Ukrainian contribution to LOFAR

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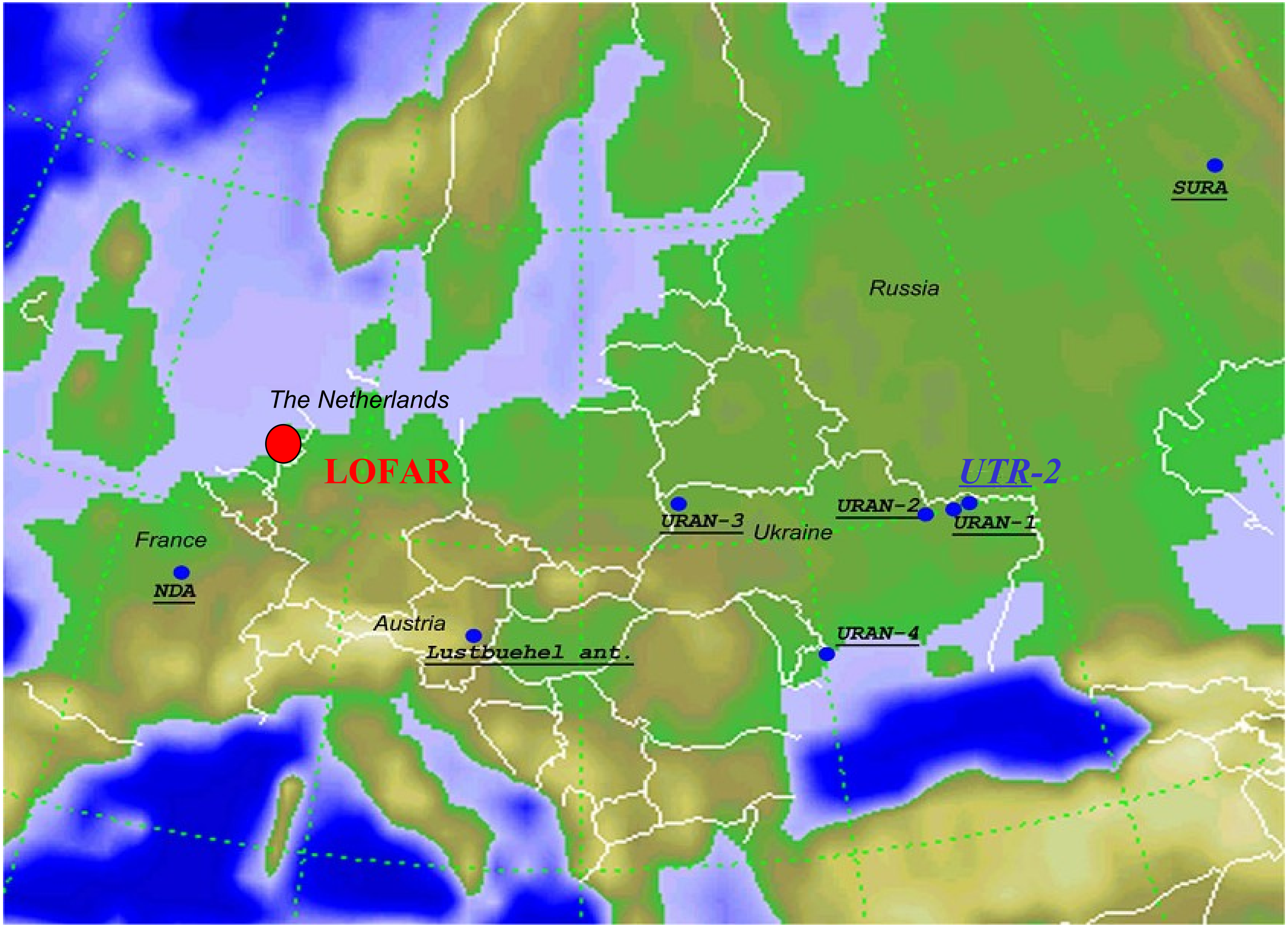


The low-frequency radio telescopes in Europe

The UTR-2 radio telescope, N-S arm (1.8 km×60m)

f = 8…32 MHz, **$A_{eff\ max}$ = 150 000 sq.m**

The UTR-2 radio telescope, E-W arm (900m×60m)

