CYLINDER – SMALL DISH HYBRID FOR THE SKA

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Abstract. No single technology can meet the current science specifications for the Square Kilometre Array (SKA). In this paper a hybrid option is explored that uses cylindrical reflectors to satisfy low frequency sensitivity and field-of-view requirements and small parabolic dishes to work at frequencies above 0.5 GHz.

Keywords: cylindrical reflector, hybrid, parabolic reflector, SKA

Introduction

None of the current design concepts for the Square Kilometre Array (SKA) can meet all the science requirements in terms of frequency coverage, sensitivity at high and low frequencies, and field-of-view. In this paper a hybrid consisting of cylindrical reflectors, to cover the lower frequencies, and small parabolic reflectors, to cover the higher frequencies, is considered. This hybrid maintains full frequency coverage and meets field-of-view and low-frequency sensitivity requirements. It does so at the expense of sensitivity at high frequencies.

1. Selection of hybrid components

One of the major challenges posed by the SKA Science Requirements (Jones, 2004) is the sensitivity requirements at high and low frequencies. At high frequencies fully steerable parabolic dishes have been the technology of choice for all existing radiotelescopes. For the SKA a small dish about 12 m in diameter represents an optimum between the costs of the reflector itself and the associated electronics (USSKA Consortium, 2002, 2003). Maximum performance is achieved if cooled receivers are used. In order to meet the SKA sensitivity specifications above approximately 1 GHz, a total effective area of 0.36 km² is needed, equivalent to 4500 dishes.

At low frequencies where sky noise dominates receiver noise larger effective areas (about 1 km²) are needed to meet the science requirements. At 0.5 GHz this could be reduced to 0.7 km², if cooled receivers were used, but remains 1 km² for
uncooled systems. Thus, additional collecting area is needed at low frequencies. Moreover, an additional SKA science requirement is a high survey speed specified at 700 MHz, but in practice this requirement may extend to frequencies as high as 1 GHz. For the $\sim 100$ deg$^2$ field-of-view needed to meet the survey speed specification, at least one million feed elements (Bunton, 2000) are needed, each with a separate receiver. The number of feeds will probably dictate the use of uncooled receivers.

A low cost solution for providing the large collecting area and feed numbers is a cylindrical reflector. The cylindrical reflector has only one axis of rotation reducing the cost of the drive system. The antenna mounts are also cheap as they can be short, they are distributed along the length of cylinder, and they only experience torque around an axis aligned along the cylinder. The cylinder also provides a solution to the minimisation of feeds numbers for a field-of-view (FoV) that matches the SKA science requirements (Bunton and Hay, 2005). The resulting FoV is highly elongated, which does not impair the cylindrical reflector’s survey capabilities but limits its ability to target multiple long track observation. The converse of this is that the area of sky accessible for short observations is significantly increased.

2. Hybrid components

The small dish for this proposal is based on the SKA Design Concept white papers 2 and 9 (USSKA Consortium, 2002, 2003). For the hybrid, the antenna does not have to operate at low frequencies. This allows a cheaper symmetric design to be used with a comparatively small subreflector as shown in Figure 1. The reflector is 12 m in diameter with a 1.6 m Gregorian subreflector allowing the dish to operate down to 0.47 GHz. With a shaped surface the aperture efficiency is 72%. Full efficiency is available up to 25 GHz. Above this frequency it is proposed to under illuminate the dish to avoid pointing problems. This allows the small dish to operate at 36 GHz with an effective aperture that is half its 25 GHz value.

The cylindrical reflector is an offset feed design 110 m $\times$ 15 m illustrated in Figure 1 (Bunton et al., 2002; Bunton, 2003). At low frequencies it will be a light

Figure 1. Illustrations of the proposed cylindrical reflector and 12-m symmetric parabolic dish.