



Russian Academy of Sciences
Keldysh Institute of Applied Mathematics

International Scientific Optical Network (ISON) activities on highly elliptical orbit (HEO), geosynchronous orbit (GEO) and Near-Earth objects (NEO) observation and analysis in 2013

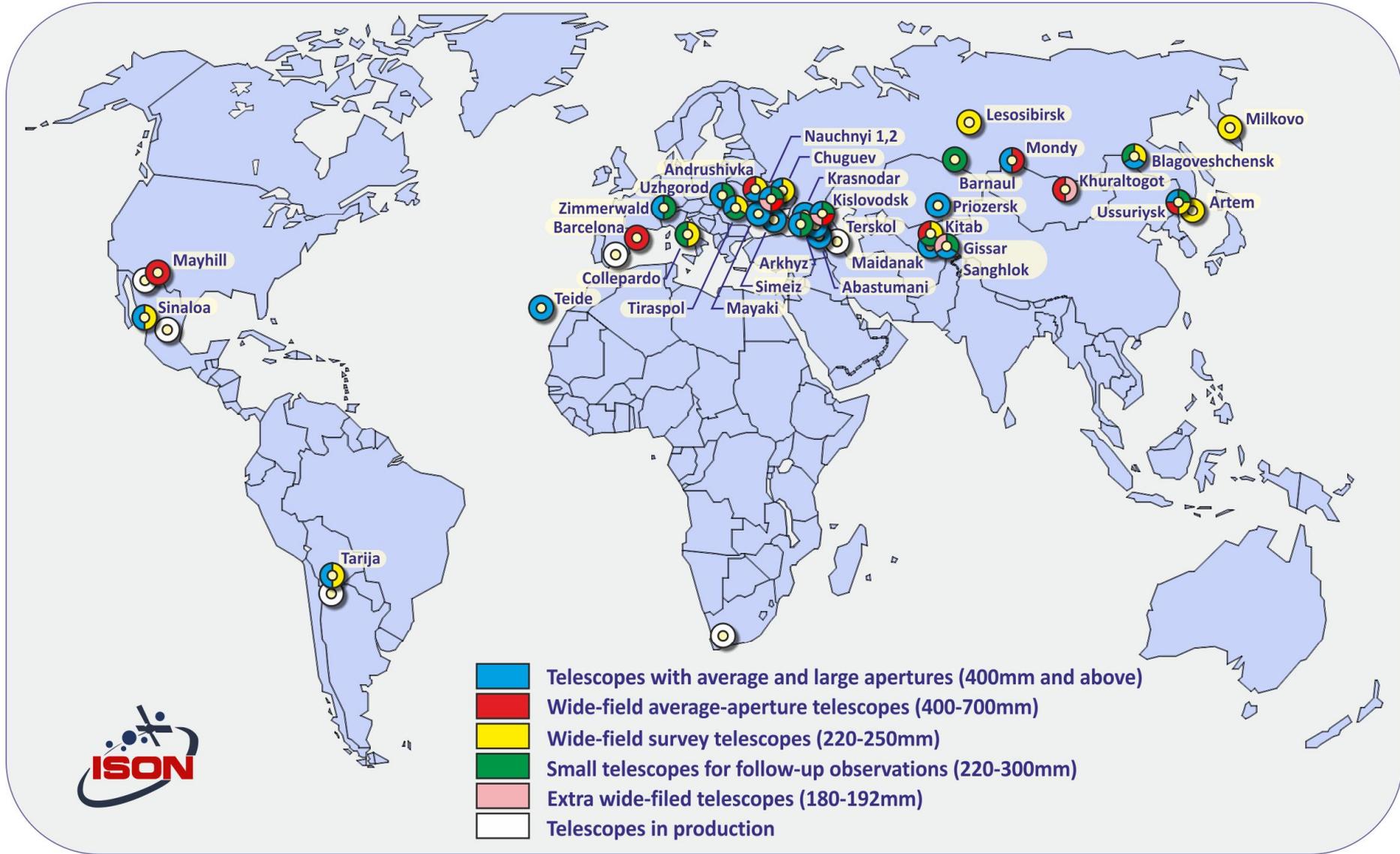
51st session of STSC COPUOS
Vienna
10-21 Feb 2014

ISON – International Scientific Optical Network

As of Dec 2013 ISON joins:

- Observation scheduling, coordination and data processing center (KIAM RAS)
- 33 facilities (including 29 ones for space debris observations) in 14 countries with more than 60 telescopes of different class (aperture from 19 cm to 2.6 m)
- Company for the network maintenance and instruments development (ASC Project-Technics)

