Interrelations between asteroid populations

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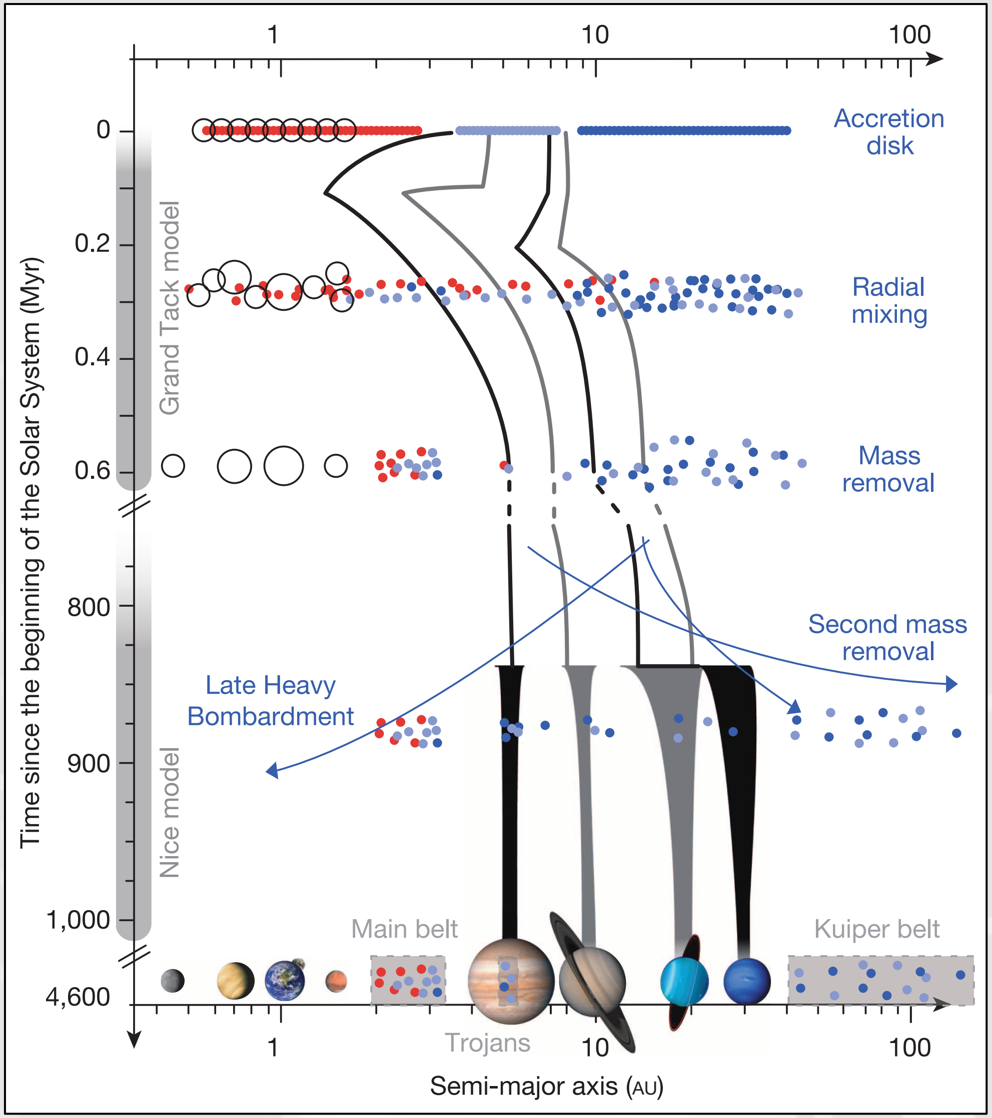
Solar-system evolution (short version…)



DeMeo & Carry (2014)

Population model

$$n(a,e,i,H) = \varepsilon(a,e,i,H)N(a,e,i,H)$$

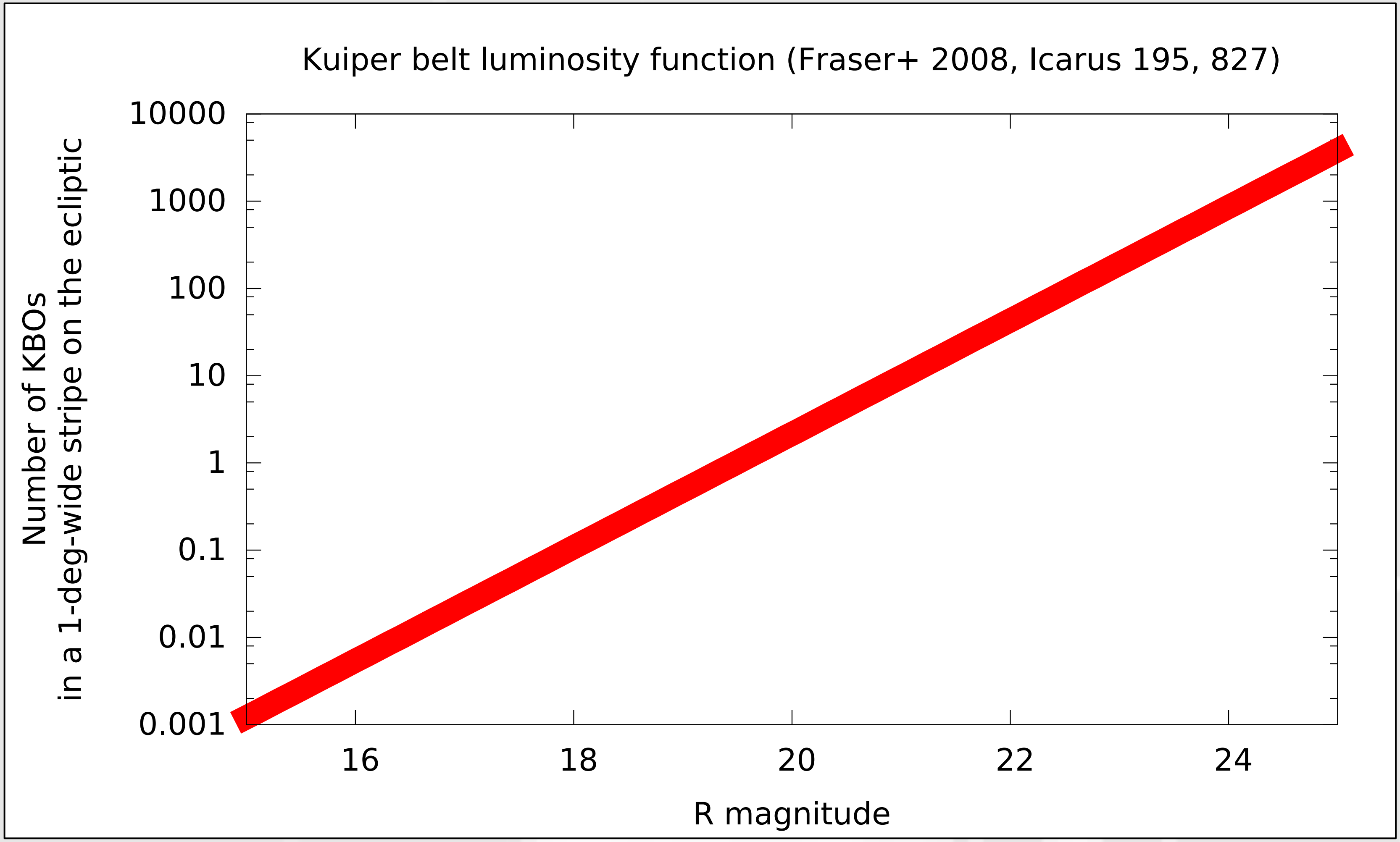
observed population
(this is what we see)

discovery efficiency
(this is estimated numerically for each survey)

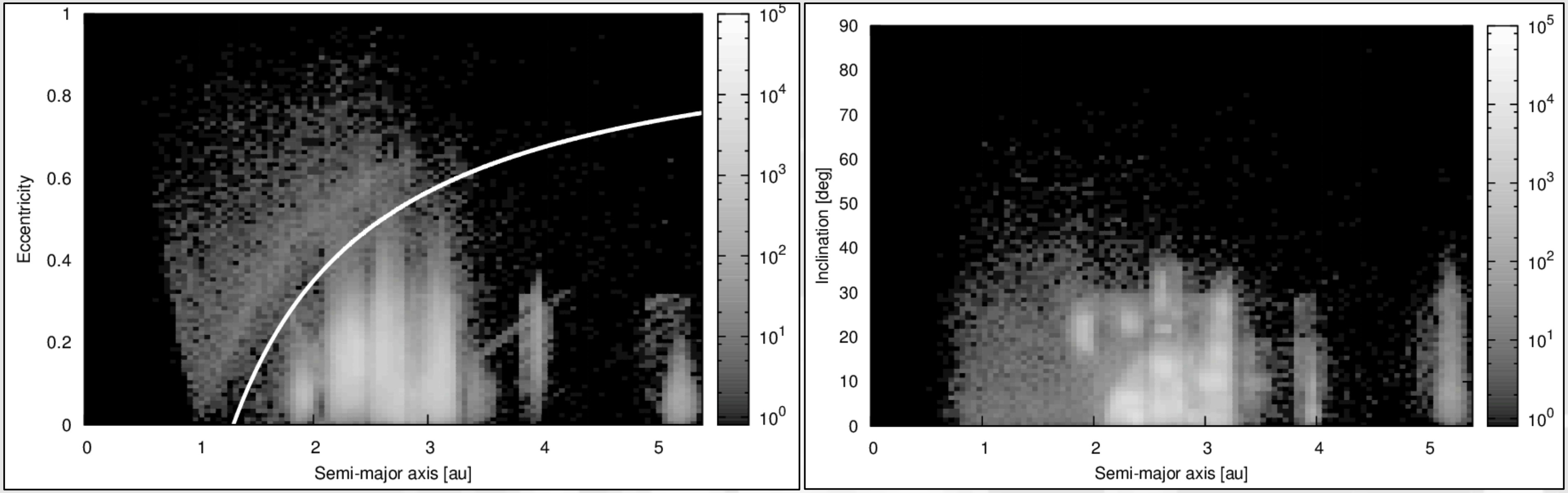
true population
(this is what we want to know)

KUIPER BELT OBJECTS (KBO)

