Kashima 34-m VLBI Station

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Abstract The Kashima 34-m diameter radio telescope is maintained by Space Time Standards Laboratory of NICT. Development of its broadband VLBI system has been conducted in the frequency transfer project. Its narrow beam width broadband feed was originally developed for a Cassegrain type 34-m antenna, and the first light observation was performed successfully in January 2014. In addition to the R&D VLBI experiments for frequency transfer and astronomical observations, the 34-m radio telescope has been regularly participating in IVS sessions.

1 General Information

Fig. 1 The Kashima 34-m radio telescope.

The 34-m diameter radio telescope has been maintained and operated by the VLBI group of Space Time Standards Laboratory (STSL) in the National Institute of Information and Communications Technology (NICT). It is located in the Kashima Space Technology Center (KSTC), which is at the east coast of the main island of Japan. Development of VLBI technology for distant frequency transfer (project name: GALA-V) is the current main mission of the VLBI project in NICT. Development of a broadband VLBI observation system is conducted in the GALA-V project. The observation frequency range and data acquisition system (DAS) of the GALA-V project are designed in the scope of joint VLBI observations with a VGOS system.

2 Component Description

2.1 Receivers

The Kashima 34-m antenna has multiple receiver systems from L-band up to Q-band. The performance parameters for each frequency are listed in Table 1. Receiving bands are changed by exchanging receiver systems at the focal point of the antenna. Each receiver is mounted on one of four trolleys, and only one trolley can be at the focal position. The focal point is adjusted by the altitude of the sub-reflector via motion of five axes actuators. When a feed system is newly mounted, the sub-reflector position is adjusted for that. The detail of each receiver status is as follows:

L-band: Influence of Radio Frequency Interference (RFI) caused by a cell phone base station was reduced by installation of a superconductor filter in

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

Receiver	Pol.	Frequency	SEFD [Jy]
L-band	RHCP/LHCP	1405-1440MHz, 1600-1720MHz	∼ 500
S-band	RHCP/LHCP	2210-2350MHz	∼ 250
X-band	RHCP/LHCP	8180-9080MHz	∼ 370
Wideband	V-Linear Pol.	6.4-15GHz	∼ 1000 – 2000
K-band	LHCP	22 - 24 GHz	∼ 1300
Ka-band	RHCP	31.7-33.7GHz	NA
Q-band		42.3-44.9GHz	∼4500

front of the LNA by the end of 2013. The L-band receiver performance almost recovered and has been used for pulsar observations.

S-band: Although there are some RFI signals in S-band, that is not so strong to saturate the LNA at the first stage. Thus the signal at an unncessary frequency is supressed by bandpass filter after the LNA. This bandpass filter was exchanged from a superconductor filter, which has been used for ten years, to a standard one in the end of 2013. Consequently, its observation frequency range was slightly changed to 2,210—2,350 MHz.

Wideband: One of the important components of the GALA-V project is the development of a broadband receiver for a large diameter antenna. Because the well-known Eleven-feed [1] and QRFH [2] broadband feeds have broad beamwidths (90-120 degrees), thus they cannot be used for the 34-m antenna, whose viewing size of subreflector from the focal point is 34 degrees. Thus, a new broadband feed with a narrow beam width has been originally developed. A prototype of the new broadband feed (code name: IGUANA) was mounted on the trolley of the C-band receiver with a room temperature LNA. The receiver has one linear (V) polarization property, and its system equvalent flux density (SEFD) is 1000—2000 Jy at the 6.5—15 GHz frequency range. A more improved feed with a broader frequency range and higher efficiency is under development.

22 GHz: This receiver has one Left Hand Circular Polarization (LHCP). The receiver performance is stable and the receiver has been used for astronomical observations.

43 GHz: Re-adjustment of the subreflector position was performed at the end of 2014, and this receiver system was re-activated.

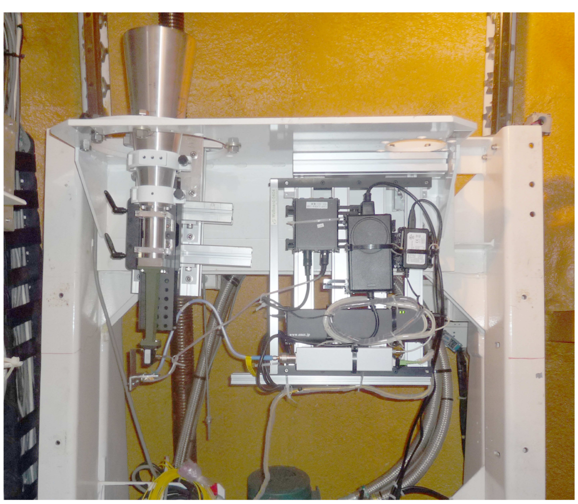

Fig. 2 Broadband (IGUANA) feed installed in the receiver room of the Kashima 34-m telescope.

2.2 Data Acquisition System

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

K5/VSSP32: is a multi-channel data acquisition system [3] and is compatible with a Mark 5 system via data format conversion. Thus most of geodetic VLBI observations are perfomed with this DAS.

K5/VSI: is a data recording system composed of a PC-VSI data capture card (PCI-X interface) and a PC with RAID disk systems. This system is used in combination with samplers (ADS1000, ADS2000, ADS3000, and ADS3000+) with a VSI-H interface. The ADS3000+ sampler is capable of broadband observations (1024 Msps/1ch/1bit, 128 Msps/1ch/8bit) and multi-channel digital BBC function. Thus combination use of ADS3000+ and

K5/VSI is essentially compatible with K5/VSSP32 and Mark 5 DAS.

