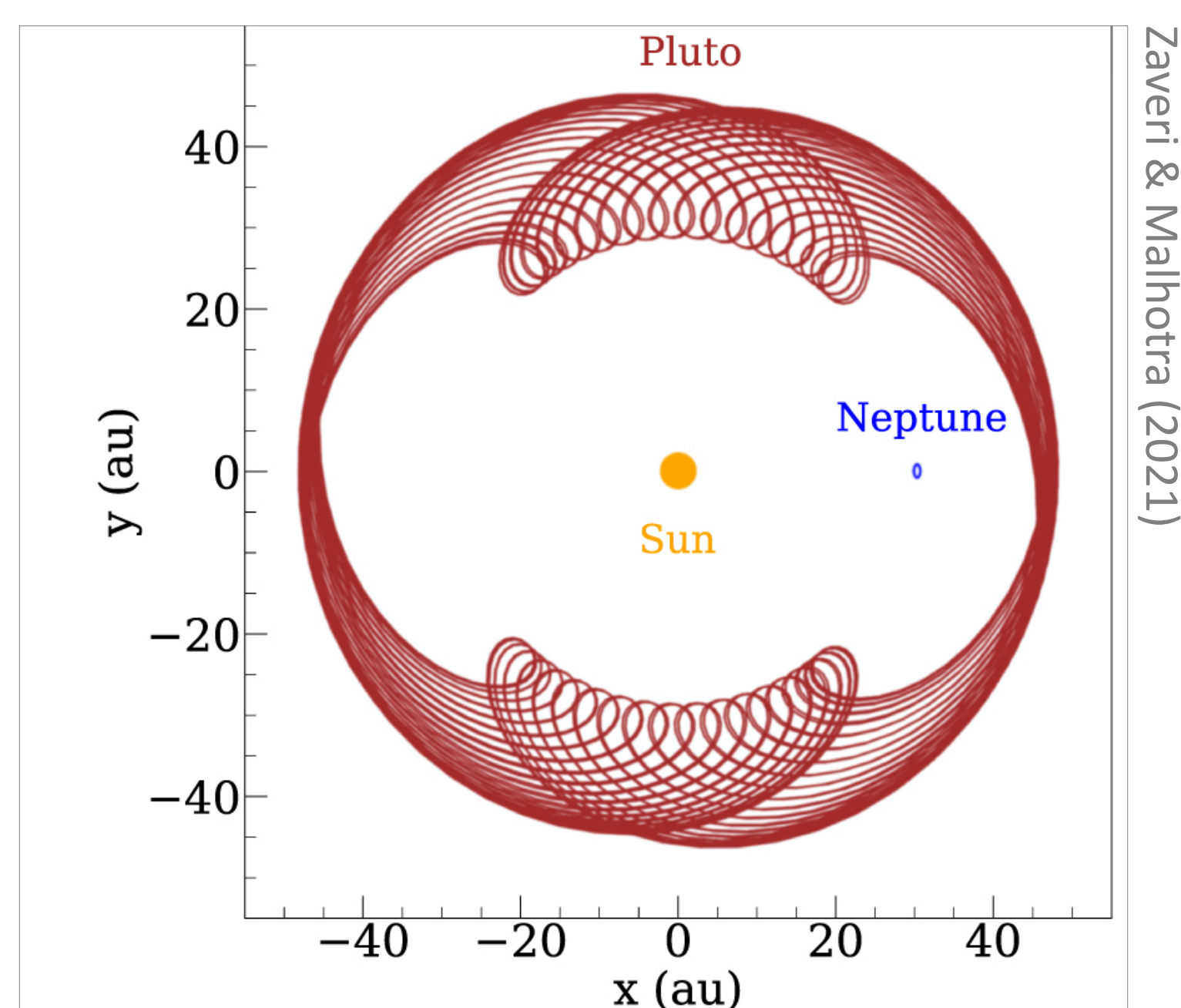


**What are Plutinos?** Like Pluto, Plutinos are TNOs with orbital period in 3/2 ratio with Neptune's. They are thought to have been captured in this *mean motion resonance* by a migratory Neptune in the ancient Solar system and are useful for insights into the nature of the giant planets' migration.

