MEĐUZVEZDANI ASTEROIDI I KOMETE

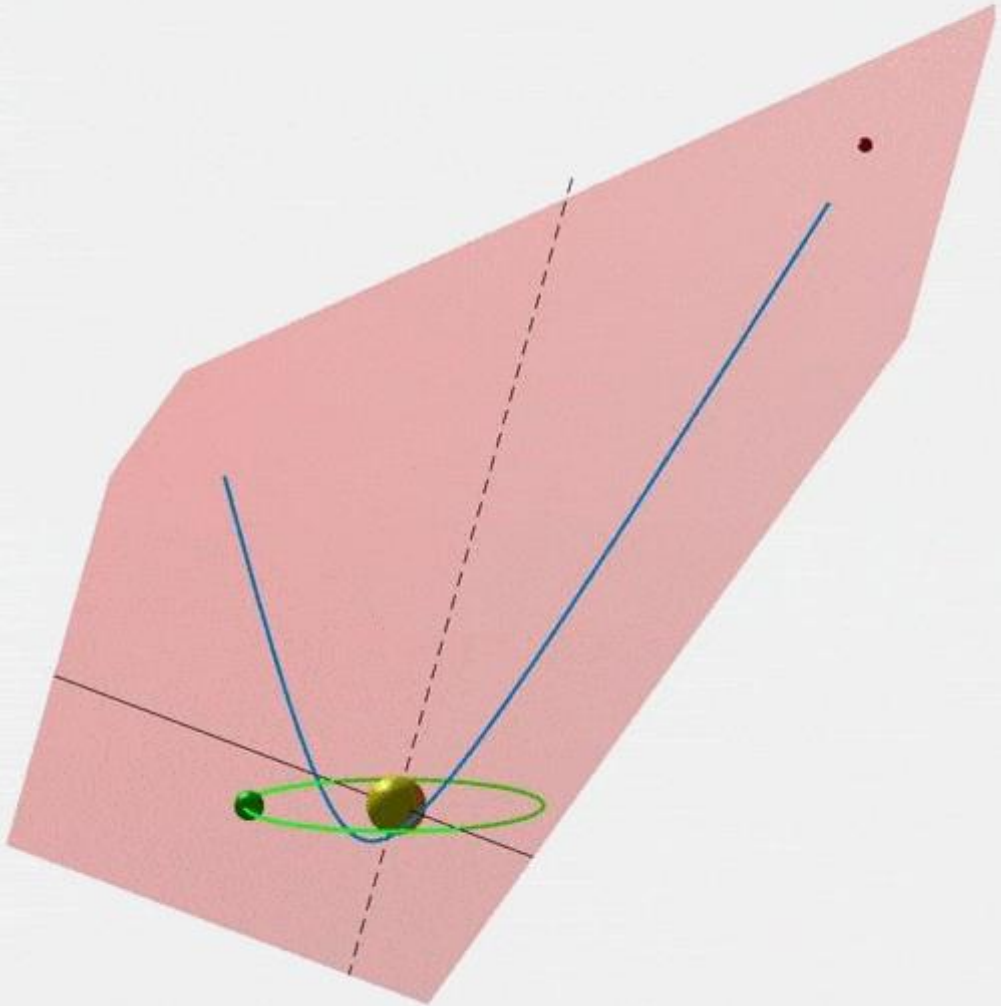
Dušan Marčeta

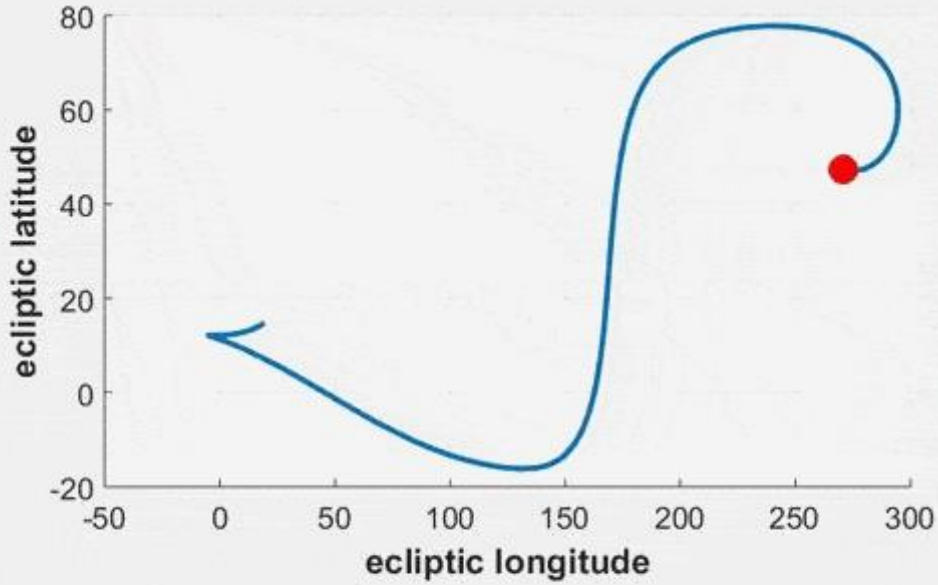
Seminar Katedre za astronomiju
19. 02. 2019.

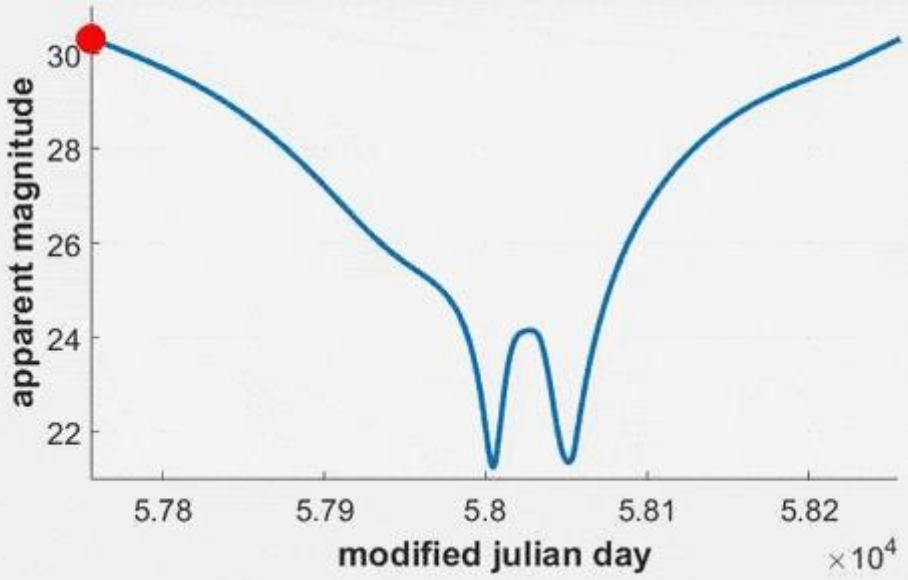
1I/2017U1 (`OUMUAMUA)

First distant messenger

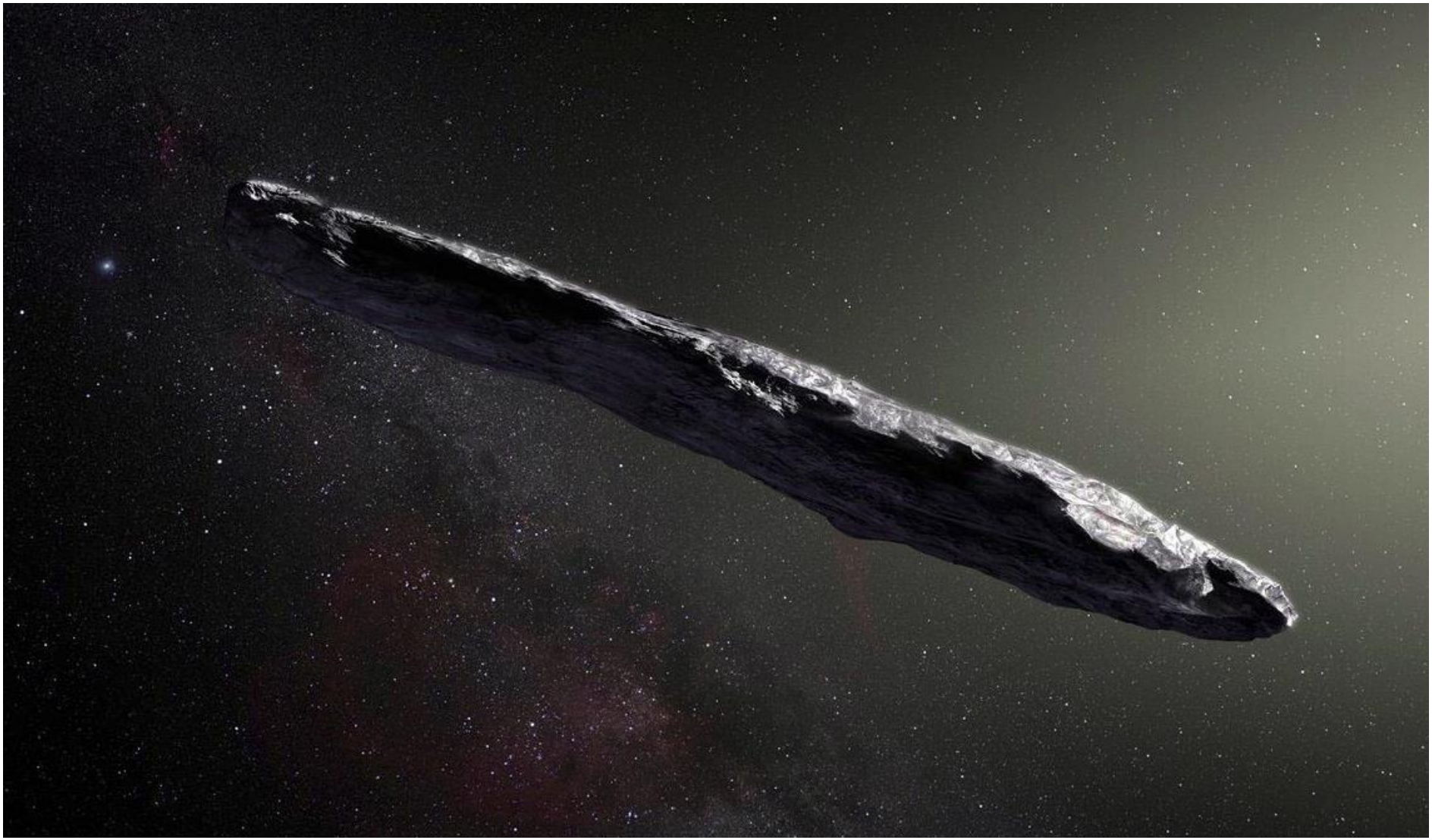
Meech et al., Nature, 2017





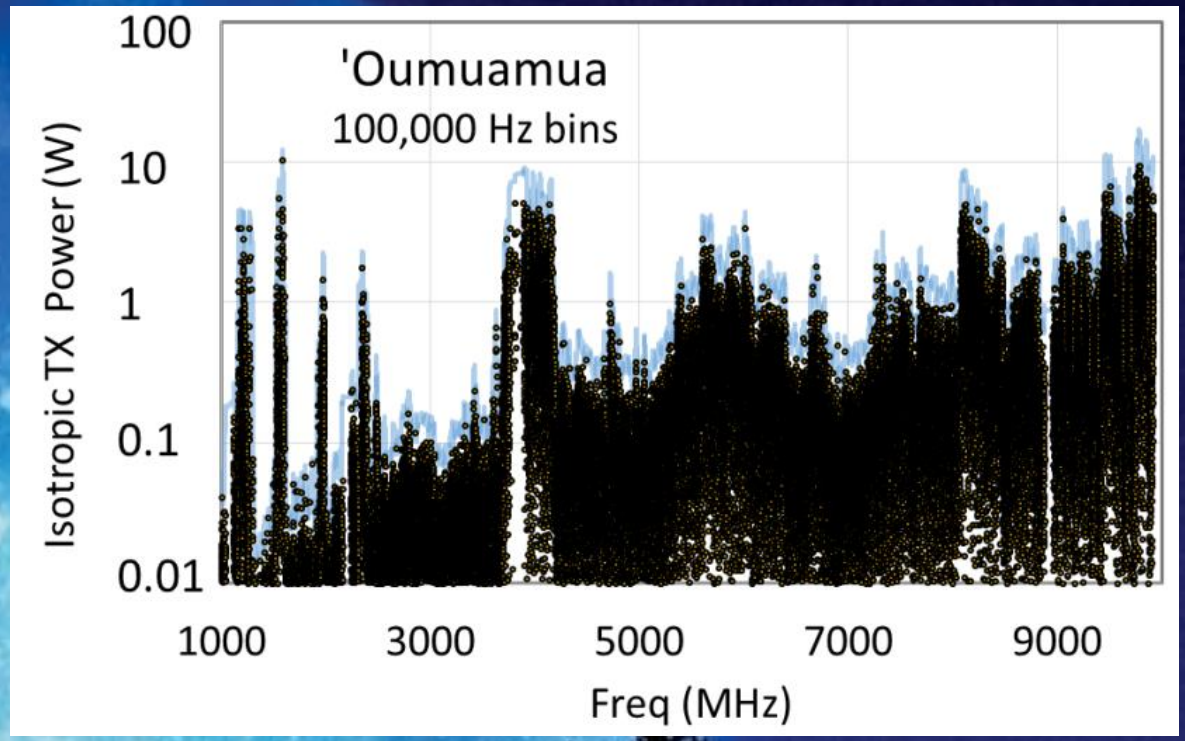


Šta nije u redu sa `OUMUAMUA?



Allen Telescope Array

Harp et al., Acta Astronautica, 2019.



"We made a careful search for artificial emissions from three nearby asteroids, including the interstellar object 'Oumuamua. No evidence for such emissions were found in the observational data."

Šta je`Oumuamua i odakle dolazi?

Broj radova zaključno sa 2016. godinom

Izvor: ADS

Interstellar + comet	Interstellar + asteroid	Interstellar + asteroid - comet
317	10	6

Meech, et al., 2016. $(200 - 10000) : 1$

Serijal AS radova

‘Oumuamua as an extinct fragment of an ejected cometary planetesimal (Raymond, at al., 2018)

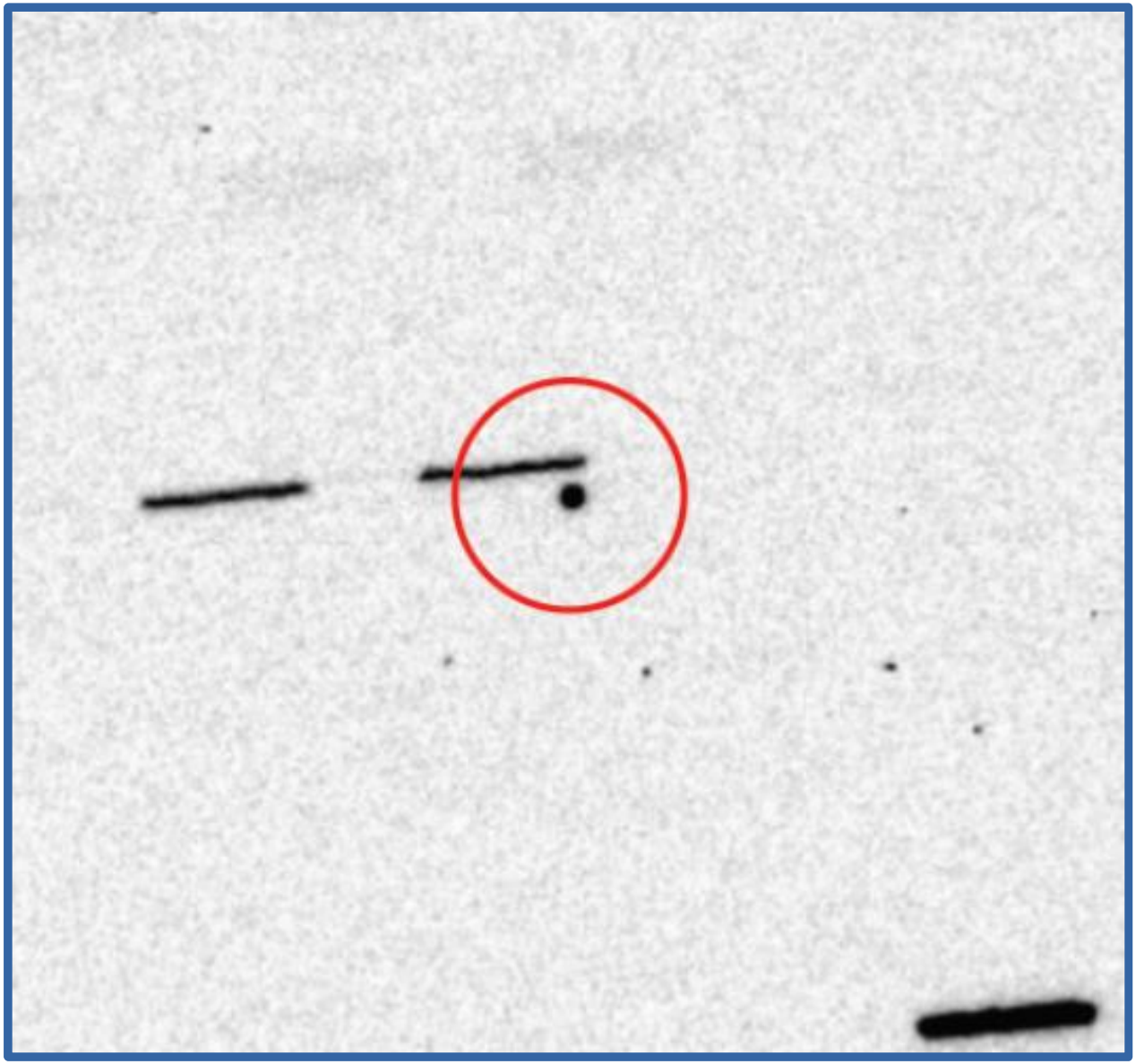
‘Oumuamua as a tidal disruption fragment from a binary star system (Ćuk, 2018)

‘Oumuamua-like interstellar asteroids as possible messengers from dead stars (Rafikov, 2018)

‘Oumuamua as debris of dwarf interstellar comet that disintegrated before perihelion (Sekanina, 2019)

...

Asteroid ili kometa!?



CFHT
22. oktobar 2017.
Meech et al., 2017.
Nema kome!