March 23, 2007

URAN-1…URAN-4 radio telescopes

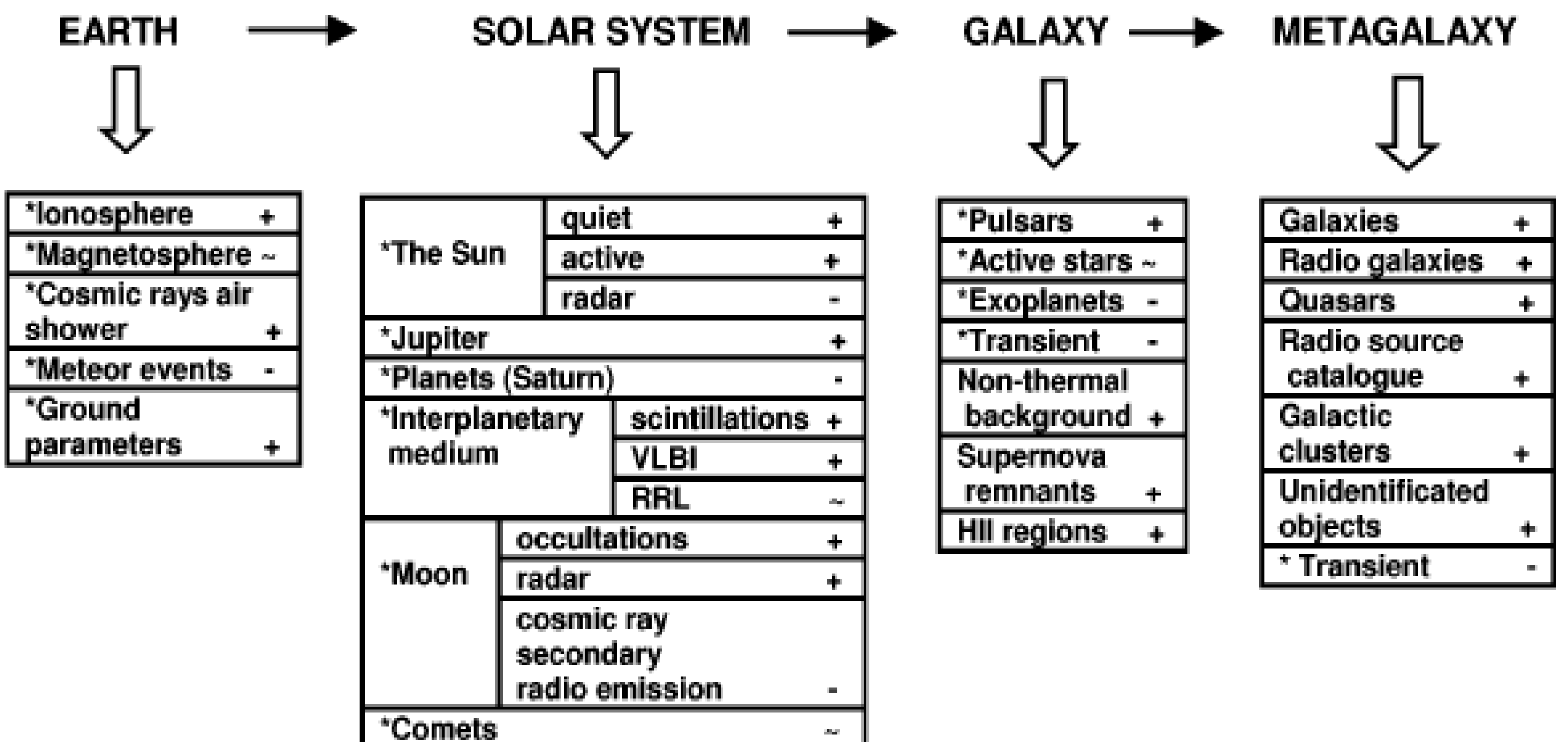
Table 1: Main parameters of existing decameter wavelengths radio telescopes

Radio telescopes	Locations	Frequency range, MHz	Maximum effective area, m^2	Number of elements, polarization	Distance to UTR-2 (LOFAR), km	Angular resolution at 25 MHz
UTR-2	Kharkov, Ukraine	8 – 32	150 000	2040 1 linear	0 ($\sim$ 2000)	$25' \times 25'$
URAN-1	Zmiev, Ukraine	8 – 32	5500	96 2 linear	42 ($\sim$ 1900)	60”
URAN-2	Poltava, Ukraine	8 – 32	28 000	512 2 linear	120 ($\sim$ 1800)	21”
URAN-3	Lviv, Ukraine	8 – 32	14 000	256 2 linear	915 ($\sim$ 1000)	2.7”
URAN-4	Odessa, Ukraine	8 – 32	7300	128 2 linear	613 ($\sim$ 1500)	4.0”
NDA	Nancay, France	8 – 88	2×4000	2×72 2 circular	3000 ($\sim$ 500)	$\sim$ 1.0” (potentially)
SURA	N.Novgorod, Russia	4 – 9	40 000	144 2 linear	1500	Trans. power $\sim$ 150 MWt

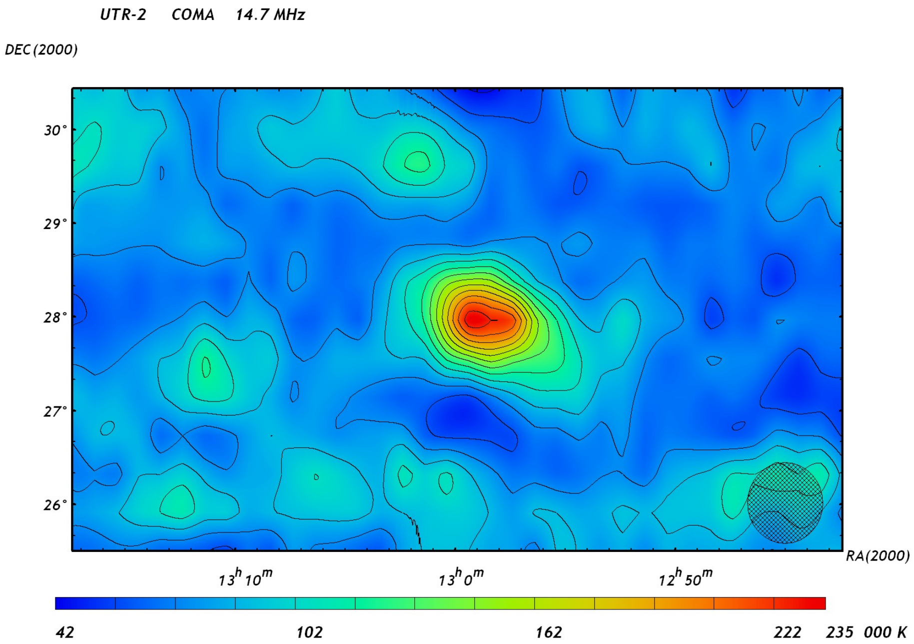
Table 2: Comparison of existing and future low-frequency instruments principal parameters

