PREDICTED DISCOVERY OF LOW-DELTA V TARGETS AMONG THE NEO POPULATION BY NEAR-EARTH OBJECT SURVEYOR

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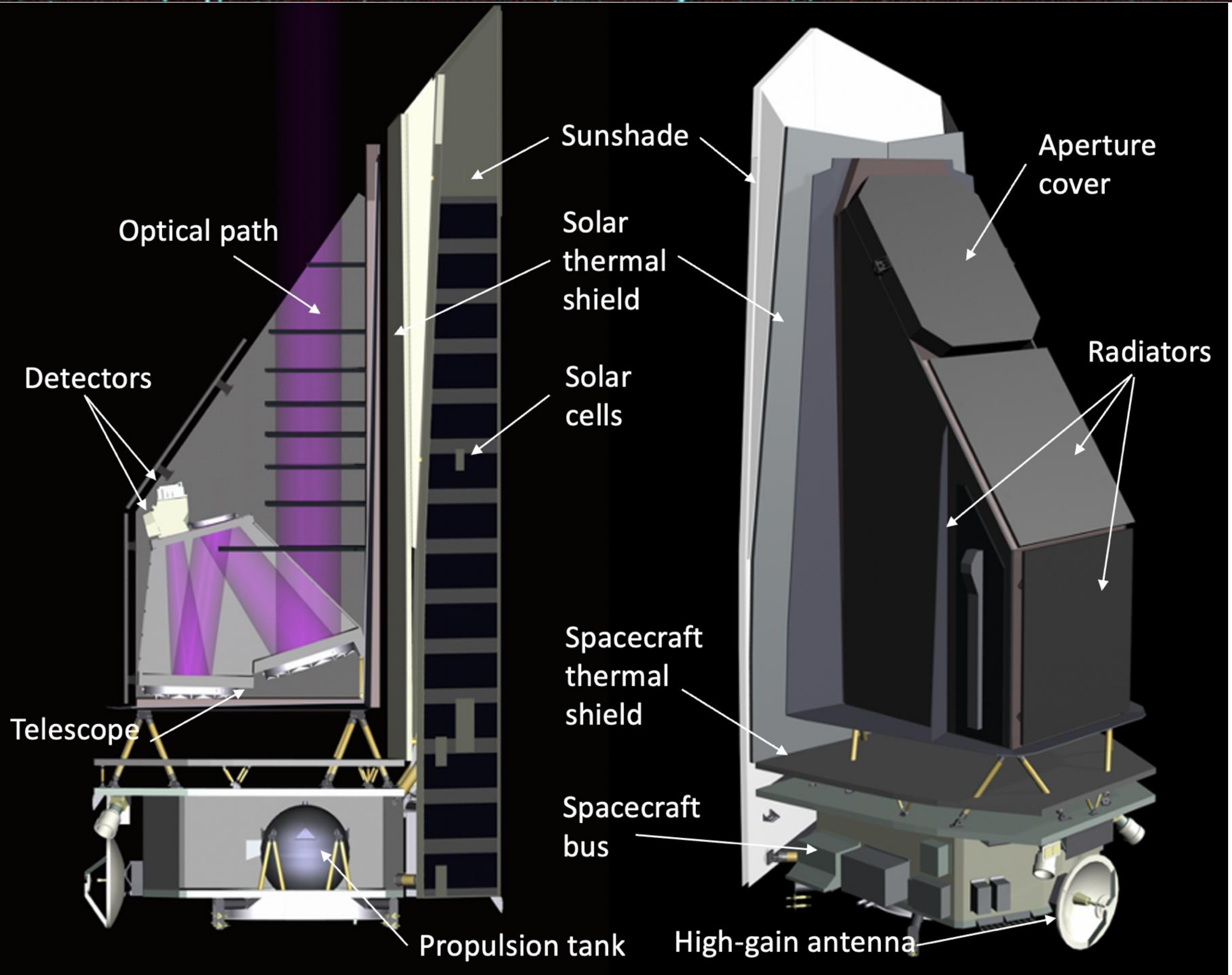
NEO Surveyor: Finding NEOs Before They Find Us

- ***NEO Surveyor*** **is a mission designed to find, catalog, and characterize NEOs.**
- **This mission responds to the 2005 George E. Brown NEO Survey Goal that requires NASA to find > 90% of NEOs larger than 140 m in diameter within 15 years (before end of 2020).**
- ***NEO Surveyor*** **is an infrared space telescope with a design and survey strategy optimized for discovering the NEOs that are most likely to impact the Earth.**
- **Why do this now?**
  - **Because mitigation is most effective with years to decades warning before an impact.**
  - **Only roughly ~40% of 140 m NEOs have been discovered to date.**
  - **Observing from Earth/Sun L1 accesses geometries that are difficult to observe from ground-based observatories and current ground-based efforts cannot reach high levels of completeness for decades (more than ~30 years).**

(NEO Survey Status as of Dec. 14, 2024)

Mission Architecture



- **Observatory will survey from halo orbit at Sun-Earth L1**
- **Instrument is passively cooled**
  - **50-cm telescope**
  - **2 IR channels imaging simultaneously**
  - **4-5.2 um and 6-10 um**
  - **Field of view 11 sq deg**
- **Spacecraft is based on BAE (formally Ball Aerospace) heritage**
  - **3-axis stabilized spacecraft**
  - **The ejectable cover is the only deployment**

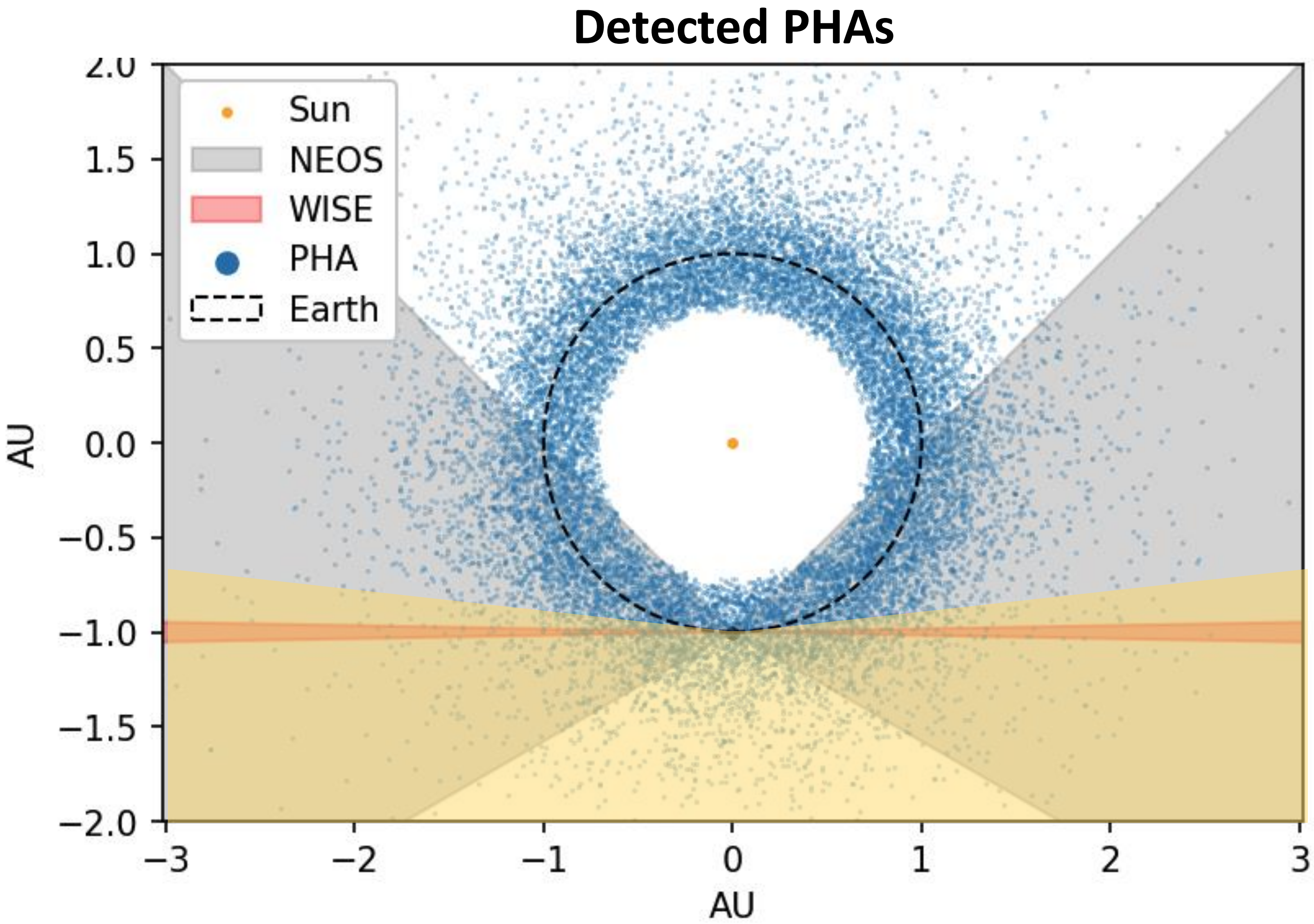
NEO Surveyor Survey Simulator

- **We have created a survey simulator to predict how many asteroids and comets we will see with *NEO Surveyor*, the NEOS Survey Simulator (NSS) (Masiero et al. 2023).**

