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Asteroid Clusters

in Major Mean Motion Resonances with Jupiter

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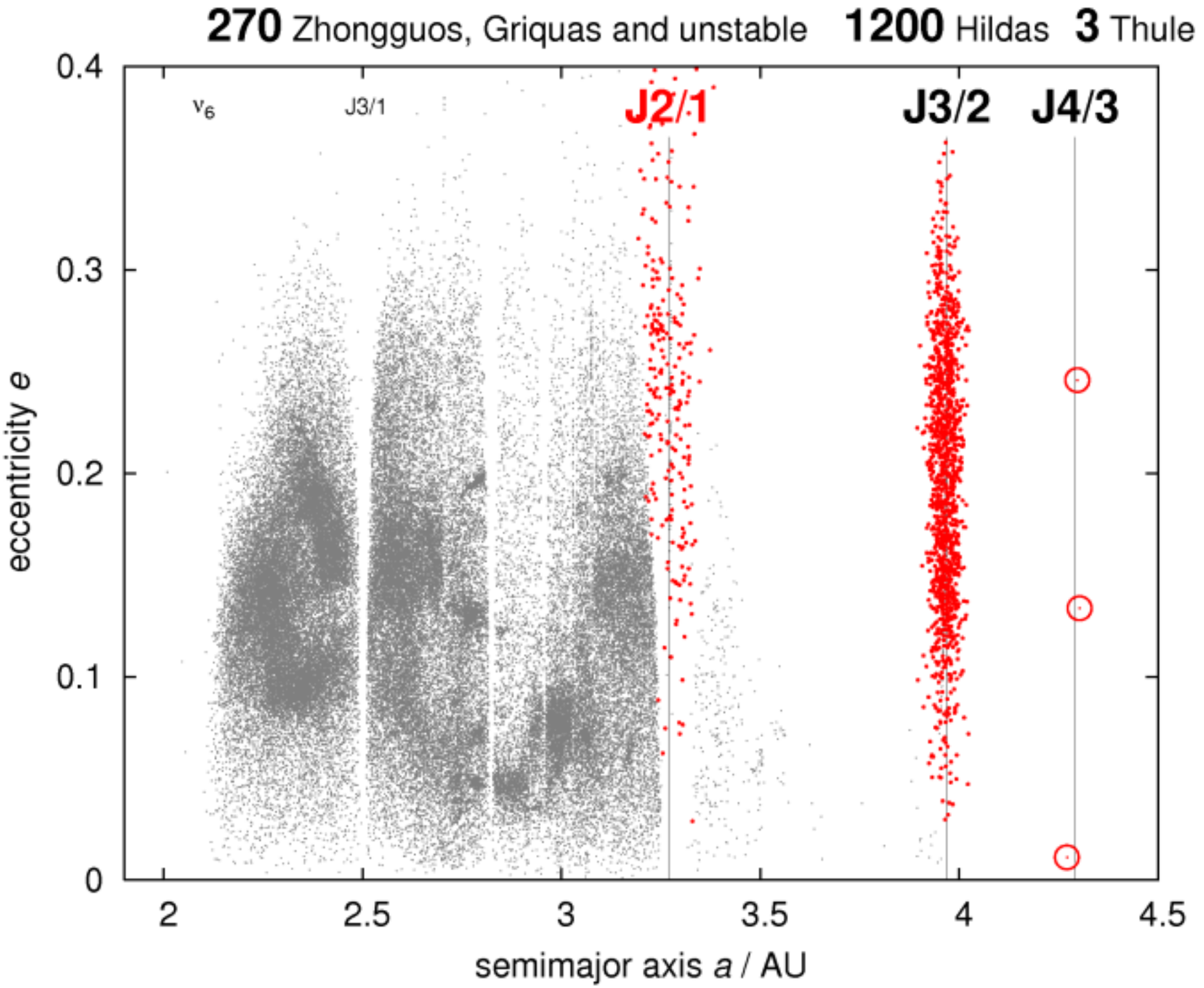
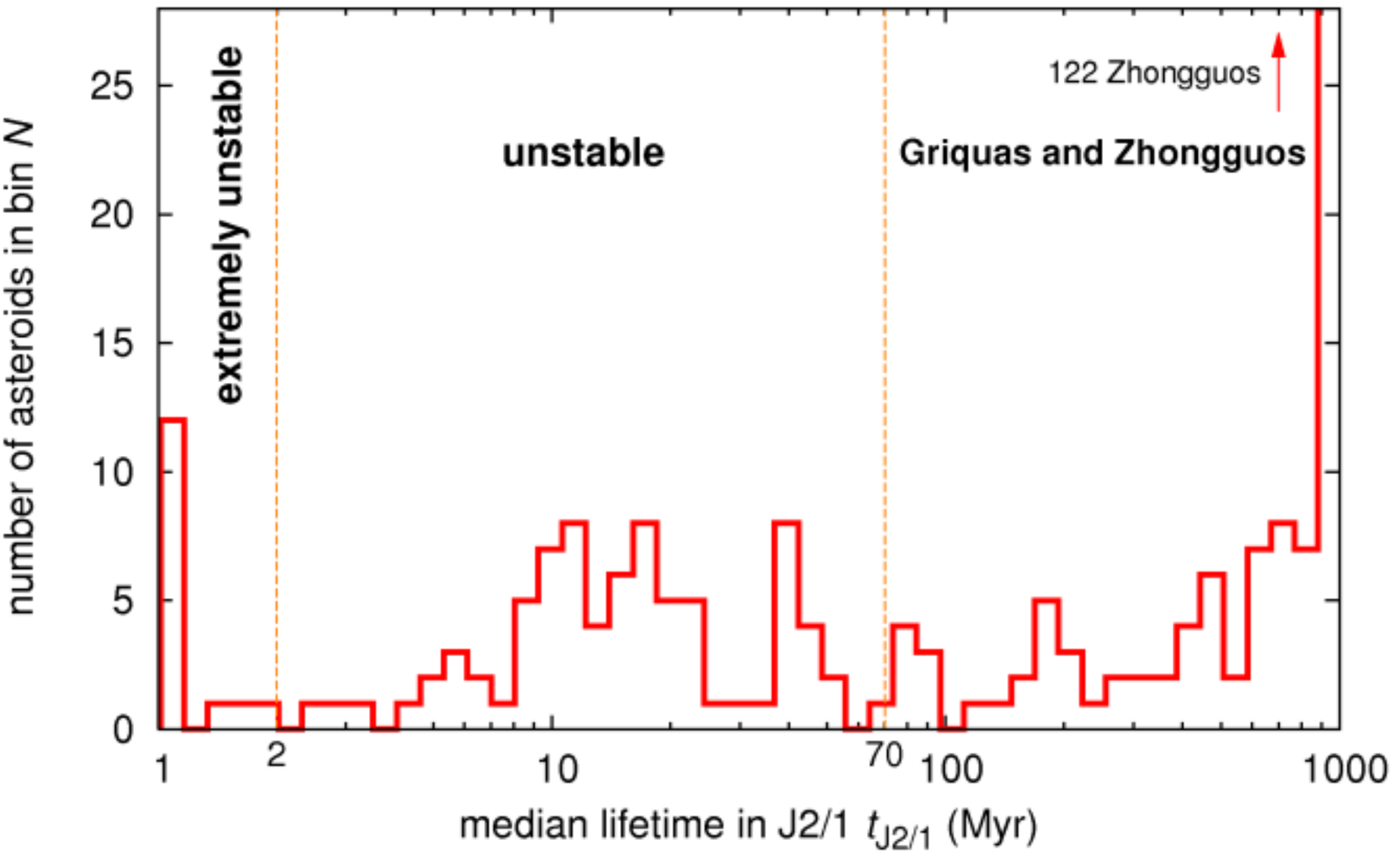
Table of contents:

Update of resonant populations (Aug 2007):

