Comparison of physical properties of GEO and HEO objects tracking by ISON derived from multiyear observation statistics

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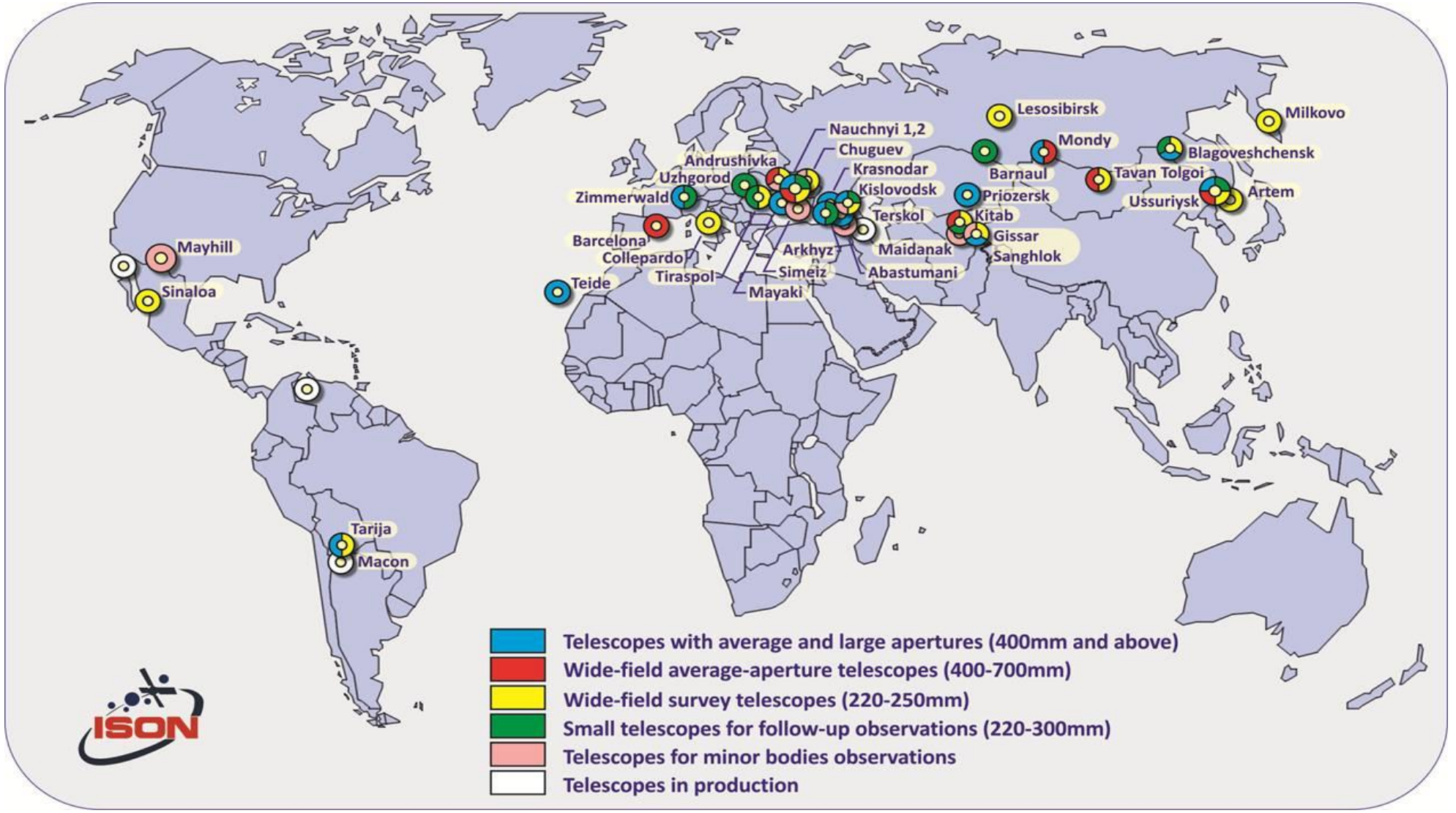
International Scientific Optical Network

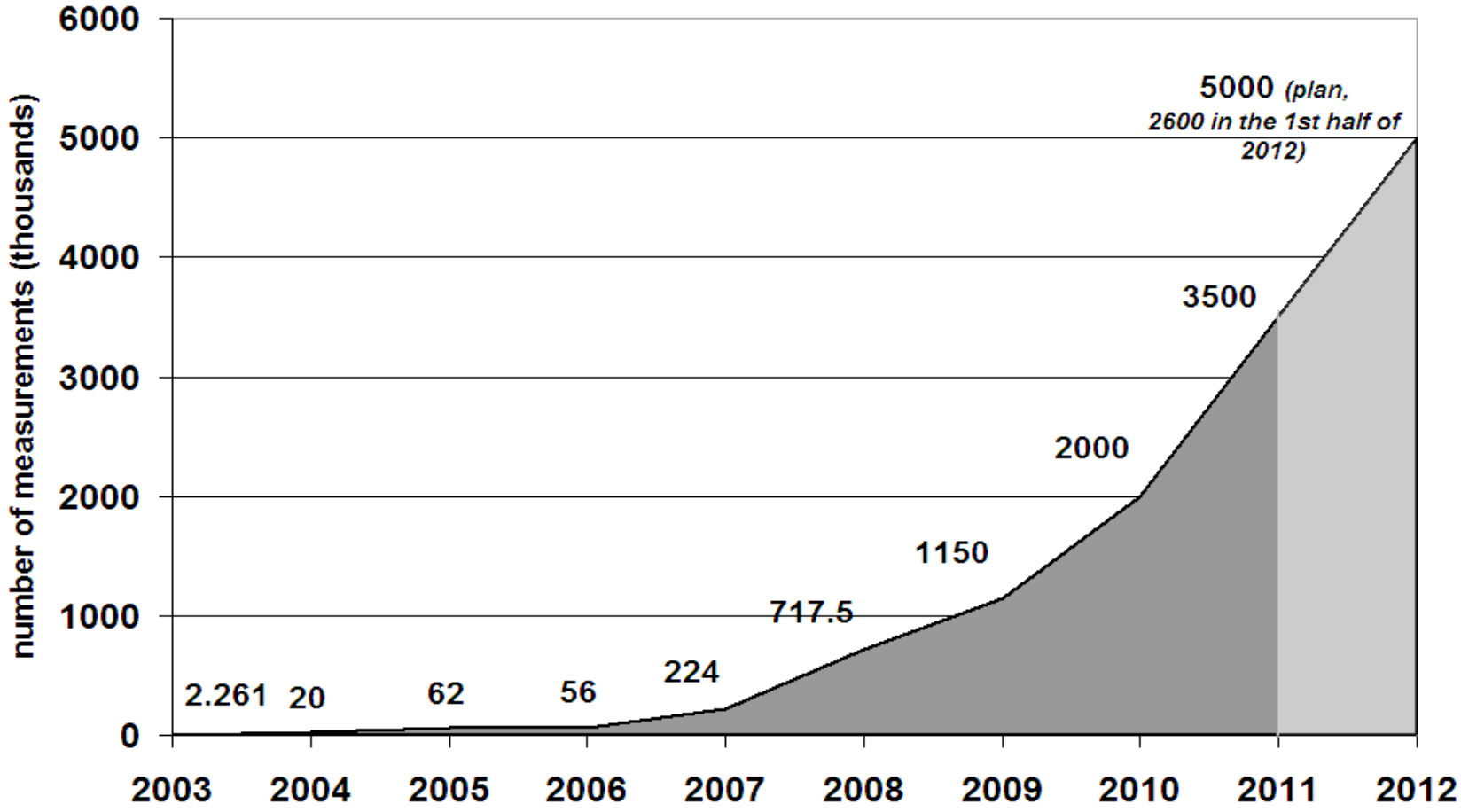
- ISON is an open international non-government project developed to be an independent source of data about space objects for scientific analysis and S/C operators
- Additional scientific goals – discovery and study of asteroids, comets and GRB afterglows
- ISON optical network represents one of largest systems specializing in observation of space objects
- Cooperation already joins 33 observation facilities of various affiliation in 14 countries, is coordinating by the Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences (KIAM) and maintaining with assistance of ASC “Project-technics”, JSC

