State Scientific Center
of the Russian
Federation

VNIIFTRI

National Research Institute for
Physical-Technical and Radio Engineering Measurements

National time scale UTC(SU) development and GNSS-receivers calibration in Russian Federation

S. Donchenko, I. Silvestrov, O. Denisenko, I. Norets

ICG-12, 2-7 December 2017

National time scale UTC(SU) development in 2016-2017

Legal basis for calculation and transferring of the National Time Scale UTC(SU)

Federal Law "On the calculation of time» № 107-FZ of 04.03.2011

National Time Scale of the Russian Federation - an ordered sequence of numbers of units of time, reproducible and stored by the State Service of Time, Frequency and Earth's Orientation Parameters on the basis of the State primary standard of time, frequency, and the National Time Scale.

Interface control document GLONASS ICD 05.01, March 2008

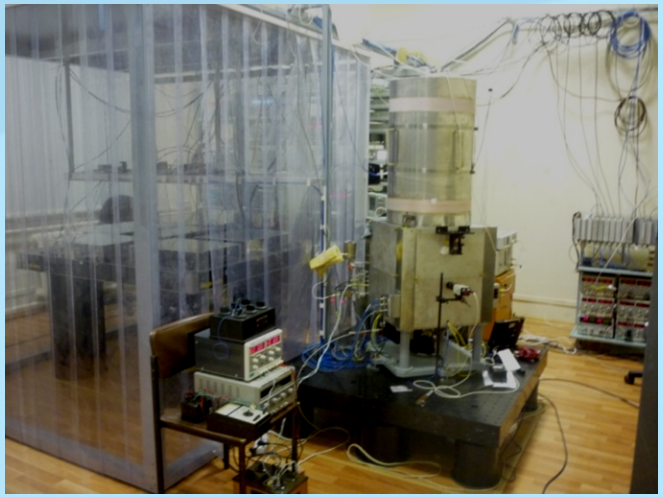
Reference time scale for the GLONASS system is a national coordinated time scale UTC(SU).

Government Decree № 323 of 30.04.2008

Federal Agency for Technical Regulation and Metrology carries out support for GLONASS reference values of time and frequency, the National Time Scale and the Earth's Orientation Parameters data.

Progress at the State Time and Frequency Standard of Russia

TA(SU) calculated on the basis of the frequency difference measurements of Cs Fountain vs H-Masers



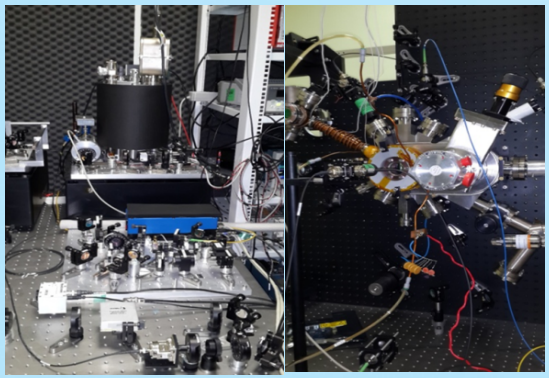
2 - CsFO2 included in calculations
TAI uB < 5 E-16

4 - Frequency standards based on the rubidium fountain σy (τ) < 2 E-16

UTC(SU) calculated on the basis of TA(SU) and steering for providing UTC - UTC(SU) ≤ 7 ns

Used for keeping TA(SU) H-Masers:

8 - Ч1-75А	σy (1 day) < 5 E-16
4 - ЯКУР.411141.030	σy (1 s) < 7 E-14
4 - ЯКУР.411141.037	σy (1 day) < 3 E-16



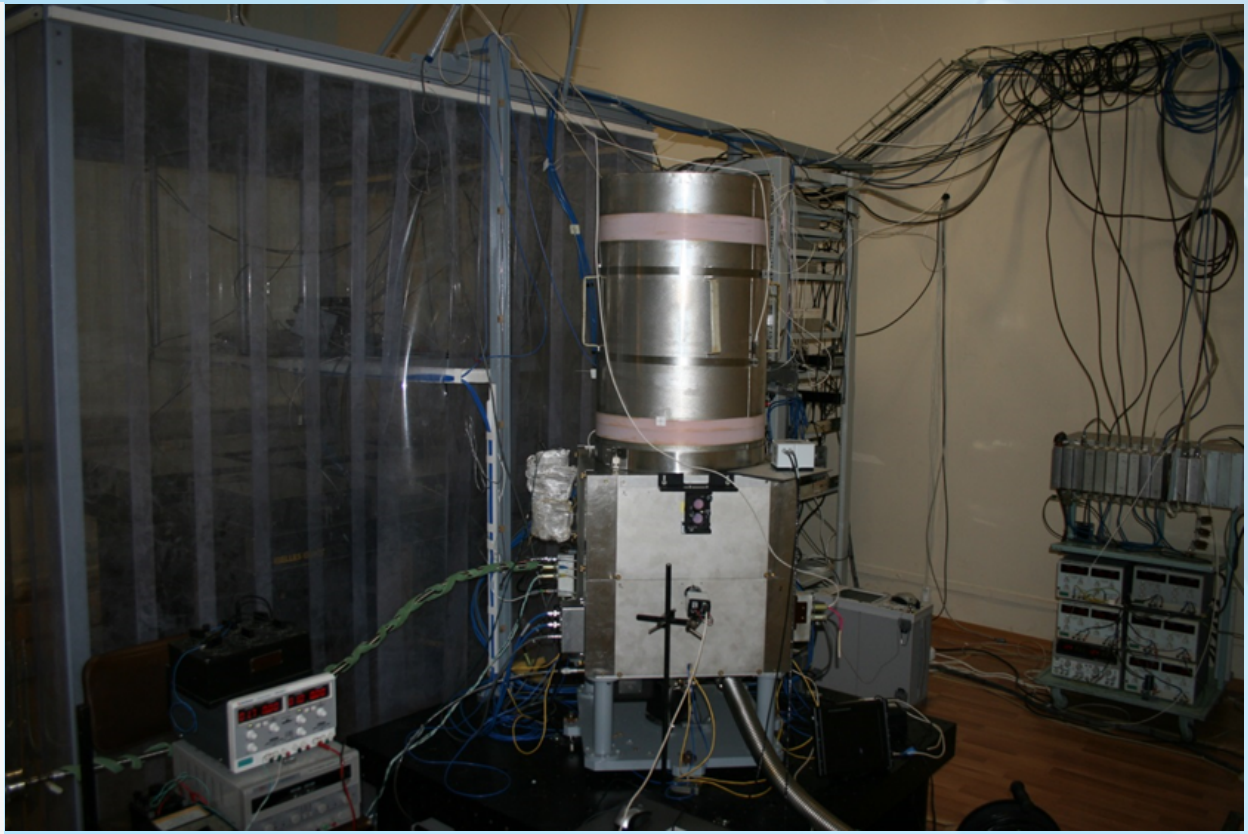
2 - Optical frequency standards on 87 Sr

