Kashima 34-m VLBI Station

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

1 General Information

Fig. 1 The Kashima 34-m Radio Telescope.

NICT Space-Time Standards Laboratory/Kashima Space Technology Center

NICT Kashima Network Station

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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 current main mission of the VLBI projct in NICT. Development of 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 observation with 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 the four trolleys and only one trolley can be at the focal position. The focal point is adjusted by altitude of sub-reflector via motion of five axes actuators. When a feed system is newly mounted, the sub-reflector position is adjusted for that. Detail of each receiver status is as follows:

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

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. L-band receiver performance was 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 signal at unncessary frequency is supressed by bandpass filter after the LNA. This bandpass filter was exchanged from superconductor filter, which has been used for ten years, to standard one in the end of 2013. Consequently, its observation frequency range was slightly changed to 2,210-2,350 MHz.

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

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

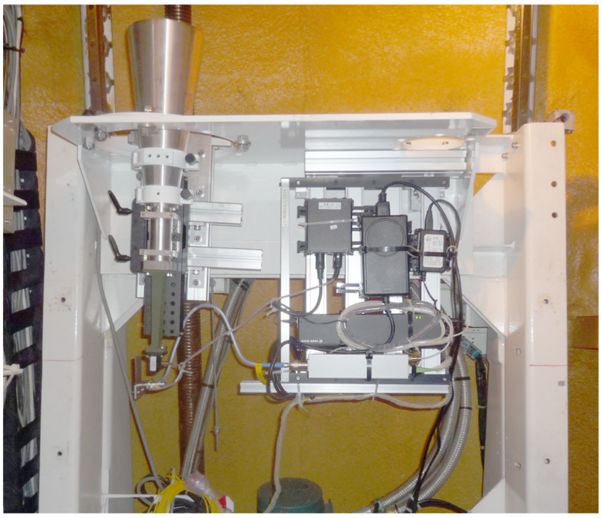

Fig. 2 Broadband (IGUANA) feed installed in the receiver room of Kashima 34m telescope.

2.2 Data Acquisition System

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

K5/VSSP32 : This DAS is multi-channel data acquisition systemhas [3] and is compatible with Mk5 system by data format conversion. Thus most of geodetic VLBI observations are perfomed with this DAS.

K5/VSI : is data recording systems 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 sampers (ADS1000.ADS2000,ADS3000, and ADS3000+) with VSI-H interface. The ADS3000+ sampler is capable of broadband observations (1024Msps/1ch/1bit, 128Msps/1ch/8bit) and multi-channel digital BBC function. Thus combination use of ADS3000+ and K5/VSI is essentially compatible with K5/VSSP32 and Mark5 DAS.

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

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

10 Gbps Network Connections and Data Server

Local area network (LAN) connecting data acquisition systems and software correlator PCs inside NICT (Kashima,Koganei) has been upgraded to 10Gbit-Ether. Out going 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 supporting engineer for IVS observation preparation and maintenance of file servers for e-VLBI data transfer.

TSUTSUMI Masanori: is 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 sub-reflector position and measurment of 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 is maintaining FS9 software for this station and operating 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. Since beamwidth of known broadband feed[1, 2] is too wide to be used in 34-m radio telescope, where beamwidth have to be 34 deg. in diameter. Thus we have developed our original broadband feed with narrow beamwidth property. The first prototype of the IGUANA feed, which has sensitivity at 6.5 - 15GHz frequency range, was installed to 34-m anntena. Its the first light observation was made in Jan-

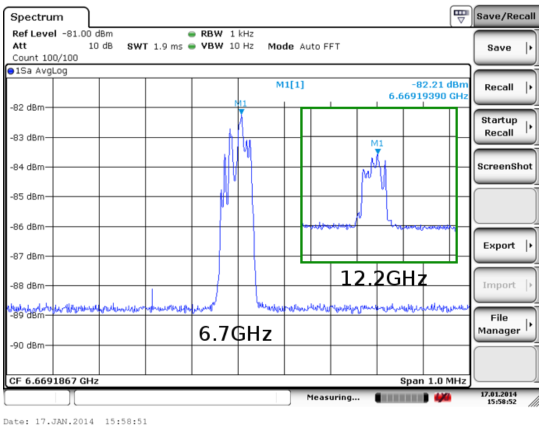

Fig. 3 Frequency spectrum of Methanol Maser line at 6.7 GHz and 12.2 GHz from radio source W3OH. The two spectral lines are simultaneously observed in the first light observation with broadband feed mounted on 34 m antenna.

uary 2014. Simultaneous observation of spectral line at 6.7 GHz and 12.2 GHz (Fig. 3) demonstrated the impact of broadband feed in astronomical observation. This new feed enables upgrade of existing Cassegrain type antenna for broadband observation.

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

5 Future Plans

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

T&F observation with broadband VLBI will be conducted in 2015 as the main mission of GALA-V project. In 2014, small diameter antennas has been 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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