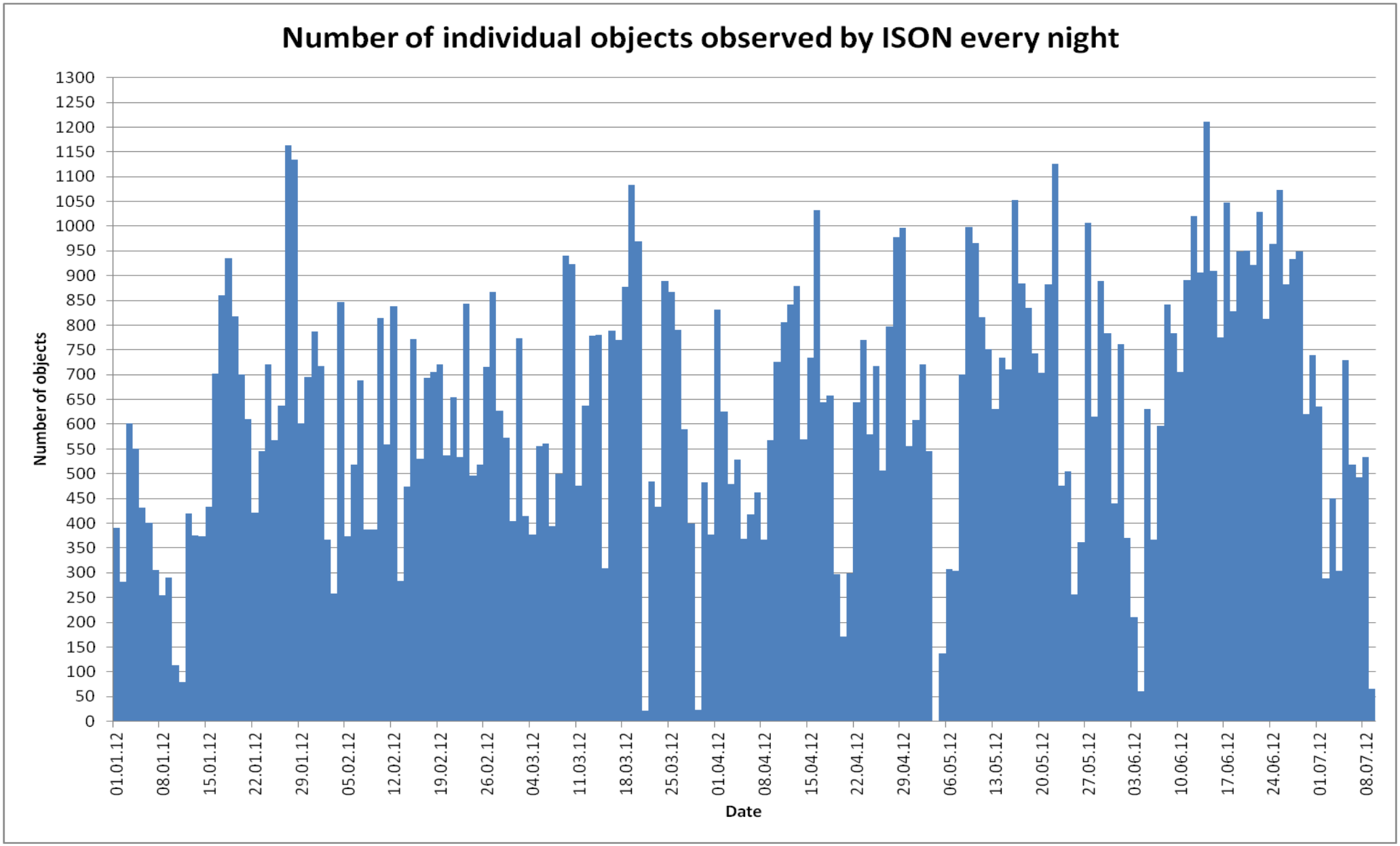
Map of ISON observatories

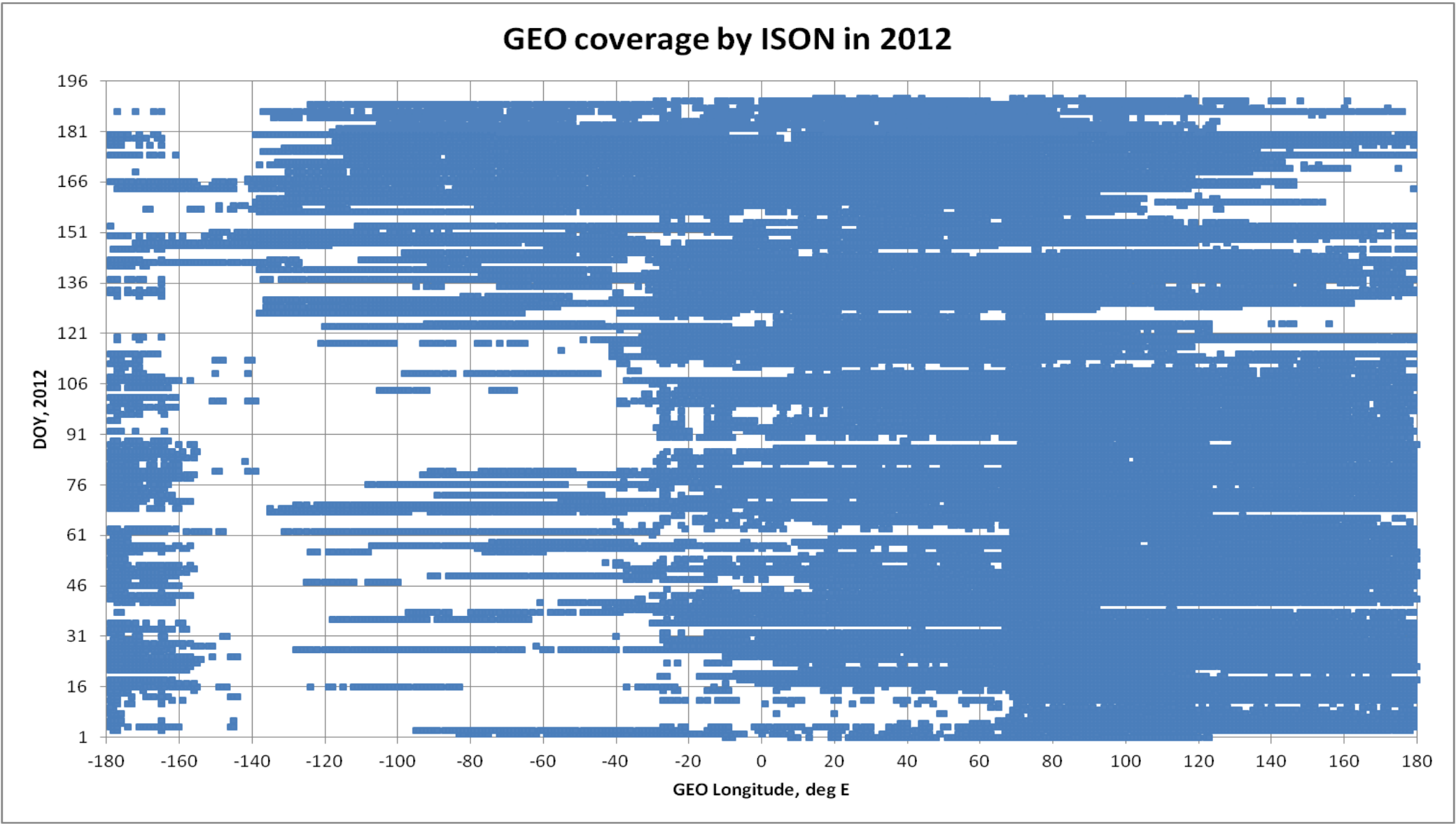


Quantity of measurements accumulated by ISON instruments (by year)

>10 millions measurements to the date




Number of individual objects observed by ISON every night
Number of objects
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
01.01.12
08.01.12
15.01.12
22.01.12
29.01.12
05.02.12
12.02.12
19.02.12
26.02.12
04.03.12
11.03.12
18.03.12
25.03.12
01.04.12
08.04.12
15.04.12
22.04.12
29.04.12
06.05.12
13.05.12
20.05.12
27.05.12
03.06.12
10.06.12
17.06.12
24.06.12
01.07.12
08.07.12
Date

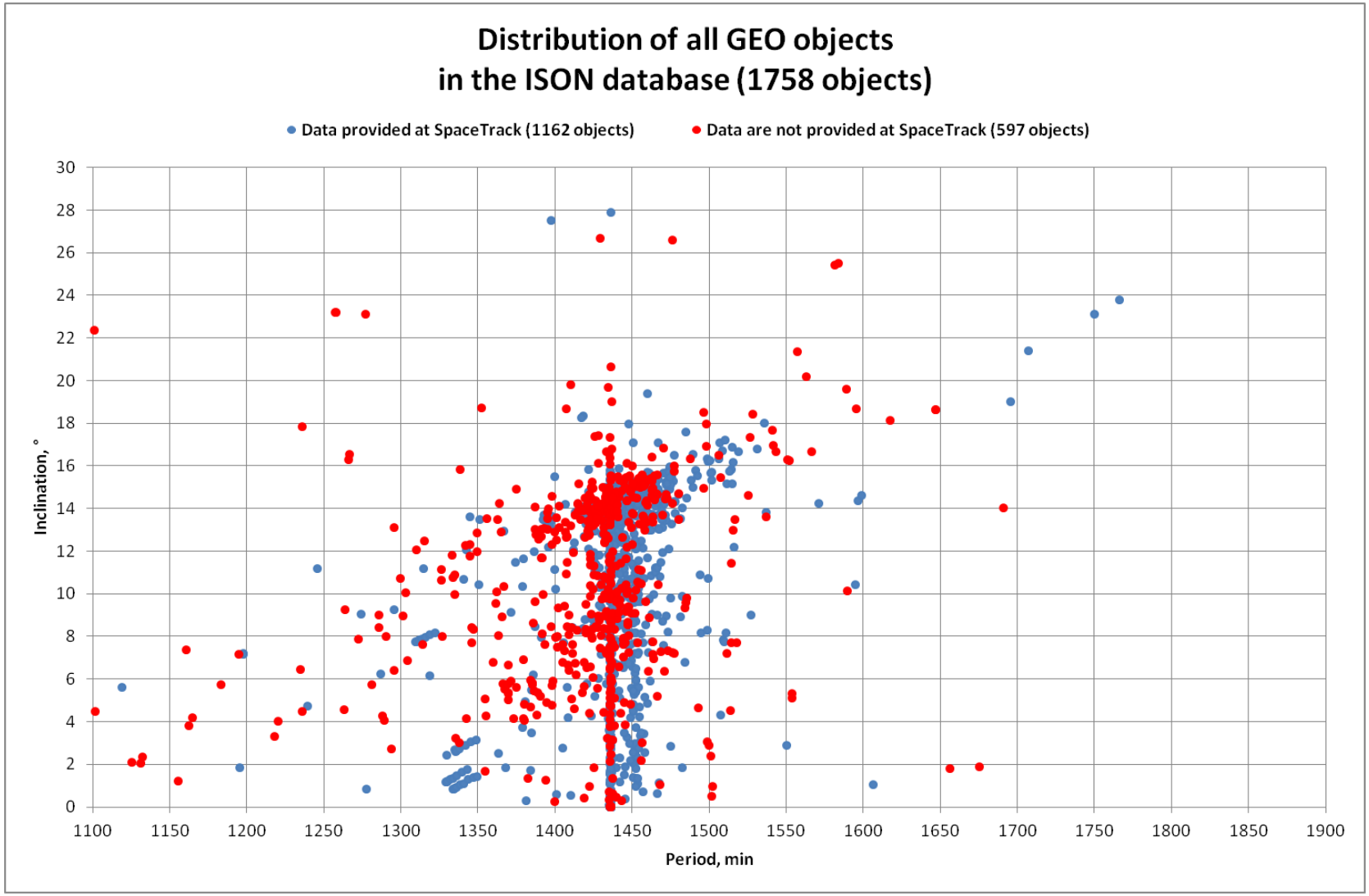

GEO coverage by ISON in 2012
DOY, 2012
196
181
166
151
136
121
106
91
76
61
46
31
16
1
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
GEO Longitude, deg E

