

Pushchino Radio Astronomy Observatory:

shortly about history

and instrumentation development.

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PUSHCHINO RADIO ASTRONOMY OBSERVATORY



PRAO is located around 120 km to South from Moscow. There are about 30 astronomers and over 20 engineers those are working here these days. Now PRAO is a part of the LPI Astro Space Center. There are three large radio telescopes in PRAO:

RT-22 ($\lambda_{\min} = 8 \text{ mm}$) - 1959

E-W arm of 1 km DKR-1000 - 1964



Large Phased Array ($\lambda \sim 3 \text{ m}$) - 1974

LPI is the cradle of Soviet and Russian radio astronomy



1946 – Young V.L. Ginzburg at the request of Acad. N.D. Papaleksi calculated the radio diameter of the Sun in the meter wavelengths and found that it should be around 20% more than the optical diameter.



Results of the first Soviet radio astronomical observations by the LPI radio physicists.

20.05.1947 they observed total solar eclipse by the Brazilian coast.

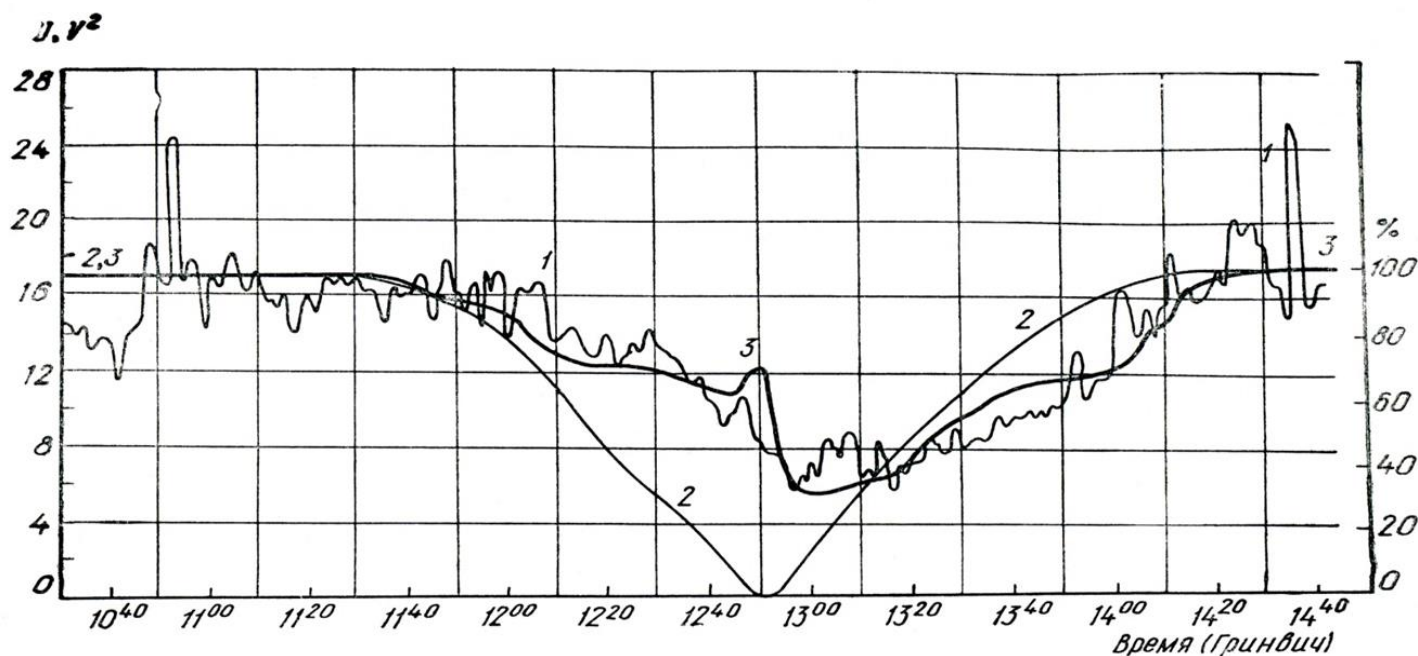


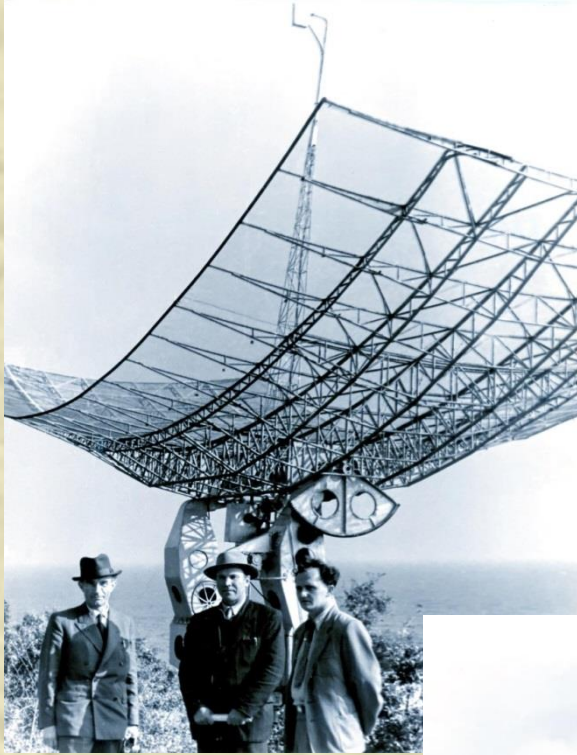
Рис. 1. Запись радиозатмения Солнца, полученная советскими радиоастрономами 20 мая 1947 г.:

1 — изменения интенсивности радиоизлучения Солнца на волне 1,5 м в условных единицах; 2 — изменения видимой площади солнечного диска; 3 — ход «затмения» эруптивных протуберанцев и волокон

1948-58 – First decade of LPI radio astronomy (Crimean period).

<-- rectangular antenna of 18m x 8m aperture (used for 21cm line observations).

