



# Recent developments within the ISON project

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# International Scientific Optical Network (ISON)

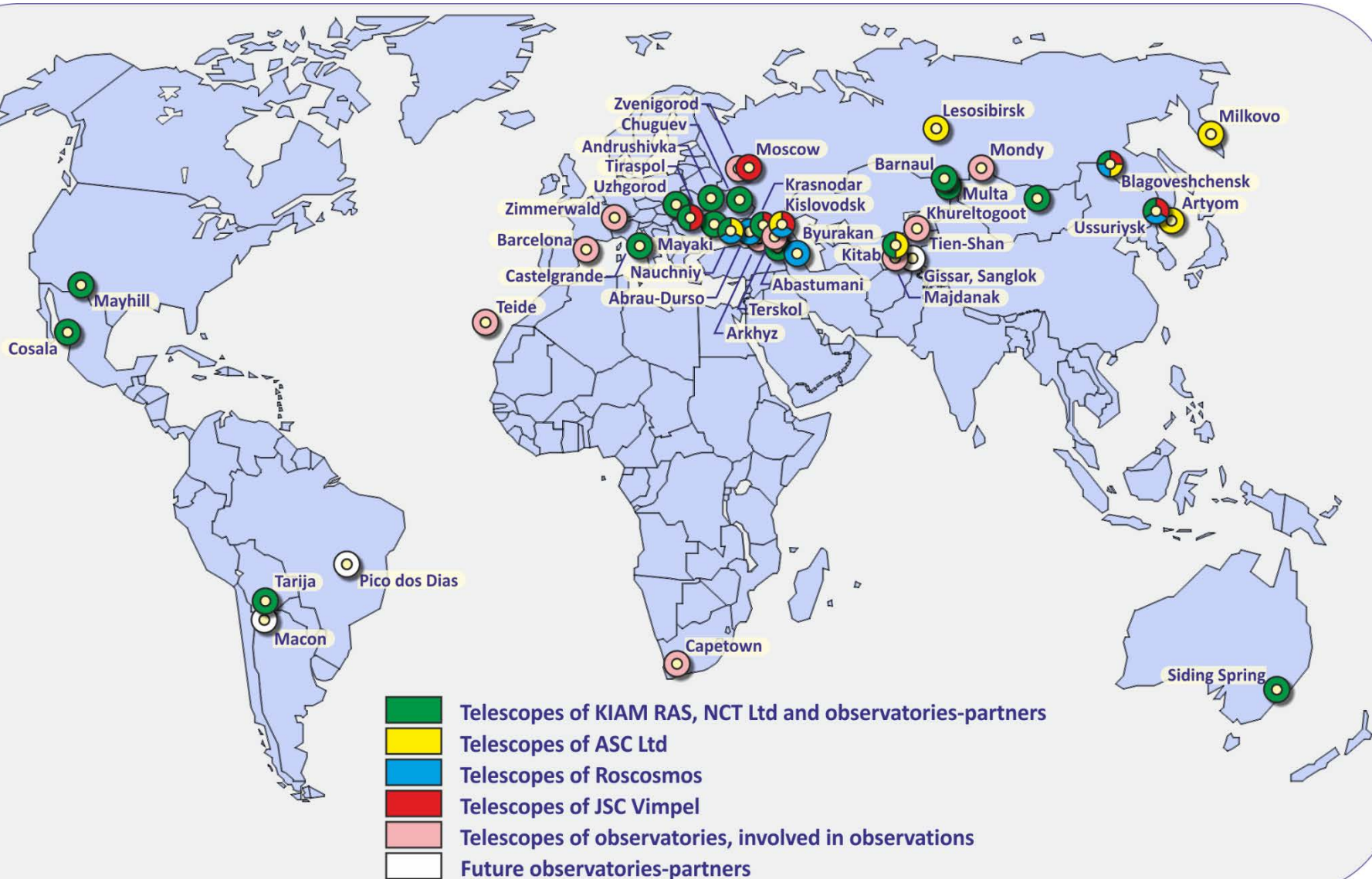
- ISON is an open international project developed to be an independent source of data about natural and artificial space objects for scientific and applied purposes
- Main observation topics: space debris, asteroids, Gamma-Ray Bursts afterglow
- ISON cooperates with 37 observation facilities of various affiliation with 79 telescopes in 15 countries. Additionally operation of 11 telescopes are in preparation, and 10 telescopes are produced (negotiations are carried out with observatories of 7 countries)
- Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences (KIAM) coordinates the ISON project, maintains space objects database and provides conjunction analysis for Russian GEO satellites



