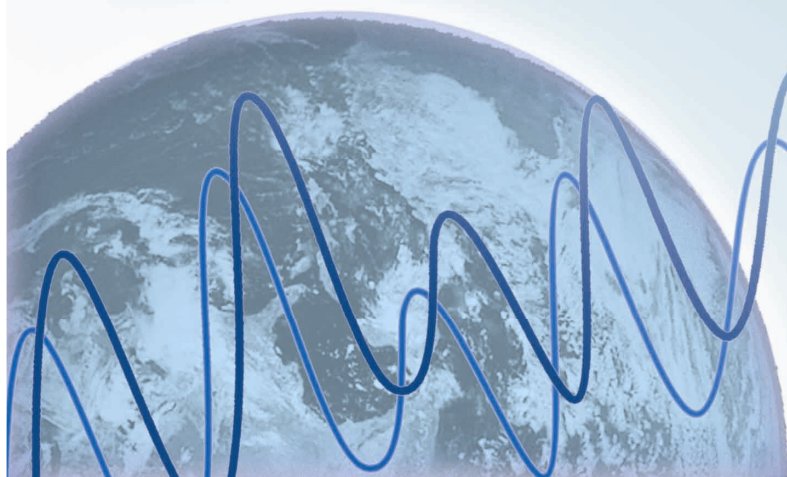


ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ  
УНИТАРНОЕ ПРЕДПРИЯТИЕ

«ВСЕРОССИЙСКИЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИНСТИТУТ  
ФИЗИКО-ТЕХНИЧЕСКИХ И РАДИОТЕХНИЧЕСКИХ ИЗМЕРЕНИЙ»



# The State Service for Time and Frequency and GLONASS Fundamental Ensuring Means



# CONTENT

- **GLONASS Fundamental Ensuring Means Composition**
- **State Service for Time and Frequency and It's Legal Status**
- **Atomic Time. Present status and Closest Changes**
  - **Present Status of the National Time Scale UTC(SU)**
  - **Investigations on Primary Standards**
  - **Changes in Time Keeping Laboratories and the Closest Goals**
  - **Investigation and Developing Programs**
- **Large Length Measurements**
  - **New Length Standards for Ranges up to 60 m, 24-3000 m and up to 4000 km**
- **Universal Time and the Earth Orientation Parameters**
  - **Data Sources and Storage**
  - **New EOP Processing Center**
- **Conclusions**

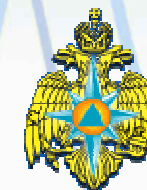
## **GLONASS Fundamental Ensuring Means Composition**

- **The Earth Orientation Parameters Determination and Forecast Means**
- **National Time Scale UTC(SU) Means**
- **Fundamental Astronomic and Geodetic Parameters Refinements Means**

Российская  
Академия  
Наук



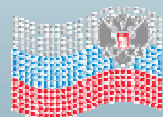
# SSTF composition



МЧС РОССИИ



МИНИСТЕРСТВО КУЛЬТУРЫ  
И МАССОВЫХ КОММУНИКАЦИЙ  
РОССИЙСКОЙ ФЕДЕРАЦИИ



МИНИСТЕРСТВО  
ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ  
И СВЯЗИ РОССИЙСКОЙ ФЕДЕРАЦИИ



МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ  
РОССИЙСКОЙ ФЕДЕРАЦИИ

ВНИИФТРИ

# Legal Status of the State Service for Time and Frequency

According to Article 10 Statute of the State Service for Time and Frequency (SSTF)

**“The SSTF Information on Time, Frequency and the Earth Orientation Parameters is obligatory within territory of the Russian Federation”**

SSTF produces and disseminates at regular basis, including for GLONASS, following information:

- Time scale difference between UTC and National Time Scale UTC(SU)
- Time scale and frequency difference between UTC(SU) and UTC (secondary laboratory)
- Time scale difference between UTC(SU) and GPS/GLONASS System Time
- Daily, Weekly and Monthly EOP data