ISON Monitored GEO Region Objects

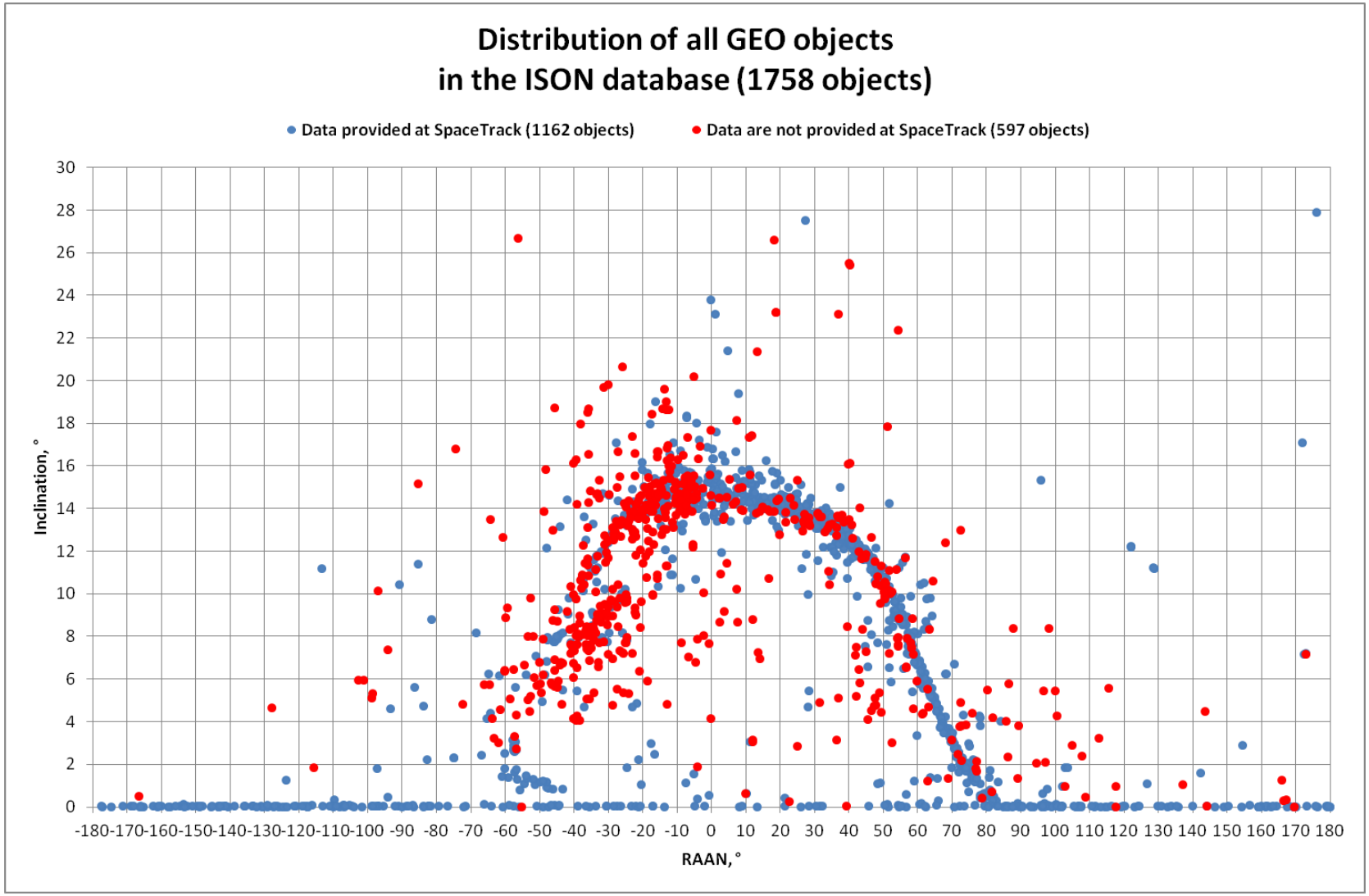
	01.01.2011	**01.01.2012**
Total objects in GEO, *including:*	**1557**	**1704**
spacecraft	922	954
active	404	422
non-active	518	532
upper stages and AKMs	257	260
fragments and undetermined type objects	378	490

- 89 new GEO region previously unknown fragments are already discovered and added to the ISON database in 2012 (as of Oct 1)

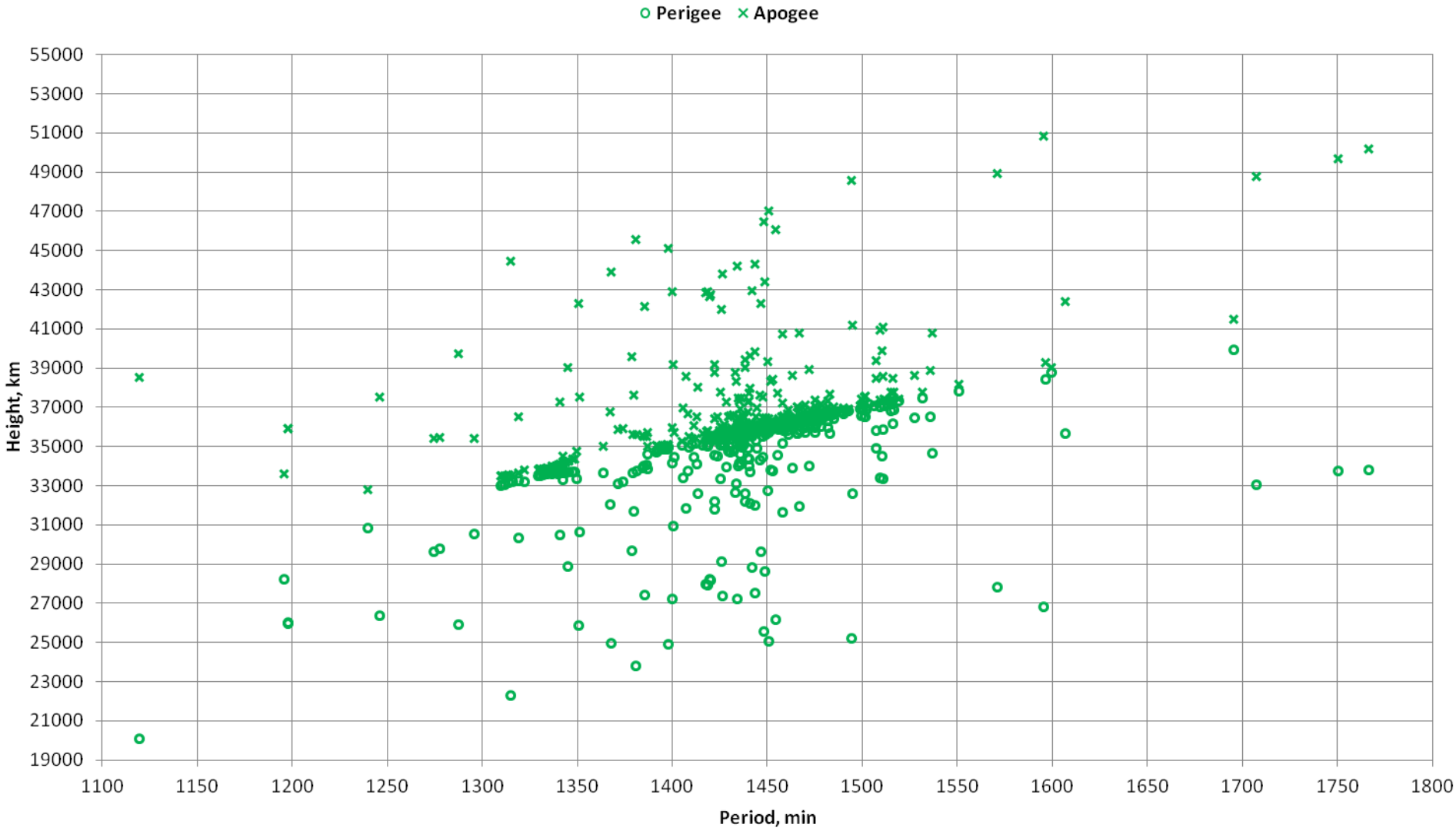
Distribution of observing GEO objects by period and inclination