### Key take-aways

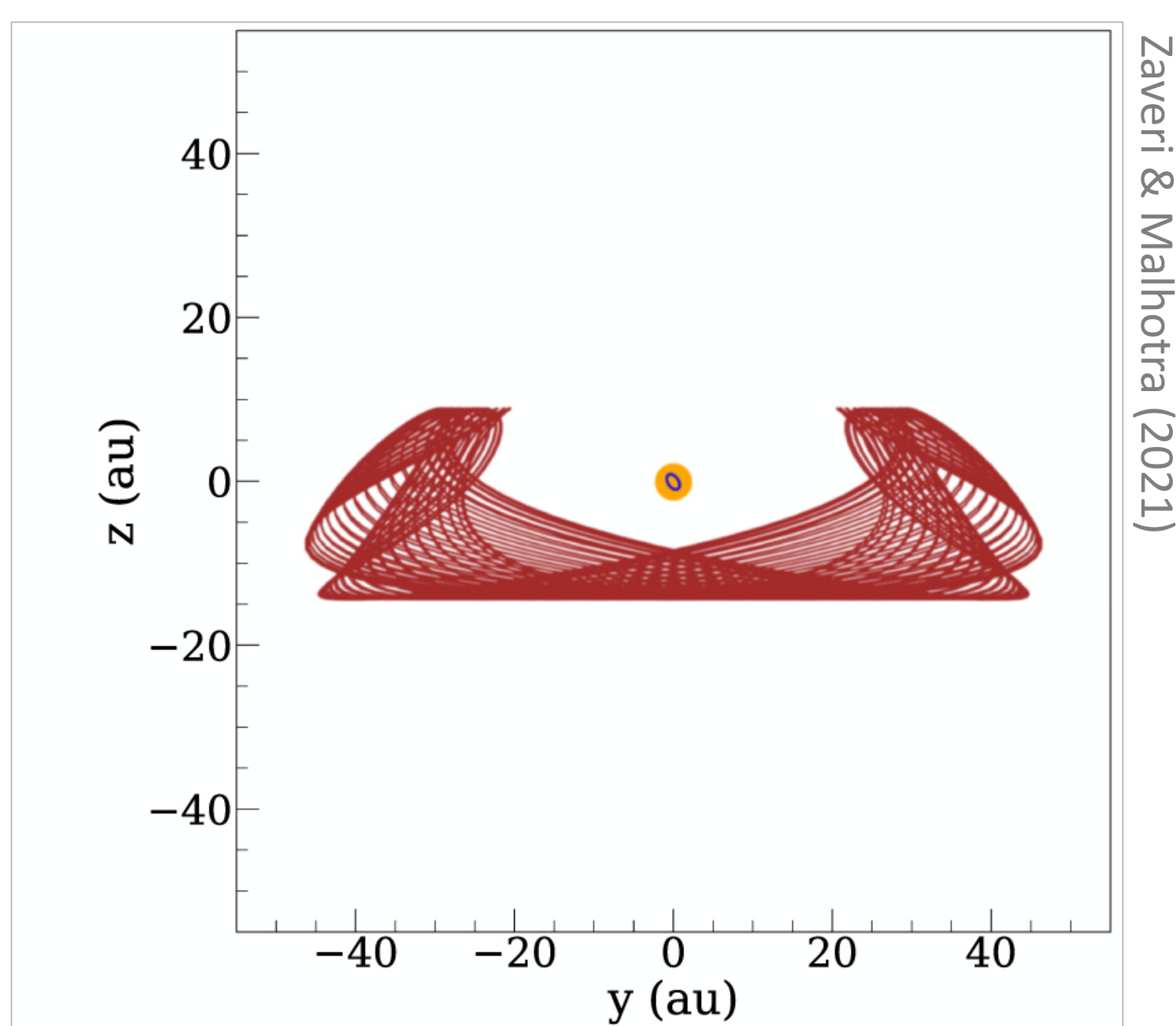
- Approximately 20% of Plutinos exhibit *g* librations
  - g* is argument-of-perihelion; its libration leads to latitudinal libration of the perihelion location
- The *g* librators have higher eccentricities and inclinations and cluster around a hyperbolic arc in the (*e*, *i*) parameter plane
- New questions: Are there physical differences between the *g* librators and other Plutinos? What does the large fraction of *g* librators tell us about the nature of the giant planets' migration?

