NICT/Kashima 34-m Report for 2019-2020

Mamoru Sekido and Eiji Kawai

Abstract The NICT Kashima 34-m diameter radio telescope had regularly participated in IVS sessions until 18 August 2019 (R1908). A strong typhoon (Faxai) passed through east coast of Japan on 9th September 2019. It has seriously damaged the elevation drive and main structure of the Kashima 34-m antenna. The antenna stopped the operation since then and decided to be dismantled in 2020-2021.
The station had been maintained by VLBI group of Space Time Standards Laboratory of NICT. VLBI application for precision frequency transfer is the main project of this group. A series of broadband VLBI experiments for comparison of optical frequency standards had conducted between Italy and Japan in 2018-2019. Small dimeter (2.4 m) antenna pair was deployed at Medicina radio Astronomical Station in Italy and at NICT headquarters at Koganei in Tokyo. Kashima 34-m antenna participated in the experiments as a 'hub' station for boosting the SNR of VLBI observation.
In addition to frequency transfer VLBI project and geodetic IVS sessions, the antenna has participated in astronomical VLBI observations of Japan VLBI network (JVN).

1 General Information

VLBI activity of NICT is operated by a group of Space-Time Standards Laboratory (STSL) of National Instate of Information and Communications Technology (NICT). The STSL is keeping Japan Standard Time (JST) at Koganei headquarters in Tokyo, and development of optical lattice clocks is a part of its activity. VLBI group is working at the Kashima Space Technology Center, where two radio telescopes: Kashima 34-m and Kashima 11-m, are located. Future re-definition of the 'second' with optical frequency standards instead of current cesium atom has been discussed in metrological community [1]. Based on the requirement of accurate comparison of optical frequency standards toward re-definition of second, NICT has conducted development of broadband VLBI system as a tool of long-distance frequency transfer.

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2 Activities during the Past Year

Transportable broadband VLBI station (MARBLE) was installed at Medicina radio astronomical station in 2018, then broadband VLBI experiments were intensively conducted with the network of two small VLBI stations and Kashima 34-m antenna.

Our broadband VLBI system [2] is capable to observe wide frequency range (3.2 GHz - 14 GHz), which is similar that of VGOS specification [3]. Unique features in our data acquisition system are full digital signal processing and utilizing virtual delay via Node-Hub style (NHS) VLBI scheme. Radio frequency signal is directly digitized by 16 GHz sampling, then desired frequency bands are extracted via digital signal processing without analog frequency conversion. The NHS is a scheme utilizes virtual delay observable derived by linear combinations of two baselines from three stations forming a triangle shape. It enables VLBI observation between small diameter antenna pair with

Fig. 1 Picture of Kashima 34-m antenna on 16 June 2019.

high sensitivity hub station. We have successfully applied this technique for geodesy and frequency transfer VLBI [4]. Please refer to literature [2] for more technical details.

Table 1 shows experiment codes of VLBI sessions in which Kashima 34-m antenna participated in 2019-2020. Broadband VLBI experiments were conducted as the main mission of our group. There observations were made by the network of two 2.4-m antenna at Medicina and Koganei and 34-m antenna at Kashima.

In addition to participation in IVS sessions, Kashima 34-m antenna has been supporting domestic astronomical VLBI observations conducted by University collaboration JVN [5].

The typhoon 'Faxai' with strong wind has passed through east coast of Japan on 9th September 2019. Elevation drive system and part of structure of the antenna was seriously damaged. By taking into account its deterioration, dismantlement of the antenna was decided. R1908 of IVS/R1 session performed on 21 August 2019 was the last IVS observation for the Kashima 34-m antenna.

Table 1 VLBI experiments of Kashima 34-m antenna during 2019-2020.

IVS and AOV sessions

Session code	Length [h]
rd1901 rd1902 rd1903 r1899 aov034 aov036 r1902 r1906 r1908 crf112 t2133	24

Broadband VLBI experiments

Session code	Length [h]
gv9015 gv9025 gv9035 gv9045	29-36
gv9091 gv9095 gv9137 gv9146	52-78
gv9150 gv9163 gv9184 gv9199	108-168
gv9212	40.5

Astronomical VLBI obseravtions.

Session code	Length [h]
u9083 u9084 u9085 u9086 u9087 u9088 u9089 u9090 u19052 u19191 u19192 u19206 u19207 u19208 u19219 u19220 u19221	1.4-10.3

Fig. 2 Broadband 'NINJA' feed mounted on Kashima 34-m antenna.

3 Brief history

Kashima VLBI group of NICT has long history in VLBI technology development. It started from a TELEX received from NASA/GSFC in 1971 for invitation of collaboration. Proving plate tectonics by the first detection of contraction of the baseline between Kashima and Hawaii was accepted as big news in Japan. Understanding of crustal deformation around Japan islands gave citizens a hope for potential prediction of earthquake. Based on those great achievement by the Kashima 26-m, the Kashima 34-m antenna was constructed as the first VLBI-dedicated antenna in Japan in 1988 [6]. The antenna was manufactured by TIW Systems Inc. of USA, and it has quite similar structure with 34-m antenna at Goldstone and Canberra of the NASA's deep space network. The Kashima 34-m was designed not only for geodesy (S/X-band), but also for radio astronomical observations (L,K,Q-band) in the scope.

Originally designed wideband 'NINJA' feed [7] (Fig. 2) was installed by replacement with C-band on the trolley No.3 in 2015. Receiver parameters of Kashima 34-m antenna is listed in Table 2. It participated in many VLBI observations and has been used for variety of technology developments. A series of VLBI observation systems (K3/K4/K5) [8, 9] and rapid UT1 determination with e-VLBI [10] contributed to the geodetic VLBI community. Please refer to a literature [11] for achievement of the Kashima 34-m antenna.

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Table 2 Parameters of receiver system of Kashima 34-m antenna. Letters in 6th column 'L' and 'R' represents left- and right-hand circular polarizations: LHCP, and RHCP, respectively. 'V' and 'H' represents linear polarization in vertical and horizontal directions. Tsys with '*' indicates effective system temperature measured by R-Sky Y-factor measurement.

Band	Freq [GHz]	Tsys [K]	Efficiency [%]	SEFD [Jy]	Polarization	Trolley Group	Note
L	1.405-1.440,1.600-1.720	80	68	200	L/R	1	Superconductor filter
S	2.193-2.35	72	65	340	L/R	2	
Wide	3.2-14	150*	20-40	1k-2k	V/H	3	Room temperature LNA
X	8.18-9.08	50	65	270	L/R	2	
K	22.0-24.0	141	50	850	L(R)	4	
Q	42.3-44.9	350	20	3500	L(R)	4	

Fig. 3 Left: Bottom view of the Kashima 34-m antenna receiver room. Receivers are separated into four groups and mounted on one of four trolleys. Observing receiver is changed by exchanging the torolleys at the focal point (center). Right: Kashima 34-m antenna and flowers.

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