Some peculiarities of orbits of observed comets.

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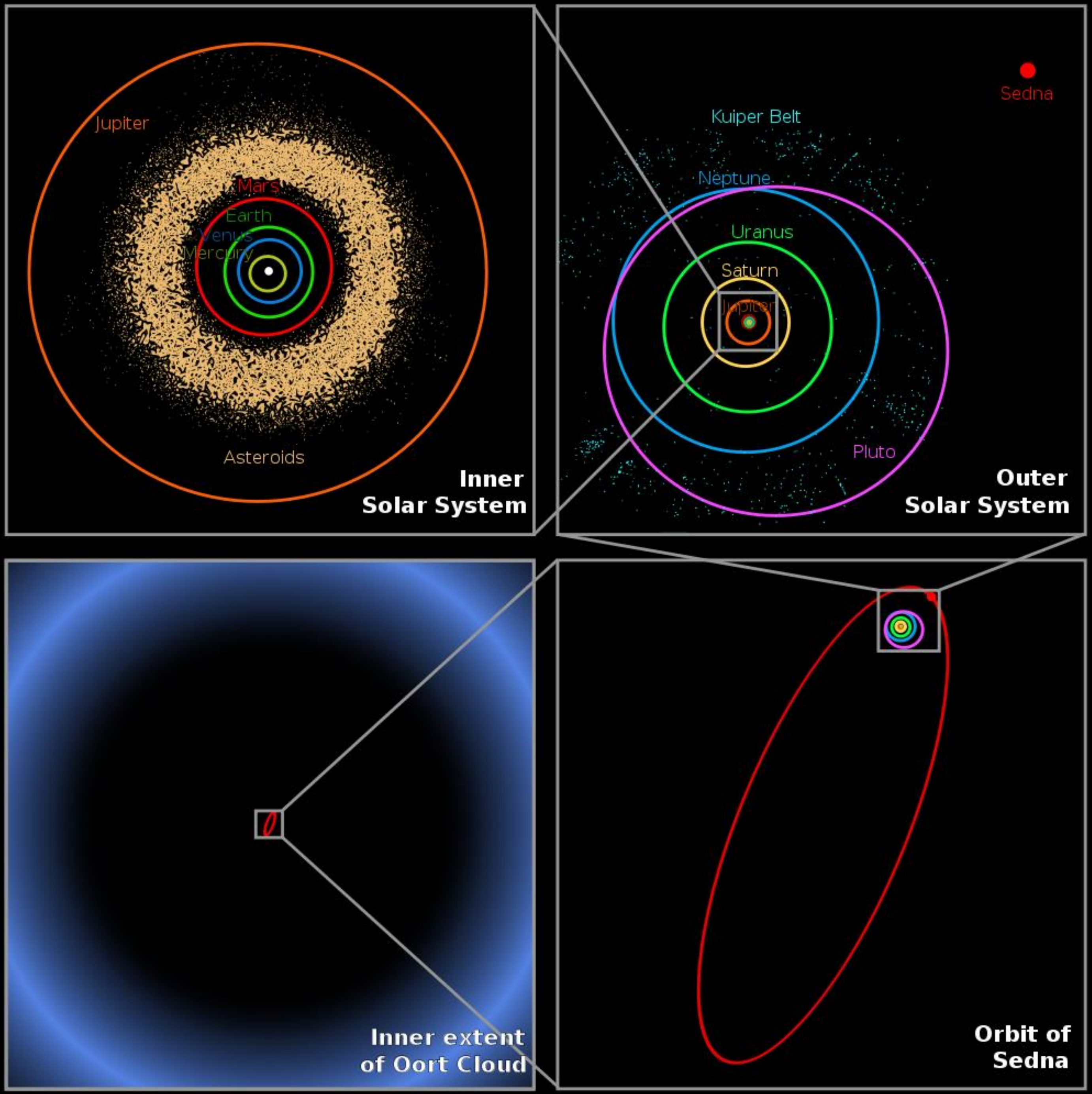
Main subject of investigation:

Spatial distribution of orbits of real (observed) comets

Data for analysis:

JPL catalogue of orbital parameters of observed comets

By September, 1, 2014 - 3 277 observed comets.



Solar system

Comet classification:

Short-period (<200 yr)

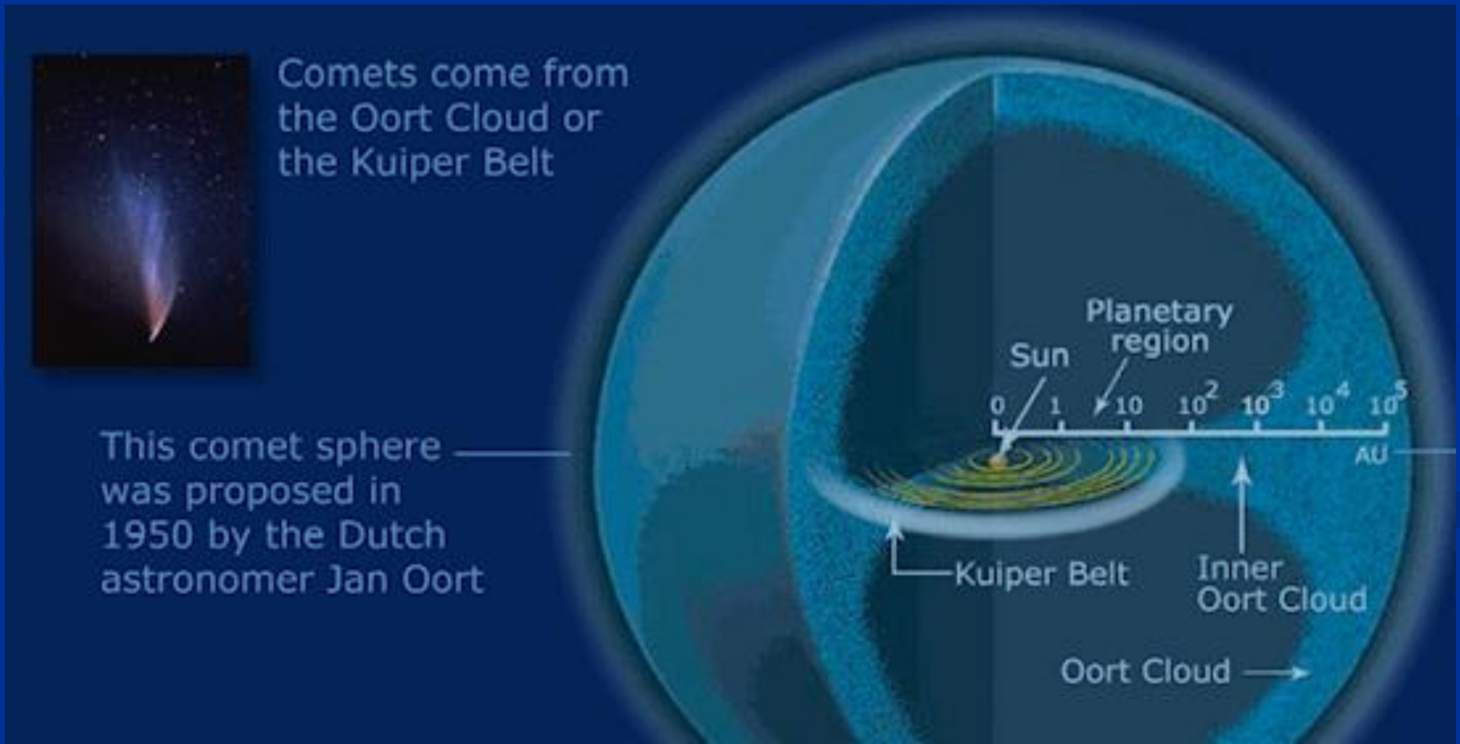
Long-period (>200 yr)

Image: NASA JPL-Caltech R. Hurt

Oort cloud:

doughnut-shaped **inner Oort cloud – Hills cloud**
2 – 20 AU (0.03 – 0.3 ly)

spherical **outer Oort cloud**
20 – 50 (- 100) AU (0.3 – 0.8 ly)



JPL catalogue of orbital parameters of comets:

http://ssd.jpl.nasa.gov/dat/ELEMENTS.COMET

By September, 1, 2014 - 3 277 observed comets.

Excluded from investigation:

a) "Very old comets" - 107 - observed before 1760
Their orbits were approximately reconstructed with eccentricity $e = 1$

b) Fragments of destroyed comets – the only object was taken into account from each group: 73P/ Schwassmann-Wachmann (66 objects),
C/1882 R1 (Great September comet - 4 objects),
D/1993 F2 (Shoemaker-Levy 9 – 21 objects).

c) Small sungrazers (Kreutz, Meyer, Marsden, Kracht – 1478 objects)
with $e = 1$, observed from the space only by SOHO, SMM, Solwind

Work with the JPL catalogue:

1604 comets were analyzed after exclusion of the aforecited objects.

Comets were divided into 4 groups by eccentricity:

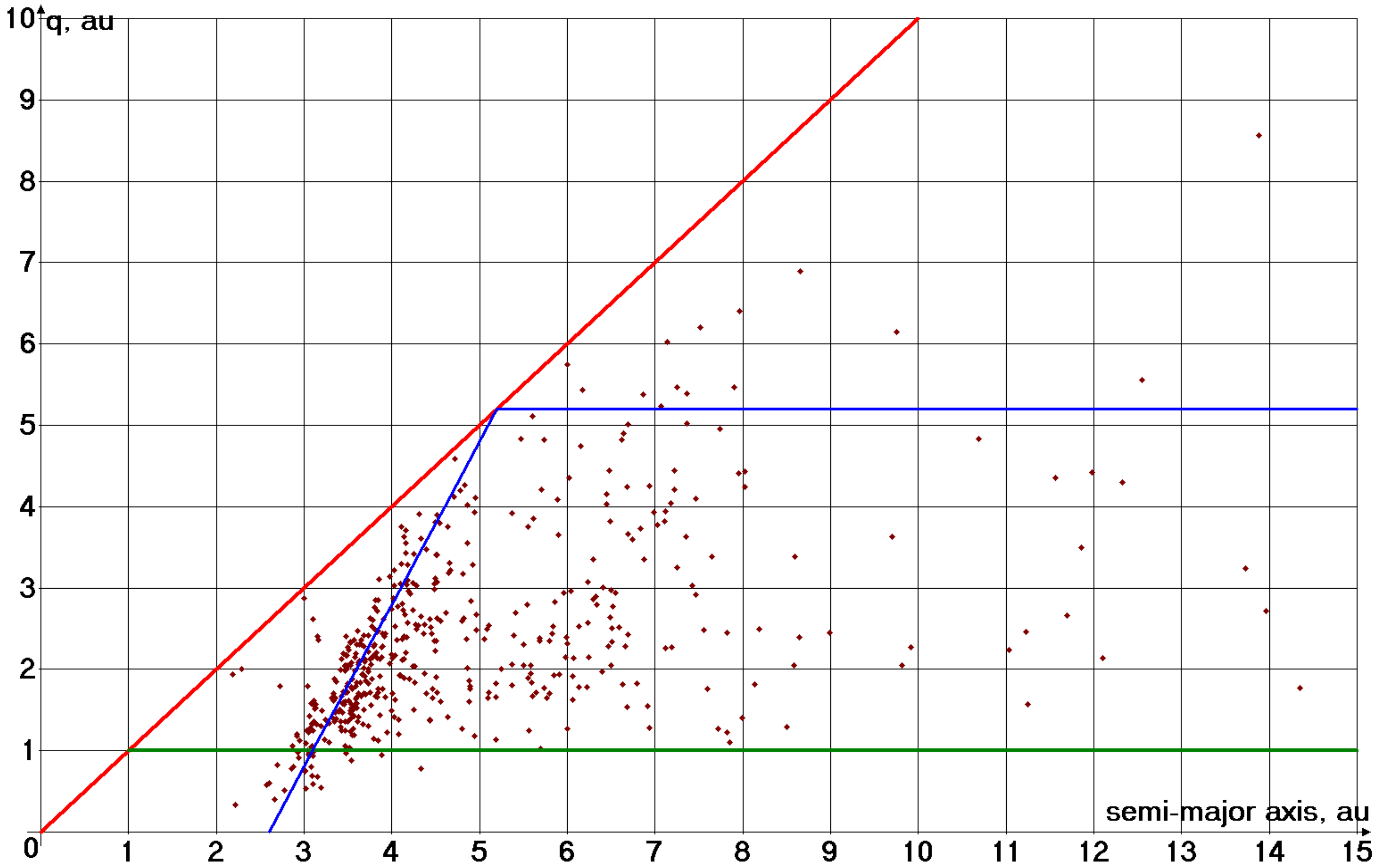
- **$e < 0.9$ - almost all are short-period comets**
- **$0.9 < e < 1$ - mainly long-period comets**
- **$e = 1$ - comets with parabolic orbits (undefined)**
- **$e > 1$ - comets with hyperbolic orbits**

Each group was analyzed separately.

