

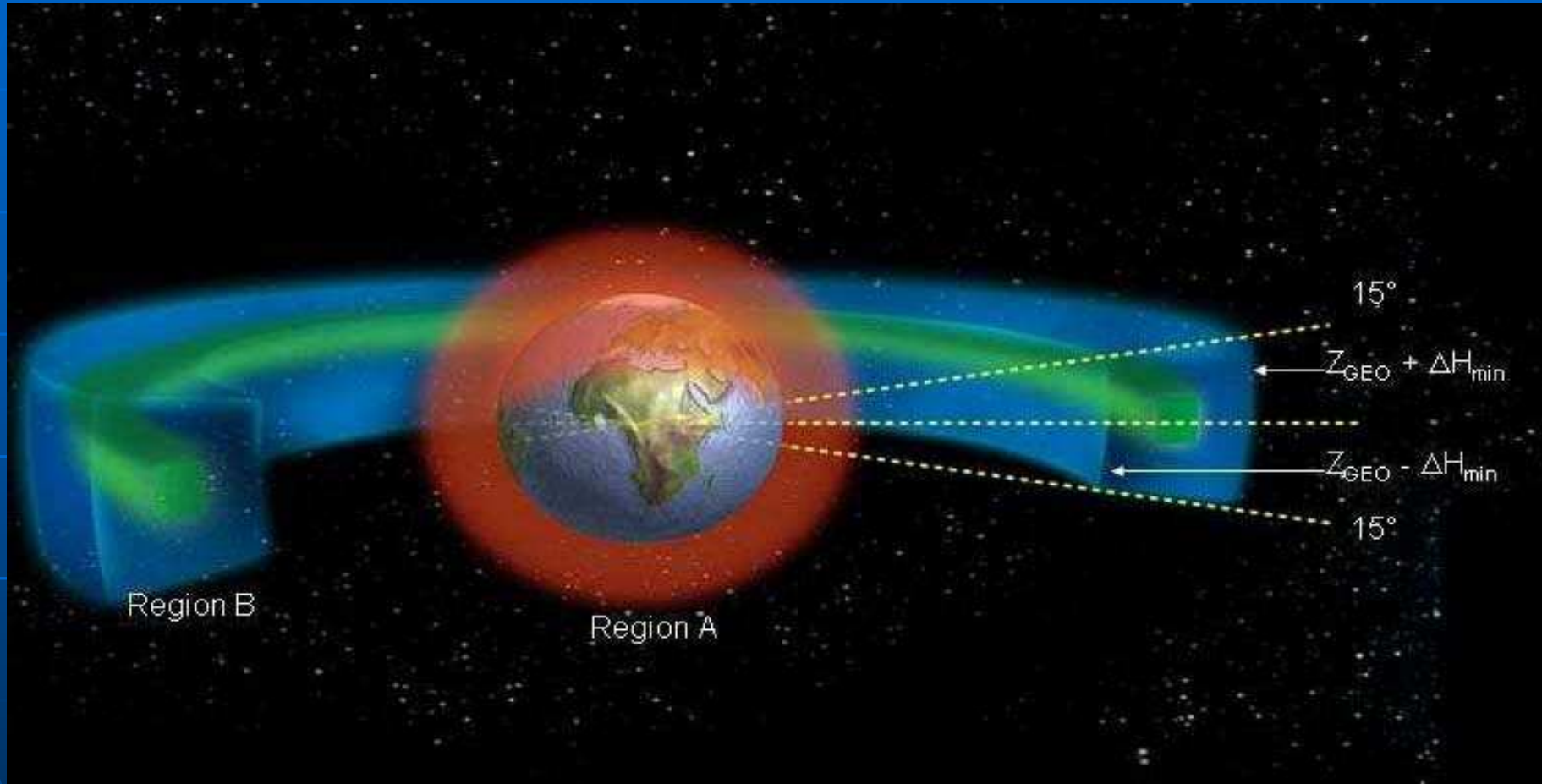


Russian Academy of Sciences
Keldysh Institute of Applied Mathematics

GEO protected region: ISON capabilities to provide informational support for tasks of spacecraft flight safety and space debris removal

Presentation for the 47th session of the COPUOS STSC
8-19 February 2010, Vienna

Protected regions of the near-Earth space



Source – IAA Position Paper on Space Debris Mitigation

Region A – LEO protected region

Region B – GEO protected region

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.

