CCTF/15-03

VNIIFTRI, RUSSIA

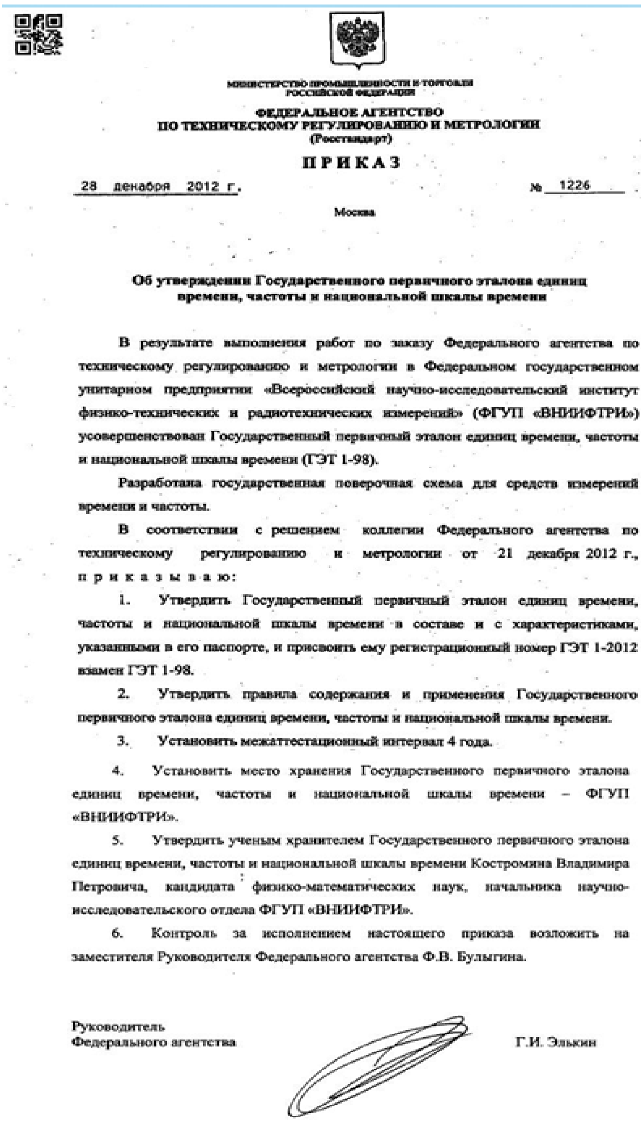
Time and Frequency activity at the VNIIFTRI

Introduction

This report contains main results obtained during last three years in Time and Frequency division of the VNIIFTRI. The main emphasis will be paid to operational activity of the Main Metrology Center State Service for Time and Frequency first of all regarding the National Time and Frequency Standard (NTFS) of Russian Federation maintenance and improvements. Along with it our main research program on further improvement of the NTFS will be depicted as well. Then we discuss briefly general issues such as VNIIFTRI position regarding “leap” second and future of the UTC time scale, and redefinition of the main units of the SI.

Operational activity

NTFS commissioning



МИНИСТЕРСТВО ПРОМЫШЛЕННОСТИ И ТОРГОВЛИ
РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНОЕ АГЕНТСТВО
ПО ТЕХНИЧЕСКОМУ РЕГУЛИРОВАНИЮ И МЕТРОЛОГИИ
(Росстандарт)

ПРИКАЗ

28 декабря 2012 г. № 1226

Москва

Об утверждении Государственного первичного эталона единиц времени, частоты и национальной шкалы времени

В результате выполнения работ по заказу Федерального агентства по техническому регулированию и метрологии в Федеральном государственном унитарном предприятии «Всероссийский научно-исследовательский институт физико-технических и радиотехнических измерений» (ФГУП «ВНИИФТРИ») усовершенствован Государственный первичный эталон единиц времени, частоты и национальной шкалы времени (ГЭТ 1-98).

Разработана государственная поверочная схема для средств измерений времени и частоты.

В соответствии с решением коллегии Федерального агентства по техническому регулированию и метрологии от 21 декабря 2012 г., приказываю:

1. Утвердить Государственный первичный эталон единиц времени, частоты и национальной шкалы времени в составе и с характеристиками, указанными в его паспорте, и присвоить ему регистрационный номер ГЭТ 1-2012 взамен ГЭТ 1-98.
2. Утвердить правила содержания и применения Государственного первичного эталона единиц времени, частоты и национальной шкалы времени.
3. Установить межаттестационный интервал 4 года.
4. Установить место хранения Государственного первичного эталона единиц времени, частоты и национальной шкалы времени – ФГУП «ВНИИФТРИ».
5. Утвердить ученым хранителем Государственного первичного эталона единиц времени, частоты и национальной шкалы времени Костромина Владимира Петровича, кандидата физико-математических наук, начальника научно-исследовательского отдела ФГУП «ВНИИФТРИ».
6. Контроль за исполнением настоящего приказа возложить на заместителя Руководителя Федерального агентства Ф.В. Булыгина.

Руководитель
Федерального агентства Г.И. Элькин

According to Russian metrological regulations all governmental standards have to be commissioned from time to time and especially if their hardware and software configuration or main stated specifications are expected to be changed. Such procedure has been done at the end of 2012 and according to the Order No 1226 dated 28 December 2012 signed by Head of the Rosstandard G.I.Elkin the NTFS has been commissioned with new set of stated specifications and considerably new hardware and software configuration.

The main changes compare to old one are:

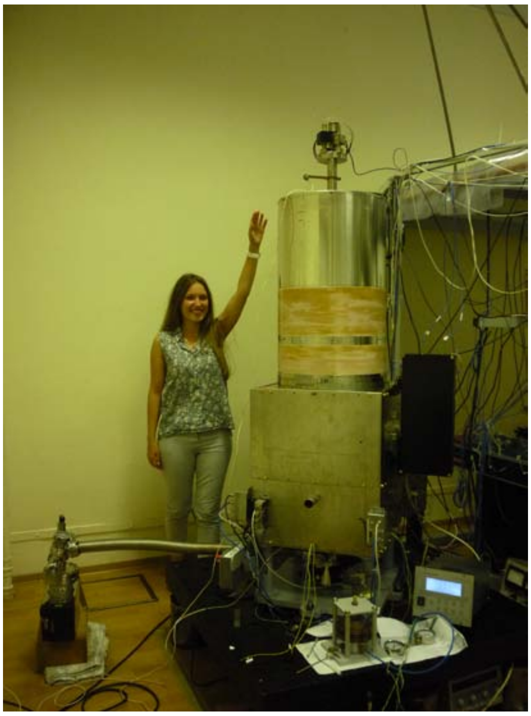
- considerably higher level of time unit accuracy 5×10^{-16} compare to that 5×10^{-14} of the previous one;
- much more wide frequency range of measurements – from 1 Hz to visible region - 5×10^{14} Hz;
- and much more rigid requirement for RMS

difference UTC-UTC ≤ 10 ns.

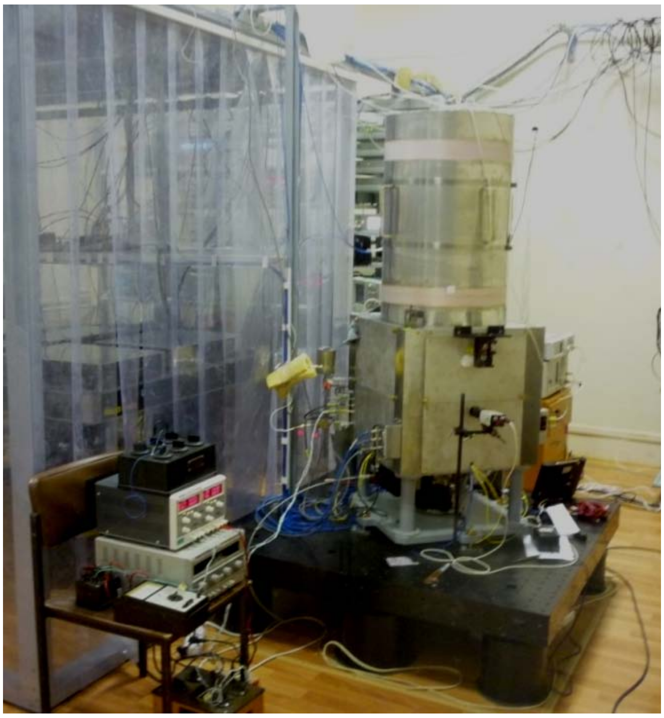
The above mentioned performances have been achieved by new CS fountain standards, including into the NTFS comb generator traceable to the primary CS standard and new clock ensemble of high stable and predictable H-maser, new time link equipment and their calibration and new time algorithm.