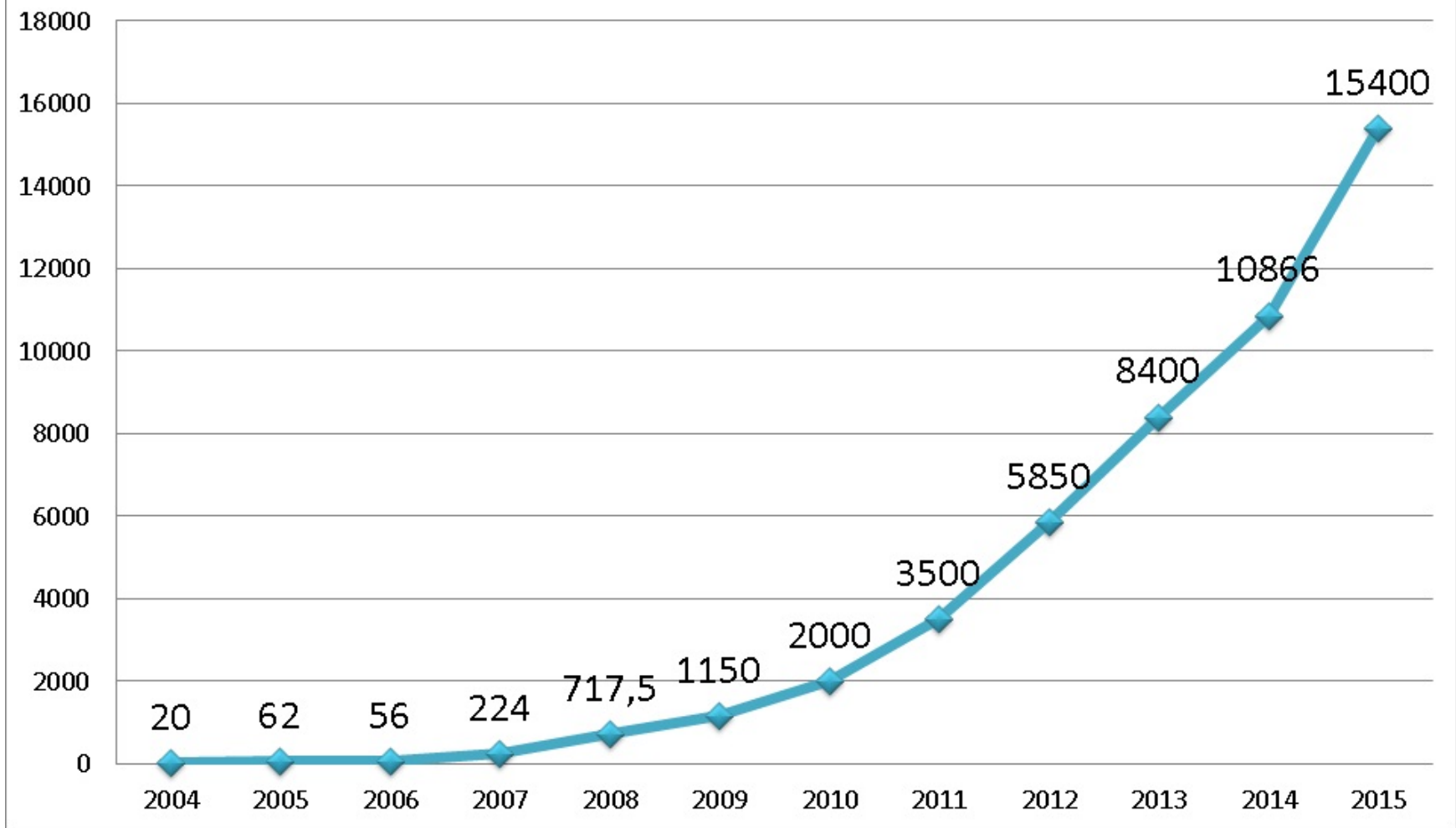
# ISON structure

- **5 telescope subsets:**
  - global GEO survey (down to 15.5<sup>m</sup>)
  - tracking the faint (fainter than 15.5<sup>m</sup>) space debris at GEO and GTO
  - tracking the bright GEO and HEO objects (partially LEO)
  - extended GEO surveys
  - for observation of asteroids (surveys and photometry)
- **types of telescope owners:**
  - Academies of Sciences and Universities
  - Roscosmos space debris dedicated mini-observatories
  - Commercial companies and individuals

# Map of ISON observatories



**Number of measurements of ISON project  
from 2003 to 2015, K.**



# 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 of Galileo at MEO (Lavochkin Association)
- Observations of Yamal-300K at Far East GEO slot (Gazprom space systems)

