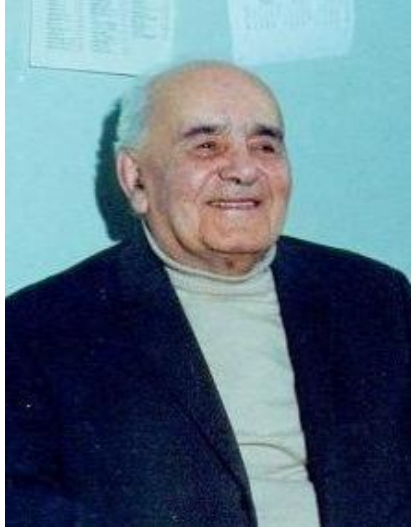
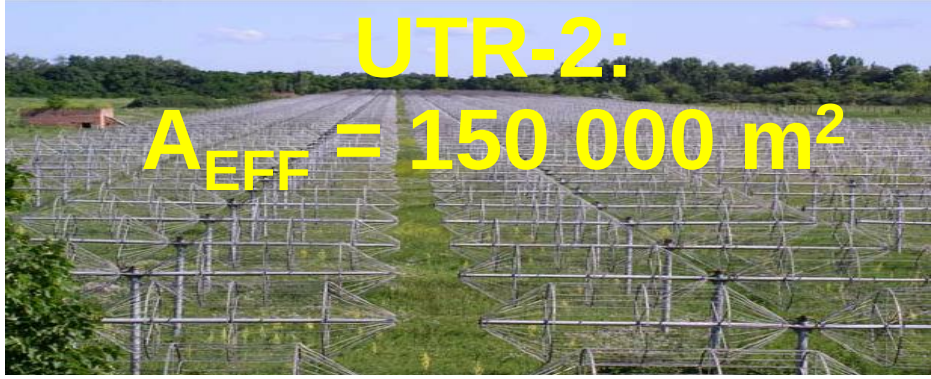
INSTITUTE of RADIO ASTRONOMY of National Academy of Sciences of Ukraine (IRA NASU)

Dr. **Vyacheslav Zakharenko**,
Corresponding Member of NAS
of Ukraine, Director



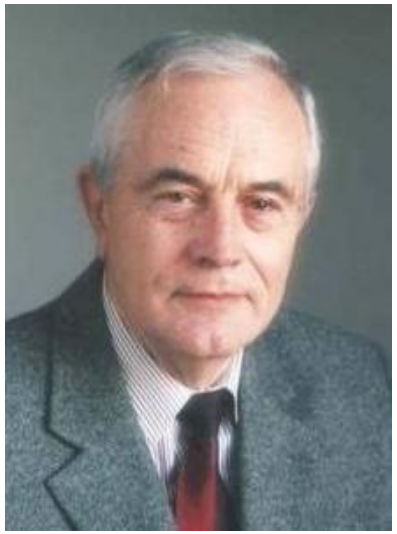


S.Braude (1911-2003)
Transmitters, Radars
Propagation of electro-magnetic waves
Radio Astronomy

S.Braude founded Laboratory of Radio Astronomy within Institute for Radio Physics and Electronics of the National Academy of Sciences of Ukraine

1970-1972 – **Ukrainian Radio Telescope UTR-2** was commissioning into operation. Construction of the system of interferometers URAN was started in 1974. In 1993 it includes 5 radio telescopes

1980 – was founded Division of Radio Astronomy within IRE and
1985 – L.Litvinenko and S.Braude founded Institute of Radio Astronomy on the base of Division of Radio Astronomy



L.Litvinenko
Director of IRA NASU 1985-2017
Theory of difraction
Propagation, dispersion of electromagnetic waves, Radio Astronomy
(from 2017 till now *Director Emeritus*)

Scientific Structure of the Institute of Radio Astronomy NASU (> 250 employees and ~ 140 scientists)

- Division of Low-frequency Radio Astronomy
  - Decameter Radio Astronomy
  - Astrophysics
  - Radio-astronomical equipment and methods of observations
- Space Radio Physics
- Millimeter-Wave Radio Astronomy
- Microwave Spectroscopy
- Theoretical Radio Physics
- Microwave Electronics
- Geospace Radio Physics

Ukraine. Constellation of radio telescopes


URAN-3


URAN-2


GURT


RT-32

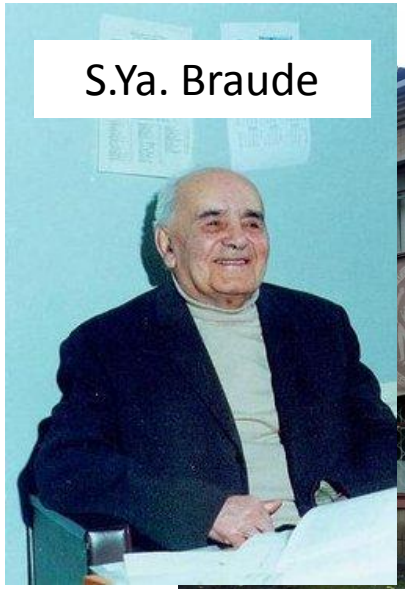

URAN-1

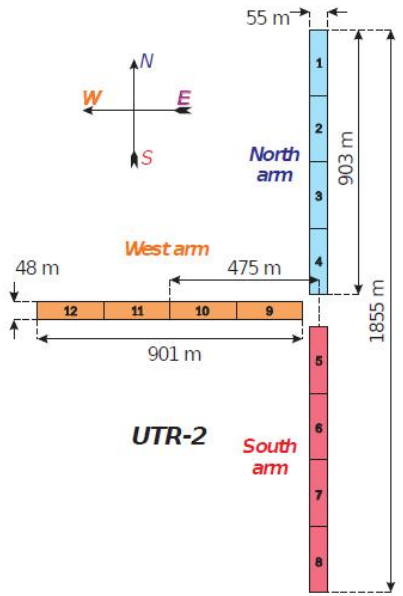

URAN-4


UTR-2

Institute of Radio Astronomy of NAS of Ukraine

Decameter radio telescope UTR-2 - the largest telescope in the world. A_{EFF} = 150000 m^2





