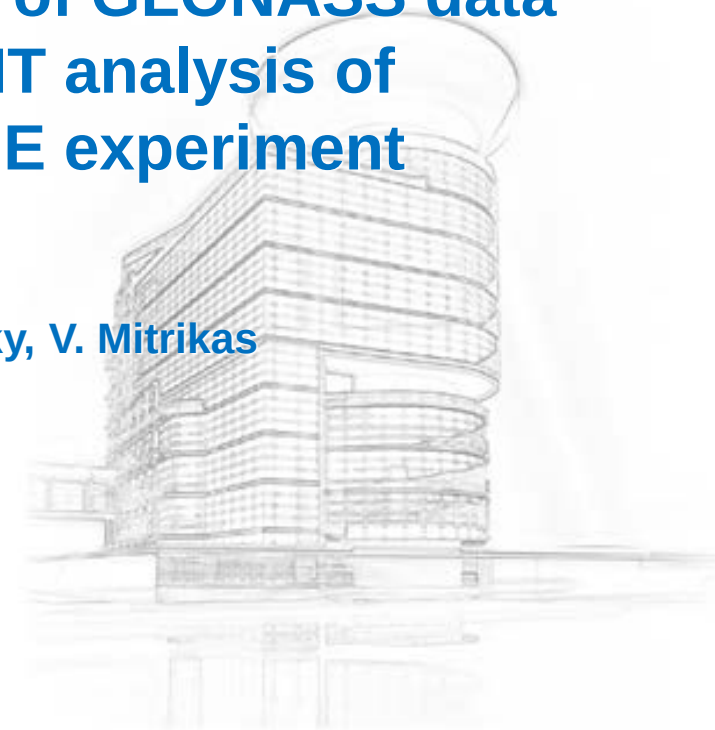
SLR data usage in the verification of GLONASS data processing methods. IAC PNT analysis of GLONASS SLR data in LARGE experiment

V. Glotov, A. Pafnutyev, M. Zynkovsky, V. Mitrikas
(TSNIIMASH)



РОСКОСМОС

ЦНИИМАШ TSNIIMASH

ИАЦ

ILRS Technical Symposium
Matera, 2015

Content

- LARGE experiment, means and goals
- Historical background : IGEX-98 experiment
- LARGE experiment, IAC PNT analysis results
- Possible further research directions

