# Feeds of the Radio Telescopes RT-13 of the Quasar VLBI Network

*V. Chernov*

Institute of Applied Astronomy, RAS, Russia

## Abstract

Tri-band and ultra-wideband feeds of the RT-13 radio telescopes of IAA RAS VLBI network are presented. Two radio telescopes of the network are equipped with tri-band receivers, operating in S, X and Ka bands. Third radio telescope will be created and equipped with ultra-wideband (3–17 GHz) receiver in nearest future. Design and characteristics of both tri-band and ultra-wideband radio telescope feeds are given in the report.

### Introduction

Sensitivity of a radio interferometer considerably are defined by a bandwidth of the registered signal. The concept of a broadband delay, developed by Bill Petrachenko [1], assumes parallel recording of a signal in several frequency bands, located in the range from 2 to 14 GHz. For practical implementation of this concept in receiving system of radio telescopes, ultra-wideband feeds mast be used. Among them are well known Eleven Feed [2] and Quad-Ridge Flared Horn [3]. There are some shortcomings of ultra-wideband feeds: relatively high back losses, linear polarization, dependence of radiation pattern and phase center position from frequency.

An alternative to the ultra-wideband feeds are multi-bands ones, for example tri-band feeds. Such feeds, as a rule, represent system of the coaxial cavities, excited by microwave dividers or bridges [4–7].

### Tri-band feed

Tri-band feed, developed by IAA, operates in S, X and Ka bands on circular polarization. Aperture part of the feed is presented in fig.1.

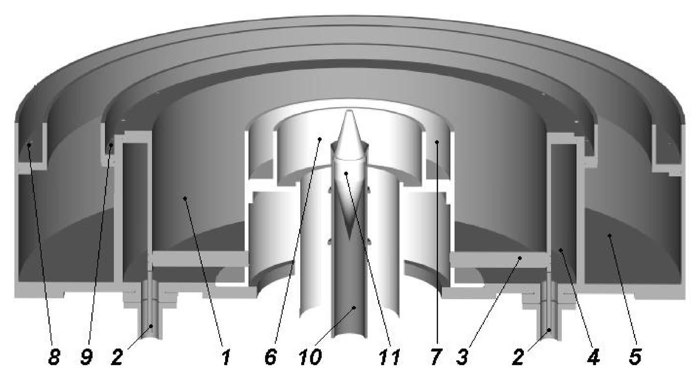


Fig.1. Aperture part of a tri-band feed

The channel of S-band (1) of a feed is fed by means of four coaxial inputs (2). The inductive rod (3) and stub (4) are used for matching of the channel. The choke (5) regulates width of radiation pattern.

The channel X (6) is fed by a coaxial waveguide with $TE_{11}$ mode. The chokes (7), (8) and (9) are forming given X-band radiation pattern.

The dielectric radiator of channel Ka (10) is fed by means of a round waveguide (11). The radiator is supplied with the short conic horn, reducing its cross-talks with other elements.

Cross-section of a tri-band feed, placed in cryogenic dewar, supplied with vacuum window, is presented in fig.2.

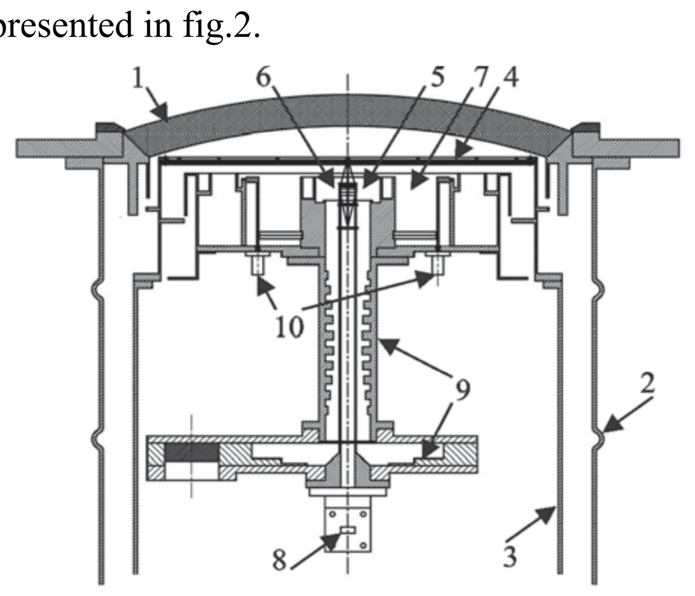

Fig.2. Tri-band into cryogenic dewar:

1—vacuum window; 2—vacuum chamber; 3—radiation shield; 4—IR shield; 5—X-band irradiator; 6—Ka-band irradiator; 7—S-band irradiator; 8—Ka-band septum polarizer; 9—X-band differential-phase section and orthomode transducer; 10—S-band ports.

