Early VLBI in the Soviet Union

Matveenko, Space research institute, Moscow

1959 – Launch of Lunniks opened epoch of the space investigations

Radio astronomers of the Physical Institute measured trajectories of the probes and hit point at the Moon.

(V.V.Vitkevitch, et al. Radiotechnika and Electronics, 1961, 9, 1420.)







The Crimea

1961: Deep Space Network, Evpatoriya, the Crimea:

FIAN collaborated in the construction of radio interferometer (B= 500 m). Accuracy of angular measurements would be 0.1". It was very high for that time.





The antennas ADU-1000 equipped by low noise 32 cm parametric and 8 cm maser preamplifiers, atomic frequency standards, and tape recorders Δf=100 kHz.

The bright compact sources with precise position were need for calibration. We invited G.Khromov and G.Sholomitsky for decide this question:

Crab nebula and objects with peculiar spectrums proposed sources of relativistic particles, which would be compact and variable radio sources.

VLBI – baby of the space epoch

1962 Mart (50 yrs ago) DSN, Evpatorija

We were discussing with G.Ya.Guskov, and E.G.Mirzabekjan:

Long baseline Doppler measurements of coordinates: the receiving signals coherently transform to the low frequency, written at magnetic tapes and than determination different frequency.

Propose: write a pilot signals for determination of a different phase – radio interferometer.

Solution: Test Simferopol - Evpatorija at λ =32 cm (B=150 km).

September : Seminar Radio Astronomy Laboratory FIAN. Matveenko: "About long baseline radio interferometer". The idea did not support - stop test and publication.



I meet G.Sholomitski and N.Kardashev (GAISh), which support me. Seminar GAISh: It is very important, would be sent to the Patent Bureau.

 1963 summer: Prof. B.Lovell (guest of M.V.Keldysh) visited DSN, Evpatorija. I meet Prof. Lovell and informed about technical and scientific directions of DSN, include possibility of the *independent radio interferometer*. (I.S.Shklovskii and G.Khromov were present too).

Prof. Lovell agreed with the idea, but doubted the necessity of the super resolution. The compact bright sources do not known.

Memorandum: Observation between ADU1000 – MK-1, JB at λ =32 cm.

To# VIII, № 4		РАДИОФИЗИКА	196
Radi	o interferometer	with a large	baseline УДК 621.396.67:523.164
о рад	иоинтерфером	етре с боль	шой базой
Л. И.	Матвеенко, Н. С. К	ардашев, Г. Б. І	Шоломицкий
Рассмо страция си каждой ант местной обр теродинов $\sqrt{\overline{hf^2}}/f_{f < c}$ стоинства	трена система раднови- тиалов по промежуточи емис (путем запися на работкой этих запися налагает следующее \$1,6 · 10 ⁻¹¹ D (D дл гакого иктерферометра.	итерферометра без юй частоте происх магнитную ленту) Использование ле условне иг стаби, кна базы в к.4).	регрансяящин. Реги- юдит независямо на с воследующей сов- кух независямых ге- льность их частоты Обсуждаются до-

1964 December : The Patent Bureau agree with publication of the paper. Radiofizika, published 1965,4, 651.

Crab Nebula occultation 1964 yr observations at 8 and 32 cm





Transit of across beam ADU 1000 at 8 cm



Occultation 3C 273 λ =8 и λ =32 cm: compact core (flat spectrum) and Jet

1967 - VLBI realized by USA radio astronomers : C.Bare, B.G.Clark, K.I.Kellermann, M.H.Cohen, D.L.Jauncey. Science 1967, 157,189. (Digital system)

& independently Canadian team: N.W.Broten, T.H.Legg, J.I.Locke, C.W.MacLeish, R.Richards, R.M.Chisholm, H.P. Gust, J.L.Jen, J.A.Galt. Science, 1967,156,48. (Analog system).