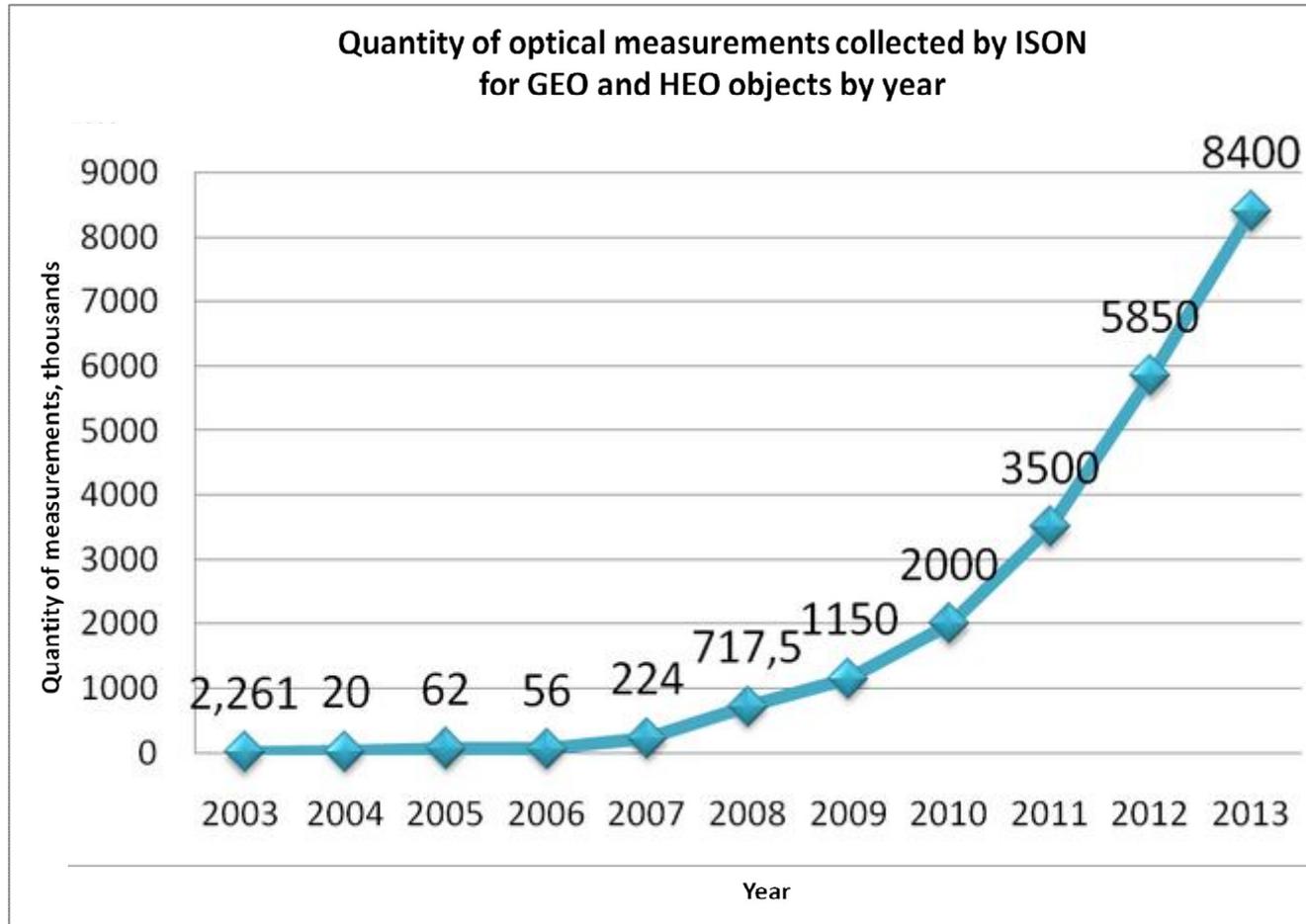
ISON observatories



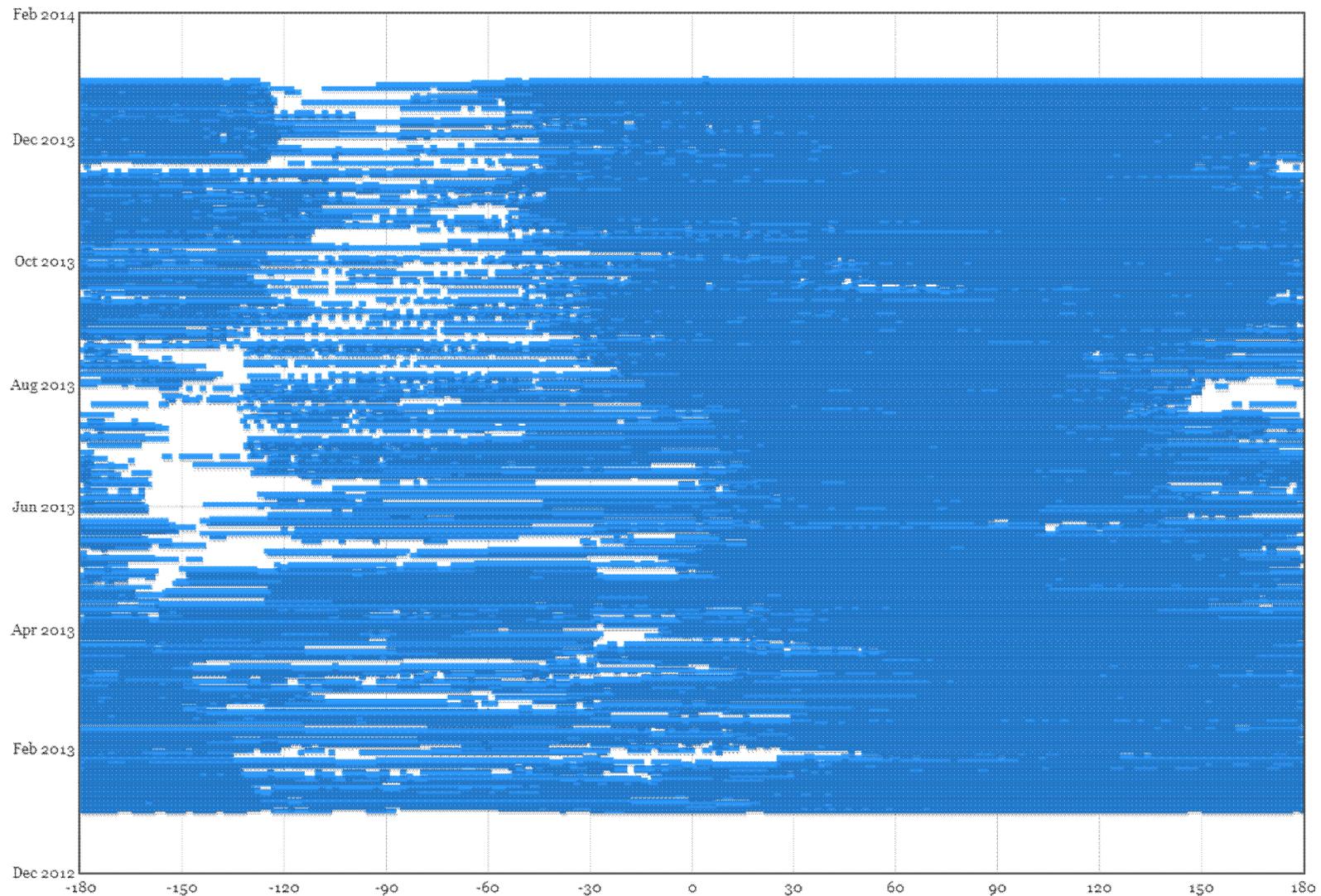
ISON Milestones in 2013

- 8.4 millions of astrometric measurements for GEO and HEO objects are collected
- New facility in Byurakan (Armenia) put into operation
- New 65-cm class instrument in Ussuriysk
- 210 new high orbit (GEO and HEO) debris are discovered in addition to 28 spacecraft and upper stages launched into GEO region in 2013
- 152647 astrometric measurements for asteroids and comets are collected by observatories ISON-NM (MPC code H15) and ISON-Kislovodsk (MPC code D00)
- 190 new asteroids are discovered, including one large (>1 km in diameter) NEA 2013 TB80

Growing amount of measurements collected by ISON for objects in GEO and HEO, 2003 – 2013



ISON GEO coverage in 2013 (Longitude vs. Date)



Updated Information on Identification of GEO Debris Discovered by ISON

ISON number	Date of detection by ISON	Associated 'parent' object	Comment
90176	25.11.2008	1970-093A	DSP sunshade cover
95557	22.09.2011	1991-080B	DSP sunshade cover
43218	15.01.2010	1994-084A	DSP sunshade cover
