

J-IAU_1210_Zakharenko

Radio astronomy in Ukraine during the wartime, 2022–2026

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Director of Institute of Radio
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Ukraine (IRA NASU)

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- Since 2014, the Russian aggression against Ukraine began. And from 24.02.2022 - a full-scale war.
- **Despite** the threat to life, very serious losses of scientific equipment and vehicles, and the destruction of buildings, **Ukrainian science are holding on and developing.** All this is happening thanks to the **power of the Defense Forces of Ukraine, the resilience of the Ukrainian people, the selfless work of our scientists, and broad international support for our just war** against the aggressor.
- A significant part of the IRA NASU budget is spent on fulfilling orders of the Defense Forces of Ukraine.
- But the main task of IRA NASU is the **restoration and development of radio astronomy**, considering that for more than six months the S.Ya. Braude Radio Astronomical Observatory, where the world's largest decameter radio telescope - UTR-2 is located, **was under occupation**, the enemy in Kharkiv stood 5 kilometers from the **Institute** and **conducted constant artillery shelling and air bombing**. In early September 2022, a large part of the Kharkiv region was liberated.

"Constellation" of Ukrainian low-frequency radio telescopes



URAN-3



URAN-2

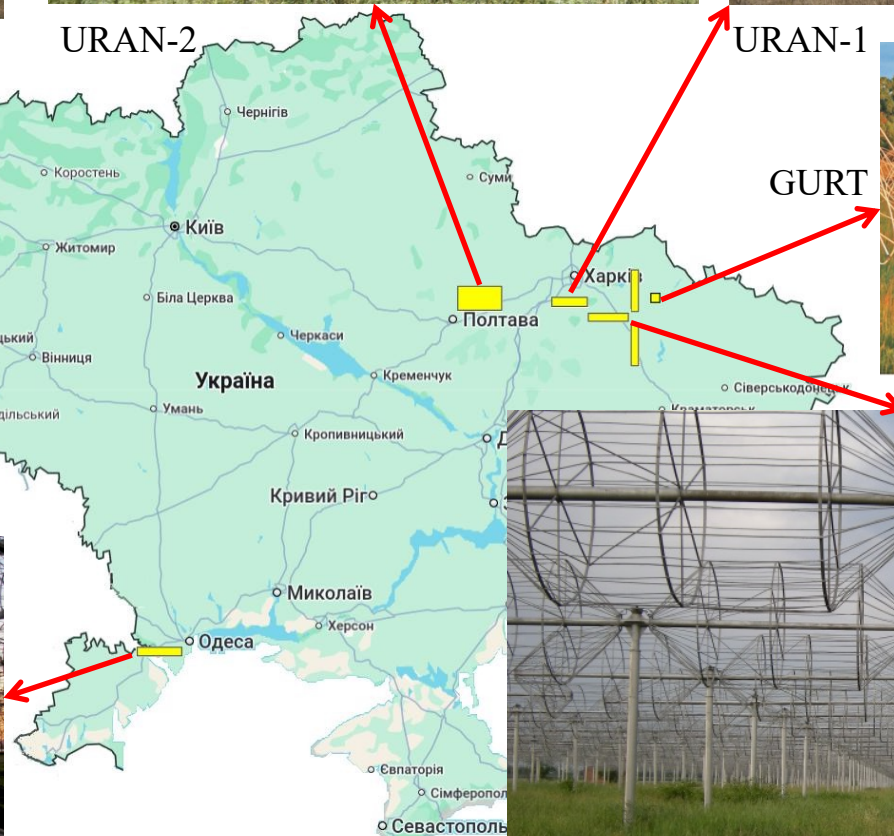


URAN-1



GURT

URAN-4



UTR-2



S.Ya. Braude Radio Astronomy Observatory radio telescope UTR-2



UTR-2:

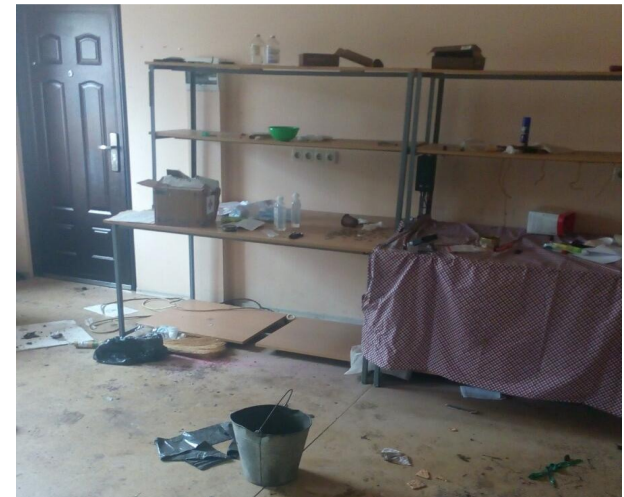
2040 antenna elements

8-33 MHz

$A_E = 150000 \text{ m}^2$

Destruction of the UTR-2 radio telescope: before Feb 2022 (top) and after Sep 2022 (bottom)

From the end of February to the beginning of September, the S.Ya. Braude Observatory was under occupation. As a result, the UTR-2 building was significantly damaged, the phasing system, the central beamforming unit and the cable system were partially destroyed, and receivers and measuring equipment were stolen.



