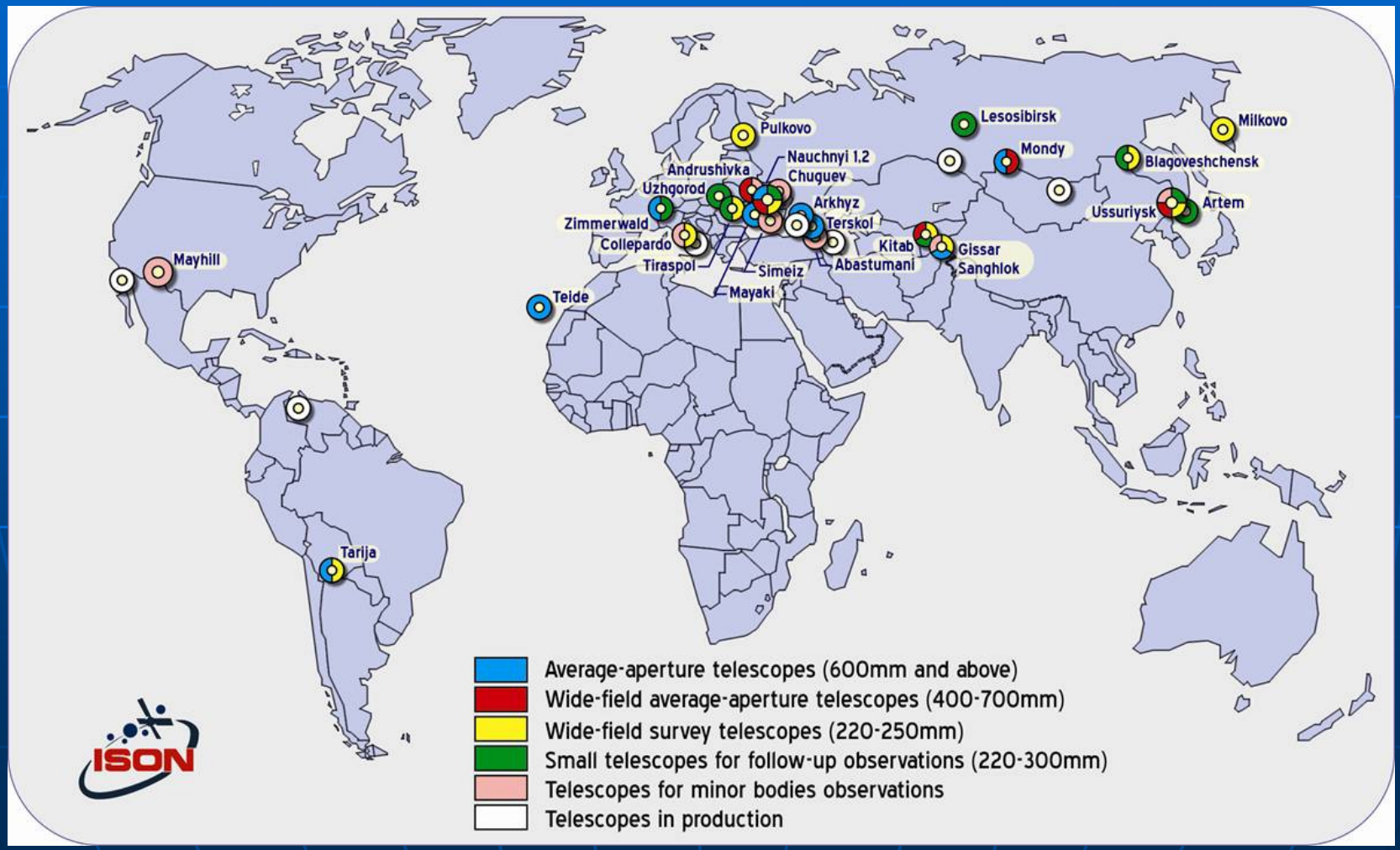
Russian Academy of Sciences
Keldysh Institute of Applied Mathematics

Review of events occurred in geostationary region in 2010 based on data obtained by ISON international network

Presentation for the 48th session of the COPUOS STSC
7-18 February 2011, Vienna

I S O N
International Scientific Optical Network



I S O N
International Scientific Optical Network

Development of ISON continues.