95057	15.06.2011	1997-008A	DSP sunshade cover
95569	14.12.2011	2007-054A	DSP sunshade cover
90132	23.11.2008	1997-049B	Meteosat 7 cover
95689	14.07.2012	2012-035B	Meteosat 10 cover
90422	12.01.2013	2012-035B	Meteosat 10 cover
95494	08.05.2011	1997-029A	FengYun 2A debris
95389	09.03.2008	2004-042A	FengYun 2C debris
90073	11.12.2007	2006-053A	FengYun 2D debris
90195	15.02.2009	2008-066A	FengYun 2E debris
90214	15.02.2012	2012-002A	FengYun 2F debris
90070	06.08.2007	1981-076	AKM GSM-2

Meteosat Covers

- Each Meteosat released 2 covers:
 - MVIRI cover and MVIRI cooler cover for the first generation spacecraft
 - SEVIRI entry baffle cover and SEVIRI passive cooler cover for the second generation spacecraft



- Protect the sensitive surfaces against possible contamination
- Total 20 covers are released from 10 spacecraft
- Separated from a spacecraft during its drift to a scheduled GEO slot
- Moderate-to-high A/m ratio (0.5-1.5 m²/kg)
- Covers released by Meteosat 9 were observed jointly by KIAM and AIUB teams almost immediately after their separation from the spacecraft