∨ 31-meter ground dish ($\lambda_{\min} = 5$ cm) for observations of the Sun and Crab nebula.



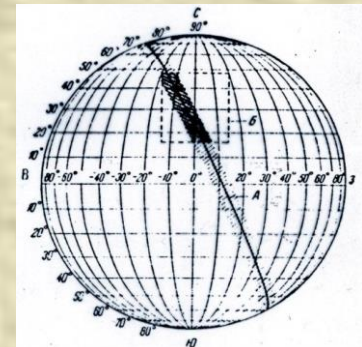
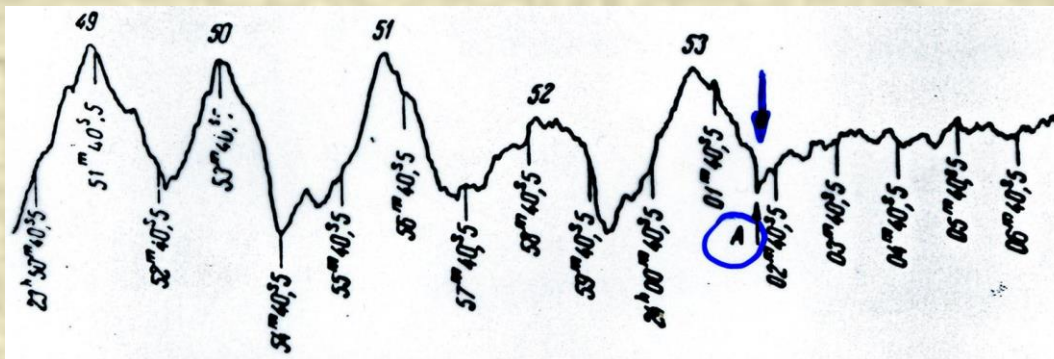
Some of the most important achievements during the first decade (Crimean period)

1953: *Discovery and study of the Supercorona of the Sun (V.V. Vitkevich)*

1957: *Discovery of polarization of the Crab Nebula radio emission (A.D. Kuzmin, V.A. Udaltsov)*

1958: *The first spectral observations of neutral hydrogen ($\lambda = 21$ cm) in our country (R.L. Sorochenko)*

1959: *Determination of the landing coordinates of the spacecraft of the "Luna" series.*



The founding of Pushchino RAS **of the LPI**

Two important (for USSR Academy of Sciences) Decisions of the Council of the Ministers of the USSR.

1956 April 11:

“Allow to Academy of Sciences of the USSR to build in the Moscow region (near Serpukhov) the building of the Radio astronomy station of the LPI and install a radio telescope at this station.”

1956 April 13:

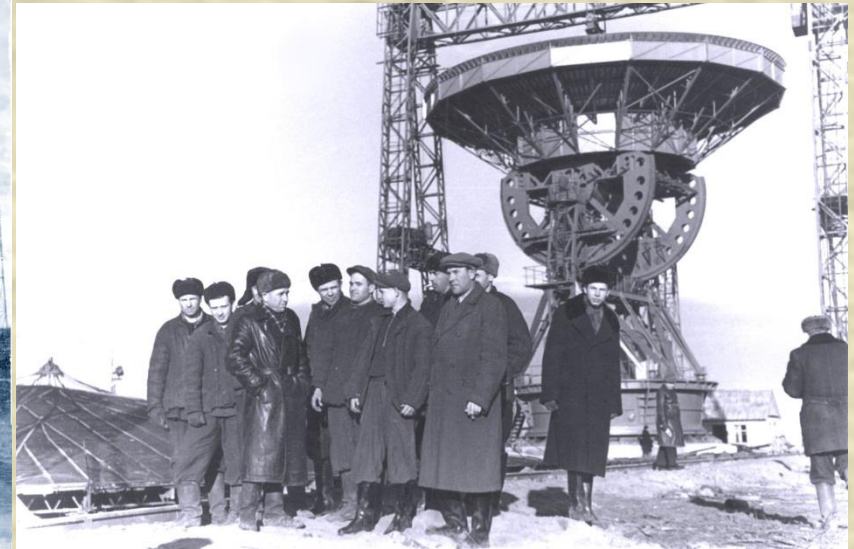
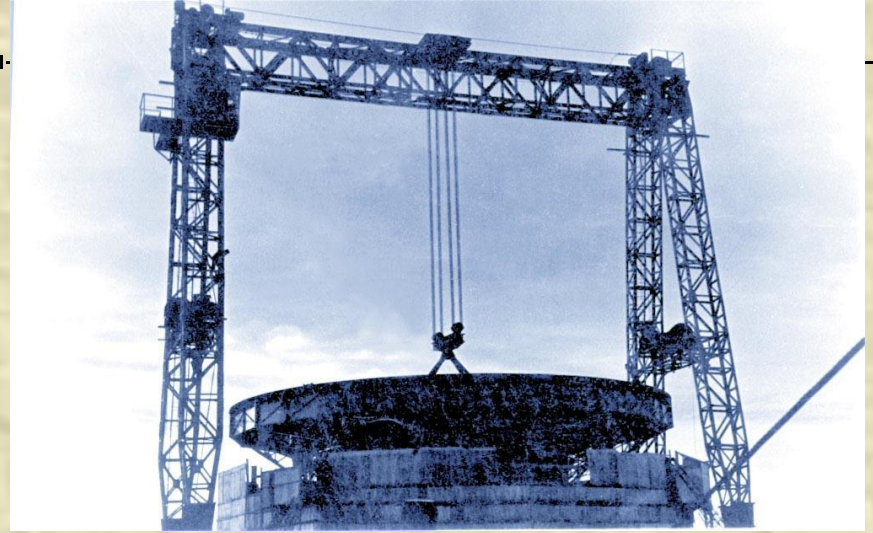
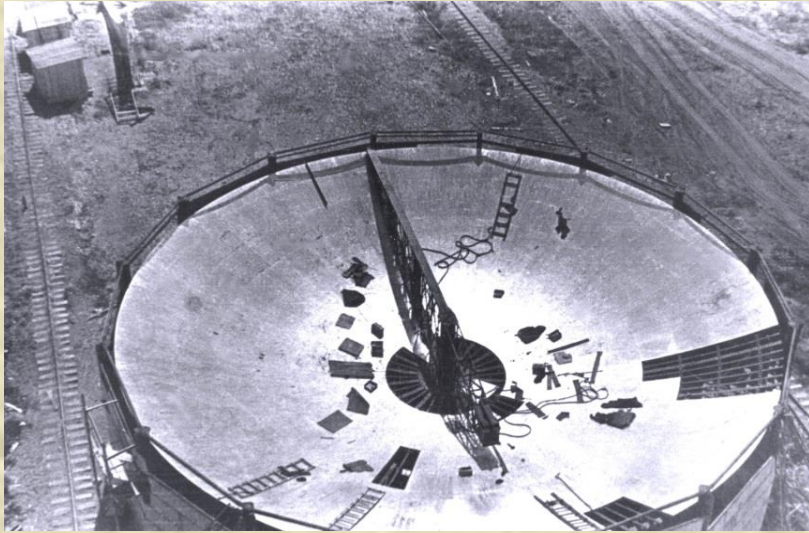
Allow to Academy of Sciences of the USSR to organize in the Moscow region (near Serpukhov) the Scientific Center of Biology with several biological institutes of the Academy of Sciences.