Special grants were provided by Roscosmos in 2010 for construction of new observation instruments of different class.

Several countries are visited in 2010 and preliminary negotiations reached with scientists from Argentina, Armenia, Brazil, Mexico and Venezuela about installation of new instruments for joint operation within the framework of ISON project

GEO region objects monitoring

GEO region definition (KIAM database)

Inclination range – 0°…30°

Eccentricity ≤ 0.2

Period range – 1100…2060 min (corresponds to mean motion range approx. 0.7…1.3 rev/day)

GEO Protected Region

Boundaries of GEO protected region:

Inclination – 0°…15°
Orbit radius – 35785 ± 200 km
Period (for circular orbits) – 1425.6 … 1446.7 min

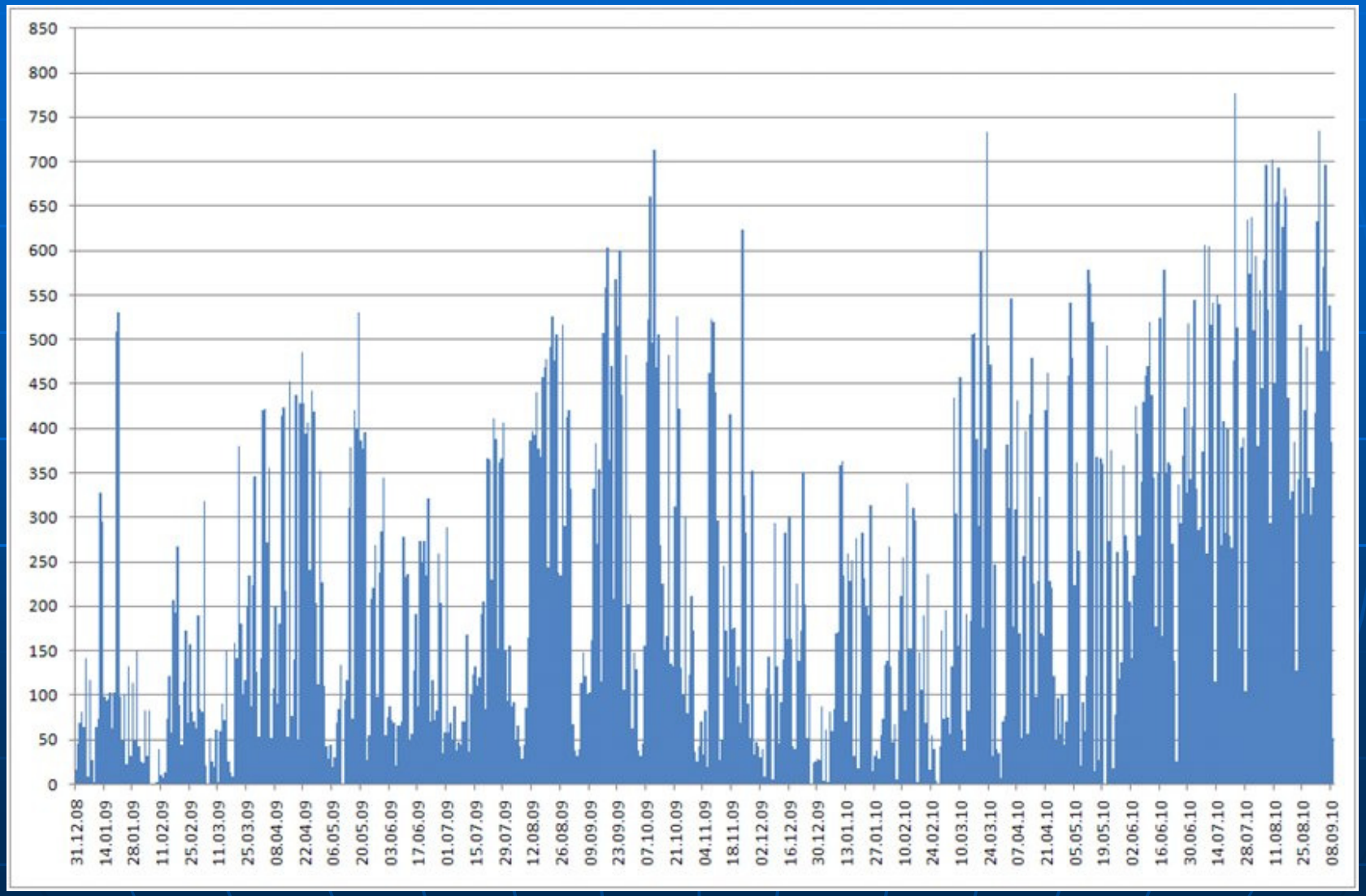
Objects on near-circular orbits (eccentricity less than 0.0002) having period within defined boundaries range and small area-to-mass ratio (AMR) are always staying in GEO protected region

