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On the dynamics of Trojans
and outer Main Belt resonant families

M. Brož [1], D. Vokrouhlický [1]

[1] Charles University, Prague

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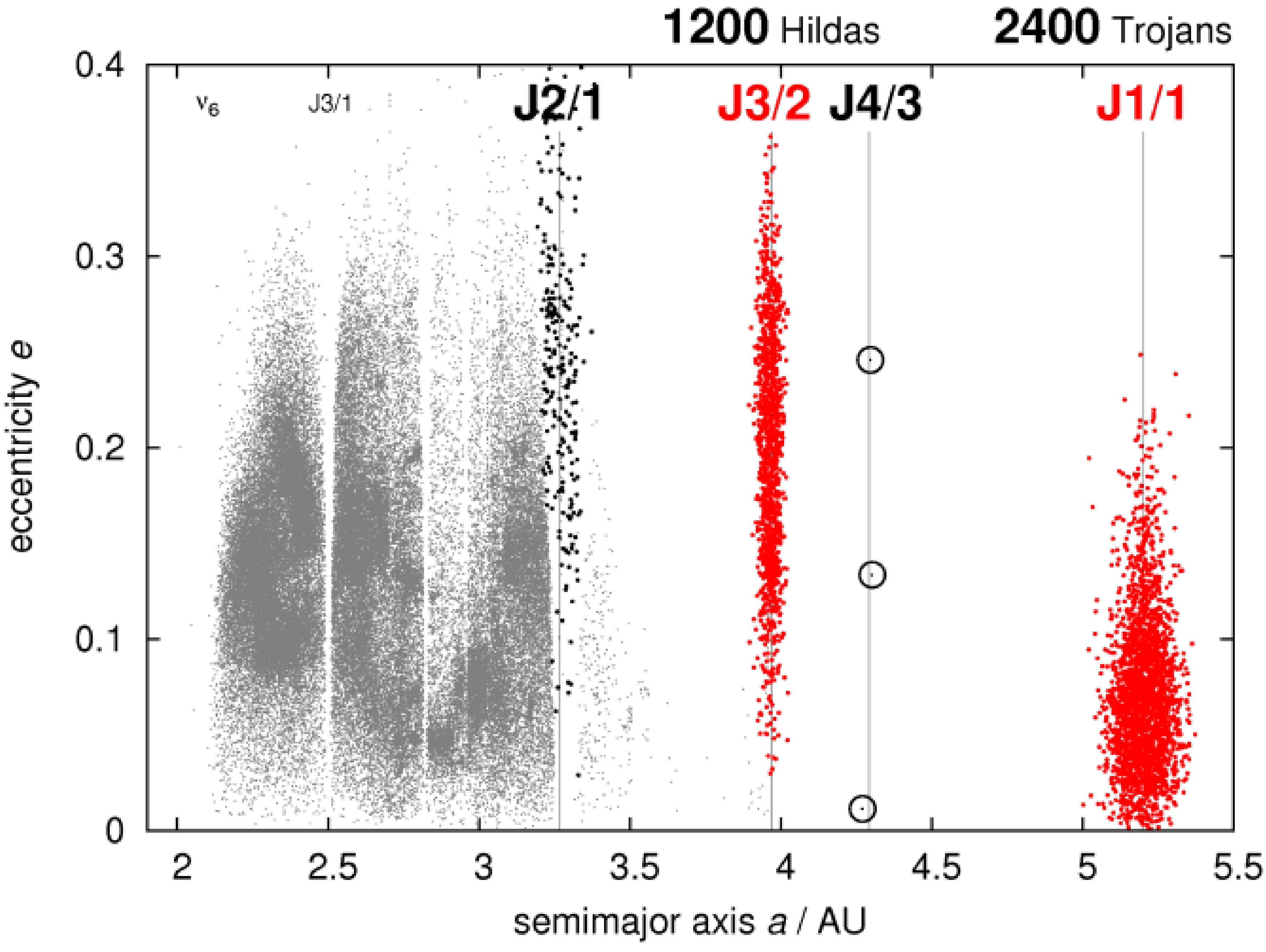
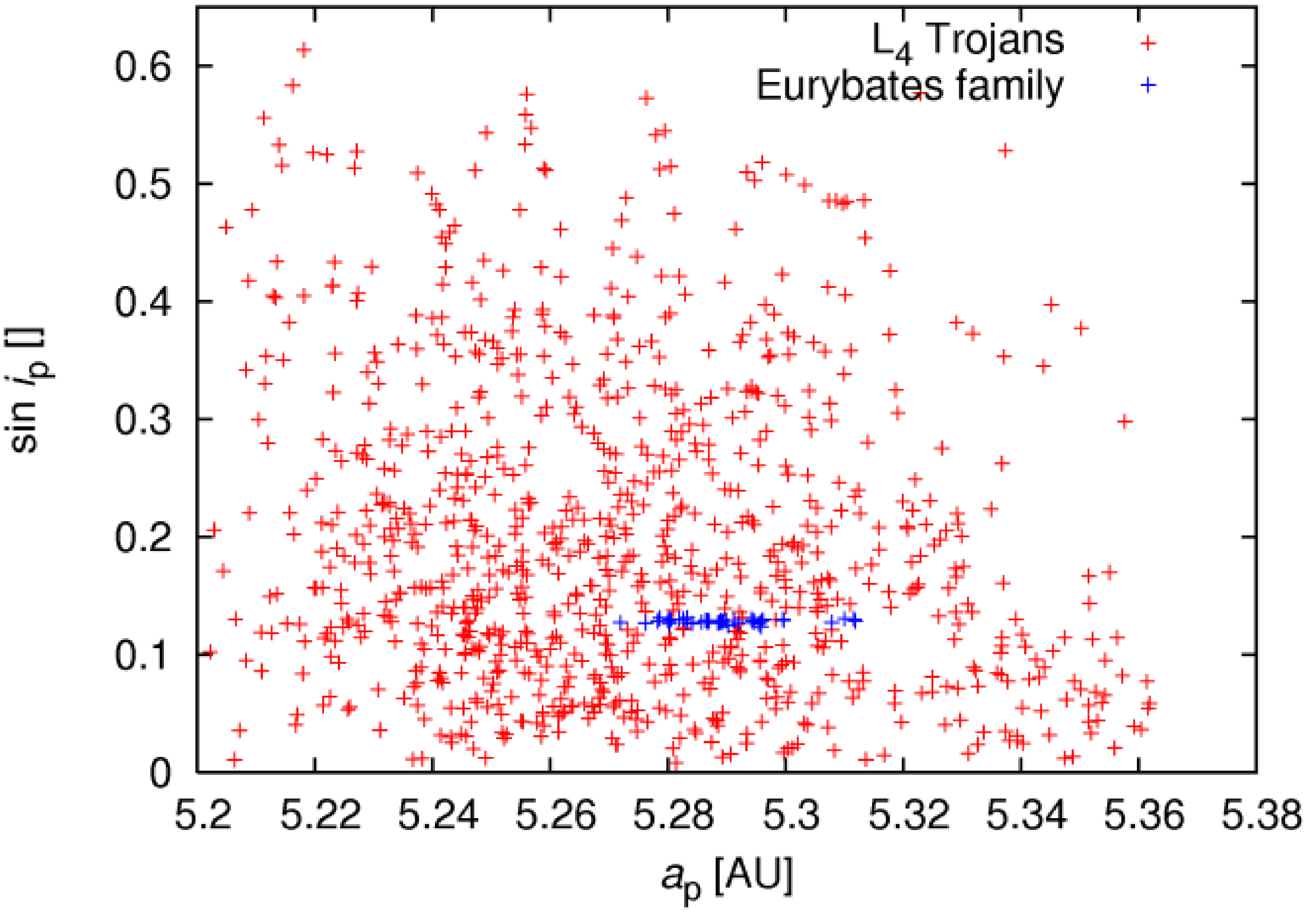
Resonant populations:



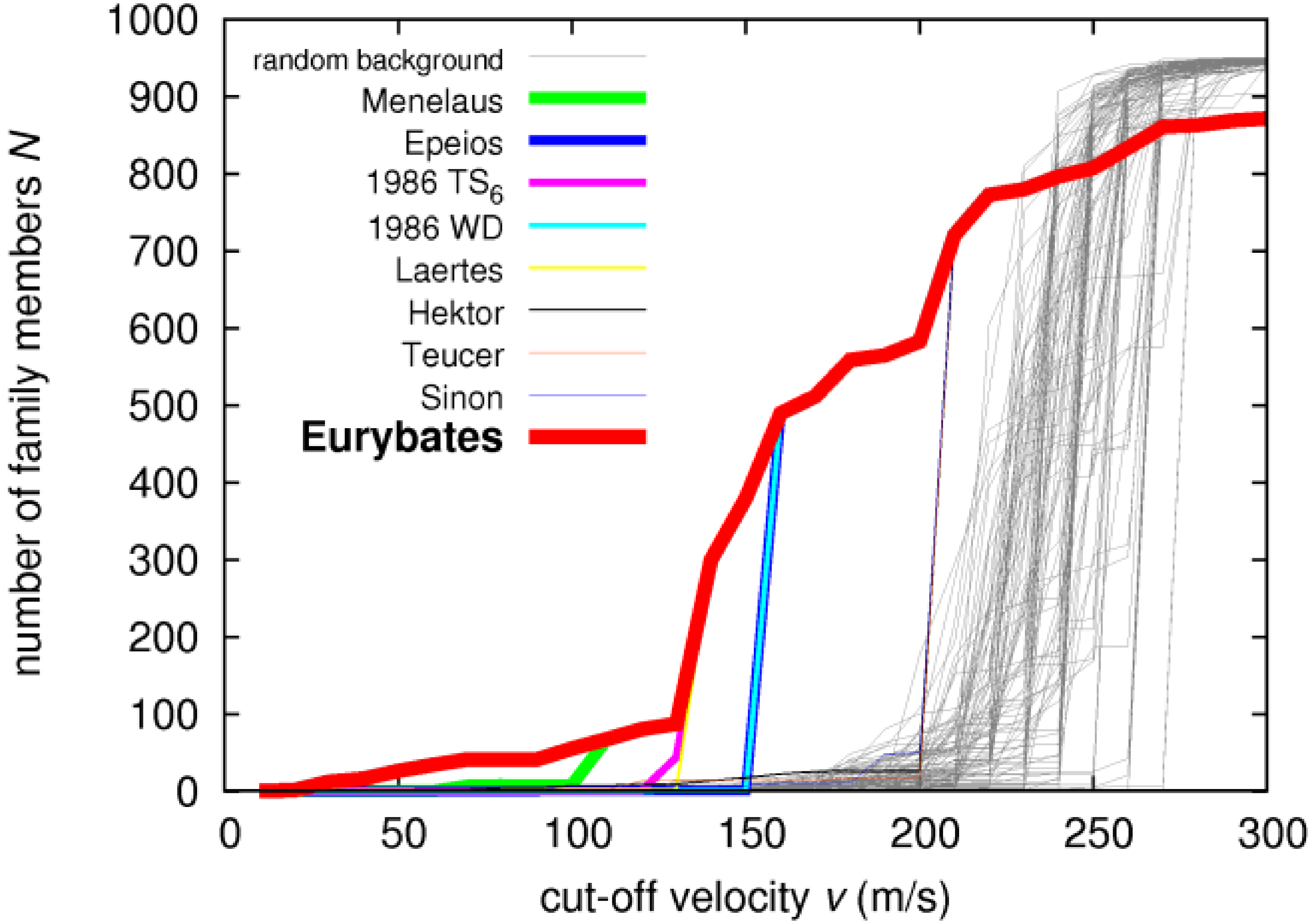
- families in J3/2 and J1/1, no families in J2/1, J4/3
- constrains migration of Jupiter and collisional models

Trojans — how many families?



- ~1500 bodies in each L_4 and L_5 clouds
- definitely not many prominent clusters…

Trojans — only 1 family in L4?



- $N(v_{\rm cutoff})$ plots compared with (random) background
- Eurybates family is the most robust case:
  it has only C-type members, no D-types (Roig *et al.* 2008),
  its SFD is steeper than the background population,
  parent body size $\simeq 100\,$km, PB/LF $\simeq 0.4$

Trojans vs Trojans collisional rates:

- Bottke *et al.* (2006):

$$d_{\mathrm{disrupt}} = \left(\frac{2Q^{\star}}{V_{\mathrm{imp}}^2}\right)^{\frac{1}{3}} D_{\mathrm{target}} \simeq 20\,\mathrm{km}$$

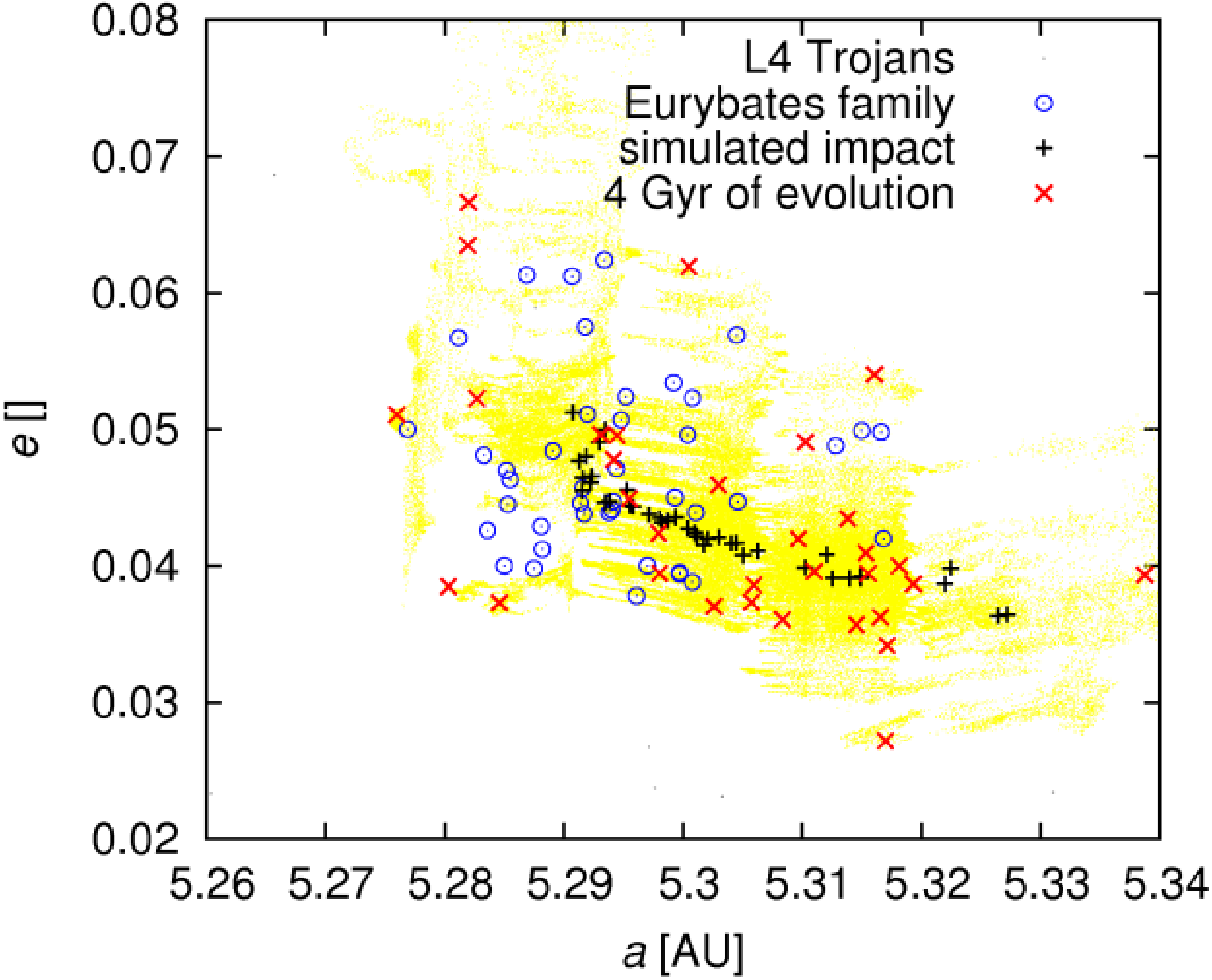
- Dahlgren (1998):

$$f_{\mathrm{disrupt}} = P_{\mathrm{i}}\,\frac{D_{\mathrm{target}}^2}{4}\,n_{\mathrm{project}}\,n_{\mathrm{target}}$$

$$\tau_{\mathrm{disrupt}} = \frac{1}{f_{\mathrm{disrupt}}} \simeq 12\,\mathrm{Gyr}$$