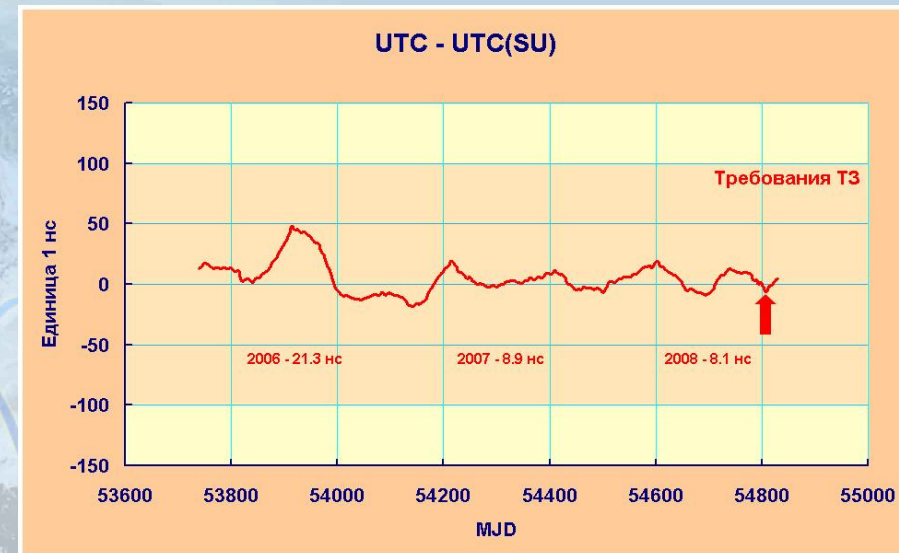
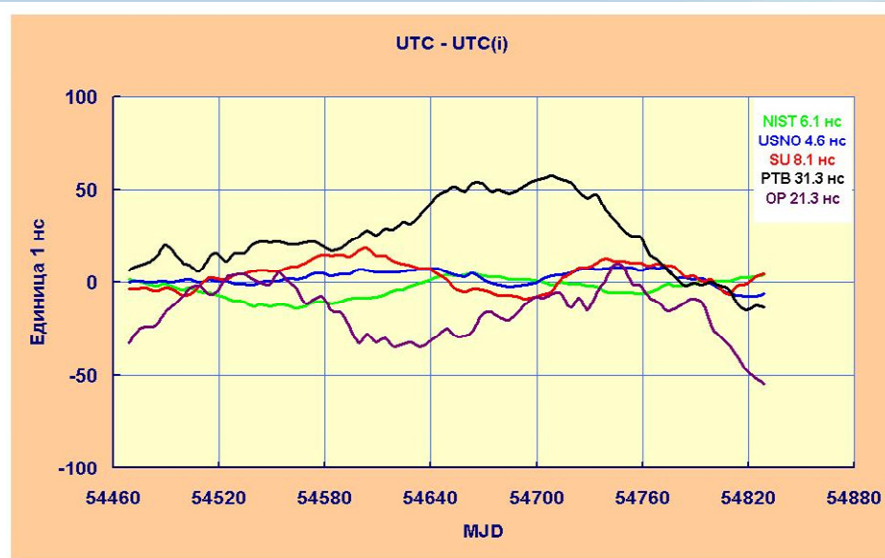
# Thermal Primary Cs Standard and Set of Continuously Operating H-Masers



- Accuracy of the old thermal beam primary Cs standard is about  $3 \times 10^{-14}$ .
- Stability of the old H-masers is about  $3 \times 10^{-15}$  for sample time from 1 to 3 days.