Winter of 1956/57: *The organization of the Biological Center was delayed up to 1963, but radio astronomers were ready to start immediately.*

The transportation of the lower base of the RT-22 that was used before as lower mount of the biggest gun of the giant linear ship (the disarmament program).



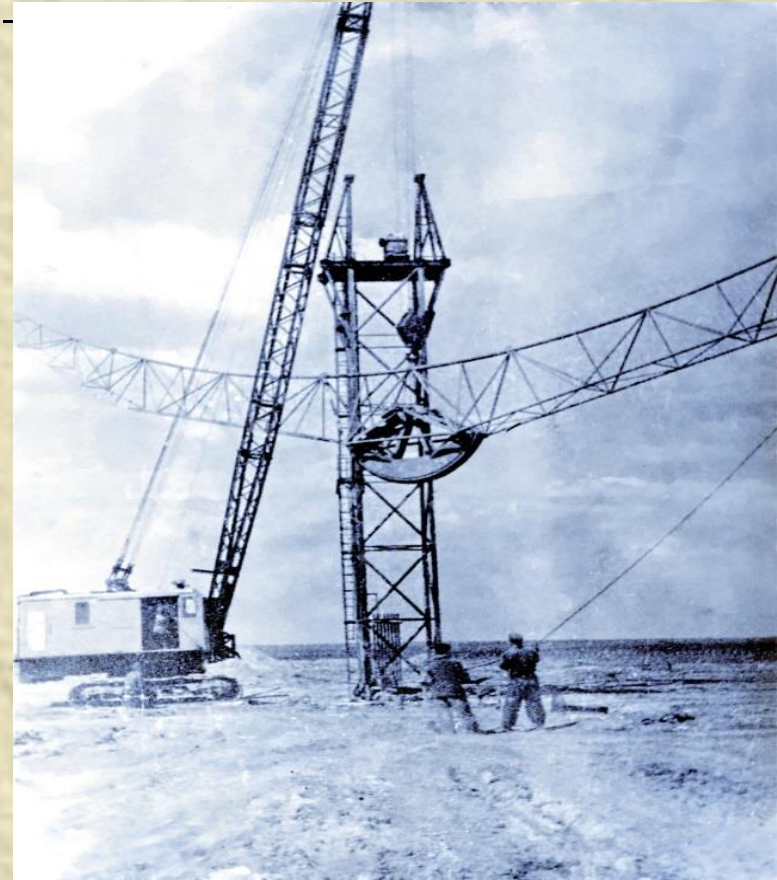
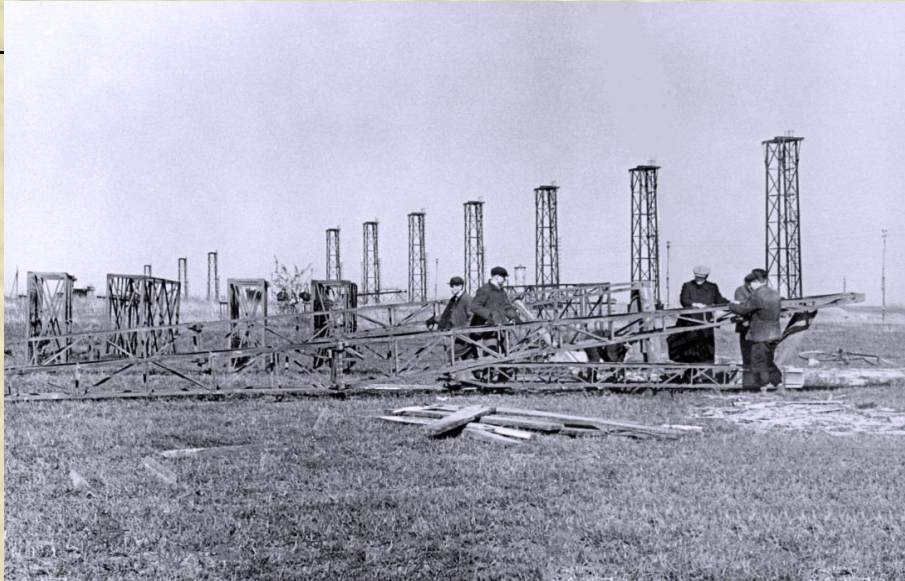
1958: Construction of RT-22



1959: *A.Salomonovich (sitting) and P.Kalachev
by the control desk of radio telescope. First
observations of the Sun was made in 1959 April.*



1960-63: *Construction of the E-W arm of our wide-band cross-type telescope (only mechanical construction without dipole-feeder system and preamplifiers).*



*1963: Sir Bernard Lowell (second from the left)
under 1 km E-W arm of Cross-type telescope.*

*First observations with this antenna was made in 1964 October.
There were many other fruitful contacts with foreign colleagues.*



1961 : Visit of 6 Soviet Radio Astronomers to the NRAO (Green Bank)



V.Vitkevich, A.Kuzmin, R.Sorochenko, P.Kalachev (from LPI), V.Sanamyman (Burakan Obs.), G.Getmantsev (NIRFI) together with the famous radio astronomers from USA.

