NICT Technology Development Center 2014 Annual Report

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Abstract The National Institute of Information and Communications Technology (NICT) is developing and testing VLBI technologies and conducts observations with this new equipment. This report gives an overview of the Technology Development Center (TDC) at NICT and summarizes recent activities.

1 NICT as IVS-TDC and Staff Members

The National Institute of Information and Communications Technology (NICT) publishes the newsletter "IVS NICT-TDC News (former IVS CRL-TDC News)" at least once a year in order to inform about the development of VLBI related technology as an IVS technology development center. The newsletter is available at a following URL **http://www2.nict.go.jp/aeri/sts/stmg/ivstdc/news-index.html**. Table 1 lists the staff members at NICT who are contributing to the technology development center.

Table 1 Staff Members of NICT TDC as of January, 2015 (alphabetical).

HASEGAWA, Shingo	KAWAI, Eiji
KONDO, Tetsuro	KOYAMA, Yasuhiro
MIYAUCHI, Yuka	SEKIDO, Mamoru
TAKEFUJI, Kazuhiro	TAKIGUCHI, Hiroshi
TSUTSUMI, Masanori	UJIHARA, Hideki

2 General Information

We have been developing a new broadband VLBI system called Gala-V, which has not only the VGOS (VLBI2010 Global Observing System) requirements, but also upgrading cassegrain 34 m antenna by replacing feed horn. Distinguishing features of Gala-V, we apply a direct sampler called K6/OCTAD-G (code name Galas) and a broadband feed horn called Iguana. Here we report the current progress and activities.

Firstly, the compact antenna (MARBLE1) was moved from GSI in Tsukuba to National Metrology Institute of Japan (NMIJ) also in Tsukuba for a purpose of time and frequency (T&F) comparison between NICT and NMIJ. Both NICT and NMIJ keep the national time standard UTC(NICT) and UTC(NMIJ). Before the time and frequency comparison, the position of MARBLE1 was determined by geodetic VLBI session in X-band. Moreover we made a fringe test by broadband frequencies. Secondly we made a VLBI experiment for broadband with recently inaugurated GSI Ishioka 13 meter antenna on December 2014. We could successfully detect fringe in 10 GHz and 13 GHz frequency range with 1024 MHz bandwidth. It was also the memorial first fringe for Ishioka station.

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3 Time comparison between NICT and NMIJ by compact antennas

For the sake of the time and frequency transfer(T&F), we moved MARBLE1 compact antenna to NMIJ in Tsukuba (Figure 3 shows MARBLE1 on the roof of NMIJ). Before the T&F, we carried out the several VLBI sessions for determining the position of MARBLE1. Each backend of the compact antenna is a direct sampling system with no analog downconverters. Normally 1024 MHz bandwidth of X-band single channel is recorded. Since we cannot obtain any fringes between MARBLE1 in Tsukuba and MARBLE2 at NICT head quarter in Tokyo, a time difference between UTC(NICT) and UTC(NMIJ) are measured by calculating a epoch difference(baseline AB) between MARBLE1-Kashima34m(baseline AO) and MARBLE2-Kashima34m(baseline OB) via large 34 m antenna. We take into account of the Earth rotation while epoch conversion, the epoch difference is obtained by following equation,

$$\tau_{AB} = \tau_{OB} - \tau_{OA} - \dot{\tau}_{AB} \times \tau_{OA} \quad (1)$$

where $\tau showsadelay$ and its subscript valuable shows a station. Figure 2 shows a recent time comparison result including VLBI and GPS and UTC(NICT)-UTC(NMIJ) provided by BIPM on 1st and 3rd August 2014. GPS has a day boundary caused by uncertain satellite orbit, however VLBI had no day boundary and also had consistent with GPS and BIPM results.

