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A broadband dielectrically loaded feed horn for the ngVLA telescope

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1 Extended Abstract

The ngVLA telescope is an interferometric radio telescope consisting of 244 18-metre antennas and 19 6-metre antennas spread across the North American continent [1]. Each antenna will have six receiving bands with continuous coverage from 1.2 GHz to 50.5 GHz and from 70 GHz to 116 GHz. The 18-metre aperture antennas are a shaped offset Gregorian design which offer exceptional performance if illuminated correctly. They exhibit a high aperture efficiency, low spillover and low far out sidelobes. Of the six frequency bands, band 2 has the highest fractional bandwidth covering 3.4-12.3 GHz, a bandwidth ratio of 3.6:1. Over this broad band it is difficult to maintain a high aperture efficiency with a standard quad-ridged feed horn.

Here we present the design of a cryogenic, dielectrically loaded quad-ridged feed horn with a corrugated skirt. The addition of a dielectric to a quad-ridged feed allows for a stable beamwidth over a wide bandwidth and greatly improved cross polar performance. Bandwidth ratios of 20:1 have been reported with this style of feed horn [2] and very good performance is readily achieved over bandwidth ratios of 6:1 [3]. A cross section of the feed horn is presented in Figure 1. The dielectric has the effect of confining the fields at high frequencies, reducing the effective aperture of the feed. This allows the beamwidth of the feed to remain constant over a wide bandwidth. The dielectric insert is machined from a single piece of PTFE allowing for very low loss when cooled. In order to reduce the dielectric constant towards the outer of the insert, radial grooves are machined into the insert.

We will present the performance that can be achieved with this style of feed horn on an offset Gregorian antenna and discuss some of the challenges associated with adding a central dielectric insert into a cryogenically cooled feed horn.

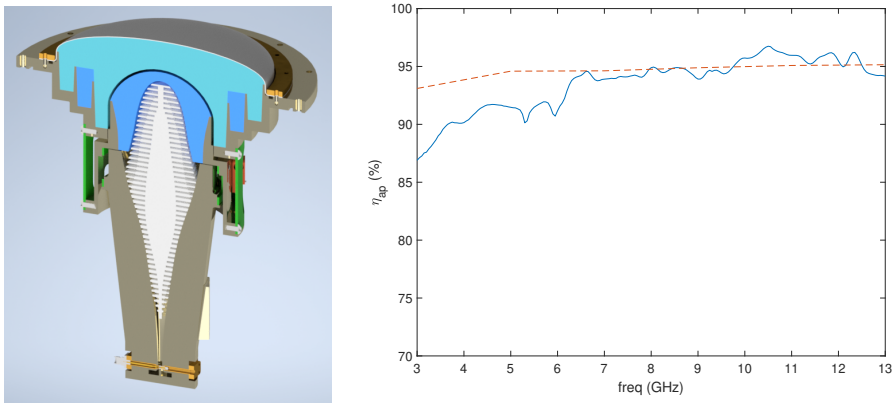

Figure 1. A cross section of the feed horn (left) and the aperture efficiency of the antenna illuminated by the feed (solid line) compared with an optimum Gaussian illumination (dashed line) (right).

References

[1] https://ngvla.nrao.edu

[2] J. Flygare et al., "Beyond-Decade Ultrawideband Quad-Ridge Flared Horn With Dielectric Load From 1 to 20 GHz," in IEEE Transactions on Antennas and Propagation, vol. 71, no. 3, pp. 2110-2125, March 2023

[3] A. Dunning, M. Bowen, M. Bourne, D. Hayman and S. L. Smith, "An ultra-wideband dielectrically loaded quad-ridged feed horn for radio astronomy," IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications, Turin, Italy, 2015