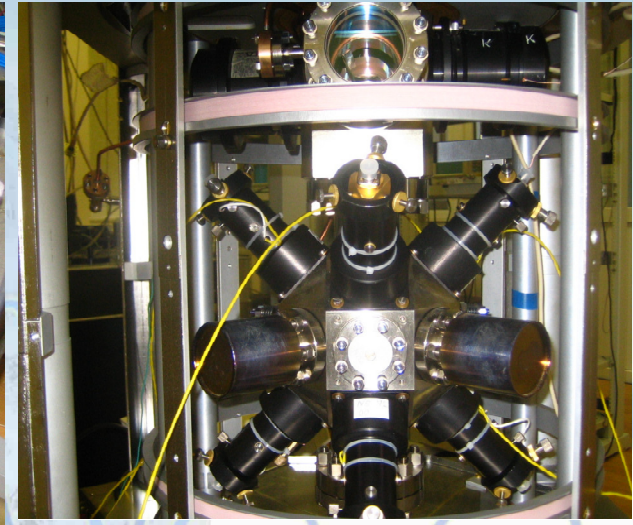
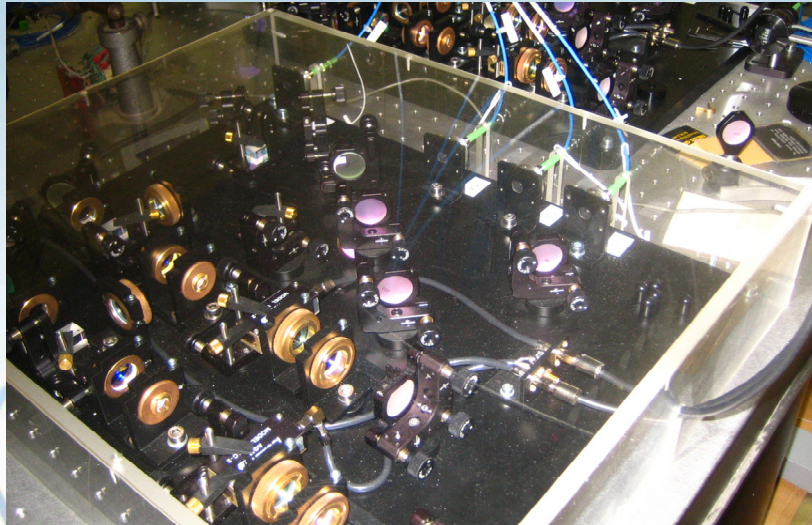
# UTC – UTC(SU) Time Difference TA(SU) Stability Level



- RMS (UTC-UTC(SU))  $\sim 8.1$  ns

- Stability level of the TA(SU) time scale based on the ensemble of old H-masers was about  $\sigma_y(\tau) \leq 3 \times 10^{-15}$  for sample time from 10 to 30 days in 2008.

# Investigations on Fountain Primary Cs Standard



- The main goal of this year is achieve on this prototype accuracy level less than  $3 \times 10^{-15}$ .
- The next prototype of fountain primary Cs standard with expected accuracy level  $\leq 5 \times 10^{-16}$  is scheduled to the end of 2011.



## Changes in Timekeeping Laboratories and the Closest Goals



The SSTF modernization program was adopted for the primary (VNIIFTRI) and secondary time laboratories (Novosibirsk, Irkutsk, Khabarovsk and Petropavlovsk at Kamchatka peninsula) under supervision of the Rostechregulirovanie (former Gosstandard)

ВНИИФТРИ



## Changes in VNIIFTRI

Today we have two specially designed climate controlled chambers for clocks and inter comparison instruments. The third one will be constructed in 2010.

Each one is designated for four H-masers type of CH1-75A with autonomous cavity auto tuning system. To eliminate mutual influence of clocks the chamber contains distributing amplifiers and H-maser inter comparison system. Minimal number of signals from clocks of other chambers is connected to inter comparison system.