Destruction of the UTR-2 radio telescope:

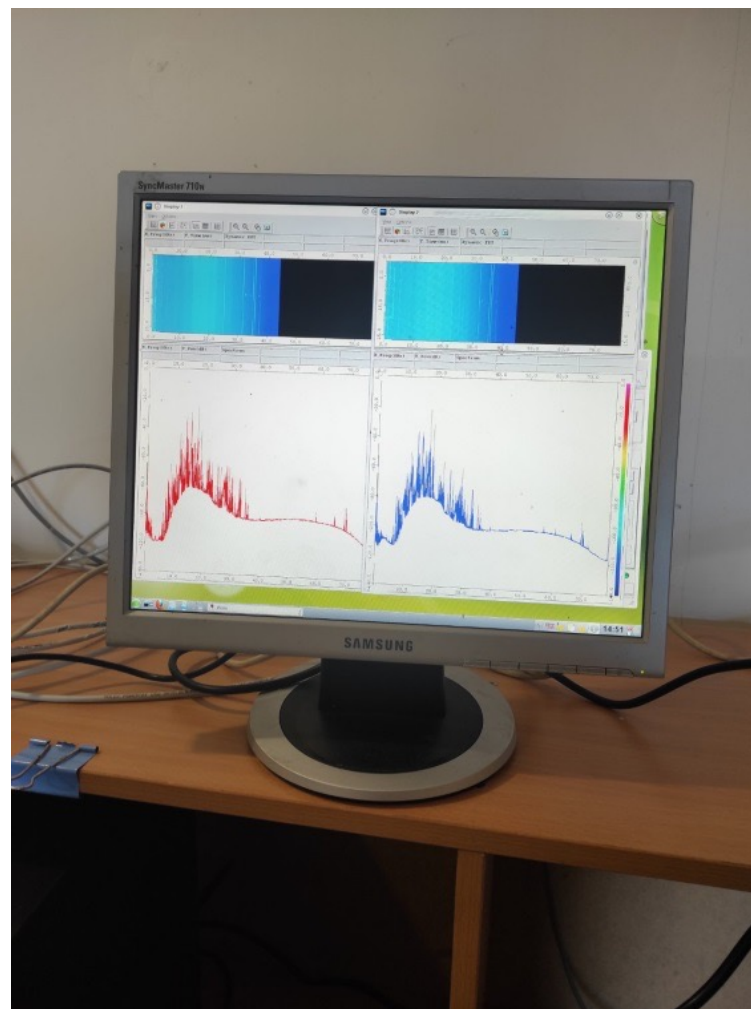
Rockets, artillery shells and consequences

Of the other 16 buildings of the observatory complex (GURT radio telescope, workshops, vehicle fleet, warehouses), 2 buildings were completely destroyed, 14 received significant damage. Of the 22 units of transport, 10 were stolen, 9 were destroyed. Landmines, petal mines, unexploded shells. Currently, the area is demined only around roads and buildings.



Restoration of radio astronomy equipment (RAO named after S.Ya. Braude)

At the deoccupied S.Ya. Braude Radio Astronomy Observatory, **two sections of the GURT radio telescope** have been restored (operating with solar power plants – 2023). All receiving equipment has been restored (receivers, frequency and time standard, remote control)



Creation of new radio astronomy equipment

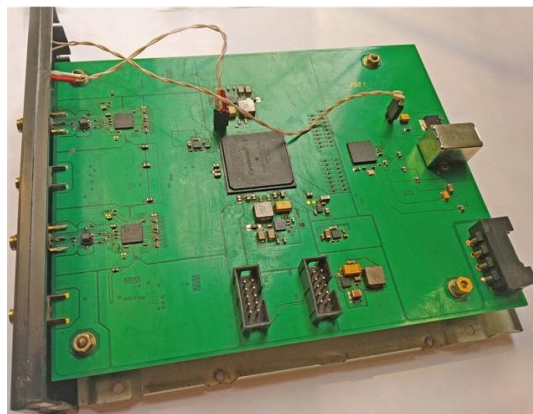
GURT sections on URAN-2:
first – 2024,
second – end of 2025

New digital receiver.

0...40 MHz,
2 channels,
16 bit ADC

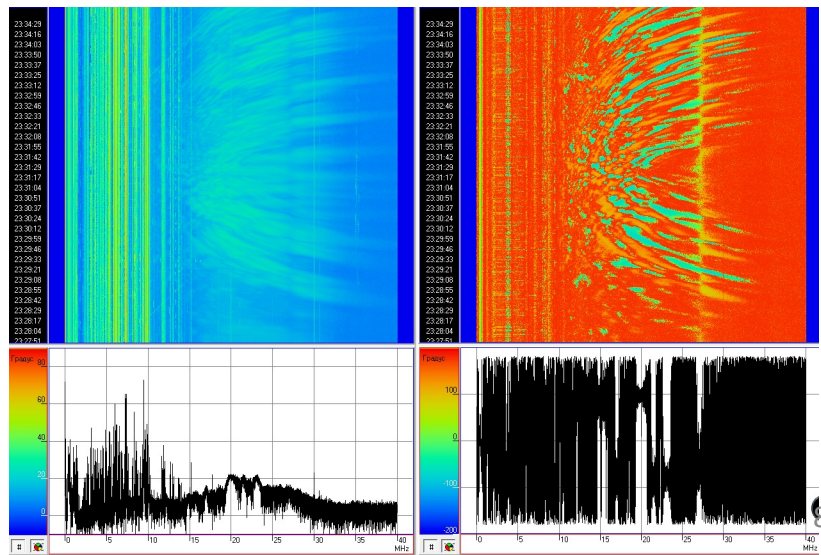
Mode:

Waveform, Spectra,
Correlation



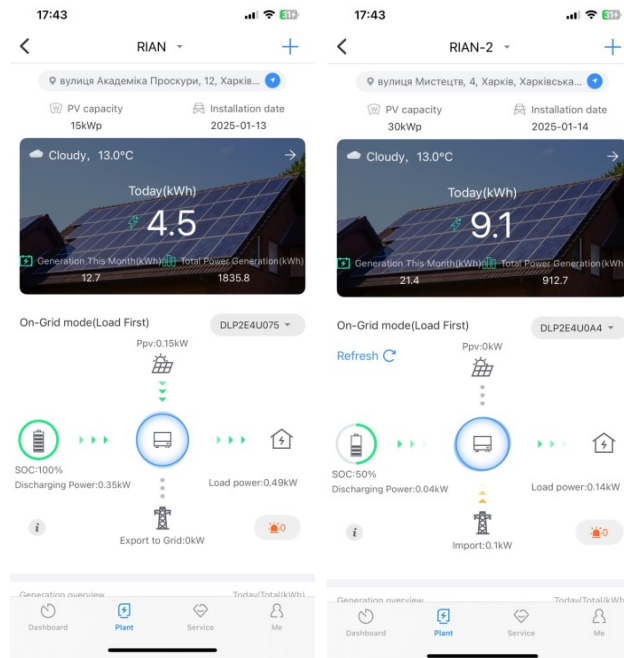
DSP-U digital receiver and

observation examples



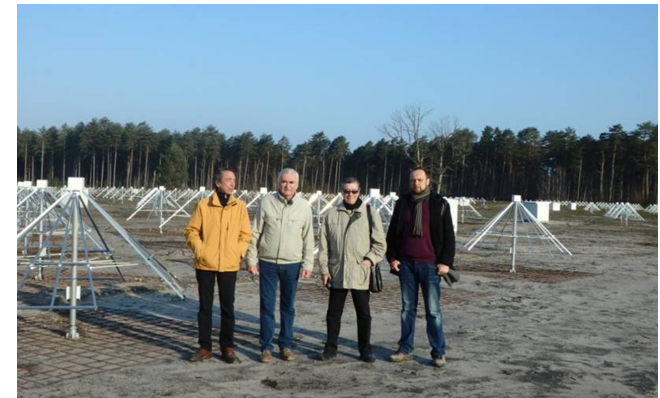
Energy independence: solar power plants, charging stations, generators, building insulation

Laboratory buildings of the institute and radio astronomy observatories



Observations at URAN-2. Joint research at NenuFAR: the Sun, pulsars, Cas A, Jupiter, RRL, and so on.

- Despite the difficult conditions, observations on Ukrainian radio telescopes are being conducted and their processing continues. Most of the observations **have been transferred to URAN-2**.
- **NenuFAR is regularly used**, in the creation of which Ukrainian scientists participated in previous years.
- **We are very grateful** for the organizational and financial assistance to our scientists who went to **France, Denmark, Poland, Italy and other countries**. Thanks to joint work at observatories and research institutions in Europe and the world, joint work is intensively continued and articles are published.
- **Processing of UTR-2 data continues**, where 3 sky surveys were conducted with different parameters of time and frequency resolutions.
- The number of articles was minimal in 2022-2023, and now it has approached to “before COVID-19” values.



Awards, prizes



- NAS of Ukraine Prize named after Academician NAS of Ukraine S.Ya. Braude: (2024)*

- I.M. Bubnov,
- O.O. Stanislavsky,
- P.L. Tokarsky

- International Astronomical Union PhD Prize (2024):*

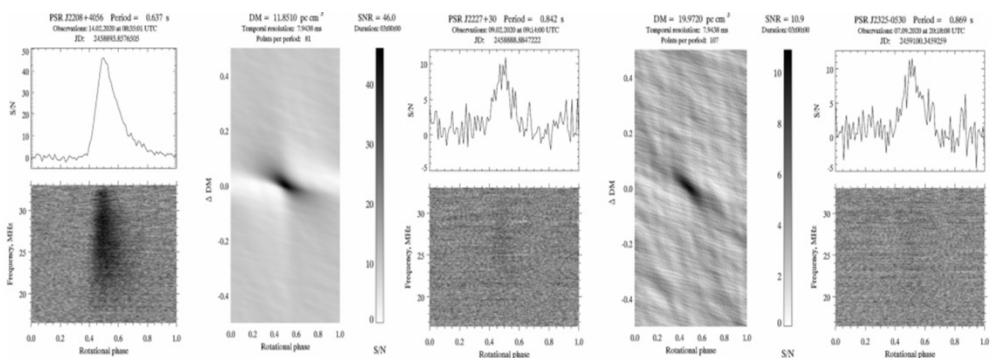
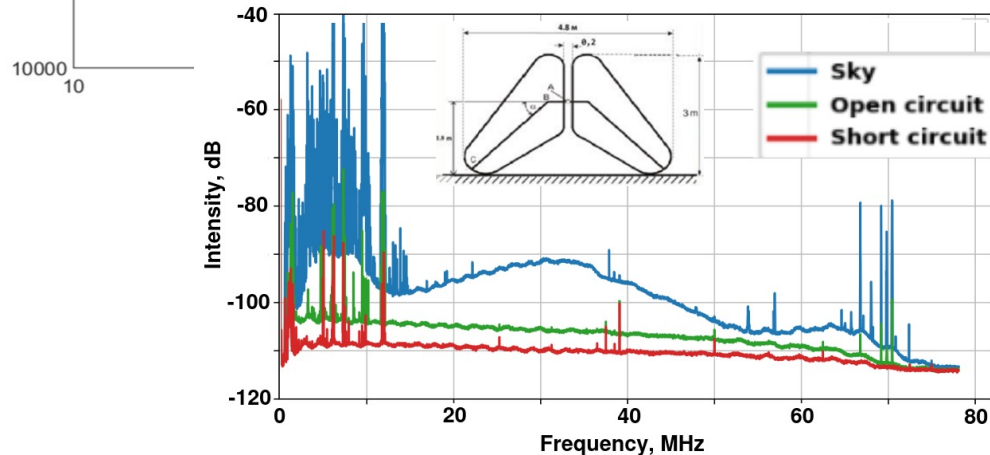
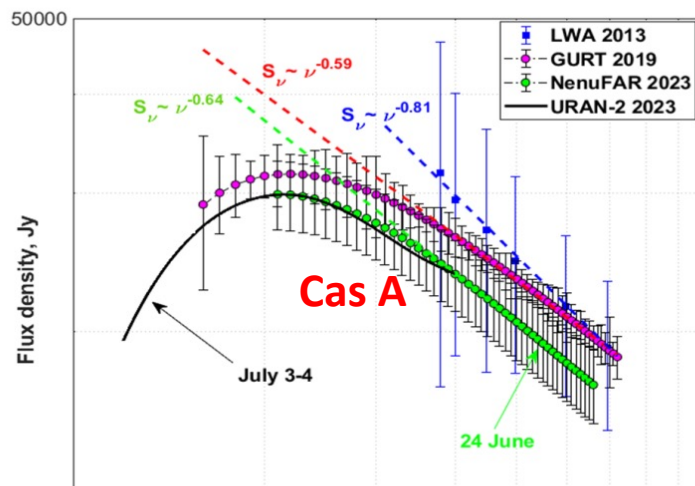
- L.O. Stanislavsky

- Prize of the Verkhovna Rada of Ukraine for Young Scientists (2023):*

- I.P. Kravtsov



2024
PhD Prize



The Northern Sky Survey contains over 100 TB of UTR-2 data with a time resolution of 8 ms

