VENTSPILS AUGSTSKOLA

VIRAC

Recent technical developments for radioastronomical observations in VIRAC

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

The International Workshop
"RT-32 ZOLOCHIV: FIRST RESULTS, EU COLLABORATION, RADIO ASTRONOMY FRONTIERS"
October 3-5, 2019, Zolochiv, Ukraine

Main areas of the VIRAC

- Radioastronomy, astrophysics and space studies
- Remote sensing
- Sattelite technologies and electronics
- High performance computing

A sustainable research excellence

Main target: to become a global research service provider in the field of space technology research, thus speeding up the international growth of companies in the engineering industry in Latvia and Ventspils.

VIRAC is carrying out this task by providing research and research services of high quality and client driven approach, in close cooperation with Ventspils University of Applied Sciences and other RTD organizations and companies with similar aims.

Ventspils International Radio Astronomy Centre - infrastructure

Ventspils University of Applied Sciences

Kristal

RT-32

RT-16

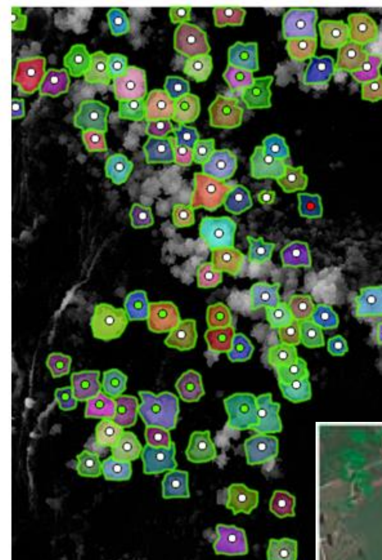
LOFAR station
in operation from 2020

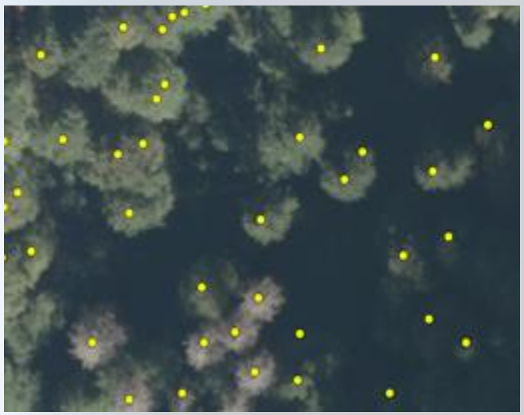
Remote sensing

1. Forest industry: monitoring forest resources

Estimation of forest inventory parameters using aerial images, Lidar data and satellite images

Delineation of tree crowns using aerial images and Lidar data

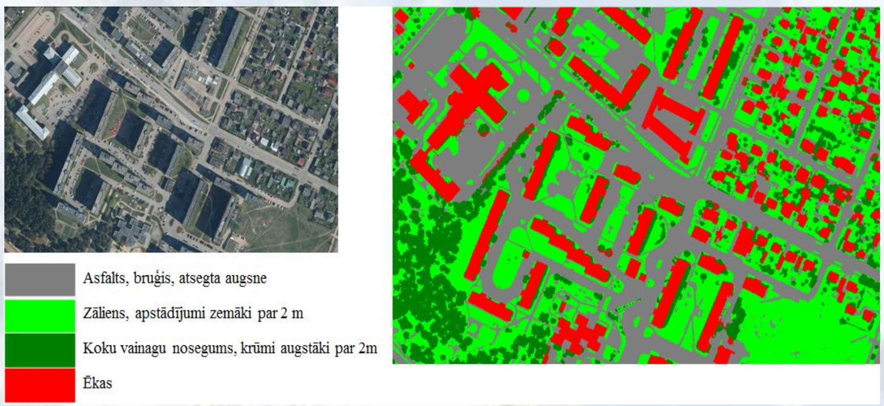


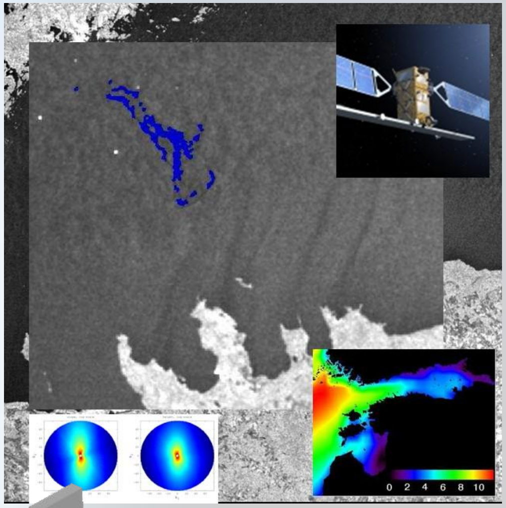


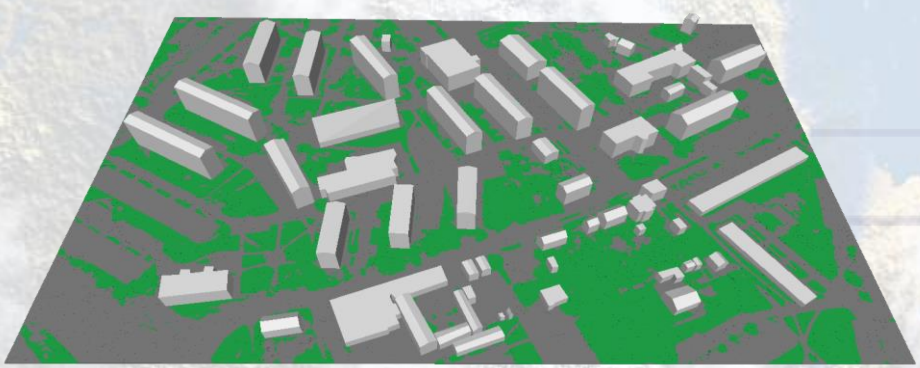
Remote sensing

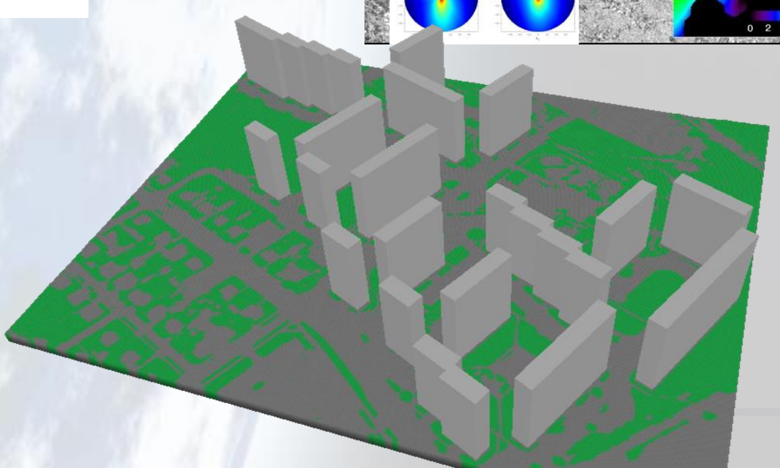
3. Environment protection: oil-spill recognition in natural water bodies using SAR images, coastline change detection using satellite images

4. Agriculture: precise agriculture using aerial, umanned aerial vehicle and satellite data

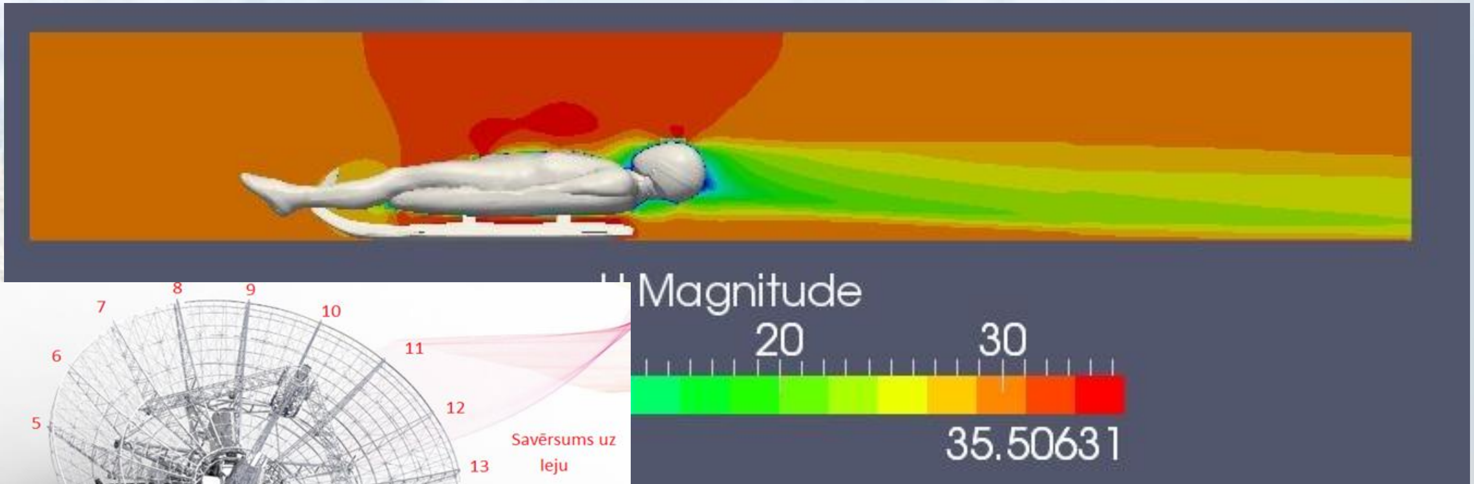


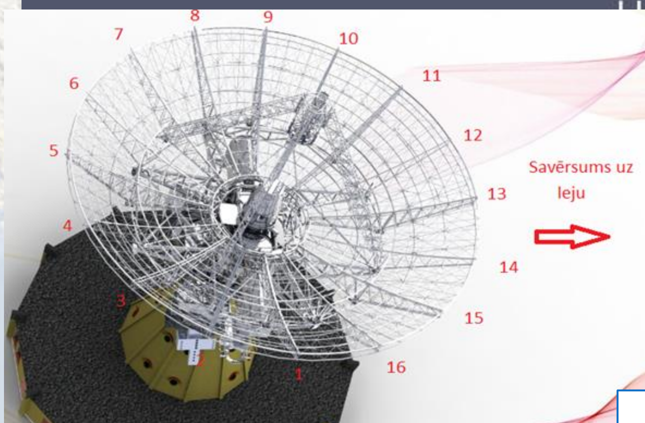


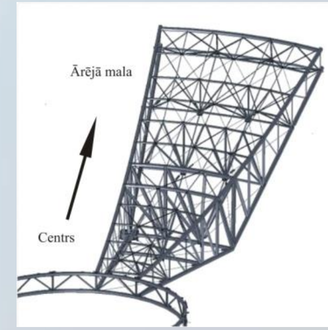


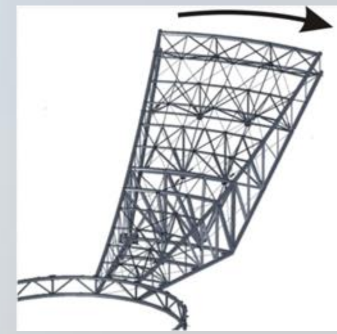


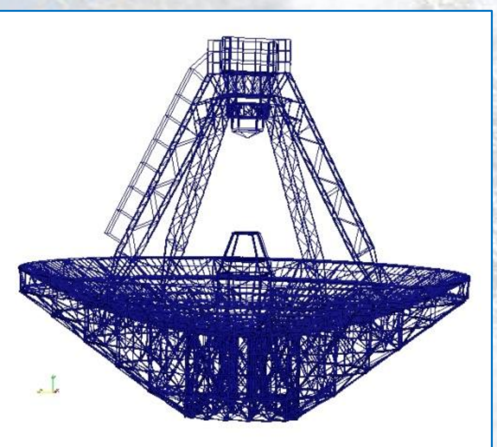
Engineering Physics HPC simulation

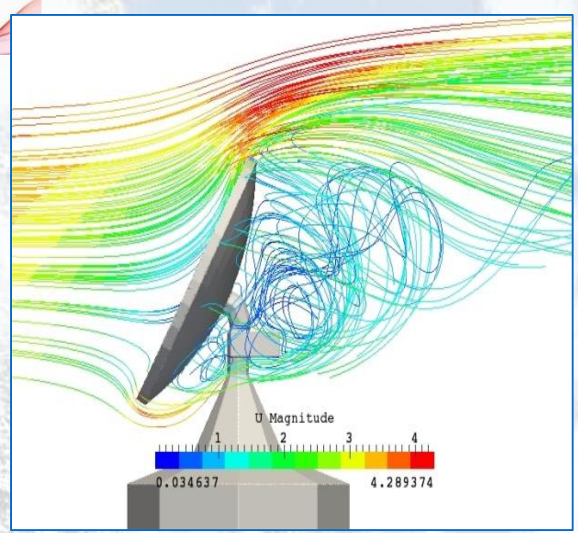


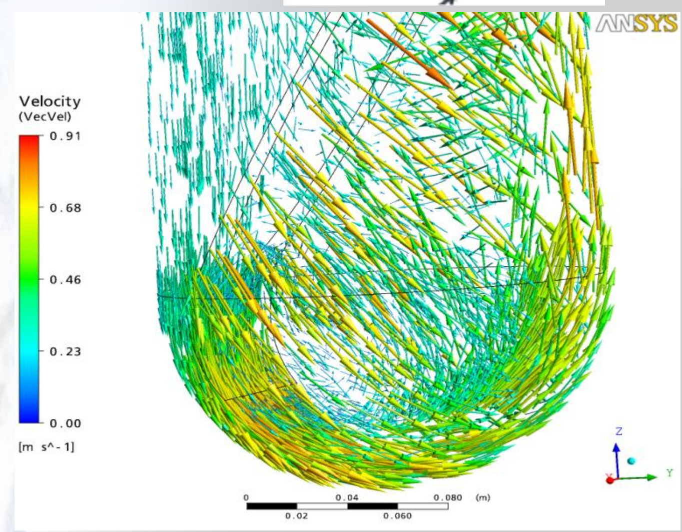






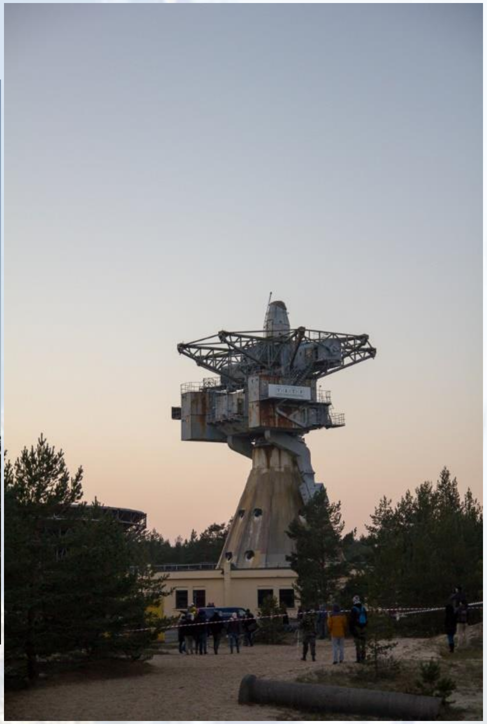


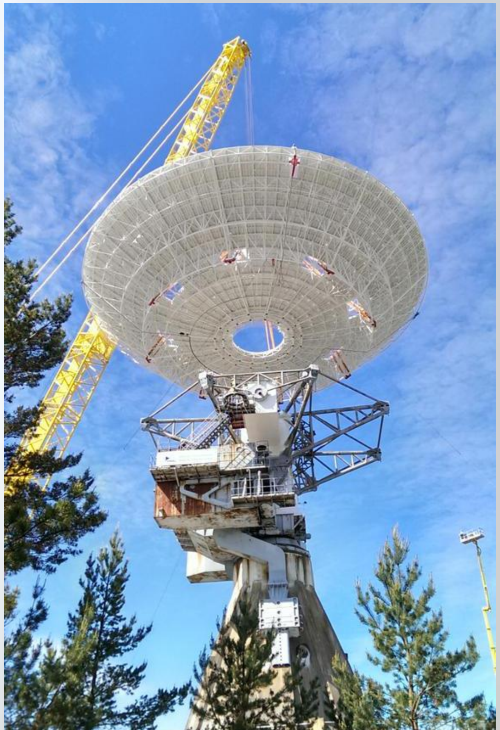




Satellite ground station at VeAUS

RT-32 antenna surface and backup structure renovation

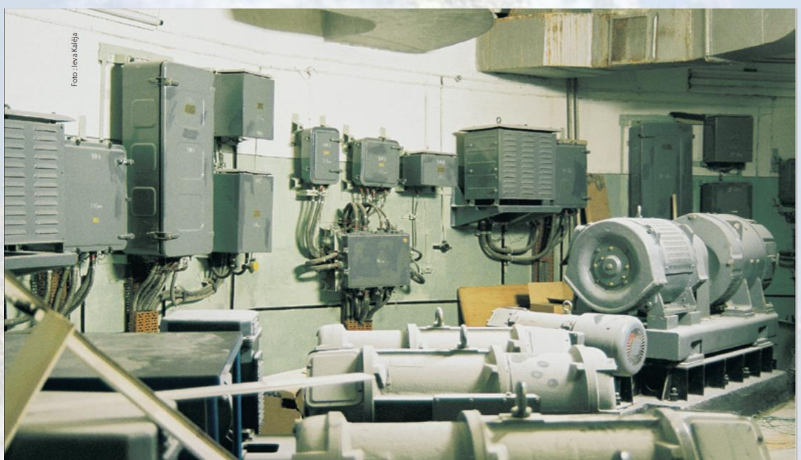




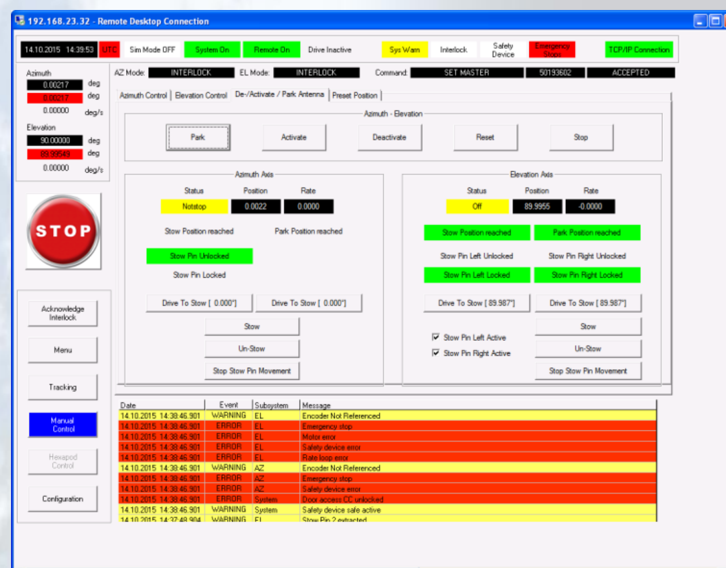
RT-32 Antenna Control Units

RT-32 vadības pults pirms modernizācijas, 2011/Control block before modernisation, 2011

RT-32 mašīnzāle ar tikko uzstādītiem jaunajiem vadības un piedziņas sistēmas blokiem, 2015/ Control room of RT-32 with newly installed components of control and drive systems, 2015



RT-32 mašīnzāle, 2008/ RT-32 engine amplifiers, 2008

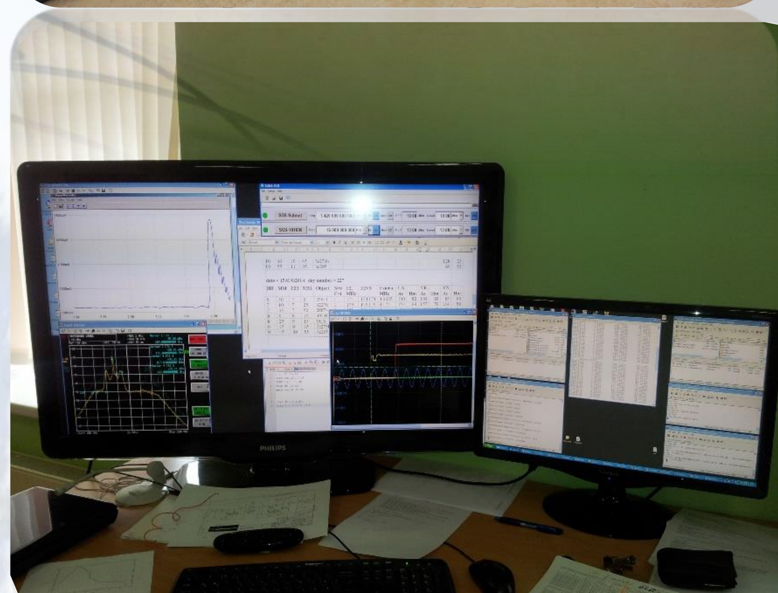


RT-32 old and new motors in the azimuth and Elevation

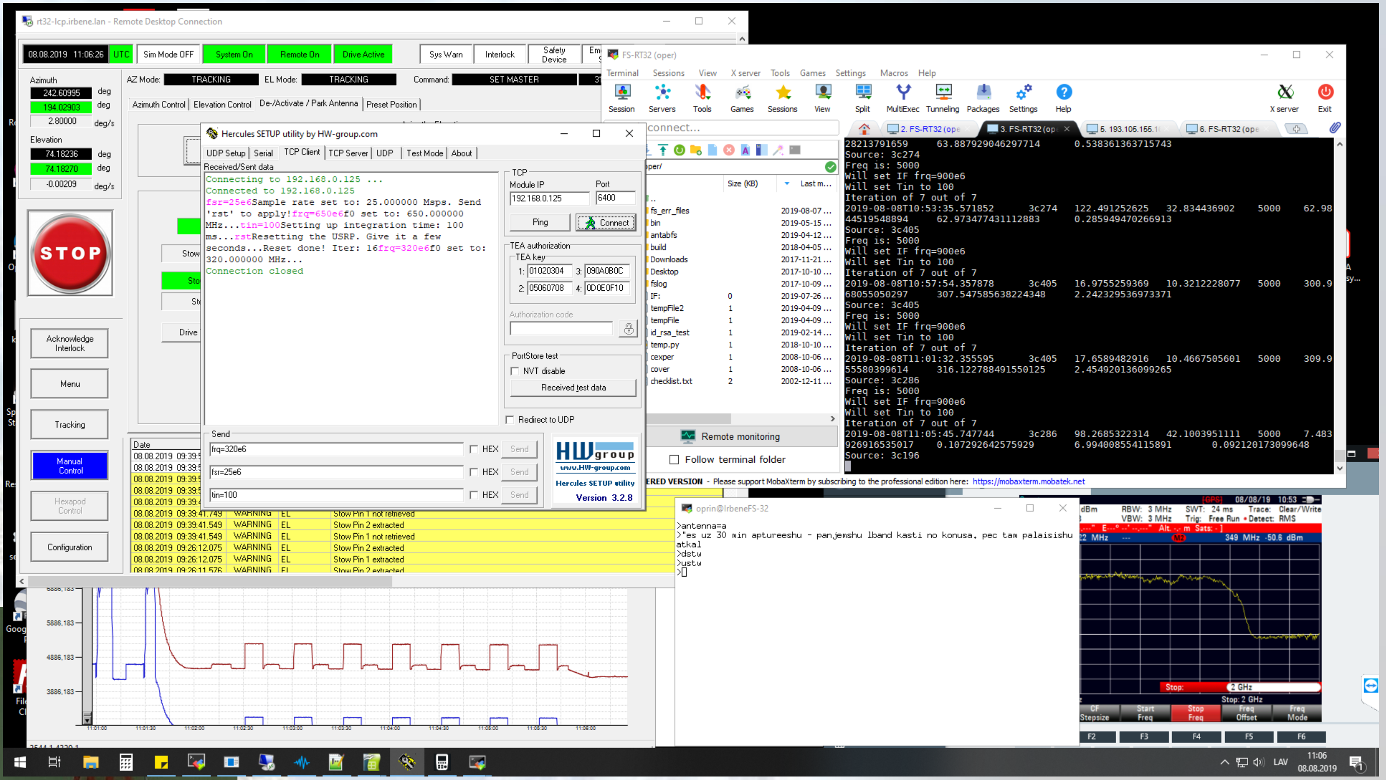
RT-32 horizontālās ass motoru komplekts, 2008/
RT-32 azimuth drives, 2008

