Our Hurtling Whirling Solar System!

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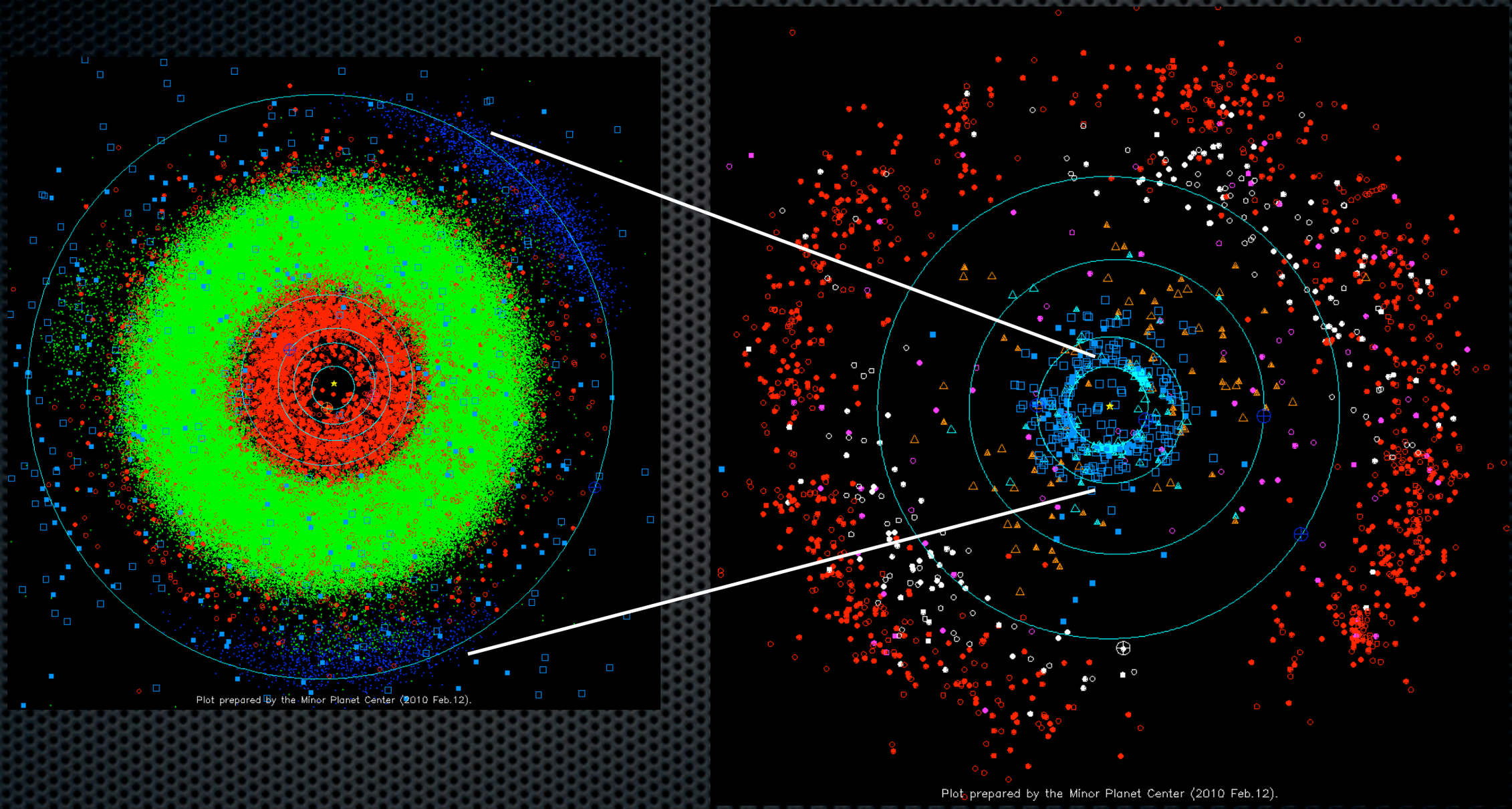
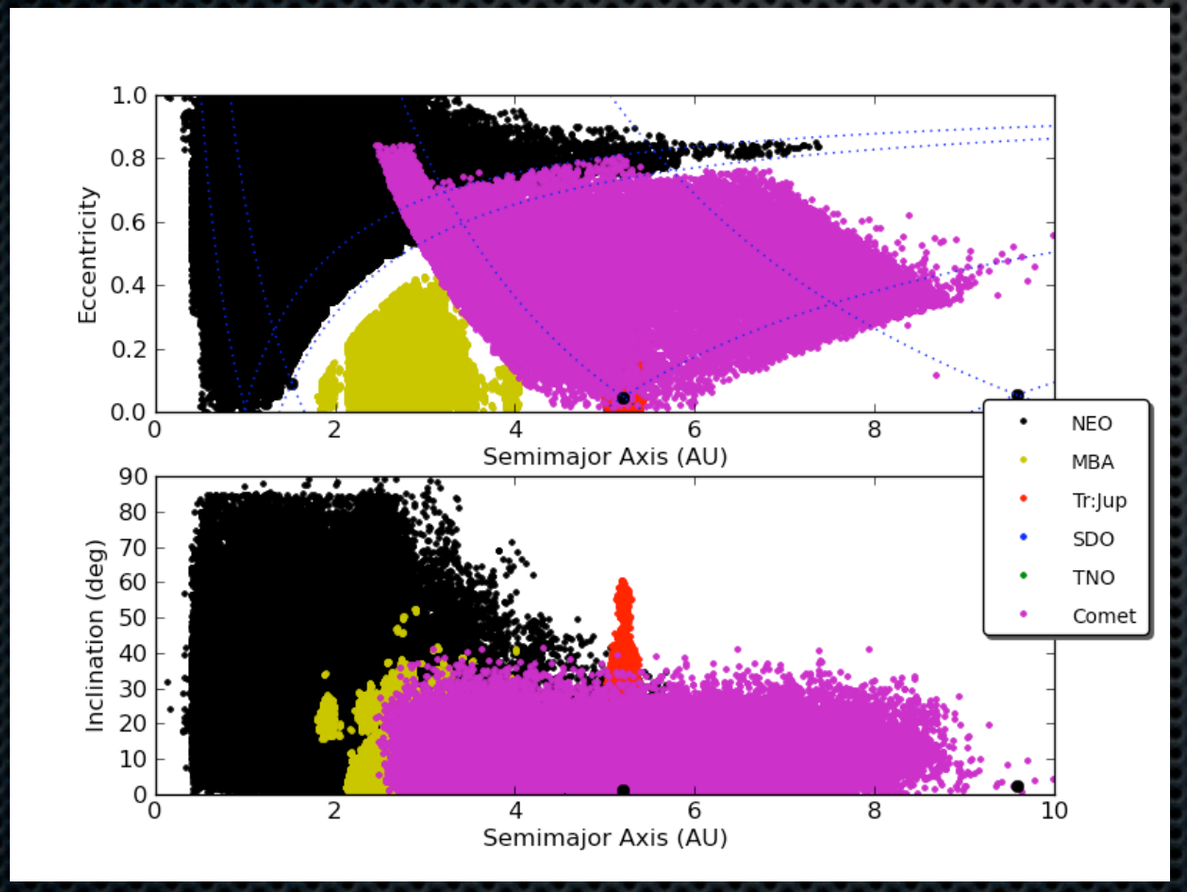
What are “small bodies in the solar system”?

