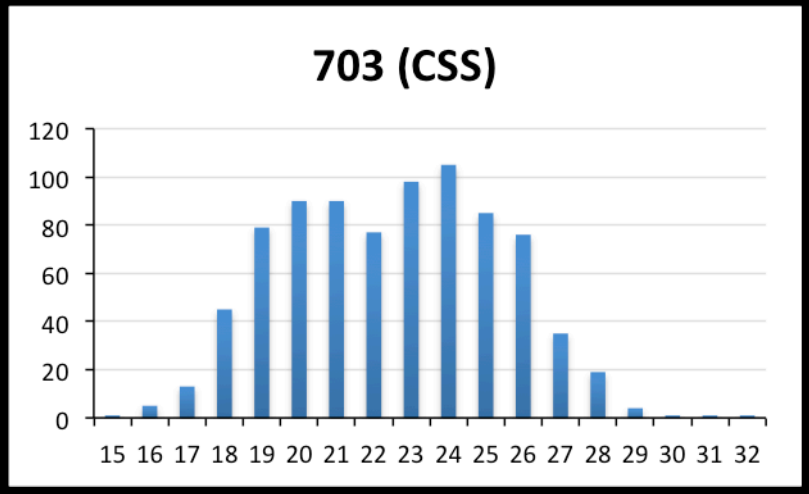
- Real-time data processing and reporting
- Visual validation, sensitive to NEOs to ~1 sigma
- Broad sensitivity to both large and small NEOs
  - Good sensitivity to large (H<22) objects
  - Best sensitivity to small objects (H>24)
  - Unique sensitivity to imminent impactors

