ISON database on space debris objects: observations at the Khureltogoot Observatory

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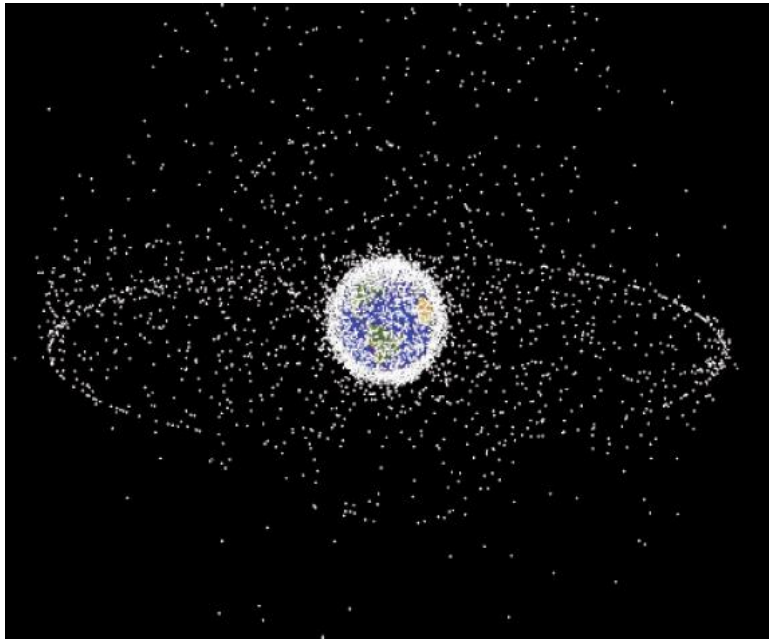
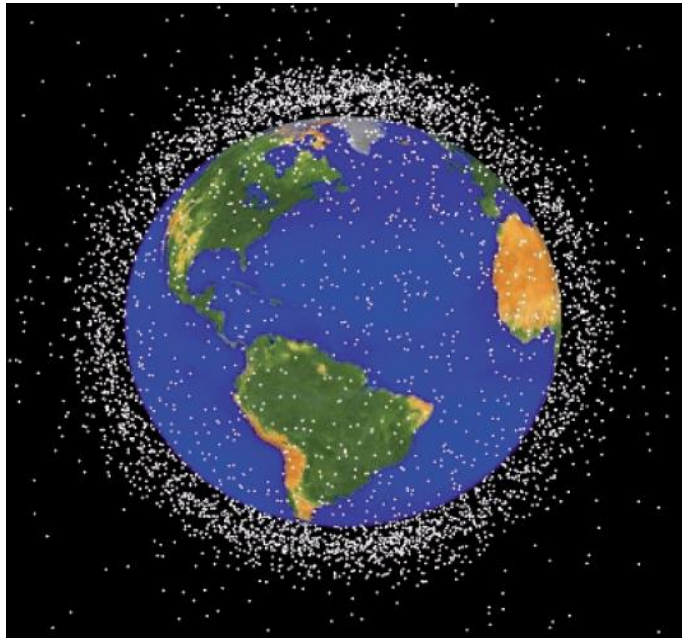
Space Debris – the problem caused by space exploration

GEO, HEO, MEO





LEO

- All non-functional artificial space objects
- Including upper stages , non-functional spacecrafts, operational fragments, fragments of breakups
- About 37000 objects of size > 10 cm
- About 80000 objects of size > 1 cm
- 100 million pieces smaller than 1cm

ISON network of optical telescopes

- **ISON has started in 2004 as open international voluntary project on self-financing basis to be an independent source of space surveillance data for scientific and applied goals**
- ISON project milestones:

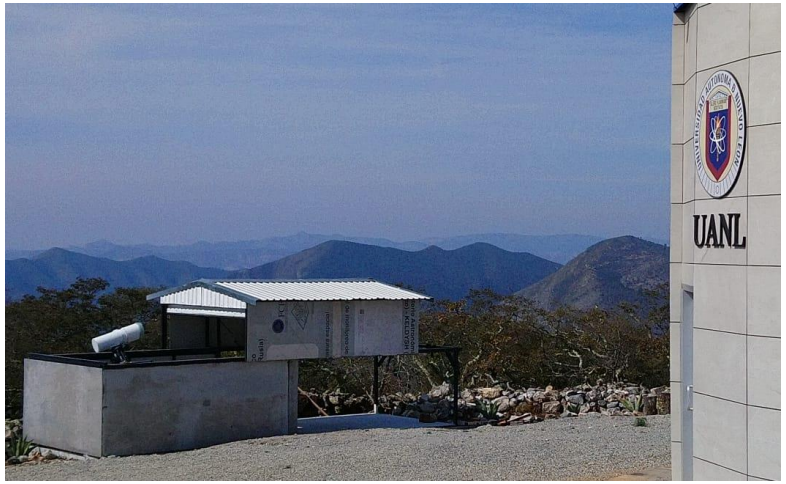
- 2004-2006: **stage of project foundation**, scientific goals, coordination from Pulkovo observatory, arranging the network with old telescopes, international partnership;
- 2007-2010: **stage of project expansion**, scientific goals, coordination from KIAM RAS, start of own telescopes production, development of standard ISON software, arranging of global survey system with overlap of all longitudes;
- 2011-2018: **stage of collaboration with Roscosmos**, rather applied goals, elaboration and deployment of 6 dedicated observatories, establishing the SIE “ISON Ballistic-Service”;
- 2019- now: **stage of rebranding**, applied project with a scientific component, coordination from SIE “ISON Ballistic-Service”, initiative on international centre for the exchange of information on space debris, arranging of data exchange

