High-sensitivity astronomical observation with GALAXY

Kenta Fujisawa[1] (*kenta@hotaka.mtk.nao.ac.jp*), **Noriyuki Kawaguchi**[1], **Hideyuki Kobayashi**[1], **Tetsuro Kondo**[2], **Junichi Nakajima**[2], **Hisashi Hirabayashi**[3], **and Yasuhiro Murata**[3]

[1] *National Astronomical Observatory of Japan (NAO)*
Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan
[2] *Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan
[3] *Institute of Space and Astronautical Science (ISAS)*
Yoshinodai 3-1-1, Sagamihara, Kanagawa 229-8510, Japan

1. Introduction

GALAXY is a research project on advanced VLBI technology, jointly conducted by CRL, NAO, and NTT. The testbed of the project is a 2.5-Gb/s ultra-high speed network using Asynchronous Transfer Mode (ATM). One of the aims of this project is to achieve high-sensitivity VLBI observation with this gigabit network [1].

The GALAXY observations have been carried out since 1998 using conventional VLBI terminal of 256-Mb/s developed for KSP [2]. Here we report the recent results of GALAXY observations with new 1-Gb/s system. Developments of new networking technology such as Internet Protocol (IP) with the GALAXY network are also presented in the section 3.

2. 1-Gbps observation system

Figure 1 shows the 1-Gb/s (1024-Mb/s) observation system, the participating telescopes are Usuda 64m (ISAS) in Nagano and Kashima 34m (CRL) in Ibaraki connected by GALAXY network provided by NTT. The gigabit sampler and the correlator have been developed by CRL for tape-based system [3], and the VLBI/ATM interface was developed by NAO. The data stream of Usuda 64m are ATM celled and transmitted to Kashima. The received ATM cells are retrieved as VLBI data stream at Kashima and correlated with the data of 34m telescope in real-time.

The first experimental observation with this 1-Gb/s system was made on June 23, 2001. Before starting the observation, a network delay was measured. This is for compensation of unpredictable delay caused by digital network.

The observing frequency was 8080-8592 MHz with lack of lower 100 MHz (8080-8180 MHz) due to the analogue bandbass character. The observed sources are 3C273, 3C279, NRAO530, and Sgr A*, which are strong enough for experimental fringe detection. As the result, strong fringes were successfully detected in real-time (Figure 2). The fringe phase and amplitude were stable during the observation for 7 hours. The detection sensitivity and brightness sensitivity derived from the Signal-to-Noise ratio are about 2-mJy and 4×10^4K respectively with 600 sec integration.

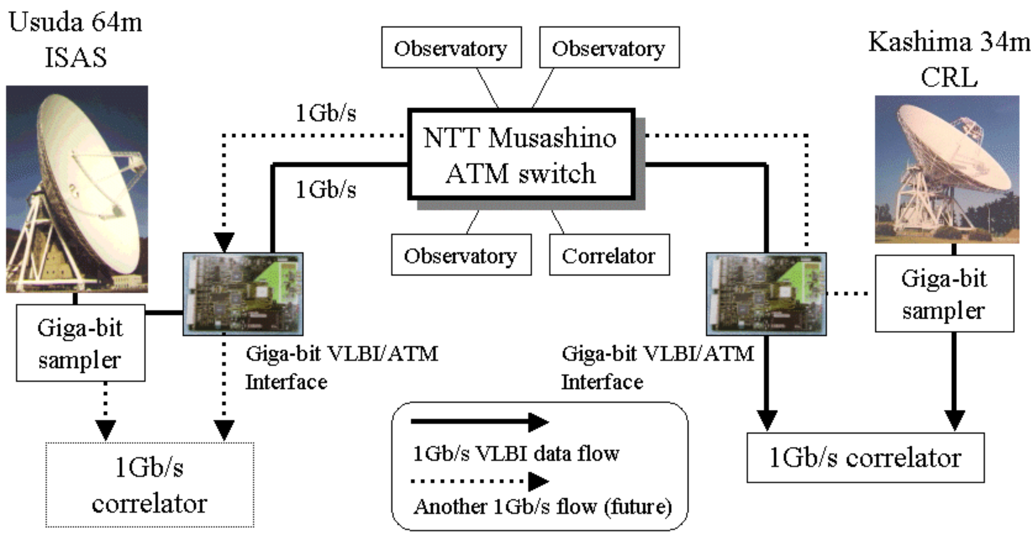

Figure 1. The network of 1-Gb/s experimet. The VLBI data sampled at Usuda are transmitted to Kashima and correlated with the data sampled at Kashima.