GURT – Giant Ukrainian Radio Telescope

Octave : $f_{high} / f_{low} = 2$

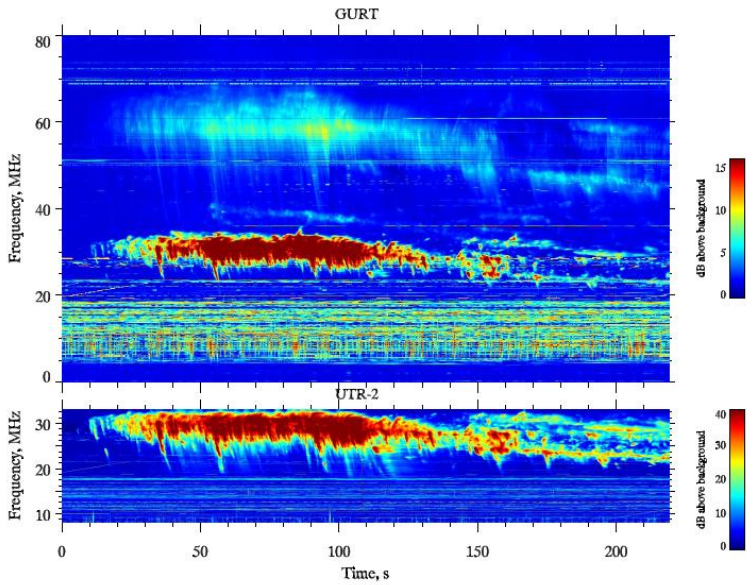
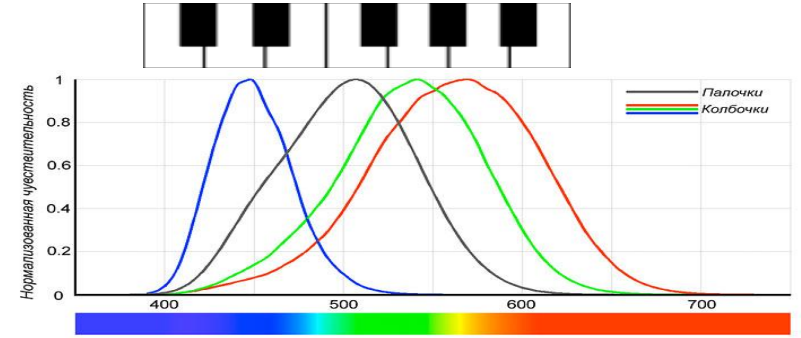
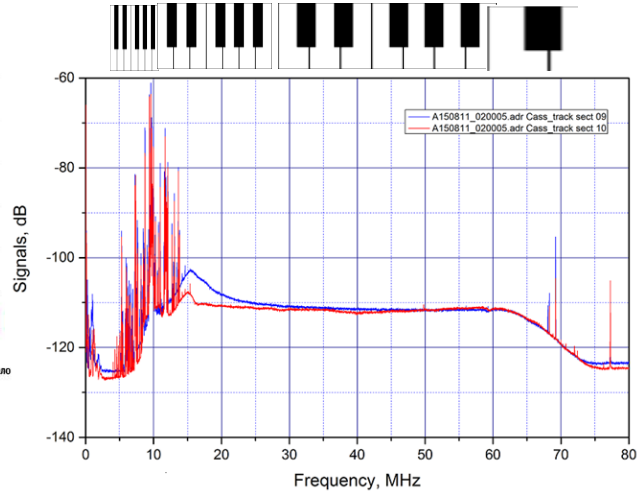


Fig. 10. Observations of a type II burst. UTR-2 frequency band 8.25 ÷ 33 MHz frequency and time resolution of 4 kHz and 100 ms, respectively. Recording was conducted on subarray GURT in the range 8 ÷ 80 MHz with the same time resolution and frequency resolution of 20 kHz. Start recording corresponds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



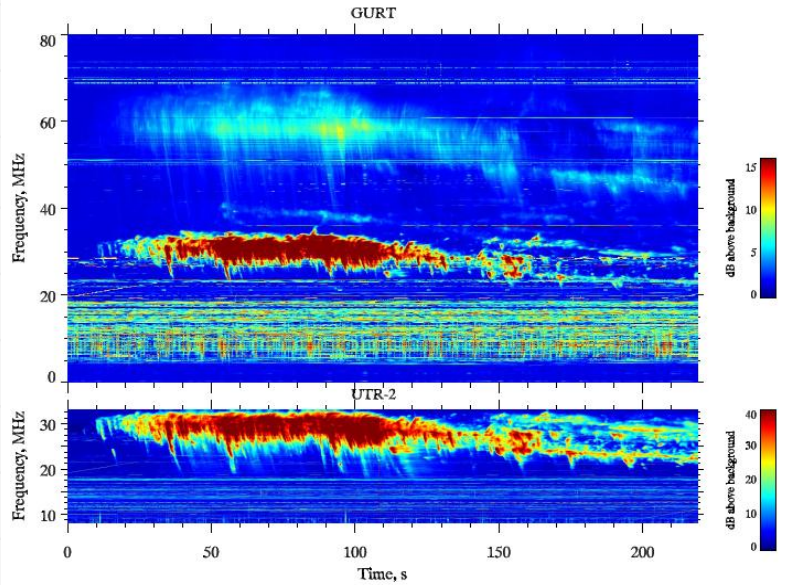


GURT transfer function

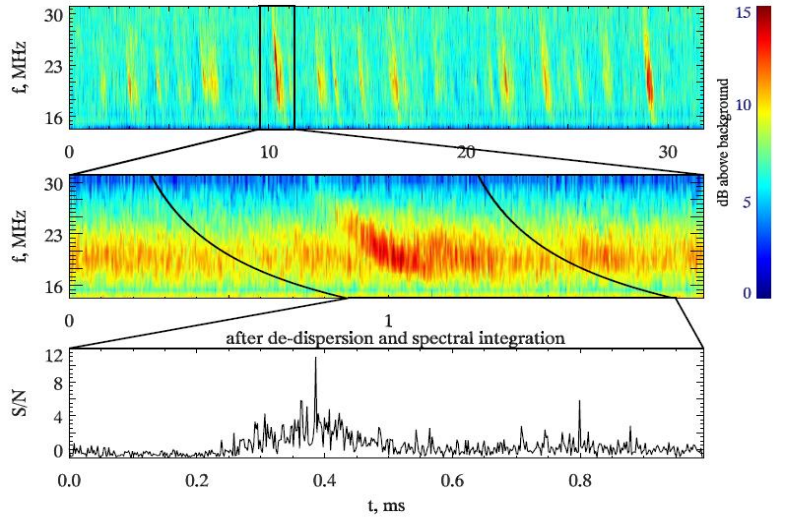
Main topics for low-frequency radio astronomy…

