



International scientific optical network (ISON) for the near-Earth space monitoring: the latest achievements and prospects

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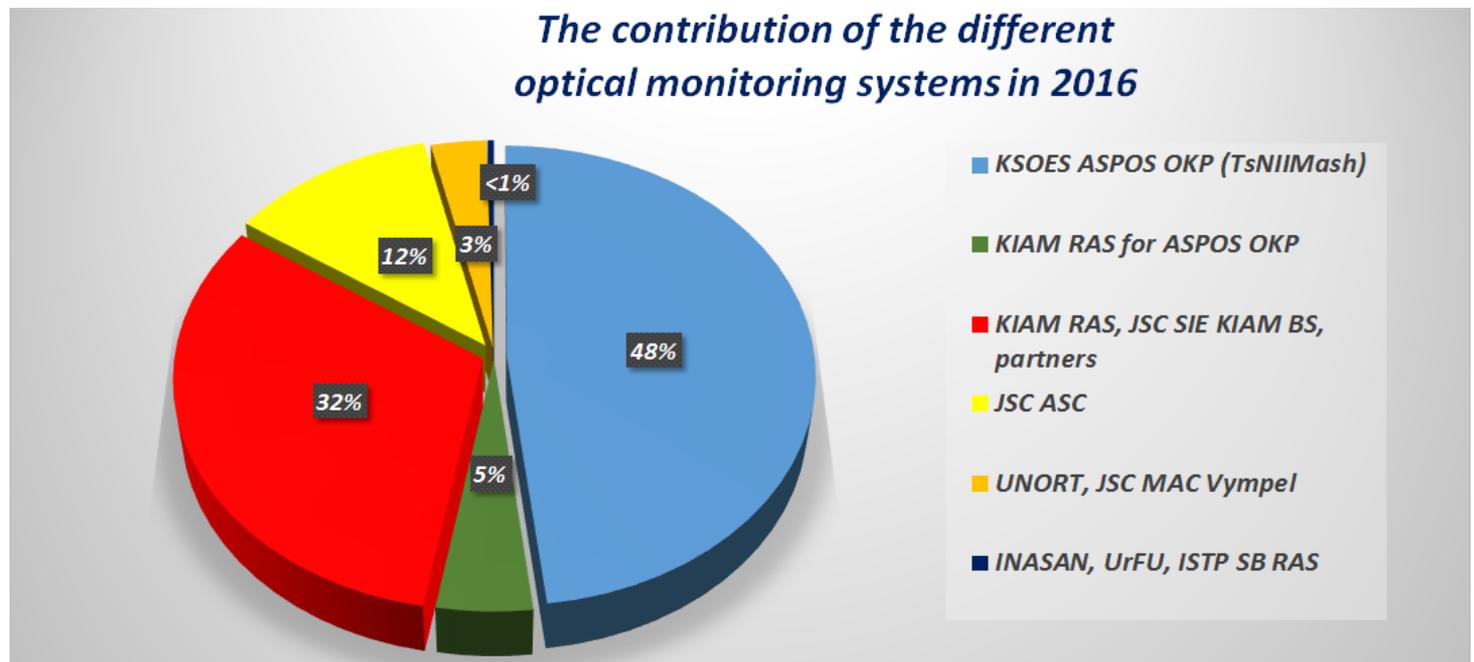
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International Scientific Optical Network (ISON)

- ISON is an open international project developed to be an independent source of data about natural and artificial space objects for scientific and applied purposes
- Main observation topics: space debris, asteroids, Gamma-Ray Bursts afterglow
- ISON cooperates with 38 observation facilities of various affiliation with 90 telescopes in 16 countries. Additionally preparatory works are carried out in observatories of 8 countries.
- Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences (KIAM) coordinates the ISON project, maintains space objects database of Russian Academy of Sciences/Federal Agency for Scientific Organizations and provides conjunction analysis for Russian satellites at high orbits under order of Roscosmos
- ISON represents now interagency association that includes the 4 main segments – scientific cooperation, Roscosmos, industry organizations and new one for commercial activities

