Design of the feed horn for the KAT-7 radio telescope

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This presentation will present the design of the feed horn for the prime focus parabolic reflector antennas of a seven-element interferometer, part of the Karoo Array Telescope project in South Africa. The dish diameter is 12 m with an F/D of 0.38. The feed horn is a wide flare angle axially corrugated conical horn, to be fed with a TE_{11} mode in a circular waveguide with radius of 92 mm, and is shown in Fig. 1. Three irises were introduced in the circular waveguide to improve the reflection coefficient of the TE_{11} mode. The frequency band is 1200 MHz to 1950 MHz.

The aim of the design was to minimize spillover and maximize gain in order to maximize A_e/T_{sys} over the frequency band. The eight corrugation depths, the front face of the horn (defined by a third order polynomial) and the iris parameters were optimized using a Nelder and Mead numerical minimization technique. The optimization goal consisted of a weighted sum of the following: 1. minimum TE_{11} mode reflection coefficient, 2. minimum cross-polarization of the dish pattern, 3. maximum efficiency of the dish illumination, and 4. maximum A_e/T_{sys} of the dish pattern.

In calculating the system temperature T_{sys}, it was assumed that the ground temperature is 270 K, and that it radiates noise as a perfect absorber, i.e. the fact that some spillover sees reflected cold sky, was compensated for by using a lower than average ground temperature. The system front-end temperature was assumed as 25 K, i.e. $T_{sys} = 25\ K + T_{spillover}$. All computational electro-magnetic analyses were done with the commercially available code FEKO. In order to make a numerical optimization feasible, effects such as horn blockage, reflections between the horn and dish and strut were ignored during optimization.

A full-wave analysis predicted a reflection coefficient (with the horn radiating into free-space) of less than -32 dB, excellent axial symmetry of the horn pattern and a flat dish A_e/T_{sys} of between 2.63 and 2.71 m^2/K over the frequency band.

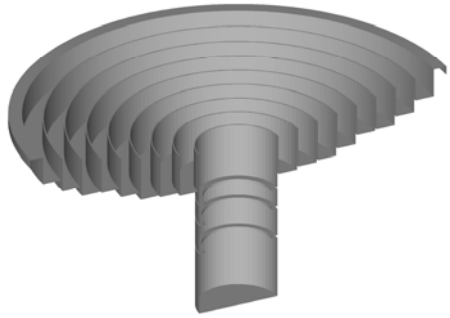

Fig. 1: FEKO model of the horn and irises.