CS fountain standards

For today the NTFS possesses two CS fountain standards: SU-CsF01 and SU-CsF02. The state-



CS fountain standards: SU-CsF01



CS fountain standards: SU-CsF02

ed accuracy of the instruments at the commissioning date was correspondingly SU-CsF01 3.0×10^{-15} and SU-CsF02 5.0×10^{-16}. There was prolonged campaign to update SU-CsF01 performances which is not finished till now.

During 2012-2013 VNIIFTRI continued investigations on SU-CsF02 uncertainty budget first of all aiming international validation accuracy level and legal presentation in the Circular T [1]. After a few steps paper exchange with experts from Working Group on Primary and Secondary Frequency Standards (WG PSFS) and consequent papers updating presented SU-CsF02 accuracy level

Physical phenomenon	Bias Unit 1×10^{-16}	Uncertainty Unit 1×10^{-16}
Second order Zeeman shift	-1072.4	0.1
Spin exchange shift	5.2	2.3
Black body radiation	179.9	1.0
Gravitation shift	-244.3	0.1
Cavity pulling	0.0	0.1
μ-wave power shift	0.0	3.8
Probe signal spectral purity	0.0	0.1
DCP	-0.4	0.7
μ-wave leakage	0.0	0.1
Light shift	0.0	0.1
Electronics	0.0	1.0
Residual gas collisions	0.0	1.0
Total bias	-1132.0	4.8

Table 1 (MJD 56608 - 56897)
SU-CsF02 fountain standards uncertainty budget

Physical phenomenon	Bias Unit 1×10⁻¹⁶	Uncertainty Unit 1×10⁻¹⁶
Second order Zeeman shift	-1069.0	0.1
Black body radiation	165.5	1.0
Gravitation shift	-244.3	0.5
Cavity pulling	0.0	0.1
μ-wave power shift	0.1	1.8
Probe signal spectral purity	0.0	0.1
DCP	-0.4	0.8
μ-wave leakage	0.0	0.1
Light shift	0.0	0.1
Residual gas collisions	0.0	1.0
Total(not including spin exchange	-1148.1	2.5

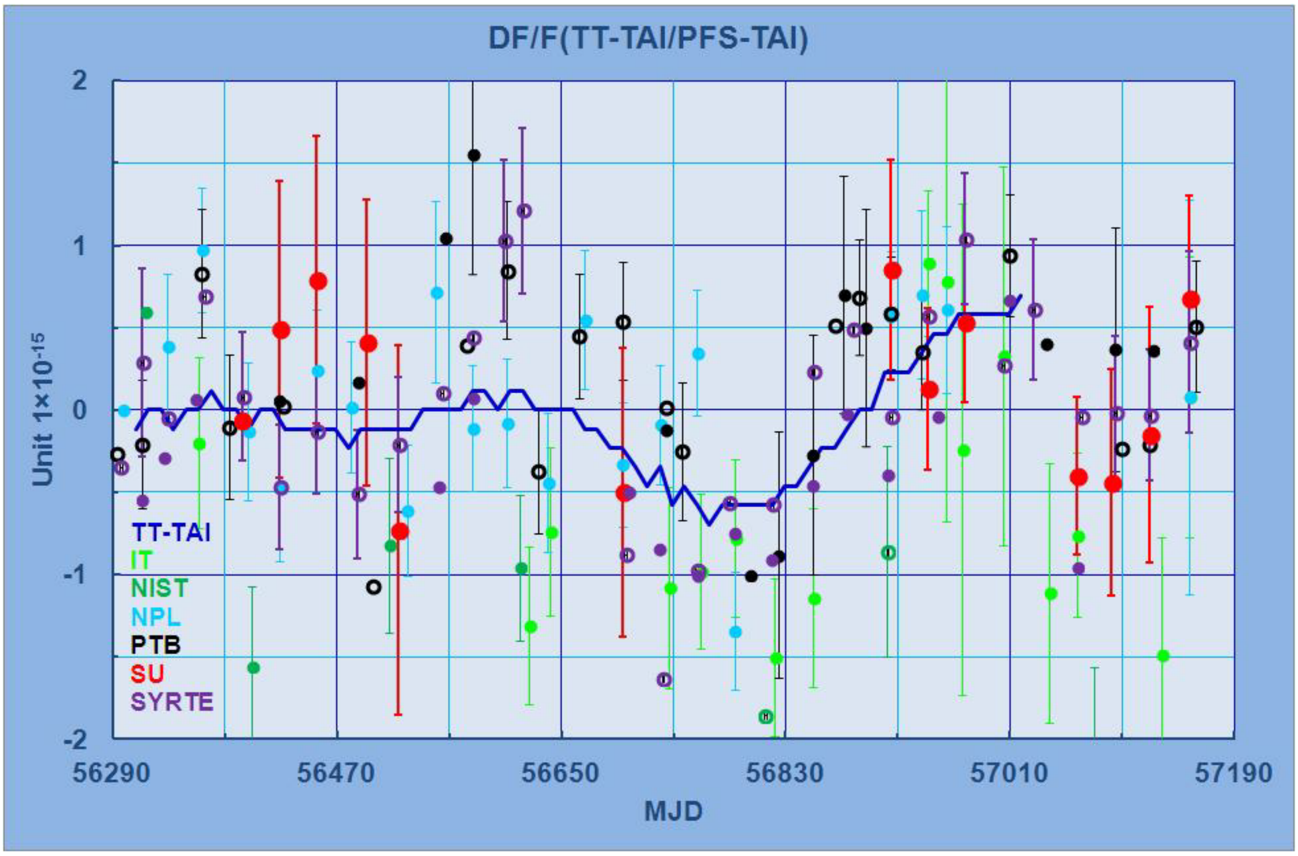
Table 2 (MJD 56897- till now)
SU-CsF02 fountain standards uncertainty budget

has been approved by WG PSFS. Beginning April 2014 Circular T 315 started official publication SU-CsF02 frequency difference relative to that TAI.

At that moment accuracy level of the primary caesium fountain standard SU-CsF02 has been stated equals to 5.0×10^{-16} and uncertainty budget presented at Table 1.

Further investigations and improvements in physical package and measurement data processing improved accuracy level of the SU-CsF02 twice, Table 2.

The whole data set of frequency comparison primary caesium fountain standard SU-CsF02 across SI unit along with frequency comparison data of leading laboratories is depicted at the following figure. All data and



corresponding error bars are extracted from Circular T 301-329. The frequency difference between TT and TAI is obtained basing on published TT14 realization. Unfortunately progress in SU-CsF02 accuracy is not clear obvious – this is result of the time link limitation. Nevertheless SU-CsF02 data distribution late MJD 56900 looks somewhat dense than before. On other hand SU-CsF02 readings does not look biased relative that of leading laboratories.

In 2013 comparison of Europe and Asia fountains were carried out by GPS and TWSTFT methods. They were Indian, Chinese, Russian's and German's fountains [2]. According to comparisons all fountains were coincident in the limits of declared uncertainties.