- **It uses a reference model population of small bodies along with a model of the Observatory, the CONOPS, and detection capabilities to calculate how many asteroids & comets will appear in each *Visit* & how many objects will be detected.**
  - The model includes NEOs down to 30 m, comets, and background objects such as main belt asteroids and Jovian Trojans.

- **Expect to discover ~200,000 - 300,000 new NEOs, millions of MBAs, and thousands of comets, a significant improvement on the number known today (Mainzer et al. 2023).**

NEO Surveyor Field of Regard



Approximate field of regard for Ground-based surveys

NEO Surveyor field of regard

- Detected PHAs are defined as having MOID ≤ 0.05 AU and diameters ≥ 50 m.
- This plot is based on a simulated 5 yr survey.

Approximate *NEOWISE* field of regard

NEOs in Earth-like Orbits

- ***NEO Surveyor's*** **ability to observe regions close to the Sun increases the likelihood that it will detect objects in very Earth-like orbits.**

- **These objects tend to have the lowest minimum orbit intersection distances (MOIDs) and thus pose the greatest risk of Earth impact.**

- **This attribute of *NEO Surveyor's* operation is not only important for planetary defense considerations, but it also provides an opportunity to identify low-delta V spacecraft mission targets.**

NHATS-like Simulation (10-year Simulation)

- **Actual NEO populations are not known, so emphasis is on fractional population numbers rather than absolute number of objects discovered.**

- **Despite the survey's focus on the ≥ 140 m population, *NEO Surveyor* is expected to find many low-Earth MOID objects even if they are smaller than 140 m. Such objects represent significant hazards and mission opportunities.**

- **NEAs are marked as discovered by a simulated 10-year *NEO Surveyor* telescope survey. Those that are discovered will have diameter information.**

- **Note: *NEO Surveyor* has 5-year prime mission with an operational goal of 10 years.**

NHATS*-like Simulation (10-year Simulation)

- **38,812 NEAs as of 2025-08-01 in the Small-Body Database (SBDB)**

- **6,294 NHATS NEAs as of 2025-08-01 (~16% of the overall NEA population) see: https://cneos.jpl.nasa.gov/nhats/**

- **125,000 simulated NEAs produced by the NEO survey simulation (W. G. Levine and T. Spahr).**
  - (100,000 NEAs with diameter 30-100 m)
  - (25,000 NEAs with diameter >100 m)

- **Actual populations are of course not known, but model suggests ~millions of 30-100 m and ~50 thousand >100 m, but the error bars are quite large.**

*Near-Earth Object Human Space Flight Accessible Targets Study

Delta-V Analysis Methodology

- **Convex hulls are computed for the current NHATS NEAs using their osculating orbital elements: p = a(1-e2) (semi-latus rectum) and inclination.**

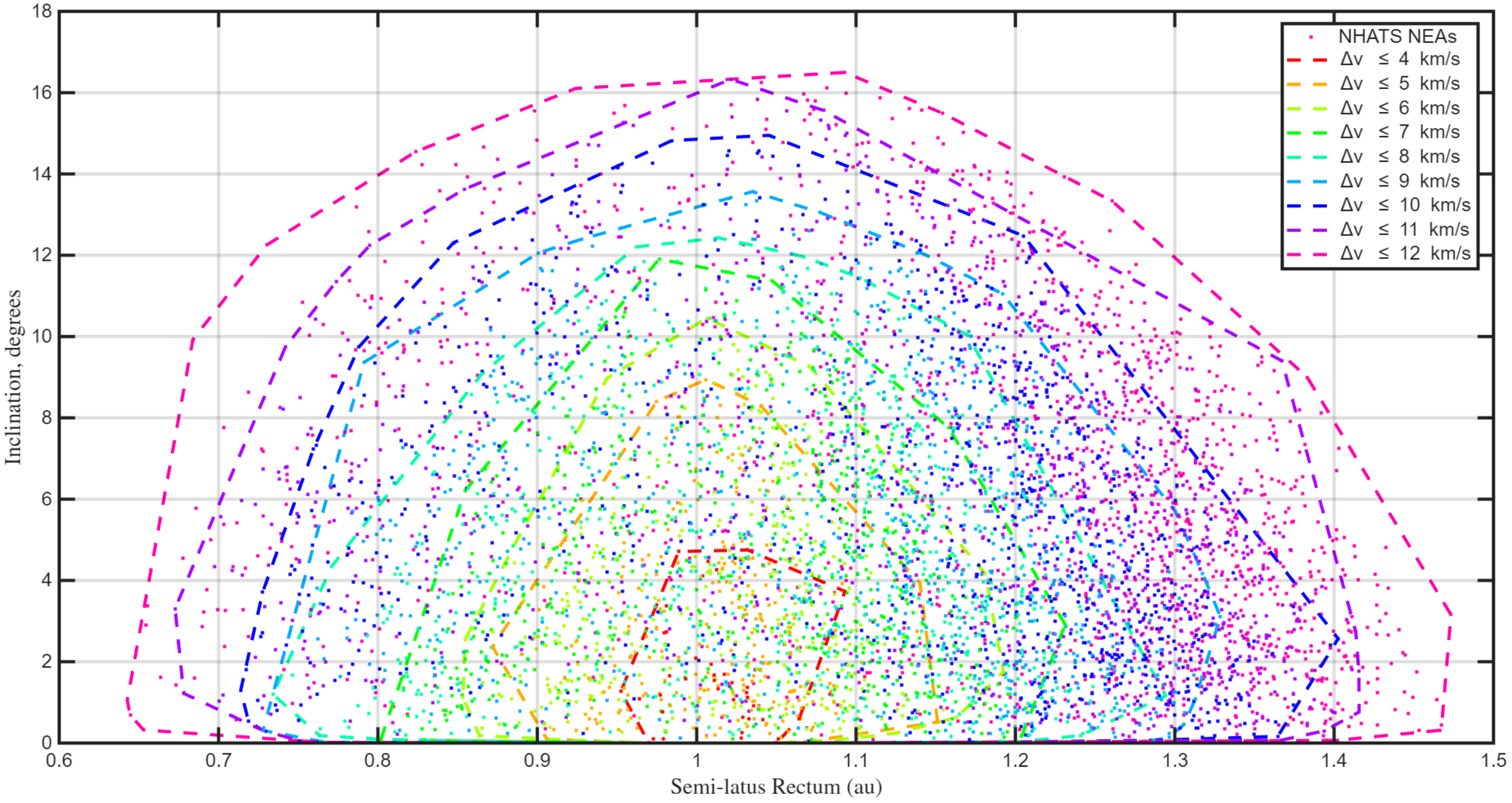
- **A convex hull is computed for each of the following total round-trip ΔV levels: ≤4, 5, 6, 7, 8, 9, 10, 11, and 12 km/s (B. Barbee).**

- **p vs. i convex hulls for those round-trip ΔV levels from NHATS are then applied to the simulated NEAs' osculating orbital elements to estimate which of the simulated NEAs could be accessible for round-trip missions at those ΔV levels.**
  - **Includes NHATS round-trip trajectory constraints, e.g. total mission duration ≤450 days and minimum stay time at NEA of 8 days (see: https://cneos.jpl.nasa.gov/nhats/caveats.html)**

