IAA VGOS GPU-based Software Correlator: current status and broadband processing

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Correlator specification

- Input data stream of up to 16 Gb/s from each of up to 6 VGOS stations:
  - 2-bit sampling,
  - 4 frequency bands:
    - 2 polarizations, 512 MHz bandwidth, or
    - 1 polarization, 1024 MHz bandwidth
- Cross-spectra resolution of up to 4096 spectral channels (near-real time)
- Extracting 32 phase calibration tones (near-real time)
- VDIF data format
- Group delay < 10 ps

Main design concepts

- FX type
- Usage Graphical Proccessing Units (GPU) for bit repacking, fringe stopping, FFT, spectra multiplication and pcal extracting
- HPC cluster based on the hybrid blade servers (2 CPU + 2 GPU)
- Bit stream transformation is perfomed in the GPU DRAM

HPC cluster

November, 2014:

- **40 compute servers**
  - 2 Intel E6-5-2670 8-core, 2.6 GHz
  - 2 Nvidia Tesla K20
  - 256 GB RAM (8 servers)
  - 64 GB RAM (32 servers)
- **56 Gbps Infiniband**
- **16x10GbE**
- **Panasas data storage 75 TB**

- **Linux Centos 6**

- **96 kW APC UPS**
- **3 A/C Stulz**

High-performance computing cluster estimation

16 Gbps input stream, 4096 channels, 4 freq. bands

Stations	Polarizations	Baselines	GPUs	Blade servers
2 2	1 2	3 10	8 14	**4** **7**
3 3	1 2	6 21	10 22	**5** **11**
4 4	1 2	10 36	14 27	**7** **14**
5 5	1 2	15 55	16 41	**8** **21**
6 **6**	1 **2**	21 **78**	22 **55**	**11** **28**

Correlator topology

Station module

Input: VGOS data (16 Gbps)

Processing: VDIF decoding, delay tracking, pcal extracting, bits repacking

Output: bit stream (16 Gbps)

Correlation module

Input: bit stream (1.5 Gbps)

Processing: fringe stopping, FFT, spectra multiplication

Output: cross-spectra data (1.25 Mbps per accumulation period)

Head module (Correlator Control System)

Control, streams distribution, logging etc

See more: *Ken V. et al. Design of a VGOS Software Correlator Based on GPUs // VGOS: The New VLBI Network. IVS 2014 General Meeting Proceedings / eds: D.Behrend, K. Baver. – 2014. P.183-187*

Correlator Control System (CCS)

Main goals:

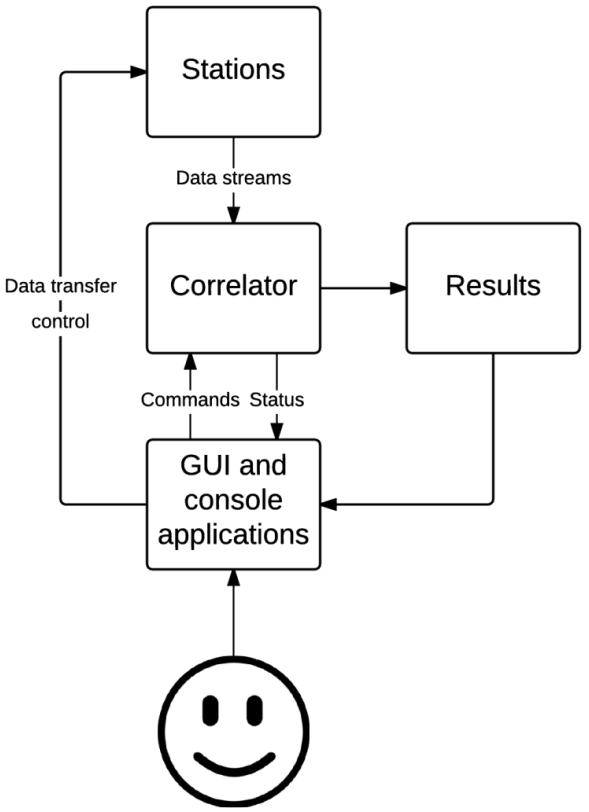
- Provide complete status and errors information for the whole system to the operator
- Provide all in one GUI and console tools for data processing and transfer control

Current development status:

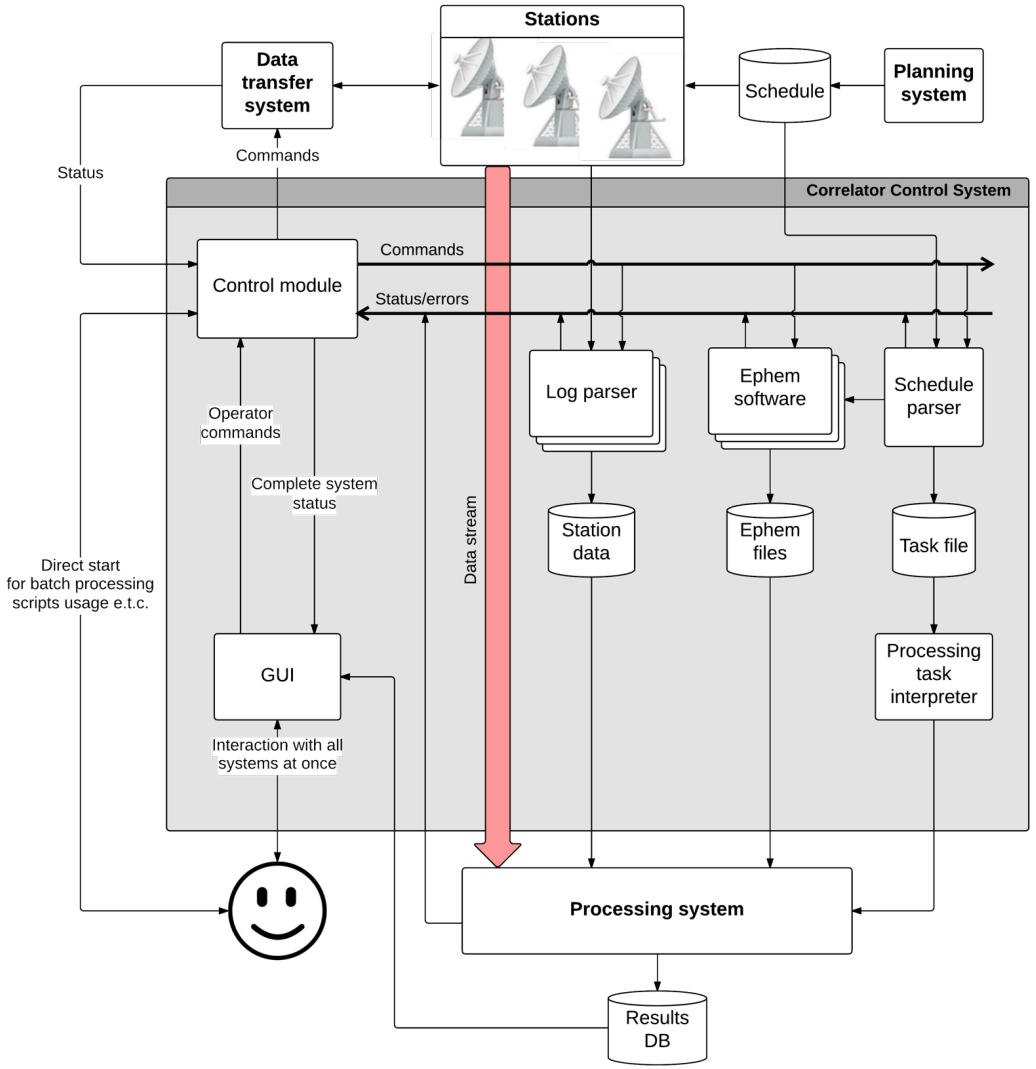
Most components are usable but some are still under active development

Estimated time to complete and test the whole system is 2-3 months.

CCS command/data flow light version



Correlator Control System (CCS)



Correlator benchmark test

Ru-TEST108 (04.09.2014) was carried out with the following setup:

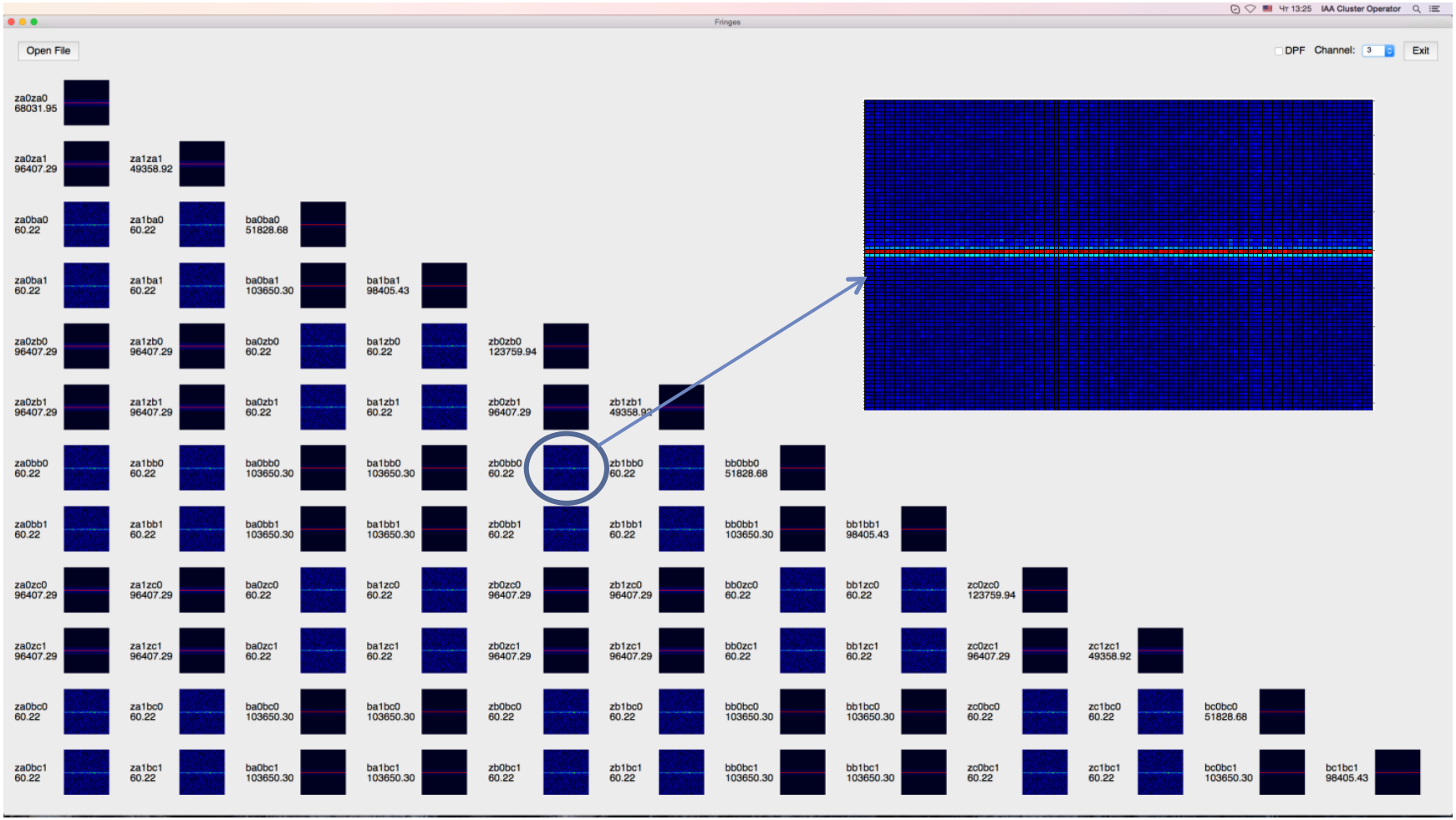
- Zelenchukskaya – Badary
- Bandwidth 512 MHz
- 2 bit sampling

Benchmark mode:

- **4 freq. bands**
- **2 polarizations (16 Gbps)**
- **4096 channels**
- **30 sec scan**