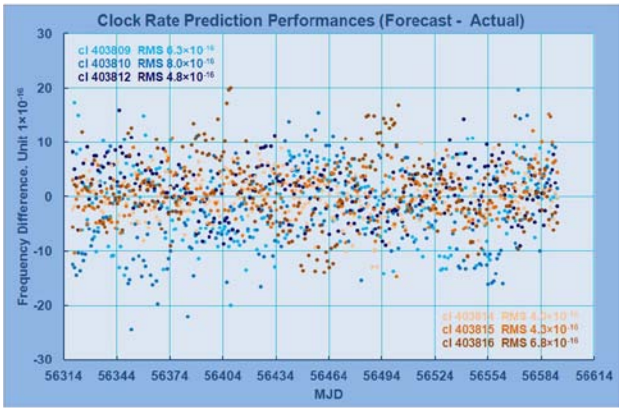
Clock Ensemble and Time Algorithm

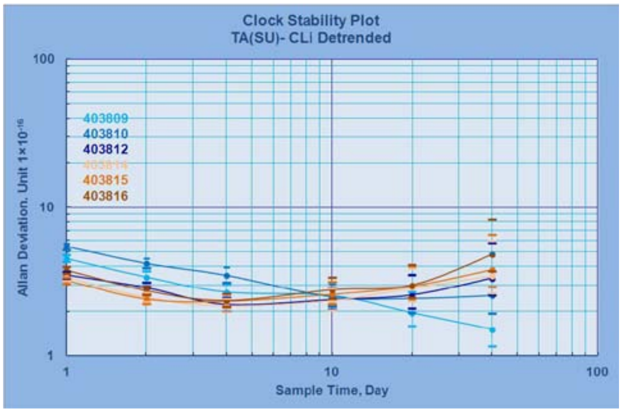
The clock ensemble and clock measuring system since period 2012-2015 didn't change considerably. The only new clock introduced into the ensemble is Cl 1403818. This is usual H-maser with cavity auto tuning system quite similar to all other clocks. It's significant difference – improved short term frequency stability, $\sigma_y(\tau) \sim 6\text{-}7\times10^{-15}$ for $\tau = 1$ s. This is specially designed clock with high quality crystal oscillator used as reference source for producing probe signal to SU caesium standards. From beginning 2014 this clock started contribution to the TAI.

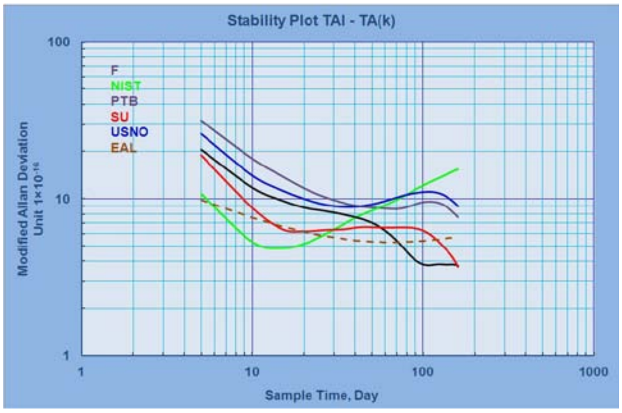
Despite minor changes in clock ensemble and clock measuring system due to introducing since MJD 56289 new time algorithm official time scales TA(SU) and UTC(SU) experienced considerable changes.

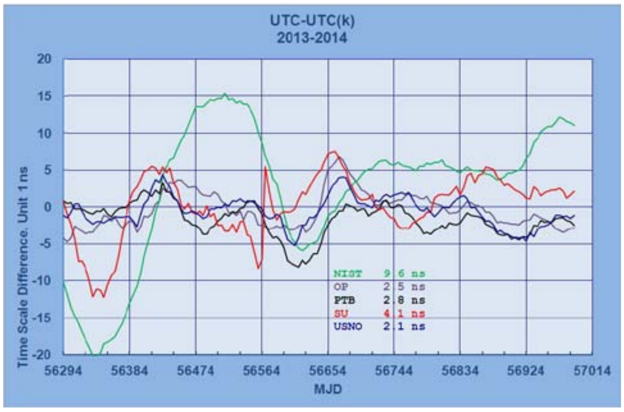
New time algorithm has been based on availability clock frequency regular calibration against primary Cs standard. The main consequence of introducing new time algorithm was time unit change in TA(SU) scale [3] . Main features of the time algorithm have been presented elsewhere [4-6], so only most significant features will be mentioned.

First of all time unit in TA(SU) since MJD 56289 (28 DEC 2012) has been matched to that reproduced by primary fountain standards SU-CsF01 and SU-CsF02 in accordance to the SI definition.
On the last standard date of the month new frequency prediction model for each clock is elaborated. This is based on regression analysis (first or second order model) for previous 10 – 11 month. In this way clock frequency drift and sometimes clock frequency acceleration are taken into consideration. Till now there is no weighting procedure, but clocks which manifest frequency departure from prediction more than $1\text{-}1.5\times10^{-15}$ are excluded from ensemble. So a key issue of clock contribution is predictability. Two following pictures, extracted from [7], demonstrate particular level of clock stability and predictability.









As result of new algorithm introduction TA(SU) stability level considerably improved and now is competitive to that of best laboratories, look at following figure.

Looking at this picture one may state that for sample time more than few months atomic time scale are not statistically independent. This originates from using high quality primary/secondary standards as a source of time unit.

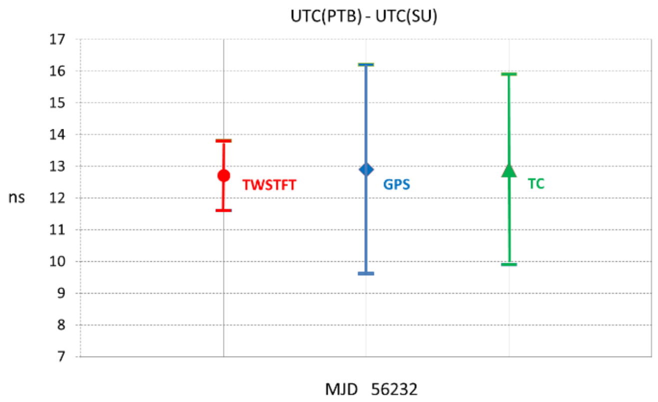
TA(SU) improved stability facilitates UTC(SU) steering ability, and as a result considerably improved RMS difference UTC-UTC(SU).

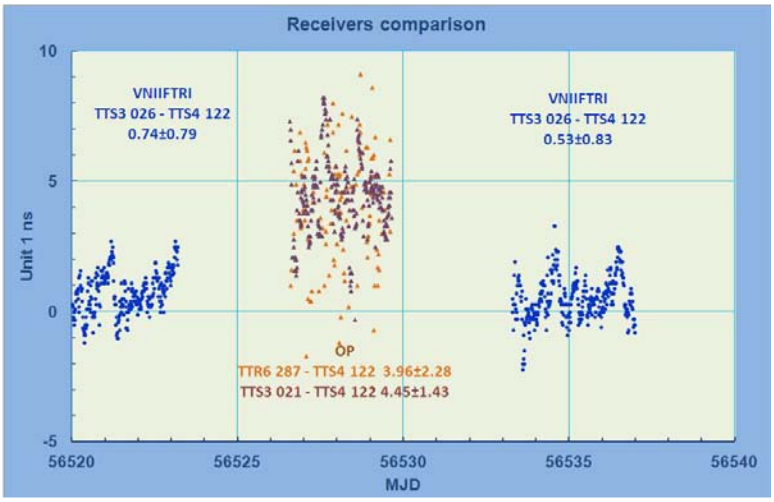
TW and CV Time Link Calibration

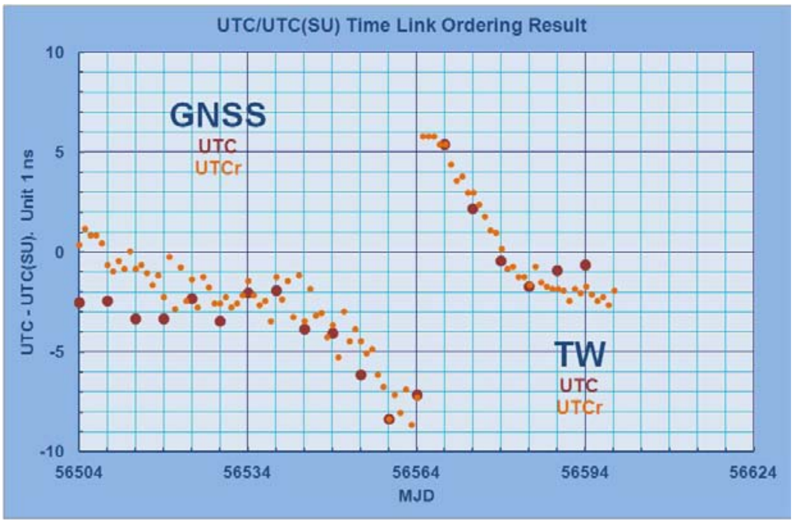
Laboratory time transfer links play a key role in two aspects: on one hand these ensure access laboratory to UTC reference scale and on other enable laboratory contribute to TAI. These to activities are strongly linked: if laboratory do not contribute to TAI it has no direct access to UTC and can't proof legal traceability local realization UTC(k) to UTC.

