FREQUENCY COMPARISON (H_MASER 40 3818) - (SU-CsFO2)
For the period MJD 56929 to MJD 56959.

The primary frequency standard SU-CsFO2 has been compared to the hydrogen Maser 40 3818 of the laboratory, during a measurement campaign between MJD 56929 and 56959 (29th September 2014 - 29th October 2014). The fountain operation covers ~ 48 % of the total measurement duration for the period MJD 56929-56959**.** The mean frequency difference at the middle date of the each period is given in the following table:

Period (MJD)	Date of the estimation	y(HMaser40 3818 – CsFO2)	u_B	u_A	u_{Link_Maser}
56929-56959	**56944**	**-99.30**	**2.5**	**2.2**	**1.1**

Table 1: Results of the comparison in 1 × 10-16.

For the uncertainty due to the clock link $\mathbf{u}_{Link\_Lab} = 0.1\times10^{-15}$ is obtained by taking into account the actual measurement time.

The CsFO2 standard uncertainty u_B is estimated as 0.25×10^{-16} (1σ) for the relevant periods.

Accuracy

The frequency is corrected from the quadratic Zeeman, the Black Body radiation, the cold collisions and cavity pulling, microwave power dependence, and gravity.
The following table summarizes the budget of systematic effects and their associated uncertainties. The accuracy is the quadratic sum of all the systematic uncertainties.

Physical Effect	**Shifts (10^{-16})**	**Uncertainty (10^{-16})**
Second-order Zeeman effect	1069	0.10

Black-body radiation	-165.5	1.0
Gravitational shift	244.3	0.5
Resonator pulling	0.014	0.1
Purity of probe signal spectrum	0	0.1
Light shift	0	0.1
Tilting(DCP)	0.37	0.75
Microwave leakage	0	0.1
Collisions with residual gas	0	1
Microwave power dependence	0.1	1.8
Spin exchange shift (low density)*	0.4*	0.3*
Total(not including spin exchange)	**1148.1**	**2.5**

Table 2: Budget of systematic effects and uncertainties for VNIIFTRI- CsFO2 *fountain for the MJD 56929 – 56959 period*

$$u_B = 2.5 \times 10^{-16}.$$

Uncertainty due to the dead times

During the evaluation period there were gaps in the data collection (dead time) due to both intentional and unintentional breaks. Most of the unintentional breaks were caused by failures of the laser locking systems(due to rapid change barometric pressure).

Start of date of measurements (MJD)	End of date of measurements (MJD)	Duration of dead Times H:m:s	second	σ_{x_i}
56926,19	56931,67			
56933,27	56935,80	38:23:53	138233	3,25E-11
56938,51	56939,15	64:57:46	233866	3,25E-11
56940,24	56942,59	26:07:12	94032	4,42E-11
56943,34	56951,02	18:10:34	65434	4,07E-11
56951,30	56952,17	6:51:32	24692	2,20E-11
56954,40	56957,23	53:32:59	54107	3,72E-11
56957,35	56959,00	2:51:07	10267	1,38E-11

Table 3: Distribution of Dead Times for the MJD 56929– 56959 period

The standard deviation of the fluctuations of frequency due to the dead times in measurements is estimated by the ratio

$$\frac{\sqrt{\sum_i \sigma_{x_i}^2}}{T} = \sigma_{Dead\_Time}$$

Period	$\boldsymbol{\sigma}_{\text{Dead\_Time}}$
56929 - 56959	3.4E-17

The uncertainty on the link Maser is obtained by the quadratic sum of the link lab uncertainty and the uncertainty due to the dead times calculated above:

$\mathbf{u}_{Link\_Lab}=1\times10^{-16}$,

$\boldsymbol{u}_{Link\_Maser}=\sqrt{(\sigma_{Dead\_Time})^2+(\sigma_{Link\_Lab})^2}$