Apache Point Observatory
29. oktobar 2018.
Bolin et al., 2018.
Nema kome!

Micheli et al., 2018.
Nešto nije u redu sa orbitom!

Asteroid ili kometa!?

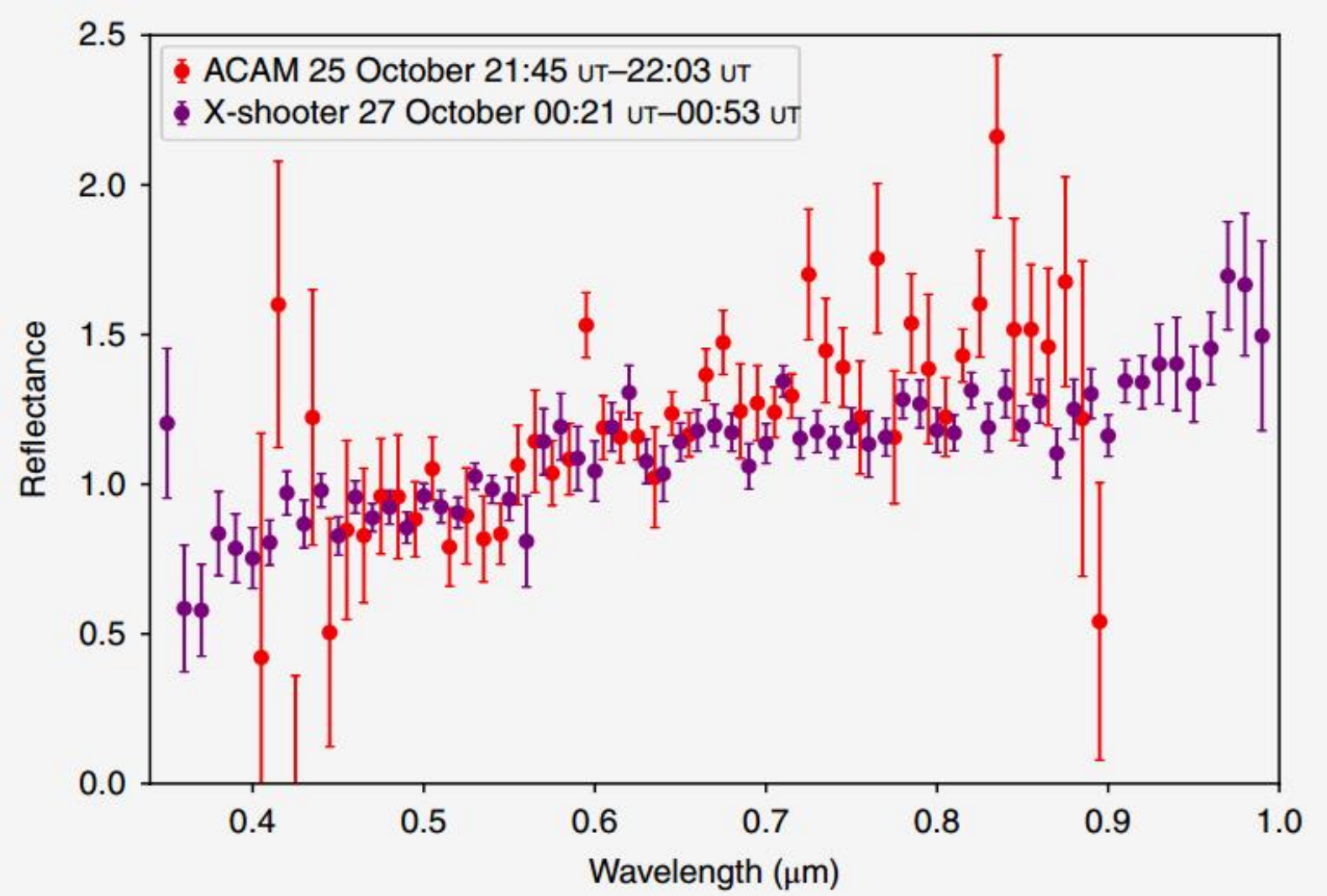
“Our analysis shows that the observed orbital arc cannot be fitted in its entirety by a trajectory governed solely by gravitational forces due to the Sun, the eight planets, the Moon, Pluto, the 16 largest bodies in the asteroid main belt and relativistic effects.”

The lack of observed dust lifted from the object by the hypothesized cometary activity can be explained by an atypical dust-grain size distribution that is devoid of small grains, a low dust-to-ice ratio or surface evolution from its long journey.

Rafikov, 2018.

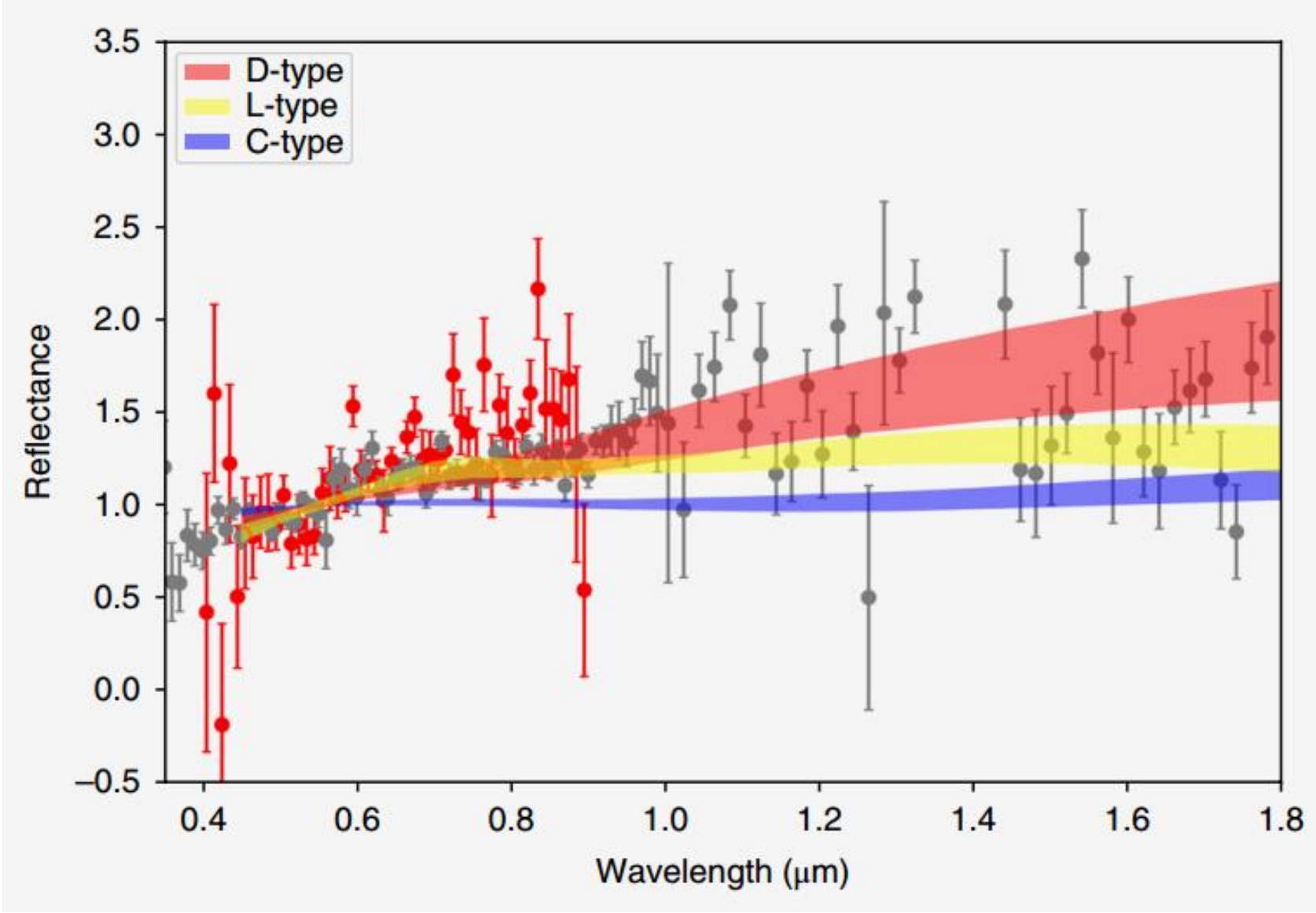
Onda nešto nije u redu sa rotacijom!

Šta kaže spektar?



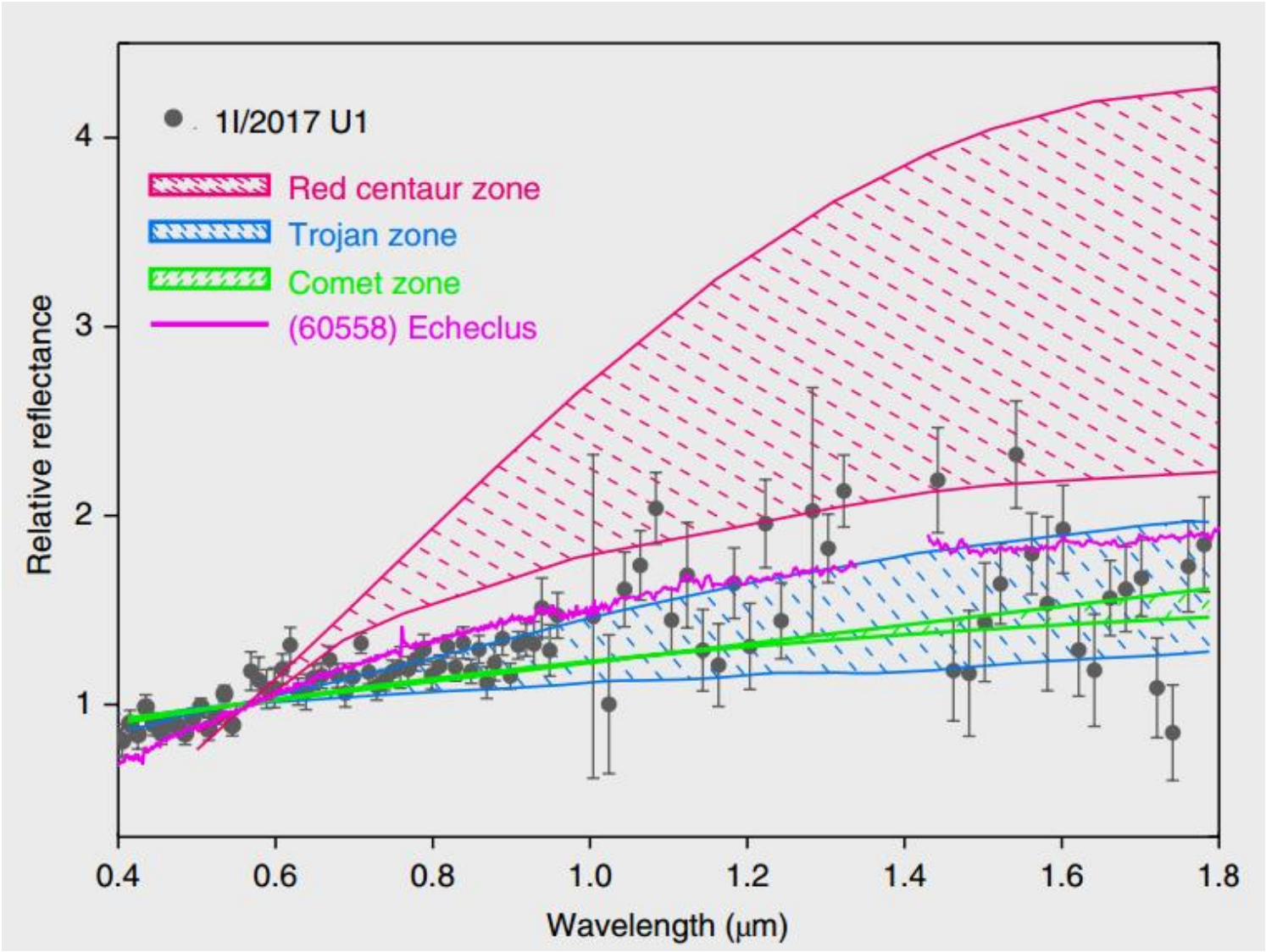
Fitzsimmons et al., Nature Astronomy Letters, 2018.

Šta kaže spektar?



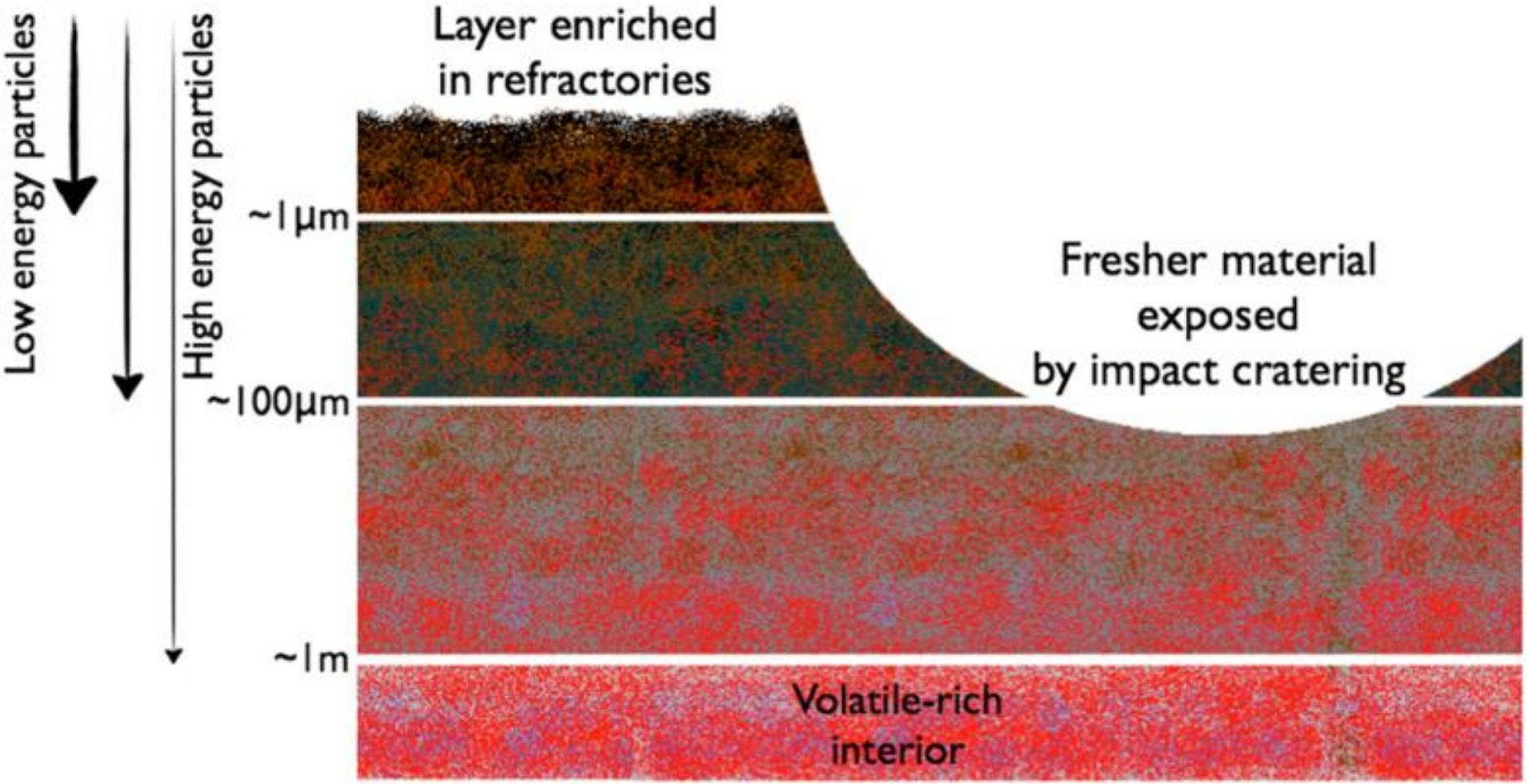
Fitzsimmons et al., Nature Astronomy Letters, 2018.

Šta kaže spektar?



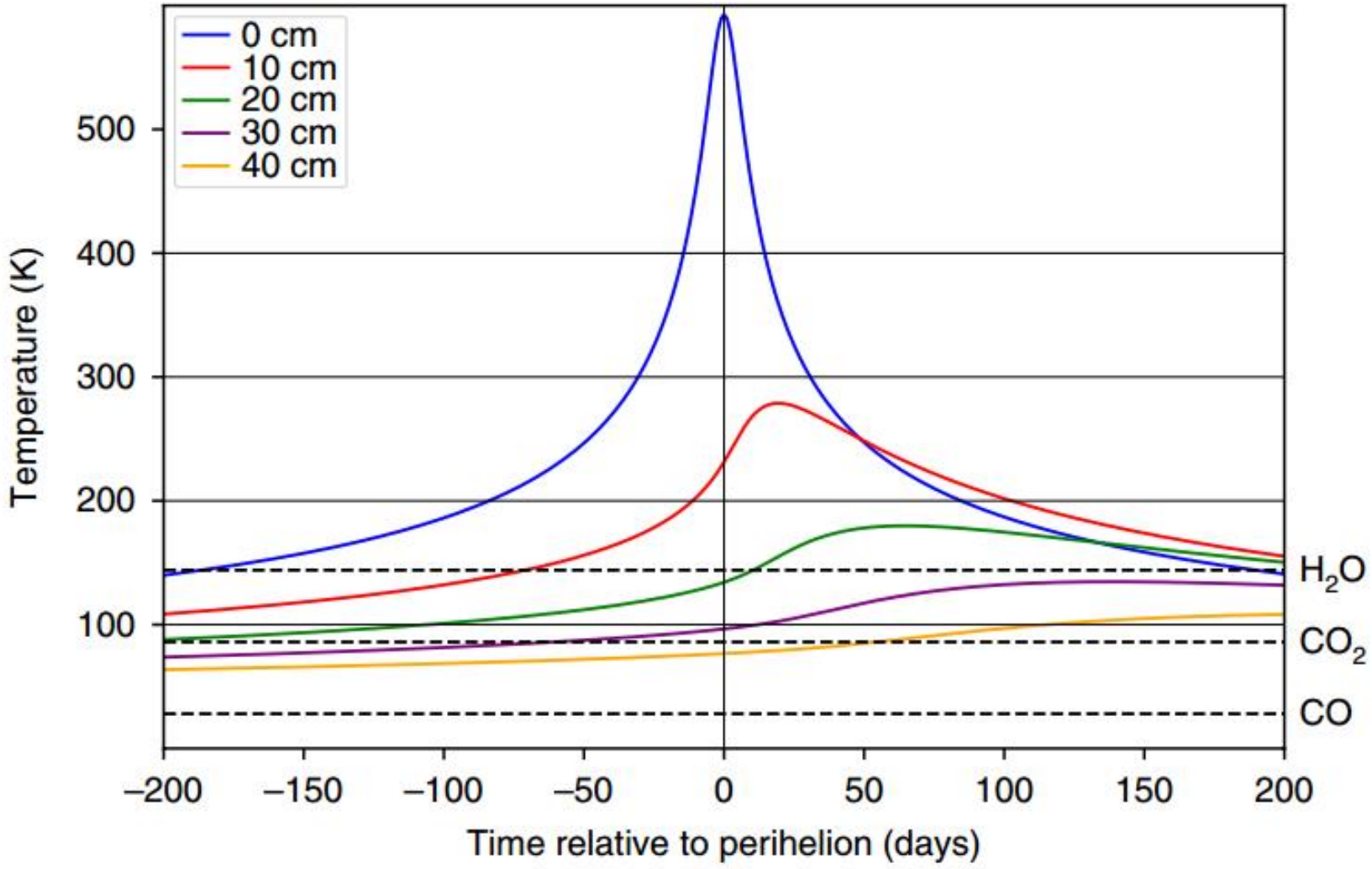
Fitzsimmons et al., Nature Astronomy Letters, 2018.