EARTH	Ionosphere	
	Magnetosphere	
	Cosmic ray air shower	
	Meteor events	
	Ground parameters	
SOLAR SYSTEM	The Sun	quite
		active
		radar
	Jupiter	
	Planets (Saturn): lightning	
	Interplanetary medium	scintillations
		VLBI
		RRL
	The Moon	occultation
		radar
		Cosmic ray Secondary radio emission
	Comets	

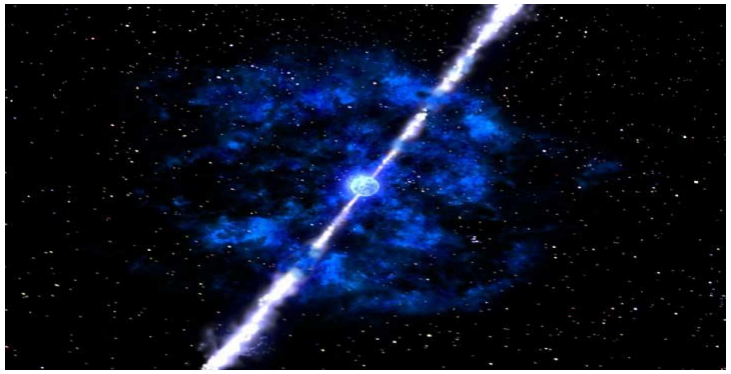
Sun: type II burst

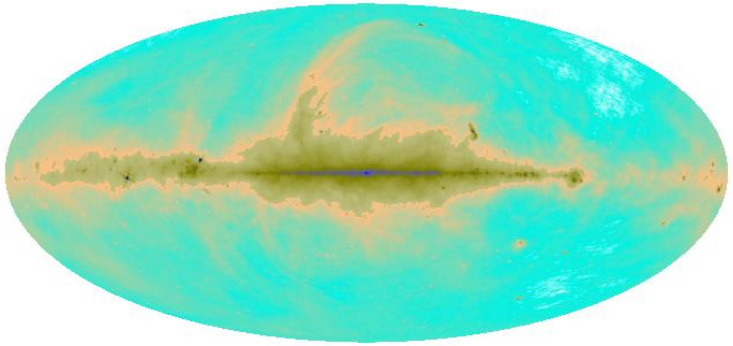


Saturn's lightning



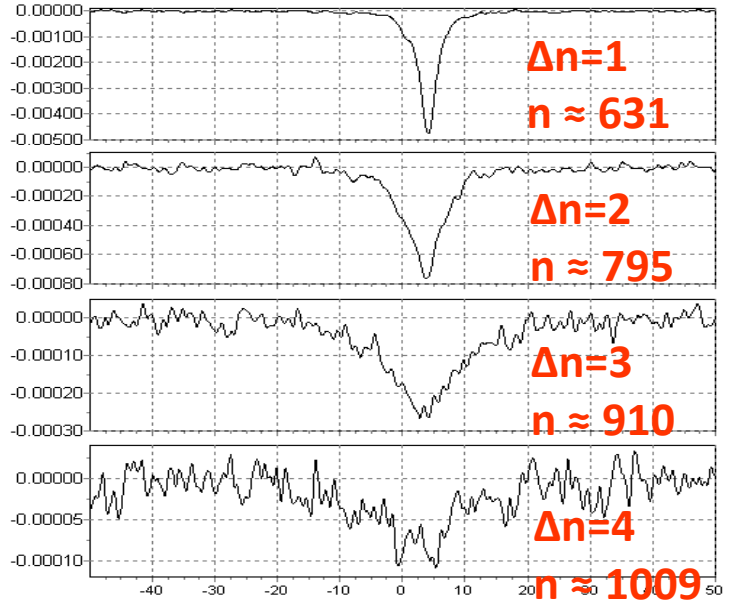
…main topics for low-frequency radio astronomy



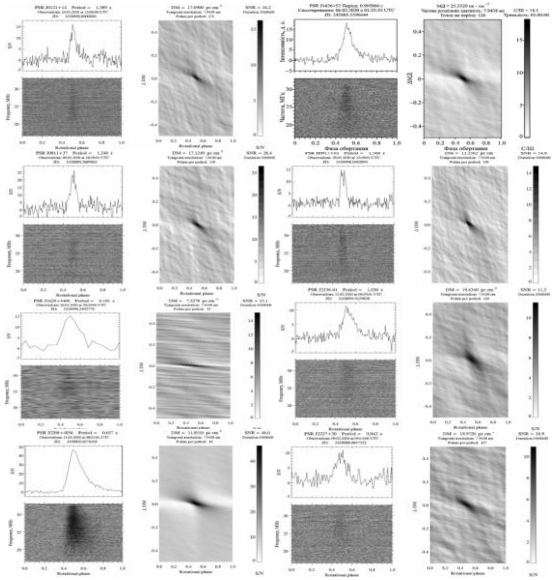


GALAXY	Pulsars
	Active stars
	Exoplanets
	Transients
	Non-thermal background
	Supernova remnants
	HII regions
EXTRA GALAXIC OBJECTS	Galaxies
	Radio galaxies
	Quasars
	Radio source catalogue
	Galactic cluster
	Unidentified objects
	Transients