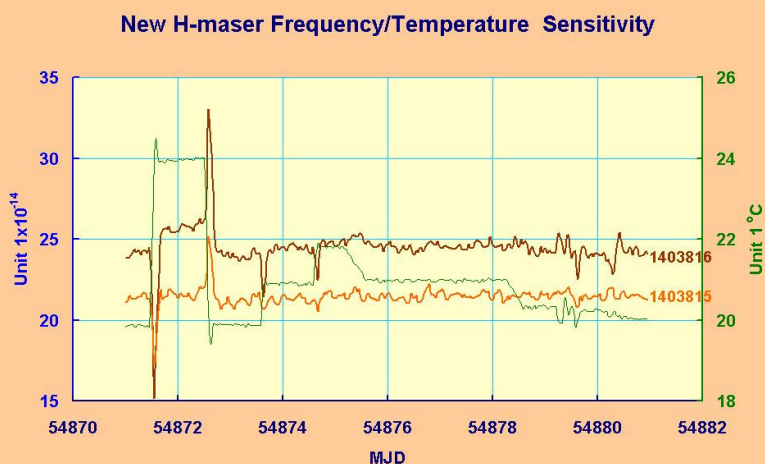
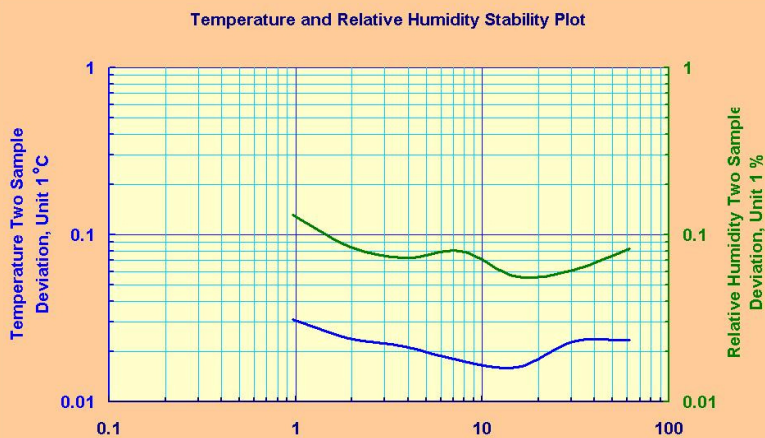
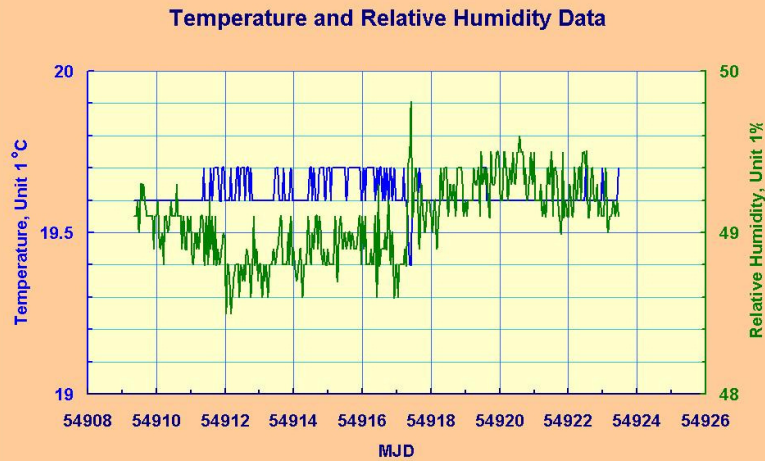
Today we have two ensembles of 4 new H-masers, total number 8. In 2010 total clocks number in VNIIFTRI will be 12.

Quite the same configuration of time keeping equipment will be installed in secondary laboratories with the only exception – each laboratory will possess only 4 H-masers.

So total number of H-masers under VNIIFTRI supervision will be 24 .

ВНИИФТРИ

# Changes in VNIIFTRI



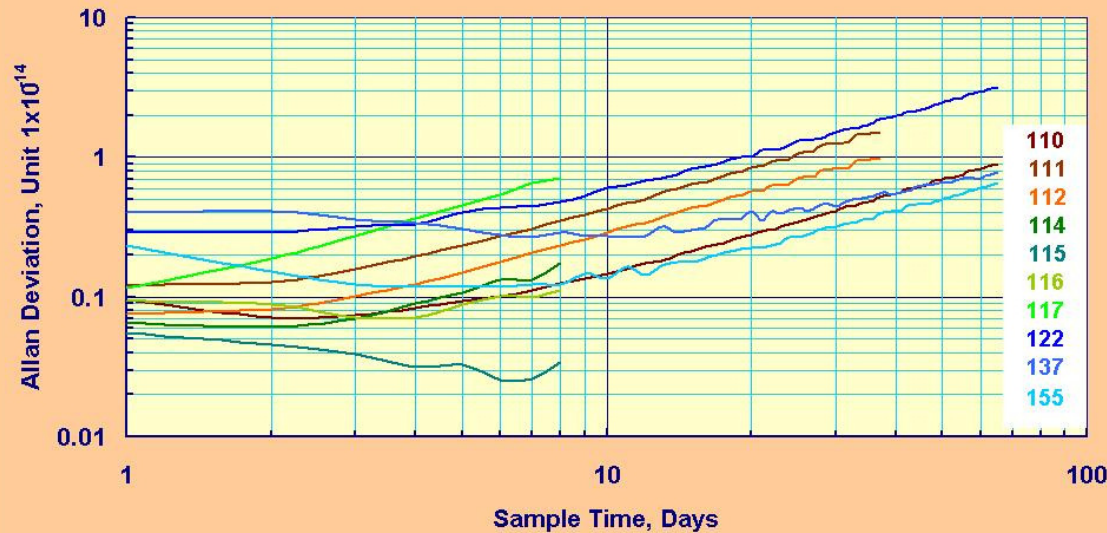
Temperature (T) and relative humidity (RH) performances of chambers.

