# R1002
# Data Acquisition System

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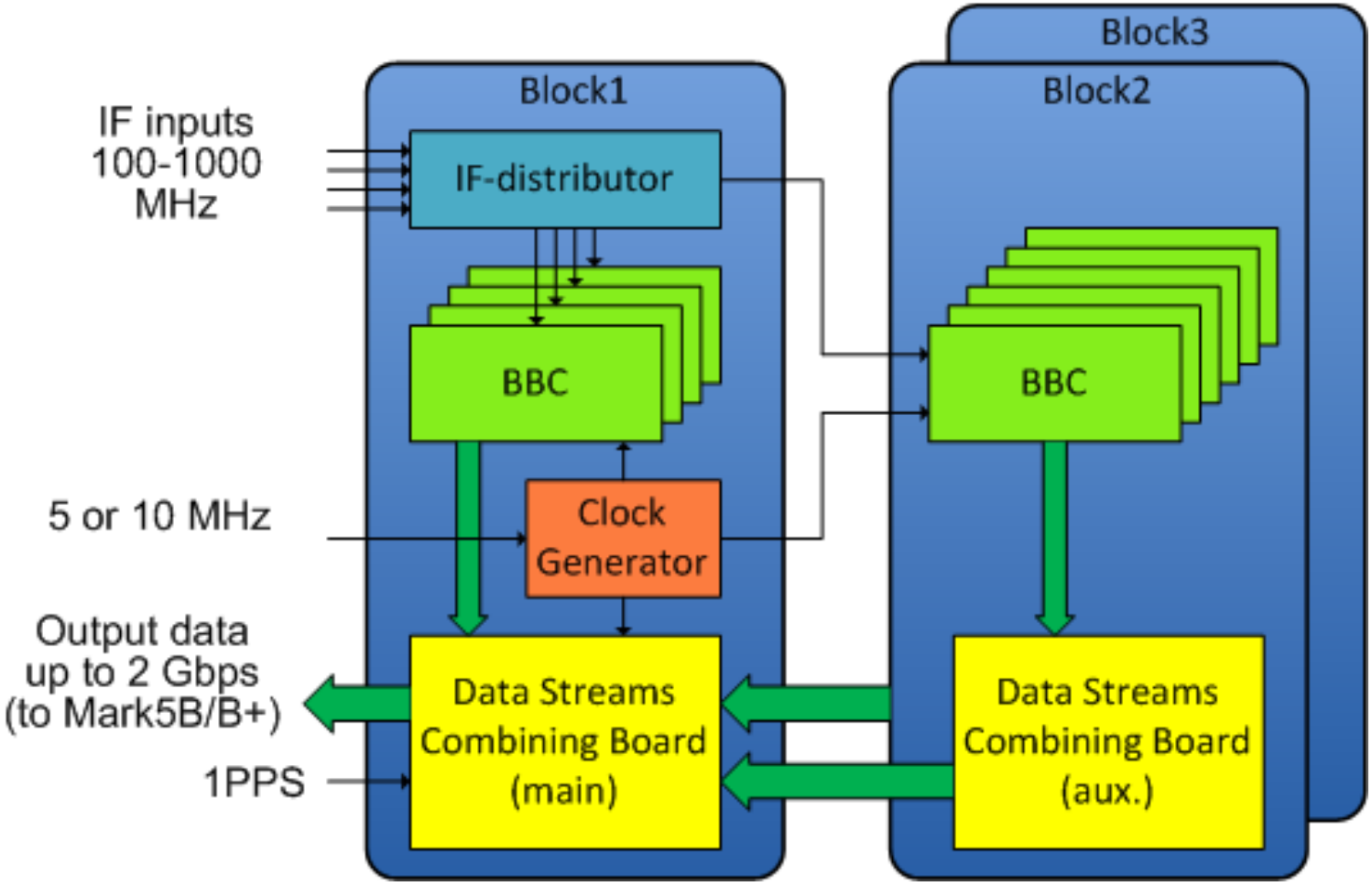
## R1002 DAS

- was created by IAA RAS to replace obsolete analog DASs of «Quasar» network
- based on digital signal processing
- has almost identical frequency response of the channels
- is compatible with existing analog DASs
- is in use since November, 2011

