Igor Surkis et al.: The IAA RAS Correlator First Results, IVS 2010 General Meeting Proceedings, p.167–170
http://ivscc.gsfc.nasa.gov/publications/gm2010/surkis.pdf

# The IAA RAS Correlator First Results

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**Abstract**

In 2009 the national Russian VLBI observations were processed by the new correlator ARC (Astrometric Radiointerferometric Correlator). The ARC is a VSI-H correlator and equipped with Mark 5B playback terminals. During 2009 ARC was used to process a series of VLBI sessions, observed on stations Svetloe, Zelenchukskaya, and Badary. NGS files were formed, and EOP parameters were obtained by IAA RAS Analysis Center. The accuracies of the pole coordinates and UT1-UTC were 1–2 mas and 0.07–0.1 ms, respectively.

Using ARC (Astrometric Radiointerferometric Correlator) the national Russian VLBI observations were processed starting from February 2009. ARC is a 6-station, 15-baseline correlator. It is able to process up to 16 frequency channels on each baseline, 240 channels total. The correlator accesses two-bit VLBI signals with 32 MHz maximal clock frequency. The maximal data rate from each station is 1 Gbps. The correlator requires VSI-H input VLBI signals, and it is equipped with Mark 5B playback terminals.

The ARC hardware consists of Mark 5B playback terminals, a system for signal distribution and synchronization, and correlator base modules.

Figure 1 shows the correlator base module. This FPGA-technology device performs all of the hardware data processing. The module enables processing of 16 single-baseline frequency channels — all data of one baseline of a typical geodetic VLBI observation.

The base module is a Compact PCI 6U front plug-in board. Up to three base modules are placed into the Compact PCI 6U crate. The crate is controlled by a computer board. The modules receive commands and model parameters from the computer board CPU and send calculated correlation data through the crate's PCI bus. The base module contains 16 correlation units which are single-baseline, single-channel XF correlators for calculating 64 complex lags and picking phase-cal tones. Each correlation unit consists of two FPGA chips and two RAM chips. The data processing algorithms are implemented as FPGA programs. The six-station, 15-baseline ARC contains 15 base modules to process 240 frequency channels simultaneously. Base modules are mounted into five Compact PCI 6U crates.

The purpose of the system of signal distribution and synchronization is the distribution of signals from the Mark 5B terminals to the base modules, so that each module receives signals from two Mark 5B. The system also generates and sends synchronization signals DPSCLOCK and DPS1PPS to the Mark 5B terminals. The system consists of the set of boards based on FPGA technology and connecting cables. The boards are mounted into two Compact PCI 6U crates.

ARC is shown in Figure 2. All of the ARC hardware parts are mounted in four racks. The two central racks contain five crates with base modules. The six Mark 5B devices are mounted into two flank racks. These racks also consist of two Compact PCI 6U crates with signal distribution and synchronization system.

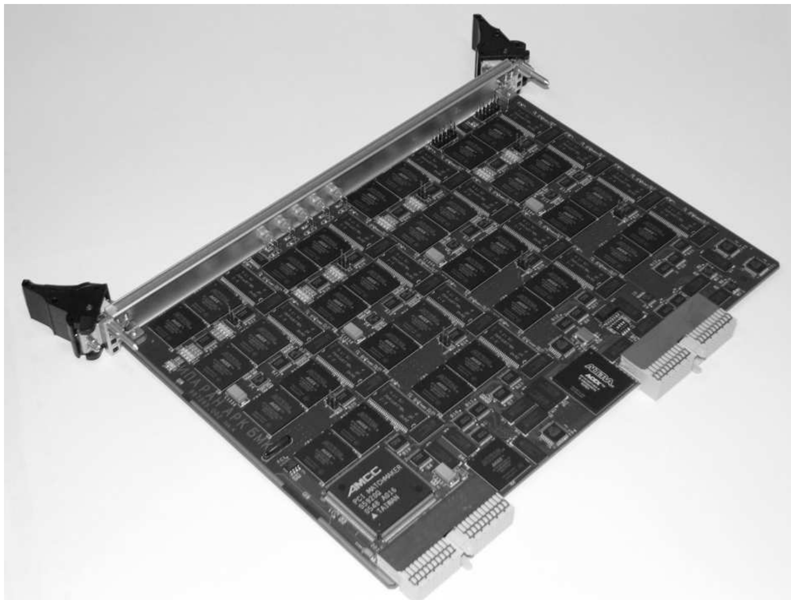

Figure 1. Correlator base module.

Figure 2. The 6-station ARC correlator.

The correlator hardware control is performed by the desktop computer, which is connected to the crates by the correlator local network. The ARC software is the distributed system between the control computer and crates. The software runs under GNU/Linux and has a GUI.

The ARC in minimal 2-station assembly was mounted at the end of 2008. In July 2009 ARC was expanded to 3-station configuration. The full-scale 6-station correlator was complete in October 2009.

Using ARC the national Russian VLBI observations were processed starting from February 2009. There are two geodetic programs which were performed by Svetloe, Zelenchukskaya and Badary observatories during 2009. The first is the Ru-E observational program aimed at EOP determination. It is a 24-hour session with the three-station network. The observing mode includes 16 MHz VC's bandwidth and one-bit sampling with total bit rate of 512 Mbit/s per station. The second program Ru-U is intended to estimate UT1-UTC. It was started with two hours of observation time and has now become a 1-hour session. The observing mode includes 8 MHz VC's bandwidth and one-bit sampling with total bit rate of 256 Mbit/s per station. One hour sessions are transferred to the correlator in e-VLBI mode.