1972-73 гг.: Assembly work at our Large Phased Array (LPA of LPI)



Some of the most important achievements during the first decades

1958-59: *Radially elongated magnetic fields in solar supercorona (V.Vitkevich).*

1962: *Kink in the spectra of the Cyg-A and the first estimate the age of any radio galaxy (A.Kuzmin).*

1964: *Discovery of highly excited ($n \sim 100$) atoms in space (R.Sorochenko).*

1964: *Determination of temperature and pressure on the surface of the Venera (A.Kuzmin).*

1966: *Measuring of solar wind speed at high heliolatitudes (V.Vitkevich, V.Vlasov).*

1969: *Change in average spectral index of the sources with flux density, i.e. with cosmological epochs (R.Dagkesaman.).*

1970th: *Theory of wave propagation in random media and model of solar wind formation (V.Shishov, M.Konyukov).*

Registration of the individual pulses of two pulsars at LPA

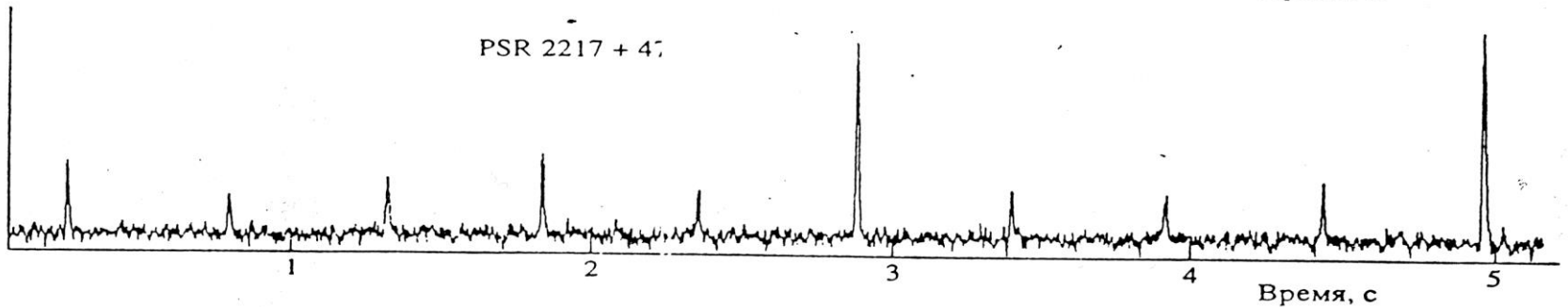
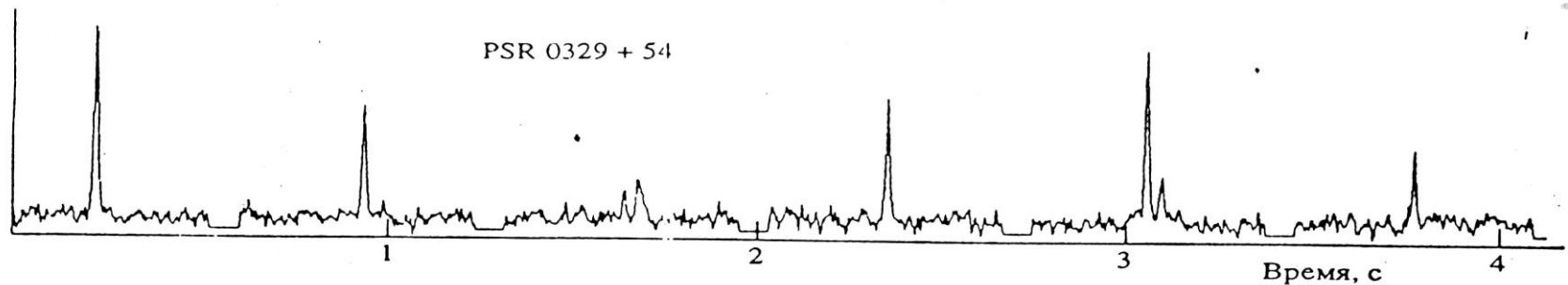
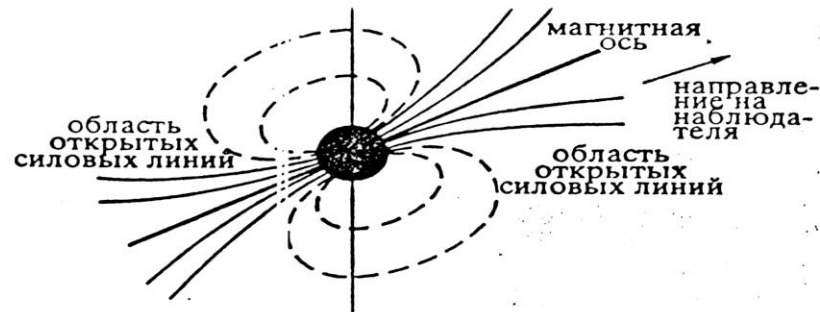
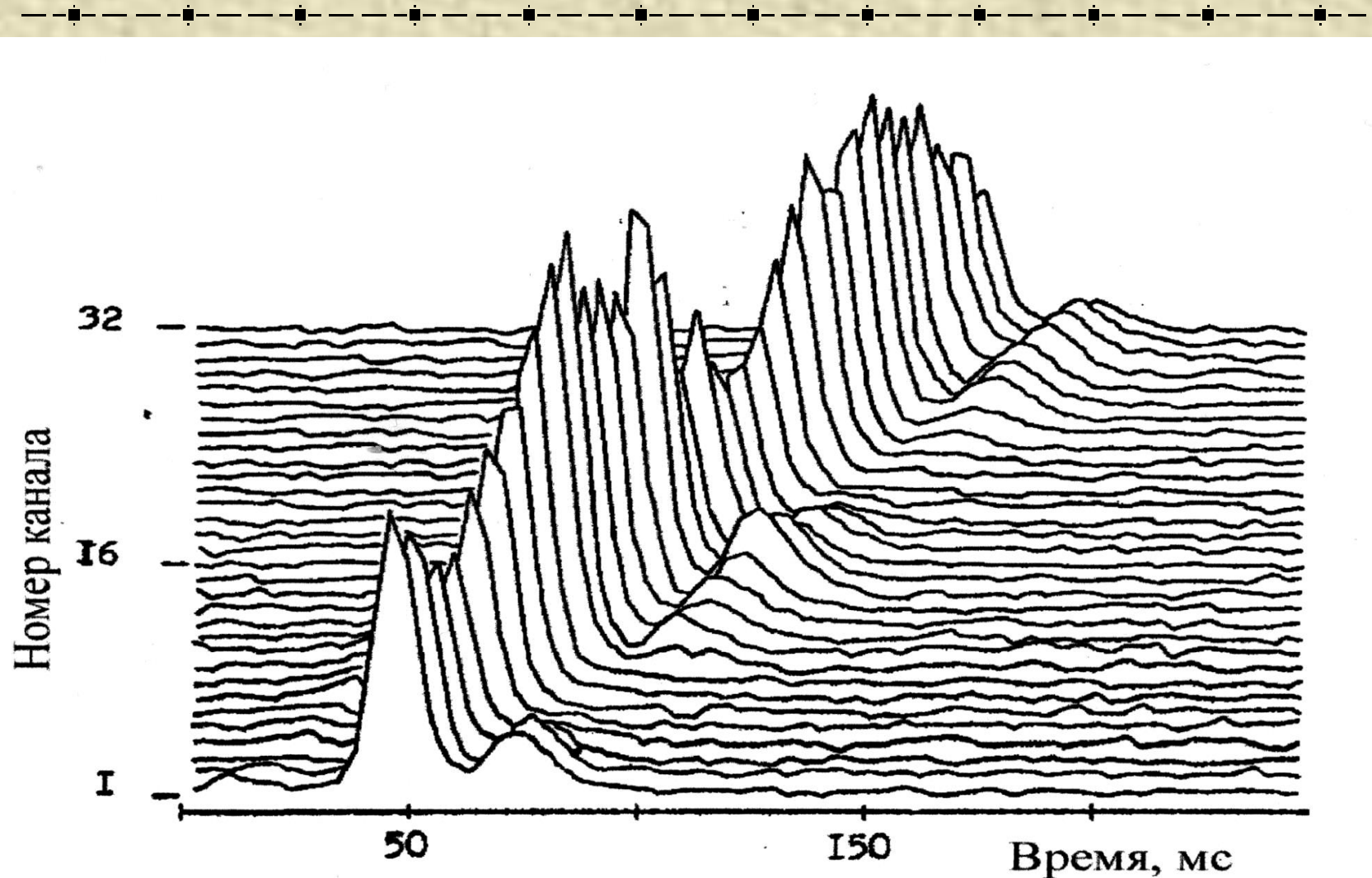