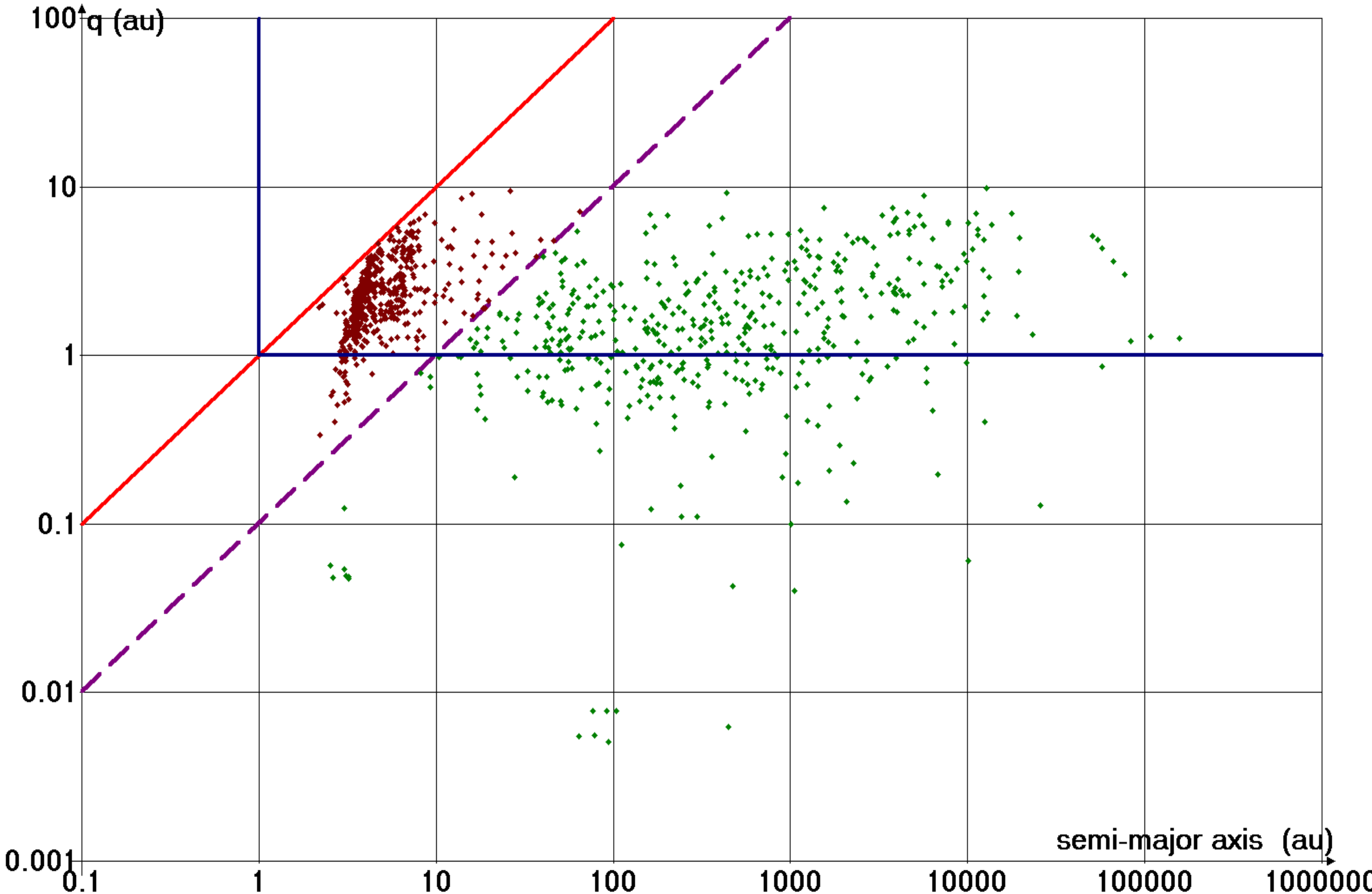
Table 1. Distribution of comets by eccentricity

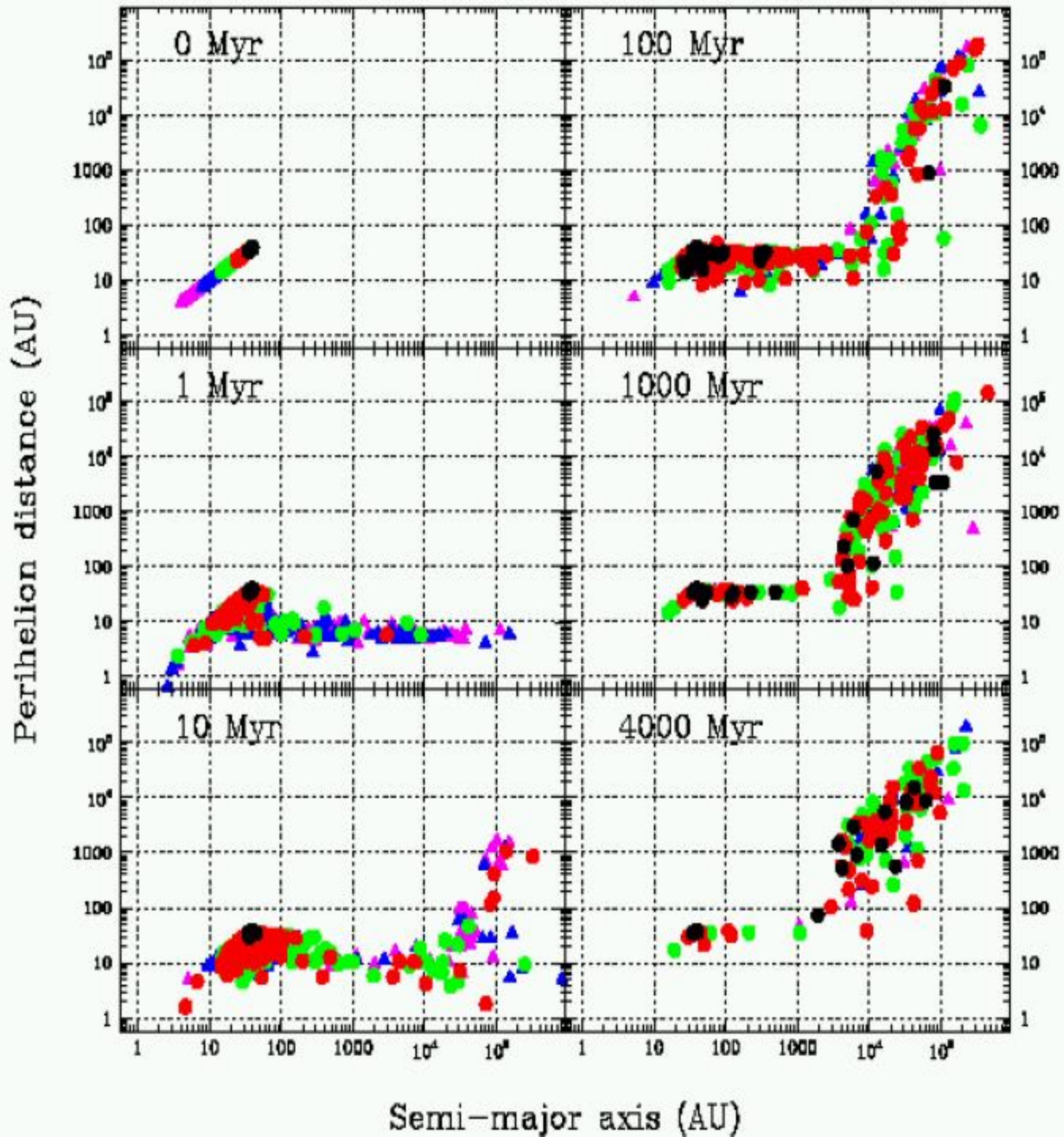
Eccentricity e	Number of comets (short-p. - long-p.)	% of total amount
e < 0.9	552 (548 + 4)	34.4
0.9 < e < 1	504 (64 + 440)	31.4
e = 1	253	15.8
e > 1	295	18.4

Comets with e < 0.9
(only 4 comets of 532 are the long-period ones, more than 200 yr)