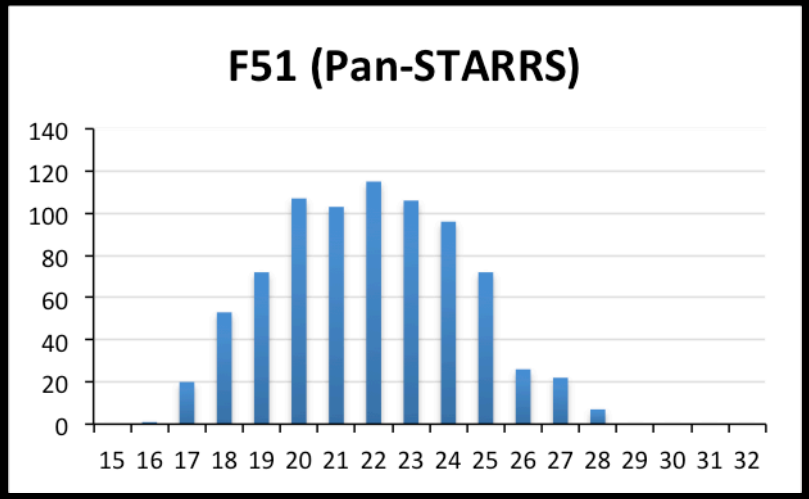


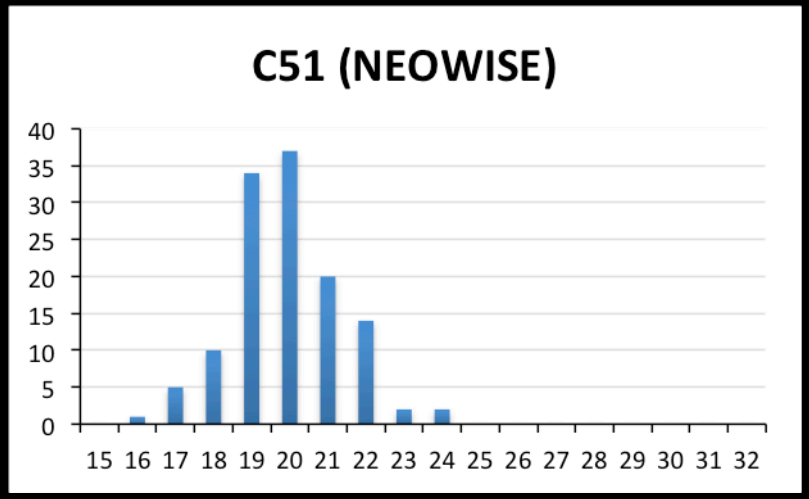
Survey biases: relative efficiencies

Plots show distribution of H magnitudes of NEO discoveries from 2010 - 2013









