NICT Correlation Center 2015–2016 Biennial Report

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Abstract This report describes the NICT Correlation Center and its activities.

1 General Information

The VLBI Correlation Center of NICT is operated by Space-Time Standards Laboratory of NICT/Applied Electromagnetic Research Institute and located in the Kashima Space Technology Center. Development of broadband VLBI technology for application to precise frequency comparison of atomic clocks is the primary mission of our group. VLBI experiments for this project have been conducted and processed.

2 Component Description

The VLBI system 'GALA-V' is a broadband VLBI system composed of two small diameter antennas and the Kashima 34-m diameter VLBI station. Upgrading the receiver system [1] and developing a wideband bandwidth synthesis technique [2] have been conducted using these stations. Small (1.6-m and 2.4-m) diameter stations have been installed at the headquarters (HQ) of NICT in Tokyo and the National Metrology Institute of Japan (NMIJ) in Tsukuba, respectively. Both institutes are in charge of keeping time standards UTC(NICT) and UTC(NMIJ) for Japan standard time (JST) and for metrology. A series of VLBI experiments for clock comparison have been conducted in 2016 between UTC(NICT) and UTC(NMIJ) [3]. This NICT–NMIJ baseline is used as a good testbed for broadband VLBI system development for clock comparison applications.

Fig. 1 Correlators of NICT/Kashima using the GICO3 software correlator.

The data acquisition mode used in the GALA-V observing is 2048 Msps/1bit/4ch. The total data rate is 8192 Mbps per station.

The correlation of the Kashima–Koganei and Kashima–Tsukuba baselines is performed for each of the four channels with the GICO3 software correlator [4]. Figure 1 shows the look of the correlation system with the GICO3 correlation system. Computer specification of the cluster computers for correlation is summarized in Table 1.

About 30 TB of data is acquired per day per station. One session of the GALA-V project continues for two to three days. Currently, observed data is collected by physical transportation of the disk set for the Tsukuba

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Table 1 Specifications of computers used for correlation at the NICT/Kashima Correlation Center.

Machine	CPU	Memory	RAID
A	Intel i7-3960x v2 6-Core 3.3GHz	64 GB	
B	Xeon E5-2680 v2 20Core 2.8GHz (Dual CPU)	64 GB	Areca ARC-1882ix-24
C	Xeon E5-2680 v2 20Core 2.8GHz (Dual CPU)	64 GB	Areca ARC-1883ix-24
D	Xeon E5-2687 v2 16Core 3.4GHz (Dual CPU)	64 GB	Areca ARC-1882ix-24

NMIJ station. Data recorded at the Koganei-HQ station is shared over a 10-Gbps network between Kashima and Koganei in collaboration with research testbed network JGN. The data processing takes one to two times the data acquisition rate. Thus, it takes a few days to correlate about a total of 150 TB of observation data.

3 Staff

Members who are contributing to the Correlation Center of NICT are listed below (in alphabetical order):

- KONDO Tetsuro: Development of wideband bandwidth synthesis software for the GALA-V project.
- SEKIDO Mamoru: Coordination of VLBI observing and data analysis with CALC/SOLVE.
- TAKEFUJI Kazuhiro: Operating the correlator to process broadband data.
- TSUTSUMI Masanori: Maintaining the computer server of the K6 VLBI recording system and the correlation cluster computers.

4 Activities

4.1 Application of High Time Resolution Output of GICO3

Recently, we adopted the high time resolution output of GICO3 for data processing of the Giant Radio Pulse (GRP) from the Crab pulsar [5]. When we process normal VLBI data with a digital FX-type correlator, data integration after Fourier transformation and multiplication are applied to improve the signal-to-noise ratio of the cross-spectrum. However, in the case of time varying radio signals such as giant radio pulses and fast radio bursts, which have instantaneous frequency characteristics, integration of a signal smears its signal characteristics. To avoid the smearing of a temporal radio signal, the high time resolution data output mode of the GICO3 software correlator was used for processing GRP signals observed from the Crab pulsar. Figure 2 shows the dynamic cross-spectrum of the GRP that arrived from the Crab pulsar and was observed by the Usuda 64-m and Kashima 34-m baseline. The curved line in the figure indicates a strong single GRP affected by frequency dependent dispersive delay. In total, 22,000 (50 ms / 16 µs × seven 32 MHz bandwidths) data points are included in the figure.

