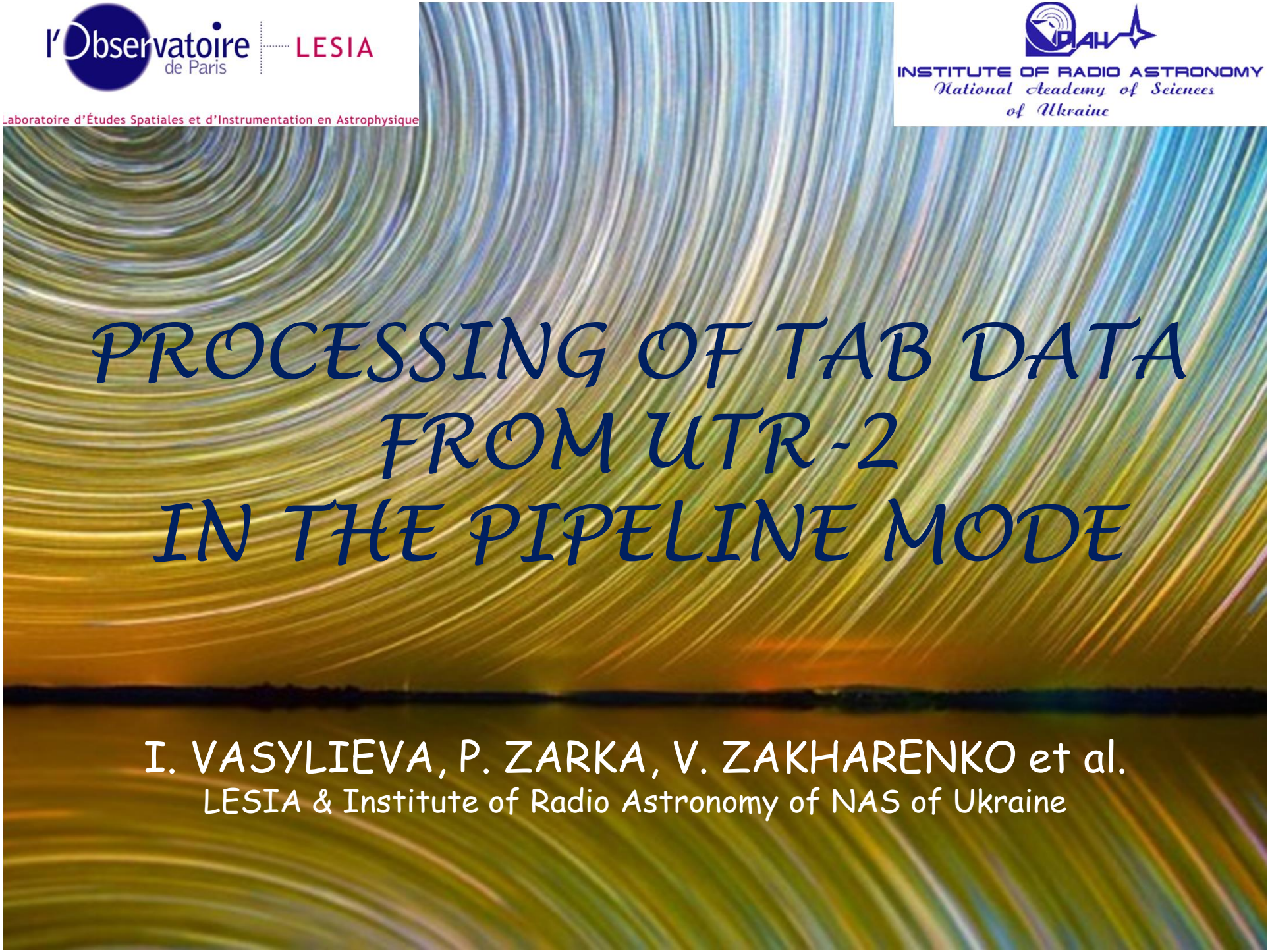
l'Observatoire de Paris | LESIA

Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique

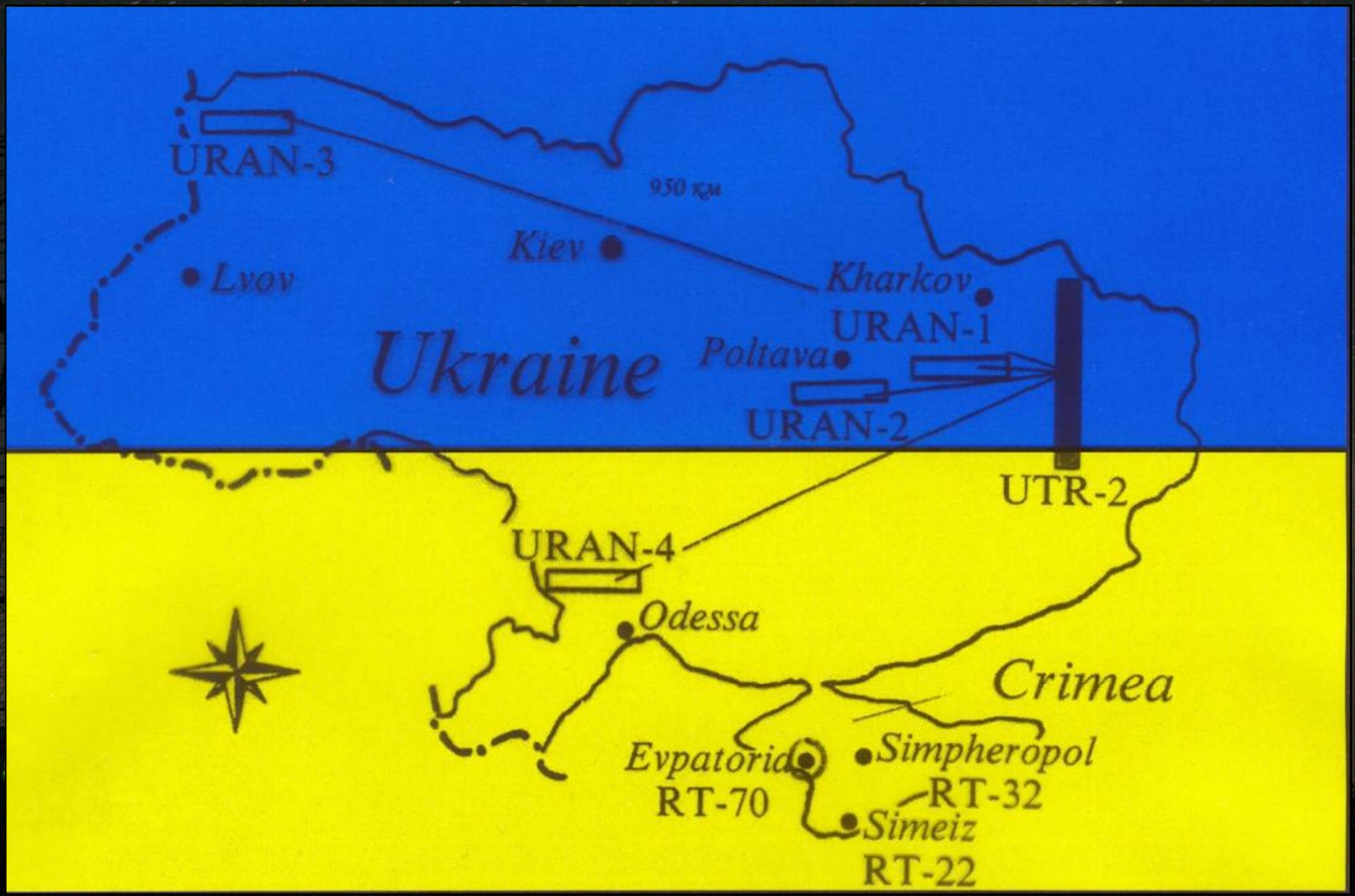
INSTITUTE OF RADIO ASTRONOMY
National Academy of Sciences of Ukraine



PROCESSING OF TAB DATA FROM UTR-2 IN THE PIPELINE MODE

I. VASYLIEVA, P. ZARKA, V. ZAKHARENKO et al.
LESIA & Institute of Radio Astronomy of NAS of Ukraine

Radio astronomy in Ukraine: covering the entire radio band



Radio astronomy in Ukraine: covering the entire radio band

http://rian.kharkov.ua

UTR-2:

Effective area:150 000 m^2

Frequency range: 8 - 33 MHz

1 linear (EW) polarization

Geometrical size: 1856 x 900 m

Beam width: $2d_{0.7}$=24ô(25 MHz)

Up to 5 beams separated by 23ô

Dynamic range (DSP-Z receiver): 71 dB

RFI immunity: SFDR=107 dB

Side lobes level: -26é -13 dB

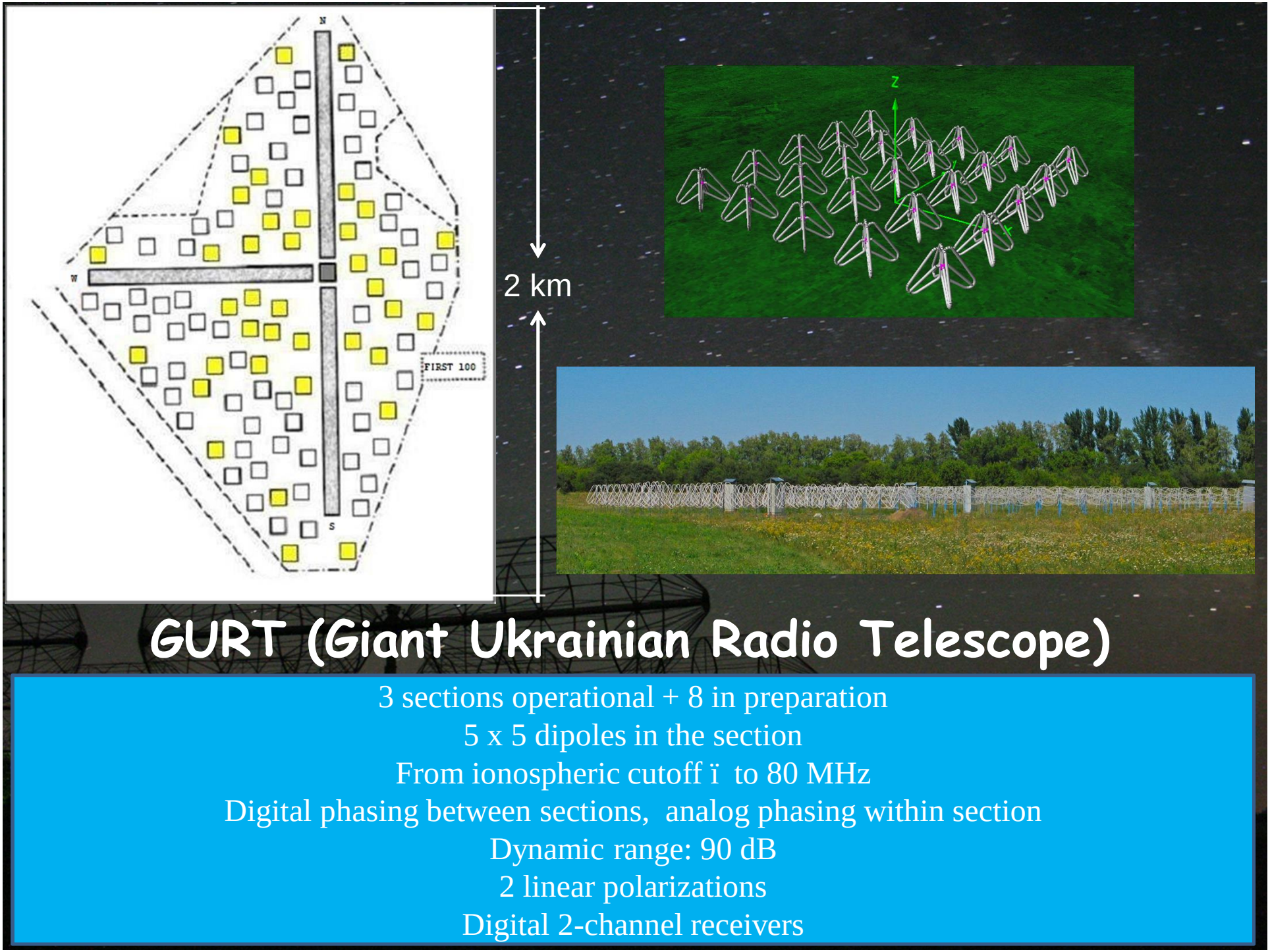
Accessible sky: N-S 180˚ , E-W 120˚

Coordinates: 36˚ 56ô27ôôE, 49˚ 38ô17ôôN

Maximum output data rate: 1Gb/s (5 rec.)

Time resolution: 15 ns

Frequency resolution: 4 kHz



GURT (Giant Ukrainian Radio Telescope)

3 sections operational + 8 in preparation

5 x 5 dipoles in the section

From ionospheric cutoff ï to 80 MHz

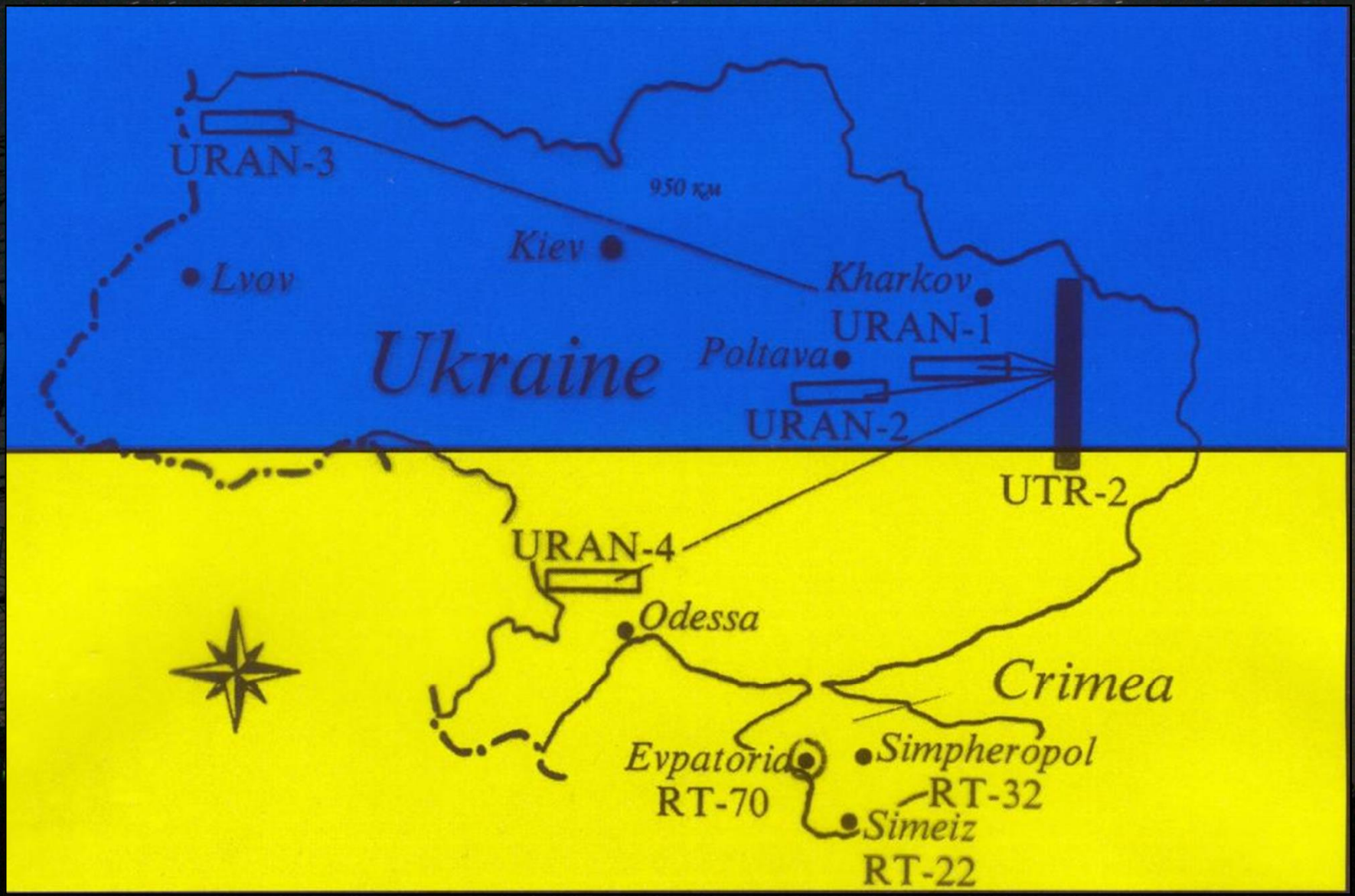
Digital phasing between sections, analog phasing within section

