# IAA Correlator Center Biennial Report 2019+2020

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**Abstract** The IAA Correlator Center activities in 2019 and 2020 are described. All regular observations of the Russian national 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 in St. Petersburg, Russia and maintained by the Institute of Applied Astronomy. The main goal of the IAA Correlator Center is the processing of the geodetic, astrometric, and astrophysical observations made with the Russian national Quasar VLBI network. The observatories "Svetloe", "Badary", and "Zelenchukskaya" are connected to the Correlator Center by a 2 Gbps link. At present, three correlators are operated by the Correlator Center: ARC, RASFX, and DiFX.

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

In 2014, the Russian Academy of Sciences FX (RASFX) six-station, near-real time GPU-based VGOS correlator was developed. The correlator software is installed on an HPC cluster, which contains 40 servers, each equipped with two Intel CPUs and two Nvidia GPUs, and is able to process up to a 96 Gbps input data rate [2].

Since 2015, multiple versions of the DiFX software correlator [3] have been installed and run on the HPC cluster.

## 2 Activities during the Past Years

ARC typically operates with data obtained from the 32-m telescopes (RT-32) "Svetloe", "Badary", and "Zelenchukskaya". ARC processes daily Intensive one-hour sessions for UT determination and weekly 24-hour sessions for EOP determination in the standard legacy IVS geodetic setup (1-bit sampling, 16 frequency channels of 8 MHz bandwidth). Since 2020, RASFX is also involved in that processing. More than 800 legacy geodetic sessions were processed in 2019–2020.

Three VGOS-compatible 13.2-m radio telescopes (RT-13) located in Badary, Svetloe, and Zelenchukskaya were used to carry out observations on a regular basis. During 2019, up to five one-hour S/X and 0.5-hour S/X/Ka sessions have been done daily with the following setup: four frequency channels of 512 MHz bandwidth each and 2-bit sampling (8 Gbps data rate per station), resulting in a total data rate of nearly 4 TB per hour. In 2020 the duration of the daily sessions was increased to four two-hour S/X sessions and one-hour S/X/Ka. The RASFX and DiFX correlators were used for these sessions' data processing.

A few five-station (three RT-32: Bd, Sv, and Zc; two RT-13: Bv and Zv) and one six-station (three RT-32 and three RT-13) 23-hour sessions were performed to tie the positions of the 13.2-m antennas. These were

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S/X observations recorded with 512 MHz bandwidth frequency channels at the RT-13 stations (4 Gbps) and with 32 MHz bandwidth frequency channels at the RT-32 stations (2 Gbps). These sessions were processed using the DiFX correlator in zoom band mode. For the same purpose, to tie the RT-13 "Svetloe" position, RT-13 "Svetloe" was added as a tag-along station to the R1972 session in 2020. This session was processed at MPIfR Bonn.

RT-13 "Svetloe" and "Badary" have participated in the EU-VGOS Intensive session ev0034 in tag-along mode to check the equipment compatibility. The data were transferred to St. Petersburg, and the correlation was done using the DiFX correlator. Post-processing of ev0034 is in progress and not finished yet.

Also we processed a few experiments with spacecraft. The signals were obtained using the RT-32 and RT-13 stations, and data processing was performed using the RASFX and DiFX correlators. High precision VLBI delays and delay rates were calculated.

The Correlator Center also processed calibration and equipment test observations for the Quasar VLBI network. In particular, we continued tri-band and ultra-wideband receiver testing, as well as a new pulse generator in 1 MHz and 5 MHz modes. Also a few three-station (RT-13) S/X/Ka sessions with 30-min scans were carried out in order to estimate the receiver's stability in terms of signal delay [4]. These sessions were processed using the RASFX correlator.

In summary, in 2019–2020 the following types of sessions were correlated:

- one-hour geodetic sessions in S/X band for UT determination ("R-I", two or three 32-m stations), daily, ARC, RASFX, and DiFX processing;
- 24-hour geodetic sessions in S/X band for EOP determination ("Ru-E", three 32-m stations), weekly, ARC, RASFX and DiFX processing;
- one- or two-hour geodetic sessions in S/X band for UT determination ("R", three VGOS 13-m stations), four to five per day, RASFX and DiFX processing;
- 0.5- or one-hour R&D sessions in S/X/Ka bands ("R-X", three VGOS 13.2-m stations), daily, RASFX and DiFX processing;

and a set of test observations ("Ru-TEST"):

- 23-hour test geodetic program in S/X band to improve the positions of the 13.2-m antennas (three 13.2-m and three 32-m radio telescopes), DiFX processing;
- Spacecraft VLBI observations test program, (32-m and 13.2-m stations), RASFX and DiFX processing;
- Determination of the instrumental errors of the RT-13 receiving and recording equipment, RASFX processing;
- Miscellaneous test sessions, including international cooperation.

## 3 Staff

The list of the staff members of the IAA Correlator Center in 2019–2020 is given below.

- Igor Surkis — leading investigator, software developer;
- Voytsekh Ken — HPC cluster maintenance, GPU software developer, data processing;
- Alexey Melnikov — DiFX maintenance and processing, scheduler;
- Vladimir Mishin — HPC cluster maintenance, software developer, data processing;
- Nadezhda Mishina — software developer, data processing;
- Alexander Kumeyko — software developer, post-processing;
- Yana Kurdubova — software developer, data processing;
- Violetta Shantyr — software developer, post-processing;
- Mikhail Zorin — software developer;
- Pavel Volkov — post-processing and analysis;
- 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 2021 and 2022, the IAA Correlator Center activities will be focused on the following aspects:

- routine processing of geodetic observations;

- international session processing;
- test sessions for equipment compatibility and stability testing;
- developing new features for the RASFX correlator.

## References

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