*Proceedings of the 6th European VLBI Network Symposium*
*Ros, E., Porcas, R.W., Lobanov, A.P., & Zensus, J.A. (eds.)*
*June 25th-28th 2002, Bonn, Germany*

# Goals and results of the ad-hoc VLBI activity with Russian antennas

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**Abstract.** The Low Frequency VLBI Network project was started in 1996 to involve Russian radio telescopes in international VLBI activity. Eight antennas in Russia, Ukraine, India and Latvia were equipped with repaired Mk-2 terminals from USA and 92 cm receivers. More modern S2 recorders were installed at Bear Lakes RT-64 and Puschino RT-22. Mk-2 and S2 experiments were arranged during 1997-2000 at 92-cm and 18-cm wavelengths using various combinations of these antennas and radio telescopes in USA, South Africa, China, Italy and Poland. Five sessions were processed by the JPL/Caltech Block II and Penticton DRAO correlators. In this paper the scientific goals of this VLBI activity, results obtained so far and further plans are presented.

## 1. Introduction

There are large Russian radio telescopes suitable for VLBI observations: Bear Lakes RT-64, Kalyazin RT-64, Puschino RT-22 (near Moscow), Ussuriysk RT-70 (Far East), Svetloe RT-32 (near St.-Petersburg). Unfortunately, Russian telescopes have not participated in European VLBI programs since 1993. The main reason for this is the lack of compatible VLBI recorders. Therefore a special program was started in 1996 in order to establish international VLBI cooperation including some Russian radio telescopes with the most accessible and cheap VLBI apparatus - Mk-2 equipment, acquired from JPL, USA and units designed earlier in Russia, and S2 equipment received from ISTC, Canada. The project was called the Low Frequency VLBI Network (`LFVN`) and was partly supported by `INTAS 96-0183` grant. Currently `LFVN` is developing in four directions, each having its own cooperation amongst observatories: (1) The Mk-2 sub-system at 92 cm wavelength for research on spikes, medium-sized irregularities in the solar corona and wind, studying the limitations to VLBI caused by scattering, compiling a source list for the RADIOASTRON Space VLBI mission; (2) The international S2 ad-hoc array at 18 cm wavelength for a survey of AGN (prior to RADIOASTRON launch, searching for CSOs in a sample of GPS, properties of BL Lac objects) and OH-masers in evolved stars, a SETI program and attempts at stellar VLBI; (3) VLBI radar (Evpatoria RT-70 transmitter + `LFVN`) at 6 cm wavelength for investigations of Earth group planets, near-Earth asteroids and space debris; (4) Integration with the European VLBI Network based on PC-disk recording terminals.

## 2. LFVN development

In the first stage, the old Mk-2 equipment was repaired and installed together with newly-produced 92 cm receivers and one-channel baseband converters at Bear Lakes RT-64, Puschino RT-22 (both near Moscow), St. Pustun RT-14 and Zimenki RT-15 (both near N. Novgorod) in Russia, Evpatoria RT-70 in Ukraine and Ventspils RT-32 in Latvia. GMRT (one 45 m antenna) at Pune and ORT (500x30 m parabolic cylinder) at Ooty in India were also equipped with Mk-2 terminals. An agreement on collaboration was obtained with the observatories at Noto in Italy (RT-32), Urumqi in China (RT-25) and Torun in Poland (RT-15), which had 92 cm receivers and kept operational Mk-2 terminals. It was