The UTR-2 decametre pulsar and transient survey

I. Transient detection

V. V. Zakharenko^{1,2,*}, I. P. Kravtsov^{1,3,}, I. Y. Vasylieva^{1,4,5,}, P. Zarka^{6,7,}, O. M. Ulyanov^{1,}, O. O. Konovalenko^{1,}, A. I. Shevtsova^{1,}, A. O. Skoryk^{1,}, and K. Y. Mylostna^{1,}

Zakharenko, V. V., et al.: A&A, 708, A4 (2026)

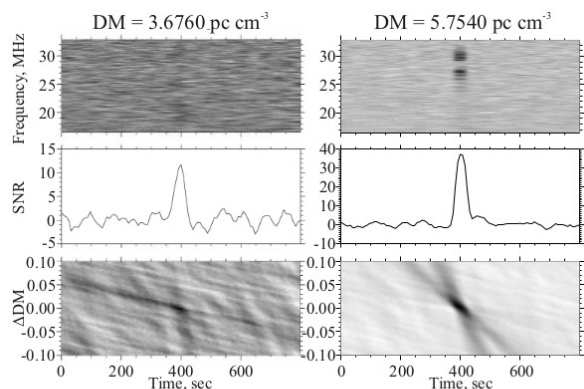


Fig. 5. Example of a transient signal from an unknown source, $DM = 3.676 \text{ pc cm}^{-3}$, (left panel) and a single pulse of PSR B0809+74 (right panel), $DM = 5.754 \text{ pc cm}^{-3}$. The top panels are dynamic spectra, the middle panels are pulse frequency averaging, and the bottom panel is the 'Time vs DM ' plane.

The number of transient radiation sources discovered on UTR-2 (which are various types of neutron stars) is comparable to the number of nearby pulsars (<2 kpc) discovered over 50+ years.

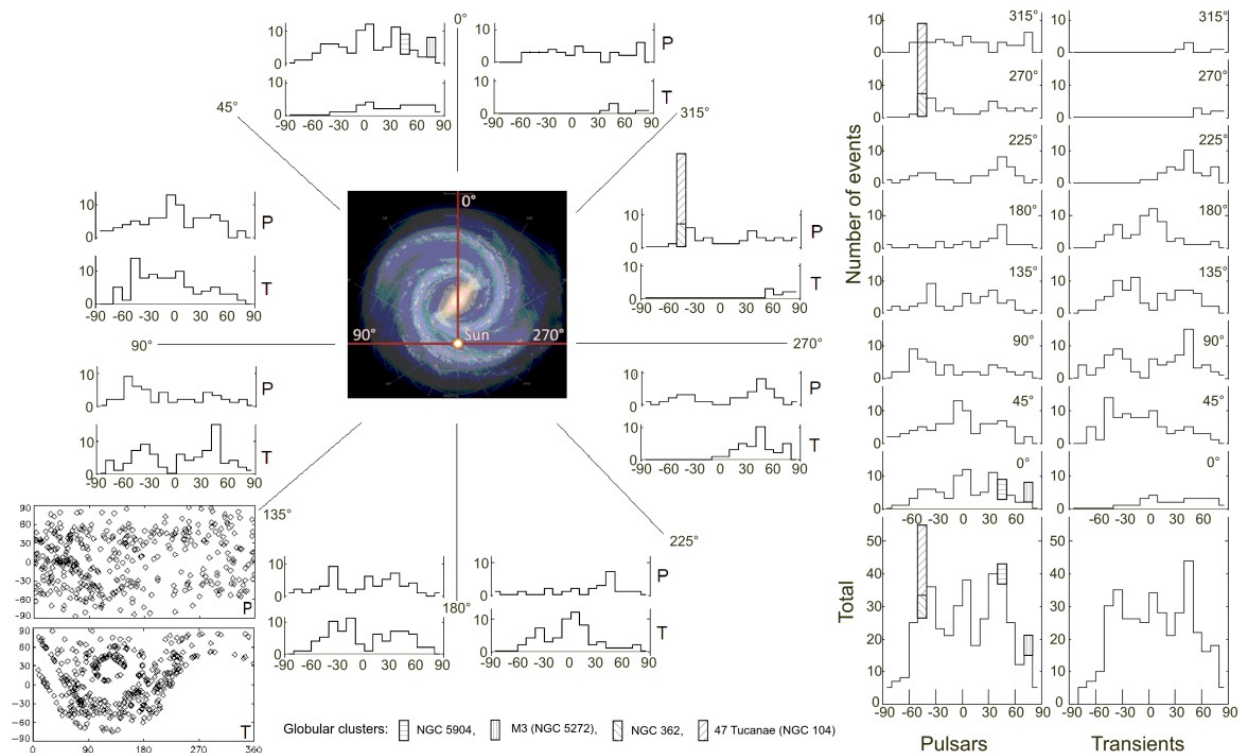
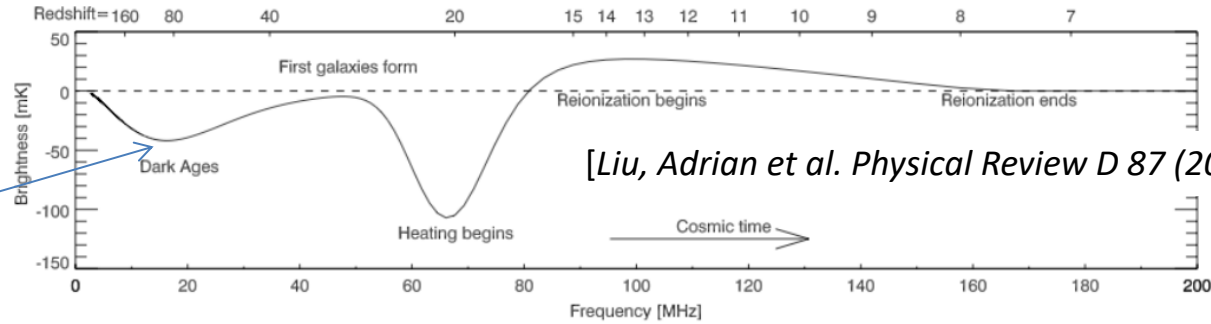