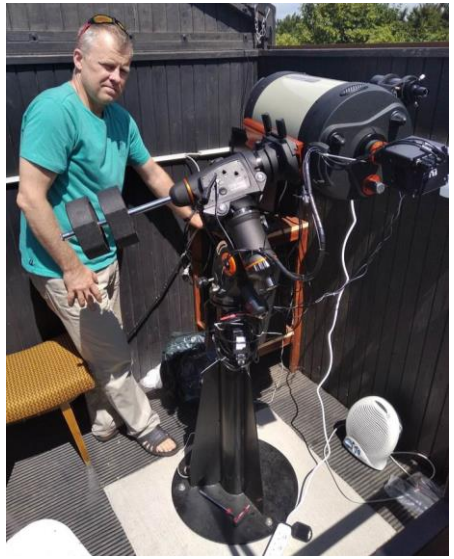
SIE “ISON Ballistic-Service

- In 2015, the IPM Ballistic-Service was created at the Keldysh Institute of Applied Mathematics. The company's balance sheet included 30 telescopes with an aperture of 19.2 to 80 cm.
- In 2019, the Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences left the co-founders and created the International Network of Optical Telescopes Collective Use Center. An attempt was made to coordinate the ISON network on behalf of the ISON Ballistic-Service. A new observation planning center was created.
- 11 cooperation agreements were signed with organizations in China, South Africa, Bolivia, Spain, Slovakia, Mexico, Switzerland, Morocco, Egypt, and Mongolia. Applications were received from the UAE, Jordan, and Saudi Arabia. Three small telescopes were installed in Slovakia, South Africa and Bolivia, two telescopes in Mongolia and one telescope in Bolivia were repaired, interaction with the 40-cm telescope in Korla (China) was established, small telescopes were put into operation in Yao'an (China), Nuevo Leon (Mexico) and near Madrid (Spain). Eight CCD cameras without shutters were received, four new small telescopes were ordered. A series of focusing devices was manufactured, a shutter was developed, a workshop was purchased. New software for telescope control was supported.
- Then the idea came to develop our own database, with the prospect of becoming an international center for the exchange of data on space debris and for orbital forecasting.

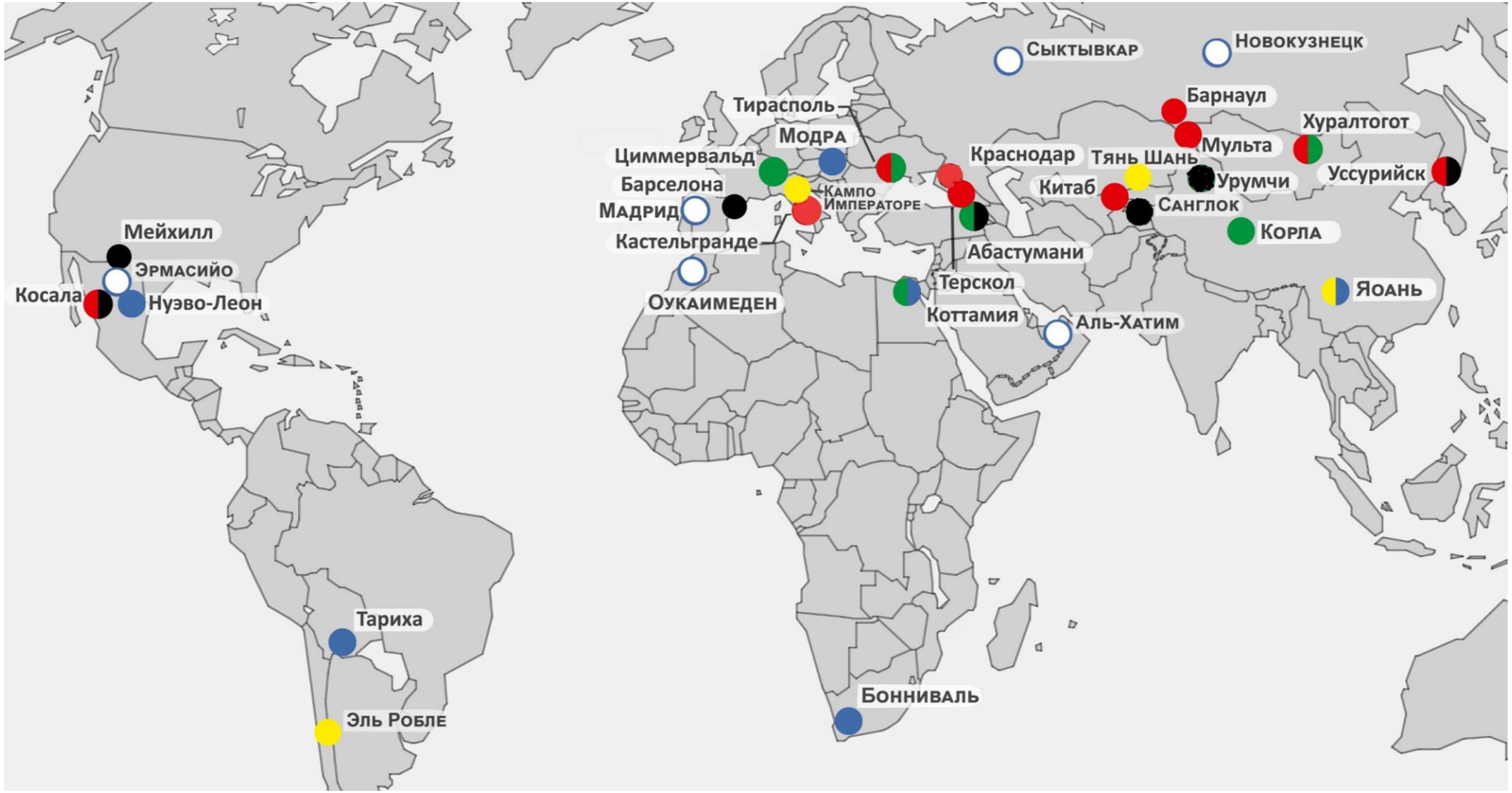
ISON survey telescopes

40-cm and 20-cm telescopes in *Mongolia*, 25-cm telescope in *Mexico*, 28-cm telescope in *Egypt*, 28-cm telescope in *China* (7x7 degree), 28-cm telescope in *Slovakia*, 60-cm and 25-cm telescopes in *Bolivia* 22-cm telescope in *South Africa*, workshop building