M.H.Cohen & K.I.Kellermann: VLBI USA-USSR

1968 Febr. Letter to Victor Vitkevich: VLBI at $\lambda = 3$ cm, PSN-GB.

Time of cold war. N.G.Basov – opened green light, A.Severny; RT-22, Simeiz

1969 Jan. (Matveenko & Moiseev), visit to NRAO : VLBI at **2.8 & 6 CM**

Burkeley, Seminar Ch.Townes: W.Welch : H₂O sources, λ=1.35 cm - best candidates for VLBI: very strong emission and narrow line. But what it is mechanism of emission?

Discussion with B.Burke, and J.Moran VLBI at λ =1.35 cm Simeiz-Haystack, first test inside USA and than CR-HST.

M.H.Cohen & K.Kellermann: Proposal GB-PSH at \lambda=3 cm



UNIVERSITY OF CALIFORNIA, SAN DIECO

February 23, 1968

Dr. V. V. Vitkevitch Department of Rodio Astronomy Lebedev Physical Institute Moscow USSR

Dear Dr. Vitkevitch:

As you may know, a group of us have been experimenting with very long baseline interferometers using atomic clocks as independent time and frequency standards. The data at each end of the interferometer are independently recorded on magnetic tape for later processing in a digital computer.

Using a baseline between Green Bank and Sweden of more than 10 λ at 6 cm, we find that there are still sources which show strong fringes and therefore have diameters less than O'OOL. We are δT course interested if nextending the resolution both by increasing the physical baseline and by going to shorter wavelengths. A baseline between the $\Im T$ meter telescope at Green Bank and the $\Im T$ meter antenna at Serpukhov near 3 cm wavelength would seem to provide nearly the highest resolution obtainable from two antennas located on the surface of the earth.

The purpose of this letter is to inquire if you and your colleagues would be interested in collaborating with us on such an experiment.

The timing and data recording equipment are portable, and could easily be transported to Moscow by commercial air services. A very good 3-cm radiometer will be available at the 37 m. Green Bank telescope at the end of this summer, and we could think of an experiment after that time.

Sincerely yours,

M. H. Cohen 24.11 5 100 K. I. Kellermann

My Kellerman



September 1969 – VLBI CR-GB, MK- I QSS, $\lambda = 6$ cm & 2.8 cm,





I.G. Moiseev, V.V. Vitkevich, and K.I. Kellermann

Fringes of quasar 3C 273, $\lambda = 6 \& 2.8 \text{ cm}$



VLBI is working at short wavelength 2.8 cm !
Realized angular resolution 0.4 mas
Structure of QSS is complex
Propose: next experiment CR-GB-GST at λ = 3.5 cm

Prepare equipment at 3.5 cm

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA SIIOS

OWENS VALLEY

September 18, 1970

Dr. L. Matveyenko Institute for Space Research Profsojuznaia 88 Moscow U.S.S.R.

Dear Dr. Matveyenko,

I have checked with JPL regarding frequencies for the proposed Goldstone-Crimea experiment. Their maser, pump, and multiplying system is set up for 7840 MHz and has very narrow bandwidth (±5 MHz). The maser will operate at other frequencies, but they have no other pump at this time. Therefore we should plan on using <u>7840</u> MHz and you should finish your maser to this frequency.

There is as yet no official decision for doing the experiment. I will let you know as soon as one is reached.

We agreed in England to receive right-circular polarization, according to the IEEE standard. This is the same polarization that would be received by a right-hand helix if it looked directly at the sky (or by a parabolic reflector fed by a left-hand helix). A picture of a right-hand helix antenna follows.



Sincerely yours,

Marshall H. Cohen

MHC:dr cc: K. I. Kellermann



Simeiz RT-22: maser preamplifier, a cassegren, and feed

NRAO/CALTECH – MK-2 terminals, Rb standard + crystal oscillator

Transcontinental baselines 1971, Crimea - Green Bank - Goldstone. λ =3.55 cm





CR-HST, H_2O , λ =1.35 cm, 6.06.71, W49





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Maser mechanism active zones

Outburst ~0.1 mas, $T_b = 10^{16} K$.

