Study of extragalactic objects with Pushchino low-frequency radio telescopes

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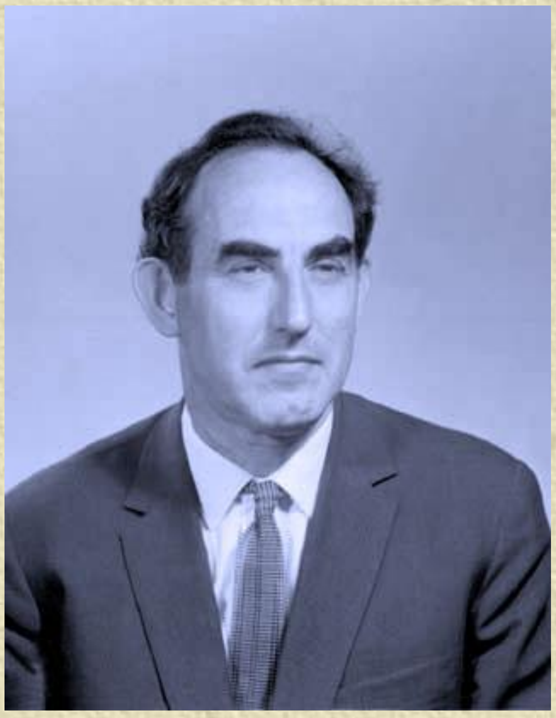
Lebedev Physical Institute is a Cradle of the Russian Radio Astronomy

1946 – V. L.Ginzburg has calculated the radio diameter of the Sun (under the request by academician N.D.Papaleksi).

The main conclusion was:

Radio diameter should be considerably (around 17%) larger than optical one.



1947 – Expedition to Brazil coast for observation of a total solar eclipse on May 20, 1947 was organized with the ship "Griboedov". The group of future radioastronomers was headed by S.E. Khaikin.

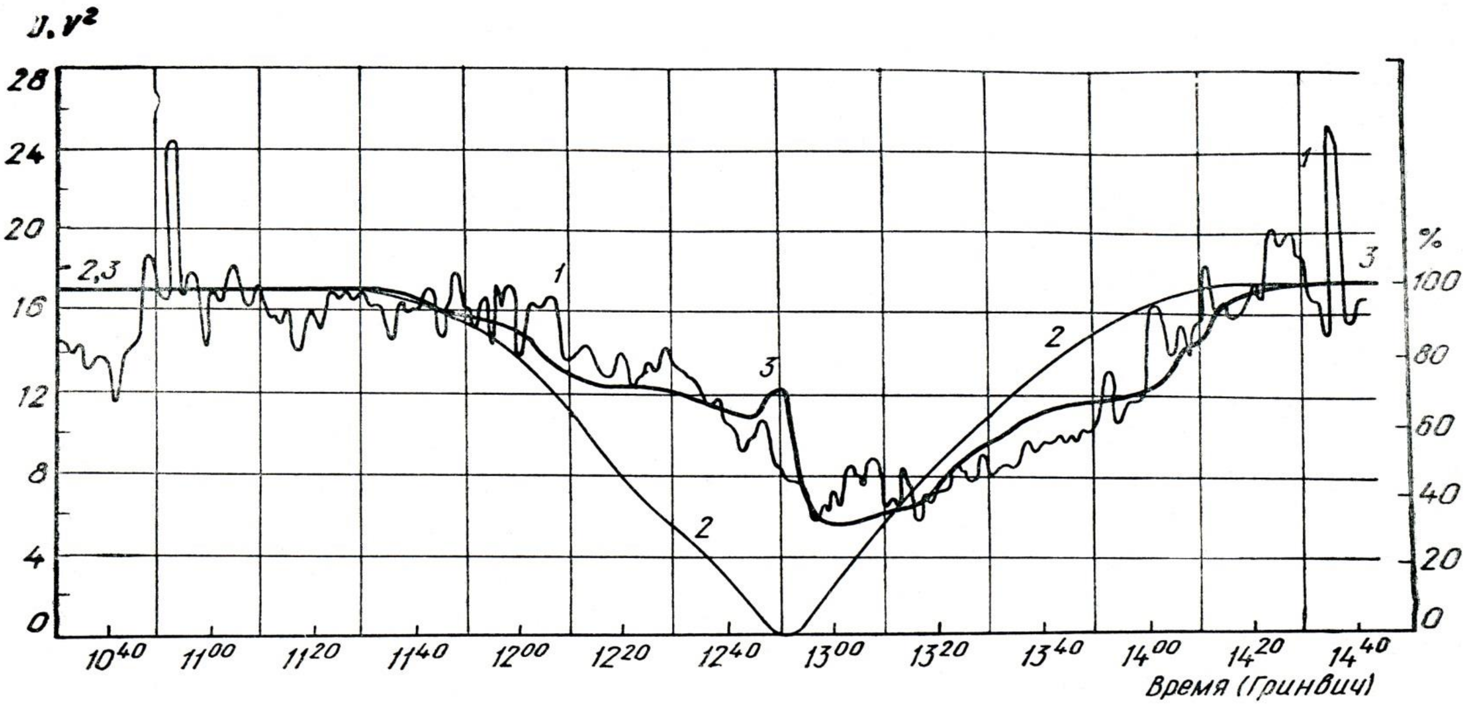


Рис. 1. Запись радиозатмения Солнца, полученная советскими радиоастрономами 20 мая 1947 г.:

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

As was predicted by V.Ginzburg, - radio emission from the Sun had reduced but only ~2.5 times.

