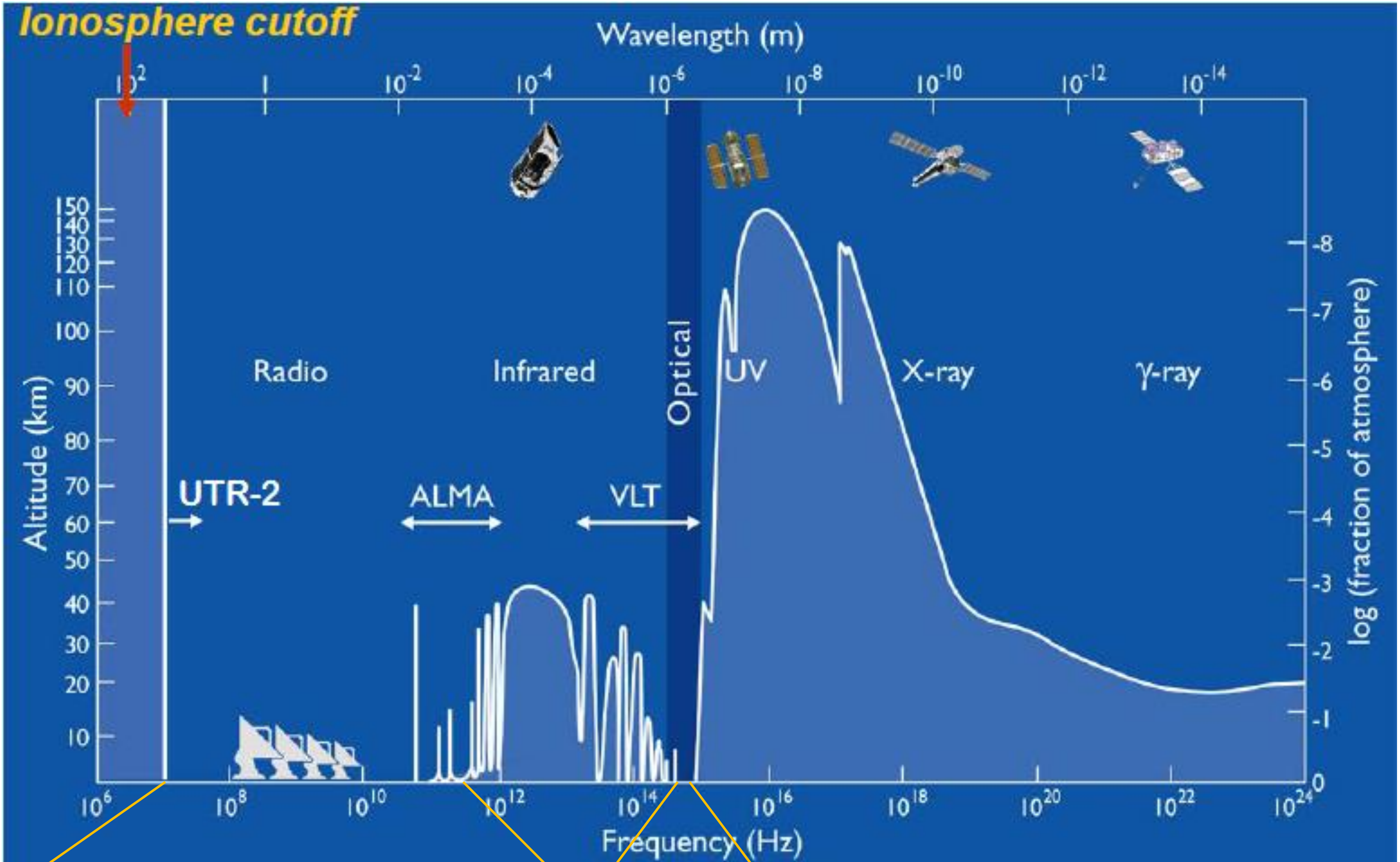
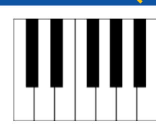
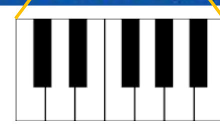
Broadband facility for radio astronomy observations. Key feature of Zolochiv's radio telescopes

V.V. Zakharenko, IRA NASU and RT-32 team



 ...  

Optics: $f_{\text{high}} / f_{\text{low}} = 2$ (one octave)

Radio: $f_{\text{high}} / f_{\text{low}} = 30000$
(15 octaves)

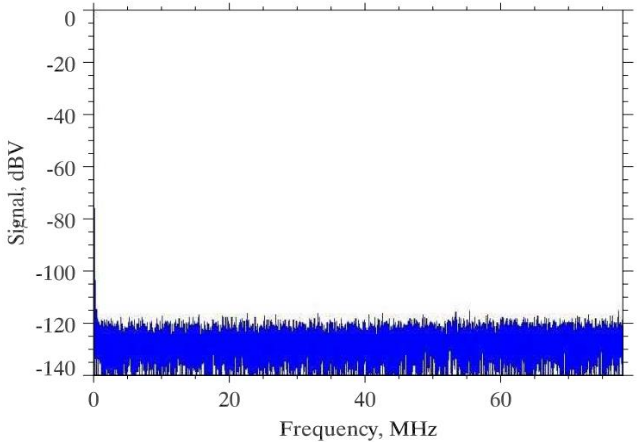
counter: $f_{\text{high}} / f_{\text{low}}$

Broadband radio telescopes in Zolochiv

- Broadband registration
- Doubled band receivers
- C- & K- range
- L-band
- GURT

  +

- Far side of the Moon RT



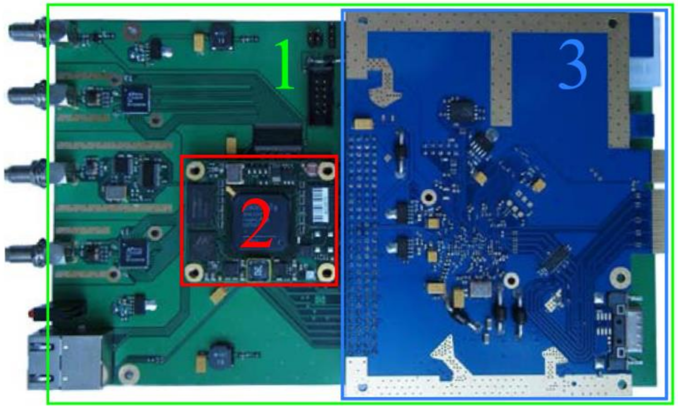


Fig. 8. ADC board (1), FPGA module (2) and high-speed waveform data transfer module (3).

Fig. 9. Front view of the ADR box, that contains the boards displayed in Fig. 8. The input labels correspond to those of Fig. 6 (with for A = input 1 and B = input 2). The receiver can operate independently in a section of the radio telescope or installed in the ADR Server).

Digital receivers for UTR-2, URAN and GURT

Table 4. Parameters of digital baseband receiver DSPZ.

Number of input channels	2
Analog input bandwidth	180 MHz
Input impedance	50 Ohm
Input voltage	1 V
ADC sampling frequency	internal: 156 MHz/external: 20–160 MHz
ADC resolution	16 bits
ADC intrinsic dynamic range	73 dB
SFDR (spurious free dynamic range) (16,384 samples per FFT)	112 dB
Intrinsic noise level (16,384 samples per FFT)	−117 dB
Digital DC bias compensation	No
Dithering option (for an increasing SFDR value)	Yes
FFT size (samples or spectral channels)	2,048, 4,096, 8,192, 16,384 and 32,768
Output FFT samples resolution	32 bit
Speed of processing	4,800 complex 32,768 points FFT per second
Count of averaged spectra	16 - 32,768
Selectable frequency band output	by groups of 1,024 spectral channels
"Spectrometer" sub-modes	1. A channel spectrum output 2. B channel spectrum output 3. A and B channels spectrum output 4. A+B and A-B channels spectrum output 5. A and B channels spectrum and cross-correlation between A and B channels spectra
Waveform sub-modes	1. A channel waveform output 2. B channel waveform output 3. A and B channels waveform output 4. A+B and A-B channels waveform output
Output type (for spectrometer mode)	1 Gb Ethernet
Connection cables (for spectrometer mode)	Cat.5 UTP
Output type (for waveform mode)	10 Gb Ethernet
Maximal data rate to host PC (waveform mode)	650 MB/s
Maximal data rate to host PC (spectrometer mode)	80 MB/s
Control interface	TCP/IP
Data interface	UDP/IP

New registrator: 1 GHz in C-band

- f_{clk} = 2.0 GHz (2 inputs)
- ADC: from 2 bits in waveform mode to 14 bits in spectral mode (up to 1 kHz resolution),
- Number of FFT-channels = 32768