Circular polarization is formed by quadrature hybrid in S-band, differential-phase section in X-band and septum polarizer in Ka-band.

Fig.3 shows top and bottom view of a tri-band feed.

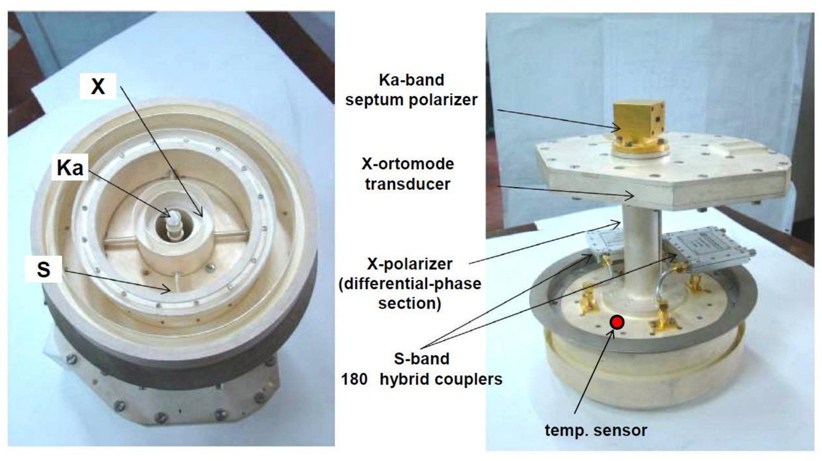


Fig.3. Top and bottom view of the tri-band

Fig.4, 5 and 6 show S, X and Ka bands co-polarized and cross-polarized radiation patterns of the tri-band feed.

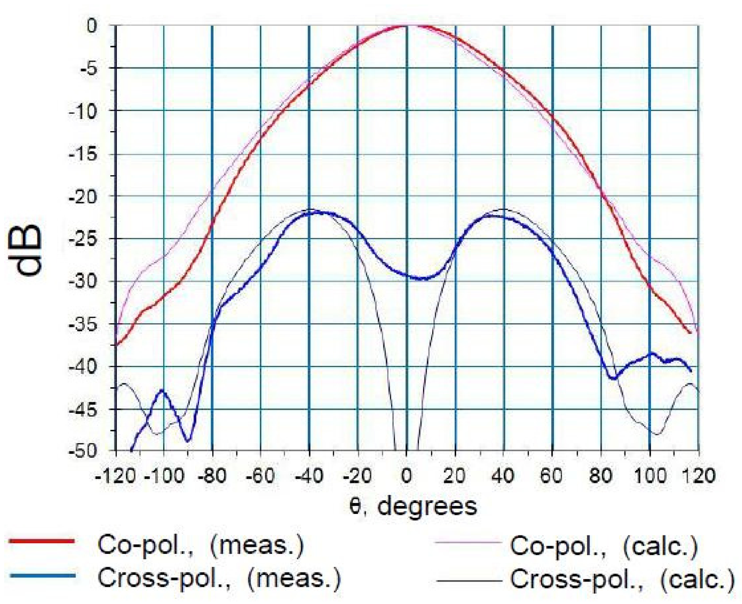


Fig.4. S-band co-polarized and cross-polarized radiation patterns of the tri-band feed

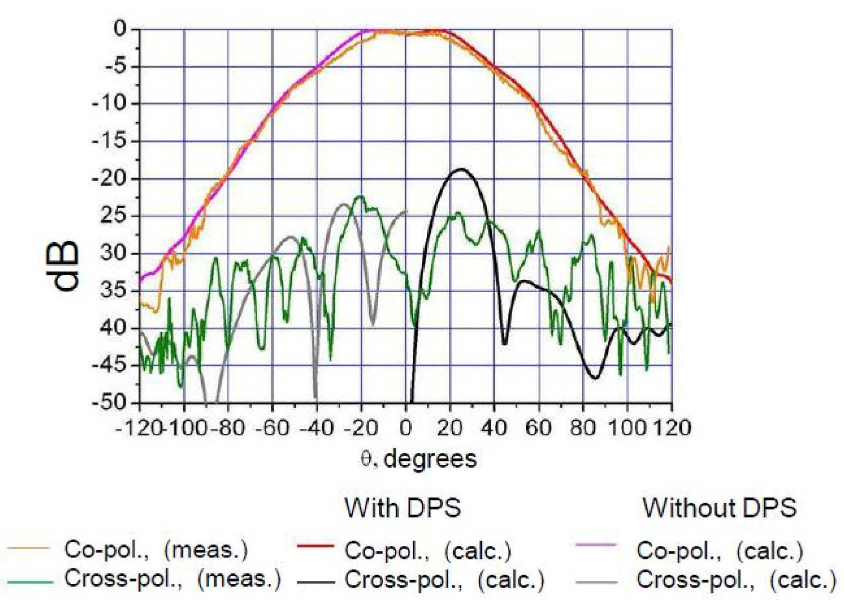


Fig.5. X-band co-polarized and cross-polarized radiation patterns of the tri-band feed