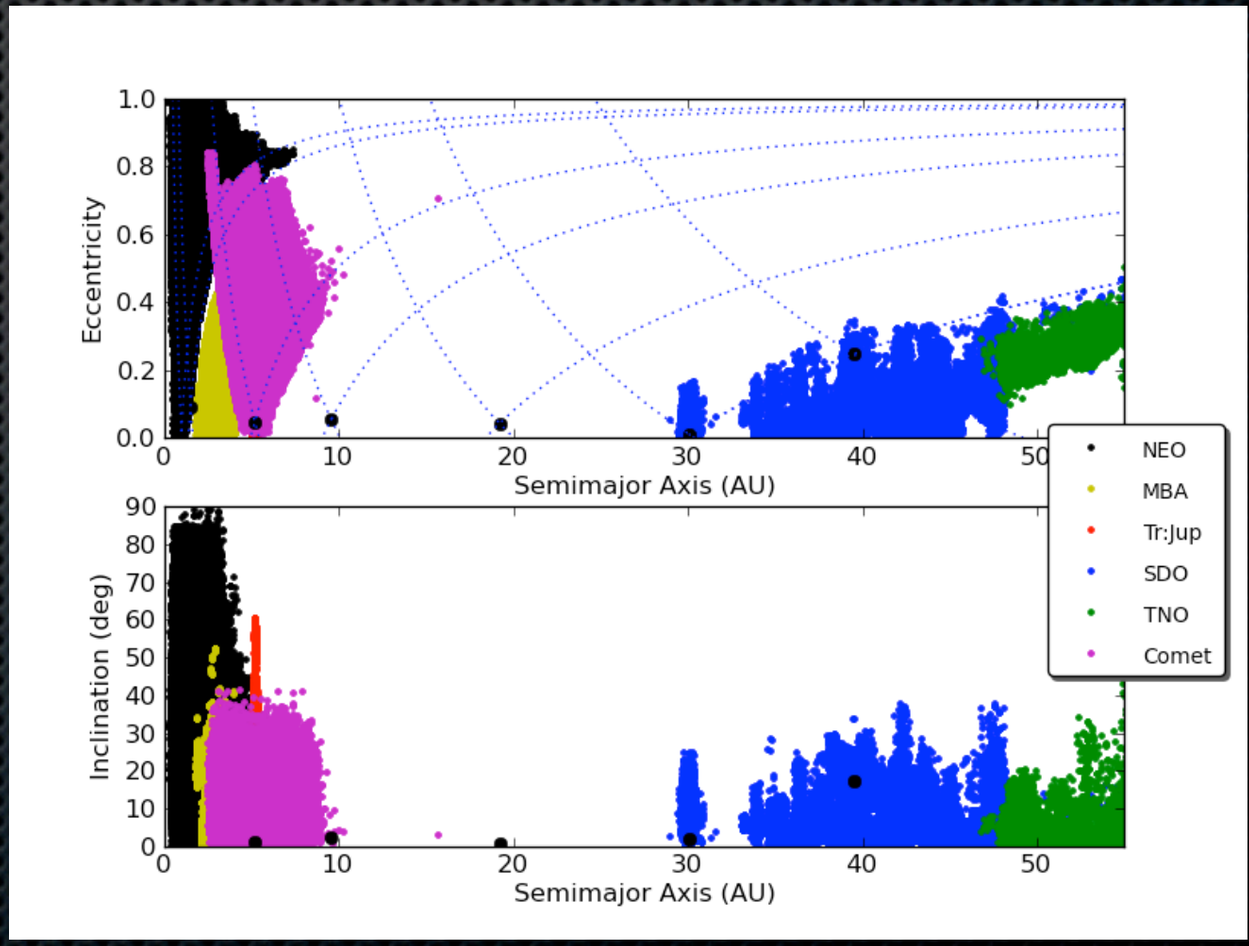


Small bodies = statistical samples

They all move!

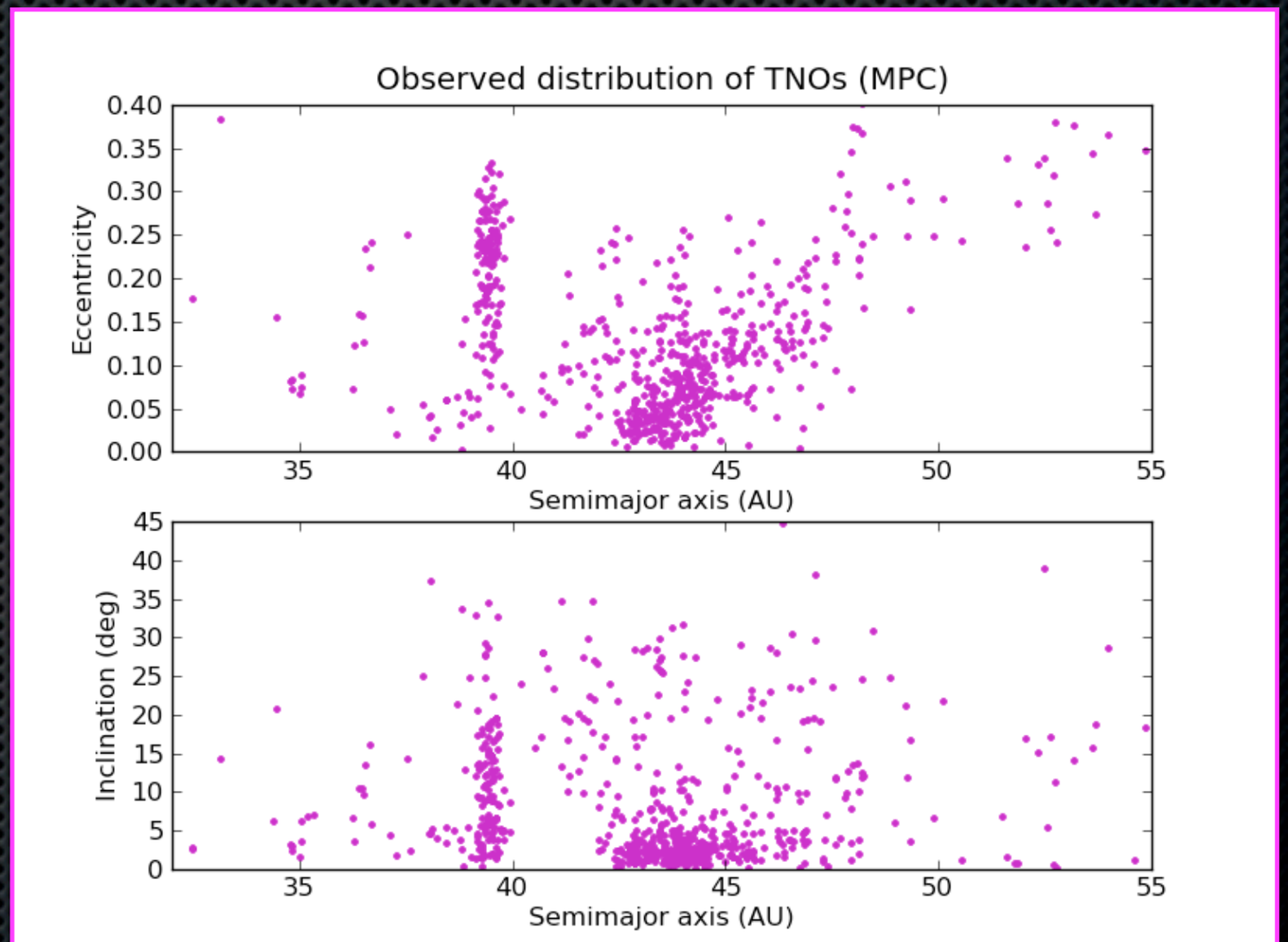
- Identification. Orbits.
  - Solar system formation & evolution