Two very important time link calibration campaign have been fulfilled during 2012-2013 in VNIIFTRI.

The first one is TW time link calibration. This was done by means TW mobile station. In late fall 2012 mobile VNIIFTRI TWSTFT mobile station has been delivered to PTB and in cooperation with colleagues from PTB calibrated TWSTFT link between VNIIFTRI and PTB. As a result in May 2013 BIPM has issued CI number 281. Within this calibration trip not only TWSTFT station has been delivered to PTB, but continuously operating portable atomic clock and GPS/GLO time receiver also. Such an equipment set played very positive role, because of each instrument produced its own readings and then one may compare results. UTC(PTB) and UTC(SU) time scale comparison were made with three independent methods, and for each of them accuracy achieved represents the current state of the art. All measurement results obtained with three independent methods agreed within their respective uncertainties.







The other calibration campaign deals with GLO/GPS time transfer receiver calibration. The main reason for this calibration was continuous difference about 10 ns between UTC(k) and UTC(SU) basing on original link data processing and that basing Circular T data. Such discrepancies forced us to arrange additional GPS receiver calibration in the Paris Observatory and to source of these. Following figure depicts calibration result, which confirms that since previous calibration no changes in delay VNIIFTRI master receiver not happen within uncertainties of previous and current calibrations. Additional mutual discussion with colleagues from BIPM W. Lewandowski and H.Konate on this issue revealed a possible source of the discrepancy arising from the link data treatment.

So basing on the results of both calibration campaigns and revealed source of fault in close co-operation with BIPM Time Department VNIIFTRI operational time link has been switched from GPS/GLO combination to TWSTFT on MJD 56564, 29 September 2013.

GNSS Monitoring & GNSS Receiver End-to-End Calibration

According to GLONASS ICD [8] UTC(SU) is a reference time scale for GLONASS System Time (GLO ST). That's why one of continuous tasks of VNIIFTRI is to monitor time difference between UTC(SU) and GLO ST. Along with it GLONASS navigation message contains time correction τ_c = UTC(SU) + 03h00m + GLO ST. The τ_c value enables GLONASS user access to the national time scale UTC(SU).

VNIIFTRI started such monitor activity since end of 80th using so called GLONASS receiver type A724 developed by RIRT (Russian Institute Radionavigation and Time) [9, 10]. At that time VNIIFTRI used receiver, antenna and antenna cable delays supplied by RIRT. Since that time many other receivers type has been used in VNIIFTRI for monitoring. Each step of receiver change included relative calibration procedure to maintain UTC(SU) –GLO ST continuous. Now we use TTS3, TTS4 receivers for this purpose.

On other hand the first western GLO receiver have been developed in Leeds University by Peter Daly. This receiver was a beginner of GLONASS receivers in western countries. Since that time in western, first of all European laboratories have been changed, similar to Russia, a few generations of the receivers and every new model has been calibrated against previous one to ensure measurement continuity [9, 10].

Since very beginning there was about 200 ns difference in GLONASS monitoring data originated VNIIFTRI and western community. More over even GLONASS control segment itself was not sure which data is more accurate VNIIFTRI or BIPM. To solve such a problem one has accurately measure absolute time delay value of receiver module itself, antenna delay and delay in antenna cable, so called end-to-end delay of the whole complex.

Measuring campaign described below has been carried out with BIPM receiver TTS4 type No 136 and consisted of two independent parts:

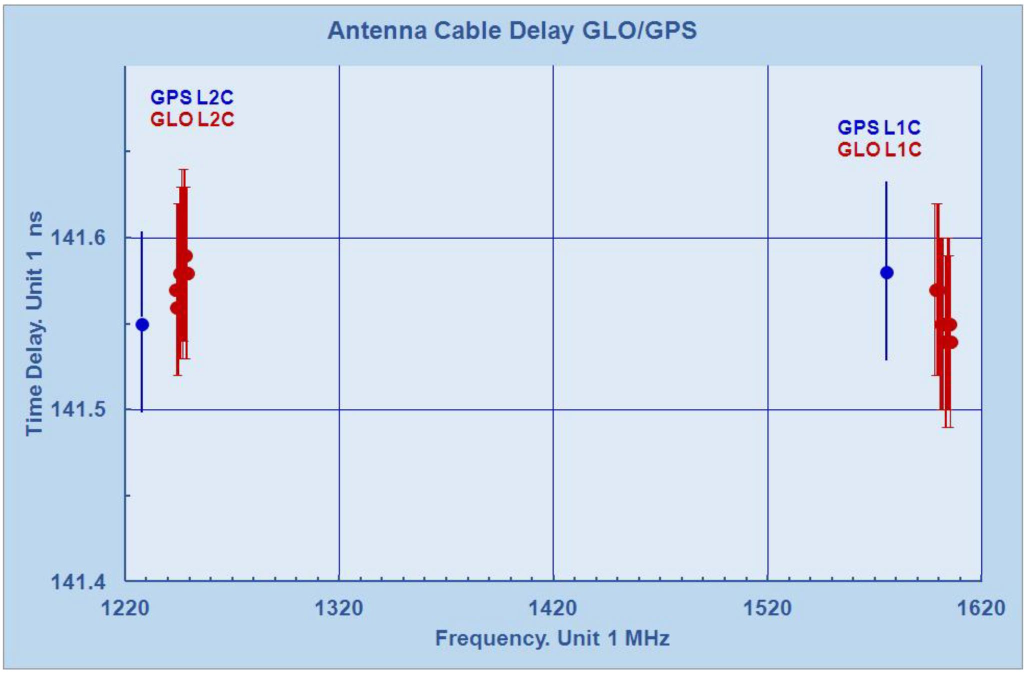
- measurement antenna cable and antenna itself delay time;
- measurement delays in receiver module.

Regarding measurement procedure one has take into consideration that contrary to GPS GLONASS uses FDMA technology. This means that each visible from specific place satellite broadcasts at different frequency, so delay may be somewhat different. The same situation not only for receiver module but for antenna and antenna cable.

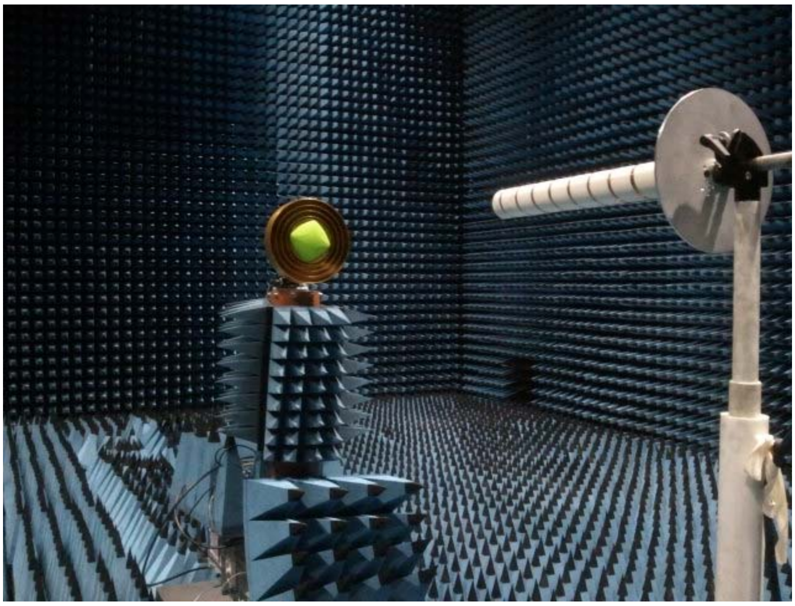
Antenna cable delays have been measured by two methods:

- by means 1 pps signal and high quality time interval meter type SR 620;
- by means Vector Network Analyzer type R&S®ZVB4

Both methods produced the same results at uncertainty level about 100 ps. Vector network analyzer produced a little bit higher resolution depicted at following figure.

