Constructing new population models for near-Earth asteroids

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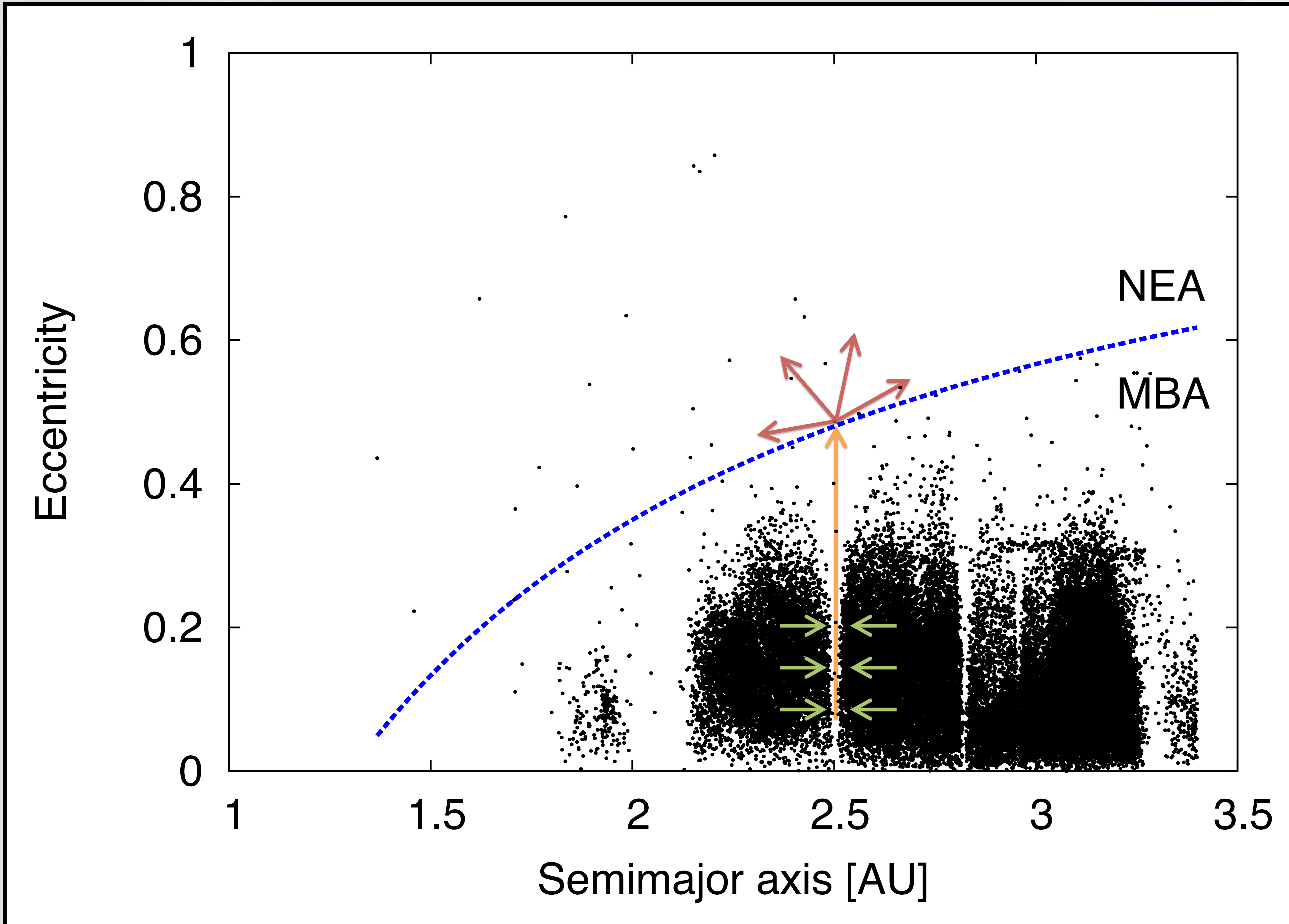
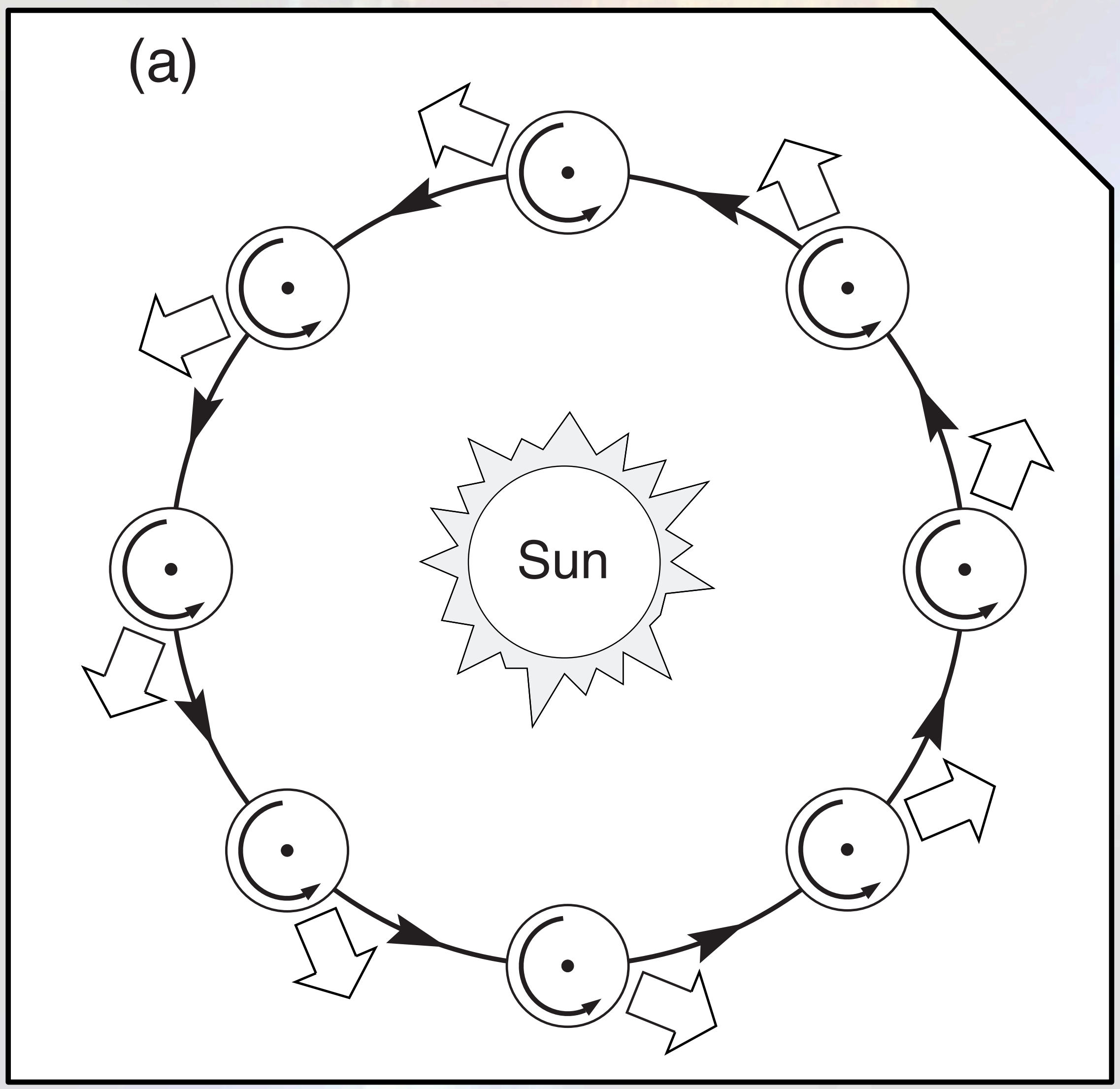
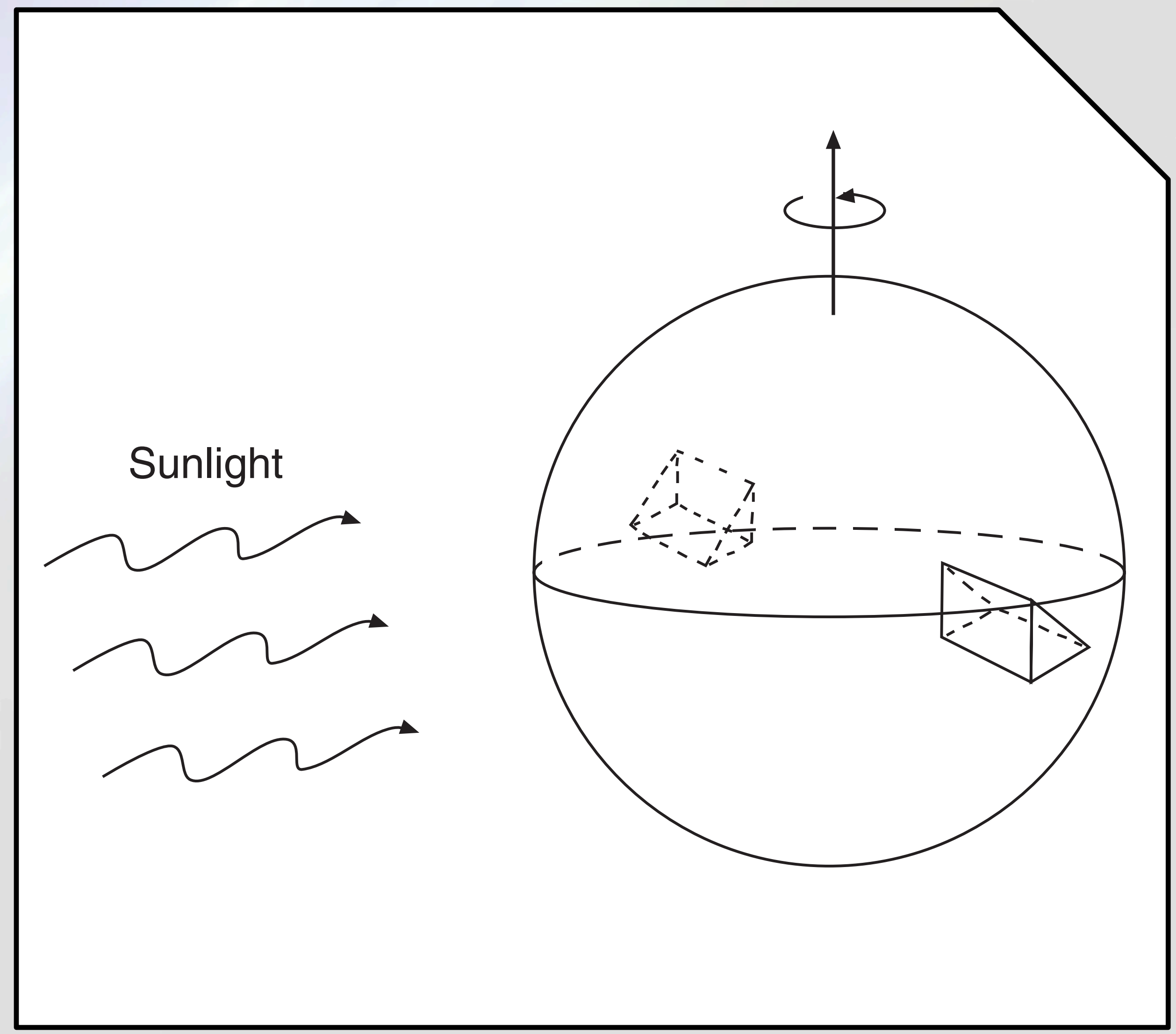