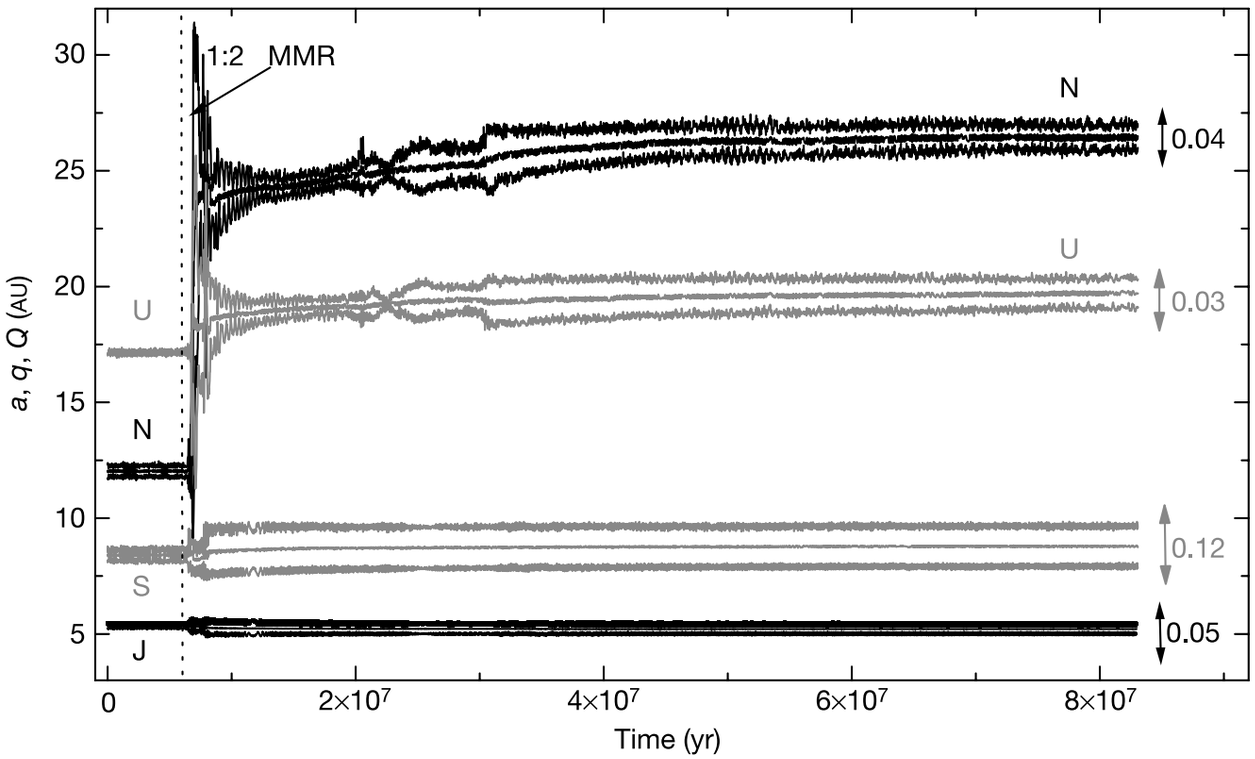


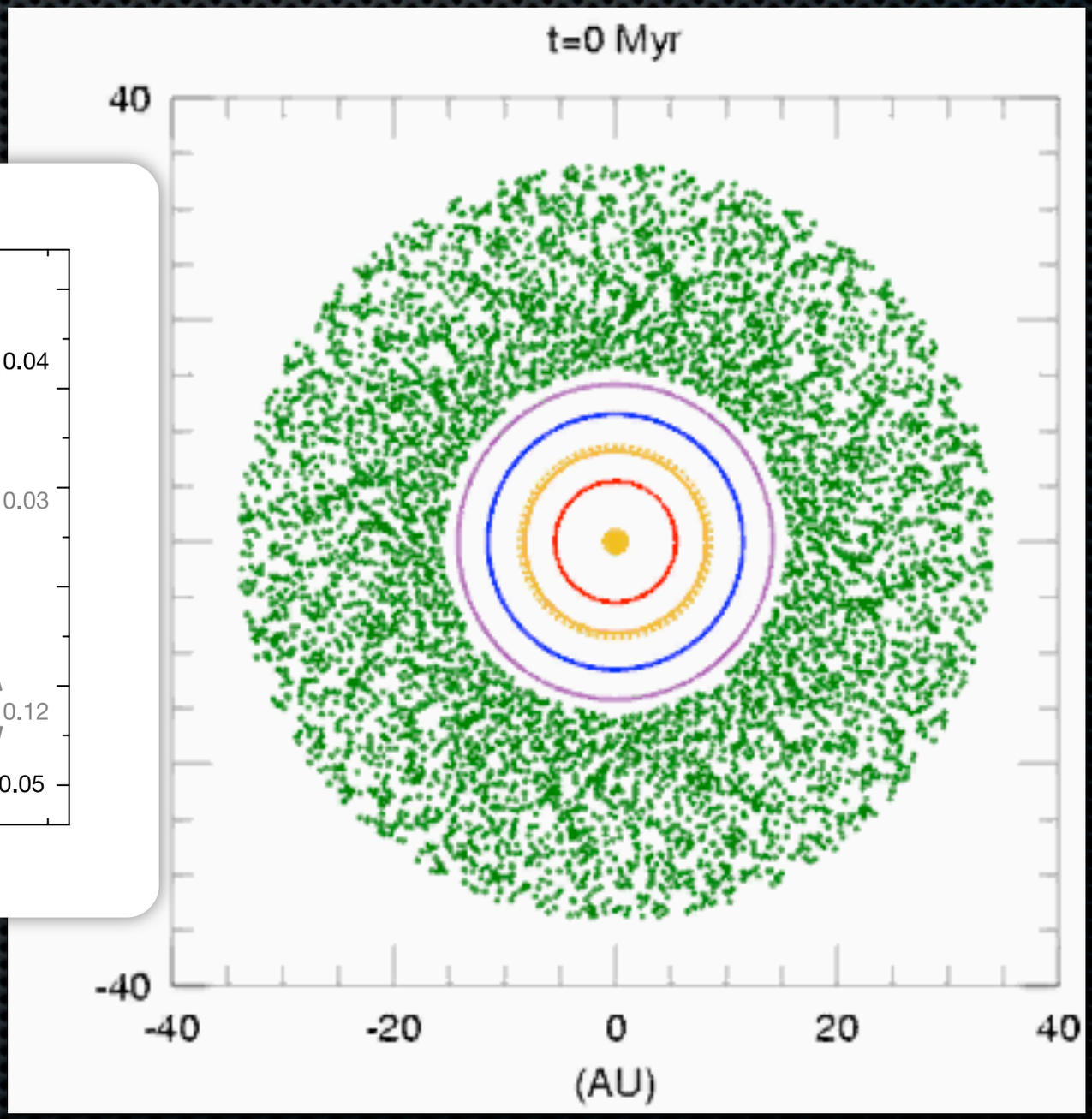
Indications of solar system evolution

- Missing mass
  - Kuiper Belt: 0.01-0.1 Me vs 10-30 Me
  - Asteroid belt: 6x10^-4 Me vs 1-3 Me
- Dynamical excitation
  - Kuiper Belt: Too many objects in mean-motion resonance
    - Migration: Malhotra 1995
  - Too much excitement!



Nice model





Levison, Morbidelli, Gomes, Tsiganis 2005

Go, Nice model, go!

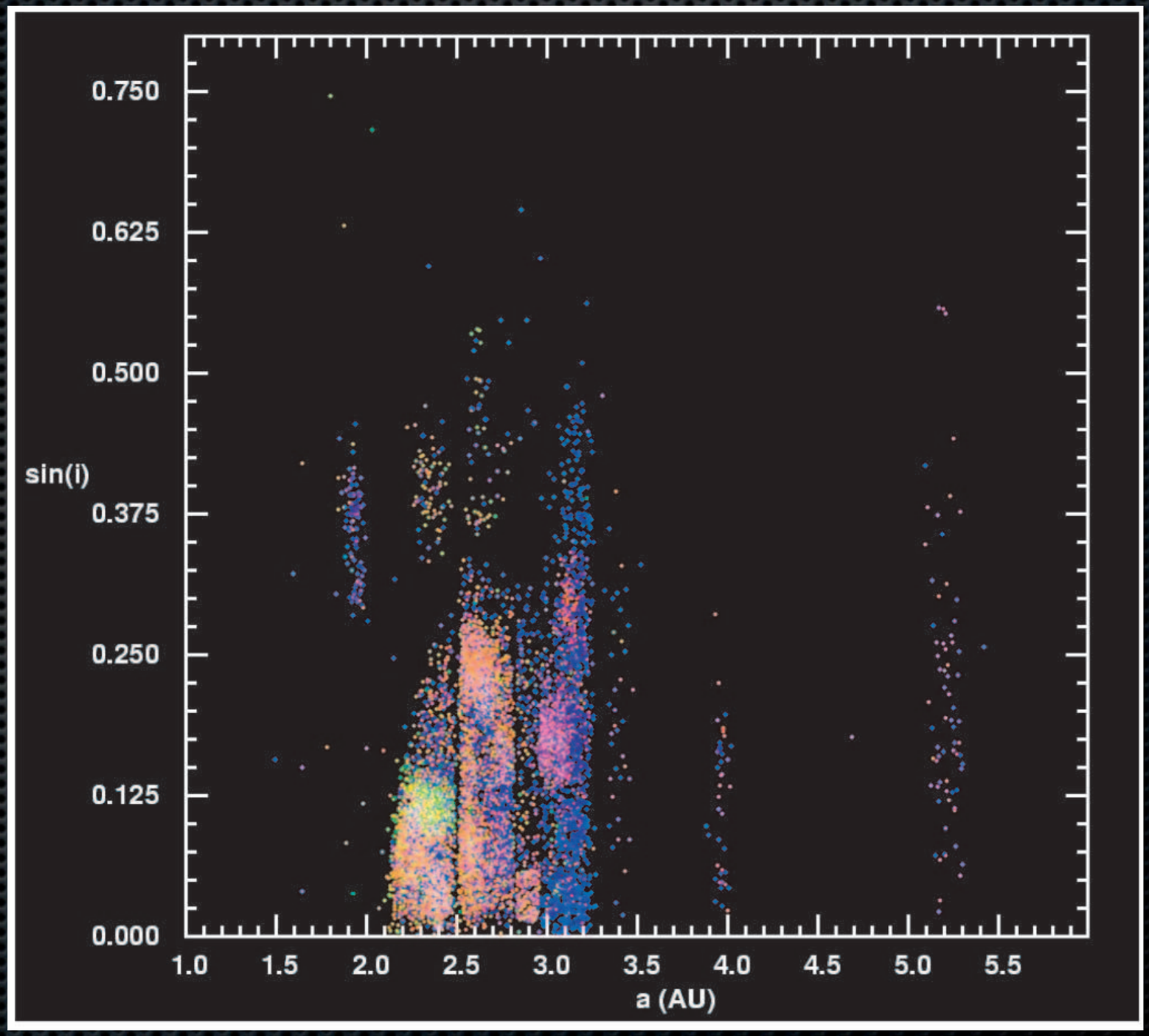
- Explains slight eccentricities of giant planets
- Predicts missing mass in MBAs
- Predict missing mass in TNOs (emplace all TNOs)
- Predicts dynamical excitement of TNOs & MBAs
  - (although not quite correctly)
- Predicts relative number of Jupiter Trojans
- Predicts Late Heavy Bombardment