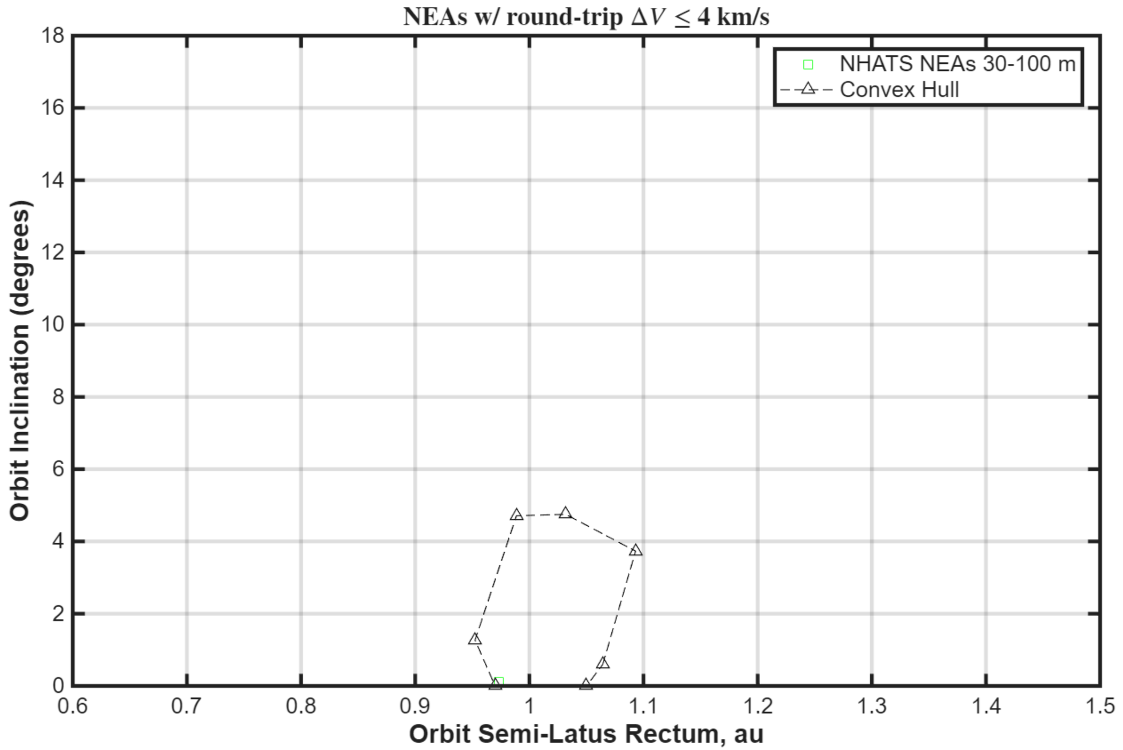
Delta-V Analysis Methodology

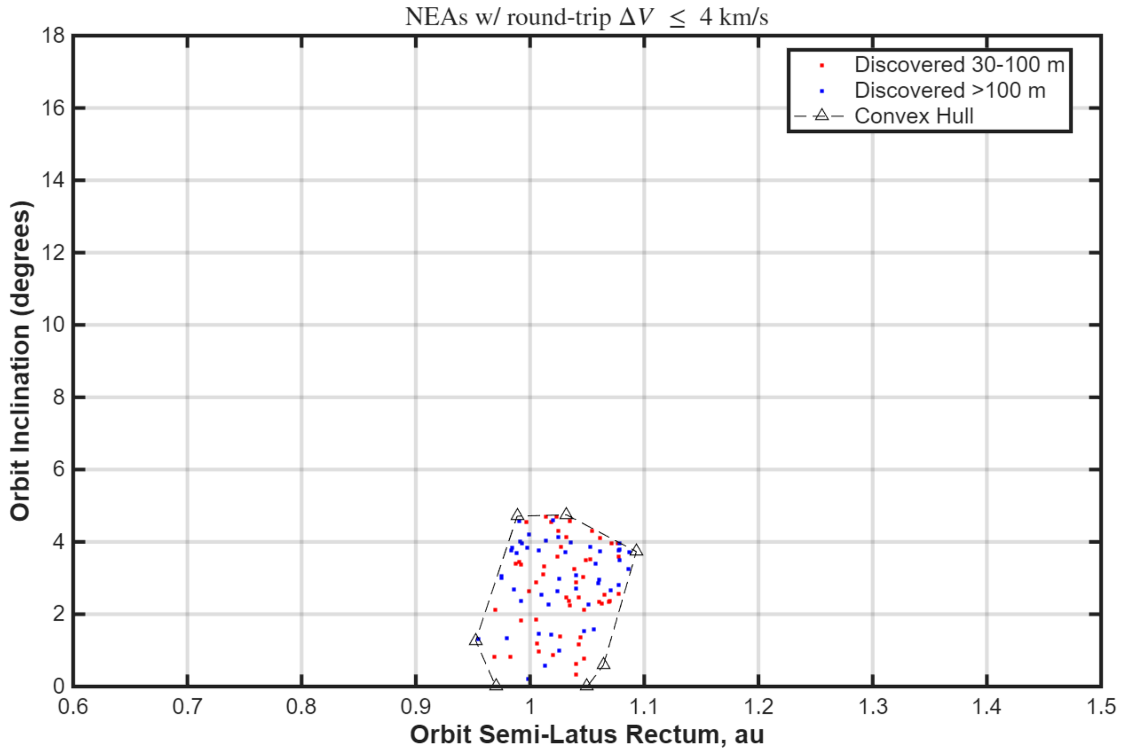
- **For NHATS NEAs diameters:**
  - **The diameter values from the SBDB are used where available.**
  - **If diameter is not available from the SBDB but albedo is available from the SBDB, then diameter is computed via the standard equation using H and albedo.**
  - **If neither diameter nor albedo are available from the SBDB, then diameter is computed via the standard equation using H and an assumed albedo of 0.14.**
  - **These are for real NHATS objects!**