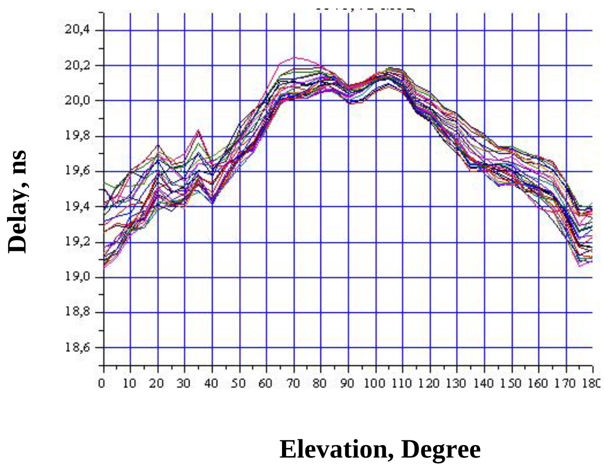


Because of high quality antenna cable type FSJ 1 there is no considerable dispersion in cable and one may use constant value of delay for any GLONASS and GPS carrier frequency within measurement uncertainty.

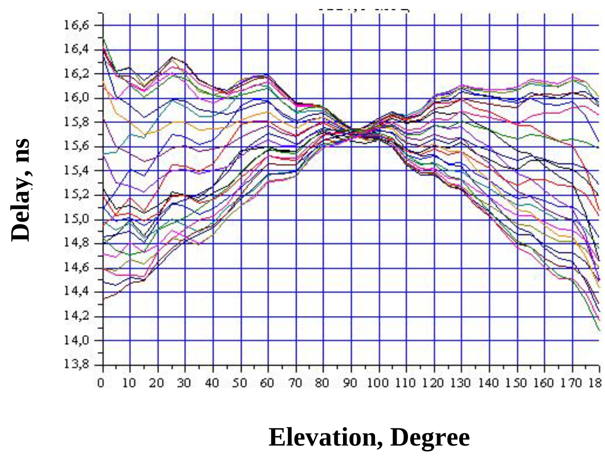


The BIPM antenna Javad made Ring Ant G3T type No 00526 delay measurements has been carried out in VNIIFTRI anechoic chamber. The chamber ensures anechoic coefficient ≤ - 35 dB for 1-40 GHz and external EMI suppression coefficient ≥ 80 dB. These measurements included not only plain delay measurements but azimuth and elevation delay dependencies.

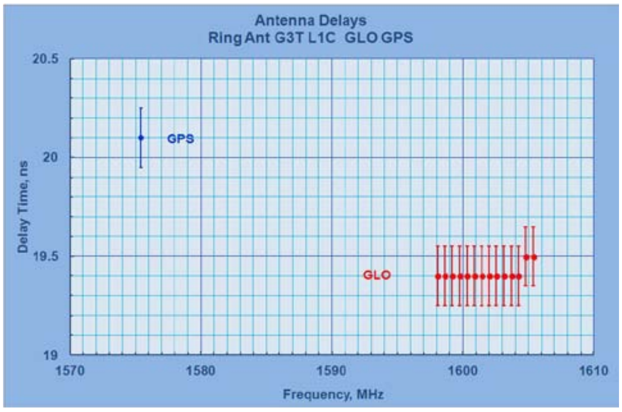
GPS L1C Antenna Delay Dependences on Elevation and Azimuth

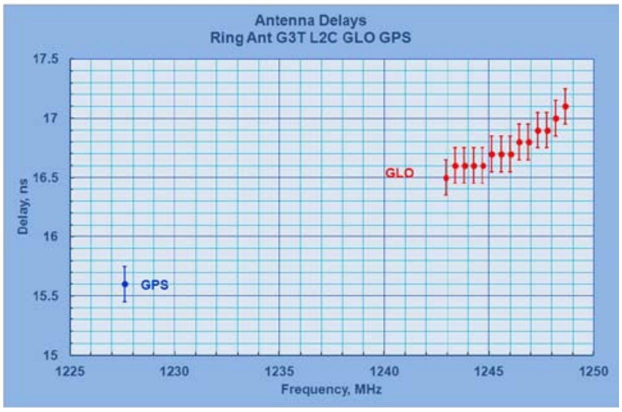


GPS L2C Antenna Delay Dependences on Elevation and Azimuth



Antenna delays dependences on frequency, due to GLO FDMA are presented on two following figures for L1 and L2C bands and elevation 90 degrees (zenith satellite).





The BIPM receiver module TTS4 No 136 delay measurements have been carried out in VNIIFTRI by GPS/GLO simulator.

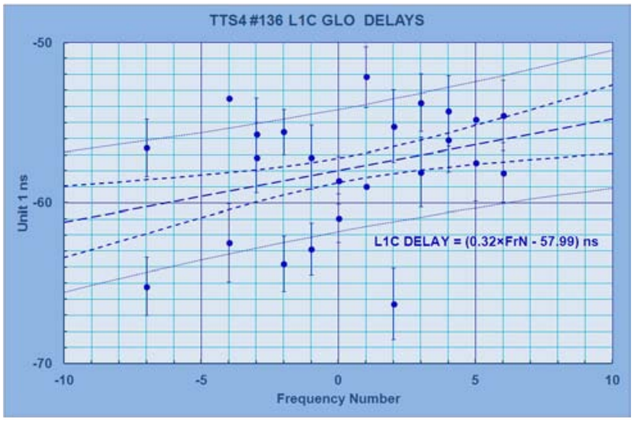
The receiver run under hardware: 133.31 and software :2.35 2014/08/29. At start point receiver configuration has been matched to that of simulator regarding antenna coordinates, CABDLY and REFDLY. REFDLY included phase difference between 1 pps and ref 10 MHz signal. All other internal delays have been booed zero.

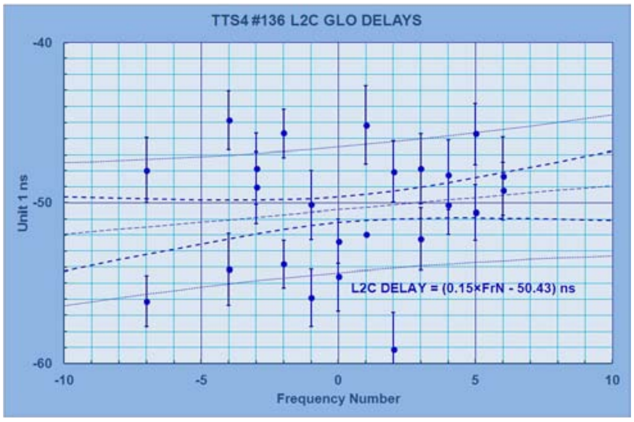
After run about four days CGGTTS files have been downloaded from receiver module TTS4 No 136 and processed. And what's result? The most interesting data are regarding GLONASS because of 200 ns difference between BIPM and VNIIFTRI.

Nevertheless we start from GPS data – we hope that BIPM receiver module TTS4 No 136 had been calibrated by its BIPM predecessor absolutely calibrated in US Naval Research Laboratory many years ago. So we are interesting does results of previous L1C GPS calibration are in conformity just obtained data?

Internal delay of TTS4 No 136 receiver for L1C GPS signal based on BIPM calibration is equal to -34.60 ns. We do not know exact value of its uncertainty – basing on Circular T data [10] “global uncertainty is of the order of 10 ns”. VNIIFTRI measurements produced internal delay of TTS4 No 136 receiver for L1C GPS signal equal to -33.80 ± 1ns (2σ). We consider this is a very impressive coincidence!

Regarding other issue - TTS4 No 136 receiver delays for L1C/L2C GLO data are depicted on the following charts.