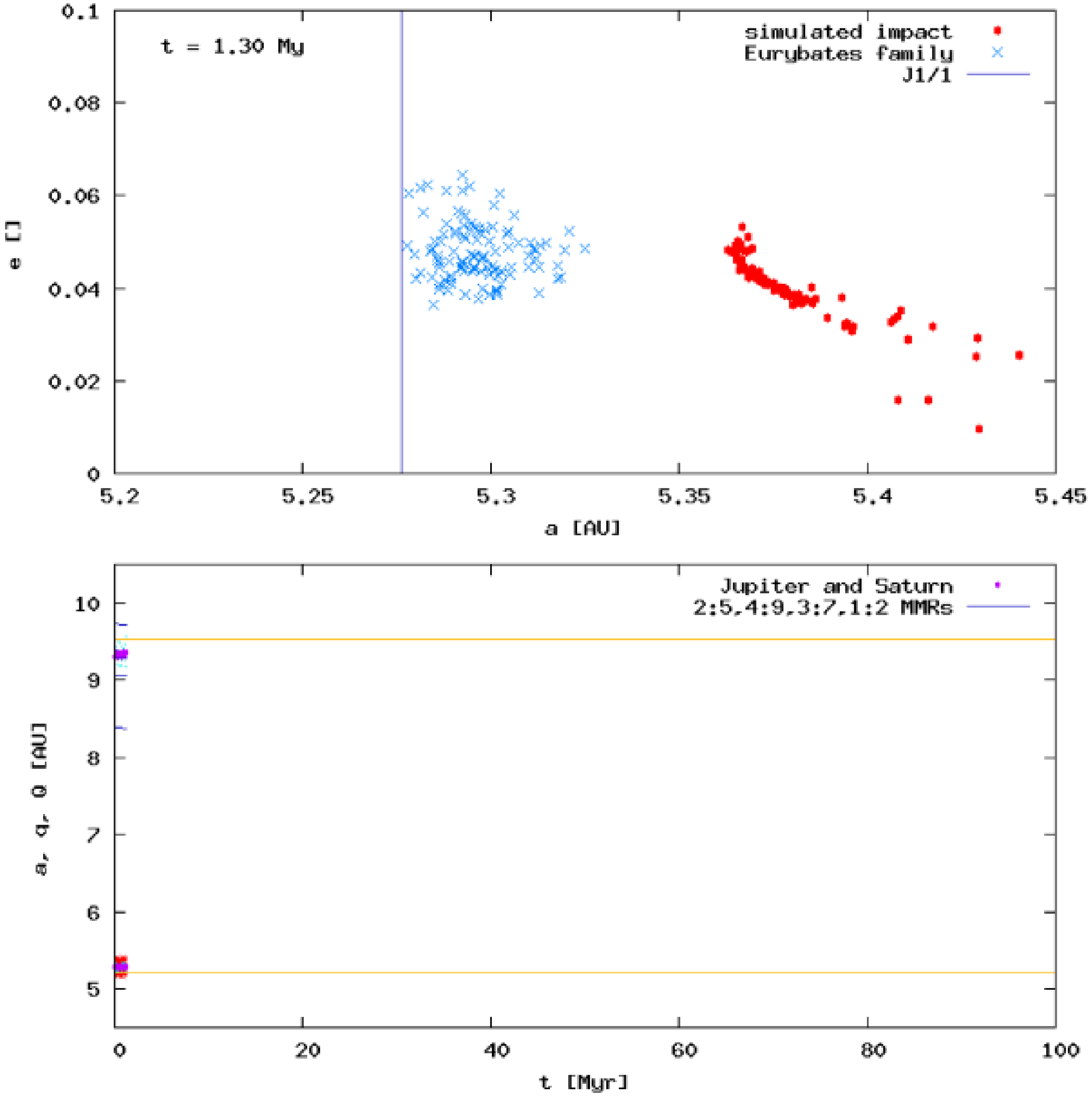
- collisional rates too low $\Rightarrow$ large # of families unlikely

Eurybates family — chaotic diffusion:



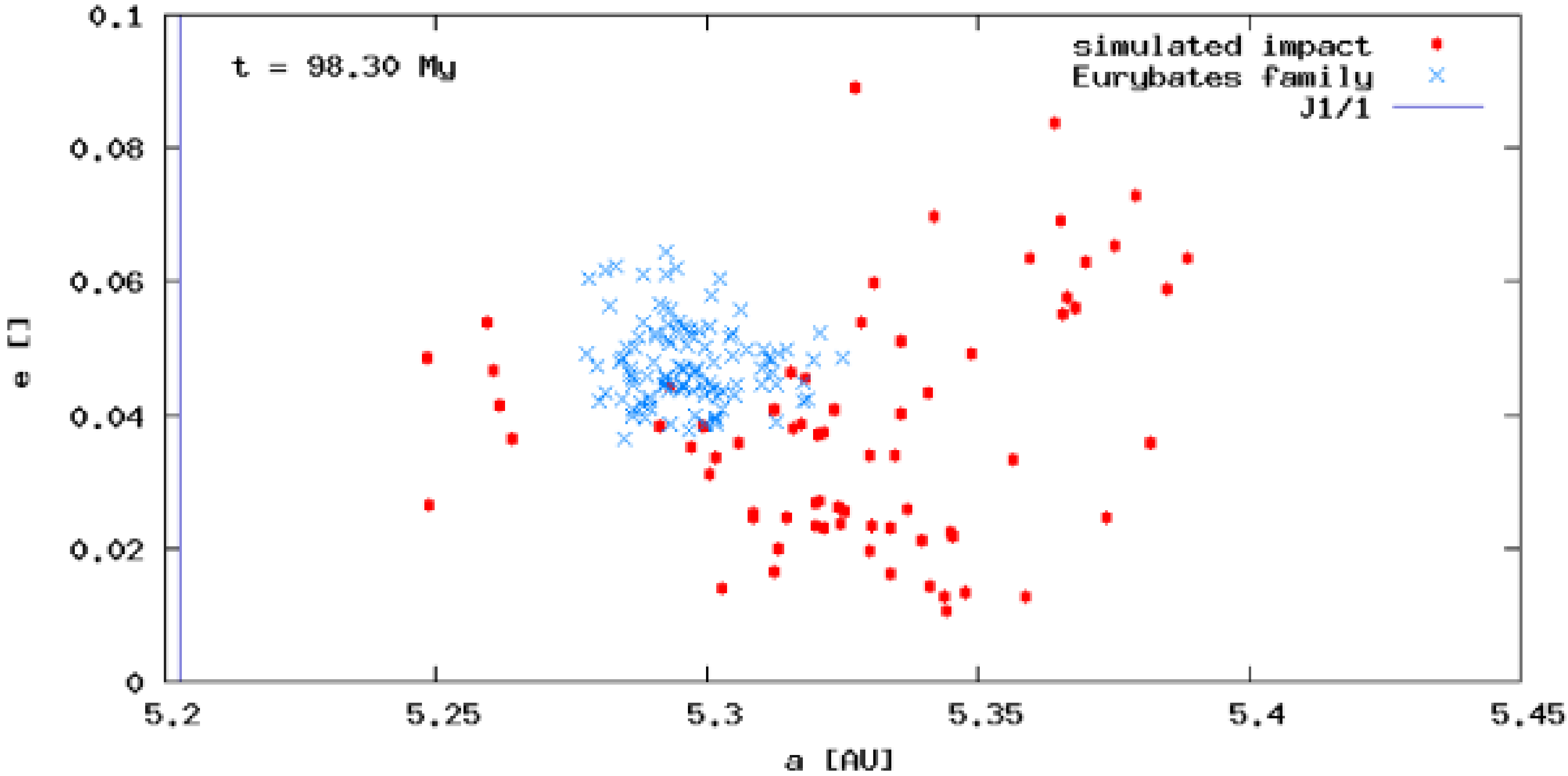
- present shape was attained due to the chaotic diffusion
- age have to be $\gtrsim 1\,\mathrm{Gyr}$ ('filament' must disappear)