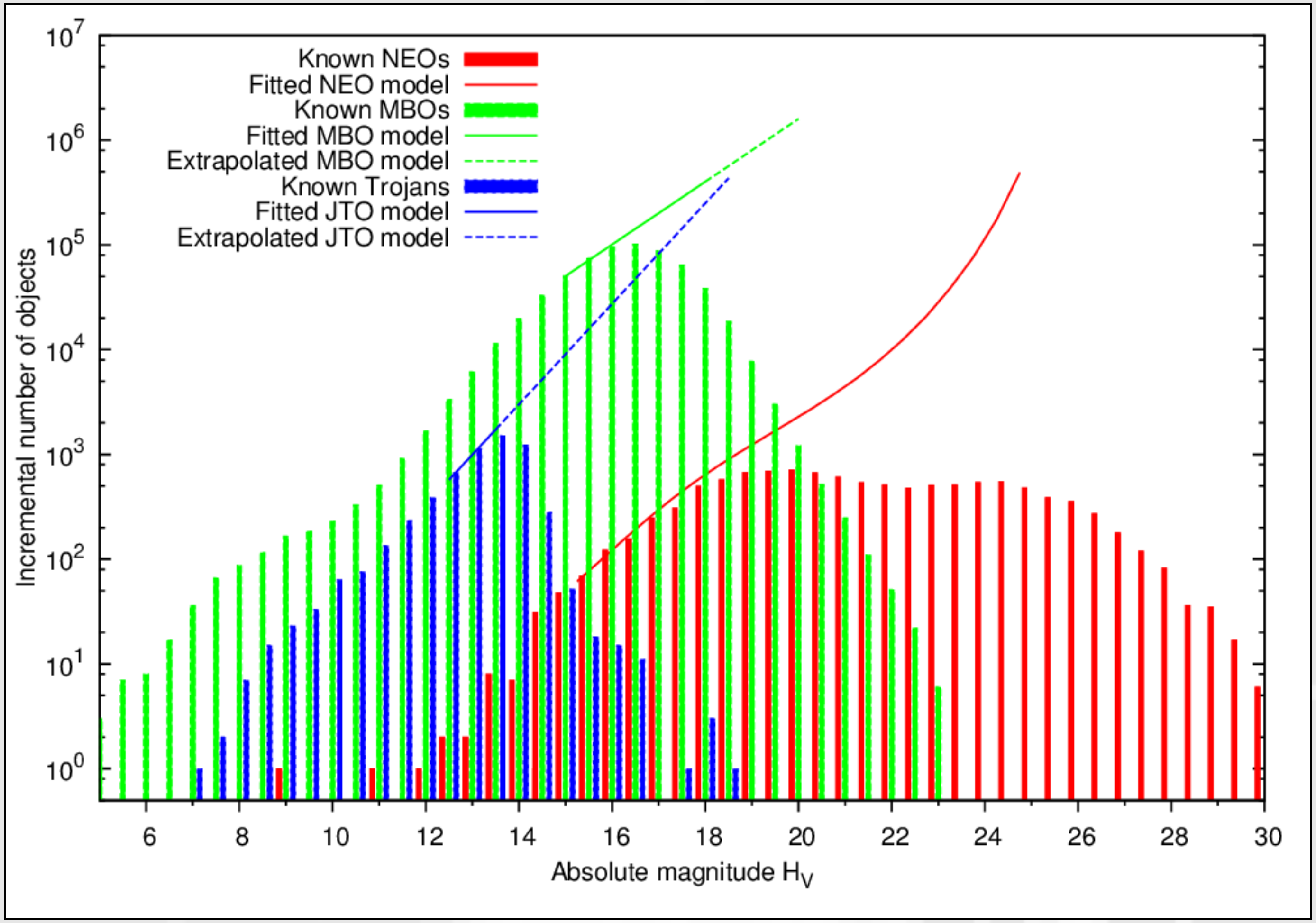
Gaia will detect very few KBOs – the focus of this talk is on the inner solar system



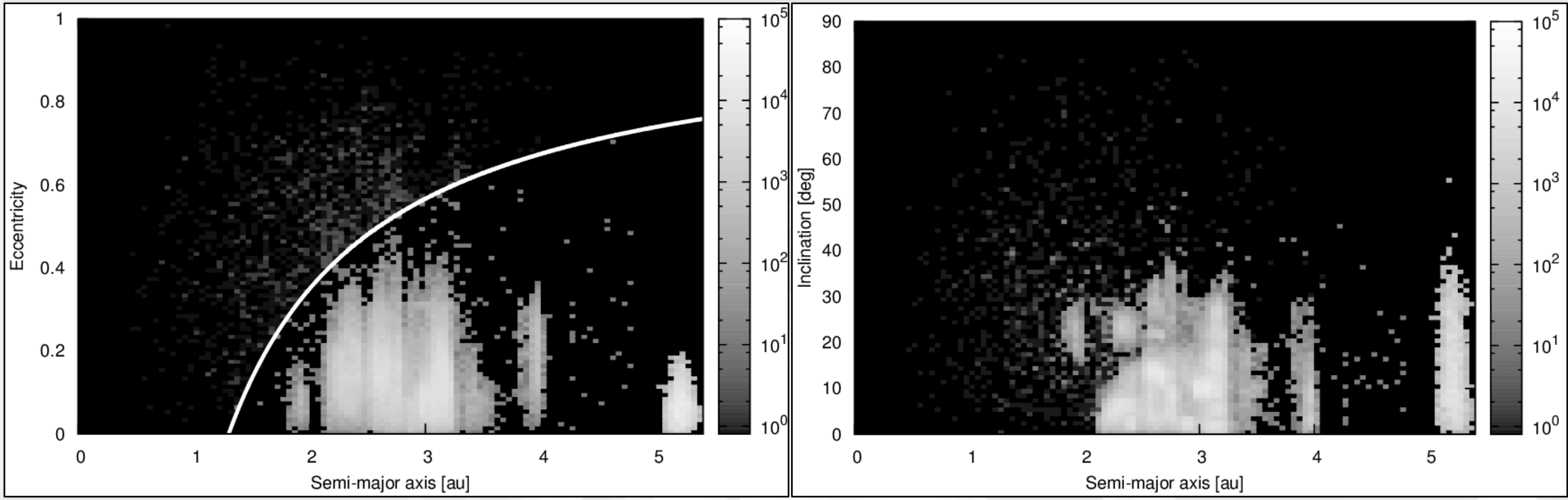
Orbit distribution for all known asteroids in the inner solar system



Absolute magnitudes for asteroids in the inner solar system

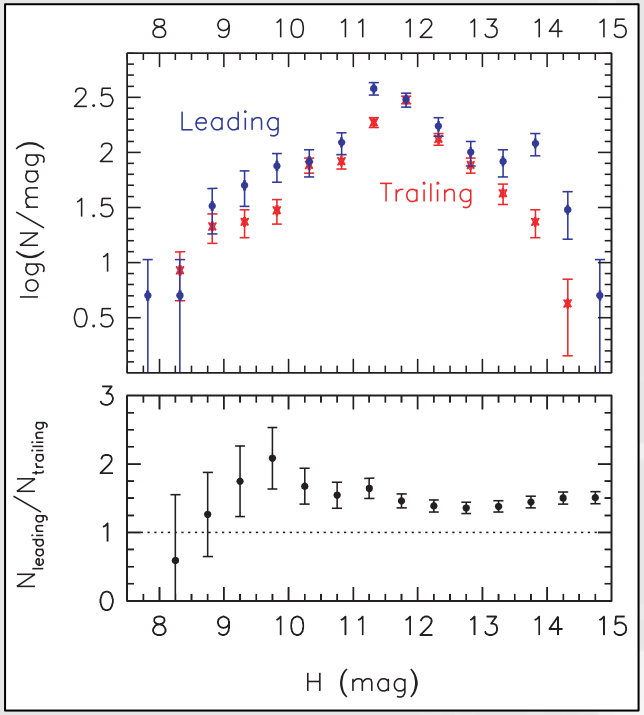


Predicted orbit distribution for H<18 asteroids in the inner solar system

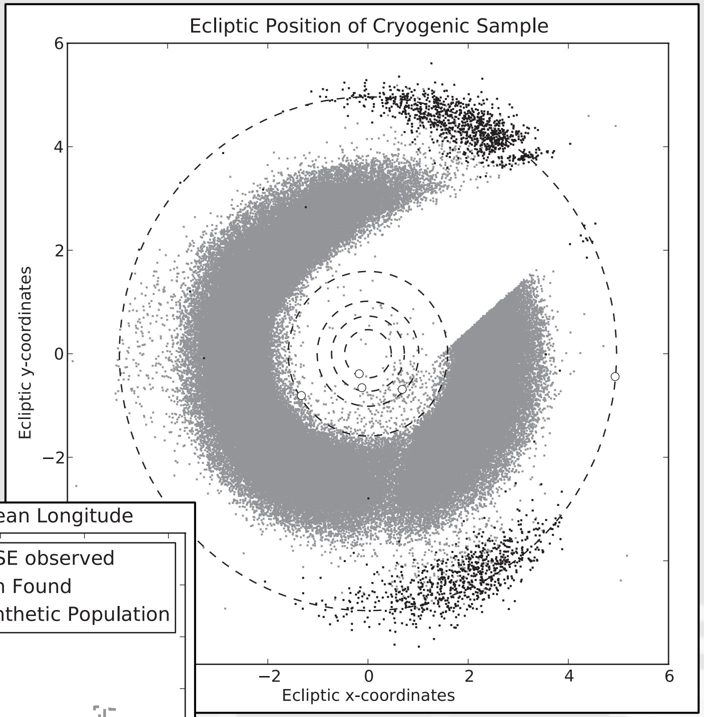


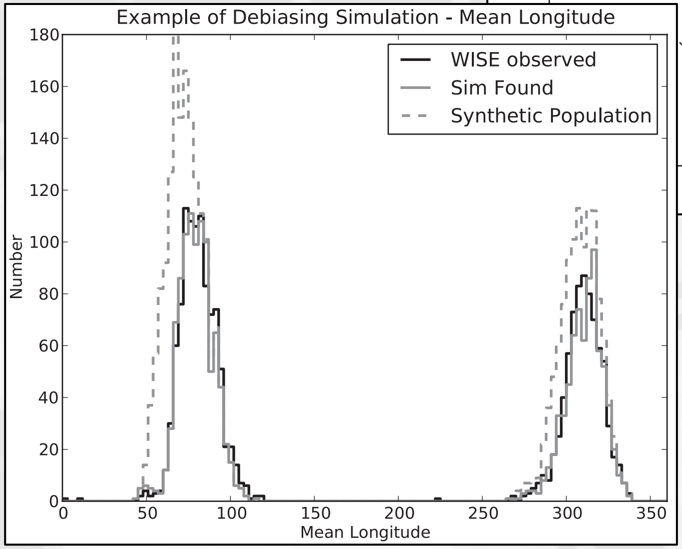
JOVIAN TROJAN OBJECTS (JTO)