# R1002 DAS structure

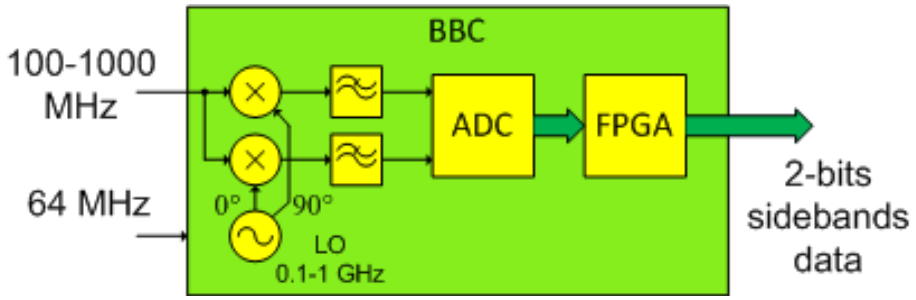


| R1002 DAS key specification | |
|---|---|
| Input frequency range | 100 ÷ 1000 MHz |
| Number of IF-inputs | 4 |
| Number of channels (BBCs) | 16 |
| Selectable bandwidths | 0.5, 2, 4, 8, 16, 32 MHz |
| Separated sidebands | Both lower and upper |
| Image rejection rate (typ.) | -40 ÷ -45 dB |
| Commutation of input and output signals | Electronically |
| Local oscillators phase noise (rms) measured in 30Hz÷30MHz range | <0.9° (*f=1000 MHz*) |
| 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 |

**R1002 DAS has following control and measurement futures:**

- Power measurement
  - in each IF-input
  - in each BBC for both sidebands
- Signal attenuation
  - in each IF-input
  - in each BBC
- Automatic gain control in BBC
- Electronic commutation of IF-inputs to BBCs and output channels to Mark5B
- Control of difference between internal and external 1PPS-signals
- Distribution measurement of quantized signals for all channels
- Autocorrelation and cross correlation between any pair of channels

## Simplified structure of the BBC




## BBC based on:

- Analog mixer
- ADC
- FPGA

## FPGA performs:

- Sidebands separation
- Filtration
- 2-bits quantizing
- Measurement and control functions

BBC has selectable bandwidth: 0.5, 2, 4, 8, 16 and 32 MHz

The shape of the filters is similar to analog BBCs (blue curve "1" on the fig.) for better compatibility

Bandwidths of 4 and 16 MHz have optional more square-like shapes (red curve "2" on the fig.)

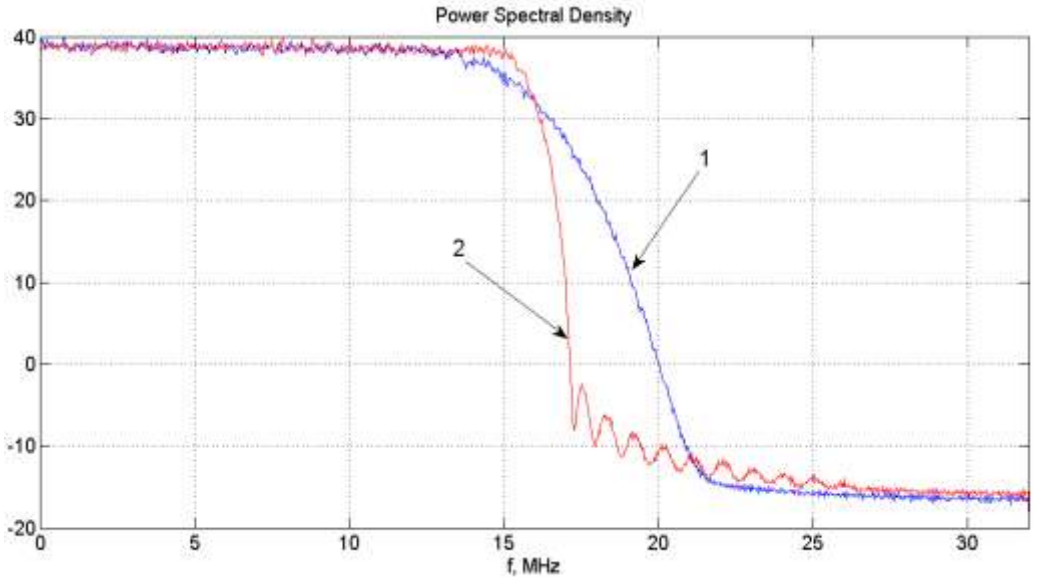



Fig. Power spectral density at the output filter of the BBC (16 MHz bandwidth, normalized to LSB)