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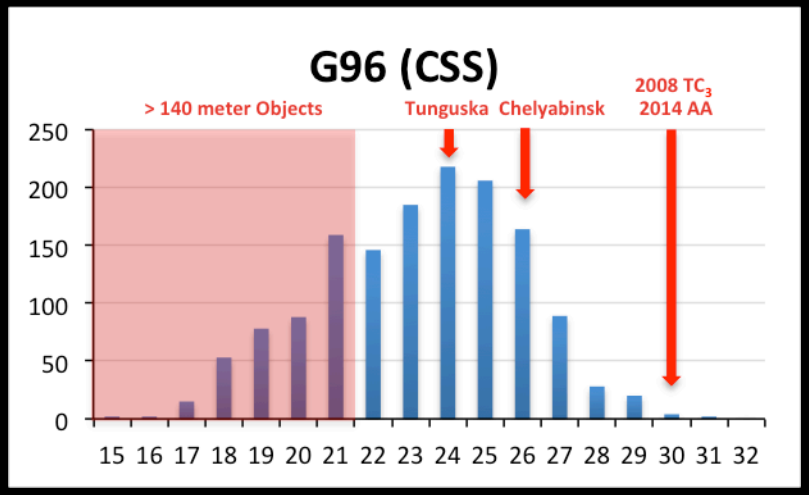
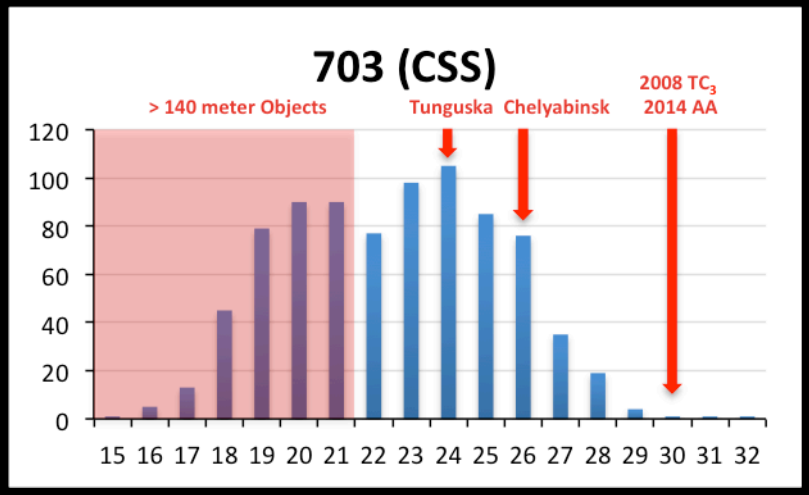
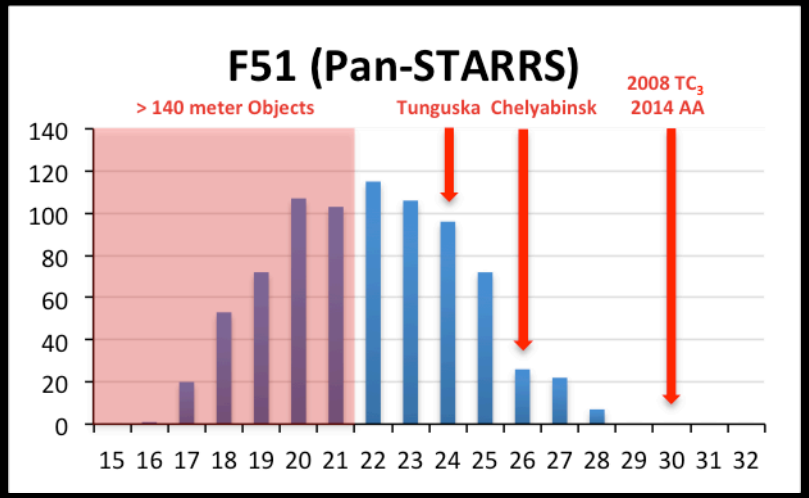
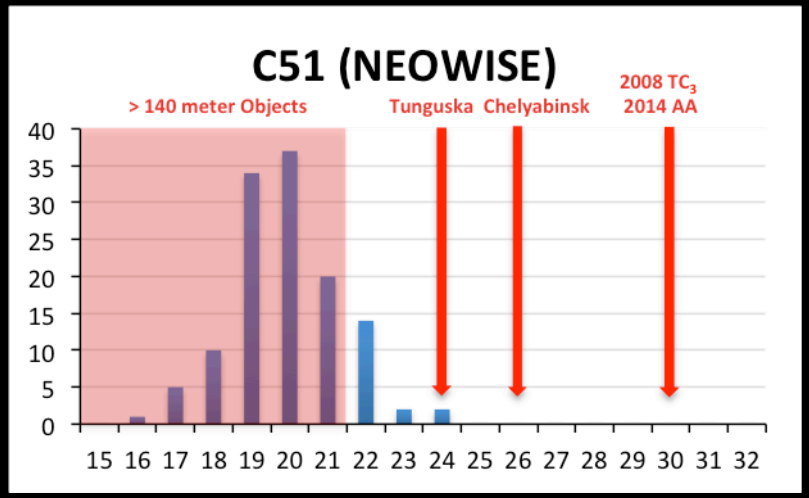