Segments of telescopes that send the data to KIAM

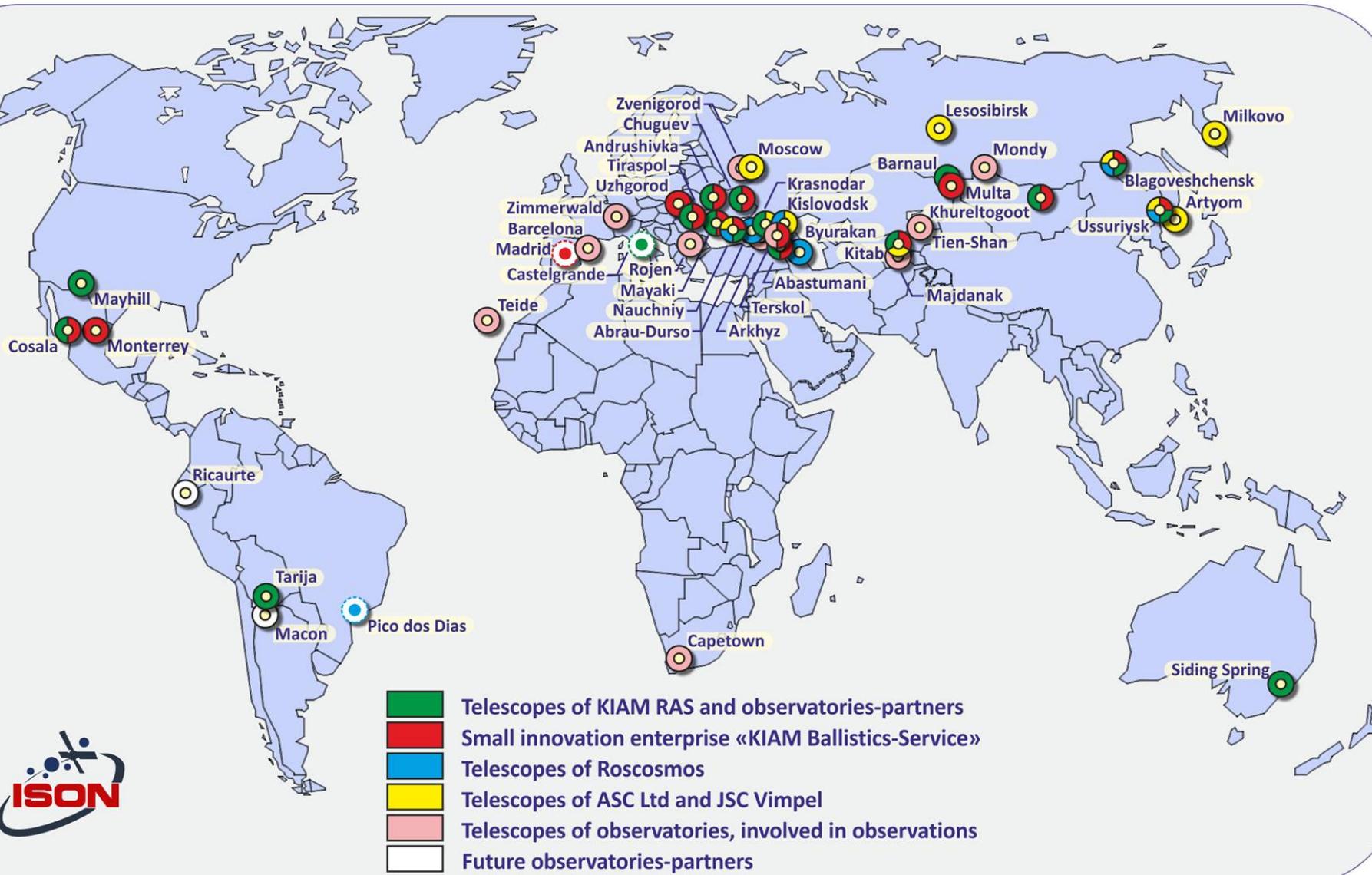
- 26 telescopes of KIAM international cooperation for scientific researches
- 24 telescopes of «Small innovation enterprise «KIAM Ballistics-Service» for usage in commercial aspects
- 22 telescopes of the Roscosmos/TsNIIMash (6 observatories EOP-1, EOP-2 + 4 pcs.) to support the conjunction analysis
- 18 telescopes of cooperation of Vimpel Corp. in interests of space situation analysis



