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Development of A Wide Band Very Long Baseline Interferometry System for Time and Frequency Comparison on Intercontinental Distances.

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Abstract: NICT is developing a new VLBI system named GALA-V for frequency comparison between distant atomic frequency standards. The GALA-V system includes a pair of small radio telescopes and one medium-size radio telescope, which is necessary for increasing the signal–to-noise-ratio when observing with the small radio telescopes. Another feature of the GALA-V system is its wide observation frequency range (3-15GHz), which helps not only to overcome the disadvantages of a small antenna collecting area but also provides highly precise delay measurements.

1. Introduction

Very Long Baseline Interferometry (VLBI) has the capability to measure the baseline vector between radio telescopes on intercontinental distances. However, it has also the potential of utilizing this technology for the comparison of atomic frequency standards which are separated by several 1000s of kilometers. Fig.1 shows the results of time comparison with VLBI, GPS and TWSTFT. This experiment demonstrates that the scattering as measured with VLBI in a 1GHz band width mode (black open squares) is reduced in comparison to VLBI with a 0.5 GHz bandwidth (blue closed circles). This indicates that the group delay measurement precision can be improved by expanding the observation bandwidth.

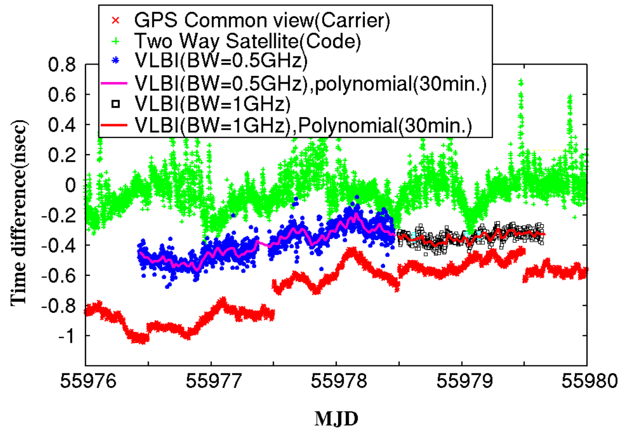

Fig. 1. Inter-comparison between multiple time-frequency transfer techniques on the 100 km Kashima-Koganei baseline.

2. New Wide Band VLBI System (Gala-V)

For VLBI based frequency comparison, we are developing a new wideband VLBI system named GALA-V which has similar specifications as the next generation wideband VLBI observation system 'VLBI2010'[1]. Our system has fixed observation frequencies at 3.2-4.2GHz, 4.8-5.8GHz, 9.6-10.6GHz, and 12.8-13.8GHz. The frequency arrangement was decided by taking into account the delay measurement performance, radio interference conditions based on field surveys, and making use of the direct sampling technique, , i.e. signals are digitized without frequency conversion by taking advantage of the aliasing effect. All of these design choices contribute to a cost reduction of the system. Fig.2 shows the transportable 1.6m radio telescope which has been designed to be easily assembled/disassembled. The GALA-V system will include a pair of these small antennas and medium size antenna (11-34m). The small antennas can be placed at frequency standard laboratories and the medium size antenna will enable VLBI observations together with the small antennas by improving the signal-to–noise-ratio, as the sensitivity of aVLBI system is proportional to the product of two antenna diameters. The anticipated precision of the delay measurements in combination with a 34m or a 11m telescope is between 6 and 8 ps for a single observation with an integration time between 7 and 40s. Test observations with this prototype system will start in 2013.

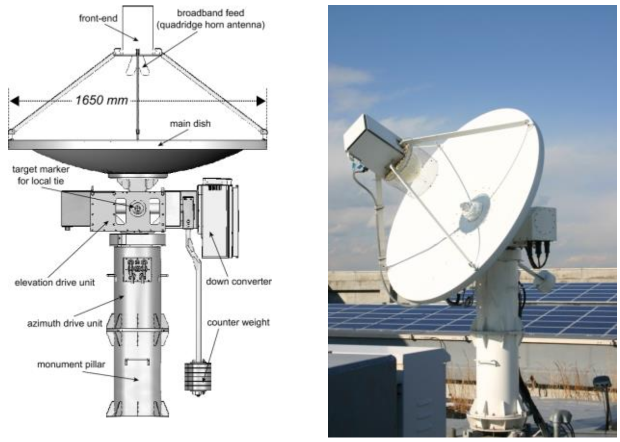

Fig. 2. 1.6m radio telescope for the GALA-V system with a wideband (3-15GHz) reception capability.

[1] Petrachenko B. Et al., "Design Aspects of the VLBI2010 System", NASA/TM-2009-214180 (2009).