The Russian backends. Developments

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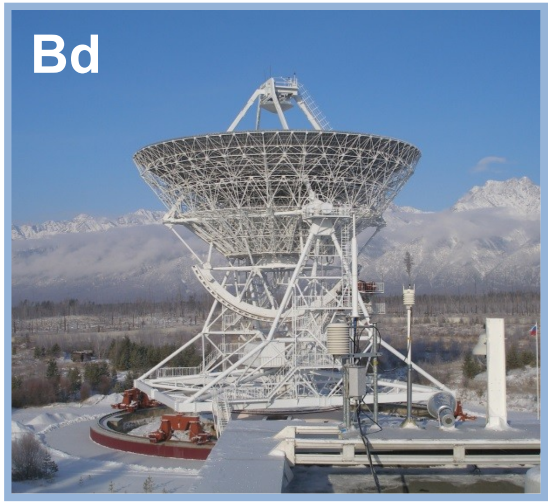
The "Quasar" VLBI Network

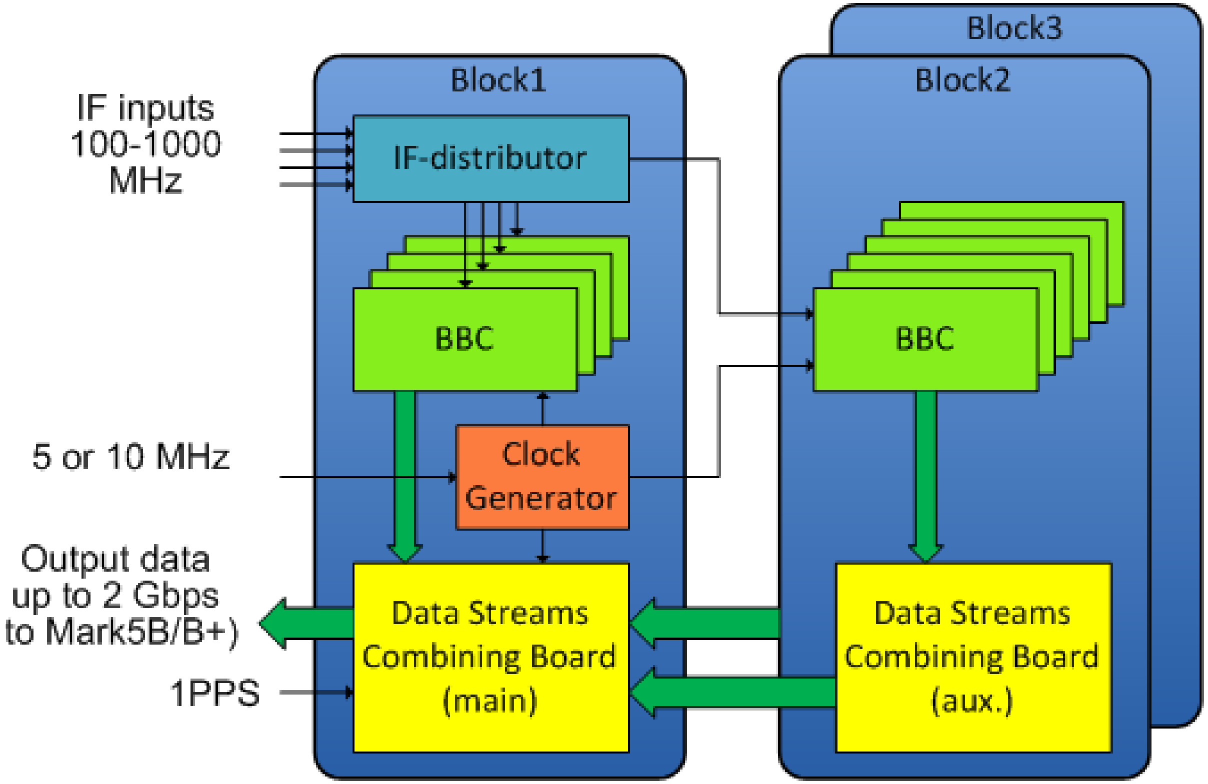
The antenna system of radio telescope RT-32



"RT-32" specifications:

- Configuration: Cassegrain with asymmetrical subreflector
- Main reflector diameter: 32 m
- Subreflector diameter: 4 m
- Focal length: 11.4 m
- Azimuth range: ±270°
- Elevation range: from -5° to 95°

R1002M Backend system (1/3)



R1002M Backend system (2/3)

