IAA Correlator Center Report 2021–2022

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Abstract The IAA RAS Correlator Center activities in 2021 and 2022 are described. All regular observations of the Russian national geodetic VLBI programs were transferred to the IAA in e-VLBI mode and correlated using RASFX and DiFX correlators.

1 General Information

The Correlator Center is located in St. Petersburg, Russia, and maintained by the Institute of Applied Astronomy. The main goal of the Correlator Center is the processing of the geodetic, astrometric, and astrophysical observations made with the Russian national Quasar VLBI network [1]. The Svetloe, Badary, and Zelenchukskaya observatories are connected to the Correlator Center by a 2-Gbps link. At present, the RASFX and DiFX correlators are hosted and operated by the Correlator Center.

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 with 85.34 Tflops performance, 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 have been installed and run on the HPC cluster.

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2 Activities during the Past Two Years

Starting in 2021, the Astrometric Radio interferometric Correlator (ARC) was outaged and no longer used in the routine processing. The observations carried out on RT-32 are being processed with RASFX correlator.

At the end of 2020, RT-13 “Svetloe” was equipped with a brand new digital acquisition system (DAS) Multifunctional Digital Backend (MDBE). In 2022, the MDBE was installed in parallel with the R1002M DAS on RT-32 “Svetloe.” During the 2021–2022 we have accomplished various compatibility tests using MDBE firmware versions designed for different applications. These experiments were processed by both RASFX and DiFX correlators.

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. In mid-July 2020, we began experimenting on scheduling regular one-hour geodetic observations using fixed Siderial Time as the session start time. Since August 7, 2020 and until the end of 2021, we carried out four two-hour S/X sessions and one-hour S/X/Ka every day.

In 2022 we returned to the traditional approach of a fixed UT start time and observed two one-hour S/X and one 0.5-hour S/X/Ka sessions until May 2022. Since May 2022 until the end of the year, we have carried out six one-hour S/X sessions evenly distributed during the day, and one 0.5-hour S/X/Ka session. S/X observations were made using two 512-MHz bandwidth frequency channels (IFs), one IF in each band; S/X/Ka observations were made using four 512-MHz IFs, single in S- and X-band, and two IFs in Ka-band. The total recording rate was 4 Gbps and 8 Gbps for S/X and S/X/Ka observations, respectively. In 2022 we have carried out four 24-hour experiments in S/X frequency mode: in March, June, October, and December. These experiments contain approximately 1,650 scans and about 5,000 observations. The RASFX and DiFX correlators were used to process the data of these sessions.

In 2021–2022, we have done a series of experiments aimed at space vehicle observations with our RT-32 and RT-13 antennae in L- and X-bands. Data processing was performed using the RASFX and DiFX correlators and during post-processing we obtatined high-precision VLBI observables: time delay and delay rate. Some preliminary results were published [3]. RASFX software was refined to semi-automatical process of space vehicle observations whose coordinates are known with low accuracy. Processing of such data by traditional methods is performed in two iterations with clarification of initial models.

Finally, the Correlator Center also continued work on testing the receiving and the recording equipment. We have done a few observations in order to calculate signal delay propogation stability and the influence of the equipment delay instability on the Universal Time determination [4]. Also, we have successfully performed on RT-13 one-hour source-tracking sessions with hydrogen frequency standard and passive frequency standard to check the possibility of applying the passive one. These sessions were processed using the RASFX correlator.

3 Staff

The list of the staff members of the IAA RAS Correlator Center in 2021–2022 was as follows:

- Igor Surkis — lead researcher, software developer;
- Voytsekh Ken — GPU software developer, data processing;
- Alexey Melnikov — DiFX processing, scheduler;
- Alexander Kumeyko — software developer, PhD student;
- 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;
- Mikhail Zorin — software developer, PhD student;
- Ivan Arnaut — software developer, PhD student;
- Ekaterina Medvedeva — data processing;
- Andrey Mikhailov — Field System support;
- Ilya Bezrukov — e-VLBI data transfer lead;
- Alexander Salnikov — e-VLBI data transfer.

4 Future Plans

In the upcoming years, we will focus on the following tasks:

- routine processing of the geodetic observations;
- sessions for testing compatibility and stability of radio telescope equipment
- research on space vehicles signal processing methods;
- development of software features to increase the level of automation of the processing.

References

1. Shuygina N., Ivanov D., Ipatov A., Gayazov I., Marshalov D., Melnikov A., Kurdubov S., Vasilyev M., Ilyin G., Skurikhina E., Surkis I., Mardyshkin V., Mikhailov A., Salnikov A., Vytnov A., Rakhimov I., Dyakov A., Olifirov V. Russian VLBI network "Quasar": Current status and outlook. Geodesy and Geodynamics, Vol. 10, Is. 2, pp. 150–156, 2019. https://doi.org/10.1016/j.geog.2018.09.008
2. Surkis I., Zimovsky V., Ken V., Kurdubova Ya., Mishin V., Mishina N., Shantyr V. A Radio Interferometric Correlator Based on Graphics-Processing Units. ISSN 0020-4412, Instruments and Experimental Techniques, Vol. 61, No. 6, pp. 772–779, 2018.
3. Vasil'ev, M.V., Zimovsky, V.F., Melnikov, A.E. et al. Space Vehicle Observations Using the Quasar VLBI Network. Instrum Exp Tech, Vol. 65, pp. 981–994, 2022. https://doi.org/10.1134/S0020441222060197
4. Vekshin Yu., Ken V., Kurdubov S. Optimal Signal Averaging Time in VLBI Sessions. International VLBI Service for Geodesy and Astrometry 2022 General Meeting Proceedings, NASA/CP–20220018789, pages 144–147, 2023.