1
0.8
0.6
0.4
0.2
0
Eccentricity
1
1.5
2
2.5
3
3.5
Semimajor axis [AU]
NEA
MBA

Yarkovsky & YORP thermal forces





NEO population model

An observational-bias-free and self-consistent model of NEOs including

1. their orbital distribution, and
2. their size-frequency distribution.

Bias (or efficiency) equation

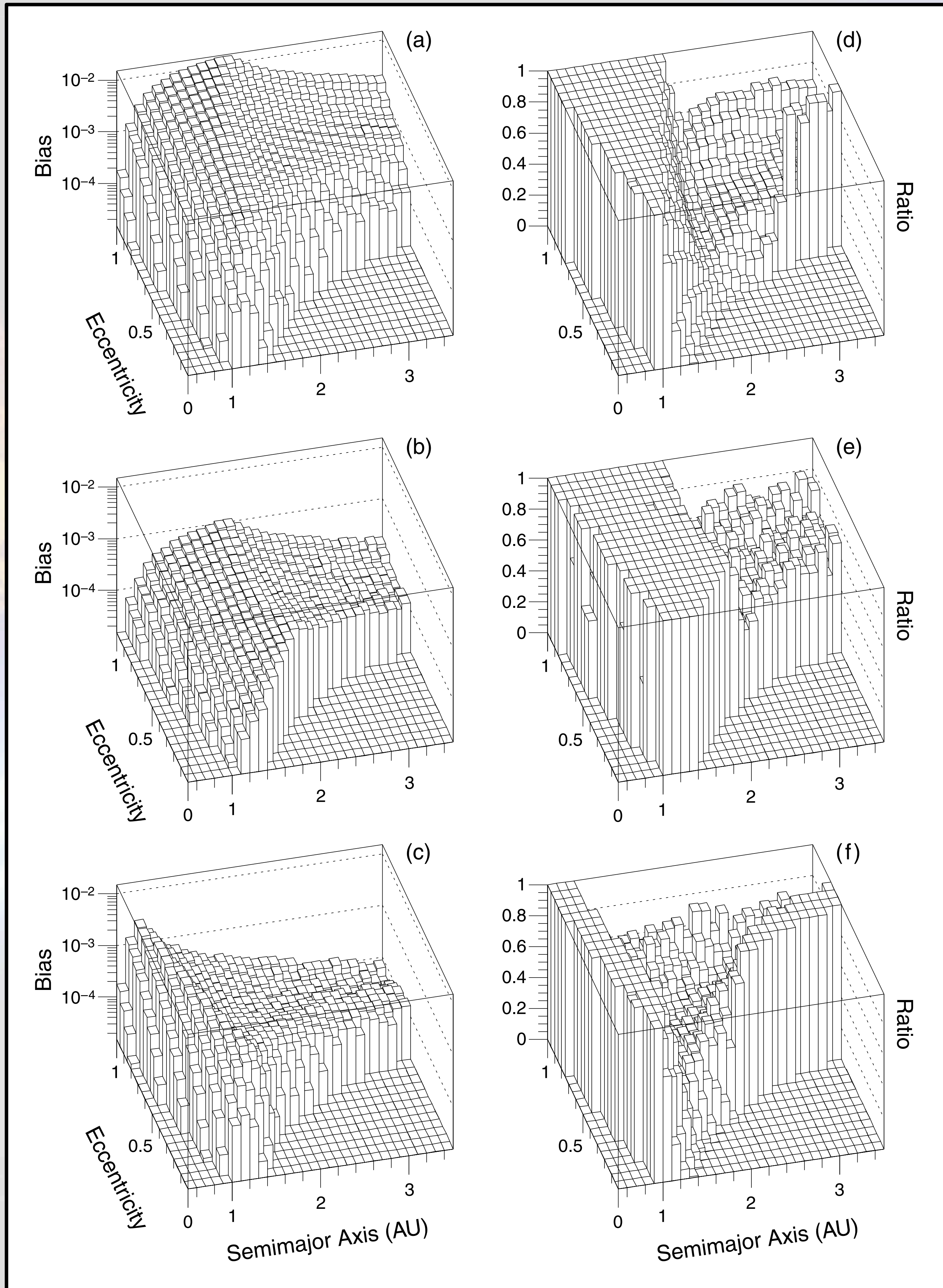
$$n(a,e,i,H) = B(a,e,i,H)N(a,e,i,H)$$

observed population

bias

true population *(this is what we want to know!)*

Bias



Jedicke et al. 2002

A simple solution

$$N(a,e,i,H) = \frac{n(a,e,i,H)}{B(a,e,i,H)}$$

Limited to 4x1D distributions because

$N_{bin} >> N_{object}$

We need to find physically meaningful constraints for the system...

... and they do exist in the form of statistically distinct orbital histories for NEOs originating in different parts of the main asteroid belt!