Рис. 1. Пример записей отдельных импульсов двух пульсаров PSR 0329+54 с периодом повторения импульсов 0.714 с и пульсара PSR 2217+47 с периодом 0.538 с, полученных на большой синфазной антенне Радиоастрономической станции ФИАН (Пущино).

**Spectrum of the 4 minutes averaged pulse
of PSR 0329+54 (oscillations with frequency is
due to partially polarized emission).**



Some of the most important achievements in pulsar research

- *Discovery of the first Pushchino pulsar PP0943 (1968 December).*
- *Suggestion for pulsar time scale (1974, A.Kuzmin, Yu.Ilyasov, Yu.Shitov et al.).*
- *Super dispersive delay of pulsar pulses (Yu.Shitov).*
- *First registration of the radio emission from the Geminga X-ray pulsar (A.Kuzmin, V.Malofeev).*
- *Theoretical models of pulsars, magnetars and anomalous X-ray pulsars (I.F.Malov).*
- *Timing of pulsars: > 30 years monitoring about 30 pulsars, their periods and glitches (T.V.Shabanova).*

1990 and later: Formation of the Astro Space Center of the LPI

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- **1990.** *Transfer of a group of astrophysicists led by Nikolai Kardashev from Space Research Institute to Lebedev Physical Institute. The merger of this group with the Department of Radio Astronomy of the Lebedev Physical Institute (i.e. with our Observatory) and the formation of the Astro Space Center of LPI.*
 - *This “grand unification” took place in 1990 and, I think, was benefited both teams.*
 - *In **1990-2019** the scientists and engineers from Pushchino Radio Astronomy Observatory were actively participated in “RADIOASTRON” project.*

Participation our scientists and engineers in “RADIOASTRON” project:

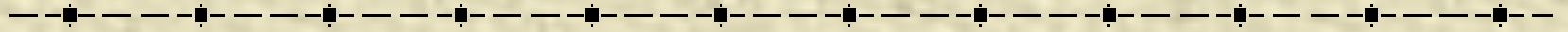
*SRT-10 radio telescope during the
ground testing at Pushchino Observatory*



*and RT-22 that was used as an
antenna of the Ground Tracking
Station from beginning by the
end of the project.*