78 fringes in one freq. band, 312 fringes total

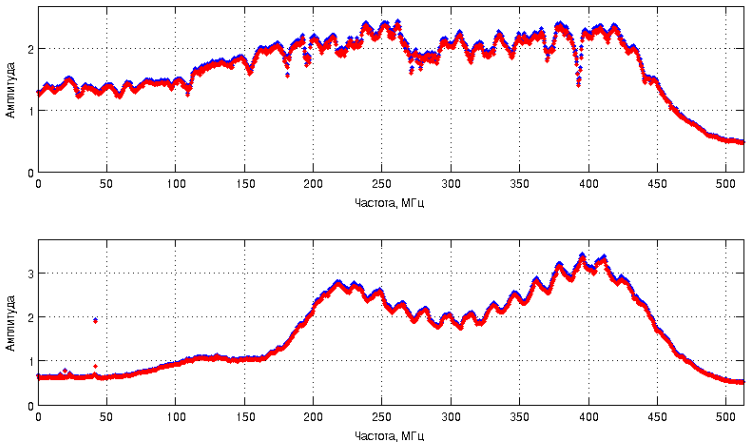
Correlator benchmark test



Comparison DiFX and IAA correlator

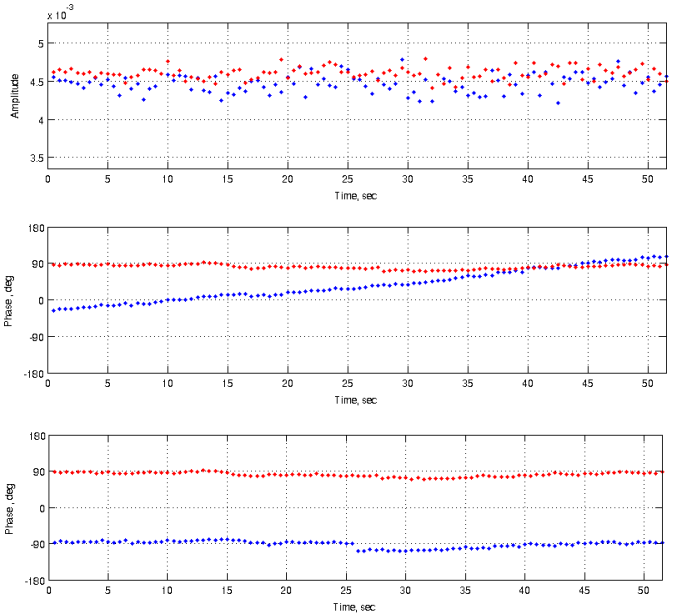
Ru-TEST108 (04.09.2014), Zc-Bd (RT-32), 512 MHz

Spectral density of Badary (up) and Zelenchukskaya (bottom)



DiFX - **red**, IAA correlator - **blue**

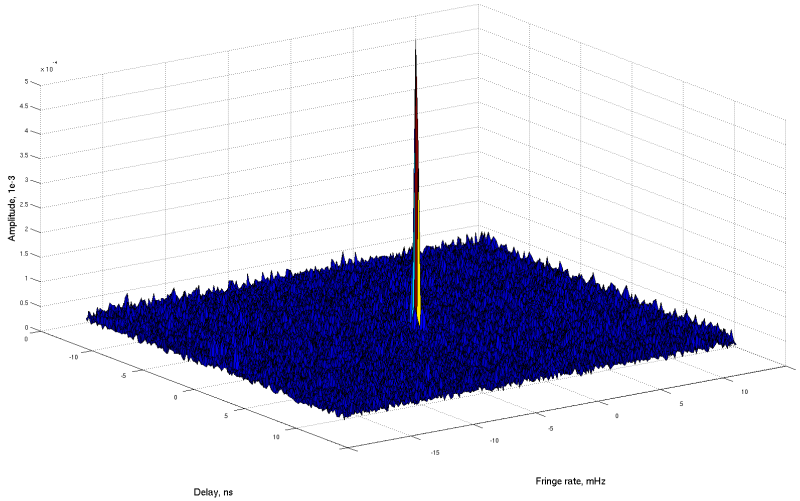
Fringe amplitude and phase



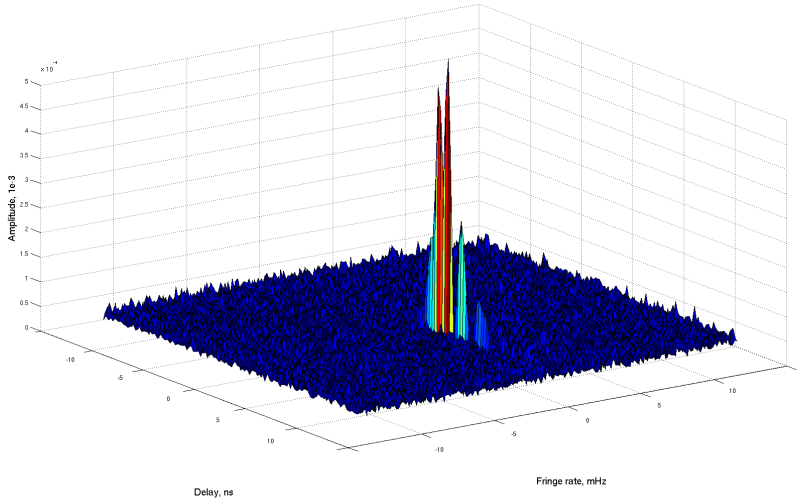
Ephemeris data is the same, residual IAA fringe rate is 0.7 ps/s

New VGOS telescopes test

- Ru-TEST119 (16.04.2015)
- Zelenchukskaya - Badary (RT-13) base
- 512 MHz bandwidth
- S/X Band
- Source 0212+735



X-band



S-band

Near future plans

- Correlator control system (3 months)
- Postprocessing software (this year)
- Joint processing with the BRAS and DBBC system (we hope this month)

Thank you!