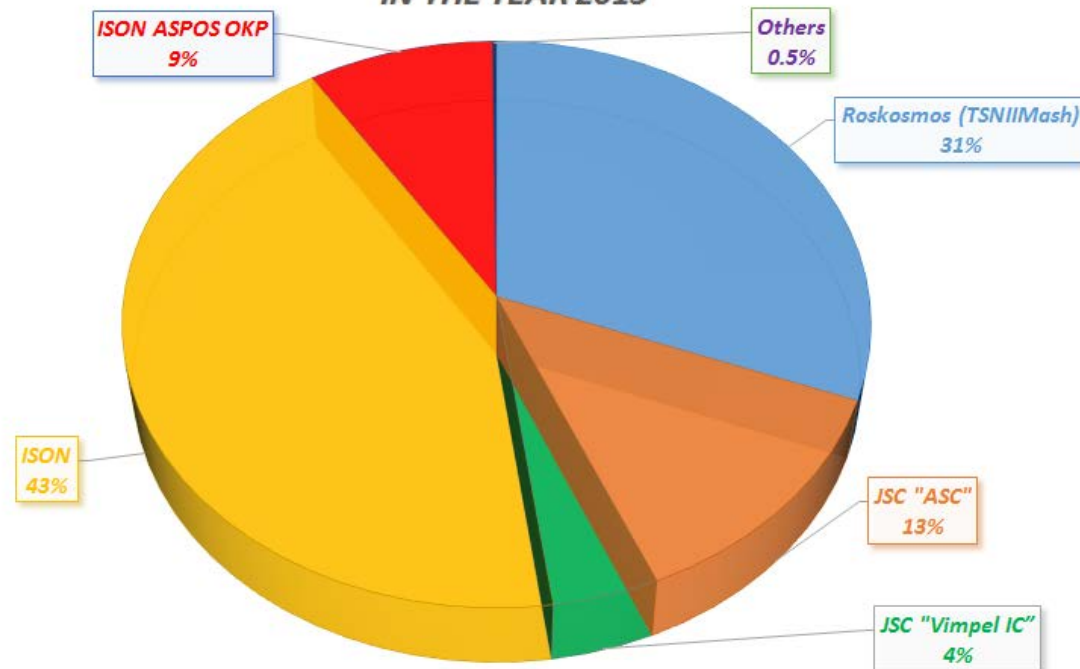
# Recent ISON news

- ISON encompasses five groups of telescopes and three scheduling centers to better serve user's requests
- Deployment of six Roscosmos mini-observatories and 3 telescopes has been completed (21 telescopes total + 9 KIAM)
- Telescopes of two European observatories have joined the ISON survey subsystem – AIUB Zimmerwald and TFRM Barcelona
- Subsystem of 7 telescopes for extended GEO surveys is created
- New group of 8 telescopes is operated by Vimpel corporation
- KIAM data center has been upgraded with new powerful PCs
- 15.4 millions measurements in 2.1 million tracklets have been collected at KIAM database in 2015
- KIAM maintains orbits for  $\sim 4100$  space objects
- 339 new objects have been discovered, 307 previously lost objects have been rediscovered

# Segments of ISON telescopes

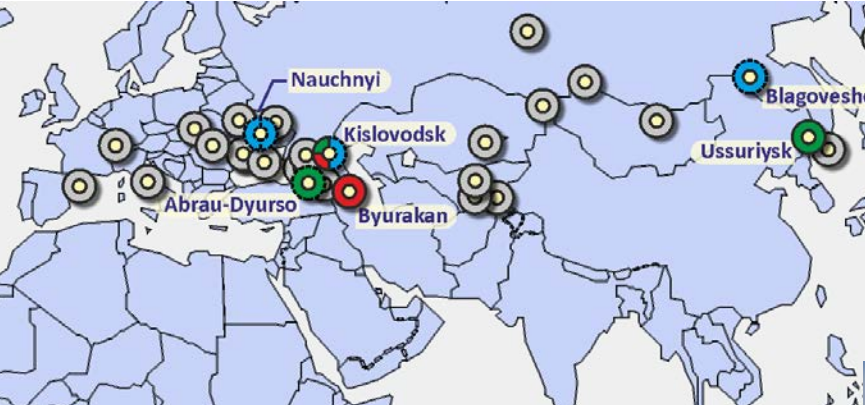
- Support of conjunction analysis – Roscosmos specialized observatories EOP-1, EOP-2 (31% data) + part of KIAM telescopes (9%)
- Space situation analysis – Vimpel telescopes (4%) + ASC Ltd telescopes (13%)
- Study of space debris population, provision of services for other users – KIAM telescopes (43% data)

CONTRIBUTION OF THE DIFFERENT SYSTEMS OF OPTICAL TELESCOPES  
IN THE YEAR 2015





Six space debris mini-observatories of Roscosmos: 4 EOP-1, 2 EOP-2 (6x19.2 cm system, 4x25 cm, 4x 40 cm and 2x65 cm telescopes) to improve conjunction analysis in KIAM



# Subsystem for extended GEO surveys



- 7 telescopes of 18 cm and 19.2 cm apertures with FOV of 7x7 degrees with centralized scheduling at KIAM
- each telescope is surveying visible part of GEO and provides up to 15 thousands measurements for 500 - 700 objects of 14 – 14.5 m and average lengths of measuring arcs up to a few hours
- these surveys allow KIAM to determine more precise GEO orbits for conjunction analysis, to detect maneuvers of active satellites and to help maintain the orbits of GEO objects in clusters