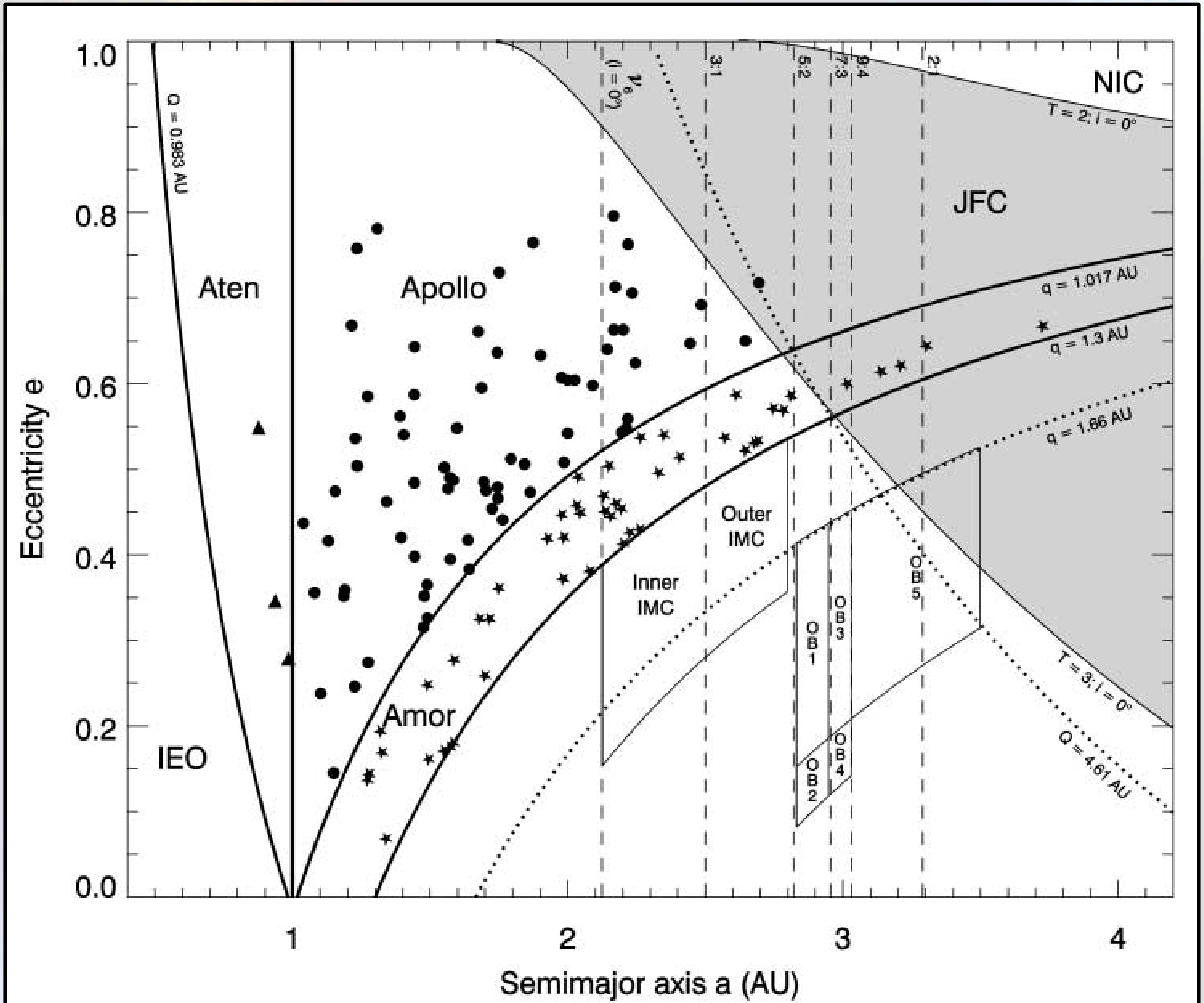
A more robust approach taking into account varying orbital dynamics corresponding to N_S different source regions

$$n(a,e,i,H) = B(a,e,i,H)N(H)\sum_{i=1}^{N_S} f_i N_i(a,e,i)$$

$$\sum_{i=1}^{N_S} f_i = 1$$

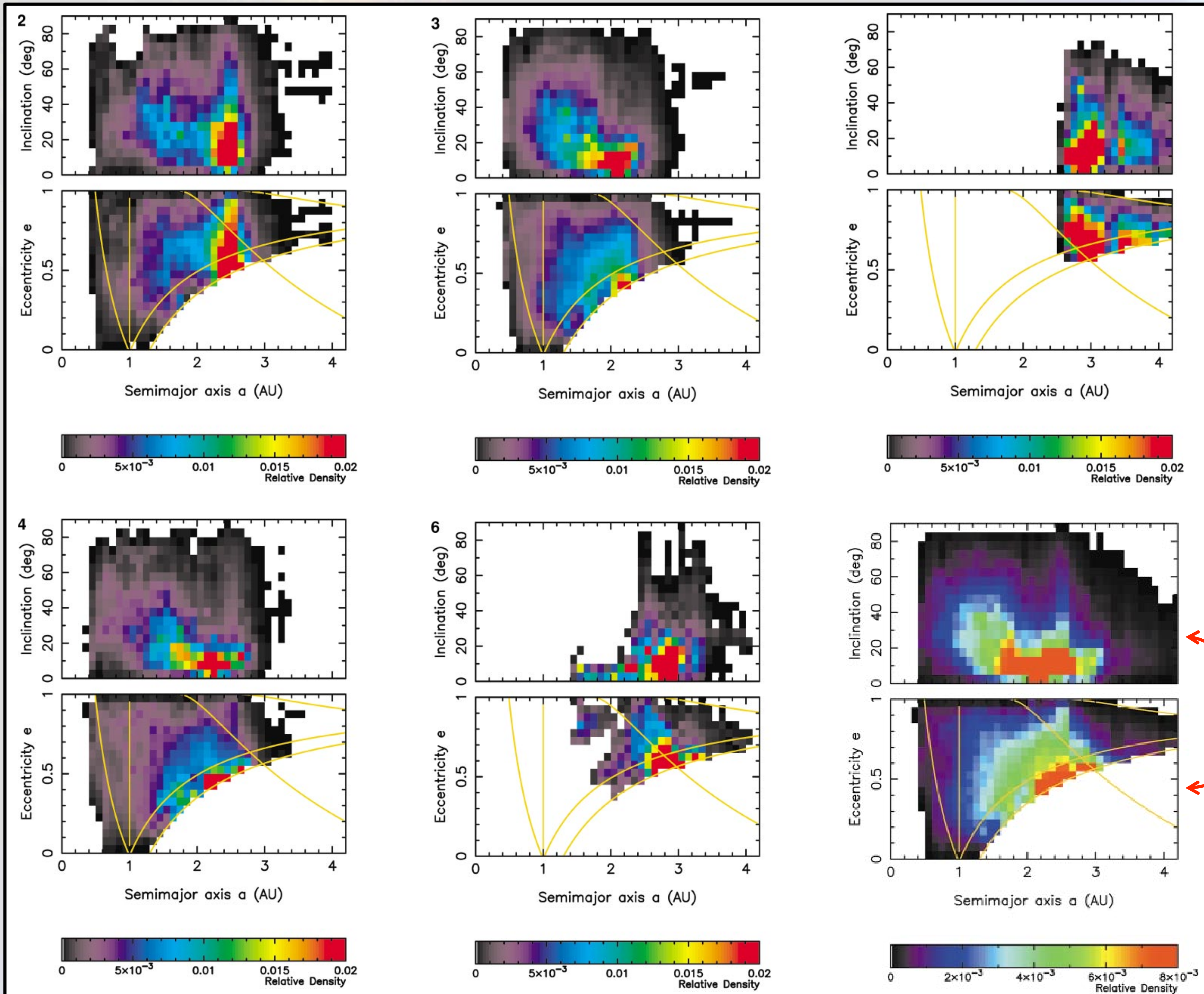
First developed by Bottke et al. (2000, 2002).

NEOs and their source regions



Bottke et al. 2002

Sources & residence-time distributions



Bottke et al. 2002

Fitted orbit distri- bution

Known shortcomings of the Bottke model

- much more Amors known than predicted (+5 σ)
- inability to explain high-i orbits
- inclination distribution for Earth-like NEO orbits
- Yarkovsky effect not modeled
- single slope for the SFD
- only valid for 13<H<22
- resolution sub-optimal (cf. minimoons)
- no observational constraints on asteroids with Q<1AU
- ...

