“Fair” UV Coverage for a Multi-resolution

John Bunton,

CSIRO Telecommunications and Industrial Physics, Australia

Introduction

If we wish to have a multi-resolution telescope with equal point source sensitivity at all resolutions then we must accept that the baseline distribution of the correlations is predetermined.

A full version of this paper available at http://www.atnf.csiro.au/SKA/techdocs/Fair_uv.pdf

Proposition: Design 7 separate fixed telescopes with resolution corresponding to baselines 1, 3.15, 10, 31.5, 100, 315 and 1000km. Each is to have the same number of antennas and the UV coverage is to be Gaussian.

The resulting sensitivities of the 7 telescopes as a function of baseline are shown below.

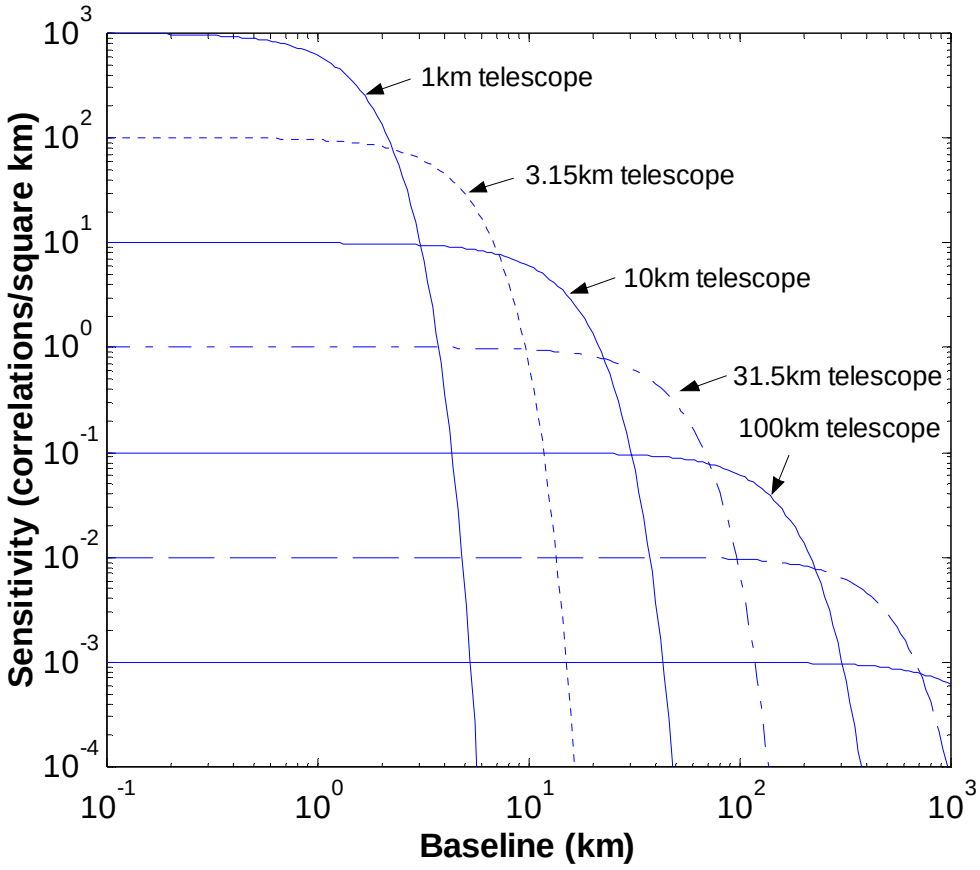

Figure 1: Correlation density versus baseline for telescopes of differing resolutions but the same effective area.

Consider a single telescope which has sensitivity at a given baseline equal to the maximum sensitivity any of the seven separate telescopes. Let the 1km telescope be the starting point. Its coverage overlaps that for the 3.15km telescope. To add the 3.15km resolution the number of correlations must be increased by 69.5%. This occurs for each added step in resolution. The effect of this is shown in the table below.

Baselines km	1	3.15	10	31.5	100	315	1000
Correlations	1	1.695	2.39	3.085	3.78	4.475	5.17
Area	1	1.302	1.546	1.756	1.944	2.115	2.274
Area increase		0.302	0.244	0.210	0.188	0.171	0.158

Table 1: Increase in correlations and effective area as SKA resolution increases.

It is seen that for the combined telescope the total number of correlations is 5.17 times the number needed for a single resolution. More importantly the total collecting area is only 2.27 times greater even though 7 resolutions are covered. This occurs because

$$\text{Number of Correlations} \propto (\text{Number of Antennas})^2$$

Add to this the increased sensitivity at shorter baselines for most resolutions and it is found that:

A multi-resolution radiotelescope has a sensitivity of about half that of an instrument optimised for one resolution

Now consider what happens if the multi-resolution instrument is designed to have any resolution in a given range. In the figure opposite this corresponds to adding curves at all resolutions from 1 to 1000 km. The envelope of these curves is a line of the form $1/\text{baseline}^2$. A small number of extra correlations is needed and the net effect on overall sensitivity is small.

If the correlation density per square km falls as $1/(\text{baseline})^2$ then the sensitivity to point sources is independent of resolution

This conclusion holds for all but the shortest baselines. To compensate one may have to increase the number of correlations devoted to the shortest baselines.