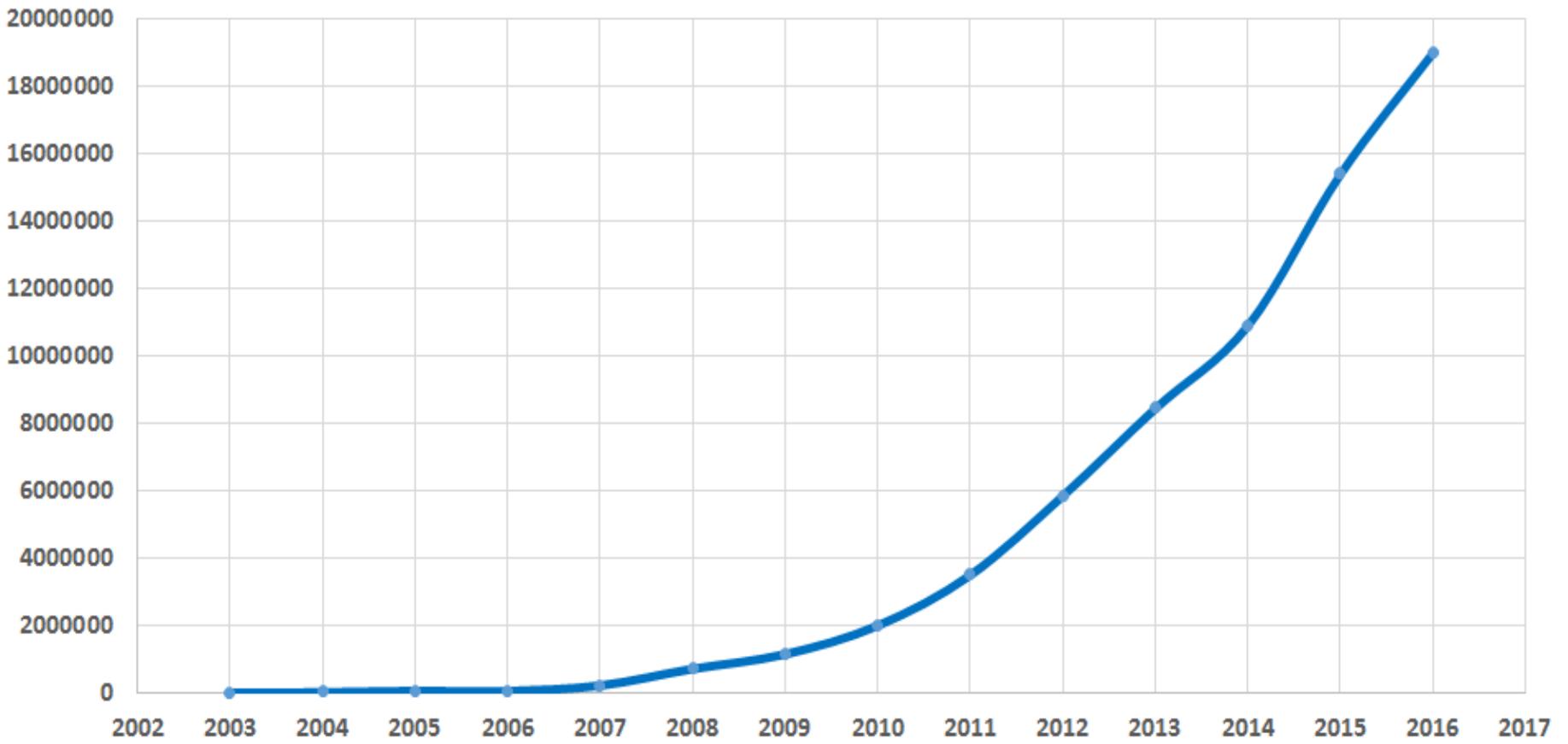
ISON structure

- **7 telescope subsets:**
 - global GEO survey (down to 15.5^m)
 - extended GEO survey (down to 14^m)
 - deep local GEO survey (down to 17^m)
 - tracking the faint (fainter than 15.5^m) space debris at GEO and GTO
 - tracking the bright GEO and GTO objects
 - tracking the bright LEO and HEO objects
 - for observation of asteroids
- *one telescope provides survey of the Molnya-type orbits
- **extended GEO surveys produce HEO object detections

Map of observatories that send the data to KIAM



The number of optical measurements obtained by ISON telescopes in 2016



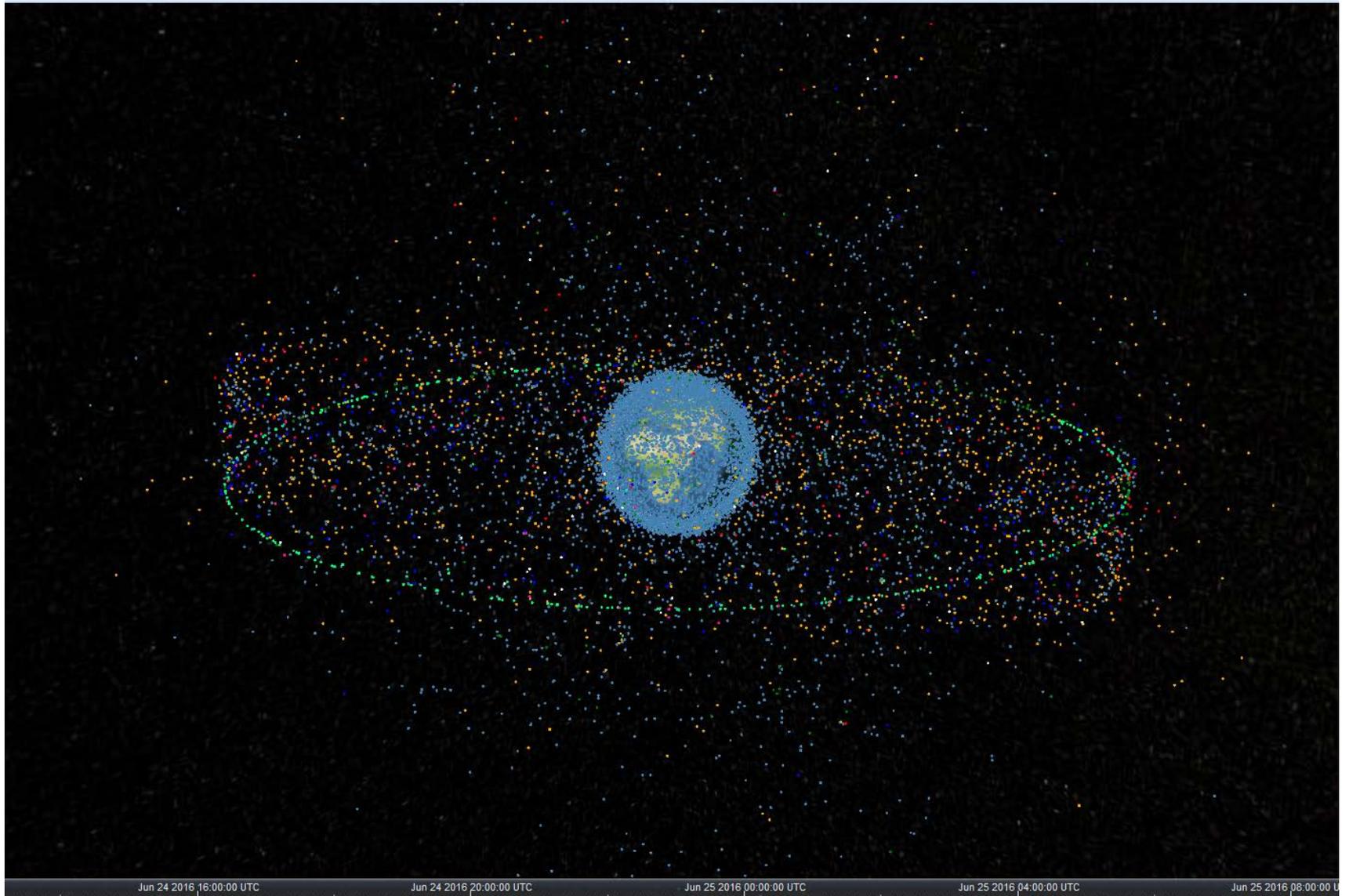
Current observations conducted upon user's requests