Dynamic range: 90 dB

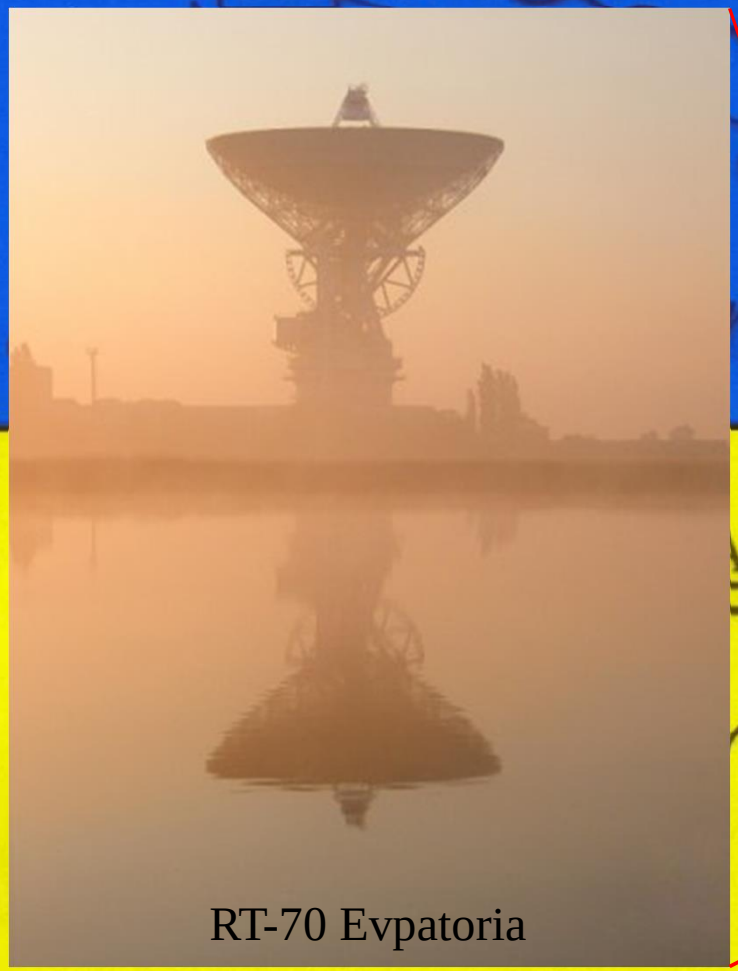
2 linear polarizations

Digital 2-channel receivers

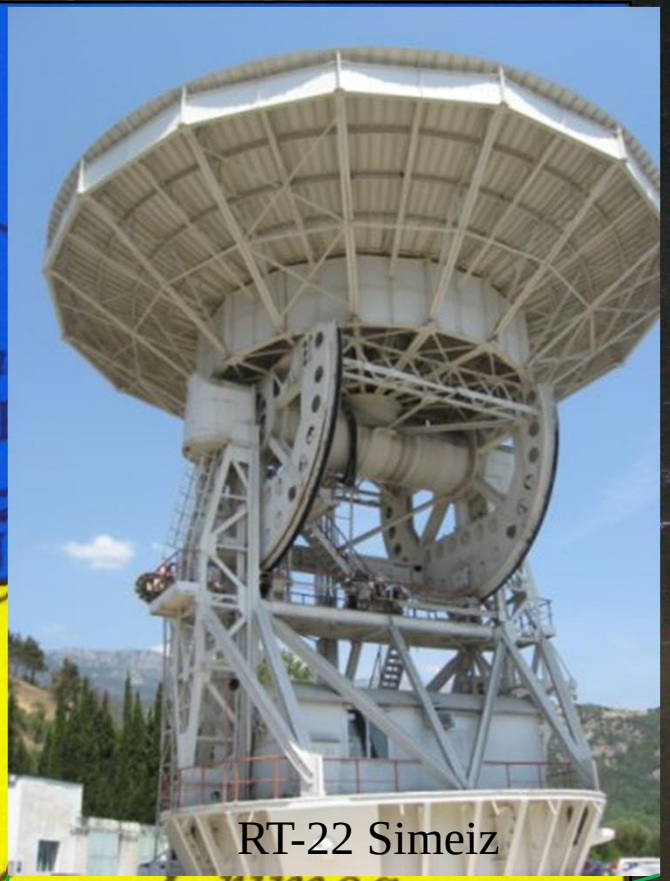
Radio astronomy in Ukraine: covering the entire radio band



Radio astronomy in Ukraine: covering the entire radio band



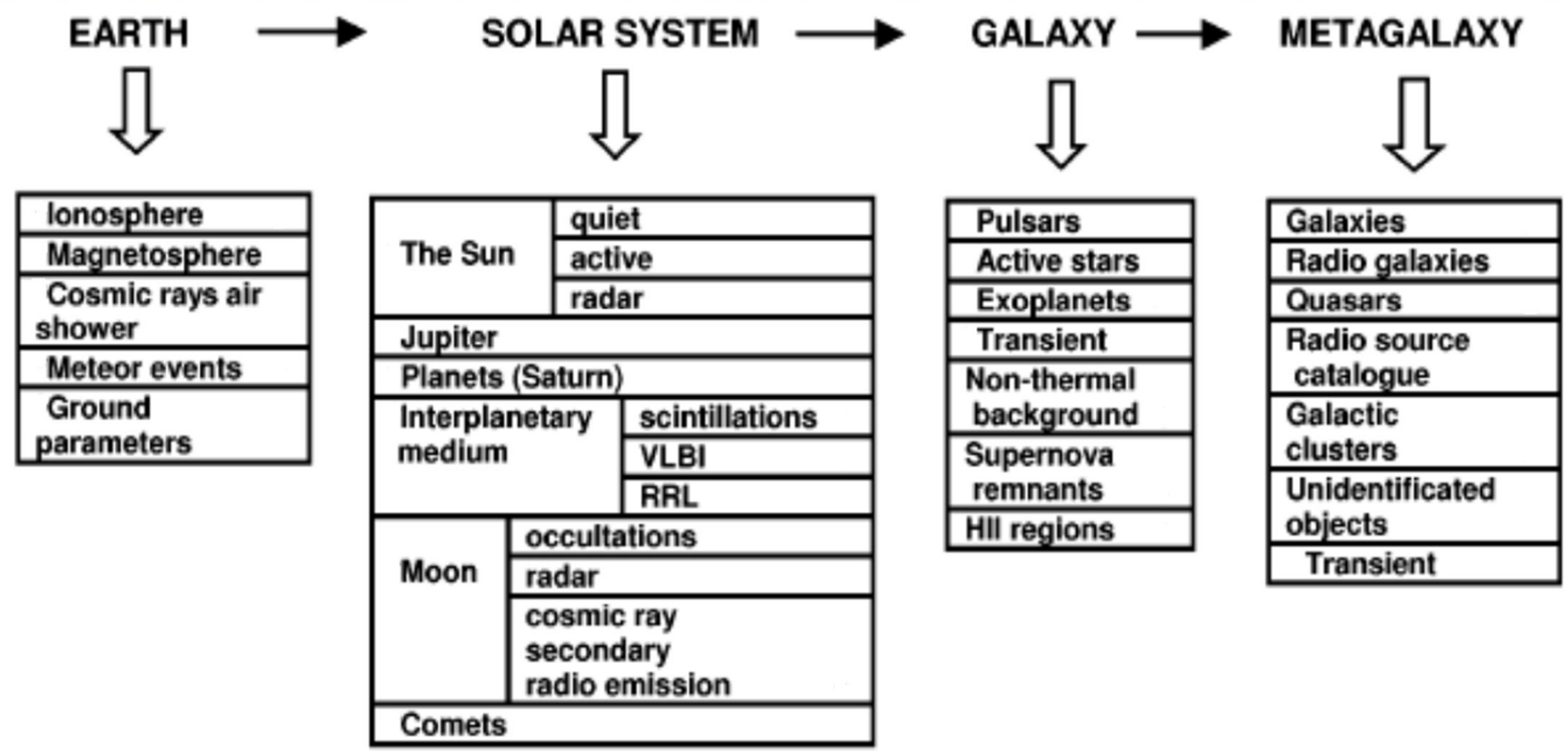
RT-70 Evpatoria



RT-22 Simeiz

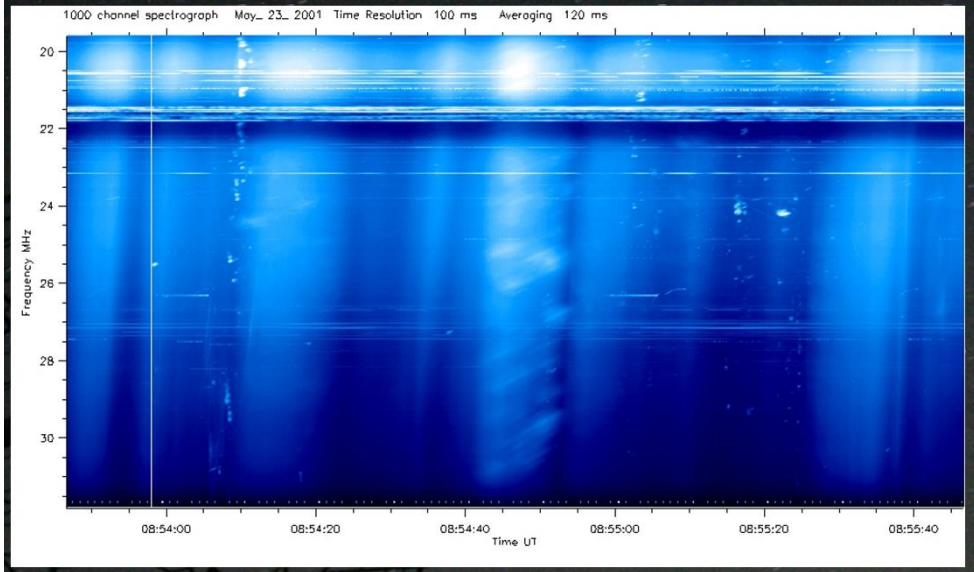
950 км
Poltava
URAN
AN-4
Odessa
Crimea
Evpatoria
RT-70
Simpheropol
RT-32
Simeiz
RT-22

Relevant tasks for low-frequency radio astronomy

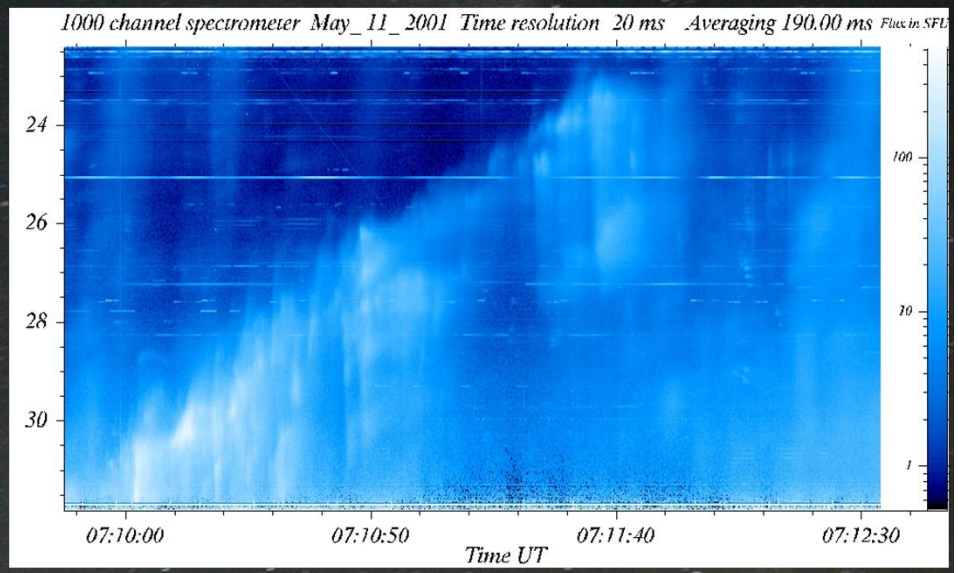


Solar bursts with fine structure

Type III

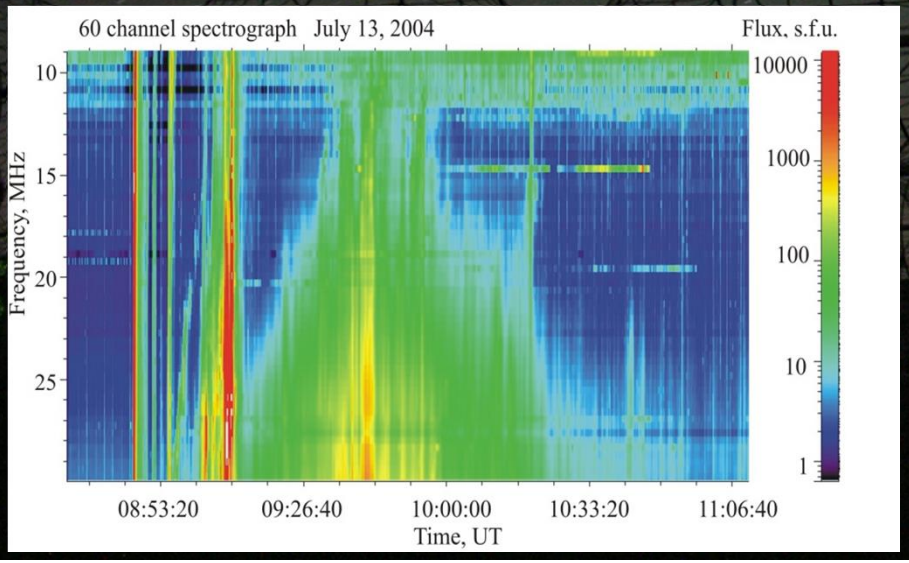


Type II

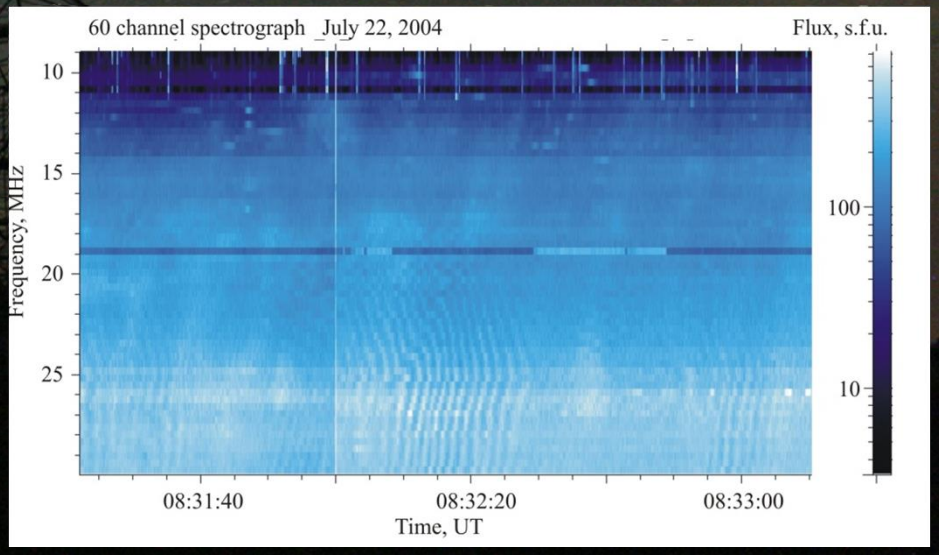


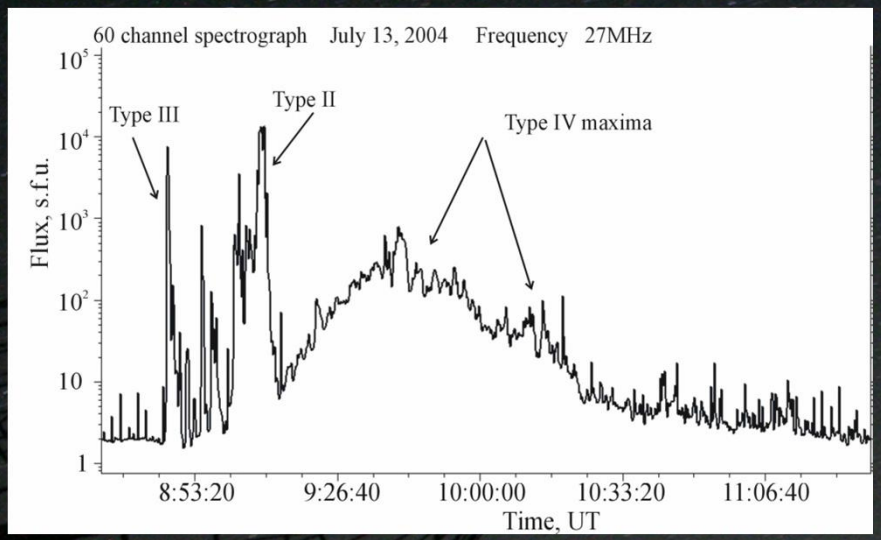
Flux: up to $1 \cdot 10^{-19}$ W.m^{-2} .Hz^{-1}

Type IV



Type IV with «zebra-structure»



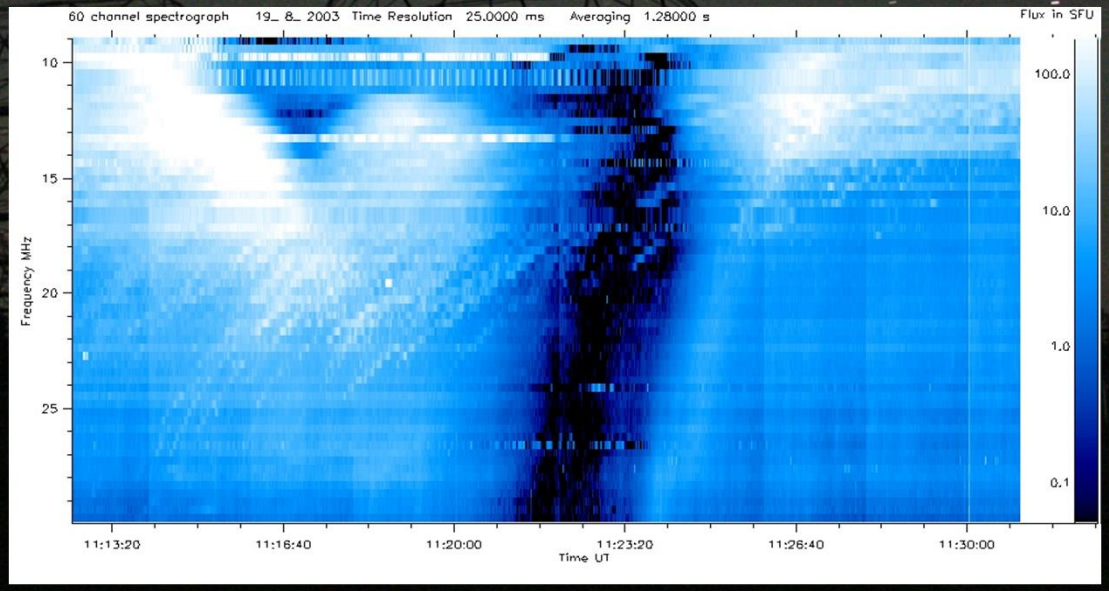


The succession of events, accompanying Type IV bursts at decameter wavelengths:

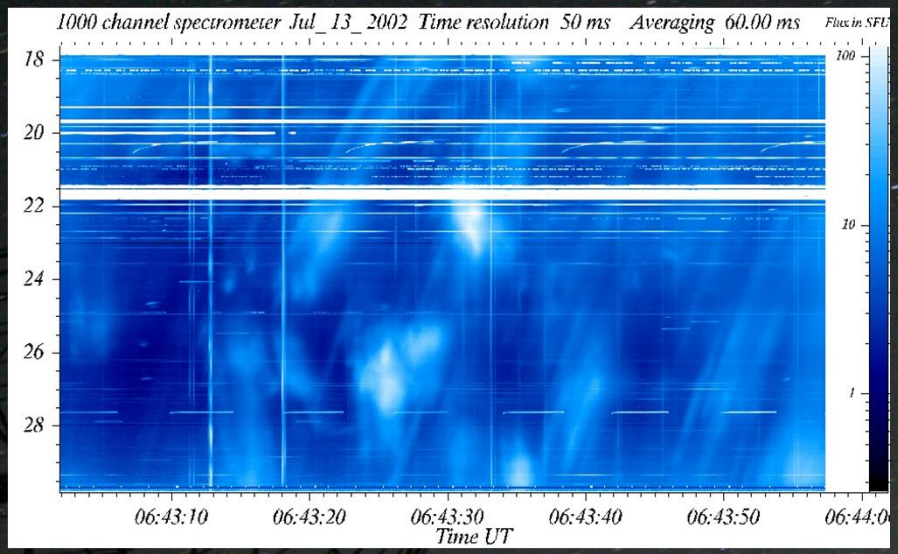
- group of intense Type III bursts
- shading area or burst in absorption
- Type II burst with the second and even third harmonics
- Type IV burst itself

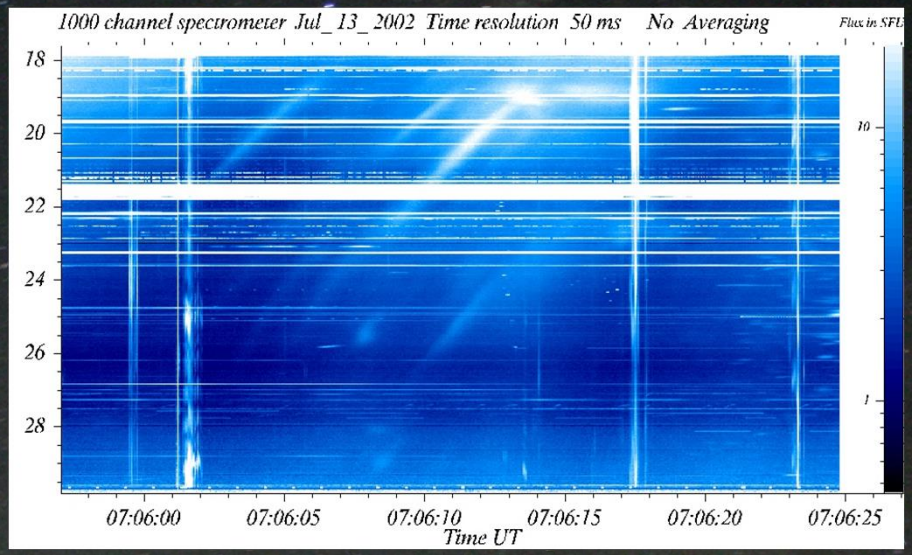
Decameter Type IV burst lasts from 2 to 6 or more hours. Its flux can reach several 1000-s of s.f.u. (s.f.u. = 10^{-22} W.m^{-2}.Hz^{-1})

Absorption burst



S-bursts

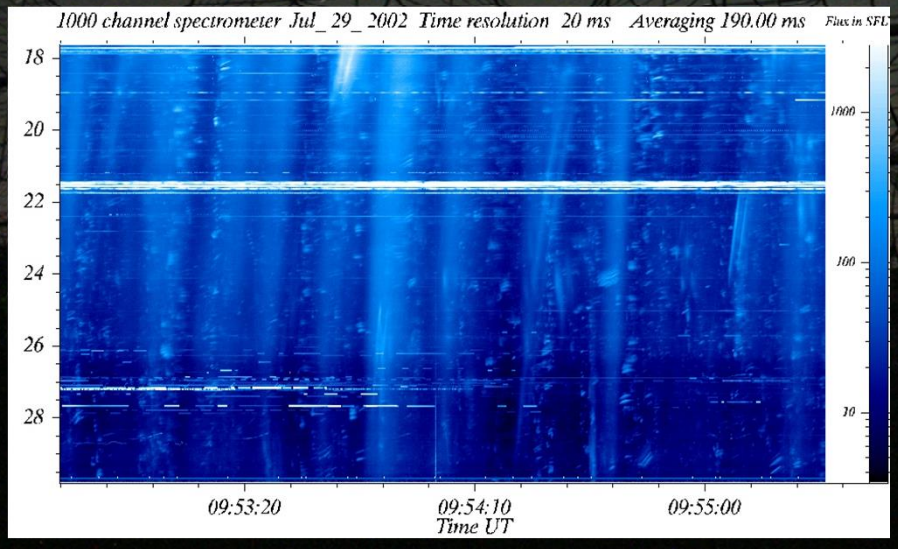


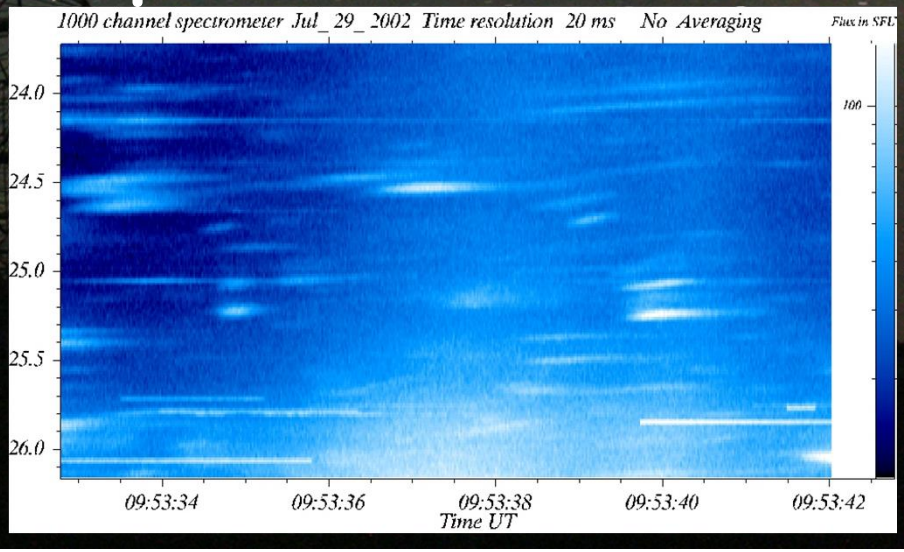


Duration: 0,3 ï 0,6 s

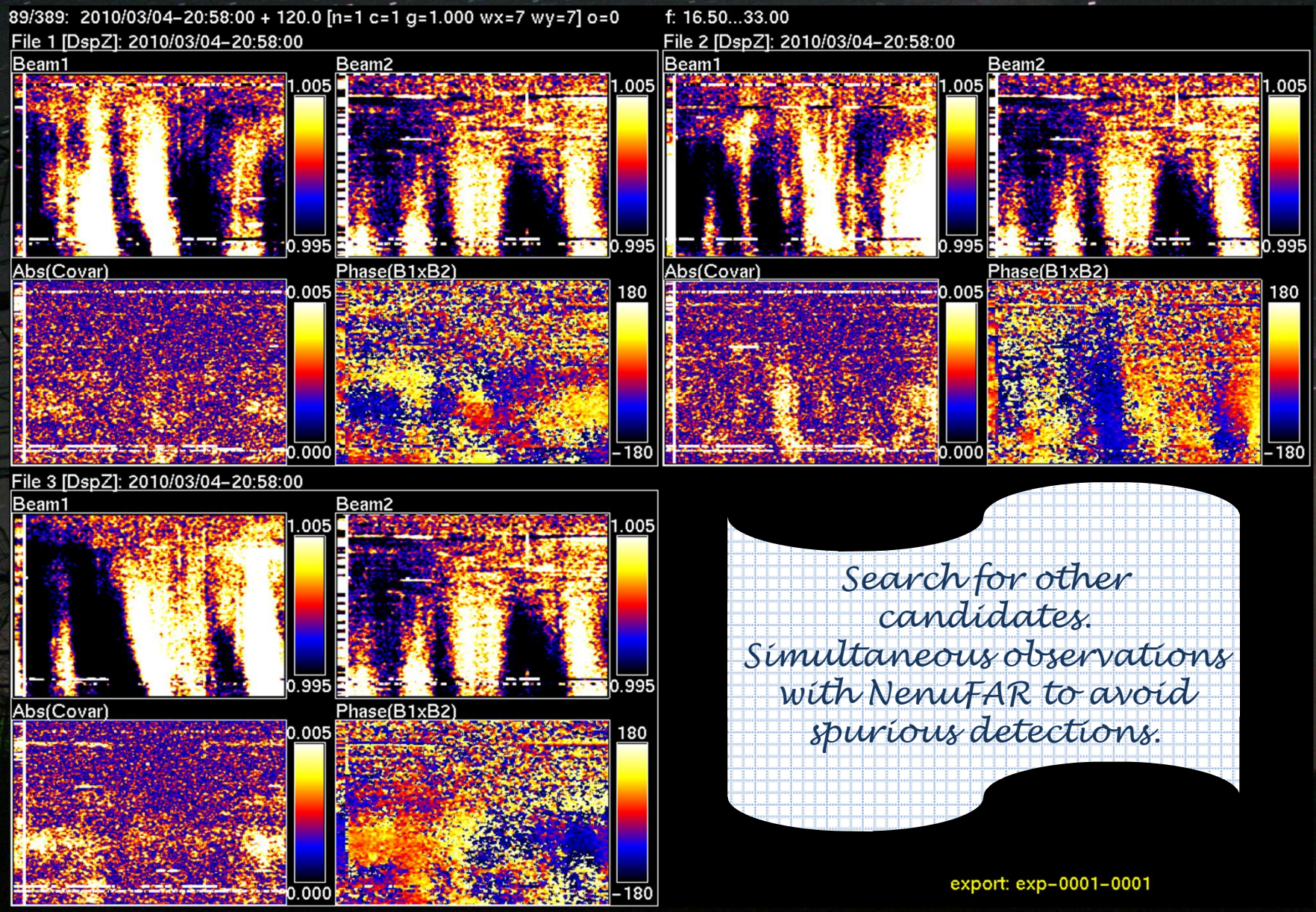
Probe magnetic field at 1,5 ï 3 R_s

Decameter spikes





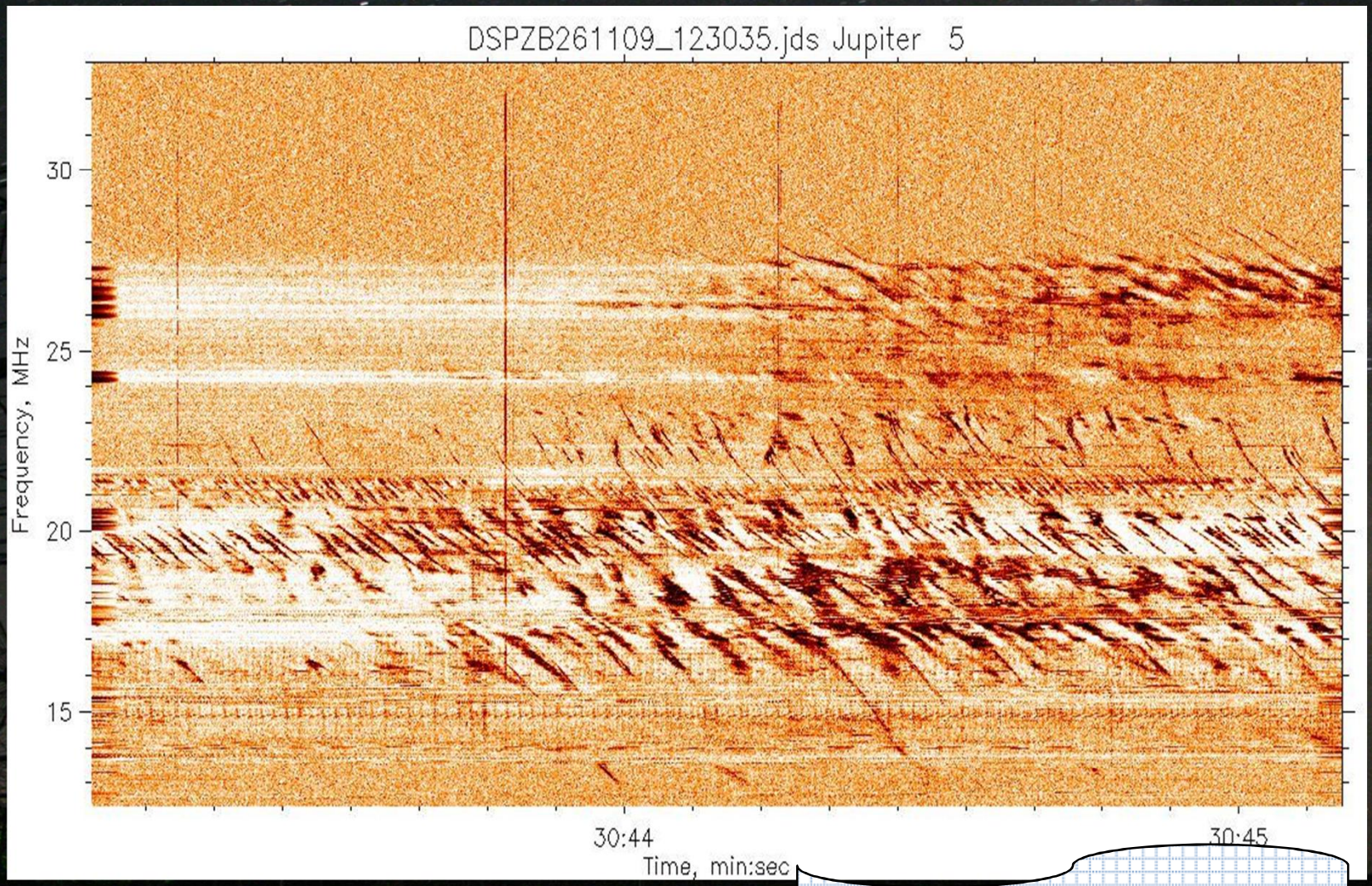
AD Leo burst, detected by UTR-2 in 3-beam operation mode



Search for other candidates. Simultaneous observations with NenuFAR to avoid spurious detections.