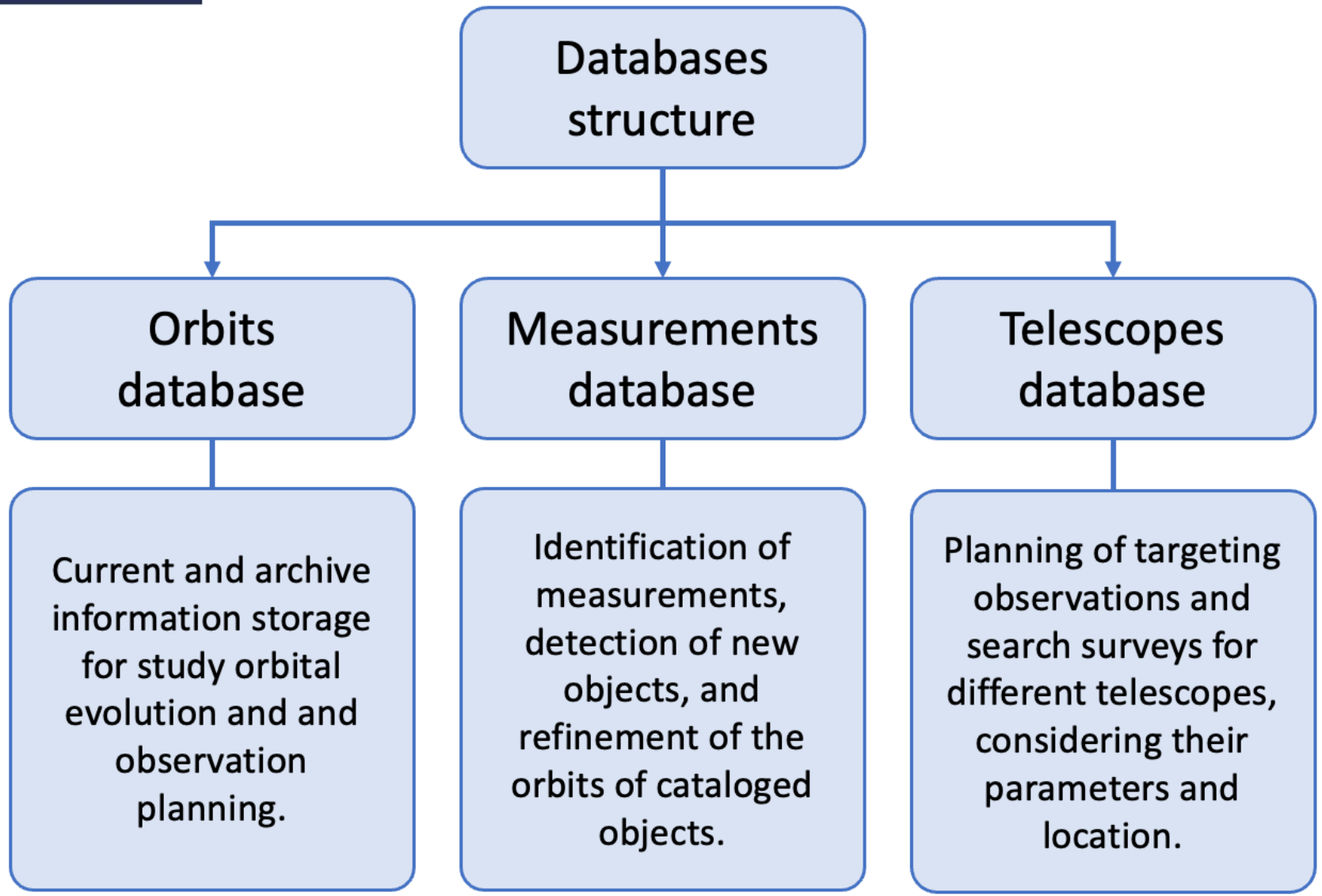




Current map of the ISON network



Main structure of the new database in ISON-BS



Total database exceeds 230 million entries and takes up more than 200 Gb of disk space.

Total orbits: 31 421 880

Total measurements: 96 333 409 (150 000 daily in average)

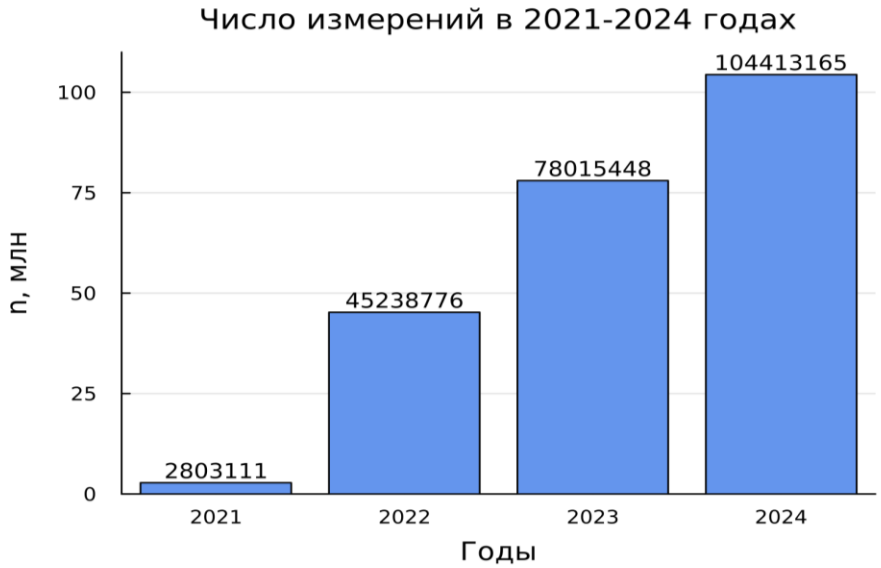
Total tracklets: 9 750 341

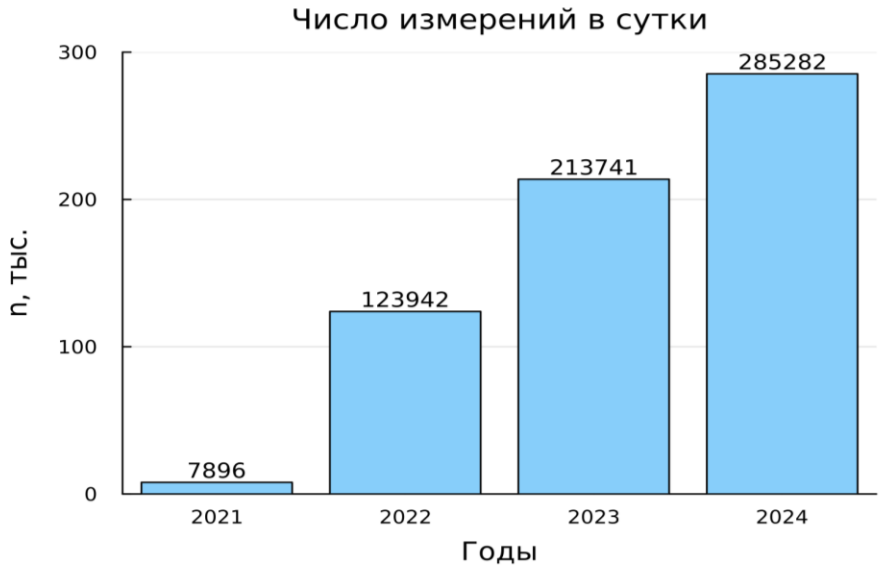
3122 GEO-objects,
5267 HEO-objects,
1697 MEO-objects.
3226 HAMR-objects,
739 operating satellites