Such a level of T and RH stability is absolutely needed because of frequency /temperature sensitivity of H-masers is about  $10^{-15}/\text{K}$ .

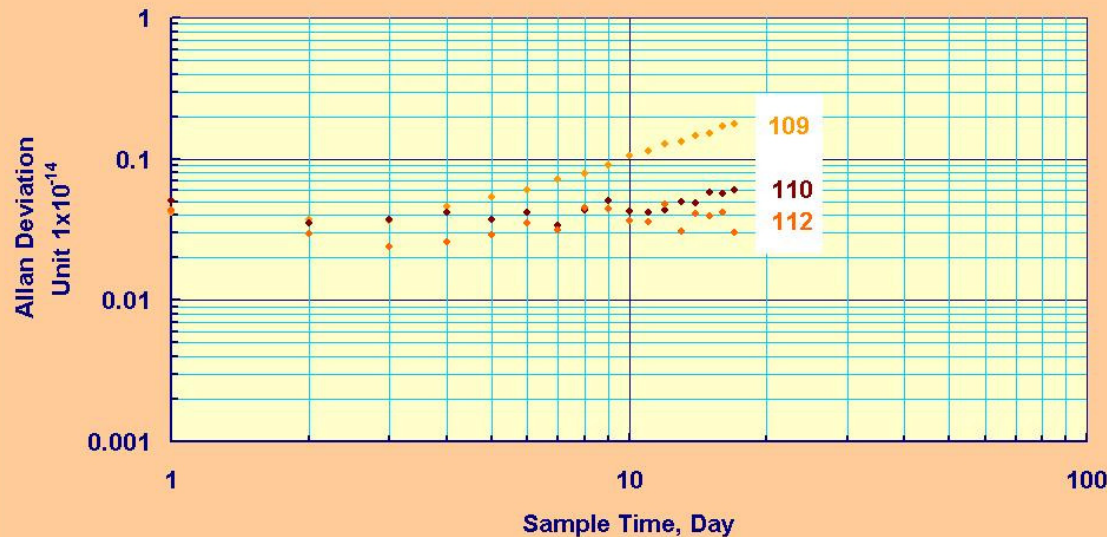
Frequency /temperature sensitivity have been confirmed experimentally and are in conformity with specification to the H-maser.

ВНИИФТРИ

Clock Stability Plot  
 $CL_i - CL_{109}$



Individual Clock Frequency Stability  
Three Corner Hat



## Changes in VNIIFTRI

Frequency stability level for the best old H-masers

$\sim 3 \times 10^{-15}$  and

$\sim 3-5 \times 10^{-16}$

for new one's for sample time from 1 to 10 days

These figures have been obtained using old measuring system because of new one with considerably better time/fre-quency resolution till now is under construction.