Leading vs trailing cloud



Szabo 2007

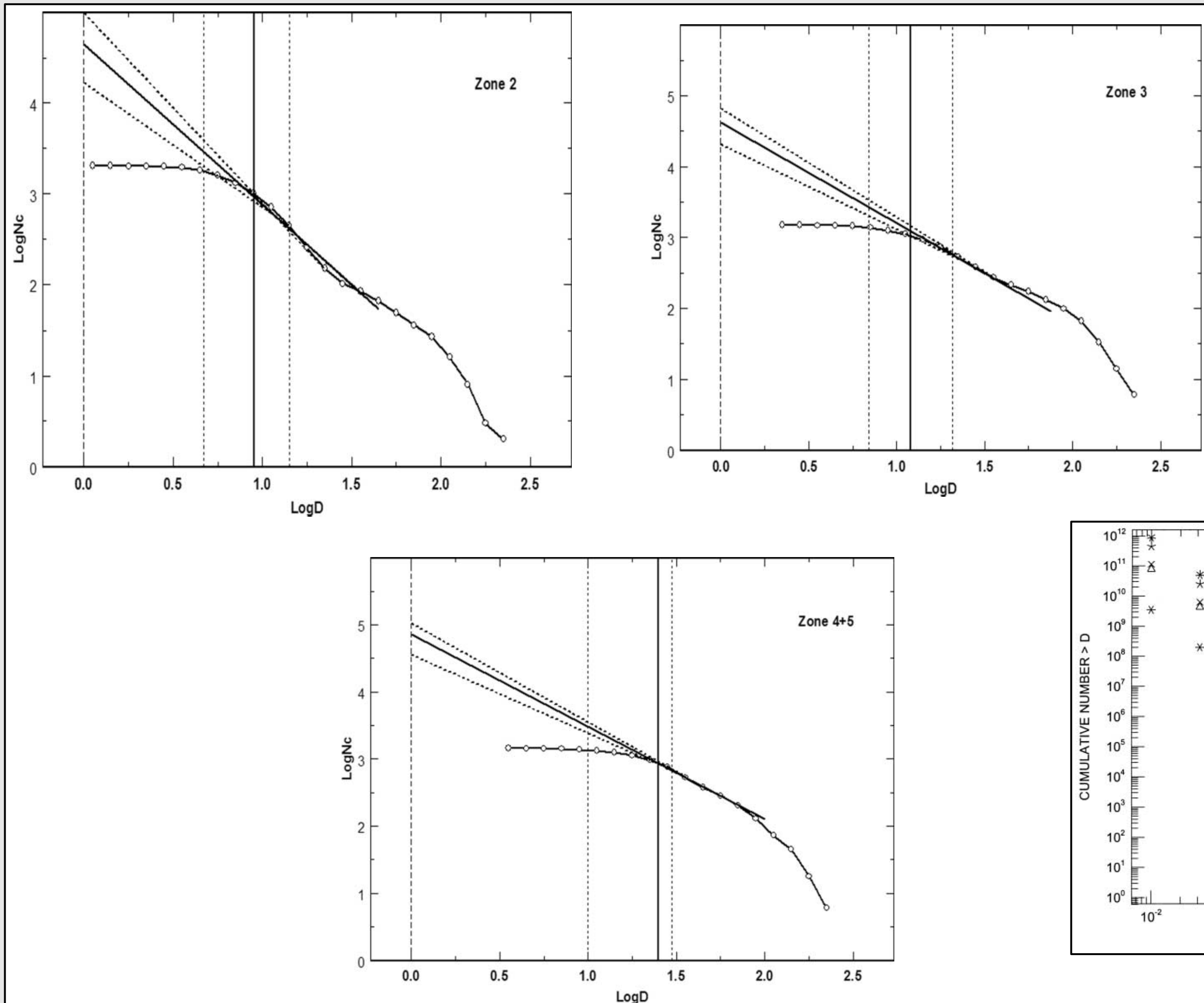




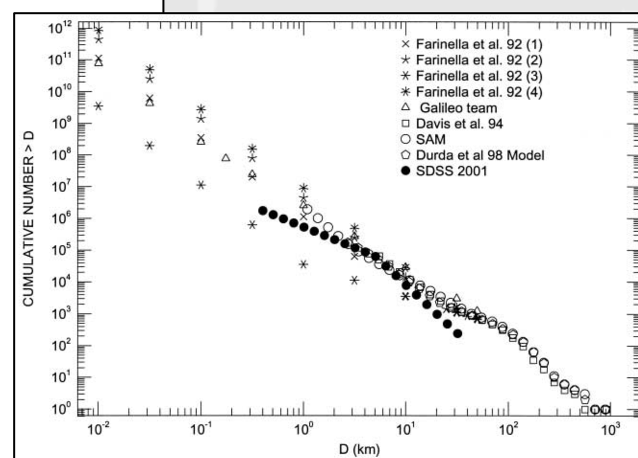
Grav+ 2011

MAIN-BELT OBJECTS (MBO)

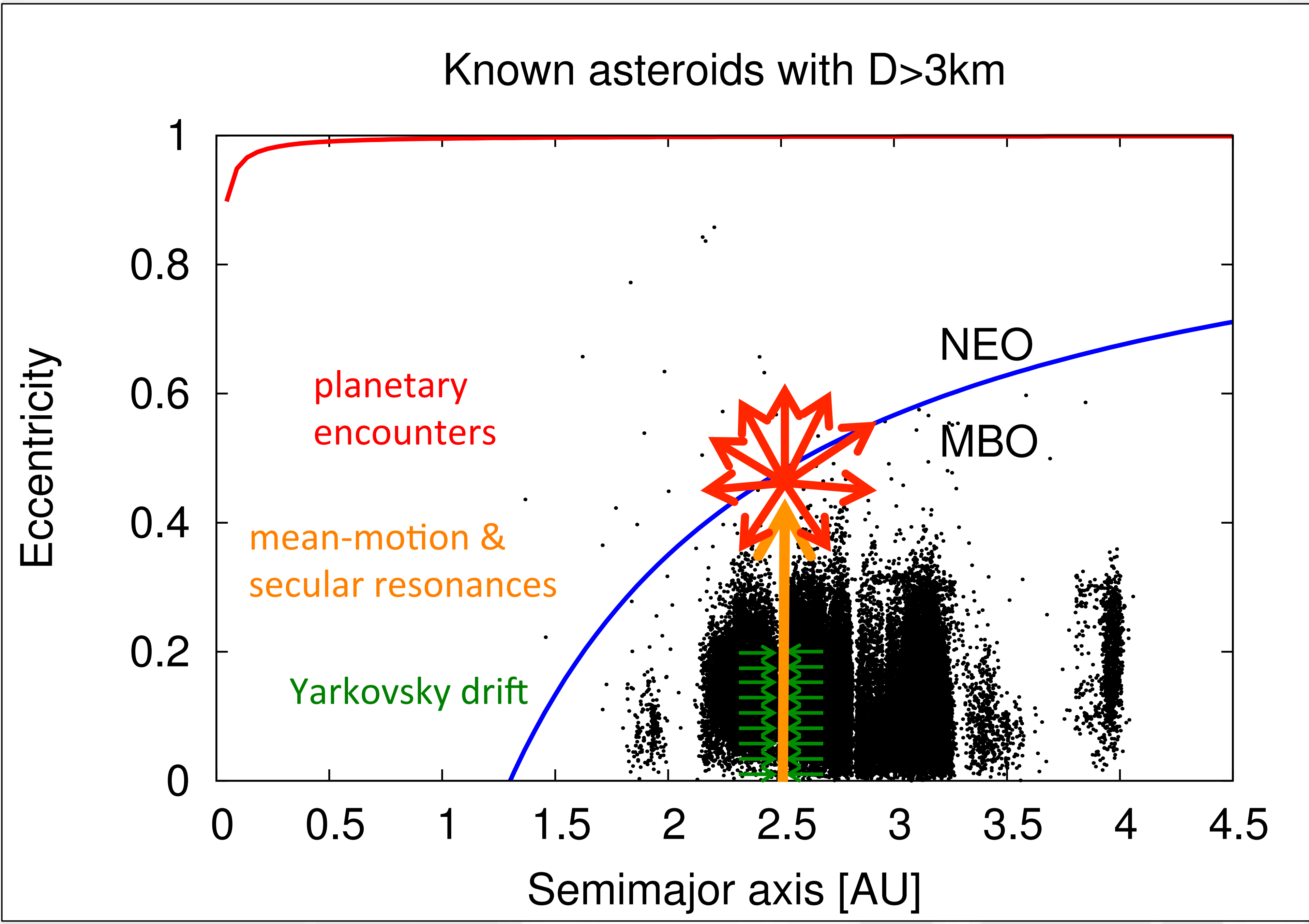
Statistical Asteroid Model (SAM)



Tedesco+ 2005



NEAR-EARTH OBJECTS (NEO)



Known asteroids with D>3km
Eccentricity
Semimajor axis [AU]
0
0.2
0.4
0.6
0.8
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
NEO
MBO
planetary
encounters
mean-motion &
secular resonances
Yarkovsky drift

Source-dependent constraints from orbital dynamics

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

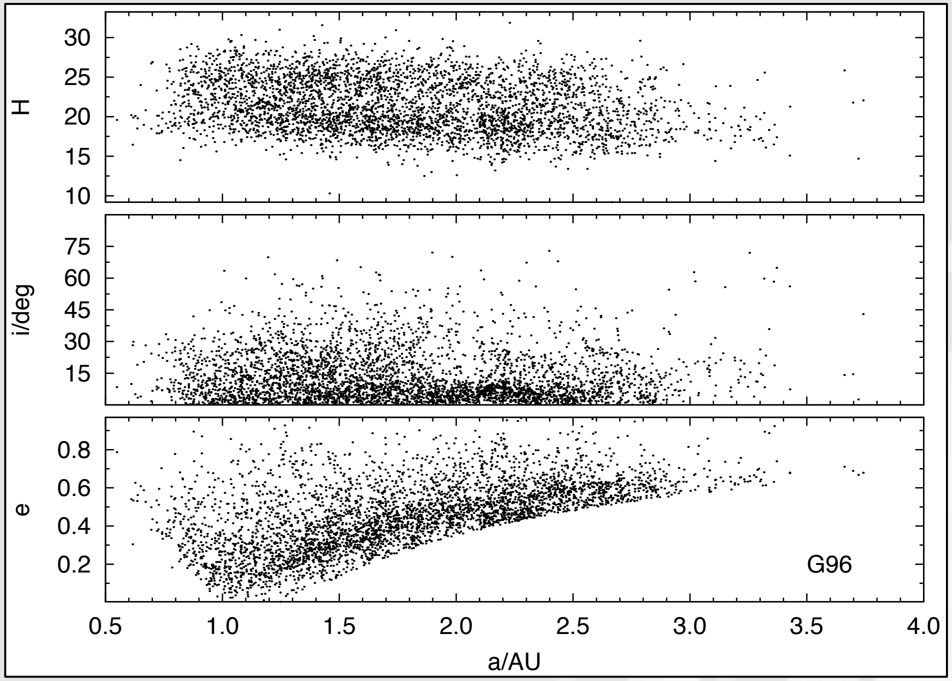
➔

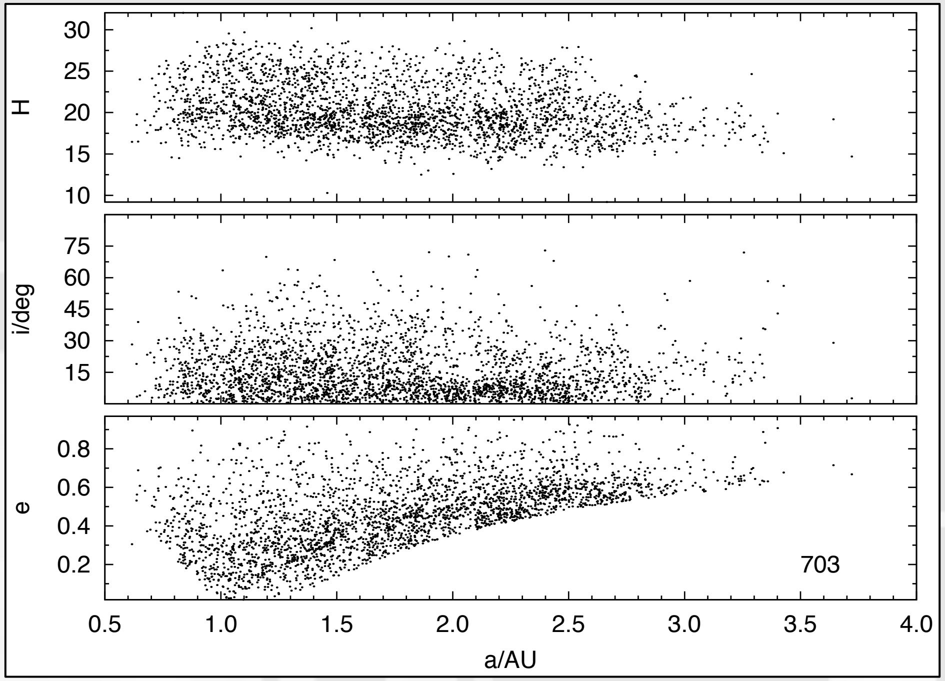
$$n(a,e,i,H) = \varepsilon(a,e,i,H)\sum_{i=1}^{N_S} f_i N_i(H) R_i(a,e,i)$$

NEO detections by CSS 2005-2012

Mt. Lemmon (G96)

Catalina (703)

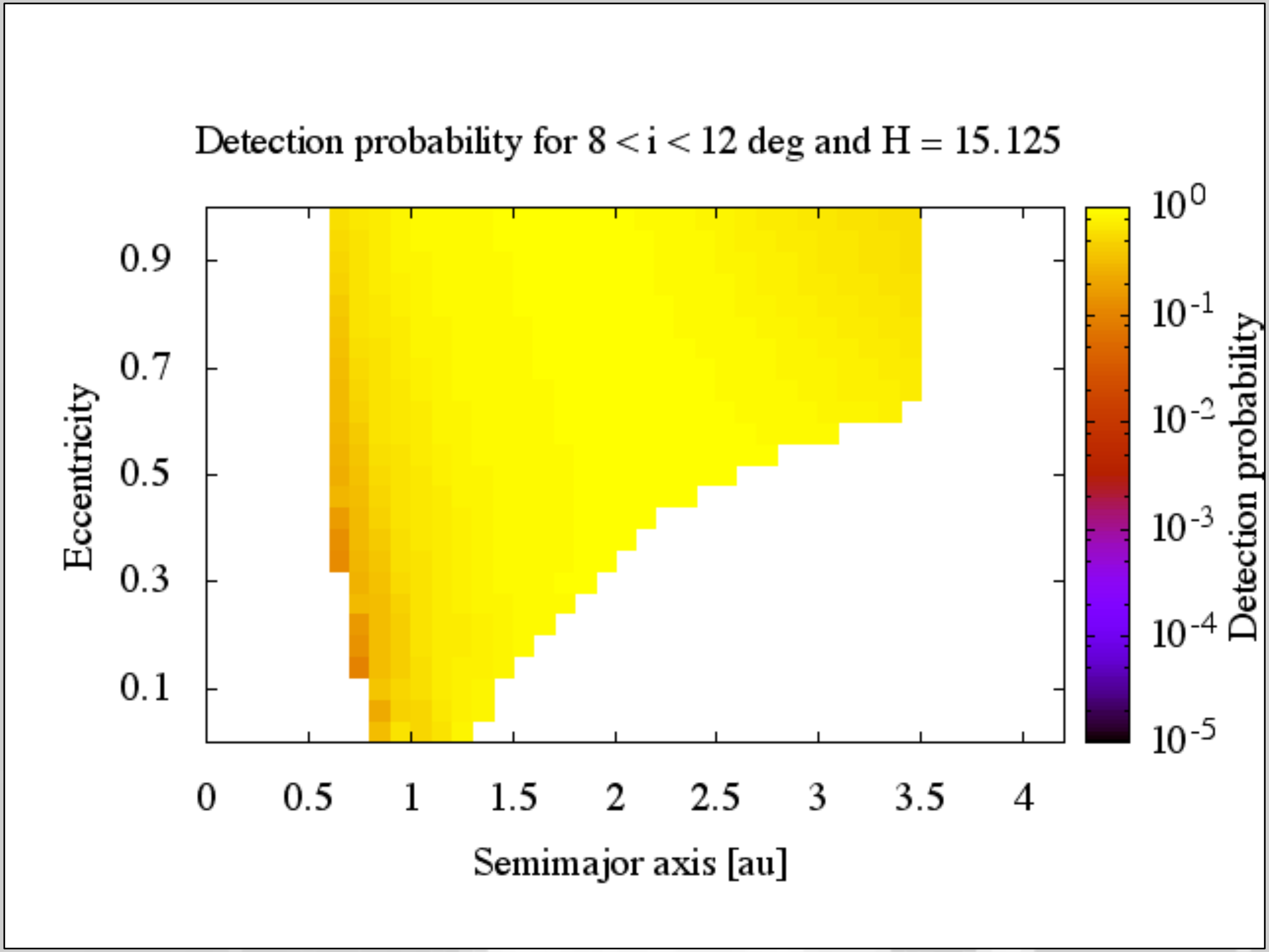




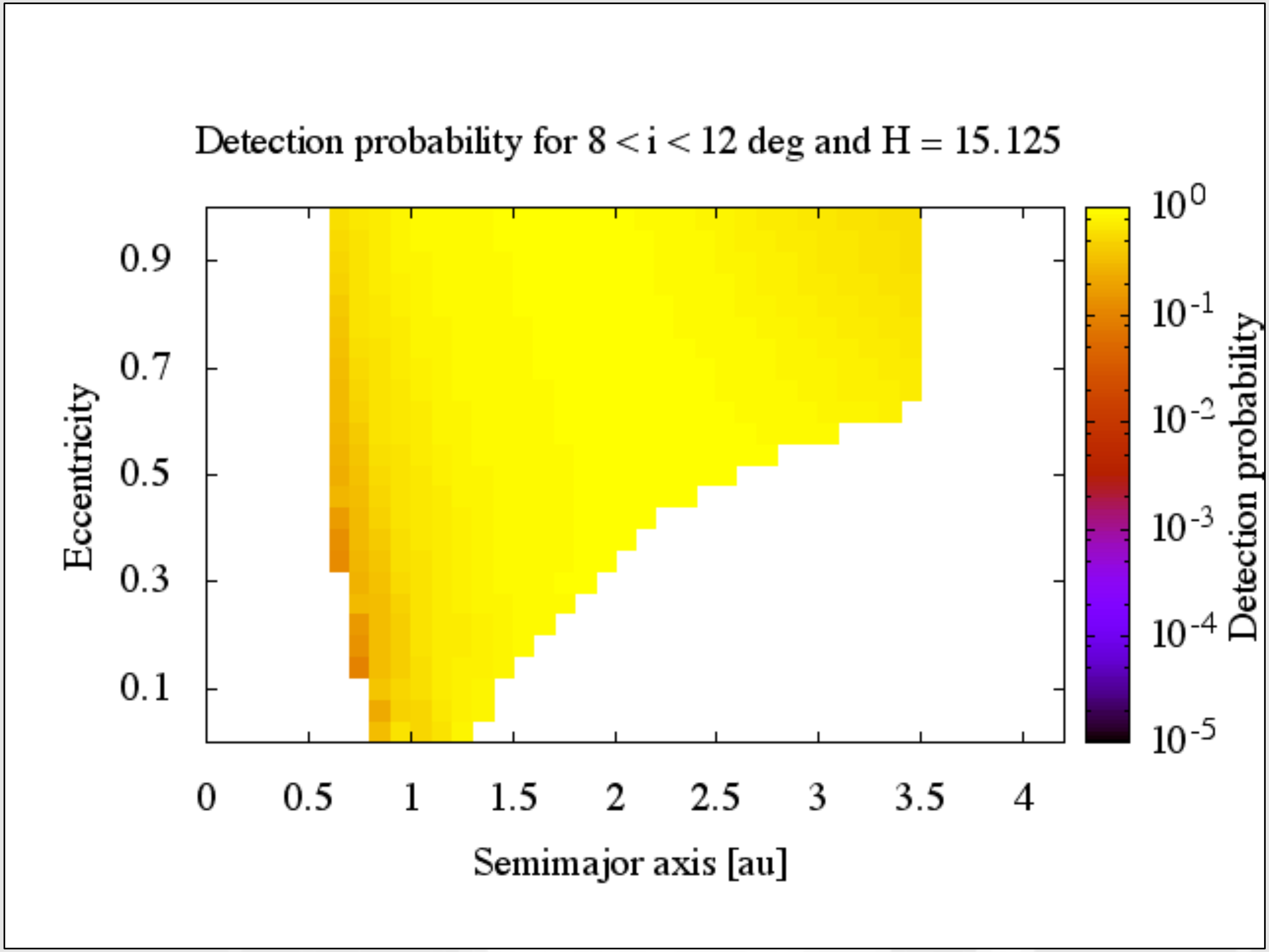
Narrow & deep

Wide & shallow

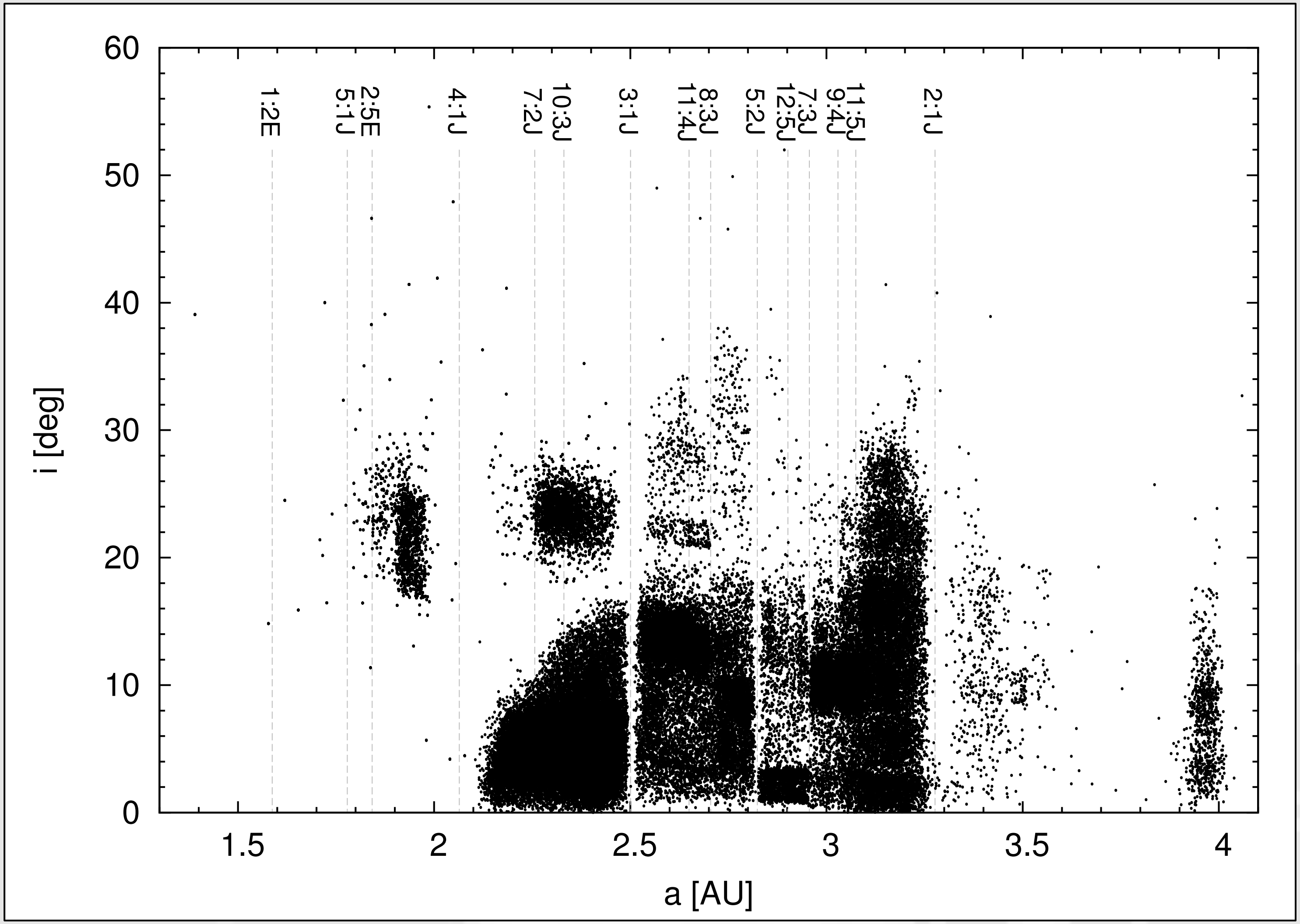
Detection probability for CSS



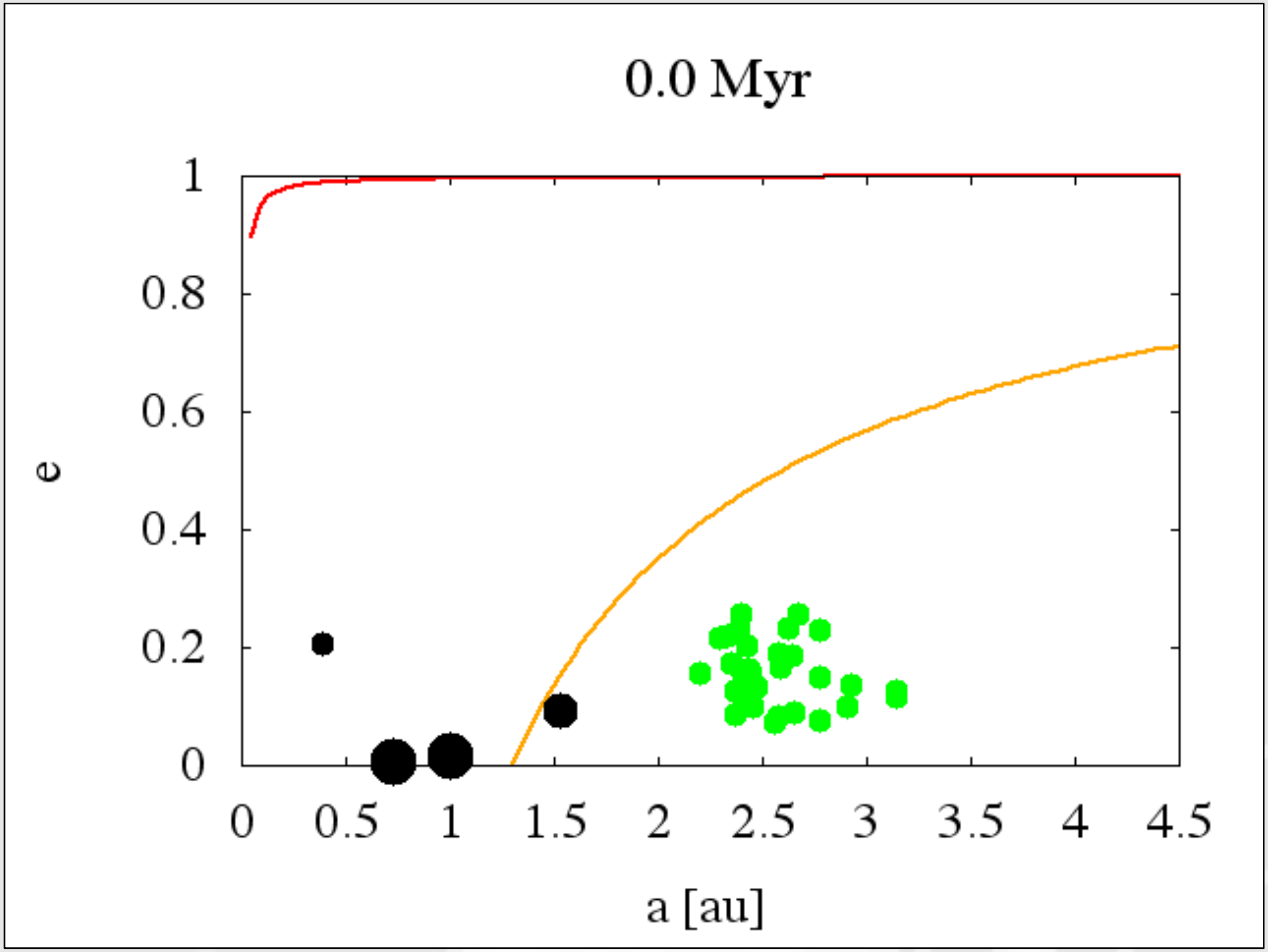
Detection probability for CSS



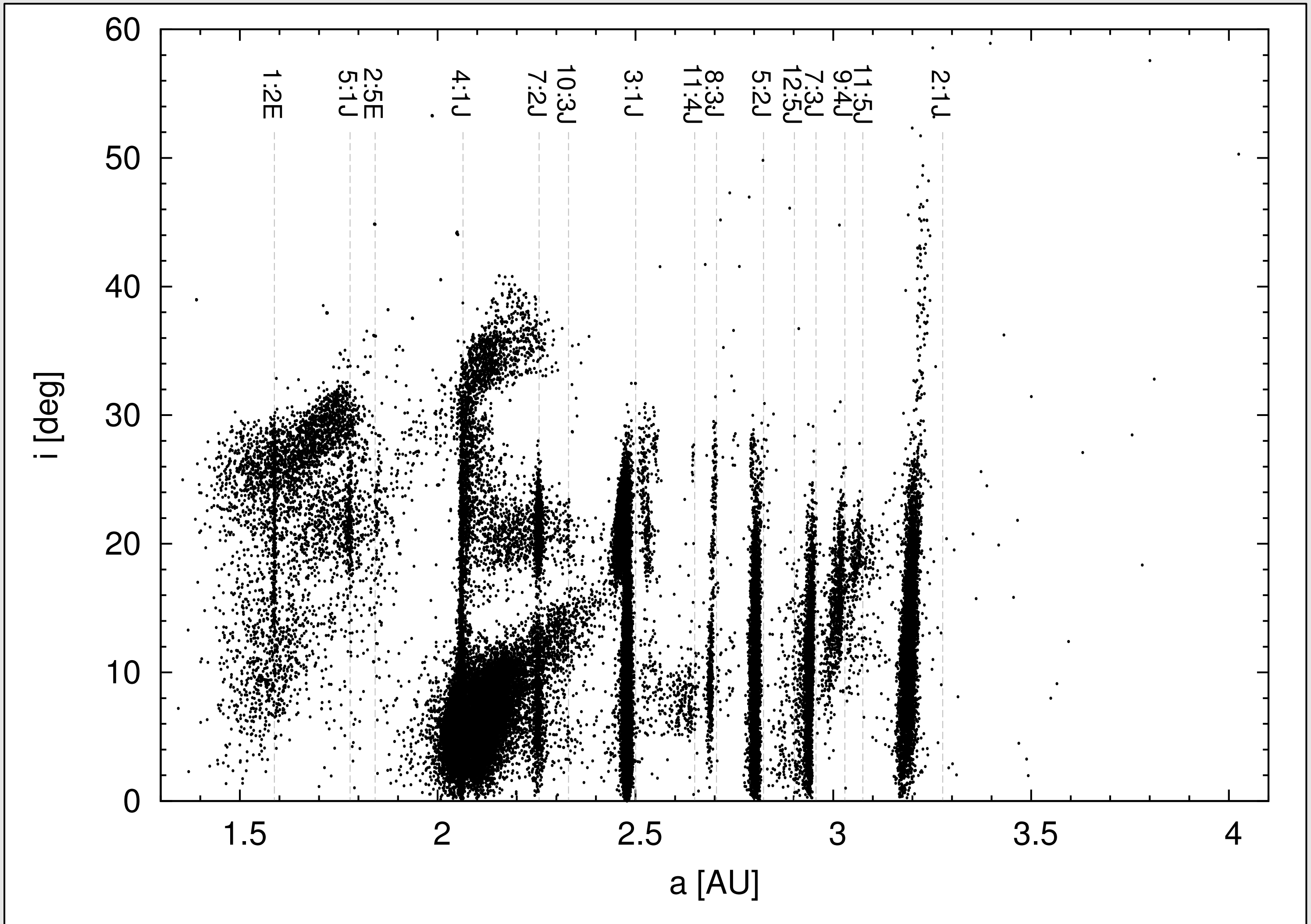
Initial conditions for residence integrations from known MBOs



Residence-time integrations

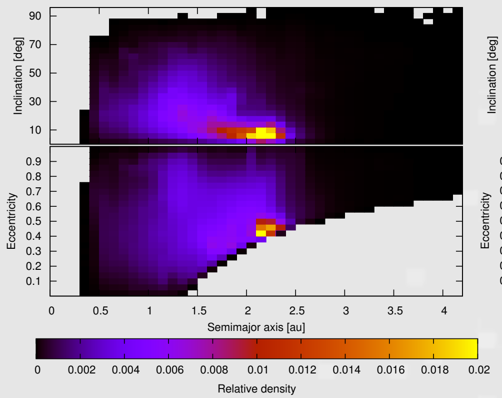


Source classification when q=1.3 au

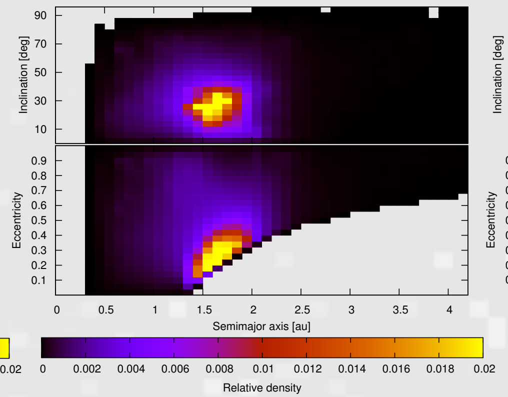


Residence-time distributions

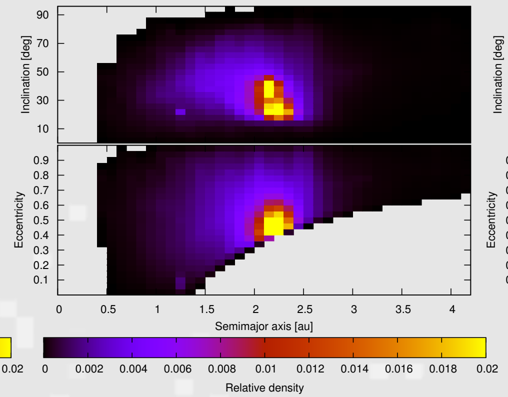
nu6



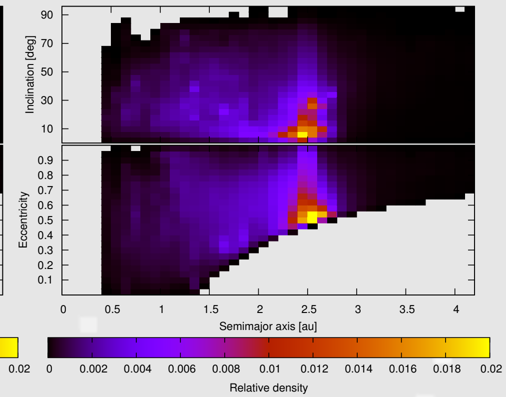
Hungaria



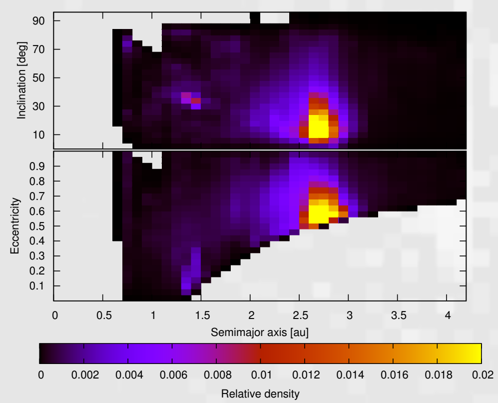
Phocaea



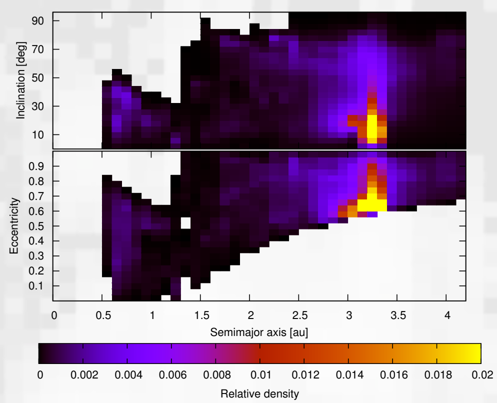
3:1J



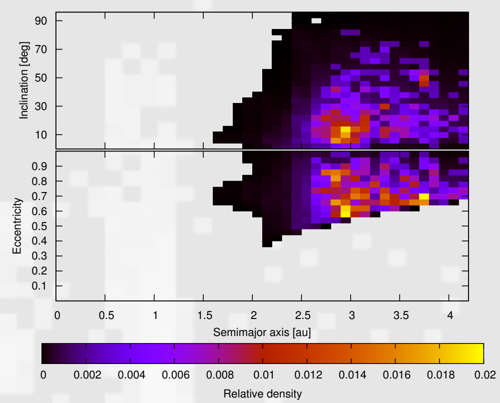
5:2J complex



2:1J complex



JFC

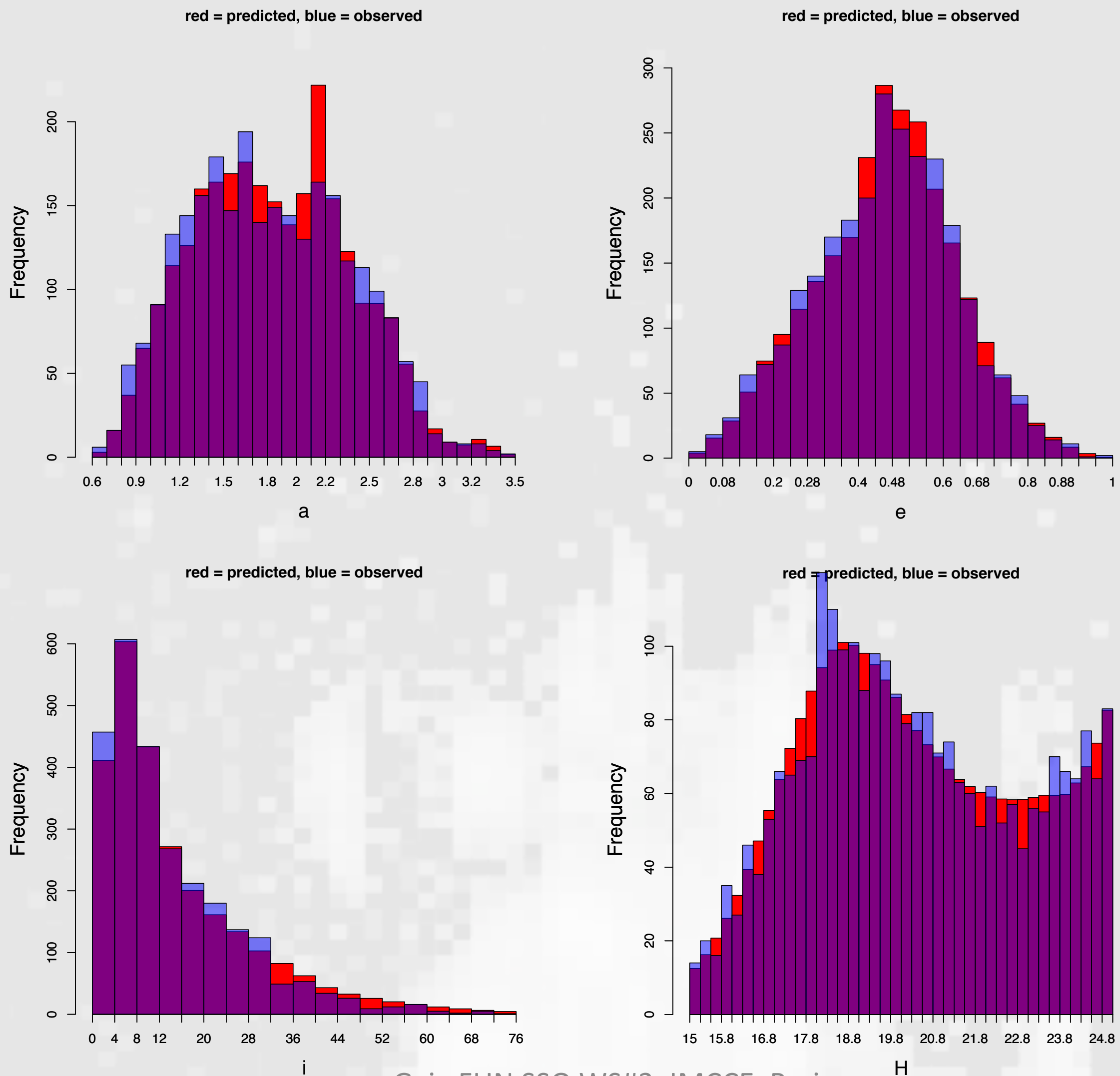


PRELIMINARY RESULTS

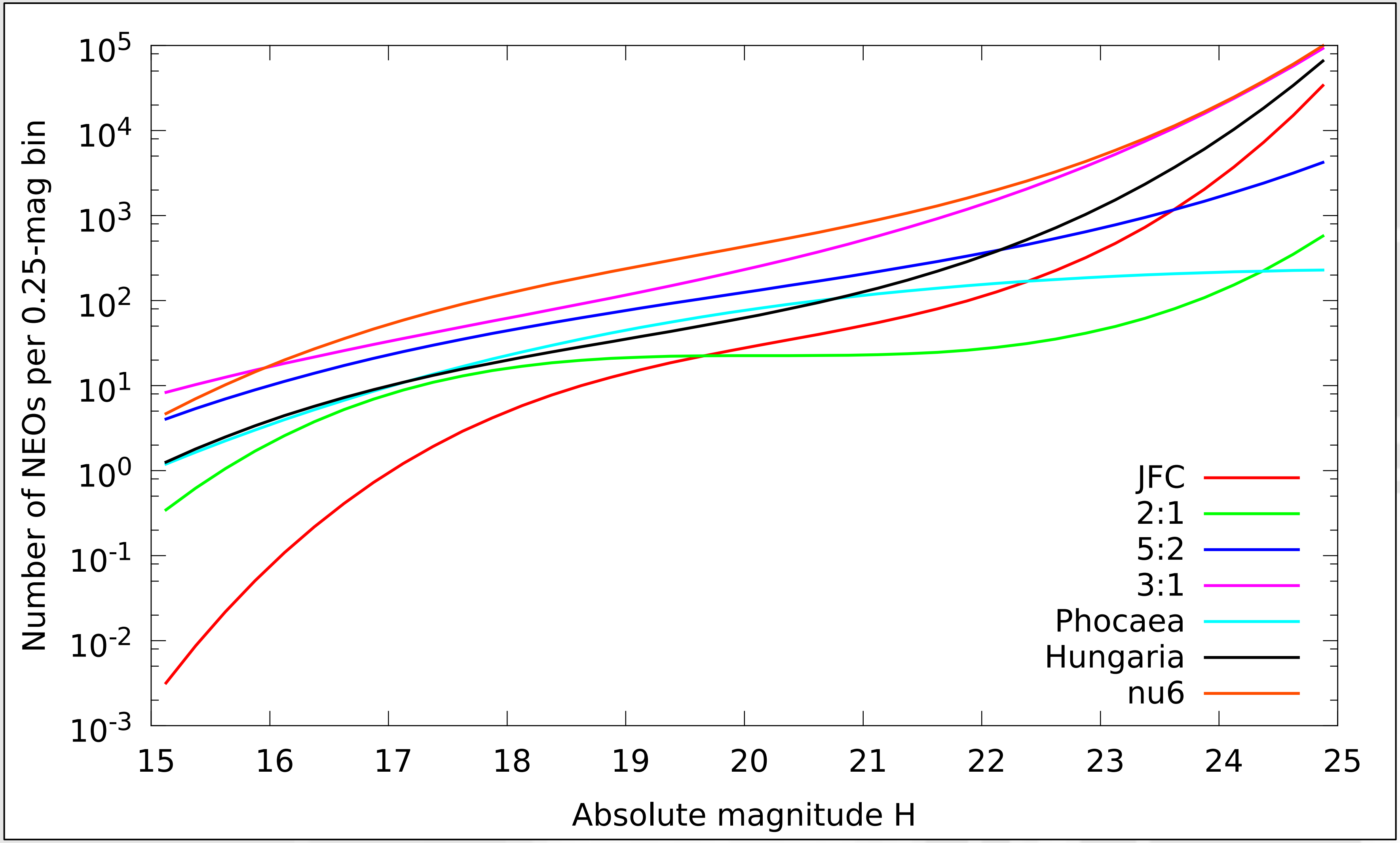
USING G96 ONLY

Model calibration

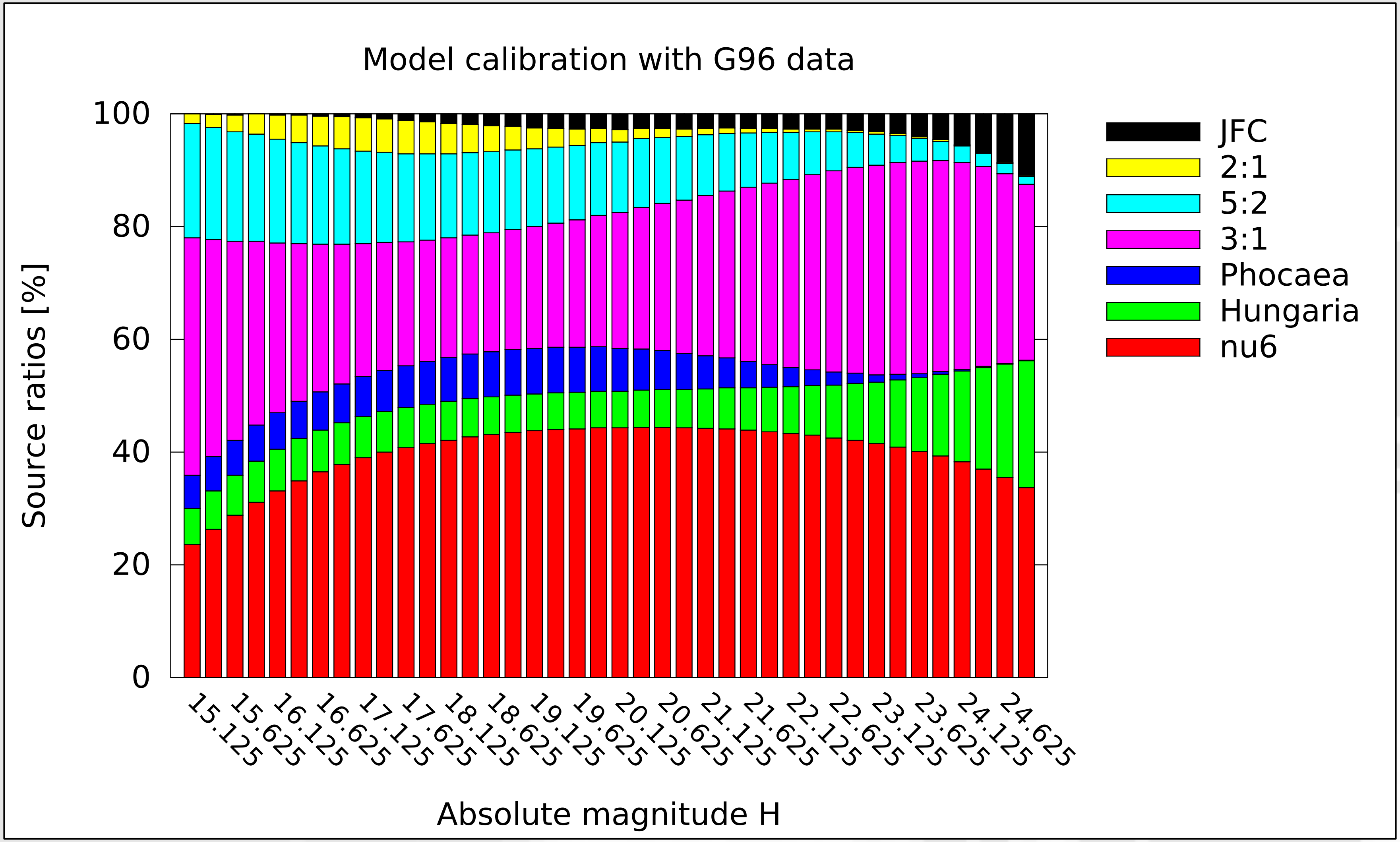
G96 model vs G96 observations

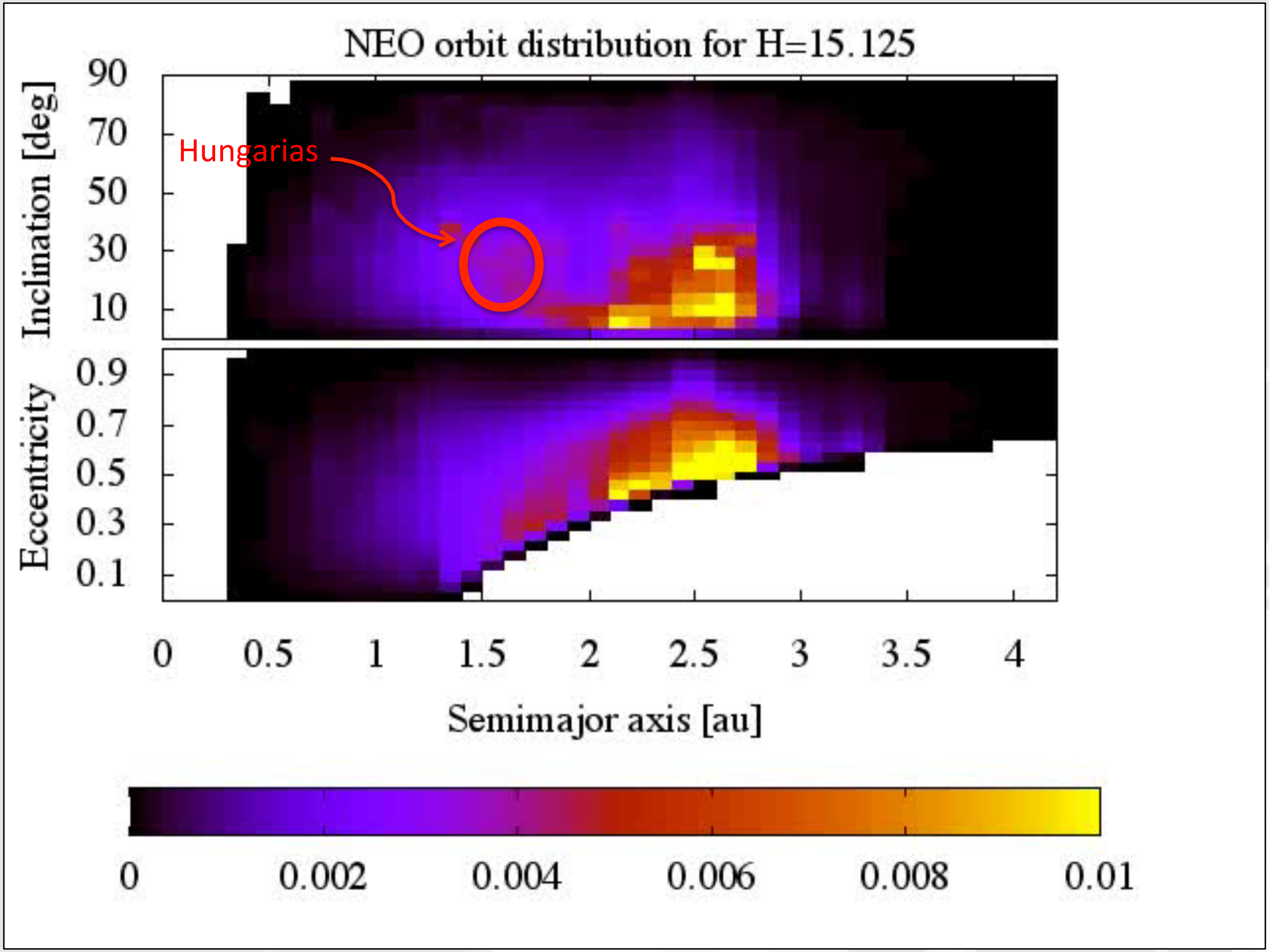


Incremental H distributions per source

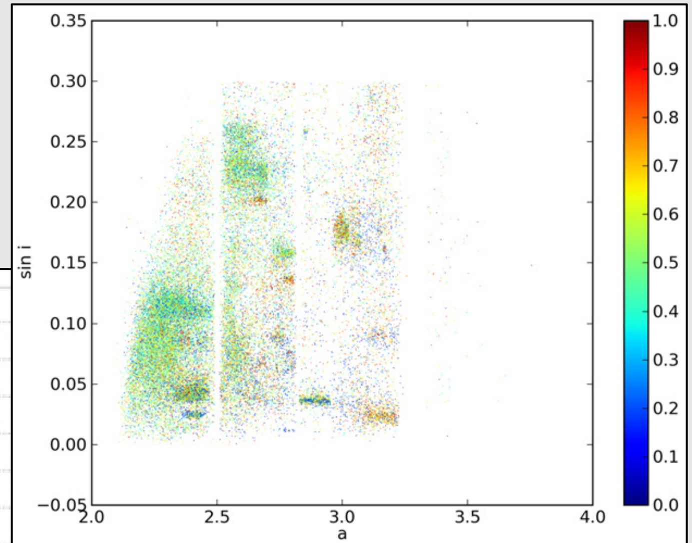


NEO source ratios as a function of H

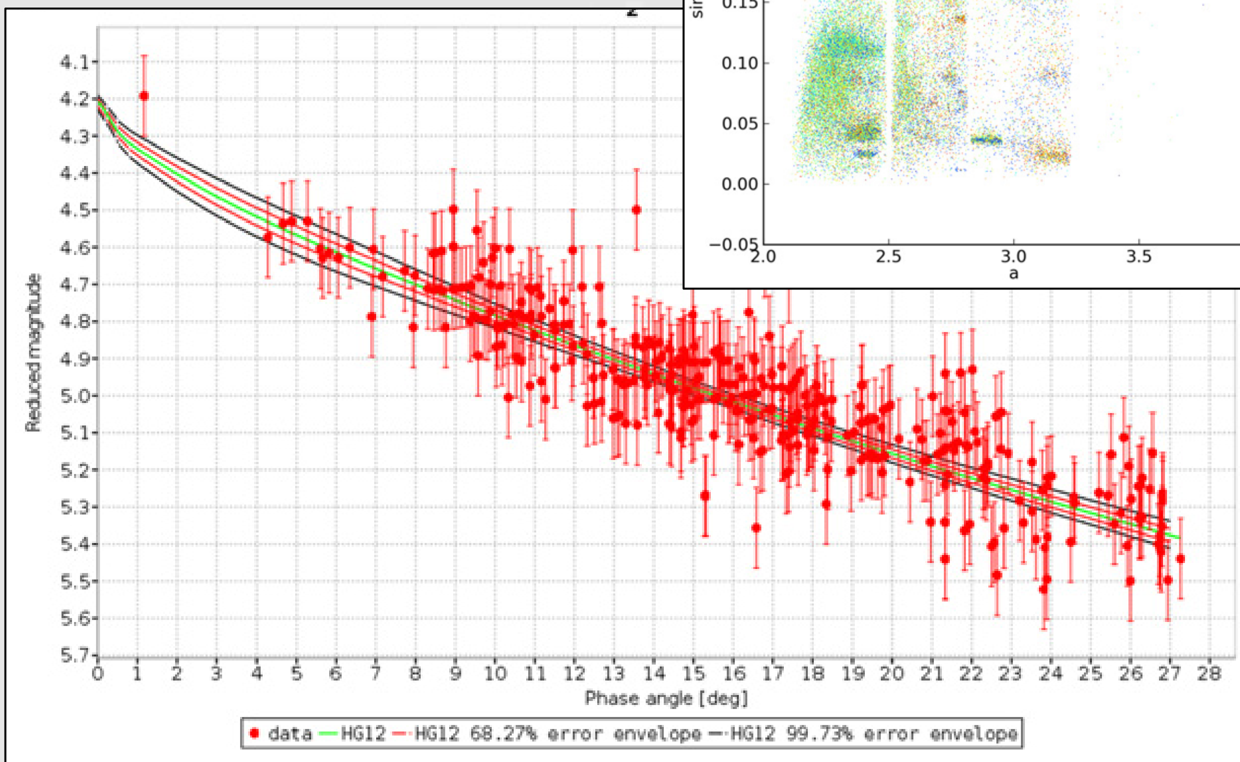



NEO orbit distribution for H=15.125
Hungarias
Inclination [deg]
90
70
50
30
10
Eccentricity
0.9
0.7
0.5
0.3
0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
Semimajor axis [au]
0
0.002
0.004
0.006
0.008
0.01

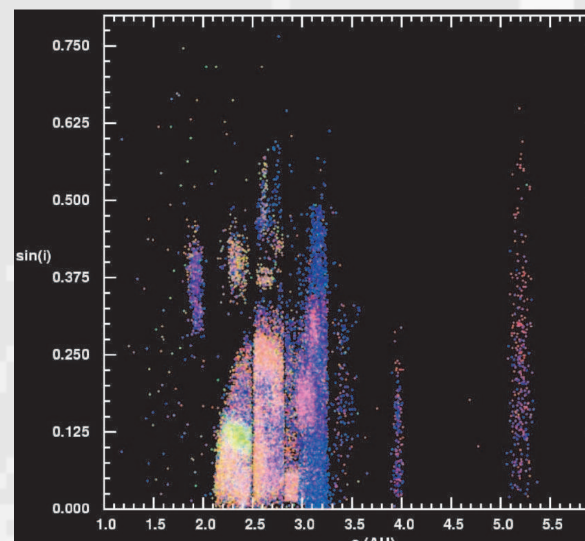
Photometric phasecurves provide a proxy for albedo and surface properties



Oszkiewicz+ 2011



Ivezic+ 2002



In the future, we will…

- include G_{12} (or, G_1 and G_2) slope parameters as a proxy for albedo and surface physical properties,
- use observed H distributions and G_{12} (and spectra?) in different source regions to constrain NEO model,
- construct MBO model with more reliable extrapolation to smaller sizes by using constraints from NEOs.

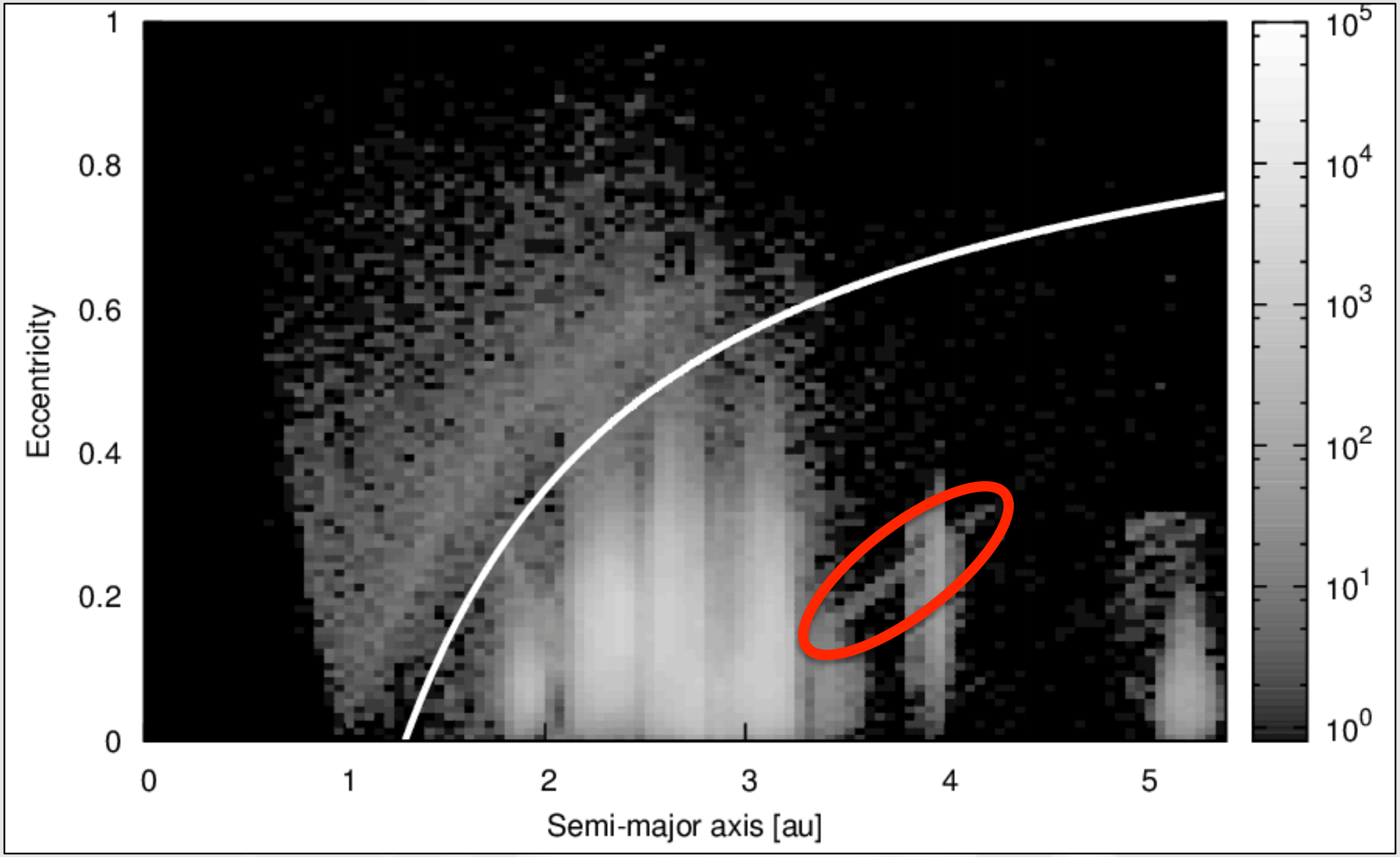
WHAT DOES GAIA PROVIDE?

Gaia provides...

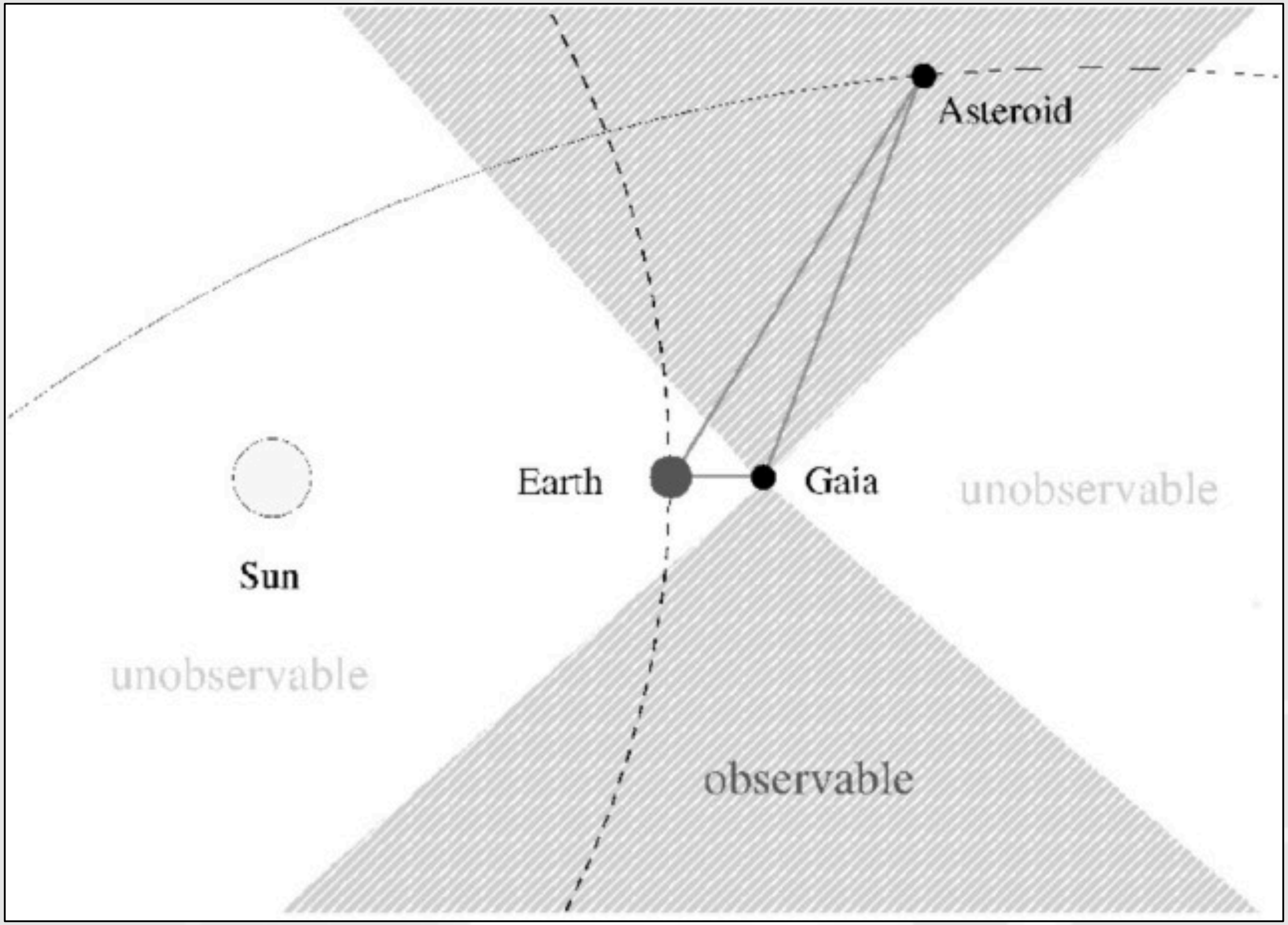
- a stable and well-understood all-sky survey,
- superb astrometry for new (and old!) discoveries,
- photometric and spectrometric characterization for a large fraction of the asteroid population,
- that is, orbits, H & G_{12}, spectral classification, asteroid families, *high-quality metadata*, etc.

WHAT IS GAIA-FUN-SSO'S ROLE?

Astrometric follow-up



Gaia does not produce photometry in the direction of opposition – need for photometric follow-up



Eggl and Devillepoix

Summary

- Reliable extrapolations to sizes below the completeness level currently only available for NEOs – simple extrapolation for MBOs and JTOs.
- Simultaneous modeling of the NEO and MBO populations will have a major impact on our understanding of both populations – physical properties for NEOs, smaller sizes for MBOs.
- Gaia offers a survey from a stable and well-understood platform, producing orbits, phase-curve parameters, and spectra.
- Gaia-FUN-SSO is a critical component in ensuring astrometric follow-up for new (NEO) discoveries and could also be critical in ensuring high-accuracy photometric (NEO) follow-up at small phase angles.