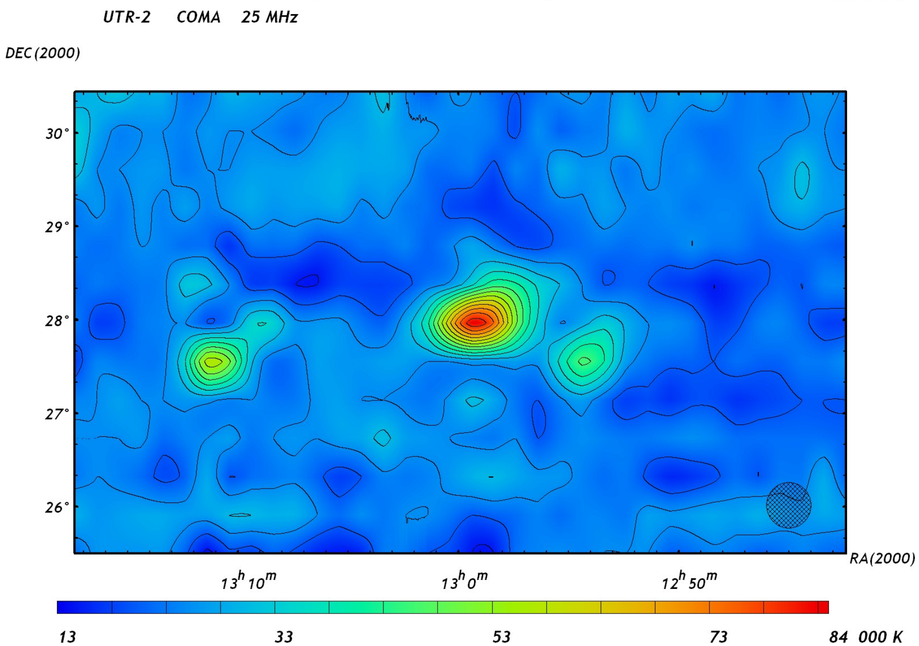
Nr.	Parameter	UTR-2, URAN, NDA	LOFAR	LWA
1	Frequency range, MHz	8…32 (NDA-8…88)	10…240	20…80
2	Number of stations	6	100	50
3	Total number of elements	~ 3000	$\sim 13\,000$	$\sim 12\,500$
4	Total number of antenna elements for one polarization	~ 4000	$\sim 26\,000$	$\sim 25\,000$
5	Number of elements per station	96 …1440	128	250
6	Station size, m	$28 \times 240 \ldots 60 \times 1900$	$\sim 100 \times 100$	~ 100 diameter
7	Maximum baseline, km	950	~ 350	~ 400
8	Minimum baseline, km	~ 0.1	~ 0.1	~ 0.1
9	Maximum angular resolution (25 MHz)	$\sim 3''$	$\sim 6''$	$\sim 6''$
10	Field of view, degree	2…20	all-sky	3…12
11	Electronic steering, degree	± 80	multi-beaming	multi-beaming
12	Polarization	2 (5 stations)	2	2
13	Maximum observable bandwidth, MHz	10 …20	32	3
14	Spectral resolution, kHz	0.1…12	< 1	< 1
15	Time resolution, ms	1…100	1	10
16	Summarized total effective area (25 MHz), m^2	$\sim 200\,000$	350 000	900 000
17	Virtual core (VC) size, km	2×1 (UTR-2)	2×2	5×5
18	VC max. eff. area (25 MHz), m^2	150 000 (UTR-2)	100 000	300 000
19	VC stations number	12 (UTR-2)	~ 25	~ 17
20	VC elements number per station	150 and 180 (UTR-2)	128	250
21	Limit of the confusion effect sensitivity for the continuum point radio source (25 MHz)	< 1000 mJy	< 1 mJy	< 1 mJy
22	Sensitivity of radio emission without the confusion effect (25 MHz, $\tau = 1$ h, $B = 4$ MHz)	~ 10 mJy	~ 1.5 mJy	~ 1.5 mJy

The diagramme bellow illustrates the set of objects and tasks which are investigated with the UTR-2 , URAN-1...URAN-4. It can been seen that this set is in good accordance with the future scientific program of LOFAR [5-7].