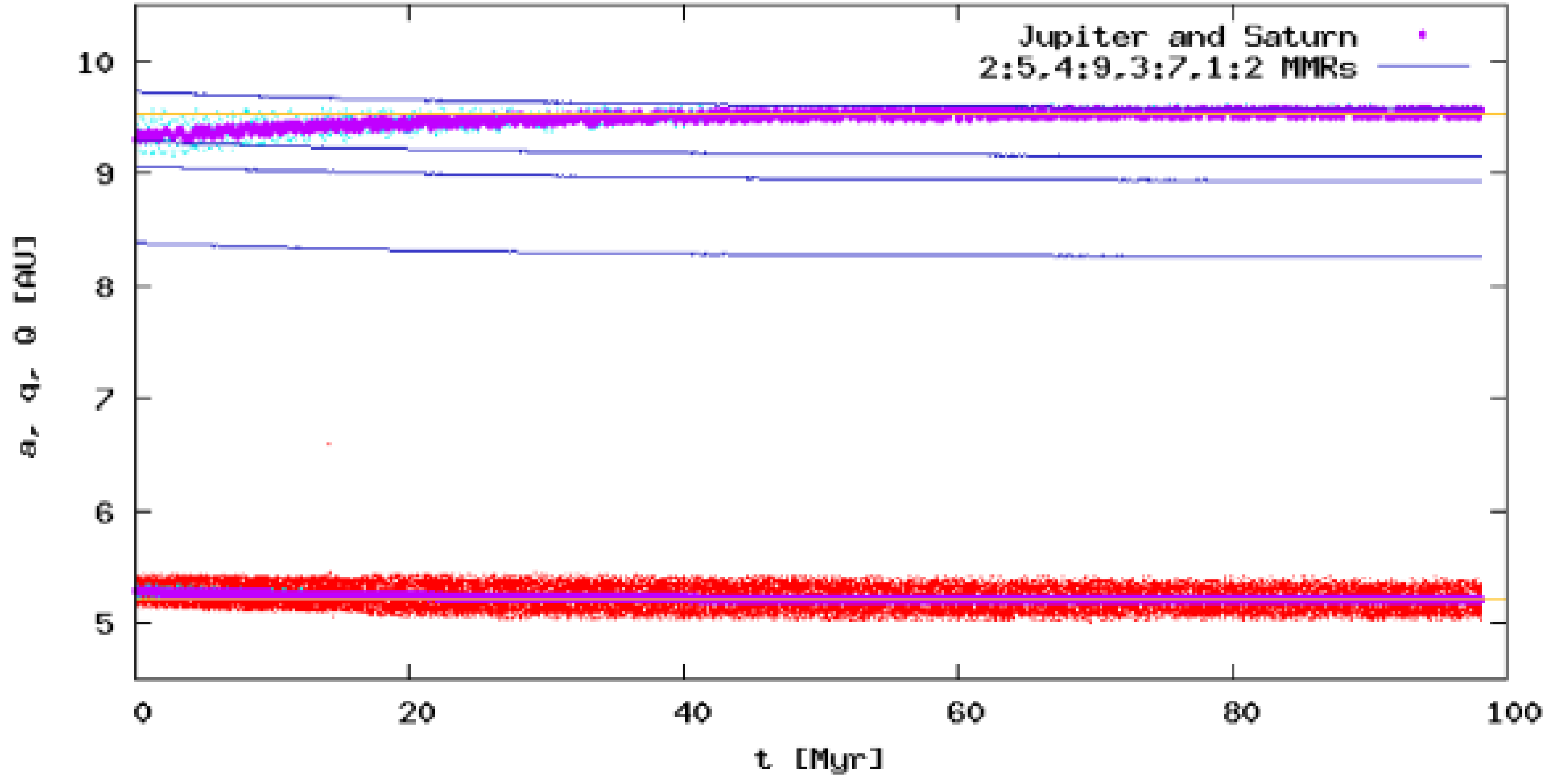
The role of planetary migration:



- SWIFT-RMVS3 integrator, with analytic dissipation and eccentricity damping (Levison *et al.* 2008)

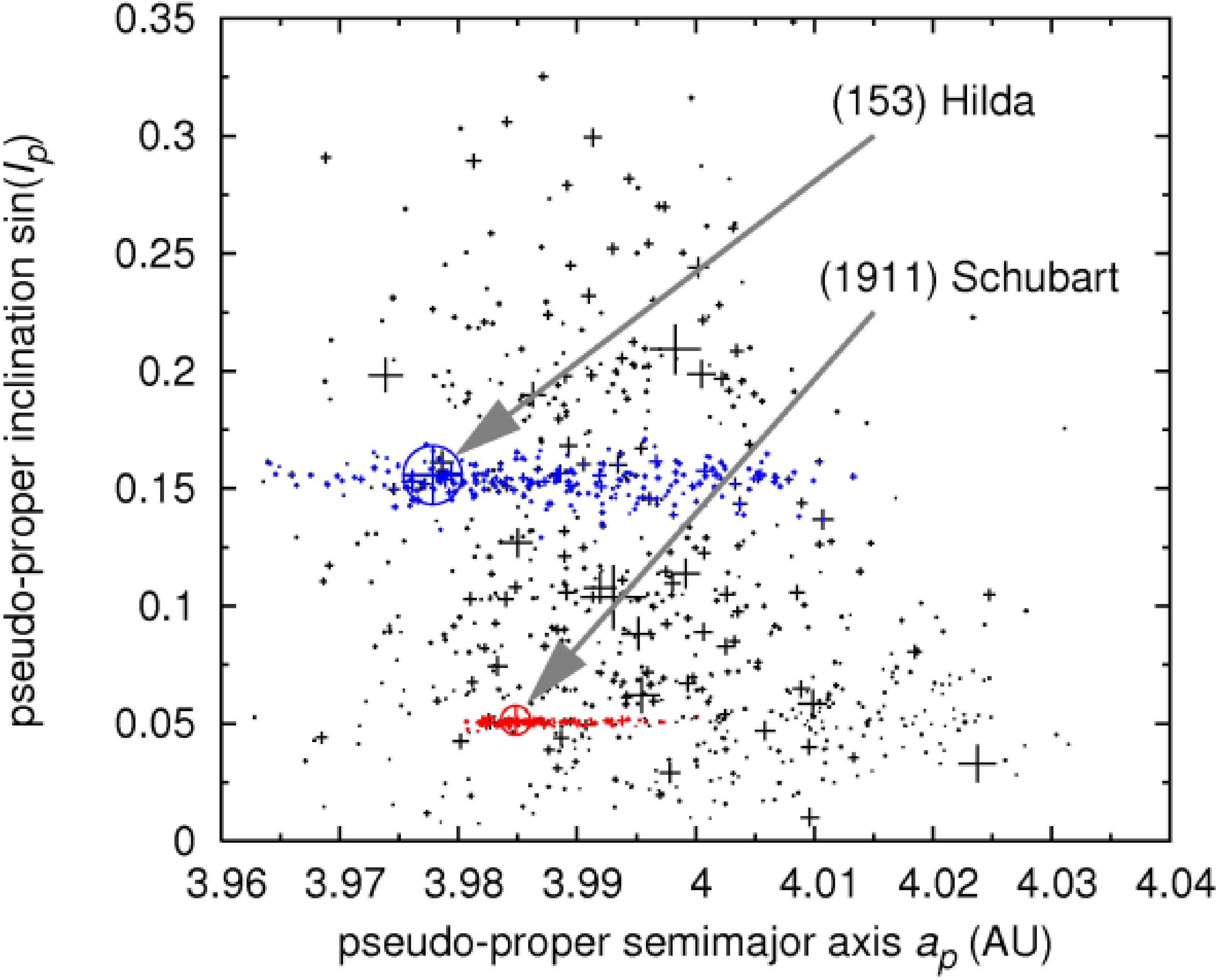
Eurybates family — planetary migration:





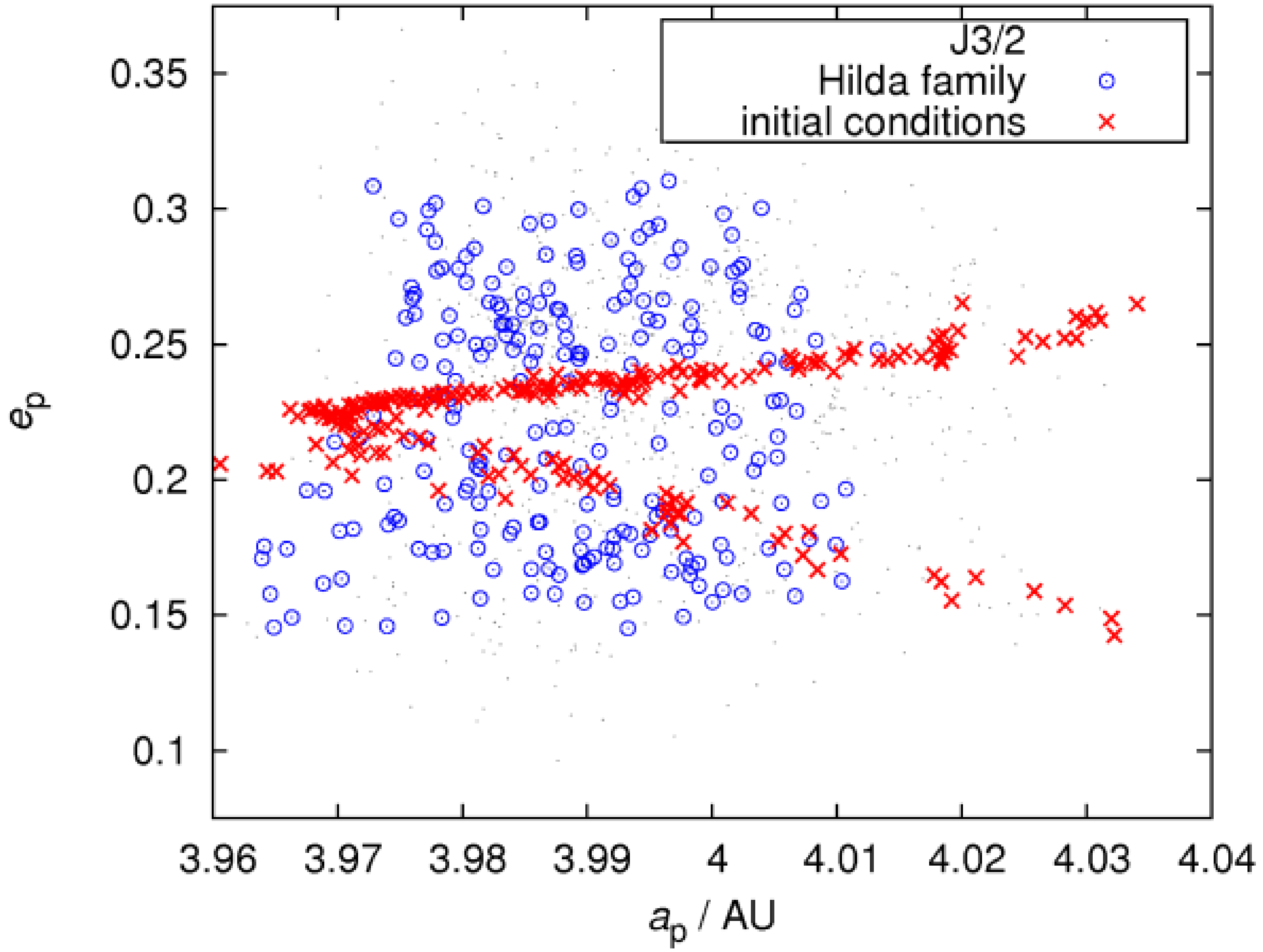
- even late migration disperses the Eurybates too much $\Rightarrow$ family is younger than $\lesssim 3.5\,\mathrm{Gyr}$