В.В. Виткевич

1948 – the radio astronomy group under Prof. S.E.Khajkin's management is organized at Laboratory of oscillations of the Lebedev Physical Institute

The new group studied of the radio refraction, scattering, scintillations and absorption in the Earth's atmosphere by observations of cosmic radio sources. Several stationary expeditions were organized at Crimea and the first Russian radio telescopes were constructed there.

From 1952 this group was headed by Victor Vitkevich. And from the end of 1950s most radio astronomical studies in LPI were moved to the south of Moscow region, where the Pushchino RAO is staying now.

Today there are 3 large radio telescopes at PRAO:

- RT-22 is full steerable precise radio dish for 8 mm and longer wavelenghs.

- E-W arm of Wide-band Cross-type meridian telescope wth aperture of 40m x 1km working in 30-120 MHz band.

- LPhA with dimensions of 187m x 384 m that is filled-aperture meridian radio telescope working now at 111 MHz.

RT-22 LPI Radio Telescope is a parabolic reflector with its main dish of 22 m in diameter. Accuracy of the dish surface provides an effective operation up to 8 mm wavelengths. The modern cooled LNAs are used in the receivers system. Today the major scientific programs deal with star formation regions research by observations of atomic and molecular radio lines, and investigations of compact radio sources structures using VLBI technique with the msec angular resolution.

From 2011 this radio telescope is used also as an antenna of the tracking station in RADIASTRON project.

E-W arm of Wide-Band Cross-type Radio Telescope DKR-1000 is a meridian instrument consisting of parabolic cylinder with the width of 40m and is 1km long. Wide-band feeds located along the focal line of the parabolic cylinder allow to observe in the wavelengths from 2.5 up to 10 meters.

LPhA (BSA) radio telescope - is a phased array comprising 16384 dipoles and covering an area of 18 acres. Its operating wavelength i around 2.7 m.

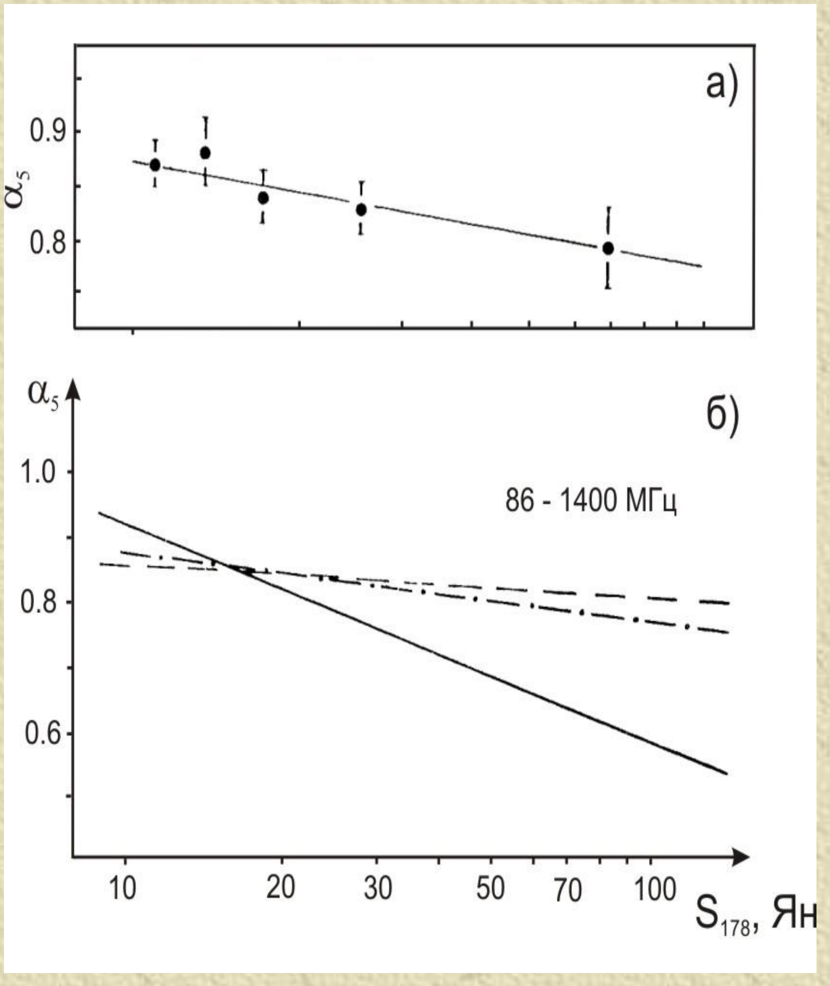
“Spectral Index–Flux Density” Dependence for 3C-sample of Extragalactic Radio Sources. 1.

- ***Observations with E-W arm of WCRT (DKR-1000) started by the end of 1964.***
- ***Counts of radio sources N(S) and conclusion about evolution of their radio luminosity with red shift (beginning of 1960s).***
- ***And what about the other parameters of radio galaxies? Does they evolve, too? May be spectral indices correlate with S?***
- ***Negative answers were obtained by:***

Conway R.G., Kellermann K.I., & Long R.J. (MNRAS, 1963), Kellermann K.I. (Aph J, 1964) and by Kellermann K.I., Pauliny-Toth I.I.K. & Williams P.J.S. (AphJ, 1969).