R1002 Key features	
Input frequency range	100 ÷ 1000 MHz
Number of IF-inputs	4
Number of channels (BBCs)	16
Selectable bandwidths	0.5, 2, 4, 8, 16, 32 MHz
Separated sidebands	Both lower and upper
Image rejection rate (typ.)	-40 ÷ -45 dB
Commutation of input and output signals	Electronically
Local oscillators phase noise (rms)	≤ 0.7° (measured in 30Hz÷30MHz range)
Ripple of amplitude-frequency response of the BBCs	≤ 0.3 dB
Output data format	VSI-H
Output data rate	Up to 2 Gbps
Available control interfaces	RS-232, RS-485, 100/10 Ethernet
Total dimension (three 19” subracks)	445 x 950 x 315 mm

Hardware Delay

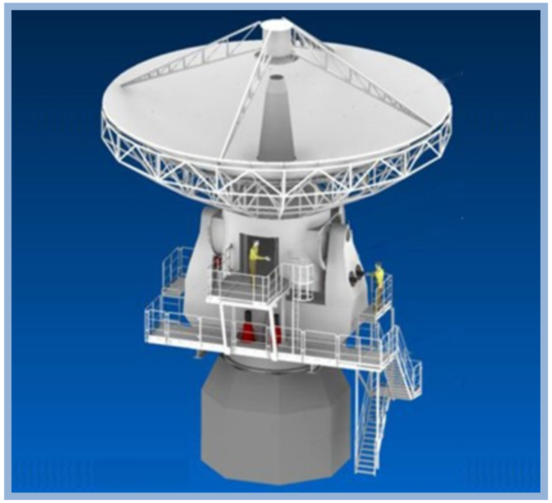
Cutoff frequency of the BBC on the lower end is 5 kHz@-6dB

To achieve this a sophisticated bank of complex filters (with real and imaginary part) was designed

The filters introduce significant delay to the signal which should be taken into account during correlation processing

Bandwidth, MHz	0.5	2	4	8	16	32
Hardware delays in BBCs, us	281.8	219.9	219.9	216.8	217.1	216.5

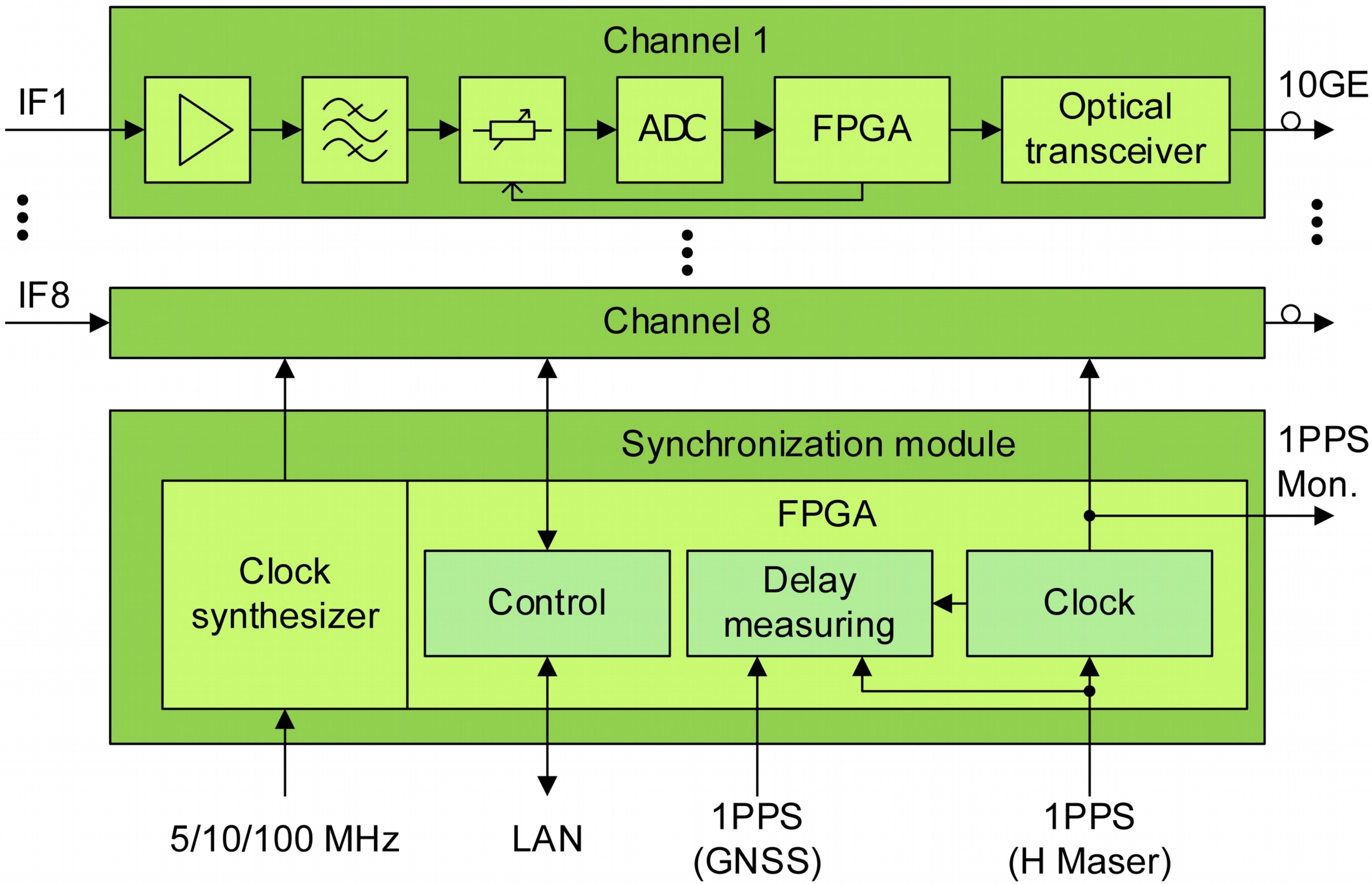
The antenna system of radio telescope RT-13