1 pps UTC(SU) generated in real-time

uB < 0.5 ns

TWSTFT equipment

GNSS receivers



Cesium frequency standards

$\Theta \leq 5$ E-16

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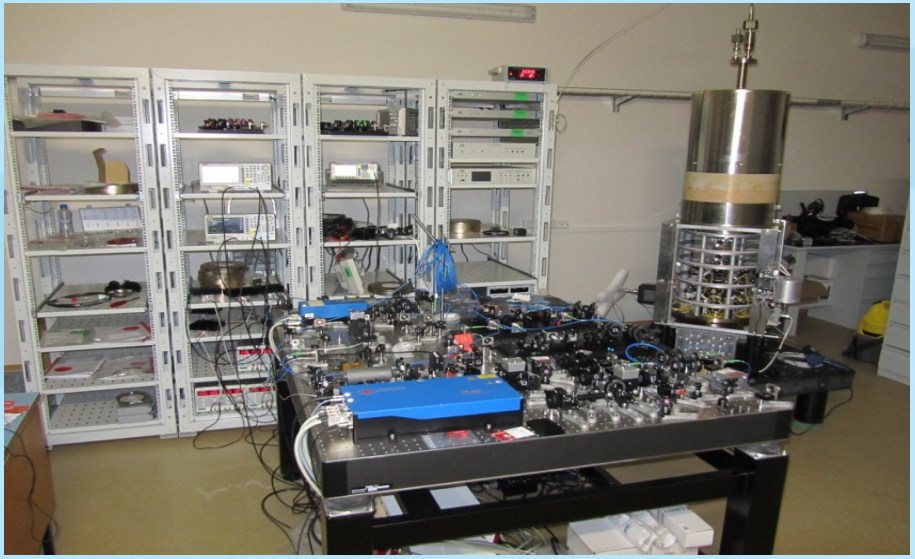