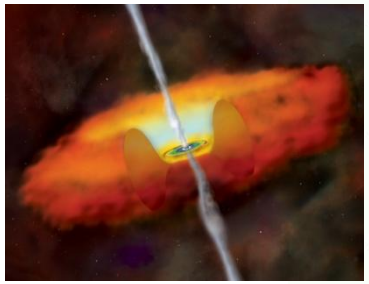
The low-frequency radio recombination lines of Carbon



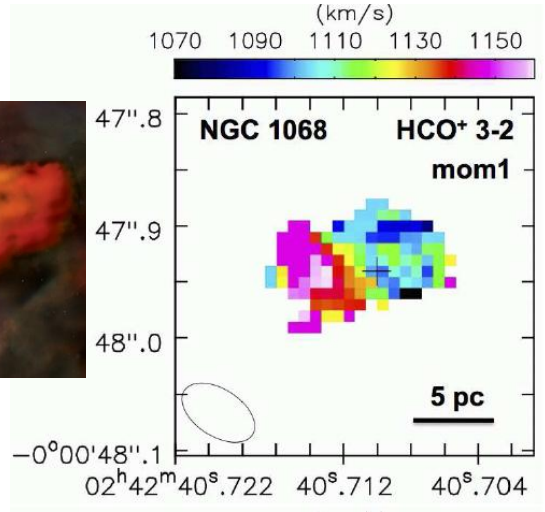
Pulsars



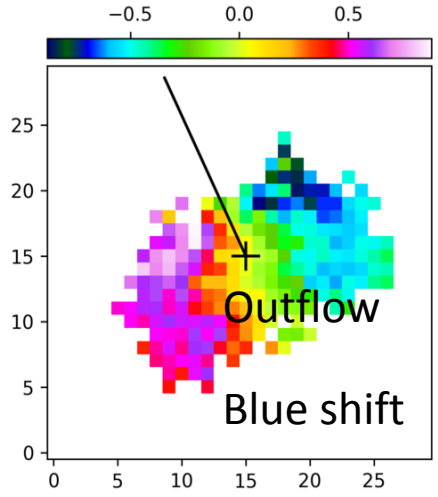
Astrophysics: active galactic nuclei, optics: gravitational lenses, satte-lites: radiation belts (new 3rd), spectroscopy: space molecules (new 4)…