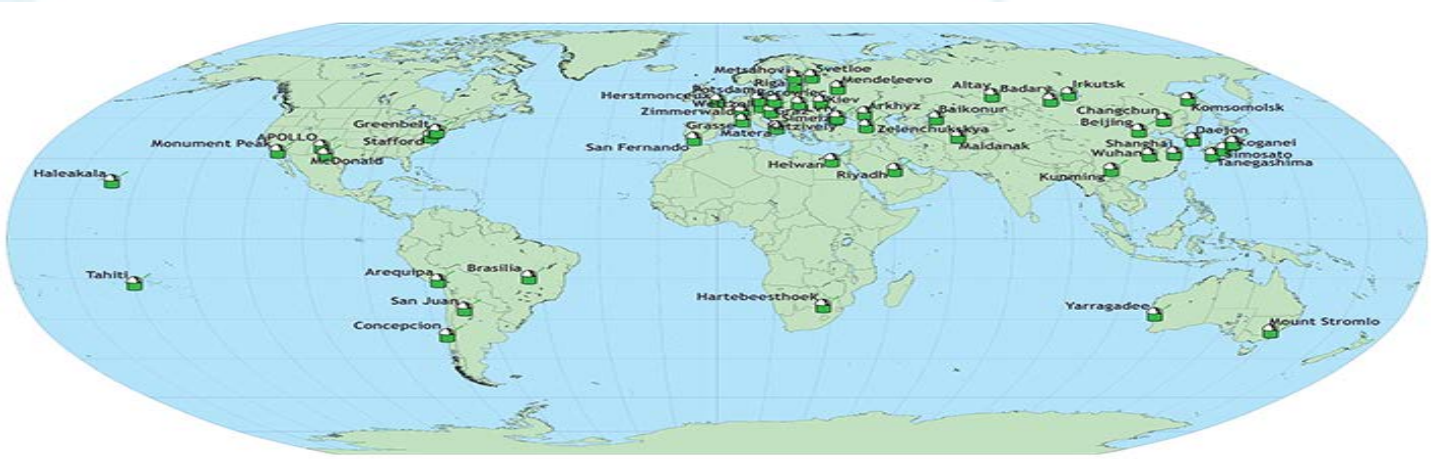
LARGE experiment goals

LARGE (Laser Ranging to GNSS) – experiment on extended laser ranging of GNSS SC. Proposed at the 18th International Workshop in November 2013 Fujieda, Japan.

Main goals of the LARGE experiment:

- **Define the measurement strategy of the ILRS stations for the effective analysis of the GNSS orbits**
- **Analysis of the SLR data to improve the accuracy of the GNSS POD and GNSS systems calibration**

ILRS network stations



Historical background: IGEX-98 experiment

The International GLONASS Experiment (IGEX-98) was conducted from 19 October 1998 to 19 April 1999.

IGEX-98 main goals:

- **Installation of a GLONASS global receiver tracking network**
- **Clarify the GLONASS orbit modeling (influence of the solar radiation, orientation, etc.)**
- **Usage SLR data to estimate the accuracy of GLONASS orbit determination**
- **Define the transition between the operating GLONASS coordinate system PZ-90 and ITRF or WGS-84 (GPS coordinate systems)**
- **Determination of GLONASS orbits with an accuracy of one meter or better in well-defined earth coordinate system (e.g., ITRF)**

Summary result:

GLONASS ephemerides computed with an error of 20-40 cm (1 sigma) including to the results of processing 6500 passes of SLR data for 9 GLONASS SCs (result is based on the solution of the main IGEX-98 goals)

Basic position

Analysis:

- Residuals SLR data concerning “final” orbits of IAC PNT for GLONASS SCs

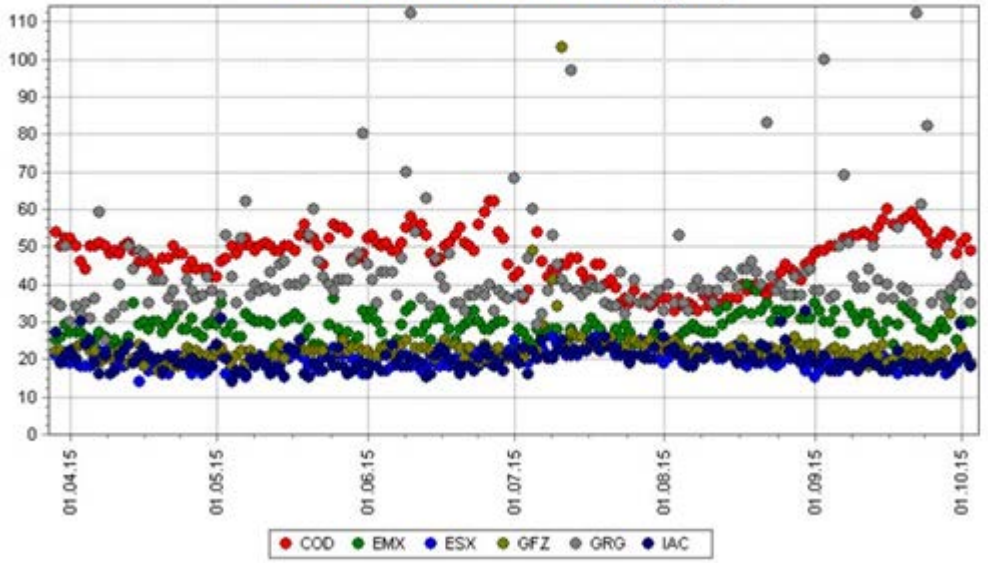
Residuals are functions of:

- Orbits accuracy (depend on SC)
- SLR data accuracy (depend on station)
- Retroreflectors errors (“target error”)
- Correctness of antenna phase center and retroreflector corrections to the SC center of mass
- SLR stations coordinates (ITRF)