### Longitudinal libration



Pluto's track for 40,000 years in a frame rotating with Neptune's mean angular speed about the Sun. This projection in the ecliptic shows the libration of its perihelion longitude away from Neptune's longitude. The critical resonant angle,  $\sigma = 3\lambda_{\text{Plutino}} - 2\lambda_{\text{Neptune}} - \varpi$ , of every Plutino librates around  $180^\circ$  with a period of  $O(10^4)$  years ( $\lambda$  denotes mean longitude,  $\varpi$  denotes longitude of perihelion)

### Latitudinal libration

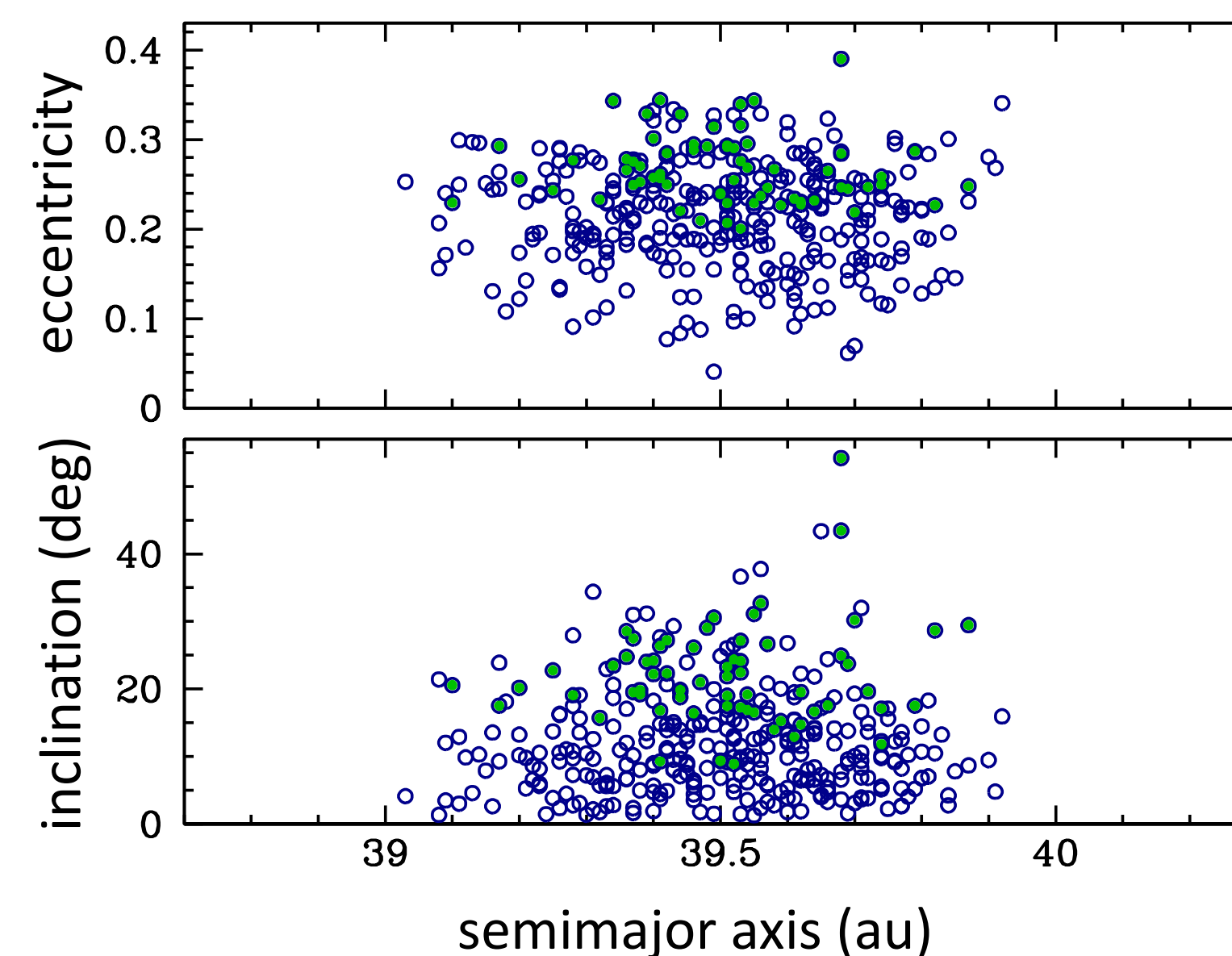


This 'sideways' projection (along the Sun-Neptune line) shows that Pluto reaches perihelion at a high ecliptic latitude. About 20% of Plutinos share this property: their argument of perihelion, *g*, librates around plus or minus  $90^\circ$  with a period of  $O(10^6)$  years.