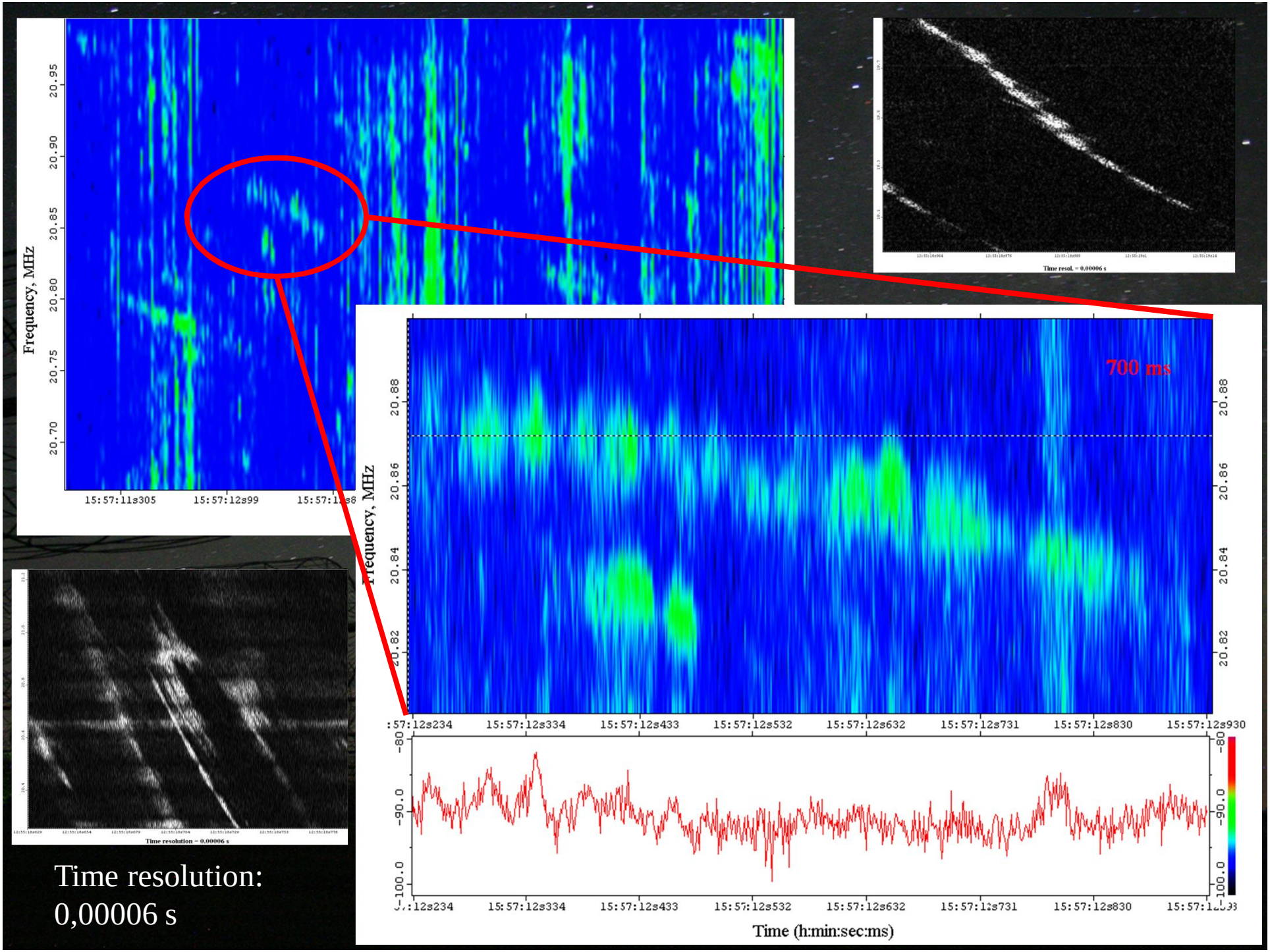
export: exp-0001-0001

Jupiter observations with UTR-2

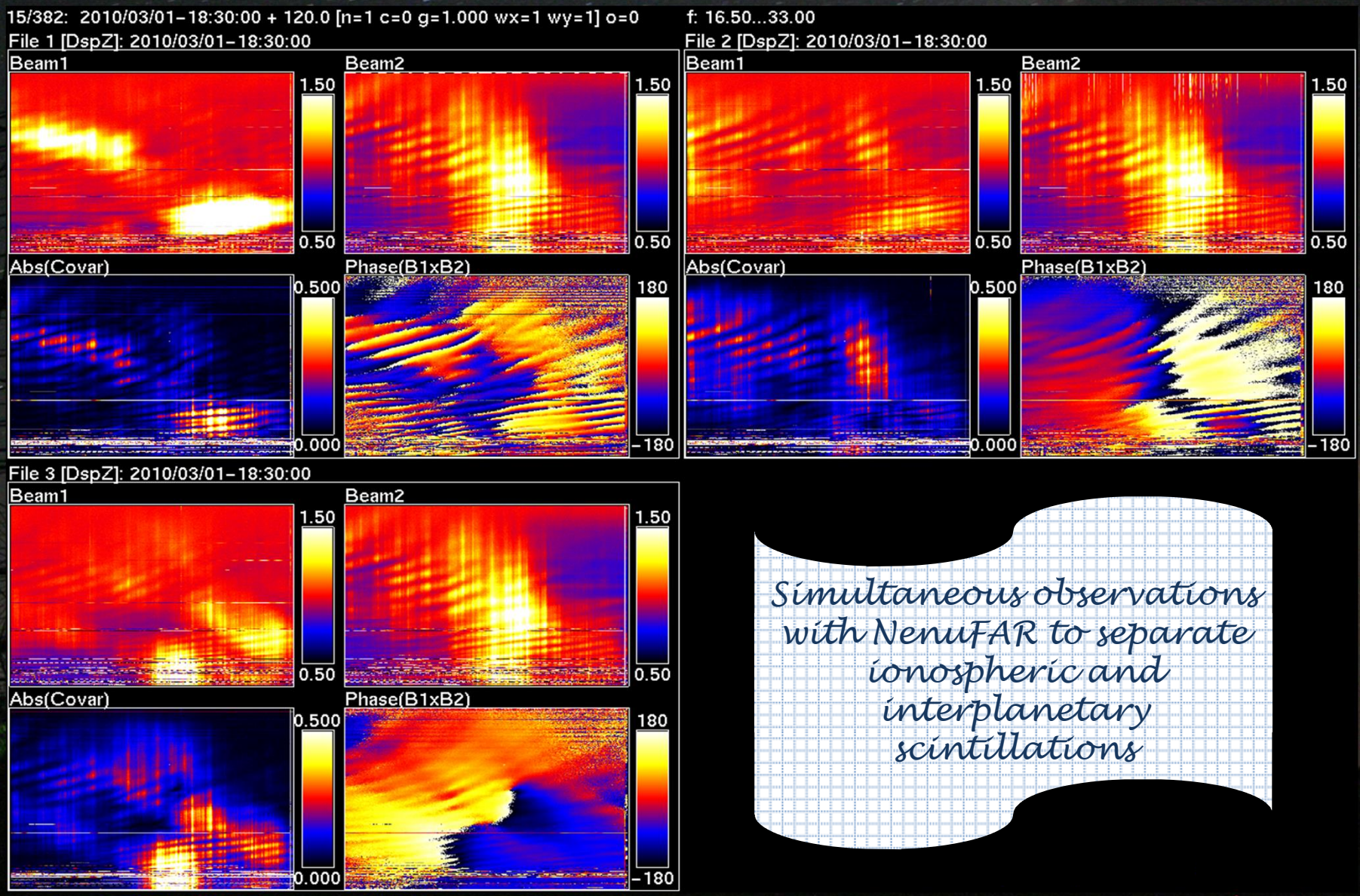


Resolved down to 15 nanosecond time scale!

Interferometry with NenuFAR (baseline about 3000 km)


Frequency, MHz
20.95
20.90
20.85
20.80
20.75
20.70
15:57:11s305
15:57:12s99
Time resol. = 0,00006 s
700 ms
20.88
20.86
20.84
20.82
15:57:12s234
15:57:12s334
15:57:12s433
15:57:12s532
15:57:12s632
15:57:12s731
15:57:12s830
-80
-90.0
-100.0
Time (h:min:sec:ms)
Time resolution = 0,00006 s
Time resolution:
0,00006 s

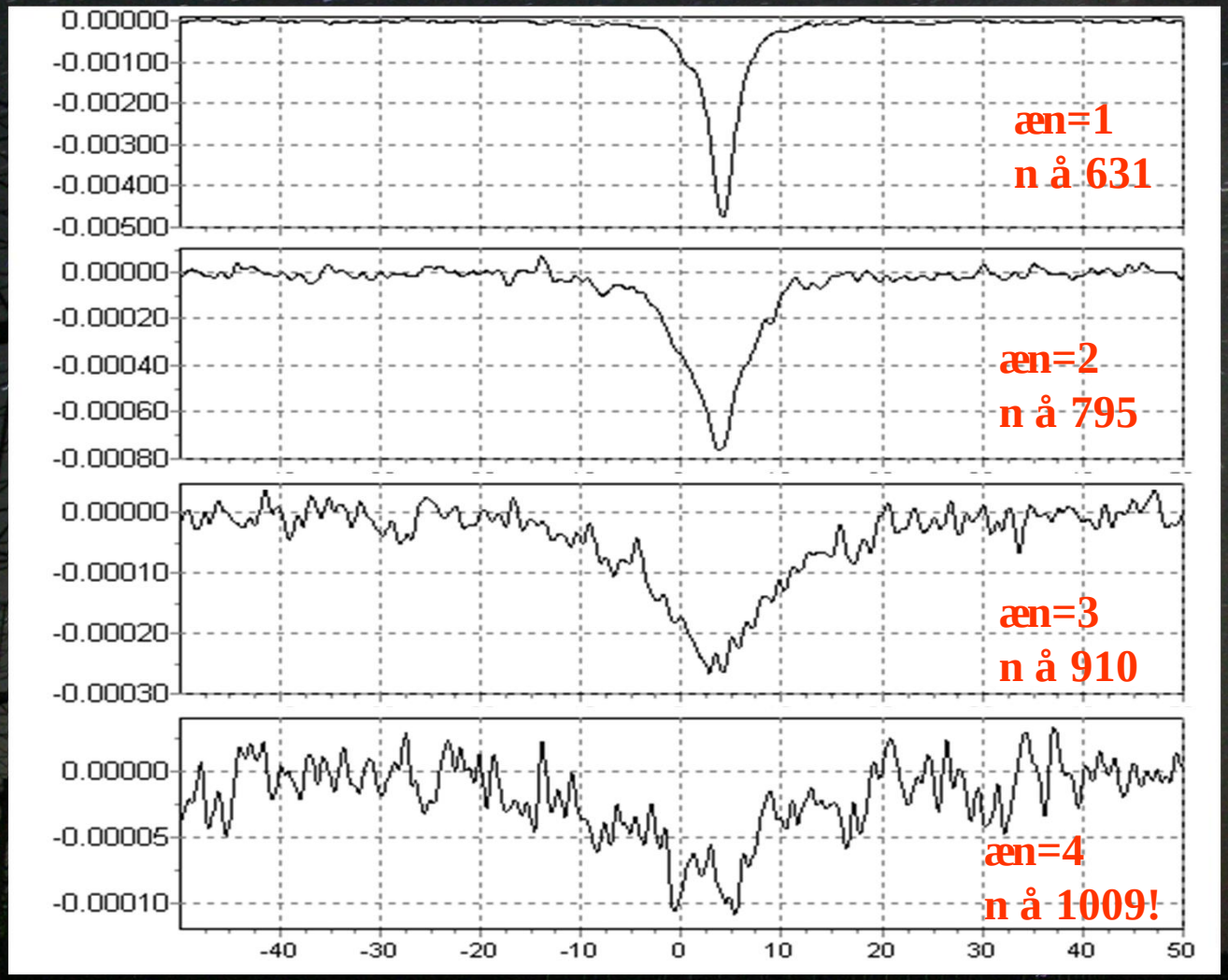
Probe of interplanetary medium: IPS of 3C 144 in 3-beam operation mode of UTR-2



Simultaneous observations with NenuFAR to separate ionospheric and interplanetary scintillations

Radio recombination lines

Carbon RRLs towards Cas A, UTR-2, 26 MHz

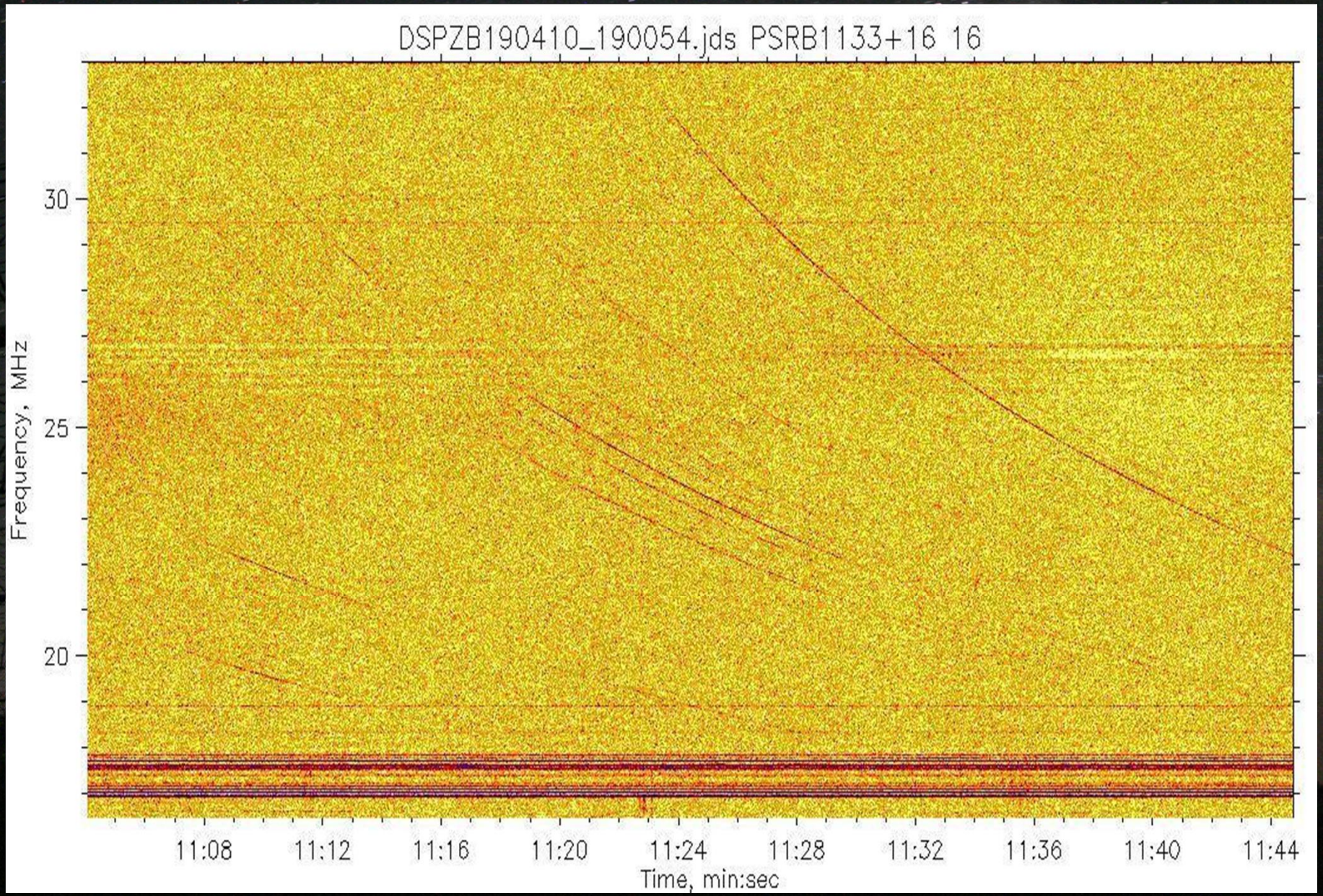


D å 0.1mm

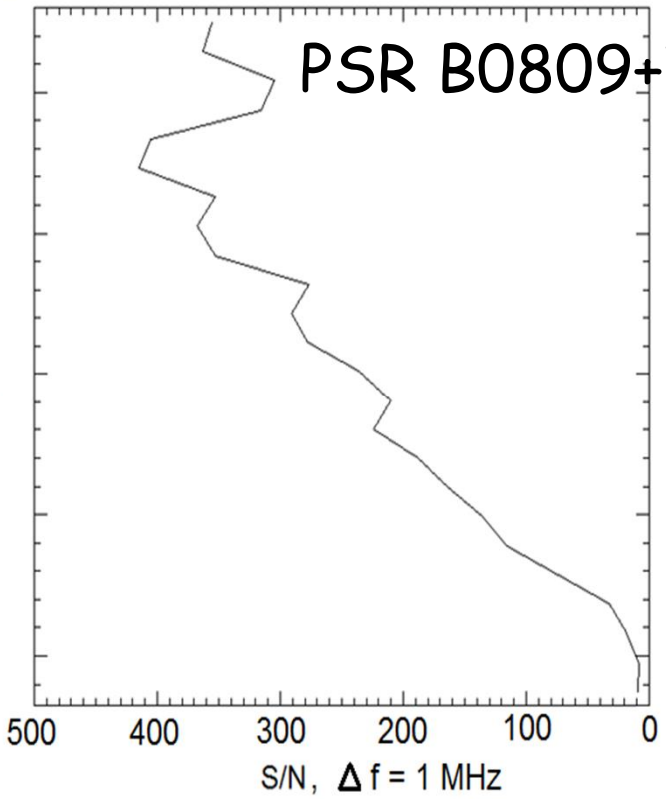
Detection of carbon RRLs with recordly high principal quantum number n~1000