All comets with e < 1



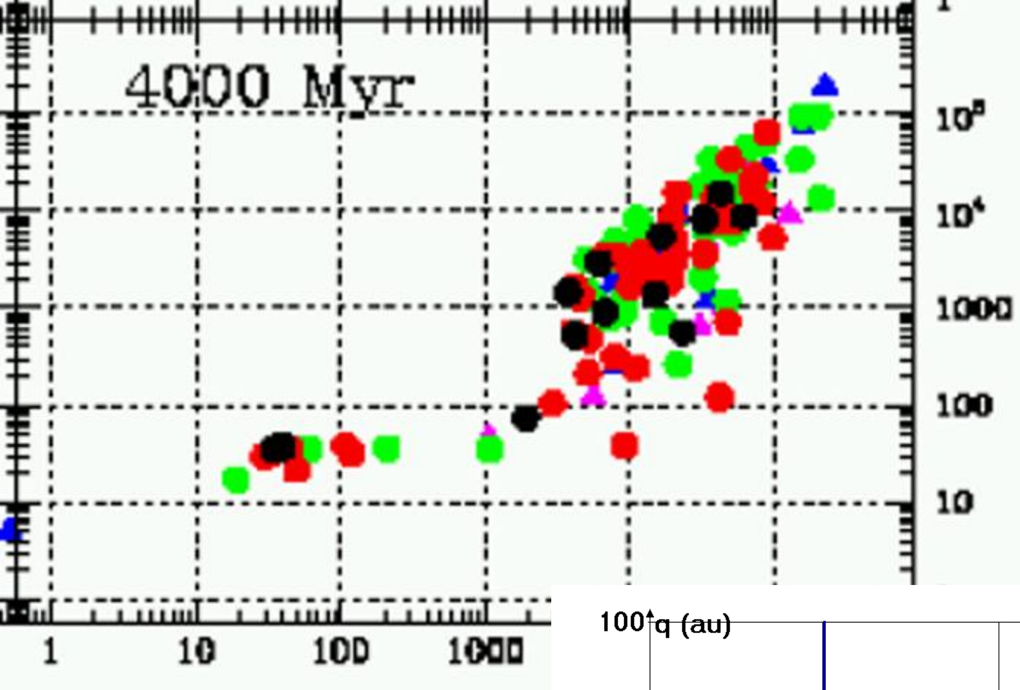


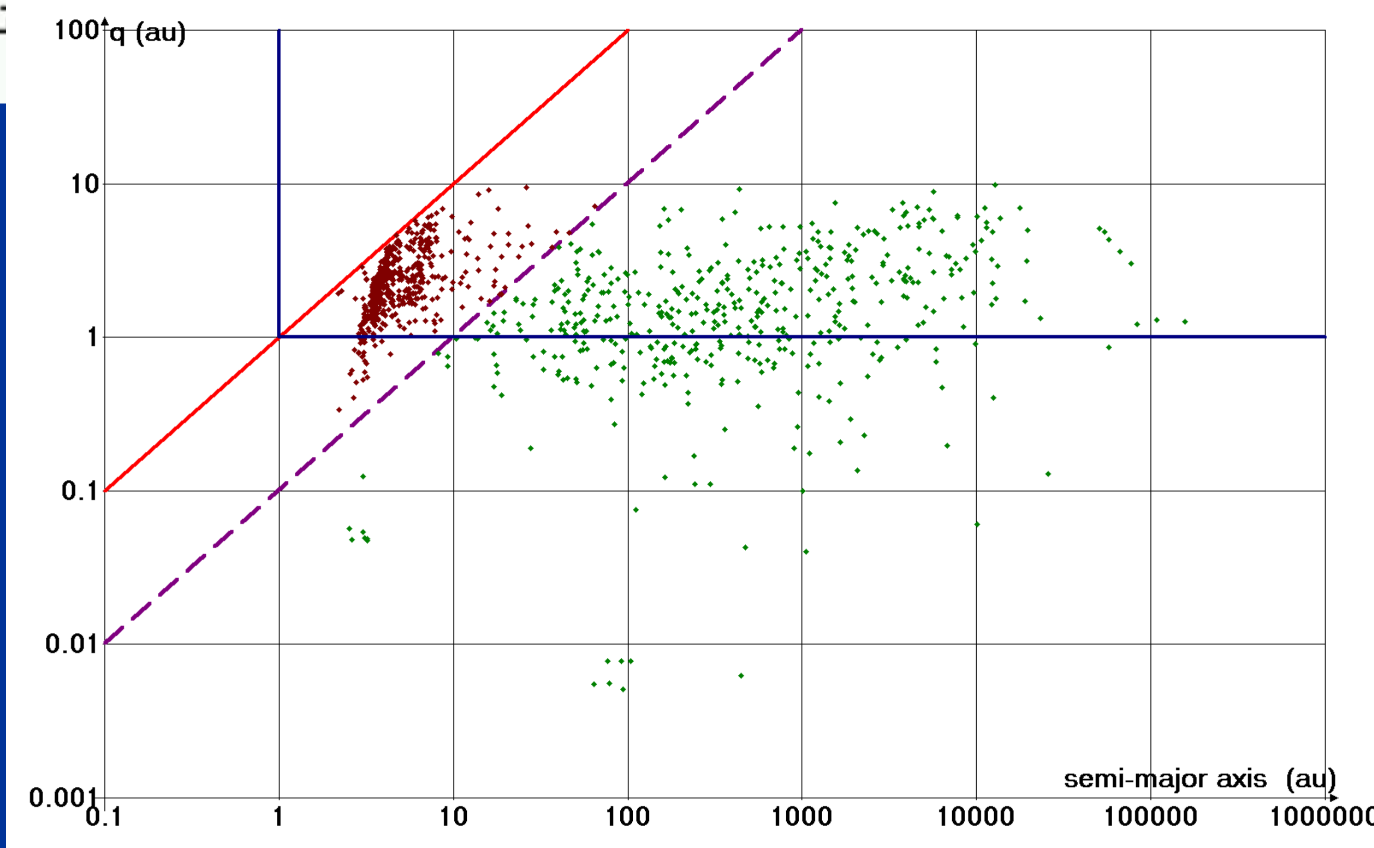
Evolution of the Oort cloud (simulation)

Alessandro Morbidelli (2005) Origin and dynamical evolution of comets and their reservoirs". arXiv:astro-ph/0512256

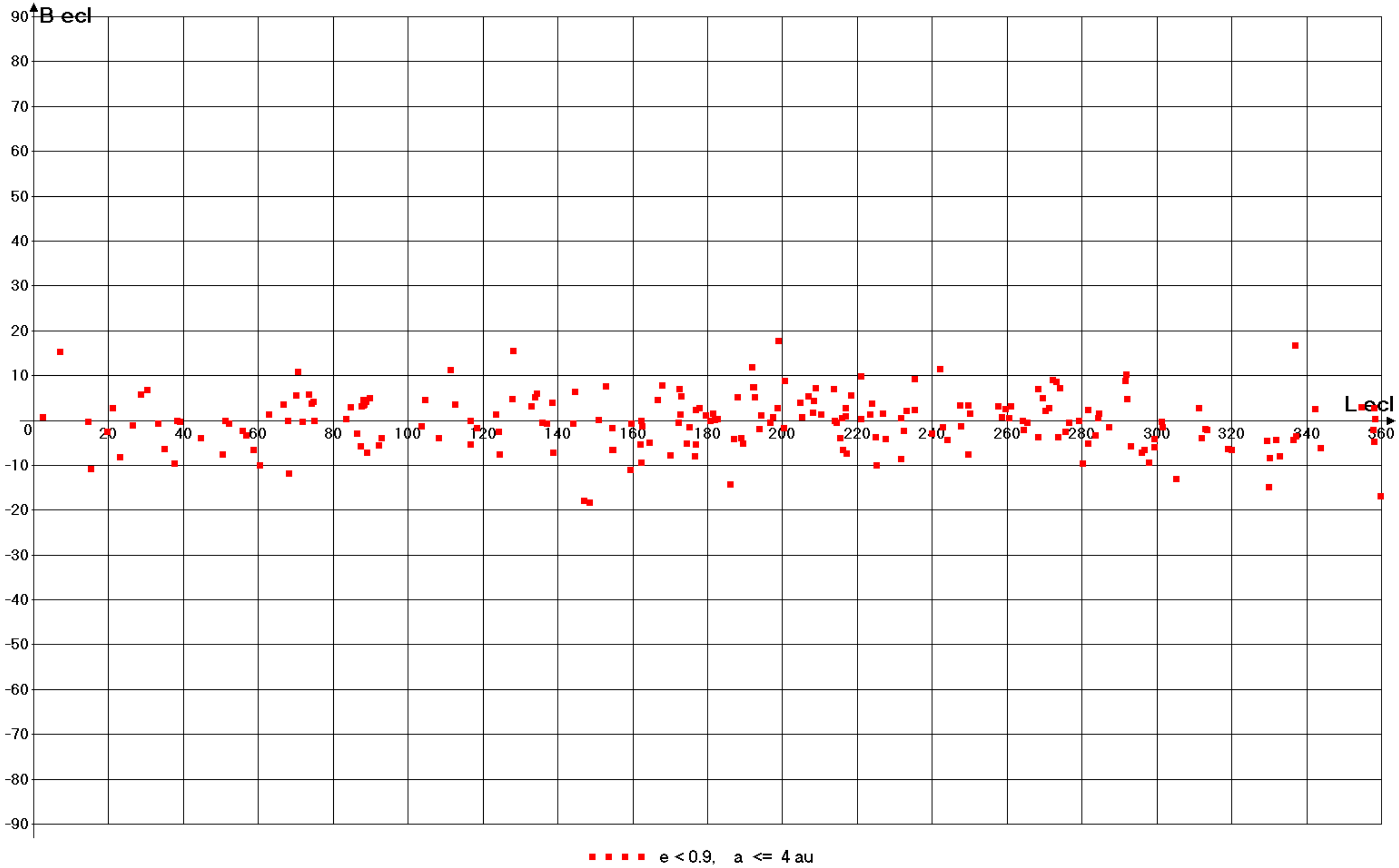
Dones L., Levison H.F., Duncan M.J., Weissman P.R., Simulations of the formation of the Oort Cloud the reference model. Icarus, 2005

Simulation and reality





Distribution of “anti-perihelia” of short-period comets with e < 0.9 (ecliptic coordinates)