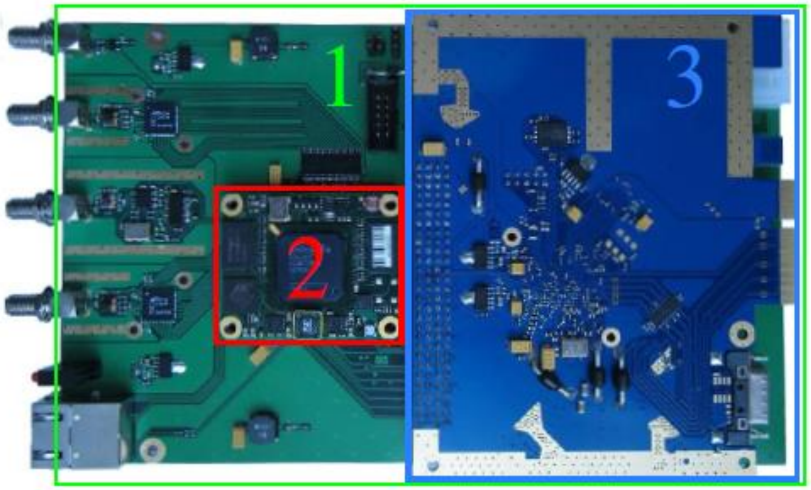
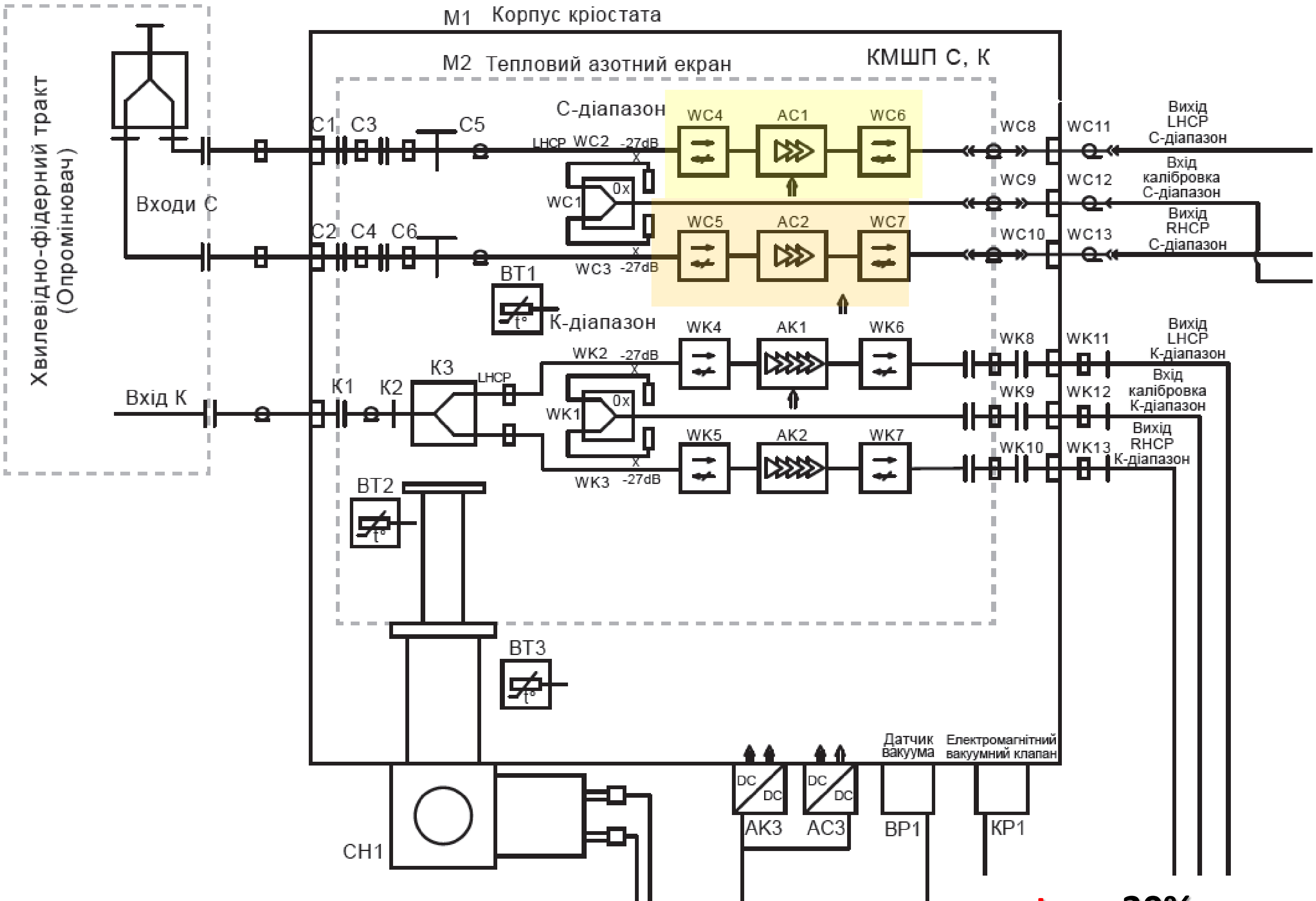


Fig. 8. ADC board (1), FPGA module (2) and high-speed waveform data transfer module (3).

counter: 15%

Doubled band receivers: C (2 GHz), K (2 GHz)



counter: 30%

Giant pulsar pulses in the Crab Nebula.

Te = 2 × 10^{41} K, duration <400 ps. Characteristic size of the emitting region <12 cm

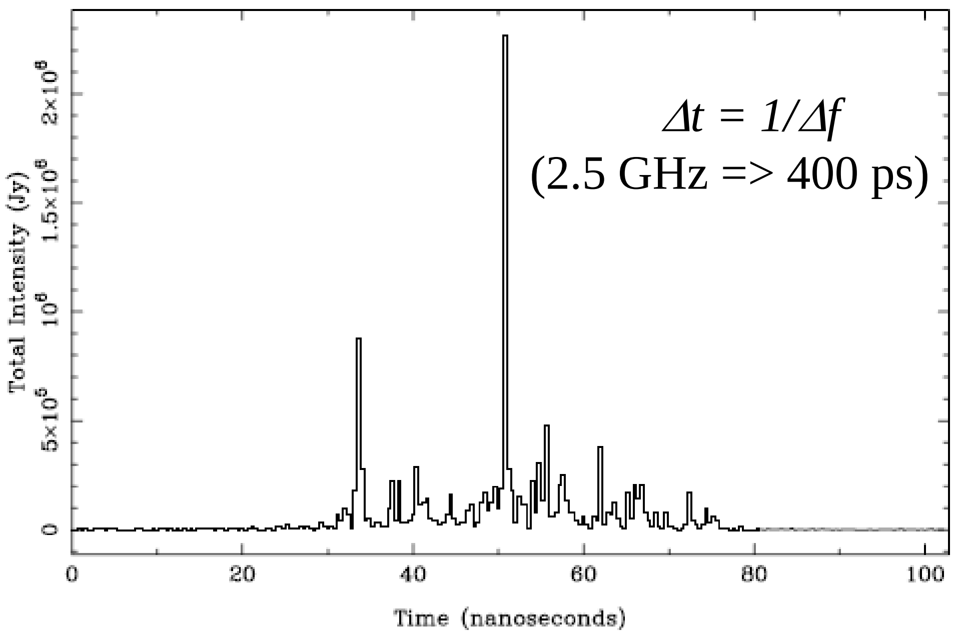
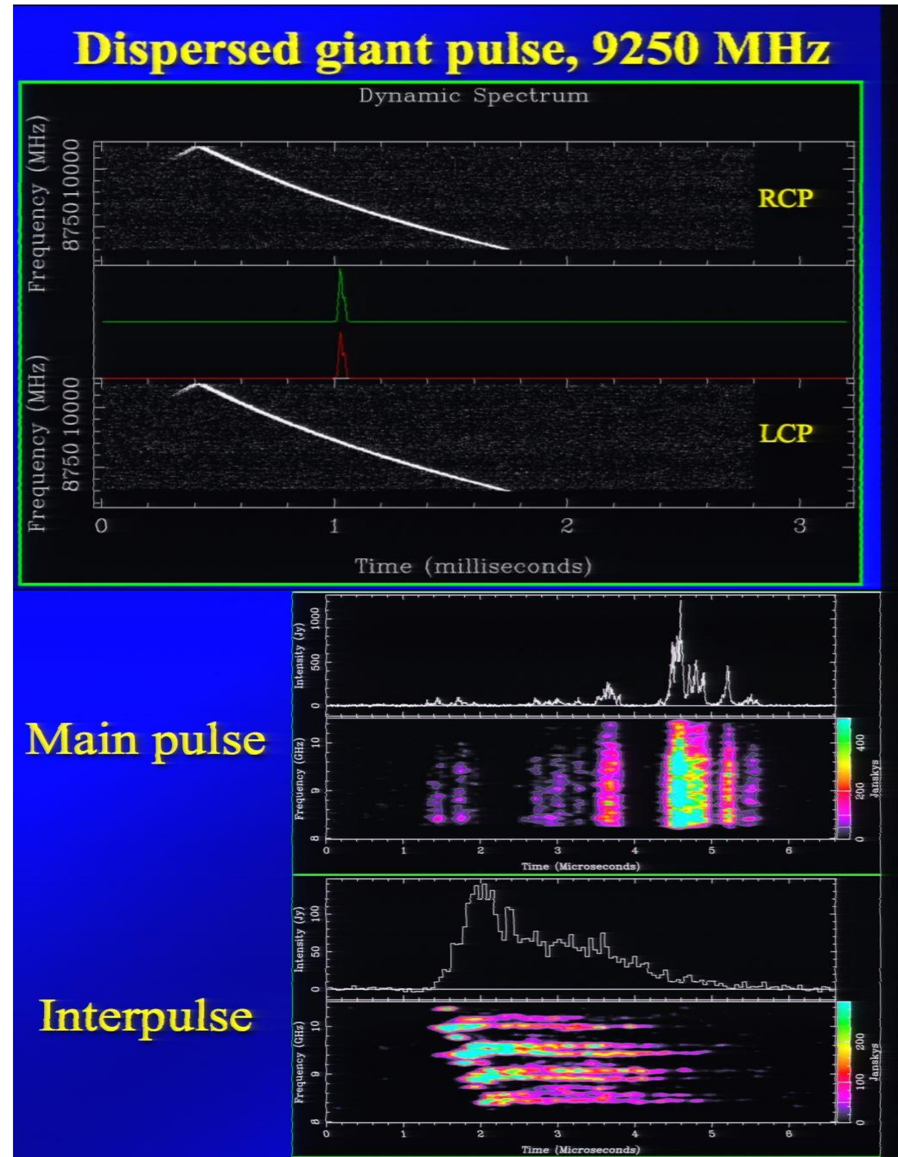
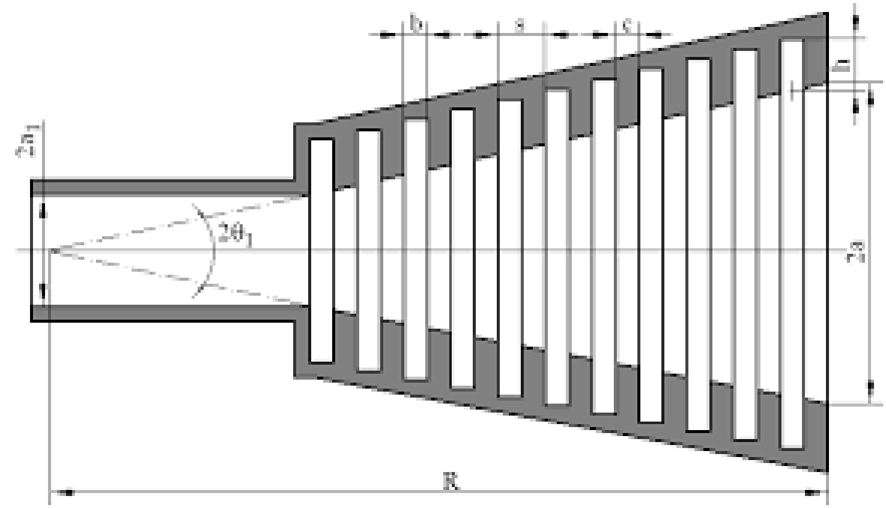