Detecting small imminent impactors

- 2008 TC_3 and 2014 AA were both discovered by CSS (G96) with ~1 day to impact, at V~19-20
- Real-time processing, real-time identification, and real-time reporting, plus same-night follow-up is REQUIRED to characterize impact probabilities, maximize time for physical studies, and accurately predict impact time and location
- Impacts by small ~3-m asteroids represent the most frequent detectable impact events, and provide real-world exercises for dealing with the impact threat. A "fire drill" for NEO impacts.
- ~40% of impactors are visible within ~30 degrees of opposition in the days leading up to impact

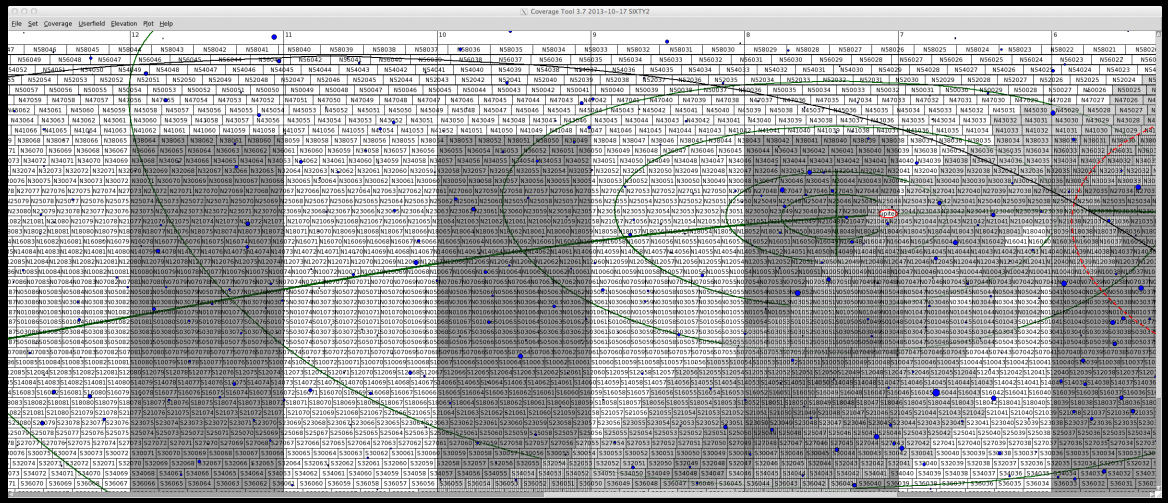
- Q: How to enable real-time sensitivity to small impactors?

A. Rich Kowalski

- Embedding humans into the discovery pipeline enables:
  - real-time awareness of interesting objects
  - flexible operation, follow-up scheduling
  - > 99% pure data stream (no false positives)
  - Sensitivity down to ~1 sigma
- CSS's reliance on real-time processing and human validation allowed the discovery of 2008 TC_3 and 2014 AA

Coordination among surveys

- CSS and Pan-STARRS are taking first steps toward inter-survey coordination
- Goal is to ensure both surveys are not looking at the same sky on the same night, and also to constructively combine survey biases to achieve better completeness
- Sky divided into regions that switch between surveys every 3 days