Other GEO and HEO objects can cross the protected region.

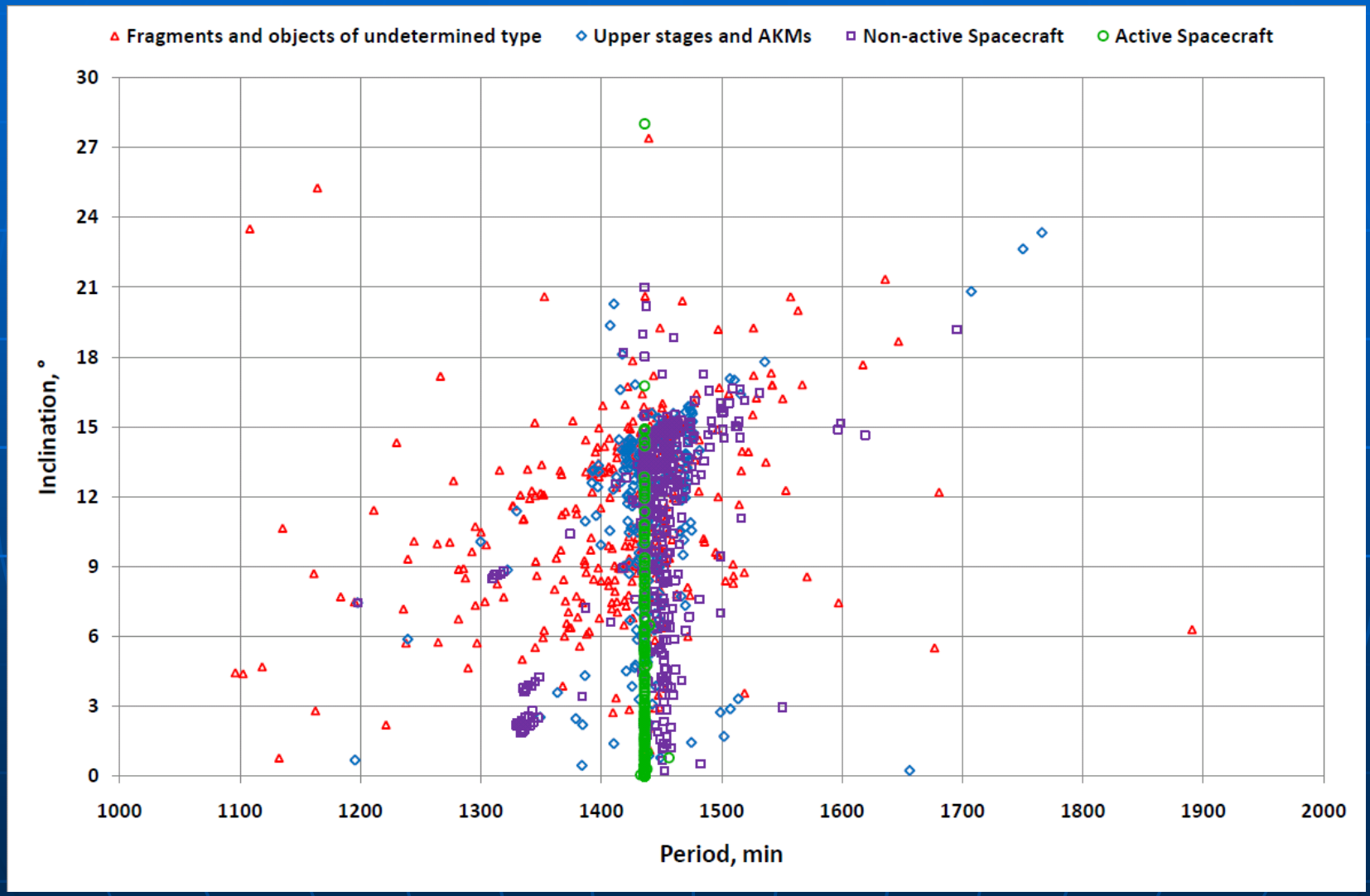
GEO Population
(KIAM database, Feb 1, 2011)