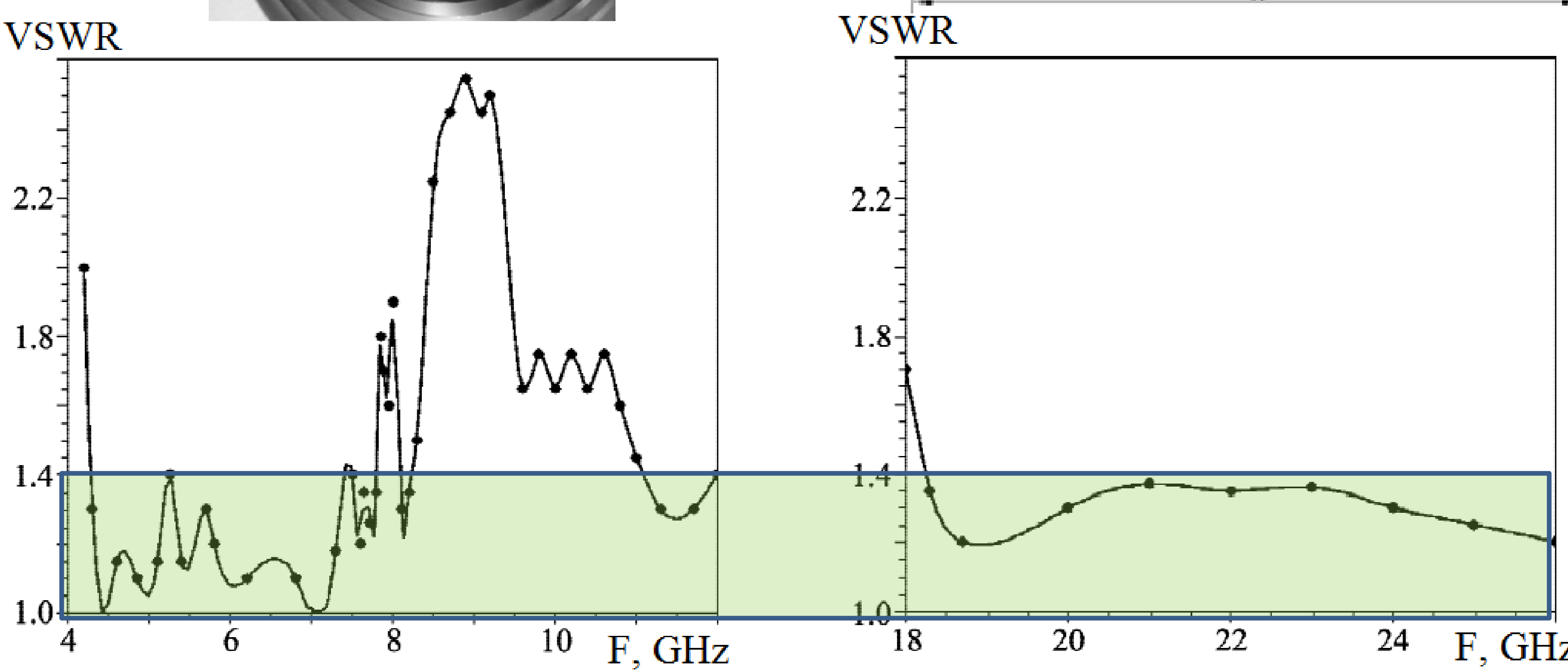
FIG. 5.—Single MP recorded at 9.25 GHz center frequency over a 2.2 GHz bandwidth and optimally dedispersed. The nanopulse shown is unresolved with the 0.4 ns time resolution afforded by our system. Despite the high peak intensity of this pulse, it is unlikely that it saturated the data acquisition system. The dispersion sweep time across the bandwidth is about 1.5 ms, so as sampled by our data acquisition system, the dispersed pulse energy is spread over ≈7.5 × 10^6 samples.



Hankins, T. H. & Eilek, J. A. 2007, ApJ, 670, 693

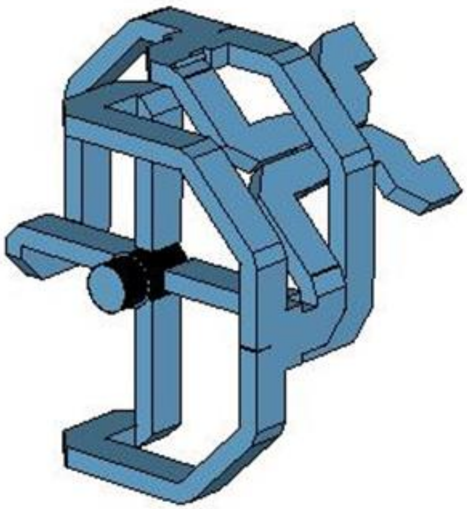
Corrugated horn

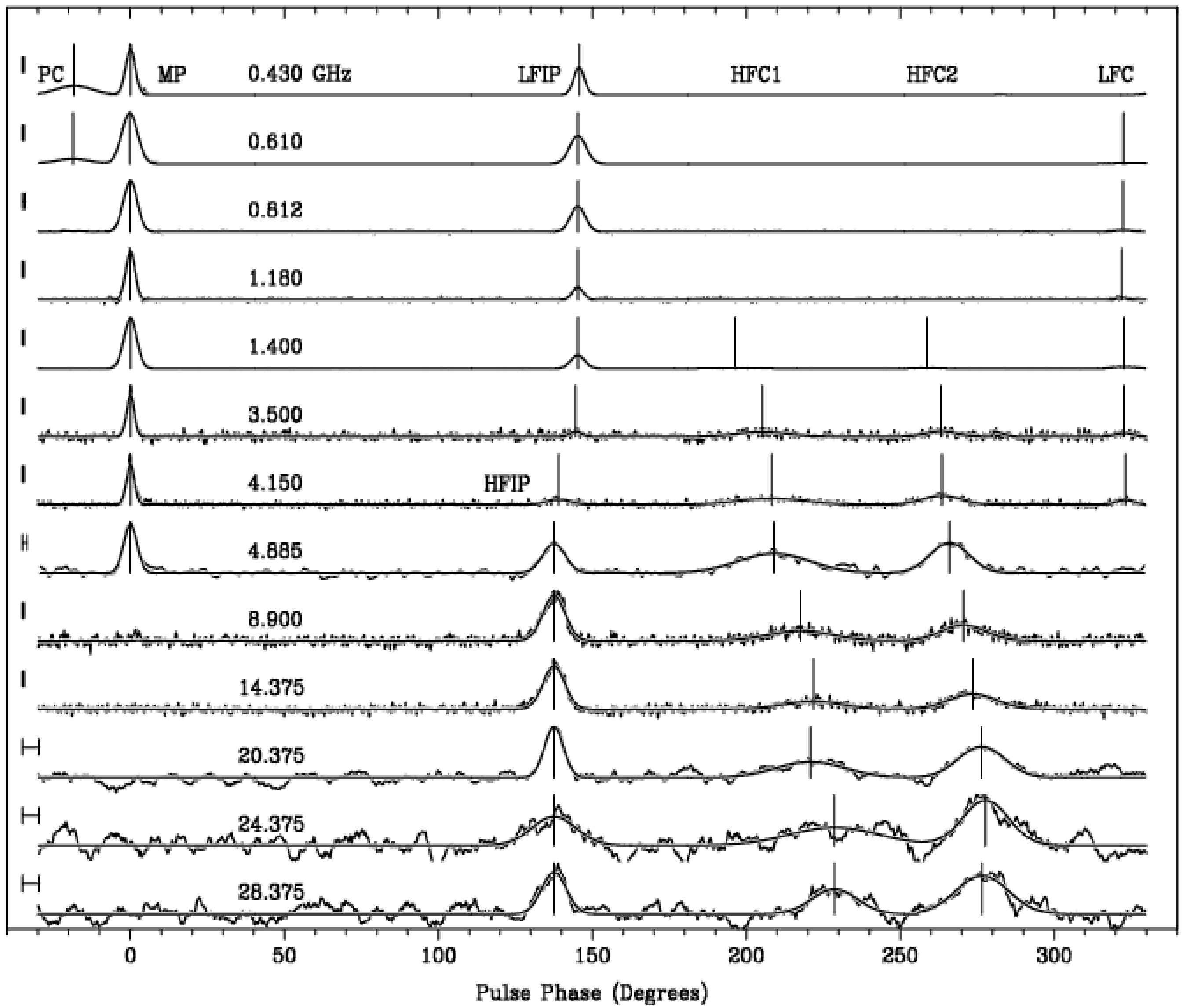




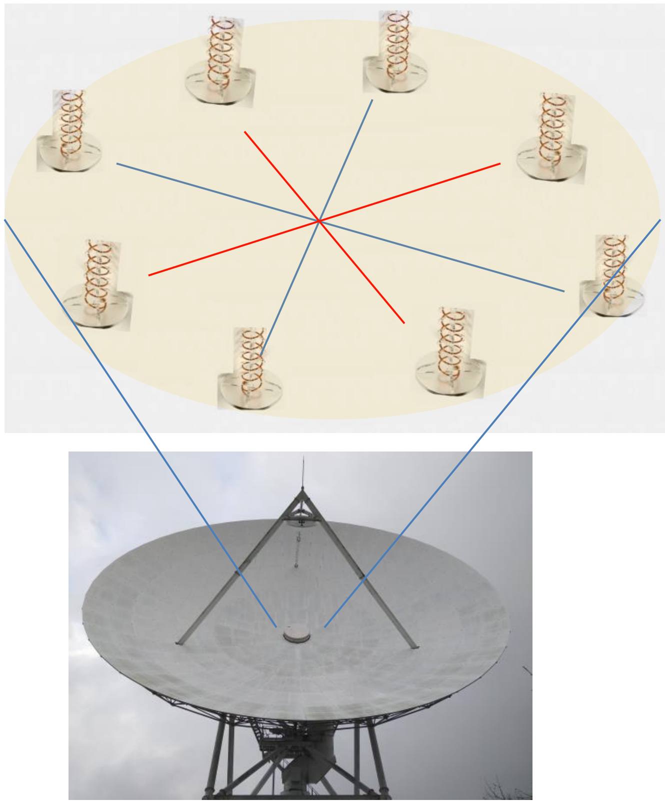
counter: **2.5 octaves**

Combined C and K band polarizer





L-band (1-2 GHz)