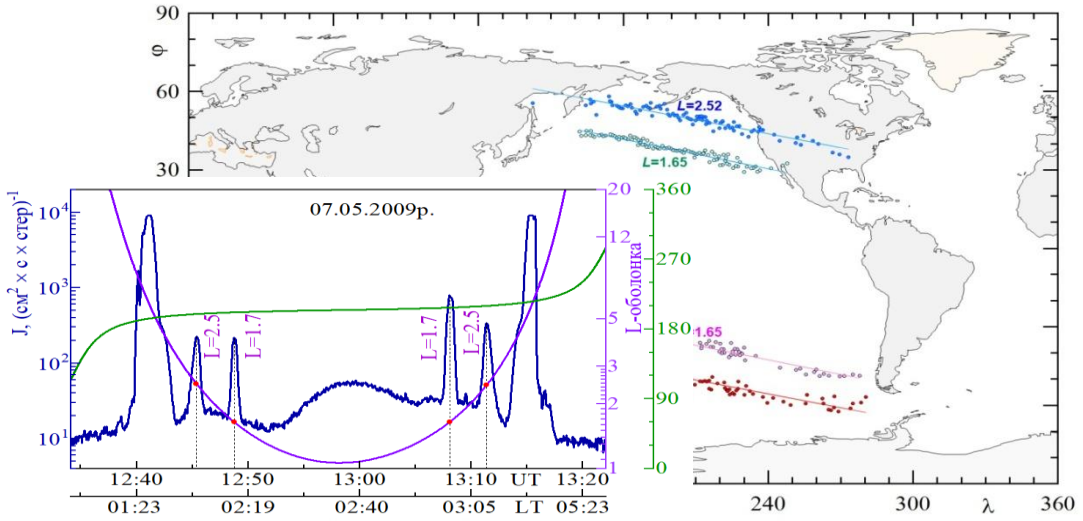


ALMA



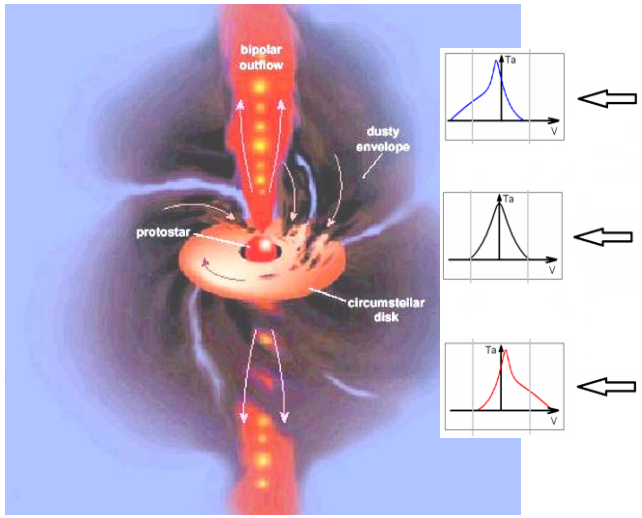
Our modeling

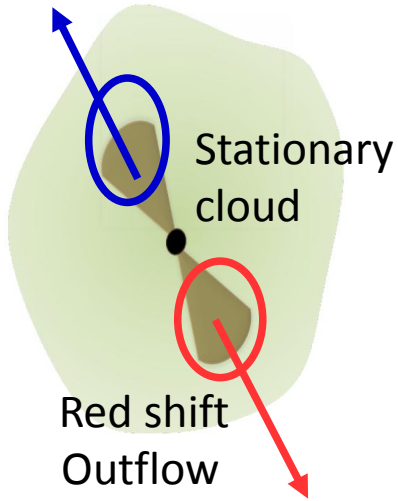


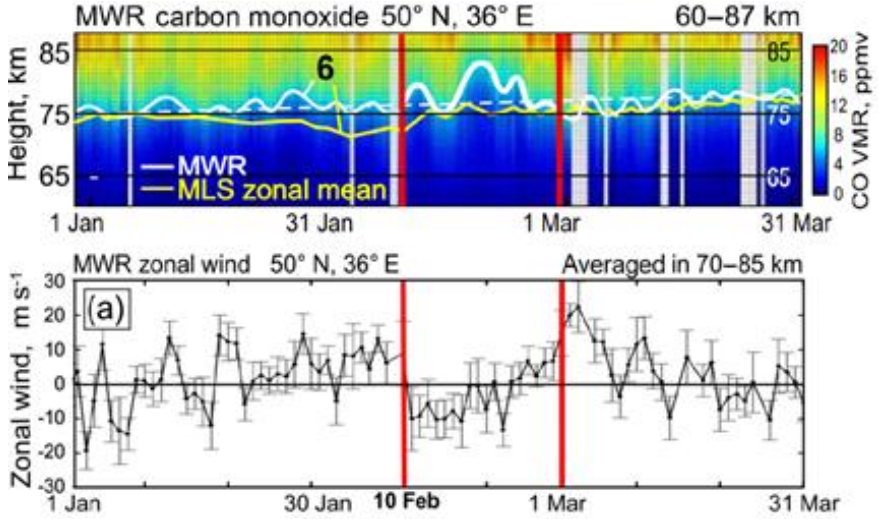


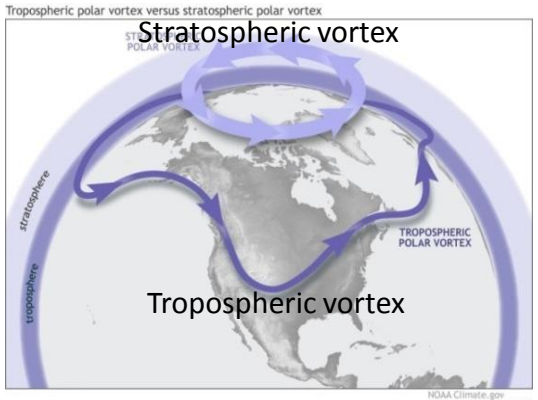
Imanishi et al., 2018

…star forming regions, galactic masers, upper atmosphere

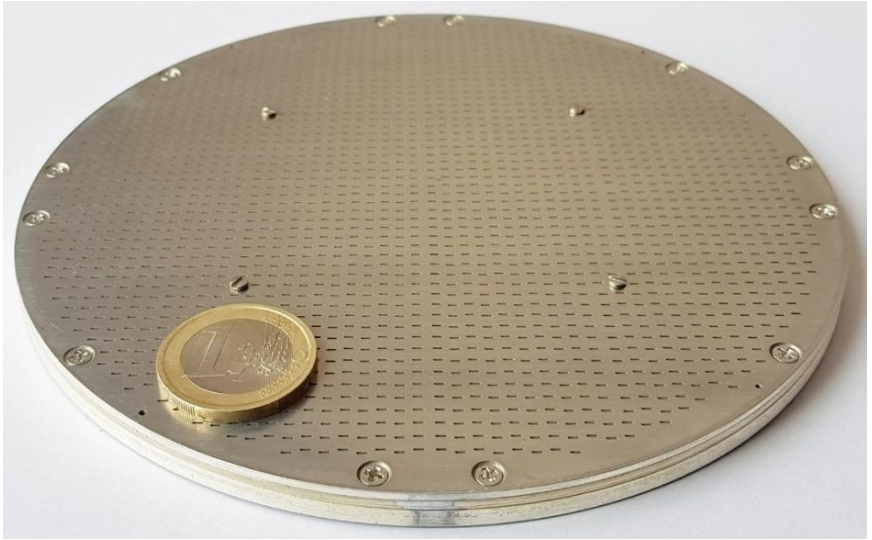


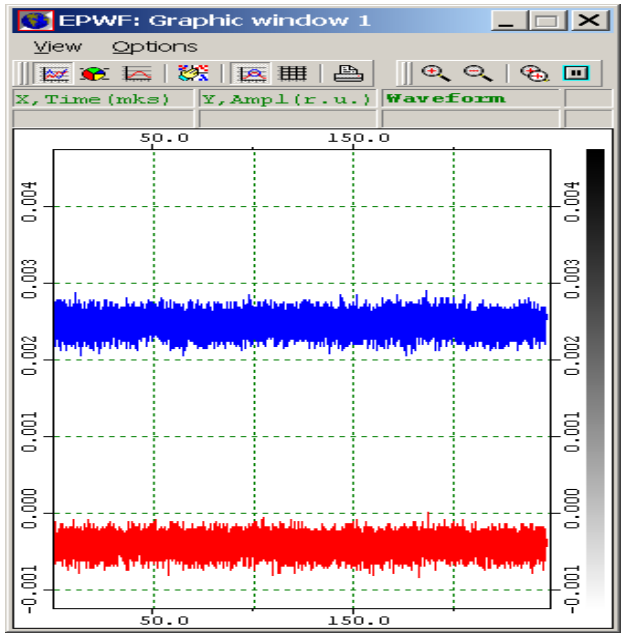


