VENTSPILS AUGSTSKOLA

NATIONAL DEVELOPMENT PLAN 2020 | EUROPEAN UNION European Regional Development Fund

INVESTING IN YOUR FUTURE

VIRAC

"Support to the Ventspils University of Applied Sciences in preparation of international cooperation projects for research and Innovation" Project No. 1.1.1.5/18/I/009

Overview about ongoing radioastronomical observations and related science projects in VIRAC

Vladislavs Bezrukovs, Aleksejs Klokovs

Artūrs Orbidāns, Mārcis Bleiders, Artis Aberfelds, Dmitrijs Bezrukovs, Artem Sukharev, Mihail Ryabov, Karina Šķirmante, Ivars Šmelds, Jānis Šteinbergs, Roberts Rasmanis, Marcis Donerblics, Agris Berzins

Engineering Research Institute "Ventspils International Radio Astronomy Centre" of Ventspils University of Applied Sciences (VIRAC), Ventspils, Latvia

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International Workshop

"RT-32 ZOLOCHIV: FIRST RESULTS, EU COLLABORATION, RADIO ASTRONOMY FRONTIERS"

October 3-7, 2021, Zolochiv, Ukraine

Radio telescope **RT-32**
32 meters Cassegrain antenna

Radio telescope **RT-16**
16 meters Cassegrain antenna

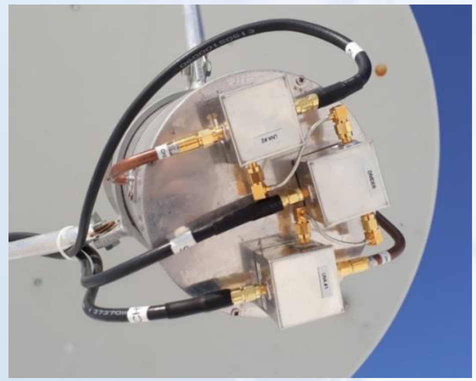
Azimuth maximum velocity:
2.8 deg/sec 5 deg/sec
Elevation maximum velocity:
1.8 deg/sec 5 deg/sec
Azimuth range:
-328 - +328 deg
Elevation range:
2.7 – 90 deg
Az/El pointing precision: ~10 arcsec
Surface accuracy (RMS):
1.0 mm 0.1 mm
Working frequency range:
0.3 – 22 GHz 1.4 – 40 GHz

Broadband cryogenic receiver 4.5 – 8.8 GHz

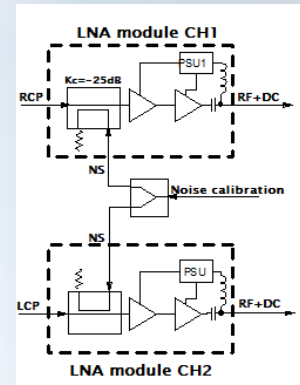
RF Sub-band	RF band (GHz)	IF Output (GHz)	Local Oscillator (GHz)	Image Band (GHz)	Main Working frequencies (GHz)
1	4.5 – 5.5	0.4 – 1.4	4.1	2.7 – 3.7	5.01
2	5.4 – 6.4	0.4 – 1.4	5.0	3.6 – 4.6	6.10
3	6.4 – 7.6	0.3 – 1.5	6.1	4.6 – 5.8	6.70
4	7.6 – 8.8	0.3 – 1.5	7.3	5.8 – 7.0	8.40 & 8.535 - 8580

L band receiver

- Frequency ranges: **1.4-1.6 & 1.6-1.72 GHz**
- LCP+ RCP polarizations
- Sensitivity: 700…800 Jy
- Noise injection cal., network remote ctl.



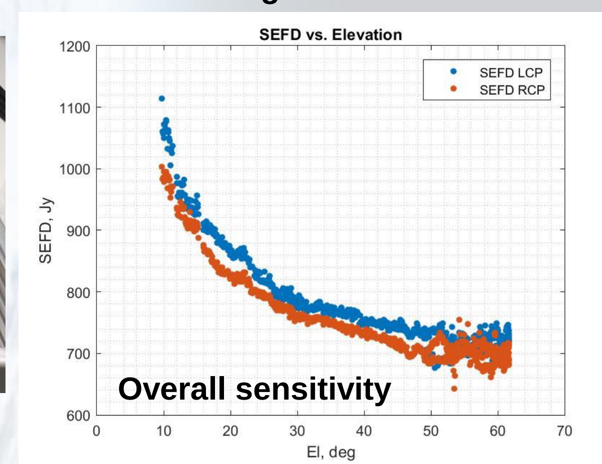
Dual circular pol. 'warm' front-end



Block diagram of front-end

Feed antenna at secondary focus of RT-32 – tripple mirror system

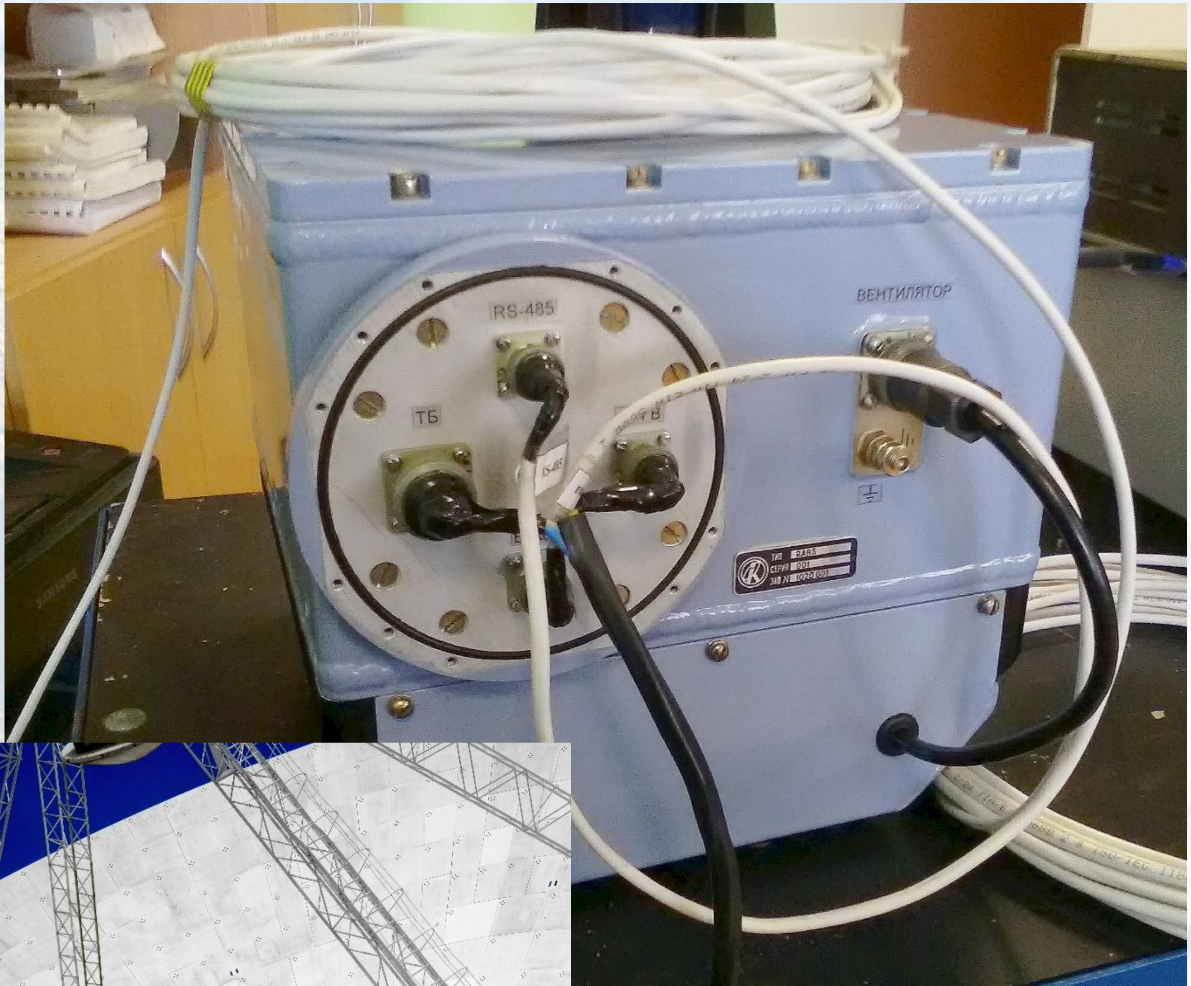
IF Unit

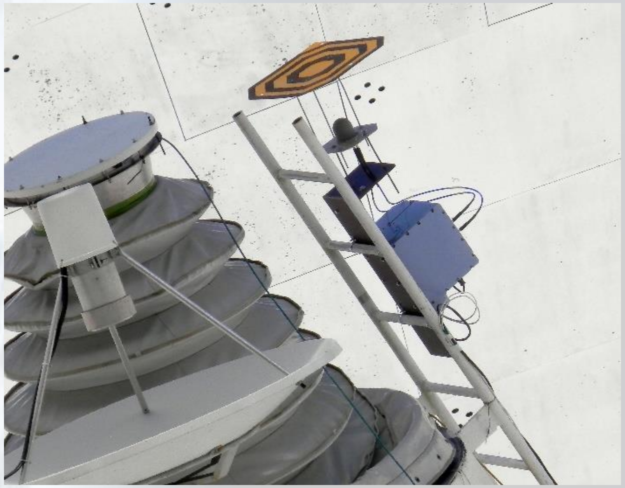


Overall sensitivity

Bleiders, M., Berzins, A., Jekabsons, N., Skirmante, K., & Bezrukovs, V. (2019). Low-cost L-band receiving system front-end for irbene RT-32 cassegrain radio telescope. *Latvian Journal of Physics and Technical Sciences, 56*(3), 50-61. doi:10.2478/lpts-2019-0019

The new Low Noise Spectral Polarimeter LNSP4 for 2.1-7.4 cm under tests in the laboratory and on the RT-32

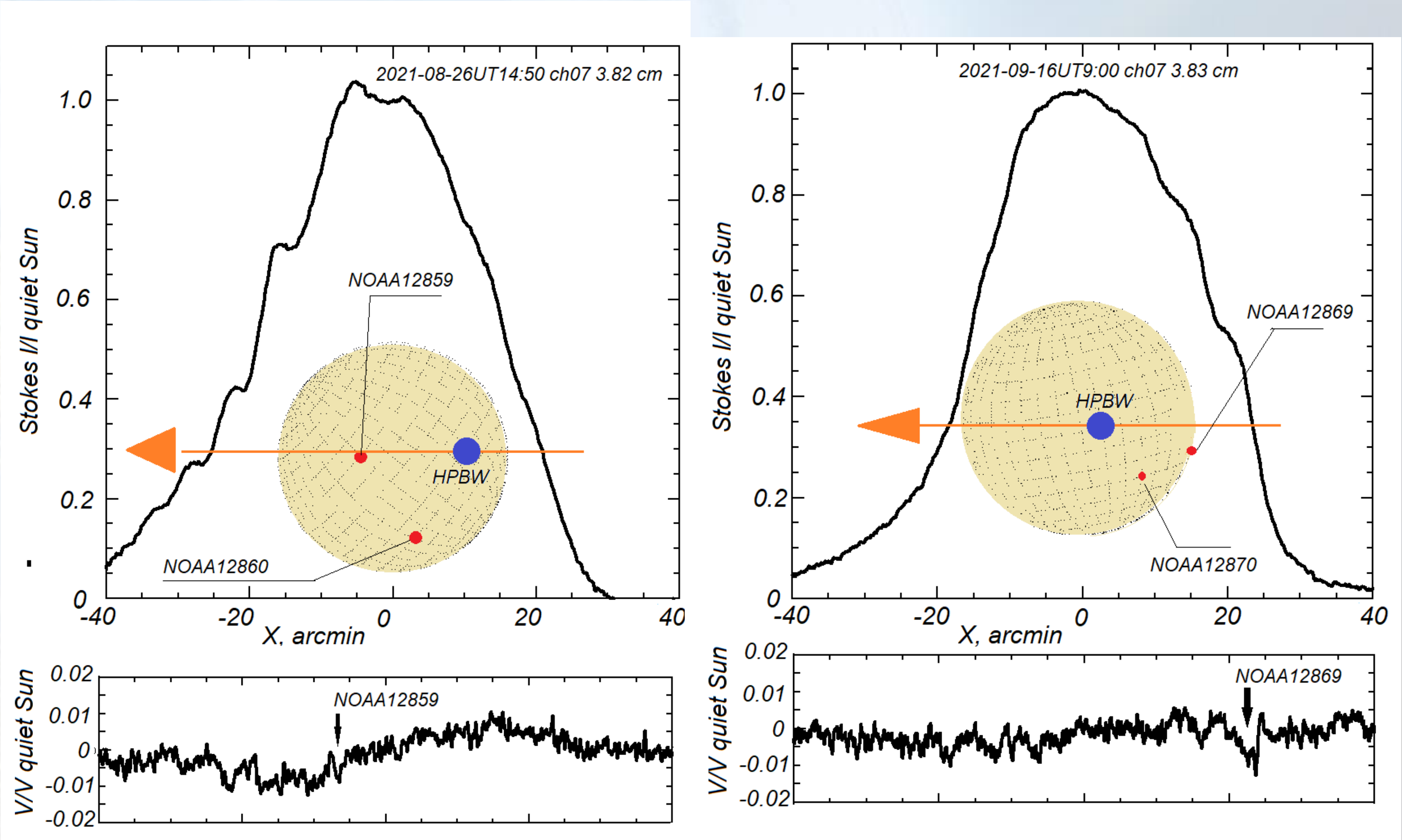




Solar spectral polarimeters VIRAC SP3 vs LNSP4

	SP3	LNSP4
Frequency range	6.3 – 9.3 GHz	4.1 – 14.2 GHz
Number of channels	16	12
Band widths	80-100 MHz	250-800 MHz
Polarization	LCP+RCP	LCP+RCP
S/N ratio ($T_{quietSun}$ / 3σ $T_{sys\ noise}$)	~14-16 db	>22-24 db
Dynamic range	~18-20 db	>32 db
Sampling rate	>30 sample/sec	~10 sample/sec
Sensitivity	~72-74 dbm	>80 dbm
ADC	16 bit	16 bit
Antenna HPBW	3.9-5.2 arc. min.	2.3-8.2 arc. min.
Internal noise generator	no	yes
Internal thermal stabilization	no	yes

Test observations of the Sun with Irbene RT-32 + LNSP4



Stokes I and V records of transits of the Sun on 2021-08-26 and 2021-09-16 over RT-32 antenna beam. LNSP4, channel 7, 3.82 cm. Some side lobes of the antenna diagram and small polarization of rather weak ARs are clearly seen.