Exp Astron
DOI 10.1007/s10686-015-9466-x

CrossMark

ORIGINAL ARTICLE

Radio astronomy ultra-low-noise amplifier for operation at 91 cm wavelength in high RFI environment

A. M. Korolev[1] · V. V. Zakharenko[1] · O. M. Ulyanov[1]

Received: 3 June 2014 / Accepted: 28 September 2014

Without cryogenic cooling:
noise temperatures at 327 MHz are 12.8 ± 1.5 K
at 1.4 GHz are 35 ± 2 K

1 dB gain compression P1dB≥22 dBm
output third order intercept point OIP3≥37 dBm

counter: 4.5 octaves

RT-32 with GURT

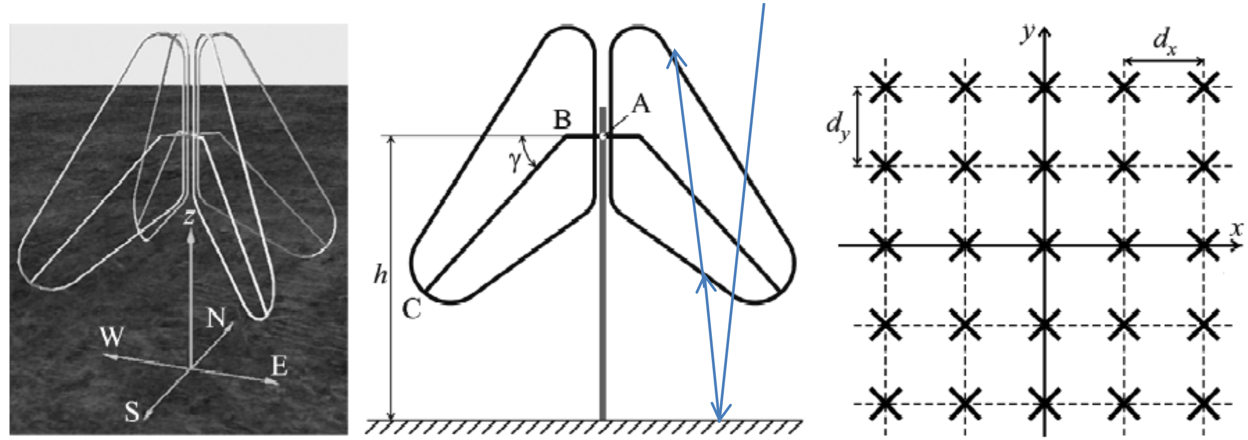
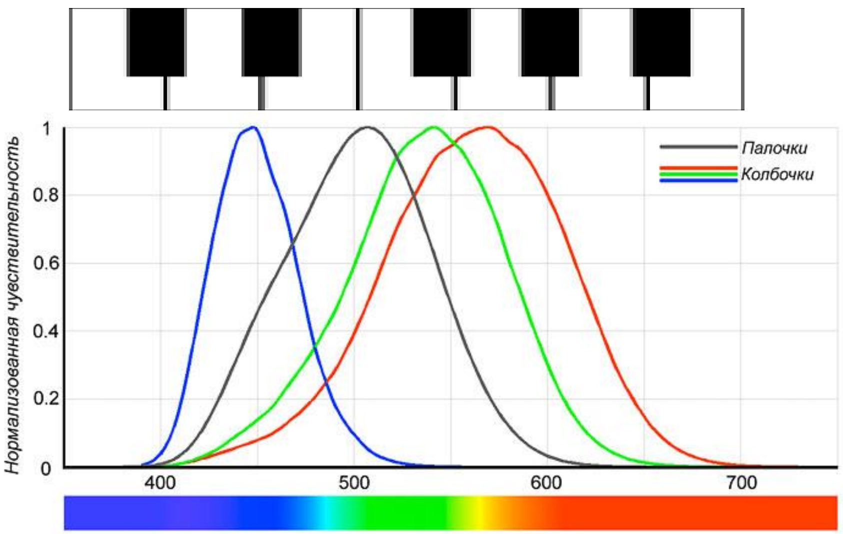
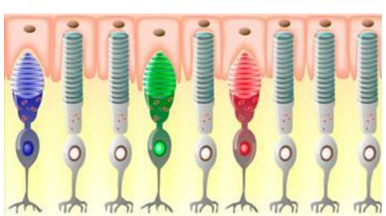
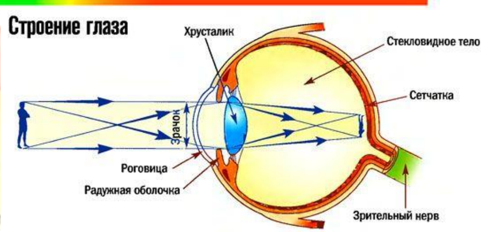
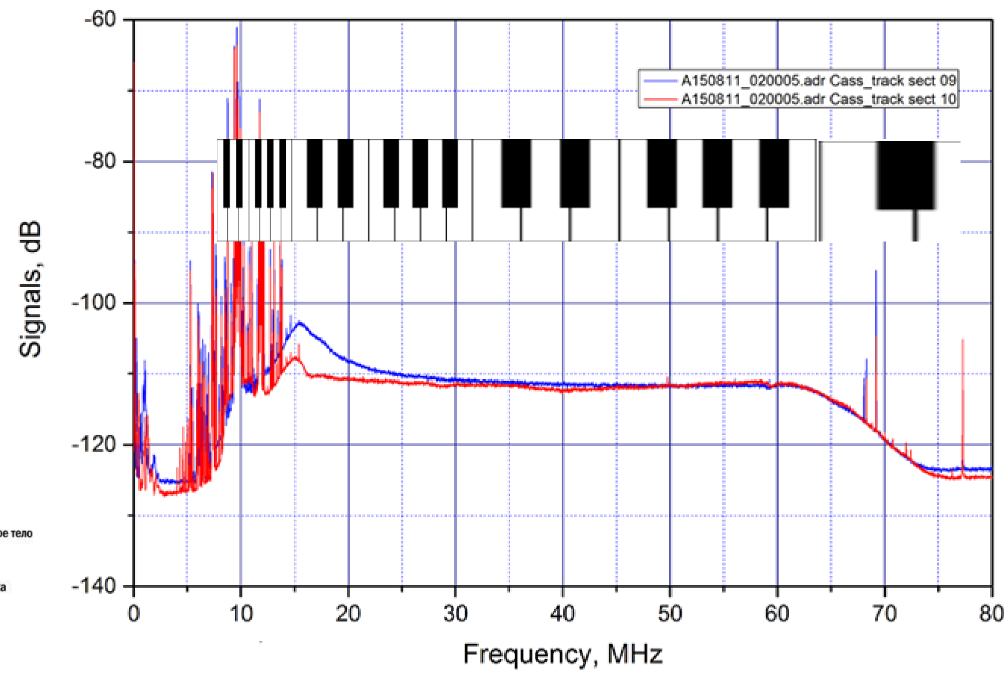


Рис. 1. Геометрия элементов и субрешетки ГУРТ: *а* – модель элемента субрешетки из двух скрещенных плоских диполей, *б* – геометрия плоского диполя ГУРТ, *в* – геометрия субрешетки ГУРТ