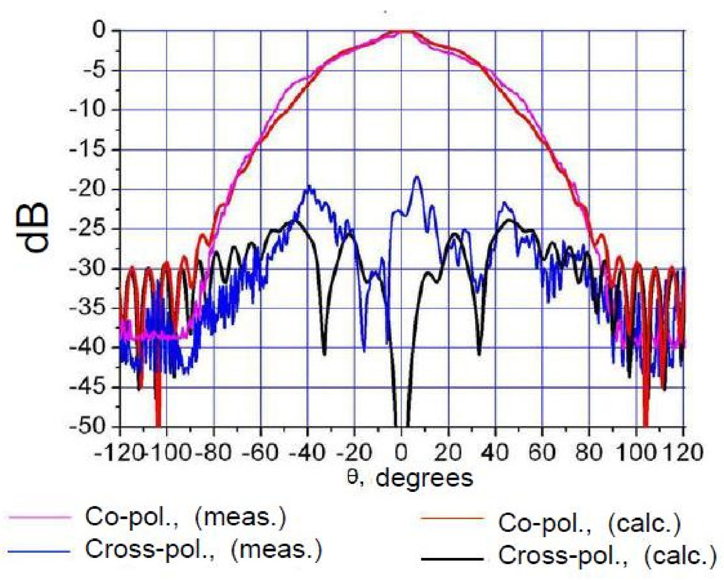


Fig.6. Ka-band co-polarized and cross-polarized radiation patterns of the tri-band feed

### Ultra-wideband feed

There are several types of ultra-wideband feeds that are currently used in radio astronomy: a log-periodic structure of the cascade-connected loop antenna (so called Eleven Feed), a feed based on the self-complementary structure, the log-periodic antenna, and Quadruple-Ridged Flared Horn (QRFH).

Well described by Ahmed Akgiray in his Ph.D. thesis, low gain QRFH [8] was chosen as a prototype. The feed most closely meets the requirements of a IAA project.

QRFH has the following advantages over other types of ultra-wideband feeds:

- Frequency ratio close to 6:1 (low gain QRFH);
- Low frequency dependent radiation pattern in E- and H-planes;
- Two separate RF outputs for the received signals with two orthogonal linear polarizations;
- Output impedance of 50 Ohms, providing easy matching with modern low-noise amplifiers;
- The nominal beam width is ± 65° measured at the -16 dB level (low gain QRFH);
- The changes in the position of the phase center with frequency and the cross-polarization levels are acceptable;
- Simple technical realization, good repeatability, and low cost.

Fig.7 shows IAA experimental model of QRFH, which has frequency range from 3 to 17 GHz.

Fig.7. Ultra-wideband (3—17 GHz) QRFH

Fig.8 shows internal design of the horn.

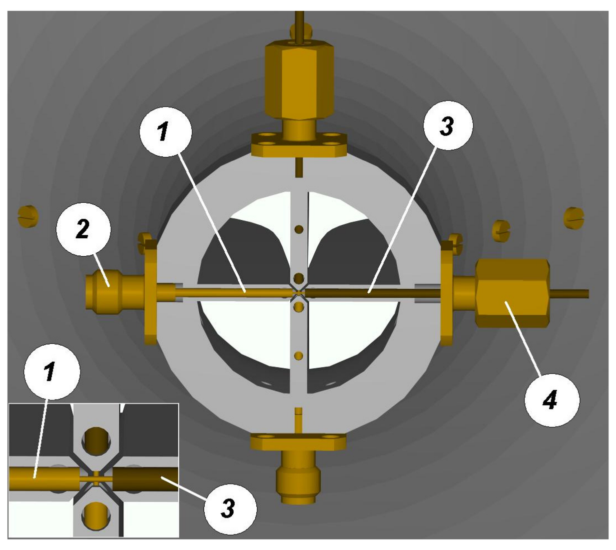


Fig.8. Internal design of experimental model of the ultra-wideband feed:

1—output cable EZ_47_TP_M17; 2—SMA connector; 3—rod with a slot; 4—collet clip

Fig.9, 10, 11 and 12 show measured radiation patterns of QRFH model in E and H planes.

Fig.13 and 14 show measured S-parameters of the horn.