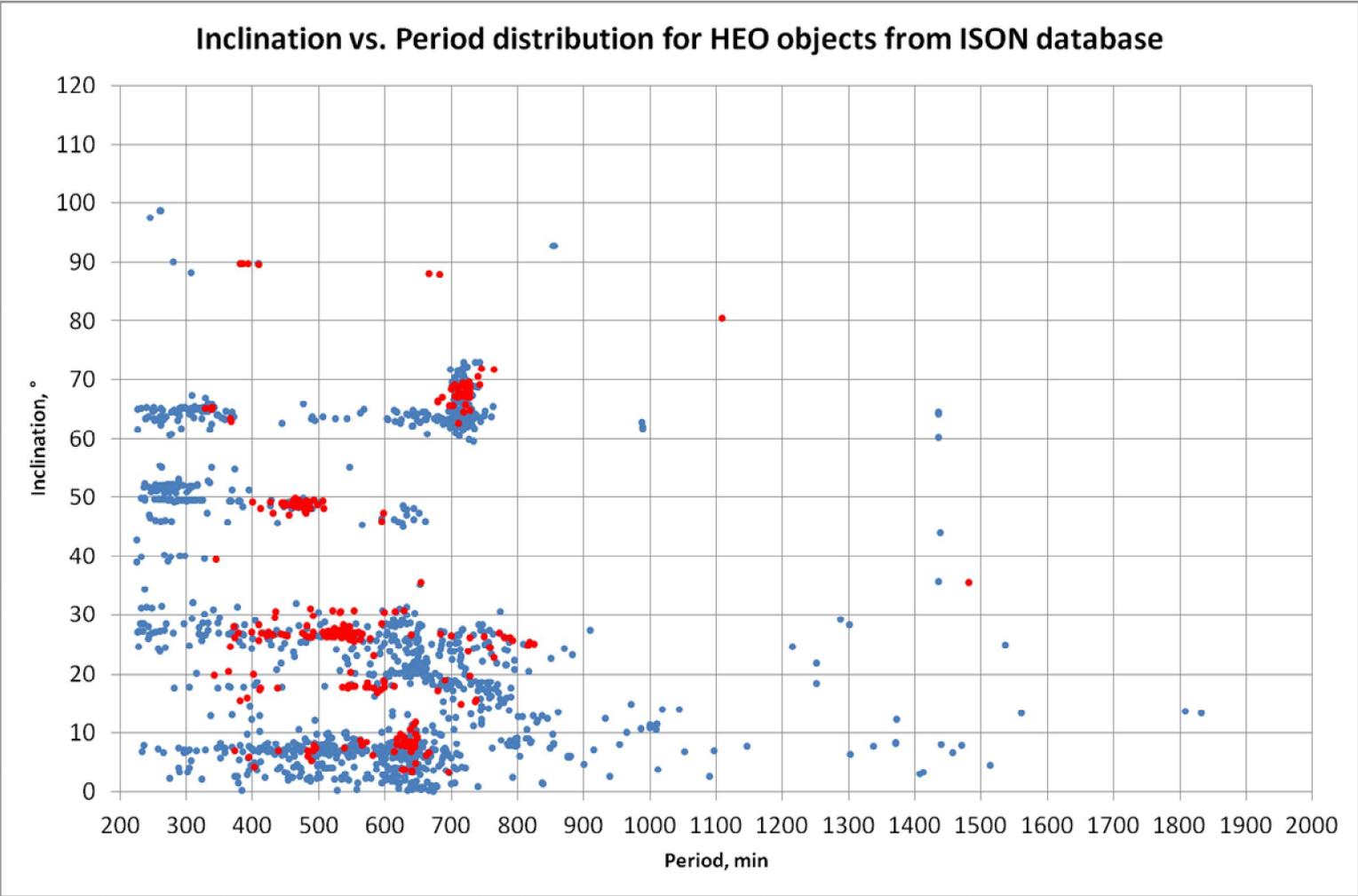
FengYun 2 Debris

- Each FengYun 2 type spacecraft released at least one fragment
- The fragment is supposedly a protecting cover similar to Meteosat's one of covers
- No additional information is available from the spacecraft operators
- Propagation of orbits for all discovered fragments of this type revealed they were separated immediately after the parent spacecraft was reaching its initial GEO position
- We would be glad to contact with FengYun 2 operators in order to understand the nature of those fragments and their release procedure. Such understanding would help to better predict possible conjunctions which may occur shortly after the release of the fragments