The UN General Assembly Resolution 62/217

The General Assembly,

.....
Considering, that space debris is an issue of concern to all nations,
.....

28. *Considers* that it is essential that Member States pay more attention to the problem of collisions of space objects, including those with nuclear power sources, with space debris, and other aspects of space debris, **calls** for the continuation of national research on this question, **for the development of improved technology for the monitoring of space debris and for the compilation and dissemination of data on space debris**, also considers that, to the extent possible, information thereon should be provided to the Scientific and Technical Subcommittee, and agrees that international cooperation is needed to expand appropriate and affordable strategies to minimize the impact of space debris on future space missions;

The ISON network

ISON joins:

- 20 scientific institutions in 11 states, including partners from astronomical organizations and facilities of Bolivia, Georgia, Italy, Moldova, Mongolia, Russia, Switzerland, Tajikistan, Ukraine, Uzbekistan, ESOC
- 23 observatories and observation facilities
- 33 optical instruments
- more than 90 observers and researchers

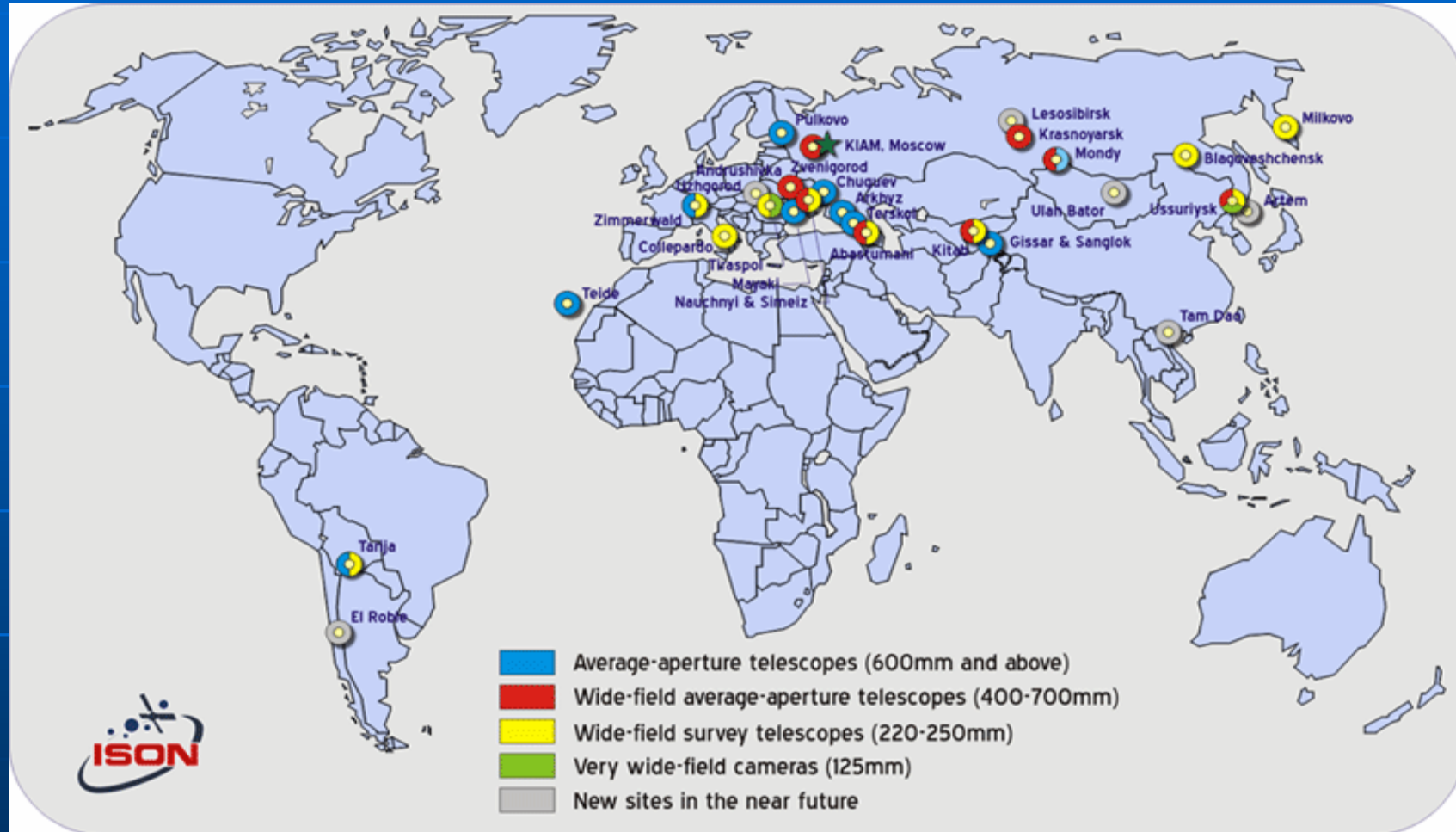
Project principal coordinator is Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences (KIAM RAS).