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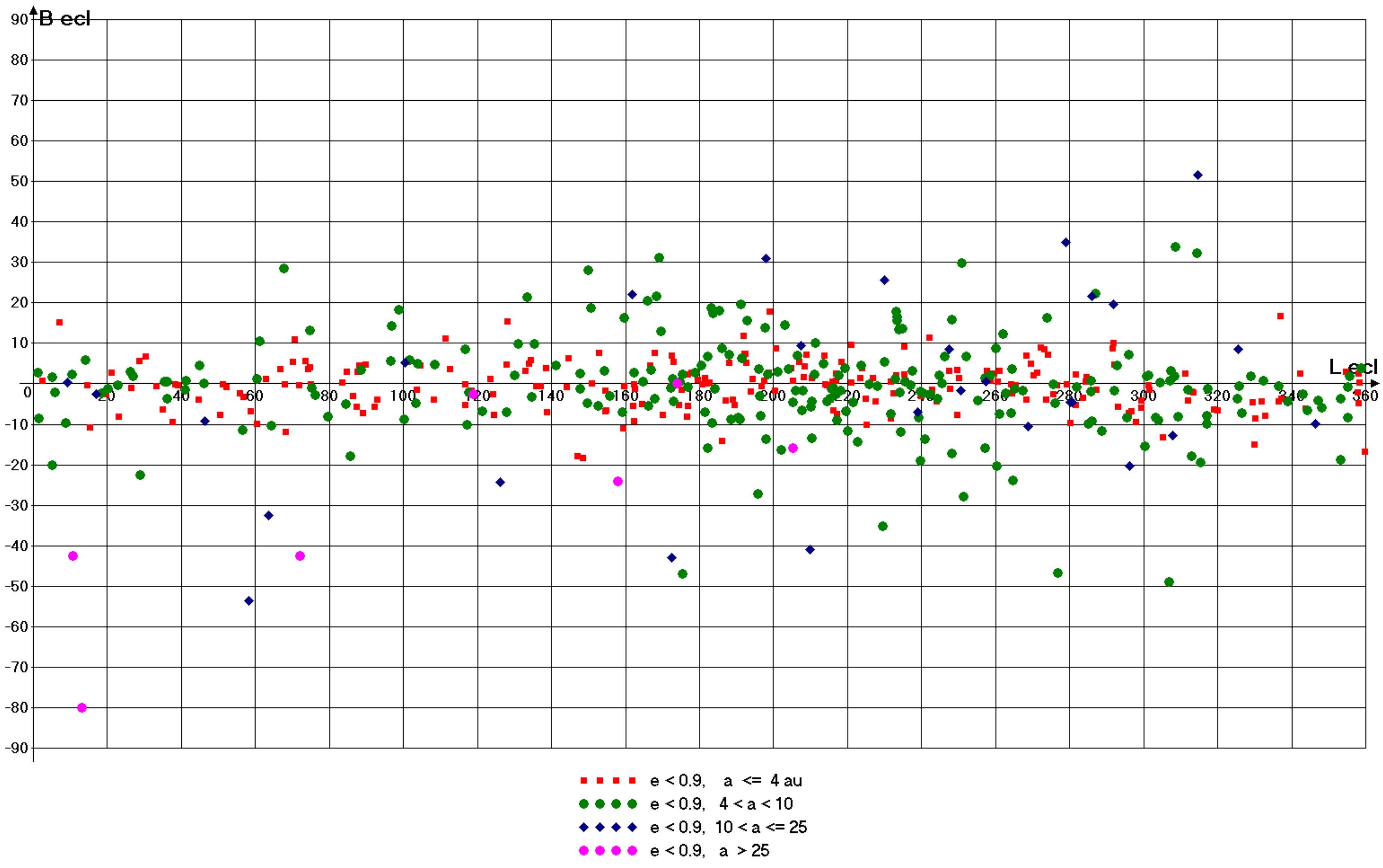
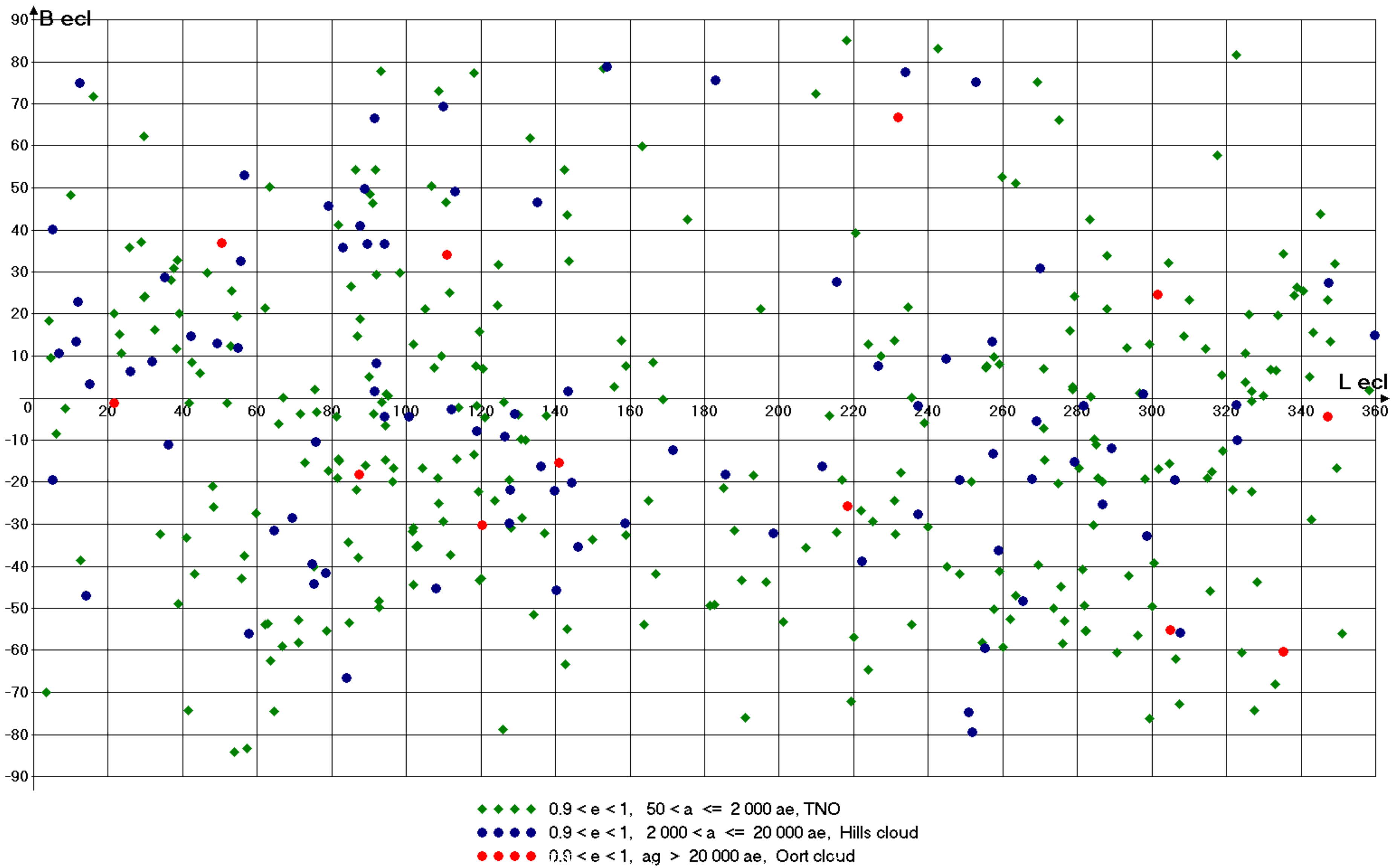
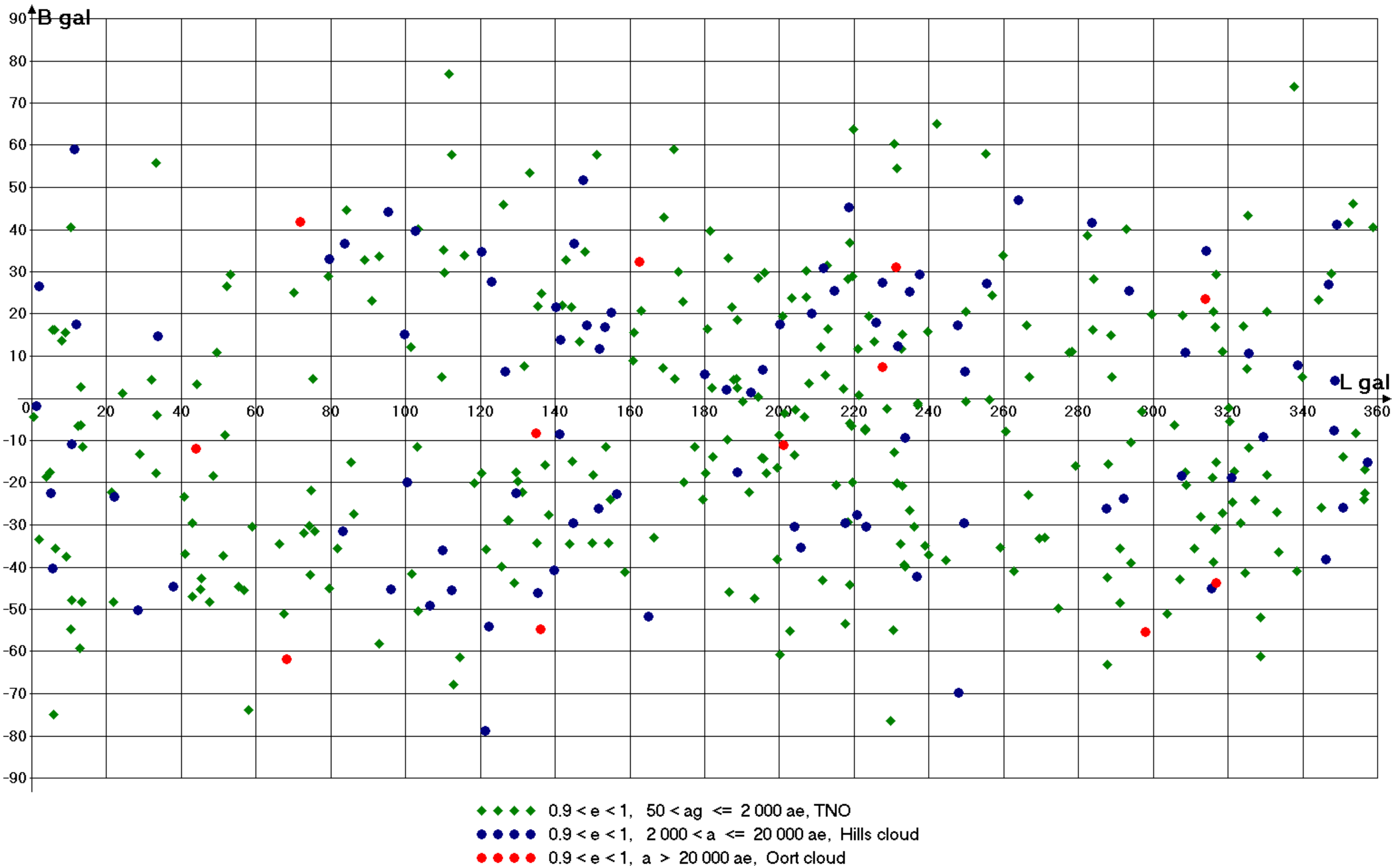


Distribution of “anti-perihelia” of long-period comets with 0.9 < e < 1 (ecliptic coordinates)



Distribution of "anti-perihelia" of long-period comets with 0.9 < e < 1 (galactic coordinates)



