A Dual-Circular Polarization Broadband Feed for Ring Focus Configuration

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Abstract A new feed topology is presented that potentially can open new solutions for covering the new VGOS configuration and its associated frequency bands. In this approach a single band from 2 to 14 GHz is considered. A log-spiral antenna is printed on a conic surface. The whole structure is adjusted in order to obtain a pure circular polarization at broadside direction. An array of four elements is proposed for obtaining a dual-circular polarization feed. Simulations show an efficiency higher than 70% on a ring focus radio telescope illuminated with this feed.

Keywords VGOS, radio telescope, ring focus, broadband feed

1 The RAEGE Ring Focus Radio Telescope

The RAEGE radio telescope optical system is shown in Figure 1. It is composed of one main parabolic mirror and an elliptical subreflector. The entire system has rotational symmetry. The diameter of the main (Dm) and secondary (ds) mirrors are 13.2 m and 1.55 m, respectively. The distance between the highest focal point of the elliptical mirror and the vertex of the parabola (fp) is 3.7 m. The feed is placed into a cryostat below the subreflector.

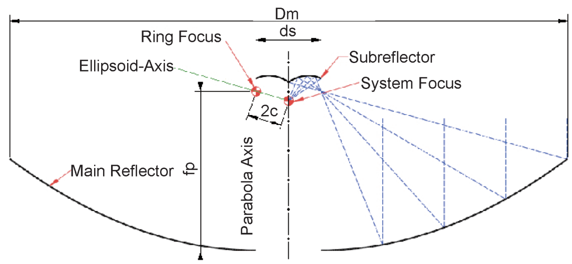

Fig. 1 The optical system of the RAEGE ring focus telescopes.

The optimum performance of this system is obtained with an ideal Gaussian feed placed in the focus of the subreflector, using a taper of −16 dB. GRASP tool has been used for analyzing the complete system. Figure 2 shows the maximum efficiency which goes from 72% to 81%. The sidelobe level is −13 dB and the antenna temperature goes from 30 to 2 Kelvin (Figure 3).

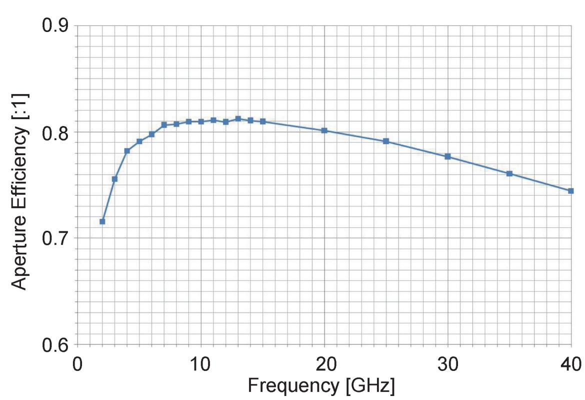

Fig. 2 Aperture efficiency of the RAEGE radio telescopes with an ideal feed and a taper of −16 dB.

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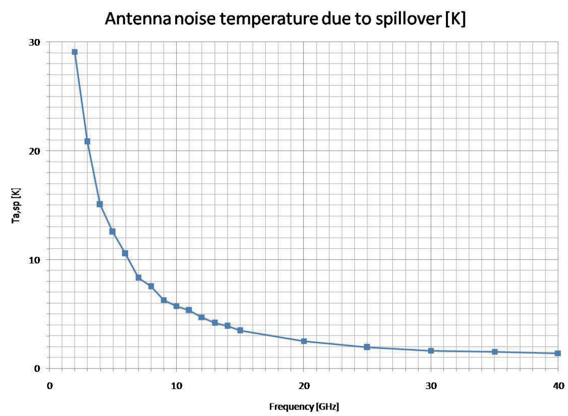

Fig. 3 RAEGE radio telescope antenna noise temperature.