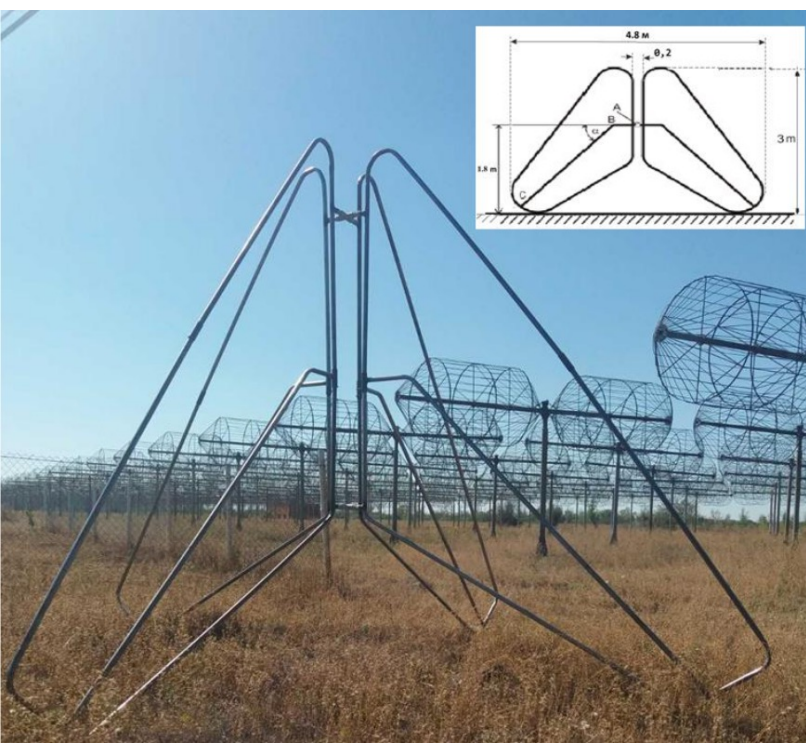
Fig. 24. Galactic latitude distributions of pulsars with $DM < 30 \text{ pc cm}^{-3}$ (Manchester et al. 2005) and the (probably) cosmic sources found in this work as a function of Galactic longitude. The lower left panel shows Galactic co-ordinates of the pulsars and transients. On the right one, the total histograms of the b distributions are presented. The number of pulsars in the globular clusters NGC 5904, Messier 3 (NGC 5272), NGC 362, and 47 Tucanae (NGC 104) is indicated by different types of hatching.

Dark Ages,
 HI, $z \sim 87$

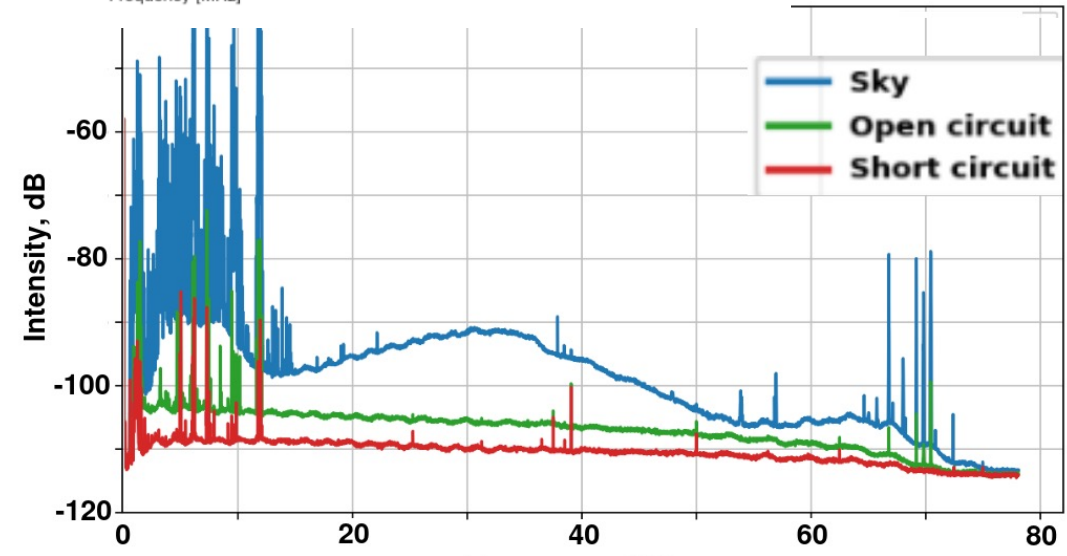


[Liu, Adrian et al. Physical Review D 87 (2012): 043002]

Extremely low-frequency
 radio astronomy

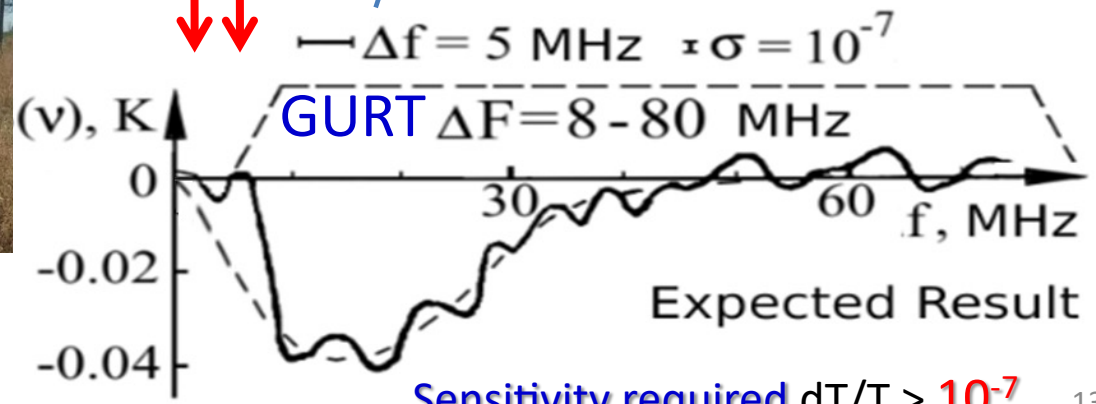


Bubnov et al. Radio phys. radio
 astron. 2021, 26(3)