Understanding the distribution of small NEOs

co-authors alphabetically: Beshore, Bottke, Jedicke, Michel, Morbidelli, Nesvorny, Tsiganis, Vokrouhlicky

Modification of the Bottke model (SFD is source dependent):

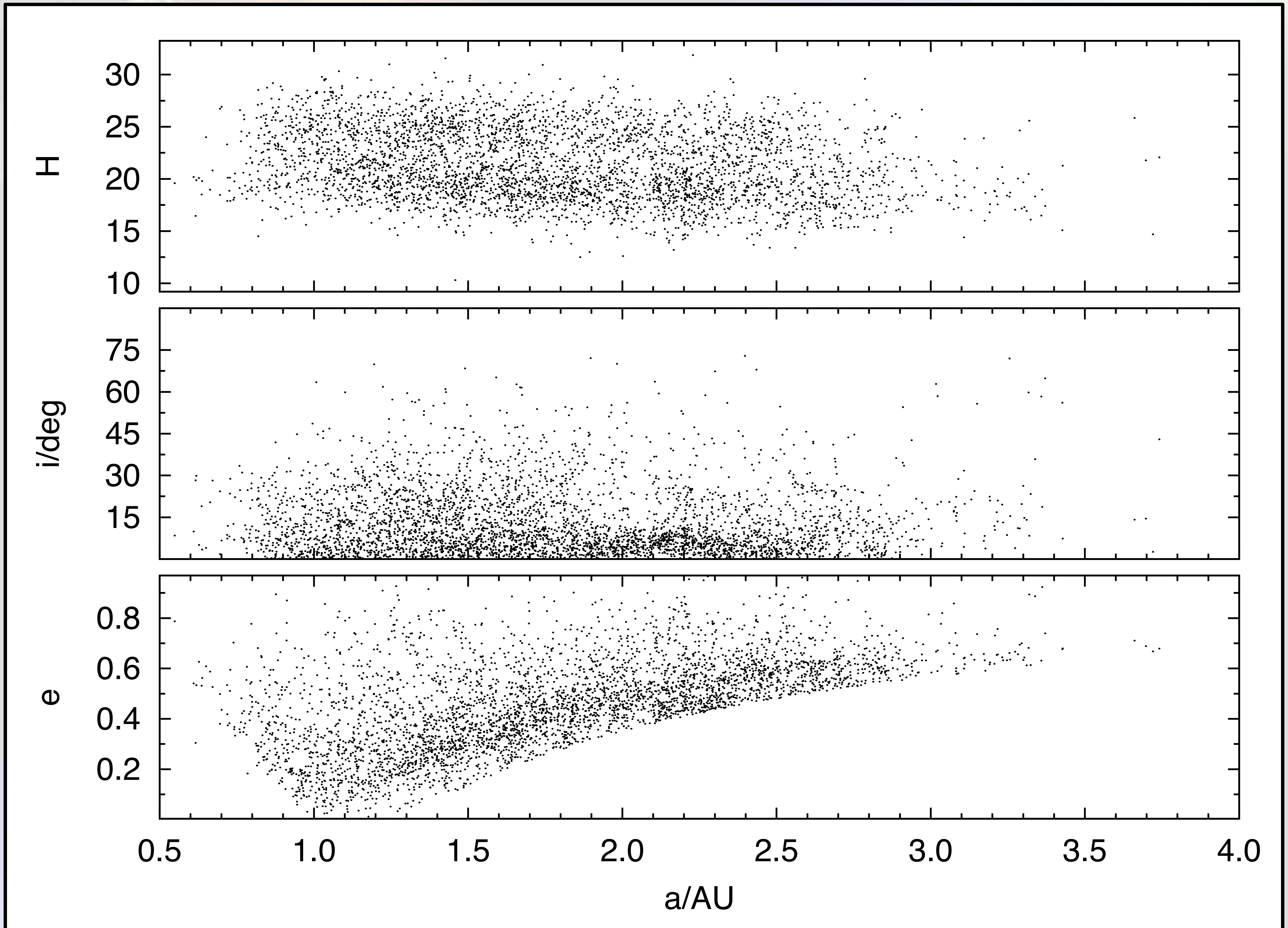
$$n(a,e,i,H) = B(a,e,i,H)\sum_{i=1}^{Ns} f_i N_i(a,e,i,H)$$

$$\sum_{i=1}^{Ns} f_i = 1$$

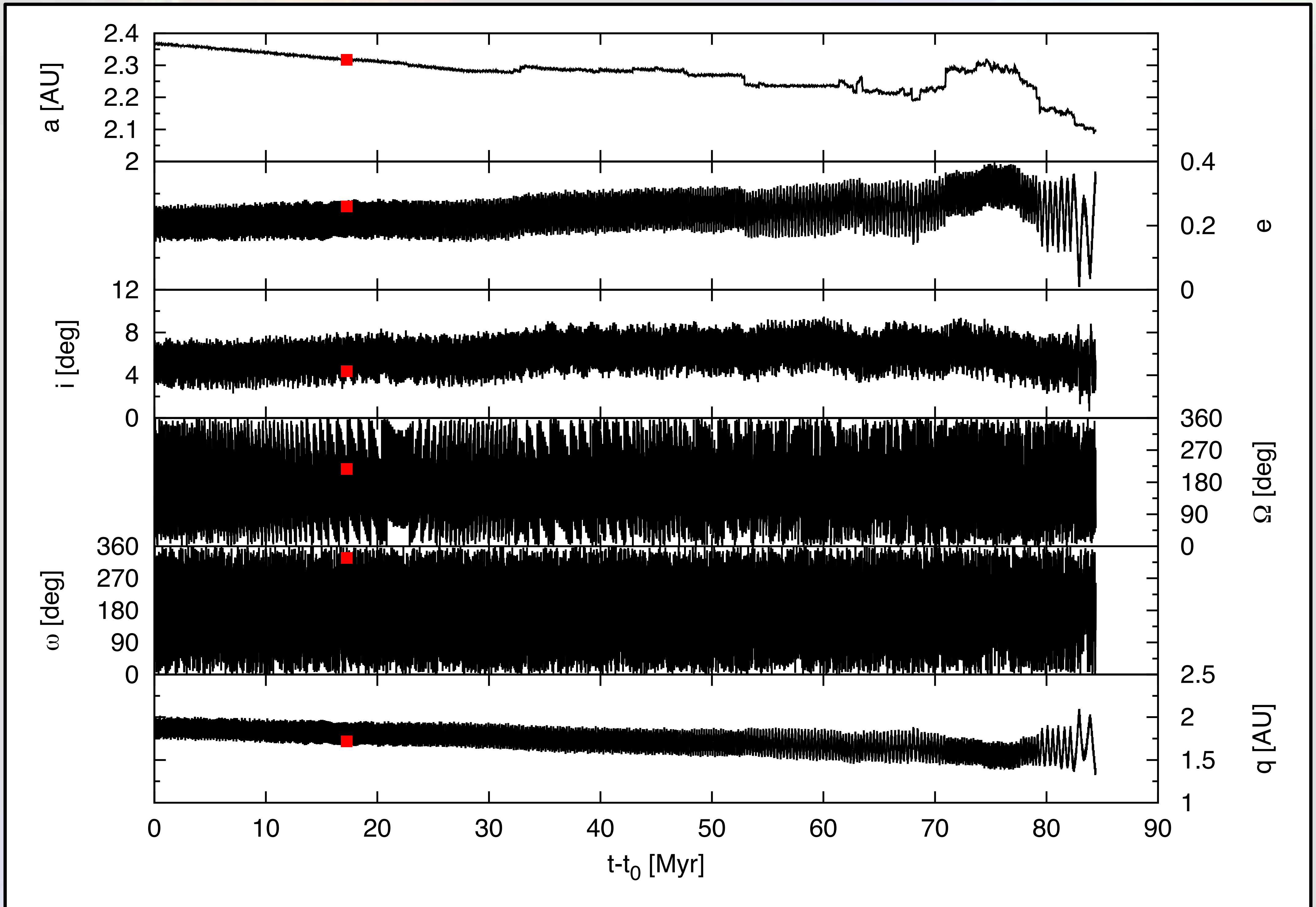
The goal and the means to reach it

- extend and improve the Bottke model
- at least 30x more observational data
- Yarkovsky modeling when populating escape hatches in the MB
- include new NEO source regions
- different SFDs for different source regions
- better resolution