Yet another test for the Nice model

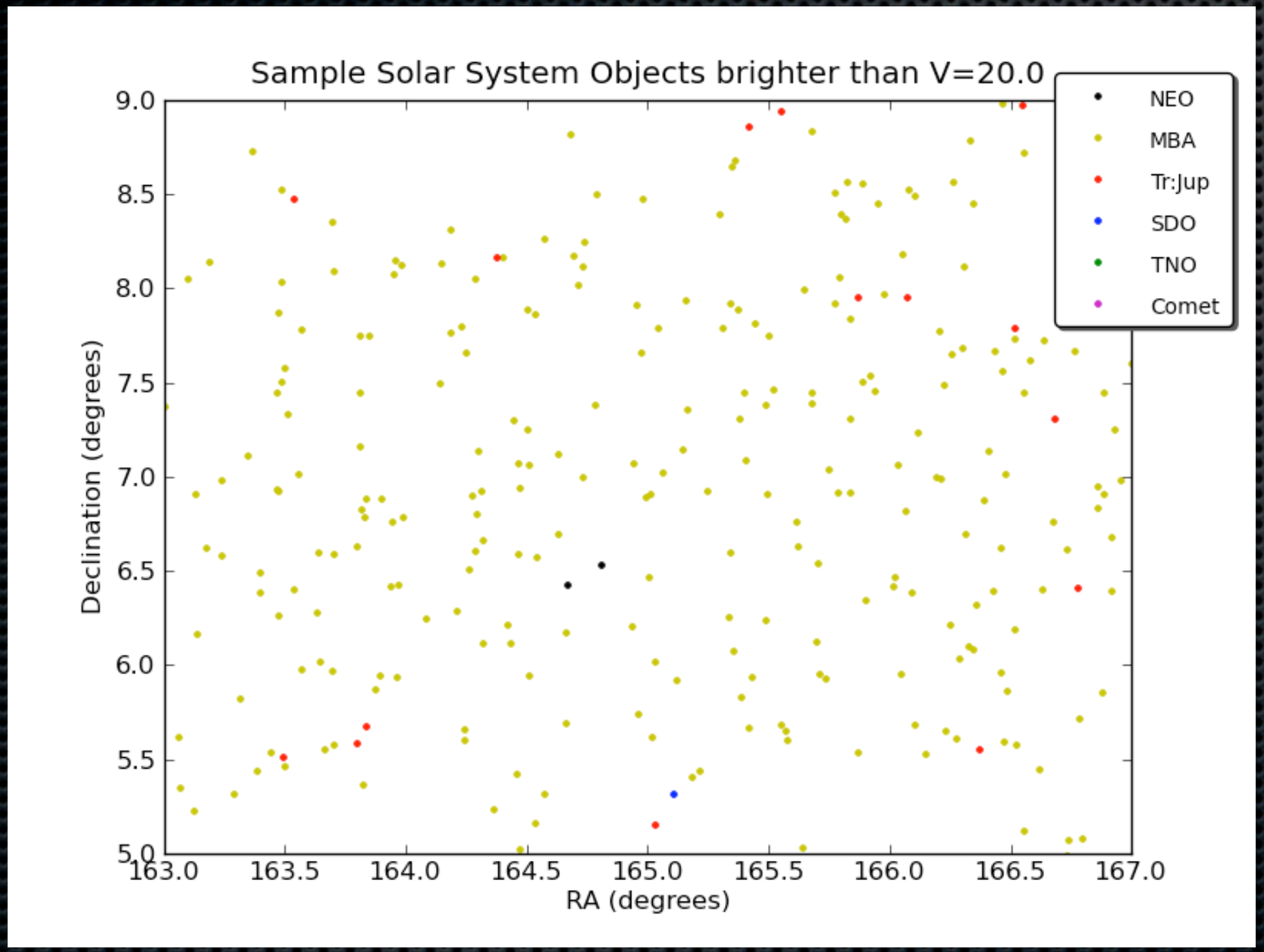
Radial mixing in the asteroid belt:

S - C - X/P

Colors of other populations?