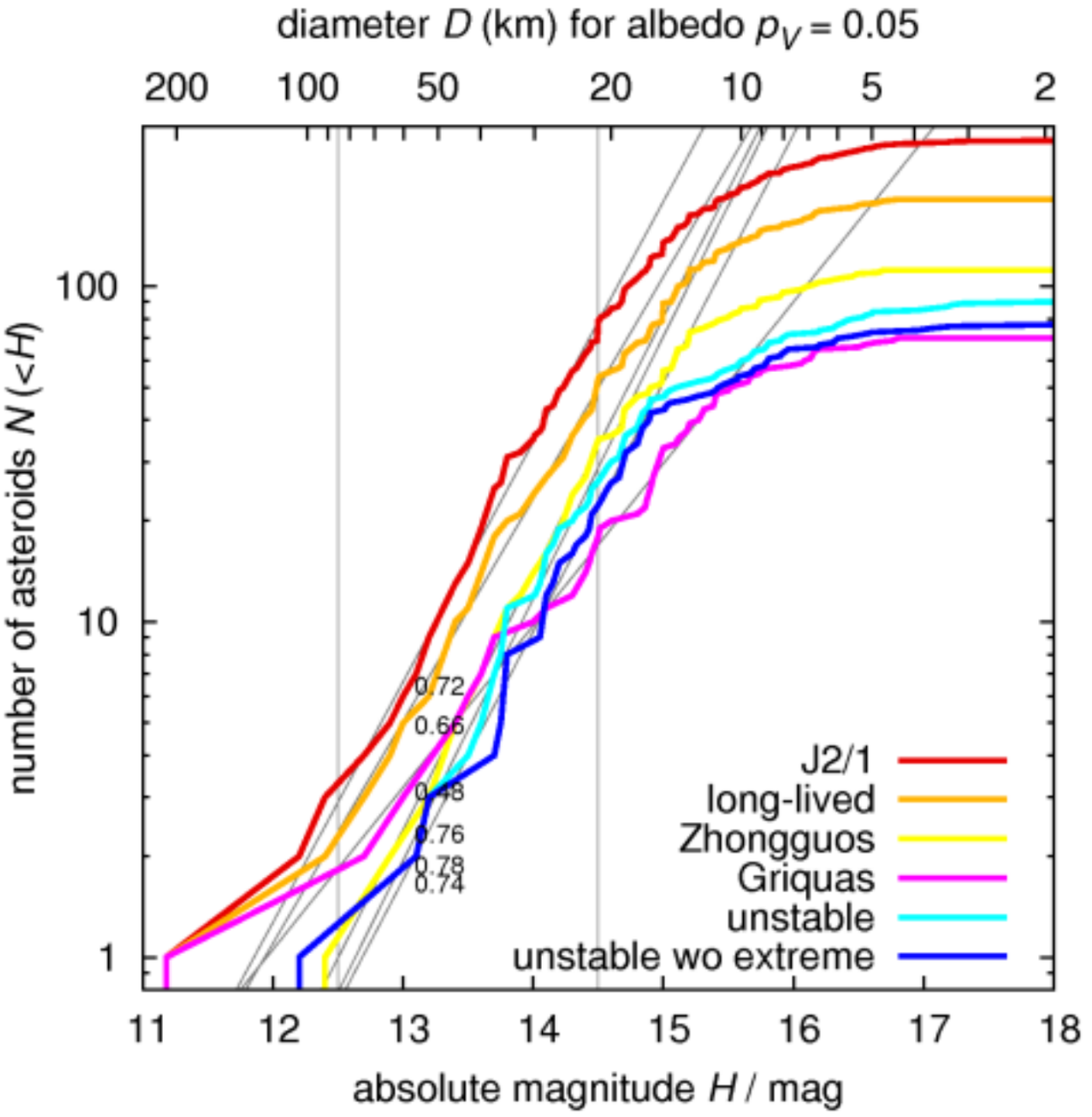


J2/1 — dynamical lifetimes:



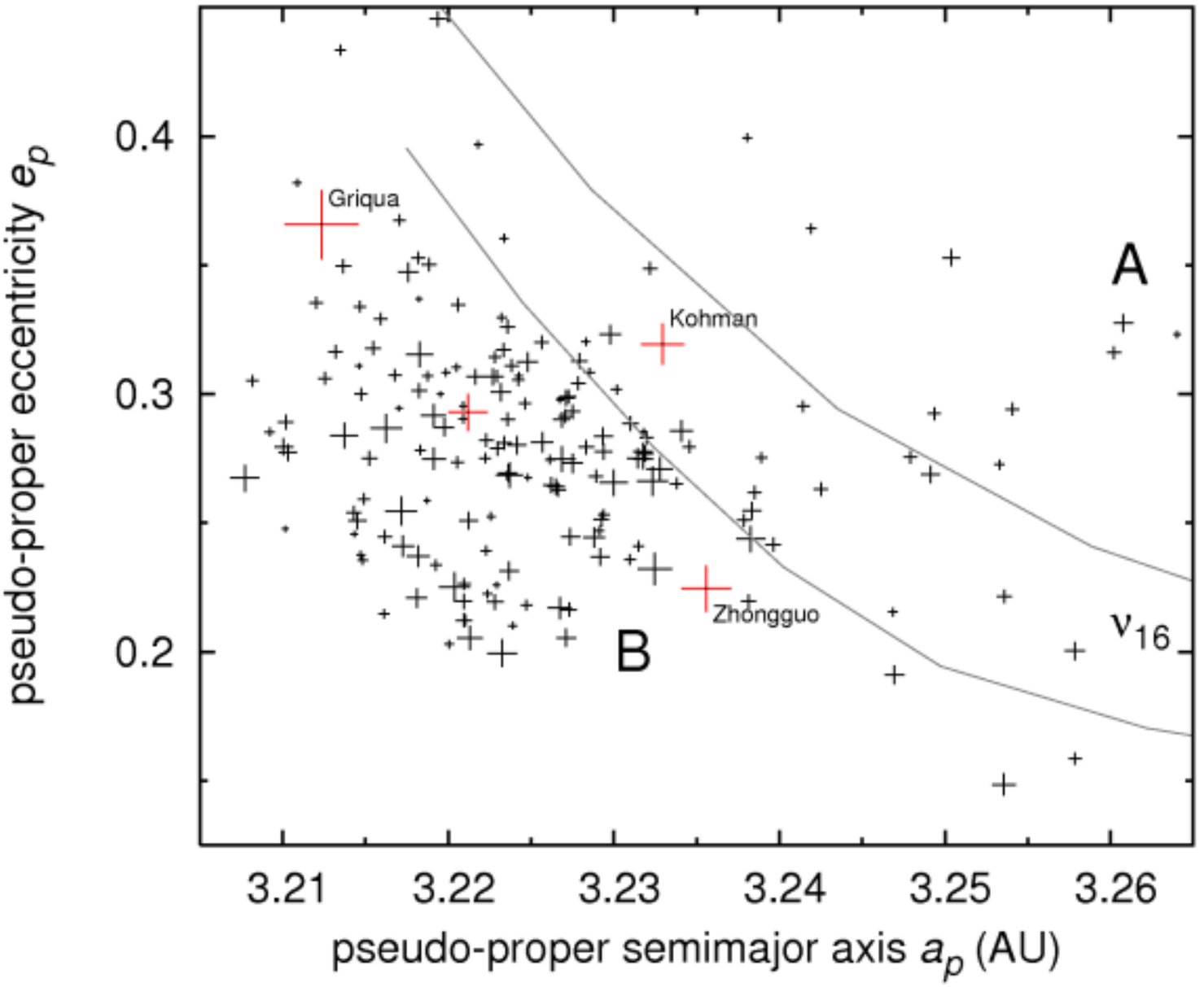
- median of 10 orbits within uncertainty ellipsoid
- 2/3 of the population long-lived > 100 My
- (the rest unstable ← Yarkovsky origin (Brož *et al.* 2005))

J2/1 — absolute magnitude distribution:



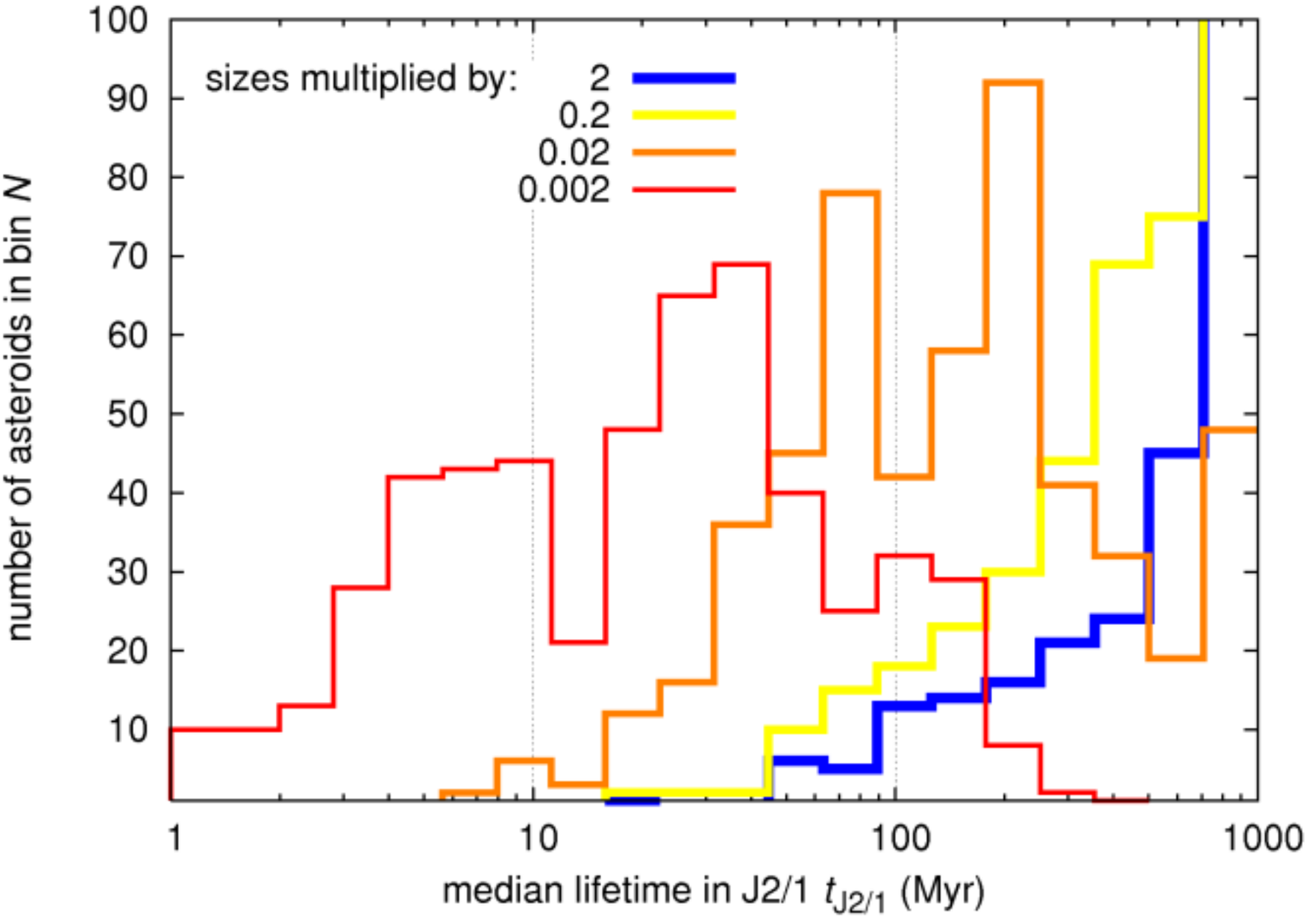
- almost all sub-populations similar!
- short-lived steep $\Leftarrow$ Yarkovsky driven transport $\propto 1/D$
- long-lived also steeper than adjacent Main Belt $\Leftarrow$?