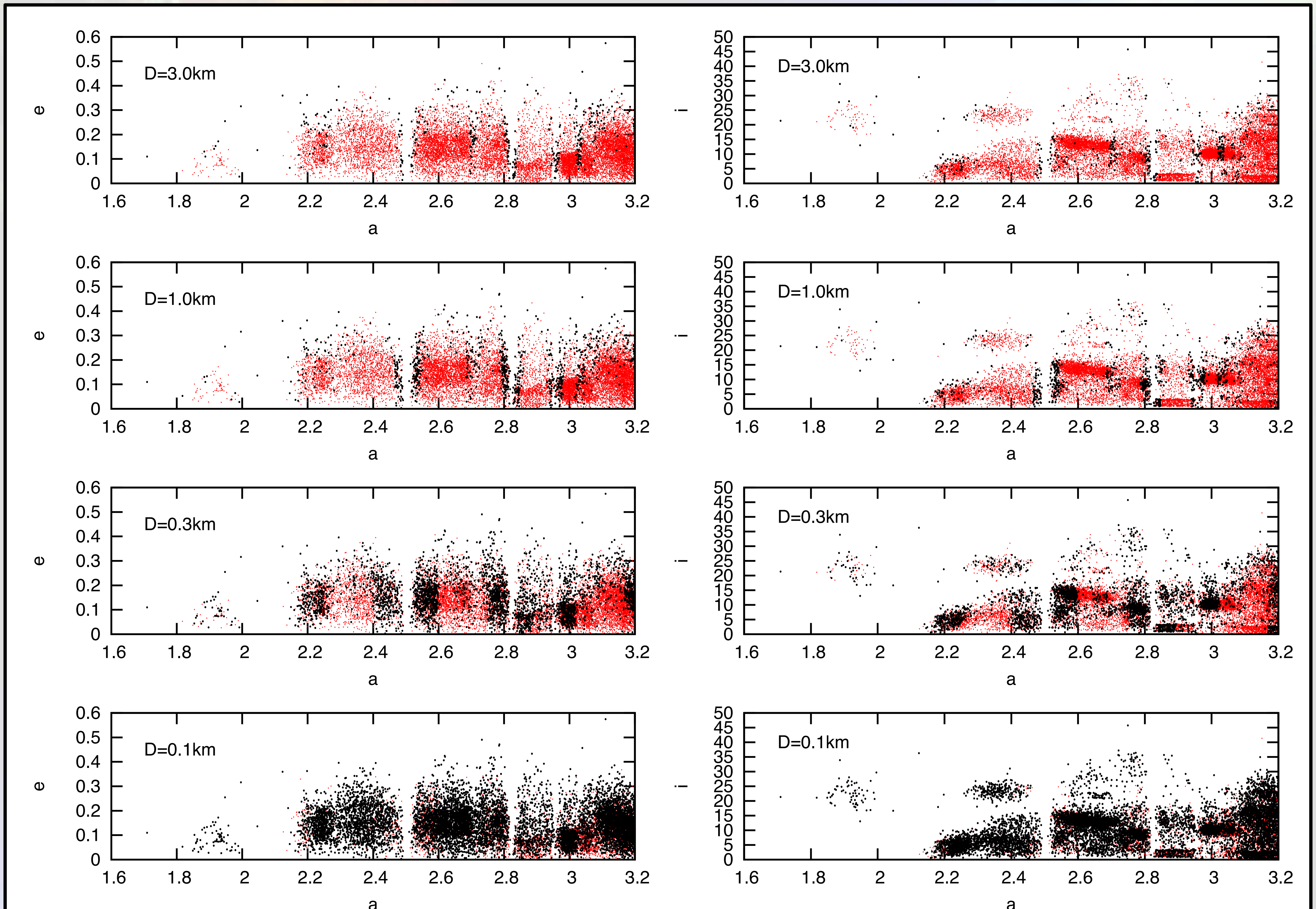
NEO detections by CSS's Mt. Lemmon station 2006-2011