Current primary tasks:

- regular GEO monitoring, new objects discovering and tracking, maintenance as complete GEO objects database as possible
- new objects on GTO and other HEO regimes discovering and individual tracking, special HEO surveys will start soon

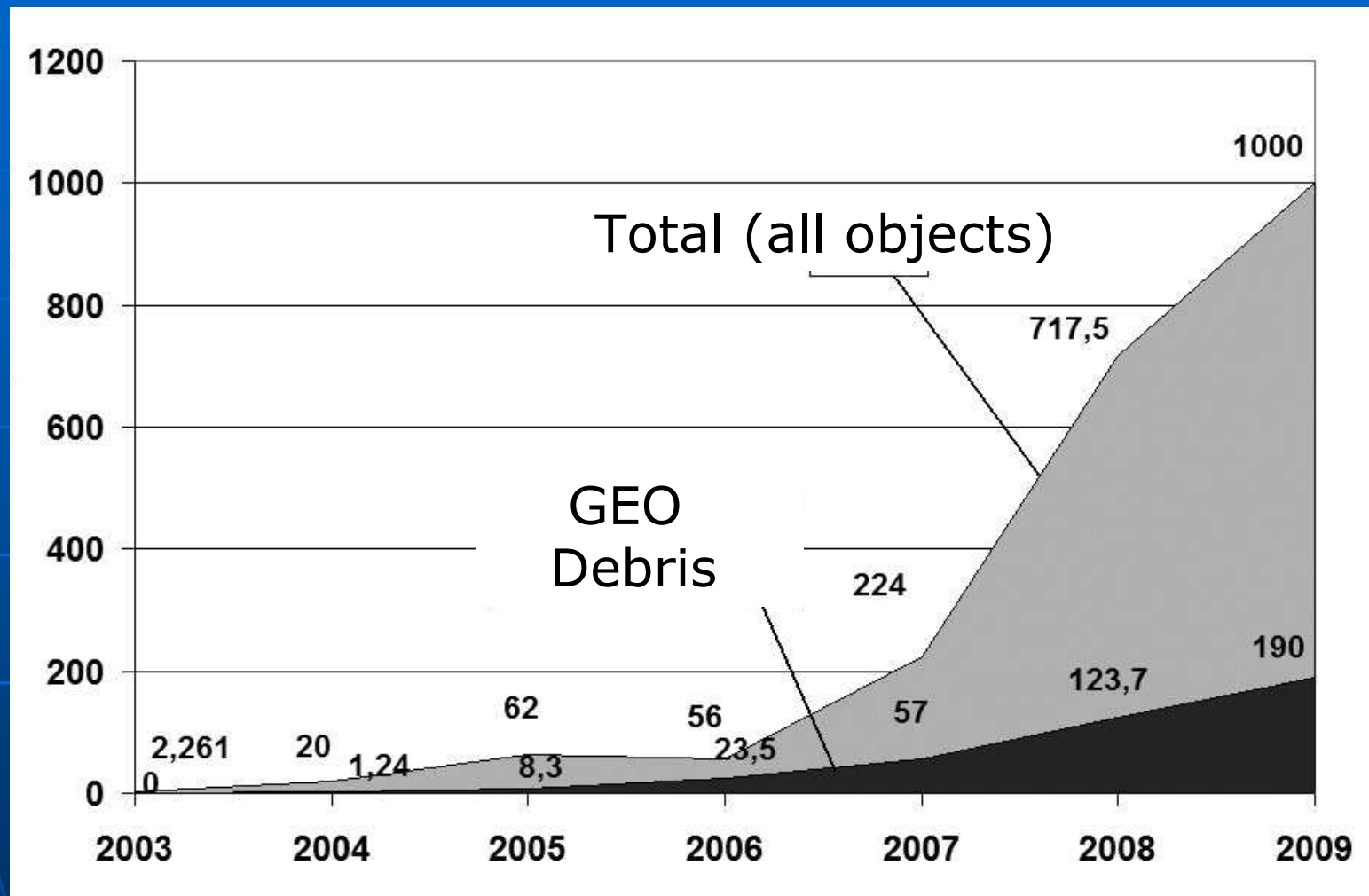
ISON

International scientific optical network



ISON is an open international project for regular monitoring of the near-Earth space, processing and compilation of data on space debris

