Long time tracking of the Sun with RATAN-600 in Radio Schmidt mode

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The long time cosmic source tracking is the most urgent problem of RATAN-600 now. Antenna system "South sector + Periscope" opens the possibility to resolve this problem (Khaikin et al, 1972). The initial solution is to change of the antenna profile in real time with change of cosmic source azimuth looks most powerful but extremely difficult. Cosmic source tracking with unmovable main mirror in a form of cylinder requires a special secondary mirror of double curvature (12 m size) or a phased array in the focal plane of an ordinary secondary mirror (Kajdanovskij, 1980).

In Radio-Schmidt mode the RATAN-600 main and periscope mirrors are calculated as two-mirror aplanatic system free from spherical and coma like aberrations. A flat periscope mirror gives the necessary curvature to remove spherical aberration caused by the main mirror in the form of unmovable "flattened" cylinder. This is technically possible for an effective aperture size of 170 – 200 m. The main advantages of Radio-Schmidt mode for solar observations with RATAN-600 are as follows:

1. The longest aberrationless focal zone and widest radio telescope field of view.
2. Possibility of long time tracking of the Sun or repeated observations with unmovable main mirror.
3. Possibility to install a multi-beam feed array with the greatest number of receiver elements along the focal plane.
4. Absence of spherical aberration and coma in radio image in wide range of 1 cm – 50 cm for optimal focal way.
5. Possibility of Sun mapping at short wavelengths with multi-element array in the focal plane.
6. The constant speed of the secondary mirror movement during one hour tracking for most of elevation angles of the Sun.

In Table 1 some characteristics of antenna system in Radio-Schmidt mode for 150 m aperture size, optimal and real focal way at 7.6 cm are presented. Calculations show that less than half an hour tracking of the Sun is available with the real focal way at more than 8 cm wavelength and one hour tracking of the Sun at 1 – 50 cm is possible with optimized focal way.

Tracking of the Sun and repeated observations at longest wavelengths (more than 10 cm) are available with RATAN-600 "reduced aperture" (< 100 m) even with the flat periscope mirror (quasi-Schmidt mode).

The focal aberrationless zone in Radio-Schmidt mode in the range of 1 – 30 cm for 150 m aperture, elevation angle 45 deg. and real focal way is shown in Fig. 1. This mode gives us a wide possibility to apply multi-beam feed arrays in the focal plane (Khaikin et al, 1998).

Table 1

Relative source azimuth deg	*Duration of solar tracking pattern* hours	*Maximal aperture phase error* deg	*Amplitude of the main lobe of beam pattern* %	*Level of side lobes of beam pattern* %	*Coma-like aberration* %	*Curvature radius of the focal way*
0		0	1.0	5.0	No	
± 1–4	< 1	< 2.0	1.0	5.0	No	optimal
± 0–8		< 10.0	1.0	5.0	No	
0		0	1.0	5.0	No	
± 2.0		18.4	0.965	7.0	Yes	
± 3.0	< 0.5	41.3	0.837	11.0	Yes	real
± 3.5		56.8	0.720	16.7	Yes	