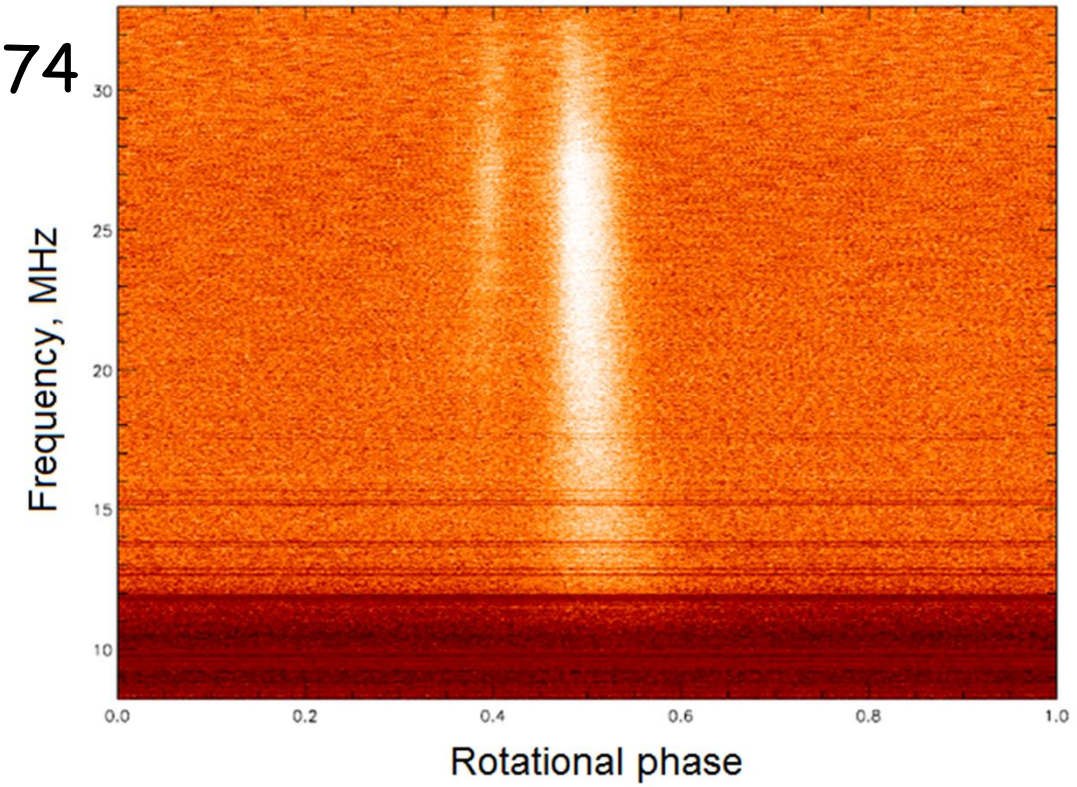
Sensitivity of ~ few mJy

Probe of interstellar medium: pulsars

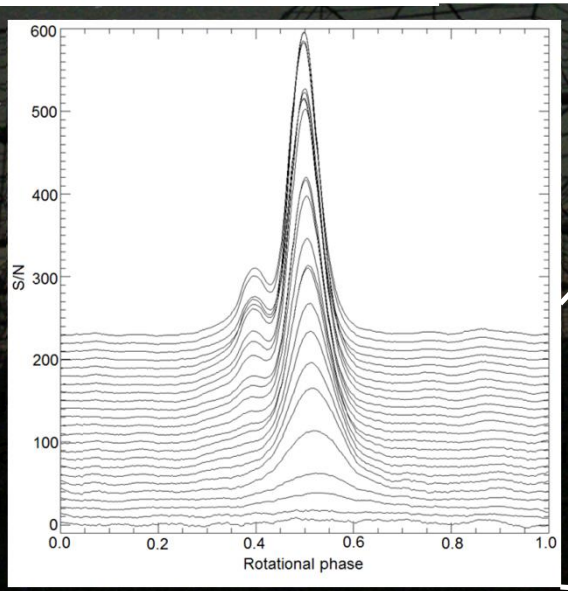


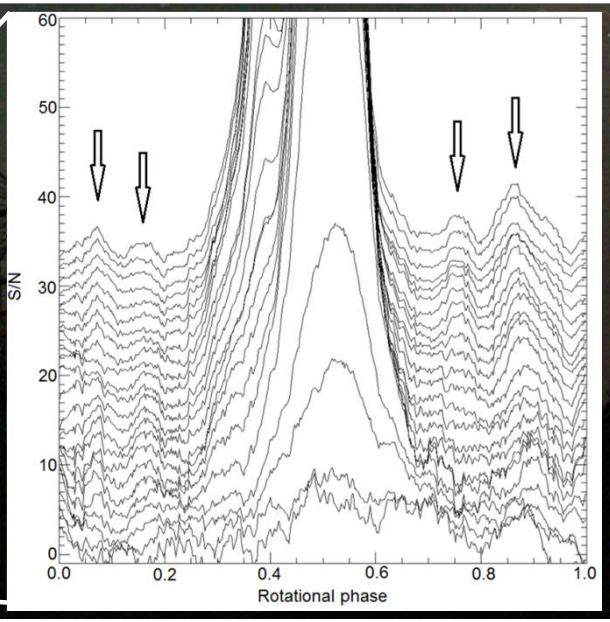
PSR B0809+74



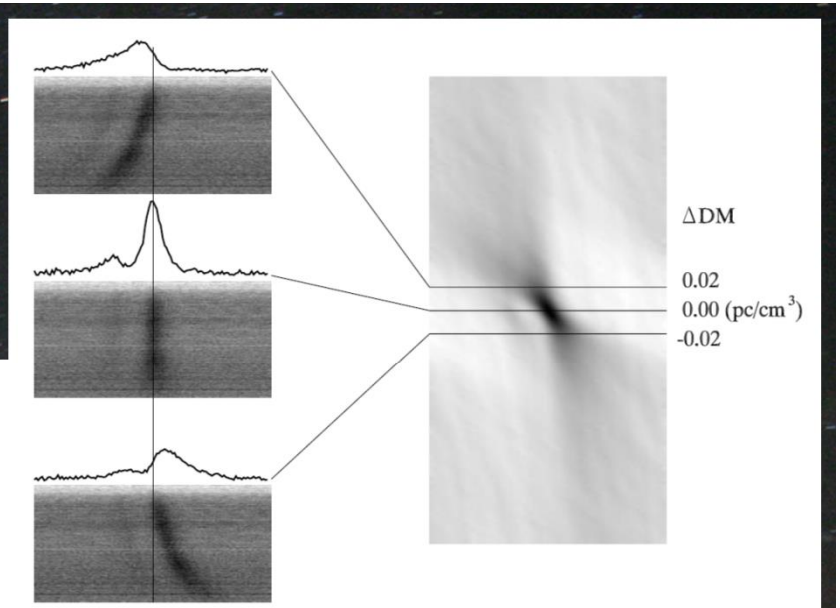


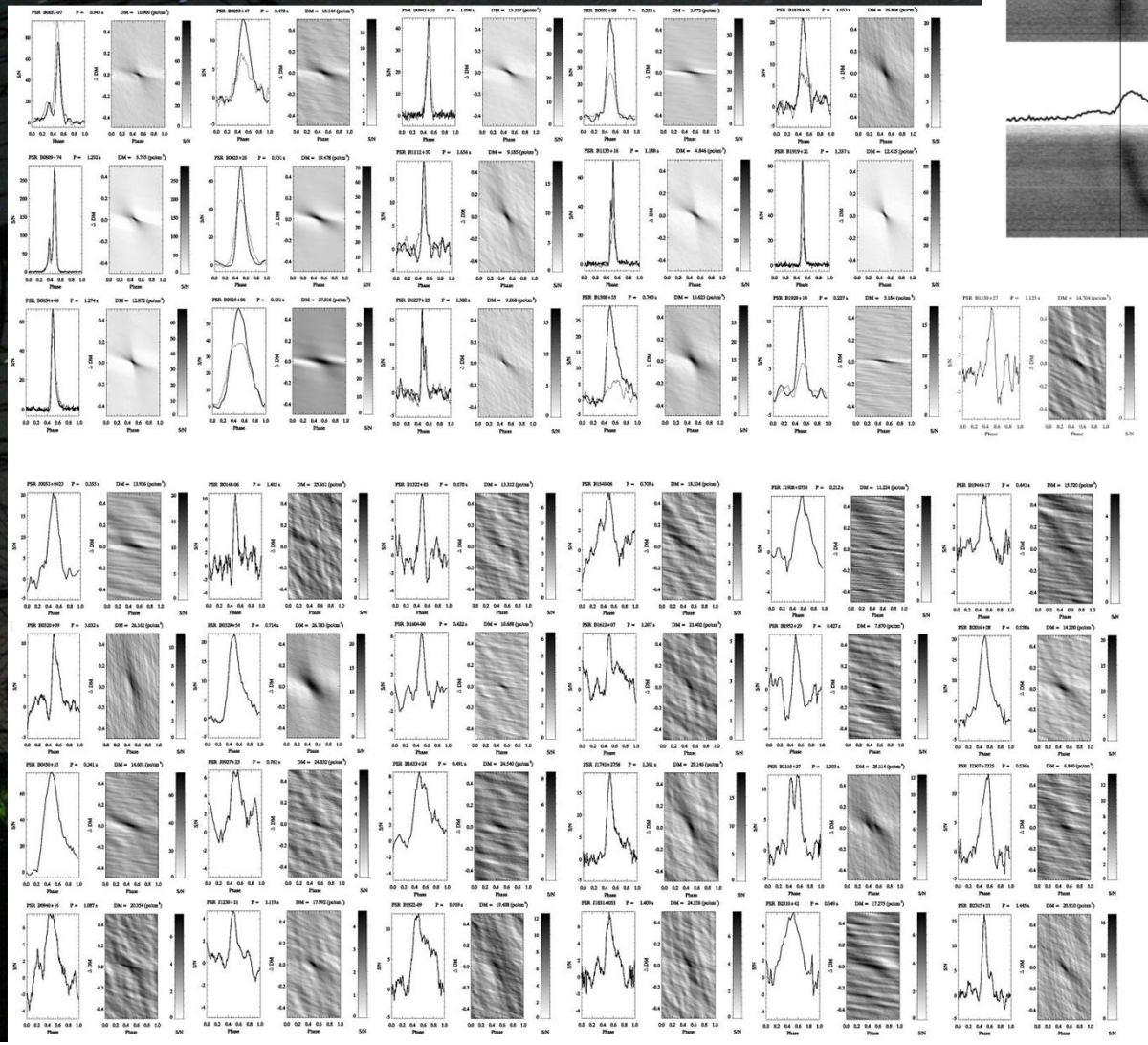
Low-frequency interpulse components



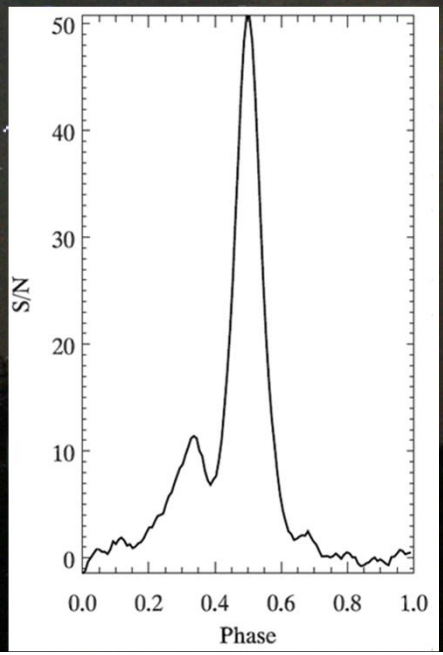


Decameter re-detection of 40 pulsars Statistical study of their low-frequency radio emission.

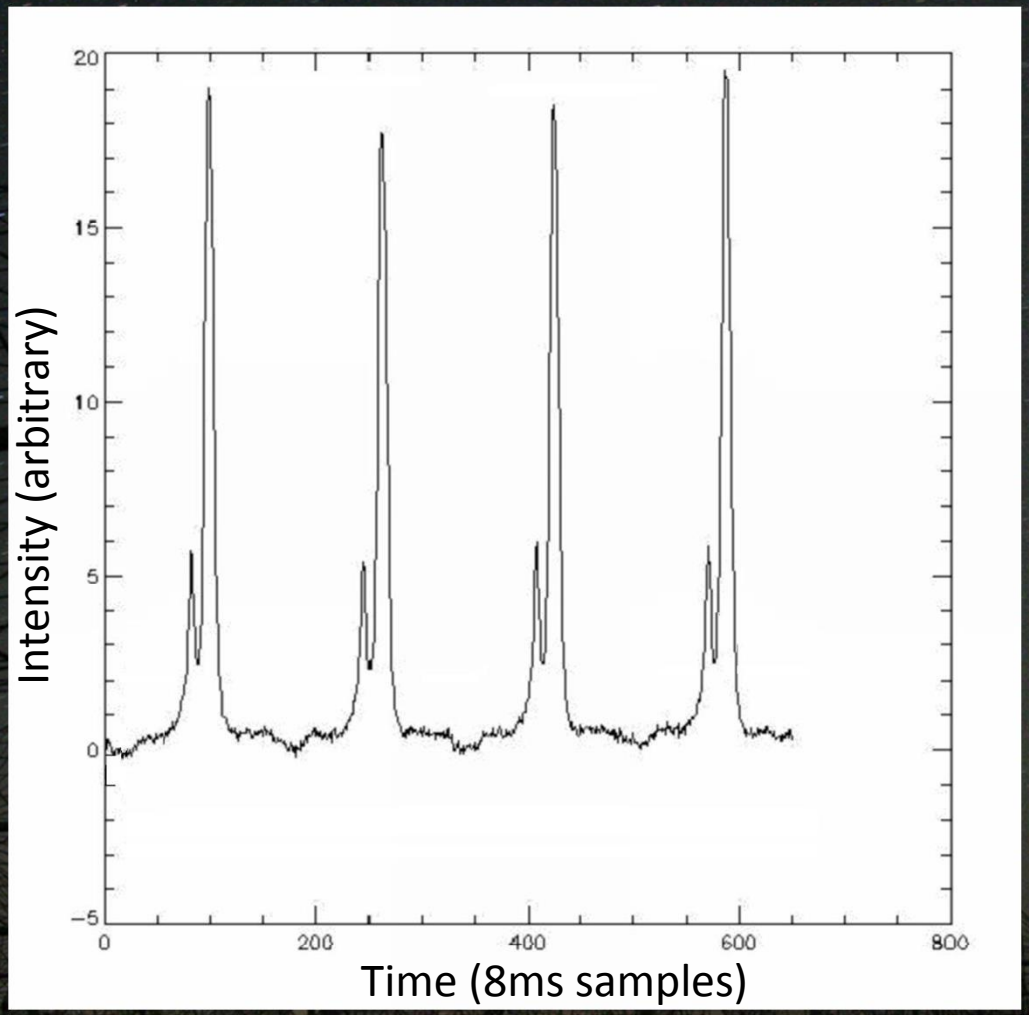


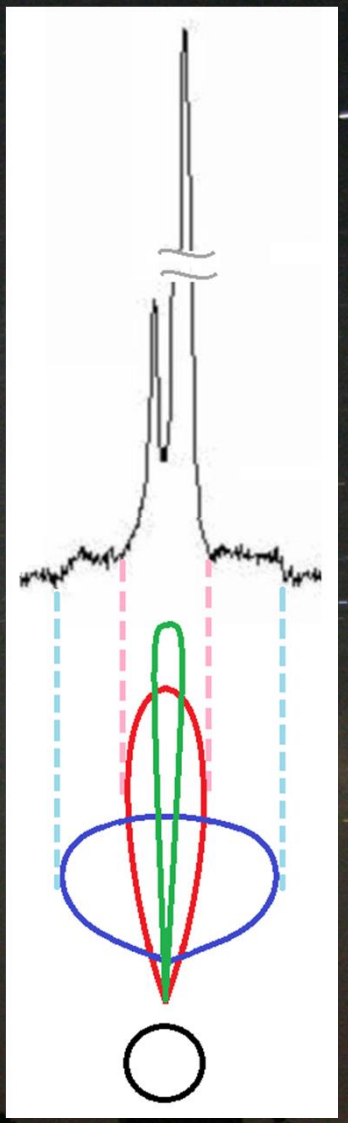


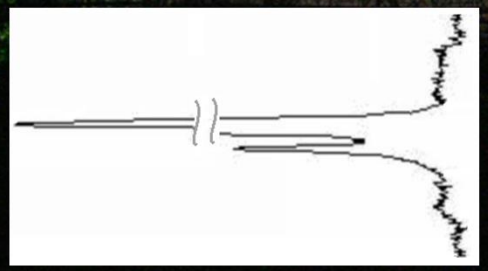
PSR B0031-07,
integration: 1.5 hours

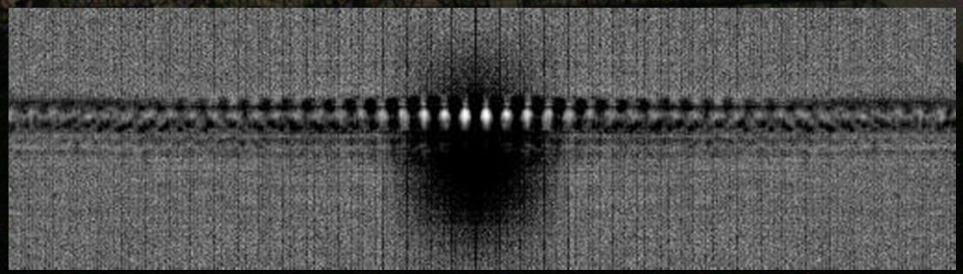


Prospects of low-frequency pulsar astronomy:



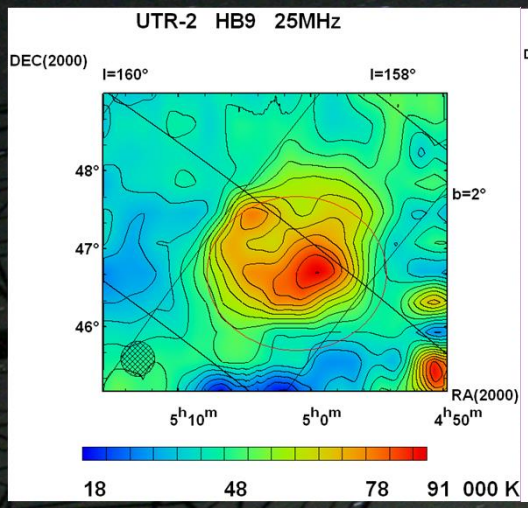


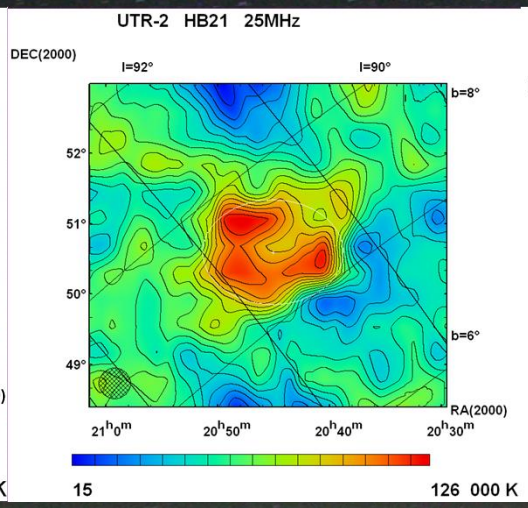


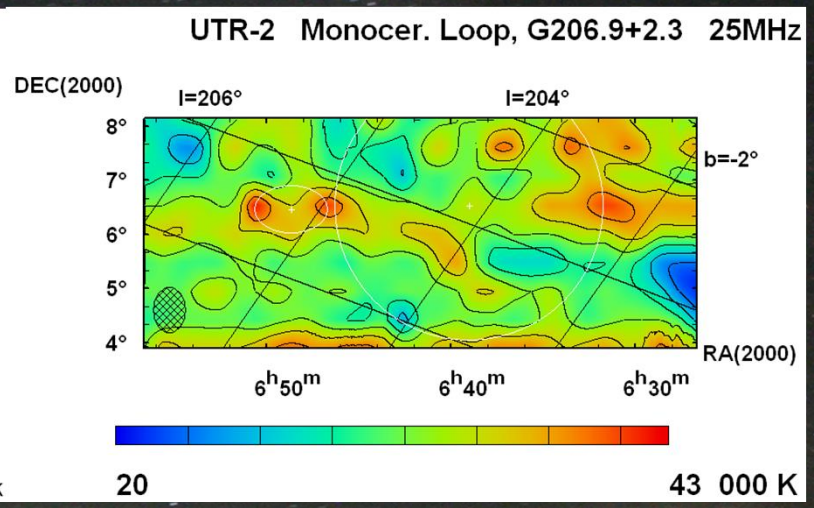


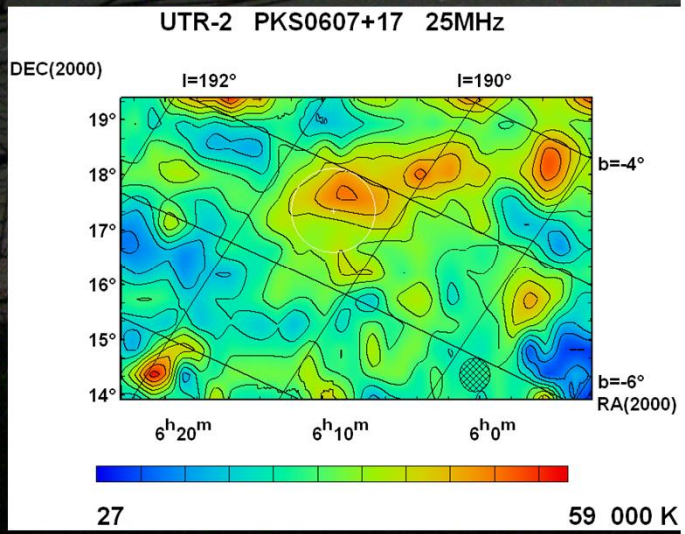
ACF (longitudinal)