# Changes in VNIIFTRI

## The New Time and Frequency Comparison System

$$\sigma_x(\text{single shot}) \leq 25 \text{ ps}$$

$$\sigma_y(1 \text{ s}) \leq 2 \times 10^{-14}$$

$$\sigma_y(10 \text{ s}) \leq 3 \times 10^{-15}$$

$$\sigma_y(100 \text{ s}) \leq 5 \times 10^{-16}$$

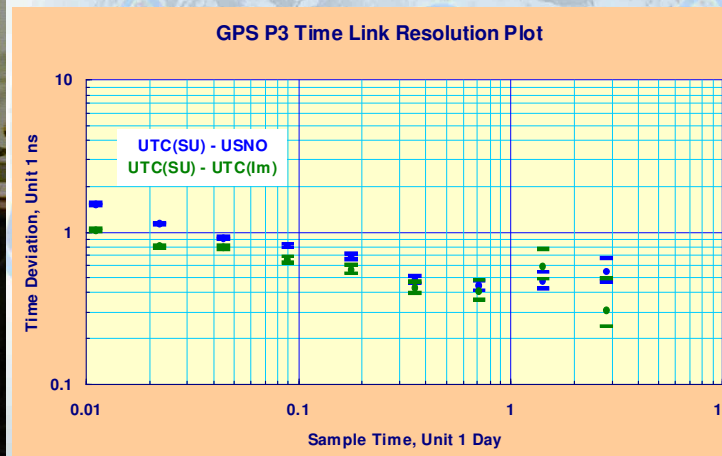
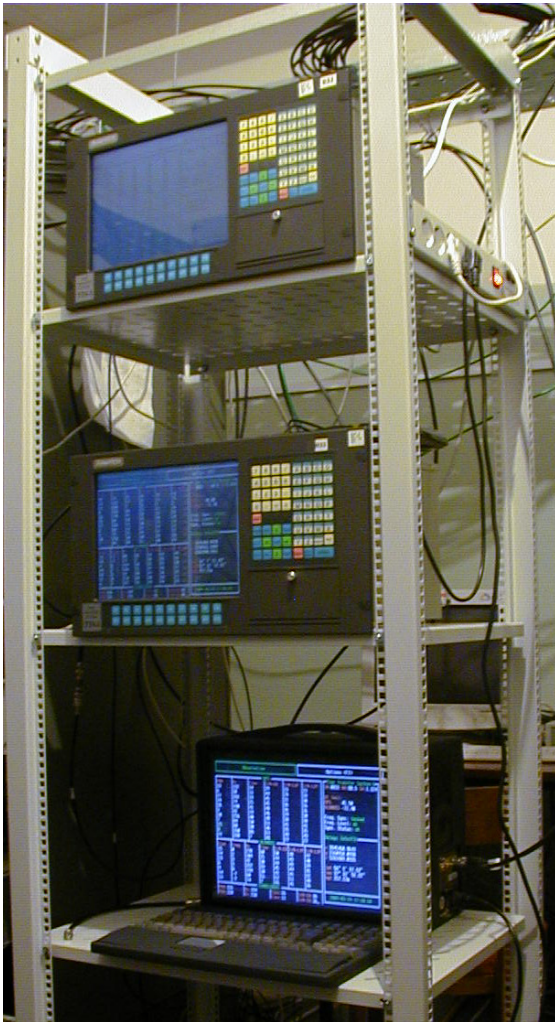
$$\sigma_y(1000 \text{ s}) \leq 1 \times 10^{-16}$$

$$\sigma_y(1 \text{ day}) \leq 2 \times 10^{-17}$$

# Changes in VNIIFTRI

## Remote clock comparisons

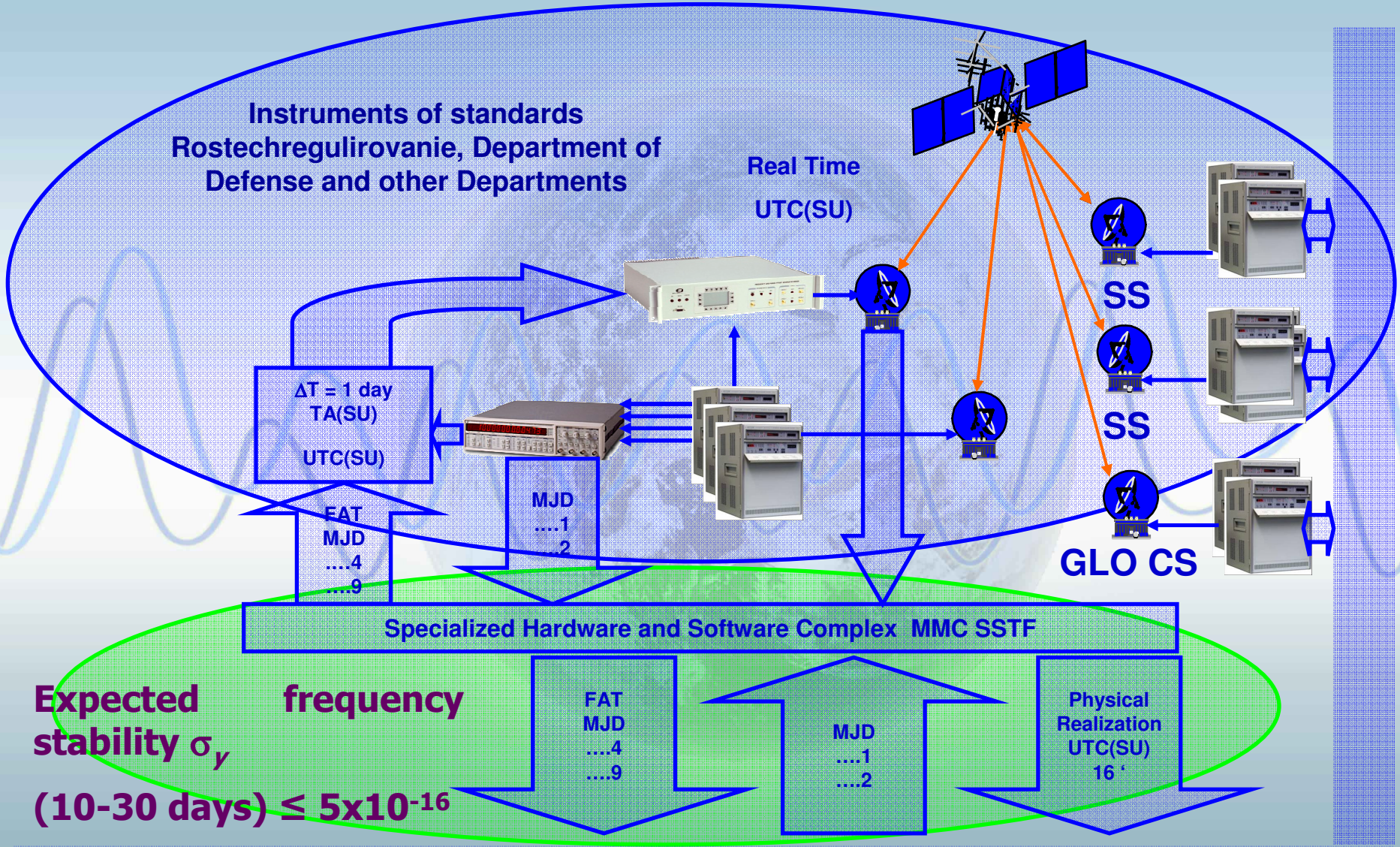
For today we have several GPS/GLONASS time receivers of TTS-3 type. These receivers have been GPS/GLONASS differentially calibrated across the BIPM TTS-3. Implementation of this receivers into operational TAI time link improved twice  $u_A$  uncertainty in Circular T