"RT-13" specifications:

- Manufacturer: Vertex Antennentechnik GmbH
- Mount: alt-azimuth
- Main reflector diameter: 13.2 m
- Surface accuracy: < 0.15 mm
- Azimuth speed: 12 °/s
- Elevation speed: 6 °/s

BRoadband Acquisition System (BRAS) structure



Digital conversion channel (Channel)

- Analog IF signal (1024-1536 MHz) conversion to digital
- IF signal power measuring
- 2-bit information flow conversion
- Output data is packed in VDIF frames
- The output VDIF data stream are transferred to recording system by 10GE interface
- Interaction with Control PC to configure and transmit telemetry data

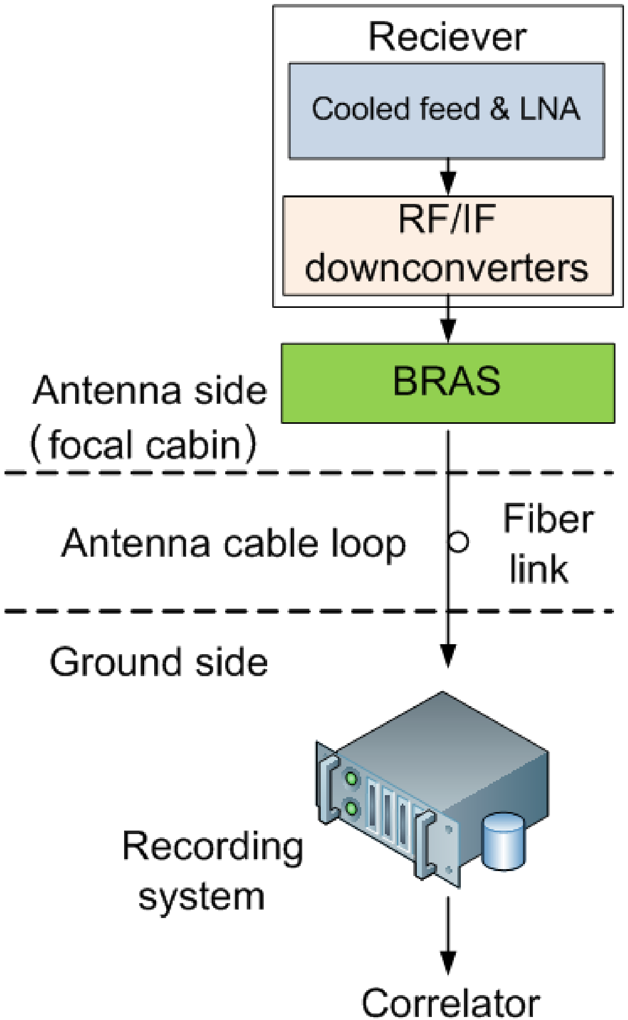
Synchronization unit

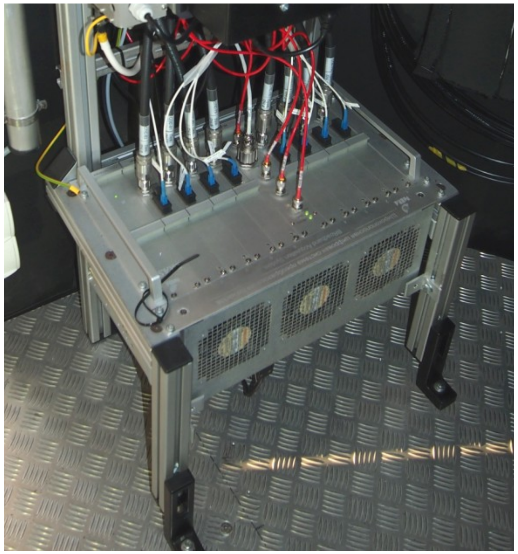
- Formation and distribution of the clock signal of 1024MHz (for ADC) и 256MHz (for FPGA)
- 1PPS formation and distribution
- Measuring delay between 1PPS and 1Hz (H-Maser) and 1PPS and 1Hz (GNSS)
- Formation and distribution of the control signals from channels to synchronization unit

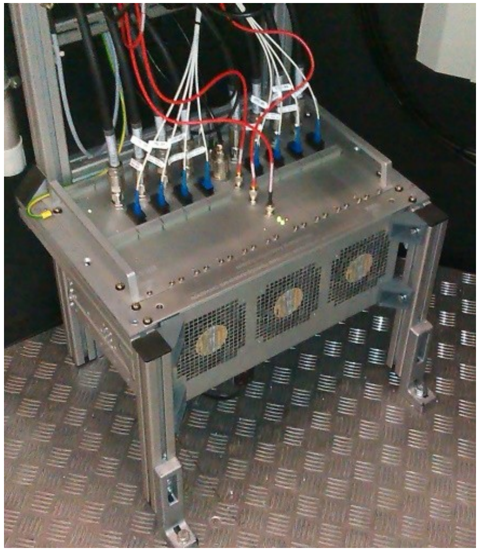
BRoadband Acquisition System Design

BRAS location

BRAS is located in the focal cabin. The output signals are digital and transmitted through fiber.







Advantages over analog signal transmitting through fiber or coaxial cable:

- No influence on frequency response
- No EMI induced in IF
- Variation of ambient temperature and cable loop bending does not affect the transmitted signal
- Reduced amount of equipment (amplifiers, equalizers, RF-to-fiber converters etc.)

Key features of BRAS (1/2)

Number of channels	8
IF	1024-1536 MHz
Channel bandwidth	512 MHz
ADC	8 bits, Fs=1024 MHz
Output samples width	2/8 bits
Automatic gain control	For each channel, 31 dB
Sync signals	5/10/100 MHz (autodetect), 1 PPS x2
Control interface	10/100 Ethernet
Telemetry	Power circuits current, temperature of PCBs and ADCs
Power consumption	75 W
Size	19” case, 483x314x242 mm (WxHxD)

Key features of BRAS (2/2)

Data frames format	VDIF
VDIF payload size, bytes	1000, 1024, 1280, 1600, 2000, … , 8000, 8192
Output interface	10G Ethernet, X2 transceiver
Output headers modes	Pure Ethernet frame, Ethernet + IP Ethernet + IP + UDP
Physical media	Fiber
Analysis features	Signal power 2-bits data statistics PCAL extraction Both 8 and 2-bits signal capture (1024 samples) Spectrum analysis of captured signal and extracted PCAL (implemented in software) 1PPS int-ext delay monitoring

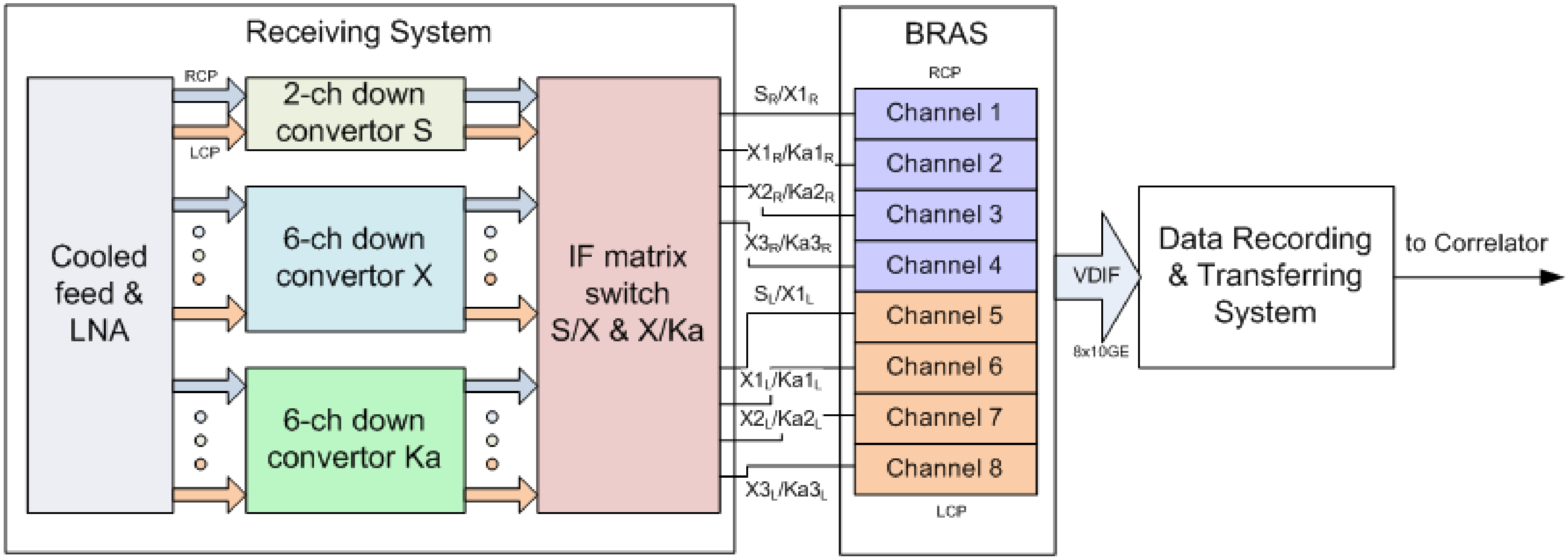
Connecting and operating modes

Receiving system frequency ranges:

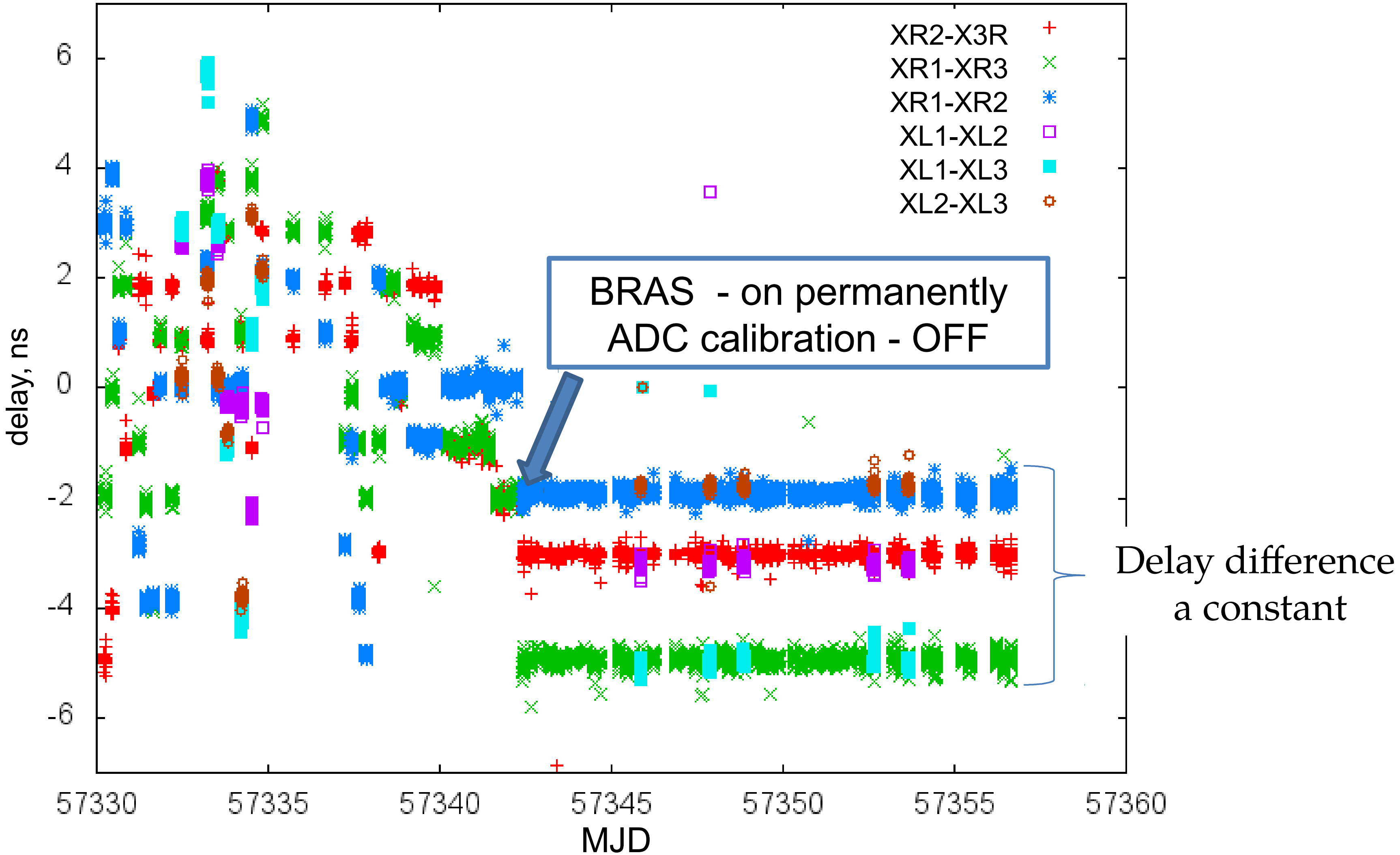
- S-band - 2,2-2,6 GHz
- X-band - 7,0-9,5 GHz
- Ka-band - 28-34 GHz

Two main mode:

- one S-band & 3 X-bands RCP (1-4 ch.) and LCP (5-8 ch.)
- one X-band & 3 Ka-bands RCP (1-4 ch.) and LCP (5-8 ch.)

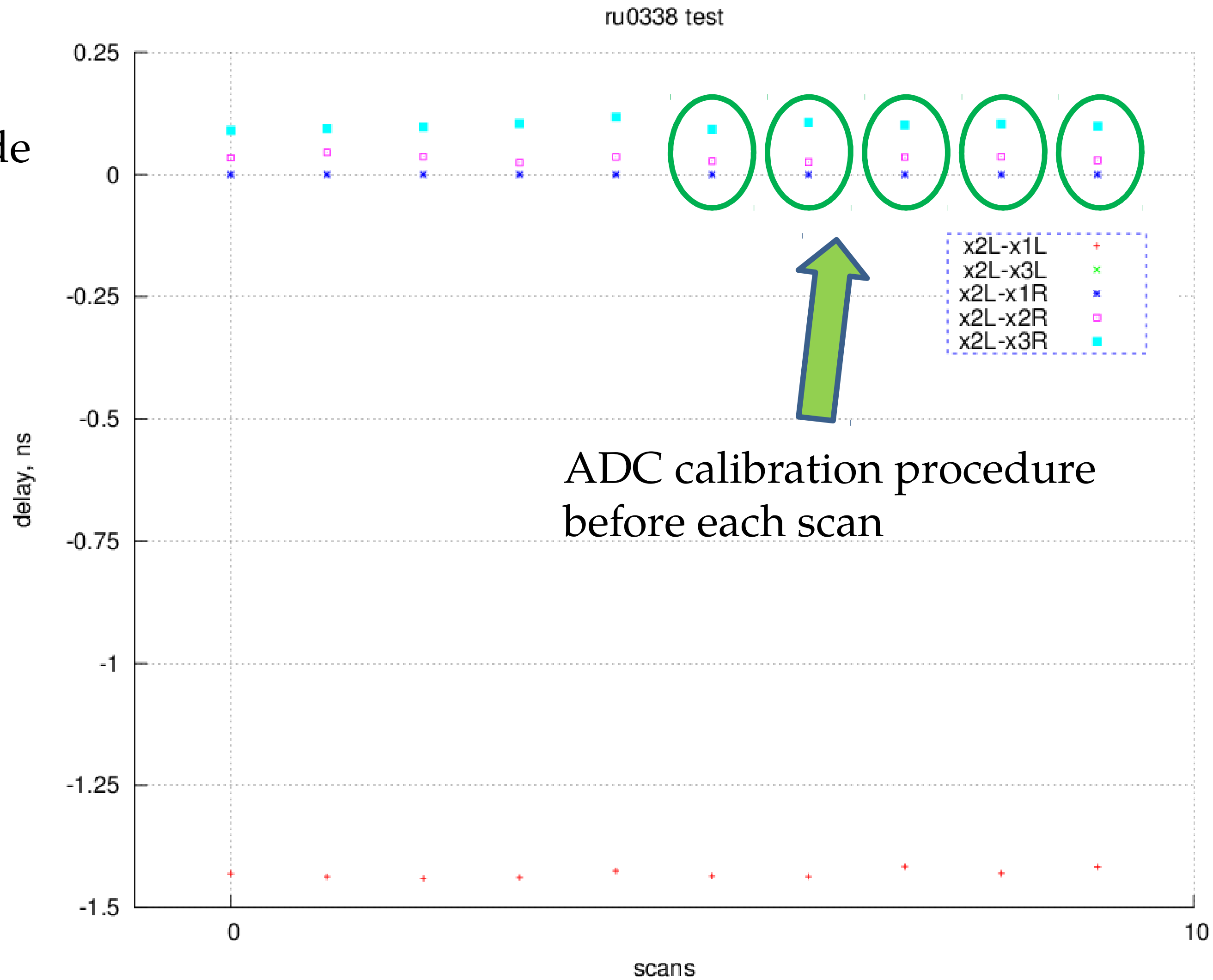