Hilda collisional family in J3/2:



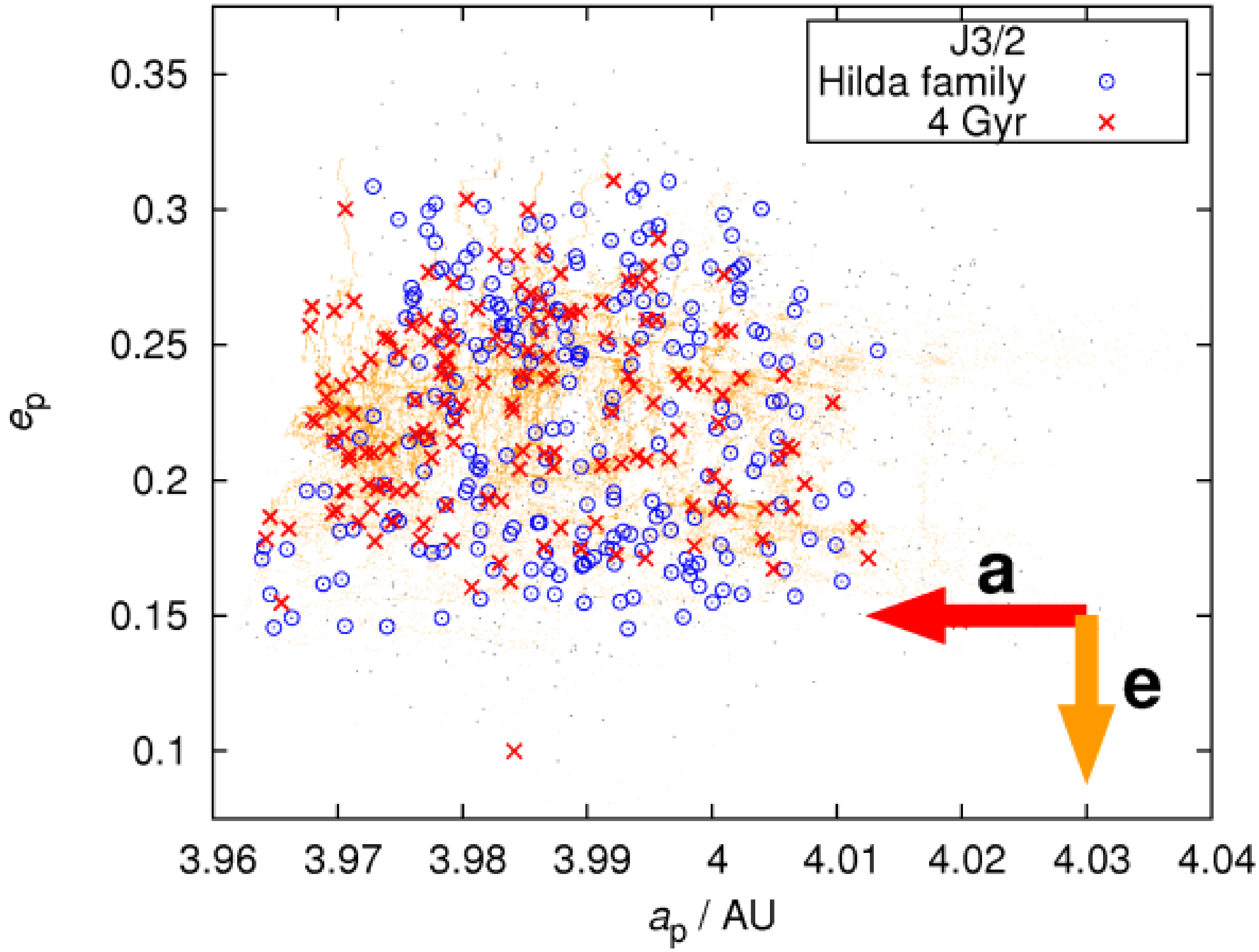
- Hilda collisional family at higher inclinations; $v_{\rm cutoff} \simeq 150\,{\rm m/s}$, $\sim 200\,{\rm km}$ parent body, LF/PB $\simeq 0.5$, mostly C/X-type members, SFD steeper than J3/2, but current $\tau_{\rm disrupt} \simeq 10^{12}\,{\rm yr}$ for J3/2 vs Main Belt

Simulated disruption in J3/2:



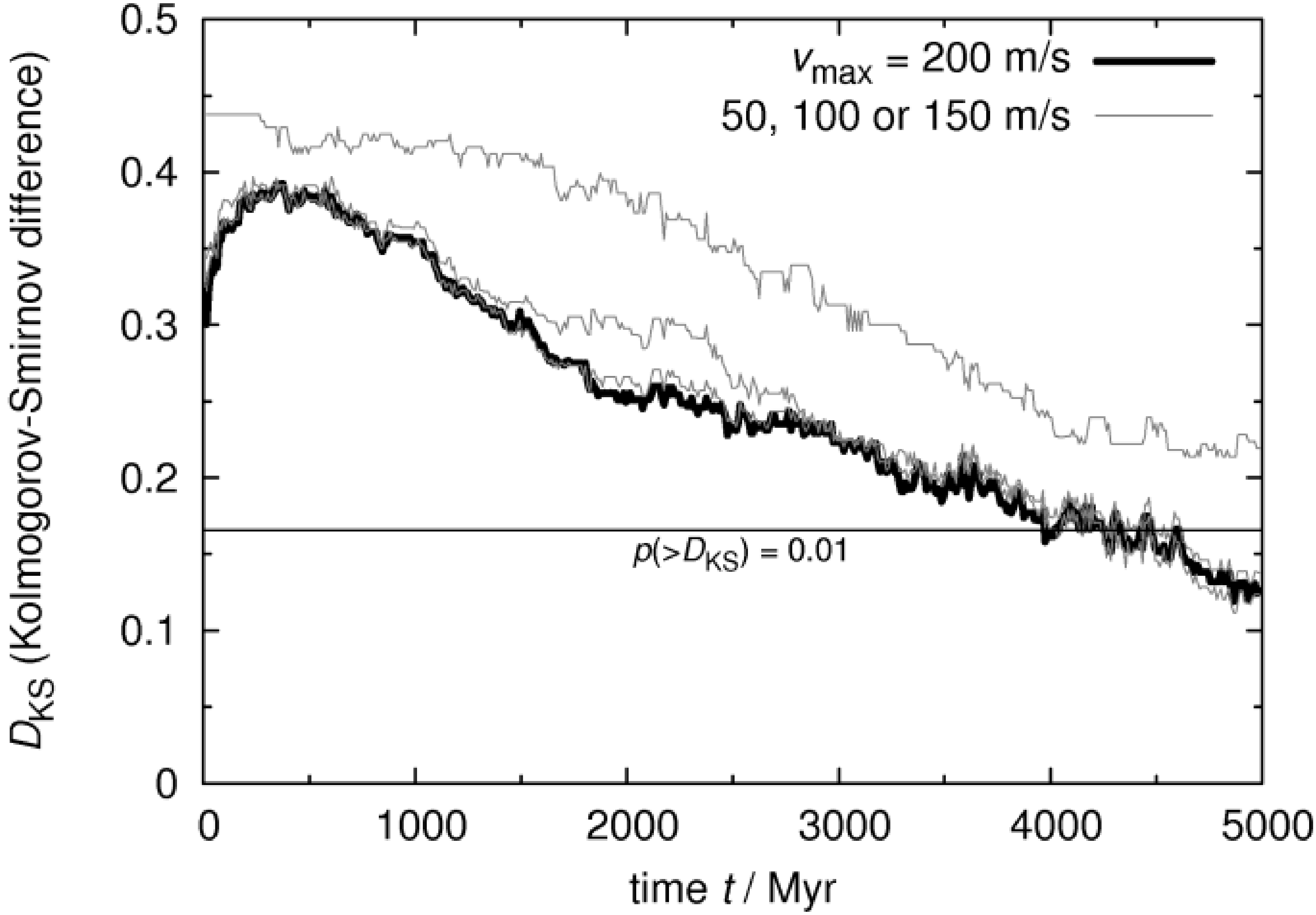
- the simulated cluster was initially very narrow in e