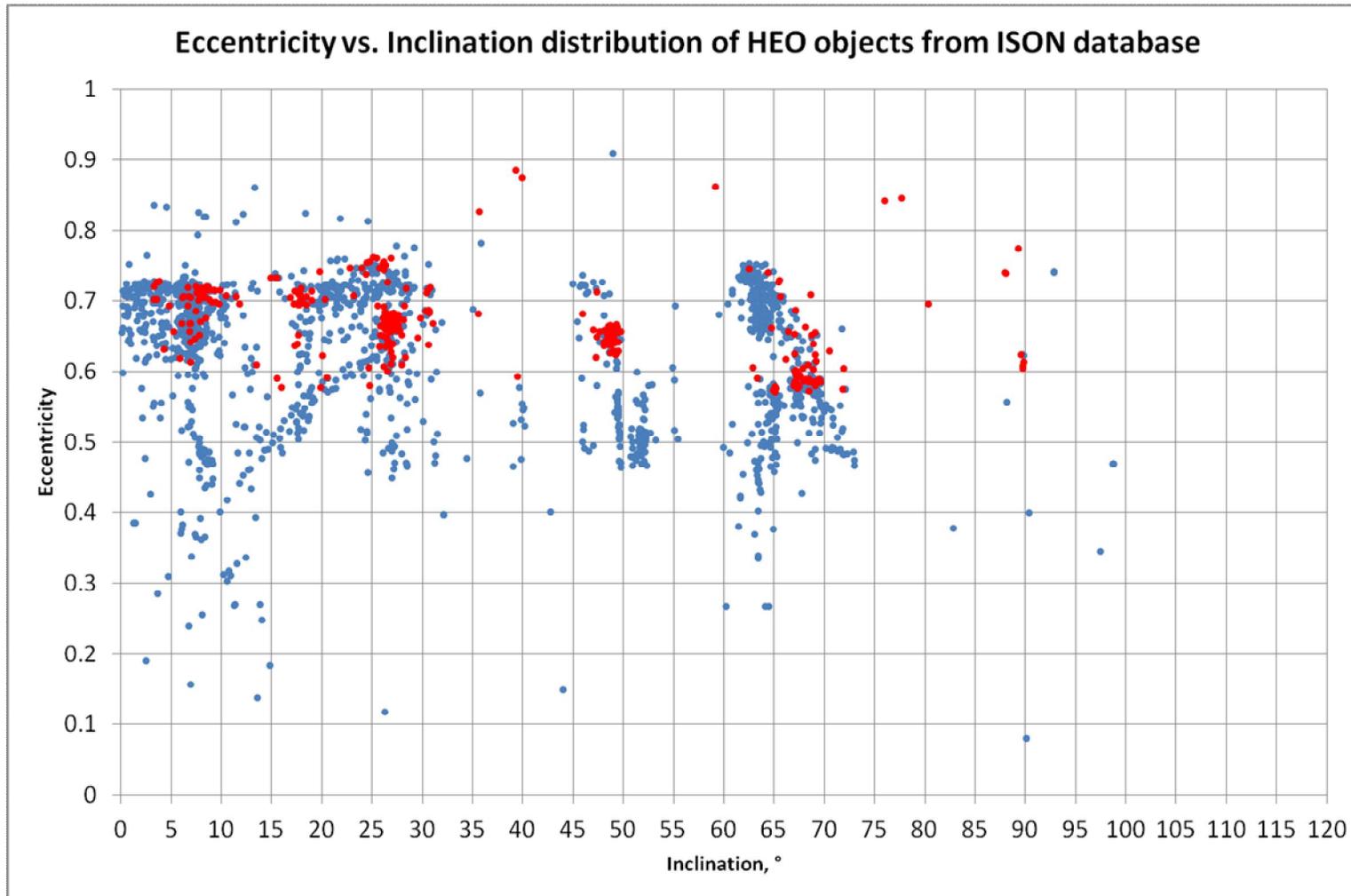
HEO Observations by ISON

- Initially observations of objects at HEO were obtained mostly as an additional output of regular GEO surveys
- Limited Molniya apogee area surveys started in April 2012. They were transformed into the regular task in 2013
- ISON have collected measurements for more than 1400 HEO objects in 2013, including regular observations for nearly 400 objects absent at the Space-Track Web site

Distribution of inclination and period for HEO objects observing by ISON



Distribution of eccentricity and inclination for HEO objects observing by ISON



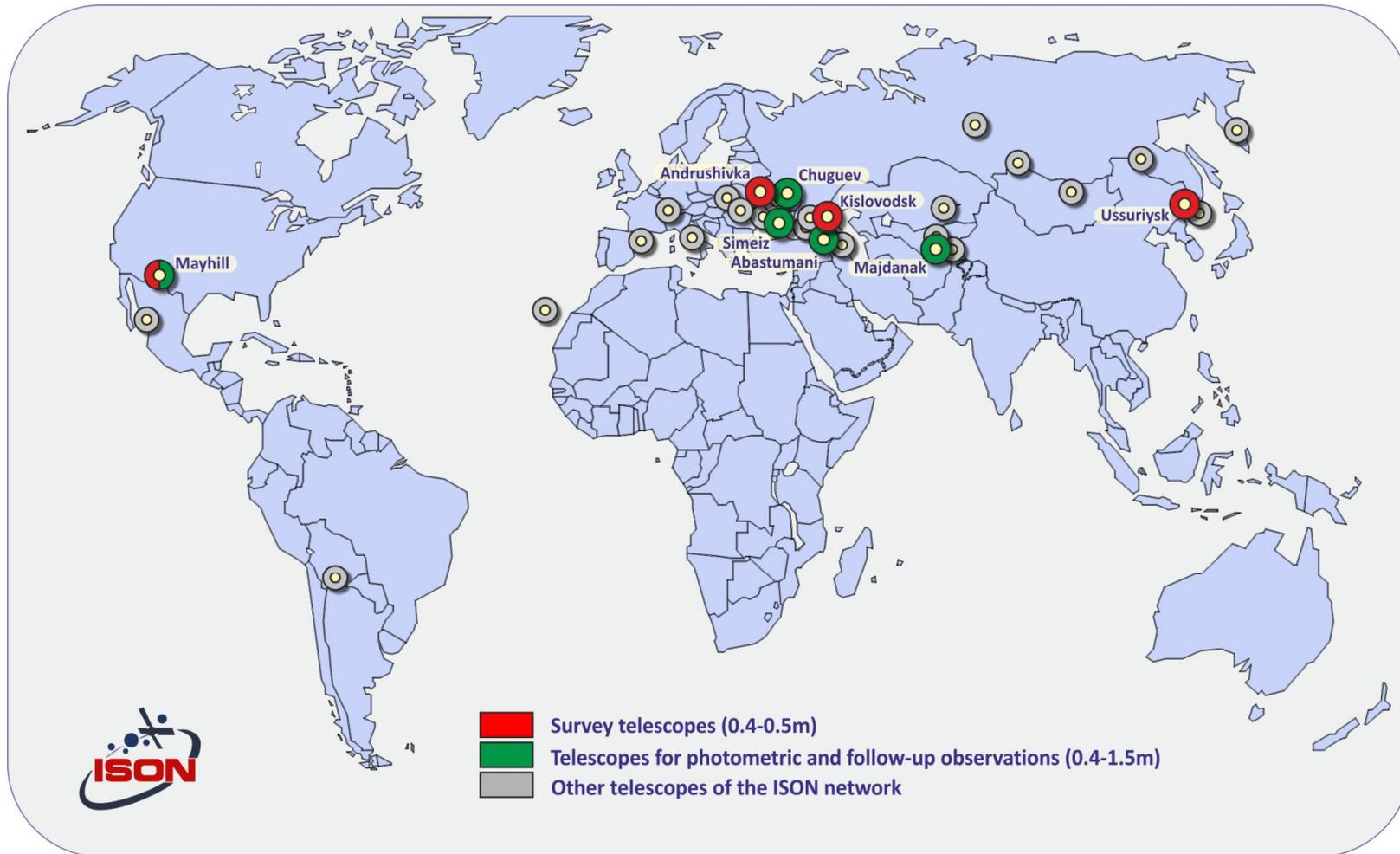
HEO clustered fragments source analysis (1)