Delay difference between X-band channels (1/2)



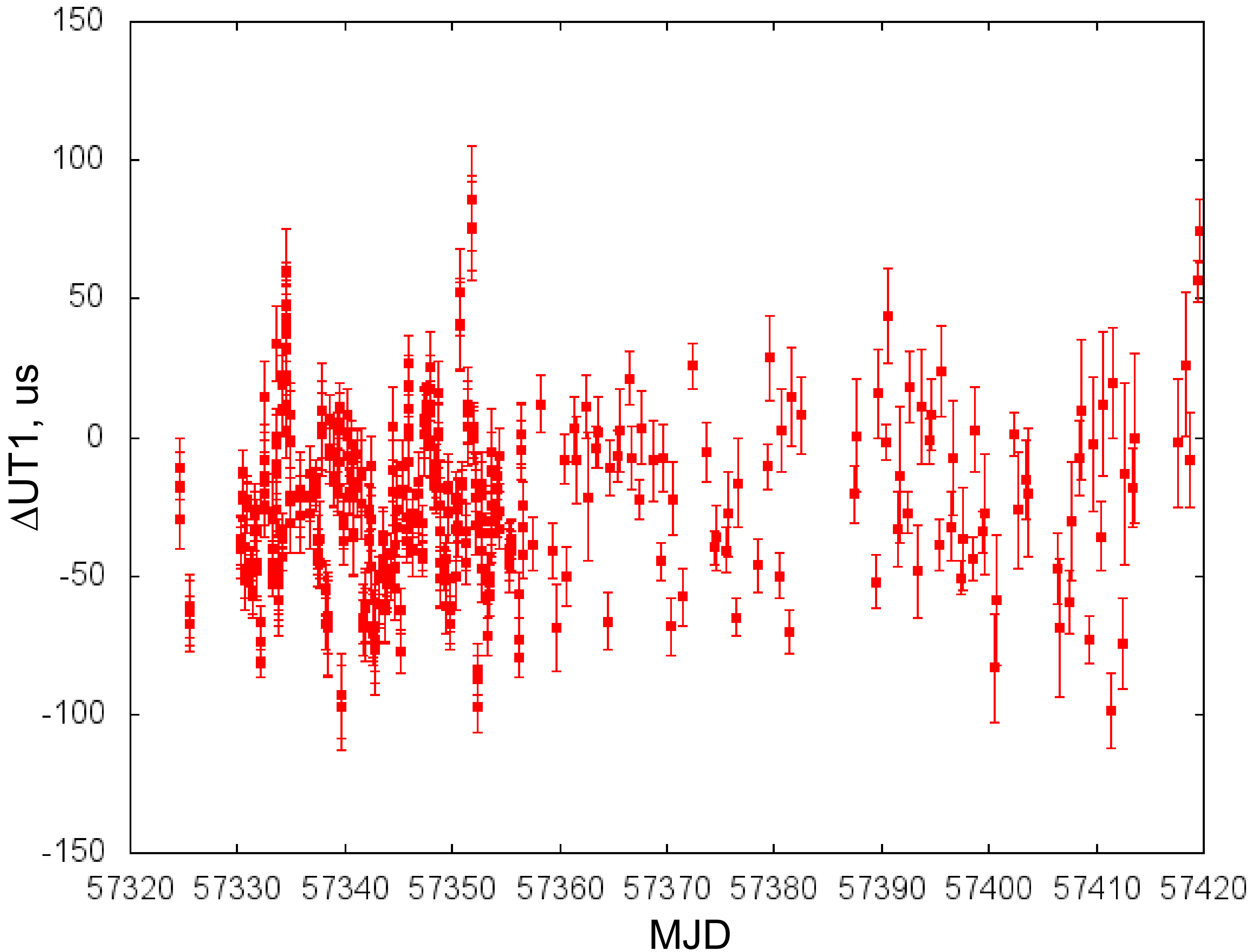
Delay difference between X-band channels (2/2)