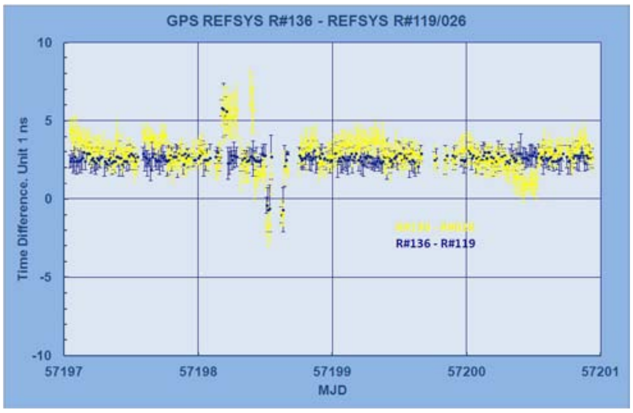


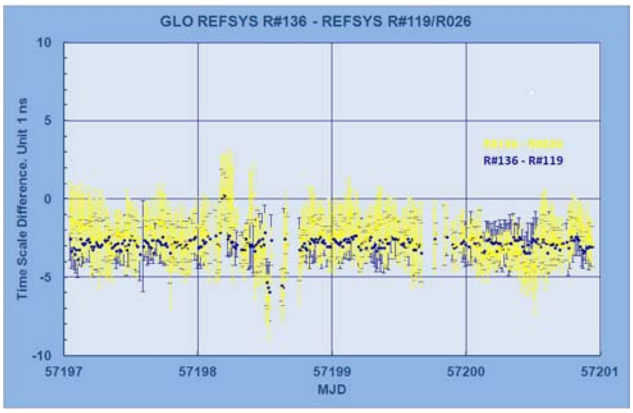


Unfortunately we couldn’t reach comparable to GPS delay uncertainty level for at least two reasons. First of all due to some drawbacks in TTS4 receiver software and GLONASS FDMA broadcasting technology, which complicates delay/frequency dependences.

For these reasons we are not able to get reliable delay values for each GLONASS satellite frequency which are distributed within a few ns, may even to about up to ten ns! Instead, we referred result to central sub-band L1 1602.0 MHz and L2 1246.0 MHz carrier frequencies estimated by regression analysis.

Then we reconfigured TTS4 No 136 receiver delays taking into account these determined separately for antenna, antenna cable and receiver module itself and compared CGGTTS data files for TTS4 No 136 receiver, master VNIIFTRI receiver TTS3 No 026 and new VNIIFTRI receiver TTS4

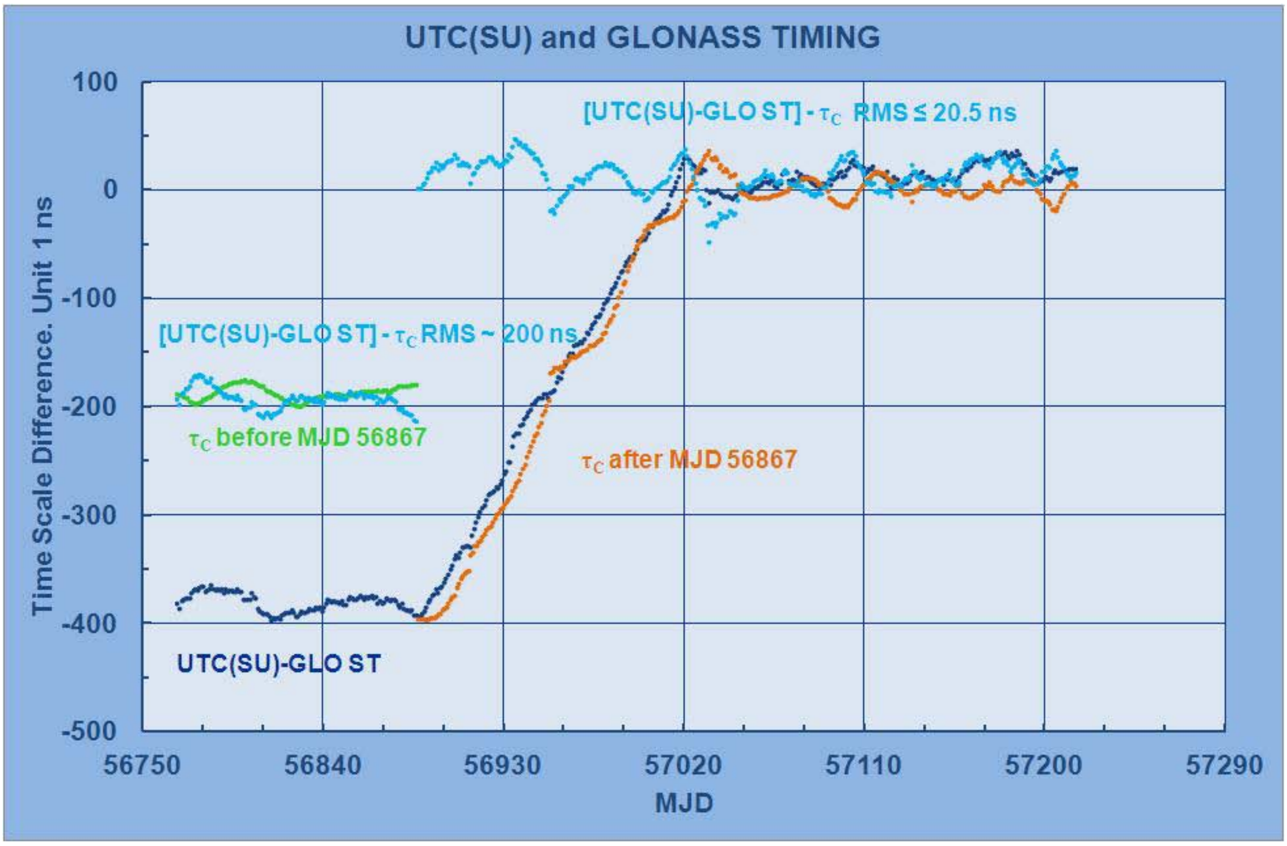




No 119. Receiver TTS4 No 119 had been calibrated against TTS3 No 026 in advance.

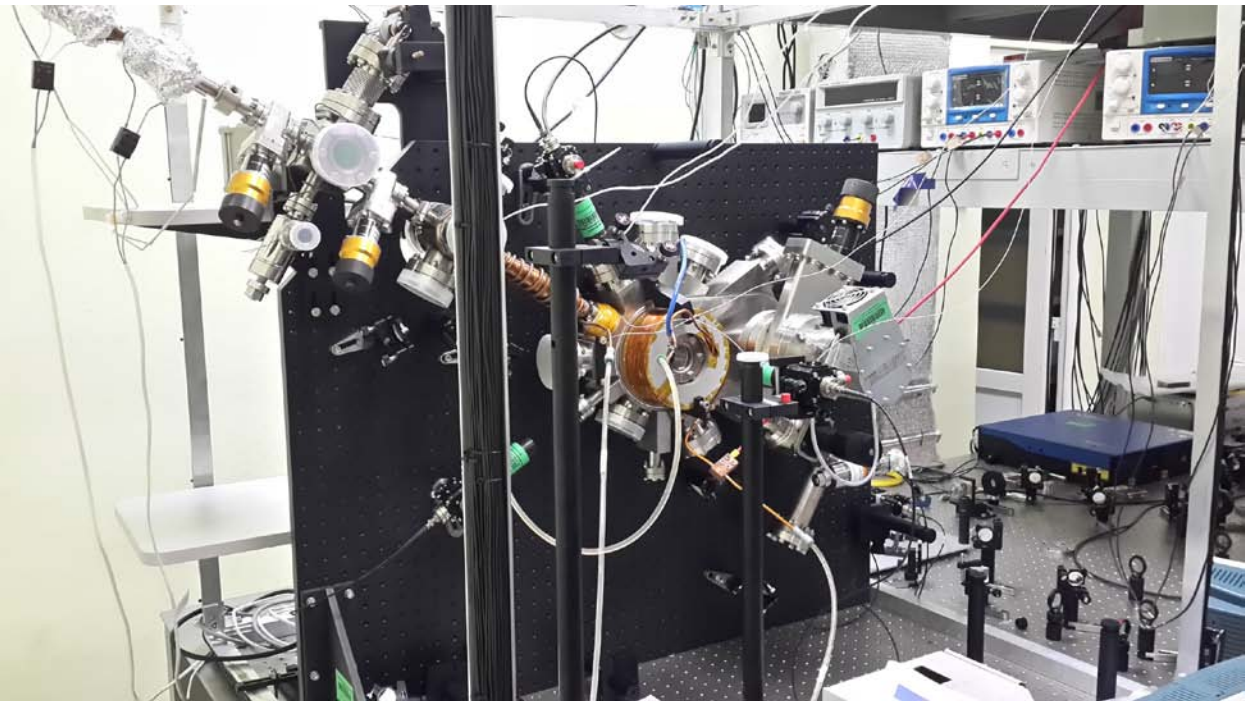
The obtained result for GPS comparison is more or less expected, because of difference in between BIPM and VNIIFTRI calibration less than 1 ns. Result for GLONASS is impressive. Determined end-to-end receiver GLO delay confirmed that original TTS3 receiver No 026 GLO calibration is correct! More over much more impressive is the fact that this GLO delay is successor of GLO receiver A-724 type since end of 1980. We are still astonished how at that time developers from RIRT succeeded to measure correctly delay in the A-724 type receiver!