Continuum stationary radio emission



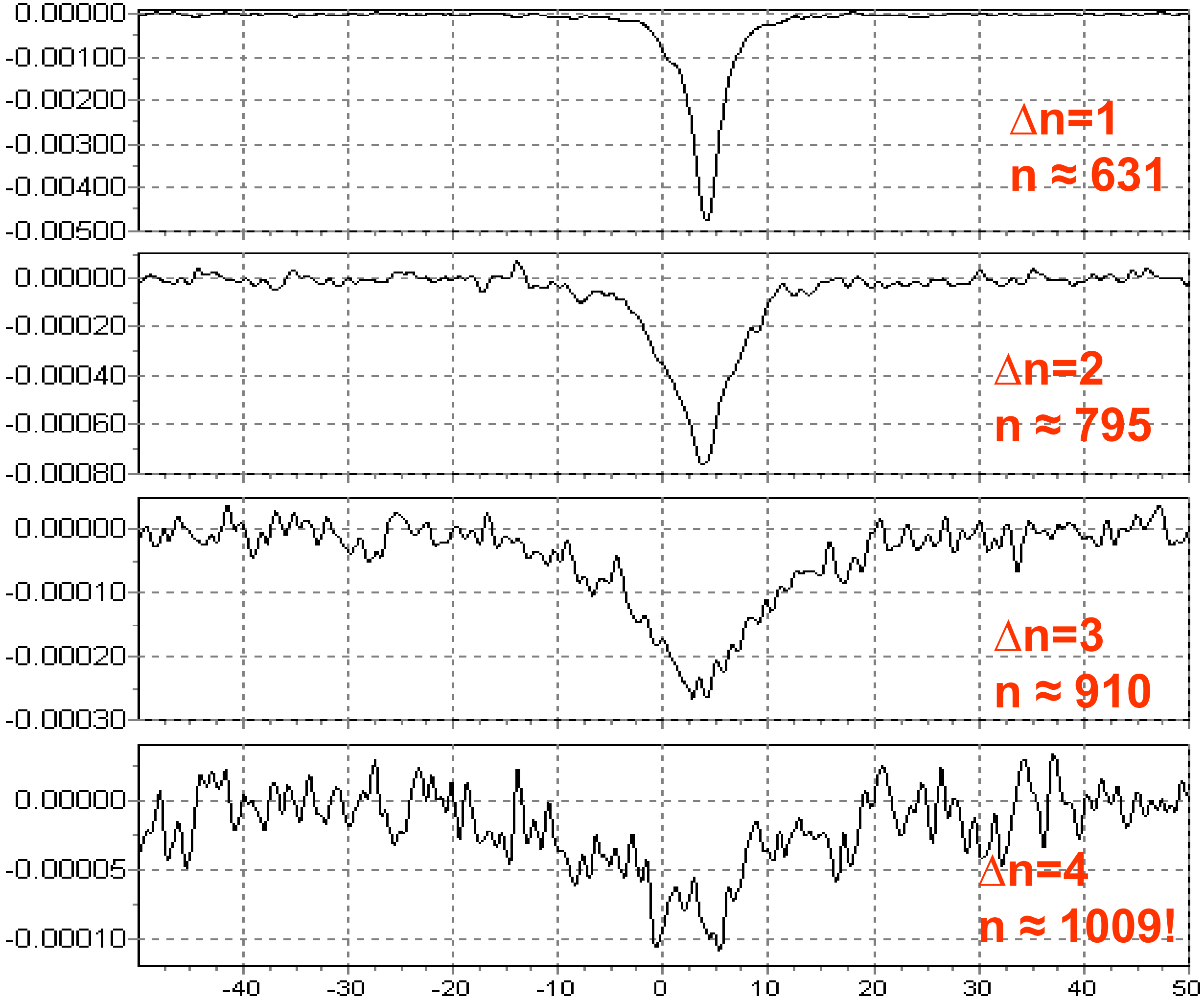


Here we present some illustrations of the UTR-2 and URAN results for the astrophysical objects with the fine structure of spectral, temporal and spatial radio emissions. These results demonstrate the high astrophysical significance of the low-frequency radio astronomy and good perspectives for the investigations with the future new generation giant radio telescopes.

UTR-2 radiomap of Coma cluster (Krymkin, Sidorchuk). The sensitivity for this kind radio emission is limited by the confusion effect (for UTR-2 it is near 1 Jy)

Fine spectral structure radio emission

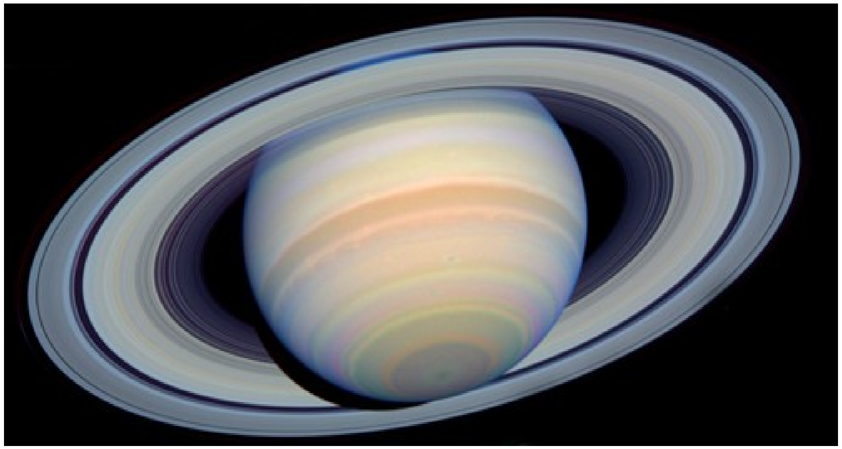
Carbon RRL‘s towards Cas A, UTR-2, 26 MHz

