NICT Kashima 34-m Report for 2019–2020

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

1 General Information

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

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2 Activities during the Past Year

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

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

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

triangle. It enables VLBI observations between a small diameter antenna pair with a high sensitivity hub station. We have successfully applied this technique for geodesy and frequency transfer VLBI [4]. Please refer to [2] for more technical details.

Table 1 shows experiment codes of VLBI sessions in which the 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 antennas at Medicina and Koganei and the 34-m antenna at Kashima.

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

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

Table 1 VLBI experiments of the 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

Table 2 Parameters of the receiver system of the Kashima 34-m antenna. Letters in 6th column ‘L’ and ‘R’ represent 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	

3 Brief History

The Kashima VLBI group of NICT has a 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. The understanding of crustal deformation around the Japanese islands gave citizens a hope for potential prediction of an earthquake. Based on those great achievements 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 as the 34-m antenna at Goldstone and Canberra of NASA’s deep space network. The Kashima 34-m was designed not only for geodesy (S/X-band), but also had the capability for radio astronomical observations (L-, K-, and Q-band) in its scope.

Fig. 2 Broadband ‘NINJA’ feed mounted on the Kashima 34-m antenna.

The originally designed wideband ‘NINJA’ feed [7] (Figure 2) was installed by replacement with C-band on the trolley No.3 in 2015. The receiver parameters of the Kashima 34-m antenna are listed in Table 2. It participated in many VLBI observations and was used for a 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 [11] for achievement of the Kashima 34-m antenna.

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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 trolleys at the focal point (center). **Right:** The Kashima 34-m antenna and flowers.

for their contribution to keep the antenna operational for 30 years.

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