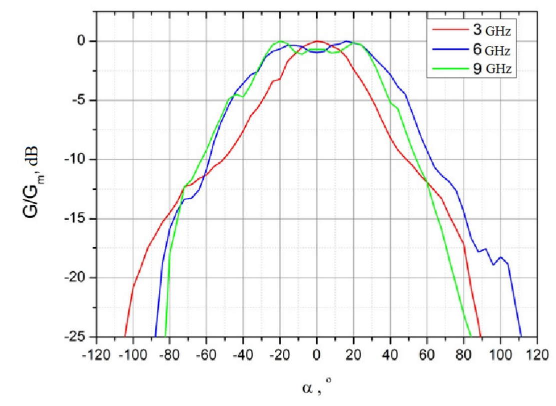

Fig.9. Measured radiation patterns of QRFH in E-plane (3, 6 and 9 GHz)

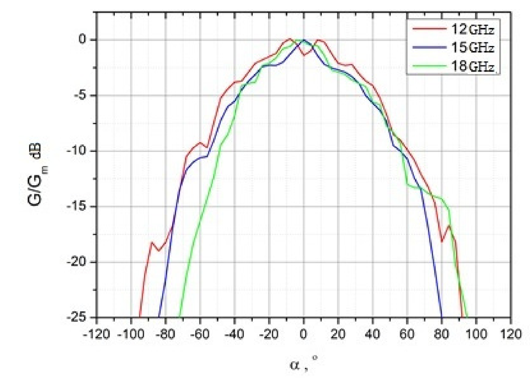

Fig.10. Measured radiation patterns of QRFH in E-plane (12, 15 and 18 GHz)

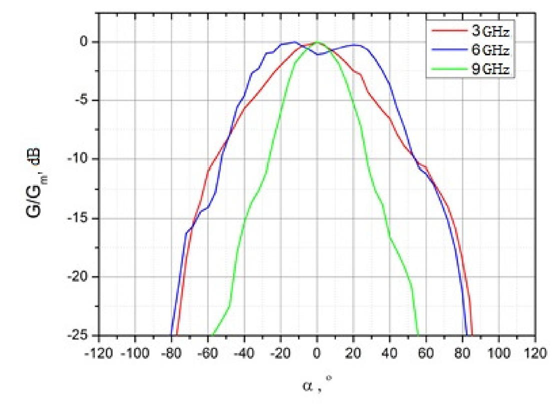

Fig.11. Measured radiation patterns of QRFH in H-plane (3, 6 and 9 GHz)

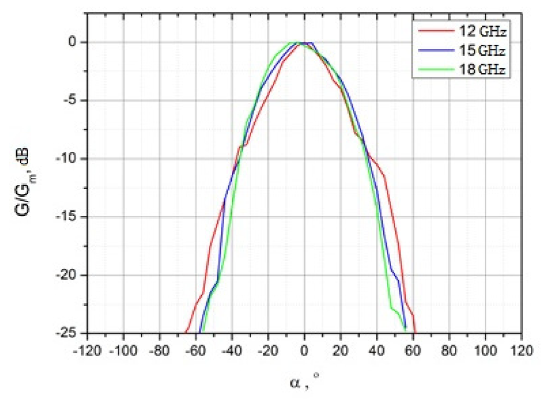

Fig.12. Measured radiation patterns of QRFH in H-plane (12, 15 and 18 GHz)

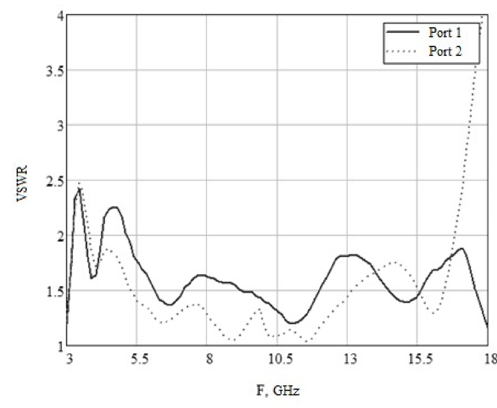

Fig.13. Measured VSWR of QRFH

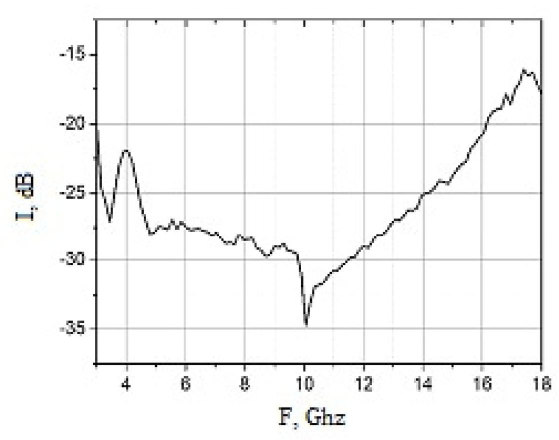


Fig.14. Measured isolation of port 1 and port 2 of QRFH

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