Three such a receivers have been delivered and installed in Irkutsk, Khabarovsk and Petropavlovsk  
Novosibirsk secondary laboratory is in the schedule

We are in realization of contract with TimeTech company, Germany, to install TWSTFT station in VNIIFTRI up to the end of the year. Today main goal is to join to European/Asia laboratories link through IS-4 satellite. As a next step TWSTFT station will be installation in Eastern part of Russian Federation, preferably in Irkutsk.

# Time Scale based on Ensemble of Distributed Clocks



Information Link

# Investigation and Developing Programs

**Investigation program on new generation of frequency standard based on  $^{87}\text{Sr}$  neutral atoms in an optical lattice.**

**The main goal is to achieve accuracy level better then  $1 \times 10^{-16}$ .**

**Investigation and developing program on time and frequency transfer by optical fiber links. First of all to link VNIIFTRI and GLONASS Control Segment.**

**The goal is to achieve transfer accuracy  $< 1 \times 10^{-17}$  in frequency and  $< 1$  ns in time.**

**Developing program on real time realization of the UTC(SU) and it's transfer to GLONASS Control Segment.**

**The goal is to achieve  $\text{RMS}(\text{UTC}(\text{SU}) - \text{UTC}(\text{SU}) \text{ real time}) < 2-3$  ns**





## Length Measurements

The main goal is to ensure range metric uniformity and traceability for GLONASS Fundamental Segment