The group delays in the X and S bands were calculated as a result of the correlator processing, and NGS card files were created. 24 Ru-E and 26 Ru-U sessions were observed and correlated. Using these NGS files the IAA RAS Analysis Center calculated EOPs and UT1-UTC.

Figure 3 shows the differences between IERS 05 C04 and results of IAA RAS EOP determination, calculated from Ru-E observation program. In Figure 4 the differences between UT1-UTC IERS 05 C04 and results of IAA RAS EOP determination, calculated from Ru-U observation program are shown.

As seen from the figures, the accuracy of the dX and dY estimates and the X and Y estimates are close to 1 and 2 mas, respectively. Accuracies of UT1-UTC estimates are within the range of 0.05–0.07 ms for 24-hour sessions and 0.07–0.10 ms for 1-hour sessions.

The closure relation for group delays on baselines Barary–Svetloe, Sveloe–Zelenchk, and Zelenchk–Badary enable the checking of the correlator accuracy, which is 60–70 ps at the present time.

Work on improving the correlator internal algorithms has started now, and we are planning to achieve the Mark IV correlator precision soon.

## References

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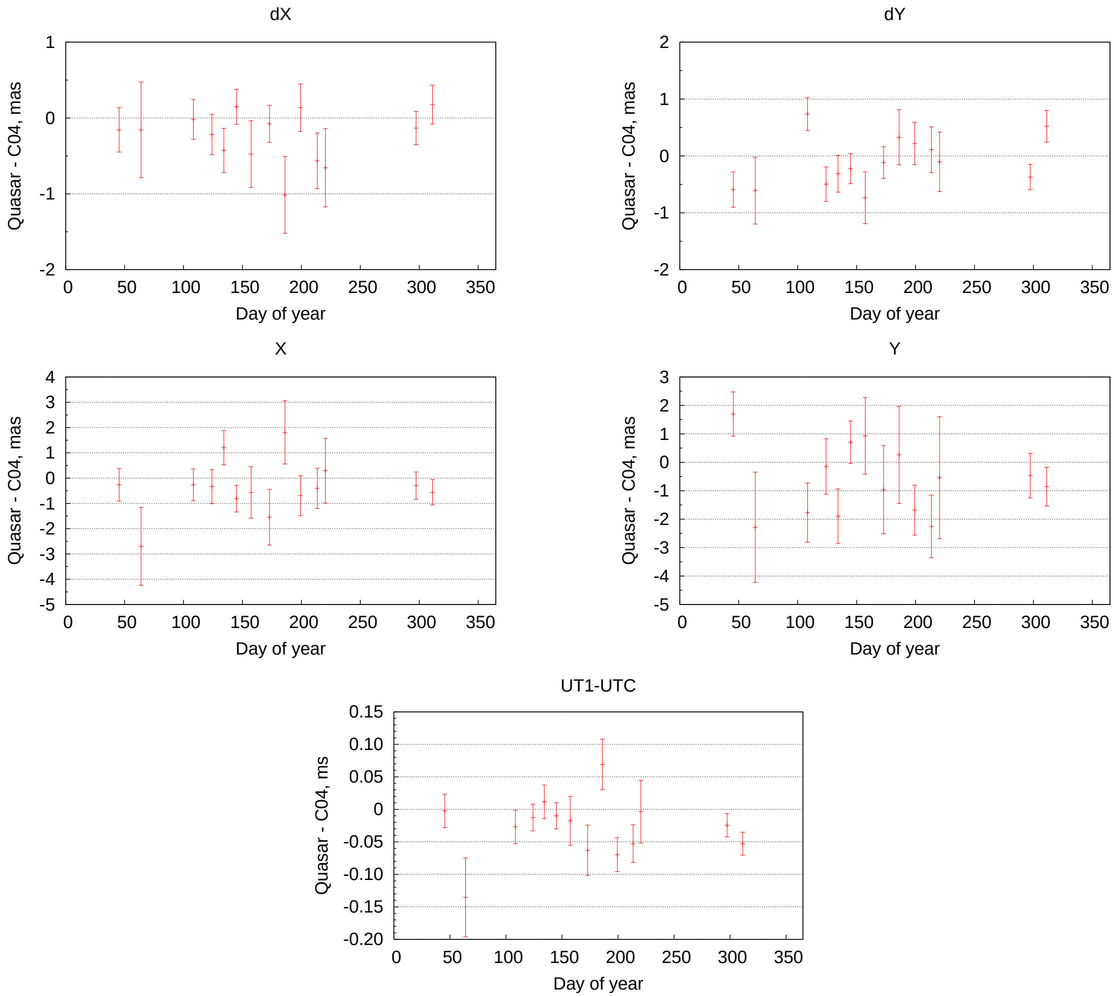


Figure 3. Difference between EOP C04 and results of IAA RAS EOP determination, calculated from 24-hour 3-station Ru-E observation program.

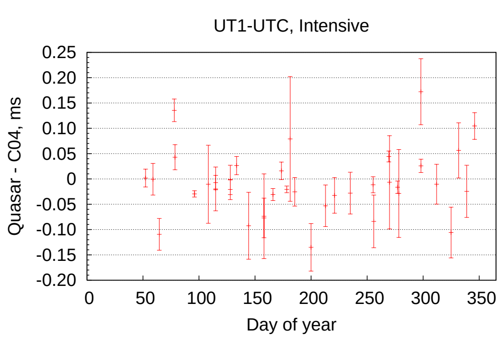


Figure 4. Difference between UT1-UTC C04 and results of IAA RAS EOP determination, calculated from 1-hour 2-station Ru-U observation program.