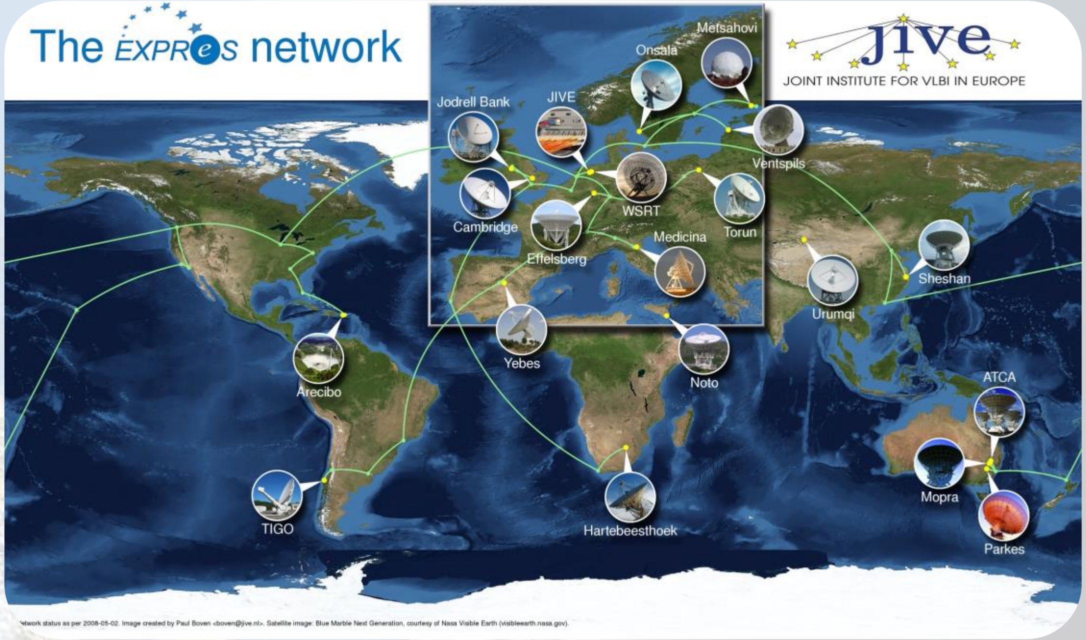
Proposals submitted for use of the VIRAC radio telescopes in 2021

1. *LZP_GMP;* A. Aberfelds, “Galactic masers project” maser monitoring multiyear campanig,
2. *LZP_GMP;* A. Aberfelds. VeA. Cooperation project of Torun and Irbene observatories: search for maser flares and light-VLBI.
3. *LZP PLA;* K. Šķirmante. VeA. Observations of comets in the framework of project LZP PLA.
4. *LZP_PERSEY;* A. Sukharev. VeA. Variability properties of the Seyfert radio galaxy Perseus A in the radio and optical bands - first results of Latvian-Ukrainian joint research project.
5. *LZP_FSR. N. Dugin.* VeA. “The application of the forward scatter radar method for the detection of space objects”.
6. *PRECISE;* M. Giroletti; INAF; Pin-pointing repeating CHIME FRBs with EVN dishes.
7. *VIRAC SUN;* D. Bezrukovs, Solar microwave spectropolarimetric observations with Irbene RT-32 radio telescope.
8. *EVN*, European Very large base interferometry Network, RT-32 un RT-16.

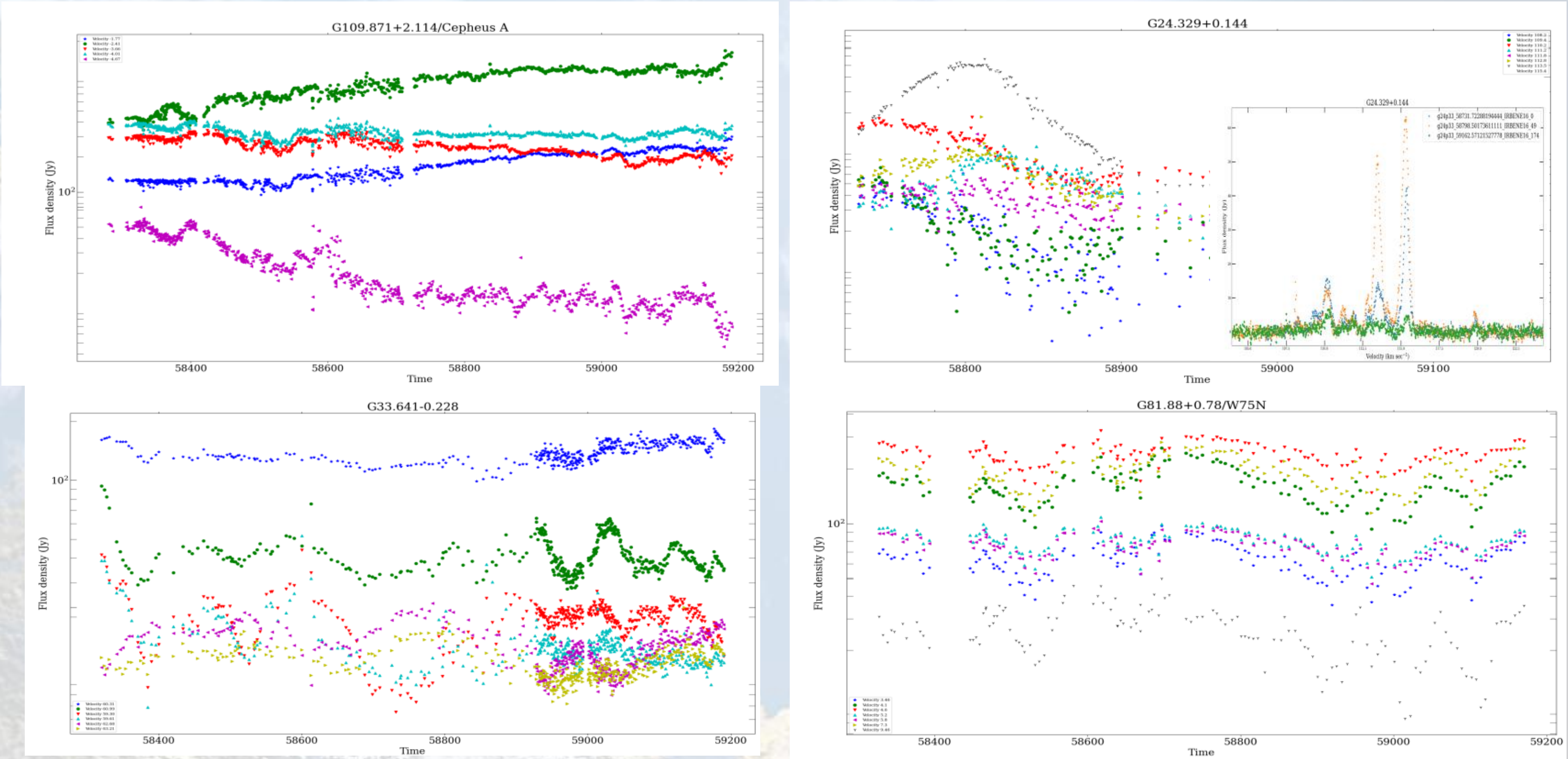
EVN - the international VLBI network

The European VLBI Network (**EVN**) is an **interferometric array of radio telescopes** spread throughout Europe (and beyond) that conducts unique, **high resolution, radio astronomical observations of cosmic radio sources.** It is the most sensitive VLBI array in the world, thanks to the collection of extremely **large telescopes** that contribute to the network.

L Band (1.6 GHz)
C Band (5 GHz)
M Band (6.7 GHz)
X Band (8.4 GHz)



VIRAC methanol maser monitoring program
4 full years



“Galactic masers project” team lead by Ivar Shmeld

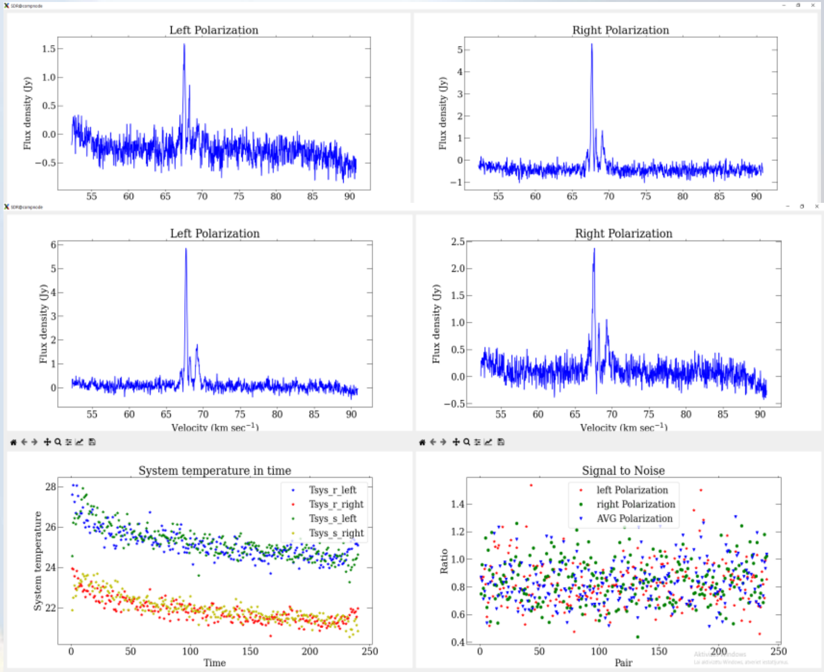
RT-32 North – sky Ex-OH (6035 MHz) maser survey is close to its completion

- New source candidates:
  - G212.06-00.74
  - G33.645-00.227
  - G37.04-00.03
  - G43.0885-00.0114
  - G45.47+00.13
  - G49.60-00.25
  - G49.405-00.370
  - G51.6783+00.7190
  - G49.64-0.51

- Ex-OH variability!?

14 apr

7 dec



"Galactic masers project" team lead by Ivar Shmeld

Patoka, O., Antyufeyev, O., Shmeld, I., Bezrukovs, V., Bleiders, M., Orbidans, A., . . . Shulga, V. (2021). New ex-OH maser detections in the northern celestial hemisphere. Astronomy and Astrophysics, 652 doi:10.1051/0004-6361/202037623

Project “Complex investigations of the small bodies in the Solar system” (No. lzp-2018/1-0401)

goal - to research the **small bodies** in the **Solar system** (mainly, focusing on **asteroids** and **comets**) using modern **methods** of **optical** and **radio astronomy** and **signal processing**.

Observations of OH masers of comets in 2020:

- C/2017 T2 (PANSTARRS) - total 149h,
- C/2019 Y4 (ATLAS) - total 133h,
- C/2020 F8 (SWAN) - total 110h,
- C/2020 F3 (NEOWISE) - total 427h

C/2020 F3 photo By SimgDe - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=92294694

Project "Complex investigations of the small bodies in the Solar system" (No. lzp-2018/1-0401)

Telescope sensitivity requirements:

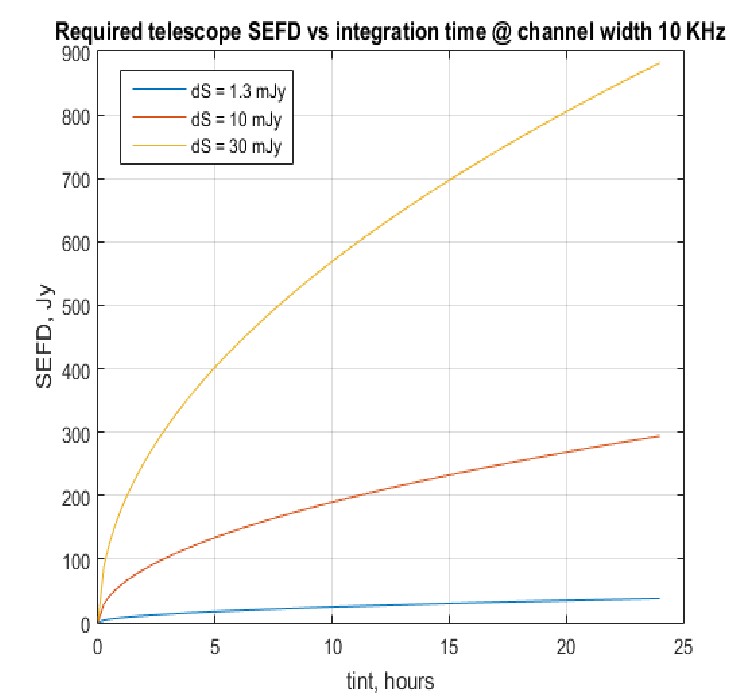
Considering typical peak source flux densities of 4 to 40 mJy, and assuming at least 3*σ detection threshold, at least **1.3 to 13 mJy** noise floor is required.

Measurement uncertainty in vicinity of Gaussian noise in case of single antenna:

$$dS = \frac{SEFD}{\sqrt{(t_{int} * BW)}}$$

SEFD – telescope sensitivity or system effective flux density [Jy], t_{int} *integration time [s], BW – resolution bandwidth [Hz]*

• For example, to obtain dS of 10 mJy with integration time 5 hours and BW = 10 KHz, single dish telescope with SEFD = 135 Jy would be required.