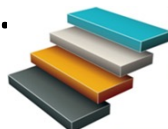
Night Day

NenuFAR



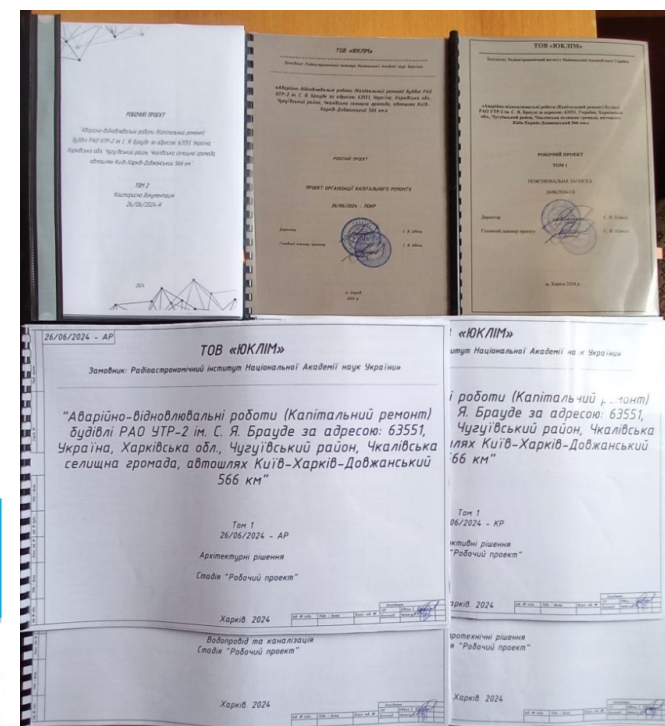
Sensitivity required $dT/T > 10^{-7}$

- In 2023, a temporary roof was installed on the UTR-2 building, and a third of the buildings of the Observatory (workshops, laboratory buildings) were renovated.
- The Horizon-Europe proposal «**UPSCALE**» (Ukraine, Netherlands, France, Poland) for the restoration of UTR-2 laid the foundations for reconstruction.
- In 2024, a project for the major renovation of the UTR-2 building was ordered and developed. However, in May 2024, another attack by the Russian Federation on the Kharkiv region began, and restoration work was suspended due to the worsening security situation.

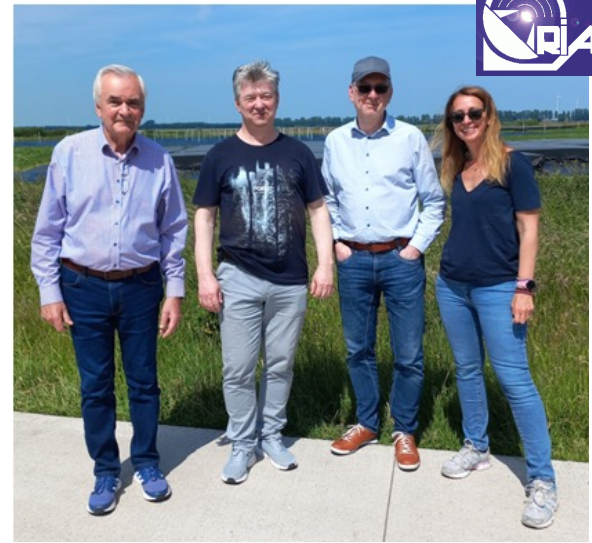


UPSCALE
Ukrainian Participation in the Science Community
for Astronomy at Low frequencies in Europe