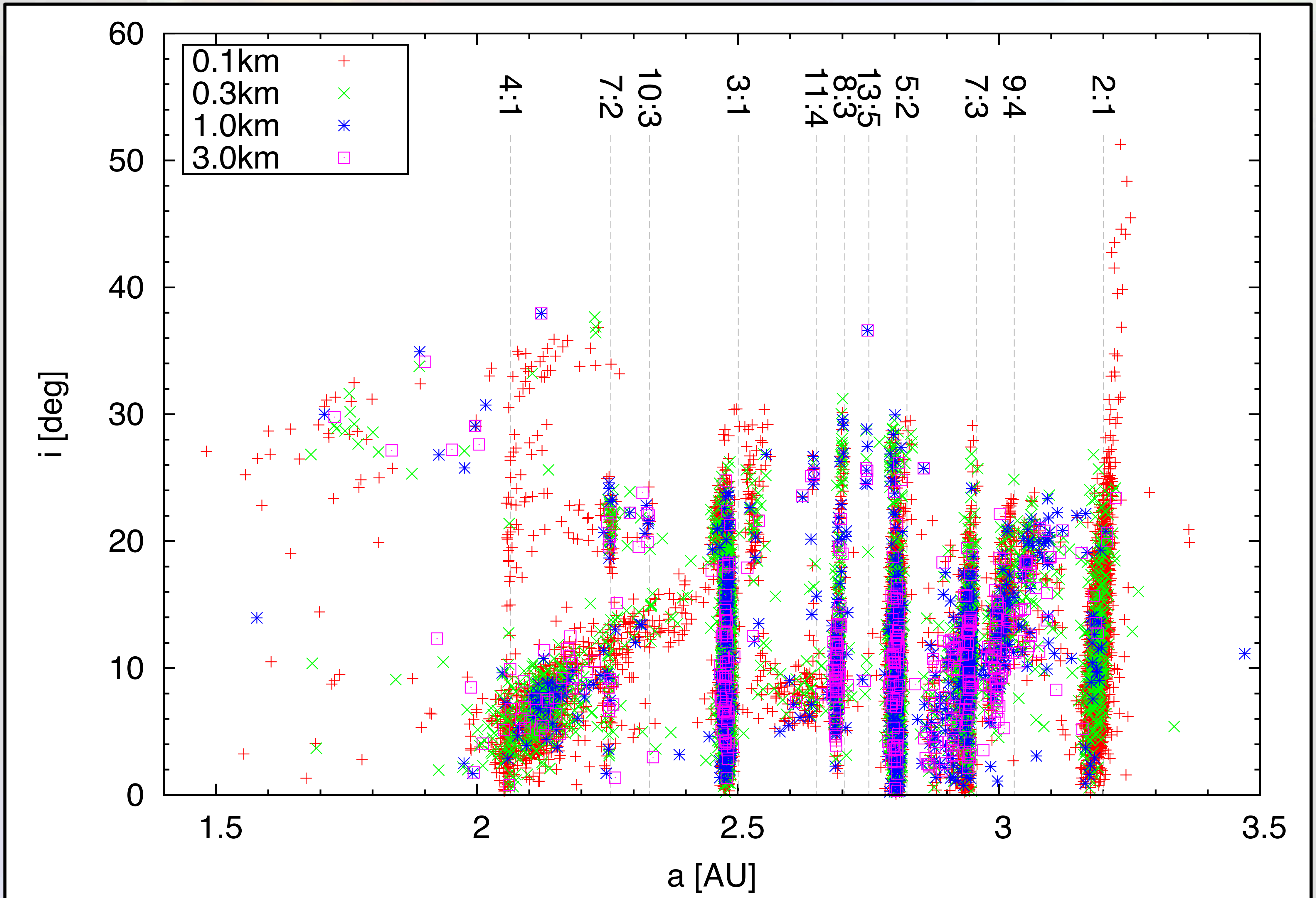
Example orbital evolution



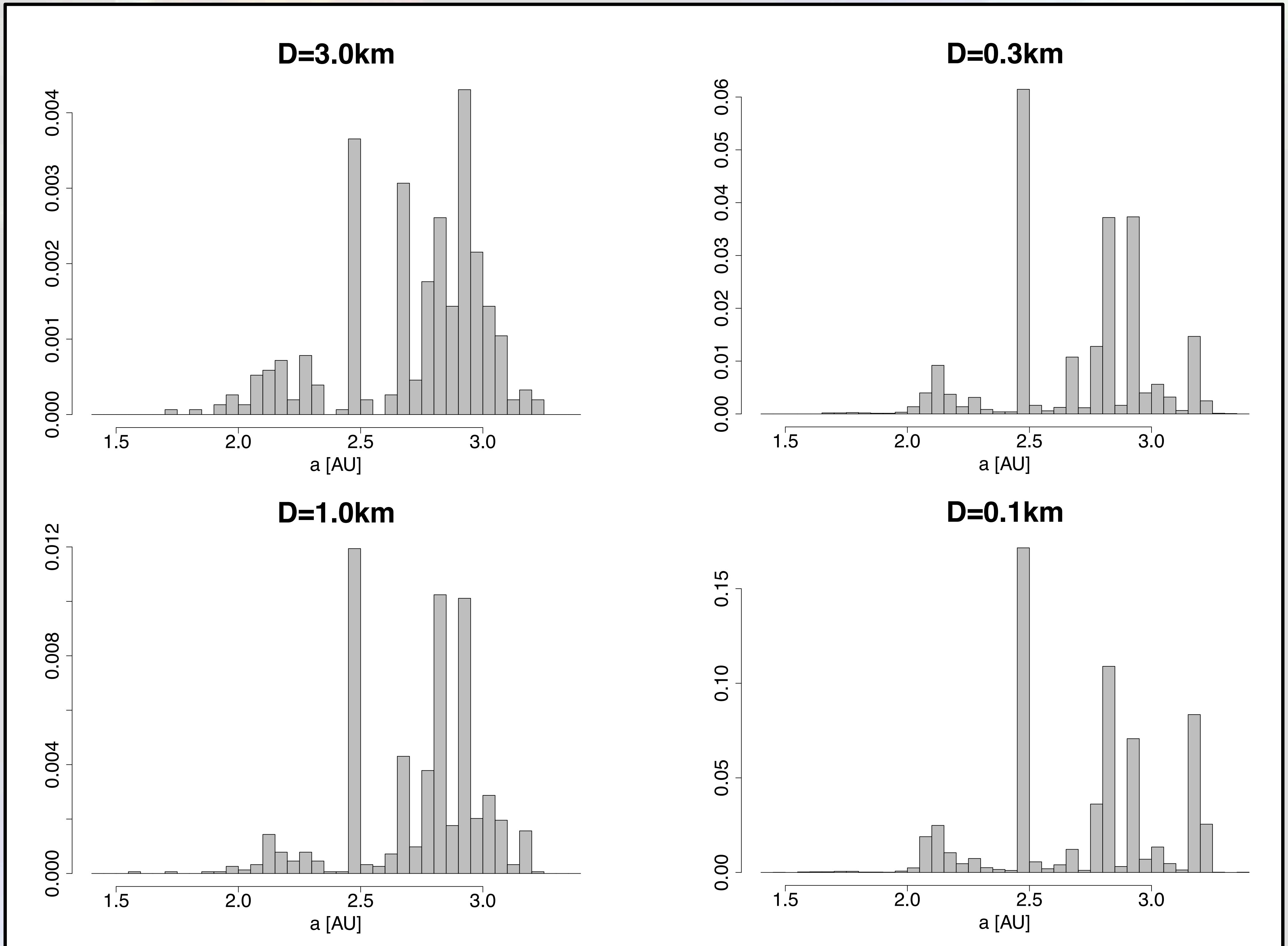
Yarkovsky in the MB



Escape hatches in the MB



Relative importance of various escape hatches as a function of asteroid diameter



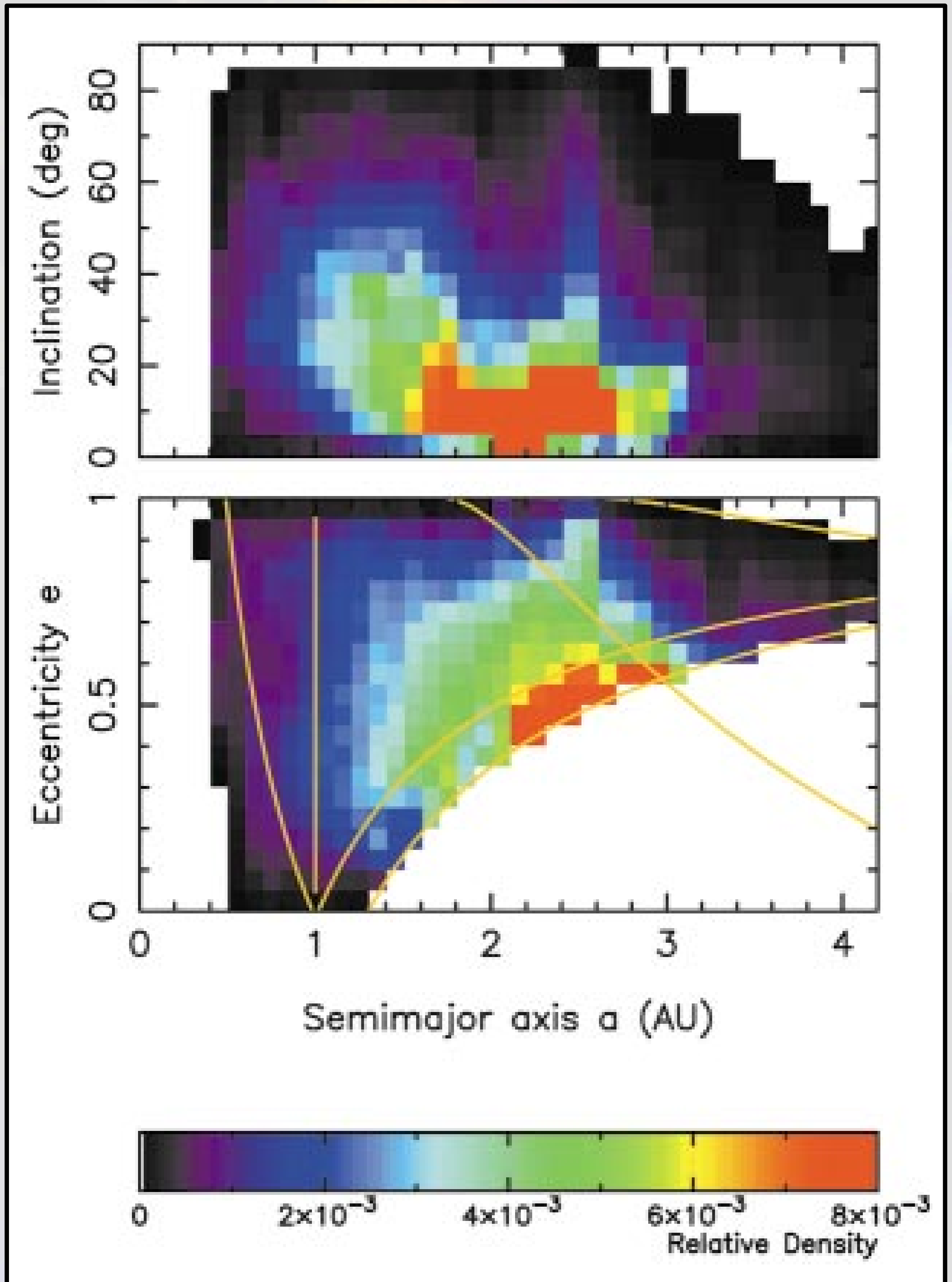
Asteroids with a<1 AU

co-authors alphabetically (the NEOSSat Science Team):
Brown, Cardinal, Chodas, Gladman, Greenstreet,
Gural, Hildebrand (NESS PI), Larson, Tedesco,
Wiegert, Worden, ...