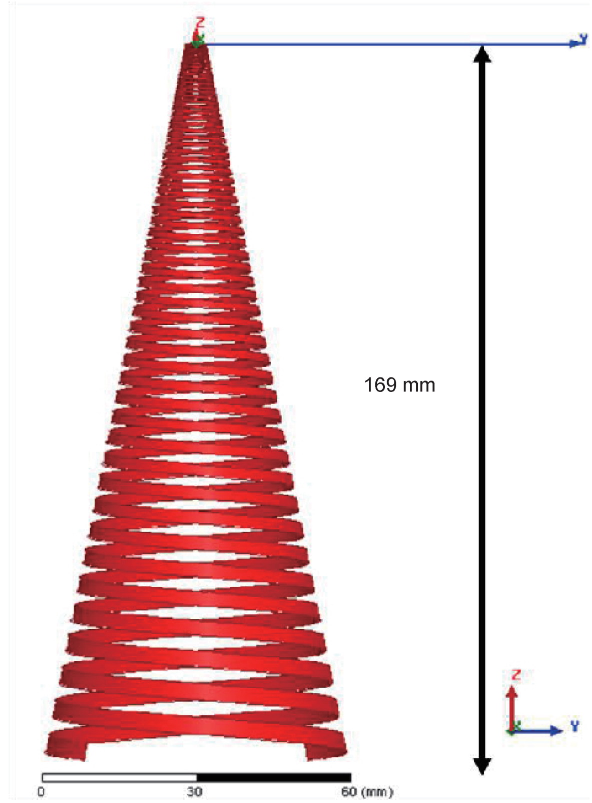

Fig. 4 Single element of the DYQSA feed.

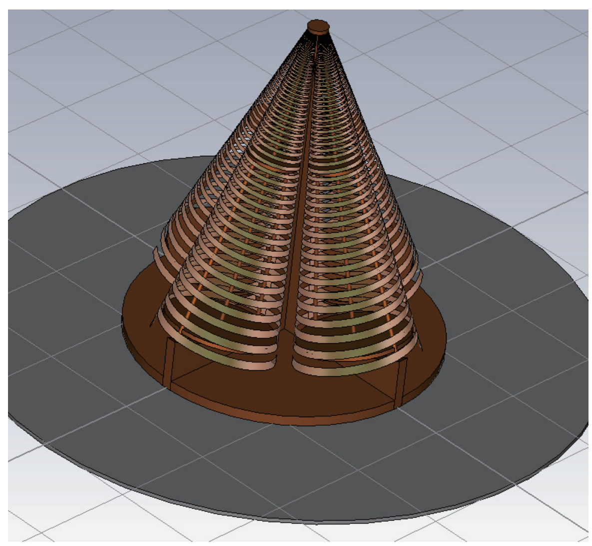

Fig. 5 The DYQSA full feed is made of four conical log-spirals. The result is a simultaneous dual-circular polarization feed.

2 The DYQSA Feed

The geometry proposed for the feed is based on a conical, log-spiral antenna (Dyson 1962, 1965). This is the origin of the name for the solution we have selected, devoted to the impressive work on this kind of antennas by Professor Dyson.

The antenna configuration is shown in Table 1. The full feed, based on the conical log-spiral antenna (see Figure 4), uses four units (Figure 5).

Table 1 Parameters of the DYQSA feed.

Parameter	Value
ρ_o	2 mm
R_{max}	30 mm
α	85^o
θ_o	10^o
δ	$\pi/2$

Two antennas are devoted to one polarization (RHCP), while the other two antennas are devoted to the opposite one (LHCP). The angle between the axis of the cones and the z-axis is 16^o. The radiation pattern of the antenna (Figure 6) was analyzed using the CST, Microwave Studio, and HFSS Ansoft softwares, obtaining the same results for both systems.