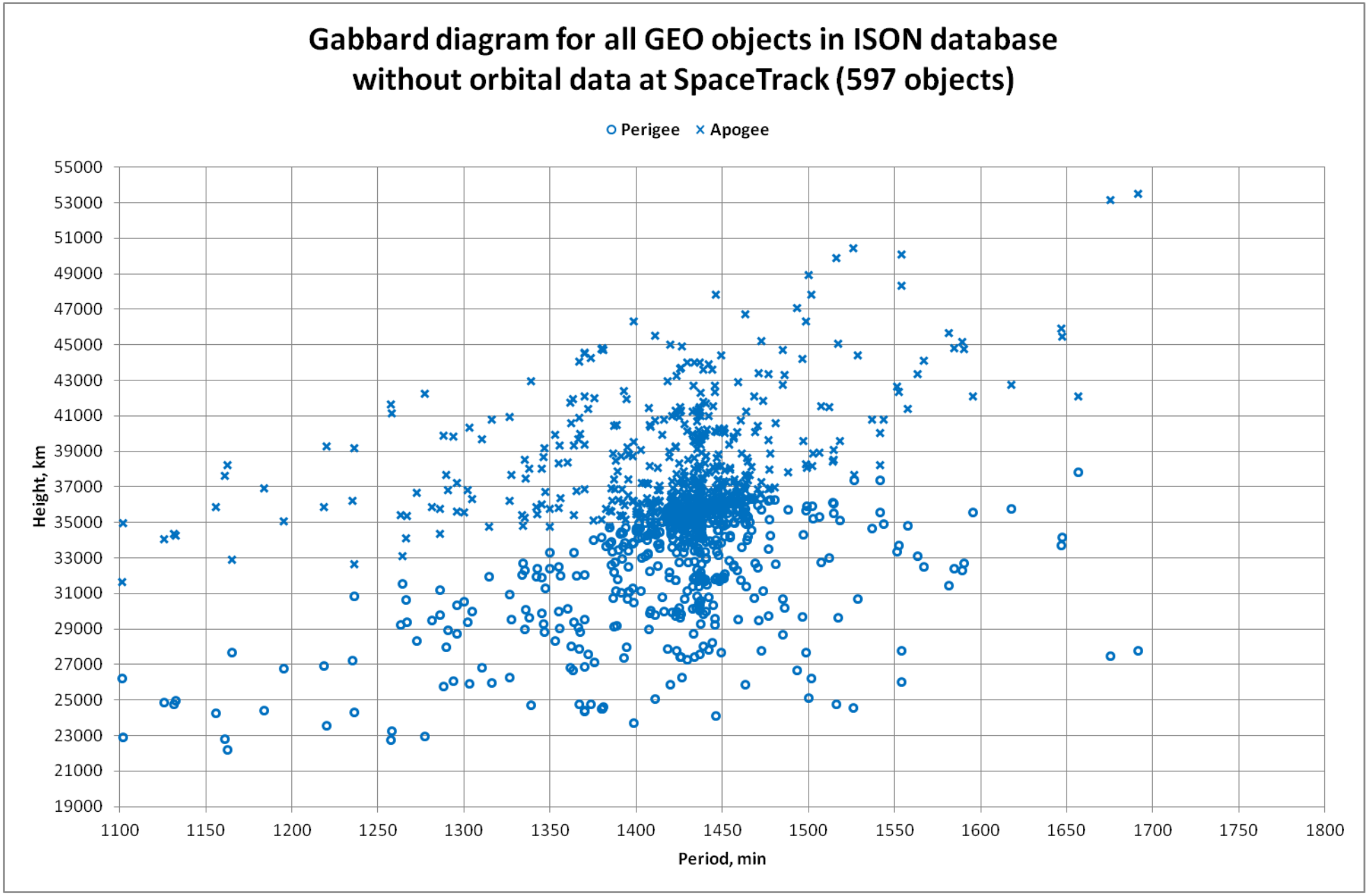


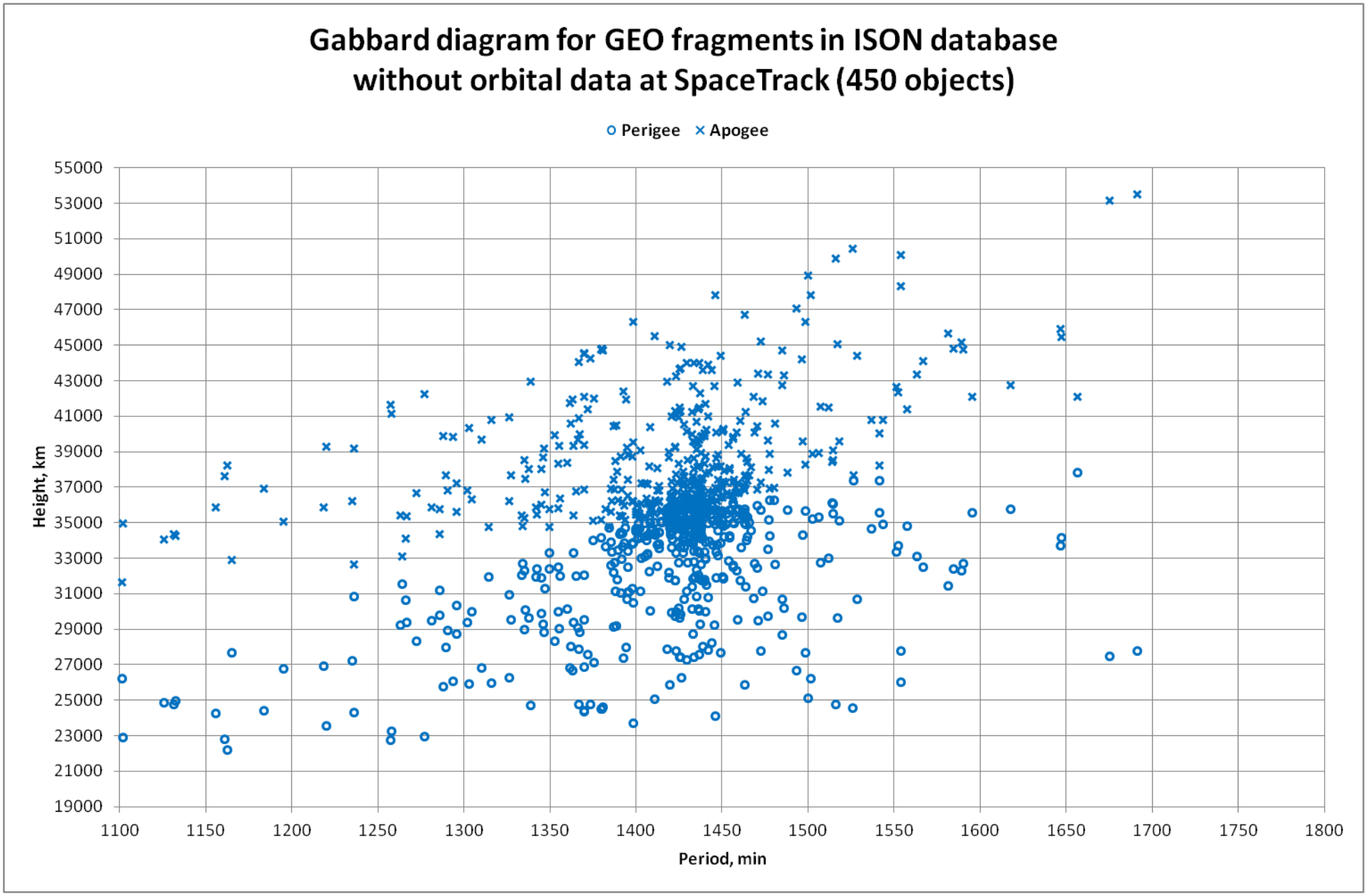
Distribution of observing GEO objects by RAAN and inclination



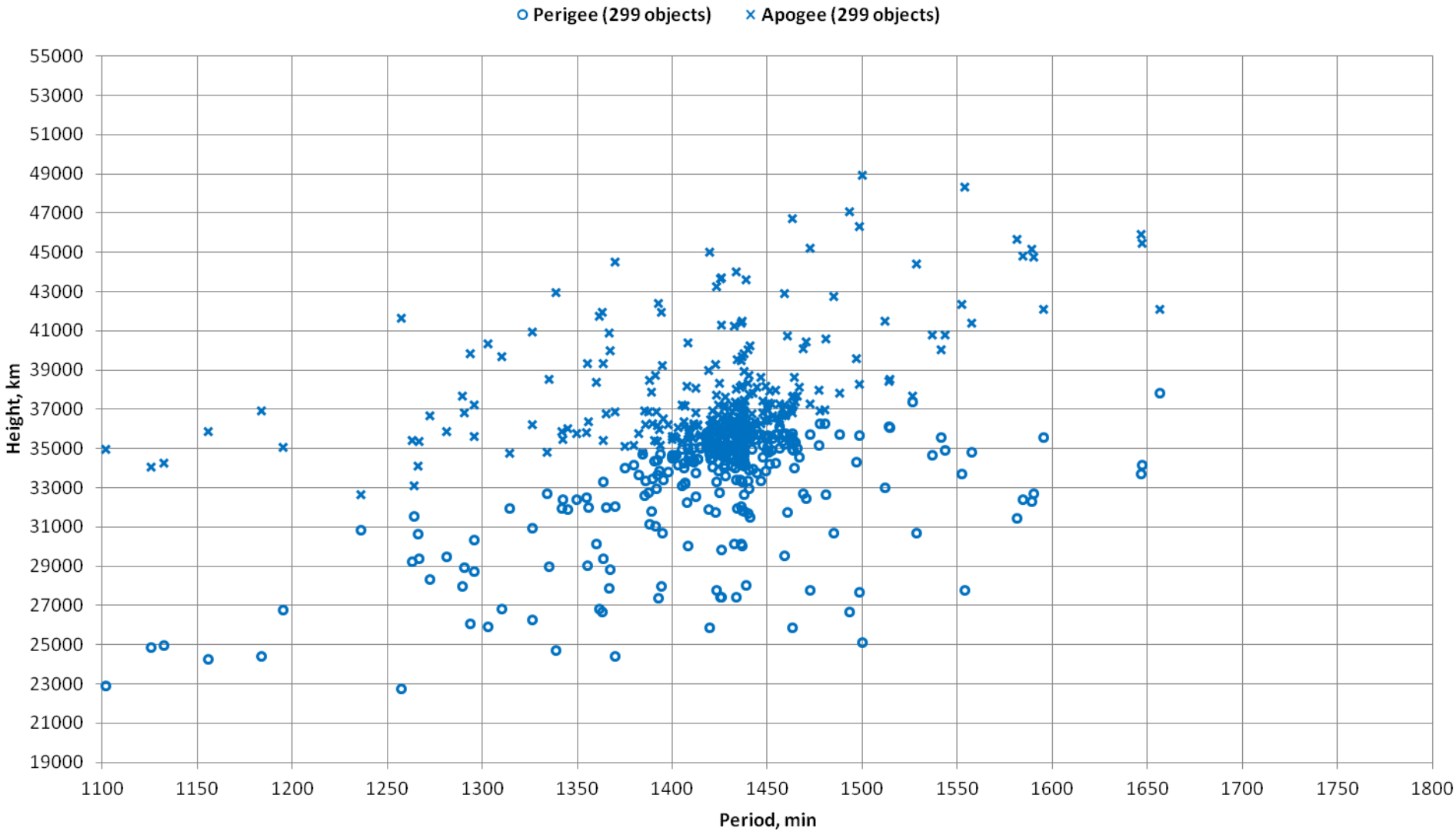
Gabbard diagram for all GEO objects with orbital data providing at SpaceTrack (1161 objects)




Gabbard diagram for all GEO objects in ISON database without orbital data at SpaceTrack (597 objects)
Perigee
Apogee
Height, km
55000
53000
51000
49000
47000
45000
43000
41000
39000
37000
35000
33000
31000
29000
27000
25000
23000
21000
19000
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
Period, min


Gabbard diagram for GEO fragments in ISON database
without orbital data at SpaceTrack (450 objects)
Perigee
Apogee
Height, km
55000
53000
51000
49000
47000
45000
43000
41000
39000
37000
35000
33000
31000
29000
27000
25000
23000
21000
19000
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
Period, min