- ***All these authors had used for their analyses almost all published measurements of 3C-sources flux densities at different frequencies with different radio telescopes.***

“Spectral Index–Flux Density” Dependence for 3C-sample of Extragalactic Radio Sources. 2.



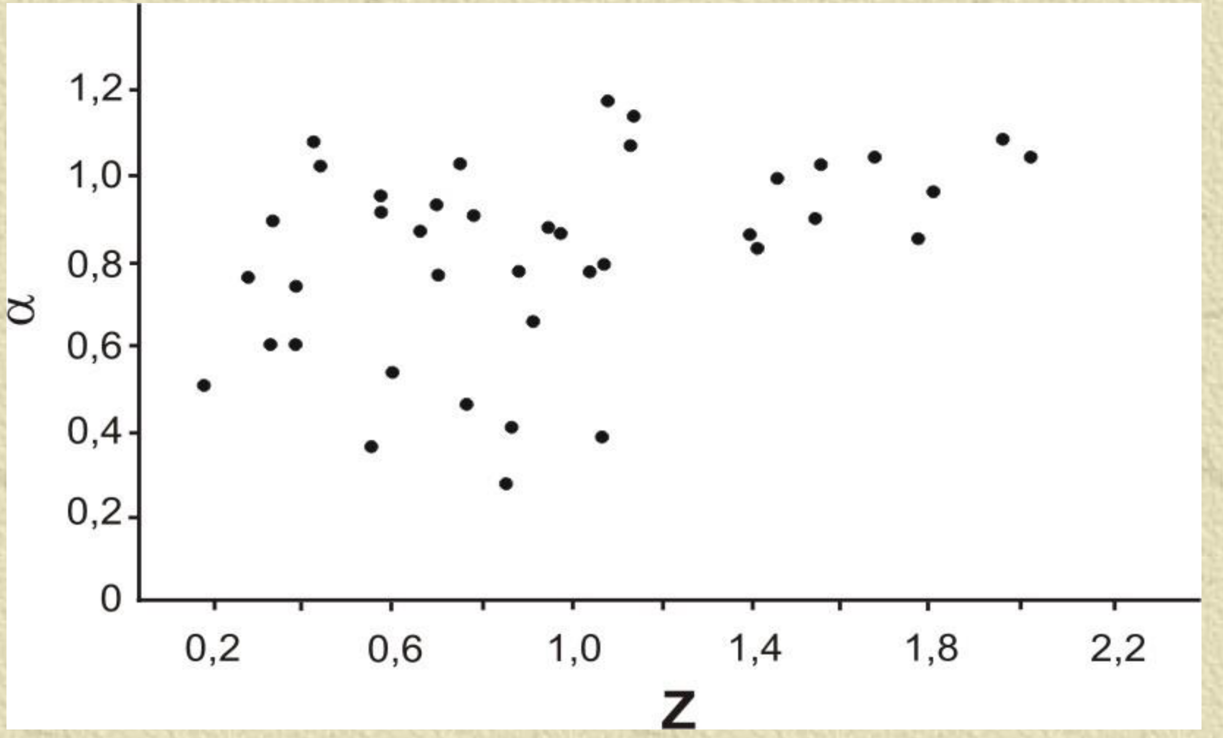
- ***We had chosen some other way and used only the measurements at 86, 178, 750 & 1400 MHz.***
- ***Upper figure corresponds to spectral indices between 86 and 1400 MHz. Spectra of the sources become more steep with decreasing of their flux densities.***
- ***Solid line at lower figure corresponds to QSS, dashed line – to RGs and the intermediate - to unidentified sources.***
- ***Some of conclusions:***

- ***Sp. indices increase with redshifts.***
- ***Unidentified sources are more distant RGs.***

(see “Astrofizika”, v.5, №2,1969)