Evolution over 4 Gyr:



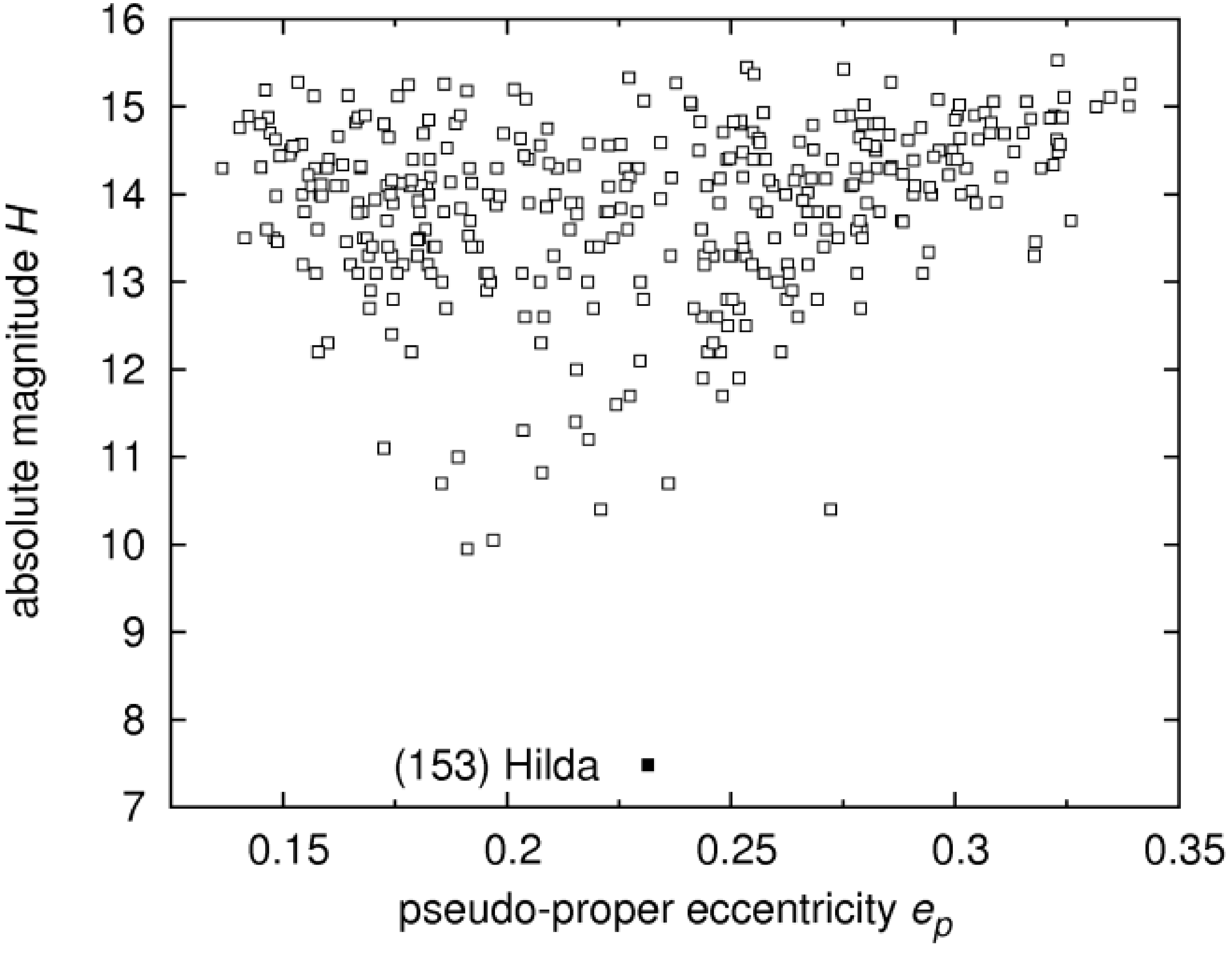
- usually, YE causes a drift in semimajor axis, but…
- Yarkovsky effect and resonant lock combined
  ⇒ systematic drift in eccentricity

Hilda family — age estimate:



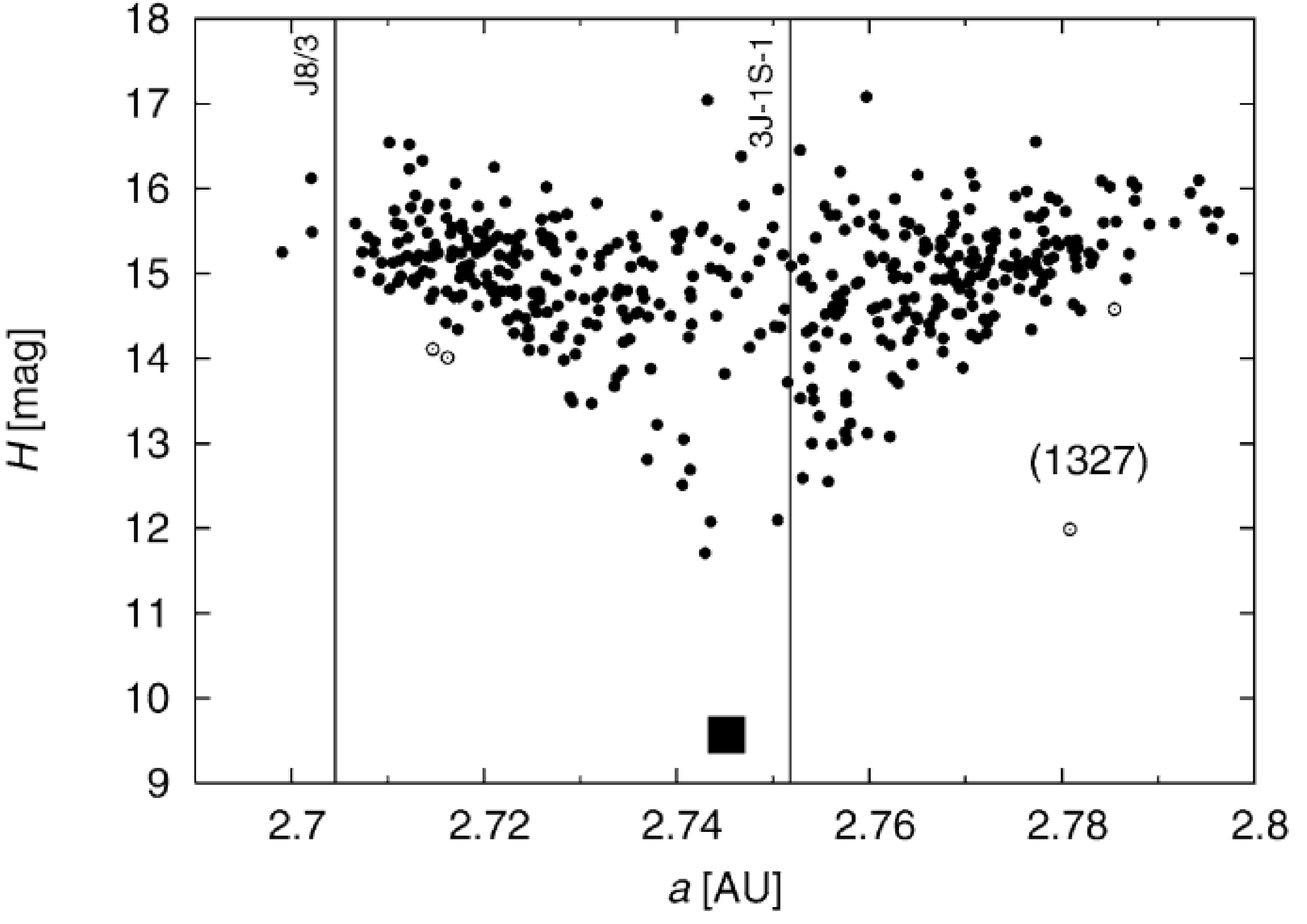
- K-S test of e-distributions $\Rightarrow$ age $\gtrsim 4\,\mathrm{Gyr}$
- possibly an LHB origin (within the Nice model)?