- Total – **1557** objects in GEO region with orbits maintained routinely, including
- *Spacecraft* – **922**
  404 under control, 518 non-functional
- *Upper stages and AKMs* – **257**
- *Fragments and objects of undetermined type* – **378**

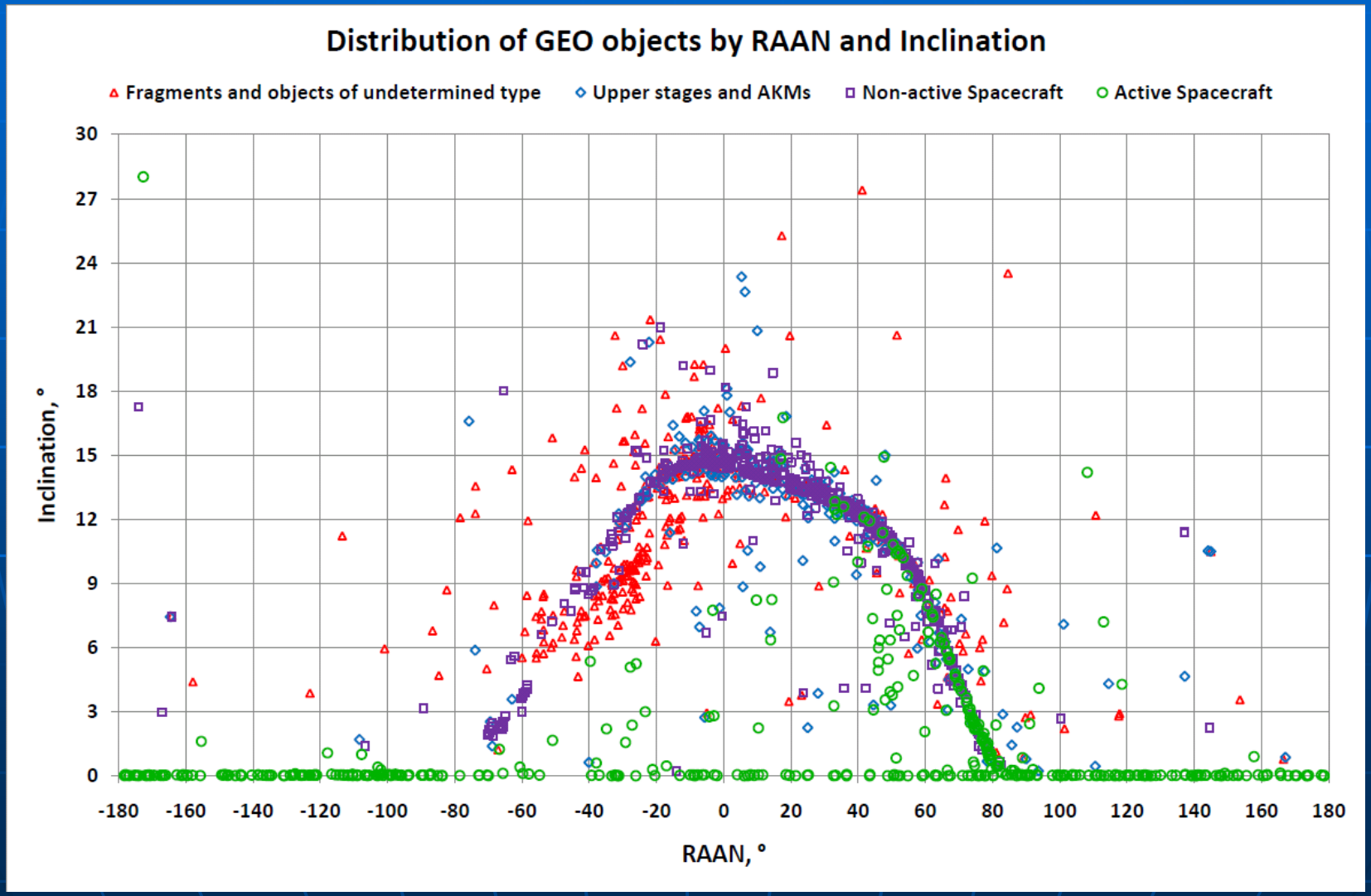
Observed Individual GEO Objects Number (by night, Jan 2009 - Sep 2010)