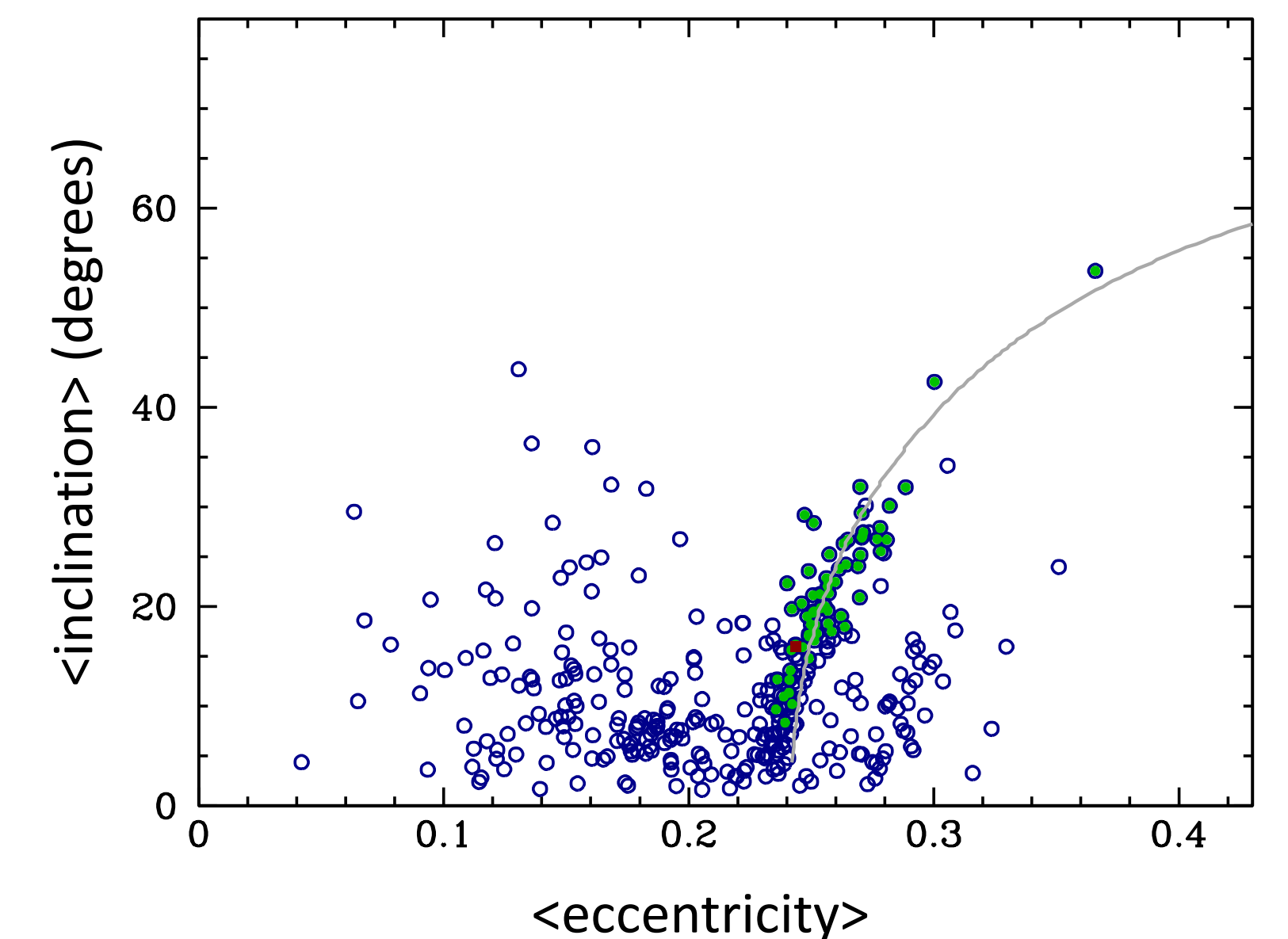
### Methods

- Orbital data and solar system parameters from JPL Horizons (retrieved on May 17, 2022)
- Numerical orbit integration: SWIFT\_RMVS3 (Levison & Duncan, 1994)
- 100 myr simulated time span
- 350 long term stable Plutinos were identified with the criterion  $1^\circ < \sigma < 359^\circ$  over 100 myr
- 64 *g* librators were identified with the criterion  $\max\{g\} - \min\{g\} < 179^\circ$