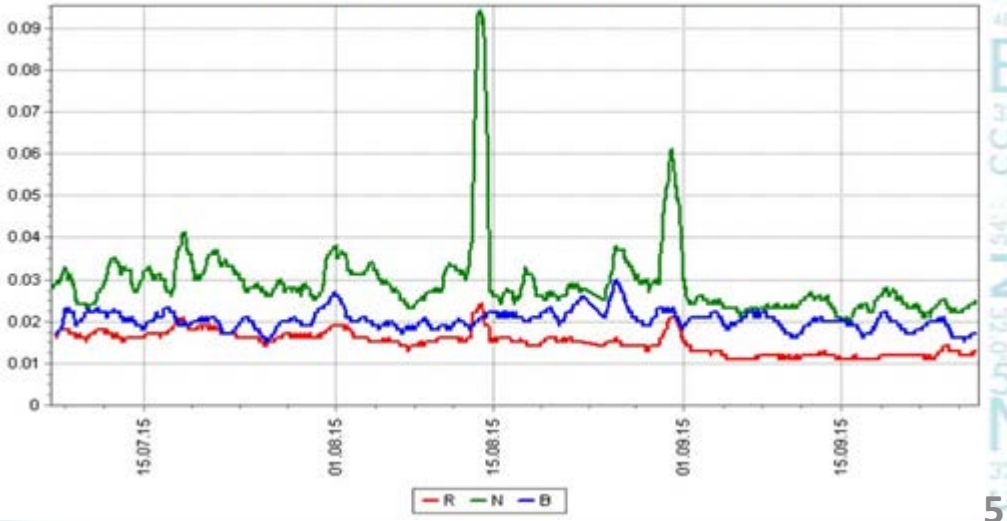
Estimated values:

- Each SC orbits accuracy :
  - average over a time interval
  - on a specific time interval (shadow crossing)
- An accuracy of different models and data processing methods

Evaluation of GLONASS ephemerides accuracy by the IGS.
RMS consistent to the final data, [mm]