UPGRADE OF THE LPA RADIO TELESCOPE IN 2011-2013 YEARS

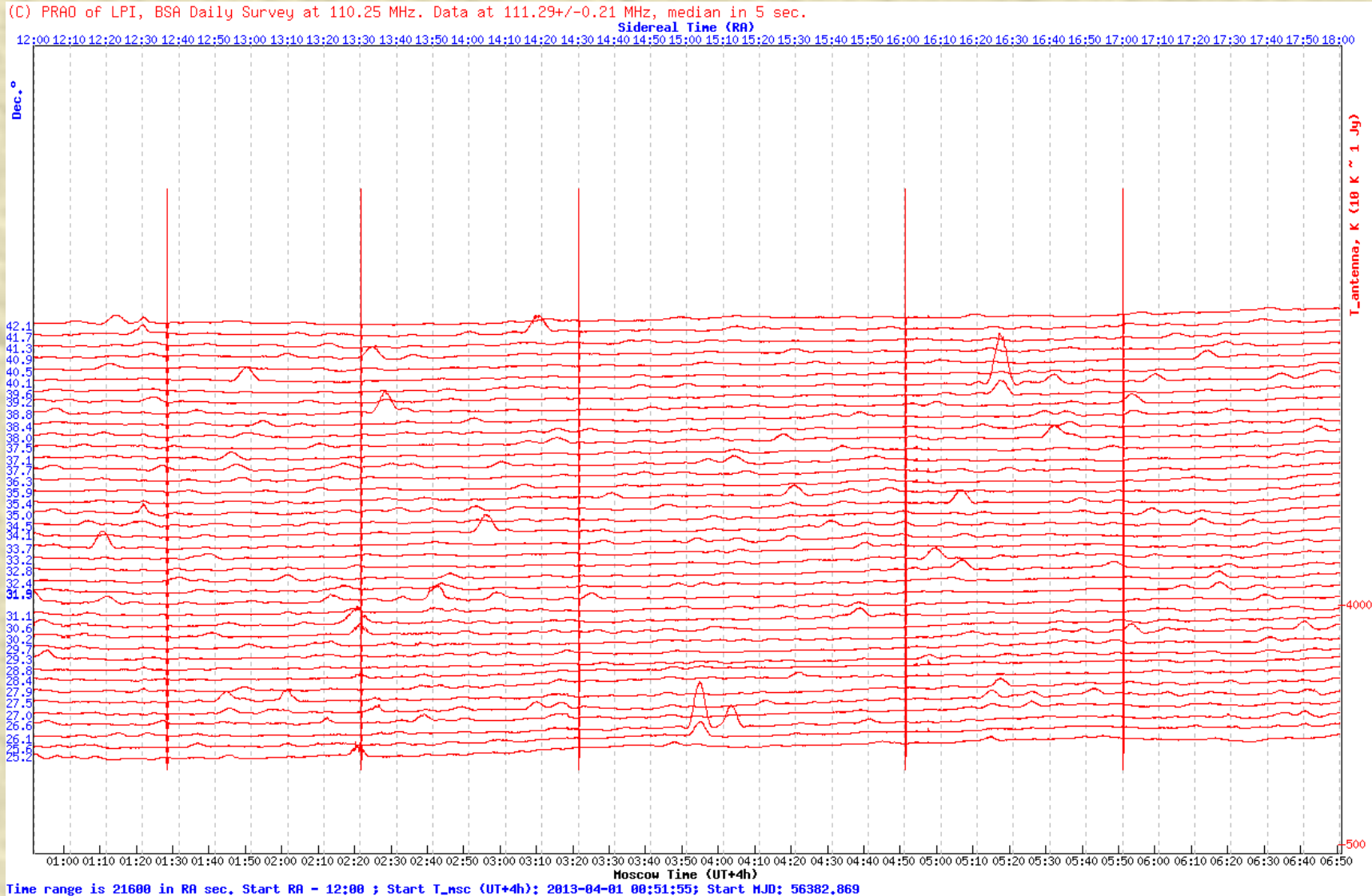


- *New 256 preamplifiers with lower noise improved the sensitivity of the phased array.*
- *Each new preamplifier has one input from linear E-W antenna (from 64-dipols) and four identical outputs.*
- *Outputs No.1 from the all 256 preamplifiers are fed to the inputs of the former beamforming system, that forms an 8-beam steering pattern, similar to that used before the upgrade.*
- *Outputs No.2 from the all 256 preamplifiers are fed to the inputs of the another, new beamforming system, that forms the stable 128-beam pattern used to monitor the state of the interplanetary plasma.*

So, now we have two radio telescopes based on the same antenna array.

6-hour records in 40 beams

(01/04/2013)