Zašto nije uočena kometarna aktivnost?



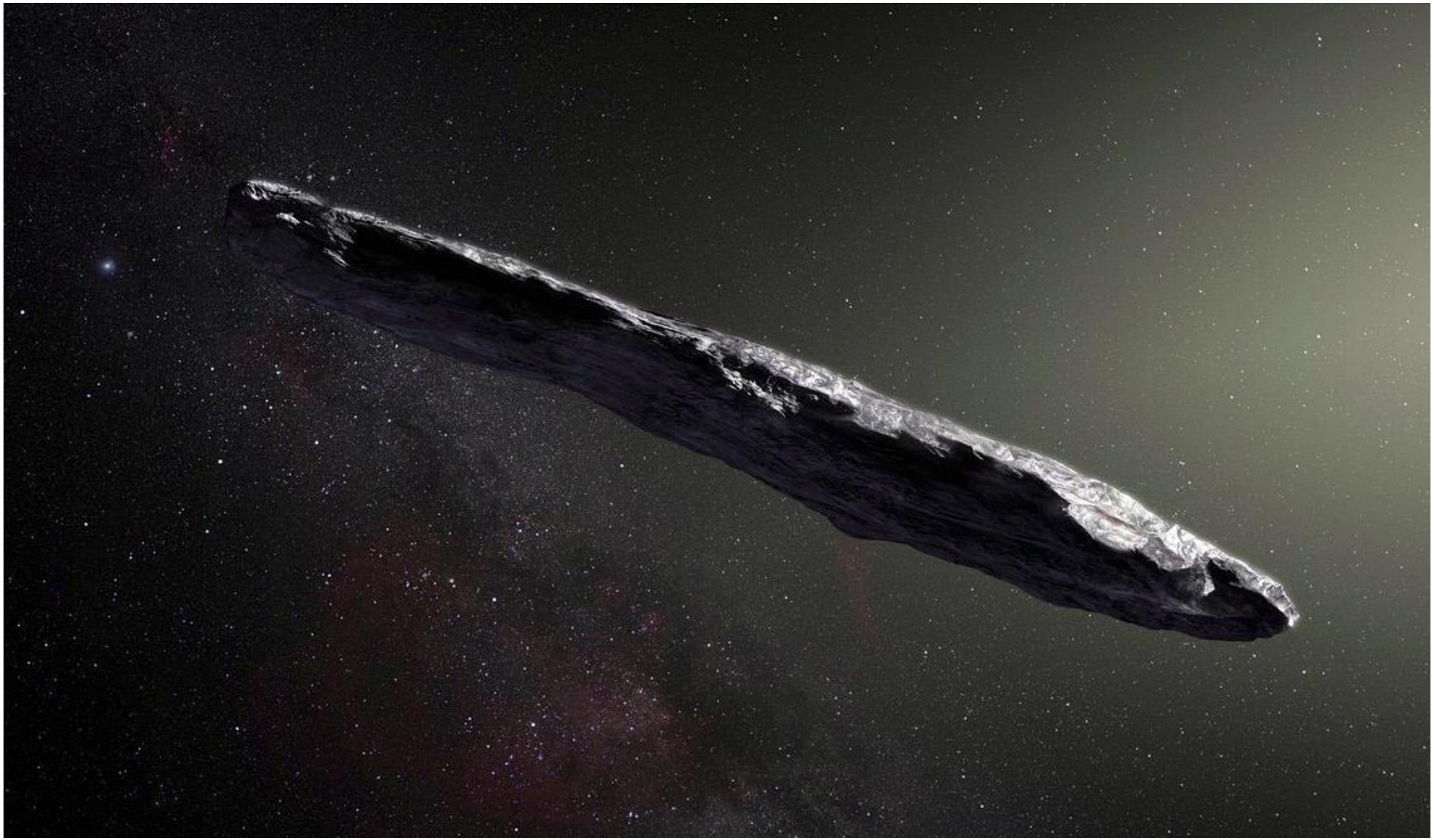
Lepoutre et al., Space Sicence Reviews, 2015.

Zašto nije uočena kometarna aktivnost?



Fitzsimmons et al., Nature Astronomy Letters, 2018.

Kakvog je oblika `Oumuamua?



Ekstremi u Sunčevom sistemu

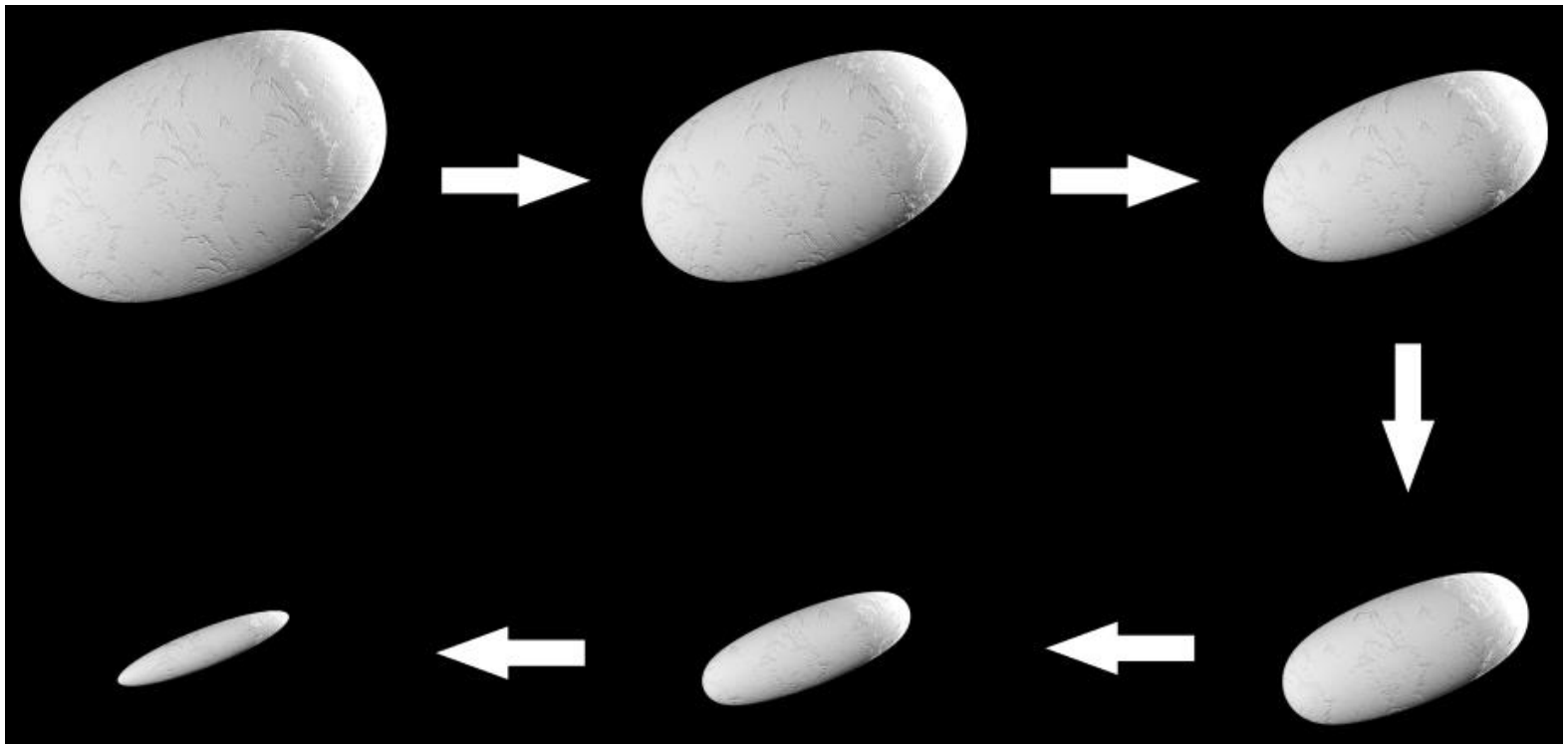
$2 : \sqrt{2} : 1$ (Ryan, 2000)

Durech et al., A&A, 2018.

$\Delta H \approx 2.3$

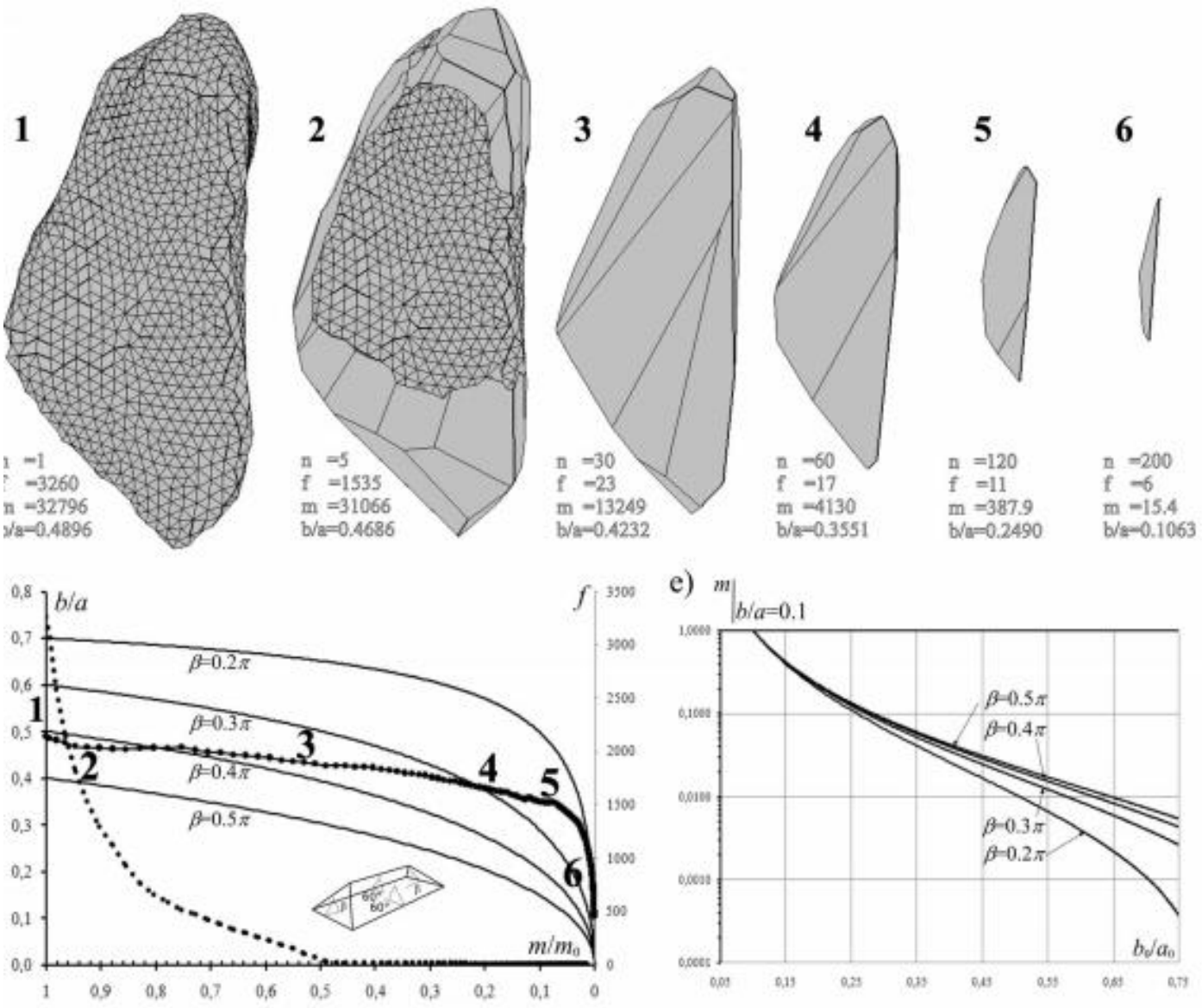
a/c ≃ 4.5
b/c ≃ 1.5

Zašto je `Oumuamua toliko izdužen?
Model izotropne erozije

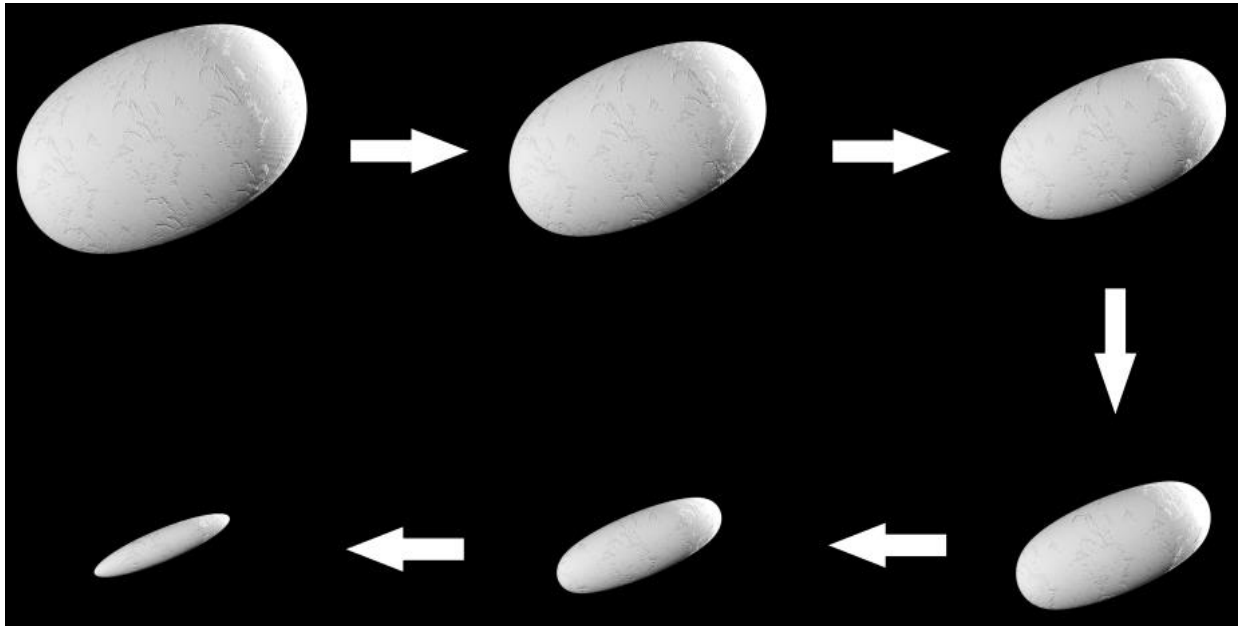


(Vavilov & Medvedev, MNRAS, 2018.)