Mentioned above results had been achieved on TTS4 No 136 GLO/GPS receiver which belong to the BIPM. Quite similar results had been got on one of VNIIFTRI GLO/GPS receivers about a year before. As a consequence basing on these results GLONASS administration changed little by little difference UTC(SU) - GLO ST and τ_c value starting MJD 56887 (18 AUG 2014).

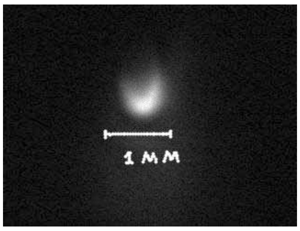


The main research programs on further improvement of the NTFS Sr Standard

At our institute the optical standard of frequency on cold atoms of ^{87}Sr is developed. First stage of laser cooling is presented in [12]. We demonstrated second stage laser cooling of ^{87}Sr atoms trapped in a magneto-optical trap at ntercombinatory transition $^1S_0$-$^3P_1$ (689 nm) [13]. Retrapping from the first stage trap operating at $^1S_0$-$^1P_1$ (461 nm) transition is studied in details. We measured the retrapping coefficient **k**, the number of atoms and their temperature in the secondary trap depending on experimental parameters. Temperature of 2 μK is reached in the second stage trap at the retrapping coefficient of **k** = 6% which confirms high efficiency of second stage cooling and is enough for metrological studies of clock transition $^1S_0$-$^3P_1$ (698 nm) in an optical lattice [14] .



Vacuum chamber system for laser cooling ^{87}Sr



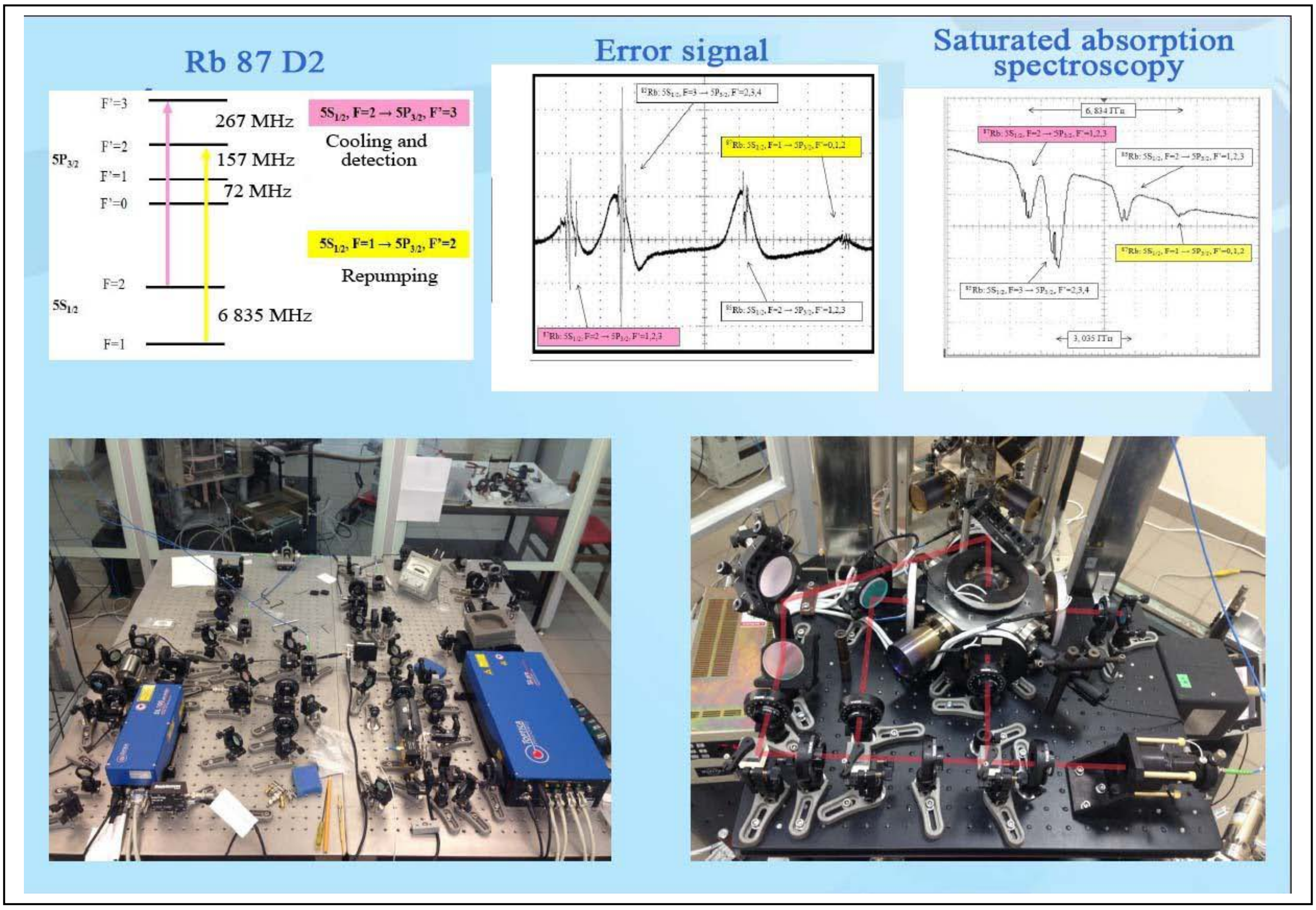
The cloud of the cooled atoms of ^{87}Sr at the end of a cycle of narrow-band secondary cooling.

An investigation of a 'clock transition' at ^{87}Sr is now in the progress.

Rb Fountain Standards

The program of Rb fountains development and investigations has been started. There are two goals of the program. One goal is a development of quantum standard for time keeping. According to this we should have in 2016 Rb fountains with $(1\text{-}2)\times10^{-16}$ instability. Another goal is the development and investigation Rb fountain for the secondary representation of the Second. At present the first prototype is almost finished [15, 16].

Some details an experimental set up are shown at the following picture.

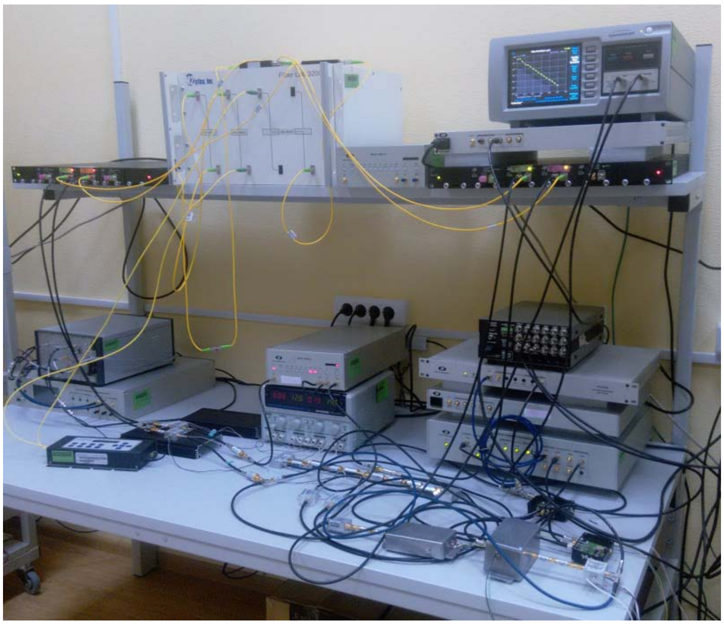


New H-maser Ensemble

At the end of 2015 VNIIFTRI expects to get new ensemble of 4 high performance H-masers and supplementary measuring instruments. In many aspects these frequency standards look quite similar to that operational instruments of VNIIFTRI. Perhaps the most striking feature in considerably lower frequency drift, expected value $\leq 1\times10^{-16}$ per day, and may be a little bit better 1 day stability ($\sigma_y(\tau) \leq 3\times10^{-16}$, $\tau = 1$ day)

We hope that during half a year these instruments will be included to the VNIIFTRI operational ensemble and will contribute to TAI.