J2/1 — pseudo-proper elements vs sizes:



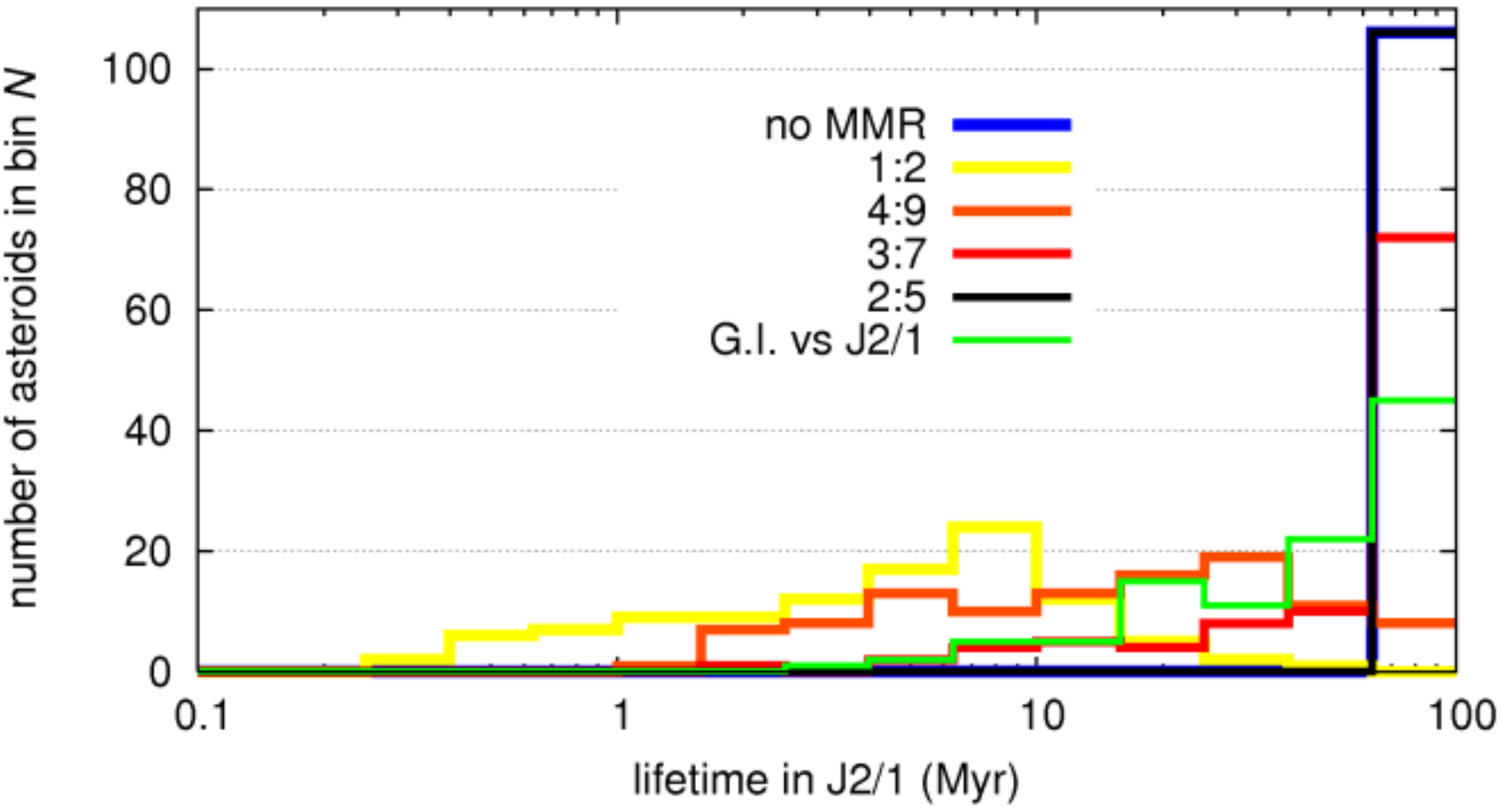
- pseudo-proper elements — surfaces of sections, averaging
- no prominent clusters, big bodies far from each other and 'isolated' ⇒ not a single collisional event?
- impact-generated clusters would spread within ∼1 Gyr

J2/1 — Yarkovsky effect vs long-lived?



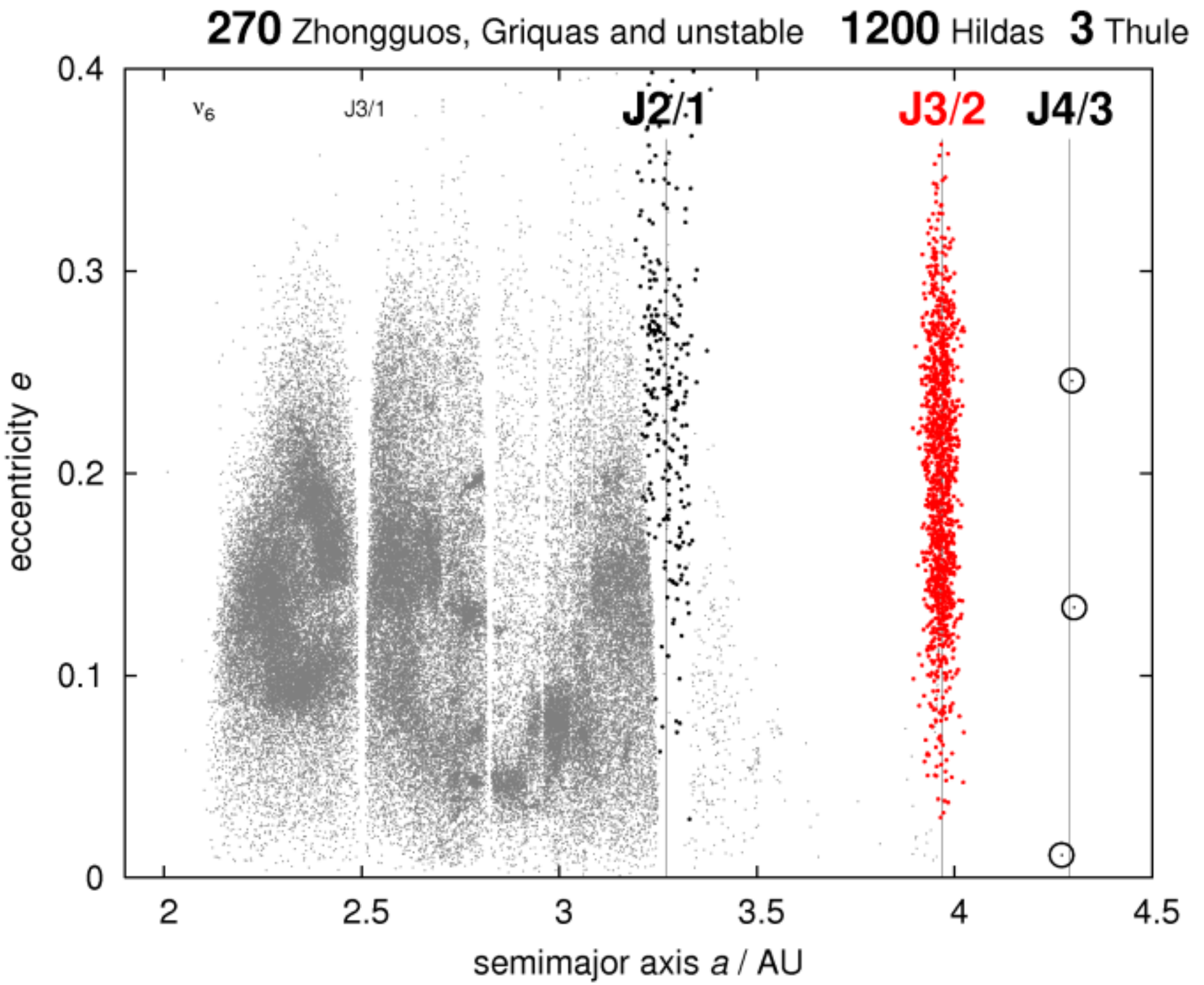
- NO! semimajor axis drift only relevant for $\lesssim 0.1$–$0.5\,\mathrm{km}$
- preferential orientation of the spin axes for the small sizes

J2/1 — planetary migration?