SPACE – GROUND VLBI: SRT- 3.1 m



DSN, Tidbinbilla



H₂O masers, λ=1.35 cm B = (20 -70)·10³ km ($\lambda_{min} \sim 1 mm$)



SRT-3



DSN, Evpatorija





70-m antennas

04.07.82 - Evpatoriya, $A_{eff} = 1400 \ m^2$, $T_{sys} = 60 \ K$

 $\lambda = 1.35$ cm



1985 – Usuriisk



 $\lambda = 6 \text{ cm}$

100700: 30345 8.0. 16 41 17.64 2001. 39 54 10.99



 $\lambda = 1.35$ cm

We are planning build 3 70-m antennas, including Sufa & India.



VEGA (USSR-France-USA)

*1985, balloons in Venus atmosphere, VLBI network - 20 radio telescopes, λ =18 cm Transmitter power - 1 W. Distance ~ 110 Mkm

Письма в АЖ, т. 12, № 1, 1986

УДК 520.27 + 521.9

СВЕРХДАЛЬНЯЯ РАДИОИНТЕРФЕРЕНЦИОННАЯ СЕТЬ НА ВОЛНЕ 18 СМ

A. H. MATBEEHRO, P. 3. CAPZEEB,
B. M. BAJEBAROB, B. H. IMEBYEHRO,
B. H. ROCTEHRO, B. A. IPHIMAMOBCRHH,
B. E. BEATXOB, C. H. HTHATOB, E. 3. RAHEBCRHH,
A. F. ROTAH, A. H. ROJAOB, T. J. ROHEAMICKHH,
A. M. MOJOJAHF, E. H. MOJOB, J. X. INAMATENDO,
A. M. MOJOAHOB, H. A. COTP'ROB, L. B. THMOØEEB,
A. B. HEBYEHRO, A. E. CEEPTHIĤ, H. F. MOICEEB,
P. R. J. COPVERIGO, J. A. CHMATE,
P. M. MAPTHPOCHH, A. M. ACTALHHH, A. F. IYJAHI,
H. C. RUKABE M. M. B. ICOMBHIA

Приведениј основные видаметры солеской радкоштерференционной сети на цине волан 16 с. Она соготат на илита закенство, образуращих иштерферонецион 10 до 2010 до 7000 ма. Антенны оснашены водродимы стандартами частосамалоштумница усвлитетами и систомами регистрации с полосој 2 МГL. 2rb. предлажачена для астрофизических поблюдений и решения прикладных март области встрованизаци и годоли.

VLBI NETWORK AT 16 CM WAVELENGTH, by L. I. Matveenko, R. 2. Sagdeev, Y. M. Batchanov, V. 15 bevehenko, V. I. Kostenko, V. A. Grishmanovski, V. E. Velikhov, S. P. 1 gnatov, B. Z. Kanovski, I. K. Kogan, A. N. Kozlov, G. D. Kopelyanski, J. P. Molodyanu, E. P. Molotov, A. H. Paptson, V. Koko, A. M. Romanov, I. A. St. I. G. Moiseev, R. L. Sorochenko, A. B. Tananov, I. G. Moiseev, R. L. Sorochenko, A. B. V. Jan, V. K. J. St. J. G. Moiseev, R. L. Sorochenko, A. P. Tsivilev, R. M. Mattirovskinding five dements with interformary freading to the Soviet ISeen VLBI network including five dements with interformative framework in demokration of 24th Endwichtherconding systems. The network is destined for astrophysical observations as well as for astronavigation and goodesy purposes.

Balloon

Balloon's trajectories

Core – Jet structure, Virgo A, 18 cm, helix

1803+784, 18 cm

3C 345

Strip brightness distribution along jet (standardized to 1 mas) : $\lambda = 1.35$ cm (c); $\lambda = 3.6$ cm (d); $\lambda = 6$ cm, 1990 (e) и 1992 (f); $\lambda = 18$ cm (g); $\lambda = 49$ cm (h); $\lambda = 92$ cm (i).

Pages of the Soviet VLBI finished

SOV. VLBI TEAM

Today we are living in the other country - Russia.

But we are remember all what you made for us, and support us.

That me talk common thanks for everybody and personal to

Richard Schilizzi

made very much for VLBI and for soviet VLBI too.

THANKS