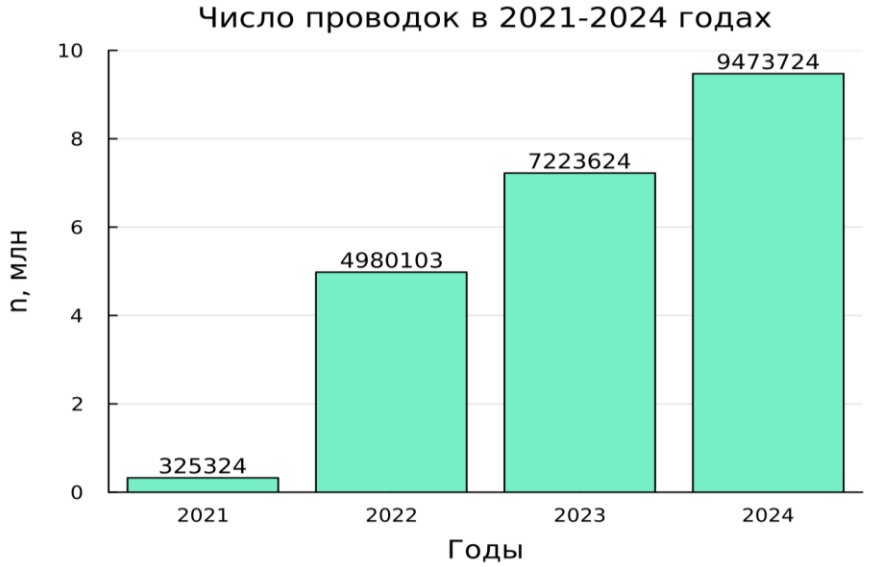
ISON Project Database on Space Debris

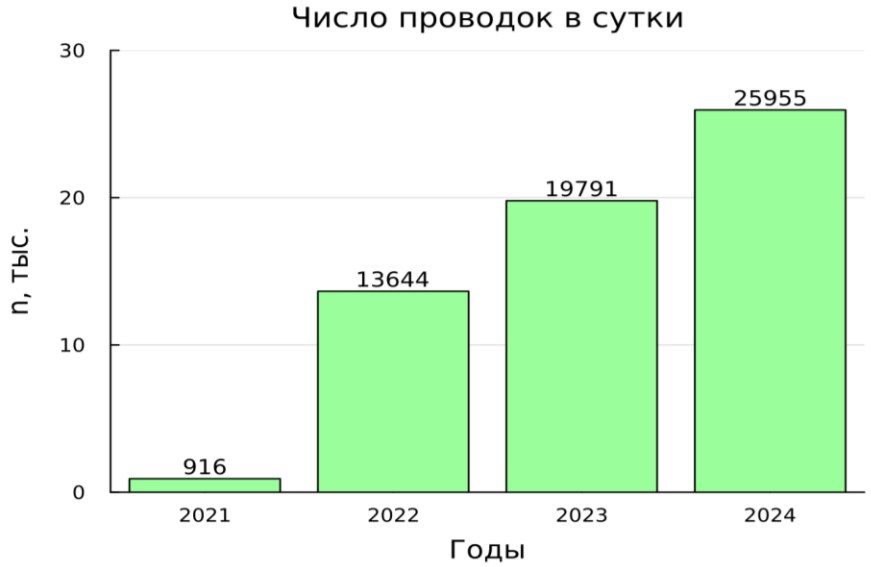
- The software package for collecting and analyzing SD data is based on the open-source object-relational database management system PostgreSQL version 12.2 under the Ubuntu Linux 20.04 LTS operating system.
- Two types of data - optical astrometric measurements and orbit lists - are sent to the server via FTP or SFTP protocols. The system supports several encodings to facilitate interaction with international partners.
- The database stores data on telescopes, including coordinates and technical parameters, for the automated observation planning subsystem.
- The software package for data processing was created on the freely distributed .NET Core 6 software platform.
- The server hardware infrastructure is based on the Intel Xeon E2697 v2 processor with 12 cores and 24 threads, as well as 64 GB of RAM. The server storage capacity is 24 TB, organized in a RAID 1 array.
- As of December 31, 2024, the total database contained 230 million measurements in 22 million tracklets and occupied more than 200 GB of disk space.