planned to use the JPL/Caltech Block II correlator as theLFVN Mk-2 processing center. Later, when Block II was unexpectedly stopped in 1998, the Russian Mk-2 correlator was developed at RRI, N. Novgorod (first fringes in 2001). Block II could process only the first INTAS1 LFVN experiment Noto-Puschino-St.Pustyn-GMRT-Ooty. Many further Mk-2 experiments are waiting for processing at N. Novgorod. As results of the INTAS1 experiment, 15 sources displayed unresolved components on the baseline Noto-GMRT (5800 km) and were proposed as candidates for Space VLBI (see Chuprikov, 1999). Also, data obtained on the interplanetary medium added to previous results and allowed the determination of a limit to solar elongation angles for VLBI (coherence is lost closer than 13 degrees to the Sun) and to theorize on the existence of average-scale irregularities in the solar wind (see Altunin, 2000). In the second stage, two more modern Canadian S2 recording terminals were installed at Bear Lakes and Puschino. Direct connections were established with radio telescope stations around the world equipped with S2 systems: Green Bank RT-43 (USA), Arecibo RT-300 (Puerto Rico), Shanghai RT-25 (China), Hartebeesthoek RT-26 (South Africa), and Svetloe RT-32 (Russia), and the Penticton S2 correlator of DRAO (Canada). First test S2 experiments were arranged and successfully processed at Penticton: INTAS98.2 (Bear Lakes-Hartebeesthoek-Green Bank) and INTAS98.5 (Bear Lakes-Puschino-Green Bank-Hartebeesthoek-Svetloe-Arecibo). The results obtained allowed the making of an informal agreement on joint ad-hoc activity between Bear Lakes, Puschino, Noto, Shanghai and GMRT observatories, and the Penticton correlator and new VLBI experiments at 18 cm wavelength were arranged: INTAS99.4 (Bear Lakes-Puschino-Noto-Shanghai-Hartebeesthoek-Svetloe) and INTAS00.3 (Bear Lakes-Puschino-Noto-Shanghai-Hartebeesthoek-GMRT). The observing programs were formed on the basis of requests from participating observatories. The pilot data post-processing of the INTAS99.4 and INTAS00.3 observing sessions (their correlation and data processing is still continuing), which was carried out at Astro Space Center, showed that resulting (u,v)-plane coverages seem to be rather regular and homogeneous (Fig 1). An interesting result has been obtained for the BL Lac type object 1308+326 in experiment INTAS99.4 (Fig 2). First results from the VLBI radar project are presented in Tuccari (these Proceedings). A plan for integration with the EVN is presented by Molotov (these Proceedings).

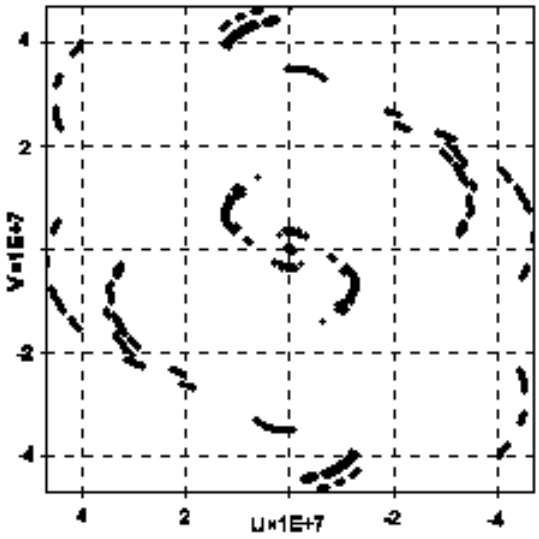


**Fig. 1.** (u, v)-plane coverage for source 1308+326. INTAS99.4.

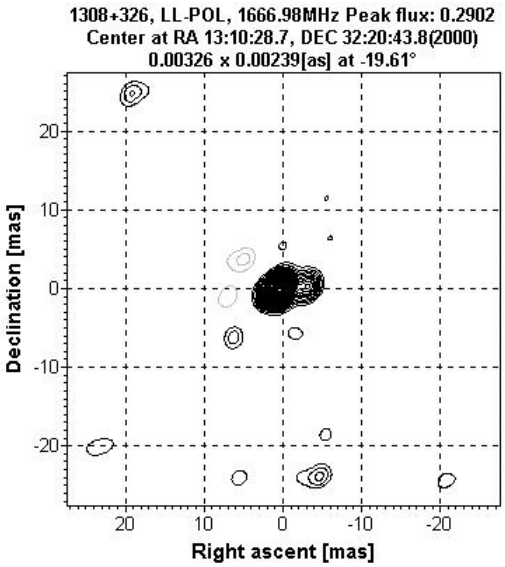


**Fig. 2.** Clean map for source 1308+326. INTAS99.4.

## 3. Conclusions

The LFVN has begun regular operations and first scientific results have been obtained. This activity allowed the large radio telescopes in the former Soviet Union to be kept in operation, a new generation of antenna staff to accumulate valuable VLBI experience, and the creation of necessary prerequisites for its integration with the EVN. The post-processing of all experiments mentioned will be continued.

We plan to concentrate special effort on interpreting solar wind data. There are objectives for further LFVN developments under INTAS-IA-01-02. Our plan is to continue the ad-hoc observations in 2002 and in future involve more radio telescopes. The immediate future plans include the VLBR02.1 at 6 cm arranged for July and LFVN02.2 at 18 cm for 2002 December.

## References

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