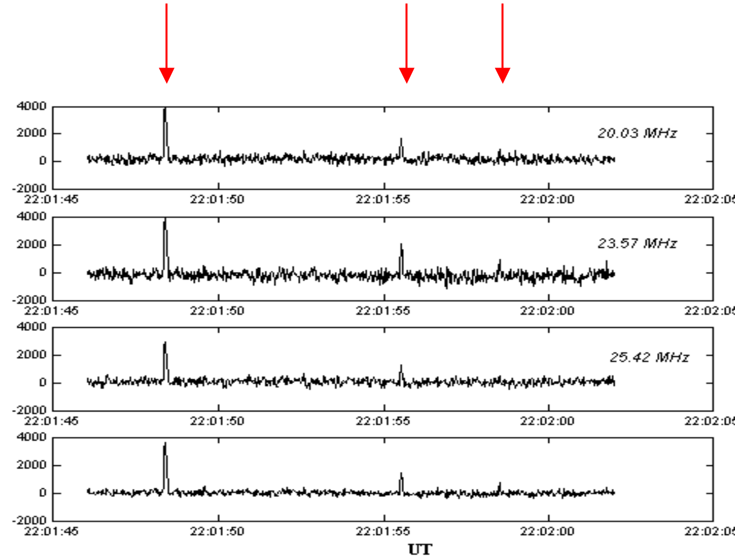


Detection of carbon RRL‘s with recordly high principal quantum number n~1000 (Stepkin, Konovalenko, Kantharia, Udaya Shankar). There is no restriction by the confusion effect (reached sensitivity after time and lines averaging is at the level of few mJy).

D ≈ 0.1mm !

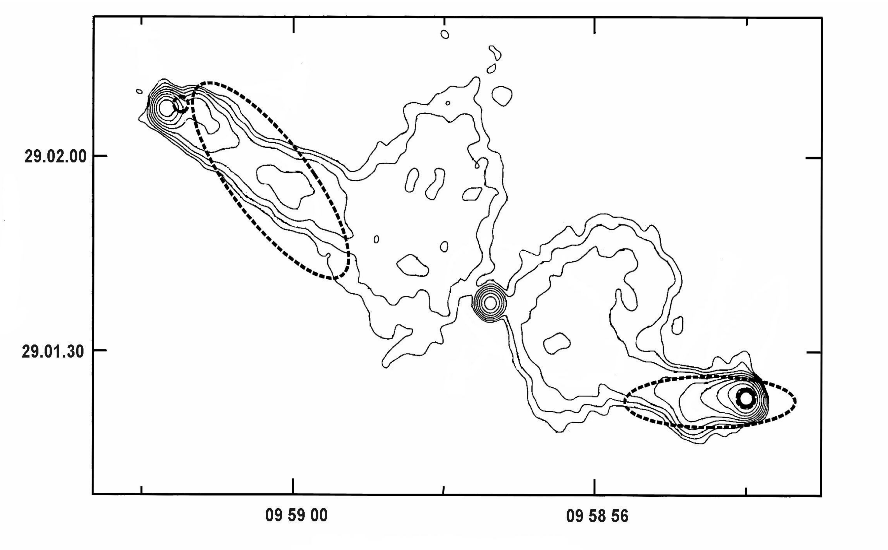
Fine time structure radio emission



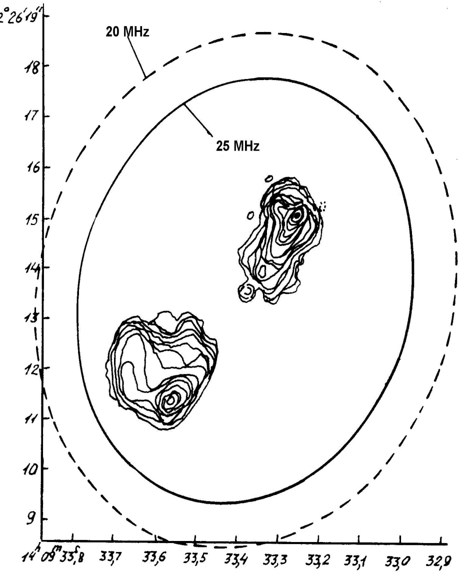


Detection of SED by the ground-based instrument (UTR-2, 20-25 MHz) (Konovalenko, Lecacheux, Rucker, Fischer, Abranin, Kali-nichenko, Sidorchuk, Falkovich, 2006)