Round-Trip ΔV Convex Hulls for NHATS NEAs

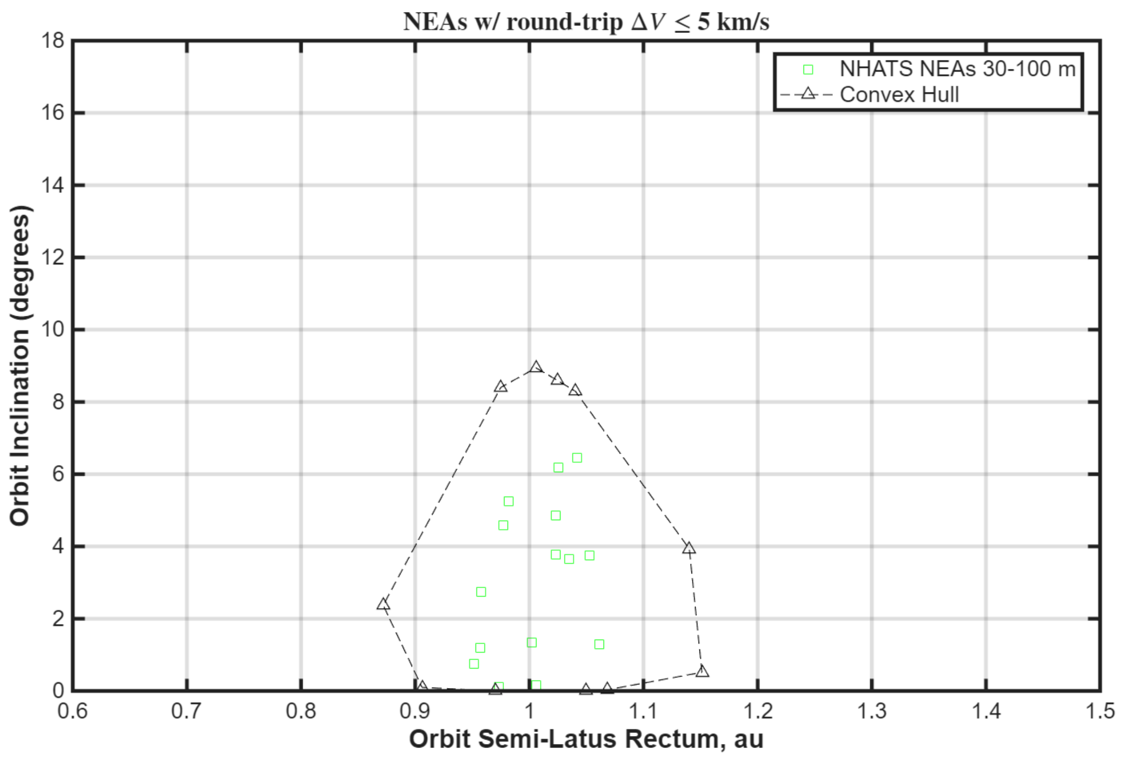


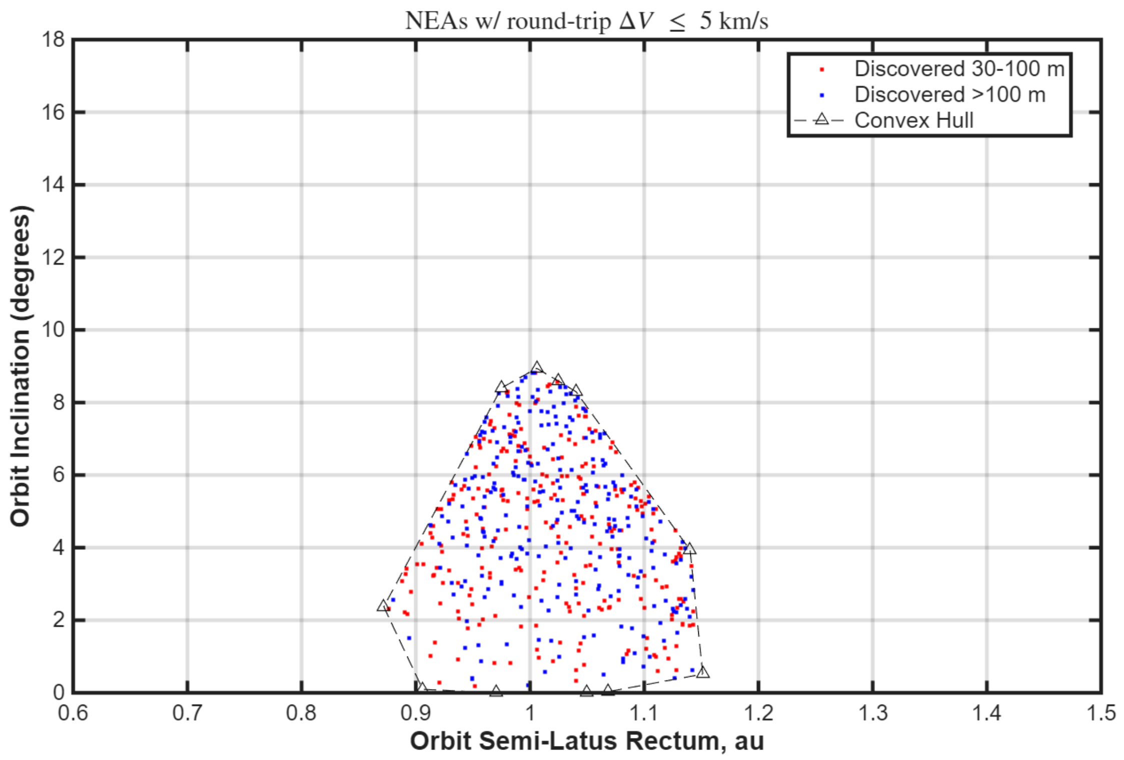
NEAs with Round-Trip ΔV ≤ 4 km/s



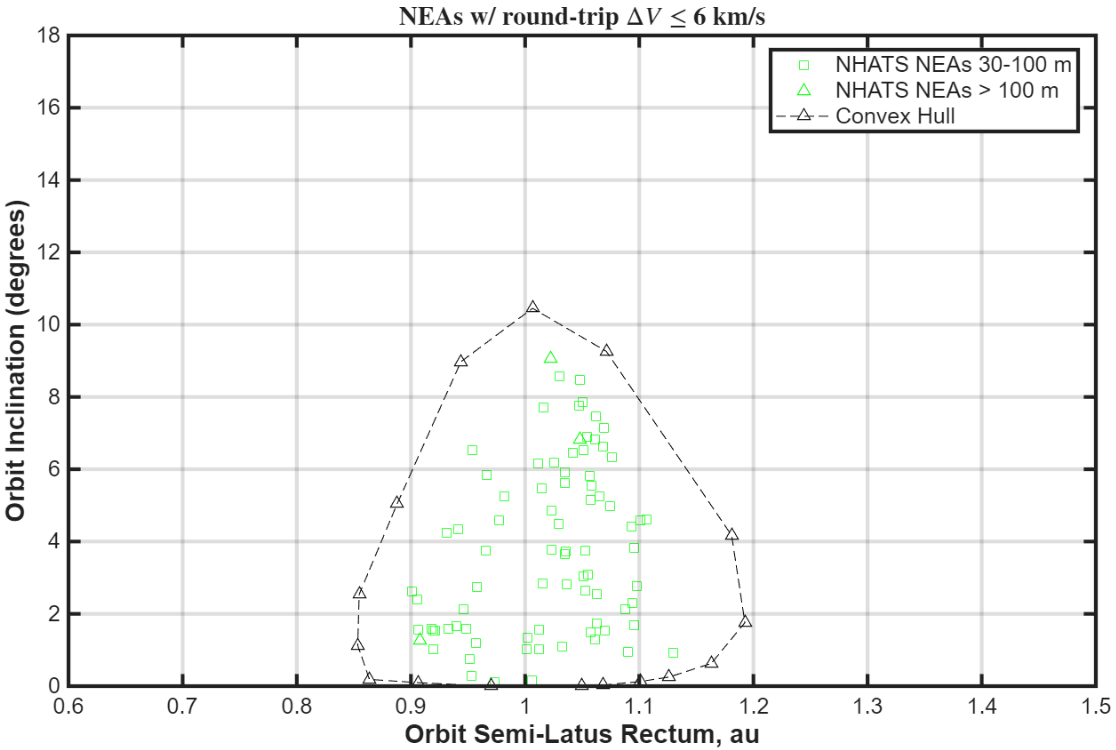


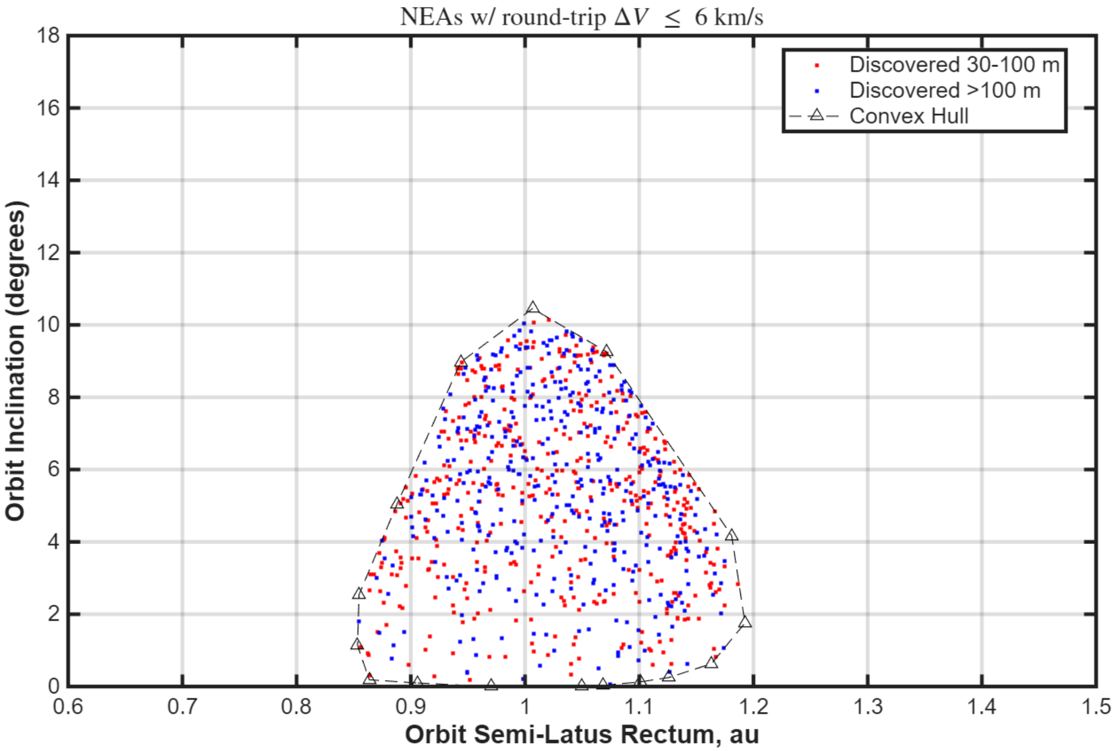
NEAs with Round-Trip ΔV ≤ 5 km/s



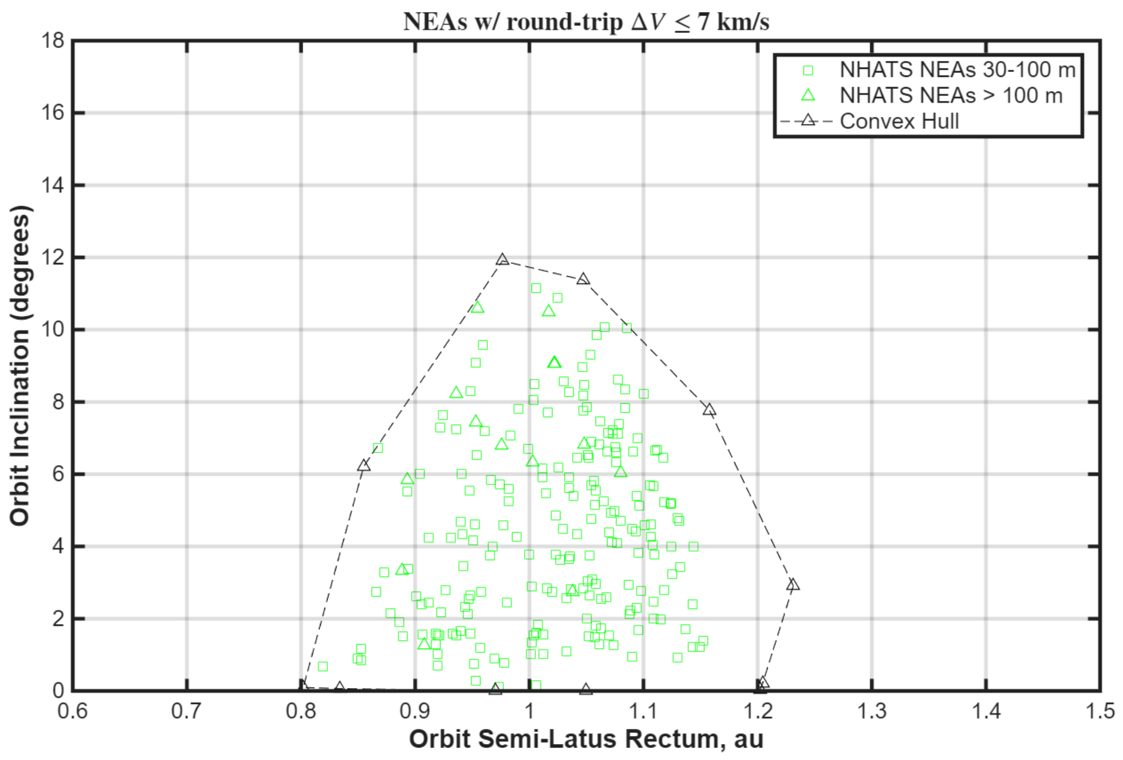


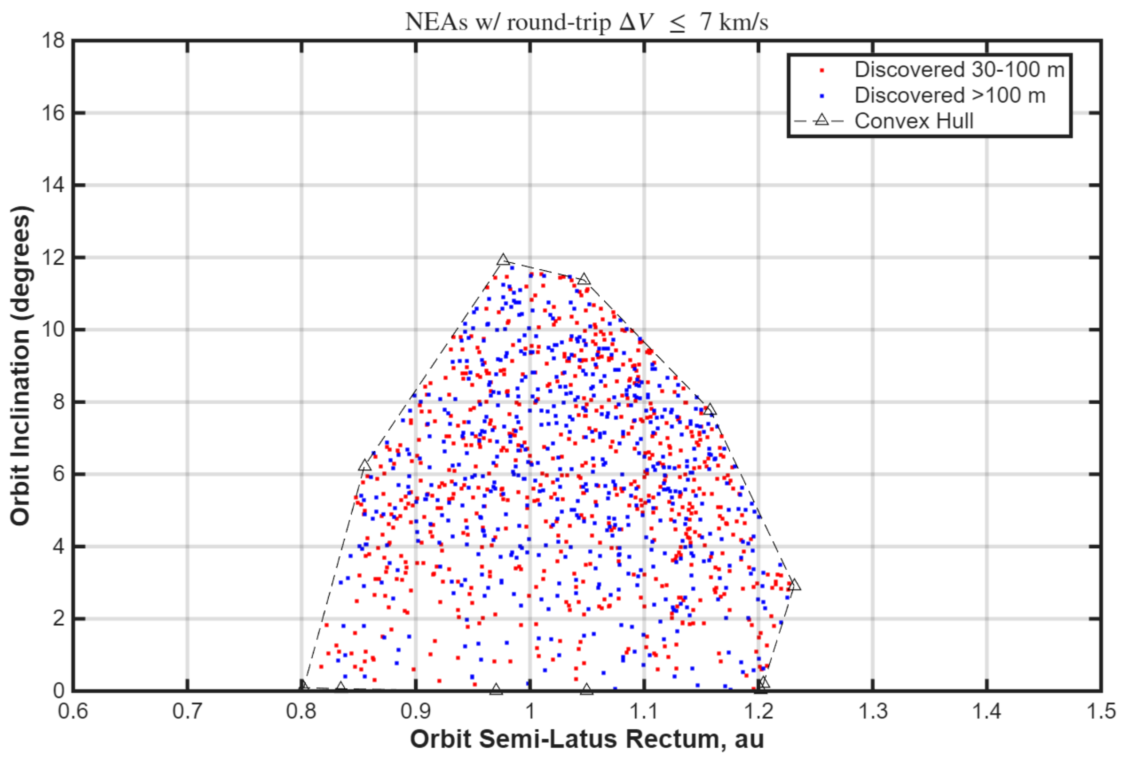
NEAs with Round-Trip ΔV ≤ 6 km/s



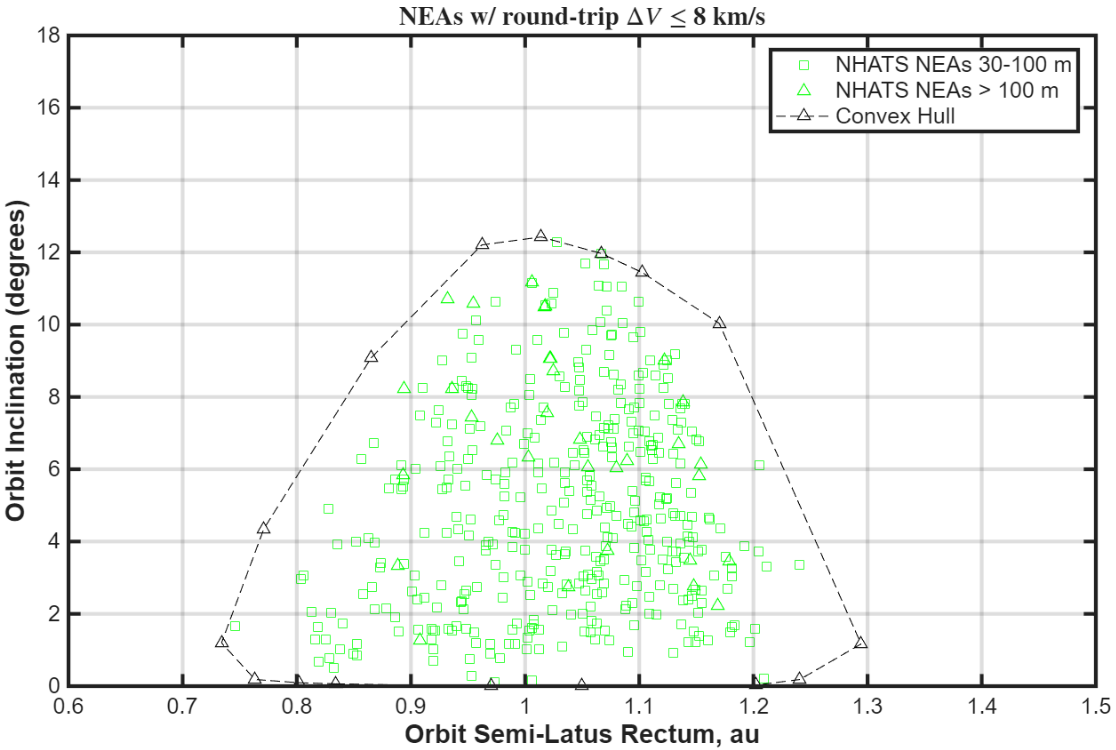


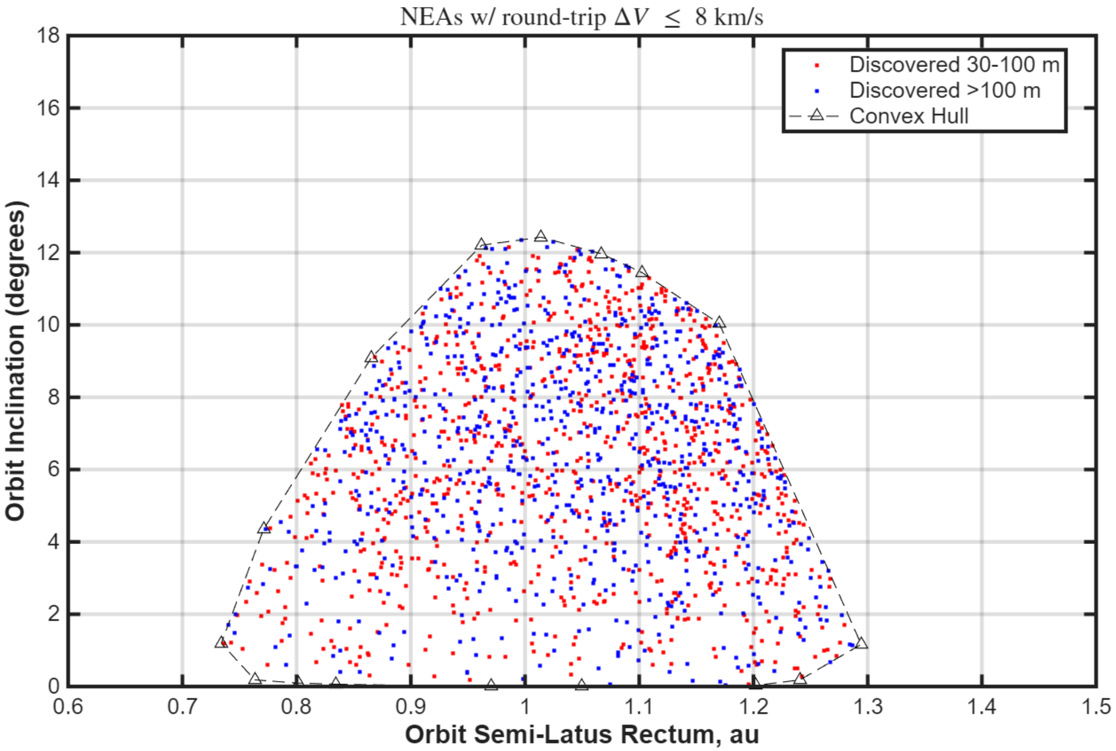
NEAs with Round-Trip ΔV ≤ 7 km/s