To improve sensitivity and functionality, new receiver was built and installed at RT-32 secondary focus

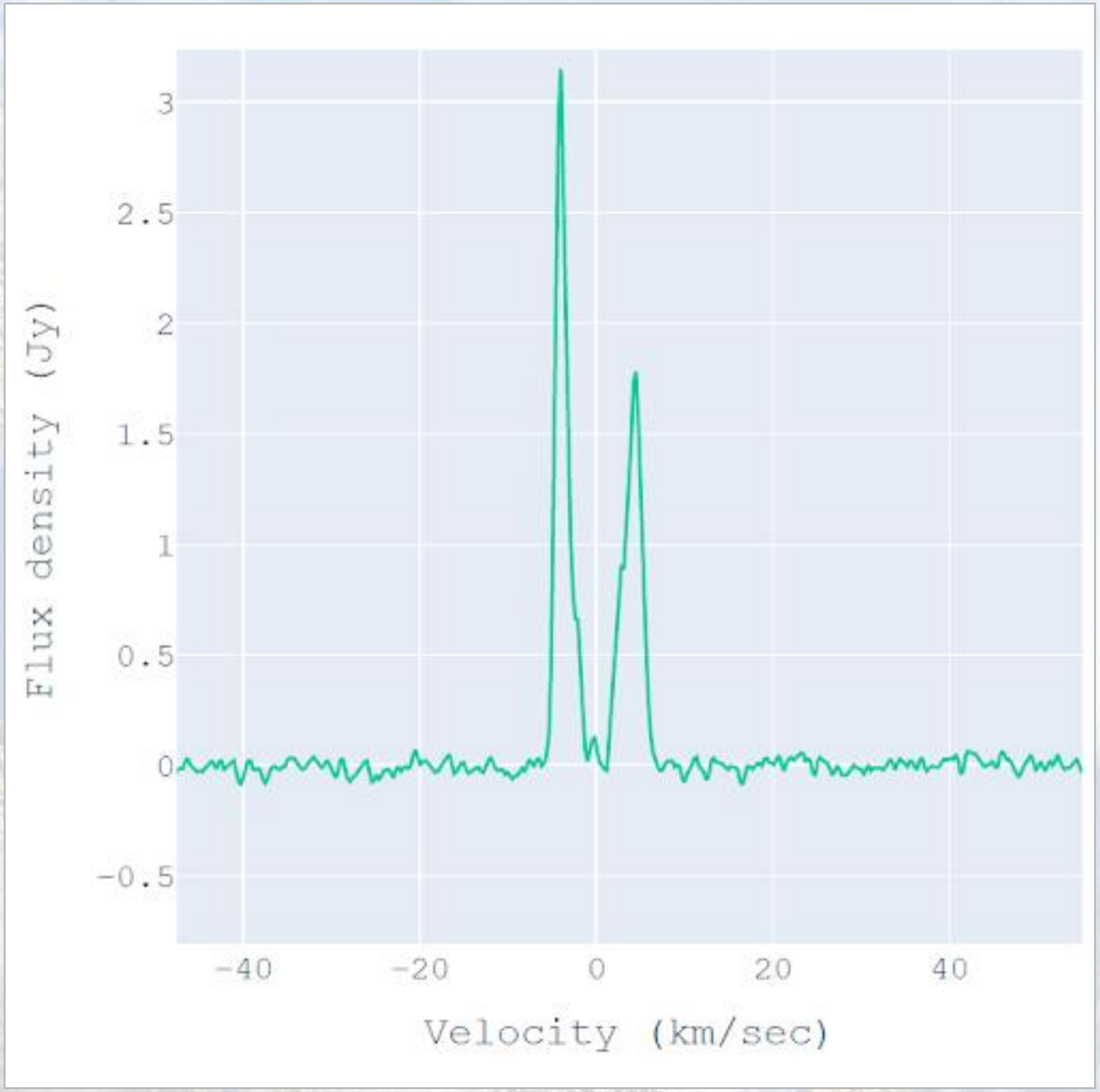
The main concept - low-cost three reflector system with compact dual circular polarization feed horn. Aperture efficiency improved to more than 30 % at 1.65 GHz

Overall estimated sensitivity **SEFD = 650 - 900 Jy** depending on elevation.

Feed antenna installed at RT-32

Dual channel IF unit

Project "Complex investigations of the small bodies in the Solar system" (No. lzp-2018/1-0401)



Object - variable star R LMi. Frequency - 1665 MHz, data set - more than **50 h.** Left circular polarisation. Noise level **below 0.15 Jy.**

"Joint Latvian-Ukrainian study of peculiar radio galaxy "Perseus A" in radio and optical bands. Nr: lzp-2020/2-0121"

Active galaxy NGC 1275 is the central, dominant galaxy in relatively nearby Perseus cluster of galaxies (Abell 426). NGC 1275 is amazingly powerful source of X-rays and radio emissions. Entire galaxy falls into it, and NGC 1275 engulfs that galaxy's material, that feeding supermassive black hole in its core.
It is possible that there is second black hole-satellite in the core, which ensures the precession of source radio-jets (long-term quasi-sinusoidal variability). Filaments of glowing gas, reaching 20,000 light years in length.
Structures ejected from the center of galaxy as result of black hole's activity are supported by magnetic fields.
The galaxy NGC 1275, also known as the radio source 3C 84 (Perseus A), is over 100,000 light-years across and about 230 million light-years away.

NGC 1275 (credit by NASA, ESA, Hubble ST team)

3C 84 is very massive galaxy in a Perseus cluster of many galaxies, in a state of gravitational interaction with its neighbors. Potential candidate for a binary black hole system in the galactic core. 3C 84 has a precession motion of relativistic jets.

In December 2020, scientific project, with participation of Ukraine, was won at a competition in Latvia, and funding was received on the topic "Joint Latvian-Ukrainian study of peculiar radio galaxy "Perseus A" in radio and optical bands".

Observations have begun on radio telescopes RT-32 Zolochiv (Ukraine), and 32-m, 16-m VIRAC (Latvia) as well as with optical telescopes of the observatories Mayaki (Ukraine), Baldone (Latvia), Vihorlat (Slovakia).
The first test results have been obtained and work is underway to improve further measurements. Optical B-V-R-I observations showed the presence of day-to-day variability and noise-like variations during individual nights.

Credit: Leonardo Orazi

V. Bezrukovs[1], M. Ryabov[1,2], A. Sukharev[1,2], S. Udovichenko[3], I. Kudzei[4], P. Dubovsky[4], A. Orbidans[1], I. Eglitis[5] , O. Ulyanov[2], V. Zakharenko[2], A. Konovalenko[2], V. Ozhinskyi[6], V. Vlasenko[6,] D. Bakun[6]

[1] Ventspils International Radioastronomy Centre of of Ventspils University of Applied Sciences, Latvia
[2] Institute of Radio Astronomy of the National Academy of Sciences of Ukraine (IRA NASU), Ukraine
[3] Mayaki Astrophysical Observatory of Odessa National I.I. Mechnikov University, Ukraine
[4] Vihorlat Astrophysical Observatory, Slovakia
[5] Baldone Astrophysical Observatory, Latvia
[6] Space Research and Communication Center of the National Space Facilities Control and Test Center, Ukraine

"Joint Latvian-Ukrainian study of peculiar radio galaxy "Perseus A" in radio and optical bands. Nr: lzp-2020/2-0121"

A) – 32-m antenna of National Space Facilities Control and Test Center, Ukraine
B) – 16-m antenna of Ventspils International Radio Astronomy Center, Latvia
C) – 32-m antenna of Ventspils International Radio Astronomy Center, Latvia

Ukrainian antenna operates at frequencies 4.7-6.8 GHz and 20-25 GHz, and equipped with cryogenic receivers (these able to work in "warm" mode) and spectrum analyzer, can conduct observations simultaneously at two frequencies in two circular polarizations.
Latvian antennas operate at 5, 6.1, 6.7, 8.7 GHz, are equipped with cryogenic receivers and spectrum analyzers, additionally there is 1.6 GHz uncooled (warm) receiver.

"Joint Latvian-Ukrainian study of peculiar radio galaxy "Perseus A" in radio and optical bands. Nr: lzp-2020/2-0121"

The research group (Ukraine-Latvia cooperation in the form of joint AGN research in the Institute of Radio Astronomy NAS of Ukraine and Ventspils International Radio Astronomy Center, Latvia) began work for study of fast intra-day and inter-day variability of AGNs in 2017. Since that time, the equipment of the VIRAC antennas and the software has been improved for this task.

VNT telescope, Vihorlat observatory, Slovakia

Schmidt camera, Baldone observatory, Latvia

Also from 2006 to 2016, the scientific group carried out studies of the radio variability of many active galactic nuclei from the Michigan Radio Monitoring catalog at frequencies 4.8, 8, 14.5 GHz.

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Optical U-B-V-R-I observations, in order to study the fast variability of AGN, are carried out at the observatories

Mayaki, Ukraine (steppe region with a good astroclimate);

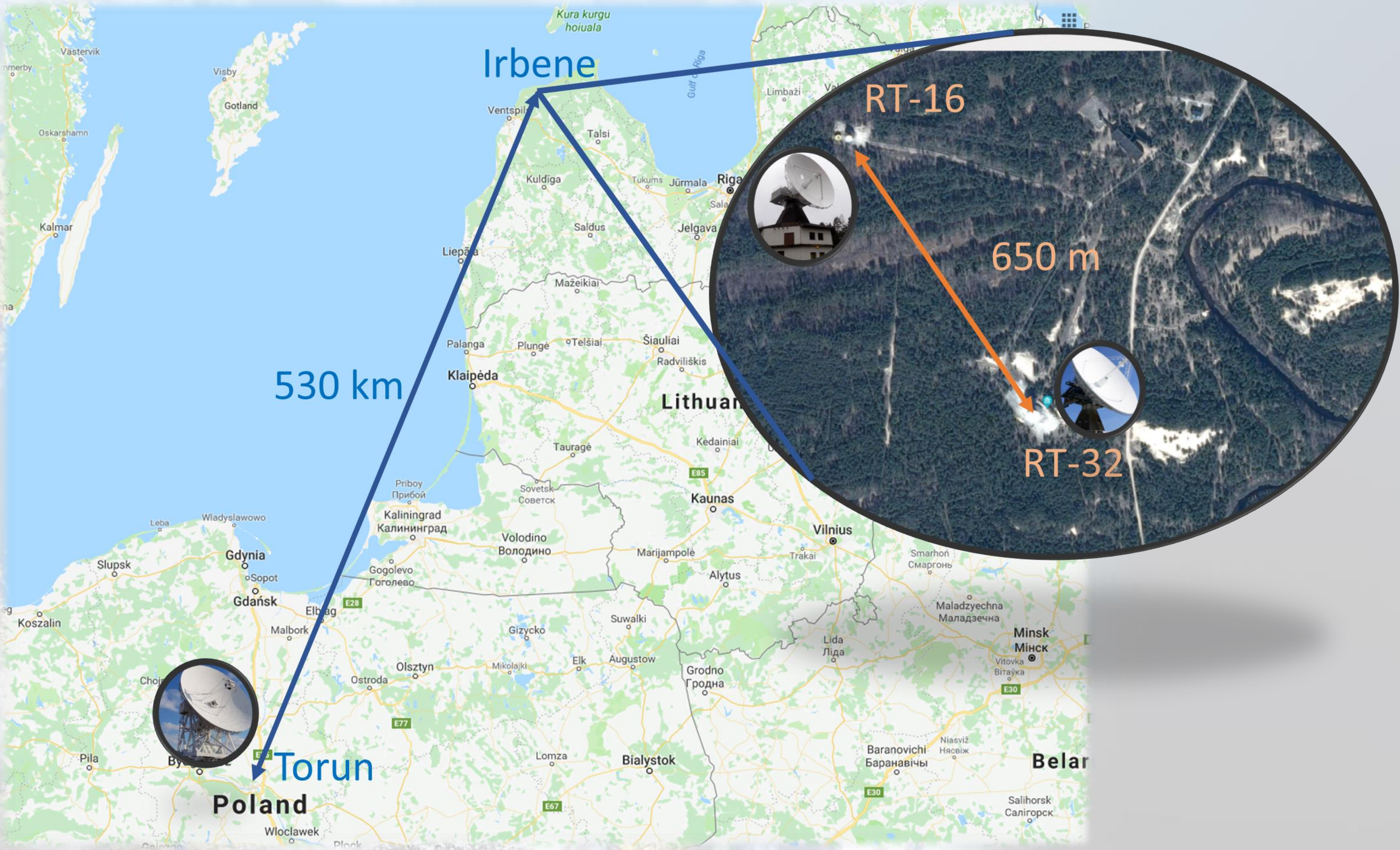
Vihorlat, Slovakia (located in a hilly area); and Baldone, Latvia (place with the best astroclimate in Latvia).

Together with these partners, several works were carried out to study the optical intra-night variability of the OJ 287 and 3C 371 BL-Lac Objects.

Optical telescopes are equipped with cooled high quality CCD sensors and automated control of the observation process.

See report on 5th Oct, 10:10 –10:30: **Sukharev Artem** «Variabiluty of the radio galaxy Perseus A (3C 84) on the data observations with RT-32 radio telescopes in the Latvia and Ukraine»

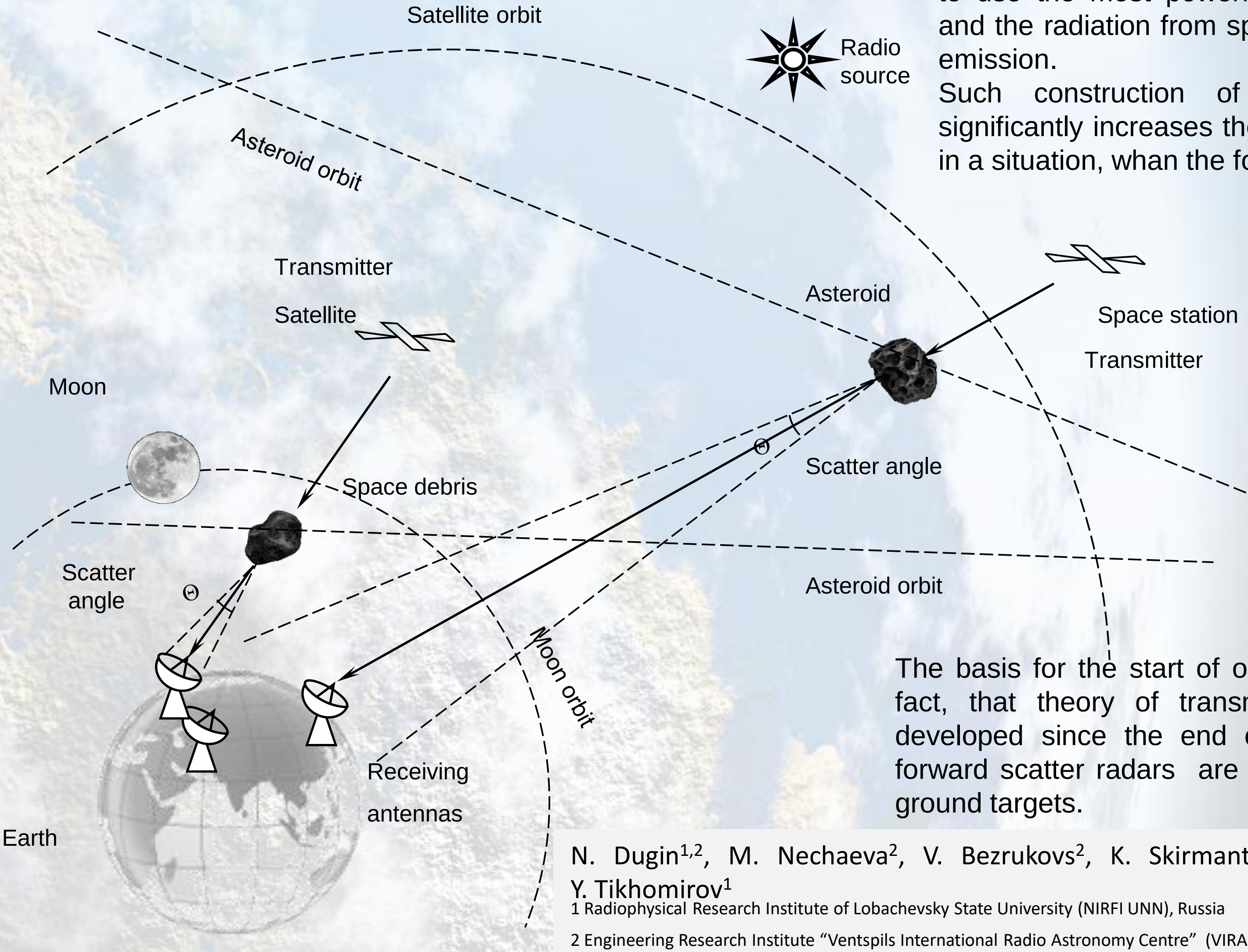
Interferometric observations Irbene +



"The application of the forward scatter radar method for the detection of space objects", Nr. lzp-2020/2-0101

We proposed to improve the radar-VLBI method, namely, to use the most powerful extraterrestrial radio sources and the radiation from spacecraft transmitters as probing emission.