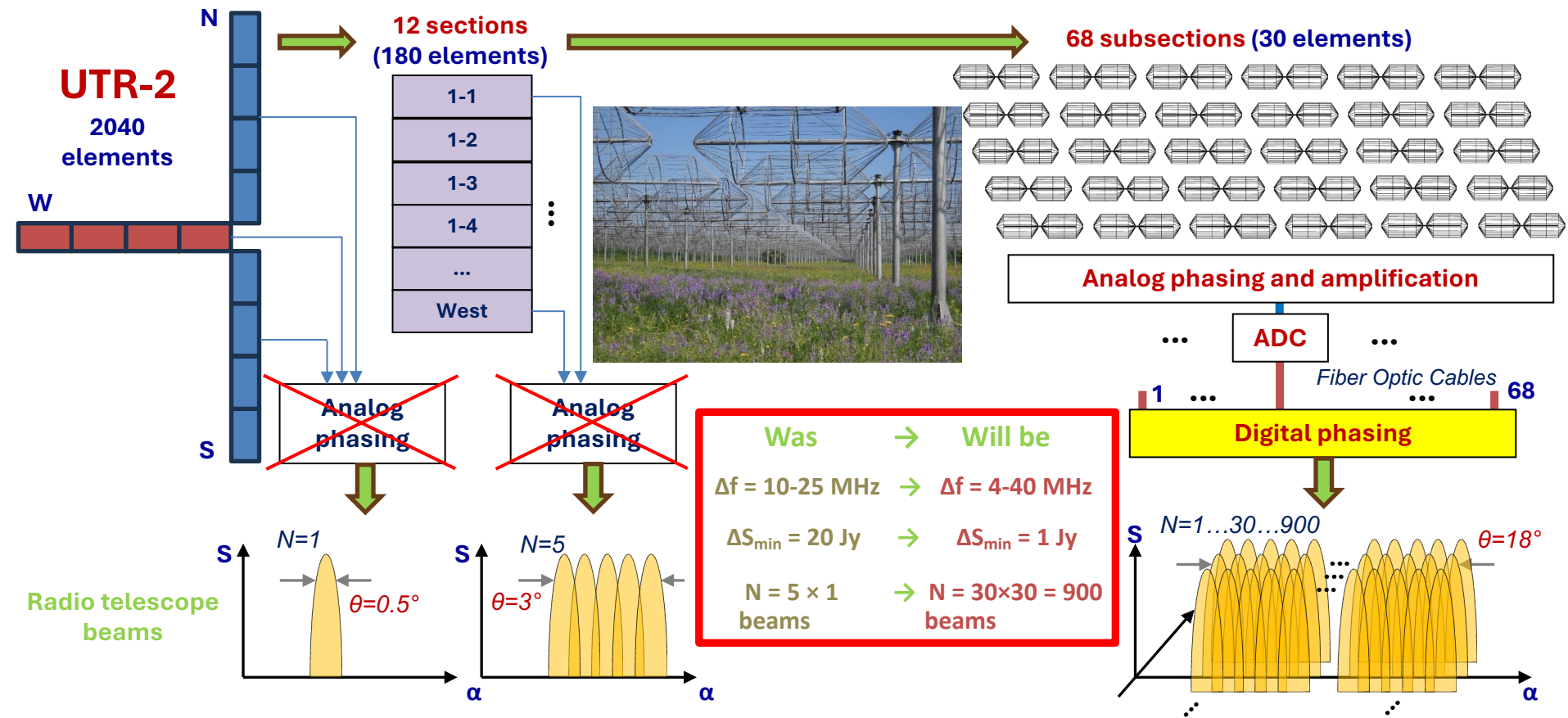
**UKRAINIAN RADIO
TELESCOPES.
"UPSCALE" IS THE PATH TO
RECOVERY**



- A significant impetus for the restoration of UTR-2 was provided by a **conference in Leiden on June 10-11, 2025**, at which **new approaches to the reconstruction of UTR-2** were proposed, compatible with those used by colleagues from the Netherlands. **By the Decision of the Presidium of the NAS of Ukraine** (No. 380 of Nov 5, 2026), **a project for the restoration and modernization of UTR-2 was created.**
- The essence is to re-divide the antenna field of 2040 antenna elements (AE) from 12 previous sections into new 68 sections of 30 AE.
- The 30-element sections are phased (internally) by an **analog phasing system**. The entire telescope is phased by a **digital system**.



Digital restoration and modernization of the world's largest decameter radio telescope UTR-2



Conclusions: The UTR-2 radio telescope has not yet exhausted its capabilities. Its gigantic effective area, record sensitivity (especially at frequencies below 30 MHz), and enormous distance to Western Europe antennas make it indispensable in the future development of the European network. The introduction of digital aperture synthesis is especially valuable, which significantly improves the efficiency of research.

Some publications from 2025-2026:

- D. Albergaria, K. Frantseva, ... O. Konovalenko, V. Zakharenko et al. Ukrainian wartime astronomy and its prospects. *Nature Astronomy*, # 9, 2025.
- L. Cros, ... S. Stepkin, ... O. Konovalenko, P. Tokarsky, O. Ulyanov, V. Zakharenko et al. Observations of carbon radio recombination lines with the NenuFAR telescope-I. Cassiopeia A and Cygnus A, 2025, *A&A* V. 701, A148, 27p.
- V. Zakharenko, I. Kravtsov, I. Vasylieva, P. Zarka, O. Ulyanov, O. Konovalenko, A. Shevtsova, A. Skoryk, K. Mylostna. The UTR-2 decametre pulsar and transient survey: I. Transient detection, 2026, *A&A* V. 708, A4.

Project for the restoration and modernization of the UTR-2 radio telescope

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Director, IRA NAS of Ukraine
Academician of the NAS of Ukraine
Vyacheslav ZAKHARENKO
« 30 » 01 2026

PROJECT RESTORATION AND MODERNIZATION OF THE UTR-2 RADIO TELESCOPE

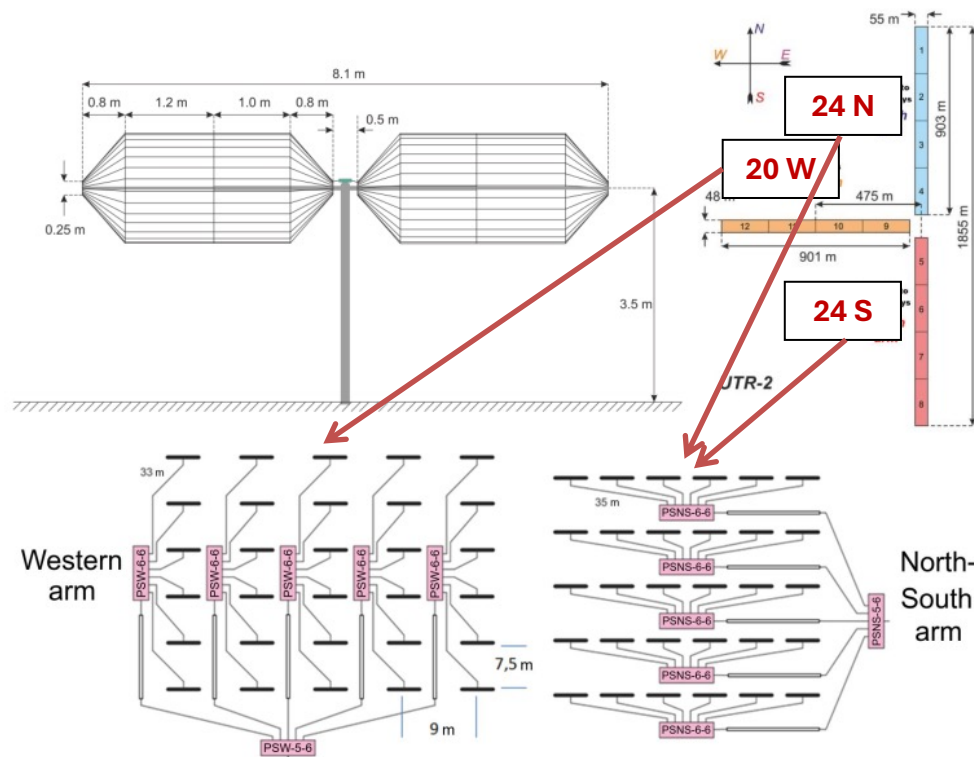


Fig. 1. UTR-2 antenna element (top, left), the planned distribution of 68 thirty-element subsections of the modernized UTR-2 radio telescope across the northern, western, and southern arms (top, right) with these configurations.

Table 3. Cost of the most expensive components of the analog beamforming modules for the entire UTR-2 radio telescope signal path.

