Kashima 34-m VLBI Station

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Abstract The Kashima 34-m radio telescope has recovered from the damages to the azimuth wheel and rail caused by the 'Tohoku Earthquake' in March 2011. VLBI observations, including IVS sessions and single dish observations, have restarted from April 2013. A newly developed wideband feed was mounted on the antenna. The frequency range of 6.4-14 GHz observations in single linear polarization became available. Further development of the improved feed for the 2-18 GHz frequency range is under progress and expected to be ready in 2014.

1 General Information

Fig. 1 The Kashima 34-m Radio Telescope in November 2013.

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The main facility of the Kashima VLBI station is the 34-m diameter antenna of modified Cassegrain focus type. This antenna is maintained and operated by the VLBI group of Space Time Standard Laboratory in the National Institute of Information and Communications Technology (NICT). The station is also a part of the Kashima Space Technology Center (KSTC) as a local branch of the NICT.

Kashima city is located on the east coast of the main island of Japan. The "Tohoku earthquake" that occurred in March 2011 affected Kashima city and the KSTC by destruction of some buildings and a tsunami. An azimuth wheel and rails of the 34-m antenna were damaged by the earthquake. The replacement work of the four azimuth wheels and all the azimuth rail wear-strip plates was done by the end of March 2013. Figure 2 shows the new wheel installed in March 2013. Alignment of each wheel was adjusted by using a telescope attached at the wheel axis, so that the wheel axis is exactly aligned to the central axis of azimuth circle with accuracy of 1.e-5 radians. It is important so that the

Fig. 2 Installation work of new azimuth wheel.

wheel rolls on the azimuth rail circle without stress. The flatness of the rail height was required to be within 0.1 mm RMS over the 10-m radius azimuth circle, which comes from the requirement of antenna tracking accuracy within a tenth beam width for the 43 GHz receiver. The repair work was completed by the end of March 2013, and work began with the same performance as before the earthquake.

2 Component Description

2.1 Receivers

The Kashima 34-m antenna is equipped with multiple receivers from its lowest frequency in L-band up to Q-band. The performance parameters for each frequency are listed in Table 1. Multiple receivers are changed by exchanging receiver systems at the focal point of the antenna. Each receiver is mounted on one of the four trolleys and only one trolley can be at the focal position. The focal position can also be moved by changing the position and direction of sub-reflector via five axes of actuators. Thus optimum sub-reflector positions are adjusted for each receiver. When a feed system is newly mounted the sub-reflector position is adjusted for that.

L-band:

Radio Frequency Interference (RFI) from the cell phone base station (1,480 MHz) has become too strong even to saturate the low noise amplifier (LNA) of the first stage in the L-band receiver. We installed a superconductor filter in front of the LNA, whose pass-band is 1405-1440 MHz and 1600-1720 MHz. Installation of the filter was completed in December 2013, and we confirmed that the problem of LNA saturation has been solved.

S-band:

A high temperature superconductor filter has been used in the S-band receiver since 2002 to avoid RFI of cell phone IMT-2000. It was located after the LNA instead of before it because the RFI was not severe enough to saturate the LNA. On 12 November 2013, the superconductor filter lost its function because of the increase of the filter temperature caused by aging of the cryogenic system. We replaced the filter with a standard bandpass filter in December. Consequently, its observation frequency range was slightly changed to 2,210-2,350 MHz.

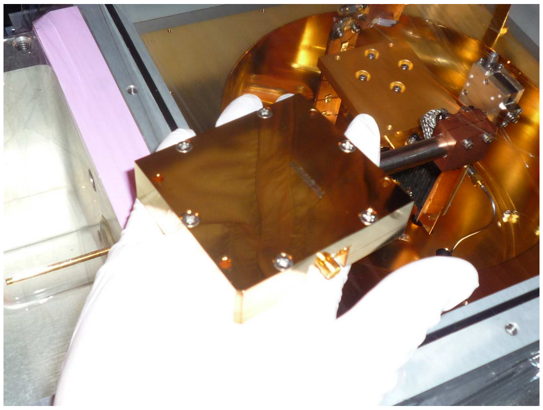

Fig. 3 Superconductor Filter installed inside L-band receiver dewar.

Wideband:

As one of the important components of the Gala-V project, which is aimed to make precise frequency comparisons over a long baseline, a new feed system (code name: IGUANA) with wideband observation capability was developed and mounted in place of the C-band receiver trolley of the 34-m antenna. Room temperature wideband LNA is used for one linear polarization in that receiver. The current performance of this antenna is 20-40% efficiency for the 6.4-14 GHz frequency range [1]. A more improved feed is planned to be installed in 2014.

32 GHz and 43 GHz Receivers:

Startup work on these two receivers is currently not completed. Therefore, system performance parameters are not measured in this report.

Table 1 Antenna Performance parameters of the Kashima 34-m telescope.