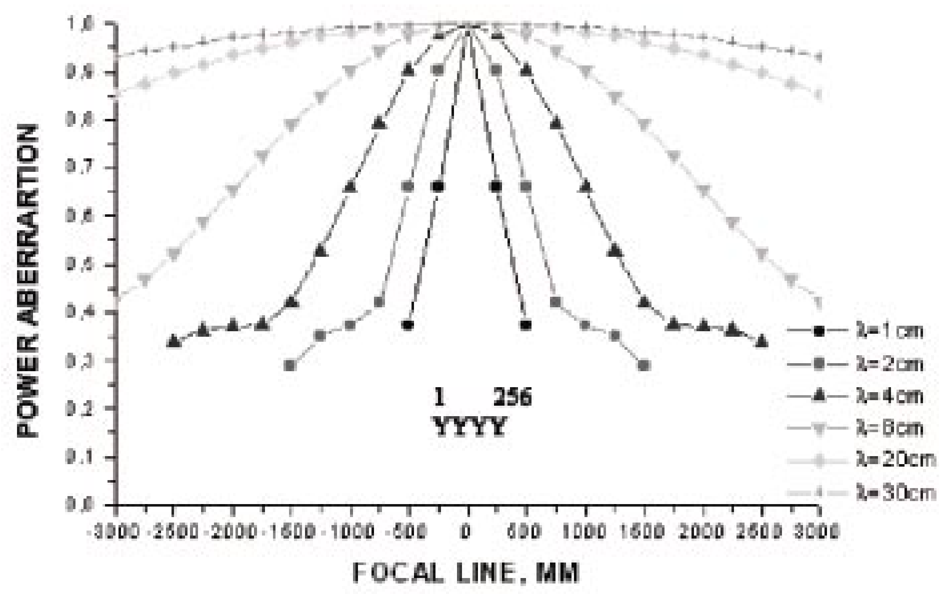

Figure 1: Power aberration curves in Radio-Schmidt mode

RATAN-600 beam patterns in Radio-Schmidt mode with 100 m aperture for different elevation angles and azimuths are shown in Fig. 2.

The first one hour tracking of the Sun in quasi-Schmidt mode with an 80 m aperture is shown in Fig. 3.