# KIAM Space Debris Data Center Overview

- KIAM data center was established in 2003 to perform space debris research in RAS and to support ISON operations:
  - Maintenance of the ISON master database on space objects, related events (launches, fragmentations, re-entires etc.), measurement data and derived products (orbits etc.)
  - Development of optical observation strategies
  - Daily scheduling of the ISON sensors for routine and special survey and tasking observations of GEO, HEO and MEO regions
  - Collecting and processing of optical measurements, determination of parameters of orbits and accuracy estimation
  - Search and analysis of probable close conjunctions at GEO
  - Processing customer's requests and preparing output products (conjunction assessment messages, raw measurements, orbital data/ephemerides etc.)

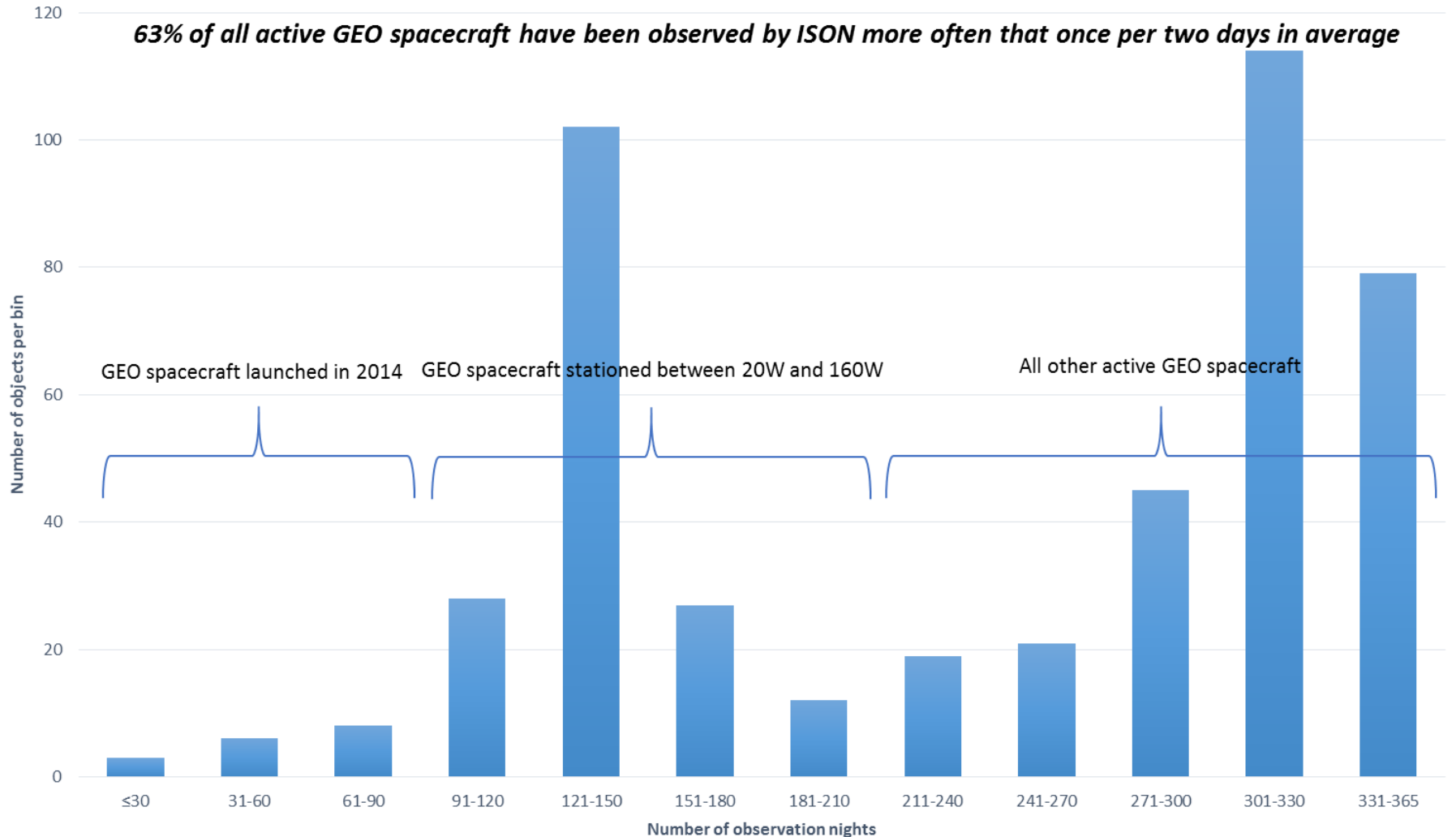


Four computation servers for KIAM database  
48 cores each ( $\sim 7,5$  TFLOPS total)  
Maintains the orbits of 1800 GEO-objects and 2300  
HEO and MEO objects