K6/OCTAD-G (code name GALAS): is the newly developed sampler for the GALA-V project [4]. Output data streams come out from 10 Gbit-Ether, and are recorded by a PC system composed of 10 Gbit-Ether and RAID disk system. A new design aspect of GALAS is so called direct sampling, which directly captures the data without frequency conversion. The sampling rate of GALAS is selectable from 16.384 GHz and 16.0 GHz. The former sampling rate is used for capturing a signal with 1024 MHz bandwidth at an arbitrary frequency via a digital filter. The latter sampling rate is designed for an experimental data acquisition mode, which captures four pre-filtered RF frequency signals with 1.6 GHz bandwidth at 3.2, 4.8, 9.6 and 12.8 at once. More details are discussed in “NICT Technology Development Center 2014 Annual Report” in this volume.

K4/VSOP terminal: has been used in domestic astronomical observations.

10 Gbps Network Connections and Data Server

A local area network (LAN) connecting data acquisition systems and software correlator PCs inside NICT (Kashima and Koganei) has been upgraded to 10Gbit-Ethernet. The outgoing network for IVS e-transfer was upgraded from 1 Gbps to 10 Gbps through JGN-X[1] and APAN[2] network. The data servers operated for e-VLBI data exchanges are listed in Table 2. Currently only k51c.jp.apan.net has 10 Gbps NIC (Network Interface Card), but others have 1 Gbps. This situation will be improved in 2015.

Table 2 Data servers at Kashima Station and its capacity.

Hostname	Path	Disk Size	Network Speed
vlbi2.jp.apan.net	/vlbi2/	12 T Bytes	1 Gbps
k51b.jp.apan.net	/vlbi3/	26 T Bytes	1 Gbps
k51c.jp.apan.net	/vlbi4/	24 T Bytes	10 Gbps

[1] Next generation Network Testbed `http://www.jgn.nict.go.jp/`

[2] Asia-Pacific Advanced Network `http://www.apan.net/`

3 Staff

KAWAI Eiji: is the main engineer in charge of the hardware maintenance and the operation of the Kashima 11-m and 34-m antennas. He is responsible for routine geodetic VLBI observations for IVS.

HASEGAWA Shingo: is the supporting engineer for IVS observation preparation and maintenance of file servers for e-VLBI data transfer.

TSUTSUMI Masanori: is the supporting engineer for maintenance of data acquisition PCs and computer network.

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 broadband IGUANA receiver including adjusting the subreflector position and measurement of the SEFD of the new receiver.

UJIHARA Hideki: designed the new broadband IGUANA feed.

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

TAKIGUCHI Hiroshi: is a researcher for analysis of T&F transfer and geodesy with GNSS observations and VLBI data.

SEKIDO Mamoru: is responsible for the Kashima 34-m antenna as the group leader. He maintains FS9 software for this station and operates the Kashima and Koganei 11-m antennas [6] for IVS sessions.

4 Current Status and Activities

The main mission of the VLBI project of NICT is the development of VLBI systems for distant frequency transfer. In that project, named GALA-V [4], upgrading the receiver of the 34-m telescope to enable broadband observation in frequency range 3.2 — 15 GHz is being conducted. Because the beamwidths of known broadband feeds [1, 2] are too wide to be used in the 34-m radio telescopes, where the beamwidth has to be 34 degrees in diameter, we have developed our original broadband feed with narrow beamwidth property. The first prototype of the IGUANA feed, which has sensitivity at the 6.5 — 15GHz frequency range, was installed in the 34-m anntena. Its first light observation was made in January 2014. Simultaneous observation

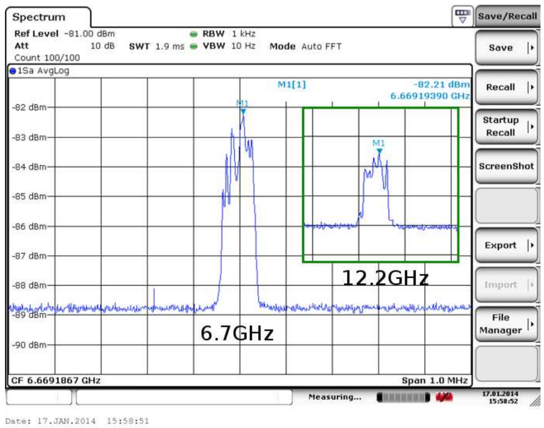

Fig. 3 Frequency spectrum of methanol maser line at 6.7 GHz and 12.2 GHz from radio source W3OH. The two spectral lines are simultaneously observed in the first light observation with broadband feed mounted on the 34-m antenna.

of spectral lines at 6.7 GHz and 12.2 GHz (Figure 3) demonstrated the impact of the broadband feed in astronomical observation. This new feed enables upgrading of the existing Cassegrain type antenna for broadband observation.

The broadband system is of course intended to make joint observations with VGOS [7] systems. Joint observations and compatibility with the VGOS system developed by Haystack Observatory is being discussed.

5 Future Plans

International test observations with the broadband feed is being planned under collaboration among Haystack, NASA/GSFC, and NICT. The first test observing was successfully finished in January 2015.

T&F observations with broadband VLBI will be conducted in 2015 as the main mission of the GALA-V project. In 2014, small diameter antennas were installed at NICT Koganei and NMIJ (National Metrology Institute of Japan) Tsukuba, where optical frequency standards are being developed. VLBI experiments for frequency comparison between UTC[NICT] and UTC[NMIJ] will be conducted with the 34-m antenna for boosting the sensitivity.

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