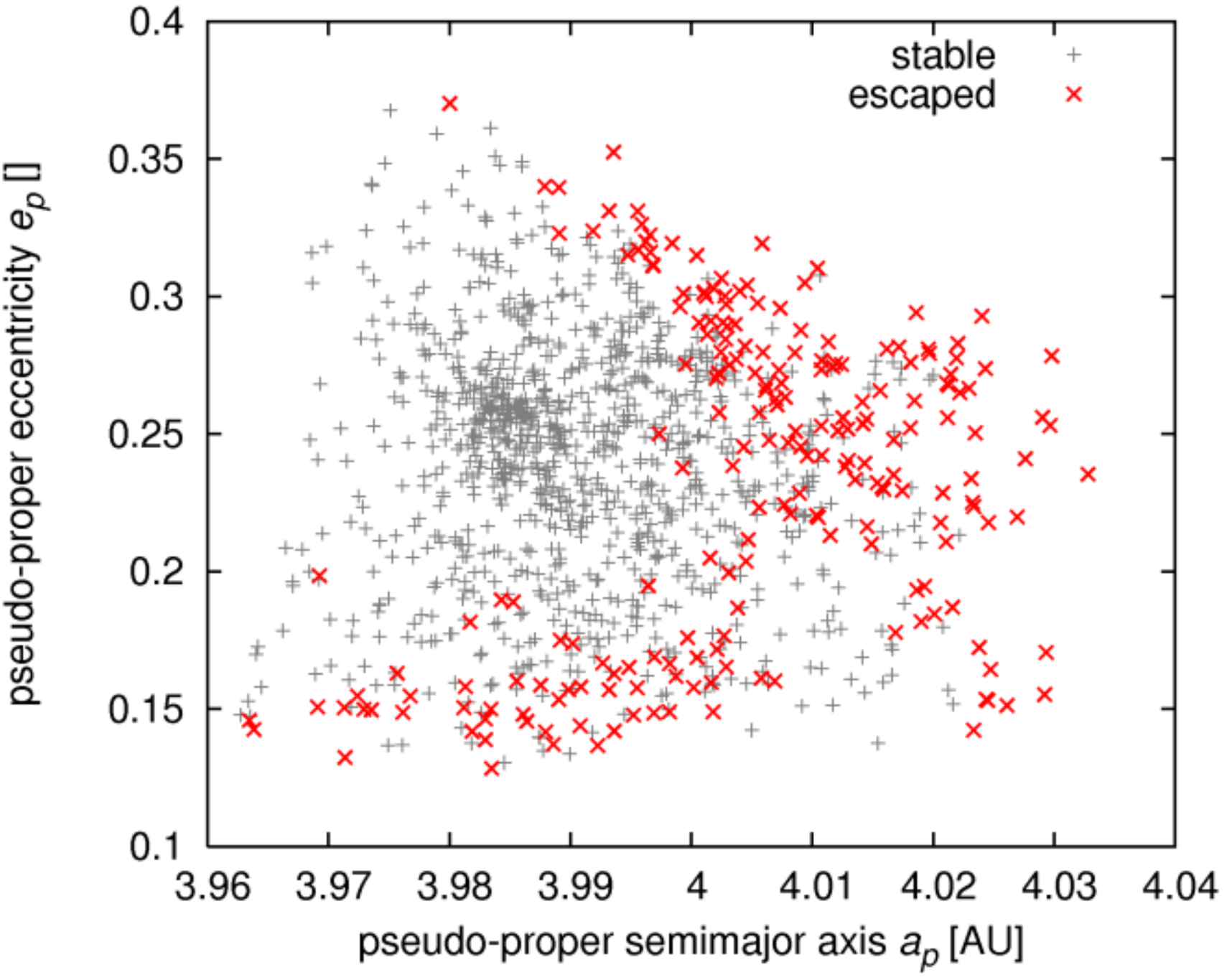


- a 'static' test — Saturn at exact resonance with Jupiter
- Zhongguos and Griquas partially unstable wrt. 1:2, 4:9, and the Great Inequality resonance

J3/2 resonance:

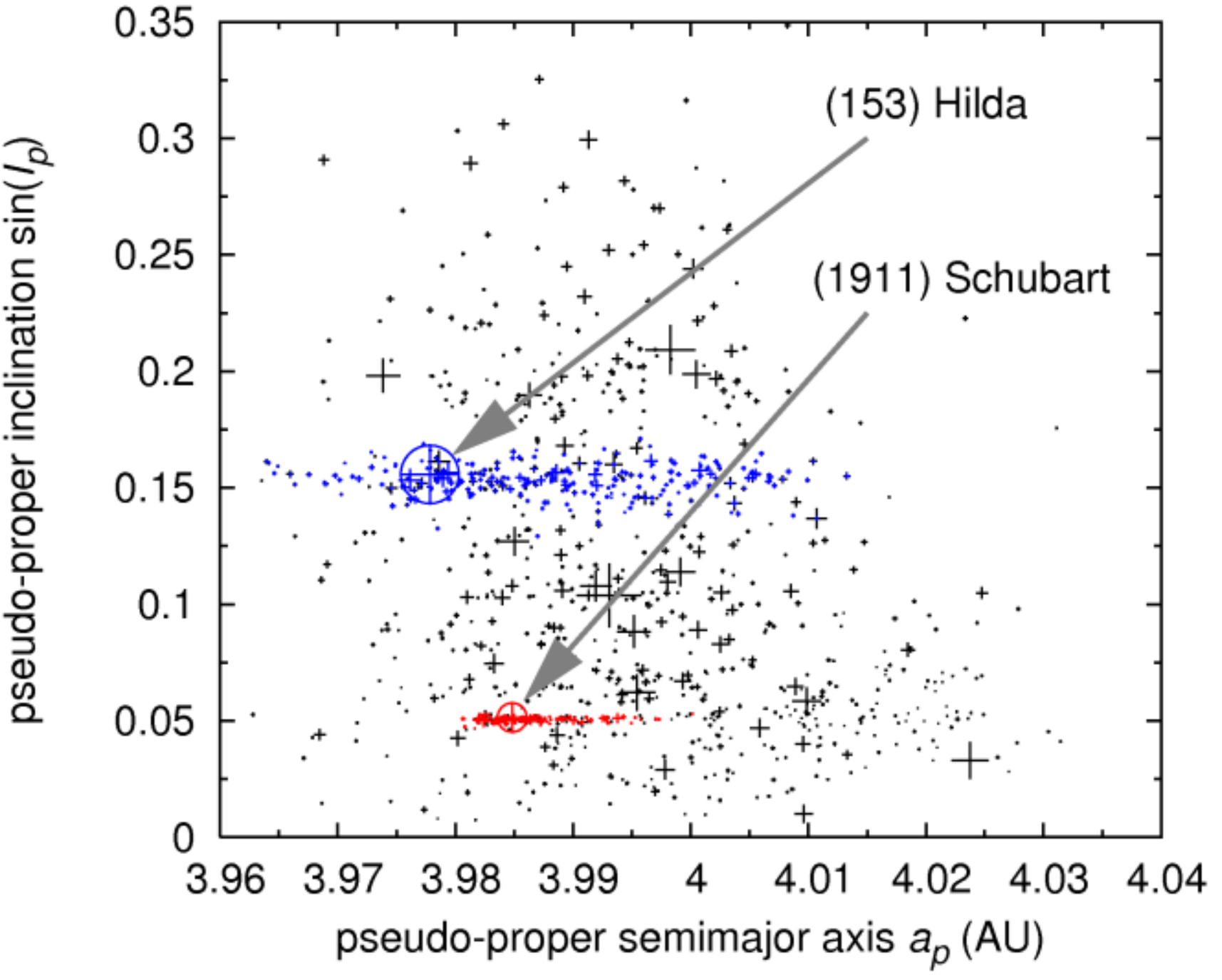


J3/2 — dynamical lifetimes:



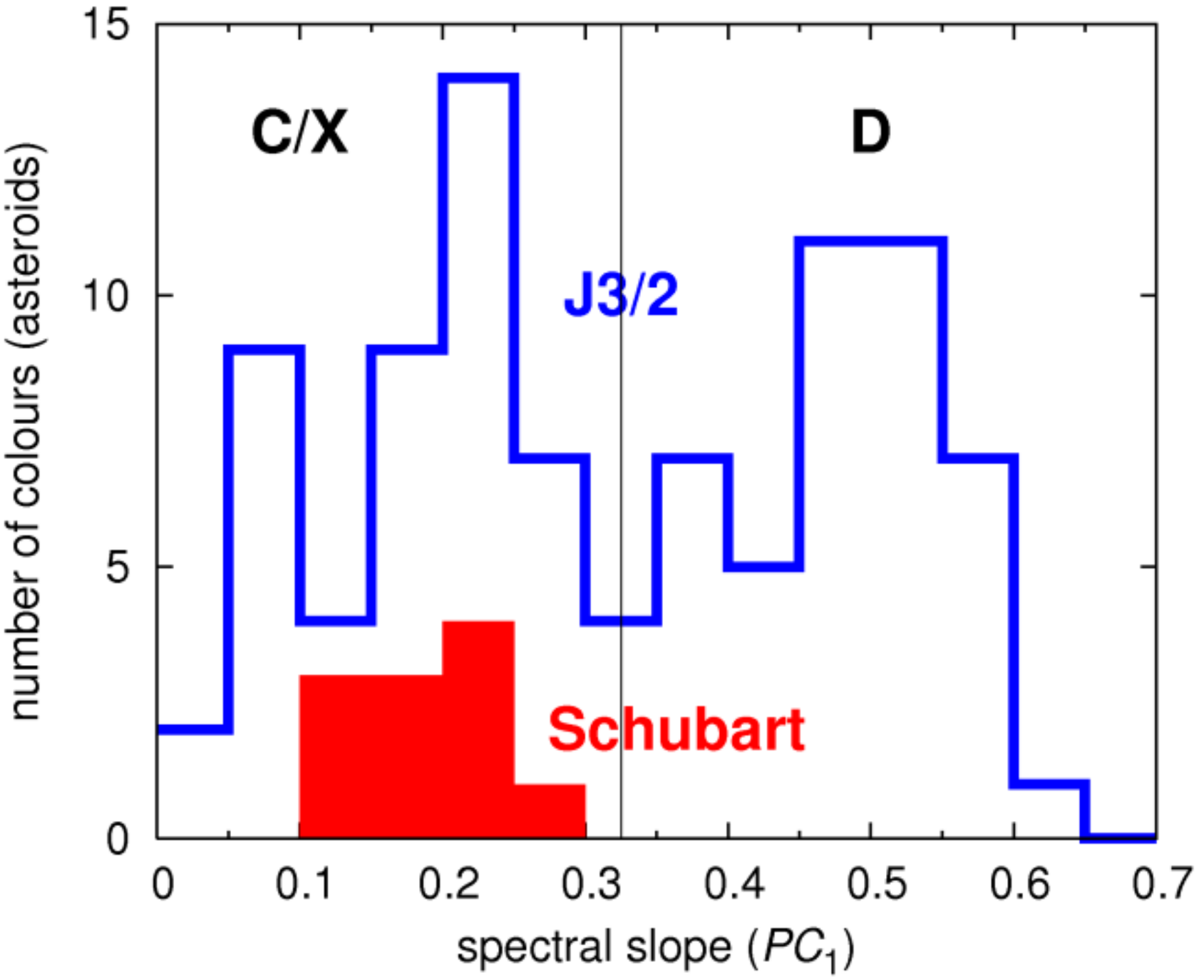
- 20 % of Hildas escape within 4 Gyr
  (large amplitude of libration, secondary resonances)