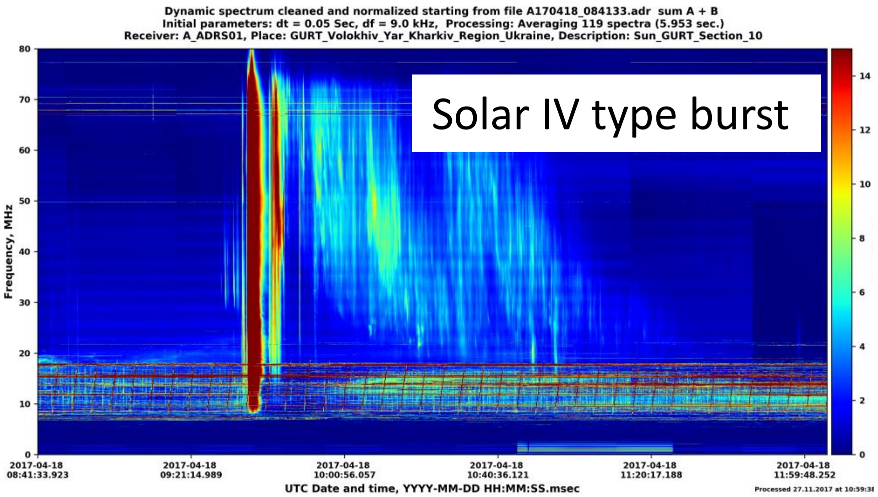




GURT transfer function

8 MHz – 25 GHz

counter: 11.5 octaves



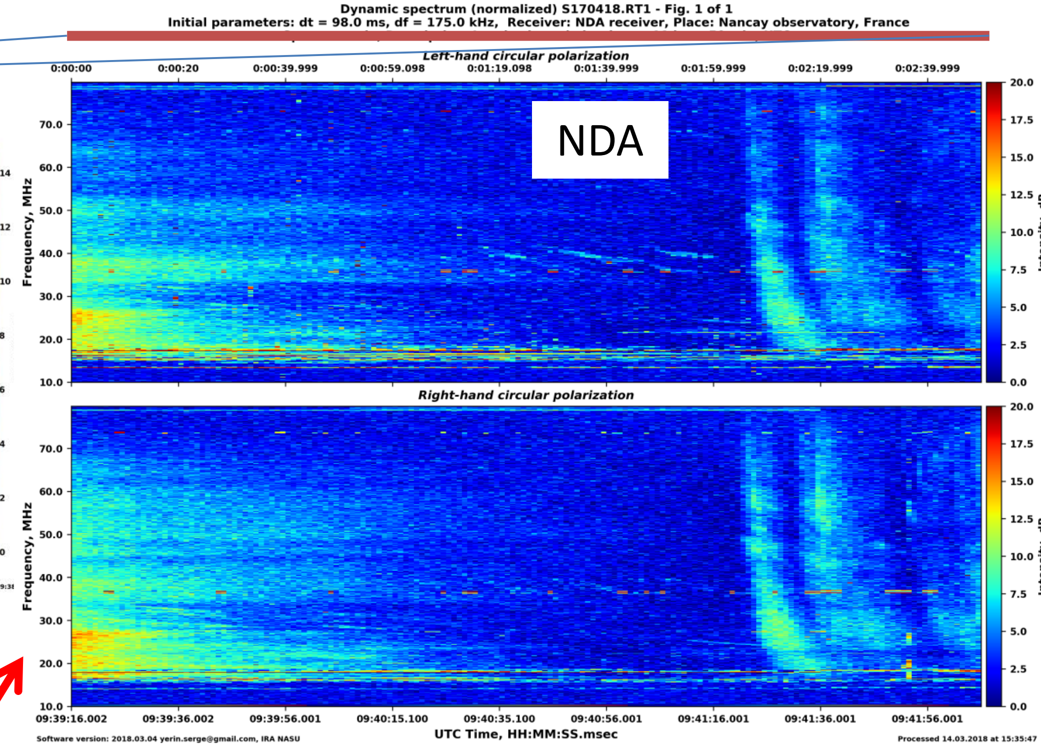
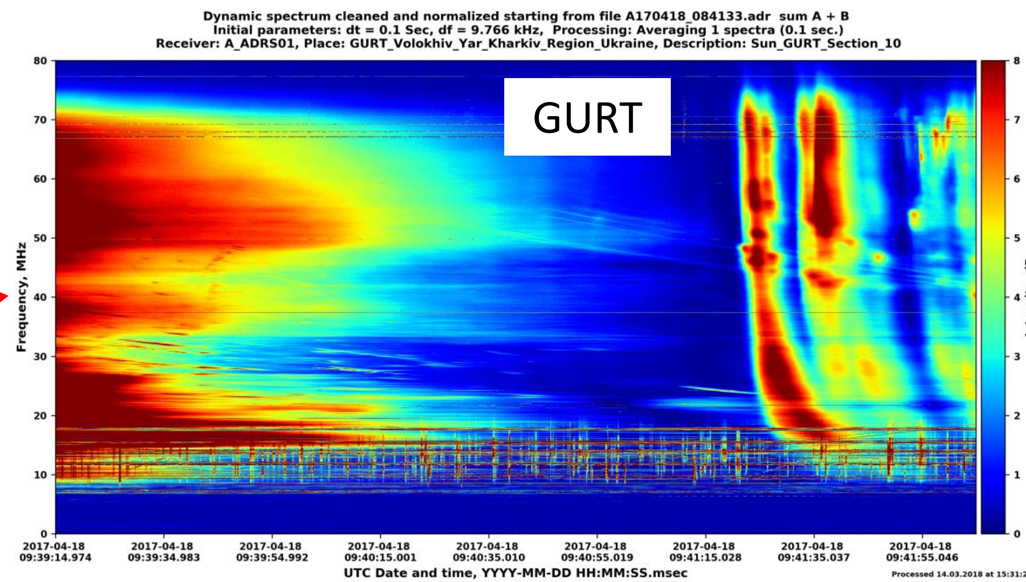


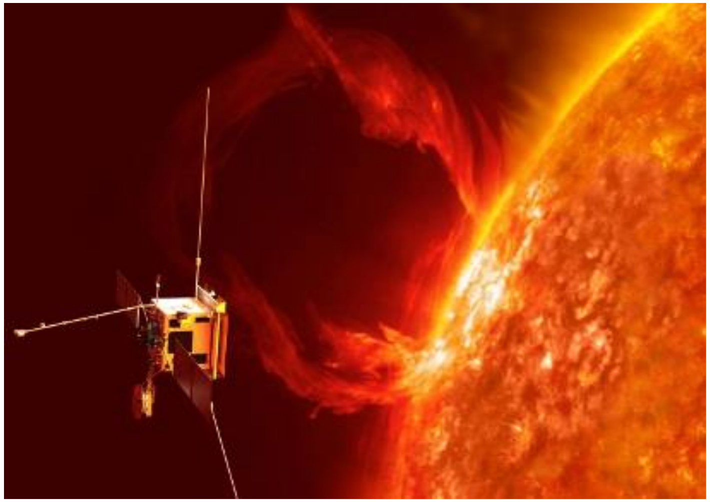
Fig. 9. Front view of the ADR box, that contains the boards displayed in Fig. 8. The input labels correspond to those of Fig. 6 (with for A = input 1 and B = input 2). The receiver can operate independently in a section of the radio telescope or installed in the ADR Server).



Solar radio emission

Solar Orbiter

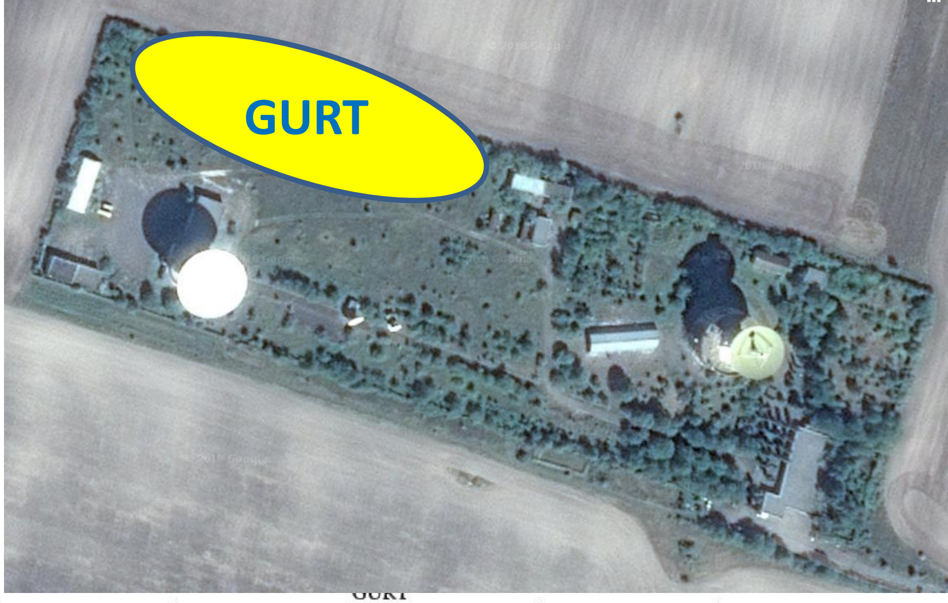
RPW: DC-20 MHz



UTR-2, URAN: 8-33 MHz

GURT: 8-80 MHz

FRT 4…40 MHz



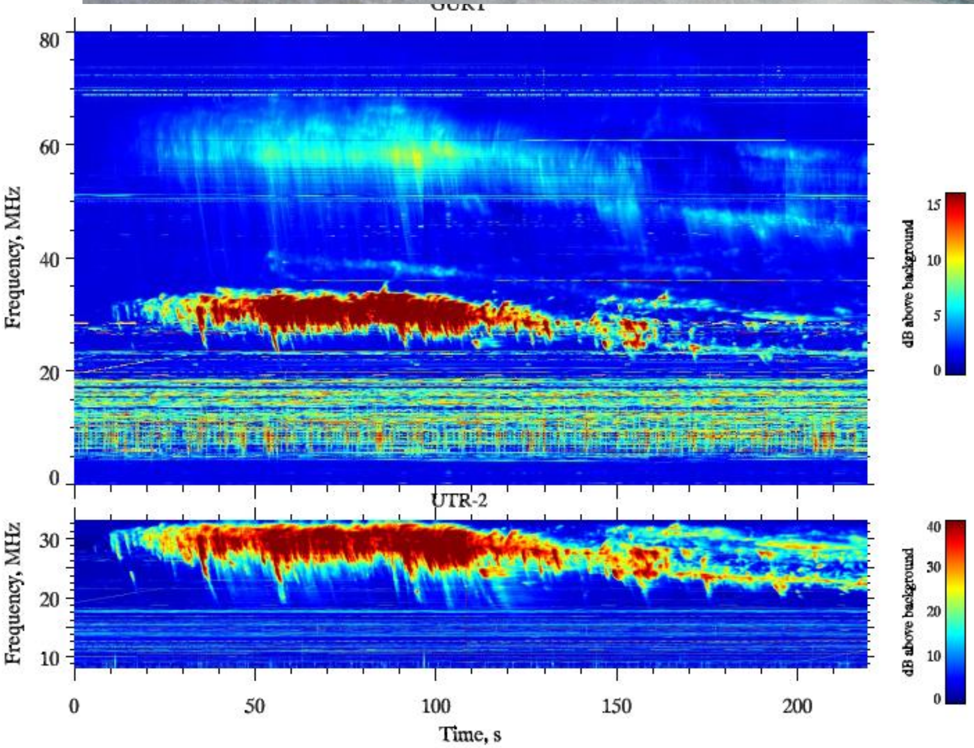
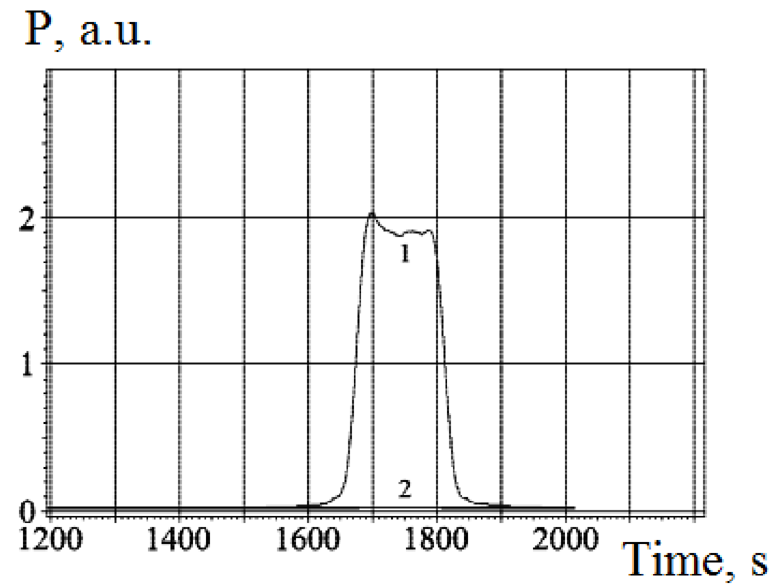