Such construction of a bistatic location system significantly increases the probability of detecting objects in a situation, whan the forward scatter effect arises.



The basis for the start of our work on this topic was the fact, that theory of transmission scattering has been developed since the end of the last century and now forward scatter radars are operating for discover air and ground targets.

N. Dugin[1,2], M. Nechaeva[2], V. Bezrukovs[2], K. Skirmante[2], G. Jasmonts[2], A. Antipenko[1], Y. Tikhomirov[1]

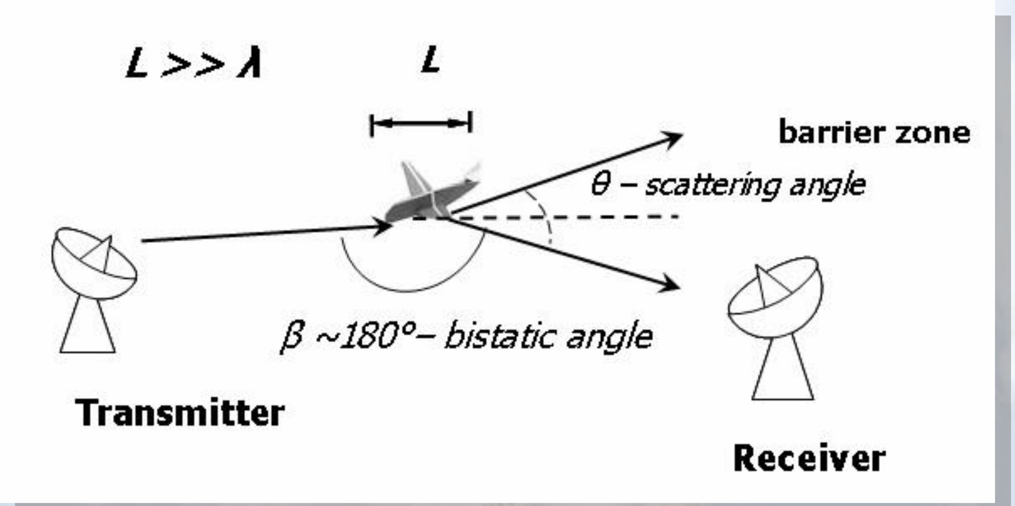
1 Radiophysical Research Institute of Lobachevsky State University (NIRFI UNN), Russia

2 Engineering Research Institute "Ventspils International Radio Astronomy Centre" (VIRAC) of Ventspils University of Applied Sciences, Latvia

Forward scatter radar (FSR) method

belongs to the class of bistatic radar systems.

The method of the forward scatter radar is based on the phenomenon of a significant increase the bistatic radar cross section of target, when the probe signal is scattered forward, along the irradiation line.



Scattering object is located between the transmitter and the receiver.

The signal of increased intensity is scattered in the direction of the object shadow.

Effect of increased reradiation becomes apparent, when the object dimensions L more larger than wavelength λ of emission.

Interest in the FSR appears in the 70-s years of the last century due to their unique ability to detect "black bodies" and aircraft, produced with Stealth technology.

Now this direction is developing rapidly. In the press the publications began to appear on FSR method, calculating the shadow field, the principles of target recognition, coordinates measurements (the location is determined from the measurements of the azimuth and the Doppler frequency).

The main features of FSR method:

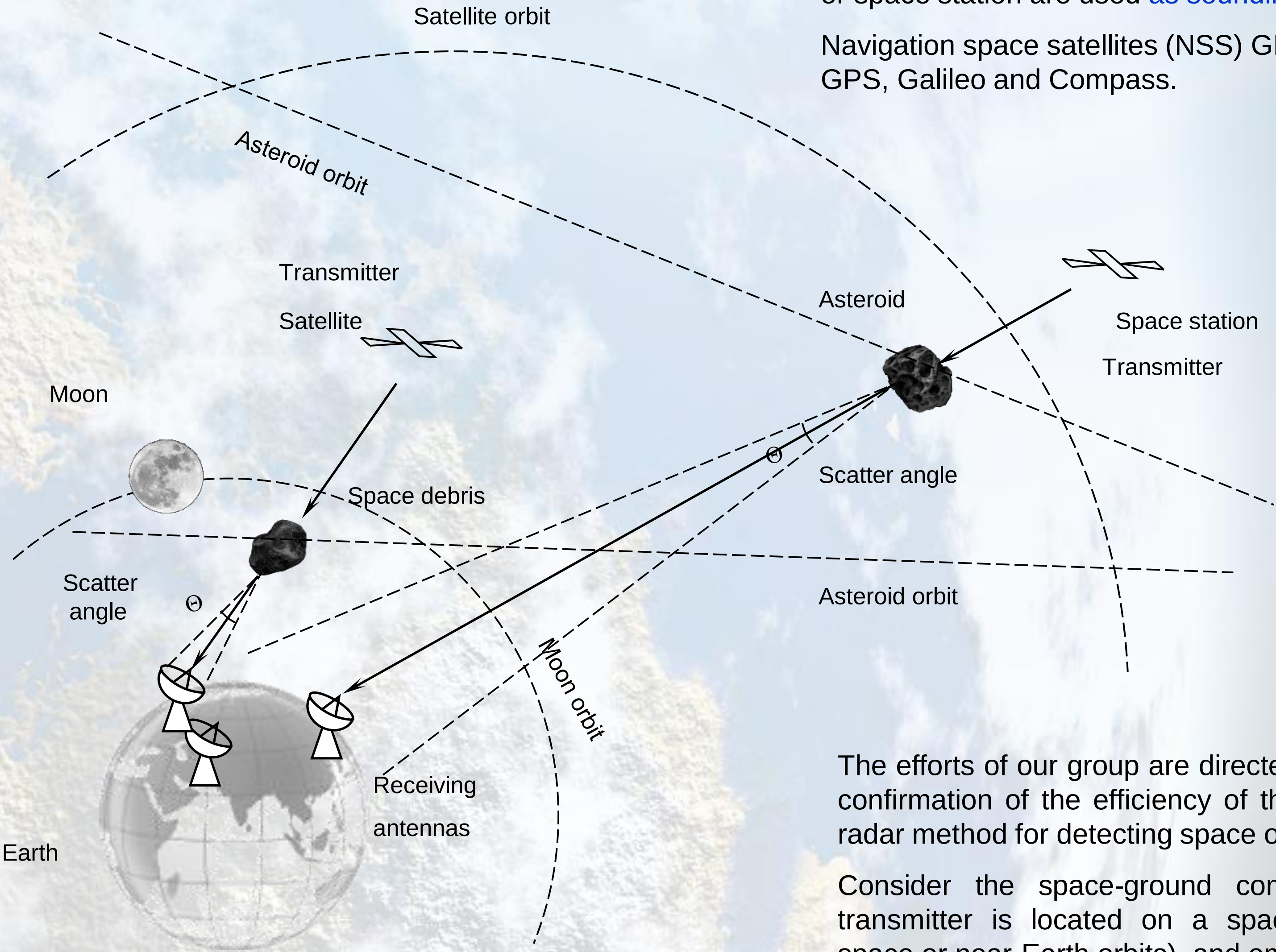
- The energy, scattered forward by three orders is grater, than the energy, scattered back.
- A barrier zone of FSR is very narrow (few degrees): radar operates only near the path “transmitter-receiver”.
- The shadow field of the object does not depend on the shape and material of the target and is determined only by the shadow contour of the object.

This is very important for the task of detecting hard-to-detect targets, built using the "Stealth" technology, or asteroids with small reflectivity factor.

The space-ground system, based on FSR-effect, for detecting space objects: transmitter in space

Signals from satellites in the near-Earth orbits or space station are used as sounding signals.

Navigation space satellites (NSS) GLONASS, GPS, Galileo and Compass.

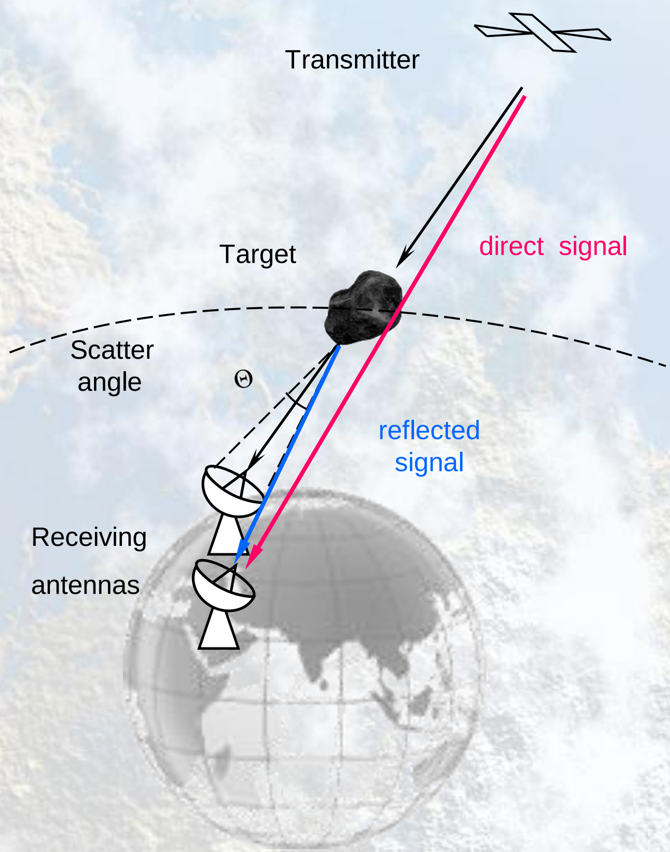


The efforts of our group are directed at experimental confirmation of the efficiency of the forward scatter radar method for detecting space objects.

Consider the space-ground complex, when the transmitter is located on a spacecrafts (in deep space or near-Earth orbits), and emission is received by single antenna or interferometer.

Reception is carried out with

single antenna
and interferometer



The ground antennas receive simultaneously direct signals from the source and reflected signal from the target.

Data processing consists of cross-correlation of direct and reflected signals, received by single antenna,

as well as correlation of signals, received separated antennas: pairs of reflected and direct signals are correlated in different combinations.

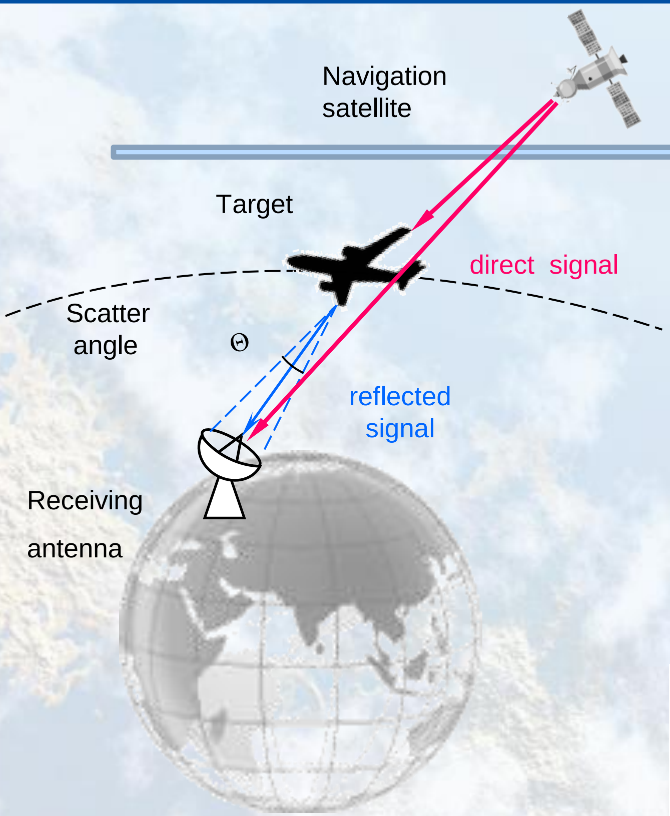
Using the VLBI-technique for data processing allows measure the signal delay and fringe rate for estimating the position and range and range rate of the object,

moreover, such estimation can be made in a single measurement.

This scheme allows to avoid the drawback of forward scatter radar method, that requires to suppress a strong direct signal from the transmitter.

In this complex using of VLBI correlation analysis makes the direct signal is useful (reference).

Experiments on radiolocation of aircraft by NSS signals



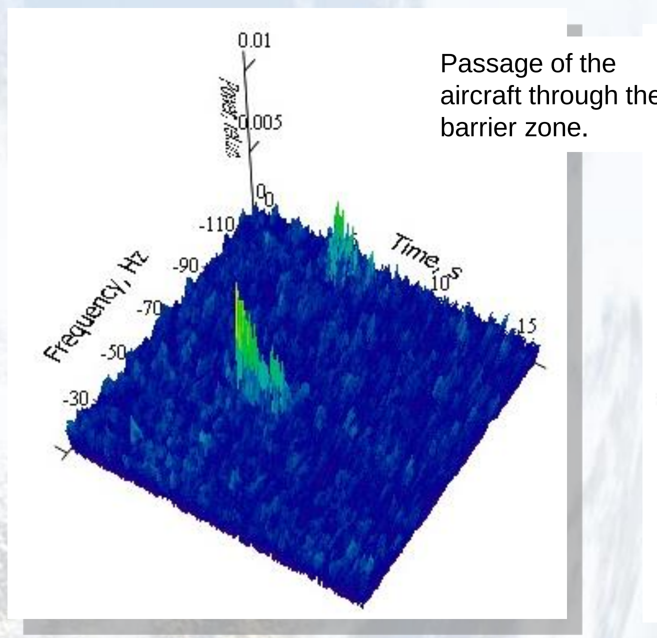
Source of sounding signals: navigation space satellites

Reception: single dish antenna with diameter 2 m (NIRFI UNN, Russia) in L-band

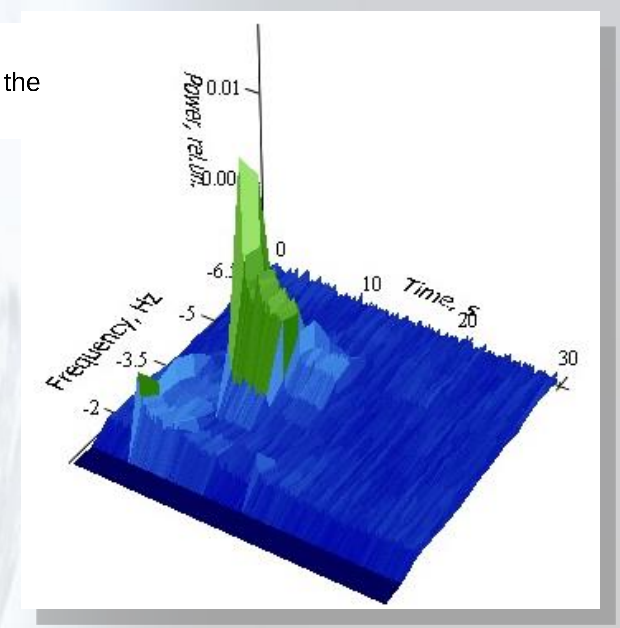
Data processing consisted of cross-correlation of the recorded signal and its copy to detect the air object and measure the delay and fringe rate.