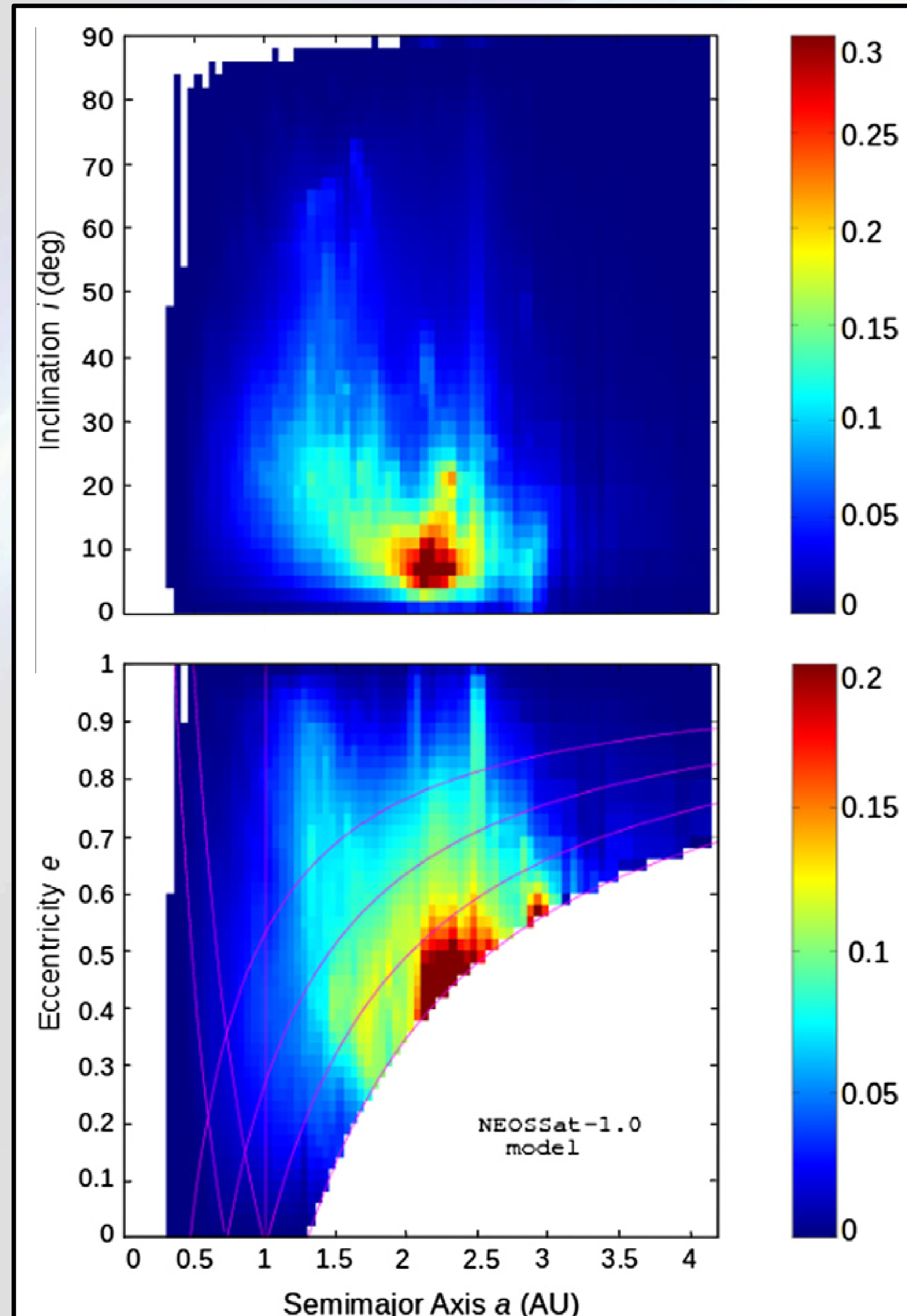
The goal and the means to reach it

- improve our understanding of asteroids with a<1AU
- ~10 Atiras (objects with $Q<q_{Earth}$) known => need to detect more to improve understanding on their population characteristics => ground-based search is tedious at solar elongations <60deg => use a space-based platform
- NEOSSat is a suitcase-sized follow-up to MOST
- launch to a polar orbit in late 2012
- expect to detect 1 Atira-class asteroid (Q<1AU) every month, nominal mission will last 2 years
- ***good handle on detection biases***