Fig. 10. Observations of a type II burst. UTR-2 frequency band 8.25 ÷ 33 MHz frequency and time resolution of 4 kHz and 100 ms, respectively. Recording was conducted on subarray GURT in the range 8 ÷ 80 MHz with the same time resolution and frequency resolution of 20 kHz. Start recording corresponds to 07:11:15 UT.

Solar activity monitor with RT-32



Sun at RT-32; 2019, March 15

2019/03/15

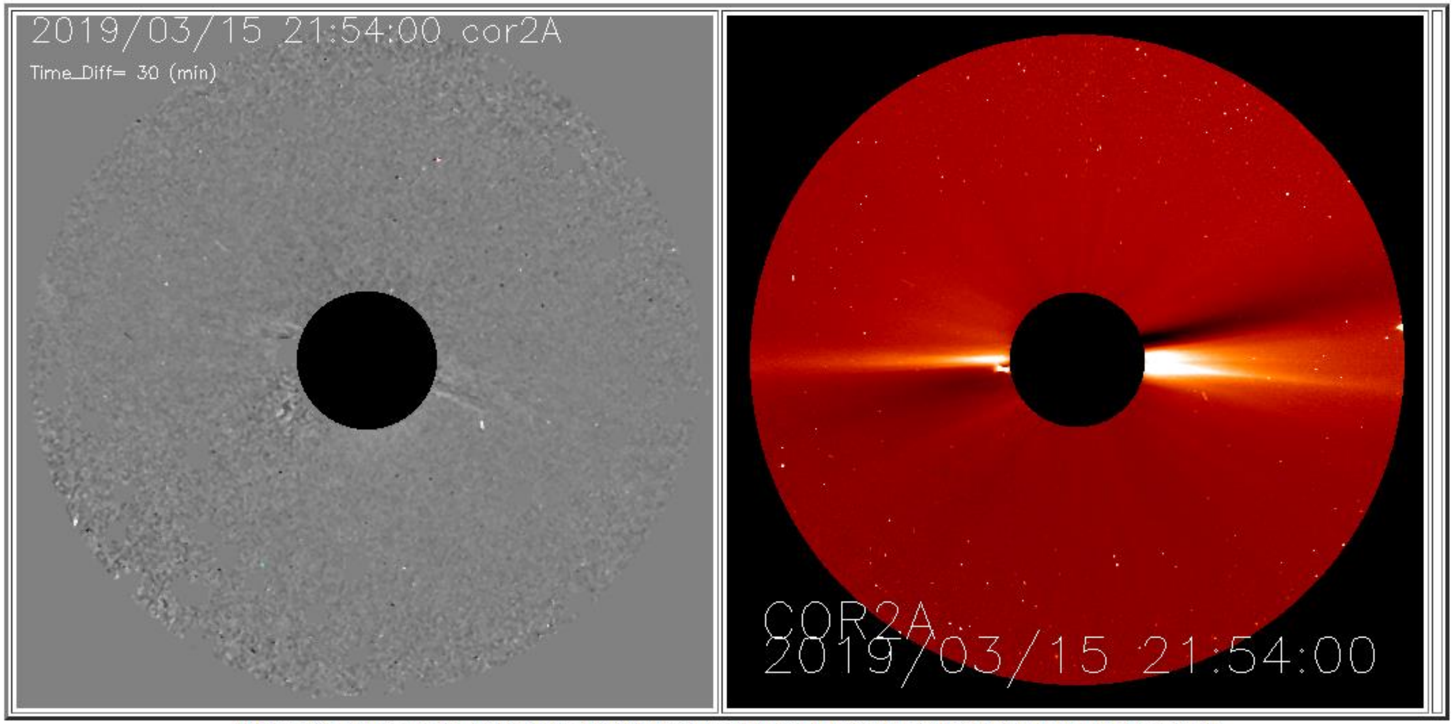
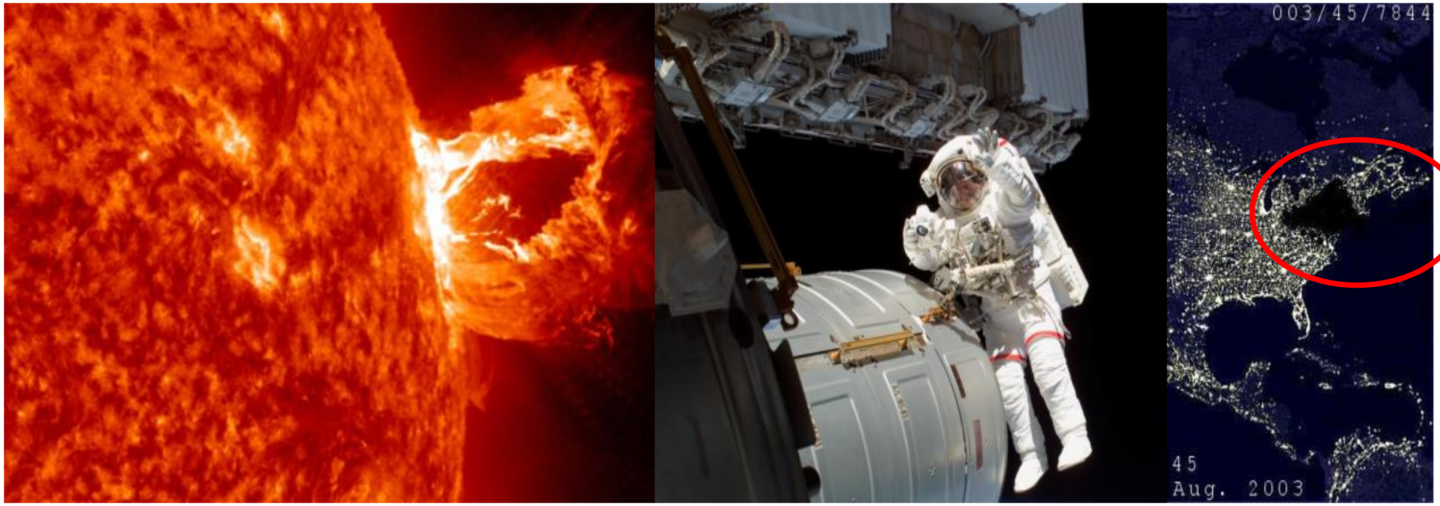
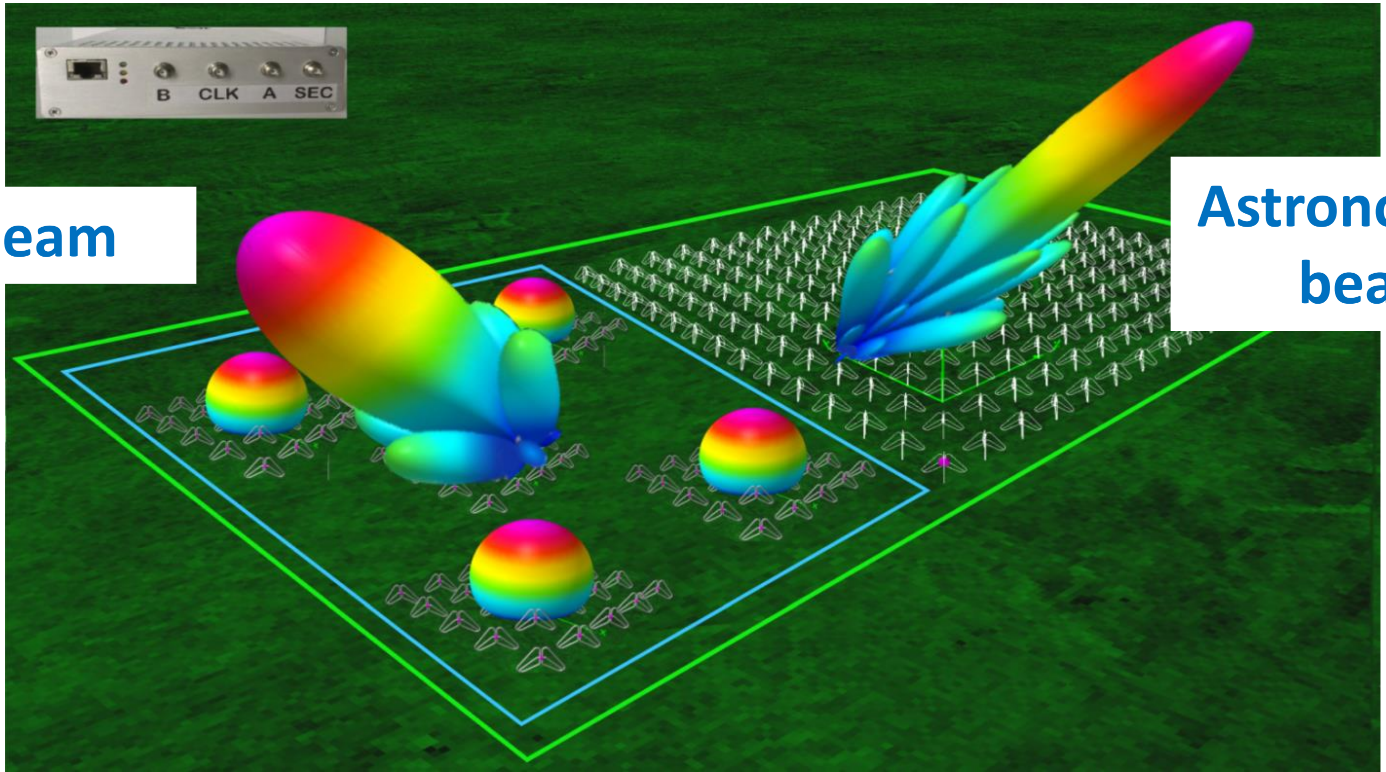