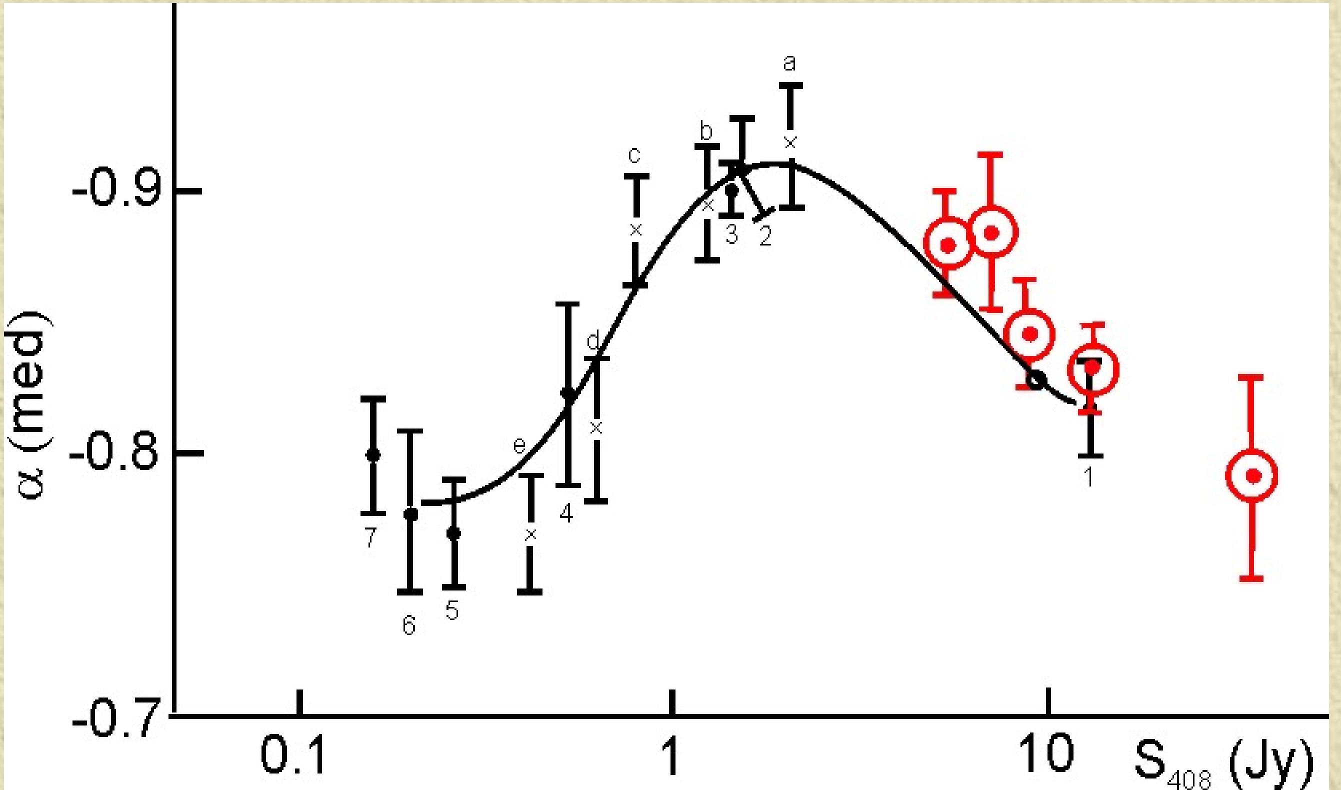
“Spectral Index – Red Shift” Diagram for QSSs from 3CR Sample.

More detail analysis of 3CR QSSs distribution on α-z plane was fulfilled next year (see picture below from** R.D.Dagkesamanskii, Nature, 1970, V.226, p.432**). We suggested that more steep spectra of distant QSSs could be due to more dense and hotter intergalactic plasma at large red shifts.



“Spectral Index – Flux Density” Dependence for Wider Range of Flux Densities

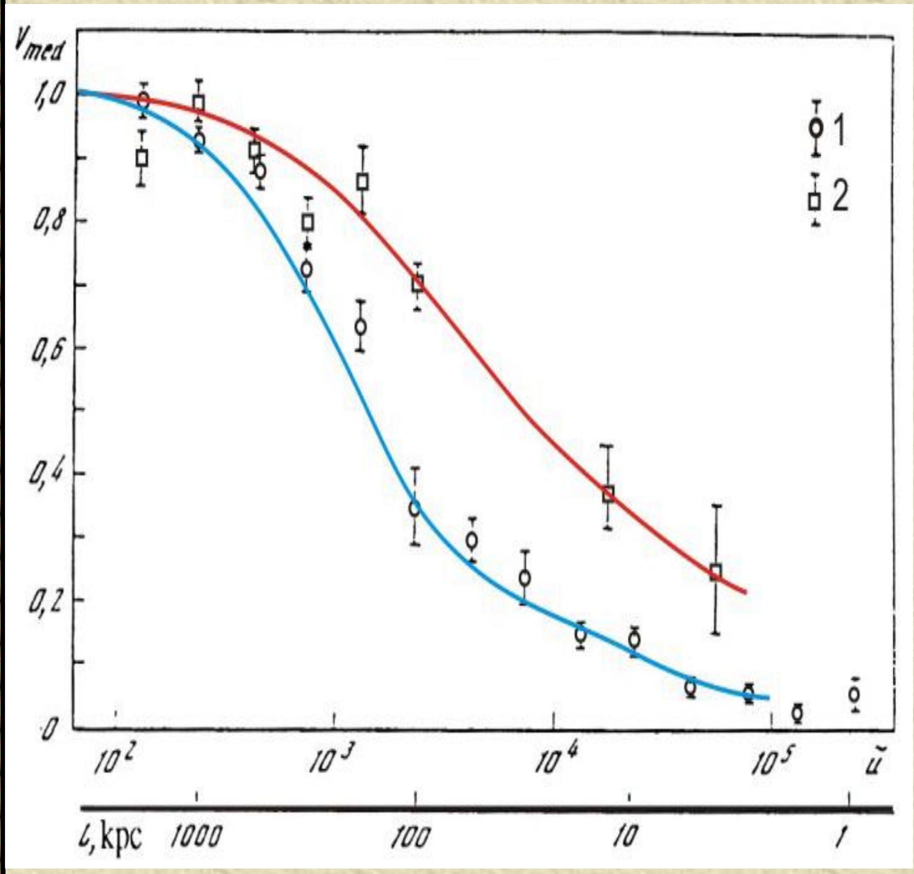
In 1982 Gopal-Krishna & Steppe H., (**A&A, V.113, pp.150**) investigated the dependence in wider range of flux densities. To the black estimates of spectral indices from their paper we added the red points from our paper (previous slide).