One of the peaks in the power spectrum corresponds to the correlation of the direct signals, the lower peak corresponds to the correlation of the direct and scattered signal. The difference in frequency is determined by the speed of the aircraft relative to the satellite.

The examples of the output signal for a number of time-sequential records depending on frequency and time:



Glonass 33379; object Boeing773, 08:44:00, 12.07.2017.

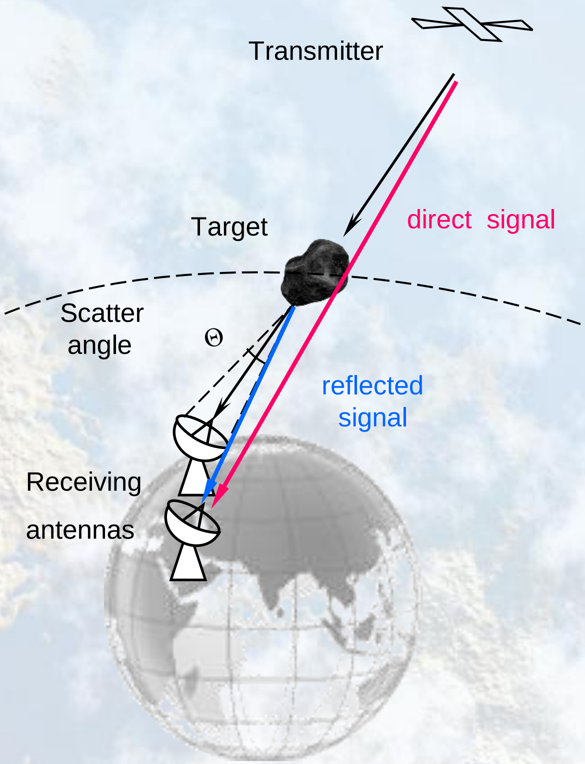


GPS 29486 (PRN31). 10:17:30, 27.07.2017

Due to the rapid movement of the object, the signal accumulation time during correlation processing was minimal (about 0.25 s).

Nevertheless, even for a small antenna area, correlation responses to a passing object are clearly visible. Those, the results of the experiment showed the feasibility of the proposed idea.

FSR-experiment with using interferometric reception on detection of space objects



Source of sounding signals: navigation space satellites

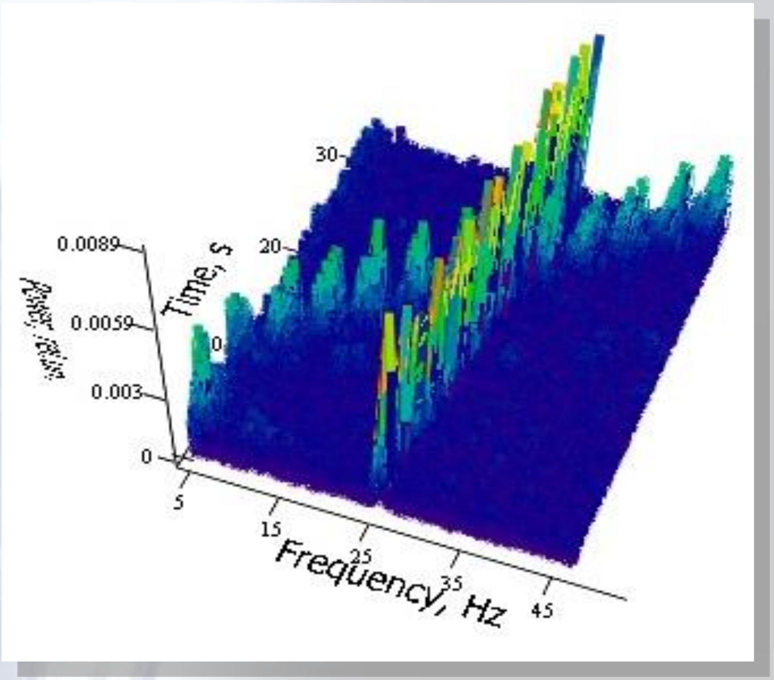
Reception: RT-32 and RT-16 “Irbene” (VIRAC) in single dish and interferometric mode in L-band

During the session, the antennas received the signals of navigation satellites and detected the passages of space objects through the line "transmitter-receiver".

Several dozen of low-flying satellites and space debris were chosen for location.

Correlation responses were obtained in more than 50% of cases. Objects of different geometrical areas, at different distances from the Earth and at different angles from the location line were detected

The signal of interferometer during the passage of large space object through the "transmitter - receiver" location line



15 measurements (correlation function) were taken during an integration time of 1 s and are sequentially shifted in time over a 30-seconds interval.

Two signals are clearly separated:
a signal with a frequency, slowly changing in time, from a navigation spacecraft,
and a signal from a fast-flying space object, the frequency of which changes rapidly over time.

Outlooks

Forward scattering radar method makes it possible to increase the reflected signal from the target by orders, and thus to increase the opportunity and range of celestial bodies detection.
However, a narrow barrier zone is significant drawback of this method.

A narrow barrier zone requires placing several receiving stations on the Earth surface to increase the probability of detecting a powerful scattered signal. The network of antennas can work in the standard VLBI mode, increasing the sensitivity and resolution of instruments.

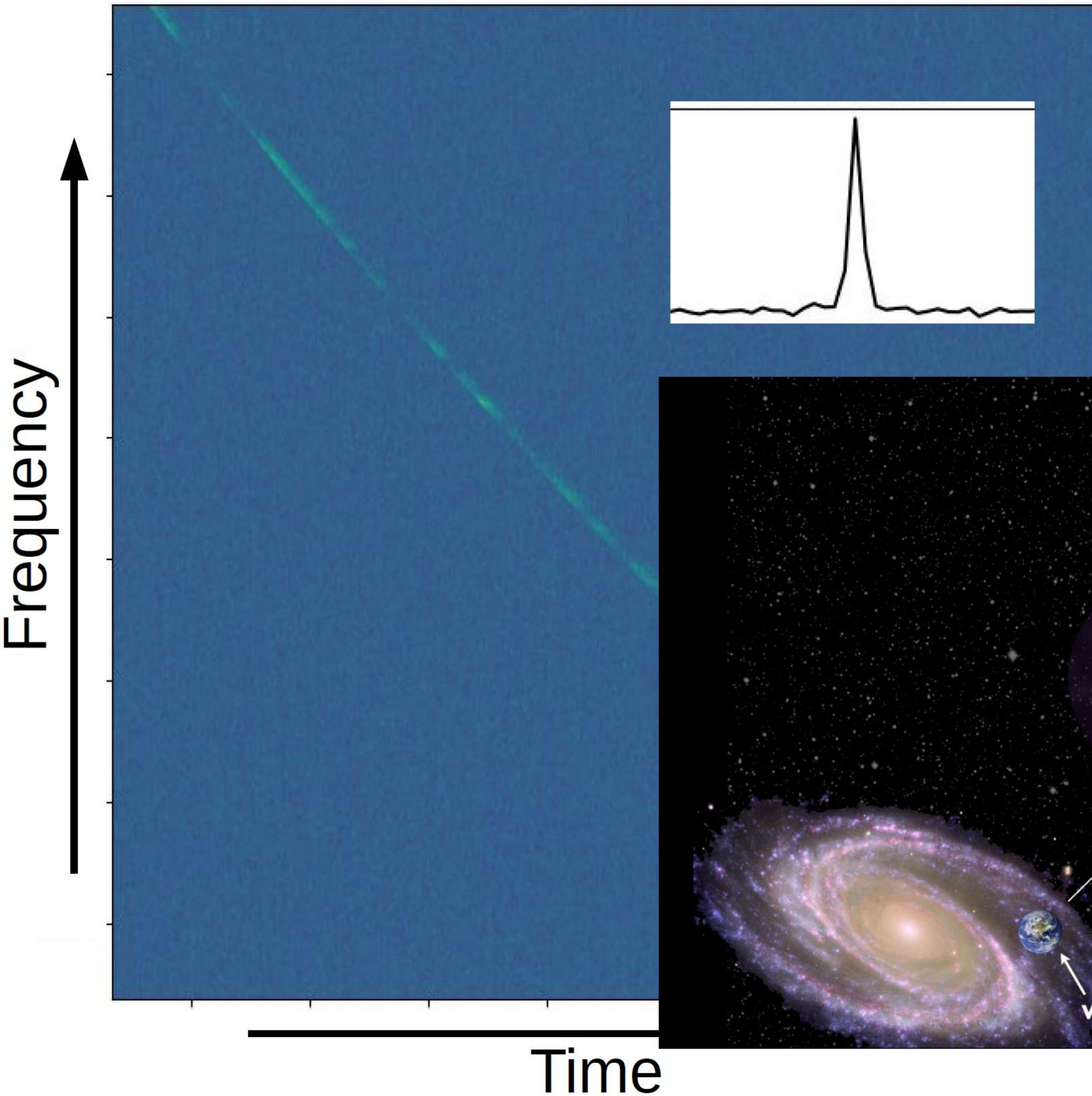
Now the low frequency module of the LOFAR system is installed in Irbene. This makes it possible to expand the frequency range and capabilities of antenna systems to continue work on the translucent location.
In future, other LOFAR modules can be involved, which will strongly increase the research efficiency.

Having receiving equipment for several frequency bands and access to the largest radiotelescopes, we are planning experiments on the radar of aircraft and satellites using the probing signals of the Sun, navigation satellites and spacecraft in deep space.

PRECISE --
Pinpointing Repeating CHIME-Sources with EVN-dishes

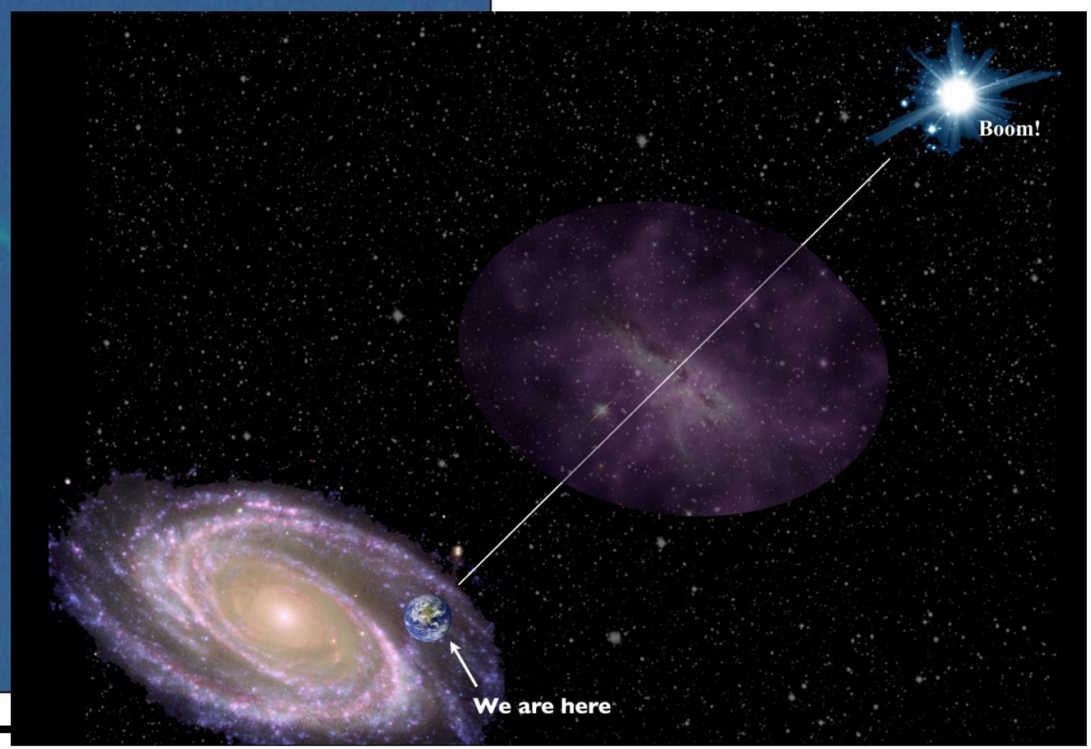
Franz Kirsten
On behalf of the PRECISE-team