Hilda family — (e, H) plot:



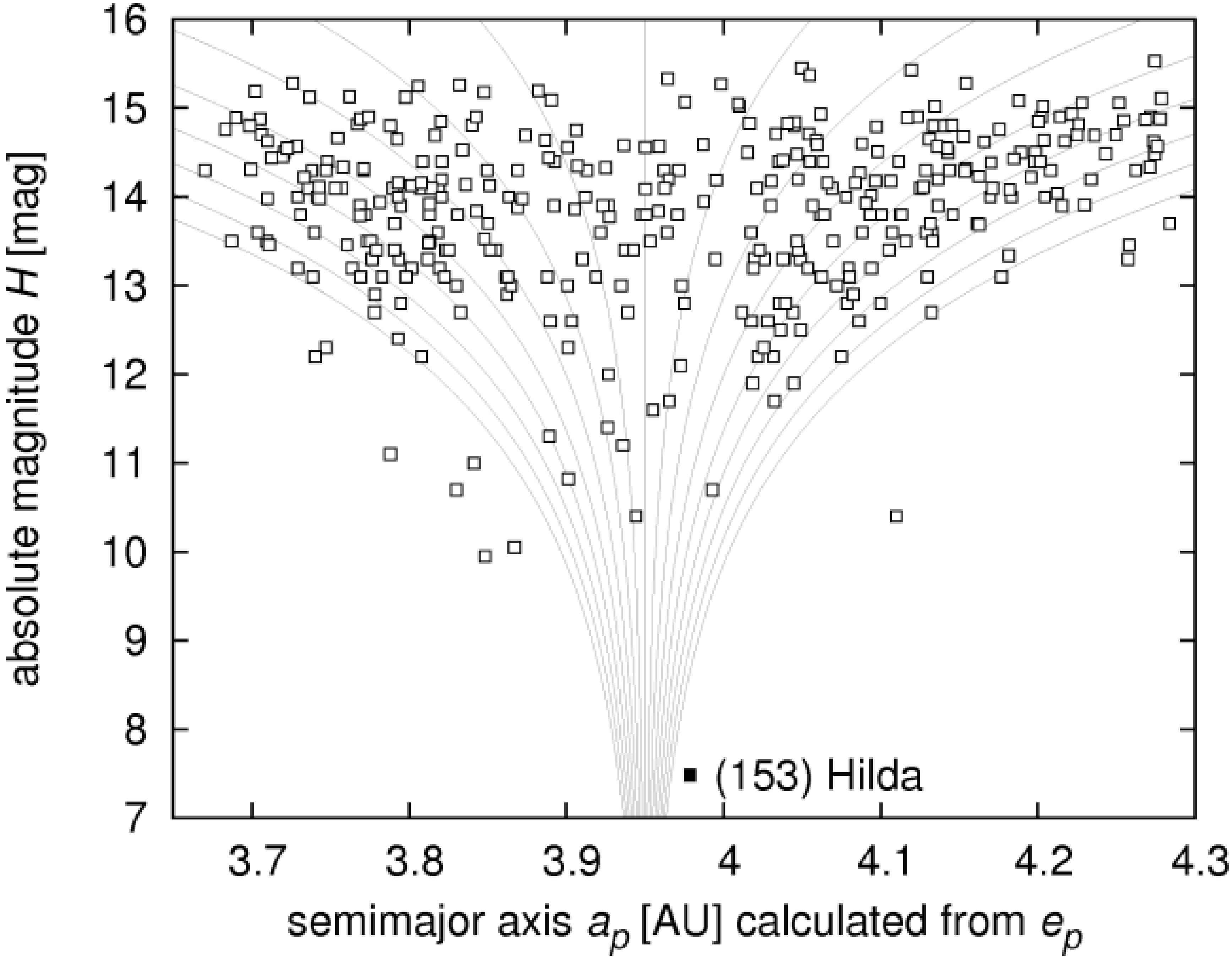
- 'ears' like in (a, H) for Eos, Erigone, Massalia, Merxia, …

Merxia family — (a, H) **plot** for comparison:



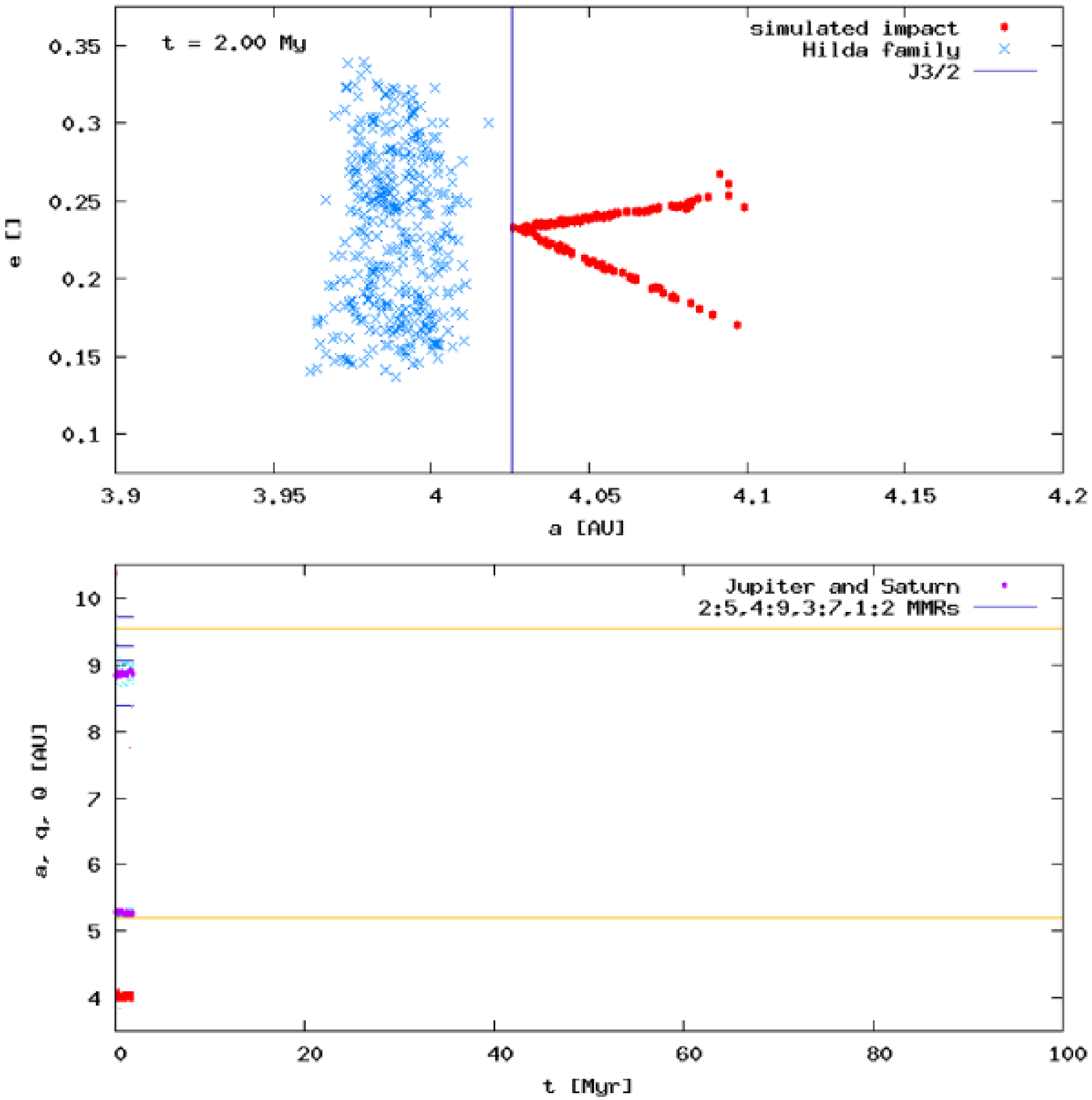
- YORP effect changes spins (Vokrouhlický *et al.* 2005) $\Rightarrow$ more precise age?