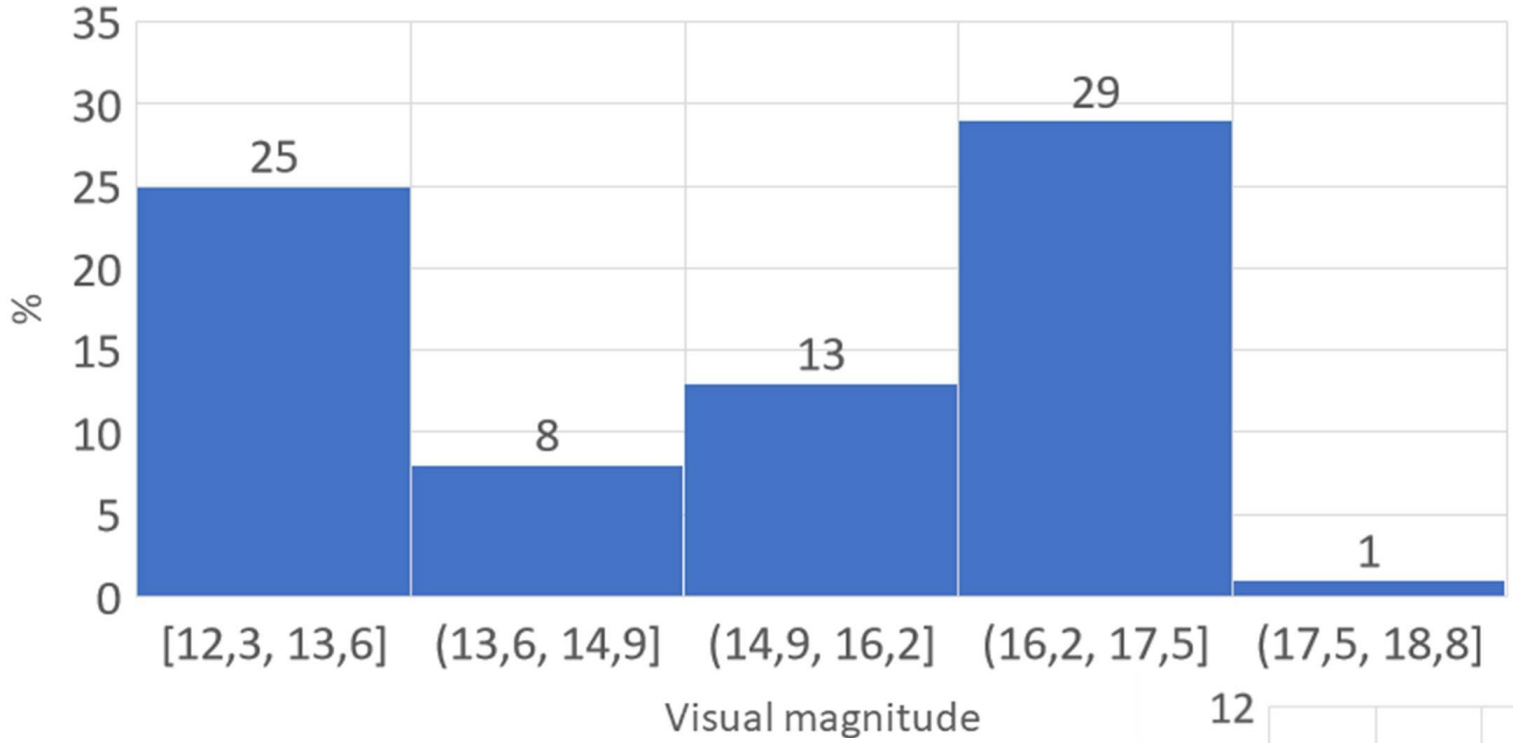
General statistic on measurement (2021-2024 years)





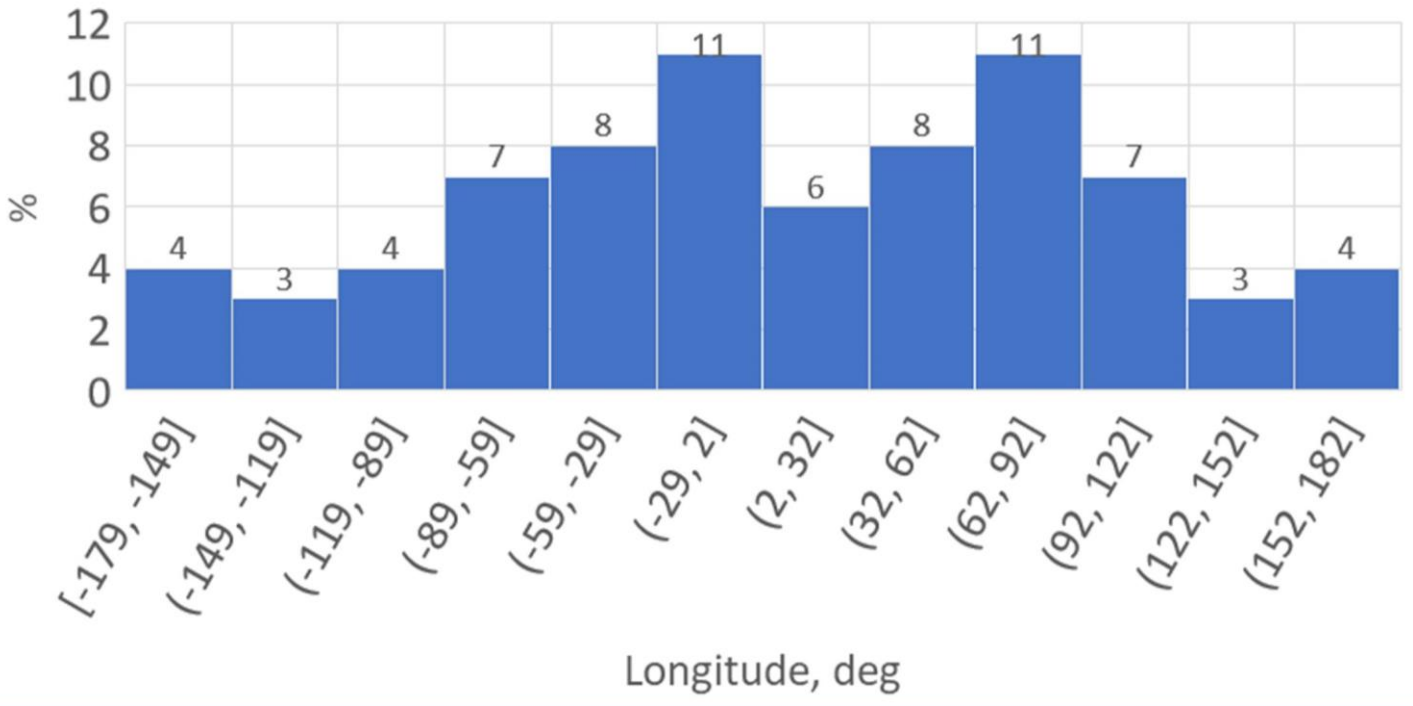






Distribution of 96 mln. measurements by visual magnitude – in %

Distribution of GEO-objects with accurate orbits by longitude – in %



Telescopes in Khureltogoot observatory

2023

Observation time: 692h 18min. (41538 min)