Fig. 1 MARBLE1 compact station on the roof of NMIJ building in Tsukuba

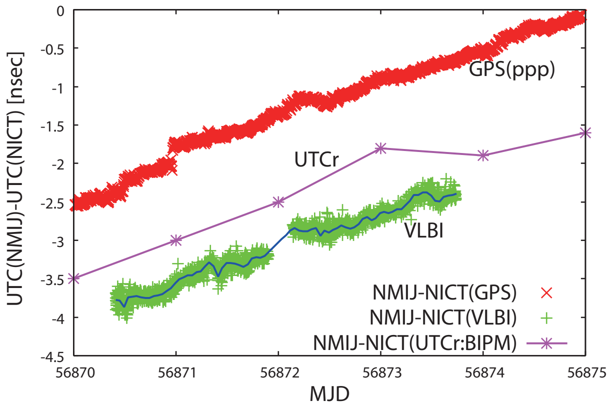

Fig. 2 A time comparison result between NICT and NMIJ, Plots include VLBI, GPS, and time difference provided by BIPM

4 Broadband fringe test between Gala-V of Kashima 34m and MARBLE1

According to latest NICT TDC annual report, we reported the simultaneously received methanol maser lines of 6.7GHz and 12.2GHz with the Gala-V system[1]. We carried out VLBI experiment of double maser lines. Each frequency downconverters were made for Gala-V for the purpose of methanol maser line. On the other hand, we set DBBC frequency of the direct sampler (nickname Galas) for MARBLE1. Figure 3 shows the fringes in frequency domain of 6.7GHz and 12.2GHz methanol maser lines from star forming region of W3OH. The 12.2GHz fringe of methanol maser was fainter than 6.7GHz one. However we could identify methanol line by checking frequency. Furthermore Kashima 34m joined cooperative observationof Japanese VLBI network (JVN) for methanol C-band session on October 2014. Since other JVN stations receive circular polarization, our linear polarization will make low SNR fringe. To make better fringes, We will install linear to circular polarization converter.

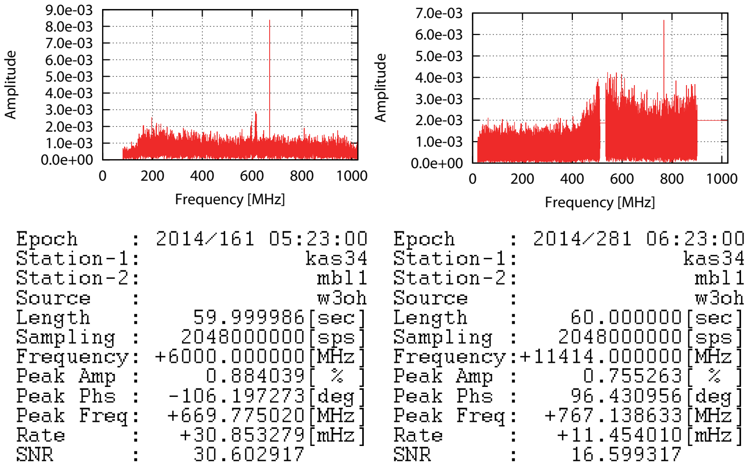

Fig. 3 Fringes of 6.7GHz and 12.2GHz methanol maser lines from W3OH between Gala-V system of Kashima 34m and MARBLE1.