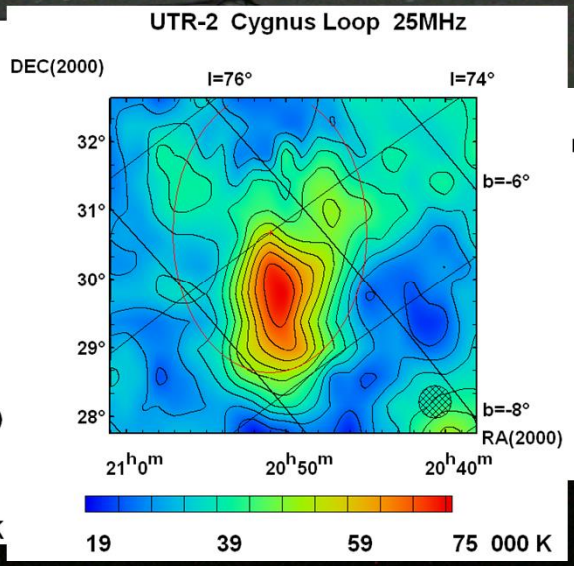
Within the Galaxy: Supernova remnants, observed with UTR-2

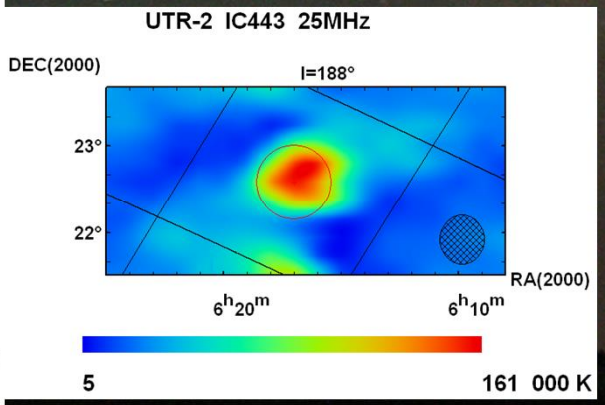




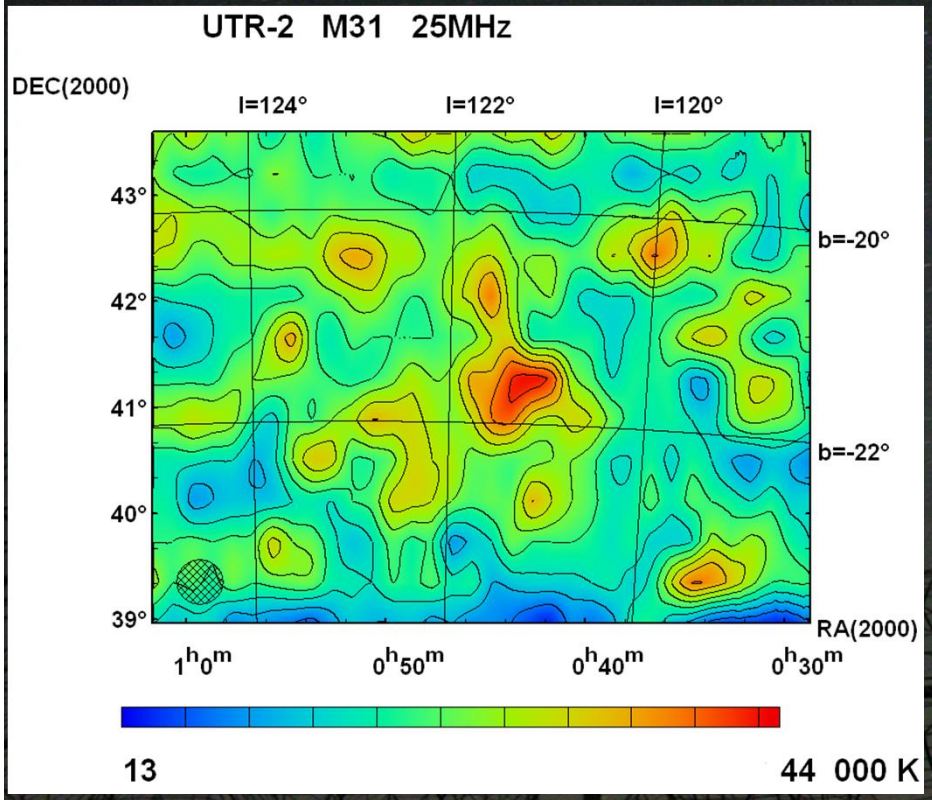








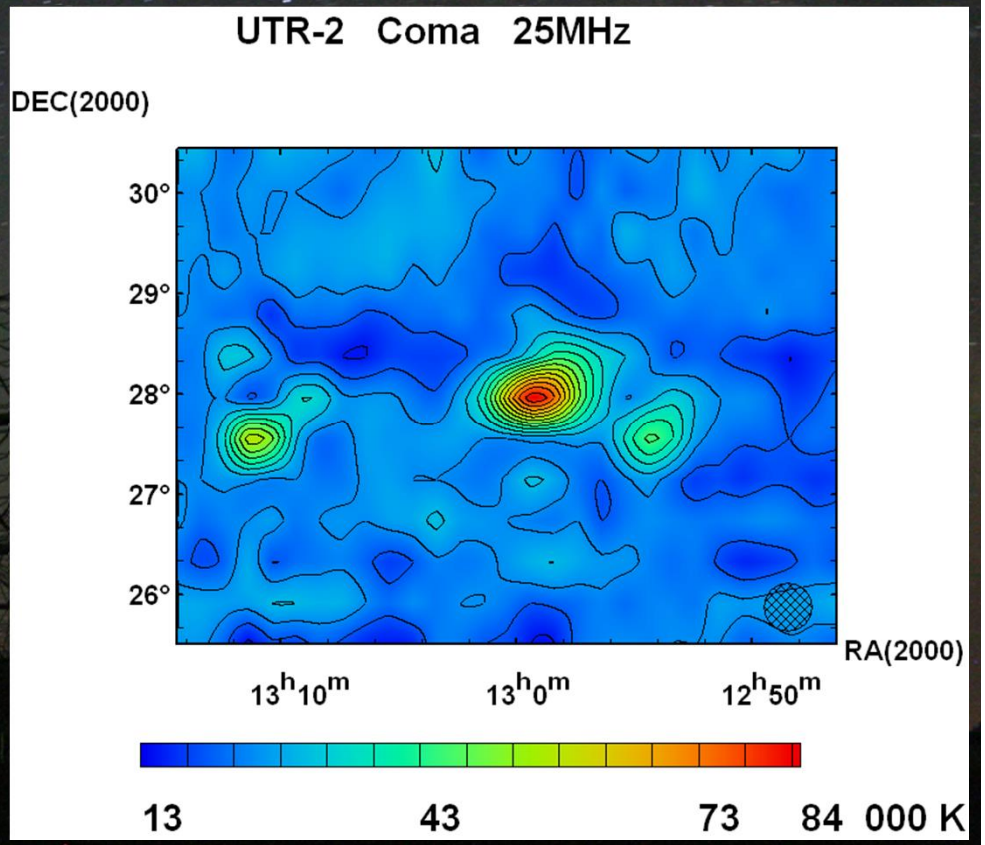
Beyond the Galaxy



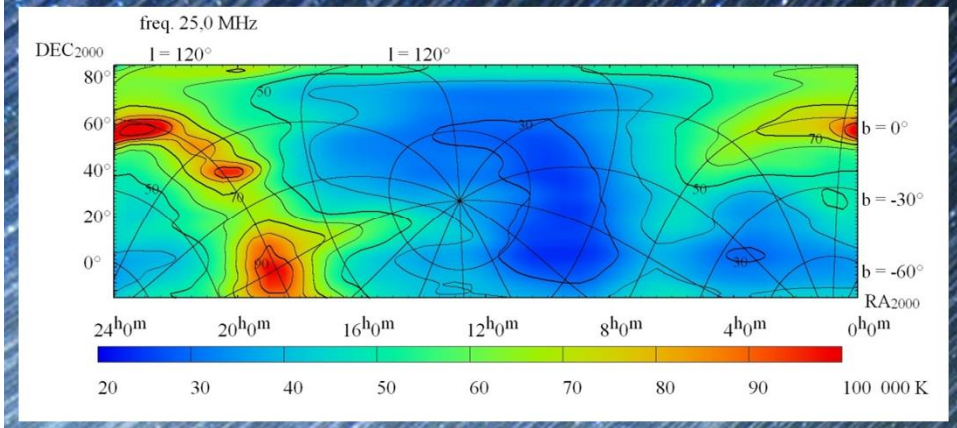
Andromeda Galaxy:

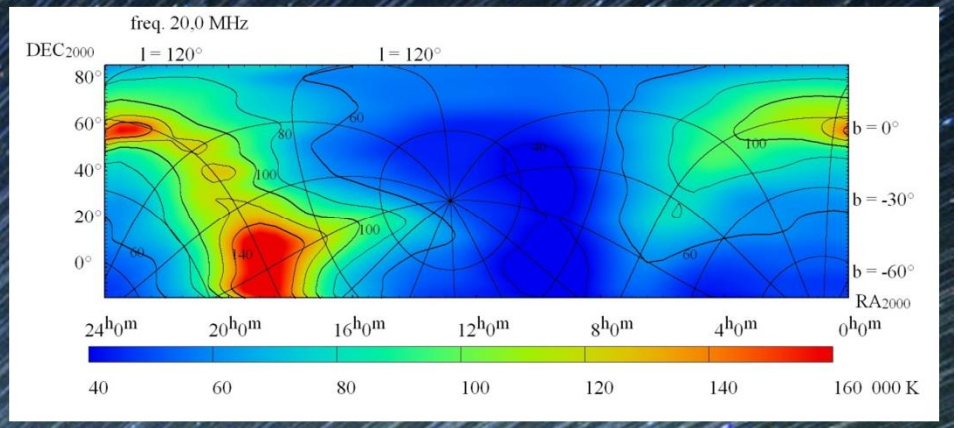
The disk is surrounded by the halo with the major axis of 240′.

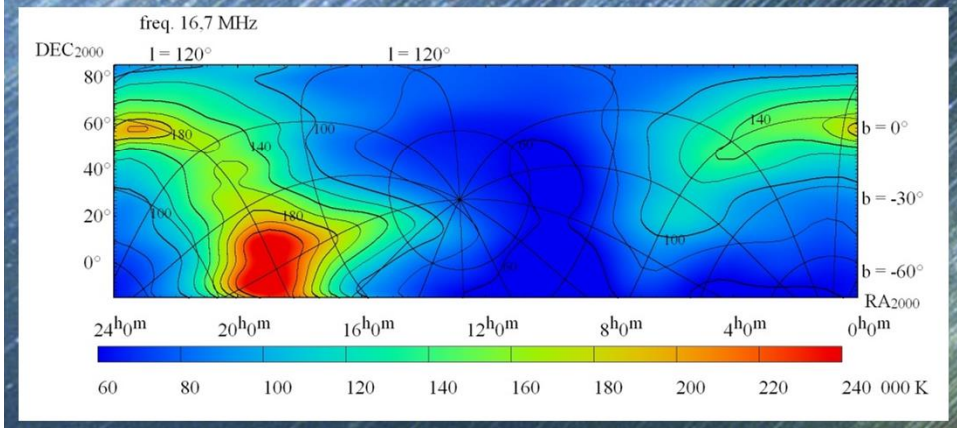
Coma Cluster

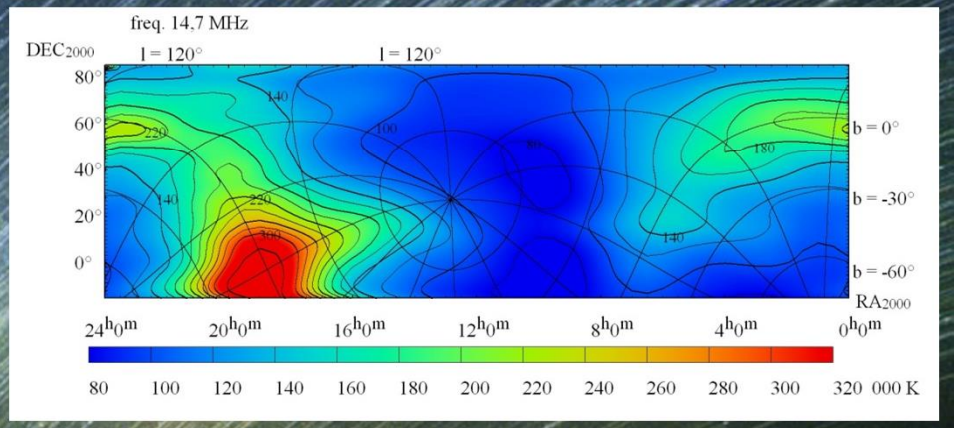


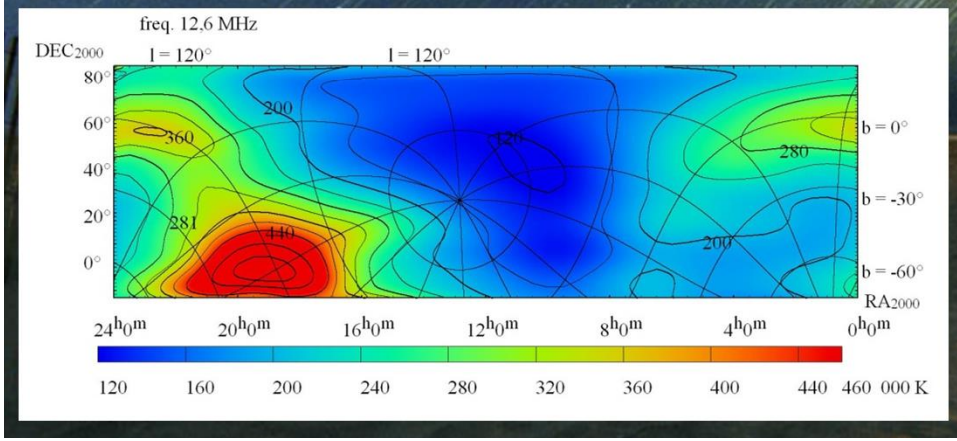
Large-scale structure of the Northern sky at decameter waves