Image of the solar corona, taken by the SECCHI outer coronagraph (COR2) on the STEREO Ahead observatory

SPACE WEATHER AND SUN MONITOR





SWSM beam

Astronomical beam

Monitoring of interplanetary plasma by IPS observations with Ukrainian UTR-2, URAN, GURT radio telescopes

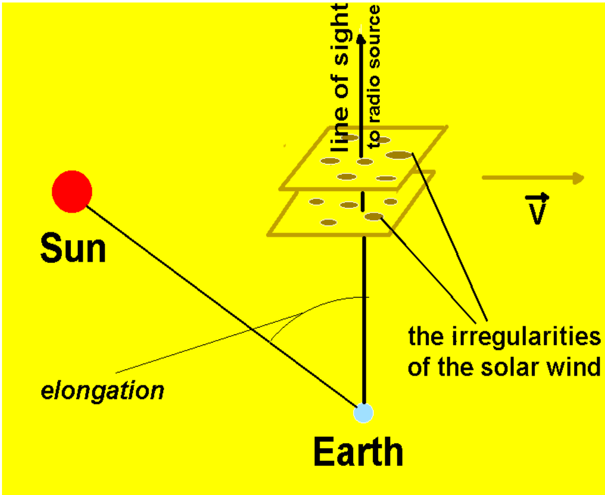


Fig. 1. Interplanetary scintillations (IPS) technique

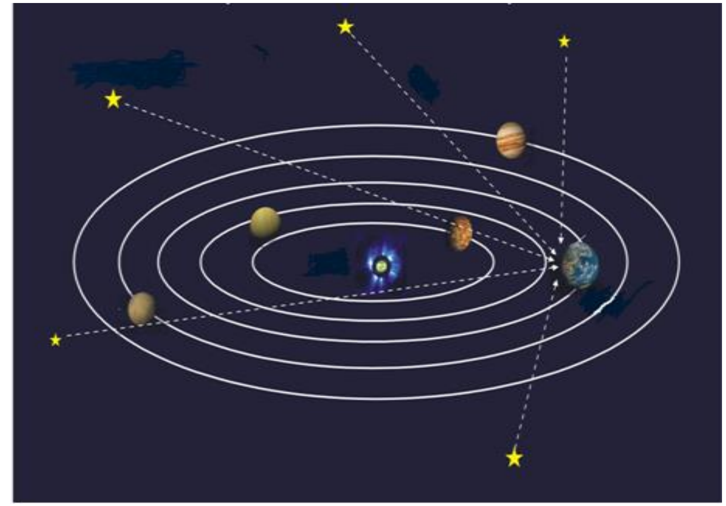


Fig. 2. Whole heliosphere monitoring with using Ukrainian radio telescopes

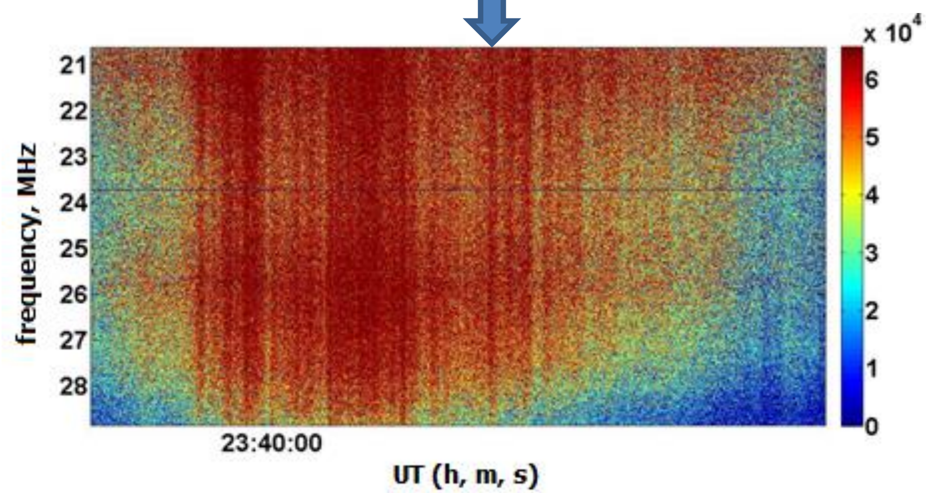


Fig. 3. An example of registration of interplanetary scintillations. UTR-2 radio telescope.

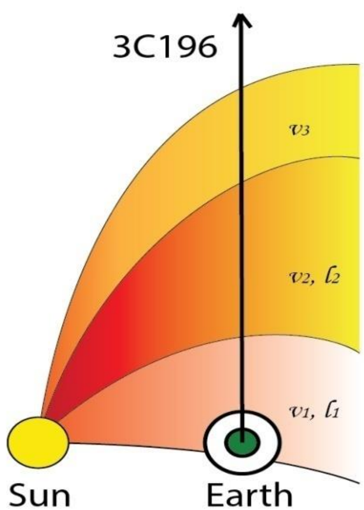


Fig. 4. Reconstruction of solar wind structure, founding of interplanetary coronal mass ejection by using IPS data from Ukrainian radio telescopes

Monitoring of interplanetary plasma by IPS observations with Ukrainian UTR-2, URAN, GURT radio telescopes

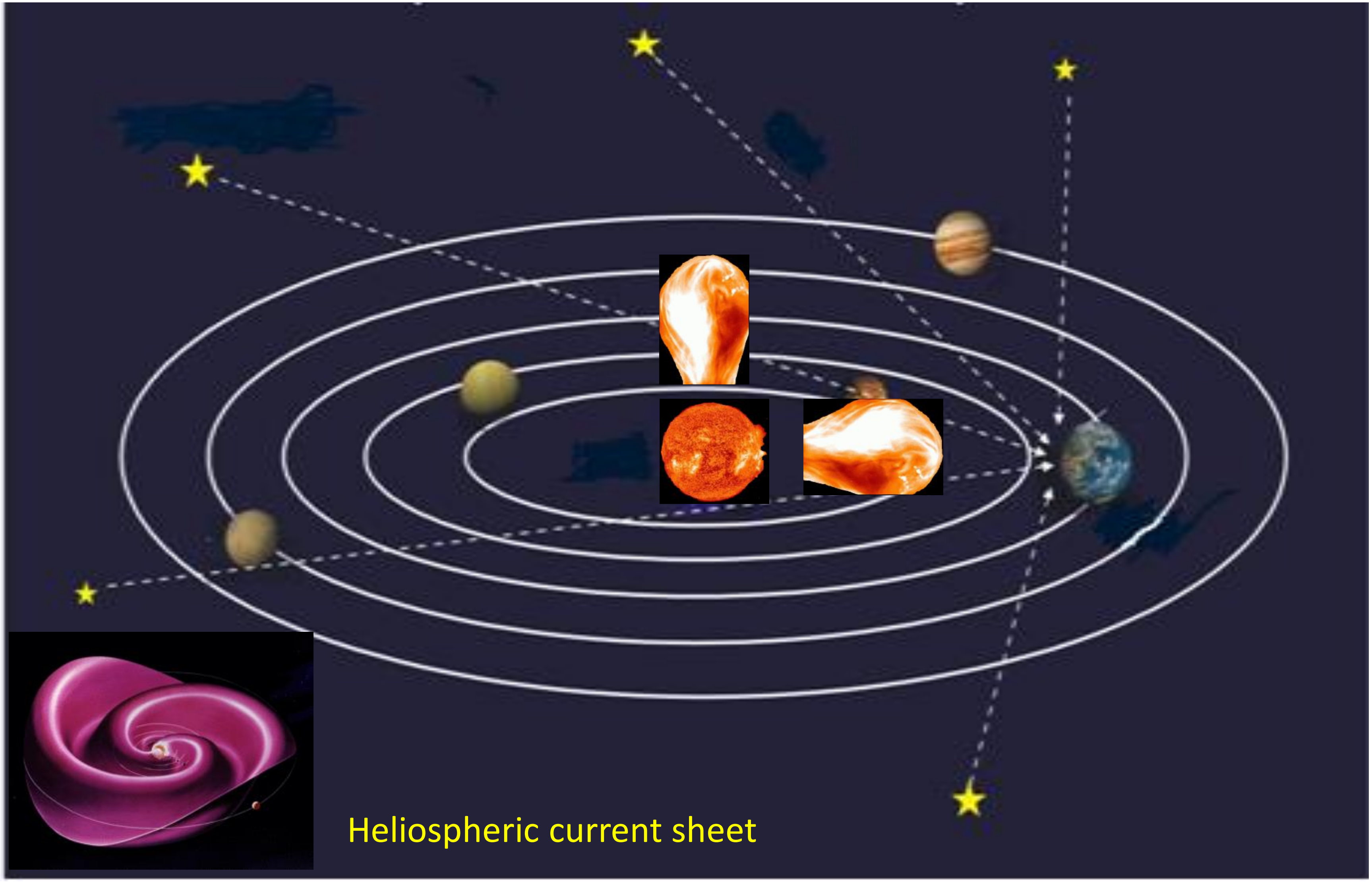


Fig. 4. Reconstruction of solar wind structure, founding of interplanetary coronal mass ejection by using IPS data from Ukrainian radio telescopes