Fine spatial structure radio emission



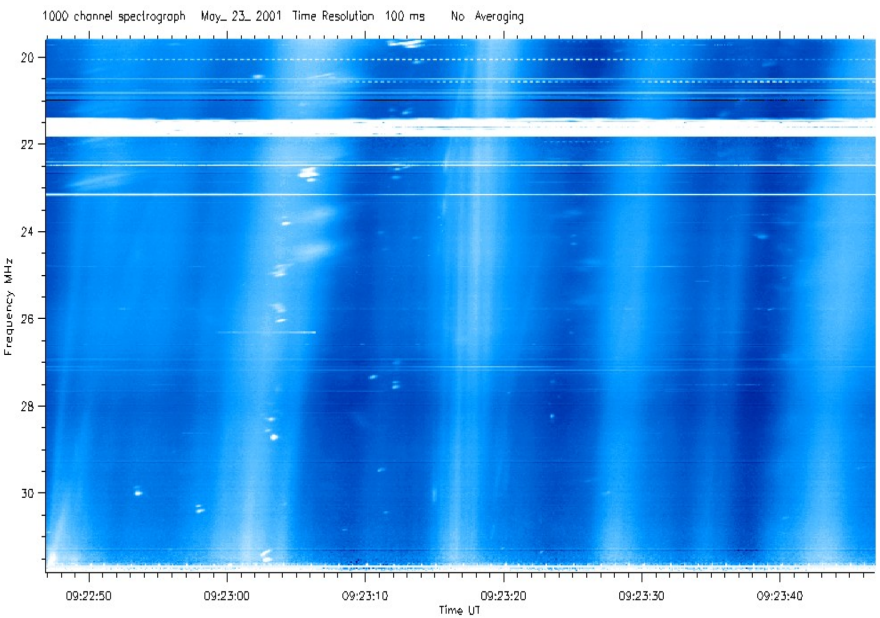
Structure of 3C234



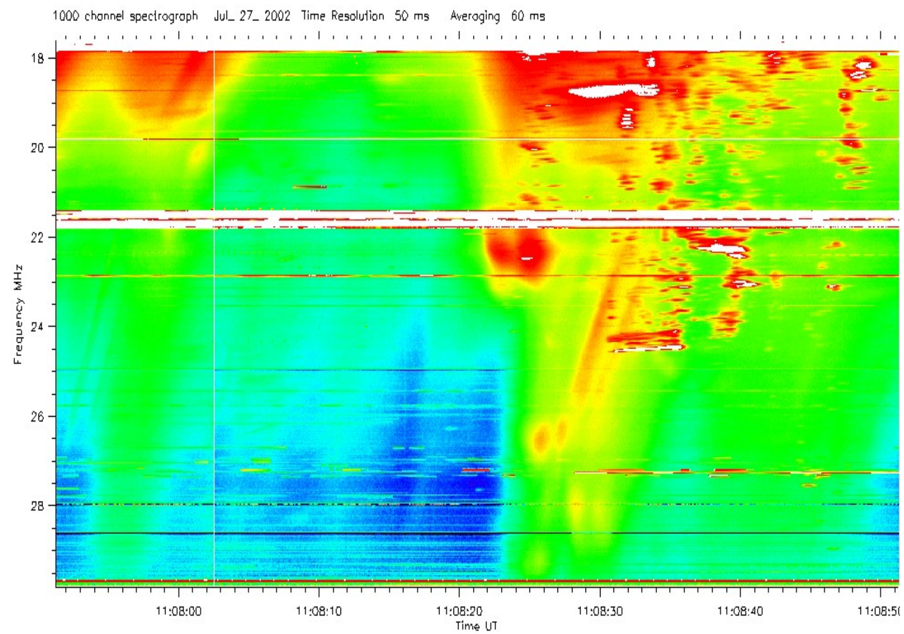
Structure of 3C295

Radio interferometry observations by UTR-2 – URAN VLBI system (Braude, Megn, Rashkovsky, Shepelev, et al.) in comparing with high frequency imaging of radio sources.

Complex fine time-spectral structure radio emission



Type III solar bursts



Spike-like radio emission

Solar sporadic radio emission with the fine time-frequency structure detected by UTR-2 (Melnik, Konovalenko, Rucker, Lecacheux, Abranin, Stanislavsky, Dorovsky).

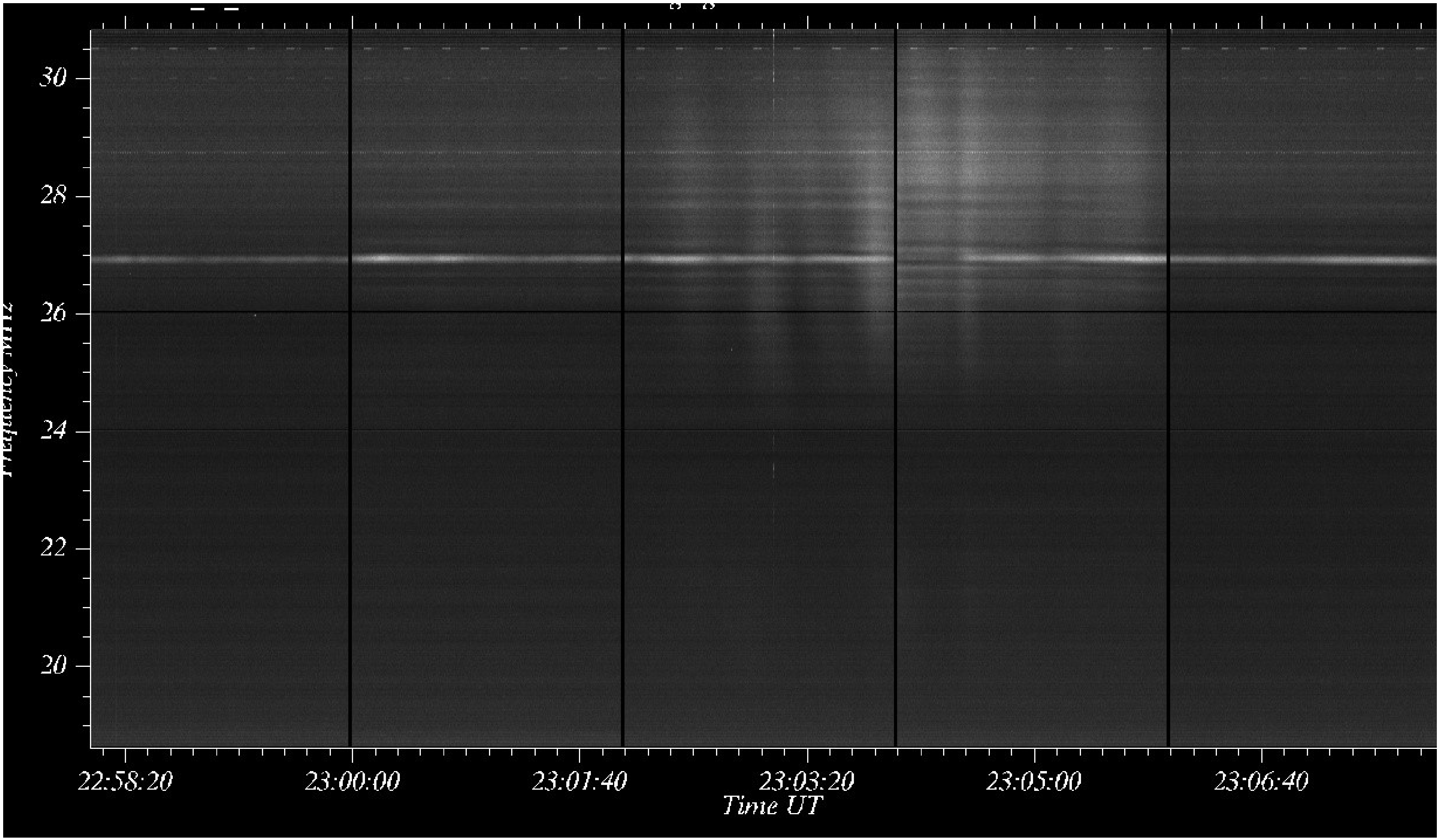
B = 33 MHz
f = 8…32 MHz
N = 16 000
Δf = 2 kHz
Δt = 1 ms
ADC 16 bit