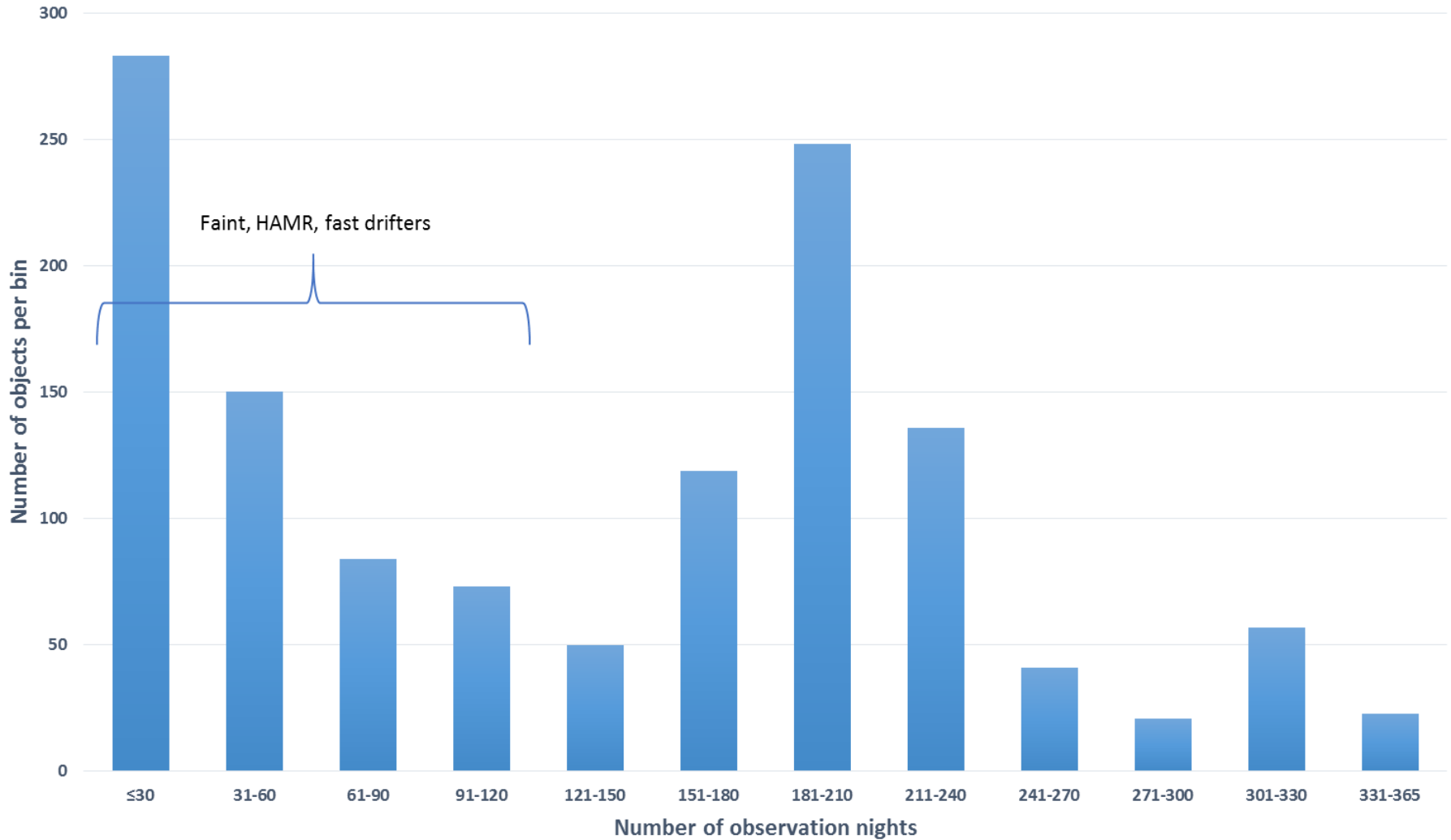
## Number of nights with ISON observations for active GEO spacecraft in 2014

*63% of all active GEO spacecraft have been observed by ISON more often than once per two days in average*