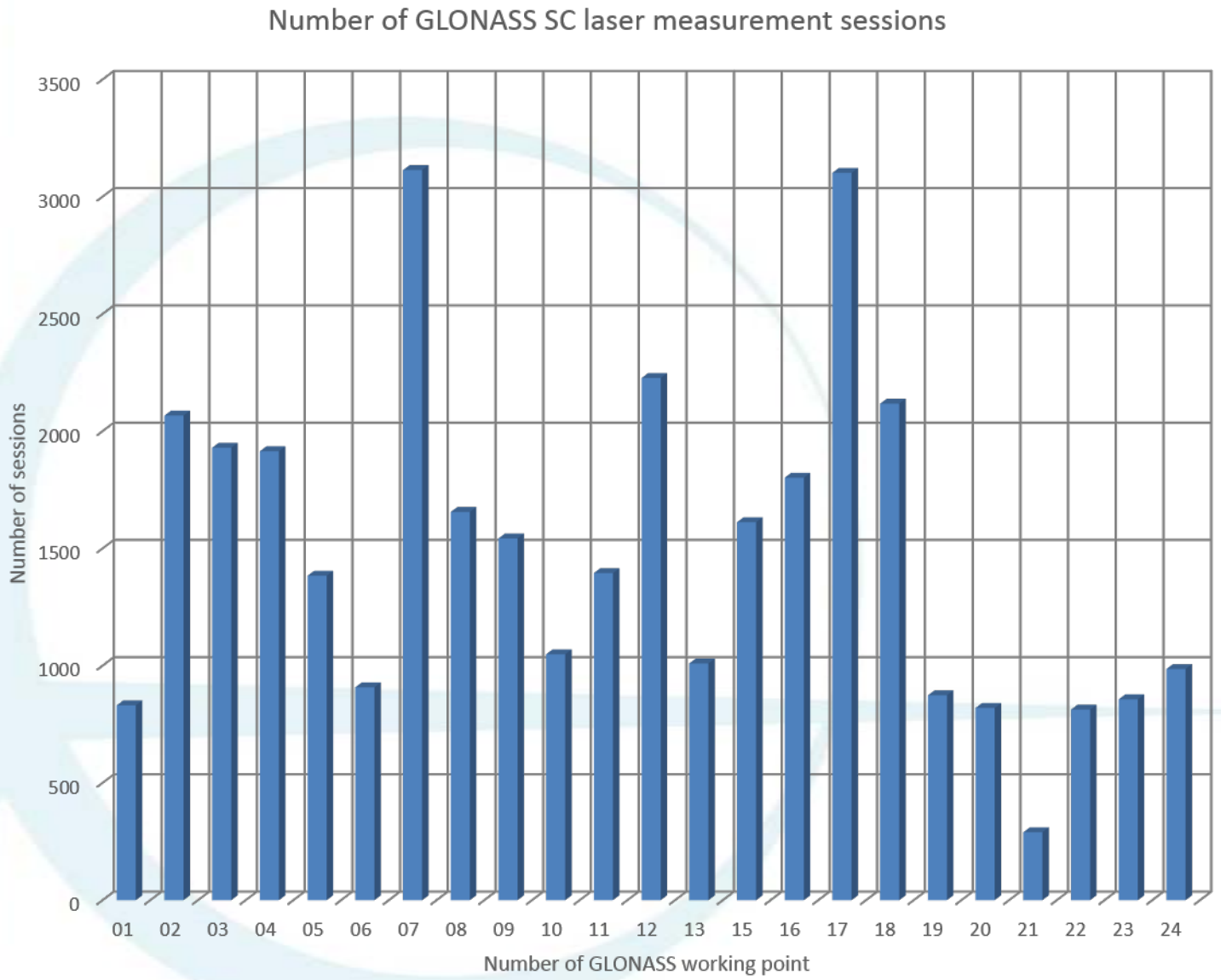


Daily RMS of the GLONASS SC ephemerides, [m]