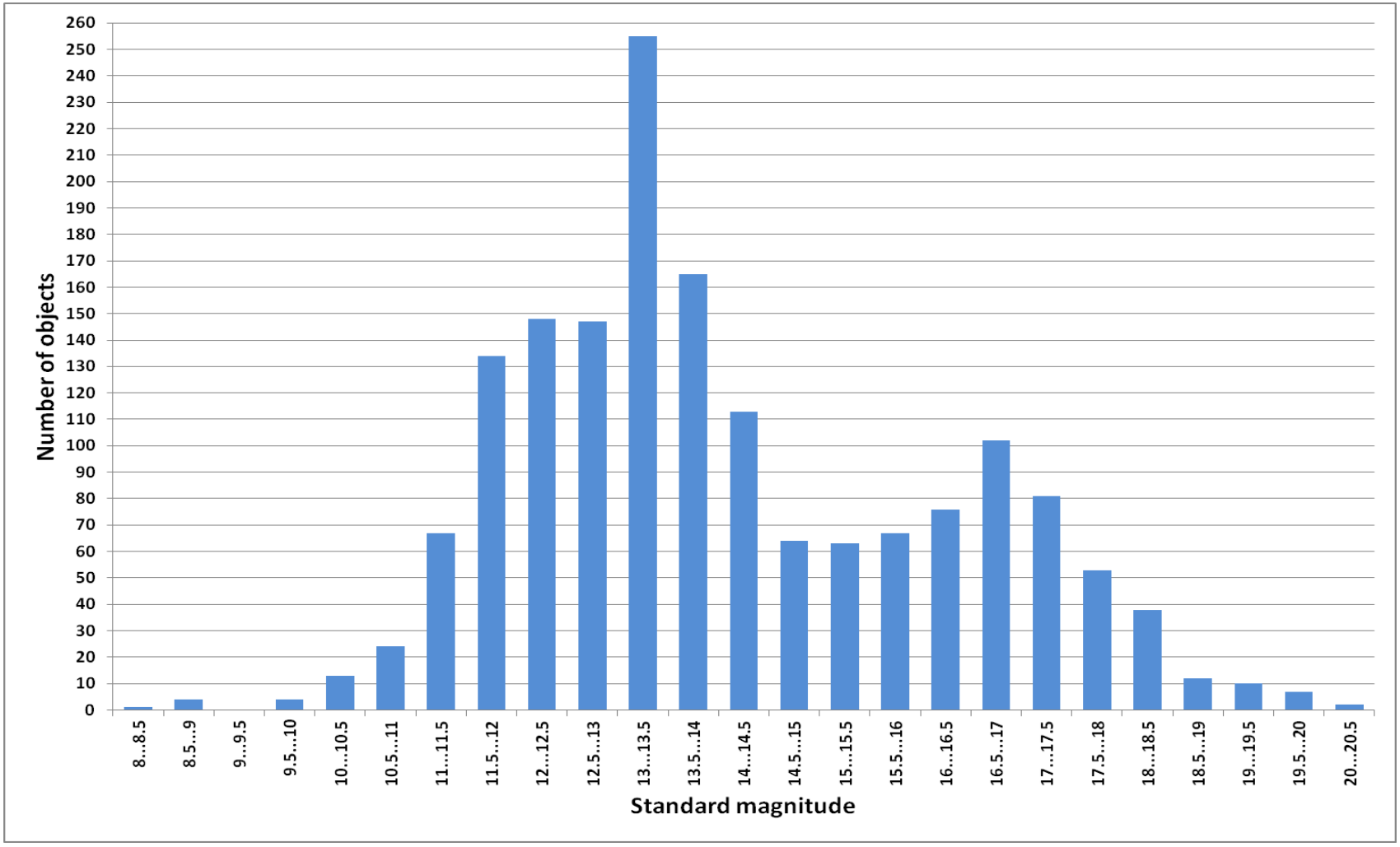
Gabbard diagram for GEO fragments in ISON database without orbital data at SpaceTrack (HAMR objects removed)



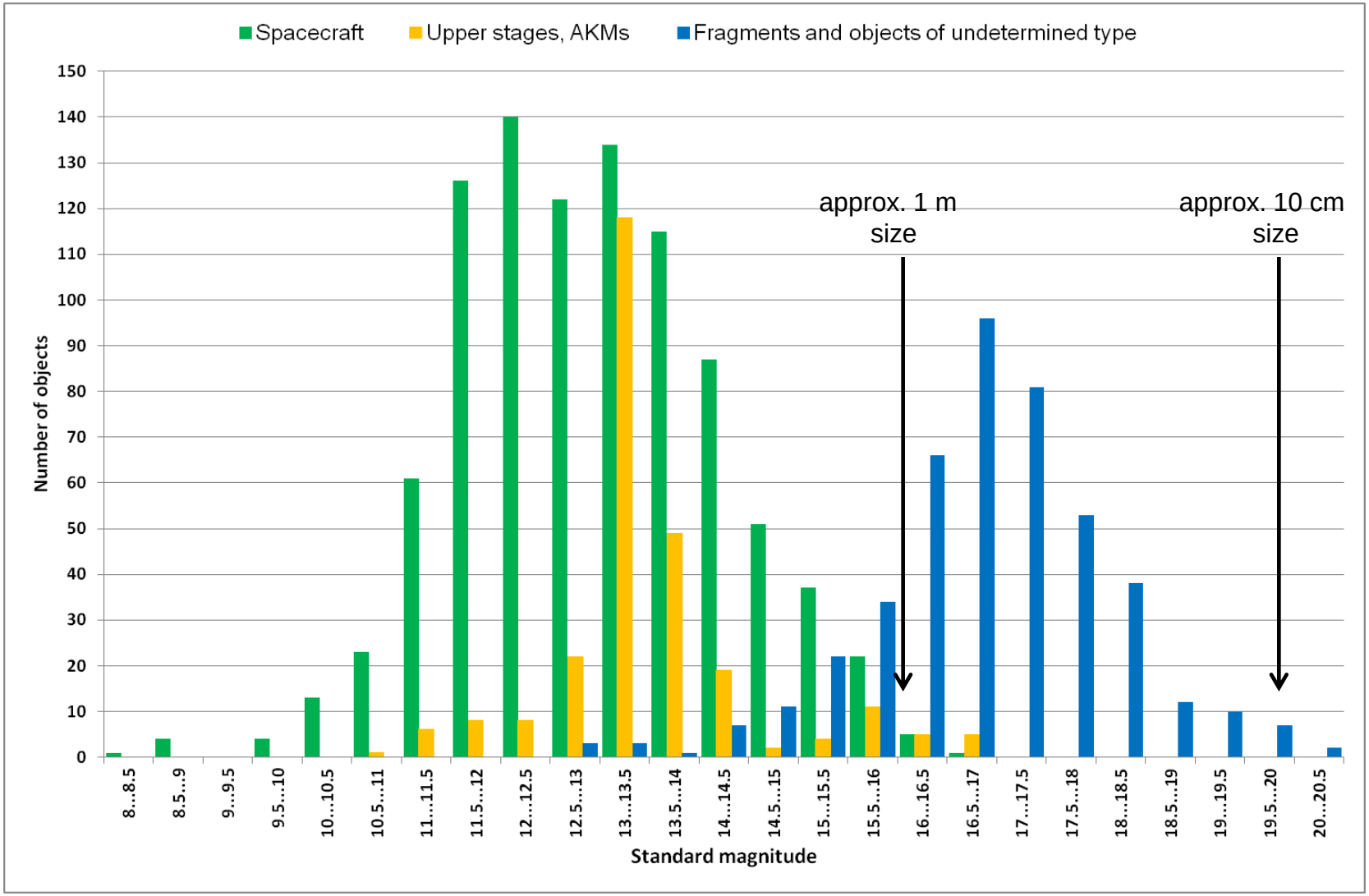
Brightness distribution of observing GEO objects

- Each object is assumed as a diffuse sphere with albedo of 0.15
- Differences between diffuse sphere phase function and real phase function for particular object are ignored
- Standard brightness (referring to a zero phase angle and 40000 km distance) is calculated for each object based on all collected measurements to the date
- Objects are split into 3 groups:
  - spacecraft,
  - rocket bodies (upper stages, AKMs),
  - fragments and objects of undetermined type

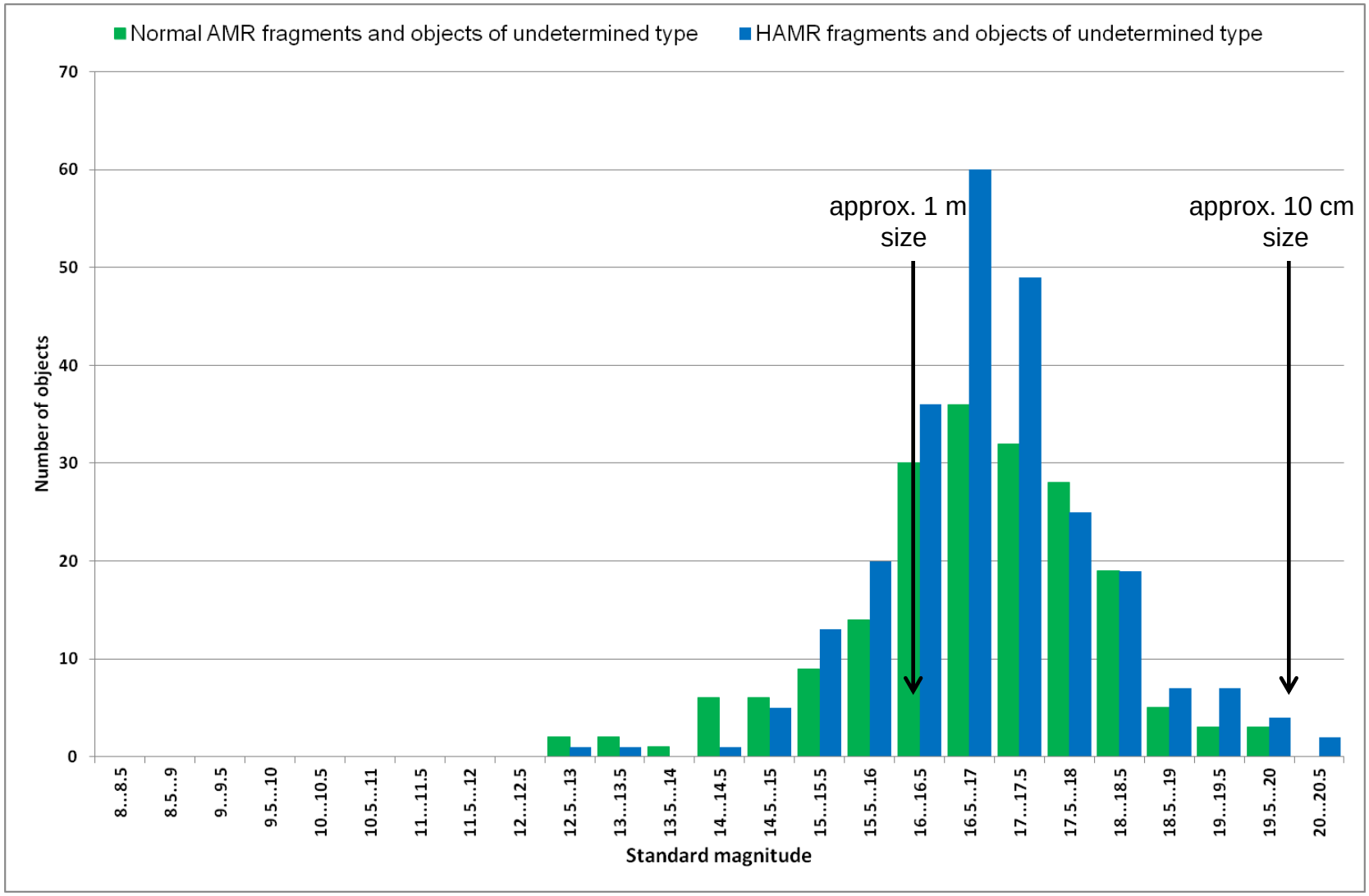
ISON Tracked GEO Objects Distribution by Standard Magnitude – 1704 objects