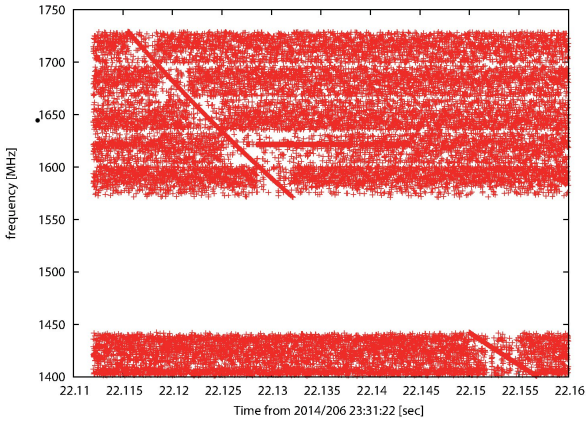

Fig. 2 Dynamic cross-spectrum of a Giant Radio Pulse from the Crab pulsar. A strong giant pulse from the Crab pulsar was detected by correlation of VLBI data between the Kashima 34-m and Usuda 64-m stations at 23:31:22 UT on 26 July 2014. Each point in the figure indicates signals exceeding a certain threshold in the cross-spectra obtained at every 16 µs. The empty frequency range around 1450–1550 MHz is out of the receiver range, because this range is excluded by the superconductor filter in front of the LNA to eliminate RFI from a cell phone base station.

4.2 Development of Cross-Correlation Spectrometry: XCS

We have developed a new method of data processing for radio telescope observation data to measure

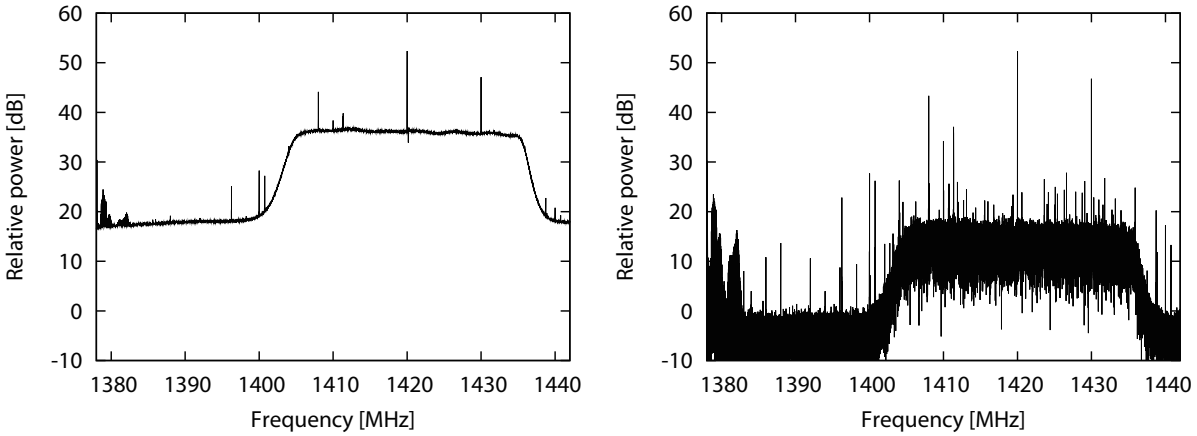

Fig. 3 Band profile of the Kashima 34-m station's L-band by general spectrometry (left). The same data processed by XCS processing (right). Some spurious signals with temporal coherence were enhanced.

time-dependent temporal coherence; we call it cross-correlation spectrometry (XCS) [6]. The XCS is an autocorrelation procedure that expands time lags over the integration time and is applied to data obtained from a single-dish observation. The temporal coherence property of received signals is enhanced by XCS. Figure 3 shows a bandpass profile of the Kashima 34-m station's L-band (1405 to 1435 MHz) processed by general spectrometry (left) and XCS (right), respectively. The XCS processed result shows that random noise is reduced and that some spurious signals with temporal coherence are enhanced.

Acknowledgements

Sharing of VLBI data for correlation of the Kashima–Koganei baseline is realized via a 10-Gbps network supported by high speed research testbed network JGN[1].

[1] http://www.jgn.nict.go.jp/

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