The phase center changes by 6 cm over the whole band (Figure 7). However, the variation is only 2 cm between 4 and 14 GHz. This will cause a reduction in efficiency for a fixed position of the antenna. However, this efficiency can be optimized to be always above 60% for different fixed positions of the feed from the focus, as is shown in Figure 9.

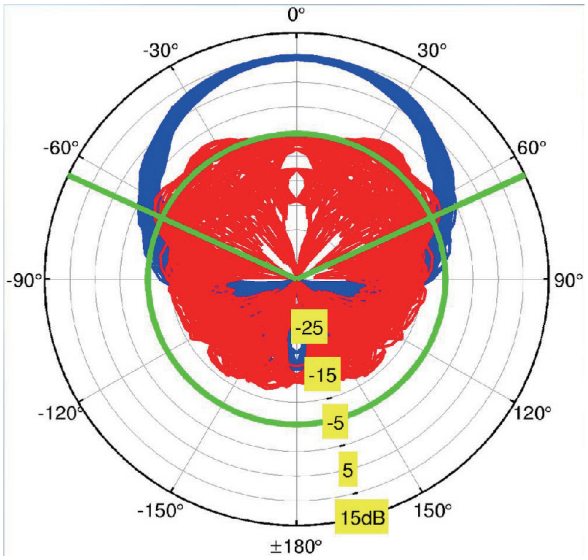

Fig. 6 Radiation patterns of the feed system from 2 GHz up to 14 GHz (step of 2 GHz) at the planes ϕ, with steps of 15^o from $\phi = 0^o$ up to $\phi = 180^o$. the blue line is copolar polarization and the red line is cross-polar polarization. Circular polarization is assumed. Green lines indicate the subtended angle from the focus of the subreflector. A pretty high symmetry in the radiation patterns at all frequencies is obtained with a maximum CP-XP level in broadside > 15 dB with a gain of 10 dB. The input impedance is also shown maintaining a quite constant behavior in the frequency band.

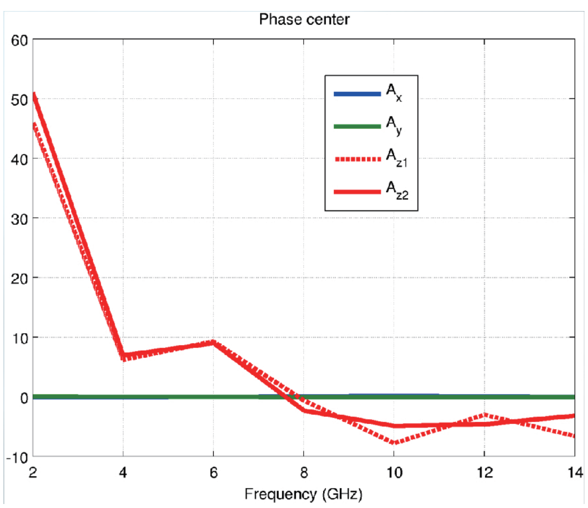

Fig. 7 Change of the phase center of the DYQSA feed.

3 First Measurements

A titanium first prototype of the feed single element has already been built (to assure no deformation of

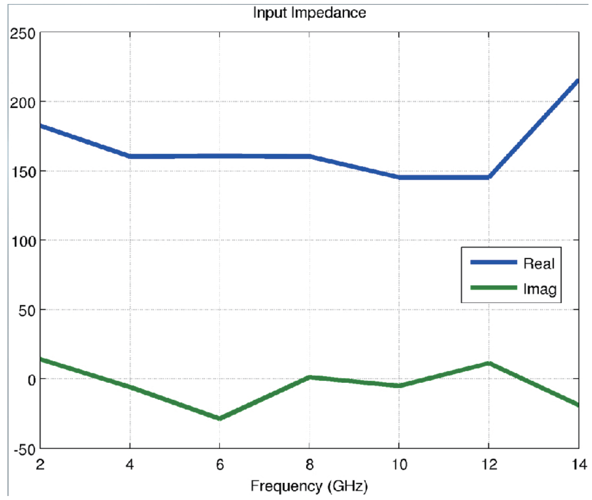

Fig. 8 Input impedance of the DYQSA feed.