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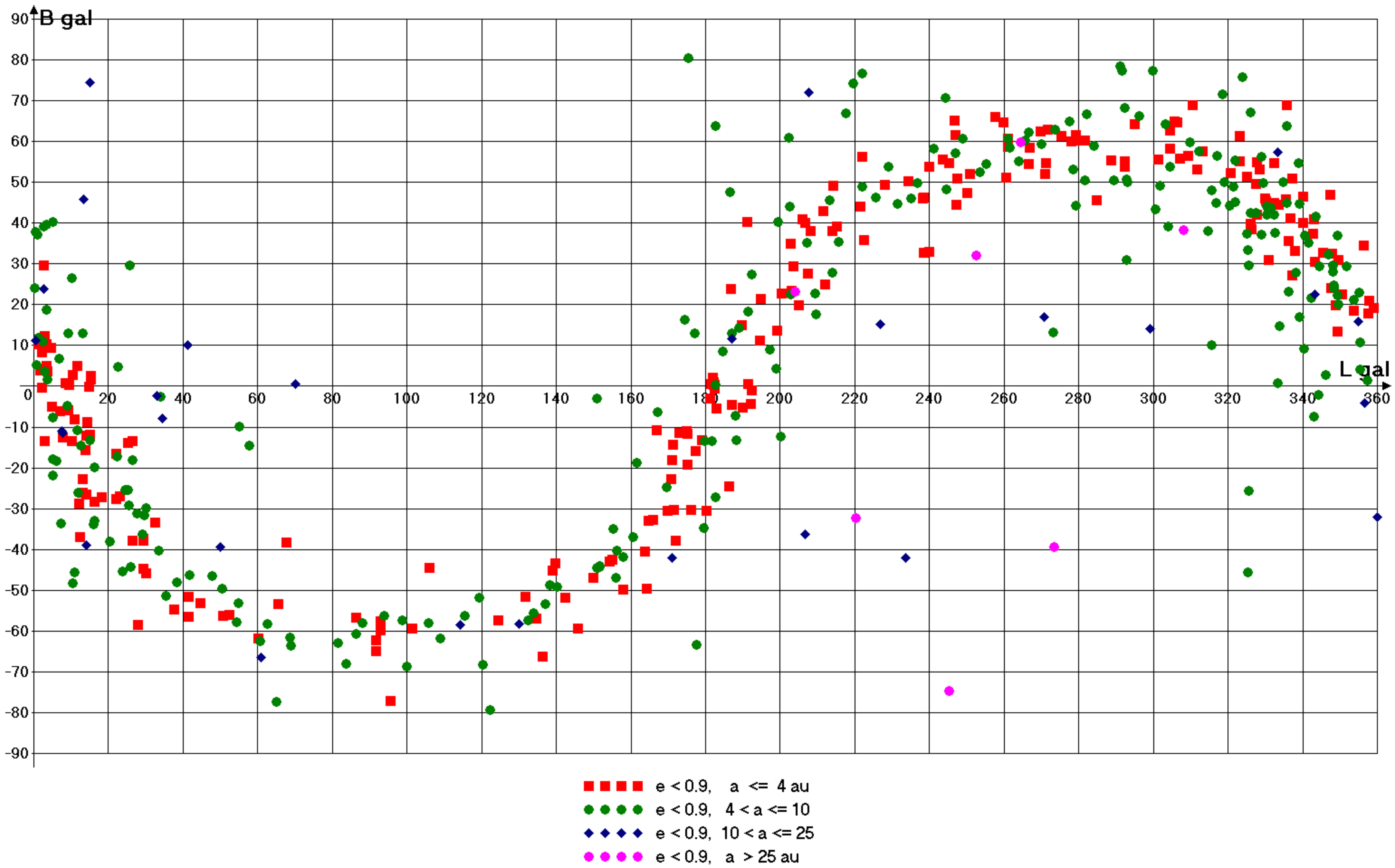
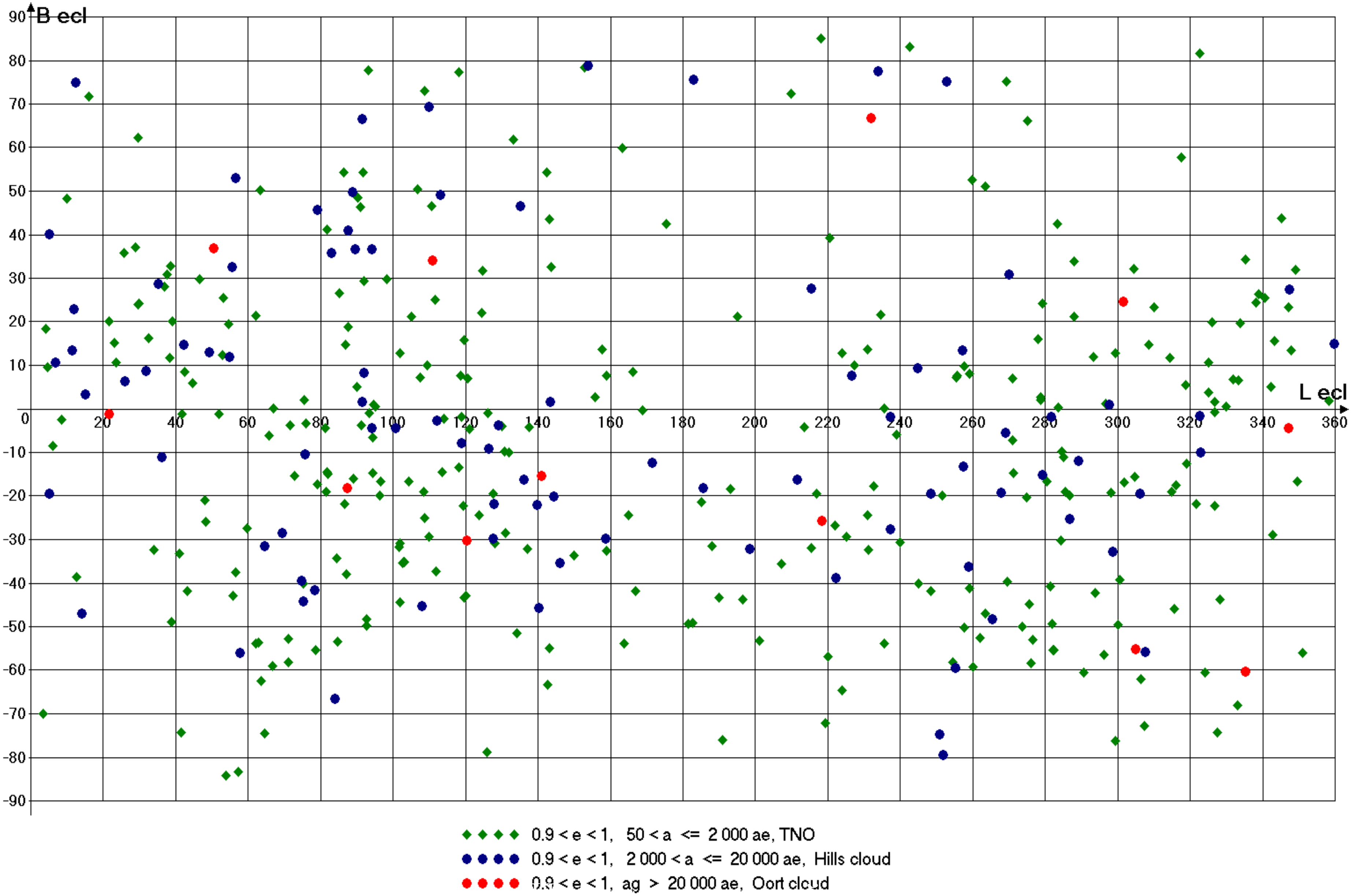
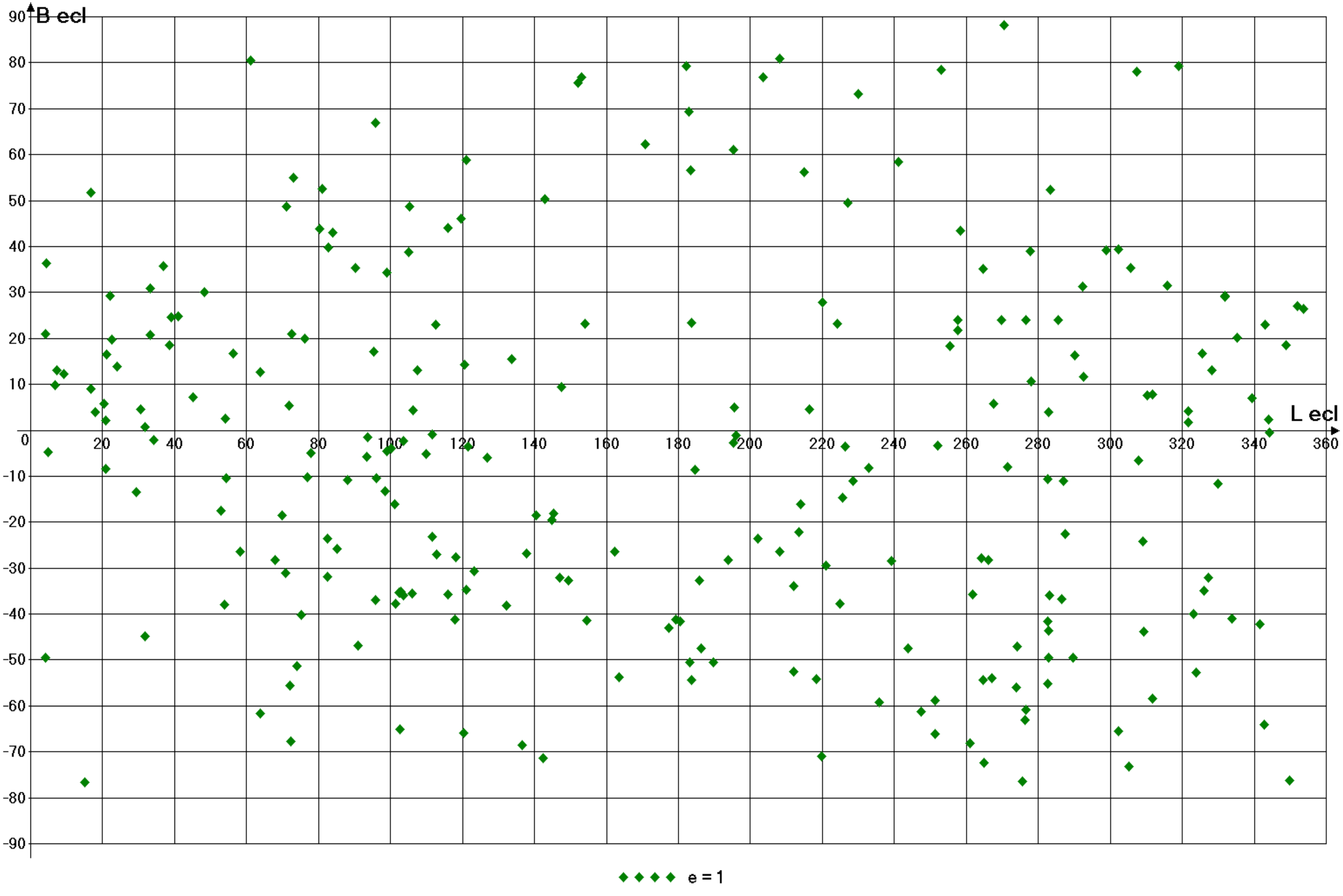


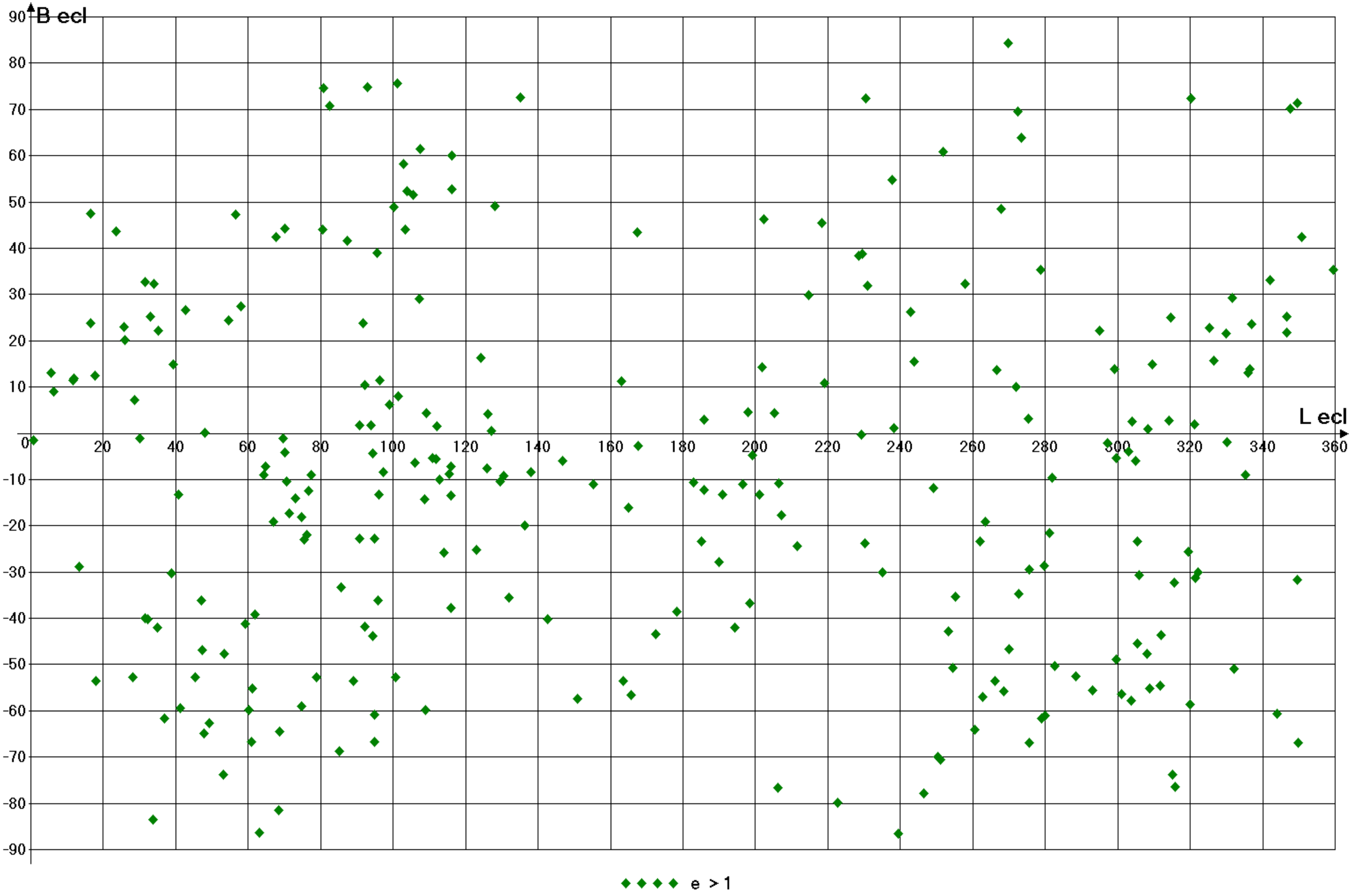
Distribution of “anti-perihelia” of long-period comets with 0.9 < e < 1 (ecliptic coordinates)