Investigations of the structure of 3C-sample extragalactic radio sources at low-frequency (86 MHz) with radio link interferometer. 1.

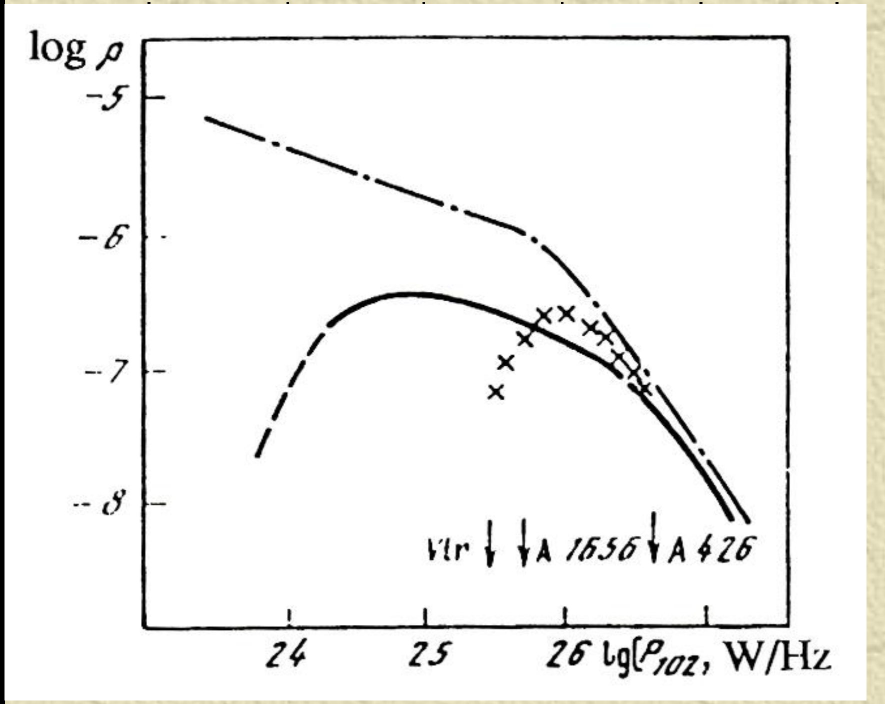
- *E-W arm of WCRT was the main antenna of the interferometer, and the remote antenna was formed by 64 Yagi-elements.*
- *The observations with 10 different positions of remote antenna were used for most radio sources.*
- *We investigated typical linear structures of RGs and QSSs. For this we compared dependences of visibility function amplitude,* |V| , *from baseline recalculated for all radio sources to the same redshift (z = 0.1). Such recalculated baseline is proportional to 1/l, where l - is corresponding linear size.*

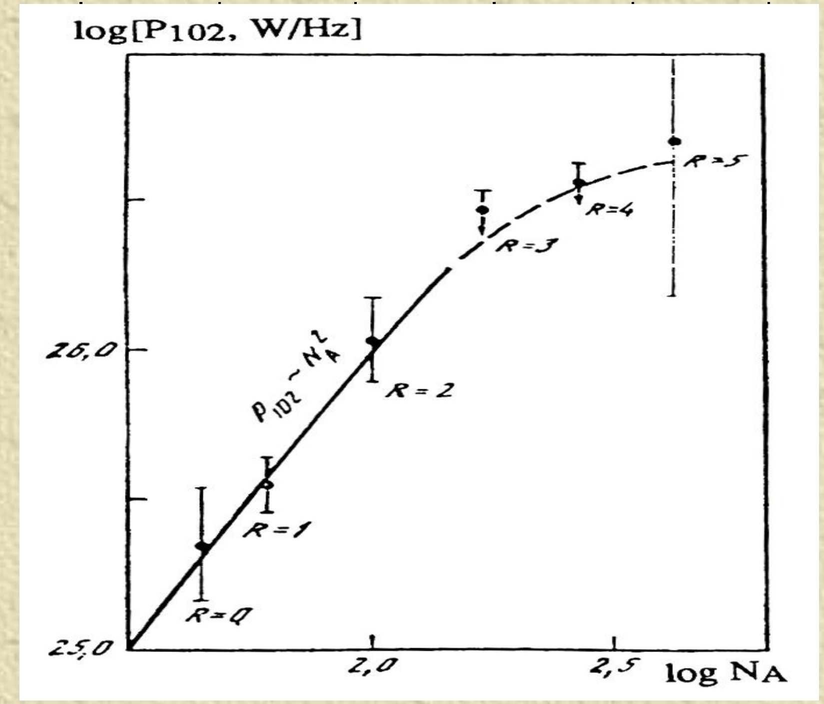
Investigations of the structure of 3C-sample extragalactic radio sources at low-frequency (86 MHz) with radio link interferometer. 2.



- *Red curve corresponds to QSSs and blue one – to RGs. Linear sizes corresponding to baselines reduced to z=0.1 show at the bottom of figure.*
- *Difference between two curves is only in relative contribution of rather small components (< 10 kpc) to the total radio emission of the sources.*

Low-Frequency Radio Emission of the Rich Clusters of Galaxies. 1.