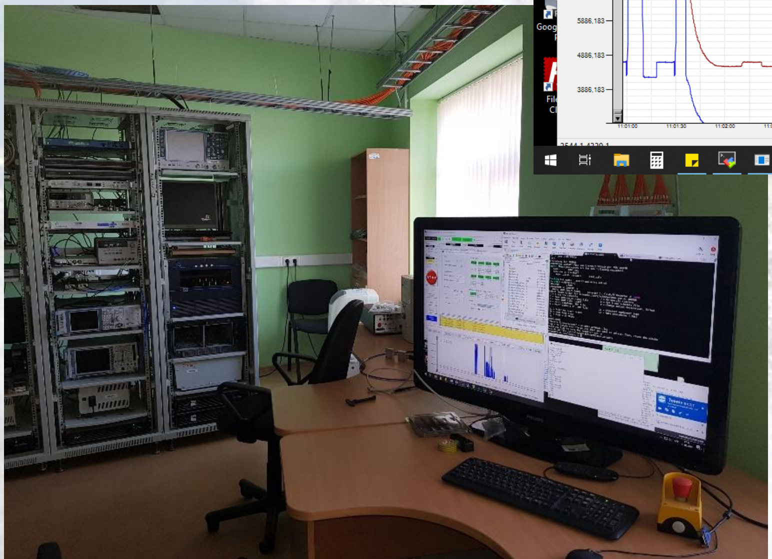
RT-32 azimuta piedziņas dzinējs un reduktors pēc modernizācijas, 2015
RT-32 azimuth drive and gear box after modernisation, 2015

RF laboratory and telescope control system



Telesocope control screen



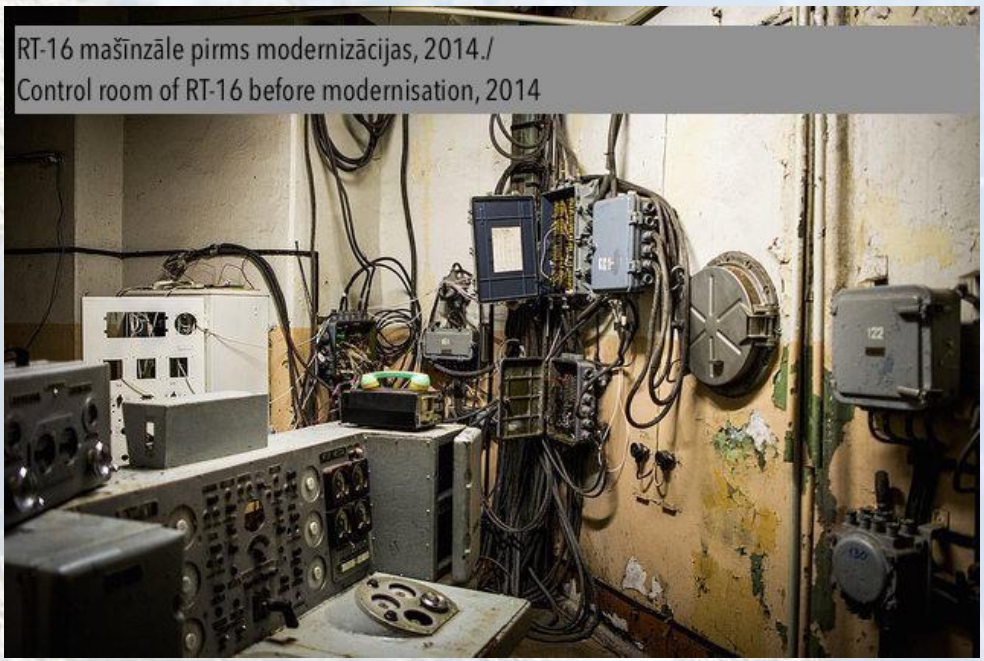


RT-16: new 16 m antenna

RT-16 reflektora uzcelšana, 2015/
Lift-on of reflector of RT-16, 2015

RT-16: new 16 m antenna

RT-16 antenna control units



RT-16 mašīnzāle pirms modernizācijas, 2014./
Control room of RT-16 before modernisation, 2014

RT-16 mašīnzāle ar tiko uzstādītiem jaunajiem vadības un piedziņas sistēmas blokiem, 2015/
Control room of RT-16 with newly installed components of control and drive systems, 2015

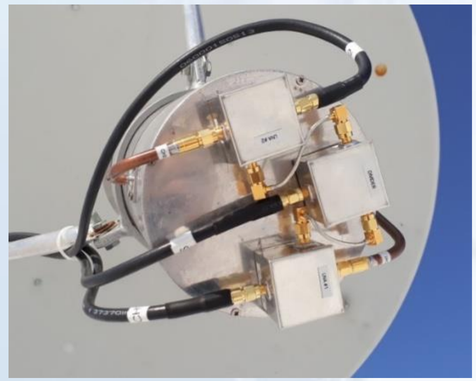
Broadband cryogenic receiver 4.5 – 8.8 GHz

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

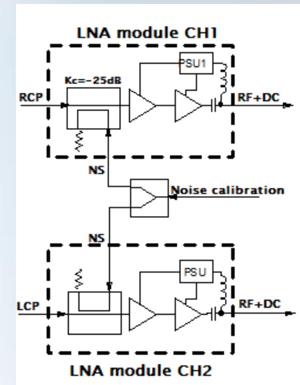
L band receiver

- Frequency ranges: 1.4-1.6 & 1.6-1.72 GHz
- LCP+ RCP polarizations
- Sensitivity: 700…900 Jy
- Noise injection cal., network remote ctl.

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

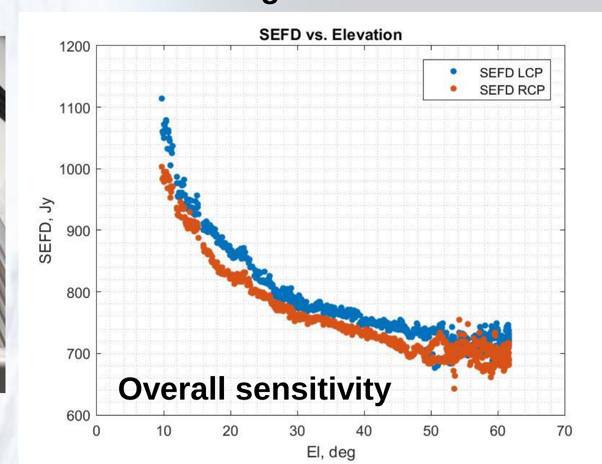


Dual circular pol. 'warm' front-end



Block diagram of front-end

IF Unit

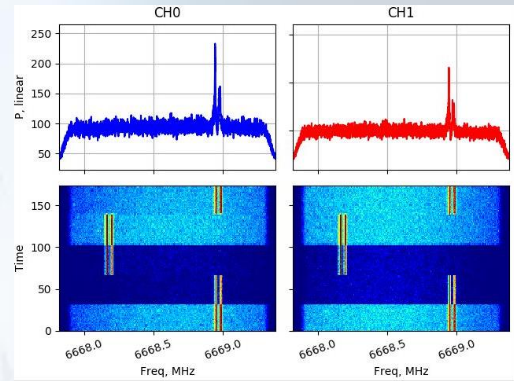


Overall sensitivity

Spectral line registration back-end based on USRP X300 software defined radio

Spectrometer features:

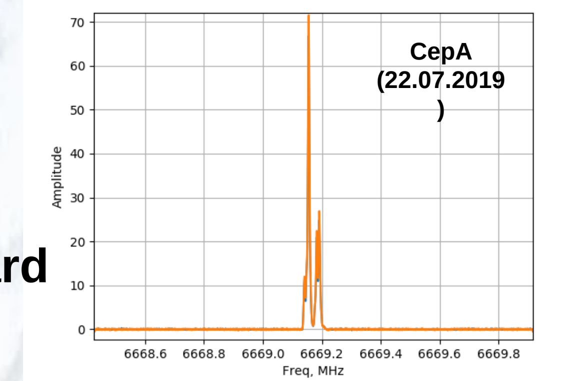
- Up to 4 simultaneous channels, possibility to run multiple SDRs on single host computer.
- Supported sample rates or bandwidths: 0.195, 0.39, 0.78, 1.56, 3.125, 6.25, 12.5, 25, 50 MHz (under testing) (F_s = 200/D, where D = 2^N, N = 1, 2, 3, …)
- Sample resolution: 14+14 bit (I+Q)
- FFT lengths: up to 32768 with 25 MHz bandwidth per channel allowing spectral resolution ≈ 0.76 KHz @ 25 MHz bandwidth (rect. win.). With smaller BW, available resolution is higher accordingly.
- FFT windowing support
- FFT overlapping integration mode
- Raw IQ sample recording mode



Real time spectrum monitoring

TwinRX RF daughterboard

USRP X300 at RT-32



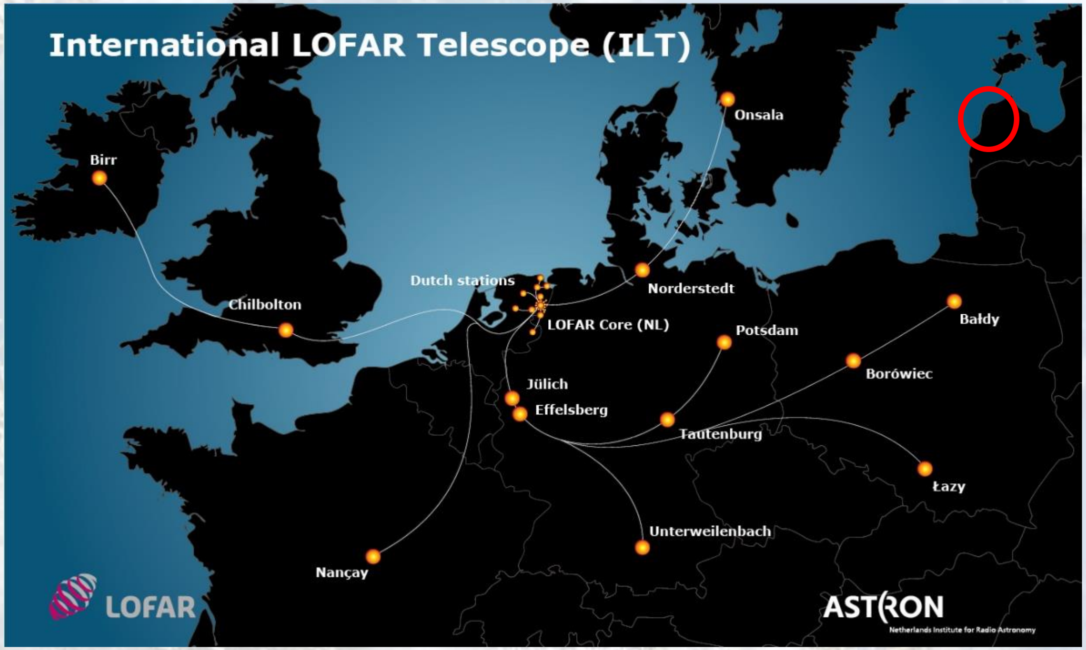
Frequency switching post-processing applied

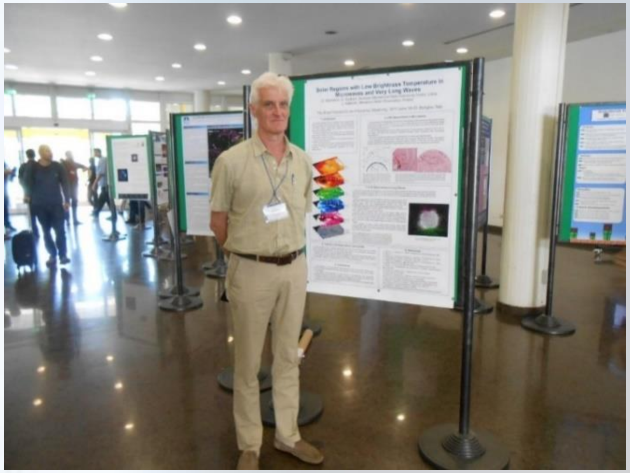
VIRAC High Performance Computing (HPC) cluster used for interferometric data processing