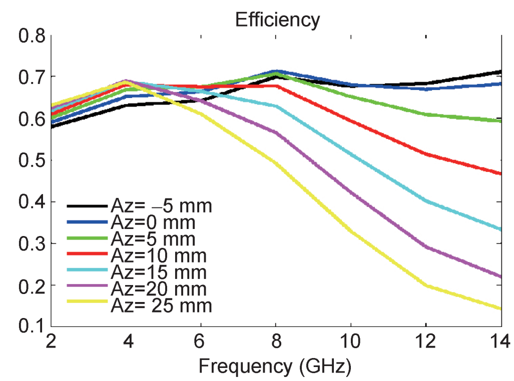

Fig. 9 Efficiency of the system obtained from GRASP allowing a geometrical displacement of the antenna along the z-axis.

the feed). The measurements were done at the Yebes anechoic chamber and they show very good agreement with theory. Simulations with GRASP show that placing this feed at the focus of the system can reach efficiencies higher than 70% in the whole band.

4 Conclusions

A totally novel antenna topology for covering the requirements of the VGOS system has been presented. The DYQSA antenna is a new solution for broadband ring focus feeds. It offers simultaneous dual-circular polarization over the whole band of 2–14 GHz. The simulated efficiency of the ring focus using this feed is approximately 70%. The DYQSA feed is similar in

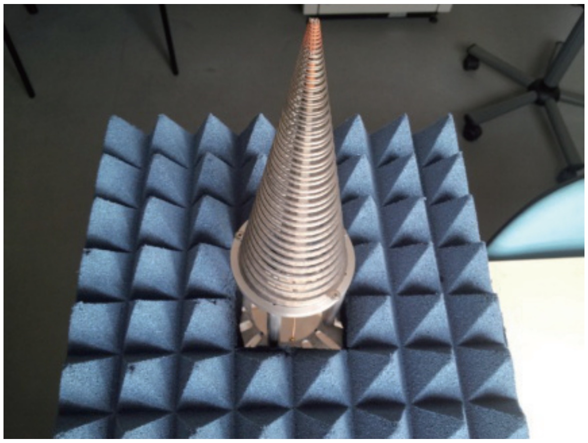

Fig. 10 First prototype of a single DYQSA element.

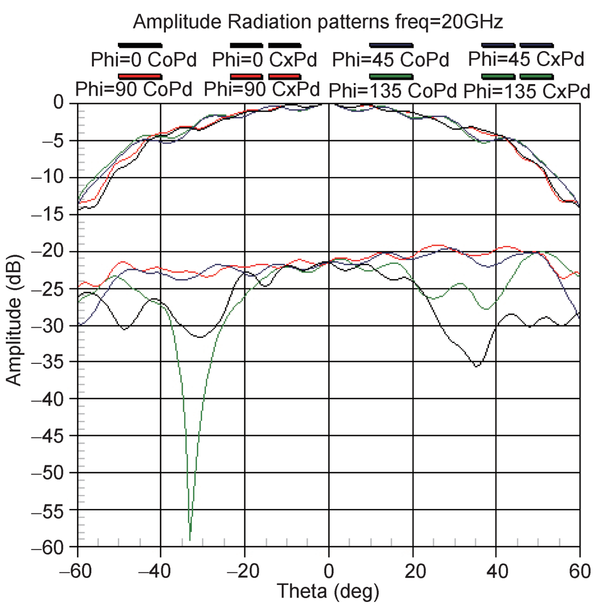

Fig. 11 Polar and cross-polar radiation patterns of a single element feed system at 2 GHz ($\phi = 0^o$, 45^o, 90^o, and 135^o).

volume to the QFRH feed. An already built prototype shows good agreement with theory. A final prototype will be finished in 2015.