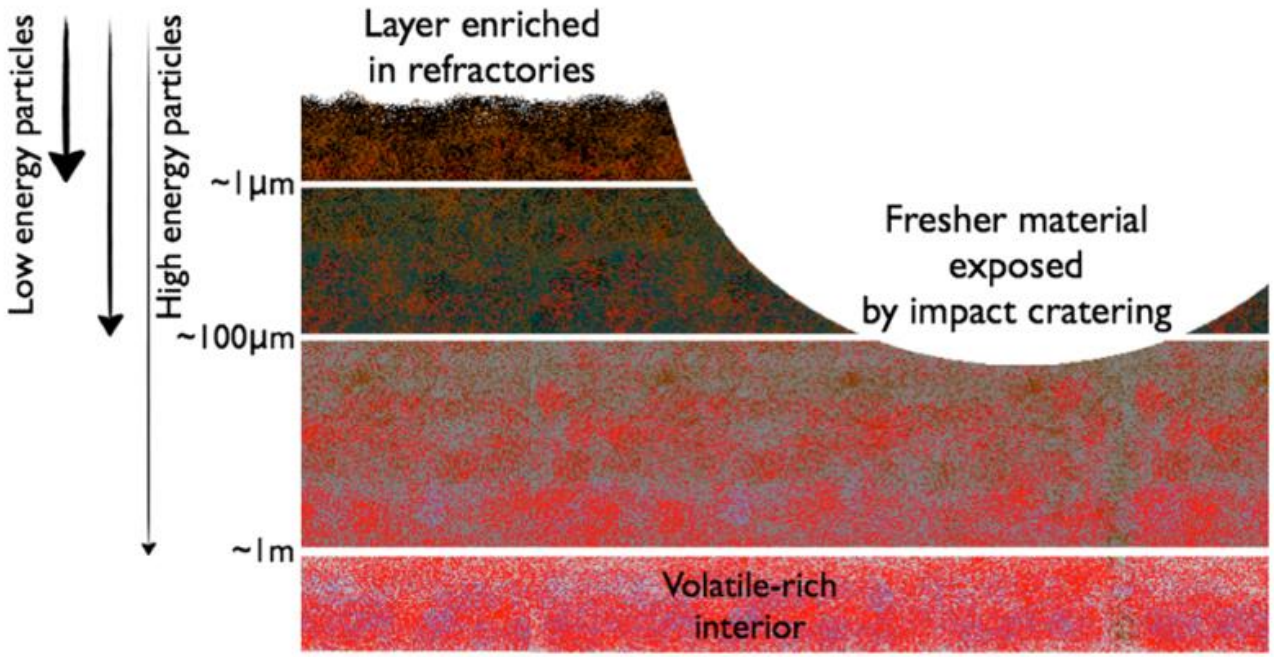
Eikonal abrasion model



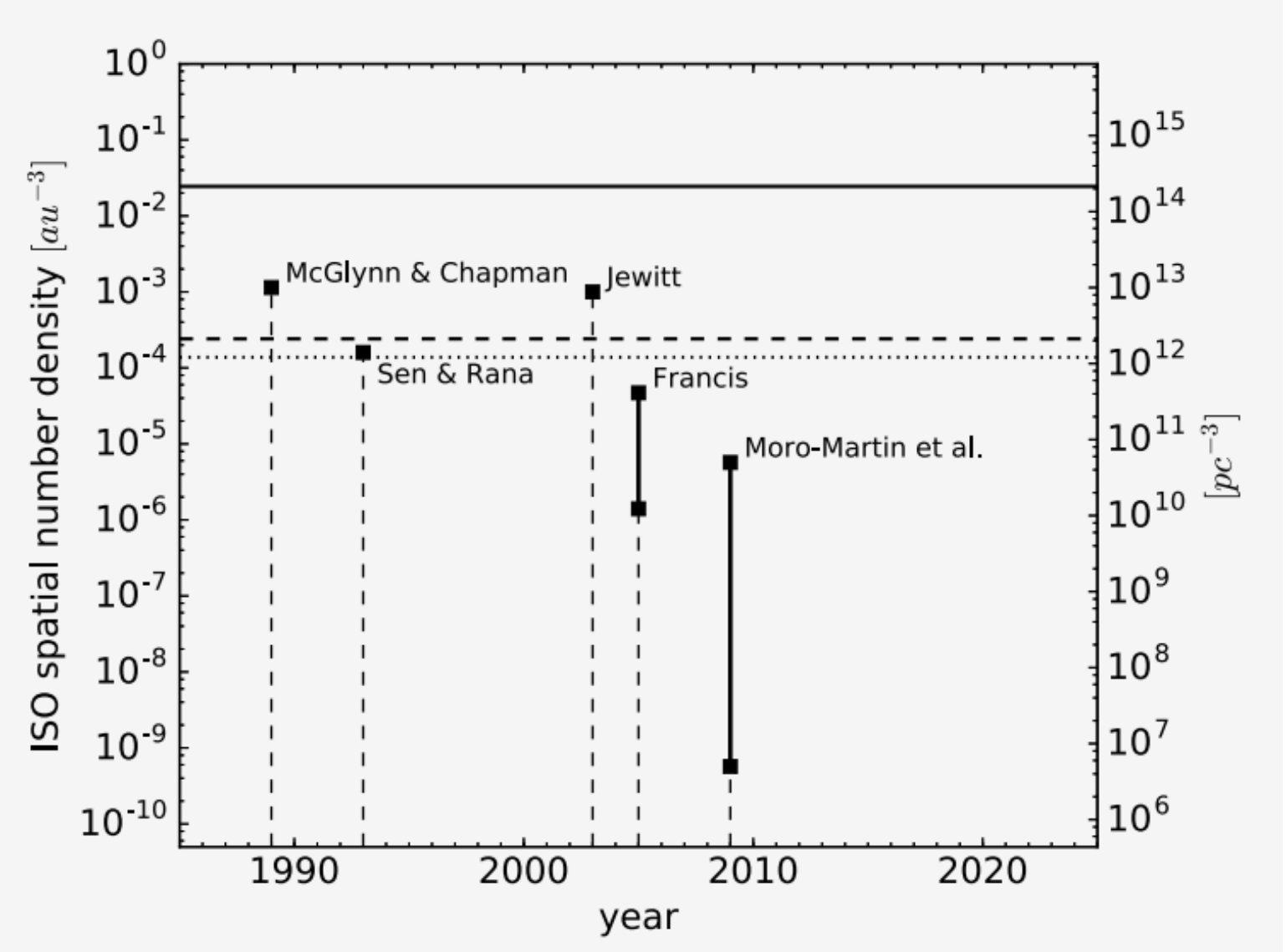
Domokos et al., 2017



VS


Low energy particles
High energy particles
Layer enriched
in refractories
~1µm
~100µm
~1m
Fresher material
exposed
by impact cratering
Volatile-rich
interior

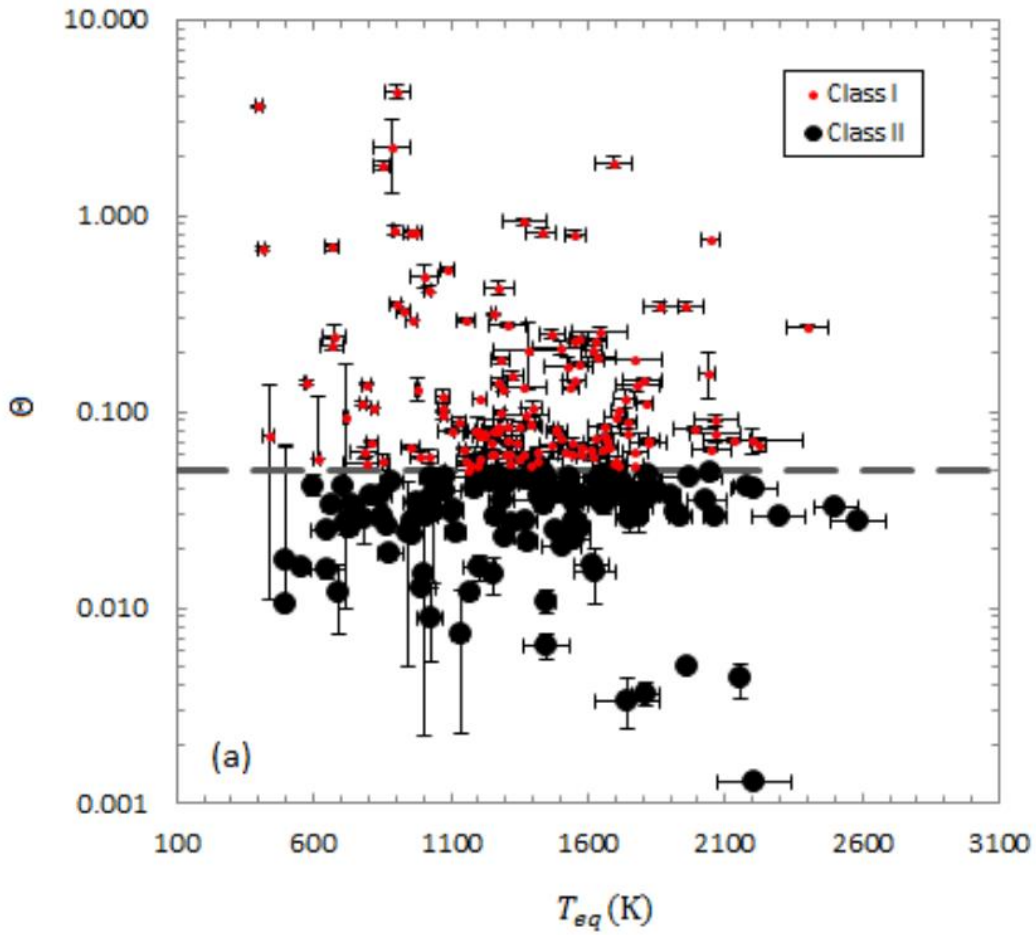
Koliko ih je?



Engelhardt et al., 2017.

Kako su dospeli u međuzvezdani prostor?

Izbacivanje planetezimala na hiperboličke orbite nakon bliskih prilaza velikim planetama, tokom evolucije planetarnih sistema



Öztürk & A. Erdem, 2018.

Alternativni mehanizmi

Dvojni sistemi, (Ĺ uk, 2017.; Jackson, 2017.)

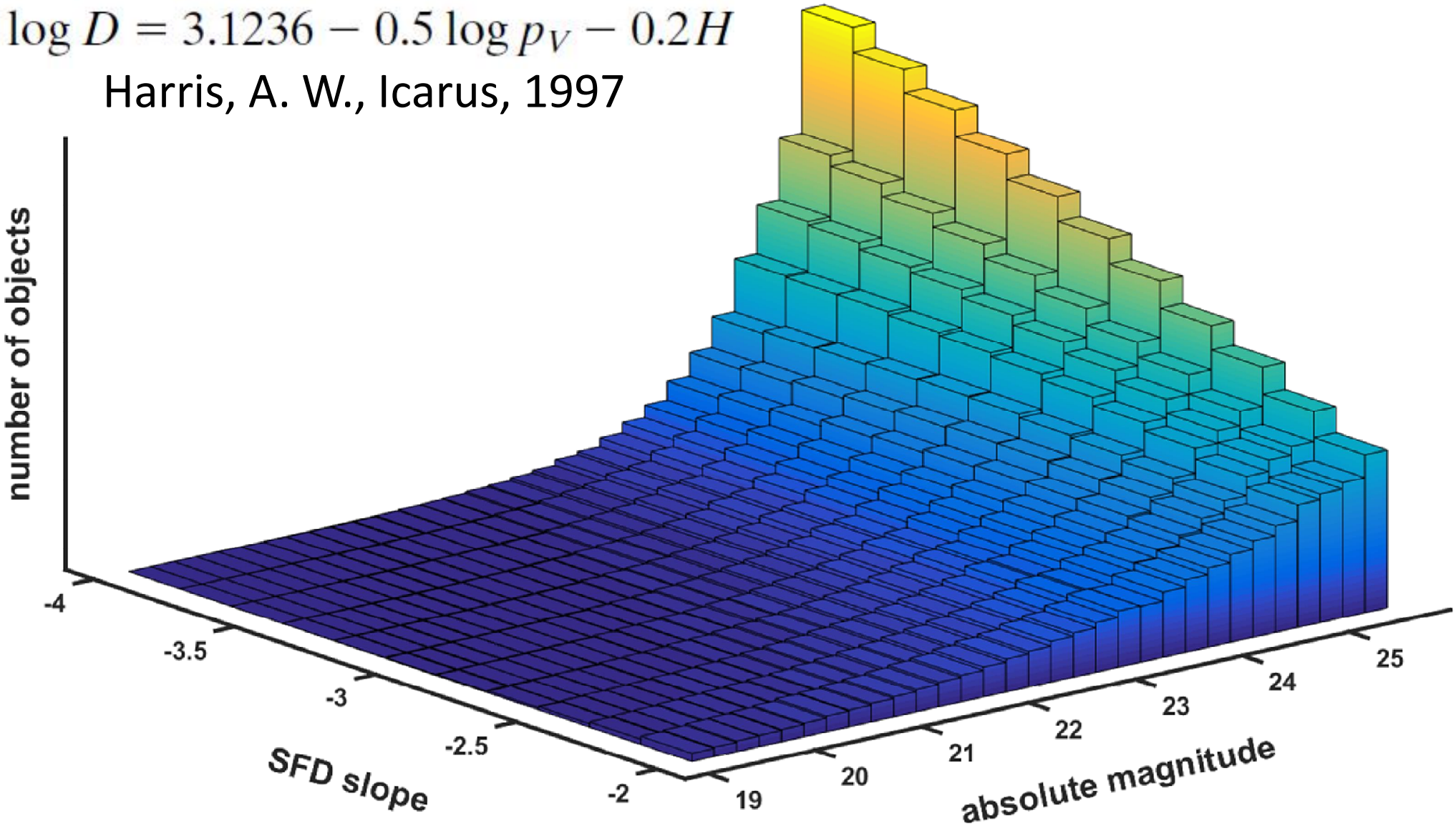
Eksplozija supernove (Rafikov, 2018.)

Raspodela po veličinama

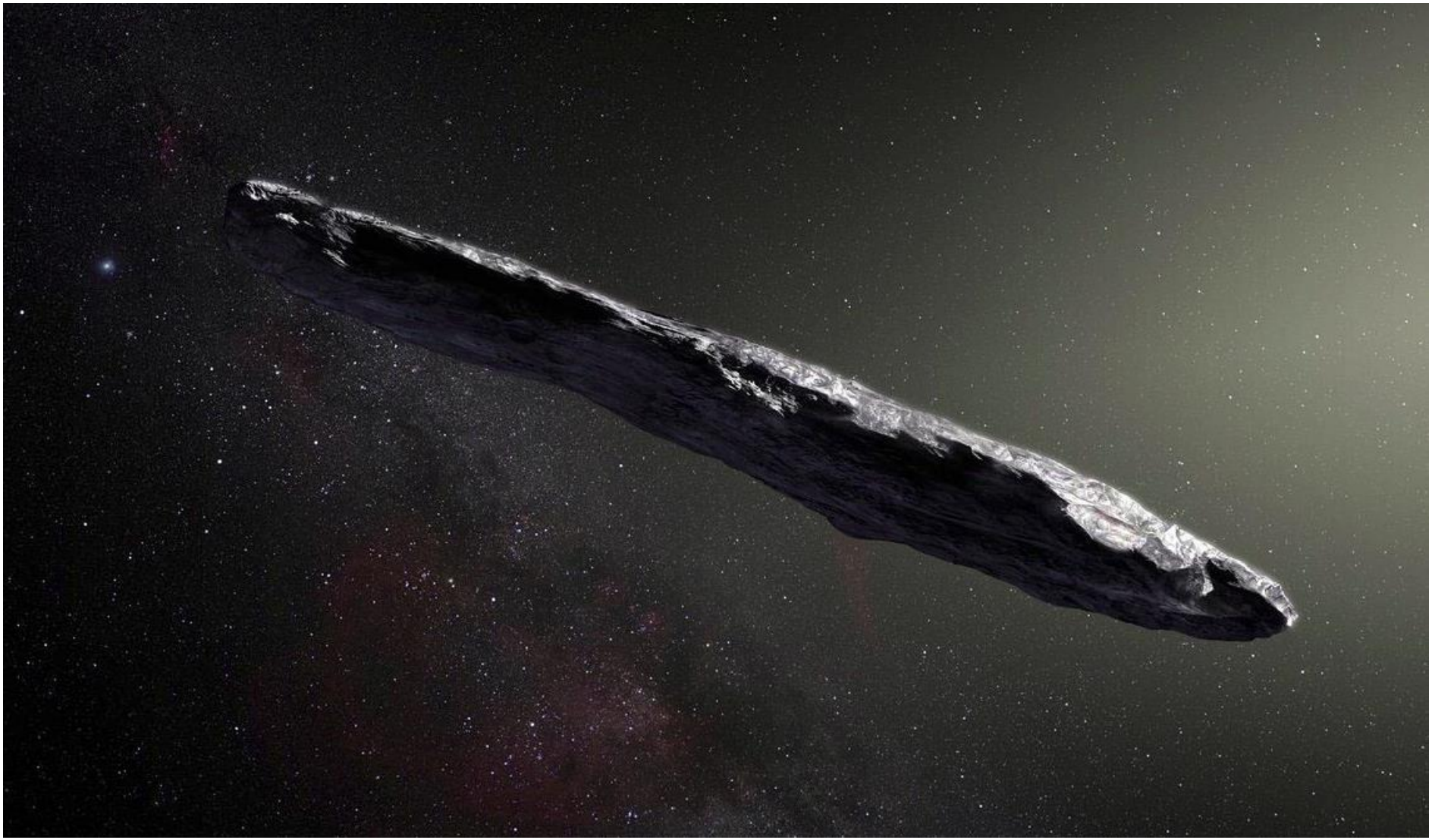
$$N(>D) \propto D^{-a}$$

$$\log D = 3.1236 - 0.5 \log p_V - 0.2H$$

Harris, A. W., Icarus, 1997

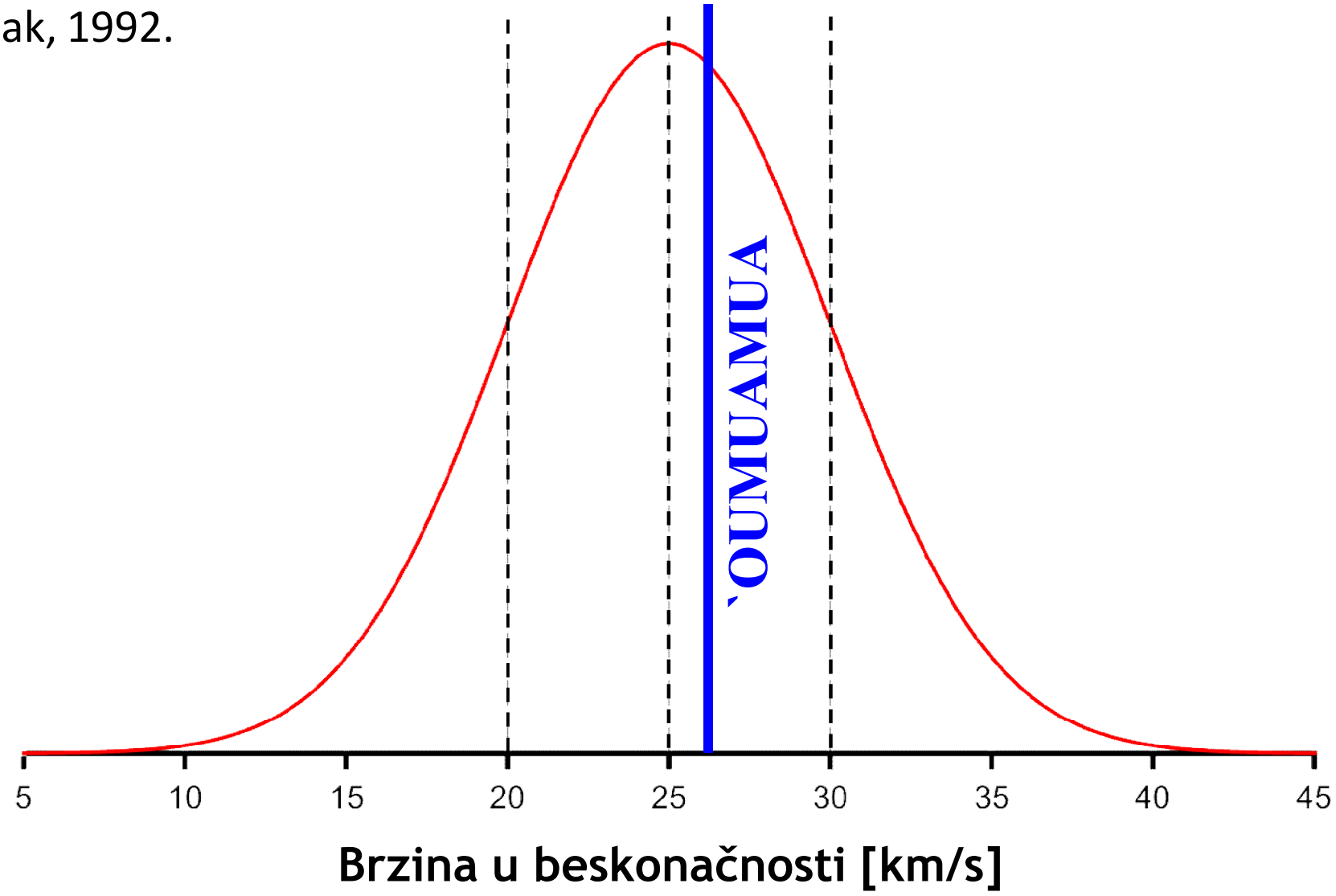


Koliko otkrića možemo očekivati u skorijoj budućnosti?