Fast Radio Bursts – FRBs

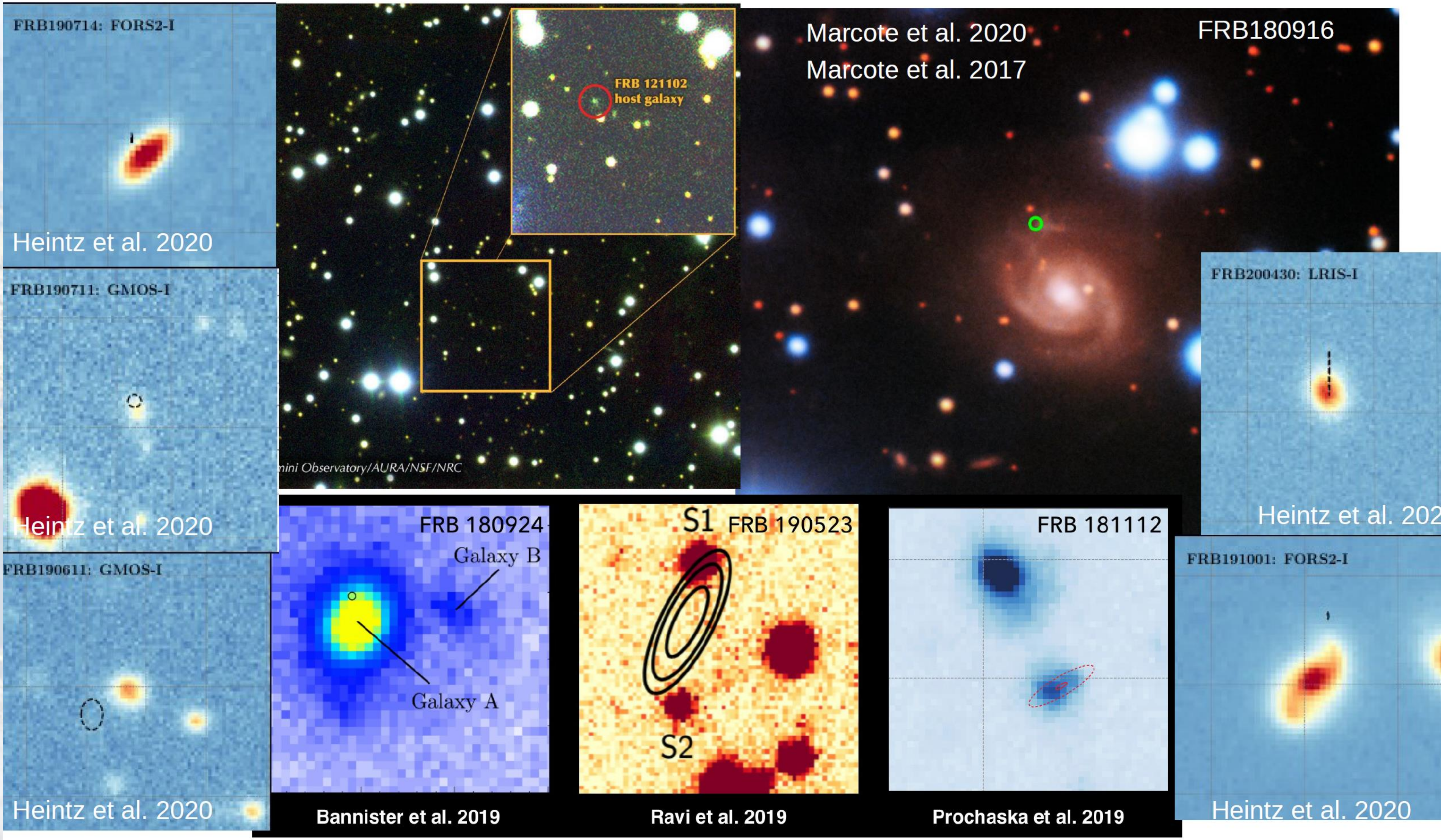


Dispersion measure
$\sim 100 < DM < \sim 3000$
$\rightarrow 0.03 < z < 0.66$

Cosmologic origin



One key is **localisation**



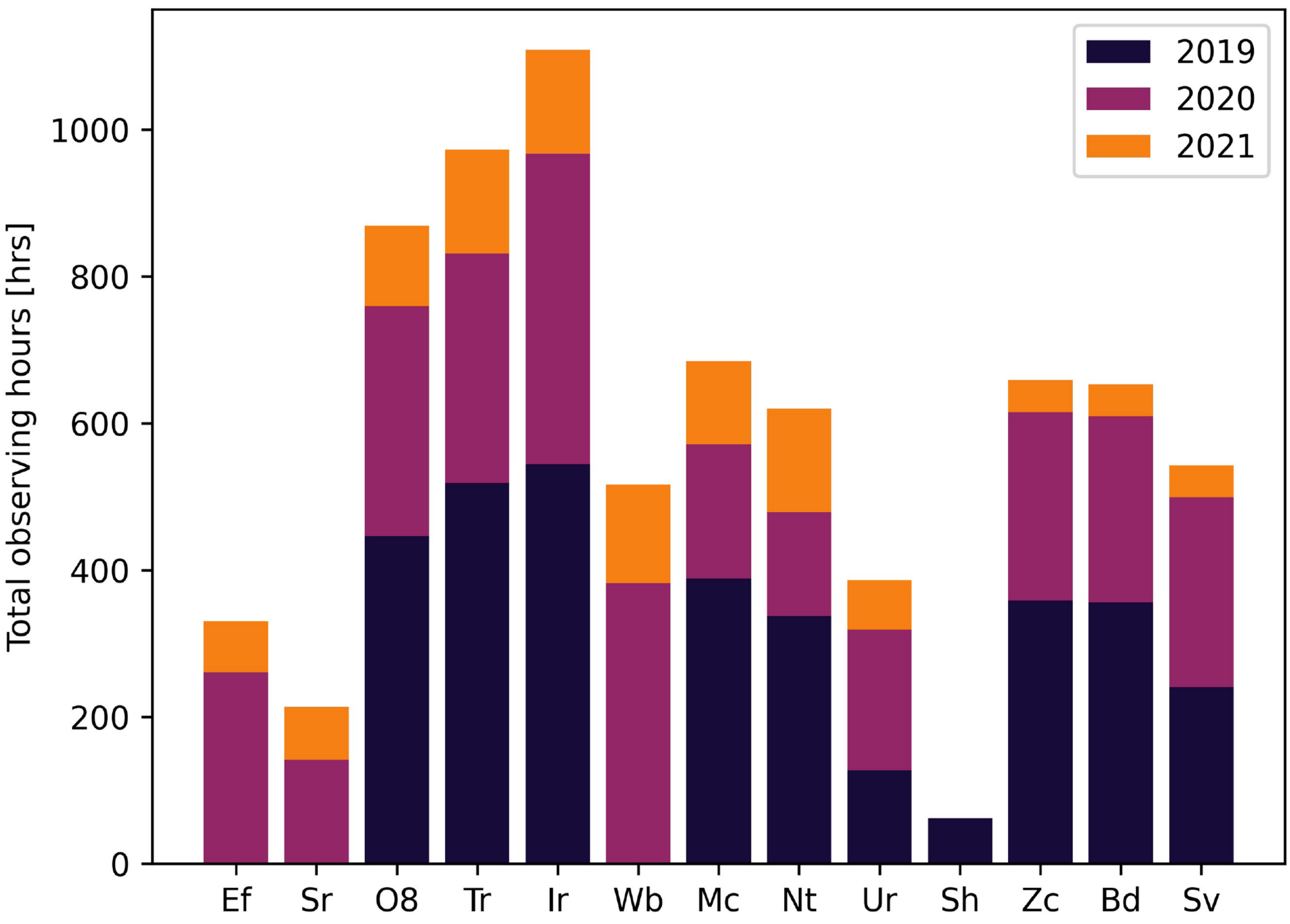
~150 published FRBs, ~20 known to repeat, 13 localisations, **2 with mas-precision**

PRECISE – shadowing CHIME

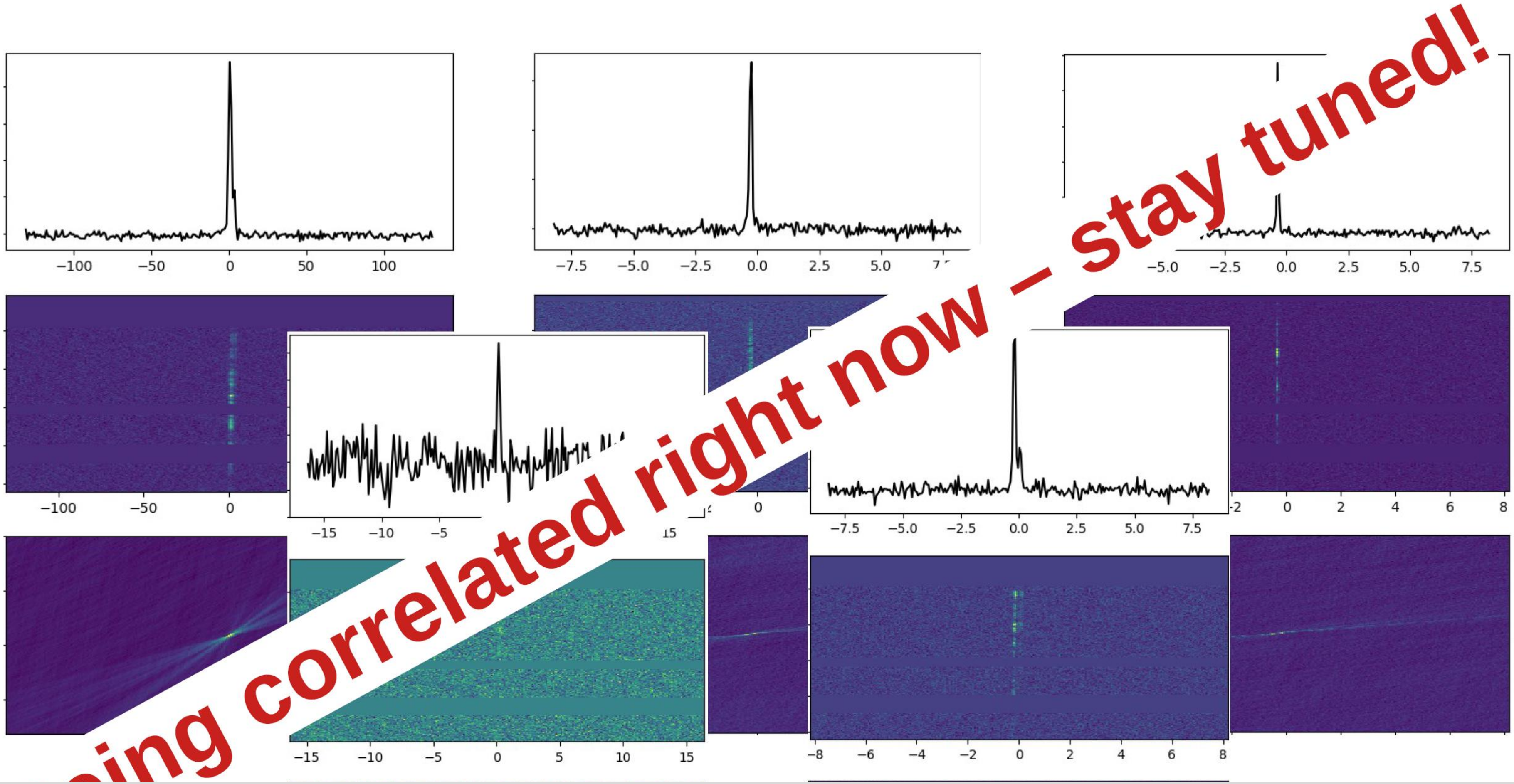
Organised via directors approval (Letters of Intent) (O8,Tr,Sv,Bd,Zc,Sh,Wb,Ur)

And proposals (Ir, Mc, Nt)

PRECISE – hours spent per dish



PRECISE – burst **detections**



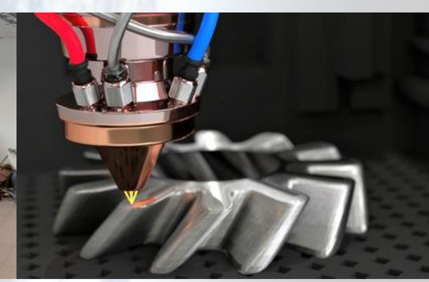
Submitted to Nature:
Kenzie Nimmo (ASTRON) et al "Burst timescales and luminosities link young pulsars and fast radio bursts".
Franz Kirsten (Chalmers University of Technology) et al "A repeating fast radio burst source in a globular cluster."

INFRASTRUCTURE DEVELOPMENT

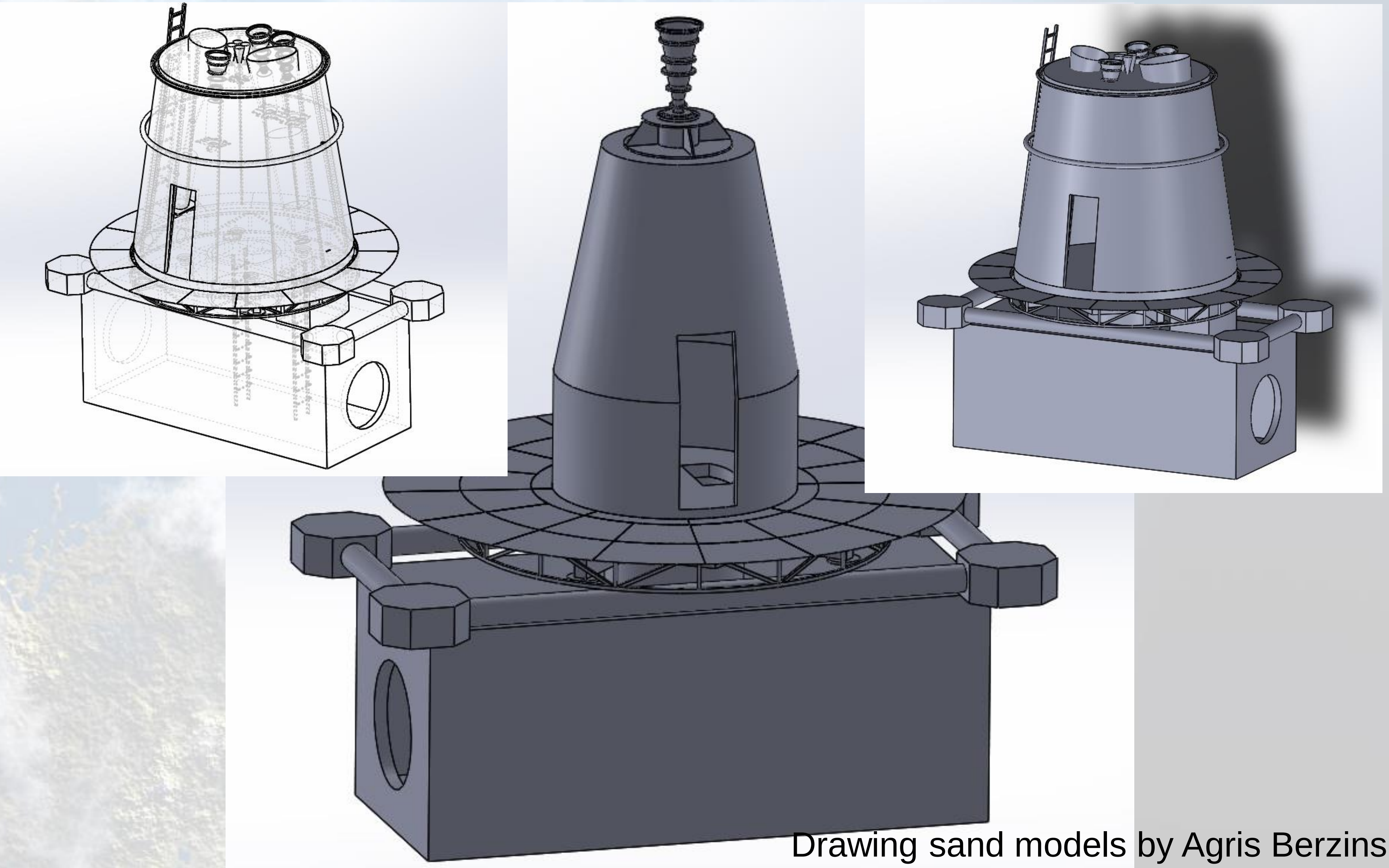
- Extension of the receivers vertex room (2022);
- Secondary focus adjustments (2022);
- RT-32 mirror surface adjustment (2022-2023);
- The new receivers for RT-32 and RT-16 (2022-2024);
- Establishment of ground base stations for satellite communication (2022);

Laboratories as commercialisation platforms for VIRAC technological developments:

- Satellite technology development and testing laboratory based on an existing 3D prototyping laboratory;
- Digital aperture antenna array (DART) laboratory;
- Radio frequency (RF) and cryogenics laboratory.



