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# Radio Astronomy Observatories Svetloe, Zelenchukskaya and Badary of VLBI Network QUASAR

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**Abstract**

The paper presents common description and the current status of the observatories of the Russian VLBI network QUASAR.

## 1. Intrduction

The QUASAR project, which is carried out under the guidance of the Russian Academy of Sciences, involves creation of the full time operating VLBI network, consisting of 3 radio astronomy observatories. The observatories are located at Svetloe, Leningrad region; Zelenchukskaya, Republic of Karachaevo-Cherkessia, and Badary, Republic of Buryatia, and linked by connecting channels with the processing center, located at the Institute of Applied Astronomy (IAA), St. Petersburg (Fig. 1). At present 2 observatories — at Svetloe (1998) and Zelenchukskaya (2000) are operating both in single dish and VLBI mode. Observatory at Badary site is under installation and testing the hardware (Fig. 2).

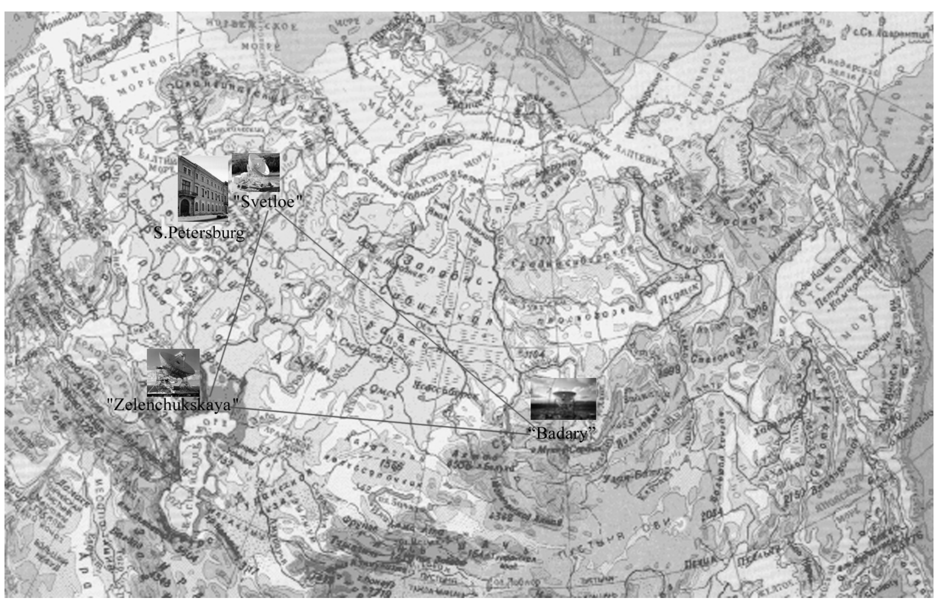
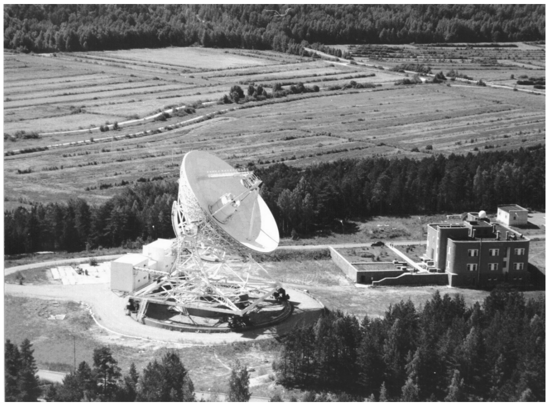
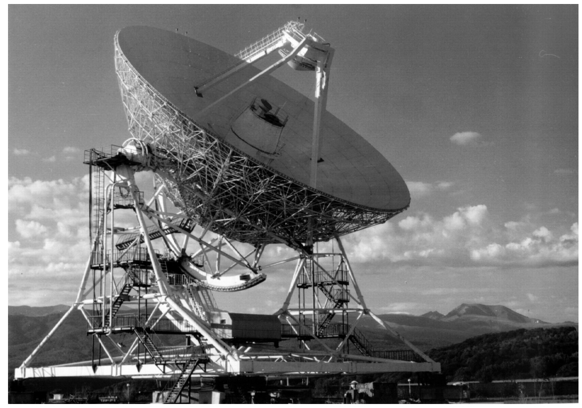



Figure 1. Geometry of the QUASAR VLBI network



Observatory Svetloe
$\varphi = 60°32', \lambda = 29°47'$



Observatory Zelenchukskaya
$\varphi = 43°47', \lambda = 41°34'$

Observatory Badary
$\varphi = 51°46', \lambda = 102°14'$

Figure 2. Observatories of the QUASAR VLBI network

## 2. Observatories Equipment

The main element of the observatories is the 32 m radio telescope for centimeteric wave length, which was designed for the Quasar project, since fundamental astrometry and geodesy tasks had special requirements for construction and dynamic qualities of this high-precision geodesic instrument (Table 1). The radiotelescope was constructed according to the Cassegrainian antenna, with the main quasi-parabolic mirror with a focus length of 11.4 meter, and with the additional mirror, which is a modified hyperboloid with a diameter of 4 meters. The only difference between these 3 telescopes is that the radio telescopes in Zelenchukskaya and Badary do not have an azimuth cabin, and the main hardware and cooling system compressors are installed in the special cabin for wire loop and in the special cabin near the angle engines respectively.