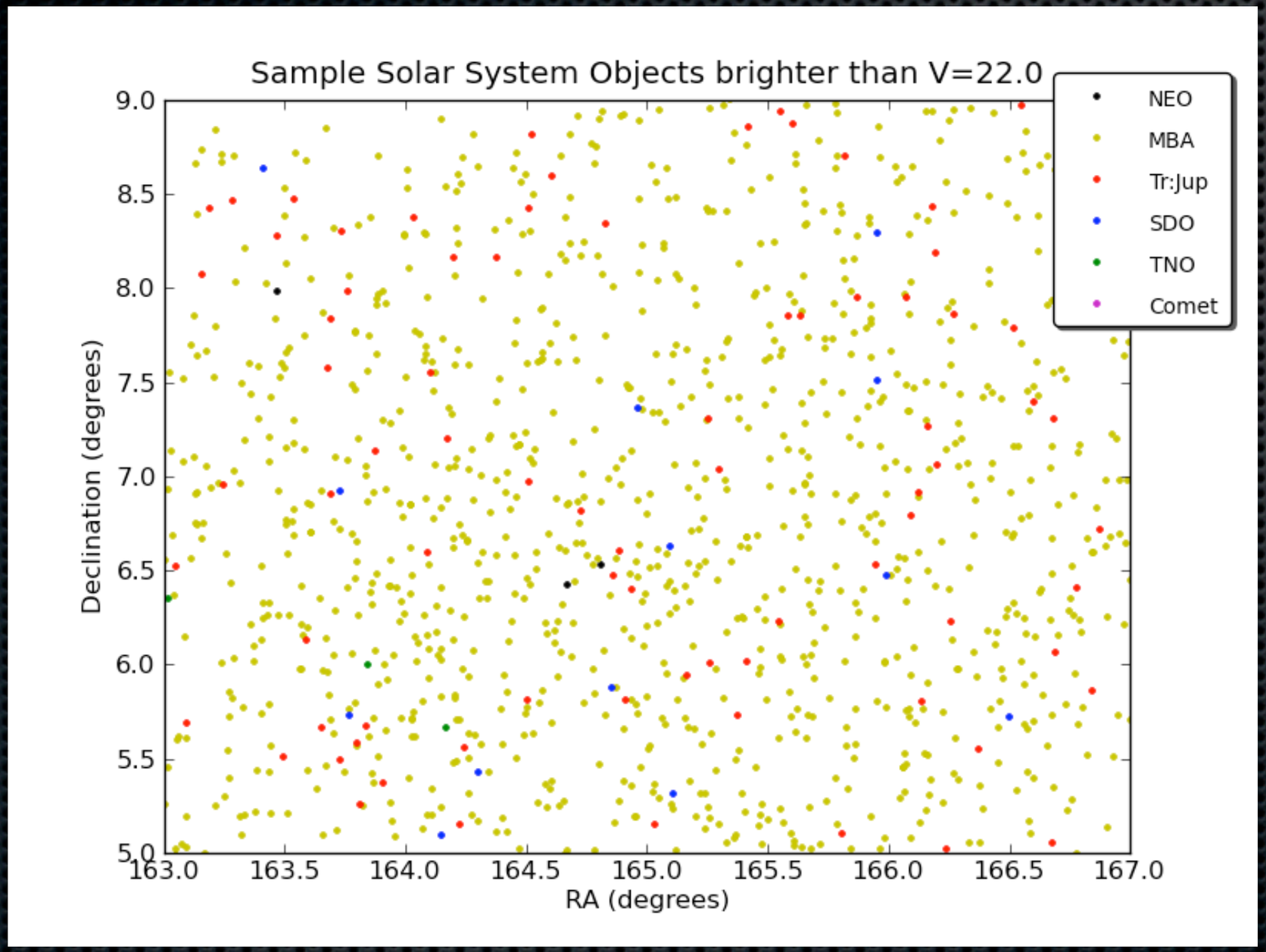


Onwards to orbits



Single nights have uses but orbits are best

Onwards to orbits



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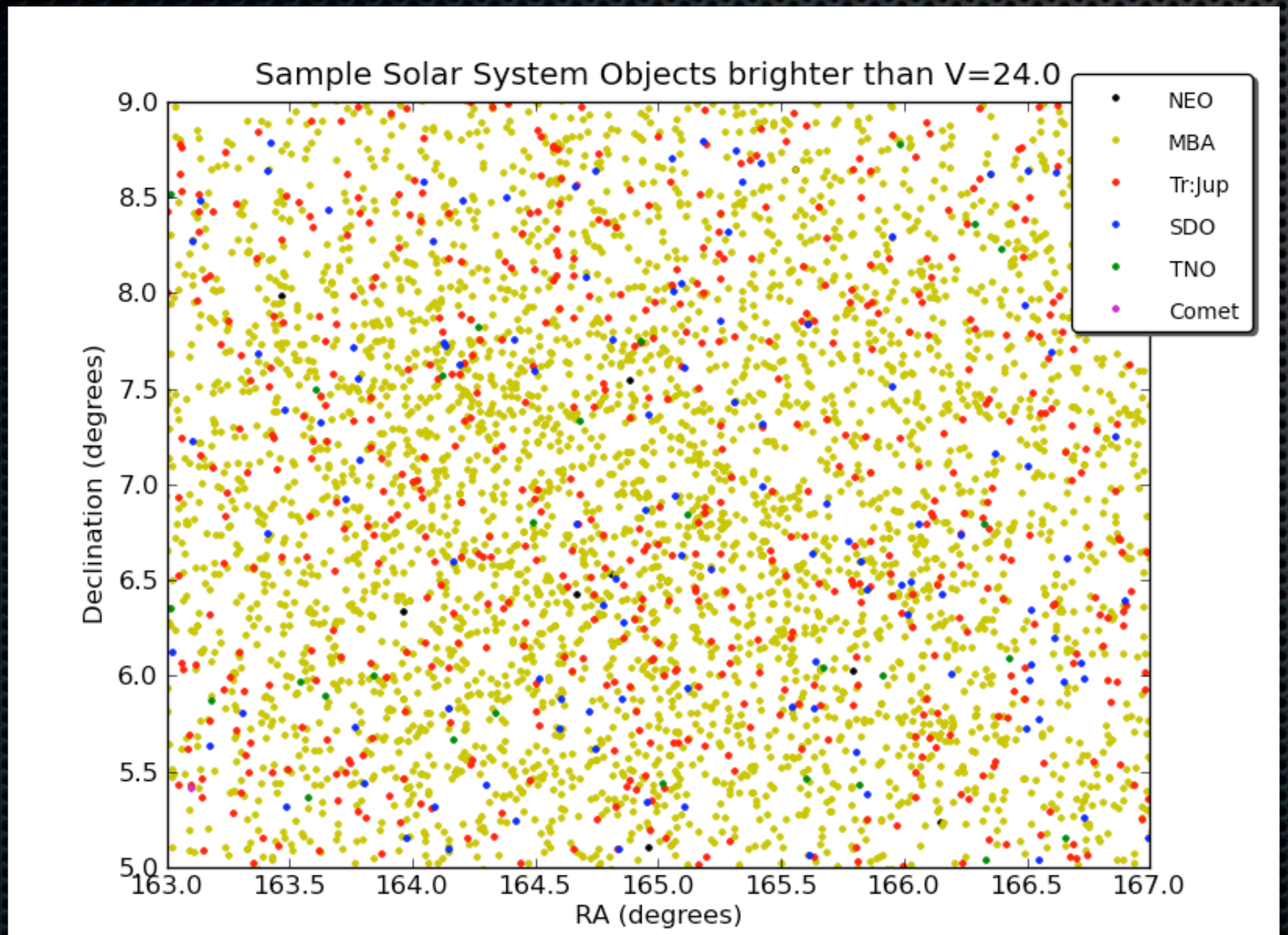
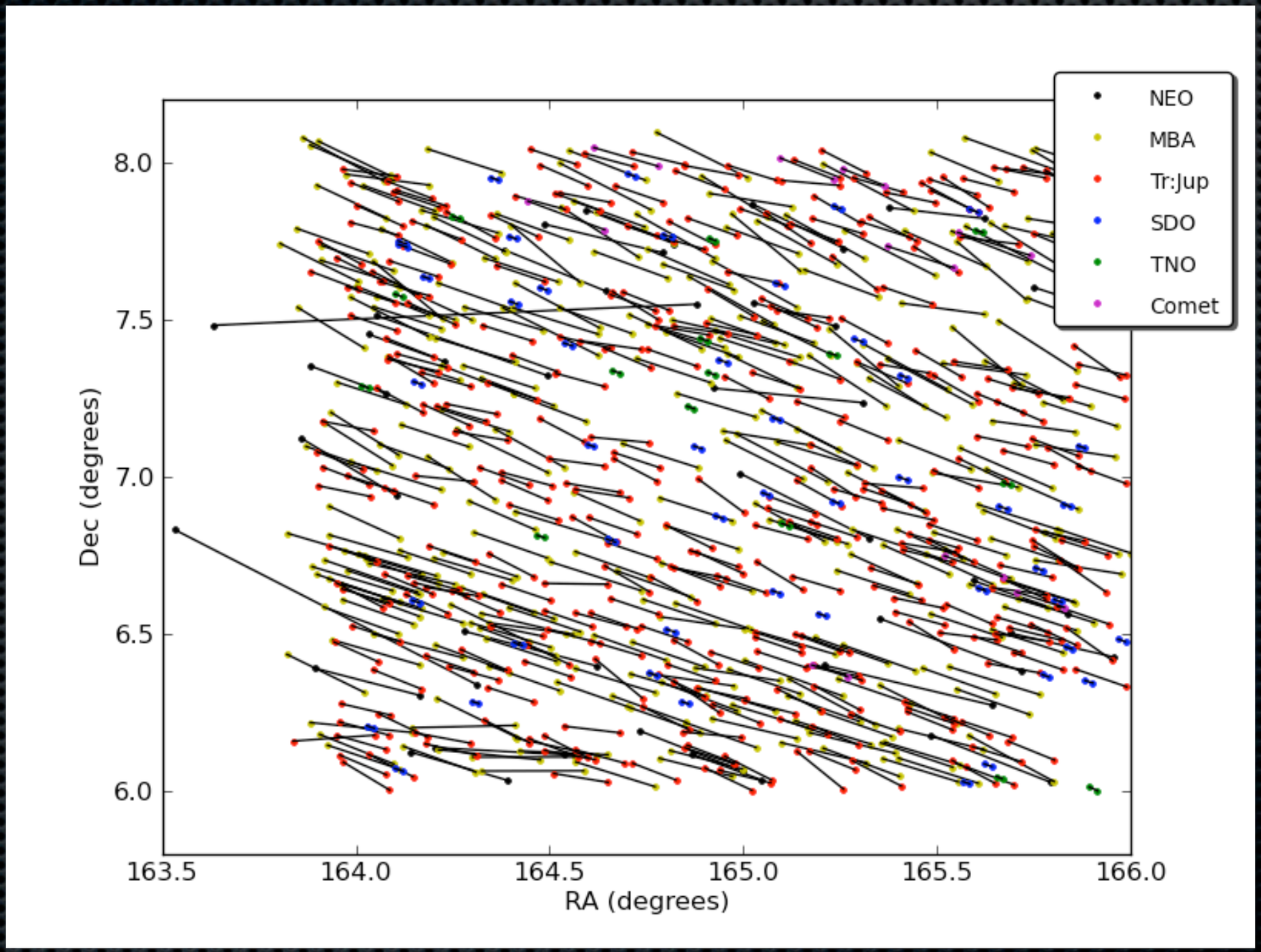
Onwards to orbits