- Rack-mounted unit with 30 nodes:
  - 8 CPU x 2 Cores Intel Xeon E5-2630 v3: Total 480 Cores
  - 128GB RAM per diskless node
  - Total 3840 GB RAM available
  - Debian Linux, shared NFS, rsh infrastructure,
  - 40Gb/s Infiniband network
- 10 Gb/s link to the GEANT network
- 288 TB Disk storage (FlexBuff)
- JIVE's SFXC correlator

International LOFAR telescope (ILT) extended to Latvia

- In total 51 station
- 38 in the Netherlands
- 13 in other countries
- New station in Irbene complex
- Since 19 June of 2017 VIRAC is observer in the ILT





RFI measurements made by ASTRON head of technical group Nico Ebbendorf in Irbene site, dedicated to the future LOFAR station

3 RFI Test setup and procedure

3.1 RFI Test setup

A practical test setup has been compiled using LOFAR type antennas and a spectrum analyzer as a receiver. With this setup, a good impression can be made of the RF spectrum with respect to strong RFI signals and general spectrum environment within the LOFAR frequency bands.
The LOFAR frequency range is divided in a low-band and high-band range. Each band is using a specific antenna. A single, standard Low-Band production antenna (LBA) is used in the test setup to cover the low-band range from 10 MHz to 100 MHz. The LOFAR high-band antenna system is made of 96 tiles with 16 individual antenna elements in each tile. For this test setup, a prototype of a single High-Band Antenna element (HBA) is used to cover the high-band frequency range from 110 MHz to 240 MHz.
Figure 3-1 showing a typical setup for LBA (left) and HBA (right) antennas. An external DC power supply is used to power-up the LNA via a bias-T and the coaxial cable. Power to supply the mains to the test equipment has been provided by a portable power generator and a 50-meter long extension cable. A laptop, running a specific software program (Linux OS) is used for equipment control and data storage (Figure 3-2).

Figure 3-1, LBA and HBA antenna as used in this setup

Figure 3-2, power cable and test receiver setup

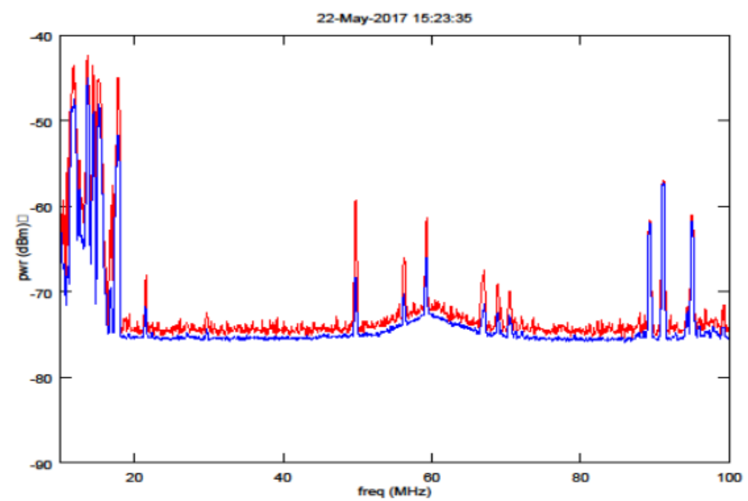


Figure 4-11, LBA peak, mean and 95th percentile, E-W direction

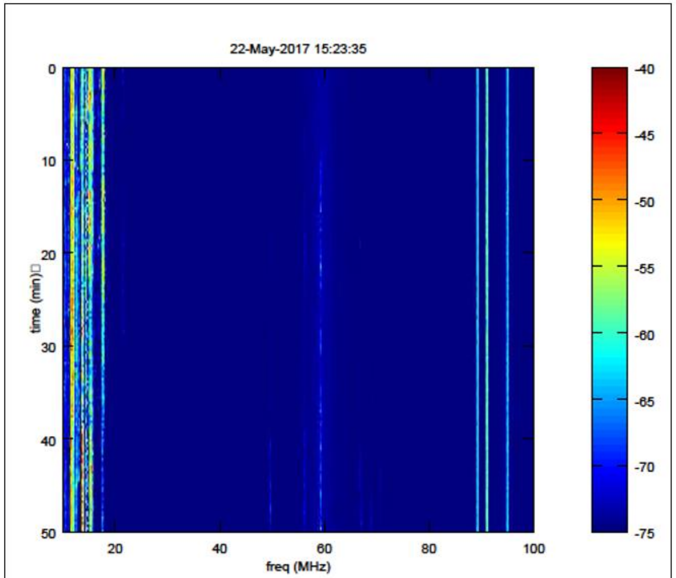
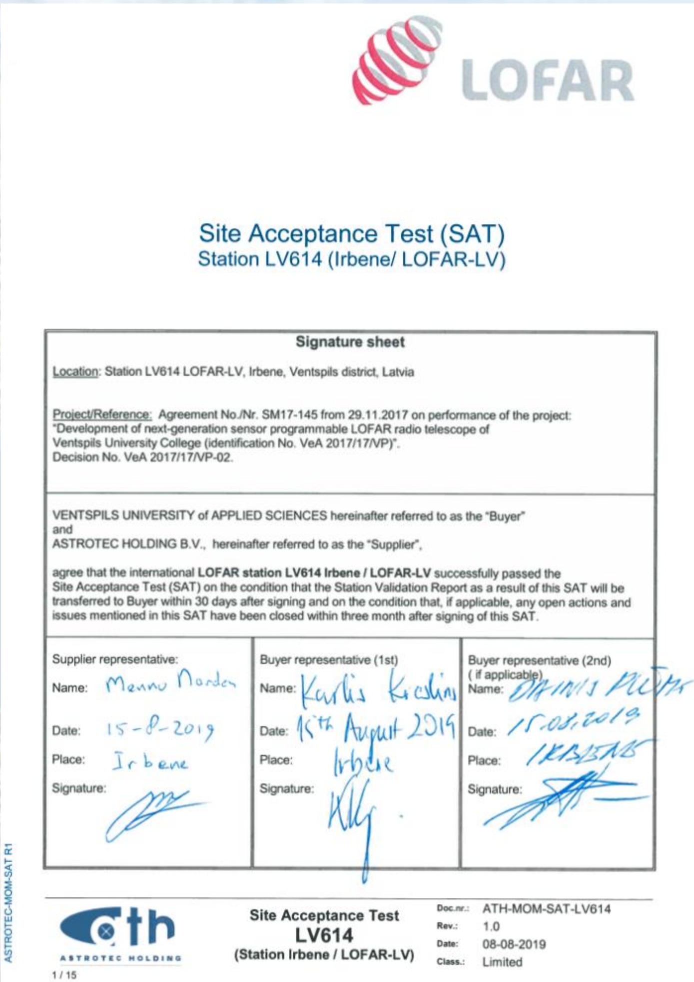


Figure 4-10, LBA, waterfall plot for E-W direction

International LOFAR telescope (ILT) extended to Latvia

Site Acceptance Test



LOFAR

Site Acceptance Test (SAT)
Station LV614 (Irbene/ LOFAR-LV)

Signature sheet

Location: Station LV614 LOFAR-LV, Irbene, Ventspils district, Latvia

Project/Reference: Agreement No./Nr. SM17-145 from 29.11.2017 on performance of the project: "Development of next-generation sensor programmable LOFAR radio telescope of Ventspils University College (identification No. VeA 2017/17/VP)". Decision No. VeA 2017/17/VP-02.

VENTSPILS UNIVERSITY of APPLIED SCIENCES hereinafter referred to as the "Buyer"
and
ASTROTEC HOLDING B.V., hereinafter referred to as the "Supplier",

agree that the international **LOFAR station LV614 Irbene / LOFAR-LV** successfully passed the Site Acceptance Test (SAT) on the condition that the Station Validation Report as a result of this SAT will be transferred to Buyer within 30 days after signing and on the condition that, if applicable, any open actions and issues mentioned in this SAT have been closed within three month after signing of this SAT.

Supplier representative:	Buyer representative (1st)	Buyer representative (2nd) (if applicable)
Name: Menno Norden	Name: Karlis Kreslins	Name: [illegible]
Date: 15-8-2019	Date: 15th August 2019	Date: 15.08.2019
Place: Irbene	Place: Irbene	Place: IRBENE
Signature:	Signature:	Signature:

ASTROTEC-MOM-SAT R1

ath ASTROTEC HOLDING

Site Acceptance Test
LV614
(Station Irbene / LOFAR-LV)

Doc.nr.: ATH-MOM-SAT-LV614
Rev.: 1.0
Date: 08-08-2019
Class.: Limited

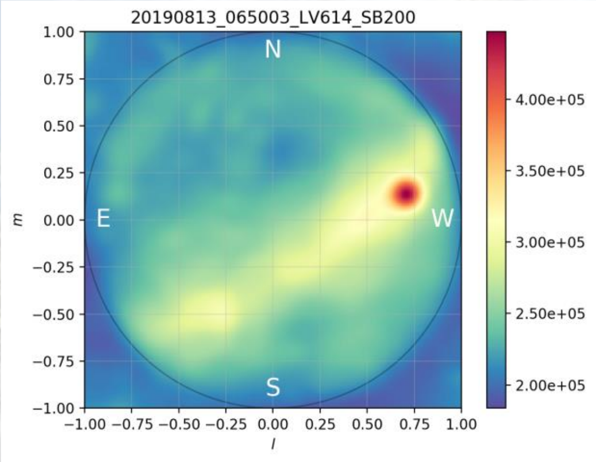
1 / 15

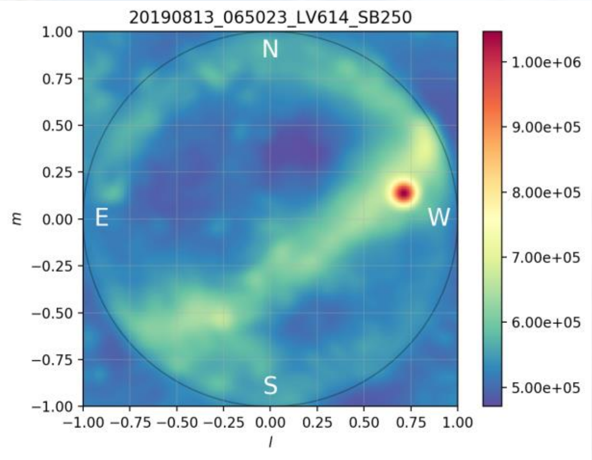
The name of the station	**LV614**
The country or geographical area in which the station is located	Latvia (Irbene)
The geographical coordinates of each transmitting or receiving antenna site constituting the station latitude and longitude in degrees and minutes	**LONG 21 E 51 21.0** **LAT 57 N 33 25.4**

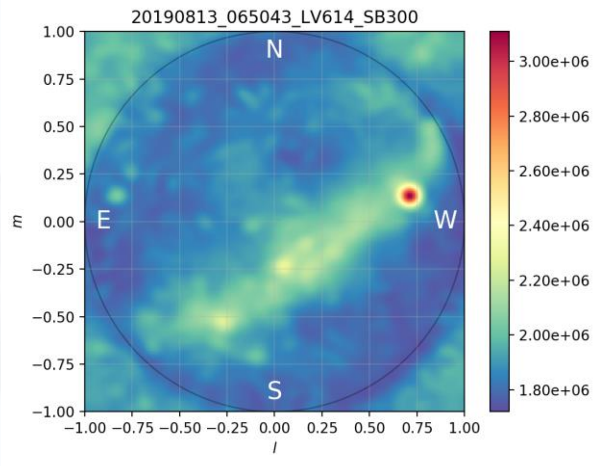
The antenna type (Co-pollar radiation pattern) and dimensions	LB antenna array: **96 half-wavelength crossed dipoles @ 1.7 meter high;** HB antenna array: **96 tiles with 16 crossed half-wavelength bowtie dipoles @ 0.6 meter high**
The effective area of the antena and angular coverage in azimuth and elevation	LB: **3200 square meters (30 MHz);** all azimuths; the angle of elevation is between 0° and 90°; HB: **2400 square meters (120 MHz);** all azimuths; the angle of elevation is between 0° and 90°