At present the telescopes are provided with HEMT radiometers for bandwidths 1.35, 2.45, 3.5, 6.0, 13 and 18/21 cm (Fig. 3), which allows production of simultaneous receiving of two orthogonal polarization. To maintain simultaneous receiving at 3.5 and 13 cm bandwidth in both orthogonal polarization (to eliminate ionosphere influence), that are the basic for fundamental astrometry and geodesy research, a combined horn has been constructed.

Table 1. Main dish parameters

| | |
|---|---|
| dish diameter | 32 m |
| subreflector diameter | 4 m |
| Type | Cassegren |
| reflector form | quasiparaboloid |
| subreflector form | quasihyperboloid |
| focus | 11.4 m |
| installation | azimuthal |
| azimuth turn limit | $\pm 270$ deg |
| elevation turn limit | $-5 \div 95$ deg |
| azimuth speed high/low | $1.5^{\circ}$/s / $1.5'$/s |
| elevation speed high/low | $0.8^{\circ}$/s / $1.0'$/s |
| surface quality | 0.5 mm |
| pointing RMS | $10''$ |

Table 2. Parameters of the feed system (see Fig. 4)

| Wavelength, cm | Horn number, i | Zi, mm | Ri, mm | Li, mm |
|---|---|---|---|---|
| 1.35 | 1 | 4128 | 1333 | 131 |
| 2.6 | 2 | 4274 | 1302 | 280 |
| 6.2 | 3 | 4592 | 1234 | 605 |
| 13/3.5 | 4 | 5858 | 965 | 1900 |
| 18 | 5 | 6103 | 913 | 2150 |

To switch wavelengths and to be able to provide multi-bandwidth observations quasi simultaneously, the Cassegrainian antenna with an asymmetrical secondary mirror and additional focuses located not on the axis of the main mirror, but at some circle with center located at this axis is constructed. Input horns of different wavelength are located above this circle, and switching of the wavelength is achieved by turning the secondary mirror to a certain angle (Fig. 4., Table 2)

For achieving noise temperatures of the radio telescope-radiometer system not higher than 50 K, low-noise amplifiers (LNA) at all bandwidths, and some input lines, are cooled by a special micro-cryogenic closed cycle refrigerator to a temperature of 20 K (hydrogen level). Fig. 5 shows that at elevation angles above 20 degrees, noise temperatures of the systems at Svetloe and Zelenchukskaya do not exceed 50 K. Low noise temperature is one of the main features of the radio telescope, and the first measurements have shown that noise parameters of the radio telescopes of a Quasar network demonstrate higher quality compared to other radio telescopes involved in VLBI programs.

Each observatory is provided with the systems of frequency-time synchronization, consisting of 4 hydrogen maser standards with very high metrology qualities: $\sigma_{1s} = 10^{-13}$, $\sigma_{1000s} = 3 \times 10^{-15}$. This system also includes devices of the preliminary time synchronization using the navigation systems GLONASS and GPS, enabling synchronization of the separated scales of the atomic time with an error up to 100 ns.