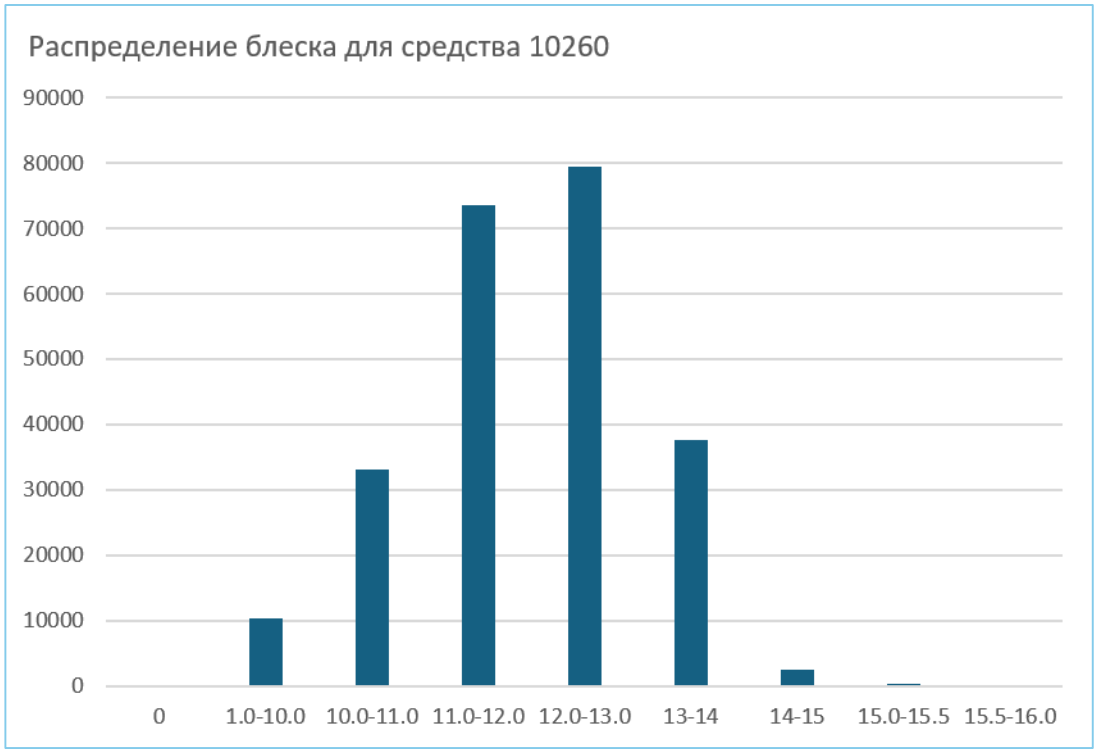
- Tracklets: 38443
- Measurements: 253523
- SAT: 12236

2024

Observation time: 710h 25min. (42625 min)

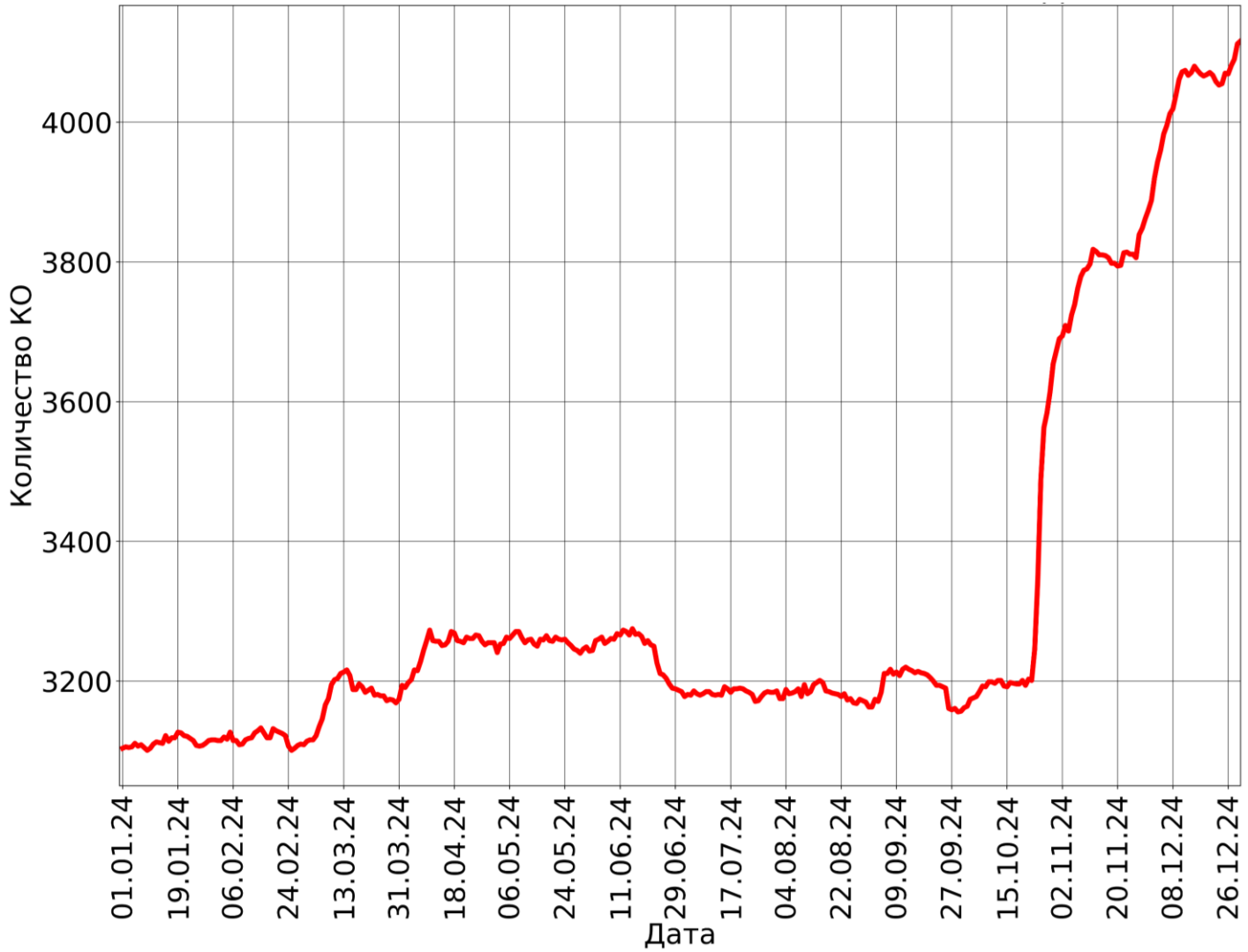
- Tracklets: 39398
- Measurements: 258349
- Excluded: 10261
- SAT: 15553