Distribution of 1557 GEO objects by period and inclination



Distribution of 1557 GEO objects by RAAN and inclination



“Bright” and “Faint” Objects in GEO

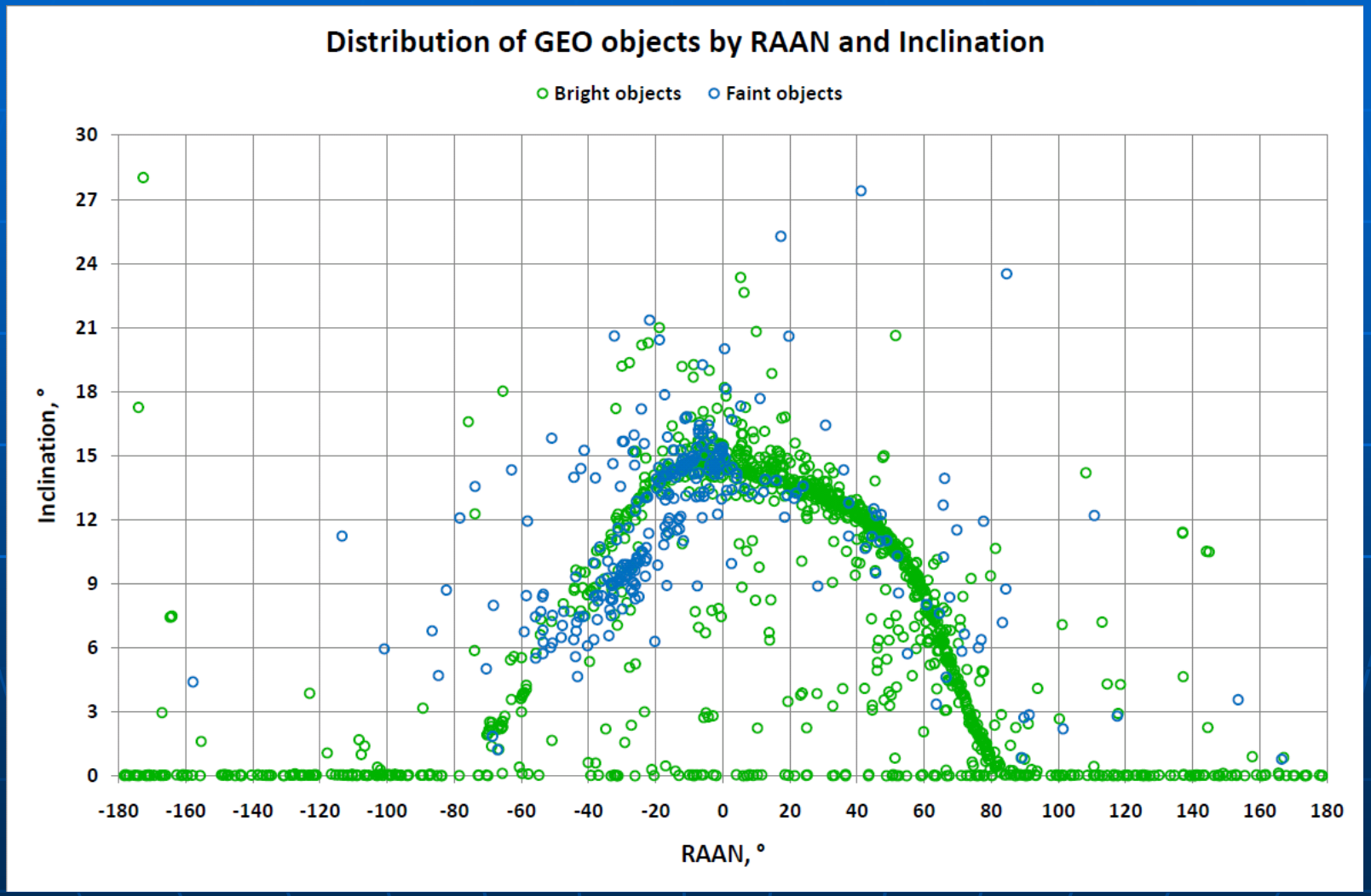
*“**Bright**” – magnitude 16^m –16.2^m or brighter*