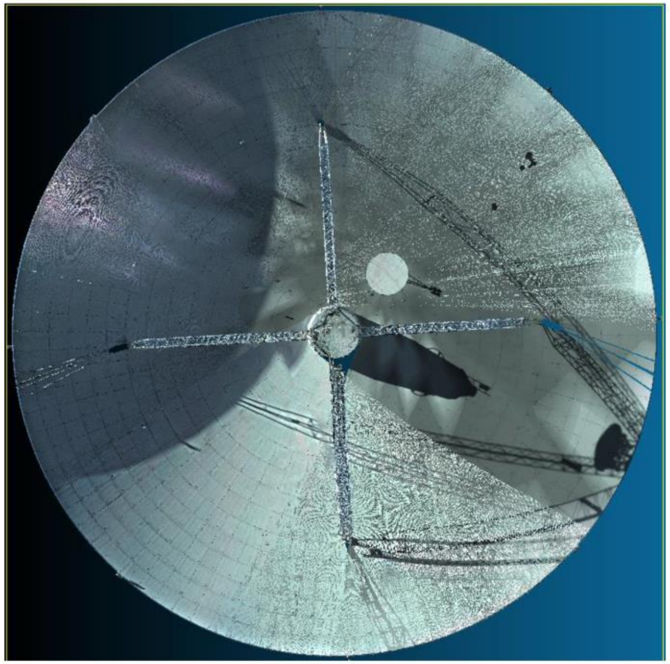
VIRAC future plans for infrastructure enhancement: new RT-32 vertex room

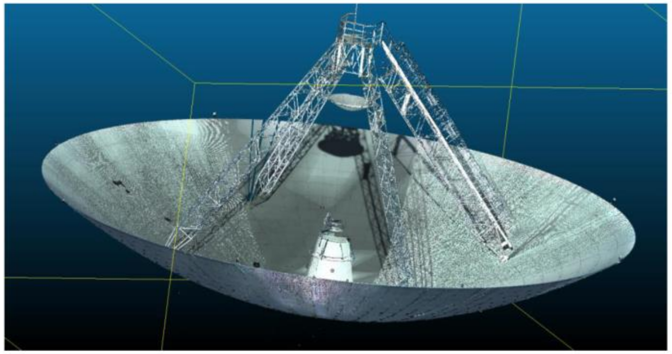


Drawing sand models by Agris Berzins

VIRAC future plans for infrastructure enhancement: radio holographic system for RT-32 and surface alignment

RT-32 laser scanning point cloud (with colors)





- Measurment date: April 2016 (no deliberate adjustements done since then, so should be compareable to current situation)
- Measurement at elevations: 90˚(best data quality), 36˚, 6˚
- Laser scanner: *Leica ScanStation P30/P40*
- Triangular mesh derived after manual point flagging/cleaning, filtering and downsampling

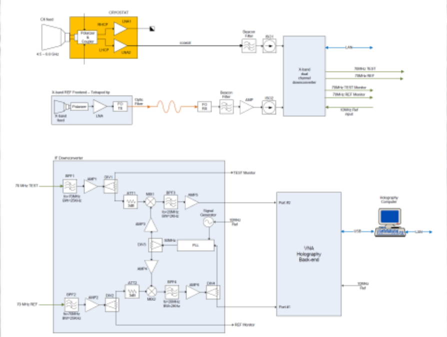


Figure 1: X-band holography system.

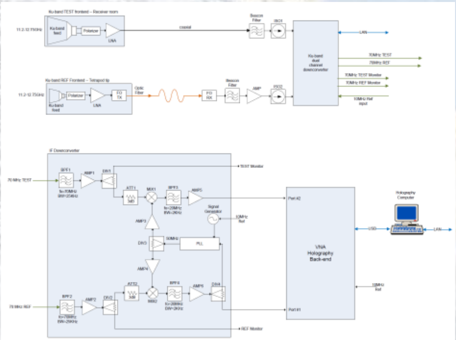
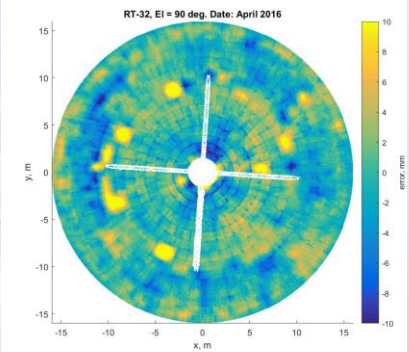
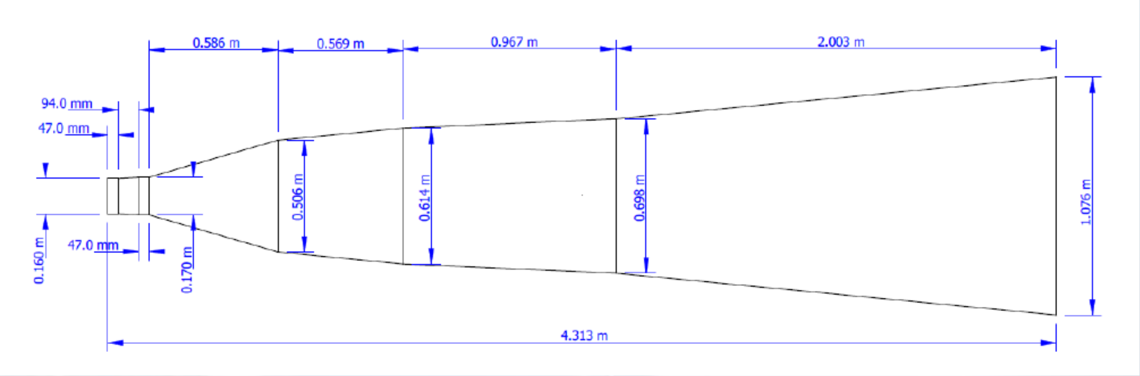


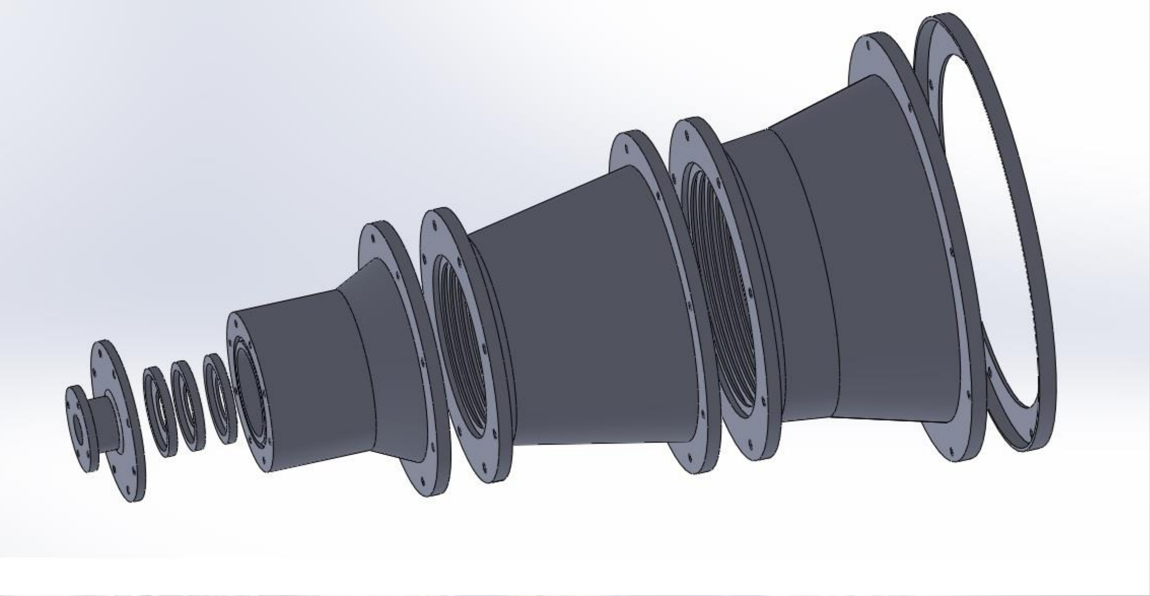
Figure 2: Ku-band holography system.



Drawings and models by MTM proposal, Marcis Bleiders and Marcis Donerblics studies

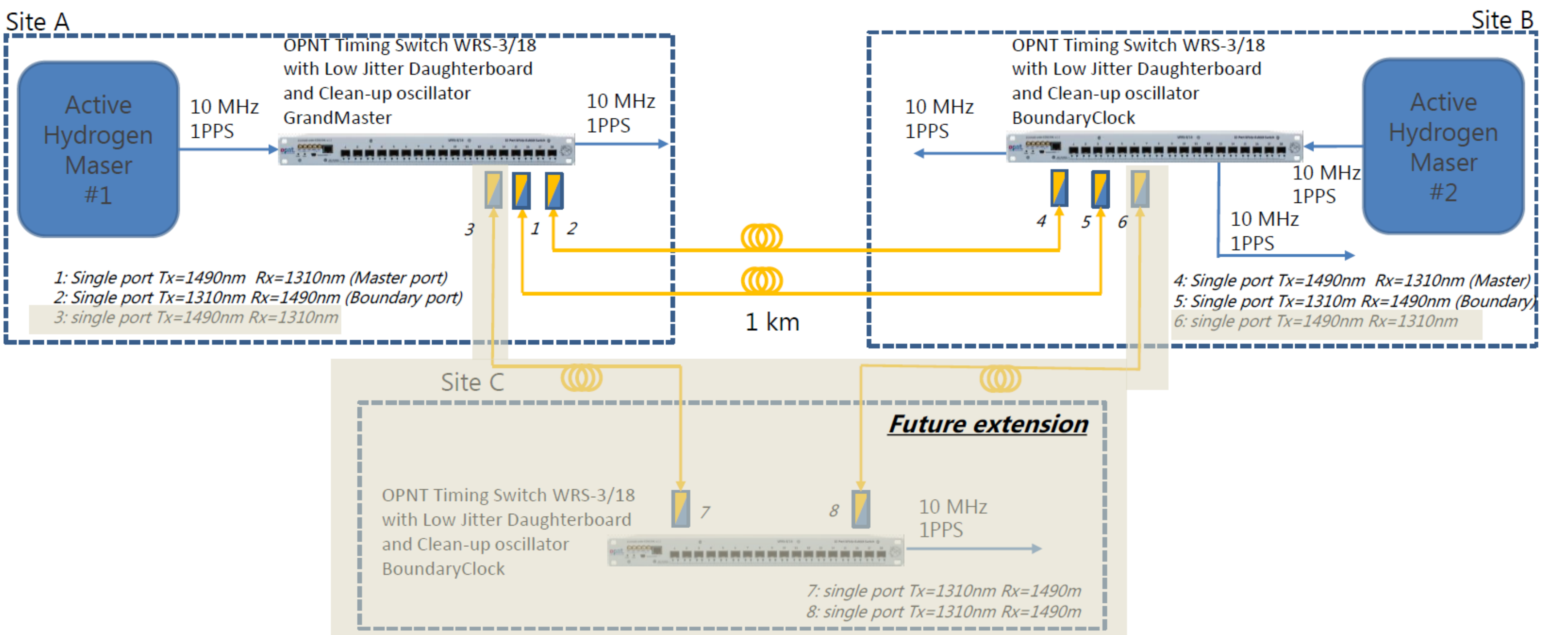
VIRAC future plans for infrastructure enhancement: new cryogenic L-band receiver for RT-32





Drawings and models by Marcis Bleiders and Agris Bezrins (article in preparation)

White rabbit in Ventspils



CURRENT LATVIAN INVOLVEMENT IN ESA ACTIVITIES:
Registered entities

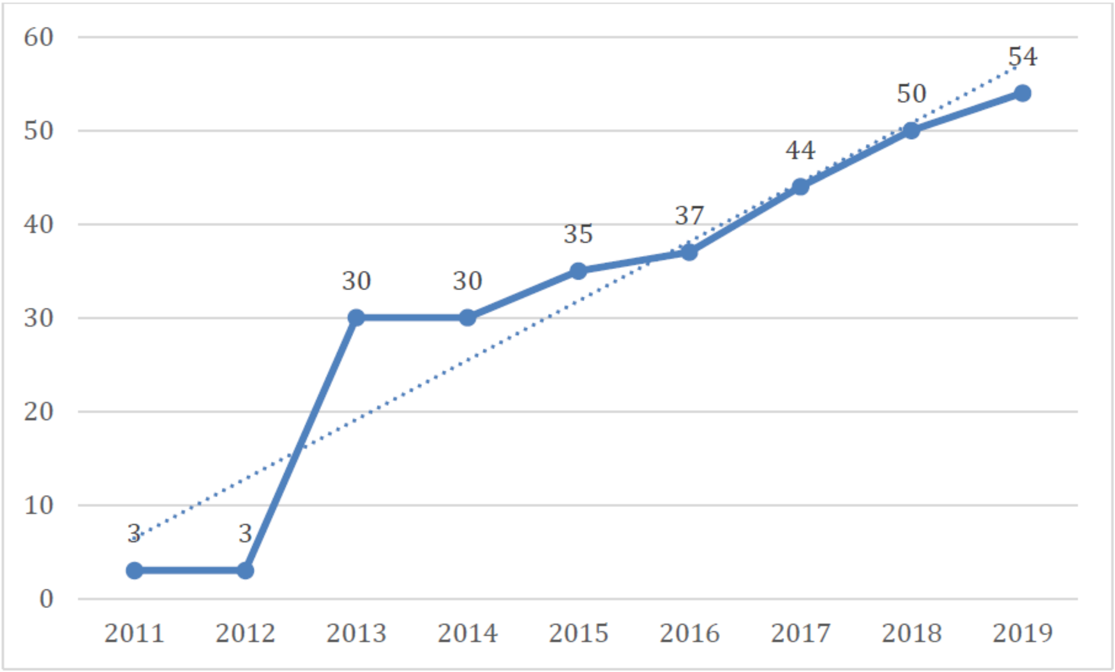


Figure 1: Growth in esa-star registrations since the start of the cooperation with ESA

Most important ESA projects in VIRAC:

- RT-16 S-band capability for TT&C service;
- RT-16 X-band capability for TT&C service;
- Development and production of a universal measuring system that meets the requirements of the ECSS standards system (MeasureRight);
- Development of university course - Satellite communications systems.

Other ESA projects in VIRAC (in preparation):

- Web service for simple interferometer network for co-located Geo-stationary communication satellites tracking (GeoSatTracking);
- Feasibility of OSI transport layer counter-fast-fading system for Railways (PauseMaker);
- Investigation of stratospheric and meteorites origin aerosols as climate impact factors using remote sensing data technologies;
- Spatio-temporal anomaly detection in multispectral satellite image time series for unsupervised water quality monitoring in Baltic Sea.