Статистика распределения блеска измеренных КО:

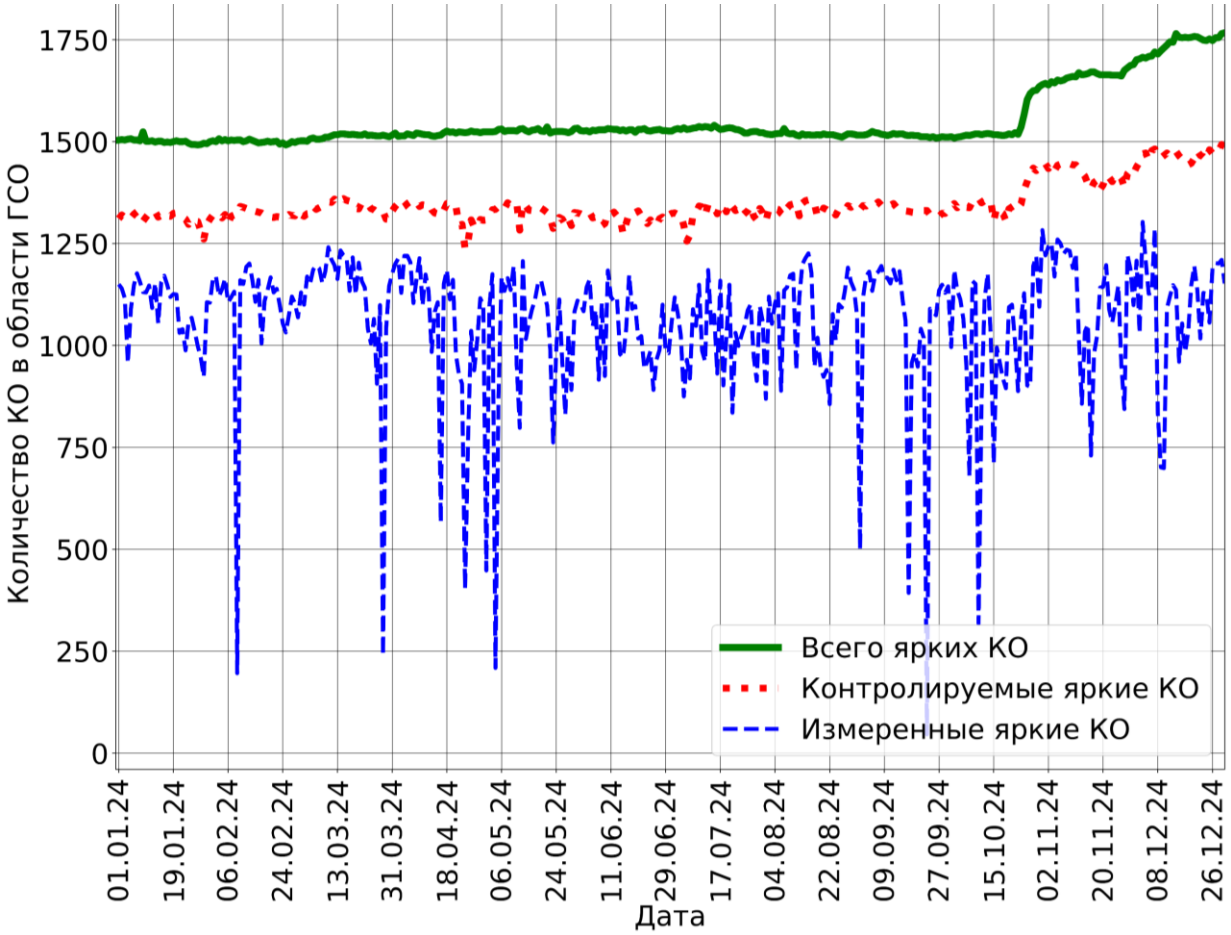


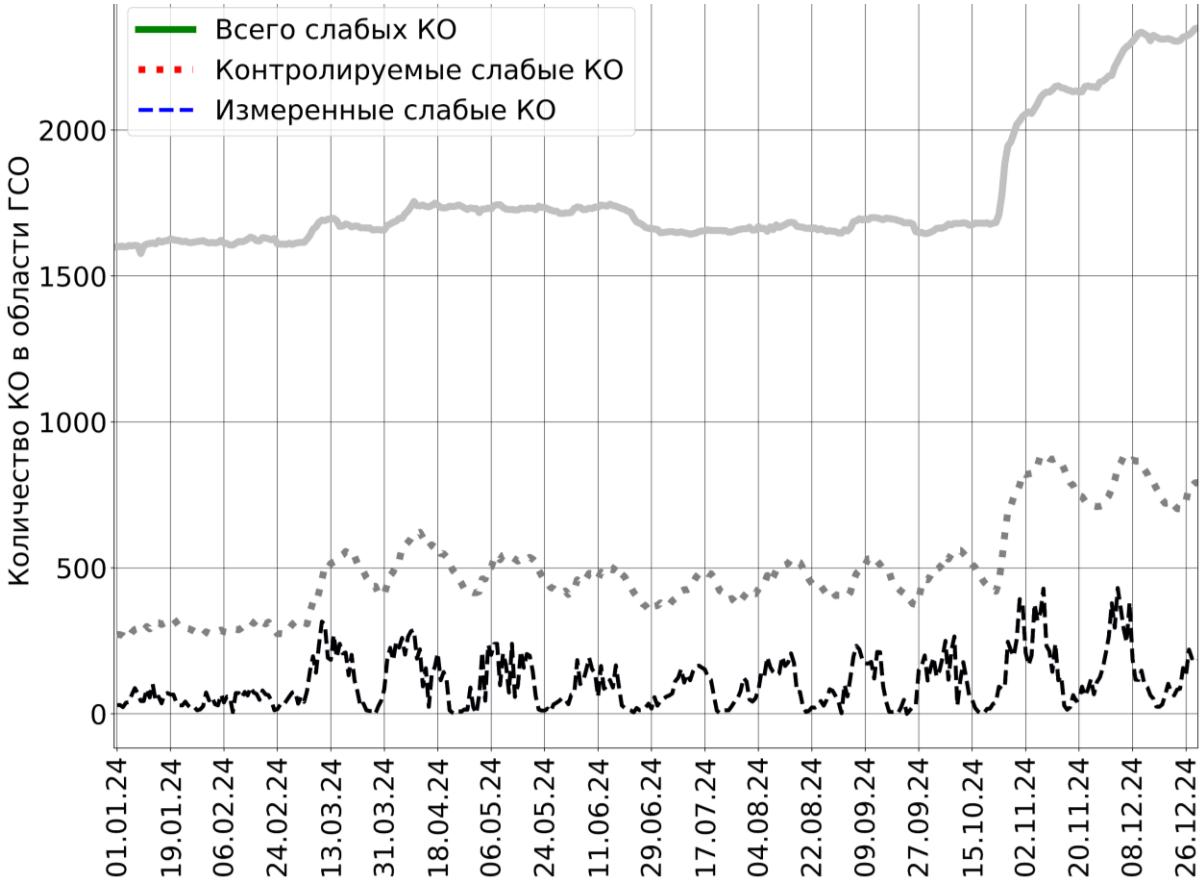
A sharp increase in the number of GEO-objects by 32.6%.