# Hardware Delay

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

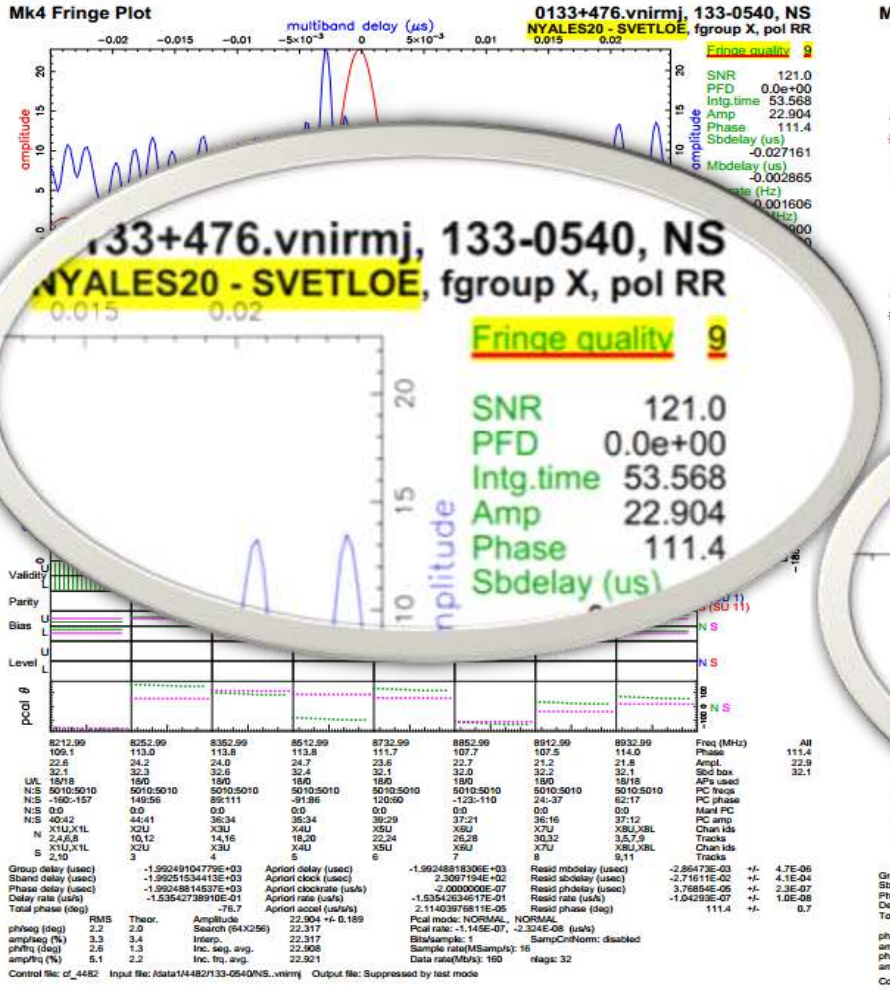
To achieve this an analysis and synthesis banks of complex filters (with real and imaginary part) was designed.

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

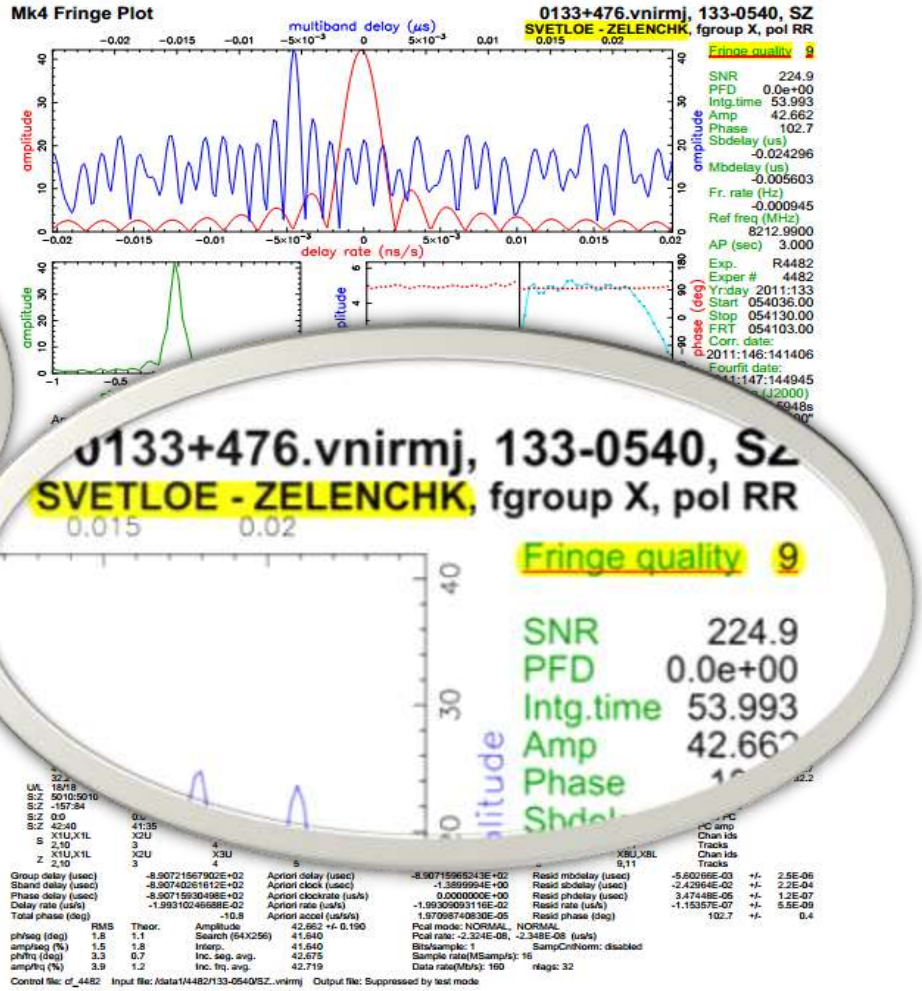
| Bandwidth, MHz | 0.5 | 2 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|---|---|
| Hardware delays in BBCs, μs | 281.8 | 219.9 | 219.9 | 216.8 | 217.1 | 216.5 |

# Compatibility of R1002 with analog DASs

*Ny-Alesund - Svetloe*

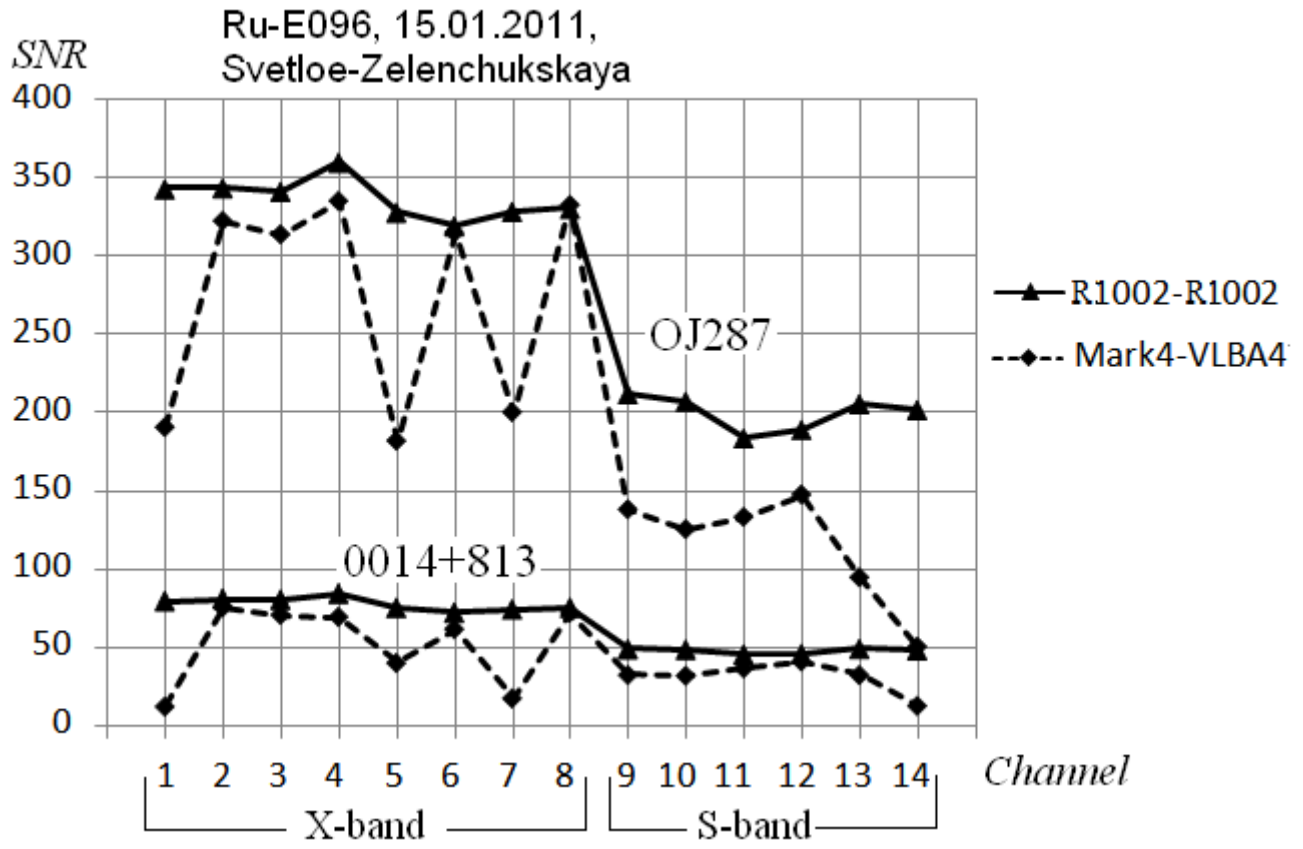



*Svetloe - Zelenchukskaya*



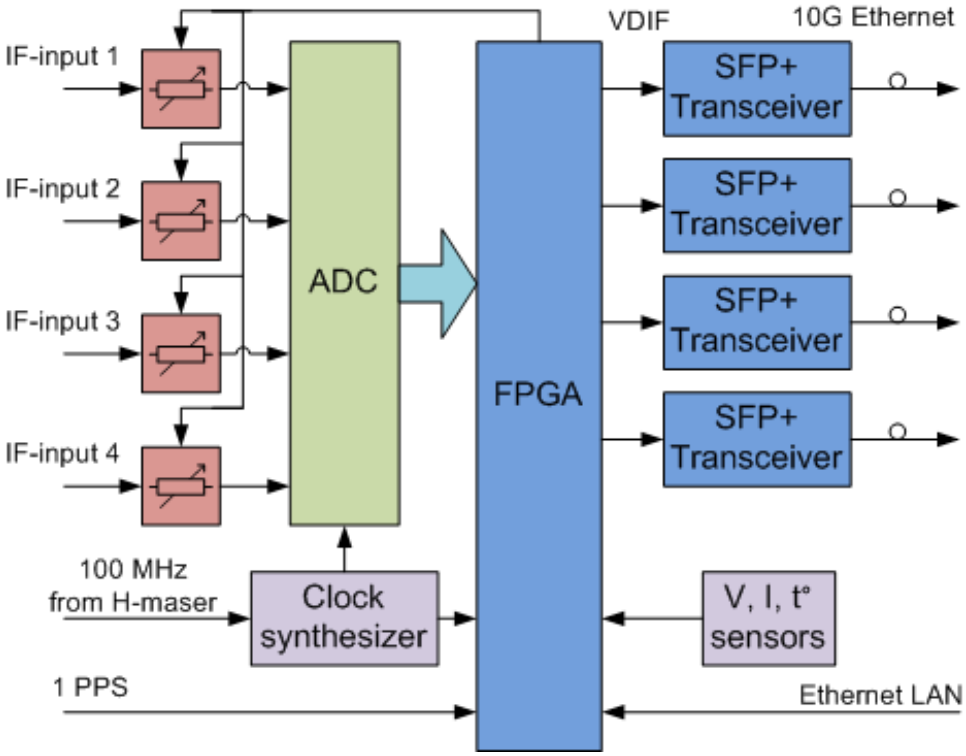
# Comparison of R1002 with previous DASs of «Quasar» network

Simultaneous observations was done by pairs of DASs R1002-R1002 and Mark4-VLBI4. Figure below presents SNR on correlator output in case of strong (OJ287 - 7.6 Jy) and weak (0014+813 - 0.9 Jy) sources for all channels for both pairs of DASs.



# Future plans

4 channels, 512 MHz bandwidth, VDIF, fiber link
2 channels, 1024 MHz bandwidth, …




1-channel prototype

# THANK YOU FOR ATTENTION!