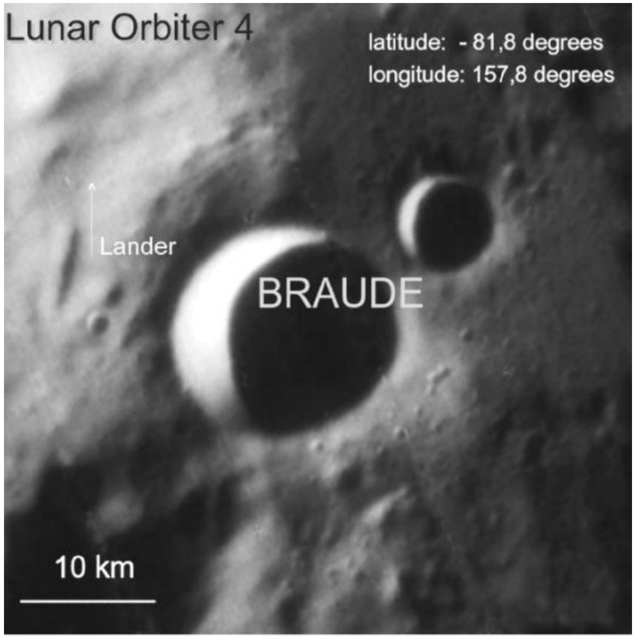
Fig. 3. An example of registration of interplanetary scintillations. UTR-2 radio telescope.

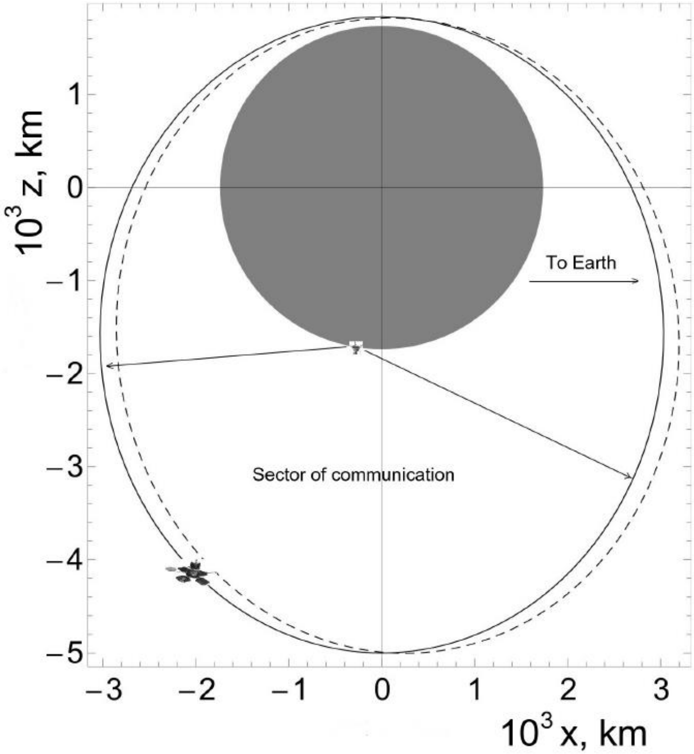
…about unlimited flight of fantasy

Ukrainian idiom:

- “якщо гусак, то нехай буде жирний”
- *(in English ~)* “if a goose, let it be greasy”

The farside radio telescope (FRT)



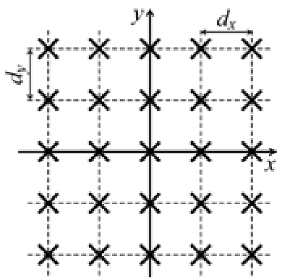


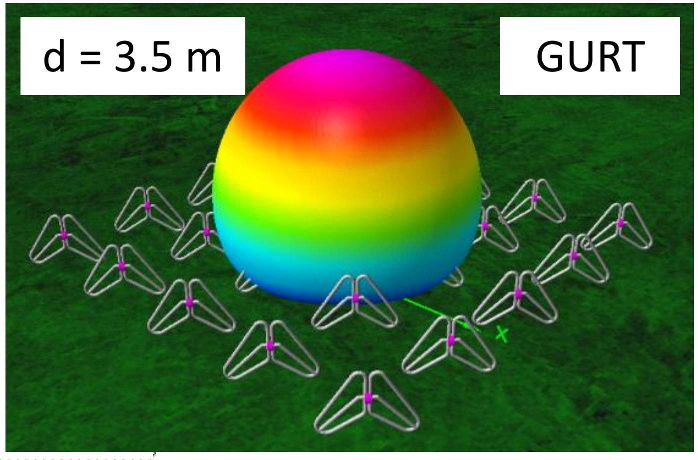
"Braude-M" : Big Radio Astronomy Universe, DEmonstration from the Moon

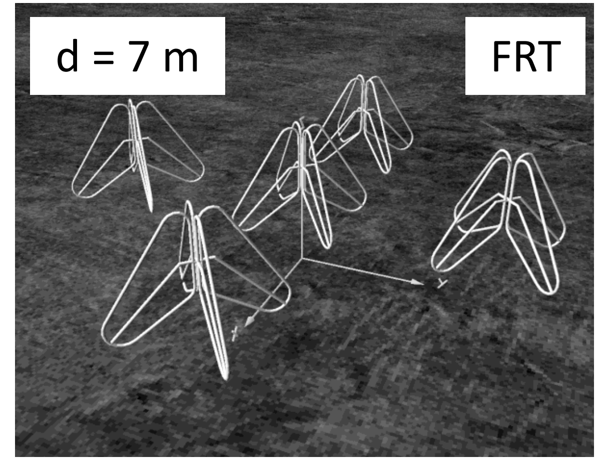
[Shkuratov Y., et al. A twofold mission to the Moon: Objectives and payloads, Acta Astronautica, 2019]

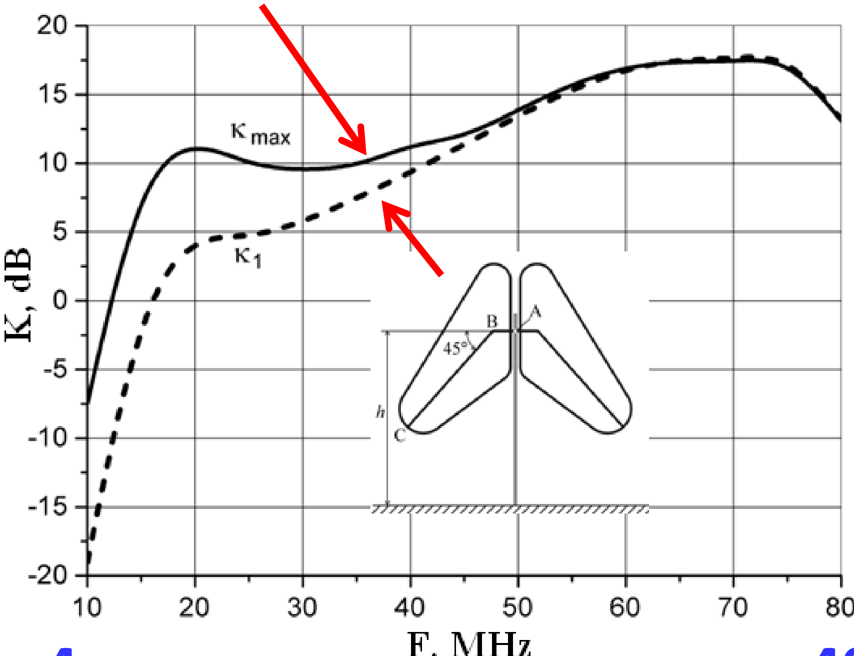
From GURT (8…80 MHz) to FRT 4…40 MHz, A_E = 400 m²@ 25 MHz

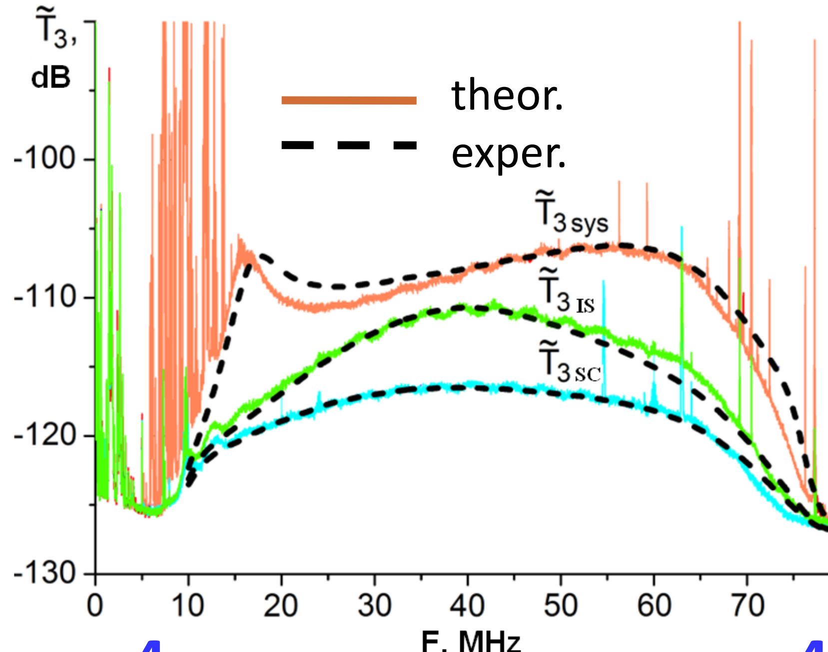
$$\sigma = \frac{kT}{A_E\sqrt{\Delta\tau \cdot \Delta f}}$$











4 40 4 40

0.8 MHz – 25 GHz

counter: 15 octaves


Thanks for your attention