Hilda — (e, H) method:



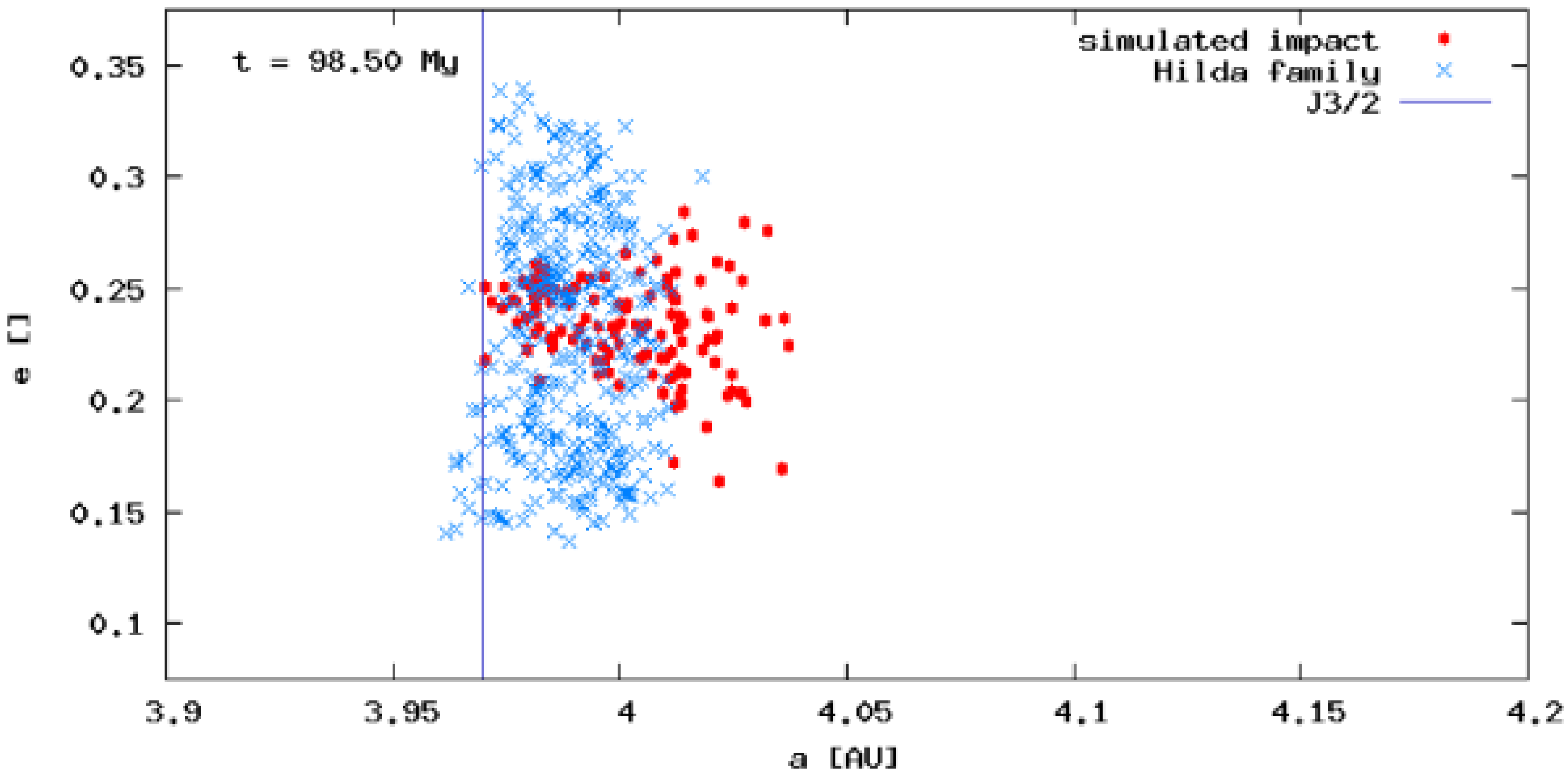
- binning in the parameter $C = (a - a_c)/10^{0.2H}$
- practical test: not yet statistically significant solution, but age $\gtrsim 4\,\mathrm{Gyr} \leftarrow$ isn't it too much?!

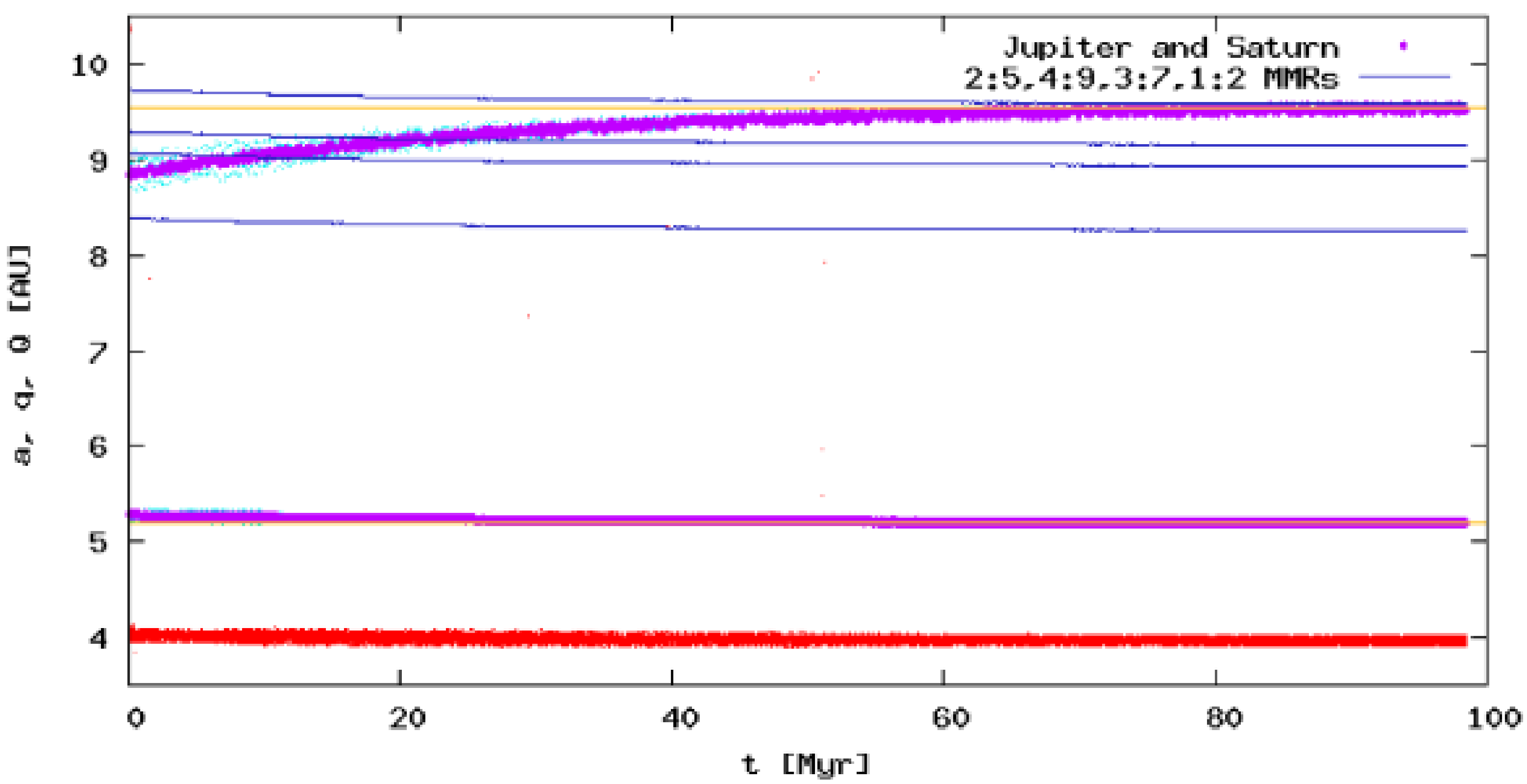
Hilda family at the beginning of migration:



- Jupiter at 5.28 AU, Saturn at 8.85 AU, $\tau_{\mathrm{migration}} \simeq 30\,\mathrm{Myr}$

Hilda family after migration has ended:





- planetary perturbations might disperse eccentricities sufficiently → then Yarkovsky drift in e takes over

Conclusions:

- planetary migration likely dispersed the Hilda family, note also f_{disrupt} was probably larger at that time
- Eurybates seems to be the only one collisional family among Trojans
- no D-type families anywhere? pulverisation of target?

Future work:

- more precise age for the Hilda family if enough bodies
- more migration scenarios $\Rightarrow$ info on τ_{mig}, $\tau_{\mathrm{damp\,ecc}}$?
- collisional models of resonant populations