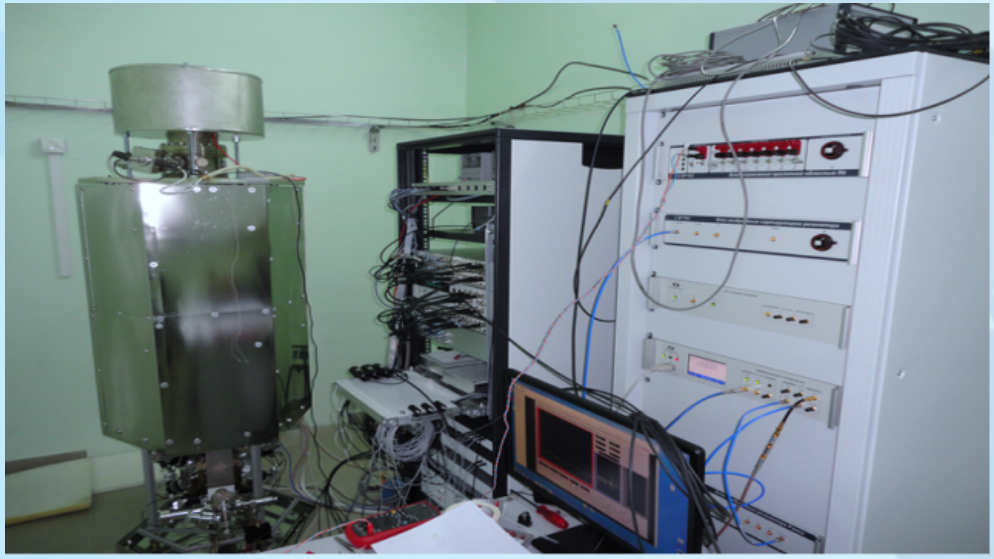

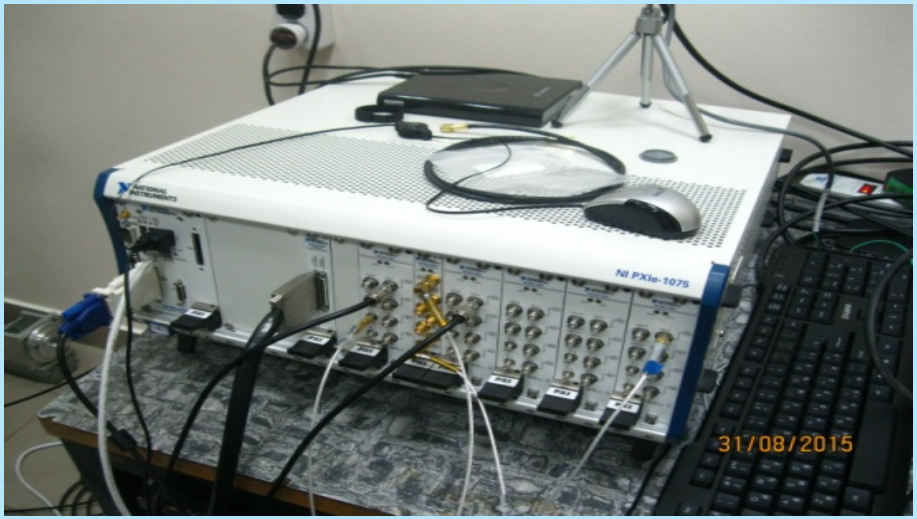

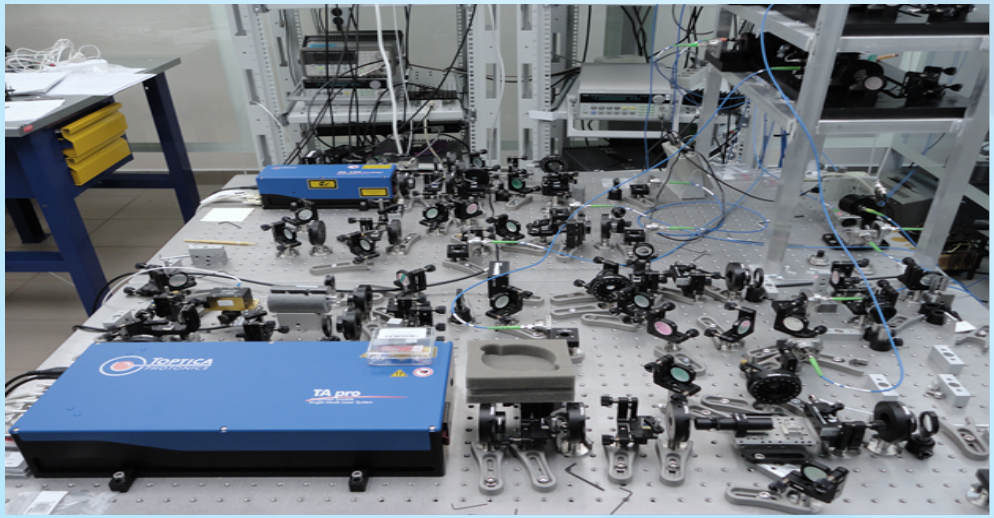

Frequency standards based on the rubidium fountain

$\sigma y(\tau) < 2 \text{ E-}16$

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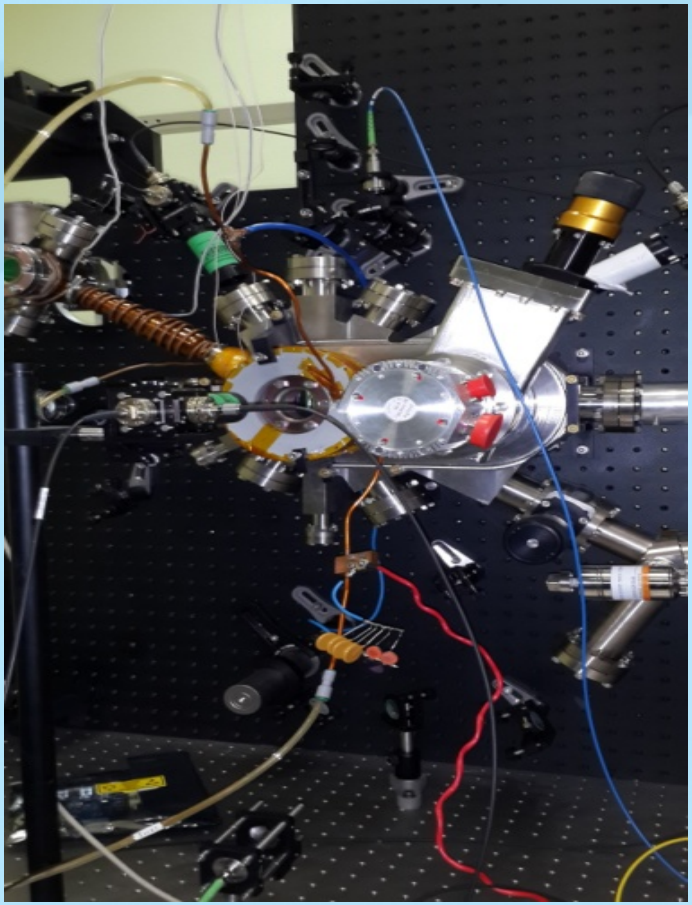
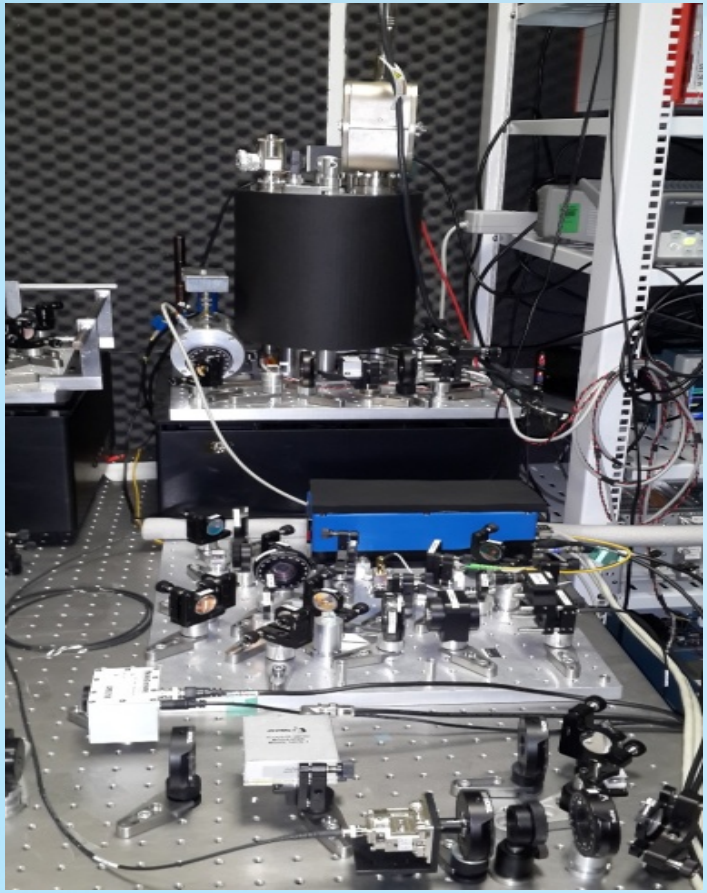
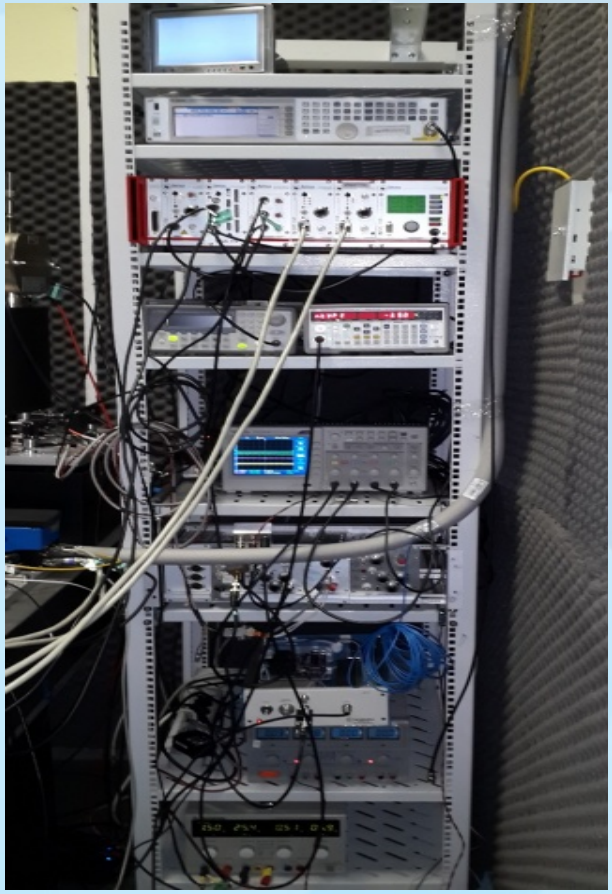

Optical frequency standards on 87 Sr

$\Theta \leq 1$ E-16

Reference complex of time and frequency

Reference complex of time and frequency

H-Masers

The device of frequency comparison of signals

Comparison of time scales

Real Time Scale System

GNSS Time Transfer System

4 New Active Hydrogen Masers $\sigma_y(\tau) < 3\text{x}10^{-16}$ / day
Two 8 Channels Phase Comparator $u_A < 1\times10^{-17}$ / day