The class of station	**Complete ILT station**
The overall receiving system noise temperature, in kelvins, referred to the output of the receiving antena	HB: **395 Kelvin** (mode 5) **177 Kelvin** (mode 6) **122 Kelvin** (mode 7) LB: **5503 Kelvin** (mode 3 or 4)

First Measurements (uncalibrated)







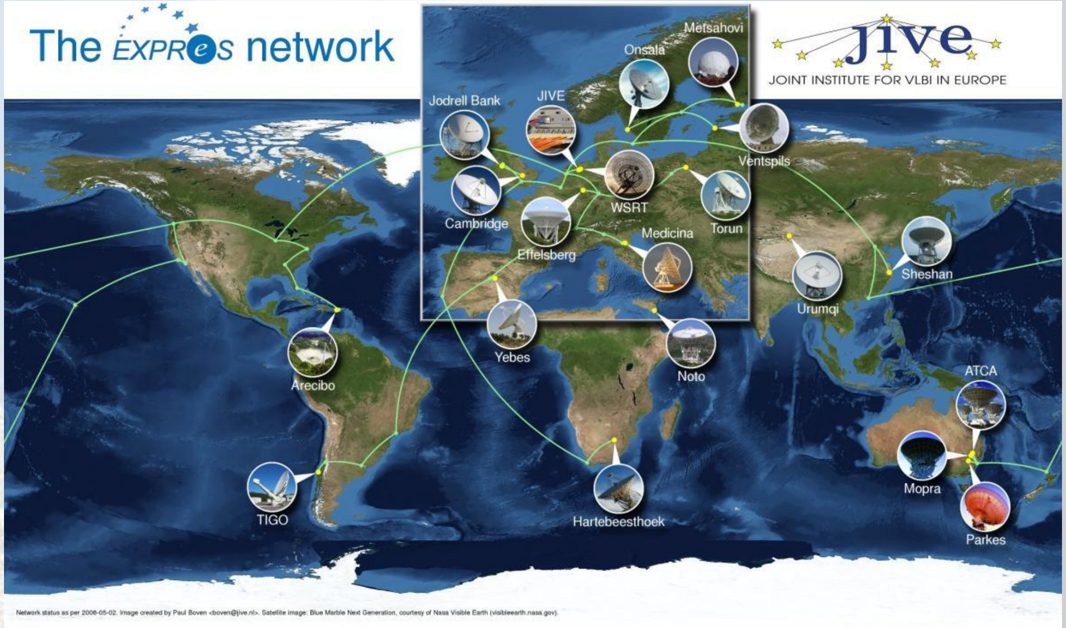
The Milky Way

EVN network is extended with VIRAC RT-32 and RT-16

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)

- Fringe tests – 2012
- Data streaming at 1 Gbps and multiantena regime - 2013
- Regular observations – 2015
- EVN member– 2016 October
- Local correlator



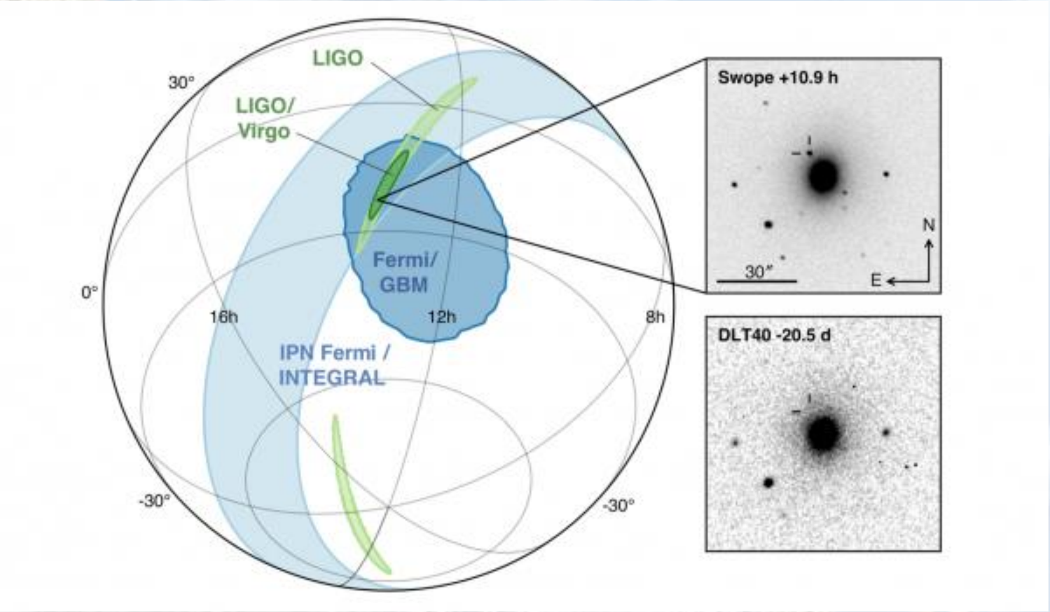
Related projects:

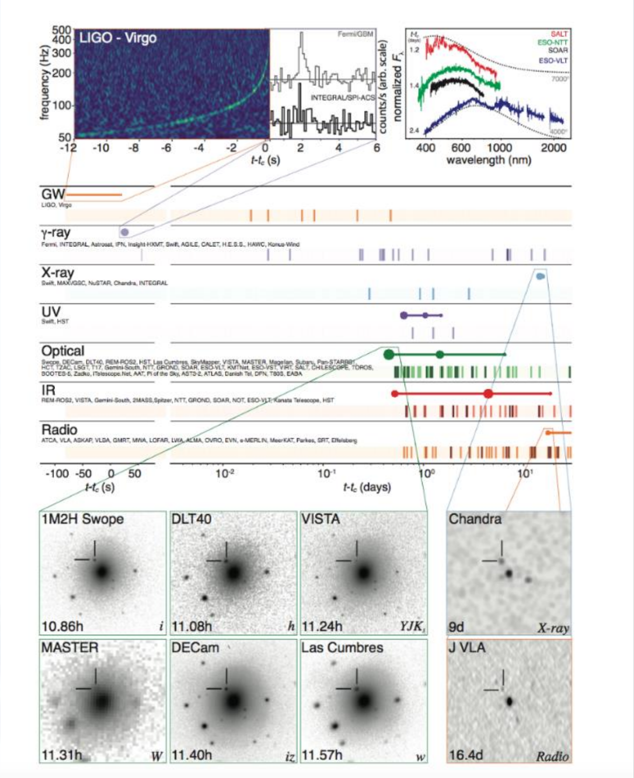
RadioNet, RadioNet2, Radionet4, Express, Nexpress, Baltics

EVN telescopes zoom in on the first detection of gravitational waves produced by colliding neutron stars

http://www.jive.nl/evn-telescopes-zoom-first-detection-gravitational-waves-produced-colliding-neutron-stars

The initial detection of the gravitational signal, named GW170817, was first made on 2017 Aug. 17 at 8:41 a.m. Eastern Daylight Time; by the two identical LIGO detectors, located in Hanford, Washington, and Livingston, Louisiana.
The discovery was made using the U.S.-based Laser Interferometer Gravitational-Wave Observatory (LIGO); the Europe-based Virgo detector; and some 70 ground- and space-based observatories.





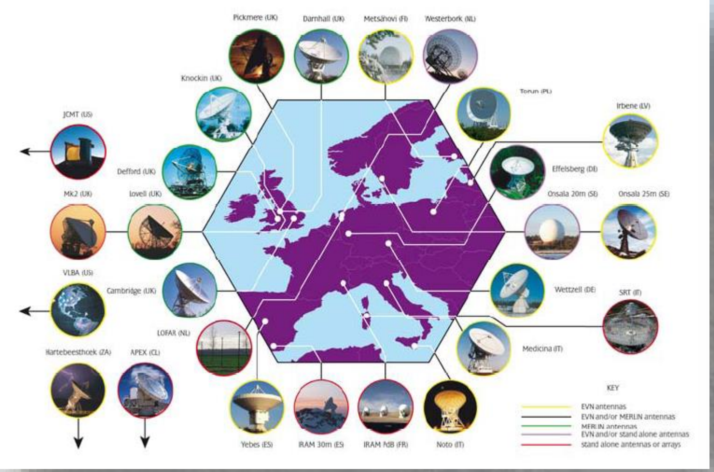
The timeline of the discovery of the gravitational wave event GW170817, the related short gamma-ray burst GRB170817A, and the optical counterpart SSS17a/AT 2017gfo. The follow-up observations are shown by messenger and wavelength relative to the time t_c of the gravitational-wave event.

VIRAC collaboration with RadioAstron space telescope: VLBI observations of Active Galactic Nuclei

RT-32 participation in the international RadioAstron collaboration started in **December 2015**

Observing bands: **18 cm** (1636 – 1692 GHz) and **6 cm** (4804 – 4860 GHz)

The European VLBI Network (EVN)