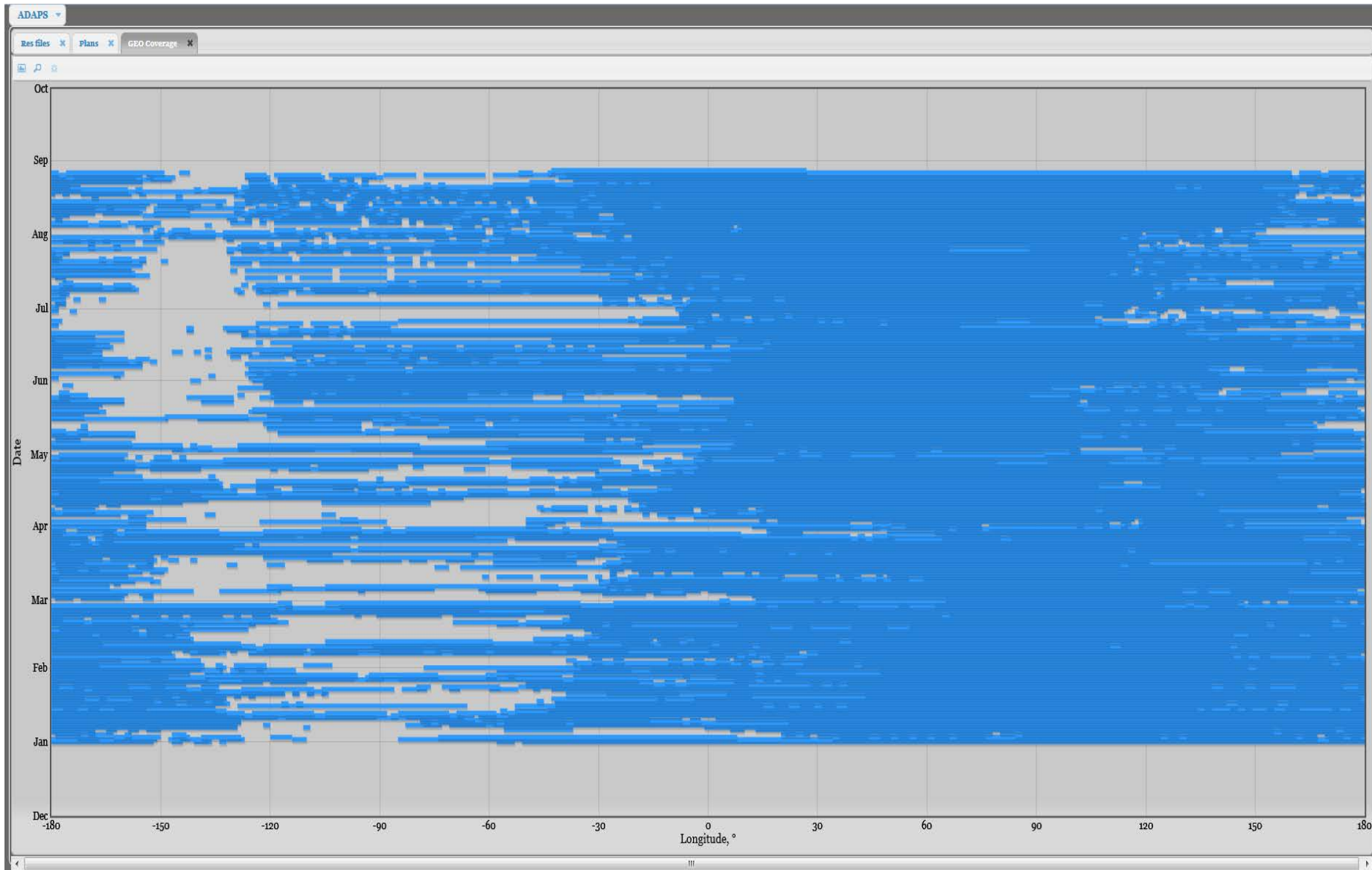


Observations frequency and overall orbit coverage arc for orbit determination are the most critical requirements for active objects