J3/2 — pseudo-proper elements:



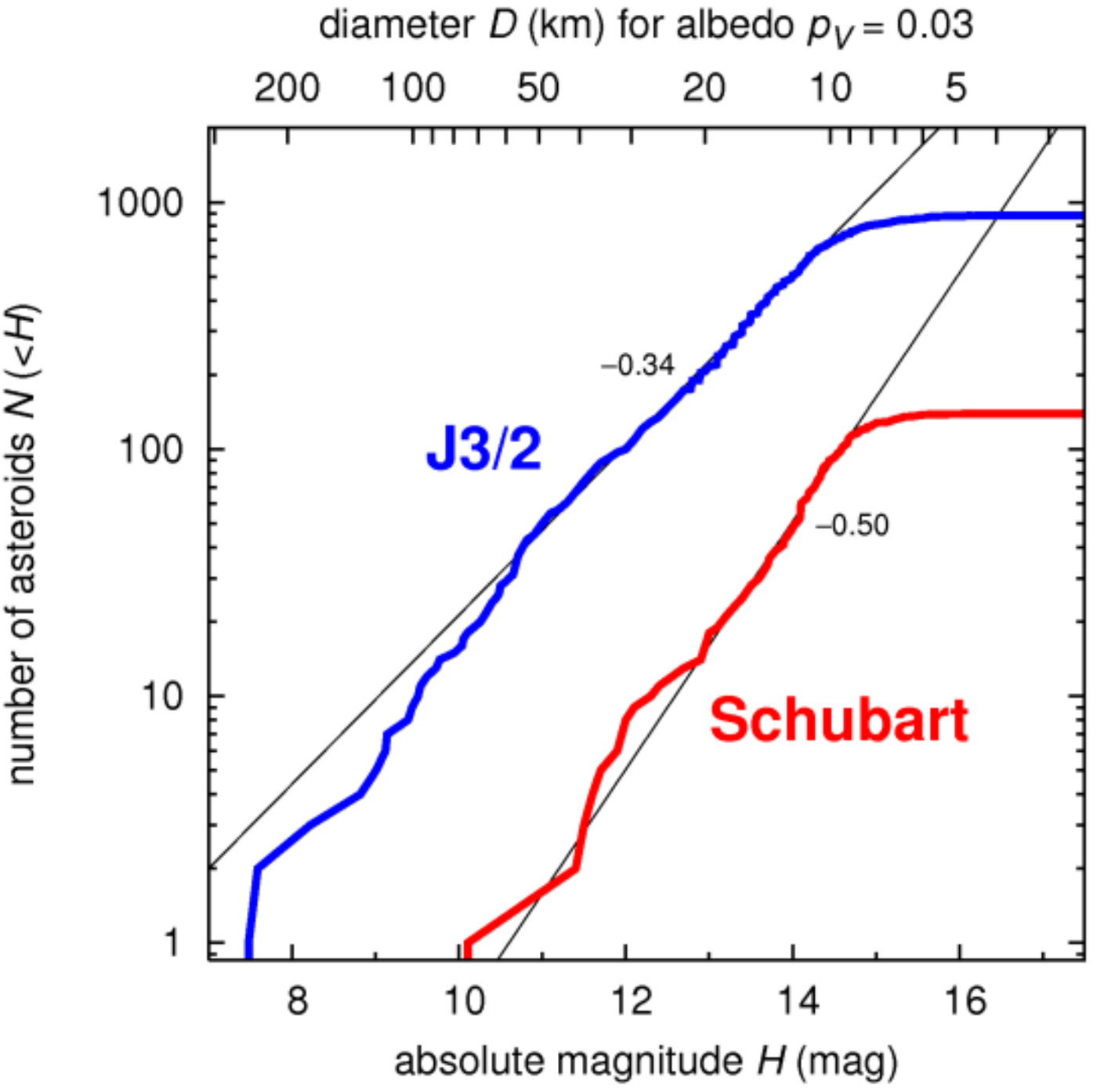
- a distinct collisional Schubart cluster (Schubart 1991); $v_{\rm cutoff} \simeq 60\,{\rm m/s}$, $\sim 100\,{\rm km}$ parent body, LF/PB $\simeq 0.25$
- Hilda cluster at higher inclinations; $\sim 200\,{\rm km}$ PB

Schubart cluster — colours:



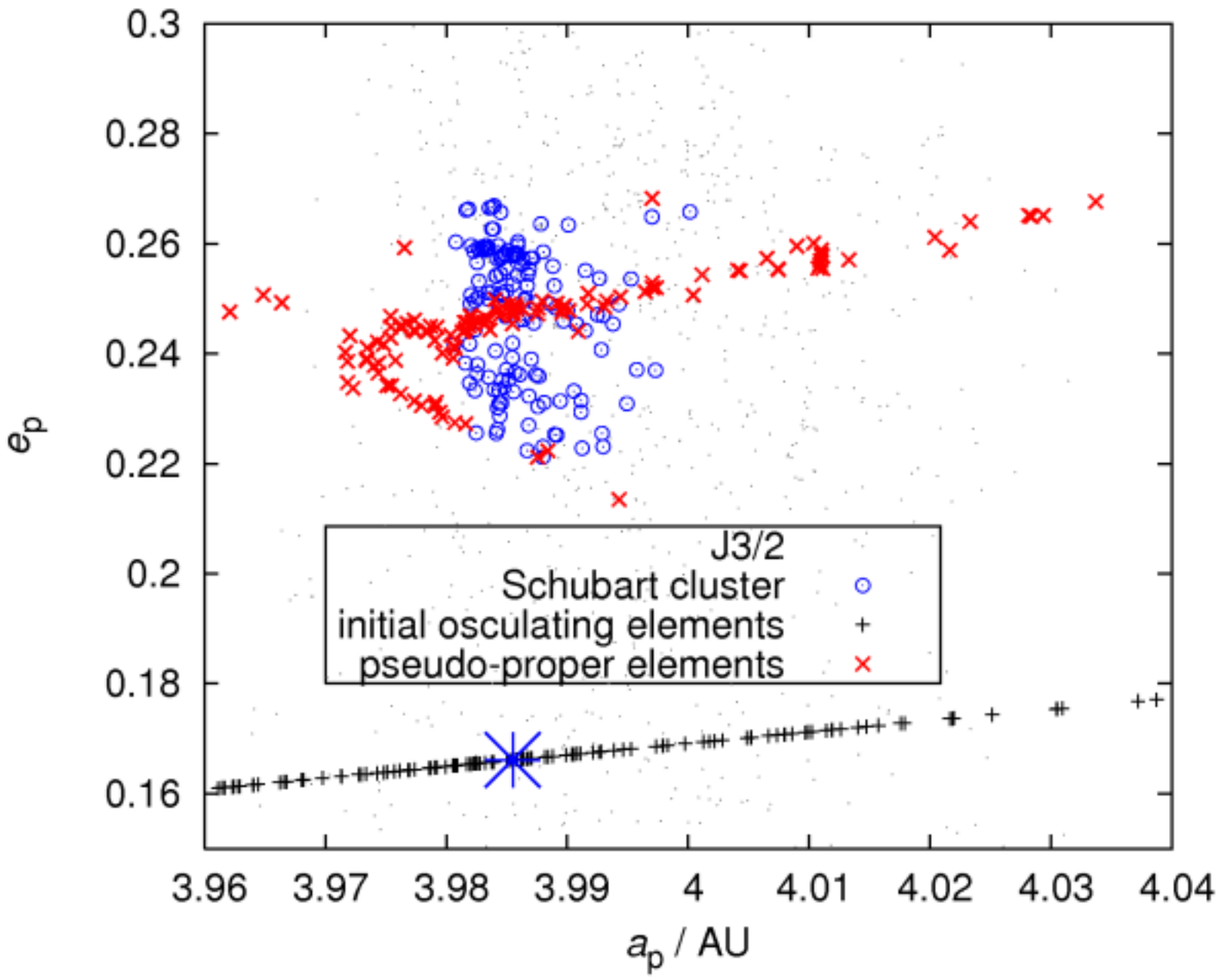
- SLOAN colours of J3/2 bimodal (C/X- and D-types)
- Schubart cluster only C/X-type ⇒ collisional origin