- A group composed of 41 objects discovered and tracked by ISON, for which orbital information is not available from other sources, was selected
- Orbital parameters:
 - inclination in range 17.43-21.11°,
 - RAAN in range 156.13-313.27°,
 - period in range 576.41-795.12 min,
 - eccentricity in range 0.5985-0.7572 and thus all perigee heights below 4000 km
- HEO orbits with such inclination are typical for launches from Xichang (China):
 - BEIDOU G navigation satellites – inclination of GTO is 20.2-20.6°
 - TIANLIAN data relay satellites – inclination of GTO is 17.9-18.2°
- Two of CZ-3C launcher upper stages used to launch BEIDOU G satellites were reported by NASA as exploded on orbit after completion of the launch mission (launches BEIDOU G4 (Oct 31, 2010) and BEIDOU G5 (Feb 24, 2012))

HEO clustered fragments source analysis (2)

- The selected group was split into 3 separate subgroups based on results of analysis of specific orbital properties
- Analysis was performed to establish a relationship between selected fragments and their most probable source of origin
- It was revealed that the largest of subgroups (composed by 24 objects) has clear relation to the 2012-008 launch of BEIDOU G5 → fragments of explosion of the CZ-3C upper stage
- Second subgroup (composed by 14 objects) has clear relation to the 2010-057 launch of BEIDOU G4 → fragments of explosion of the CZ-3C upper stage
- 3 remained objects are not correlated yet with specific origin

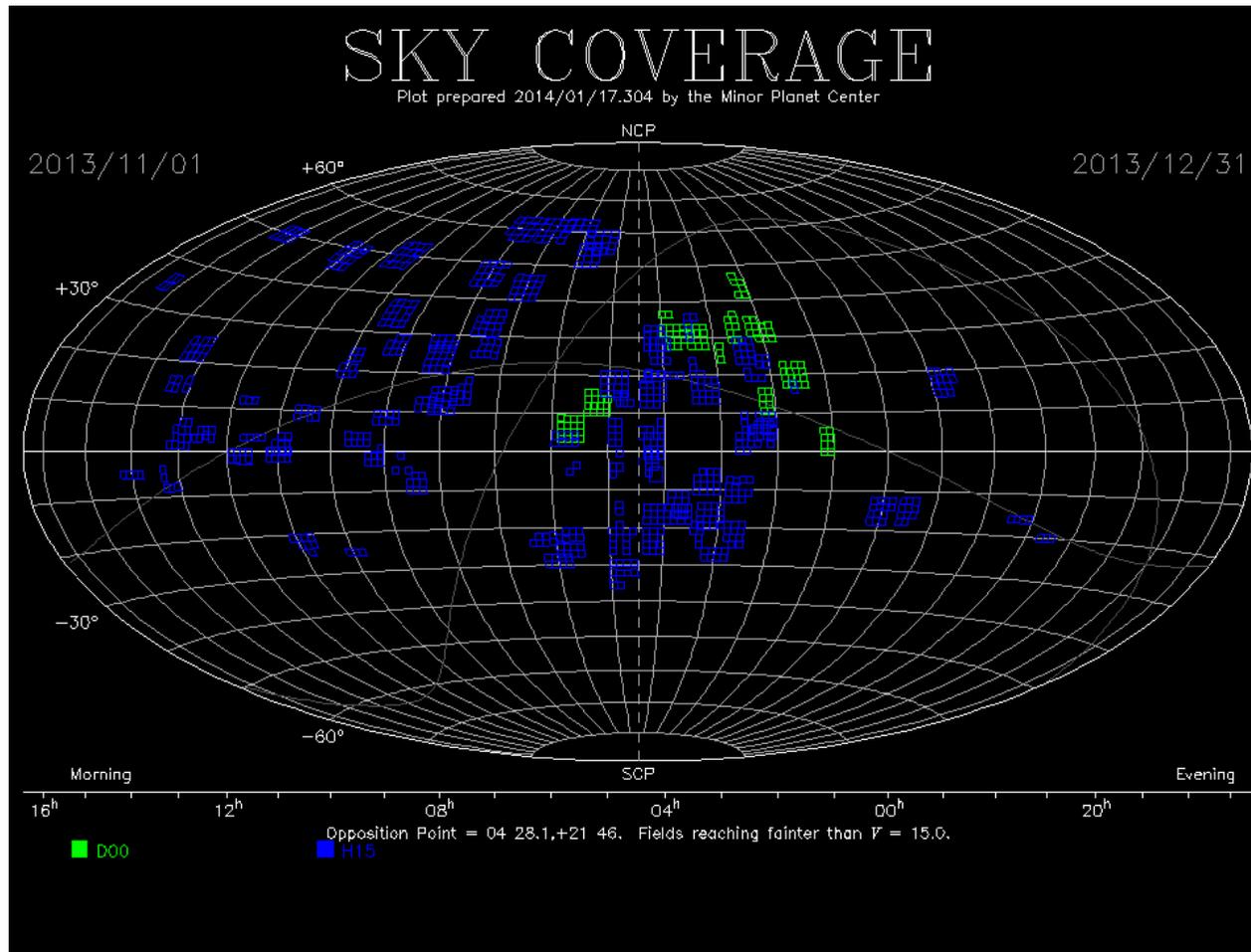
ISON telescopes for NEO surveys and follow-up observations