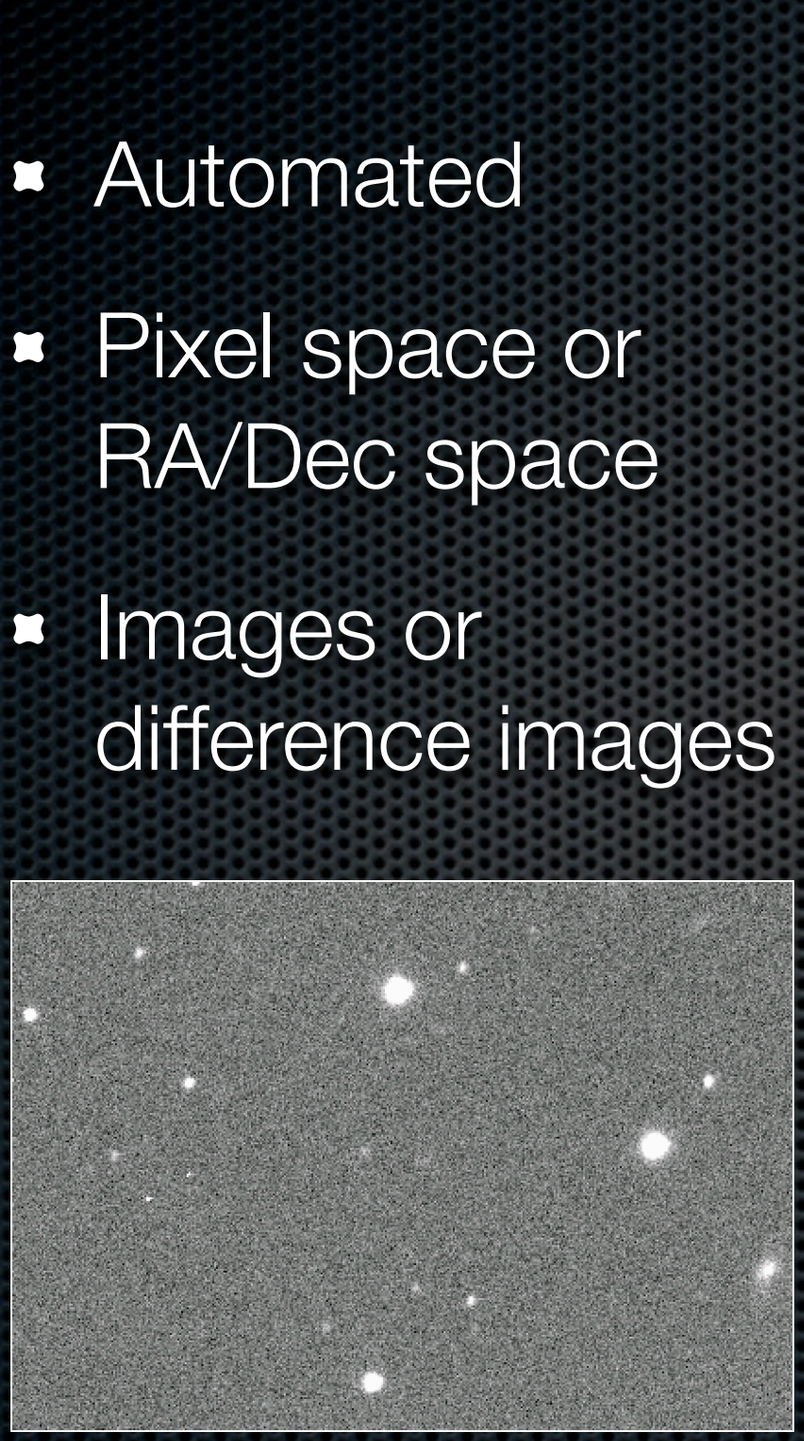
Single nights have uses but orbits are best