- Support of conjunction analysis (Roscosmos/TsNIIMash)
- Space situation analysis (Vimpel Corporation)
- Information support of the GEO launch operations (Reshetnev ISS company)
- Observation of Radioastron mission, observations of the launches at MEO (Lavochkin Association)
- Observation service under commercial requests

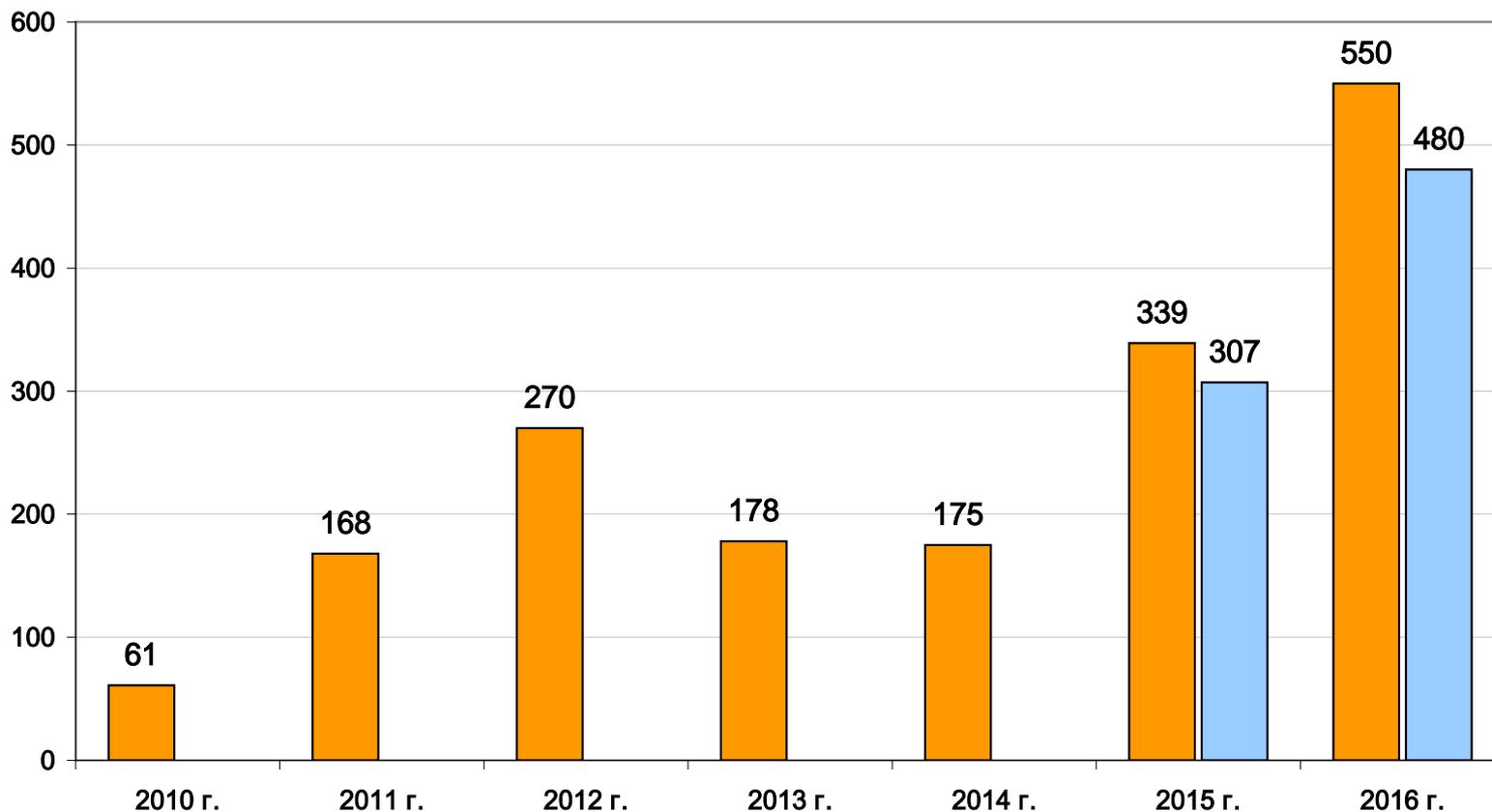
Recent ISON interagency network news

- Observation started with two updated telescopes, 80-cm K-800 at Terskol (North Caucasus) and 60-cm Ceiss-600 Tarija, Bolivia
- First measurements were received from new 1.6 telescope AZT-33VM at Mondy (Sayan mountains, Siberia)
- Second Mexican observatory (at Monterrey) joined to the ISON
- Subsystem for deep local GEO surveys is arranged
- Regular optical observations of LEO objects are started
- 19 millions measurements in 2.4 millions tracklets have been collected at KIAM database in 2016 (23% more)
- 550 new objects (62% more) have been discovered, 480 previously lost objects (56% more) have been rediscovered in 2016
- KIAM maintains orbits for ~6150 space objects (2040 GEO and 4110 HEO objects)
- The work on creation of model of space debris population have been started in KIAM jointly with TSNIlmash

