# The RASFX VGOS GPU Based Software Correlator

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The RASFX correlator is a VGOS compatible software correlator designed in the IAA RAS. The correlator is capable of processing data at maximum rate of 16 Gb/s from each station in near-real time mode (up to 6 stations simultaneously).

Distinctive feature of the RASFX correlator is the usage of Graphical Processing Units (GPUs) for the Fourier transformation, spectra multiplication, PCal extraction and bits repacking.

Regular VLBI data processing with the correlator started in November 2015. More than 900 sessions were processed from that moment by December 2016. The results of processing are used for UT1-UTC determination.

**Keywords**: VLBI, VGOS, Correlator.

The RASFX correlator is a VGOS compatible software correlator designed in the IAA RAS [1]. The correlator is capable of processing data at maximum rate of 16 Gb/s from each station in near-real time mode (up to 6 stations simultaneously).

The correlator is a FX software one. The basic principles comes from the DiFX correlator. A distinctive feature of the RASFX correlator is the usage of Graphical Processing Units (GPUs) for the Fast Fourier Transformation, spectra multiplication, PCal extraction and bits repacking.

The correlator hardware is based on hybrid blade HPC cluster (Fig. 1). Each of 40 servers holds two Intel Xeon CPUs and two Kepler K20x GPUs.

The correlator software consists of control, processing and post-processing blocks.

The processing software is MPI-based and can be run on different compute nodes (servers) forming desired correlator configuration by the control

Fig. 1. RASFX HPC cluster

block and head module. The processing core consists of station modules, correlation modules (Fig. 2). Correlator is able to handle up to $6 \times 16$ Gbps input streams and calculate auto- and cross-correlation spectra in each band.

Each station module receives input stream from one station and performs input stream decoding, delay tracking, phase calibration signal extraction, data synchronization and bits repacking.

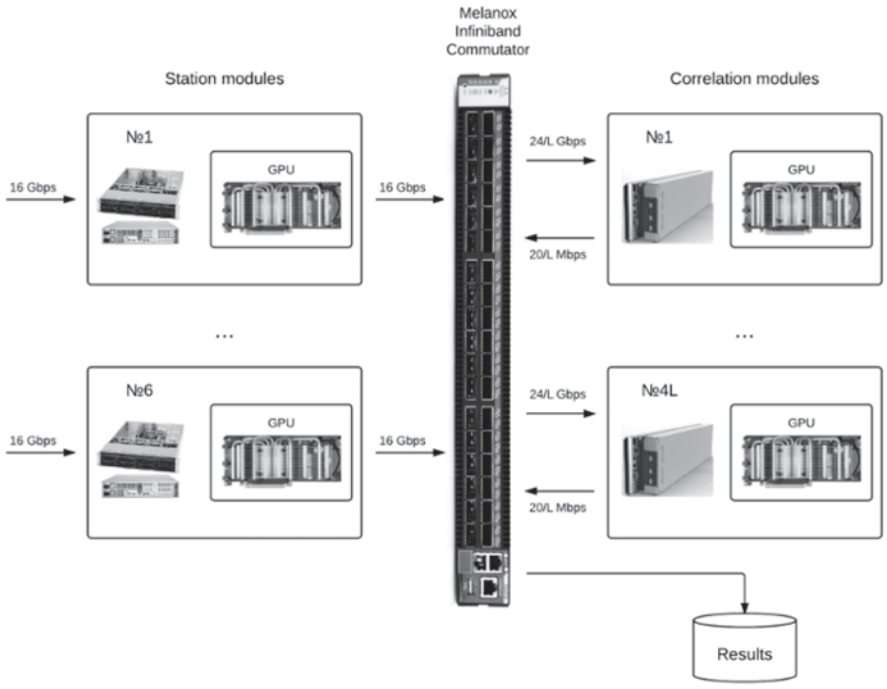


Fig. 2. RASFX program topology

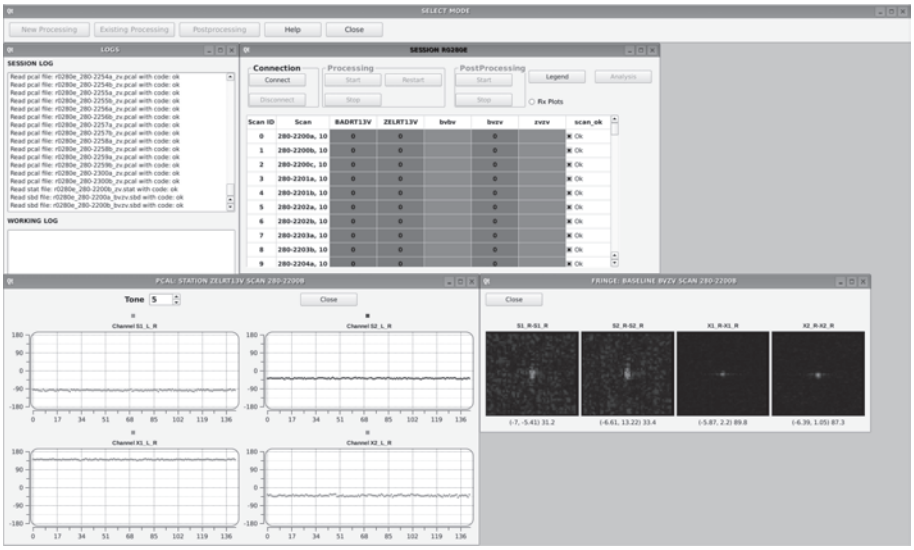

Fig. 3. RASFX control software GUI screenshot

Two correlation modules can be executed independently on one server. They perform bits transformation, fringe rotation, and spectra calculations.

Head module performs interblock communication and results collecting.

The post-processing software provides fringe searching, estimates results quality, calculates group delays and delay rates.

The control software prepares task and MPI configuration for the correlator. The processing flow control includes access to a remote storage in order to the scans availability check and provides graphical user interface (Fig. 3).

At present correlator carries out routine procecessing up to 6 observation sessions on a daily basis with following setups: 4 frequency channels of 512 MHz bandwidth (X/S bands), and 2 frequency channels of 512 MHz bandwidth (X/Ka bands), 3 frequency channels of 512 MHz in (S/X/Ka bands).

The correlator accuracy was estimated using the special modeled signals. The model of 2-station VLBI system was created using 3 normally distributed pseudorandom numbers noise generators ($G_{n1}$, $G_{n2}$, $G_s$) included in the MATLAB numerical computing environment. The $G_s$ generator imitates quasar signal, $G_{n1}$ and $G_{n2}$ — the receiving system noise. Two scans with 1 ms baseline were generated and processed with prior ephemeris delay models. Two 16 s 2-bit 1 channel wideband scans were created, the 1 ms baseline delay was included. A clock offset and a fringe rate were produced using ephemeris delays. 28 combinations of delays and delay rates were used for the scans processing with the 8248 MHz carrier frequency, 2048 spectra channels resolution and 0.0625 s accumulation period. 28 resulting fringes were analyzed

and compared with the prior estimate.

The delay residuals vector were calculated as the difference of RASFX correlator calculated delays and prior delays at the scan center. The formal error of the delay estimation for this fringe is about 9.6 ps. The mean of delay residuals is 12 ps, it is a RASFX correlator systematic error. The delay standard deviation is 4.4 ps, less than the formal error.

The regular VLBI data processing with the correlator started in November 2015. More than 900 sessions were processed from that moment by December 2016. The results of processing are used for UT1-UTC determination [2].

**References**


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