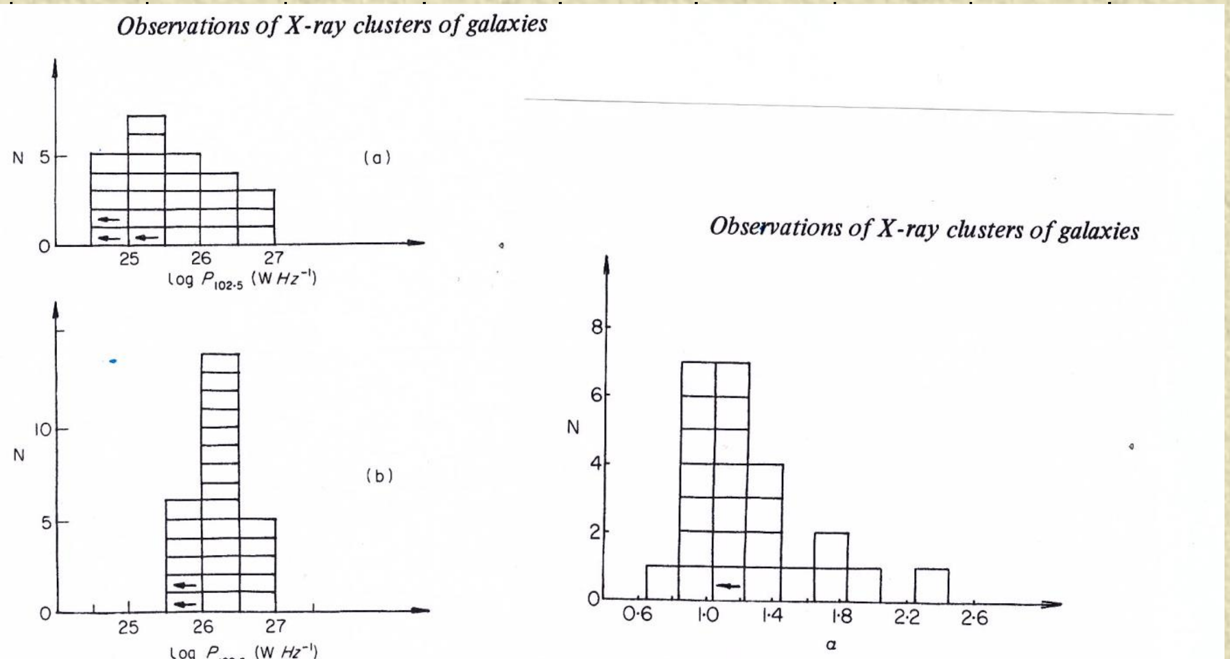




Luminosity function of Abell clusters of galaxies (left curve) and correlation between P_{102} and richness of the clusters (right curve). The fact that $P_{102} \sim N_A^2$ shows that interaction between galaxies stimulate their activity.

All observations were made with our LPhA and the results were published in Proceedings of LPhI,, V.189 (1988). This Proceedings was translated to English by Nova Science Publishers in 1990 as a book "Clusters of Galaxies and Extragalactic Radio Sources".

Study of Low-Frequency Radio Emission of X-ray clusters of galaxies at 102.5 MHz



…r distributions: (a) for the sample of nearby (D ≤ 2) …alaxies.

Figure 4. Distribution of spectral indices α for X-ray clusters.

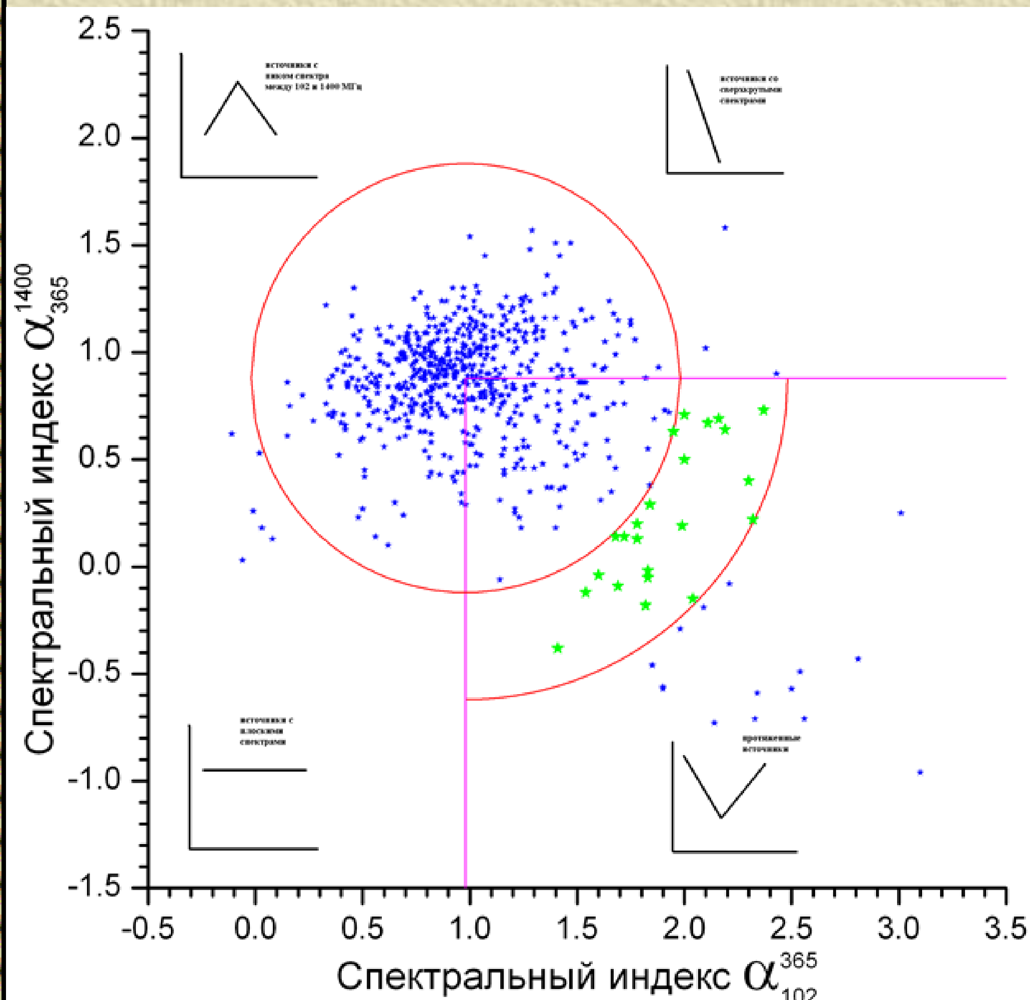
Radio power distribution of X-ray clusters compared with the same distribution for relatively nearby clusters of galaxies (left figure) and distribution of spectral indices for X-ray clusters (right figure). *From MNRAS, V.200, p.971, 1982*