Acknowledgements

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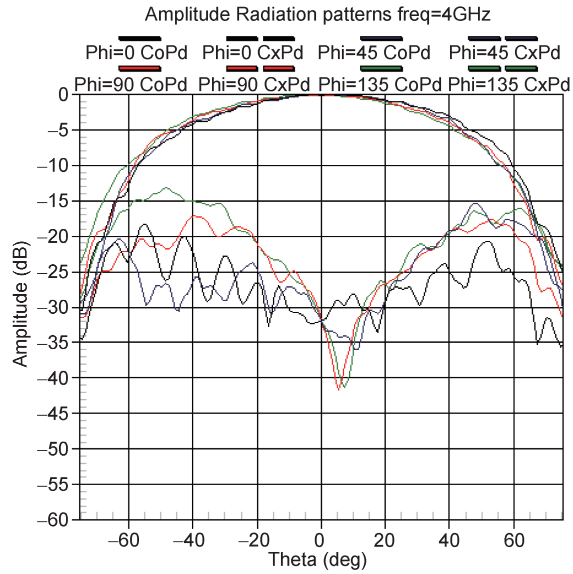

Fig. 12 Polar and cross-polar radiation patterns of a single element feed system at 4 GHz ($\phi = 0^o$, 45^o, 90^o, and 135^o).

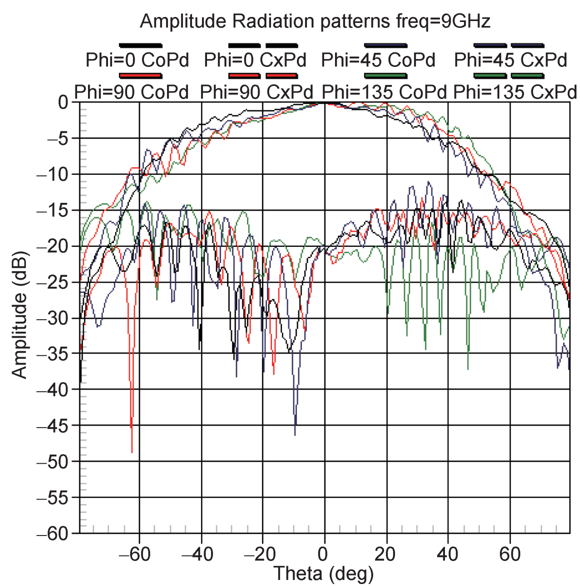

Fig. 13 Polar and cross-polar radiation patterns of a single element feed system at 9 GHz ($\phi = 0^o$, 45^o, 90^o, and 135^o).

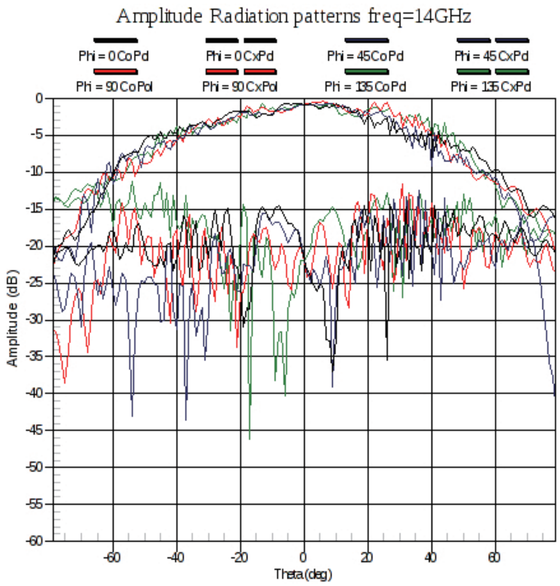

Fig. 14 Polar and cross-polar radiation patterns of a single element feed system at 14 GHz ($\phi = 0^o$, 45^o, 90^o, and 135^o).

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