ISON output

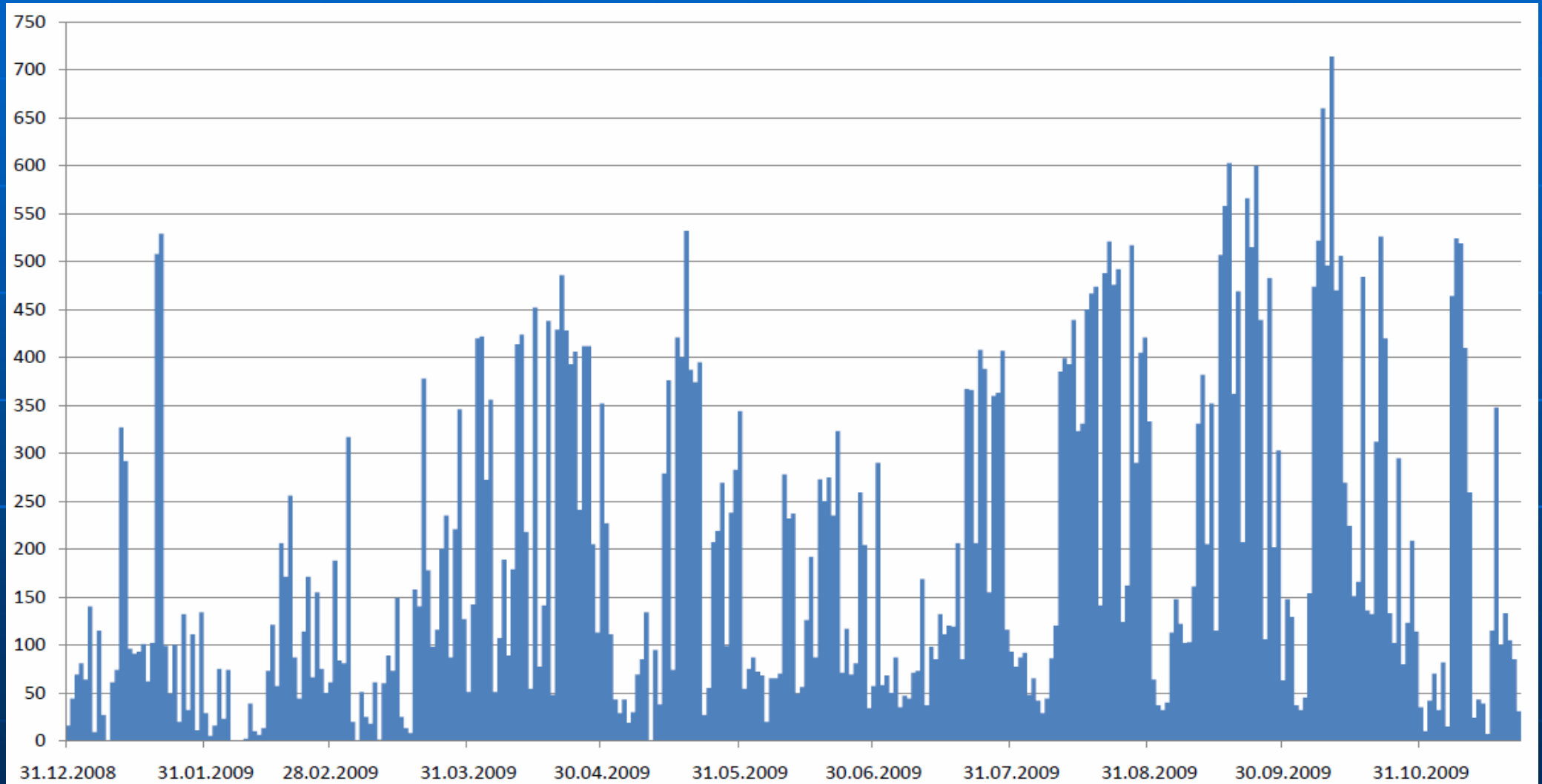


Number of measurements (in thousands)
produced by ISON

Known GEO Population (KIAM database, Dec 31, 2009)

- Total tracking by ISON – **1467** objects in GEO region (compare to 1016 objects for which data are provided by the U.S. SSN via SpaceTrack Web-service), including
 - *Spacecraft* – **892**
391 under control, 501 non-functional
 - *Upper stages* – **250**
of more than 15 different types
 - *Fragments and objects of undetermined type* – **325**
only 20 GEO fragments are officially catalogued still by the U.S. SSN

Observed GEO Objects Number (by night, Jan-Nov 2009 г.)



GEO space debris population

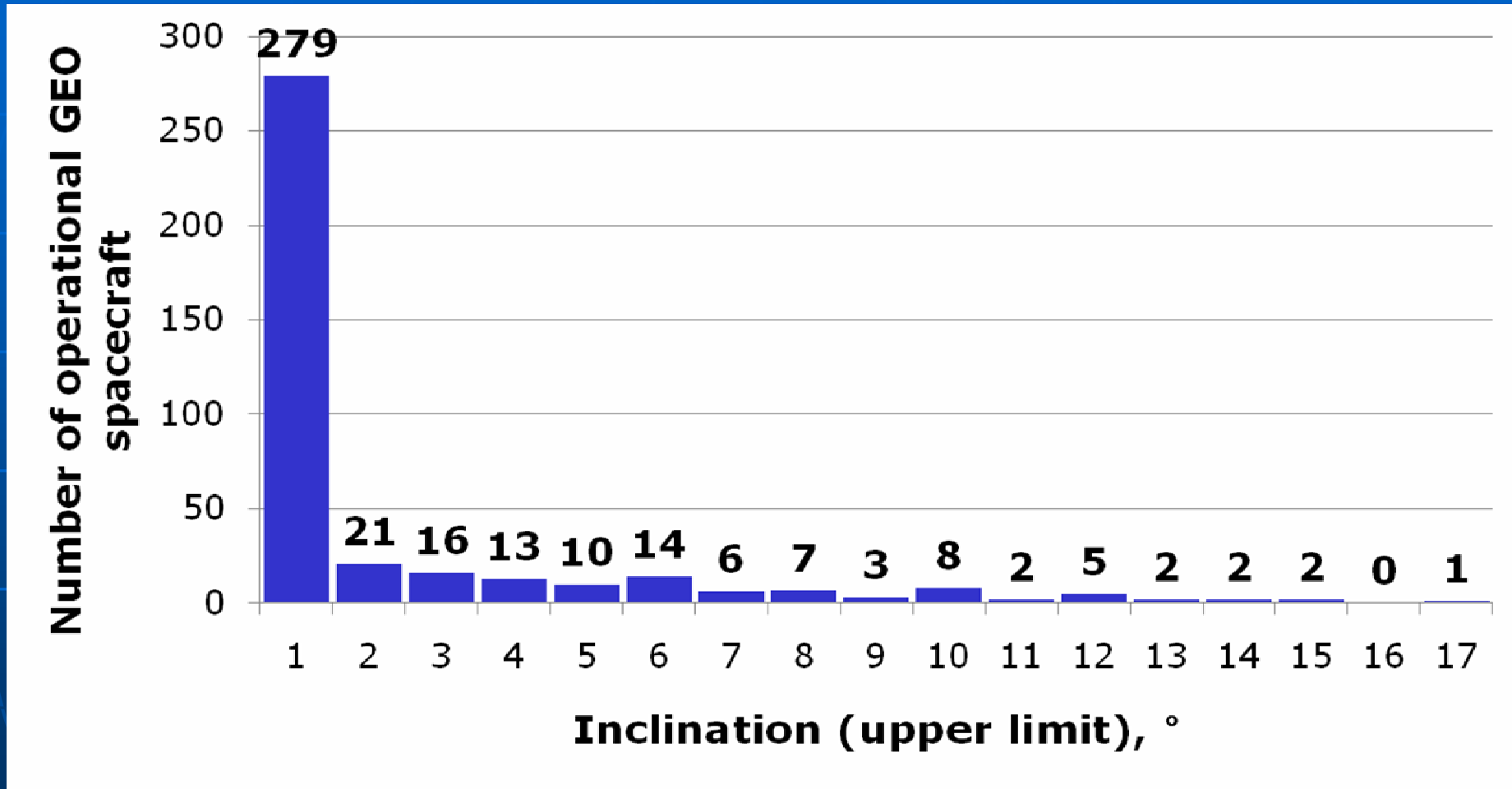
- Surprisingly, number of discoveries of relatively bright GEO debris objects (brighter than 16 magnitude) continues to grow. Every month at about 10 new of such debris objects are discovering
- Many of newly discovered GEO space debris are crossing or permanently staying in GEO protected region increasing threat to operational spacecraft. It is important to discover as many such debris as possible and understand the sources from which they are originating
- It is expected that at least another several hundreds of GEO space debris brighter than 18th magnitude (that corresponds to larger than 30-40 cm in size assuming standard reflectivity characteristics) exist in GEO region. Number of fainter (and thus smaller) objects is not yet estimated correctly