The appearance of 1,012 new objects was primarily associated with the destruction event of the Intelsat-33E satellite *(2016-053B)*, which occurred on October 19, 2024.

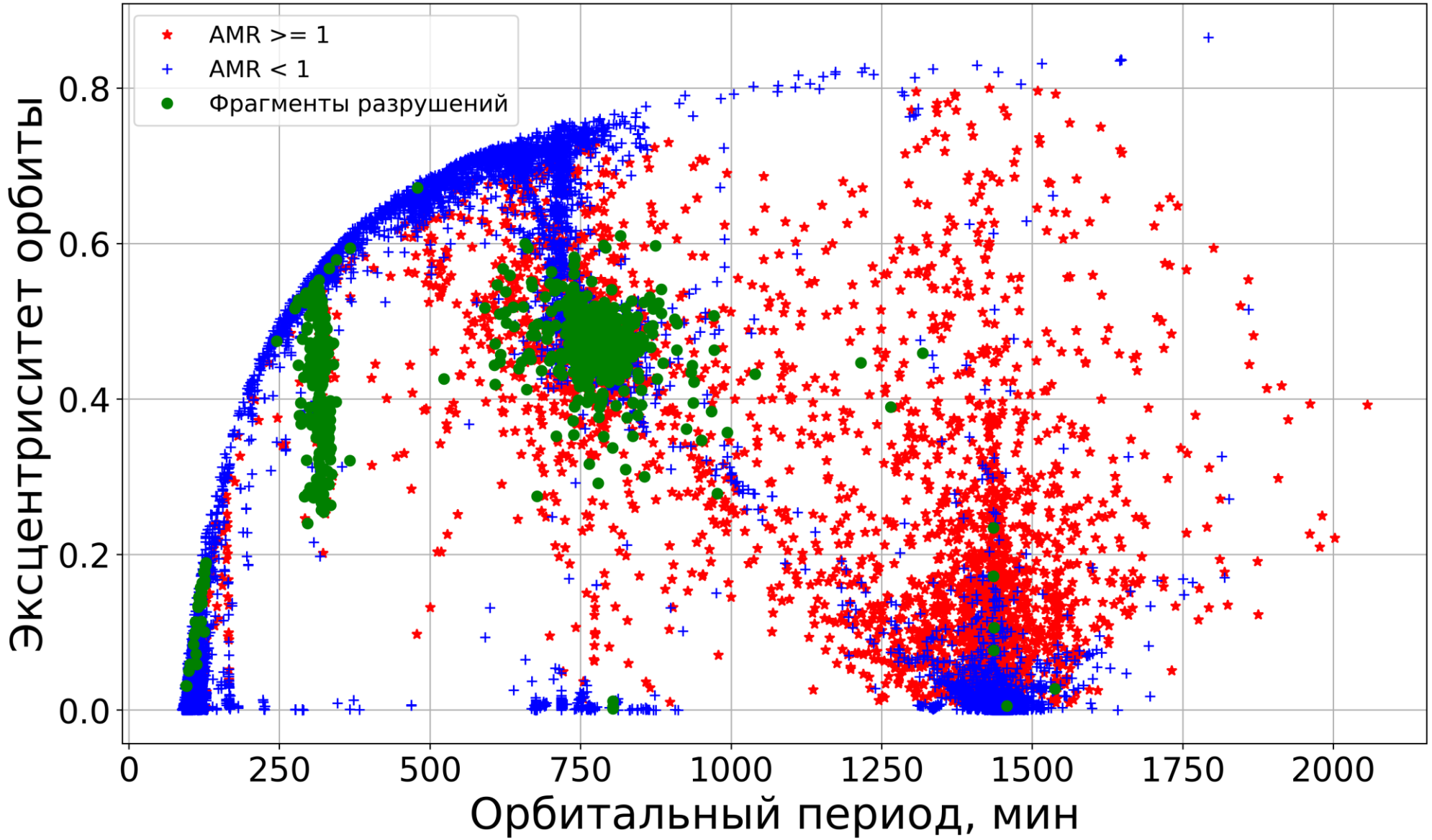


Parameters for tracking bright and faint GEO-objects in the database





Distribution of space objects in the database by orbital parameters



Proposed areas of work

- **Organization of supplementary observations of the Spektr-RG spacecraft during periods of limited visibility from Russian territory.** The spacecraft is located at the L2 libration point, approximately 1.5 million kilometers from Earth.
- **Construction of observational pavilions in Mexico, Morocco, Saudi Arabia, and Jordan.**
- **Enhancement of data exchange with interested international institutions**, currently including collaborations with organizations in China and Switzerland.
- **Establishment of an orbital prediction center** — for a new European client not constrained by current sanction regimes. Negotiations have been ongoing for over a year.
- **Development and manufacturing of a cluster telescope module** — a 29 cm Cassegrain optical system with a 7×7 degree field of view, optimized for a 50×50 mm photosensitive matrix.
- **Initiation of research and development activities focused on low Earth orbit (LEO) objects:** – Chinese partners have proposed access to data from two optical systems with annular fields of view, each comprising 64 telescopes with 30 cm apertures;
- – Deployment of wide-field monitoring systems based on compact optical assemblies with large fields of view.

THANK FOR YOUR ATTENTION!