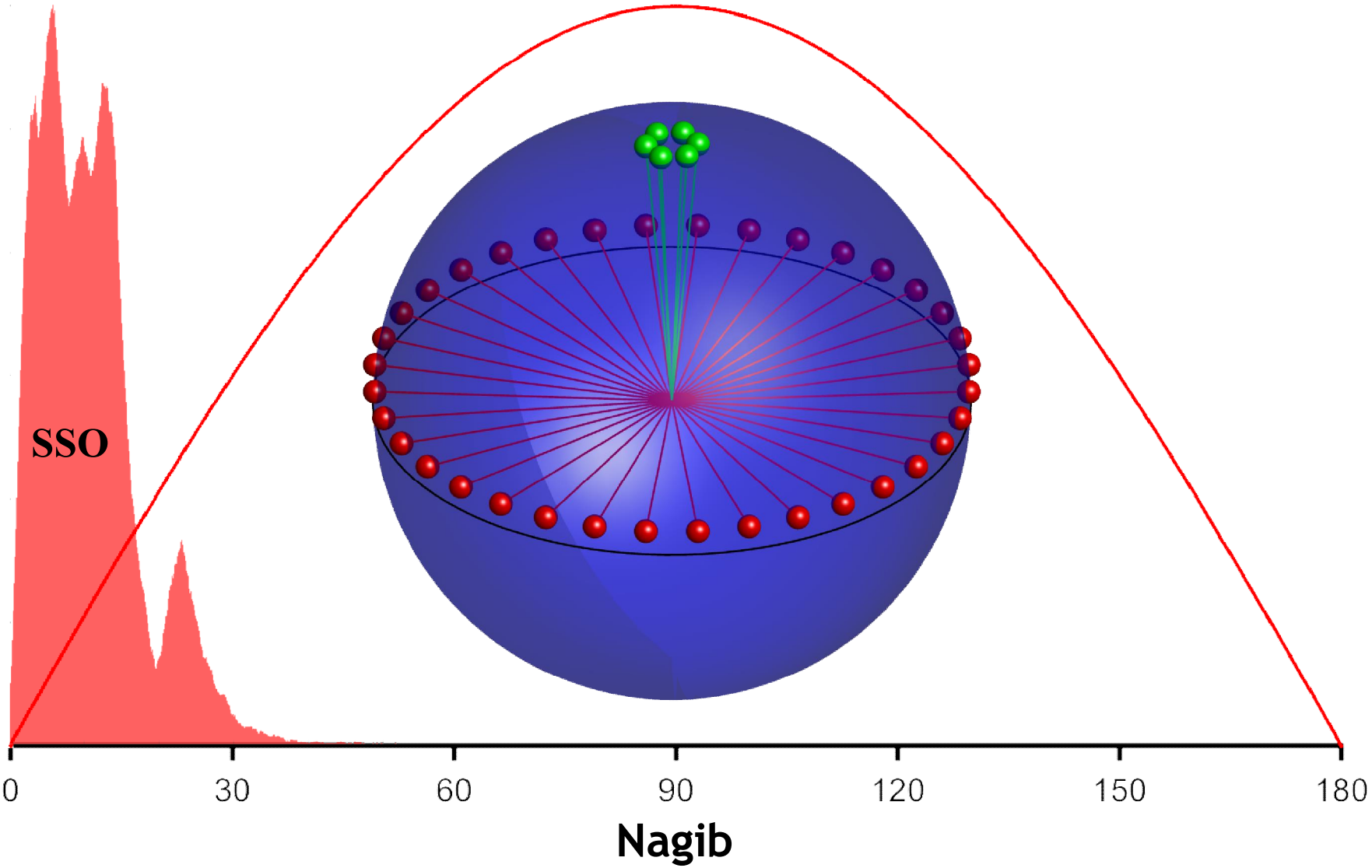
Populacija međuzvezdanih objekata

Grav et al., 2011.
Dehnen and Binney, 1998.
Kresak, 1992.