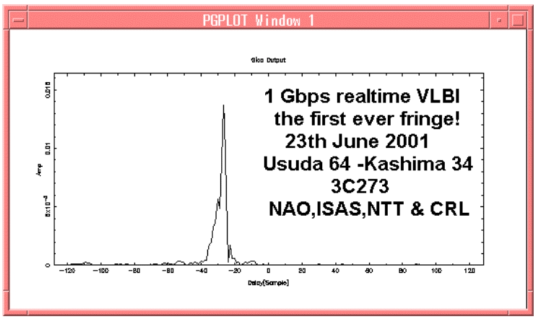

Figure 2. 1-Gb/s real-time the first ever fringe between Usuda and Kashima on June 23, 2001. The source is 3C273.

The successive astronomical observations have been carried out with this 1-Gb/s system since Oct 29, 2001. According to the preliminary analysis, a source with total flux density of 3 mJy was detected. This result demonstrates that GALAXY does have capability for detecting weak radio sources.

3. Future Plan

At present, GALAXY is using ATM for the network transmission system. The explosive spread of the Internet, however, is making Internet Protocol (IP) a major data transmission protocol. A research and development of IP transfer technique for high-speed VLBI data, and improvement of connectivity with a number of other research observatories are undergoing using GALAXY network. These activities are reported in this issue by Kondo and by Iwamura, respectively.

The current 1-Gb/s observation system consists of single baseline. At least three baselines are required to obtain a closure phase for astronomical study of radio source structure. Such multi-baseline observation will be realized with the ‘ distributed-gigabit network interface ’ and the ‘ distributed-gigabit correlator ’those are under development in National Astronomical Observatory of Japan. These equipments are designed suitable for network-type VLBI observation. This new system will have observation capability of 2-Gb/s VLBI data for 3-baselines. Moreover, a 4-Gb/s observation could be achieved using full-duplex network capability. This ultra-wideband system will make GALAXY as a unique VLBI network in the world (Figure 3), and let us observe thermal objects with low brightness temperature of a few tens of thousand Kelvin.

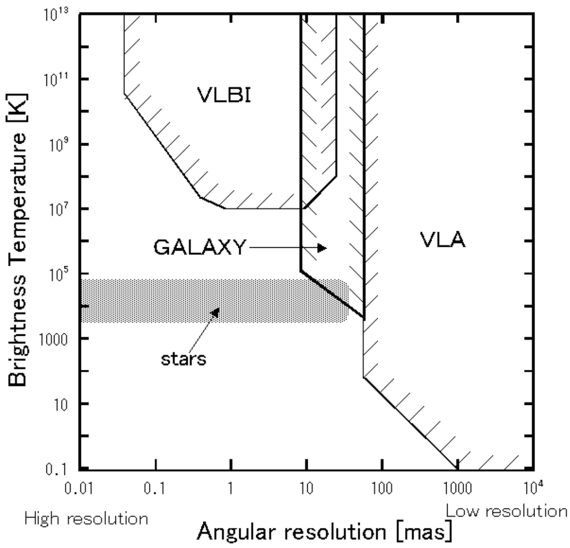

Figure 3. Angular resolution and brightness sensitivity. The mild resolution and high-sensitivity of GALAXY make it a unique network for detecting small and low brightness radio sources, such as stars.

Acknowledgement: The authors would like to thank all members of GALAXY team of CRL, NAO, ISAS and NTT.

References

[1] Kenta Fujisawa, Noriyuki Kawaguchi, Hideyuki Kobayashi, Satoru Iguchi, Takeshi Miyaji, Kazuo Sorai, Tetsuro Kondo , Yasuhiro Koyama, Junichi Nakajima, Mamoru Sekido, Hiro Osaki, Hiroshi Okubo, Hitoshi Kiuchi, Yukio Takahashi, Akihiro Kaneko, Hisashi Hirabayashi, Yasuhiro Murata, Hisao Uose , Sotetsu Iwamura, and Takashi Hoshino, “GALAXY — Real-time VLBI for Radio Astronomy Observations ”, Journal of the Communications Research Laboratory, Vol.46, No.1, pp.47-58, March 2001

[2] Hitoshi Kiuchi, Tetsuro Kondo, Mamoru Sekido, Yasuhiro Koyama, Michito Imae, Takashi Hoshino, and Hisao Uose, “Real-Time VLBI Data Transfer and Correlation System”, Journal of the Communication Research Laboratory, Vol.46, No.1, pp83-89, March 1999

[3] Nakajima J., Koyama Y., Sekido M., Kurihara N., Kondo T., Kimura M., Kawaguchi N., “ 1-Gb/s VLBI, the first detection of fringes ” Experimental Astronomy, Vol.11, pp.57-69, 2001