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

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 primary mission of our group. VLBI experiments for this project have been conducted, and processed.

2 Component Description

VLBI system 'GALA-V' is broadband VLBI system composed of two small diameter antennas and Kashima 34m diameter VLBI station. Upgrading of receiver system[1] and development of wideband bandwidth synthesis technique[2] have been conducted by using these stations. Small (1.6m and 2.4m) diameter stations have been installed at headquarter (HQ) of NICT in Tokyo and 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 test-bed for broadband VLBI system development for clock comparison application.,

Fig. 1 Correlators of NICT/Kashima by using GICO3 Software correlator.

Data acquisition mode used in the GALA-V observation is 2048 Msps/1bit/4ch. Total data rate is 8192 Mbps per station.

Correlation processing of Kashima -Koganei, and Kashima - Tsukuba baselines are performed for each four channels with GICO3 software correlator[4]. Fig. 1 shows the outlook of correlation system with GICO3 correlation system. Computer specification of cluster computers for correlation processing is summarized in Table 1.

About 30 TB of data is acquired per a day per station. One session of GALA-V experiment continues 2-3 days. Currently observed data is collected by physical transportation of disk set for Tsukuba NMIJ station.

1. Kashima Space Technology Center, National Institute of Information and Communications Technology

Table 1 Specifications of Computers used for Correlation Processing at Correlation Center NICT/Kashima

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

Data recorded at Koganei-HQ station is shared over 10-Gbps network between Kashima and Koganei under collaboration with research testbed network JGN. The data processing takes 1-2 times of the data acquisition rate. Thus, it takes a few days for correlation about 150 TB of total 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: Coordinating of VLBI observation and making data analysis with CALC/SOLVE.
- TAKEFUJI Kazuhiro: Operating correlation processing of broadband data.
- TSUTSUMI Masanori: Maintaining the computer server of K6 VLBI recording system and correlation cluster computers.

4 Activities

4.1 Application of High-time-resolution output of GICO3

Recently, we adopted the high-time-resolution output to GICO3 for data processing of the Giant Radio Pulse (GRP) from Crab pulsar [5]. When we process normal VLBI data with digital FX-type correlator, data integration after Fourier transformation and multiplication are applied to improve signal to noise ratio of the cross spectrum. However, in case of time varying radio signal such as giant radio pulses and Fast radio bursts, which have instantaneous frequency characteristics, integration of signal smears its signal characteristics. To avoid smearing of temporal radio signal, high time resolution data output mode of GICO 3 software correlator was used for processing GRP signal observed from Crab pulsar. Fig. 2 shows the dynamic cross-spectrum of the GRP arrived from the Crab pulsar observed by Usuda 64 m and Kashima 34 m baseline. Curved line in the figure indicates a strong single GRP affected by frequency dependent dispersive delay. In total, 22,000 (50 ms / 16 μs $\times$ seven 32MHz bandwidths) data points are included in the figure.

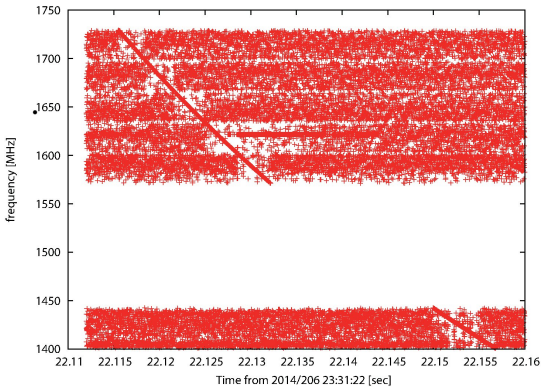

Fig. 2 Dynamic cross-spectrum of Giant Radio Pulse from Crab pulsar. A strong giant pulse from the Crab pulsar was detected by correlation processing of VLBI data between Kashima 34 m and Usuda 64 m baseline at 23:31:22 UT on 26 July 2014. Each points in figure indicates signals exceeding certain threshold in the cross-spectra obtained by every 16 μs. Empty frequency range around 1450 - 1550 MHz is out of receiver range, because this range is excluded by superconductor filter in front of LNA to eliminate RFI from 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 time-dependent temporal coherence, we call it cross-correlation spectrometry (XCS)[6]. The XCS is an au-

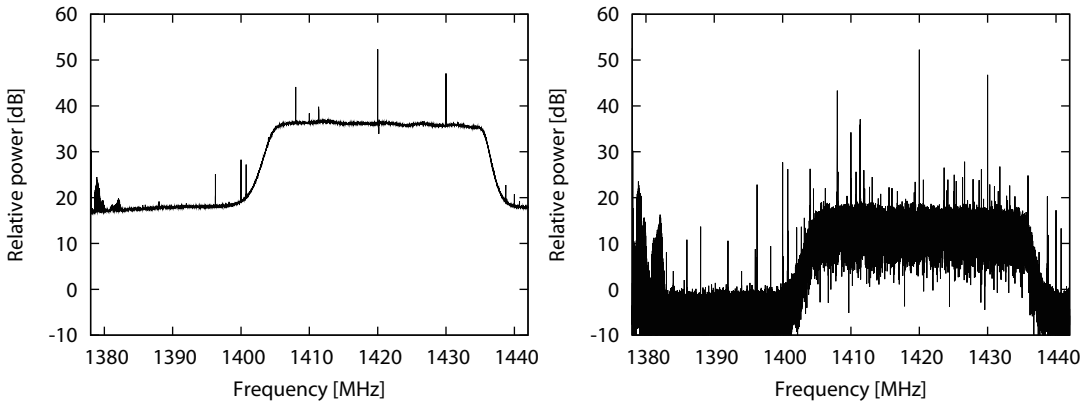

Fig. 3 Band-profile of Kashima 34m L-band by the general spectrometry(left). The same data processed by XCS processing (right). Some spurious signals with temporal coherence were enhanced.

tocorrelation 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. Fig. 3 shows a bandpass profile of Kashima 34 m L-band (1405 to 1435 MHz) processed by general spectrometry (left) and XCS (right), respectively. The XCS processed result (left) shows that random noise are reduced and some spurious signals with temporal coherence are enhanced.

Acknowledgement

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

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