IAA Correlator Center Biennial Report 2017+2018

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Abstract The IAA Correlation Center activities in 2017 and 2018 are described. All regular observations of the Russian geodetic VLBI programs were transferred to the IAA in e-VLBI mode and correlated using the ARC, RASFX, and DiFX correlators.

1 General Information

The IAA Correlator Center is located at St. Petersburg, Russia and maintained by the Institute of Applied Astronomy. The main goal of the IAA Correlator Center is processing geodetic, astrometric, and astrophysical observations made with the Russian VLBI network Quasar. At present three correlators are involved in this processing: ARC, RASFX, and DiFX.

The ARC (Astrometric Radio Interferometric Correlator) is a six-station 15-baseline hardware correlator. The ARC was designed and built by the IAA RAS in 2007–2009. The correlator is the XF-type and based on FPGA technology. The ARC maximum data rate is 1 Gbps for each station, 6 Gbps total.

In 2014 the Russian Academy of Sciences FX (RASFX) six-station near-real time GPU-based VGOS correlator was developed [1]. The correlator software is installed on an HPC cluster, which contains 40 servers, each equipped with two Intel CPUs and two Nvidia GPUs. Due to high GPU performance, the RASFX correlator is able to process up to 96 Gbps input data rate. Since 2015, the DiFX software correlator has been up and running on the HPC cluster.

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2 Activities during the Past Years

ARC commonly operates with data obtained from 32-m telescopes RT-32 “Svetloe”, “Badary”, and “Zelenchukskaya”. ARC processes daily Intensive single hour sessions for UT determination and weekly 24-hour sessions for EOP determination in the standard legacy IVS geodetic setup (1-bit, 16 frequency channels of 8 MHz bandwidth). More than 800 sessions were processed in 2017–2018.

During 2017–2018, two new VGOS-compatible 13-m telescopes RT-13 located in Badary and Zelenchukskaya carried out observations on a regular basis with a 2 Gbps data transfer rate from the stations to the Correlation Center. Up to five single hour S/X and one half hour S/X/Ka sessions are performed daily with the following setup: four frequency channels with 512 MHz bandwidth and two-bit sampling (8 Gbps per station), which forms a total data rate of nearly 4 TB per hour. The RASFX and DiFX correlators are used for these sessions’ data processing.

The five-station (three RT-32 and two RT-13) 23-hour session was performed to clarify the 13-m antennas’ positions. The S/X observations were recorded with 512 MHz bandwidth frequency channels at the RT-13 stations and with 32 MHz bandwidth frequency channels at the RT-32 stations. This session was processed using the DiFX correlator.

Experiments for Intensive GLONASS satellite observations were made during 2017. Satellite signals were obtained using the three RT-32 stations, and data processing was performed using the RASFX correlator. High precision VLBI delays were calculated.

The new 13-m VGOS-compatible telescope in Svetloe was constructed in 2017–2018. The first three-station VLBI observations were made in S/X on September 2018. Fringes were obtained by the RASFX and DiFX correlators.

The experiments of the mobile VLBI station project were carried out. A small 4-m antenna in Svetloe was used as a mobile prototype. The observations in X-band with 512 MHz bandwidth 2-bit sampling frequency channels were performed with RT-13 Badary and Zelenchukskaya. The correlation fringes were also calculated by the RASFX and DiFX correlators.

The Correlation Center also processed calibration and equipment test observations for the Quasar VLBI network. A zero-baseline radio interferometer model was created at IAA RAS in 2017 in order to analyze VLBI radio interferometer characteristics in laboratory conditions. The model consists of the radio telescope RT-13 tri-band and ultra-wideband receivers (UWB) [2] heterodyne type receivers, broadband data acquisition system, and RASFX correlator. The radio interferometric sessions were carried out in S/X/Ka-bands with 512 MHz channel bandwidth and 2-bit sampling. The session duration was varied from single 5 to 20 minute "scans" to a single hour that consisted of 120 10-second "scans". To simulate cosmic radio sources, the noise generator signal was injected into the receivers. We performed more than 200 such sessions. Correlator fringe characteristics obtained with RASFX were analyzed: signal-to-noise ratio (SNR), group delay, group delay rate, fringe phase, and their standard deviations [3].

The comparison of group delays obtained by the RASFX and DiFX correlators using PIMA post-processing software was made. It was found that the differences between the group delays from both correlators are mainly due to the different mathematical implementations of the correlation and post-processing algorithms. The data converter software has been developed, which allows the use of the PIMA post-processing routine on RASFX correlator data instead of the native RASFX post-processing software WOPS. The calculated group delays from WOPS and PIMA software are in good agreement and differ by 0.9 ps or less [4].

In 2017–2018 the following types of sessions were performed:

- a one-hour geodetic program in S/X band for UT determination ("RI", two or three 32-m stations), daily
- a 24-hour geodetic program in S/X band for EOP determination ("RU-E", three 32-m stations), weekly
- a one-hour geodetic program in S/X band for UT determination ("R", two VGOS 13-m stations), five per day, RASFX and DiFX processing
- 0.5-hour test programs in S/X/Ka bands ("RX", two VGOS 13-m stations), RASFX and DiFX processing.

The set of test observations ("Ru-TEST") included:

- a 23-hour test geodetic program in S/X band to improve positions for 13-m antennas (two 13-m and three 32-m radio telescopes), DiFX processing
- a GLONASS observation test program, (three 32-m radio telescopes), RASFX processing
- New 13-m antenna "Svetloe" tests, RASFX and DiFX processing
- 4-m mobile antenna prototype "Svetloe" tests, RASFX and DiFX processing
- Miscellaneous test sessions, including international cooperation ("Ru-TEST").

More than 4,000 sessions were carried out during 2017–2018.

3 Staff

The list of the staff members of the IAA Correlator Center in 2017–2018 is given below.

- Igor Surkis — lead researcher, software developer;
- Voytsekh Ken — GPU software developer, data processing;
- Alexey Melnikov — DiFX processing, scheduler;
- Vladimir Mishin — software developer, data processing;
- Nadezhda Mishina — software developer, data processing;
- Yana Kurdubova — software developer, data processing;
- Violetta Shantyr — software developer;
- Vladimir Zimovsky — data processing lead;
- Ekaterina Medvedeva — data processing;
- Alexander Salnikov — e-VLBI data transfer lead;

- Ilya Bezrukov — e-VLBI data transfer;
- Vladislav Yakovlev — e-VLBI data transfer.

4 Future Plans

In 2019 and 2020, the IAA Correlator Center activities will be focused on the following aspects:

- Routine processing of the geodetic observations,
- Clarifying station positions with VLBI techniques,
- Developing new features for the RASFX correlator.

References

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