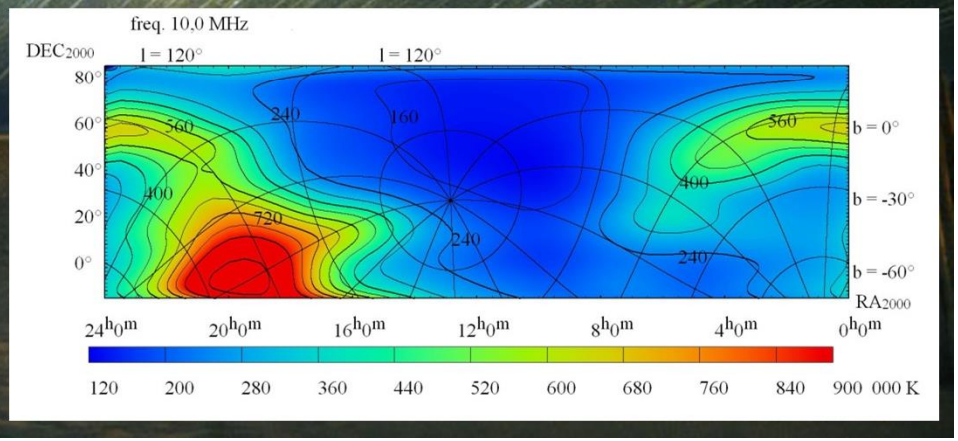




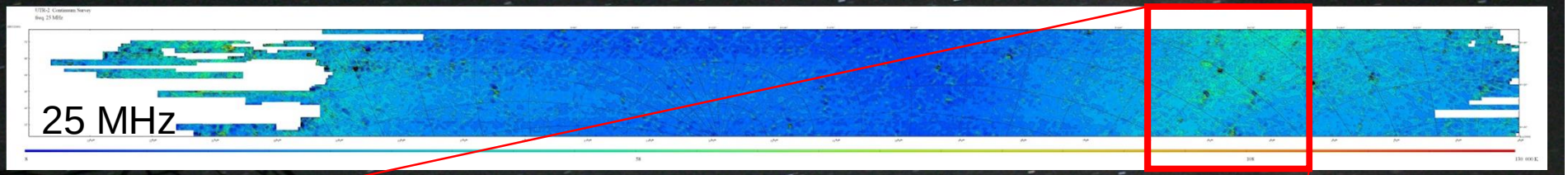


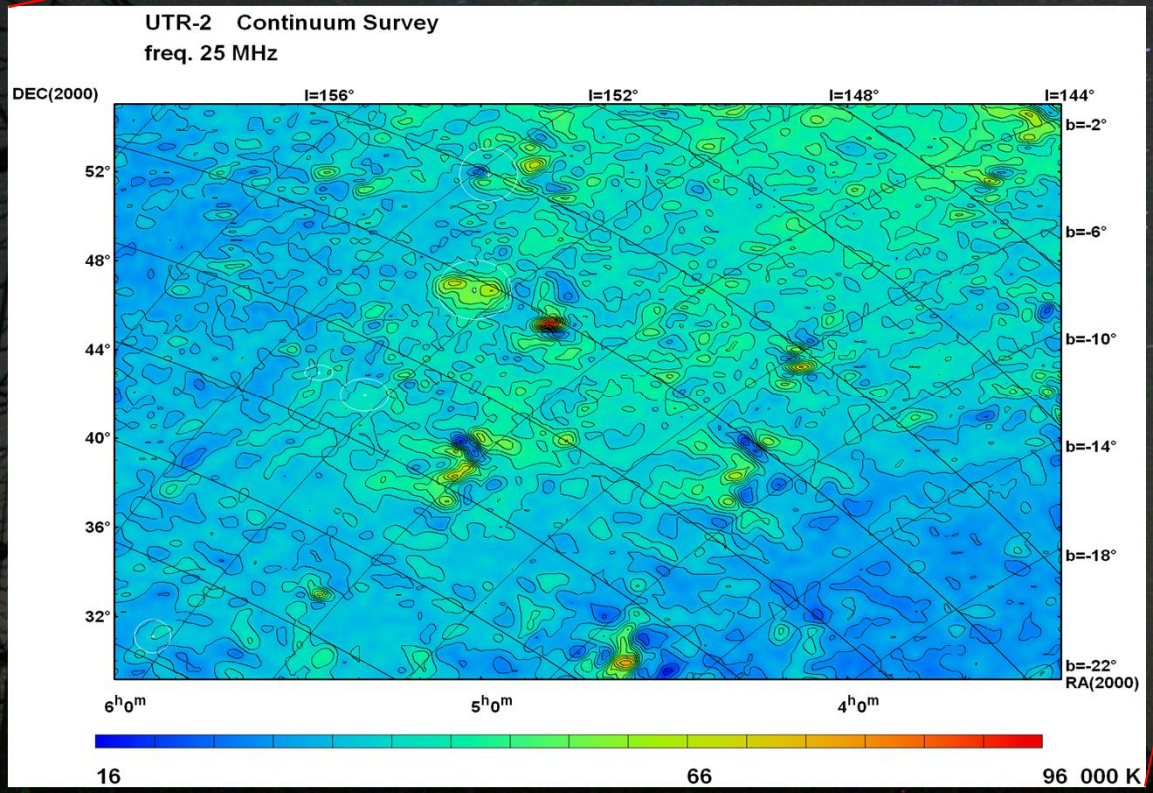


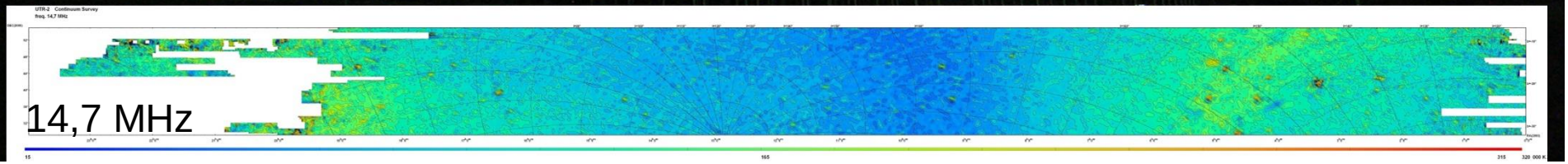




UTR-2 Northern Sky Survey







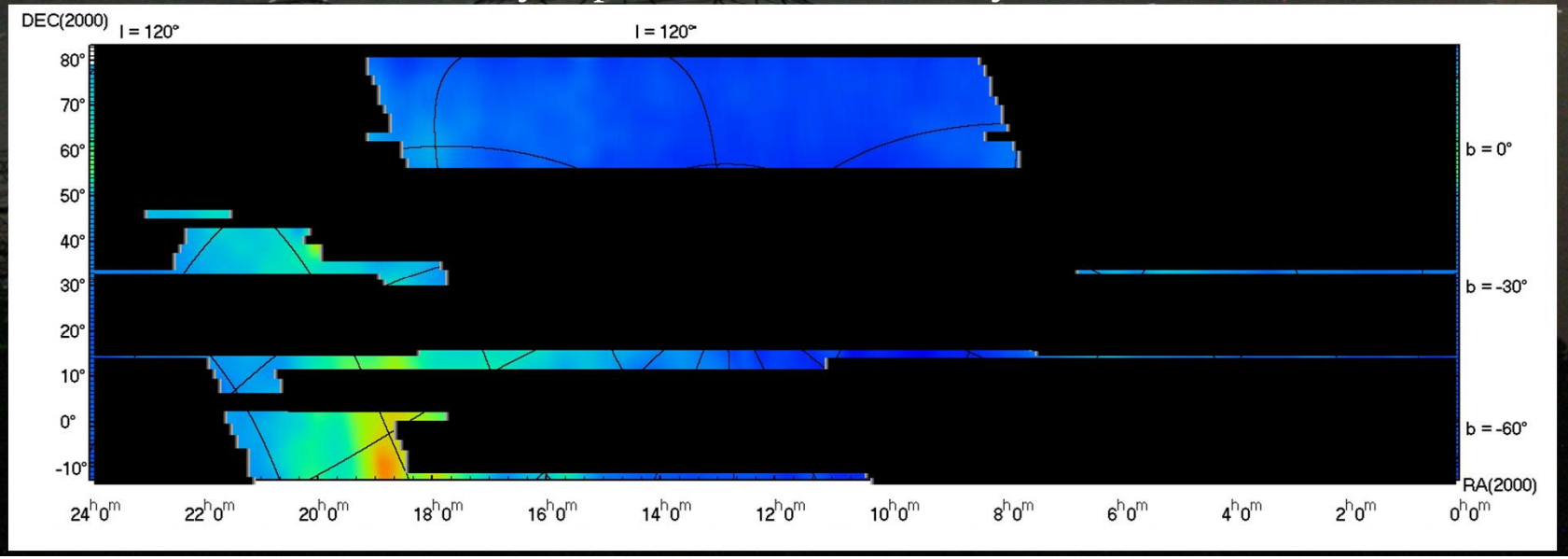
Transient survey: DARTS

DARTS ï Decameter Array Rapid Transients Survey

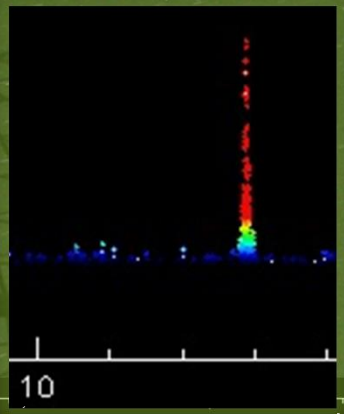
6 beams
Integration time: 1h
Time resolution: 8 ms

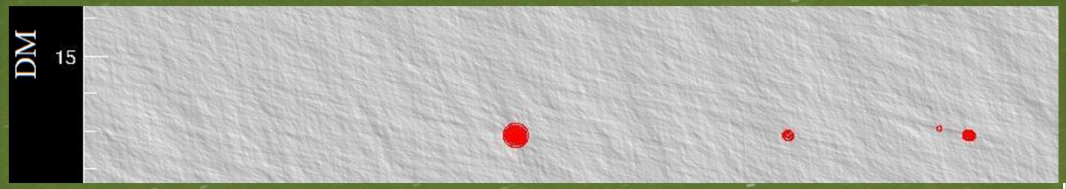
~80 % data recorded
~20 % processed

Surveyed part of the northern sky:

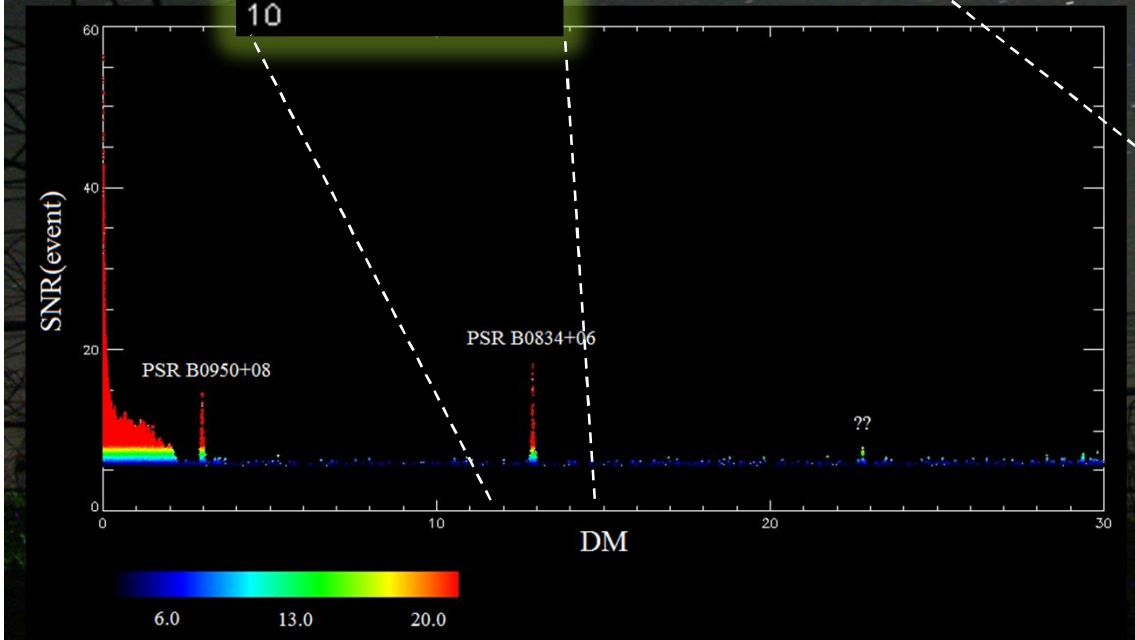


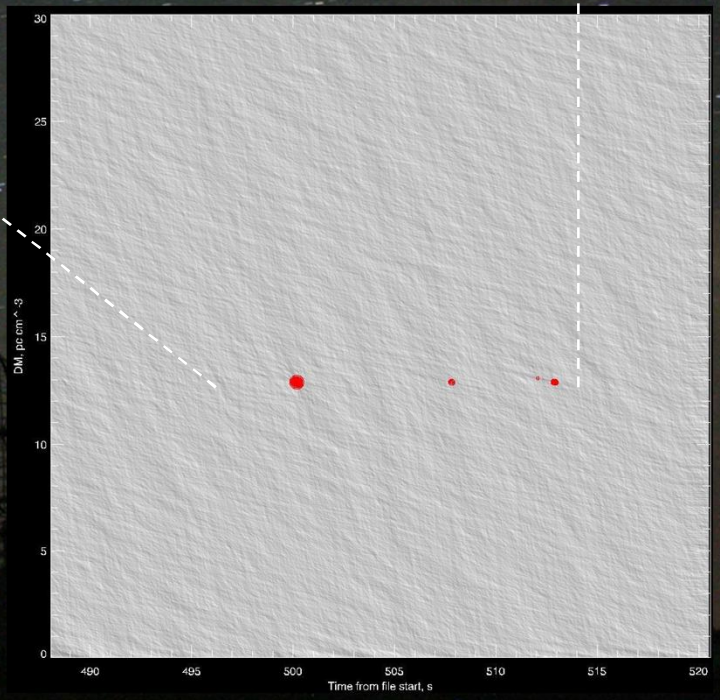
Pulsar redetections





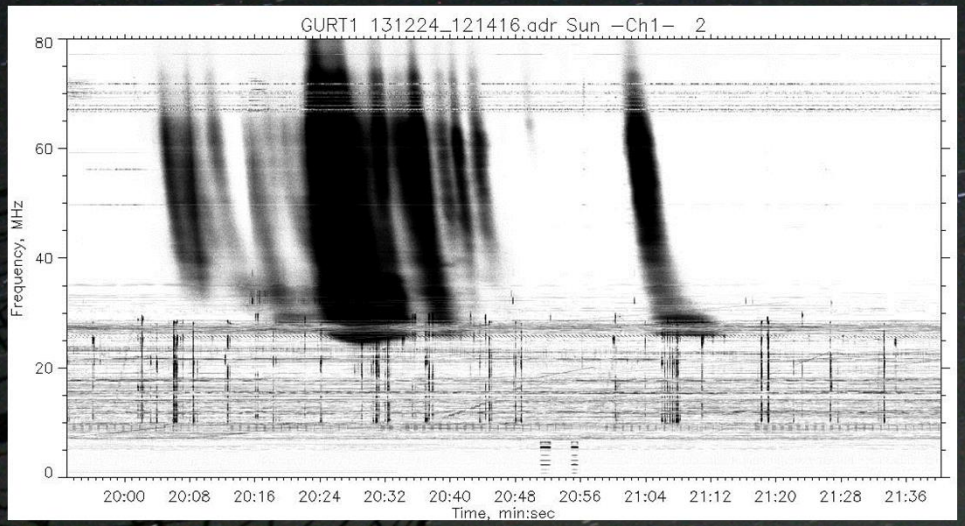
DM=12,89



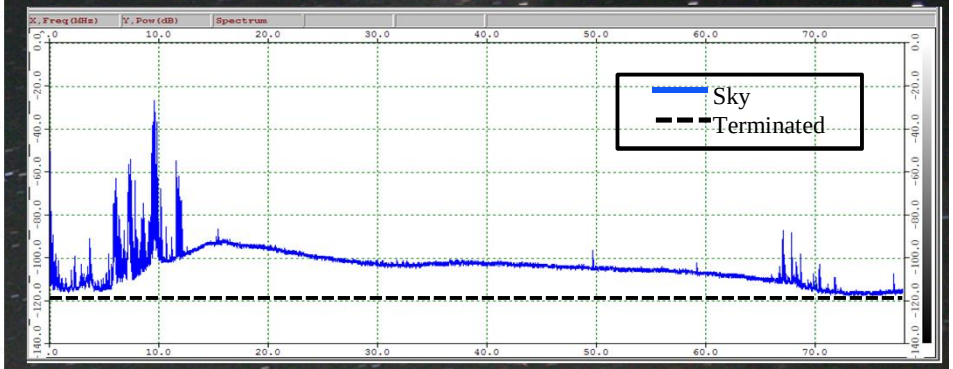


GURT: first results

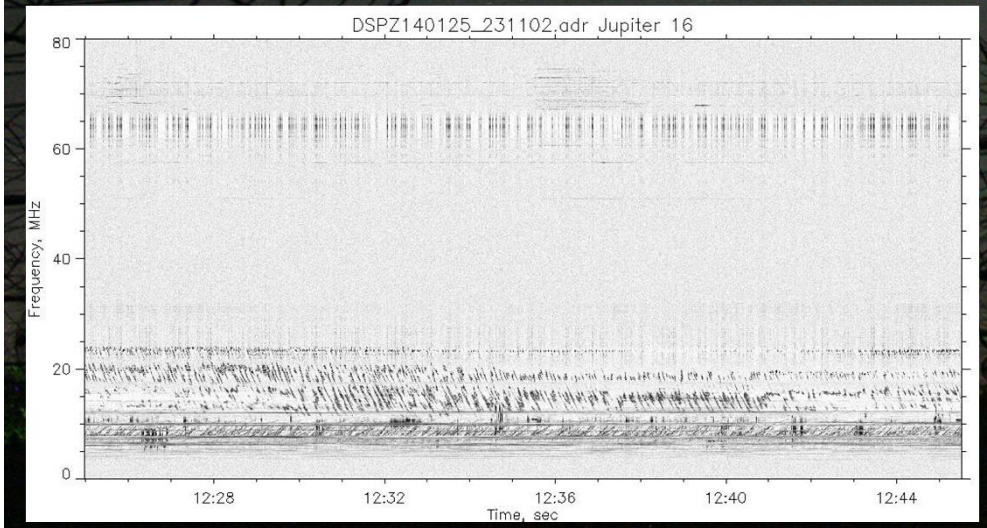
Solar type III burst



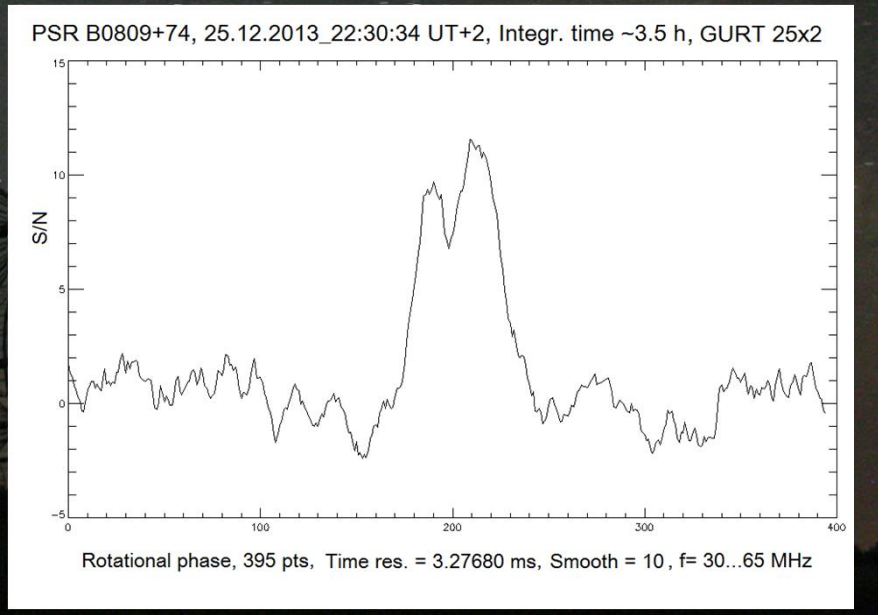
GURT spectrum (existing sections)



Jupiter radio emission



First pulsar



Minimal data rate: 640 Mb/s (for 1 beam)
Multibeam mode - ?