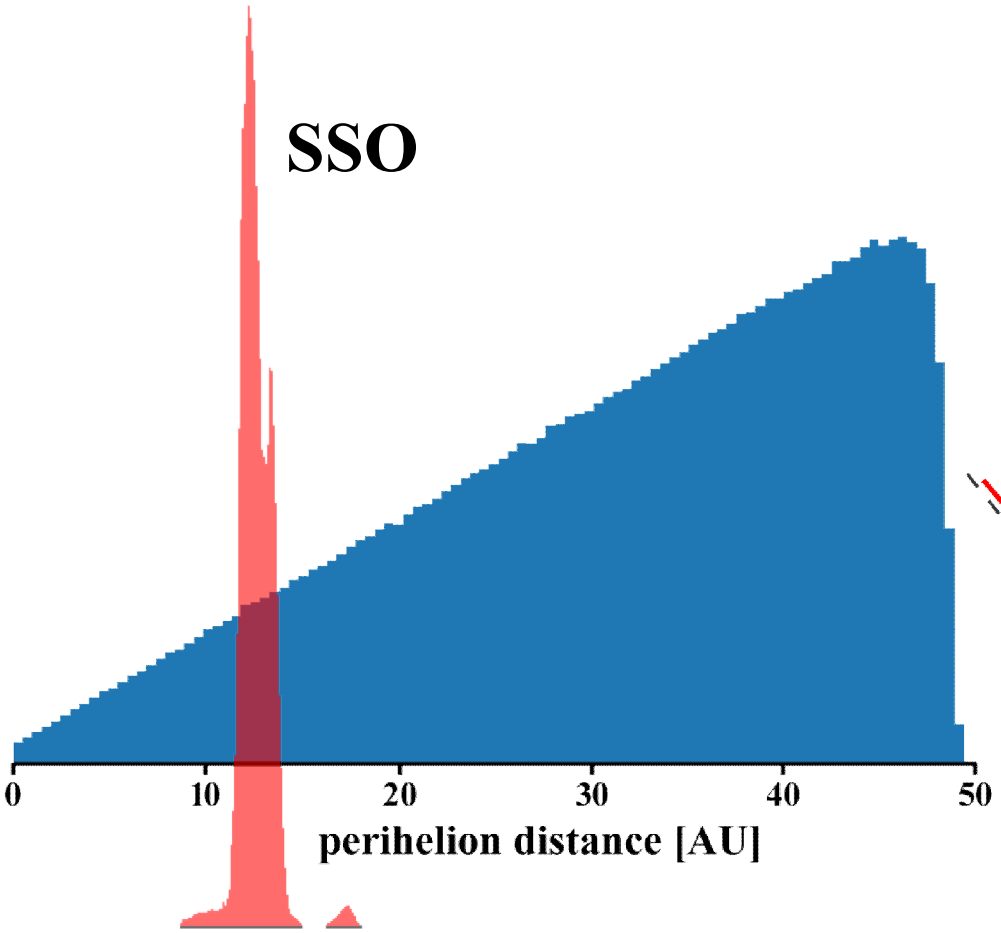


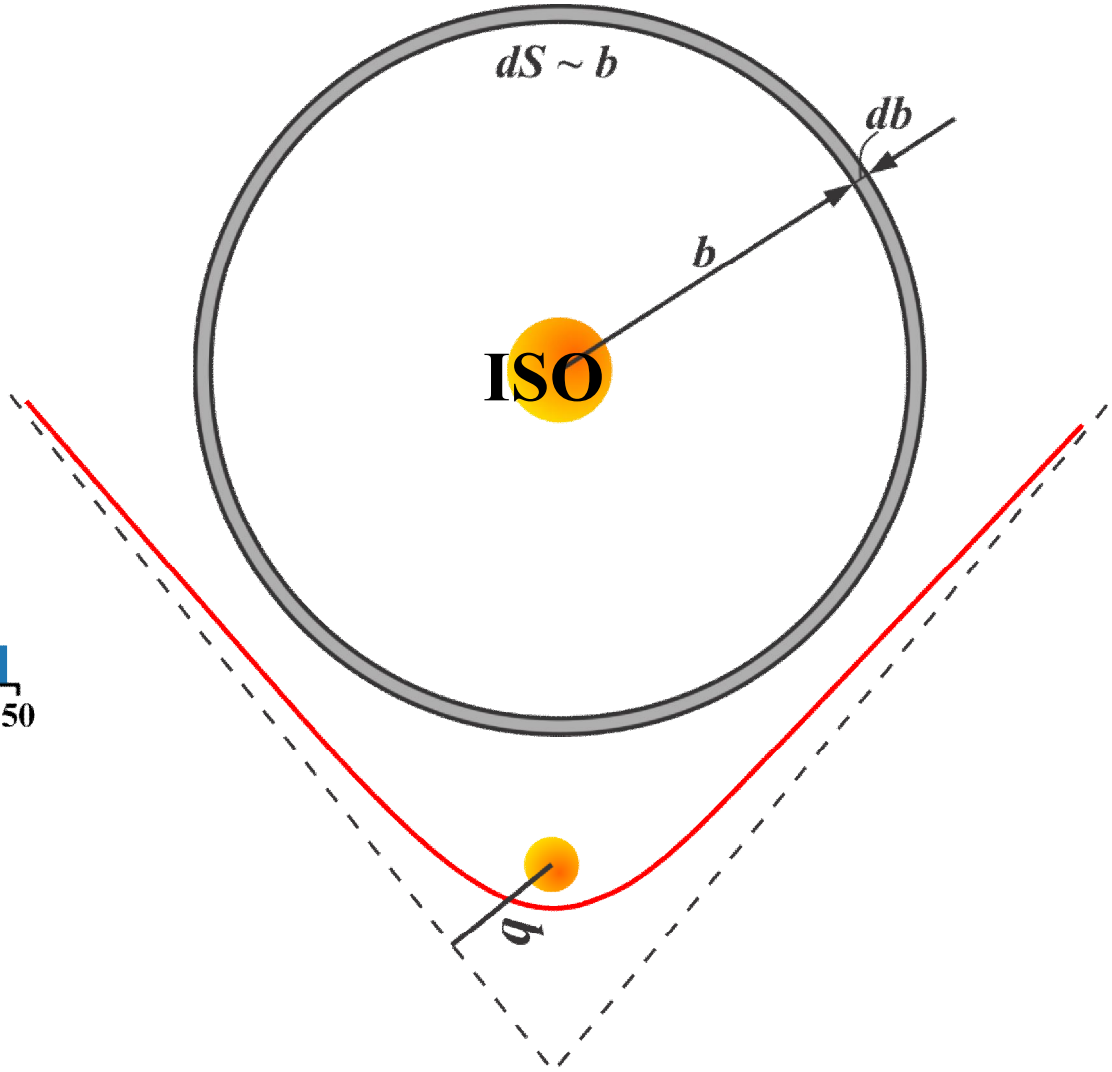
Nagibi orbitalnih ravni

Grav et al., 2011

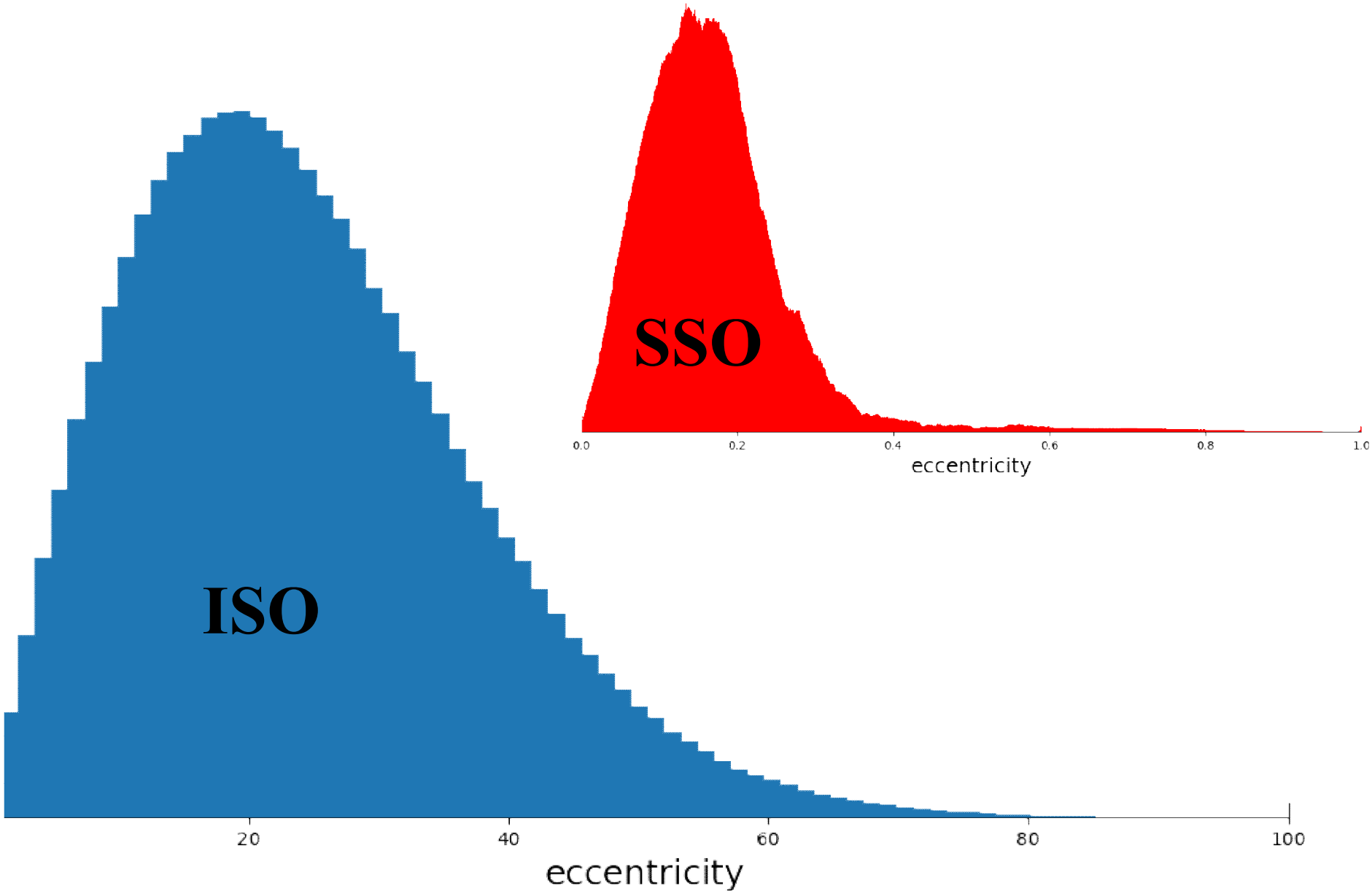


Perihelska rastojanja

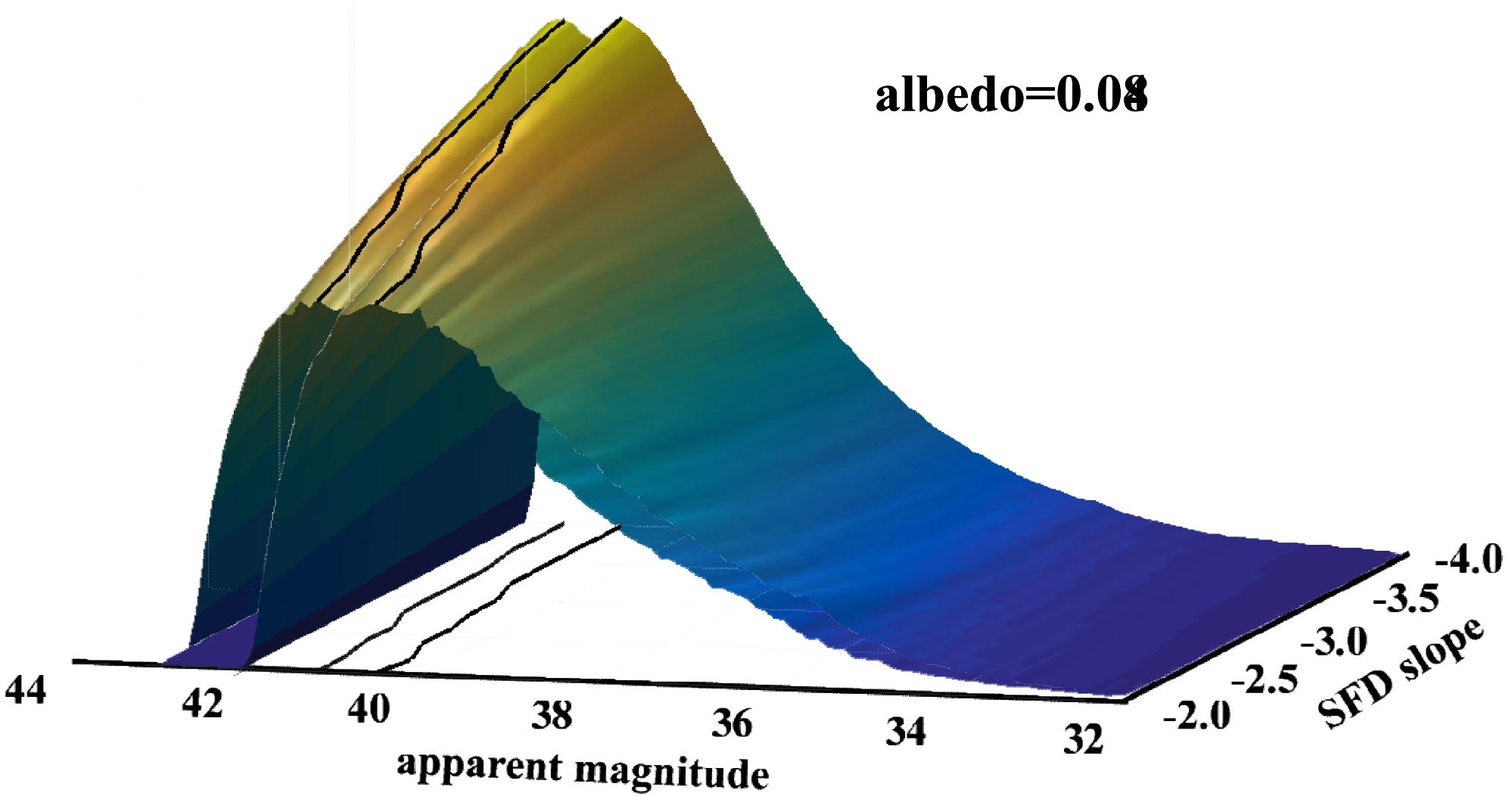




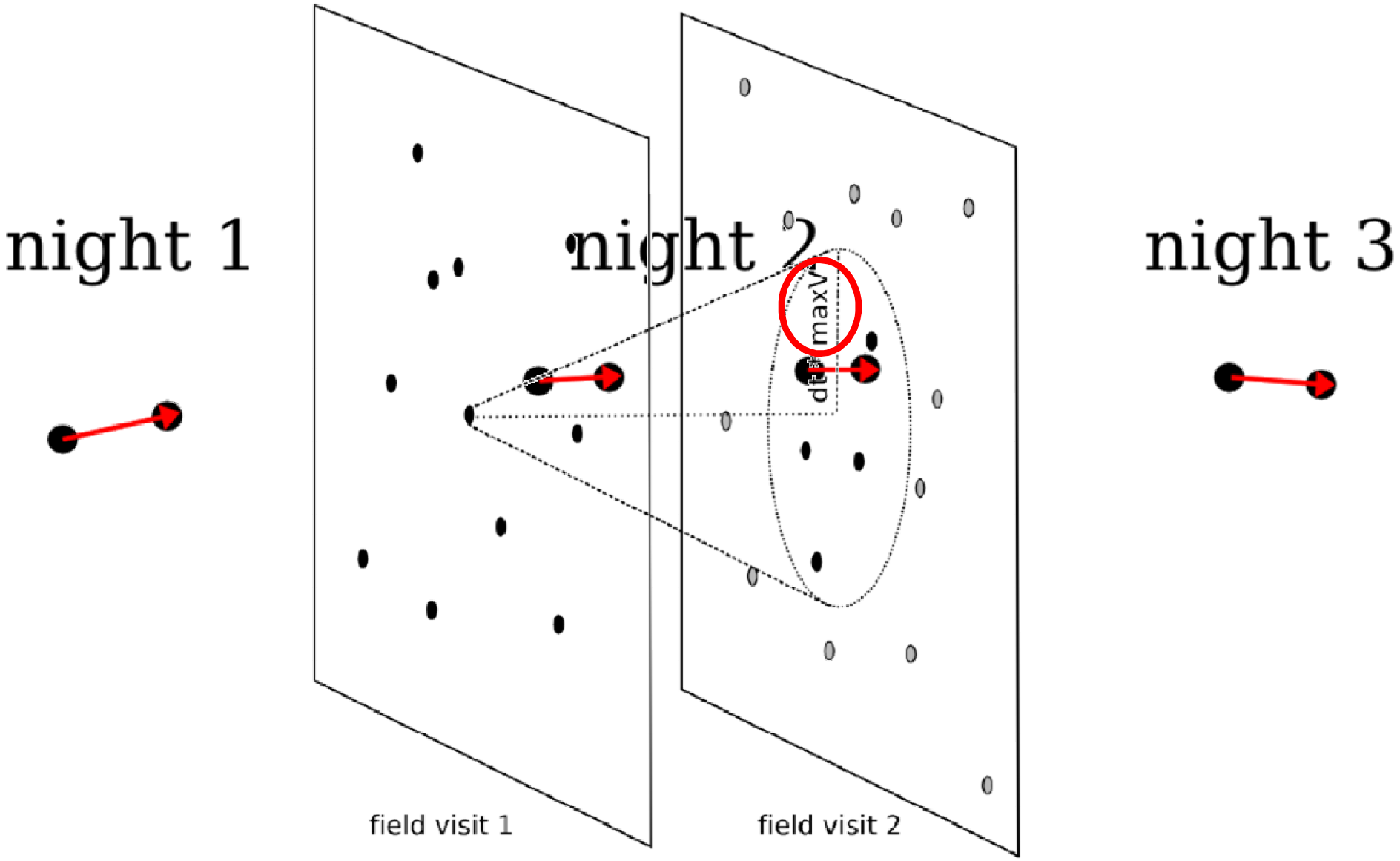
Ekscentričnost



Prividne magnitude



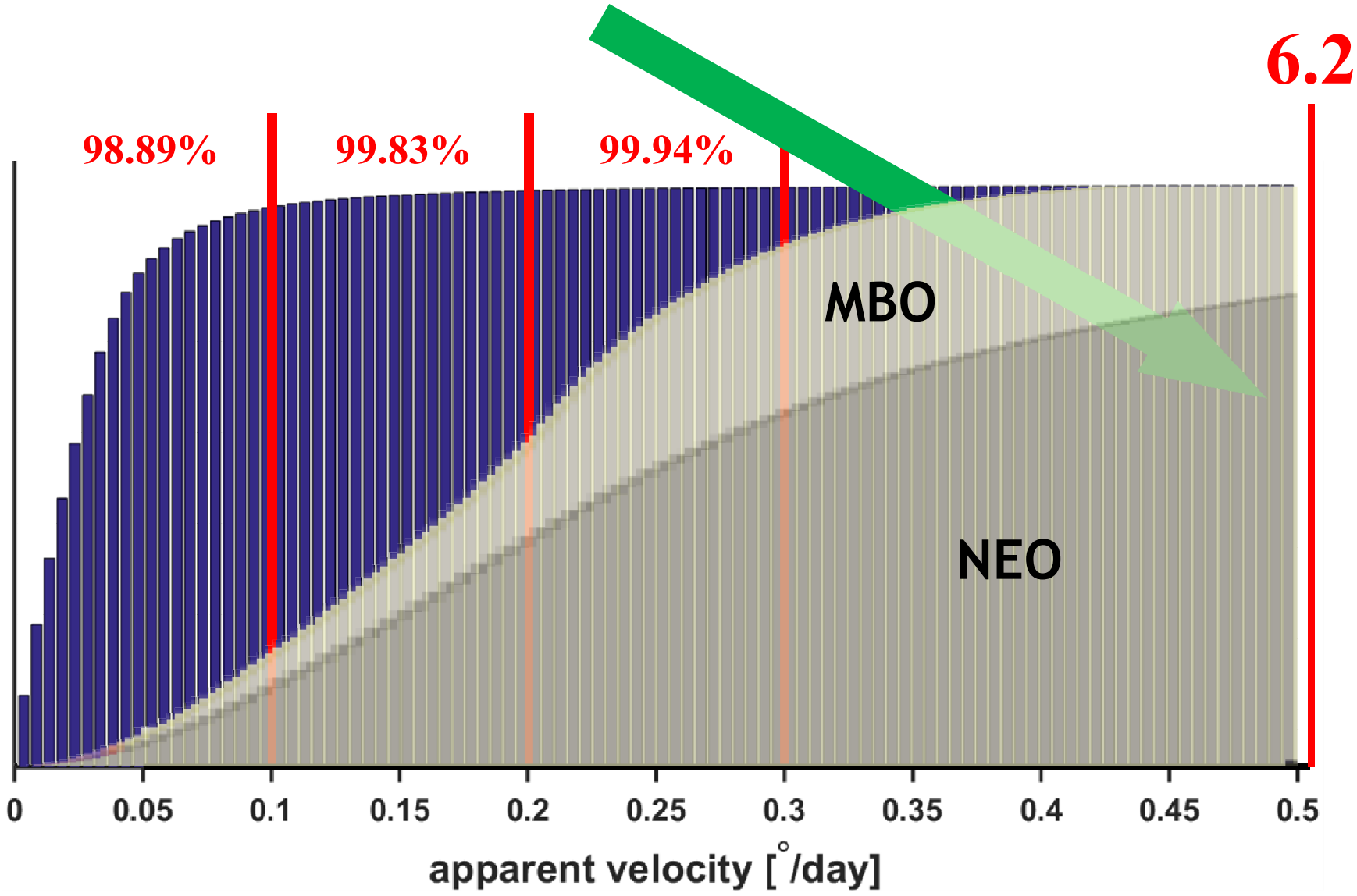
Problem povezivanja



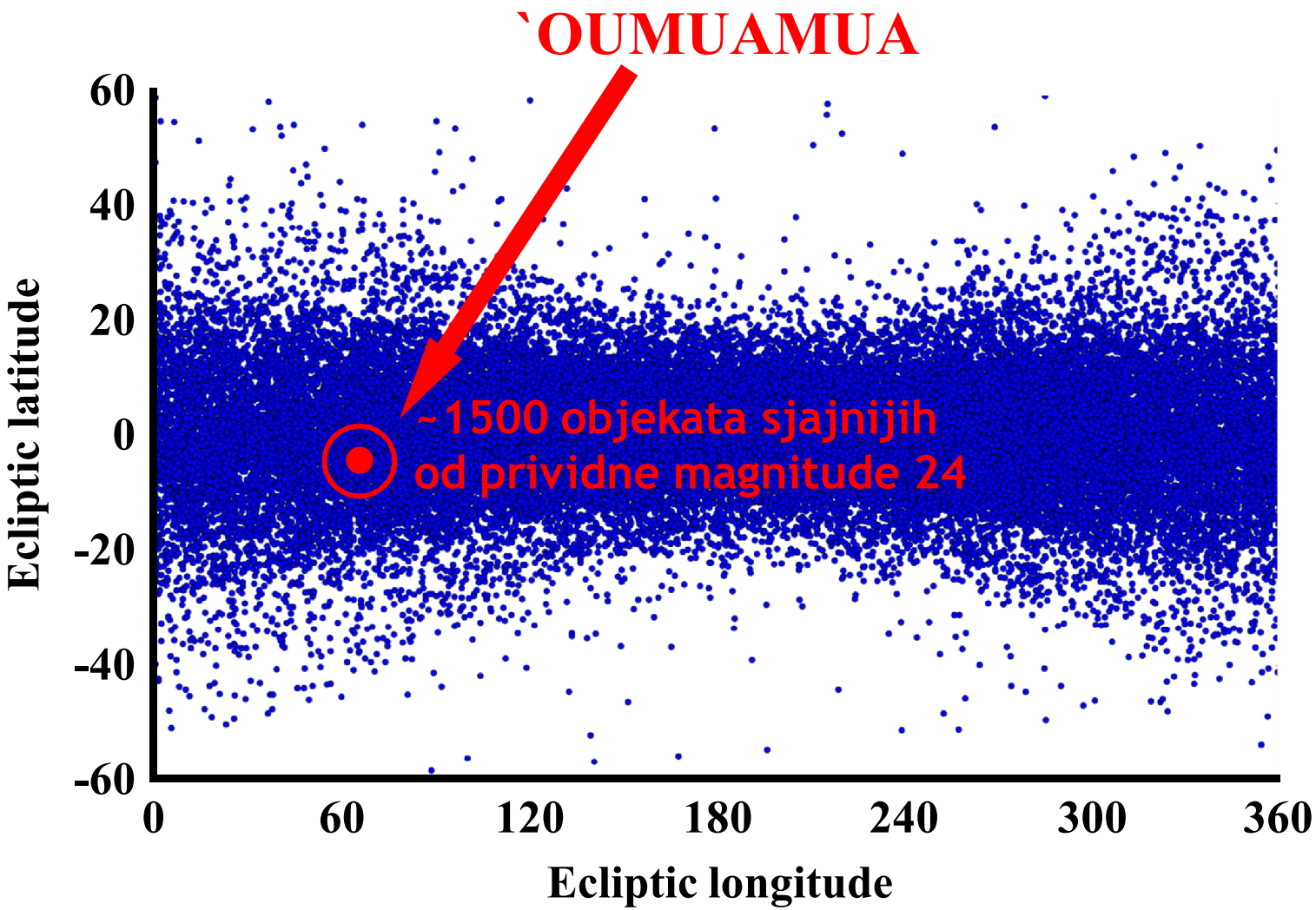
Myers et al., 2013

Problem povezivanja

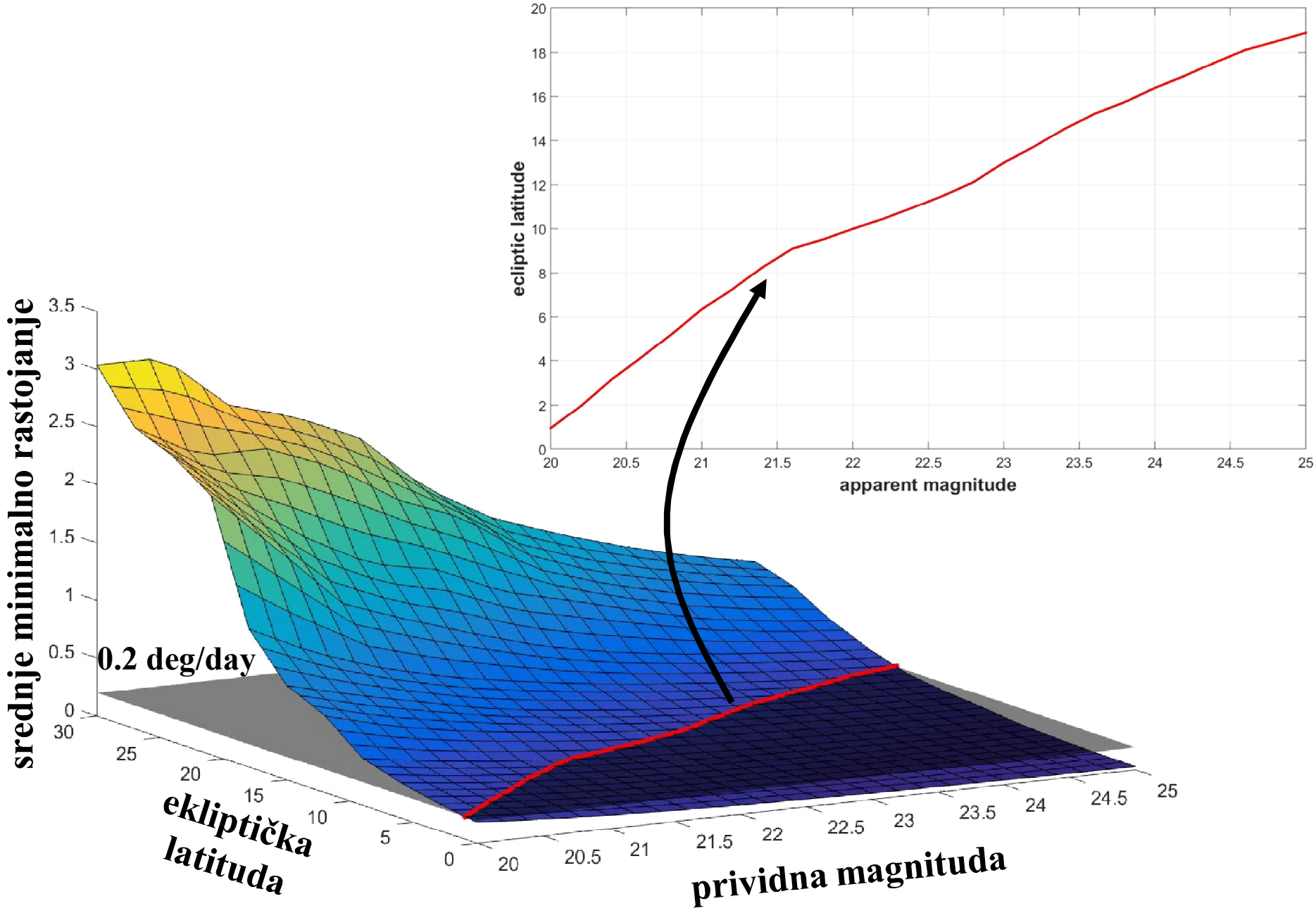
Gde je bio ‘Oumuamua u trenutku otkrivanja?



Problem povezivanja



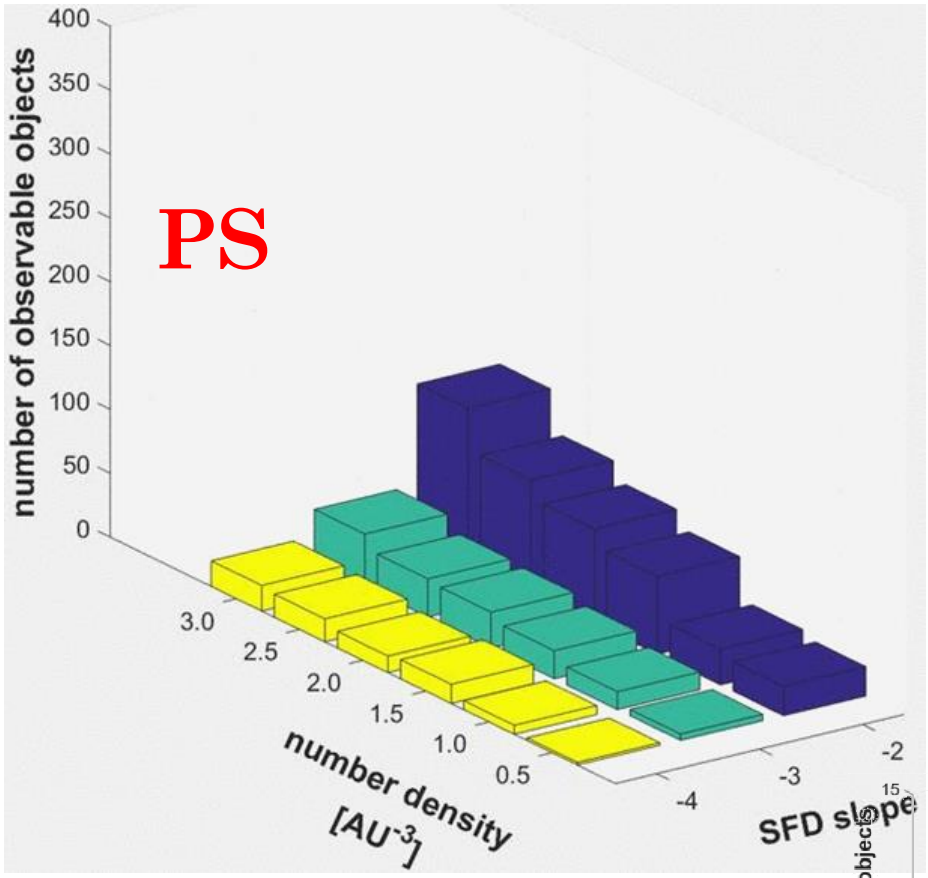
Kolika je gužva na nebu?