## Number of nights with ISON observations for non-active GEO objects in 2014



# GEO coverage by ISON in January-August 2015



# Goals of ISON observations of asteroids

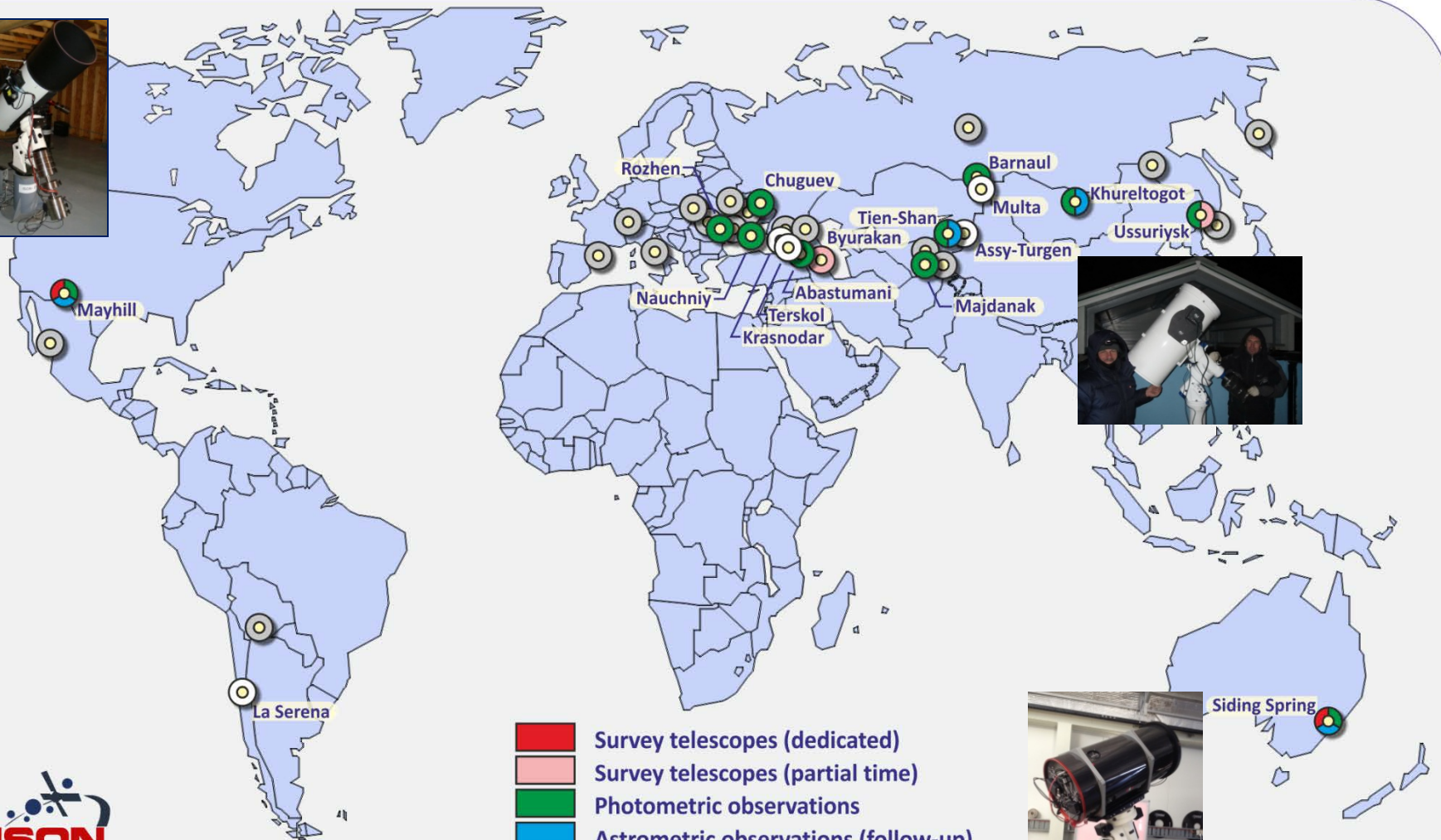
- Search of new asteroids and comets
- Photometry observations of NEAs to investigate their physical properties (searching for binary asteroids and determining parameters of the binary systems, detection of the influence of YORP-effect on asteroid's rotation, support radar observations of NEAs)
- Follow up observations of discovered objects
- Developing of telescopes and software for elaboration of concept of “second wave” asteroid survey – survey with small telescopes that provide full sky coverage during night to detect fast NEAs missed in the dedicated asteroid surveys with large telescopes