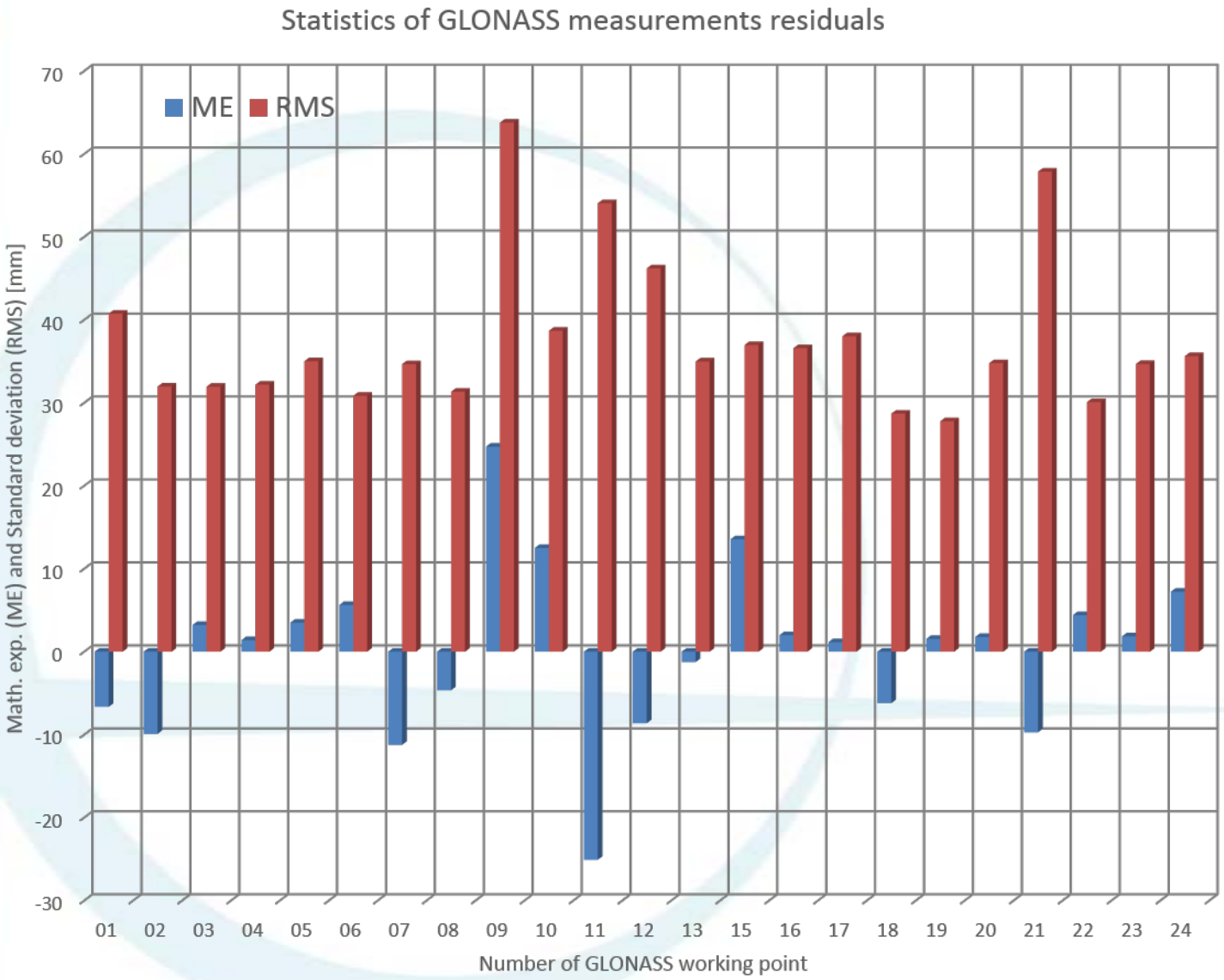
5

LARGE experiment (Results - 1)