- easy to track
- can be monitored with small telescopes (20-40 cm aperture)

*“**Faint**” – magnitude fainter than 16.2^m*

- only a few hundreds are known
- several thousands more are expected
- larger telescopes (up to 1-1.5 m aperture and more) are required

Distribution of 1557 bright and faint GEO objects by RAAN and inclination



GEO region events monitoring

Launches to GEO in 2010

- *Total* – **22** launches to 'classical' GEO
- *New spacecraft* – **27** launched to 'classical' GEO
- *New upper stages and AKMs* – **4**
- *Operational fragments* – no detected

New upper stages on GEO

- 3 Russian and 1 US
- 3 upper stages left on orbits lower than GEO:
  - 1 US one with apogee inside of GEO protected region
  - 2 Russian ones with orbit completely outside of GEO protected region
- 1 upper stage (Russian) left on proper graveyard orbit above GEO protected zone

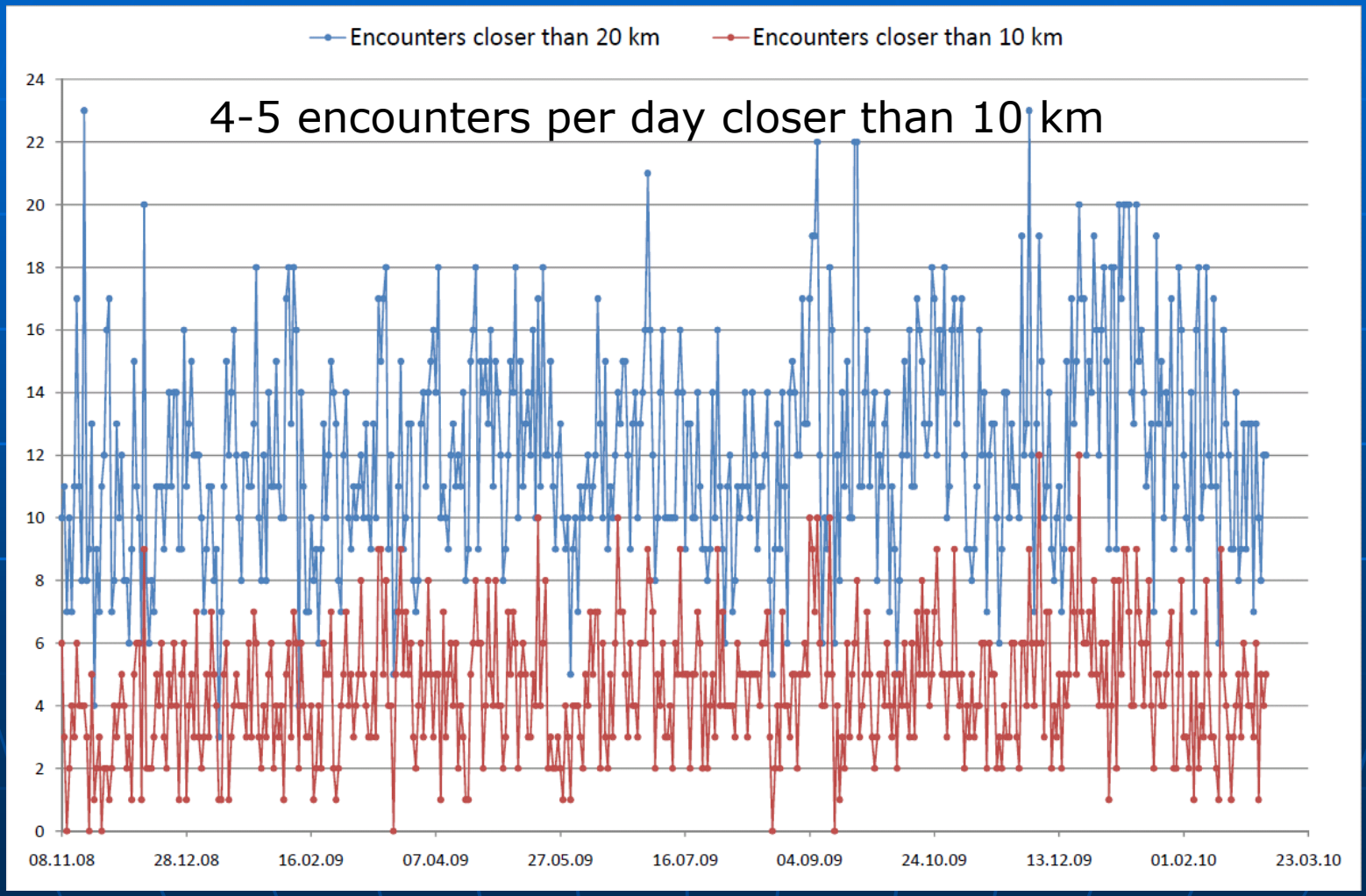
New near-GEO spacecraft

- New type of operational orbits inaugurated in 2010: near-zero eccentricity highly inclined geosynchronous (period 1436 min) orbits
- 4 spacecraft launched:
  2 by China (inclination 55.2 deg, eccentricity 0.001)
  1 by Japan (inclination 40.9 deg, eccentricity 0.075)
  1 by US (inclination 27.9 deg, eccentricity 0.000)
- Much higher encounter velocities with 'classical' GEO operational spacecraft when crossing GEO protected region

Spacecraft movements on GEO in 2010

- More than 30 GEO spacecraft performed relocation operations which were observed
- There were just a few announcements about GEO spacecraft relocations issued publicly prior to the start of operations
- As a rule, there were no announcements at all even in case of the end-of-life operations and re-orbiting of a spacecraft to the graveyard orbit