Top 30. Number of observations in 2010-2013

No	MPC code	Observations	Objects	Discoveries	Observatory name
1.	G96	7575459	1381391	67711	Mt. Lemmon Survey
2.	703	6186338	1013872	10390	Catalina Sky Survey
3.	F51	6037423	1404446	41714	Pan-STARRS 1, Haleakala
4.	704	5628876	807335	2593	Lincoln Laboratory ETS, New Mexico
5.	C51	4008160	207099	35037	WISE
6.	691	3221788	605533	34974	Steward Observatory, Kitt Peak-Spacewatch
7.	E12	867753	199141	1260	Siding Spring Survey
8.	D29	862778	209077	825	Purple Mountain Observatory, XuYi Station
9.	I41	469350	55688	4097	Palomar Mountain--PTF
10.	J75	407501	95277	2000	OAM Observatory, La Sagra
11.	H15	406570	97704	1357	ISON-NM Observatory, Mayhill
12.	926	343311	101432	1565	Tenagra II Observatory, Nogales
13.	J43	267461	52934	1653	Oukaïmeden Observatory, Marrakech
14.	645	245718	58569	7	Apache Point-Sloan Digital Sky Survey
15.	106	204623	49178	309	Crni Vrh
16.	291	180787	47795	1562	LPL/Spacewatch II
17.	J04	140559	36365	1474	ESA Optical Ground Station, Tenerife
18.	W84	110213	8518	4160	Cerro Tololo-DECam
19.	644	95804	19044	1766	Palomar Mountain/NEAT
20.	A14	92556	25962	311	Les Engarouines Observatory
21.	461	76584	17745	1495	University of Szeged, Piszkesteto Stn. (Konkoly)
22.	D00	76152	18253	95	ISON-Kislovodsk Observatory
23.	H21	69945	12736	502	Astronomical Research Observatory, Westfield
24.	A50	63394	19207	113	Andrushivka Astronomical Observatory
25.	G92	51727	13673	107	Jarnac Observatory, Vail
26.	A24	42014	6775	0	New Millennium Observatory, Mozzate
27.	A77	39351	9729	488	Observatoire Chante-Perdrix, Dauban
28.	G32	38997	5086	680	Elena Remote Observatory, San Pedro de Atacama
29.	695	38209	8149	1779	Kitt Peak
30.	807	36346	8026	10	Cerro Tololo Observatory, La Serena

Example of the Sky Coverage by ISON-NM and ISON-Kislovodsk instruments (Nov – Dec 2013, plot by the MPC)