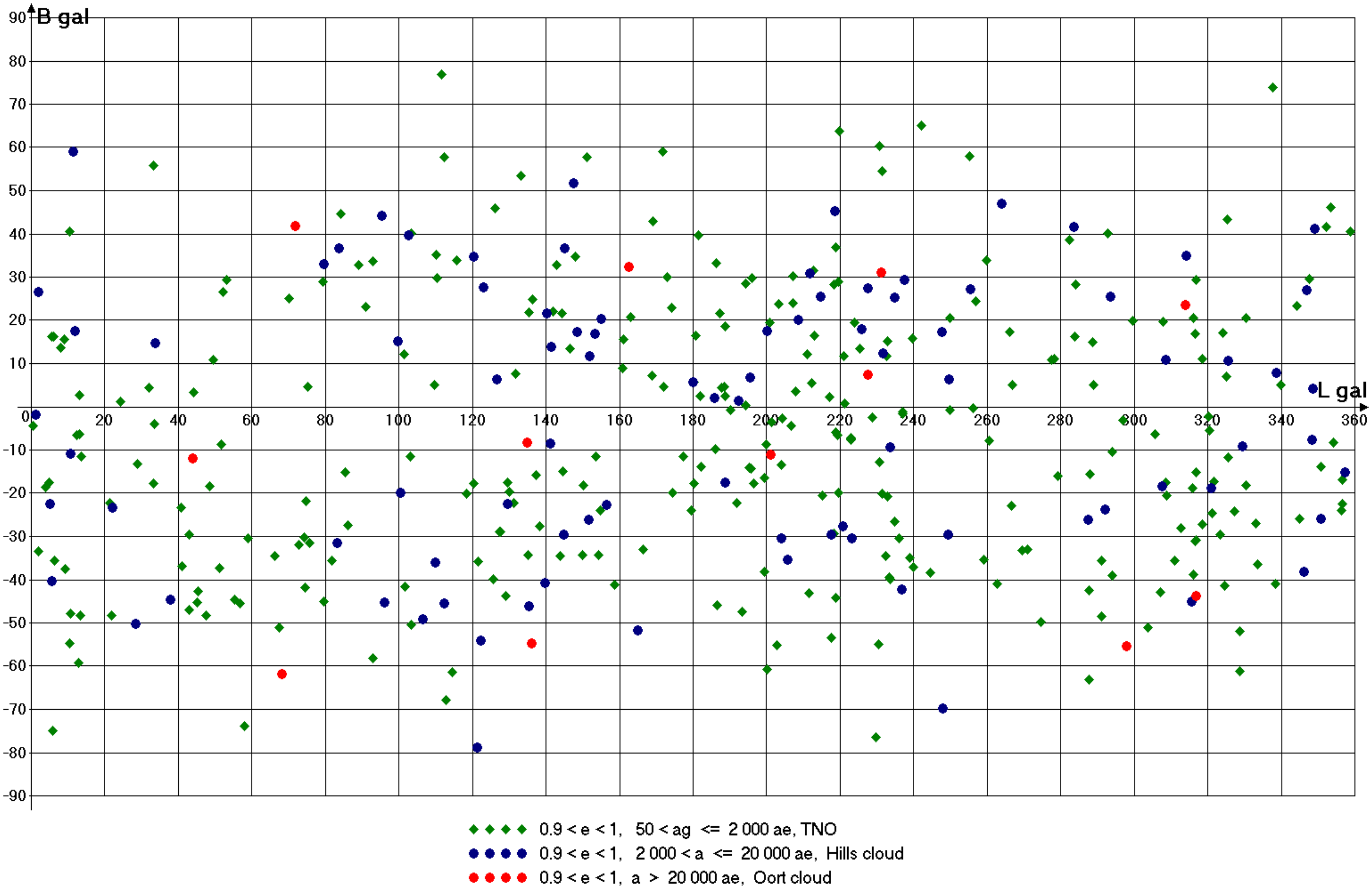
Distribution of "anti-perihelia" of comets with e = 1 (ecliptic coordinates)



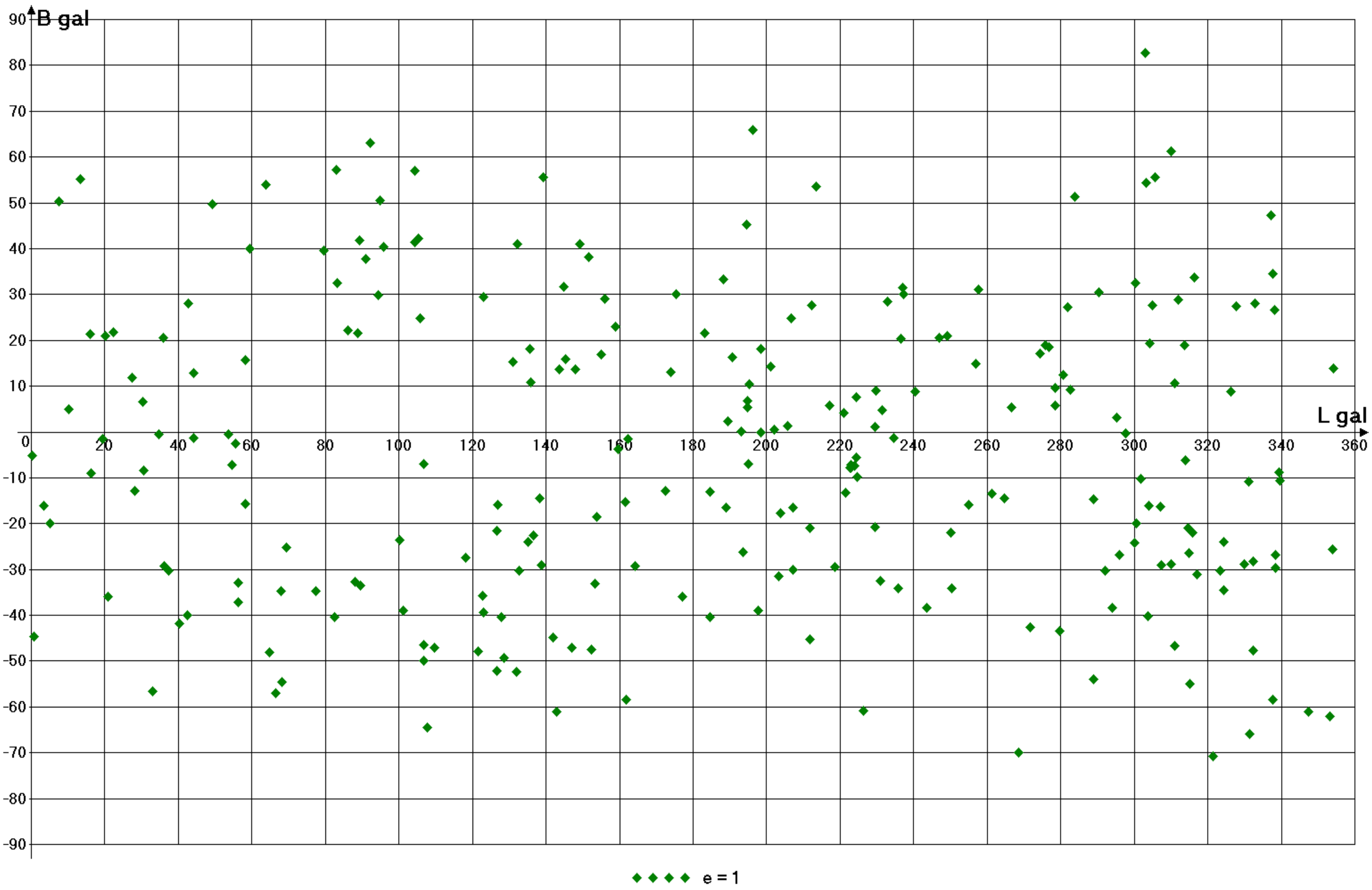
Distribution of “anti-perihelia” of comets with e > 1 (ecliptic coordinates)



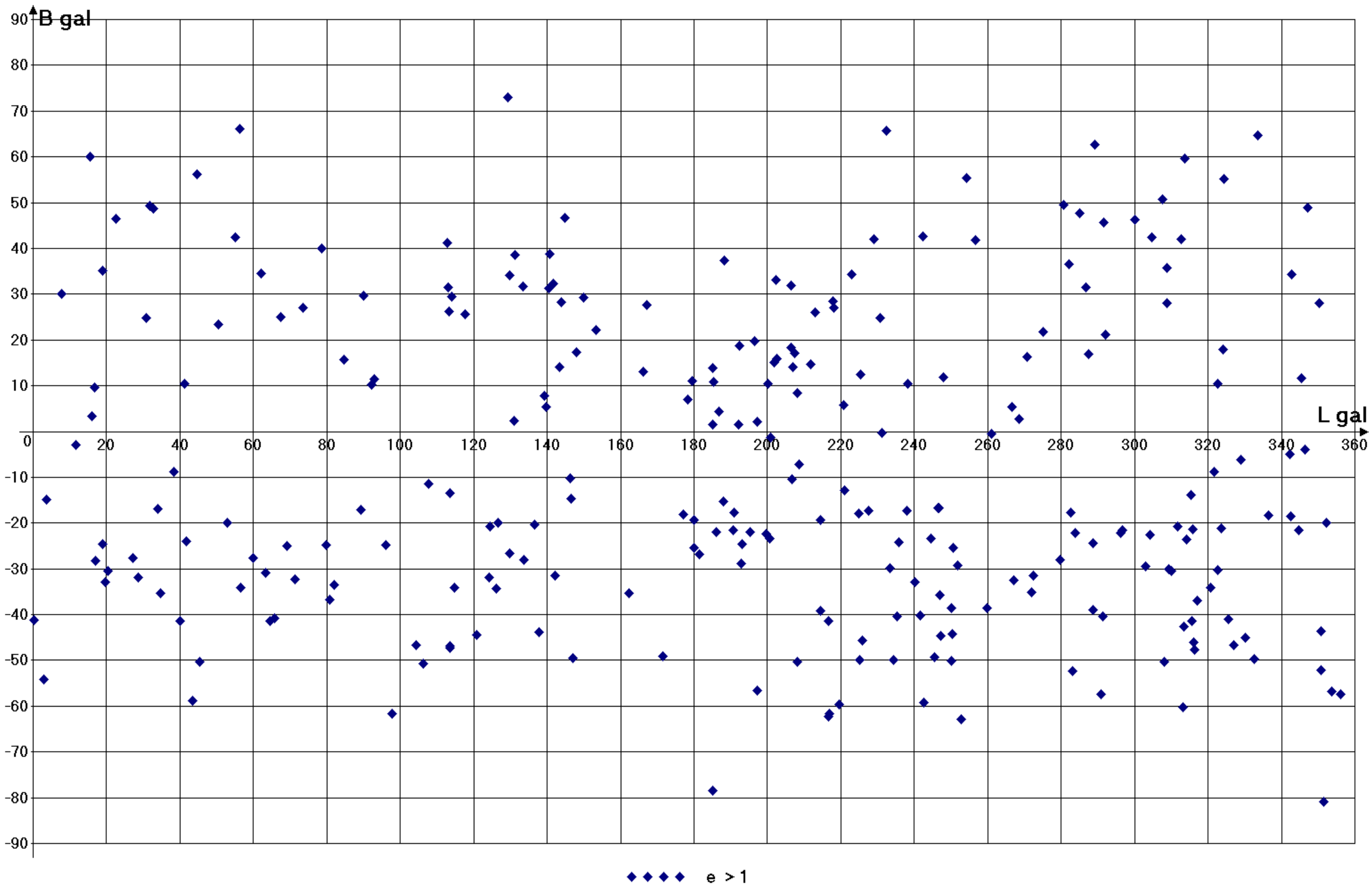
Distribution of "anti-perihelia" of long-period comets with 0.9 < e < 1 (galactic coordinates)