Receiver	Pol.	Frequency	Parameter (2013)
L-band	RHCP/LHCP	1405-1440MHz, 1600-1720MHz	SEFD ~ 500Jy
S-band	RHCP/LHCP	2210-2350MHz	SEFD ~ 250Jy
X-band	RHCP/LHCP	8180-9080MHz	SEFD ~ 370Jy
WIDE	V-Linear Pol.	6.4-15GHz	SEFD ~ 1500 Jy
K-band	LHCP	22 - 24 GHz	SEFD ~ 1300 Jy
Ka-band	RHCP	31.7-33.7GHz	NA
Q-band		42.3-44.9GHz	NA

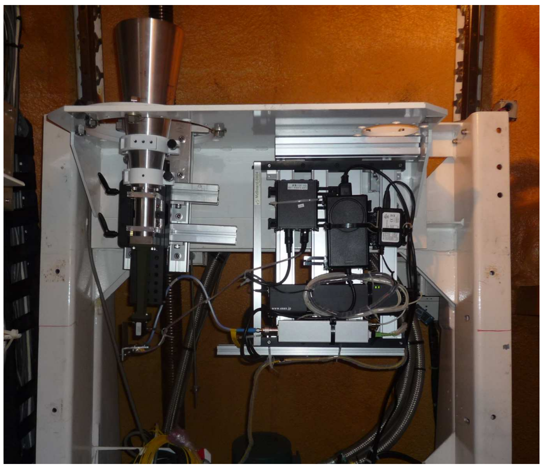

Fig. 4 Wideband (IGUANA) feed installed in the receiver room of Kashima 34m telescope.

2.2 Data Acquisition System

Several VLBI data acquisition systems have been developed and installed in the Kashima 34-m telescope.

K5/VSSP32 [2]: has been employed for all geodetic VLBI observations as a multi-channel data acquisition system.

K5/VSI data recording systems: is composed of a PC-VSI data capture card (PCI-X interface) and a PC with raid disk systems. This system has been used in combination with an ADS3000+ sampler for wideband observations (1024Msps/1ch/1bit, 128Msps/1ch/8bit).

K6/OCTAD-G (code name 'GALAS') sampler: is the newly developed sampler for the Gala-V project [3]. The GALAS samples the RF signal without frequency conversion and acquires four wideband signals with 1024 MHz bandwidth via the digital filter function implemented in it. This sampler is under evaluation and will be employed for the project in 2014.

K4/VSOP terminal: has been used for joint astronomical observations with JVN [4].

Network Connections and Data Server

Due to the collaboration with JGN-X, a high speed research network provider hosted by NICT, the 10 Gbps network is available between the Kashima and Koganei stations. Due to the limiting of network switch and connection, the VLBI data server used for e-VLBI data transfer is connected via 1 Gbps network to the Internet. Therefore about 600 Mbps in/out transfer speed is constantly available. Currently three data servers are operated for e-VLBI data exchanges (Table 2).

Table 2 Data servers at Kashima Station and its capacity.

Hostname	Path	Disk Size
vlbi2.jp.apan.net	/vlbi2/	12 T Bytes
k51b.jp.apan.net	/vlbi3/	26 T Bytes
k51c.jp.apan.net	/vlbi4/	24 T Bytes

3 Staff

Kawai Eiji: is the main engineering researcher in charge of the hardware maintenance and the operation of the Kashima 11-m and 34-m antennas [5]. He is responsible for routine geodetic VLBI observations for IVS.

Hasegawa Shingo: is supporting staff for IVS observation preparation and maintenance of file servers for e-VLBI data transfer.

Tsutsumi Masanori: is supporting staff for data acquisition PCs and networks.

Takefuji Kazuhiro: is a researcher using the 34-m antenna for the Gala-V project and the Pulsar observations. He performed startup work of the wideband IGUANA receiver including adjusting sub-reflector position and measured the SEFD of the new receiver.

Ujihara Hideki: has designed the new wideband IGUANA feed.

Ichikawa Ryuichi: is in charge of keeping GNSS stations and GNSS observations.

Sekido Mamoru: is responsible for the Kashima 34-m antenna as the group leader. He is maintaining Field System FS9 software for this station and operating the Kashima and Koganei 11-m antennas [5] for IVS sessions.

4 Current Status and Activities

The Kashima 34-m telescope has completely recovered from the damage of the "Tohoku earthquake" and has rejoined VLBI observations (IVS-T2, IVS-CRF, JADE, and JVN) and single dish observations (Sgr-A* and Jupiter) since April 2013. Strong RFIs in L-band became more severe from cell phone base stations. We observed saturation of LNA in the worst case scenario and decided to introduce a superconductor filter in front of the LNA as a countermeasure. Production and installation of the filter was completed in December 2013. Now we confirmed that the filter suppresses RFI signal from cell phone base stations and receiver performance was recovered.

The main mission of the VLBI group of NICT is the development of VLBI systems for distant frequency comparison. That project, named GALA-V [3], includes upgrading the receiver of the 34-m telescope to enable wideband observation in frequency range 2.2 - 18 GHz, which covers the frequency range (2-14 GHz) of VGOS [6]. Based on the requirement of narrow beam width on the wideband feed, original designing of the feed system was made for the 34-m telescope.

5 Future Plans

Evaluation of the wideband receiver system will be performed in 2014. Additionally, an improved version of the feed is under development and expected to be ready in the first half of 2014. Wideband VLBI observations in combination with small diameter antennas and the Kashima 34-m telescope will be performed, and engineering evaluation including feed, sampler, and phase calibration systems will be made.

Acknowledgements

The development of the wideband feed was supported by the "Joint Development Research" fund provided from the National Astronomical Observatory of Japan in 2013. We acknowledge Professor K. Fujisawa of Yamaguchi University and M. Honma and M. Matsumoto of NAOJ for supporting this development. We thank the research network JGN-X and the Information System Section of NICT for supporting the network environment for e-VLBI.

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