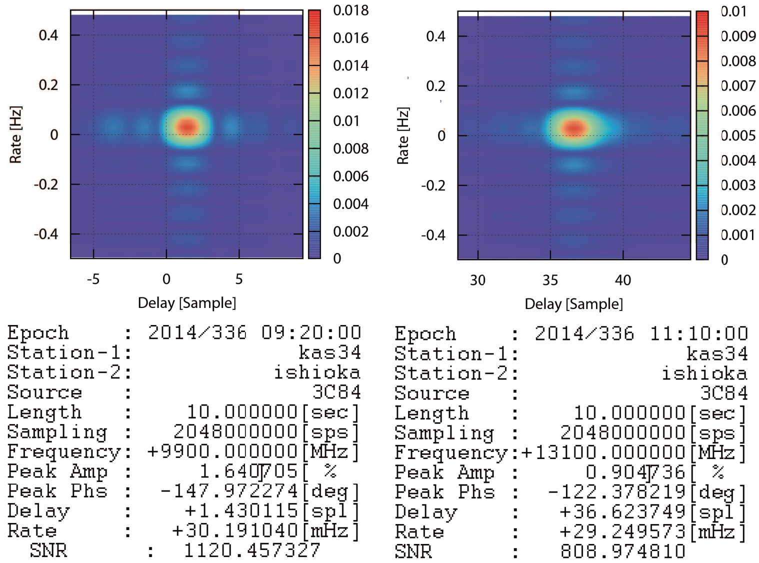

Fig. 4 First fringe between Kashima 34 meter and Ishioka 13m

5 Broadband fringe test with a VGOS-type Ishioka 13 meter

we made a VLBI experiment for broadband with recently inaugurated GSI Ishioka 13 meter antenna on December 2014. Ishioka locates north-west direction and far from Kashima about 60 km. A field system and backends included down-converters, digital samplers and VSI-recorder were moved and installed in Ishioka from Kashima, then we carried out the broadband session in 10GHz and 13GHz frequency range. A frontend cartridge of Ishioka consisted from Eleven-feed system assembled by Omnisys. The cartridge can be replaced to other feed systems such as Tri-band feed and Quad-ridge flared feed horn (QRFH). Each frequency had 1024 MHz bandwidth by 2048 MHz sampling speed and 1bit quantization. Unfortunately there was no internet connection in Ishioka, we had to send VLBI data by a car classically. Figure 4 shows the fringe map. They were memorial fringes for Ishioka station. We will expand a bandwidth of Gala-V system of Kashima 34m to 3.2 GHz to 18 GHz, so that much wider VLBI experiment are going to be planed in next summer or autumn.

6 New wideband feed (NINJA)

Two types of wideband feed NINJA have been developing for 34m and MARBLE in 3.2-14.4GHz frequency range for Gala-V. Firstly, parabolic focus feed was initially designed for MARBLE which has -10dB beam width of 50-60 degrees to opposite parabolic mirror. However, for getting a better SNR, we decided to replace the main mirror of the MARBLE 1.6m to 2.4m, from prime focus to Cassegrain focus. The NINJA feed was also redesigned for shaper 20-30 degrees beam width. Figure 5 shows initial version of NINJA feed under the far field measurement in the METLAB of Kyoto Univ. Secondary, Iguana daughter feed 2 deployed in 2014 will be left in 34m. Furthermore NINJA feed, which is newly developed for 34m, will be installed beside the Iguana in this spring. Figure 6 shows the NINJA feed and Iguana prototype 1. Near side feed shows prototype, which is currently used for initial checking such as aperture efficiency in early 2014. Far side feed will be for 34m without beam shaping lens

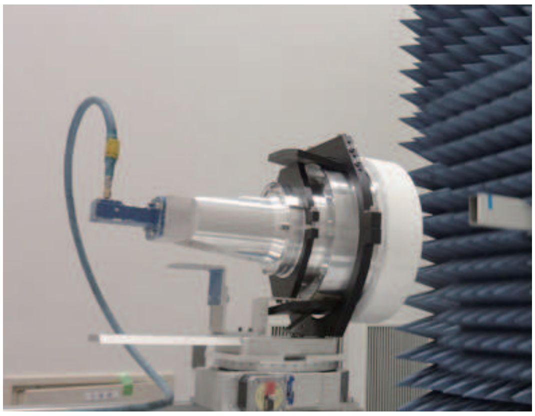

Fig. 5 Initialy designed wideband NINJA feed equipped beam shaping lens.

Fig. 6 NINJA feeds displayed in Micro Wave Exhibition 2014 in Yokohama, Japan.

7 Future Plans

The upgrade is on going to the Kashima 34m antenna for wider bandwidth such as 3.2-18GHz. The NINJA feed will be installed in this spring. We also have a plan to install cryogenic receivers hopefully in next fiscal year.

References

1. Kazuhiro Takefuji, Hideki Ujihara, NICT Technology Development Center 2013 Annual Report, in International VLBI Service for Geodesy and Astrometry 2013 Annual Report, edited by K. D. Baver, D. Behrend, and K. L. Armstrong, NASA/TP-2014-217522, 2014.