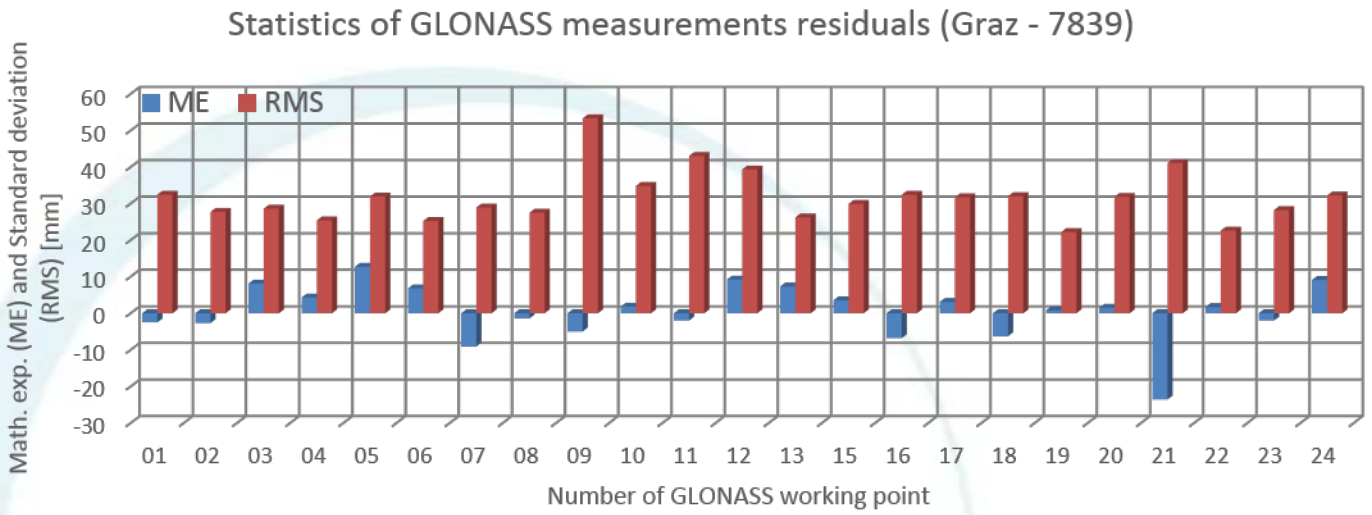


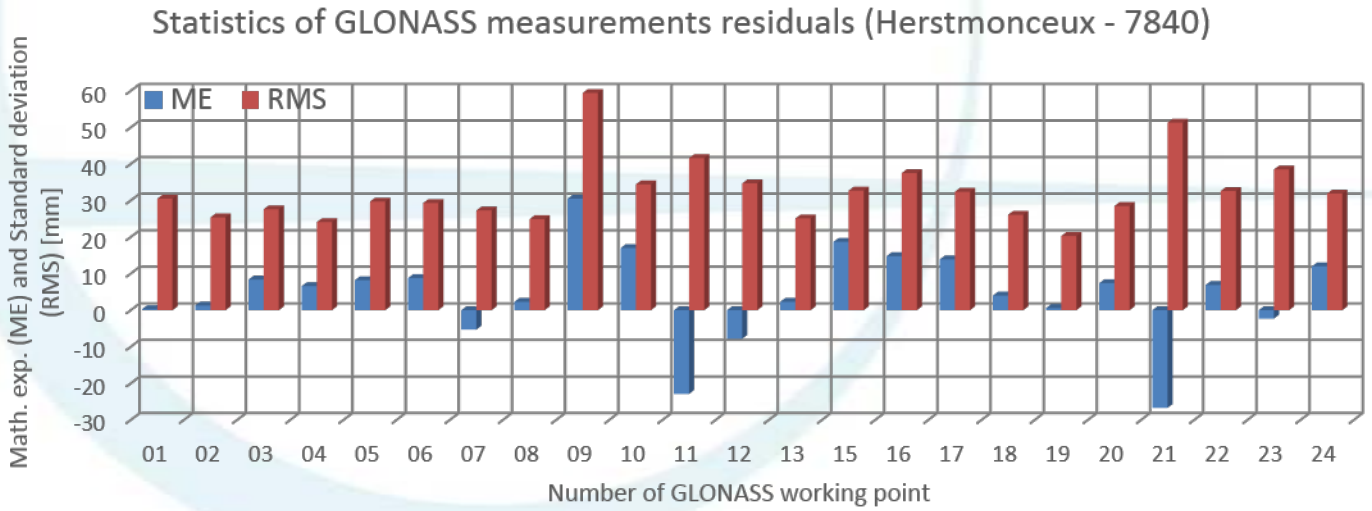
* Near 35000 sessions overall

LARGE experiment (Results - 2)