Results after the firmware upgrade at 23/12/2016



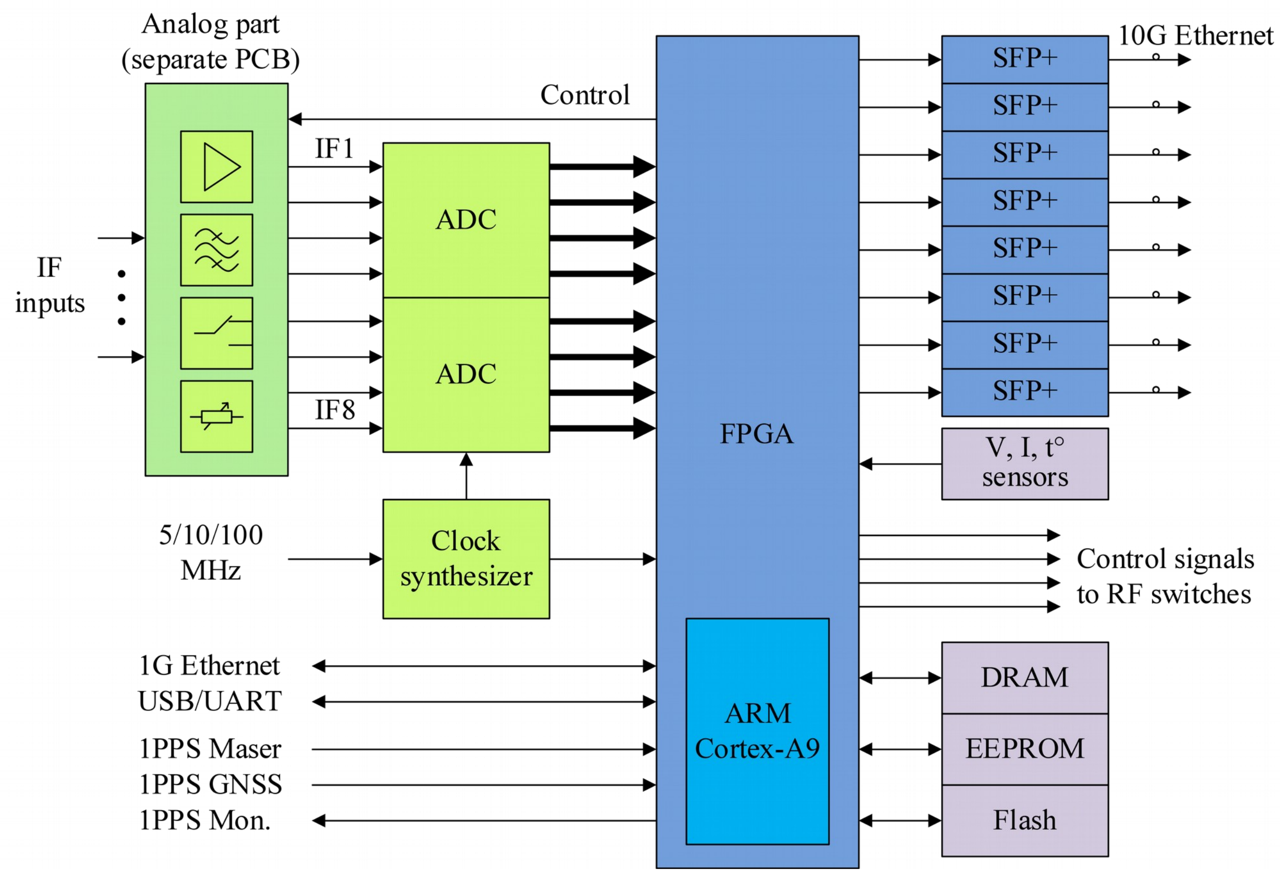
ADC calibration procedure before each scan

Results for ΔUT1 IAA-IERS



Current developments

Multipurpose Digital Backend (MDBE)



more information: http://www.oan.es/raege/evga2015/PDF/T2/T2-3-EVGA2015.Nosov.pdf

Thank you!

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

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!