GEO protected region population

Object type	Overall number	Inclination range, °	Eccentricity range	Period range, min
Operational spacecraft	391	0.0-16.3	0.0000-0.1067	1435.52-1436.14
Non-operational spacecraft	282	0.3-21.1	0.0000-0.1804	1197.7-1458.2
<i>including permanently staying in GEO protected region</i>	212	0.8-15.3	0.0000-0.0039	1430.4-1445.2
Spent upper stages and AKMs	174	0.2-23.1	0.0003-0.1784	1197.6-1766.0
<i>including permanently staying in GEO protected region</i>	67	1.2-15.3	0.0003-0.0044	1428.9-1444.1
Fragments and objects of unknown type	250	0.2-20.6	0.0009-0.2045	1161.2-1617.3
<i>including permanently staying in GEO protected region</i>	13	10.9-14.4	0.0009-0.0042	1433.1-1439.7
Total	1097	0.0-23.1	0.0000-0.1784	1161.2-1766.0
<i>including permanently staying in GEO protected region</i>	683	0.0-15.3	0.0000-0.1067	1428.9-1445.2

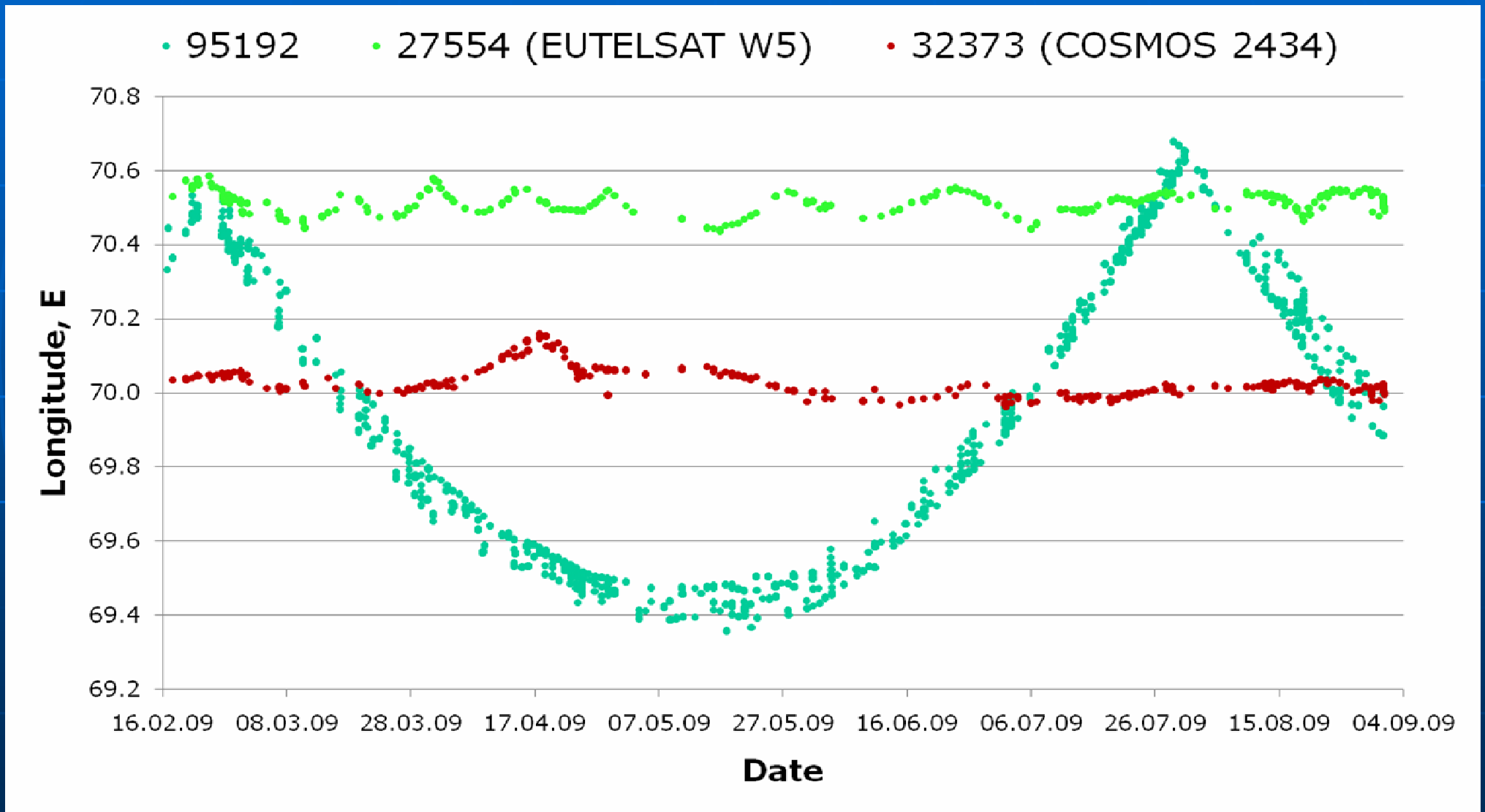
Operational spacecraft represent 35.6% of overall GEO protected region population (57.2% of objects permanently staying in this region)