Giant Radio Galaxies: do they form the separate class of RGs? 1.

Usually we say <u>giant radio galaxy</u> when we are talking about the object of around 1 Mpc or more in size. These extremely large linear dimensions were measured first time at WSRT in 1974 (*see A.G.Wills, R.G.Strom & A.S.Wilson, Nature,* ***250****, 625****). Many papers were published for more than 40 years with the attempts to find any concrete cause responsible for so large dimensions.***

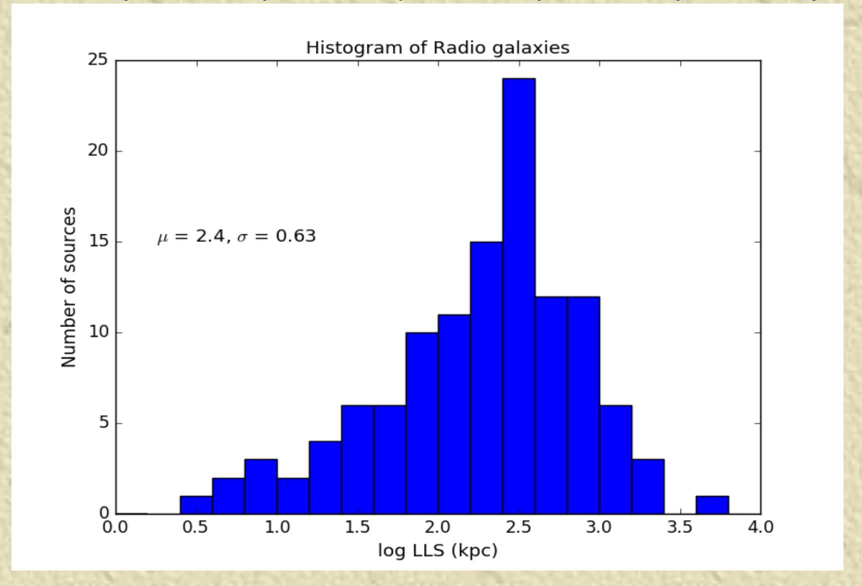
To make our contribution in this field we tried to form another sample of GRGs. For this we used the Pushchino Catalogue (PC102) compiled on sky survey made with our LPhA (*AstRep.,****44,*** *p.18,2000****), identified the sources from PC102 with well known TEXAS survey (****Douglas et al., Astron.J.,*** ***111,*** *1945, 1996****) at 365 MHz and with GB-catalogue (****White & Becker, Astron.J. Suppl. Ser.,****79****, 331, 1992*** ***) at 1400 MHz. For all identified sources we calculated two-frequency spectral indices*** $\alpha_{102\text{-}365}$ ***and*** $\alpha_{365\text{-}1400}$.