ISON : results on asteroids

Hundreds of light curves were constructed for tens of NEAs

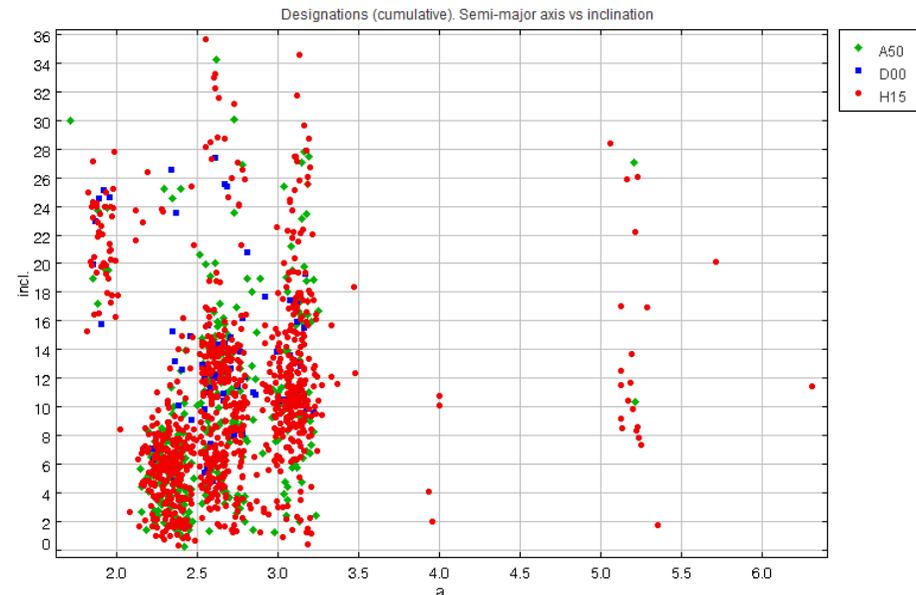
(3122) Florence, (20187) Janapittichova, (25916) 2001 CP44, (162004) 1991 VE,
(7888) 1993 UC, 1998 VO, (47035) 1998 WS, 2000 WN22, 2001 WC47, 2002 GT,
2012 EG5, 2012 DX75, 2012 KP24, 2012 KT42, 2012 LZ1, 2012 QG42, 2012 TC4,
2012 DA14...

YORP-effects is estimated: (2100) Ra-Shalom и (88710) 2001 SL9

Binarity of asteroids:

(3352) McAuliffe, (8373) Stephengould, (7888) 1993 UC, (68216) 2001 CV26,
(137170) 1999 HF1, (329437) 2002 OA22, (8306) SHOKO

Discoveries: 6 comets - C/2010 X1
(Elenin), P/2011 NO1 (Elenin),
C/2012 S1 (ISON), C/2013 V3
(Nevski), C/2013 N4 (Borisov),
C/2013 V2 (Borisov),
8 NEAs, 1500+ asteroids



ISON : some instruments implemented for



ISON-NM: SANTEL-400AN, D=400 mm, f/3, FOV 106'x106'
CCD – FLI ML09000-65

Kislovodsk observatory (25-cm, 2x20 cm and 40-cm telescopes)



50-cm telescope ORI-50 in
Andrushivka (Ukraine)



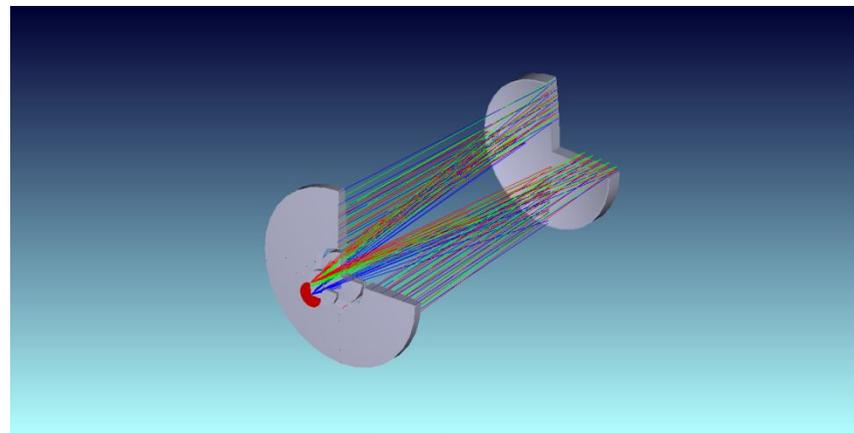
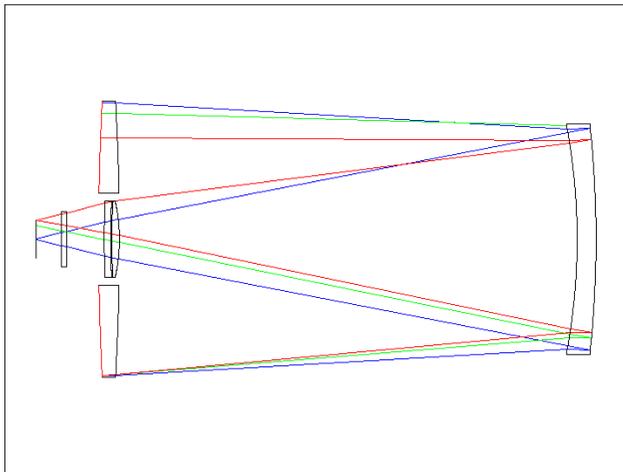
SANTEL-400AN, D=400 mm, f/3,
FOV 106'x106'
CCD – FLI ML09000-65

New telescope

**SANTEL-650A
(Ussuriisk)**

0.65-m f/2 + FLI PL4301

FOV 2.2° x 2.2°



Perspective very large field survey system



4 x VT78e (Genon)

0.19-m f/1.54

Overall FOV - $14^\circ \times 14^\circ$

Limiting mag. in survey mode - 18^m

Conclusions

- ISON network collects on a routine basis astrometric and brightness measurements for more than 1800 objects in GEO region and more than 1400 objects at HEO orbits
- 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
- ISON continues to develop an asteroid research program
- Development of ISON – the first international network for monitoring near-Earth space – continues and all nations are welcome to join us

Thank you for your attention!