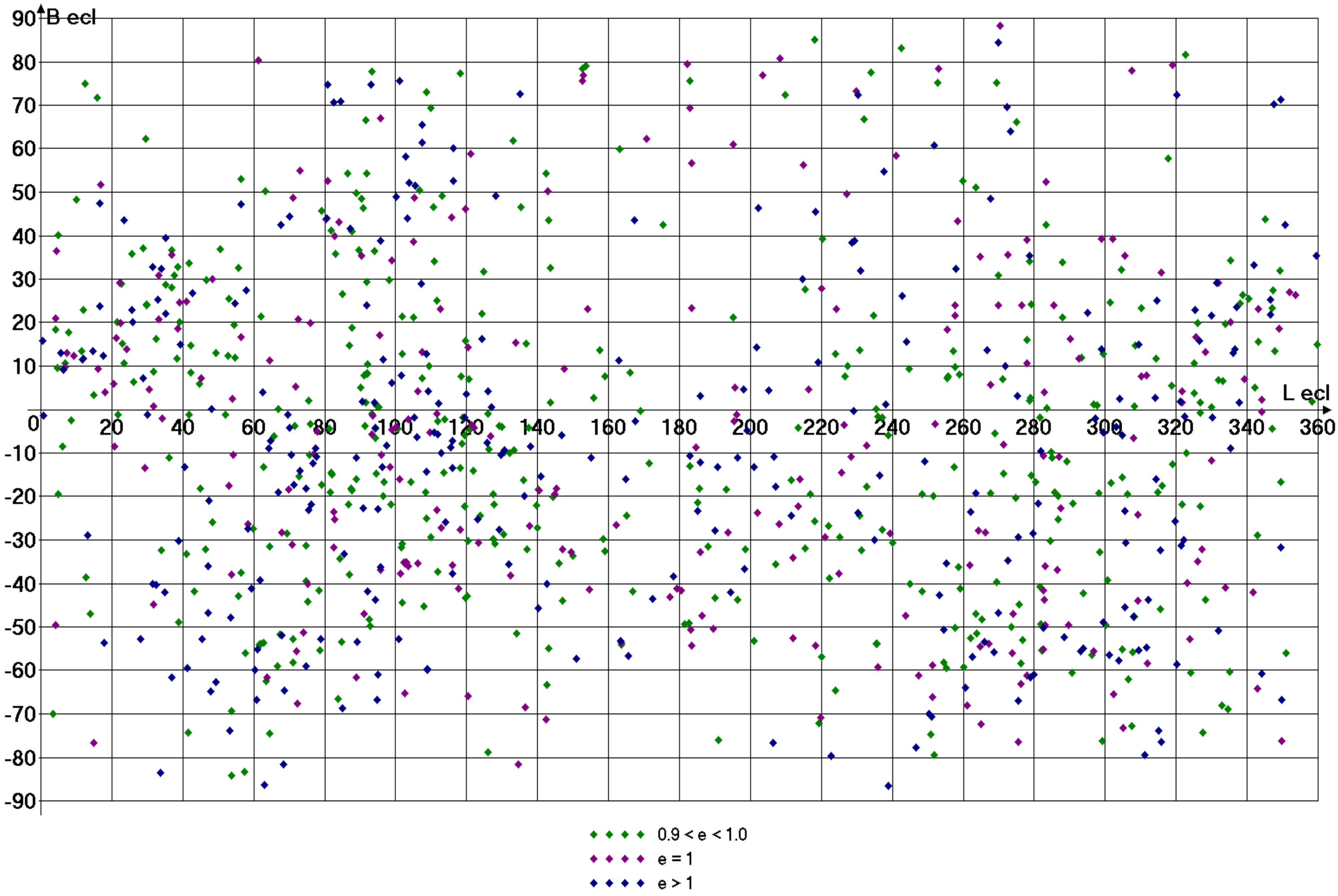
Distribution of “anti-perihelia” of comets with e = 1
(galactic coordinates)



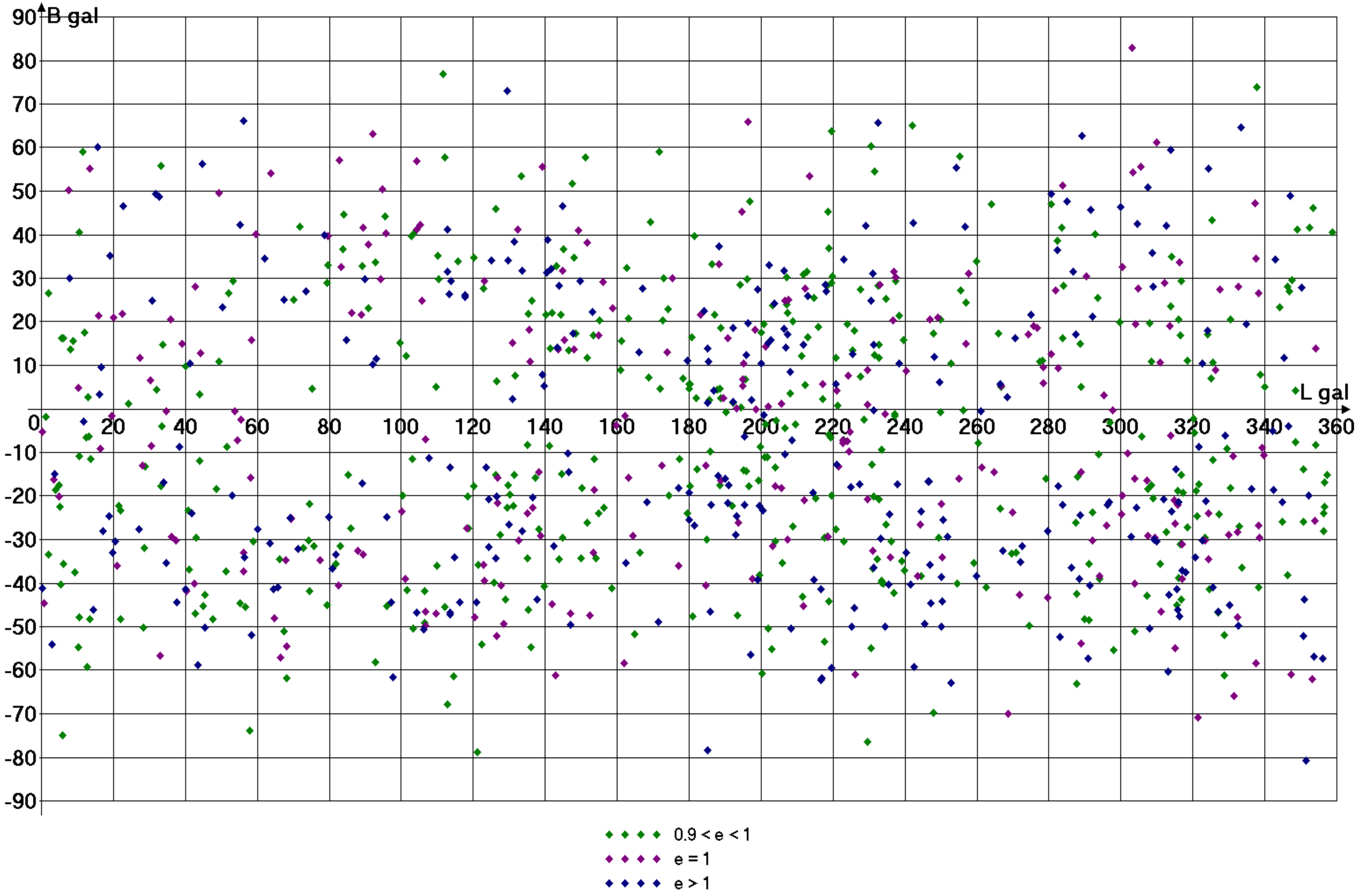
Distribution of "anti-perihelia" of comets with e > 1 (galactic coordinates)



Distribution of “anti-perihelia” of comets with e > 0.9
(ecliptic coordinates)