Display KIAM RAS space debris database on 24.06.2016 12:13:19 UTC



Annual new objects discovery statistic



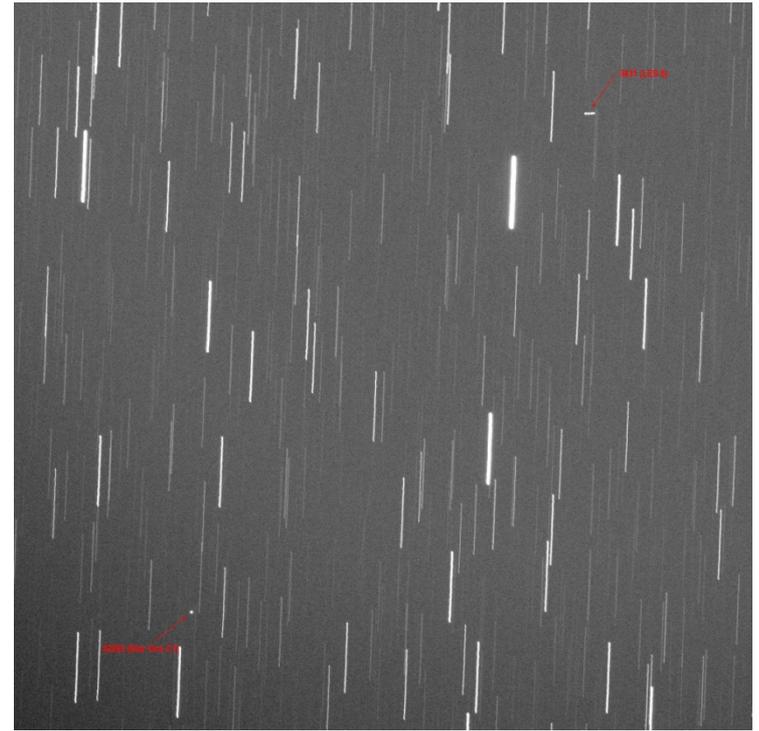
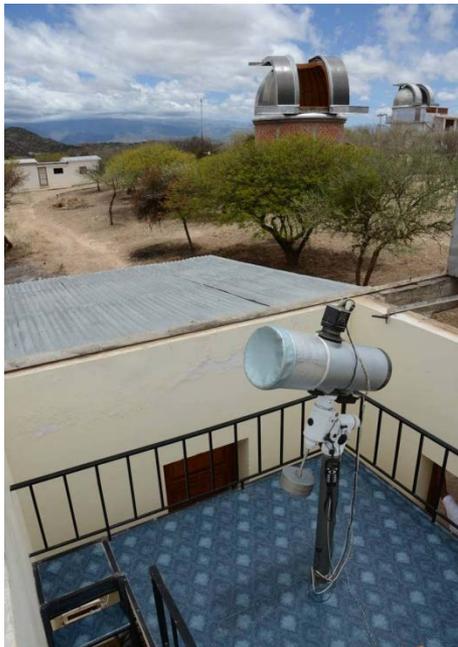
Yellow color – discovered objects, blue color - rediscovered

80-cm K-800 at Terskol, 25-cm ORI-25 at Monterrey and 1.6 m AZT-33 in Mondy



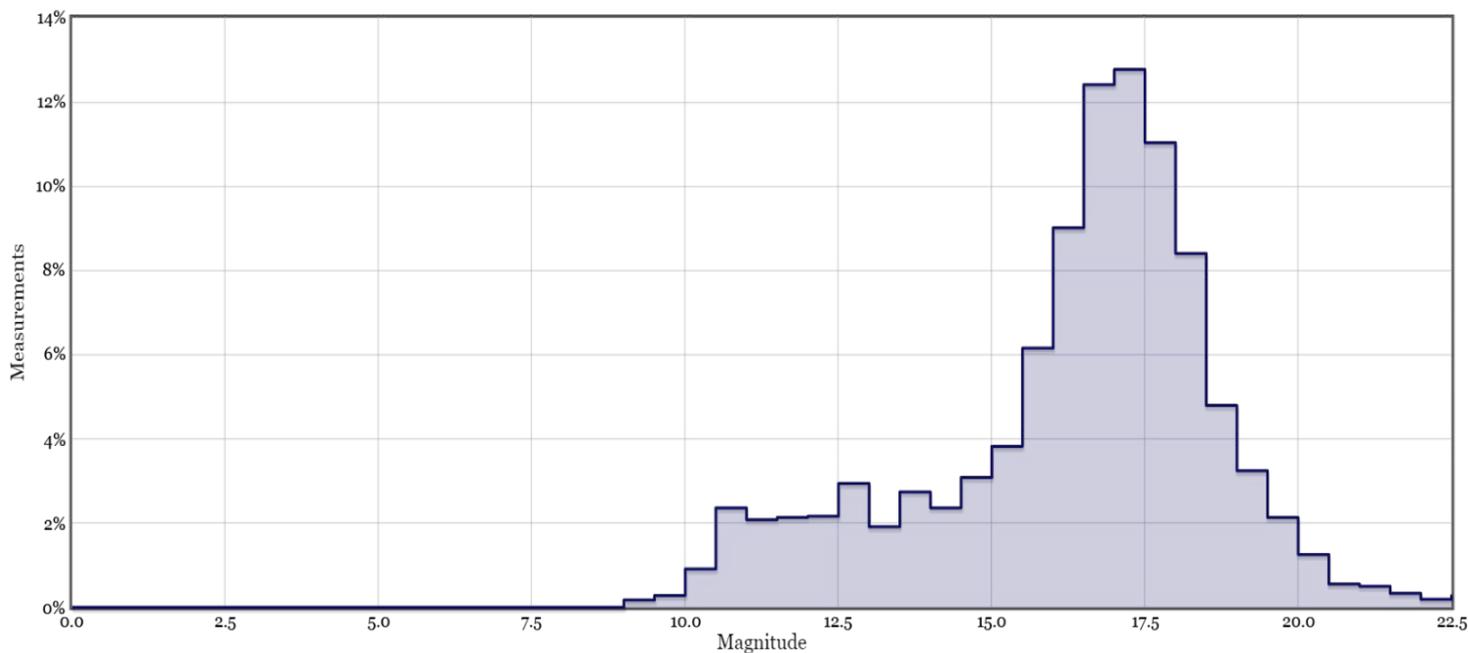
First ISON observations of close approach in Western Hemisphere: Star One C1 + Les 6