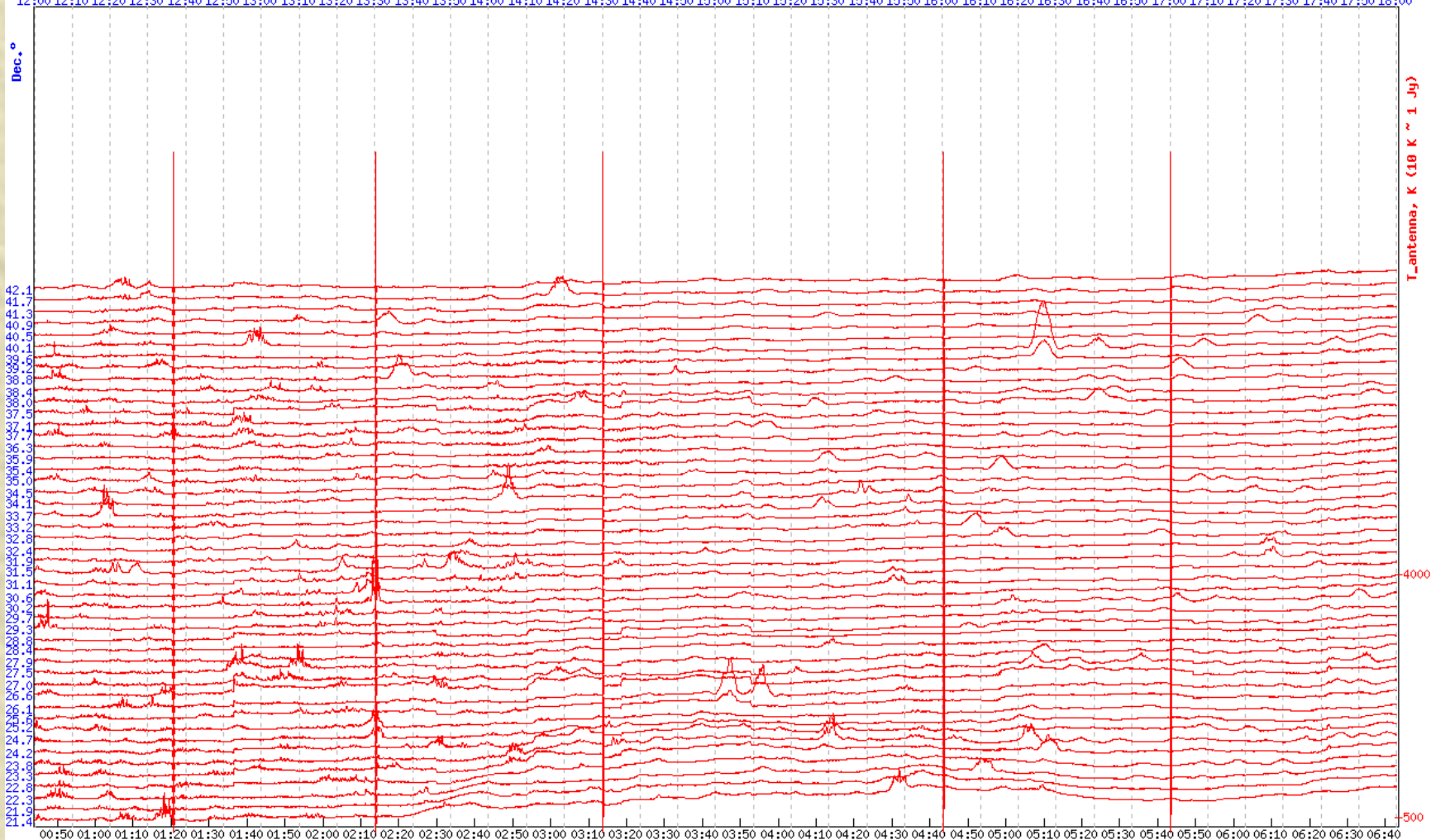
6 hours records in 48 beams

(03/04/2013)

(C) PRAO of LPI, BSA Daily Survey at 110.25 MHz. Data at 111.29+/-0.21 MHz, median in 5 sec.

Sidereal Time (RA)

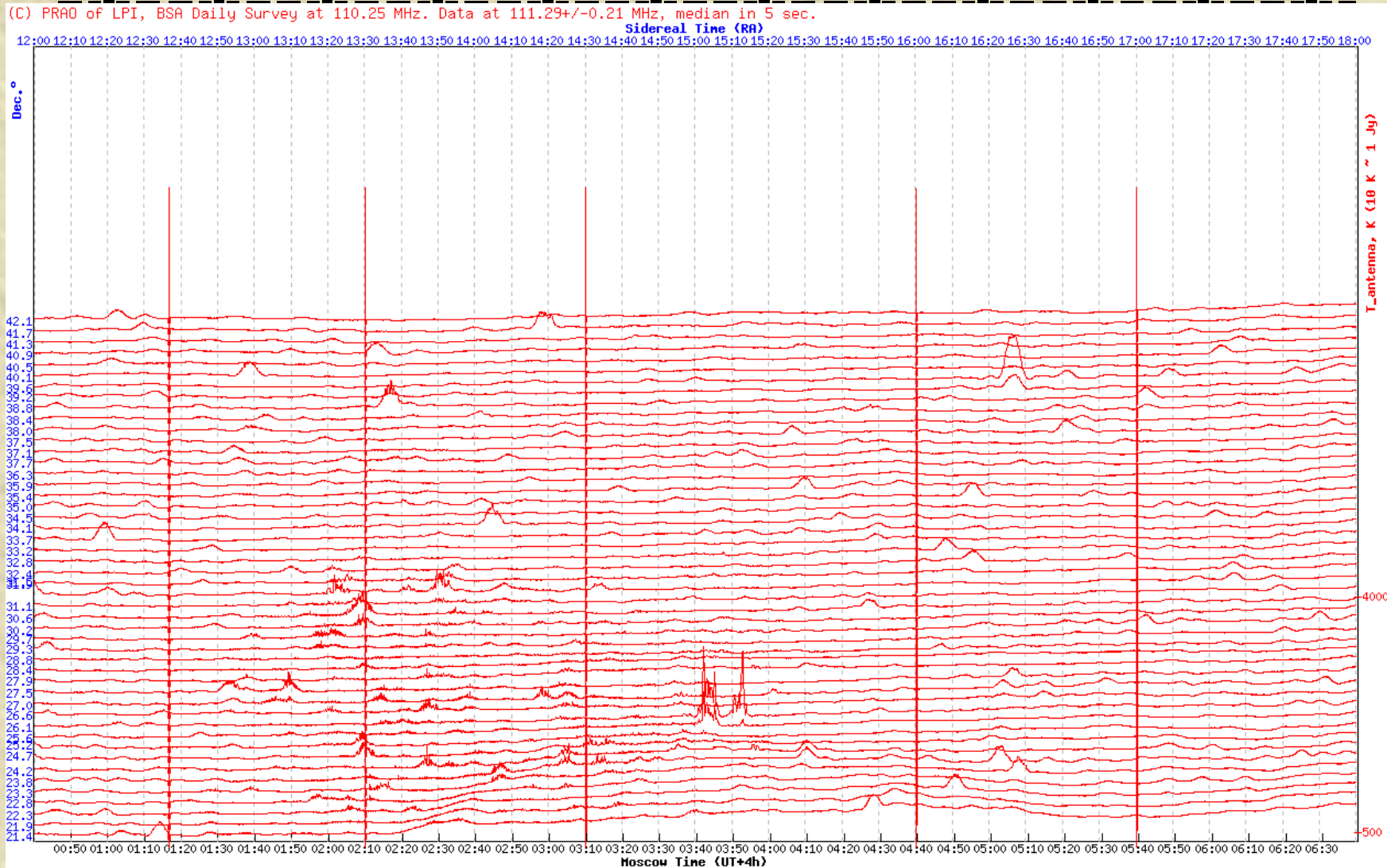
12:00 12:10 12:20 12:30 12:40 12:50 13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20 14:30 14:40 14:50 15:00 15:10 15:20 15:30 15:40 15:50 16:00 16:10 16:20 16:30 16:40 16:50 17:00 17:10 17:20 17:30 17:40 17:50 18:00