Establishing RT-16 S-band uplink and downlink RF to IF chain for TT&C service (RTGS)

The project currently has reached only the first Mile Stone Review. At this point, Technical Requirements from SSC as well as systems concept design, and theoretical designs of dual band Feed System and S-band HPA are available.

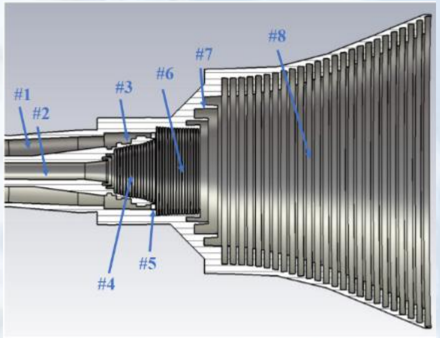


Figure 2. CST model of S/X band feed horn for VIRAC 16-m antenna.

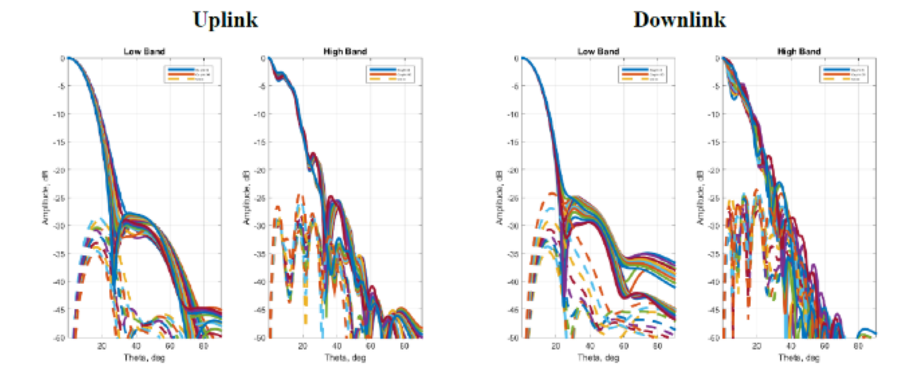


Figure 3. Calculated linear polarized far field radiation patterns of feed horn at uplink and downlink frequencies of S-band (Low band) and X-band (High band). Overlay of multiple frequency results within respective frequency bands is shown.

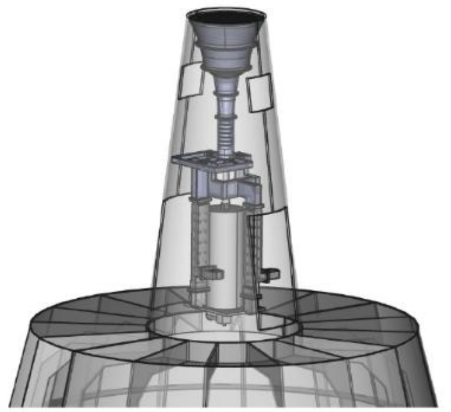


Figure 38. Complete feed system inside the RT-16 secondary focus vertex room.

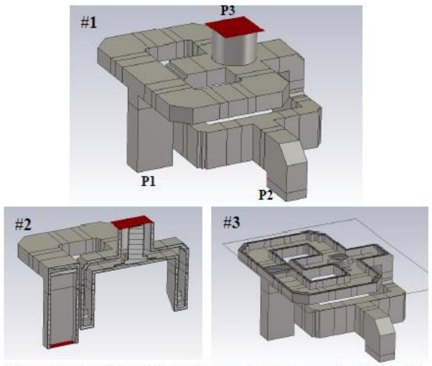


Figure 15. CST model of S-band orthomode transducer. Top figure – overall view. Bottom figures - views of two sectional cuts.

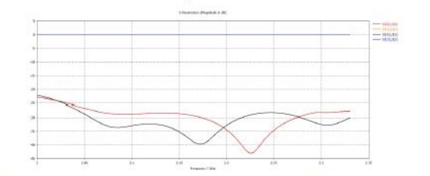


Figure 16. OMT rectangular waveguide port TE10 mode return losses (S11, S22) and insertion losses between rectangular TE10 and appropriately polarized coaxial TE11 modes (S3(2)1(1), S3(3),2(1)).

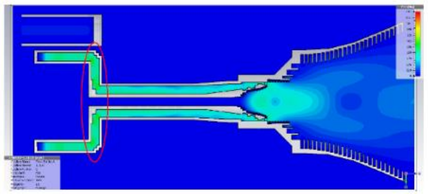


Figure 20. Distribution of time average electric field intensity at 2100 MHz. Combined absolute value of vector components is shown.

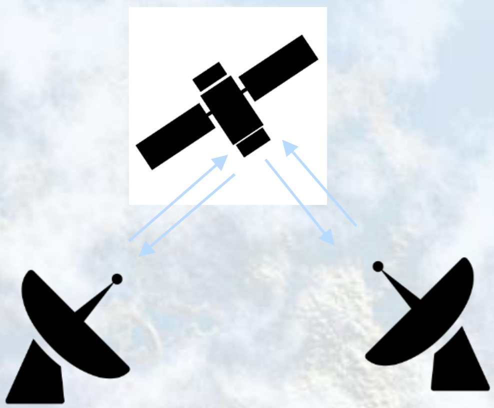
Mechanical design (exploded view) of feed system

Future of RT-16 as a ground station

- The project has allowed to establish strong industry collaboration between VIRAC and SSC.
- It has provided an opportunity to become a key player in Latvian Space Industry and in fulfilment of Latvian Space Strategy as Latvia has become an Associate ESA Member State.
- The opportunities discovered has allowed to **set up two start-up companies**.
- Follow-up projects for further development of VIRAC large aperture antennas for **satellite communications has already been submitted together with SSC**.
- It is our ambition **to become a part of European Space Industry with Ground Segment services** based on adaptation and sharing of infrastructure model providing maximum benefit on European and Global scale for **both Space Missions and Fundamental Research in Radio Astronomy**.

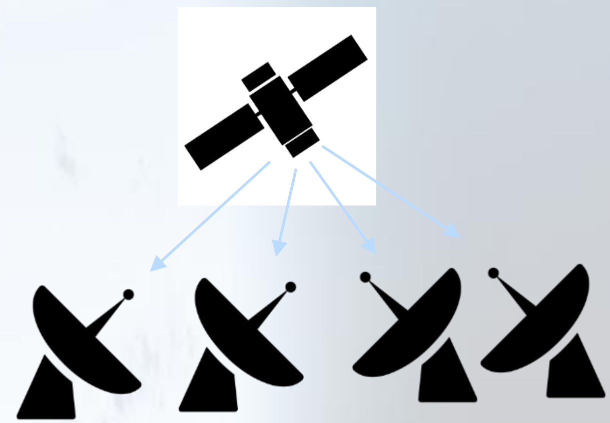
ORBITAL POSITION MONITORING OF CO-LOCATED GEOSTATIONARY COMMUNICATION SATELLITES BY SIMPLE INTERFEROMETER NETWORK USING MULTISTANDARD RECEIVERS: Conception

Active ranging radars



Two-way radar ranging

Simple INTerferometer NETwork (SintNet) or PAssive COrrelation RAnging (PaCoRa)



SintNet

SintNet Features:

The standard deviation of the TDOA (Time Difference Of Arrival) is **8.6 ns** (60 s averaging interval).

The standard deviation of the satellite's coordinates estimation is about ***200 m*** using the *numerical model* of satellite motion and ***24h observation data***.

The network of ***three stations*** provides coordinate precision close to the precision of networks of 4 and more stations.

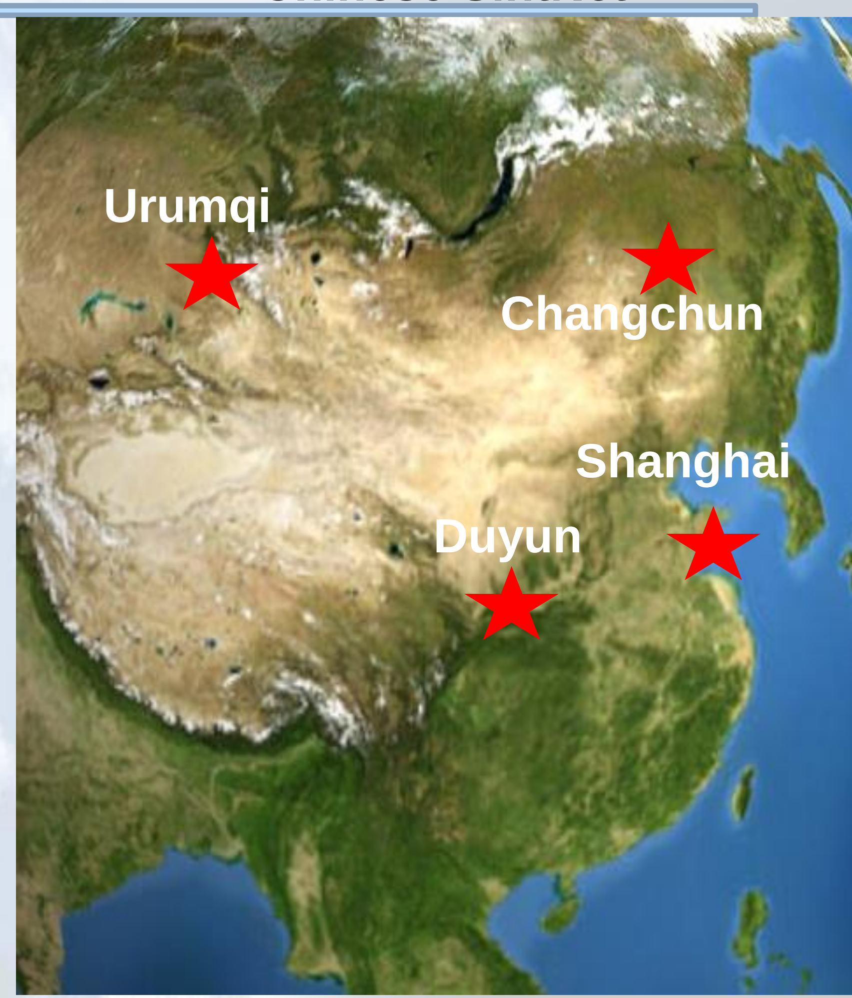
Simple interferometer networks

European SintNet

Baselines: West-East – 2000 km, North-South – 2000 km

10 stations: Mykolaiv – 3, Rivne – 2, Ventspils – 2, Kharkiv, Mukacheve and Pietramarina -1

Chinese SintNet

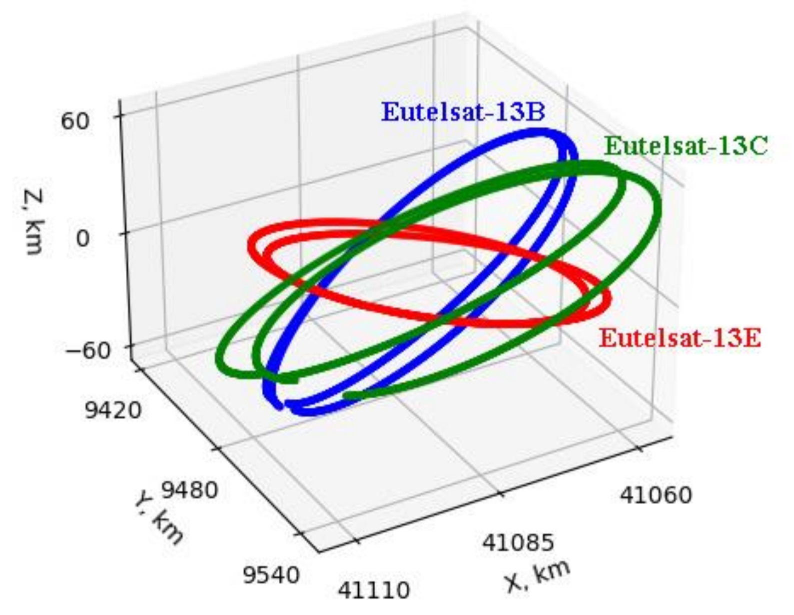


Baselines: West-East – 3000 km, North-South – 3000 km

4 stations: Shanghai, Urumqi, Duyun, Changchun

Operation of the European SintNet

Operates since Sep., 2015.
Now tracks Eutelsat-13B, 13C and 13E (all three satellites in 13ºE cell)
Tracking of the third satellite Eutelsat-13E started on May 27, 2021



3D positions of Eutelsat-13B, 13C and 13E in ITRF2008. May 29-30, 2021.
Minimum distance is **7 km**, maximum – **81 km**.

Catalog of orbital elements (the numerical model) is obtained for Eutelsat-13B (1820 days), Eutelsat-13C (628 days) and Eutelsat-13E (35 days).

NATIONAL DEVELOPMENT PLAN 2020
EUROPEAN UNION
European Regional Development Fund
INVESTING IN YOUR FUTURE

"Support to the Ventspils University of Applied Sciences in preparation of international cooperation projects for research and Innovation" Project No. 1.1.1.5/18/I/009

Thank you!

Related projects:

1. **"Complex investigations of the small bodies in the Solar system". Nr. lzp-2018/1-0401**

2. **"The application of the forward scatter radar method for the detection of space objects". Nr. lzp-2020/2-0101**

3. **"Joint Latvian-Ukrainian study of peculiar radio galaxy "Perseus A" in radio and optical bands. Nr: lzp-2020/2-0121"**

4. **Research of Galactic Masers. Nr.: lzp-2018/1-0292**

H2020 programme ORP Pilot:
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004719.

Cryogenic insulation thermal conductivity testing system

1. Potential customers are **ESA** and other space technology developers and manufacturers;
2. The duration of the test process shall be between **48** and **720** hours;
3. The cost of testing one hour (by analogy with similar tests performed by NASA) is **up to €200 per hour**, depending on the complexity of the test;
4. Possible sale of test services after project implementation.

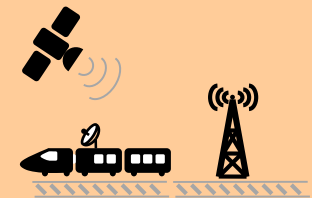
cryogenic and vacuum systems

koksnes ķīmijas institūts · institute of wood chemistry

Technical parameters:

Mērījumu ievades skaits	Ne mazāk kā 12
Ieejas pretestība	> 10 MΩ
Atlases laika posms	Ne vairāk kā 10ms
Izolēšana starp mērījumkanāliem	Ne mazāk kā 500 V d.c.
Mērījuma kanāla izolācija	Ne mazāk kā 500 V d.c
Mērījumu kļūda	Mazāk nekā 0,05% no diapazona

VIRAC for Railways



SatCom
Railway link quality enhancer

TerraNet
Terrestrial 5G+SatCom integration

PauseMaker

LEO + (MEO) orbits (<10000 km)

Variable Interleaver

GEO + (MEO+HEO) orbits (>10000 km)

NMF DTN Solutions

Educational programs