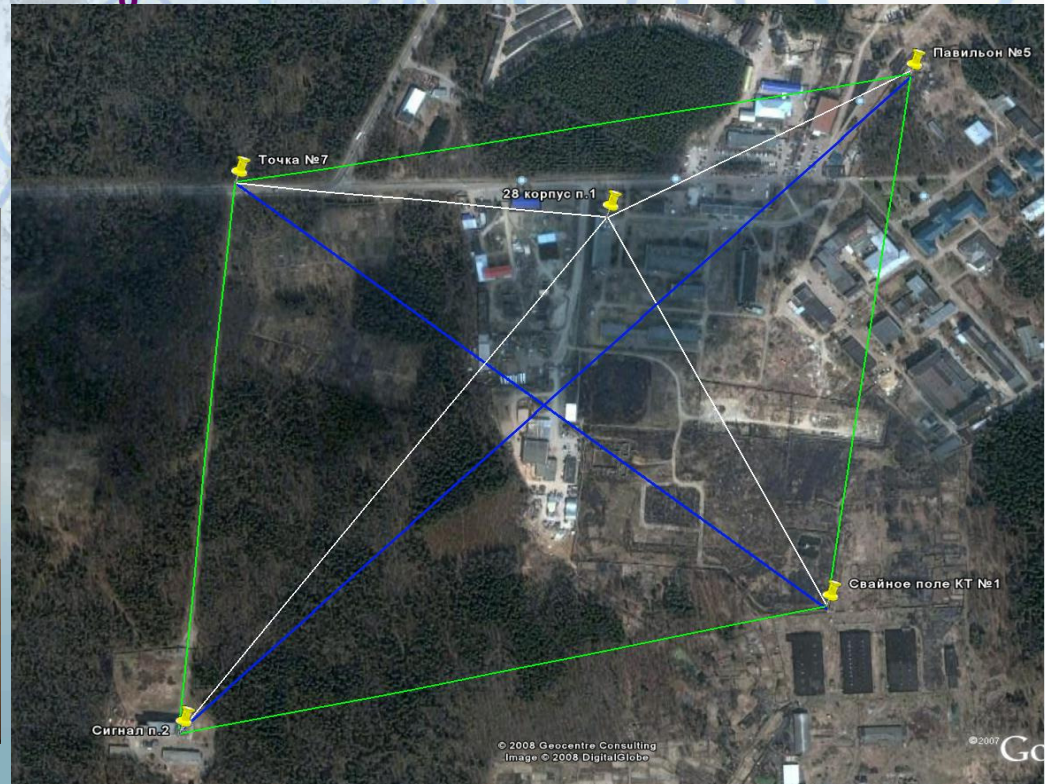
New Length Standard for ranges up to 60 m. The Meter realization according to the SI definition.

$$\Theta_0 \leq (10 + 0.5 \times L) \mu\text{m},$$

$L$  – basis length in meters

$$S_0 \leq 10 \mu\text{m}$$

New Length Standard and Geodetic Bases for Ranges from 24 m to 30 m

$$S_0 \leq 0.05 - 1 \text{ mm}$$




## Length Measurements

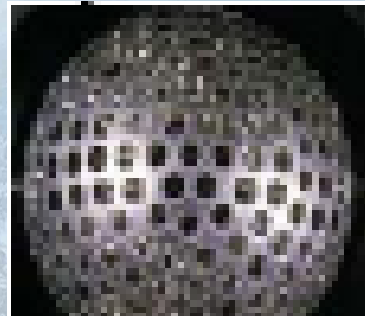
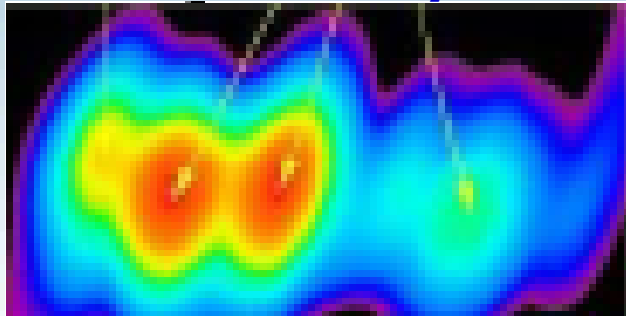
**New Length Standard and  
Geodetical Basises for Ranges  
from 1 up to 4 000 km**

**$S_0 \leq 1 - 20$  mm**

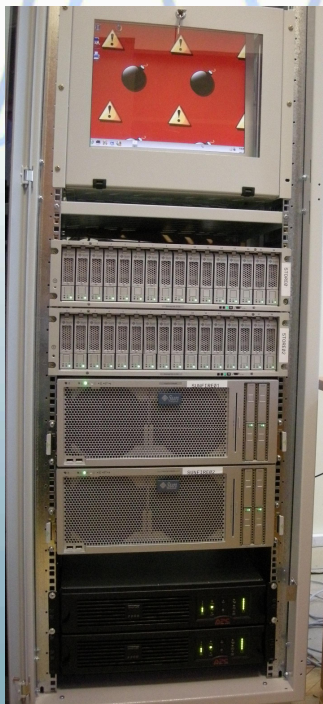
# Universal Time and the Earth Orientation Parameters

## Data Sources and Storage

VLBI data as the only source of accuracy



## New EOP Processing Center



ERROR: stackunderflow  
OFFENDING COMMAND: ~  
STACK: