The New Generation Russian VLBI-Network

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WPLTN-2012, 24-28 September, St. Petersburg

The main principles of the new generation Russian VLBI network development

- Radio telescopes of this network should be fully compatible with QUSAR radio telescopes.
- This project should be based on the results of VLBI-2010 work group.
- The real site radio climate conditions should be taken into account.
- Radio telescopes should work on 24 by 7 basis.
- Radio telescopes should be placed at maximal longitude distance from each other.

Proposed location of the new generation Russian VLBI network radio telescopes

Working frequency bands for the new generation Russian VLBI network

Data acquisition parameters

- 4 frequency bands:
  - 512 MHz bandwidth x 2 polarisations
  - or 1024 MHz bandwidth x 1 polarisation
- 2-bit sampling
- Data rate
  - 2 Gbps in each channel
  - 16 Gbps total

First project stage
Frequency bands placing

- 3 bands side by side, on 8.0 – 9.5 GHz frequencies (X-band), for group delay obtaining
- 1 band – on 2.2 GHz (S-band), near to 300 MHz bandwidth really (high noise) – for ionosphere delay calculation

Group delay accuracy – to 4 ps

Second project stage
Frequency bands placing

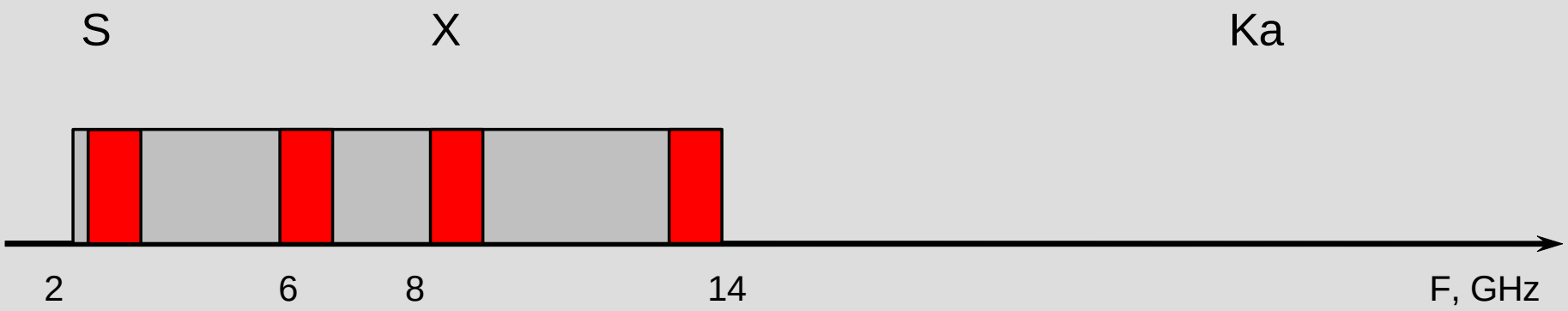
- 3 bands, on 27 – 33 GHz frequencies (Ka-band), with 6 GGz synthesis bandwidth – for group delay obtaining
- 1 band – on 8-9 GHz (X-band) – for ionosphere delay calculation

Group delay accuracy – to 2 ps

Future system

"Bill Petrachenko" projects

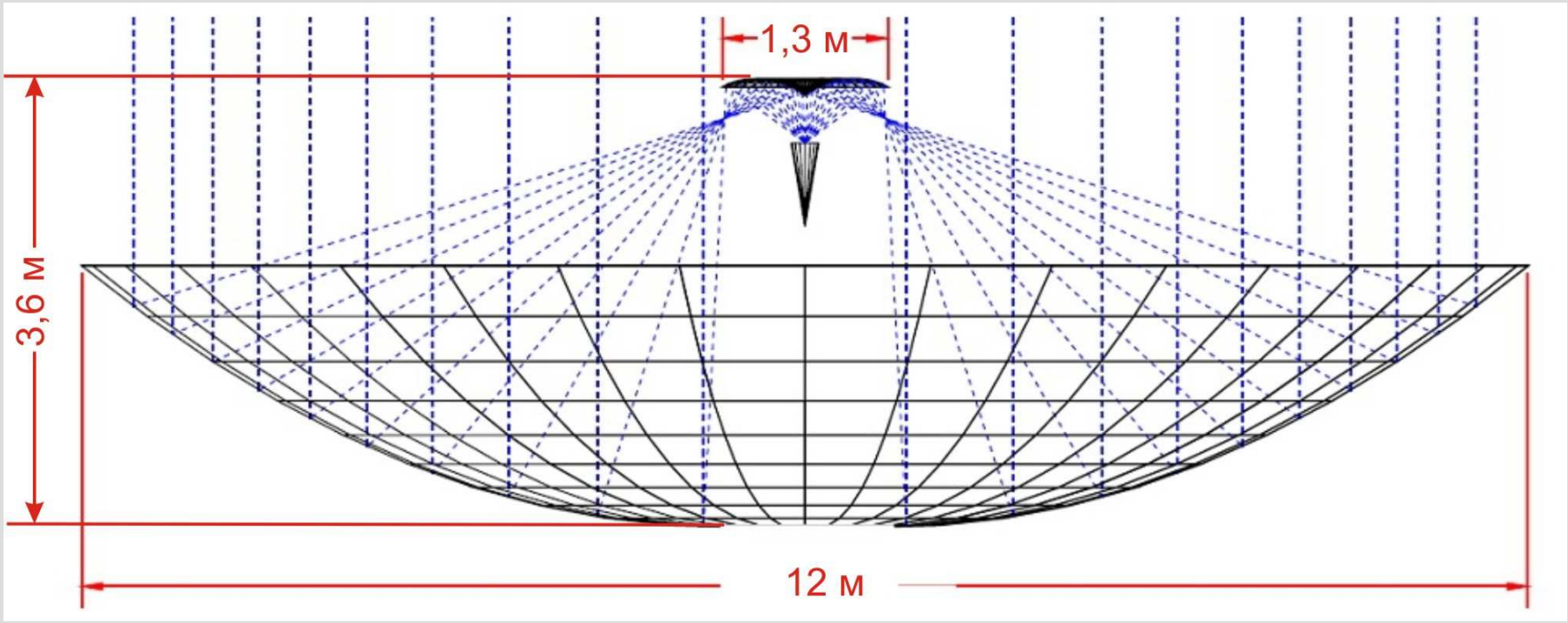
- Preliminary frequency channels placing, 4 bands:
  - band on 2.2 GHz
  - band on 6.4 GHz
  - band on 8.2 GHz
  - band on 13.5 GHz
- Synthesis bandwidth from 2 to 14 GHz



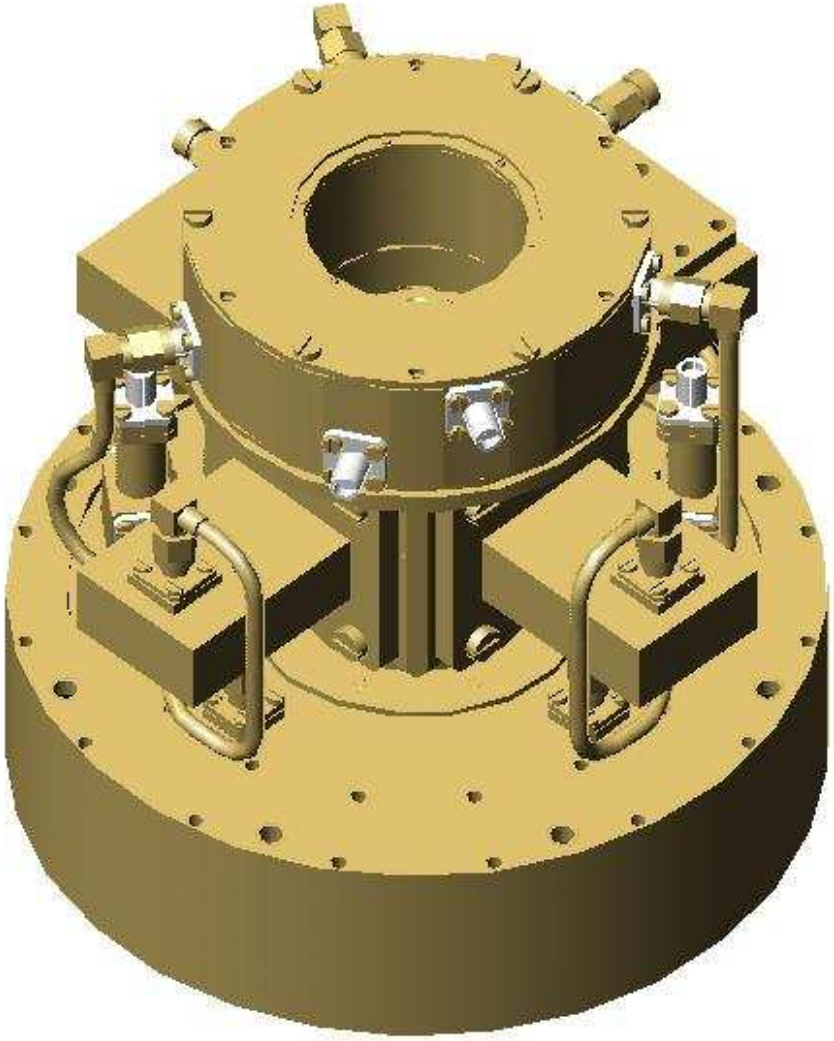
Group delay accuracy up to 1 ps (theoretical)

New 13.2 m VERTEX antenna in Wettzell

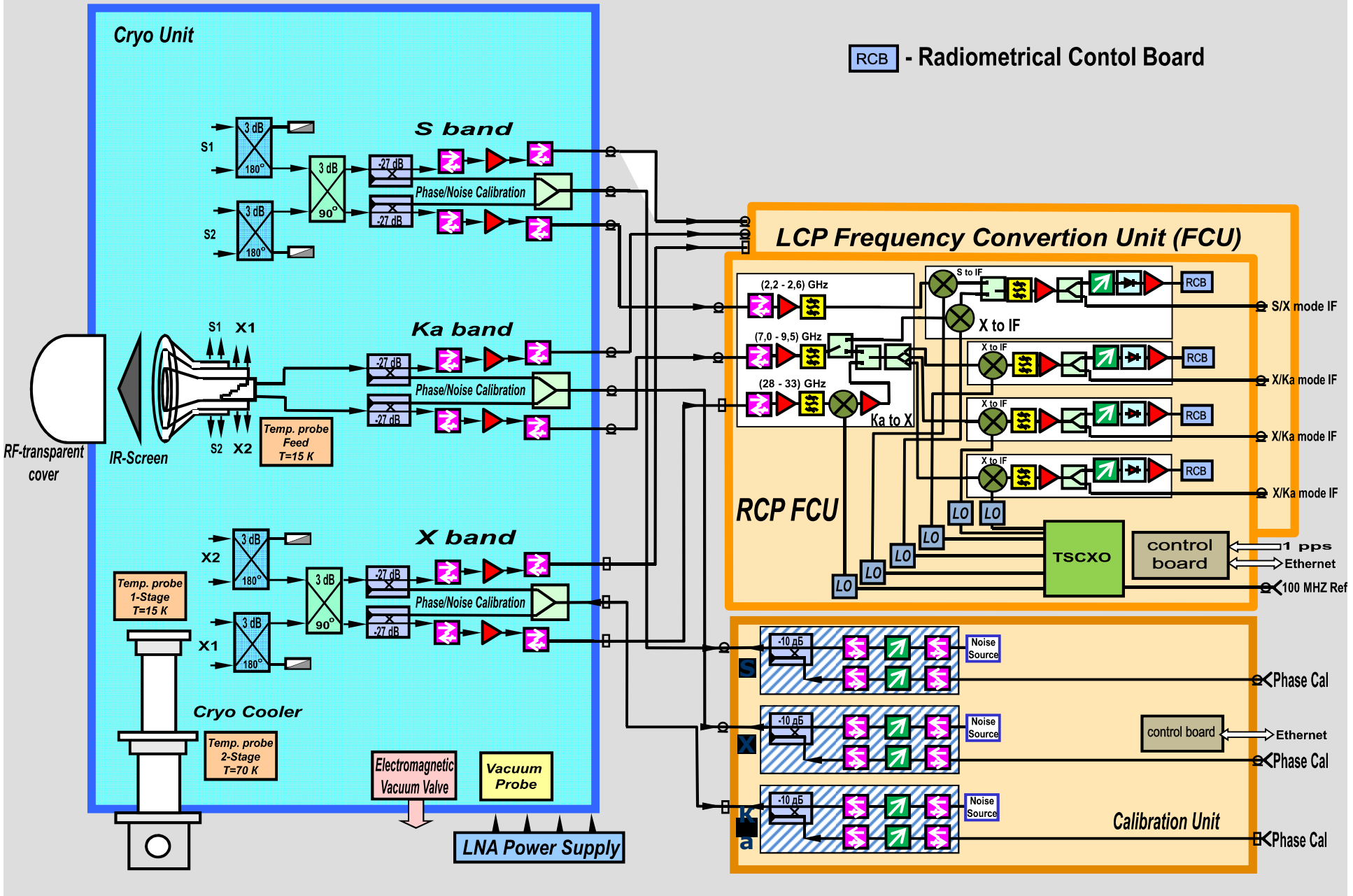
Antenna reflection system geometry



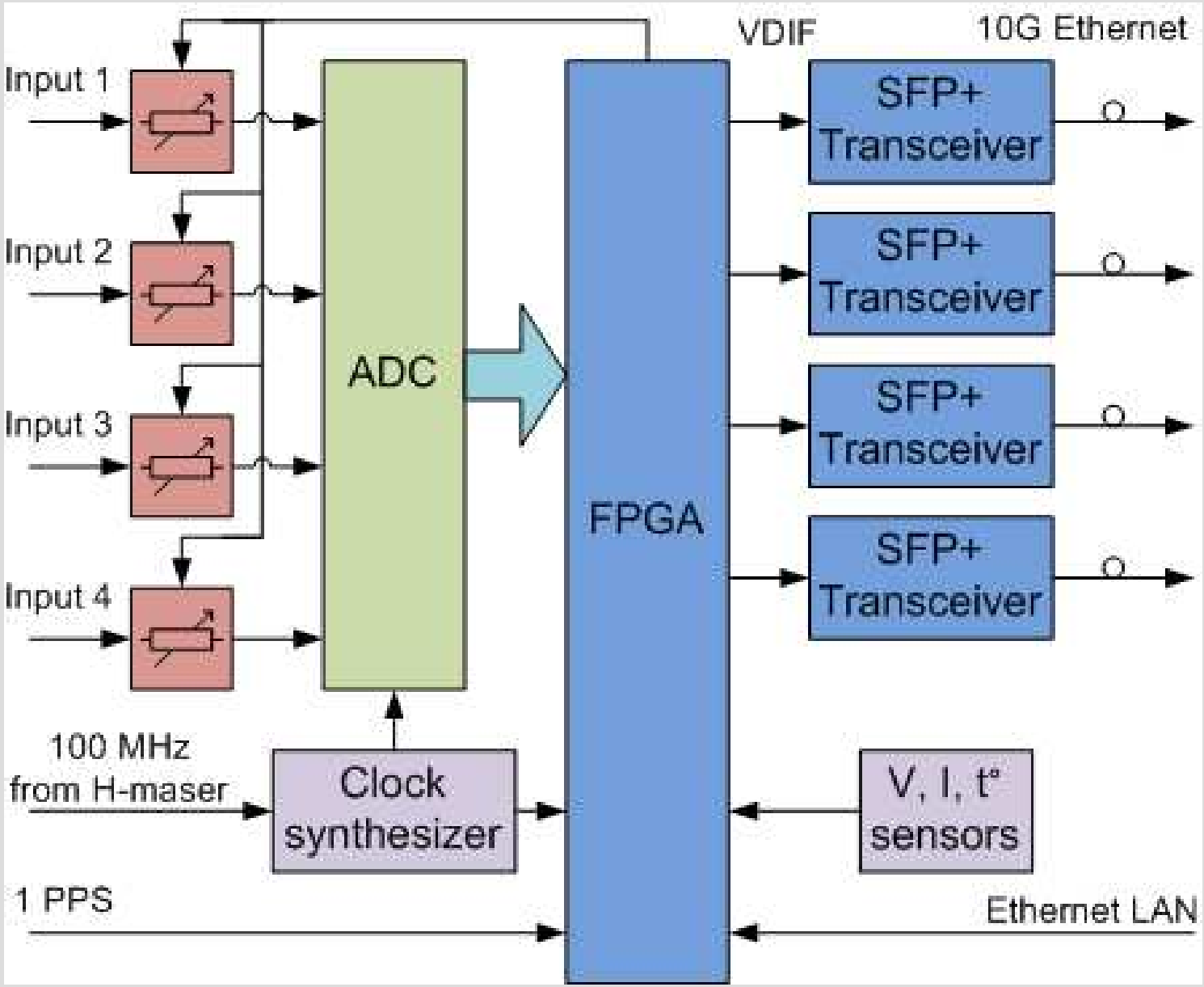
The three-band S, X and K_a feed for the new generation Russian VLBI network



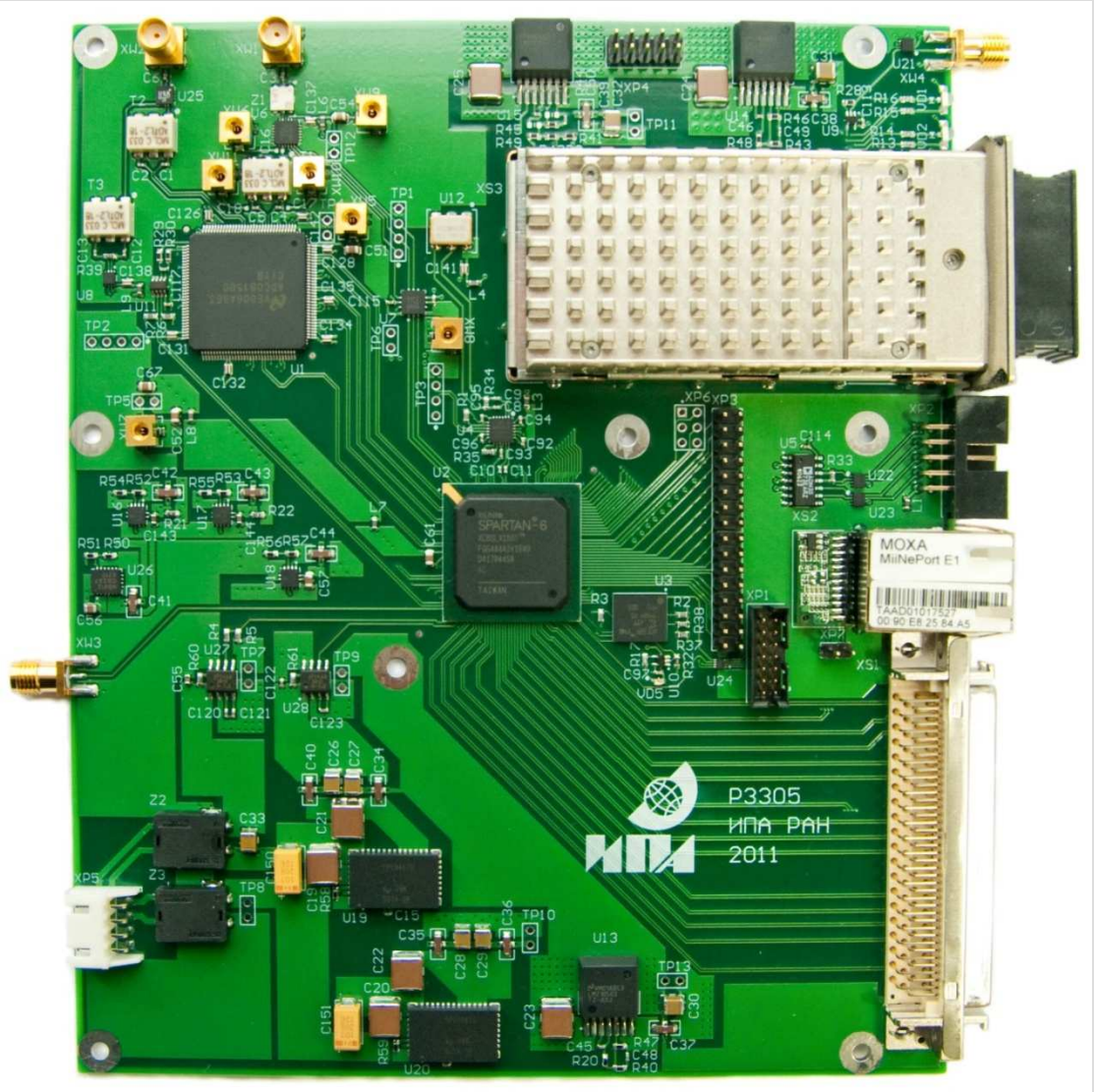
Front-end block scheme for the new generation Russian VLBI network



The Digital Data Acquisition System for the new generation Russian VLBI network

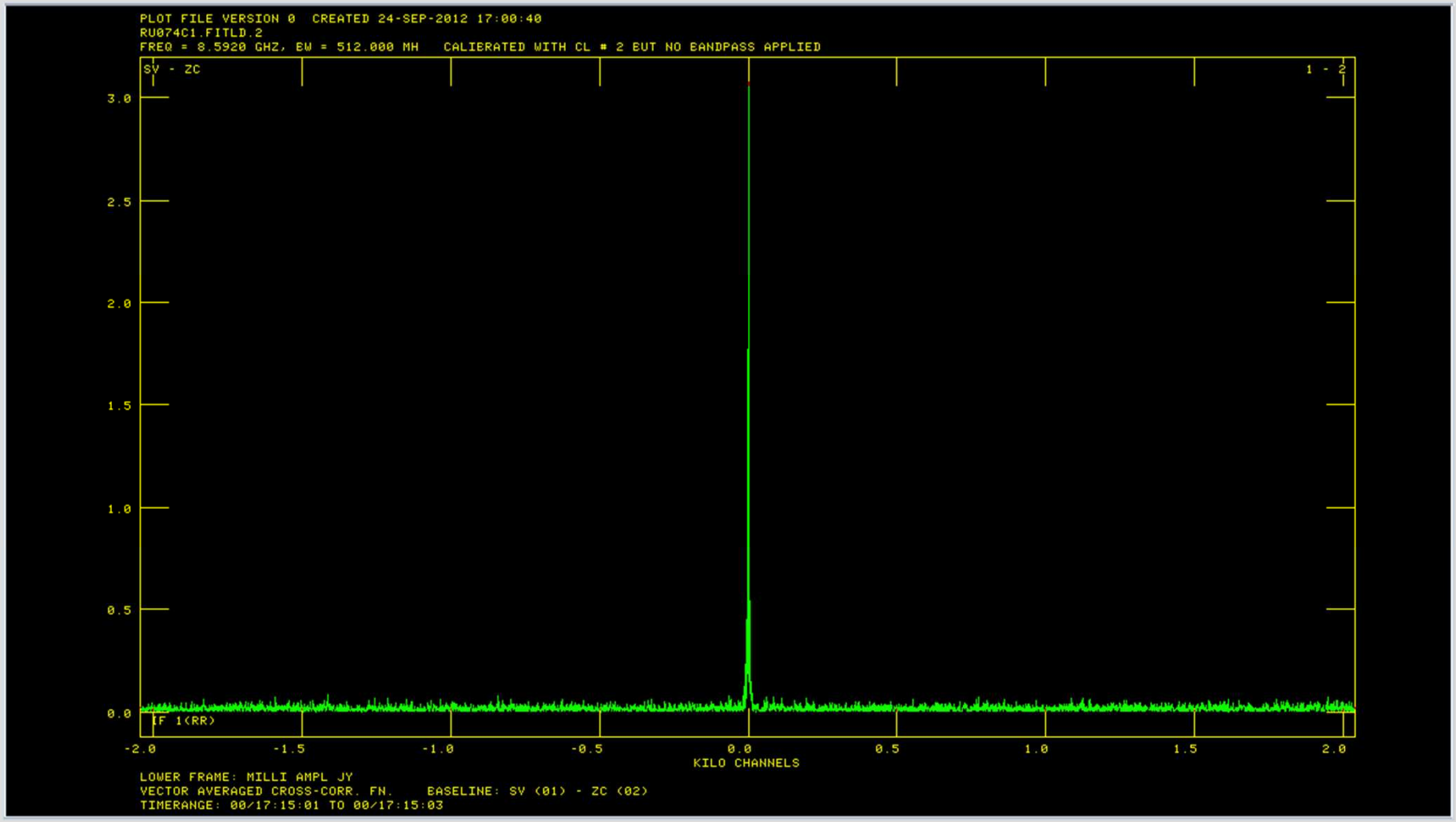


The prototype of the DSP unit of the Digital Data Acquisition System



The prototype of the DSP unit of the Digital Data Acquisition System

First test experiment of the prototype of the DSP unit of the Digital Data Acquisition System

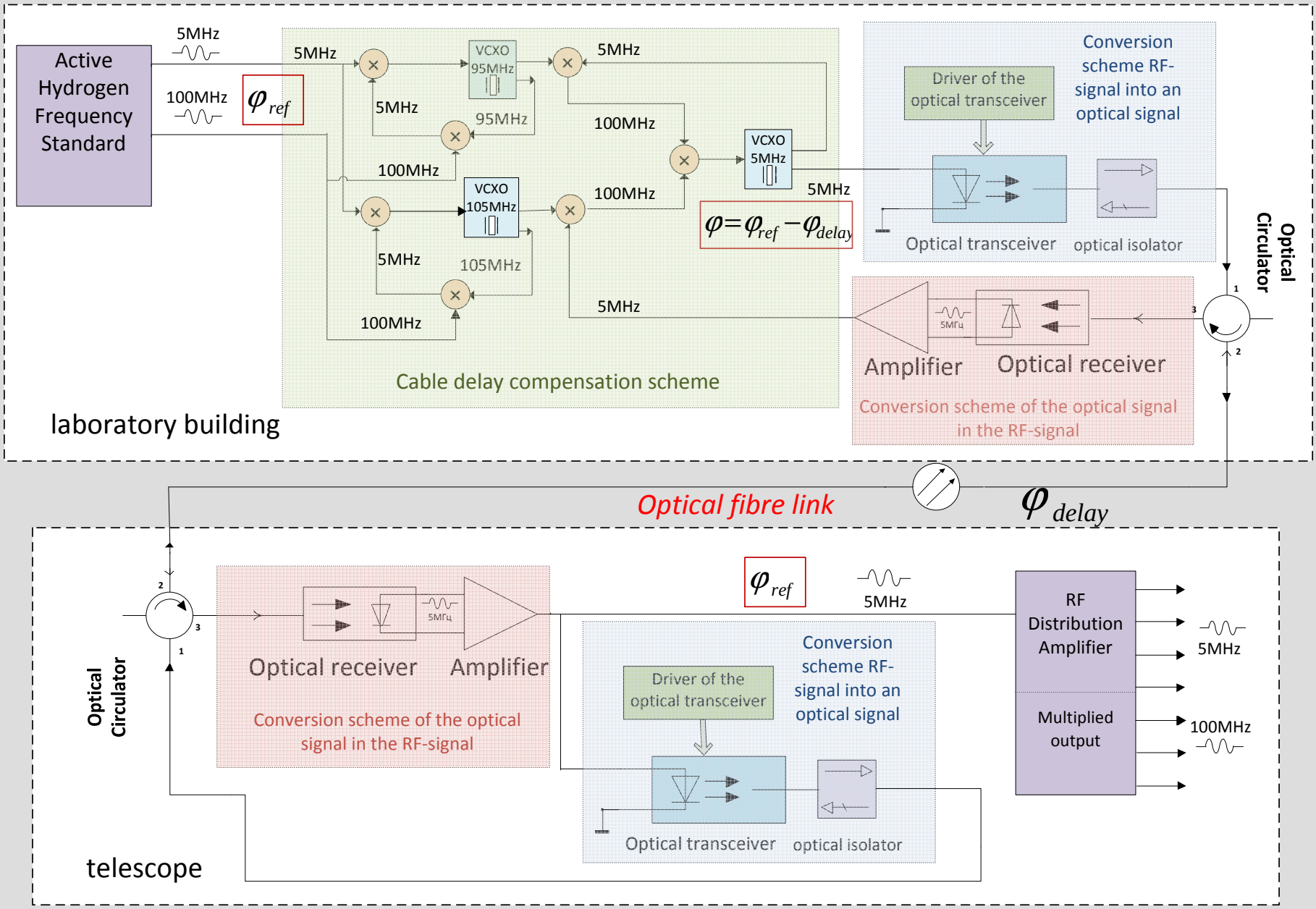


Svetloe - Zelenchukskaya

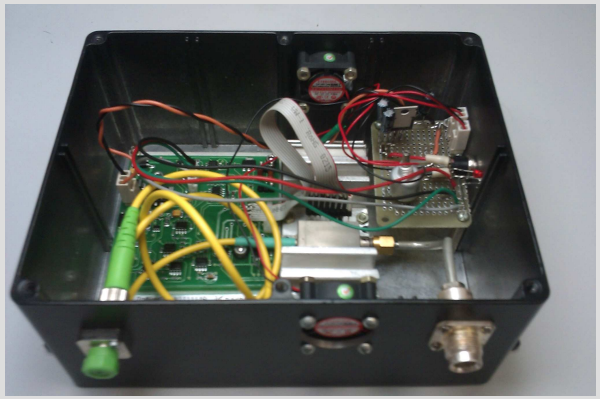
Source 1803+784, Flux ~2 Jy, X band, RCP, Δf = 512 MHz, t_i = 2 sec

SNR ~135 (theoretical – 186)

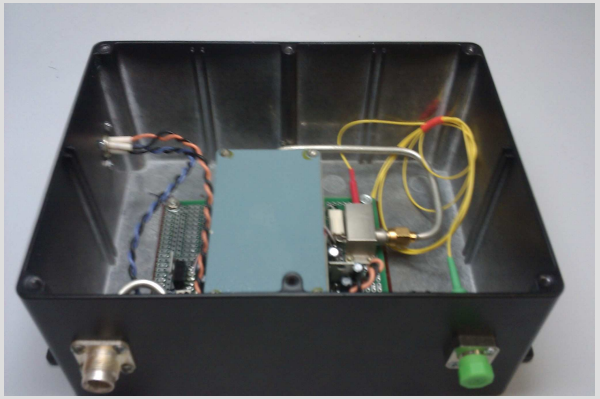
Phase compensation system



Parts of phase compensation system



Conversion scheme RF-signal into an optical signal



Conversion scheme of the optical signal in the RF-signal

Optical Circulator and optical isolator

Frequency instability (Allan variance) after passing through the optical cable (the results of the experiment)

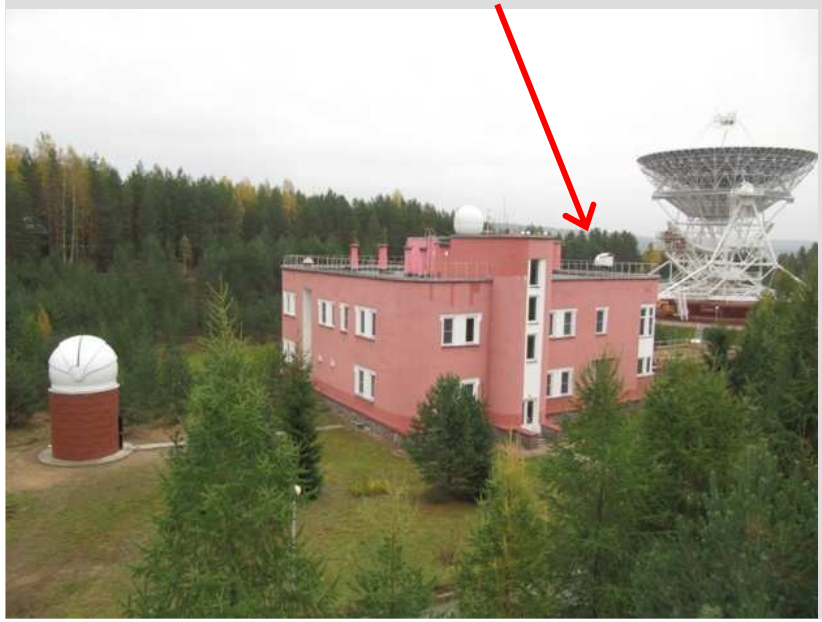
Integration time, s	Frequency instability at the input of the optical transceiver	The instability of the signal after conversion RF signal→optical signal→RF-signal
1	$4{,}7 \cdot 10^{-13}$	$5{,}4 \cdot 10^{-13}$
10	$5{,}7 \cdot 10^{-14}$	$8{,}3 \cdot 10^{-14}$
100	$1{,}3 \cdot 10^{-14}$	$1{,}7 \cdot 10^{-14}$
1000	$3{,}6 \cdot 10^{-15}$	$5{,}1 \cdot 10^{-15}$

Software Correlator for data processing for new generation VLBI network

- Input data:
  - 6 stations
  - 16 Gbps from each station
  - 4 frequency bands, 2 polarizations, 2 Gbps in each channel
  - 512 MHz bandwidth, 2-bit sampling
- Correlating
  - Each polarization of one station with each polarization of another station for each frequency band
  - 4096 points of cross-spectra
  - Multiple tones of calibration signals from each band

- FX program correlator
- Realising on blade-servers with NVIDIA's GPU
- Blade-servers T-Platforms V-Class V200F
- 2xCPU Intel E5-2670, 8-core, 2.6 GHz, 2xNVidia Tesla M2090 on each blade-server

Water vapour radiometer



Parameters :

Frequency bands: 21 GHz и 32 GHz

ΔT ~ 50-60mK , τ = 1s (Ts ≤ 120K-190K, Δf ≈ 0,5GHz),

$\Delta G/G \sim (2 \div 3) \cdot 10^{-4}$ on 10 ÷ 60 minutes

Total power measurement

Continuous observations

Two-level thermo stabilization

WVR prototype in Svetloe Observatory

Thank you for the attention!

Badary Observatory