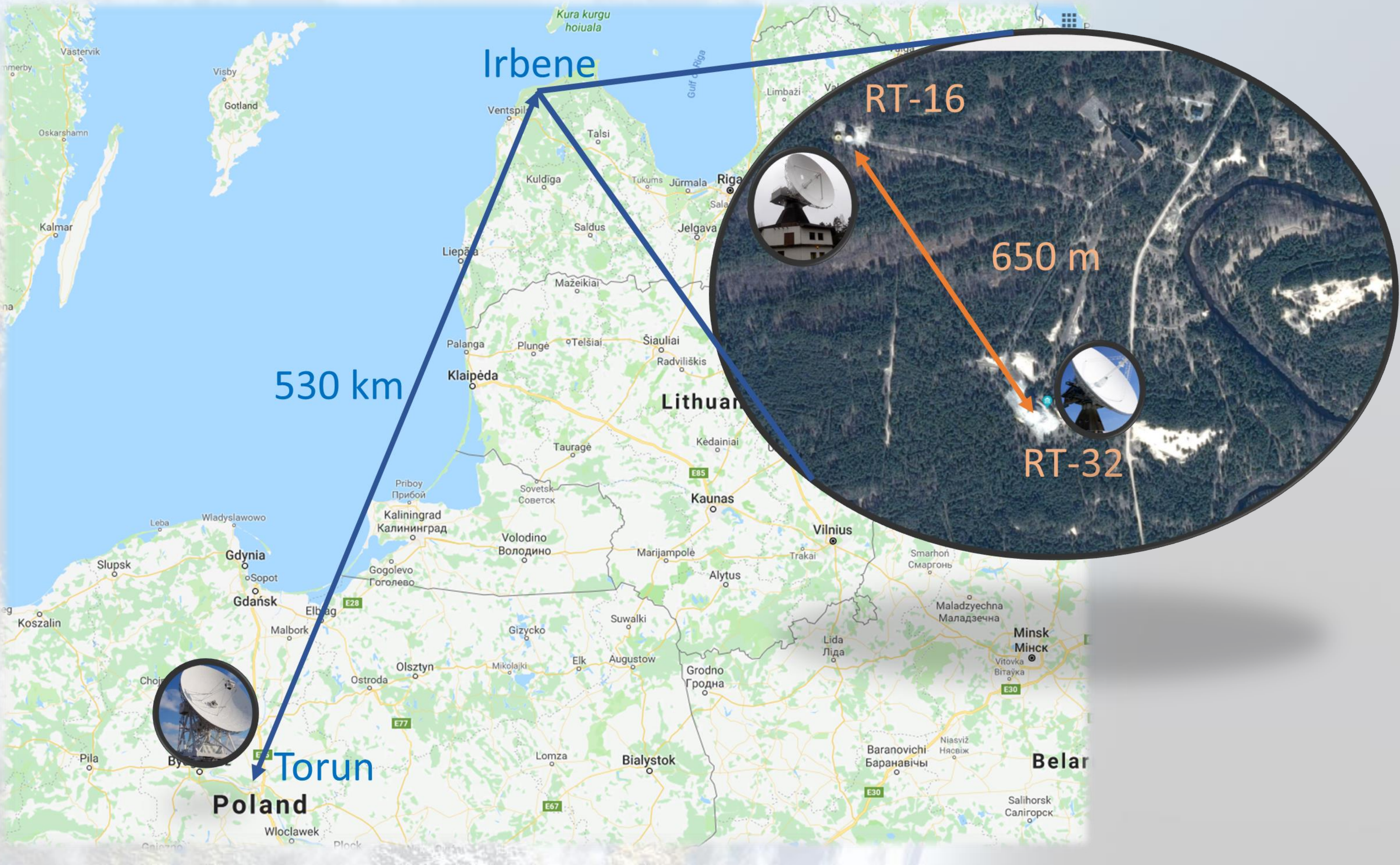


VIRAC RT-32

Spektr-R or RadioAstron

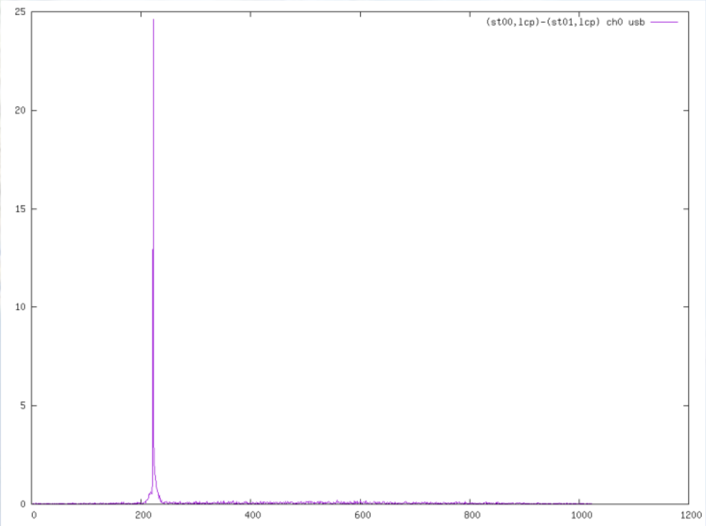
- The European VLBI Network (EVN) is an interferometric array of radio telescopes spread throughout Europe (and beyond) that conducts unique, high resolution, radio astronomical observations of cosmic radio sources (http://www.evlbi.org/).
- The RadioAstron is an international space VLBI project led by the Astro Space Center of Lebedev Physical Institute in Moscow, Russia (http://www.asc.rssi.ru/).

VLBI observations Irbene – Torun 2018

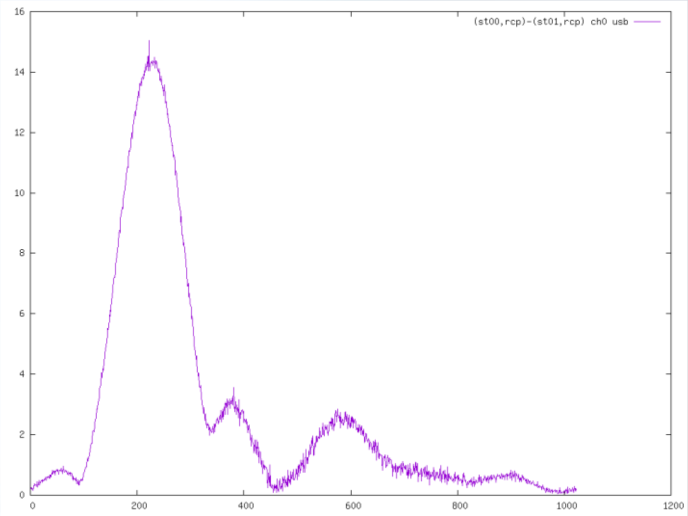


First successful interferometric observations in RT-32 - RT-16 baseline

Source 3C84 (quasar)



Source W3(OH) (methanol maser)



Experiment date: 2. May 2019,

Frequency: 6667.49MHz;

Baseline: RT-32 – RT-16;

Upper Side Band (USB);

Left circular polarization (Lcp-Lcp).

Irbene – Onsala – Torun VLBI observations

Two 3 hours observations

Date:	**June 4, 2019**
Start time:	**11:00:00 UTC**
Stop time:	**12:59:30 UTC**
Fringe finder:	**J0854+2006 (AGN)**
Phase calibrator:	**J0940+2603 (AGN)**
Target source:	**J0932+2837 (new radio source (AGN?)**

Date:	**June 5, 2019**
Start time:	**10:00:00 UTC**
Stop time:	**11:58:55 UTC**
Fringe finder:	**J0102+5824 (AGN)**
Phase calibrator	**J2302+6405 (AGN)**
Target source	**Cepheus A (Galactic methanol maser)**

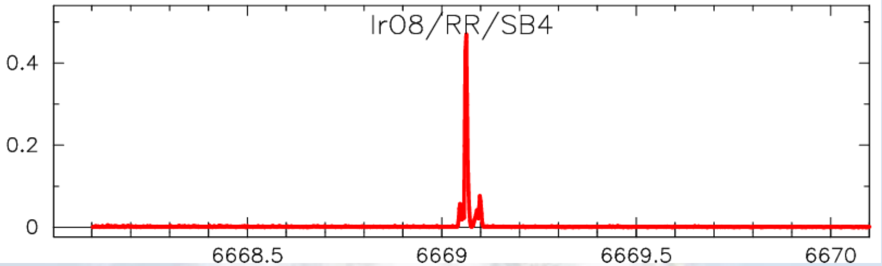
tio1_	Auto correlations			Cross correlations		
	Ir	O8	Tr	Ir-O8	Ir-Tr	O8-Tr
6667.49MHz, LSB, Rcp-Rcp	1	1	1	26.74 A P offset: -317	144.1 A P offset: -108	53.03 A P offset: 210
6667.49MHz, LSB, Rcp-Lcp	Cross hands			4.396 A P offset: -42	46.13 A P offset: -108	6.706 A P offset: 210
6667.49MHz, LSB, Lcp-Lcp	9	9	9	31.06 A P offset: -317	168.6 A P offset: -108	54.94 A P offset: 210
6667.49MHz, LSB, Lcp-Rcp	Cross hands			7.648 A P offset: -317	83.94 A P offset: -108	16.83 A P offset: 209
6667.49MHz, USB, Rcp-Rcp	1	1	1	24.28 A P offset: 317	132.4 A P offset: 108	57.76 A P offset: -210
6667.49MHz, USB, Rcp-Lcp	Cross hands			4.472 A P offset: 59	43.34 A P offset: 108	5.504 A P offset: -210
6667.49MHz, USB, Lcp-Lcp	9	9	9	28.5 A P offset: 317	162.8 A P offset: 108	51.08 A P offset: -210
6667.49MHz, USB, Lcp-Rcp	Cross hands			6.773 A P offset: 317	88.8 A P offset: 108	14.91 A P offset: -209
6699.49MHz, LSB, Rcp-Rcp	2	2	2	27.1 A P offset: -317	135.1 A P offset: -108	58.54 A P offset: 210
6699.49MHz, LSB, Rcp-Lcp	Cross hands			5.723 A P offset: -51	44.38 A P offset: -108	4.149 A P offset: -3
6699.49MHz, LSB, Lcp-Lcp	10	10	10	32.22 A P offset: -317	155.8 A P offset: -108	53.87 A P offset: 210
6699.49MHz, LSB, Lcp-Rcp	Cross hands			6.814 A P offset: 19	81.91 A P offset: -108	16.3 A P offset: 209
6699.49MHz, USB, Rcp-Rcp	2	2	2	26.37 A P offset: 317	135.8 A P offset: 108	51.22 A P offset: -210
6699.49MHz, USB, Rcp-Lcp	Cross hands			4.446 A P offset: -134	36.92 A P offset: 108	4.097 A P offset: 132
6699.49MHz, USB, Lcp-Lcp	10	10	10	30.31 A P offset: 317	153.4 A P offset: 108	53.65 A P offset: -210
6699.49MHz, USB, Lcp-Rcp	Cross hands			5.541 A P offset: 318	87.36 A P offset: 108	15.32 A P offset: -209
6731.49MHz, LSB, Rcp-Rcp	3	3	3	25.87 A P offset: -317	135 A P offset: -108	53.87 A P offset: 210
6731.49MHz, LSB, Rcp-Lcp	Cross hands			5.549 A P offset: 92	33.52 A P offset: -108	4.568 A P offset: 210
6731.49MHz, LSB, Lcp-Lcp	11	11	11	32.97 A P offset: -317	162.7 A P offset: -108	58.03 A P offset: 210
6731.49MHz, LSB, Lcp-Rcp	Cross hands			6.035 A P offset: -317	82.26 A P offset: -108	14.27 A P offset: 209
6731.49MHz, USB, Rcp-Rcp	3	3	3	25.41 A P offset: 317	139.5 A P offset: 108	52.99 A P offset: -210
6731.49MHz, USB, Rcp-Lcp	Cross hands			4.829 A P offset: -17	31.29 A P offset: 108	6.394 A P offset: -209
6731.49MHz, USB, Lcp-Lcp	11	11	11	32.46 A P offset: 317	164.3 A P offset: 108	50.75 A P offset: -210
6731.49MHz, USB, Lcp-Rcp	Cross hands			7.847 A P offset: 317	78.42 A P offset: 108	15.27 A P offset: -209
6763.49MHz, LSB, Rcp-Rcp	4	4	4	27.31 A P offset: -317	138.9 A P offset: -108	45.87 A P offset: 210
6763.49MHz, LSB, Rcp-Lcp	Cross hands			4.706 A P offset: -63	45.04 A P offset: -108	6.81 A P offset: 210
6763.49MHz, LSB, Lcp-Lcp	12	12	12	31.99 A P offset: -317	161.6 A P offset: -108	53.94 A P offset: 210
6763.49MHz, LSB, Lcp-Rcp	Cross hands			6.922 A P offset: -317	96.8 A P offset: -108	15.09 A P offset: 209
6763.49MHz, USB, Rcp-Rcp	4	4	4	24.98 A P offset: 317	131.5 A P offset: 108	50.59 A P offset: -210
6763.49MHz, USB, Rcp-Lcp	Cross hands			5.11 A P offset: 27	46.33 A P offset: 108	8.289 A P offset: -210
6763.49MHz, USB, Lcp-Lcp	12	12	12	28.55 A P offset: 317	165.5 A P offset: 108	52.14 A P offset: -210
6763.49MHz, USB, Lcp-Rcp	Cross hands			6.908 A P offset: 318	101.9 A P offset: 108	13.84 A P offset: -209

Irbene – Onsala – Torun VLBI observations

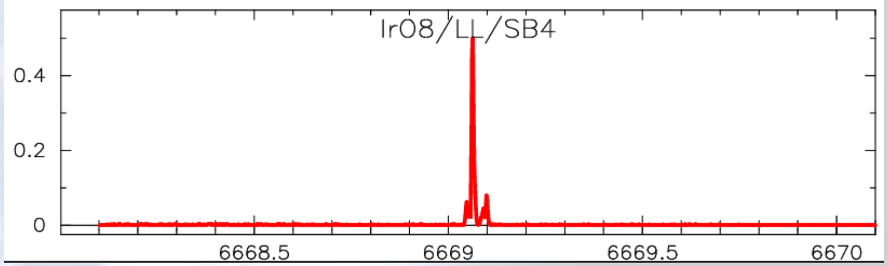
Specter of target source **Cepheus A**

Irbene – Onsala baseline cross-correlation

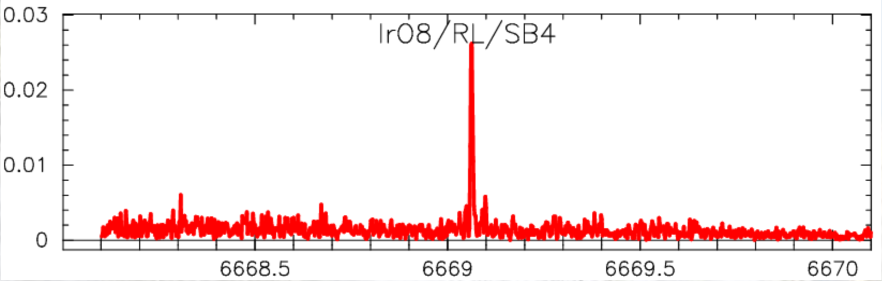
RCP – RCP

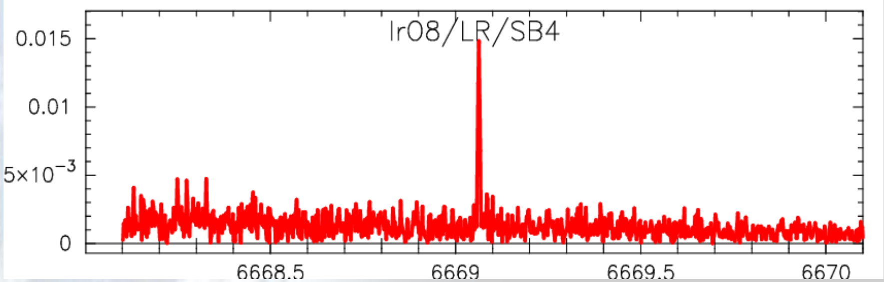


LCP - LCP



Cross Polarization (RCP – LCP)