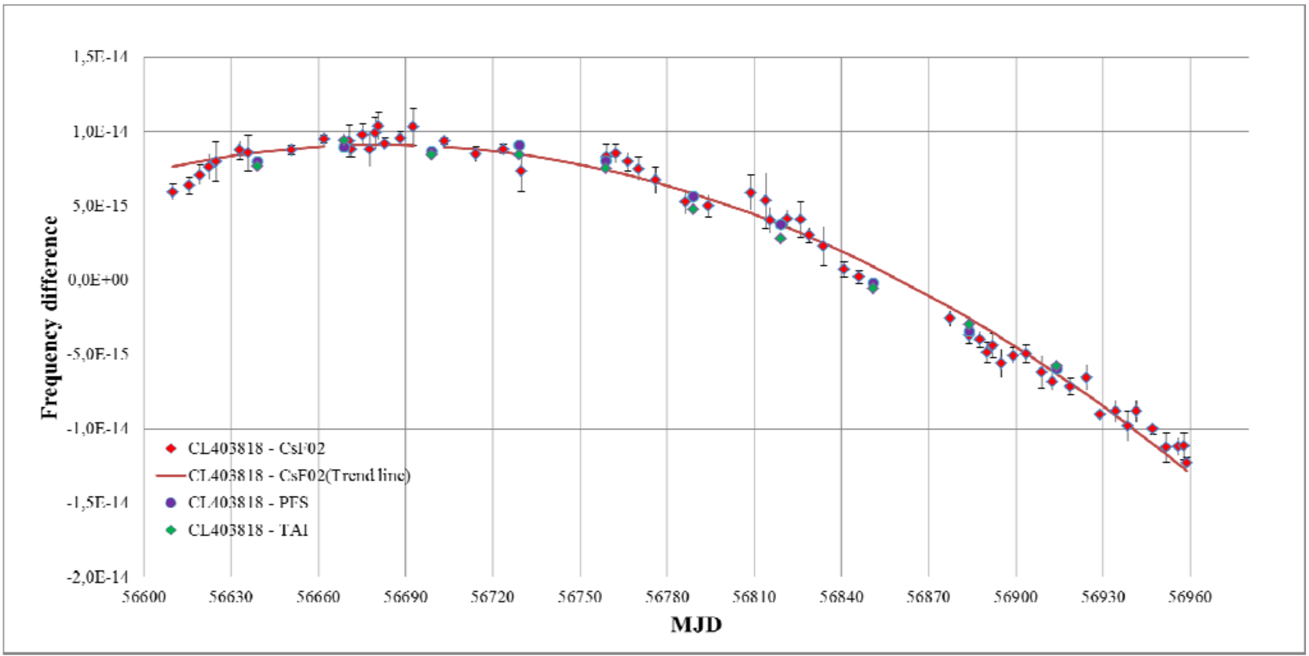
Period	$\boldsymbol{u}_{Link\_Maser}$
56929-56959	1.1E-16

References

[1] Domnin, Yu.; Baryshev, V.; Boyko, A.; Elkin, G.; Novoselov, A.; Kopylov, L.; Kupalov, D., “The MTsR-F2 fountain-type cesium frequency standard”, Measurement Techniques, Volume 55, Number 10, January 2013 , pp. 1155-1162(8)

ADDENDUM 1

Frequency measurement of H-Maser(CL40 3818) vs SU-CsF02 fountain during one year and the quadratic fit curve.



MJD	CL403818 – CsF02	U_a	MJD	CL403818 – CsF02	U_a
56609,9	5,92E-15	5,33E-16	56813,9	5,34E-15	1,85E-15
56615,7	6,35E-15	5,81E-16	56815,4	4,02E-15	8,63E-16
56619,3	7,07E-15	6,63E-16	56821,3	4,12E-15	5,81E-16
56622,3	7,61E-15	8,45E-16	56825,9	4,05E-15	1,19E-15
56624,8	7,96E-15	1,34E-15	56828,8	3,03E-15	5,01E-16
56633,0	8,73E-15	6,25E-16	56833,9	2,27E-15	1,33E-15
56635,9	8,55E-15	1,22E-15	56840,9	7,13E-16	5,18E-16
56650,8	8,75E-15	3,40E-16	56846,0	2,02E-16	4,43E-16
56662,0	9,47E-15	2,69E-16	56877,2	-2,60E-15	5,11E-16
56670,7	9,37E-15	1,10E-15	56883,8	-3,73E-15	5,48E-16
56671,3	8,81E-15	5,36E-16	56887,6	-4,01E-15	5,48E-16
56675,3	9,77E-15	7,27E-16	56890,2	-4,89E-15	7,04E-16
56677,8	8,81E-15	1,15E-15	56892,1	-4,44E-15	8,30E-16
56679,6	9,88E-15	1,05E-15	56894,9	-5,63E-15	9,67E-16
56680,7	1,03E-14	9,24E-16	56899,0	-5,09E-15	5,12E-16
56682,9	9,16E-15	4,21E-16	56903,5	-4,96E-15	6,01E-16
56688,3	9,52E-15	4,84E-16	56908,8	-6,20E-15	1,08E-15
56692,7	1,03E-14	1,24E-15	56912,7	-6,87E-15	5,44E-16
56703,3	9,35E-15	2,30E-16	56918,7	-7,18E-15	5,38E-16
56714,2	8,48E-15	4,93E-16	56924,4	-6,56E-15	8,58E-16
56723,7	8,81E-15	2,89E-16	56929,0	-9,08E-15	3,94E-16
56729,8	7,30E-15	1,36E-15	56934,3	-8,82E-15	7,24E-16
56759,1	8,29E-15	8,45E-16	56938,5	-9,84E-15	1,01E-15
56762,2	8,51E-15	6,14E-16	56941,4	-8,82E-15	7,24E-16
56766,4	7,96E-15	6,24E-16	56947,2	-1,00E-14	3,83E-16
56770,2	7,47E-15	8,08E-16	56951,7	-1,13E-14	9,99E-16
56775,9	6,72E-15	8,94E-16	56955,8	-1,12E-14	5,88E-16
56786,4	5,25E-15	8,17E-16	56957,8	-1,12E-14	8,98E-16

56794,2	5,01E-15	7,35E-16	56958,8	-1,23E-14	3,65E-16
56808,8	5,87E-15	1,16E-15			