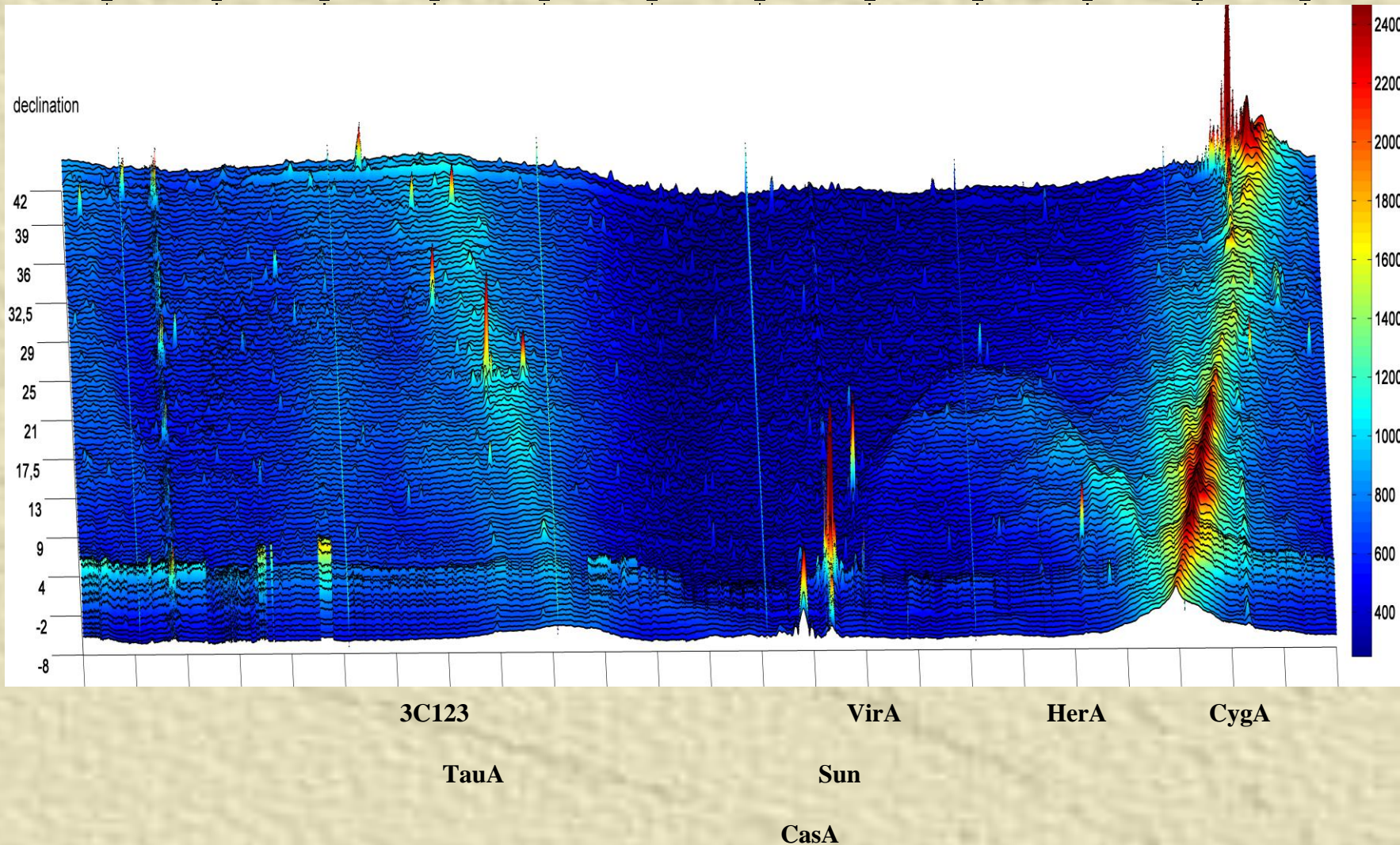
Time range is 21600 in PR sec. Start PR = 12:00 * Start T sec (UT+4h): 2013-04-03 00:44:03: Start MID: 56384.864

The same region (48 beams)

one day later (04/04/2013)




A typical 24-hours record with a stationary LPA pattern (23.09.2015)



Conclusion

So, our LPA is used for observations by two independent scientific programs. In other words, **there are 2 LPA radio telescopes**, and the both work very efficiently.

Today there are already the hundreds of terabytes of data that can be used not only to study the state of the interplanetary plasma, and we will welcome those who wish to use this data for any other purpose, too. We are also interesting in any proposals for the use of outputs No. 3 and 4 of LPA 256 preamplifiers.



Thank you for your attention!





1947 April - an expedition of the astronomers and radio physicists just before departure from Leningrad to the coast of Brazil for observation of the total solar eclipse (to check Ginzburg's conclusion). The group of LPI radio physicists was headed by Prof. Semen Khaikin. V. Ginzburg and I. Shklovsky were participated in the expedition, too.



1964 October: Viktor Vitkevich looks on his “child”.