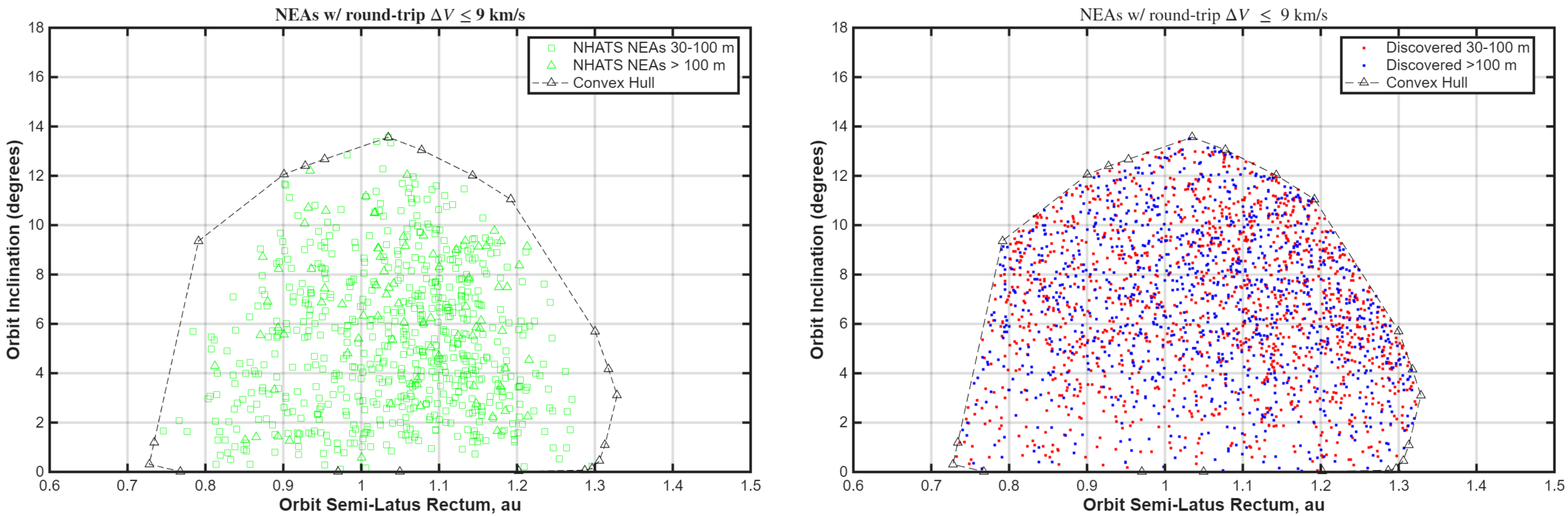


NEAs with Round-Trip ΔV ≤ 8 km/s

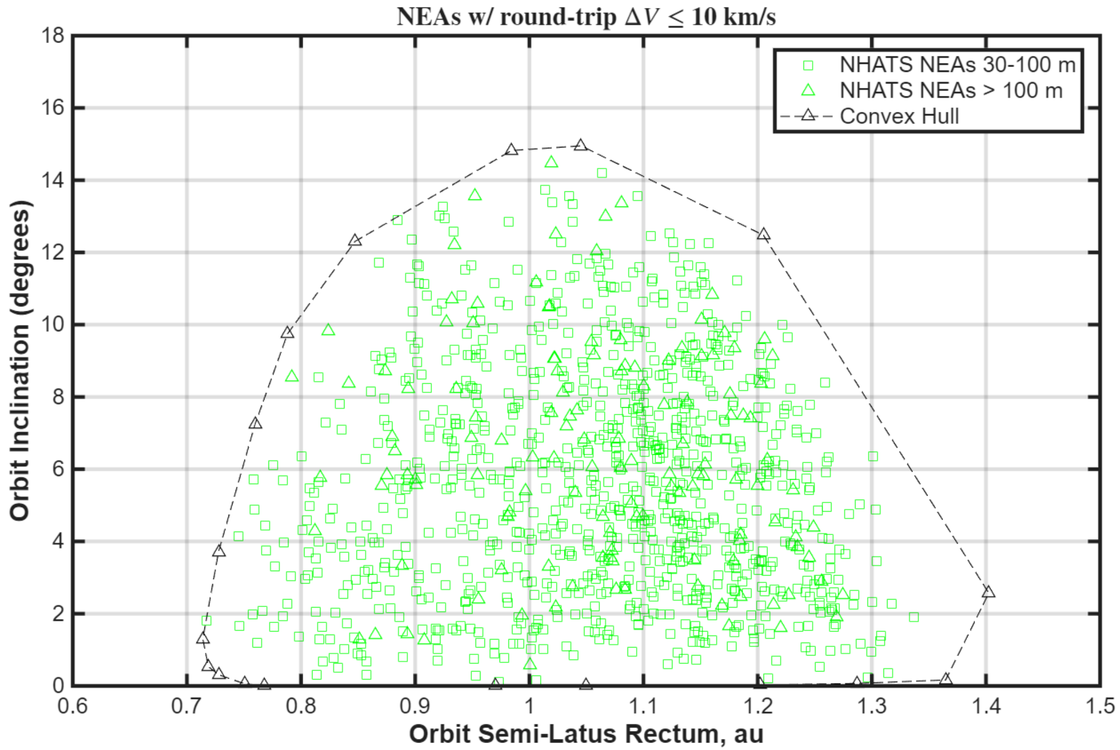


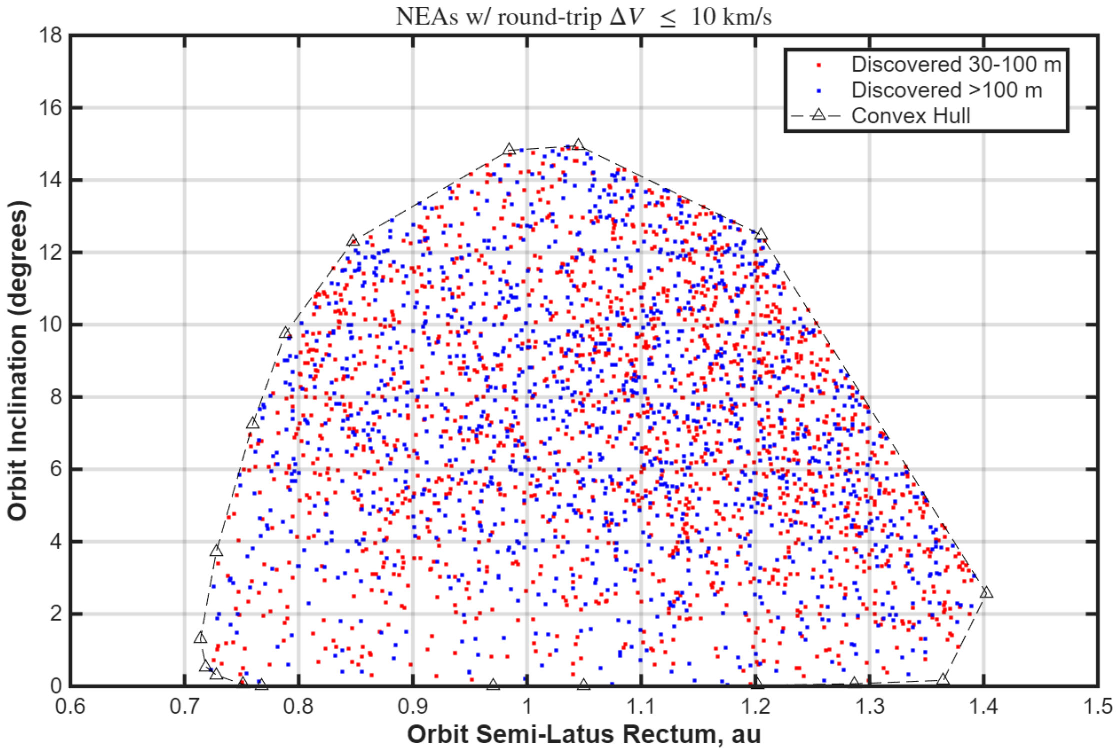


NEAs with Round-Trip ΔV ≤ 9 km/s

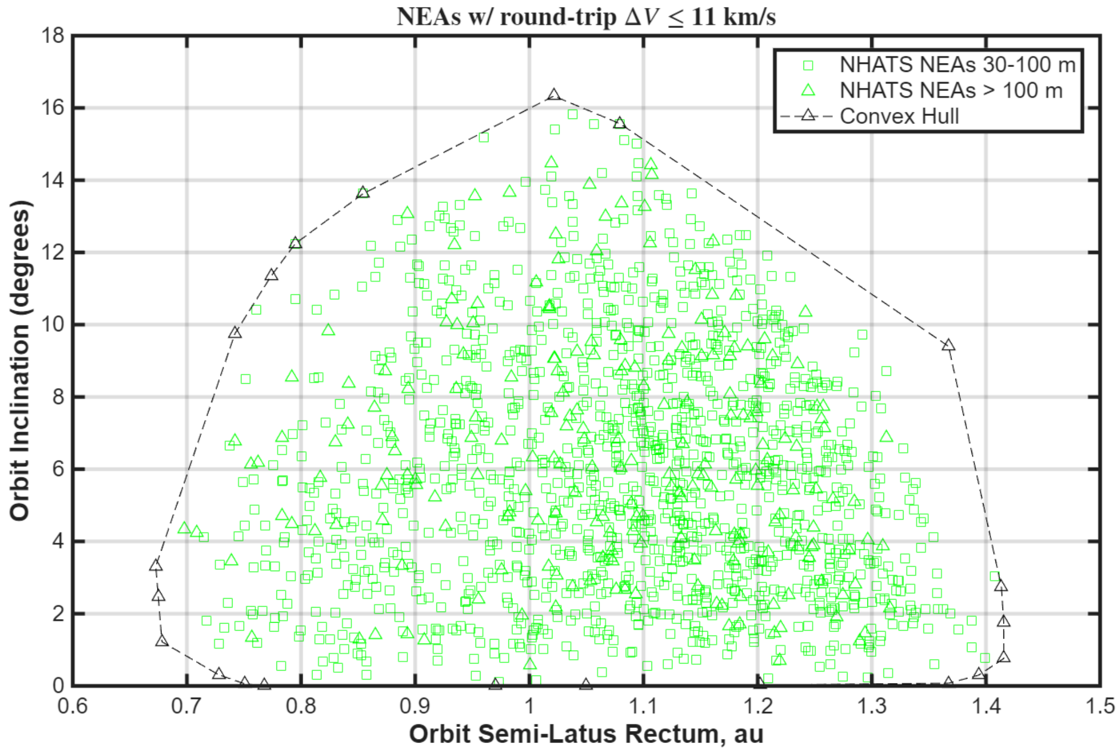


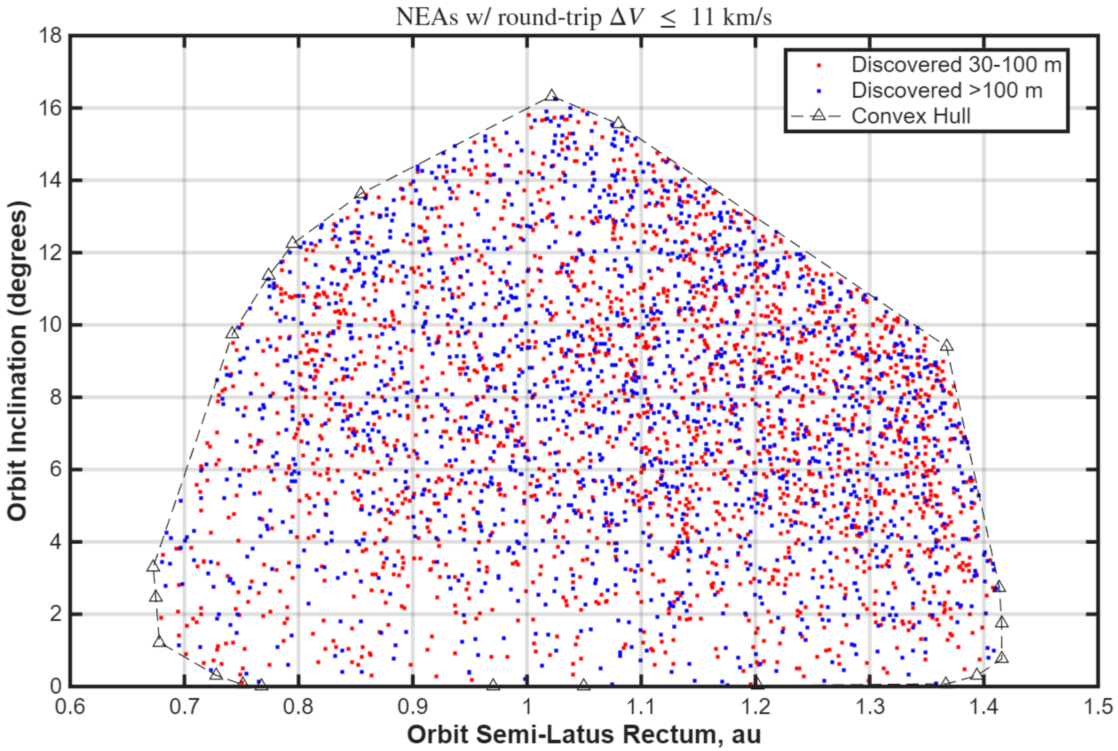
NEAs with Round-Trip ΔV ≤ 10 km/s



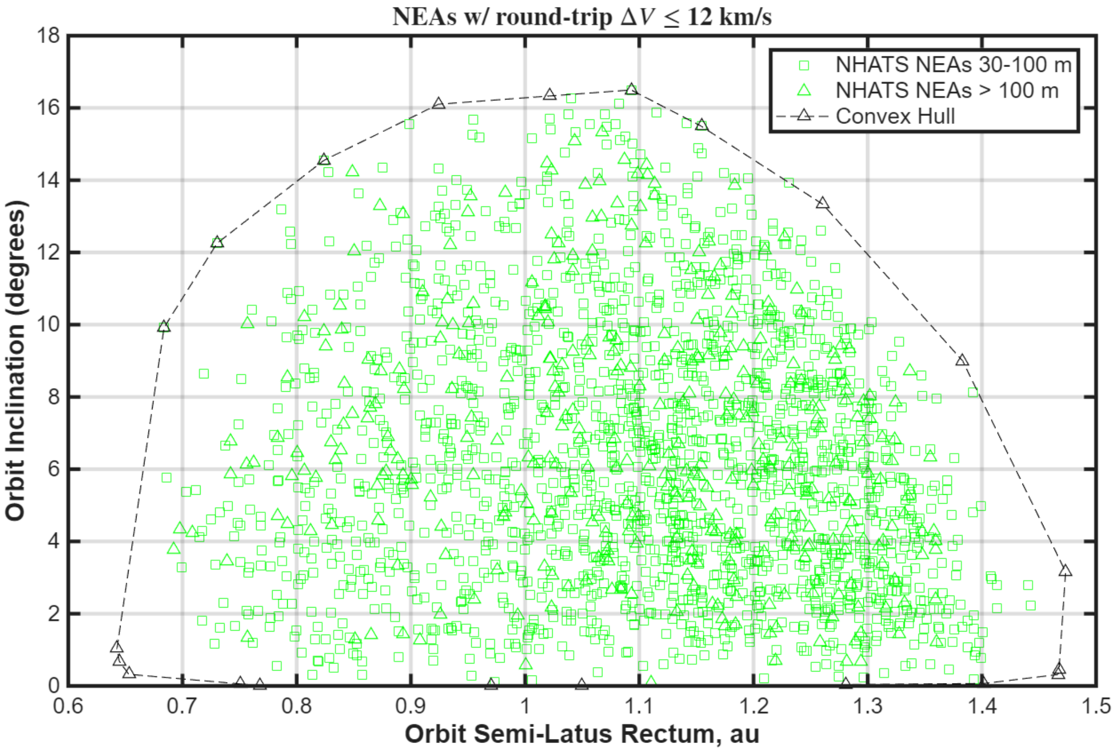


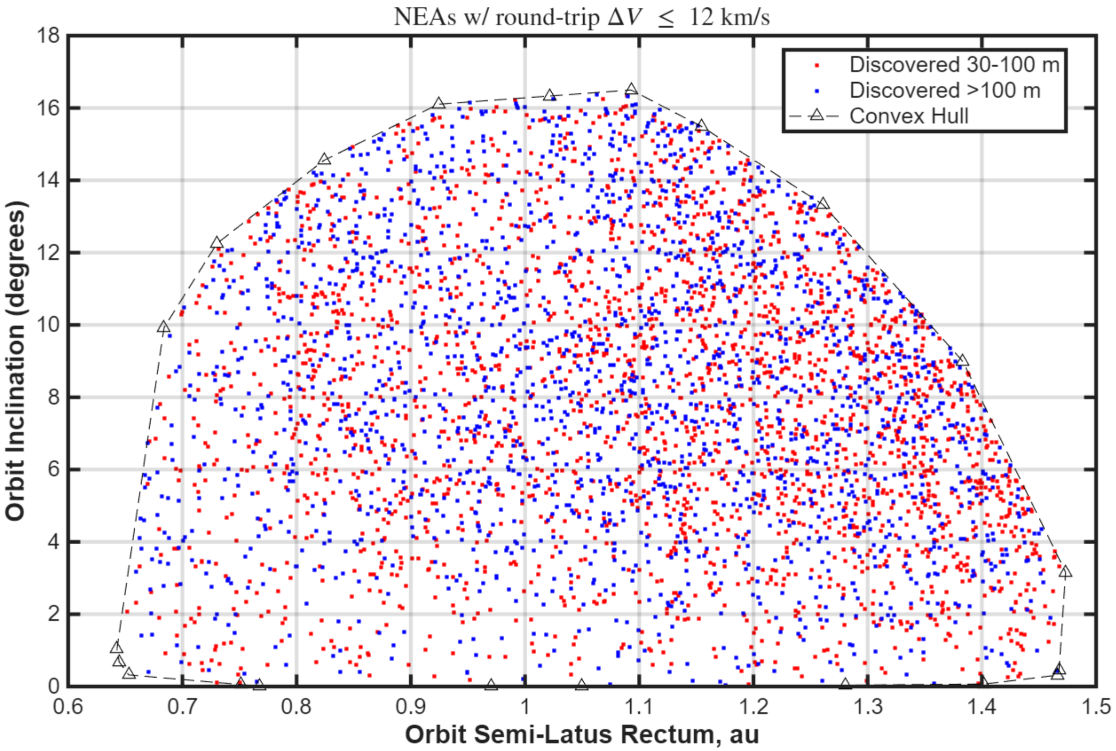
NEAs with Round-Trip ΔV ≤ 11 km/s





NEAs with Round-Trip ΔV ≤ 12 km/s





Delta-V Statistics for 10-year Simulated Survey of NEAs