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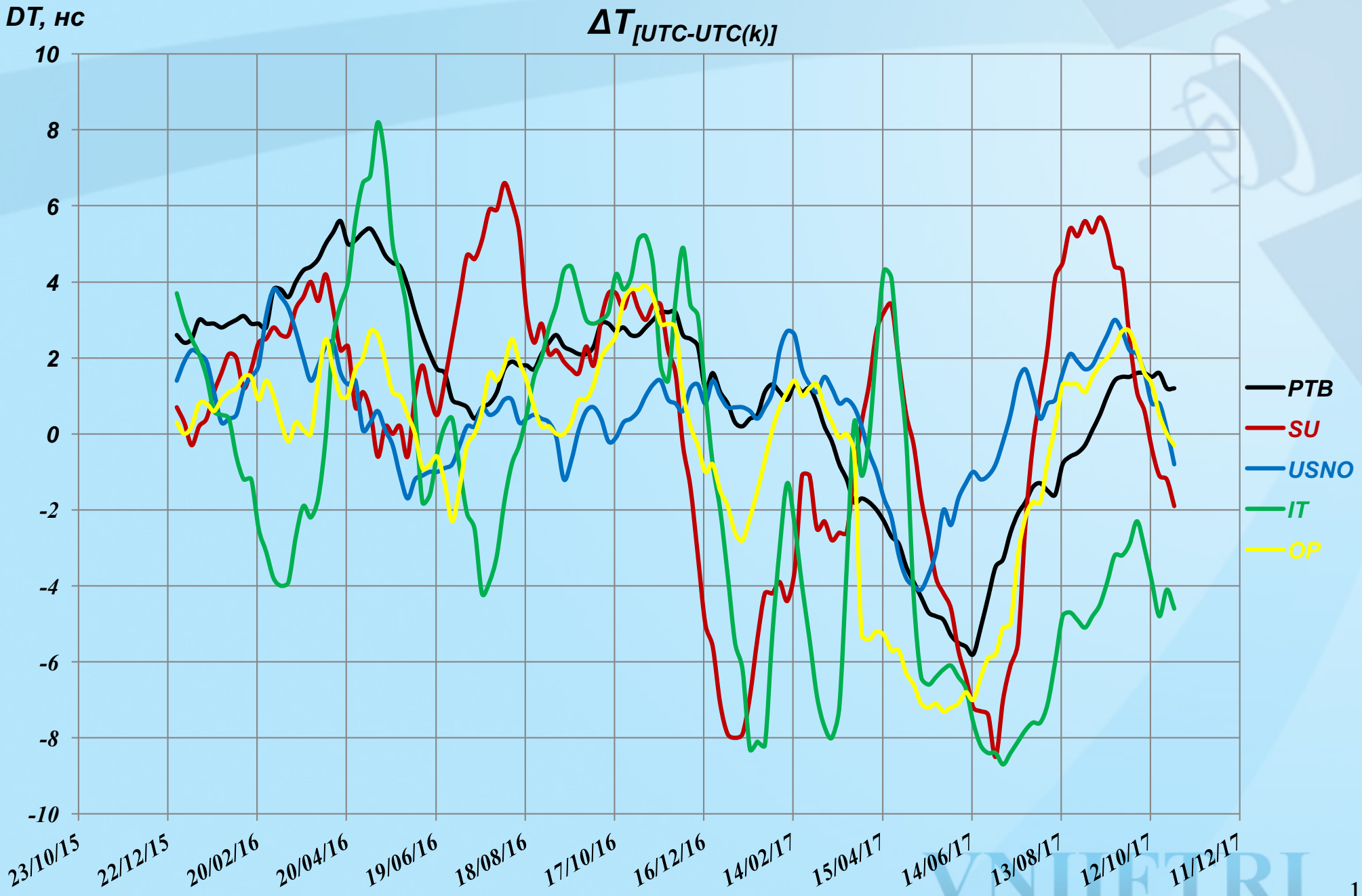
DT, нс
ΔT[UTC-UTC(k)]
10
8
6
4
2
0
-2
-4
-6
-8
-10
23/10/15
22/12/15
20/02/16
20/04/16
19/06/16
18/08/16
17/10/16
16/12/16
14/02/17
15/04/17
14/06/17
13/08/17
12/10/17
11/12/17
PTB
SU
USNO
IT
OP

Development of GNSS-receivers calibration systems in 2016-2017

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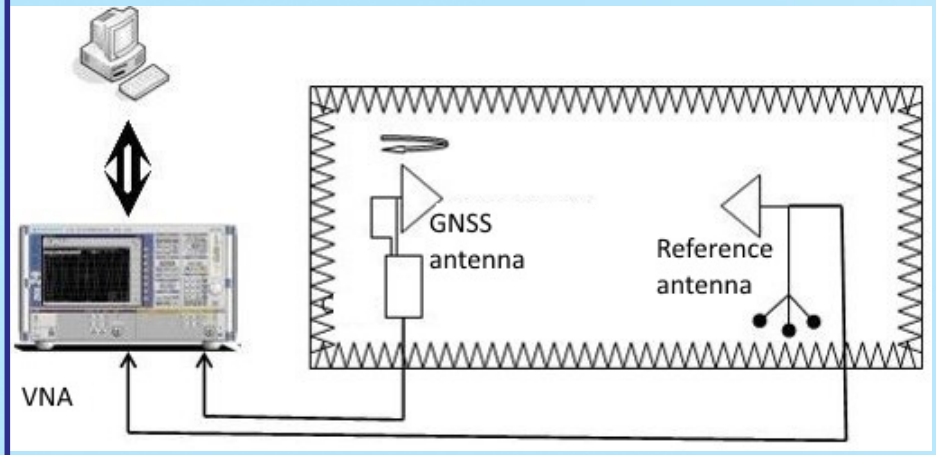
Receiver Calibration