# Status of ISON asteroid observations

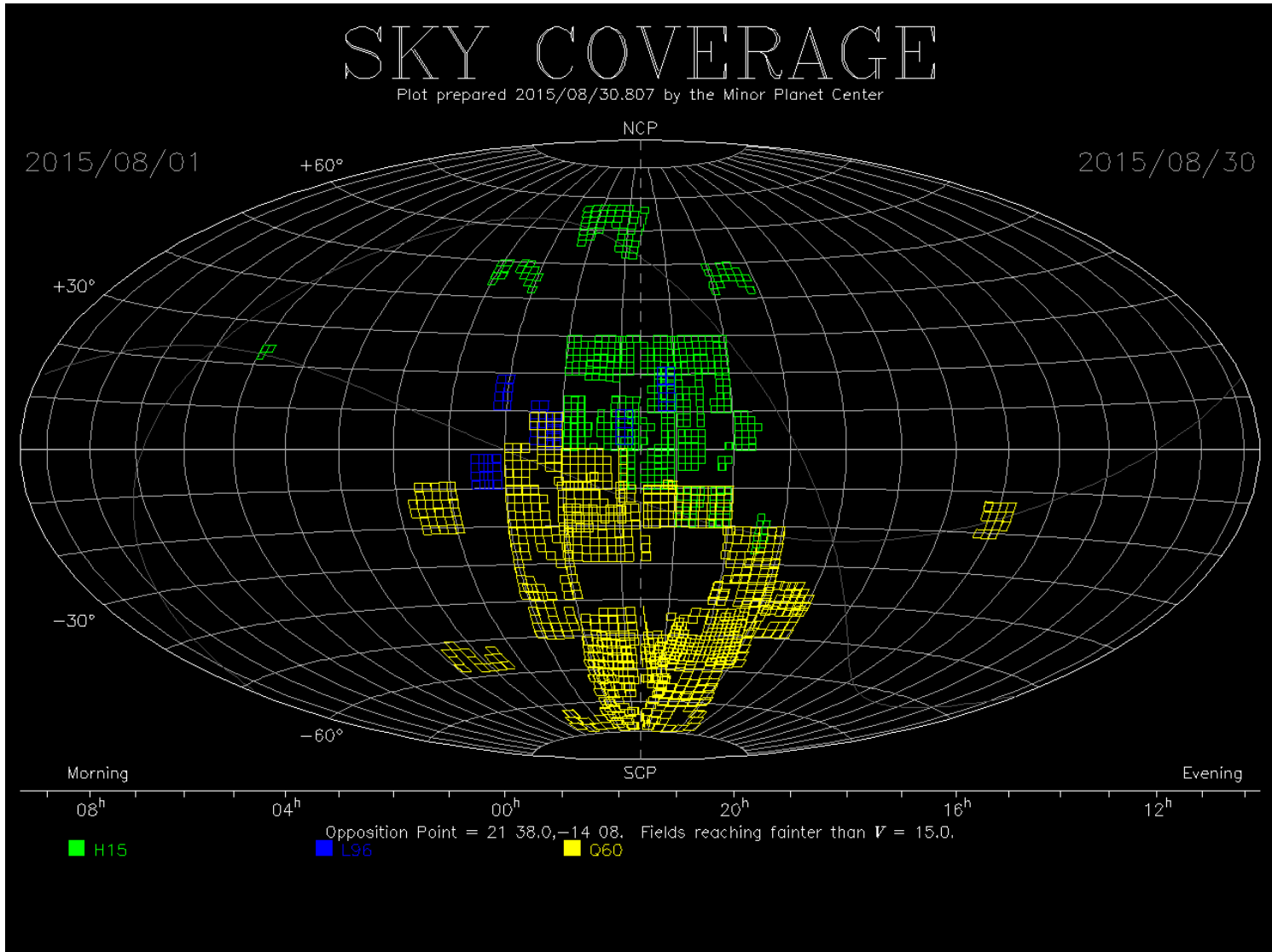
- 2 surveys with 40 cm telescopes in New Mexico, USA and Siding Spring, Australia (joint project with AIUB team of Switzerland) with centralized processing in KIAM
- 1 follow up 40 cm telescope in Khureltogot, Mongolia
- 16 telescopes of apertures from 2.6 m to 25 cm participated in 5 photometry observation campaigns (including 2 m telescope in Rozhen, Bulgaria)
- it is planned to install 5 new survey telescopes:
  - two 50 cm (2x2 degree) for new surveys in Russia (Multa, Altay and Mezmay, North Caucasus)
  - three 40 cm (4x4 degree) – two for replacement in New Mexico and Siding Spring and third for new survey in Chile

# ISON observatories participating in observations of asteroids



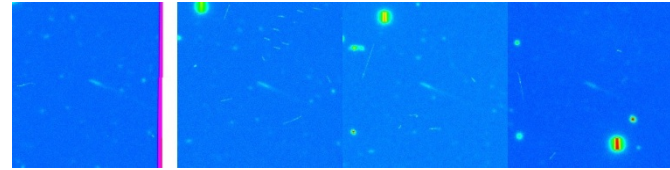
- Survey telescopes (dedicated)
- Survey telescopes (partial time)
- Photometric observations
- Astrometric observations (follow-up)
- New telescopes in progress
- Other telescopes of ISON network

# Sky coverage of 3 ISON surveys for august 2015



# Results of 2015

- Survey: 278726 measurements, 79 new objects, including 7 NEAs (1PHA) and 2 comets: **P/2015 PD229 (ISON-Cameron)** and **C/2015 X4 (Elenin)**
- Follow up: 69 MPEC circulars
- Photometry (joint project with Astronomical Institute of the Czech Academy of Sciences) :
  - 320 light curves for 80 asteroids (including 69 NEAs). Measured or clarified the rotation periods for 20 NEAs (including 9 asteroids of 200-300 m size)
  - observed 13 NEAs in support of radar researches
  - discovered two binary systems: (4541) Mizuno and (8474) Rettig
  - YORP-effects is investigating for (1620) Geographos and 138852 (2000 WN10)





# Conclusion

- ISON project is continuously developing – new observatories are joining, new telescope subsystems are forming and KIAM database is upgrading. 71 telescopes of 34 observation facilities is producing 15.4 million measurements on space debris in 2015
- KIAM database keeps records on about 4100 high altitude objects, including 1300+ space debris objects in GEO that is 41% more than in any other available source
- KIAM performs orbit determination and conjunction analysis on a routine daily basis
- ISON develops the conception of “second wave” asteroid survey (three 40 cm telescopes discovered 13 NEAs and 7 comets, obtained 1 million measurements) and carries out regular photometry observations (9 binary asteroids, 5 with YORP-effect)
- ISON project is open for cooperation and invites new partners to collaborate with us in different ways