Schubart cluster — SFD:



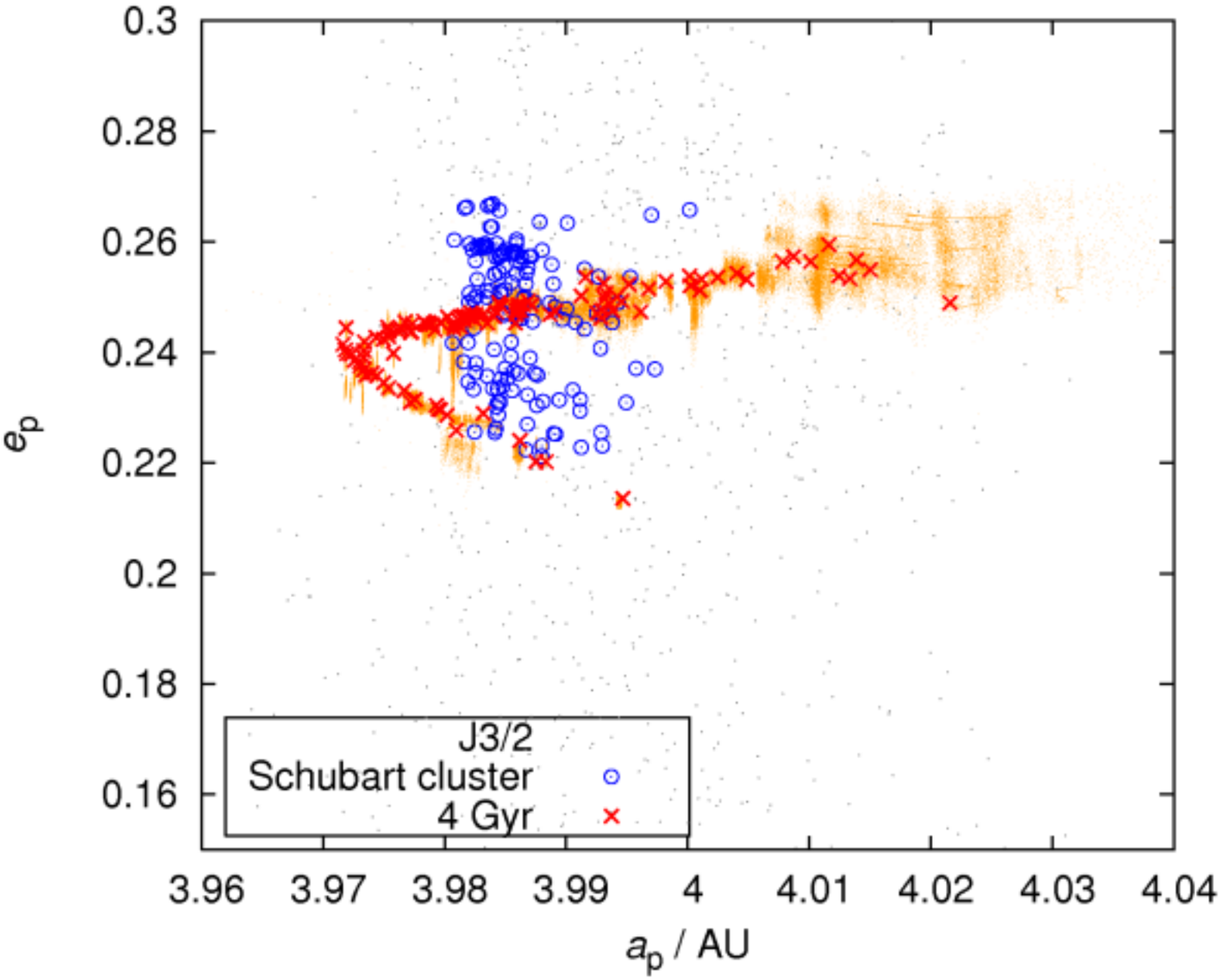
- Schubart cluster significantly steeper than the rest of J3/2 $\Rightarrow$ collisional origin (but not as steep as MB families)

Simulated impact in J3/2:



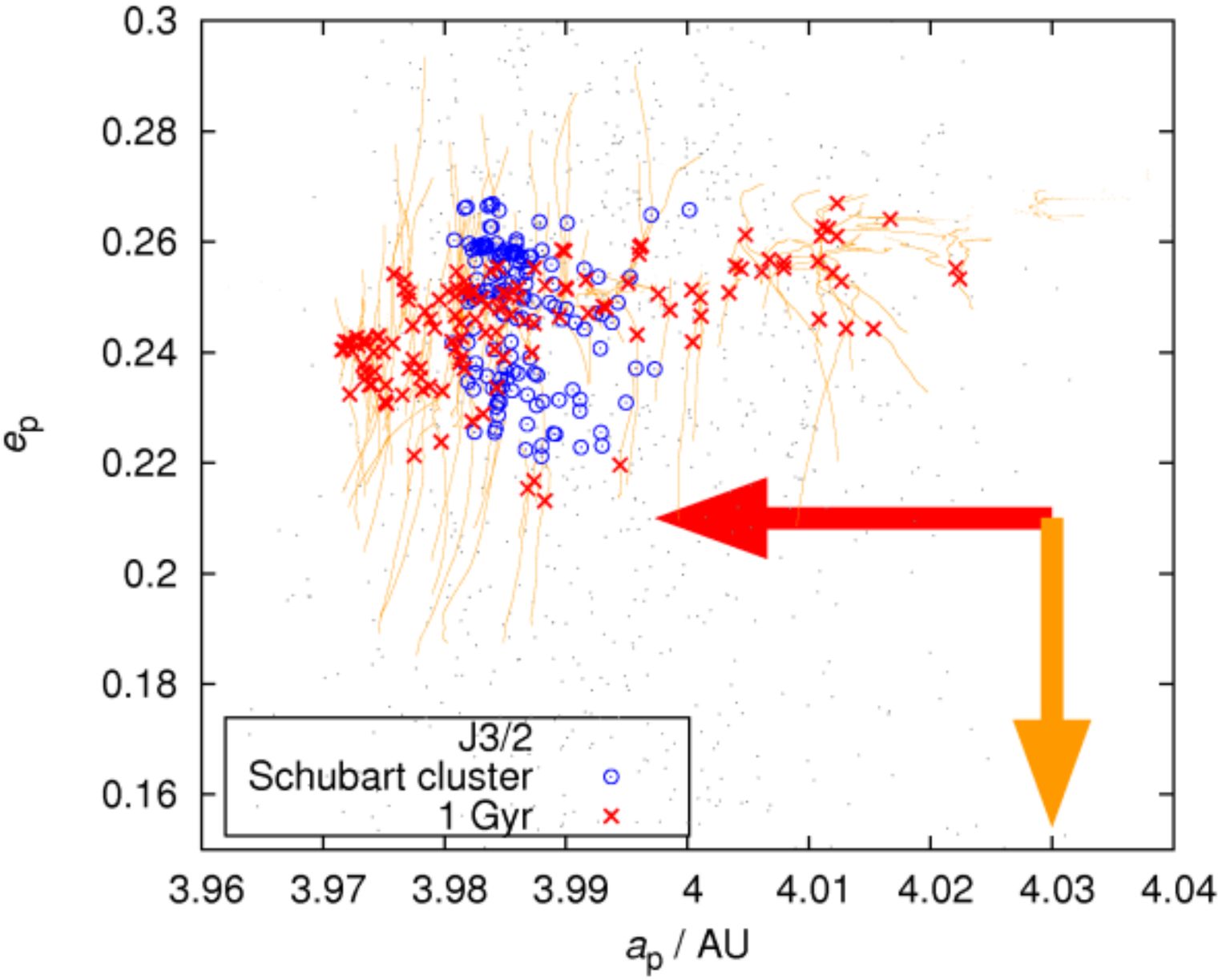
- a disruption of a 100 km PB; isotropic velocity field with $v_{\text{mean}} = 50\,\text{m/s}$, $f = 0$, $\omega + f = 180°$
- 'mapping' of the osculating elements into pseudo-proper

Impact in J3/2 — evolution over 4 Gyr:



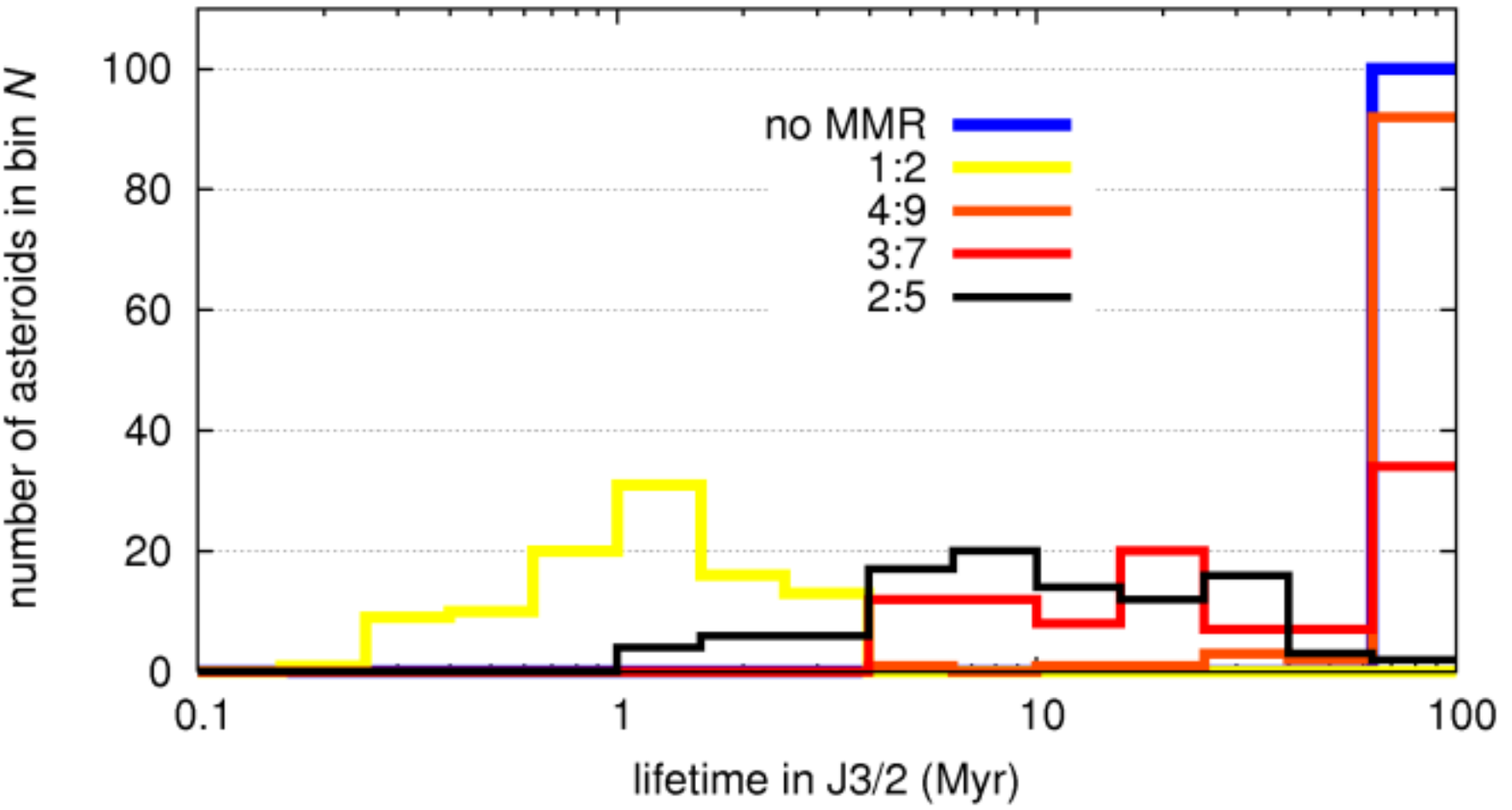
- N-body simulation, SWIFT integrator, 4 planets only
- the shape of the swarm is well preserved for 4 Gyr
- problem: observed Schubart cluster has larger spread in e

Impact in J3/2 — Yarkovsky effect:



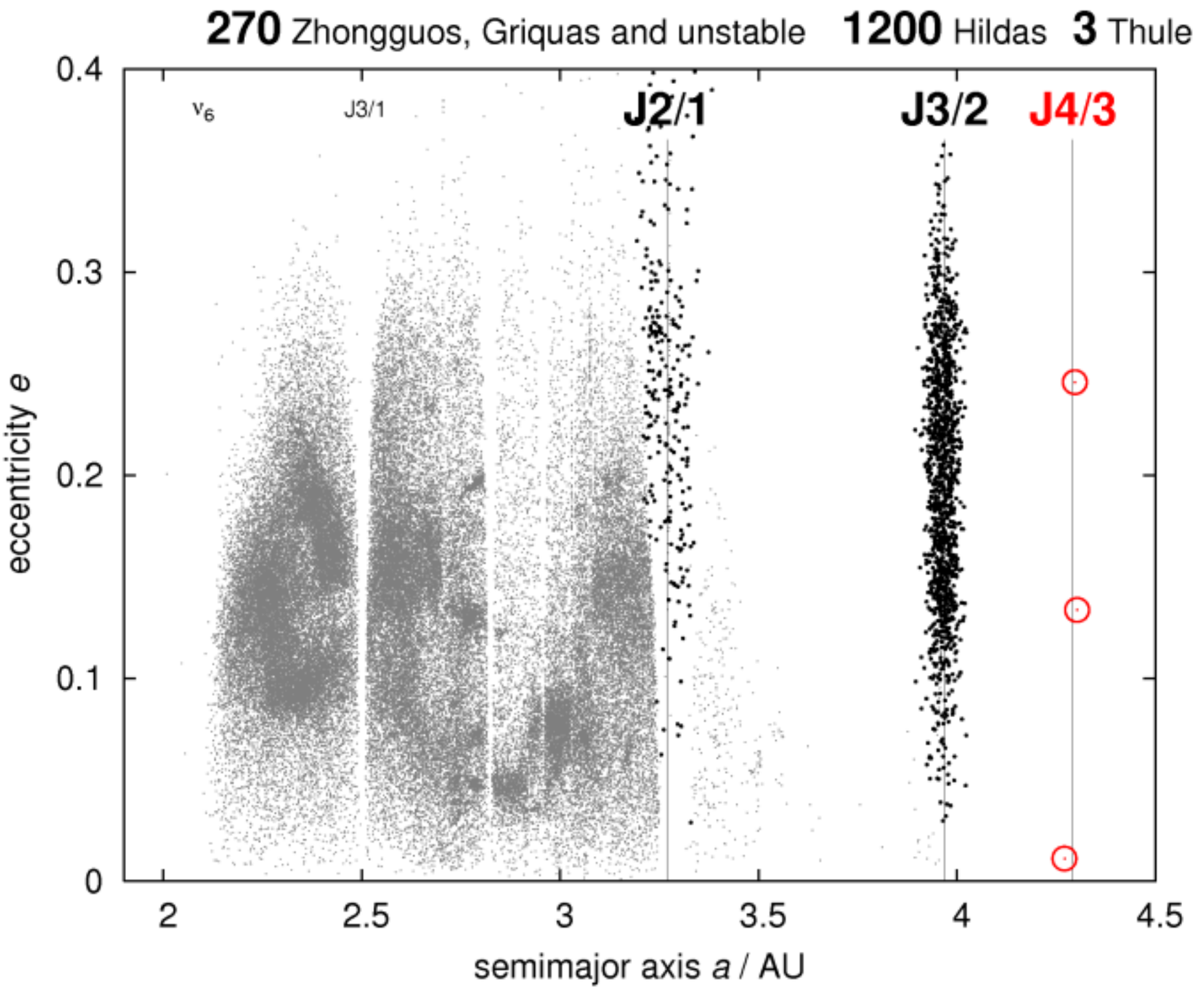
- the Yarkovsky enhances the diffusion in eccentricity
  → different mechanism than for Main Belt families!

J3/2 — planetary migration:

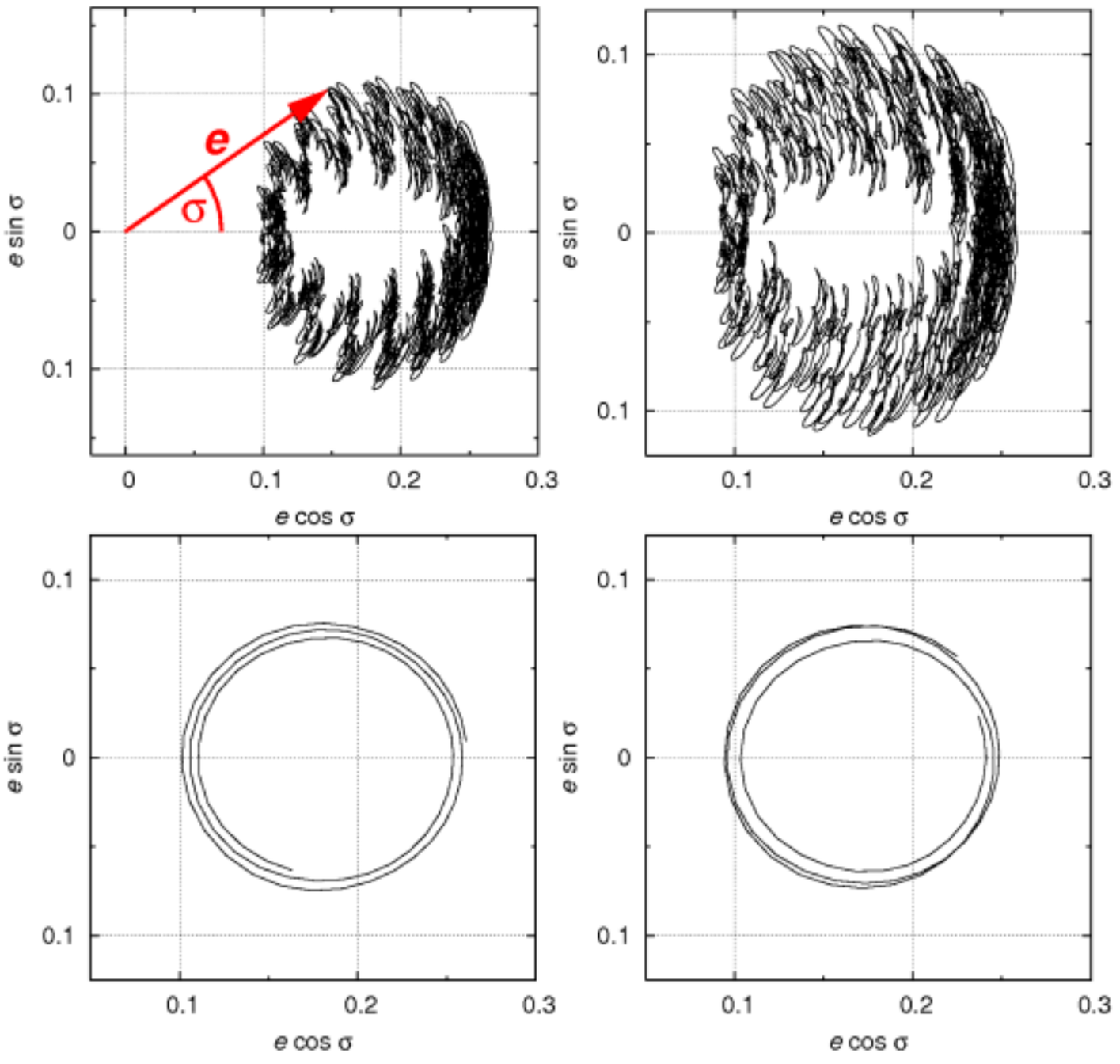


- Hildas strongly unstable wrt. 2:1 Jupiter–Saturn MMR (and partially also to 3:7)
- talk 12.05 by H. Levison on capture of D-type Hildas