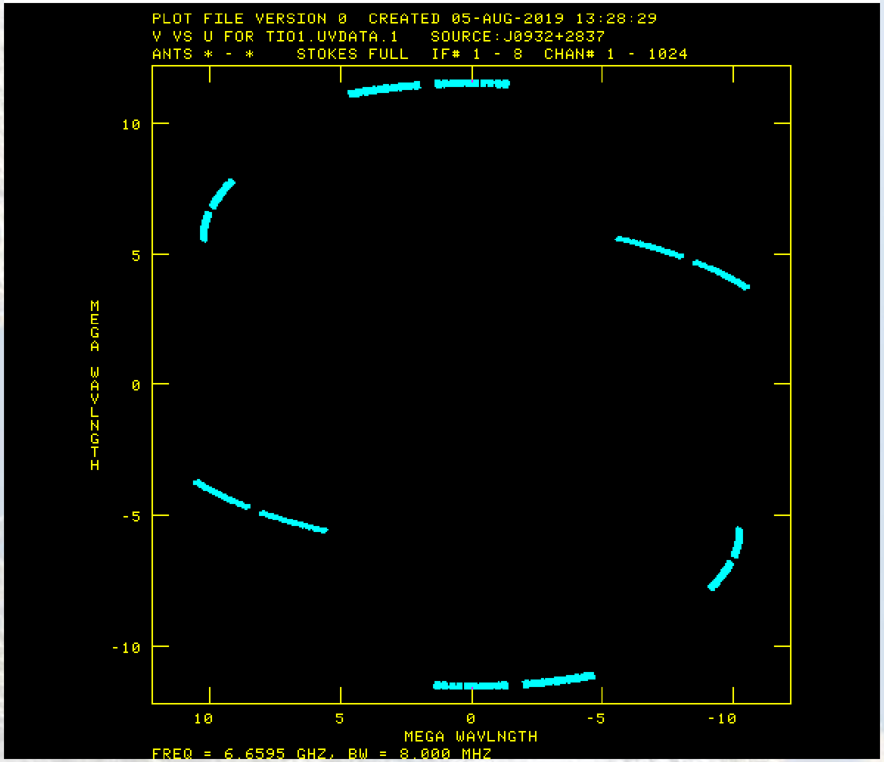


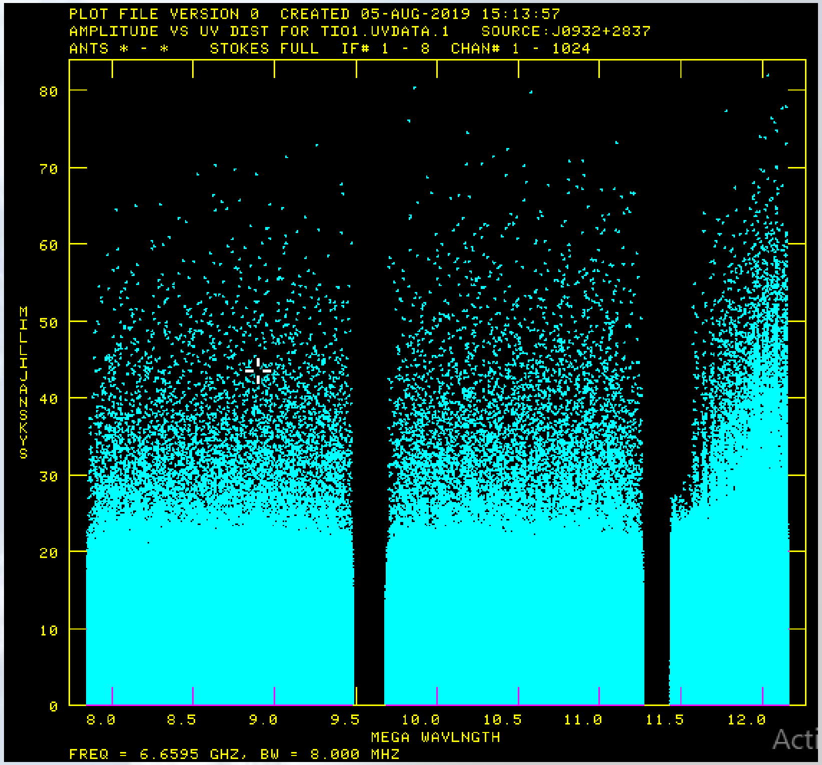


x-axis – frequency (MHz), y-axis – relative amplitude

How Irbene – Torun – Onsala *uv*-plane looks

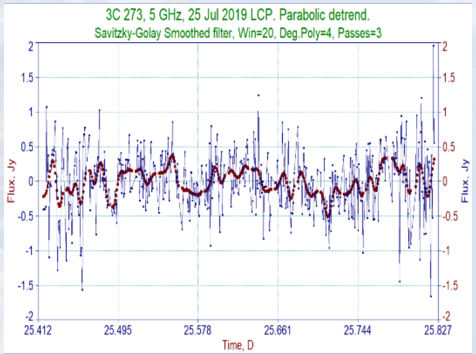
Target source J0932+2837

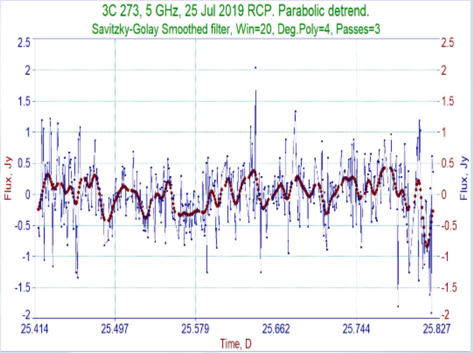


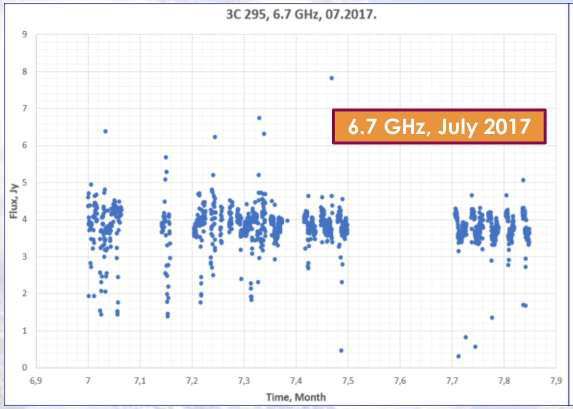


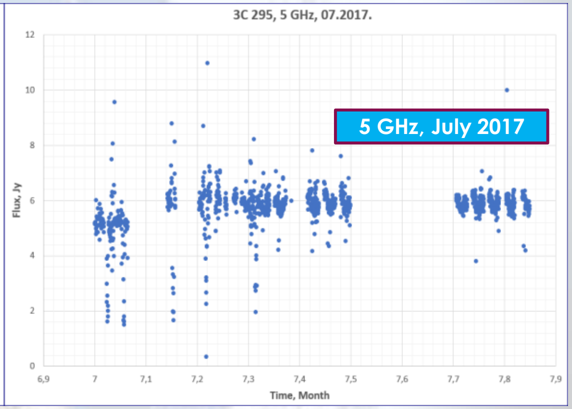
Preparation for monitoring of intra-day variability of AGN with VIRAC radio telescopes

Research program formulation for study of short-time variability in the eight radio extragalactic sources 3C 273 (quasar / Seyfert galaxy I type) 3C 120 (Seyfert galaxy I type) 3C 345 3C 454.3 (quasars) 3C 446, OJ 287, BL Lac, OT 081 (BL objects) using VIRAC radio telescops and data processing methods based on Fourier and wavelet analysis.









Sukharev A.L., Bezrukovs V.V., Bleiders M.Y., Orbidans A.A., Ryabov

Galactic Maser Observations on Ventspils Radio Telescopes

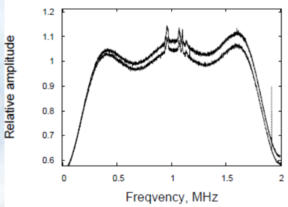


Figure 1. Input spectra. Two lines are LRP and RRP.

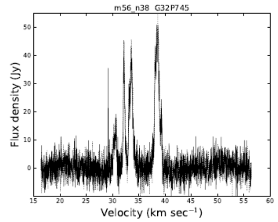


Figure 2. Gain dependence from frequency corrected, the region with maser lines excreted

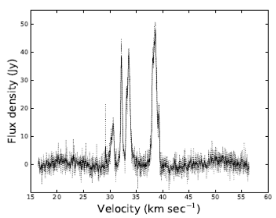


Figure 3. Averaging between LRP and RRP and primary noise filtering done

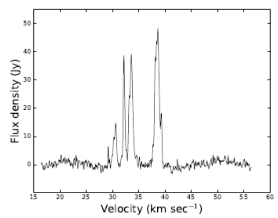
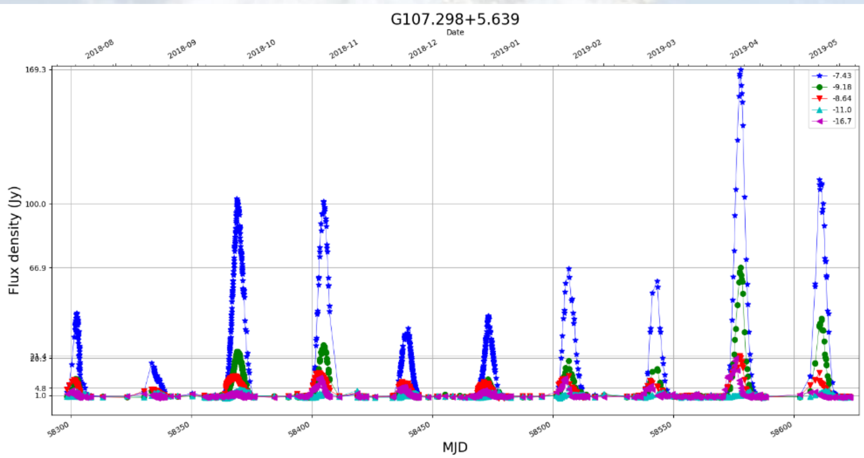
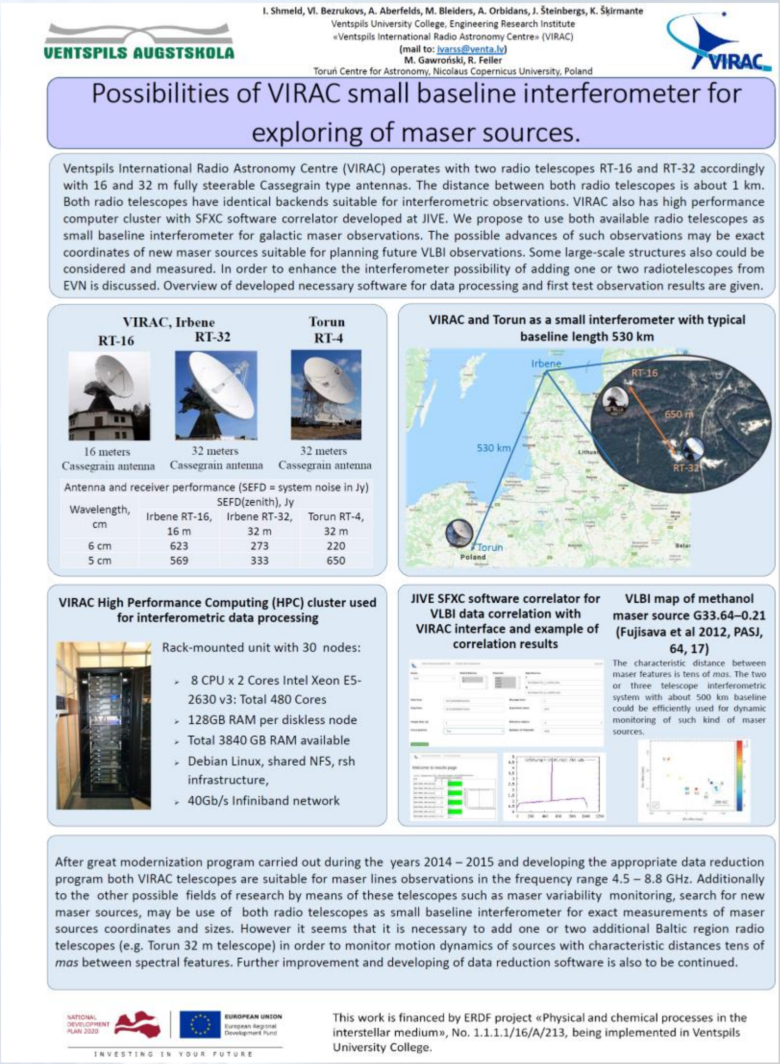


Figure 4. Final spectra: noise filtering by using Gaussian kernel done





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VENTSPILS AUGSTSKOLA

Possibilities of VIRAC small baseline interferometer for exploring of maser sources.

