

# Operating Experience of Broadband Acquisition System on RT-13 Radio Telescopes

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### **BRoadband Acquisition System (BRAS)**







BRAS is used on RT-13 radio telescopes in «Badary» (Bv) and «Zelenchukskaya» (Zv) observatories since the beginning of 2015.

### **BRAS** location





#### **BRAS structure**



- > 8 x 512 MHz inputs
- 2 or 8 bits quantization
- 8 x 10Gbit Ethernet outputs





### Synchronization module

### **One channel of BRAS**



### **Switching modes**







> Data transfer medium: **fiber (default)** or copper (optionally)

VDIF frames with tunable payload size:
1000, 1024, 1280, 1600, 2000, 2048, 2560, 3200,
4000, 4096, 5000, **5120 (default)**, 6400, 8000, 8192 bytes

Data transfer protocol: Raw 10G Ethernet frames (default) or UDP frames

Test pattern available



- Signal power measurement
- 2-bits samples distribution
- PCAL extraction
- > 8/2 bits signal capture (1 us)
- ➢ 1PPS int.-ext. delay monitoring
- > Monitoring of currents in power circuits, temperatures, lock
  - detect signals of clock synthesizers



Normal noise with quantization thresholds  $\pm 1\sigma$  has 16%, 34%, 34%, 16% distribution.

Strong RFI and signal distortions can be detected by distribution deviation from these levels.



#### Typical distribution

## Distribution in S-band with DORIS system enabled



### Signal analysis features: signal capture





#### Captured signal in time domain. 1024 samples (1 us)

![](_page_9_Figure_4.jpeg)

Captured signal in frequency domain. Averaging is switched on. 0-512 MHz

![](_page_10_Picture_1.jpeg)

#### Extracted PCAL pulse in time domain. 1'000'000 periods averaging (1 second)

![](_page_10_Figure_3.jpeg)

Time, samples

![](_page_11_Picture_1.jpeg)

#### PCAL tones phase after linear trend elimination

![](_page_11_Figure_3.jpeg)

![](_page_12_Picture_1.jpeg)

#### tone phase over time

![](_page_12_Figure_3.jpeg)

![](_page_13_Picture_1.jpeg)

It is possible to estimate relative delay between signal chains by using PCAL signal.

The table shows the delays in X-band measured for ZELEN13M (Zv) and BADAR13M (Bv). All delays are measured relative to X1 RCP channel.

Ch.	X1_R	X2_R	X3_R	X1_L	X2_L	X3_L
Bv	Ref.	0,6 ns	0,8 ns	0,7 ns	1,0 ns	1,5 ns
Zv	Ref.	0,4 ns	0 <i>,</i> 8 ns	1,1 ns	1,7 ns	1 <i>,</i> 8 ns

X1\_R, X2\_R, X3\_R – RCP X-band channels X1\_L, X2\_L, X3\_L – LCP X-band channels

#### Black line: sampling clock phase noise with real reference clock from H-maser. RMS Jitter: 150 fs @ 30 Hz to 10 MHz

![](_page_14_Figure_2.jpeg)

![](_page_15_Picture_1.jpeg)

Date: 04.09.2014 Baseline: ZELENCHK - BADARY (Zc-Bd), 32-m antennae Frequency: 8.592-9.104 GHz (512-1024 MHz in IF) 25 sources with flux density from 0.6 to 7.6 Jy and duration from 20 to 127 s Mark5C recording system

![](_page_15_Picture_3.jpeg)

#### First observation with BRAS on RT-32 radio telescopes

1803+784.xsmmzw, No0002, BR

0212+735

1803+784

![](_page_16_Figure_4.jpeg)

![](_page_16_Figure_5.jpeg)

Control file: default Input file: home>tra/Documents/HCPS\_IV1234No0002/ERJeanmaw Output file: Suppressed by test mode

![](_page_17_Picture_1.jpeg)

- 16.04.2015 First domestic observation with RT-13 radio telescopes.
   Baseline: Zv-Bv.
   Correlator: DiFX in IAA RAS.
- 29.04.2015 First international test observation Baseline: Zv-Wn-Yj. Correlator: DiFX-IAA, DiFX-Bonn.

19.05.2015 – Official inauguration of RT-13 during EVGA2015. Baseline: Zv-Bv-Wn-Yj-Ys. Correlator: IAA GPU-based correlator, DiFX-IAA, DiFX-Bonn.

![](_page_18_Picture_1.jpeg)

- By 29.02.2016 BRAS has been used in:
- > 25 equipment test observation sessions
- 256 regular observation sessions

Still searching for optimal scheduling:

> From 30.11.2015 to 01.12.2015:

25-90 scans in 1 hour session.

> Since 02.12.2015:

55-60 scans in 30 minutes session.

#### **Domestic observations: BRAS-BRAS**

![](_page_19_Picture_1.jpeg)

#### Mk4/DiFX fourfit 3.11 rev 1142

#### 3C279.ytrcop, No0001, bz BADAR13M - ZELEN13M, fgroup X, pol RR

![](_page_19_Figure_4.jpeg)

![](_page_20_Picture_1.jpeg)

#### Sept-Nov 2015

8 sessions Yj-Zv-Bv to find optimal set-up for DBBC-BRAS joint observations. See poster **«First 2 Gbps observations between KVAZAR VGOS antennas and Yebes RAEGE antenna»** for details.

### <u>28 Oct 2015</u> Fringe test for TianMa 65-m Radio Telescope. T6-Wn-Zv.

<u>Dec 2015</u>

2 sessions Bv-Yj-Wn-Zv for FAST program. See poster **«First results of the FAST-S/X-sessions with new VGOS antennas»** for details.

## International observations: DBBC-BRAS

![](_page_21_Picture_1.jpeg)

![](_page_21_Figure_2.jpeg)

![](_page_22_Picture_1.jpeg)

- In operation since spring of 2015
- More than 300 international and domestic observation sessions
- Used in observation on daily basis since Nov 2015
- BRAS-DBBC compatibility confirmed in real observations
- Regularly used for monitoring signal chain equipment performance and hardware debugging

![](_page_23_Picture_1.jpeg)

## **THANK YOU FOR YOUR ATTENTION!**

- 13th EVN Symposium & Users Meeting will be held in September 20-23 in Saint-Petersburg
- The TOG meeting is scheduled on September 19
- Information available on <a href="http://www.ipa.nw.ru/EVN2016">http://www.ipa.nw.ru/EVN2016</a>

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#### INTRODUCTION

The Institute of Applied Astronomy of the Russian Academy of Sciences (IAA RAS), on behalf of the European VLBI Consortium, will host the **13th European** VLBI Network Symposium and Users Meeting on September 20-23, 2016. The Symposium will be held at the St. Petersburg Scientific Center, located in the heart of St. Petersburg.

Technical development from VLBI, space VLBI and e-VLBI and the latest scientific results from a number of radio facilities around the globe, such as e-MERLIN, LOFAR, EVLA, ALMA, MeerKAT, ASKAP, SKA will be reported. Scientific sessions will include life cycle of matter in stars and galaxies, AGN and cosmic star-formation, Extreme Astrophysics, Astrometry and Geodesy, planetary and space science, as well as techniques and developments. The programme will also include an EVN Users Meeting to foster interaction between the EVN users and the EVN organization.

The Scientific Organizing Committee invites all scientists who have interests in the various research fields of VLBI and in related fields to participate in the Symposium, submit contributions to the topical sessions and share their research with colleagues and friends. We are looking forward to welcome you in St. Petersburg!