J4/3 resonance:

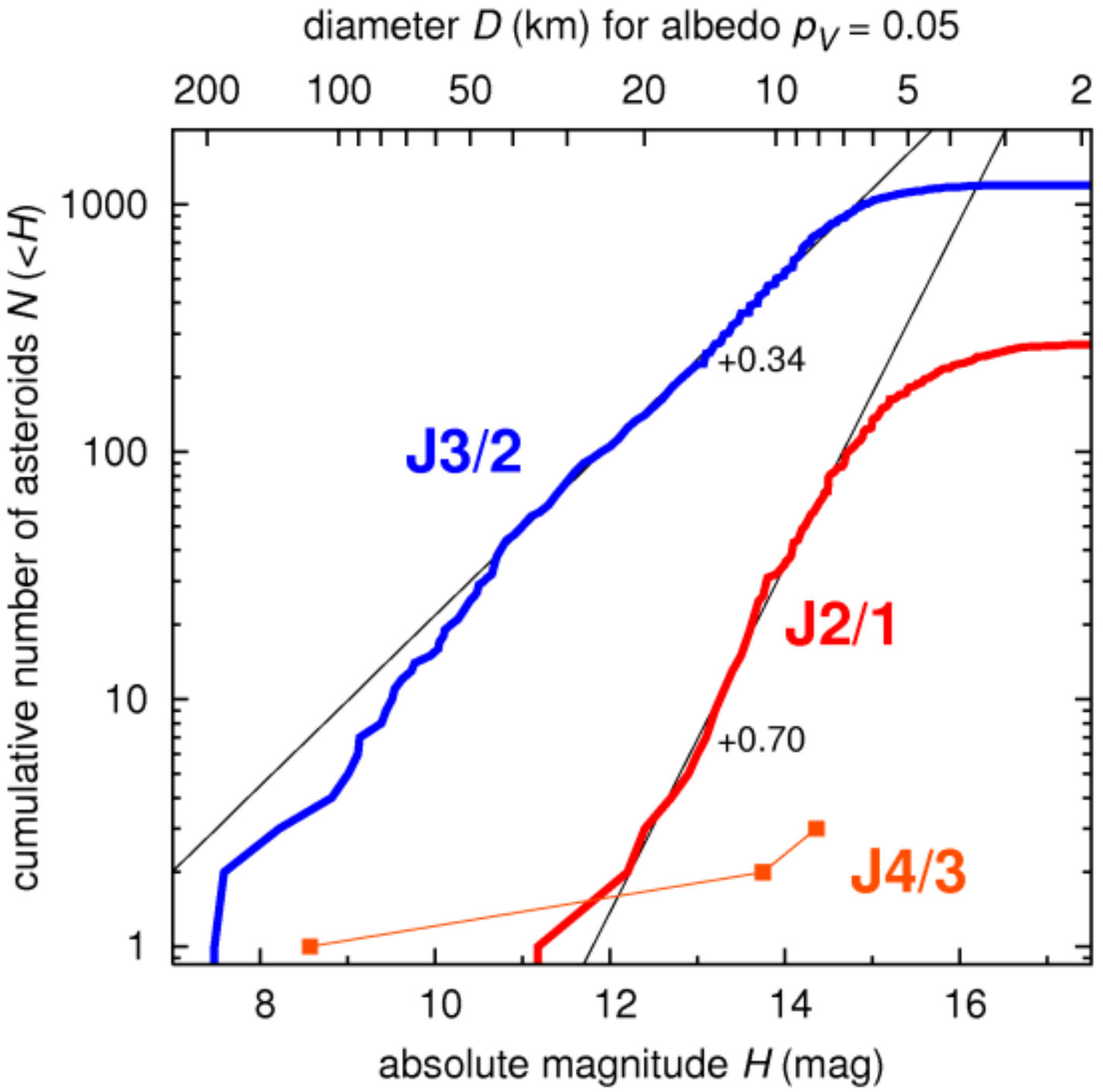


J4/3 — 2001 QG_{207} and 2006 UB_{219}:



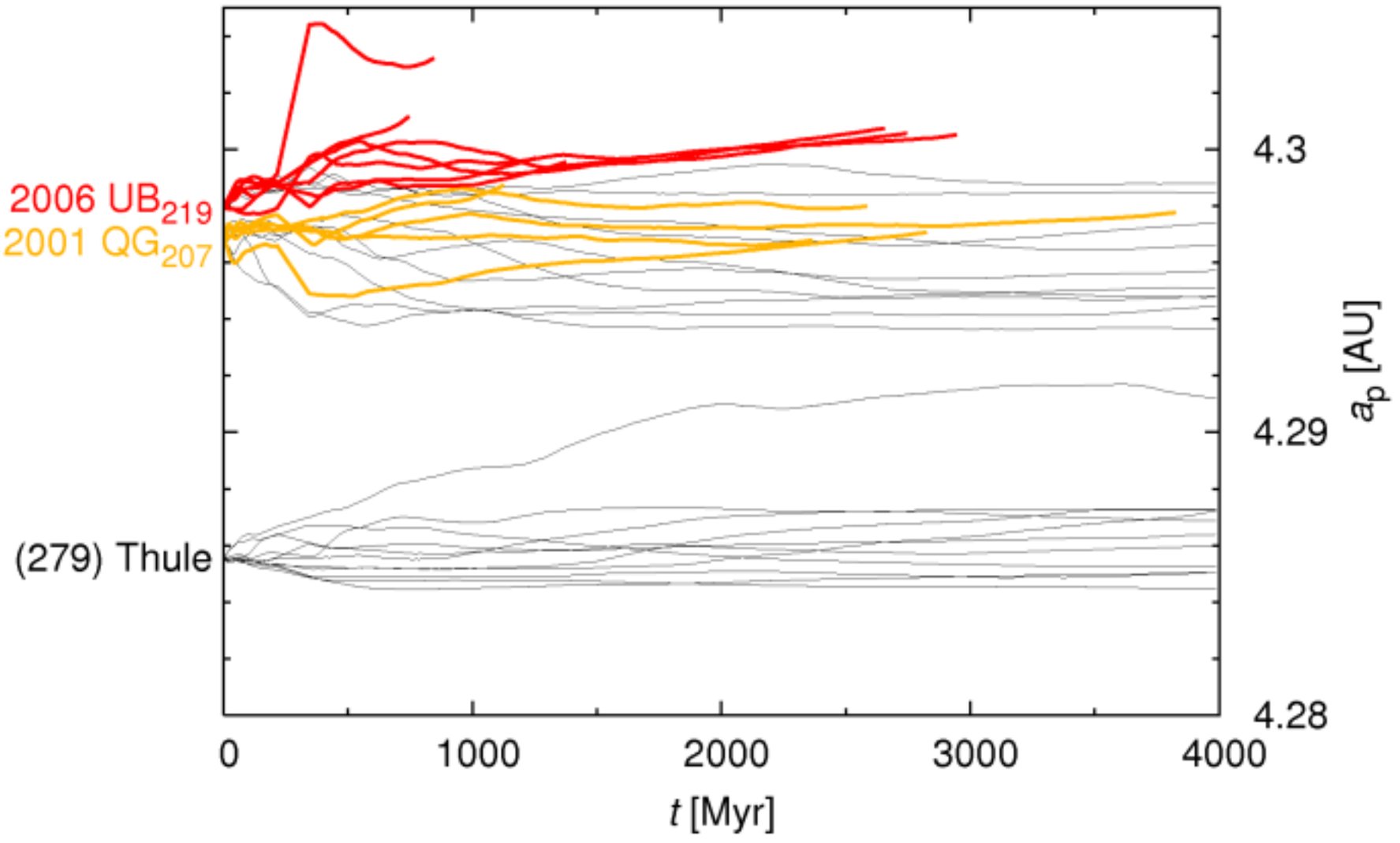
- 2 new objects ⇒ a real Thule *group*
- libration about pericentric branch of the J4/3

J4/3 — absolute magnitude distribution:



- J4/3: strongly *depleted* (even though stable orbits exist)

J4/3 — dynamical lifetimes:



- (279) Thule orbit stable over 4 Gyr
- 2001 QG_{207}, 2006 UB_{219}: 45 % and 60 % of clones escape

Conclusions:

- J2/1 population almost doubled
- two collisional families in the J3/2 resonance (probably old, different from MB families)
- two more asteroids in the J4/3
- constrains for planetary migration models

Future work:

- stability wrt. analytical planetary migration
- influence of close encounters with massive asteroids