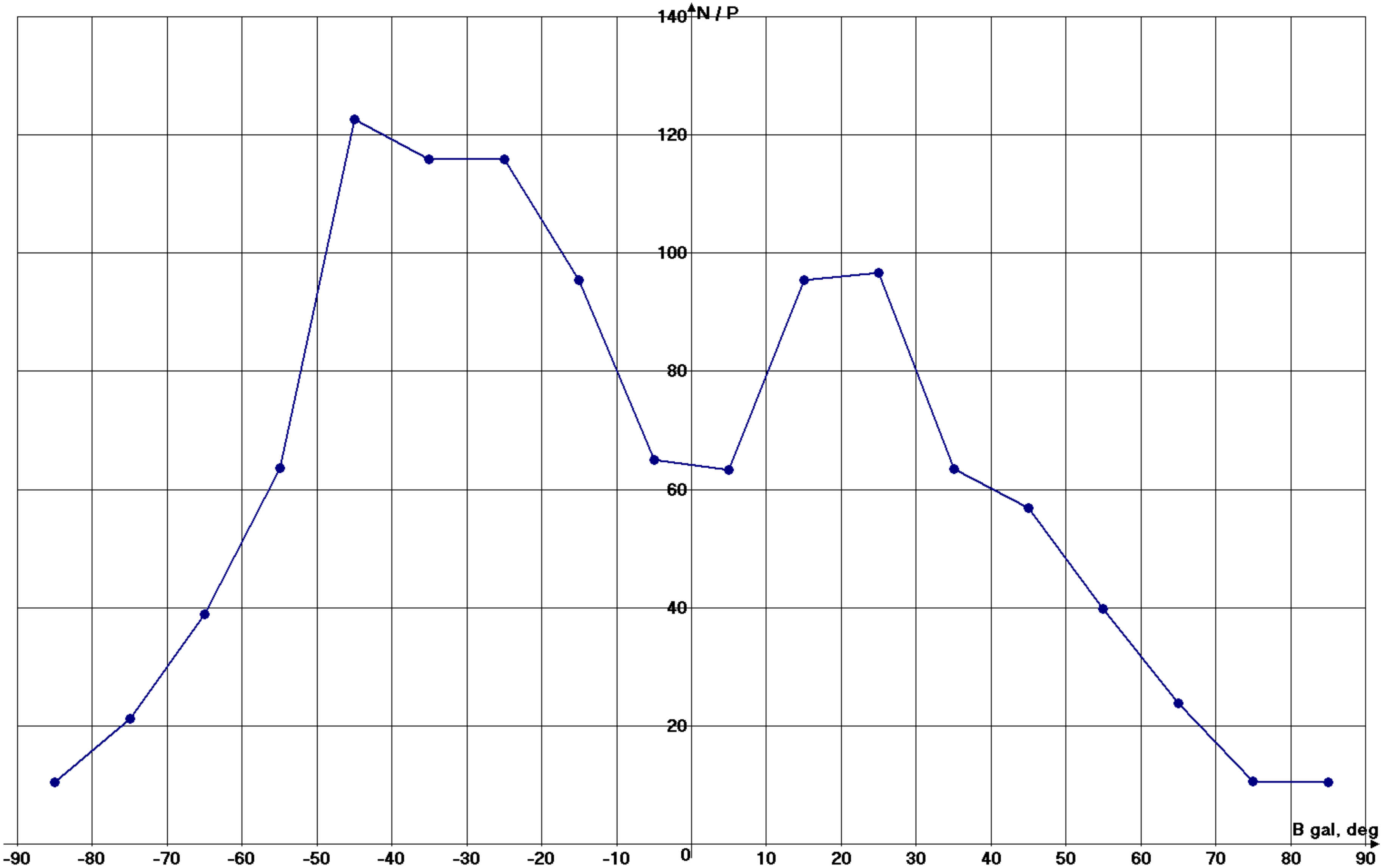


Distribution of "anti-perihelia" of comets with e > 0.9 (galactic coordinates)



Density of distribution by latitude bands (ecliptic coordinates)

Density of distribution by latitude bands (galactic coordinates)



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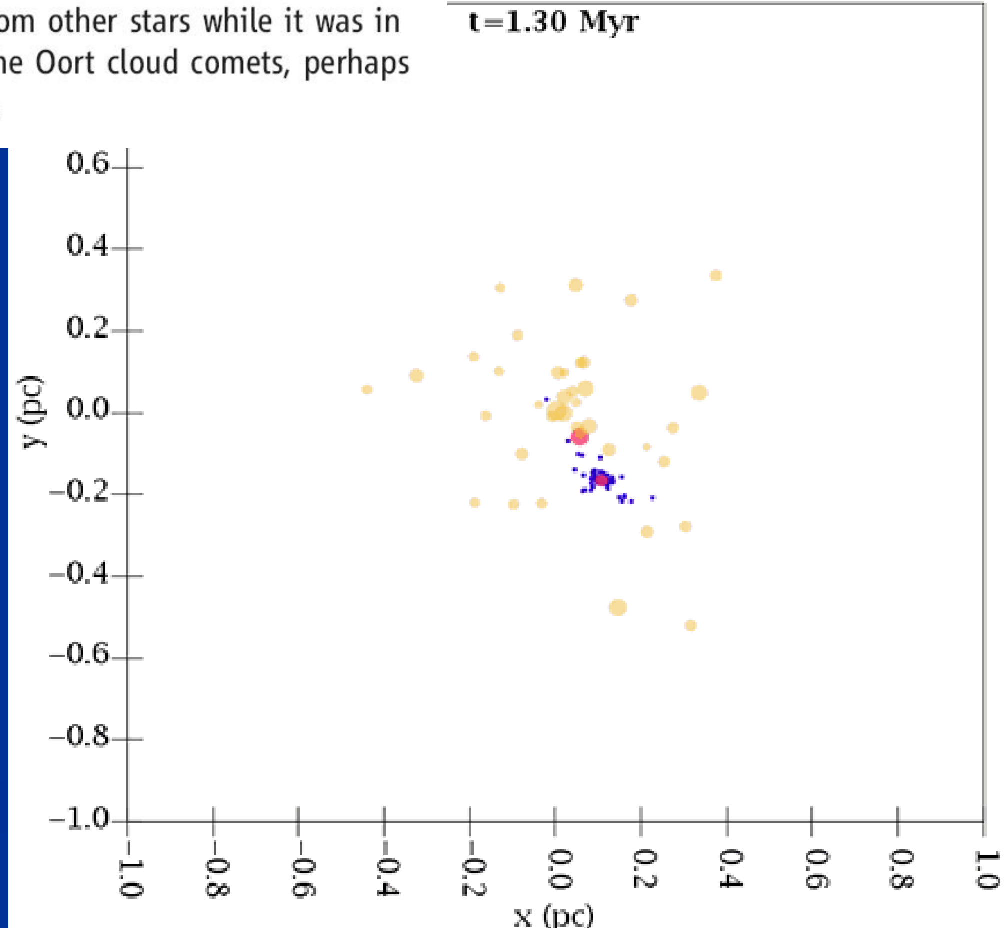
Capture of the Sun's Oort Cloud from Stars in Its Birth Cluster

Harold F. Levison,[1*] Martin J. Duncan,[2] Ramon Brasser,[3] David E. Kaufmann[1]

Oort cloud comets are currently believed to have formed in the Sun's protoplanetary disk and to have been ejected to large heliocentric orbits by the giant planets. Detailed models of this process fail to reproduce all of the available observational constraints, however. In particular, the Oort cloud appears to be substantially more populous than the models predict. Here we present numerical simulations that show that the Sun captured comets from other stars while it was in its birth cluster. Our results imply that a substantial fraction of the Oort cloud comets, perhaps exceeding 90%, are from the protoplanetary disks of other stars.

"A substantial fraction of the Oort cloud comets, perhaps exceeding 90%, are from the protoplanetary disks of other stars"

"The Sun's Hill sphere has an unstable maximum boundary of 230,000 AU (1.1 parsecs (3.6 light-years))"



Nearest massive stars:

α Cen - ~ 2 M_{sun} (1.1 + 0.9)
G2 / K1

Dist: 4.366 ly = 1.34 pc
π = 747 mas
RV = -21.6 km/s

Equatorial coordinates:
α = 14h 39m 36.495s = 219.902
δ = -60º 50' 02.31" = -60.834

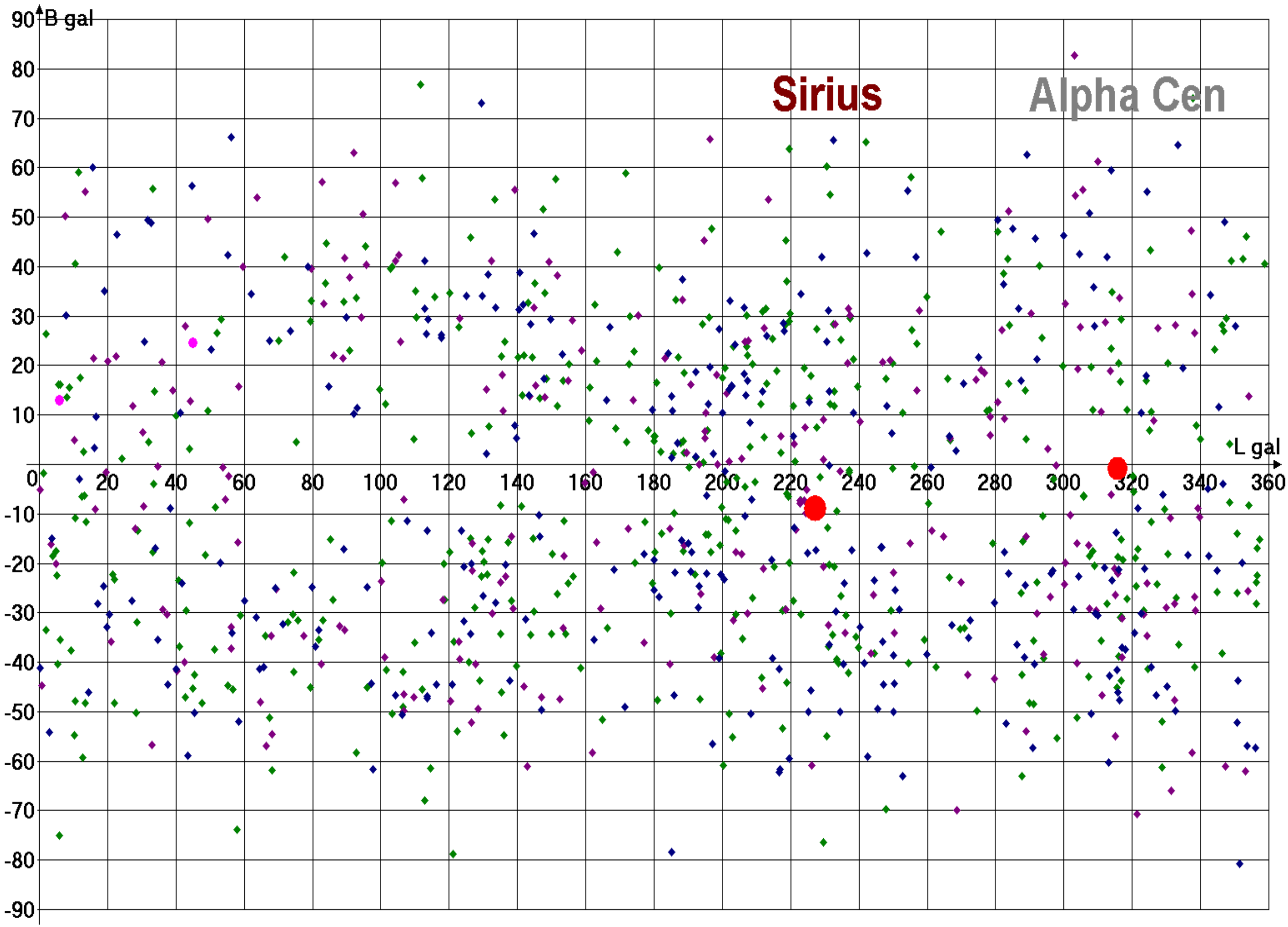
Galactic:
l = 315.734º
b = -0.680º

Sirius - ~ 3 M_{sun} (2 + 1)
A0/DA2

Dist: 8.60 ly = 2.64 pc
π = 379 mas
RV = -7.6 km/s

Equatorial coordinates:
α = 06h 45m 08.917s = 101.287º
δ = -16º 42' 58.02" = -16.716º

Galactic:
l = 227.230º
b = -8.890º


B gal
L gal
Sirius
Alpha Cen
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360

Main results:

1. Amount of short-period, long-period comets and sum of comets with parabolic and hyperbolic orbits is about equal.

2. Short-period comets have perihelia / aphelia near the ecliptic plane and show a weak concentration near the direction to the galactic center.

3. Long-period comets, comets with parabolic and hyperbolic orbits have very similar distributions of their “anti-perihelia”, flattened to the galactic plane. It allows to suppose their common origin from the birth stars cluster.

4. These groups of comets have not evident concentration near the direction to the galactic center, that could be expected as a result of galactic tidal forces.

5. Probably, some revealed concentrations are connected with nearest massive stars.

Thanks !