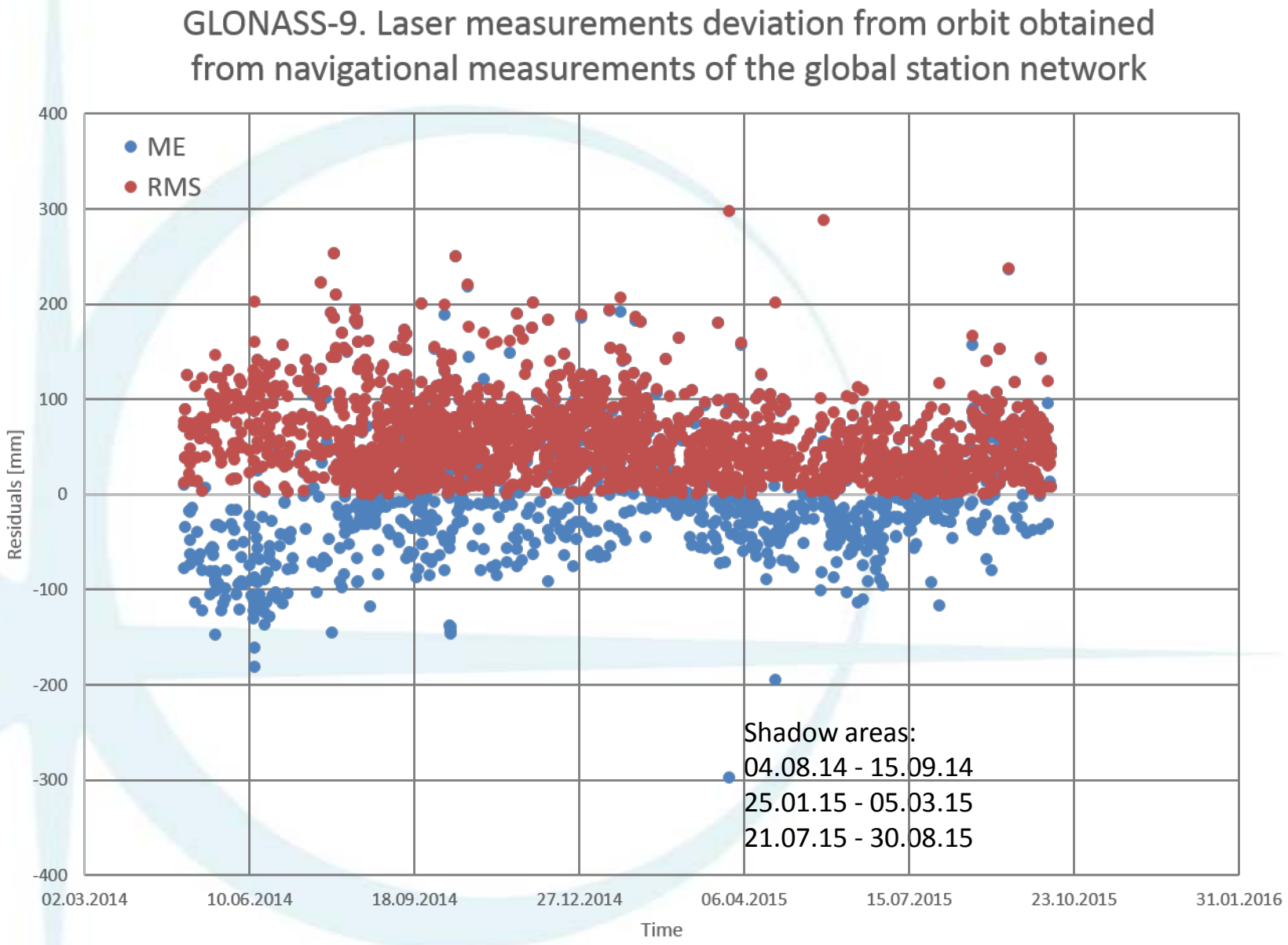


LARGE experiment (Results - 3)