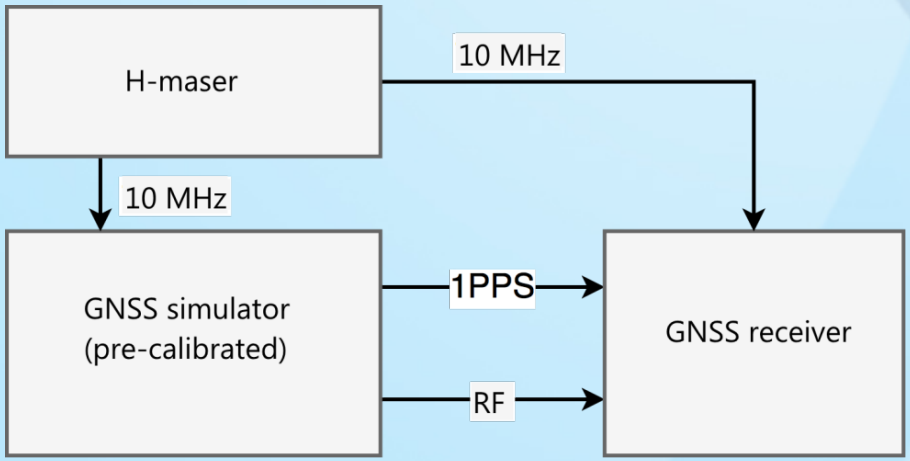
GNSS receiver calibration

Measuring of time group delay:
- antenna
- receiver

GNSS antenna calibration

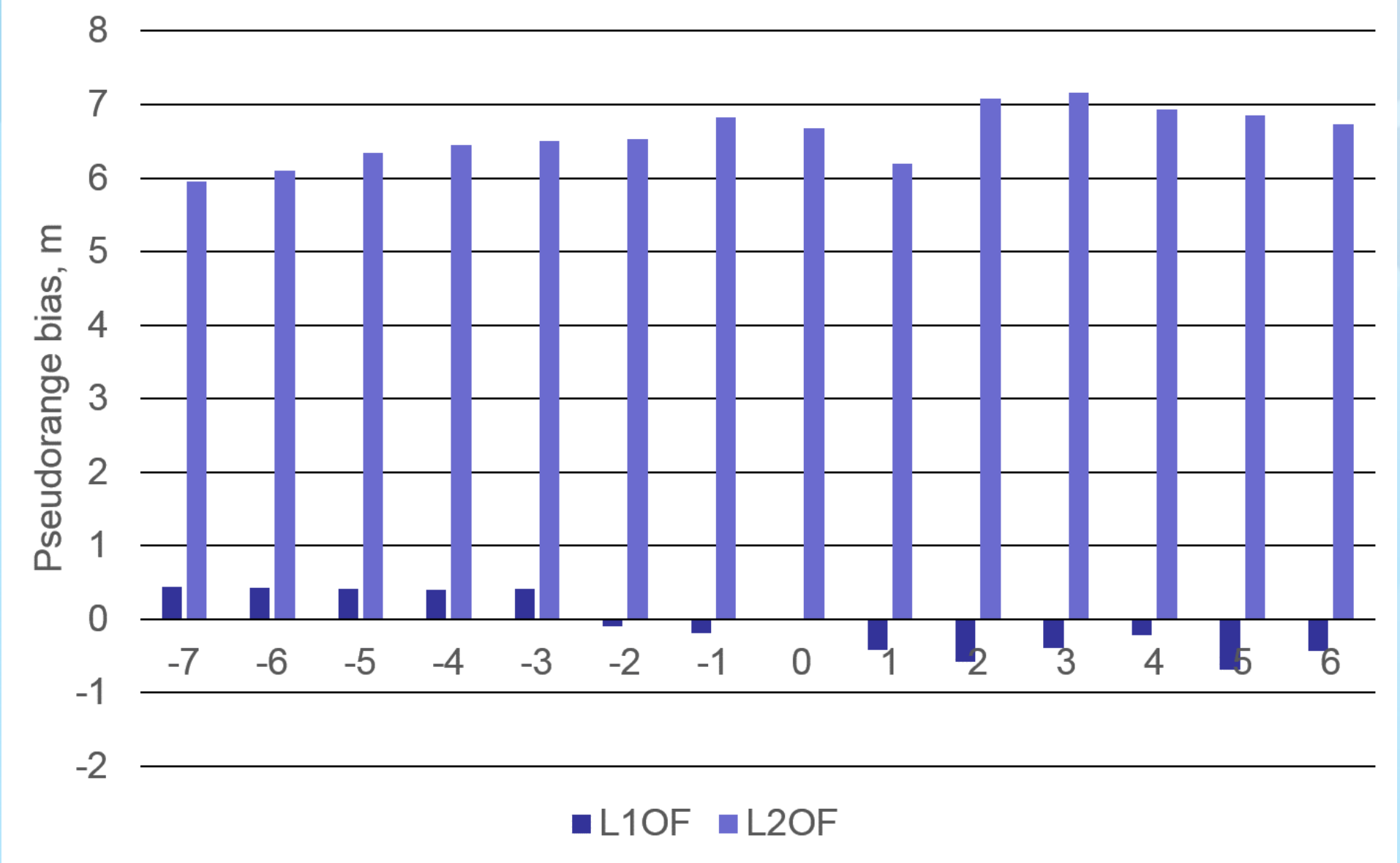


GNSS receiver calibration



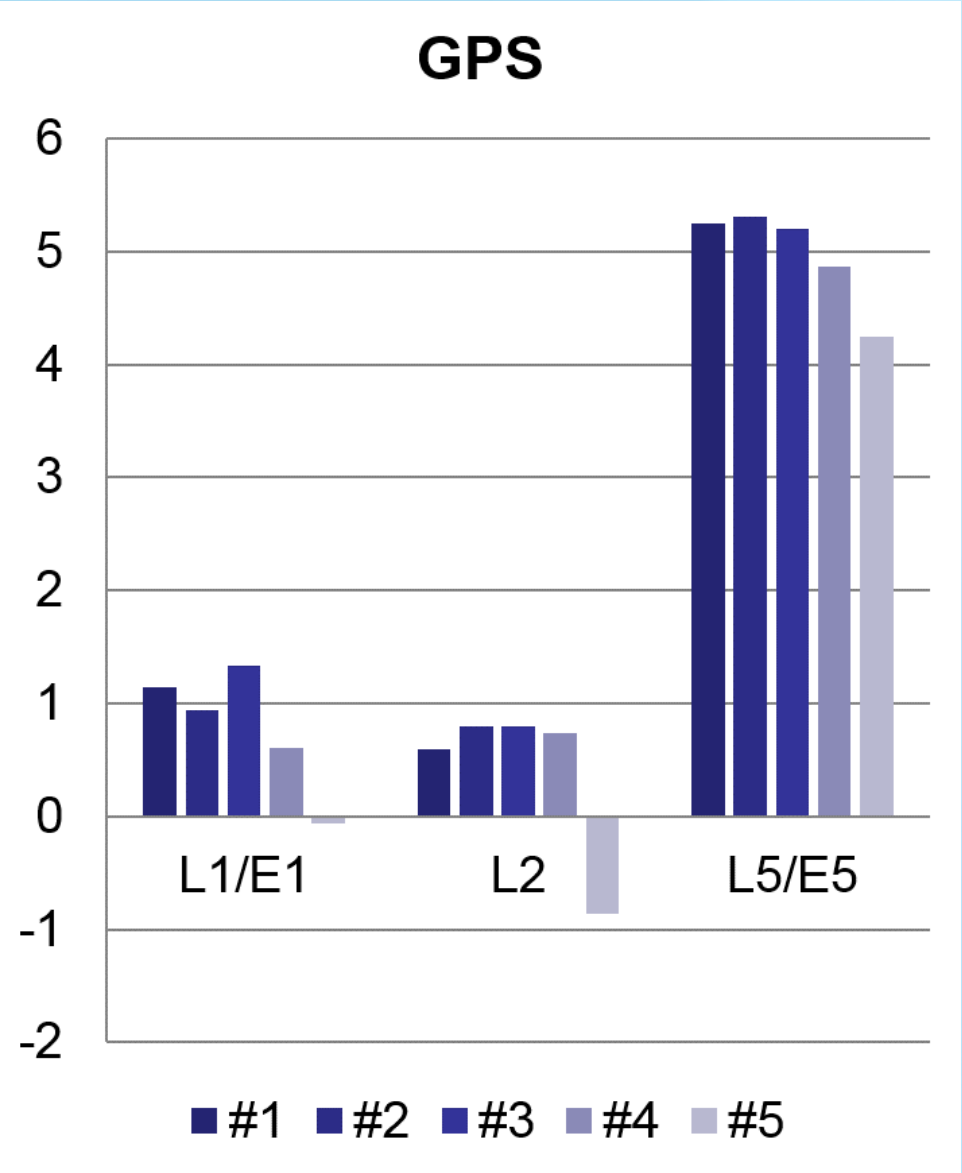
Calibration results

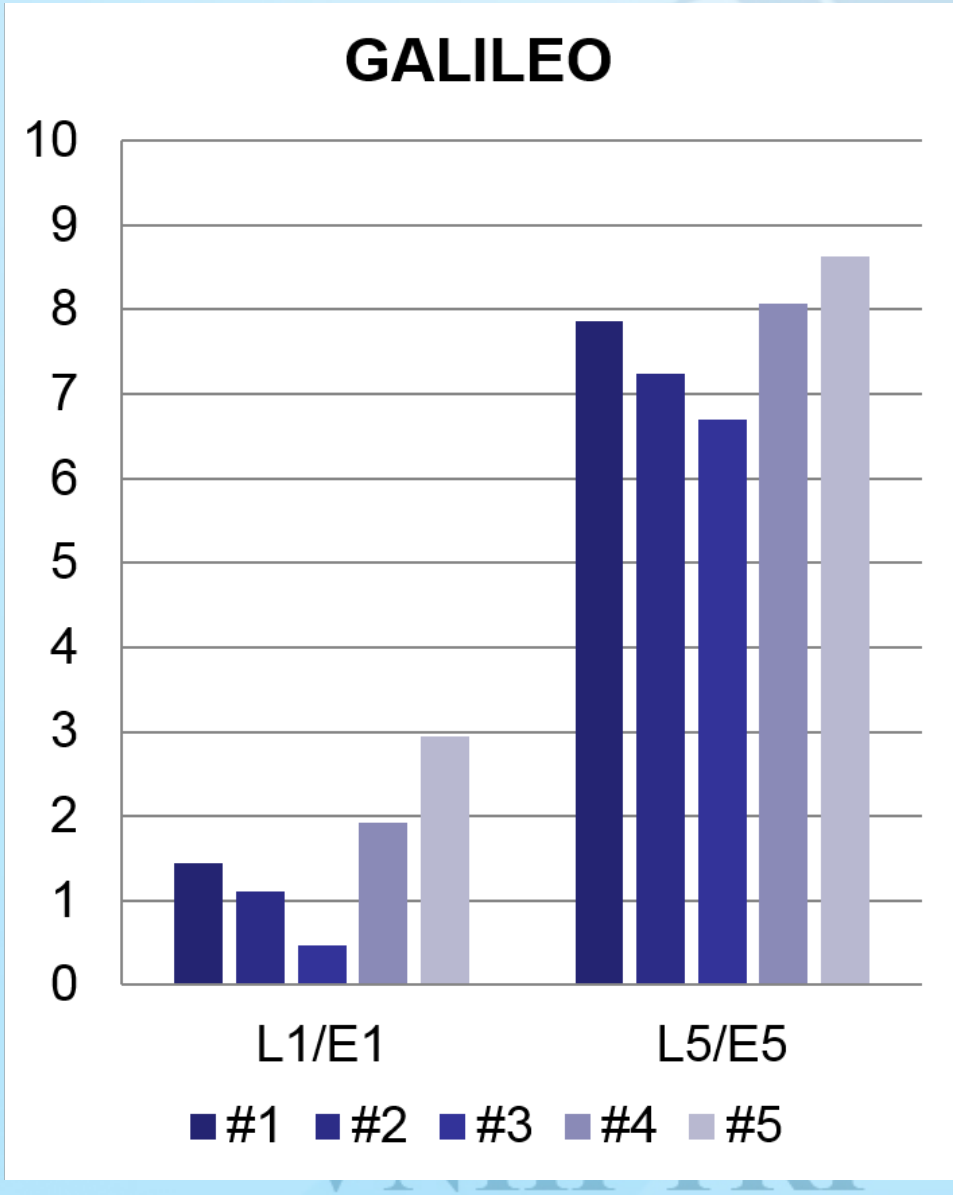
- GLONASS



Calibration results

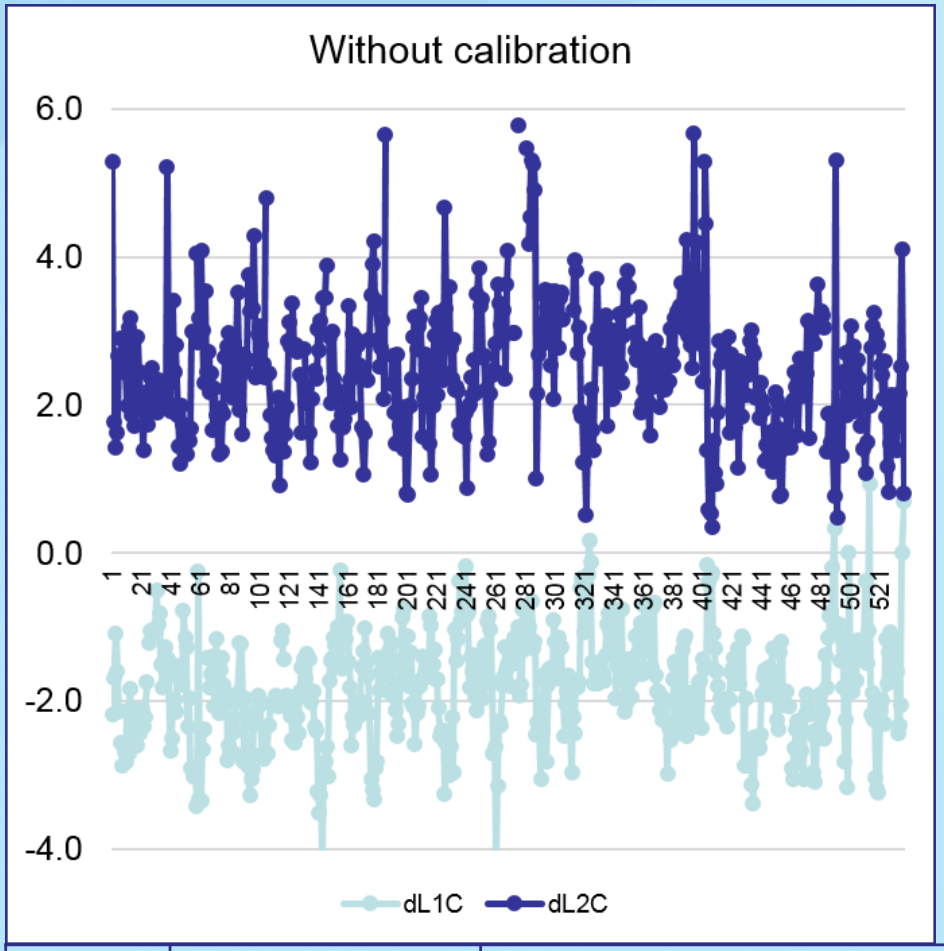
- GPS & GALILEO

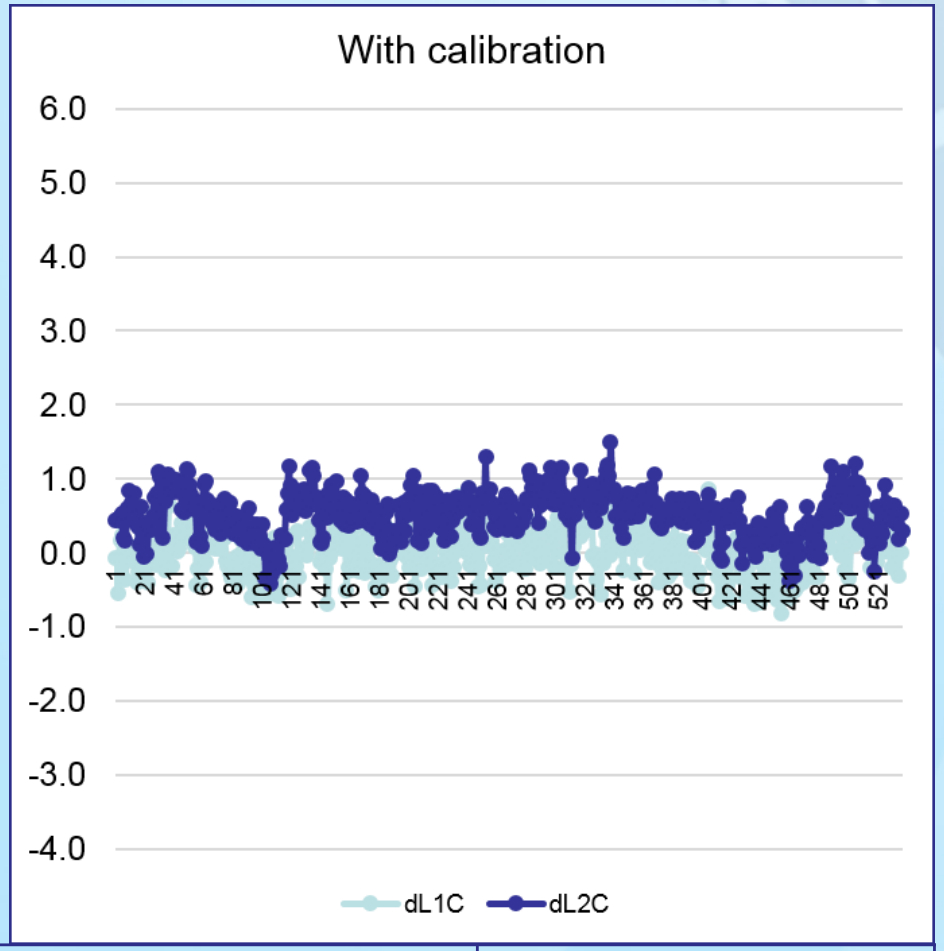




GLONASS calibration results

- Timescale





	Θ, ns	RMS, ns	Θ, ns	RMS, ns
L1C	-1,8	0,7	0,1	0,3
L2C	2,5	0,8	0,4	0,3

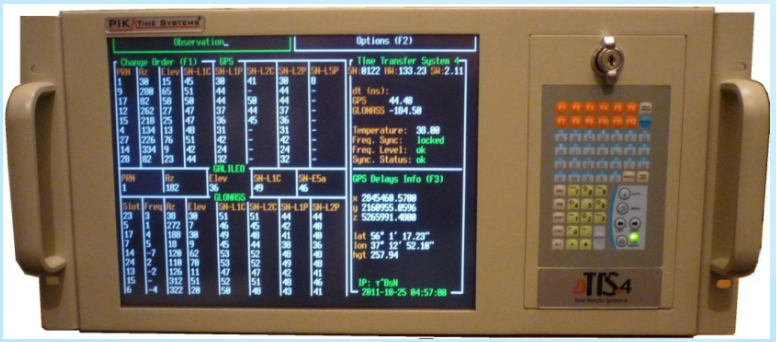
The Agreement on absolute calibration receiver TTS-4 BIPM

Agreement on calibration
M- 9/14
« 28 **»** 07 **2014**