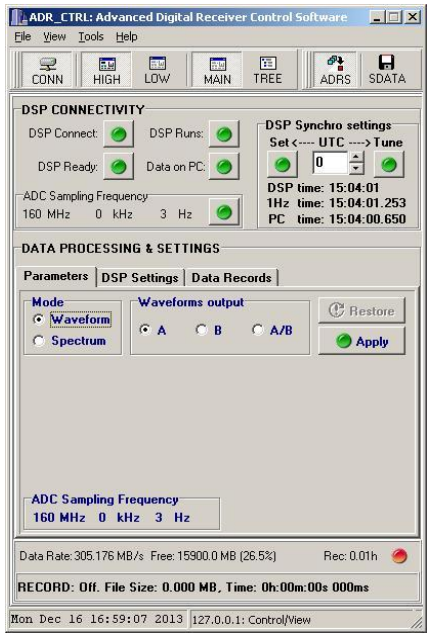


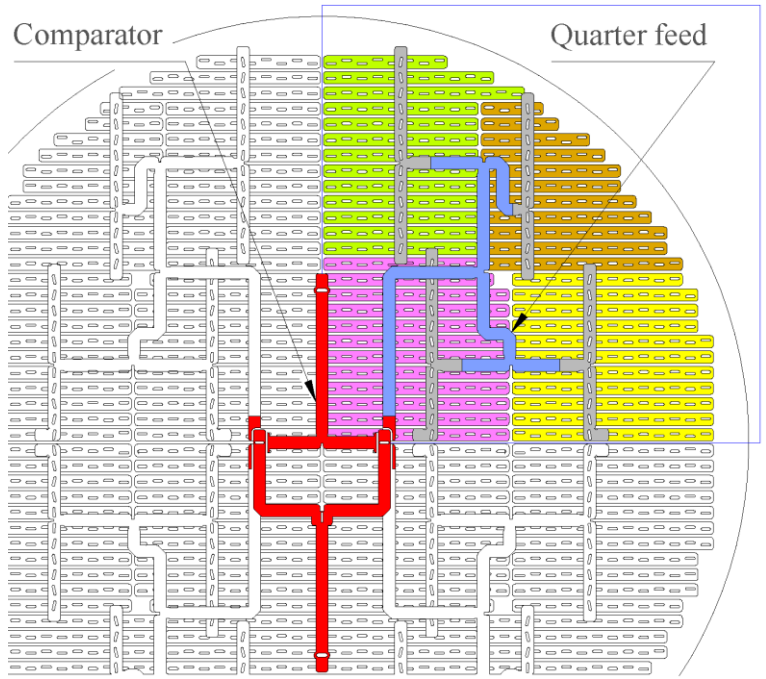


Meteorological radars, phased antenna arrays (supply and transfer of technologies to **Rheinmetall Italia SpA**), microwave receivers





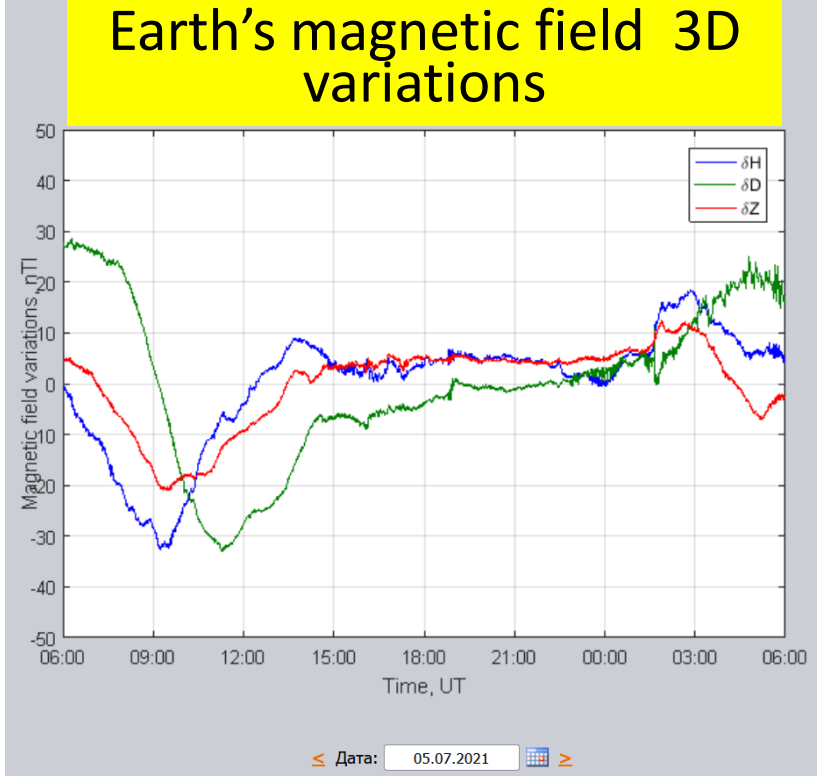


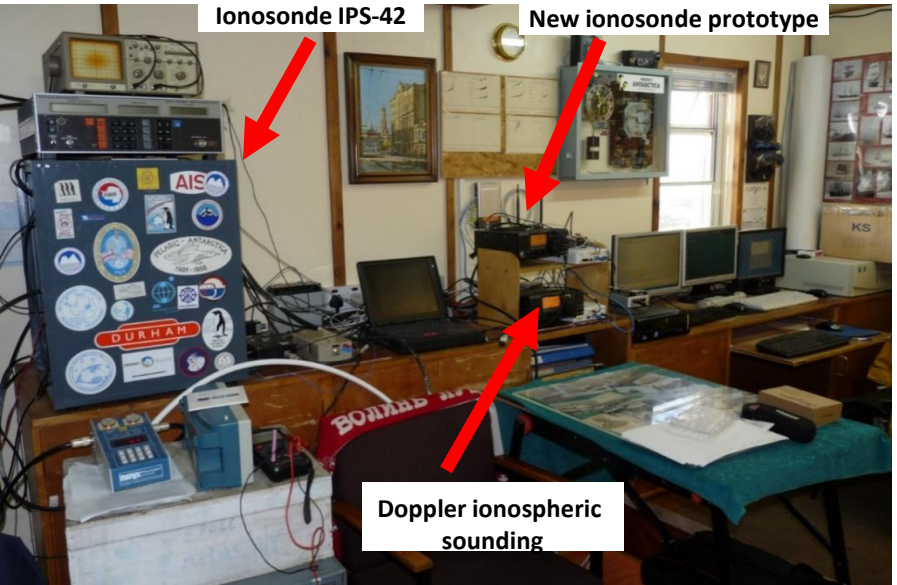


- Receiving VLF complex
- Meteomagnetic station
- HF Doppler Receiver
- GPS/TECU receiver
- Muon monitor
- Solar photometer