May 31 – June 8, 2016 with participation of 3 telescopes in two university observatories – Tarija (Bolivia) and Cosala (Mexico)

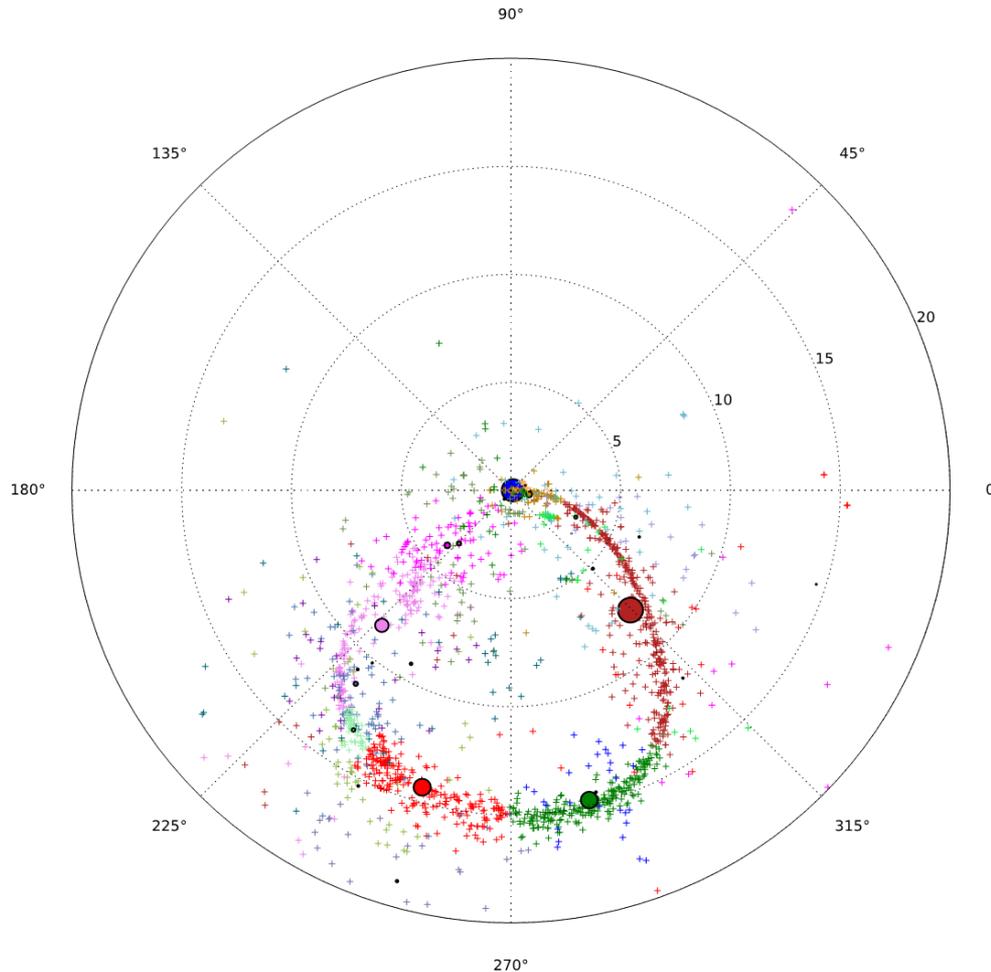


Terskol 80-cm telescope observation statistics

Month	Working Nights	Tracklets	Measurements	New and Re-found objects
July	5	86	929	0
August	20	812	9580	19
September	11	806	7579	13
October	4	498	4336	4
November	7	676	5784	2
December	12	739	6628	2
Total	59	3617	34836	40