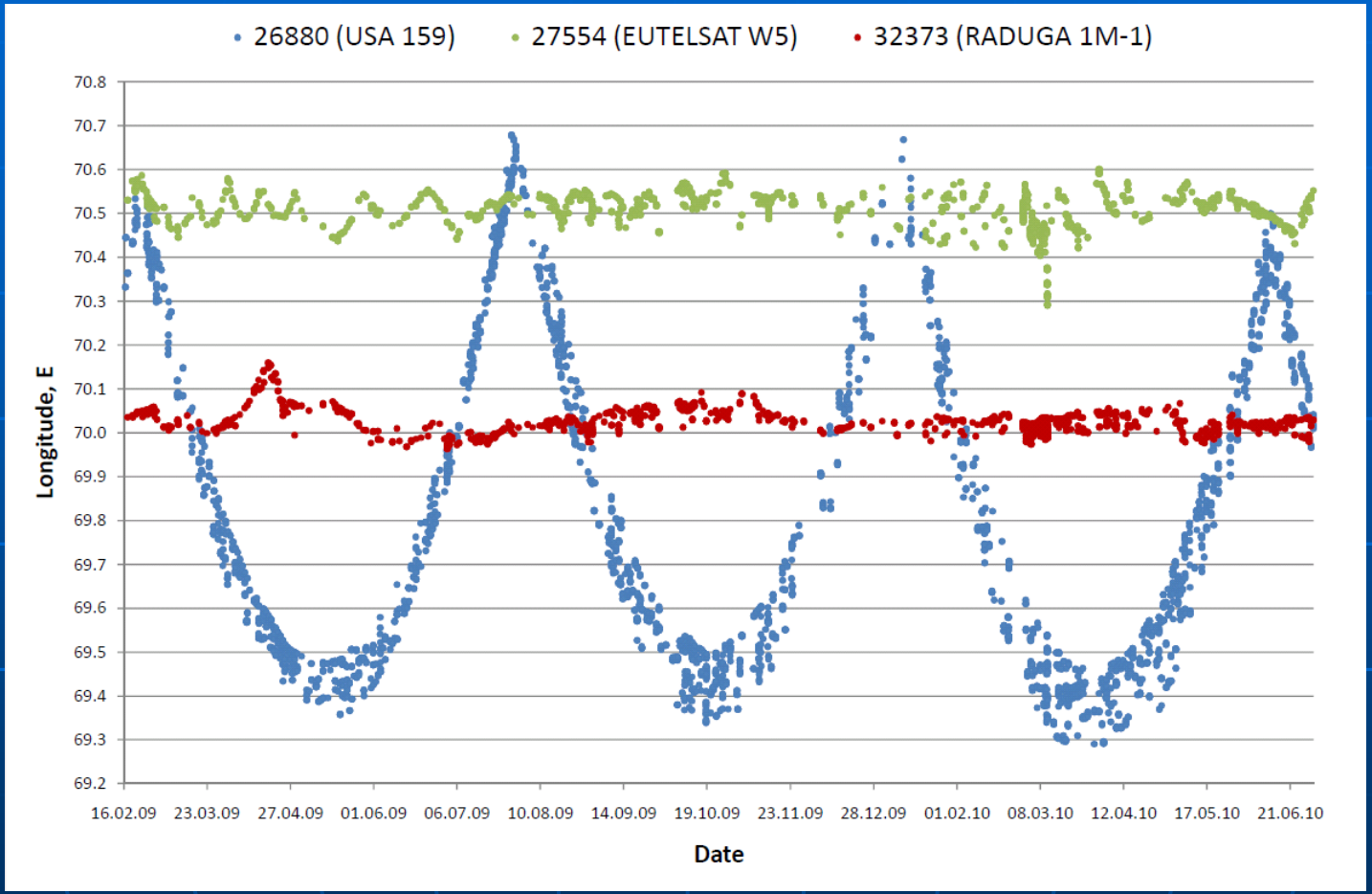
Close encounters on GEO statistics (Nov 2008 - Mar 2010)



Close encounters on GEO in 2010

- More than 180 GEO slots are occupied, including 71 with spacecraft located closer than 0.1-0.3 deg by longitude
- At least 26 slots are occupied by co-located spacecraft of different operators
- During routine orbit maintenance co-located spacecraft in the same slot do experience encounters as close as a few kilometres

Co-located spacecraft around 70E



Nothing changed for this slot during 2010. Close encounters are still happening from time to time.

Close encounters between 70E slot residents

Encounters between 27554 (EUTELSAT W5) and 26880 (USA 159):

23 Jul 2009 15:42:17 UTC
miss-distance 4.67 km, RIC = {-4.08, 2.28, -0.09} km
relative velocity 0.232 km/s

13 Jun 2010 06:09:33 UTC
miss-distance 4.77 km, RIC = { 4.47, 1.65, 0.07} km
relative velocity 0.273 km/s

Encounters between 32373 (RADUGA 1M-1) and 26880 (USA 159):

29 May 2010 07:15:58 UTC
miss-distance 4.87 km, RIC = {-0.62,-4.83, -0.21} km
relative velocity 0.269 km/s

01 Jul 2010 16:55:08 UTC – objects observed just 9 min 44 sec after the event
miss-distance 3.88 km, RIC = { 3.85, 0.43, -0.02} km
relative velocity 0.274 km/s

Conclusions

- ISON network collects on a routine basis astrometric and brightness measurements for more than 1550 objects in GEO region
- Obtained measurement data are processing to improve orbits and to find various events (appearance of a new object due to launches, fragments separation etc., possible close encounter, manoeuvres of different purpose)
- Accumulated information is using to support spaceflight safety tasks, including those ones solving within the framework of ASPOS OKP system by Roscosmos jointly with RAS