№	Part name	Units	Quantity	Unit price, thousand UAH	Amount, thousand UAH
1	Relay OMRON 21Y4YH G6K 2FRF-S DC12	pc.	7560	1.0	7560.0
2	Radio frequency cable PK-4-11 75 Ohm	m	40000	0.06	2400.0
3	Optic fiber cable	reel	68	13.8	938.4
4	Chip ADC LTC2208IUP#PBF	pc.	68	12.5	850.0
TOTAL:					11748.4 (~€228'480)

The project was reviewed at a meeting of the Institute's Academic Council.
Minutes No. 16 dated 24 December 2025.

COMMENTS ON THE PROPOSED PROJECT FOR THE RESTORATION AND MODERNISATION OF THE UTR-2 RADIO TELESCOPE

G. K. Miley, Leiden University

I strongly support this proposal for both scientific and geopolitical reasons.

A restored and modernised UTR-2 would

1. enable world-class ground-breaking multidisciplinary science in astronomy, ionospheric and solar physics,
2. be a visible demonstration that Ukraine science and scientists are an essential part of the European scientific infrastructure, strengthen the unification of European science and symbolise an open pan-European approach to the exploration of the Universe.
3. emphasise Ukraine's role as one of the initiators and leaders of decametre radio science.

A restored UTR-2 would operate both independently to carry out national science and as part of the LOFAR VLBI network. The large collecting area of UTR-2 when added to the LOFAR "superterp" in the Netherlands and the NenuFAR low-frequency telescope in France and the many smaller LOFAR stations throughout Europe would increase both the sensitivity and angular resolution of the trans-European low-frequency radio array substantially.

Comments and conclusion on the proposed project for the restoration and modernization of the UTR-2 radio telescope



Thank you very much for sharing your proposal and for outlining the current status and future vision for the restoration and modernization of the UTR-2 radio telescope. We greatly appreciate the long-standing collaboration between the Ukrainian low-frequency radio astronomy community and partners involved in LOFAR, in particular in France and the Netherlands. The resilience and continued scientific commitment of your teams under extremely difficult circumstances are deeply respected.

We also appreciate your explicit support for the participation of LOFAR ERIC in activities related to HORIZON-INFRA-2026-DEV-01-05.

As you noted, LOFAR technologies and concepts feature prominently in the modernization approach for UTR-2, including the envisaged digital beamforming architecture.

In this context, **we will do our utmost to explore possibilities for preserving relevant digital hardware from the LOFAR station that could potentially support future developments in Ukraine.**

At present, LOFAR ERIC is involved as a partner in a proposal under the INFRA-2026-DEV-01-05 call, for which preparations are progressing positively. It is important to us to support the radio astronomy community in Ukraine, while recognizing that the prioritization and selection of activities should remain fully with the Ukrainian partners.

With best regards,
Michiel van Haarlem
Executive Director
LOFAR ERIC

Comments and conclusion on the proposed project for the restoration and modernization of the UTR-2 radio telescope



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Tel 331 47 23 82 15, Fax 331 47 23 82 16
Web Site <http://www.iaaweb.org>

To: National Academy of Sciences of Ukraine
54 Volodymyrska St.
Kyiv, 01030
Ukraine

Subject: “Restoration and Modernization of the UTR-2 Radio Telescope” project

I am writing to express my strong and unequivocal support for the project entitled “Restoration and Modernization of the UTR-2 Radio Telescope”, developed by the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine. This project represents a scientifically compelling, technically robust, and strategically important initiative in the field of low-frequency radio astronomy.

...

In conclusion, I consider the proposed “Restoration and Modernization of the UTR-2 Radio Telescope” project to be of outstanding scientific value and fully deserving of strong support. Its successful implementation will not only restore a unique observational facility but will also transform it into a modern, versatile instrument capable of addressing key questions in low-frequency astrophysics.

Prof. Leonid Gurvits,
Delft University of Technology, The Netherlands
Academician IAA

Dear President, Dear Directors, Dear colleagues,

In name of the French radio astronomy community, I would like to express our support of the UTR-2 modernization project presented by Drs. Vyacheslav Zakharenko and Oleksandr Konovalenko.

In addition to its intrinsic qualities (large effective area, 100% instantaneous filling of the UV plane, 4-40 MHz bandwidth, ...), UTR-2 is a strong symbol and cement of the Ukrainian radio community, and it fully deserves being restored.

One limitation is the single EW polarization of its antennas, that prevents to perform Stokes V or full Stokes observations. This is of course an important modification of the proposed project, but we feel that it deserves being explored via simulations and by testing effectively the response of one such sub-array.

We fully support LOFAR-ERIC participation to the project HORIZON-INFRA-2026-DEV-01-05 (but it should be reminded that France - in spite of being involved in LOFAR since 2004 - is only a "collaborator » of the ERIC via the CNRS).

Upon solicitation by M. van Haarlem, who has been invited to deliver a talk at the EAS Annual Meeting 2026 (SS43: Saving Astronomy in Ukraine) **focusing on collaborations between the radio astronomy community and Ukrainian astronomers, I wrote and sent to him the attached brief (and likely biased) summary of our 35 years of France-Ukraine collaboration.**

Very Sincerely,

Philippe Zarka

(Director of Research at CNRS, P.I. of NenuFAR, foreign member of NASU)

Conclusions:

After serious losses caused by the aggression of the Russian Federation, Ukrainian radio astronomy has resumed intensive scientific research. The emphasis is on observations at the URAN-2 and NenuFAR radio telescopes, as well as on processing the huge data set of UTR-2.

Scientific, technical and organizational work is underway for the earliest possible restoration and modernization of UTR-2. A **Radio Telescope Modernization Project** and a **Radio Telescope Building Major Repair Project** have been developed.

Prototypes of all blocks of the analog part of the UTR-2 tract have been developed. Production and installation are expected. The use of **“relevant digital hardware from the LOFAR station that could potentially support future developments in Ukraine”** is a way to increase the efficiency of research and unify formats.

The restoration of UTR-2 and its inclusion, as well as other telescopes of the URAN system, in the LOFAR system will be a powerful step in the development of the European ecosystem of low-frequency radio astronomy research.

**Thank you for your
attention!**

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