Creation of model of space debris population

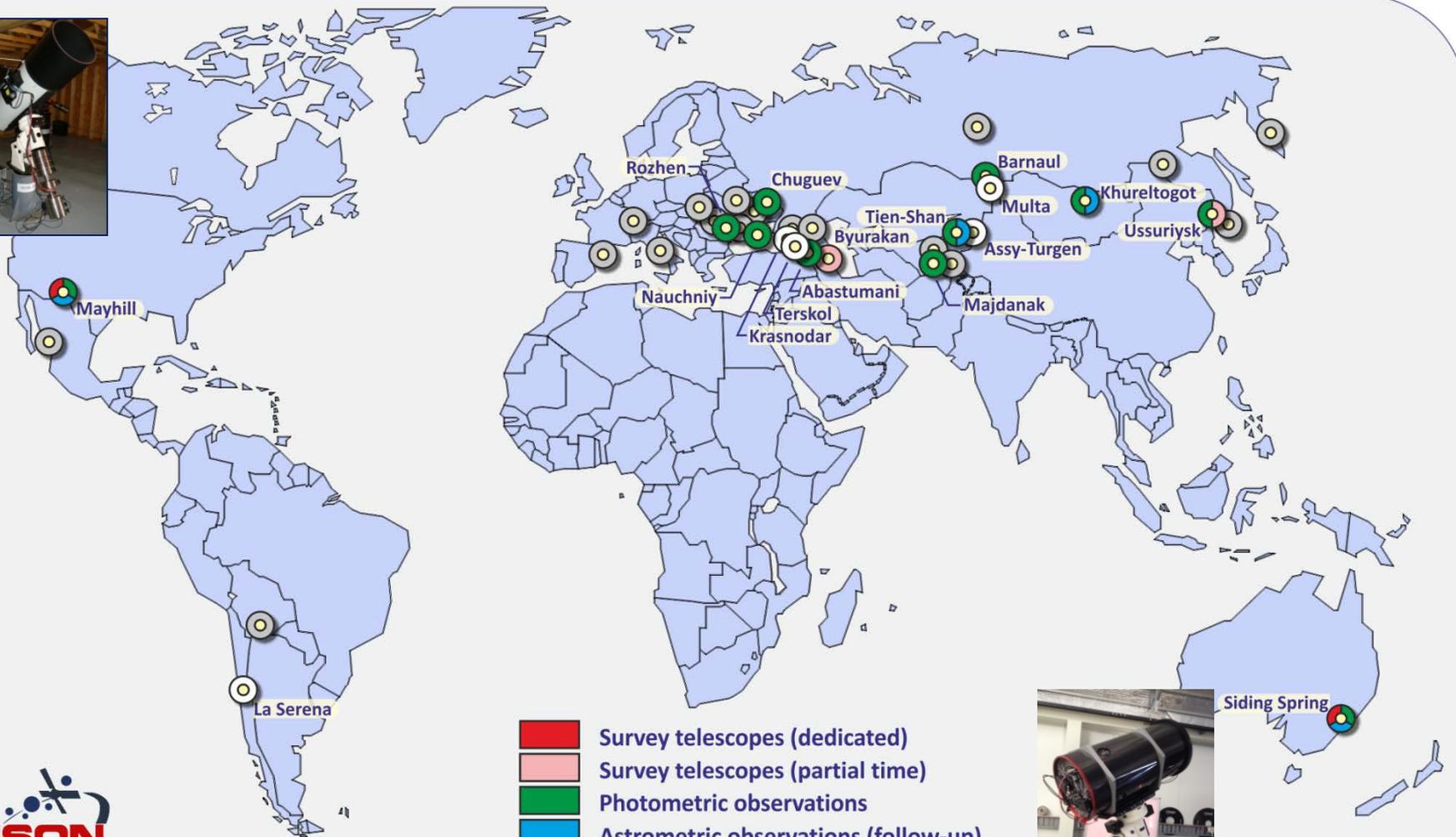


New representation of GEO objects for elaboration of model of space debris population. It is displayed known GEO objects ('+') from KIAM database and plotted point of thickening ('o') in parameters - the normal to the plane of the orbit. Color of thickening is the same as color of forming objects, size is proportional of quantity of objects

Status of ISON asteroid observations

- 2 surveys with 40 cm telescopes in New Mexico, USA and Siding Spring, Australia (joint project with AIUB team of Switzerland) with centralized processing in KIAM, received 217 measurements in 2016, discovered 22 asteroids, including NEA 2016 NX, and also C/2017 A3 (Elenin) in January 5, 2017
- 7 observatories with telescopes of apertures from 2.6 m to 0.7 m provides 200 night of photometry observations that allowed to observe 44 NEAs
- Rotation period is estimated for 15 asteroids and confirmed/improved for 20 asteroids; it was detected the signs of possible duality for two asteroids: (3122) Florence and (337866) 2001 WL15
- New telescope software for observation carrying out have been elaborated and tested that on 25% increased the area of survey
- First test of new survey telescopes 40 cm (4x5.5 degree) is planned in May

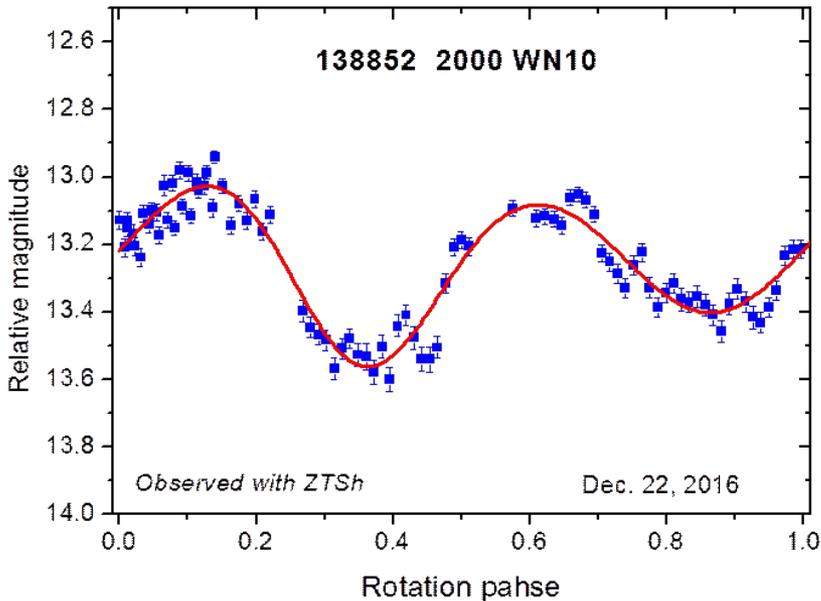
ISON observatories participating in observations of asteroids