NEOSSat-1.0 NEA model

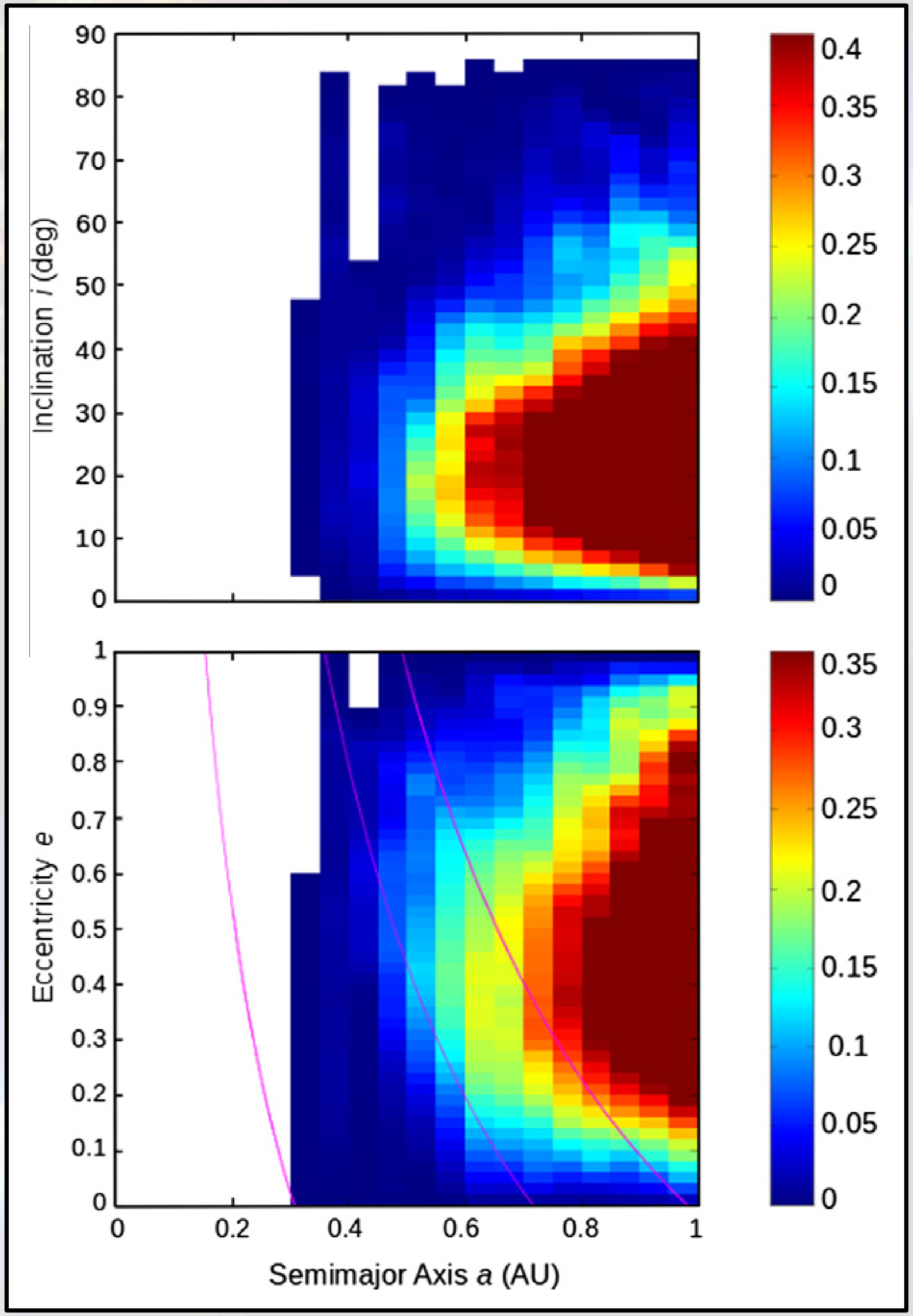


Bottke et al. 2002



Greenstreet et al. 2012

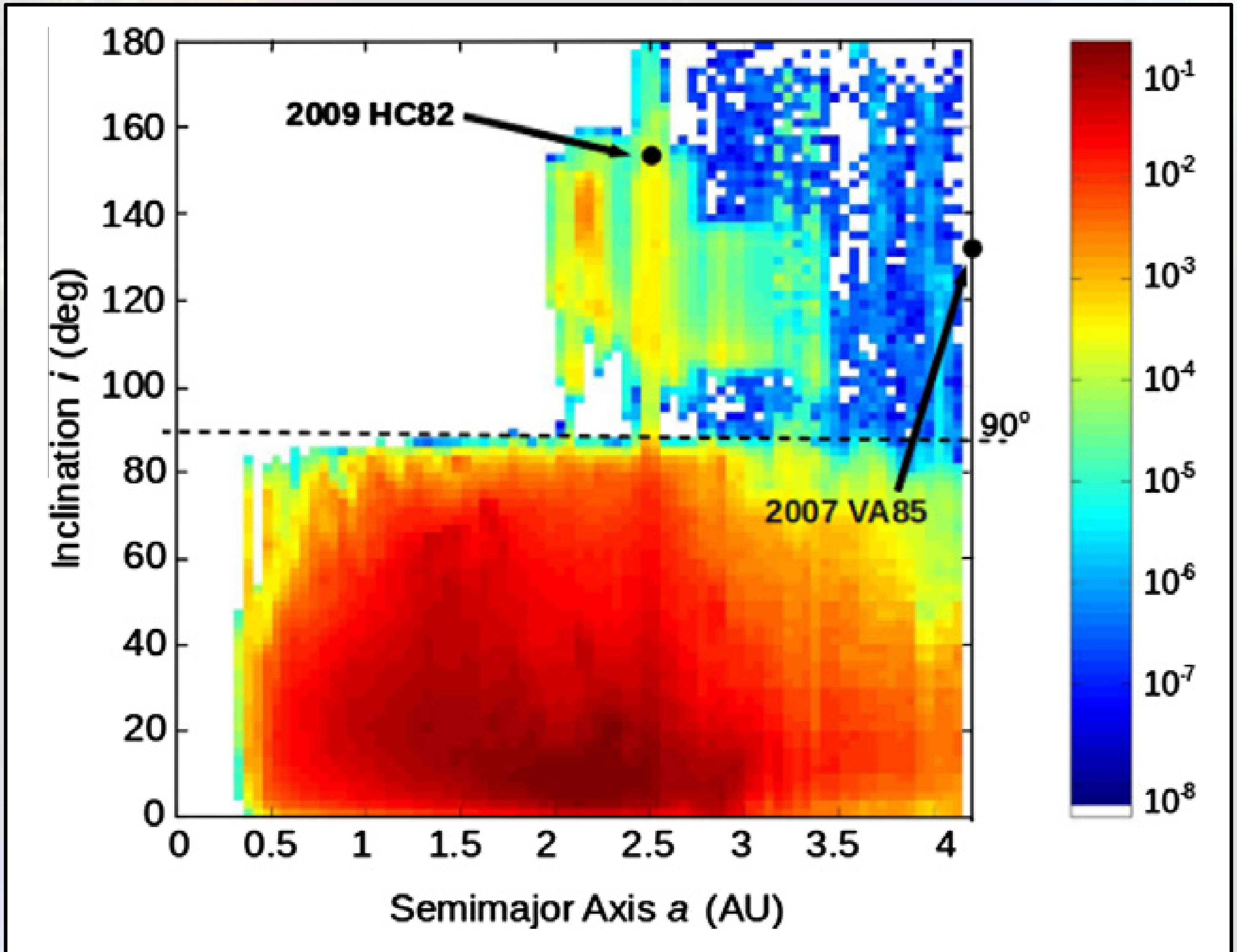
NEOSSat-1.0 NEA model



Greenstreet et al. 2012

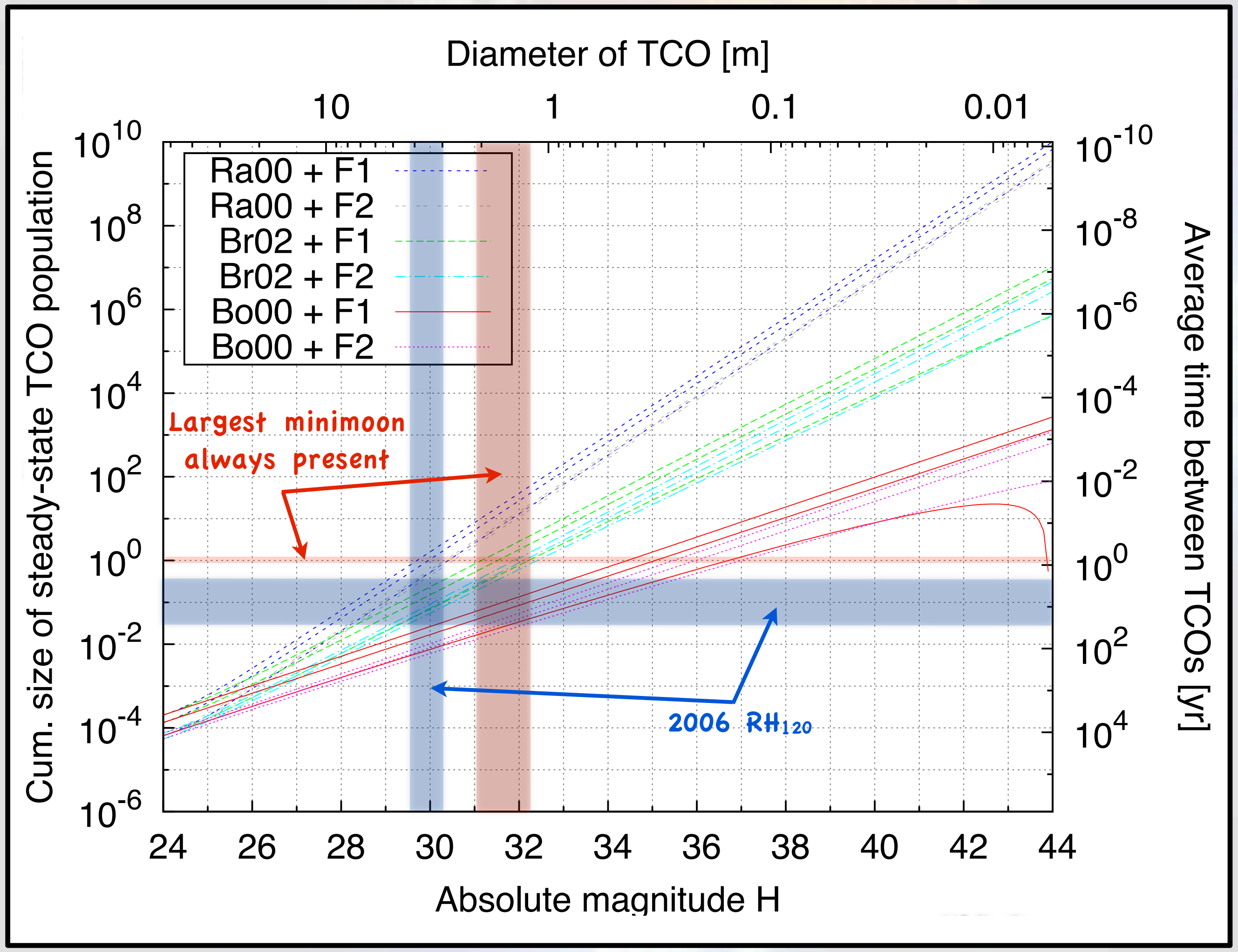
Testing the resulting models with peculiar objects

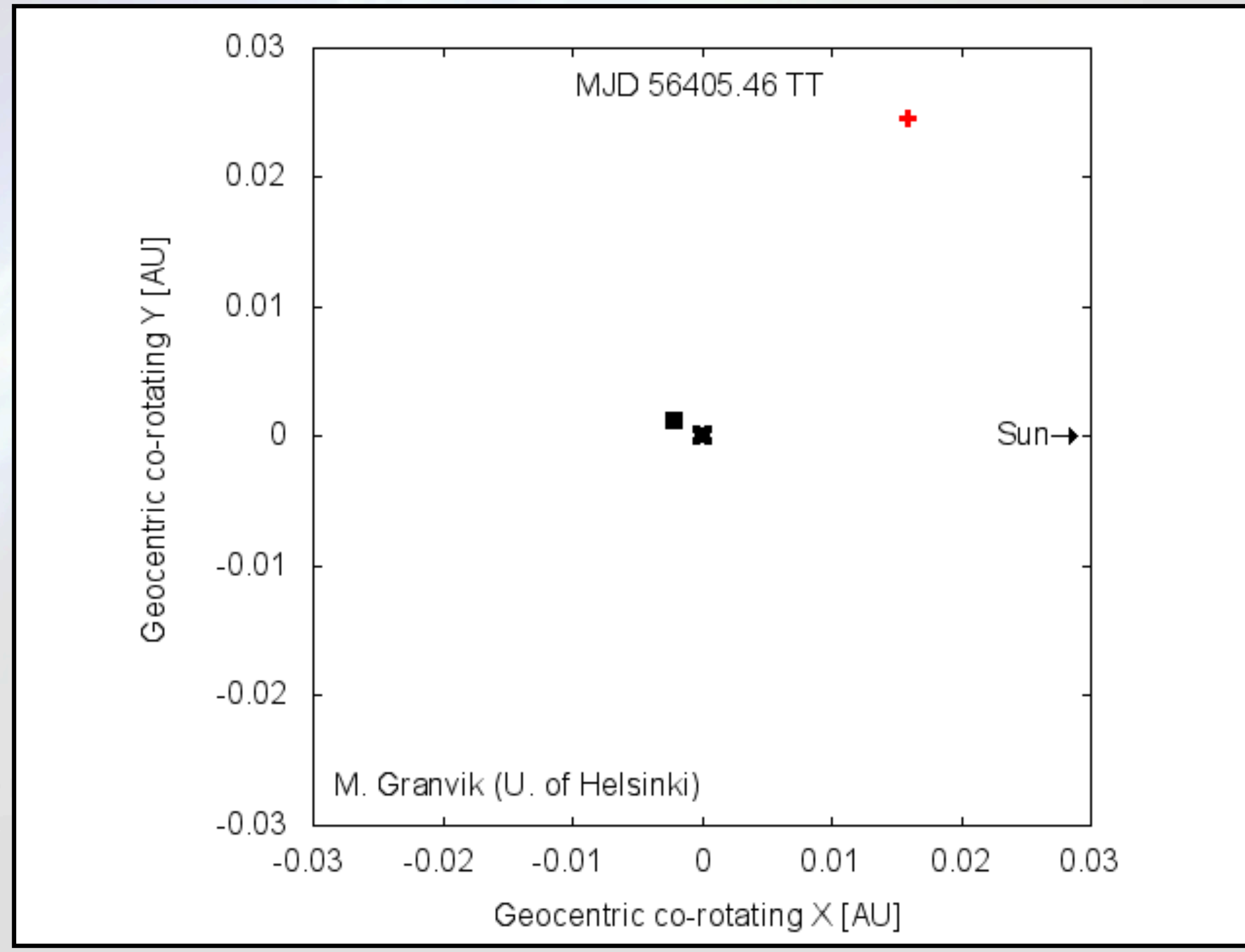
NEAs on retrograde orbits



Greenstreet et al. 2012

NEOs temporarily captured by the Earth-Moon system





Granvik et al. 2012