The **International Bureau of Weights and Measures (BIPM)**, an intergovernmental organisation, the headquarters of which are located Pavillon de Breteuil, 92312 Sèvres Cedex, FRANCE, represented by Director, Dr Martin Milton (hereinafter "the BIPM"),

and

Federal State Unitary Enterprise "Russian Metrological Institute of Technical Physics and Radio Engineering"(the FSUE VNIIFTRI), the headquarters of which are located MLB, urban settlement Mendeleevo, Solnechnogorsk district, Moscow region, 141570, RUSSIA, represented by General Director Sergey Donchenko, (hereinafter "the FSUE VNIIFTRI"), acting in accordance with the company rules. The Parties, noting the existence of the Arrangement on the Mutual Recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes (CIPM MRA), the fact that the FGUP VNIIFTRI is a participant in the Key Comparisons and the necessity to calibrate regularly time links used for these purposes,
have concluded this Agreement as follows:



1. Subject of the Agreement
The BIPM accepted the FSUE VNIIFTRI offer to carry out free of charge absolute calibration complete set of TTS-4 receiver (hereinafter the Receiver). The FSUE VNIIFTRI agrees to undertake all procedures to calibrate the Receiver and to issue a calibration Certificate. The FSUE VNIIFTRI will use the receiver for mutual time link calibration which results will released by the BIPM in the BIPM report.

The results of absolute calibration of BIPM GLONASS/GPS receivers TTS-4 in VNIIFTRI

