Kashima 34-m VLBI Station

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Abstract Kashima 34-m radio telescope has recovered from the damages on the azimuth wheel and rail caused by the 'Tohoku Earthquake' in March 2011. VLBI observations including IVS sessions and single dish obsrvations have re-started from April 2013. Newly developed wideband feed was mounted on the antenna. Frequency range of 6.4-14GHz observation in single linear polarization became available. Further development of the improved feed for 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 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 at the east coast of the Japan main island. "The Tohoku earthquake" occurred in March 2011 affected to Kashima city and the KSTC by destruction of some buildings and Tsunami. An azimuth wheel and rails of the 34-m antenna was damaged by the earthquake. The replacement work of the four azimuth wheels and all the azimuth rail (wearstrip plates) has been done by the end of March 2013. Fig. 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 stresses. 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 of 43GHz receiver. The repair work has finished by the end of March 2013 and started to work with the same performance with that before the earthquake.

2 Component Description

2.1 Receivers

Kashima 34m antenna is equipped with multiple receivers from lowest frequency in L-band up to Q-band. The performance parameters on 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 position and direction of sub-reflector via 5 axes of actuators. Thus optimum sub-refractor positions are adjusted for each receiver. When new feed system is mounted, thus sub-reflector position is adjusted for that.

L-band:

Radio Frequency Interference (RFI) from cell phone base station (1480MHz))has become too strong even to saturate the low noise amplifier (LNA) of the first stage in the L-band receiver. We decided to install a superconductor filter in front of the LNA, whose passband is 1405-1440MHz and 1600-1720MHz. Installation of the filter has finished in December 2013 and we confirmed the problem of LNA saturation has solved.

S-band:

High temperature superconductor filter has also been used in S-band receiver since 2002 to avoid RFI of cell phone IMT-2000. It was located after the LNA instead of before it, because it was not too severe to saturate the LNA. Although on 12 November 2013, the superconductor filter has lost its function because of increase

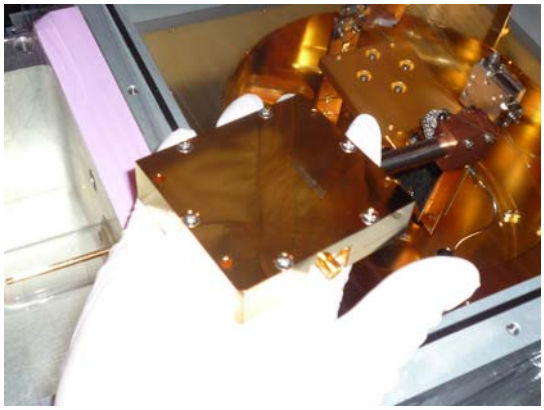

Fig. 3 Superconductor Filter installed inside L-band receiver dewar.

of filter temperature caused by aging of the cryogenic system for it. Thus we replaced the filter with standard bandpass filter in December. Consequently its observation frequency range was slightly changed to 2210-2350 MHz.

Wide band:

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

32 GHz and 43 GHz Receivers:

Startup work on there two receivers are not fully finished at present. Thus system performance parameters are not measured in this year.

2.2 Data acquisition System

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

Table 1 Antenna Performance parameter of the Kashima 34-m Telescope

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

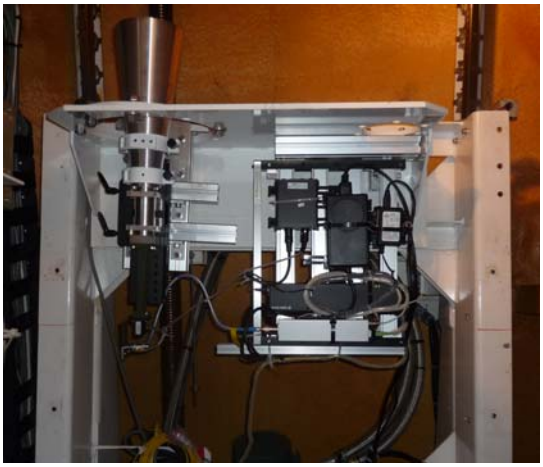

Fig. 4 Wideband (IGUANA) feed installed in the receiver room of Kashima 34m telescope.

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

K5/VSI data recording system is composed of PC-VSI data capture card (PCI-X interface) and a PC with raid disk systems. This system has been used with combination with 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 wide band signals with 1024 MHz bandwidth via 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

Owing to the collaboration with JGN-X, which is high speed research network provider hosted by NICT, 10 Gbps network is available between Kashima and Koganei. Due to the limiting of network switch and connection, 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 main engineering researcher in charge of hardware maintenance and operation of 34m antenna and Kashima 11m antenna[5]. He is responsible for routine geodetic VLBI observations for IVS.

Suzuki Ryuu is supporting staff for maintenance of the 34m antenna and 11m antenna.

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 network.

Takefuji Kazuhiro is researcher using 34m antenna for Gala-V project, and Pulsar observations. He performed startup work of the wideband IGUANA re-

ceiver 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 overall on the Kashima 34m antenna as the group leader. He is maintaining field system FS9 software for this station and operating Kashima and Koganei 11-m antennas[5] for IVS sessions.

4 Current Status and Activities

Kashima 34-m telescope have completely recovered from the damage of "The Tohoku earthquake" and restarted to join VLBI observations (IVS-T2, IVS-CRF, JADE, JVN) and single dish observations (Sgr-A*, Jupiter) since April 2013. Strong RFIs in L-band became severer from cell phone base stations and even we observed saturation of LNA in worst case. We decided to introduce superconductor filter in front of LNA as a countermeasure, and production and installation of the filter has 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 development of VLBI system for distant frequency comparison. That project named GALA-V[3] includes upgrading of receiver of the 34-m telescope to enable wideband observaiton in frequency range 2.2 - 18 GHz, which covers frequency range (2-14 GHz) of VGOS[6]. Based on the requirement of narrow beam width on the wideband feed, original designing of feed system was made for the 34m telescope.

5 Future Plans

Evaluation of the wideband receiver system will be performed in 2014. Additionally 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 Kashima 34-m telescope will be performed, and engineering evaluation including feed, sampler, phase calibration systems will be made.

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