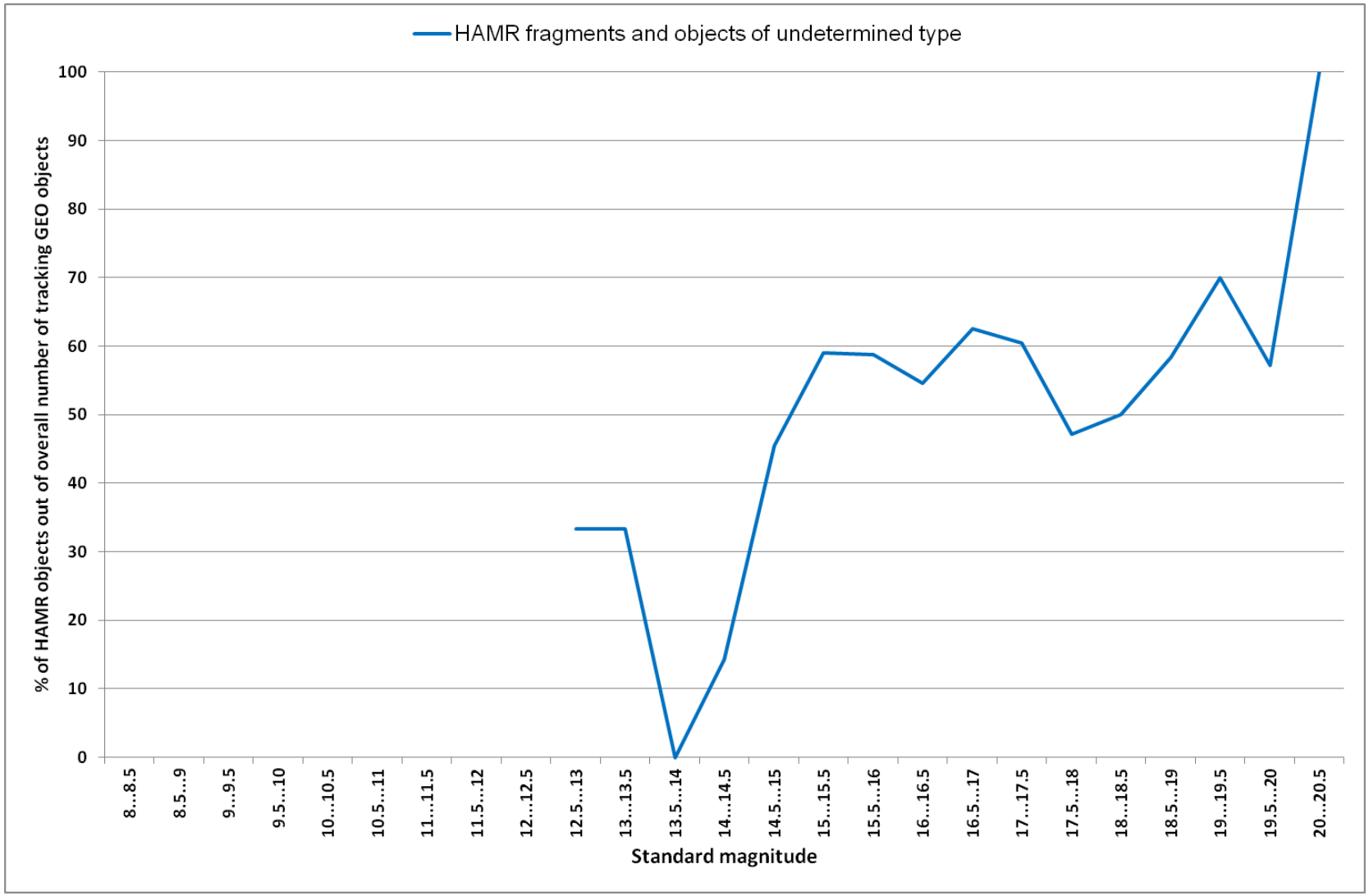
ISON Tracked GEO Objects Distribution by Standard Magnitude – 1704 objects



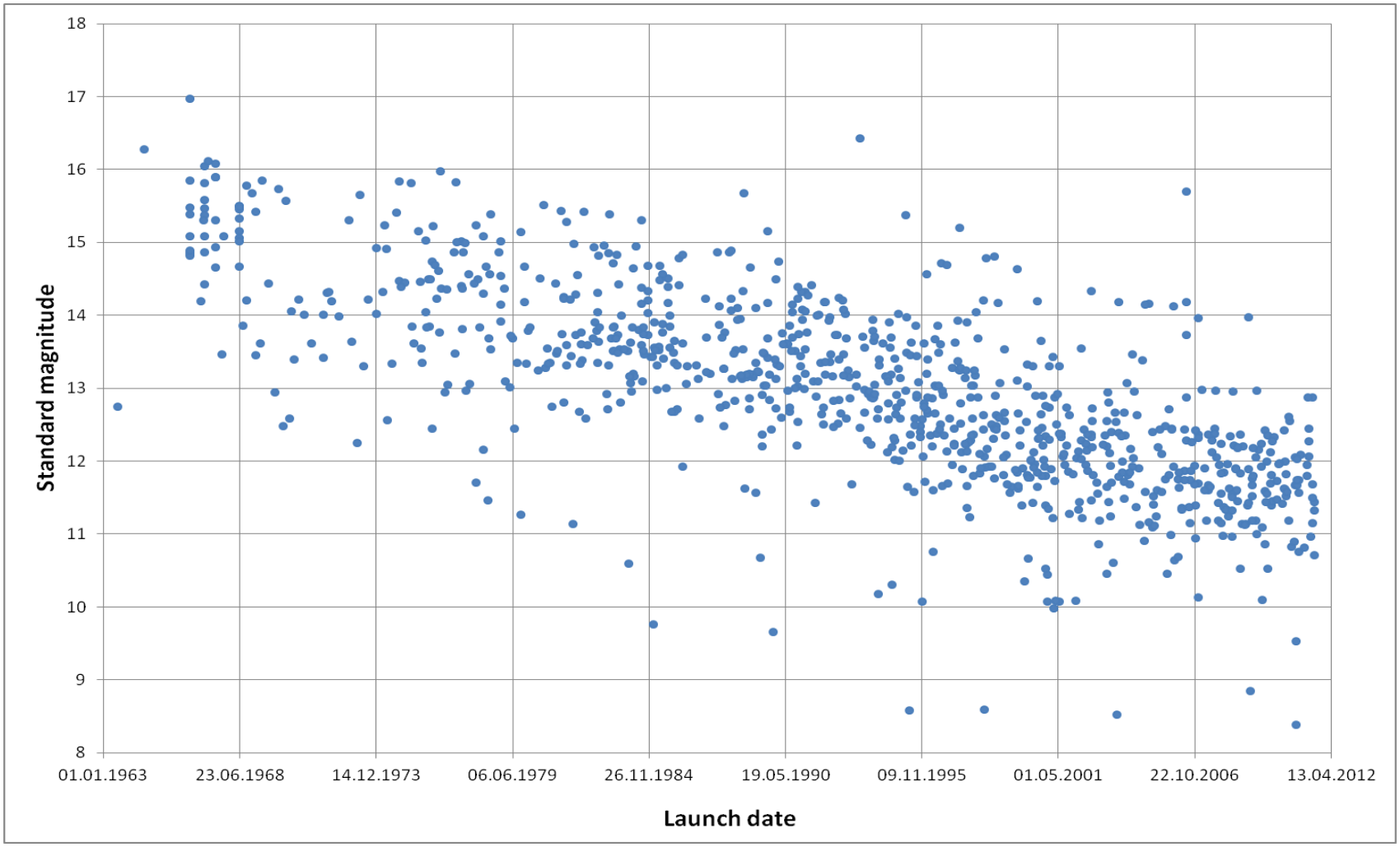
ISON Tracked GEO Fragments and Objects of Undetermined Type