- Survey telescopes (dedicated)
- Survey telescopes (partial time)
- Photometric observations
- Astrometric observations (follow-up)
- New telescopes in progress
- Other telescopes of ISON network

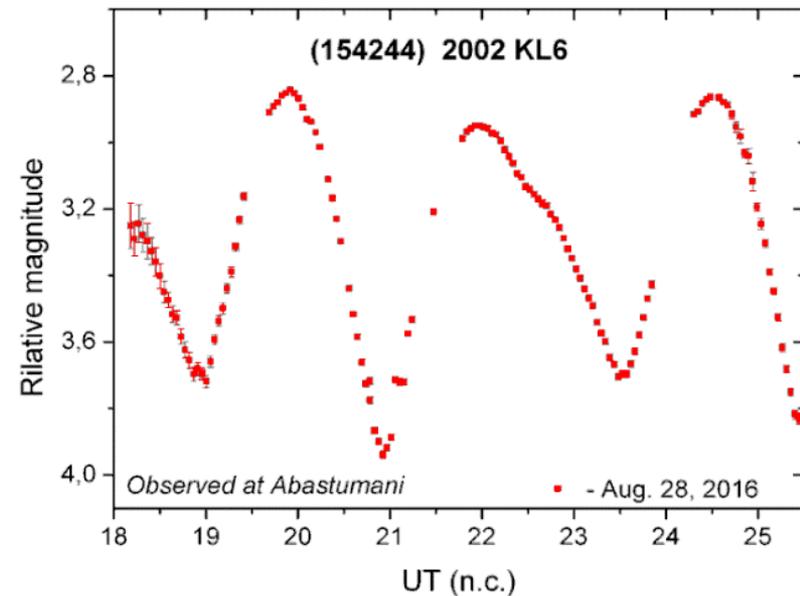


Results of photometry observations

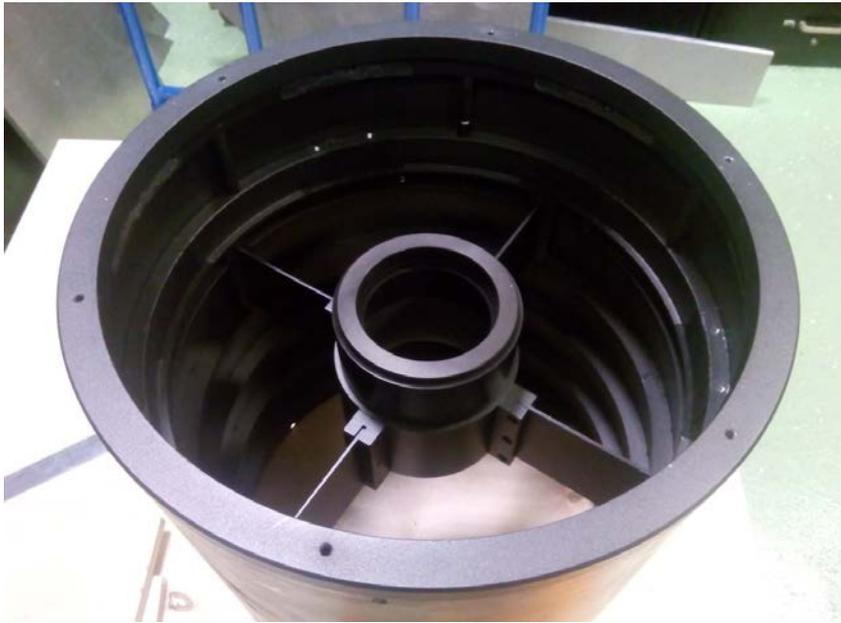


(138852) 2000 WN10 asteroid was studied with 2.6 m telescope in Nauchniy to detect the influence of YORP effect on rotation

(154244) 2002 KL6 asteroid was observed in Abastumani Georgia in support of USA radar studying with Goldstone and Arecibo. Rotation period is 4.606 ± 0.001 hour



New 40-cm telescope with FOV of 4x5.5 degree for replacement in New Mexico. It must increase the survey area in 5 times.
Fist test is planned in May



Conclusion

- ISON network represents now interagency association and consists of 4 main segments and 7 telescope subsets
- New telescopes and observatories have been putted in operation during 2015-2016 years, including 80-cm telescope in Terskol, 1.6-m telescope in Mondy and 25-cm telescope in Monterrey, Mexico
- 550 new objects were discovered in 2016 (339 – in 2014).
- 80 telescopes of 34 observation facilities produced 19 million measurements on space debris in 2016
- Knowledge on HEO-objects have been significantly updated (4110 objects)
- First ISON observation of close approach in Western Hemisphere have been arranged
- 200 night of photometry observations allowed to study 44 NEAs. Rotation period of 15 asteroids is estimated. Two new candidates of binary systems have been identified
- Close plan of ISON development foresees the installation of telescopes in China, Ecuador, South Africa, Spain and Argentina