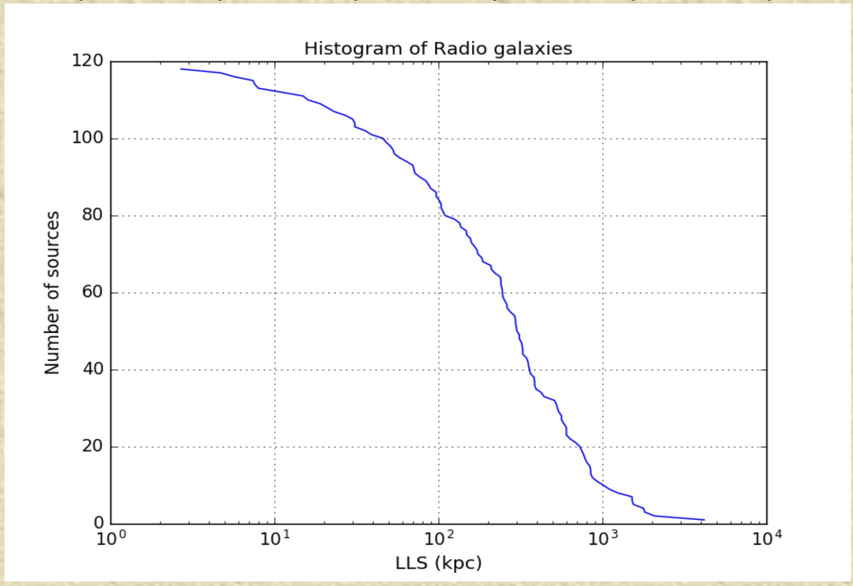
Giant Radio Galaxies: do they form the separate class of RGs? 2.



Here is distribution of these sources at $\alpha_{102\text{-}365}$ - $\alpha_{365\text{-}1400}$ diagram. The distribution is easy understandable. At 102 and 1400 are total power measurements, and at 365 MHz - interferometric. Large angular structures are underestimated at 365 MHz, and the such sources are shifted below and to right. We carefully studied these sources, but most of them are nearby sources with several hundreds kpc in size. Almost the same result we have got from analyses the other sources in this angle.

Giant Radio Galaxies: do they form the separate class of RGs? 3.

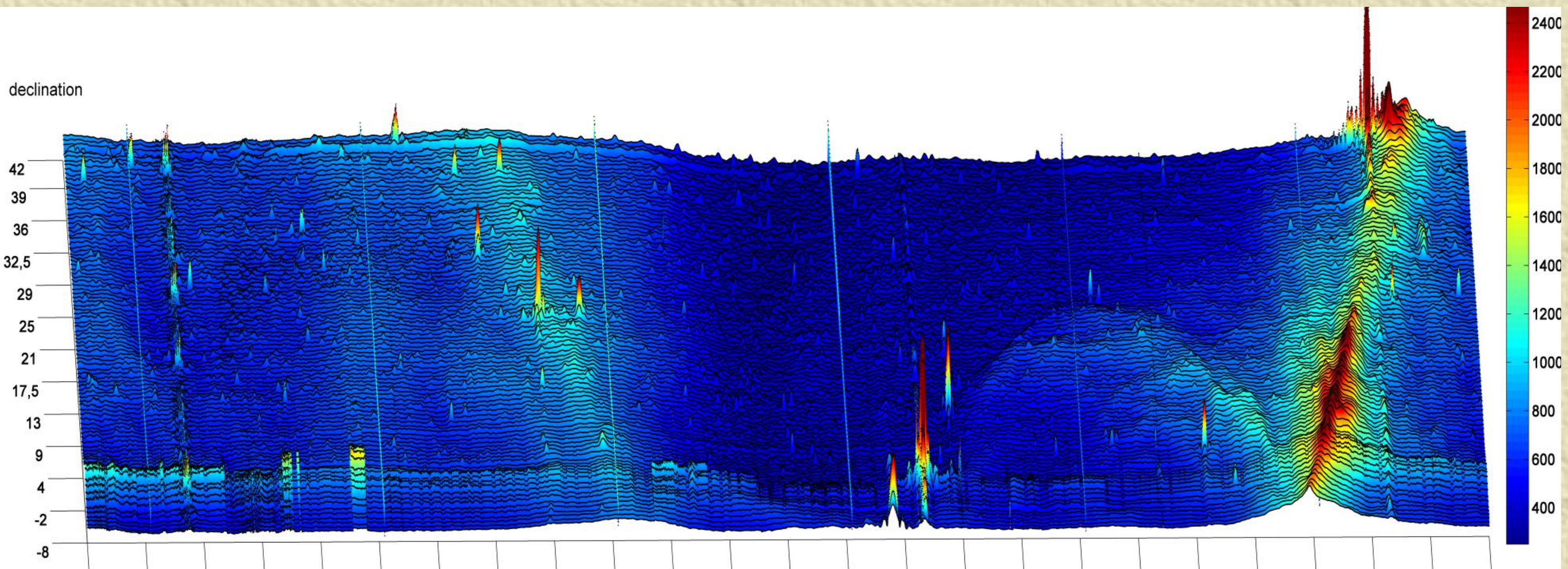




Then we have turned to well known and studied 3C-sample of RGs. We had carefully analyzed their LLS (large linear size) distribution presented in the pictures above. Our conclusion: GRGs is not separate group. It is seems, that they are natural rather small group of RGs those have favorable intrinsic parameters (power of engine, age, etc.) and surrounding conditions (low dense external IG medium, line of sight is almost perpendicular to the source's axis, etc.).

Some of the new prospects for extragalactic studies with Pushchino LPhA.

- ***Radically upgrade of LPhA in several last years. Stationary 128-beams of new BFS are used independent from steerable 8 beams for different tasks.***
- ***Main parameters of the new BFS: FOV is ~ 60 sq.degrees; up to 12.5 msec time resolution; ~80 kHz frequency resolution.***
- ***New prospects for investigations of the different kind variations of the cosmic radio emission (searching pulsars, sporadic pulses, transients, etc.)***



Thank you very much!

And welcome to Pushchino RAO