### Orbital parameter distributions of Plutinos

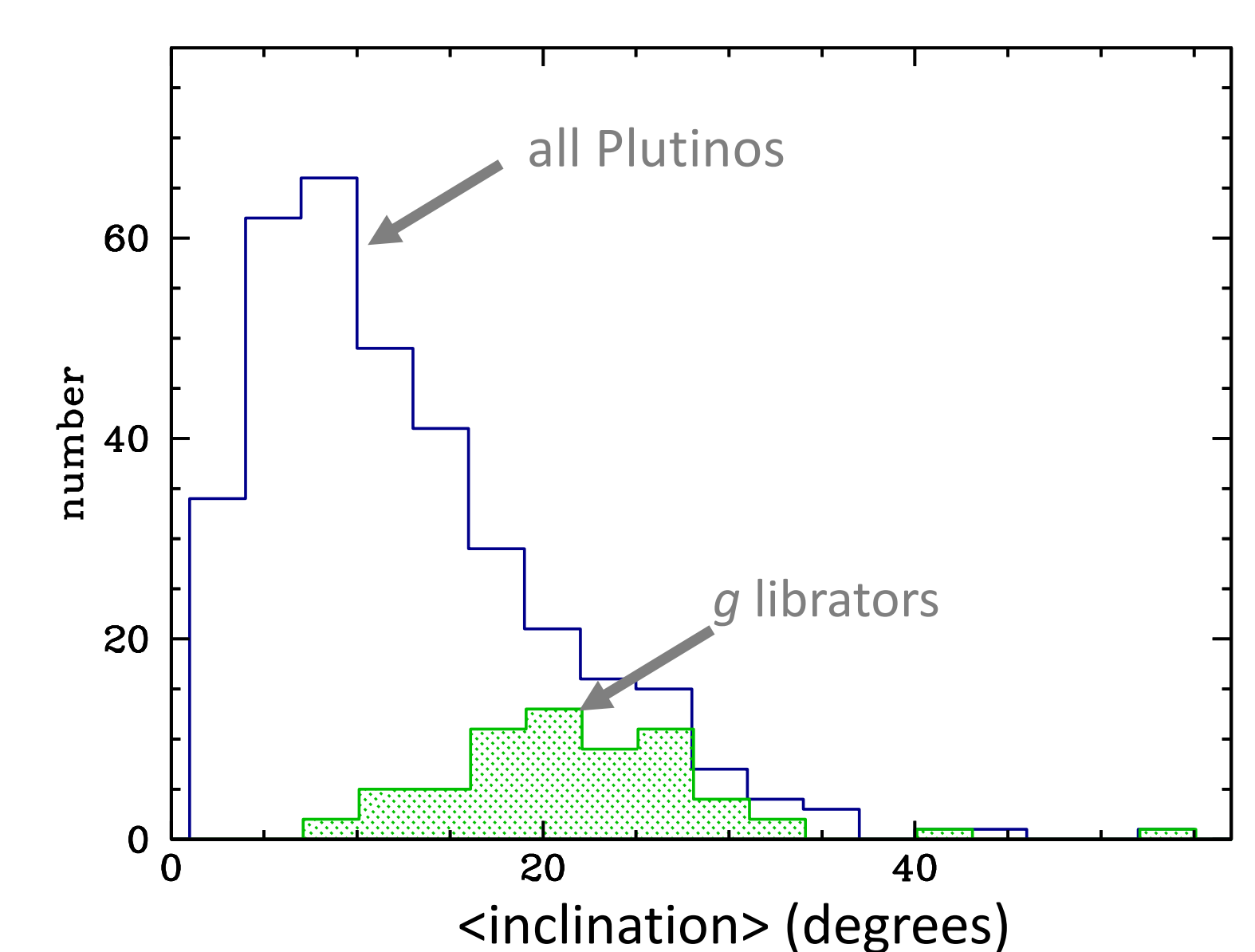
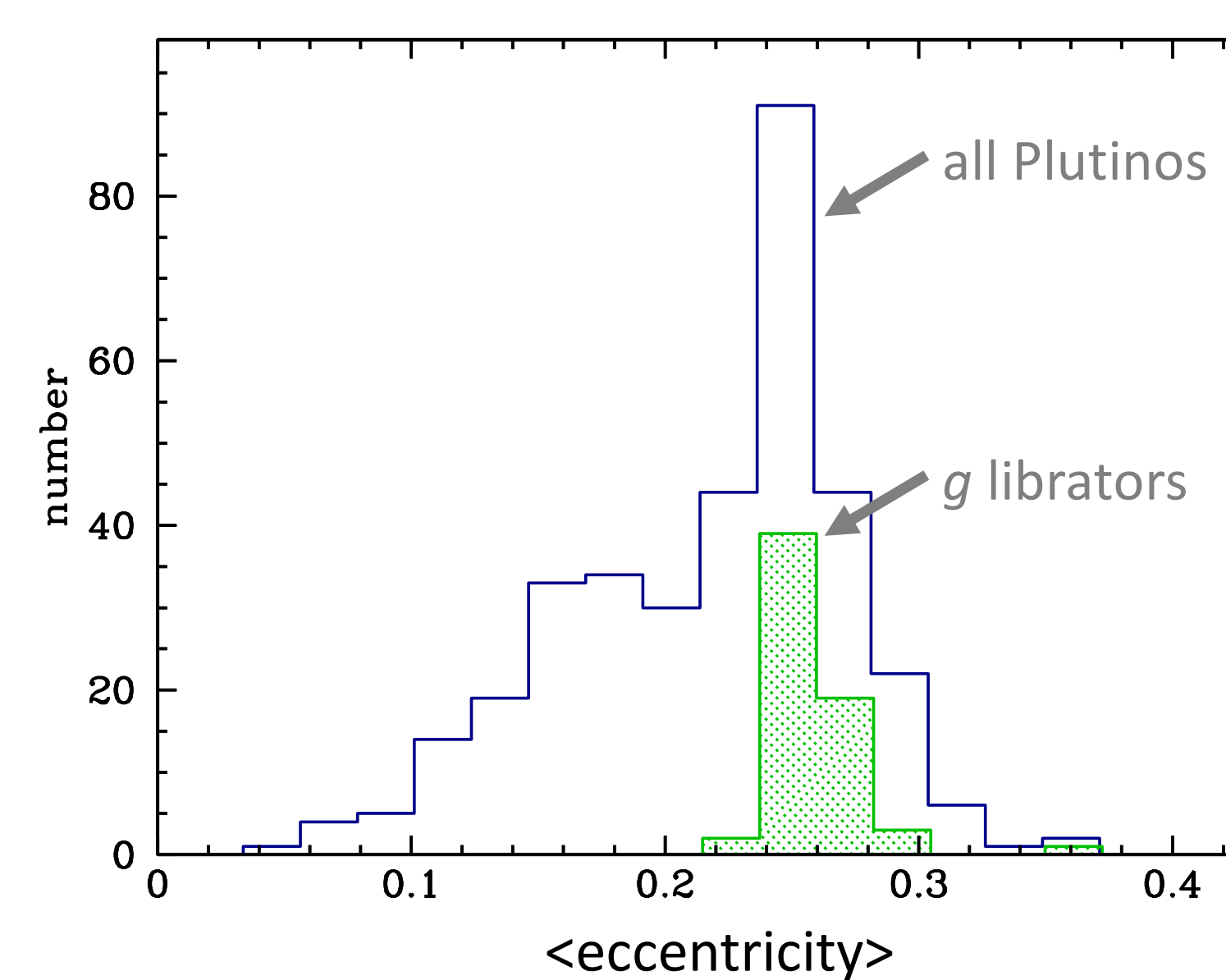


Scatter plots of osculating eccentricity, inclination and semimajor axis. The *g* librators are in green.



Scatter plot of time-averaged eccentricity and inclination. The gray curve is the *locus of the center of g librations* in a model of the restricted problem of the Sun + four giant planets + Plutino

### Time-averaged *e*, *i* distributions the *g* librators have higher eccentricities and inclinations



### Libration amplitudes