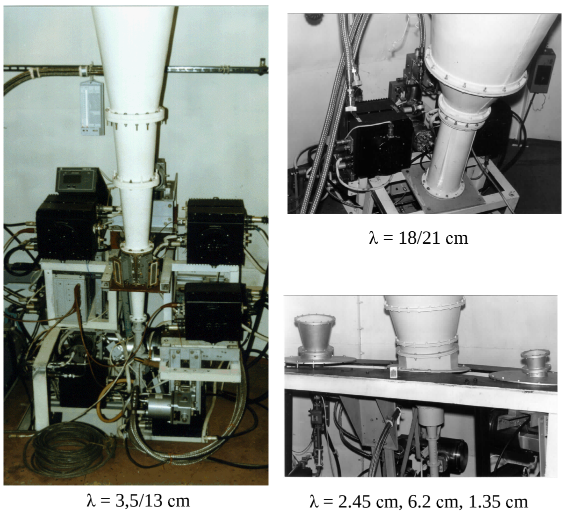



Figure 3. QUASAR — network radiometers

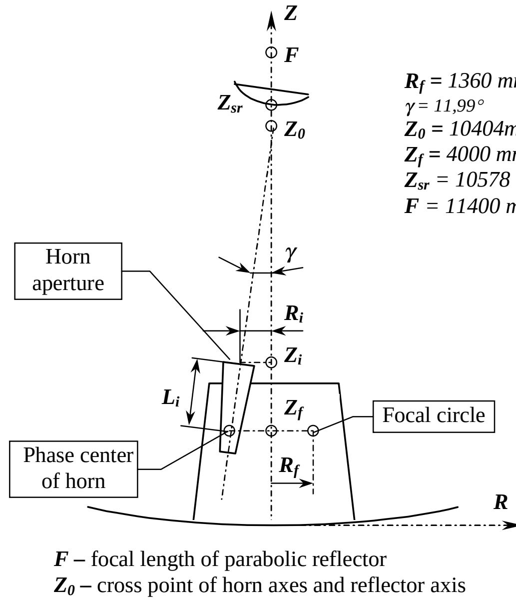



Figure 4. Schema of feeds arrangement

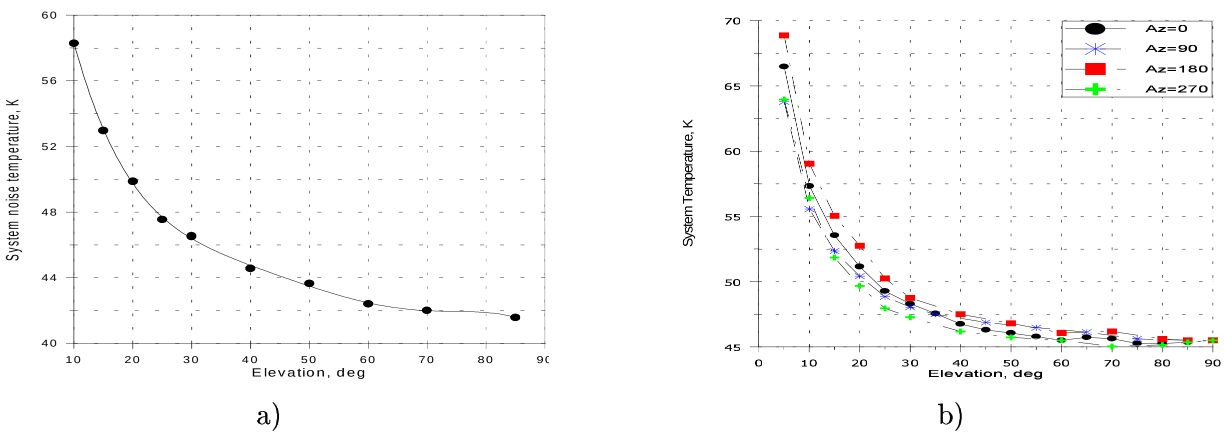



Figure 5. System noise temperatures at X-band Svetloe (a) and Zelenchukskaya (b)


Figure 6. Video converters, developed in the IAA RAS

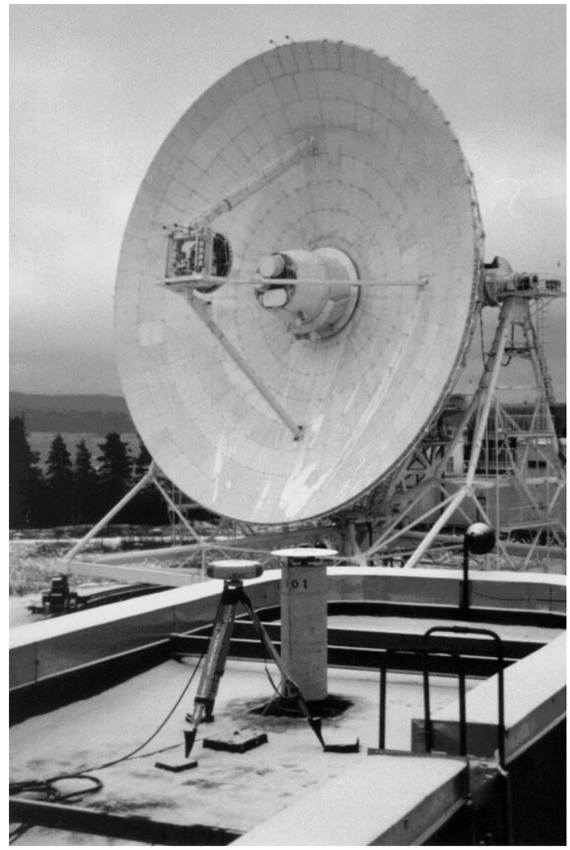


Figure 7. GPS, GLONASS Antennas on 32-m Antenna background

For registration, the Canadian system S2 is used with converters developed at the IAA (Fig. 6).

All the hardware of the Quasar network observatories — the radio telescope, receivers, systems of frequency-time synchronization and registration of signals on to magnetic tapes, are coordinated through the central computer, which is installed with a programming system — FS 9.0, which was adjusted for operating the hardware designed in Russia. Therefore, the radio telescopes of the Quasar system are capable of receiving data for observations from the international VLBI networks.

Electric power of the observatories is provided by two lines from different electric power stations, constant energy systems, diesel electric generators and batteries.

The Observatories Svetloe and Zelenchukskaya are supplied with geodetic GPS receivers — Turbo Roque (Zelenchukskaya) and Trimble 4000SST (Svetloe) (Fig. 7) and automatic meteorology stations, measuring temperature, pressure, humidity and the wind power.

Each observatory has a highly developed local geodesy network (Smolentsev S., Ivanov D., Malkin Z. Svetloe Radio Astronomical Observatory. 2000 IVS Annual Report, 123–126), fixed by geodesy pillars and supported by regular measurement according to methods of classical and space geodesy.