⇨ Data deluge

Processing pipeline blocks

Reading and format decoding

RFI Mitigation

T_{rfi} å T_{obs}

Search by dispersion measure

T_{disp} å $20 \cdot T_{obs}$

Integration / t,f

T_{ind} å $0{,}3 \cdot T_{obs}$

Search for individual bursts

FFT

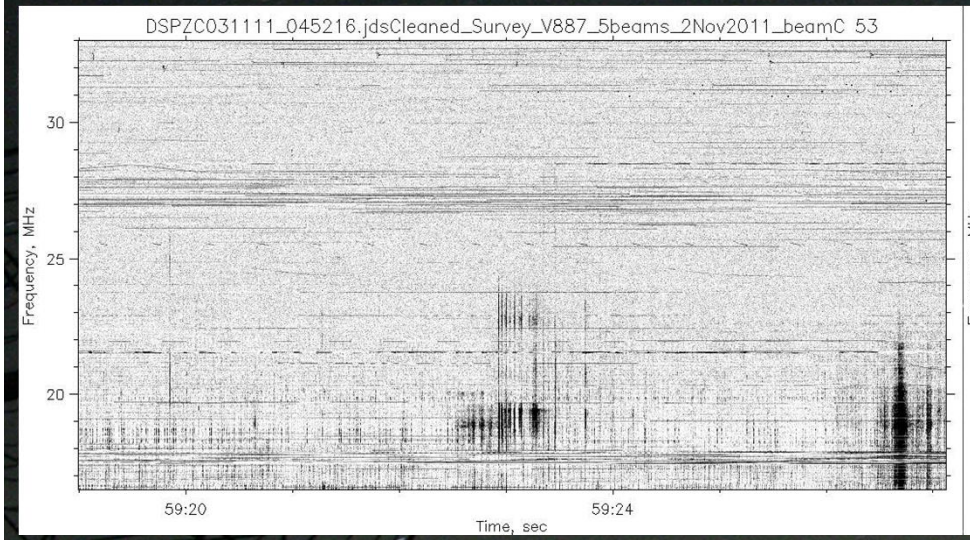
T_{fft} å $0{,}1 \cdot T_{obs}$

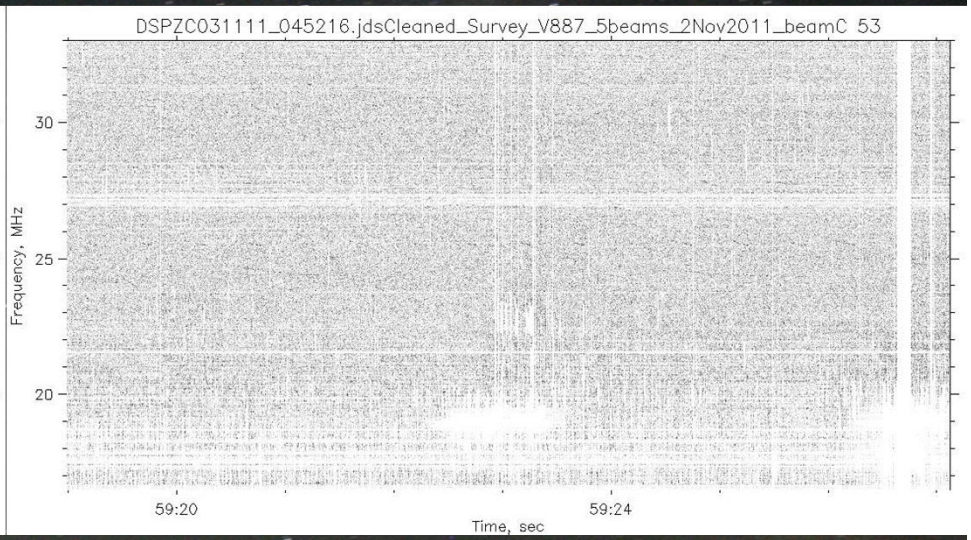
Folding

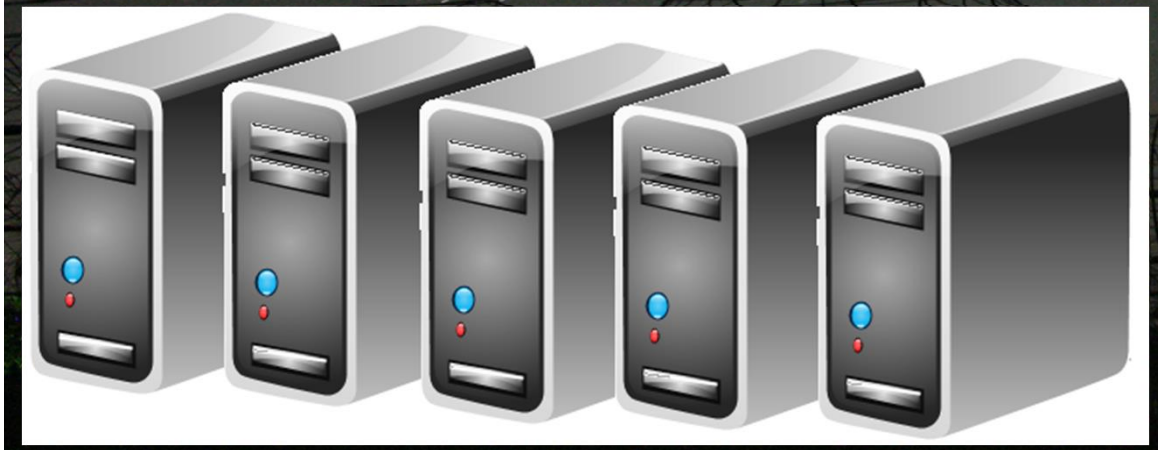
WANTED:

-like backend

Online RFI mitigation





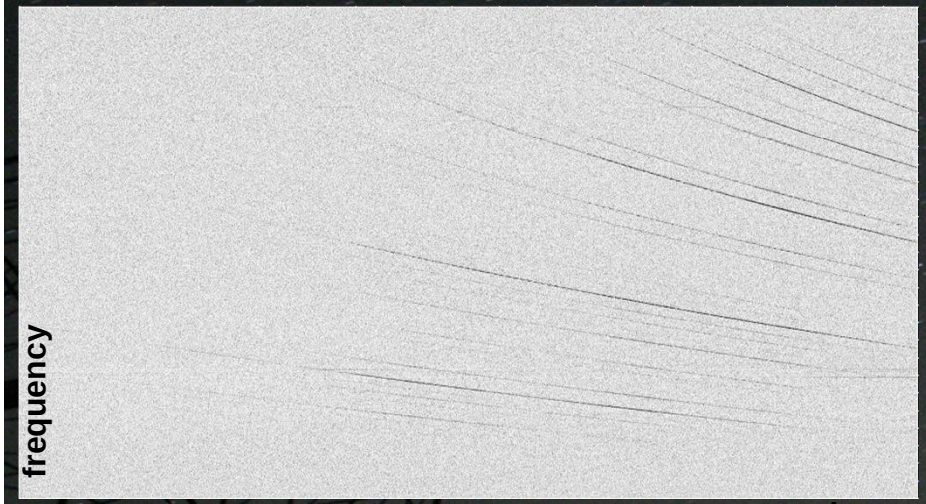


NVIDIA CUDA

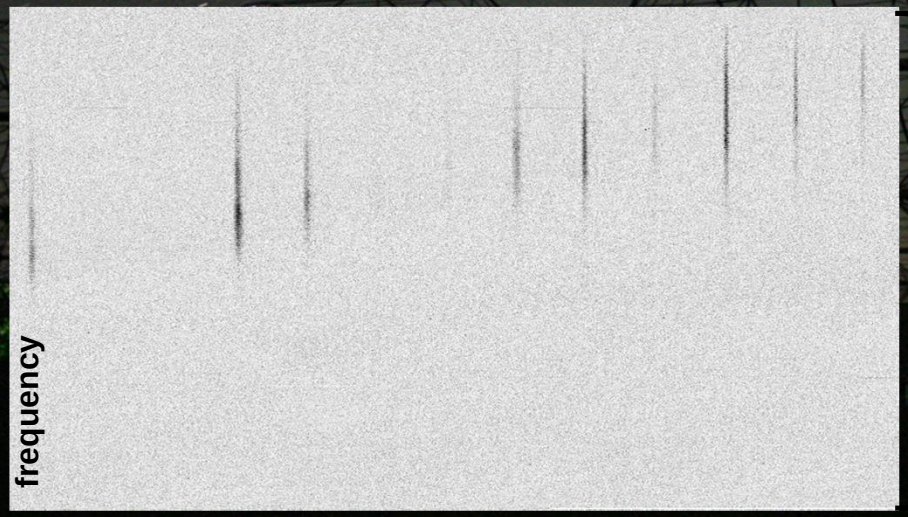
5 servers @ UTR-2 *

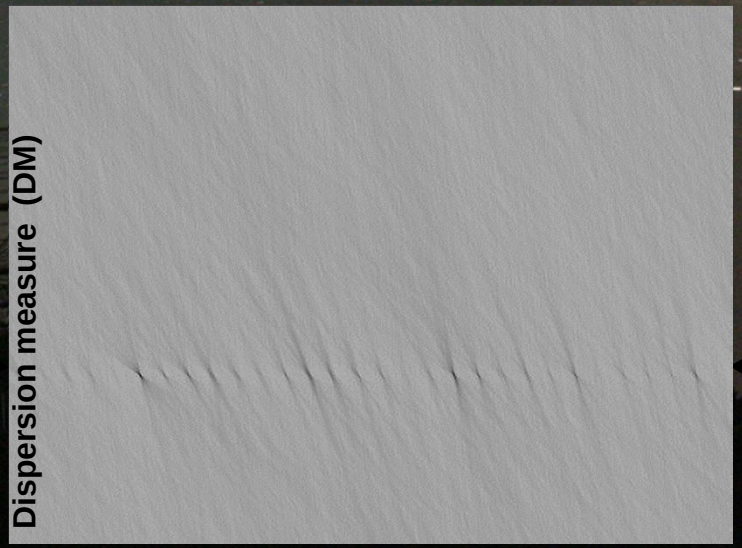
* by now 2 servers with GPU NVidia GTX680 and GTX770, CPU Intel Core i7

Dedispersion

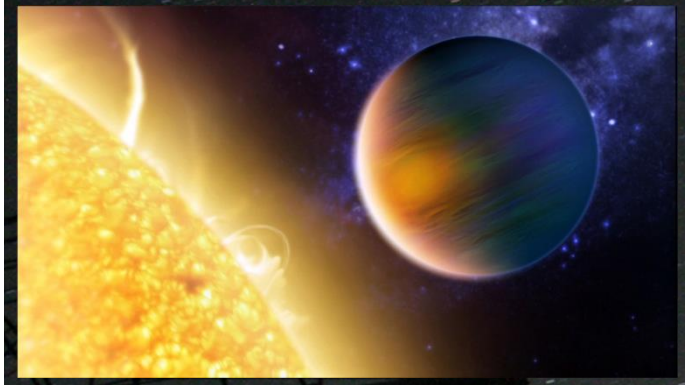


Parallel and distributed computing



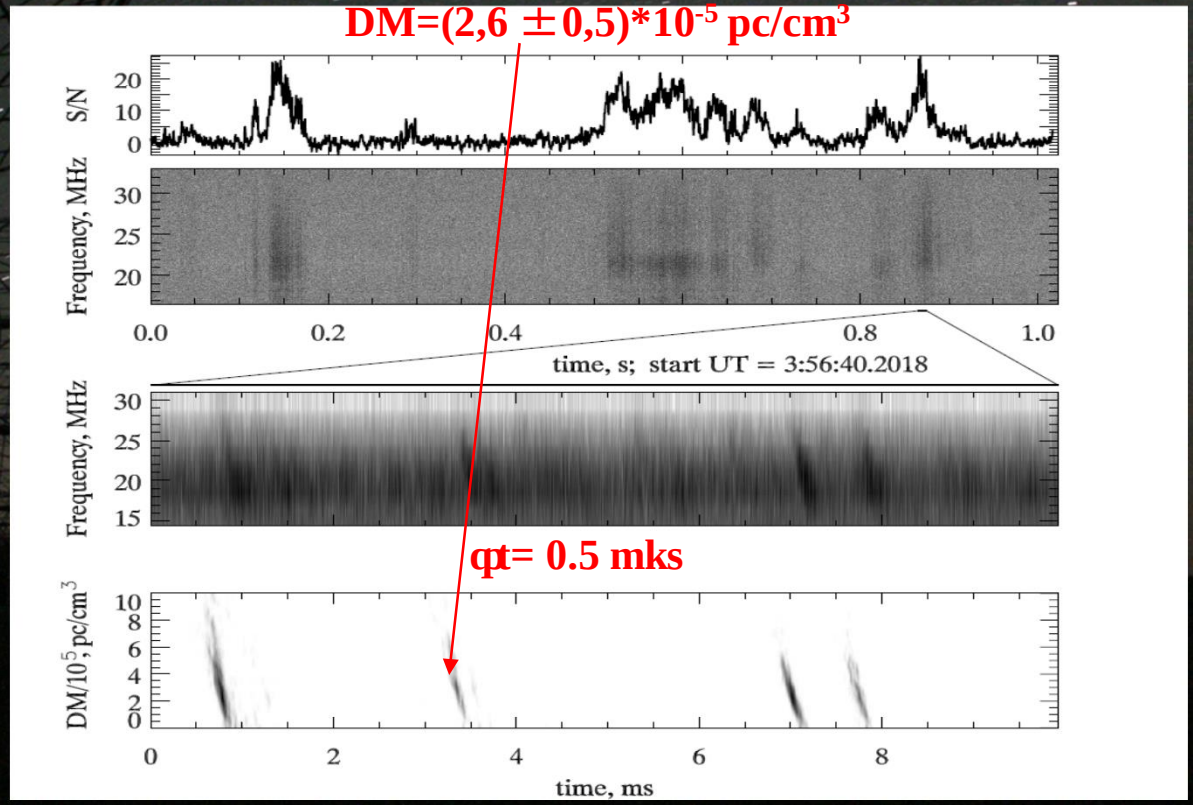


Dedispersion needed:



e.g.
- Exoplanets
- Planetary lightning

Dispersion of Saturn Electrostatic Discharges (SED)



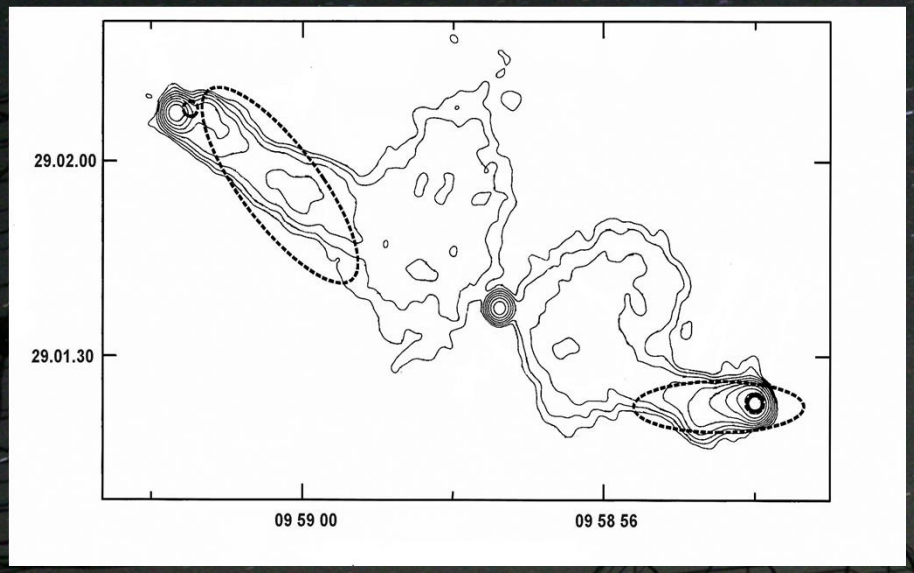
Summary:

- The collaboration between Ukrainian and French radio astronomers exists already for many years
- Various interesting results have been obtained and are expected in the future
- Simultaneous observations at GURT, UTR-2 and LOFAR, NenuFAR will open the new posibilities for the very low frequency radio astronomy
- The concepts of GURT and NenuFAR have a lot in common, therefore similar pipelines can be developed for data processing
- To deal with data deluge, the enhanced backend is required. It can be joint effort of French and Ukrainian radio astronomers.

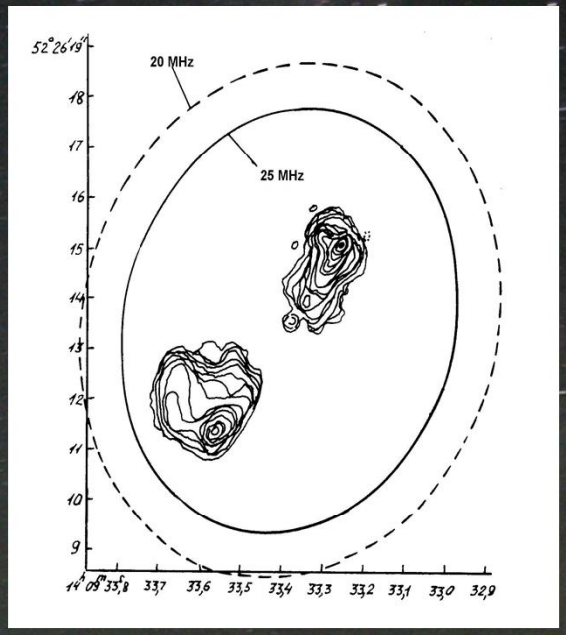
Thank You!

And happy St. Valentine's Day!

Fine spatial structure radio emission



Structure of 3C234



Structure of 3C295

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