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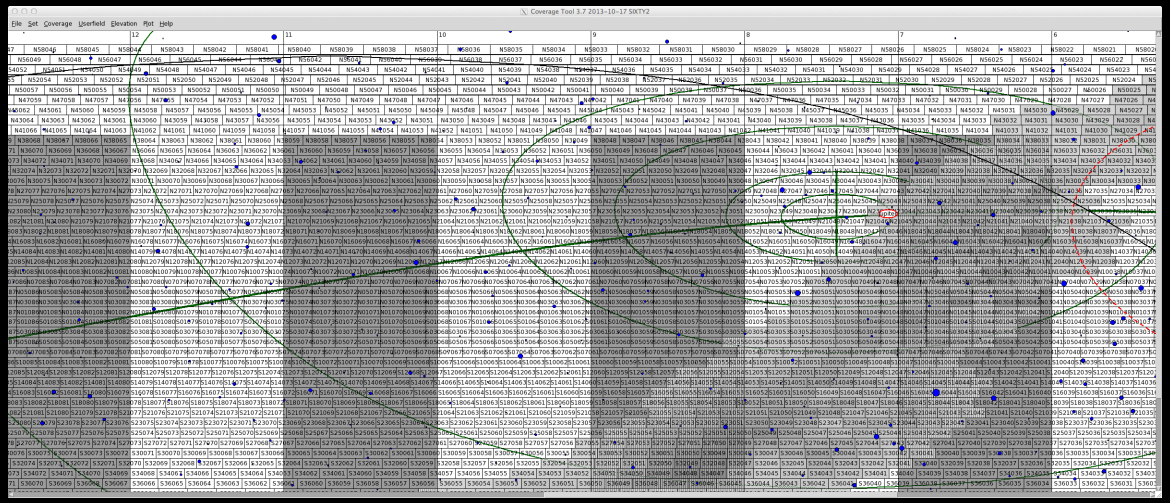

Ground-based NEO surveys

- Ground-based visible light surveys have advantages and disadvantages relative to space-based IR surveys, which can be measured in terms of:
  - Discovery capability / Scientific output
  - Cost
  - Risk of downtime / failure / loss
  - Available observing hours (daytime / moonlight / weather)
  - Longevity: ability to maintain / upgrade
  - Operational flexibility
- Ground-based visible light surveys and space-based IR surveys are *complementary*: each enhances and is enhanced by the other
- CSS is studying designs, costs, and capabilities for a dedicated, purpose-built next-generation NEO survey telescope(s)

Questions?

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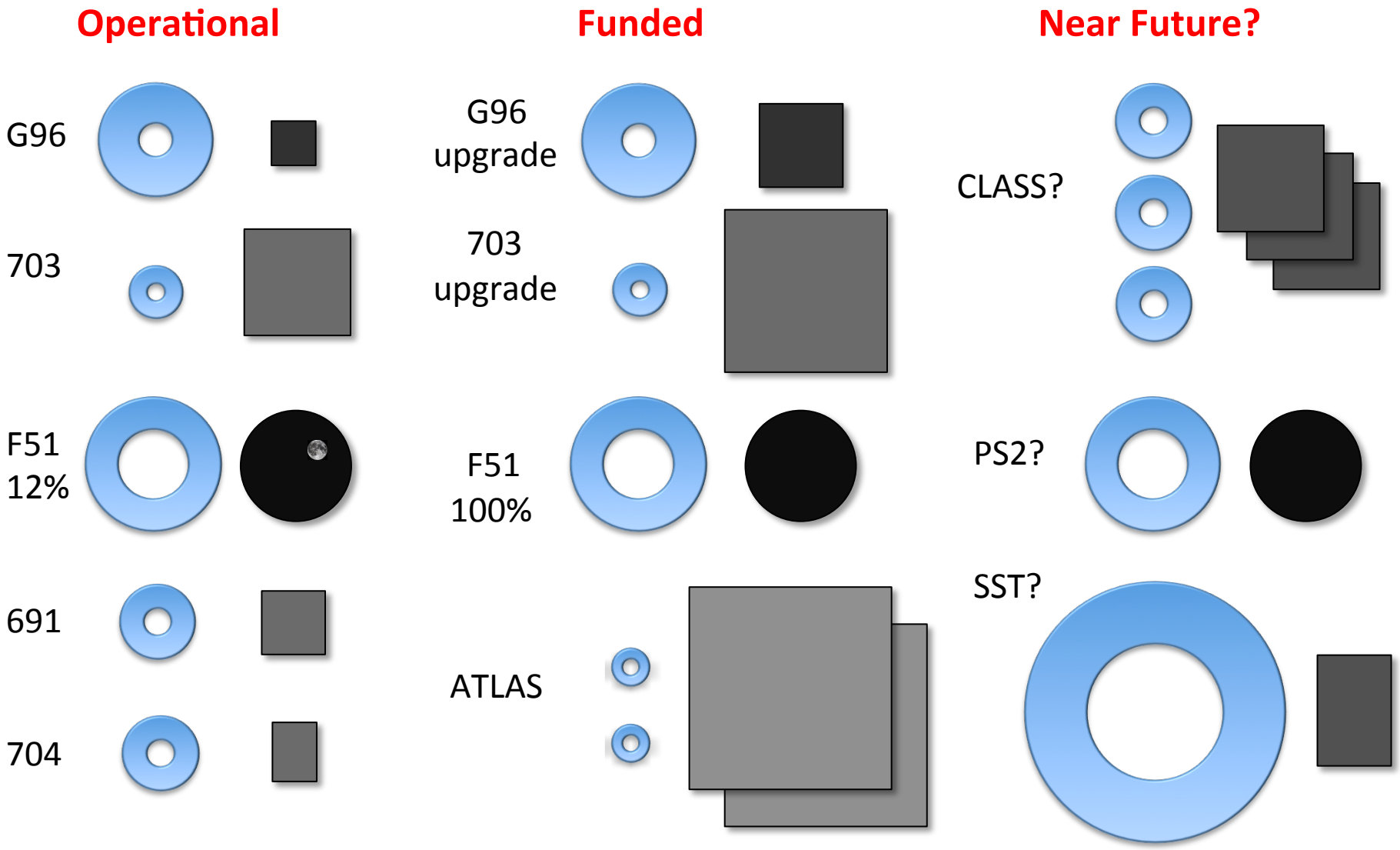
Ground-based NEO survey assets