Search of exoplanets radioemission with UTR-2 and new digital receiver (France – Ukraine – Japan), December, 2006 – March, 2007

B = 12 MHz
f = 18…30 MHz
N = 1024
Δf = 12 kHz
Δt = 1 ms
ADC 12 bit

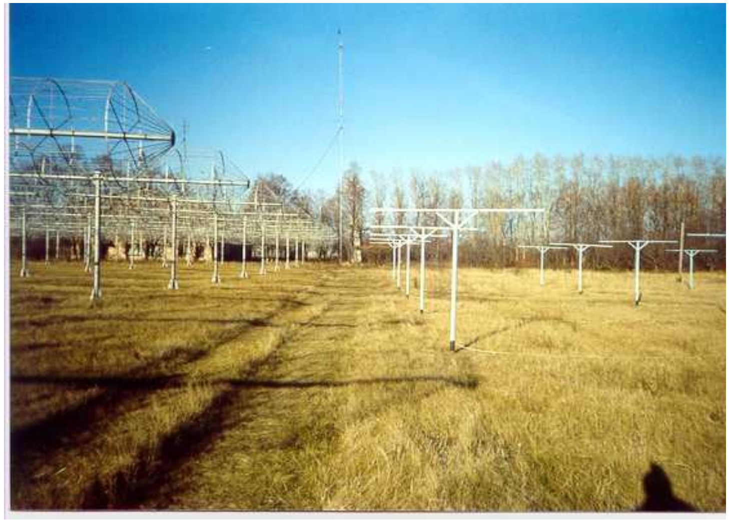
Search of flare stars radio emission with UTR-2 and DSP, February 2-12, 2007

Preliminary results of AD Leo radio emission search with UTR-2 and DSP, February 7, 2007, f = 18…32 MHz

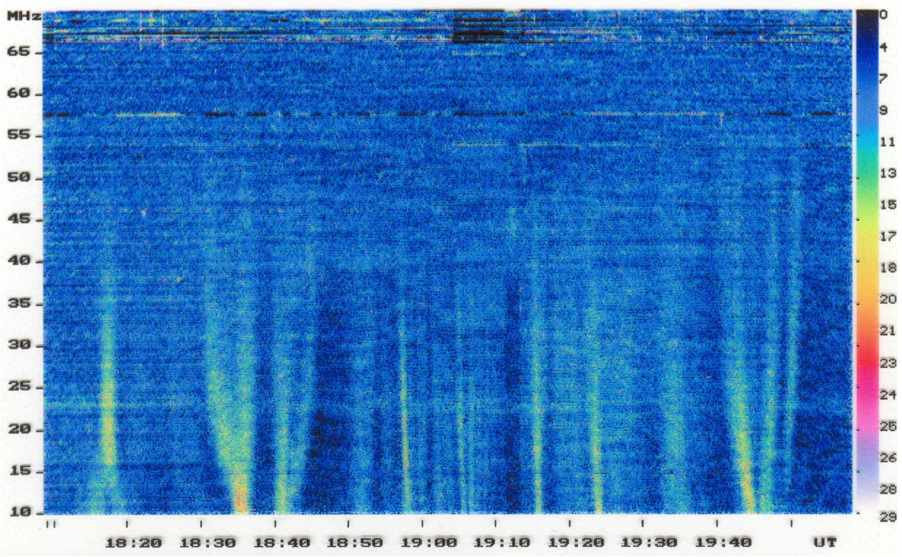


Ukrainian plan for the perspective development of low-frequency radio astronomy (Order of Presidium of National Academy of Sciences of Ukraine N 357 from 01.04.2006 with the corresponding financial support).

