IAA Correlator Center 2014 Annual Report

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Abstract The activities of the six-station IAA RAS correlator include the regular processing of national geodetic VLBI programs Ru-E, Ru-U (R-I), and Ru-F. The Ru-U (R-I) sessions have been transferred to the IAA Correlator Center automatically in e-VLBI mode and correlated there since 2011. The new six-station FX correlator's HPC was developed and mounted at IAA.

1 Introduction

The IAA Correlator Center is situated at St.-Petersburg, Russia and maintained by the Institute of Applied Astronomy in Russia.

The main goal of the IAA Correlator Center is processing geodetic, astrometric, and astrophysical observations made with the Russian national VLBI network Quasar.

2 Component Description

The ARC (Astrometric Radiointerferometric Correlator) (Figure 1) was the main data processing instrument at the IAA Correlator Center in 2014. The ARC was designed and built at the IAA RAS in 2007 - 2009. The correlator is XF-type and is based on FPGA technology.

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The ARC is a six-station 15-baseline correlator. It is able to process up to 16 frequency channels on each baseline for a total of 240 channels. The correlator is able to handle two-bit VLBI signals with 32 MHz maximum clock frequency. The maximum data rate from each station is 1 Gbit per second. The correlator uses VSI-H input signals, and it is equipped with Mark 5B playback systems.

Since 2011, the DiFX software correlator has been used in some astrophysical experiments. DiFX is installed at the IAA on a Sun Fire X4450 Server as a virtual machine under the VMware.

Since 2012 the six-station software FX VGOS GPU-based near-real time correlator has been under design. First fringes were obtained.

Fig. 1 View of the six-station ARC correlator, showing four racks containing (left to right) signal distribution and synchronization system (SDSS) and three Mark 5B playback units, two correlator crates and a KVM, three correlator crates, and one more cabinet with an SDSS and three Mark 5B playback units.

3 Current Status and Activities

The ARC correlator was used for processing of all the national geodetic VLBI observations at the IAA Correlator Center in 2014. The RUE and RUU (R-I) geodetic VLBI sessions were observed at IAA RAS.

The three-station 24-hour RUE sessions for EOP determination were observed one time per week, as in 2013.

The two-station one-hour sessions for UT1-UTC determination in e-VLBI mode were observed once a day. The RUU (R-I) sessions setup was the following: frequency channel bandwidth of 8 MHz and total bitrate of 256 Mbps. The data transfer rate from stations to correlator was increased in 2012, and near-realtime correlation processing with a data bitrate of 256 Mbps was achieved.

The DiFX software correlator continued to be the main tool for processing spectral line sources for VLBI in 2014. Several 2-Gbps tests with new broadband acquisition system BRAS were done, and data were processed with DiFX. Twenty-seven Ru-P low data rate experiments were scheduled, observed, and processed with high spectral resolution. The HartRao station joined the Ru-P Orion KL observations, and data were transferred from South Africa to Saint-Petersburg using the Tsunami protocol. During 2014, several wideband test experiments were carried out. DiFX was used to get first fringes in these experiments. DiXF copies are installed on three GNU/Linux VMware virtual machines at a Sun Fire X4450 Server and at a new hybrid-blade cluster. Wideband experiments were processed using cluster DiFX installation. Running at 60 cluster cores, DiFX is more than 50 times faster than DiFX on a four-core virtual machine.

4 FX Correlator Design

The design of a new FX software correlator intended for the new small antenna VLBI network was started in 2012. The correlator design is supposed to process a data stream of up to 16 Gbps from each observatory. VLBI data are recorded from four frequency bands with bandwidths of up to 1024 MHz in one circular polarization or up to 512 MHz in two linear polarizations using 2-bit sampling. The input data format is VDIF. The correlator computes cross-spectra with a resolution of up to 4,096 spectral channels and extracts up to 32 phase calibration tones in each frequency band of each station in near-real time.

We have developed six-station correlator software in 2014. In cooperation with the company “T-Platforms”, the high-performance computing cluster (Figure 2) was mounted at IAA.

Fig. 2 View of the high-perfomance computing cluster based on the hybrid blade servers.

The correlator’s hardware is based on hybrid blade server technology. Each blade server contains two Intel CPU and two Nvidia Tesla K20 GPUs and 64 GB RAM. The present hardware contains 32 blade servers, which are mounted into seven chassis. These servers are used for FX data processing algorithms (doppler tracking, FFT, and spectra multiplication) computing. Also the HPC contains eight 19-inch servers; each of them provides data receiving operation, pcal extraction, delay tracking, and bit repacking. These servers are equipped with two GPUs, 256 GB RAM and 2x10 Gb fiber optic input. Data storage is based on Panasas with 80 TB capacity. The interblock data communication is provided by infiniband network. Cluster components are mounted on four racks.

In the end of 2014, the two-station Ru0108 series was processed. All fringes were obtained.

The six-station benchmark tests with a 96 Gbps input data stream were performed. The 16 Gbps data stream from each station consisted of four bands and two polarizations. 312 spectra total (78 spectra in each band) with 4,096 frequency points each were calculated in near to real time. The results showed that our algorithms require 80 Tesla K20 GPUs for near-real time processing.

The next year will be devoted to upgrading our GPU software according to new CUDA specifications, developing post-processing software, and developing GUI software.

5 Staff

- Igor Surkis — leading investigator, software developer;
- Voytsekh Ken — GPU software developer;
- Alexey Melnikov — DiFX processing, scheduler of the Ru-sessions;
- Vladimir Mishin — software developer, data processing;
- Nadezhda Mishina — software developer;
- Yana Kurdubova — software developer;
- Dmitry Pavlov — software developer;
- Violet Shantyr — software developer, post processing;
- Vladimir Zimovsky — leading data processing;
- Ekaterina Medvedeva — data processing;
- Alexander Salnikov — leading e-VLBI data transfering; and
- Ilya Bezrukov — e-VLBI data transfering.