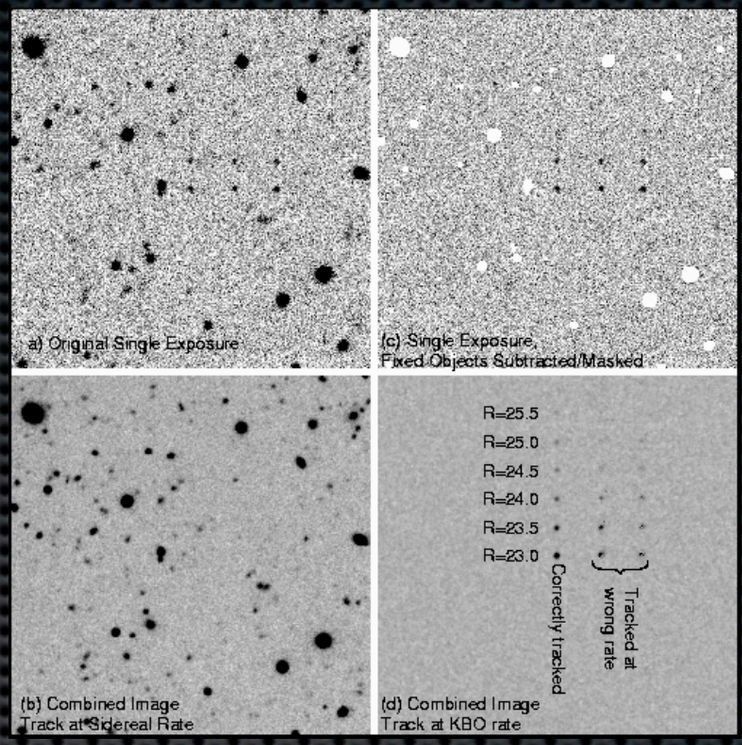
Followup requirements

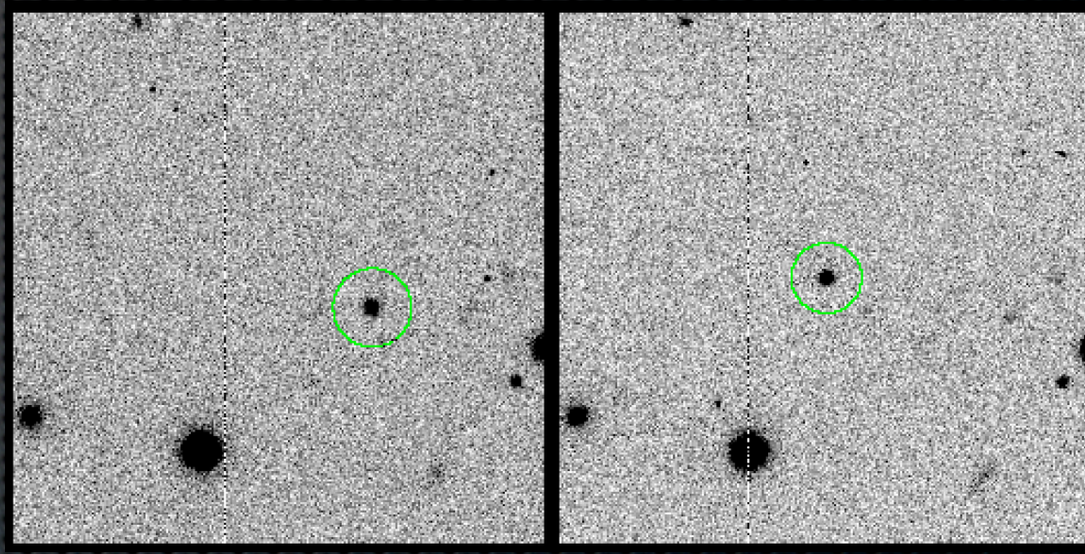


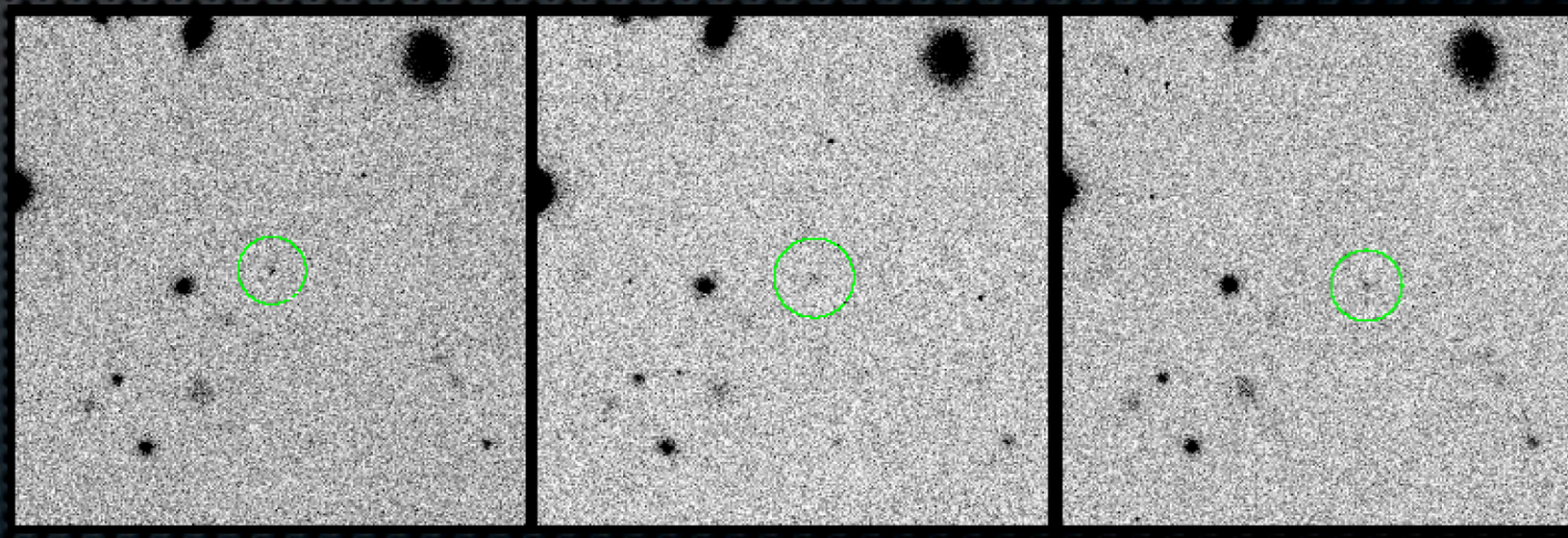
Initial Detection

- Automated
- Pixel space or RA/Dec space
- Images or difference images

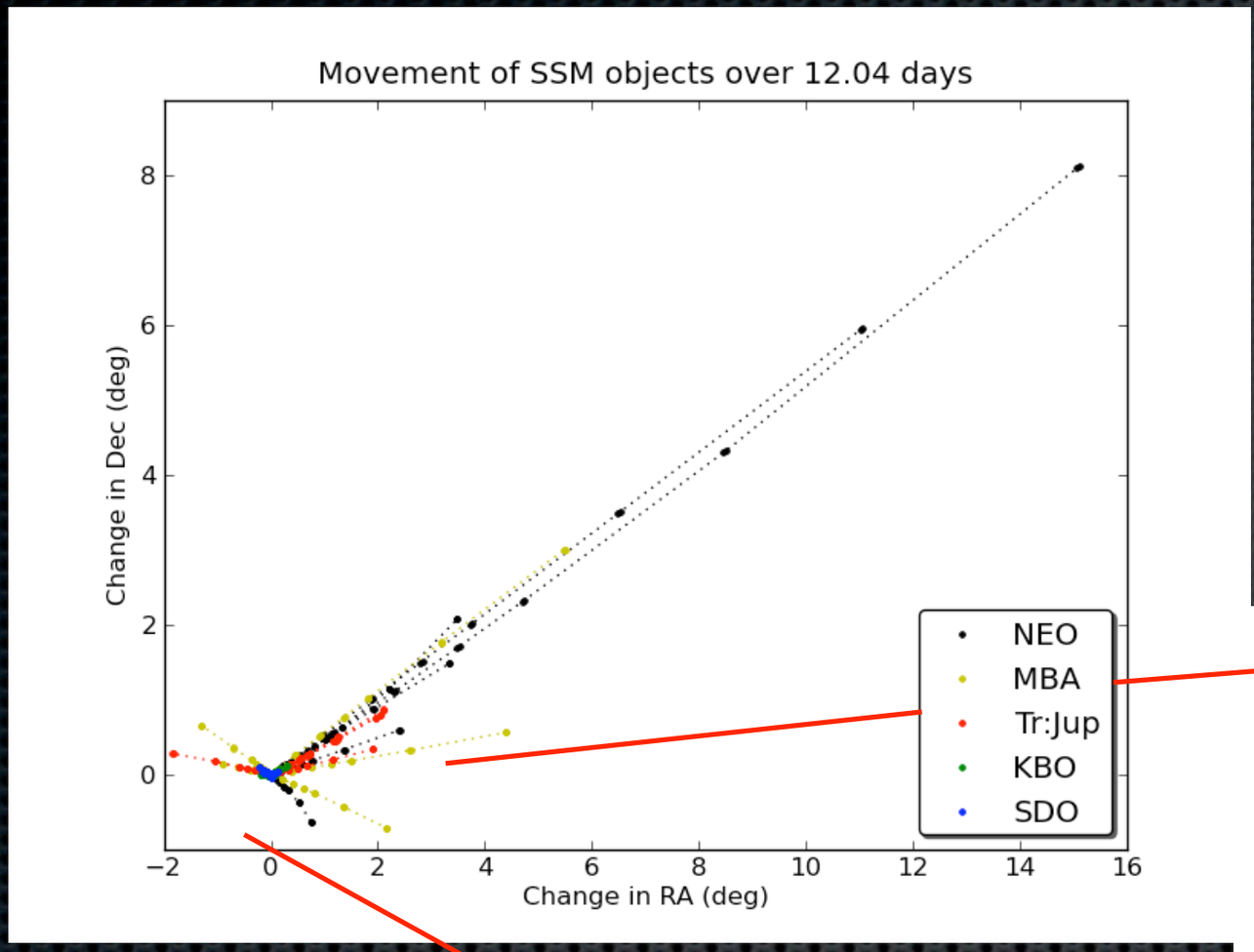




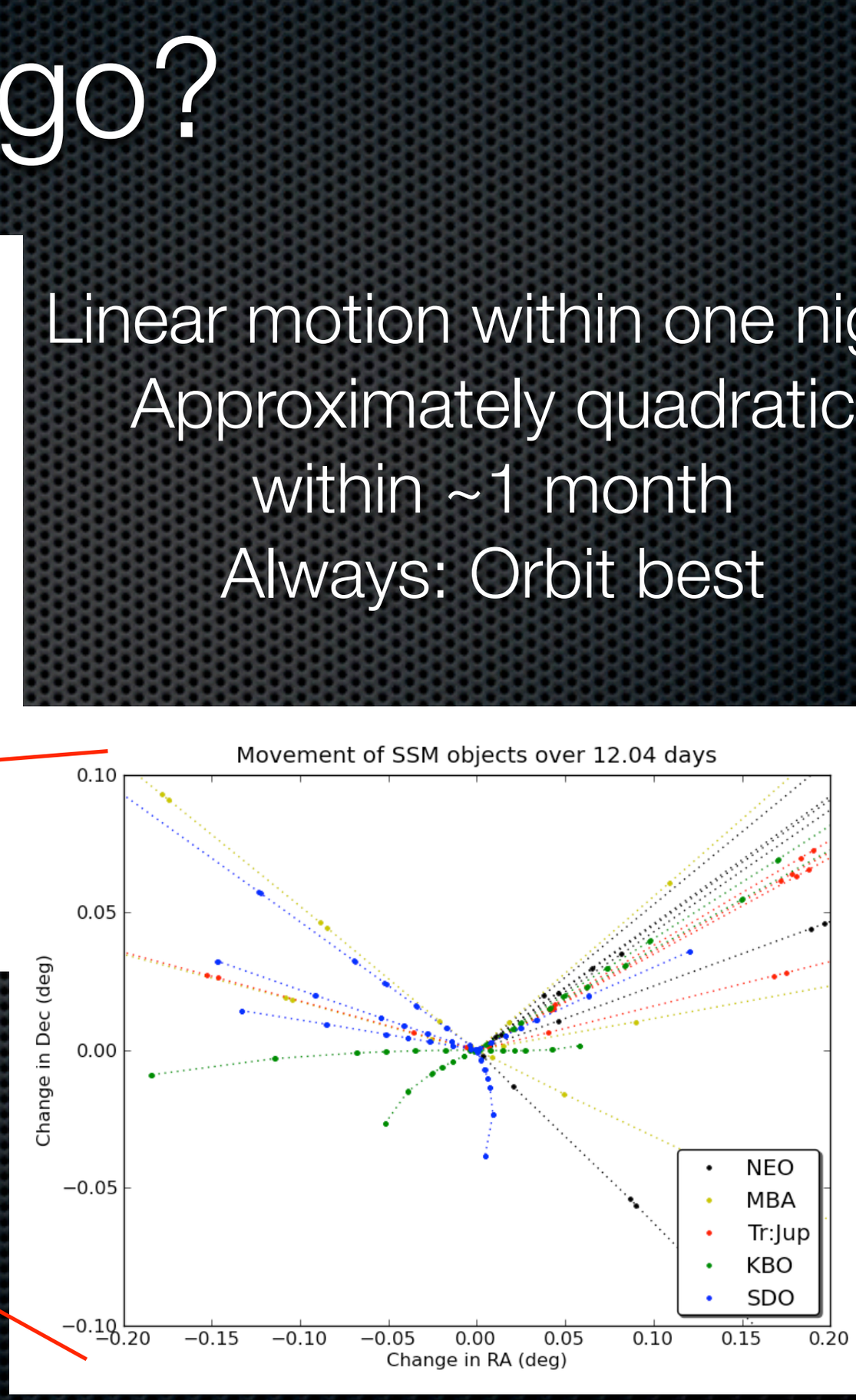




Where does it go?

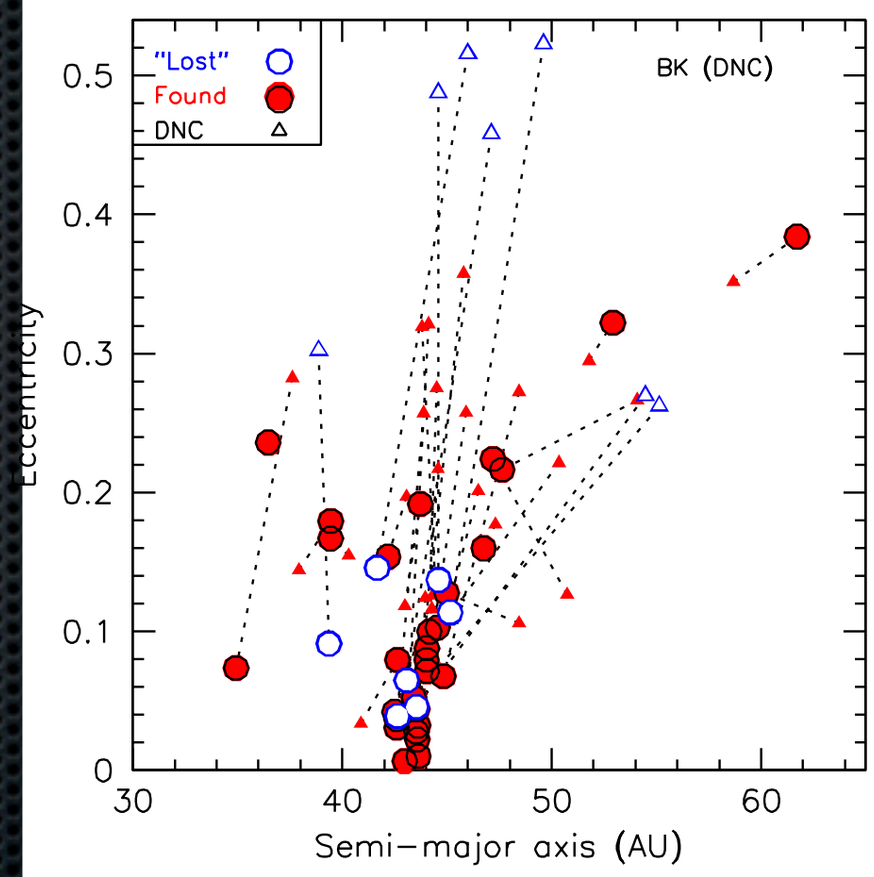


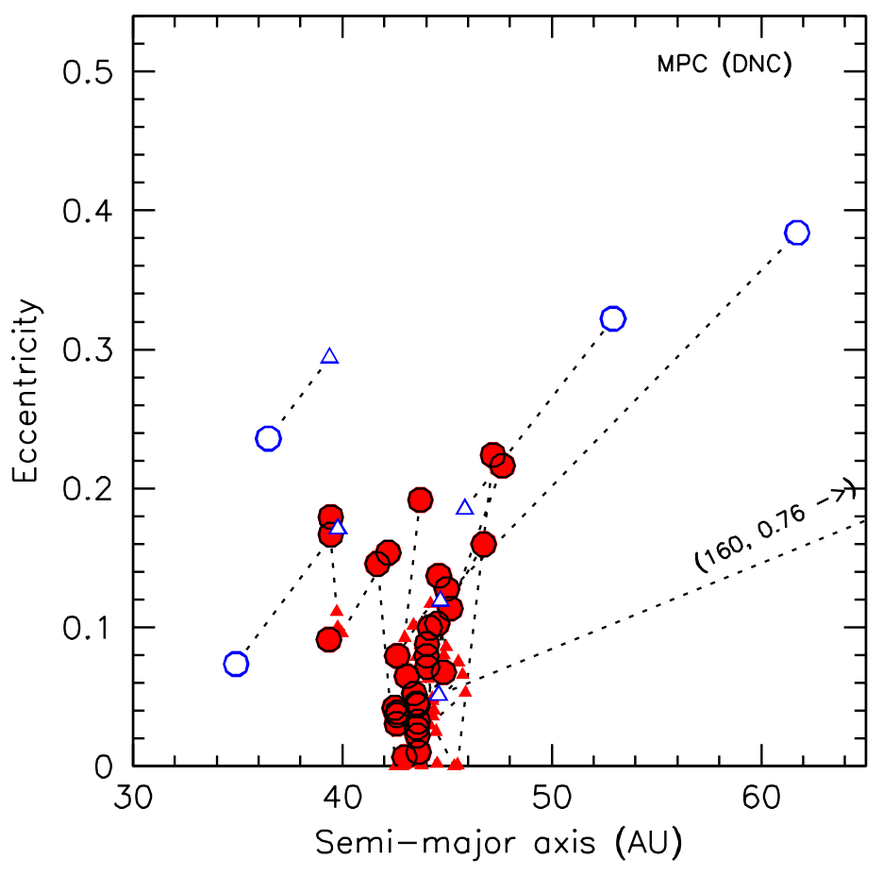
Linear motion within one night
Approximately quadratic
within ~1 month
Always: Orbit best



Orbit fitting

- OrbFit (Milani)
- Oorb (Granvik)
- orbfit (Bernstein & Khushalani) - TNO only
- Minor Planet Center





Some recent surveys for further references

- NEOs - Catalina Sky Survey
- Asteroids - SDSS (Ivezic etal 2001). “SKADS” (Gladman etal 2009)
- Trojans (Jupiter) - SDSS (Szabo etal 2007)
- TNOs - “DES” (Millis etal 2002). “CFEPS” (Kavelaars 2009).

Conclusions

- Finding moving objects, linking them into orbits can be tough
- Biases can creep in everywhere (initial selection, linking, orbit fitting, followup)
- What you learn from orbits (and physical properties if you get that bonus) is worth it - planetary formation and evolution!