Test array on UTR-2 observatory, 2000 year [8]



Cas A observations



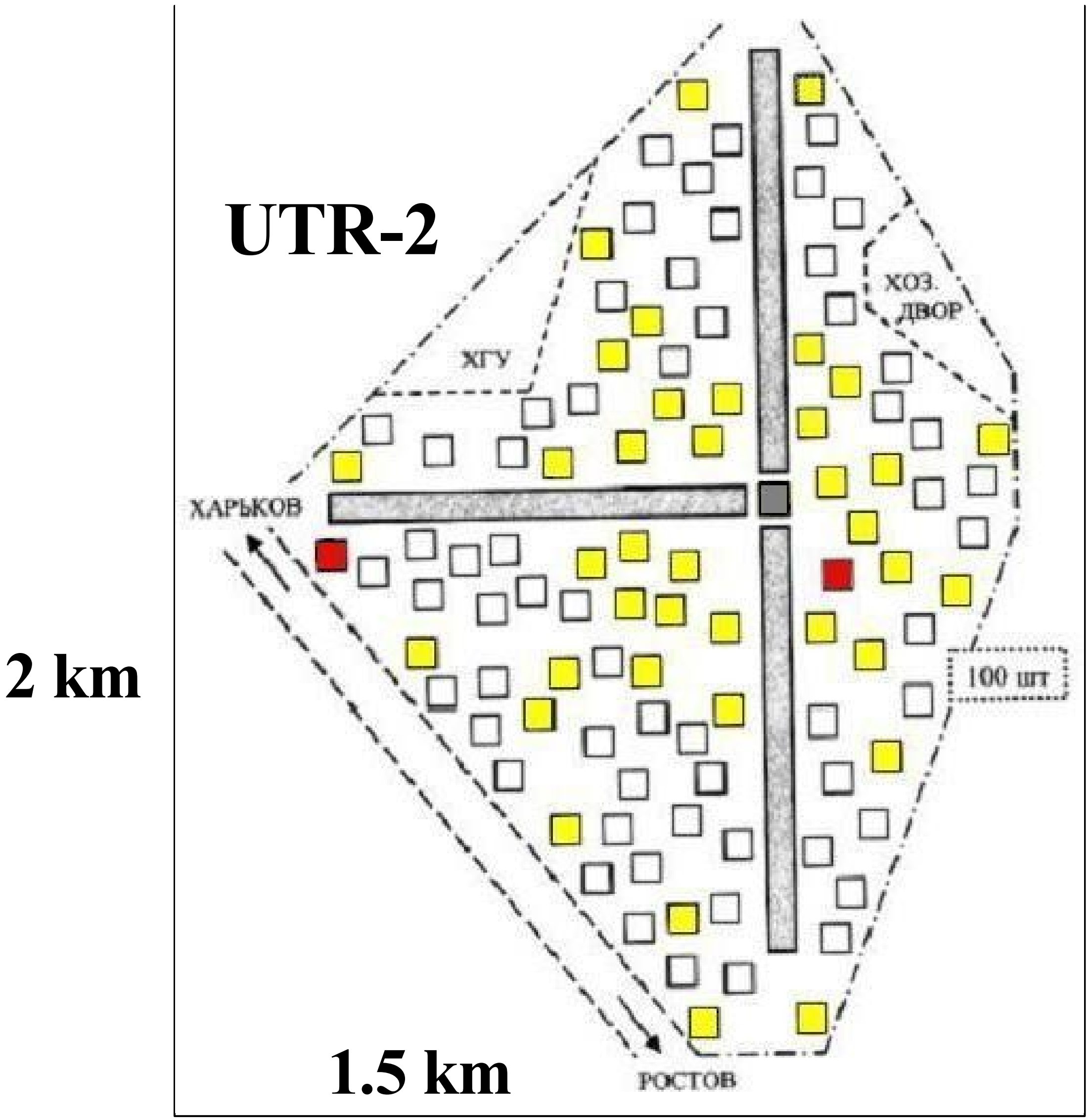
f = 10…70 MHz

New 25-elements test array, 2006 year

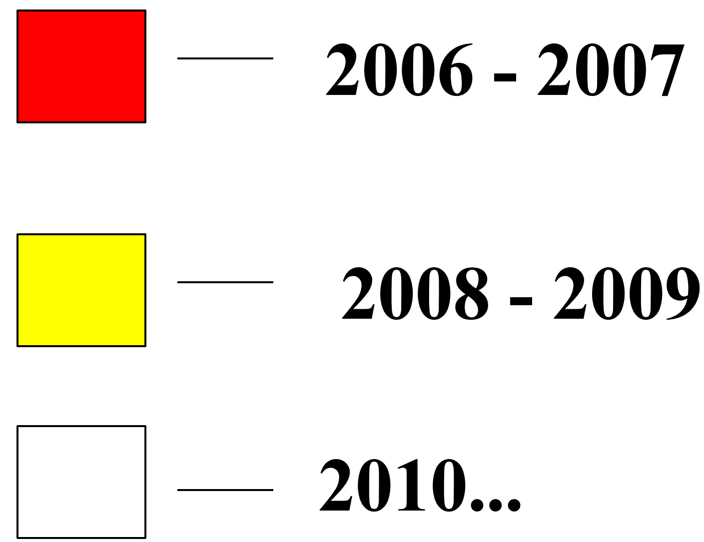
f = 10…70 MHz

New 25-elements test array, 2007 year

Possible distribution of new active antenna elements array (f = 10…70 MHz) on UTR-2 observatory (S = 1 500 000 sq.m)



It should be compatible with LOFAR format



CONCLUSION.

The existing world largest decameter wavelength instruments are the good precursors for the investigations with the future new generation low-frequency radio telescopes from astrophysucal, methodical and technical point of view. The high astrophysical importance of low-frequency radio astronomy is evident. The creation of new giant meter-decameter wavelength radio telescopes is very actual and in time. They will give a huge amount of new astrphysical results.