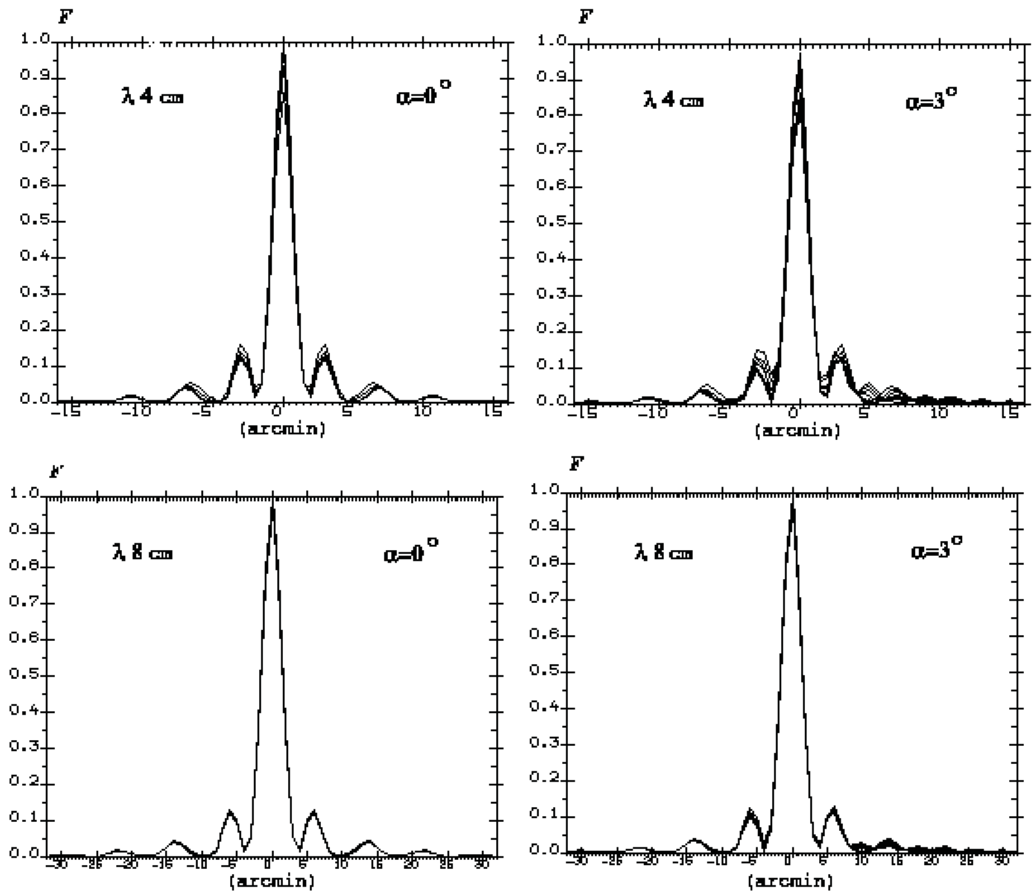

Figure 2: RATAN-600 beam patterns at 4 cm and 8 cm in Radio-Schmidt mode

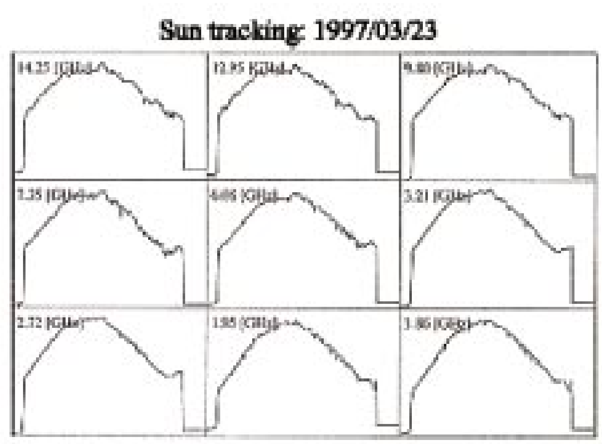

Figure 3: The Sun in channels of the panoramic analyser of spectrum of the RATAN-600 observation cabin No 3 during trial one hour tracking of the Sun in quasi-Schmidt mode with 80 m aperture

To realize high accuracy dynamic control of the Secondary mirror in the process a long time tracking of a cosmic source existing DC drive was replaced on modern AC drive with MOVITRAC 31C frequency inverter. Speed control mode is provided by using of incremental 10 bits encoder, fitted directly onto the AC squirrel-cage motor shaft. MOVITRAC 31C with FRN 31C speed control optional pcb has an improved static and dynamic characteristics and a control of braking. The built-in PI-regulator provides maintenance with high accuracy of average speed control in the process the Secondary mirror movement. As a result a given speed of the secondary mirror movement on arc rail way is supported with accuracy 0.1 % in 10 min intervals. The FPI 31C position control optional pcb together with computer controlled system of electronic markers, placed on arc rail way with an interval 5 m provides a possibility of the Secondary mirror setting in a given point of arc rail way of 160 m length with a maximum position error 5 mm.

Fig. 4 shows the Sun tracking with new drive in speed control mode starting from meridian. The slow fall of antenna temperature during tracking of the Sun in Fig. 3. and Fig. 4. is caused by unoptimal configuration of the main mirror in both experiments.

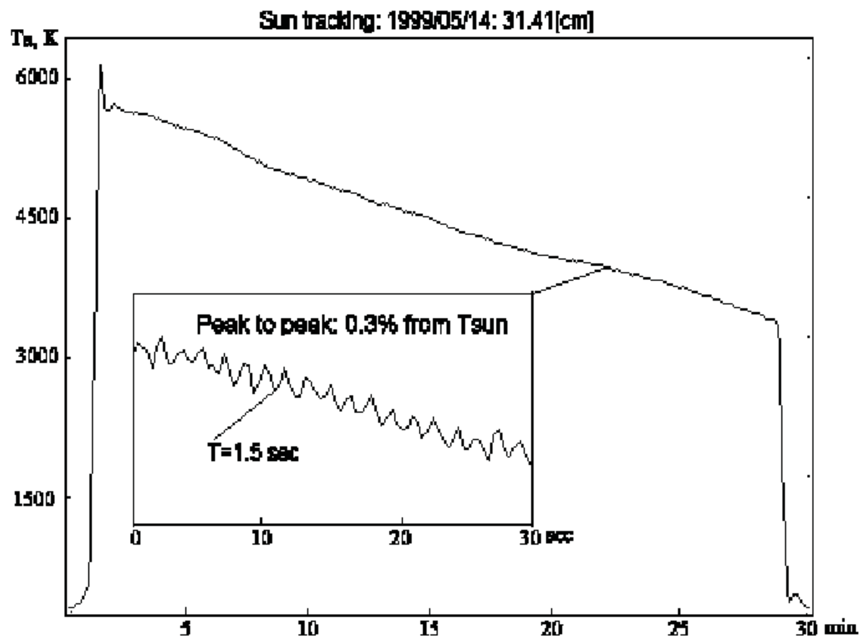

Figure 4: Trial tracking of the Sun with new drive in speed control mode during half an hour beginning in 5 min. after passing a meridian. Horizontal aperture size is 240 m.

The long time tracking of the Sun in the Radio-Schmidt mode will give us new possibilities to study fast-variable solar events.

References

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