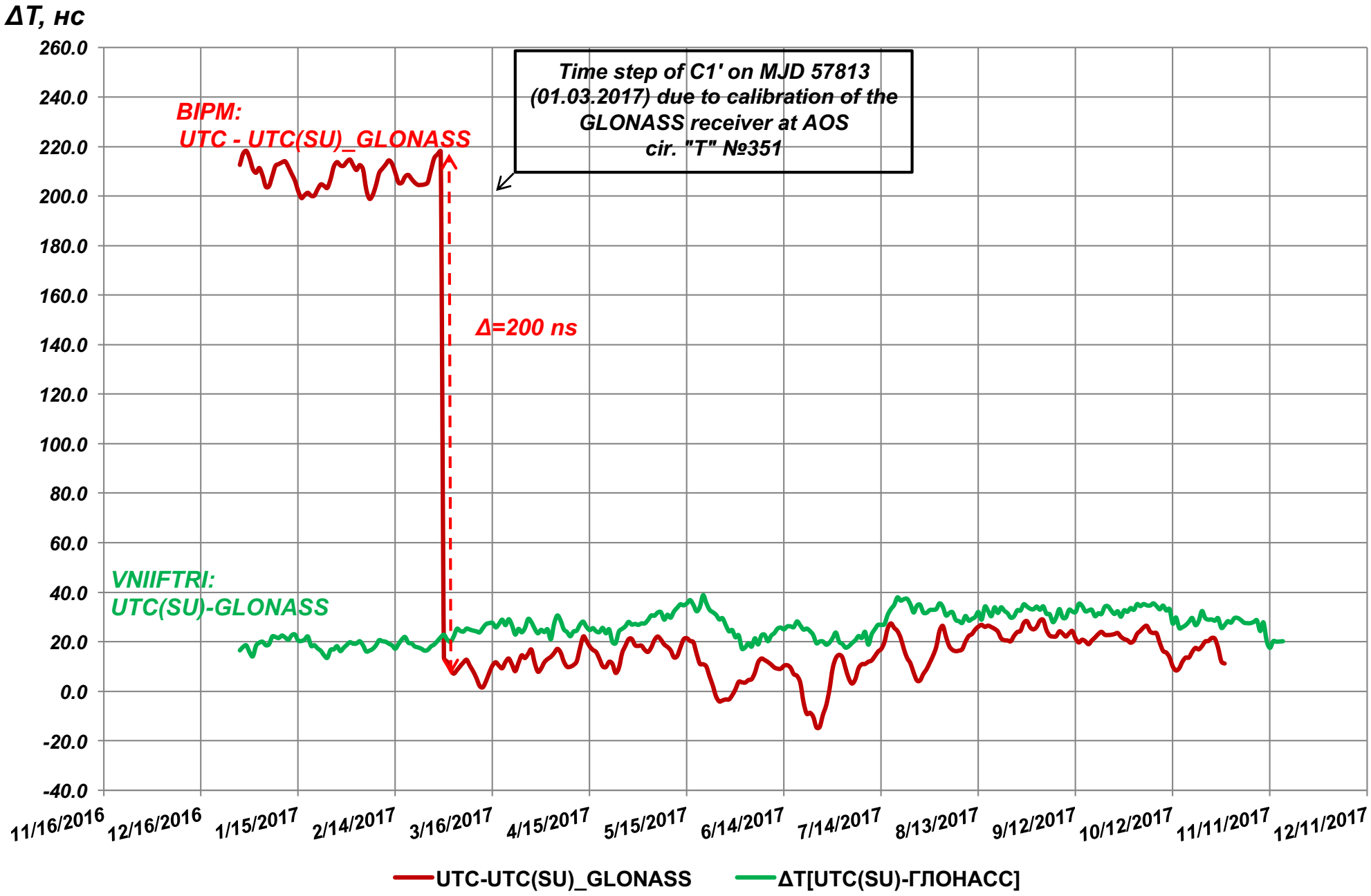
Table 1 GPS L1 C/A

Receiver TTS–4	INT DLY, ns	Diff, ns
OLD	-34.6	0.8
NEW	-33.8	

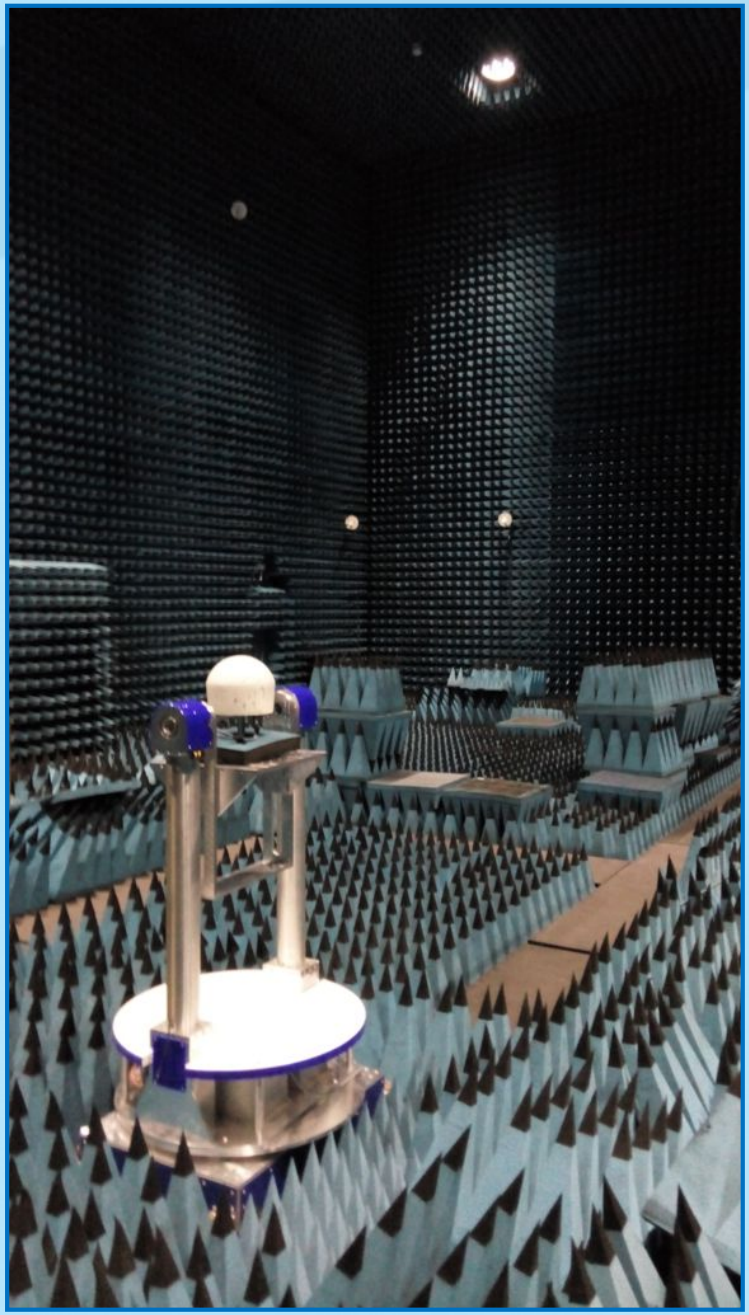
Table 2 GLONASS L1 C/A

Receiver TTS–4	INT DLY, ns	Diff, ns
OLD	- 242.2	203.6
NEW	– 38.6	

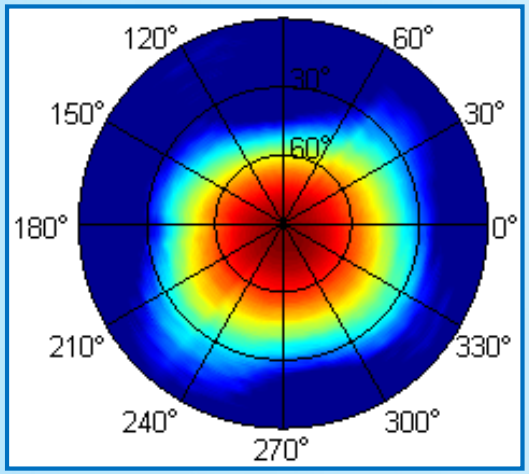
We hope that upon completion of the BIPM receiver TTS-4 calibration GLONASS Time estimation of BIPM will be equal to VNIIFTRI estimation.

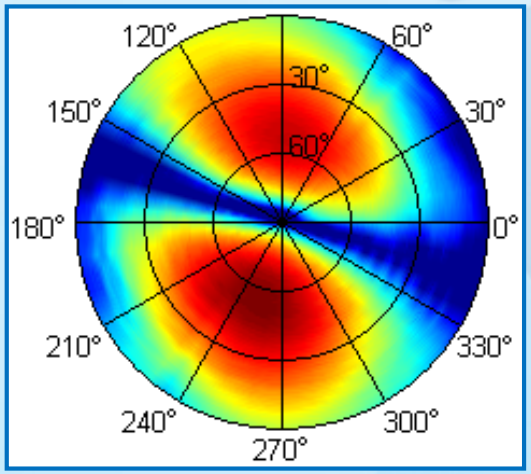

ΔT, нс
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-40.0
Time step of C1' on MJD 57813
(01.03.2017) due to calibration of the
GLONASS receiver at AOS
cir. "T" №351
BIPM:
UTC - UTC(SU)_GLONASS
Δ=200 ns
VNIIFTRI:
UTC(SU)-GLONASS
11/16/2016
12/16/2016
1/15/2017
2/14/2017
3/16/2017
4/15/2017
5/15/2017
6/14/2017
7/14/2017
8/13/2017
9/12/2017
10/12/2017
11/11/2017
12/11/2017
UTC-UTC(SU)_GLONASS
ΔT[UTC(SU)-ГЛОНАСС]

Spatially distributed GNSS field simulation



24 antennas for GLONASS and GPS simulation





Thank you for attention

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