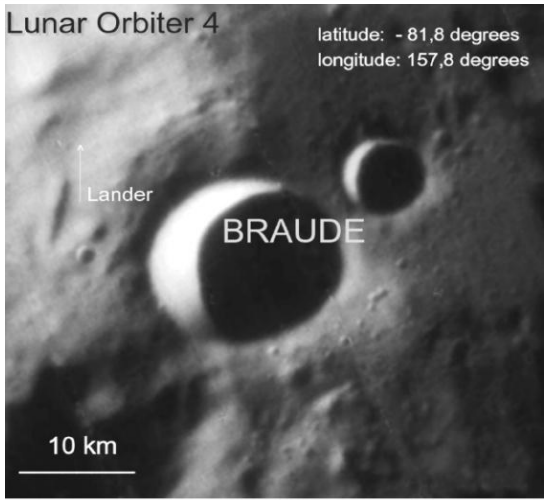
Propagation of radio waves, radio physics of geocosm, global thunderstorm activity, Earth's magnetic field

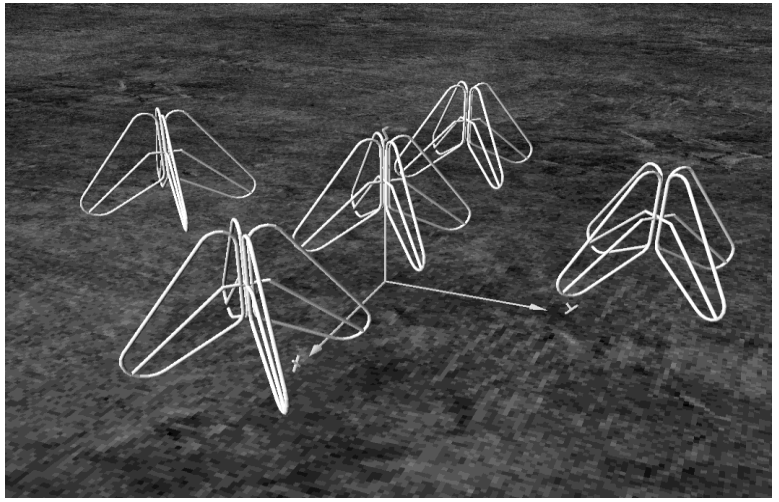
Research laboratories: "Earth's electromagnetic environment" (Kharkiv region), Svalbard Island (Arctic), Vernadsky Ukrainian Antarctic Station (Antarctica)

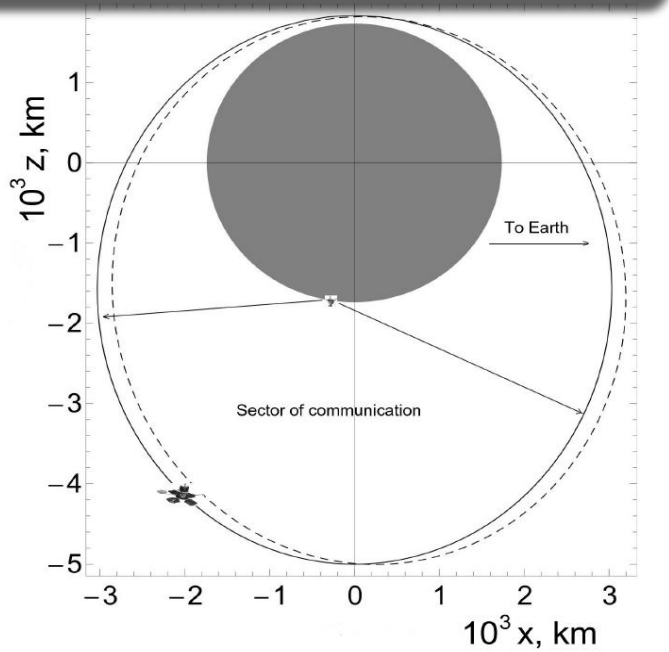




Space mission Braude-M







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

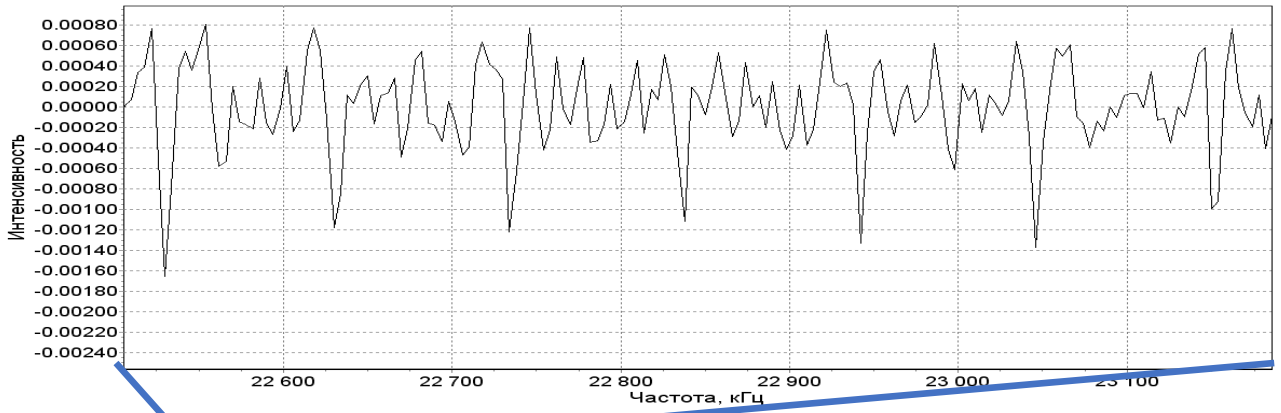
Highlights:

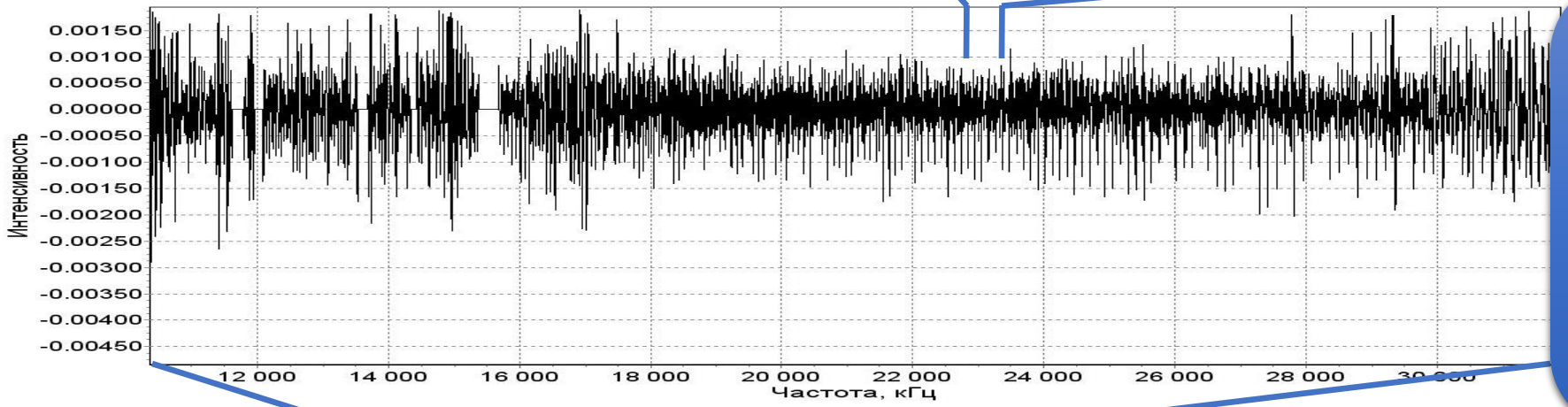
- The mission includes a lander with radio astronomy antennas located on the lunar farside
- Low-frequency antennas shielded by Moon from Earth radio interference allow unique observations
- A relay orbiter uses a 5-hour polar orbit with pericenter near the north pole at a height of 100 km
- The orbiter is equipped with a 3-mm radar for surface mapping with 100-m resolution
- The orbiter payload also includes an IR spectrometer to study OH/H_2O compounds in regolith

One of the main task: RRL at low frequencies, high-z red-shifted HI line, Dark Ages;

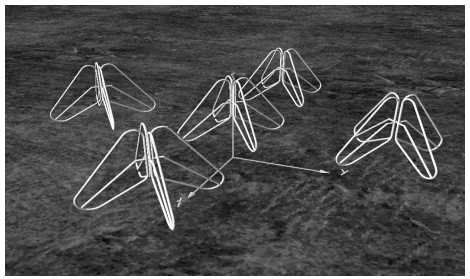
Radio recombination lines. Dark Ages:

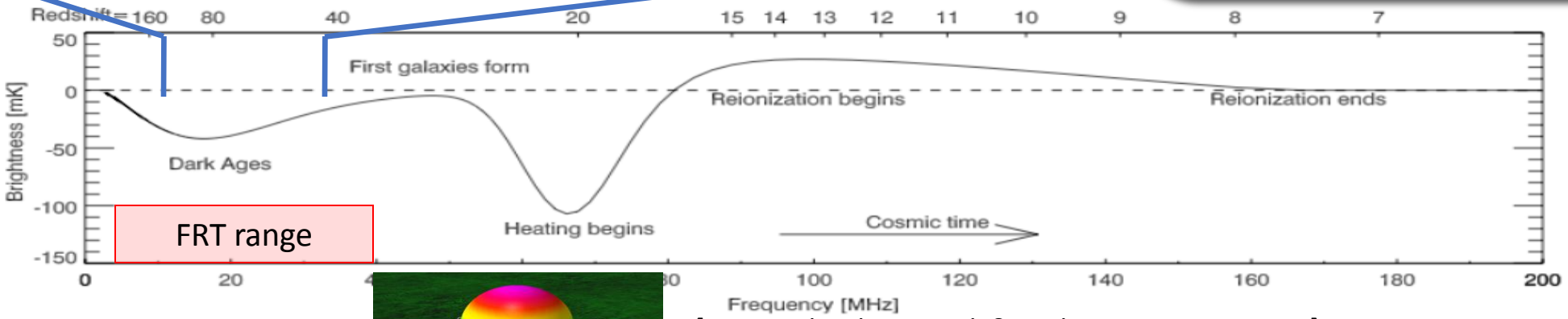
HI, z ~ 100

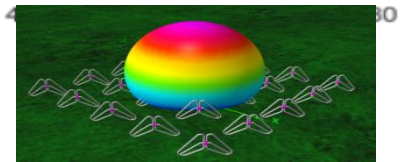




UTR-2.
Direction - Cas A. In the range 10.5 - 31 MHz there are Carbon RRL C854α ... C596α.
Integration time – 55 min.
With ~100 h int. time
-> dT/T ~ 2*10^{-6}







[Liu, Pritchard, Tegmark & Loeb arXiv:1211.3743v3]

Instead of conclusion:

A twofold mission to the Moon: objectives and payloads
Decision Letter - Revise: 13 February 2018
Mr Johnson
Special Issue Managing Guest Editor (**Acta Astronautica**)
-**Reviewer 3:**

"Many of the pioneering steps…"

- This proposal carefully stepped through the MANY genuinely interesting scientific questions that can be addressed by
- 1) getting away from the Earth's ionosphere, and
- 2) getting away from the Earth's RFI.

Many of the pioneering steps have been taken by this group:

- both on the technical side with electrically short, active antennas working in a regime of Galactic background dominance,
- in being pioneers for many of the most interesting scientific questions, including RRLs,
- and emission from solar system bodies.
- "So I really like this paper a lot, **it is based on LOTS of experience!"**
- "The **key** is to get in **contact with other groups** that are pushing similar missions, and to **work together**. You have a very strong background in technology and REAL science at low frequencies, so you can be a real asset to other groups that have much less REAL experience."

Thank you for your attention!