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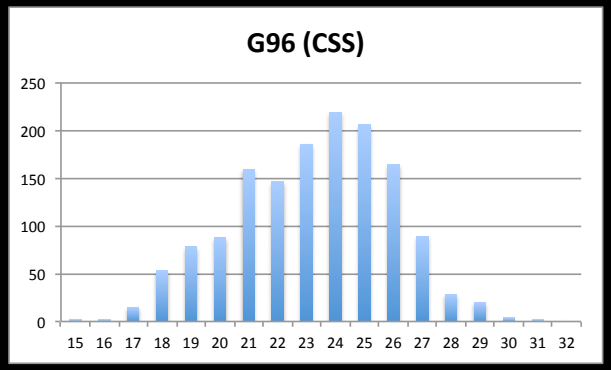

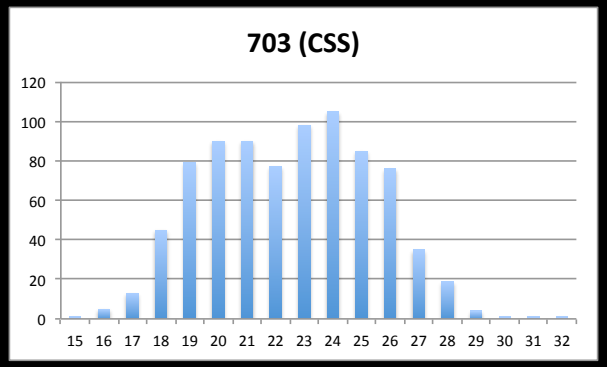

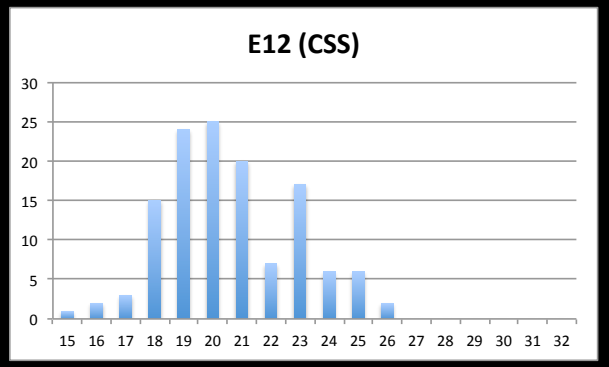

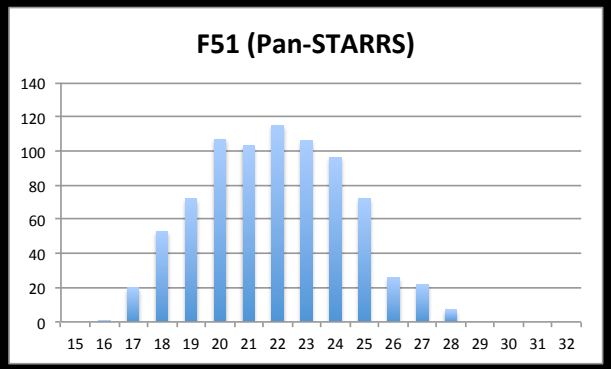

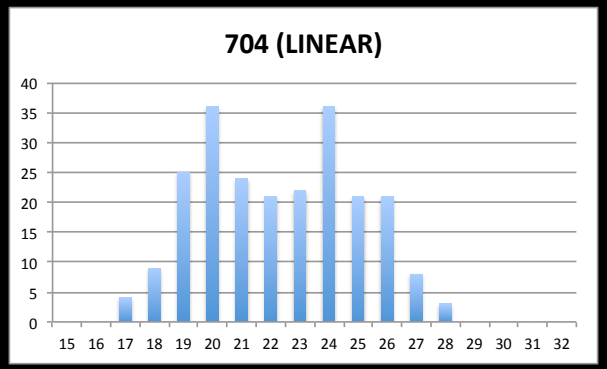

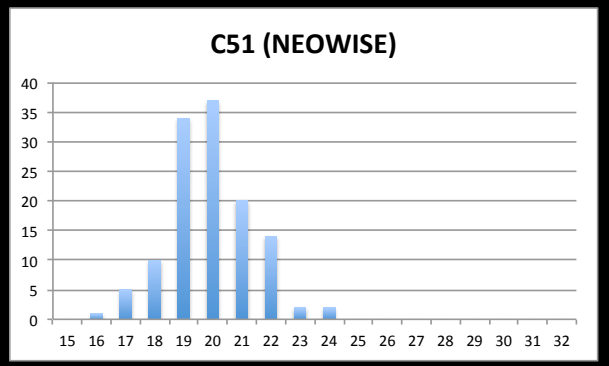

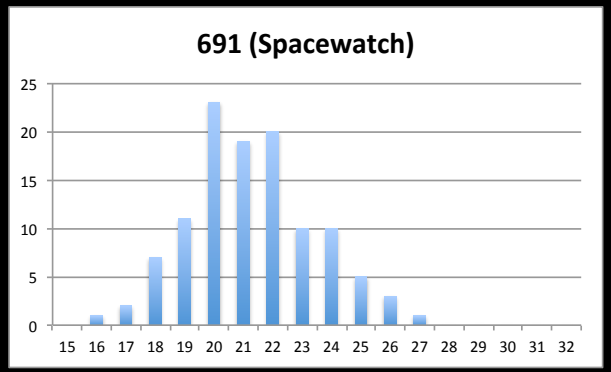

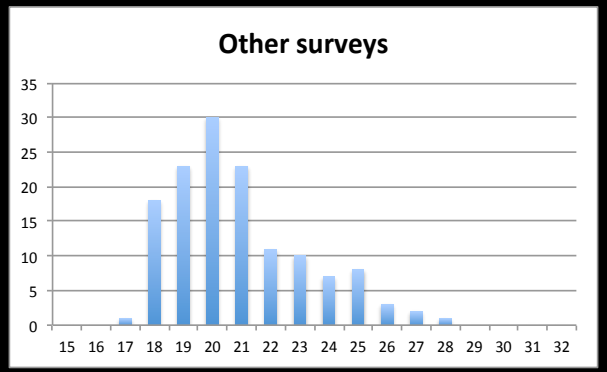

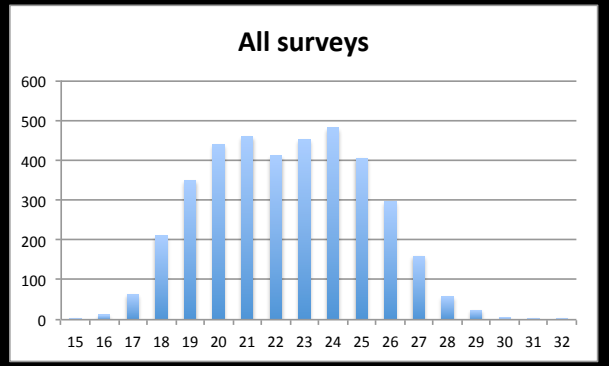

Ground-based NEO surveys

- CSS studying cost/engineering/performance issues for dedicated next-gen NEO survey
- All existing and past NEO survey telescopes were built for another mission, and re-purposed for NEO survey
- A ~4m-class system could efficiently survey to V~23-24, covering the sky ~2-4x per lunation
- Could be built and operated for ~10 years, for less than the *launch costs* of a dedicated space-based IR survey
- Complementary with space-based IR surveys