GEO operational spacecraft distribution by inclination

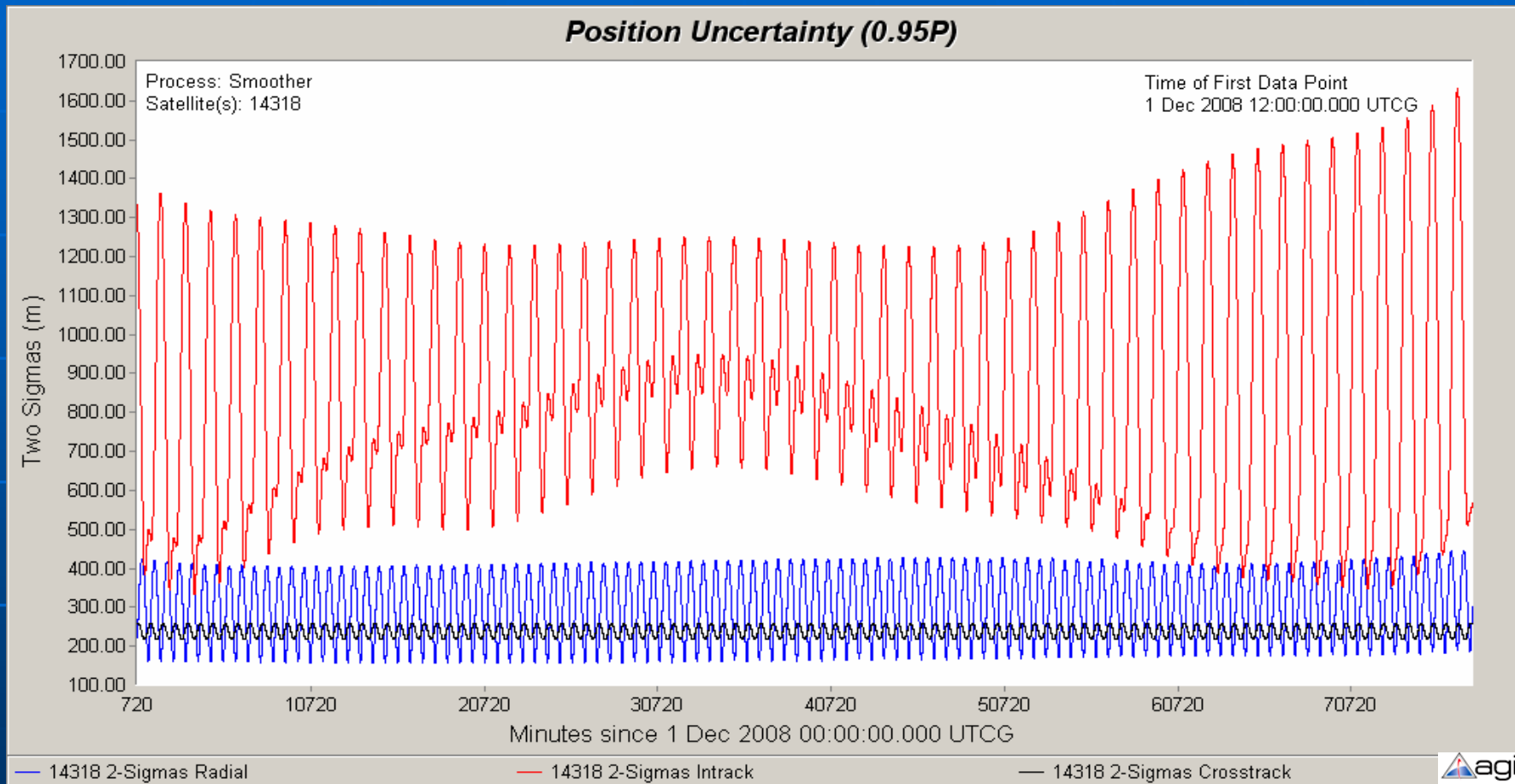


112 spacecraft (almost 29% of all operational GEO satellites) are located on inclined orbits

Co-located spacecraft around 70E



ISON-produced orbital data accuracy (object 14318, INSAT-1B)



One of commercial communication satellite operated by SES performed collision-avoidance maneuver based on ISON-produced orbital data for 14318

Observations in Support of the Future Space Debris Removal from GEO Protected Region

- Planning of removal of an object requires preliminary study of its current state (intact or not, characteristics of tumbling). Photometry observations can give a lot of information to answer these questions. ISON plans to establish special photometry collecting program to gather information on not operational objects permanently staying in GEO protected region
- Not all old objects (spacecraft, upper stages) were passivated at the end-of-life. Penetration of a fuel tank by a small particle can result in a small but continuous (for weeks, months or even years) leak producing additional acceleration which can be detected during routine orbit determination if precise enough measurements are used.
We already detected such events while processing ISON measurements.

Conclusions

- Deep study of GEO population by ISON network continues. Nearly 1470 objects in GEO region are already continuously tracking
- Quantity and quality of obtaining information permit to perform analysis of potentially dangerous situations in GEO (close encounters of non-cooperating operational spacecraft as well as space debris approaches to functioning satellites)
- Success of the ISON project proved feasibility of creation of international observation network and data centre (similar to the Minor Planet Centre) on space debris information for high altitude (GEO, MEO, GTO and other HEO) objects in full compliance with the UN General Assembly Resolution 62/217
- Organizations and researcher from all nations are welcome to join ISON project