Round-Trip ΔV	Fraction of Discovered NEAs 30-100 m	Fraction of Discovered NEAs > 100 m
≤ 4 km/s	~52%	~76%
≤ 5 km/s	~58%	~76%
≤ 6 km/s	~58%	~74%
≤ 7 km/s	~58%	~74%
≤ 8 km/s	~58%	~75%
≤ 9 km/s	~61%	~75%
≤ 10 km/s	~60%	~74%
≤ 11 km/s	~60%	~75%
≤ 12 km/s	~59%	~75%

Remarks

- **Further discussion is needed to:**
  - Understand what the simulated NEA population represents in relationship to the currently known NEA population.
  - Leverage that understanding to properly interpret the foregoing results.
- **These results indicate that:**
  - A 10-year *NEO Surveyor* mission could result in >50% completeness for sub-100m NHATS-type targets.
  - The discovery rate for these small near-Earth objects is approximately linear with time, so the 5-year prime mission could result in >25% completeness from *NEO Surveyor* alone.
- **Importantly, *NEO Surveyor* will return thermal infrared data that constrains diameter better than reflected optical light.**

Conclusions

- ***NEO Surveyor* is well-suited to detect NEOs in very Earth-like orbits.**

- **In addition to the planetary defense benefits, *NEO Surveyor* also provides an opportunity to identify low-delta V spacecraft mission targets.**

- **These targets are of interest to the science, *in situ* resource utilization, and exploration communities.**

BACKUP

Survey Design – Visits

- Observatory receives "Visit" commands and performs all actions within them
  - Visits are the fundamental unit of the survey
  - 6 exposures of ~30 sec each (180 sec/Visit)
- All Exposures are returned to ground for processing by Survey Data System