

Comparison of Cesium Fountain Clocks in Europe and Asia

A. Zhang¹, K. Liang¹, Z. Yang¹, F. Fang¹, T. Li¹, D. Piester², V. Gerginov², S. Weyers²,
A. Bauch², M. Fujieda³, I. Blinov⁴, A. Boiko⁴, Y. Domnin⁴, A. Naumov⁴, Y. Smirnov⁴,
A. Sen Gupta⁵, P. Arora⁵, A. Acharya⁵, A. Agarwal⁵

¹Time and Frequency Division, National Institute of Metrology, Beijing, China

²Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

³Space-Time Standards Laboratory, National Institute of Information and Communications
Technology, Tokyo, Japan

⁴Scientific Research Institute of Physical-Technical and Radiotechnical Measurements, Moscow,
Russia

⁵Time & Frequency Division, National Physical Laboratory, New Delhi, India

Email: zhangam@nim.ac.cn

A remote comparison campaign of cesium fountain clocks from four National Metrology Institutes in Europe and Asia was carried out in May 2013. Six fountains at Physikalisch-Technische Bundesanstalt (PTB) Germany, Scientific Research Institute of Physical-Technical and Radio Technical Measurements (VNIIFTRI-SU) Russia, National Physical Laboratory of India (NPLI) India and National Institute of Metrology (NIM) China were compared by Two-Way Satellite Time and Frequency Transfer (TWSTFT) and GPS Carrier Phase (GPS CP) techniques. The frequency differences and the comparison uncertainties between the compared fountain pairs were evaluated and are listed in Table 1. The comparison uncertainty (u) results from combining the uncertainties of the two compared fountain clocks and the uncertainty introduced by the comparison link. It has been shown that all the frequency differences between the fountains agreed within the 1-sigma uncertainty in the low 10^{-15} level. We shall present the measurement campaign and the evaluation techniques in detail.

Table 1: Mean frequency differences and comparison uncertainties (u) in parts of 10^{-15} between the fountains

Fountains	TWSTFT	GPS CP	u
PTB CSF1-NIM	0.3	-0.1	2.3
PTB CSF2-NIM	0.5	0.1	2.2
SU CSF1-NIM	0.2	-1.1	2.9
SU CSF2-NIM	0.5	-0.8	2.2
PTB CSF1-SU CSF1	-0.1	1.1	1.2
PTB CSF1-SU CSF2	-0.7	0.5	1.0
PTB CSF2-SU CSF1	-0.2	1.0	1.8
PTB CSF2-SU CSF2	-0.8	0.4	0.8
PTB CSF1-NPLI	1.2	1.0	2.6
PTB CSF2-NPLI	1.1	0.9	2.6
NIM-NPLI	0.0	0.5	3.3
SU CSF1-NPLI	1.1	-0.1	3.1
SU CSF2-NPLI	1.8	0.6	2.6