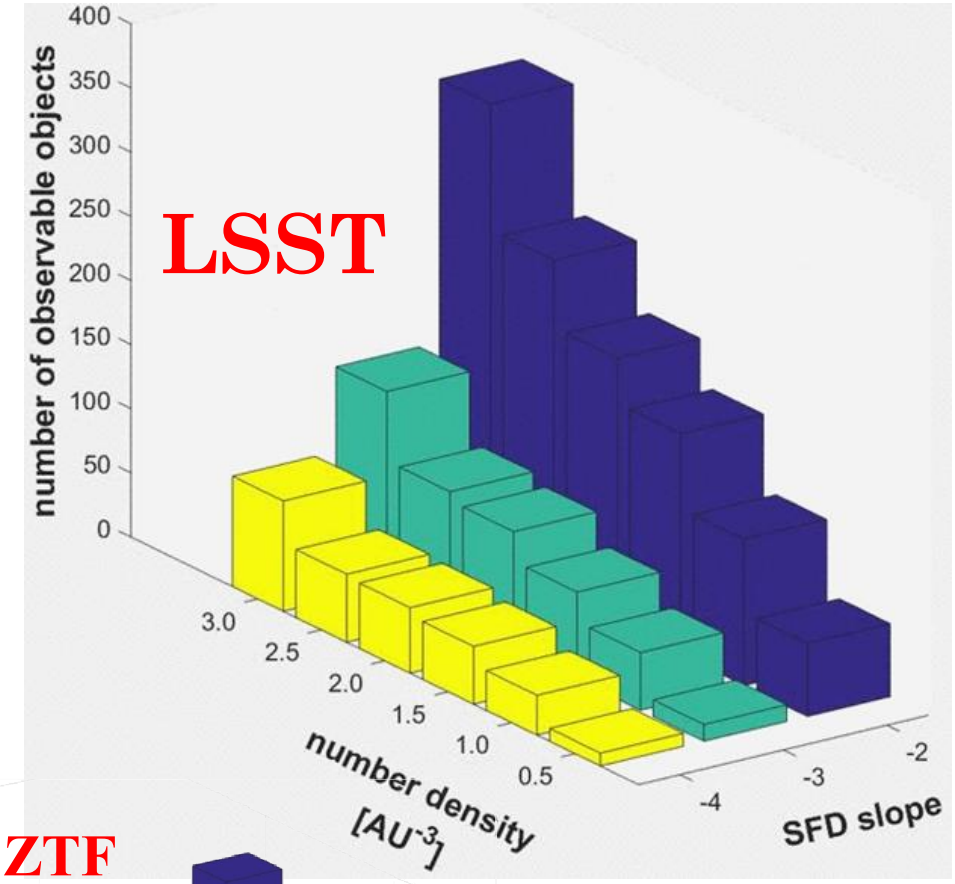


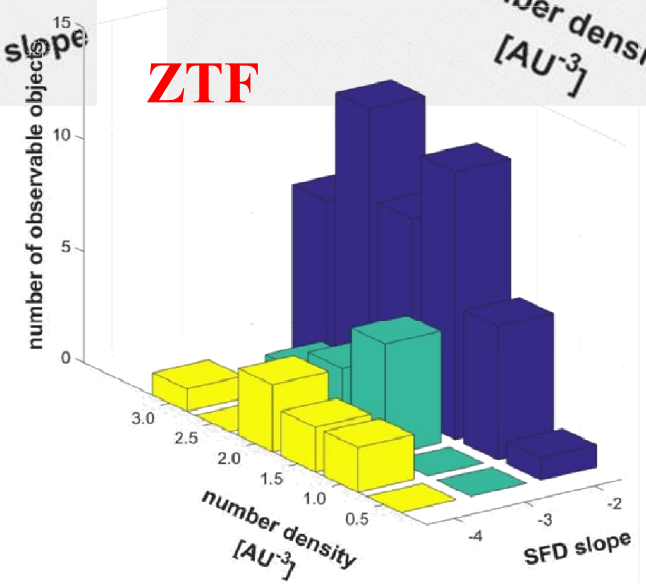
Desetogodišnja simulacija

	LSST	Pan-STARRS	ZTF
Prividna magnituda	<24.5	<22.7	<20.5
Elongacija	>60	>60	>60
Deklinacija	<20	>-30	>-17
Galaktička latituda	<-20, >20	<-20, >20	<-20, >20

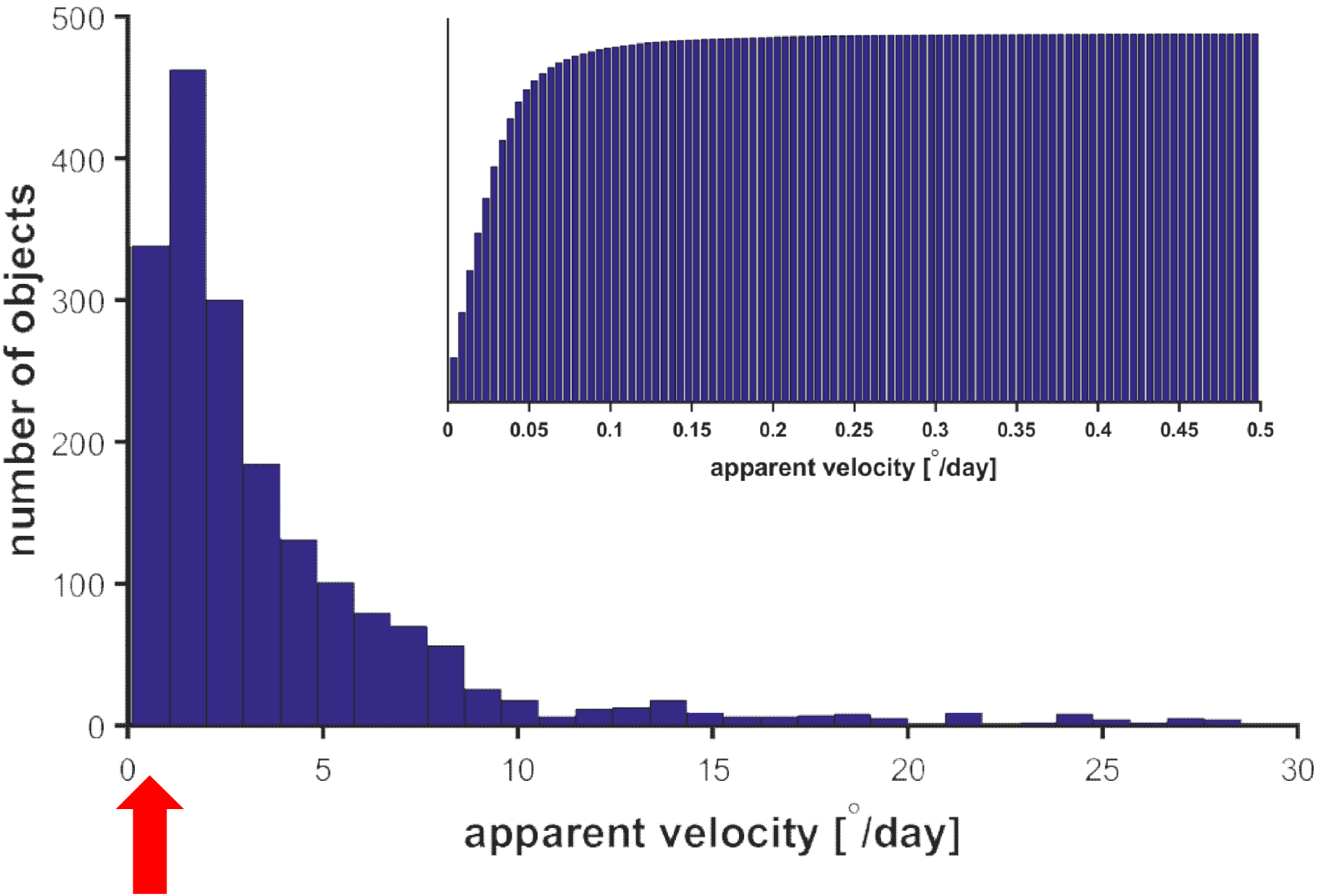
Desetogodišnja simulacija



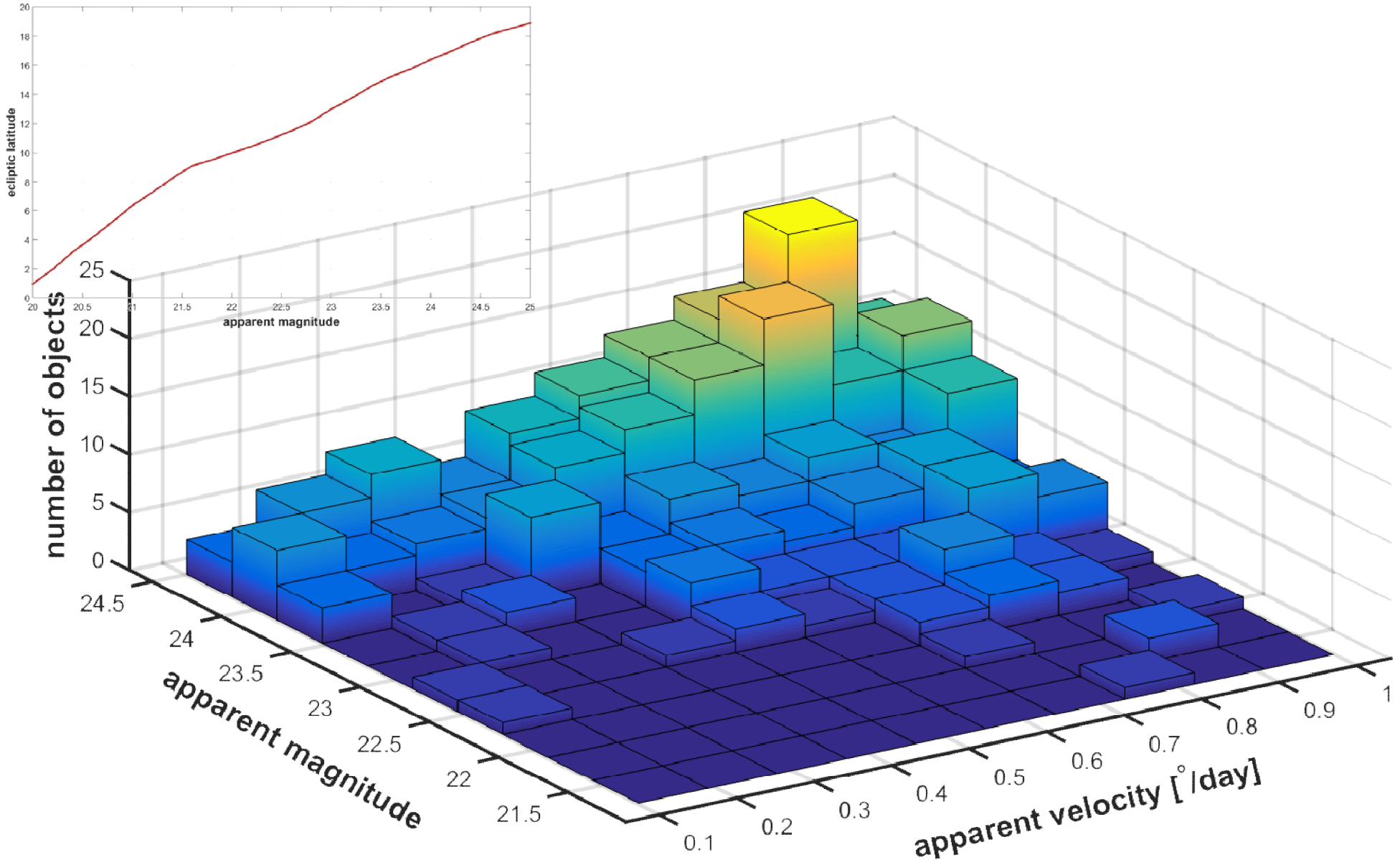




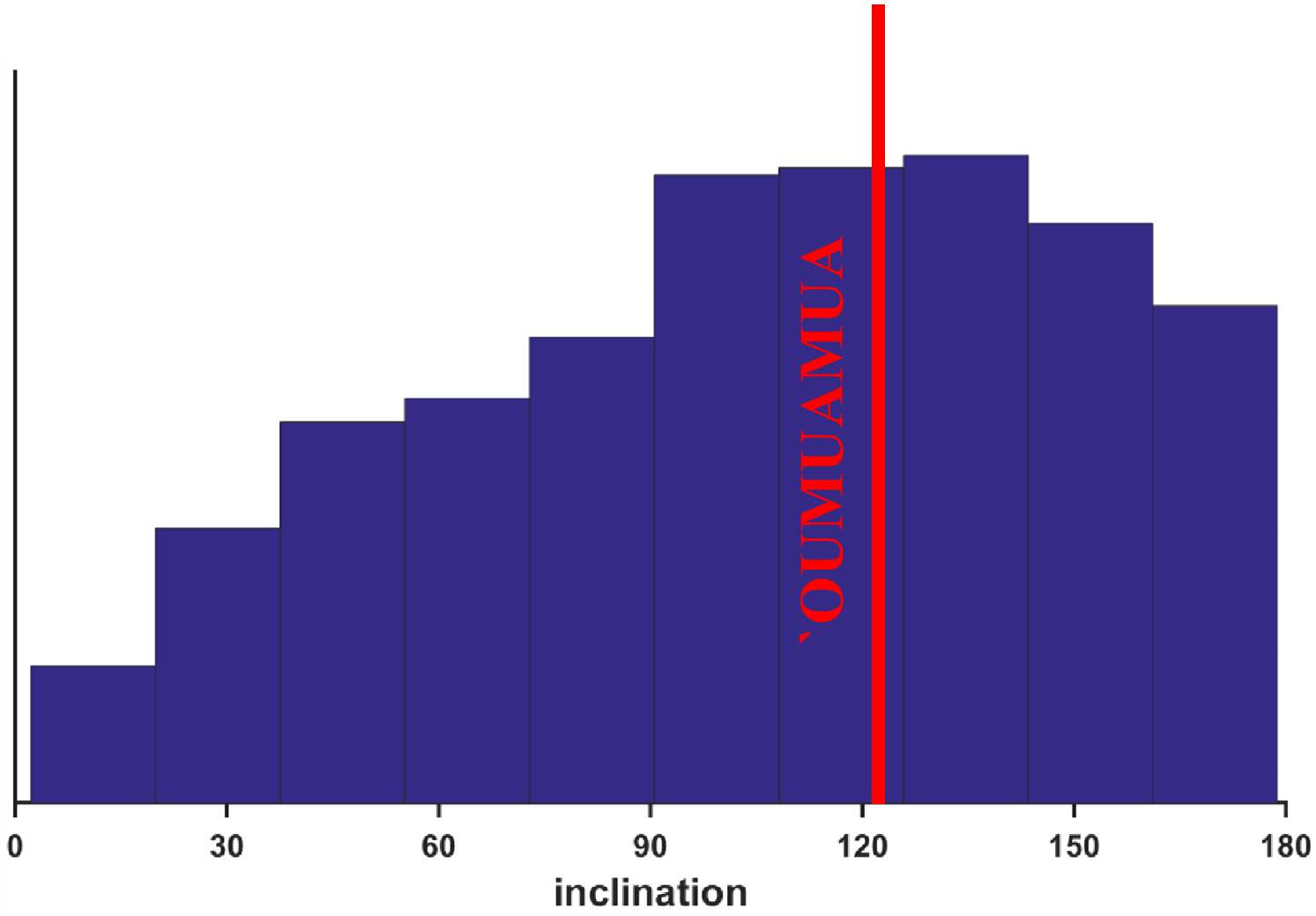
Prividne brzine



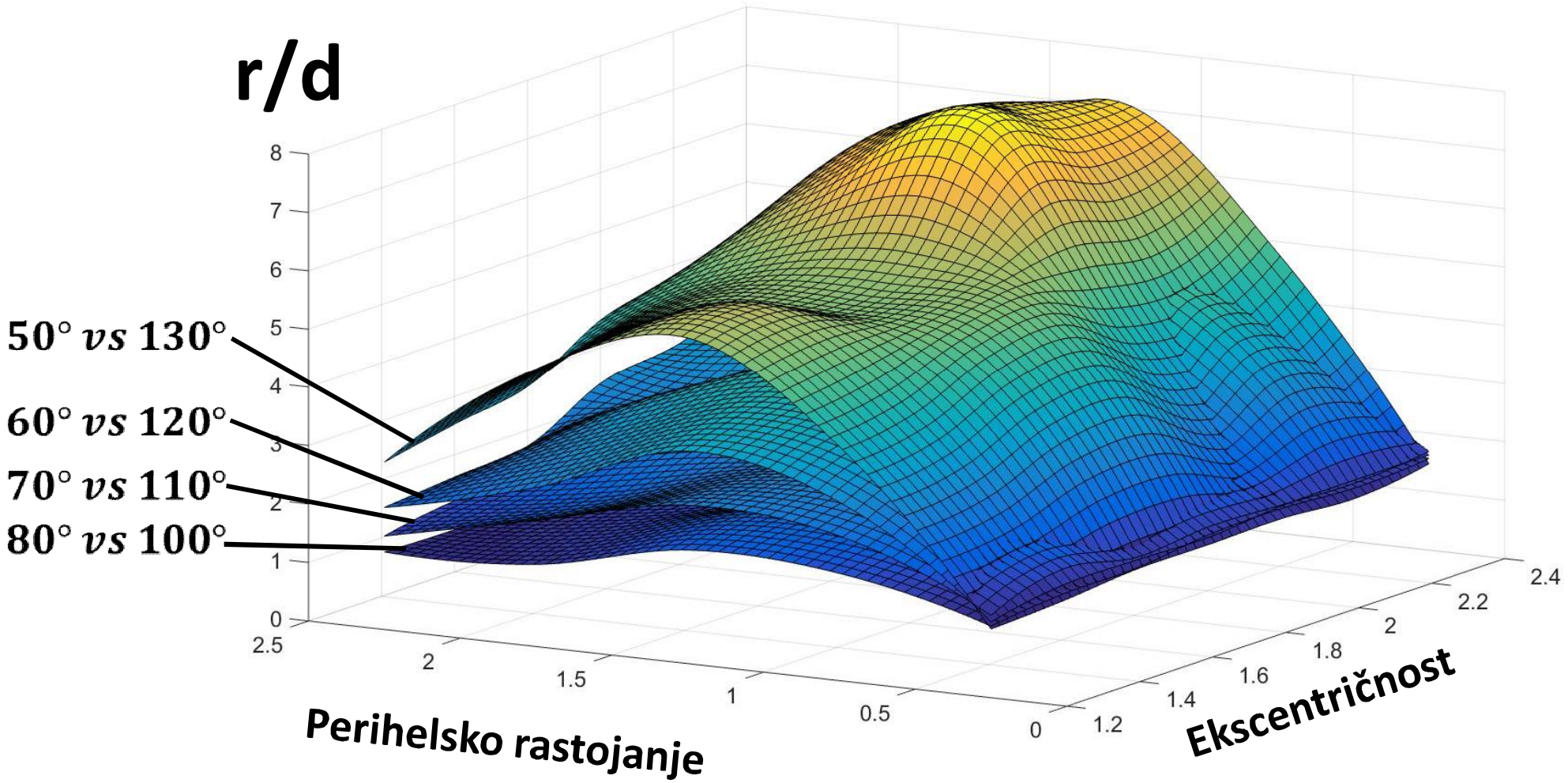
„Spori“ objekti



Inklinacije



Zašto možemo očekivati veći broj retrogradnih nego direktnih objekata?



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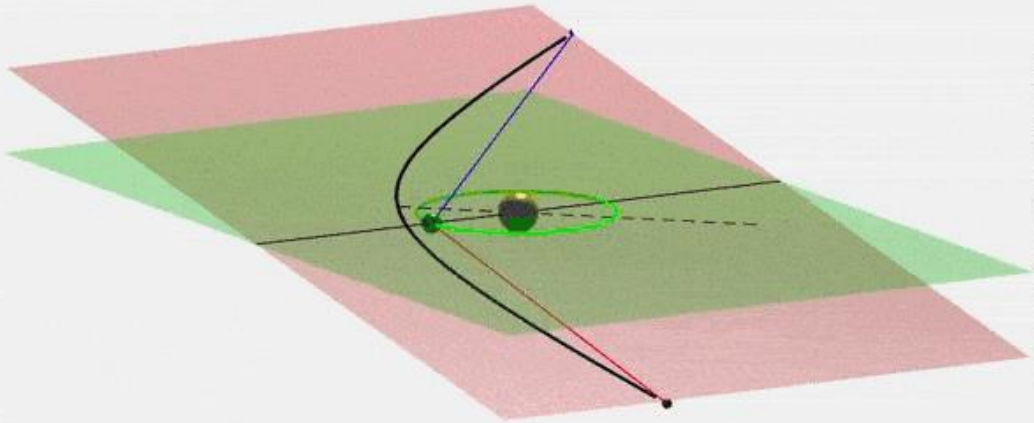
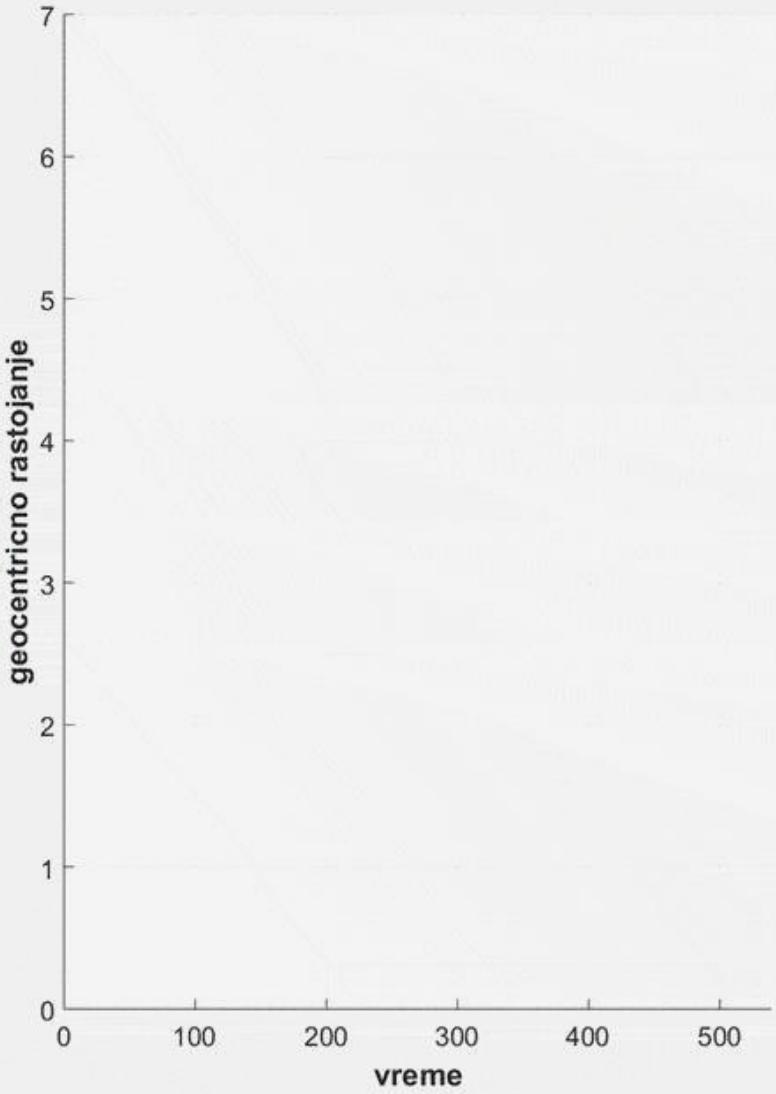
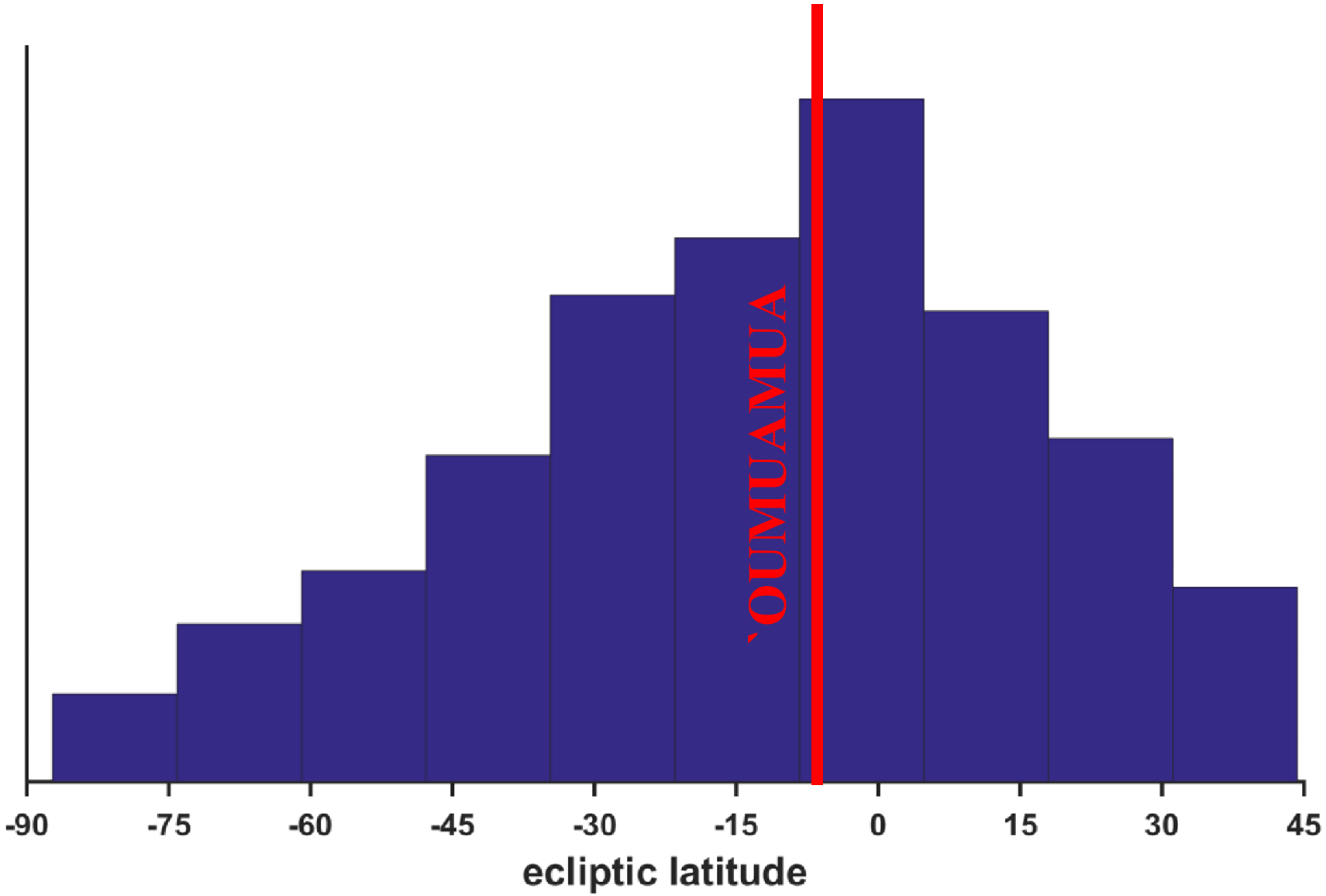
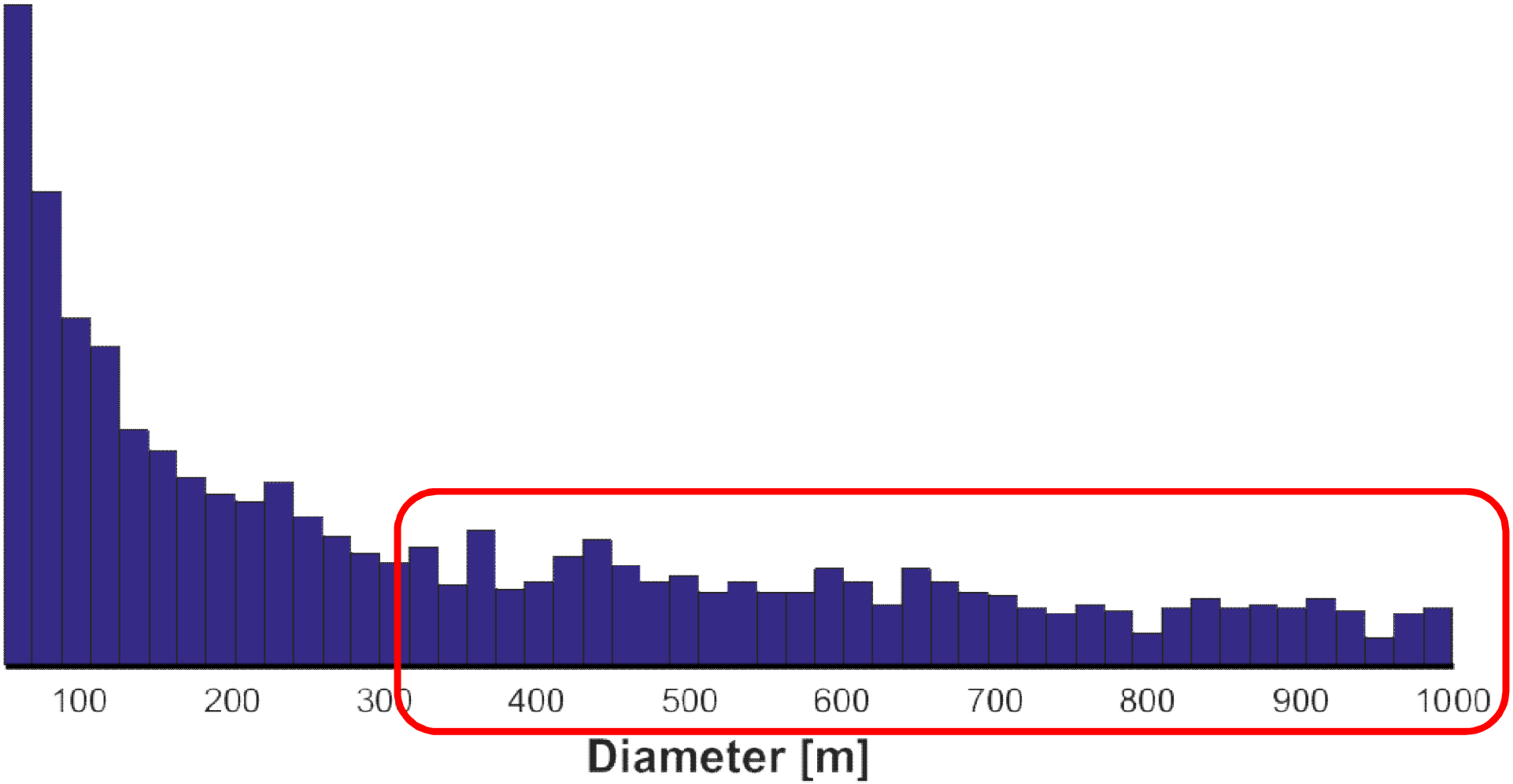


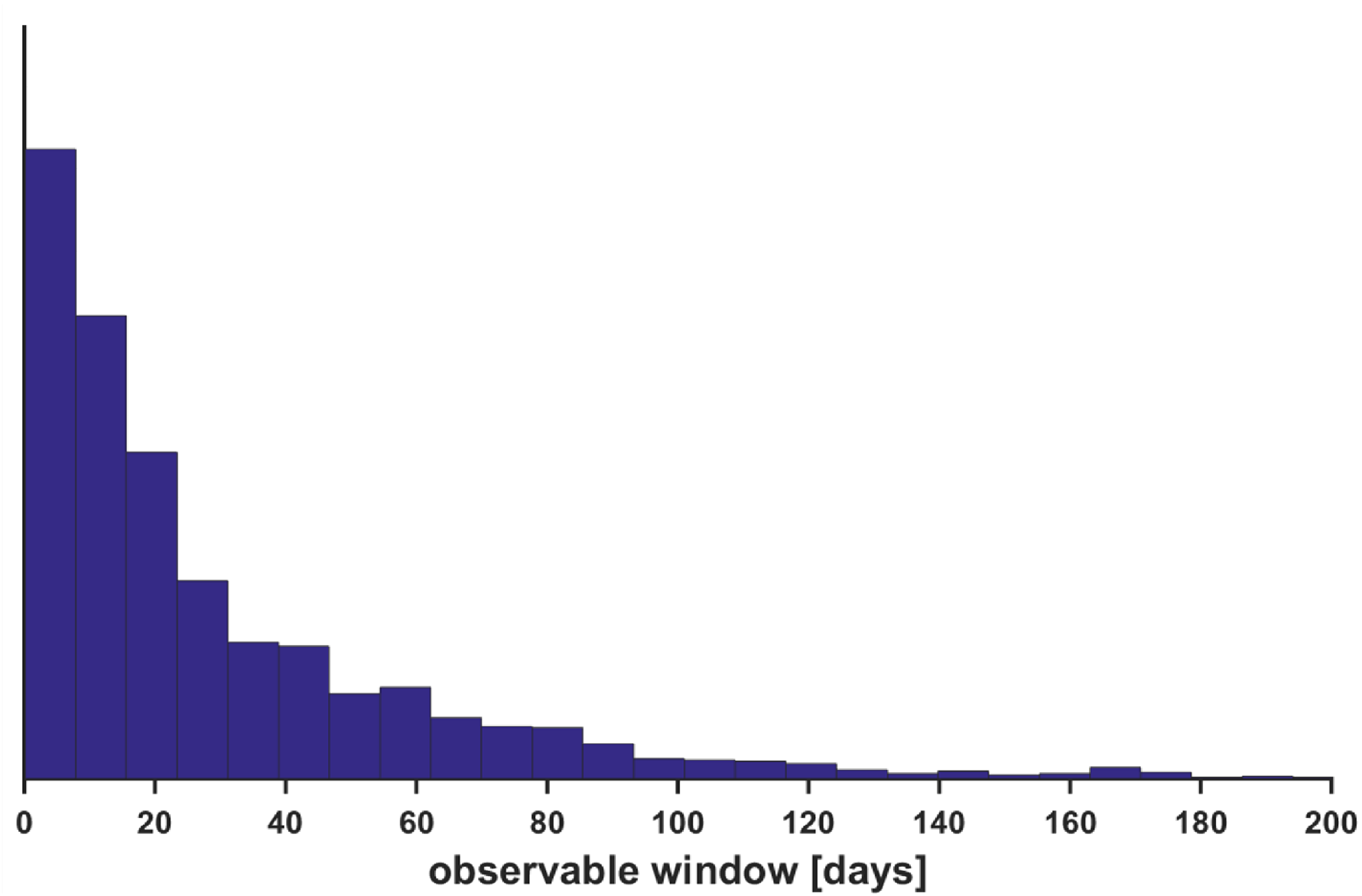


Ekliptička latituda



Veličine objekata




0
20
40
60
80
100
120
140
160
180
200
observable window [days]

Zaključak

- Moǵemo oļekivati desetine (moǵda i stotine) otkriĺa pomoĺu LSST, u zavisnosti od broja objekata u meĽuzvezdanom prostoru, kao i njihove raspodele po veliļinama i ostalim relevantnim parametrima

- Broj otkriĺa Í e u velikoj meri zavisiti od kvaliteta MOPS-a

- Nove metode za odreĽivanje orbita poput povezivanja integralima dva tela bi mogle biti od velike pomoĺi (Gronchi et al., 2010, 2011, 2015)

- Mogao bi se oļekivati znaļajan broj otkriĺa od ñjeftinijihò pretraga daleko od ekliptike