Investigations on Time and Frequency Fiber Transfer



The standard radio frequency transfer over a 100 km fiber optic line was carried out in 2014. The transfer of radio frequency was carried out by experimental model formed by bobbins of optical fiber with disturbances active electronic compensation. Allan deviation of transferred 100 MHz standard signal was below the level of 4×10^{-17} for sample time 1 day [17,18].

In 2015 similar experiments on time and frequency transfer with 100 km fiber on bobbins have been repeated using SATRE modem. The uncertainty of a time signal transmission to the end of the 100 km optical line: $u_A \leq 15$ ps, $u_B \leq 100$ ps .

At the nearest future we expect to repeat time and frequency transfer experiments with optoelectronic compensated by controllable optical delay lines 200 km fiber on bobbins added by EDFA amplifiers. Then next step using SATRE modems. In the latter experiment expected uncertainty for frequency transfer ~1×10^{-17} and $\sqrt{u_A^2 + u_B^2} \leq 100$ ps for time transfer.

The main goal of our activity in time and frequency transfer for forthcoming one-two years is to arrange reliable and accurate time link within Moscow region connecting the national primary time and frequency standard with secondary ones, including laser range stations participating in optical time transfer.

General Issues

As the first paragraph we would like present report of our Russian colleagues from geodesy society regarding very important issue for primary frequency standards – gravitational potential.

Demianov G.V., Mayorov A.N., Sermiagin R.A., The Joint Height System Establishment Tasks, Extracts from the National Report of the Russian Academy of Sciences National Geophysical Committee to the International Association of Geodesy of the International Union of Geodesy and Geophysics 2007 – 2010. Presented to the XXV General Assembly of the International Union of Geodesy and Geophysics, Moscow, 2011.

Following to the tendency of globalization and simplifying practical application of Molodenskiy theory we have to accept joint origin of height reference and set $U0 = W0$ picking out one more geoid – common earth equipotential surface which potential $W0$ equals to potential $U0$ of normal gravity on the reference ellipsoid [Demianov G.V., Mayorov A.N., Yurkina M.I., 2009, Demianov G.V., Mayorov A.N., 2010].

Common Earth ellipsoid represents the earth as an average value on the oceans in particular. Common earth ellipsoid taken as a normal one satisfies the condition for the whole earth. …..

… In these conditions, the problem to create new modern planetary gravitation models becomes very important. In 2008 TsNIIGAiK construct new global gravitational model GAO 2008 using given projects (GRACE and CHAMP) to solve the problem of creation of gravimetrical geoid.

Using models GAO 2008 and EGM 2008 we valued possibilities to determine corrections to regional systems of normal heights according to suggested technology. The results of such valuation are shown in table 1. All scope of using data was divided at three groups on territorial location. First group includes the data for the territory of the USA, second – for the territory of West Europe. For the territory of Russia we used data of its European part. All calculations for the both models were done due to total range of coefficients up to 360- range.

Corrections to the regional height systems. Region	Mean difference Hmean (m)		Number of points
	GAO2008	EGM2008	
USA	+0.55	+0.53	6169
West Europe	+0.07	+0.09	87
European Russia	-0.09	-0.14	320

The principal to divide the data for groups first of all is connected with those idea that each group is using its own system of leveling heights. For the territory of the USA – NAVD-88, for the territory of West Europe – Amsterdam system, for Russia – Baltic (Kronshtadt) system.

Thus, $\Delta Hmean$ values for different groups characterize difference between height systems for the territories of the USA, Europe and Russia from common earth one established according to the above mentioned principles. The data about the difference between leveling data of Amsterdam and Baltic system proves the actual situation of the obtained results. Due to leveling data and GAO2008 model data this difference is equal to 16cm.

Because of preliminary evaluation of model EGM-2008 along with creation of the model we could assume that Bouguer anomalies were used as an initial data for the territory of Russia but not anomalies on the free air. Calculated differences *ΔHmean* are having systematic differences correlated over amount and sign with the Bouguer correction.

We have all base to think that the use of data of European space complex GOCE will bring to substantial identification of parameters of global navigation models and consequently will increase accuracy of construction of common European system of normal heights.

It is not possible to solve the problems both of creation of precise quasigeoid (and creation of global models as well) and determination of joint system of heights independently. It is not difficult to calculate, if we have systematic error about 0,1mgl in the anomalies of gravity for the territory of about 1000km in radius this will bring to the error of 10cm in determination of height of quasigeoid. In its turn, if a system of heights for the territory differs at 30cm from the common earth W0=U0 (and this is quite real case), this is a reason of a systematic error of gravity anomaly at 0,1mGl. That's why both tasks must be solved together.

Leap Second

VNIIFTRI supports RECOMMENDATION ITU-R TF.460-6 "Standard-frequency and time-signal emissions" as regards ANNEX 1, Time scales, Coordinated universal time (UTC), "UTC is the time-scale maintained by the BIPM, with assistance from the IERS, which forms the basis of a coordinated dissemination of standard frequencies and time signals".

VNIIFTRI is in favour of the future uniform international time scale without leap second. VNIIFTRI is not in favour of establishing new uniform international time scale along with existing UTC.

Redefinition of the SI Units

Let us compare existing definition of the SI unit of time (second):

"The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom". At its1997 meeting CIPM affirmed that: **"This definition refers to a caesium atom at rest at a temperature of 0 K".**

and proposed by Resolution 1 of the 24 meeting of the General Conference on Weight and Measures (2011):

“The second, symbol s, is the unit of time; its magnitude is set by fixing the numerical value of the ground state hyperfine splitting frequency of the caesium 133 atom, at rest and at a temperature of 0 K, to be equal to exactly 9 192 631 770 when it is expressed in the SI unit s^{-1}, which is equal to Hz”.

Current definition is much more clear and representative – it explains how to realize the second and appeals to (duration) time intervals counting.

The proposed new one doesn’t explain how to realize the second and appeals to the derivative unit – Hz.

Quite the same situation is regarding the SI unit of length (metre).

The existing definition of the SI unit of length (metre):

“The metre is the length of the pass travelled by light in vacuum during a time interval of 1/299 792 458 of a second”

and proposed by Resolution 1 of the 24 meeting of the General Conference on Weight and Measures (2011):

“The metre, symbol m, is the unit of length; its magnitude is set by fixing the numerical value of the speed of light in vacuum to be equal to exactly 299 792 458 when it is expressed in the SI unit ms^{-1}”

And quite the same comments.

Current definition is much more clear and representative – it explains how to realize the metre and appeals to length.

The proposed new one doesn’t explain how to realize the metre and appeals to the derivative unit – Hz.

To our understanding the main intentions of the CGPM, and CIPM particularly, reflected in Resolution 1 of the 24 meeting CGPM (2011) and Resolution 1 of the 25 meeting CGPM (2014) are very positive. Forty five years of nonstop progress since adoption by 13 CGPM in 1967 of the new definition of the SI time unit – the second, and about thirty years since adoption by 17 CGPM in 1983 of the new definition of the SI length unit – the meter, successfully demonstrate beneficial of SI base units defined in terms of the invariants of nature − the fundamental physical constants or properties of atoms.

But this outlines beneficial aspects not only physical basement of these definition but also very clear and well understandable for users linguistic definition of the SI time and length base units. The existing definitions of the SI time and length base units have to stimulate metrology community to follow these positive examples.

Proposed by Resolution 1 of the 24 meeting CGPM (2011) the reformulation of the existing definitions of the second and metre are in a formal conflict with section **invites** of the Resolution 1 “the CIPM to continue its work **towards improved formulations for the definitions of the SI base units in terms of fundamental constants, having as far as possible a more easily understandable description for users in general, consistent with scientific rigour and clarity**”

VNIIFTRI time division supports Resolution 1 of 24 CGPM regarding the SI base units definition in terms of the invariants of nature. Along with it VNIIFTRI is not in favour of redefinitions of existing SI base units of the time and length which proved their successful justifiability based on invariants of nature and clear understandable linguistic definition during ten years.

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