Ventspils International Radio Astronomy Centre (VIRAC) operates with two radio telescopes RT-16 and RT-32 accordingly with 16 and 32 m fully steerable Cassegrain type antennas. The distance between both radio telescopes is about 1 km. Both radio telescopes have identical backends suitable for interferometric observations. VIRAC also has high performance computer cluster with SFXC software correlator developed at JIVE. We propose to use both available radio telescopes as small baseline interferometer for galactic maser observations. The possible advances of such observations may be exact coordinates of new maser sources suitable for planning future VLBI observations. Some large-scale structures also could be considered and measured. In order to enhance the interferometer possibility of adding one or two radiotelescopes from EVN is discussed. Overview of developed necessary software for data processing and first test observation results are given.

VIRAC, Irbene — **RT-16**: 16 meters Cassegrain antenna; **RT-32**: 32 meters Cassegrain antenna
Torun RT-4: 32 meters Cassegrain antenna

Antenna and receiver performance (SEFD = system noise in Jy)

Wavelength, cm	SEFD(zenith), Jy Irbene RT-16, 16 m	Irbene RT-32, 32 m	Torun RT-4, 32 m
6 cm	623	273	220
5 cm	569	333	650

VIRAC and Torun as a small interferometer with typical baseline length 530 km

Irbene, RT-16, 650 m, RT-32, 530 km, Torun, Poland

VIRAC High Performance Computing (HPC) cluster used for interferometric data processing

Rack-mounted unit with 30 nodes:

- 8 CPU x 2 Cores Intel Xeon E5-2630 v3: Total 480 Cores
- 128GB RAM per diskless node
- Total 3840 GB RAM available
- Debian Linux, shared NFS, rsh infrastructure,
- 40Gb/s Infiniband network

JIVE SFXC software correlator for VLBI data correlation with VIRAC interface and example of correlation results

VLBI map of methanol maser source G33.64–0.21 (Fujisava et al 2012, PASJ, 64, 17)

The characteristic distance between maser features is tens of *mas*. The two or three telescope interferometric system with about 500 km baseline could be efficiently used for dynamic monitoring of such kind of maser sources.

After great modernization program carried out during the years 2014 – 2015 and developing the appropriate data reduction program both VIRAC telescopes are suitable for maser lines observations in the frequency range 4.5 – 8.8 GHz. Additionally to the other possible fields of research by means of these telescopes such as maser variability monitoring, search for new maser sources, may be use of both radio telescopes as small baseline interferometer for exact measurements of maser sources coordinates and sizes. However it seems that it is necessary to add one or two additional Baltic region radio telescopes (e.g. Torun 32 m telescope) in order to monitor motion dynamics of sources with characteristic distances tens of *mas* between spectral features. Further improvement and developing of data reduction software is also to be continued.

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

This work is financed by ERDF project «Physical and chemical processes in the interstellar medium», No. 1.1.1.1/16/A/213, being implemented in Ventspils University College.

EWASS 2018 - European Week of Astronomy and Space Science 3 – 6 April 2018

VIRAC proposal for EVN observations - approved

Sources

- G78.122+3.633(IRAS 201126+4104)
- G90.92+1.49
- G94.602-1.796(V645 Cyg)

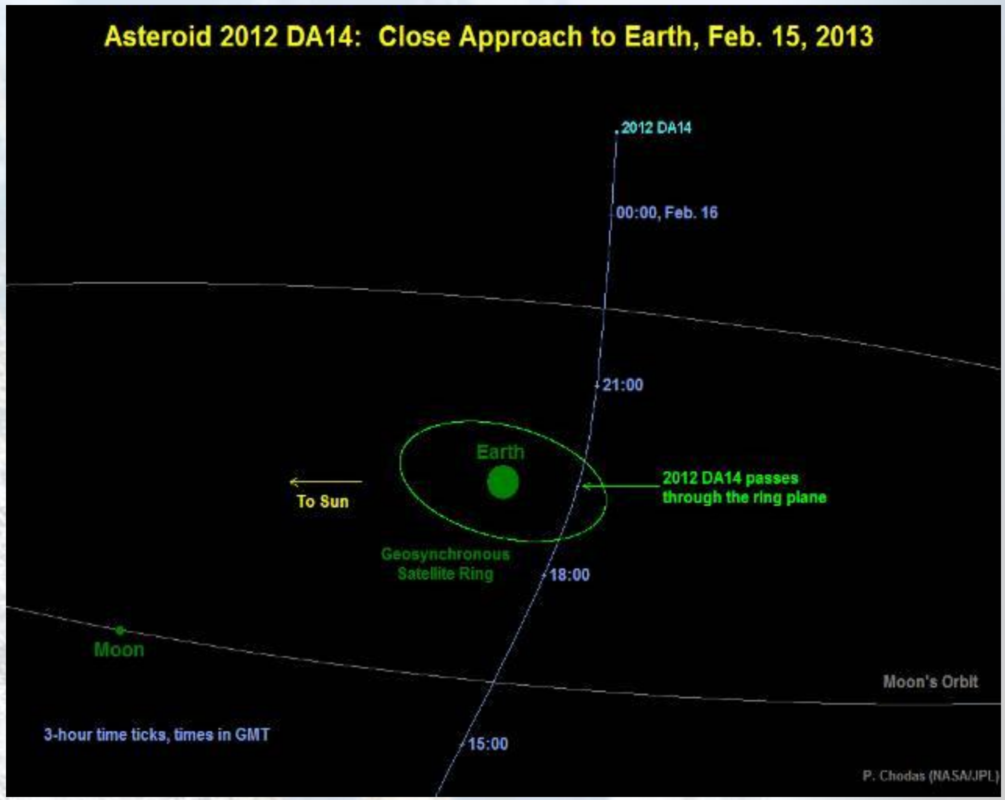
Goals

- Structural change studies of G78.122+3.633 and G94.602-1.796
- First imaging of G90.92+1.49
- Proper motion studies

VIRAC and NEO radar VLBI observations

VLBI-radar method was applied to observation of asteroid 2012DA14, which approached the Earth at a distance of about 30 thousand km (*Nechaeva et al 2016)*

February, 15-16, 2013
Asteroid 2012 DA14
Distance: less 30000 km,
Diameter: 25-75 m
Rotation period: near 9 hours



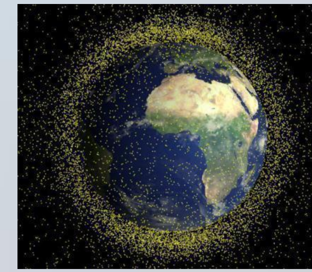


Image from internet resources of University of Southampton:http://www.southampton.ac.uk/mediacentre/news/2008/oct/08_185.shtml

Trajectory of **asteroid 2012 DA14** during its close approach, as seen edge-on to Earth's equatorial plane. **Its trajectory went inside the ring of geostationary satellites.**

Image credit: NASA/JPL-Caltech, http://www.jpl.nasa.gov

Complementary SLR and VLBI-location observations of active satellites on NEO

The combination of several optical and radar:

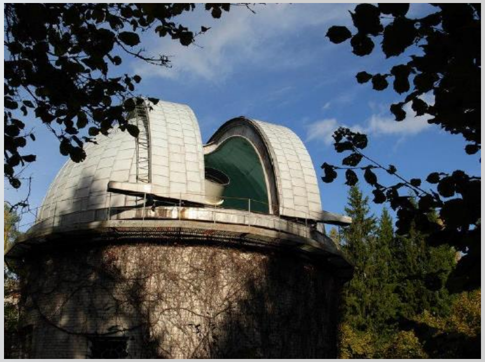
- radar for good range and radial velocity resolution;
- VLBI for angle and angular rate information;
- SLR for instantaneous range measurements of centimeter or millimeter level precision

VIRAC and VUC
RT-32, 32 m antenna + RT-16, 16 m antenna + VUC 2 m, + Kristal 2 m antenna
as an interferometric array with baseline ~ 35 km



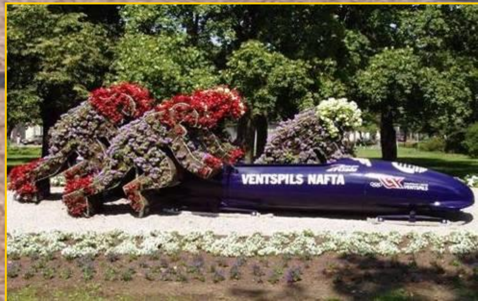

Astronomy Institute of the University of Latvia (AI)

Satellite Laser Ranging (SLR) station Riga (located in Riga) Schmidt telescope (located in Baldone)



This work was supported by
Latvian Council of Science
Research of Galactic Masers,
Project Nr.: lzp-2018/1-0292

Ventspils – city of innovative environment



Thank you for your attention!

New live for Irbene radio telescopes RT-32 and RT-16

RT-32

General Data	Azimuth	Elevation
Motion limits	-328.0° / +328.0°	+2.7° / +95.5°
Number of Motors	2	2
Max. velocity **(old values 0.16 °/s)**	**2.8°/s**	**2.25°/s**
Max. Acceleration during normal operation	0.5°/s²	0.5°/s²
Rated Motor torque	230Nm	230Nm
Pointing and tracking accuracy **(old values ~ 1 arc min)**	**< 10 arc sec**	**< 10 arc sec**

RT-16

General Data	Azimuth	Elevation
Motion limits	-328.0° / +328.0°	+2.7° / +95.5°
Number of Motors	2	2
Max. velocity **(old values 0.16 °/s)**	**5.0°/s**	**4.0°/s**
Max. Acceleration during normal operation	2.5°/s²	2.0°/s²
Rated Motor torque	60Nm	60Nm
Pointing and tracking accuracy **(old values ~ 1 arc min)**	**< 10 arc sec**	**< 10 arc sec**

New live for Irbene radio telescopes RT-32 and RT-16

RT-32

Antenna backup structure renovated and painted;
Antenna surface painted and now adjustable;
Secondary mirror support structure exchanged.

RT-16

Completely new carbon-fiber 16 m antenna placed on old foundation;
New Secondary mirror, supporting legs and vertex cabin.

RT-32 and RT-16

Improved performance of gears and gearboxes;
New motors with differential movement control;
New angular sensors wish ~1.2 arc sec accuracy;
New Antenna control Unit;
New Vertex room with conditioning system.

Frontends:

327 MHz receiver, one polarization;
1.6 GHz receiver, one polarization;
4.5 – 8.8 GHz receiver, 2 polarizations with full cryogenic chain and phase calibration unit;
6.8 – 9.4 GHz Solar multi channel spectro-polarimeter, 2 polarizations;

Backends:

DBBC2, in 2016 FILA10G added;
Mark5C, and Flexbuff 288 TB.

Network:

Network connection improved to 10 Gbps to GEANT network. (with 40 Gbps in future)