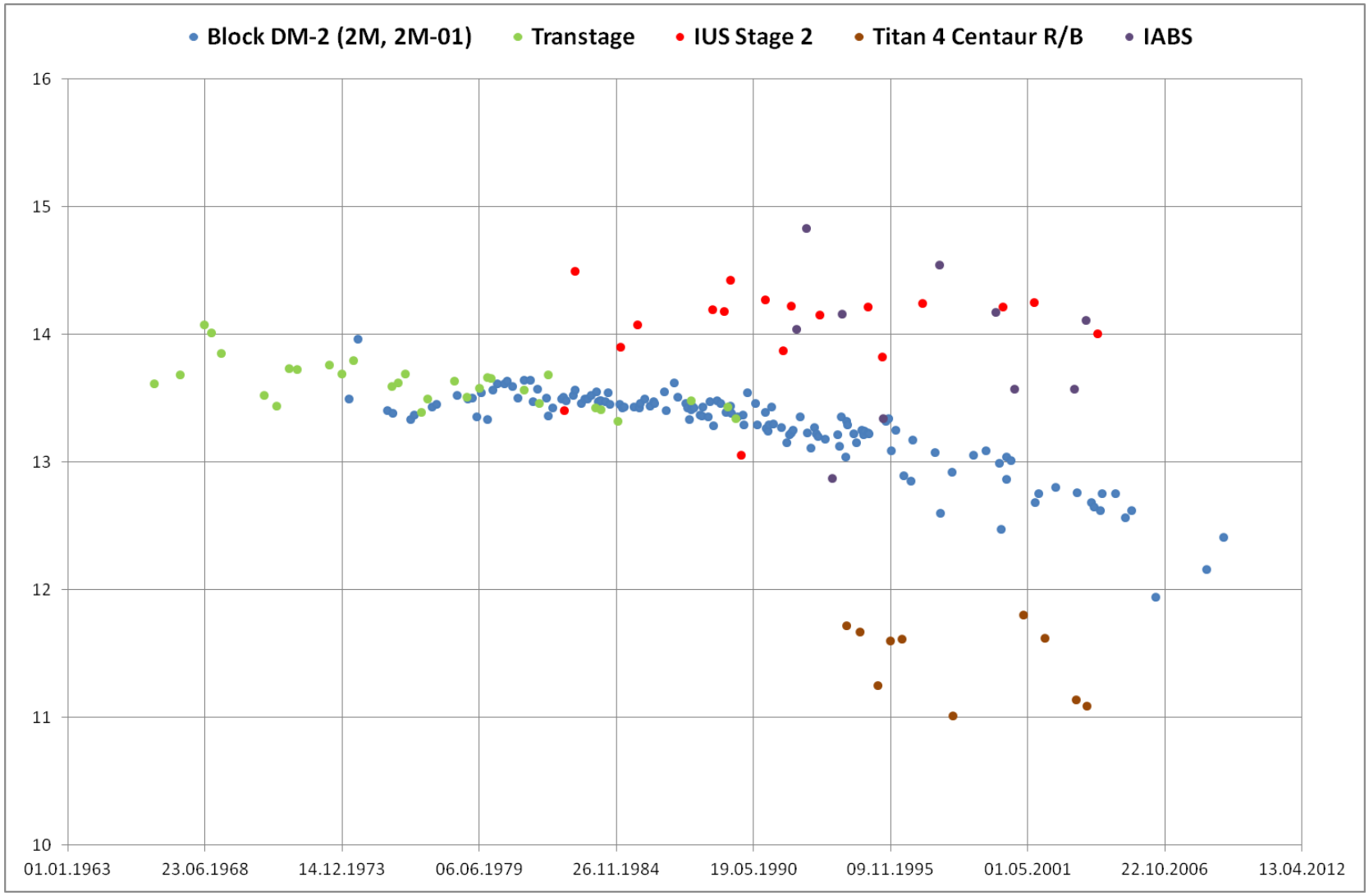
GEO HAMR Objects. How many?



ISON Tracked GEO Spacecraft Standard Magnitude vs. Launch Date



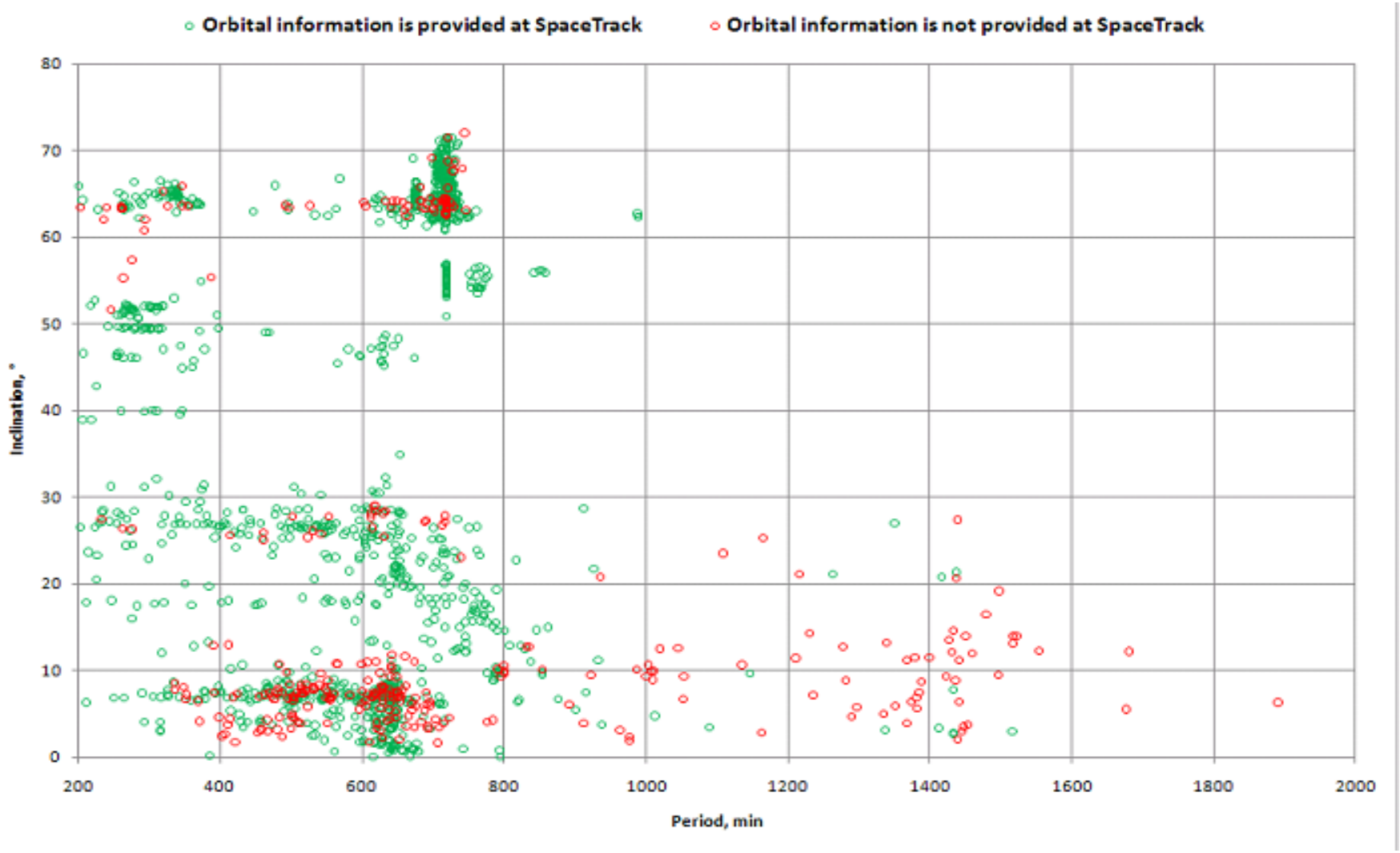
ISON Tracked GEO Upper Stages Standard Magnitude vs. Launch Date