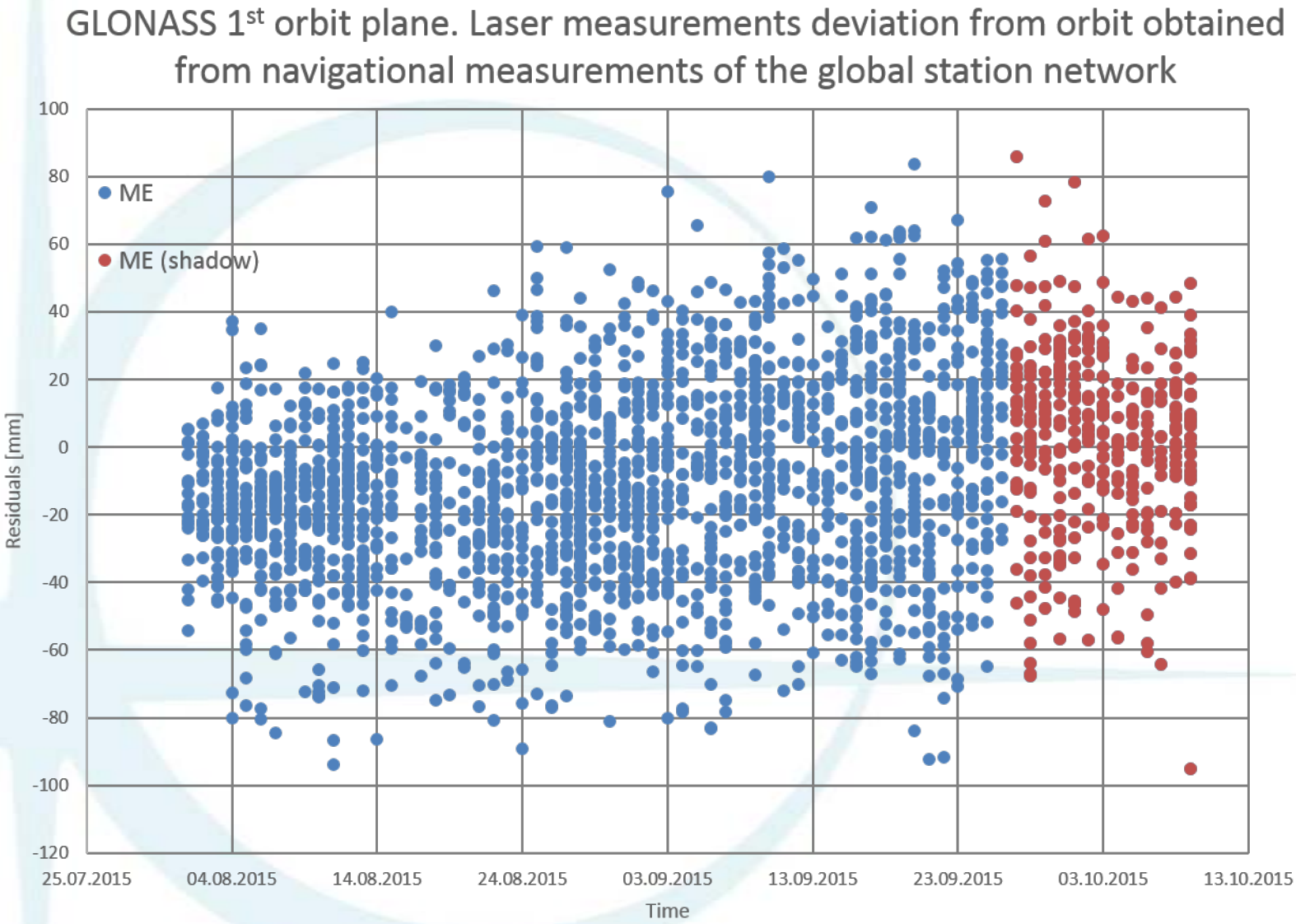




LARGE experiment (Results - 4)



LARGE experiment (Results - 5)



LARGE experiment (Results - 6)

Results:

- For 2014-2015 ILRS stations made about 40,000 sessions of laser measurements for all GLONASS SCs (unique material to improve models and their validation in future)
- Number of daytime measurements is 6-10 time less than of nighttime
- All sessions processed in IAC PNT on the one software package in ITRF2008 (software collocation)
- No significant difference in the accuracy of GLONASS SC orbit determination in shadow and shadow-free areas
- Deviations for new SCs on average are smaller, which may be due to the use of more accurate retroreflector panels

LARGE experiment (Results - 7)

Results:

- The coherence of SLR data and the final GLONASS SC orbits, calculated in IAC PNT by the receiver data of the IGS network, in average is 25-35 mm
- Orbit determination error for SCs in the second plane (especially in operating points 9, 11 and 12) 1.5 - 2 times higher than in the overall group, which may be explained by different orientation of this plane relative to the Ecliptic
- Some SC got significantly different results of its evaluation on different stations
- Research needs to be continued in a detailed mode for every SC

Possible directions for further research

Main goal: **Methodological and metrological support for GNSS ephemeris calculating based on receivers by verification and comparative analysis of different models and processing algorithms on the base of SLR data**

Ways to results:

- **Precise clarification of the retroreflector panel correction to the SC mass center, agreed with displacement of the antenna phase center and calibration corrections (collocation in space)**
- **Detailed analysis of the dependence of the data processing results from retroreflectors type, the type of station, the orbital plane with the specific recommendations on data processing for each individual GLONASS SC**
- **Check "physical reality level" of the daily corrections results of the receivers stations coordinates by substituting these results into the model of collocated SLR stations coordinate calculations**
- **Estimate the dependence of results on the coordinate systems (ITRF 2008 and ITRF 2014) for different SLR stations by comparing data obtained on similar SLR data (total, on separate satellites, etc.)**

THANK YOU
FOR YOUR ATTENTION!