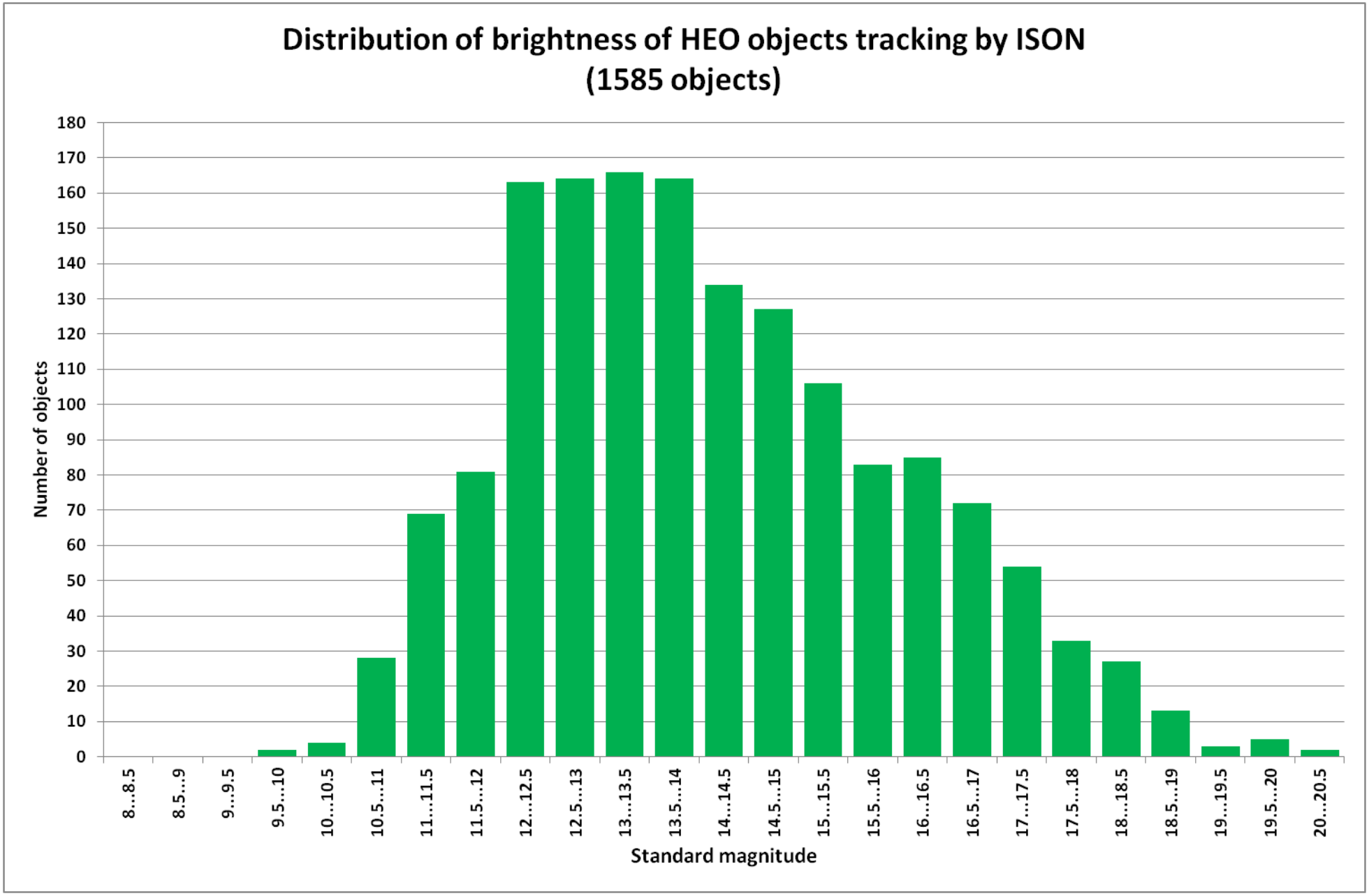


HEO Observations by ISON

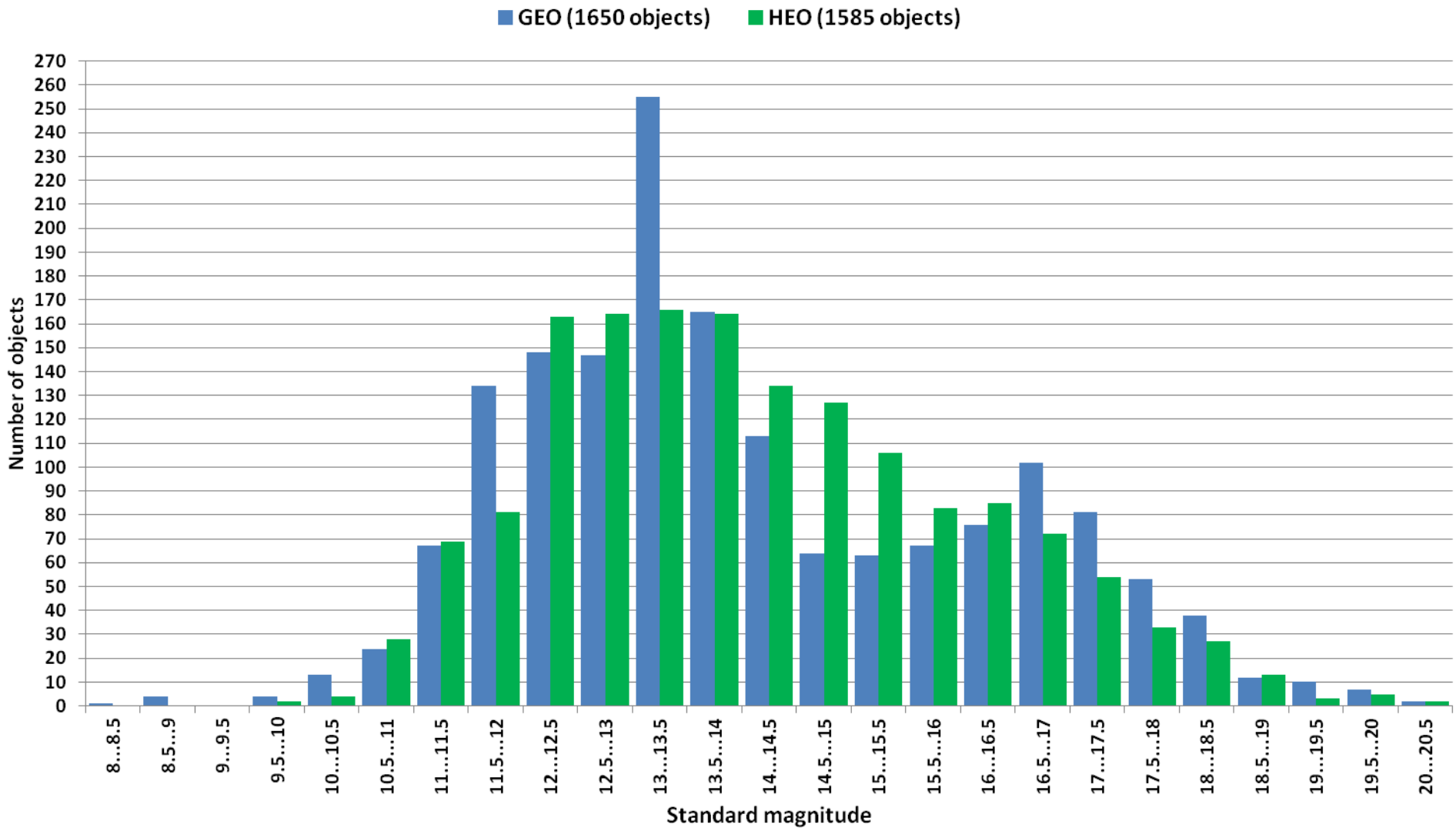
- Observations of objects at HEO are obtained mostly as an additional output of regular GEO surveys
- As of Jan 1, 2012 measurements are collected for 1585 HEO objects, including 270 ones for which data are not provided at SpaceTrack. 78 previously unknown HEO debris are discovered in 2012 (as of Oct 1)
- Data are not analyzed yet by category of object (spacecraft, upper stages, fragments) in a manner of GEO objects so only integrated data are presented
- Standard brightness (referring to 40000 km distance and zero phase angle, model of a diffuse reflecting sphere with albedo of 0.15) is estimated for all tracked HEO objects

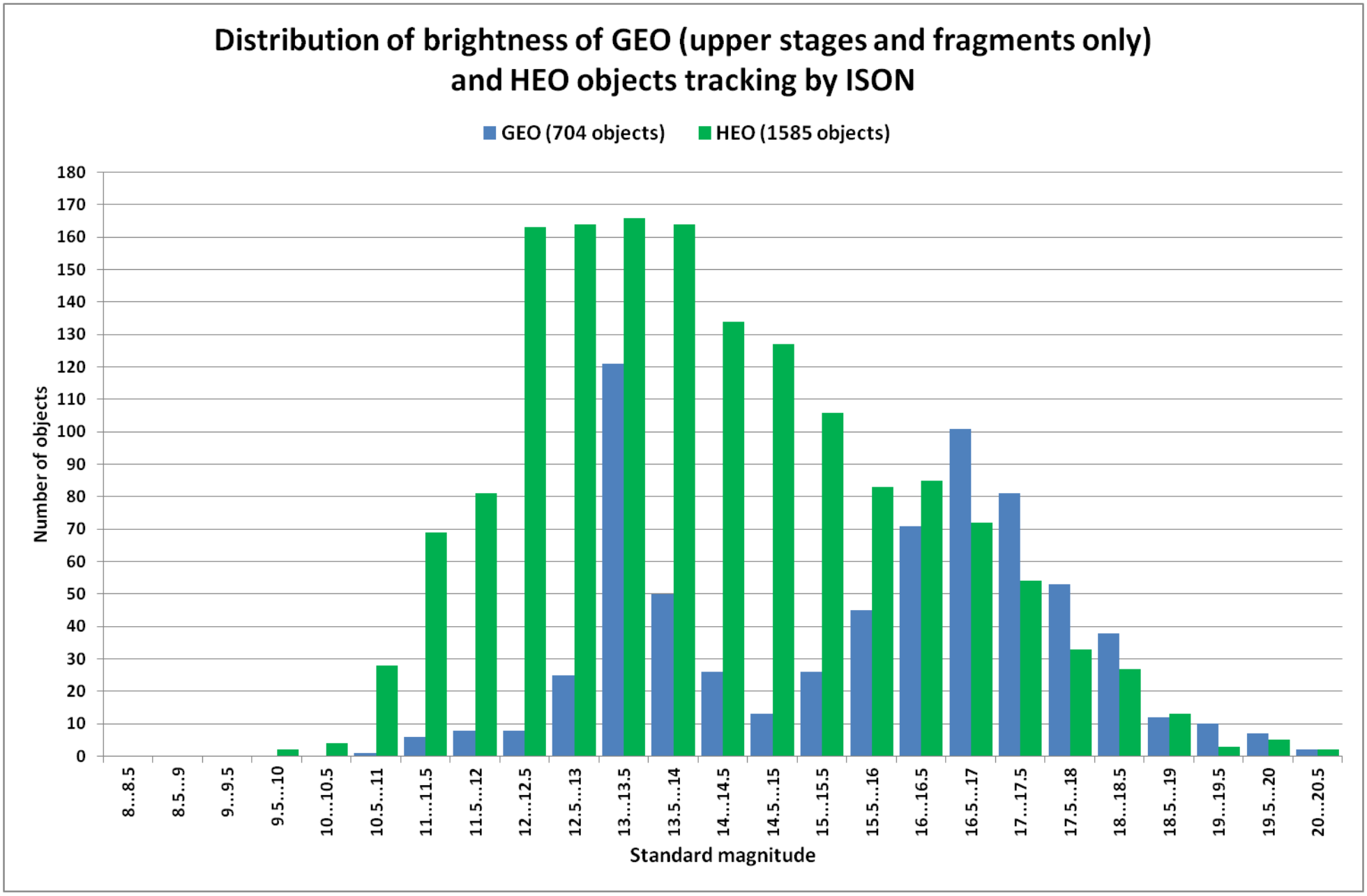
Distribution of HEO objects observing by ISON




Distribution of brightness of HEO objects tracking by ISON
(1585 objects)
Number of objects
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
8...8.5
8.5...9
9...9.5
9.5...10
10...10.5
10.5...11
11...11.5
11.5...12
12...12.5
12.5...13
13...13.5
13.5...14
14...14.5
14.5...15
15...15.5
15.5...16
16...16.5
16.5...17
17...17.5
17.5...18
18...18.5
18.5...19
19...19.5
19.5...20
20...20.5
Standard magnitude

Distribution of brightness of GEO (spacecraft, upper stages and fragments) and HEO objects tracking by ISON




Distribution of brightness of GEO (upper stages and fragments only) and HEO objects tracking by ISON
GEO (704 objects)
HEO (1585 objects)
Number of objects
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
8...8.5
8.5...9
9...9.5
9.5...10
10...10.5
10.5...11
11...11.5
11.5...12
12...12.5
12.5...13
13...13.5
13.5...14
14...14.5
14.5...15
15...15.5
15.5...16
16...16.5
16.5...17
17...17.5
17.5...18
18...18.5
18.5...19
19...19.5
19.5...20
20...20.5
Standard magnitude

Conclusions

More than 10 millions of measurements (RA, DECL, visual magnitude) are collected within the ISON project since 2003

Nearly 1800 GEO objects are tracked by ISON as of the end of Sep 2012, including ~630 ones without orbital data at SpaceTrack

Nearly 1700 HEO objects are tracked by ISON as of the end of Sep 2012, including ~250 ones without orbital data at SpaceTrack

Large population of HAMR objects is discovered and studied

Brightness properties of tracking GEO and HEO objects are studied and compared. Study is continuing

Acknowledgements

Great thanks to all ISON observers and engineers, including ASC “Project-technics” employers providing invaluable support in software developing and observation planning

Special thanks to the AIUB team for support of continuing multiyear cooperative GEO and HEO debris research especially for HAMR objects